MAURY MICROWAVE
CORPORATION

Operating Manual

Automated Tuner System

PC Based Application Software

Models:

MT993A
MT993B
MT993C
MT993D
MT993D01
MT993D02
MT993F
MT993G
MT993H
MT993N01
MT993N07

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Operating Manual
MT993-2 Rev L 10/24/02

Automated Tuner System

PC Based Application Software

Revision 3.00

Models:

MT993A	**MT993D01**	**MT993H**
MT993B	**MT993D02**	**MT993N01**
MT993C	**MT993F**	**MT993N07**
MT993D	**MT993G**	

- S-Parameters
- Noise Characterization
- Power Characterization
- Intermodulation Distortion
- Adjacent Channel Power
- Signal Synthesis
- DC I-V Curves
- Harmonic Tuning
- Oscillator Load Pull
- Enhanced Graphics

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1 General Information

1.1 Introduction

1.1.1 This manual is provided with the following Maury Microwave Corporation Application Software Packages:

a. Model MT993A Power Characterization Application.

b. Model MT993B Noise Characterization Application.

c. Model MT993C Both Power and Noise Characterization Applications.

d. Model MT993D Intermodulation Distortion and Adjacent Channel Power Measurement Applications. (This requires the MT993A or MT993C, since it is an extension of the power characterization application.)

e. Model MT993D02 Oscillator characterization (This requires the MT993A or MT993C, since it is an extension of the power characterization application.)

f. Model MT993F System Control. (This requires the MT993A or MT993C, since it is an extension of the power characterization application.)

g. Model MT993G DC I-V Curve measurement option. (This requires the MT993A/B/C since it is an add-on option, not a stand-alone program).

h. Model MT993H Harmonic Tuning measurement option. (This option requires the MT993A/C since it is an extension of the power characterization application.)

i. Model MT993D01 Signal Synthesis. (This requires the MT993A or MT993C, since it is an extension of the power characterization application.)

j. Model MT993N01 No Tuner option limits the software to s-parameter, noise figure, and/or swept power measurements without tuners.

k. Model MT993N07 Enhanced Graphics.

l. Model MT956D Fixture Version 3.1.

1.1.2 These software packages all use the Maury Microwave Automated Tuner System (**ATS**), and additional microwave instrumentation. The manual describes the hardware requirements, and the installation and operation of the application program (**SNPW**).

1.2 Description

1.2.1 The SNPW program is an integrated interactive program that uses network analyzers to measure s-parameters (Model MT993A/B/C/D), the Maury Automated Tuner System (**ATS**) to find power characteristics (Models MT993A/C/D), noise characteristics (Models MT993B/C), and intermodulation distortion and adjacent channel power (MT993D) of devices.

1.2.2 The MT993A or MT993C software performs rapid and accurate power characterization measurements using the **ATS**, an RF power source, a bias supply, and one to three power meters. It improves the accuracy and reduces the tedium involved compared to more traditional manual measurement methods. Refer to Appendix 4 for the basic theory of power measurements.

1.2.3 The MT993B or MT993C software performs rapid and accurate noise characterization measurements using the **ATS**, a noise source, a local oscillator (if needed), a bias supply, and a noise gain analyzer (noise figure meter). The software also allows the use of a noise figure test set. Refer to Appendix 5 for the basic theory of noise measurement.

1.2.4 The MT993C software is a combination of the power and noise characterization applications. This feature speeds up the design process.

1.2.5 The MT993D software is an extension to the MT993A/C which adds intermodulation distortion (IMD or intermod) and adjacent channel power (ACP) measurement capability. Refer to Appendix 6 for the basic theory of intermodulation distortion measurements.

1.2.6 The Model MT993D01 Signal Synthesis option is an extension to the MT993 A/C/D which adds the ability to use custom I/Q modulation data for ACP measurements. The I/Q data may be calculated for some common modulation types, or read from a file.

1.2.7 The Model MT993D02 Oscillator characterization is an extension to the MT993 A/C which adds oscillator measurements.

1.2.8 The Model MT993F System Control Option allows the use of RF switches to measure s-parameters, noise parameters, and power data with one setup. This also allows complete in-situ calibrations.

1.2.9 The Model MT993G DC I-V Curve Option adds the ability to do DC characterization in the form of I-V Curves.

1.2.10 The Model MT993H Harmonic Tuning Option is an extension to the MT993A/C which adds independent control at harmonic frequencies. Refer to Appendix 4 for the basic theory of power measurement.

1.2.11 The MT993N01 Option limits the ability to make s-parameter, noise figure and/or swept power measurements **without tuners**. The noise figure measurement requires the user_nf user function.

1.2.12 The MT956D Fixture Software can be a stand-alone software product, or it may be an extension to the MT993 Series software. As an extension, it provides a number of unique s-parameter calibration and measurement functions.

1.2.13 The MT993 Series application packages include utilities to measure 1-port and 2-port s-parameters using a variety of vector automatic network analyzers. The editors for Noise Source and Power Sensor file creation automatically measure and combine s-parameter data with the required user entered data. Automatic and manual tuner characterization (relating RF parameters to tuner positions) utilities take data for later use by the software. These utilities allow for embedding the data (reference plane shift to the DUT reference plane) with provided models or models created by the user.

1.3 Hardware Key

A hardware key, Maury Model number MT993K, is supplied, and connects directly to the parallel printer port on the computer. The software will not operate without the hardware key installed.

☞ ***NOTE:*** *The hardware keys are distinguished by serial numbers that have been programmed into the keys. The serial number on the key should be recorded below by the user. Any correspondence regarding the software must include this serial number.*

Hardware Key SN __________.

1.4 Computer Requirements

The MT993 series software is designed to run under MS-Windows® on PC compatible computers using a Pentium® II processor or better. A National Instruments GPIB 32-bit interface card is required to communicate with the instrumentation. See below for a listing of applicable interface cards:

A PCI-GPIB (Plug and Play) 32-bit GPIB card for Windows 2000/XP #778032-01. For Windows® 98, use #777158-01

A PCMCIA-GPIB card, #777156-02 for Windows® 98 or #778034-02 for Windows 2000/XP.

1.5 Equipment Requirements

The Maury MT993 series **ATS** PC software currently supports the following GPIB controllable auxiliary equipment:

ATS Components (used with MT993A/B/C/D/H)

Maury MT986 Series Tuner Controller
Maury MT981 Series Automated Tuners
Maury MT982 Series Automated Tuners
Maury MT983 Series Automated Tuners
Maury MT984 Series Automated Tuners
Maury MT975 Series Automated Tuners
Maury MT977 Series Automated Tuners
Maury MT979 Series Automated Tuners
Maury MT999 Automated Harmonic Tuner

Network Analyzers (used with MT993A/B/C/D/H)

See Appendix 2 for network analyzer instrument setup.

Vector receiver (used with MT933A/C).

This is normally a vector network analyzer with external sampler access.

See Appendix 2 for network analyzer instrument setup.

RF Switch (used MT993F)

See Appendix 2 for RF switch control instrument setup.

RF Sources (used with MT993A/B/C/D/H)

See Appendix 2 for RF source instrument setup.

RF Sources (used with MT993B/C only)

If the HP8970B noise figure meter is used, then any of the SIB supported sources may also be used for noise measurements. See Appendix 2 for details.

Bias Instruments (used with MT993A/B/C/D/H)

Up to six bias supplies may be used. Voltage and Current measurement for each supply can be done with the supply itself, or with optional voltmeters or current meters.

See Appendix 2 for bias setup.

Power Meters (used with MT993A/C/D only)

See Appendix 2 for power meter instrument setup.

Noise Instruments (used with MT993B/C only)

See Appendix 2 for noise instrument setup.

Spectrum Analyzers (used with MT993D only)

See Appendix 2 for spectrum analyzer instrument setup.

ACP Analyzers (used with MT993D only)

See Appendix 2 for adjacent channel power instrument setup.

Frequency Meter (used with MT993A/C/D02)

See Appendix 2 Frequency Meter instrument setup.

Sample source code for each type of driver is provided (except the tuner controller driver) so that additional drivers may be easily written. New drivers must be written in Microsoft Visual C++. See Appendix 3 for details.

1.6 Software Limits

The following is a listing of software imposed limits on the number of frequencies, power levels and other elements of the program. All frequency ranges may have non-uniform step sizes; however, the power range used in the power sweep must have a uniform step size.

Maximum number of calibrated network analyzer frequencies: 801
Maximum number of S-parameter calibration frequencies: 801
Maximum number of tuner frequencies: 51
Maximum number of noise calibration frequencies: 51
Maximum number of power calibration frequencies: 51
Maximum number of S-parameter measurement frequencies: 801
Maximum number of noise measurement frequencies: 51
Maximum number of power measurement frequencies: 51
Maximum number of power levels in a power sweep: 101
Maximum number of ENR frequencies: 101
Maximum number of noise source reflection coefficient frequencies: 801
Maximum number of power sensor efficiency frequencies: 101
Maximum number of power sensor reflection coefficient frequencies: 801

Other limits are:

Maximum number of contours: 124
Maximum calculation resolution for contours: 180
Maximum number of noise or gain circles: 120

The maximum number of characterized tuner positions at any frequency is limited by available RAM and disk space. These are dynamically allocated as the tuners are characterized or read from a file.

2
Introduction to the System

2.1 General

2.1.1 The **SNPW** program automates measurement of s-parameter, noise, power, intermod, harmonic and Adjacent Channel Power (ACP) parameters of RF/microwave devices using the Maury Automated Tuner System. The excellent repeatability, low loss, and well-behaved response of the tuners allows this wide range of applications.

The SNPW program also automates DC I-V characterization of devices. The ability to properly terminate the DUT at RF frequencies can be very important during DC tests, and the automated bias equipment is typically already part of the system.

2.1.2 The five types of RF measurements (s-parameters, noise, power, intermod and ACP) can be made from within the same program if all of the options are installed. However, they require separate setups as shown in Figures 2-1, 2-2, 2-3, 2-4 and 2-5. A basic power setup with harmonic load/ source pull is shown in Figure 2-6.

The setups may be combined using RF switches. This is shown in Figure 2-7.

The DC measurements may be done with any of the setups.

2.1.3 Reference Planes

Before setting up the system, it is important to lay out all of the system components, in order to decide on the reference planes for each major block diagram block. Include all adapters needed to connect blocks together.

A major consideration is to provide the most accurate network analyzer calibrations possible for measuring each block. Choose the connector interface for compatibility with the most accurate vector network analyzer (VNA) cal kits, and make the blocks insertable if possible (i.e. male to female for sexed connector types). For example, if a fixture has female to female, connectors, you could add a male-male adapter on one side to make the fixture male-female.

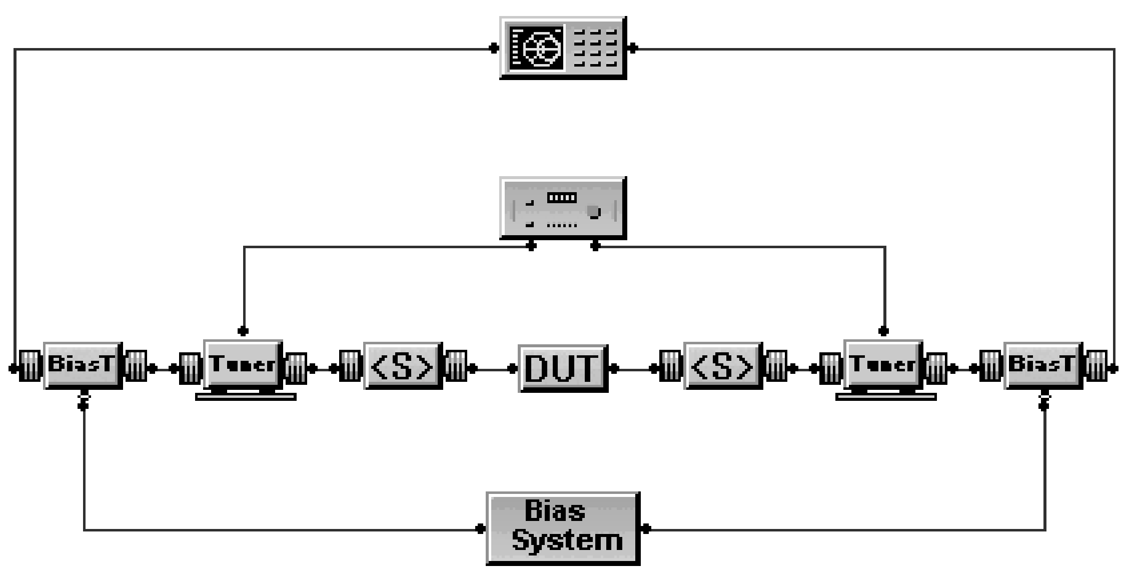


Figure 2-1. Typical Setup for Performing S-Parameter Measurements

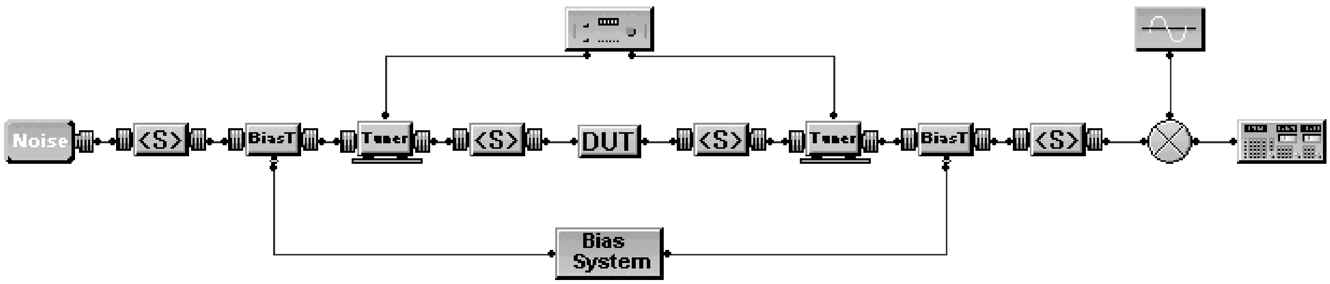


Figure 2-2. Typical Setup for Performing Noise Measurements

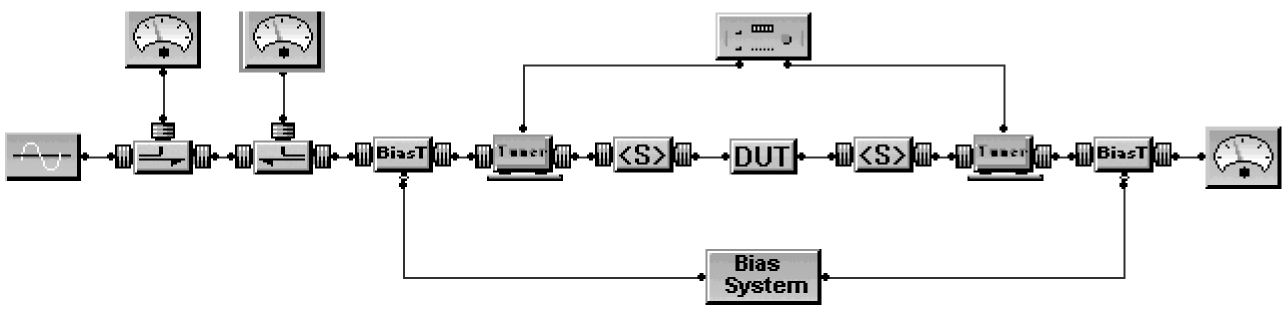


Figure 2-3. Typical Setup for Performing Power Measurements

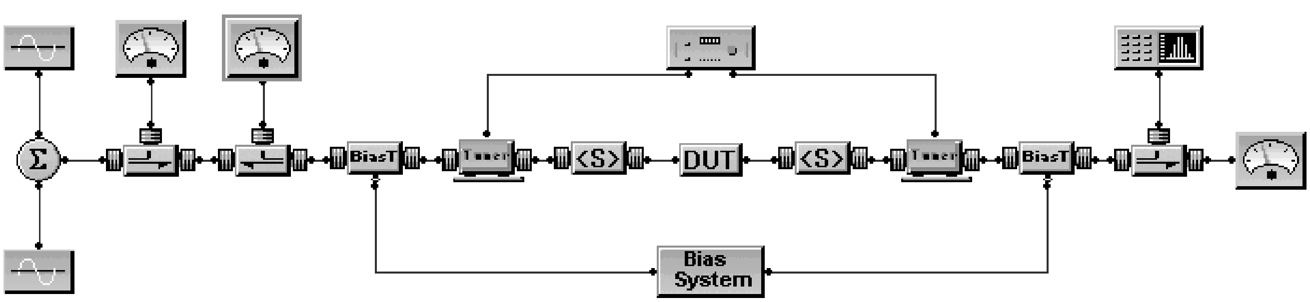


Figure 2-4. Typical Setup for Performing Power/Intermod Measurements

2.1.4 Calibration Approaches

The two basic approaches to calibrating the system are 1) pre-characterize all system blocks separately, and 2) in-situ calibration.

The pre-characterization method minimizes the test equipment that must be tied up with the system, and provides some flexibility to switch blocks in and out without re-calibration.

The in-situ calibration (called SNP Cal) uses the System Control option, and requires a vector network analyzer (VNA) to be permanently connected to the system. However, it allows the entire system to be calibrated without breaking any critical connections. This leaves fewer possibilities for connection error or changes because of cable bending, etc.

A hybrid approach is to do the time-consuming calibrations of stable components (tuners and possibly fixtures) and use the SNP Cal for everything else. This provides a fast calibration while maintaining the benefits of the in-situ calibraiton, minimizing disconnections and movement of unstable components like cables, etc.

2.1.5 System Components to Characterize

The following components need to be characterized, regardless of the calibration approach selected:

a. **Tuners.** The complete 2-port s-parameters, as a function of tuner position, are recorded for both the source and load tuners. Bias tees, adapters, or other 2-port components cascaded with the tuners may be lumped with the tuners so all mismatches and losses may be taken into account.

b. **Noise Source.** The excess noise ratio (ENR) and the reflection coefficients in the hot and cold states vs. frequency are recorded. This is needed only for noise measurements.

c. **Output Power Sensor.** The sensor efficiency, loss of an optional attenuator, and the reflection coefficient versus frequency are recorded. This is needed only for power, intermod or ACP measurements.

d. **Thru.** The thru is used for calibration in both noise and power. It should install in the same place as the DUT, and the reference plane of the S-parameters should be the same as the DUT. It does not need to be a perfect thru, since the measured s-parameters allow accounting for its mismatch and loss.

e. **Fixture.** This is optional, but is useful when the desired DUT reference plane is not at a connector interface. The s-parameters of each half of the fixture from the connector plane to the DUT plane

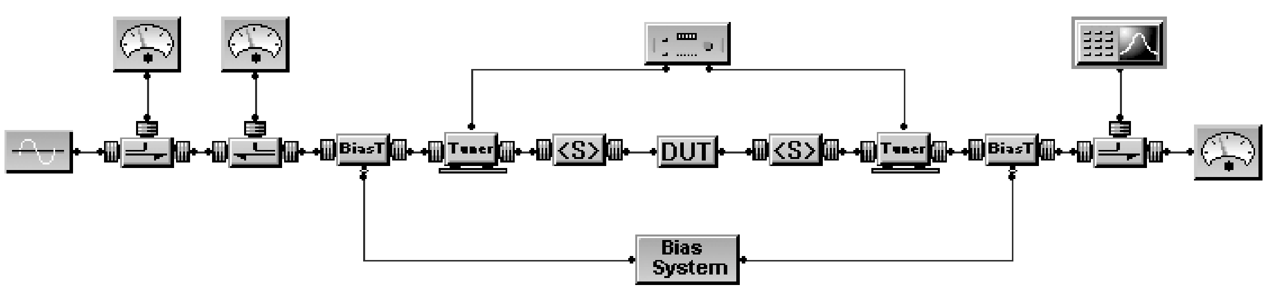


Figure 2-5. Typical Setup for Performing ACP Measurements

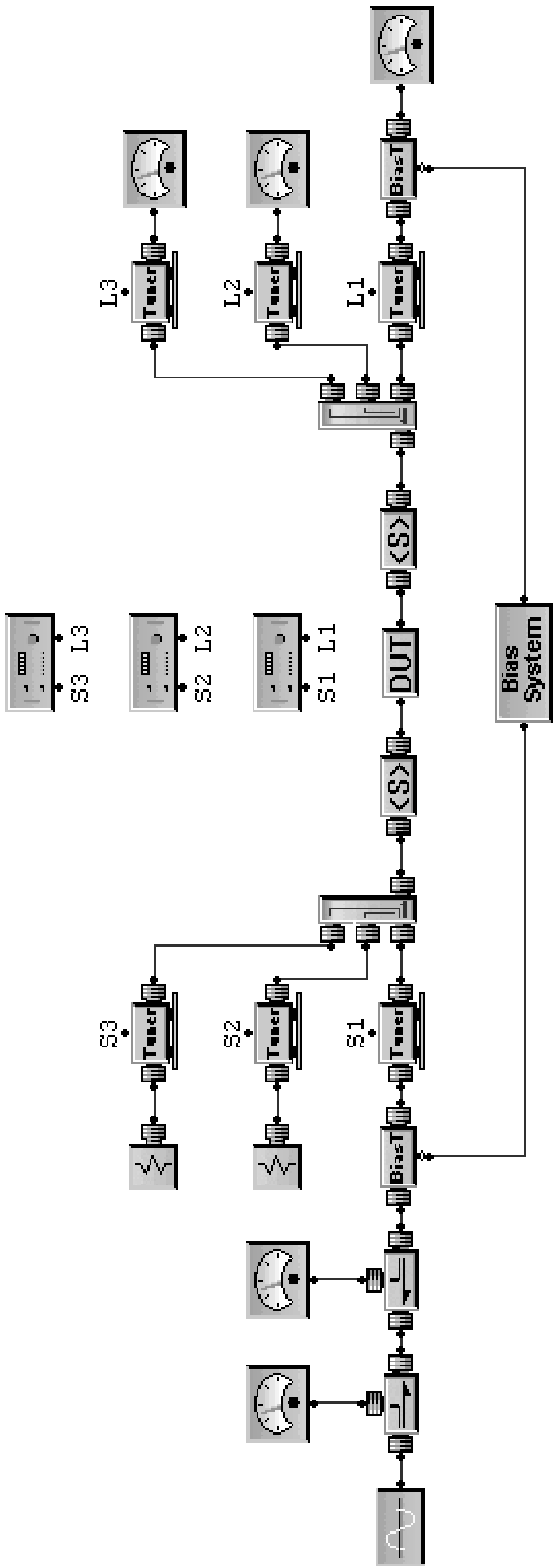


Figure 2-6. Typical Setup for Performing Harmonic Tuning Measurements

can be stored in separate files. This allows accurate calibration of the network analyzer at well-defined connector interfaces, while providing the final data at the DUT planes.

These fixture files are not needed if the built-in models for the Maury Transistor Test Fixture (TTF) are used. They are also not needed if the network analyzer is always calibrated at the desired DUT plane, including the tuner characterization stage and the thru and DUT s-parameter measurements.

f. **Input and Output S-Parameter Blocks.** These are optional, but are useful to characterize block diagram components separately from the tuners. Typical components that might be included could be adapters, bias tees, attenuators, or filters.

g. **Multiplexer S-Parameter Blocks.** These are required to do harmonic tuning. One 2-port s-parameter file is required for each path through the multiplexer that is used (fundamental, 2nd harmonic, and 3rd harmonic). Multiplexers can be used on either the source, load, or both.

2.1.6 The system configuration is also normally saved in a file. This file includes the system file names, instrument descriptions, and measurement options to be set up once, and then easily recalled. Many configuration files can be saved to cover different applications or user preferences, if desired.

2.1.7 Before real measurements can be made, all of the setup files mentioned above must be created. The software provides a variety of menus and editors to do this, and this is covered in detail in Section 4. A step by step overview of the process is also given later in Section 5.

2.2 Text Conventions Used

The following conventions are used within this manual to describe keystroke and data entry conventions:

a. When you are instructed to “Press”, simply type the indicated key or key combination.

b. When you are instructed to "Select", select an item from the indicated menu or dialog.

c. Items shown within angle brackets < > and which include a capital letter, such as **<F1>**, **<ESC>** or <Calibrate> may indicate either a key, a menu item, or a button in a dialog box. When you are instructed to "Press", it indicates the key on the keyboard which has those specific letters printed on it. When you are instructed to "Select", it indicates a menu item.

d. Items shown within angle brackets < > and which begin with a lower case letter, such as <down arrow> and <up arrow>, indicate the key on which the described symbol is printed or the key that performs the described action.

e. Items shown within square brackets [ ], such as [d:] or [path], are optional items and may be ignored if the default operation is desired.

2.3 Menu Structure Overview

2.3.1 Menu Bar

The SNPW software has many different views, and each view has it's own menu. The menu bar showing at any time will be associated with the active view. The block diagram view has the main menu, so it is the starting point for doing most of the major actions.

NOTE: *Some menus also have tool bars for faster access to some of the most common menu items.*

The <File> menu available in most views typically will apply to file and print functions which are specific to that view. For example, the <File> menu in the block diagram view handles configuration files and will print the block diagram, whereas the <File> menu in the swept power display handles just the swept power files and will print the swept display.

The <Edit> menu available in most views typically includes editing of the label, and copying the data from the view to the clipboard. This data can then be pasted into other Windows applications.

The <View> menu available in most views relates to displaying data. This menu in the block diagram view is used to recall data from files or memory for display. This menu will adjust the display format in most of the data displays.

The <Window> menu available in most views controls the display of multiple windows. The background color of most data displays can also be changed here.

NOTE: *The background color in most views can be toggled from black to white from the <Window> menu. However, the print functions will always use a white background.*

The <Help> menu available in most views provides access to help topics. The <About> item gives information about the software revision, serial number, and installed options.

NOTE: *If a menu item is displayed with a gray color, it is inactive and cannot be selected. This is usually because some other action must be done first to make it active, or it is part of an option which was not purchased.*

2.3.2 Popup Menus

Many views have popup menus that are accessed by a right click on a display object, such as the Smith chart. This will typically provide functions such as zoom or selecting points. The power measurement control screen is an example.

2.3.3 Active Text

Some views have text that will highlight when the mouse is moved over it. Typically, this will be something like a scale value or formatting variable. Left clicking the text while it is highlighted will change it or bring up a dialog.

2.4 Getting Help

On-line help is available at many places within the program. It is accessed by pressing <Help><Help Topics>.

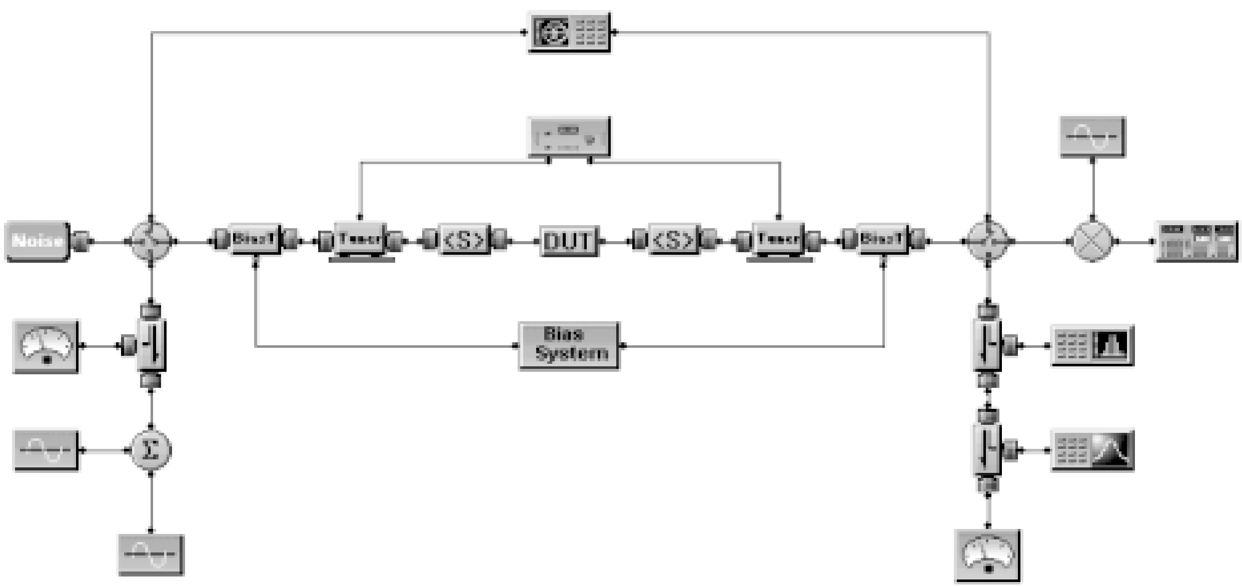


Figure 2-7. Typical Setup Using RF Switches to Measure S-Parameters, Noise and Power With One Connection

2.5 Demo Mode

A demonstration mode is built into the software to simplify learning how to use the software. This mode is set when the factory default configuration is selected, or can be turned on or off in the setup options dialog box.

When the demo mode is set, the program will not talk to any instruments, but will use a built-in system model to generate simulated data. The simulated data is sufficiently realistic to give a feel for the program operation.

☞ ***NOTE:*** *The configuration file, demo.cfg, which is provided, is already setup to use all of the demonstration data files.*

It is recommended that new users start with the demo mode to learn what to expect from the program before starting real measurements. See Appendix 1 for details.

3
Installing the Maury ATS Application Software

3.1 General

3.1.1 The Maury **ATS** Application Software Install program copies the Maury **ATS** Application Software programs and directory structure to your hard disk. Before you can start using Maury **ATS** Application Software, you must install the software using the Setup Program found on Master Distribution CD-ROM.

3.1.2 In this chapter you will learn how to set up Maury **ATS** Application Software on your hard disk. You will also learn how to start Maury **ATS** Application Software and what to do next to put Maury **ATS** Application Software to work for you.

3.2 System Requirements

3.2.1 To use Maury **ATS** Application Software you need the following:

a. The master Maury **ATS** Application Software distribution CD-ROM and Hardware Key.

b. A personal computer operating MS-Windows® 98, 2000, or XP with a Pentium® II processor or better, 64 megabytes (MB) of random access memory (RAM) minimum (128 MB recommended), 20 MB of free disk space (40 recommended), and a CD-ROM drive.

c. The computer must have an available PCI slot and parallel port.

☞ **NOTE:** *Minimum RAM and hard disk space requirements assume no optional components or network installation.*

d. A VGA (800 x 600) or compatible, video graphics adapter with 16MB of Video Ram.

e. National Instrument GPIB interface board. This may be either a PCI-GPIB card or a PCMCIA card.

☞ **NOTE:** *See Appendix 2.*

f. A Microsoft® Mouse, or compatible, pointing device.

3.3 Setting Up the National Instruments GPIB Card

3.3.1 Install National Instruments Software and Configure Hardware.

Follow National Instruments directions to install their Windows® 32-Bit GPIB software (Version 2.00 or later). Be sure to use their software to test the installation before proceeding.

3.3.2 Modify the National Instruments Default Settings.

☞ **NOTE:** *The following details are for windows® 98. Access to these setup dialogs will vary, depending on the operating system in use.*

Right click on “My Computer” and then select “properties”. Select the Device Manager tab, and then with “National Instruments GPIB Interfaces” highlighted, select properties. Activate the “Device Templates” tab. You will need to modify the settings for Dev1 through Dev30. Change Dev1 through Dev30 settings by adding check marks to “Terminate Read on EOS”, and “Set EOI with EOS on Write”. Also change the EOS byte from “0” to “10” for all devices. Modify Dev17 through Dev30 to use Interface “GPIB0” and set the “GPIB address” to correlate with the “Device Name”. See Figure 3-1 for examples of before and after.

The above changes were for each device, you will now need to make changes to the “Board” settings as follows:

Right click on “My Computer” and then select “properties”. Select the Device Manager Tab, and then click the + (plus) in front of the “National Instruments GPIB Interfaces”. Highlight the expanded item and choose properties. Select the “NI-488.2 Settings” tab. Verify that the “Interface Name” is “GPIB0” and that “System controller” is checked. Also, check the first three “Termination Methods”, and set the “EOS” byte to 10.

Now select the “Advanced” button and change/verify the following settings: “Bus Timing” = 2 µsec, “Parallel Poll Duration” = default, “Cable Length for HS-488” = off. Turn off (uncheck) the following: “Automatic Serial Polling”, “Assert REN when SC”, “CIC Protocol”, and “Demand Mode DMA”. Click “OK”. See Figure 3-2.

You are now ready to install the Maury **ATS** Application Software.

3.4 Installing Maury ATS Software Under Windows® 98/2000/XP

3.4.1 Software Installation

☞ ***NOTE:*** *Reboot computer just before beginning.*

CD-ROM D: drive example:

a. Insert SNPW CD-ROM into CD-ROM drive of computer.

b. Start Setup by selecting:

Start
Run
D:\Setup
OK

c. Follow the instructions of the installation screen.

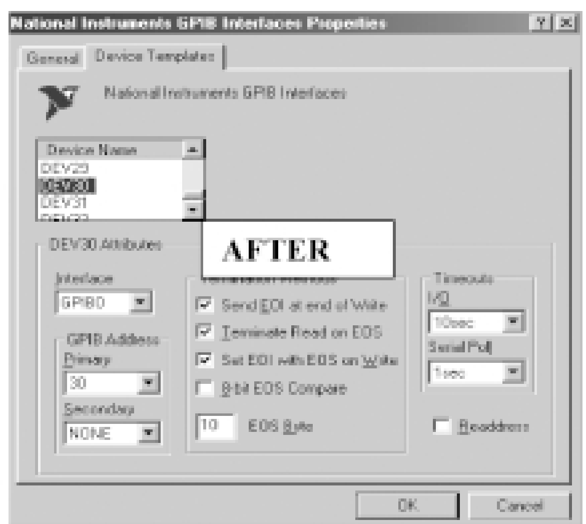


Figure 3-1. GPIB Device Template Setup

3.4.2 Connecting the Hardware Key

Install the Hardware Key to the parallel port of your computer, with the end marked "Computer" connected directly to the parallel port. An existing printer can be reconnected to the other end of the key.

3.4.3 Compatibility With Files From Previous Release

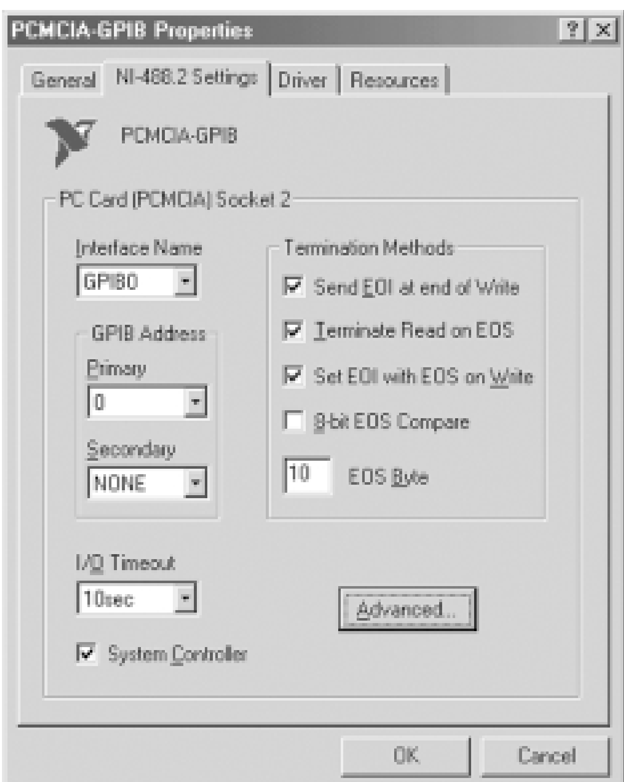
The following file types (with extension) may be safely copied to the appropriate directories in the new structure:

Tuner characterization (.TUN)
S-parameter (.S1P and .S2P)
Noise Source (.NS)
Noise Measurement (.SF and .SB)
Power Sensor (.PM)
Load pull (.LP)
Source pull (.SP)
Swept power (.SWP)
Sweep Plan (.SPL)

Configuration files from past releases (starting with Version 2.00) may be read in and converted. The path portions of the driver file names will be optionally stripped to avoid using drivers from the old directory.

3.4.4 Starting Maury ATS Application Software

After you have installed your Maury **ATS** Application software, you can start the application. Click <Start> <Programs> <Maury Automated Measurement> <Snpw>. (This is the default location used in the installation.)



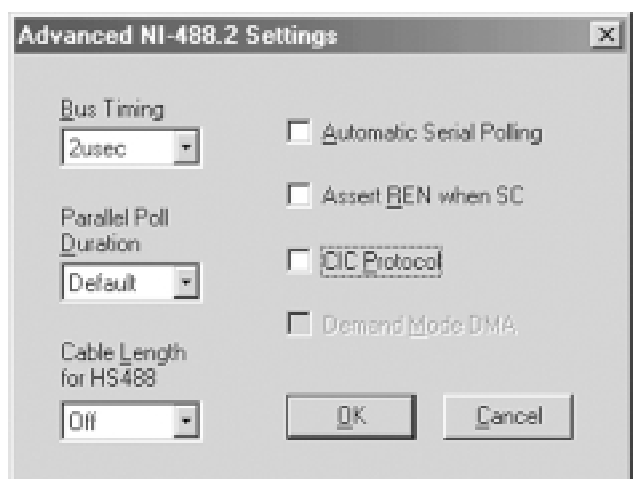


Figure 3-2. GPIB Board Template Setup, Advanced Setting.

4
Setting Up the System Configuration

4.1 Overview of the Setup Process

4.1.1 This section outlines the various steps required to prepare the system for use and which section to use for detailed instructions. Use this as a check list and guide when setting up the system for the first time.

4.1.2 All software options require the same basic steps:

a. Install Software per Section 3.0.

b. The recommended way to initially set up a new configuration is to choose <Default> from the <File> menu. This will clear the block diagram and file specifications. This helps to ensure that you don't accidentally use demo data in your setup.

c. Define the instruments you are going to use. See Section 4.3.

d. Specify where to save and recall calibration and measurement data files. See Section 4.4.

e. Specify special measurement options. See Section 4.5.

☞ ***NOTE:*** *Set Demo Mode to "No" for real data.*

f. Decide on the reference planes. Setup the bench with all adapters, cables, etc., and choose the planes that will divide each of the blocks in the block diagram. Since system accuracy depends on s-parameter calibrations during the setup phase, choose planes at connectors that will produce the most accurate calibrations. Then separate the blocks at these reference planes for characterization of the support data files.

☞ ***NOTE:*** *Try to select reference planes that produce insertable blocks whenever possible. This means that the connectors on opposite ends will be either sexless or of the opposite sex from each other. Otherwise, non-insertable s-parameter calibrations will be required, and that adds more chances for errors and takes longer to do.*

g. Create the following support data files (if needed):

1. Tuner Characterization files (MT993A/B/C/D/H). See Section 5.1.
2. Thru s-parameter files (MT993A/B/C/D/H). See Sections 5.2 and 6.3.
3. Fixture files (optional for deembedding). See Sections 4.8 and 6.3.
4. Input and Output s-Parameter blocks (Optional). See Section 4.4.2 and 6.3.
5. Noise Source file (MT993B/C only). See Section 4.6.
6. Power Sensor file (MT993A/C/D/H only). See Section 4.7.
7. DUT s-parameter files (MT993A/D optional, MT993B/C required). See Sections 4.8 and 6.3.
8. Multiplexer s-parameter files (MT993H only). See Section 4.8.3 and 6.3.

h. Tell the system the names and location of these support files as required. See Section 4.4.

i. Save the system information. See Section 4.9.

j. After verifying the proper system setup, calibrate the system. See Section 5.2 for S-parameter, Section 5.3 for Noise, Section 5.4 for Power, Section 5.5 for Intermod, and Section 5.6 for Adjacent Channel Power.

k. Make measurements. See Section 6 for S-parameter, Section 7 for Power, Section 8 for Intermod, Section 9 for Adjacent Channel Power, Section 10 for Noise, and Section 11 for DC-IV Curves.

4.2 System Configuration

4.2.1 The System Configuration

The SNPW program allows the user to use a variety of instruments and to set up options for the specific application. For convenience, a variety of default Windows path names and filenames can also be entered. This system configuration can be saved at any time to avoid repetitive entries. This feature can also be used to save different configurations for different users or applications.

Configuration files are used to store the system's setup information. This includes the instrument definitions, default Windows path names and filenames, system options, and a variety of other calibration, measurement, and display parameters.

After either saving or recalling a configuration file, the filename will become the new start up configuration filename.

NOTE: *Be sure to save desired configurations, otherwise they will be lost as soon as the program is stopped.*

4.2.2 Selecting a System Configuration at Program Start-up

When the program starts, the last configuration file either saved or read will be loaded. This simplifies the entry after the system has been set up. The current configuration filename will be shown in the caption of the block diagram view.

To clear the block diagram and setup files, select <File><Default>. This will initialize all of the system variables to a fixed starting point. To set up a demonstration mode, select <File><Open> and then select demo.cfg with the browser. This is useful for learning the flow of the SNPW program.

NOTE: *It is recommended that new users start with the demo mode to learn what to expect from the program before starting real measurements. See Section 2.6 and Appendix 1.*

4.2.3 Saving Configuration Files

The current system configuration settings may be saved anytime before the program is exited.

To save the active configuration, select the Block Diagram View as the active view, then select either <Save> or <Save As> on the <File> menu. If <Save As> was selected, enter a filename when prompted without any extension. The software automatically appends ".cfg" to configuration filenames when they are saved.

4.2.4 Recalling Configuration Files

A previously saved configuration can be recalled any time while the program is running. Select the Block Diagram view as the active view, then select <File> from the SNPW Menu, then select <Open>.

When prompted, select a filename. The default extension is ".cfg".

NOTE: *See Section 4.2.2 for details on selecting a configuration at program start-up.*

4.2.5 Printing The Configuration

Select <File> from SNPW Main Menu (with the Block Diagram view active), then select <Print > to print the block diagram.

4.2.6 The Setup Menu

Most of the system configuration is done from the Setup Menu. This includes all of the instrument definitions, default filenames, and major system options. The Setup Menu provides editors for the Noise Source files and Power Sensor files, and also does the tuner characterization.

When the SNPW program is first installed, set up the configuration in the Setup Menu and save it in a file before starting any measurements.

NOTE: *Although many default values can be set up in the Setup Menu, they can also be modified during the running of the program. This includes items like tuner filenames, bias values, or ambient temperature. Other default values, such as the display parameters and scales, can only be set during the running of the program.*

4.3 Editing the Block Diagram

4.3.1 General

The configuration setup is now displayed visually as shown in section 2. Three standard measurement configurations, s-parameter, Noise and Power, can now be selected from the <Setup> pulldown menu. These three configurations are all saved in the same configuration file.

All three block diagrams will be combined into the SNP System Block Diagram if the RF switches are turned on. See Figure 2-7. (SNP means S-parameters, Noise, and Power.) This setup allows all measurement types to be done in the same setup.

The port conventions of the various S-parameter blocks can be displayed by setting "Show RF port numbers" to yes in the <Setup><Options><System>. See Figure 4-15.

Each block diagram configuration setup includes a descriptive text label. This allows the user to quickly identify the setup. This label text is entered from the <Edit><Label> pulldown menu.

4.3.2 Editing Block Diagram Components

The configuration setup can be modified by either double clicking on an icon or adding equipment from the <Setup> pulldown menu.

Double clicking on a tuner icon brings up the tuner properties control. See Figure 4-1.

Double clicking on an S-parameter icon brings up the S-parameter properties control. See Figure 4-2.

Double clicking on a harmonic multiplexer icon brings up the Multiplexer properties control. See Figure 4-3.

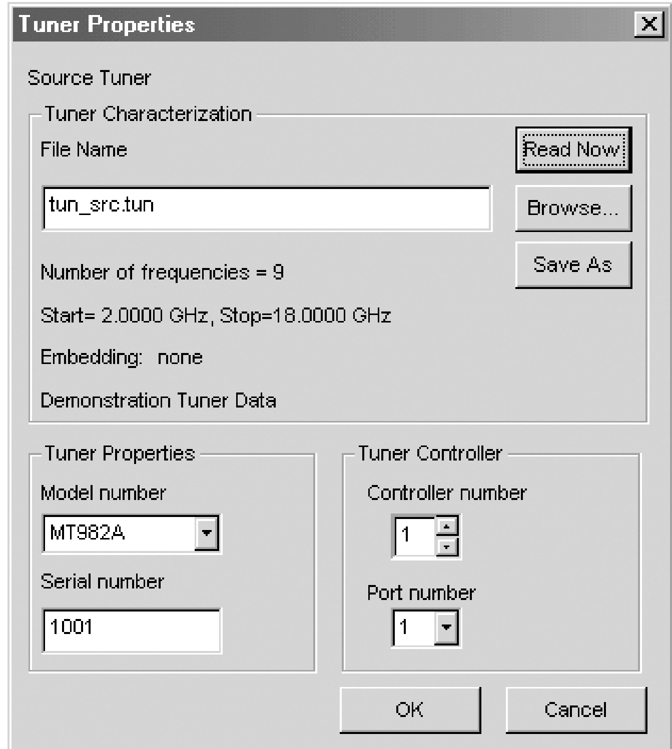


Figure 4-1. Tuner Properties

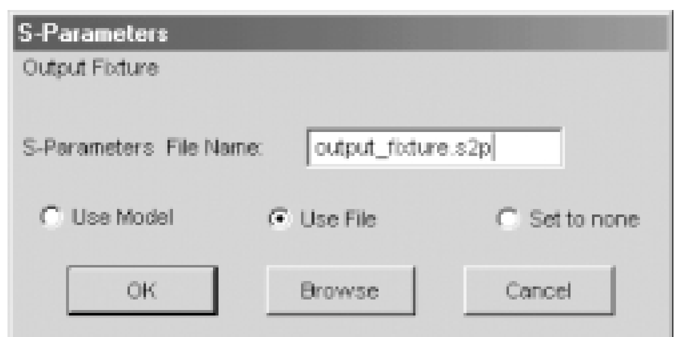


Figure 4-2. S-Parameter Properties

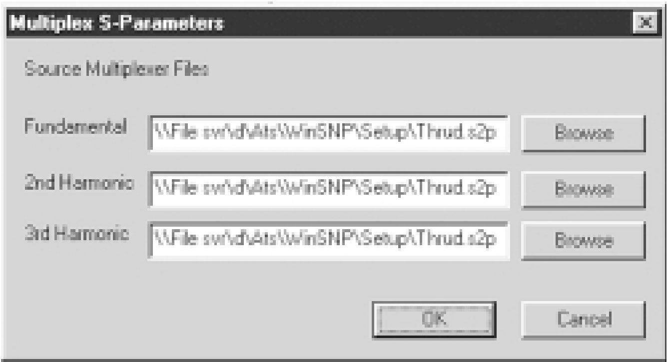


Figure 4-3. Multiplexer S-Parameter Files

Double clicking on the Bias System icon brings up the bias system setup control. See Figure 4-4.

Double clicking on an instrument icon brings up the Instrument controls. For example, double clicking on the VNA in the standard s-parameter Block Diagram brings up the VNA driver control. See Figure 4-5.

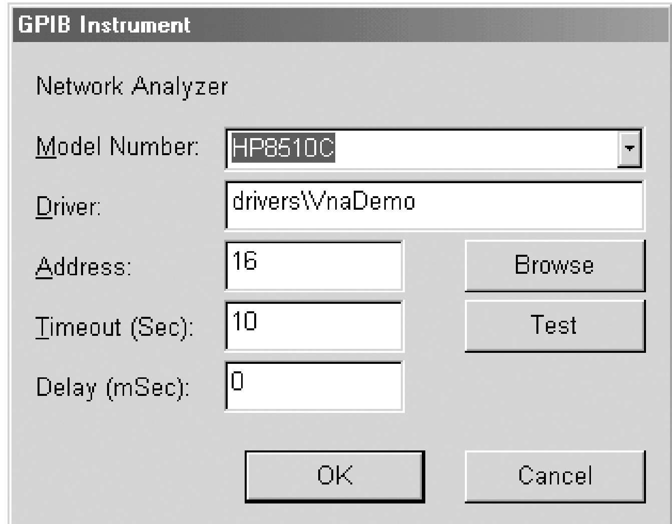


Figure 4-5. Typical Instrument Properties

S-parameter blocks can be added on the input of the source tuner and the output of the load tuner. This makes it easier to change bias tees, attenuators, etc. These s-parameter blocks are added from the <Setup> <Default Files/

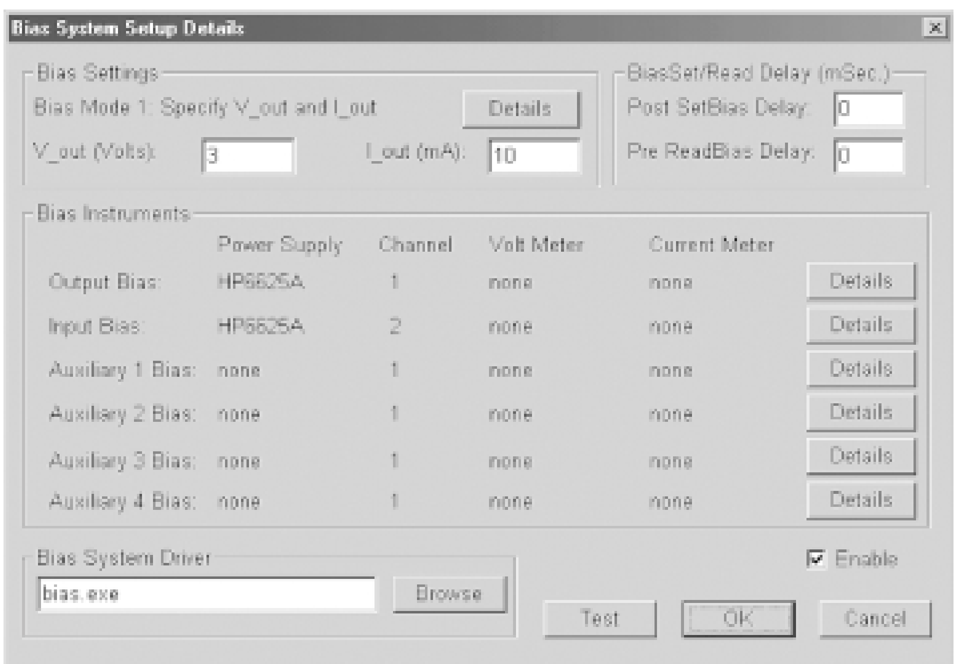


Figure 4-4. Bias System Setup

Directories> <Deembedding> control. See Figure 4-10.

4.4 Setting Up the Instruments

The SNPW Instrument Editor is used to specify the system instruments. From the SNPW Menu, select <Setup>, then <Instruments...> to start the Instrument Editor shown in Figure 4-6. For each required instrument, set up the model, driver, GPIB address, and time out value. First, click to select an instrument**.** Next, edit each item in the dialog. Click <Browse> to browse for the driver filename. See Section 4.4.1 for details on selecting the bias instruments and setting up the bias conditions.

NOTE: *Instrument properties may also be edited by clicking on the icon in the block diagram, if it is already there.*

Clicking on the <Test> button in the instrument properties dialog will start the driver in a stand-alone mode. In this mode, the driver will create a window with some descriptive information, and a test menu. This is useful for checking the capability of a driver, or testing the operation of a single instrument.

NOTE: *To see the model numbers that are supported by the driver, click the <Test> button, and select <Find> from the test menu.*

NOTE: *Set the model number to "none" for any instrument category that is not in the setup. It is also good practice to avoid having unused instruments connected to the GPIB. When the model is set to "none", the item is removed from Block diagram. To get it back, go to <Setup>.*

NOTE: *The term driver refers to the executable file which drives the particular instrument. This will normally be an .EXE file in the subdirectory DRIVERS. Due to the potential complexity of bias systems, bias supplies and monitors are programmed from the single executable file \bias.exe. This file then calls user-selected instruments from a list of *.dll files.*

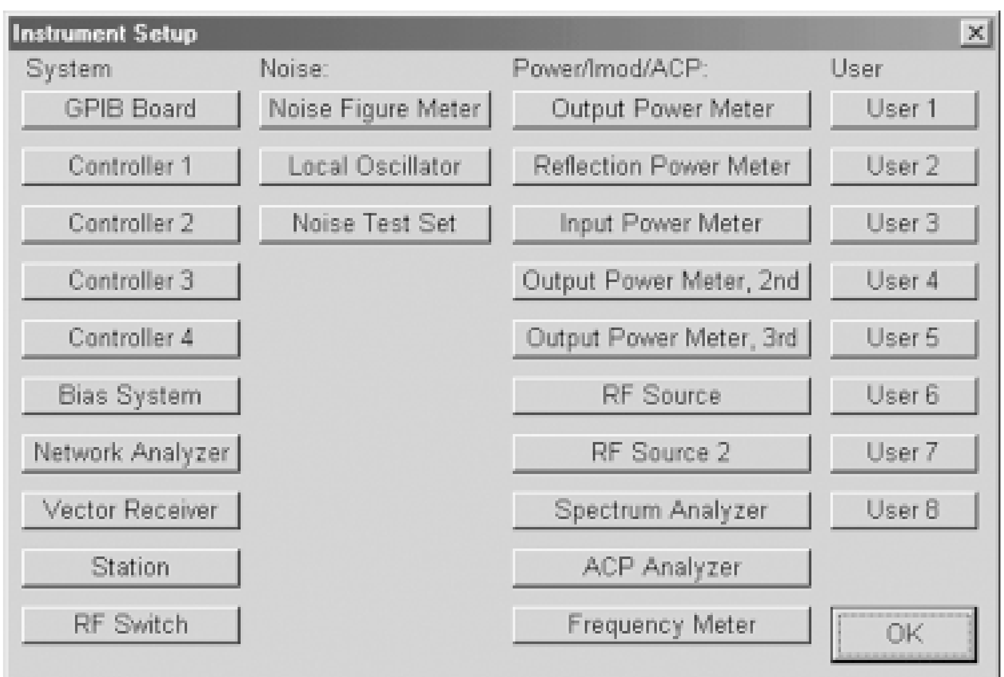


Figure 4-6. SNPW Instrument Editor

A detailed listing of the Maury supplied drivers, along with critical setup information, can be found in Appendix 2. The model numbers and time-out values are typed in or selected from a list, and the driver is most easily selected by browsing. The GPIB address should be the same as the address set inside the actual instruments, and this must be unique for each instrument.

☞ ***NOTE:*** *If a desired instrument driver is not available, a custom driver for that specific instrument may be written. Appendix 3 defines how to write such a driver.*

The "USER" Group of instruments can be setup for special requirements. This group will not be used by the main program except to initialize the driver names and to pass the setup information to each driver.

☞ ***NOTE:*** *After setting up the instruments, be sure to save the system configuration so it can be recalled in future measurement sessions.*

4.4.1 Setting Up the Bias System

Click on <Bias System> in the Instrument Editor to bring up the Bias System Setup dialog (see Figure 4-4).

Bias Settings:

The bias mode, values, and other details may be set here or in the System Options editor. Click on details to bring up the entry dialog. For the first time user, it is recommended that these settings be entered in the Options editor since both dialogs are of equal priority, and changes made later will be reflected here. See Section 4.6.2 and Figure 4-16 for entry details.

Bias Set/Read Delay (mSec):

If the system requires time to stabilize after setting or before reading a bias value, enter the delay time here.

Bias Instruments:

Click on <Details> next to a specified bias (Output, Input, etc.) to bring up the instrument selection dialog (See Figure 4-7). Each selection includes a bias supply and any included meters. Click browse to bring up the file listing for the individual instrument drivers. Note that these are *.dll files located in the Snpw\drivers folder.

Bias System Driver:

The bias system is operated by a single overall driver, bias.exe. This driver will then call the selected DLL files for each bias instrument. This allows any combination of bias instruments to be used with the one bias driver.

Enabling the Bias:

To add the bias system to the block diagram, check the <Enable> box. Unchecking the <Enable> box will remove the bias system from the block diagram.

If the system is to make real measurements, make certain the <Enable> box is checked.

4.5 Setting Up the Default Files and Directories

From the SNPW Menu, select <Setup>, then <Default Files/Directories> to start the property sheet. Supply the requested information, then exit by clicking <OK>.

☞ ***NOTE:*** *This property sheet should be used whenever new system data files are created. Be sure to save changes per Section 4.2.*

Windows filename and path conventions should be followed, except that no extension should be entered, as the program will add default extensions automatically. If an extension is included, the program will use it, but if it's non-standard, it may be difficult to find later.

Many times, when prompted to enter a file name, a default file name or directory is pre-

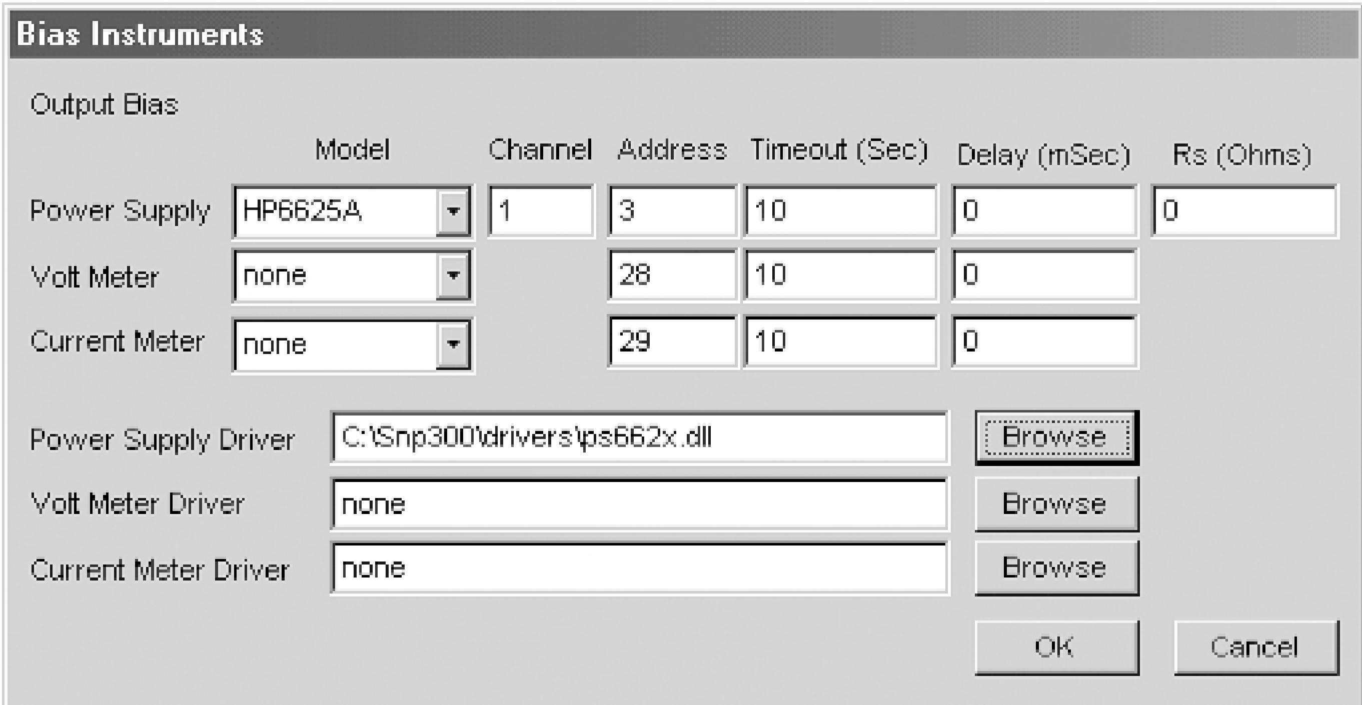


Figure 4-7. Bias Instrument Setup

typed onto the entry line. This default entry can be edited, or click the Browse button. The default filenames and directories are set up in the configuration editor to avoid retyping the same directory/file name repeatedly.

