Chapter 8
Measurements

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Chapter 8
Measurements

8-1 INTRODUCTION

This section discusses typical measurements that can be made with the Model 37XXXD Vector Network Analyzer.

8-2 TRANSMISSION AND REFLECTION

This discussion provides information on general measurement considerations and transmission and reflection measurements using the 37XXXD.

Setup and Calibration

To get started, apply power to the system.

After turning on the power, allow the system to warm up for at least 60 minutes before operation.

In normal operation, the system comes on line in the state that it was in when last turned off. If you want to return the system to its default state, you can do so by pressing the Default Program key twice.

The default parameters provide a known starting point. For example, they reset the start and stop frequencies for maximum sweep width, the source control to 0 dB, and the display resolution to 401 data points.

The Sweep Setup menu should now appear on the display (it also can be displayed using the Setup Menu key). If you like, you can select a new start frequency, stop frequency, or source power.

You can further reduce the power level at Ports 1 and 2 with the built-in attenuators. Using the Reduced Test Signals option in the Sweep Setup menu, you can change the setting of the Port 1 source attenuator over a range of from 0 to 70 dB. The Port 2 test attenuator has a range of from 0 to 40 dB (in 10 dB steps) (if Option 6 is installed).

Install the calibration kit devices to the test ports as instructed by the U3 menu. Both the capacitance coefficients for the Open and the offset lengths for the Open and Short can be modified or defined.

Selecting the Begin Cal key starts the calibration process. The Calibration menus step you through the calibration process, as follows:

Select the type of calibration desired.

Select the frequency range of calibration. Using the Data Points key, you can choose from 51 up to 1601 measurement data points.

When the calibration is completed, you can store the calibration data on a disk. You are now ready to install the test device and proceed with the measurement. At this point you have a number of measurement options to consider such as displays, markers, limits, outputs, sweeps, and enhancements.

You can select any of the available graph types and display them for any calibrated parameter on any of the four channels (if a 12-term calibration was performed).

Up to six markers are available. Using the Marker Menu, you can set the frequency of each one, you can set each one in the delta marker mode, and you can set each marker's level to maximum or minimum.

In some cases—such as in a production environment—limit lines are desirable. Options within the menu called up using the Limits key, provide for one or two flat, sloped, or single-point-segmented limit lines for each channel. These limit lines function with all of the graph types, including Smith and admittance. The color of the limit lines (blue) differs from that of the measurement trace. This allows for easy analysis of results.

The Hard Copy Menu key menu (Figure 8-1) gives you a choice between a printer and a colored-pen plotter. It also lets you select menus from which you may chose from a variety of print or plot options.To output the display, press the Start Print key. The default setting provides for a full display printout from the associated printer.

SELECT OUTPUT
DEVICE
PRINTER
PLOTTER
OUTPUT OPTIONS
SETUP OUTPUT
HEADERS
OPERATIONS
PRINT OPTIONS
PLOT OPTIONS
PRESS <ENTER>
TO SELECT

Figure 8-1*.* *Output Menu*

To label the output, select Setup Output Headers in the Output Menu or press the Device ID key.

On the output to the printer, plotter, or disk. a menu then appears that lets you specify the device name/serial number, the date, the operator's name, and user comments (Figure 8-2).

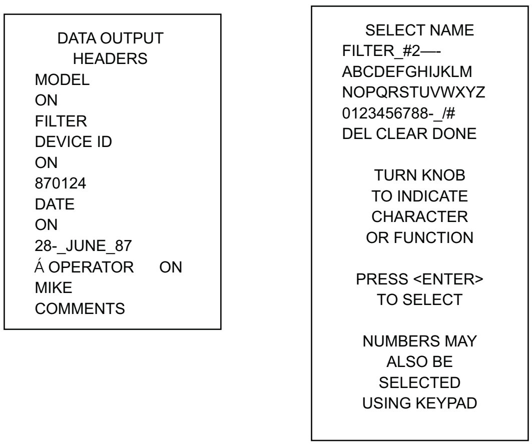


***Figure 8-2**.* *Label Menus*

Sweep frequencies can be changed with the calibration applied as long as the frequencies are between the calibration start and stop frequencies.

Additionally, a marker sweep can be selected from the Setup Menu. This allows you to sweep between any two active markers as long as the frequency of each falls between the calibrated start and stop frequencies.

Using the Data Points key, you can select the number of data points for optimal resolution-vs-speed.

Finally, you can enhance the measurement data by reducing the IF bandwidth and using averaging and/or smoothing.

- ❑ Change the IF bandwidth by selecting the Video IF BW key
- ❑ Set the averaging and smoothing values by selecting the Avg/Smooth Menu key
- ❑ Turn on the averaging and smoothing using the Trace Smooth and Average keys, which have LED's to let you know that the enhancement is being applied

Measurement Discussion

Before going any further, let us take a few moments to review some basic principles of network measurements. First, we apply incident energy to the input of a test device. If the device's input impedance differs from the measurement system's impedance, some of that energy is reflected. The remainder is transmitted through the device. We call the ratio of reflected-to-incident energy the reflection coefficient. The ratio of transmitted-to-incident energy we call the transmission coefficient (Figure 8-3).

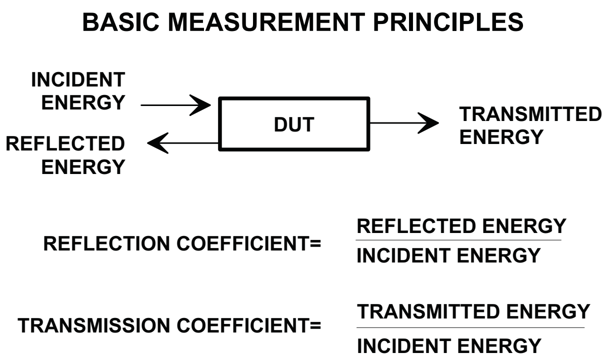


Figure 8-3. *Basic Measurement Principles*

These ratios are complex quantities that have magnitude and phase components. Using vector representation, the vector magnitude is the ratio of reflected-to-incident magnitude (or transmitted-to-incident magnitude), while the vector phase is the difference in phase between the incident energy and the reflected/transmitted energy (Figure 8-4).

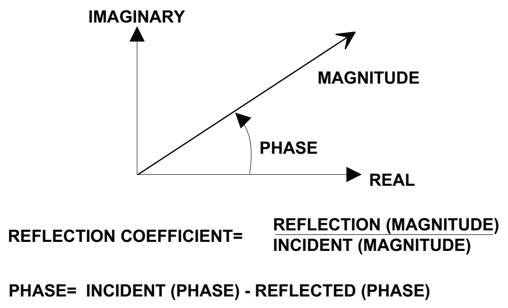


Figure 8-4. Magnitude/Phase Vector

The measurement reference for the incident energy is the point at which the device connects to the measurement system. We call this point the reference plane. The incident energy at the reference plane is defined as having a magnitude of 1 and a phase of 0 degrees. We establish this during the calibration.

- ❑ The ratio of reflected and transmitted energy to the incident energy can be represented by a number of different measurements and units, as shown below.
- ❑ The default display for reflection measurements is the Smith chart. The default display for transmission measurements is the Log Magnitude and Phase graph.

The Smith chart is a convenient way to display device impedance and is a useful aid for the graphical design and analysis of microwave circuits (Figure 8-5).

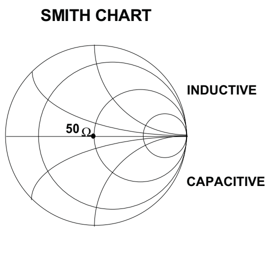


Figure 8-5 Smith Chart Display 1

Let us assume both that our system is already calibrated and that we have equalized the system for the test port in use. We would then

1. *Connect the Short*: A Short always appears as a dot at the left-most edge of the Smith chart's horizontal axis.

2. *Connect a Termination*: Now you will see another dot located at the center (1+j0) of the chart (this assumes a 50-ohm load).

3. *Connect the Open*: An Open appears as an arc on the chart's right edge. This is due to the fringing capacitance of the Open standard (Figure 8-6).

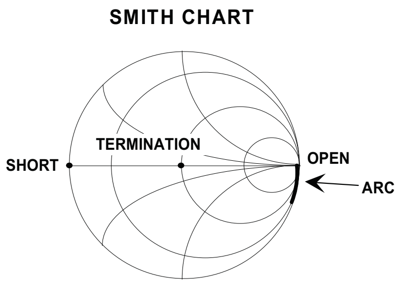


Figure 8-6. Smith Chart Display 2

Now let's perform a reflection measurement on a 20 dB attenuator over the 1 to 18 GHz range.

We need to determine the setup, calibration, and measurement requirements.

A known good starting point is to reset with Default Program parameters. Since our measurement lies between 1 and 18 GHz, set the Start and Stop frequencies using the Sweep Setup menu that appears on the display following system reset.

Let's perform a simple *Reflection Only* calibration, which uses an open, a short, and a broadband load. To do this, press the Begin Cal key and follow the directions in the menu area.

When you complete the calibration, the "CHANNEL 1 WITH S11" Smith chart appears on the display. Now:

1. Select the Log Magnitude display and install the attenuator.

2. Select Auto Scale to optimize the display data.

3. Use Markers 1 and 2 to find the maximum and minimum impedance.

Now let us perform a transmission measurement on the same 20 dB attenuator over the same frequency range. We will follow the same steps as before, but this time we will use additional features.

Once again, reset the system using the Default Program key.

In this calibration we will select the N-Discrete Frequencies menu option and step all frequencies in increments of 50 MHz.

When the calibration is complete, Channel 1 will display “S21 FORWARD TRANSMISSION WITH LOG MAGNITUDE AND PHASE.” You can use Markers 1 and 2 to find the maximum and minimum values of the attenuators insertion loss.

8-3 LOW LEVEL AND GAIN

This discussion provides methods and techniques for making gain and low-signal-level measurements. It is divided into 37XXXD system considerations and test device considerations.

37XXXD System Considerations

The 37XXXD system is limited in its ability to test low-signal levels by its dynamic range and signal-to-noise-power ratio. First we will discuss receiver dynamic range, which is the difference between the maximum and minimum acceptable signal levels (Receiver Dynamic Range = Pmax – Pmin).

Receiver Dynamic Range

The dynamic range of the 37XXXD is limited by the 0.1 dB compression level of the samplers at high signal levels. It is further limited at low signal levels by leakage signals and noise.

Figure 8-7 shows the detected output signal as a function of the power level at the sampler. The 0.1 dB compression level is on the order of –10 dBm. The 37XXXD is designed such that all other conversions compress at a much greater level, which leaves the samplers as the main source of nonlinearity.

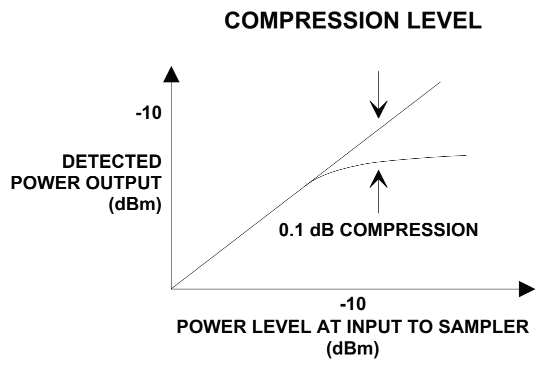


Figure 8-7. *Compression at 0.1 dB*

The small signal response is limited by errors due to noise and leakage signals. The leakage signals are both from within the 37XXXD and at the device-under-test (DUT) connectors.

The detected signal is the vector sum of the desired signals, the noise signals, and the leakage signals. These signals introduce an error or uncertainty (Figure 8-8).

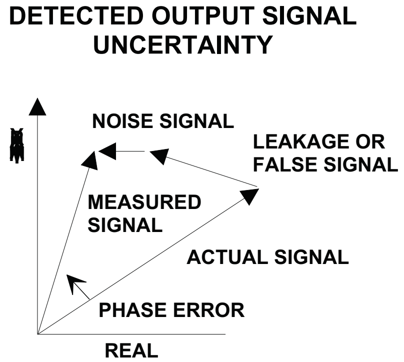


Figure 8-8. *Amplitude and Phase Uncertainty*

Some of the possible leakage paths for the 37XXXD are the transfer switch, the frequency conversion module, and the DUT. The system limits these leakages to greater than 100 dB. The 12-term error correction can reduce this leakage to better than 110 dB at 18 GHz and 90 dB at 40 GHz.

NOTE

We recommend using an isolation cell to decrease leakage signals for sensitive measurements. For best results, increase the default averaging value and decrease the default IF bandwidth setting during calibration and measurement. Using higher enhancement during the measurement than the calibration will not result in any accuracy improvements.

The DUT connectors should have internally captivated center pins. Those connectors which use external pins to captivate the center conductor should have silver loaded epoxy on the pins to reduce radiation to better than 80 dB.

Signal-to-Noise-Power Ratio

The signal-to-noise-power ratio for each of the test or reference channels is as shown. The “signal power” is the power level of the 80 kHz IF signal at the internal synchronous detectors, and the “noise power” is the total power contained within the bandwidth of the bandpass filter at 80 kHz.

The uncertainty, or error, in a measurement is a function of the amplitude of leakage signals and of the noise level. The uncertainty in the measurement of magnitude and phase of the S-parameters are calculable and shown in Figures 8-9 and 8-10.

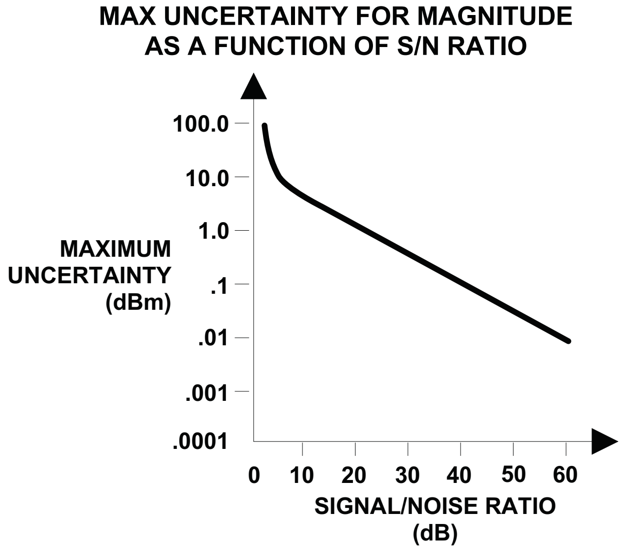


Figure 8-9. *The Effect of S/N Ratio On Magnitude Measurements (Noise Only)*

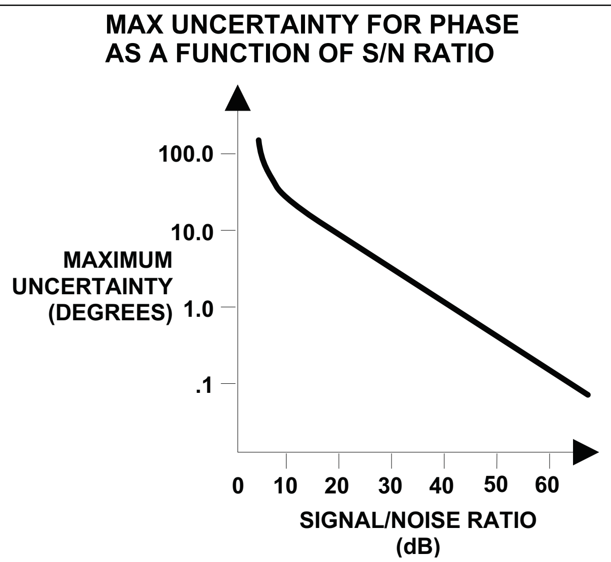


Figure 8-10. *The Effect of S/N Ratio On Phase Measurements (Noise Only)*

The most difficult types of measurements are those that exercise the full dynamic range of the 37XXXD, such as filters (Figure 8-11. Filter measurements are examples of where one must observe both low-insertion loss (in the passband) and high attenuation (in the stop band).

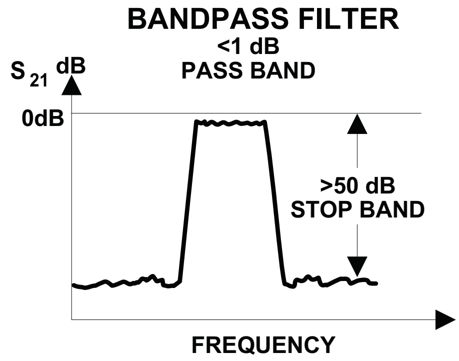


Figure 8-11. Filter Measurements

There are two techniques that you can use to optimize the signal-to-noise ratio. They are (1) maximizing the RF signal level and (2) using signal enhancement.

To maximize the RF signal level, use the default settings of the 37XXXD.

The 37XXXD provides two enhancements for improving the signal-to-noise ratio: IF bandwidth reduction and averaging.

Reducing the IF bandwidth is a primary method for enhancing accuracy. The 37XXXD has a choice of four bandwidths available from the front panel: Maximum (10 kHz), Normal (1 kHz), Reduced (100 Hz), and Minimum (10 Hz). The noise level should decrease by a factor equal to the square root of the IF bandwidth. Using IF Bandwidth reduction makes for faster measurements than with the use of an equivalent amount of averaging.

Averaging is another way to improve accuracy. The improvement is proportional to the square root of the number of averages. Two types of averaging are supported: Sweep-by-sweep and point-by-point.

Point-by-point averaging works by collecting multiple measurements while at each frequency point and then averaging them together. Sweep-by-sweep averaging works by performing multiple complete sweeps and averaging the individual the individual frequency points by taking data from the different sweeps. The primary difference is the amount of time between samples at a given frequency point (short for point-by-point, longer for sweep-by-sweep).

Sweep-by-sweep averaging may produce lower trace noise because the averaging time is more likely to exceed the coherence time of the noise source. The disadvantage is that any slow drift or transient response of the device under test will be lost in the averaging process. Sweep-by-sweep is hence less suitable for use during device tuning.

Conversely, point-by-point averaging will better preserve device tuning response or device drift. It may, however, result in slightly elevated trace noise (relative to sweep-by-sweep) since the measurement time may be less than the coherence time of the noise source.

Figure 8-12 shows the measured reduction in noise due to bandwidth and averaging.

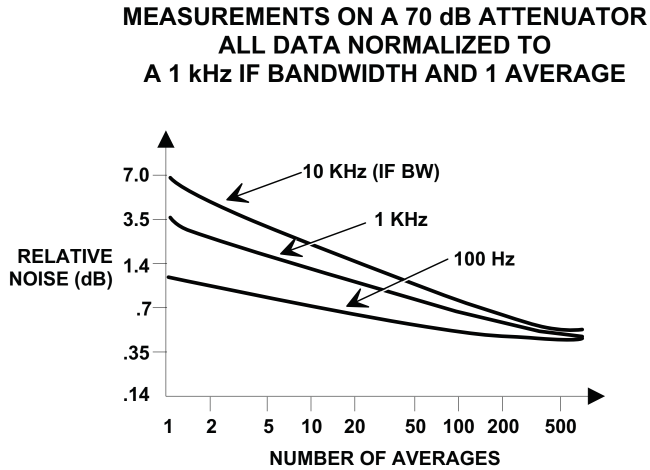


Figure 8-12. Reduction in Noise Using Averaging

Example: Using 1 kHz BW reduction and 10 averages, you would increase the signal-to-noise ratio by 7.6 dB but would lengthen the time required for the measurement by a factor of 4.3. This example assumes a constant signal power.

Test Device (DUT) Considerations

In order to test a device, the required input RF level and the expected device output RF level must be determined.

The RF level at Port 1 must be set for the device input RF power level required. Attenuation can be added in steps of 10 dB up to 70 dB using the built-in source attenuator. Amplification can be added by removing the front panel loop and adding an external amplifier.

Before calibration, ensure that the test setup is correct by setting the power level and adding attenuation as needed.

The 37XXXD uses enhancements in the calibration to ensure a wide dynamic range. It automatically selects 1 kHz IF bandwidth and varies the number of averages with the calibration device. Terminations require the most averages.

If desired, the Video IF bandwidth and number of averages can be specified for the calibration measurements. Using 100 averages (Avg = 100) appears to be sufficient for most measurements.

To obtain the maximum performance from the 37XXXD for measurements of attenuation, you can use the capability of the N discrete frequency calibration to spot check measurements in the frequency band of interest.

Wide Dynamic Range Device - Filter

Since you do both low-insertion-loss and high- attenuation measurements simultaneously, use the maximum RF signal level and no attenuation. Selecting the 1 kHz Video IF BW setting and 100 averages will likely suffice for this kind of measurement (Figure 8-13).

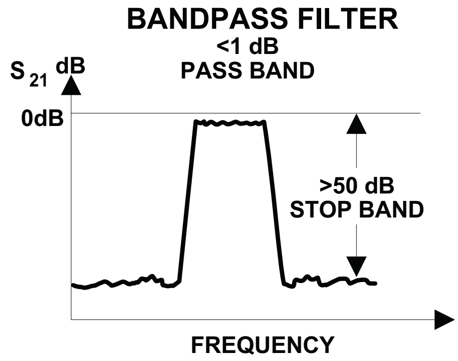


Figure 8-13. Filter Measurements

High Gain Device - FET

This device has a typical 15 dB gain and requires an input level of about –30 dBm. Set the Port 1 Source Attenuator to 30 dB. Since the device RF output level is –15 dBm (–30 dBm + 15 dB[gain] = –15 dBm) no attenuation is needed at Port 2.

Medium Power Device - Amplifier

Measure the small signal parameters of a 10 dB gain device that requires an input power level of 0 dBm. Here, Port 1 will have no attenuation. The device RF output level is 10 dBm. This level equals 10 dBm (0 dBm + 10 dB[gain] = 10 dBm) into Port 2 and will cause compression in the measurement. At least 10 dB of test attenuation will be needed at Port 2, which will reduce the Port 2 RF level to 0 dB.

8-4 GROUP DELAY

Group delay is the measure of transit time through a device at a particular frequency. Ideally, we want to measure a constant—or relatively constant—transit time over frequency. The top waveform shown in Figure 8-14 is measured at one frequency. The bottom waveform is identical to the first, simply delayed in time.

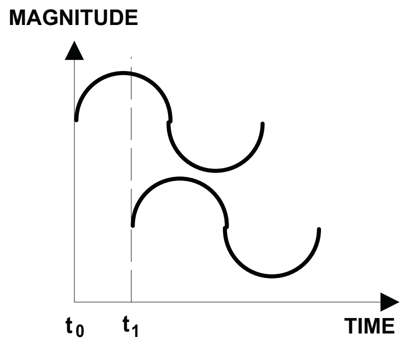


Figure 8-14. Two Waveforms Delayed in Time

Referring to Figure 8-15, the first waveform shown is the original waveform. It is made up of many frequency components. After traveling through a device the signal is delayed in time. Some frequencies are delayed more than others and thus our waveform does not have exactly the same shape as before.

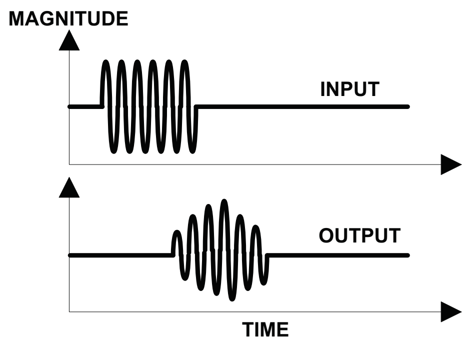


Figure 8-15. Waveform with Frequency Differences

When delay is nonlinear, as shown above, distortion occurs. By measuring group delay with a network analyzer you can characterize the distortion that occurs from a signal traveling through your test device.

When designing components it is important to measure group delay so that you can compensate for any distortion caused by the component. You may be able to tune the device so as to optimize the performance of group delay over the frequency range of interest. Outside of the specified frequency range, the group delay may or may not be linear.

So how is group delay measured? Signals travel too fast to enable measuring the input and output times of each frequency component. Consequently, we must use mathematical calculations to derive the group delay from the phase slope.

Group delay is mathematically represented by the following equations:

$$\tau = -\frac{-d\theta}{d\omega} = \frac{-1}{2\pi}\frac{d\theta}{df} = \frac{-1}{360}\frac{d\theta}{df} = \frac{1}{2\pi}\frac{\Delta\theta}{\Delta f}$$

What this equation shows is that group delay is a measure of the change in phase with relation to the change in frequency.

The change in frequency is referred to as an aperture.

$$\Delta f = Aperture$$

To measure group delay the frequency aperture must be selected. Depending on the size of aperture, different levels of precision can result for the measurement of group delay.

$$Aperture = \frac{Frequency\ Range}{Of\ Data\ Points}$$

A wide aperture results in a loss of fine-grain variations but gives more sensitivity in the measurement of time delay. A small aperture gives better frequency resolution, but at the cost of lost sensitivity. Thus, for any comparison of group delay data you must know the aperture used to make the measurement (Figure 8-16).

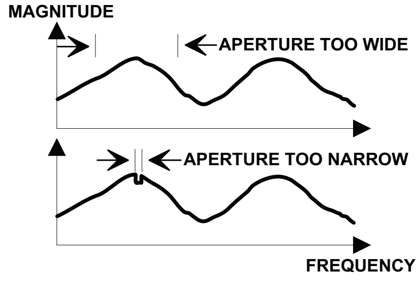


Figure 8-16. Waveforms With Aperture Differences

Let us take a look at a group delay measurement made on the Anritsu 37347D Vector Network Analyzer. Group delay, as a measurement option, can be found in the Graph Type menu. After selecting the option, the VNA displays the data in a time-vs-frequency graph, or to be more exact, a group-delay-vs-frequency graph (Figure 8-17).

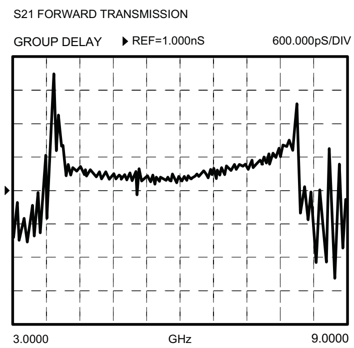


Figure 8-17. Group Delay-vs-Frequency Graph

The 37XXXD automatically selects the frequency spacing between data points—that is, the aperture. Notice that this value is displayed on the screen with the measurement (Figure 8-18).

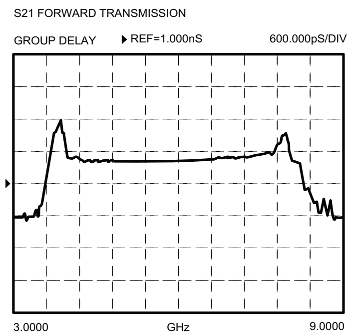


Figure 8-18. Group Delay Screen Showing Aperture

The aperture defaults to the smallest setting for the frequency range and number of data points selected. This value is displayed in the Set Scale key menu when measuring group delay (Figure 8-19).

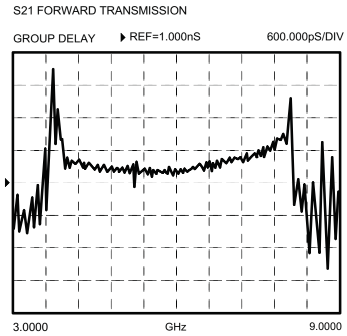


Figure 8-19. 37XXXD Aperture

Group delay applications are found throughout the microwave industry, although the majority of such measurements are made in the telecommunications area.

One occurrence of group delay that you may have experienced is with a long-distance telephone call. Occasionally a phone call can be disturbing because of the delay in time from when you speak and when the other person responds. If there is simply a delay, then time delay—or linear group delay—has occurred. But if the voices are also distorted, then non-linear group delay has occurred. It is this distortion that we must avoid. We can avoid linear group delay by measuring group delay both during the design and development stages and during recalibration in the field.

One final group-delay application is found in the development of components. In this application, group delay is measured for the transit time of a signal through the device. When time is of the essence in a fast switching system, as in a modern computer, the travel time through a device is critical.

8-5 ACTIVE DEVICE

Active devices are key components in microwave systems.

The measurements that are made on active devices are similar to those made on passive devices.

Active devices come in many shapes and sizes. In most cases we are going to have to develop a fixture in which to mount the device.

Active devices require bias voltages, and in many cases they are easily damaged. High gain amplifiers may saturate with input signals of –50 dBm. With active devices, we have a new set of measurement requirements.

The 373XXD has been designed to help you make these types of measurements. It includes one 70 dB step attenuator (60 dB for 37377D and 37397D) used to adjust the Port 1 power level. A second 40 dB step attenuator is also included (with Option 6) in the forward transmission path to allow measurement of high gain devices without sacrificing reverse transmission and reflection measurements (S_{12}, S_{22}). Bias tees on each port are used to bias the device via the test port center conductor. This approach to bias is useful for testing transistors; however, MMIC's usually require bias injection at other points (Figure 8-20).

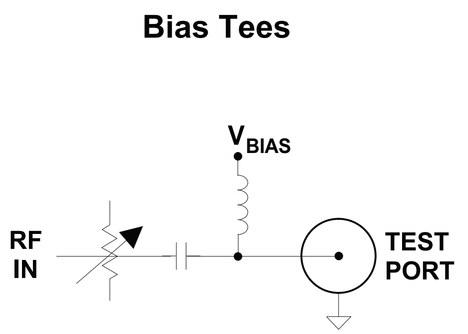


Figure 8-20. Bias Tee

Test fixtures are necessary for mounting the device so that it can be measured in our coaxial (or waveguide) measuring system (Figure 8-21).

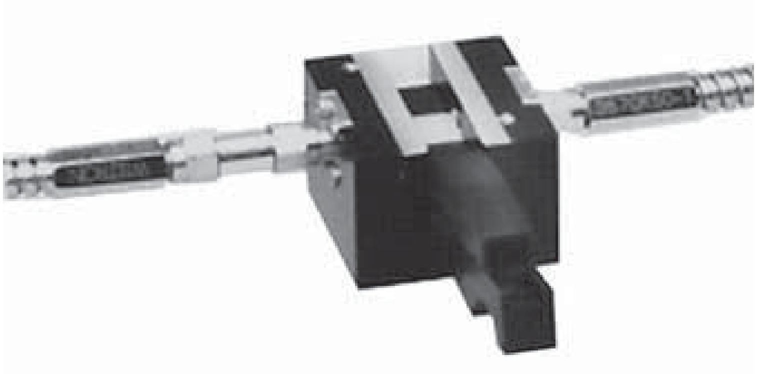


Figure 8-21. Active Device Test Fixture

Now we have an interesting situation. While we can measure the performance at the connector—which is the calibration plane—what we really want to know is how our device performs (Figure 8-22).

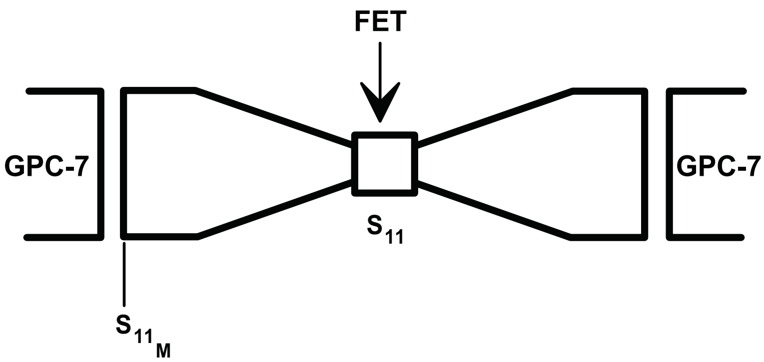


Figure 8-22. View of a Test Device

You can consider the device embedded in the fixture and can measure the S-parameters of the fixture with the device installed.

The most elementary situation is a system in which the test fixture is electrically ideal or transparent. In this case, the solution is simple—merely move the reference plane out to the device (Figure 8-23).

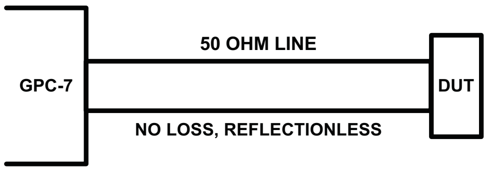


Figure 8-23. Simple Example of De-Embedding

In some cases—depending on the fixture or the device being measured—this is satisfactory. But when it is not, we need to employ other techniques.

One of the reasons that moving the reference plane out to the device does not always work, is that the test fixture includes a transition from coax to a structure such as microstrip, coplanar waveguide, or stripline (Figure 8-24).

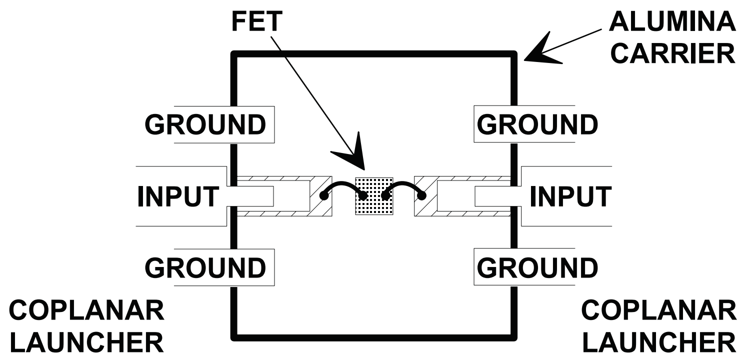


Figure 8-24. Coax-to-Substrate Transition

Engineers have come to grips with the general problem. However, there is no established standard approach. Two of the more common approaches are to calibrate the fixture as a part of the analyzer, and to characterize the fixture and compute the desired result.

In the discussion on calibration we saw that the calibration components establish the reference plane and determine the quality of the measurement. If we have a good Open, Short and Z_0 load to place at the end of a microstrip line, we can calibrate the system at the point of measurement.

Figure 8-25 shows some of the special test-fixture calibration standards that are available.

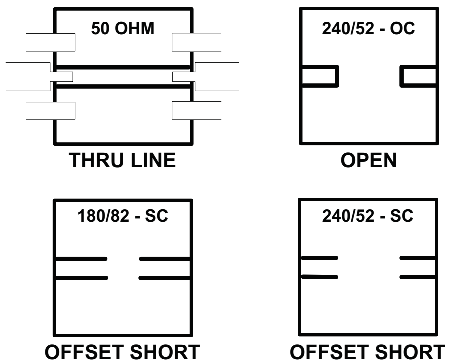


Figure 8-25. Special Test Fixtures

These special calibration kits are far from perfect, but they are superior to our perfect transmission line assumption.

You may also have heard of the probe stations built to permit on-wafer calibration measurements.

The Open, Short, termination approach provides three known standards that permit the analyzer to solve for three unknowns (Figure 8-26).

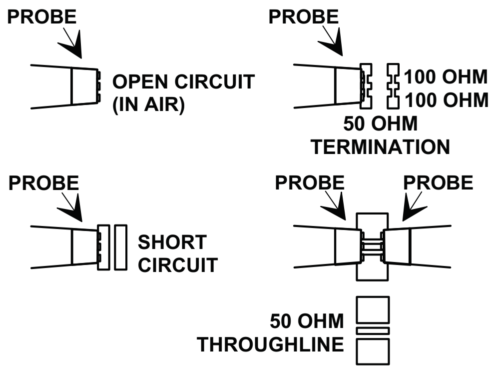


Figure 8-26. Solving for Unknowns

CAUTION

CAUTION ⚠

You should turn off or disconnect the bias supplies during the calibration, since you are using a Short as the calibration standard.

It is also possible to use three known impedances. For instance, a varactor with three voltages applied (Figure 8-27).

SPECIAL CALIBRATION KITS

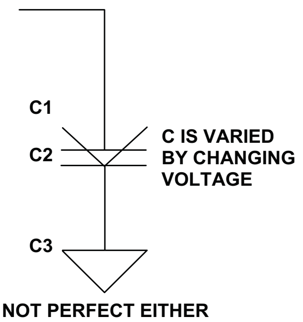


Figure 8-27. Three Known Impedances

The second approach is to model the fixture. Modeling is elegant but of limited use due to the non-ideal characteristics of the fixture. Modeling can be accomplished in a CAD system.

In summary, there are quite a variety of approaches—all with their own characteristic pitfalls. Engineers try to choose the most appropriate technique for their application.

8-6 MULTIPLE SOURCE CONTROL

The Multiple Source Control mode permits independent control of the 37XXXD source, receiver, and an external Anritsu synthesizer (67XXB, 68XXXB, MG36XXA/B), without the need of an external controller (Figure 8-28).

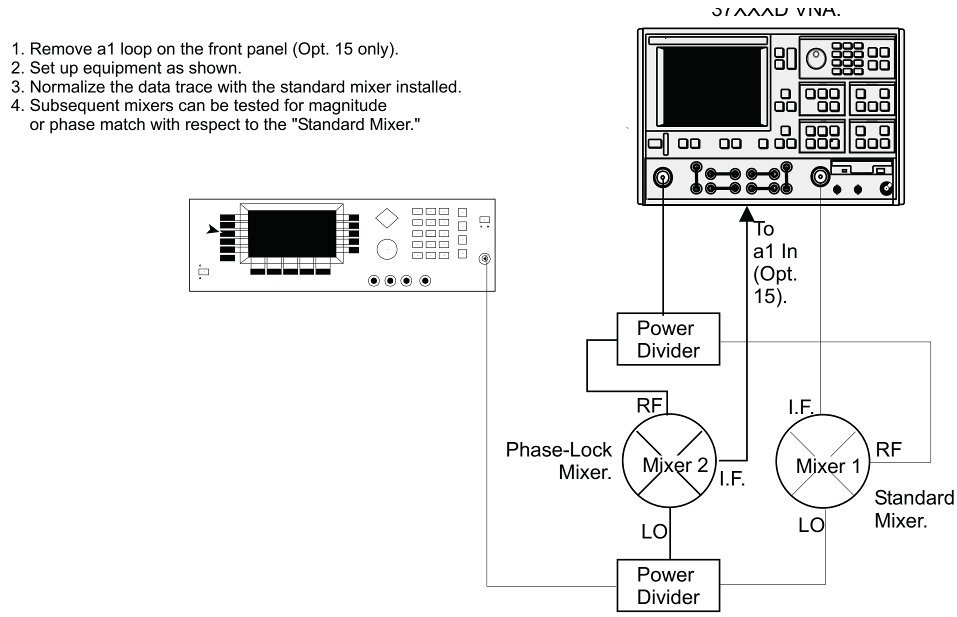


Figure 8-28. Test Setup for Mixer Measurement Using Multiple Source Control Operation

Operation in this mode requires Option 15. Removing the reference loop lets you isolate the receiver from the source. This permits testing of frequency converters such as mixers.

The software lets the frequency ranges and output powers of the two sources be specified. A frequency sweep can comprise up to five separate bands, each with independent source and receiver settings for convenient testing of frequency translation devices such as mixers. Up to five sub-bands (harmonics) can be tested in one sweep.

Control Formula

Multiple Source control is specified as a displayed frequency range partitioned into from one-to-five consecutive bands. For each band Source 1, Source 2, and receiver frequencies may be interdependently specified per the formula:

Source 1 = (1/1) * (F+0.000000000 GHz)
Source 2 = (1/1) * (F+0.000000000 GHz)
Receiver = (1/1) * (F+0.000000000 GHz)
where, the multiplier, divisor and frequency offset can be entered specific to the DUT.

MENU U1

SELECT UTILITY
FUNCTION OPTIONS

GPIB ADDRESSES

DISPLAY
INSTRUMENT
STATE PARAMS

GENERAL DISK
UTILITIES

CAL COMPONENT
UTILITIES

AUTOCAL UTILITIES

COLOR
CONFIGURATION

DATA ON(OFF)
DRAWING

BLANKING
FREQUENCY
INFORMATION

SET DATA/TIME

PRESS <ENTER>
TO SELECT
OR TURN ON/OFF

MENU 7

GPIB ADDRESSES

IEEE 488.2
GPIB INTERFACE

ADDRESS
6

DEDICATED
GPIB INTERFACE

EXTERNAL SOURCE 1
4

EXTERNAL SOURCE 2
5

PLOTTER
8

POWER METER
23

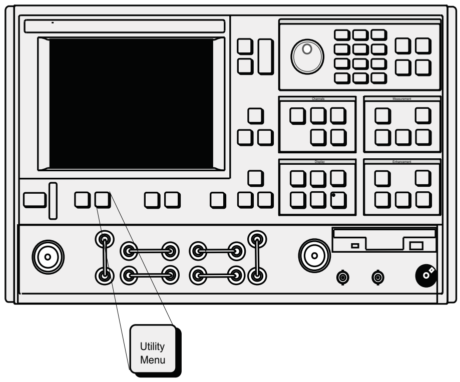
FREQUENCY COUNTER
7

Multiple Source Control Pre-operational Setup

The two sources receive control information from the 37XXXD VNA. The GPIB address assigned to the external source must be identical to the address contained in the data directed to the source by the 37XXXD VNA. Assure source/VNA address compatibility as follows:

Step 1. Install Sources 1 and 2 on the Dedicated GPIB bus.

Step 2. Press the Utility Menu key.



Step 3. Move cursor to GPIB ADDRESSES and press Enter, when menu U1 (left) appears.

Step 4. When menu GP7 (left) appears, observe that the address number is correct. If necessary, use the keypad to enter a new address.

MENU OPTNS

OPTIONS

TRIGGERS

REAR PANEL OUTPUT

DIAGNOSTICS

MULTIPLE SOURCE CONTROL

RECEIVER MODE

SOURCE CONFIG

RF ON/OFF DURING RETRACE

PRESS <ENTER> TO SELECT

MENU OM1

MULTIPLE SOURCE CONTROL

DEFINE BANDS

SOURCE CONFIG

MULTIPLE SOURCE MODE

OFF

STANDBY

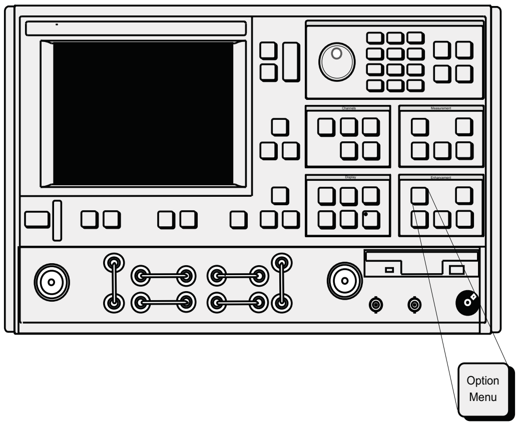
ON

MORE

PRESS <ENTER> TO SELECT

Multiple Source Control Operation

Step 5. Press the Option Menu key.



