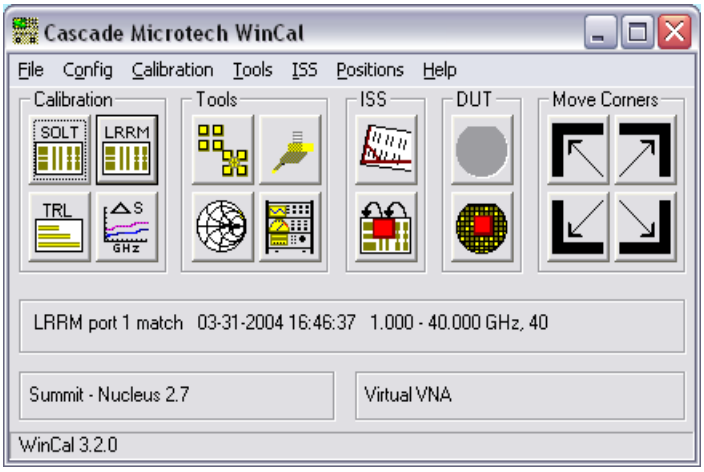
Technical Publication

Innovating Test Technologies

WinCal 3.2

User's Guide



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Before You Begin

About This Guide

Welcome to the *WinCal 3.2 User's Guide*. The purpose of this guide is to serve as an introduction to the features and benefits of WinCal, and to serve as a reference to the application. For information on how to use WinCal, consult the online Help.

Guide Contents

Chapter		Description
1	Getting Started	Provides a brief overview of the WinCal application and lists instructions for setting up, configuring, and starting the WinCal system.
2	Navigating in WinCal	Provides an explanation of how to navigate the main windows and buttons that activate the key features of WinCal.
3	Calibration	Describes several calibration methods and why they are important, including SOLT/SOLR, TRL and LRM/LRRM.
4	Graphs Overview	Explains how to generate and customize an automatic graph of your results using WinCal.
5	Semiautomatic Features	Explains how to use WinCal on a Cascade semiautomatic probe station in conjunction with Nucleus software.
6	Accuracy Tools	Describes the interpretation of verification graphs, calibration stability graphs, and probe tests to ensure accuracy in calibrations.
7	Measurement Tools	Describes how to read, display, save and print S-parameters in WinCal. Includes information on removing pad parasitics.
8	Automating and Extending WinCal's Functions	Describes standard, and WinCal-specific Automation features used for making advanced calibrations.

Appendices		Description
A	GPIB Switch Box	Explains installation and use of the GPIB switch box.
B	Nucleus GPIB Driver for WinCal	Explains installation and configuration of the Nucleus GPIB driver for WinCal.

NOTATIONAL CONVENTIONS

This manual may use the following warnings or comments:



WARNING is used to indicate the presence of a hazard which can cause severe personal injury, death, or substantial property damage if the warning is ignored.



DANGER is used to indicate the presence of a hazard which will cause severe personal injury, death, or substantial property damage if the warning is ignored.



CAUTION is used to indicate the presence of a hazard which will or can cause minor personal injury or property damage if the warning is ignored.

This includes situations that ***may*** cause damage to hardware via electrostatic discharge (ESD).



NOTE is used to indicate important information about the product that is not hazard related.

For More Information

For more information about WinCal 3.2, refer to the following:

- Read the text file "wcreadme.txt" for release notes and late-breaking news
- Use online Help for details on the user interface
- *See also*, additional documents on the CD. You may want to install them to a sub-directory in WinCal.
- Check out Cascade's web site for answers to "frequently asked questions" (FAQ) and to retrieve application notes: (www.cascademicrotech.com)
- Contact Cascade's Customer Support at (800) 550-3279

CHAPTER

1 Getting Started

Overview

WinCal is a high performance on-wafer measurement environment for vector network analyzers (VNA). WinCal guides you through the error-prone process of VNA calibration and gives you valuable tools for making measurements and ensuring their accuracy:

A complete probe database provides proper calibration coefficients for any Cascade microwave probe. Calibration verification and stability displays help you to diagnose measurement system flaws or determine when system drift has occurred and when a new calibration is needed. WinCal functions are unobtrusive while allowing you to retain control with maximum flexibility and adaptability.

WinCal is a fully functional windows application. Measurements can be displayed in a variety of formats, and may be printed or pasted into other applications, such as Microsoft Word; thereby, allowing quick and simple documentation of laboratory results. WinCal's use of industry standard S-parameter file formats and rich Automation features, ensure compatibility and easy customization. Visual Basic, or any of the many programming, application, or test environments with Automation capability may be used.

When used with a Cascade PS21; R61-, S300- or Summit-series semiautomatic probe stations, WinCal provides the ultimate in calibration convenience — the one button calibration. WinCal features are also fully integrated with Cascade's Nucleus software. Precision Impedance Standard Substrate (ISS) movements are controlled by WinCal, providing the best calibration repeatability, consistency, and convenience available.

PC Requirements

- 150 MHz Pentium II compatible processor or better
- Windows 98-second edition, Windows NT 4-SP6, Windows 2000-SP2 and Windows XP
- 128 MB RAM for 98, 512 MB for 2000/XP
- 9 MB (minimal install) to 50 MB (full install) available hard disk space
- CD-ROM drive
- Mouse or other pointing device

- GPIB card and drivers with the VISA runtime library installed and passing internal self test.
  - For an Agilent card, an I/O library version of K1.0 or later is required
  - For a National Instruments card, the driver must be 1.6 or later with VISA runtime 2.5 or later (the latest version of drivers and VISA runtime modules are available for download on the manufacturer's websites)
- Nucleus 2.0.13 (or later 2.0 version), Nucleus 2.1.1 (or later 2.1 version), PS21 v.2.0.10 (or later 2.0 version), or a manual probe station



NOTE

PCS-based probers are NOT supported.

Setting Up WinCal



CAUTION

When installing WinCal, you will be prompted to indentify your VISA setup. If you select National Instruments VISA, you may be asked to re-boot your computer after WinCal installs National's VISA application. Select "No" (DO NOT REBOOT at this time), and continue to finish the WinCal installation. Then, re-boot for both applications to be successfully installed.

If you select Agilent's VISA application, WinCal will identify Agilent's VISA application as being resident on your computer, if indeed it exists. If Agilent's VISA is not resident on your computer prior to the WinCal installation, you will need to install version "K" or later before installing WinCal. WinCal will not work with versions prior to "K".

The option "None" is for virtual setup only and is not used with any VISA application.

Manual or Non-Cascade Summit-Series Semiautomatic Probe Stations

For all operating systems, insert the WinCal installation disk into the appropriate drive. The setup program will autostart. Then, follow the on-screen instructions.

By default, the setup program puts WinCal in C:\ProgramFiles\Cascade \WinCal32 and creates a WinCal 3.2 program group and desktop icon. You can change the defaults during the installation, but we recommend that you install WinCal into its own directory.



NOTE

See Nucleus documentation to add motorized positioners

Cascade Summit-Series Semiautomatic Probe Stations

Install Nucleus software before installing WinCal. Also, install WinCal in a separate directory from Nucleus. Follow the previous installation procedure.

Updating Older Versions

WinCal can be installed over an older version. When you restart WinCal, you may see a message relating to the default configuration file (default.wcf) that will have an older version number (a newer default.wcf file is yet to be installed). This is not an error condition, but tells the operator that the old file will be ignored and that a new file will be created when WinCal is terminated.

Hardware Key Drivers

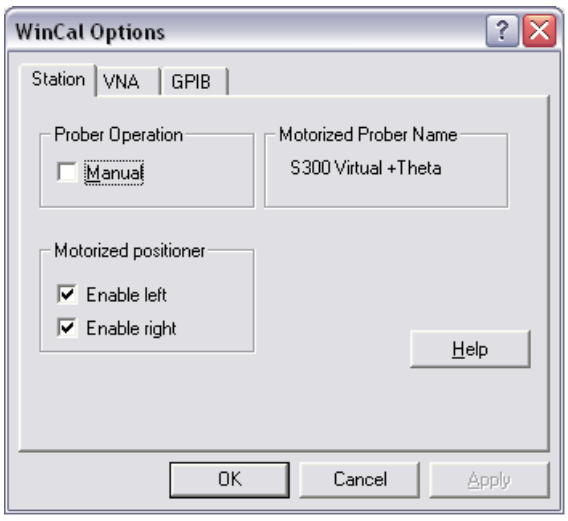
The hardware key (Sentinel SuperPro) is attached to the parallel port on the PC. Other Windows programs, such as the printer spooler, may also access that port. The regular WinCal installation program adds a parallel port driver, unless you install WinCal as "demo only."

Configuring WinCal

Select the **Config-Options** menu to verify or change probe station operation between manual and semiautomatic, or to change VNA's and GPIB handshaking settings. Normally, configuring WinCal requires only that you select your Vector Network Analyzer (VNA) model and that it have the appropriate GPIB parameters. For Summit-series semiautomatic probe stations, verify that the proper station and optional positioners are identified properly.

Installing Motorized Positioners

When you purchase a Cascade probe station configuration that includes motorized positioners, the system is set up for you at the factory. However, if you install motorized positioners yourself, you will have to first activate them in Nucleus before WinCal can control them. In the WinCal Options Stations tab you can then enable the positioners for use by WinCal.



SELECTING A VNA

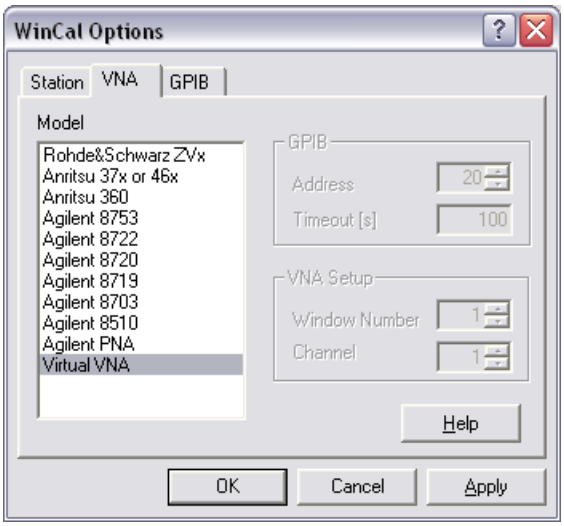
A vector network analyzer (VNA), combined with Cascade 50-ohm probes, provides a powerful tool for IC or module characterization, verification, or screening measurements. Calibrating the VNA with on-wafer standards at the probe tips enables you to subtract repeatable errors from the VNA, cable, and from probe losses and reflections. The VNA in your system controls many of the options available for setting up WinCal. Make sure you select the correct type of VNA.

WinCal supports the following VNA's:

- Agilent 83xx series (PNA)
- Agilent 8510 B and C
- Agilent 87xx series (most models)
- Anritsu 360B
- Anritsu 37xxx series (Lightning) and 46xxx series (Scorpion)
- Rohde & Schwarz ZVK, ZVM

WinCal also has a Virtual VNA mode, so you can review WinCal functions when not connected to a VNA. This is useful for demonstrations or training.

Select your VNA from the Config-Options VNA tab.



GPIB

The IEEE-488 general purpose interface bus (GPIB) allows test and measurement instruments to communicate with each other. WinCal uses the GPIB to control the VNA for automated calibrations and measurements. In addition, WinCal supports primitive control of other equipment using Literal GPIB Instrument Commands. Also see, the GPIB Switch Box on page 53.

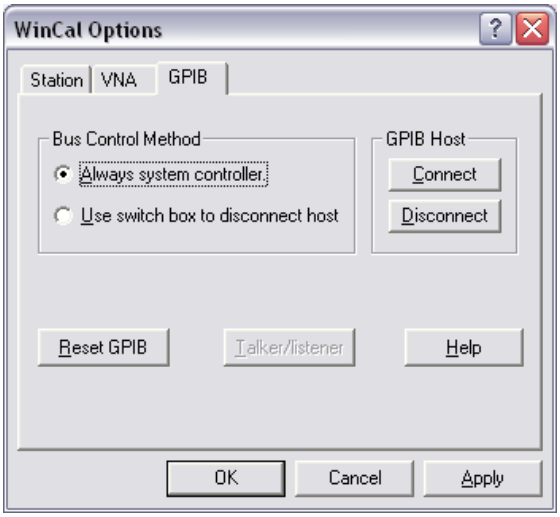
For detailed information about the GPIB, refer to the *Nucleus Communications Guide* or to *IEEE standards 488.1-1987 and 488.2-1987*.

A GPIB board (and its drivers from National Instruments or Agilent), should be installed before WinCal is installed. The Virtual Instrument Software Architecture layer (VISA) and its driver (visa32.dll) should also be installed. Use National's or Agilent's instructions and CD to install the GPIB and VISA drivers (this does not apply for demo installations without any GPIB boards).

WinCal will not run if the existing GPIB drivers and VISA runtime library are outdated. The required National Instrument driver version is 1.6 (or later) for all operating systems, and their VISA runtime library (version 2.5 or later) is also needed. Contact National Instrument's web site for updated drivers. The current and required I/O library for an Agilent card is L1.0 (or later) and contains both drivers and VISA runtime. It can also be downloaded from Agilent's website.

Any card that is too old to be supported by the driver's version, which was stated previously, is outdated and should not be used with WinCal 3.2.

Before you can use the GPIB to communicate with your VNA, you must make some handshaking and configuration selections. Consult online Help for instructions on setting up GPIB communications.



What's New in this Version

Version 3.2

- Support for Rohde & Schwarz VNA, models ZVK and ZVM
- Some corrections were made to the PS300 prober driver
- The step sizes of wide pitch ISS's were corrected

Version 3.1.2

- Supports reading up to 6401 data points (previous max was 1601). See the wcReadme.txt that comes with the application.
- New probe calibration coefficients have been added for the 110 GHz Infinity GSG probe.

- A new and improved On-Line Help file is included.
- The Pad Parasitic Removal feature can now manage less than perfect data.

VERSION 3.1.1

- New probe calibration coefficients have been added for the Infinity Probe.
- Improved safety: a warning is now displayed if Nucleus' contact height setting has changed since a WinCal position was recorded.
- Support has been added for the Anritsu Scorpion (46xxx -series) VNA.
- The ability to send SOLT calkits to the Anritsu Lightning (27xxx & 37xxx) and the Scorpion (46xxx) series VNA has been added.

VERSION 3.1

- Support for Agilent Network Analyzers (PNA's)—models 835x-series and 836x-series—has been added.
- For the PNA-series and for the 8510 Vector Network Analyzer, calibration can now be done on a specific channel.
- The S-Parameter tool now supports overlaying traces. Up to six traces can be overlaid on the display at one time.
- S-Parameter files can be saved in Magnitude-Angle and dB-Angle (in addition to the real-imaginary format available in previous versions).
- Support has been added for Agilent HPIB interface cards. Note that this capability is only valid on manual probe stations. Semiautomatic stations that use Nucleus will still need to use the National Instruments GPIB card. See the most current version of the *Nucleus User's Guide* for further details.