Click on the appropriate tab in the property sheet to set up the following:

4.5.1 System Files

Used for listing and reviewing the name and location of the tuner files and calibration thru data file. See Figure 4-8.

4.5.2 Deembedding Files

Used to set up the 2-port s-parameter blocks for deembedding. See Figure 4-9.

Input Fixture:

This selects the s-parameter block on the input side of the DUT. Click the Change button to bring up the selection dialog. See Figure 4-10. First, select whether it is a Transistor Test Fixture (TTF) model, a file, or NONE. If it is a TTF model, select from the pulldown list. If a 2-port s-parameter file, use the browse button to find the file. See Section 4.9 for more information on fixture files.

Output Fixture:

This selects the s-parameter block on the output side of the DUT. A model or file is selected the same way as the input fixture.

Input S-parameters:

This is a 2-port s-parameter block on the input side of the fundamental source tuner. Select the file using the Browse button.

Output S-parameters:

This is a 2-port s-parameter block on the output side of the fundamental load tuner. Select the file using the Browse button.

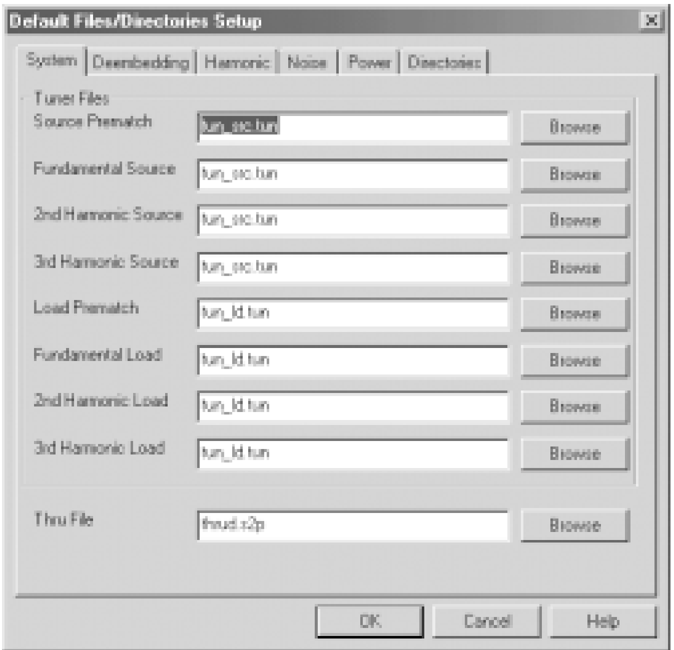


Figure 4-8. SNPW Default System Files

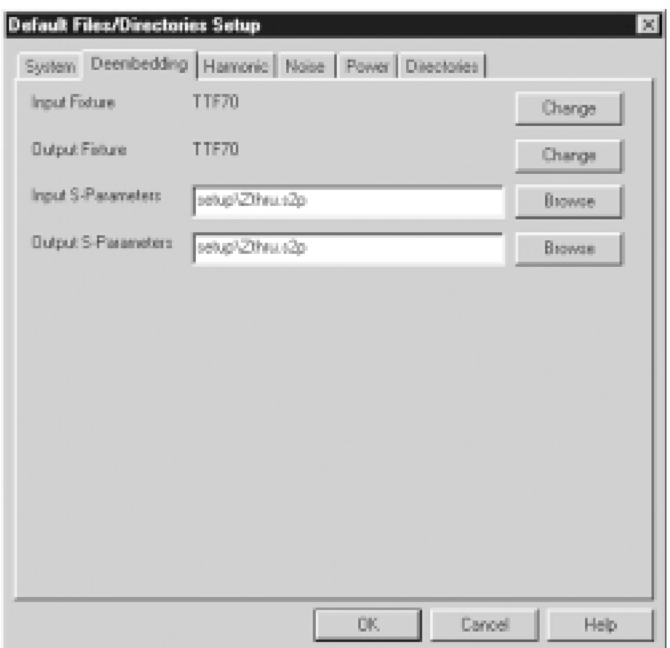


Figure 4-9. Deembedding System Files

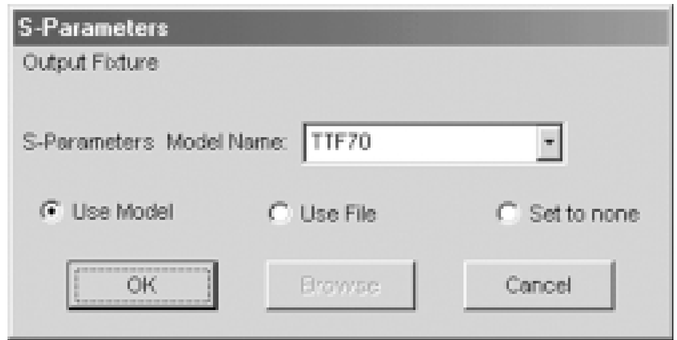


Figure 4-10. Test Fixture Selection

4.5.3 Harmonic Tuning Files

This sets the filename and paths for the multiplexer and termination s-parameter files for the harmonic tuners. See Figure 4-11.

4.5.4 Noise Files

This sets the filename and paths for the noise source and noise receiver input s-parameter files. See Figure 4-12.

4.5.5 Power Files

This sets the filename and paths for the power sensors and RF source output s-parameter files. See Figure 4-13.

4.5.6 Default Directories

This sets the default paths for various categories of files. See Figure 4-14.

4.6 Selecting Setup Options

From the SNPW Menu, select <Setup>, then <Options> to bring up the options property sheet with five tabs (System, Noise, Power, Intermod, ACP, and User).

4.6.1 System Options

This dialog is used to setup the options used by all applications. See Figure 4-15.

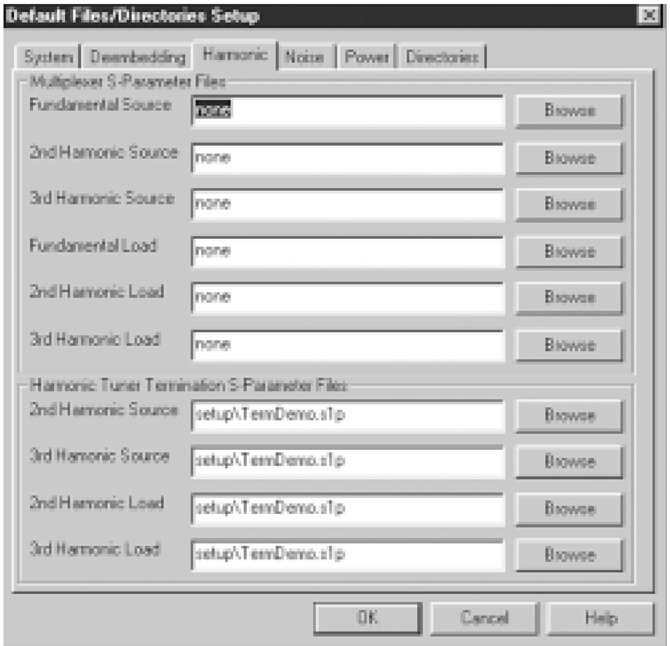


Figure 4-11. Harmonic Tuning System Files

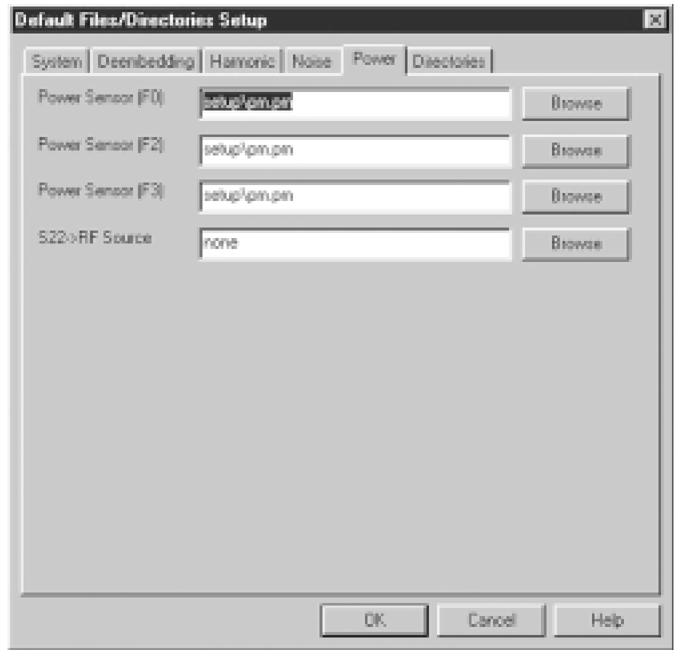


Figure 4-13. Power System Files

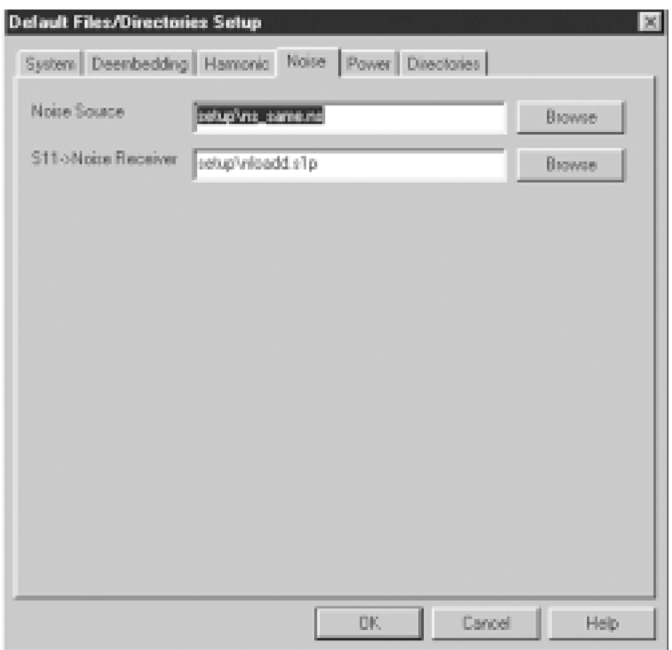


Figure 4-12. Noise System Files

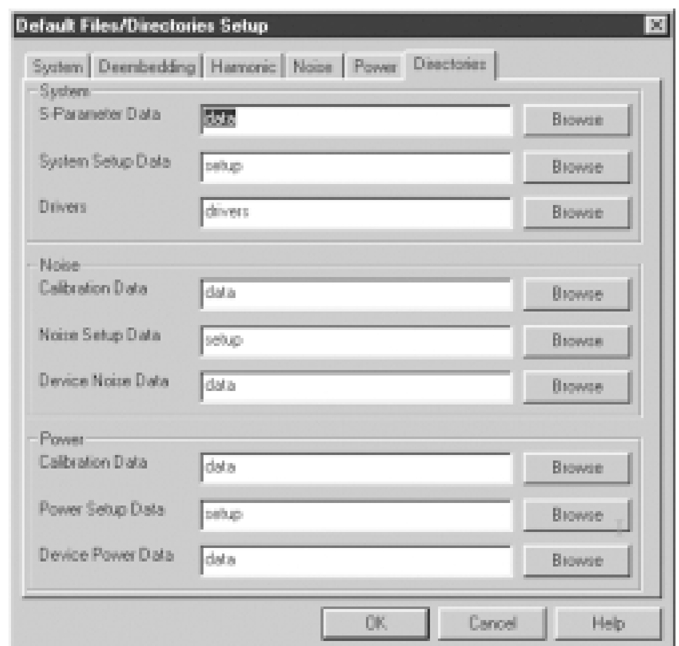


Figure 4-14. SNPW Default Directories

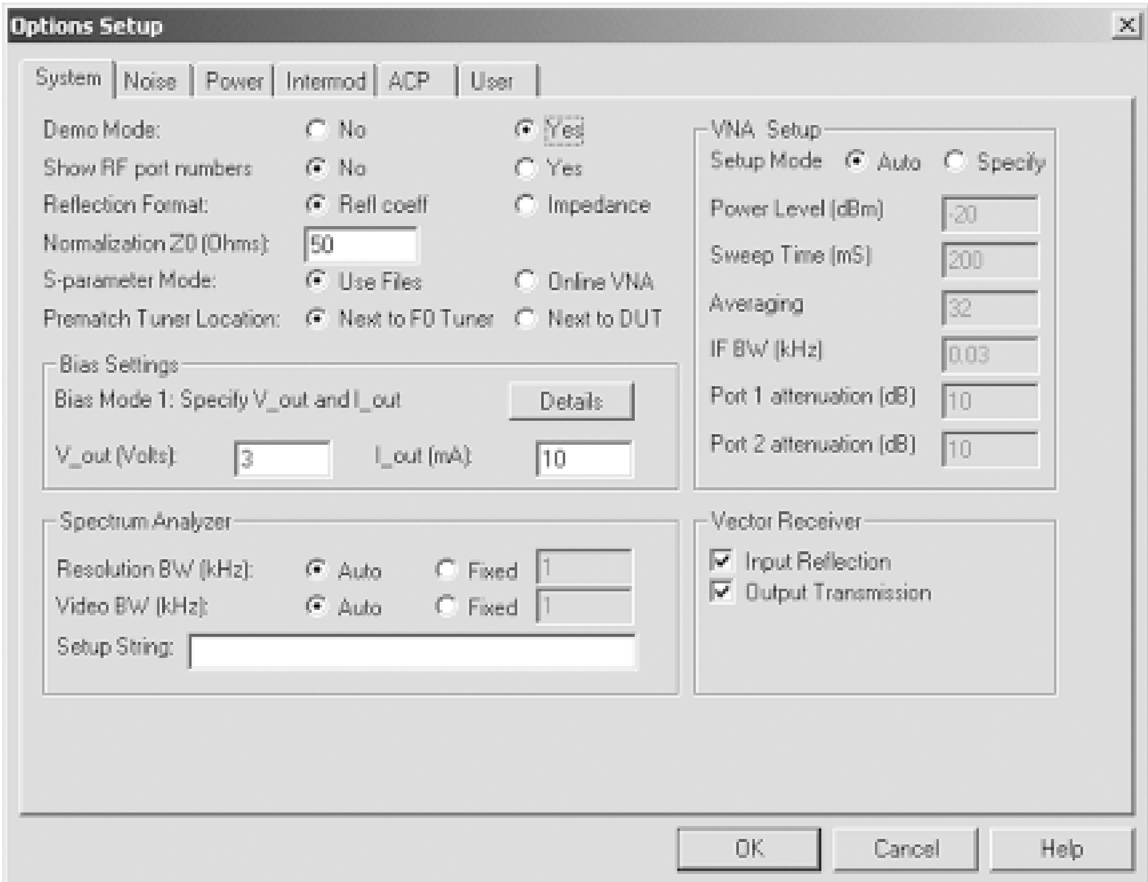


Figure 4-15. System Options Dialog

Demo Mode:

Select <Yes> to allow the program to run without any of the equipment. Calibration and measurment data are simulated.

Select <No> to make real measurements. All specified equipment must be present and connected to the GPIB.

☞ ***CAUTION:*** *Set Demo Mode to "No" for real data.*

Show RF Port Numbers:

This controls the s-parameter port conventions display on configuration block diagrams.

Select <Yes> to display the port numbers.

Select <No> to turn off the port number display.

Reflection Format:

Select either reflection coefficient or impedance as the format for reflection data used in various measurement and display screens.

Normalization Zo (Ohms):

Enter the normalization impedance used for the Smith charts in the various measurement and display screens. The default is 50 Ohms.

S-parameter Mode:

If set to <Online VNA>, RF switches are used in the block diagram, and s-parameters, such as those required for noise meaasurements, are read directly from the VNA. The MT993f System Control Option is required for this mode.

If set to <Use Files>, the S-parameters must be measured off-line, stored, and will be read from a file when needed by the program.

Pre-match Tuner Location:

If a pre-matching is employed, this option sets the location of the pre-matching tuner.

Bias Settings:

This option establishes the bias mode, quiescent bias, bias limits and other parameters of the bias system. Click on <Details> to bring up the DC Bias Setup dialog box (see figure 4-16) and refer to section 4.6.2 for an explanation of the bias options.

Spectrum Analyzer:

Select the method of establishing the resolution bandwidth and video bandwidth of the spectrum analyzer.

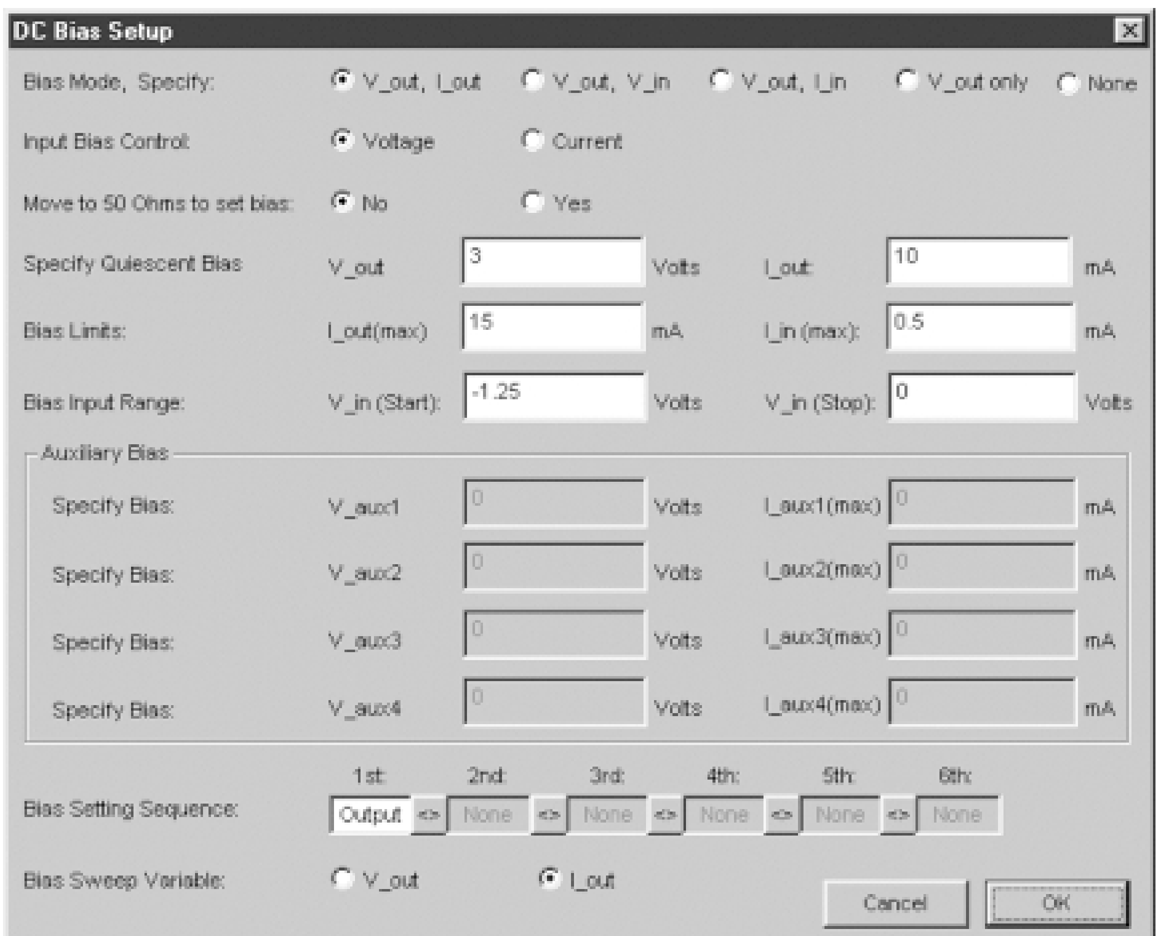


Figure 4-16. DC Bias Details Setup

Select <Auto> and the optimum setting consistent with the scan width and sweep speed settings is determined automatically. This usually provides fairly fast measurements, but may not provide the best dynamic range. Typically, this mode will reduce the bandwidth as the tone spacing and span ratio are reduced.

Select <Fixed> and enter a value in kHz to override the automatic setting. A smaller value lowers the noise floor and provides better dynamic range and accuracy, but also increases the measurement time.

The spectrum analyzer setup string is used with some drivers to specify special setup conditions. To see what text is expected by a driver (or if it's even used), click the test button for the instrument, and read the comments in the stand-alone window for that driver.

NOTE: *If the spectrum analyzer measurement is slowed by a small resolution bandwidth setting, it may be necessary to increase the spectrum analyzer time-out via the instrument editor (see Section 4.4).*

Vector Receiver:

If a vector receiver is used, select the measurements to be made.

The vector receiver is normally a Vector Network Analyzer (VNA) with sampler access, connected into the system with couplers. The incident signal is always connected to the reference channel. If the reflected channel is connected, DUT input reflection coefficient may be measured. If the transmission channel is connected, then transmission phase is measured. This allows AM to PM conversion to be measured as part of a power sweep.

VNA Setup:

The operational settings of the vector network analyzer used for s-parameters measurements are established from this block. Select <Auto> to use the VNA default settings. Select <Specify> and enter the control settings to override the defaults.

4.6.2 DC Bias Setup

Click on <Details> in the "Bias Settings" section of the <Setup>, <Options>, <System> dialog box to bring up the following options (see Figure 4-16):

Bias Mode, Specify:

Select what bias values are going to be specified. Choices are: V_out, I_out; V_out, V_in; V_out, I_in; V_out only; and None. These are designated Bias Modes 1 through 4, respectively. (None is mode zero.)

Input Bias Control:

This option is applicable only to bias mode 1 and determines whether input voltage or current is swept to establish the selected output current. In bias modes 2 and 3, voltage and current, respectively, are the only choices. The option is inactive in bias mode 4 (no input bias) or if the mode selected is none (no bias applied).

Move to 50 ohms to set bias:

Select <Yes> to move all tuners to 50 ohms before applying bias.

Select <No> to leave the tuners at their current positions.

Select Quiescent Bias:

Enter the default bias values. These values may be changed in the Bias Settings box in the System Options dialog box.

Bias Limits:

The bias limits should be set to values larger than the expected bias to avoid interference with the normal bias operation, but low enough to protect the DUT. These limits are set for bias parameters that are not directly controlled by the specified bias values. For example, if input and output voltages are specified, the input and output currents are not set directly; therefore, current limits are set to prevent accidental burn-out of the DUT.

The bias limits that apply depend upon the bias mode and the type of input bias control. The first limit is for output current. The second limit is for input current when an input voltage is specified or for input voltage when an input current is specified.

Bias Input Range:

The bias input range applies only in bias mode 1 (V_out, I_out). The values that apply will be displayed only if this mode is selected. In bias mode 1, the input bias will initialize at the start value and ramp up until the selected output current is reached; however, the ramp up will be terminated if the input bias reaches the stop value even if the selected output current has not yet been reached. The input bias range is displayed in volts or milliamps depending upon whether the selected input bias control is voltage or current, respectively.

Auxiliary Bias:

Enter the bias values for any auxiliary supplies required by the DUT (e.g., a multi-stage DUT requiring different bias levels at each stage).

Bias Setting Sequence:

Enter the turn-on sequence for the various bias supplies.

Bias Sweep Variable:

Select the variable for swept bias measurements. The choice is limited to the parameters specified by the selected bias mode; for example, in bias mode 1, select either V_out or I_out.

4.6.3 Noise Options

To set up the system conditions for the noise characterization application, click on the <Noise> tab in the <Setup> <Options> dialog box. This will bring up the noise options dialog box (see figure 4-17).

Ambient Temp. Celsius:

Enter the temperature of the tuners, bias tees, fixture, and other components between the noise source and the noise receiver reference planes (typically, ambient temperature). This temperature is used to calculate the noise contribution from the losses of these system components.

IF Freq:

If frequency conversion is required to translate the measurement frequency to within the range of the noise figure meter, select a frequency consistent with the sideband selection (see below). If upper (USB) or lower (LSB) single sideband is selected, the IF must be relatively large (usually several hundred MHz) to insure that the sideband filter does not overlap the measurement frequency range. If double sideband (DSB) is selected, the frequency should be low (typically 30 MHz) so that perturbations in the noise passband of the DUT and the tuners have little or no effect on the measurement accuracy.

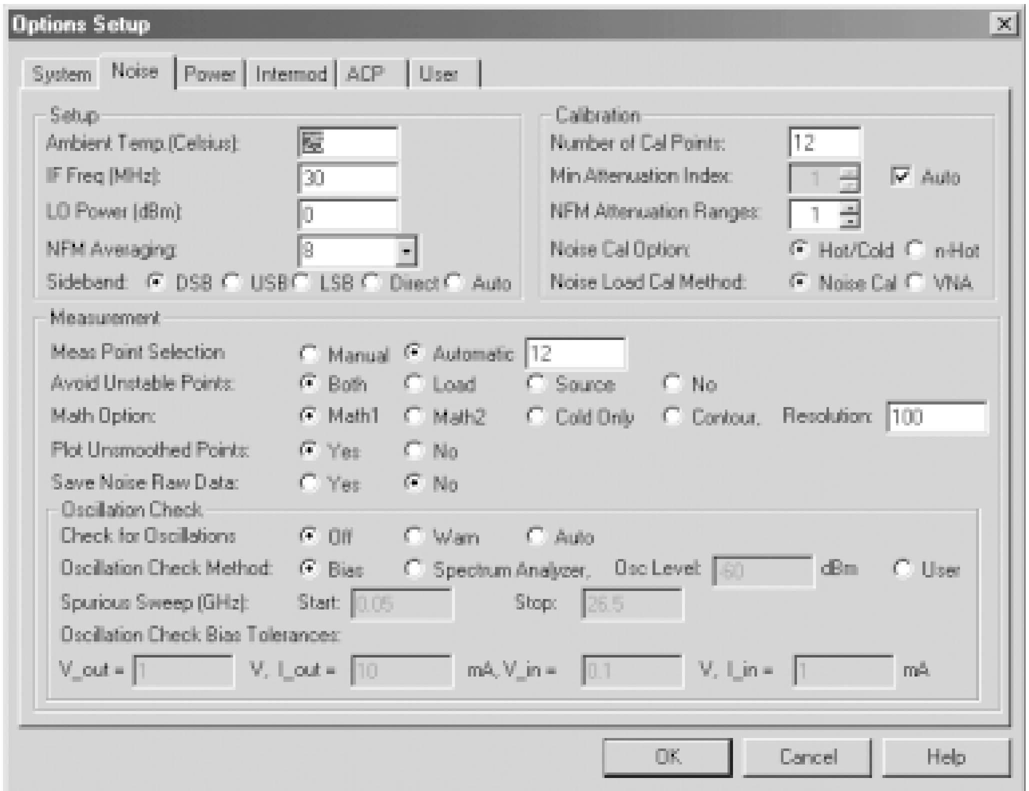


Figure 4-17. Noise Options Dialog

If the setup includes a captive frequency converter, such as the Agilent (HP) 8971C Noise Figure Test Set, select <Auto>. If frequency conversion is not necessary (the measurement frequency is within the range of the noise figure meter), select <Direct>.

LO Power

Enter a value, in dBm, for the local oscillator (LO) power required by the frequency converter for best operation. This entry is inactive if <Direct> is selected for the Sideband entry below.

NFM Averaging:

Enter a value that is a power of two (2, 4, 8, 16, etc.). More averaging improves data smoothness but slows the measurement process. Eight is generally a good compromise for most applications.

Sideband:

If individual components (mixer and LO) are used to implement the frequency conversion, select <DSB> (double sideband), <LSB> (lower sideband), or <USB> (upper sideband) in accordance with the following criteria:

Select <DSB> if the measurement frequency range is higher than about 1700 MHz and the DUT noise passband is relatively flat, or if a filter is not inserted ahead of the mixer to discriminate against the image sideband.

Select <LSB> if a low pass filter is inserted ahead of the mixer to discriminate against the image (USB) sideband.

Select <USB> if a high pass filter is inserted ahead of the mixer to discriminate against the image (LSB) sideband.

Consult the operating manual for the noise figure meter for a more detailed explanation of the preceding sideband options.

If frequency conversion is implemented by means of a noise figure test set and LO controlled by the noise figure meter on its captive system interface bus (SIB), select <Auto>.

If the DUT and the load tuner are connected directly to the input of the noise figure meter, select <Direct>.

4.6.3.2 Calibration

Number of Cal Points:

The entry determines the number of source points used during a noise calibration.

Min Attenuation Index:

Most noise figure meters (NFM) have a step attenuator at the input to prevent overload of the internal circuitry. This entry selects the minimum value set used during the calibration and measurement. If the setup does not include an external preamplifier, set the index to “1” (minimum RF attenuation). If an external preamplifier is used, the index must be set to “2” or “3” depending upon the gain of the preamplifier. If the index is set too low, the noise figure meter will return an error message such as “Detector Overload” during the calibration.

Select <Auto> and the system will establish a setting. Refer to the NFM manual for more information.

NFM Attenuation Range:

The noise calibration may be done for up to 3 values of the RF attenuator in the NFM. Each value used will require calibration over the entire measurement frequency range. Setting this entry to “1” causes the system to dispense with the calibration of the remaining two values and will significantly reduce the time required for calibration. Large variations in DUT gain, however, require additional ranges to be available.

Noise Load Cal Method:

Two methods are available to determine the input reflection coefficient of the noise measurement receiver. Select <Noise Cal>, and the input reflection coefficient is calculated during the noise calibration. Select <VNA> and the system uses pre-measured 1-port S-parameter data saved in a Touchstone compatible file. The default file is set up in the SNPW Default File property sheet (see section 4.5).

4.6.3.3 Measurement

Meas Point Selection:

Select <Automatic> and the system uses the built-in point selection algorithm. The number of points used may be entered in the adjoining box. <Manual> permits the user to select specific points and is available for the expert user.

Avoid Unstable Points:

The software automatically determines possible unstable source and load tuner positions from the DUT S-parameters. <Both> is generally the preferred setting. The other selections are <Load>, <Source>, or <No>.

Math Option:

There are four methods available for calculating the noise parameter solution.

<MATH1> is the original Maury method, which rigorously accounts for the Hot/Cold reflection coefficient differences in the noise source. It has greatly reduced sensitivity to the DUT s-parameters compared to any published algorithm.

<MATH2> makes a very minor approximation relative to the Hot/Cold reflection coefficient differences of the noise source, but is often less sensitive to other errors than Math1.

<COLD ONLY> uses only cold noise power data during the noise measurement. (The noise source is still used in the hot state during noise calibration.) This math option is rigorous, and is included for completeness since it is advocated in the published literature. However, it is generally less robust and more sensitive to error than Math1 or Math2, so it is generally not recommended.

The best choice depends on the measurement setup and the device parameters under test. They generally have good agreement, but which produces smoother data may vary with the situation.

<Contour> uses a rectangular contouring algorithm similar to that used in the power application to determine the noise parameters.

<Resolution> should normally be a number between 50 and 100. A higher number produces smoother and more accurate plots, but takes longer. A small number is quick, but less accurate, and straight line segments may be visible in the contours.

The contours are calculated over a rectangular area, based on the points selected. Sometimes a high resolution will produce anomalous contours in areas not surrounded by measured points. This can be corrected by reducing the calculation resolution.

Plot Unsmoothed Points:

Select <Yes> and the unsmoothed data points will be plotted with a smoothed curve.

If NO is selected, the smoothed data points will be plotted on top of a smoothed curve.

Save Noise Raw Data:

Select <Yes> and the raw data will be saved on comment lines at the end of the file, so the Touchstone format is still valid. In this case, these comment lines are formatted specifically so the SNPW software can retrieve the raw data.

4.6.3.4 Oscillation Check

At certain source and/or load termination conditions the DUT may oscillate at one or more frequencies which may be within or well outside the measurement frequency range. Such oscillations may be detected by monitoring the bias levels for changes from the quiescent settings or by scanning the output with a spectrum analyzer. These options select the mode, method, and parameters of the automatic check for oscillations.

Check for Oscillations:

Select <Off> to disable the feature.

Select <Warn> and the program will stop running with a warning if an oscillation is detected. When the operator responds, the program will resume and the data at the unstable position will be ignored.

Select <Auto> and the measurement will continue without interruption even if an oscillation has been detected; however, the data at the unstable position(s) will be ignored.

Oscillation Check Method:

Select <Bias> to monitor bias levels as the means to detect oscillations (see Oscillation Check Bias Tolerances below).

Select <Spectrum Analyzer> to scan the DUT output for spurious oscillations.

Enter a value in the <Osc Level> box in dBm as seen on the spectrum analyzer that would indicate a spurious oscillation.

Select “User” if a user function will be used to detect oscillations.

Spurious Sweep (GHz):

Enter the <Start> and <Stop> frequencies for the spectrum analyzer scan range.

Oscillation Check Bias Tolerances:

Enter the tolerances on the normal bias readings for the purpose of detecting oscillations. Tolerance values should be entered for each bias value read in the bias driver.

4.6.4 Power Options

To set up the system conditions for power characterization applications, click on the <Power> tab in the <Setup> <Options> dialog box. This will bring up the power options dialog box (see figure 4-18).

Cal RF Source Match:

Select <No>, and the tuner will move during power or imod calibration to do a "load pull" on the RF source. This will determine the output reflection coefficient of the RF source.

Select <Yes>, and the output reflection coefficient of the RF source will be determined by a load pull measurement implemented by moving a tuner during the power and imod calibration.

Select <Use S1P file>, and the tuner probes will remain retracted throughout the power or imod calibration, and the RF source will be assumed to have a perfect output match. Also, a short and an open will be required to calibrate the input reflection coupler.

If "use.S1P FILE" is selected, the reflection coefficient of the RF Source will be read from a 1-port s-parameter file, specified in the power tab of the default files property sheet. The file can be created by using a VNA to measure the RF source reflection coefficient at the power cal plane.

Prompt for PM Zero:

Select <No>, and the zeroing will be done automatically without stopping for a prompt.

Select <Yes>, and a prompt to prepare the system for zeroing will be displayed before the power meters are zeroed. This provides any opportunity to turn off high power sources or amplifiers that don't completely turn off by GPIB control. When the system is ready to zero, click on <OK>.

If Yes was selected, a second prompt to prepare the system for operation will be displayed. At this point , turn on any equipment that was turned off for zeroing, then click on <OK>.

☞ ***NOTE:*** *Normally, the power meters are zeroed as part of every power, Imod, or ACP calibration. This prompt also provides an option to click on <Skip> to skip the zeroing, if desired.*

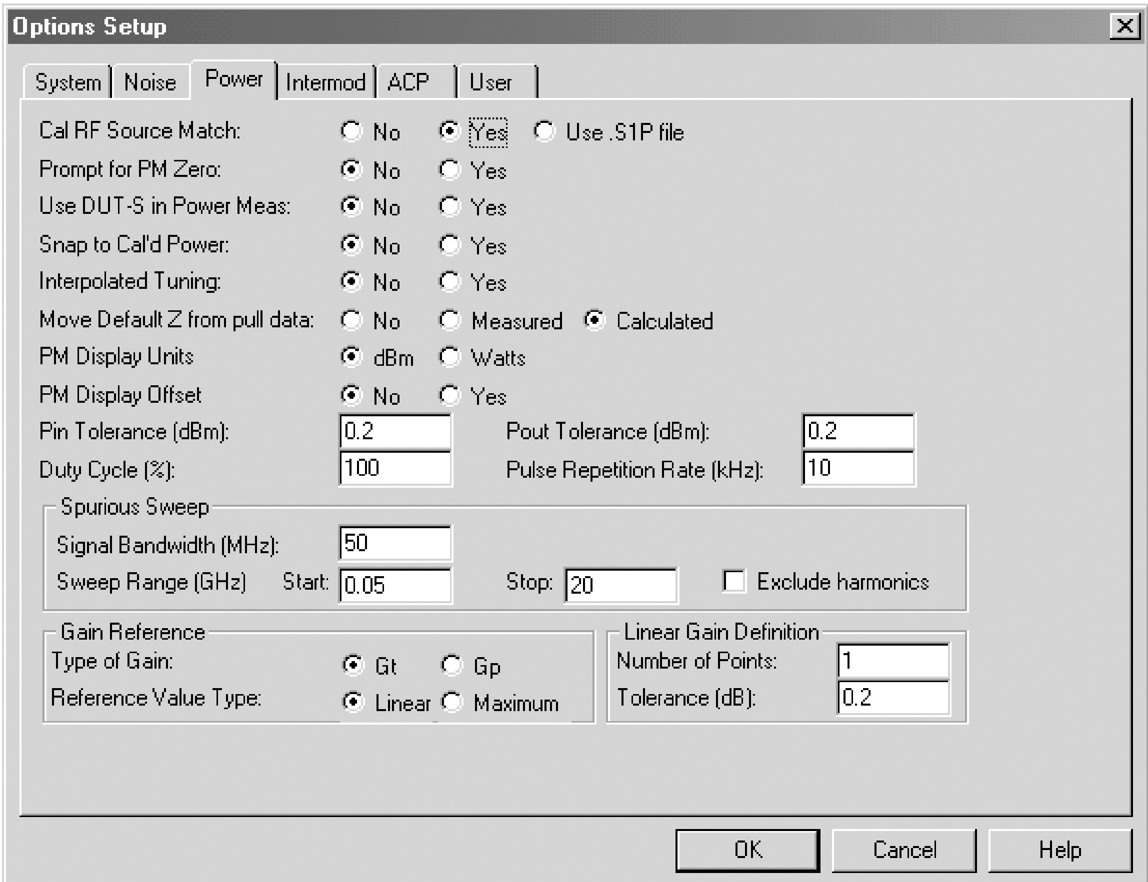


Figure 4-18. Power Options Dialog

Use Dut-S in Power Measurement:

Select <No>, and the DUT s-parameters will not be used during the power measurements, nor will the stability circles, if applicable, appear on the Smith chart displays depicting the source and load tuner positions.

Select <Yes>, and the software will use DUT s-parameters in the power measurement. The main use is to send them to the user function in case they are needed. They are not used by the main program except to display the stability circles.

Snap to Cal'd Power:

Select <No>, then the RF power settings may be interpolated between the calibrated power values. If an input power meter is used, then power settings may be extrapolated as well as interpolated. See Section 7.3.5 for more details.

If YES is selected, the power settings on the RF power sources will be restricted to calibrated settings.

Interpolated Tuning:

Select <No>, and the tuners will be moved only to pre-characterized positions.

Select <Yes>, and the tuners may be moved to intermediate, uncharacterized positions. The relevant impedances are then interpolated.

Move Default Z from Pull Data:

Select <No>, and the tuners will remain at the pre-selected default position after display of a load or source pull.

Select <Measured>, and the tuners will move to the measured optimum position after a display of load or source pull.

Select <Calculated>, and the tuners will move to the optimum position calculated from the countouring data.

PM Display Units:

Select either <dBm> or <Watts> as the units for display and output of the power meters.

PM Display Offset:

Select <No>, and the power meters will display the actual power measured.

Select <Yes>, and the powers meter displays will be offset to indicate the power at the DUT reference planes.

Pin Tolerance (dBm):

If "Snap to Cal'd Power" is set to NO and an input power meter is used, then the RF power level will be adjusted to provide the specified available power at the DUT plane within this tolerance. If this tolerance cannot be achieved, an error message will be displayed.

Pout Tolerance (dBm):

If a constant Pout source or load pull is selected, the source power will be adjusted to get the specified output power within this tolerance. If this tolerance cannot be achieved, an error message will be displayed.

Duty Cycle (%):

This specifies the duty cycle in percent. It must be greater than zero, and less than or equal to 100%. This value is not used in the main program, but is sent to the power meter drivers in case a calculation of peak power is needed.

Pulse Repetition Rate (KHz):

This value is not used by the main program, but is sent to the power meter drivers in case it is needed.

4.6.4.1 Spurious Sweep

Signal Bandwidth (MHz):

Enter a value for the signal bandwidth. This entry is used when the applied signal is modulated to insure that the spurious sweep will not include valid signal components and prevent these from being measured.

Sweep Range (GHz):

Enter a <Start> and <Stop> frequency for the spurious sweep range.

Click on <Exclude Harmonics> to exclude these from the spurious sweep.

4.6.4.2 Gain Reference

Type of Gain:

This is the gain measurement type for gain compression or expansion calculation.

<Gt> selects transducer gain.

<Gp> selects power gain.

Reference Value Type:

This option specifies the gain reference definition.

<Linear> selects linear gain.

<Maximum> selects maximum gain.

4.6.4.3 Linear Gain Definition

Number of Points:

Enter the number of data points to define linear gain value.

Tolerance (dB):

Enter the tolerance applied to the linear gain definition.

4.6.5 Intermod Options

This dialog is used to set up the system for intermodulation distortion measurements. See Figure 4-19.

Tone Spacing (MHz):

Enter the frequency spacing between the signals from the two RF sources. A close spacing improves the assumption that the tuner impedances are the same at both frequencies. A wider spacing helps separate less stable sources.

Tone Equality:

Enter the tolerance value for equalizing the output of the two RF sources during calibration. It should be large enough to accommodate the power setting resolution of RF source 2. (Note that if the two RF sources have different power setting resolutions, the best equality can be achieved if RF source 2 is the one with the best resolution.)

Span Ratio (max = 1.0):

The frequency span that the spectrum

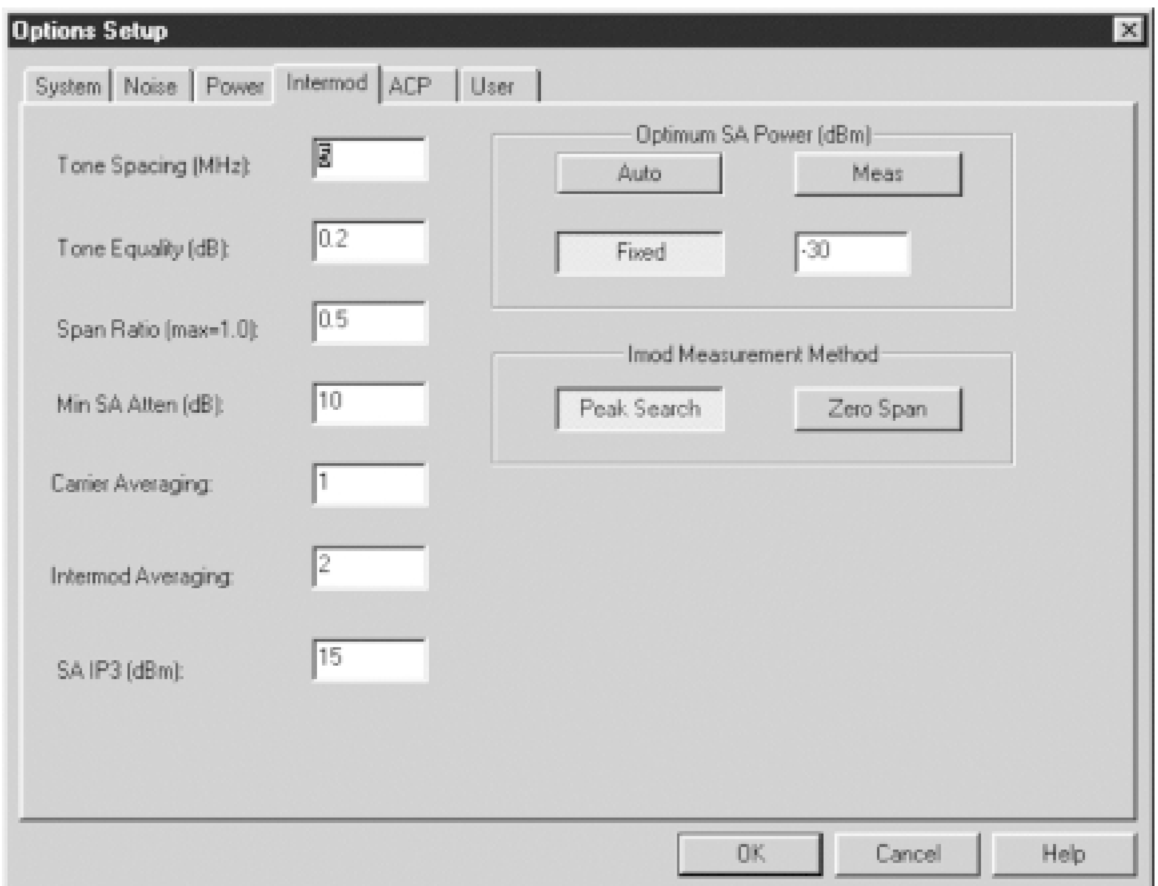


Figure 4-19. Intermod Options Dialog

analyzer will use for peak searches will be the tone spacing multiplied by this number. The maximum of 1.0 will make the span equal to the tone spacing, putting the edge of the span halfway between adjacent signals. This should guarantee that the span will never overlap more than one signal.

A smaller span ratio will result in better resolution and accuracy from the spectrum analyzer, but may be slower. A larger span ratio may be needed if less stable sources are used.

Min SA Atten (dB):

Enter the minimum attenuation setting to be allowed for the spectrum analyzer. A value greater than zero may be needed to protect the spectrum analyzer mixer or to improve the spectrum analyzer impedance match. However, this could also be a limitation on dynamic range.

Carrier Averaging:

Enter the number of averages to use when measuring the carrier amplitudes and frequencies.

Intermod Averaging:

Enter the number of averages to use when measuring the intermod signal amplitudes.

SA IP3 (dBm):

Enter the specified third order intercept of the spectrum analyzer should be entered here in dBm.

4.6.5.1 Optimum SA Power

This option selects the method by which the power to the spectrum analyzer mixer is set.

Select <Auto>, and the spectrum analyzer (or the driver) will automatically set the attenuators consistent with other settings. This option usually provides the fastest measurement, because it minimizes the number of measurements and attenuator setting changes. However, it may not provide the optimum dynamic range.

Select <Meas>, and the spectrum analyzer noise floor and the input signals are measured. The mixer power that provides the best dynamic range is then calculated based on a balance between the noise floor and the analyzer IP3. The attenuators will then be set accordingly. This mode is the slowest, but usually gives the best dynamic range automatically.

Select <Fixed>, and the attenuators are set to hold the mixer power to the fived value entered in the adjoining box.

Note that with all three modes, control of power or the spectrum analyzer mixer is limited to the resolution of the spectrum analyzer attenuators.

4.6.5.2 Imod Measurement Method

This option selects the method by which the intermod signal is measured.

<Peak Search> sets the span and does a peak search to find the intermod signal. This is best if the time bases of either of the two RF sources or the spectrum analyzer are not stable. However, if the signal is close to the noise floor, a false noise peak could be read instead of the true intermod signal. Also, if averaging is used, this method will be slower.

<Zero Span> sets the exact frequency of the expected intermod signal. This prevents false noise peaks from being read, and helps to do fast averaging. With averaging,

it helps to pull a CW signal out of the noise, so provides the best dynamic range. However, it does require both RF power sources and the spectrum analyzer to have stable time bases relative to each other. The frequency is calculated from the frequency measured by the spectrum analyzer for both of the carrier frequencies. The limitation is that if the time bases are not stable, the measurement may not be at the signal peak, thus causing an error.

☞ **NOTE:** *To reduce the effects of frequency stability errors, connect the time bases of both RF source and the spectrum analyzer together.*

4.6.6 ACP Options

This dialog is used to set up the system for adjacent channel power (ACP) measurements. See Figure 4-20.

4.6.6.1 Source

This option sets up the modulation parameters for the RF source used during the ACP calibration and measurement.

Modulation Setup:

Click on <Specify String> to select the string sent to the RF source driver. The title of the following box will change to “Modulation String”. Click on the selector

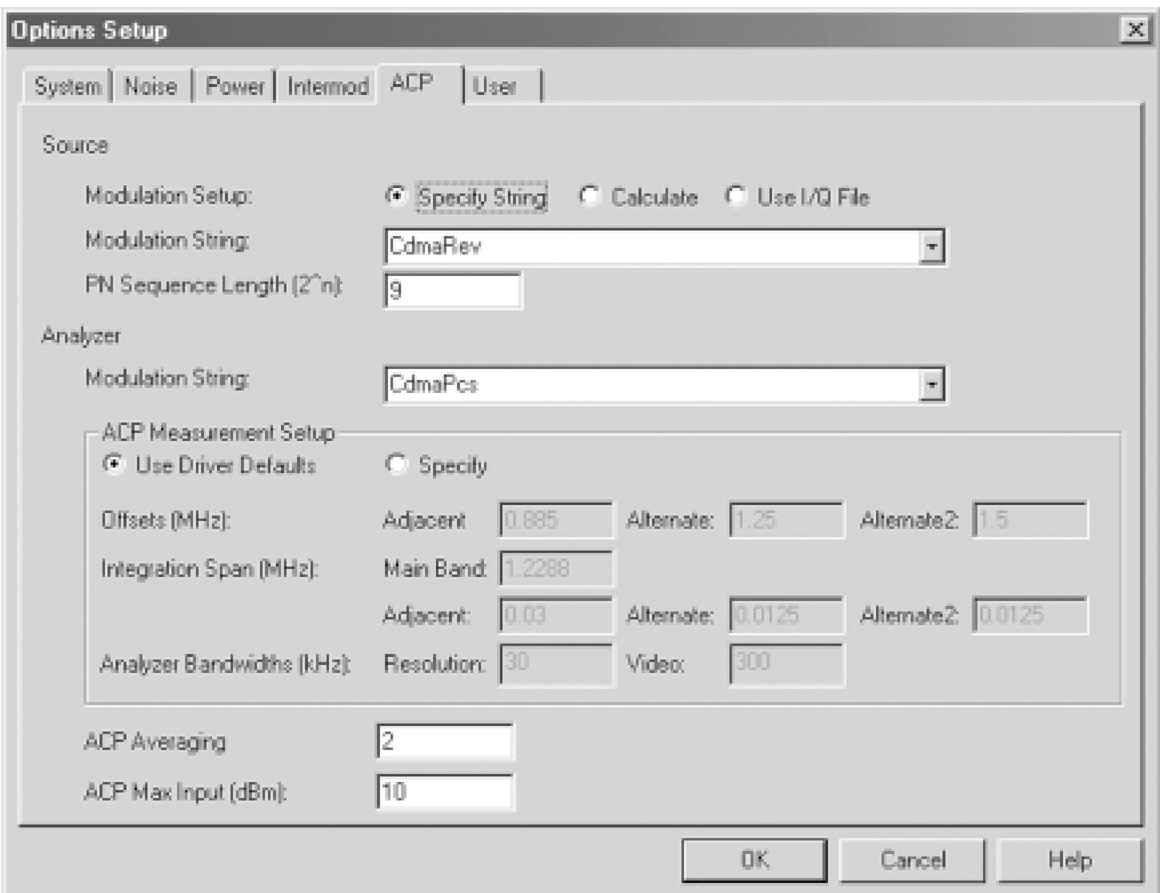


Figure 4-20. ACP Options Dialog

button to the right to bring up a list of source modulation strings.

The format of the modulation string depends on the selected RF source driver. Click the <Test> button on the instrument properties dialog to run the driver stand-alone. A listing of the supported modulation string formats will generally be displayed in the driver window.

Click on <Calculate> to set the modulation in accordance with an accepted standard. The title of the following box will change to “Modulation Standard”. Click on the selector button to the right to bring up a list of applicable modulation standards.

Click on <Use I/Q File> to set the modulation in accordance with a pre-stored file. The title of the following box will change to “Modulation Filename”. Click on the <Browse> button to bring up a list of file names.

PN Sequence Length (2^n):

This entry sets the length of the pseudo-random noise sequence before it repeats. The actual length is 2 raised to this integer power.

4.6.6.2 Analyzer

These options set up the analyzer conditions to be used during the calibration and measurement of ACP.

Modulation String:

This string is sent to the ACP analyzer driver to select the type of modulation used during the calibration and measurement. Click on the selector button to the right to bring up a list of analyzer modulation strings.

The format of the modulation string depends on the selected ACP analyzer driver. Click the <Test> button on the instrument properties dialog to run the driver stand-alone. A listing of the supported modulation string formats will generally be displayed in the driver window.

ACP Measurement Setup:

Click on <Use Driver Defaults> to use the default settings established for the analyzer driver. These settings are generally applicable and to most measurements but may not be optimum for some specific measurements.

Advanced user may click on <Specify> and enter the appropriate values for a specific measurement.

ACP Averaging:

Enter the amount of averaging to be used for ACP measurements.

ACP Max Input (dBm):

Enter the maximum power expected at the ACP analyzer input.

4.6.7 User Options

This dialog is used to set up the user function driver and user specified control strings. See Figure 4-21.

Driver:

This specifies the user function driver. Use the Browse Button to find the executable file. Enter "none" to turn off the user function.

Control Text:

Up to 25 separate control strings may be entered here. These will be sent to all of the drivers, in case any of them need special setup information.

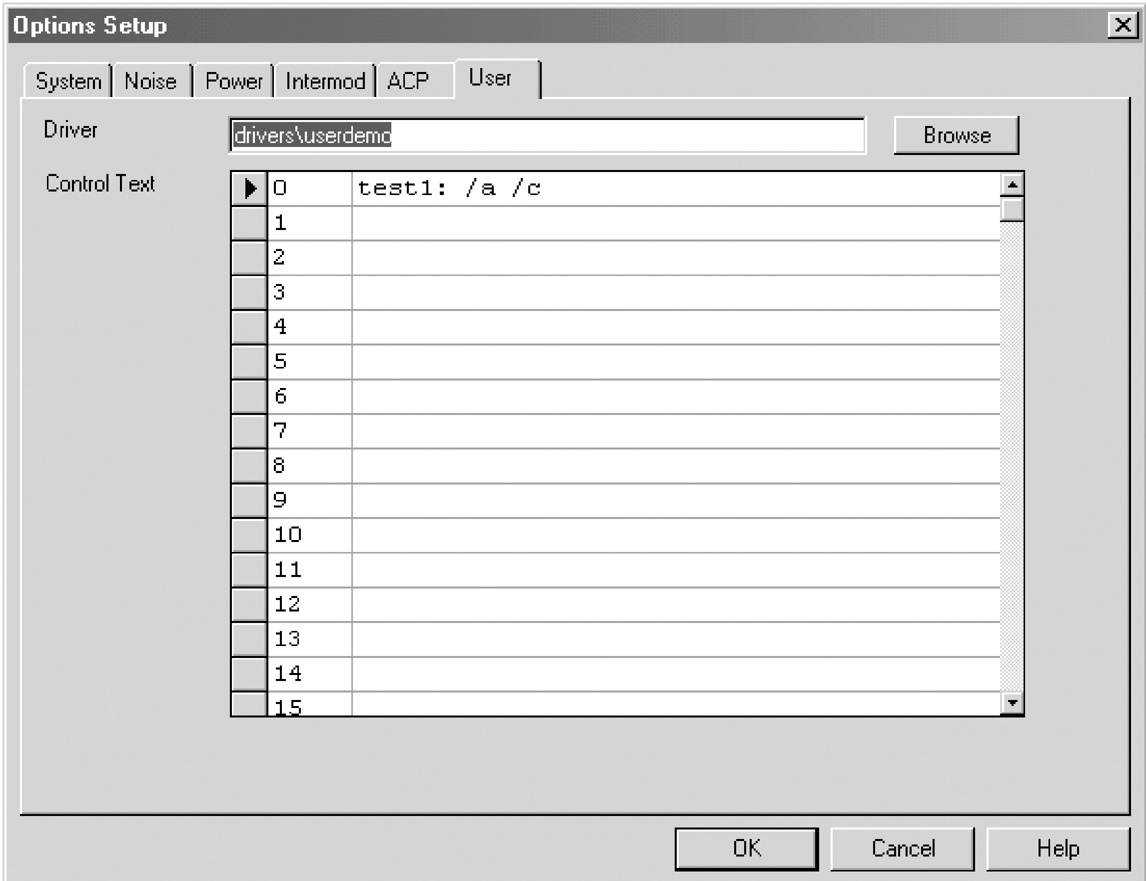


Figure 4-21. User Options Dialog

A suggested way to use this is to make up a unique keyword for each piece of special data needed by any driver or user function. A driver can search through the strings to find one with that keyword, and then decode the data from that string. This will allow multiple strings to be used for different types of setup information without conflict.

4.7 Editing Noise Source Files

A noise source file includes excess noise ratio (ENR) data and hot/cold (on and off) reflection coefficients versus frequency. The Noise Source Editor is used to create or modify noise source files. The ENR data is supplied by the noise source manufacturer and should be available and ready for entry before starting the editor. The reflection data can be read from existing one-port s-parameter files (one each for the hot and cold conditions) or measured. In the latter case, make certain the system is not in “Demo” mode (see section 4.6.1) and that a calibrated vector network analyzer is recognized on the GPIB (see section 5.2).

From the Block Diagram View menu select <Setup>, <Characterize Noise source> to bring up the noise source file listing. A sample file is included with the software to facilitate start-up. Select and open an existing file to start the editor (see figure 4-22).

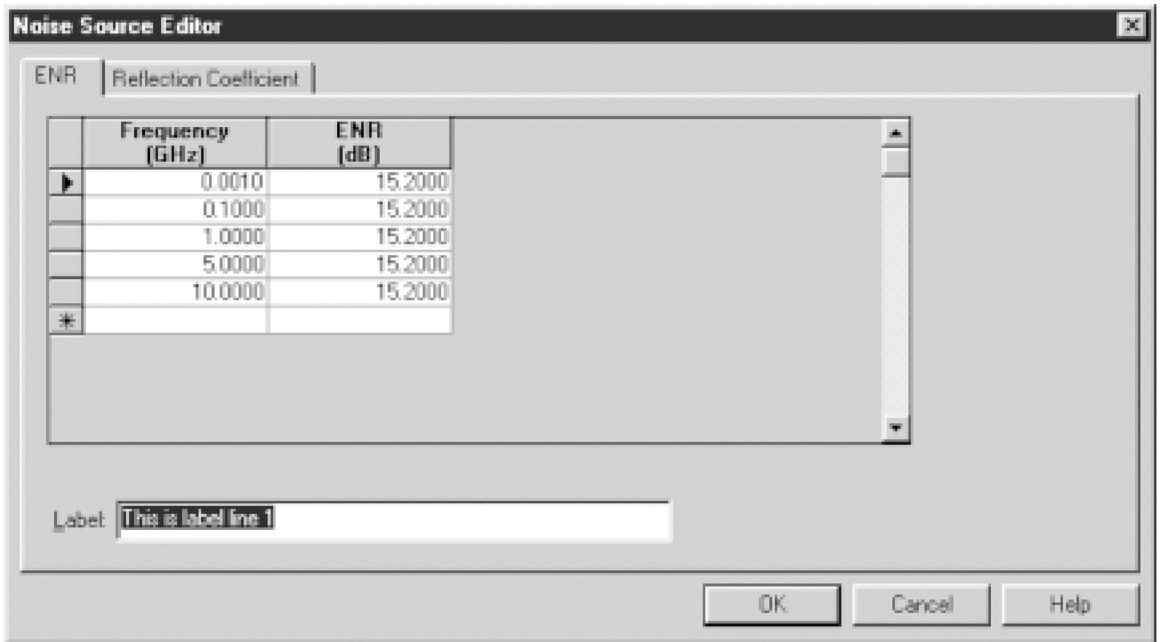


Figure 4-22. Noise Source Editor, ENR Dialog

Select the <ENR> tab to edit the ENR. Use the <UP/DOWN> arrow keys to move the cursor and enter new values. To insert a new frequency, click on the blank line at the bottom and enter the frequency and ENR. When the cursor is moved to a new position the inserted frequency and associated ENR will automatically be placed in the proper sequential order. To delete a frequency and the associated ENR, click on the control column to the left to highlight the entire row and press the <Delete> key. At the bottom of the ENR dialog enter a label.