Step 6. When menu OPTIONS (left) appears, move cursor to MULTIPLE SOURCE CONTROL and press the Enter key.

Step 7. When menu OM1(left) appears, move cursor to DEFINE BANDS and press the Enter key. This brings menu OM 1 to the screen.

MENU OM2

DEFINE BANDS

BAND 1

DISPLAYED
FREQ RANGE

BAND START F
XXX.XXXXXX XXX GHz

BAND STOP F
XXX.XXXXXXXXX GHz

BAND FUNCTIONS

EDIT SYSTEM
EQUATIONS

STORE BAND 1
BANDS STORED:
(1 2 3 4 5)

CLEAR ALL
DEFINITIONS

SET MULTIPLE
SOURCE MODE

PRESS <ENTER>
TO SELECT

Step 8. Coincident with menu OM2 (left), the data display area of the screen presents a chart entitled "RANGES OF BANDS STORED." This chart shows the band start and band stop frequencies that have been stored for each of five bands.

Using menu OM2, the displayed frequency range can be divided into one to five bands.

Band 1 must start at the beginning of the frequency range and end at either the user-specified stop frequency or the end of the frequency range.

Band 2 must begin at the next point after band 1 ends and end at either the user-specified stop frequency or the end of the frequency range.

Step 9. Move cursor to BAND; select BAND 1 by entering "1" using the keypad or rotary knob.

Step 10. Move cursor to BAND START F, and use keypad or rotary knob to enter the band 1 start frequency.

Step 11. Move cursor to BAND STOP F, and enter the band 1 stop frequency.

MENU OM3

EDIT SYSTEM
EQUATIONS

EQUATION
TO EDIT

SOURCE 1

SOURCE 2

RECEIVER

EQUATION
SUMMARY

C.W. OFF

MULTIPLIER
XX

DIVISOR
XX

OFFSET FREQ
XXX.XXXXXXXXX GHz

PREVIOUS MENU

PRESS <ENTER>
TO SELECT

Step 12. Move cursor to EDIT SYSTEM EQUATIONS and press the Enter key.

Step 13. When menu OM3 (left) appears, select SOURCE 1.

Step 14. Move cursor to MULTIPLIER and use keypad or rotary knob to enter desired multiplier for Source 1. This is the multiplier term in the following equation:

Freq = (Multiplier/Divisor) X (F + Offset Frequency)

Step 15. Move cursor to DIVISOR and use keypad or rotary knob to enter desired DIVISOR for source 1. This is the divisor term given in the above equation.

Step 16. Move cursor to either OFFSET FREQUENCY, and use keypad or rotary knob to enter desired offset frequency for Source 1; or C.W., and press Enter to toggle C.W. to OFF.

The Offset Frequency choice is the offset frequency given in the above equation. The C.W. choice removes F from the equation and places Source 1 in the CW mode.

MENU OM2

DEFINE BANDS
BAND 2
DISPLAYED FREQ RANGE
BAND START F XX.XXXXXX GHz
BAND STOP F XX.XXXXXX GHz
BAND FUNCTIONS
EDIT SYSTEM EQUATIONS
STORE BAND 1
BANDS STORED: (NONE)
CLEAR ALL DEFINITIONS
SET MULTIPLE SOURCE STATE
PRESS <ENTER> TO SELECT

Step 17. Move the cursor to PREVIOUS MENU and press the Enter key. This returns you to menu OM2 (left).

Step 18. Move cursor to STORE BAND 1 and press the Enter key. This stores the band start frequency, the band stop frequency and the Source 1, Source 2 and Receiver equations.

Step 19. Note that the BAND number has incremented to 2.

Step 20. Repeat the above steps to define the start and stop frequencies for bands 2 through 5. Set up the system equations for each band.

NOTE

Except for band 1, the system software constrains all start frequencies to follow the previous band's stop frequency. However, while frequency bands are being defined or the system equations are being edited, the system is automatically placed in the standby mode. In this mode, frequencies that may be entered are not supervised by the system software; any frequency can be entered and displayed. When the mode is switched to ON (in menu OM1, left), the system software restricts the frequencies to band limits. When the mode is switched to OFF, the frequencies are restricted to system limits.

MENU OM1

MULTIPLE SOURCE CONTROL
DEFINE BANDS
SOURCE CONFIG
MULTIPLE SOURCE MODE
OFF
STANDBY
ON
MORE
PRESS <ENTER> TO SELECT

Source Lock Polarity: Normal/Reverse

When making frequency translated devices measurements using the Multiple Source Control mode, enter the RF (source 1) and LO (source 2) frequencies. If the LO frequency is lower than the RF frequency, no phase inversion is expected by the VNA. The opposite is true if the LO frequency is higher than the RF frequency. These determinations may be wrong if the DUT is a cascaded multiple conversion device. In that case, determine if the final phase polarity is inverse of what is assumed by the VNA, and set the Source Lock Polarity to Reverse. Failure to do so may cause the RF source to be erroneously locked at a 5 MHz offset.

8-7 ADAPTER REMOVAL

Using adapters in VNA measurement applications can introduce complex errors that add to measurement uncertainty. The VNA Adapter Removal procedure provides for adapter compensation. This on-screen, menu-driven procedure allows the use of a through-line device or adapter with different connector types (non-insertables) on either end to be used for measurement calibration. The electrical effects are subsequently compensated for. The Adapter Removal procedure is described below.

NOTE

For purposes of explanation, assume that the adapter to be used is a length of rigid coax with a type N male connector on one end and an SMA male connector on the other end. Further assume that the Test Port 1 connector is a type N female and that the Test Port 2 connector is an SMA female (below).

MENU APPL

APPLICATIONS

ADAPTER REMOVAL

SWEPT FREQUENCY GAIN COMPRESSION

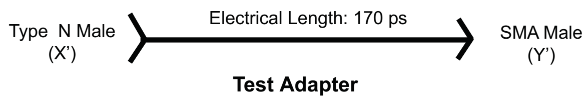
SWEPT POWER GAIN COMPRESSION

E/O MEASUREMENT

O/E MEASUREMENT

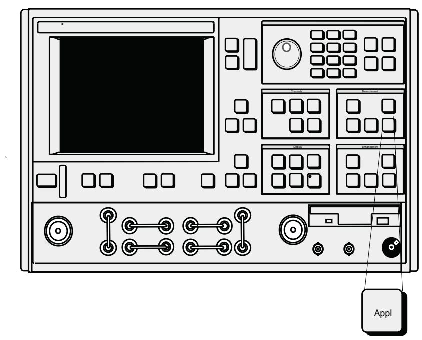
MERGE CAL FILES

PRESS <ENTER> TO SELECT



Procedure:

Step 1. Press the Appl key (below) to display the APPLICATIONS menu (top left).



Step 2. Move the cursor to ADAPTER REMOVAL and press the Enter key.

Step 3. Select HELP in the next menu (bottom left) to produce the step-by-step procedure shown in Figure 8-29 (next page).

MENU CAR1

ADAPTER REMOVAL

12-TERM CALS FOR X AND Y MUST EXIST IN THE CURRENT DIRECTORY

ELECTRICAL LENGTH OF THE ADAPTER +XXX.XXXXX ps

REMOVE ADAPTER

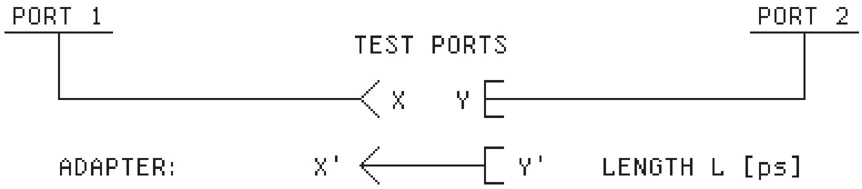
HELP

PRESS <ENTER> TO SELECT

Step 4. Follow the on-line procedure and connect the Adapter's N male connector (X') to the N female connector on the VNA's Test Port 1.

- ADAPTER REMOVAL -

THE ADAPTER REMOVAL APPLICATION PERMITS THE USER TO ACCURATELY MEASURE NON-INSERTABLE DEVICES. THE PROCESS INVOLVES USING AN ADAPTER OF KNOWN ELECTRICAL LENGTH AND PERFORMING TWO FULL 12-TERM CALIBRATIONS.



X AND Y ARE COAXIAL OR WAVEGUIDE CONNECTOR TYPES.
L IS THE LENGTH OF THE ADAPTER [ps].

- INSTRUCTIONS -

1. CONNECT ADAPTER TO PORT 1. PERFORM A FULL 12-TERM CALIBRATION USING Y' AND Y AS THE TEST PORTS AND STORE CALIBRATION TO DISK (e.g. YPRIME_Y.CAL).
2. CONNECT ADAPTER TO PORT 2. PERFORM A FULL 12-TERM CALIBRATION USING X AND X' AS THE TEST PORTS AND STORE CALIBRATION TO DISK (e.g. X_XPRIME.CAL).
3. BOTH X AND Y CAL FILES MUST BE PLACED IN THE CURRENT DIRECTORY OF THE HARD OR FLOPPY DISK.
4. ENTER THE ELECTRICAL LENGTH OF THE ADAPTER.
5. SELECT <REMOVE ADAPTER> TO READ THE X AND Y CAL FILES AND CALCULATE THE NEW SET OF 12-TERM ERROR COEFFICIENTS. IF DESIRED, SAVE RESULTS.

Figure 8-29. Adapter Removal Help Screen

MENU SR1

SAVE/RECALL
FRONT PANEL
AND CAL DATA

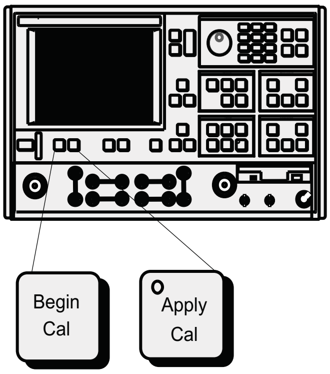
SAVE

RECALL

SET UP OUTPUT
HEADERS

PRESS <ENTER>
TO SELECT
FUNCTION

Step 5. Press the Begin Cal key (below).



Step 6. Follow the menu prompts and choose to perform a full 12-term calibration. Use the Adapter's SMA male connector (Y) as Test Port 1 and the VNA's Test Port 2 connector as Test Port Y (Figure 8-27).

MENU SR2

SAVE

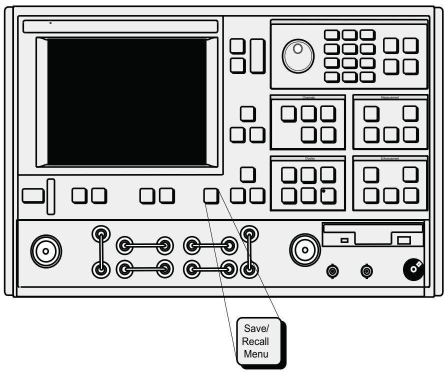
FRONT PANEL
SETUP IN
INTERNAL MEMORY

FRONT PANEL
SETUP AND
CAL DATA
ON HARD DISK

FRONT PANEL
SETUP AND
CAL DATA
ON FLOPPY DISK

PRESS <ENTER>
TO SELECT

Step 7. Press the Save/Recall Menu key (below).



Step 8. Choose SAVE from the displayed menu (top left).

Step 9. Choose the appropriate hard or floppy disk location, based on individual preference (Menu SR2, bottom left).

Step 10. When prompted, select CREATE NEW FILE and enter a conventional DOS filename, such as YPRIME_Y.CAL. (Store this file in the current directory.)

Step 11. Now connect the Adapter's SMA male end to the VNA's Test Port 2 SMA female connector.

MENU CAR1

ADAPTER REMOVAL

12-TERM CALS FOR
X AND Y
MUST EXIST IN THE
CURRENT DIREC-
TORY

ELECTRICAL LENGTH
OF THE ADAPTER
+170.0000 ps

REMOVE ADAPTER

HELP

PRESS <ENTER>
TO SELECT

Step 12. Press the Begin Cal key again.

Step 13. Follow the menu prompts; again choose to perform a full 12-term calibration. Now use the Adapter's Type N male connector (X') as Test Port 2. Use the VNA's Test Port 1 connector as Test Port X.

Step 14. Save the calibration as described in Steps 7 and 8, above. Give this file a unique filename, such as X_XPRIME.CAL. (Store this file in the current directory.)

Step 15. Press the Appl key and chose ADAPTER REMOVAL to return to Menu CAR1 (top left).

Step 16. Enter the electrical length of the Adapter (170 ps for the test adapter) in the appropriate place in Menu CAR1.

NOTE

Electrical length does not have to be precise. Plus or minus 5 ps is adequate for this procedure.

MENU CAR2

ADAPTER REMOVAL

READ CAL FILE OF
THE X TEST PORT
FROM HARD DISK
(ADAPTER ON
PORT 2)

READ CAL FILE OF
THE X TEST PORT
FROM FLOPPY DISK
(ADAPTER ON
PORT 2)

PRESS <ENTER>
TO SELECT

PRESS <CLEAR>
TO ABORT

Step 17. Move the cursor to REMOVE ADAPTER, and press the Enter key.

Step 18. Move the cursor to the appropriate READ CAL FILE OF THE X TEST PORT . . . , depending on where the calibration data is stored (hard or floppy disk). Press the Enter key.

NOTE

At this juncture, the "X" calibration file is marked for reading, but not actually read. Both the "X" and "Y" files will be read into the VNA together in the next step.

MENU CAR3

ADAPTER REMOVAL

READ CAL FILE OF THE Y TEST PORT FROM HARD DISK (ADAPTER ON PORT 2)

READ CAL FILE OF THE Y TEST PORT FROM FLOPPY DISK (ADAPTER ON PORT 2)

PRESS <ENTER> TO SELECT

PRESS <CLEAR> TO ABORT

Step 19. Move the cursor to the appropriate READ CAL FILE OF THE Y TEST PORT. . . choice (top left) and press the Enter key.

Step 20. Observe that the text READING . . . FROM DISK appears in the menu area.

Step 21. When the file has finished reading, the procedure is complete and the program returns to the SWEEP SETUP menu (below).

If the adapter is still connected, the display will show the S-parameters of the adapter. Any device to be measured with that same connector configuration will be measured in an absolute sense.

Also, you may wish to store the resulting Adapter Removal calibration for later use.

MENU SU1

SWEEP SETUP

START XX.XXXXXXXXX GHz

STOP XX.XXXXXXXXX GHz

SET CENTER/SPAN

XXX DATA POINT(S) XX.XXXXXXXXX GHz STEP SIZE

C.W. MODE ON (OFF) XX.XXXXXXXXX GHz

MARKER SWEEP

DISCRETE FILL

HOLD BUTTON FUNCTION

TEST SIGNALS

PRESS <ENTER> TO SELECT OR TURN/OFF

8-8 GAIN COMPRESSION

There are a number of ways to measure Gain Compression. With a VNA two approaches are possible: Swept Frequency Gain Compression (SFGC) and Swept Power Gain Compression (SPGC). The 37XXXD offers a very straightforward approach to each of these measurements.

It is normally desirable to make S-parameter measurements in the linear operating region of an amplifier and then observe Compression or amplitude-modulation/phase-modulation (AM/PM) characteristics by increasing the input power to drive the amplifier into it s nonlinear region. The characteristics of the amplifier-under-test (AUT) dictate the operating power levels required for the tests. Prior to making measurements on a specific amplifier the user must determine the desired operating levels. A recommended level for linear region operation is:

P = PG   Gain   15dB (PGC=Nominal l dB compression of the AUT)

The actual level is constrained by the power available from the VNA and the built in 70 dB step attenuator. (In the case of the 37XXXD, available power is easily supplemented by the addition of an external amplifier/attenuator combination.) Power input to Port 2 must also be considered as the test should not drive the VNA into nonlinear operation. Typical specifications show 0.1dB compression at a VNA receiver input level of –10 dBm. The receiver signal is derived through a 13 dB coupler from the Port 2 signal. The 37XXXD also includes a 40 dB step attenuator in this path that enables linear operation with input signals as high as 30 dBm (1 watt), the maximum signal level that should be input to Port 2. Higher power levels can be measured by attenuating the signal prior to Port 2.

A typical power configuration example that will also be used throughout this section is included in Figure 8-28. A 10 dB pad has been used at both Port 1 and Port 2 to minimize mismatch errors.

Power and VNAs

It is necessary to measure absolute power to determine Gain Compression. VNA receiver channels are typically down-converters and do not measure power directly. They are, however, linear so that an accurate power calibration at one level will result in a receiver channel that will accurately indicate power in dBm.

The 37XXXD firmware supports calibration with the following power meters: Anritsu ML2430A, HP437B, HP438, and Gigatronics 8541C/8542C. These meters differ in the way they handle sensor efficiency (consult the power meter manual), and the 37XXXD does expect to receive corrected data from the power meter.

Gain Compression Power Configuration

Amplifier Specifications:

Frequency Range:	8 to 12 GHz
Gain	25 dB nominal
1 dB Gain Compression (GC)	12 dBm minimum

Gain Compression Formula: P = 12 – 25 – 15 = –28 dBm

37369C Setup

Default Power:	–7 dBm
Power Control:	–8 dB
Port 1 Attenuator:	0 dB
External Port 1 Attenuator:	10 dB
The above setting result in Port 1 Power:	–25 dBm
Maximum Amplifier Output	≅15 dBm
Coupler Loss:	≅13 dB
Port 2 Attenuator:	10 dB

Figure 8-28. Gain Compression Measurement Plan (Example)

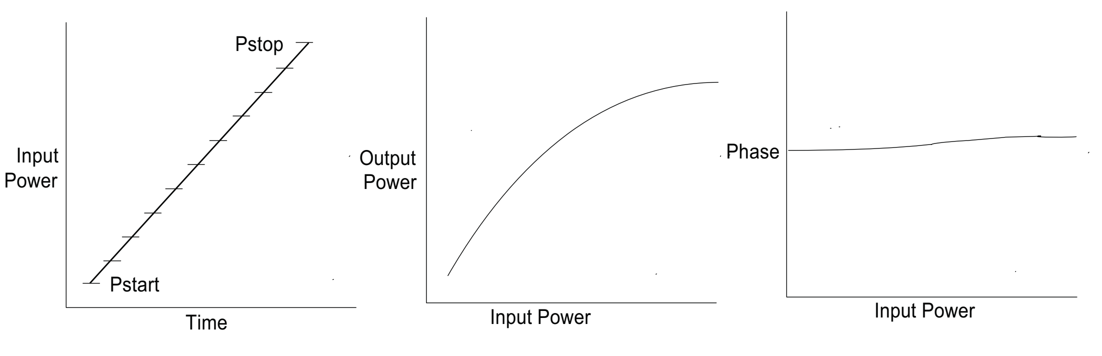


Figure 8-29. Power In (Pi) versus Power Out (Po) Graphical Example

Errors can result if the proper correction factor is not applied by the power meter, as shown below.

Correction Factor (%)	Error (dB)
1	0.043
3	0.128
5	0.212
10	0.414

It is desirable to set the power control at or near the minimum (this varies from –20 to–30 dB, depending upon model) when establishing P, as this provides the full ALC range for a power sweep.

The vector error correction available in VNAs is dependent upon ratioed S-parameter measurements. Power is measured using a single, unratioed channel; therefore, when power is being measured error correction is turned off.

Swept Power Gain Compression

A swept power test is done at a CW frequency. The input power will be increased with a step sweep starting at Pstart and ending at Pstop. The step increment is also user defined. This lets you observe the conventional *Po* vs. *Pi* presentation or a display of *Phase* vs. *Pi*. Figure 8-29 (previous page) illustrates this process. The SPGC process is implemented in the 37XXXD by following the procedure that begins on page 8-43. The test setup required for this procedure is shown in Figure 8-30 (page 8-42).

Swept Frequency Gain Compression

This is a manual procedure that provides a normalized amplifier response as a function of frequency at *Pstart* and manually increases the input power while observing the decrease in gain as the amplifier goes into compression. This lets you easily observe the most critical compression frequency of a broadband amplifier. The SFGC process is implemented in the 37XXXD by following the procedure that begins on page 8-52. The test setup required for this procedure is shown in Figure 8-30 (following page).

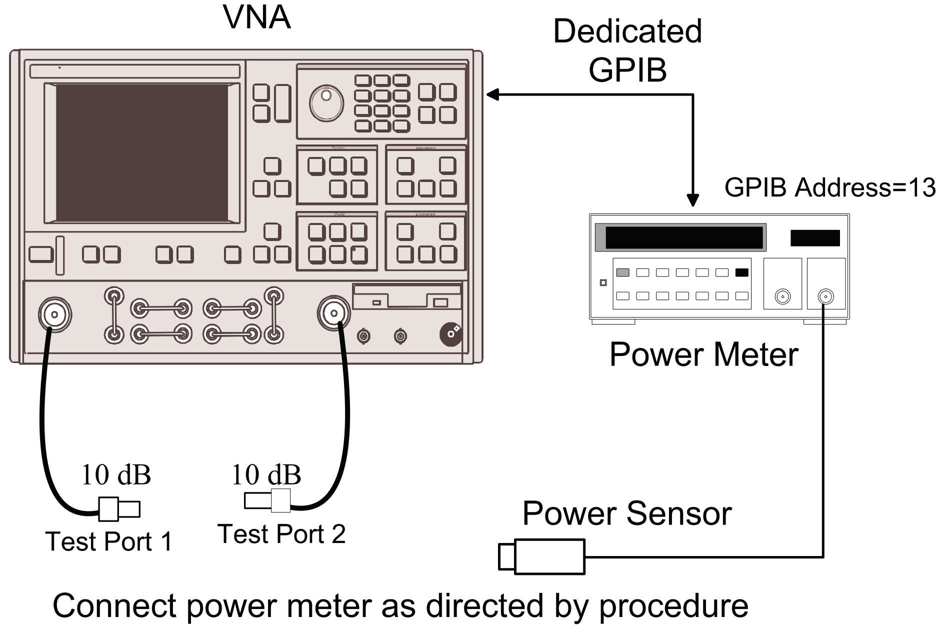


Figure 8-30. Test Setup for Gain Compression Measurements

MENU APPL

ADAPTER REMOVAL
SWEPT FREQUENCY GAIN COMPRESSION
SWEPT POWER GAIN COMPRESSION
E/O MEASUREMENTS
O/E MEASUREMENTS
MERGE CAL FILES
PRESS <ENTER> TO SELECT

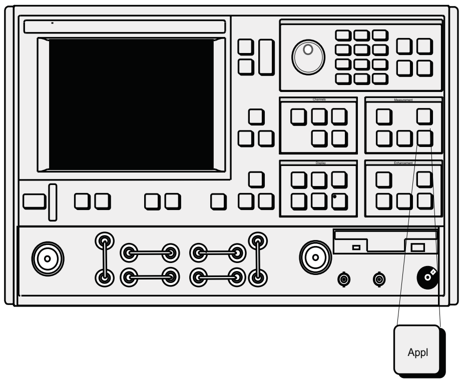
MENU GC2

SWEPT POWER GAIN COMPRESSION
SET FREQUENCIES
P START –25.00 dBm
P STOP –5.00 dBm
STEP SIZE 1.00 dB
ATTENUATION
GAIN COMPRESSION POINT (MAX REF) 1.00 dB
NOMINAL OFFSET 0.00 dB
MORE
PRESS <ENTER> TO SELECT

Swept Power Gain Compression Measurement

The following procedures describes the Swept Power Gain Compression Measurement.

Step 1. Press the Appl key.



NOTE

A 12-Term S-parameter calibration is not necessary for gain compression calibration and measurement. If such a calibration is in place, it will be disabled during the gain compression operation.

Step 2. Move cursor to SWEPT POWER GAIN COMPRESSION and press Enter, when menu Appl (top left) appears.

Step 3. When menu GC2 (bottom left) appears, follow the directions that appear adjacent to the menu, as described below:

Move cursor to SET FREQUENCIES, press Enter and select from 1 to 10 frequencies.

Enter the frequency value, press a terminator key (e.g. GHz/10^3/μs/m), *then* Enter *to add the frequency to the list.*

NOTE

The number of frequencies and step size, that is entered later, directly affect the time required for Linear Power Calibration, in a later step.

MENU GC_DF2

SWEPT POWER
FREQUENCIES

INPUT A FREQ,
PRESS <ENTER>
TO INSERT

SWEPT POWER
FREQUENCY
12.000000000 GHz

CLEAR FREQ NUMBER
1

CLEAR ALL

FINISHED, RETURN TO
POWER SWEEP SETUP

PRESS <ENTER>
TO SELECT

Move cursor to FINISHED, RETURN TO POWER SWEEP SETUP and press Enter.

Move cursor to P START (previous page), set per power plan (Figure 8-28), and press Enter.

Move cursor to P STOP (previous page), set per power plan, and press Enter.

Move cursor to STEP SIZE (previous page), enter a value, and press Enter.

The 1 dB default value is reasonable. This value, along with the number of frequencies entered in a previous step, directly affect the time required for Linear Power Calibration, in a later step.

Move cursor to ATTENUATION (previous page) and press Enter. Set power values (bottom left) per power plan. Move cursor to PREVIOUS MENU and press Enter when finished.

MENU GC_DF2

SWEPT POWER
GAIN COMPRESSION

PORT 1 ATTN
0*10 dB (0 - 70)

PORT 2 ATTN
2*10 dB (0 - 40)

PREVIOUS MENU

PRESS <ENTER>
TO SELECT

Move cursor to GAIN COMPRESSION (previous page), enter the desired value (1 dB is typical), and press Enter.

Move cursor to NOMINAL OFFSET (previous page), enter the value of any external device(s) connected between the front panel Input and Output connectors. Press Enter when done. In the example use –10 dB.

A setting of 0.00 dB is normal when no external devices are connected.

Move cursor to *MORE (previous page) and press* Enter to proceed to the next menu (GC3) (next page).

MENU GC3

SWEPT POWER
GAIN COMPRESSION

CALIBRATE
FOR LINEARITY
([NO] CAL EXIST)

LINEARITY ON [OFF]
CORRECTION

CALIBRATE
RECEIVER
([NO] CAL EXISTS)

S21 OPTIONS
([NOT] STORED)

AUT TEST TYPES

GAIN COMPRESSION

AM/PM

MULTIPLE FREQ
GAIN COMPRESSION

RETURN TO SWEPT
FREQUENCY MODE

PREVIOUS MENU

Step 4. Move the cursor to *CALIBRATE FOR LINEARITY,* press Enter, and follow the instructions that (1) appear adjacent to the follow-on menu and (2) are described below.

If a calibration already exists, the menu choice will indicate CAL EXIST *in blue letters.*

NOTE

This step is not required for a successful gain compression measurement; however, linearizing the power from Port 1 (which is what this step does) provides increased accuracy.

Prepare the power meter as described in the following instructions:

a. Preset, zero, and calibrate the power meter.

b. Set power meter offset, if required.

c. Connect the power meter to the dedicated GPIB interface and the power sensor to the test port.

d. Select <START LINEAR POWER CALIBRATION>.

Connect the power sensor to Test Port 1.

With *START LINEAR POWER CALIBRATION* highlighted (bottom left), press Enter to begin the calibration.

MENU GC_SU8A

CALIBRATE FOR
LINEAR POWER

FORWARD
DIRECTION ONLY

START LINEAR
POWER CALIBRATION

PREVIOUS MENU

PRESS <ENTER>
TO SELECT

Step 5. Observe *LINEARITY CORRECTION* choice (top left). If a linearity correction has been performed, it will indicate ON in blue letters.

Step 6. Move cursor to *CALIBRATE RECEIVER* and follow the instructions, as follows:

Connect a through line between Test Port 1 and Test Port 2. Be sure to include all components that are part of the measurement path.

MENU GC3

SWEPT POWER
GAIN COMPRESSION

CALIBRATE
FOR LINEARITY
([NO] CAL EXIST)

LINEARITY ON [OFF]
CORRECTION

CALIBRATE
RECEIVER
([NO] CAL EXISTS)

S21 OPTIONS
([NOT] STORED)

AUT TEST TYPES

GAIN COMPRESSION

AM/PM

MULTIPLE FREQ
GAIN COMPRESSION

RETURN TO SWEPT
FREQUENCY MODE

PREVIOUS MENU

MENU GC_NORM

NORMALIZE S21

CONNECT AUT
AND APPLY BIAS .

WAIT FOR ONE
COMPLETE SWEEP
BEFORE STORING

PRESS <ENTER>
TO STORE

PRESS <CLEAR>
TO ABORT

Wait until one complete sweep has completed, then press Enter to store the calibration.

NOTE

It is likely that the trace will be off screen at the bottom of the display. If so, press Autoscale to obtain a discernable trace. If this trace shows vertical instability, then do the following:

1. Press Video IF BW and select REDUCED (100 Hz) from the menu.

2. Press Avg/Smooth Menu and select AVERAGING 100 MEAS. PER POINT from the menu.

3. Press Average to turn averaging on.

Step 7. Press Appl to return to the gain compression menu set, and follow the prompts to return to Menu GC3. Repeat Step 6.

Step 8. Move the cursor to *S21 OPTIONS* (top left), select NORMALIZE S21 in the next menu (not shown), then NORMALIZE S21 again (bottom left); then press Enter and follow the menu instructions:

Remove the through line and connect the amplifier-under-test (AUT) between Port 1 and Port 2.

Apply bias to the AUT.

Wait until one complete sweep has completed, then press Enter to store the normalization measurement.

Step 9. Move the cursor to the desired test and press Enter. The steps that follow presume that gain compression has been selected.

MENU SU3A

SWEPT POWER
SETUP

SWEPT POWER
FREQUENCY
9.000000000 GHz

P START
–25.00 dBm

P STOP
–5.00 dBm

STEP SIZE
1.00 dB

POWER SWEEP ON

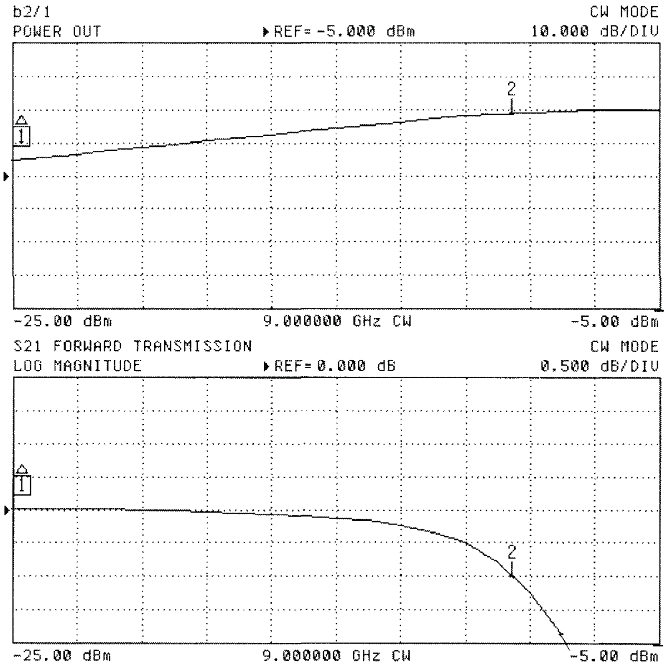
HOLD BUTTON
FUNCTION

MULTIPLE FREQ
GAIN COMPRESSION

RETURN TO SWEPT
FREQUENCY MODE

PRESS <ENTER>
TO SELECT
OR TURN ON/OFF

Step 10. Observe that the SWEPT POWER SETUP menu and the dual-trace display resembles that shown below.



MENU M7

SEARCH

VALUE
–1.000dB

REFERENCE
MAXIMUM VALUE
ΔREF MARKER
0 dB

VALUE AT REFERENCE
–0.000 dB

SEARCH LEFT
SEARCH RIGHT

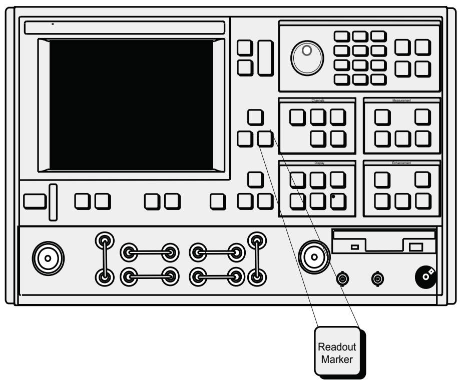
–9.56 dBm

SEARCH MRKR VALUES
CH1: 13.753dBm
CH2:
CH3: –1.000 dB
CH4:

TRACKING ON

MARKER READOUT
FUNCTIONS

Step 11. Press Readout Marker (below) for a display of gain compression at the marker frequency.



Step 12. Observe the readout marker values from the displayed menu (left).

MENU SU3A

SWEPT POWER SETUP

SWEPT POWER FREQUENCY
9.000000000 GHz

P START
–25.00 dBm

P STOP
–5.00 dBm

STEP SIZE
1.00 dB

POWER SWEEP ON

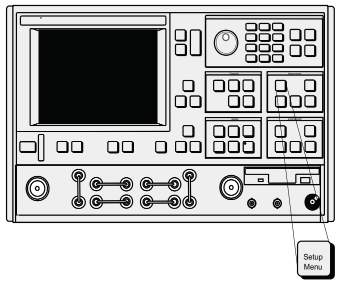
HOLD BUTTON FUNCTION

MULTIPLE FREQ GAIN COMPRESSION

RETURN TO SWEPT FREQUENCY MODE

PRESS <ENTER>
TO SELECT
OR TURN ON/OFF

Step 13. Press Setup Menu (below) to return to SWEPT POWER SETUP menu.



Step 14. Move cursor to SWEPT POWER FREQUENCY (top left), select the next frequency from the SET FREQUENCY list, and press Enter.

Step 15. Repeat Steps 11 through 13.

Step 16. Repeat Steps 14 and 15 until all frequencies have been observed.

Step 17. To examine the phase performance for a swept input power, AM/PM should be selected. This leads to the two channel display (Channels 2 and 4) with Channel 4 active shown below. The sweep mode is continuous to facilitate tuning, Markers are set to the ΔReference mode on the active channel.

MENU

CH2 - 21

REFERENCE PLANE
0.0000mm

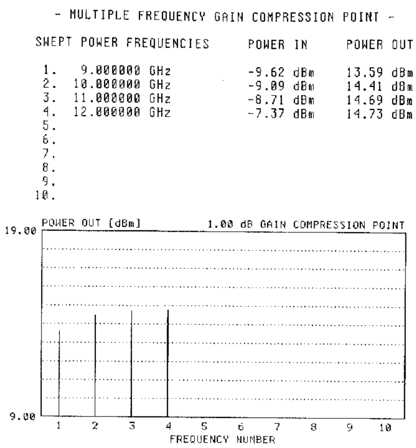
MARKER 1
-25.00 dBm

MARKER TO MAX

MARKER TO MIN

Δ(1-2)
-15.44 dBm
4.17°

MARKER READOUT FUNCTIONS



MENU GC4

MULTIPLE FREQUENCY GAIN COMPRESSION

TEST AUT

TEXT DATA TO HARD DISK

TEXT DATA TO FLOPPY DISK

SWEPT POWER GAIN COMPRESSION

RETURN TO SWEPT FREQUENCY MODE

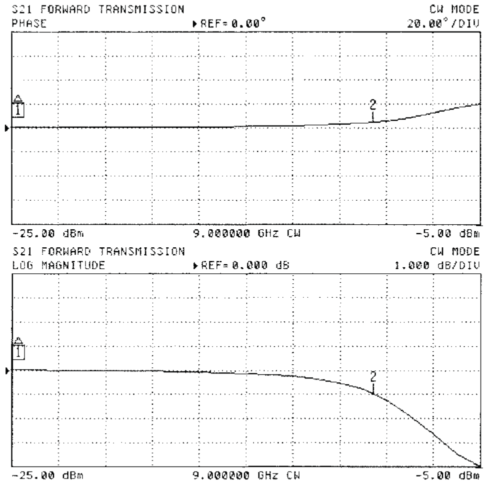
PRESS <ENTER> TO SELECT

Step 18. Repeat Steps 13 through 16 until all desired frequencies have been observed.

Step 19. If desired, a multiple frequency gain compression display can be obtained by selecting MULTIPLE FREQUENCY GAIN COMPRESSION (left) and pressing Enter.

Step 20. Move cursor to TEST AUT (top left) and press Enter.

Step 21. Observe that the Multiple Frequency Gain Compression display resembles that shown below.



Step 22. Make desired selection from menu to copy text and data to hard or floppy disk (top left).

Step 23. The power linearity calibration, receiver calibration, and DUT normalized data exists in volatile memory. At this time, the data can be stored for subsequent recall using the SAVE function.

NOTE

It is prudent to save this calibration; otherwise, it will be destroyed if you move anywhere in the program except between this calibration and the S-parameters menu.

Step 24. Move cursor to RETURN TO SWEPT FREQUENCY MODE and press Enter to exit the gain compression mode.

NOTE

When exiting the Swept Frequency Power Gain Compression mode, the DUT should be turned off, unless the user has selected the proper attenuator settings for standard swept frequency (S-parameter) operation.

Swept Frequency Gain Compression Measurement

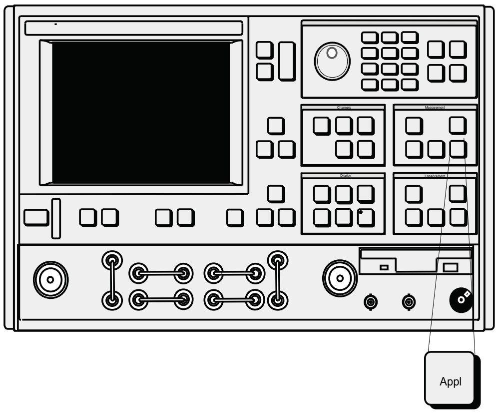
The following procedure describes the Swept Frequency Gain Compression Measurement.

Preliminary: Refer to Figure 8-28 and set the Power Control and Port 1 Attenuator for the values shown in the power plan for the example, or in the power plan constructed for measurement of a test device. These power plan values should also be used in the S-parameter calibration that may be performed using the Begin Cal key and menus.

MENU APPL

ADAPTER REMOVAL
SWEPT FREQUENCY GAIN COMPRESSION
SWEPT POWER GAIN COMPRESSION
E/O MEASUREMENTS
O/E MEASUREMENTS
MERGE CAL FILES
PRESS <ENTER> TO SELECT

Step 1. Press the Appl key.



MENU GC3

SWEPT FREQUENCY GAIN COMPRESSION
NOMINAL OFFSET 0.00 dB
CALIBRATE FOR FLATNESS (N0 CAL EXISTS)
FLATNESS CORRECTION OFF
CALIBRATE RECEIVER [NO CAL EXISTS)
NORMALIZE S21 (NOT STORED)
GAIN COMPRESSION POINT (0 dB REF) 1.00 dB
TEST AUT
EXIT APPLICATION

Step 2. Move cursor to SWEPT FREQUENCY GAIN COMPRESSION and press Enter, when menu APPL (top left) appears.

Step 3. When menu GC3 (bottom left) appears, follow the directions that appear adjacent to the menu, as described below:

Move the cursor to NOMINAL OFFSET, enter the value of any external device(s) connected between the front panel Input and Output connectors. Press the Enter key when done.

Optionally, move the cursor to CALIBRATE FOR FLATNESS, press Enter and follow the instruction menu as described on the following page.

If a calibration already exists, the menu choice will indicate CAL EXIST in blue letters.

NOTE

This step is not required for a successful gain compression measurement; however, calibrating the power from Port 1 (which is what this step does) provides increased accuracy.

Prepare the power meter as described in the following instructions:

a. Preset, zero, and calibrate the power meter.

b. Set power meter offset, if required.

c. Connect the power meter to the dedicated GPIB interface and the power sensor to the test port.

d. Select <START LINEAR POWER CALIBRATION>.

Connect the power sensor to Port 1.

Set the number of power calibration points.

If, in a previous menu, data points had been set to 401 points, entering 8 provides 50 power points (every 8th point); entering 4 provides 100 power point (every 4th point)s, and entering 1 provides 401 power points. The VNA interpolates between power calibration frequencies.

Enter a POWER TARGET value.

Make this value the same as resulting Port 1 power value shown in Figure 8-28 (page 8-40). –25 dBm for the example.

With START FLAT POWER CALIBRATION highlighted (bottom left), press Enter to begin the calibration.

MENU GC_SU8A

CALIBRATE FOR
FLAT PORT POWER

FORWARD
DIRECTION ONLY

101 POINTS
MEASURE 1 PWR
POINT EVERY
1 POINT(S)

POWER TARGET
–25.00 dBm

START FLAT
POWER CALIBRATION

PREVIOUS MENU

PRESS <ENTER>
TO SELECT

TURN KNOW TO
CHANGE NUMBER
OF POINTS

NOTE

When the above calibration finishes, the source power will have been accurately calibrated. In the next step, this power calibration will be transferred via the through line to the receiver.

MENU GC1

SWEPT FREQUENCY
GAIN COMPRESSION

NOMINAL OFFSET
-10.00 dB

CALIBRATE
FOR FLATNESS
(]CAL EXISTS)

FLATNESS
CORRECTION
AT -25.00 dBm

CALIBRATE
RECEIVER
(CAL EXISTS)

NORMALIZE S21
([NOT]STORED)

GAIN COMPRESSION
POINT (0 dB REF)
1.00 dB

TEST AUT

EXIT APPLICATION

Step 4. Move cursor to CALIBRATE RECEIVER and follow the instructions, as follows:

Connect a through line between Test Port 1 and Test Port 2. Be sure to include all components that are part of the measurement path.

