SERIES
37XXXD
VECTOR NETWORK ANALYZER

OPERATION MANUAL

490 JARVIS DRIVE • MORGAN HILL, CA 95037-2809

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DECLARATION OF CONFORMITY

Manufacturer's Name: ANRITSU COMPANY

Manufacturer's Address: Microwave Measurements Division
490 Jarvis Drive
Morgan Hill, CA 95037-2809
USA

declares that the product specified below:

Product Name: Vector Network Analyzer

Model Number: 371XXA, 372XXA, 373XXA, 371XXB, 372XXB, 373XXB
371XXC, 3722XXC, 373XXC

conforms to the requirement of:

EMC Directive 89/336/EEC as amended by Council Directive 92/31/EEC & 93/68/EEC
Low Voltage Directive 73/23/EEC as amended by Council directive 93/68/EEC

Electromagnetic Interference:

Emissions: CISPR 11:1990/EN55011: 1991 Group 1 Class A
EN 61000-3-2:1995 Class A
EN 61000-3-3:1995 Class A

Immunity: EN 61000-4-2:1995/EN50082-1: 1997 - 4kV CD, 8kV AD
EN 61000-4-3:1997/EN50082-1: 1997 - 3V/m
ENV 50204/EN50082-1: 1997 – 3V/m
EN 61000-4-4:1995/EN50082-1: 1997 - 0.5kV SL, 1kV PL
EN 61000-4-5:1995/EN50082-1: 1997 - 1kV L-L, 2kV L-E
EN 61000-4-6:1994/EN61326: 1998 – 3V
EN 61000-4-8:1994/EN61326: 1998 – 3A/m
EN 61000-4-11:1994/EN61326: 1998 – 100% @ 20msec

Electrical Safety Requirement:

Product Safety: EN 61010-1:2001

Will have a new doc end of August

Marcel Dubois, Corporate Quality Director

Morgan Hill, CA

22 DEC 2003

Date

European Contact: For Anritsu product EMC & LVD information, contact Anritsu LTD, Rutherford Close, Stevenage Herts, SG1 2EF UK, (FAX 44-1438-740202)

DECLARATION OF CONFORMITY

Manufacturer's Name: ANRITSU COMPANY

Manufacturer's Address: Microwave Measurements Division
490 Jarvis Drive
Morgan Hill, CA 95037-2809
USA

declares that the product specified below:

Product Name: Broadband System

Model Number: ME7808A

conforms to the requirement of:

EMC Directive 89/336/EEC as amended by Council Directive 92/31/EEC & 93/68/EEC
Low Voltage Directive 73/23/EEC as amended by Council directive 93/68/EEC

Electromagnetic Interference:

Emissions:
CISPR 11:1990/EN55011: 1991 Group 1 Class A
EN 61000-3-2:1995 Class A
EN 61000-3-3:1995 Class A

Immunity:
EN 61000-4-2:1995/EN50082-1: 1997 - 4kV CD, 8kV AD
EN 61000-4-3:1997/EN50082-1: 1997 - 3V/m
ENV 50204/EN50082-1: 1997 – 3V/m
EN 61000-4-4:1995/EN50082-1: 1997 - 0.5kV SL, 1kV PL
EN 61000-4-5:1995/EN50082-1: 1997 - 1kV L-L, 2kV L-E
EN 61000-4-6:1994/EN61326: 1998 – 3V
EN 61000-4-11:1994/EN61326: 1998 – 100% @ 20msec

Electrical Safety Requirement:

Product Safety: IEC 1010-1:1990 + A1/EN61010-1: 1993

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Director of Corporate Quality

Morgan Hill, CA

10-DEC-01

Date

European Contact: For Anritsu product EMC & LVD information, contact Anritsu LTD, Rutherford Close, Stevenage Herts, SG1 2EF UK, (FAX 44-1438-740202)

Safety Symbols

To prevent the risk of personal injury or loss related to equipment malfunction, Anritsu Company uses the following symbols to indicate safety-related information. For your own safety, please read the information carefully BEFORE operating the equipment.

Symbols used in manuals

DANGER — This indicates a very dangerous procedure that could result in serious injury or death if not performed properly.

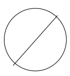
WARNING — This indicates a hazardous procedure that could result in serious injury or death if not performed properly.

CAUTION — This indicates a hazardous procedure or danger that could result in light-to-severe injury, or loss related to equipment malfunction, if proper precautions are not taken.

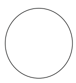
Safety Symbols Used on Equipment and in Manuals

Some or all of the following five symbols may or may not be used on all Anritsu equipment. In addition, there may be other labels attached to products that are not shown in the diagrams in this manual.

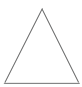
The following safety symbols are used inside or on the equipment near operation locations to provide information about safety items and operation precautions. Ensure that you clearly understand the meanings of the symbols and take the necessary precautions BEFORE operating the equipment.



This indicates a prohibited operation. The prohibited operation is indicated symbolically in or near the barred circle.



his indicates a compulsory safety precaution. The required operation is indicated symbolically in or near the circle.



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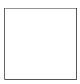
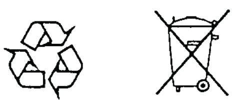


This indicates a note. The contents are described in the box.



These indicate that the marked part should be recycled.

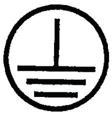
For Safety

WARNING

Always refer to the operation manual when working near locations at which the alert mark, shown on the left, is attached. If the operation, etc., is performed without heeding the advice in the operation manual, there is a risk of personal injury. In addition, the equipment performance may be reduced.

Moreover, this alert mark is sometimes used with other marks and descriptions indicating other dangers.

WARNING



or

When supplying power to this equipment, connect the accessory 3-pin power cord to a 3-pin grounded power outlet. If a grounded 3-pin outlet is not available, use a conversion adapter and ground the green wire, or connect the frame ground on the rear panel of the equipment to ground. If power is supplied without grounding the equipment, there is a risk of receiving a severe or fatal electric shock.

WARNING

Repair

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

WARNING

Use two or more people to lift and move this equipment, or use an equipment cart. There is a risk of back injury, if this equipment is lifted by one person.

Narrative Table Of Contents

Chapter 1—General Information
This chapter provides a general description of the Anritsu Model 37XXXD Vector Network Analyzer System and its major units: network analyzer, test set, and frequency source. It also provides descriptions for the precision component kits, and equipment options. Additionally, it contains the listing of recommended test equipment.

Chapter 2—Installation
This chapter provides instructions for performing an initial inspection, preparing the equipment for use, setting up for operation over the IEEE-488.2 (GPIB) Bus, using a printer, and preparing the units for storage and/or shipment. It also provides a listing of Anritsu Customer Service Centers.

Chapter 3—Network Analyzers, A Primer
This chapter provides an introduction to network analysis and the types of measurements that can be made using them. It provides general and introductory description.

Chapter 4—Front Panel Operation
This chapter describes the front panel controls and provides flow diagrams for the menus called up using the front panel controls. It contains the following sub-chapters:

- Front Panel Control-Group Descriptions
- Calibration Keys and Indicators, Detailed Description
- Save/Recall Menu Key and Menus, Key Description and Menu Flow
- Measurement Keys and Menus, Key Descriptions and Menu Flow
- Channel Keys and Menu, Key Descriptions and Menu Flow
- Display Keys and Menus, Key Descriptions and Menu Flow
- Enhancement Keys and Menus, Key Descriptions and Menu Flow
- Hard Copy Keys and Menus, Key Descriptions and Menu Flow
- System State Keys and Menus, Key Descriptions and Menu Flow
- Markers/limits Keys and Menus, Key Descriptions and Menu Flow
- Disk Storage Interface, Detailed Description

Chapter 5—Error And Status Messages
This chapter describes the type of error messages you may encounter during operation and provides a tabular listing. This listing describes and defines the error types.

Chapter 6—Data Displays
This chapter provides a detailed description of the various data displays. It describes the graph types, frequency markers, measurement limit lines, status displays, and data display controls.

Chapter 7—Measurement Calibration

This chapter provides a discussion and tutorial on measurement calibration. It contains step-by-step calibration procedures for the Standard (OSL), Offset-Short, TRM, and LRL/LRM methods. It also has a procedure for calibrating using a sliding termination.

Chapter 8—Measurements

This chapter discusses measurements with the 37XXXD VNA. It contains sub-chapters that provide a detailed descriptions for Transmission and Reflection, Low Level and Gain, Group Delay, Active Device, Multiple Source Control, Adapter Removal, Gain Compression, and Receiver Mode measurements

Chapter 9—Time Domain

This chapter describes the Option 2, Time Domain feature. It provides an operational procedure and a flowchart of the time domain menus.

Chapter 10—AutoCal

This chapter describes the Automatic Calibrator (AutoCal) feature and provides operational information and procedures.

Chapter 11—Operational Checkout Procedures

This chapter provides a procedure for operational checkout

Chapter 12—Calibration Kits

This chapter provides a description and listing of components for the calibration kits.

Chapter 13—Millimeter Wave System

This chapter contains description, operation, and checkout procedures for the millimeter wave measurement capability that can be added to the 371XXC Vector Network Analyzer.

Chapter 14—ME7808A Broadband Measurement System

This chapter contains description, operation, and checkout procedures for the optional broadband measurement capability that can be added to the 37XXXD Vector Network Analyzer.

Appendix A—Front Panel Menus, Alphabetical Listing

This appendix shows all of the menus that are called up using the front panel controls. It provides a replica of the menu and descriptive text for all of the various menu choices. The listing is alphabetical by the menu call letters mentioned and/or illustrated in Chapter 4.

Appendix B—Model 37XXXD VNA Rear Panel Connectors

This appendix describes the rear panel connectors. It also provides pinout listing.

Appendix C—Performance Specifications

This appendix contains the Technical Data Sheet, part number 11410-00350, which provides performance specifications.

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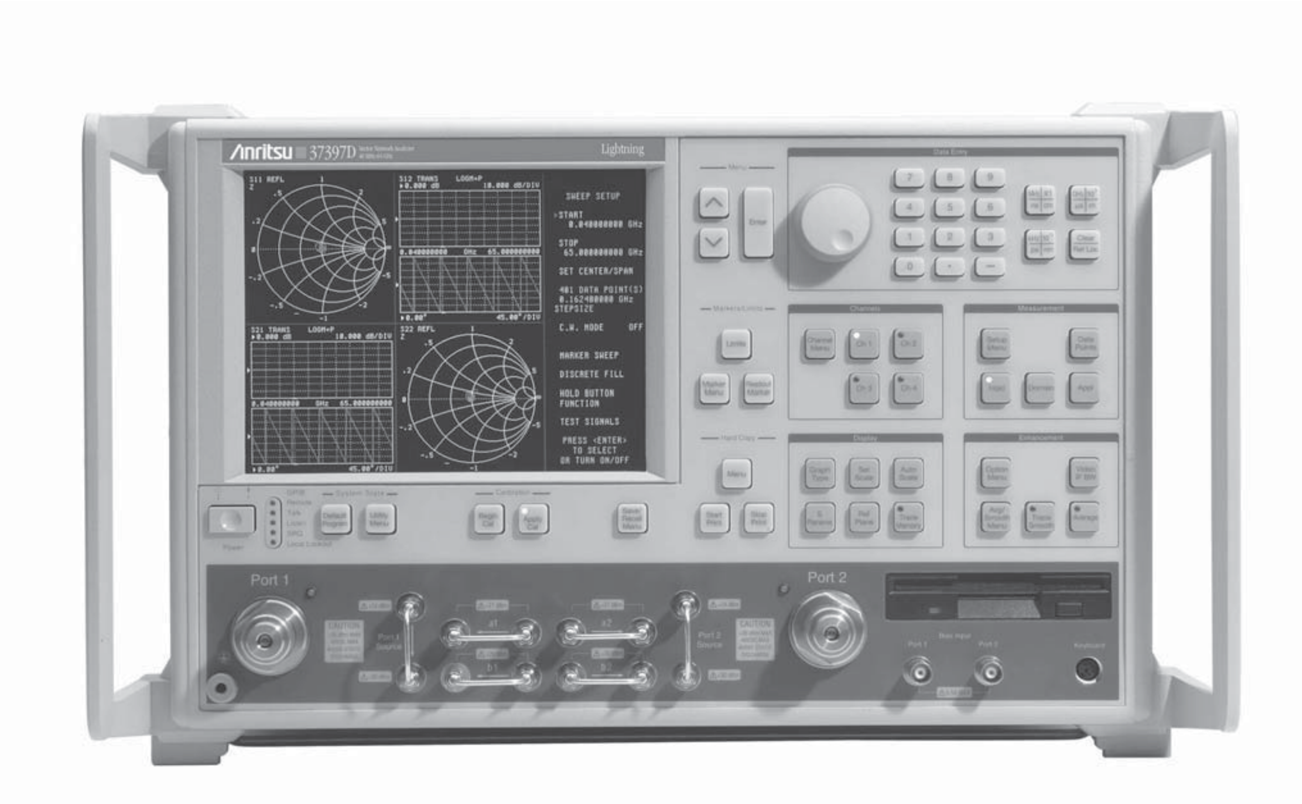

Figure 1-1. *Model 37397D Vector Network Analyzer System*

Chapter 1
General Information

1-1 SCOPE OF MANUAL

This manual provides general information, installation, and operating information for the Model 37XXXD Vector Network Analyzer (VNA) system. (Throughout this manual, the terms VNA, 37XXXD VNA, and 37XXXD will be used interchangeably to refer to the system.)

1-2 INTRODUCTION

This section provides general information about the 37XXXD VNA system and one or more precision-component calibration or performance verification kits. The section also provides a listing of recommended test equipment.

1-3 IDENTIFICATION NUMBER

All Anritsu instruments are assigned a unique six-digit ID number, such as “940101.” This number is affixed to a decal on the rear panel of each unit. In any correspondence with Anritsu Customer Service, please use this number.

1-4 ONLINE MANUALS

Manual updates, if any, are available on Anritsu's Internet download page (http://www.us.anritsu.com/downloads/).

1-5 SYSTEM DESCRIPTION

The 37XXXD Network Analyzer (Figure 1-1) is a single-instrument system that contains a built-in source, test set, and analyzer. It is produced in two series— 372XXD and 373XXD—described below. All models provide up to 1601 measurement data points, a built-in hard-disk drive for storing and recalling front panel setups and measurement and calibration data. They also provide an on-screen display of total operational time and dates of system calibrations. They support operation over the IEEE 488.2 General Purpose Interface Bus (GPIB).

372XXD

The 372XXD is a fully functioning VNA for making passive-device measurements. The series offers five models that cover a range from 22.5 MHz to 65 GHz. The models are shown below:

Model	Frequency Range
37247D	40.0 MHz to 20.0 GHz
37269D	40.0 MHz to 40.0 GHz
37277D	40.0 MHz to 50.0 GHz
37297D	40.0 MHz to 65.0 GHz

373XXD

The 373XXD is a fully functioning VNA for making passive- and active-device measurements. The series offers five models that cover a range from 22.5 MHz to 65 GHz. The models are shown below.

Model	Frequency Range
37347D	40.0 MHz to 20.0 GHz
37369D	40.0 MHz to 40.0 GHz
37377D	40.0 MHz to 50.0 GHz
37397D	40.0 MHz to 65.0 GHz

1-6 MILLIMETER WAVE MEASUREMENTS

Any 37XXXD VNA can be used for making millimeter-wave measurements using the rear panel IF inputs. A description of this measurement mode is described in Chapter 13.

1-7 PRECISION COMPONENT KITS

Two types of precision-component kits are available: calibration and verification. Calibration kits contain components used to identify and separate error sources inherent in microwave test setups. Verification kits consist of components with characteristics traceable to the National Institute of Standards and Technology (NIST). This type of kit is usually kept in the metrology laboratory where it provides the most dependable means of checking system accuracy. Each of these kits contains a micro-floppy disk providing coefficient or measurement data for each component. Details of these kits are described in the following paragraphs.

Model 3650 SMA/3.5 mm Calibration Kit

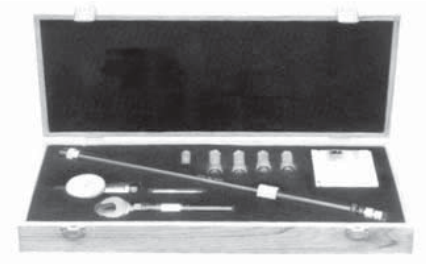

Figure 1-2. *Typical Model 365X Calibration Kit*

The 3650 Calibration Kit (Figure 1-2) contains all the precision components and tools required to calibrate the 37XXXD VNA for 12-term error-corrected measurements of test devices with SMA or 3.5 mm connectors. Components are included for calibrating both male and female test ports. The kit supports calibration with broadband loads. The kit consists of the following components:

- ❑ 23S50 Short, SMA/3.5 mm Male
- ❑ 23SF50 Short, SMA/3.5 mm Female
- ❑ 24S50 Open, SMA/3.5 mm Male
- ❑ 24SF50 Open, SMA/3.5 mm Female
- ❑ 28S50–2 Termination, SMA/3.5 mm Male, 2 ea. (dc–26.5 GHz)
- ❑ 28SF50–2 Termination, SMA/3.5 mm Female, 2 ea.(dc–26.5 GHz)
- ❑ 33SFSF50 Insertable, SMA/3.5 mm Female/Female, 2 ea.
- ❑ 33SS50 Insertable, SMA/3.5 mm Male/Male
- ❑ 33SSF50 Insertable, SMA/3.5 mm Male/Female, 2 ea.
- ❑ 34AS50–2 Adapter, GPC–7 to SMA/3.5 mm Male, 2 ea.
- ❑ 34ASF50-2 Adapter, GPC–7 to SMA/3.5 mm Female, 2 ea.
- ❑ 01–201 Torque Wrench
- ❑ 01–210 Reference Flat
- ❑ 01–222 Connector Gauge
- ❑ 01–223 Gauge Kit Adapter
- ❑ Data Disk

Option 1: Adds 17S50 Sliding Load, SMA/3.5 mm Male; 17SF50 Sliding Load, SMA/3.5 mm Female; 01–211 Female Flush Short; and 01–212 Male Flush Short.

Model 3651 GPC–7 Calibration Kit

The 3651 Calibration Kit (Figure 1-3) contains all the precision components and tools required to calibrate the 37XXXD for 12-term error-corrected measurements of test devices with GPC–7 connectors. The kit supports calibration with broadband loads. Option 1 adds a sliding load and a pin depth gauge.

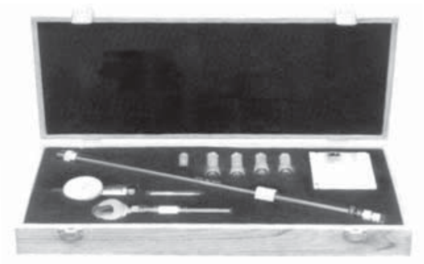

Figure 1-3. *Typical Model 365X Calibration Kit*

The kit consists of the following components:

- ❑ 23A50 Short, GPC–7
- ❑ 24A50 Open, GPC–7
- ❑ 28A50–2 Termination, GPC–7, 2 ea. (dc–18 GHz)
- ❑ 01–200 Torque Wrench
- ❑ 01–221 Collet Extractor Tool and Vial of Four Collets
- ❑ Data Disk

Option 1 Adds:

- ❑ 17A50 Sliding Load, GPC–7
- ❑ 01–220 GPCP–7 Connector Gauge
- ❑ 01–210 Reference Flat Model 3652 K Connector® Calibration Kit

Model 3652 K Connector Calibration Kit

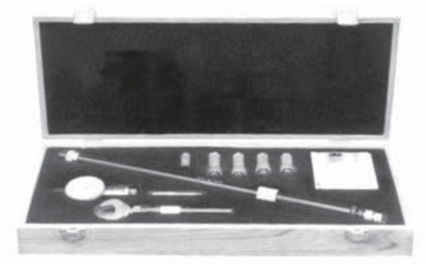

Figure 1-4. *Typical Model 365X Calibration Kit*

The 3652 Calibration Kit (Figure 1-4) contains all the precision components and tools required to calibrate the 37XXXD for 12-term error-corrected measurements of test devices with K Connectors. Components are included for calibrating both male and female test ports. The kit supports calibration with broadband loads. Option 1 adds sliding loads.

The kit consists of the following components:

- ❑ 23K50 Short, K Male
- ❑ 23KF50 Short, K Female
- ❑ 24K50 Open, K Male
- ❑ 24KF50 Open, K Female
- ❑ 28K50 Termination, K Male, 2 ea. (dc–40 GHz)
- ❑ 28KF50 Termination, K Female, 2 ea. (dc–40 GHz)
- ❑ 33KK50 Insertable, K Male/Male
- ❑ 33KFKF50 Insertable K Female/Female, 2 ea
- ❑ 33KKF50 Insertable, K Male/Female, 2 ea
- ❑ 34AK50 Adapter, GPC–7/K Male, 2 ea
- ❑ 34AKF50 Adapter, GPC–7/K Female, 2 ea
- ❑ 01–201 Torque Wrench
- ❑ 01–210 Reference Flat
- ❑ 01–222 Connector Gauge
- ❑ 01–223 Gauge Kit Adapter
- ❑ Data Disk

Option 1 Adds:

- ❑ 17K50 Sliding Load, K Male
- ❑ 17KF50 Sliding Load, K Female
- ❑ 01–211 Female Flush Short
- ❑ 01–212 Male Flush Short.

Model 3653 Type N Calibration Kit

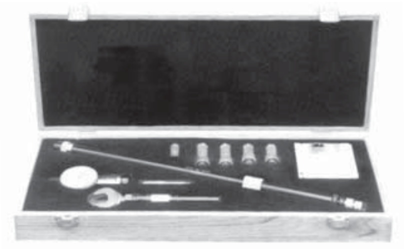

Figure 1-5. *Typical Model 365X Calibration Kit*

The 3653 Calibration Kit (Figure 1-5) contains all the precision components and tools required to calibrate the 37XXXD for 12-term error-corrected measurements of test devices with Type N connectors. Components are included for calibrating both male and female test ports. The kit supports calibration with broadband loads. Option 1 for sliding loads is not available in this calibration kit.

The kit consists of the following components:

- ❑ 23N50 Short, N Male
- ❑ 23NF50 Short, N Female
- ❑ 24N50 Open, N Male
- ❑ 24NF50 Open, N Female
- ❑ 28N50–2 Termination, N Male, 2 ea. (dc–18 GHz)
- ❑ 28NF50–2 Termination, N Female, 2 ea. (dc–18 GHz)
- ❑ 34AN50–2 Adapter, GPC–7/N Male, 2 ea.
- ❑ 34ANF50–2 Adapter, GPC–7/N Female, 2 ea.
- ❑ 01–213 Type N Reference Gauge
- ❑ 01–224 Type N Connector Gauge
- ❑ Data Disk Model 3654B

Model 3654B V Connector® Calibration Kit

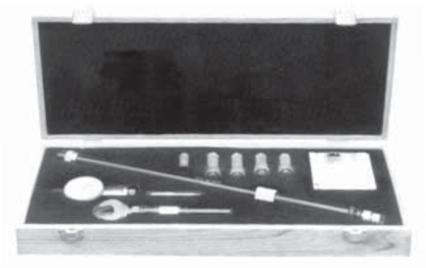

Figure 1-6. *Typical Model 365X Calibration Kit*

The 3654B Calibration Kit (Figure 1-6) contains all the precision components and tools required to calibrate the 372XXD for 12-term error-corrected measurements of test devices with V Connectors. Components are included for calibrating both male and female test ports.

The kit consists of the following components:

- ❑ 17VF50B Female Sliding Termination
- ❑ 17V50B Male Sliding Termination
- ❑ 33VVF50 Male-Female Adapter (2)
- ❑ Calibration Software, 2360-54B
- ❑ 28V50B Male and 28VF50B Female Broadband Terminations (2 ea.)
- ❑ 24V50B Male and 24VF50B Female Opens
- ❑ 23V50B-5.1 Male and 23VF50B-5.1 Female Shorts 5.1mm
- ❑ 33VV50 Male-Male Adapter
- ❑ 33VFVF50 Female-Female Adapter (2)
- ❑ Connector Thumb Wheel (4)
- ❑ 01-201 Torque Wrench
- ❑ 01-323 Female Adapter for Pin Gauge
- ❑ 01-322 Pin Depth Gauge
- ❑ 01-210 Reference Flat, 01-204 Adapter Wrench
- ❑ 01-312 Male Flush Short
- ❑ 01-311 Female Flush Short

Model 3656 W1 Connector Calibration Kit

Figure 1-7. *3656 (W1) Calibration Kit*

The 3656 W1 (1.0 mm) Connector Calibration Kit (Figure 1-7) consists of precision components to calibrate the VNA to 110 GHz. The kit supports SOLT calibrations with opens, shorts, and loads to 65 GHz, and Triple Offset short calibrations from 65 GHz to 110 GHz. The kit also includes verification devices for determining system accuracy of the VNA. A diskette containing factory measured test data is supplied for comparison with customer measured data.

- ❑ 23W50-1, Male Offset Short 2.02 mm
- ❑ 23WF50-1, Female Offset Short 2.02 mm
- ❑ 23W50-2, Male Offset Short 2.65 mm
- ❑ 23WF50-2, Female Offset Short 2.65 mm
- ❑ 23W50-3, Male Offset Short 3.180 mm
- ❑ 23WF50-3, Female Offset Short 3.180 mm
- ❑ 24W50, Male Open 1.510 mm
- ❑ 24WF50, Female Open 1.930 mm
- ❑ 28W50, Male Broadband Termination
- ❑ 28WF50, Female Broadband Termination
- ❑ 33WW50, Male-Male Adapter (1)
- ❑ 33WWF50, Male-Female Adapter (1)
- ❑ 33WFWF50, Female-Female Adapter (1)
- ❑ 01-401, Interchangeable Adapter Fixed Female
- ❑ 01-402, Interchangeable Adapter Fixed Male
- ❑ 18WWF50-1, 50 Matched Thruline (Verification Device)
- ❑ 18WWF50-1B, Stepped Impedance Thruline (Verification Device)
- ❑ 01-504, Torque Wrench
- ❑ 01-505, End Wrench
- ❑ Calibration coefficients diskette
- ❑ Verification kit diskette

Model 3666 3.5 mm Verification Kit

Figure 1-8. *Typical Model 366X Verification Kit*

The 3666 Verification Kit (Figure 1-8) contains precision 3.5 mm components with characteristics that are traceable to the NIST. Used primarily by the metrology laboratory, these components provide the most dependable means of determining system accuracy. A disk containing factory-measured test data for all components is supplied for comparison with customer-measured data.

The 3666 consists of the following components:

- ❑ 19S50–7 7.5 cm Air Line
- ❑ 19S50–7B 7.5 cm Stepped Impedance Air Line (Beatty Standard)
- ❑ 42S–20 20 dB Attenuator
- ❑ 42S–50 50 dB Attenuator

Model 3667 GPC–7 Verification Kit

Figure 1-9. *Typical Model 366X Verification Kit*

The 3667 Verification Kit (Figure 1-9) contains precision GPC–7 components with characteristics that are traceable to the NIST. Used primarily by the metrology laboratory, these components provide the most dependable means of determining system accuracy. A disk containing factory-measured test data for each component is supplied for comparison with customer-measured data.

