Chapter 2 — AutoCal Procedures

2-1 Chapter Overview

This chapter describes common procedures for both Internal Through and True-Through calibration using Anritsu AutoCal® modules including the **36585-Series Precision AutoCal Modules** and the **36581KKF Standard AutoCal Module**. Two examples of using a precision adapter with an AutoCal unit to create difference-sexed reference planes are described as is adapter removal with an AutoCal unit. The chapter concludes with user-based AutoCal module characterization and working with older Anritsu AutoCal units.
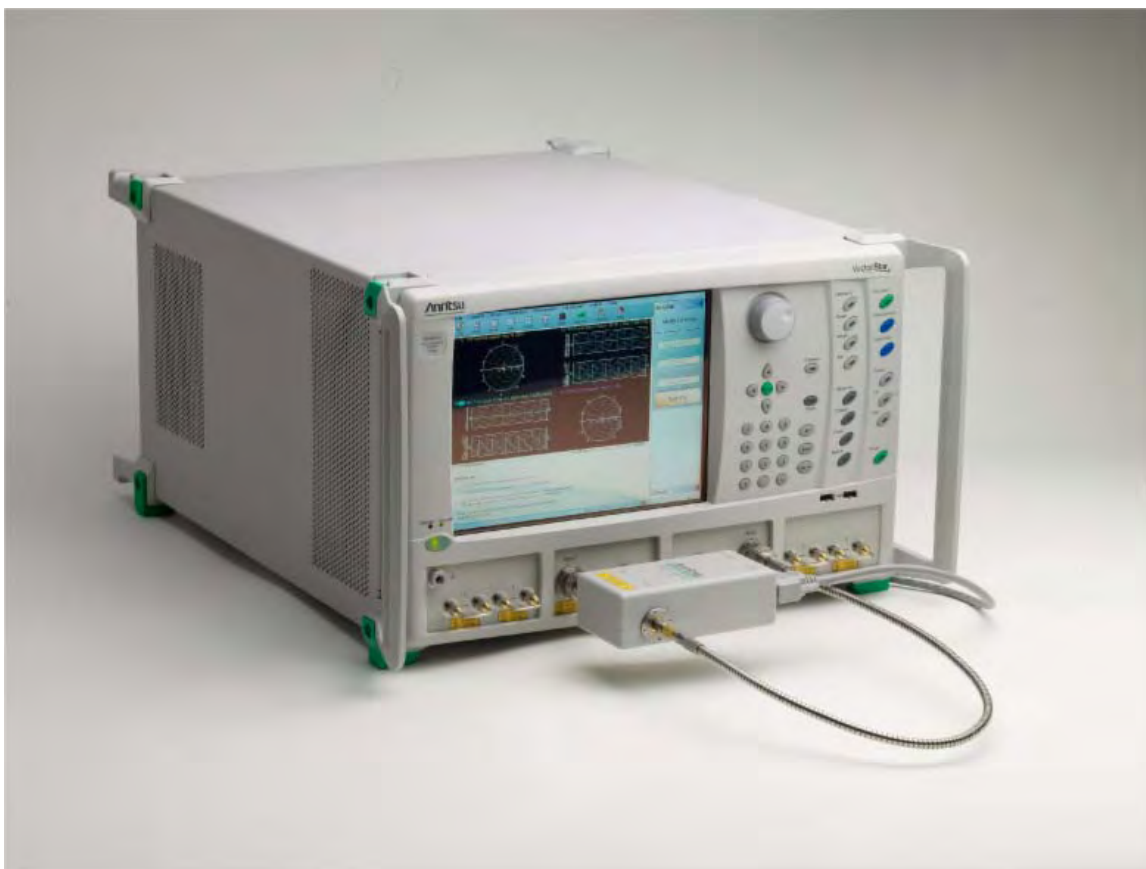
Figure 2-1. MS4647A VNA with 36585V-Series Precision AutoCal Module

2-2 Automatic Calibrator (AutoCal) Terms

This section defines various terms used with AutoCal modules and the calibration procedures used with the VectorStar.

Insertable and Non-Insertable Devices

Insertable devices have an insertable connector pair such as a male input connector and a female output connectors. These devices can be measured after a through calibration. A non-insertable device has a non-insertable pair of connectors such as female connectors on both ports or different connector types such as a DUT with both a K and V connector. Non-insertables cannot be connected directly into the measurement path without an adapter.

- **Thru** – A *thru* (properly called a "through") is a connection of the two test ports. Two kinds of through connections—internal through and true through— are defined for the AutoCal calibration.

- **Internal Through** – An Internal Through is an internal path through the calibrator requiring no operator involvement in the AutoCal setup.

- **True Through** – A True-Through is a direct cable connection between the test ports, with no intervening connectors. An internal through is not as accurate as a true through but requires more operator involvement and takes more time to accomplish. The true through can be more accurate than the internal through (if very well-matched and of very low loss) but the length and loss must be entered. The return loss of the adapters must be very good to avoid added error.

Auto-Sense

A selectable function of the AutoCal module where, if enabled, the AutoCal module decides the left/right test cable assignment. If not enabled, the operator defines the port number to left/right assignment.

Characterization File

Each calibrator module has a file containing data which characterizes each standard in the calibrator. This file also contains information (identification number, start and stop frequencies) concerning the capabilities of the calibrator. Each characterization file has the extension ".acd." When modules are changed, the appropriate new characterization file must be installed. The files are typically stored on a Characterization Memory Device (USB memory device). Insert the **Characterization Memory Device** into a **VectorStar USB** port. This file can be installed by navigating to the INSTALL (AUTOCAL CHARACTERIZATION/CAL KIT) dialog box:

- Navigation: MAIN MENU | Calibration | CALIBRATION | Cal. Kit/AutoCal Characterization | CAL KIT/ AUTOCAL | Install Kit/Charac. | INSTALL (AUTOCAL CHARACTERIZATION/CAL KIT) dialog box

From the dialog box, navigate to the location of the Characterization Memory Device. Select the file, and copy it to a location within the C:\AnritsuVNA folder. In addition, each AutoCal module can be re-characterized using the VNA, although specifications are only valid if Anritsu has performed the characterization (recommended re-characterization interval is 12 months). A valid 12-term calibration must be active, which is used to characterize the standards within the module.

2-3 AutoCal Introduction

Note	Throughout this document and on some menus and screens, S11 is used to represent the S_{11} calibration parameter, S12 for S_{12}, S21 for S_{21}, and S22 for S_{22}.

The auto calibration (AutoCal) process represents both a calibration kit and an algorithm that is used to speed up the calibration process with extremely high accuracy, minimizing the number of manual steps and test operator involvement.

Transfer Calibration

The **36585x-Series Precision AutoCal** and the **36581KKF Standard AutoCal** module calibrates the VNA by a process known as "transfer calibration." There are a number of impedance and transmission states in the module designed to be extremely stable in time and these states are carefully "characterized", generally by the Anritsu factory but also in a customer laboratory in certain cases. When the same states are re-measured during an actual calibration, and the results compared to the characterization data, an accurate picture can be generated of the behaviors and error terms of the VNA and setup being calibrated.

Calibration Accuracy

A very high calibration accuracy is maintained through the use of certain principles

- The use of many impedance and transmission states
- The creation of very stable states that are further enhanced with a constant-temperature thermal platform inside the module.

- The use of very reliable and repeatable solid-state switching constructed to provide a great variety of state impedances (for better calibration stability) and clean transmission paths.
- The use of a very careful characterization process that can generate excellent starting data.

The resulting accuracy can exceed that obtained with typical mechanical calibration typically performed in a metrology laboratory. The AutoCal results may not be better than that of an exotic manual calibration (such as calibration performed during factory characterization), but is far better than that typically done.

AutoCal Components

The AutoCal unit consists of the calibration module itself, a separate external power supply, a control cable that runs to the VNA, and the characterization data that is initially provided on a USB memory device. The AutoCal unit should be powered up and allowed to warm up prior to use (typically a few minutes, the blue **Operate LED** will illuminate when the unit is at temperature). The control cable should be connected to the serial port on the back of the VNA.

Connector Care

Since an AutoCal calibration is a very high performance calibration, connector care is of the utmost importance.