Starting WinCal

All operating systems:

Start Windows, and then click the Start button.

- Select WinCal from the Launch menu.

-OR-

- If you're installing from Nucleus software, select WinCal from the toolbar.

Using Virtual Mode

For demonstration or for training purposes, you can operate WinCal software on a computer without a VNA attached. WinCal will simulate measurements and calibration data. The virtual VNA setting is useful for learning WinCal functions or for developing Automation applications. WinCal will run in virtual mode without a security key, allowing experimentation and development away from the laboratory.

CHAPTER

2 Navigating in WinCal

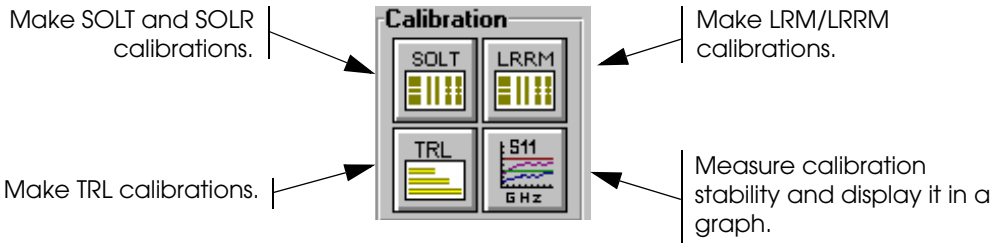
Features

Full descriptions of the features follow this section.

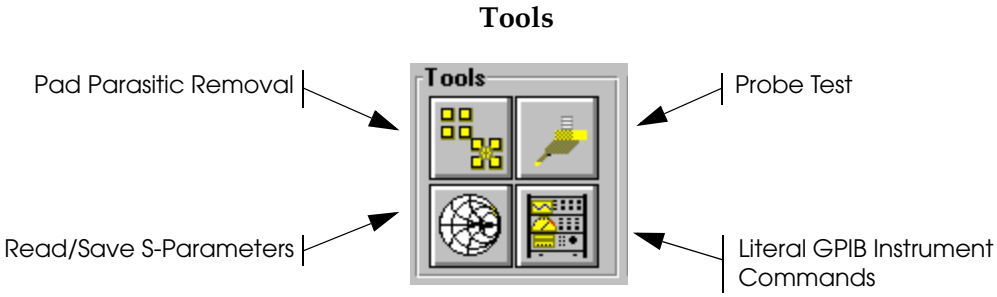
KEY FEATURES

The buttons that activate the key features of WinCal are described in this section.

Calibration



Tools



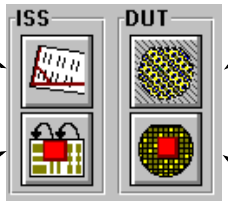
ADDITIONAL FEATURES

The following features are available when using automatic and semiautomatic probe stations.

ISS

Make a software alignment of the ISS for use with automatic calibrations.

Record positions of ISS standards for use with automatic calibrations.



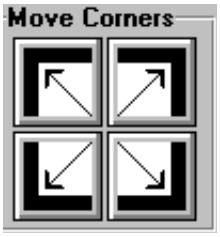
DUT

Move to the recorded wafer die site on the DUT.

Record the wafer die site on the DUT.

Move Corners

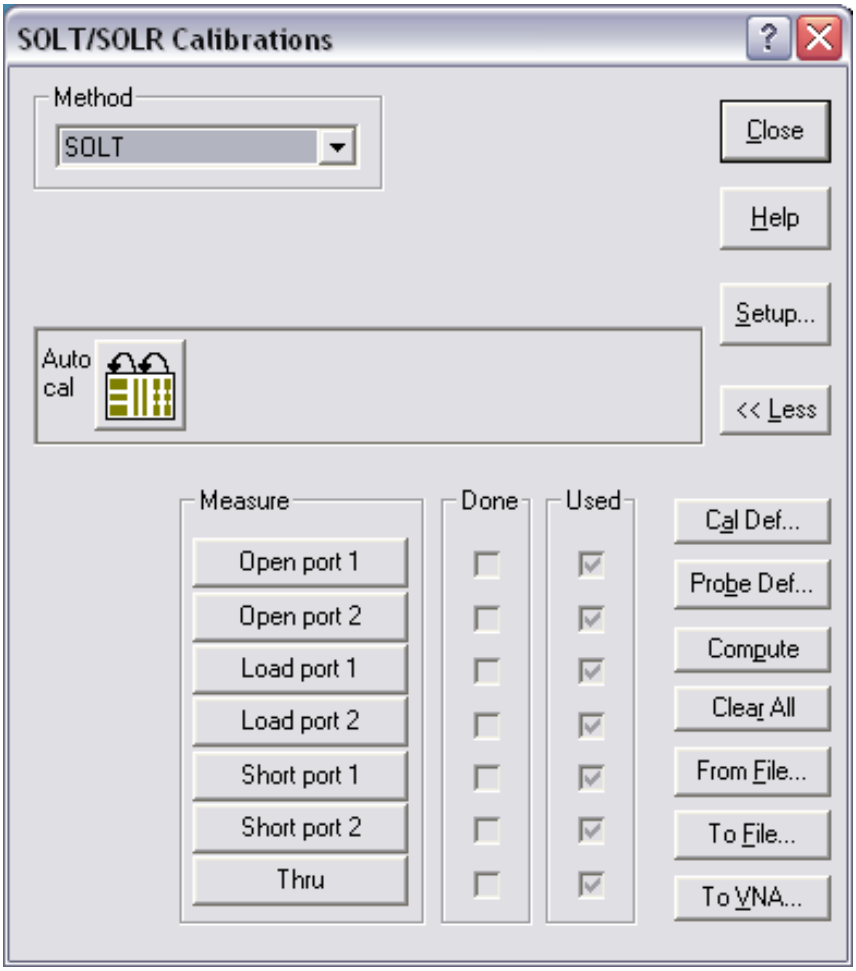
Move stage to position the probes in one of the four corners.



Calibration

MANUAL STATIONS

A typical calibration dialog box on a manual station will appear similar to the ones below. *See also*, Chapter 5, Semiautomatic Features, to see the dialog for semiautomatic stations.



Method

The *Method* pull-down menu allows selection of a specific calibration method within a calibration type.

Setup

Setup provides configuration options for the calibration sequence.

Auto-cal

Auto-cal begins a sequence of steps to complete a calibration. For manual probe stations, this is accomplished interactively. For S300, PS21, and Summit-series semiautomatic probe stations, Auto-cal will run independently to completion.

More/Less

The *More/Less* » button enables or disables additional elements in the dialog box.

Measure

The *Measure* buttons allow measurement of individual calibration standards. This is useful for the measurement of standards that are out of the sequence order used for Auto-cal, or they're useful to re-measure a single standard.

Check boxes

The *Done* check boxes indicate whether data has already been measured (or loaded) for each particular calibration standard.

The *Used* check boxes indicate which calibration standard measurements are required for the selected calibration method.

Cal Def

The *Cal Def* button allows entry of calibration standard information that may be required.

Probe Def

The *Probe Def* button (SOLT only) is used to choose probes or probe calibration coefficients.

Compute

The *Compute* button will perform the calibration computation and optionally display a verification plot. This is used when independently measuring or re-measuring standards to re-compute the calibration.

Clear All

The *Clear All* button deletes the recorded data.

To File

The *To File* button allows saving the calibration standard's data to a named file.

From File

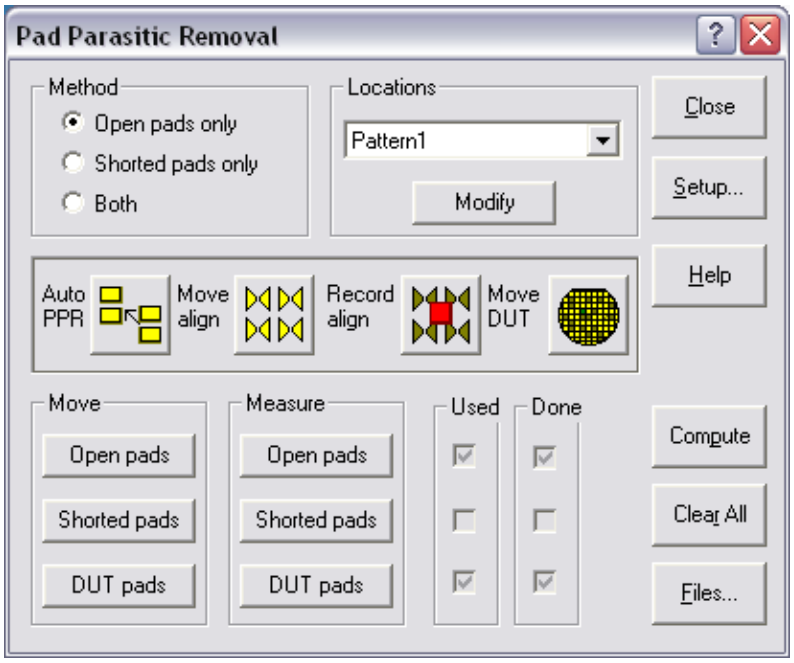
The *From File* button allows loading the calibration standards data from a named file.

To VNA

The *To VNA* button completes the calibration by downloading the computed error coefficients to the VNA. Subsequent VNA measurements with or without WinCal will benefit from the calibration.

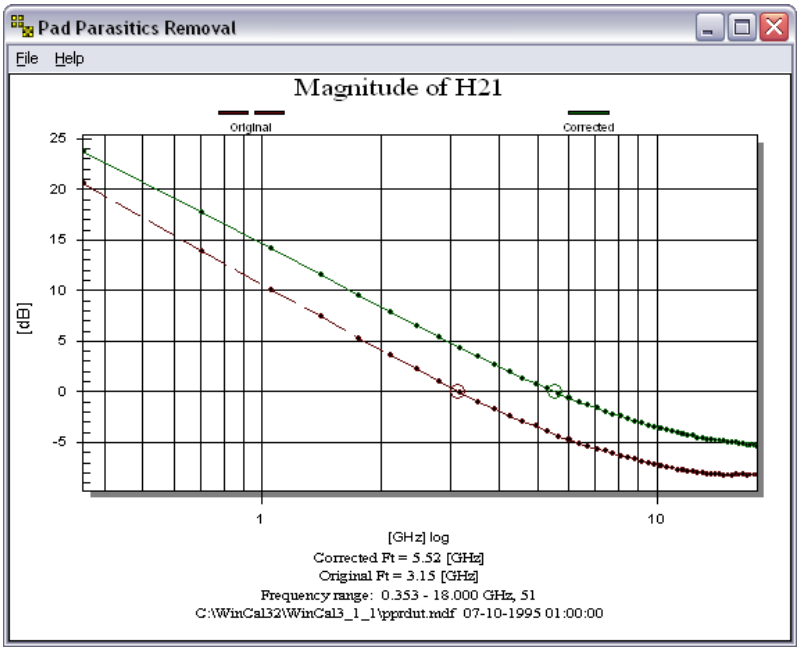
PAD PARASITIC REMOVAL

The Pad Parasitic Removal (PPR) feature removes pad effects from the S-parameter of a device under test (DUT) measurement.



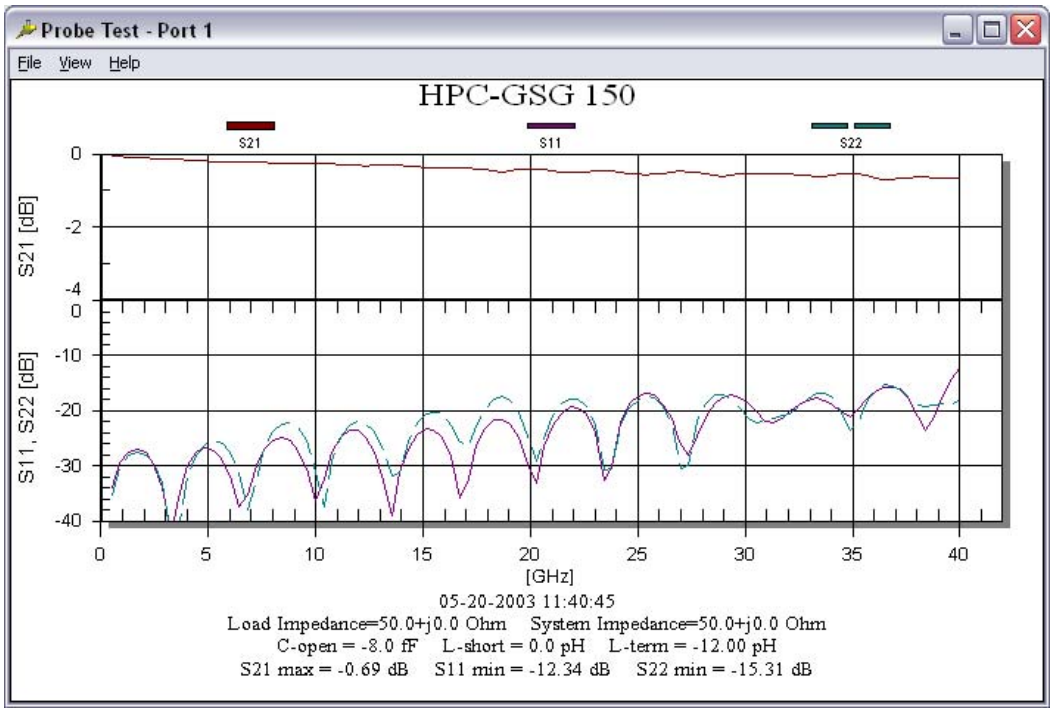
To view the pad parasitic removal window

Click , or choose *PPR* from the Tools menu.



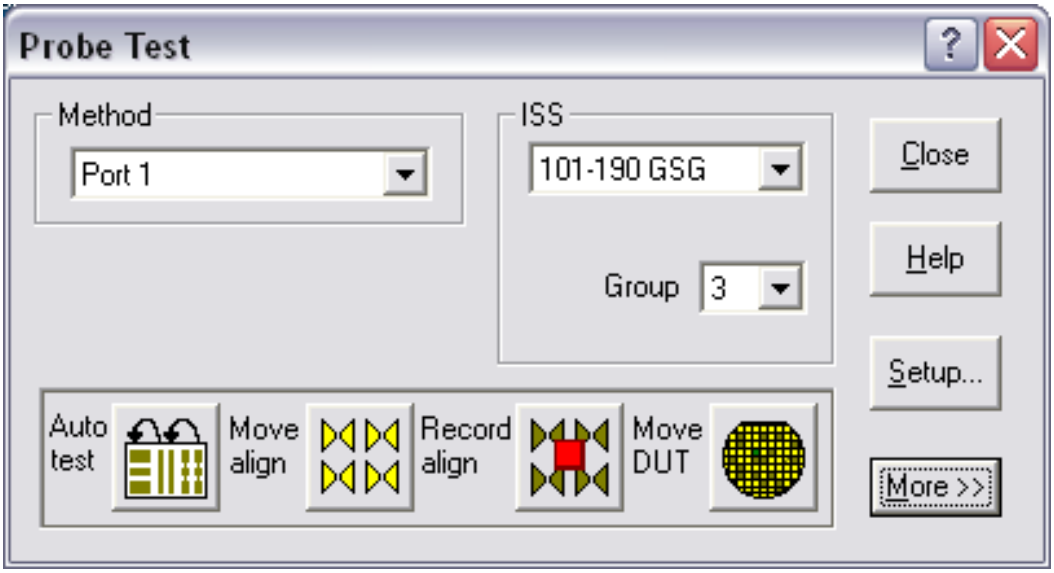
PROBE TEST

The Probe Test feature lets you measure the S-parameters of your probe and evaluate its condition in a graph.