☞ ***NOTE:*** *The user must correct the ENR for the adapter loss (if used) at the noise source output connector. If the adapter loss is small (e.g.: <0.2 dB) and the ambient temperature is within the range of 290 to 300 kelvins (nominally, 17° to 27°C or 62° to 82°F), then the correction can be as simple as subtracting the adapter loss from the manufacturer's calibrated ENR.*

☞ ***NOTE:*** *The ENR table does not need to match the measurement frequencies exactly. Linear interpolation will be used for measurement frequencies between the calibrated points.*

Click on the <Reflection Coefficient> tab to bring up the editor for the noise source hot and cold reflection coefficients (see figure 4-23). Click <Read> to bring in previously measured and stored data. Click on <Measure> and follow the instructions for calibrating the VNA, measuring the reflection coefficients, and storing the data. It is recommended (although not required) that the measurement frequencies be the same as those at which the tuners are characterized. It is not necessary that they be the same as the ENR frequencies.

When the entries are completed, click on <OK> and enter a file name when prompted. It is not necessary to enter an extension to the file name. The program will apply a *.ns extension to the file. Other extensions can be used; however, the program may have difficulty finding these when needed.

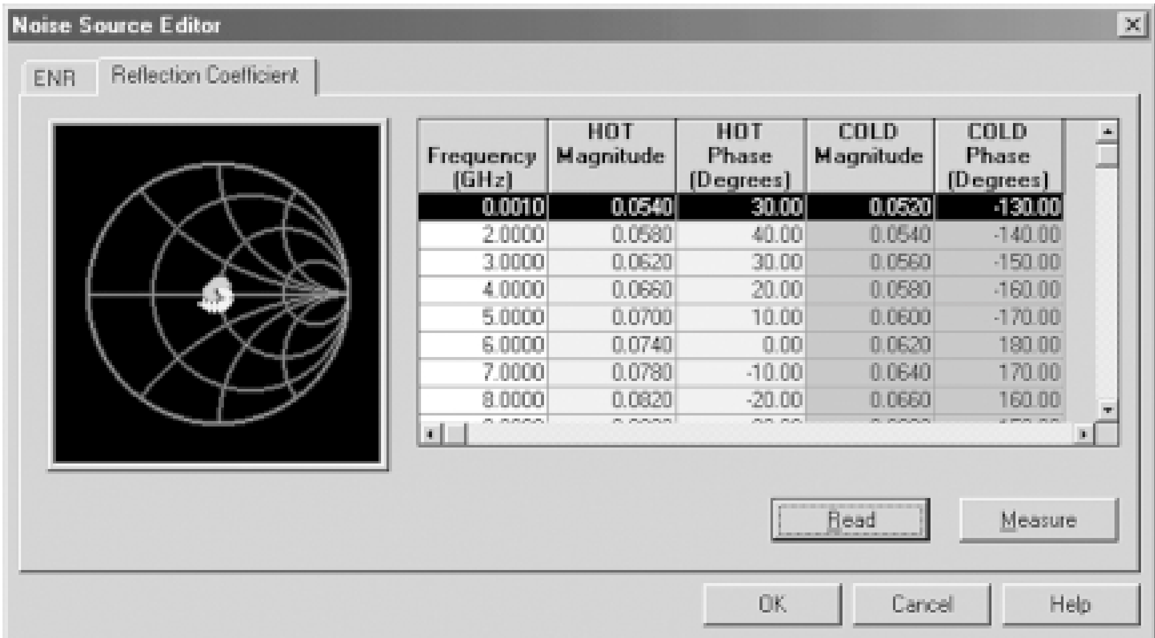


Figure 4-23. Noise Source Editor, Reflection Coefficient Dialog.

4.8 Editing Power Sensor Files

A power sensor file includes sensor efficiency, loss, and reflection coefficients versus frequency. The Power Sensor Editor is used to create or modify power sensor files. The sensor manufacturer usually provides a table of efficiency data versus frequency (in percent); however, some sensors have this table stored on an internal ROM chip, and the power meter automatically adjusts the readings accordingly. In these cases, enter 100% for the efficiency at all frequencies. The loss table is provided to account for attenuation placed between the sensor and the output s-parameter block (or the load tuner reference plane, if the output s-parameter block is not used). If no attenuation is inserted, enter 0 dB at all frequencies. These data should be available and ready for entry prior to starting the editor, The reflection data can be read from an existing one-port s-parameter file or measured. In the latter case, make certain the system is not in “Demo” mode (see section 4.6.1) and that a calibrated vector network analyzer is recognized on the GPIB (see section 5.2).

From the Block Diagram View menu select <Setup>, <Characterize Power sensors> to bring up the power sensor file listing. A sample file is included with the software to facilitate start-up. Select and open an existing file to start the editor (see figure 4-24).

Select the <Efficiency, Loss> tab to edit these data. Use the <UP/DOWN> arrow keys to move the cursor and enter new values. To insert a new frequency, click on the blank line at the bottom and enter the frequency (GHz), efficiency (%) and loss (dB). When the cursor is moved to a new position the inserted frequency and associated data will automatically be placed in the proper sequential order. To delete a frequency and the associated data, click on the control column to the left to highlight the entire row and press the

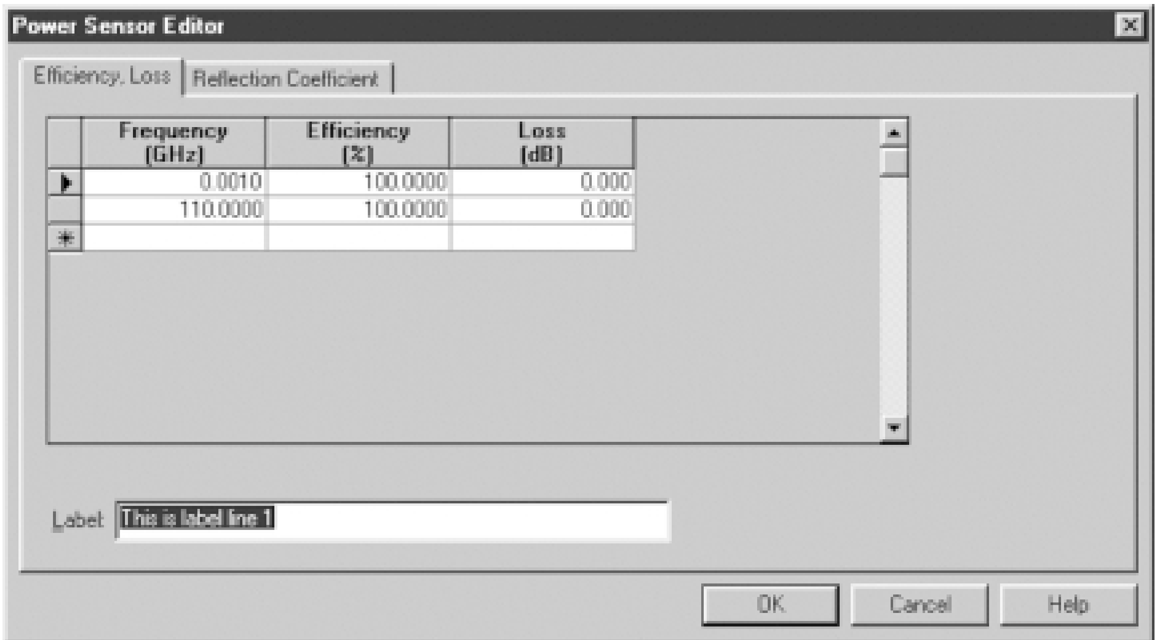


Figure 4-24. Power Sensor, Efficiency, Loss Dialog.

<Delete> key. At the bottom of the dialog box enter a label.

☞ **NOTE:** *The Efficiency/Loss table does not need to match the measurement frequencies exactly. Linear interpolation will be used for measurement frequencies between the calibrated points.*

Click on the <Reflection Coefficient> tab to bring up the editor for the power sensor reflection coefficients (see figure 4-25). Click <Read> to bring in previously measured and stored data. Click on <Measure> and follow the instructions for calibrating the VNA, measuring the reflection coefficients, and storing the data. It is recommended (although not required) that the measurement frequencies be the same as those at which the tuners are characterized. It is not necessary that they be the same as the efficiency/loss frequencies.

When the entries are completed, click on <OK> and enter a file name when prompted. It is not necessary to enter an extension to the file name. The program will apply a *.pm extension to the file. Other extensions can be used; however, the program may have difficulty finding these when needed. The new file name may also be set up as the default (see section 4.5).

4.9 Fixture Deembedding

4.9.1 Deembedding Options

Each half of the fixture is treated as a s-parameter block that can be specified either as a model for a Maury Transistor Test Fixture (TTF) or as a two-port s-parameter file. See section 4.9.3 for more information on the TTF models and section 4.9.4 for information on creating fixture s-parameter files. Fixture deembedding is specified in the property sheet brought up from the Block Diagram View by clicking on <Setup>, <Default Files/ Directories>, and <Deembedding> (see section 4.5.2). These files may also be specified by double-clicking on the <S> blocks immediately adjacent to the DUT in the block diagram.

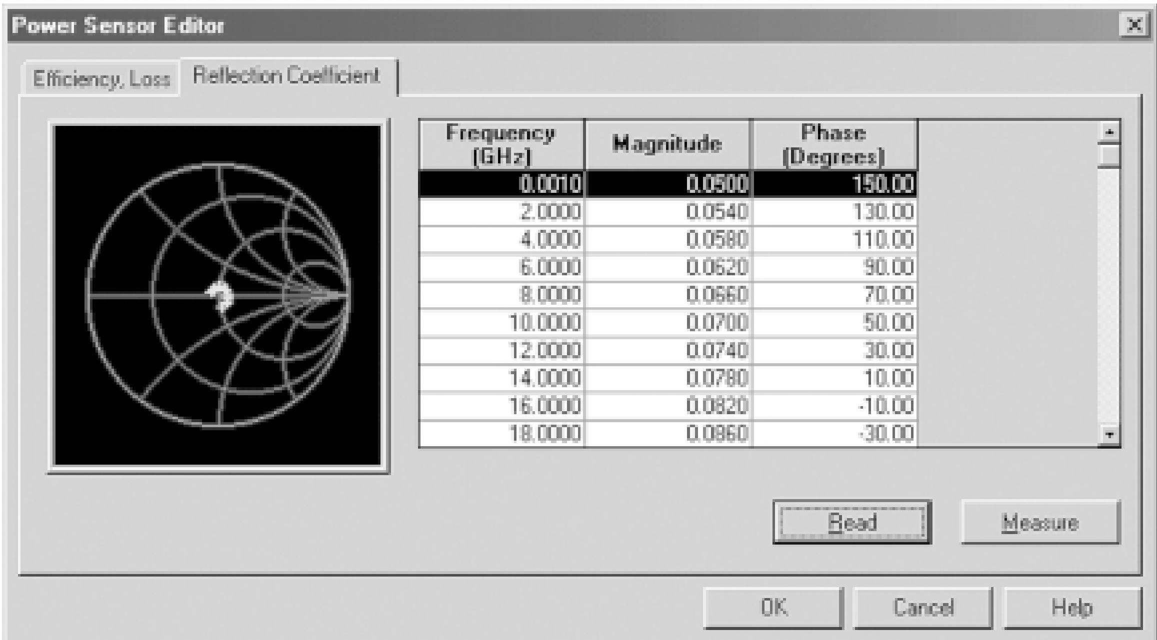


Figure 4-25. Power Sensor Editor, Reflection Coefficient Dialog.

Multiplexers are used to separate the fundamental and harmonic signals in a harmonic tuning application. The multiplexer s-parameters must also be deembedded. Separate s-parameter files are used for each path of each multiplexer used in the setup (see section 4.9.5). Multiplexer s-parameter files are specified in the property sheet brought up from the Block Diagram View by clicking on <Setup>, <Default Files/Directories>, and <Harmonic> (see section 4.5.3). These files may also be specified by double-clicking on the multiplexer blocks in the block diagram.

4.9.2 Tuner Embedding

In most cases, the tuners will be characterized independently of the fixture and multiplexers (if used). It is possible to embed the tuners files instead of specifying the deembedding s-parameters separately; however, embedding the tuner files has the disadvantage of not allowing for a fixture change without complete re-characterization of the tuners.

Embedding tuner data is most useful when only a limited phase range is desired for the tuner characterization. In this case, if the tuner data is not embedded, the phase will be rotated away from the desired range when the fixture s-parameters are de-embedded.

Embedding the tuner data during characterization is done by shifting the reference plane of the VNA port 1 to where the DUT plane will later be when the fixture is added. Even though the fixture is not physically connected, the correct reflection data (at the DUT plane) will be shown directly on the VNA display. This allows the desired phase to be selected based on the DUT reference plane.

4.9.3 TTF Models

If the Maury TTF (MT950 Model Series) is used as the device test fixture, the fixture s-parameter blocks may be specified as models. This fixture has interchange able inserts for different package styles. The following models are available for various fixture inserts:

TTF70: Use the original model for Maury MT950B2 with MT951A2 70 mil insert.

TTF100: Use the original model for Maury MT950B2 with MT951D2 100 mil insert.

TTFA: Use the new model for Maury MT950B2 with MT951A2 70 mil insert.

TTFB: Use the model for Maury MT950B2 with MT951B insert.

TTFC: Use the model for Maury MT950B2 with MT951C insert.

TTFD: Use the new model for Maury MT950B2 with MT951D2 100 mil insert.

TTFE: Use the model for Maury MT950B2 with MT951E insert.

TTFJ: Use the model for Maury MT950B2 with MT951J insert.

TTFM: Use the model for Maury MT950B2 with MT951M insert

4.9.4 Creating Fixture Files

When creating fixture files, the user must be aware of the following: two files must be set up, one for the input half of the fixture and one for the output half of the fixture. As shown in Figure 4-26, the reference plane convention for the fixture s-parameters is that port 1 is at the tuner, and port 2 is at the DUT, on either the input or output. Consequently, the same file can be used for both input and output if the fixture is symmetrical (or assumed to be). Including exact frequencies is recommended for best accuracy, although the program will interpolate if required. The accuracy with which the fixture s-parameters can be determined is very much fixture dependent. With some fixtures, network analyzer calibrations can be done inside the fixture at the DUT planes. With other fixtures, this is not possible, so approximation techniques must be used.

The fixture menu, an adaptation of the Maury MT956D Fixture Characterization Software, has three basic approaches to fixture characterization. The first two, 1-port and 2-port calibration approaches, require an estimate of the electrical length of each fixture half. The estimate need be accurate only to one-quarter wavelength throughout the frequency range. Alternatively, if the minimum frequency step size is such that the phase shift between frequencies is less than 180°, the software can calculate the length automatically.

☞ ***NOTE:*** *If large frequency step sizes are desired, use a non-uniform frequency list where at least one frequency step in the range is small enough. Alternately, the delay can be determined by first characterizing the fixture over a narrow range and using the automatic delay calculation feature. The value can then be recorded and entered manually for a characterization with wide frequency step sizes.*

a. The 1-port calibration approach requires 1-port network analyzer calibrations at the input plane and at the DUT plane for each fixture half. The software will then read both sets of 1-port calibration data from the VNA and subtract the two reference planes to get the 2-port s-parameters of the one fixture half. This approach assumes that the fixture is passive and reciprocal, and since each fixture half must be measured separately, requires a total of four calibrations (two each for each half of the fixture) unless the fixture is assumed to be symmetrical. See section 4.9.4.1 for a description of this technique.

b. The 2-port calibration approach requires 2-port network analyzer calibrations at the fixture input planes and at the DUT planes inside the fixture. The software will then read both sets of 2-port calibration data from the VNA and subtract the two reference planes to get the 2-port s-parameters of both fixture halves. This approach assumes that the fixture is passive and reciprocal, and requires only two calibrations. This method is excellent for fixtures where 2-port calibrations are the most accurate, such as a TRL calibration in microstrip. See section 4.9.4.2 for a description of this technique.

c. The third approach is an approximation that may be used when calibration inside the fixture at the DUT planes is not possible. The fixture is assumed to be passive and reciprocal. The s-parameters are calculated from measurements of the delay and loss of the fixture, which can be accomplished by either a reflection or transmission measurement. Both techniques assume the fixture is reflectionless. These methods are commonly used below 2 GHz and are primarily useful for fixtures consisting of a 50 ohm line from the connector to the DUT input plane. The reflection technique measures each half independently; however, it is more sensitive to mismatch errors than the transmission method. The latter technique, while somewhat less sensitive to mismatch, does assume that the fixture is symmetrical, but it is sometimes difficult to determine the length of the in-circuit thru used during the measurement. See sections 4.9.4.3 and 4.9.4.4 for a description of these techniques.

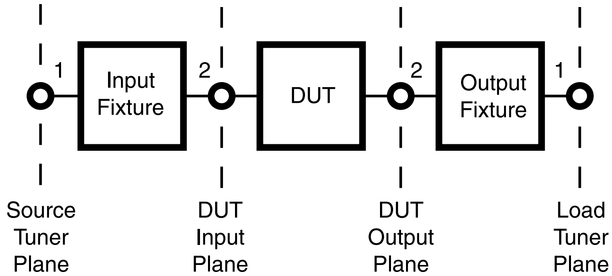


Figure 4-26. Reference Plane Convention

4.9.4.1 1-Port Fixture Calibration Procedure

a. Set up the VNA so that the fixture input can be connected directly to the test port.

b. From the Block Diagram View Menu click on <Fixture>, <Fixture 1-port> to bring up the dialog box for step 1 of the procedure.

c. If the frequencies have been previously set up in the network analyzer, click on <Re-Read VNA frequencies>. Otherwise, follow the on-screen instructions to enter a new frequency list, then click <Write new VNA frequencies>. It is recommended that the frequencies coincide with the tuner characterization frequencies; however, the program will interpolate if necessary. Note the maximum calculable airline length for the selected frequency step size. If the fixture half is longer than this value, it will be necessary to enter the length later in the procedure.

d. Perform an off-line, 1-port calibration at the VNA test port connector (*without the fixture*) using the analyzer front panel controls (the software will put the VNA in the local mode after reading the frequencies).

e. Enter the calibration set number and click <Next>. The software will then read the error correction terms from the network analyzer and bring up the dialog for step 2 of the procedure.

f. Connect the input half of the fixture to the VNA test port used in the prior calibration, and perform an off-line, 1-port calibration at the DUT plane *inside* the fixture using the analyzer front panel controls.

g. Enter the calibration set number for this last calibration and click <Next>. The software will then read the error correction terms from the network analyzer and bring up the fixture s-parameter display.

h. If the fixture-half electrical length is less than the maximum calculable air line length noted in the step 1 dialog, click on <Calculate length automatically>. Otherwise enter the estimated fixture length in centimeters.

☞ ***NOTE:*** *If the S12 or S21 trace suddenly jumps from one side of the polar chart to the other, check the fixture length value.*

If the system reference impedance for either calibration is not 50 ohms, click on <Renormalize> and enter the correct values.

Enter a label where indicated in the dialog box and click <Finish>.

i. Enter a file name for the fixture input half. Do not enter an extension. The software will automatically append ".s2p" as the extension. If the fixture is symmetrical (or assumed to be), the same file can be used for both the input and output halves. Otherwise, the entire procedure must be repeated for the output half.

4.9.4.2 2-Port Fixture Calibration Procedure

a. Set up the VNA with a return cable and test port connectors so that the fixture can be inserted when needed.

b. From the Block Diagram View Menu click on <Fixture>, <Fixture 2-port> to bring up the dialog box for step 1 of the procedure.

c. If the frequencies have been previously set up in the network analyzer, click on <Re-Read VNA frequencies>. Otherwise, follow the on-screen instructions to enter a new frequency list, then click <Write new VNA frequencies>. It is recommended that the frequencies coincide with the tuner characterization frequencies; however, the program will interpolate if necessary. Note the maximum calculable airline length for the selected frequency step size. If the fixture half is longer than this value, it will be necessary to enter the length later in the procedure.

d. Perform an off-line, 2-port calibration at the VNA test port connectors (*without the fixture*) using the analyzer front panel controls (the software will put the VNA in the local mode after reading the frequencies).

e. Enter the calibration set number and click <Next>. The software will then read the error correction terms from the network analyzer and bring up the dialog for step 2 of the procedure.

f. Connect the fixture between the VNA test ports used in the prior calibration, and perform an off-line, 2-port calibration at the DUT planes *inside* the fixture using the analyzer front panel controls.

g. Enter the calibration set number for this last calibration and click <Next>. The software will then read the error correction terms from the network analyzer and bring up the fixture s-parameter display.

h. If the fixture-half electrical length is less than the maximum calculable airline length noted in the step 1 dialog, click on <Calculate length automatically> for both the input and output fixture halves. Otherwise enter the estimated fixture lengths in centimeters.

☞ ***NOTE:*** *If the S12 or S21 trace suddenly jumps from one side of the polar chart to the other, check the fixture length value.*

If the system reference impedance for either calibration is not 50 ohms, click on <Renormalize> and enter the correct values.

Enter a label where indicated in the dialog box and click <Finish>.

i. Enter a file name for the fixture input half. Do not enter an extension. The software will automatically append ".s2p" as the extension. When prompted, enter a file name for the fixture output half.

4.9.4.3 Calculating Fixture S-Parameters: Reflection Method

a. Set up the VNA with a return cable an so that the fixture input can be connected directly to the test ports and calibrate the VNA at a single frequency for a 1-port measurement.

b. Connect the input half of the fixture to the VNA port, and insert a short at the DUT plane. Measure the reflection delay (picoseconds) and reflection loss (dB). Since this is the 2-way delay and loss, divide both values by 2 to get the 1-way delay and loss.

c. From the Block Diagram View menu, click on <Fixture>, <Fixture Calculate> to bring up the Fixture S-Parameter Estimation dialog box.

d. Enter the frequency range over which the fixture s-parameters are to be calculated, the delay and loss recorded in (b) above, the frequency at which these were measured, and a label, then click <OK>.

e. Enter a file name for the fixture input half. Do not enter an extension. The software will automatically append ".s2p" as the extension. The s-parameter display will now be visible. Use the <LEFT/RIGHT ARROW> keys to move the frequency marker and read the s-parameters at each frequency.

f. If the fixture is symmetrical (or assumed to be), the same file may be used for both input and output halves. Otherwise, repeat the procedure starting with (b) above.

4.9.4.4 Calculating Fixture S-Parameters: Transmission Method

a. Set up the VNA with a return cable so that the fixture input can be connected directly to the test ports and calibrate the VNA at a single frequency for a 2-port measurement.

b. Connect the fixture between the test ports, insert a thru in the fixture, and measure the delay (picoseconds) and loss (dB). If the thru is not "zero length", subtract its delay and loss from the measured results, divide the remainders by two, and record the results.

c. From the Block Diagram View menu, click on <Fixture>, <Fixture Calculate> to bring up the Fixture S-Parameter Estimation dialog box.

d. Enter the frequency range over which the fixture s-parameters are to be calculated, the delay and loss recorded in (b) above, the frequency at which these were measured, and a label, then click <OK>.

e. Enter a file name for the fixture half. Do not enter an extension. The software will automatically append ".s2p" as the extension. The s-parameter display will now be visible. Use the <LEFT/RIGHT ARROW> keys to move the frequency marker and read the s-parameters at each frequency.

f. Since this procedure assumes the fixture to be symmetrical, use the same file for both the input and output halves of the fixture.

4.9.5 Creating Multiplexer Files

When creating multiplexer files, the user must be aware of the following: several files must be set up, one for the fundamental section of the multiplexer, one for the 2nd harmonic section of the multiplexer and another for the 3rd harmonic section of the multiplexer. Including exact frequencies is recommended for best accuracy, although the program will interpolate if required. The most direct way to create multiplexer files is to calibrate the network analyzer at the proper reference plane on both sides of the multiplexer and then measure the s-parameters using the s-parameter measurement function.

The orientation of the multiplexer s-parameter data (ports 1 and 2) is the same as for the fixture, shown in Figure 4-26. The multiplexer will be inserted between the fixture and the tuner on either the load or source side. This can also be seen in the block diagram if the option to show the port numbers is selected.

Refer to Section 6.3 for 2-port s-parameter measurements, also refer to the network analyzer manual for calibration instructions.

4.10 Manipulating S-Parameters

The fixture menu, an adaptation of the Maury MT956D Fixture Software, contains several functions that are useful to manipulate s-parameter files. These can be used to make reference planes match the block diagram.

4.10.1 Cascade S-Parameters

This is used to cascade two 2-port s-parameter files, and create a resulting combined file. Select <Fixture><Cascade S-Parameters> to bring up the dialog shown in Figure 4-27.

Click the <Reverse> buttons as required to set up the desired port conventions for each s-parameter block. Click on each <Change>

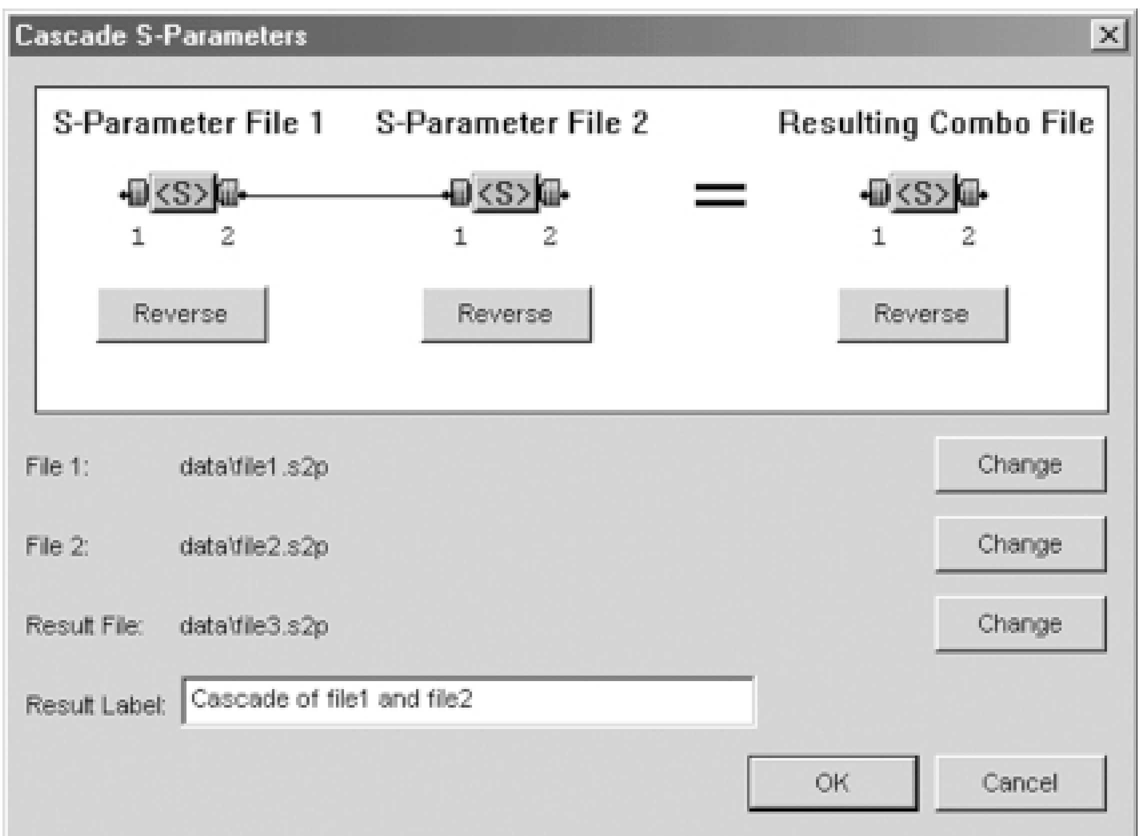


Figure 4-27. Cascade S-Parameters Dialog

button to setup the filenames for the input files and the resulting files. Enter a label for the resulting s-parameter file.

When the filenames, port conventions, and label are correct, click OK to create and save the cascaded s-parameter file.

4.10.2 Un-cascade S-Parameters

This is used to un-cascade a known 2-port s-parameter block away from a known combined s-parameter block, and create a residual result file. Select <Fixture><Un-cascade S-parameters> to bring up the dialog shown in Figure 4-28.

Click the <Reverse> buttons as required to set up the desired port conventions for each s-parameter block. Click on each <Change> button to set up the filenames for the input files and the resulting files. Enter a label for the resulting s-parameter file.

When the filenames, port conventions, and label are correct, click OK to create and save the un-cascaded s-parameter file.

4.10.3 Reverse S-Parameters

This is used to reverse the port conventions of an s-parameter file. From the fixture menu, select <Reverse S-Parameters>. Browse for a filename, and that file will be read, reversed, and displayed as shown in Figure 4-29. If the result looks correct, click <OK> and enter a new filename to save the reversed s-parameter data.

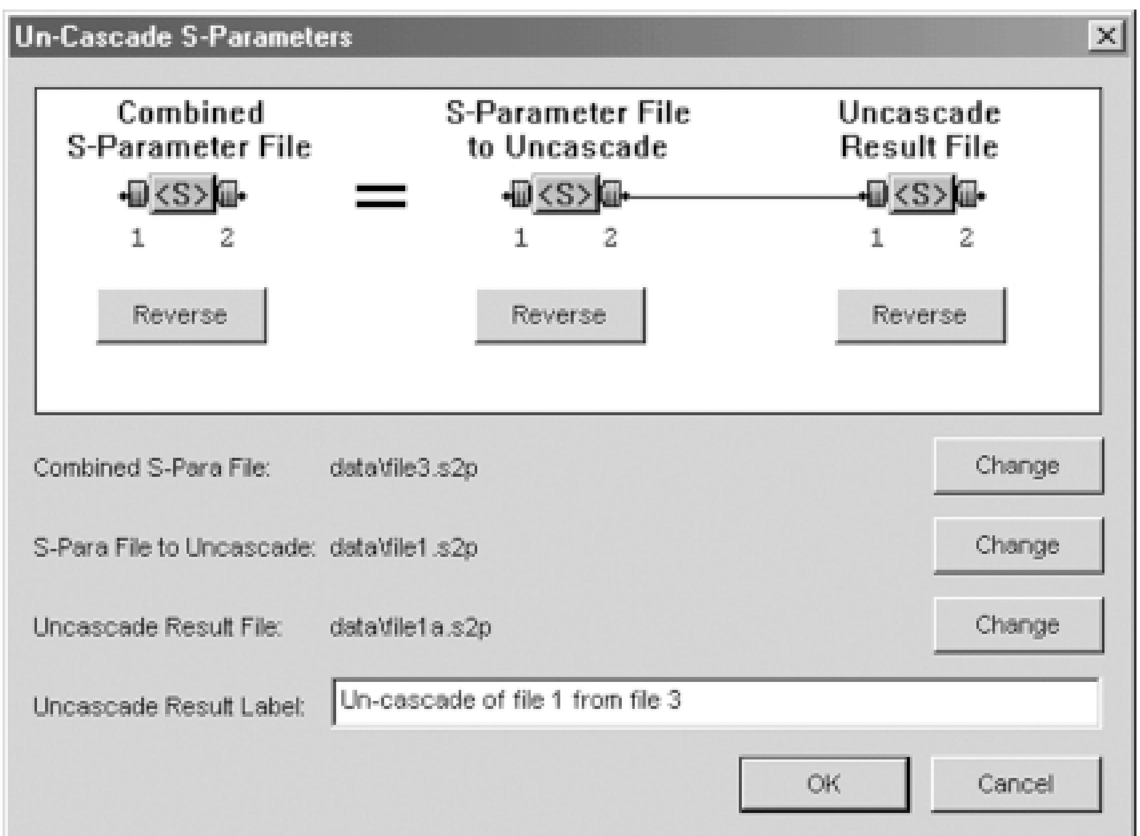


Figure 4-28. Un-Cascade S-Parameters Dialog

4.10.4 Re-Normalize S-Parameters

This is used to re-normalize s-parameter data to difference reference impedances. It will operate on 2-port s-parameter data that is already in memory.

In general, s-parameters are relative quantities, and the s-parameter definition allows every port to be normalized separately. From the Fixture Menu, select <Re-normalize S-parameter memory> to bring up the dialog shown in Figure 4-30. Adjust the current and desired reference impedance entries, and click OK.

To view and save the result, use the View S-parameter menu to access the s-parameter data in memory.

4.11 Displaying Software Version

Select <Help> from the SNPW menu, then select <About SNPW> to display the software version and release date, serial number, and installed options. The copyright notice is also displayed here.

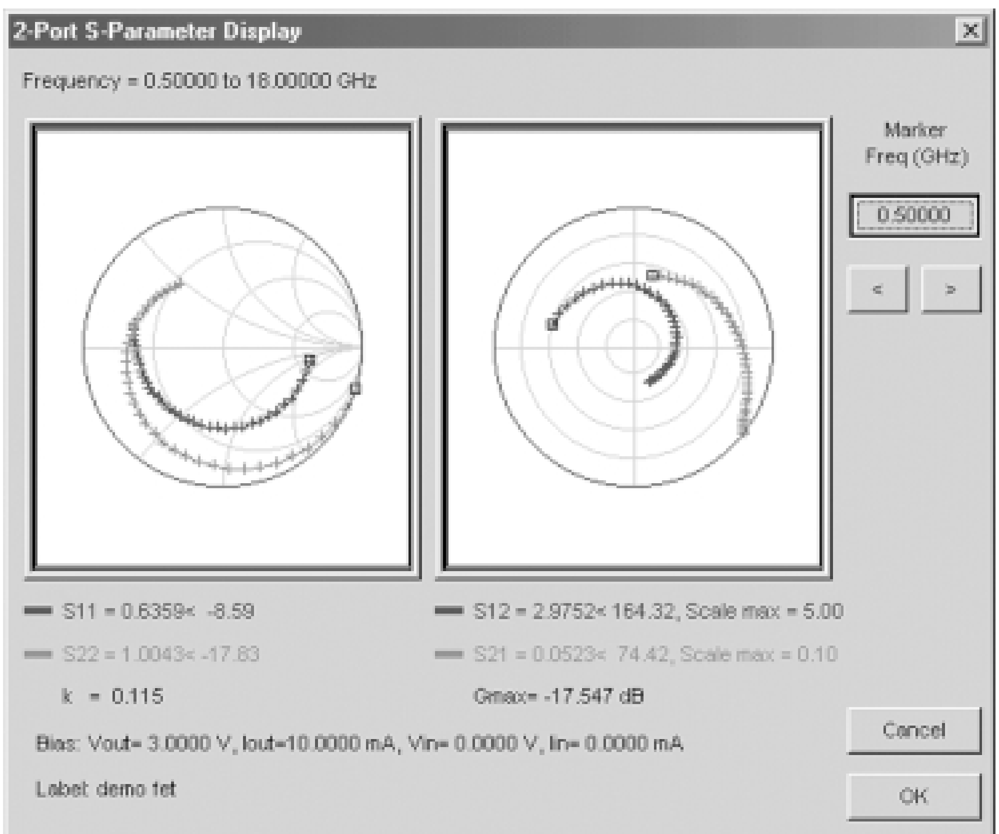


Figure 4-29. Display of Reversed S-Parameters

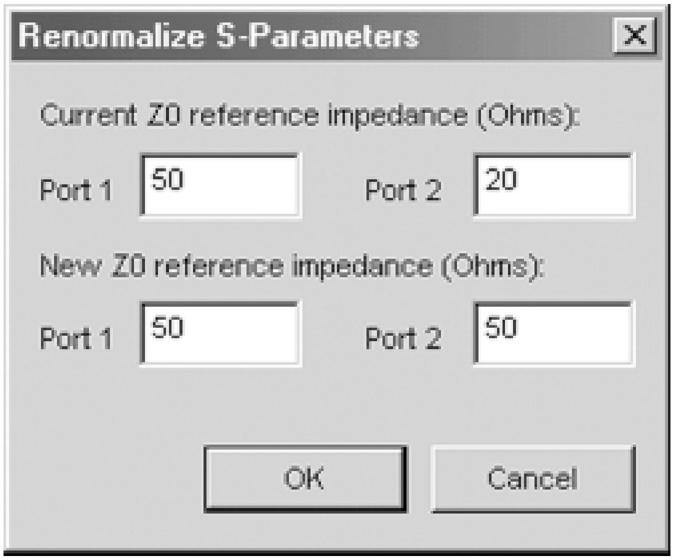


Figure 4-30. Renormalize S-Parameters Dialog

5
Calibrating the System

5.1 Calibrating the Tuners

Before any operation using tuners can be done, the tuners must be calibrated. This consists of entering tuner data into memory for both tuners. This is initially done by characterizing the tuners by direct measurement with the network analyzer. Subsequently, this is normally done by reading previously saved tuner files.

The tuner data consists of measured 2-port s-parameter data and corresponding tuner positions for a number of discrete tuner positions at every frequency. **Although referred to always as "tuner data", the s-parameters may include bias tees, adapters, and other passive components cascaded with the tuners.**

When connecting the tuners to the network analyzer for characterization, the end of the tuner which will be closest to the DUT should be connected to port 1 of the network analyzer. This convention, shown in Figure 5-1, provides a symmetry which allows a tuner to be used in either the source or load position after characterization. Bias tees, filters, and other lossy components should be on the opposite side of the tuner.

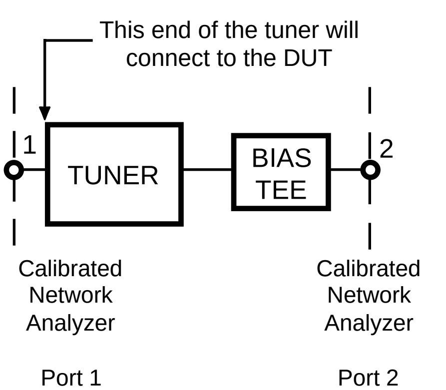


Figure 5-1. Tuner Orientation Convention During Characterization

There are two general methods of characterizing the tuners: step reflection and step position. The step reflection method is based on a specified reflection coefficient range (magnitude and phase), and the step position is based on a position range (carriage and probe). The step reflection method is normally preferred, as it provides much more uniform coverage of the Smith chart.

5.1.1 Automatic Step Reflection Tuner Characterization

This tuner characterization method selects positions with a constant separation on the Smith Chart. This method first measures the tuner to model the tuner, then selects positions to fully characterize the tuner based upon the model.

From the Block Diagram view, select: <Setup>, <Characterize Tuners>, <Step Reflection>. Select the tuner to be calibrated. Note that with the established port conventions, a tuner may be used in any position (source, load, etc.), regardless of the selection here, simply by recalling its file – provided the frequency range is correct for that position. A prompt to re-initialize the tuner will appear. Select <Yes> if the tuner has not been previously initialized within the past few hours (recommended with a new characterization).

a. A prompt to calibrate the network analyzer for a 2-port measurement will be displayed.

   The network analyzer frequencies will be read and displayed, and you can accept them, or enter new values. If you enter new frequencies, click the <Write New VNA Frequencies> button before starting the calibration.

   Calibrate the network analyzer by turning on a previous calibration, or by doing a new one. The network analyzer should be calibrated from it's front panel using whatever calibration method available which will give the best accuracy.

When the 2-port VNA calibration is ready, click Next.

NOTE: *Be sure to leave the network analyzer frequencies alone after they are read by the SNPW program.*

b. The next wizard page provides for embedding the VNA calibration.

NOTE: *See Section 5.1.3 for more discussion of Embedding Tuner Data.*

If embedding is needed, first make sure the fixture and multiplexer files are correct. If not, click the change buttons to select new files (or

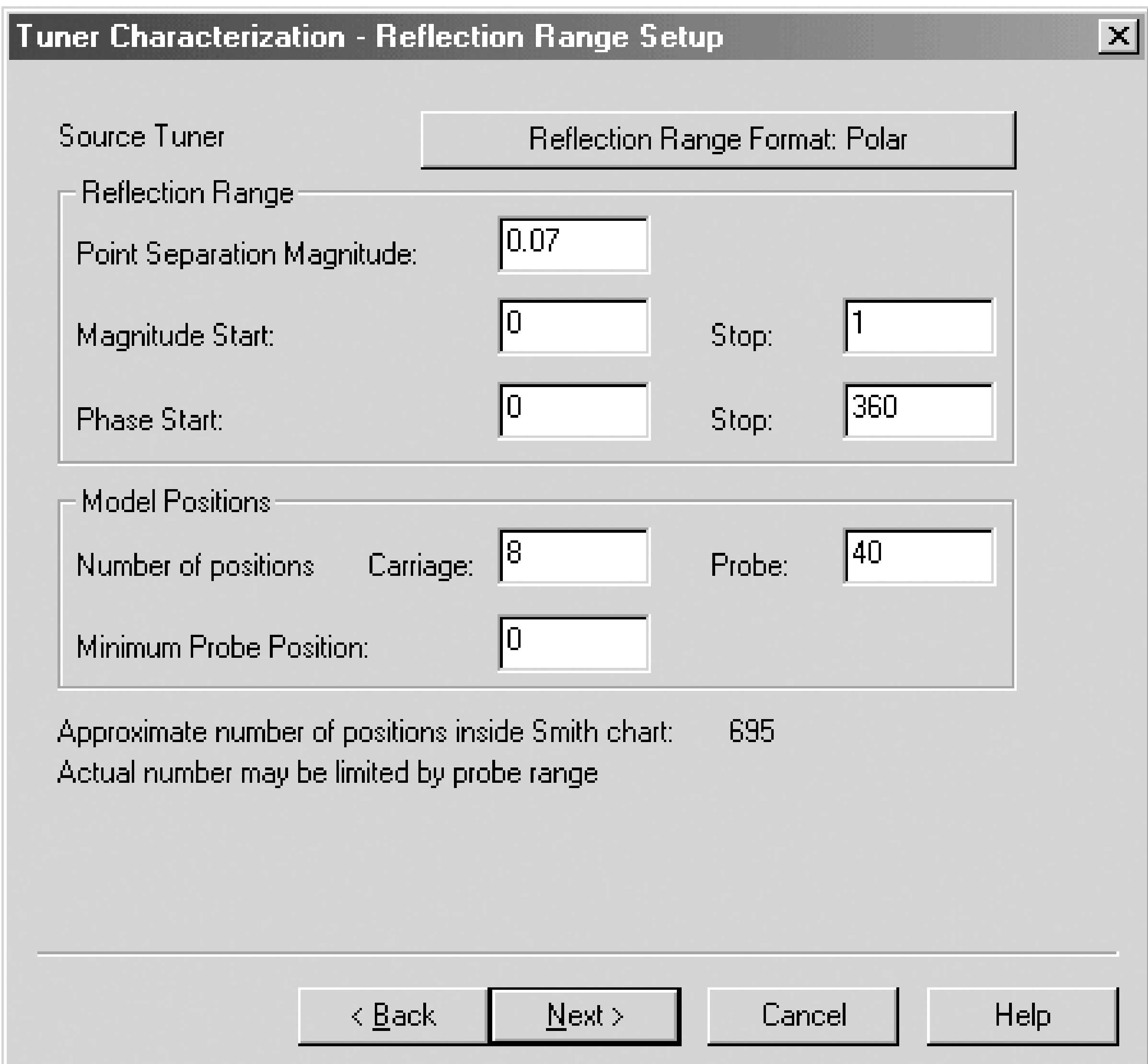


Figure 5-2. Tuner Step Reflection Range Setup Editor

fixture model). Next, specify the VNA Cal. set numbers to read and write before clicking the <Embed VNA Calibration> button.

This will read the current error terms from the specified cal set, shift the reference plane of the VNA port 1 thru the s-parameters of the fixture/multiplexer, and then write the new error terms back to the specified cal set to write. The reference plane of the VNA port 2 will not change.

If the VNA calibration was previously embedded, just click the check box to indicate that, but do not embed the calibration a second time.

☞ ***NOTE:*** *If embedding is done, the model or filenames will be written into the tuner file.*

When the embedding is done, or if embedding is not needed, click Next.

c. The next wizard page prompts to select the characterization frequencies as a subset of the VNA frequency range. The initial default will be the same as the VNA frequencies.

   Also, click the "Harmonics Selected" button to toggle through the choices to select the number of harmonic frequencies to measure.

   If the VNA calibration has insufficient frequency range to measure all specified harmonics over the full fundamental frequency range, a warning will be displayed on the screen. In this case, the harmonics that are available will be measured. Therefore, the tuner data or file could have harmonic frequencies at the low fundamental frequencies, and fewer (or zero) harmonic frequencies at the higher fundamental frequencies.

   Click <Next> to proceed.

d. The next step is to edit the range of reflection coefficients, if desired. The default range (see Figure 5-2) will provide nominal reflection coefficient coverage of the entire Smith chart.

   To change the coverage of the Smith chart, edit the magnitude and phase start/stop values in the Reflection Range box.

   The Point Separation Magnitude specifies the density of the measured points (how close they are together). The approximate number of points that will result is shown at the bottom of the dialog. (It's approximate because the specified magnitude range could go beyond the physical capability of the tuner.) Edit the value of the Point Separation Magnitude, then click on another edit box to update the approximate number of points.

e. On the last page of the wizard, enter the label and filename for the data, then select <Finish> to start the characterization.

f. When the characterization is complete, the program will store the file under the selected file name and bring up a S11 Smith chart display of all characterized tuner points at the start frequency. See Section 5.1.7 for more information on the tuner display.

5.1.2 Automatic Step Position Tuner Characterization

This automatic tuner characterization will step the tuner motors over a range of positions to create a grid of impedance points. The default ranges will spread the points over the entire Smith chart. The ranges can be modified at each frequency to cover desired Smith chart areas.

From the Block Diagram view, select: <Setup>, <Characterize Tuners>, <Step Position>. Select the tuner to be calibrated. Note that with the established port conventions, a tuner may be used in any position (source, load, etc.), regardless of the selection here, simply be recalling its file – provided the frequency range is correct for that position. A prompt to re-initialize the tuner will appear. Select <Yes> if the tuner has not been previously initialized within the past few hours (recommended with a new characterization).

To do Step Position automatic tuner characterization, select <Characterize Tuners> from the <Setup> Menu, then <Step Position> and choose either <Source Tuner>, <Source2 Tuner>, <Source3 Tuner> or <Load Tuner>, <Load2 Tuner>, or <Load3 Tuner>. This starts the tuner characterization wizard with the following sequence:

a. A prompt to calibrate the network analyzer for a 2-port measurement will be displayed.

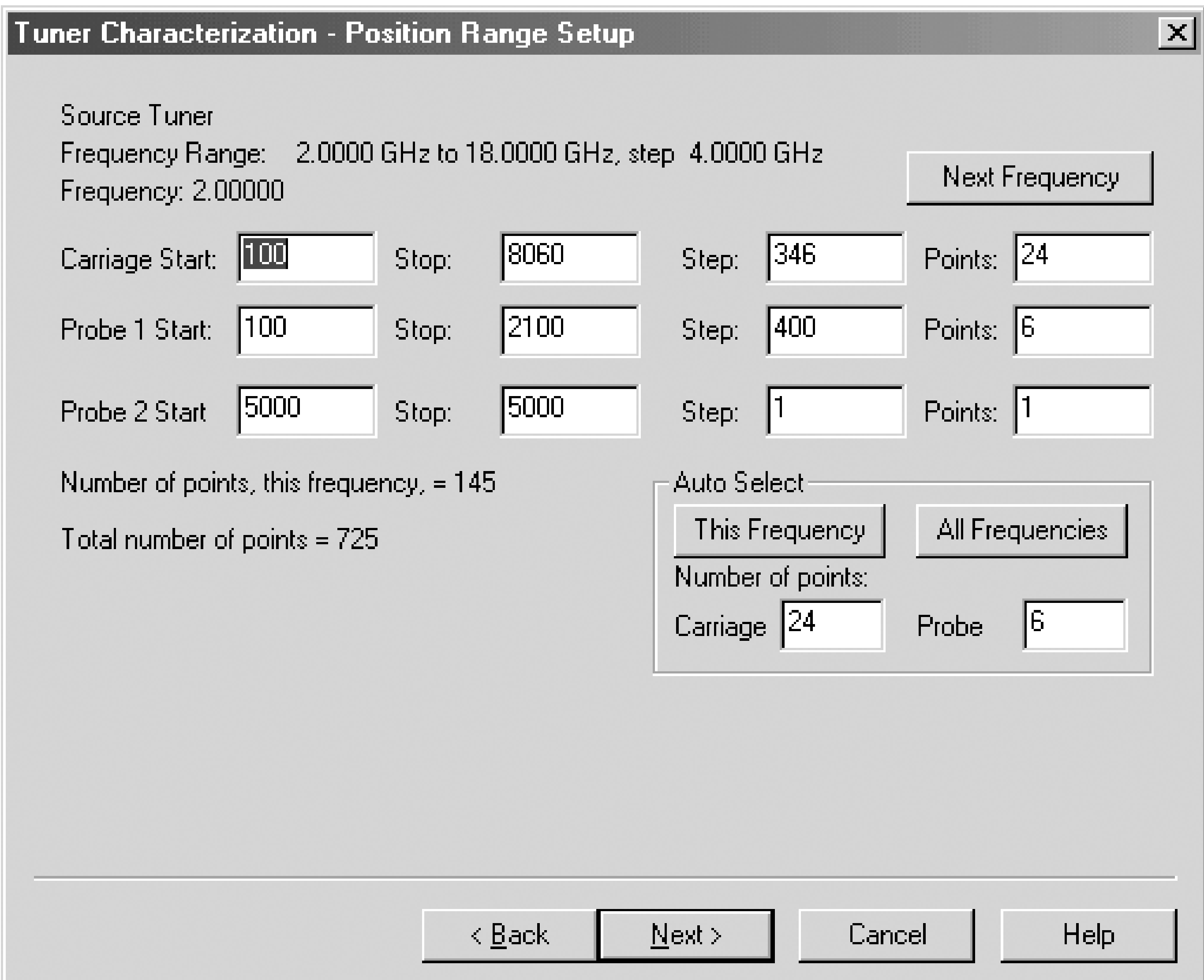


Figure 5-3. Tuner Step Position Range Setup Editor

The network analyzer frequencies will be read and displayed, and you can accept them, or enter new values. If you enter new frequencies, click the <Write new VNA Frequencies> button before starting the calibration.

Calibrate the network analyzer by turning on a previous calibration, or by doing a new one. The network analyzer should be calibrated from it's front panel using whatever calibration method available which will give the best accuracy.

When the 2-port VNA calibration is ready, click <Next>.

☞ ***NOTE:*** *Be sure to leave the network analyzer frequencies alone after they are read by the SNPW program.*

b. The next wizard page provides for embedding the VNA calibration.

☞ ***NOTE:*** *See Section 5.1.3 for more discussion of Embedding Tuner Data.*

If embedding is needed, first make sure the fixture and multiplexer files are correct. If not, click the change buttons to select new files (or fixture model). Next, specify the VNA cal set numbers to read and write before clicking the <Embed VNA Calibration> button.

This will read the current error terms from the specified cal set, shift the reference plane of the VNA port 1 thru the s-parameters of the fixture/multiplexer, and then write the new error terms back to the specified cal set to write. The reference plane of the VNA port 2 will not change.

If the VNA calibration was previously embedded, just click the check box to indicate that, but do not embed the calibration a second time.

☞ ***NOTE:*** *If embedding is done, the model or filenames will be written into the tuner file.*

When the embedding is done, or if embedding is not needed, click <Next>.

c. The next wizard page prompts to select the characterization frequencies as a subset of the VNA frequency range. The initial default will be the same as the VNA frequencies.

Also, click the "Harmonics Selected" button to toggle through the choices to select the number of harmonic frequencies to measure.

If the VNA calibration has insufficient frequency range to measure all specified harmonics over the full fundamental frequency range, a warning will be displayed on the screen. In this case, the harmonics that are available will be measured. Therefore, the tuner data or file could have harmonic frequencies at the low fundamental frequencies, and fewer (or zero) harmonic frequencies at the higher fundamental frequencies.

Click <Next> to proceed.

d. The next step is to edit the range of positions, if desired. The default range (see Figure 5-3) will provide nominal reflection coefficient coverage of the entire Smith chart. The density depends on the default number of carriage and probe positions, shown in the lower right corner of the Position Range Setup Page.

The position range is set independently at each frequency, to optimize coverage. The probe which is out of band will stay retracted.

To change the coverage of the Smith chart, edit the carriage position range to modify phase, and edit the active probe position range to modify magnitude.

The easiest way to get uniform phase coverage is to set the default number of positions, then auto-select. This can be done one frequency at a time, or for all frequencies at once.

☞ ***NOTE:*** *The active probe is determined by the frequency if there are two probes. Probe 1 is the low frequency probe and probe 2 is the high frequency probe. The crossover frequency can be seen by the probe selection in the automatic range selection. It is also listed in the appropriate tuner manual.*

If complete coverage of the Smith chart is not needed, the easiest way to determine what position range is needed is to put the system in local, and move the tuners manually to determine the start and stop points for the carriage and the active probe. This works best if you start the characterization, and choose tuner embedding to get the network analyzer reference plane shifted to the device plane. Then back out and go to local. Then the limits can be determined and the characterization started again. This time, select embedding so the tuner file will be properly labeled, but do not modify the network analyzer cal set a second time.

e. On the last page of wizard, enter the label and filename for the data, then select <Finish> to start the characterization.

f. When the characterization is complete, the program will store the file under the selected file name and bring up a S11 Smith chart display of all characterized tuner points at the start frequency. See Section 5.1.7 for more information on the tuner display.

5.1.3 Embedding Tuner Data During Characterization

If desired, the reference plane of the network analyzer calibration can be shifted away from the tuner port to what will be the device reference plane when the fixture is connected to the tuner. The purpose is to have the network analyzer display the tuner reflection coefficient that the device will see. This is normally very important when partial coverage of the Smith chart is desired during a step reflection characterization, and is useful for choosing a tuner position range in local mode prior to a step position characterization. It does reduce the flexibility of the tuner data, since it can later be used only with the one fixture.

Once a tuner position range is determined, embedding is normally not selected for a step position characterization. This is because an unembeded tuner file can later be used with any fixture, so it is more flexible. Also, since the tuner is moved automatically and the measurement will run unattended, there is little need to view the data at the device plane during the characterization.

If embedding is selected, the network analyzer calibration will be read into the computer, modified, then written back to the network analyzer. If the network analyzer can store only one calibration, the original calibration will be lost. However, if the network analyzer can store multiple cal sets, you will be prompted for a cal set number to read and write. The cal set to read should be the current calibration. The cal set to write will be where the modified calibration terms will be written and will become the current calibration.

☞ ***NOTE:*** *If the modified cal set cannot be saved into a different cal set, the original calibration will be lost. It may be useful to save the original calibration on disk before embedding if the network analyzer has that provision.*

5.1.4 Saving Tuner Files

Since tuner characterization is time consuming, it is important to save the tuner data in files. This can be done during the tuner characterization, and can also be done by selecting <Save As> from the <File> menu of the tuner display view.

It is sometimes useful to save additional copies of a tuner file. For example, if a special set of points has been selected in the noise or power measurement, that selection will be saved.

5.1.5 Recalling Tuner Files

From the Block Diagram view, select: <Setup>, <Characterize Tuners>, <Get Tuner File>. Then select the position of the tuner (load, source, etc.). The default file name will be pre-typed on the entry line to minimize effort when the same files are always used.

5.1.6 Combining Tuner Files

Tuner files may be combined to consolidate frequency ranges or density of reflection coverage at frequencies that two tuner files have in common.

Tuner file combining reads in two tuner files; compares these files for common model numbers and embedding, then produces a new tuner file. To combine tuner files, select <Characterize Tuners> from the <Setup> Menu, then <Combine Tuner Files>. This produces the following sequence:

a. A prompt for the first tuner data file. Enter the desired file name or press <Browse> to select a tuner data file. This file will be opened and read.

b. The next prompt will be for the second tuner data file. Enter the desired file name or press <Browse> to select a tuner data file. This file will be opened and read.

☞ ***NOTE:*** *These data files will be compared for common tuner model numbers and embedding. If one of these comparisons fails, the program will return a warning message and stop the combining process.*

c. The final prompt will be for the combined data file name.

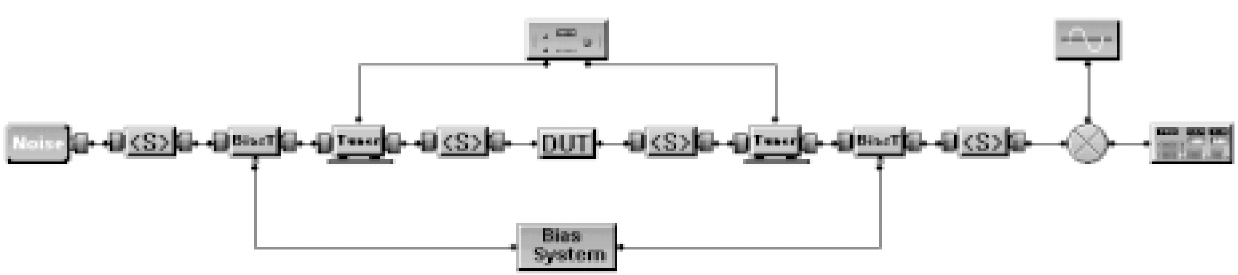


Figure 5-4. Typical Setup for Performing Noise Measurements

5.1.7 *Displaying the Tuner Data*

The tuner data is displayed immediately after a characterization. It can also be displayed from the block diagram view by reading a tuner file: Select <View >, <Tuners> and select the tuner to be displayed. The initial display will be a S11 Smith chart showing all the characterized tuner points at the start frequency.

Press a <Right/Left Arrow> key to toggle through the entire frequency range. Alternatively, press <Ctrl-F> or select <View>, <Change Frequency>, and use the <Up/Down Arrow> keys to select a specific frequency for display.

When the mouse cursor is moved within the chart, its position is continuously displayed just below the chart. Clicking the left mouse button on a characterized point brings up a readout of all four s-parameters at that point. A readout of the s-parameters between characterized points can be obtained by selecting <View> from the menu bar, checking <Interpolate>, and left clicking on the area of interest in the chart.