AutoCal Calibration Parameters and Types

AutoCal requires four general parameters be defined, as shown in the AutoCal dialog box:
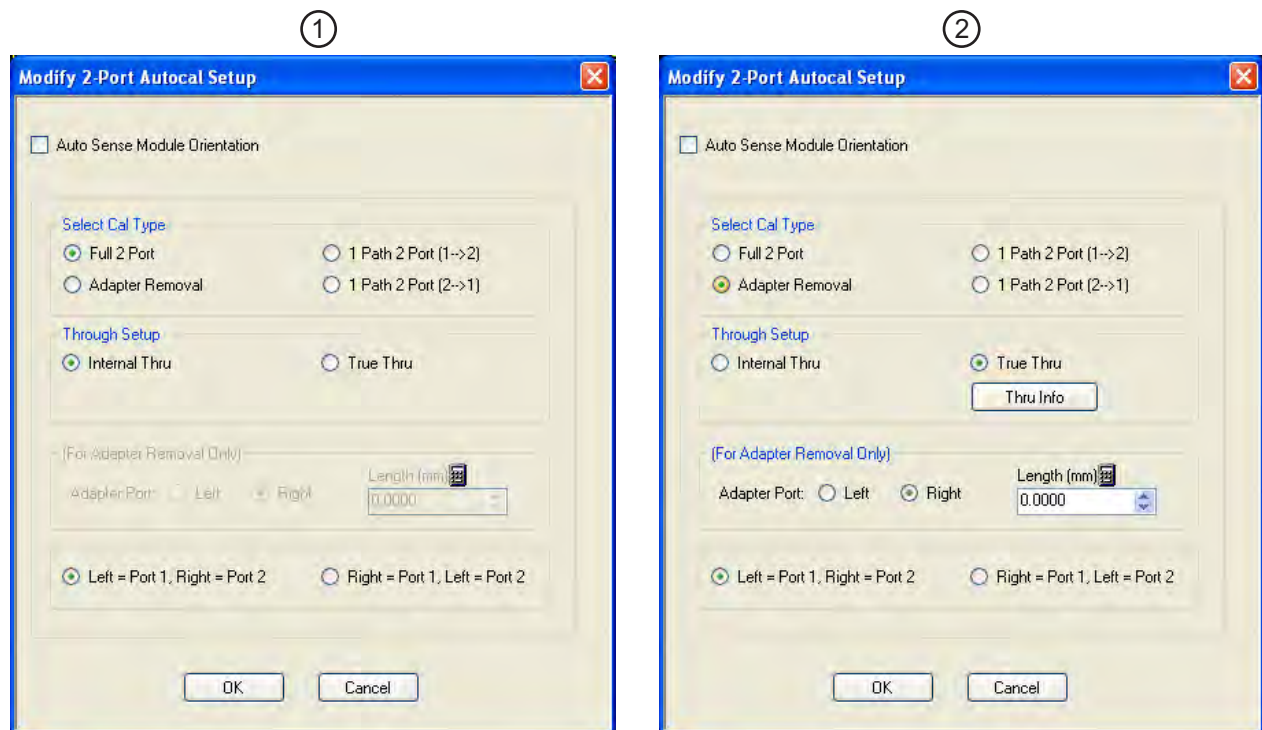

Figure 2-2. MODIFY 2-PORT AUTOCAL SETUP Dialog Box

 — 1. Settings (at left) for Full Two Port Calibration with Internal Thru. — 2. Settings (at right) for Adapter Removal and True Thru.

The parameters are:

- the calibration type required
- the through type to be used
- whether to automatically or manually define the left/right test port assignments
- whether an adapter will be used with the AutoCal module.

Most standard calibration types are available with the AutoCal units. Frequency response calibrations are the only ones omitted since the AutoCal unit would provide no benefit in these cases since only a through or high reflect standard is needed for these calibrations. The AutoCal modules support:

- Full Two Port (also called Full 2-Port) calibration
- Full Port 1 (S11) reflection only calibration
- Full Port 2 (S22) reflection only calibration
- 1 Path 2 Port Forward (S11, S21) calibration
- 1 Path 2 Port Reverse (S22, S12) calibration

Adapter Removal

The DUT may require a different connector configuration than is on the current autocal unit (e.g., F-F DUT and the autocal is M-F). AutoCal adapter removal is one way of handling this situation by performing two autocalibrations with an adapter connected to the AutoCal. The instrument will guide the user through the required connections.

Thru Options

For each calibration type above, there are two through AutoCal calibration options:

- **Internal Thru** – The AutoCal module provides the internal through connections without the user having to move or reconnect the test cables. The benefit is speed of calibration balanced against potentially less accuracy and accommodates inexperienced operators such as in an assembly line testing station.

- **True Thru** – All AutoCal modules can also be configured to allow True Thru where the user is prompted when and how to connect the test cables to complete the calibration. The benefit is a higher accuracy calibrations balanced against a longer calibration time and more operator involvement.

Test Port Left/Right Naming Assignments

The AutoCal module setup allows the user to specify the left/right identification of the test port cables as either:

- **Auto Sense Module Orientation = ON** – Where the module determines the left/right identification of the test port cables

- **Auto Sense Module Orientation = OFF** – Where the user defines either Left = Port 1 and Right = Port 2, or Left = Port 2 and Right = Port 1

Typical AutoCal Module Connections

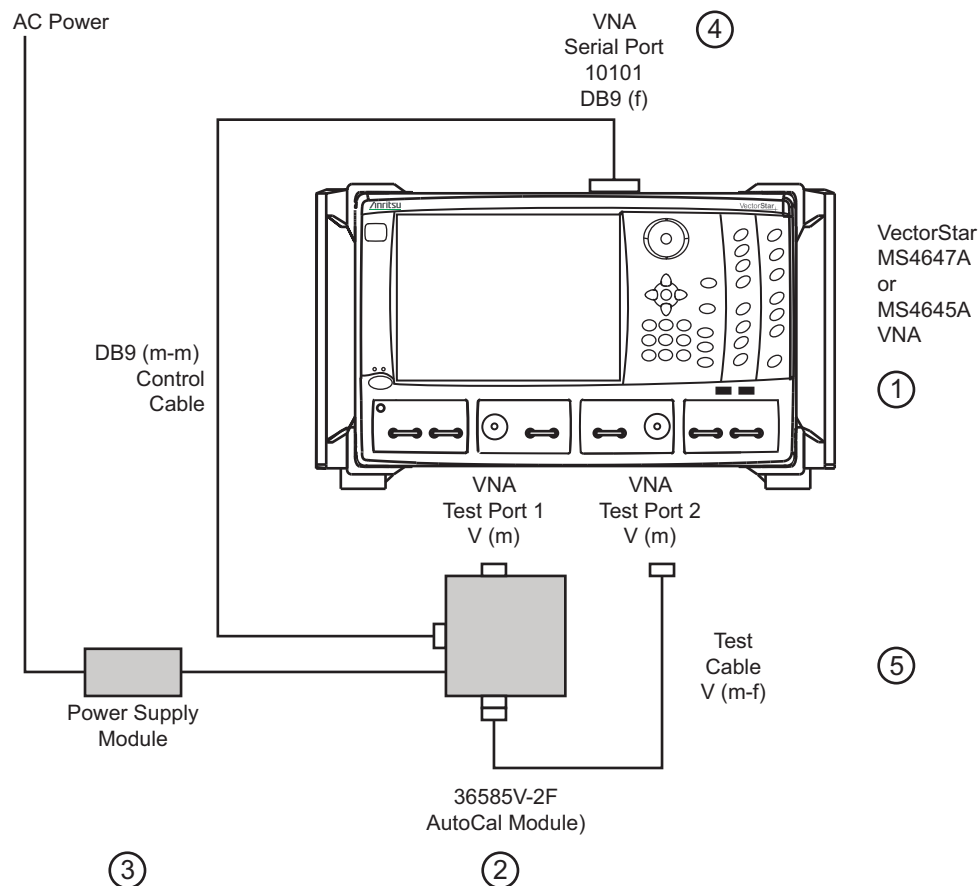The typical **F-F AutoCal** module connections are shown below in Figure 2-3.

Figure 2-3. AutoCal Module Connections for Internal Through

 — 1. MS4645A or MS4647A VNA — 2. 36585V-2F AutoCal Module — 3. AutoCal Power Supply Module — 4. AutoCal DB9 (m-m) Control Cable connected between AutoCal Module and VNA rear panel Serial 10101 Port. — 5. Test Cable V(m-f)

1. Prepare the **VectorStar MS4647A or MS4645A VNA** and power it up. The instrument has two V (m) test ports.

2. Connect the **366565V-2F Precision AutoCal Module V (f)** connected directly to **VNA Test Port 1 V(m).**

3. The AutoCal module is then connected to its **AC Power Supply Module** and it to AC power

4. Connect the **DB-9 (m-m) Serial Control Cable** to the AutoCal module and the VNA rear panel **Serial Port (10101)**.

5. The second **AutoCal V (f)** connector is connected to the **V (m)** end of the **Test Cable**. The test cable can be changed depending on measurement requirements. Cables on both VNA ports may be used, different types of cables may be used, or other configurations established. Then connect the **V (f)** end of the **Test Cable** to the **VNA Test Port 2 V(m).**