To view the probe test window

Click , or choose *Probe Test* from the Tools menu.



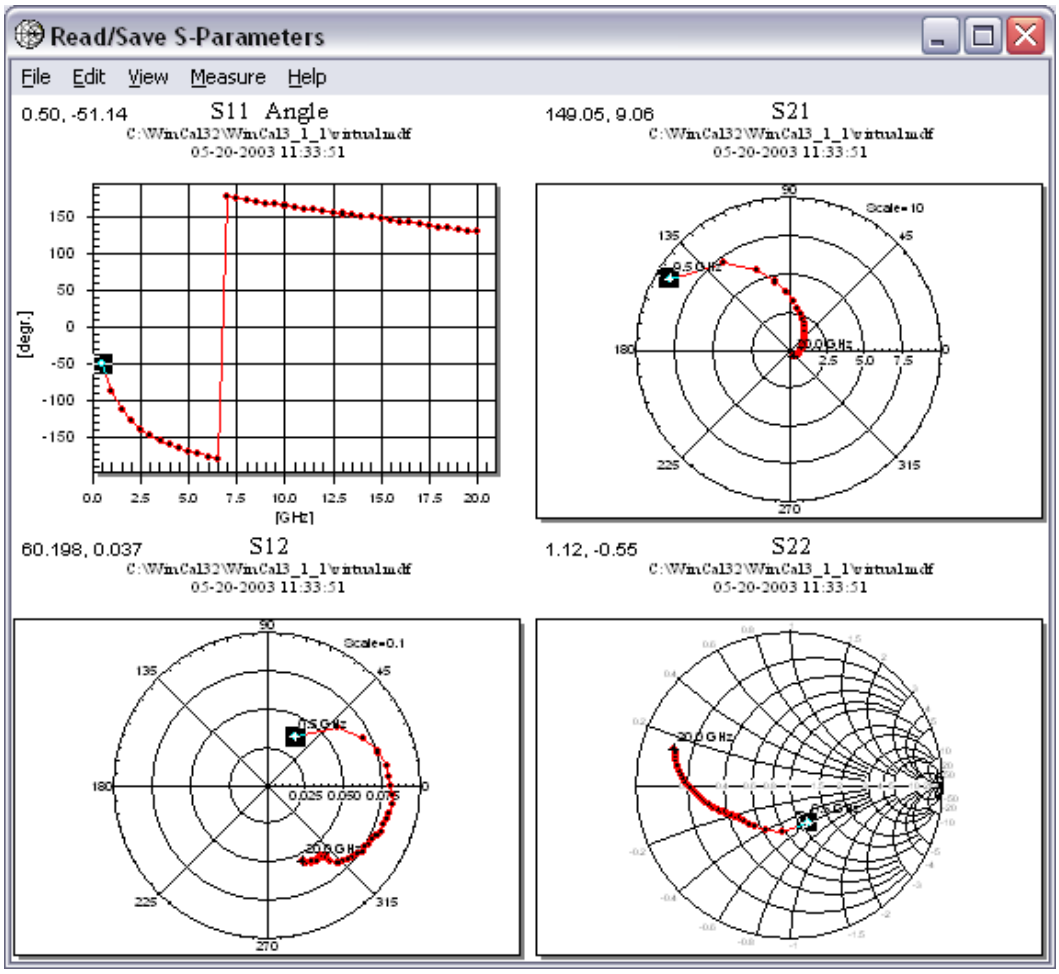
S-PARAMETER

The *S-parameter* feature allows you to read uncorrected or corrected S-parameters from the VNA and display them in various graphing formats. You can also save them to a Touchstone-format file and then re-read the files at another time.

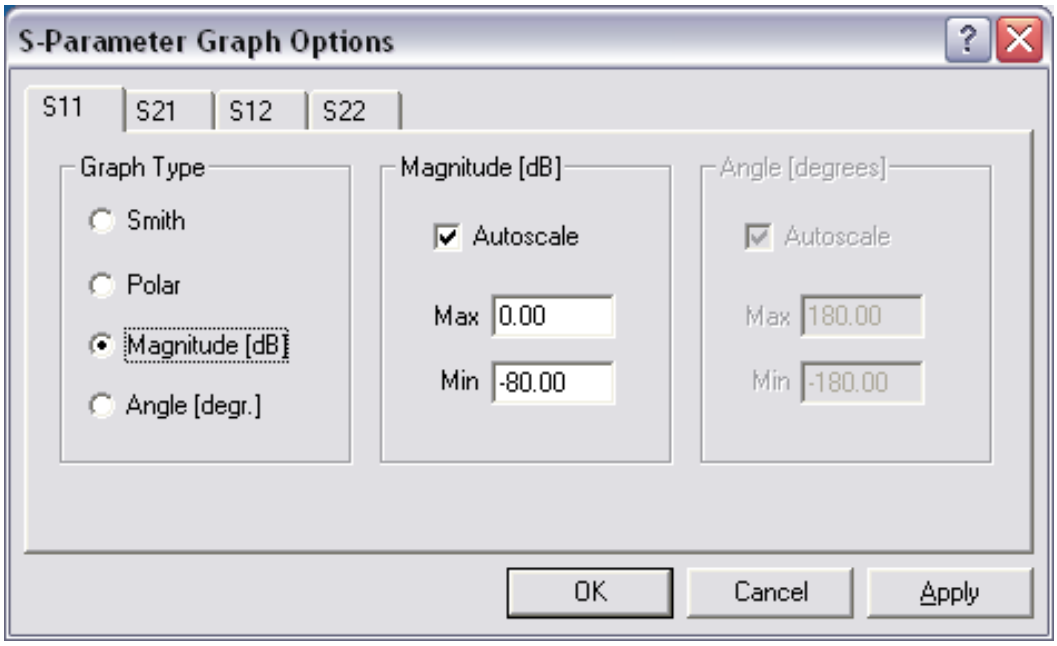
To view the Read/Save S-Parameter window

Click , or choose *S-para* from the Tools menu.

After selecting "Measure 2-port VNA calibrated (or raw) S-parameters", use "All four S" to display the following window:

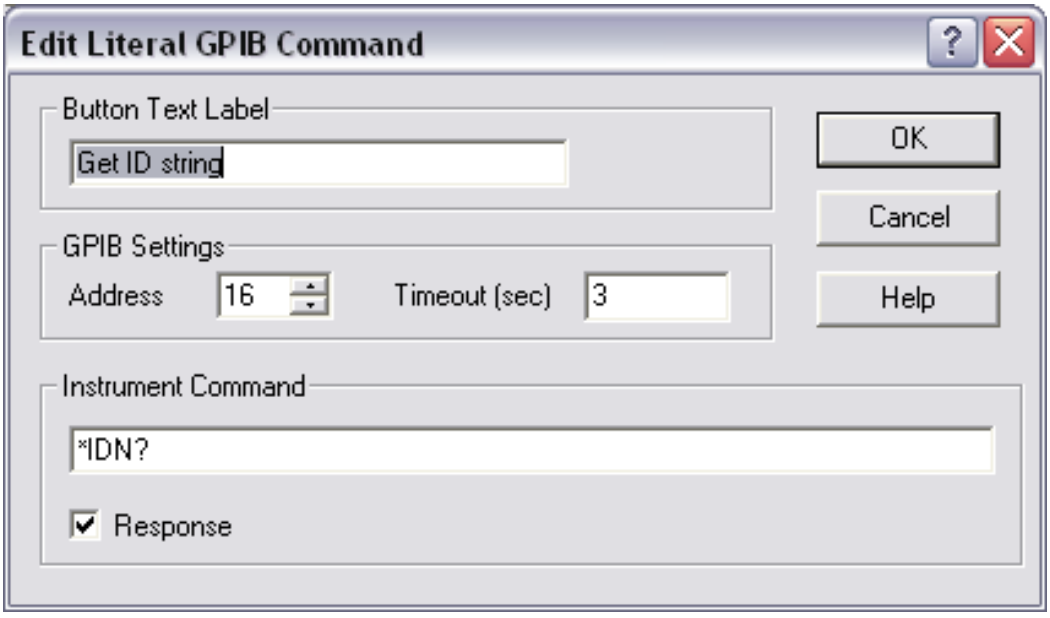


Use “View/Options” to display the following dialog:



LITERAL GPIB COMMANDS

The *Literal GPIB Commands* feature allows you to send direct commands to your instruments by using that instrument’s GPIB command set, and also allows a response from the instrument when applicable. This feature will store up to 10 commands for later use. Use the Literal GPIB Commands “Edit” dialog box to enter the command string with a label for the button that sends it.



To activate literal GPIB commands

Click , or choose Literal GPIB Commands from the Tools menu.

ISS

The Software Align of an ISS allows you to have the wafer mechanically aligned and allows WinCal to compensate in software for the difference in alignment between the ISS and the wafer (N/A for manual stations).

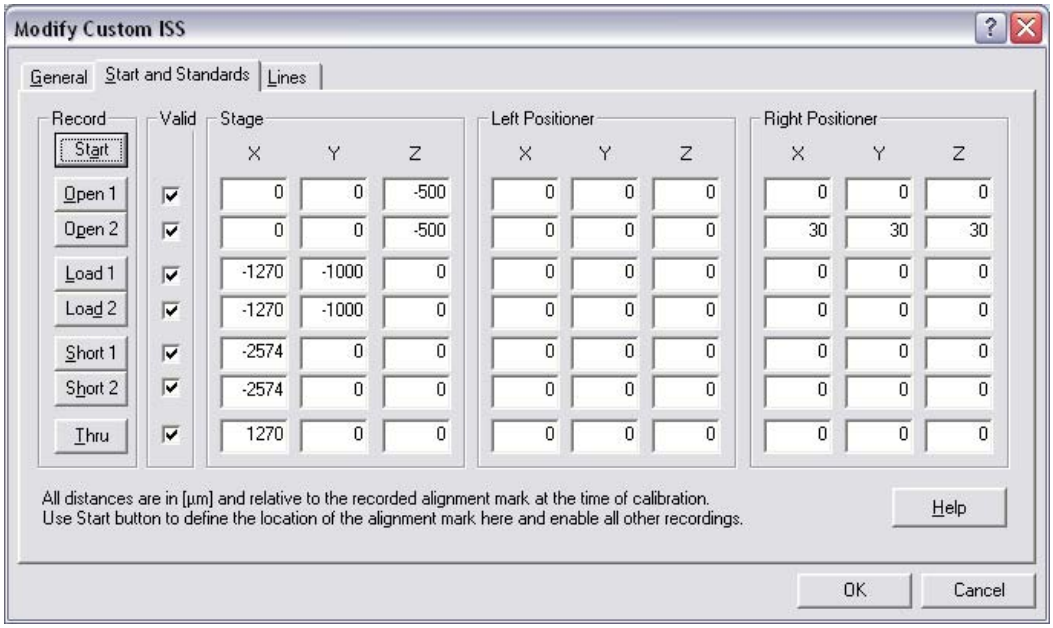
To activate ISS

Click , or choose *Align ISS* from the ISS menu.

The *Record ISS* feature allows for automatically moving to calibration standards at any custom location. Standards can be recorded by moving to them, or if the layout is known, the relative distances can be entered directly. This is useful if you are using a non-Cascade ISS and have the standards on your wafer, or if you want to use TRL calibrations where the lines must be recorded in this manner (N/A for manual stations).

To activate "Record ISS"

Click , or choose *Record ISS* from the ISS menu.



DUT

Device under test (DUT) allows recording of any position, moving stage and motorized positioners when applicable, and later moving back to the same position. This feature can be used on any DUT; not just on a wafer (N/A for manual stations).

To activate "Move to DUT"

Click , or choose *Move to DUT* from the Positions menu.

To activate "Record DUT"

Click , or choose *Record DUT* from the Positions menu.

CHAPTER

3 Calibration

What is a Calibration?

VNA calibration is the process of measuring devices with known (or partly known characteristics) and using these measurements to establish measurement reference planes. Calibration also corrects for imperfections in the measurement system. These imperfections not only include the non-ideal nature of cables and probes, but also the internal characteristics of the VNA itself.

The VNA is calibrated in much the same manner as the "zero" button on your ohmmeter subtracts out the resistance of the test leads. On an ohmmeter, when you push the "zero" button, it stores a measurement that is subtracted from all future measurements. These corrected measurements are referred to as "de-embedded". The obvious error is simply a resistance in series with the test port.

A VNA does the same thing, but uses a more complex error model with terms for each frequency point. The measurement system is described as an ideal VNA, with an error adapter network that models all of the systems non-idealities: directivity of the couplers; imperfect match looking back into the reflectometer (test set ports); imperfect frequency response of the reflectometers; the transmission between ports; and the cross-talk between ports.

Why is Calibration Important?

VNA's rely on calibration for accuracy, even in measurements with the reference plane defined at the instrument front panel connectors, or at the ends of cables. Calibration functions are provided that allow the user to record measurements of standards, compute the error models, and automatically apply corrections to DUT measurements.

Where an ohmmeter's calibration simply used a short circuit (connecting the test leads together) to determine the extra resistance term in the error model, a VNA uses multiple calibration standards (typically open circuits, short circuits, loads, and thru connections).

Calibration Features

Wincal automates your two-port Line Reflect Match (LRM), Line Reflect Reflect Match (LRRM), Short Open Load Thru (SOLT), Short Open Load Reciprocal Thru (SOLR), and Thru Reflect Line (TRL) calibration tasks.

WinCal also provides you with advanced LRM, LRRM, and TRL features to let you manually control the calibration sequence for experiments and troubleshooting.

WinCal can:

- Simplify calibration of the Vector Network Analyzer (VNA) using the SOLT, SOLR, LRM, LRRM, or TRL methods.
- Record the locations of calibration standards from a custom or user-defined calibration substrate.
- Load a calibration to the VNA directly from WinCal (automatically modified for your particular probe).
- Check calibration drift by displaying the difference in open S_{11} or S_{22} magnitudes between a previous calibration and the current VNA reading.
- Align Impedance Standard Substrates (ISS) independently from wafers.
- Control motorized positioners for calibrations using standards of varying length.
- Compute and remove pad-parasitic effects from your calibrations.
- Read S-Parameters from the VNA, display them in Smith or Polar charts, print the charts, and save the S-parameters to a file.
- Test your probes by calculating their S-parameters.
- Be used with a manual probe station. WinCal prompts you to make all moves.
- Compute error coefficients and store them in the VNA.