The kit consists of the following components:

- ❑ 18A50–10B 10 cm Stepped Impedance Air Line (Beatty Standard)
- ❑ 18A50–10 10 cm Air Line
- ❑ 42A–20 20 dB Attenuator
- ❑ 42A–50 50 dB Attenuator

Model 3668 K Connector® Verification Kit

Figure 1-10. *Typical Model 366X Verification Kit*

The 3668 Verification Kit (Figure 1-10) contains precision K Connector components with characteristics that are traceable to the NIST. Used primarily by the metrology laboratory, these components provide the most dependable means of determining system accuracy. A disk containing factory-measured test data for each component is supplied for comparison with customer-measured data.

The kit consists of the following components:

- 19K50–7 7.5 cm Air Line
- 19K50–7B 7.5 cm Stepped Impedance Air Line (Beatty Standard)
- 42K–20 20 dB Attenuator
- 42K–50 50 dB Attenuator

Model 3669/3669B V Connector® Verification Kits

The 3669 and 3669B Verification Kits (Figure 1-11) contain precision V Connector components with characteristics that are traceable to the NIST. Used primarily by the metrology laboratory, these components provide the most dependable means of determining system accuracy. A disk containing factory-measured test data for each component is supplied for comparison with customer-measured data.

Figure 1-11. *Typical Model 366X Verification Kit*

The kit consists of the following components:

- ❑ 19-V50-5 5 cm Air Line
- ❑ 19V50-5B 5 cm Stepped Impedance Air Line (Beatty Standard)
- ❑ 42V-20 20 dB Attenuator
- ❑ 42V-40 40 dB Attenuator

1-8 OPTIONS

The following options are available:

- ❑ Option 1: Rack Mount Kit
- ❑ Option 2: Time (Distance) Domain Measurement Capability
- ❑ Option 4: External SCSI Hard Drive Interface
- ❑ Option 15: Flexible test set (provides access to all four samplers and Source loops for each port)

1-9 PERFORMANCE SPECIFICATIONS

System performance specifications are provided in Appendix C.

1-10 PREVENTIVE MAINTENANCE

The 37XXXD VNA system does not require any preventive maintenance.

Chapter 2
Installation

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Chapter 2
Installation

2-1 INTRODUCTION

This chapter provides information for the initial inspection and preparation for use of the 37XXXD Vector Network Analyzer. Information for interfacing the 37XXXD to the IEEE-488 General Purpose Interface Bus and reshipment and storage information is also included.

2-2 INITIAL INSPECTION

Inspect the shipping container for damage. If the container or cushioning material is damaged, retain until the contents of the shipment have been checked against the packing list and the instrument has been checked for mechanical and electrical operation.

If the 37XXXD is damaged mechanically, notify your local sales representative or Anritsu Customer Service. If either the shipping container is damaged or the cushioning material shows signs of stress, notify the carrier as well as Anritsu. Keep the shipping materials for the carrier's inspection.

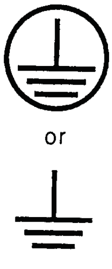
WARNING

Use two or more people to lift and move this equipment, or use an equipment cart. There is a risk of back injury, if this equipment is lifted by one person.

2-3 PREPARATION FOR USE

Except for units with Option 4 (see following page), no initial setup is required. After unpacking, the 37XXXD is ready for use. The 37XXXD is equipped with automatic line-power sensing, and will operate with any of the following line voltages: 100V, 120V, 220V, 240V +5%, –10%, 48–63 Hz, 350 VA. The 37XXXD is intended for Installation Category (Overvoltage Category) II.

WARNING



When supplying power to this equipment, always use a three-wire power cable connected to a three-wire power line outlet. If power is supplied without grounding the equipment, there is a risk of receiving a severe or fatal electric shock.

Option 4, External SCSI Drive Setup

The 37XXXD is available with an external SCSI drive interface as Option 4. This option deletes the usual internal hard disk and provides support for the use of an external SCSI drive.

An external SCSI drive and interface cable are not included with Option 4, but may be purchased from Anritsu. Contact your local sales representative for information on availability and price. Compatible drives may also be purchased from your local computer retailer.

Requirements:

- ❑ Interface: SCSI, SCSI-2
- ❑ Supported Drives: Iomega® Zip® 100MB SCSI, Zip® 250MB SCSI, Jaz 1, Jaz 2 (other drives may operate, but are not guaranteed)
- ❑ Connector: Centronics 50 Male Pro Series SCSI I (37XXXD is Female)
- ❑ SCSI ID: 5
- ❑ Terminated: Yes

System Boot:
Depending on your system configuration at the time of shipment, a drive (and cartridge) may be included. If not, your external drive must be connected to the 37XXXD and initialized with the system files as described below *before* proceeding.

Ensure that the drive is configured correctly and powered on. If the drive is a cartridge type, ensure that a cartridge with the system file on it is installed. Turn on the 37XXXD and the system should boot normally. Cartridges may then be exchanged if you wish to share files.

Initializing the Drive:
A set of 37000 Basic Measurement Software floppy disks, Anritsu part number 2300-212, is required. This 4-disk set is supplied with your shipment. Anritsu recommends BMS version 4.01 or above when using an external SCSI drive.

NOTE
This operation will erase all of the files on the SCSI drive. Copy any important files before proceeding.

Step 1. Connect the external drive to the 37XXXD's rear panel SCSI port with the interface cable (refer to Appendix B for information on the rear panel connectors). Ensure that the external SCSI drive is powered on with a cartridge installed (if applicable).

Step 2. With the 37XXXD powered off, insert Disk 1 of the 37000 BMS into the 37XXXD floppy drive.

Step 3. Power up the 37XXXD and immediately press any key to view the "Format Hard Drive" menu.

Step 4. Press 1 to format the drive. Disk 1 will load automatically.

Step 5. Follow the instructions on the 37XXXD display to load the next three disks. During this step, the system files are transferred to the SCSI drive.

The SCSI drive initialization is now complete. The 37XXXD should sweep with no displayed errors and is now ready to boot-up from the external drive at power-on.

2-4 GPIB SETUP

All functions of the 37XXXD (except power on/off and initialization of the hard disk) can be controlled remotely by an external computer/controller via the IEEE-488.2 GPIB. The information in this section pertains to interface connections and cable requirements for the rear panel GPIB connector. Refer to the Model 37XXXD Programming Manual, Anritsu Part Number 10410-00262, for information about remote operation of the 37XXXD using the GPIB.

The 37XXXD GPIB operates with any IBM XT, AT, or PS/2 compatible computer/controller equipped with a National Instruments GPIB-PCII/IIA interface card and software.

Interface Connector

Interface between the 37XXXD and other devices on the GPIB is via a standard 24-wire GPIB interface cable. For proper operation, order Anritsu part number 2100-1, -2, -4, or -5 (1, 2, 4, or 0.5 meter length) cables through your local sales representative. This cable uses a double-sided connector; one connector face is a plug, the other a receptacle. These double-function connectors allow parallel connection of two or more cables to a single instrument connector. The pin assignments for the rear panel GPIB connector are shown in Figure B-2, located in Appendix B.

Cable Length Restrictions

The GPIB system can accommodate up to 15 instruments at any one time. To achieve design performance on the bus, proper timing and voltage level relationships must be maintained. If either the cable length between separate instruments or the accumulated cable length between all instruments is too long, the data and control lines cannot be driven properly and the system may fail to perform. Cable length restrictions are as follows:

- No more than 15 instruments may be installed on the bus.
- Total accumulative cable length in meters may not exceed two times the number of bus instruments or 20 meters—whichever is less.

NOTE

For low EMI applications, the GPIB cable should be a fully shielded type, with well-grounded metal-shell connectors. (Use Anritsu 2100-series cables.)

2-5 SYSTEM GPIB INTERCONNECTION

There are two rear panel GPIB IEEE-488 connectors. The IEEE 488.2 connector used to interface the 37XXXD to an external computer/ controller via a standard GPIB cable. The Dedicated GPIB connector is used to interface to plotters and a second source for multiple source operation via a standard GPIB cable.

GPIB Interface to an External Plotter

The 37XXXD GPIB interface can be configured to control a suitable external plotter (refer to Chapter 6, Data Displays). In this mode of operation, the GPIB is dedicated to this application and only the 37XXXD and the plotter are connected to the GPIB. Standard GPIB cables are used to interconnect to the plotter.

GPIB Addresses

The 37XXXD leaves the factory with the default GPIB address set to six. This address may be changed using the GP7 menu (see Appendix A).

2-6 ETHERNET SETUP AND INTERCONNECTION

The 37XXXD can be remotely controlled via a network server and an Ethernet connection via the standard RJ45 connector on the rear panel. The 37XXXD software supports the TCP/IP network protocol. The TCP/IP protocol setup requires the following:

- ❑ IP Address: Every computer/electronic device in a TCP/IP network requires an IP address. An IP address has four numbers (each between 0 and 255) separated by periods. For example: 128.111.122.42 is a valid IP address
- ❑ Subnet Mask: The subnet mask distinguishes the portion of the IP address that is the network ID from the portion that is the station ID. The subnet mask 255.255.0.0, when applied to the IP address given above, would identify the network ID as 128.111 and the station ID as 122.42. All stations in the same Local Area Network (LAN) should have the same network ID but different station IDs
- ❑ Default Gateway: A TCP/IP network can have a gateway to communicate beyond the LAN identified by the network ID. A gateway is a computer or electronic device that is connected to two different networks and can move TCP/IP data from one network to the other. A single LAN that is not connected to other LANs requires a default gateway setting of 0.0.0.0. This (0.0.0.0) is Lightning's default gateway setting. If you have a gateway, then the default gateway would be set to the appropriate value of your gateway.

NOTE

The default gateway setting is only activated after the system power is recycled.

- ❑ Ethernet Address: An Ethernet address is a unique 48-bit value that identifies a network interface card to the rest of the network. Every network card has a unique ethernet address permanently stored into its memory Inappropriate setting of the Default Gateway IP Address will cause the Lightning system to appear to be locked up at start up. The instrument will appear to stop working at the following message:

  Application loaded successfully, starting system…

2-7 EXTERNAL MONITOR CONNECTOR

The rear panel External Monitor connector allows the internal display information of the 37XXXD to be connected to an external VGA monitor (either color or monochrome). The pinout of this 15-pin Type D connector is shown in Figure B-5, located in Appendix B.

2-8 RACK MOUNT

To install the Option 1 Rack Mount rails, refer to the below-listed procedure.

Step 1. Disconnect the line cord and any other attachments from the instrument.

Step 2. Carefully place the instrument on its top (bottom-side up) on a secure and stable work surface.

Step 3. Using a Phillips screwdriver, remove the two handles or four bumper assemblies (and tilt bail, if installed) from the front of the unit, and the four feet at the rear (Figure 2-1). Save the screws for later use.

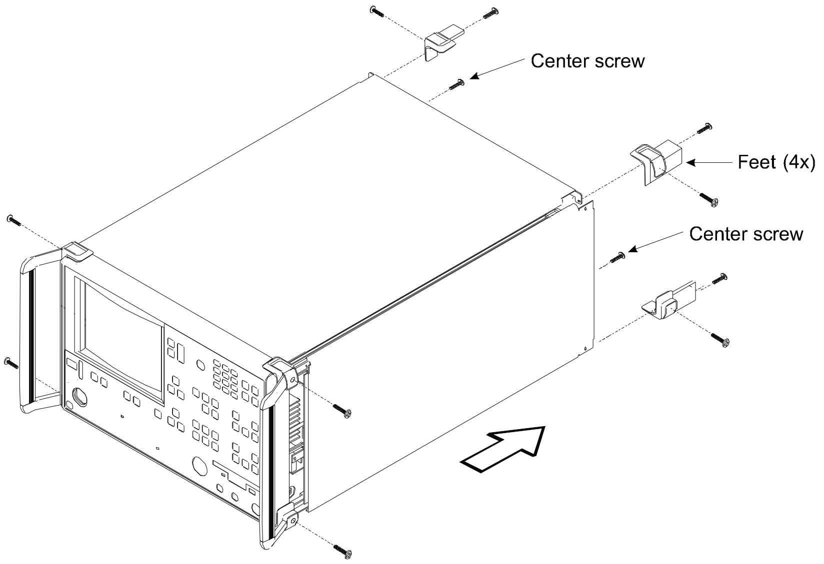


Figure 2-1. *Removing Cover*

NOTES

- The green-headed screws are metric threads and must be used only in the appropriately tapped holes
- The feet, handles, and bumpers are not reused in this application

Step 4. Remove the center screws from the rear of the left and right side covers.

Step 5. Remove the two side carrying handle screws (if so equipped) located under the plastic handle ends.

Step 6. Remove the left and right side covers. These side covers are not reused in this application.

Step 7. Install the two Rack Mount Handles using the green-headed screws removed earlier.

Refer to Figure 2-2, on the following page, for the remainder of the assembly procedure.

Step 8. Secure the new left cover (2) from this retrofit kit to the left side chassis of the instrument by installing the two center screws (6) to the top and bottom and the previously removed center screw at the rear of the left cover.

Step 9. Secure the slide assembly (4) to the left cover by installing the four mounting screws (5) to the left chassis.

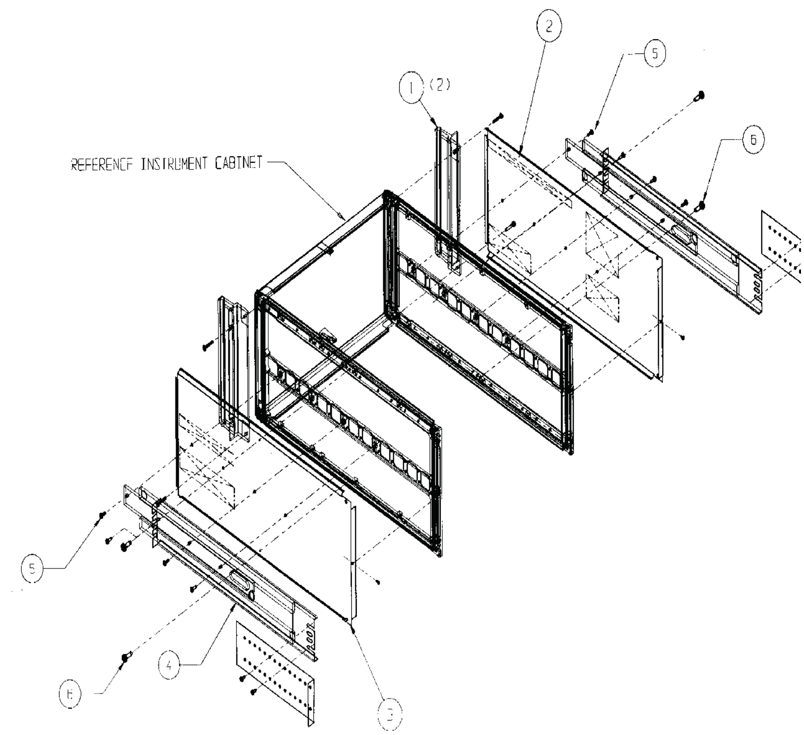


Figure 2-2. *Mounting Rails*

Step 10. Secure the new right cover (3) from this retrofit kit to the right side chassis of the instrument by installing the center screw (6) through the center of the right side cover and the previously removed center screw at the rear of the right side cover.

Step 11. Secure the slide assembly (4) to the right cover by installing the four mounting screws (5) to the right chassis.

This completes the installation of the slide assembly.

2-9 STORAGE OR SHIPMENT

The following paragraphs describe the procedure for preparing the 37XXXD for storage or shipment.

Preparation for Storage

Preparing the 37XXXD for storage consists of cleaning the unit, packing the inside with moisture-absorbing desiccant crystals, and storing the unit in a temperature environment that is maintained between –40 and +70 degrees centigrade (–40 to 156 degrees Fahrenheit).

Preparation for Shipment

To provide maximum protection against damage in transit, the 37XXXD should be repackaged in the original shipping container. If this container is no longer available and the 37XXXD is being returned to Anritsu for repair, advise Anritsu Customer Service; they will send a new shipping container free of charge. In the event neither of these two options is possible, instructions for packaging and shipment are given below.

Use a Suitable Container
Obtain a corrugated cardboard carton with a 275-pound test strength. This carton should have inside dimensions of no less than six inches larger than the instrument dimensions to allow for cushioning.

Protect the Instrument
Surround the instrument with polyethylene sheeting to protect the finish.

Cushion the Instrument
Cushion the instrument on all sides by tightly packing dunnage or urethane foam between the carton and the instrument. Provide at least three inches of dunnage on all sides.

Seal the Container
Seal the carton by using either shipping tape or an industrial stapler.

Address the Container
If the instrument is being returned to Anritsu for service, mark the Anritsu address and your return address on the carton in one or more prominent locations. Refer to the address of your local representative listed in Table 2-1 on the following page.

2-10 SERVICE CENTERS

Table 2-1 provides a list of international service centers.

Table 2-1. *Anritsu Service Centers*

UNITED STATES
ANRITSU COMPANY
490 Jarvis Drive
Morgan Hill, CA 95037-2809
Telephone: (408) 776-8300
1-800-ANRITSU
FAX: 408-776-1744

ANRITSU COMPANY
10 New Maple Ave., Unit 305
Pine Brook, NJ 07058
Telephone: (973) 227-8999
1-800-ANRITSU
FAX: 973-575-0092

ANRITSU COMPANY
1155 E. Collins Blvd
Richardson, TX 75081
Telephone: 1-800-ANRITSU
FAX: 972-671-1877

AUSTRALIA
ANRITSU PTY. LTD.
Unit 3, 170 Foster Road
Mt Waverley, VIC 3149
Australia
Telephone: 03-9558-8177
FAX: 03-9558-8255

BRAZIL
ANRITSU ELECTRONICA LTDA.
Praia de Botafogo, 440, Sala 2401
CEP22250-040, Rio de Janeiro, RJ, Brazil
Telephone: 021-527-6922
FAX: 021-53-71-456

CANADA
ANRITSU INSTRUMENTS LTD.
700 Silver Seven Road, Suite 120
Kanata, Ontario K2V 1C3
Telephone: (613) 591-2003
FAX: (613) 591-1006

CHINA
ANRITSU ELECTRONICS (SHANGHAI) CO. LTD.
2F, Rm B, 52 Section Factory Building
No. 516 Fu Te Rd (N)
Shanghai 200131 P.R. China
Telephone:21-58680226, 58680227, 58680228
FAX: 21-58680588

FRANCE
ANRITSU S.A
9 Avenue du Quebec
Zone de Courtaboeuf
91951 Les Ulis Cedex
Telephone: 016-09-21-550
FAX: 016-44-61-065

GERMANY
ANRITSU GmbH
Grafenberger Allee 54-56
D-40237 Dusseldorf, Germany
Telephone: 0211-968550
FAX: 0211-9685555

INDIA
MEERA AGENCIES PVT. LTD.
23 Community Centre
Zamroodpur, Kailash Colony Extension,
New Delhi, India 110 048
Phone: 011-2-6442700/6442800
FAX : 011-2-644250023

ISRAEL
TECH-CENT, LTD.
4 Raul Valenberg St
Tel-Aviv 69719
Telephone: (03) 64-78-563
FAX: (03) 64-78-334

ITALY
ANRITSU Sp.A
Roma Office
Via E. Vittorini, 129
00144 Roma EUR
Telephone: (06) 50-99-711
FAX: (06) 50-22-425

KOREA
ANRITSU CORPORATION LTD.
Head Office:
8F, Hyunjuk Building, 832-41
Yeoksam-Dong, Kangnam-Ku
Seoul 135-080, South Korea
Telephone: 02-553-6603
FAX: 02-553-6605

JAPAN
ANRITSU CUSTOMER SERVICES LTD.
1800 Onna Atsugi-shi
Kanagawa-Prf. 243 Japan
Telephone: 0462-96-6688
FAX: 0462-25-8379

SINGAPORE
ANRITSU (SINGAPORE) PTE LTD.
10, Hoe Chiang Road
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Chapter 3
Network Analyzers, A Primer

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Chapter 3
Network Analyzers, A Primer

3-1 INTRODUCTION

This section provides front panel operating and measurement application information and data. It includes discussions on the following topics:

- System description
- General discussion about network analyzers
- Basic measurements and how to make them
- Error correction
- General discussion on test sets

3-2 GENERAL DESCRIPTION

The Model 37XXXD Vector Network Analyzer System measures the magnitude and phase characteristics of networks, amplifiers, attenuators, and antennas. It compares the incident signal that leaves the analyzer with either the signal that is transmitted through the test device or the signal that is reflected from its input. Figure 3-1 and Figure 3-2 illustrate the types of measurements that the 37XXXD can make.

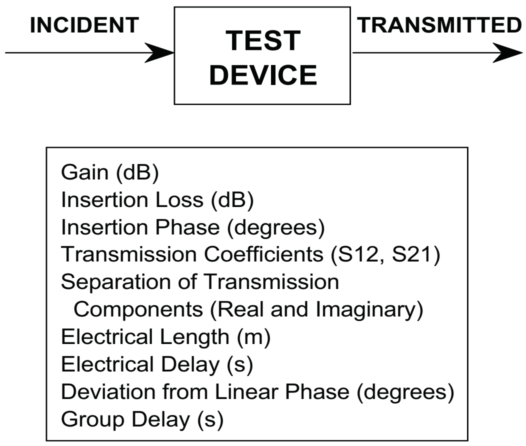

Figure 3-1. *Transmission Measurements*

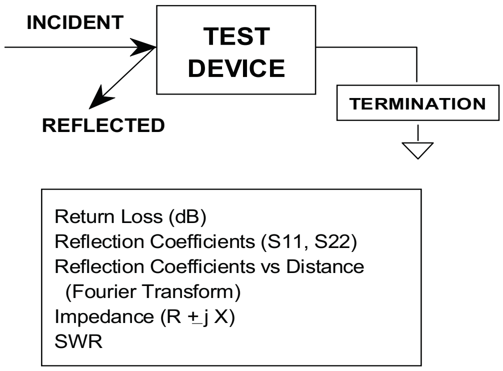

Figure 3-2. *Reflection Measurements*

The 37XXXD is a self-contained, fully integrated measurement system that includes an optional time domain capability. The system hardware consists of the following:

- Analyzer
- Precision components required for calibration and performance verification
- Optional use of Anritsu 67XXB, 68XXXA/B/C, or 69XXXA/B as a second source

The 37XXXD internal system modules perform the following functions:

Source Module

This module provides the stimulus to the device under test (DUT). The frequency range of the source and test set modules establish the frequency range of the system. The frequency stability of the source is an important factor in the accuracy (especially phase accuracy) of the network analyzer. Hence, the 37XXXD always phase locks the source to an internal 10 MHz crystal reference.

Test Set Module

The test set module routes the stimulus signal to the DUT and samples the reflected and transmitted signals. The type of connector used is important, as is the “Auto Reversing” feature. Auto Reversing means that it applies the stimulus signal in both the forward and reverse direction. The direction is reversed automatically. This saves you from having to reverse the test device physically to measure all four scattering parameters (S-parameters). Frequency conversion (1st and 2nd IFs) occurs in the test set module.

Analyzer Module

The analyzer module down-converts, receives, and interprets the 3rd IF signal for phase and magnitude data. It then displays the results of this analysis on a large, 190 mm (7-1/2 inch) diagonal color display. This display can show all four S-parameters simultaneously. In addition to the installed display, you can also view the measurement results on an external color monitor.

3-3 NETWORK ANALYZERS

We will begin this discussion with a subject familiar to most Anritsu customers: scalar network analysis. After showing comparisons, we will proceed to the fundamentals of network analyzer terminology and techniques. This discussion serves as an introduction to topics presented in greater detail later in this section. This discussion will touch on new concepts that include the following:

- ❑ Reference Delay
- ❑ S-parameters: what they are and how they are displayed
- ❑ Complex Impedance and Smith Charts

Scalar Analyzer Comparison

Network Analyzers do everything that scalar analyzers do except display absolute power. In addition, they add the ability to measure the phase characteristics of microwave devices and allow greater dynamic range.

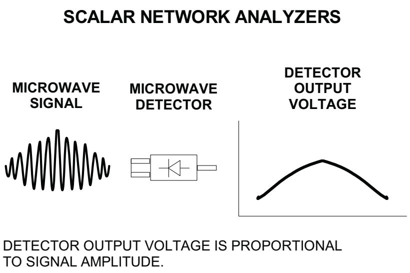

Figure 3-3. *Scalar Analyzer Detection*

If all a Network Analyzer added was the capability for measuring phase characteristics, its usefulness would be limited. While phase measurements are important in themselves, it is the availability of this phase information that unlocks many new features for complex measurements. These features include Smith Charts, Time Domain, and Group Delay. Phase information also allows greater accuracy through *vector error correction* of the measured signal.

First, let us look at scalar network analyzers (SNAs). SNAs measure microwave signals by converting them to a DC voltage using a diode detector (Figure 3-3). This DC voltage is proportional to the magnitude of the incoming signal. The detection process, however, ignores any information regarding the phase of the microwave signal.

In a network analyzer, access is needed to both the magnitude and phase of a microwave signal. There are several different ways to perform the measurement. The method Anritsu employs (called Harmonic Sampling or Harmonic Mixing) is to down-convert the signal to a lower intermediate frequency (IF). This signal can then be measured directly by a tuned receiver. The tuned receiver approach gives the system greater dynamic range. The system is also much less sensitive to interfering signals, including harmonics.

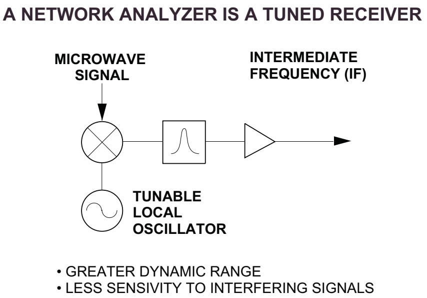

Figure 3-4. *Network Analyzer is a Tuned Receiver*

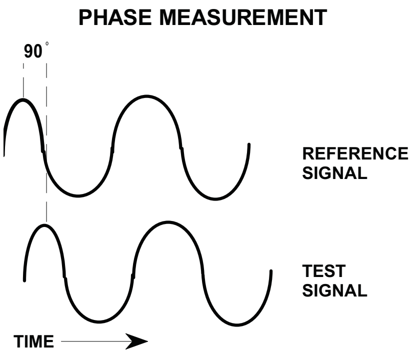

Figure 3-5. *Signals with a 90 Degree Phase Difference*

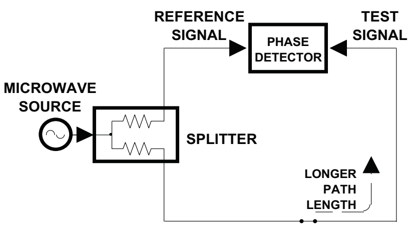

Figure 3-6. *Split Signal where a Length of Line Replaces the DUT*

Vector Network Analyzer Basics

The network analyzer is a tuned receiver (Figure 3-4, left). The microwave signal is down converted into the passband of the IF. To measure the phase of this signal, we must have a reference to compare it with. If the phase of a signal is 90 degrees, it is 90 degrees different from the reference signal (Figure 3-5, left). The network analyzer would read this as –90 degrees, since the test signal is delayed by 90 degrees with respect to the reference signal.