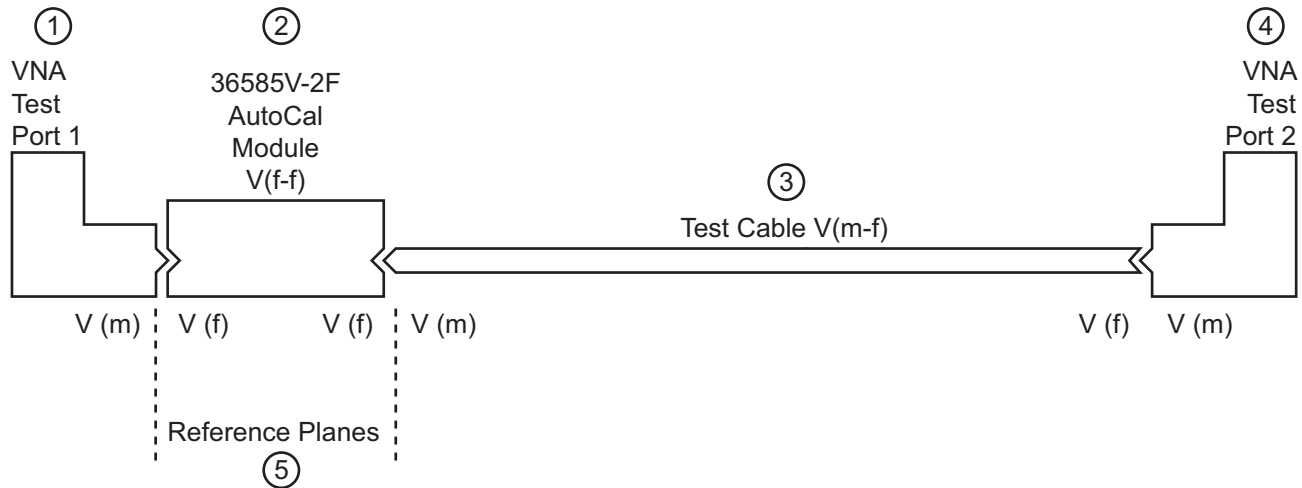Schematically, this setup is shown in Figure 2-4.

Figure 2-4. Schematic of AutoCal 36585V-2F Module Connections for Internal Thru

— 1. VNA Test Port 1 V(m) — 2. 36585V-2F Autocal Module — 3. V(m-f) Test Cable — 4. VNA Test Port 2 V(m) — 5. Resultant reference planes

For optimal results, use the shortest cable lengths that do not require excessive bending when performing calibration or measurements. Results will be improved using the most practical phase- and amplitude-stable cables.

The power supply and control cables may be bundled for ease of routing or may be separated for convenience in some cases.

Using the AutoCal Module

The calibration procedure can be broken up into several simple steps:

1. Power up the VNA and connect the control cable to the AutoCal unit.

2. Install the characterization file if not already done. Copy the AutoCal Characterization File from the Characterization Memory Device (a USB memory device) onto the VectorStar hard disk drive.

Note	The AutoCal Characterization File (.acd file) is provided on a USB memory device and can be installed directly from that device. The file(s) can also be copied from the USB memory device to the VectorStar hard drive and installed from there. The preferred method is to copy all .acd files on to the hard drive, and then install the file for the specific AutoCal being used.

3. Connect the AutoCal module to the VNA:

   • AutoCal Module directly to one **VNA Test Port**
   • A test cable between the AutoCal and **VNA Test Port**
   • The Serial Control Cable between the AutoCal module the VectorStar back panel **Serial 10101** port

4. Connect the AutoCal Module to its power supply and AC power. The green **Power LED** illuminates immediately. When the module is at operating temperature, the blue **Operate LED** will illuminate.

5. Setup the VNA instrument for the desired calibration:

   • The required minimum settings are Frequency Start, Frequency Stop, and Number of Points.
   • If required, optional settings for Segmented Sweep, IF Bandwidth, and/or Averaging are applied.

6. Select the AutoCal parameters of interest and connect the test port cables to the AutoCal unit. Make the required selections for Cal Type, Thru Select, Adapter Removal, and Auto Sense Module.

7. Perform the calibration by clicking Begin Cal to start the auto calibration.

8. A status dialog box with a progress bar appears after an AutoCal sequence has started. The status messages define has far the program has progressed and if any user actions are required.

9. At any time, the AutoCal sequence can be cancelled by clicking the dialog box Abort button.

10. If any manual steps are requested such as specifying a true-through, a dialog box will prompt for the action.

11. When the auto calibration is complete, a status message appears with a statement about assurance passing or failing. On the Calibration menu, the Cal Status field button shows ON.

Each procedure is described in greater detail in the following sections.

2-4 Available AutoCal Modules and Adapters

The Precision and Standard AutoCal modules are show in the figure below.

Figure 2-5. AutoCal Modules

— 36581KKF Standard AutoCal Module (at left) — 36585-Series Precision AutoCal Module (at right)

AutoCal Modules and Adapters

Anritsu has both Precision AutoCal modules as well as a Standard AutoCal module.

Table 2-1. Precision and Standard AutoCal Kits and Adapters *(1 of 2)*

Part Number	Name	Frequency Range	Connectors
Precision AutoCal Kits			
36585K-2M	Precision AutoCal Kit K, 2-port (*Note 1*)	70 kHz to 40 GHz	K (m) to K (m)
36585K-2F			K (f) to K (f)
36585K-2MF			K (m) to K (f)

Table 2-1.   Precision and Standard AutoCal Kits and Adapters *(2 of 2)*

Part Number	Name	Frequency Range	Connectors
36585V-2M	Precision AutoCal Kit V, 2-port (*Note 1*)	70 kHz to 70 GHz	V (m) to V (m)
36585V-2F			V (f) to V (f)
36585V-2MF			V (m) to V (f)
Standard AutoCal Kit			
36581KKF	Standard AutoCal Kit (*Note 2*)	40 MHz to 20 GHz	K (m) to K (f)
Standard AutoCal Kit Matched Adapters			
36583K	Matched K Adapters Set, 2 adapters (*Note 3*)	40 MHz to 20 GHz	K (f) to K (m) adapters (*Note 4*)
36583L	Matched 3.5 mm Adapters Set, 4 adapters	40 MHz to 20 GHz	K(f) to 3.5 mm (m) adapters, 2 each / K (f) to 3.5 mm (f) adapters, 2 each (*Note 4*)
36583S	Matched SMA Adapters Set, 3 adapters	40 MHz to 20 GHz	K (f) to SMA (m) adapter, 1 each / K (f) to SMA (f) adapters, 2 each (*Note 4*)
Table Notes			
Note 1:	The 36585V-Series Precision AutoCal Kits can be used with VectorStar Models MS4642A or MS4644A with adapters and the cal range will be limited to that of the VNA. The 36585K-Series Precision AutoCal Kits can be used with VectorStar Models MS4647A with adapters but the cal range will be limited to 40 GHz. The standard AutoCal can be used with any of the MS464XX VNAs (possibly with adapters) but the cal range will be limited to 20 GHz.		
Note 2:	The standard AutoCal can also be used with the MS4647A if adapters are used on the VNA.		
Note 3:	Matched adapters are recommended only for use with the 36581KKF Standard AutoCal Kit. The standard precision AutoCal module can be ordered with connector adapters which assume the use of K (m) test port cables.		
Note 4:	Matched adapter use assumes the use of K (m) test port cables. These adapters can be also used on the Precision AutoCal modules, but with some degradation of precision. See Chapter 1 —Calibration Overview for a general description of available calibration tools and accessories and for descriptions of each AutoCal and manual calibration kit, tool, and accessory.		

2-5 Copying the AutoCal Module Characterization File to the VectorStar

The AutoCal Characterization File (.acd file) is provided on a USB memory device and can be installed directly from that device. The file(s) can also be copied from the USB memory device to the VectorStar hard drive and installed from there. The preferred method is to copy all .acd files to the hard drive, and then select the file for the specific AutoCal being used.

Procedure

1. Inspect the AutoCal kit and make a note of its serial number. Typical AutoCal Kit serial numbers are six-digit integers such as "123456."

2. Insert the AutoCal Characterization Memory Device (USB memory device) into one of the VectorStar USB Ports.

Note	Alternatively, Windows Explorer can also be used to move files from the USB memory device to the VectorStar hard drive.