Calibration Types

Various types of calibration methods are possible and are normally referred to by the standards they use.

Calibrating with the SOLT/SOLR Method

By far the most commonly used method, the Short-Open-Load-Thru (SOLT) calibration, is available on every commercially available VNA. This calibration is the combination of two one-port Short-Open-Load calibrations, with additional measurements of a thru standard to complete the two-port calibration. All of the standards must be fully known and specified.

The SOLT standards are reasonably well-modeled with simple lumped elements: open-circuit capacitance, short-circuit inductance, load inductance, and thru delay (and loss). Often the open-circuit capacitance will have a negative value since the probe lifted in air has less tip loading than when in contact with a wafer.

The short and load standards are difficult to specify accurately, since their inductance values are very dependent on correct probe placement on a standard. A small 1 mil (0.001-inch=0.0254 mm) change in the overlap of the probe tip over the standard can result in a significant change in the inductance value.

Calibration coefficients must be correctly entered into the VNA to do any good. This would seem to be an easy task with only three coefficients per probe, but improper cal kit entry is one of the largest sources of error in on-wafer VNA measurements. VNA front panel data entry of calibration coefficients can be tedious and error prone.

An alternative to the SOLT calibration is the Short-Open-Load-Reciprocal (SOLR) advanced calibration. This algorithm is similar to the SOLT calibration for one-port correction, but the redundant information available in the standards set allows the "R" standard to be any reciprocal two-port. Only an estimate of the delay of the thru standard is required to complete the calibration.

The SOLR algorithm is very powerful when only non-ideal thru standards are available: orthogonal probes, excess thru line length, lossy or mismatched thru line, incompatible port geometries (pitch), etc. The SOLR calibration algorithm is an advanced calibration method and is not directly available on any VNA presently made.

WinCal makes it easy to define one-port SOL and two-port SOLT/SOLR calibrations. When you use supported probes, WinCal defines their calibration constants for you.

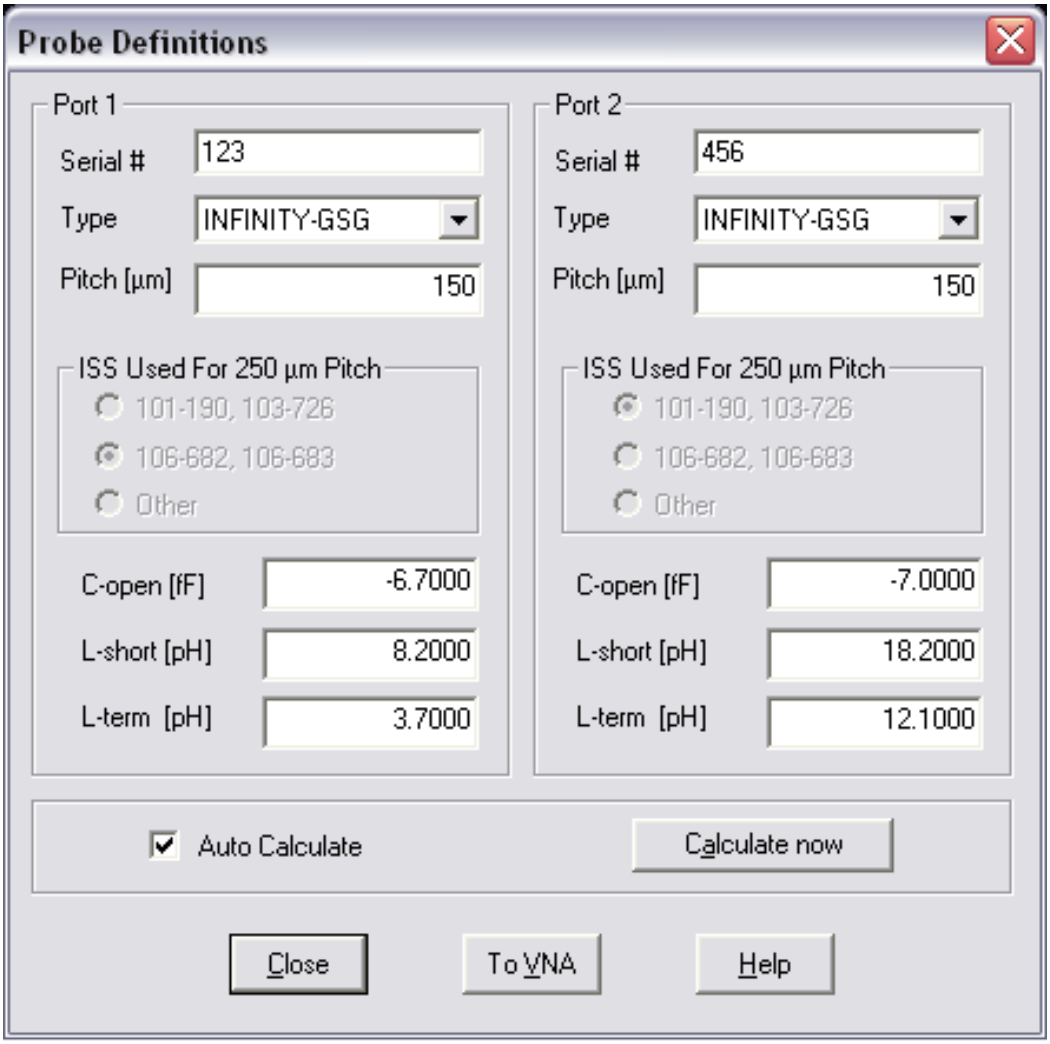
If you use unsupported probes, you must enter the appropriate values. See *WinCal Online Help* for a current list of probes that are supported.

For some VNAs, WinCal can also set up a VNA SOLT cal kit.

If you use Cascade probes supported by WinCal, you need not input probe information manually. Instead, once you select a supported probe, WinCal loads their calibration constants automatically into the SOLT probe definitions dialog box. You then download this calibration kit into the VNA. Note that you don't need to "download the calibration kit" to the VNA unless you plan to do a front panel SOLT calibration on the VNA later.

If you use WinCal to do the SOLT calibration it will do all the math for you and put the result (error coefficents) into the VNA.

For other probes, you specify the probe parameters in the Probe Definitions dialog box. Once you specify parameters, download the modified calibration kit to the VNA.



CALIBRATING WITH THE TRL METHOD

The most fundamental of these methods, the Thru-Reflect-Line (TRL) calibration algorithm, uses the characteristic impedance of a transmission line as the reference for calibration. Line pairs differing only in length are measured with a reflect standard that is known only to the sign of the reflection coefficient. The line length difference must not be near 180 degrees of phase since a half wavelength transmission line mimics a zero length line and provides no additional information. In practice, a line pair will only provide useful results over a 20 to 160 degree range of phase difference. Wider bandwidths require multiple line lengths to provide suitable phase differences over a wide frequency range.

The TRL calibration process itself does not determine the characteristic impedance that is the reference for the resulting S-parameters. Additional assumptions and measurements are required to determine the frequency dependant Z_0, due to loss. At low frequencies where the per-unit-length inductive

reactance is small compared to the ohmic loss, the imaginary part of Z_0 can be large. This effect is present at higher frequencies for high resistivity transmission lines, such as found in thin film circuits.

In the TRL calibration (and its variations), the thru line must be fully known to allow the measurement reference plane to be moved to the probe tips from the midpoint of the thru line.

Calibrating with LRM and LRRM Methods

An alternative to the TRL is the Line-Reflect-Match (LRM) calibration. An LRM (line-reflect-match) calibration is a method using three calibration standards: a line (or thru) standard, a reflect standard (that does not require definition), and two identical match (load) standards.

The LRM calibration uses TRL-like mathematics, but uses a broadband match standard to set the system impedance. The match essentially acts as an infinitely long, infinitely attenuating transmission line.

The LRM calibration standards are suitable for fixed probe spacing and can be used with probe cards or manual positioners. The standards are a subset of those used for SOLT since either the short or open can be used as the reflect standard. In on-wafer measurements, the open standard is preferred since it has no probe placement issues to effect repeatability. The conveniently available standards, combined with superior performance, make the LRM calibration a natural step to improving calibration accuracy that is beyond the accuracy achieved with SOLT.

A variation of the LRM method, the LRRM (line-reflect-reflect-match) calibration is a method where the unknown reflects are undefined shorts and undefined opens. You must measure the match on only one of the two ports. The match doesn't need to be precisely 50-ohms.

The LRRM method requires that you use the following calibration standards: a line (or thru) standard, two different reflect standards (that do not require characterization), and a match (or load) standard.

The LRRM method has one key advantage over the LRM method: it avoids discrepancies between the load reactance seen by the “port 1” and “port 2” probes.

You can specify load inductance with an LRM/LRRM calibration. If a load inductance is specified, WinCal includes the specified value in the calibration. This feature helps you determine where a calibration error occurs in the system.

CHAPTER

4 Graphs Overview

Introduction

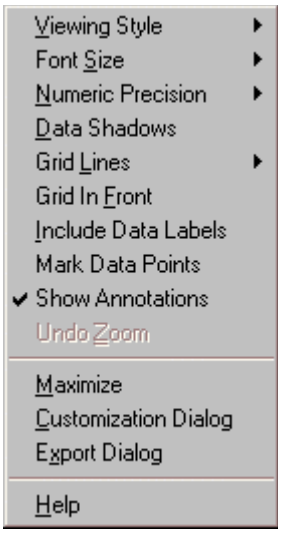
After completing a calibration, a probe test, a PPR computation, or when reading S-parameters, WinCal can automatically produce a graph where both visual and functional attributes are adjustable. The automatic displaying of a graph can be disabled in the setup for a calibration, a probe test, and a PPR.

Some graphs can be configured to display the data in different formats, e.g., S-parameters in Smith, Polar, dB-magnitude, or angle. Look for the menu item view, and if present, explore the different options.

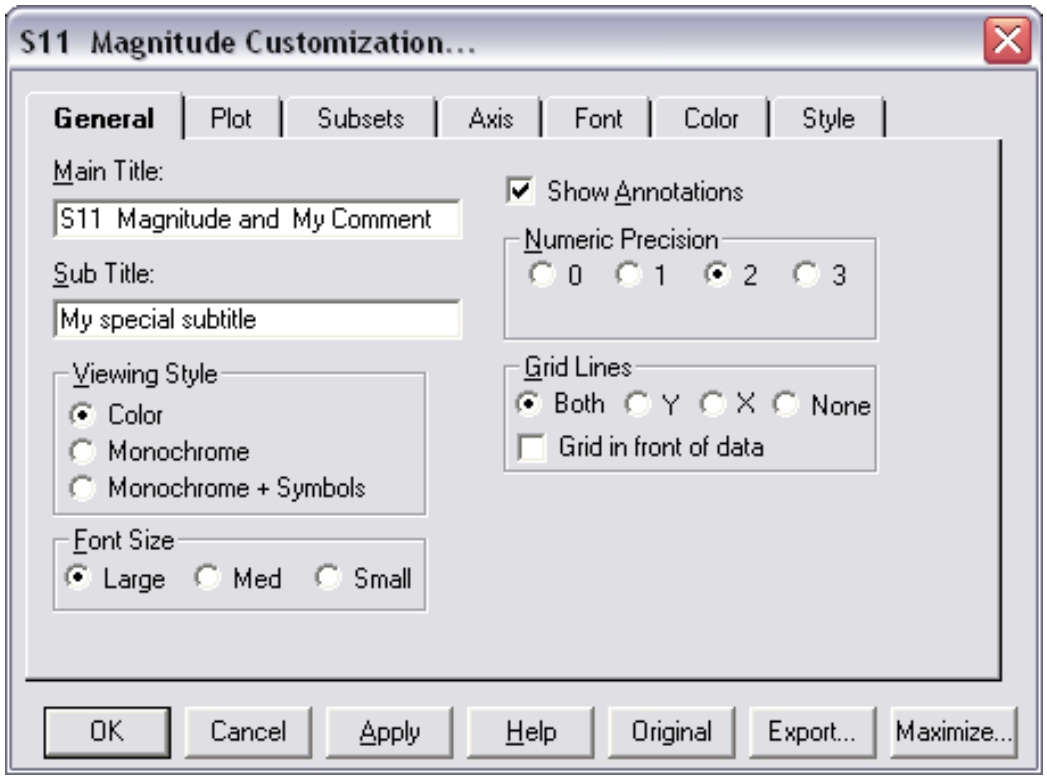
For the S-parameter graph you can also add a personal comment that will appear as one of the headers, and overlay traces using the S-parameter tool.

Right-Button Commands

Right-clicking the mouse in a graph window invokes a pop-up menu with options for customizing the graph. Most of these features are described in this chapter.



CUSTOMIZATION DIALOG



ZOOMING AND MAXIMIZATION

Zooming is the process of using the mouse to select new extents of the graph's grid, by pressing and holding down the left mouse button in a graph, and then dragging the mouse so that the data of interest is covered by the visible square. The right click menu has a "un-zoom" feature, or you can press the "Z" key to undo the change.

The graph windows have a special maximize feature that is different from standard Windows maximizing. Try it by pressing the "M" key when a graph has focus, or by right-clicking the mouse to invoke the pop-up menu and then selecting Maximize. There is also a button in the Graph Customization Dialog. You can return from maximize by pressing the *Esc* key or by clicking the mouse in the top bar.

VIEWING STYLES

Graphs support three viewing styles: color, monochrome, and monochrome with symbols. There are two sets of color parameters. A monochrome color set and a color set. Depending on the viewing style, the Colors Dialog will customize the appropriate set. Viewing style changes are not memorized by WinCal.

FONTS

Graphs only support True Type fonts (because they're scalable). You can select fonts for the main title, sub title, grid numbers and labels.

For the main title, sub title, and labels, you can also select font attributes for bold, italic, and underline text.

Support is for three font sizes: large, medium, and small. Depending on the size of the graph, you can select the font size that is most readable. When printing the graph, a medium or small font size is suggested. There are occasions (mainly when attempting to generate an image for a highly rectangular graph) when the graph may automatically reduce the size of the font in order to produce a higher quality image. Font changes are not memorized by WinCal.

PLOTTING STYLES

The graph supports many plotting styles: lines, points, points and line, bar, and stick are just a few of the available styles. Depending on the implementation, some plotting styles may not be available. Plotting style changes are not memorized by WinCal.

NUMERIC PRECISION

When placing data labels onto the graph, exporting Text/Data from the Export Dialog, or just scanning over the graph with the mouse, the number of decimal positions can optionally display between zero and three.

All graph objects have their own individual customization dialogs. The customization dialogs allow you to adjust visual and functional attributes of the object as well as gain access to the Export and Maximization dialogs.