To bring up a display of any of the other three s-parameters, select <View>, <Format> and toggle through the selections in the pop-up window.

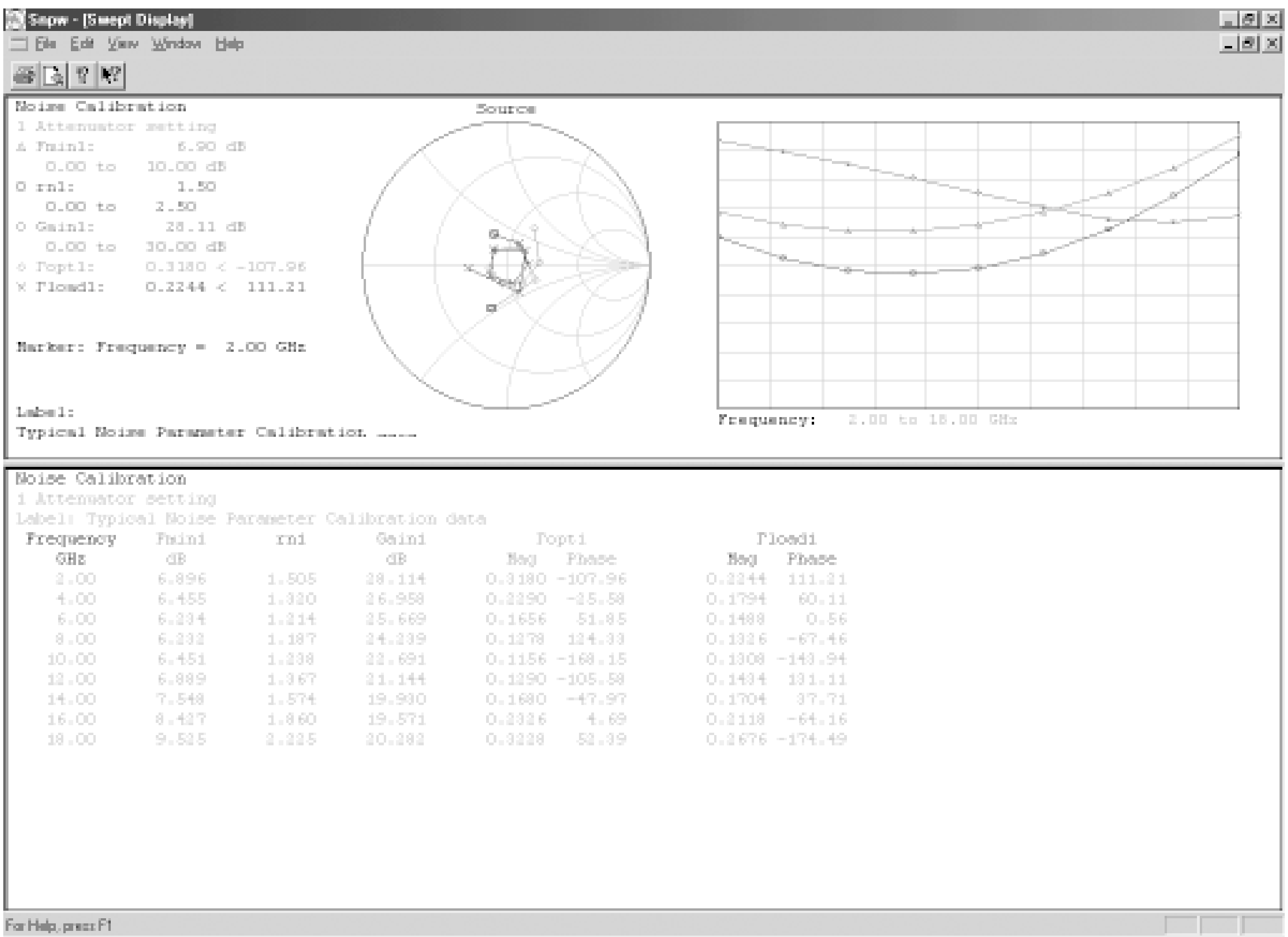


Figure 5-5. Noise Calibration Display

Areas of the displayed chart can be viewed in more detail by a right-click within the chart and selecting <Zoom window> from the pop-up menu. Hold the left mouse button and drag the rectangular window over the area of interest. When the button is released, the area within the rectangle will be magnified. Right click again and select <Zoom all> to return to the original chart.

The tuner may be moved to a specific point by a right-click to bring the pop-up menu and selecting <Move Tuner>. Move the boxed cross-hair cursor to the position of interest and left-click the mouse.

The tuner data does not normally include any de-embedding s-parameters that are specified in the block diagram. To see the de-embed-emded tuner data, select <View>, <Cascade S-Parameters> from the menu bar. Clicking that menu item again will toggle the cascade mode off.

Press <Esc> or click on the close window box on the menu bar to exit the tuner display.

5.1.8 Initializing Tuners

Before the tuners can be used, they must be physically initialized. This consists of finding the lower optical limit sensors to provide a repeatable starting point for the stepper motor operation. Normally, this is done automatically the first time that the tuners are needed in any calibration procedure.

To initialize (or re-initialize) the tuners separately from any other function, select <Calibrate><Initialize Tuners>.

☞ ***NOTE:*** *Re-initialize is needed when the controller is turned off, or a limit is encountered (this may happen during local control, or during system troubleshooting).*

5.2 S-Parameter Calibration

5.2.1 Calibrating the Network Analyzer

S-parameter calibration is done in local mode on the vector network analyzer (VNA), so any available calibration technique can be used. However, only a linear frequency range is

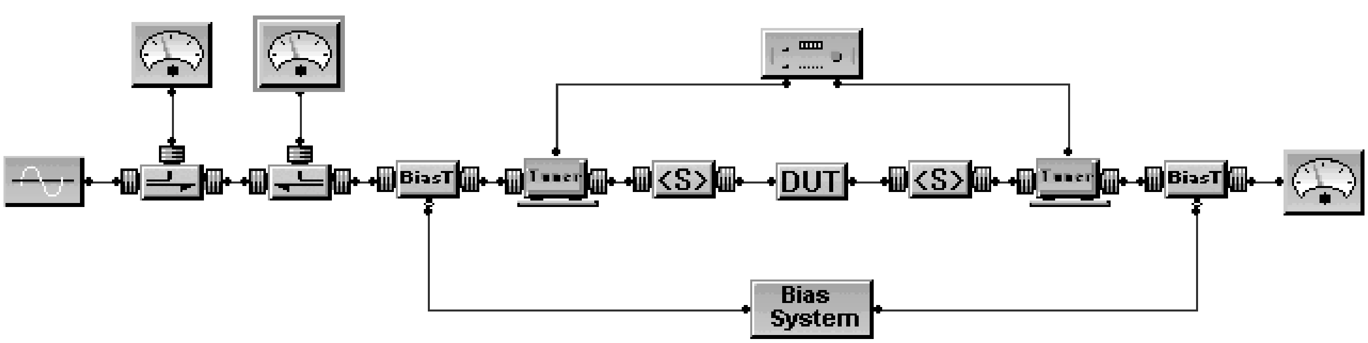


Figure 5-6. Typical Setup for Performing Power Measurements

allowed, so the program will set up a frequency list on the network analyzer prior to prompting the user to do the calibration.

Even though the actual network calibration is done off-line, the program will not allow any s-parameter measurements until this step has been done.

The sequence is as follows:

a. Select <Calibrate>, then either <1 Port S-Parameters> or <2 Port S-Parameters> as required. If a 2-port calibration is done, either 1-port or 2-port measurements may be done. A 1-port calibration can be used for noise source or power sensor measurement, or general 1-port s-parameter measurements.

b. The software will read the network analyzer frequencies, and then put the network analyzer into local mode so it can be calibrated off-line. The VNA Calibration Dialog will display the frequencies, and prompt to do the calibration.

   To change the network analyzer frequencies prior to the calibration, enter the new range and click the <Write new Frequencies> button.

   If a 2-port calibration is being done, the dialog will also include a de-embedding block, this allows the reference plane of the network analyzer to be shifted through the specified s-parameter. This is important, for example, if you calibrate at the coaxial plane, but want to measure at the de-embedded DUT plane.

   To de-embed the network analyzer calibration, make sure that the de-embedding specifiers are correct, enter the cal set numbers to read and write, and click the "De-embed VNA Calibration" button. This will read the current error terms from the specified cal set, shift the reference planes of both VNA ports away from the VNA through the specified s-parameters, and then write the new error terms back to the specified cal set to write.

c. When the calibration is complete, or if the network analyzer was previously calibrated, press <VNA Cal Ready> and verify that the calibration is still on and active. Most network analyzers turn the calibration off when the frequencies are written to them.

5.2.2 Accuracy Considerations for S-parameter Calibration

When calibrating the network analyzer, it is very important to get the best accuracy possible. In noise measurements, very complex, nonlinear mathematics are used to solve for the noise parameter solution, and small errors anywhere can be amplified into larger errors in the final result. Power measurements are somewhat less sensitive, but errors can still be carried through to the end result.

NOTE: *TRL (or LRL) calibration are generally recommended when highly reflective devices (such as tuners or transistors) are to be measured. TRL calibrations tend to produce better source match, which improves measurements at the edge of the Smith chart.*

It is highly recommended that the residual source match be measured to verify the accuracy prior to continuing. This can be done fairly simply by connecting a long offset short to each port and looking at the measured return loss vs. frequency. Ideally, the response should be smooth, and flat, and some loss (a few tenths of a dB) is normal. A large peak to peak (p-p) ripple (or gain) indicates poor calibration.

5.3 Noise Calibration

5.3.1 The noise measurement system should be set up per Figure 5-4. For the noise calibration, a thru will be put in place of the DUT, and the complete noise and gain parameters of the receiver will be measured vs. frequency. Tuner files must be already read into memory. During the noise calibration, a noise source file and a thru 2-port s-parameter file will be needed. The noise source file contains the ENR and the reflection coefficients of the noise source in the hot/cold states. The thru does not need to be perfect, but must have known s-parameters in a file.

5.3.2 The sequence of the noise calibration is as follows:

a. Select <Noise> from the <Calibrate> Menu.

b. Select <New Cal> from the Noise Calibration Menu.

c. The available frequency range and the current frequency range will be displayed. The available range consists of frequencies which the two tuner files have in common. The current frequencies will be the same or a subset (if a subset was selected previously).

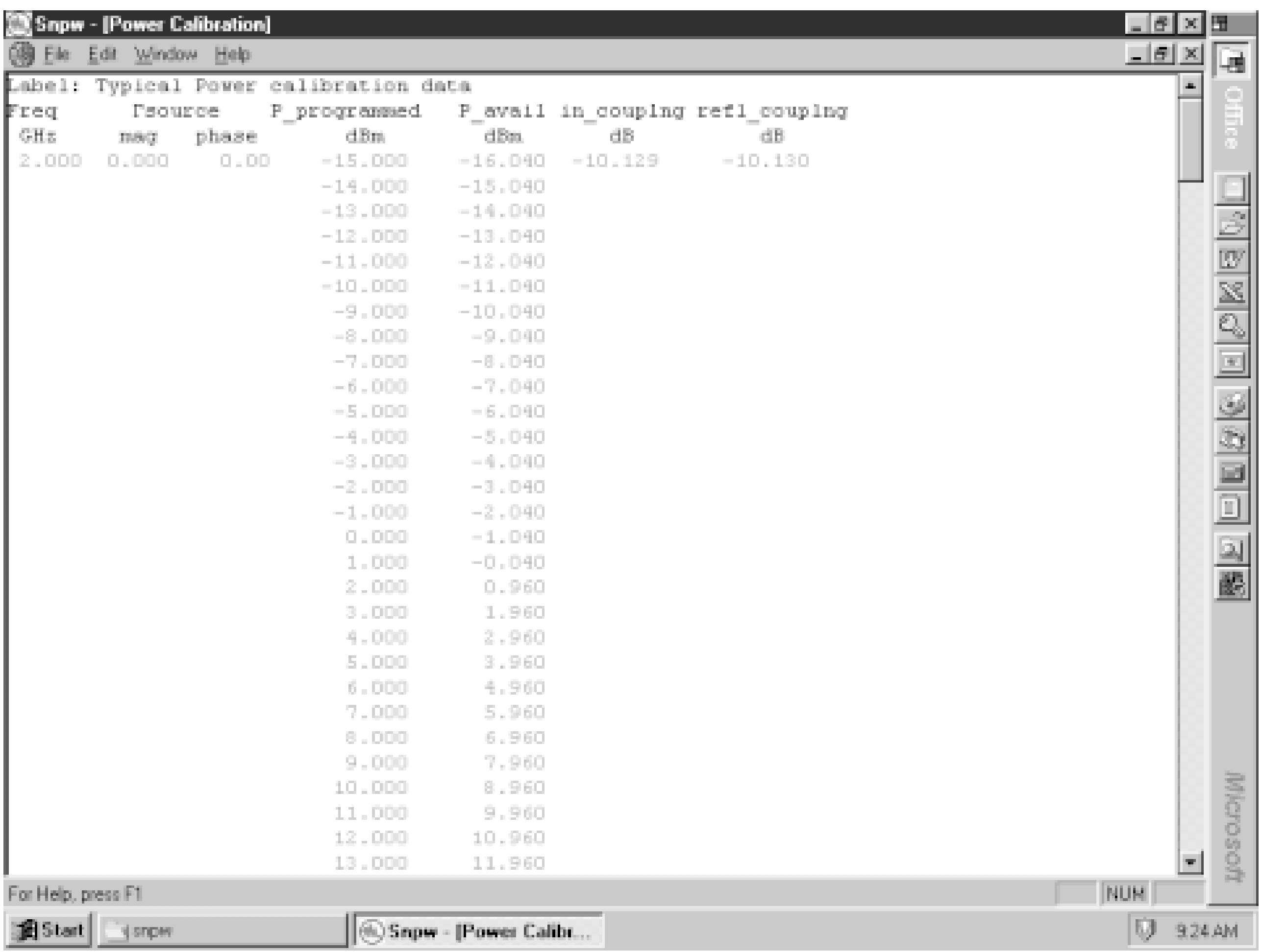


Figure 5-7. Power Calibration

The default thru filename will be pre-typed onto the entry line for convenience, since often the same file is always used. Enter or browse to select a new filename.

The ambient temperature in degrees Celsius may also be changed here. This value is needed to accurately model the noise contribution of the passive components of the system (such as tuners, adapters, etc.).

d. When all entries are complete, click <OK>. The program will then read the noise source file established on the Setup Files menu and will then do an on-line check to insure that all required instruments in place and connected to the GPIB. A prompt to re-initialize the tuners will appear. Click <Yes> if the tuners have not been recently initialized.

e. The last prompt before starting the calibration is to connect the thru. Make sure that it is in place, then click <OK>. The number of calibration impedance points will be the current values setup in the noise options editor. As the calibration progresses, the data will scroll through the lower part of the screen, and will be progressively plotted in the top part. The number of lines tabulated per frequency depends on the RF attenuator range to be calibrated.

If there is any problem with the calibration data, press the <End> key to abort the calibration. The program will revert to the Block Diagram view. Select <Setup> and <Go to local> to troubleshoot the system.

f. When the calibration is complete, a prompt to enter a label will appear. If this was the first calibration of the session, the label entry line will be blank. If an earlier calibration had been completed and labeled, that label will appear on the entry line. Select <Don't Change> to accept the label shown or, if the line is blank, to skip this step and not apply a label. Otherwise, enter a new label and click <OK>. This will bring up a prompt to save the data. Enter a file name and click <Save>, or <Cancel> to avoid saving the data. The calibration may be saved later during the session by selecting <File>, <Save As> in the calibration display menu.

g. After completing the file save dialog, the noise calibration display shown in Figure 5-5 will be visible.

Use the <Up/Down Arrow> keys to scroll through the data table in the lower window. The parameter values displayed in the upper window are those at the marker frequency. Use the <Left/Right Arrow> keys to move the marker in the swept frequency

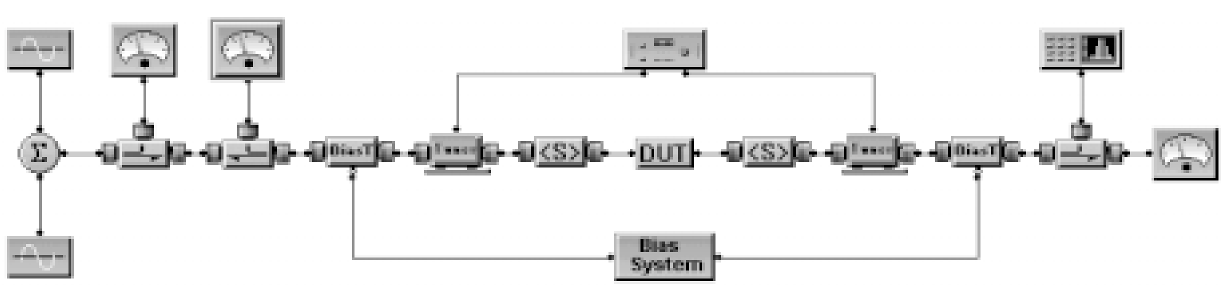


Figure 5-8. Typical Setup for Performing Power/Intermod Measurements

display through the calibrated frequencies. Highlight and click on <Marker> at the left of the window to go to a specific frequency of interest. Left click with the mouse pointer between calibrated frequencies to obtain interpolated parameter values. Highlight and click on a parameter to bring up the parameter selection box and change, add, or delete displayed parameters. Highlight and click on the maximum and minimum scale values for the parameters plotted on the swept display to modify the vertical scales.

h. Press the <Esc> key or click on the close window box to return to the Block Diagram view. To retrieve the noise calibration data while it is still in memory select <View>, <Noise>, and <Cal Data> from the menu bar in Block Diagram view. To retrieve previously stored calibration data, select <Calibrate>, <Noise>, <Get Cal File>, and select the file to be displayed.

5.4 Power Calibration

5.4.1 The power measurement system should typically be set up per Figure 5-6 with a thru in place of the DUT. The available power at the input of the source tuner will be measured over a range of programmed power levels at each frequency. If the setup includes the optional input and/or reflection power meters and couplers, the respective coupling values will be measured.

If the "Cal RF source match" option has been set to YES (see Section 4.6.3, Power Options Editor), the tuner will move to several positions in order to determine the reflection coefficient looking back into the RF source. The same tuner positions will also create the reflection needed to measure the reflection coupling.

During the power calibration, a power sensor file (one for each of the output power sensors) and a thru 2-port s-parameter file will be needed. The power sensor file contains the efficiency, loss and reflection coefficient values of the output power sensor. If the optional input power sensor and/or reflection power sensors are used, they will be calibrated by the fundamental output power meter, so no input or reflected power sensor files are needed. The thru does not need to be perfect, but must have known s-parameters in a file.

NOTE: *If using a reflection power meter, the range on the power head will need to be in the appropriate range. If not, the power head will be reading noise and will average an extensive amount.*

5.4.2 The sequence of the power calibration is as follows:

a. Select <Calibrate>, <Power>, <New Cal> from the Block Diagram view menu.

b. The available frequency range, which consists of those frequencies common to both tuners, and the current frequency range will be displayed. The current frequencies will be the same as those available unless a subset had been previously selected.

The default thru file name will be pre-typed on the entry line. If another file is required, select <Browse> to find the file or type the file name in the entry box.

The programmed power range of the signal source is also displayed here. This range should be based on the capabilities of the programmable power source, the amount of gain or loss between the source and the DUT, and the amount of power required at the DUT. The available power will be measured at each power level; therefore, no assumptions are made regarding the linearity of the power source or optional amplifier. Accept the displayed range or enter a new one.

NOTE: *If an input power meter is used, the measurement range is not restricted to the calibrated range, so a single power level may be sufficient here. However, if the RF source (or power amplifier, if needed) is non-linear, more calibration levels may provide better starting estimates of the programmed power required to provide the desired power at the DUT. This could reduce the measurement time.*

When all desired measurement conditions have been entered, select <OK> to start the calibration.

c. The program will then read the output power sensor files established in the Setup Files menu and then do an on-line check to insure that all required instruments are in place and connected to the GPIB.

d. The completion of the on-line check will bring up a prompt to insert the thru in place of the DUT. When this is done, click <OK>.

e. The next series of prompts instructs the user to calibrate each power sensor in the system by connecting a sensor to the power reference in its associated power meter and then reconnecting it to the system after the meter has completed its calibration routine. Click <OK> at the completion of each step.

The power sensor calibration sequence can be avoided by selecting <SKIP> at the first prompt for the output power meter; however, it is recommended that the power sensors be calibrated at least once at the start of each session. Subsequently, zeroing may be sufficient if the power meters are stable.

f. At the completion of the last power meter calibration and the system is assumed to be stabilized, the power meter(s) will be zeroed unless “Prompt for PM Zero” had been previously set to <Yes> in the <Setup>, <Options>, <Power> dialog of the Block Diagram view menu. In this case, the completion of the power meter calibration routine will bring up a prompt and the program will stop. This feature permits the user to manually disable the RF power at the power source(s) and/or amplifier if these do not have this capability via a GPIB command. When the RF power is disabled, click <OK>. The meter(s) will then be zeroed, and a second prompt will appear. Re-enable the RF power and click <OK>. The procedure can be bypassed by clicking on <SKIP> at the first prompt (not recommended).

g. The next prompt asks whether the tuners are to be re-initialized. Click <Y> if the tuners have not been recently initialized. When initialization is complete (or if <N> is selected) the actual calibration will begin. The available power levels corresponding to the programmed power levels will be scrolled on the screen. If the data seems invalid, press <End> to abort the calibration. The program will revert to the Block Diagram view. Select <Setup> and <Go to local> to troubleshoot the system

h. When the calibration is complete, a prompt to enter a label will appear. If this was the first calibration of the session, the label entry line will be blank. If an earlier calibration had been completed and labeled, that label will appear on the entry line. Select <Don’t Change> to accept the label shown or, if the line is blank, to skip this step and not apply a label. Otherwise, enter a new label and click <OK>. This will bring up a prompt to save the data. Enter a file name and click <Save>, or <Cancel> to avoid saving the data. The calibration may be saved later during the session by selecting <File>, <Save As> in the calibration display menu.

i. Use the scroll bar on the right of the display to move through the data. <Page up> or the <Page Down> keys will move the data a page at a time. Press the <Esc> key or click on the close window box to return to the Block Diagram view.

To retrieve the power calibration data while it is still in memory select <View>, <Power>, and <Cal Data> from the menu bar in the Block Diagram view.

To retrieve previously stored calibration data, select <Calibrate>, <Noise>, <Get Cal File>, and select the file to be displayed.

5.5 Intermod Calibration

The 2-tone intermodulation measurement system should be set up per Figure 5-8.

To calibrate for intermod, select <Calibrate> from the SNPW Menu, <Intermod> and then <New Cal>. If the <Intermod> option is not available, check that both tuners have been calibrated.

The calibration for intermod includes everything in the standard power calibration, plus calibration of RF source 2 and the spectrum analyzer coupler.

The user interaction is identical to the power calibration, except that the offset of RF Source 2 compared to RF Source 1 should be entered. This nominal offset is used as a starting point in setting the power level of RF source 2 to be equal to that of RF source 1. Accuracy here is not crucial, but will help speed up the calibration process.

The calibration of RF source 2 is done while the thru is in place. At each power level for every frequency, RF source 2 will be also turned on after the available power from RF source 1 is calibrated with the output power meter. The spectrum analyzer will then read the two carrier levels, and RF source 2 power level will be adjusted until they are equal within the specified equality tolerance. If the specified equality tolerance cannot be achieved, an error message will be given and the calibration aborted.

Calibration of the RF coupler for the spectrum analyzer is done at the same time as calibration of RF source 2. Since the carrier signal from RF source 1 is already measured with the power meter, a comparison to the spectrum analyzer reading provides the spectrum analyzer coupling value.

After the RF source 2 and the spectrum analyzer coupler are calibrated, RF source 2 is turned off, and the calibration continues at the next power level or frequency.

5.6 ACP Calibration

To calibrate for Adjacent Channel Power (ACP), select <Calibrate> from the SNPW Menu, and then <ACP> and <New Cal>.

The ACP calibration is identical to the Power cal, except that it will be done with the selected modulation on. Therefore, see Section 5.4 for the calibration sequence.

5.7 SNP System Calibration

The SNP System calibration does a complete, unified calibration for s-parameter, noise, and power measurements. Tuner files may be used with automatic reference plane shifting, or the tuners may be characterized in place.

The system calibration is controlled by wizard which walks you through the process, step by step. When the process is complete, the new measured files will be saved so that simpler calibrations may be used in the future. The new measured files will also be entered as the defaults, so the configuration can be saved with the complete setup.

6
S-Parameter Measurements

6.1 Introduction

The SNPW program includes a general purpose s-parameter measurement function using a calibrated vector network analyzer (VNA). All s-parameter data files are saved using a Touchstone™ [1] compatible format.

☞ ***NOTE:*** *Before making s-parameter measurements, the appropraite Calibration Menu function must be executed, or the s-parameter measurement menu items will not be available. See Section 5.2 for details on the s-parameter calibration functions.*

6.2 1-Port Measurements

a. Calibrate the VNA for either 1-port or 2-port measurements per Section 5.2. Connect the DUT to the VNA.

b. From the Block Diagram view menu, select <Measure>, <S-Parameters>, and <1-Port> to bring up the measurement dialog.

c. The available and current frequency ranges will be displayed. The available frequencies will be the VNA calibration frequencies. The current frequencies will either be the same or a sub-set (if one had been previously selected). Follow the on-screen instructions to modify the measurement frequencies if necessary. Note that if an uncalibrated frequency is added, a prompt indicating that it is not a sub-set of the available frequencies will come up.

d. Use the parameter button in the lower left corner of the dialog to select the measurement parameter (11 = S11, 22 = S22), then click on <Measure>.

e. When the measurement is complete, a prompt to enter a label will appear. See Section 6.4 for instructions on labeling and saving the data.

f. The s-parameter display shows the selected parameter on a Smith chart. Use the <Left/Right Arrow> keys to move through the frequency range. The parameter value at each frequency is displayed on the left side of the screen. To display the parameter value at a specific frequency: select <View>, <Marker Frequency> from the menu bar; highlight and click on <Marker Frequency>; or, press <Ctrl-F>. Then select the frequency from the pop-up window.

g. Press <Esc> or click on the Close Window box to exit the display and return to the Block Diagram view. The display can be recalled while it is still in memory by selecting <View>, <S-parameters>, and <Memory>.

6.3 2-Port Measurements

6.3.1 Fixed Bias Measurements

a. Calibrate the VNA for 2-port measurements, and de-embed the calibration (if necessary) per Section 5.2. Connect the DUT to the VNA.

b. From the Block Diagram view menu, select <Measure>, <S-Parameters>, and <2-Port> to bring up the measurement dialog.

c. The available and current frequency ranges will be displayed. The available frequencies will be the VNA calibration frequencies. The current frequencies will either be the same or a sub-set (if one had been previously selected). Follow the on-screen instructions to modify the measurement frequencies if necessary. Note that if an uncalibrated frequency is added, a prompt indicating that it is not a sub-set of the available frequencies will come up.

d. Note the conditions displayed in the DC Bias dialog section. If the DUT requires different conditions, Click <Details> to bring up the DC Bias Setup dialog. Refer to

[1] Touchstone™ is a trademark of HP EEsof, Inc.

Section 4.6.2 for entry details. Be aware, however, that a change here will be reflected in the earlier <Setup>, <Instruments> and <Setup>, <Options> bias editors. If the DUT does not require bias, click <none> on the “Bias Mode, Specify” line of the DC Bias Setup editor.

e. When the frequency and bias conditions are correctly set, click <Measure>. When the measurement is complete, a prompt to enter a label will appear. See Section 6.4 for instructions on labeling and saving the data.

f. The s-parameter display (see Figure 6-1) shows all four parameters on a Smith chart (reflection) and a polar chart (transmission). Use the <Left/Right Arrow> keys to move through the frequency range. The parameter values at each frequency are displayed on the left side of the screen. To display the values at a specific frequency: select <View >, <Marker Frequency> from the menu bar; highlight and click on <Marker Frequency>; or, press <Ctrl-F>. Then select the frequency from the pop-up window.

g. Press <Esc> or click on the Close Window box to exit the display and return to the Block Diagram view. The display can be recalled while it is still in memory by selecting <View>, <S-Parameters>, <Memory>.

6.3.1 Swept Bias Measurements

a. Calibrate the VNA for 2-port measurements, and de-embed the calibration (if necessary) per Section 5.2. Connect the DUT to the VNA.

b. From the Block Diagram view menu, select <Measure>, <S-Parameters>, and <2-Port vs Bias> to bring up the measurement dialog.

c. The available and current frequency ranges will be displayed. The available frequencies

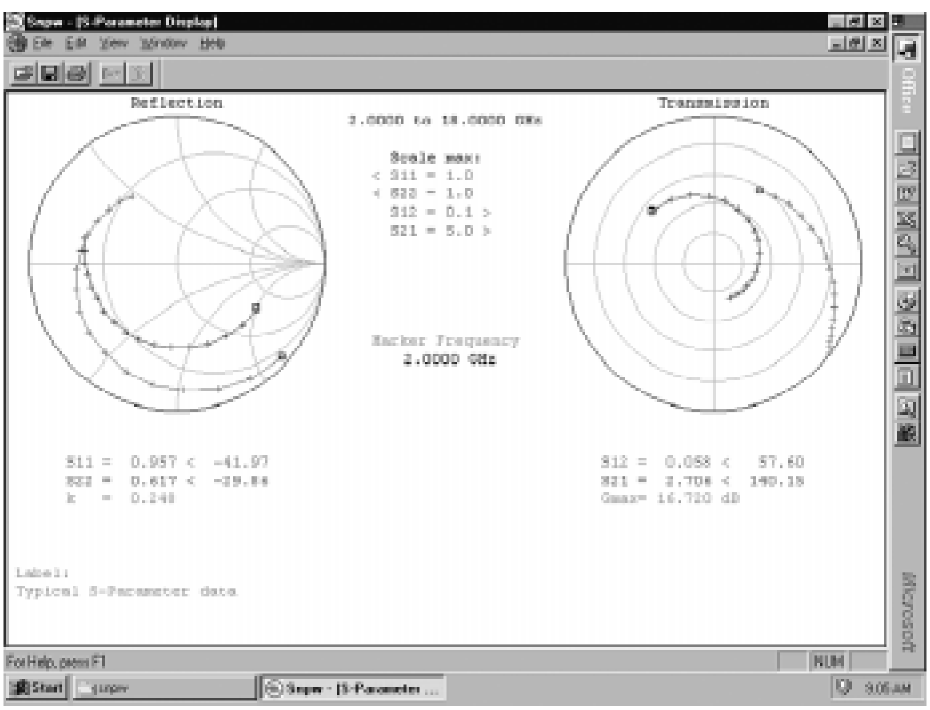


Figure 6-1. Typical S-Parameter Display

will be the VNA calibration frequencies. The current frequencies will either be the same or a sub-set (if one had been previously selected). Follow the on-screen instructions to modify the measurement frequencies if necessary. Note that if an uncalibrated frequency is added, a prompt indicating that it is not a sub-set of the available frequencies will come up.

d. The bias mode and the current swept bias setup are also displayed here. If the mode, bias limits, or other options need to be changed, click <Details> to bring up the DC Bias Setup dialog. Refer to Section 4.5.2 for entry details. Be aware, however, that a change here will be reflected in the earlier <Setup>, <Instruments> and <Setup>, <Options> bias editors. Select <OK> to return to the 2-Port s-Parameter Measurement vs Bias dialog box.

   Select the swept bias variable by clicking on the <Bias Variable:> button to toggle between I_out (mA) and V_out (Volts). This selection can also be made from the DC Bias Setup dialog.

e. When the frequency and bias conditions are correctly set, click <Measure>. When the measurement is complete, a prompt to enter a label will appear. See Section 6.4 for instructions on labeling and saving the data. The swept bias data is saved in a Touchstone compatible MDIF format. See the Touchstone manual Truth Model information for details on usage of the swept bias data file.

f. The s-parameter display shows all four parameters on a Smith chart (reflection) and a polar chart (transmission). The display is similar to Figure 6-1 except that the data applies to a single bias value shown at the bottom of the screen. Use the <Left/Right Arrow> keys to move through the frequency range. The parameter values at each frequency are displayed on the left side of the screen. To display the values at a specific frequency: select <View>, <Marker Frequency> from the menu bar; highlight and click on <Marker Frequency>; or, press <Ctrl-F>. Then select the frequency from the pop-up window.

g. Use the <Up/Down Arrow> keys to move through the bias range. To display the values at a specific bias value, select <View>, <Bias Marker> from the menu bar; or highlight and click on <Bias> at the bottom of the screen. Then select the bias value from the pop-up window.

h. Press <Esc> or click on the Close Window box to exit the display and return to the Block Diagram view. The display can be recalled while it is still in memory by selecting <View>, <S-Parameters>, <Memory>.

6.4 Saving S-Parameter Data

When a measurement is complete, a prompt will appear to label the data. If this was the first measurement of the session, the label entry line will be blank. If an earlier measurement had been completed and labeled, that label will appear on the entry line. Select <Don't Change> to accept the label shown or, if the line is blank, to skip this step and not apply a label. Otherwise, enter a new label and click <OK>. This will bring up a prompt to save the data. Enter a file name and click <Save>, or click <Cancel> to bypass saving the data. The data may be saved later during the session by selecting <File>, <Save As> in the s-parameter display menu. The program will automatically apply the extension ".S1P" to 1-port s-parameter files, ".S2P" to 2-port, fixed bias s-parameter files, and ".S2B" to swept bias, 2-port s-parameter files.

6.5 Recalling S-Parameter Data

S-parameter files can be brought back into memory and displayed from the Block Diagram view menu. Select <View>, <S-Parameters>, and the file type (1-Port, etc.), then select the file for display.

7
Power Measurements

7.1 General

The SNPW program provides for measuring a variety of power parameters at any available source and load impedance combination. The measurement is corrected for tuner losses to provide data at the DUT reference plane. Single power measurements, swept power measurements, load pull and source pull can all be done from an interactive graphical screen menu.

The system must first be calibrated for power or intermod. If a power calibration has not been done, the <Power> option in the Measurement Menu will not be active.

7.2 Power Parameters

Forty-one standard power parameters plus an array of user defined parameters may be measured with any power measurement, if the appropriate equipment is available in the block diagram. These are:

a. **Available Input Power (Pin_avail):**

This is the available power at the DUT input plane. It is normally specified as an independent parameter. However, if the option "Snap to Cal'd Power" is set to YES (see Section 4.5.3), then the value will vary with the source tuner loss. If "Snap to Cal'd Power" is set to NO, then the power level of the RF source will be adjusted to keep the available power at the DUT input plane constant within the specified tolerance.

b. **Delivered Input Power (Pin_deliv):**

This is the power actually delivered to the input reference plane of the device. This value necessarily depends upon source tuner matching. A reflection power meter is required.

c. **Reflection Coefficient Magnitude (Refl_coef):**

This is the voltage ratio of the reflected signal to the available signal at the DUT reference plane.

d. **Return Loss (Refl_log):**

This is return loss in dB at the DUT plane. It is equal to $20*\log_{10}$ (Refl_coef). A better match will result in a more negative number in dB.

e. **Output Power (Pout):**

This is the power delivered to the load seen by the DUT. This is displayed in dBm.

f. **Transducer Gain (Gt):**

This is a ratio of the delivered output power to the available input power at the DUT reference planes, displayed in dB. This parameter requires an output power meter.

g. **Power Gain (Gp):**

This is a ratio of the delivered output power to the delivered input power at the DUT reference planes. This is displayed in dB. This parameter requires an output power meter and a reflection power meter. This is normally not a function of source impedance, except as it changes the operating point of the DUT because of changes in delivered power.

h. **Power Added Efficiency (Eff):**

This is the ratio of added RF power to the DC input power. The added RF power is the delivered output power minus the delivered input power. This is displayed in percent. The formula is:

$$\mathrm{Eff} = 100 * \frac{(\mathrm{P_{OUT}\_delivered} - \mathrm{P_{IN}\_delivered})}{\mathrm{DC\quad power}}$$

Where

$$\mathrm{DC\ power} = \mathrm{V\_out} * \mathrm{I\_out} + \mathrm{V\_in} * \mathrm{I\_in}$$

If the delivered input power is not known because there is no reflection power meter, then the available input power is used.

Since available power is always greater than (or equal to) the delivered power, this will reduce the calculated power added, therefore reducing the calculated efficiency. This error can be eliminated by matching the source impedance, but otherwise will produce a conservative result.

i. **Measured Voltages and Currents (V_out, I_out, V_in, I_in, V_aux1, I_aux1, V_aux2, I_aux2, V_aux3, I_aux3, V_aux4, I_aux4):** These parameters are the measured input and output DC voltages and currents. Those designated *_aux* are associated with auxiliary bias supplies used when they are used.

NOTE: *These bias parameters will be available whenever a nonzero output voltage is specified.*

j. **Source Reflection Coefficient Magnitude at the 2nd Harmonic (Γs_2nd_mag):** This parameter is available only if the source tuner has data at the 2nd harmonic of the measurement frequency.

k. **Source Reflection Coefficient Phase at the 2nd Harmonic (Γs_2nd_phase):** This parameter is available only if the source tuner has data at the 2nd harmonic of the measurement frequency.

l. **Source Reflection Coefficient Magnitude at the 3rd Harmonic (Γs_3rd_mag):** This parameter is available only if the source tuner has data at the 3rd harmonic of the measurement frequency.

m. **Source Reflection Coefficient Phase at the 3rd Harmonic (Γs_3rd_phase):** This parameter is available only if the source tuner has data at the 3rd harmonic of the measurement frequency.

n. **Load Reflection Coefficient Magnitude at the 2nd Harmonic (Γld_2nd_mag):** This parameter is available only if the load tuner has data at the 2nd harmonic of the measurement frequency.

o. **Load Reflection Coefficient Phase at the 2nd Harmonic (Γld_2nd_phase):** This parameter is available only if the load tuner has data at the 2nd harmonic of the measurement frequency.

p. **Load Reflection Coefficient Magnitude at the 3rd Harmonic (Γld_3rd_mag):** This parameter is available only if the load tuner has data at the 3rd harmonic of the measurement frequency.

q. **Load Reflection Coefficient Phase at the 3rd Harmonic (Γld_3rd_phase):** This parameter is available only if the load tuner has data at the 3rd harmonic of the measurement frequency.

r. **Power at the 2nd Harmonic Frequency (C_2nd):** This parameter is the DUT output power at the 2nd harmonic of the measurement frequency (see the note following sub-paragraphs).

s. **Power at the 3rd Harmonic Frequency (C_3rd):** This parameter is the DUT output power at the 3rd harmonic of the measurement frequency (see the following note).

NOTE: *When only fundamental tuners are used, harmonic power is measured with a spectrum analyzer and can be measured only if the following is true:*

1) The system must be calibrated for intermodulation distortion (intermod or Imod), even though the harmonic power(s) may be measured from the <Power> menu, because the intermod calibration is required to determine the spectrum analyzer coupler and losses.

2) *The load tuner file must have data at the harmonics of the measurement frequency in order to de-embed the tuner losses.*

When harmonic tuners are used, the harmonic power(s) can be measured with a power meter.

t. **Gain Compression:**
This parameter is available only from a swept power measurement. This may be a single power sweep or a swept load/source pull.

u. **Gain Expansion:**
This parameter is the gain increase from a measured linear or maximum gain value. It is available only from a swept power measurement. This may be a single power sweep or a swept load/source pull.

v. **Spurious Signal Power (Spurious):**
Spurious signal power is measured with a spectrum analyzer. See Note 1) preceding sub-paragraph (t) above.

w. **Spurious Frequency (Spur_freq):**
Spurious signals are detected and measured with a spectrum analyzer. See Note 1) preceding sub-paragraph (t) above.

x. **Measured Frequency (Meas_freq):**
This is the measured frequency in GHz, measured with a frequency meter.

y. **Input Reflection Coefficient Magnitude (Γin_mag):**This is the magnitude of the DUT input reflection coefficient, measured with a vector receiver.

z. **Input Reflection Coefficient Phase (Γin_pha):** This is a phase of the DUT input reflection coefficient in degrees, measured with a vector receiver.

aa. **Transmission Phase (Trans_pha):**
This is the uncalibrated transmission phase through the DUT in degrees, measured with a vector receiver. It is required for AM to PM conversion measurements.

bb. **AM to PM Conversion (am/pm):**
This is the ratio of transmission phase change to output power change in degrees/dB. Therefore, it requires both Trans_pha and Pout. It is available only from a swept power measurement. This may be a basic swept power measurement or a swept load/source pull.

cc. **Calculated Transducer Gain (Gt(s))**:
This parameter is the transducer gain calculated from the small signal s-parameters. See Section 7.18 for details on the use of Gt(s).

dd. **Transducer Gain Differential (Delta_Gt):**
This parameter is the difference between Gt(s) and Gt, the transducer gain derived from an actual power measurement. See Section 7.18 for details on the use of Delta_Gt.

ee. **User Functions (User):**
This is an optional array of parameters defined by a user written measurement driver. Each user parameter can be any scalar value which varies as a function of power or impedance. See Section 7.11 and Appendix 3.

7.3 Power Measurement Screen

7.3.1 Getting to the Measurement Screen

To do a power measurement, select <Measure> from the SNPW menu, and <Power> from the Measurement Menu. This brings up the power measurement dialog. Select a frequency from the list of available calibrated frequencies. Also, the current bias levels are displayed, and new values may be entered here, if needed. To change the bias mode, bias limits, and other bias options, click <Details>.

If small signal s-parameters are to be used, click the box and the <Read S-Parameter File> button to read and display the s-parameters. To view the s-parameters already in memory, click <Show S-Parameters>.

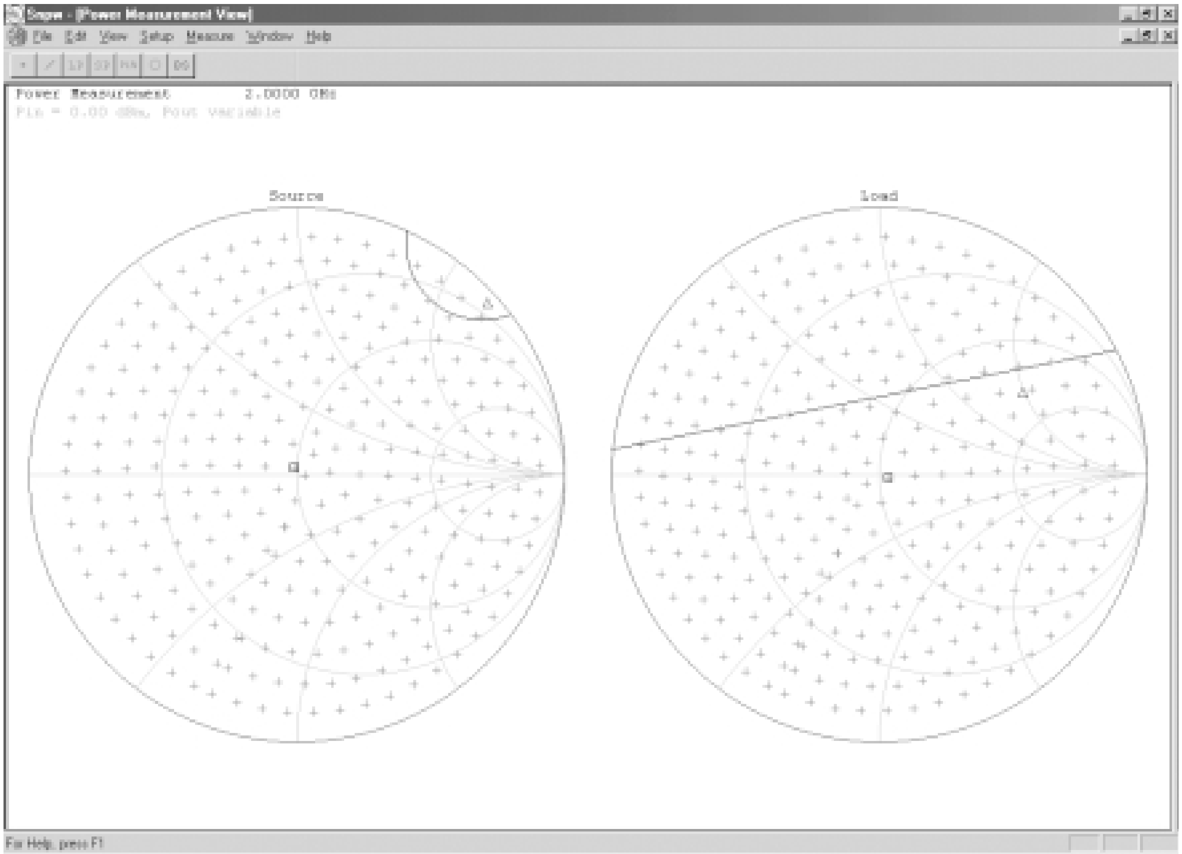


Figure 7-1. Power Measurement Screen

When frequency, bias, and s-parameters are set up, click <OK> to bring up the measurement screen shown in Figure 7-1.

The left Smith Chart on the measurement screen shows the source impedances seen by the DUT. The right chart shows the load impedances. Harmonic tuner charts will be labeled Source2 or Load2 for the 2nd harmonic and Source3 or Load3 for the 3rd harmonic.

If the DUT s-parameters are selected, S11 conjugate and S22 conjugate will be plotted as small yellow triangles. If the stability factor "k" is less than one (indicating a potentially unstable device as calculated from the s-parameters), the stability circles will also be shown as white plots.

7.3.2 Selecting Tuner Charts for Display

The Smith charts with the points for each tuner may be turned on or off individually in this display. From the menu, select <View>, then <Tuners>, and then the tuner to toggle on or off from the display. Check marks identify the selected tuners on the menu.

7.3.3 Zoom Function

The "Zoom Window" function allows any region of the Smith chart to be magnified. Click the right mouse button while pointing to either the left (source) or right (load) chart, then click <Zoom Window> on the popup menu. Then click and hold the left mouse button while dragging the box enclosing the area to be magnified (similar to Figure 7-2). This can be repeated to progressively zoom in until the maximum zoom ration is reached.

☞ ***NOTE:*** *If the drag box is not square, the larger dimension is used, since the result is always square.*

Click the right mouse button on the expanded chart and select <Zoom all> to restore the chart to the normal view.

7.3.4 Selecting Points

7.3.4.1 Single Point Selection

As the mouse cursor moves over either chart, the reflection coefficient or impedance at the cursor position is continuously displayed immediately below the chart. Click the left mouse button while the pointer is in a chart and the nearest tuner point will be toggled between selected and not selected. The color of selected points is green. Non-selected points are gray. This function selects the measurement points for a load or source pull.

7.3.4.2 Block Point Selection

Block point selection is used to make a large block of tuner positions either available or unavailable for load/source pull measurements. See Figure 7-2.

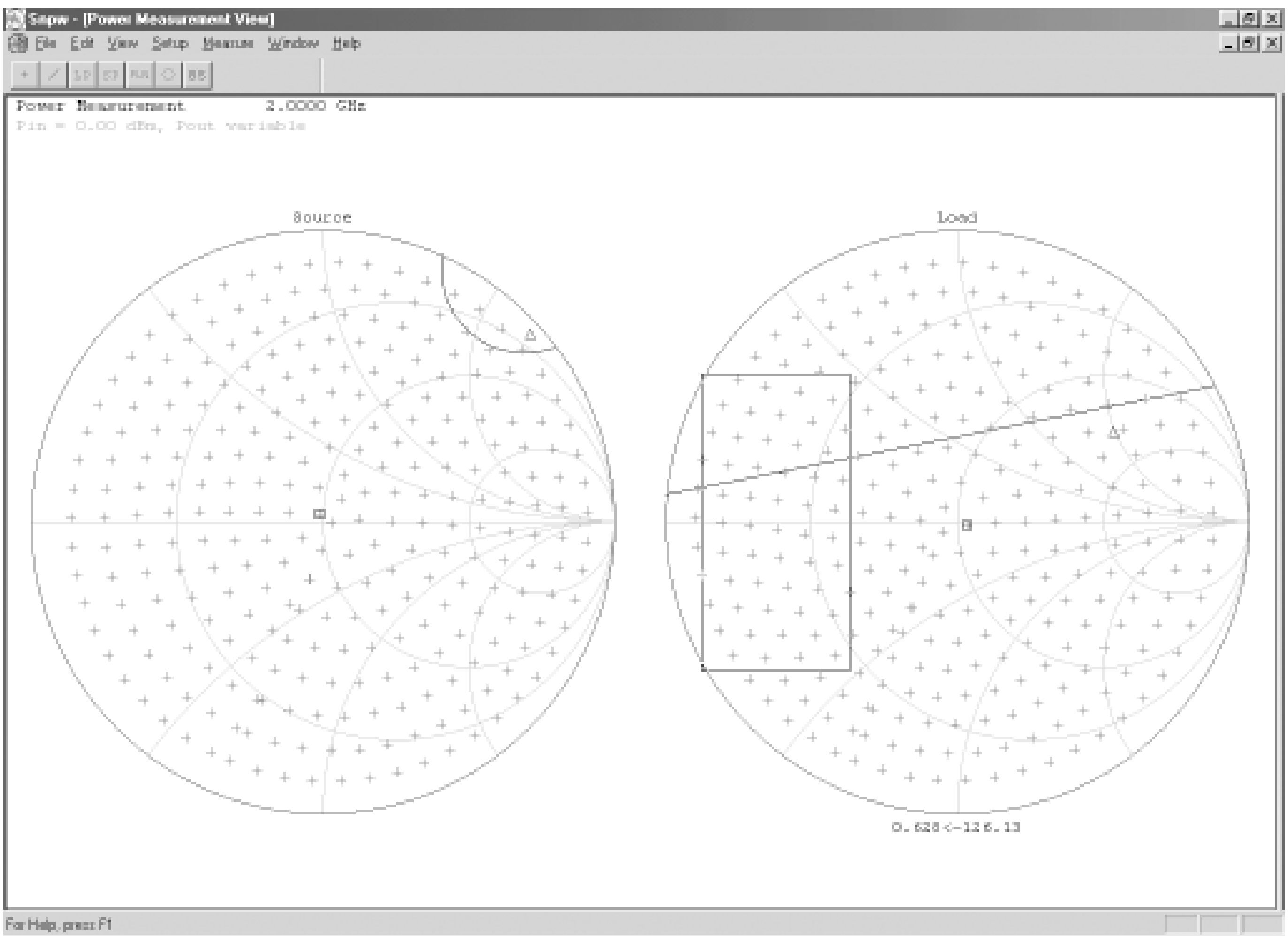


Figure 7-2. Block Point Selection

Click the right mouse button while pointing to the desired chart. Choose <Select Points ON> or <Select Points OFF> and then click and hold down the left mouse button while dragging the mouse pointer until the points to be turned ON/OFF are enclosed in the rectangle. This process may be repeated.

☞ **NOTE:** *A selected set of impedances for load/source pull can be saved by saving the tuner file. See Section 5.1.5.*

7.3.4.3 Measurement Default Point

The measurement default position is the tuner setting which will be used for a single or swept power measurement. It is indicated on the screen by a white box around the point.

To move the default point, click the right mouse button while pointing to the desired chart. Choose <Select Default Point> from the menu, and then move the square cursor to the new desired position, and click the left button.

The default point may also be moved by specifying an impedance or reflection coefficient. Click the right mouse button while the pointer is in a chart, then select <Enter Default point> and enter the desired default point position in the pop-up window.

☞ **NOTE:** *If <Interpolated Tuning> had been selected in the <Setup>, <Options>, <Power> editor, the default point will move to the exact position selected or entered. If this option is set to <No>, the default point will move to the nearest calibrated tuner position.*

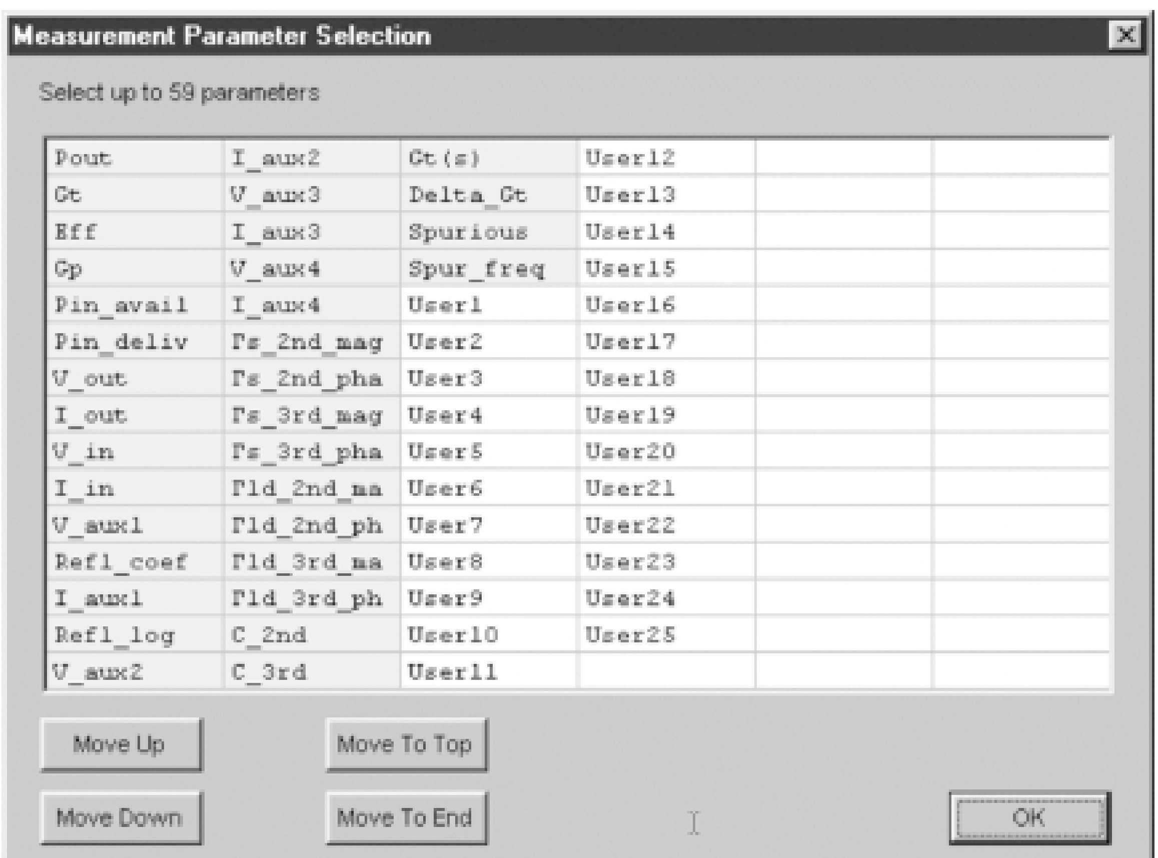


Figure 7-3. Measurement Parameter Selection Editor

NOTE: *The tuners do not move immediately when the default point is changed. To move the tuners to the default positions, select <Measure> and then <Move Tuners> from the menu.*

7.3.5 Measurement Setup

Most of the measurement options can be accessed from the measurement screen by highlighting and clicking on <Setup>.

7.3.5.1 Selecting Measurement Parameters

Select <Setup>, <Select Parameters> to open the Measurement Parameter Selection window with a list of all available parameters. See figure 7-3.

Double-click on any parameter to select it. Double-click on a selected parameter to deselect it. Selected parameters are highlighted in blue. After making the selection, click <Move Up>, <Move Down>, <Move to Top> or <Move to End> to adjust the measured parameters order. Press <OK> to return to the measurement screen.

Selection of some parameters depends on others. For example, “Pout” is required for gain and efficiency. Also, the intermod signals (I3, I5, etc.) are required for carrier to intermod ratios (C/I3, etc.).

7.3.5.2 Changing Frequency

Select <Setup>, <Frequency> to open the frequency selection window. Use the <Up/ Down Arrow> keys or point and click with the mouse to highlight the desired measurement frequency, then click <OK>.

7.3.5.3 Changing the Input Power Level

Select <Setup>, <Power Level> to open the power level entry window. If “Snap to Cal’d Power” had been set to <Yes> in the <Setup>, <Options>, <Power> editor, this entry will adjust to the nearest calibrated power level.

The displayed power level is the available input power level at the DUT input reference plane. If "Snap to Cal'd Power" is YES, this depends on the dissipative losses of the source tuner, and the value may change as the source measurement default impedance is changed. If the option "Snap to Cal'd Power" is set to NO, the available power will not change with the source tuner, since the RF source power will be adjusted to compensate for the loss change.

Click on the button alongside “Power Setting Mode:” to select this mode as either constant input or output power. If <Constant Pout> is selected, the input power will be adjusted upward from the input power declared on the screen until the selected output power or the maximum is attained.

7.3.5.4 Changing Bias

If <Bias> is selected, the current bias value will be displayed, and new bias values may be entered.

7.3.5.5 Options

If <Options> is selected, the corresponding options dialog box will come up. These are the same as described in Sections 4.6.3, 4.6.4, and 4.6.5.

If <Default Files/Directories...> is selected, the Default Files and Directories property sheet will come up. This is the same as described in section 4.5.

7.3.6 Going to Local

Move the mouse pointer to highlight <Measure>, <Go to Local>, and click the left button to put the whole system into Local control. This allows the system to be checked manually.

This is often useful for gaining a "feel" for the operation, and for troubleshooting unexpected results.

7.4 Single Power Measurements

After all setup conditions are established (frequency, bias, power level, etc., see the preceding sections), this measurement mode can be used to make a single measurement of all enabled parameters with the tuners set to the default positions (see Section 7.3.4.3). From the menu bar select <Measure>, <Single Measurement> (or click on the single measurement icon at the top left of the screen (rectangle with a center dot). The tuners will move, the bias will be set, the RF power will be set to the selected value, and the active power parameters will be measured.

The measured data will be displayed in a single column on the right of the screen. If the data extends past the bottom of the screen, use the vertical scroll bar on the right to move it up or down. If the data extends past the right of the screen use the horizontal scroll bar to move it left or right. Alternatively, click and drag the vertical window divider to increase the width of the data window.

7.5 Power Sweep

This mode can be used to make a series of measurements of all enabled parameters with the tuners set at the default positions while the input power is stepped over a selected range.