3. Navigate to the CAL KIT/AUTOCAL menu:

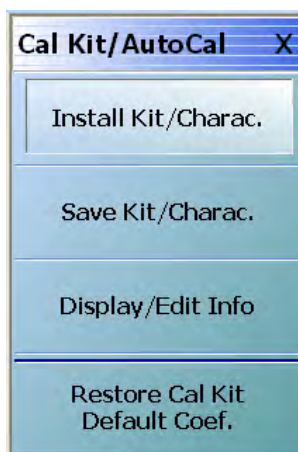- Navigation: MAIN | Calibration | Cal Kit/AutoCal Characterization | CAL KIT/AUTOCAL

Figure 2-6. CAL KIT/AUTOCAL Utility Menu

4. On the CAL KIT/AUTOCAL menu, select Install Kit/Charac. The Install (AutoCal Characterization/CalKit) dialog box appears.
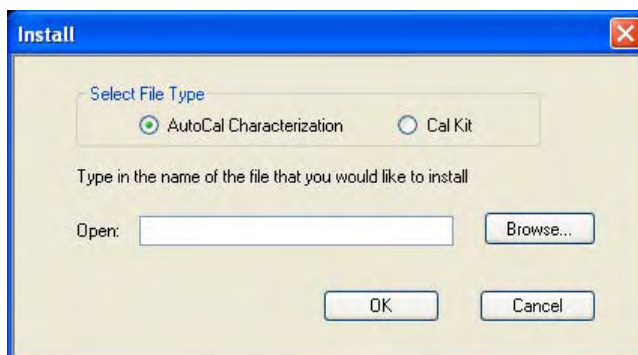

Figure 2-7. INSTALL (AUTOCAL CHARACTERIZATION/CAL KIT) Dialog Box

5. Select the AutoCal Characterization radio button and then click Browse. The Open (AutoCal ACD File) dialog box appears.

6. Navigate to the USB port location holding the USB memory device and select the file "V123456.ACD," where "123456" is the serial number of the AutoCal kit.

7. Click the dialog box Open button. The Open dialog box closes; the Install dialog box re-appears.

8. Click OK in the Install dialog box. Another install dialog box appears (this one showing the AutoCal controller serial number, which is not the module serial number). Click Install in this box close it.

9. On the Cal Kit/AutoCal menu, select Save Kit/Charac. The Save (AutoCal Characterization) dialog box appears. Click OK.

10. Navigate to the required storage directory for the characterization file. The recommended directory destination on the VectorStar is C:\Anritsu\VNA\AutoCal

11. Click Save. The Save dialog box closes, the CAL KIT/AUTOCAL menu reappears.

12. Repeat the steps above to copy each new AutoCal Characterization File to the VectorStar.

2-6 Loading a Previously Stored AutoCal Characterization File

Use this procedure if the AutoCal Characterization File has already been copied onto the VectorStar hard drive.

Procedure

1. Navigate to CAL KIT/AUTOCAL menu.
   - Navigation: MAIN | Calibration | CALIBRATION | Cal Kit/AutoCal Characterization | CAL KIT/ AUTOCAL

2. On the CAL KIT/AUTOCAL menu, select Install Kit/Charac.

3. Select the AutoCal Characterization radio button and then click Browse.

4. Navigate to the hard drive (or USB memory device) location of the AutoCal Characterization file for the AutoCal module in use. The recommended directory destination on the VectorStar is C:\Anritsu\VNA\AutoCal

5. Select the AutoCal Characterization file, such as "V123456.ACD," where "123456" is the serial number of the AutoCal kit. Click Open.

6. Click OK in the Install dialog box. Another install dialog box appears (this one showing the AutoCal controller serial number, which is not the module serial number). Click Install in this box close it.
   - The Install dialog box closes and the Cal Kit/AutoCal menu is again available.

2-7 Pre-Calibration Instrument Setup

Use this procedure to setup the minimum required instrument configuration parameters:

- Frequency Start
- Frequency Stop
- Number of Points

Any other required measurement parameters must be defined and applied before the AutoCal procedure. This section provides a highlight of typical additional measurement parameters.

Segmented Sweep

If required, segmented sweep must be setup in advance if the calibration needs a custom frequency list. See Section 14-5 "Frequency-Based Segmented Sweep" on page 14-12.

IF Bandwidth (IFBW) and Averaging

IF Bandwidth and Averaging control the digital filtering and post-processing that determine the effective noise floor, the amount of trace noise, and, in some cases, the immunity to interfering signals. The trade-off for improved noise performance is slower sweep speed.

Port Power

Port power is less critical than IFBW or Averaging due to the excellent linearity of the VectorStar MS4640A Series receivers. The AutoCal unit has an absolute maximum power limit of +10 dBm. The preferred calibration power is –10 dBm for improved accuracy at frequencies <100 MHz.

If power adjustments are required, any step attenuator settings must be selected before the calibration. Changes in the step attenuator settings alters both the RF match and the insertion loss in the measurements paths. Power can be changed after a calibration, but an attenuator change after a calibration invalidates the prior calibration.

Example Procedure

This example procedure assumes the VectorStar is equipped with the MS4640-070 70 kHz Low-End Frequency Extension and that only Frequency Start, Frequency Stop, Number of Points, and CW Mode settings are required.

1. Determine the values for the minimum setup parameters:

- Frequency Start: 70 kHz
- Frequency Stop: 70 GHz
- Number of Points: 200
- CW Mode: OFF
- Segmented Sweep: Not required
- IFBW: Defaults to 1 kHz
- Averaging: Defaults to no averaging

2. Power up the VectorStar and allow it to stabilize its internal temperature.

3. Navigate to the FREQUENCY menu:

- Navigation: MAIN | Frequency | FREQUENCY

Figure 2-8. FREQUENCY Menu - Setting Initial AutoCal Parameters

4. On the FREQUENCY menu, click the Start frequency button.

- The frequency Start toolbar appears just below the icon toolbar.

5. Enter the required start frequency number value.

- For this example, set the start frequency value at 70.

6. Enter the required start frequency units.

- For this example, set the units to kilohertz by clicking kHz.
- The Start frequency field button now shows 70.000 kHz.

| Note	If the MS4640A is not equipped with the 70 kHz Low-End Frequency Extension (P/N: MS4640A-070), the lowest available starting frequency is 10 MHz.

7. On the FREQUENCY menu, click the Stop frequency field button.
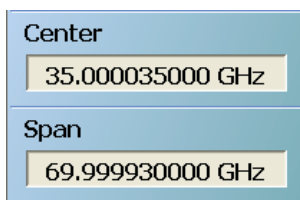
- The frequency Stop toolbar appears.

8. On the Stop frequency toolbar, enter the required frequency number value and units.

- For this example, set the stop value at 70 and click the GHz units button.
- The Stop frequency button now shows 70.000000000 GHz.
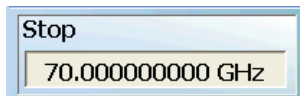
9. The Center and Span display buttons show calculated values based on settings made above.

- The Center frequency field button shows a value of 35.000035000 GHz.
- The Span frequency field button shows a value of 69.9999930000 GHz.

10. On the Frequency menu, click the # of Points (Number of Points) field button.

- The # of Points toolbar appears

11. On the # of Points toolbar, enter the required number of points.

- In this example, set the # of Points to 200 and then click Enter on the toolbar..

- The # of Points field button shows 200.
- The Step Size display button shows 351.758442 MHz.

12. Click the CW Mode toggle button so it is set to OFF.

13. If optional parameters are required, do any of the following optional procedures described elsewhere in this manual:

- Segmented Sweep: Section 14-5 "Frequency-Based Segmented Sweep" on page 14-12.
- IFBW: Section "IFBW" on page 12-26.
- Averaging
- Power and Attenuation

14. If no optional parameters are required, the AutoCal is ready to proceed.

- See: Section 2-8 "AutoCal - Full Two Port - Internal Through" on page 2-14.

2-8 AutoCal - Full Two Port - Internal Through

This procedure performs an AutoCal calibration using a full two port calibration with an internal through, which is sufficiently accurate for most DUTs. The AutoCal Characterization file has already been loaded onto the VectorStar.

Required Equipment

- VectorStar MS4645A or MS4647A VNA with V (m) test port connectors, with MS4640A-070 70 kHz Low-End Frequency Extension
- 36585V-2F Precision AutoCal Module, with V (f) connectors and required power and control cables. The AutoCal Characterization File has been loaded onto the VectorStar.
- Test port cable, V (f) to V (m)

Procedure

1. Power up the VectorStar.

2. Set the required Frequency Start, Frequency Stop, and Number of Points parameters.

    - See Section 2-7 "Pre-Calibration Instrument Setup" on page 2-11.

3. If required, set up other parameters as required such as Segmented Sweep, IFBW, Averaging, and Power and Attenuation.

AutoCal Module Connections

4. Make the necessary cable connections between the **AutoCal Module**, its **Power Module**, and the **VectorStar** rear panel.

5. Connect the **AutoCal V (f)** connector directly to the VectorStar left side **V (m) Test Port 1**.

6. Connect the **Serial Control Cable** between the DB-9 connector on the top of the AutoCal Module and the **Serial (10101) Port** on the VectorStar rear panel.

7. Connect the coaxial power plug from the **Power Supply Module** to the **AutoCal Module**. Connect the other end to AC power.

8. Once connected to power, the **AutoCal Module Power LED** is illuminated green. When the module has warmed up to operating temperature, the **LED** illuminates as blue.