This phase reference can be obtained by splitting off some of the microwave signal before the measurement (Figure 3-7, below).

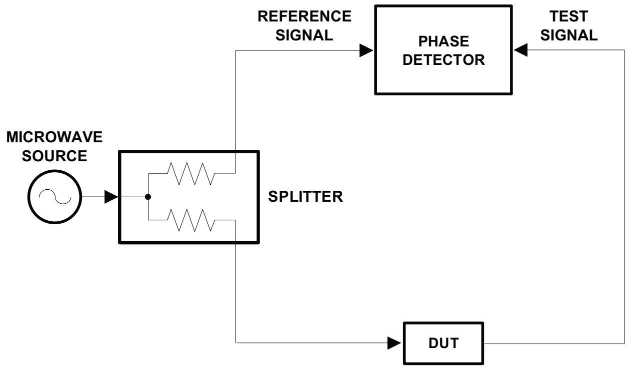

Figure 3-7. *Splitting the Microwave Signal*

The phase of the microwave signal after it has passed through the device under test (DUT) is then compared with the reference signal. A network analyzer test set automatically samples the reference signal, so no external hardware is needed.

Let us consider for a moment that you remove the DUT and substitute a length of transmission line (Figure 3-6, left). Note that the path length of the test signal is longer than that of the reference signal. Now let us see how this affects our measurement.

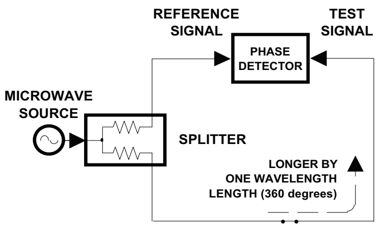

Figure 3-8. *Split Signal where Path Length Differs by Exactly One Wavelength*

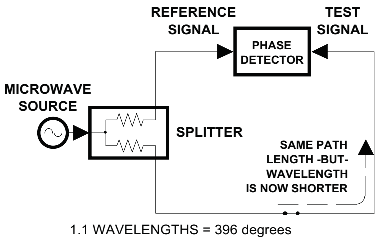

Figure 3-9. *Split Signal where Path Length is Longer than One*

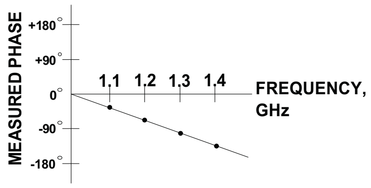

Figure 3-10. *Electrical Delay*

Assume that we are making a measurement at 1 GHz and that the difference in path-length between the two signals is exactly 1 wavelength. This means that test signal is lagging the reference signal by 360 degrees (Figure 3-8). We cannot really tell the difference between one sine wave maxima and the next (they are all identical), so the network analyzer would measure a phase difference of 0 degrees.

Now consider that we make this same measurement at 1.1 GHz. The frequency is higher by 10 percent so therefore the wavelength is shorter by 10 percent. The test signal path length is now 0.1 wavelength longer than that of the reference signal (Figure 3-9). This test signal is:

$$1.1 \times 360 = 396 \text{ degrees}$$

This is 36 degrees different from the phase measurement at 1 GHz. The network analyzer will display this phase difference as –36 degrees.

The test signal at 1.1 GHz is delayed by 36 degrees more than the test signal at 1 GHz.

You can see that if the measurement frequency is 1.2 GHz, we will get a reading of –72 degrees, –108 degrees for 1.3 GHz, etc. (Figure 3-10). There is an electrical delay between the reference and test signals. For this delay we will use the common industry term of reference delay. You also may hear it called phase delay. In older network analyzers you had to equalize the length of the reference arm with that of the test arm to make an appropriate measurement of phase vs. frequency.

To measure phase on a DUT, we want to remove this phase-change-vs.-frequency due to changes in the electrical length. This will allow us to view the actual phase characteristics. These characteristics may be much smaller than the phase change due to electrical length difference.

There are two ways of accomplishing this. The most obvious way is to insert a length of line into the reference signal path to make both paths of equal length (Figure 3-11, below). With perfect transmission lines and a perfect splitter, we would then measure a constant phase as we change the frequency. The problem using this approach is that we must change the line length with each measurement setup.

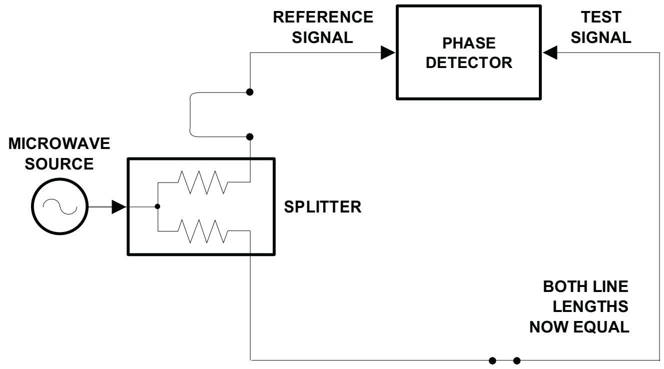

Figure 3-11. *Split Signal where Paths are of Equal Length*

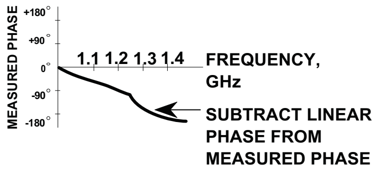

Figure 3-12. *Phase Difference Increases Linearly with Frequency*

Another approach is to handle the path length difference in software. Figure 3-12 (left) displays the phase-vs.-frequency of a device. This device has different effects on the output phase at different frequencies. Because of these differences, we do not have a perfectly linear phase response. We can easily detect this phase deviation by compensating for the linear phase. The size of the phase difference increases linearly with frequency so we can modify the phase display to eliminate this delay.

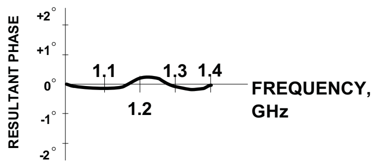

Figure 3-13. *Resultant Phase with Path Length*

The 37XXXD offers automatic reference delay compensation with the push of a button. Figure 3-13 (left) shows the resultant measurement when we compensate path length. In a system application you can usually correct for length differences; however, the residual phase characteristics are critical.

Network Analyzer Measurements

Now let us consider measuring the DUT. Consider a two port device; that is, a device with a connector on each end. What measurements would be of interest?

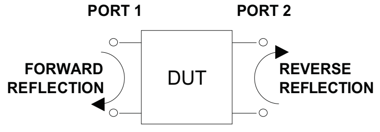

Figure 3-14. *Forward and Reverse Measurements*

First, we could measure the reflection characteristics at either end with the other end terminated into 50 ohms. If we designate one end as the normal place for the input that gives a reference. We can then define the reflection characteristics from the reference end as forward reflection, and those from the other end as reverse reflection (Figure 3-14).

Second, we can measure the forward and reverse transmission characteristics. However, instead of saying “forward,” “reverse,” “reflection,” and “transmission” all the time, we use a shorthand. That is all that S-parameters are, a shorthand! The “S” stands for scattering. The second number is the device port that the signal is being injected into, while the first is the device port that the signal is leaving. S_{11}, therefore, is the signal being injected into port 1 relative to the signal leaving port 1. The four scattering parameters (Figure 3-15) are:

- ❑ S_{11} Forward Reflection
- ❑ S_{21} Forward Transmission
- ❑ S_{22} Reverse Reflection
- ❑ S_{12} Reverse Transmission

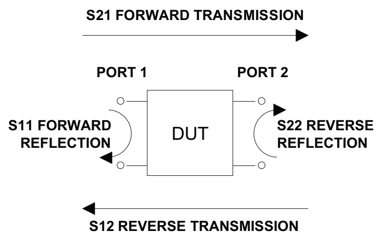

Figure 3-15. *S-parameters*

S-parameters can be displayed in many ways. An S-parameter consists of a magnitude and a phase. We can display the magnitude in dB, just like a scalar network analyzer. We often call this term *log magnitude.*

We can display phase as “linear phase” (Figure 3-16). As discussed earlier, we can’t tell the difference between one cycle and the next. Therefore, after going through 360 degrees we are back to where we began. We can display the measurement from –180 to +180 degrees. The –180 to +180 approach is more common. It keeps the display discontinuity removed from the important 0 degree area used as the phase reference.

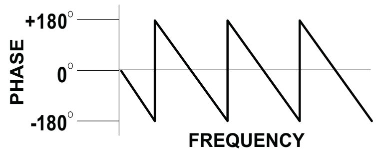

Figure 3-16. *Linear Phase-with-frequency Waveform*

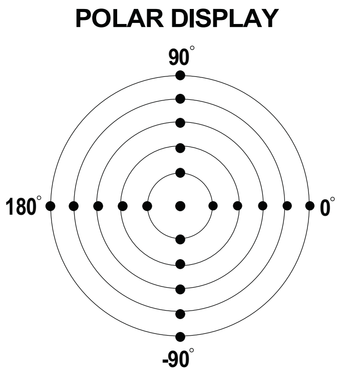

Figure 3-17. *Polar Display*

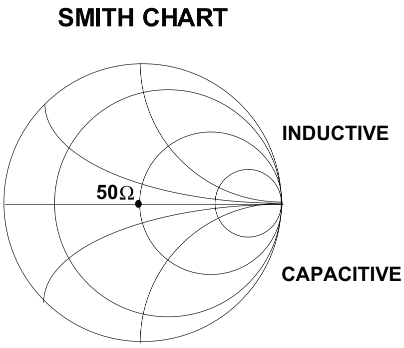

Figure 3-18. *Smith Chart*

There are several ways in which all the information can be displayed on one trace. One method is a polar display (Figure 3-17). The radial parameter (distance from the center) is magnitude. The rotation around the circle is phase. We sometimes use polar displays to view transmission measurements, especially on cascaded devices (devices in series). The transmission result is the addition of the phase and log magnitude (dB) information of each device's polar display.

As we have discussed, the signal reflected from a DUT has both magnitude and phase. This is because the impedance of the device has both a resistive and a reactive term of the form $r+jx$. We refer to the r as the real or resistive term, while we call x the imaginary or reactive term. The j, which we sometimes denote as i, is an imaginary number. It is the square root of –1. If x is positive, the impedance is inductive; if x is negative, the impedance is capacitive.

The size and polarity of the reactive component x is important in impedance matching. The best match to a complex impedance is the complex conjugate. This complex-sounding term simply means an impedance with the same value of r and x, but with x of opposite polarity. This term is best analyzed using a Smith Chart (Figure 3-18), which is a plot of r and x.

To display all the information on a single S-parameter requires one or two traces, depending upon the format we want. A very common requirement is to view forward reflection on a Smith Chart (one trace) while observing forward transmission in Log Magnitude and Phase (two traces). Let us see how to accomplish this in the 37XXXD.

The 37XXXD has four channels. Each channel can display a complete S-parameter in any format on either one or two traces. All four S-parameters can be seen simultaneously in any desired format. A total of eight traces can be viewed at the same time. While this is a lot of information to digest, the 37XXXD's large color display makes recognizing and analyzing the data surprisingly easy.

Another important parameter we can measure when phase information is available is group delay. In linear devices, the phase change through the DUT is linear-with-frequency. Thus, doubling the frequency also doubles the phase change. An important measurement, especially for communications system users, is the rate of change-of-phase-vs.-frequency (group delay). If the rate of phase-change-vs.-frequency is not constant, the DUT is nonlinear. This nonlinearity can create distortion in communications systems.

Measurement Error Correction

Since we can measure microwave signals in both magnitude and phase, it is possible to correct for six major error terms:

- Source Test Port Match
- Load Test Port Match
- Directivity
- Isolation
- Transmission Frequency Response
- Reflection Frequency Response

We can correct for each of these six error terms in both the forward and reverse directions, hence the name 12-term error correction. Since 12-term error correction requires both forward and reverse measurement information, the test set must be *reversing*. “Reversing” means that it must be able to apply the measurement signal in either the forward or reverse direction.

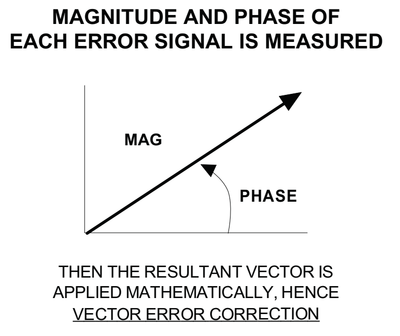

Figure 3-19. Magnitude and Phase

To accomplish this error correction, we measure the magnitude and phase of each error signal (Figure 3-19). Magnitude and phase information appear as a vector that is mathematically applied to the measurement signal. This process is termed *vector error correction*.

Summary

A vector network analyzer is similar to a scalar network analyzer. The major difference is that it adds the capability for measuring phase as well as amplitude. With phase measurements comes scattering, or S-parameters, which are a shorthand method for identifying forward and reverse transmission and reflection characteristics. The ability to measure phase introduces two new displays, polar and Smith Chart. It also adds vector error correction to the measurement trace. With vector error correction, errors introduced by the measurement system are compensated for and measurement uncertainty is minimized. Phase measurements also add the capability for measuring group delay, which is the rate of change-of-phase vs. frequency (group delay). All in all, using a network analyzer provides for making a more complete analysis of your test device.

Chapter 4
Front Panel Operation

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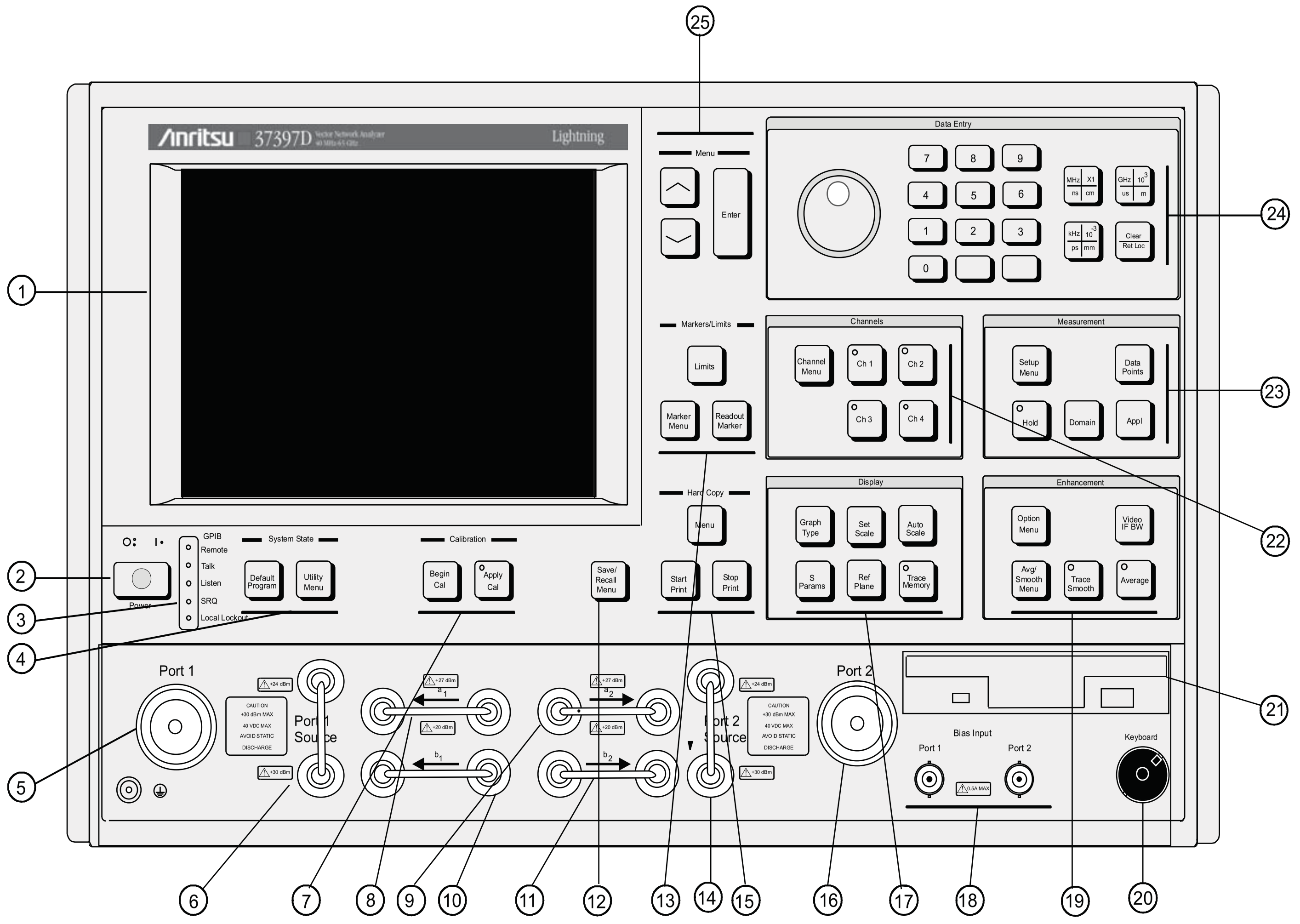


Figure 4-1. Model 37XXXD Front Panel

Chapter 4
Front Panel Operation

4-1 INTRODUCTION

This chapter describes the front panel keys, controls, and menus. The chapter is organized into an overall description of the front panel key-groups and detailed descriptions of individual keys within the key-groups.

4-2 KEY-GROUPS

The following pages provide descriptions of the front panel key-groups illustrated in Figure 4-1 on the previous page.

Index 1. **LCD display:** Displays any or all of the four measurement channels, plus menus.

Index 2. **Power:** Turns the 37XXXD on and off. When on, the operating program runs a self test then recalls the parameters and functions in effect when previously powered down.

Index 3. **GPIB Indicators:**

Remote: Lights when the 37XXXD switches to remote (GPIB) control. It remains lit until the unit returns to local control.

Talk: Lights when you address the 37XXXD to talk and remains lit until unaddressed.

Listen: Lights when you address the 37XXXD to listen and remains lit until unaddressed.

SRQ: Lights when the 37XXXD sends a Service Requests (SRQ) to the external controller. The LED remains lit until the 37XXXD receives a serial poll or until the controller resets the SRQ function.

Local Lockout: Lights when a local lockout message is received. The LED remains lit until the message is rescinded. When lit, you cannot return the 37XXXD to local control via the front panel.

Index 4. **System State Keys:** (Refer to section 4-10, page 4-33, for details and menu flow diagrams.)

Default Program: Resets the front panel to the factory-preset state and displays Menu SU1 or SU3 (Appendix A). Pressing this key in conjunction with the "0" or "1" key resets certain internal memories and front panel key states (refer to sections 4-5 and 4-10).

NOTE

Use of the Default Program key will destroy front panel and calibration setup data, unless they have been saved to disk.

Utility Menu: Displays the first in a series of menus that let you perform diskette and other utility-type functions and operations.

Index 5. **Port 1 Test Connector:** Provides an input test connection for the device-under-test (DUT).

Index 6. **Port 1 Source Loop:** Provides for inserting additional amplification on Port 1 before the coupler.

Index 7. **Calibration Keys:** (Refer to section 4-3, page 4-10, for details and menu flow diagrams.)

Begin Cal: Calls up the first in a sequence of menus that guide you through a measurement calibration. Refer to section 4-3 for a detailed discussion of the calibration keys, indicators, and menus.

Apply Cal: Turns on and off the applied error correction and tune mode.

Index 8. **a1 Loop:** Provides direct access to Reference A channel on Port 1 over the entire frequency range. Refer to the front panel for damage levels.

Index 9. **a2 Loop:** Provides direct access to Reference B channel on Port 2 over the entire frequency range. Refer to the front panel for damage levels.

Index 10. **b1 Loop:** Provides direct access to Test A channel on Port 1 over the entire frequency range. Refer to the front panel for damage levels.

Index 11. **b2 Loop:** Provides direct access to Test B channel on Port 2 over the entire frequency range. Refer to the front panel for damage levels.

Index 12. **Save/Recall Menu Key:** Displays the first of several menus that let you save the current calibration or front panel setup or recall a previously saved calibration or setup. Refer to section 4-4, page 4-20, for menu flow diagram.

Index 13. **Markers/Limits Keys:** (Refer to section 4-11, page 4-36, for details and menu flow diagrams.)

Marker Menu: Displays the first in a series of menus that let you set and manipulate marker frequencies, times, and distances.

Readout Marker: Displays a menu that lists all of the active markers. If no markers are active, the marker menu is displayed.

Limits: Displays one of the menus that let you manipulate the limit lines.

Index 14. **Port 2 Source:** Provides for inserting additional amplification on Port 2 before the coupler.

Index 15. **Hard Copy Keys:** (Refer to section 4-9, page 4-31, for details and menu flow diagrams.)

Menu: Displays option menus that let you define what will happen each time you press the Start Print key. The displayed menu also selects disk I/O operations.

Start Print: Tells the printer or plotter to start output based on the current selections.

Stop Print: Immediately stops printing the data, clears the print buffer, and sends a form-feed command to the printer.

Index 16. **Port 2 Test Connector:** Provides an input test connection for the device-under-test (DUT).

Index 17.

Display Keys: (Refer to section 4-7, page 4-25, for details and menu flow diagrams.)

Graph Type: Displays the two menus that let you choose the graph type for the active channel.

Set Scale: Displays the appropriate scaling menu, based on the graph type for the active channel.

Auto Scale: Automatically scales the active channel for optimum viewing.

S Params: Displays Menu SP (Appendix A), which lets you choose between S11, S12, S21, or S22. You may display the same parameter on two or more channels.

Ref Plane: Displays the first of two menus that let you set the reference plane for the active channel in time or distance. For a correct distance readout, you must set the dielectric constant to the correct value. Refer to the discussion in menu RD2 (Appendix A).

Trace Memory: Displays the menus that let you do any of the following. (1) Store the measured data in memory. (2) View the stored data. (3) Add, subtract, multiply, or divide the measured data from the stored data (normalize to the stored memory). (4) View both the measured and the stored data simultaneously on the active channel. (5) Store/Recall saved data to disk. Four memories exist—one for each channel. This lets you normalize the data in each channel independently. The LED on this button lights when the active channel is displaying memory data or measurement data normalized to memory.

Index 18.

Bias Input Connectors:

Port 1: Provides for supplying a bias voltage for the Port 1 input.

Port 2: Provides for supplying a bias voltage for the Port 2 input.

Index 19. **Enhancement Keys:** (Refer to section 4-8, page 4-29 for details and menu flow diagrams.)

Option Menu: Displays a series of menus showing the choice of optional features.

Video IF BW: Displays a menu that lets you chose between 10 kHz, 1 kHz, 100 Hz, or 10 Hz intermediate frequency (IF) bandwidth filters.

Avg/Smooth Menu: Displays a menu that lets you enter values for Averaging and Smoothing.

Trace Smooth: Turns the trace smoothing function on and off.

Average: Turns the average function on and off.

Index 20. **Keyboard Connector:** Provides for connecting any external keyboard with a standard PS2 connector. All alphanumeric field entries can be input from this keyboard. These inputs include Device ID, Model, Date, Operator Identification, frequencies, filenames, as well as comment-type entries. The analog knob and keypad input for these entries remains active. The F1 through F12 function keys can be used to access certain key and menu functions. A template is provided. Two versions of an actual-size template are provided in a foldout page at the end of this chapter in the event a replacement is needed.

Index 21. **Diskette Drive:** Provides a drive for the 3.5-inch, high-density (1.44 MB) floppy diskette used to store selected front panel setups and calibrations. Refer to section 4-12, page 4-40, for disk storage information.

Index 22. **Channels Keys:** (Refer to section 4-6, page 4-24, for details and menu flow diagrams.)

Channel Menu: Displays a menu that lets you select the format for the number of channels displayed.

Ch 1: Makes Channel 1 the active channel. The active channel is the one acted on by the keys in the Display section. Only one channel can be active at any one time.

Ch 2: Makes Channel 2 the active channel.

Ch 3: Makes Channel 3 the active channel.

Ch 4: Makes Channel 4 the active channel.

Index 23. **Measurement Keys:** (Refer to section 4-5, page 4-21 for details and menu flow diagrams.)

Setup Menu: Displays the first of several menus that let you select functions affecting measurements.

Data Points: Displays a menu that lets you select between 1601, 801, 401, 201, 101, or 51 data points.

Hold: Toggles the instrument in and out of the hold mode; or it triggers a sweep, depending on the function selected in menu SU4 (Appendix A).

Domain: Displays the first in a series of menus that let you set the Time Domain display parameters. (This key is only active if your 37XXXD is equipped with the Time Domain option.)

- If already in the Domain menus, pressing this key will return to the first menu in the sequence.
- If in the Domain menus and another (non-time domain) menu is displayed by pushing a menu key, the last displayed domain menu redisplays when the Domain key is next pressed.

Applications Menu: Displays the first in a series of menus that provide instructions for adapter removal and gain compression.

Index 24. **Data Entry Keys:**

Rotary Knob: Used to alter measurement values for the active parameter (Start Frequency, Stop Frequency, Offset, etc.).

Keypad: Provides for entering values for the active parameter. The active parameter is the one to which the menu cursor is pointing.

MHz/X1/ns/cm: Terminates a value entered on the keypad in the units shown—that is; megahertz for frequency, unity for dimensionless or angle entries, nanoseconds for time, or centimeters for length.

GHz/10^3/ms/m: Terminates a value entered on the keypad in the units shown—that is; gigahertz for frequency, 1×10^3 power for dimensionless or angle entries, microseconds for time, or meters for length.

kHz/10^{-3}/ps/mm: Terminates a value entered on the keypad in the units shown—that is; kilohertz for frequency, 1×10^{-3} for dimensionless or angle entries, picoseconds for time, or millimeters for length.

- *Clear/Ret Loc:* Local (Non-GPIB) Mode: (1) The key clears entries not yet terminated by one of the terminator keys above, which allows the previously displayed values to redisplay. Or (2) the key turns off the displayed menu and expands the data area to fill the entire screen, if you have not made any keypad entries needing termination.

- *GBIB Mode:* The key returns the instrument to local (front panel) control, unless the controller has sent a local lockout message (LLO) over the bus.

Index 25. **Menu Keys:**

Arrow Keys: Moves the menu cursor up and down to select items appearing in the menu area of the LCD.

Enter: Implements the menu selection chosen using the arrow keys.

4-3 CALIBRATION KEY-GROUP

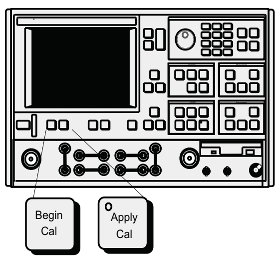
The Calibration keys (Begin Cal and Apply Cal, below) are described below. The calibration menus are diagramed according to the method of calibration performed: Standard, Offset-Short, TRM or LRL/LRM. The menu sequencing is complex and looping and can be said to have two parts: setup and calibration. The setup flow for the four calibration methods is diagramed in Figures 4-3 through 4-6. Each setup flow chart leads to the main calibration sequence, which is diagramed in Figure 4-6. A full description of each menu is provided in Appendix A, where the menus are arranged in alphabetical order by call letter (C1, C2, C3, etc).