Wait until one complete sweep has completed, then press Enter to store the calibration.

NOTE

It is likely that the trace will be off screen at the bottom of the display. If so, press Autoscale to obtain a discernable trace. If this trace shows vertical instability,

- Press Video IF BW and select REDUCED (100 Hz) from the menu
- Press Avg/Smooth Menu and select AVERAGING 100 MEAS. PER POINT from the menu
- Press Average to turn averaging on

Step 5. Press Appl to return to the gain compression menu, and follow the prompts to return to Menu GC1. Repeat Step 4.

MENU GC_SU8A

RECEIVER
CALIBRATION

CONNECT
THROUGHLINE
BETWEEN
TEST PORTS

INCLUDE ANY
COMPONENTS WHICH
ARE PART OF THE
MEASUREMENT PATH

WAIT FOR ONE
COMPLETE SWEEP
BEFORE STORING

PRESS <ENTER>
TO STORE

PRESS <CLEAR>
TO ABORT

Step 6. Move the cursor to NORMALIZE S21 (top left), press Enter, and follow the menu instructions (bottom left):

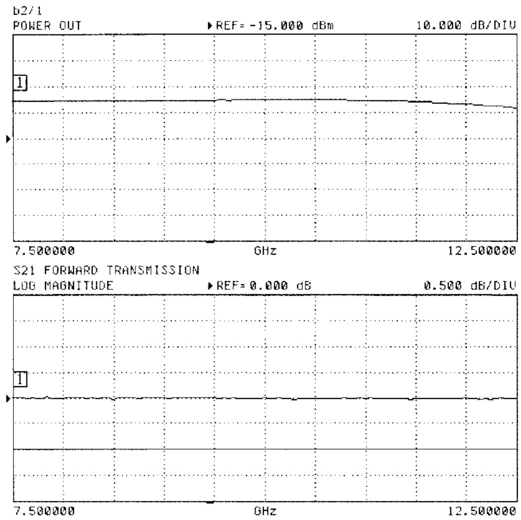
Remove the through line and connect the amplifier-under-test (AUT) between Port 1 and Port 2.

Apply bias to the AUT.

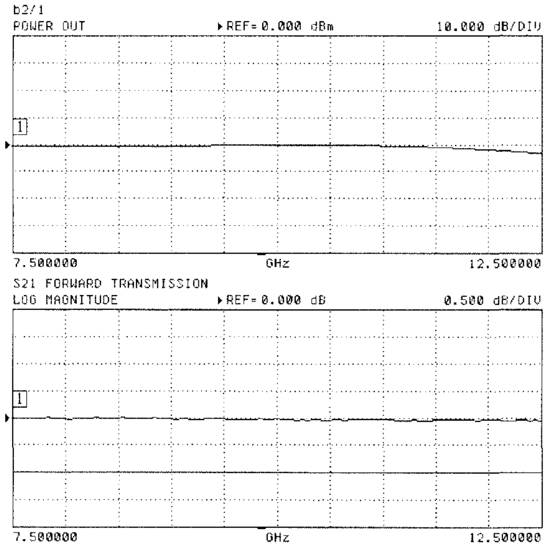
Wait until one complete sweep has completed, then press Enter to store the normalization measurement.

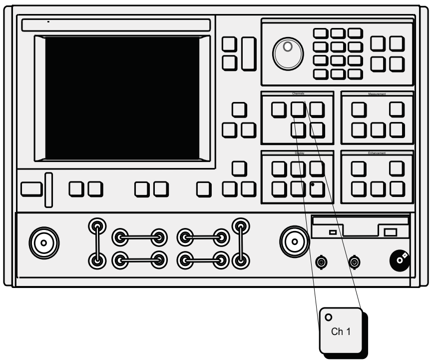
Step 7. Move the cursor to TEST AUT (top left) and press Enter.

Step 8. Observe that the dual-trace display resembles that shown below.



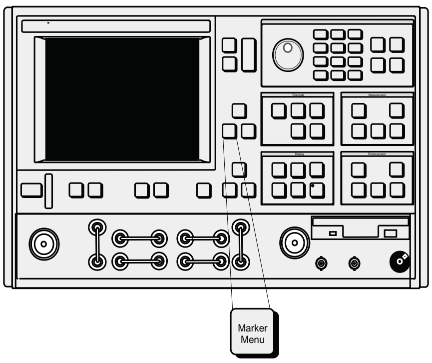
Step 9. Note that the top display (Channel 1), shows the power out from the AUT. For the example test device, the nominal output power is about 0 dBm with the input at –25 dBm. To better evaluate this device, turn on markers and set the Channel 1 reference to 0 dB, as shown below.

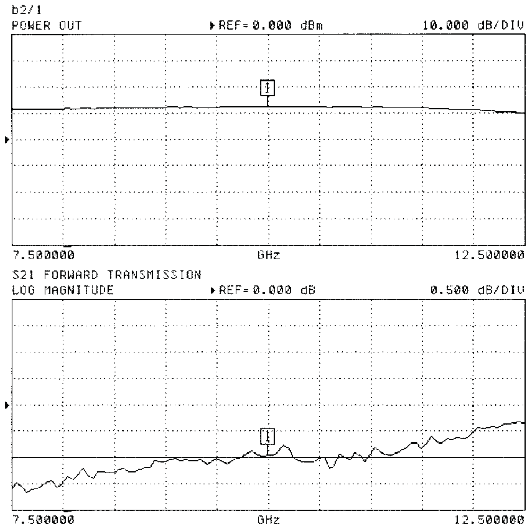




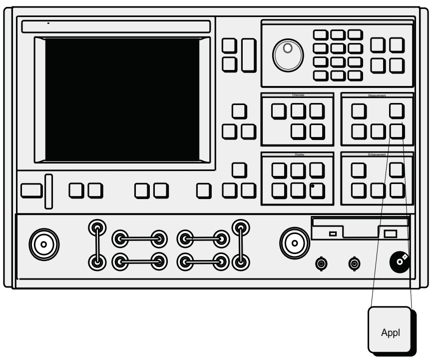
Step 10. Press the Ch1 key (top left) to make channel 1 active.

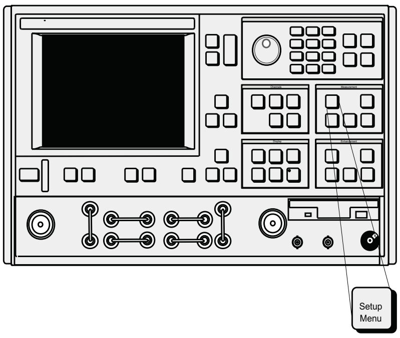
Step 11. Press the Marker Menu key (middle left), turn on marker 1, and position it to a desired point on the trace (below). (Press the Readout Marker key for frequency and amplitude information.)





Step 12. Press the Appl key to return to the TEST SIGNALS menu (Menu SU2, next page).





Step 13. Press the Setup Menu key (top left), select POWER CONTROL (bottom left) and increase the value while observing compression in channel 3 (S_{21}).

NOTE

The rotary knob or the keypad can be used to set the POWER CONTROL value. In using the rotary knob, the displayed value does not change in real time with movement of the control. Change occurs after the rotation of the knob is complete.

Step 14. Press the Marker Menu key again, and observe the displayed Ch 3 trace and the marker values from the displayed menu (below).

MENU SU2
TEST SIGNALS
POWER CONTROL 5.47 dB 0 TO –20.00 dB
PORT 1 ATTN 0 * 10 dB (0 – 70)
PORT 1 POWER –1.53 dBm
PORT 2 ATTN 0 * 10 dB (0 –40)
CALIBRATE FOR FLATNESS (CAL EXISTS)
FLATNESS CORRECTION AT –11.53 dBm
PORT 2 POWER 0.00 dBm
EXIT APPLICATION
PRESS <ENTER> TO SELECT OR TURN ON/OFF

MENU SU2
MARKER 1 ALL DISPLAYED CHANNELS
CH 1 - S11 USER 10.000000 GHz 12.06 dBm
CH 2 - S12
CH 3 - S21 10.000000 GHz -0.992 dB
CH 4 - S21
MARKER TO MAX MARKER TO MIN
MARKER READOUT FUNCTIONS
PRESS <ENTER> TO SELECT

Step 15. The power linearity calibration, receiver calibration, and DUT normalized data exists in volatile memory. At this time, the data can be stored for subsequent recall using the SAVE function.

NOTE

It is prudent to save this calibration; otherwise, it will be destroyed if you move anywhere in the program except between this calibration and the S-parameters menu.

MENU SU2

TEST SIGNALS

POWER CONTROL
5.47 dB
0 TO –20.00 dB

PORT 1 ATTN
0 * 10 dB (0 – 70)

PORT 1 POWER
–1.53 dBm

PORT 2 ATTN
0 * 10 dB (0 –40)

CALIBRATE
FOR FLATNESS
(CAL EXISTS)

FLATNESS
CORRECTION
AT –11.53 dBm

PORT 2 POWER
0.00 dBm

EXIT APPLICATION

PRESS <ENTER>
TO SELECT
OR TURN ON/OFF

Step 16. Move cursor to RETURN TO SWEPT FREQUENCY MODE and press Enter to exit the gain compression mode.

Step 17. Press the Appl key to return to the TEST SIGNALS menu (left), highlight EXIT APPLICATION and press Enter to exit the gain compression measurement area.

CAUTION

When exiting the Swept Frequency Power Gain Compression mode, the DUT should be turned off, unless the user has selected the proper attenuator settings for standard swept frequency (S-parameter) operation.

8-9 RECEIVER MODE

The Receiver Mode provides three distinct modes of operation:

- Sweep/Source Lock mode, phase locks the internal source
- Synthesizer/Tracking mode, lets the receiver track a 67XXB, 68XXXB, or 69XXXA synthesizer
- Set-On mode, lets the VNA operate as a tuned receiver

Source Lock Mode

The Source Lock mode enables the 37XXXD to phase lock to its internal source.

Tracking Mode

In the Tracking Mode, the 37XXXD steers its second local oscillator frequency and phase signal so as to phase-lock itself to the reference signal. Typically the source is a synthesizer, since it must be accurate to better than ±10 MHz for the 37XXXD to achieve lock. Due to the inherent resolution of the 37XXXD, frequency resolution is limited to 1 kHz intervals. If Option 3 is installed frequency resolution is limited to 1 Hz.

For receive frequencies outside the indicated test set range, the use of external mixers and a synthesizer is required. Dual Source Control is required in this case.

Set-on Mode

In the Set-On mode, the source lock circuitry of the 37XXXD is completely by-passed. Reference signals are no longer necessary for system operation. This allows all of the 37XXXD samplers to operate over their full dynamic range. As a result, the source and the 37XXXD must be locked to the same 10 MHz time base, otherwise coherent detection is not possible. Only synthesized sources may be used in this mode. Dual source control is required.

Due to the inherent resolution of the 37XXXD local oscillators, frequency resolution is limited to 1 kHz intervals over the frequency range of the VNA. If Option 3 is installed, frequency resolution is limited to 1 Hz.

Receiver Mode Block Diagram

The block diagram shown in Figure 8-31 shows how the system is configured for all of the possible modes of operation. With the switches set as shown, the system operates in the Set-On mode. LO1 and LO2 are pre-set to allow only a prescribed signal to be detected by the synchronous detector. With the switch in SOURCE LOCK position the system is operating in the internal source-lock mode. With the switch in the TRACKING position, the system is in the synthesizer tracking mode.

Receiver Mode Menus

The menus associated with the Receiver Mode are described in the alphabetical listing (Appendix A) under their call sign: RCV1, RCV2, RCV3, etc.

Procedure, Receiver Mode Operation

A detailed procedure for operation using the Receiver Mode option is provided in the following pages.

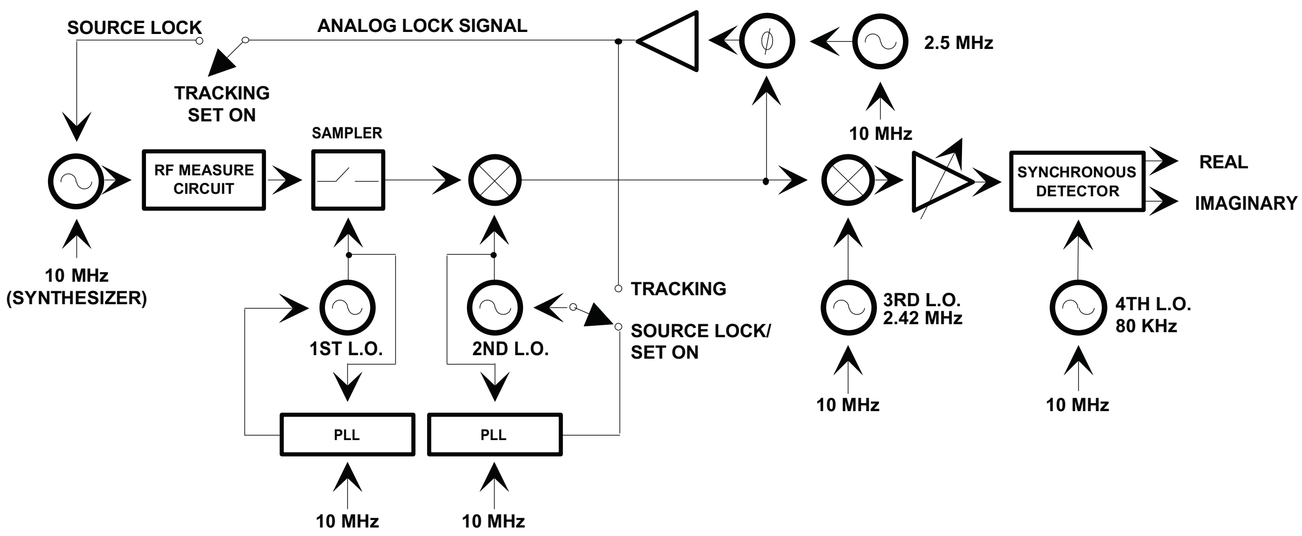


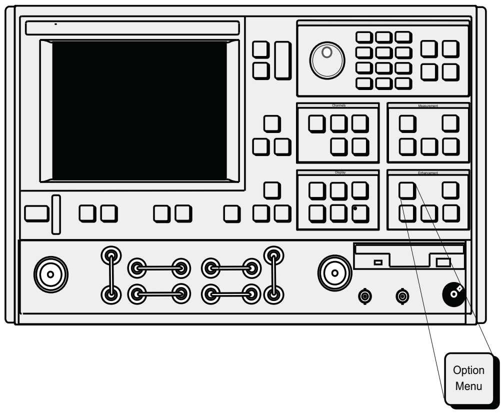
Figure 8-31. 37XXXD Phase Lock Modes

MENU OPTNS
OPTIONS
TRIGGERS
REAR PANEL OUTPUT
DIAGNOSTICS
MULTIPLE SOURCE CONTROL
RECEIVER MODE
SOURCE CONFIG
RF ON/OFF DURING RETRACE
PRESS <ENTER> TO SELECT

Operating Procedure, Receiver Mode

The three operational modes that comprise the Receiver Mode can be set up as follows:

Step 1. Press the Option Menu key (below).



MENU RCV1
RECEIVER MODE
STANDARD
USER DEFINED
SOURCE CONFIG
SPUR REDUCTION NORMAL/OFF
PRESS <ENTER> TO SELECT

Step 2. When menu OPTNS (top left) appears, select RECEIVER MODE.

Step 3. When menu RCV1 (middle left) appears, select either STANDARD (Step 4) or USER DEFINED (Step 5). Your selection depends on the application.

Step 4. The Standard mode uses the Source Lock mode for operation with the internal source. The user has no control over selections within the Standard Mode.

Because entering the standard mode from the User Defined Mode erases the current stored calibration data, a warning menu (RCV3, bottom left) appears when STANDARD is selected. Press Enter to enter into the Standard mode or press Clear to abort.

MENU RCV3
STANDARD RECEIVER MODE
WARNING:
CONTINUING MAY INVALIDATE CURRENT SETUP AND CALIBRATION
PRESS <ENTER> TO CONTINUE
PRESS <CLEAR> TO ABORT

NOTE

Spur Reduction: Normal/OFF: Spur Reduction Off may be selected when making non-ratioed measurements or using the Set-On Receiver mode. Under those measurement conditions, it may reduce high level noise. In normal S-parameter measurement mode, Spur Reduction should remain "Normal," as the noise level is not affected.

MENU RCV1

RECEIVER MODE
STANDARD
USER DEFINED
SOURCE CONFIG
SPUR REDUCTION
NORMAL/OFF
PRESS <ENTER>
TO SELECT

MENU RCV2

USER DEFINED
RECEIVER MODE
SOURCE LOCK
TRACKING
SET ON
PRESS ENTER
TO SELECT

MENU RCV4

USER DEFINED
RECEIVER MODE
WARNING:
CONTINUING
MAY INVALIDATE
CURRENT
SETUP AND
CALIBRATION
PRESS <ENTER>
TO CONTINUE
PRESS <CLEAR>
TO ABORT

Step 5. Selecting USER DEFINED RECEIVER MODE in menu RCV1 brings menu RCV 2 to the screen. When menu RCV 2 appears, the last mode selected is highlighted in red. The default selection is SOURCE LOCK.

Source Lock, Tracking or Set-On modes can be selected from this menu. When a mode is selected, information about that mode is displayed on the screen. This information describes the mode and the capabilities required of the RF source.

8-10 EMBEDDING/ DE-EMBEDDING

In many S-parameter measurements, the measurement of the DUT may also include other set-up components that affect the overall measurement result. For example, there may be a test fixture required between the normal coaxial calibration planes and the DUT. It may be useful to see the DUT performance with a certain matching network in place or it may be desired to see what the subsystem performance would be when the given DUT is inserted, etc. The classical purposes of embedding and de-embedding are shown in Figure 8-32, below.

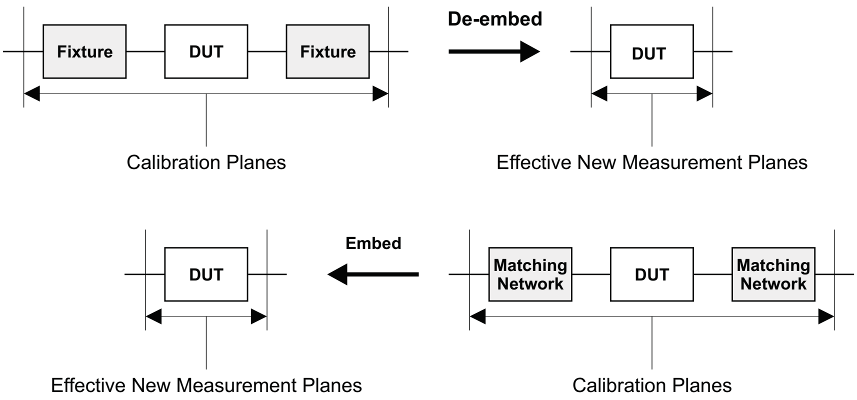


Figure 8-32. Classic Embedding and De-embedding

One way of handling these chores within the instrument itself is through embedding and de-embedding: the process of mathematically adding or subtracting networks to or from the measured result. This feature is available in all 37XXXD VNAs as shown in the following paragraphs.

Embedding

MENU DE8

EMBED/DE-EMBED
S2P FILE

PORT 1/PORT 2

METHOD
EMBED/DE-EMBED

SWAP PORTS OFF
OF S2P DATA

APPLY NETWORK
S2P FILE DATA TO
CAL FILE DATA

PRESS <ENTER>
TO SELECT
OR CHANGE

MENU DE9

EMBED/DE-EMBED
S2P FILE

ORIGINAL CAL FILE
TO APPLY NETWORK

READ CAL FILE
FROM HARD DISK

READ CAL FILE
FROM FLOPPY DISK

PRESS <ENTER>
TO SELECT

PRESS <CLEAR>
TO ABORT

MENU DE9A

EMBED/DE-EMBED
S2P FILE

S2P FILE DATA
OF THE NETWORK

READ S2P FILE
FROM HARD DISK

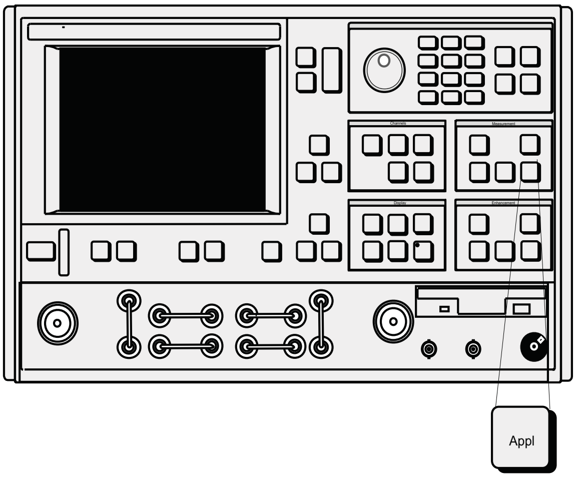
READ S2P FILE
FROM FLOPPY DISK

PRESS <ENTER>
TO SELECT

PRESS <CLEAR>
TO ABORT

Embedding of Matching Networks, or other components, can be done as follows:

Step 1. Press the APPL menu key on the instrument's front panel.



Step 2. Select the VNA test port where the network will be embedded, then select the EMBED function under the EMBED/DE-EMBED S2P FILE menu (menu DE8, top left).

Step 3. Select APPLY NETWORK S2P FILE TO CAL FILE DATA. This will take you to the EMBED/DE-EMBED S2P FILE menu (menu DE9, middle left).

Step 4. Select where to read the calibration file from.

The calibration file to be embedded can be stored on either the floppy or the hard disk. Once the calibration file is recalled, the EMBED/DE-EMBED S2P FILE menu (menu DE9A, bottom left) is displayed.

Step 5. Menu DE9A allows you to choose the .S2P file to be embedded from either the floppy or hard disk. Select the .S2P file to read.

Once the .S2P file is selected, it is embedded with the calibration file. To embed additional files, save the calibration along with the embeded .S2P file onto the hard disk or floppy disk for later recall upon the next embedding operation.

De-embedding

MENU DE8

EMBED/DE-EMBED
S2P FILE

PORT 1/PORT 2

METHOD
EMBED/DE-EMBED

SWAP PORTS OFF
OF S2P DATA

APPLY NETWORK
S2P FILE DATA TO
CAL FILE DATA

PRESS <ENTER>
TO SELECT
OR CHANGE

MENU DE9

EMBED/DE-EMBED
S2P FILE

ORIGINAL CAL FILE
TO APPLY NETWORK

READ CAL FILE
FROM HARD DISK

READ CAL FILE
FROM FLOPPY DISK

PRESS <ENTER>
TO SELECT

PRESS <CLEAR>
TO ABORT

MENU DE9A

EMBED/DE-EMBED
S2P FILE

S2P FILE DATA
OF THE NETWORK

READ S2P FILE
FROM HARD DISK

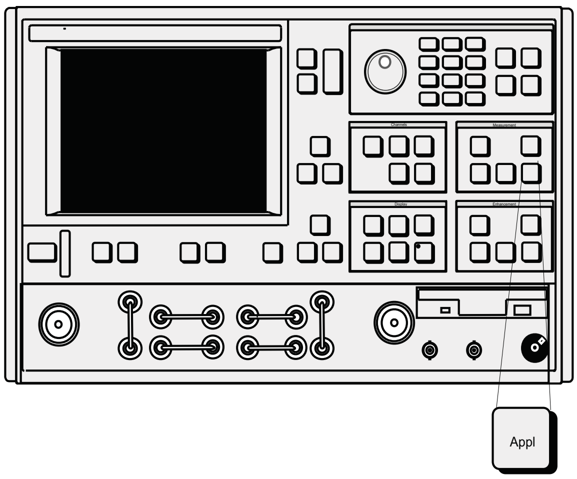
READ S2P FILE
FROM FLOPPY DISK

PRESS <ENTER>
TO SELECT

PRESS <CLEAR>
TO ABORT

De-embedding is a common technique for removing test fixture effects from a calibration, generally of microstrip or on-wafer devices. This is performed by the following:

Step 1. Press the APPL key on the instrument's front panel.



Step 2. Select the VNA test port where the network will be embedded, then select the DE-EMBED function under the EMBED/DE-EMBED S2P FILE menu (menu DE8, top left).

Step 3. Select APPLY NETWORK S2P FILE TO CAL FILE DATA. This will take you to the EMBED/DE-EMBED S2P FILE menu (menu DE9, middle left).

Step 4. Select where to read the calibration file from.

The calibration file to be embedded can be stored on either the floppy or the hard disk. Once the calibration file is recalled, the EMBED/DE-EMBED S2P FILE menu (menu DE9A, bottom left) is displayed.

Step 5. Menu DE9A allows you to choose the .S2P file to be de-embedded from either the floppy or hard disk. Select the .S2P file to read.

Once the .S2P file is selected, it is de-embedded with the calibration file. To de-embed additional files, save the calibration along with the de-embeded .S2P file onto the hard disk or floppy disk for later recall upon the next de-embedding operation.

8-11 OPTICAL APPLICATION

Optical applications are divided into two measurement categories, electro-optical (E/O) and opto-electrical (O/E).

E/O measurements can be performed with the 372XXD/373XXD series VNAs using the built-in E/O measurement application. On-screen menu-driven procedures guide you through the set-up and calibration required for E/O measurements of optical modulators such as bandwidth, flatness, and group delay.

O/E measurements of a photo-diode or photo-receiver can be performed with the 372XXD/373XXD series VNAs by using the built-in O/E measurement application. On-screen-menu-driven procedures guide you through the set-up and calibration required for O/E measurements such as bandwidth, flatness, and group delay.

E/O Measurements

Optical modulators modulate digital data signals over a light wave carrier and send it over fiber optic networks. Since a VNA is only capable of generating and measuring electrical signals, a laser source is required to provide optical input to the modulator DUT and a photo-diode/photo-receiver is required to convert the modulator output back to an electrical signal that can be measured by the VNA. The MN4765A (65 GHz characterized photo-diode) is used with the following procedure. The equipment set up for an E/O measurement is shown in Figure 8-33, below.

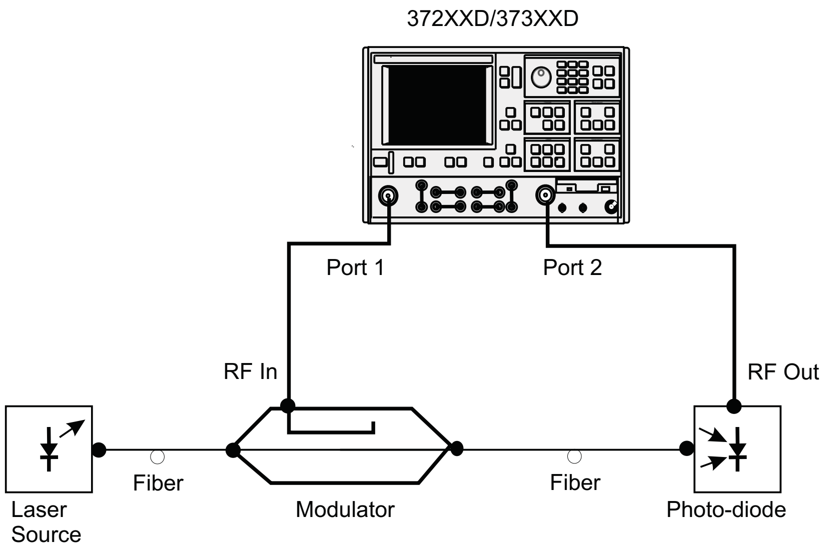


Figure 8-33. E/O Measurement Setup

The E/O measurement application de-embeds the response of the photo-diode/photo-receiver transfer standard from a 12-term calibration to enable measurements of a modulator DUT.

MENU APPL

APPLICATIONS
ADAPTER REMOVAL
SWEPT FREQUENCY GAIN COMPRESSION
SWEPT POWER GAIN COMPRESSION
E/O MEASUREMENT
O/E MEASUREMENT
MERGE CAL FILES
PRESS <ENTER> TO SELECT

MENU DE1

E/O MEASUREMENT
MEASURE E/O DUT MODULATOR
DE-EMBED TRANSFER FUNCTION OF A GENERIC NETWORK
PRESS <ENTER> TO SELECT

E/O Measurement Procedure

The following procedure will explain ways of using the MN4765A photo-diode to make an E/O measurement of a modulator DUT. The same set up can be used for a user characterized photo-diode as well.

Step 1. Set-up the measurement as shown in Figure 8-33.

Step 2. Perform a 12-term calibration on the VNA over the frequency range of interest with reference planes at the DUT input and the photo-diode output. (Refer to section 7-4 for the 12-term calibration steps.)

Step 3. Press Save/Recall to save the calibration and set-up to the hard disk or a floppy disk.

Step 4. Press the Appl key to display the applications menu (left).

Step 5. Move the cursor to E/O MEASUREMENT and press Enter.

This brings up menu DE1 (left) and the step-by-step procedure, Figure 8-34, for making the measurement.

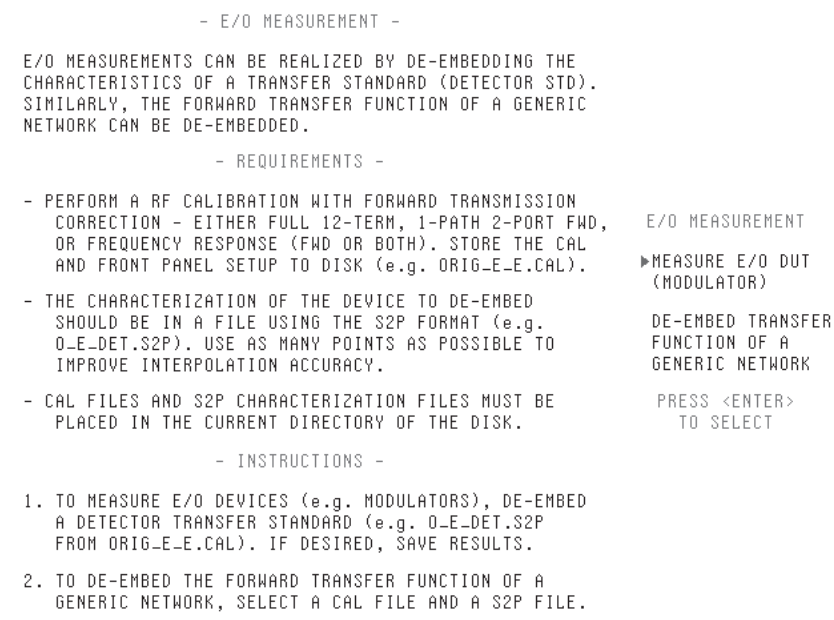


Figure 8-34. E/O Measurement Menu

Step 6. Select MEASURE E/O DUT (MODULATOR) and press Enter.

MENU DE3
E/O MEASUREMENT
ORIGINAL CAL FILE WITH FWD TRANS CORRECTION
READ CAL FILE FROM HARD DISK
READ CAL FILE FROM FLOPPY DISK
PRESS <ENTER> TO SELECT
PRESS <CLEAR> TO ABORT

MENU DSK2
SELECT FILE TO READ
TESTCAL CAL
PREVIOUS MENU
PRESS <ENTER> TO SELECT
PRESS <1> FOR PREVIOUS PAGE
PRESS <2> FOR NEXT PAGE

MENU DE3A
E/O MEASUREMENT
TRANSFER STANDARD TO BE DE-EMBEDDED (DETECTOR STD)
READ S2P FILE FROM HARD DISK
READ S2P FILE FROM FLOPPY DISK
PRESS <ENTER> TO SELECT
PRESS <CLEAR> TO ABORT

This brings up menu DE3 (top left).

Step 7. Select READ CAL FILE FROM HARD DISK or READ CAL FILE FROM FLOPPY DISK depending on where the 12-term calibration was saved in Step 3.

This bring up menu DSK2 (middle left).

Step 8. Select the calibration file and press Enter.

Step 9. Read the S2P file (characterization data file) for the photo-diode transfer standard. This will de-embed the photo-diode for an E/O measurement (menu DE3A, bottom left).

NOTE

If an S2P file is not available, it can be generated from the characterization data provided by the vendor. This is explained on page 8-74.

The VNA now displays the measurement of the modulator DUT. An example measurement of a 40 Gb/s NRZ modulator is shown in Figure 8-35 below.

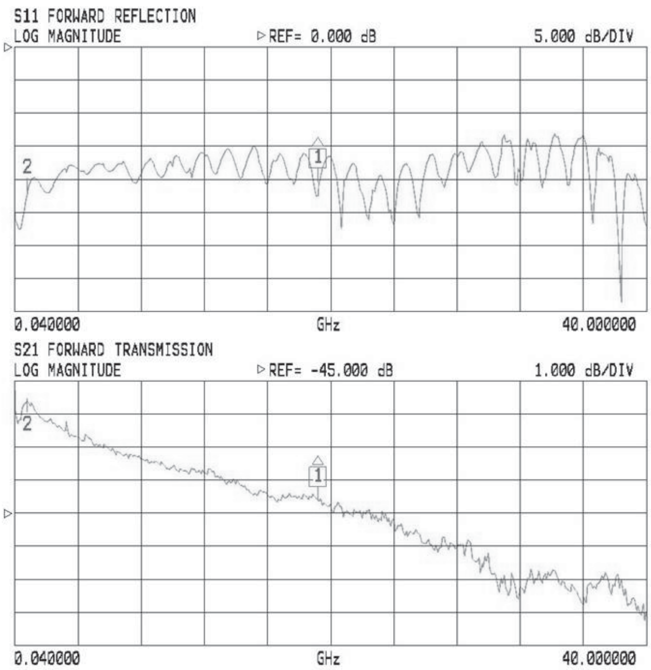


Figure 8-35. E/O Measurement of a 40 Gb/s NRZ Modulator

Step 10. Press Save/Recall and save this de-embedded calibration to the hard disk or the floppy disk.

NOTE

Observe that the S11 graph displays the electrical return loss (port match) of the modulator and S21 represents the transfer function of the modulator. The bandwidth of the modulator can be calculated from the S21 data by setting the delta markers or using the marker search function to find the 3 dB change in magnitude. The 3 dB bandwidth of the modulator measured in this example is 24 GHz.

O/E Measurements

Photo-diodes/photo-receivers convert an optical signal into an electrical signal. Bandwidth measurements can be made on a photo-diode/photo-receiver by stimulating its input with a modulated optical source and measuring the output signal. A laser and a characterized modulator are required, in addition to the VNA, to make O/E measurements. See Figure 8-36, below, for the equipment set-up.

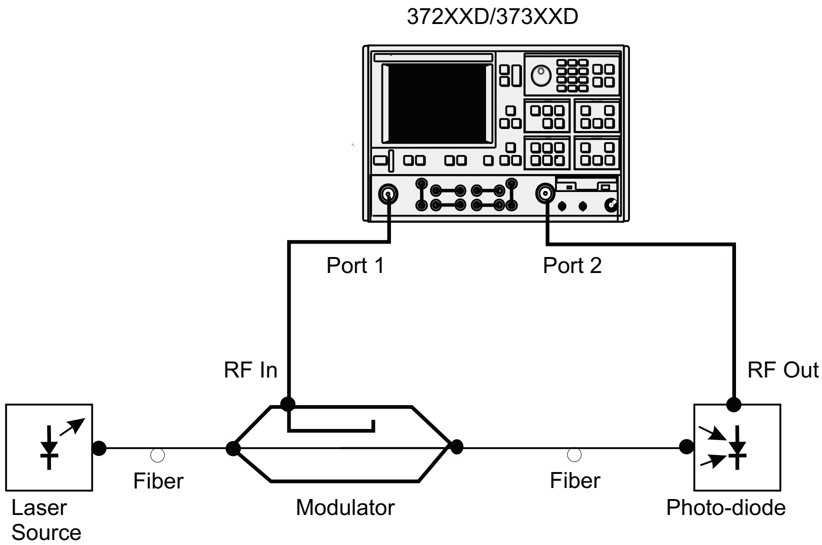


Figure 8-36. O/E Measurement Set-up

The O/E measurement application de-embeds the response of the modulator transfer standard from a 12-term calibration to enable measurements of the photo-diode DUT.

O/E Measurement Procedure

The following procedure will explain ways of obtaining characterization data for a modulator and then how to use it to make an O/E measurement of a photo-receiver.

Step 1. Set-up the measurement as shown in Figure 8-36, previous page.

Step 2. Perform a 12-term calibration on the VNA over the frequency range of interest with reference planes at the modulator input and the photo-receiver DUT output. (Refer to section 7-4 for the 12-term calibration steps.)

Step 3. Press Save/Recall to save the calibration and set up to the hard disk or a floppy disk.

Step 4. Press the Appl key to display the applications menu (left).

Step 5. Move the cursor to O/E MEASUREMENT and press Enter.

This brings up menu DE2 (bottom left) and the step-by-step procedure for making the measurement as shown in Figure 8-37, below.

MENU APPL

APPLICATIONS
ADAPTER REMOVAL
SWEPT FREQUENCY GAIN COMPRESSION
SWEPT POWER GAIN COMPRESSION
E/O MEASUREMENT
O/E MEASUREMENT
MERGE CAL FILES
PRESS <ENTER> TO SELECT

MENU DE2

O/E MEASUREMENT
DE-EMBED O/E S2P (DETECTOR STD)
GENERATE E/O S2P CHARACTERIZATION (MODULATOR)
MEASURE O/E DUT (DETECTOR)
PRESS <ENTER> TO SELECT
PRESS <CLEAR> TO ABORT

```
                  - O/E MEASUREMENT -

O/E MEASUREMENTS CAN BE REALIZED BY DE-EMBEDDING THE
CHARACTERISTICS OF A TRANSFER STANDARD (MODULATOR).

                  - REQUIREMENTS -

- PERFORM A RF CALIBRATION WITH FORWARD TRANSMISSION
   CORRECTION - EITHER FULL 12-TERM, 1-PATH 2-PORT FWD,
   OR FREQUENCY RESPONSE (FWD OR BOTH). STORE THE CAL       O/E MEASUREMENT
   AND FRONT PANEL SETUP TO DISK (e.g. ORIG_E_E.CAL).
- THE CHARACTERIZATION OF THE DEVICE TO DE-EMBED           ▶DE-EMBED O/E S2P
   SHOULD BE IN A FILE USING THE S2P FORMAT (e.g.           (DETECTOR STD)
   O_E_DET.S2P AND E_O_MOD.S2P). USE AS MANY POINTS
   AS POSSIBLE TO IMPROVE INTERPOLATION ACCURACY.           GENERATE E/O S2P
- CAL FILES AND S2P CHARACTERIZATION FILES MUST BE          CHARACTERIZATION
   PLACED IN THE CURRENT DIRECTORY OF THE DISK.             (MODULATOR)

                  - INSTRUCTIONS -                          MEASURE O/E DUT
                                                            (DETECTOR)
1. DE-EMBED A DETECTOR STANDARD (e.g. O_E_DET.S2P
   FROM ORIG_E_E.CAL). IF DESIRED, SAVE RESULTS.             PRESS <ENTER>
                                                               TO SELECT
2. MEASURE THE INTENDED MODULATOR TRANSFER STANDARD
   AND CAPTURE ITS CHARACTERIZATION BY GENERATING A
   S2P FILE (e.g. E_O_MOD.S2P). THIS IS THE SAME AS
   USING THE S2P DISK FILE HARDCOPY FEATURE.

3. TO MEASURE O/E DEVICES (e.g. DETECTORS), DE-EMBED
   THE MODULATOR TRANSFER STANDARD (e.g. E_O_MOD.S2P
   FROM ORIG_E_E.CAL). IF DESIRED, SAVE RESULTS.
```

Figure 8-37. O/E Measurement Menu

MENU DE5

DE-EMBED O/E S2P

ORIGINAL CAL FILE
WITH FWD TRANS
CORRECTION

READ CAL FILE
FROM HARD DISK

READ CAL FILE
FROM FLOPPY DISK

PRESS <ENTER>
TO SELECT

PRESS <CLEAR>
TO ABORT

The measurement of the photo-receiver DUT relies on a characterized modulator standard. If a characterized modulator is not available, an S2P file can be created by using a characterized photo-diode and de-embedding it from the 12-term calibration performed in Step 2.

Step 6. With the measurement set-up as shown in Figure 8-36, select DE-EMBED O/E S2P (DETECTOR STD) (menu DE2, previous page).

This brings up menu DE5 (top left).

Step 7. Select READ CAL FILE FROM HARD DISK or READ CAL FILE FROM FLOPPY DISK depending on where the 12-term calibration was saved in Step 3.

This brings up menu DSK2 (middle left).

MENU DSK2

SELECT FILE
TO READ

TESTCAL CAL

PREVIOUS MENU

PRESS <ENTER>
TO SELECT

PRESS <1> FOR
PREVIOUS PAGE

PRESS <2> FOR
NEXT PAGE

Step 8. Select the calibration file and press Enter.

Step 9. Select READ THE S2P FILE FROM HARD DISK or READ THE S2P FILE FROM FLOPPY DISK (menu DE5A, bottom left). This is the characterization data file for the photo-diode transfer standard. This will de-embed the photo-diode for an O/E measurement.

Step 10. Press the Appl key, select O/E MEASUREMENT. Again, then press Enter. This recalls menu DE2 (left).

MENU DE5A

DE-EMBED E/O S2P

TRANSFER STANDARD
TO BE DE-EMBEDDED
(DETECTOR STD)

READ S2P FILE
FROM HARD DISK

READ S2P FILE
FROM FLOPPY DISK

PRESS <ENTER>
TO SELECT

PRESS <CLEAR>
TO ABORT

MENU DE2
O/E MEASUREMENT
DE-EMBED O/E S2P (DETECTOR STD)
GENERATE E/O S2P CHARACTERIZATION (MODULATOR)
MEASURE O/E DUT (DETECTOR)
PRESS <ENTER> TO SELECT
PRESS <CLEAR> TO ABORT

Step 11. Move the cursor to GENERATE E/O S2P CHARACTERIZATION (MODULATOR STD) (menu DE2, left) and press Enter. This will generate an S2P characterization file for the modulator.