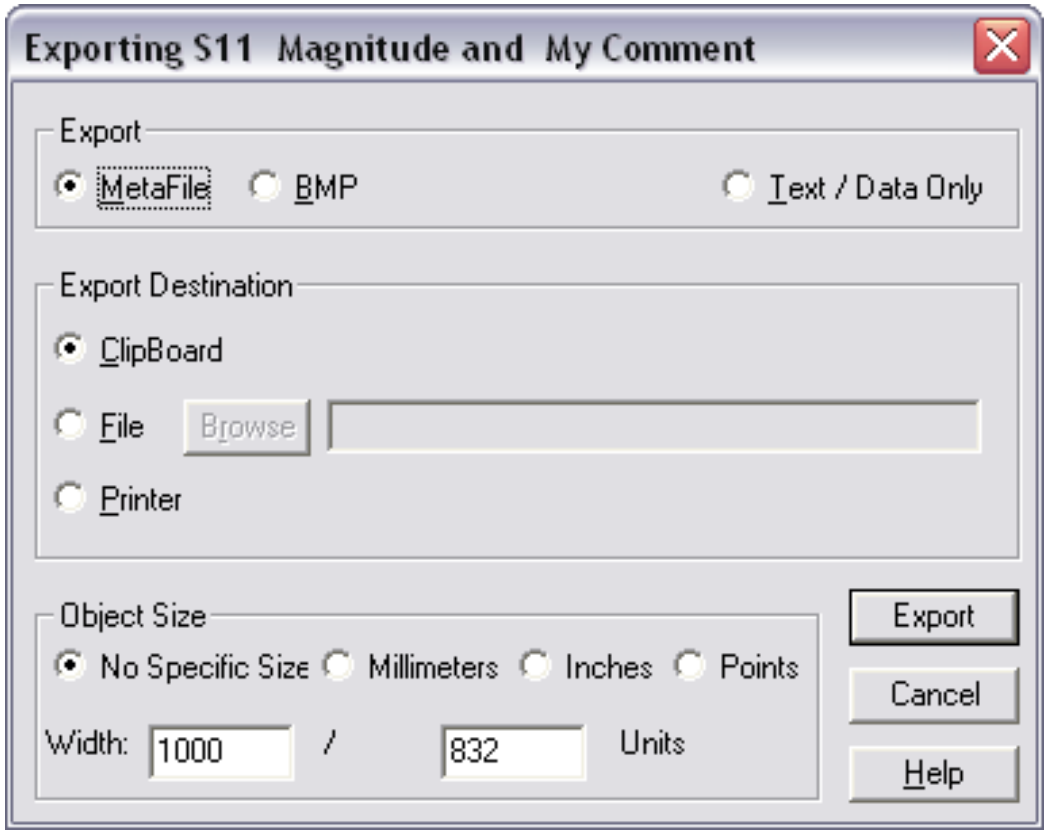
When the customization dialog is shown, the parameters it shows reflect the current state of the object. By making adjustments to the customization dialog and then pressing the "OK" button, you can update the custom set of parameters controlling the object. By pressing the "Original" button, the object will show the object with the original set of parameters. Precision changes are not memorized by WinCal.

SAVING GRAPHS

In the S-parameter graph you can save the S-parameter data to file. The setting regarding what S-parameters are displayed, the graph type and the scaling, will be saved in WinCal's standard configuration file. No customizing, such as font or color, or any other choices that affect viewing style can be saved. However, by exporting to the clipboard or to a printer, you may retain a paper or electronic copy of your graph with the customized settings.

EXPORT DIALOG

When exporting a Metafile or Bitmap graph to another program, you are exporting an image. Once the image is exported it's difficult to make adjustments to the image, e.g., transforming a color image to a monochrome image and re-sizing. Export choices include Metafile, Bitmap, or Text/Data Only. Because of the faithful reproduction that vector scaling provides to text, the Metafile is more flexible than the Bitmap.



NOTE

Any right-click operation is on a per graph window basis. If you are viewing the S-parameter graph that shows all four S-parameters, you have to click on the particular graph you want. If you want the same configuration/export operation for all four, you have to repeat it for all of them. You can, however, print all four on one paper, if you use the file print menu item.

Printing graphs

WinCal provides a print option so graphs can be analyzed off site. This is the standard print command from the file menu. You can also press the "P' key to invoke a print dialog for the graph that has focus.

CHAPTER

5 Semiautomatic Features

Introduction

Wincal supports both manual and semiautomatic stations. WinCal also supports Cascade's PS21, but only in semiautomatic mode. To use the semiautomatic features, WinCal must be installed on the PC that is controlling the station, and correctly configured with Nucleus software, or with the System Manager (PS21).

WinCal doesn't communicate directly with the station hardware, but uses the remote interface of Nucleus/PS21 instead. This applies to both the chuck (stage) and any optionally-installed motorized positioners. You should configure and test your hardware in Nucleus/PS21 before using it with WinCal.

WinCal's method of operating stage and positioners require that you first record or specify a location, and then later return to it. All other "live" movements should be done through Nucleus/PS21 and its tools. The exception is the command "Move Corner", which moves to the selected corner of the chuck near the general area where the ISS is typically located.

Each time WinCal is started it checks to see if you have any absolute positions recorded. If true, it will prompt you to verify that the positions are valid. Be careful and always answer "no" if you have made changes in wafer, ISS, or probe placement that would render currently recorded positions invalid. WinCal won't know that you have changed the physical coordinates and will try to move to the recorded coordinates. This move comes with a high risk of probe damage.

The DUT Position

WinCal's main window incorporates an interface to record a location called the "DUT position", and once recorded, move to it. The calibration dialogs also have an interface to move to this location, but do not record it. You can record any position you want as the DUT location. Motorized positioners will be included if they are enabled.

Impedance Standard Substrate

The ISS plays a central role in WinCal's automation. The ISS concept in WinCal is more than the physical substrate. It's also the mechanism for knowing where to move during an automated calibration or probe test. There are two types of ISS' in WinCal: standard and custom, where custom may not be a physical ISS at all. Both are described in following sections.

Because of the lines, the TRL calibration requires a custom ISS, but others may use both kinds of ISS.

The PPR feature has a different concept called "Locations". PPR does not use calibration standards, but instead uses open pads, shorted pads, and pads with a DUT. It's very similar to custom ISS' in the way it operates, but it's independent of them.

Software Align

The software align feature is useful if you have a physical ISS in one of the corner locations and a wafer in the middle. You would typically align the stage mechanically for the wafer using Nucleus, but that would move the ISS around and change it's alignment. WinCal's "software align" feature should therefore be used after the wafer is aligned, or when the physical orientation of the ISS has been changed. WinCal measures the x/y-locations of the left and right edge of the ISS and computes the angle. WinCal then compensates for the physical misalignment during the calibration sequence. An angle of up to approximately three degrees can be corrected without much skew on probe placement. First, try to visually place the ISS as straight as possible, as it's usually possible to stay well within the three degree limit.

THETA ON A PS21

The PS21 has motorized theta and commands to move theta, which WinCal will use to try to maintain a constant ISS angle between wafer loadings. In order to restore theta when moving back to the wafer, it is important to record a position on the wafer (that includes theta) *before* moving to a recorded ISS position. This can be done with both WinCal (main window DUT buttons or Positions menu) and PS21 (preset locations).

THETA ON AN S300

The S300 has motorized theta, but it only moves the wafer area and not the auxiliary chucks where an ISS is typically placed. Therefore, it should be enough to perform a software align of the ISS once and then leave it, as long as the ISS is not moved.

New probers with motorized theta

There may be newer prober models with motorized theta and auxiliary chucks that are moving along with the wafer, but then theta is programmable and also memorized by WinCal as part of a position. Just make sure to memorize a wafer

position with theta included, before moving to the ISS for calibration and different theta settings. Otherwise, the wafer may need to be re-aligned after the calibration.

STANDARD ISS

For SOLT/SOLR, LRM/LRRM and Probe Test, you can use WinCal's knowledge about the layout of Cascade's standard ISS'. Then you would use "probes in the air" for an Open, and Thru-Short-Load standards that are adjacent to each other. WinCal recognizes this as a group of standards, with the left group as group one. Where you record the alignment mark will determine which row is used. When using this kind of ISS you need not record the location of each standard, but only the alignment mark. Then you can specify which group to use in that row. The WinCal "soft align" feature is normally used for a standard ISS, to keep the probes landing correctly on any standard in the same row.

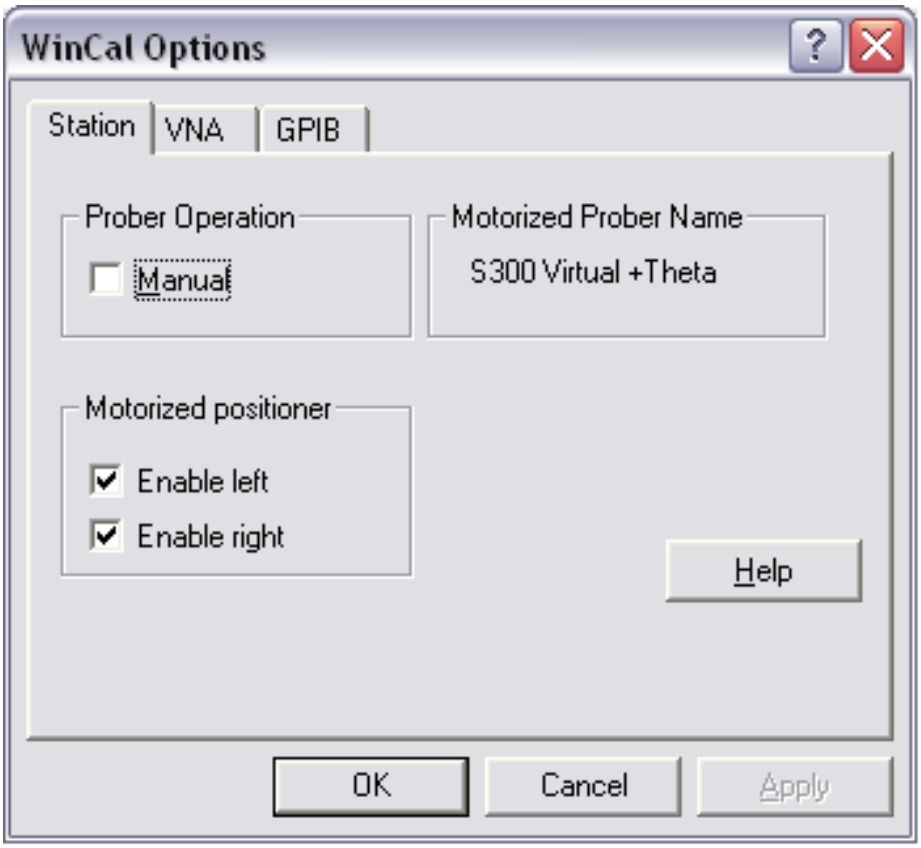
CUSTOM ISS

If you want to use a special ISS or standards on the DUT, or to move out of the group on a standard ISS, you can define a custom ISS in WinCal. A custom ISS is a set of memorized locations for calibration standards (optionally including lines for TRL). You can both record and edit these x-, y-, and z-locations for the stage and any enabled motorized positioner. You can also first record and later adjust the numbers manually. The locations are kept as a distance from a starting point to all standards. This, or an equivalent starting point, must be recorded as the alignment mark before the custom ISS is used in a calibration. Typically, you would edit in exact numbers if you know the distances. In this case you can also use the WinCal "software align" feature. If you record positions "as is", you would probably not need to apply any additional "software align" over the entries, as you have already exact current locations in the recording.

A custom ISS is generic in nature, and you can give it a name that appears in all the calibration dialogs as an available selection. If your layout is such that your recorded pattern repeats, i.e., if you have several equivalent starting points, you can keep recording different alignment marks before calibrating and use the same custom ISS pattern repeatedly. The relative distances within a custom ISS are not lost when absolute alignment mark recordings are erased, for example, when changing the physical ISS position.

Motorized Positioners

Motorized positioners need to be installed and enabled in Nucleus before they can be used by WinCal. Once they are initialized in Nucleus you can enable left and/or right motorized positioners by selecting Config/Options/Station from WinCal's main window. All "recording of" and "moving to" positions in WinCal include enabled positioners.



The "software align" feature in WinCal does not apply to positioners. All positions are absolute machine coordinates and are initialized when the positioners are run through their "find home" sequence in Nucleus.

CAUTION

If you turn off the power to the ECX-56 box and then move the positioner knobs manually, you will have lost your initialization and your memorized positions will be inaccurate. Leave the power on as long as it is needed to remember the positioner locations. You can move the station's knobs manually with power on without losing anything. Naturally, if you physically move the whole positioner block, all recorded positions are offset with the amount you moved and therefore useless.

CAUTION

The motorized positioners have a "hold" feature. If they are powered on and driven to an x- ,y-, or z-coordinate, they will move back to this location if moved manually with the station's knobs. If you are adjusting probes on the ISS (or anywhere), use WinCal to record a position first. This will take the positioners out of the hold mode, so that they can be moved manually.

Auto-Calibration/Test PPR Sequence

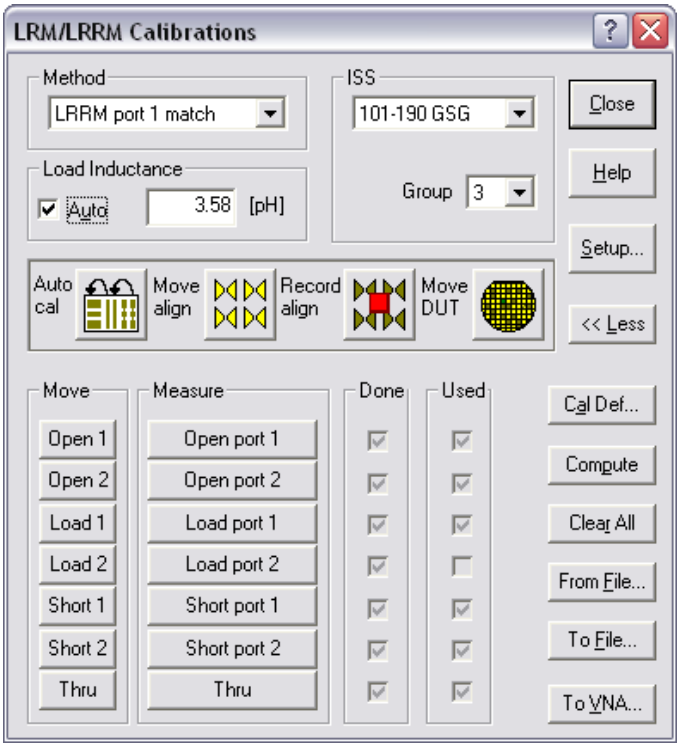
Each calibration dialog, Probe Test, and PPR have a button called Auto-calibrate/test/PPR. For this button to be active you must have an ISS (or pattern for PPR) selected that has valid positions for the standards that are required for the particular selected operation. There must also be valid recorded positions for the alignment mark. In TRL, you must also select only line(s) that have valid locations in the currently selected custom ISS.