Begin Cal Key: This key displays a menu that lets you initiate the calibration sequence. That is, to begin a sequence of steps that corrects for errors inherent in a measurement setup.

Apply Cal Key: This key displays a menu (below) that lets you turn on and off the error correction that may be applied to the displayed channel(s) using the currently valid error-correction indicator. Additionally, the menu lets you turn the tune mode on and off and change the number of forward sweeps between reverse sweeps (or reverse sweeps between forward sweeps).

NOTE

Pressing the Clear key while in a calibration setup or sequencing will let you abort the calibration and return to the first setup menu. Pressing the Setup Menu key will do the same, but without requesting confirmation.



MENU CAL_APPLIED

APPLY
CALIBRATION

FULL 12-TERM
(S11, S21
X22, S12

APPLY ON (OFF)
CALIBRATION

TUNE MODE ON (OFF)

NO. OF FWD (REV)
SWEEPS BETWEEN
REV (FWD) SWEEPS
XXXXX SWEEPS
(XXXXX (REMAINING)

PRESS <APPLY CAL>
TO TURN ON/OFF

PRESS <ENTER>
TO TURN ON/OFF

Figure 4-2. *Calibration Key Group Menu*

Standard Calibration Setup Flow—Description

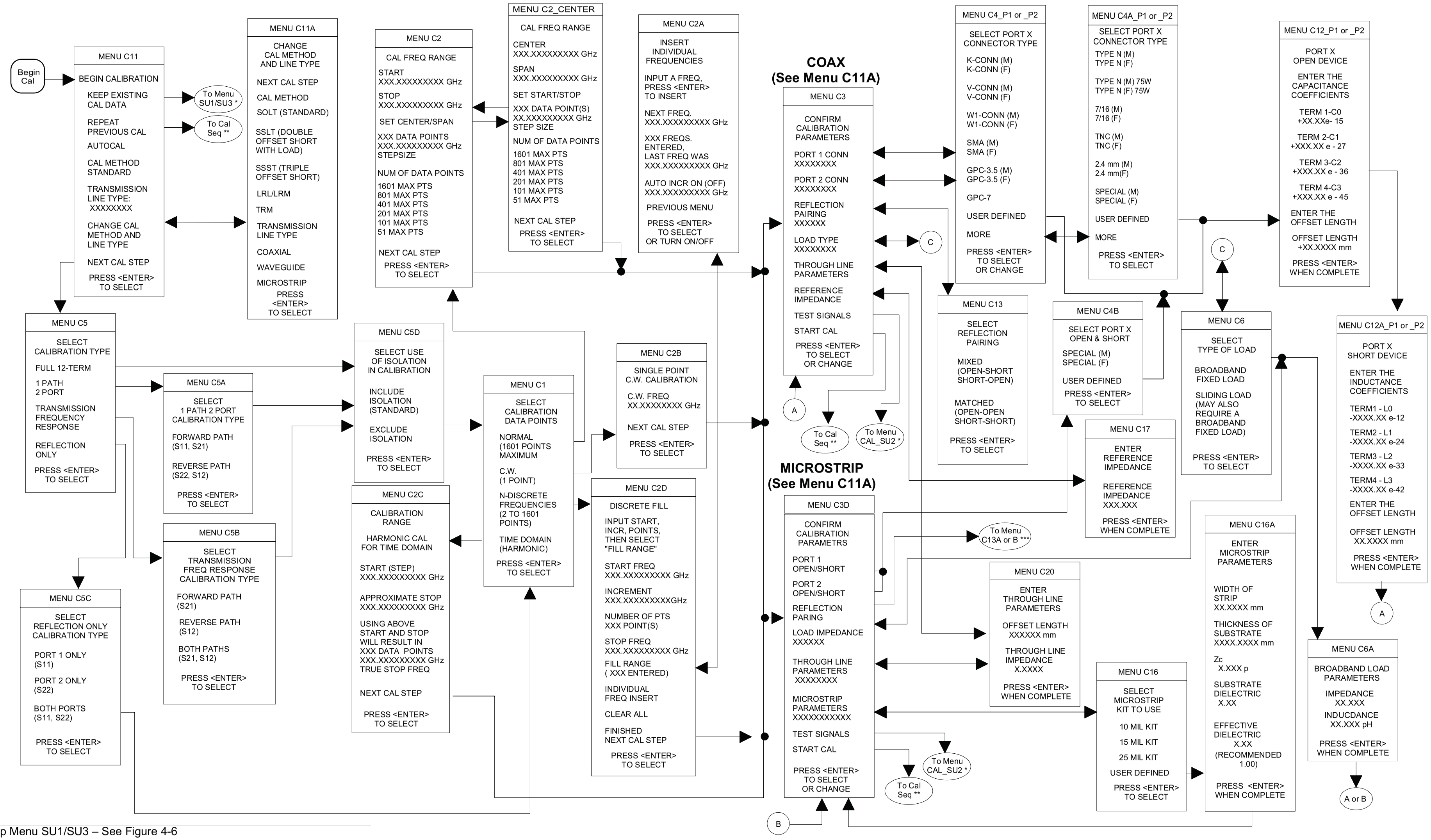
1. Pressing the Begin Cal key calls Menu C11.

2. With one exception, the flow is from left to right in the direction of the arrow head. The exception occurs in Menu C1, for the TIME DOMAIN choice. Here the flow direction reverses to Menu C2C then returns to a left-to-right flow on to Menu C3 or C3D.

3. Arrowheads that point both left and right indicate that the flow returns to the right-most menu after a choice had been made.

4. The group of menus to the left of Menu C3 and C3D are the initial selection set and are essentially the same for all four calibration types: Standard, Offset-Short, TRM, and LRL/LRM.

5. The group of menus that follow Menu C3 or C3D are, for the most part, type specific. The selection of Menu C3 or C3D depends upon the choice made in Menu C11A: COAXIAL or MICROSTRIP. For the Standard Calibration, the WAVEGUIDE selection in Menu C11A is not used.



* Setup Menu SU1/SU3 – See Figure 4-6
** Cal Seq (Calibration Sequence) – See Figure 4-5
*** Reflection Pairing Menu C13A or C13B – See Figure 4-4

Figure 4-3. Menu Sequencing, Standard Calibration

SSLT and SSST (Offset-Short)
Calibration Setup Flow—Description

1. Pressing the Begin Cal key calls Menu C13.

2. With one exception, the flow is from left to right in the direction of the arrow head. The exception occurs in Menu C1, for the TIME DOMAIN choice. Here the flow direction reverses to Menu C2C then returns to a left-to-right flow on to Menu C3A, C3C, or C3B.

3. Arrowheads that point both left and right indicate that the flow returns to the right-most menu after a choice had been made.

4. The group of menus to the left of Menu C3A, C3C, or C3B are the initial selection set and are essentially the same for all four calibration types: Standard, Offset-Short, TRM, and LRL/LRM.

5. The group of menus that follow Menu C3A, C3C, or C3B are, for the most part, type specific. The selection of Menu C3A, C3C, or C3B depends upon the choice made in Menu C11A: COAXIAL, WAVEGUIDE, or MICROSTRIP.

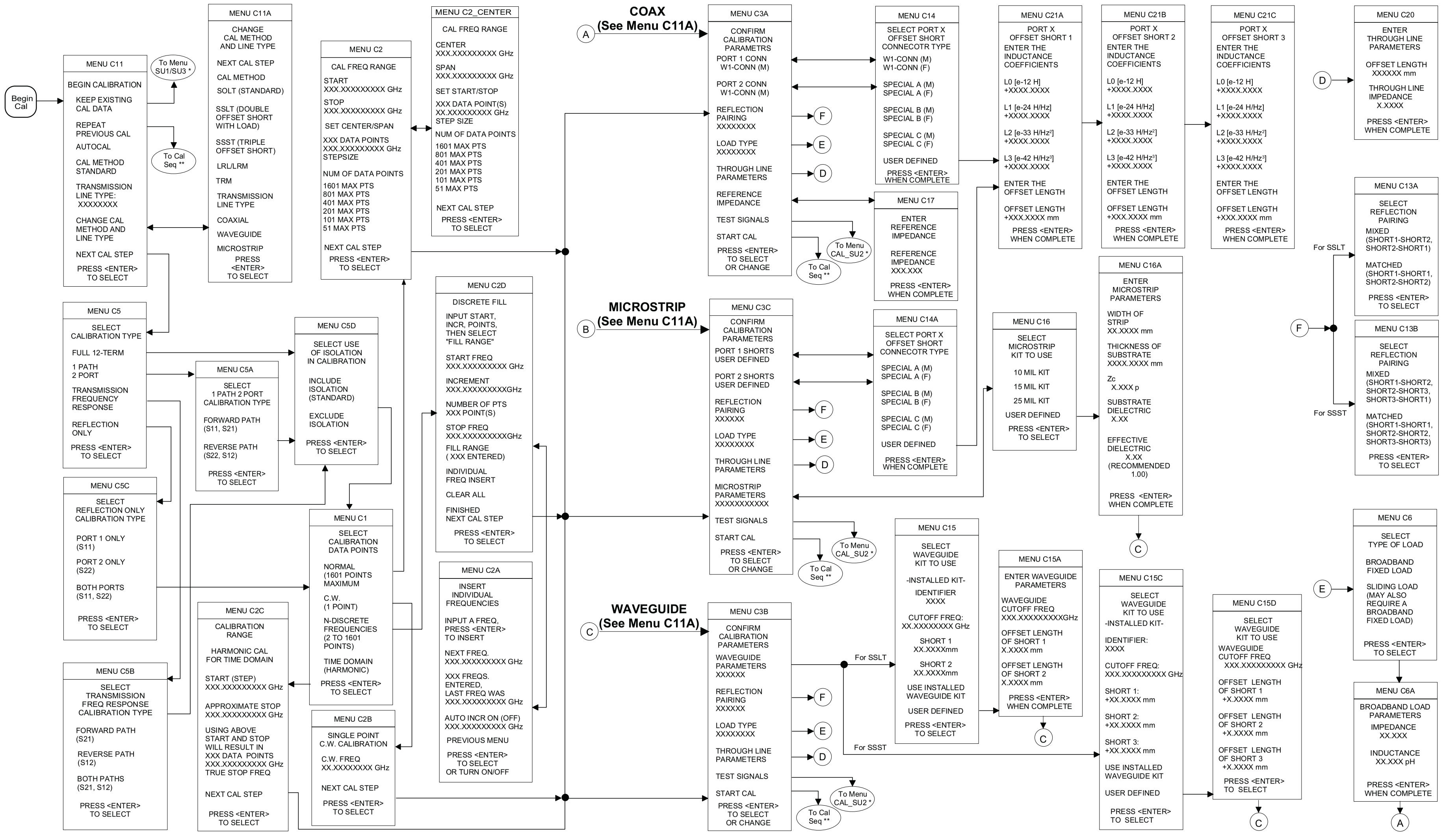


Figure 4-4. *Menu Sequencing, SSLT and SSST (Offset-Short) Calibration*

LRL/LRM Calibration Setup Flow—Description

1. Pressing the Begin Cal key calls Menu C15.

2. With one exception, the flow is from left to right in the direction of the arrow head. The exception occurs in Menu C1, for the TIME DOMAIN choice. Here the flow direction reverses to Menu C2C then returns to a left-to-right flow on to Menu C3E, C3G, or C3F.

3. Arrowheads that point both left and right indicate that the flow returns to the right-most menu after a choice had been made.

4. The group of menus to the left of Menu C3E, C3G, or C3F are the initial selection set and are essentially the same for all four calibration types: Standard, Offset-Short, TRM, and LRL/LRM.

5. The group of menus that follow Menu C3E, C3G, or C3F are, for the most part, type specific. The selection of Menu C3E, C3G, or C3F depends upon the choice made in Menu C11A: COAXIAL, WAVEGUIDE, or MICROSTRIP.

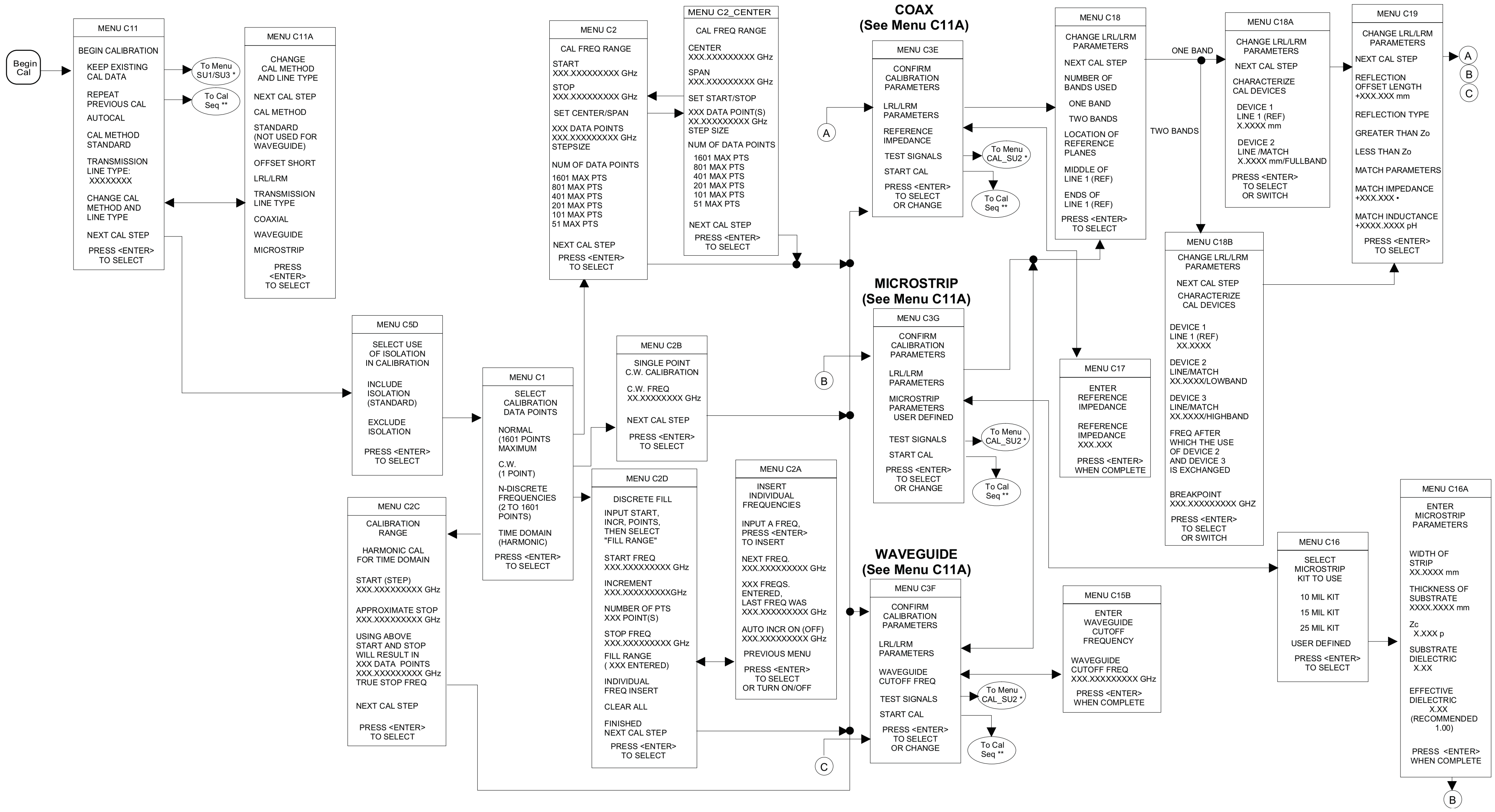


Figure 4-5. Menu Sequencing, LRL/LRM Calibration

TRM Calibration Setup Flow—Description

1. Pressing the Begin Cal key calls Menu C17.

2. With one exception, the flow is from left to right in the direction of the arrow head. The exception occurs in Menu C1, for the TIME DOMAIN choice. Here the flow direction reverses to Menu C2C then returns to a left-to-right flow on to Menu C3H, C3J, or C3I.

3. Arrowheads that point both left and right indicate that the flow returns to the right-most menu after a choice had been made.

4. The group of menus to the left of Menu C3H, C3J, or C3I are the initial selection set and are essentially the same for all four calibration types: Standard, Offset-Short, TRM, and LRL/LRM.

5. The group of menus that follow Menu C3H, C3J, or C3I are, for the most part, type specific. The selection of Menu C3H, C3I, or C3J depends upon the choice made in Menu C11A: COAXIAL, WAVEGUIDE, or MICROSTRIP.

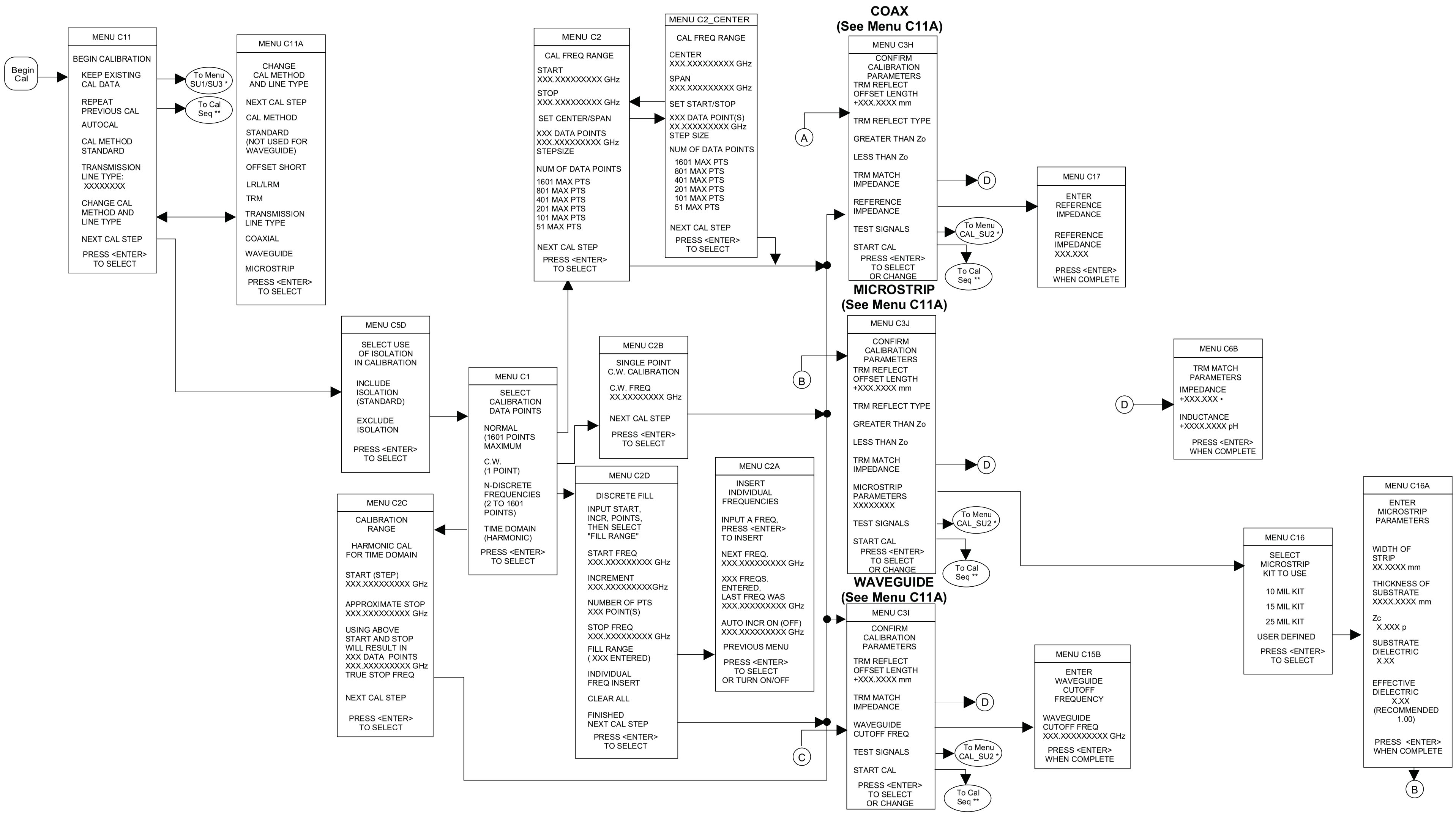


Figure 4-6. Menu Sequencing, TRM Calibration

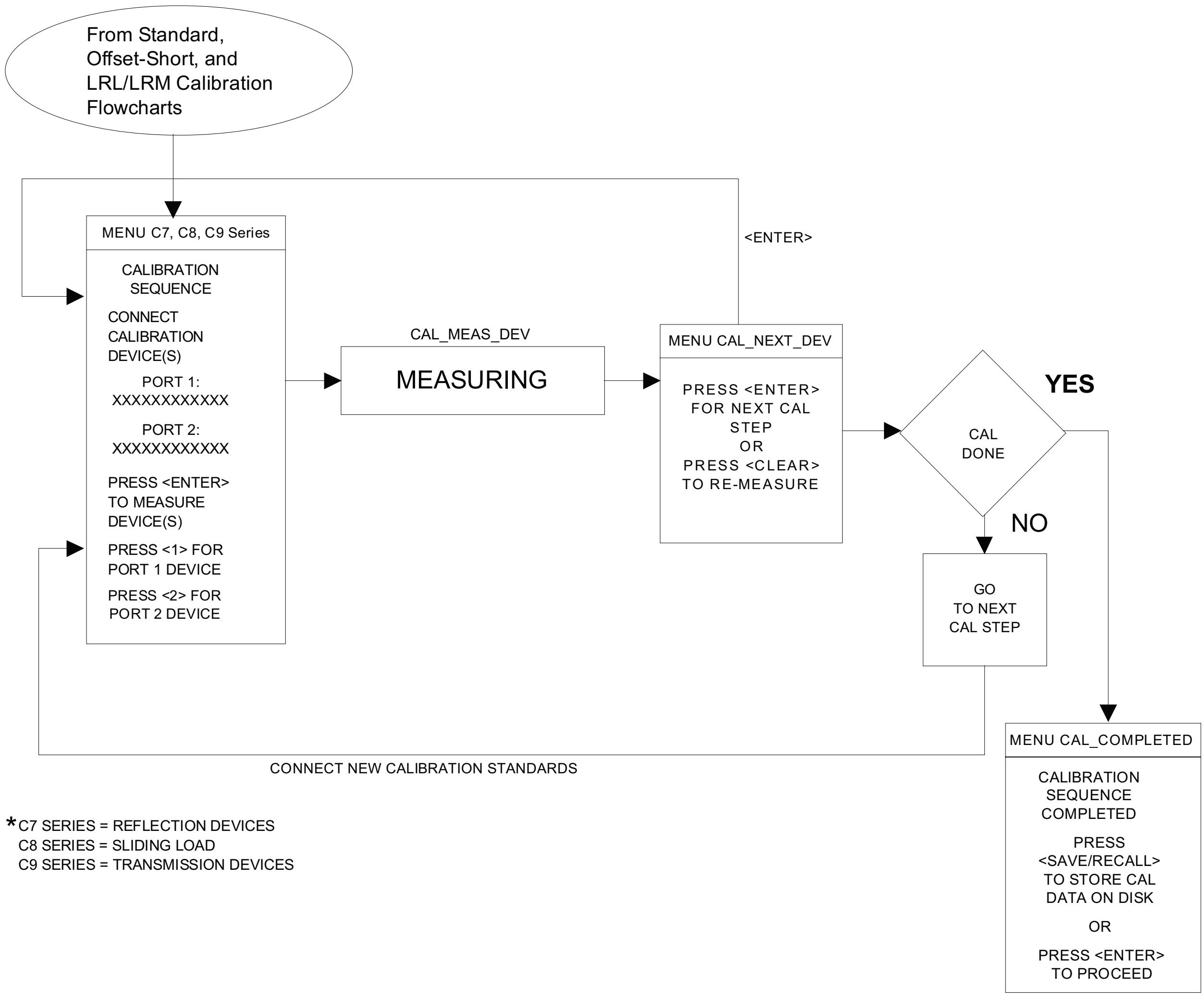


Figure 4-6. *Calibration Sequence Menus*

4-4 SAVE/RECALL MENU KEY

Pressing this key displays the first of a menu set (below) that lets you save or recall control panel setups and calibration data. Full menu descriptions can be found in the alphabetically ordered Appendix A under the menu's call letters (SR1, SR2, SR3, etc).

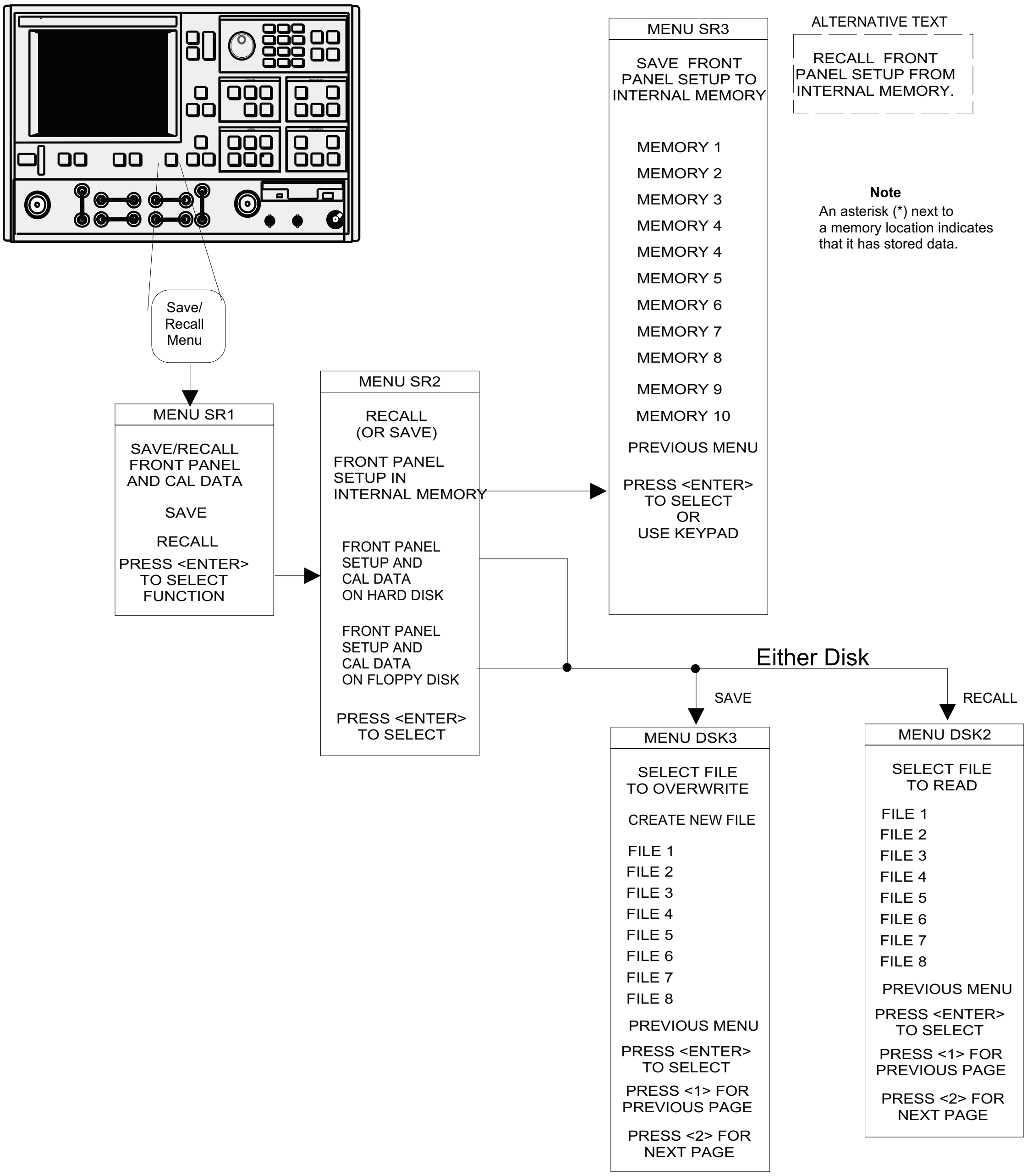


Figure 4-7 *Save/Recall Key-Group Menus*

4-5 MEASUREMENT KEY-GROUP

The individual keys within the Measurement key-group are described below. Flowcharts of the Setup Key and Data Points key menus are shown in Figure 4-8. As described for the calibration menus, the flow is left-to-right and the double arrowhead lines indicate that the flow returns to the calling menu once a selection has been made. Full menu descriptions can be found in the alphabetically ordered Appendix A under the menu's call letters (SU1, SU2, DF, etc).