Once the modulator characterization S2P file has been generated, it can be used as a transfer standard for the photo-receiver DUT measurement.

After the characterization file has been saved, the VNA returns to the O/E measurement menu shown in Figure 8-38, below.

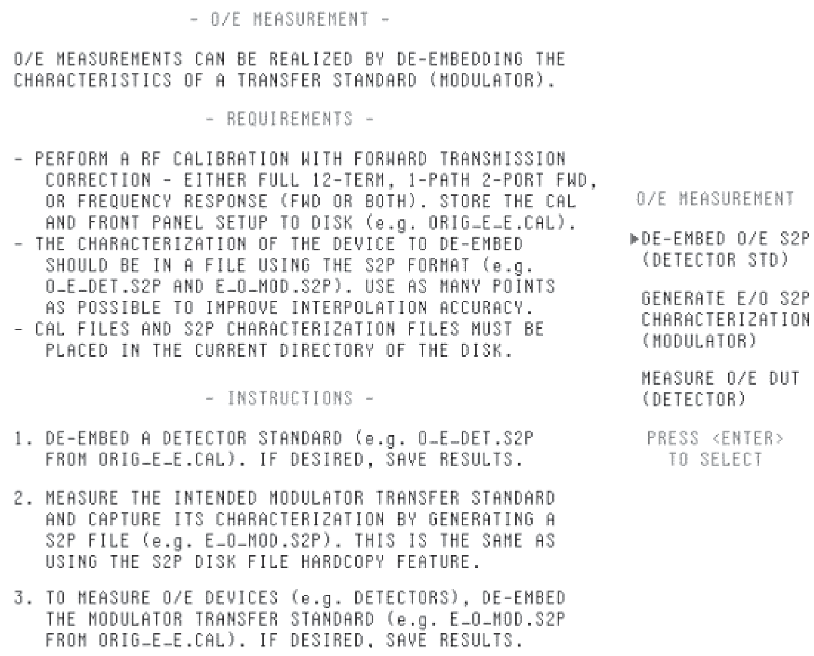


Figure 8-38. O/E Measurement Menu

Step 12. Press the Appl key, select O/E MEASUREMENT. Again, then press Enter. This recalls menu DE2 (top left).

Step 13. Move the cursor to MEASURE O/E DUT (DETECTOR) (menu DE2, top left) and press Enter.

This brings up menu DE7 (middle left).

Step 14. Select READ CAL FILE FROM HARD DISK or READ CAL FILE FROM FLOPPY DISK depending on where the original 12-term calibration was saved in Step 3.

This brings up menu DSK2 (bottom left).

MENU DE2

O/E MEASUREMENT

DE-EMBED O/E S2P
(DETECTOR STD)

GENERATE E/O S2P
CHARACTERIZATION
(MODULATOR)

MEASURE O/E DUT
(DETECTOR)

PRESS <ENTER>
TO SELECT

PRESS <CLEAR>
TO ABORT

MENU DE7

O/E MEASUREMENT

ORIGINAL CAL FILE
WITH FWD TRANS
CORRECTION

READ CAL FILE
FROM HARD DISK

READ CAL FILE
FROM FLOPPY DISK

PRESS <ENTER>
TO SELECT

PRESS <CLEAR>
TO ABORT

MENU DSK2

SELECT FILE
TO READ

TESTCAL CAL

PREVIOUS MENU

PRESS <ENTER>
TO SELECT

PRESS <1> FOR
PREVIOUS PAGE

PRESS <2> FOR
NEXT PAGE

MENU DE7A

O/E MEASUREMENT

TRANSFER STANDARD
TO BE DE-EMBEDDED
(MODULATOR)

READ S2P FILE
FROM HARD DISK

READ S2P FILE
FROM FLOPPY DISK

PRESS <ENTER>
TO SELECT

PRESS <CLEAR>
TO ABORT

Step 15. Read the S2P file for the modulator that was generated in Step 10 from the hard drive or floppy drive (menu DE7A, left). This will de-embed the modulator response from the set-up for an O/E measurement.

NOTE

If an S2P file is not available, it can be generated from the characterization data provided by the vendor. This is explained on page 8-74.

An O/E measurement of a photo-receiver is shown in Figure 8-39 below. The S21 measurement represents the transfer function of the photo-receiver and S22 represents the electrical return loss.

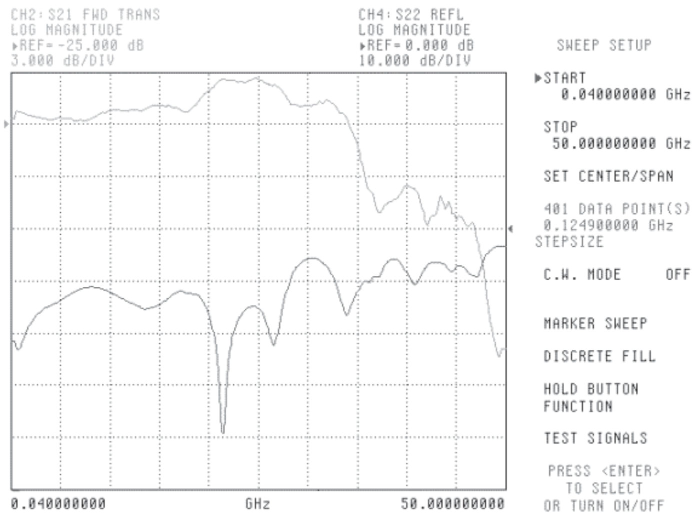


Figure 8-39. O/E Measurement of a Photo-receiver

Creating a Characteri ation (.S2P) File for E/O and O/E Measurements*

This section guides you through the process of creating an S2P file from vendor supplied characterization data. The S2P file can then be read into the VNA for de-embedding the response of the transfer standard used for either a modulator or photo-diode.

Microsoft Excel is the recommended application for creating and storing the S2P file containing the characterization data. A sample S2P file is available for reference (contact Anritsu MMD Customer Service for a copy).

The file format is the standard S2P format that includes the four S-parameters (see the section below for details on the S2P format). The transfer function data supplied by the vendor should be copied into the columns designated for S21 data and the frequencies into the FREQ column. Once the data has been entered, the file should be saved as an S2P file (as shown in Figure 8-40 below).

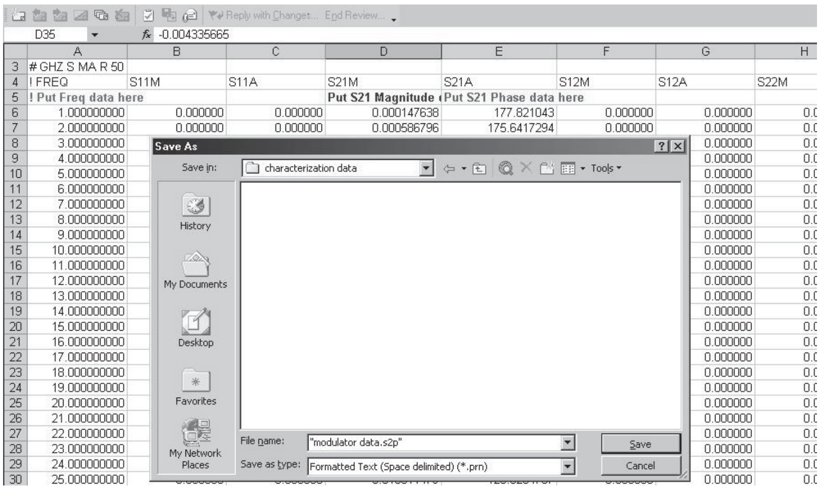


Figure 8-40. Saving the S2P File in Excel

S2P File Format

S2P data files are ASCII text files in which data appears line by line, one line per data point, in increasing order of frequency. Each line of data consists of a frequency value and one or more pairs of values for the magnitude and phase of each S-parameter at that frequency.

Values are separated by one or more spaces, tabs, or commands. Comments are preceded by an exclamation mark ( ). Comments can appear on separate lines or after the data on any line.

The standard S2P file format consists of:

- ❑ Option Lines
- ❑ Data Lines
- ❑ Comments

The option line contains the specifications of the data, for example, the frequency units, the normalizing impedance, and the measured parameter (S, Y, Z, etc.).

The option line format is:

<frequency unit> <parameter> <format> <Rn>

where:

#	The delimiter that tells the program you are specifying these parameters
frequency unit	The set of units desired (GHz, MHz, KHz, Hz)
parameter	The parameter desired (S, Y or Z for S1P components; S, Y, Z, G, or H for S2P components; S for S3P or S4P components)
format	The format desired (DB for dB-angle, MA for magnitude-angle, or RI for real-imaginary)
R n	The reference resistance in ohms, where n is a positive number of ohms (the real impedance to which the parameters are normalized)

The default option line for a component data files is:

GHZ S MA R 50

For Y-parameters with real imaginary data, the option line header will change to:

GHz Y RI R 50

The data lines contain the data of interest. Data for all four S-parameters will be listed on a single line for a particular frequency point. The format is:

Frequency S11 S21 S12 S22

Data Line Examples:
Frequency S11 (magnitude) S11 (angle)
0.040000000 1.426492E-04 18.642
0.139900000 2.840961E-03 22.262

Finally, the comment lines begin with an exclamation point " ." They can be inserted at any point in an S2P file and are ignored by the application program. An S2P file example appears in Figure 8-41 below.

! Anritsu Company
! DATE 04/11/2002 13:16 PAGE 1
! Photo-diode receiver characterization – NRZ-40G
GHz S MA R 50.00

!FREQ	S11M	S11A	S21M	S21A	S12M	S12A	S22M	S22A
0.040000000	1.426492E-04	18.642	3.008963E-04	87.040	1.618370E-04	27.317	2.708149E-04	129.056
0.139900000	2.840961E-03	22.262	6.185992E-03	-114.026	2.539190E-03	125.940	5.977178E-03	-7.691
0.239800000	3.072268E-03	97.851	7.423908E-03	109.019	3.147963E-03	-88.205	7.634960E-03	-75.071
0.339700000	1.887820E-02	81.836	3.814256E-02	-135.753	1.632677E-02	-27.669	3.348942E-02	117.818
0.439600000	2.173782E-02	142.412	4.595363E-02	72.973	1.962434E-02	107.429	3.946349E-02	40.979
0.539500000	2.634556E-02	-62.971	5.206176E-02	31.589	2.257828E-02	-22.787	4.638838E-02	70.663
0.639400000	3.060178E-02	-103.325	6.416773E-02	120.463	2.732290E-02	5.656	5.685493E-02	-124.645

Figure 8-41. S2P File Example

C 9
T D

T C

C 9
T D

9-1 INTRODUCTION

This chapter describes the optional Time Domain feature.

9-2 TIME DOMAIN MEASUREMENTS

The Option 2, Time Domain feature provides a useful measurement tool for determining the location of impedance discontinuities. Some typical applications are identifying and analyzing circuit elements, isolating and analyzing a desired response, locating faults in cables, and measuring antennas.

The relationship between the frequency-domain response and the time-domain response of a network is described mathematically by the Fourier transform.

The 37XXXD makes measurements in the frequency domain then calculates the inverse Fourier transform to give the time-domain response. The time-domain response is displayed as a function of time (or distance). This computational technique benefits from the wide dynamic range and the error correction of the frequency-domain data.

Let us examine the time-domain capabilities. Two measurement modes are available: lowpass and bandpass.

We use the lowpass mode with devices that have a dc or low-frequency response. In the lowpass mode two responses to the device-under-test (DUT) are available: impulse or step response.

The frequencies used for the test must be harmonically related (integer multiples) to the start frequency. The simplest way to calculate this relationship is to divide the highest frequency in the calibration by 1600 (the default number-of-points available); this is the start frequency. For example, if the highest frequency is 40 GHz, the calculated start frequency is 0.025 GHz (40/1600). If the highest frequency is 65 GHz, the calculated start frequency is 0.040625 GHz (65/1600).

The lowpass impulse response displays the location of discontinuities as well as information useful in determining the impedance (R, L, or C) of each discontinuity.

The impulse response is a peak that goes positive for $R>Z_0$ and negative for $R<Z_0$. The height of the response is equal to the reflection coefficient:

$$\rho = \frac{R - Z_0}{R + Z_0}$$

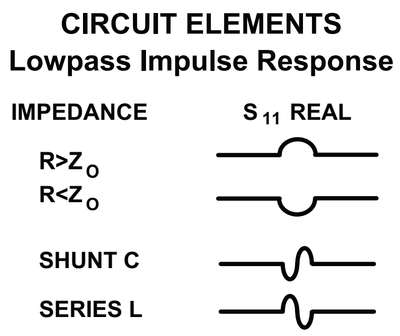


Figure 9-1. Lowpass Impulse Response

The impulse response for a shunt capacitance is a negative-then-positive peak and for a series inductance is a positive-then-negative peak (Figure 9-1).

An example of using an impulse response is a circuit impedance analysis. With an impulse response we can observe the circuit response of a passive device, such as a multi-element step attenuator (Figure 9-2), and make final, realtime adjustments during the test.

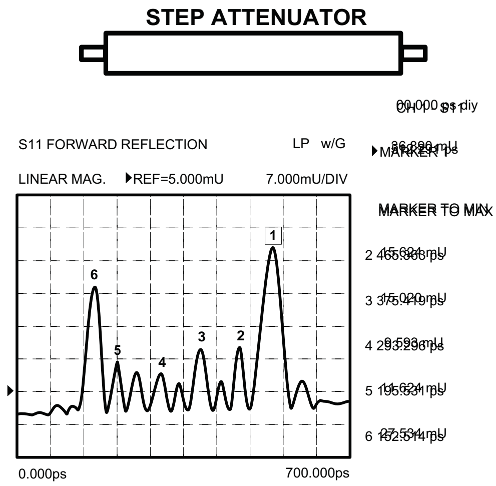


Figure 9-2. Example of Lowpass Impulse Response

In the above example, the connectors at each end have been gated out (page 9-12), which lets you better observe the internal circuit response. Each displayed marker has been manually set to the peak of the response at each adjustable circuit element. In this way, the data display lets you make the adjustment in realtime, while the marker menu shows the magnitude of the response at each marker.

The lowpass step response displays the location of discontinuities as well as information useful in determining the impedance (R, L, or C) of each discontinuity. If you are familiar with time-domain reflectometry (TDR) you may feel more comfortable with step response, as the displays are similar.

The lowpass step response for a resistive impedance is a positive level shift for $R>Z_0$ and a negative level shift for $R<Z_0$. The height of the response is equal to the reflection coefficient

$$\rho = \frac{R - Z_0}{R + Z_0}$$

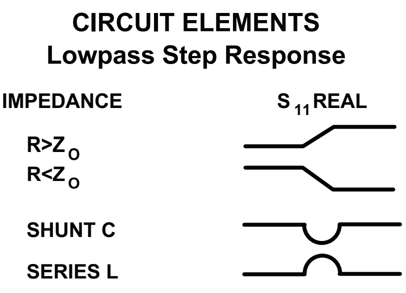


Figure 9-3. Lowpass Step Response

The step response for a shunt capacitance is a negative peak, and for a series inductance it is a positive peak (Figure 9-3).

An example of using the lowpass step response is cable-fault location. In the frequency domain a cable with a fault exhibits a much worse

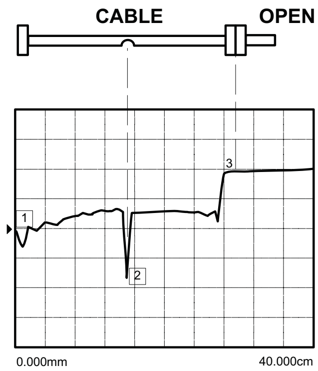


Figure 9-4. Example of Lowpass Step Response

match than a good cable. Using lowpass step response, both the location of the discontinuity and the information about its type are available (Figure 9-4).

In the above example, the dip in the display shows the shunt-capacitive response caused by a crimp in the cable. The response at the end of the cable shows the step-up that is typical of an open (Figure 9-3, left).

The 37XXXD bandpass mode gives the response of the DUT to an RF-burst stimulus. Two types of response are available: impulse and phasor-impulse. An advantage of the bandpass mode is that any frequency range can be used. Use this mode with devices that do not have a dc or low-frequency path.

Use the bandpass-impulse response to show the location of a discontinuity in time or distance, as indicated by changes in its magnitude. Unlike the lowpass mode, no information as to the type of the discontinuity is available. A typical use for this mode is to measure devices—such as, filters, waveguide, high-pass networks, bandpass networks—where a low-frequency response is not available.

The bandpass-impulse response for various impedance discontinuities is shown in Figure 9-5. As we can see, no information about the type of discontinuity is available.

An example of using the bandpass-impulse response, is the pulse height, ringing, and pulse envelope of a bandpass filter (Figure 9-6).Use the phasor-impulse response with bandpass response to determine the type of an isolated impedance discontinuity.

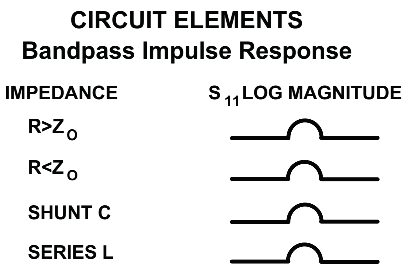


Figure 9-5. Bandpass Impulse Response

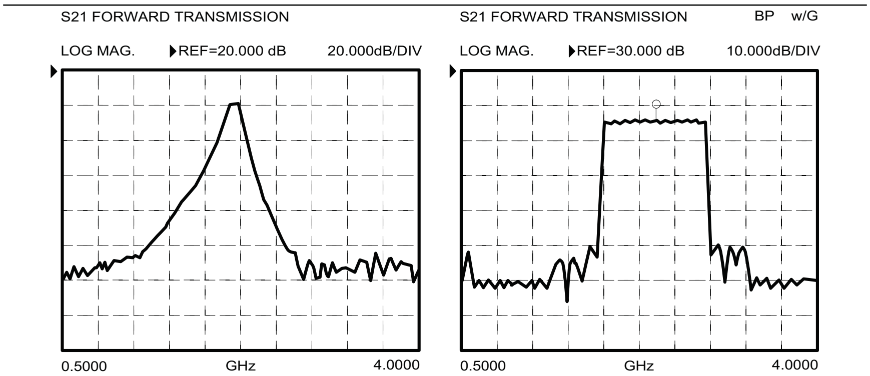


Figure 9-6. Example of Bandpass-Impulse Response

After the bandpass-impulse response has been isolated, the phasor-impulse response for a resistive-impedance-level change is a peak that goes positive ($R>Z_0$) for the real part of S_{11} and negative for $R<Z_0$. The imaginary part remains relatively constant. In each case the peak is proportional to the reflection coefficient. The phasor-impulse response for a shunt capacitance is a negative-going peak in the imaginary part of S_{11}. For a series inductance, it is a positive going peak (Figure 9-7).

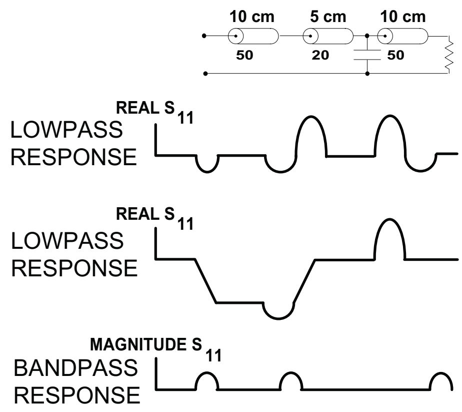


Figure 9-7. Complex Impedances

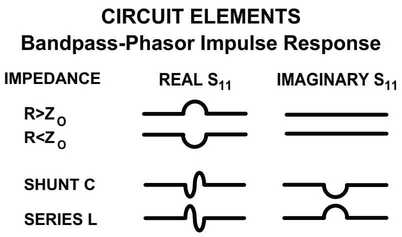


Figure 9-8. Bandpass Phasor Response

Next, let us look at a complex circuit. A resistive impedance change $R<Z_0$ and a shunt capacitance and series inductance. These impedance changes are shown in the time domain for the lowpass-impulse response, lowpass-step response, and bandpass-impulse response (Figure 9-8).

The 37XXXD processes bandpass-impulse-response data to obtain phasor-impulse response. This becomes most advantageous where both a reactive reflection and an impedance change occur at the same location. The real part of the time-domain response shows the location of impedance level changes, while the imaginary part shows the type of reactive discontinuity. Phasor-impulse response displays one discontinuity at a time (Figure 9-9).

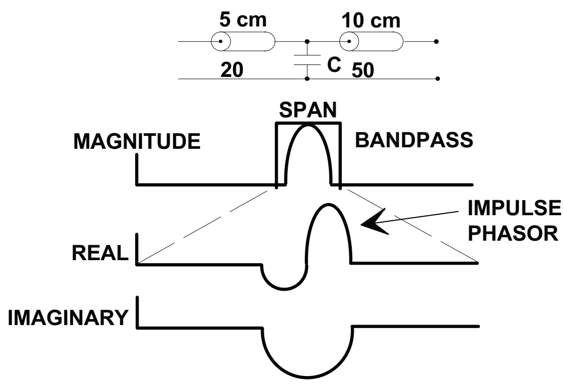
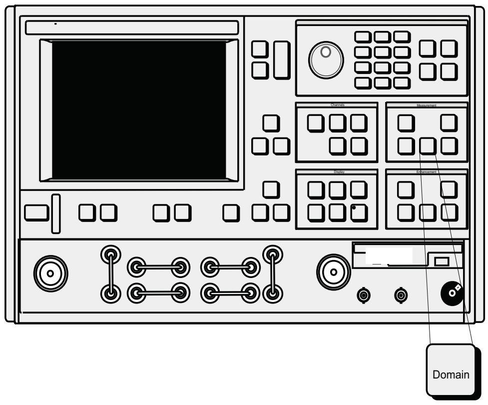


Figure 9-9. Phasor-Impulse Response Data

9-3 OPERATING TIME DOMAIN

To operate in the time domain mode, press the Domain key (below). A domain menu (Figure 9-10) lets you select the frequency- or time-domain modes by simple cursor selection. The 37XXXD defaults to the frequency domain.

Select time or distance for the horizontal axis. The 37XXXD defaults to time axis.



NOTE

If you select distance, be sure to set the dielectric constant in the Reference Delay menu (Figure 9-11).

SET
DIELECTRIC
CONSTANT
AIR
(1.000649)
POLYETHYLENE
(2.26)
TEFLON
(2.10)
MICROPOROUS
TEFLON
(1.69)
OTHER
XXXX.XX
PRESS <ENTER>
TO SELECT

Figure 9-11. Reference Delay Menu

DOMAIN
FREQUENCY
FREQUENCY
WITH TIME
GATE
TIME
LOWPASS MODE
TIME
BANDPASS
MODE
DISPLAY
TIME/DISTANCE
SET RANGE
SET GATE
GATE ON/OFF
HELP
PRESS <ENTER>
TO SELECT
OR SWITCH

DOMAIN
FREQUENCY
FREQUENCY
WITH TIME
GATE
TIME
LOWPASS MODE
TIME
BANDPASS
MODE
DISPLAY
TIME/DISTANCE
SET RANGE
SET GATE
GATE ON/OFF
HELP
PRESS <ENTER>
TO SELECT
OR SWITCH

DOMAIN
FREQUENCY
FREQUENCY
WITH TIME
GATE
TIME
LOWPASS MODE
TIME
BANDPASS MODE
DISPLAY
TIME/DISTANCE
SET RANGE
SET GATE
GATE ON/OFF
HELP
PRESS <ENTER>
TO SELECT
OR SWITCH

Figure 9-10. Domain Menu

Select SET RANGE and use the START/STOP or GATE/SPAN selections to set the range (Figure 9-12).

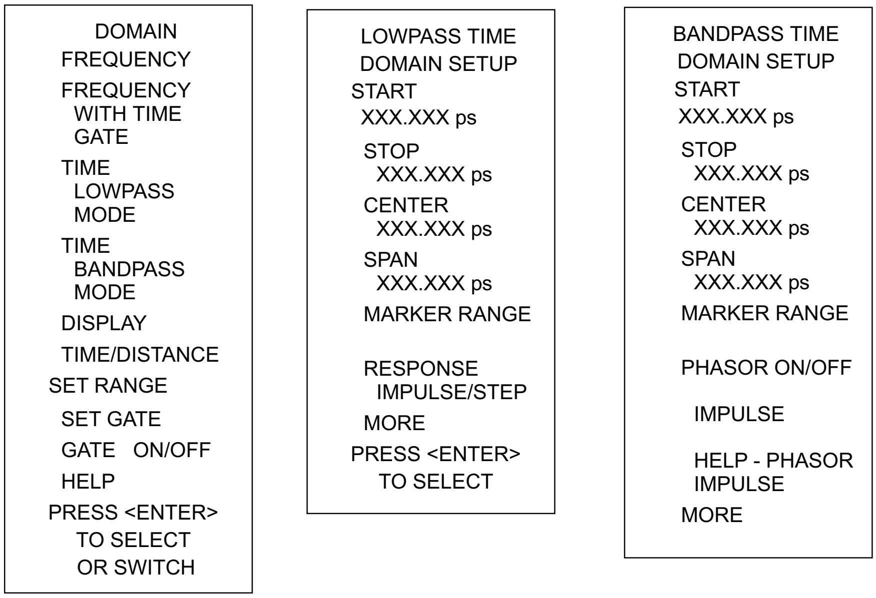


Figure 9-12. Set Range Menu

For the lowpass mode select either IMPULSE or STEP Response and set the DC term. The 37XXXDdefaults to the IMPULSE Response and the AUTO EXTRAPOLATE mode for the DC term (Figure 9-13).

NOTE
The bandpass mode displays Bandpass Impulse Response unless we select Phasor Impulse Response.

LOWPASS TIME
DOMAIN SETUP
START
XXX.XXX ps
STOP
XXX.XXX ps
CENTER
XXX.XXX ps
SPAN
XXX.XXX ps
MARKER RANGE

RESPONSE
IMPULSE/STEP
MORE
PRESS <ENTER>
TO SELECT

SET D.C. TERM
FOR LOWPASS
PROCESSING
AUTO
EXTRAPOLATE
LINE
IMPEDANCE
OPEN
SHORT
OTHER
–XXX.XXX #
ABOVE VALUE
REPRESENTS A

REFLECTION
COEFF. OF
XX.XXX mU
PREVIOUS MENU
PRESS <ENTER>
TO SELECT

BANDPASS TIME
DOMAIN SETUP
START
XXX.XXX ps
STOP
XXX.XXX ps
CENTER
XXX.XXX ps
SPAN
XXX.XXX ps
MARKER RANGE

PHASOR ON/OFF
IMPULSE

HELP-PHASOR
IMPULSE
MORE
PRESS <ENTER>
TO SELECT

Figure 9-13. Response Menus

The Marker Range menu allows us to zoom in and display the range between two selected markers (Figure 9-14).

LOWPASS TIME
DOMAIN SETUP
START
XXX.XXX ps
STOP
XXX.XXX ps
CENTER
XXX.XXX ps
SPAN
XXX.XXX ps
MARKER RANGE
RESPONSE
IMPULSE/STEP
MORE
PRESS <ENTER>
TO SELECT

TIME
MARKER SWEEP
START TIME
MARKER ( )
XXX.XXX nS
STOP TIME
MARKER ( )
XXX.XXX nS
RESTORE
ORIGINAL
RANGE
PREVIOUS MENU
USE KEYPAD
TO CHOOSE
MARKER (1 - 6)
OR
PRESS <ENTER>
TO SELECT

Figure 9-14. Marker Range Menus

9-4 WINDOWING

Windowing is a frequency filter that we apply to the frequency-domain data when we convert it to time-domain data. This filtering rolls off the abrupt transition at F1 and F2. This effectively produces a time-domain response with lower sidelobes. Windowing allows a limited degree of control over the pulse shape, trading off ringing (sidelobes) for pulse width (Figure 9-15).

We select windowing from the Time Domain Setup menu. Four different windows are available: RECTANGLE, NOMINAL, LOW SIDELOBE, and MIN SIDELOBE. The RECTANGLE option provides the narrowest pulse width, while the MIN SIDELOBE option provides the least ringing (fewest sidelobes). The 37XXXD defaults to the NOMINAL option, which is acceptable for most measurements. Windowing menus are shown in Figure 9-16.

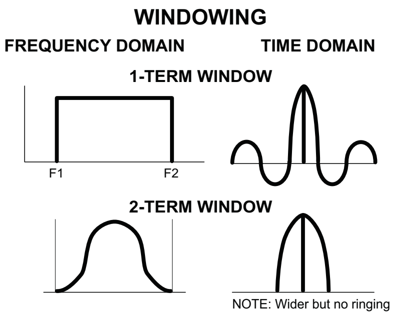


Figure 9-15. Windowing

LOWPASS TIME
DOMAIN SETUP
START
XXX.XXX ps
STOP
XXX.XXX ps
CENTER
XXX.XXX ps
SPAN
XXX.XXX ps
MARKER RANGE

RESPONSE
IMPULSE/STEP
MORE
PRESS <ENTER>
TO SELECT

LOWPASS TIME
DOMAIN SETUP
SET WINDOW
NOMINAL
SET GATE
SET D.C. TERM
XXX.XXX
PREVIOUS MENU
PRESS <ENTER>
TO SELECT

SHAPE
RECTANGULAR
NOMINAL
LOW SIDELOBE
MIN SIDELOBE
HELP
PRESS <ENTER>
TO SELECT

Figure 9-16. Window Shape Menus

9-5 GATING

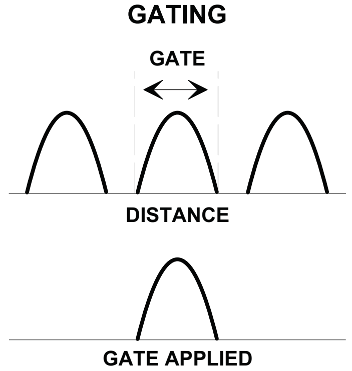


Figure 9-17. Gating

Gating is a time filter that allows for removing unwanted time-domain responses by gating the desired response. We can view the isolated response in both time domain—and in the frequency domain—using the FREQUENCY WITH TIME GATE selection (Figure 9-17).

There are four different gate shapes available: MINIMUM, NOMINAL, WIDE, and MAXIMUM (Figure 9-18). The 37XXXD defaults to the NOMINAL gate. To specify a different shape simply enter the Gate menu and select the desired gating shape. The MINIMUM has the sharpest rolloff and some frequency domain ripple, while MAXIMUM has the least rolloff and best residual ripple. Figures 9-18A through 9-18D, on the next page, show gating shapes.

The combinations of gate/window shapes will be restricted. For the MINIMUM gate shape, the LOW and MIN SIDELOBE window shape will not be allowed. For the NOMINAL gate shape, the MIN SIDELOBE window will not be allowed. If the user has set the window shape to MIN or LOW SIDELOBE and changes the-gate shape to MINIMUM, the window will be reset to NOMINAL. If the user has set the window to MIN SIDELOBE and changes the gate shape to NOMINAL, the window will be reset to LOW SIDELOBE. Gate shapes will be adjusted in a similar manner.

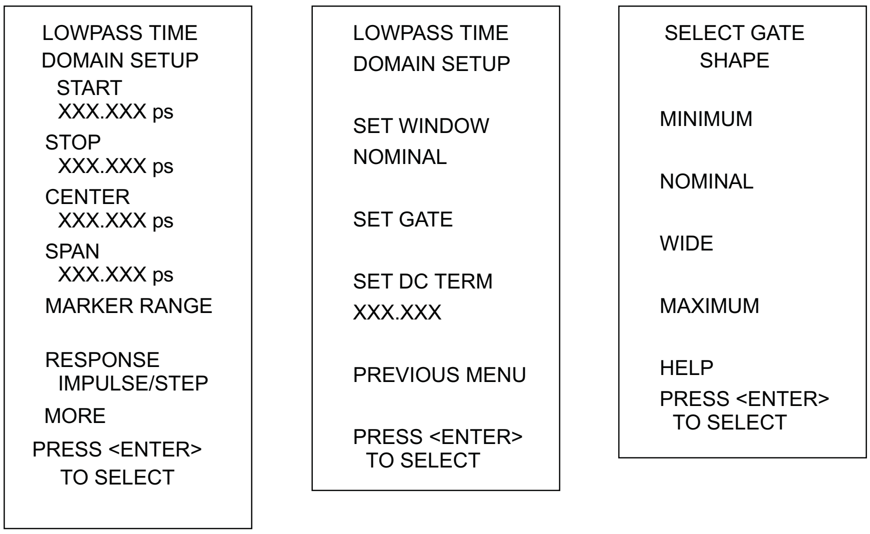


Figure 9-18. Gating Menus

An informational message will be displayed in the data area when the window or gate shape reset in this way. The message will last two sweeps and will say:

"GATE SHAPE ADJUSTED" or "WINDOW SHAPE ADJUSTED" depending on which was changed by the software.

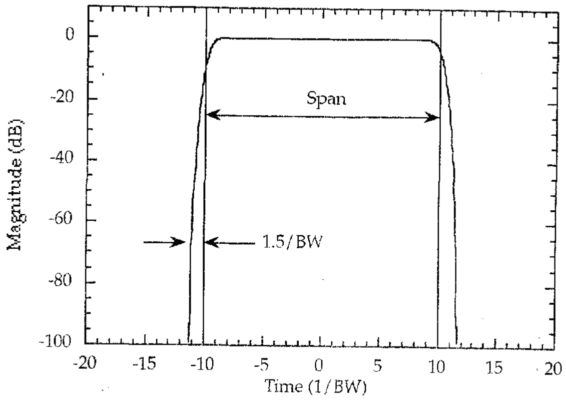


Figure 9-18A. Minimum Gate Shape

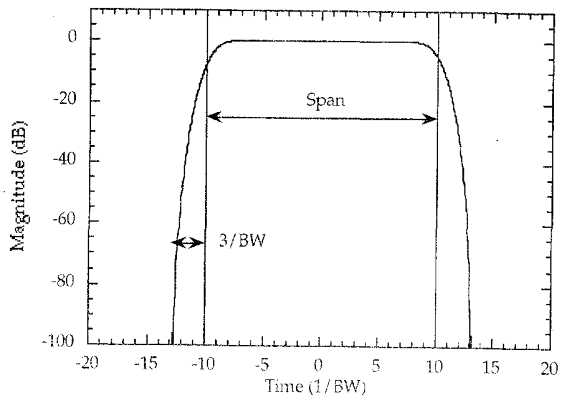


Figure 9-18B. Nominal Gate Shape

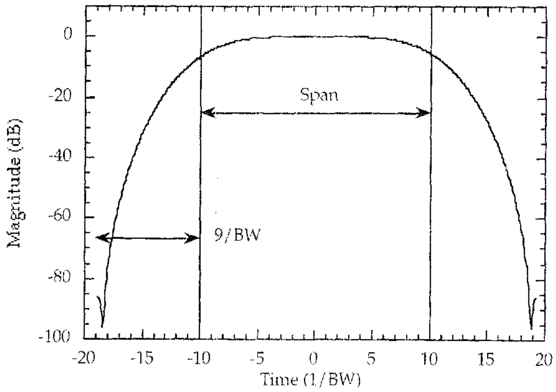


Figure 9-18C. Wide Gate Shape

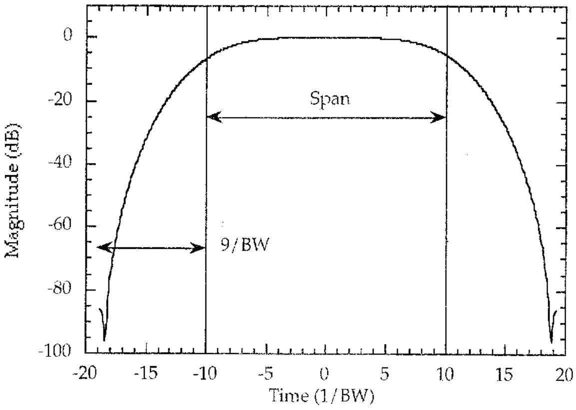


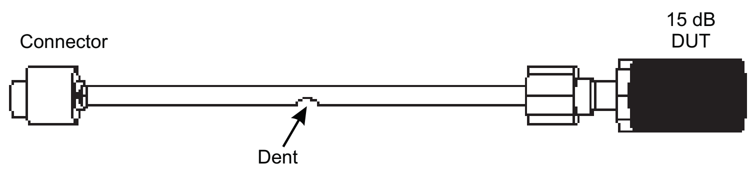
Figure 9-18D. Maximum Gate Shape

9-6 ANTI-GATING

Anti-gating is the opposite of gating. Whereby, gating provides for removing all but the desired response, anti-gating displays all but the desired response. To provide anti-gating, gate in the normal manner, except use a minus value for the SPAN width.

9-7 EXAMPLES, GATING AND ANTI-GATING

Examples of anti-gating are shown in Figures 9-19 through 9-24. The figures, all captured from an actual VNA display, show a sequence of measurements using gating and anti-gating to enhance measurement technique and accuracy. The examples use a dented length of semi-rigid cable having a connector on one end and a connector-DUT on the other end, as shown below. The DUT has a smoothly varying 15 dB return loss.



9-8 TIME DOMAIN MENUS

A flow diagram of the menus associated with the Time Domain Option is shown in foldout Figure 9-25. The menu choices are described in Appendix A. They appear in alphabetical order by their call letters: TD1, TD2, TD2dl, etc.