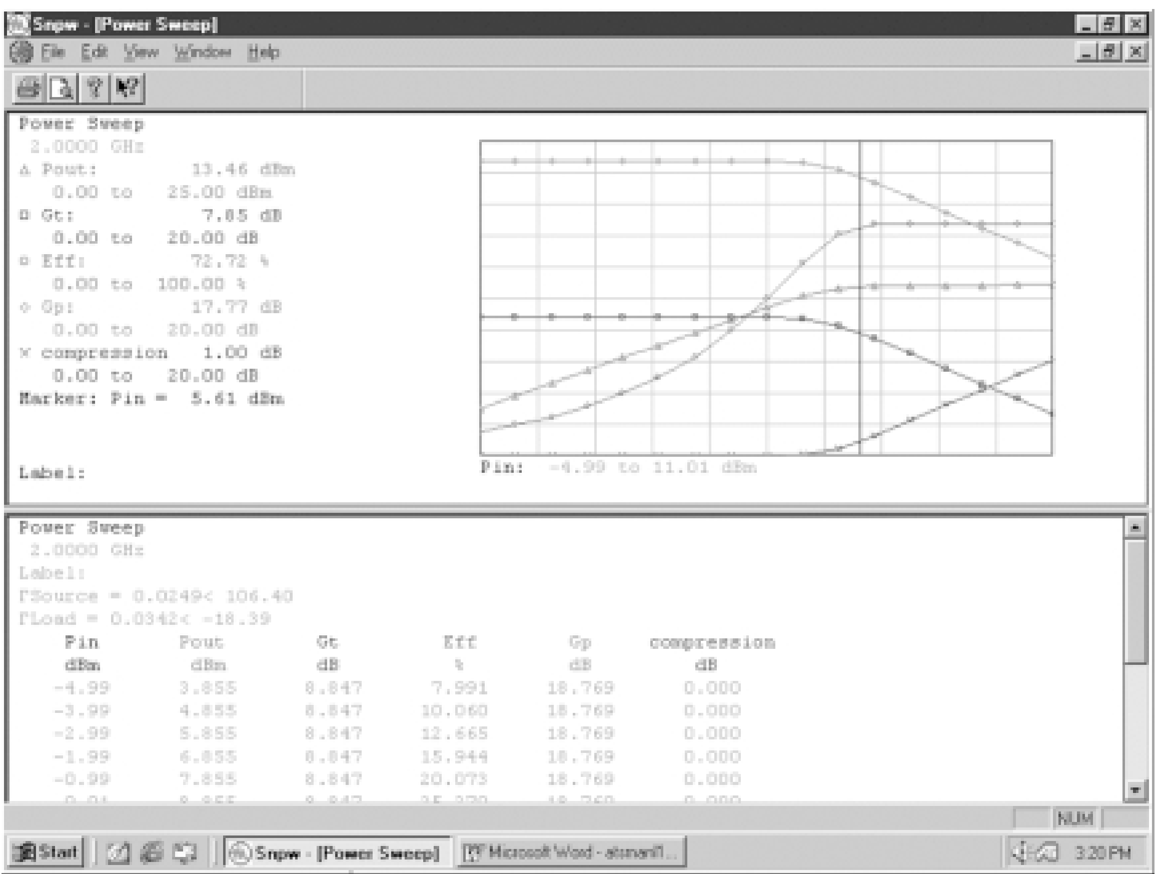


Figure 7-4. Swept Power Display

7.5.1 Swept Power Measurements

After all setup conditions are established (frequency, bias, power level, etc., see the preceding sections), set the default positions of the tuners (see Section 7.3.4.3), and enable the parameters to be measured (see Section 7.3.5.1). From the menu bar select <Measure>, <Power Sweep> (or click on the power sweep icon at the top left of the screen (rectangle with a diagonal line). This will bring up a prompt showing the calibrated available input power range, the current power range, and the maximum gain compression limit. Select <OK> to accept the current values or enter new values.

NOTE: *If an input power meter is used the available calibrated power range will NOT be displayed here, because it is irrelevant. With an input power meter, the measurement power range is unrestricted (except for the physical limits of the equipment in use.*

After entry of the power range, the tuners will move, the bias will be set, the RF power will be enabled and the power sweep will begin with the lowest power level. At each power level, the active parameters will be measured and progressively plotted on the screen. Press <End> to abort the sweep.

Completion of the power sweep will bring up a prompt to label the data. See Section 7.15 for instructions on applying a label and saving the data.

7.5.2 Swept Power Display

The interactive Swept Power Display will plot the measured power parameters versus input available power in the upper part of the screen and display the tabular data below. See Figure 7-4.

A maximum of five parameters may be displayed. See Section 7.5.2.1 for instructions on selecting the displayed parameters from the list of those made active in the setup procedures.

7.5.2.1 Graphical Display

At the left of the upper window, the measurement frequency, the parameter values at the marker position for each of those selected, the available input power at the marker position, and the maximum and minimum scale limits for each parameter are displayed. The parameters are plotted on the graph on the right side of the window. The parameter designations, scales, and values at the marker position are displayed in the same colors as their respective plotted traces. A bright vertical line identifies the marker position on the graph.

To change the displayed parameters to others on the list of active parameters, use the mouse to highlight and left-click on any parameter designation in the upper window. This will bring up the “Parameter Selection for Swept Display”. The procedure for selection, de-selection, and movement of the parameters within the selection display is identical to that described in Section 7.3.5.1 with one exception: selection of more than five parameters will bring up a prompt to deselect one before adding another. Note also that some parameters, such as ″compression″ and ″expansion″ may have been added to the parameter list, as these are available only in a swept power measurement.

Any of the following procedures can be used to move the marker to discrete measured points:

a) Use the <Left/Right Arrow> keys to move successively through the input power range;

b) Use the mouse pointer to highlight and left-click on “Marker” at the left of the display, select a power level and click <OK>.

c) From the menu bar select <View >, <Marker>, select a power level and click <OK>.

Click on the plot between calibrated points to display interpolated data.

If the plot of a parameter is compressed or goes off scale, the scale range may be changed. Highlight and left-click the maximum or minimum scale value for the parameter. Enter a value and click <OK> in the pop-up window.

The 1 dB compression point may be found by making “compression” one of the plotted parameters and moving the marker to find the input power (and other parameters) at which it occurs.

7.5.2.2 Tabular Display

The lower window of the swept power display tabulates the measured data. The parameters shown are those selected in the graphical display. Use the <Up/Down Arrow> keys or the scroll bar on the right of the window to view the data if the listing extends past the bottom of the screen. Alternatively, click on, hold and drag the horizontal window divider to expand the tabular listing (at the expense of the graphical display).

7.5.2.3 Surfer Swept Display

The Enhanced Graphics option, Model MT993NO7, provides Surfer, a third party graphics software package, to display the swept data in a flexible window that can be modified by the user. This option will format the swept data and load it into Surfer. See Section 12 for details on the Enhanced Graphics option.

7.6 Bias Sweep

This measurement mode steps the bias value over a selected range with the tuners set to the default position.

After all setup conditions are established (frequency, bias, power level, etc., see the preceding sections), set the default positions of the tuners (see Section 7.3.4.3), and enable the parameters to be measured (see Section 7.3.5.1). From the menu bar select <Measure>, <Bias Sweep> or click on the bias sweep icon at the top left of the screen (rectangle enclosing “BS”). This will bring up a prompt showing the current bias setup and the bias variable range. Click <Details> to bring up the bias editor and change the setup (see Section 4.5.2). If necessary, enter new values for the bias variable range. Otherwise, if the conditions and bias range are acceptable, click <OK>.

After entry of the swept bias setup, the tuners will move, the bias will be set to the lowest level of the variable range, the RF power will be set and the bias sweep will begin. At each bias level, the active parameters will be measured and progressively plotted on the screen. Press <End> to abort the sweep.

Completion of the bias sweep will bring up a prompt to label the data. See Section 7.15 for instructions on applying a label and saving the data.

The swept bias display is identical to the swept power display except that the variable is the bias value. See Section 7.5.2 for instructions on manipulating the display.

7.7 VSWR Circle Measurements

This mode provides measured data of the active parameters at those tuner positions closest to a specified VSWR circle on the Smith chart (Power Measurement View).

After all setup conditions are established (frequency, bias, power level, etc., see the preceding sections), enable the parameters to be measured (see Section 7.3.5.1). Select <Measure>, <VSWR Circle> from the menu bar, or click on the icon at the top left of the screen (rectangle enclosing a circle) to bring up the measurement setup dialog box. Enter the VSWR, and the phase start and stop values. If necessary, enter a reflection coefficient or impedance to specify the center of the circle. When the entries are completed, click <Start>.

The bias will be set, and the RF power turned on. The tuner will move to those positions closest to the specified VSWR circle, and the active parameters will be measured at each position. At each tuner position the tuner impedance and the measured data are displayed at the bottom of the screen, and a line is drawn on the Smith chart from the preceding point eventually describing the VSWR circle (or arc if less than 360 degrees was specified in the setup dialog).

☞ ***NOTE:*** *If "Interpolated Tuning" was set to <No> in the options setup, the circle or arc may be distorted as the calibrated tuner positions may not fall exactly on the VSWR circle. If this option was set to <Yes>, a true circle will be drawn and the data derived from interpolated tuner positions.*

Completion of the VSWR circle measurements will bring up the "Fixed Pull vs. Phase Display" and a prompt to label the data. See Section 7.15 for instructions on applying a label and saving the data.

The swept phase display is identical to the swept power display except that the variable is

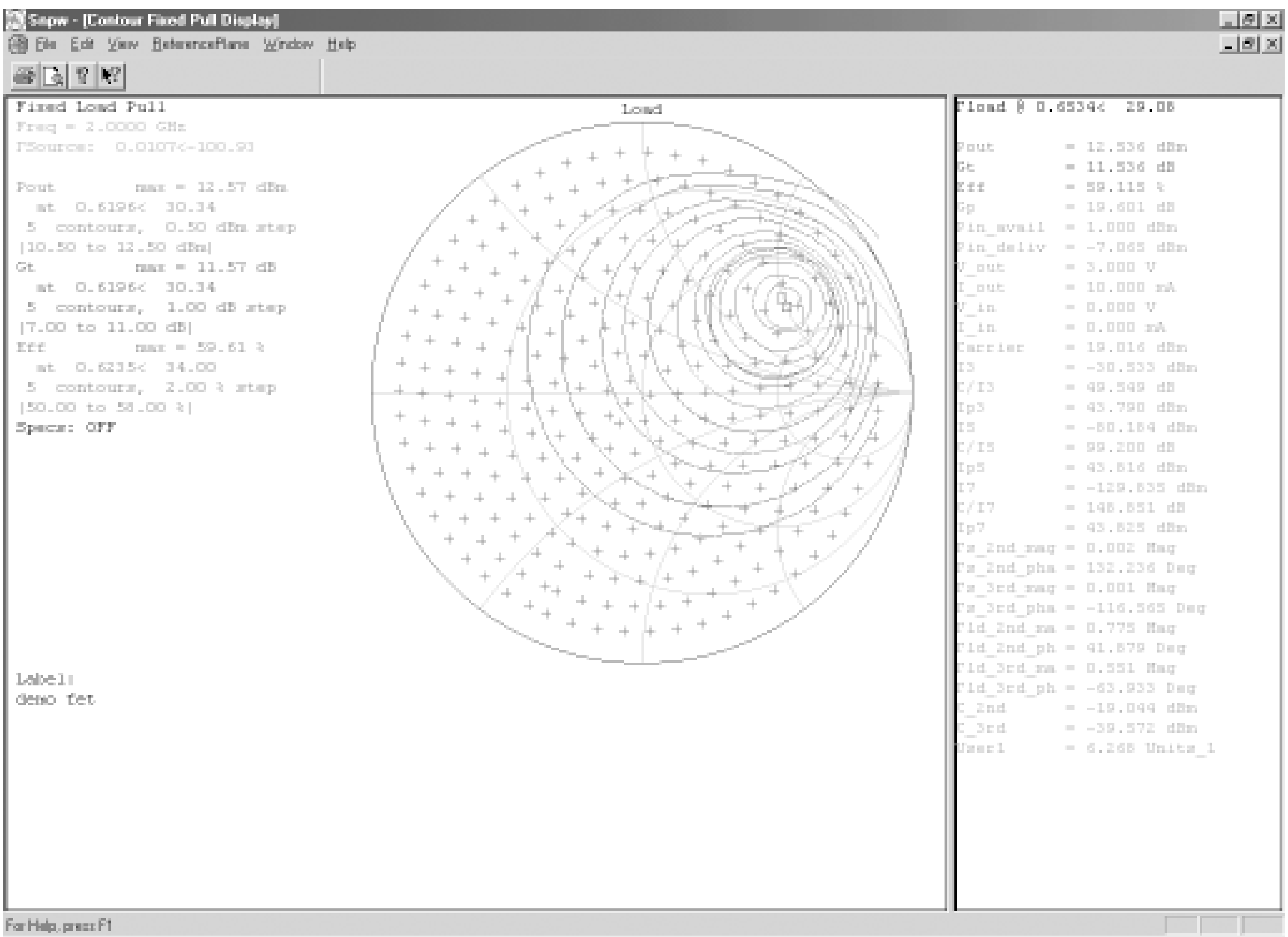


Figure 7-5. Load Pull Contour Display

the phase. See Section 7.5.2 for instructions on manipulating the display.

7.8 Load Pull

Load pull measurements may be made with constant input power or constant output power. Prior to a load pull measurement, the Power Setting Mode must be set to one of these options. Select <Setup><PowerLevel...> from the power measurement screen menu, and click the button to toggle the choices.

7.8.1 Load Pull Measurements

After all setup conditions are established (frequency, bias, power level, etc., see the preceding sections), set the source tuner reflection coefficient (see section 7.3.4.3) and select the block of points on the load tuner chart to be used for the measurement (see Section 7.3.4.2). From the menu bar select <Measure>, <Load Pull> or click on the single measurement icon at the top left of the screen (rectangle enclosing "LP"). The bias will be set, the RF power will turn on, and the tuners will begin to move to each selected load point. Progress can be monitored by watching each point change from green to yellow as it is measured. The measurement parameters and the load point will be displayed in a single column on the right of the screen as each point is finished, during the load pull.

Completion of the load pull will bring up a prompt to label the data. See Section 7.15 for instructions on applying a label and saving the data.

NOTE: *The load pull data will be saved with the file extension ".lp" for the fundamental frequency, ".lp2" for the 2nd harmonic, and ".lp3" for the 3rd harmonic.*

The load pull data will then be displayed, as shown in Figure 7-5. See Section 7.8.2 for details on this display.

NOTE: *After a load pull, the load cursor for the current frequency will be set to the measured load point which produced the best value for the optimization parameter, if the option to "Move Default Z from pull data" is enabled. (The optimization parameter may be changed by selecting <View><Options...> from the Load Pull display menu). See Figure 7-6.*

7.8.2 Load Pull Display

The interactive Load Pull Display plots constant contours of selected parameters on the load reflection coefficient plane. Up to three parameters may be selected from the list of measured power parameters.

To select the parameters to be plotted, move the mouse pointer to highlight any current parameter name and click the left mouse button, or select <View>, <Parameters> from the load pull display menu bar. A screen similar to Figure 7-3 will now be displayed. Double click on a desired parameter to toggle its selection on or off. A maximum of three parameters may be selected for a contour display.

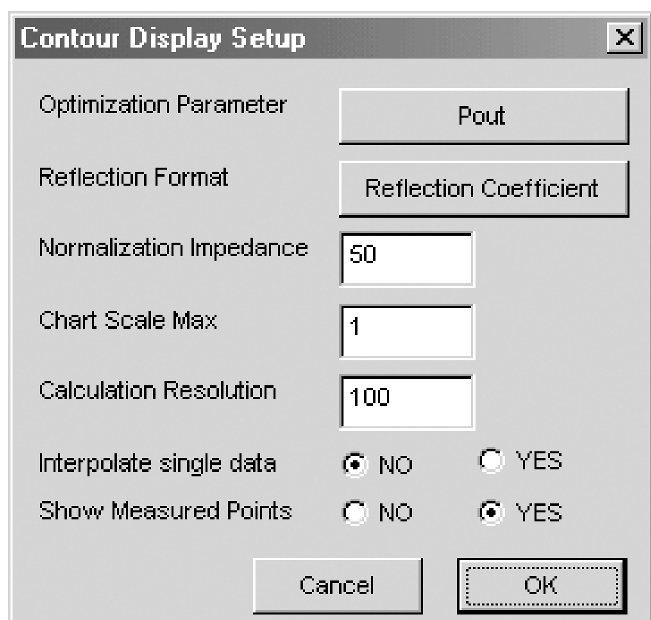


Figure 7-6. Contour Display Setup Dialog

To change the number of contours and the step size between contours for the parameters currently displayed, move the mouse pointer to highlight the value to be changed and click the left mouse button, or select <View>, <Contour Scales> from the load pull display menu bar. Then enter the new value(s) in the dialog window. The contour value closest to the optimum value will be computed by rounding off to the multiple of the step size value that is nearest to the computed optimum value. Contours may be calculated around either a maximum or minimum depending on the nature of the particular parameter. To toggle this selection for a particular parameter, first display the contours of that parameters, then highlight the word "min" or "max" with the mouse pointer and click the left mouse button.

To zoom in on a portion of the chart, right-click on the chart to bring up the pop-up menu. See Section 7.3.3 for details.

If the "Show measured points" option is set to <Yes> (see Section 7.8.3), all but one are displayed as green +'s. The point plotted as a white square is that which would be selected as the new default position based on the optimization parameter.

The measured data at any discrete measured point can be displayed by pointing the mouse pointer at the desired measured point on the chart, and clicking the left mouse button. This is a way of comparing the actual measured data against the calculated contours. The data is displayed in a single column in the right side window. If the data extends past the bottom of the screen, use the scroll bar at the right of the window to move it up or down. If some lines of data extend past the right of the screen, click, hold, and drag the vertical window separation bar until the full line(s) are visible. Note however, that this will crop the contour display. Click <View>, <Single Point Data> to turn off the single point list display.

7.8.3 Load Pull Display Setup

Select <View>, <Options> from the load pull display screen to bring up the Contour Display Setup dialog box shown in Figure 7-6.

The Optimization parameter may be selected from the list of available measurement parameters. After a load pull (or source pull) the new default position will be selected as the measured point which gives the best value for this parameter.

The Reflection Format toggles between reflection coefficient and Impedance. This determines the format of the reflection data displayed on the power measurement and display screens. It may also be set in the System Options Editor described in Section 4.5.1.

The Normalization Impedance defines the reference impedance at the center of the Smith charts in all of the Power Measurement and display screens. It may also be set in the System Options Editor described in Section 4.5.1.

The Chart Scale Max defines the maximum Reflection Coefficient value at the edge of the displayed chart.

The Calculation resolution should normally be a number between 50 and 100. A higher number produces smoother and more accurate plots, but takes longer. A small number is faster, but less accurate, and straight line segments may be visible in the contours.

The contours are calculated over a rectangular area, based on the points selected. Sometimes a high resolution will produce anomalous contours in areas not surrounded by measured points. This can usually be corrected by reducing the calculation resolution.

"Interpolate single data" refers to the single point measurement that occurs when the mouse is clicked inside the contour display. If set to <No>, the data will be that at the nearest calibrated tuner point. If set to <Yes>, the data will be interpolated between calibrated tuner points.

If the "Show measured points" option is set to YES, the measured points will be displayed with the contours in the Load Pull Display. If set to NO, the contours will be displayed without the measured points.

7.8.4 Shifting the Data Reference Planes

Select <Reference Plane> to shift the reference plane of the measured data and the contours through a 2-port network defined by 2-port s-parameters in a file.

<Reference Plane><Deembed> will prompt for a 2-port s-parameter file name which de-embeds toward the DUT plane, allowing a fixture to be de-embedded AFTER the measurement. (This is normally done by de-embedding the tuner data before the measurement.)

<Reference Plane>, <Embed> will prompt for a 2-port s-parameter file name which adds a matching network, shifting the plane away from the DUT. This can predict how well a matching network design will work before it is built.

The two <Reference Plane> options are opposites. If either one is done after the other, with the same s-parameters, the displayed data will return to the original reference plane.

7.8.5 Saving Contour Data in Spreadsheet Files

The contour data may be saved to a spreadsheet compatible file while the contours are displayed. The spreadsheet file uses tab delimiters, and a spreadsheet program such as Microsoft Excel can read it and present 3D displays of the contour data.

To save contour data in a spreadsheet file, first display the desired contours as described in Section 7.8.2, and then select <File><Save Spreadsheet>. If multiple contours are displayed, they will all be saved in the spreadsheet file.

When prompted, enter the desired file name to save the contour data (the default extension of .xls will be added automatically). The file with contour data for the currently selected parameters will then be saved.

To access the saved spreadsheet files, launch the spreadsheet program. Then follow instructions of the spreadsheet program to pull up and display the spreadsheet data. For example, Microsoft Excel has menus for displaying either 2D or 3D contours, and many options for adjusting the viewing angle, perspective, colors, and other display variables.

7.8.6 Surfer Contour Display

The Enhanced Graphics option, Model MT993NO7, provides Surfer, a third party graphics software package, to display the contour data in a flexible window that can be modified by the user. This option will format the contour data and load it into Surfer. See Section 12 for details on the Enhanced Graphics option.

7.8.7 Incremental Mode

If the contours displayed do not fully cover the area of interest, it may be necessary to add measurement points. This can be done without a complete re-measurement of all points if “Incremental Mode” was checked in the <Measure> menu. From the power measurement screen, select <Measure>, <Incremental Mode>. Use the point selection procedure (see Section 7.3.4) to add the new points. Start the measurement as described in Section 7.8.1. The system will then measure only the new points and display the combined results.

7.9 Source Pull

Source pull measurements are made in the same manner as load pull. Select <Source Pull> from the Power measurement menu or click on the icon at the upper left of the screen

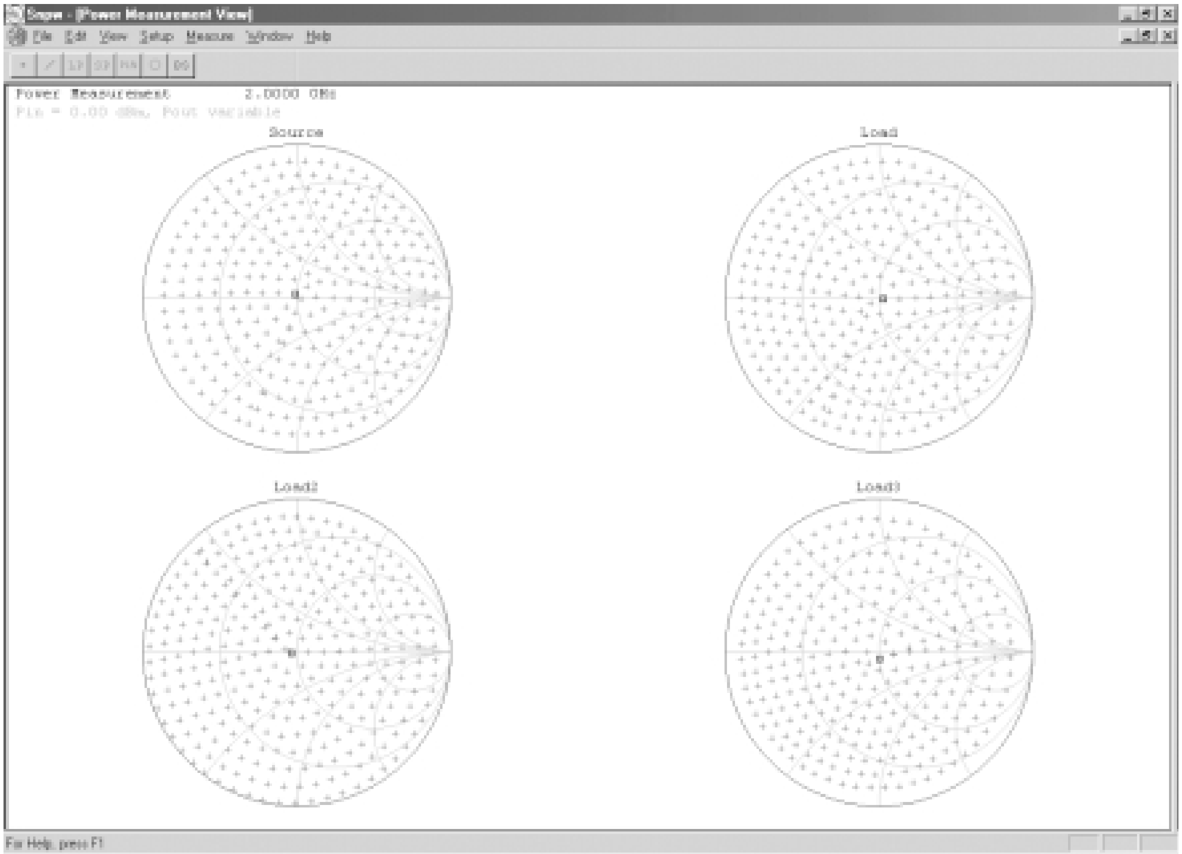


Figure 7-7. Harmonic Impedance Control Display

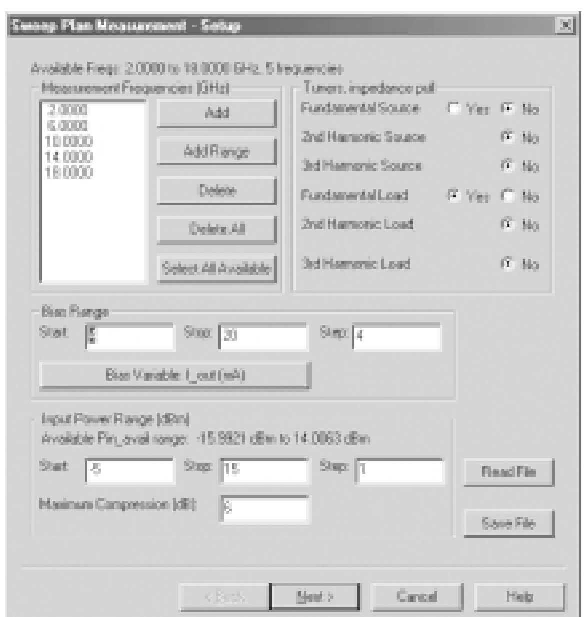


Figure 7-8. Sweep Plan Setup Dialog

(rectangle enclosing "SP") and follow the pattern of Section 7.8.1.

7.10 Harmonic Source/Load Tuning

Harmonic Tuning uses separate tuners to move the impedance at the harmonics independently from the fundamental frequency. Figure 7-7 shows the Power Measurement Screen with the second and third harmonic tuner charts displayed. The additional tuner charts are selected in the measurements setup editor. See Section 7.3.2.

Harmonic source and load pull measurements are made in essentially the same manner as those at the fundamental. From the Measurement View menu bar select <Measure>, <Load Pull> or <Source Pull>. When the dialog box appears, select the tuner to be pulled, then follow the pattern of Section 7.8.1.

7.11 Optimum Search

The optimum search feature provides a fast, efficient means of determining the impedance or reflection coefficient that optimizes a specified parameter without resorting to a full-up pull measurement. It is available for both fundamental and harmonic setups. From the Measurement View menu select <Measure>, <Optimum search>. When the dialog box appears, select the parameter to be optimized and whether the optimum is a maximum or minimum. Select the tuner to be pulled, then click on <Start>.

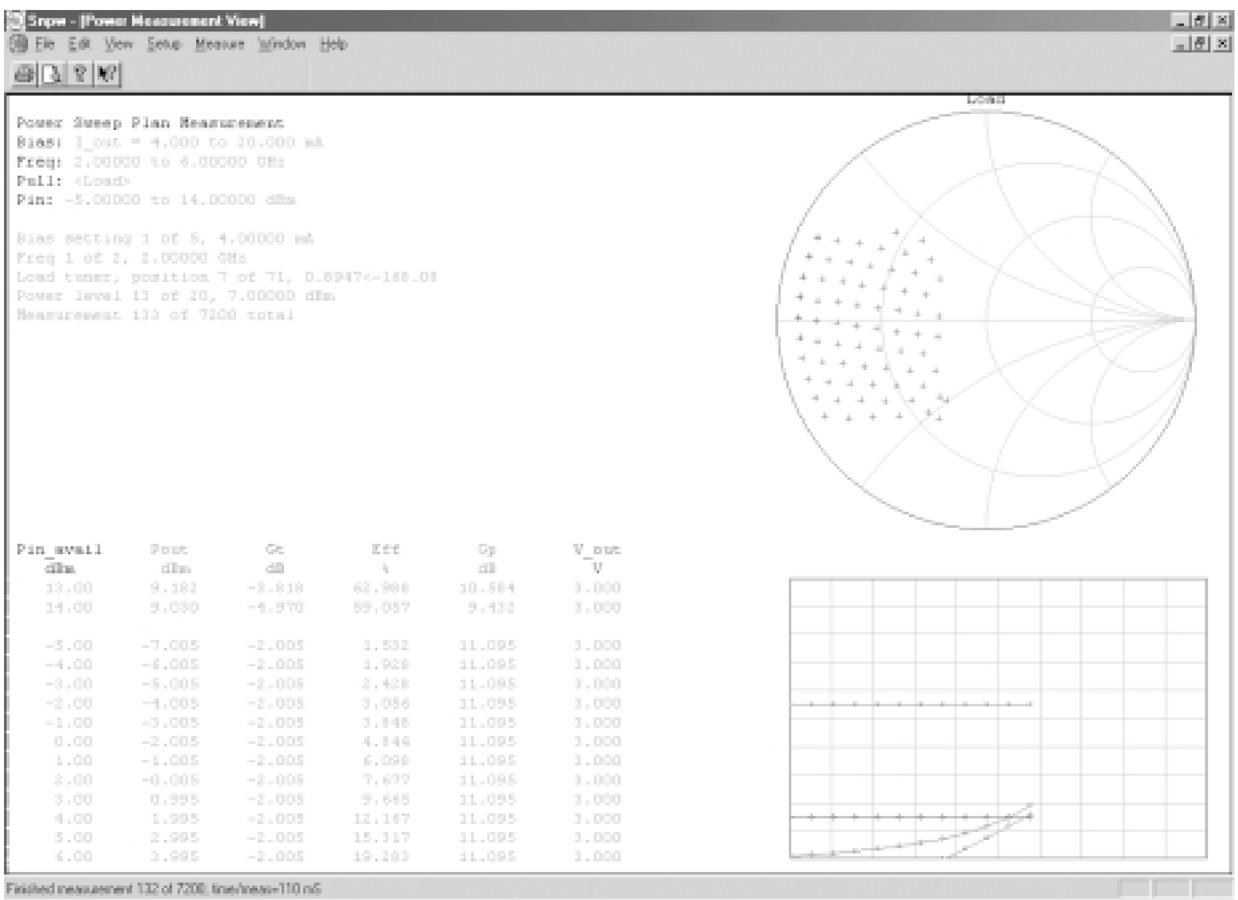


Figure 7-9. Progressive Display During Sweep Plan Measurement

When the measurement is complete, the optimum impedance will be shown on the selected tuner chart as a white rectangle. Left click on the point to select it on, then do a single point measurement to bring up the data listing at that point. See Section 7.4 for single point measurement and display details.

7.12 Sweep Plan

The sweep plan feature provides for sweeping power, bias, and impedance of multiple tuners over a frequency range.

7.12.1 Sweep Plan Measurements

Sweep plan measurements are initially set up from the Power Measurement view (see Section 7.3).

Select the parameters to be measured.

At every frequency in the plan:

Select the default position for each tuner in the setup. This is important because when a selected tuner is being pulled, all others are set to their respective default positions.

Select the measurement points for each tuner to be pulled. A minimum of seven points is required if contours are to be plotted.

When these conditions are set for each frequency, select <Measure>, <Sweep Plan> from the menu bar or click on the icon at the top left of the screen (rectangle enclosing "PLN") to bring up the Sweep Plan Setup dialog. See Figure 7-8.

If the setup had been previously saved, click on <Read File> and open the file. Otherwise:

Within the setup dialog box:

Enter the measurement frequencies.

Select the tuner(s) to be pulled – fundamental source and/or load.

Enter the bias range. The bias variable may be selected from the bias values that are specified for the current bias mode.

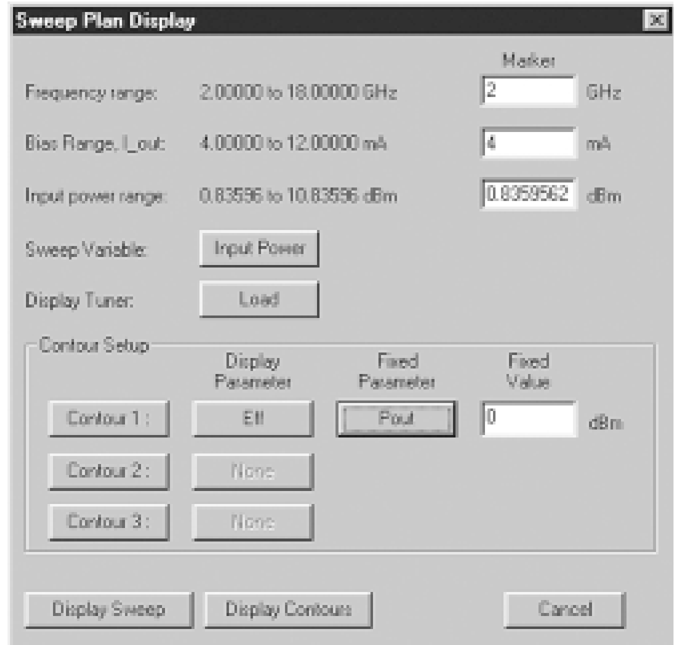


Figure 7-10. Sweep Plan Display Setup

Enter the maximum compression input level. If this level is reached during any of the sweeps, the sweep will terminate early and go on to the next sweep.

To save the setup without actually starting the measurement, click <Save File> and enter a file name.

Click <Next> to bring up the File name Entry box. Since a sweep plan may entail a rather large number of measurements, and may often run unattended, the program asks for a file name to save the data automatically at the end of the measurement. This step may be bypassed, but it is not recommended. Sweep plan data will be saved with the file extension ".spl".

Click <Finish> to start the measurements. Since the power sweep is the fastest moving variable, the progressive display will show a series of power sweeps for each selected tuner impedance at the start frequency and lowest bias level. See Section 7-9. When all impedances have been swept, the process will repeat at the next frequency. When all

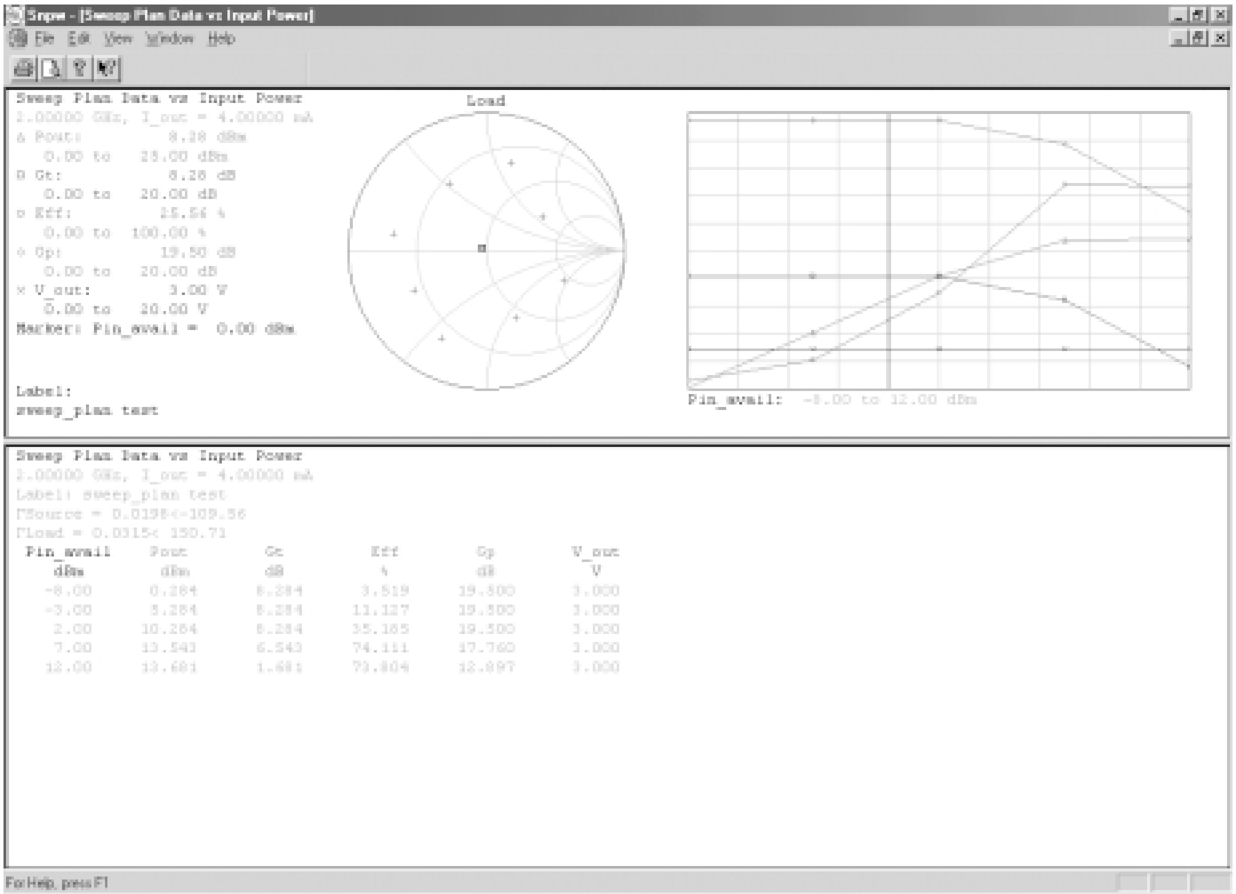


Figure 7-11. Sweep Plan Swept Display

frequencies have been measured, the system will repeat the entire sequence at the next bias level. The process will continue until all bias levels, frequencies, and tuner points have been swept.

Press <End> to abort the measurement.

7.12.2 Sweep Plan Display

The sweep plan display provides versatile viewing of the multidimensional sweep plan data. It includes flexible contour displays at the various tuner impedance planes, and swept displays versus input power, bias, and frequency. An individual sweep at one impedance point versus power, bias, or frequency may also be displayed.

7.12.3 Sweep Plan Display Setup

When the Sweep Plan Display is first started, the Sweep Plan Display dialog shown in Figure 7-10 will come up. This dialog may also be brought up after the display is showing by clicking <View><Parameters> from the Sweep Plan Display menu.

Marker value for frequency, bias and input power should be entered. These will apply when that parameter is not a variable in a sweep or contour calculation.

The sweep variable may be frequency, bias or input power. This is used if a swept display is selected.

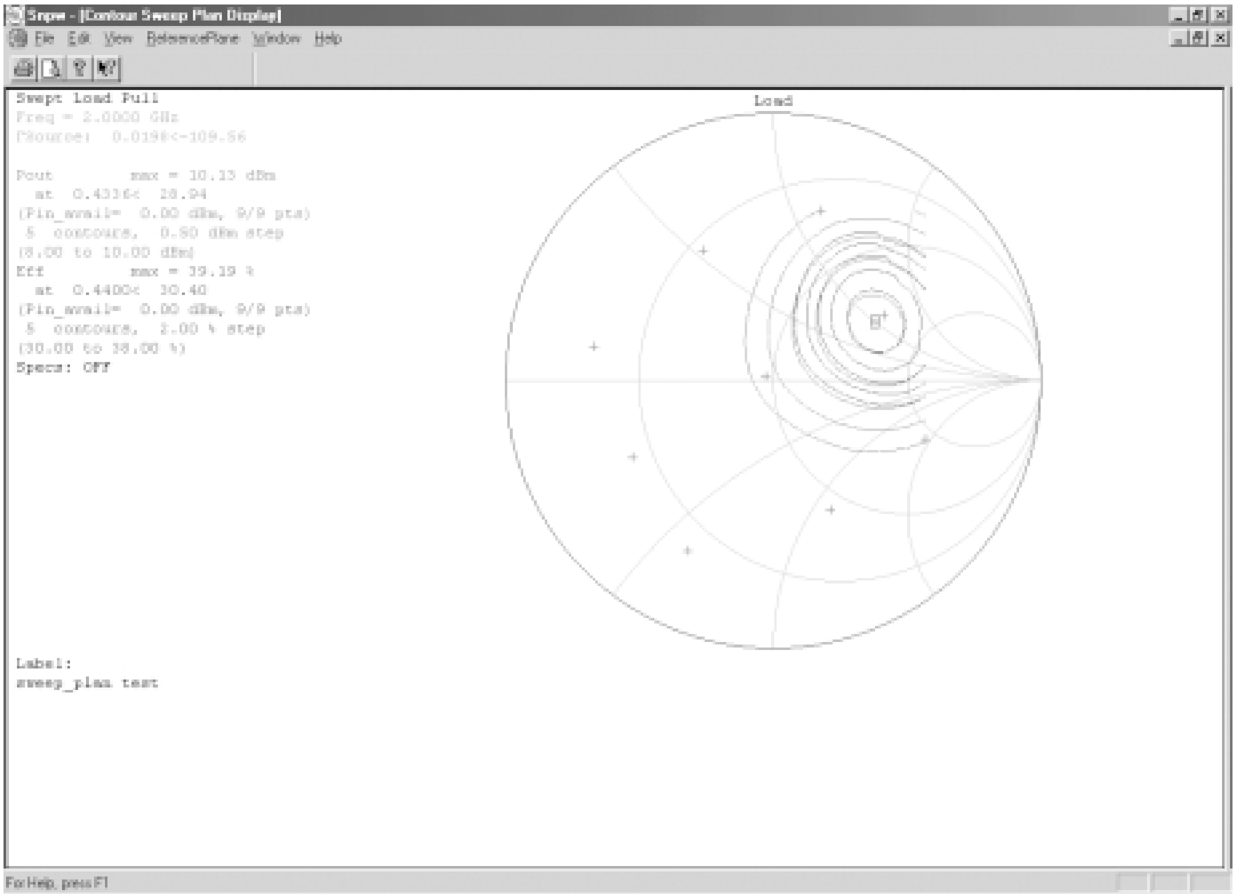


Figure 7-12. Sweep Plan Contour Display

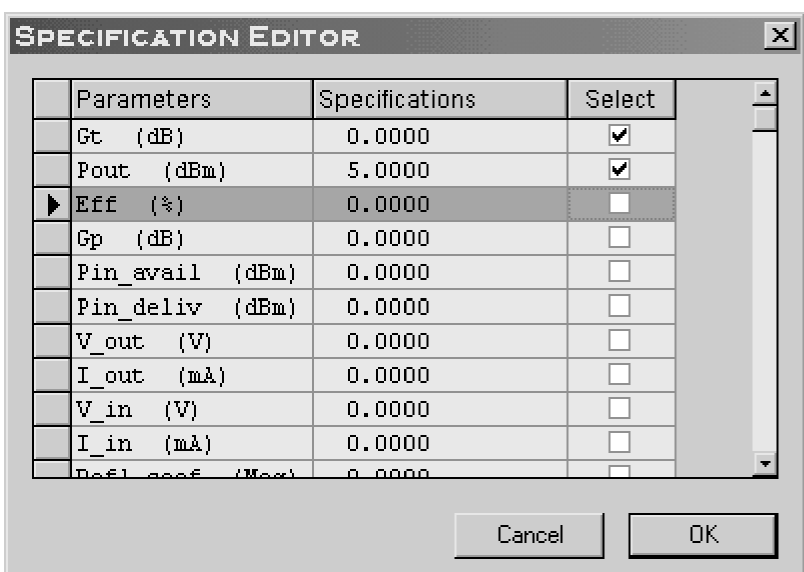


Figure 7-13. Specification Editor

The display tuner may be toggled through the tuners that were pulled during the sweep plan measurement. This will determine the tuner impedance plane for plotting contours, and also the impedance plane for showing and selecting points for the swept display.

For the contour display, each contour set may be toggled on or off by selecting the contour number. To select the parameters to be plotted, click the buttons in the "Display Parameter" column.

Contours of any measured parameter may be displayed with any other measured parameter at a fixed value. Select the fixed parameter in the same manner as the display parameter. Enter the desired values in the "Fixed Value" column. The resulting contours will all be at the active parameter values which meet the fixed parameter value. Up to three contour sets may be overlaid. This allows one parameter to be examined under different conditions, as well as the overlay of multiple parameters.

☞ ***NOTE:*** *The criteria for a given contour may not be met at all measured impedance points. In this case, the contour calculation will be based only on the subset where the criteria is met. The number of points in the subset will be shown on the line with the contour criteria. If the subset has fewer than 7 points, the contour will not be calculated.*

Selecting <Display Sweep> will bring up the swept display. Section 7.9.4.

Selecting <Display contour> will bring up the swept load/source pull display. See Section 7.12.4.

7.12.4 Sweep Plan Swept Display

An example of the Sweep Plan Swept Display is shown in Figure 7-11. The swept data of up to five parameters is shown on the rectangular chart. Selecting parameters, changing scales or moving the marker is the same as with the swept power display described in section 7.5.2.

If the independent parameter is input power or bias, the Smith chart will show the impedance points where data was measured at the selected tuner plane. Click on a point, and the swept display will change to show the swept data for that impedance.

If the independent parameter is frequency, then the Smith chart will show the selected impedance at each frequency in the sweep.

To change just the selected parameters in the swept display, highlight the parameter name and click on it. The available measured parameters may be toggled on or off by double clicking.

Select <View>, <Parameters> to go back to the Sweep Plan Display dialog.

7.12.5 Sweep Plan Contour Display

An example of a Sweep Plan Contour Display is shown in Figure 7-12. It is very similar to the fixed pull display except that a line describing the fixed condition is added to each block of display parameter information at the left of the screen.

See section 7.8.2 for details on this display.

7.13 Setting Specifications

Specifications may be set for any subset of measured parameters in any power measurement contour display. A contour will be drawn showing the Smith Chart region where all the specifications are met simultaneously. Such a contour is shown in the Sweep Plan Contour Display, Figure 7-12. The result is a target region which will be acceptable for the matching network design. If any one of the specification values are not met then the failure is reported.

Select <View><Specifications> to bring up the Specification Editor. This has a list of all available parameters as shown in Figure 7-13. Click on the check box in the Select column to toggle whether a particular parameter has a specification or not. The specification value can be entered in the Specifications column for each parameter.

7.14 The User Functions

The "user functions" use a user programmable measurement driver to allow special or unique measurements to be set up. For these parameters to be useful, the programmable user module must be programmed.

There are five functions in the user module that relate to power:

a. The user_online_check routine will be called right after the standard on-line check. The purpose is to check if the "user" instruments are on line, and to put them in a safe state with no SRQ's or other GPIB effects. This routine is called at the beginning of a normal calibration, or when a calibration file is read.

b. The user_cal_power routine is called after the normal power, intermod, or ACP calibration is complete. The purpose is to allow special calibration sequences to be programmed by the user when needed to support the user function or the user instruments.

c. The user_init_meas_power routine will be called when the power measurement screen is first entered so equipment can be set up into the desired operating mode.

   This routine also returns the number of user functions that will be in the array and sets up the string arrays with the names of each parameter and the units of each parameter.

d. The user_pre_meas_power routine is called as soon as the bias, RF power, and tuners are set. It is called prior to measurement of selected built-in parameters, so special measurement conditions may be set up.

   A flag returns to indicate whether to continue or abort. This can be used to check for conditions which could burn out a device. For example, if a destructive value of gate current or drain current is detected, the flag could be set to “abort”. In that case, the power and bias will immediately be turned off and the measurement aborted.

e. The user_function_power routine is called for every power measurement point and returns an array of power parameters. This routine is called after all standard parameters which are selected have been measured.

   All of the data related to the measurement point is sent to this routine. This includes instrument information, calibration data, raw and de-embedded measured data from the selected built-in parameters for this point. This provides a lot of flexibility. This function can: a) create new parameters which are just calculations, b) create new parameters which are measured by this routine, and c) recalculate the built-in parameters to change assumptions or calculation methods.

   The default user module provided with the distribution software will return zero array elements during real measurements. In demo mode, an array of twenty five values proportional to output power will be used to illustrate how it can work.

See Appendix 3 for information on programming custom drivers.

7.15 Saving Measured Power Files

Completion of a power measurement will bring up a prompt to label the data. If this is the first measurement of the session, the entry line will be blank (or if no label was assigned to a prior measurement). Enter a label and click <OK>, or click <Don't Change> to accept the current label or to bypass this step if the entry line is blank. The next prompt will ask for a file name to save the data. Enter a file name and click <Save>, or click <Cancel> if the data is not to be saved.

The program will assign a unique extension to each measurement type. These extensions can be changed; however, it is not recommended as the program may have difficulty finding the file at a later time.

7.16 Displaying Measured Power Data

Previously measured power data can be read from a file into memory. To display previously measured power data, go to the Block Diagram View menu, and select <View>, <Power>, and the type of power data, (<Source Pull>, <Load Pull>, <Power Sweep> or <Sweep Plan>) then <Memory>, or <File>.

The power data will then be displayed as described in those sections relative to the type of data (swept power, contour, etc.).

7.17 Displaying Power Calibration Data

To display the power calibration data, go to the Block Diagram View menu, and select <View>, <Power> and then <Cal Data>. Review the cal data by scrolling through the tabular list.

7.18 Gt(s) and Delta_Gt

These two parameters are useful in verifying the integrity of the s-parameters that describe the various system blocks. Gt(s) is the transducer gain calculated from s-parameters (as opposed to Gt, which is derived from the actual measurement). Delta_Gt is the difference between the two, i.e.: Gt(s) – Gt. This parameter is very sensitive and mostly shows errors due to s-parameter interaction. It generally indicates errors in network analyzer calibrations used for measurements of the system blocks.

The typical application is after a power calibration. The s-parameters in memory will be those of the thru. Leave the thru in place. From the Block Diagram view select <Measure>, <Power> to bring up the power measurement dialog. Select a frequency, set the bias to "none", and make certain the "Use S-Parameters" box is checked, See Section 7.3.1 for details on these procedures. Click <OK> to bring up the Power Measurement view.

Start the VSWR circle measurement routine (see Section 7.7). In the setup dialog, enter a very large VSWR (e.g.: 50:1) and the start and stop phase at 0 and 360 degrees, respectively. This will insure that the phase will be swept around the entire outer edge of the Smith chart. Click <Start> to make the measurement.

When the swept phase display comes up, select Gt(s) and Delta_Gt as the displayed parameters (see Section 7.5.2). Typically, Gt and Gt(s) will be about a 6 to 8 dB loss. The errors will add at some phase values and subtract at others. Delta_Gt will, therefore, usually have a sinusoidal pattern. A peak-to-peak ripple of about 0.2 dB is nominal and acceptable. If the ripple exceeds 0.5 dB peak-to-peak, it is suggested that the s-parameters of the system blocks be re-examined for accuracy.

A sinusoidal pattern offset from zero usually indicates a non-linearity in the system. The output power sensor is generally the most suspect. Often, the power levels are outside of its optimum range. Do a power sweep with the thru still in place (See Section 7.5) and examine the gain flatness to check for this possibility.

7.19 Oscillator Measurements

The Snpw program can be used to make oscillator power measurements. Power output, frequency, and other parameters of oscillators may be measured using all the measurement types described earlier in this chapter except swept input power and frequency. System calibration is not required since there is no RF source to be calibrated.

From the Block Diagram view select <Measure>, <Oscillator> to bring up the setup dialog. Complete the entries in the dialog as outlined in Section 7.3.1. The measurement screen that comes up is identical in appearance and function to that described in Section 7.3 except that available input power will not be displayed and the power sweep icon will be blank. Single point, load pull, and the variety of measurements described in Sections 7.3 through 7.14 may now be made.

At the completion of a measurement the entire list of enabled parameters will be displayed. Some of these, such as transducer and power gain will be disabled since they have no meaning in an oscillator measurement. See Section 7.3.5. If a spectrum analyzer is included in the setup spurious signals and harmonics can also be measured.

The measured data may be saved and recalled in the same manner as described in Sections 7.15 and 7.16, respectively.

8
Intermodulation Distortion Measurements

8.1 General

In general, intermodulation distortion (intermod) measurements are the same as the standard power measurement except that eighteen additional parameters are available. These are:

a. C: Power of the carrier signal in dBm.

b. Carrier_up: Power at the upper two-tone carrier frequency in dBm.

c. Carrier_lo: Power at the lower two-tone carrier frequency in dBm.

d. I3: Power of the third order intermodulation signal in dBm.

e. I3_up: Power at the upper frequency of the third order intermodulation signal in dBm.

f. I3_lo: Power at the lower frequency of the third order intermodulation signal in dBm.

g. C/I3: Ratio of carrier power to the power of the third order intermodulation signal.

h. IP3: Third order intercept point.

i. I5: Power of the fifth order intermodulation signal in dBm.

j. I5_up: Power at the upper frequency of the fifth order intermodulation signal in dBm.

k. I5_lo: Power at the lower frequency of the fifth order intermodulation signal in dBm.

l. C/I5: Ratio of carrier power to the power of the fifth order intermodulation signal.

m. IP5: Fifth order intercept point.

n. I7: Power of the seventh order intermodulation signal in dBm.

o. I7_up: Power at the upper frequency of the seventh order intermodulation signal in dBm.

p. I7_lo: Power at the lower frequency of the seventh order intermodulation signal in dBm.

q. C/I7: Ratio of carrier power to the power of the seventh order intermodulation signal.

r. IP7: Seventh order intercept point

These parameters are discussed further in Appendix 6, "The Theory of Intermodulation Distortion Measurements".

8.2 Intermod Measurements

The intermod measurement is identical to a single-tone (CW) power measurement except that the measurement is made with two signals or tones applied. From the block diagram view, select <Measure>, <Intermod> to bring up the setup dialog. Follow the pattern of Section 7.3.1 to set the measurement conditions (frequency, bias, etc.). When these conditions are set, click <OK> to bring up the measurement screen. This is the same as that shown in Figure 7-1 and described in Section 7.3.1 except for the note "(two tone)" at the top of the screen.

All subsequent measurements are made in the same manner as described in Section 7, Power Measurements. This applies to single point, swept power and bias, pull measurements, etc. Follow the instructions in Section 7 for performing these measurements.

Intermodulation distortion measurements may be toggled on and off by selecting or deselecting I3, I5, and I7 from the parameter selection table (see Section 7.3.5.1). The carrier, C/I ratios and intercept points will depend on the activation of these three parameters.

NOTE: *If no intermod parameters are selected, the power measurements will still be done with the 2-tone RF input. This makes all of the parameters correspond to each other relative to total input power and saturation.*

NOTE: *Single-tone measurements may be made by selecting <Measure>, <Power> from the Block Diagram view menu – even though the system was calibrated for intermod.*

8.3 Displaying Intermod Data

The parameter displays for intermod are identical to those described in Section 7 for power parameters. Refer to Section 7 for details on the various types of measurements and displays.

The Swept display of intermod data is especially useful in checking for the proper power range for determining IP3. An example is shown in Figure 8-1. Note that the scale range for Pout is one-third that for I3, and the two traces are parallel. This is a result of the 3:1 ratio in the slope of the two parameters (see Appendix 6).

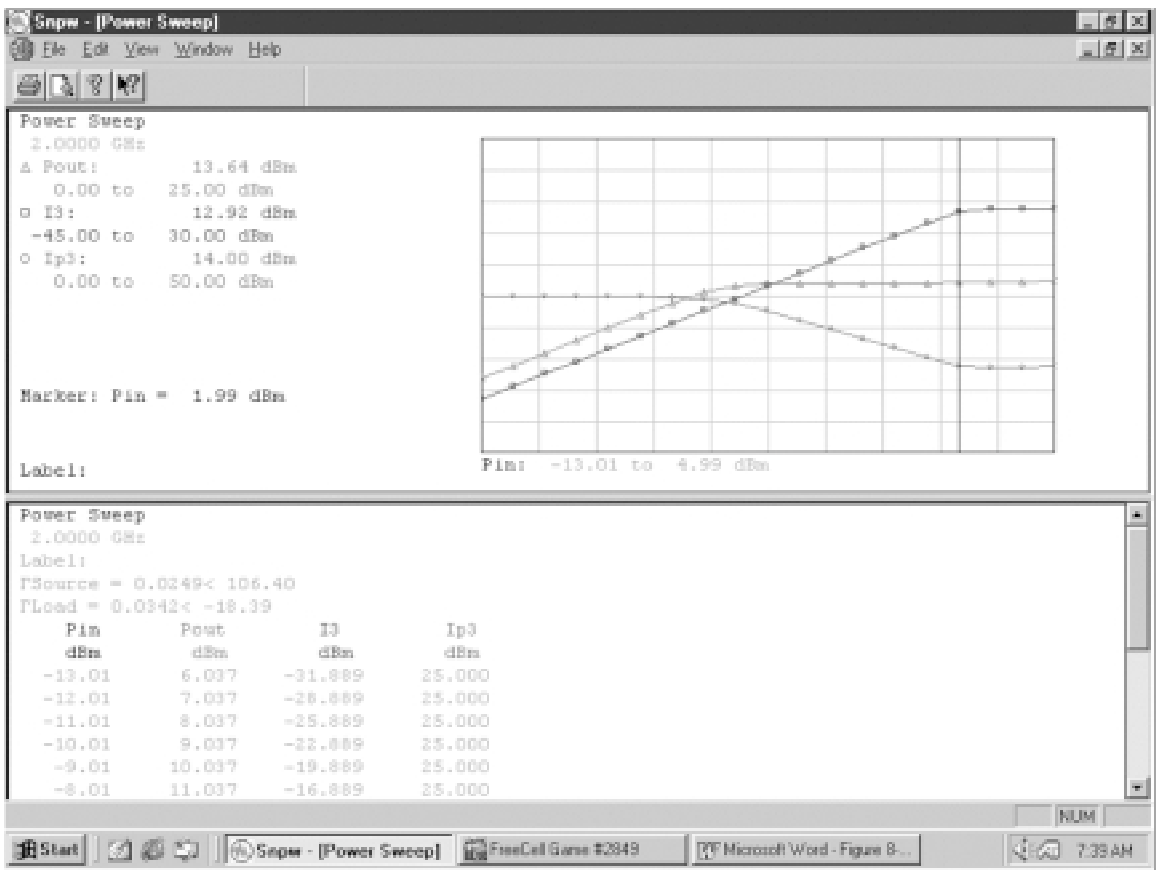


Figure 8-1. Swept Intermod Display

9
Adjacent Channel Power Measurements

9.1 General

Adjacent channel power (ACP) measurements are a test of how much modulated power in a specific frequency channel spills over into adjacent channels. The modulated signal contains a band of frequencies, and non-linearities will cause intermodulation distortion among the various frequencies. This produces power at new frequencies, causing interference with signals in the adjacent channels.

The phenomena tested with adjacent channel power measurements is similar to that of the 2-tone intermod test, except that ACP is measured with a specific, typically digital, modulation format.

Measurement of ACP as a function of impedance allows matching networks to be optimized for the specific modulation type, rather than for general purpose use.

NOTE: *Measurement parameters specific to adjacent channel power are set in the ACP options. See Section 4.5.6 for details on setting these parameters.*

The ACP measurement is an extension of the power measurement. It adds eight new parameters that can be selected just like the other power or intermod parameters. The eight new parameters are:

a. **acp_adj_up:** The ratio, expressed in dB, of the power in the upper adjacent channel to that in the signal channel.

b. **acp_adj_lo:** The ratio, expressed in dB, of the power in the lower adjacent channel to that in the signal channel.

c. **acp_alt_up:** The ratio, expressed in dB, of the power in the upper alternate adjacent channel to that in the signal channel.

d. **acp_alt_lo:** The ratio, expressed in dB, of the power in the lower alternate adjacent channel to that in the signal channel.

e. **acp_alt2_up:** The ratio, expressed in dB, of the power in the 2nd upper alternate adjacent channel to that in the signal channel.

f. **acp_alt2_lo:** The ratio, expressed in dB, of the power in the 2nd lower alternate adjacent channel to that in the signal channel.

g. **acp_ve_rms:** The RMS vector error of the recovered, digitally modulated signal. This is also known as error vector magnitude (EVM).

h. **acp_ph_err:** The phase error of the recovered, digitally modulated signal.