Setup Menu Key: Pressing this key calls Sweep Setup Menu SU1 or SU3. Depending upon which menu items you select, additional menus may also be called.

Data Points Key: Pressing this key calls Menu SU9 or SU9A. Menu SU9 provides for data point selection. Menu SU9A is called if the C.W. MODE selection in Menu SU1 is on.

Hold Key: If the instrument is sweeping, pressing this key results in an immediate halt of the sweep at the current data point. The LED on the button lights, indicating that the Hold Mode is active.

If you restart the sweep after performing any recall-from-disk operations in the Hold Mode (sweep stopped at some data point), the sweep restarts from the beginning. The instrument may be taken out of the hold mode as follows:

- ❑ By pressing the Default Program key. This causes the 37XXXD to revert to a predefined state
- ❑ By pressing the Begin Cal key. This causes the 37XXXD to resume sweeping and begin the Calibration Menu sequence

NOTE

See the description for Menu SU4 for a discussion of the interaction between the Hold Mode and the selection of "Single Sweep" or "Restart Sweep."

Domain Key: This key function is fully described in paragraph 4-2 (page 4-8). Additionally, if the Time Domain option is installed, making a selection other than "Frequency Domain" lets you display measured data in the time domain. It also calls a further sequence of Time Domain Menus. Refer to section 9-2 for additional details.

Appl: Pressing this key calls a menu that lets you select the following applications: Adapter Removal, Swept Frequency Gain Compression, or Swept Power Gain Compression.

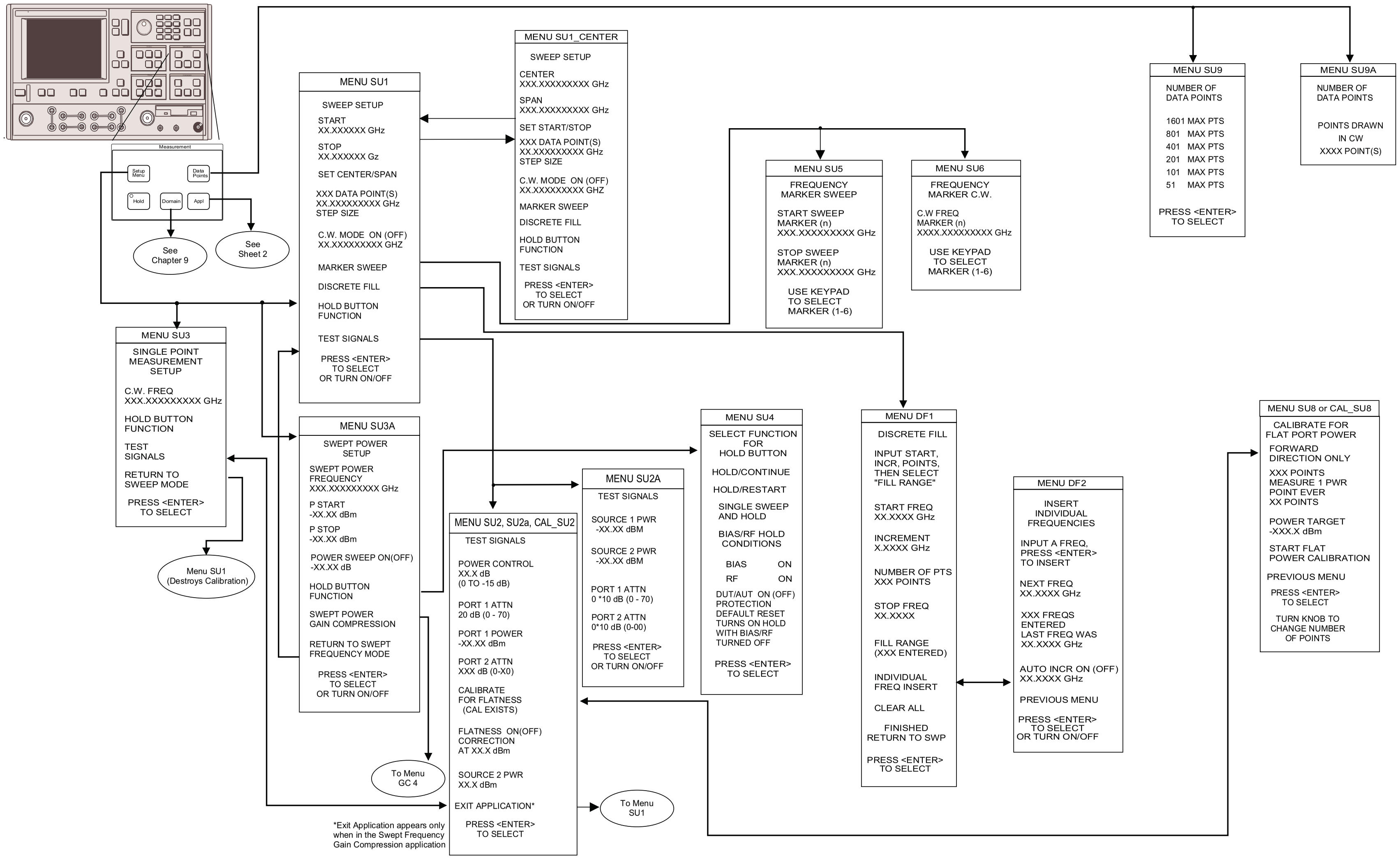


Figure 4-8. Measurement Key-Group Menus Menu Flow (Sheet 1 of 2)

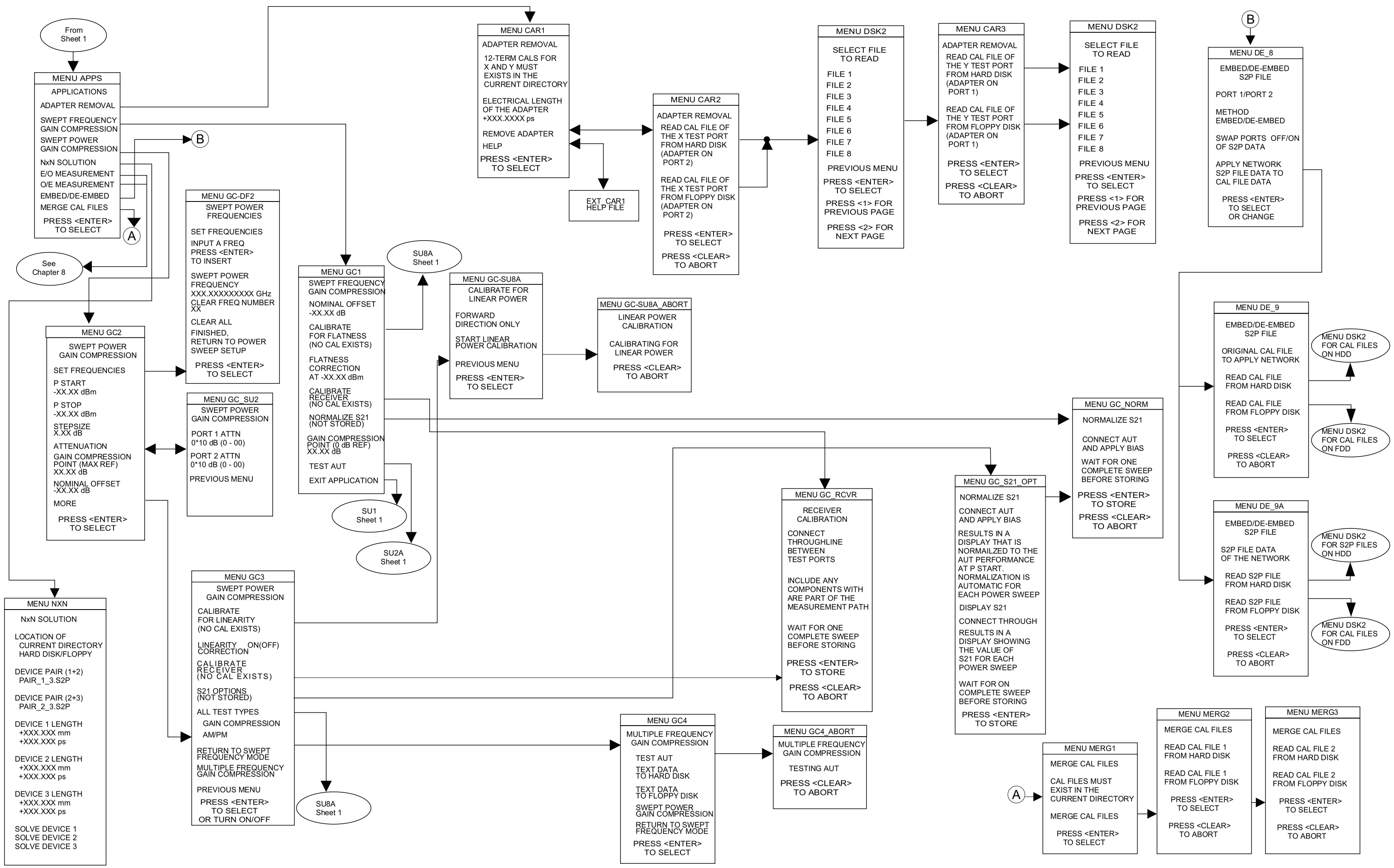


Figure 4-8. Measurement Key-Group Menus Menu Flow (Sheet 2 of 2)

4-6 CHANNELS KEY-GROUP

The individual keys within the Channels key-group are described below:

Ch 1-4 Keys: These keys (below) define the active channel. One (and only one) must always be active as indicated by the associated LED. Pressing a button makes the indicated channel active. If channel indicated by the key is already active, pressing the key has no effect.

The active channel will be the channel acted upon by the S Params, Graph Type, Ref Plane, Trace Memory, Set Scale, Auto Scale, Markers/Limits and Domain keys. When in the single channel display mode, the active channel will be the one displayed.

Channel Menu: Pressing this key calls menu CM (below). Here, you select the number of channels to be displayed. When in the single display mode, only the active channel will be displayed. Full menu description can be found in the alphabetical listing (Appendix A) under the menu's call letters (CM).

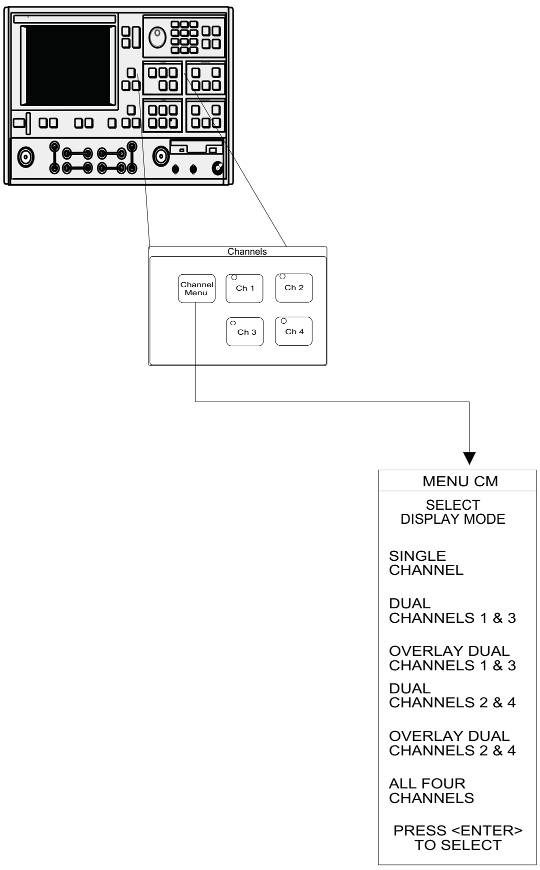


Figure 4-9. *Channel Key-Group Menu*

4-7 DISPLAY KEY-GROUP

The individual keys within the Display key-group are described below. Menu flow diagrams are shown in Figure 4-10. Full menu description(s) for menu SP and all others mentioned below can be found in the Appendix A alphabetical listing under the menu's call letters (SP, GT1, RD1, etc.).

Graph Type Key: Pressing this key calls menu GT1 or GT2. These menus let you select the type of display to appear on the active channel for the selected S-Parameter.

Set Scale Key: Pressing this key calls the appropriate scaling menu (SS1, SS2, SS3, etc.) depending upon the graph type being displayed on the active channel for the selected S-Parameter.

Auto Scale Key: Pressing this key autoscales the trace or traces for the active channel. The new scaling values are then displayed on the menu (if it is displayed) and graticule. The resolution will be selected from the normal sequence of values you have available using the knob. When the active channel has a Real and Imaginary type display, the larger of the two signals will be used to autoscale both the real and imaginary graphs. Both graphs will be displayed at the same resolution.

S Params Key: Pressing this key calls menu SP. This menu allows you to select the S-Parameter to be displayed by the active channel for the selected S-Parameter.

Ref Plane Key: Pressing this key calls menu RD1. This menu lets you input the reference plane in time or distance. You do this by selecting the appropriate menu item. For a correct distance readout, the dielectric constant must be set to the correct value. This is accomplished by selecting SET DIELECTRIC, which calls menu RD2.

On menu RD1, selecting AUTO automatically adjusts the reference delay to unwind the phase for the active channel.

The 37XXXD unwinds the phase as follows:

- First, it sums the phase increments between each pair of measured data points, then it takes the average “Pdelta” over the entire set of points
- Next, it corrects the phase data by applying the following formula:

$$P_{correct} = P_{measured} - NxP_{delta}$$

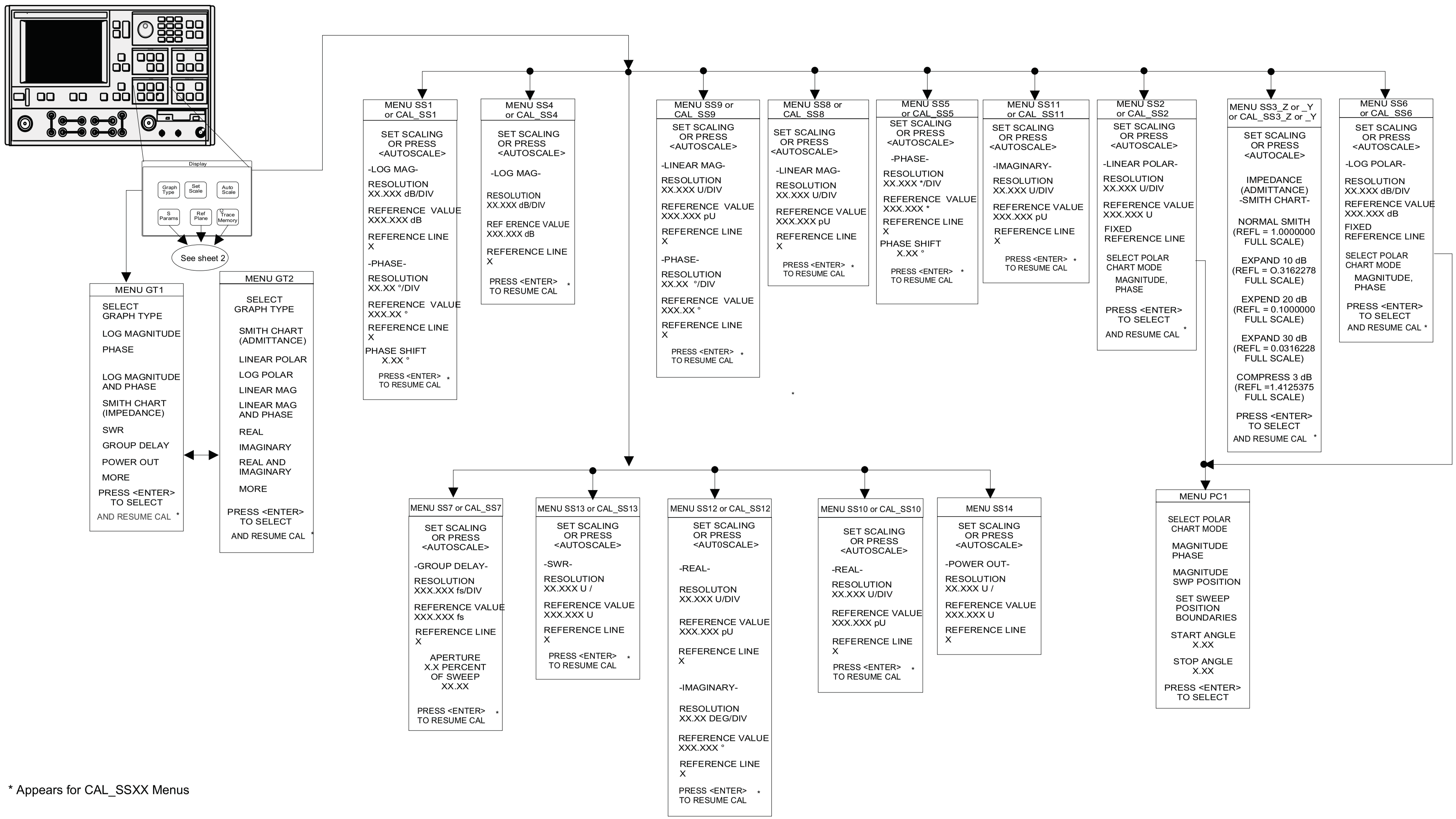
Where P = phase

Assuming there are fewer than 360 degrees of phase rotation between each data point, the operation described above removes any net phase offset. The endpoints of the phase display then fall at the same phase value.

Trace Memory Key: Pressing this key brings up menu NO1. This menu—which relates to the active channel—allows you to store data to memory, view memory, perform operations with the stored memory, and view both data and memory simultaneously. Four memories exist, one for each channel. This allows each channel to be stored and normalized independent of the other channels. Data from the trace memory may be stored on the disk or recalled from it.

NOTE

Trace memory will automatically be set to VIEW DATA (that is, turned off), if a sweep with a greater number of points is selected while operating on a stored trace.



* Appears for CAL_SSXX Menus

Figure 4-10. Display Key-Group Menus (1 of 2)

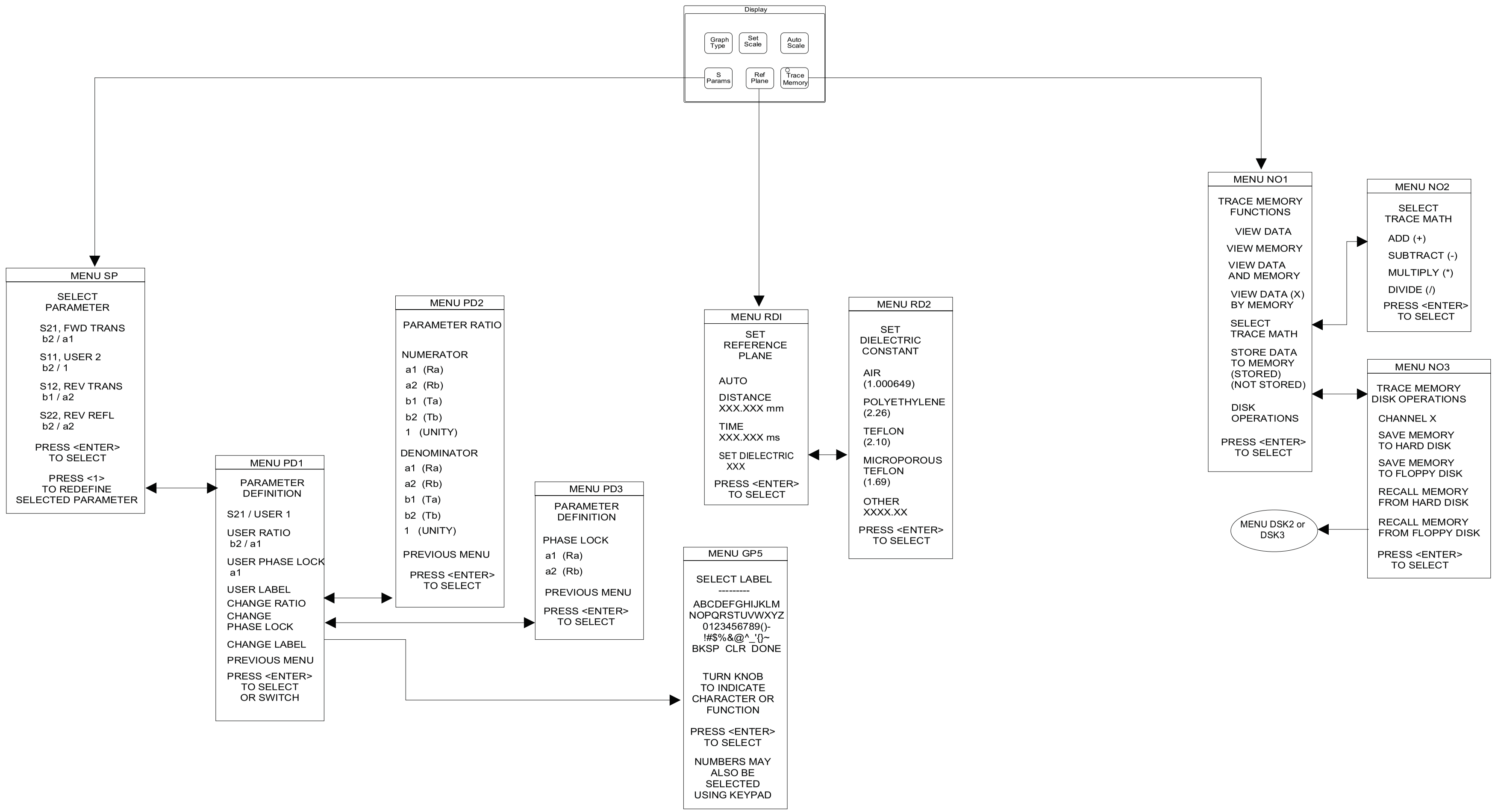


Figure 4-10. Display Key-Group Menus (2 of 2)

4-8 ENHANCEMENT KEY-GROUP

The individual keys within the Enhancement key-group are described below. Full menu description(s) for menu OPTNS and all others mentioned below can be found in the Appendix A alphabetical listing under the menu's call letters (OPTNS, EM, CAL_BW, etc).

Option Menu Key: This key brings up the OPTNS menu. Depending on choices selected, this menu causes other menus to appear. A menu flow diagram for this key is shown in Figure 4-12 on the following page.

Video IF BW Key: Pressing this produces a menu that lets you choose between four different IF bandwidths. This menu is shown below.

Avg/Smooth Menu Key: Pressing this key brings up the EM Menu (Figure 4-11). When pressed during the calibration sequence, it brings up the EM Cal Menu instead. These menus are shown below.

Trace Smooth and Average Keys: The Average and Trace Smooth keys set their respective functions on and off with the appropriate LED indicating when the function is selected.