Once the "Auto..." button is available, you can start an automated sequence. If you have motorized positioners, WinCal moves you to the standards from any location, but without motorized positioners you will need to be at the alignment mark when the auto sequence is started. WinCal will not assume that you can start a safe move unless this is the case, as probes could touch down in the wrong locations. The "move to align mark" button is available as soon as an alignment mark is recorded.

The auto sequence moves to all standards that are needed. It then gathers the data from the VNA, computes and displays a resulting graph, and then stores the resulting error coefficients (for calibrations) to the VNA. This sequence can be adjusted in the Setup dialog. You can pause between standards and between the reading of each port. You can also turn on/off the auto display and optionally display a dialog with target choices, before storing the calibration coefficients to the VNA.

SEMIAUTOMATIC DIALOG

Each calibration dialog box adds other features when in semiautomatic mode, such as Auto cal; Move align; Record align, etc.



Move buttons

With the “Move” group of buttons you can move directly to any standard (with a valid ISS location) for troubleshooting or evaluation.

CHAPTER

6 Accuracy Tools

Interpreting Verification Plots

After each calibration WinCal displays a verification graph. This graph shows the magnitude in dB of an open circuit. The open is the raw reading with error coefficients applied by WinCal, i.e., a calibrated open. For calibration methods like LRM/LRRM and TRL, this is a sanity test of the calibration. The closer the trace is to 0 dB, the better the calibration. Some ripple is to be expected, particularly at higher frequencies, but large swings outside the limit lines may indicate probe misplacement, bad cables or other problems. For SOLT, it is merely a repeatability check, since the SOLT algorithm defined the *open* as part of the calibration sequence.

The placement of limit lines, displaying the graph, and whether S_{11} or S_{22} is used, is configurable. You can also force a reading of a calibrated open from the VNA instead of letting WinCal compute a calibrated trace.

Checking Calibration Stability

Calibration Stability is a measurement of how much your calibration has drifted. Use this to determine if your measurements are accurate enough for your application. To determine calibration stability, WinCal measures the S_{11} or S_{22} parameters of an open circuit. The new open-circuit data is compared to the stored S_{11} or S_{22} circuit data. A calibration stability graph then displays both new and old traces. This graph may be configured to show the magnitude of the vector difference between the traces.

Keep WinCal running to use the Calibration Stability feature. WinCal remembers the last calibration for stability comparison purposes, as long as WinCal is still running.

Testing Probes

Test up to two probes at once by reading Open, Short, and Load standards with a *cable calibration active on the VNA* with the probe to be tested connected to that cable. The result is an S-parameter graph of the probe(s) that can also be saved to a file.

PROBE TEST

WinCal can test your probe by measuring known standards (typically on an ISS). You will need to enter information about the Cascade probes and the calibration substrates used for this test measurement. If you use Cascade probes supported by WinCal, you will not need to input probe information manually. Instead, once you select a supported probe, WinCal loads their calibration constants automatically into the Probe Test Definitions dialog box. For other probes, you need to specify the probe parameters from within this dialog.

CHAPTER

7 Measurement Tools

Reading, Displaying and Saving S-Parameters

WinCal provides a software tool that allows you to read S-parameters from your VNA and display them in Smith, Polar Magnitude (dB) or Angle graphs. You can then save them to a file, load them from a file and print them out. Graphs can also be copied to the clipboard for inclusion in other documents. *See also*, Chapter 4, Graphs Overview, or online Help for more details.

If you are using a Windows test environment that supports Automation, such as Visual Basic or Excel, you can get S-parameters from WinCal. WinCal can save them to a file and display or hide it's S-parameter graph. *See also*, Chapter 7, Measurement Tools, for more details.

There are three kinds of Touchstone file formats supported for S-parameters. All are regular text (ASCII) files.

1. The classic two-port S-parameter (S2P) format, which includes just the data with no information about it (except in file comments that cannot be read back in).
2. One-port data (S1P) format.
3. Measurement Data Interchange Format (MDIF), such as Truth Models and Large Signal measurements.

The third format has the advantage of defining custom VAR statements that allow WinCal to store the date and comments in the file and then later retrieve them when reading the file. WinCal can also read these formats.

WinCal's convention is to use the extension.MDF for files of this format.

Pad Parasitic Removal (PPR)

Pad parasitics are a complex combination of capacitances and inductances resulting from the bond pads and interconnects. These effects are undesirable if you are trying to model an intrinsic device that will be part of an integrated circuit without bond pads.

WinCal's PPR tool enables you to measure S-parameters for pad parasitics and remove them from measured device S-parameters.

You are getting the corrected S-parameter trace (pad parasitics removed) and a calculated “Ft” from that corrected trace as a result of the WinCal PPR operation. You can choose to display the results of both original and resulting S-parameters, as well as a Bode plot of the “Ft” calculation. Configure this in the PPR Setup dialog.

CHAPTER

8 Automating and Extending WinCal's Functions

Advanced Calibrations

WinCal enables you to make advanced calibrations on semiautomatic or manual probe stations.

You can measure any standard on any port in any order. You can also recompute your calibration data by using different calibration methods with the same raw data. By measuring each standard and port separately, you can achieve detailed control of the calibration.

Automatic and advanced manual calibrations share raw data. When making manual calibrations, you re-measure any standard and re-compute the calibration data. However, the frequency range for all measurements of standards must be identical for WinCal to recompute a calibration. When measuring standards "manually", you must also compute and send error coefficients to the VNA manually.

You can save a SOLT/SOLR raw calibration file and read it back as an LRM/LRRM calibration and vice versa. In this way, you can compare the SOLT and LRRM algorithm with the same data.

Automation

WinCal supports an Automation interface. You can use Visual Basic, VC++, or any Windows development tool that supports Automation to call available functions in WinCal.

The purpose of this feature is to enable a test program to test an entire wafer while reading and retrieving S-parameters for each die, and to repeat an already-configured calibration as needed. All of this is unattended by the operator, once it is set up and started. The intention is not to duplicate the WinCal user interface in a test application. The operator needs to set up calibration parameters, select/record ISS alignment marks and other details before using automated calibrations, PPR or Probe Test. Always run through the intended operation manually at least once before trying the automation.

For an overview of Automation, Cascade recommends that you read the manuals for your development environment. The manuals for Visual Basic describe Automation in great detail.

Cascade supplies Visual Basic example code in the *wincal31\VBexamp* directory. Use Visual Basic to load the project file and run the examples. There are many alternatives to Visual Basic (Delphi is a good example). Check our web site (www.cascademicrotech.com) for future examples and notes.

WinCal provides a type library file. Open this file with an object browser (in your development environment) to view the objects, functions, properties, and methods, which WinCal supports and the parameters that WinCal exports. There is also a link to online Help there.

Standard Automation Features

The following objects are standard to all Automation interfaces:

Quit Function

Terminate WinCal. This will terminate WinCal even if it was started from its icon. Default setup is being saved unless that feature is turned off in the WinCal file menu.

Input	nothing
Return	Boolean TRUE for success

Name Read Only Property

A string with the name of the application.

FullName Read Only Property

A string with the full path and name of the application.

DefaultFilepath Read Only Property

A string with the full WinCal startup directory as <drive letter>:<path>.

Visible Read/Write Property

A Boolean to control and sense if WinCal is visible or not. This applies to the main window. If generated, some graphs are visible anyway.

Help Function

Invoke general online Help for WinCal.

Input	nothing
Return	nothing

WinCal Specific Automation Features

PARAMETERS

CalTypeCode

This parameter specifies main calibration and related tool types used by WinCal. The different types map into corresponding dialogs in WinCal, i.e., SOLT type covers SOLT, SOL-1-port and SOLR, etc. Each type has it's own align mark, various setup, ISS selection and all position recordings. To use these positions and settings, they must be recorded manually in WinCal's user interface first. Make it a rule to run through the actions in WinCal itself before repeating them with Automation. Any attempt to use an invalid position will result in returned errors.

Numeric values follow:

CAL_TYPE_NONE = 0	
CAL_TYPE_SOLT = 1	
CAL_TYPE_LRRM = 2	
CAL_TYPE_TRL = 3	
CAL_TYPE_PTEST = 4	Probe Test
CAL_TYPE_PPR = 5	Pad Parasitic Removal

CalMethod

This parameter describes which method is used, given a certain CalTypeCode.

SOLT-SOLR Cal Methods

SOLT = 0
SOL_PORT_1 = 1
SOL_PORT_2 = 2
SOLR = 3

LRRM-LRM Cal Methods

LRRM_PORT_1 = 0
LRRM_PORT_2 = 1
LRM_OPEN_LOAD = 2
LRM_SHORT_LOAD = 3

TRL Methods

Method number equals the number of lines used (maximum five).

PPR Methods

OPEN_PAD_ONLY = 0
SHORTED_PAD_ONLY = 1
BOTH_OPEN_SHORTED_PADS = 2

Probe Test Methods

PTEST_BOTH_PORTS = 0

PTEST_PORT_1 = 1

PTEST_PORT_2 = 2

PROPERTIES AND FUNCTIONS

The following objects are specific to the WinCal Automation interface:

Version Read Only Property

A string of format major.minor <space> <beta or other special information>.

BringToTop Function

Bring the WinCal main window to the top. This only applies if WinCal is also visible.

Input	nothing
Return	Boolean TRUE for success

ToggleStatusDisplay Function

Changes the size of the WinCal main window. This is the same as *Display Status* under the *Config* menu. This only applies if WinCal is also visible.

Input	nothing
Return	Boolean TRUE for success

ReDisplay Function

Re-displays WinCal main window. This only applies if WinCal is also visible.

Input	nothing
Return	Boolean TRUE for success

StationName Read Only Property

Name of the connected probe station, or Cascade 9000/11000 if a manual station is used.

stationId Read Only Property

The Nucleus software station ID number for the probe station in use (for example, Summit 12000=2). A return code of [0] implies that Nucleus is not installed and that any automatic move command would be N/A. However, it's still possible to read S-parameters.

PassCommandToProber Function

Use this function to pass a string command to Nucleus. Valid commands are documented in the Nucleus manual set for Summit 10000- and 12000-series probers. N/A for manual stations.

Input	Nucleus remote command string to be passed on to Nucleus
Return	Nucleus response string. First char of response is @ if an error occurred.

LastResult Read Only Property

"OK" or message describing last problem since start or last ClearResult call. Use this property to get a problem description if a function you called returned false.

ClearResult Function

Sets the lastResult property string to "OK".

Input	nothing
Return	Boolean TRUE for success

SetupForGpibControl Function

Resets the PC's GPIB board, makes it a system controller and disconnects any other host, if set up in WinCal. This is needed before any VNA action takes place. It should be matched by a call to *RestoreAfterGpibControl* when the VNA session is finished. This is especially important if the GPIB switch box is used, since these calls control that switching. If the switch box is not used you could skip these calls.

Input	nothing
Return	Boolean TRUE for success

RestoreAfterGpibControl Function

Restores the PC's GPIB board as needed after a GPIB session, makes it listener/talker and reconnects any other host, if so set up in WinCal. This is needed after any VNA action has taken place. It should be matched by a call to *SetupForGpibControl* at start up of the VNA session. This is especially important if the GPIB switch box is used, since these calls control that switching.

If the switch box is not used you could skip these calls.

Input	nothing
Return	Boolean TRUE for success

CalTypeStr Function

Get a string description for a cal type code. The CalType is a number that is used as a parameter in many calls to WinCal to specify which calibration object to work with.

Input	short integer-calTypeCode
Return	string

MethodStr Function

Returns a string, describing the currently selected method for this calTypeCode. A method is what you can select within the dialog for a particular type in WinCal's user interface.

Examples of methods: SOLT type contains SOLT, SOL-l-port, and SOLR methods.

Input	short integer-calTypeCode
Return	string

MethoddIdx Function

Returns index of currently selected cal method for this calTypeCode. A method is what you can select within the dialog for a particular type in WinCal's user interface.

Input	short integer-calTypeCode
Return	short integer-calMethod (***see*** Cal Type codes)

SetCalMethod Function

Select cal method for given calTypeCode. This duplicates the function of selection method in WinCal's own user interface. For TRL it means "number of lines" and should only be changed in WinCal itself.

Input	short integer-calTypeCode short integer - calMethod This is the same parameter as is returned in MethodIdx
Return	Boolean TRUE for success

SetupForCalMoves Function

This function must be called once before any other function that uses this particular calTypeCode. For example, if you want to do LRRM related moves and standards measurements, you must call this function first, and pass corresponding calTypeCode (2 for LRRM type) to perform setup in WinCal, so that moves and other actions will use correct ISS and align mark recordings.

Input	short integer-calTypeCode
Return	Boolean TRUE for success

MoveToPos Function

This is the same as the "Move" group buttons in all calibration, PPR and Probe Test dialogs in WinCal. Move to a position that is defined for this particular calTypeCode. It is either using a predefined ISS or pre-recorded positions, also called custom ISS.

Input	short integer-calTypeCode
Return	calStandardMeasCode



NOTE

In Visual Basic, if a string variable is passed it must be enclosed in parenthesis to have the right format.

This is a position with one of the predefined (enumerated) values below. Exactly what is applicable depends on the "calTypeCode" and what positions are recorded, e.g., only TRL can move to lines and they have to be defined in the ISS currently selected for TRL.

"PPRDutPad"
"AlignMark"
"OpenStandard", or "OpenStandard Port1", or "OpenStandard Port2"
"LoadStandard", or "LoadStandard Port1", or "LoadStandard Port2"
"ShortStandard", or "ShortStandard Port1", or "ShortStandard Port2"
(ShortStandard Port1 or Port2 are not available for TRL or PPR)
"ThruStandard"
"Line1Standard"
"Line2Standard"
"Line3Standard"
"Line4Standard"
"Line5Standard"
Return Boolean true for success

MeasureStandard Function

This is the same as the "Measure" group buttons in all calibration, PPR and Probe Test dialogs in WinCal. Measure a standard that is defined for this particular calTypeCode.

Input	short integer-calTypeCode
string	calStandardMeasCode

This is a measurement definition with one of the predefined (enumerated) values below. Exactly what is applicable depends on the calTypeCode and what standards need to be measured, e.g., only TRL can measure lines and only PPR would understand "PPRDutPadPorts".

"PPRDutPadPorts"
"OpenStandardPortI"
"OpenStandardPort2"
"LoadStandardPort I"
"LoadStandardPort2"
"ShortStandardPort 1"
"ShortStandardPort2"
"ThruStandardPorts"
"ThruStandardPorts"
"Line1StandardPorts"
"Line2StandardPorts"
"Line3StandardPorts"
"Line4StandardPorts"
"Line5StandardPorts"
Return Boolean true for success

ComputeCalCoeff Function

This is the same as the "Compute" button in all calibration, PPR and Probe Test dialogs in WinCal. Call it when all standards are measured and before StoreToVna.

Input	short integer-calTypeCode
Return	Boolean TRUE for success

StoreToVna Function

This is the same as the "To VNA" button in all calibration dialogs in WinCal. Sends computed calibration coefficients to the VNA. Calset and instrument state settings will be as set up in WinCal. N/A for PPR and Probe Test.