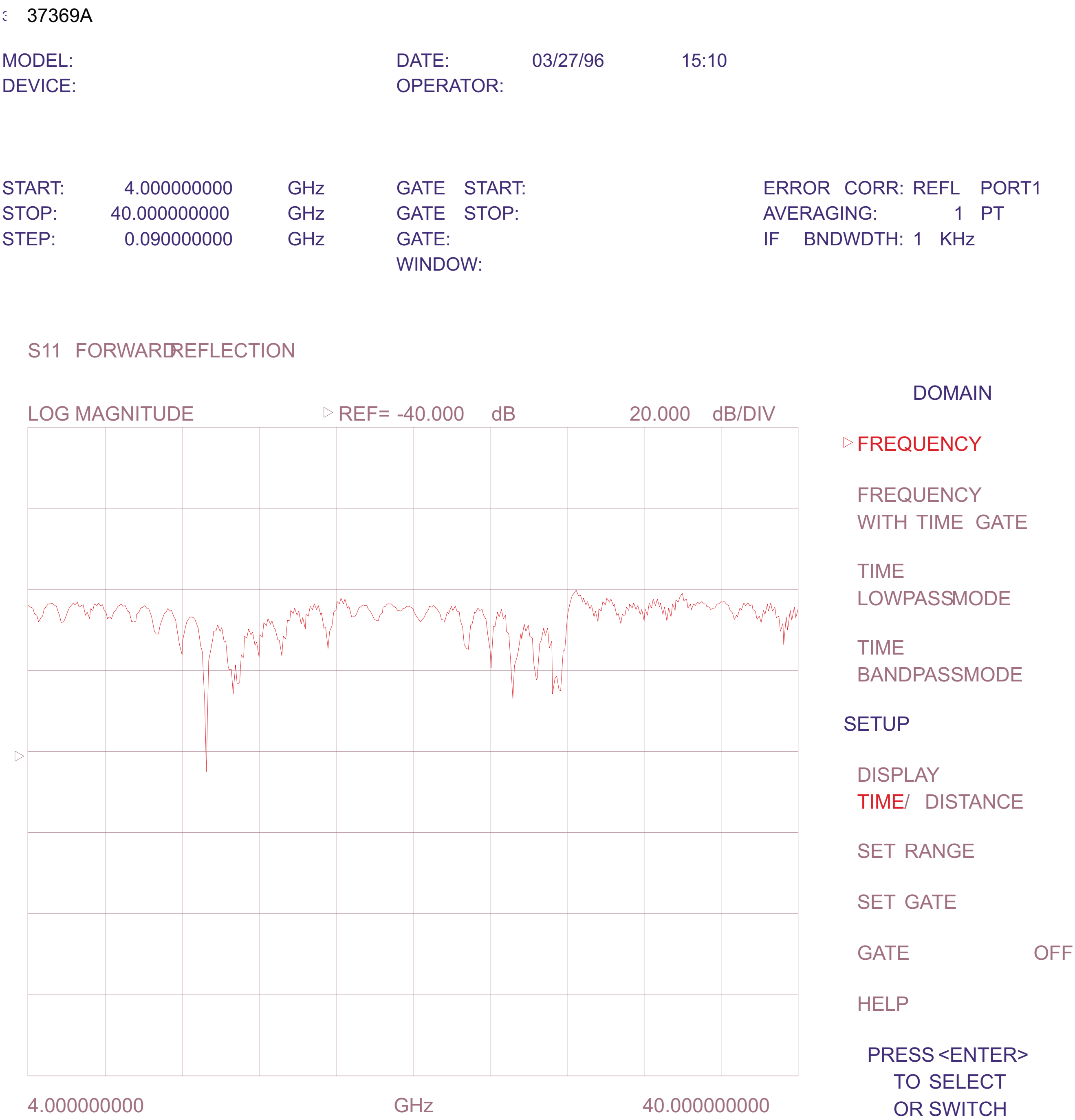


Figure 9-19. Frequency Domain Trace of Test Cable Gating Off

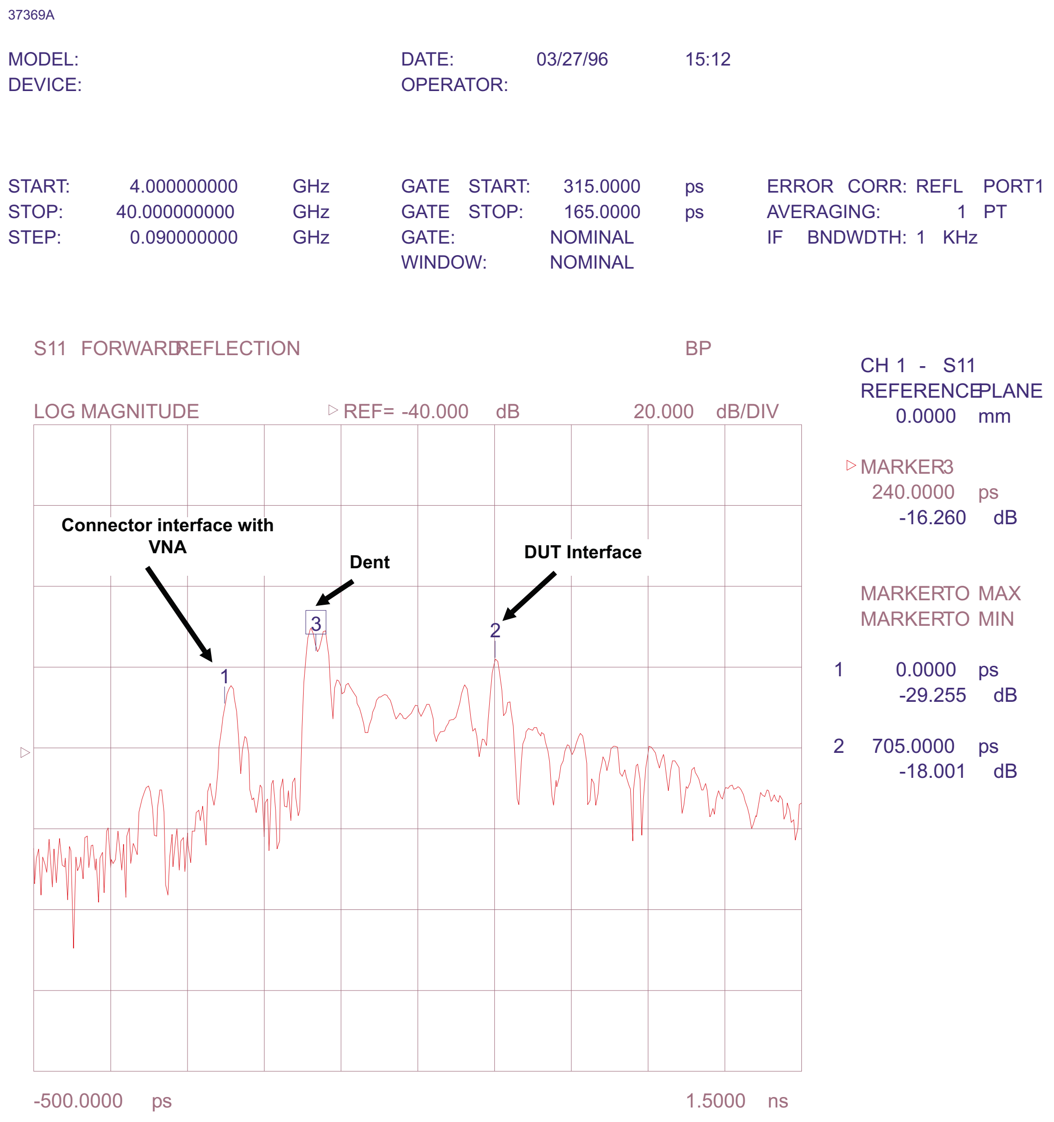


Figure 9-20. Time Domain Trace of Test Cable Gating Off

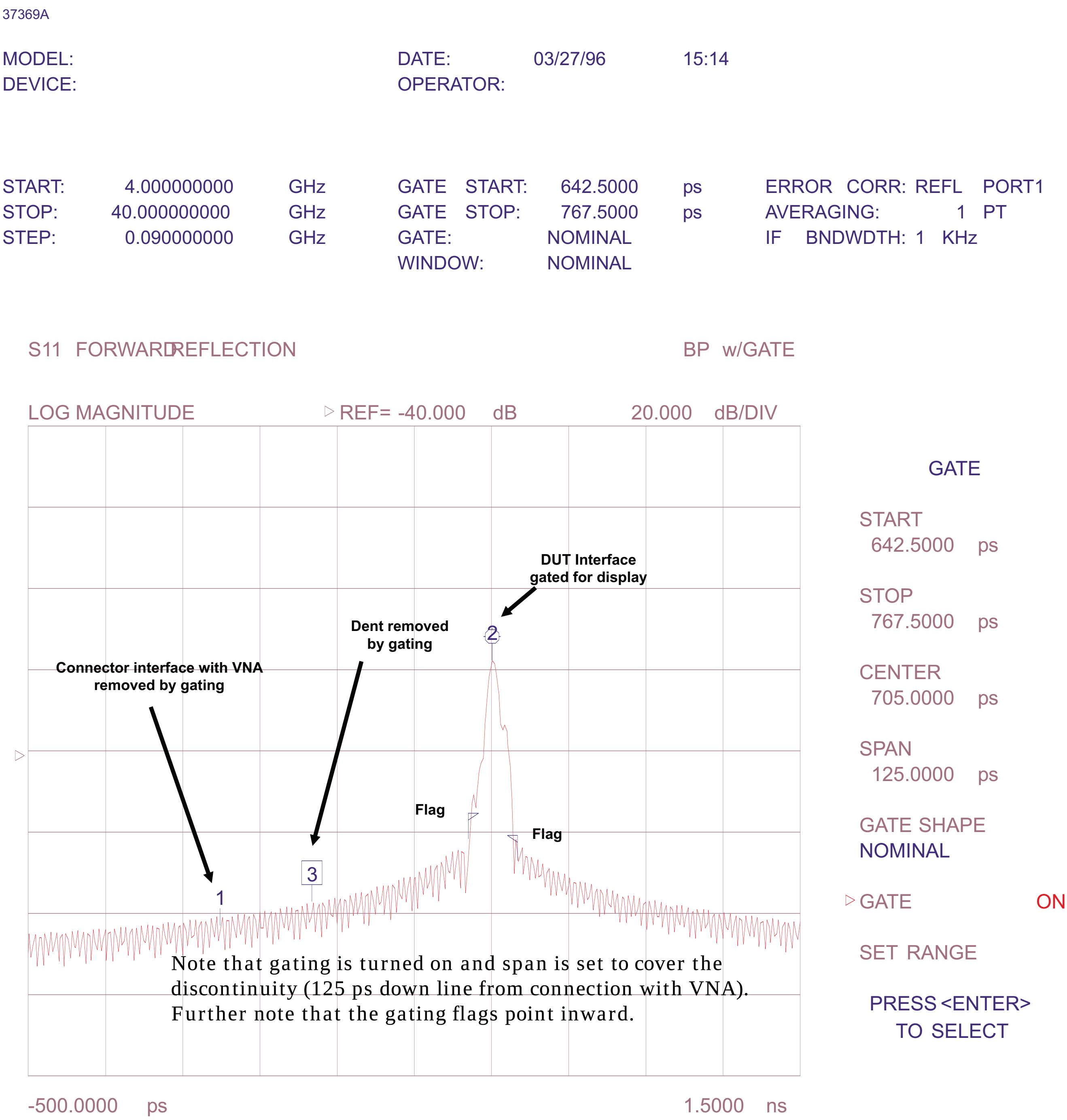


Figure 9-21. Time Domain Trace of Test Cable Gating On and Positioned Over DUT Interface Discontinuity.

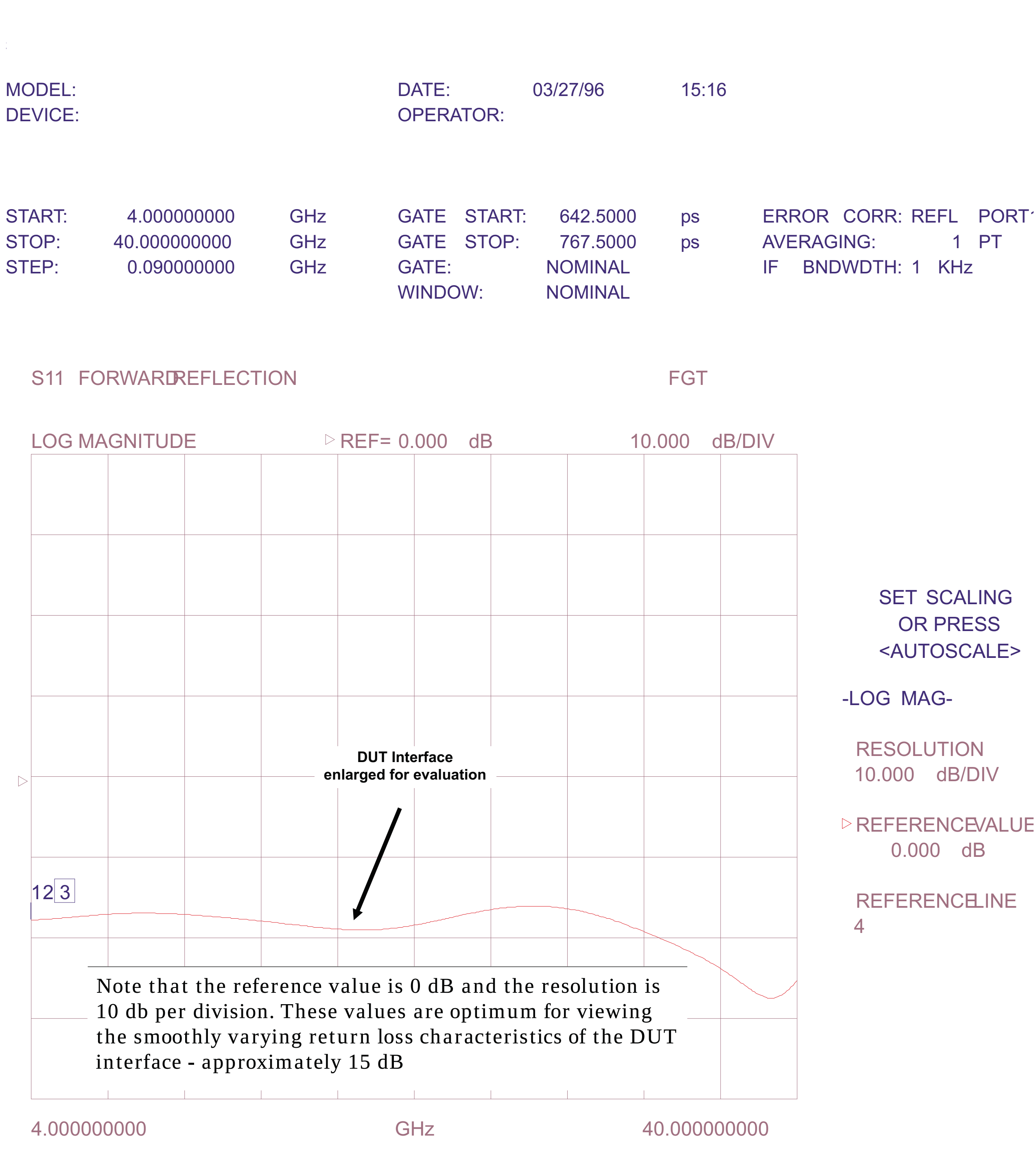


Figure 9-22. Frequency Domain Trace of DUT

Figure 9-23. Time Domain Trace of Test Cable Gating On and Positioned Over Dent (Cable Fault) Interface Discontinuity.

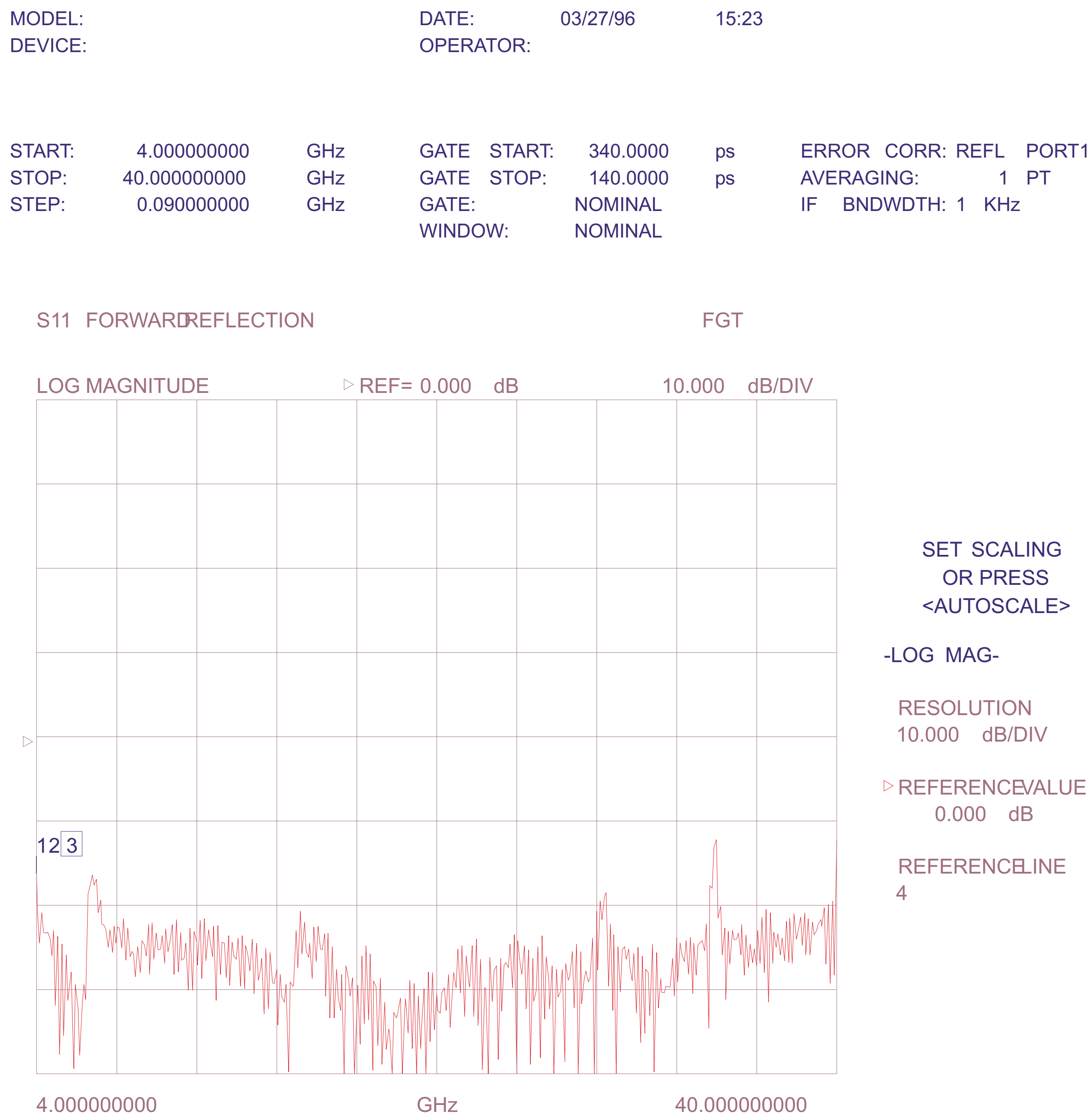


Figure 9-24. Frequency Domain Trace of Test Cable Gating On

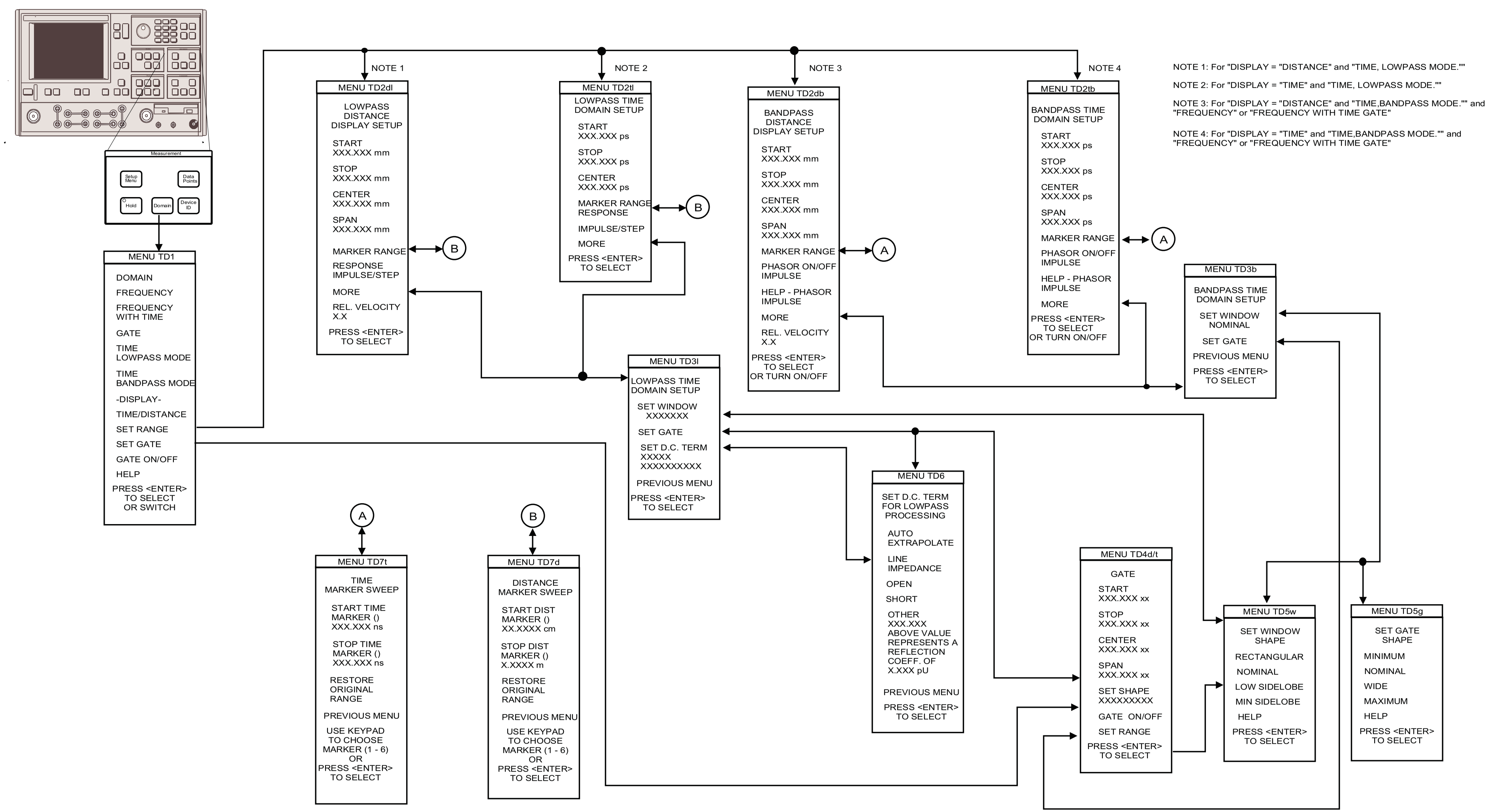


Figure 9-25. Time Domain Menu Flow

C 10
A C

T C

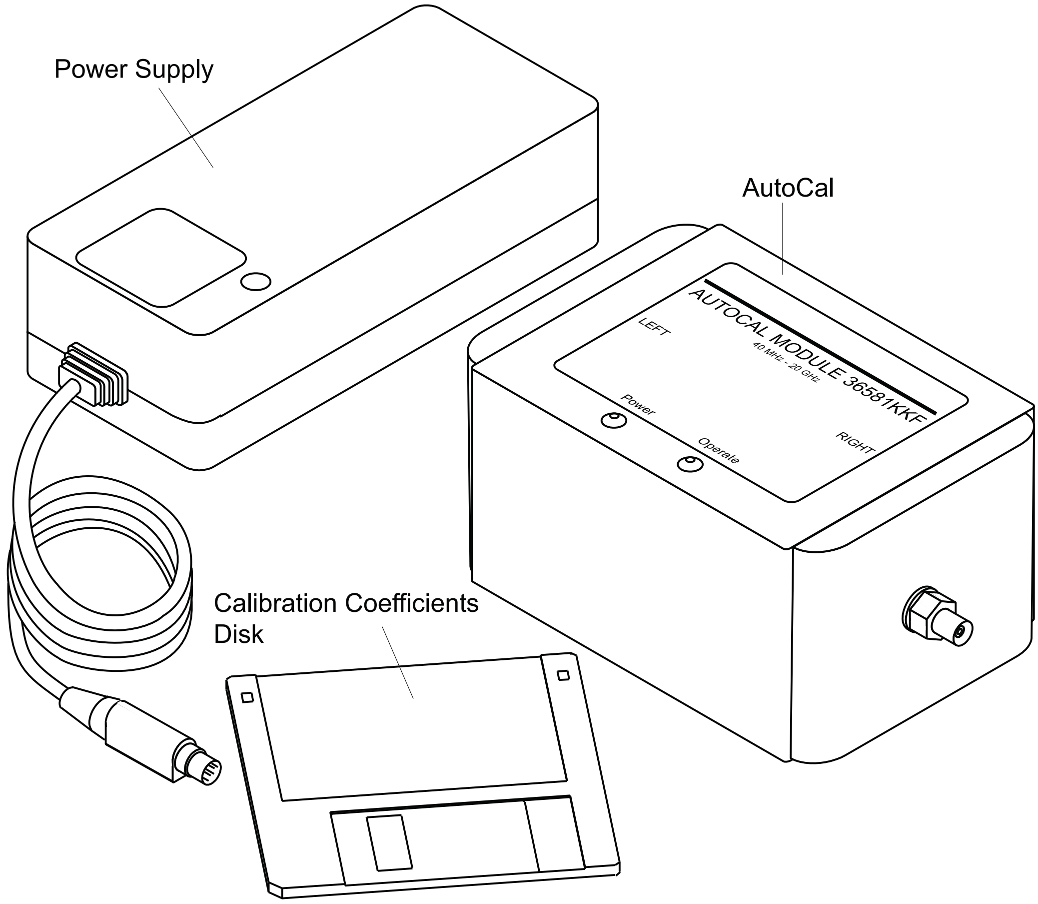


Figure 10-1. AutoCal Module, Power Supply, and Calibration Coefficients Disk

Chapter 10
AutoCal

10-1 INTRODUCTION

This chapter provides a general description of the AutoCal calibrators, including specifications, setup, and the use of the associated software and on-line documentation. This series has three models, as shown below. Throughout this manual, the term AutoCal will refer to the series. Individual models will be referred to by model number. Figure 10-1 shows the AutoCal module and all of its attaching parts.

Model	Switch	Freq. Range	Connector
36581NNF	Electronic	40MHz-18 GHz	N (Male)-N(Fem)
36581KKF	Electronic	40MHz-20 GHz	K(Male)-K(Fem)
36582KKF	Mechanical	40MHz-40 GHz	K(Male)-K(Fem)

10-2 DESCRIPTION

The AutoCal module provides an automatic system for fast, repeatable high-quality calibrations of a Vector Network Analyzer (VNA). The AutoCal module is connected between the VNA s test ports 1 and 2 to perform the calibration. Refer to Figure 10-2 for a diagram of the AutoCal connections.

The *electronic* AutoCal modules use solid state electronic switches to exchange the internal calibration standards. Note that these units have a lower frequency limit (18 and 20 GHz). The *mechanical* module uses electro-mechanical actuators to exchange the standards and has the highest frequency limit, but has a small non-repeatability error. The *mechanical* module contains internal standards used to measure port isolation; the *electronic* module does NOT contain isolation standards and requires a manual operation to perform this measurement.

A standard serial RS-232 interface cable is used to connect the AutoCal module to the 37XXXD. Power is supplied by a connecting cable from a universal power supply (+5V, +15V, –15V for the electronic modules; +5V, +24V for the mechanical modules). A power on-off switch is not provided.

Test Port Cable Converters (Anritsu series 36583) are used during and after the calibration process to establish the desired test port connector type and sex.

10-3 CALIBRATIONS

Four types of calibration can be performed using AutoCal:

One-Port: S11 1-Port and S22 1-Port are 1-port calibrations performed on the indicated port of the VNA and are equivalent to the traditional Open-Short-Load calibrations.

Full 2-Port: This type is equivalent to the traditional Open-Short-Load-Thru (OSLT) calibration.

Thru Update: This type is a new form of calibration which is used to update an existing 12-term calibration in the VNA. This calibration could have been performed using any method of calibration which yields 12 terms (LRL, LRM, AutoCal, or OSLT). Due to cable movement and aging, the calibration may have degraded over time. The Thru Update refreshes the calibration by measuring a Thru connection and updating the Transmission Tracking and Load Match calibration coefficients.

Adapter Removal: This calibration measures the characteristics of male-male or female-female test port cables for subsequent measurement of non-insertable devices. An adapter is required for this calibration. Adapter Removal requires two calibration procedures in order to calculate the parameters and electrical length of the adapter.

10-4 DEFINITIONS

The following terms are used in explaining the calibration procedure using the AutoCal module:

Thru: A *thru* is a connection of the two test ports. Two kinds of thru connections are defined for the AutoCal calibration: (1) a *Calibrator* thru is an internal path through the calibrator. (2) a *True* thru is a direct cable connection between the test ports, with no intervening connectors. The calibrator thru is not as accurate as a true thru, so the you have the option during a calibration to use the more accurate method, if necessary.

Switch Averaging: The mechanical AutoCal module uses electro-mechanical switches to select calibration standards. These switches have a small amount of non-repeatability (typically less than –55 dB). For most calibrations, this is more than adequate because it is below connector repeatability error. If desired, you can choose to reduce the effect of this non-repeatability in the mechanical module by using *Switch Averaging*, which causes additional calibration measurements. By setting a Switch Averaging factor larger than 1, switch repeatability error will be reduced. The tradeoff is that calibration time will be proportionally increased.

Isolation: For certain measurements which require accurate S21 or S12 readings for very small values of those parameters, an *isolation* step is required to characterize the leakage of the VNA and test setup. The isolation step can be performed automatically as part of a "Full 2-Port" calibration when using the *mechanical* module. The isolation step requires a manual operation for the *electronic* module. In order to achieve high accuracy for the characterization of the leakage, a high averaging factor is needed.

VNA Measurement Averaging Factor: This is the number of measurements taken at a given data point (frequency) and may be adjusted to meet the measurement requirements. The average of all the measurements will become the measured data. For example, if 256 averages is selected, each data point is measured 256 times and the average of these measurements is displayed, then the VNA moves to the next data point.

VNA Video IF Bandwidth: The bandwidth of the receiver may be changed to enhance the measurement accuracy or, conversely, to increase the measurement speed. Selecting the minimum IF bandwidth results in the greatest accuracy for low-signal-level measurements and the slowest measurement speed. Selecting the maximum IF bandwidth results in the greatest measurement speed and reduced accuracy on low-signal-level measurements.This can be set by using the Video IF BW key and selecting the desired IFBW.

Characterization File: Each calibrator module has a file containing data which characterizes each standard in the calibrator. This file also contains information (identification number, start and stop frequencies) concerning the capabilities of the calibrator. Each characterization file has the extension ".acd." When modules are changed, you must install the appropriate new characterization file. This file can be installed using the Util key (AutoCal Utilities) to recall the characterization file from a disk. In addition, each AutoCal module can be re-characterized using the VNA. A valid 12-term calibration must be active, which is used to characterize the standards within the module.

10-5 PHYSICAL SETUP

See Figure 10-2 for an illustration of the connections necessary to perform an automatic calibration using the AutoCal module. Note that the connection is very simple. Different power cable connectors are used with the mechanical modules and the electronic modules to prevent connecting the wrong power supply in error.

There is no on-off switch. When power is connected to the AutoCal module, the LED labeled POWER should come on immediately. The second LED, labeled OPERATE, should come on in about five minutes, after the internal temperature control oven has stabilized. The internal temperature is held within a 5 ^{o}C window.

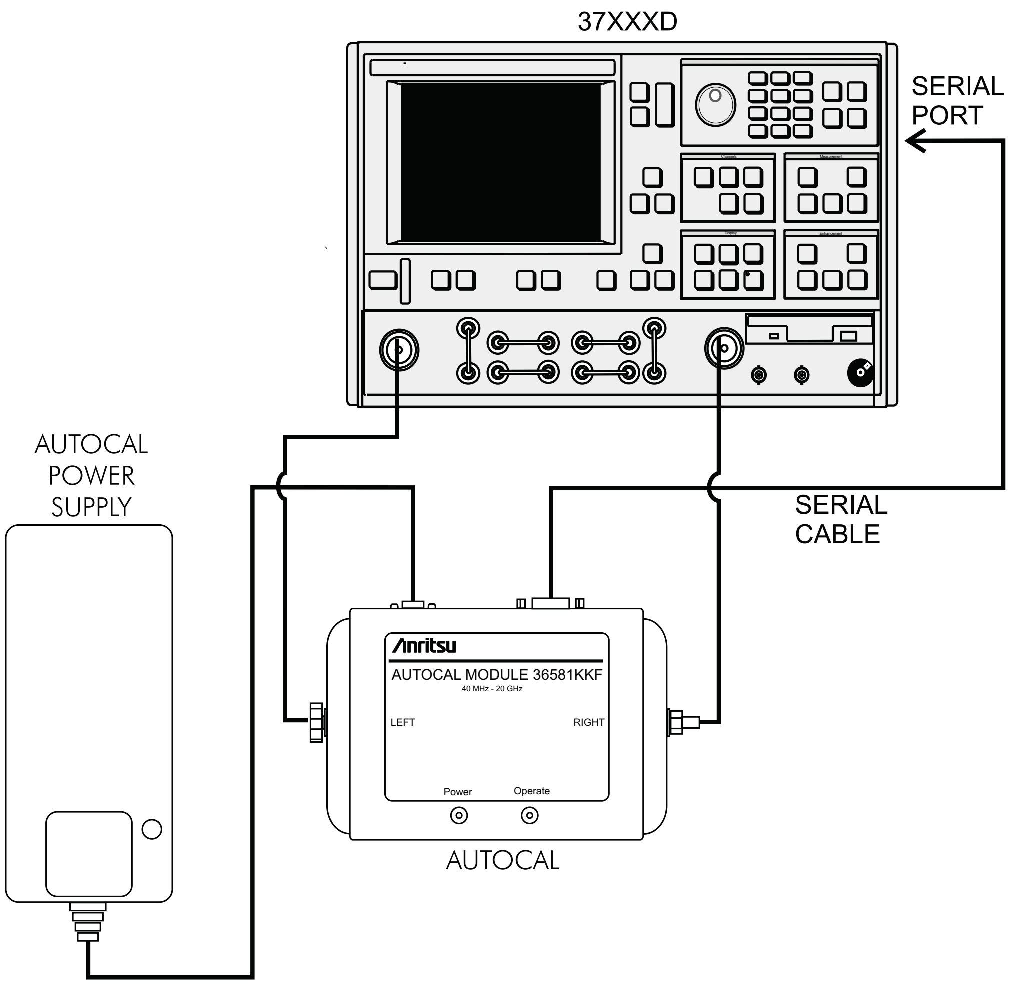
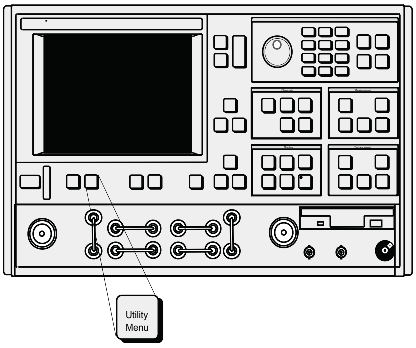


Figure 10-2. AutoCal Equipment Setup

10-6 CHARACTERIZATION FILES



MENU UTIL

SELECT UTILITY
FUNCTION OPTIONS

GPIB ADDRESSES

DISPLAY
INSTRUMENT
STATE PARAMS

GENERAL DISK UTILITIES

CAL COMPONENT
UTILITIES

AUTOCAL
UTILITIES

COLOR
CONFIGURATION

DATA ON (OFF)
DRAWING

BLANKING
FREQUENCY
INFORMATION

SET DATE/TIME

PRESS <ENTER>
TO SELECT
OR TURN ON/OFF

Before performing an AutoCal on a 37XXXD, the Characterization File for the AutoCal Module has to be loaded. This file may be recalled from the floppy disk accompanying the Module. It may also be recalled from one generated using the user s specialized manual calibration.

Insert the AutoCal Module Characterization Disk into the floppy drive. Press the Utility Menu key (left), then select the following menu options, in turn: AUTOCAL UTILITIES, RECALL FROM FLOPPY DISK. Select the file “Lxxxxxx.ACD“.

If a copy of the Characterization File is in the hard-disk, you can recall it by choosing RECALL FROM HARD DISK instead. Select the same file “Lxxxxxx.ACD”.

NOTE

The “xxxxxx” in the above paragraphs correspond to the serial number of the AutoCal module.

Should you desire to re-characterize the module, which is recommended every six months of usage, perform the following procedure:

Step 1. Using a 365x or 375x Calibration Kit, perform a 12-Term calibration over the desired frequency range of characterization, but within the range of the AutoCal module and the VNA.

NOTE

Any calibration method may be used (Standard, Offset Short, LRL/LRM, or TRM) along with either the Coaxial or Waveguide line types.

Step 2. Upon completion of the calibration, press the Utility Menu key.

Step 3. Select AUTOCAL UTILITIES then AUTOCAL CHARACTERIZATION, from the next menu to appear.

AUTOCAL
UTILITIES

AUTOCAL
CHARACTERIZATION

SAVE
TO HARD DISK

SAVE
TO FLOPPY DISK

RECALL
FROM HARD DISK

RECALL
FROM FLOPPY DISK

PRESS <ENTER>
TO SELECT

AUTOCAL
CHARACTERIZATION

SWITCH AVERAGING
XXXX

PORT CONFIG
L=1, R=2
R=1, L=2

NUMBER OF
AVERAGES

REFLECTION
XXXX

LOAD
XXXX

THRU
XXXX

ISOLATION
XXXX

START AUTOCAL
CHARACTERIZATION

PRESS <ENTER>
TO SELECT
OR SWITCH

Step 4. Select an appropriate amount of SWITCH AVERAGING (recommend 4 for the electronic modules, and 16 for the electro-mechanical modules).

Step 5. Ensure the Module Configuration is correct (L=1, R=2 or R=1, L=2).

Step 6. If desired, you may change the amount of averaging during characterization of each standard, by entering the NUMBER OF AVERAGES.

Step 7. Ensure the Autocal Module is connected between the Test Ports, power is applied, and the serial cable is connected to the VNA. Verify that both the “Power” and “Operate” LED’s are ON.

Step 8. Select START AUTOCAL CHARACTERIZATION. The VNA will proceed through a characterization of the attached Autocal Module.

Step 9. When the calibration is complete, press the Save/Recall key.

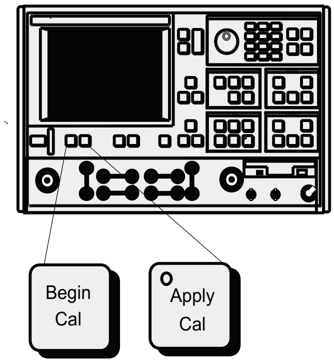
Step 10. Select SAVE then FRONT PANEL SETUP AND CAL DATA TO HARD DISK (middle and bottom left).

Step 11. Select a file or CREATE NEW FILE and press Enter.

If you are creating a new file, enter the filename and select DONE when finished.

10-7 USING AUTOCAL

An example procedure for using the AutoCal module is given below. This example assumes a frequency range of 40 MHz to 40 GHz, a power level of –7 dBm, and use of a Series 36582 AutoCal module.



MENU C11

BEGIN CALIBRATION

KEEP EXISTING
CAL DATA

REPEAT
PREVIOUS CAL

AUTOCAL

CAL METHOD
XXXXXXXXX

TRANSMISSION
LINE TYPE:
XXXXXXXXX

CHANGE CAL
METHOD AND
LINE TYPE

NEXT CAL STEP

PRESS <ENTER>
TO SELECT

Step 1. Press the Begin Cal key (top left).

Step 2. Select AUTOCAL from the displayed menu (C11, left).

MENU ACAL

AUTOCAL

AUTOCAL TYPE:
XXXXXXXX

CHANGE
AUTOCAL SETUP

START AUTOCAL

THRU UPDATE

CONNECT THROUGH
LINE BETWEEN
PORTS 1 AND 2

NUMBER OF AVGS
XXX

START THRU UPDATE

USE PREVIOUS
AUTOCAL SETUP

PRESS <ENTER>
TO SELECT
OR SWITCH

Step 3. The selections in the next menu to appear, MENU ACAL, will depend on current instrument conditions, as follows:

a. THRU UPDATE lets you update the Thru calibration of an active 12-term Calibration. This updates the transmission frequency response and load match coefficients.

b. START AUTOCAL lets you start a calibration using the current setup.

c. CHANGE AUTOCAL SETUP lets you set up a new calibration, which is what we will do for this example. This example also assumes that you have selected the transmission medium and, if waveguide, identified the cutoff frequency.

MENU ACAL_SETUP

AUTOCAL SETUP

LINE TYPE
COAXIAL/WAVEGUIDE

WAVEGUIDE CUTOFF
XX.XXXXXX GHz

SWITCH AVERAGING
8

NUMBER OF AVGS

REFLECTION
XXXX

LOAD
XXXX

THRU
XXXX

ISOLATION
XXXX

AUTOCAL TYPE

SII 1 PORT
S22 1 PORT
FULL 2 PORT
ADAPTER REMOVAL

Step 4. Select CHANGE AUTOCAL SETUP. This causes MENU ACAL_SETUP (left) to appear.

Step 5. Enter a SWITCH AVERAGING value of 8.

To improve the effect of switch repeatability error with the 36582 series (mechanical switch), you can change the switch averaging. Note, however, that switch averaging will have no affect on the 36581 series (electronic switch).

Step 6. Select FULL 2 PORT. This displays a menu (MENU ACAL_FULL) that lets you set up the calibration (bottom left).

You could have also selected S11 1-PORT, S22 1-PORT, or ADAPTER REMOVAL. The last of these lets you remove the effects of an adapter used in the calibration.

Step 7. Select the PORT CONFIG setting that matches the physical setup (R-1, L=2 or L=1, R=2).

It is critical to ensure the correct module orientation is established. Each side (left) and right) of the module is labeled.

MENU ACAL_FULL

AUTOCAL
FULL 2-PORT

ISOLATION
AVERAGING

OMIT

DEFAULT

AVERAGING
FACTOR
XXXX

THRU TYPE
CALIBRATOR/TRUE

PORT CONFIG
L=1, R=2
R=1, L=2

START AUTOCAL

PRESS <ENTER>
TO SELECT
OR SWITCH

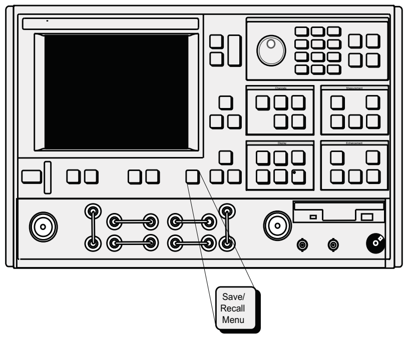
Step 8. Select the THRU TYPE to be either CALIBRATOR or TRUE.

By default, the CALIBRATOR (internal) thru standard is used for the Thru Calibration. The transmission response of the calibration may be improved by selecting the TRUE thru standard. This will result in an added manual step.

Step 9. Observe that OMIT is shown for the ISOLATION AVERAGING.

Isolation may be omitted (default). You may also select DEFAULT to use the default value during the isolation step. You may also use your own AVERAGING FACTOR. Including isolation involves a manual step for the 36581 models.

Step 10. Ensure the AutoCal module is properly connected between Ports 1 and 2, then select START AUTOCAL.



Follow the on-screen instructions and do not disturb the setup during the calibration. Please note that you should not start a calibration until both LED s on the AutoCal module are lit. This will ensure accurate calibration of the VNA.

Step 11. When the calibration is complete, press the Save/Recall key.

Step 12. Select SAVE then FRONT PANEL SETUP AND CAL DATA TO HARD DISK (middle and bottom left).

Step 13. Select a file or CREATE NEW FILE and press Enter.

If you are creating a new file, enter the filename and select DONE when finished.

MENU SR1
SAVE/RECALL FRONT PANEL AND CAL DATA
SAVE
RECALL
PRESS <ENTER> TO SELECT FUNCTION

MENU SR2
SAVE
FRONT PANEL SETUP IN INTERNAL MEMORY
FRONT PANEL SETUP AND CAL DATA TO HARD DISK
FRONT PANEL SETUP AND CAL DATA TO FLOPPY DISK
PRESS <ENTER> TO SELECT

10-8 PIN DEPTH SPECIFICATIONS

The depth of the center pin on connectors is a critical specification, which if not met, can cause damage to mating connectors. Table 10-1 provides pin depth examples and Table 10-2 provides pin-depth specifications for associated AutoCal connectors.

Table 10-1. Checking Connector Pin Depth (Example)

<u>*Example 1:*</u>		
FEMALE MASTER GAUGE BLOCK (protrusion)		
	Desired nominal value:	0.2070
Case1	Actual value of master gauge	0.2071 (protrusions 0.0001 more than desired)
	Gauge should be set to indicate:	+0.0001
Case2	Actual value of master gauge	0.2069 (protrusions 0.0001 less than desired)
	Gauge should be set to indicate:	-0.0001
<u>*Example 2:*</u>		
MALE MASTER GAUGE BLOCK (cavity)		
	Desired nominal value:	0.2070
Case1	Actual value of master gauge	0.2071 (cavity 0.0001 deeper than desired)
	Gauge should be set to indicate:	-0.0001
Case2	Actual value of master gauge	0.2069 (cavity 0.0001 shallower than desired)
	Gauge should be set to indicate:	+0.0001

Table 10-2. AutoCal Module Connector Pin Depth Specifications

Device	Connector	Pin Depth (inches)
3658XXX	K-Female	+0.0000 to -0.005
3658XXX	K-Male	+0.0000 to -0.005
3658XXX	N-Female	*[0.207](+0.000, -0.005)
3658XXX	K-Female	*[0.207](+0.000, -0.005)
32K50 32KF50	K-Male (cable side)	**Negative Indication
	K-Female	+0.0000 to -0.0005
	K-Male (DUT side)	+0.0000 to -0.0005
32L50 32LF50	K-Male (cable side)	**Negative Indication
	3.5mm-Female (DUT side)	+0.006 to -0.008
	3.5mm-Male (DUT side)	+0.006 to -0.008
32S50 32SF50	K-Male (cable side)	**Negative Indication
	SMA-Female (DUT side)	+0.0005 to -0.0015
	SMA-Male (DUT side)	+0.0005 to -0.0015

Gauging Type N Connectors:* The actual value of a Type N master gauge block will always vary to some degree from the desired nominal value. The recorded measured value of the master gauge must be observed when calibrating the Pin Depth Gauge to the desired nominal value. Although the **AutoCal Module Pin Depths are not critical, this information may be helpful in the measurement of Type N mating components. Examples are shown in Table 10-1, on the preceding page.