9. Connect the **test cable** between the **V (m) Test Port 2** and the remaining **AutoCal V(f)** port.
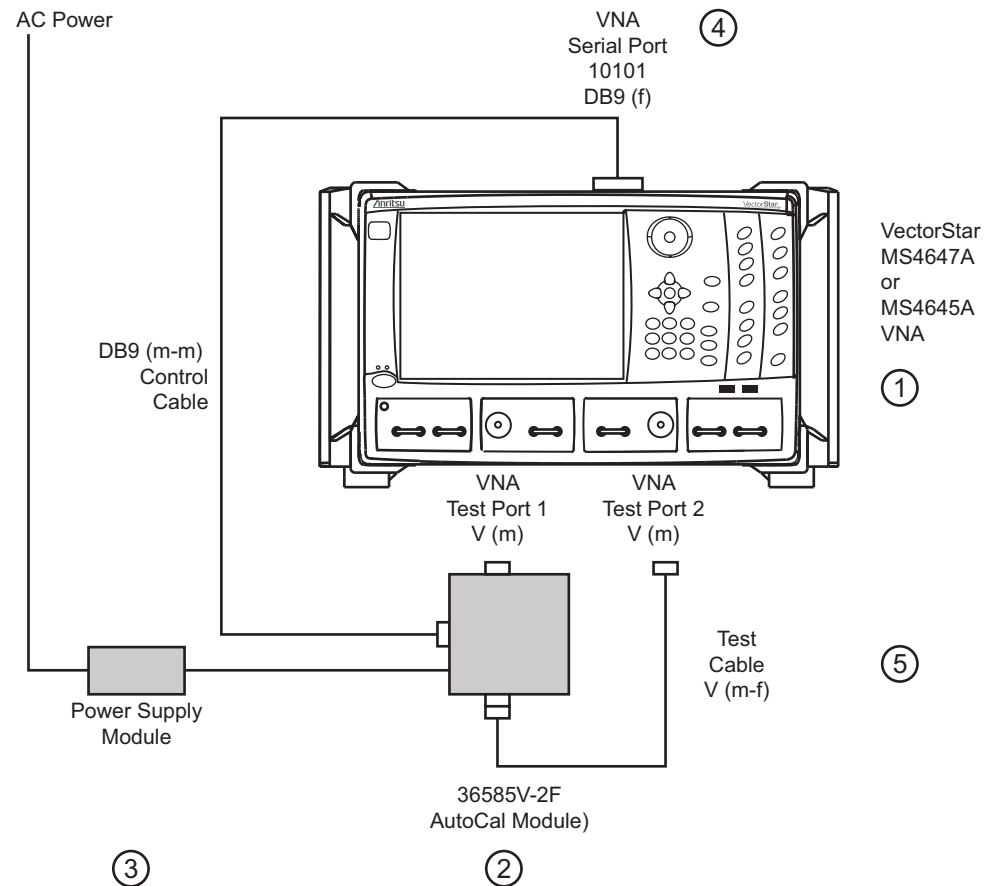

Figure 2-9. Precision AutoCal 36585V-2F Cable Connections for Internal Through

— 1. MS4645A or MS4647A VNA — 2. 36585V-2F AutoCal Module — 3. AutoCal Power Supply Module — 4. AutoCal DB9 (m-m) Control Cable connected between AutoCal Module and VNA rear panel Serial 10101 Port. — 5. Test Cable V(m-f)

10. Navigate to the AUTOCAL SETUP (2-Port) menu:

- Navigation: MAIN | Calibration | CALIBRATION | Calibrate | CALIBRATE | AutoCal | AUTOCAL PORTS | 2-Port Cal | AUTOCAL SETUP (2-Port)

11. On the AUTOCAL SETUP (2-Port) menu, if the Port Selection, Cal Type, Thru Type, and Module Orientation display buttons do not show the correct values, click the Modify Cal Setup button.

- The MODIFY AUTOCAL SETUP dialog box appears. The exact name depends on the VNA mode and the user selections for the number of ports. The dialog box can be named:
  - MODIFY 1-PORT AUTOCAL SETUP dialog box
  - MODIFY 2-PORT AUTOCAL SETUP dialog box
  - MODIFY 4-PORT AUTOCAL SETUP dialog box

12. In this example, the required settings are for a Full 2 Port Calibration, with Auto Sense Module Orientation ON, and Internal Through while running on a VNA in 2-Port Mode. The resultant configuration dialog box is names MODIFY 2-PORT AUTOCAL SETUP..

Figure 2-10. MODIFY 2-PORT AUTOCAL SETUP Dialog Box

— Settings for Full 2 Port - Internal Through - Auto Sense On - 2-Port VNAs

13. On the MODIFY 2-PORT AUTOCAL SETUP dialog box, select the settings:

    a. Cal Type Select area: Select the Full Two Port radio button.

    b. Thru Select area: Select the Internal Thru radio button.

    c. Auto Sense Module Orientation check box selected: Allows the AutoCal module determine left/right cable identification.

    d. When the settings are complete, select OK to close the dialog box.

14. The AUTOCAL SETUP (2-Port) menu reappears with new values for Cal Type, Thru Type, and Module Orientation.

15. The window area at the bottom of the instrument display area appears with general instructions:

    a. Ensure correct cable connections to AutoCal module.

    b. Ensure that the **Power** and **Operate LEDs** are both illuminated.

    c. Ensure characterization file is loaded before starting Cal. To load characterization file, go to the INSTALL (AUTOCAL CHARACTERIZATION) dialog box.

        • Navigation: MAIN | Calibration | CALIBRATION | Cal Kit/AutoCal Characterization | CAL KIT/ AUTOCAL | Install Kit/Charc. | INSTALL (AUTOCAL CHARACTERIZATION)

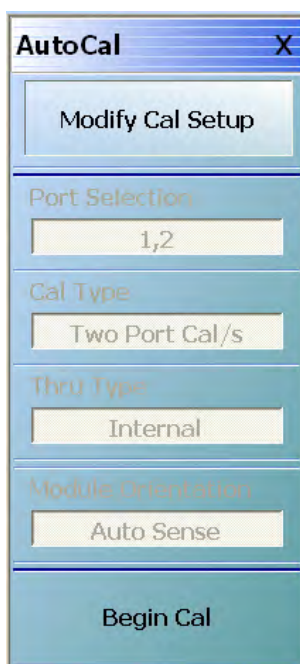   **d.** Existing system setups such as averaging, power level, etc. will be applied during the cal.

Figure 2-11. Configured AUTOCAL 2-Port Menu

— Port 1 and 2 - Full Two Port - Internal Through - Auto Sense On

  16. When ready, click the Begin Cal button.

  17. If the AutoCal module is connected incorrectly, the AUTOCAL MODULE NOT DETECTED warning message appears.

     • Correct the connections as required and click Retry.

Note	A different dialog box may appear if the RF cables are connected incorrectly (with Autosense on) that states that Autosense was unable to determine the orientation of the module. If this dialog appears, and a large amount of loss is not present between the port and the AutoCal module, check the connections. If a known large amount of loss is present (from fixturing or the use of very long cables), the orientation should be manually entered.

  18. When the calibration is complete, the Status Message dialog box will close and the display will return to the CALIBRATION menu with the Cal Status button set to ON. The assurance dialog will remain up with the pass/fail message, and must be manually closed.

2-9 AutoCal - Two Port Cal - True Through

This procedure performs an AutoCal procedure using a full two port calibration where a True Through (or external through) is required.

Required Equipment

- VectorStar MS4645A or MS4647A VNA, with V (m) test port connectors, with MS4640A-070 70 kHz Low-End Frequency Extension
- 36585V-2MF Precision AutoCal Module, with V (f) and V (m) connectors and required power and control cables. The AutoCal Characterization file has been loaded onto the VectorStar.
- Test port cable with V (f) to V (m) connectors
- Test port cable with V (f) to V (f) connectors, or a V(f)-V(f) adapter.

Procedure

1. Power up the VectorStar.

2. Set the required Frequency Start, Frequency Stop, and Number of Points parameters.

   - See: .

3. If required, set up other parameters as required such as Segmented Sweep, IFBW, Averaging, and Power and Attenuation.

4. Make the necessary cable connections between the **AutoCal Module** and the **VectorStar**:

   a. Connect the **Test Cable V (f) - V (m)** between Test Port 2 V (m) and the AutoCal V (f) port.

   b. Connect the **Test Cable V (f) - V (f)** between Test Port 1 V (m) and the AutoCal V (f) port.

   c. Connect the **Serial Control Cable** between the DB-9 connector on the AutoCal Module and the Serial (10101) Port on the VectorStar back panel.

   d. Connect the **coaxial power plug** on the Power Supply Module to the AutoCal Module and the other end to AC power.