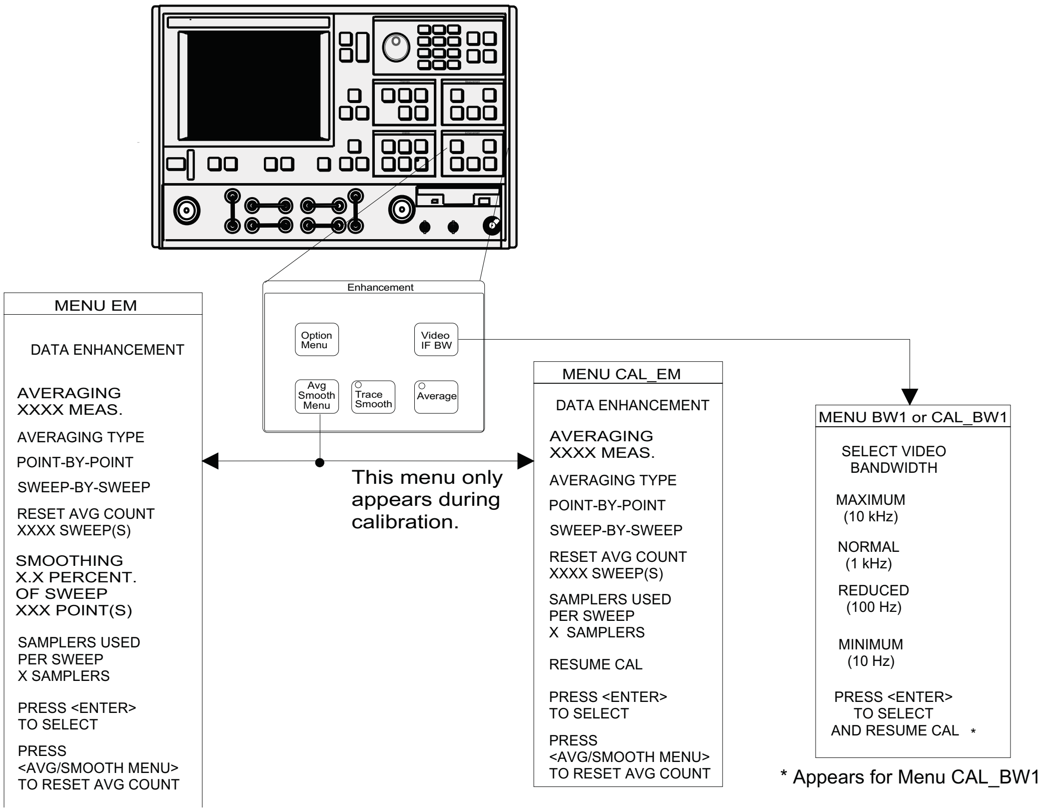


Figure 4-11. Enhancement Key-Group Menus

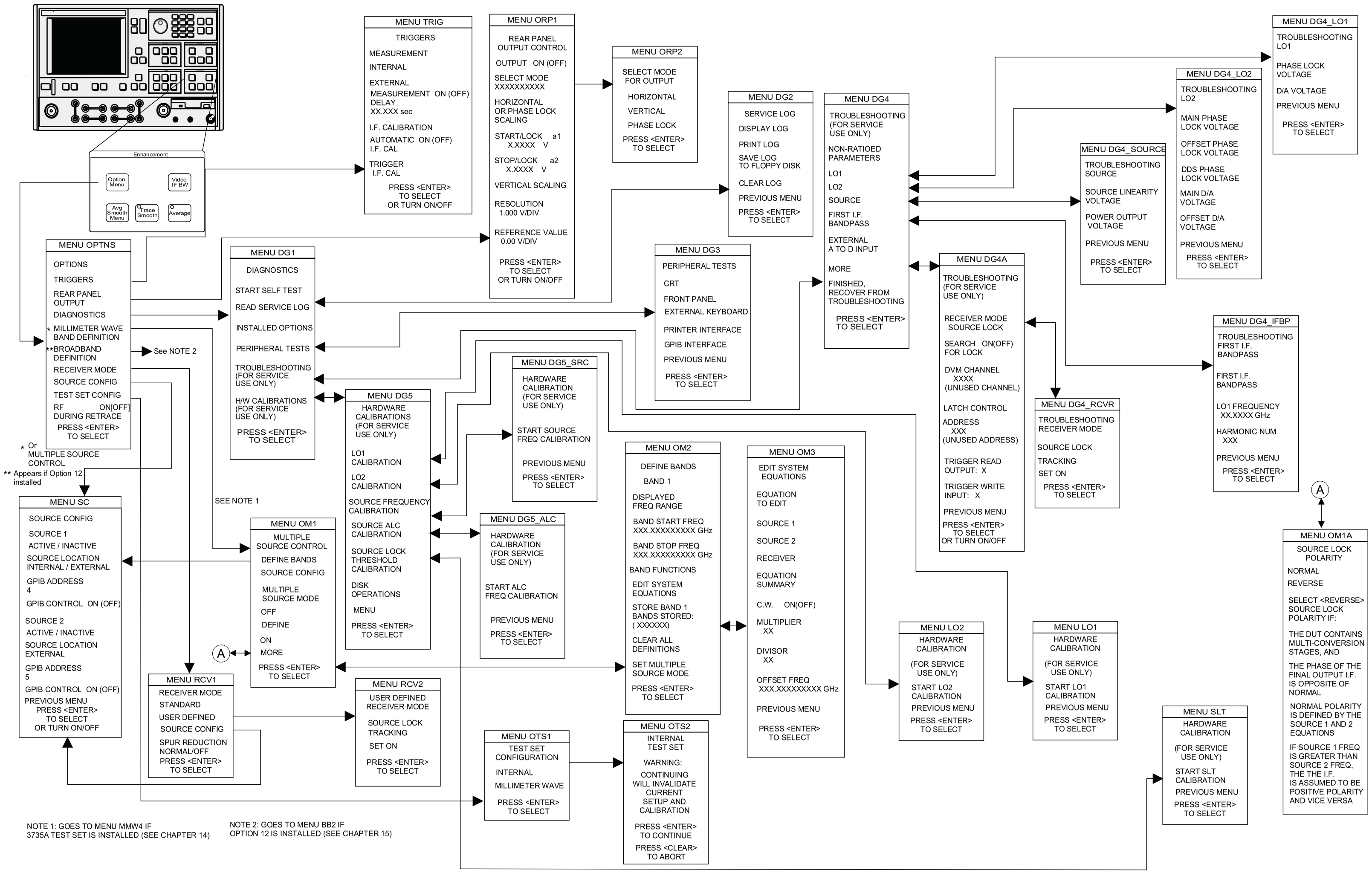


Figure 4-12. Enhancement Key-Group (Options Menu Key)

4-9 HARD COPY KEY-GROUP

The individual keys within the Hard Copy key-group are described below. Full descriptions for menus can be found in the alphabetical listing (Appendix A) under the menu's call letters (PM1, PM2, PM3, etc.)

Menu Key: Pressing this key brings up menu PM1. This menu allows you to define what will happen every time you press the Start Print key. A menu flow diagram is shown in Figure 4-13.

Start Print Key: Pressing this key starts outputting the measured data as defined by the setup defined by the selected MENU key.

Stop Print Key: Pressing this key can result in any of the following actions if the printer is selected:

- If the printer is active, the key aborts the printing and sends a form feed command to the printer. Aborting the printing clears the print buffer
- If the printer is not active and another form of output is active, pressing this key aborts printing, but does not send a form feed to the printer

Plotting Functions: The 37XXXD can plot an image of either the entire screen or subsets of it. Plots can be either full size or they can be quarter size and located in any of the four quadrants. You can select different pens for plotting different parts of the screen. You cannot, however, plot tabular data.

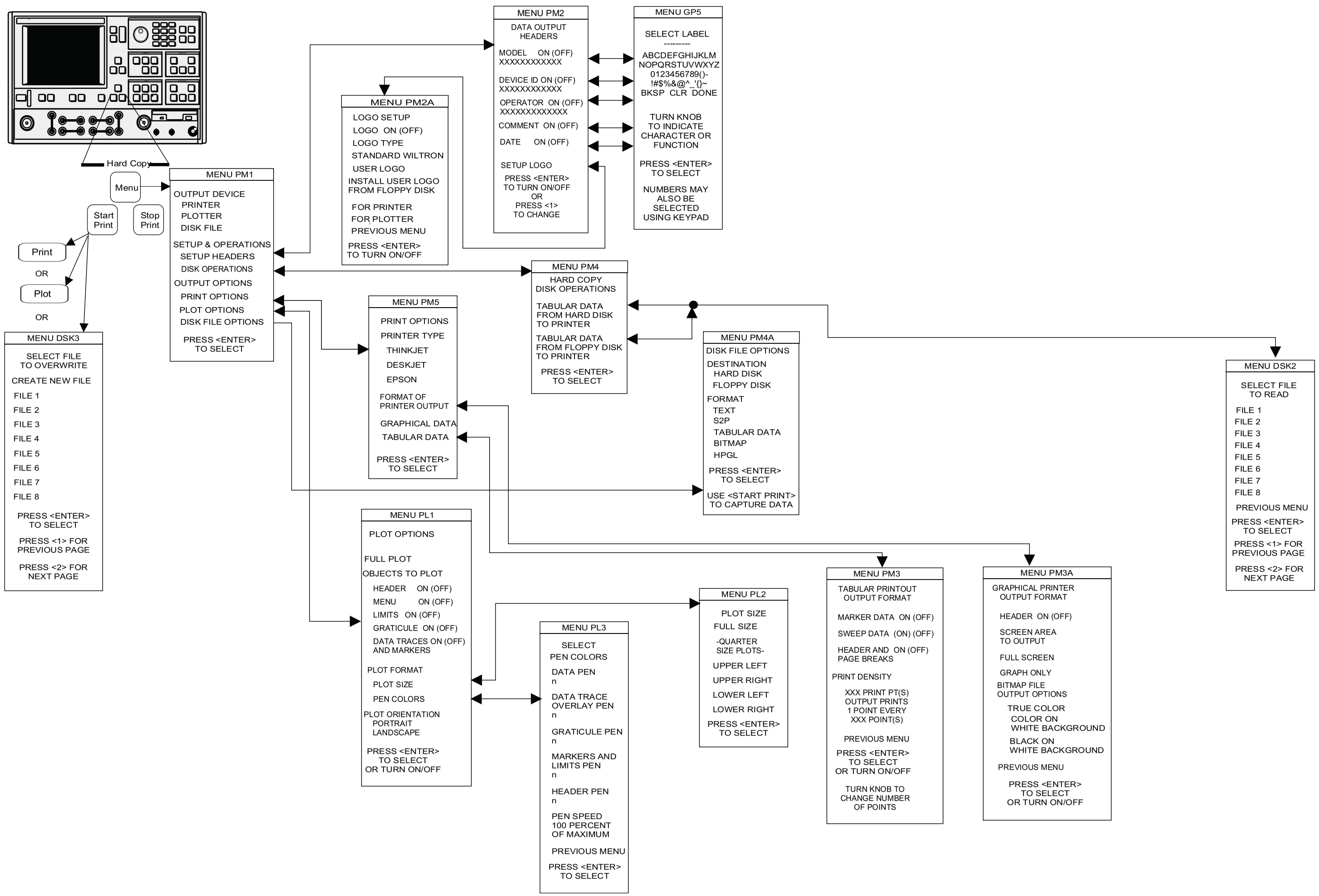


Figure 4-13. Hard Copy Key-Group Menus

4-10 SYSTEM STATE KEY-GROUP

The individual keys within the System State key-group are described below. The menu flow for the Utility Menu key is shown in Figure 4-14 on page 4-35. Full descriptions for menus can be found in the alphabetical listing (Appendix 1) under the menu's call letters (U1, U2, U3, etc.)

Default Program Key: Pressing this key brings up the default menu. If pressed again, it recalls the factory selected default values for the control panel controls. The values are defined in Table 4-2 on the following page.

Pressing this key then the 1 key resets front panel key states and internal memories 1 through 4.

Pressing this key then the 0 key resets front panel key states, internal memories 1 through 10, and certain hardware settings.

NOTE

Use of this key will destroy control panel and calibration setup data, unless they have been saved to disk.

Utility Menu Key: Pressing this key calls menu U1. This menu accesses subordinate menus to perform system, disk, and system utilities. The only functions performed directly from the U1 Menu are "Blank Frequency Information." and "Data Drawing."

Table 4-2. *Default Settings*

Function	Default Setting
Instrument State	Measurement Setup Menu Displayed
Measurement	Maximum sweep range of source and test set *Source Power:* Model Dependent *Resolution:* Normal (401 points)
Channel	Quad (four-channel) display Channel 1 active
Display	*Channel 1:* S11, 1:1 Smith Chart *Channel 2:* S12, Log Magnitude and Phase *Channel 3:* S21, Log Magnitude and Phase *Channel 4:* S22, 1:1 Smith Chart *Scale:* 10 dB/Division or 90/Division *Offset:* 0.000dB or 0.00 degree *Reference Position:* Midscale *Electrical Delay:* 0.00 seconds *Dielectric:* Air (1.000649) *Normalization:* Off *Normalization Sets:* Erased
Enhancement	*Video IF Bandwidth:* Normal *Averaging:* Off *Smoothing:* Off
Calibration	*Correction:* Off and Calibration erased *Connector:* K Connector *Load:* Broadband
Markers/Limits	*Markers On/Off:* All off *Markers Enabled/Disabled:* All enabled Marker Frequency: All set to the start-sweep frequency (or start -time distance) Δ *Reference:* Off *Limits:* All set to reference position value (all off all enabled)
System State	*GPIB Addresses:* Unchanged *Frequency Blanking :* Disengaged, *Error(s): GPIB SRQ errors are cleared, Service Log errors are not cleared* *Measurement:* Restarted

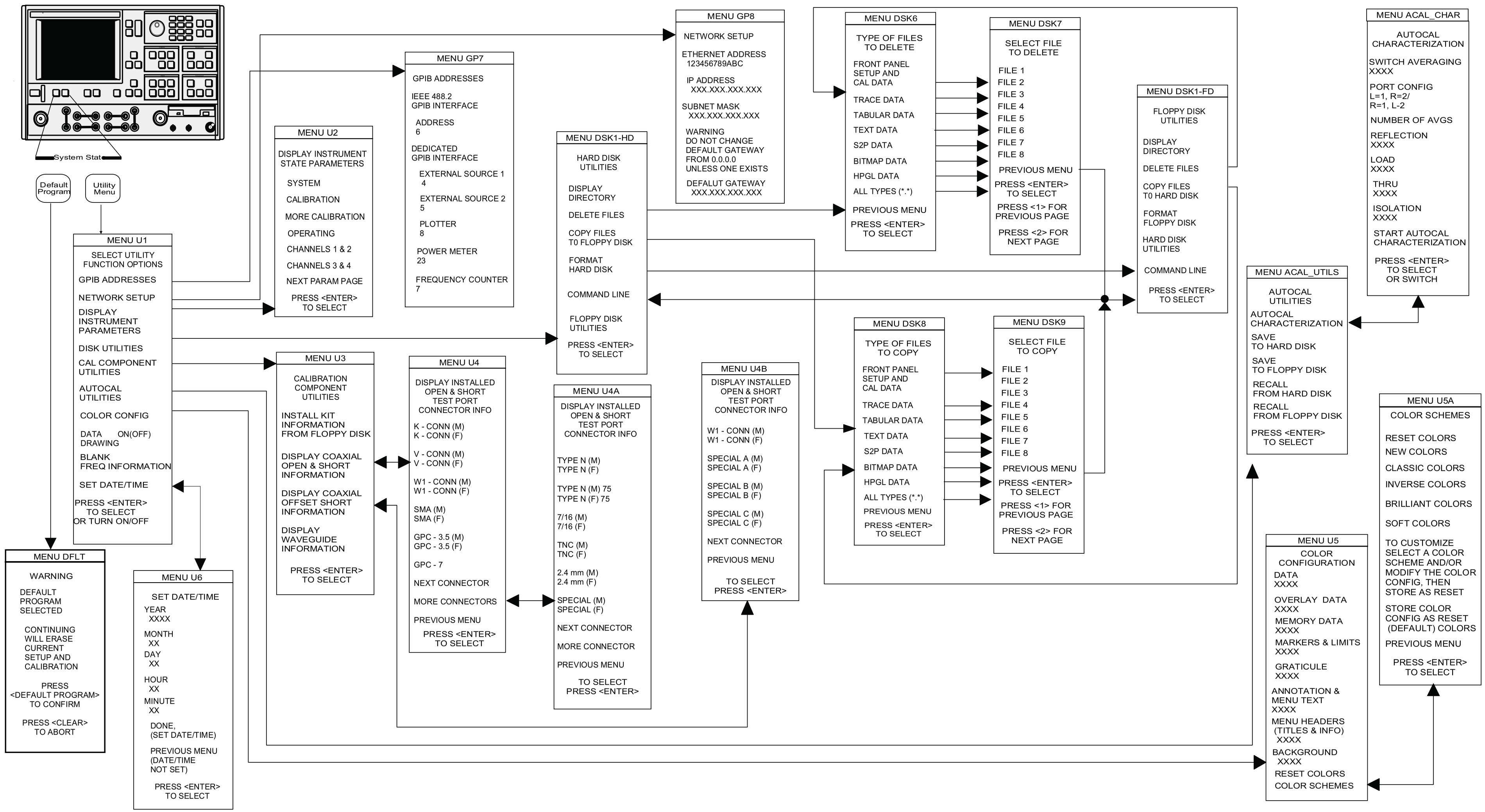


Figure 4-14. System State Key-Group Menus

4-11 MARKERS/LIMITS KEY-GROUP

The individual keys within the Markers/Limits key-group are described below. The menu flow for the Marker Menu key is shown in Figure 4-15 on the following page. Full descriptions for these menus can be found in the alphabetical listing (Appendix A) under the menu's call letters (M1, M2, M3, etc.)

Marker Menu Key: Pressing the Marker Menu key calls Menu M1. This menu lets you toggle markers on and off and set marker frequencies, times, or distances.

Readout Marker Key: Pressing this key calls different menus, depending upon front panel key selections, as described below:

- It calls menu M1 if there are no markers available within the selected frequency range
- It calls menu M3 if no Delta ref marker has been selected
- It calls menu M4 if the DReference mode is off and the selected marker is in the current sweep range (or time/distance)
- It calls menu M5 if the DReference mode and marker are both on and the DReference marker is in the selected sweep range (or time/distance)
- It calls menu M6 if ACTIVE MARKER ON ALL CHANNELS has been previously selected in menu M9
- It calls menu M7 if SEARCH has been previously selected in menu M9
- It calls menu M8 if FILTER PARAMETER has been previously selected in menu M9

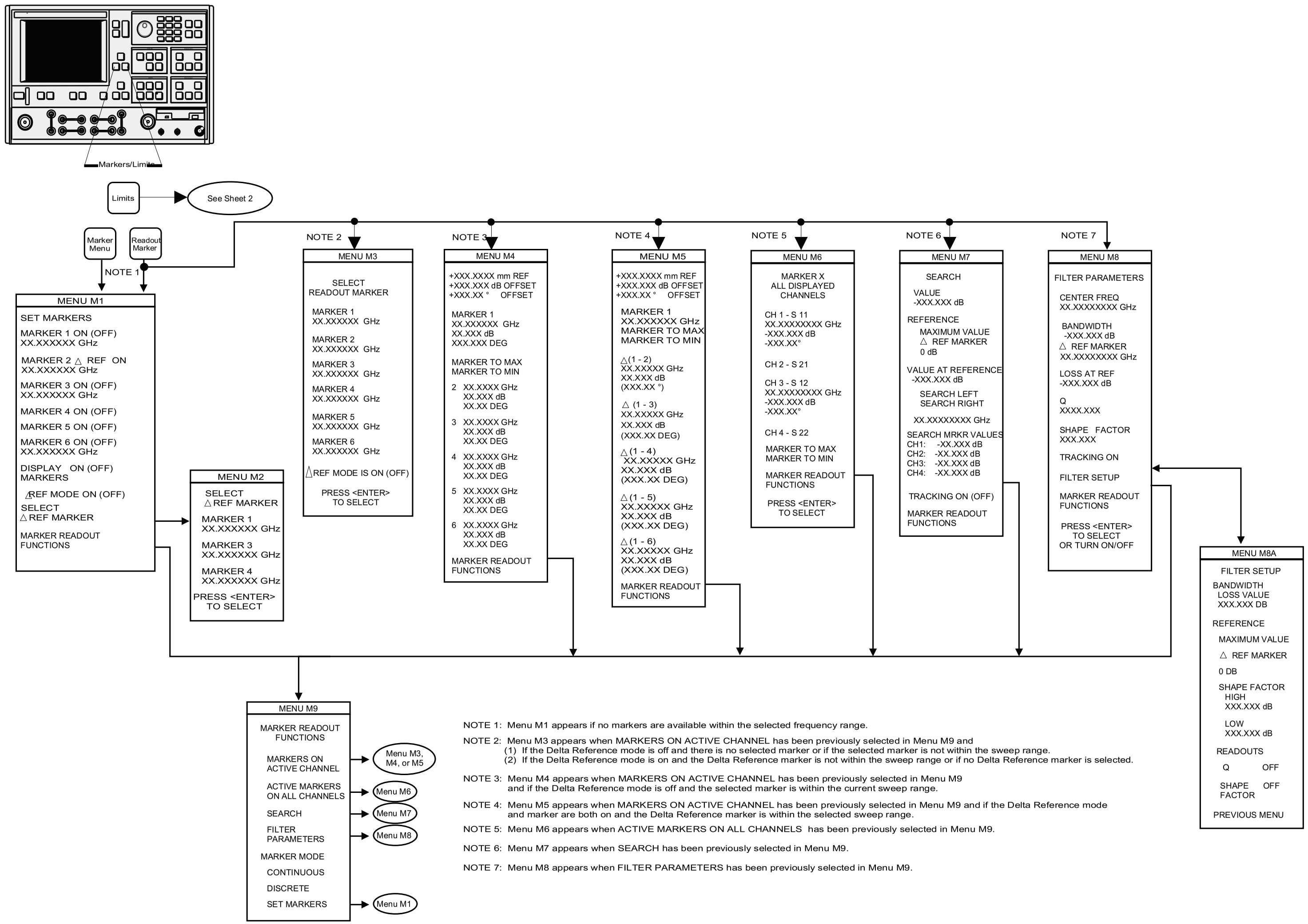
Limits Key: Pressing this key calls the appropriate Limit menu based on the graph type selected using the Graph Type key and menu.

Marker Readout Functions: This menu choice, which appears on several marker menus, provides for several filter-related measurements. It also allows for performing a marker-value search and for reading the active marker value on all displayed channels.

Limit Frequency Readout Function: The 37XXXD has a Limit-Frequency Readout function. This function allows frequency values to be read at a specified level (such as the 3 dB point) on the data trace. This function is available for all rectilinear graph-types.
The graph-type and their menu call letters are listed below:

- Log Magnitude, Menu LF1
- Phase, Menu LF2
- Group Delay, Menu LF3
- Linear Magnitude, Menu LF4
- SWR, Menu LF5
- Real, Menu LF6
- Imaginary, Menu LF7
- Power Out, Menu LF8
- Real, Menu LF6
- Imaginary, Menu LF7
- Power Out, Menu LF8

> **NOTE**
> Full menu descriptions can be found in the alphabetical listing (Appendix A) under the menu call letters (LF1, LF2, LF3, etc.)



NOTE 1: Menu M1 appears if no markers are available within the selected frequency range.

NOTE 2: Menu M3 appears when MARKERS ON ACTIVE CHANNEL has been previously selected in Menu M9 and
(1) If the Delta Reference mode is off and there is no selected marker or if the selected marker is not within the sweep range.
(2) If the Delta Reference mode is on and the Delta Reference marker is not within the sweep range or if no Delta Reference marker is selected.

NOTE 3: Menu M4 appears when MARKERS ON ACTIVE CHANNEL has been previously selected in Menu M9 and if the Delta Reference mode is off and the selected marker is within the current sweep range.

NOTE 4: Menu M5 appears when MARKERS ON ACTIVE CHANNEL has been previously selected in Menu M9 and if the Delta Reference mode and marker are both on and the Delta Reference marker is within the selected sweep range.

NOTE 5: Menu M6 appears when ACTIVE MARKERS ON ALL CHANNELS has been previously selected in Menu M9.

NOTE 6: Menu M7 appears when SEARCH has been previously selected in Menu M9.

NOTE 7: Menu M8 appears when FILTER PARAMETERS has been previously selected in Menu M9.

Figure 4-15. Markers Menus (1 of 3)

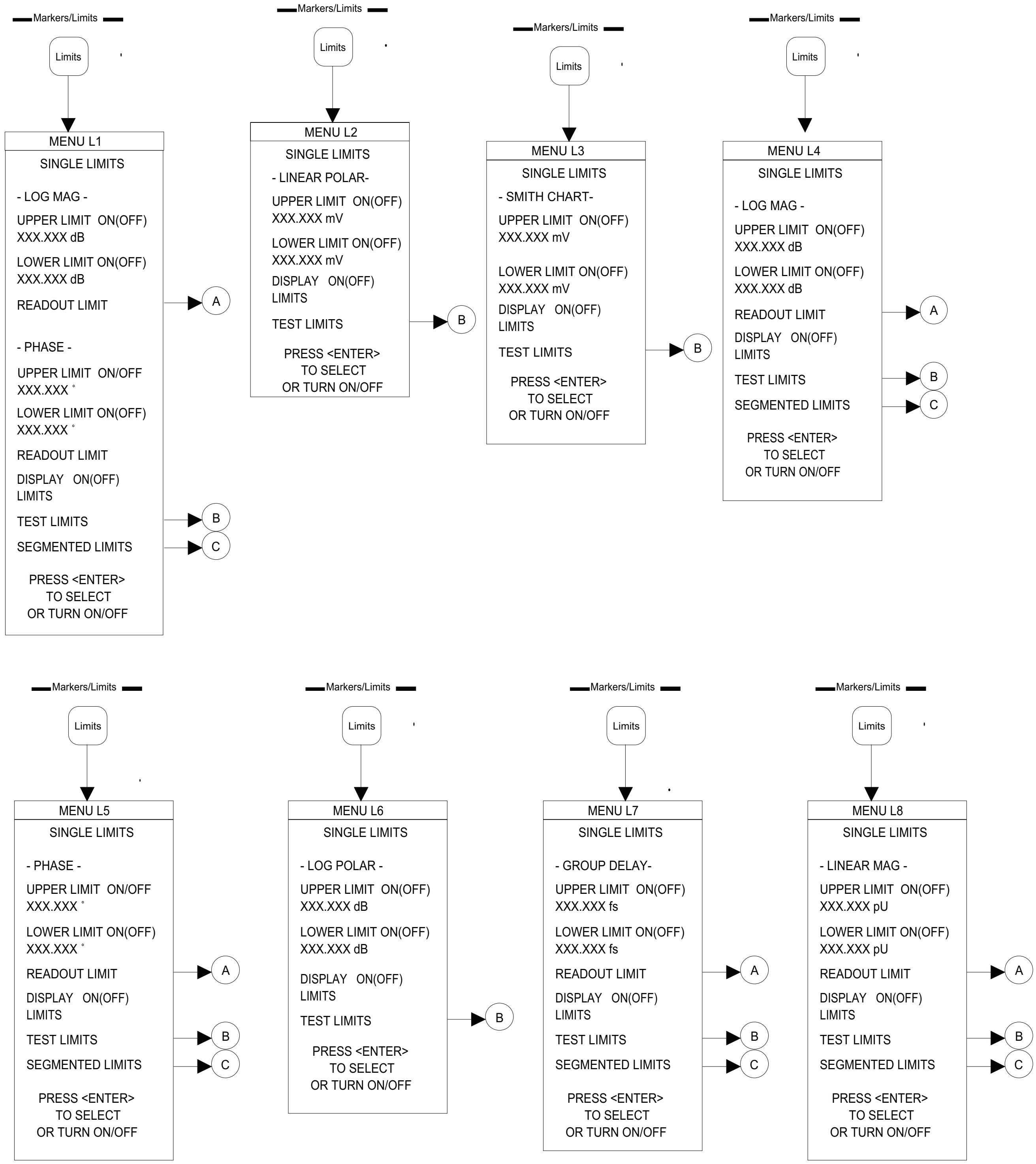


Figure 4-15. *Markers/Limits Key-Group Menus (2 of 3)*

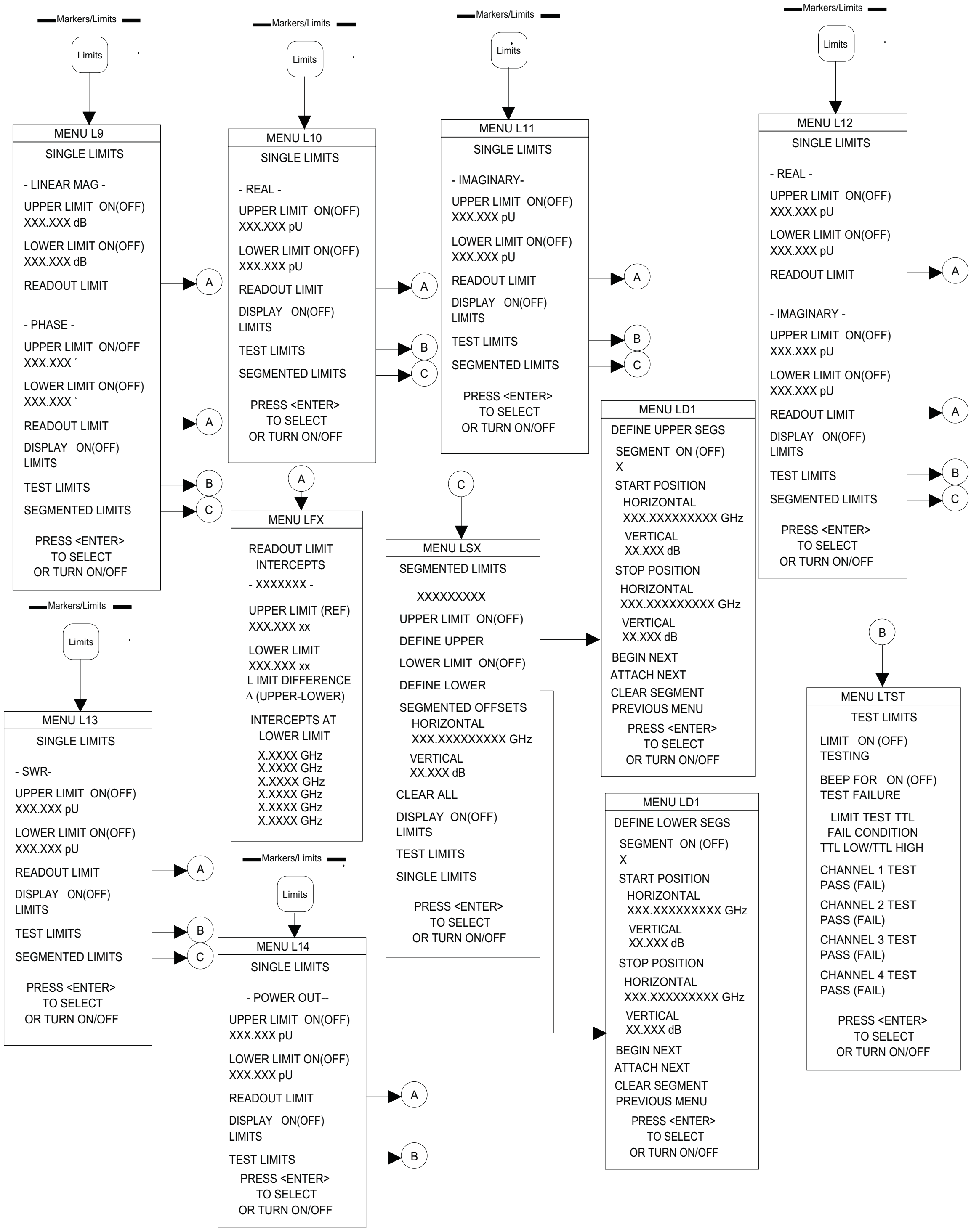


Figure 4-15. *Markers/Limits Key-Group Menus (3 of 3)*

4-12 DISK STORAGE INTERFACE

The 37XXXD has two internally mounted disk drives: an 80 MB hard disk and a 3.5 inch floppy. The format, files, and directory are compatible with MS-DOS, Version 5.0 and above.