10-9 AUTOCAL MENUS FLOW DIAGRAM

A flow diagram for the AutoCal menus is provided in Figure 10-3.

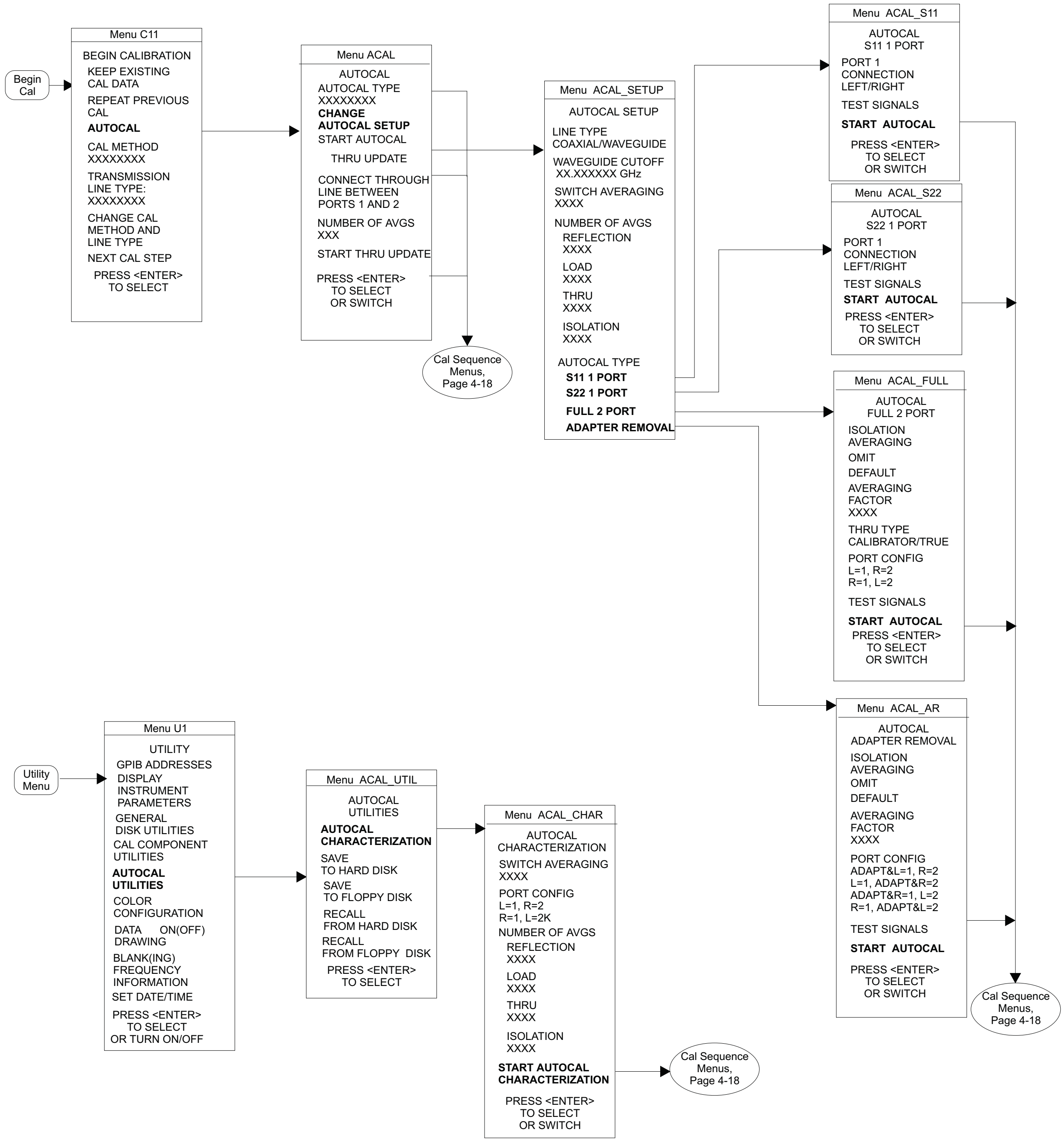


Figure 10-3. AutoCal Menus Flow Diagram

C 11
O C
P

T C

Repair

WARNING ⚠

WARNING

This equipment can not be repaired by the operator. DO NOT attempt to remove the equipment covers or to disassemble internal components. Only qualified service technicians with a knowledge of electrical fire and shock hazards should service this equipment. There are high-voltage parts in this equipment presenting a risk of severe injury or fatal electric shock to untrained personnel. In addition, there is a risk of damage to precision components.

C 11
O C
P

11-1 INTRODUCTION

This chapter provides quick operational checkout procedures that may be used by incoming inspectors to ensure that the Model 37XXXD Vector Network Analyzer is operational. This is a quick-check procedure. For the full performance verification procedure, refer to the Series 37XXXD Maintenance Manual, Anritsu Part Number 10410-00264.

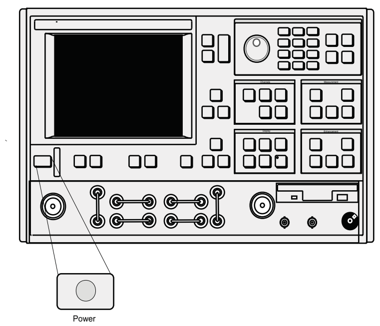
11-2 REQUIRED EQUIPMENT

The following equipment is required for the procedures in this chapter:

- ❑ Flexible microwave cable (through line)
- ❑ Short

11-3 INITIAL SETUP

Before starting the performance tests, press the Power key (left) to On.



NOTE

Allow the system to warm up for at least 60 minutes to ensure operation to performance specifications.

11-4 SELF TEST

Perform an instrument self test to ensure that the VNA is operating properly. To start a self test, Press the Option Menu key and make the menu choices shown in Figure 11-1.

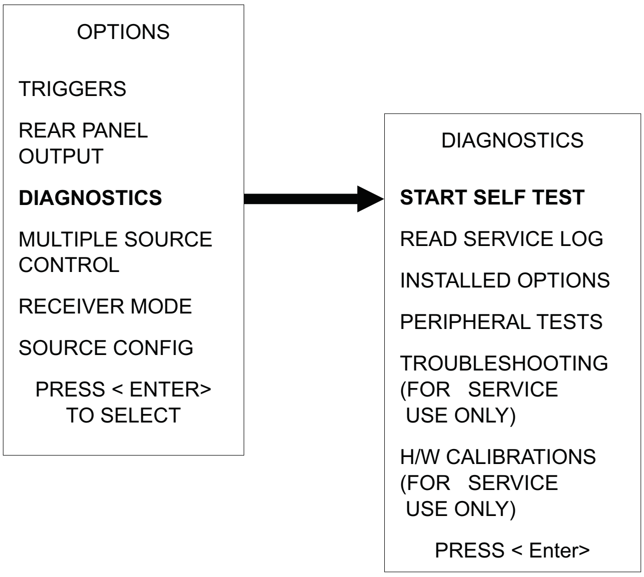
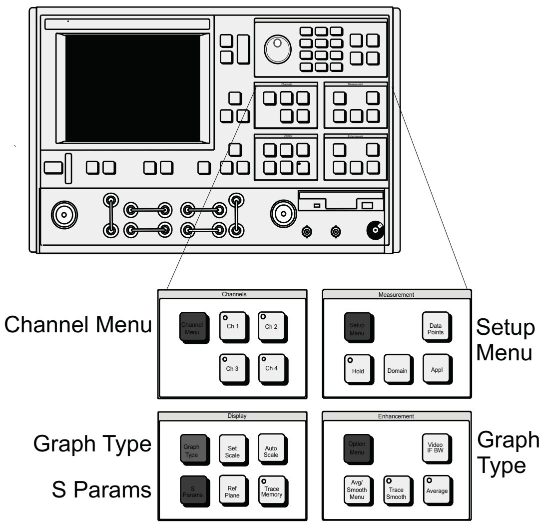


Figure 11-1. Performing a Self Test

11-5 NON-RATIO POWER

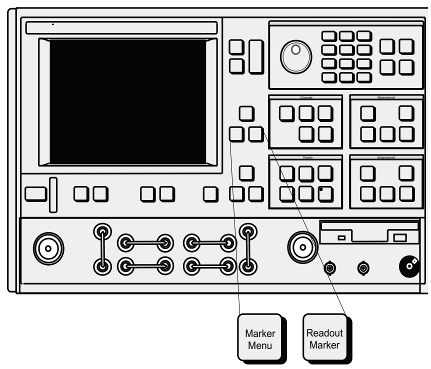
This test verifies that each individual receiver channel operates properly. Measurement calibration of the system is *not* required for this test.

This test requires that you press specified front panel keys and make choices from the displayed menu(s). The keys used in this test are shown below.



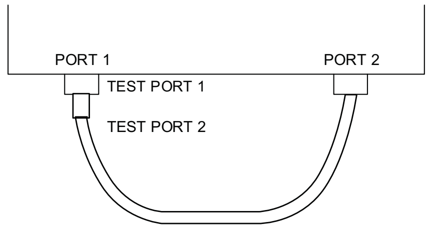
Test Procedure

Key	Menu Choice
Options Menu	Non-Ratioed Parameters, see Figure 11-2
Setup Menu	START: 1 GHz STOP: High-End Frequency
Channel Menu	FOUR CHANNELS
Graph Type	LOG MAGNITUDE (All channels)
S-PARAMS	USER 1: (Channel 3) Parameter: Ra/1 Phase Lock: Ra USER 2: (Channel 1) Parameter: Ta/1 Phase Lock: Ra USER 3: (Channel 2) Parameter: Tb/1 Phase Lock: Ra USER 4: (Channel 4) Parameter: Rb/1 Phase Lock: Rb
SET SCALE	RESOLUTION: 20 dB/DIV REF VALUE: 0 dB (All four channels)



Perform test as described below.

Step 1. Connect Test Ports 1 and 2 together using a high-quality through line (below).



Step 2. Reset the VNA using the Default Program key.

Step 3. Set up the VNA as shown in table at left.

Step 4. Observe the sweep indicators and allow at least one complete sweep to occur on all four channels.

Step 5. Verify that the minimum amplitude meets the specifications shown below.

Model	Test Channel	Reference Channel
37217C	>–28 dB	>–35 dB
37317C	>–28 dB	>–35 dB
37225C	>–25 dB	>–34 dB
37325C	>–30 dB	>–32 dB
37247C	>–26 dB	>–35 dB
37347C	>–31 dB	>–33 dB
37269C	>–40 dB	>–40 dB
37369C	>–34 dB	>–34 dB
37277C	>–45 dB	>–45 dB
37377C	>–45 dB	>–45 dB
37297C	>–60 dB	>–55 dB
37397C	>–60 dB	>–55 dB

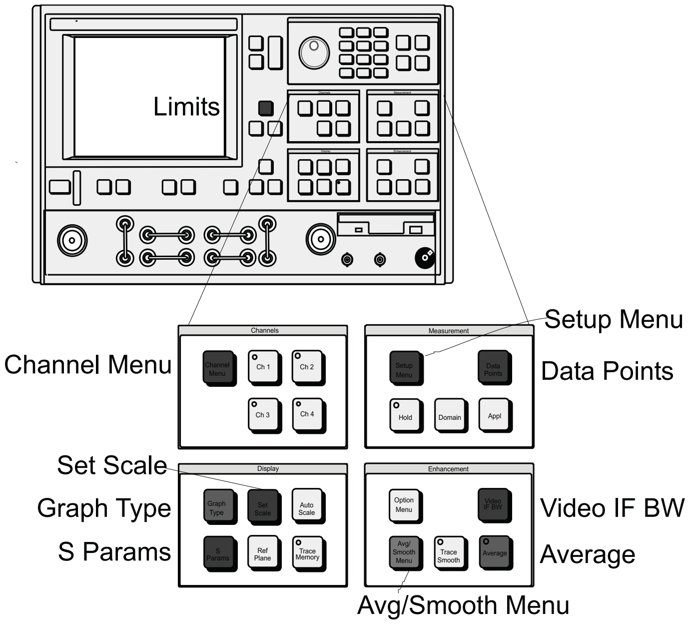
NOTE

Use the Marker Menu and Readout Marker keys (left) and menus to obtain precise frequency and amplitude values.

11-6 HIGH LEVEL NOISE TEST

The following test verifies that the high-level signal noise in the VNA will not significantly affect the accuracy of subsequent measurements. Calibration of the system is *not* required for this test.

This test requires that you press specified front panel keys and make choices from the displayed menu(s). The keys used in this test are highlighted below.



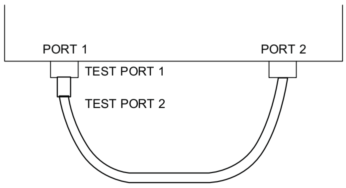
Key	Menu Choice
Setup Menu	START: 40 MHz STOP: High-end frequency
Channel Menu	DUAL CHANNELS 1-3
Graph Type	LOG MAGNITUDE (Both channels)
Set Scale	RESOLUTION: 0.020 dB/DIV REF VALUE: 0.0 dB (Both channels)
S-Params	Channel 1 – S_{12} Channel 3 – S_{21}
Data Points	201
Video IF BW	NORMAL (1 kHz)
Limits	UPPER LIMIT ON 0.015 if less than 40 GHz 0.04 if 40 GHz 0.14 if above 40 GHz LOWER LIMIT ON -0.015 if less than 40 GHz -0.04 if 40 GHz -0.14 if above 40 GHz DISPLAY LIMITS ON

Setup the VNA as described in the table at the left.

Perform the test as described below:

Step 1. Reset the VNA using the Default Program key.

Step 2. Connect Test Port 1 and Test Port 2 (top left) together.



Step 3. Press the Ch 1 key.

Step 4. Press the Trace Memory key.

Step 5. Choose VIEW DATA from the menu and press the Enter key.

Step 6. While observing the sweep indicators, allow at least two complete sweeps to occur.

Step 7. Choose STORE DATA TO MEMORY from the menu and press the Enter key.

Step 8. Choose VIEW DATA / MEMORY from the menu and press the Enter key.

Step 9. While observing the sweep indicators, allow at least two complete sweeps to occur.

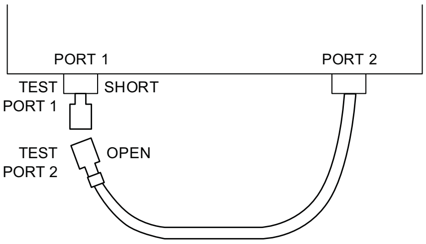
Step 10. Verify that the peak-to-peak High Level Noise falls within the area between the two limit lines (Figure 11-2, following page).

Step 11. Press the Ch 3 key.

Step 12. Repeat Steps 4 through 9 for channel 3.

Step 13. Press the S Params key; set Ch 1 for S_{11} and Ch 3 for S_{22}.

Step 14. Connect a Short to Test Port 1 and an Open to Test Port 2 (left).



Step 15. Repeat Steps 2 through 9.

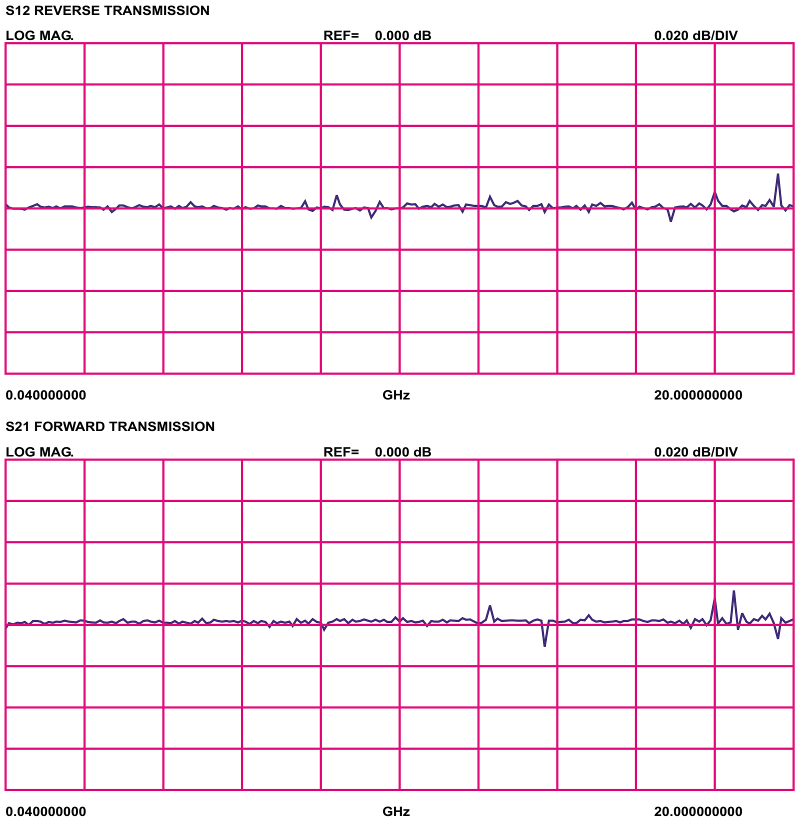


Figure 11-2. High Level Noise Test Waveform

C 12
C K

T C

C 12
C K

12-1 INTRODUCTION

This chapter provides illustrations and contents for the Models 3650, 3651, 3652, 3653, 3654/3654B, 36550 and 36552 Calibration Kits.

12-2 PURPOSE

The calibration kits contain all of the precision components and tools required to calibrate the 37XXXD Vector Network Analyzer System for a 12-term error-corrected measurement.

12-3 KIT CONTENTS

The contents and illustrations of the calibration kits are listed on the following pages.

Model 3650 Calibration Kit

Table 12-1. Model 3650 (SMA/3.5 mm) Calibration Kit Contents

Index	Anritsu Part Number	Description	Qty.
1	01-212	Female Flush Short (Option 1)	1
2	01-211	Male Flush Short (Option 1)	1
3	17SF50	Female Sliding Termination	1
4	17S50	Male Sliding Termination (Option 1)	1
5	34ASF50-2	Female Adapter	2
6		Calibration Software Diskette	1
7	33FSF50	Female-Female Adapter	2
8	33SS50	Male-Male Adapter*	1
9	28S50-2	Male Termination	2
10	28SF50-2	Broadband Female Termination	2
11	33SSF50	Male-Female Adapter*	2
12	24S50	Male Open	1
13	23SF50	Female Open	1
14	23S50	Male Short	1
15	23SF50	Female Short	1
16	34AS50-2	Male Adapter	2
17		Connector Thumb Wheel	4
18	01-201	Torque Wrench	1
19	01-210	Reference Flat	1
20	01-222	Pin Depth Gauge	1
21	01-223	Pin Depth Gauge	1

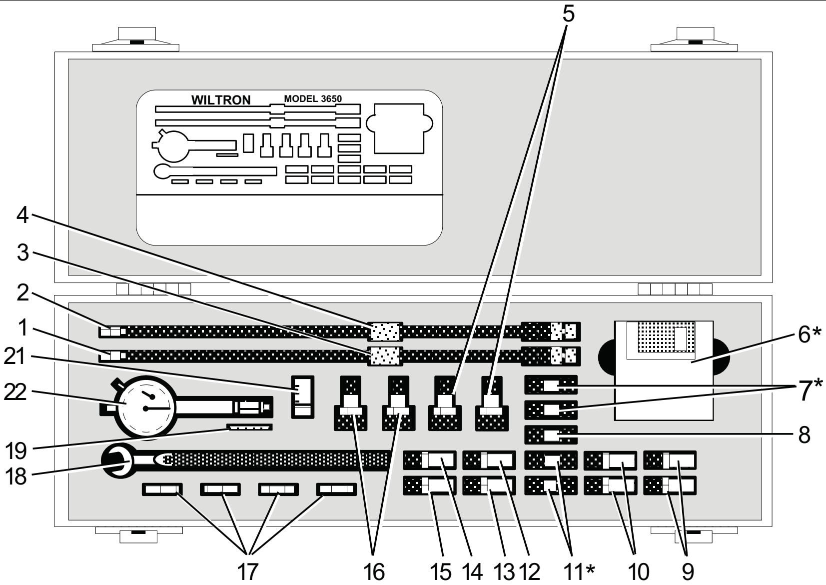


Figure 12-1. Model 3650 (SMA/3.5 mm) Calibration Kit Components

* Phase Equal Adapters

Model 3651 Calibration Kit

Table 12-2. Model 3651 (GPC-7) Calibration Kit Contents

Index	Anritsu Part Number	Description	Qty.
1	01-221	Collet and Extractor Tool	1
2	28A50-2	Broadband Termination	2
3	24A50	Open	1
4	23A50	Short	1
5		Calibration Software Diskettet	1
6	17A50	Sliding Termination (Option 1)	1
7	01-200	Torque Wrench	1
8	01-210	Reference Flat	1
9	01-220	Pin Depth Gauge	1

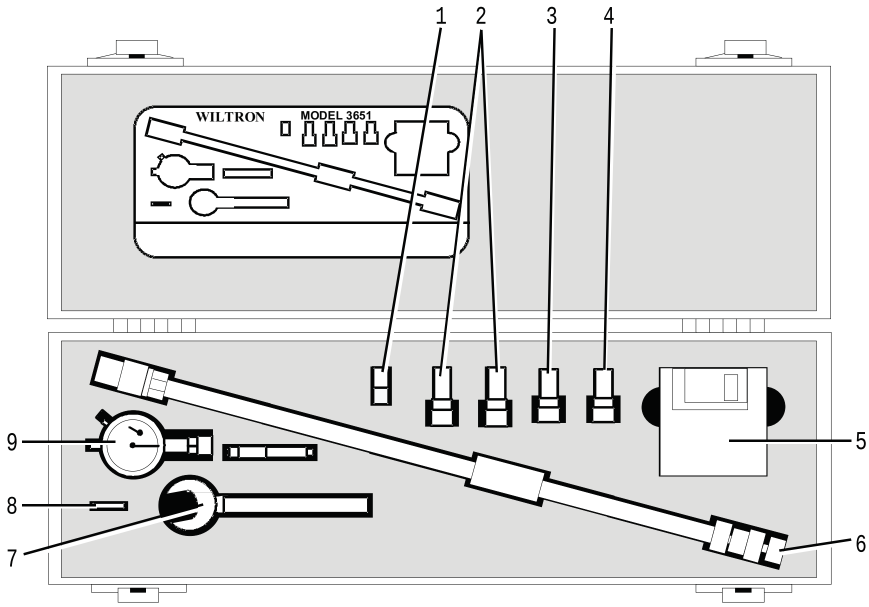


Figure 12-2. Model 3651 (GPC-7) Calibration Kit Components

Model 3652 Calibration Kit

Table 12-3. Model 3652 (K-Connector) Calibration Kit Contents

Index	Anritsu Part Number	Description	Qty.
1	01-212	Female Flush Short (Option 1)	1
2	01-211	Male Flush Short (Option 1)	1
3	17KF50	Female Sliding Termination	1
4	17K50	Male Sliding Termination (Option 1)	1
5	34AKF50-2	Female Adapter	2
6		Calibration Software Diskette	1
7	33FKF50	Female-Female Adapter	2
8	33KK50	Male-Male Adapter*	1
9	28K50-2	Male Termination	2
10	28KF50-2	Broadband Female Termination	2
11	33KKF50	Male-Female Adapter*	2
12	24K50	Male Open	1
13	23KF50	Female Open	1
14	23K50	Male Short	1
15	23KF50	Female Short	1
16	34AK50-2	Male Adapter	2
17		Connector Thumb Wheel	4
18	01-201	Torque Wrench	1
19	01-210	Reference Flat	1
20	01-222	Pin Depth Gauge	1
21	01-223	Pin Depth Gauge	1

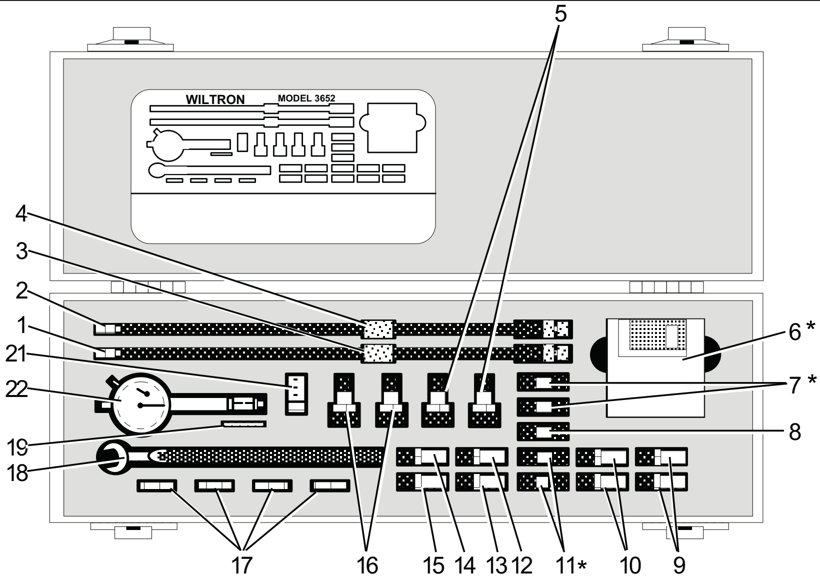


Figure 12-3. Model 3652 (K-Connector) Calibration Kit Components

* Phase Equal Adapters

Model 3653 Calibration Kit

Table 12-4. Model 3653 (Type N) Calibration Kit Contents

Index	Anritsu Part Number	Description	Qty.
1	28N50-2	Broadband Male Termination	2
2	34AN50-2	Male Adapter	2
3		Calibration Software Diskette	1
4	34ANF50-2	Female Adapter	2
5	28NF50-2B	Braodband Female Termination	2
6	24NF50	Female Open	1
7	24N50	Male Open	1
8	23NF50	Female Short	1
9	23N50	Male Short	1
10	01-213	Reference Gauge	1
11	01-224	Pin Depth Gauge	1

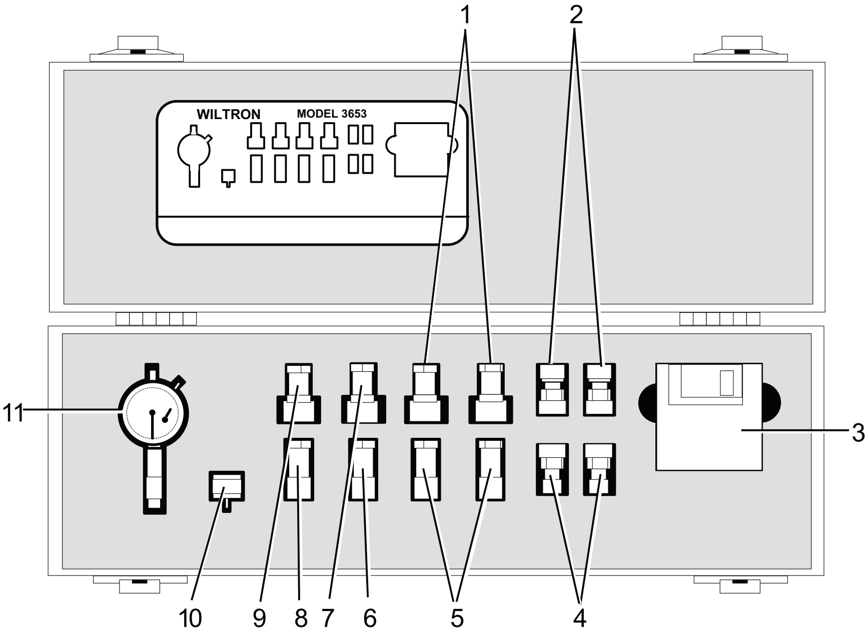


Figure 12-4. Model 3653 (Type N) Calibration Kit Components

Model 3654/3654B Calibration Kit

Table 12-5. Model 3654 (V-Connector) Calibration Kit Contents

Index	Anritsu Part Number	Description	Qty.
1	17VF50B	Female Sliding Termination	1
2	17V50B	Male Sliding Termination	1
3	33VVF50	Male-Female Adapter	2
4	2360-54B	Calibration Software Diskette	1
5	28V50B	Male Broadband Termination	2
6	28VF50B	Female Broadband Termination	2
7	24V50B	Male Open	1
8	24VF50B	Female Open	1
9	23V50B-5.1	Male Short, 5.1 mm	1
10	23VF50B-5.1	Female Short, 5.1 mm	1
11	33VV50	Male-Male Adapter	1
12	33VFVF50	Female-Female Adapter	2
13		Connector Thumb Wheel	4
14	01-201	Torque Wrench	1
15	01-323	Female Adapter For Pin Gauge	1
16	01-322	Pin Depth Gauge	1
17	01-210	Reference Flat	1
18	01-204	Adapter Wrench	1
19	01-312	Male Flush Short	1
20	01-311	Female Flush Short	1

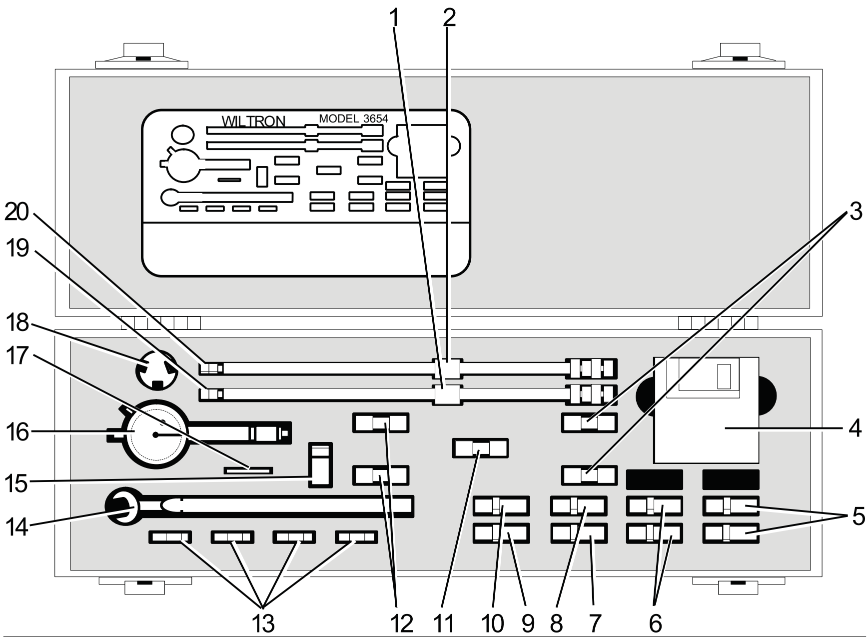


Figure 12-5. Model 3654 (V-Connector) Calibration Kit Components

* Phase Equal Adapters

Model 3656 Calibration Kit

Table 12-6. Model 3656 (W1-Connector) Calibration Kit Contents

Index	Anritsu Part Number	Description	Qty.
1	23W50-1 23W50-2 23W50-3	Male Offset Short 1 (2.02 mm) Male Offset Short 2 (2.65 mm) Male Offset Short 3 (3.180 mm)	1 1 1
2	24W50	Male Open (1.510 mm)	1
3	28W50	Male Broadband Termination	1
4	23WF50-1 23WF50-2 23WF50-3	Female Offset Short 1 (2.02 mm) Female Offset Short 2 (2.65 mm) Female Offset Short 3 (3.180 mm)	1 1 1
5	28WF50	Female Broadband Termination	1
6	24WF50	Female Open (1.930 mm)	1
7	33WSC50	Fixed Male SC Connector	1
8	33WFSC50	Fixed Female SC Connector	1
9		Interchangeable Sliders, SC Connectors	1
10		Locking Keys, SC Connectors	1
11	01-402	Interchangeable Adapter Fixed Male	1
12	33WWF50	Male-Female Adapter	1
13	33WW50	Male-Male Adapter	1
14	33WFWF50	Female-Female Adapter	1
15	01-504	6 mm Torque Wrench	1
16	01-505	6x7 mm End Wrench	1
17	18-WWF50-1B	Stepped Impedance Thruline (Verification Device)	1
18	18-WWF50-1	50Ω Matched Thruline (Verification Device)	1
19		Calibration/Verification Software	

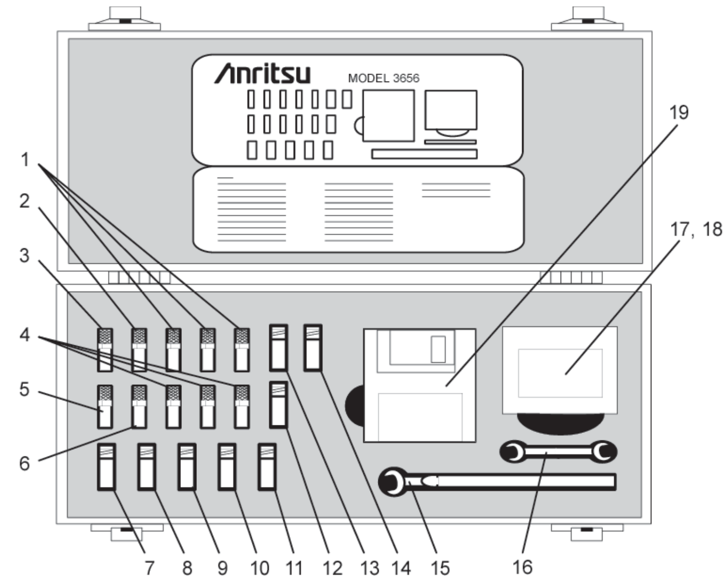


Figure 12-6. Model 3656 (W1-Connector) Calibration Kit Components

12-4 PRECAUTIONS

The following are precautionary notes related to the use of connectors. For specific information on setting pin depths on sliding terminations, refer to the 37XXXD Operation Manual, Chapter 7.

Pin Depth

Before mating, measure the pin depth (Figure 12-7) of the device that will mate with the RF component, using an Anritsu Pin Depth Gauge or equivalent (Figure 12-8). Based on RF components returned for repair, destructive pin depth of mating connectors is the major cause of failure in the field. When an RF component is mated with a connector having a destructive pin depth, damage will likely occur to the RF component connector. (A destructive pin depth has a center pin that is too long in respect to the connector's reference plane.)

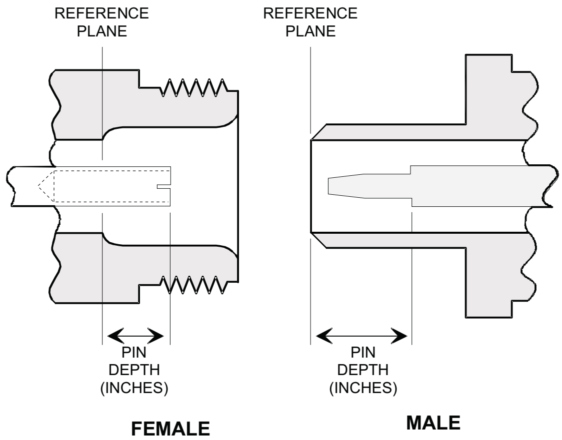


Figure 12-7. N-Connector Pin Depth

Pin Depth Tolerance

The center pin of RF component connectors has a precision tolerance measured in mils (1/1000 inch). Connectors on test devices that mate with RF components may not be precision types and may not have the proper depth. They must be measured before mating to ensure suitability. When gauging pin depth, if the test device connector measures out of tolerance (Table 12-7) in the “+” region of the gauge (Figure 12-8), the center pin is too long. Mating under this condition will likely damage the termination connector. On the other hand, if the test device connector measures out of tolerance in the “–” region, the center pin is too short. While this will not cause any damage, it will result in a poor connection and a consequent degradation in performance.

Table 12-7. Pin Depth Tolerances

Port/Connector Type	Pin Depth (mils)	Anritsu Gauge Setting
GPC 7	+0.000 to –0.003	Same as pin depth
N Male	.207 +0.003 –0.003	Same as pin depth
N Female		
WSMA Male	–0.0025 –0.0035	Same as pin depth
WSMA Male		
K Male	+0.000 to –0.003	Same as pin depth
K Female		
V Male	+0.000 to –0.001	Same as pin depth
V Female	+0.000 to –0.001	

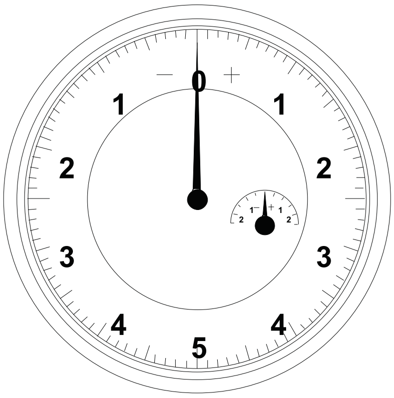


Figure 12-8. Pin Depth Gauge

Over Torquing Connectors

Over torquing connectors is destructive; it may damage the connector center pin. Finger-tight is usually sufficient, especially on Type N connectors. *Never* use pliers to tighten connectors.

Teflon Tuning Washers

The center conductor on most RF components contains a small teflon tuning washer located near the point of mating (interface). This washer compensates for minor impedance discontinuities at the interface. The washer’s location is critical to the RF component’s performance. *Do not disturb it.*

Mechanical Shock

RF components are designed to withstand years of normal bench handling. However, do not drop or otherwise treat them roughly. They are laboratory-quality devices, and like other such devices, they require careful handling.

12-5 CLEANING INSTRUCTIONS

Connector interfaces—especially the outer conductors on the GPC 7 and SMA connectors—should be kept clean and free of dirt and other debris.

Denatured alcohol applied with a cotton swab applicator is recommended for cleaning connector interfaces.

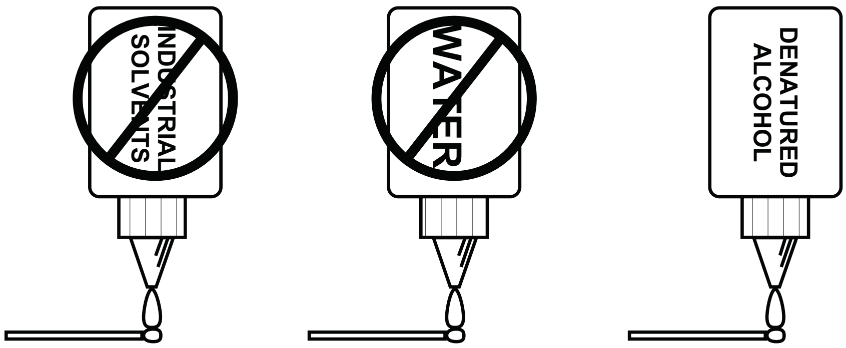
NOTE

Most cotton swabs are too large to fit in the smaller connector types. It is necessary to remove most of the cotton and then twist the remaining cotton tight. Be sure that the remaining cotton does not get stuck in the connector.

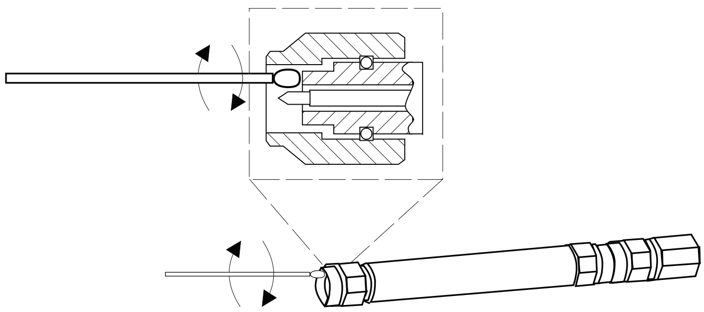
The following are some important tips on cleaning connectors:

- ❑ Use only denatured alcohol as a solvent
- ❑ Always use an appropriate size of cotton swab
- ❑ Gently move the cotton swab around the center conductor
- ❑ Never put lateral pressure on the connector's center pin
- ❑ Verify that no cotton or other foreign material remains in the connector after cleaning
- ❑ Only dampen the cotton swab. Do NOT saturate it
- ❑ Compressed air can be used to remove foreign particles and to dry the connector
- ❑ Verify that the center pin has not been bent or damaged

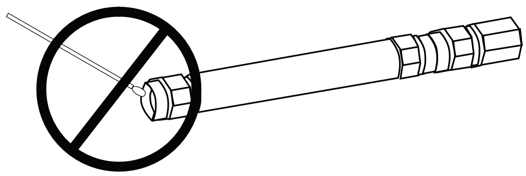
Figure 12-9, following page, illustrates how to clean connectors.



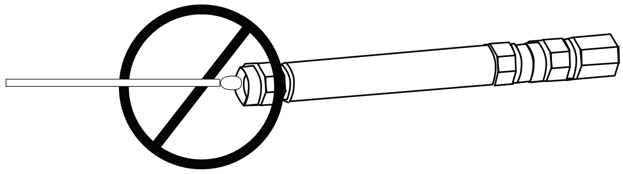
Do NOT use Industrial Solvents or Water on connector. Use only Denatured Alcohol.



Use only denatured alcohol and the proper size of cotton swab. Gently rotate the swab around the center pin being careful not to stress or bend the pin or you will damage the connector.



Do NOT put cotton swabs in at an angle, or you will damage the connectors.



Do NOT use too large of cotton swab, or you will damage the connectors.

Figure 12-9. How to Clean Connectors

C 13
M W
S

T C

C 13
M W S

13-1 INTRODUCTION

This chapter describes the ME7808B Millimeter Wave System, its operation, and its measurement capabilities. For information on ME7808B Broadband System, refer to Chapter 14.