5. Once connected to power, the **Power LED** illuminates as green. When the AutoCal module has warmed up, the **LED** illuminates as blue.
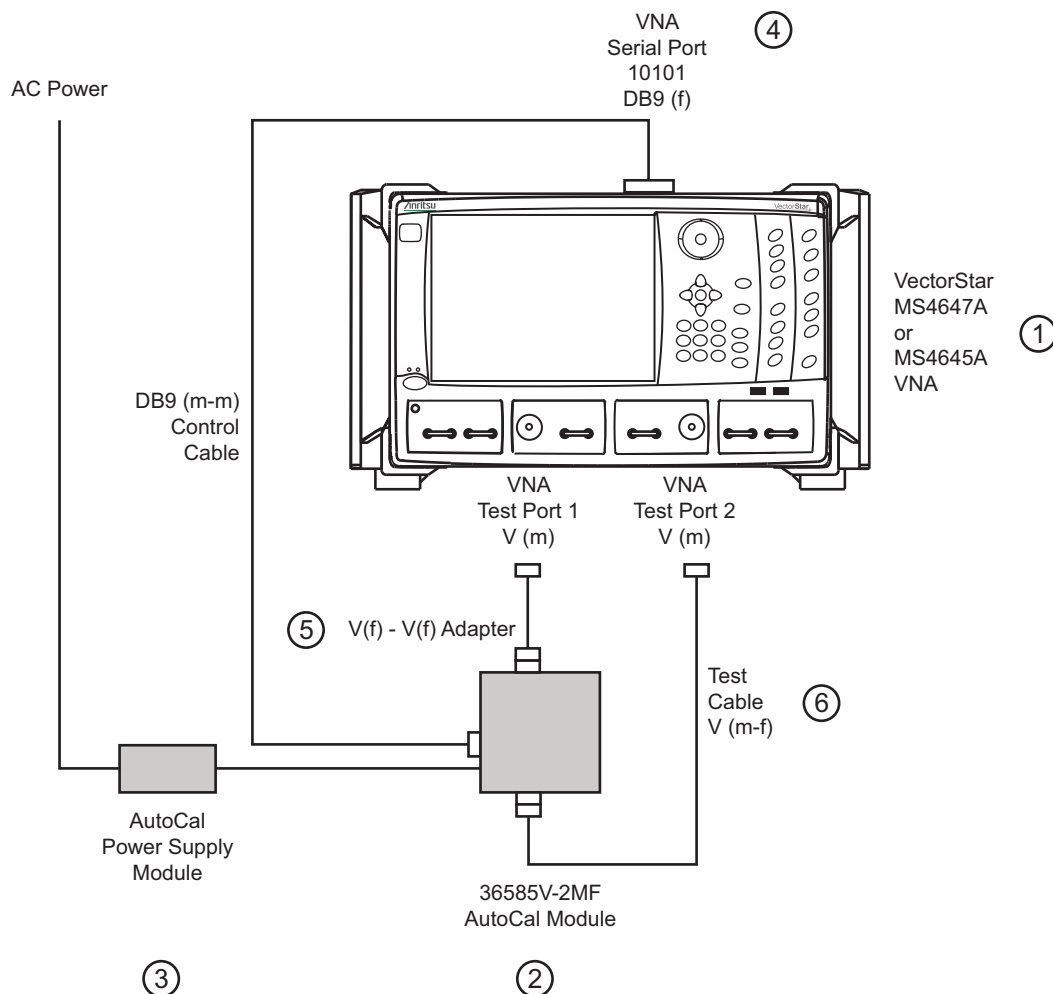

Figure 2-12. Precision AutoCal 36585V-2MF Cable Connections for True Through

 — 1. VectorStar MS4645A/MS4647A VNA — 2. 36585V-2F Precision AutoCal Module — 3. AutoCal Power Supply Module connected to AC Power — 4. AutoCal DB9(m-m) Signal Cable connected to VNA Rear Panel Serial 10101 Port. — 5. V(f-f) Adapter connected to VNA Test Port 1. — 6. V(m-f) Test Cable connected to VNA Test Port 2.

- Schematically, the connections shown in Figure 2-12 are also shown in Figure 2-13.
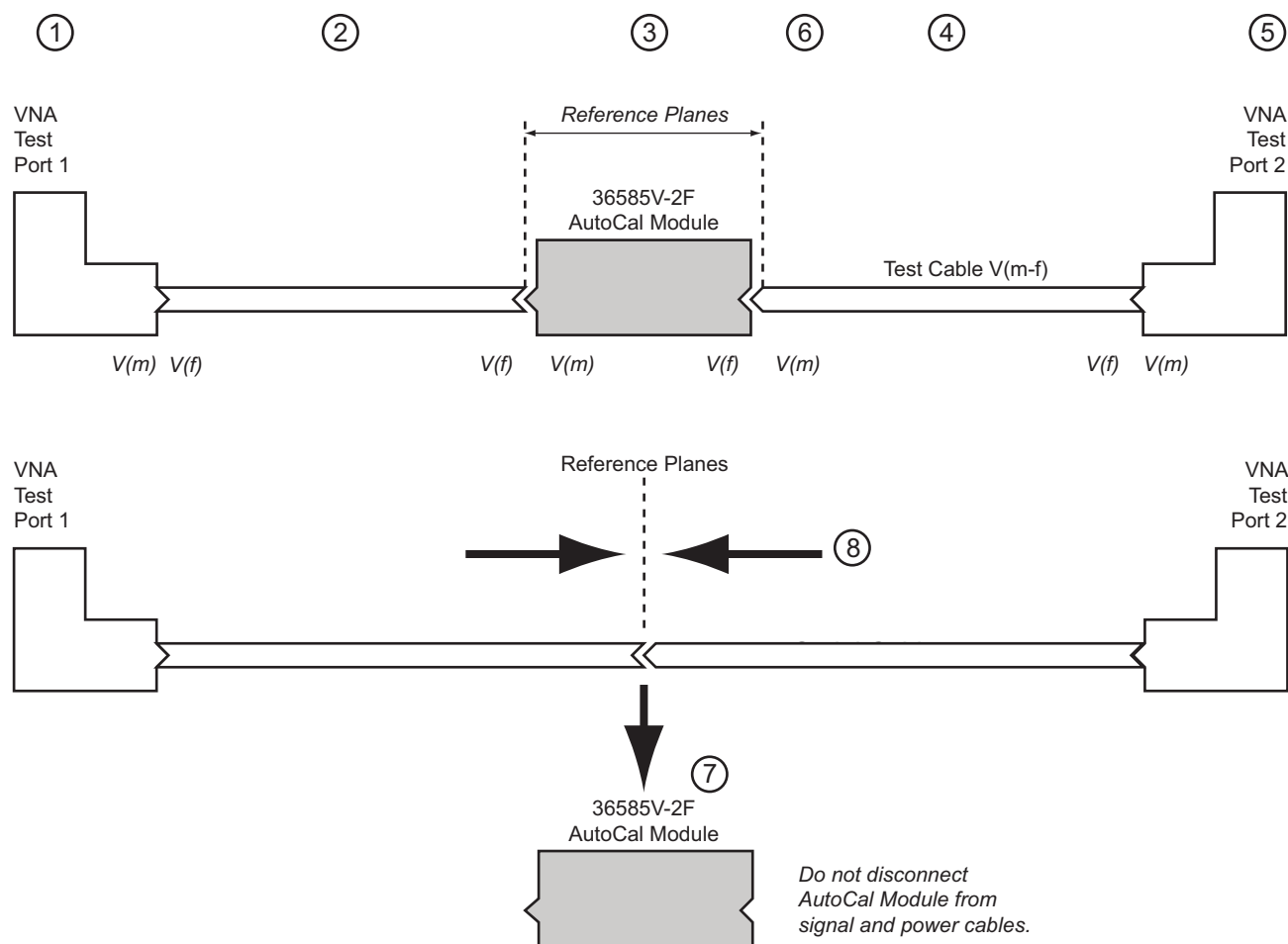

Figure 2-13. AutoCal True-Through Connections

— Callouts 1 to 6 represent the first AutoCal procedure. - Callouts 7 and 8 represent the second AutoCal True Through procedure. — 1. VNA Test Port 1 V(m) — 2. V(f-f) Test Cable — 3. 36585V-2MF AutoCal Module — 4. V(m-f) Test Cable — 5. VNA Test Port 2 V(m) — 6. Resultant reference planes during first AutoCal procedure. — 7. After initial calibrations, user is directed to remove AutoCal module and connect test cables. At all times during the calibration procedure, the AutoCal module must be connected to the VNA and to AC power. — 8. Connect the two Test Cables together to complete the through calibration.

6. Navigate to the AUTOCAL SETUP menu:
    - Navigation: MAIN | Calibration | CALIBRATION | Calibrate | CALIBRATE | AutoCal | AUTOCAL PORTS | 2-Port Cal | AUTOCAL SETUP
    - The AUTOCAL SETUP menu appears.