9.2 ACP Measurements

The ACP measurement is identical to power measurements except that all measurements are made with a modulated source, and the ACP parameters listed above are added to the list of available parameters. From the block diagram view, select <Measure>, <ACP> to bring up the setup dialog. Follow the pattern of Section 7.3.1 to set the measurement conditions (frequency, bias, etc.). When these conditions are set click <OK> to bring up the measurement screen. This is the same as that shown in Figure 7-1 and described in Section 7.3.1 except for the note "(ACP)" at the top of the screen.

All subsequent measurements are made in the same manner as described in Section 7, Power Measurements. This applies to single point, swept power and bias, pull measurements, etc. Follow the instructions in Section 7 for performing these measurements.

NOTE: *Many RF sources and their drivers are not set up for digital modulation. In this case, the specified modulation settings will be ignored and measurement of the ACP parameters will cause errors.*

9.3 Displaying ACP Data

The parameter displays for ACP are identical to those described in Section 7 for power parameters. Refer to Section 7 for details on the various types of measurements and displays.

10 Noise Measurements

10.1 General

The SNPW Noise Characterization program provides for automatic noise parameter measurements. Three measurement conditions are available:

a. Noise parameters versus frequency at a single bias level,

b. Noise parameters versus bias at a single frequency.

c. Noise parameters at a single frequency using an interactive graphical menu,

Noise parameters are determined by measuring noise power at each of a variety of source tuner positions at each frequency or bias level. The program then computes and displays the noise parameters.

The most common noise parameter set consists of:

a. **Fmin:** The minimum noise figure of the device

b. **Γopt:** The complex source reflection coefficient at which Fmin occurs.

c. **rn:** The equivalent noise resistance of the device normalized to 50 ohms.

☞ ***NOTE:*** *See Appendix 5, Theory of Noise Measurement, for more details on these parameters.*

The following parameters are also available:

d. **k:** The stability factor calculated using the device s-parameters. A value less than unity indicates a potentially unstable device.

e. G**max:** The maximum available gain calculated using the device s-parameters. This becomes maximum stable gain when k is less than unity.

f. **Γgain:** The complex source reflection coefficient at which Gmax occurs. Γgain is not available when k is less than unity.

g. **Assoc_gain:** The available gain of the device when the source reflection coefficient equals Γopt.

h. **Assoc_NF:** The noise figure of the device when the source reflection coefficient equals Ggain.

i. **N_Lange:** Lange's reference plane invariant parameter[1].

J. **UserX:** The user functions comprise an optional array of up to 25 parameters defined by a user-written driver. Each user parameter can be a scalar value that varies as a function of noise or impedance. See Appendix 3 for more information on user-defined functions.

Before starting a measurement, it is highly recommended that the setup options described in Section 4.6.3 be carefully reviewed, particularly with regard to point selection method, number of source points, and calculation method. For the beginning user, it is recommended that these be set to "Automatic", "12", and "Math1" respectively.

The calculations used to derive noise parameters from the measured noise power data require knowledge of the DUT s-parameters. Unless an on-line vector network analyzer is used, these s-parameters must be measured off-line and stored in an accessible file. See Chapter 6 for detailed instructions on s-parameter measurements.

1 Julius Lange, IEEE Journal of SSC, June 1967, pp37-40.

10.2 Swept Frequency

The swept frequency mode measures the noise parameters of the device under test (DUT) over a range of frequencies at one bias level. Graphical and Tabular displays of the noise and gain parameters are provided after the measurement.

10.2.1 Swept Frequency Noise Measurements

Calibrate the system for noise measurements (see Section 5.3). From the Block Diagram View menu, select <Measure>, <Noise>, <Sweep Freq> to bring up the startup dialog. The available (calibrated) frequency range is shown at the top of the screen. The current, or most recently measured frequency range is also displayed. Follow the on-screen instructions to add or delete frequencies. If the entire available range is to be measured, and the dialog shows a subset, click <Set to Available Frequencies>.

In the “Bias Mode” box, click on <Details> to change the bias mode and values if necessary. Refer to Section 4.6.2 for instructions on bias settings. When all entries are complete, click <OK> to continue.

If the S-parameter Mode is set to “Use Files”, the browse dialog to select the DUT s-parameter file will then appear. Refer to Section 6 for information on measuring and storing the DUT s-parameters. Select or enter the file name under which the DUT s-parameters are stored. When the file is opened, the s-parameters will then be displayed. After verifying that the s-parameters are correct, click <OK> to start the measurement. The bias will then come on before starting the noise measurements.

If the S-parameters Mode is set to “Online VNA”, the tuners will move to the Z0 position, the bias will come on, and the DUT s-parameters will be measured.

After the s-parameters are acquired and the bias is set, the noise measurement will begin. The load tuner will move to its one selected position (at the start frequency), and the noise power at the start frequency will be measured at each selected source tuner position (see sections 10.4.4 and 10.4.5 for point selection details). When all the source positions have been measured, the program will use the currently selected solution method (see Section 10.4.8) to compute the noise parameters. The gain parameters are calculated using the device s-parameters. If there is no solution, the contingent point(s) will be measured and the computation repeated. The measurement will then proceed to the next frequency.

As the measurements at each frequency are completed the results are tabulated and plotted on-screen. Completion of the measurements at the stop frequency will bring up a prompt to label and save the data. Refer to Section 10.6 for labeling and saving instructions.

NOTE: *The swept frequency noise data will be saved in a Touchstone compatible file with the file extension ".SF".*

The swept noise data will then be displayed , as shown in Figure 10-1. See Section 10.2.2 for details on this display.

NOTE: *If the MANUAL point selection option was chosen, be sure to select points at every frequency before attempting swept measurements, otherwise the result will be "no solution".*

10.2.2 Swept Noise Display

The graphical, interactive Swept Noise Display (see Figure 10-1) will plot the measured noise parameters vs. frequency or bias in the upper part of the screen and display the tabular data below.

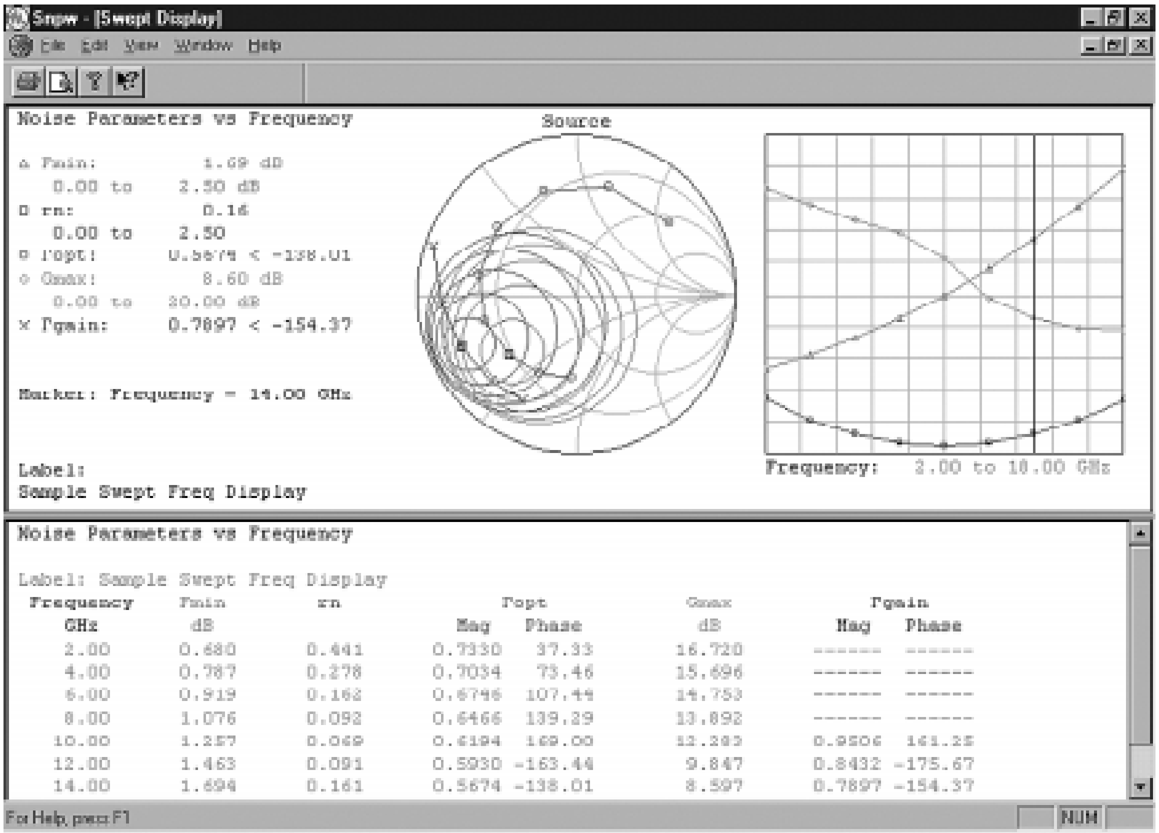


Figure 10-1. Swept Noise Display

Up to five parameter may be displayed at one time. Scalar parameters, such as Fmin, rn, and the maximum gain, are plotted on the rectangular chart, and complex parameters, such as Γopt and Γgain are plotted on a Smith chart. Γgain is the source reflection coefficient which produces maximum available gain. A unique value for Γgain only exists if the stability factor “k” is greater than or equal to one, so if “k” is less than one, Γgain will not be plotted. At the left of the screen, the minimum and maximum scale limits are displayed for the parameters plotted on the rectangular chart.

The current marker values are displayed for all the active parameters. The marker position on the rectangular chart is identified by a bright vertical line. The markers on the Smith chart are small bright squares on the reflection coefficient curves.The marker position value is displayed just below the parameter listing on the left of the graphic window.

Use the scroll bar or the up/down arrows to scroll the tabulated data if the list is too long to fit in the tabular window.

10.2.2.1 Selecting Displayed Parameters

To bring up the Noise Parameter Selection Window, as shown on Figure 10-2, point the mouse to highlight the parameter name and click the left button. This allows selection of alternate noise parameter sets, and turning on and off of individual parameter plots.

Some parameters are alternate but equivalent forms of the same noise paramter data. Fmin,Γopt, r_n make up the traditional and most commonly used set, but other forms have advantages in some applications. For example, N_Lange is the Lange's reference plane invariant parameter[2]. The noise user function may also add parameters here.

In the Noise Parameter Selection Window, click on a parameter to toggle it on or off. Click on <Move Up>, <Move Down>, <Move to Top>, or <Move to End> to change the order of the parameters in the display.

When the plot is on, the parameter name and marker value wil be displayed in the same color as the plotted trace. When the plot is off, the marker value is also turned off, and the marker name will change to a gray color.

10.2.2.2 Changing Scales

The scaling on the rectangular chart is independent for each parameter. The scales may be changed to accommodate the plotted data. Highlight and click on a scale value below a parameter name to change just that one value. Select <View><Scales> from the menu bar to change the values for more than one parameter at a time.

☞ ***NOTE:** The scaling values selected in this display for each parameter will be saved if the configuration file is saved.*

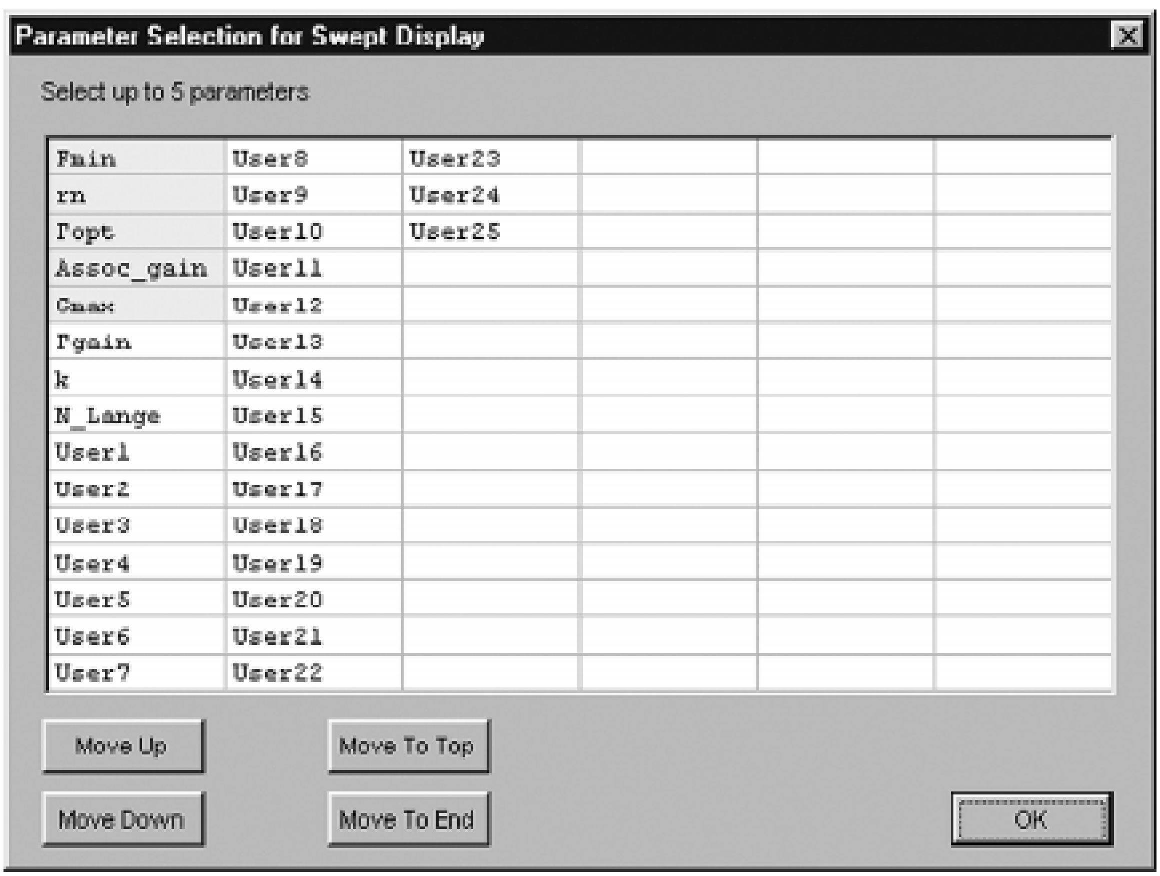


Figure 10-2. Noise Parameter Selection Display

2 Ibid.

10.2.2.3 Selecting the Marker Position

The marker may be moved in three ways:

a. Move the marker to discrete measured points with the left or right arrow keys.

b. Move the marker to interpolated points by moving the mouse pointer to the desired horizontal position in the rectangular chart and clicking the left mouse button.

c. Select the marker value from the marker list from <View><Marker>.

10.2.2.4 Displaying Noise, Gain and Stability Circles

Constant noise figure and gain circles and stability circles may be plotted on the Smith chart. Select <View>, <Circles> from the menu bar. Toggle the circles on or off and enter new values for the number of circles and the interval between them if necessary. The gain circles will be visible only at those frequencies where the stability factor is greater than unity. The stability circles, plotted in white, will be visible only at those frequencies where the stability factor is less than unity.

10.2.2.5 Smoothing the Plotted Data

Zero, first, or second order smoothing may be applied to the plotted data to better understand parameter trends and reduce random variability. Select <View>, <Smoothing> from the menu bar. Click on a smoothing order. If “Plot Unsmoothed Points” is checked the original data will still be plotted on the screen when <OK> is clicked; however, the tabulated data in both windows will be that of the smoothed curves.

10.2.2.6 Verification Parameters

Data saved from prior measurements can be brought into the display and compared to the current data. Select <View>, <Verification>, <File> from the menu bar to bring up the file selection window. Select the file to be compared. When the file is opened, the program will add the noise parameters to the parameter list of the current display; however, these will be labeled Fmin_v, rn_v, and Γopt_v for identification purposes. The verification parameters can then be handled in the same manner as any of the displayed parameters and will appear in the parameter selection dialog.

If the DUT is a passive device, select <View >, <Verification>, <Passive> from the menu bar. The noise parameters will be calculated from the s-parameters of the device and the ambient temperature. These will then be added to the parameter list as *_v parameters in the same manner as noted above.

10.2.2.7 Reviewing the Noise Statistics

The Noise Data Statistics screen provides access to the measured data and the solution method. This dialog can be used to restrict the data range and eliminate obviously invalid data points. Each action in this dialog will result in a re-calculation of the noise parameters shown at the bottom of the screen using any one of the four solution methods. This dialog may be used as a troubleshooting tool in the event a measurement results in no solution (see Section 10.2.2.8 below). From the menu bar, select <View>, <Statistics> to bring up the Noise Data Statistics screen shown in Figure 10-3.

At each tuner position, the displayed data shows: the magnitude and angle of the source reflection coefficient; the measured noise figure, the calculated noise figure using the noise parameters; and the difference between the measured and calculated noise figures. The noise parameter solution is shown at the bottom of the screen.

Each time a menu item on the right of the screen is clicked, the solution will be recalculated. These menu items are:

Solution Method: Click the top button to toggle through the four solution method options. When the bottom item is set to “Cal Data”, this button toggles through the noise load options.

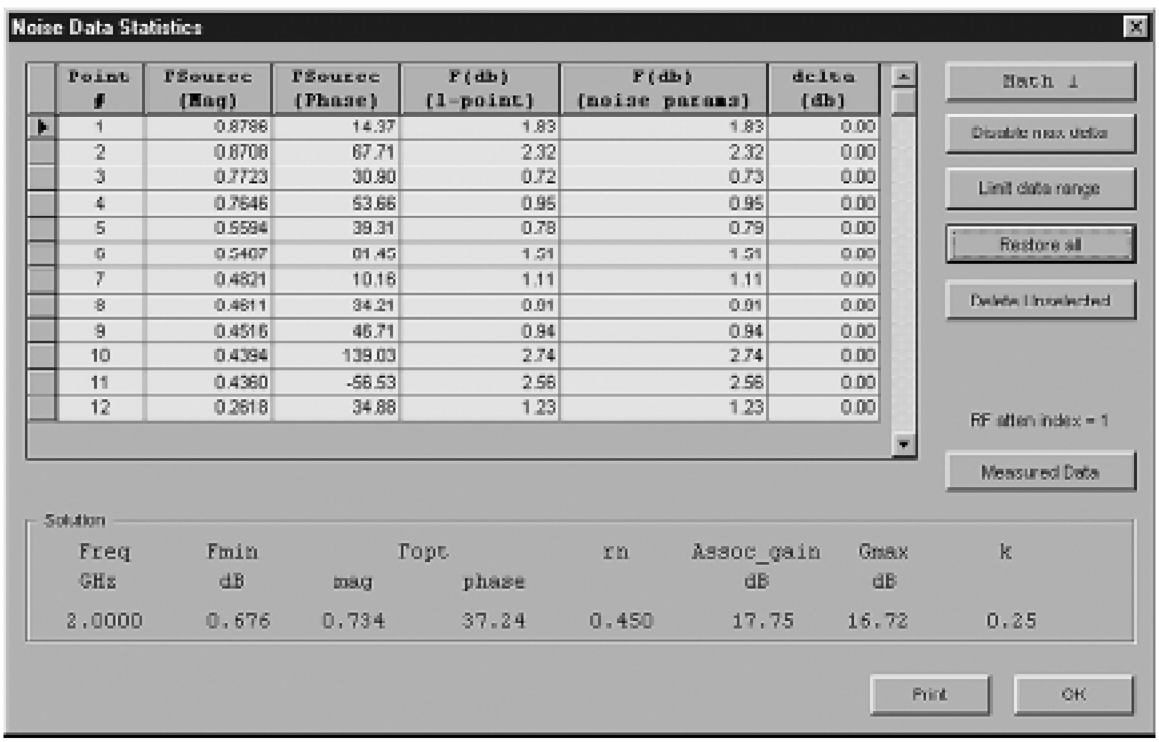
Disable max delta: Disables the data with the maximum deviation between measured and calculated noise figures. Continued clicks will progressively eliminate each new “max delta”.

Limit data range: Click and enter a data range in the pop-up window to disable data outside the selected range.

Restore all: Reactivates all disabled data.

Delete Unselected: Deletes all points not selected in the data table.

Measured/Cal Data: Toggles between the measurement data and the calibration data. When this item is set to “Cal Data”, the measured calibration points are shown.



Point #	ΓSource (Mag)	ΓSource (Phase)	F(db) (1-point)	F(db) (noise params)	delta (db)
1	0.8786	14.37	1.83	1.83	0.00
2	0.8708	67.71	2.32	2.32	0.00
3	0.7723	30.90	0.72	0.73	0.00
4	0.7646	53.66	0.95	0.95	0.00
5	0.5594	39.31	0.78	0.79	0.00
6	0.5407	01.45	1.51	1.51	0.00
7	0.4821	10.16	1.11	1.11	0.00
8	0.4611	34.21	0.91	0.91	0.00
9	0.4516	46.71	0.94	0.94	0.00
10	0.4394	139.03	2.74	2.74	0.00
11	0.4360	-58.53	2.56	2.56	0.00
12	0.2618	34.88	1.23	1.23	0.00

Freq GHz	Fmin dB	Γopt mag	Γopt phase	rn	Assoc_gain dB	Gmax dB	k
2.0000	0.676	0.734	37.24	0.450	17.75	16.72	0.25

Figure 10-3. Noise Statistics Dialog

10.2.2.8 Noise Parameter Solutions with Poorly Conditioned Data

Occasionally, ill-conditioned data, usually a symptom of an unstable DUT, will cause the calculation of noise parameters to result in "no solution", even after measuring with the contingent point(s). The SNPW program offers some potential remedies to that condition.

a. Change the method used to solve for the noise parameters: "Math1" is the most exact of the solution method options and is generally preferred; however, it will sometimes fail to provide a solution. "Math2" uses some minor approximations and may provide a solution when Math1 fails. "Cold Only" is the most sensitive to errors and is not recommended. The advantage of "Contour" is that solutions can often be found even when the data is very poorly conditioned. It can also display a visual plot that will make problem areas of the Smith chart more obvious. A disadvantage of the contour method is that it generally requires more measured tuner positions for good data, and the measurement can take longer. The easiest way to see the effects of changing the solution method is to go to the Noise Data Statistics screen described in Section 10.2.3.3 above. See Section 10.2.3.2 above for instructions on changing the solution method in the interactive screen for an actual measurement.

b. Review the noise data: Refer to Section 10.2.3.4 for details on reviewing the noise statistics.

c. Modify the tuner point selection: Often changing the position, deleting or adding tuner positions will result in a valid solution. In general, no points should be enclosed by the stability circles, and it is advisable to move points close to the circles further away. Refer to Section 10.2.2.2 for details on selecting and de-selecting tuner positions. Note that deleting a point will delete the data only at that point, and the noise parameters may still be recalculated with the remaining data. Adding a point will delete the data at all points requiring a new measurement before the noise parameters can be displayed.

10.3 Swept Bias

The swept bias mode measures the noise parameters of the device under test (DUT) over a range of bias levels at one frequency. Graphical and Tabular displays of the noise and gain parameters are provided after the measurement.

10.3.1 Swept Bias Noise Measurements

Calibrate the system by noise measurements (See Section 5.3). From the Block Diagram View menu, select <Measure>, <Noise>, <Swept Bias> to bring up the setup dialog. Select a frequency from the list of available (calibrated) frequencies.

In the "Bias Mode" box, click on <Details> to change teh bias mode, swept variable, and value if necessary. Refer to Section 4.5.2 for instructions on bias settings. Enter the swept variable start, stop and step values. When all entries are complete, click <OK> to continue.

If the s-parameter mode is set to "USe Files", the browse dialog to select the DUT s-parameter file vs. bias will appear then appear. Refer to Section 6 for information on measuring and storing the DUT s-parameters. Select or enter the file file under which the DUT s-parameters are stored. When the file is opened, the s-parameters will then be displayed. After verifying that the s-parameters are correct, click <OK> to start the measurement.

☞ ***NOTE:*** *When the s-parameter mode is to "Use Files", the default bias values come from the swept bias s-parameter file, so make sure the bias variable is the same, and use care not to go outside the bias range of that file. Extrapolation is not allowed.*

If the s-parameter mode is set to “Online VNA”, the tuners will be moved to the Z0 position, and teh DUT s-parameters will be measured vs. bias, starting with the lowest bias value.

The bias will then turn on at the start level, the load tuner will move to its one selected position, and the noise power at the start frequency will be measured at each selected source tuner position (See Section 10.2.2.1 and 10.2.2.2 for point selection details). When all the source positions have been measured, the program will use the currently selected solution method (See Section 10.2.3.2) to compute the noise parameters. The gain parameters are calculated using the device s-parameters. If there is no solution, the contingent point(s) will be measured and the computation repeated. The measurement will then proceed to the next bias level.

As the measurements at each bias level are completed, the results are tabulated and plotted on-screen. Completion of the measurements at the stop bias will bring up a prompt to label and save the data. Refer to Section 10.6 for labeling and saving instructions.

10.3.2 Swept Bias Display

The Swept bias display is identical in appearance and function as the swept frequency display except tha the variable is bias. Refer to Section 10.3.2 for operational and functional details on this display.

10.4 Interactive Noise Measurements

The interactive measurement mode is a valuable tool used to examine the noise and gain performance of the DUT at a single frequency:

a. Noise and gain parameters may be measured.

b. Point selection and the calculation method may be changed to improve the integrity of the results and make the measurement more robust.

c. Noise figure may be measured at various source and load tuner positions to verify the calculated parameter data.

10.4.1 Starting Procedure

Calibrate the system for noise measurements (see Section 5.3). From the Block Diagram menu, select <Measure>, <Noise>, <Interactive> to bring up the startup dialog.

Select a frequency from the list of available calibrated frequencies.

In the “Bias Mode” box, click on <Details> to change the bias mode and values if necessary. Refer to Section 4.5.2 for instructions on bias settings.

In the S-Parameters box: If this is the first measurement of the session, click <Read S-Parameters> to select the DUT s-parameter file, or click <Measure S-Parameters> if an on-line VNA is in the setup; if prior measurements have been made, click <Show S-Parameters> to verify that the s-parameters in memory are those of the DUT to be measured.

Click <OK> to bring up the Interactive Measurement screen.

10.4.2 Interactive Noise Measurement View

The Interactive Noise measurement screen consists of two Smith charts showing the calibrated source and load tuner positions (see Figure 10-4). If a load tuner is not used, then only the source Smith chart will show. The position of the mouse cursor in a tuner chart is continuously displayed just below the chart. The DUT S11 and S22 conjugates are displayed as yellow triangles on their respective charts. If the DUT stability factor, k, is less than unity, the stability circles are plotted in white. If the stability factor is greater than unity, a magenta rectangle identifies the source reflection coefficient for maximum available gain (Γgain).

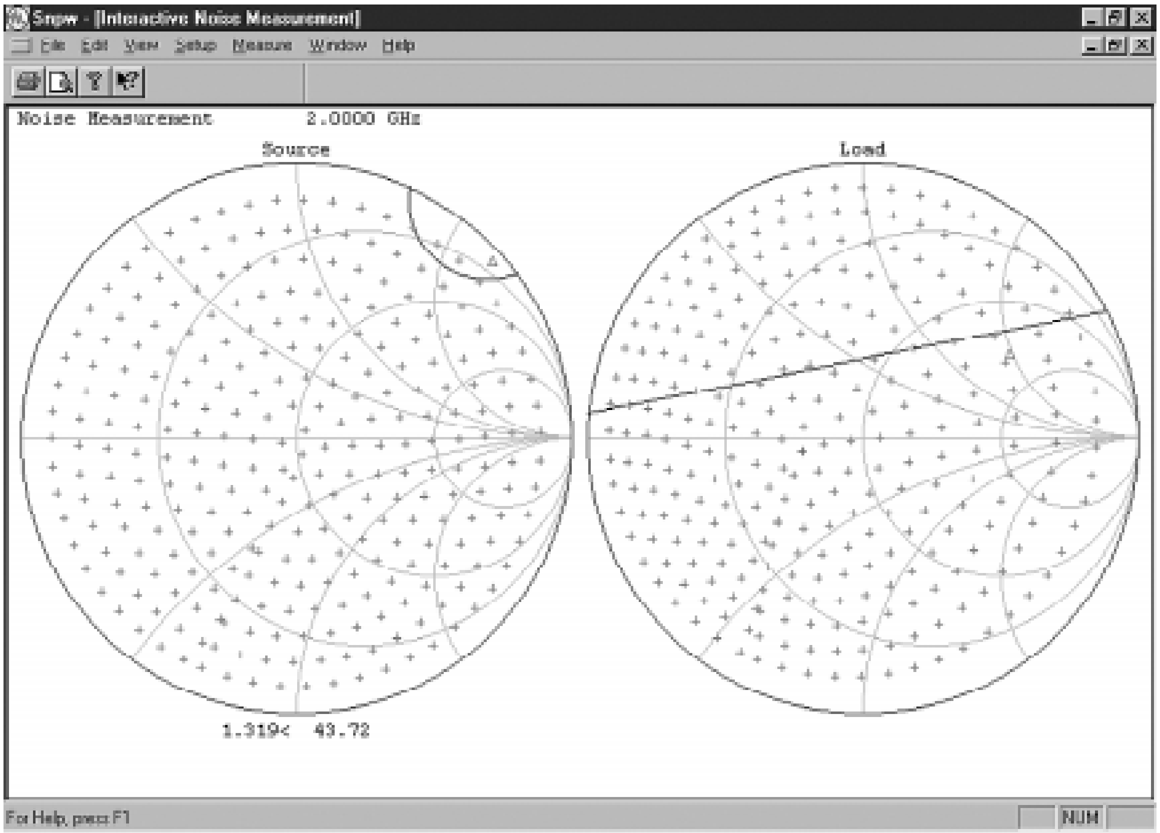


Figure 10-4. Interactive Noise Measurement Screen

The selected tuner points are shown in green. Contingent points are shown in magenta. Initially, if no prior measurements have been made, there may be no selected positions on the source chart. The load tuner position used during calibration may still be selected.

Contingent points will be used in a noise parameter measurement if the selected points fail to provide a noise parameter solution.

If there is currently raw noise data in memory, the noise parameter solution will be displayed along with the noise and gain circles if they are selected.

10.4.3 Changing Frequency

Select <Setup><Frequency>, and select a frequency from the list of those available.

10.4.4 Automatic Point Selection

Select <Setup><Auto Select> to automatically select the load and source points using the automatic algorithm with the noise options settings.

The number of automatically selected tuner positions used for the measurement can be increased or decreased. Select <Setup>,

<Options> from the menu bar. Enter the new number of points on the "Meas Point Selection" line and click <OK>. When the interactive screen is again visible, select <Setup>, <Auto Select> from the menu bar. The new tuner positions will then be displayed.

Active, available and contingent tuner positions can be toggled between on and off as described below. These actions are required at each measurement frequency if the manual point selection method was chosen in the setup options.

10.4.5 Manual Point Selection

As the mouse pointer moves over either chart, the reflection coefficient or impedance is displayed immediately below the chart.

If the left mouse button is clicked while the pointer is on the source chart, the nearest tuner point will be toggled between selected or not selected. If the left mouse button is clicked while on the load chart, the nearest tuner point will become the new load position.

☞ ***NOTE:*** *If noise parameters have already been measured, deleting a source point will delete the noise data at that point only. The noise parameters may still be recalculated with the remaining points. Adding a source point will cause the noise data to be deleted for all points, requiring a new measurement before noise parameters can be displayed.*

If the <SHIFT> key is held down and the left mouse button is clicked while the pointer is on either chart, the nearest tuner point will be toggled between available or unavailable. This determines which points will be available for the automatic point selection. This is useful to force the automatic selection to avoid points at which the DUT will oscillate. Avoiding oscillation this way normally works best by avoiding load points near the stability circle, and leaving all of the source points available to get a good selection pattern.

If the <CTRL>(control) key is held down and the left mouse button is clicked while the pointer is on the source chart, the nearest tuner point will be toggled between contingent or not contingent. Contingent points are used in the noise parameter measurement if "no solution" occurs using the selected points.

To select a block of source points, click the right mouse button on the source Smith chart, and select <SelectPointsOn> or <SelectsPointsOff> from the pop up menu. Then move the cross-hair cursor to a starting point and hold the left button down while dragging a rectangle to enclose the desired points. Release the left button to complete the selection.

To select the load point, click the left button on the desired point on the load Smith chart. Only one point is used at a time, so the current selection will move to the new impedance.

☞ ***NOTE:*** *A selected set of impedances for noise measurements can be saved by saving the tuner file. See Section 5.1.4.*

☞ ***CAUTION:*** *Even though the "Avoid Unstable Points" may be enabled in the noise options menu (See Section 4.5.3), the program will permit manual selection of potentially unstable tuner positions within the stability circles. These positions should be avoided unless necessary to obtain a solution to the calculation.*

10.4.6 Noise Parameter Measurement

Noise and Gain parameters are available directly from the interactive screen. From the menu bar, select<Measure><Measure noise parameters>. The bias will turn on, the load tuner will move to its one selected postion, and the noise power will be measured at each selected source tuner position. When all the source positions have been measured, the program will use the currently selected solution method to compute the noise parameters. The gain parameters are calculated using the device s-parameters. If there is no solution, the contingent point(s) will be measured and the computation repeated.

Figure 10-5 is a typical example of the interactive screen after the noise parameter measurement. The noise and gain data are displayed at the bottom of the screen. The optimum source reflection coefficients for minimum noise figure (Γopt) and maximum available gain (Γgain) are identified by blue and magenta rectangles, respectively (the latter only if the stability factor is greater than unity).

10.4.7 Displaying Constant Noise Figure/Gain Circles and Contours

From the menu bar at the top of the interactive screen, select <View>, <Circles> to bring up the circle selection dialog box. Toggle the selected circles on or off in the dialog box and, if necessary, enter the new values for the number of circles and the interval between circles. Note that gain circles are available only if the stability factor of the DUT is greater than unity at the measurement frequency.

Contours will be displayed only if the contour solution method was previously selected. To

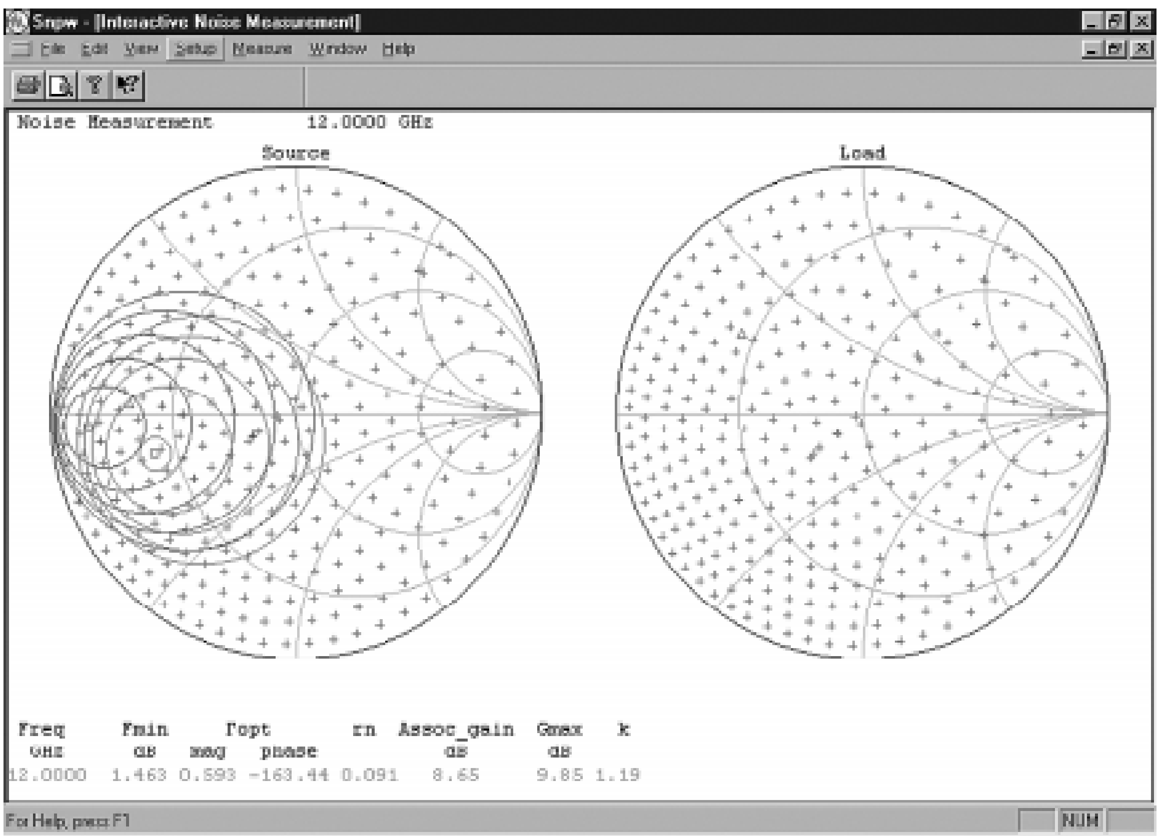


Figure 10-5. Noise Parameter Measurement Screen

1 Julius Lange, IEEE Journal of SSC, June 1967, pp37-40.

select the contour method slick <Setup>, <Option> on the menu bar. Click <Contour> on the "Math Options" line in the options dialog And enter a contour resolution. The resolution is usually a number between 50 to 100. A high resolution will result in smoother contours but will take longer to compute. A lower resolution will compute faster, but the contours may show some straight-line segments. After the contour method is set and the resolution entered, click <OK> to return to the interactive screen. Select <View>, <Circles> from the menu bar and enter the number of contours and the interval. Click <OK> when finished.

10.4.8 Selecting the Solution Method

There are two methods of solving for the noise parameters from the Interactive screen:

a. The "DIRECT" method, and

b. The "CONTOUR" method.

The current selection will be checked and will be used when the noise parameters are calculated. Ths solution method is selected by clicking the desired option on the <Setup> menu in the interactive noise measurement view.

Selecting (or re-selecting) the solution method will cause re-calculation and display of the noise parameters if the raw data has already been measured (either in the Interactive Menu or by a previous Swept Noise Measurement). If there is no raw Data, then the new selection will just be checked to indicate the selection.

☞ ***NOTE:*** *Adding points to the point selection or changing the load point will clear the raw data. This ensures that the solution displayed corresponds to the current point selection.*

The Direct Solution uses all of the over determined noise power data, and solves directly for the four noise parameters using a least means squares approach. This is the method always used in the swept frequency measurement.

☞ ***NOTE:*** *From the Direct Solve Method, there is a choice of math algorithms. See Section 4.6.2 for details on selecting noise options.*

The Contour Solution Method takes the raw data and solves for noise figure at each individual measured source impedance. It then draws contours of noise figure. Fmin and Γopt are determined directly from the contouring algorithm. Once Fmin and Γopt are known, rn is calculated from the every individual noise figure measurement and averaged.

The advantage of the Contour Solution Method is that solutions can often be found even when part of the data is poorly conditioned, such as due to oscillation. It also can display a visual plot which will make problems at certain areas of the Smith chart easier to see.

A disadvantage of the Contour Solution Method is that more measured points are normally needed to get good data, so the measurement usually takes longer.

To select the calculation resolution for the noise figure contours, go to the noise tab of the Options Setup Property sheet (See Setion 4.6.2) and enter a new value.

The calculation resolution should normally be a number between 50 and 100. A higher number produces smoother and more accurate plots, but takes longer. A small number is quick, but less accurate, and straight line segments may be visible in the contours.

The contours are calculated over a rectangular area, based on the points selected. Sometimes a high resolution will produce anomalous contours in areas not surrounded by measured points. This can usuall be corrected by reducing the calculation resolution.

10.4.9 Reviewing the Noise Statistics

The noise data statistics screen provides access to the raw measured data and the solution method. This dialog can be used to restrict the the data range and eliminate obviously invalid data points. Select <View> <Statistics> from the menu bar. The screen and it's functions are described in Section 10.2.2.7.

10.4.10 Measuring Noise Figure

Noise figure may be measured at any available tuner position directly from the interactive screen. Click the right mouse button and select <Measure Noise Figure> from the pop-up window. Move the rectangular cursor to the source tuner position to be measured and click the left mouse button. The bias will come on, the tuners will move and the noise figure will be measured.

For a single noise figure measurement, the hot/cold reflection coefficient of the noise source is almost completely taken into account. (There is not enough information available to be completely rigorous without knowledge of the DUT noise parameters.) The small residual error is reduced by the ENR of the noise source, and is often smaller than the instrumentation uncertainties.

After the noise figure is measured,the tuner reflection coefficients and the measured noise figure will be displayed at the bottom of the screen under the source tuner chart.

10.4.11 Zoom

The tuner displays can be examined in more detail by using the zoom function. Click the right mouse button and select <Zoom window> from the pop-up menu. Click and hold the left mouse button and drag the rectangular window over the area of the chart to be magnified. Release the button to see the expanded view. Click the right button and select <Zoom all> from the pop-up menu to return to the normal view.

10.4.12 Local Operation

The system may be put into the local mode for manual troubleshooting of the instrument setup. Select <Measure>, <Go to local>. When finished click <OK> to return to the interactive view.

10.5 User Functions

The "user functions" use a user programmable measurement driver to allow special or unique measurements to be set up. For these parameters to be useful, the programmable user module must be programmed.

These are five functions in the user module that relate to noise:

a. The user_online_check routine will be called right after the standard online check. The purpose is to check if the "user" instruments are on line, and to put them to a safe state with no SRQ's or other GPIB effects. This routine is called at the beginning of a normal calibration, or when a calibration file is read.

b. The user_cal_noise routine is called after the normal noise calibration is complete. The purpose is to allow special calibration sequences to be programmed by the user when needed to support the user function or the user instruments. This routine is called at the end of a normal calibration.

c. The user_init_meas_noise routine will be called prior to the start of a noise measurement so equipment can be set up into the desired operating mode.

This routine also returns the number of user functions that will be in the array and sets up the string arrays with the names of each parameter and the units of each parameter.

d. The user_check_osc_noise routine is called as soon as the bias, noise source and tuners are set for each position. A flag returns to indicate if an oscillation occured.

e. The user_function_noise routine is called for every noise measurement point. This allows the noise solution to be recalculated if desired. It also allows up to 25 user defined parameters to be calculated or measured.

The Default user module provided with the distribution software will not do anything during real measurements.

10.6 Saving Measured Noise Data

Completion of a noise measurement will bring up a prompt to label the data. If this is the first measurement of the session, the entry line will be blank (or if no label was assigned to a prior measurement). Enter a label and click <OK>, or click <Don't Change> to accept the current label or to bypass this step if the entry line is blank. The next prompt will ask for a file name to save the data. Enter a file name and click <Save>, or click <Cancel> if the data is not to be saved.

The program will assign a unique extension to each measurement type. These extensions can be changed; however, it is not recommended as the program may have difficulty finding the file at a later time. See Appendix 7 for a list of standard Snpw file extensions.

10.7 Displaying Swept Noise Data

Previously measured noise data can be read from a file and displayed. Select <View>, <Noise>, and either <Swept Frequency> or <Swept Bias>. Select and open a file. The <Memory> option will be available only if data was previously entered into memory by either measurement or read from a file. The display will be identical to those described in Sections 10.2.2 and 10.3.2 and can be manipulated as described in those sections.

10.8 Displaying Noise Calibration Data

The noise calibration data may be recalled and displayed for review. Select <View>, <Noise>, <Cal Data> from the Block Diagram view menu. The display format is the same as the swept noise display and operates in the same manner (see Section 10.2.2).

11
DC I-V Curve Measurement

11.1 General

DC characterization of RF/Microwave devices is often desirable, and the Automatic Tuner System already has the automatic bias control capability to do this. Therefore, no additional equipment is needed.

A second benefit of using the **ATS** system for DC characterization is that the devices can be properly terminated at the RF frequencies while the DC test is done. Some devices may oscillate and/or self-destruct on standard DC test stations which do not provide RF terminations.

11.2 Measurement Parameters

A DC I-V curve measurement consists of sweeping the device output voltage, and measuring the device output current. This is usually repeated for a range of input bias settings, creating a family of curves. The input bias parameter may be voltage or current.

An important consideration is the maximum DC dissipation capability of the device. The actual dissipation is the product of V_out and I_out, and if this is too high, the device may be damaged or destroyed. Therefore, at input bias settings which allow high output currents, the V_out sweep may need to truncate in order to protect the device.

11.3 Making the DC I-V Measurement

To start the DC measurements, select <Measure> from the Block Diagram view, then <DC I-V>. This will bring up the DC-IV Curve Measurement dialog.

Enter the start, stop, and step size for the output voltage. Also, enter the start, stop and step size for the input bias parameter. Finally, enter the maximum safe power dissipation in Watts for the DUT.

Click <Details> to change the bias mode, input control type (voltage or current), and other bias setup values.

During the DC measurement, if the V-out* I_out product exceeds the maximum dissipation at any point during the output voltage sweep, the sweep will stop, and the measurement will move to the next input bias setting.

NOTE: *The Maximum DC dissipation should be conservative, or else use small steps in the output voltage sweep. The voltage sweep will not truncate due to excess dissipation until one point actually exceeds the specified dissipation. This is because it is not possible to know the limit will be exceeded until the point is measured.*

When the bias ranges are correct, click <OK> to start the measurement.

When prompted, enter a label and filename, or click <Cancel> to skip saving the data.

The measured DC I-V curve data will then be displayed. See section 11-4 for details on this.

11.4 DC I-V Curve Display

The DC I-V Curve Display can be accessed in three ways:

a. by selecting <View> from the block diagram view, then <DC I-V Curves>, and <File>. A File name will be selected and read into memory for the display.

b. by selecting <View> from the block diagram view, then <DC I-V Curves>, and <Memory>. The current DC data in memory will then be displayed. (If there is no DC data in memory, then the <Memory> option will be unavailable.)

c. The display will be entered automatically at the end of a measurement.

The Interactive DC I-V curve display plots a family of DC curves on a rectangular chart, as shown in figure 11-1. The independent (horizontal) axis is output voltage (V_out), and the dependent (vertical) axis is output current (I_out). The parameter which selects the individual curve is the input bias value.

Use the arrow keys to move left, right, up, or down between the various measured points, or point the mouse at a desired point and click the left button.

To change the vertical scale, move the mouse pointer to highlight the start or stop value, and click the left button. Then at the prompt, enter a new value. (The horizontal scale is set by the measured V_out range).

11.5 Saving Measured DC Data Files

At the end of each DC I-V curve measurement, a prompt to label the data will appear. If no label has been assigned to DC data in the session, the entry line will be blank. Enter a label and click <OK>, or click <Don't Change> to accept the current label (or to bypass this step if the entry line is blank. The next prompt will ask for a file name to save the data. Enter a file name and click <Save>, or click <Cancel> if the data is not to be saved yet. The data may also be saved later by selecting <File>, <Save As> from the DC I-V curve display.

The program will assign the extension to the data file. The extension can be changed; however, it is not recommended as it may be difficult to locate the file at a later time.

11.6 Recalling Measured DC Data Files

Previously measured DC Data can be read from a file into memory by selecting <View> <DC I-V Curves> and <File> from the block diagram view. This brings up the browser to select the desired file.

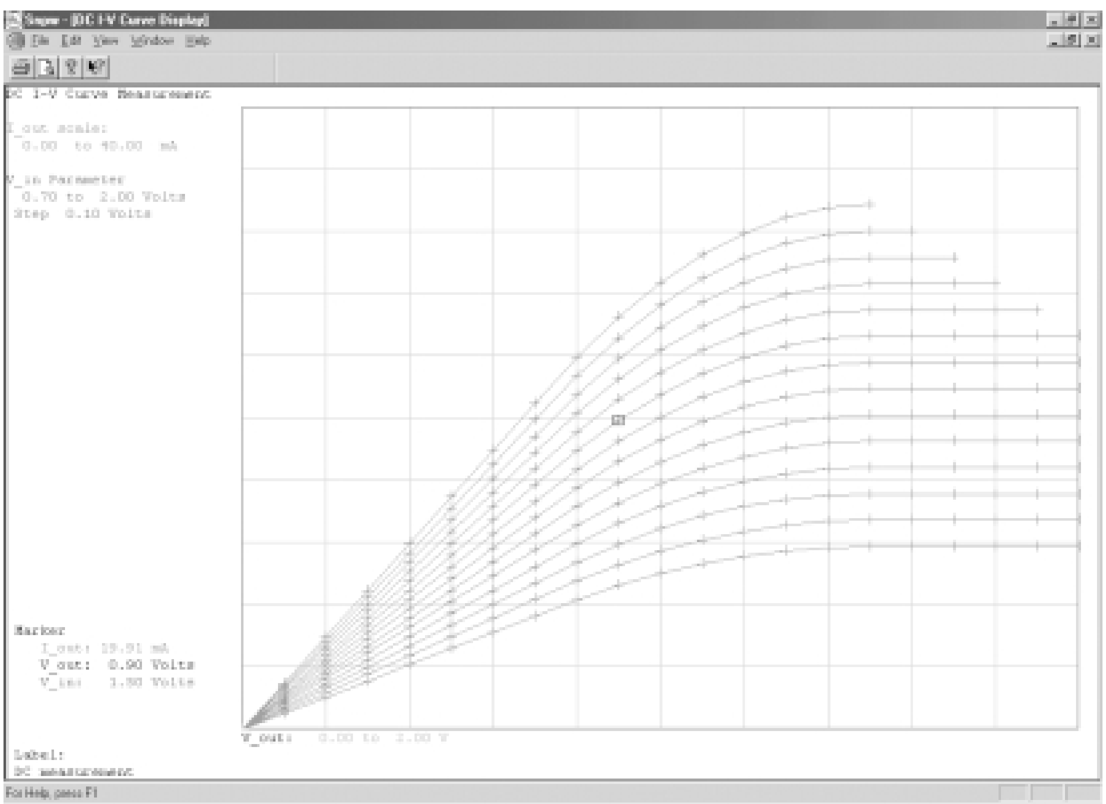


Figure 11-1. DC I-V Curve Display

12
Enhanced Graphics

12.1 Introduction

The Enhanced Graphics option, model MT993NO7, provides:

a. Surfer, a third party graphics software package,

b. An interface to format swept data and load it into the Surfer program for display on a rectangular graph, and

c. An interface to format contour data and load it into the Surfer program for display of 2-dimensional or 3-dimensional contours.

This allows users to customize their graphical displays.

Access to this enhanced graphical display is from the <View> menu of either the swept plot view or the contour view. This produces a seamless and simple interface, with no issues related to file formats or data selection.

12.2 Surfer Rectangular Graphical Display

To use the Surfer Rectangular display, select <View><View Surfer> from the swept display to bring up the dialog shown in Figure 12-1.

Up to five parameters may be selected by clicking on the <Select Parameters> button. The scales for all selected parameters may then be entered manually or auto-selected. The location of the scale for each parameter may also be selected to be either on the left or the right side of the graph.

The scale for the independent axis may also be entered manually or auto-selected.

When the parameters are selected and the scales specified, click <View Graphic> to bring up the display in Figure 12-2. This will be in the Surfer program, and may be manipulated with the full power of that software.

Refer to the software manual for the Surfer program for instructions on manipulating the display.

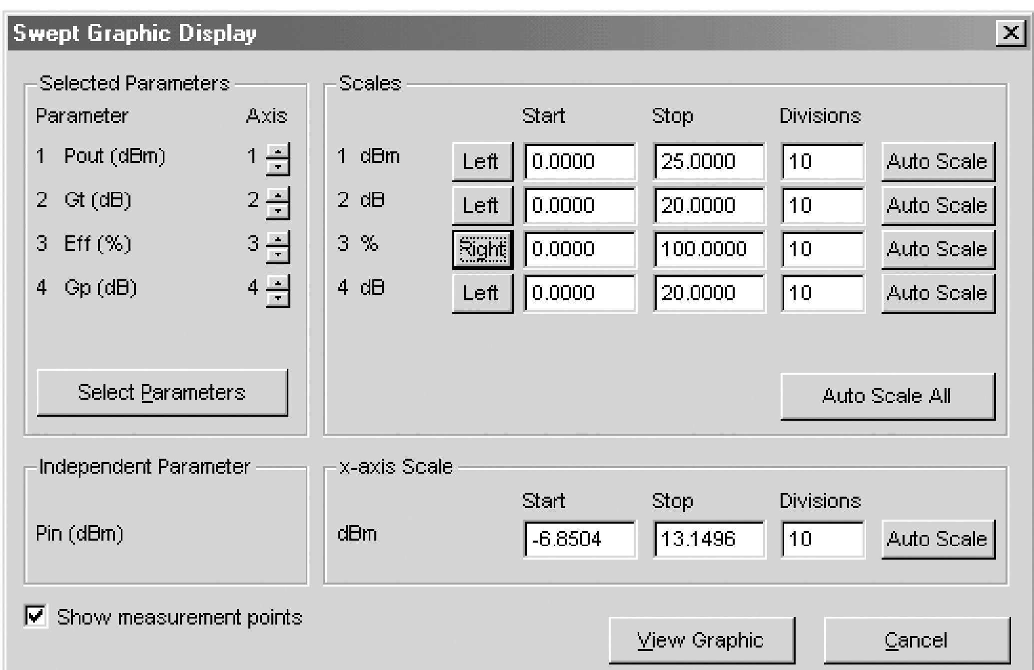


Figure 12-1 Surfer Rectangular Display Dialog

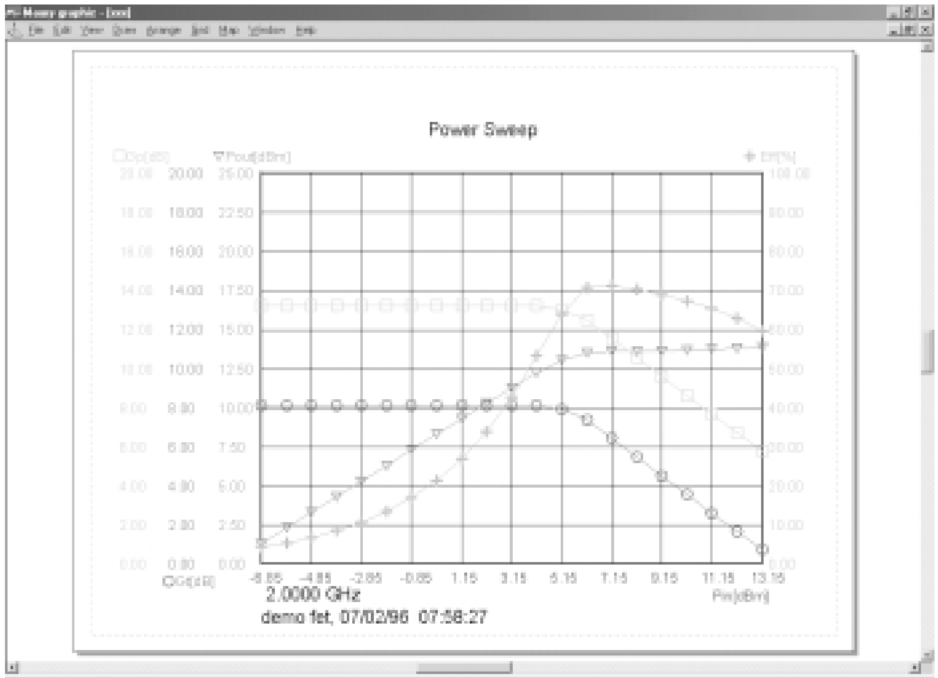


Figure 12-2 Surfer Rectangular Display

12.3 Surfer Contour Graphical Display

To use the Surfer contour display, select <View><View Surfer> from the contour display to bring up the dialog shown in Figure 12-3.

Select either the 2D or 3D display. If the 2D display is choosen, then up to three parameters may be selected by clicking on the <Select Parameter> button. If the 3D display is selected, then only one parameter may be selected.

Click on the <Options> button to select the chart type, line colors and thickness, scales, and other options, as shown in Figure 12-4. The other options are:

Reflection Format:
Mag/Phase is reflection Coefficient, Ohms is impedance.

Show impedance points:
Check to include the measured impedance points with the contours.

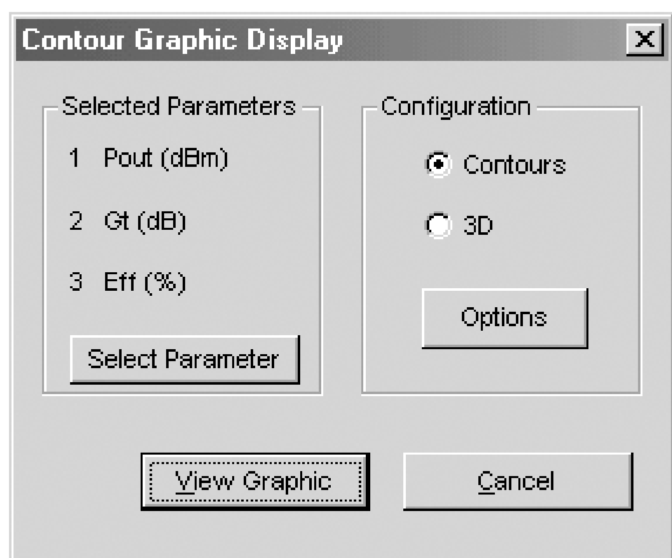


Figure 12-3 Surfer Contour Dialog

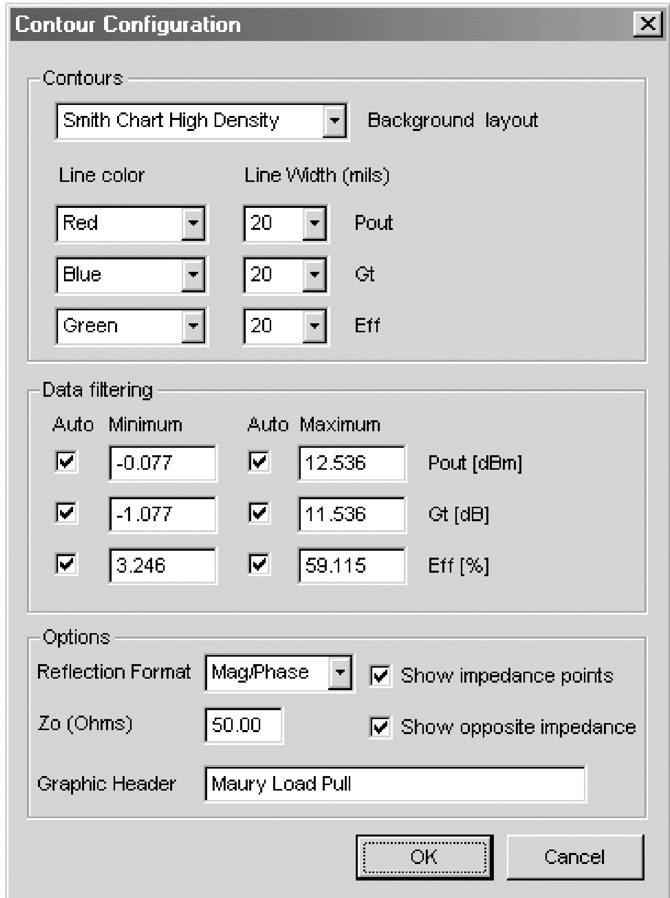


Figure 12-4 Surfer Contour Options Dialog

Z0:
The reference impedance at the center of the Smith chart.