13-2 DESCRIPTION

The ME7808B Millimeter Wave System can be constructed upon any 37XXXD VNA, 37247D being the most economical choice. It also requires two 680XXC or MG369XA Frequency Synthesizers, and a 3735B Millimeter Test Set having two 374X Millimeter Wave Modules. There are 14 different 374X modules available (below) to accommodate different measurement types and frequency ranges.

- ❑ 3741A-V 50 to 75 GHz Transmission Module
- ❑ 3741A-E 60 to 90 GHz Transmission Module
- ❑ 3741A-EE56 to 94 GHz Transmission Module
- ❑ 3741A-W 75 to 110 GHz Transmission Module
- ❑ 3741A-EW 65 to 110 GHz Transmission Module
- ❑ 3740A-V 50 to 75 GHz Transmission/Reflection Module
- ❑ 3740A-E 60 to 90 GHz Transmission/Reflection Module
- ❑ 3740A-EE 56 to 94 GHz Transmission/Reflection Module
- ❑ 3740A-W 75 to 110 GHz Transmission/Reflection Module
- ❑ 3740A-EW 65 to 110 GHz Transmission/Reflection Module

13-3 PERFORMANCE SPECIFICATIONS

Performance specifications are given below in Table 13-1.

System Performance

"Receiver Dynamic Range" is defined as the ratio of the maximum signal level at Port 2 for 0.1 dB compression to the noise floor at Port 2. System Dynamic Range is defined as the ratio of the power incident on Port 2 in a through line connection (reference) to the noise floor at Port 2 (forward measurements only). The Noise Floor is the maximum measured signal with the test ports terminated using 10 Hz IF bandwidth and 512 averages.

Table 13-1. Performance Specifications, Millimeter Wave Modules

Specification	Model				
	V Band (WR-15)	**E Band (WR-12)**	**Extended E Band**	**W Band (WR-10)**	**Extended W Band**
Frequency Range (GHz)	50–75	60– 90	56–60 60–85 85–94	75–100 100–110	65–75 75–100 100–110
Frequency Resolution	3 Hz	6 Hz	6 Hz	6 Hz	6 Hz
Max Signal Into Port 2	+8 dBm	+8 dBm	+8 dBm	+6 dBm	+6 dBm
Noise Floor	–90 dBm	–90 dBm	–85 dBm –90 dBm –76 dBm	–90 dBm –90 dBm	–90 dBm –89 dBm –87 dBm
Receiver Dynamic Range	98 dB	98 dB	93 dB 98 dB 84 dB	96 dB 96 dB	96 dB 95 dB 93 dB
High Level Noise (typical)	0.05 dB	0.06 dB	0.08 dB	0.06 dB	0.08 dB
Power Out (typical)	+7 dBm	+6 dBm	+5 dBm +6 dBm +4 dBm	+5 dBm +2 dBm	–5 dBm +5 dBm +2 dBm
System Dynamic Range	97 dB	96 dB	90 dB 96 dB 80 dB	95 dB 92 dB	85 dB 94 dB 89 dB

Test Port Characteristics

Test port characteristics for the waveguide connector used on the various modules are given in Table 13-2.

Table 13-2. Test Port Characteristics

Specification	Waveguide Designation									
	Offset Short Calibration					LRL Calibration				
	WR-15	WR-12	WR-12 Ext.	WR-10	WR-10 Ext.	WR-15	WR-12	WR-12 Ext.	WR-10	WR-10 Ext.
Frequency (GHz)	50–75	60–90	56–94	75–110	65–110	50–75	60–90	56–94	75–110	65–110
Directivity (dB)	>46	>46	>44	>46	>40	>46	>46	>44	>46	>40
Source Match (dB)	>37	>36	>33	>36	>30	>46	>46	>43	>46	>40
Load Match (dB)	>46	>46	>44	>46	>40	>46	>46	>44	>46	>40
Reflection Frequency Tracking (dB)	±0.030	±0.040	±0.080	±0.040	±0.080	±0.02	±0.02	±0.06	±0.02	±0.06
Transmission Frequency Tracking (dB)	±0.060	±0.060	±0.100	±0.070	±0.100	±0.02	±0.02	±0.06	±0.02	±0.06
Isolation (dB)	>90	>90	>80	>90	>80	>90	>90	>80	>90	>80

Measurement Capabilities

Measurement capabilities are the same as the standard 37XXXD. That is: Four Channels, Standard S-parameters as well as User Defined Parameters, Auto-Reversing, Data Points 1601, 801, 201, 51, N Discrete, and CW (see Appendix D).

NOTE

When a 37XXXD is configured as a Millimeter Wave System, the frequency range is extended per the specifications of the Millimeter Wave Modules and the system will be limited to operate with only two external sources. That is, the internal source is removed or disabled.

13-4 INSTALLATION

This section describes installation and system check-out. For instructions on installation of the wafer probe test station, refer to section 14-5.

IMPORTANT NOTES

- The empty console weighs approximately 66kg (145 pounds). Use two people to remove the console from the pallet.
- Many of the instruments are quite heavy and require two people to lift them.
- Instruments should be loaded into the bottom sections of the console first, to prevent tipping of the console.
- The VNA instrument has fragile RF cables connected to both the front and rear panels. Be careful not to bend these cables when handling the instrument.
- If the synthesizers are not installed precisely as described below, the system will be non-functional.
- We suggest using an 8 in/lb torque wrench to tighten SMA connectors (available in most Anritsu VNA Calibration kits) Do not tighten any connectors over 8 in/lbs.

Console and Table Setup

Set up the console and table as described below.

Step 1. Remove the shipping container and all packaging and accessories from around the console. Set the table aside. Instructions for table installation appear later.

Step 2. Lift or roll the console off the pallet (to lift: insert two sections of lumber through the console top and lift it, using one person on each side).

Step 3. Cut the tie wraps which are securing the table mounting rails at the console rear door. Cut the tie wraps which are securing the power cords and wrist strap ground wire.

Step 4. Attach the mounting rails to the table as shown in Figure 13-1.

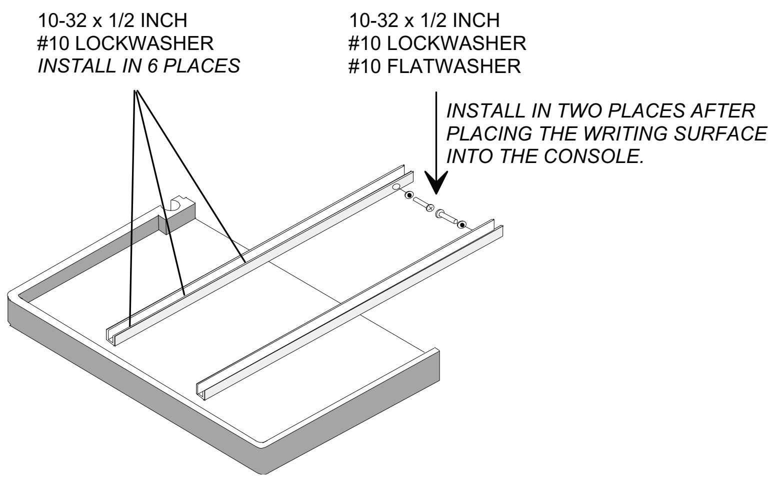


Figure 13-1. Console Table

Instrument Installation into Console

Refer to Figures 13-2, 13-3, and 13-4 for installation of major instruments and cables.

Step 1. Check the rear panel serial number labels of the synthesizers. The instrument without Option 15 belongs in the bottom compartment (“RF” synthesizer).

Step 2. Install the synthesizer with Option 15 in the second opening from the bottom.

Step 3. Install the VNA into the top compartment. Ensure the three small RF cables are installed onto the front and rear panels (one in front, and two in back).

Step 4. Install the 3738A Test Set into the compartment below the VNA.

Step 5. Secure all instruments in the console using the screws provided.

Step 6. On the left front of the console, move the black ground wire away from the guide of the table-mounting rail, and install the table by sliding the table rails into the guides.

Step 7. Secure the table rails at the rear of the console using the screws provided.

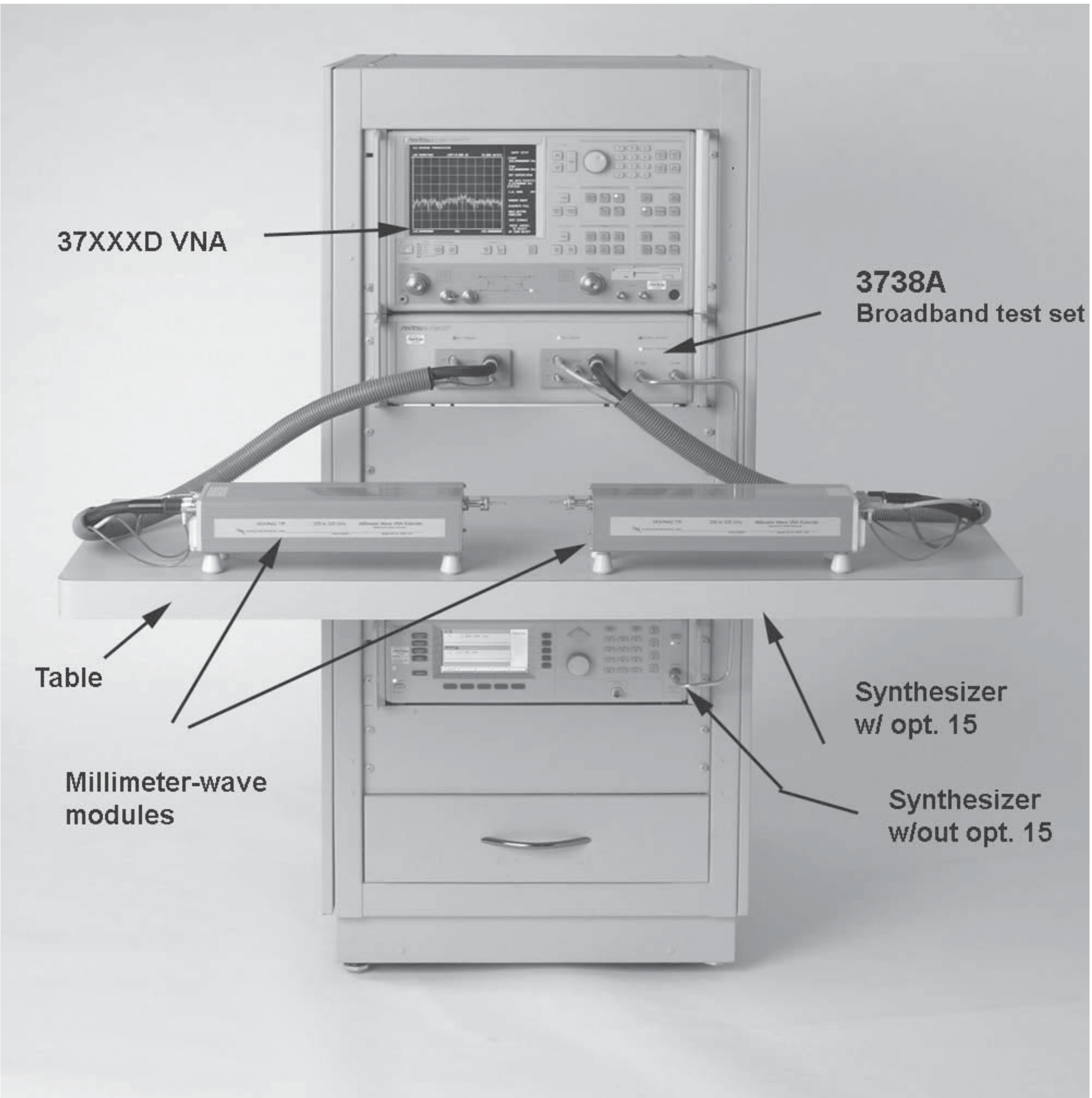


Figure 13-2. ME7808B Console Showing Major Components

Step 8. Lay the static-safe mat on the table and attach the ground cable.

Step 9. Unpack the millimeter-wave modules and set them on the table.

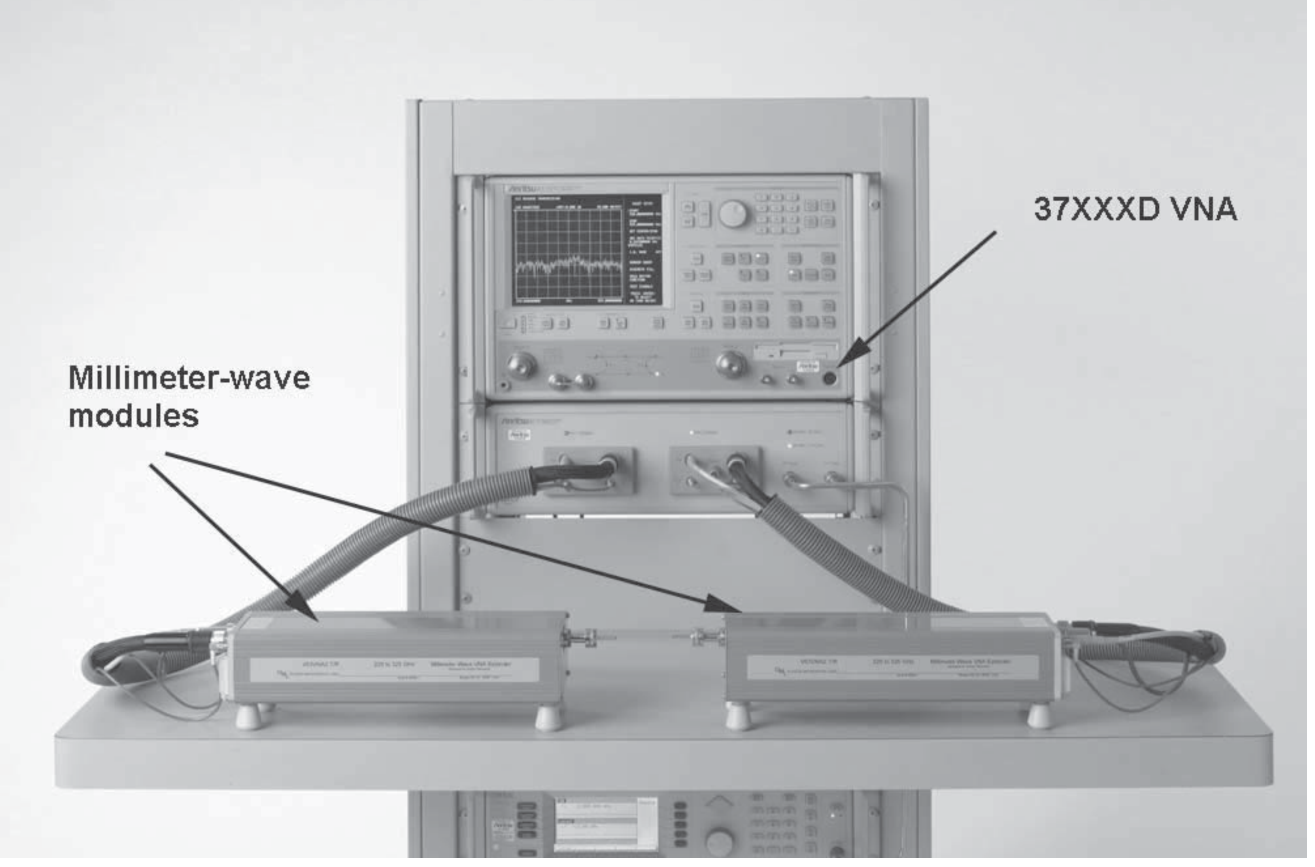


Figure 13-3. ME7808B Console Showing Table and Module Setup

System Cabling

Connect ME7808B system cables as described below and shown in Figure 13-4 on the following page.

Step 1. From the front, connect the rigid RF cable between the upper synthesizer and the 3738A LO IN connector. Ensure the connectors are seated correctly and tightened securely.

Step 2. From the front, connect the rigid RF cable between the bottom synthesizer and the 3738A RF IN connector. Ensure the connectors are seated correctly and tightened securely.

Step 3. From the front, install the two RF cable sets between the 3738A and the mmW modules. Connect exactly as the labels indicate.

Step 4. From the rear, unscrew the four small chain-mounted terminations from on VNA (let them hang loose) and install the Cable Set. Connect individual cables as indicated on the labels .

Step 5. Connect one GPIB cable from the lower (Dedicated) GPIB connector of the VNA to the upper synthesizer. Connect the second GPIB cable between the two synthesizers.

Step 6. Insert the power cords into all 4 instruments and turn all the instruments on.

Step 7. Ensure that the two synthesizers GPIB addresses are set correctly. The top unit should be set to address 4 and the bottom unit should be set to address 5. This can be verified or changed by pressing SYSTEM |CONFIG |GPIB ADDRESS and entering the appropriate GPIB address.

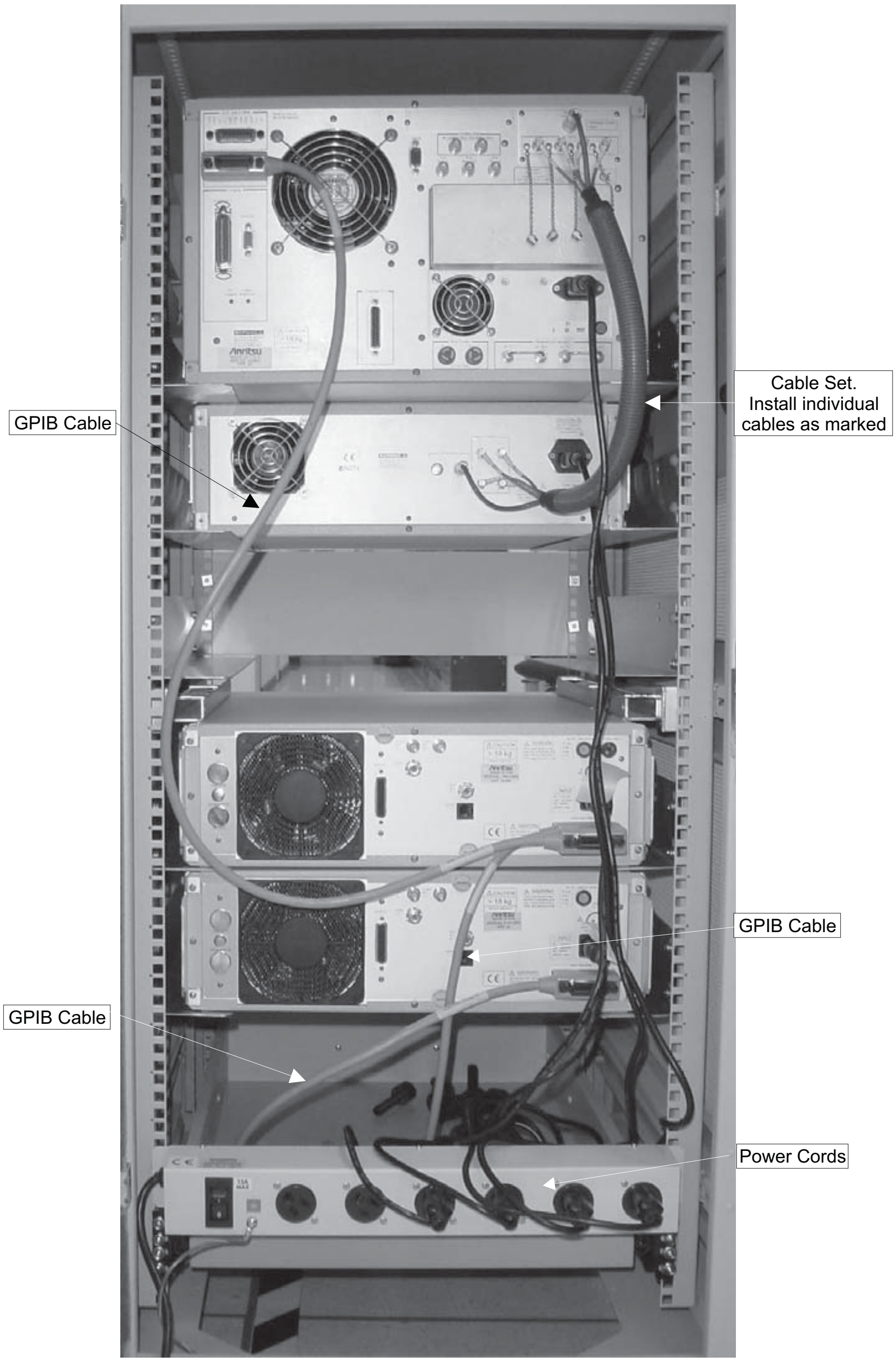


Figure 13-4. ME7808B Console Rear Panel Cabling

13-5 CALIBRATION

Calibration for millimeter wave measurements is accomplished using a waveguide offset-short method. Anritsu provides the Series 3655X, 3655X-1, 3755X, and 3755X-1 Calibration Kits, which contain all required precision calibration components. For optimum calibration and measurement results, the following apply to modules that are not provided with precision waveguide extensions. (Refer to Figure 13-5 below, for a supporting illustration.)

- ❑ Use the precision waveguide extension from the calibration kit to connect to the waveguide module
- ❑ During calibration connect the highly polished (non-beveled) side of the short toward the module

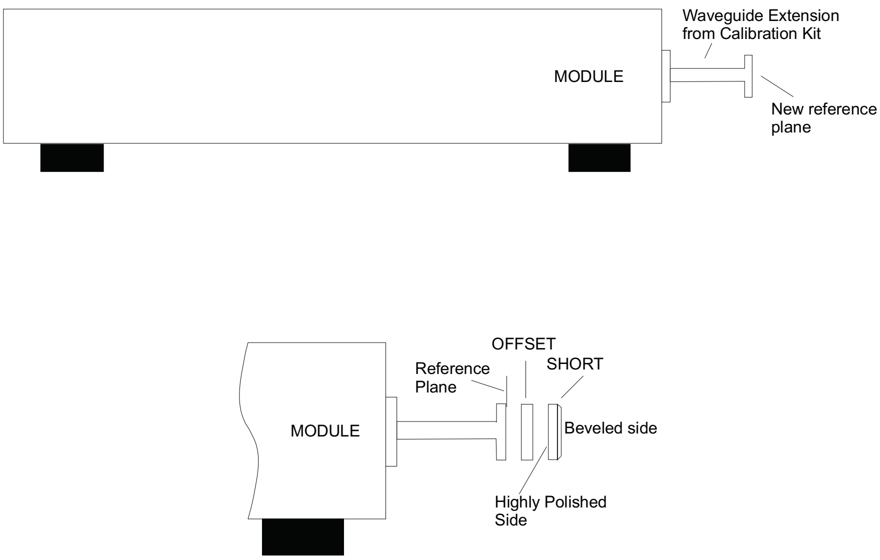


Figure 13-5. Waveguide Connections for Optimum Measurement and Calibration Results

13-6 **OPERATION**

The ME7808B Millimeter Wave System is menu driven and the millimeter wave operation is entered into via the Enhancement Key-Group's Options Menu key. Selecting Millimeter Wave BAND DEFINITION in that menu provides for defining measurement parameters; selecting TEST SET CONFIG provides for configuring the 3735B Test Set parameters (Figure 13-6, next page).

The menu options shown in Figure 13-6, Millimeter Wave System Menu Flow, are described in Appendix A, along with all of the other ME7808B menus. Additional operating instructions are provided below.

Entering/Leaving Millimeter Wave Operation

MENU OPTNS
OPTIONS
TRIGGERS
REAR PANEL OUTPUT
Millimeter Wave BAND DEFINITION
RECEIVER MODE
SOURCE CONFIG
TEST SET CONFIG

MENU OTS1
TEST SET CONFIGURATION
INTERNAL
MILLIMETER WAVE

Before entering the Millimeter Wave mode, users should have completed all of the steps in the "Installation" section of this manual. The system should be ready for operation, with all connections properly made to the Millimeter Wave test set, modules, and frequency synthesizers. The system should then be powered up, and the procedure below followed.

NOTE

Until the Millimeter Wave configuration is activated, the system will not operate and it will fail to lock.

CAUTION

The transition to or from Millimeter Wave operation is a major setup change that does NOT preserve the previous setup. All current set up and RF calibration information will be lost on entering or leaving the Millimeter Wave mode configuration. If the existing setup needs to be saved, this should be done before the system is reconfigured for Millimeter Wave mode operation.

When the millimeter wave band is selected, the system automatically reconfigures itself to measure at that frequency range. The lower and upper limits of the displayed sweep frequencies will change to the band selected. The frequency resolution changes to account for multiplier factors. However, users will (1) have access to the multiple source control definitions and (2) be able to change the sweep frequencies as desired.

Procedure

The first step is to press the Options button on the front panel. This brings up the menu OPTNS (top left). Select TEST SET CONFIG. This causes the menu OTS1 (bottom left) to appear.

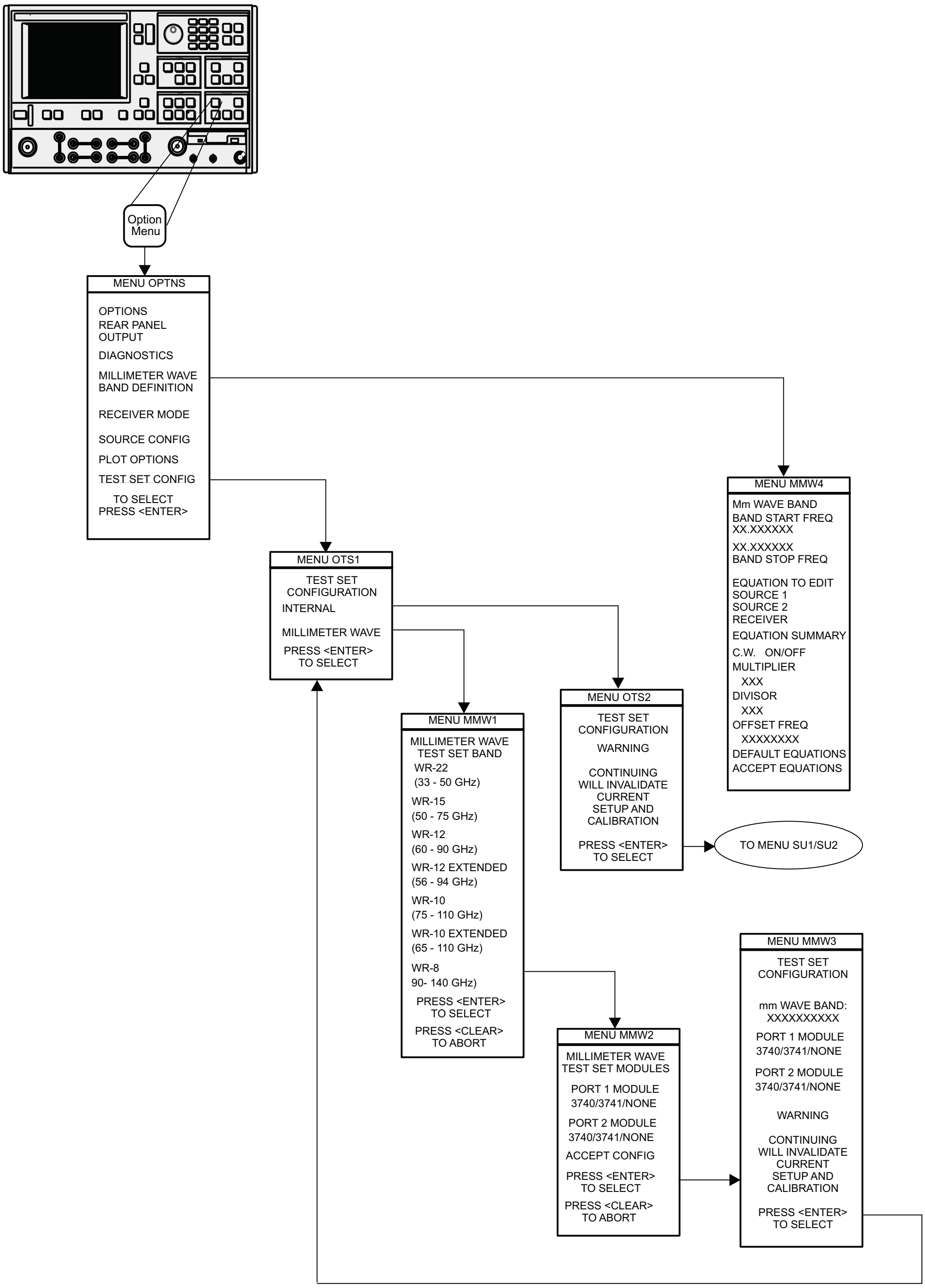


Figure 13-6. Millimeter Wave System Menu Flow

MENU MMW1

MILLIMETER WAVE
TEST SET BAND

WR-22
(33 - 50 GHz)

WR-15
(50 - 75 GHz)

WR-12
(60 - 90 GHz)

WR-12 EXTENDED
(56 - 94 GHz)

WR-10
(75 - 110 GHz)

WR-10 EXTENDED
(65 - 110 GHz)

MENU MMW2

MILLIMETER WAVE
TEST SET MODULES

PORT 1 MODULE
3740/41/42/NONE

PORT 2 MODULE
3740/41/42/NONE

ACCEPT CONFIG

PRESS <ENTER>
TO SELECT

PRESS <CLEAR>
TO ABORT

If the system is not already configured for Millimeter Wave operation, select Millimeter Wave to call menu MMW1 (top left).

In menu MMW1, select the millimeter wave band for which modules have been installed.

CAUTION

A band other than the one for which hardware is installed can be selected. In this case, the system may appear to operate normally, but it will not make accurate measurements.

Upon completing the selection in the menu MMW1, menu MMW2 (bottom left), appears.

MENU MMW3

TEST SET
CONFIGURATION

mmWAVE BAND
XXXXXXXX

PORT 1 MODULE
3740

PORT 2 MODULE
3740

WARNING

CONTINIUING
MAY INVALIDATE
CURRENT
SETUP AND
CALIBRATION

PRESS <ENTER>
TO SELECT

PRESS <CLEAR>
TO ABORT

In this menu, select which module is Transmission-Reflection and which is Transmission Only. Do this carefully, as an incorrect selection causes the wrong S-parameters to be displayed. Once the selection is made in this menu, MMW3 (left) appears.

At this point, users have one last opportunity to abort the change in configuration, by pressing the Clear key. If the Enter key is pressed, the old configuration is lost. The system is reconfigured for millimeter wave operation.

Changing Bands/Modules While in Millimeter Wave

The effect of changing millimeter wave bands while in Millimeter Wave mode operation will be to (1) change the sweep frequency range to the default range for the new band and (2) delete any current RF calibrations. Therefore, the Caution on page 13-14 applies. Actually, it is unlikely that any calibration would be valid if the modules are changed. (This is because of manufacturing variations from module to module.)

To configure the system for a different band or for one or more different modules, follow the exact same steps as described on pages 13-14 through 13-16, except that only the new band or module types are changed.

Allowable Millimeter Wave Module Configurations, Measurements and Calibrations

The S-parameter measurements and RF calibrations allowed are a function of the type of millimeter wave module users have selected in menu MMW2. Note that one could actually have only one module and still make reflection-only measurements. The criteria in Table 13-4 applies.

Table 13-4. Calibration Criteria

MMW Modules		Allowed S-parameters				Allowed RF Calibrations						
Port 1	**Port 2**	**S11**	**S12**	**S21**	**S22**	**12 Term**	**Forward 1 Path 2 Port**	**Reverse 1 Path 2 Port**	**Reflection P1**	**Reflection P2**	**Forward Trans**	**Reverse Trans**
3740	3740	X	X	X	X	X	X	X	X	X	X	X
3740	3741	X		X			X		X		X	
3741	3740		X		X			X		X		X
3741	3740	b1/1	b2/1	b2/1	b1/1			X		X		X

Effect of Default Program

Because the system is reconfigured for Millimeter Wave mode operation, the effects of performing a “Default Program” are somewhat different. Performing a default program operation, either from the front panel or via the GPIB will have the following results:

- ❑ Pressing the Default Program key twice:
  The Millimeter Wave operating band, its associated frequency range, multipliers, and millimeter wave module types will remain unchanged. If the frequency range has been modified from the default values for the band, the modified values will remain in force. The current sweep range will be set to the band frequency range. This is consistent with other similar setup parameters, such as GPIB addresses
- ❑ Pressing the Default Program key, then the 1 data entry key:
  Except for clearing the internal setup memories, the effect will be the same as for pressing the Default Program key twice
- ❑ Pressing the Default Program key, then the 0 data entry key:
  The system resets to its default, non-millimeter wave configuration; that is, internal source active, no multiple source equations, normal default system frequency range, and internal test set configuration. If the “delete source” option is active, the system will attempt to use an external source for source 1

The restrictions stated in the above “Allowable Microwave Modules Configurations, Measurements, and Calibrations” section (previous page) will impact the display resulting from a “Default - Default” action. S-parameters displayed will be as indicated above, while the channel configuration will be as shown in Table 13-5.

Table 13-5. Channel Configuration

MMW Modules		Default Channel Configuration	S-parameters Assigned			
Port 1	Port 2		Ch 1	Ch 2	Ch 3	Ch 4
3740	3740	All Four Channels	S11	S12	S21	S22
3740	3741	Dual, Channels 1 and 3	S11	S21	S21	S11
3741	3740	Dual, Channels 2 and 4	S22	S12	S12	S22
3741	3741	All Four Channels	b1/1	b2/1	b2/1	b1/1

Note: In the case of two 3741’s, the system will be put into SET ON mode. If users provide a phase-lock signal, they may set the “user-defined” receiver mode to TRACKING.

Redefinition of Band Frequency Ranges

MENU OPTNS
OPTIONS
TRIGGERS
REAR PANEL OUTPUT
Millimeter Wave BAND DEFINITION
RECEIVER MODE
SOURCE CONFIG
TEST SET CONFIG

It is possible to modify the Millimeter Wave band equations to a range different than the default range for the band currently installed. This is done by pressing the Options key to display menu OPTNS (top left). In this menu, select Millimeter Wave BAND DEFINITION and cause menu MMW4 (bottom left) to appear.

The receiver equation or either of the sources may be edited. New values for the multiplier, the divisor, or the offset may be entered. To apply the selections, select ACCEPT EQUATIONS. Or select DEFAULT EQUATIONS to return selections or edits to the standard default values.

The EXT_MILLIMETER WAVE 4 menu (Figure 13-7) appears next to menu Millimeter Wave 4 to provide the current or proposed band information.

CAUTION

It is possible for the equations to be set to values that may prevent normal operation of the system, due to excessive frequency range beyond the capabilities of the system hardware. The only way of restoring the system to its known default settings is by selecting DEFAULT EQUATIONS then ACCEPT EQUATIONS in menu MMW 4. Using the DEFAULT-DEFAULT method *will not* reset the equations.

MENU MMW4
mmWAVE BAND
BAND START FREQ 65.000000
BAND STOP FREQ 110.000000

If the frequency range of a millimeter wave band is changed to a range where some or all of the frequencies are outside of the default range for that band, or if the frequency multipliers are altered, the change will be allowed, but upon selecting ACCEPT EQUATIONS in menu MMW4, a warning message will be issued in the data area: “CAUTION: NON-STD BAND DEFINITION.” If the frequency range of a Millimeter Wave band is changed to a range that is a subset of the default range for that band, no warning message will be issued.

- MILLIMETER WAVE BAND DEFINITION SUMMARY -

BAND FREQUENCY RANGE

BAND START F

BAND STOP F

XXX,XXXXXX XXX

XXX.XXXXXX XXX

FREQUENCY = (MULTIPLIER/DIVISOR) * F + OFFSET FREQ)

SOURCE 1 = (1/ 8) * (F– 0.270000 GHz)

SOURCE 2 = (1/ 6) * (F + 0.000000 GHz)

RECEIVER = (1/ 1) * (0.270000 GHz C.W.)

- NOTES -

1. SELECT <DEFAULT EQUATIONS> TO OVERWRITE DEFINITION WITH VALUES SUITABLE FOR THE MILLIMETER WAVE BAND.
2. SELECT <ACCEPT EQUATIONS> TO CONFIRM ANY CHANGES.
3. PERFORMANCE SPECIFICATIONS ARE VALID ONLY WHILE USING THE DEFAULT EQUATIONS OVER THE DEFAULT BAND FREQUENCY RANGE.
4. DEVIATING FROM THE DEFAULT MAY CAUSE LOCK FAILURES.

Figure 13-7. Menu EXT_MMW4

Use of Normal Multiple Source Mode

While the millimeter wave feature is active, the normal multiple source mode *will not* be available. Access to the menus OM0 through OM2 *will not* be allowed. If the system is in multiple source mode when switched to millimeter wave, all multiple source information will be lost, and the unit will return to normal (single source) operation when millimeter wave operation is ended. In Millimeter Wave mode, users may change the default values of the current waveguide band frequency range, multipliers, and offset (CW-IF) frequency, by using menu MMW4.

Stored Setups and Calibrations

The Millimeter Wave band definition and module information is stored with a stored setup in internal memory, and with the setup and RF CAL on disk. When a setup is recalled, first the band and module types will be compared with the current settings. If different, the setup will be rejected, and a message “ABORTED: HARDWARE DIFFERENT” will be posted. If the hardware settings are compatible, the frequency range of the stored setup will be compared with the current system low and high frequency limits, in case the user has employed a customized-band definition. If the recalled setup is within the current frequency range of the system, it will be recalled with no warning—even if the current range is customized. If the recalled setup is outside the normal frequency range, or if it has changed equations (been customized) it will be recalled. However, a time-out warning message will be issued in the data area: “CAUTION: NON-STD BAND DEFINITION.”

External Source and Power Levels

When MILLIMETER WAVE has been selected in menu OTS1, the system checks for the existence of two external sources. If either source is not connected and operating, a warning message is posted to the screen. On entering Millimeter Wave mode operation, the system will automatically be configured to use the two external sources. The Millimeter Wave mode will not function properly with low source-power levels. Therefore, on entering this mode the source-power levels will be adjusted to a predefined level. However the Source Config and Test Signals menus will still be available to users, to change power settings and source configuration if so desired.

13-7 MEASUREMENT PROCEDURE

MENU MMW1
MILLIMETER WAVE TEST SET BAND
WR-22 (33 - 50 GHz)
WR-15 (50 - 75 GHz)
WR-12 (60 - 90 GHz)
WR-12 EXTENDED (56 - 94 GHz)
WR-10 (75 - 110 GHz)
WR-10 EXTENDED (65 - 110 GHz)
WR-8 (90 - 140 GHz)
PRESS <ENTER> TO SELECT

MENU MMW2
MILLIMETER WAVE TEST SET MODULES
PORT 1 MODULE 3740/3741/NONE
PORT 2 MODULE 3740/3741/NONE
ACCEPT CONFIG
PRESS <ENTER> TO SELECT

The measurement of a Device Under Test (DUT) using the Millimeter Wave mode is quite similar to one using a coaxial measurement technique. However, due to the more complex nature of the Millimeter Wave System equipment, additional care must be taken to ensure that everything is set up properly. Depending upon the type of measurement being performed, the setup may vary. The following is a description of a typical measurement procedure for a passive two-port DUT.

Step 1. *Verify Correct Band Definition*
Use menu MMW1 (top left) to examine the current millimeter wave band selection, and menu MMW2 (bottom left) to examine the current module selections to be sure that they match the installed hardware. Examine menuMMW4 (next page) to verify that the band equations are set correctly. If there is any doubt whether the setting are correct, use the DEFAULT EQUATIONS selection to reset them.

Step 2. *Verify Correct Setup for the System*
The safest way to do this is to press the Default key twice. This returns the system to the proper frequency range and power settings for the current millimeter wave hardware configuration. It is very important that the RF sources be set to the correct power levels. Set Source 1 (LO) to +17 dBm and Source 2 (RF) to +13 dBm.

Step 3. *Perform and Verify an RF Calibration*
The system may now be calibrated using an appropriate Anritsu Calibration Kit. Be sure to load the calibration kit information from the provided floppy disk into the instrument first. The default calibration type is Offset-Short, but an LRL/LRM calibration may also be used. See Chapters 4 and 7 for help with RF Calibration details. Consult Table 13-4 for limitations on which calibrations may be performed as a function of the module types installed.

Step 4. *Attach the DUT*
Use the calibrated torque wrench provided with the Calibration Kit to tighten the waveguide flange retaining screws on the DUT. This results in more reproducible measurements.

Step 5. *Select the S-parameter(s) and Graph Type(s) to Be Used for the Measurement*
The selection may be limited due to the types of millimeter wave modules installed. Consult Table 13-4 on page 13-18 for further information.

MENU MMW4
mmWAVE BAND
BAND START FREQ 65.000000
BAND STOP FREQ 110.000000
EQUATION TO EDIT
SOURCE 1
SOURCE 2
RECEIVER
EQUATION SUMMARY
CW OFF
MULTIPLIER 1
DIVISOR 8
DEFAULT EQUATIONS

Step 6. *Set the Display Scale*

This may be done most quickly by selecting each active channel, and pressing the Autoscale key. The scale and reference values may then be set to a desired value using the appropriate SET SCALE menu for the graph type selected.

Step 7. *Observe the Measured Data*

It should not vary from sweep to sweep, and should be within the range expected for the type of measurement. Re-check tightness of the flange retaining screws if data appears abnormal.

Step 8. *Save the Calibration and Setup On the Hard Disk*

Press the Save/Recall key to initiate the saving of the current setup. An instrument setup in the millimeter wave configuration may be saved exactly like any other VNA setup and RF calibration.

NOTE

Anritsu strongly recommends that any setup and calibration used for measurement be saved.

13-8 REMOTE OPERATION

All functions of the ME7808Bmm can be controlled remotely, via the IEEE 488 Bus (GPIB). The remote operation and controlling commands are provided in the 37XXX Programming Manual (PN: 10410-00262).

13-9 OPERATIONAL CHECKOUT—GENERAL

The Operational Checkout subsection provides for checking that the ME7808B Millimeter Wave System is functioning properly.