7. On the AUTOCAL SETUP menu, if the Cal Type, Thru Type, and Module Orientation display buttons do not show the correct values, select the Modify Cal Setup button.
    a. The MODIFY 2-PORT AUTOCAL SETUP dialog box appears.
    b. Change the settings as required.
    c. In the Cal Type Select area: Select the Full Two Port radio button.
    d. In the Thru Select area, select the True Thru radio button and the THRU INFO dialog box appears.

    e. Enter information about the through line. Enter 0 length and 0 dB/mm loss (and a reference frequency of 0, which forces it to use that loss at all frequencies) and 50 ohm impedance. Select OK to close the dialog box.

- Select the Auto Sense Module Orientation check box which allows the AutoCal module determine the left/right cable identification.

- Click OK to close the dialog box.

Note	All existing system setups such as IF Bandwidth, Averaging, and Power Level will be applied during the calibration procedure.

8. When ready, click the Begin Cal button.

9. If the AutoCal module is connected incorrectly, the AUTOCAL MODULE NOT DETECTED warning message appears.

- Correct connections as required and click Retry.

10. A status dialog box with a progress bar appears after an AutoCal sequence has started. The status messages define has far the program has progressed and if any user actions are required.

11. At any time, the AutoCal sequence can be cancelled by clicking the dialog box Abort button.

12. A dialog box will appear when the true through is to be connected.

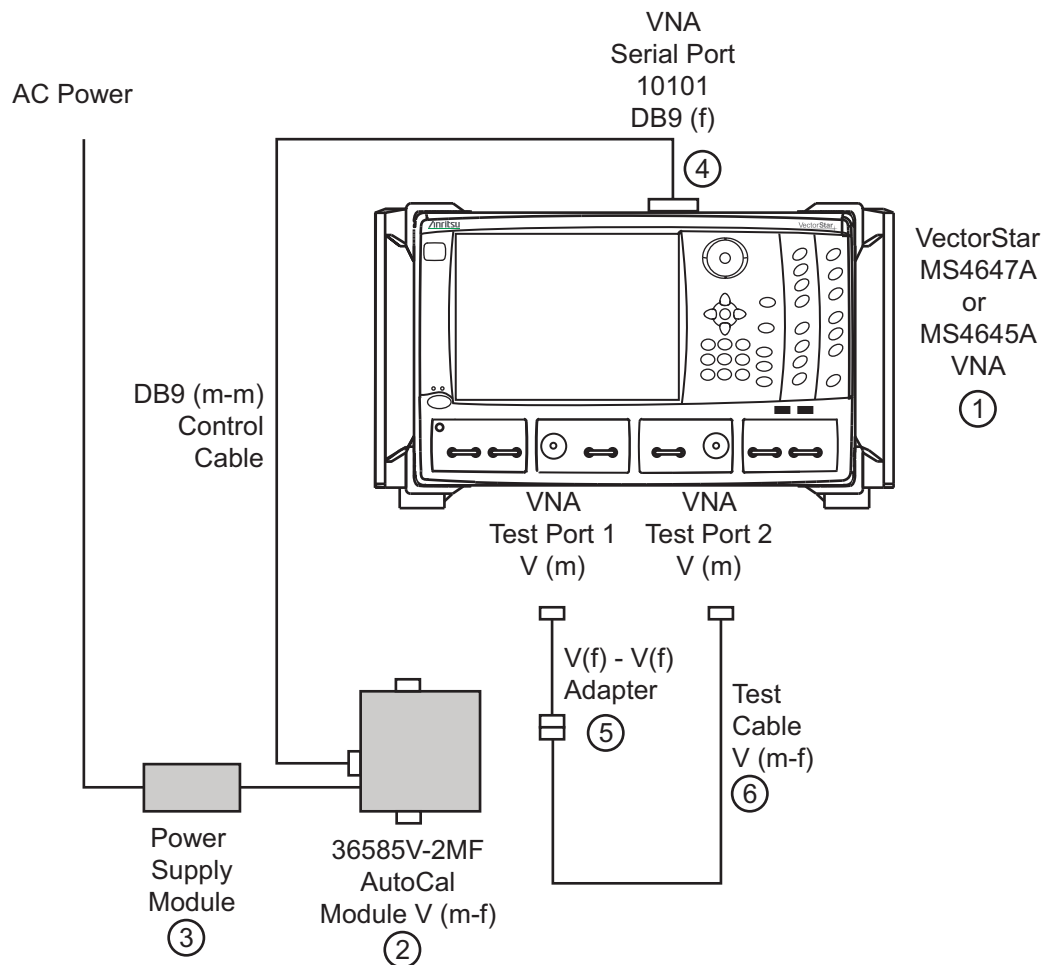**13.** Connect the **Test Port 1 test cable** to the **Test Port 2 test cable**.

Figure 2-14. AutoCal True-Through Connections - Module Removed

14. After connecting the through, select Continue.

15. When the auto calibration is complete, a status message appears with a statement about assurance passing or failing. On the CALIBRATION menu, the Cal Status field button shows ON.

16. Closing the dialog box returns to the CALIBRATION menu.

2-10 AutoCal Module Characterization

Characterization

Typically, characterization is performed by Anritsu since the process can be very carefully controlled for maximum accuracy. In certain cases, the customer may wish to perform the characterization themselves but it is important to note that all specifications for the calibration are void and the customer takes responsibility for performing a characterization of adequate quality. With that caveat, the process for performing a characterization is as follows:

1. Setup the instrument for the frequency range, point count, power level, and IFBW desired. It is particularly important to use as many points as reasonable in order to reduce interpolation needs.

2. Perform as high a quality manual calibration as possible at the reference planes that will be connected to the AutoCal module. LRL/LRM is recommended if possible.

3. Connect the AutoCal module to the reference planes, apply power, and connect the control cable to both the AutoCal module and to the MS4640A Series VNA. Allow the AutoCal module to reach operating temperature so the blue **Operate LED** illuminates.

4. Select the AUTOCAL CHARAC. menu (shown below) to start characterization. The VNA will automatically switch the unit through its various states and characterize them. Alternatively, the connected test port order may be specified and may be necessary if there is substantial loss in the test setup (note that this may indicate an accuracy hazard).

    • Navigation: MAIN | System | SYSTEM | Utility | UTILITY | AutoCal Characterization | AUTOCAL CHARAC.

5. Save the characterization file as appropriate. Note that the characterization file will be tied by serial number to the particular AutoCal module that was characterized.
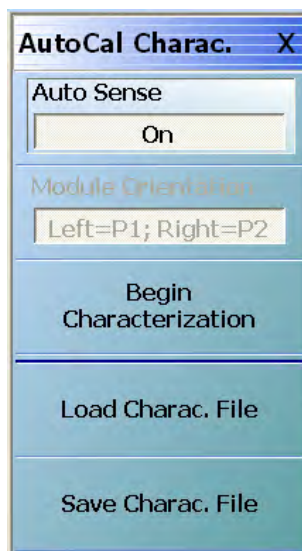

Figure 2-15. AUTOCAL CHARAC. (AUTOCAL CHARACTERIZATION) Menu

2-11 Working with Older AutoCal Modules

Auto Calibration Units 36581x and 36582x

Older Anritsu auto calibration units are supported by the MS464X VNA but with somewhat lower performance and different functionality. Fewer reflection states are available in these older models so an over-determined algorithm is not employed and a different characterization process is typically employed; both of which result in lower accuracy (see data sheets for quantities). These differences are practically less significant at 20 GHz and below where one may use the 36581X; they may be more significant at higher frequencies. The 36582X is an electromechanical switch-based unit unlike the other modules so it may suffer from additional degradation due to switch repeatability.

The characterization load process is similar. It may be required to transfer the characterization file from a floppy to a USB stick for transfer to the VNA (or transfer by network or GPIB).

A maximum of 1601 characterization points are possible on the older platforms so interpolation errors may be higher. These AutoCal units may be re-characterized with the MS464XA to increase point count with the caveats discussed in Section 2-10 "AutoCal Module Characterization" on page 2-23.

Autosensing of the AutoCal orientation is not possible. The current orientation must be entered correctly or large errors will result.

Adjustable switch averaging is no longer supported. A factory recommended level will automatically be invoked for electromechanical units.

2-12 Adapter Removal - M-M or F-F Reference Plane with a M-F AutoCal

Adapter Removal Overview

Adapter removal for AutoCal modules primarily refers to the case of a sex incompatibility when it is not desired to use test port converters such as when the user has a M-F AutoCal module and M-M reference planes are required. A separate menu item is provided for AutoCal adapter removal to speed up the process since fewer manual steps are needed. In this calibration sequence, one uses an adapter (that can mate the desired reference plane connectors) as port of the calibration. Two possible scenarios are covered; both use a pair of calibration sequences to remove the effects of the adapter. In both of the cases below, it is assumed all connectors are from the same family. If not (e.g., one is using a special inter-series AutoCal unit), then this AutoCal-specific adapter removal technique may not be applied; see the standard adapter removal section.

This procedure performs an AutoCal procedure when an adapter is required to accommodate either the AutoCal unit or the DUT connector genders and a M-M reference plane is required.