Show the opposite impedance:
Check to display the source impedance with load pull data, and vice versa.

Graphic Header:
This will be a title in the display.

When the parameters are selected and the options specified, click on <View Graphic> to bring up the 2D contour display in Figure 12-5 or the 3D contour display in Figure 12-6. This will be in the Surfer program, and may be manipulated with the full power of the software.

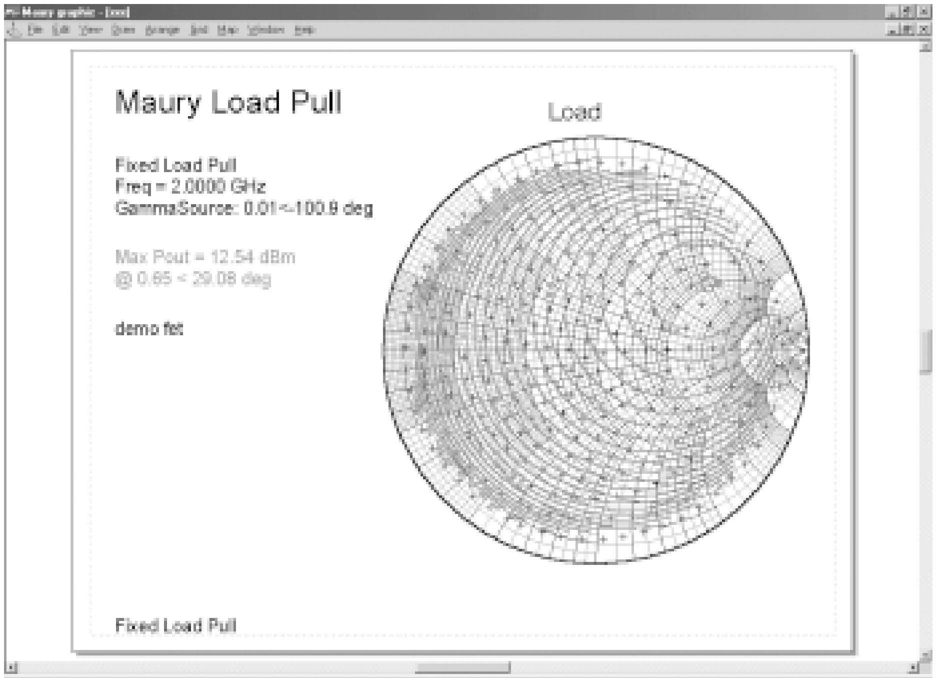


Figure 12-5 Surfer 2D Contour Display

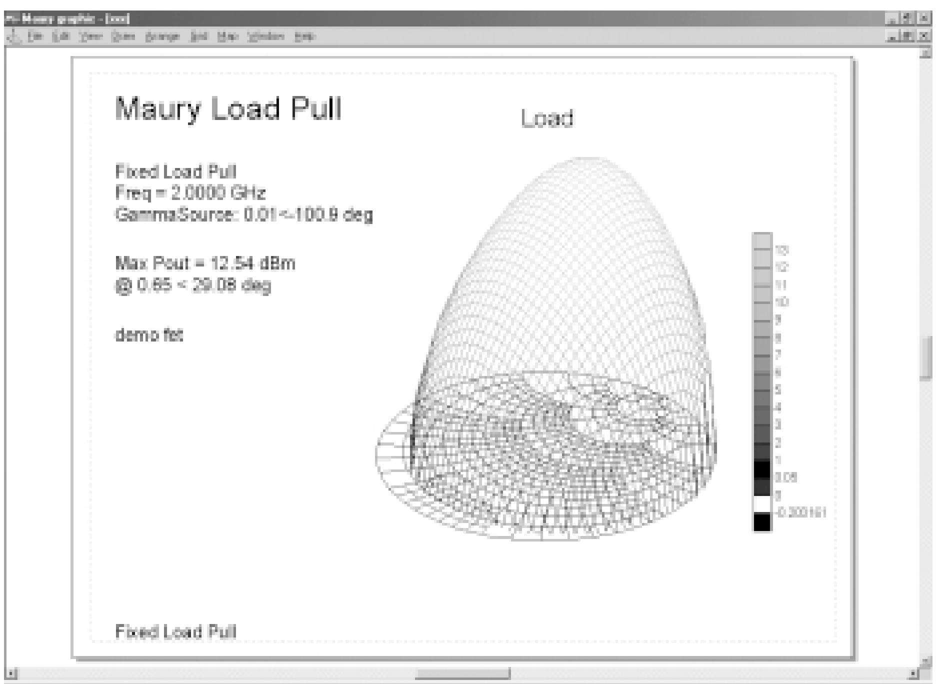


Figure 12-6 Surfer 3D Contour Display

13
Software Feedback

Software development at Maury Microwave is an ongoing process and we are very interested in feedback from our users. As we make improvements and release new versions, our intent is to make the system work better in your applications.

As you use your software, please write down any comments or suggestions about software changes which could solve your problems or make your job easier. User feedback has high priority and influence as we consider what improvements to make.

For your convenience, you can use copies of the Software Feedback Form, Table 13-1, to record your comments. Please address them to:

Software Support Manager
Maury Microwave Corporation
2900 Inland Empire Blvd.
Ontario, CA 91764
USA

Fax Number: (909) 987-1112
E-mail: ats@maury mw.com

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Software Feedback Form

Date:

Please use this form to provide your comments concerning your present Maury ATS and inputs for future releases.

Direct your input to:

Maury Microwave Corporation
Attention - Software Support Manager
2900 Inland Empire Blvd.
Ontario, CA 91764
Fax : (909) 987-1112
E-mail: ats@maurymw.com

Name/Company: ______________________ Phone/Fax/E-mail: __________ Key No: ______

Present ATS Application

Software: ______________________ Model No: __________ Rev No. Software Date: __________

Comments/Inputs: ....

Support Equipment:
Please provide Model No. & driver used for current support equipment or equipment for which support is desired.

Network Analyzers:

RF Sources:

Noise Instruments:

Power Meters:

Power Supplies:

Computer (type, memory, graphics card, GPIB board, etc.): __________

Other: __________

For Engineering Use..
Log#..

Table 13-1. Software Feedback

Appendix 1

Running the SNPW Program in Demo Mode

A1.1 General

This appendix will describe a step by step procedure to run the SNPW program in demonstration mode, making use of the sample files which are included. This will help a new user to quickly learn how to use the software, and to see the various measurement sequences and modes. This understanding will later help in setting up the system for doing actual measurements.

The demo mode uses a built-in system model to generate simulated data, which is generally good enough to give a feel for the program operation. No real instruments are used, so this can be done as soon as the software is installed on the computer. This appendix assumes that the SNPW program is already installed on the hard disk.

The conventions used in this appendix are as follows:

a. Items enclosed by angle brackets indicate either a key on the keyboard or a menu item. **<ESC>** is an example of a key, and <Calibrate> is an example of a menu item.
b. "Press" means to type the indicated key.
c. "Enter" means to type in the indicated response, and then press **<ENTER>**.
d. "Select" refers to selecting a menu item. In most menus, do this by pressing the left mouse button. In graphical screens, point the mouse to highlight the menu item, and then double click the left mouse button.

A1.2 Program Startup

To start the program:

Start -> Programs -> Maury Automated Measurements -> SNPW

After the SNPW program starts, look at the caption, and make sure that the filename Demo.cfg is in the brackets. This is a configuration file which sets the demo mode and sets up the various demo files as the defaults. The Block Diagram view menu will then appear, and you are ready to begin.

To open the right configuration file, select <File><Open>, and then browse for the file Demo.cfg.

At this point, the power block diagram will be displayed. To switch to the noise or s-parameter block diagram, select the desired choice from the top of the <Setup> menu.

A1.3 Calibration

The first step is to calibrate the system, so select <Calibrate> to pull down the Calibration menu.

A1.3.1 Noise Calibration

To calibrate for noise, follow this procedure:

a. Select <Calibrate><Noise> from the Block Diagram view menu.
b. Select <New Cal> to start a new calibration.
c. Press **<OK>** to accept the default conditions.
d. When prompted to connect the thru in demo mode, simply press **<OK>**.
e. When the calibration is complete, you will be prompted to enter a label. Either type in a label and click **<OK>**, or click <Don't Change> to leave it as it is (even if its blank).
f. Next, you will be prompted for a file name to save the calibration. That isn't important in the demo mode, so press <Cancel> to avoid saving the cal file.
g. The system then goes into display mode. Press **<ESC>** to exit the display mode and return to the Block Diagram view.

A1.3.2 Power Calibration

To calibrate for power, follow this procedure:

a. Select <Calibrate><Power> from the Block Diagram view menu.
b. Select <New Cal> to start a new calibration.
c. Press **<OK>** to accept the default conditions.
d. When prompted to connect the thru in demo mode, simply press **<OK>**.
e. When prompted to connect the output sensor to the power reference, press **<SKIP>** to skip the sensor calibration. It isn't needed in the demo mode.
f. If prompted to initialize the tuners, simply press **<NO>** to skip the re-initialization.
g. When the calibration is complete, you will be prompted to enter a label. Either type in a label and click **<OK>**, or click <Don't Change> to leave it as it is (even if its blank).
h. Next, you will be prompted for a file name to save the calibration. That isn't important in the demo mode, so press **<Cancel>** to avoid saving the cal file.
i. The system then goes into display mode. Press **<ESC>** to exit the display mode.

A1.3.3 Intermod Calibration

To calibrate for intermod, follow this procedure:

The Intermod calibration sequence is identical to power calibration. The difference is that with real measurements, an Intermod calibration will be done with two RF sources turned on, while the power calibration is done with only one RF source.

To do an Intermod calibration in demo mode, follow the instructions in Section A1.3.2, except start by selecting <Calibrate> <Intermod> from the Block Diagram view.

A1.3.4 ACP Calibration

The ACP calibration sequence is identical to power calibration. The difference is that with real measurements, an ACP calibration will be done with the selected modulation turned on, while the power calibration is done with NO modulation.

To do an ACP calibration in demo mode, follow the instructions in section A1.3.2, except start by selecting <Calibrate><ACP> from the Block Diagram View menu.

A1.4 Measurement

Select <Measure> from the Block Diagram view menu to pull down the Measurement menu.

A1.4.1 Swept Frequency Noise Measurements

To do a swept frequency noise measurement, do a noise calibration, then follow this procedure:

a. Select <Measure><Noise> from the Block Diagram view menu.
b. Select <Sweep Freq> from the Noise Measurement menu.
c. Press **<OK>** to accept the default conditions.
d. At the prompt for the DUT S-parameter file, select FETD.S2P.
e. The noise measurement will start, with the data plotted progressively in the rectangular chart at the top of the screen, and tabulated in the lower window.
f. When the measurement is complete, you will be prompted to enter a label. Either type in a label and click **<OK>**, or click <Don't Change> to leave it as it is (even if its blank).
g. Next, at the prompt for a file name to save the data, press **<Cancel>** to avoid saving the data.
h. The Swept Noise Display will then appear. When finished looking at the data, press **<ESC>** to exit the display mode.

A1.4.2 Swept Bias Noise Measurements

To do a swept bias noise measurement, do a noise calibration, then follow this procedure:

a. Select <Measure><Noise> from the Block Diagram view menu.
b. Select <Sweep Bias> from the Noise Measurement menu.
c. Choose a frequency in GHz from the available calibrated frequencies and enter bias values.
d. At the prompt for the device S-parameter vs. bias file select FETD.S2B.
e. The noise measurement vs. bias will start, with the data plotted progressively in the rectangular chart at the top of the screen, and tabulated in the lower window.
f. When the measurement is complete, you will be prompted to enter a label. Either type in a label and click **<OK>**, or click <Don't Change> to leave it as it is (even if its blank).
g. Next, at the prompt for a file name to save the data, press **<Cancel>** to avoid saving the data.
h. The Swept Noise Display will then appear. When finished looking at the data, press **<ESC>** to exit the display mode.

NOTE: *The demo device model does not include any noise parameter dependence on bias. Therefore, the swept bias data will be flat.*

A1.4.3 Interactive Noise Measurement

To do an interactive noise measurement at one frequency, do a noise calibration, then follow this procedure:

a. Select <Measure><Noise> from the SNPW menu.
b. Select <Interactive> from the Noise Measurement menu.
c. Choose a frequency from the list, and keep the default bias values.
d. Press <Read S-Parameter File> and then select FETD.S2P. Press **<OK>** to exit the s-parameter display, and return to the main startup dialog. Then press **<OK>** to bring up the measurement control screen.
e. In the Noise Interactive Measurement Control screen, select <Setup><Auto Select> to select points with the automatic algorithm.
f. Then select <Measure><Measure Noise Parameters> to make a measurement. The noise parameter solution will be displayed near the bottom of the screen.
g. The Noise Interactive Measurement Control provides a lot of interactive control. See Section 10 for more details.

A1.4.4 Power Measurement

To do a power measurement, do a power calibration, then follow this procedure:

a. Select <Measure><Power> from the Block Diagram view menu.
b. Choose a frequency from the list, and keep the default bias values.
c. Click **<OK>** to bring up the power measurement control screen.
d. From the Power Measurement Screen, use the menu to select measurement parameters, change frequency, set input power, or set the system to local mode. Left click on a Smith chart to toggle individual points. Right click on a Smith chart to get a popup menu to select blocks of points to be used during measurement, zoom in on a portion of the Smith chart, or to set the source and load measurement cursor position.

Eight types of measurements can be made: a single power measurement, a swept power measurement, a bias sweep, a load pull, a source pull, a VSWR circle, an optimum search, or a sweep plan.

When a measurement is done, you will be prompted to enter a label and then a file name for most of the measurement types. In that case, enter a label, but click <Cancel> to skip saving the data. The interactive data display will appear. If all of the setup parameters (including bias) are turned on, up to 49 data items may be displayed (not all at once). After a single power measurement, the scroll bar is used to scroll the data display (Up/Down).

When finished looking at the display, press **<ESC>** to exit the display. This will bring up the Power Measurement Screen again.

A1.4.5 Harmonic Tuning Measurement

Power measurement at harmonic frequencies requires multiple tuners to control each harmonic load impedance. To do harmonic power measurements, follow this procedure:

a. Select <Setup><Instruments> from the Block Diagram view menu.
b. Click <Controller 3>.
c. Select <Model Number:>, to view the available tuner controllers.
d. Select <MT986B02> and click **<OK>**.
e. Complete the power calibration procedure in Section A1.3.2.
f. Select <Power> from the <Measure> menu.
g. Choose a frequency from the list.
h. Click **<OK>** to bring up the power measurement control screen.
i. From the Power Measurement Screen menu, select <View><Tuners>. Select <Source2 Tuner> and <Load2 Tuner> to view the harmonic load impedances.
j. From the Power measurement screen, make the power measurements in the same way as described in section A1.4.4. If a load or source pull is selected, a dialog will come up to select which tuner (fundamental or harmonic) will be pulled. The same displays will be used.

☞ ***NOTE:*** *The demo device model does not include any harmonic data. Therefore, no load pull contours will be generated.*

A1.4.6 Intermod Measurement

The Intermod measurement is identical to the power measurement, except that the Intermod parameters are added, and all data is taken with the two RF tones turned on.

To do an Intermod measurement in demo mode, follow the instructions in Section A1.4.4, except start by selecting <Measure><Intermod> from the Block Diagram view menu.

A1.4.7 ACP Measurement

The ACP measurement is identical to the power measurement, except that the ACP parameters are added, and all data is taken with the selected modulation turned on.

To do an ACP measurement in demo mode, follow the instructions in Section A1.4.4, except start by selecting <Measure><ACP> from the Block Diagram view menu.

A1.4.8 DC I-V Curve Measurement

To do an DC I-V curve measurement, follow this procedure:

a. Select <Measure><DC I-V> from the SNPW menu.
b. Press **<OK>** to accept the default range of bias values.
c. The DC measurements will begin, and the family of curves will be progressively plotted.
d. When the measurement is complete, you will be prompted to enter a label. Either type in a label and click <OK>, or click <Don't Change> to leave it as it is (even if its blank).
e. Next, at the prompt for a file name to save the data, press **<Cancel>** to avoid saving the data.
f. The DC I-V Curve Display will then come up. Use the up/down/right/left arrow keys to move the marker, or move the mouse pointer to a desired marker position and click the left mouse button.

A1.5 Display

Previously measured data can be displayed at any time from the display menu. From the Block

Diagram menu, select <View>. Then select <S-Parameters>, <Noise>, <Power>, or <DC I-V Curves>.

After the type of data display is selected comes a choice of <Memory> or <File>. <Memory> will display data already in memory, but is only available if a measurement was previously done or a file was previously read in. <File> will prompt for a file name to read into memory before displaying it.

The displays are the same routines which are used at the end of a measurement. The sample data files which are provided are all named FETD with an appropriate file extension for the type of file (FETD.S2P is a 2-port s-parameter file, for example).

A1.6 Changing the Setup

After you have gone thru the program using the factory default setup, and understand the calibration and measurement sequence, select <Setup> from the Block Diagram view menu. The Setup menu provides a variety of dialog boxes to modify the system options and defaults. Refer to Section 4.0 for setup information.

Appendix 2

Instrument Drivers Supplied

A2.1 General

The main SNPW program is designed to be independent of specific instruments. All control and data transfer from programmable instruments is done using software modules called instrument drivers. Different instruments within one category (such as the RF source category) can be selected by specifying a different driver. This selection is done from the Setup Instruments Editor (See Section 4.2).

The driver filenames must follow the Windows conventions to specify the complete path and file name. The supplied executable drivers are normally all installed into the \ATS\DRIVERS directory and all except the bias instruments (See Section A2.10) have .EXE as the file extension. Since the \ATS directory is always current while the program is running, the DRIVERS subdirectory and the driver file name without the extension is normally all that is needed to specify the driver file name.

The SNPW program uses nine categories of instruments. The sections which follow describe the supplied drivers for each of those categories. Each section begins with general comments about the instrument category, followed by setup information for each supported instrument within the category. The default GPIB address is given as a suggestion, but may be changed to accommodate system requirements.

A2.2 GPIB Board

The GPIB board provides communication to all of the instruments.

- Instrument Model: **National Instruments PCII board**
  Specified Model: PCII
  Driver: drivers\gpibw
  Default GPIB address: 0
  Timeout: 10 seconds

- Instrument Model: **National Instruments PCI-GPIB**
  Specified Model: PCI-GPIB
  Driver: driver\gpibw
  Default GPIB address: 0
  Timeout: 10 seconds

- Instrument Model: **National Instruments AT-GPIB/TNT**
  Specified Model: AT-GPIB/TNT
  Driver: drivers\gpibw
  Default GPIB address: 0
  Timeout: 10 seconds

- Instrument Model: **National Instruments PCMCIA GPIB card**
  Specified Model: PCMCIA
  Driver: drivers\gpibw
  Default GPIB address: 0
  Timeout: 10 seconds

- Instrument Model: **National Instruments PCMCIA GPIB card**
  Specified Model: PCMCIA-VER2
  Driver: drivers\gpibw
  Default GPIB address: 0
  Timeout: 10 seconds

A2.3 GPIB Board/Card Part Numbers (National Instruments)

PCI-GPIB (Plug and Play) 32-bit GPIB card for Windows 2000/XP #778032-01. For Windows® 98, use #777158-01

PCMCIA-GPIB card, #777156-02 for Windows® 98 or #778034-02 for Windows 2000/XP.

A2.4 Tuner Controller

The tuner controller provides the programmable interface to the Maury tuners.

- Instrument Model: **Maury MT986A01**
  Specified Model: MT986A01
  Driver: drivers\tun986
  Default GPIB address: 11
  Timeout: 10 seconds
- Instrument Model: **Maury MT986A02**
  Specified Model: MT986A02
  Driver: drivers\tun986
  Default GPIB address: 11
  Timeout: 10 seconds
- Instrument Model: **Maury MT986B01**
  Specified Model: MT986B01
  Driver: drivers\tun986
  Default GPIB address: 11
  Timeout: 10 seconds
- Instrument Model: **Maury MT986B02**
  Specified Model: MT986B02
  Driver: drivers\tun986
  Default GPIB address: 11
  Timeout: 10 seconds
- Instrument Model: **Maury MT986B21**
  Specified Model: MT986B21
  Driver: drivers\tun986
  Default GPIB address: 11
  Timeout: 10 seconds
- Instrument Model: **Maury MT986B22**
  Specified Model: MT986B22
  Driver: drivers\tun986
  Default GPIB address: 11
  Timeout: 10 seconds
- Instrument Model: **Maury MT986B24**
  Specified Model: MT986B24
  Driver: drivers\tun986
  Default GPIB address: 11
  Timeout: 10 seconds
- Instrument Model: **Maury MT986B26**
  Specified Model: MT986B26
  Driver: drivers\tun986
  Default GPIB address: 11
  Timeout: 10 seconds

A2.5 Vector Network Analyzer

The network analyzer is used for tuner characterization, reflection coefficient measurement of the noise source and power sensor, and 2-port s-parameter measurement of the THRU, DUT, and possibly fixture halves.

Once the required s-parameters are measured and saved in files, the network analyzer is not needed for either noise or power measurements.

☞ ***NOTE:*** *The timeout required for the network analyzer depends on the sweep time. If many frequencies and averages are used, the timeout may need to be increased.*

- Instrument Model: **Rohde & Schwarz ZVx**
  Specified Model: RS_ZVR
  Driver: drivers\vna_Zux
  Default GPIB address: 16
  Timeout: 30 seconds
- * Instrument Model: **Agilent E8356A**
  Specified Model: E8356A
  Driver: drivers\vna835xx.exe
  Default GPIB address: 16
  Timeout: 30 seconds
- Instrument Model: **Agilent E8357A**
  Specified Model: E8357A
  Driver: drivers\vna835xx.exe
  Default GPIB address: 16
  Timeout: 30 seconds
- Instrument Model: **Agilent E8358A**
  Specified Model: E8358A
  Driver: drivers\vna835xx.exe
  Default GPIB address: 16
  Timeout: 30 seconds
- Instrument Model: **Agilent E8364A**
  Specified Model: E8364A
  Driver: drivers\vna835xx.exe
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Agilent 8510A**
  Specified Model: HP8510A
  Driver: drivers\vna8510
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Agilent 8510B**
  Specified Model: HP8510B
  Driver: drivers\vna8510
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Agilent 8510C**
  Specified Model: HP8510C
  Driver: drivers\vna8510
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Agilent 8719**
  Specified Model: HP8719
  Driver: drivers\vna8720
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Agilent 8720C**
  Specified Model: HP8720C
  Driver: drivers\vna8720
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Agilent 8720D**
  Specified Model: HP8720D
  Driver: drivers\vna8720D
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Agilent 8720E**
  Specified Model: HP8720E
  Driver: drivers\vna8720E
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Agilent 8722D**
  Specified Model: HP8722D
  Driver: drivers\vna8720D
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Agilent 8753C**
  Specified Model: HP8753C
  Driver: drivers\vna8753
  Default GPIB address: 16
  Timeout: 30 seconds

☞ ***NOTE:*** *The HP8753C must have firmware revision 4.12 or later.*

- Instrument Model: **Agilent 8753D**
  Specified Model: HP8753D
  Driver: drivers\vna8753D
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Agilent 8753E**
  Specified Model: HP8753E
  Driver: drivers\vna8753E
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Anritsu 360**
  Specified Model: W360
  Driver: drivers\vna360
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Anritsu MS4622B**
  Specified Model: MS4672B
  Driver: driver\vna462xx.exe
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Anritsu MS4623B**
  Specified Model: MS4623B
  Driver: drivers\vna462xx.exe
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Anritsu 37200 Series**
  Specified Model: W37200
  Driver: drivers\vna37200
  Default GPIB address: 16
  Timeout: 30 seconds

- Instrument Model: **Anritsu 37300 Series**
  Specified Model: W37300
  Driver: drivers\vna37200
  Default GPIB address: 16
  Timeout: 30 seconds

A2.6 Noise Figure Meter

The noise figure meter makes the measurements from which the device noise parameters are determined. It is used for the power measurement applications.

- Instrument Model: **Maury MT2075B or MT2075B05**
  Specified Model: MT2075B
  Driver: drivers\nfm2075
  Default GPIB address: 8
  Timeout: 30 seconds

- Instrument Model: **Maury MT2075C or MT2075C05 or MT2075C06**
  Specified Model: MT2075C
  Driver: drivers\nfm2075
  Default GPIB address: 8
  Timeout: 30 seconds

- Instrument Model: **Eaton 2075B**
  Specified Model: MT2075B
  Driver: drivers\nfm2075
  Default GPIB address: 8
  Timeout: 30 seconds

☞ ***NOTE:*** Firmware Revision 3.0 is required.

- Instrument Model: **Agilent 8970A**
  Specified Model: HP8970A
  Driver: driver\nfm8970
  Default GPIB address: 8
  Timeout: 10 seconds

☞ ***NOTE:*** *This routine is reported to work with an HP8970A. However, it is not tested or guaranteed by Maury Microwave. Also, it is known that not all HP870As respond the same, especially in timing. This driver may need modification to work with a specific HP8970A.*

- Instrument Model: **Agilent 8970B**
  Specified Model: HP8970B
  Driver: driver\nfm8970
  Default GPIB address: 8
  Timeout: 10 seconds

☞ ***NOTE:*** *The HP8970 driver includes control of the HP8971B/C test set. See Section A2.7*

- Instrument Model: **Agilent NFA8973A**
  Specified Model: N8973A
  Driver: drivers\nfm897x.exe
  Default GPIB address: 8
  Timeout: 10 seconds

- Instrument Model: **Agilent NFA8974A**
  Specified Model: N8974A
  Driver: drivers\nfm897x.exe
  Default GPIB address: 8
  Timeout: 10 seconds

- Instrument Model: **Agilent NFA8975A**
  Specified Model: N8975A
  Driver: drivers\nfm897x.exe
  Default GPIB address: 8
  Timeout: 10 seconds

A2.7 Noise Test Set

The Agilent noise test sets (8971B & 8971C) can only be used with the HP8970B noise figure meter, and must be connected to the SIB connector. If a test set is connected, it will be detected automatically. Also, if a test set is used, the local oscillator source must also be connected to the HP8970B SIB to allow fine tuning of the test set to be done. The N8975AK40 test set may only be used with the N8975A noise figure analyzer.

- Instrument Model: **Agilent 8971B**
  Specified Model: HP8971B
  Driver: none
  Default GPIB address: 9
  Timeout: 10 seconds

- Instrument Model: **Agilent 8971C**
  Specified Model: HP8971C
  Driver: none
  Default GPIB address: 9
  Timeout: 10 seconds

- Instrument Model: **Agilent N8975AK40**
  Specified Model: N8975AK40
  Driver: drivers\nfm897x.exe
  Default GPIB address: 8
  Timeout: 10 seconds

☞ ***NOTE:*** *This test set does not require an external L. O.*

A2.8 RF Source (for Local Oscillator or Power Source)

An RF source is required for power characterization of amplifiers, and for noise characterization if down conversion is required external of the noise figure meter.

Even if the same source is used for both measurements in one setup, they must be specified separately.

☞ ***NOTE:*** *Some sources turn power on when preset. If possible, set source plug-in, etc. so the preset leaves RF power off. If the preset for a particular source can not be set for a power off preset, choose a different source for high power system. Also, a low phase noise type must be used as an L. O.*

- Instrument Model: **Anritsu MG3633A**
  Specified Model: A3633
  Driver: drivers\src3633
  Default GPIB address: 19
  Timeout: 10 seconds
- Instrument Model: **Anritsu MG3660A**
  Specified Model: A3660A
  Driver: drivers\src3660
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Anritsu MG3670B**
  Specified Model: A3670B
  Driver: drivers\src3670
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Anritsu MG3671A**
  Specified Model: A3671A
  Driver: drivers\src3670
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Fluke 6060B**
  Specified Model: F6060B
  Driver: drivers\src6060
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Fluke 6062A**
  Specified Model: F6062A
  Driver: drivers\src6060
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Gigatronics 1026**
  Specified Model: G1026
  Driver: drivers\src1026
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Gigatronics 12000A Series**
  Specified Model: G12508A/708A
  Driver: drivers\src12000.exe
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Gigatronics 12000A Series**
  Specified Model: G12528A/728A
  Driver: drivers\src12000.exe
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Gigatronics 12000A Series**
  Specified Model: G12520A/720A
  Driver: drivers\src12000.exe
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Gigatronics 12000A Series**
  Specified Model: G12522A/722A
  Driver: drivers\src12000.exe
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Gigatronics GT9000**
  Specified Model: GT9000
  Driver: drivers\src8340
  Default GPIB address: 17
  Timeout: 10 seconds

☞ ***NOTE:*** *Must be set to emulate 8340.*

- Instrument Model: **Agilent 8340A**
  Specified Model: HP8340A
  Driver: drivers\src8340 or drivers\src8340r
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *src8340r ramps the power level up or down instead of setting it suddenly. This is slower, but can prevent power surges in some systems using a TWT amplifier.*

- Instrument Model: **Agilent 8340B**
  Specified Model: HP8340B
  Driver: drivers\src8340 or drivers\src8340r
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *src8340r ramps the power level up or down instead of setting it suddenly. This is slower, but can prevent power surges in some systems using a TWT amplifier.*

- Instrument Model: **Agilent 8341B**
  Specified Model: HP8341B
  Driver: drivers\src8340 or drivers\src8340r
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *src8340r ramps the power level up or down instead of setting it suddenly. This is slower, but can prevent power surges in some systems using a TWT amplifier.*

- Instrument Model: **Agilent 8340,60 Series and Gigatronics 9000**
  Specified Model: HP8340
  Driver: drivers\src8340_atten.
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *The driver requires a step attenuator controlled by an HP11713. The HP11713 should be specified in User Instrument 1.*

- Instrument Model: **Agilent 8340, 60 Series and Gigatronics GT9000**
  Specified Model: HP8340 or another in series
  Driver: drivers\src8340_wtripler.c
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *The driver will only work when connected to external tripler.*

- Instrument Model: **Agilent 8350 Series**
  Specified Model: HP8350A or HP8350B
  Driver: drivers\src8350 or drivers\src8350r
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *This driver has been tested using an HP8350A with an HP83592A plug-in.The src8350r ramps the power level up instead of setting it suddenly. This is slower, but can prevent power surges in some systems using a TWT amplifier.*

- Instrument Model: **Agilent 8360 Series**
  Specified Model: HP8360
  Driver: drivers\src8340 or drivers\src8340r
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *src8340r ramps the power level up or down instead of setting it suddenly. This is slower, but can prevent power surges in some systems using a TWT amplifier.*

- Instrument Model: **Agilent 8642A**
  Specified Model: HP8642A
  Driver: drivers\src8642
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 8642B**
  Specified Model: HP8642B
  Driver: drivers\src8642
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 8644B**
  Specified Model: HP8644B
  Driver: drivers\src8644
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 8648C**
  Specified Model: HP8648C
  Driver: drivers\src8648
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 8657A**
  Specified Model: HP8657A
  Driver: drivers\src8657
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 8657B**
  Specified Model: HP8657B
  Driver: drivers\src8657
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 8664A**
  Specified Model: HP8664A
  Driver: drivers\src866X
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 8665A**
  Specified Model: HP8665A
  Driver: drivers\src866X
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 8665B**
  Specified Model: HP8665B
  Driver: drivers\src866X
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 8672A**
  Specified Model: HP8672A
  Driver: drivers\src8672
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 8673G**
  Specified Model: HP8673G
  Driver: drivers\src8673
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 83711**
  Specified Model: HP83711
  Driver: drivers\src83700
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 83712**
  Specified Model: HP83712
  Driver: drivers\src83700
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 83731**
  Specified Model: HP83731
  Driver: drivers\src83700
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 83732**
  Specified Model: HP83731
  Driver: drivers\src83700
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 83752**
  Specified Model: HP83752
  Driver: drovers\src83752
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent 89441A**
  Specified Model: HP89441A
  Driver: drivers\src89441
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *This driver requires a radio test personality card.*

☞ ***NOTE:*** *Does not currently support CDMA.*

- Instrument Model: **Agilent PSG Series**
  Specified Model: G8241A
  Driver: drivers\srce82xxa
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent PSG Series**
  Specified Model: E8244A
  Driver: drivers\ srce82xxa
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent PSG Series**
  Specified Model: E8251A
  Driver: drivers\srce82xxa
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent PSG Series**
  Specified Model: E8254A
  Driver: drivers\srce82xxa
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent ESG-4000A**
  Specified Model: HP_ESG
  Driver: drivers\srcesga
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *This driver requires a radio test personality card. Does not currently support CDMA.*

- Instrument Model: **Agilent ESG-4000D**
  Specified Model: HP_ESG
  Driver: drivers\srcesgd
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Agilent MCSS**
  Specified Model: HP_MCSS
  Driver: drivers\srcmcss
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *This driver modifies the MCSS control (.ini) file.*

- Instrument Model: **Marconi 2024**
  Specified Model: M2024
  Driver: drivers\src2024
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Marconi 2050**
  Specified Model: M2050
  Driver: drivers\src2050
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *This source is capable of digital modulation.*

- Instrument Model: **Marconi 6200 test set**
  Specified Model: M6200
  Driver: drivers\src6200S
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *Driver src 6200S puts the Marconi Test Set in source only mode. This driver will not work in conjunction with pm6200.*

- Instrument Model: **Marconi 6203 test set**
  Specified Model: M6203
  Driver: drivers/src6203S
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *Driver src 6203S puts the Marconi Test Set in source only mode. This driver will not work in conjunction with pm6203.*

- Instrument Model: **Marconi 6203 test set**
  Specified Model: M6203
  Driver: drivers\src6203T
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *Driver src6203T puts the Marconi Test Set in test set mode and allows the test set to be used both as a source and dual power measurement system. Use this mode in conjunction with pm6203.*

- Instrument Model: **Rohde & Schwarz SME**
  Specified Model: RS_SME
  Driver: drivers\src_sme
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *This source is capable of digital modulation.*

- Instrument Model: **Rohde & Schwarz SMHU**
  Specified Model: RS_SMHU
  Driver: drivers\src_smhu
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *This source is capable of digital modulation.*

- Instrument Model: **Rohde & Schwarz SMIQ**
  Specified Model: RS_SMIQ
  Driver: drivers\src_smiq
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *This source is capable of digital modulation.*

- Instrument Model: **Rohde & Schwarz SMS**
  Specified Model: RS_SMS
  Driver: drivers\src_sms
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Rohde & Schwarz SMT**
  Specified Model: RS_SMT
  Driver: drivers\src_smt
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Wavetek 2520**
  Specified Model: WT2520
  Driver: drivers\src2520
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Wavetek 2520A**
  Specified Model: WT2520A
  Driver: drivers\src2520
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Anritsu 6600B Series sweepers**
  Specified Model: W6600B
  Driver: drivers\src6600
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Anritsu 6600B Series sweepers**
  Specified Model: W6600B
  Driver: drivers\src6600r
  Default GPIB address: 19
  Timeout: 10 seconds

☞ ***NOTE:*** *This driver is a special ramping driver. All level requests greater than -4 dBm are started from -5 dBm and increments in 1 dB steps to the requested level (the final step may be less than 1 dB).*

- Instrument Model: **Anritsu 6700 Series synthesizers**
  Specified Model: W6700
  Driver: drivers\src6700
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Anritsu 68000A Series synthesizers**
  Specified Model: W68XXA
  Driver: drivers\src68_69
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Anritsu 69000A Series synthesizers**
  Specified Model: W69XXXA
  Driver: drivers\src68_69
  Default GPIB address: 19
  Timeout: 10 seconds

- Instrument Model: **Any manually controlled source**
  Specified Model: MANUAL
  Driver: drivers\src_man
  Default GPIB address: not used
  Timeout: not used

☞ ***NOTE:*** *With this selection, the user will be prompted to set the source frequency and set the power levels. The GPIB address and timeout are not used.*

A2.9 Power Meter (for Output, Input or Reflection)

An output power meter is required for power measurements, and an input power meter or reflection power meter are optional. An input power meter may be used to correct for RF source drift. If the reflection power meter is used, the power delivered to the DUT can be measured. If two separate instruments are used for two power meters, they must have different GPIB addresses. If a dual power meter is used, the model number is specified differently for each channel, but the GPIB address will be the same for both.

- Instrument Model: **Anritsu ML2407A**
  Specified Model: A2407
  Driver: drivers\fm2407
  Default GPIB address: 13
  Timeout: 10 seconds

- Instrument Model: **Anritsu ML2408A**
  Specified Model: A2408CHA
  Driver: drivers\pm2408
  Default GPIB address: 13
  Timeout: 10 seconds

- Instrument Model: **Anritsu ML2408A**
  Specified Model: A2408CHB
  Driver: drivers\pm2408
  Default GPIB address: 13
  Timeout: 10 seconds

- Instrument Model: **Anritsu ML2437A**
  Specified Model: A2437CHA
  Driver: drivers\pm2437A
  Default GPIB address: 13
  Timeout: 10 seconds

- Instrument Model: **Anritsu ML2437A**
  Specified Model: A2437CHB
  Driver: drivers\pm2437A
  Default GPIB address: 13
  Timeout: 10 seconds

- Instrument Model: **Anritsu ML2438A**
  Specified Model: A2438CHA
  Driver: drivers\pm2438
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Anritsu ML2438A**
  Specified Model: A2438CHB
  Driver: drivers\pm2438
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Boonton 4220**
  Specified Model: B4220
  Driver: drivers\pm4220
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Boonton 4230 using channel 1**
  Specified Model: B4230CH1
  Driver: drivers\pm4230
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Boonton 4230 using channel 2**
  Specified Model: B4230CH2
  Driver: drivers\pm4230
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Gigatronics 8502 using 8542C channel A**
  Specified Model: G8502CHA
  Driver: drivers\pm8502
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Gigatronics 8502 using channel B**
  Specified Model: G8502CHB
  Driver: drivers\pm8502
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Gigatronics 8541B using channel A**
  Specified Model: G8541CHA
  Driver: drivers\pm8541
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Gigatronics 8541B using channel B**
  Specified Model: G8541CHB
  Driver: drivers\pm8541
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Gigatronics 8542 using channel A**
  Specified Model: G8542CHA
  Driver: drivers\pm8542
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Gigatronics 8542 using channel B**
  Specified Model: G8542CHB
  Driver: drivers\pm8542
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Gigatronics 8542C using channel A**
  Specified Model: G8542CHA
  Driver: drivers\pm8542CO
  Default GPIB address: 13
  Timeout: 30 seconds

☞ ***NOTE:*** *This is a modified version of the standard pm8542 driver. This special power meter driver adjusts its displayed power using the values specified for loss in the power sensor file. Use only for output power display.*

- Instrument Model: **Gigatronics 8542C using channel B**
  Specified Model: G8542CHB
  Driver: drivers\pm8542CO
  Default GPIB address: 13
  Timeout: 30 seconds

☞ ***NOTE:*** *This is a modified version of the standard pm8542 driver. This special power meter driver adjusts its displayed power using the values specified for loss in the power sensor file. Use only for output power display.*

- Instrument Model: **Agilent 436A**
  Specified Model: HP436
  Driver: drivers\pm436
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Agilent 437B**
  Specified Model: HP437B
  Driver: drivers\pm437
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Agilent 437B using high sensitivity sensor**
  Specified Model: HP437B
  Driver: drivers\pm437_hs
  Default GPIB address: 13
  Timeout: 30 seconds

☞ ***NOTE:*** *This driver was verified with an HP8481D high sensitivity sensor. This driver could significantly speed up measurements when used to measure reflected power.*

- Instrument Model: **Agilent 438A**
  Specified Model: HP438CHA
  Driver: drivers\pm438
  Default GPIB address: 13
  Timeout: 10 seconds

- Instrument Model: **Agilent 438A**
  Specified Model: HP438CHB
  Driver: drivers\pm438
  Default GPIB address: 13
  Timeout: 10 seconds

- Instrument Model: **Agilent 438A using high sensitivity sensor on channel A**
  Specified Model: HP438CHA
  Driver: drivers\pm438_hs
  Default GPIB address: 13
  Timeout: 30 seconds

☞ ***NOTE:*** *This is a modified version of the standard pm438 driver. Channel A was modified for use of a high sensitivity sensor only. The driver was verified using an HP8481D sensor on Channel A. This driver could significantly speed up measurements when channel A is used to measure reflected power.*

- Instrument Model: **Agilent 438A using high sensitivity sensor on channel B**
  Specified Model: HP438CHB
  Driver: drivers\pm438_hs
  Default GPIB address: 13
  Timeout: 30 second

- Instrument Model: **Agilent 438A using high power sensor on channel A**
  Specified Model: HP438CHA
  Driver: drivers\pm438_hp
  Default GPIB address: 13
  Timeout: 30 seconds

☞ ***NOTE:*** *This is a modified version of the standard pm438 driver. This driver was modified for use of a high power sensor only. The driver was verified using an HP8484A sensor.*

- Instrument Model: **Agilent 438A**
  Specified Model: HP438CHB
  Driver: drivers\pm438_hp
  Default GPIB address: 13
  Timeout: 10 seconds

☞ ***NOTE:*** *This is a modified version of the standard pm438 driver. This driver was modified for use of a high power sensor only. The driver was verified using an HP8484A sensor.*

- Instrument Model: **Agilent 438A using channel A**
  Specified Model: HP438CHA
  Driver: drivers\pm438os
  Default GPIB address: 13
  Timeout: 30 seconds

☞ ***NOTE:*** *This is a modified version of the standard pm438 driver. This special power meter driver adjusts its displayed power using the values specified for loss in the power sensing file. Use only for output power display.*

- Instrument Model: **Agilent 438A using channel B**
  Specified Model: HP438CHB
  Driver: drivers\pm438os
  Default GPIB address: 13
  Timeout: 30 seconds

☞ ***NOTE:*** *This is a modified version of the standard pm438 driver. This special power meter driver adjusts its displayed power using the values specified for loss in the power sensing file. Use only for output power display.*

- Instrument Model: **Agilent EPM441A**
  Specified Model: HP441A
  Driver: drivers\pm441
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Agilent EPM-442A**
  Specified Model: HP442CHA
  Driver: drivers\pm442
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Agilent EPM-442A**
  Specified Model: HP442CHB
  Driver: drivers\pm442
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Agilent E4416A**
  Specified Model: E4416A
  Driver: drivers\pm4416
  Default GPIB address: 13
  Timeout: 30 seconds

☞ ***NOTE:*** *Use the "TEST" button to view how to set up the available modulation types.*

- Instrument Model: **Agilent E4417A**
  Specified Model: E4417AchA
  Driver: drivers\pm4417
  Default GPIB address: 13
  Timeout: 30 seconds

☞ ***NOTE:*** *Use the "TEST" button to view how to set up the available modulation types.*

- Instrument Model: **Agilent E4417A**
  Specified Model: E4417AchB
  Driver: drivers\pm4417
  Default GPIB address: 13
  Timeout: 30 seconds

☞ ***NOTE:*** *Use the "TEST" button to view how to set up the available modulation types.*

- Instrument Model: **Agilent E4418A**
  Specified Model: HP4418A
  Driver: drivers\pm4418
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Agilent E4418A**
  Specified Model: HP4418A
  Driver: drivers\pm4418os
  Default GPIB address: 13
  Timeout: 30 seconds

☞ ***NOTE:*** *This driver will show corrected power when used as output meter.*

- Instrument Model: **Agilent E4419A**
  Specified Model: HP4419CHA
  Driver: drivers\pm4419
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Agilent E4419A**
  Specified Model: HP4419CHB
  Driver: drivers\pm4419
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Agilent 5347A**
  Specified Model: HP5347A
  Driver: drivers\pm5347A
  Default GPIB address: 13
  Timeout: 30 seconds

- Instrument Model: **Marconi 6200 test set using Channel A**
  Specified Model: M62A
  Driver: drivers\pm6200
  Default GPIB address: 13
  Timeout: 30 seconds

☞ ***NOTE:*** *This driver requires a diode detector connected to channel A.*

- Instrument Model: **Marconi 6200 test set using channel D**
  Specified Model: M62D
  Driver: drivers\pm6200
  Default GPIB address: 13
  Timeout: 30

☞ ***NOTE:*** *This driver requires a power sensor connected to channel D.*

- Instrument Model: **Marconi 6203 test set using channel A**
  Specified Model: M62A
  Driver: drivers\pm6203
  Default GPIB address: See note below
  Timeout: 30 seconds

☞ ***NOTE:*** *The GPIB address must be the same as that set for src6203T. This driver requires a diode detector connected to channel A on the test set.*

- Instrument Model: **Marconi 6203 test set using channel D**
  Specified Model: M62D
  Driver: drivers\pm6203
  Default GPIB address: See note below
  Timeout: 30 seconds

☞ ***NOTE:*** *The GPIB address must be the same as that set for src6203T. This driver requires a power sensor connected to channel D on the test set.*

- Instrument Model: **Marconi 6960B**
  Specified Model: M6960B
  Driver: drivers\pm6960
  Default GPIB address: 13
  Timeout: 30 seconds

A2.10 Bias Supply

A bias supply can be as simple as a single bias supply or consist of a complex combination of a number of different instruments (input and output supplies, current and voltage meters). The program uses a single bias driver (drivers\bias.exe) that, in turn, calls the specified drivers from a library. The individual driver files for the bias system all have the file extension .dll.

The dlls are divided into three categories as follows: power supply, voltmeter, and current meter. If a voltmeter or current meter is not specified, the internal readback for the specified power supplies will be used. Many of the dlls support several different models of a manufacturer's series. Also, if the power supply selected has multiple outputs, the desired output is selected by setting the channel number for the particular output. If the supply has only a single output, the channel number is ignored. The user should search the list of models available and select the dll that includes the desired model. The user should type in the exact model if it isn't already in the drop down list. Currently, the model's selected when using the "TEST" button are not transferred back to the main program.

A2.10.1 Power Supply

- Manufacturer: **Advantest**
  Bias Supply Driver: ps_6143.dll
  Models Available: TR6143
- Manufacturer: **Agilent**
  Bias Supply Driver: ps3631.dll
  Models Available: E3631A
- Manufacturer: **Agilent**
  Bias Supply Driver: ps3632.dll
  Models Available: E3632A, E3633A
- Manufacturer: **Agilent**
  Bias Supply Driver: ps4142.dll
  Models Available: 4142B_41420, 4142B_41421
- Manufacturer: **Agilent**
  Bias Supply Driver: ps4156.dll
  Models Available: HP4156
- Manufacturer: **Agilent**
  Bias Supply Driver: ps4352.dll
  Models Available: HP4352B
- Manufacturer: **Agilent**
  Bias Supply Driver: ps6032.dll
  Models Available: HP6032A
- Manufacturer: **Agilent**
  Bias Supply Driver: ps6038.dll
  Models Available: HP6038A
- Manufacturer: **Agilent**
  Bias Supply Driver: ps661x.dll
  Models Available: HP6611C, HP6612C, HP6613C, HP6614C
- Manufacturer: **Agilent**
  Bias Supply Driver: ps662x.dll
  Models Available: HP6621A, HP6622A, HP6623A, HP6624A, HP6625A, HP6626A, HP6627A, HP6628A, HP6629A
- Manufacturer: **Agilent**
  Bias Supply Driver: ps663x.dll
  Models Available: HP6631A, HP6631B, HP6632A, HP6632B, HP6634A, HP6634B
- Manufacturer: **Agilent**
  Bias Supply Driver: ps664x.dll
  Models Available: HP6641A, HP6642A, HP6643A, HP6644A, HP6645A
- Manufacturer: **Agilent**
  Bias Supply Driver: ps665x.dll
  Models Available: HP6651A, HP6652A, HP6653A, HP6654A, HP6655A
- Manufacturer: **Agilent**
  Bias Supply Driver: ps667x.dll
  Models Available: HP6671A, HP6672A, HP6673A, HP6674A, HP6675A

- Manufacturer: **Agilent**
  Bias Supply Driver: ps668x.dll
  Models Available: HP6681A, HP6682A, HP6683A, HP6684A, HP6685A

- Manufacturer: **Any**
  Bias Supply Driver: ps_ent.dll
  Models Available: ENTRY

☞ ***NOTE:*** *This driver prompts for setting the bias manually and prompts for manual entry of readback.*

- Manufacturer: **Any**
  Bias Supply Driver: ps_man.dll
  Models Available: MANUAL

☞ ***NOTE:*** *This driver prompts for setting the bias manually and assumes all bias values are same as requested!*

- Manufacturer: **Keithly**
  Bias Supply Driver: ps228.dll
  Models Available: K228A

- Manufacturer: **Keithly**
  Bias Supply Driver: ps2304.dll
  Models Available: K2304A

- Manufacturer: **Keithly**
  Bias Supply Driver: ps236.dll
  Models Available: K236A, K238A

- Manufacturer: **Sorensen**
  Bias Supply Driver: ps_hpd60.dll
  Models Available: SR-HPD60-5

- Manufacturer: **Sorensen**
  Bias Supply Driver: ps_xt15.dll
  Models Available: SR-XT-15

A2.10.2 Voltmeter

These instruments may be used to monitor the DUT input and /or output DC voltage.

- Manufacturer: **Agilent**
  Voltmeter Driver: vm34401.dll
  Models Available: HP34401A

- Manufacturer: **Agilent**
  Voltmeter Driver: vm3478.dll
  Models Available: HP3478A

- Manufacturer: **John Fluke**
  Voltmeter Driver: vm8840.dll
  Models Available: Fluke8840A

A2.10.3 Current Meter

These instruments may be used to monitor the DUT input and /or output DC current.

- Manufacturer: **Advantest**
  Current Meter Driver: im6846.dll
  Models Available: TR6846A

- Manufacturer: **Agilent**
  Current Meter Driver: im34401.dll
  Models Available: HP34401A

- Manufacturer: **Agilent**
  Current Meter Driver: im3478.dll
  Models Available: HP3478A

- Manufacturer: **John Fluke**
  Current Meter Driver: im45.dll
  Models Available: Fluke45

- Manufacturer: **John Fluke**
  Current Meter Driver: im8840.dll
  Models Available: Fluke8840A

A2.11 Spectrum Analyzer

The spectrum analyzer is used in intermodulation distortion and ACP measurements. It may also be used to detect oscillations in noise measurements.

☞ ***NOTE:*** *The timeout required for the spectrum analyzer depends on the measurement configuration. For example, if a very small setting for resolution bandwidth is used, the timeout may need to be increased.*

- Instrument Model: **Anritsu MS2602A spectrum analyzer**
  Specified Model: A2602A
  Driver: drivers\sa2602
  Default GPIB address: 15
  Timeout: 10 seconds

- Instrument Model: **Agilent 4406A**
  Specified Model: E4406A
  Driver: drivers\sa4406
  Default GPIB address: 15
  Timeout: 10 seconds
- Instrument Model: **Agilent 4407B**
  Specified Model: E4407B
  Driver: drivers\sa4407B
  Default GPIB address: 15
  Timeout: 10 seconds
- Instrument Model: **Agilent 8560A spectrum analyzer**
  Specified Model: HP8560A
  Driver: drivers\sa8560
  Default GPIB address: 15
  Timeout: 10 seconds
- Instrument Model: **Agilent 8560E spectrum analyzer**
  Specified Model: HP8560E
  Driver: drivers\sa8560
  Default GPIB address: 15
  Timeout: 10 seconds
- Instrument Model: **Agilent 8561E spectrum analyzer**
  Specified Model: HP8561E
  Driver: drivers\sa8560
  Default GPIB address: 15
  Timeout: 10 seconds
- Instrument Model: **Agilent 8562A spectrum analyzer**
  Specified Model: HP8562A
  Driver: drivers\sa8560
  Default GPIB address: 15
  Timeout: 10 seconds
- Instrument Model: **Agilent 8562E spectrum analyzer**
  Specified Model: HP8562E
  Driver: drivers\sa8560
  Default GPIB address: 15
  Timeout: 10 seconds
- Instrument Model: **Agilent 8563E spectrum analyzer**
  Specified Model: HP8563E
  Driver: drivers\sa8560
  Default GPIB address: 15
  Timeout: 10 seconds
- Instrument Model: **Agilent 8564E spectrum analyzer**
  Specified Model: HP8564E
  Driver: drivers\sa8560
  Default GPIB address: 15
  Timeout: 10 seconds
- Instrument Model: **Agilent 8565E spectrum analyzer**
  Specified Model: HP8565E
  Driver: drivers\sa8560
  Default GPIB address: 15
  Timeout: 10 seconds
- Instrument Model: **Agilent 8566B spectrum analyzer**
  Specified Model: HP8566B
  Driver: drivers\sa8566
  Default GPIB address: 15
  Timeout: 10 seconds
- Instrument Model: **Agilent 8568B spectrum analyzer**
  Specified Model: HP8568B
  Driver: drivers\sa8568
  Default GPIB address: 15
  Timeout: 10 seconds
- Instrument Model: **Agilent 8592B spectrum analyzer**
  Specified Model: HP8592B
  Driver: drivers\sa8592
  Default GPIB address: 15
  Timeout: 10 seconds
- Instrument Model: **Agilent 8593E spectrum analyzer**
  Specified Model: HP8593E
  Driver: drivers\sa8592
  Default GPIB address: 15
  Timeout: 10 seconds

- Instrument Model: **Agilent 8595E spectrum analyzer**
  Specified Model: HP8595E
  Driver: drivers\sa8595
  Default GPIB address: 15
  Timeout: 10 seconds

- Instrument Model: **Agilent 70000 spectrum analyzer**
  Specified Model: HP70000
  Driver: drivers\sa70000
  Default GPIB address: 15
  Timeout: 10 seconds

☞ ***NOTE:*** *This is a modular type instrument. The driver requires the following components: HP700001A Main Frame, HP70205A Graphics Display, HP70900A Local Oscillator, HP70902A IF Section, and HP70904A RF Section (100 Hz-2.9 GHz).*

- Instrument Model: **Rohde & Schwarz FSEB Spectrum Analyzer**
  Specified Model: RS-FSE
  Driver: drivers\sa_fseb
  Default GPIB address: 3
  Timeout: 10 seconds

- Instrument Model: **Tektronix 2784 spectrum analyzer**
  Specified Model: TEK2784
  Driver: drivers\sa2784
  Default GPIB address: 15
  Timeout: 10 seconds

☞ ***NOTE:*** This driver may work for the entire Tektronix 2780 series.

- Instrument Model: **Tektronix 2794 spectrum analyzer**
  Specified Model: TEK2794
  Driver: drivers\sa2794
  Default GPIB address: 15
  Timeout: 10 seconds

☞ ***NOTE:*** This driver may work for the entire Tektronix 2790 series.

A2.12 ACP Analyzer

The ACP analyzer is used for Adjacent Channel Power measurements.

- Instrument Model: **Anritsu MS2602A adjacent channel power analyzer**
  Specified Model: A2602A
  Driver: drivers\acp2602
  Default GPIB address: 1
  Timeout: 10 seconds

- Instrument Model: **Anritsu MS2661A adjacent channel power analyzer**
  Specified Model: A2661A
  Driver: drivers\acp2661
  Default GPIB address: 1
  Timeout: 10 seconds

- Instrument Model: **Agilent 4406A**
  Specified Model: HP4406A
  Driver: drivers\Acp4406
  Default GPIB address: 1
  Timeout: 30 seconds

- Instrument Model: **Anritsu MS8604A adjacent channel power analyzer**
  Specified Model: A8604A
  Driver: drivers\acp8604
  Default GPIB address: 1
  Timeout: 10 seconds

- Instrument Model: **Agilent 8560 series adjacent channel power analyzer**
  Specified Model: HP8560 to HP8565
  Driver: drivers\acp8560
  Default GPIB address: 1
  Timeout: 30 seconds

☞ ***NOTE:*** This version just reads the marker at the center of each channel. Run the driver in test mode to see available modulation types.

- Instrument Model: **Agilent 8560 series adjacent channel power analyzer**
  Specified Model: HP8560 to HP8565
  Driver: drivers\acp8560i
  Default GPIB address: 1
  Timeout: 30 seconds

☞ ***NOTE:*** *This version integrates over each channel. Run driver in test mode to see available modulation types.*

- Instrument Model: **Agilent 8590 adjacent channel power analyzer**
  Specified Model: HP8590
  Driver: drivers\acp8590
  Default GPIB address: 1
  Timeout: 10 seconds

☞ ***NOTE:*** *This driver requires the PDC personality card.*

- Instrument Model: **Agilent 8590 adjacent channel power analyzer**
  Specified Model: HP8509E, HP893E, HP8595E
  Driver: drivers\acp8590C
  Default GPIB address: 1
  Timeout: 10 seconds

☞ ***NOTE:*** *This version integrates over each channel. Run driver in test mode to see available modulation types.*

- Instrument Model: **Agilent 8595C adjacent channel power analyzer**
  Specified Model: HP8595C
  Driver: drivers\acp8590
  Default GPIB address: 1
  Timeout: 10 seconds

☞ ***NOTE:*** *This driver requires the CDMA personality card. This driver has built in delay of 4 minutes.*

- Instrument Model: **Agilent 89441A adjacent channel power analyzer**
  Specified Model: HP89441A
  Driver: drivers\acp89441
  Default GPIB address: 1
  Timeout: 10 seconds

☞ ***NOTE:*** *Requires radio personality card.*

- Instrument Model: **Agilent 89441A adjacent channel power analyzer**
  Specified Model: HP89441A
  Driver: drivers\acp8944X
  Default GPIB address: 1
  Timeout: 30 seconds

☞ ***NOTE:*** *This driver does not require the radio personality, but it hasn't been fully tested.*

- Instrument Model: **Rohde & Schwarz FSEB adjacent channel power analyzer**
  Specified Model: RS-FSE
  Driver: drivers\acp_fse
  Default GPIB address: 1
  Timeout: 10 seconds

- Instrument Model: **Rohde & Schwarz FSEB adjacent channel power analyzer**
  Specified Model: RS-FSE
  Driver: drivers\acp_fse2
  Default GPIB address: 1
  Timeout: 10 seconds

☞ ***NOTE:*** *This driver is capable of wide band CDMA. It can also read a files to adjust cf.*

- Instrument Model: **Rohde & Schwarz FSEB adjacent channel power analyzer**
  Specified Model: RS-FSE
  Driver: drivers\acp_fse_spec
  Default GPIB address: 1
  Timeout: 10 seconds

☞ ***NOTE:*** *Run this driver in test mode to see special options.*

- Instrument Model: **Rohde & Schwarz FSIQ adjacent channel power analyzer**
  Specified Model: RS-FSIQ
  Driver: drivers\acp_fsiq
  Default GPIB address: 1
  Timeout: 10 seconds

☞ ***NOTE:*** *The modulation string can be PHS, PPC, NADC, CDMA or WCDMA. Also run this driver in test mode to see the available modulation modifiers.*

A2.13 Old Bias Drivers

Beginning with version 3.00, it is strongly recommended to use separate bias driver DLLs for each power supply, voltmeter or current meter. The individual DLLs are used with the main Bias System Driver bias.exe. This allows any combination of bias instruments to be combined as required. This approach replaces all of the old drivers, where each driver was written for a specific combination of bias instruments.