Input	short integer-calTypeCode

Optional parameter that only applies to SOLT type, to accomplish one port calibrations:

String	portSelection (enumerated values below) "One PortS11" "OnePortS22" "FullTwoPort" (this is default if omitted)

Return	Boolean TRUE for success

MeasureCalStability

Measure calibration drift by dropping the chuck and reading S_{11} or S_{22} open. Compares to the same reading at the time of the last calibration. Note that this only works as long as WinCal has been running, since the last calibration was made. You cannot exit WinCal between a calibration and a stability check.

Input/ Output	(by reference)
	Short calStabilityResult
	0=good
	1=acceptable
	2=bad
	double maxDeltaDb
	double maxDeltaPercent
	double maxDeltaRfeq
Return	Boolean TRUE for success

Read VNA Function

This function makes WinCal read S-parameters from the VNA into it's own data arrays. They can be displayed by using OpenGraphWinSPara, retrieved by using GetDataPointSingleSPara or GetDataPointAllSPara, and saved to file by SaveSParaToFile.

Input	(all parameters are optional)
string	which S-parameter to read
	(enumerated values below)
"thisS"	no change, use what the VNA is already set to
"S11"S11 only	
"S21"S21 only	
"S12"S12 only	
"user1"	user defined 1
	(***see*** 8510 manual)
"user2"	user defined 2
	(***see*** 8510 manual)
"user3"	user defined 3
	(***see*** 8510 manual)
"user4"	user defined 4
	(***see*** 8510 manual)
"allFourS"	all four S-parameters (default)
string	dataLevel (enumerated values below)

"uncorrectedS"	un-calibrated S
	"correctedS"calibrated S (default)
"corrected S"	calibrated S (default)
"smoothS"	as displayed on VNA (but still re, im)
string	comment
	Comment to be added to graph and file if saved (default empty string)

Return Boolean TRUE for success

NumPointsSPara Read Only Property

Contains number of points of S-parameters that were read with Read VNA or zero if not valid.

FreqScaleSPara Read Only Property

Contains scale of frequency that were read with Read VNA (multiply with it to get Hz) or zero if not valid.

Example: a freqScaleSPara of 1.0 means you are getting Hz if you ask for frequency with GetDataPointFreqSPara.

GetDataPointFreqSPara Function

Retrieve frequency for passed in data point "idx." This is internal WinCal data that WinCal has already read from the VNA with the Read VNA function. Use the property numPointsSPara to find out how many points there are and FreqScaleSPara to find out the unit (Hz or GHz).

Input	long integer point index (zero-based)
double float	variable to get frequency value returned in (pass by reference)

Return Boolean TRUE for success

GetDataPointSingleSPara Function

Retrieve one S-parameter for passed in data point. This is internal WinCal data that WinCal has already read from the VNA with the Read VNA function. Use the property numPointsSPara to find out how many points there are.

Input	long integer point index (zero-based)
string	which S parameter to retrieve
	(enumerated values below)
"Sl l"	
"S21"	
"S12"	
"S22"	

double float	variable to get the real part returned in (pass by reference)
double float	variable to get the imaginary part returned in (pass by reference)
Return	Boolean TRUE for success

GetDataPointAllSPara Function

Retrieve all S-parameters for passed in data point. This is internal WinCal data that WinCal has already read from the VNA with the Read VNA function. Use the property numPointsSPara to find out how many points there are.

Input	long integer point index (zero-based)
double float	variable to get the S11 real part returned in (pass by reference)
double float	variable to get the S11 real part returned in (pass by reference)
double float	variable to get the 21 real part returned in (pass by reference)
double float	variable to get the 21 real part returned in (pass by reference)
double float	variable to get the 12 real part returned in (pass by reference)
double float	variable to get the 12 real part returned in (pass by reference)
double float	variable to get the 22 real part returned in (pass by reference)
double float	variable to get the 22 real part returned in (pass by reference)
Return	Boolean TRUE for success

OpenGraphWinSPara Function

Opens up WinCal's graph windows with S-parameters already read from the VNA with ReadVNA. This window will be visible even if WinCal itself is hidden. Use CloseGraphWinSPara to close the graph window when done. There is no harm in closing the graph in it's own user interface and then calling CloseGraphWinSPara in your test application. Reading new S-parameters from within the graph window is equivalent with calling Read VNA and will work fine with other functions to later retrieve those S-parameters.

Input	nothing
double float	Boolean TRUE for success

CloseGraphWinSPara Function

Closes the S-para graph window. Matches function OpenGraphWinSPara. No harm done if window was already closed

Input	nothing
double float	Boolean TRUE for success

DeleteAllSPara Function

Closes any open WinCal S-parameter graph window and deletes the S-parameter data from WinCal's internal data structures.

Input	nothing
double float	Boolean TRUE for success

SaveSParaToFile Function

Save the S-parameters that WinCal has read with Read VNA to a disk file in TouchStone format. The formats choices are the same as in WinCal itself.

All parameters are optional and have defaults.

Input	string filename (default is "ole.mdf")
	short integer format 1=*.MDF (MDIF)
	2=plain *.S2P (default is 1)
string	comment saved in MDIF under VAR NAME key ("default")
Return	Boolean TRUE for success

PPRNumPoints Function

Contains number of points of S-parameters that were read with MeasureStandard where calTypeCode was PPR (5) or zero if not valid.

Input	input string pprDataType: which S-parameter (enumerated values below)
"openPads"	
"shortedPads"	
"dutOriginal"	
"dutCorrected"	

PPRFreqScale Function

Returns scale of specified PPR frequency (multiply with it to get Hz) or zero if not valid

Input	input string pprDataType: which S-parameter (enumerated values below)
"openPads"	
"shortedPads"	
"dutOriginal"	
"dutCorrected"	

PPRGetDataPointFreq Function

Fills in frequency for passed in PPR data type and data point "idx" (zero-based).

Input	input string pprDataType: which S-parameter (enumerated values below)
"openPads"	
"shortedPads"	
"dutOriginal"	
"dutCorrected"	
long integer	point index (zero-based)
double float	variable to get frequency value returned in (pass by reference)

Return Boolean TRUE for success

PPRGetDataPointSingle Function

Fills in one S-parameter for passed-in PPR data type and data point (zero-based).

Input	input string pprDataType: which S-parameter (enumerated values below)
"openPads"	
"shortedPads"	
"dutOriginal"	
"dutCorrected"	
long integer	point index (zero-based)
string	which S-parameter to retrieve (enumerated values below)
"S11"	
"S21"	
"S12"	
"S22"	

double float	variable to get the real part returned in (pass by reference)
double float	variable to get the imaginary part returned in (pass by reference)

Return Boolean TRUE for success

PPRGetDataPointAllS Function

Fills in all S-para for passed in PPR data type and data point (zero-based).

Input	input string pprDataType: which S-parameter (enumerated values below)
"openPads"	
"shortedPads"	
"dutOriginal"	
"dutCorrected"	
long integer	point index (zero-based)
double float	variable to get the S11 real part returned in (pass by reference)
double float	variable to get the S11 imaginary part returned in (pass by reference)
double float	variable to get the S21 real part returned in (pass by reference)
double float	variable to get the S21 imaginary part returned in (pass by reference)
double float	variable to get the S12 real part returned in (pass by reference)
double float	variable to get the S12 imaginary part returned in (pass by reference)
double float	variable to get the S22 real part returned in (pass by reference)
double float	variable to get the S22 imaginary part returned in (pass by reference)

Return Boolean TRUE for success

PPROrigFtStr Read Only Property

Last computed *Ft* for original (non-corrected) S-trace in a string

PPRCorrFtStr Read Only Property

Last computed *Ft* for corrected S-trace in a string

PPROrigFtBin Read Only Property

Last computed *Ft* for original (non-corrected) S-trace as double floating point value.

PPRCorrFtBin Read Only Property

Last computed *Ft* for corrected S-trace as double floating point value.

APPENDIX

A GPIB Switch Box

Overview

The GPIB Switch Box is only used when WinCal runs on a Cascade Prober to calibrate the VNA, such as the Summit, S300 or PS21. Another computer/ workstation (the remote host) is used to take measurements from the VNA. The switch box is not used with a manual station or if all test software runs on the prober computer.

GPIB protocol does not allow for two (2) controllers on the bus at the same time. GPIB can pass control between controllers, but the other controller needs to be advised of the change. Since GPIB operations cannot assume that the other controller is aware of a change, the GPIB Switch Box was introduced. The switch box allows two (2) controllers to share control of the VNA, without any knowledge of the other's existence.

The procedure is to connect the probe station-WinCal-VNA to one of the GPIB connectors on the switch box and the remote host computer/workstation, together with any instruments it uniquely uses, on the other connector.

The GPIB switch box breaks the GPIB connection between the two connectors on the top, i.e., between the remote host and the probe station-WinCal-VNA. When the probe station is a GPIB instrument (WinCal is idle), the box maintains the connection between the host and the probe station computer. When the probe station is a GPIB controller, the box breaks the connection between the remote host and the probe station-WinCal-VNA. This switching is automatic and is controlled by the probe station hardware via a separate cable.



NOTE

GPIB is short for General Purpose Interface Bus and is defined by the ANSI/IEEE standard 488.1 and 488.2

Installation

Refer to the *GPIB Switch Box Installation Guide* (PN 107-109). This printed manual ships with the box itself, but the document is also present on the WinCal 3.2 CD as a "pdf" file.

How WinCal uses the GPIB Switch Box

The Hardware Configurator/System Manager in Nucleus/PS21 directly controls the GPIB Switch Box. It use the remote command "`:SET:HOST ON/OFF`", which WinCal uses to make the switching occur.

The Hardware Configurator/System Manager (System Manager) has a component called "Communications: GPIB" that is acting as listener/talker on the GPIB. This is the method that the remote host uses to control the probe station. As stated previously, if you don't use a remote host computer you don't need the GPIB Switch Box and you should delete this component from "default.cfg" in System Manager.

When WinCal takes control of GPIB it sends the "`:SET:HOST OFF`" command to Nucleus/PS21, which disconnects the host (by switching the box) and stopping the "Communications: GPIB" component from running. WinCal then changes the GPIB card from being talker/listener to system controller.

When WinCal releases control, the reverse occurs. The GPIB board is changed to talker/listener, and by sending "`:SET:HOST OFF`" to Nucleus/PS21 the host will be connected again (by switching the box) and the "Communications: GPIB" component will also be restarted, so that the probe station can be controlled over GPIB.

The aforementioned activity can be controlled and tested in the GPIB dialog. Note that the "Use switch box to disconnect host" must be checked for all the above to work.

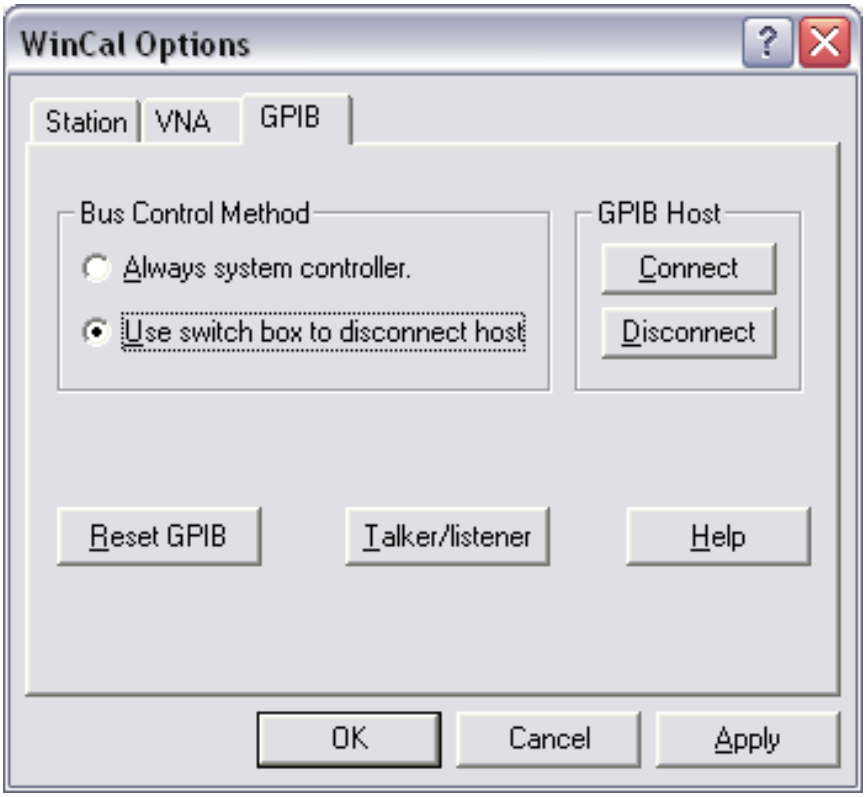


Fig. 1. WinCal Options dialog box_GPIB tab.

When WinCal Switches the Box

With the setting displayed as in figure 1, WinCal will take GPIB control and disconnect the external host computer each time a calibration dialog (SOLT/LRRM/TRL), Probe Test or PPR dialog is entered. WinCal keeps GPIB control until the dialog is closed.

The WinCal S-Parameter Tool will switch and take control for each measurement, instead of maintaining control while waiting for the window to be closed.

CAUTION

If the S-parameter Tool window is left open while a calibration dialog is opened, and the user makes a measurement in the S-parameter Tool window while the cal dialog is still open, the GPIB switching will lose synchronization, since the measurement completion will restore talker/listener before the cal dialog is closed. Avoid leaving the S-parameter Tool window open. If it inadvertently is left open, just exit the cal dialog and then re-open it again.

WinCal Automation and GPIB control

If WinCal is being controlled via Automation from another application, the following applies:

- Before calling other WinCal Automation methods that would access the VNA, the controlling application must call the WinCal Automation method "SetupForGpibControl". This method will make WinCal handle the GPIB Switch Box as displayed in the setup dialog of figure 1. This is to say that WinCal must be first used manually to have the correct setting (using the switch box or not).
- After VNA activity is complete, the Automation method "RestoreAfterGpibControl" should be called again to enable an external host to control the probe station.

These methods are documented in Chapter 8, Automating and Extending WinCal's Functions.

Cabling and requirements for the external host computer

CAUTION

Don't cable the external computer in such a way that it bypasses the GPIB switch box, i.e., don't have any GPIB cables connected from the external computer (direct or indirect via instruments) to the VNA and the probe station. The only GPIB path must be through the switch box connector. The probe station and the VNA are plugged in on the other connector on the box.

While WinCal is calibrating and measuring, i.e., has control of the VNA over GPIB, the external host must not attempt to use the VNA. Any attempt will fail, since they are disconnected.

When WinCal is done with the VNA and has restored connection to the external host, it is possible to continue the host program and access the VNA and the probe station again.

Regaining GPIB control for the external host

When the external host-PC/Workstation has regained control after a WinCal session, it may be necessary to execute a GPIB reset on that external computer. Most measurement software programs have a menu item to accomplish this.