MENU OPTNS
OPTIONS
TRIGGERS
REAR PANEL OUTPUT
Millimeter Wave BAND DEFINITION
RECEIVER MODE
SOURCE CONFIG
TEST SET CONFIG

Required Equipment

The following equipment is required to perform the verification tests.

Model	Description	Quantity
Anritsu 3655 Series	Waveguide Calibration Kit, with Option 1: Sliding Termination	1

Step 1. Remove the silver straight waveguide sections from the modules, if installed.

Step 2. Install the precision-straight waveguide sections that are contained in the calibration kit on the waveguide output connector of each millimeter module.

NOTE

These waveguide sections (test port adapters) use high precision flanges to improve connection repeatability and calibration quality. They must be used to ensure specified system performance.

Step 3. Apply power to both system Sources and allow them to complete self test.

Step 4. Apply power to the network analyzer.

Step 5. Press the Option Menu key, select TEST SET CONFIG to configure the system for the types of millimeter modules used.

Step 6. Allow the system to warm up for at least 60 minutes to ensure operation to performance specifications.

13-10 OPERATION CHECKOUT—IF POWER LEVEL TEST

Key	Menu Choice
SETUP MENU	START: Low-end Frequency STOP: High-end Frequency
CHANNEL MENU	DUAL CHANNELS 1 & 3
GRAPH TYPE	LOG MAGNITUDE (both channels)
S-PARAMS	Channel 1 User Ratio: a1/1 User Phase Lock: a1 Channel 3 User Ratio: b1/1 User Phase Lock: a1
SET SCALE	RESOLUTION: 10.0 dB/DIV REF VALUE: -10.0 dB (both channels)

Key	Menu Choice
CHANNEL MENU	DUAL CHANNELS 2 & 4
S-PARAMS	Channel 2 User Ratio: a2/1 User Phase Lock: a2 Channel 4 User Ratio: b2/1 User Phase Lock: a2

Key	Menu Choice
CHANNEL MENU	SINGLE CHANNEL
S-PARAMS	Channel 3 User Ratio: b2/1 User Phase Lock: a1

This test verifies that each individual receiver channel operates properly. Measurement calibration of the system is not required for this test.

Test Setup

Set up test equipment as described below:

Step 1. Install a flush short on the output of the 3740A-X module connected to Port 1.

Step 2. Set up the network analyzer controls as shown at left.

NOTE

For 3741A Series, use limit settings for b1/1 (b2/1).

Test Procedure

The test procedure is described below:

Step 1. Observe sweep indicator and allow at least one complete sweep to occur.

Step 2. Verify that the measurement traces fall within the limit lines (Table 13-6).

Step 3. If the second module connected to Port 2 is also a Model 3740A-X Transmission/Reflection module, change the setup to that shown at the top left and perform Step 4. Otherwise, skip to Step 7.

Step 4. Install a flush short to the output of the 3740A-X module on Port 2.

Step 5. Verify that the measurement traces fall within the limit lines.

Step 6. If the second module to be tested is a Model 3741A-X, connect the two modules together and change the setup to that shown at the bottom left.

Step 7. Verify that the measurement trace falls within the limit lines.

Table 13-6. Limit Line Settings

Limit Type	Model and Frequency Range (GHz)									
	3740A-Q 33-50	3740A-V 50-75	3740A-E 60-90	3740A-EE 56-60	60-85	85-94	3740A-W and 3740A-EW 65-75	75-100	100-110	3740A-F 90-140
a1/1 (a2/1) UPPER LIMIT dB	–5	–5	–5	–5	–5	–5	–5	–5	–5	–5
a1/1 (a2/1) LOWER LIMIT dB	–29	–27	–29	–34	–29	–39	–39	–24	–34	–39
b1/1 (b2/1) UPPER LIMIT dB	–2	–2	–2	–2	–2	–2	–2	–2	–2	–2

13-11 OPERATIONAL CHECKOUT— TRANSMISSION HIGH LEVEL NOISE TEST

Key	Menu Choice
SETUP MENU	START: Low-end Frequency STOP: High-end Frequency
CHAN-NEL MENU	DUAL CHANNELS 1 & 3 (two 3740A-X's) SINGLE CHANNEL 3 (one 3740A-X and one 3741A-X)
GRAPH TYPE	LOG MAGNITUDE (both channels)
SET SCALE	RESOLUTION: 0.050 dB/DIV REF VALUE: 0.0 dB (both channels)
S-PARA MS	Channel 1 S12 Channel 3 S21
DATA POINT	401
VIDEO IF BW	1 KHz

The following test verifies that the transmission high-level noise in the ME7808B Millimeter VNA System will not significantly affect the accuracy of subsequent measurements. High-level noise is the random noise that exists in the ME7808B Millimeter VNA System. Because it is non-systematic, it cannot be accurately predicted or measured. Thus, it cannot be removed using conventional error-correction techniques. Measurement calibration is not required for this test.

NOTE

This test is not applicable if you are only using a single 3740A-X module on Port 1.

Test Setup

Set up the ME7808B Millimeter VNA System controls as shown at left.

Test Procedure

The test procedure is described below.

Step 1. Connect the two modules together.

Step 2. If using two 3740A-X's, press the Ch 1 key and perform Steps 3 through 9. Otherwise, go to Step 10.

Step 3. Press the Trace Memory key.

MENU NO1

TRACE MEMORY FUNCTIONS

VIEW DATA

VIEW MEMORY

VIEW DATA AND MEMORY

VIEW DATA (/) MEMORY

SELECT TRACE MATH

STORE DATA TO MEMORY

DISK OPERATIONS

Step 4. Choose VIEW DATA from the menu (left) and press the Enter key.

Step 5. While observing the sweep indicator, allow at least two complete sweeps to occur. (One complete sweep if using single channel display.)

Step 6. Choose STORE DATA TO MEMORY from menu and press the Enter key.

Step 7. Choose VIEW DATA / MEMORY from the menu and press the Enter key.

Step 8. While observing the sweep indicator, allow at least two complete sweeps to occur. (One complete sweep if using single channel display.)

Step 9. Verify that the peak-to-peak High Level Noise falls within the area between the two limit lines.

NOTE

Displayed data is only valid for the first few sweeps.

Step 10. Press the Ch 3 key.

Step 11. Repeat Steps 4 through 9 for channel 3.

13-12 OPERATIONAL CHECKOUT— REFLECTION HIGH LEVEL NOISE TEST

Key	Menu Choice
SETUP MENU	START: Low-end Frequency STOP: High-end Frequency
CHANNEL MENU	DUAL CHANNELS 1 & 3 (two 3740A-X's) SINGLE CHANNEL 3 (one 3740A-X and one 3741A-X)
GRAPH TYPE	LOG MAGNITUDE (both channels)
SET SCALE	RESOLUTION: 0.050 dB/DIV REF VALUE: 0.0 dB (both channels)
S-PARAMS	Channel 1 S11 Channel 3 S22
DATA POINT	401
VIDEO IF BW	1 KHz

The following test verifies that the reflection high-level noise in the ME7808B Millimeter VNA System will not significantly affect the accuracy of subsequent measurements. High-level noise is the random noise that exists in the ME7808B Millimeter VNA System. Because it is non-systematic, it cannot be accurately predicted or measured. Thus, it cannot be removed using conventional error-correction techniques. Measurement calibration is not required for this test.

Test Setup

Set up the ME7808B Millimeter VNA System controls as shown at left.

Test Procedure

The test procedure is described below:

Step 1. Attach the flush short to the waveguide port on the 3740A-X on Port 1 (and Port 2, if two are used); leave the waveguide port on 3741A-X unterminated.

Step 2. Press the Ch 1 key.

Step 3. Press the Trace Memory key.

MENU NO1
TRACE MEMORY FUNCTIONS
VIEW DATA
VIEW MEMORY
VIEW DATA AND MEMORY
VIEW DATA (/) MEMORY
SELECT TRACE MATH
STORE DATA TO MEMORY

Step 4. Choose VIEW DATA from the menu (left) and press the Enter key.

Step 5. While observing the sweep indicator, allow at least two complete sweeps to occur. (One complete sweep if using single channel display.)

Step 6. Choose STORE DATA TO MEMORY from the menu and press the Enter key.

Step 7. Choose VIEW DATA (/) MEMORY from the menu and press the Enter key.

Step 8. While observing sweep indicator, allow at least two complete sweeps to occur. (One complete sweep if using single channel display.)

Step 9. Verify that the peak-to-peak High Level Noise falls within the area between the two limit lines.

NOTE

Displayed data is only valid for the first few sweeps.

Step 10. If two 3740A-X's are used, press the Ch 3 key and repeat Steps 4 through 9 for channel 3.

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M S

14-1 INTRODUCTION

This chapter describes the ME7808B Broadband Measurement System and the broadband mode of operation (40 MHz to 110 GHz). For other setup modes, refer to Chapter 13 (Millimeter Wave System), or other pertinent chapters in this manual. Model 3742A-EW modules (65 to 110 GHz) are assumed to be installed on the system, even though other modules are available.

The W1 Calibration Kit (P/N 3656) is designed for the purpose of performing coaxial calibrations with the ME7808B Vector Network Analyzer up to 110 GHz. The calibration kit comprises of Open, Short, and Load standards to enable two sets of calibrations—a Short Open Load Thru (SOLT) calibration from 40 MHz to 65 GHz, and a Triple Offset Short (SSST) calibration from 65 to 110 GHz (refer to Chapter 7, Measurement Calibration for these calibration procedures). The ME7808B firmware supports concatenation to allow merging of the two calibrations for broadband corrected measurements from 40 MHz to 110 GHz (discussed later in this chapter). In addition, the calibration kit includes fixed and interchangeable adapters, which may be used as test port connector savers. The interchangeable adapters have one fixed end and one interchangeable end that can be changed to a male or female for non-insertable device measurements.

14-2 SYSTEM DESCRIPTION

The ME7808B Broadband system is normally composed of the following Anritsu instruments and accessories (your system may vary depending on your application):

Measurement Instruments

- ❑ 37397D Vector Network Analyzer with Option 12
- ❑ 68037D or MG3692A Synthesized Signal Generator with Option 15A
- ❑ 68037C or MG3692A Synthesized Signal Generator (no options necessary)
- ❑ 3738A Millimeter Test Set
- ❑ 3742A-EW Millimeter Module (quantity 2)
- ❑ 57215 (left) and 57216 (right) Coupler (quantity 1)

Console and Associated Hardware

- ❑ Console
- ❑ Table
- ❑ Mounting rails for Table (quantity 2)
- ❑ Static Dissipative Mat for Table
- ❑ Wrist Strap

Cables

- ❑ Rigid RF Cable (Upper synthesizer to 3738A)
- ❑ Rigid RF Cable (Lower synthesizer to 3738A)
- ❑ Cable Assembly (3742A to 3738A front panel) (quantity 2)
- ❑ Cable Assembly (3738A rear panel to VNA rear panel) (quantity 1)
- ❑ Flexible RF Cable (coupler to VNA) (quantity 2)
- ❑ GPIB Cable (VNA to Synthesizer) (quantity 2)
- ❑ Power Cord (quantity 4)

14-3 INSTALLATION

This section describes installation and system check-out without making use of a wafer-probe test station. For instructions on installation of the wafer probe test station, refer to section 14-5.

IMPORTANT NOTES

- The empty console weighs approximately 66kg (145 pounds). Use two people to remove the console from the pallet.
- Many of the instruments are quite heavy and require two people to lift them.
- Instruments should be loaded into the bottom sections of the console first, to prevent tipping of the console.
- The VNA instrument has fragile RF cables connected to both the front and rear panels. Be careful not to bend these cables when handling the instrument.
- If the synthesizers are not installed precisely as described below, the system will be non-functional.
- We suggest using an 8 in/lb torque wrench to tighten SMA connectors (available in most Anritsu VNA Calibration kits) Do not tighten any connectors over 8 in/lbs.

Console and Table Setup

Set up the console and table as described below.

Step 1. Remove the shipping container and all packaging and accessories from around the console. Set the table aside. Instructions for table installation appear later.

Step 2. Lift or roll the console off the pallet (to lift: insert two sections of lumber through the console top and lift it, using one person on each side).

Step 3. Cut the tie wraps which are securing the table mounting rails at the console rear door. Cut the tie wraps which are securing the power cords and wrist strap ground wire.

Step 4. Attach the mounting rails to the table as shown in Figure 14-1.

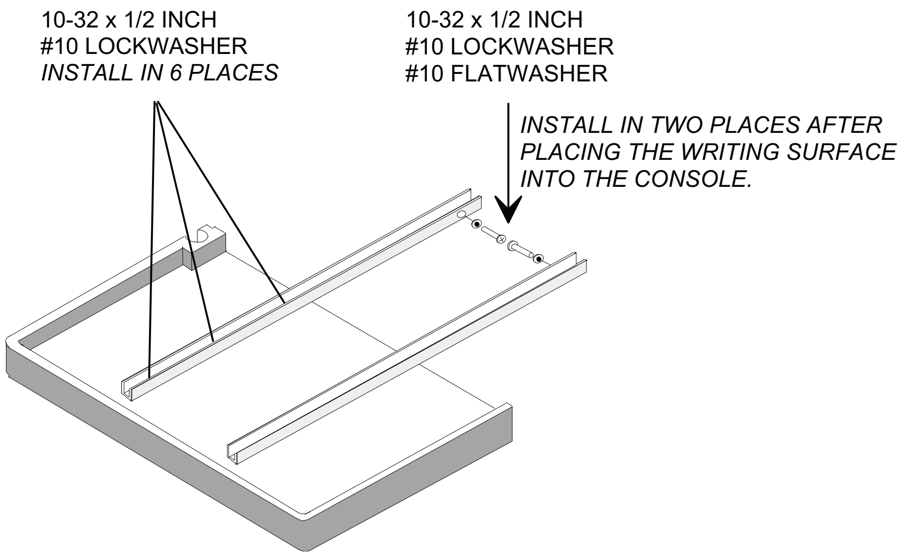

Figure 14-1. Console Table

Instrument Installation into Console

Refer to Figures 14-2, 14-3, and 14-4 for installation of major instruments and cables.

Step 1. Check the rear panel serial number labels of the synthesizers. The instrument without Option 15 belongs in the bottom compartment (“RF” synthesizer).

Step 2. Install the synthesizer with Option 15 in the second opening from the bottom.

Step 3. Install the VNA into the top compartment. Ensure the three small RF cables are installed onto the front and rear panels (one in front, and two in back).

Step 4. Install the 3738A Test Set into the compartment below the VNA.

Step 5. Secure all instruments in the console using the screws provided.

Step 6. On the left front of the console, move the black ground wire away from the guide of the table-mounting rail, and install the table by sliding the table rails into the guides.

Step 7. Secure the table rails at the rear of the console using the screws provided.

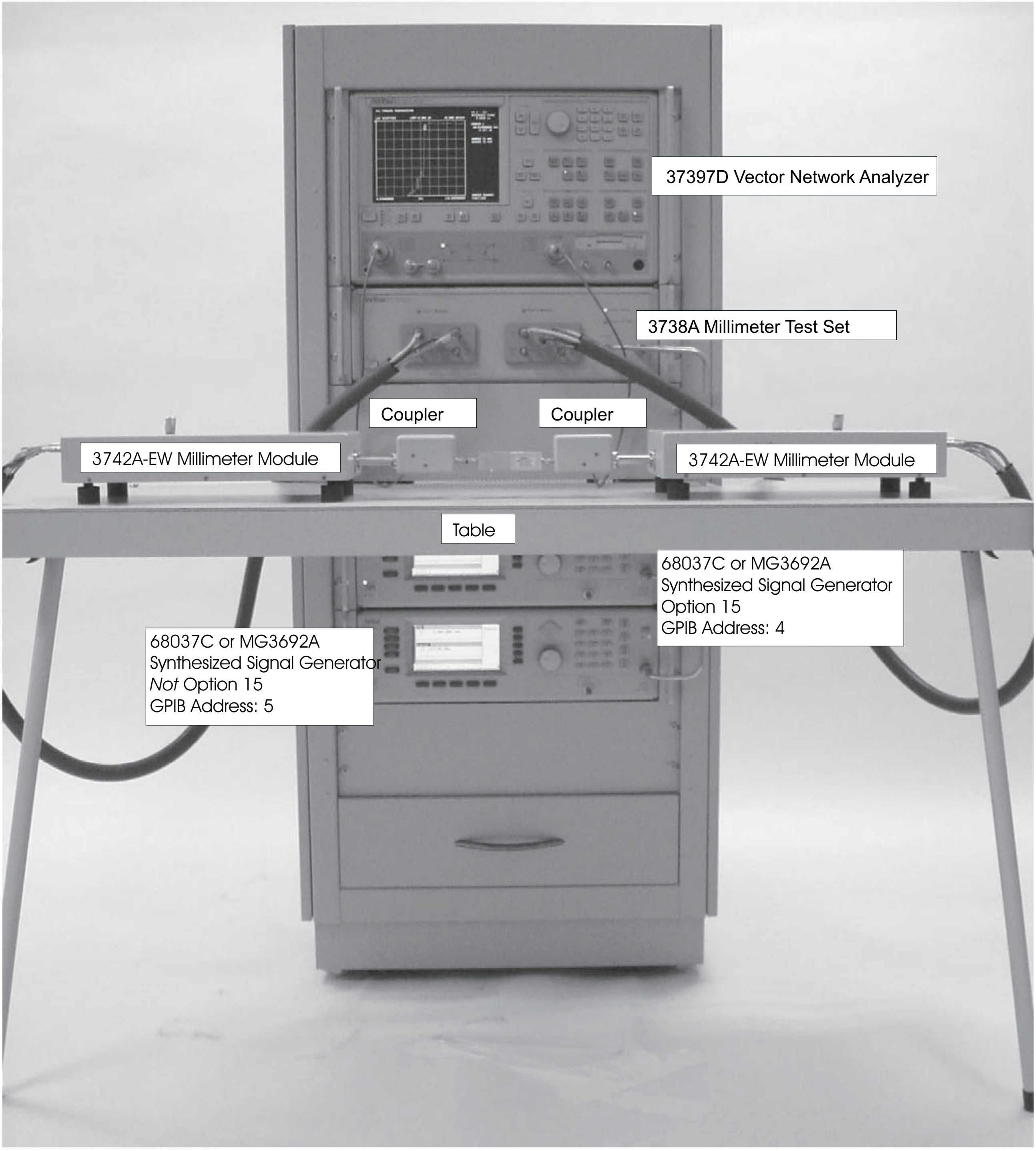

Figure 14-2. ME7808B Console Showing Major Components

Step 8. Lay the static-safe mat on the table and attach the ground cable.

Step 9. Unpack the 3742A-EW modules and set them on the table. Do not attach the couplers to the module test ports - they will not be tested at this time. (To test the couplers requires a W1 (1 mm) Male-Male adapter for mating of Port 1 to Port 2, or a full installation on a wafer probe station.)

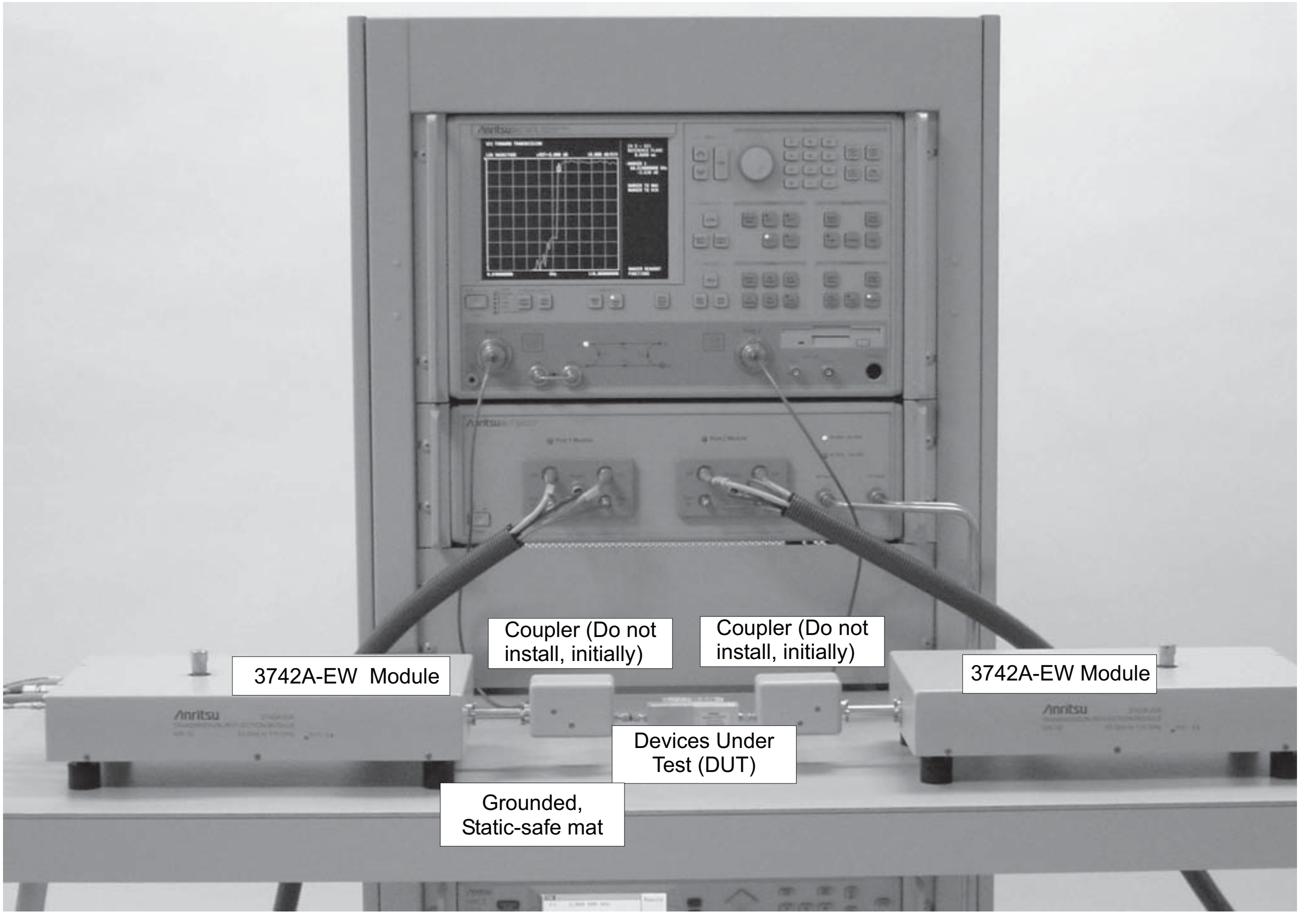

Figure 14-3. ME7808B Console Showing Table and Module Setup

System Cabling

Connect ME7808B system cables as described below and shown in Figure 14-4 on the following page.

Step 1. From the front, connect the rigid RF cable between the upper synthesizer and the 3738A LO IN connector. Ensure the connectors are seated correctly and tightened securely.

Step 2. From the front, connect the rigid RF cable between the bottom synthesizer and the 3738A RF IN connector. Ensure the connectors are seated correctly and tightened securely.

Step 3. From the front, install the two RF cable sets between the 3738A and the 3742A-EW modules. Connect exactly as the labels indicate.

Step 4. From the rear, unscrew the four small chain-mounted terminations from on VNA (let them hang loose) and install the Cable Set. Connect individual cables as indicated on the labels .

Step 5. Connect one GPIB cable from the lower (Dedicated) GPIB connector of the VNA to the upper synthesizer. Connect the second GPIB cable between the two synthesizers.

Step 6. Insert the power cords into all 4 instruments and turn all the instruments on.

Step 7. Ensure that the two synthesizers GPIB addresses are set correctly. The top unit should be set to address 4 and the bottom unit should be set to address 5. This can be verified or changed by pressing SYSTEM | CONFIG | GPIB ADDRESS and entering the appropriate GPIB address.

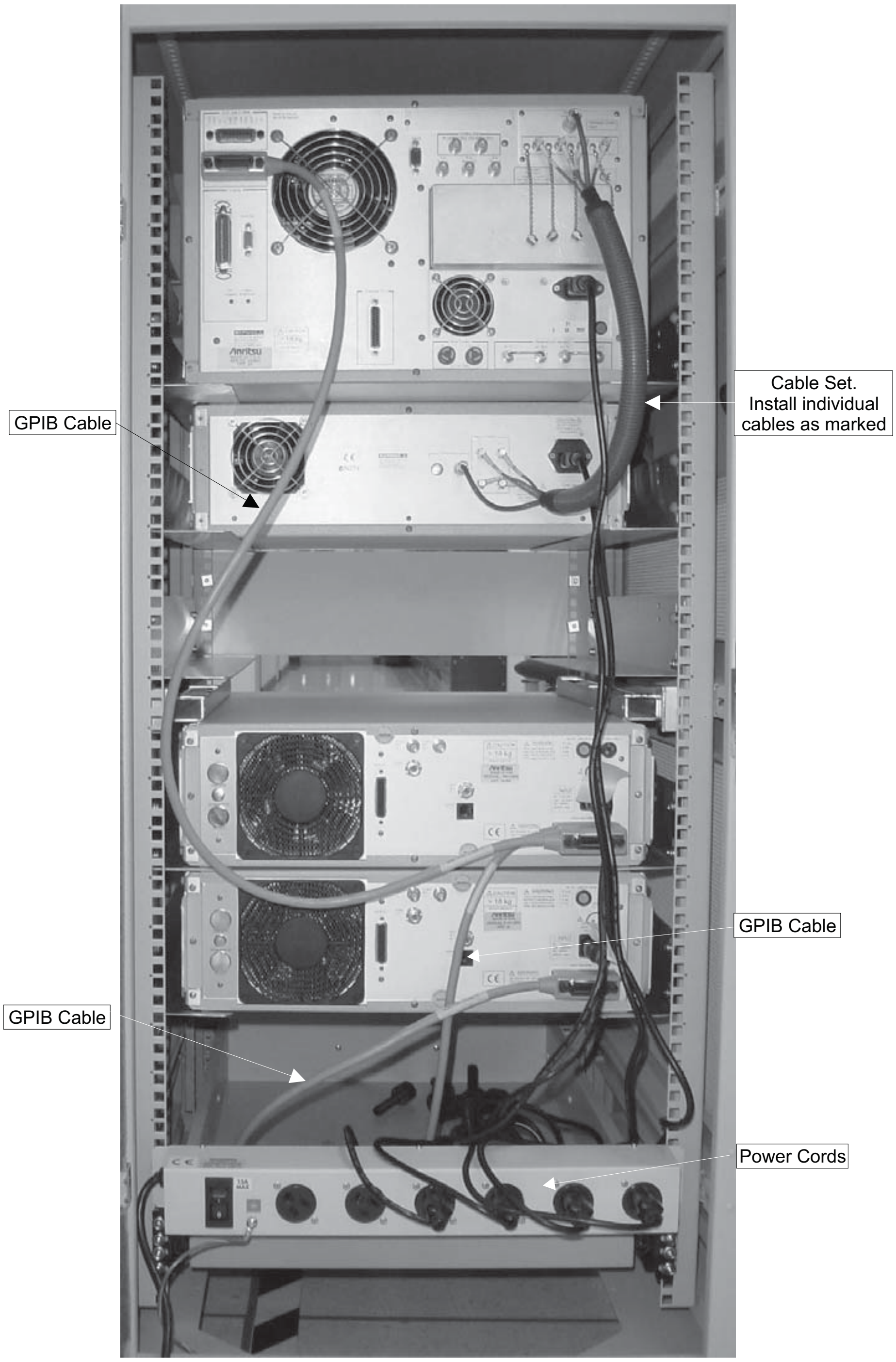

Figure 14-4. ME7808B Console Rear Panel Cabling

14-4 INITIAL ELECTRICAL TESTS

Perform electrical tests as described below:

Millimeter Module Checkout

Check out the Millimeter Modules as described below:

Step 1. Ensure the VNA displays “Self-Test Passed”. If self-test fails, contact your Anritsu Representative.

Step 2. To put the system into the “Millimeter” mode, press the Option Menu key, and select TEST SET CONFIG / MILLIMETER WAVE, then press Enter. Select the correct WR modules for your system.

Step 3. Connect the Port 1 and Port 2 3742A-EW waveguide test ports tightly together.

Step 4. If error messages appear, or the system does not sweep:

- Look for error messages displayed on the synthesizers’ front panels (“ovn cold” is not an error)
- Double-check all cable connections
- Verify the synthesizers’ GPIB addresses are set correctly
- Verify the power control verniers on top of the 3742A-EW modules are set to maximum power (fully CW)

Step 5. Ensure the system is set to default settings (press the Default Program key twice to reset the system).

Step 6. Set the VNA display as follows:
a. Press the Channel Menu key and select SINGLE CHANNEL from the display menu.
b. Press the Ch3 key
c. Press the Graph Type key and select LOG MAGNITUDE from the displayed menu.

Step 7. Ensure the display is similar to Figure 14-5 (next page).

Step 8. Press the Ch2 key.

Step 9. Press the Graph Type key and select LOG MAGNITUDE from the displayed menu.

Step 10. Ensure the display resembles Figure 14-5.

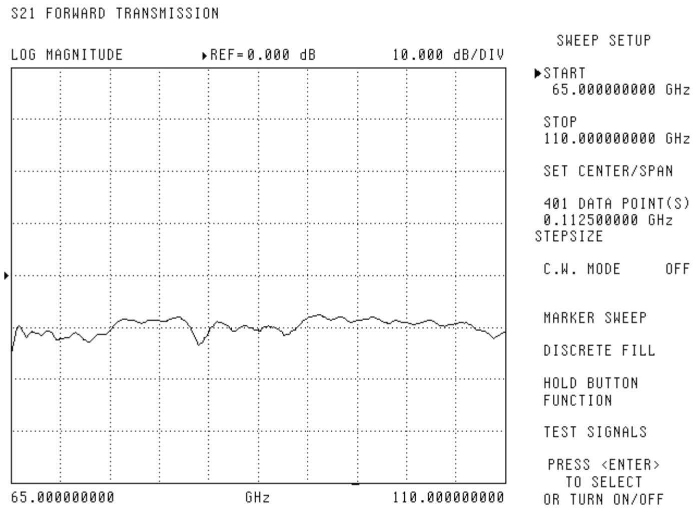

Figure 14-5. Normal S21 Display of MM Module Uncalibrated Transmission

40 MH to 65 GH Checkout

Checkout the 40 MHz to 65 GHz range as described below.

Step 1. Install a throughline between the test ports on the VNA.

Step 2. Disconnect the cables from the rear panel of the VNA that connect to the Test Set. Install the four small terminations, which are hanging from the chains, to the VNA.

Step 3. Press the Option Menu key and select TEST SET CONFIG / INTERNAL from the displayed menu.

Step 4. View single channel S21 and S12 as described above and verify that the traces are similar in appearance to Figure 14-6 on the following page.

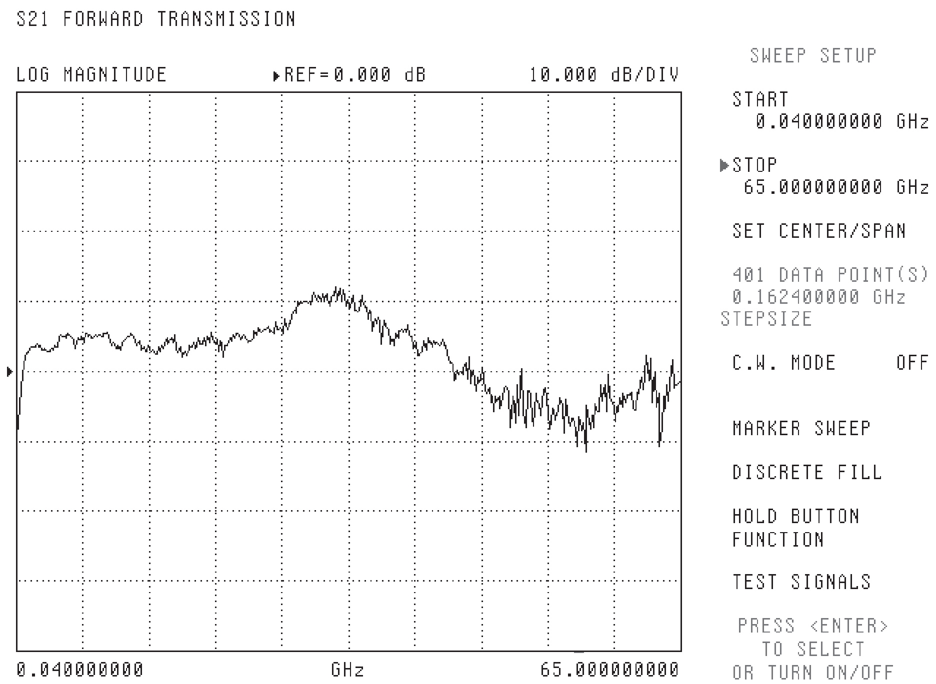

Figure 14-6. S21 or S12 Forward Transmission

The preliminary checkout is complete. (Coupler operation can be checked using the wafer probe station).

You are now ready to install the system to the wafer probe station or configure it to your needs. To activate the full 40 GHz to 110 GHz sweep, press the Option Menu key, and select BROADBAND.

14-5 WAFER PROBE STATION

The ME7808B VNA can be integrated with any standard probe station (manual or semi-automatic) for making on-wafer measurements of active or passive components to 110 GHz. However, there are some considerations for set-up that will ensure accurate and repeatable measurements.

Figure 14-7 (following page) shows integration of the ME7808B VNA with a probe station. The primary connection is from the W1 (1.00 mm) coaxial output on the multiplexing coupler to the wafer probes. If losses through the probes and cables are excessive, the result can be a poor calibration. Therefore, it is recommended that the distance between the couplers and the probes be kept as small as possible. This can be achieved by mounting the millimeter wave modules (3742A-EW) on top of the positioners, as shown in the following figure.

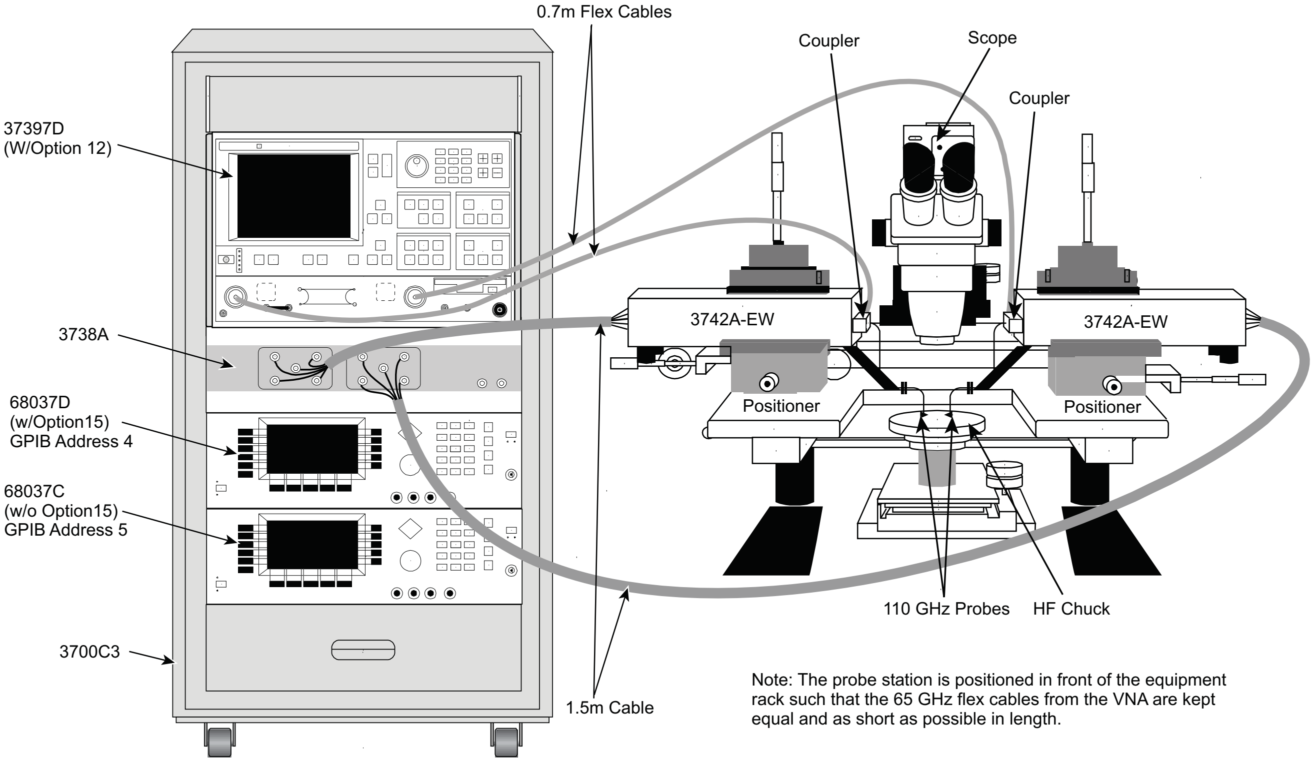

Table 14-7. Probe Station Interconnection

This results in increased output power and hence, enhanced system dynamic range. This concern also applies for the V-connector cables that connect the 37397D VNA to the multiplexing couplers. Placing the probe station directly in front of the ME7808B can minimize these cable lengths. Note that the probe station is shown on the side of the rack simply for clarity purposes.

For more information on wafer probe station integration, please contact Anritsu at 1-800-ANRITSU.

14-6 BROADBAND MENUS, FLOW

The menus associated with the broadband system are shown in Figure 14-8.

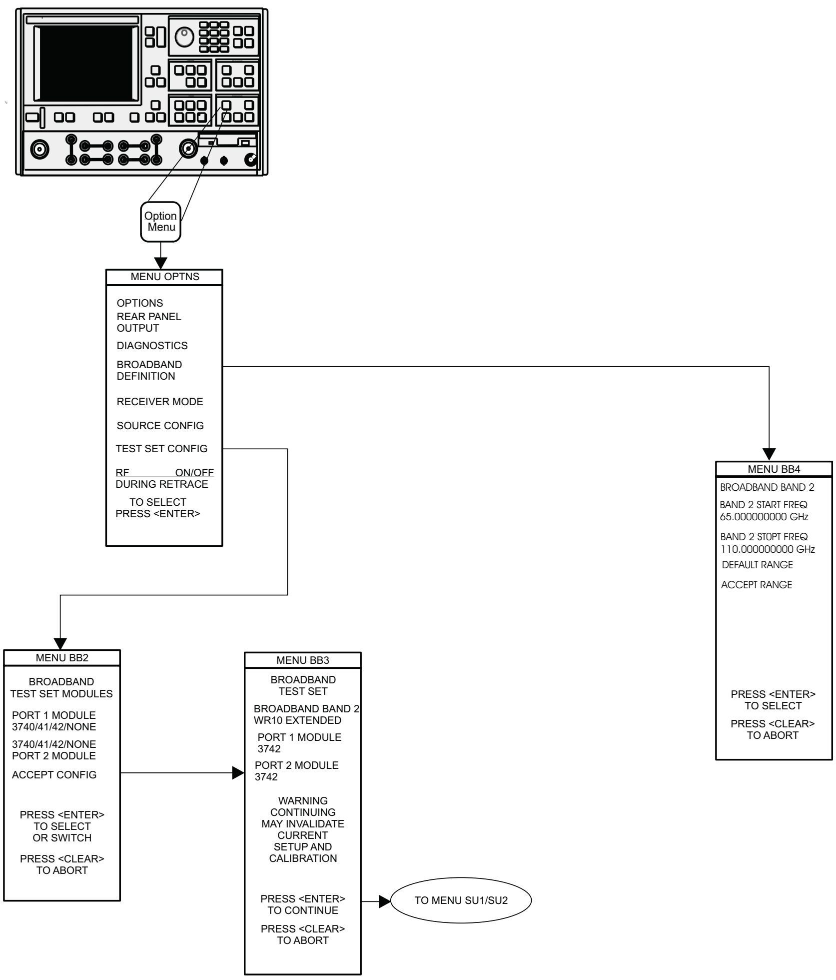

Table 14-8. Broadband System Menu Flow

14-7 BROADBAND CALIBRATION

Broadband coaxial calibrations on the ME7808B are performed using the W1 calibration kit (3656). The most accurate calibration can be achieved during two separate calibrations, an SOLT from 40 MHz to 65 GHz and an SSST from 65 GHz to 110 GHz. Once the SOLT and SSST calibrations have been performed and saved, they can be merged for a continuous, single sweep broadband calibration. (Refer to Chapter 7, Measurement Calibration for SOLT and SSST calibration procedures.) Alternatively, the user may perform an SOLT over the entire band, 40 MHz to 110 GHz, which will result in degraded performance, compared to the previously mentioned routine.

Merging Calibrations

Procced as follows:

Step 1. Press the Appl key.

Step 2. Select MERGE CAL FILES to open menu MRG1 (left).

MENU MRG1

MERGE CAL FILES

CAL FILES MUST EXIST IN THE CURRENT DIRECTORY

MERGE CAL FILES

PRESS <ENTER> TO SELECT

Step 3. Select MERGE CAL FILES again to open menu MRG2 (below left).

Step 4. Select READ CAL FILE 1 FROM HARD DISK or READ CAL FILE 1 FROM FLOPPY DISK to select the SOLT calibration file.

Step 5. After loading the SOLT cal file, select READ CAL FILE 2 FROM HARD DISK or READ CAL FILE 2 FROM FLOPPY DISK from menu MRG3 (below right) and select the SSST calibration file. This step merges the calibration files together.

MENU MRG2

MERGE CAL FILES

READ CAL FILE 1 FROM HARD DISK

READ CAL FILE 1 FROM FLOPPY DISK

PRESS <ENTER> TO SELECT

PRESS <CLEAR> TO ABORT

MENU MRG3

MERGE CAL FILES

READ CAL FILE 2 FROM HARD DISK

READ CAL FILE 2 FROM FLOPPY DISK

PRESS <ENTER> TO SELECT

PRESS <CLEAR> TO ABORT

Step 6. The system is now ready for calibrated measurements over the 40 MHz to 110 GHz frequency range.