Required Equipment

- **VNA** – A VectorStar MS4642A or MS4644A
- **AutoCal Module** – A Precision AutoCal Module, 36585K-2MF, with K (f-m) connectors.
    - Includes the necessary Power Supply Module with cords to AutoCal Module and to AC power
- **Test Cable** – A test port cable with K (m-f) connectors
- **K (f-f) Adapter** – A Matched K Adapter, 36583K with K (f-f) connectors.

Prerequisites

The following prerequisite procedures have already been accomplished:

- AutoCal Characterization file previously loaded.
- VectorStar powered up.
- Required settings for Frequency Start, Frequency Stop, Number of Points, and CW Mode configured.
- Optional settings as required for Segmented Sweep, IF Bandwidth, Averaging, and Port Power configured.

Procedure

1. Make the necessary cable connections between the AutoCal Module, its Power Module, AC power, and the VectorStar back panel.

    - When the blue **Operate LED** is illuminated, the module has warmed up and is ready for calibration operations.

2. Connect the **36583K (f-f) Adapter** to the **AutoCal K (m) connector**.

    - Consider the Adapter and AutoCal module as an "assembly" for the duration the AutoCal procedure.

Note	Once assembled, do not break the connection between the adapter and the AutoCal module, do not disconnect the assembly from the VNA Serial 10101 Port, and do not disconnect the assembly from AC power. If the connection between the adapter is broken before the AutoCal procedure is completed, the entire calibration is invalidated and must be repeated.

3. Connect the remaining **36583K (f) connector** to the VectorStar **Test Port 1 K (m) connector**.

4. Connect the **Test Cable K (f) connector** to the VectorStar **Test Port 2 K (m) connector**.

5. Connect the **Test Cable K (m) connector** to the **AutoCal Module K (f) connector**.
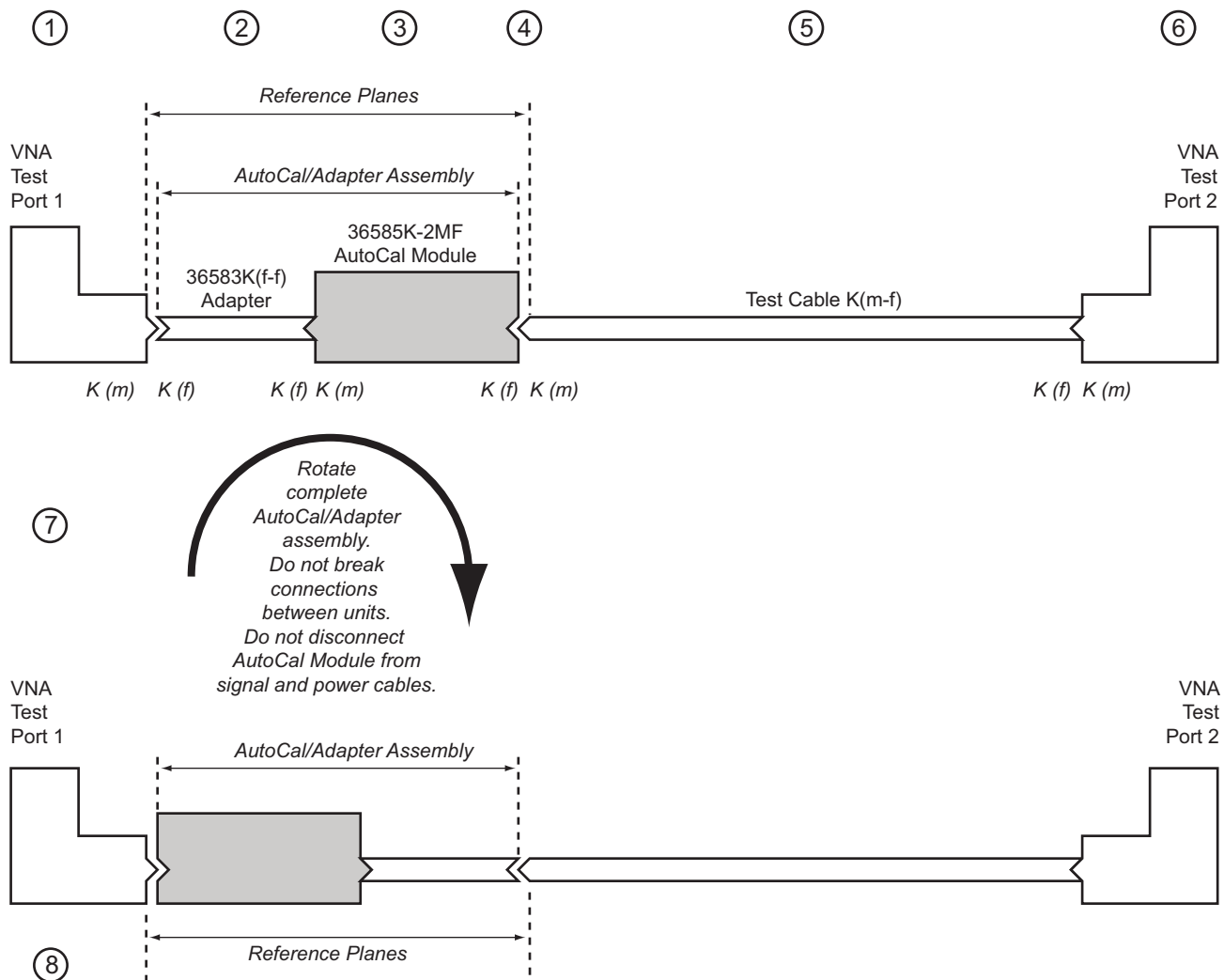

Figure 2-16. Precision MF AutoCal 36585K-2MF, Adapter Removal, Internal Thru

— Callouts 1 to 6 represent the first AutoCal procedure. Callouts 7 and 8 represent the second AutoCal procedure. — 1. VNA Test Port 1 — 2. 36583K (f-f) Adapter — 3. 36585K-2MF AutoCa Module. For the duration of the calibration, the K (f-f) Adapter and the AutoCal Module must be connected and remain as an assembly. — 4. Resultant calibration reference planes — 5. K(m-f) Test Cable — 6. VNA Test Port 2 — 7. After the first calibration, rotate the complete assembly so that the AutoCal K(f) connector is connected to VNA Test Port 1 — 8. The reference planes remain in place.

6. Navigate to the AUTOCAL SETUP menu.

- Navigation: MAIN | Calibration | CALIBRATION | Calibrate | CALIBRATE | AutoCal | AUTOCAL PORTS | 2-Port Cal | AUTOCAL SETUP

7. If the Cal Type, Thru Type, and Module Orientation display buttons do not show the correct values, select the Modify Cal Setup button.

- The Modify AutoCal Setup dialog box appears.

8. Make the following changes to the Modify AutoCal Setup dialog box settings:

a. Select the Auto Sense Module Orientation check box which allows the AutoCal module determine the left/right cable identification.

a. In the Select Cal Type area, select the Adapter Removal radio button. The For Adapter Removal Only area becomes available.

b. In the Through Setup area, select the Internal Thru radio button and Adapter Removal.

c. In the For Adapter Removal Only area, enter the estimate of electrical length (in mm) and select which AutoCal port the adapter is attached to.

d. Select OK to close the dialog box. The AUTOCAL SETUP menu reappears with new values for Cal Type, Thru Type, and Module Orientation.

Note	All existing system setups such as IF Bandwidth, Averaging, and Power Level will be applied during the calibration procedure.

9. When ready, click the Begin Cal button.

10. If the AutoCal module is connected incorrectly, the AutoCal Module Not Detected warning message appears.

   • Correct connections as required and click Retry.

11. A status dialog box with a progress bar appears after an AutoCal sequence has started. The status messages define has far the program has progressed and if any user actions are required.

12. At any time, the AutoCal sequence can be cancelled by clicking the dialog box Abort button.

   • When the first AutoCal process is complete, the user is prompted to reverse the Adapter/AutoCal assembly.

Note	Once assembled, do not break the connection between the adapter and the AutoCal module. If the connection between the adapter is broken before the AutoCal procedure is completed, the entire calibration is invalidated and must be repeated.

13. The instrument will prompt the user to reverse the module-adapter assembly.

14. As shown above in Figure 2-16, disconnect the **Adapter** from **Test Port 1** and the **AutoCal Module** from the **Test Cable** on Test Port 2.

15. Reverse the **Adapter/AutoCal Module assembly** so that the Adapter end is pointing towards Test Port 2.

16. On the AutoCal module, connect the free **AutoCal Module K (f) connector** to Test Port 1 K (m).

17. On the Adapter, connect the free **Adapter K (f) connector** to the Test Cable connected to Test Port 2.

18. When the auto calibration is complete, a status message appears with a statement about assurance passing or failing. Closing the dialog will return to the regular menu system. On the CALIBRATION menu, the Cal Status field button shows ON.