Disk Format

Floppy diskettes are MS-DOS compatible and have a 1.44 MByte capacity.

Disk Files

You may find any of the following file-types on the 37XXXD disk:

- Program Files: These are binary files used to load the operating program. They are provided on the hard drive, and a backup copy is provided on floppy diskettes. Application programs cannot read them
- Calibration Data Files: These are binary files used to store and retrieve calibration and other data. Application programs cannot read them. File size depends on calibration type
- Text Files: These are tab-delimited ASCII files with the “txt” file extension. They can be read by application programs
- S2P Parameter Data Files: These files define a 2-port file format that includes all four S parameters. They can be read by applications programs. They have a file extension of “S2P”
- Tabular Measurement Data Files: These are ASCII files used to store actual measurement data. They can be read by applications programs. File size depends on selected options
- Trace Memory Files: These are binary files used to store trace data. Applications programs cannot read them. You use them to perform trace math operations on data
- Cal Kit File for Coax or Waveguide
- AutoCal Characterization file

NOTE

File names must begin with alphabetical, not numeric characters.

Disk File Output Device

You can select the output drive destination for the disk file as either the hard disk (C:) or the floppy drive (A:). The format of the disk file is also selected. The default condition is text disk file to the hard disk.

You may then proceed with normal measurements. The Start Print key may then be used at the instant you intend to capture the data. Menu DISK 3 then appears and allows the creation of a new file or to overwrite an existing file in the current directory.

Note that the output for text and S2P files have predefined formats. Tabular data format is configured via the Print Options (Menu PM5) or Tabular Data (Menu PM3). Bitmap format is configured via the Print Options (Menu PM5), Options (Menu PM5, or Graphical Data (Menu PM3A). HPGL format is configured via the Plot Options (Menu PL1).

You are able to direct hard copy output to the HDD or floppy, in addition to the printer and plotter. In addition to text (*.txt), S2P (*.s2p), and tabular (*.dat) files, bitmaps (*.bmp) and HPGL (*.hgl) files are offered to satisfy your desktop publishing requirements. Specifically, color bitmaps and graphic language files can be imported into Windows applications, such as Cap3700.

Formatting a Data File Disk

You may format additional diskettes to hold calibration, tabular measurement, and trace-memory data files. Do this using the FORMAT DISK selection on the “Floppy Disk Utilities” menu. Using this selection will format the target disk and overwrite any existing data it contains.

A format hard disk utility is provided in case of hard disk failure. Using this feature overwrites your system software and requires booting from the backup floppy diskettes.

Copying Data Files From Disk to Disk

Use the COPY FILES selection on the “Floppy Disk Utilities” and “Hard Disk Utilities” menus to copy data files between hard and floppy diskettes.

Recovering From Disk Write/Read Errors

If you experience a read or write error during a disk operation, you should:

- ❑ Verify first character of filename is alphabetical and not numeric
- ❑ Verify that the diskette has been properly formatted
- ❑ Verify that the diskette is high density (1.44 MB). Low density (720 KB) diskettes are not supported
- ❑ Verify that the write-protect tab on the disk is engaged
- ❑ Retry the disk operation

Repeated disk errors may indicate a defective diskette and format.

4-13 COMMAND LINE

The Command Line menu choice provides several DOS compatible commands. Command line options are:

- ❑ CREATE DIRECTORY (MD)
- ❑ LIST DIRECTORY (DIR)
- ❑ CHANGE DIRECTORY (CD)
- ❑ DELETE FILES (DEL)
- ❑ REMOVE DIRECTORY (RD)
- ❑ COPY FILES (COPY)

These options are NOT case sensitive.

Create Directory

This command is performed by: MD c:\pat-h\dir_name or MD a:\path\dir_name. The c: is used to refer to the hard disk, and a: is for the floppy disk.

List Directory

This command is performed by "DIR" command. This may be used as DIR c:\path or without any path specified. The syntax is:

DIR c:\path or DIR a:\path.

If c: or a: is not used, the default is the current hard disk directory. You may use wild cards as follows:

- ❑ DIR *.cal
- ❑ DIR filter?.cal

Change Directory

This command is performed by CD c:\path or CD a:\path. Both of these options do not require a device name. The device name is referred to by c: or a:.

If you choose to do CD dir_name, this implies the current Hard disk directory.

Delete Files

This command is used to delete a particular file(s) in a directory, or delete the entire contents of the directory by using the wild card option. The command line is:

- ❑ DEL filename
- ❑ DEL c:\path\filename
- ❑ DEL a:\path*

Remove Directory

This command is used to delete a particular directory. The command is only valid when the entire directory is empty:

- ❑ RD c:\path\directory
- ❑ RD a:\path\directory

Copy Files

This command is performed by the command line COPY source: destination:

COPY c:\path\name a:\path\name

Any combination of the drive is allowed, except for the same directory, and the same name.

Once the COMMAND LINE is selected, the system will prompt a one line dialog box to allow command entry. The dialog box remains open only for the user interface.

Conventions

Be aware of the following conventions when using the Command Line choice. There is a limitation of five sublevel directories in the 37XXXD models:

- ❑ Any directory change will force the system to use that as the current directory for other menus that deal with the file system. For example, if the user changes the directory to c:\lib\junk, then any activity for saving hard copy or calibration files will be saved on the junk directory.
- ❑ The default directory is the root directory.
- ❑ GPIB support: GPIB mnemonics will provide functionality for each of the above operations. The format is shown below:

Function	Path
List directory	DIR “[device:/][”
Make directory	MD “[device:/][path]name”
Change directory	CD “[device:/][path]napath]nameme”
Delete File(s)	DEL “[device:/][path]name”
Remove directory	RD “[device:/][path]name”
Copy files	COPY “[device:][/path/][source]” “[device:][/path/][destination]”

Vector Network Analyzer

Clear/Ret Loc _____ **Esc**
Start Print ________ **Print Screen, F12**
Hold ____________ **Pause**

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	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
Ctrl	Default Program		Utility Menu	Options Menu	Command Line	Recall	Recall CAL from HDD	Recall NRM from HDD	Save TXT to Floppy	Save S2P to Floppy	Save DAT to Floppy	
Alt	Avg/Smooth Menu	Trace Smooth	Average	Video IF BW		Save	Save CAL to HDD	Save NRM to HDD	Save TXT to HDD	Save S2P to HDD	Save DAT to HDD	Hardcopy Menu
Shift	Channel Menu	Marker Menu	Readout Marker	Limits	S Params	Set Scale	Ref Plane	Trace Memory	Domain	Applications	Begin Cal	Stop Print
	Ch 1	Ch 2	Ch 3	Ch 4	Graph Type	Auto Scale	Auto Ref Plane	Store Data to Memory	Setup Menu	Data Points	Apply Cal	Start Print

Vector Network Analyzer

Clear/Ret Loc _____ **Esc**
Start Print ________ **Print Screen, F12**
Hold ____________ **Pause**

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	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
Ctrl	Default Program		Utility Menu	Options Menu	Command Line	Recall	Recall CAL from HDD	Recall NRM from HDD	Save TXT to Floppy	Save S2P to Floppy	Save DAT to Floppy	
Alt	Avg/Smooth Menu	Trace Smooth	Average	Video IF BW		Save	Save CAL to HDD	Save NRM to HDD	Save TXT to HDD	Save S2P to HDD	Save DAT to HDD	Hardcopy Menu
Shift	Channel Menu	Marker Menu	Readout Marker	Limits	S Params	Set Scale	Ref Plane	Trace Memory	Domain	Applications	Begin Cal	Stop Print
	Ch 1	Ch 2	Ch 3	Ch 4	Graph Type	Auto Scale	Auto Ref Plane	Store Data to Memory	Setup Menu	Data Points	Apply Cal	Start Print

Actual-Size Keyboard Templates for 37XXXD

Chapter 5
Error and Status

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Chapter 5
Error and Status Messages

5-1 INTRODUCTION

This chapter lists, describes, and provides corrective action for the error messages that point to problems that the operator can correct. Any error messages that appear on the display but do not appear in this chapter will require action by a qualified service representative.

5-2 ERROR MESSAGES

Error messages are provided in Tables 5-1 and 5-2.

Table 5-1. *General Error Messages (1 of 3)*

Error Message	Description	Corrective Action
ATTENUATOR UNAVAILABLE	Option 6 Port 2 Test Step Attenuator is not installed.	Install Option 6 Step Attenuator,
BANDS MUST SEQUENCE	Frequency bands in Multiple Source mode must sequence in a 1-2-3-4-5 order.	None, no skipping is allowed.
BOTH LIMITS MUST BE ON	Must have both limits activated.	Turn on limits.
DIFFERENT H/W SETUP. RECALL ABORTED	Source is different from the recalled setup.	Reconfigure system to duplicate the hardware setup that was used to store the saved data.
DIFFERENT S/W VERSION, RECALL ABORTED	Saved state not compatible with hardware or software version.	Load compatible software (S/W) version and retry.
DISCRETE FREQS LOST	Change in frequency caused discrete fill frequencies to be lost.	None.
DISPERSIVE MEDIUM, ONLY TIME USED	Distance does not apply for dispersive media.	None.
FREQUENCIES HAVE REACHED UPPER LIMIT	Frequencies being defined in Multiple Source mode have reached upper limits of Sources.	Redefine frequencies to not exceed limits of Sources.
ILLEGAL IN C.W. MODE	Attempted to readout limit frequency.	None, no limit lines are permitted in CW mode.
ILLEGAL IN TIME DOMAIN	Attempted to readout limit frequency	None.
LOGO FILE NOT FOUND	Attempted to read a non-existent logo file from disk.	Create user-defined logo using application on external controller.
MEAS DATA NOT AVAILABLE FOR STORAGE	Measurement data is not available for storage on floppy or hard disk.	None.
MEMORY LOCATION CORRUPTED	Requested memory location is corrupted.	None. If problem reoccurs after storing a new setup, contact Anritsu Customer Service.
NO BANDS ARE STORED	No frequency bands have been defined and stored.	Need to define and store frequency bands to turn on Multiple Source mode.

Table 5-1. *General Error Messages (2 of 3)*

Error Message	Description	Corrective Action
NO STORED MEMORY DATA	No data is stored in floppy or hard disk memory.	None.
OPTION NOT INSTALLED	Selected an option that is not installed.	None.
OUT OF CAL RANGE	Entered values out of the selected calibration range.	Change calibration range or re-enter values that are within the current range.
OUT OF H/W RANGE	Entered value is out of the instrument's hardware range.	Re-enter values that are within range.
OUT OF RANGE	Entered value is out of range.	Re-enter values that are within range.
OUT OF RANGE, 10 PERCENT MIN	Entered value is out of the instrument's range by greater than 10 percent.	Re-enter frequency or power value.
OUT OF RANGE, 20 PERCENT MAX	Entered smoothing or group delay value exceeds the range by greater than 20 percent.	Re-enter values that are within range, 0 to 20%.
OUT OF SWEEP RANGE	Entered a frequency that is out of the instrument sweep range.	Re-enter frequency.
OUT OF WINDOW RANGE	Attempted to set marker outside start to stop range.	Redefine marker to be within frequency start/stop range.
POWER OUT OF CALIBRATED RANGE	Power range has been changed to be outside the range of the active linearity calibration. Linearity calibration is turned off.	Perform linearity calibration over new power range.
POWER RESTORED TO CAL RANGE	Power range is outside of the linearity calibration range when the calibration was turned on. The power range is changed to the calibration range.	If new power range is desired, perform new linearity calibration over new power range.
RECEIVER OUT OF RANGE BY EQUATION	Equation defined in Multiple Source mode places receiver frequency out of range when attempting to store band.	Redefine frequency.
SOURCE 1 OUT OF RANGE BY EQUATION	Equation defined in Multiple Source mode places Source 1 frequency out of range when attempting to store band.	Redefine frequency.
SOURCE 2 OUT OF RANGE BY EQUATION	Equation defined in Multiple Source mode places Source 2 frequency out of range when attempting to store band.	Redefine frequency.
STANDARD CAL NOT VALID FOR WAVEGUIDE	Cannot use waveguide when calibrating with the standard method.	Use the Offset Short method with waveguide.
START F FOLLOWS PREVIOUS STOP F	Start frequency of current band immediately follows stop frequency of previous band. Cannot be modified.	None.
START GREATER THAN STOP	Entered start frequency is greater than the stop frequency.	Re-enter frequency values such that the start frequency is lower than the stop frequency.
START MUST BE LESS THAN STOP	Entered start frequency is greater than the stop frequency.	Re-enter frequency values such that the start frequency is lower than the stop frequency.
STEP IS TOO LARGE	Entered discrete fill step extends the stop fill out of range.	Re-enter so that step is within range.

Table 5-1. General Error Messages (3 of 3)

Error Message	Description	Corrective Action
STOP IS OVER RANGE	Entered value exceeds the instrument's stop frequency.	Re-enter stop frequency.
SYSTEM BUS ADDRESSES MUST BE UNIQUE	GPIB address is being used by another bus instrument.	Select a different, unique GPIB address.
SYSTEM UNCALIBRATED	37XXXD is uncalibrated for the selected measurement values.	Perform a measurement calibration.
TOO FEW POINTS, 2 MINIMUM	Entered too few discrete file points, 2 is minimum.	Re-enter data points.
TOO MANY POINTS, 1601 MAXIMUM	Entered too many discrete file points, 1601 points are the maximum allowed.	Re-enter data points.
UNDEFINED DIVIDE BY ZERO	Denominator cannot be zero in equation.	Make denominator a value other than zero.
WARNING: NO GPIB CONTROL OF SOURCE SWEEP	Neither Source power nor flat-port power can be modified when receiver mode is user-defined with NO Source GPIB control.	None.
WARNING: SET ON RECEIVER MODE	Phase-lock setting is undefined when VNA is Set-On Receiver mode.	None.
WARNING: SOURCE 2 DOES NOT EXIST	2nd, external, frequency source is not present.	Connect frequency source.
WINDOW TOO SMALL	Attempted to set start greater than or equal to stop.	Re-enter frequency values.

Table 5-2. *Disk Error Messages*

Error Message	Description	Corrective Action
7140: FLOPPY DISK GENERAL ERROR	Invalid disk media or format.	Use 1.44 MB diskette and format in the 37XXXD.
7142: FLOPPY DISK READ ERROR	Read error when accessing disk file.	Use 1.44 MB diskette and format in the 37XXXD.
7143: DISK WRITE ERROR	Error in writing to disk file.	Use 1.44 MB diskette and format in the 37XXXD.
7147: FLOPPY DISK UNAVAILABLE	Floppy disk is not available.	Install floppy diskette or floppy disk drive.
7170: HARD DISK GENERAL ERROR	General error in accessing hard disk.	Retry and if still fails, reformat the hard disk drive.
7172: HARD DISK READ ERROR	Read error when accessing disk file.	Retry and if still fails, reformat the hard disk drive.
7173: HARD DISK WRITE ERROR	Error in writing to disk file.	Retry and if still fails, reformat the hard disk drive.
7177: HARD DISK UNAVAILABLE	Hard disk is not available.	Install hard disk drive circuit board.
8140: GENERAL DISK BUFFER ERROR	Out of RAM.	Press the System State, Default Program key and retry.
FILE NOT FOUND	Disk file not found.	None.
FLOPPY DISK HAS NO ROOM FOR FILE	Floppy diskette is full.	Delete files or install new diskette.
FLOPPY DISK NOT READY	Floppy disk is not ready (or not installed.).	Install diskette in floppy drive.
FLOPPY DISK WRITE PROTECTED	Write protect tab in place on floppy diskette.	Remove write-protect tab.
HARD DISK HAS NO ROOM FOR FILE, DELETE EXISTING FILES(S) TO CREATE SPACE	Hard disk is full.	Delete files.

Chapter 6
Data Displays

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Chapter 6
Data Displays

6-1 INTRODUCTION

This chapter provides discussion and examples of the various types of data displays.

6-2 DISPLAY MODES AND TYPES

The 37XXXD displays measurement data using a “Channel Concept.” This means that each channel can display both a different S-Parameter and a different graph type. As you select each channel, the graph type, scaling, reference delay, S-Parameter, etc., associated with that channel appears on the screen. You can display the same S-Parameter on two or more channels.

Several graph-types are possible: polar, rectilinear, or Smith chart. The rectilinear graph-type may be magnitude, phase, magnitude and phase, SWR, group delay, real, imaginary, and real and imaginary. The Smith chart graph-type is specifically designed to plot complex impedances.

Single Channel Display: Ch 1, 2, 3, 4

You select this display type (Figures 6-1 and 6-2) by choosing “Single Display” on Menu CM (Appendix A). Possible graph types are Smith, polar, rectilinear, or dual (split) rectilinear (magnitude and phase).

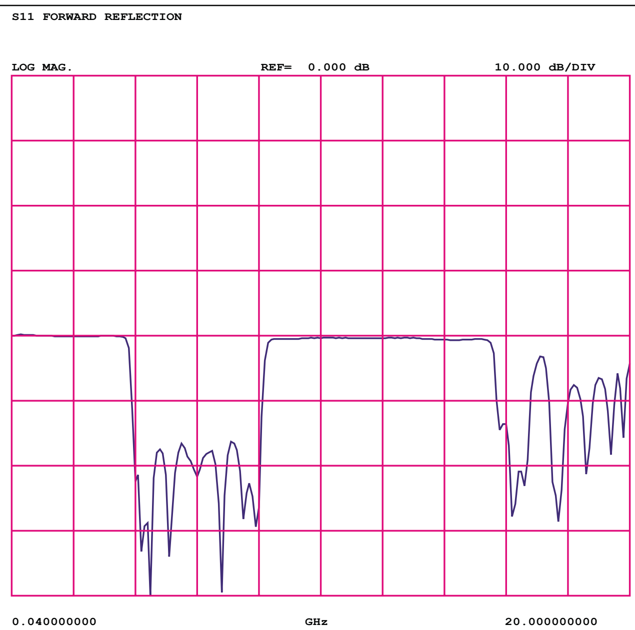


Figure 6-1. *Single Channel Display, Log Magnitude*

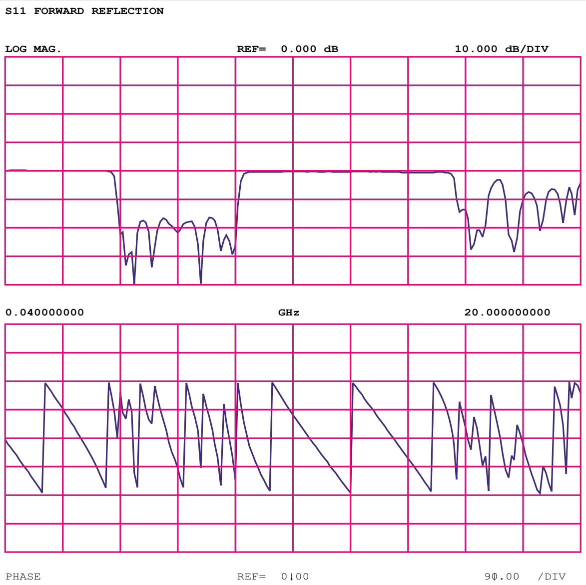


Figure 6-2. *Single Channel Display, Magnitude and Phase*

Dual Channel Display: Ch 1 and 3 or Ch 2 and 4

If you have chosen a dual display of magnitude and phase, the affected area of the LCD screen is subdivided into two smaller portions (Figure 6-3). You select this display type by choosing "Dual Display" in Menu CM (Appendix A).

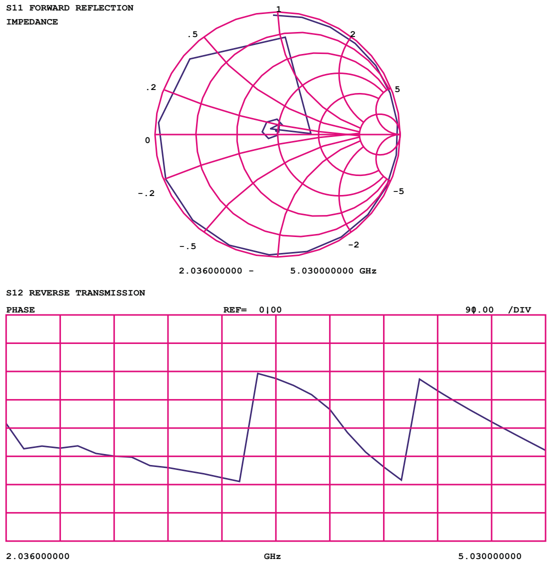


Figure 6-3. *Dual Channel Display*

Four Channel Display: Ch 1, 2, 3, 4

From four-to-eight graph types are displayed. In each quadrant, the graph type can be any of the possible choices listed in the GT menu (Appendix A). If you have chosen to display magnitude and phase on a channel, the quadrant displaying that channel is further subdivided as described above. You select this display type by choosing “All Four Channels” in Menu CM. An example of a four-channel display appears in Figure 6-4, below.

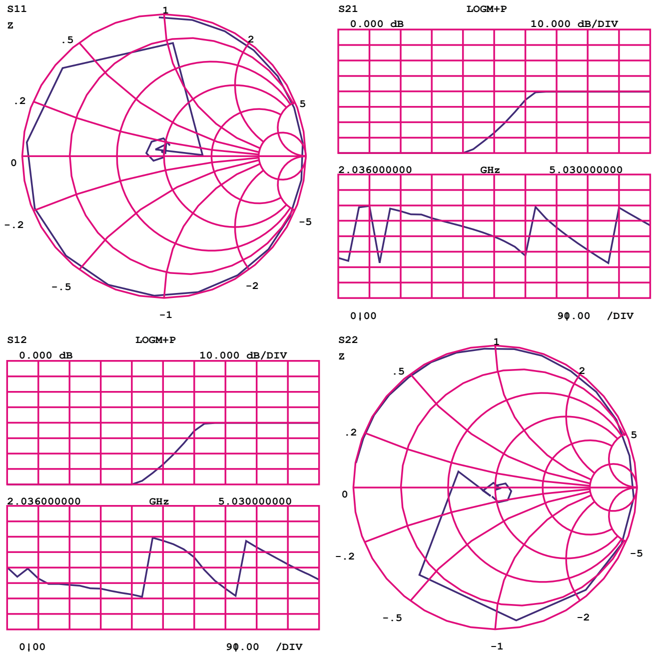


Figure 6-4. *Four-Channel Display*

Dual Trace Overlay

For rectilinear graph types, two traces can be displayed, one overlaid (superimposed) on the other (Figure 6-5). By menu selection, the two traces can be Channel 1 overlaid on Channel 3 or Channel 2 overlaid on Channel 4. Each trace is in a different color. Channels 1 and 2 are displayed in red, while Channels 3 and 4 are displayed in yellow.

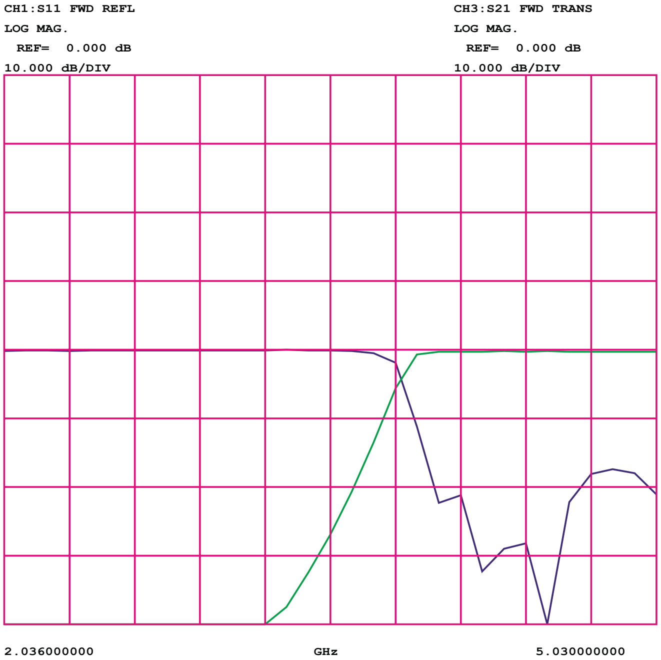


Figure 6-5. *Dual Trace Overlay*

Graph Data Types

The data types (real, imaginary, magnitude, phase) used in the displayed graph-types reflect the possible ways in which S-Parameter data can be represented in polar, Smith, or rectilinear graphs. For example: Complex data—that is, data in which both phase and magnitude are graphed—may be represented and displayed in any of the ways described below:

- Complex Impedance—displayed on a Smith chart graph
- Real and imaginary—displayed on a real and imaginary graph
- Phase and magnitude components—displayed on a rectilinear (Cartesian) or polar graph
- Group delay plot—group-delay measurement units are time, those of the associated aperture are frequency and SWR

The quantity group delay is displayed using a modified rectilinear-magnitude format. In this format the vertical scale is in linear units of time (ps-ns-μs). With one exception, the reference value and reference line functions operate the same as they do with a normal magnitude display. The exception is that they appear in units of time instead of magnitude.

Examples of graph-data types are shown in Figure 6-6 through 6-11, on the following pages.