APPENDIX

B Nucleus GPIB Driver for WinCal

Introduction

The Nucleus GPIB driver for WinCal provides a software solution for driving Nucleus remotely. The driver is delivered as part of WinCal version 3.2 (or later). A wafer probing system with Nucleus software might be configured in one of the two following ways (figure 2 and figure 3):

1. Test software is located on the same computer as Nucleus. In this case, WinCal and Nucleus are running on the same computer, so the Nucleus GPIB driver for WinCal is not used.

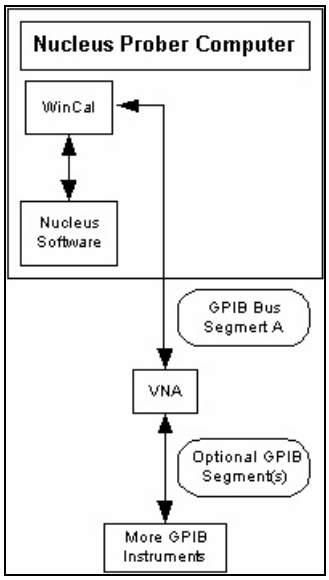


Figure 2. Nucleus software configuration possibility #1.

2. Test software is located on a separate computer from Nucleus. In this case, WinCal is controlling Nucleus through the GPIB interface. The Nucleus GPIB driver for WinCal acts as a proxy for forwarding commands and responses between WinCal and Nucleus.

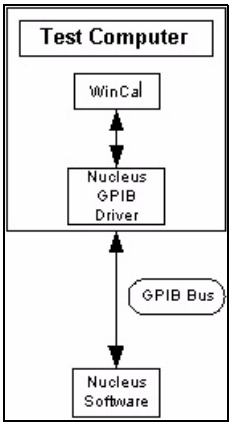


Figure 3. Nucleus software configuration possibility #2.

Installation

The Nucleus GPIB driver application is located in the "Nucleus GPIB Driver" folder on the WinCal CD. Launch the setup.exe file and follow the on-screen instructions to install the Nucleus GPIB driver.

The following events will occur during the installation process:

- The Win.Ini file will be automatically altered to include the line: *SysMgrWindowCaption="simulator"* under the [CascadeMicrotech] section.
- If the PS300 software is present, a message will appear indicating that it should be removed before the new software is installed.
- If Nucleus software is present, a message will appear indicating that it should be removed before the new software is installed.
- If WinCal software is NOT present, a message will appear indicating that it should be installed before installing the new software. If WinCal software is already present, the new software will be installed in the same location as WinCal.

System Requirements

- Microsoft Windows NT 4.0, 2000, or XP
- WinCal version 3.1.1 or higher

Configuration

Configure Nucleus GPIB Driver

After installation, the driver will be configured to talk to the Nucleus prober on GPIB address 28. In most cases, no changes will be required.

Make any required configuration changes before starting WinCal, as WinCal will attempt to talk to the prober immediately after being configured. Follow the steps in this section to configure the driver.

1. Select the Nucleus GPIB driver from the start menu.

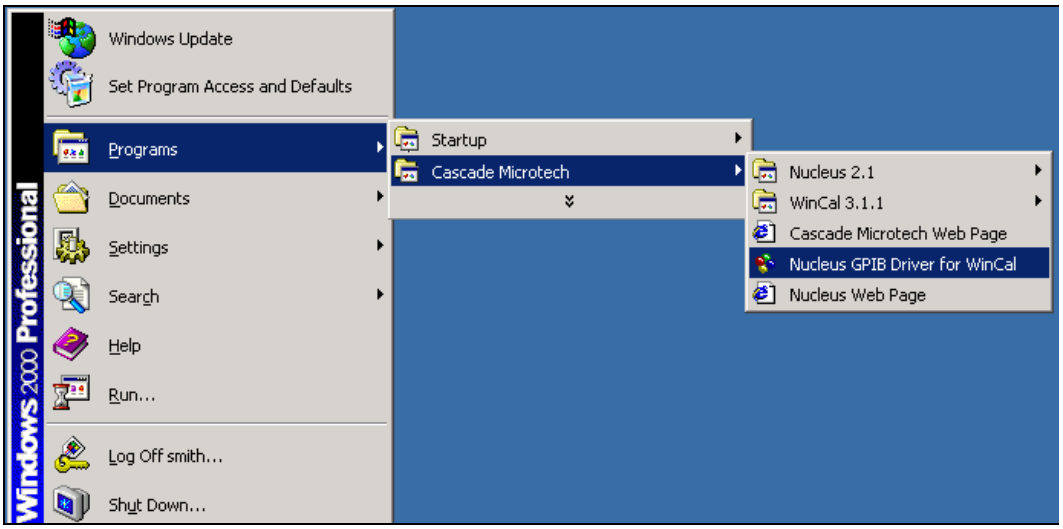


Figure 4. Start menu.

2. The driver will start, but will remain unconnected to the Nucleus Prober.

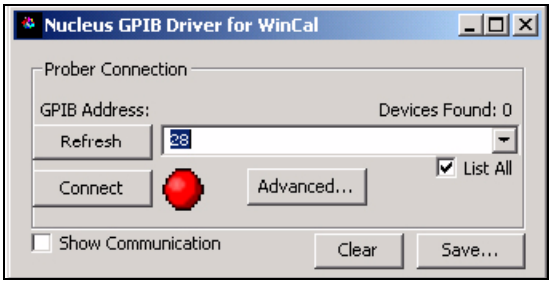


Figure 5. Driver started, but unconnected.

3. Click on the Refresh button to refresh the device list (note that this process may take up to two minutes). The combo box will display a list of devices and corresponding ID strings available on the GPIB bus. GPIB devices that are too old to comply with the IEEE 488.2 standard commands may not appear on the list (e.g., Agilent 8510 VNA). If the instrument cannot be located, the message "[GPIB address] : No Instrument Found" will appear on the screen.

4. Select the GPIB address of the Nucleus prober. When the driver verifies communication, the red connection light will turn green.

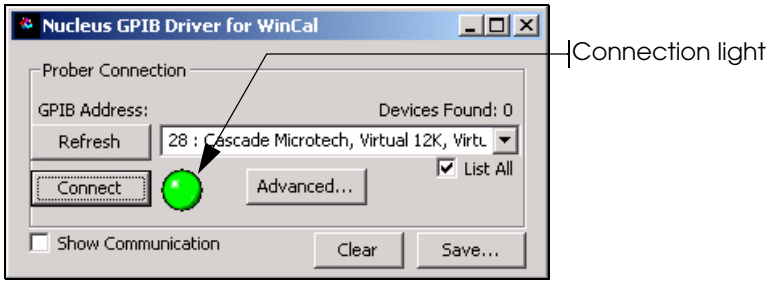


Figure 6. Driver connected.

5. At this point, the driver is configured and can start automatically with WinCal. WinCal, however, may still require configuration to control the Nucleus prober. The default configuration is set for use with a manual prober.

CONFIGURE WINCAL

1. Launch WinCal and open the Options dialog.
2. Select the Manual checkbox.

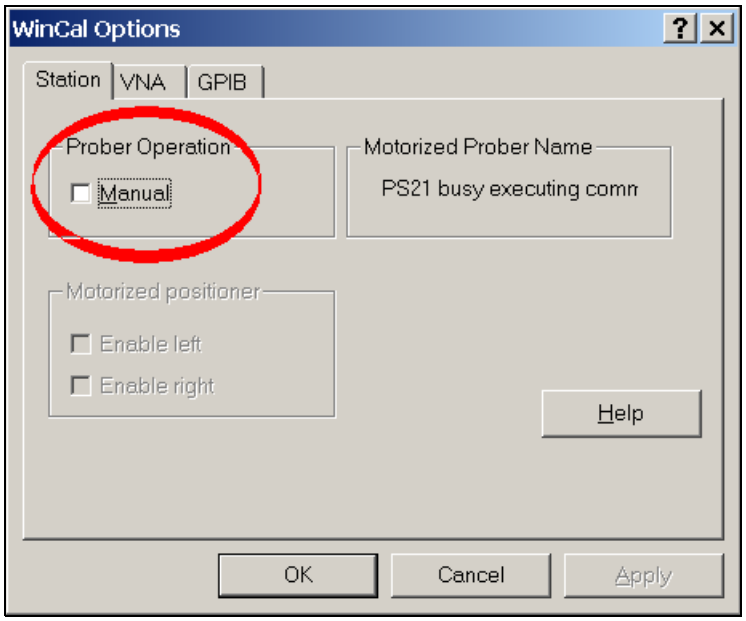


Figure 7. Prober Operation setting.

3. If the Manual checkbox is not selected, the Nucleus GPIB driver will start automatically (if it was not started previously). If no configuration errors exist, such as an incorrect Nucleus GPIB address, the Nucleus GPIB driver will run silently in a minimized state.

CORRECT GPIB ADDRESS ERRORS

The last saved GPIB device address will be restored from the previous program session. If the application cannot connect the address, the window shown in figure 8 will be displayed.

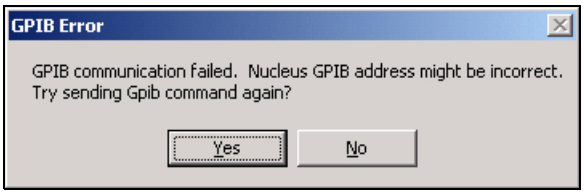


Figure 8. GPIB Error window.

The GPIB Driver window gives the user an opportunity to locate and fix the GPIB connect problem and to retry the GPIB communication. Press the OK button to continue.



Figure 9. GPIB driver unconnected.

CONFIGURE DRIVER DISPLAY OPTIONS

The GPIB configuration window contains the following options (*see* figure 10):

NOTE

The application window may be resized using standard Windows drag methods.

- Toggling the Hide/Show Conversation button will show or hide the GPIB Communication log.
- Pressing the Refresh button will update the address list with the most current information. Each address will show the identification string returned by the GPIB device for that address (with the exception of non 488.2 compliant instruments, like the Agilent 8510 VNA).
- Pressing the Clear button will clear the conversation list.
- Pressing the Save button will save the conversation list to disk.

- Selecting the List All check box will populate the GPIB Address list with all available addresses, regardless of their state. If the List All check box is not selected, only the active devices reported by the GPIB connection will be listed. The only exception to this rule occurs if a previously inactive address was selected before the 'List All' check box was deselected. In this case, the current inactive address will still be displayed along with the available active devices.

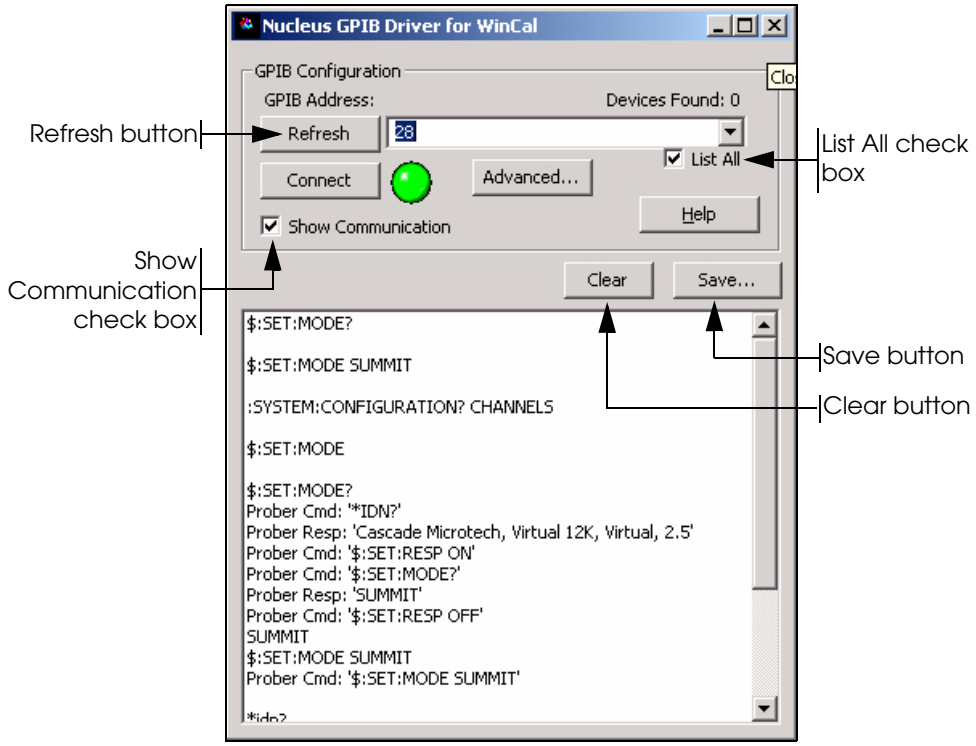


Figure 10. GPIB Configuration window (Communication log shown).

SELECT A GPIB ADDRESS

Pressing the Connect button (see figure 11) at any time will cause an attempt at communication with the Nucleus prober. The Connection light will be updated according to the response from the address device.

- When an address with an active Nucleus prober is selected, the Connection light will turn green.
- If the selected address device is inactive, the Connection light will turn red.

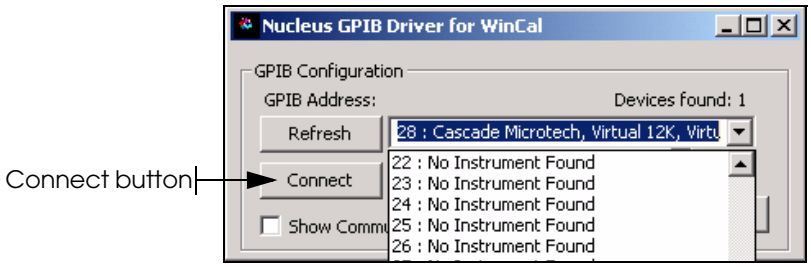


Figure 11. Connect button (Communication log hidden).

ADVANCED CONFIGURATION

The advanced configuration allows users to set the response mode (after the WinCal GPIB communication is finished) to either on or off. Nucleus GPIB communication can return responses after commands, or the user can rely upon GPIB status register values. Since WinCal needs the textual responses, the Nucleus GPIB driver turns response strings on when sending WinCal commands to the Nucleus prober. However, some users may wish to turn the Nucleus response mode off.

- ON (unchecked) = response mode is turned on by the driver before each command and never turned off.
- OFF (checked) =response mode is turned on by the driver before each command and then turned off again afterwards.

See the product documentation for requirements or further information regarding settings for any other software in use. If GPIB communication problems become apparent after using WinCal with other software, the on/off setting may be changed.

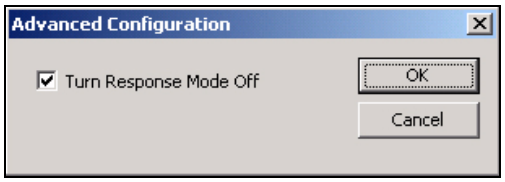


Figure 12. Advanced Configuration window.

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