However, because this is a significant system change, the old bias drivers are provided in version 3.00 to ensure a smooth transition. One of these drivers could be used in place of the bias system driver bias.exe, and the individual driver specification would be ignored. The old bias drivers are installed in a sub-directory named BiasOld.

If a situation does require use of one of the old drivers in the BiasOld directory, please notify Maury so that the problem can be corrected. In future revisions, the old style bias drivers will be obsolete and no longer supported.

A description of the old bias drivers follows:

- Instrument Model: **Agilent E3631A and 34401A**
  Specified Models:
    Bias Supply: E3631A
    Output I Meter: HP34401A
  Bias Supply Driver: drivers\bias3631
  Default GPIB addresses:
    Bias Supply: 3
    Output I Meter: 29
  Timeout:
    Bias Supply: 10 seconds
    Ouput I Meter: 10 seconds

☞ ***NOTE:*** *Uses an HP34401A to read back output current.*

- Instrument Model: **Agilent E3631A**
  Specified Model:
    Bias Supply: E3631A
  Bias Supply Driver: drivers\bias3631i
  Default GPIB addresses:
    Bias Supply: 3
  Timeout:
    Bias Supply: 10 seconds

☞ ***NOTE:*** *This driver uses the +25V for DUT input and the 6V supply for DUT output. Uses internal read back for voltage and current.*

- Instrument Model: **Agilent E3632A**
  Specified Models:
    Bias Supply: Multiple
    Input Supply: E3632A
    Output Supply: E3632A
  Bias Supply Driver: drivers\bias3632
  Default GPIB addresses:
    Bias Supply: 3
    Input Supply: 24
    Output Supply: 25
  Timeout:
    Bias Supply: 10 seconds
    Input Supply: 10 seconds
    Output Supply: 10 seconds

- Instrument Model: **Agilent 4142B**
  Specified Model: HP4142B
  Driver: drivers\pm4142
  Default GPIB address: 3
  Timeout: 10 seconds

☞ ***NOTE:*** *This driver requires an HP41420A SMU to be installed slots 1-2, and connected to the DUT output. An HP41421B SMU must be installed in slot 3, and connected to the DUT input.*

- Instrument Model: **Agilent 4145A**
  Specified Model: HP4145A
  Driver: drivers\bias4145
  Default GPIB address: 3
  Timeout: 10 seconds

☞ ***NOTE:*** *Connect channel 2 to the DUT input, and channel 3 to the DUT output.*

- Instrument Models: **Agilent 6032A**
  Specified Model: HP6032A
  Driver: drivers\bias6032
  Default GPIB address: 3
  Timeout: 10 seconds

☞ ***NOTE:*** *This driver only will set V_out using specified current limit. Readback from bias supply.*

- Instrument Models:
  - Bias Supply: **Agilent 6032A**
  - Input V Meter: **John Fluke 8840A**
  - Input I Meter: **John Fluke 8840A**

  Specified Models:
  - Bias Supply: HP6032A
  - Input I Meter: FL8840A
  - Input I Meter: FL8840A

  Bias Supply Driver: drivers\bi6032V
  Default GPIB addresses:
  - Bias Supply: 3
  - Input V Meter: 26
  - Input I Meter: 27

  Timeout:
  - Bias Supply: 10 seconds
  - Input V Meter: 10 seconds
  - Input I Meter: 10 seconds

☞ ***NOTE:*** *This driver set V_out using specified current limit, then reads back input & output values. The input readings are obtained using external meters, while the output is readback from the bias supply.*

- Instrument Models:
  - Input Supply: **Agilent 6038A**
  - Output Supply: **Agilent 6632A**

  Specified Models:
  - Bias Supply: Multiple
  - Input Supply: HP6638A
  - Output Supply: HP6632A

  Bias Supply Driver: drivers\bias6038
  Default GPIB addresses:
  - Bias Supply: 3
  - Input Supply: 24
  - Output Supply: 25

  Timeout:
  - Bias Supply: 10 seconds
  - Input Supply: 10 seconds
  - Output Supply: 10 seconds

☞ ***NOTE:*** *Set HP6653A for SCPI interface. Do not set HP6632A for SCPI interface.*

- Instrument Models:
  - Input Supply: **Agilent 6612B**
  - Output Supply: **Agilent 6612B**

  Specified Models:
  - Bias Supply: Multiple
  - Input Supply: HP6612B
  - Input Supply: HP6612B

  Bias Supply Driver: drivers\bias6612
  Default GPIB addresses:
  - Bias Supply: 3
  - Input Supply: 24
  - Output Supply: 25

  Timeout:
  - Bias Supply: 10 seconds
  - Input Supply: 10 seconds
  - Output Supply: 10 seconds

☞ ***NOTE:*** *Set both supplies for SCPI interface.*

- Instrument Models: **Advantest TR6143**
  Specified Models:
  Bias Supply: Multiple
  Input Supply: TR6143
  Input Supply: TR6143
  Bias Supply Driver: drivers\bias6143
  Default GPIB addresses:
  Bias Supply: 3
  Input Supply: 24
  Output Supply: 25
  Timeout:
  Bias Supply: 10 seconds
  Input Supply: 10 seconds
  Output Supply: 10 seconds

- Instrument Models:
  Input Supply: **Agilent 6613C**
  Output Supply: **Agilent 6614C**
  Specified Models:
  Bias Supply: Multiple
  Input Supply: HP6613C
  Input Supply: HP6614C
  Bias Supply Driver: drivers\bias6614
  Default GPIB addresses:
  Bias Supply: 3
  Input Supply: 24
  Output Supply: 25
  Timeout:
  Bias Supply: 10 seconds
  Input Supply: 10 seconds
  Output Supply: 10 seconds

- Instrument Models: **Agilent 6621A**
  Specified Models:
  Bias Supply: HP6621A
  Bias Supply Driver: drivers\bias6621
  Default GPIB addresses:
  Bias Supply: 3
  Timeout:
  Bias Supply: 10 seconds

☞ ***NOTE:*** *Use outport 1 for DUT input and output 2 for DUT output.*

- Instrument Models:
  Input Supply: **Agilent 6612B**
  Output Supply: **Agilent 6032A**
  Specified Models:
  Bias Supply: Multiple
  Input Supply: HP6612B
  Input Supply: HP6032A
  Bias Supply Driver: drivers\bi32_12
  Default GPIB addresses:
  Bias Supply: 3
  Input Supply: 24
  Output Supply: 25
  Timeout:
  Bias Supply: 10 seconds
  Input Supply: 10 seconds
  Output Supply: 10 seconds

- Instrument Models: **Agilent 34401 meters** used to read input and output voltage and current. Any manually set bias supply may be used. All four (4) meters are optional.
  Specified Models:
  Bias Supply: Manual
  Input V Meter: HP34401
  Input I Meter: HP34401
  Output V Meter: HP34401
  Output I Meter: HP34401
  Bias Supply Driver: drivers\biasbi34401
  Default GPIB addresses:
  Bias Supply: 3
  Input V Meter: 26
  Input I Meter: 27
  Output V Meter: 28
  Output I Meter: 29
  Timeout:
  Bias Supply: 10 seconds
  Input V Meter: 10 seconds
  Input I Meter: 10 seconds
  Output V Meter: 10 seconds
  Output I Meter: 10 seconds

- Instrument Models: **Agilent 6032A**
  Specified Models:
  Bias Supply: HP6032A
  Bias Supply Driver: drivers\bi6032
  Default GPIB addresses:
  Bias Supply: 3

☞ ***NOTE:*** *This is a single output supply. The driver will allow the user to specify output voltage and current limits only.*

- Instrument Models: **Agilent 6612C and E3632A**
  Specified Models:
  Bias Supply: Multiple
  Input Supply: HP6612C
  Input Supply: E3632A
  Bias Supply Driver: drivers\bi6612_3632
  Default GPIB addresses:
  Bias Supply: 3
  Input Supply: 24
  Output Supply: 25
  Timeout:
  Bias Supply: 10 seconds
  Input Supply: 10 seconds
  Output Supply: 10 seconds

☞ ***NOTE:*** *Both supplies must be sent to SCPI command set.*

- Instrument Models:
  Bias Supply: **Agilent 6623A**
  Input I Meter: **HP34401 (Emulating HP3478)**
  Specified Models:
  Bias Supply: HP6623A
  Input I Meter: HP34401
  Bias Supply Driver: drivers\bi6623a
  Default GPIB addresses:
  Bias Supply: 3
  Input I Meter: 27
  Timeout:
  Bias Supply: 10 seconds
  Input I Meter: 10 seconds

☞ ***NOTE:*** *Connect supply output 1 to the DUT input, and supply output 3 to the DUT output. This is a unipolar supply, so if negative bias is needed, this must be done by the physical connection.*

- Instrument Model: **Agilent 6624A**
  Specified Model: HP6624A
  Driver: drivers\bias6624
  Default GPIB address: 3
  Timeout: 10 seconds

☞ ***NOTE:*** *Connect supply output 1 to the DUT input, and supply output 3 to the DUT output. This is a unipolar supply, so if negative bias is needed, this must be done by the physical connection.*

- Instrument Model: **Agilent 6625A**
  Specified Model: HP6625A
  Driver: drivers\bias6625
  Default GPIB address: 3
  Timeout: 10 seconds

☞ ***NOTE:*** *Connect supply output 1 to the DUT input, and supply output 2 to the DUT output. This is a unipolar supply, so if negative bias is needed, this must be done by the physical connection.*

- Instrument Model: **Agilent 6626A**
  Specified Model: HP6626A
  Driver: drivers\bias6625
  Default GPIB address: 3
  Timeout: 10 seconds

☞ ***NOTE:*** *Connect supply output 1 to the DUT input, and supply output 3 to the DUT output. This is a unipolar supply, so if negative bias is needed, this must be done by the physical connection.*

- Instrument Models:
  Input Supply: **Agilent 6632A**
  Output Supply: **Agilent 6653A**
  Specified Models:
  Bias Supply: Multiple
  Input Supply: HP6632A
  Output Supply: HP6653A
  Bias Supply Driver: drivers\bias6632
  Default GPIB addresses:
  Bias Supply: 3
  Input Supply: 24
  Output Supply: 25
  Timeout:
  Bias Supply: 10 seconds
  Input Supply: 10 seconds
  Output Supply: 10 seconds

☞ ***NOTE:*** *Set HP6653A for SCPI interface. Do not set HP6632A for SCPI interface.*

- Instrument Models:
  Input Supply: **Agilent 6634A**
  Output Supply: **Agilent 6653A**
  Specified Models:
  Bias Supply: Multiple
  Input Supply: HP6634A
  Output Supply: HP6653A
  Bias Supply Driver: drivers\bias6634
  Default GPIB addresses:
  Bias Supply: 3
  Input Supply: 24
  Output Supply: 25
  Timeout:
  Bias Supply: 10 seconds
  Input Supply: 10 seconds
  Output Supply: 10 seconds

☞ ***NOTE:*** *Set HP6653A for SCPI interface. Do not set HP6634A for SCPI interface.*

- Instrument Model: **Agilent 6673A**
  Specified Model: HP6673A
  Driver: drivers\bias6673
  Default GPIB address: 3
  Timeout: 10 seconds

☞ ***NOTE:*** *This driver will set V_out using specified current limit. Set HP6673A for SCPI interface.*

- Instrument Model: **Agilent 3478A used as an output volt meter with a manually operated bias supply.**
  Specified Model:
  Bias Supply: Manual
  Output V Meter: HP3478A
  Bias Supply Driver: drivers\bias3478
  Default GPIB addresses:
  Bias Supply: 3
  Output V Meter: 29
  Timeout:
  Bias Supply: 10 seconds
  Output V Meter: 10 seconds

- Instrument Model: **Agilent 3478A used as an output current meter with a manually operated bias supply.**
  Specified Model:
  Bias Supply: Manual
  Output I Meter: HP3478A
  Bias Supply Driver: drivers\bi3478vc
  Default GPIB addresses:
  Bias Supply: 3
  Output I Meter: 28
  Timeout:
  Bias Supply: 10 seconds
  Output I Meter: 10 seconds

- Instrument Model: **Agilent 6626A**
  Specified Model: HP6626A
  Driver: drivers\bi14852
  Default GPIB address: 3
  Timeout: 10 seconds

☞ ***NOTE:*** *Connect supply output 1 to the DUT input, and supply output 3 to the DUT output with HP14852 bias cable.*

- Instrument Models:
  - Bias Supply: **Agilent 6622A**
  - Input I meter: **Agilent 3478A**
  - Output I meter: **Agilent 3478A**

  Specified Models:
  - Bias Supply: HP6622A
  - Input I meter: HP3478A
  - Output I meter: HP3478A

  Bias Supply Driver: drivers\bias6622

  Default GPIB addresses:
  - Bias Supply: 3
  - Input I meter: 27
  - Output I meter: 29

  Timeout:
  - Bias Supply: 10 seconds
  - Input I meter: 10 seconds
  - Output I meter: 10 seconds

- Instrument Models:
  - Bias Supply: **Agilent 6623A**
  - Input I meter: **Advantest TR6846**
  - Output I meter: **Advantest TR6846**

  Specified Models:
  - Bias Supply: HP6623A
  - Input I meter: TR6846
  - Output I meter: TR6846

  Bias Supply Driver: drivers\bias6623

  Default GPIB addresses:
  - Bias Supply: 3
  - Input I meter: 27
  - Output I meter: 29

  Timeout:
  - Bias Supply: 10 seconds
  - Input I meter: 10 seconds
  - Output I meter: 10 seconds

- Instrument Models:
  - Input Supply: **Agilent 6623A**
  - Input I meter: **Agilent 34401 (Emulating HP3478)**
  - Output I meter: **Agilent 34401 (Emulating HP3478)**

  Specified Models:
  - Bias Supply: HP6623A
  - Input I meter: HP34401
  - Output I meter: HP34401

  Bias Supply Driver: drivers\bi6623A

  Default GPIB addresses:
  - Bias Supply: 3
  - Input I meter: 27
  - Output I meter: 29

  Timeout:
  - Bias Supply: 10 seconds
  - Input I meter: 10 seconds
  - Output I meter: 10 seconds

- Instrument Models:
  - Bias Supply: Multiple
  - Input I meter: **Agilent 6634A**
  - Output I meter: **Agilent 6653A**

  Specified Models:
  - Bias Supply: Multiple
  - Input I meter: HP6634A
  - Output I meter: HP6653A

  Bias Supply Driver: drivers\bias6634_53

  Default GPIB addresses:
  - Bias Supply: 3
  - Input I meter: 24
  - Output I meter: 25

  Timeout:
  - Bias Supply: 10 seconds
  - Input I meter: 10 seconds
  - Output I meter: 10 seconds

☞ ***NOTE:*** *The HP6653A uses the SCPI command language.*

- Instrument Models:

Input Supply:	**Agilent 6642**
Output Supply:	**Agilent 6654A**
Specified Models:	
Bias Supply:	Multiple
Input Supply:	HP6642
Output Supply:	HP6654A
Input I Meter:	HP34401A
Bias Supply Driver:	drivers\biasmhc2
Default GPIB addresses:	
Bias Supply:	3
Input Supply:	24
Output Supply:	25
Input I Meter:	27
Timeout:	
Bias Supply:	10 seconds
Input Supply:	10 seconds
Output Supply:	10 seconds
Input I Meter:	10 seconds

- Instrument Models:

Input Supply:	**Sorenson XT-15**
Output Supply:	**Sorenson**
All four monitors:	**Agilent HP34401A**
Specified Models:	
Bias Supply:	Multiple
Input Supply:	SR-XT-15
Output Supply:	SR-XT-15
Input V Meter:	HP34401A
Output V Meter:	HP34401A
Output I Meter:	HP34401A
Bias Supply Driver:	drivers\biasxt15
Default GPIB addresses:	
Bias Supply:	3
Input Supply:	24
Output Supply:	25
Input V Meter:	26
Input I Meter:	27
Output V Meter:	28
Output I Meter:	25
Timeout:	
Bias Supply:	10 seconds
Input Supply:	10 seconds
Output Supply:	10 seconds
Input V Meter:	10 seconds
Input I Meter:	10 seconds
Output V Meter:	10 seconds
Output I Meter:	10 seconds

☞ ***NOTE:*** *The HP meters are optional. Set the model if you want to use any or all of the HP meters to monitor.*

- Instrument Models:

Input Supply:	**Agilent 6632A**
Output Supply:	**Agilent 6653A**
Input I meter:	**Agilent 34401 (Emulating HP3478)**
Output I meter:	**Agilent 34401 (Emulating HP3478)**
Specified Models:	
Bias Supply:	Multiple
Input Supply:	HP6632A
Output Supply:	HP6653A
Input I meter:	HP34401
Output I meter:	HP34401
Bias Supply Driver:	drivers\biasmult
Default GPIB addresses:	
Bias Supply:	3
Input Supply:	24
Output Supply:	25
Input I meter:	27
Output I meter:	29
Timeout:	
Bias Supply:	10 seconds
Input Supply:	10 seconds
Output Supply:	10 seconds
Input I meter:	10 seconds
Output I meter:	10 seconds

- Instrument Model: **Agilent 6643A**

Bias Supply:	HP6643A
Bias Supply Driver:	drivers\bi6643m4
Default GPIB addresses:	
Bias Supply:	3
Timeout:	
Bias Supply:	10 seconds

☞ ***NOTE:*** *The driver can only set V_out and the out-current limit. Uses supplies' readback.*

- Instrument Models:
  Bias Supply: **Agilent 6634A**
  Output Supply: **Agilent 6643A**
  Specified Models:
  Bias Supply: Multiple
  Input Supply: HP6634A
  Output Supply: HP6643A
  Bias Supply Driver: drivers\bias6643
  Default GPIB addresses:
  Bias Supply: 3
  Input Supply: 24
  Output Supply: 25
  Timeout:
  Bias Supply: 10 seconds
  Input Supply: 10 seconds
  Output Supply: 10 seconds

☞ ***NOTE:*** *Set HP6643A to SCPI interface. Do not set HP6634A for SCPI interface.*

- Instrument Models:
  Bias Supply: **Agilent 6653A**
  Output Supply: **Agilent 6653A**
  Specified Models:
  Bias Supply: Multiple
  Input Supply: HP6653A
  Output Supply: HP6653A
  Bias Supply Driver: drivers\bias6653
  Default GPIB addresses:
  Bias Supply: 3
  Input Supply: 24
  Output Supply: 25
  Timeout:
  Bias Supply: 10 seconds
  Input Supply: 10 seconds
  Output Supply: 10 seconds

☞ ***NOTE:*** *Use SCPI interface for both supplies.*

- Instrument Models:
  Bias Supply: **Keithly 228A**
  Output Supply: **Keithly 228A**
  Specified Models:
  Bias Supply: Multiple
  Input Supply: K228A
  Output Supply: K228A
  Bias Supply Driver: drivers\bias228
  Default GPIB addresses:
  Bias Supply: 3
  Input Supply: 24
  Output Supply: 25
  Timeout:
  Bias Supply: 10 seconds
  Input Supply: 10 seconds
  Output Supply: 10 seconds

- Instrument Models:
  Bias Supply: **Keithly 236A**
  Output Supply: **Agilent 6643A**
  Specified Models:
  Bias Supply: Multiple
  Input Supply: K236A
  Output Supply: HP6643A
  Bias Supply Driver: drivers\biask_hp
  Bias Supply: bias
  Input Supply: ps_in
  Output Supply: ps_out
  Default GPIB addresses:
  Bias Supply: 3
  Input Supply: 24
  Output Supply: 25
  Timeout:
  Bias Supply: 10 seconds
  Input Supply: 10 seconds
  Output Supply: 10 seconds

- Instrument Models:
  Input Supply: **Sorenson HPD60-5**
  Output Supply: **Agilent 6032A**
  Specified Models:
  Bias Supply: Multiple
  Input Supply: SR-HPD60-5
  Output Supply: HP60332A
  Bias Supply Driver: drivers\bi_hp_sr
  Default GPIB address:
  Bias Supply: 3
  Input Supply: 26
  Output Supply: 27
  Timeout:
  Bias Supply: 10 seconds
  Input V Supply: 10 seconds
  Output Supply: 10 seconds

☞ ***NOTE:*** *Do not set HP6032A for SCPI interface.*

- Instrument Model: **Any manually controlled bias supply**
  Specified Model: MANUAL
  Driver: drivers\bias_man
  Default GPIB address: 3
  Timeout: 10 seconds

☞ ***NOTE:*** *Bias_man assumes all specified settings are obtailed without further prompt.*

- Instrument Model: **Any manually controlled bias supply**
  Specified Model: MANUAL
  Driver: drivers/bias_ent
  Default GPIB address: 3
  Timeout: 10 seconds

☞ ***NOTE:*** *SWith this selection, the user will be prompted to set the bias on and off. The GPIB address and timeout are not used.*

Appendix 3

Programming Custom Instrument Drivers and User Functions

A3.1 General

The SNPW program controls and takes data from a variety of instruments. But the main program never talks to an instrument directly; all communication between the SNPW program and the instruments is done through instrument drivers. Each driver is a small stand-alone module, which is created independently from the SNPW program. Each driver has a defined set of subroutines which do the various functions required of the type of instrument it supports.

When the main program begins a measurement, it spawns all of the specified driver modules. Then when it needs to talk to an instrument, it uses the specific driver for that instrument. The driver will perform the specified function and pass the data back to the main program, allowing the SNPW program to continue. When the entire measurement is complete, the drivers are removed from memory.

The user function is a programmable measurement driver that operates in the same way as the instrument drivers. This has a defined set of subroutines that are called at various points during the calibration and measurement of both noise and power. The purpose is to provide the flexibility for the user to tailor the measurement to meet unique requirements.

A big advantage of this approach is the ease of programming custom drivers. Each module is small and relatively simple, and can be written, compiled, and tested independent of the main program.

A3.2 Source Code Structure

The existing driver modules are written in the C language using the Microsoft Visual C++ Studio, version 6.0. The source code is provided, so copies of existing drivers may be used as templates for new or modified drivers. These source code modules are installed into the <drivers> subdirectory during the installation of the MT993( ) series software.

For each driver type, there are four "main" files that must be linked with each individual driver. These four filenames for each driver category are listed in Table A3-1.

Driver Catagory	**“main” files to link with each driver**
GPIB board	gpibmain.c gpibmain.h gpibmain.rc gpibmain.ico
Bias System	biasmain.c biasmain.h biasmain.rc biasmain.ico
Noise Figure Meter	nfmmain.c nfmmain.h nfmmain.rc nfmmain.ico
Power Meter	pmmain.c pmmain.h pmmain.rc pmmain.ico
Spectrum Analyzer	samain.c samain.h samain.rc samain.ico
ACP Analyzer	acpmain.c acpmain.h acpmain.rc acpmain.ico
RF Source	srcmain.c srcmain.h srcmain.rc srcmain.ico
Frequency Meter	fmmain.c fmmain.h fmmain.rc fmmain.ico
RF Switch	swmain.c swmain.h swmain.rc swmain.ico
Vector Network Analyzer	vnamain.c vnamain.h vnamain.rc vnamain.ico
User Function	usermain.c usermain.h usermain.rc usermain.ico

Table A3-1. "Main Files for Each Driver Category"

In addition, the following files are linked with every driver:

decl-32.h
gpib-32.obj
ni488.h
gpib_ni.c
drv.h

In each individual driver module, the first section contains comments describing the driver, and some declaration statements. The comments will include a list of required routines that should be modified when making a new driver.

The first subroutine in each driver is called get_driver_info( ). This routine defines information about the driver that can be queried. It includes a list of model numbers supported by the driver, a caption for the stand-alone test window, a date, and a description string. Some driver categories also include lists of other items, such as the list of supported modulation strings for RF source drivers and ACP analyzer drivers.

The rest of the driver contains the various functions which are defined for the particular driver category. The required functions which are called by the SNPW program are listed at the top in the comments. There may also be some extra routines which are used to support these required functions. These extra routines may be deleted if not needed by the new driver.

Each of the required functions has a header which describes the purpose, parameters, and return values. Further detail on the data structures of the parameters can be seen by looking in the include file drv.h and the "main".h file for the particular driver category.

A3.3 Data Structures

The data structures are defined in the include files drv.h and nhead.h. These are the same data structures as used by the main SNPW program, so that the driver can use and write data to the same memory locations used by the SNPW program.

Data structures in the C language consist of named elements of any combination of data types, including other structures. This is a convenient way to lump all related variables together to simplify passing data to and from subroutines. The main SNPW program typically passes a small number of structures to the driver modules, but this can include a lot of data.

To access an individual variable within a data structure, specify the full hierarchy from the variable name of the entire structure down to the specific variable. For example, the measured output voltage is the "vmeas[bias_out]" part of the "bias_type" structure, which is the "bias" part of the "user_setup_type" structure. In the routine "user_function_power( )", the variable "*setup" is a "user_setup_type", and the asterisk means that it is a pointer. Therefore, to specify the measured output voltage, specify:

```
setup->bias.vmeas[bias_out]
```

Many books are available with more information on specific syntax of the C language.

An explanation of the elements of some key structures defined in drv.h is as follows:

The structure **instrument_type** contains the following elements:

address	integer GPIB address
bin_address	a binary number returned from the National Instruments IBFIND routine
delay_ms	number of mSec to wait after GPIB initialization
filename	string containing the driver file name
gpib_name	string containing the GPIB name
model	string containing the model number
name	string containing instrument name
timeout	string containing the timeout value

The structure **bias_type** contains the following elements:

control	integer specifying input control. It will be one of the constants VOLTAGE_CONTROL or CURRENT_CONTROL
enabled	flag indicating if bias is used in the block diagram
filename	string containing the main bias driver file name
i_in_start	start input current in mA for mode 1 with current control

i_in_stop	stop input current in mA for mode 1 with current control
i_limit[ ]	current limit in mA for each power supply
imeas[ ]	measured current in mA for each power supply
imeter[ ]	instrument_type structure for each current meter
ireq[ ]	requested current for each power supply
mode	integer specifying the bias mode 0 = bias is disabled 1 = specify V_out, I_out 2 = specify V_out, V_in 3 = specify V_out, I_in 4 = specify V_out only (self bias on input)
ps[ ]	instrument_type structure for each power supply
ps_channel[ ]	channel to use for each power supply
r_series[ ]	series resistance in ohms for each power supply
read_delay-ms	delay in mSec after setting bias
sequence[ ]	position of each power supply in the turn on/off sequence
set_delay_ms	delay in mSec after setting bias
v_in_limit	input bias voltage limit in volts
v_in_start	start input voltage in volts for mode 1 with voltage control
v_in_stop	stop input voltage in volts for mode 1 with voltage control
vmeas[ ]	measured voltage in volts for each power supply
vmeter[ ]	instrument_type structure for each voltmeter
vreq[ ]	requested voltage in volts for each power supply

The structure **user_setup_type** contains the following elements:

acp_adj_low	ratio in dB of power in the lower adjacent channel to power in the desired channel
acp_adj_up	ratio in dB of power in the upper adjacent channel to power in the desired channel
acp_alt_low	ratio in dB of power in the lower alternate channel to power in the desired channel
acp_alt_up	ratio in dB of power in the upper alternate channel to power in the desired channel
acp_alt2_low	ratio in dB of power in the 2nd lower alternate channel to power in the desired channel
acp_alt2_up	ratio in dB of power in the 2nd upper alternate channel to power in the desired channel
acp_anal	instrument_type structure for ACP analyzer
acp_phase_err	phase error in degrees in the demodulated signal
acp_pn_length	pseudonoise sequence length before repetition
acp_setup_type	structure with information about the ACP analyzer setup
acp_ve_rms	RMS vector error in percent in the demodulated signal
bias	bias_type structure with bias data
c	carrier power in dBm at DUT output plane
c_2nd	delivered output power in dBm at the 2nd harmonic
c_3rd	delivered output power in dBm at the 3rd harmonic
cal_carr [ ]	carriage positions of tuners during calibration
cal_p1 [ ]	probe 1 positions of tuners during calibration
cal_p2 [ ]	probe 2 positions of tuners during calibration
cal_thru	spara_type structure of the thru used for calibration
cal_tuner [ ]	spara_type structure of tuners in calibration position
carr [ ]	carriage positions of tuners during measurement
context	structure with information about the context of the power measurement
control_string	string with information from setup menu
coupling_in	coupling factor of the input coupler (ratio)
coupling_refl	coupling factor of the reflection coupler (ratio)
coupling_spectrum	coupling factor of the spectrum analyzer coupler (ratio)
c_i3_ratio	carrier to 3rd order intermod ratio in dB at DUT output plane
c_i5_ratio	carrier to 5th order intermod ratio in dB at DUT output plane
c_i7_ratio	carrier to 7th order intermod ratio in dB at DUT output plane

c_raw1	uncorrected reading of the lower carrier amplitude in dBm
c_raw2	uncorrected reading of the upper carrier amplitude in dBm
c_lo	lower carrier signal at DUT plane in dBm
c_up	upper carrier signal at DUT plane in dBm
delta_gt_dut	difference between gt_dut and gt_s_dut
demo_mode	integer flag (0=NOT demo mode,1=demo mode)
dut_s	spara_type structure of DUT
dut_s_valid	integer flag for existing DUT spara 0 = spara do not exist 1 = spara exist
duty_cycle	duty cycle in %
eff_pwr_added	power added efficiency in percent at DUT plane
freq	Frequency in GHz
gamma_s	complex source reflection coefficient looking into RF source
gp_dut	power gain at DUT plane (ratio)
gpib_board	instrument_type structure for the GPIB board
gt_dut	transducer gain at DUT plane (ratio)
gt_s_dut	transducer gain at DUT plane calculated from s-parameters (ratio)
i3	3rd order intermod power in dBm at DUT output plane
i5	5th order intermod power in dBm at DUT output plane
i7	7th order intermod power in dBm at DUT output plane
i3_lo	lower 3rd order intermod power in dBm at DUT plane
i3_raw1	uncorrected reading of the lower 3rd order intermod amplitude in dBm
i3_raw2	uncorrected reading of the upper 3rd order intermod amplitude in dBm
i3_up	upper 3rd order intermod power in dBm at DUT plane
i5_lo	lower 5th order intermod power in dBm at DUT plane
i5_raw1	uncorrected reading of the lower 5th order intermod amplitude in dBm
i5_raw2	uncorrected reading of the upper 5th order intermod amplitude in dBm
i5_up	upper 5th order intermod power in dBm at DUT plane
i7_lo	lower 7th order intermod power in dBm at DUT plane
i7_raw1	uncorrected reading of the lower 7th order intermod amplitude in dBm
i7_raw2	uncorrected reading of the upper 7th order intermod amplitude in dBm
i7_up	upper 7th order intermod power in dBm at DUT plane
imod_meas_method	integer flag for intermod measurement method (0 = Peak Search, 1 = Zero Span)
ip3	3rd order intercept point in dBm at DUT output plane
ip5	5th order intercept point in dBm at DUT output plane
ip7	7th order intercept point in dBm at DUT output plane
meas_freq_ghz	measured frequency in GHz
meas_mode	integer flag showing measurement type (equal to one of the constants POWER, IMOD, or ACP)
num_user	number of user functions
p1 [ ]	probe 1 positions of tuners during measurement
p2 [ ]	probe 2 postions of tuners during measurement
pin_avail	available input power at the input of the source tuner in mW
pin_avail_dut	available input power in mW at DUT plane
pin_deliv_dut	delivered input power in mW at DUT plane
pin_tol-db	tolerance in dBm for setting pin
pin_raw	uncorrected reading from the input power meter in mW
pm_in	instrument_type structure for input power meter
pm_out	instrument_type structure for fundamental output power meter
pm_out_2nd	instrument_type structure for 2nd harmonic output power meter
pm_out_3rd	instrument_type structure for 3rd harmonic output power meter
pm_refl	instrument_type structure for reflection power meter
pout_dut	delivered output power in mW at DUT plane
pout_raw	uncorrected reading from the output power meter in mW
pout_req_db	requested pout in dBm
pout_tol_db	tolerance in dBm for setting pout
power_mode	power_mode structure. Each element of this structure with a value greater than zero is selected for measurement.
p_prog_db	programmed power for the RF source in dBm

p_prog2_db	programmed power for the second RF source in dBm
prefl_raw	uncorrected reading from the reflection power meter in mW
prf_khz	pulse repetition rate in KHz
ps_out [ ]	pm_type structure of output power sensor efficiency, loss and complex load reflection coefficient
refl_coef_dut	voltage reflection coefficient ratio at DUT plane (ratio)
refl_db_dut	return loss at DUT plane (dB)
source	instrument_type structure for RF source
source2	instrument_type structure for second RF source
spa_avg_lower	number of averages for intermod measurement
spa_avg_upper	number of averages for carrier measurement
spa_ip3_db	third order intercept point of the spectrum analyzer in dBm
spa_min_atten_db	minimum allowable spectrum analyzer attenuation in dB
spa_popt_db	optimum power to spectrum analyzer mixer in dBm
spa_popt_mode	integer flag for spectrum analyzer power setting mode (0 = fixed,1 = auto, 2 = measured)
spa_res_bw_khz	spectrum analyzer resolution bandwidth in KHz
spa_res_bw_mode	integer flag for resolution bandwidth mode (0 = fixed, 1 = auto)
spa_span_ratio	tone span ratio
spectrum_anal	instrument_type structure for spectrum analyzer
spur_db	worst case measured spurious signal
spur_freq_ghz	frequency for spur_db
src_modulation_type	string with information about modulation type
tone_spacing_mhz	tone spacing in MHz
trans_phase	measured transmission phase
tuner [ ]	spara_type structure of tuners in measurement position
user [ ]	array of instrument_type structures for user defined instruments
user_name	an array of strings containing the name of each user parameter
user_units	an array of strings containing the units of each user parameter

The structure **noise_power_type** contains the following elements:

cal_noise_load	integer flag for noise receiver reflection coeff cal method 0 = use noise data only 1 = use 1-port s-parameters
enr	ENR value of noise source in dB
freq	Frequency in GHz
gamma_cold	noise source reflection coefficient, cold state
gamma_hot	noise source reflection coefficient, hot state
gamma_ld	measured noise receiver reflection coefficient
number	number of measured source positions 0 = use noise data only 1 = use 1-port s-parameters
pcold[ ]	array of measured cold noise power values
phot[ ]	array of measured hot noise power values
rf_atten	noise figure meter RF attenuator setting for measured data
selected[ ]	array of flags to show which measured points were used for the noise parameter calculation
t_amb	ambient temperature in Celcius
tuner1_s[ ]	array of s-parameters of the source tuner
tuner2_s	s-parameters of the load tuner

The structure **noise_para_type** contains the following elements:

dut_s	s-parameters of the DUT
fmin	minimum noise figure (linear ratio)
freq	frequency in GHz
gam1	receiver input reflection coefficient (cal data only)
gopt	optimum source reflection coefficient for fmin
imeas[ ]	measured current in mA for each power supply
p0	receiver gain (linear ratio, cal data only)
raw_data	noise_power_type structure containing noise raw data

rn	normalized noise resistance
solved	integer flag indicating noise parameter solution found
user[ ]	array of user-defined parameters
vmeas[ ]	measured voltage in Volts for each power supply

The structure **noise_cal_type** contains the following elements:

cal_tuner	tuner used for cal (0 = source, 1 = load)
max_atten	index to the maximum calibrated noise figure meter RF attenuation
min_atten	index to the minimum calibrated noise figure meter RF attenuation
npara[ ]	array of noise_para_type structures with noise parameters for each calibrated RF attenuator setting

The structure **user_noise_setup_type** contains the following elements:

averaging	number of noise figure meter averages
bias	bias_type structure with bias data
check_osc	integer flag for checking oscillations (0=don't check, 1=check bias for oscillation)
control_string	string with information from setup menu
demo_mode	integer flag in demo mode setting (0=NOT demo mode,1=demo mode)
freq	Frequency in GHz
freq_if	IF Frequency in MHz
gpib-board	instrument_type structure for the GPIB board
i_atten	index to the actual noise figure meter RF attenuation
lo_on_mainbus	integer flag for local oscillator (0=local oscillator is on the private GPIB of the noise figure meter,1=local oscillator is on the main GPIB)
lo_power	local oscillator power in dBm
max_atten	index to the maximum valid noise figure meter RF attenuation
min_atten	index to the minimum valid noise figure meter RF attenuation
ncal_para	noise_cal_type structure with cal data
nf_calc_method	single noise figure calculation method integer flag (0=y-factor, 1=hot only, 2=cold only)
nfm	instrument_type structure for the noise figure meter
noise_mode	structure indicating which parameters are measured
noise_ts	instrument_type structure for the noise test set
npara	noise_para_type structure with noise parameter data
nparam_math_option	math algorithm integer flag (0=math1, 1=math2, 2=cold only)
num_user	number of user functions
oscillation	integer flag showing if oscillation was found (0=no oscillation, 1=oscillation found)
osc_tol_i_in	I_in tolerance to indicate oscillation
osc_tol_i_out	I_out tolerance to indicate oscillation
osc_tol_v_in	V_in tolerance to indicate oscillation
osc_tol_v_out	V_out tolerance to indicate oscillation
sideband	sideband type integer flag (0=DSB, 1=LSB, 2=USB, 3=DIRECT, 4=AUTO)
source_lo	instrument_type structure for the local oscillator
t_amb	ambient temperature in Celsius
user[ ]	array of instrument_type structures for user defined instruments
user_name	array of user funtion names
user_units	array of user function units

A3.4 Driver Development Process

The general process of driver development is as follows:

a. Select an existing driver module which is the most similar to the driver to be written. Copy this module to a new name prior to any editing.

b. Edit the new copy of the driver module to put in the proper commands and codes for the new instrument.

c. Compile and link the new driver to create the .EXE file. This may be done in the Microsoft Developer Studio, or by using a batch file from the DOS command line.

   The Developer Studio is generally suggested since it also provides for debugging, if necessary. See Section

A3.5, for details on setting up a Developer Studio project.

To compile and link from the DOS command line, use the following syntax:

drvw newfile ...main

where "newfile" is the name of the new .c driver file, and "...main" is the name of the main module for the driver category listed in Table A3-1.

d. Run the new .EXE file by itself with no command line arguments. Use the test menu to test the operation of each of the required functions.

e. Run the SNPW program. In the <Setup> <Instruments> Menu, enter the new driver path and file name and other information. Then run the measurement and do a complete test with the new driver.

A3.5 Procedure to Create a Developer Studio Project to Work on a Driver

This procedure will set up a project in Microsoft's Developer Studio that can be used and re-used to work on driver development. The Developer Studio comes as part of the Microsoft Visual C++ package.

1. **Start the Microsoft Developer Studio**

2. **Create a new project** by clicking menu item <File> <New...>. When the dialog comes up, select the project tab and do the following:

   a. Click on the button to the right of the location edit box, and browse for the "Drivers" directory of the ATS software.

   b. Click on the Project name edit box, and type in a project name. A generic name such as DrvTest is suggested, since you may want to use this project for a variety of drivers in the future.

   c. Finally, double click on "Win32 Application". This will open the new project in the Developer Studio.

3. **Add the National Instruments object file and the common controls library to the project** by clicking menu item <Project> <Settings...>. When the dialog comes up, select the Link tab and do the following:

   a. Click on the left side of the Object/ Library Modules edit box to put the cursor there.

   b. Use the left arrow key to make sure that the cursor is all the way to the left.

   c. Type in "..\gpib-32.obj comctl32.lib", followed by a space to separate it from the next library file.

   d. If you want to, you may also change the name of the output .EXE file in this dialog.

   e. click "OK" to close the Settings dialog.

4. **Make a copy of an existing driver of the same type to use as a starting template,** if this is going to be a new driver.

   a. Click the menu item <File> <Open...>, and browse up one directory level to the drivers directory. Select and open the file that you intend to copy. This will bring that file into the Studio window.

   b. Click the menu item <File> <SaveAs...>, and browse to the drivers directory. Enter a new filename. It is recommended that you start the name with the same first few letters of other drivers in that category, to make it easier to browse for later. Be sure to include the .c extension in the name.

5. **Add the source files to the project** by clicking menu item <Project> <Add To Project> <Files...>. When the file

browser comes up, click the "Up one level" button to get back to the drivers directory. Then select the files that you need for the drivers. This will include:

a. The driver file that you want to work on. If it is a new driver, this should be the copy of an existing driver that you will use as a template.

b. The .c and .rc files associated with the "main" module of this driver type. For example, if you are working on a source driver, this will be " "Srcmain.c", and "Srcmain.rc". Don't worry about the remaining files, as the Developer Studio will add these automatically.

6. **You are now ready to go.** To compile, Click menu item <Build> <Rebuild All>. For subsequent builds, just click on the build tool button. You can also edit, debug, or just run the driver from this environment.

7. **Copy the completed .EXE file to the drivers directory.** When you finish editing and compiling, the executable file will be named DrvTest.exe unless you renamed it in step 4. It will be in the subdirectory drivers\DrvTest\debug. Rename it, and move it up to the drivers subdirectory for use.

8. T**o use this project to work on a different driver in the future,** just delete the current files, and then add the files that you want to work on.

A3.6 Updating Custom Drivers to Work with New Software Versions

Existing drivers must usually be re-compiled with the new copy of drv.h when a new software version is installed. Normally, this is all that is required, unless the driver is to be updated to take advantage of some new capability. The simplest way to do the re-compiling is to maintain a batch file similar to drvw.bat, but with one line for every custom driver in use. Then, after installing the new SNPW version, the batch file can be executed one time, and everything is done.

The reason for re-compiling is that new software releases always have new features and capability added, and this usually means that the data structures have expanded to include new items.

If the drivers were compiled with the old data structures, then the memory locations of some variables within a data structure will be offset from what the main SNPW program expects. It is therefore absolutely necessary for the drivers to use the same data structures as the main program.

A3.7 Converting Drivers from Version 2.20 to Version 3.30

In version 3.30, some major changes were made in some driver categories that will require modification of existing custom drivers. The modifications are as follows:

1. There is now only one main bias driver (bias.c), that will call all the specified power supply, voltmeter and current meter drivers. The individual drivers are in DLL format, and can be compiled with the batch file drvDLL.bat.

   This allows any combination of bias instruments to be used without re-writing any drivers. It is strongly recommended that custom bias drivers be converted to the new format of individual bias instrument DLL drivers.

   Although not recommended, prior bias drivers can still be used, but need modification to compile because of several varibles that have been changed to array structures.

2. User functions that use bias variables may need modification to compile, because of several variables that have been changed to array structures. Index constants to get data for various power supplies are: BIAS_OUT, BIAS_IN, BIAS_AUX1, BIAS_AUX2, BIAS_AUX3, and BIAS_AUX4.

3. User functions that make use of harmonic tuner s-parameters may need modification to compile because of a new data

definition. The s-parameters of all tuners, embedded with all applicable s-parameter blocks, are now contained in one array. Index constants to get tuner s-parameters are: SRC_TNR, SRC_2ND_TNR, SRC_3RD_TNR, LOAD_TNR, LD_2ND_TNR, LD_3RD_TNR.

4. Power meter drivers have a new function added, init_pmeter( ). This was added to support some of the new power meters that can be setup for different bandwidths or operating modes, although it will do nothing in most power meters drivers. The easiest way to add the function is to copy the function from a driver such as pm437.c where the function does nothing except return(0).

Appendix 4

Theory of Load and Source Pull Measurement

Load pull consists of varying or "pulling" the load impedance seen by a Device Under Test (DUT) while measuring the performance of the DUT. Source pull is the same as load pull, except that the source impedance is changed instead of the load impedance.

Load and source pull is used to measure a DUT in actual operating conditions. This method is important for large-signal, nonlinear devices where the operating point may change with power level or tuning. Load or source pull is not usually needed for linear devices, where performance with any load can be predicted from small signal s-parameters.

Calibrating to measure output power and gain consists of measuring the available input power at the power source reference plane and the coupling value of the directional couplers. An input power coupler is calibrated by measuring the offset from the available input power at the Power Calibration Plane. Output couplers, connecting either a spectrum analyzer or ACP analyzer, are calibrated by measuring the offset from the measured output power at the power sensor plane. A reflection coupler is calibrated by measuring the reflection at multiple reflection phase values, relative to the Power Calibration Plane. This minimizes directivity errors, although good coupler directivity is still important for the best accuracy.

Once the available input power and coupling are known, the output power, transducer gain, and power gain can all be measured with any combination of source or load impedance. Output power is the power delivered to the load. Transducer gain is the ratio of delivered output power to available input power. Power gain is the ratio of delivered output power to delivered input power.

The objective of the measurement is to get the power and gain values at the DUT reference planes. Although the tuners are very low loss, bias tees and other components may need to be deembedded, so the loss must be considered. To get the output power at the DUT reference plane, the dissipative loss of the load tuner is added to the raw measured output power. To get the available input power at the DUT reference plane, the dissipative loss of the source tuner is subtracted from the calibrated available input power. To get the delivered input power at the DUT input reference plane, the reflected power at the source is subtracted from the calibrated available power at the source. The dissipative loss of the source tuner is then subtracted from the result to shift from the source power reference plane to the DUT input reference plane.

☞ ***NOTE:*** *Power gain errors are likely if there are large mismatches at the DUT input. Here, the measured delivered power is a small difference between two large numbers. Errors from noise, drift, finite coupler directivity, vary wildly. If the apparent reflected power is greater than the calibrated available power, delivered power cannot be calculated at all.*

The major errors in power gain are avoided by using the source tuner to match the DUT input, if the DUT does not oscillate. Therefore, if power gain is to be measured, be sure to do a source pull after the load pull, and then look at power gain.

If a DUT begins to oscillate, power gain becomes almost meaningless. Also, an oscillating DUT may generate some power in the reverse direction causing the apparent reflected power to be greater than the calibrated input power, even when the DUT input is matched. This is indicated by asterisks in the delivered power or power gain columns of the printouts.

In the full load pull measurement, the source tuner is set to a fixed position, and power and gain are measured at a variety of randomly located load impedance points. After all of the data are taken, the reflection plane is divided into a rectangular grid, and the apparent power at each grid point is calculated. This is done by interpolating on a surface determined by the surrounding points; the closest points are weighted most. Higher resolution comes from using finer grid spacing, and accuracy depends upon the spread and resolution of the points in the area.

The advantage of the random contouring method is that no knowledge of what contours are desired is required before the measurement. This provides much more flexibility than an approach requiring contours to be searched, for example, and allows the tuners to be pre-characterized for best accuracy. Extrapolation outside the measured points is not reliable, so it is important to surround the area of interest on the reflection plane.

The contouring method makes no assumption about linearity or other behavior of the DUT. Contours of nonlinear DUTs are usually not circular, and may take unexpected shapes, especially when the DUT comes close to oscillation. Contour plotting often tells more about a device than any other method. Source pull contours are measured and calculated in the same way as the load pull contours are measured and calculated. The only difference is that the load tuner is set to a fixed position, and the source tuner is the one that is varied.

Appendix 5

Theory of Noise Measurement

Noise, a natural phenomenon, affects most microwave and RF systems. It masks the desired signal, so it is important to minimize its effects. Although there are several types of noise, thermal noise greatly affects linear microwave and RF systems, so it is the focus of this software.

Noise figure, a measure of the noise generated by a 2-port device, is easily determined. Commercial noise figure meters have been developed to measure this, but they are limited because they only measure SIMPLE NOISE FIGURE. That is the noise figure of a device terminated with a particular value of source impedance. The problem is that the noise figure usually varies as the source reflection varies.

To minimize the effects of device noise figure then, the relationship between noise figure and source impedance (or source reflection coefficient) must be known. The noise figure depends on the COMPLETE NOISE PARAMETERS as shown in Equation A5-1 below:

A5-1:

$$F = F_{min} + \frac{4\ R_n}{Z_o} \frac{|\Gamma_s - \Gamma_{opt}|^2}{|1+\Gamma_{opt}|^2(1-|\Gamma_s|^2)}$$

where

F = Noise figure (linear ratio)

F_{min} = Minimum noise figure (linear ratio)

Γ_{opt} = Optimum complex reflection coefficient

R_n = Noise resistance

Γ_s = Complex source reflection coefficient

The purpose of this software is to find the complete set of noise parameters consisting of F_{min}, Γ_{opt} and R_n. Since Γ_{opt} is complex, this makes a total of four scalar parameters.

Γ_{opt} is the source reflection coefficient which corresponds to F_{min}. R_n is a scale factor which shows how fast F changes with Γ_s. (The software actually displays r_n, which is R_n normalized to 50 ohms.)

To find F_{min}, Γ_{opt} and R_n the simple noise figure must be measured at a variety of source impedances using the ATS. In principle, since four scalar variables are to be found, only four measurements are required. In practice, however, it is much more effective to measure more points, and use a least means square's mathematical technique to extract the parameters from over determined data.

Noise characterization also requires the parameters of the Device Under Test (**DUT**) to be separated from the parameters of the measuring system to which the DUT is connected. To do this, the system must be calibrated to learn the system parameters. The noise contribution of the system (often called the second stage since it follows the DUT) will vary with its source impedance according to equation A5-1.

Therefore, the complete noise and gain parameters of the system must be known to determine the system noise contribution when a particular DUT is connected.

After the system is calibrated, noise characterization of a DUT can be done. This consists of measuring the total noise figure, F_{total}, with several different source impedances. The noise figure of the DUT for each position, F_{dut}, is then given from the Friis cascade equation as shown in equation A5-2 below. G_{dut} is the available gain of the DUT as resolved from the DUT S-parameters and the source reflection coefficient.

A5-2:

$$F_{dut} = F_{total} - \frac{F_{sys} - 1}{G_{dut}}$$

A practical consideration shown by Equation A5-2 is that if F_{sys} is high and G_{dut} is low, then F_{dut} will be a small difference between large numbers. This would make it very sensitive to errors. Therefore, if DUTs with low noise figure values are to be measured, it is important to keep F_{sys} as low as practical. That is why a load tuner is important when the DUT has a high output reflection coefficient. The effect of losses in the tuners, bias tees, and the fixture is eliminated in this software. The losses are resistive in nature, so they add noise proportional to the ambient temperature in kelvins (absolute temperature scale). During the setup, the ambient temperature is entered in degrees Celsius and is later read by the program during a calibration, conversion to kelvins is automatic.

Another practical consideration is that the reflection coefficient of the noise source usually changes when switched between the hot and cold states. This software takes this rigorously into account by using the noise power function given in Equation A5-3. The noise power equations allow the source impedance to be independent for each power measurement, and therefore eliminate this traditional source of error.

A5-3:

$$P = kB\{[t_{ns} + t_0(F_1\text{-}1)]G_{al} + t_0(F_2\text{-}1)\}G_{t2}$$

where

P = The total measured noise power.

k = Boltzmann's constant.

B = The system bandwidth.

t_o = 290 kelvins.

t_{ns} = Temperature of the noise source in kelvins.

F_1 = The DUT noise figure (function of source impedance).

F_2 = The system noise figure (a function of the DUT output impedance).

G_{a1} = The DUTs available gain (a function of source impedance).

G_{t2} = System transducer gain (function of DUT output impedance).

Appendix 6

Theory of Intermodulation Distortion Measurements

A6.1 Introduction

Intermodulation distortion occurs when the non-linearity of a device or system with multiple input frequencies causes undesired outputs at other frequencies. In a communications system, this means that signals in one channel can cause interference with adjacent channels. As the spectrum becomes busier and the channels become more tightly spaced, minimizing intermodulation distortion becomes more important.

A6.2 Two-Tone Intermodulation Testing

A convenient way to measure intermodulation distortion is to combine two equal power signals with a set frequency spacing at the input of the device under test. The output spectrum will look like Figure A6-1. The two largest signals are the amplified carrier signals, and the smaller signals, moving away from the carriers in both directions, are the 3rd order, 5th order, and 7th order intermodulation products respectively. The frequency spacing between all of the signals is equal.

The ten measurement parameters of interest here are as follows:

Carrier (C): This is the power of the carrier signal in dBm units. It is similar to the Pout parameter, except that C is measured with a spectrum analyzer, and Pout is measured with the power meter with only one RF input signal.

3rd Order Intermodulation Product (I3): This is the power of the spurious 3rd order intermodulation signal in dBm units, measured with the spectrum analyzer.

Carrier to 3rd Order Intermodulation Ratio (C/I3): This is the ratio of the carrier power to the spurious 3rd order intermodulation power in dB.

Third Order Intercept Point (IP3): This is a figure of merit in dBm for the device and normally varies with tuning.

5th Order Intermodulation Product (I5): This is the power of the spurious 5th order intermodulation signal in dBm units, measured with the spectrum analyzer.

Carrier to 5th Order Intermodulation Ratio (C/I5): This is the ratio of the carrier power to the spurious 5th order intermodulation power in dB.

5th Order Intercept Point (IP5): This is a figure of merit in dBm for the device and normally varies with tuning.

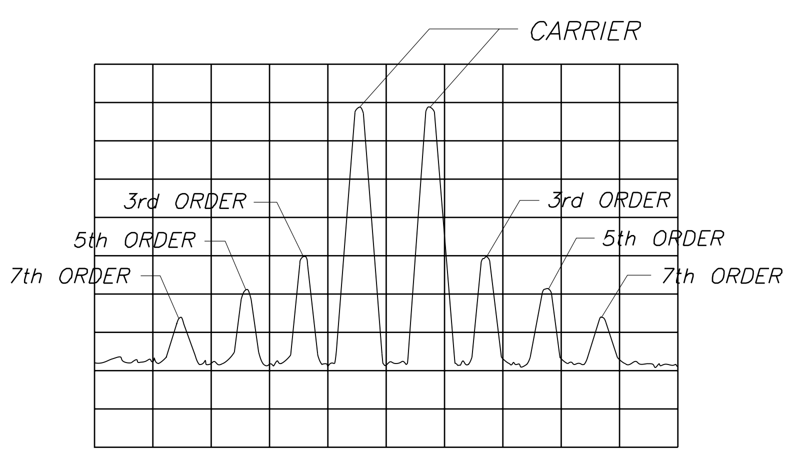

Figure A6-1. Output Spectrum of Two-Tone Intermod Test

7th Order Intermodulation Product (I7): This is the power of the spurious 7th order intermod signal in dBm units, measured with the spectrum analyzer.

Carrier to 7th Order Intermod Ratio (C/I7): This is the ratio of the carrier power to the spurious 7th order intermod power in dB.

7th Order Intercept Point (IP7): This is a figure of merit in dBm for the device and normally varies with tuning.

A6.3 Third Order Intercept Point

The non-linear transfer function of a device or system can be expressed as a series expansion:

$$f(x) = a0 + a1(x) + a2(x)^2 + a3(x)^3 + a4(x)^4 + ...$$

The intermod signals shown in Figure A6-1 come from the third order term in the series expansion, hence the name third order intermod product. Because of the third order, it will increase with input power much faster than the carrier as shown in Figure A6-2. In dBm units, which is a logarithmic function, the intermod signal will increase with power three times as fast as the carrier signal.

The measurement of the third order intercept point is illustrated in Figure A6-2. If the linear portion of the C v. Pin and the I v. Pin curves are extrapolated out, the interception point is called the third order intercept point (IP3). In Figure A6-2, this is the intersection of the dotted lines. This theoretical point is never reached in practice, because both curves will saturate before reaching it. However, IP3 is often used as a merit function for the device.

If the 3:1 theoretical slope difference is assumed, then the IP3 can be calculated from only one power level. If a power sweep is done, IP3 calculated this way will be constant in the linear region if the 3:1 slope assumption was correct. As the carrier and intermod signals saturate, the IP3 value will usually drop off, indicating an invalid measurement. At the lower power levels, IP3 will start to change as the spectrum analyzer noise floor is reached, also indicating an invalid measurement. The correct measurement is therefore in the power range where IP3 stays constant.

☞ ***NOTE:** Theoretically, IP3 is not a function of power level. However, the dynamic range is limited by the spectrum analyzer noise floor on the low end, and DUT saturation or spectrum analyzer intermodulation on the high end. Looking at IP3 as a function of power provides a good way of checking the valid measurement range.*

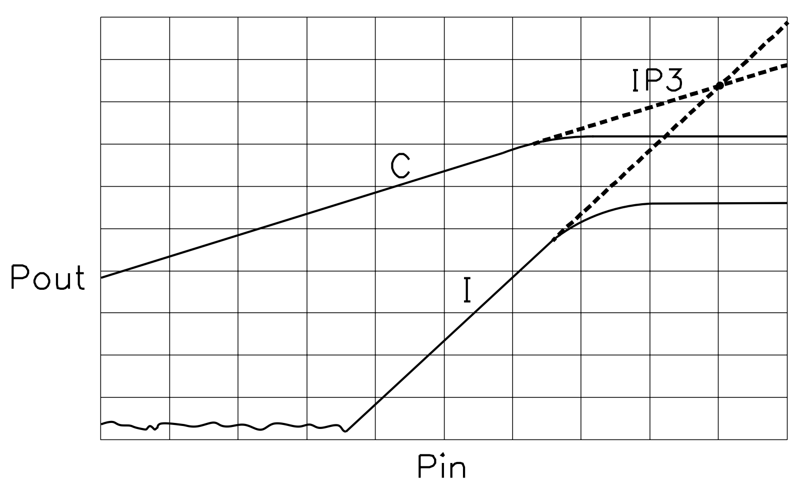

Figure A6-2. Measurement of Third Order Intercept Point

A6.4 5th and 7th Order Intercept Points

The 5th and 7th order intercept points (IP5 and IP7) are determined in a manner to IP3. The main difference is that the 5th order intermod increases with input power five times as fast as the carrier (in dBm units). The 7th order intermod increases with input power seven times a fast as the carrier (in dBm units).

Appendix 7

SNP Standard Files

Extension	File Description
.ACL	Adjacent channel power calibration file
.CFG	System configuration file
.CTL	Automatic sequence control file
.DC	DC I-V measurement data file
.ICL	Intermodulation Distortion calibration file
.LP	Load Pull data file
.LP2	2nd Harmonic Load Pull data file
.LP3	3rd Harmonic Load Pull data file
.NCL	Noise calibration file
.NS	Noise source definition file
.PCL	Power calibration file
.PM	Power Meter sensor definition file
.TUN	Automatic Tuner characterization file
.S1P	1-port S-Parameter data file
.S2P	2-port S-Parameter data file
.S2B	Swept bias noise data file
.SF	Swept frequency noise data file
.SNP	Default system files
.SP	Source Pull data file
.SP2	2nd Harmonic Source Pull data file
.SP3	3rd Harmonic Source Pull data file
.SWP	Swept power measurement data file
.SPL	Sweep Plan data file
.TP	Sweep Plan setup file
.XLS	Spread sheet file with contour data