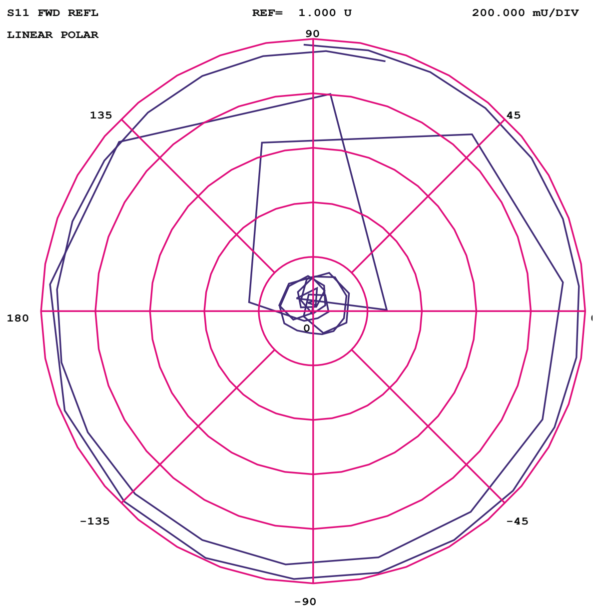


Figure 6-6. *Linear Polar Graticule*

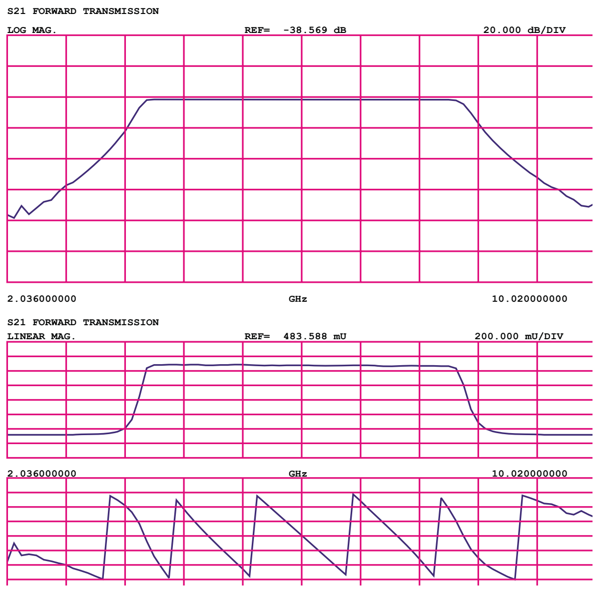


Figure 6-7. *Dual Channel Rectilinear Graticule*

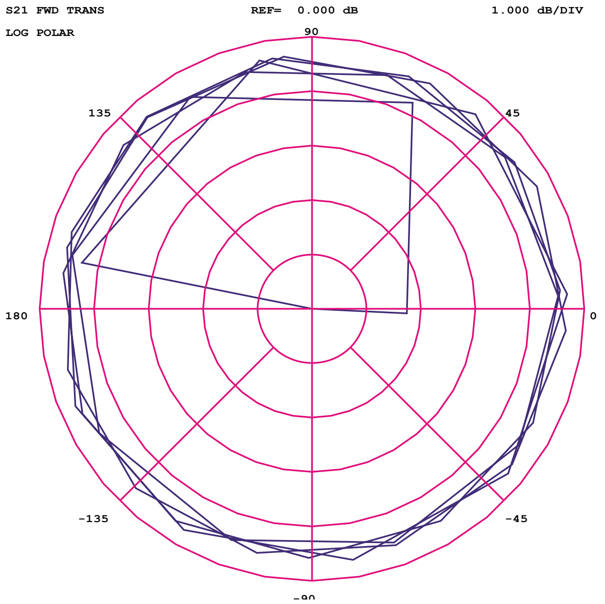


Figure 6-8. *Log Polar Graticule*

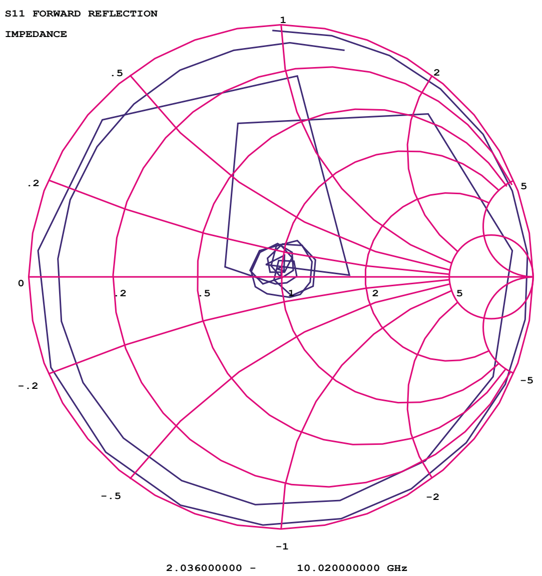


Figure 6-9. *Normal Smith Chart*

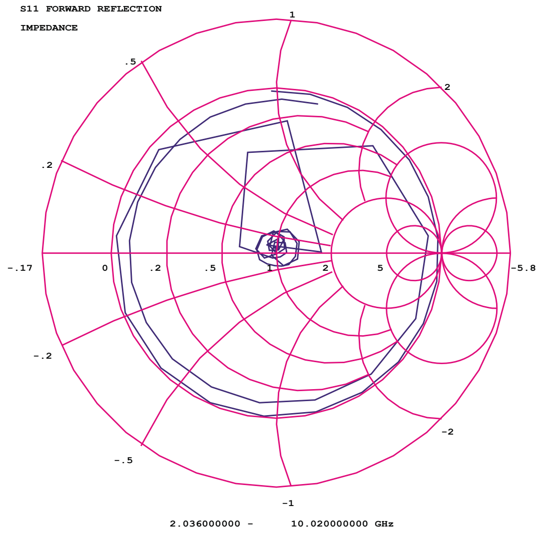


Figure 6-10. *3 dB Compressed Smith Chart*

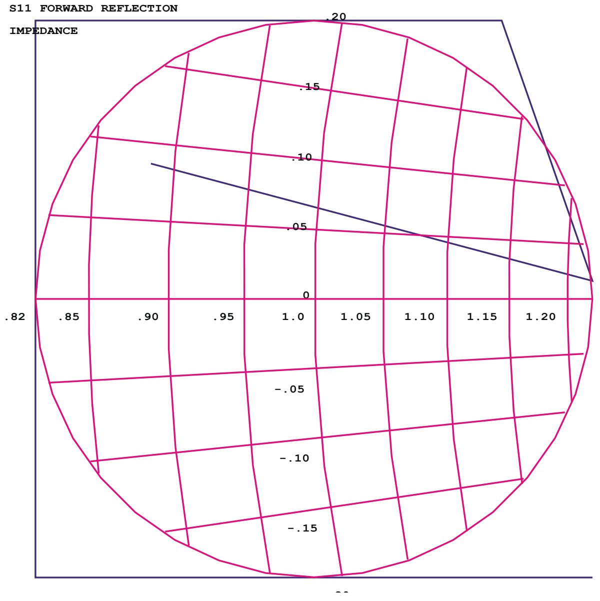


Figure 6-11. *20 dB Compressed Smith Chart*

6-3 FREQUENCY MARKERS

The example below shows how the 37XXXD annotates markers for the different graph-types. Each marker is identified with its own number. When a marker reaches the top of its graticule, it will flip over and its number will appear below the symbol. When markers approach the same frequency, they will overlap. Their number will appear as close to the marker as possible without overlapping.

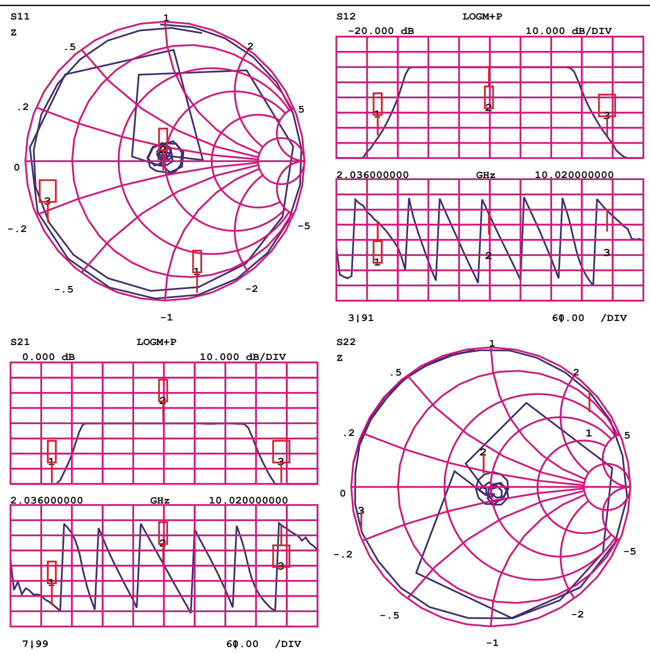


Figure 6-12. Marker Annotation

Marker Designation

Depending on menu selection, you may designate a marker as the "active" or the "delta reference" marker. If you choose a marker to be active—indicated by its number being enclosed in a square box—you may change its frequency or time (distance) (or point number in CW Draw) with the Data Entry keypad or knob. If you have chosen it to be the delta-reference marker, a delta symbol (Δ) appears one character space above the marker number (or one character space below a "flipped" marker). If the marker is both active and the delta reference marker, the number and the delta symbol appear above (below) the marker. The delta symbol appears above (below) the number.

6-4 LIMITS

Limit lines function as settable maximum and minimum indicators for the value of displayed data. These lines are settable in the basic units of the measurement on a channel-by-channel basis. If the display is rescaled, the limit line(s) will move automatically and thereby maintain their correct value(s).

Each channel has two limit lines (four for dual displays), each of which may take on any value. Limit lines are either horizontal lines in rectilinear displays or concentric circles around the origin in Smith and polar displays.

Each channel can produce segmented limits. They allow different upper and lower limit values to be set at up to ten segments across the measurement range.

6-5 STATUS DISPLAY

In addition to the graticules, data, markers, and marker annotation, the 37XXXD displays certain instrument status information in the data display area. This information is described below.

Reference Position Marker

The Reference Position Marker indicates the location of the reference value. It is displayed at the left edge of each rectilinear graph-type. It consists of a green triangular symbol similar to the cursor displayed in the menu area. You can center this symbol on one of the vertical graticule divisions and move it up or down using the “Reference Position” option. When you do this, the data trace moves accordingly. If you also select the reference value option, the marker will remain stationary and the trace will move with the maximum allowable resolution. When changing from a full-screen display to half- or quarter-screen display, the marker will stay as close to the same position as possible.

Scale Resolution

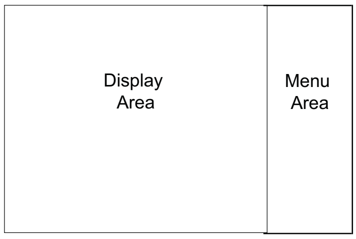
Each measurement display is annotated with the scale resolution. For log-magnitude displays resolution ranges from 0.001 to 50 dB per division. Linear displays of magnitude range from 0.001 to 50 units per division. Cartesian phase displays can range from 0.01 to 90 degrees per division. The polar display is 45 degrees per display graticule.

Frequency Range

Each measurement display is annotated with the frequency range of the measurement.

Analog Instrument Status

The 37XXXD displays analog-instrument-status messages (in red when appropriate) in the upper right corner of the data-display area (left). They appear at the same vertical position as line 2 of the menu area. If more than one message appears, they stack up below that line.



Display screen showing the data

Measurement Status

The 37XXXD displays measurement-status messages (in red when appropriate) in the upper-right corner of the graticule (channel) to which they apply.

Sweep Indicator Marker

A blue sweep-indicator marker appears at the bottom of each displayed graph-type. It indicates the progress of the current sweep. When measuring quiet data—that is, data having few or no perturbations—this indicator assures that the instrument is indeed sweeping. Its position is proportional to the number of data points measured in the current sweep. If the sweep should stop for any reason, the position of the indicator will stop changing until the sweep resumes.

6-6 DATA DISPLAY CONTROL

The following figure shows the algorithm that the 37XXXD uses to display the active channel.

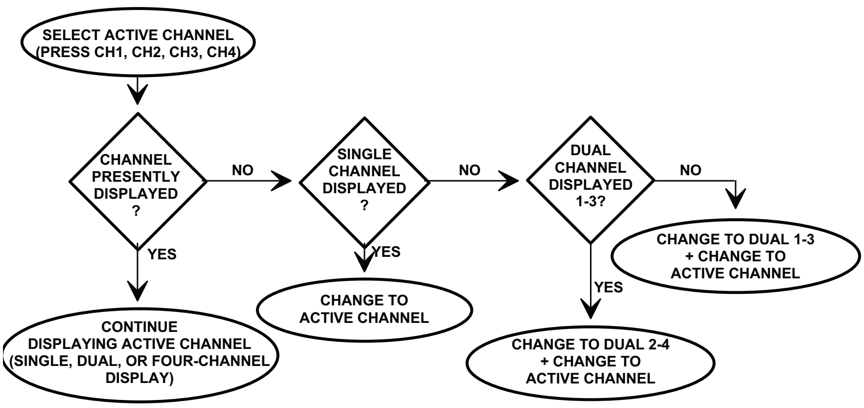


Figure 6-13. *Active Channel Algorithm*

S-parameter Selection

If you select a new S-parameter using Menu SP (Appendix A), it appears on the then-active channel in the same graph-type in which it was last displayed. The following table shows the displayable S-parameters based on the correction type you have in place. If you attempt to display other S-parameters, an error message appears. In cases when there is no last-displayed S-parameter stored, the display will default as shown. If an S-parameter is selected for which there was no last-displayed graph-type, the display defaults to S_{21}, S_{12} Log Magnitude and Phase and S_{11}, S_{22} Smith.

Data Display Update

When you change a control panel parameter that affects the appearance of the display, the entire display changes immediately to reflect that change. For example, if you press Autoscale, the entire display rescales immediately. You do not have to wait for the next sweep to see the results of the change. The following parameters are supported for this feature: Reference Delay, Offset, Scaling, Auto Scale, Auto Reference Delay, Trace Math, IF BW, and Smoothing. In the case of Averaging, the sweep restarts.

Correction Type	Displayable S-parameters	Default Display Position			
		CH1	CH2	CH3	CH4
None	All	S_{11}	S_{12}	S_{21}	S_{22}
Frequency Response					
Reverse Transmission	S_{12}		S_{12}		
Forward Transmission	S_{21}			S_{21}	
Both	S_{12}, S_{21}		S_{12}	S_{21}	
Port 1 Reflection Only	S_{11}	S_{11}			
Port 2Reflection Only	S_{22}				S_{22}
Reflection Only, Both	S_{11}, S_{22}	S_{11}			S_{22}
Forward 1-Path 2-Port	S_{11}, S_{21}	S_{11}		S_{21}	
Reverse 1-Path 2-Port	S_{12}, S_{22}		S_{12}		S_{22}
12-Term	All	S_{11}	S_{12}	S_{21}	S_{22}

If the knob is used to vary any of the above parameters, the change occurs as the measurement progresses–that is, the continuing trace will reflect the new setting(s).

When you change a marker frequency or time (distance), the readout parameters will change. This change reflects the changes in measurement data at the marker's new frequency, using data stored from the previous sweep.

Display of Markers

Once you have selected a marker to display, it will appear on the screen. It does not matter what resolution you have selected. When you set a marker to another calibrated frequency and then lower the resolution, that frequency and the marker will continue to display. It will display even if its frequency is not consistent with the data points in the lower-resolution sweep.

6-7 HARD COPY AND DISK OUTPUT

In addition to the LCD screen, the Model 37XXXD is capable of outputting measured data as a:

- Tabular Printout
- Screen-Image Printout
- Pen Plot
- Disk Image of the Tabular Data Values

The selection and initiation of this output is controlled by the Hard Copy keys.

Tabular Printout

An example of a tabular format is shown in Figure 6-14 (page 6-16). The tabular formats are used as follows:

- *Tabular Printout Format:* Used when printing three or four channels.
- *Alternate Data Format:* Used when printing one or two channels.

In tabular printouts, the 37XXXD shifts the data columns to the left when an S-Parameter is omitted. Leading zeroes are always suppressed. The heading (Model, Device ID, Date, Operator, Page) appears on each page.

Screen-Image Printout

In a Screen-Image Printout, the exact data displayed on the screen is dumped to the printer. The dump is in the graphics mode, on a pixel-by-pixel basis.

Plotter Output

The protocol used to control plotters is “HP-GL (Hewlett-Packard Graphics Language). HP-GL contains a comprehensive set of vector graphics type commands. These commands are explained in the Interfacing and Programming Manual for any current model Hewlett-Packard plotter, such as the 7470A.

When the plotter is selected as the output device, it is capable of drawing the graph shown on the screen or of drawing only the data trace(s). Multiple traces may be drawn on a single sheet of paper (in different colors, if needed).

Disk Output

The 37XXXD can write-to or read-from the disk all measured data. This data is stored as an ASCII file in the exact same format as that shown for the tabular printout in Figure 6-14 (page 6-16). If read back from the disk, the data is output to the printer. There, it prints as tabular data.

37247A

MODEL: DATE:
DEVICE ID: OPERATOR:

SWEEP DATA

START:	0.040000000 GHz	GATE START:	-
STOP:	20.000000000 GHz	GATE STOP:	-
STEP:	0.099800000 GHz	GATE:	-
		WINDOW:	-

------------CH1------------

PARAMETER:	-S11-
NORMALIZATION:	OFF
REFERENCE PLANE:	0.0000 mm
SMOOTHING:	0.0 PERCENT
DELAY APERTURE:	-

MARKERS:

MKR #	FREQ GHz	MAGNITUDE dB

FREQUENCY POINTS:

PNT #	FREQ GHz	MAGNITUDE dB
1	0.040000000	-54.881
2	0.139800000	-60.875
3	0.239600000	-59.163
4	0.339400000	-55.751
5	0.439200000	-53.856
6	0.539000000	-53.139
7	0.638800000	-51.019
8	0.738600000	-49.457
9	0.838400000	-48.807
10	0.938200000	-48.195
[illegible]	[illegible]	-40.402
192	19.101800000	-41.057

Figure 6-14. *Example of a Tabular Printout*

Chapter 7 Measurement Calibration

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Chapter 7
Measurement Calibration

7-1 INTRODUCTION

This section provides discussion and examples for performing a measurement calibration. It also provides a detailed procedure for calibrating with a sliding termination.

7-2 DISCUSSION

Measurements always include a degree of uncertainty due to imperfections in the measurement system. The measured value is always a combination of the actual value plus the systematic measurement errors. Calibration, as it applies to network analysis, characterizes the systematic measurement errors and subtracts them from the measured value to obtain the actual value.

The calibration process requires that you establish the test ports, perform the calibration, and confirm its quality. Let us examine each of these steps.

Establishing the Test Ports

Figures 7-1 and 7-2 are two of the most common approaches used to make measurements on two-port devices. In many cases, you may need adapters to change between connector types (N, SMA, GPC-7, etc.) or between genders (male [M] or female [F]).

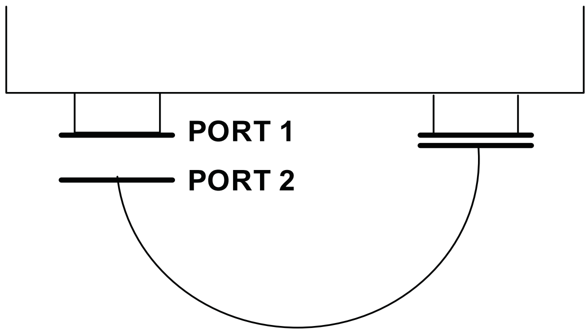


Figure 7-1. *Establishing the Test Port*

The use of cables and/or adapters does not effect the final measurement result, if they were in place for the calibration process. The vector error corrections established during the calibration process eliminates cable and/or adapter effects as long as the ports used are stable and exhibit good repeatability. Figure 7-2 shows such a configuration.

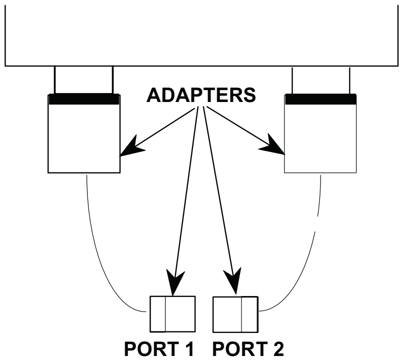


Figure 7-2. *Using Adapters on the Test Port*

Many calibration kits include adapters that are designed to have equal phase length. These parts are called phase equal adapters (PEA). Anritsu designs in-series adapters (e.g., K Connector M-M, M-F, F-F) to be phase insertable when technically possible. When available, it is good practice to use PEAs to establish test ports (Figure 7-3).

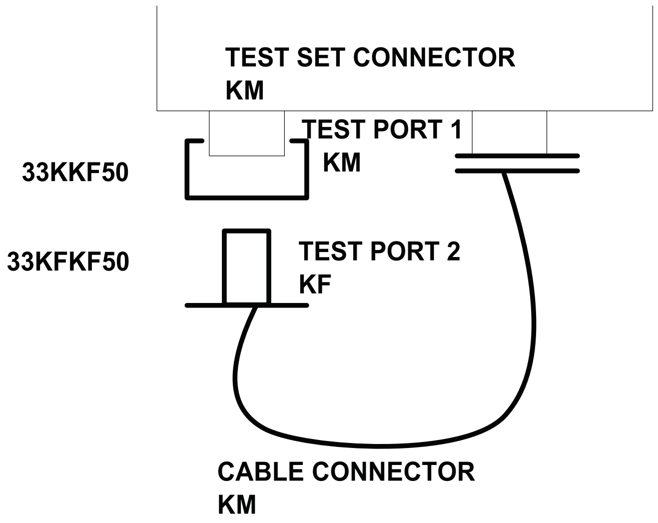


Figure 7-3. *Use of PEAs to Establish Test Ports*

This approach offers two advantages:

- It minimizes wear on the more expensive test set and cable connectors
- It provides a simple solution to measuring non-insertable devices (e.g., a filter with K female input and output connectors) by merely swapping PEAs after calibration. See Figure 7-4

NOTE

In this and other discussions, we will talk about "insertable" and "non-insertable" devices. Insertable devices have an insertable connector pair (i.e., male input and female output connectors) and can be measured after a through calibration. A non-insertable device has a non-insertable pair of connectors. This would be the case if it included female connectors on both ports or different connector types on each port. Therefore, "non-insertables" cannot be connected directly into the measurement path without an adapter.

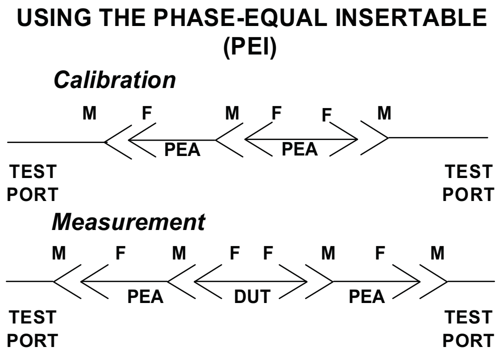


Figure 7-4. *Using Phase-Equal Insertables*

Understanding the Calibration System

Measurement errors must be reduced by a process that uses calibration standards. The standards most commonly used are Opens, Shorts, and Z_0 (Characteristic Impedance) Loads. In conjunction with a through connection, these standards can correct for the major errors in a microwave test system. These errors are Directivity, Source Match, Load Match, Isolation, and Frequency Tracking (reflection and transmission).

Calibration also corrects for many internal system errors, such as RF leakage, IF leakage, and system component interaction.

Random errors such as noise, temperature, connector repeatability, DUT sensitive leakages, frequency repeatability, and calibration variables are not completely correctable. However, some of them can be minimized by careful control. For instance: temperature effects can be reduced by room temperature control, calibration variables can be reduced through improved technique and training, and frequency errors can be virtually eliminated by the fully synthesized internal source.

ERRORS REDUCED BY CALIBRATION

- Directivity
- Source Match
- Load Match
- Frequency Sensitivity (Tracking)
- Isolation

We know that adapters and cables degrade the basic directivity of the system, but these errors are compensated by vector error correction.

In general, transmission measurement errors are source match, load match, and tracking; while reflection measurement errors are source match, directivity, and tracking.

Error modeling and flow graphs are techniques used to analyze the errors in a system. Error models describe the errors, while flow graphs show how these errors influence the system. Error models (Figure 7-5) can become quite complex.

INTERNAL SYSTEM ERRORS

- RF Leakage
- IF Leakage
- System Interaction

RANDOM ERRORS

- Frequency
- Repeatability
- Noise
- Connector Repeatability
- Temperature/Environmental Changes
- Calibration Variables

TRANSMISSION MEASUREMENT ERRORS

- Source Match
- Load Match
- Tracking

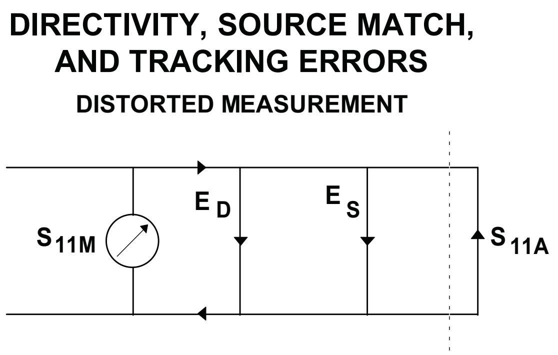


Figure 7-5. *Example of Error Modeling*

The 37XXXD offers a selection of calibration possibilities depending on the user's needs. These possibilities are as follows:

- ❑ Frequency Response
- ❑ Reflection Only—1 Port
- ❑ 1 Path, 2 Port
- ❑ 12-Term—2 Port, Both Directions

These calibration types are described below.

Frequency Response: Corrects for one or both of the transmission error terms associated with measurements of S21, S12, or both.

Reflection Only: Corrects for the three error terms associated with an S11 measurement (EDF, ESF, and ERF), an S22 measurement (EDR, ESR, and ERR), or both.

REFLECTION MEASUREMENT ERRORS

- Source Match
- Directivity
- Tracking

1 Path, 2 Port: Corrects for the four forward-direction error terms (EDF, ESF, ERF, and ETF), or the four reverse-direction error terms (EDR, ESR, ERR, and ETR).

Full 12-Term: Corrects for all twelve error terms associated with a two-port measurement. A 12-Term error model is shown in Figure 7-6.

Measurement calibration using the 37XXXD is straightforward and menu directed. A short time spent in preparation and preplanning will make the process simple and routine. (Example: Adjusting the coaxial cables used in the measurement setup such that insertion of the DUT causes minimal flexing of these cables).

CALIBRATION TYPES

- Frequency Response
- Reflection Only—1 Port
- 1 Path, 2 Port
- 12 Term—2 Port, Both Directions

The screen prompts on the 37XXXD guide you through the calibration process—a process that consists of connecting and disconnecting connectors and moving the slide on a sliding load (if one is used).

The most critical part of the calibration process is properly seating and torquing the connectors. Also, you will notice that the calibration takes longer when the ports are terminated with a load. This is intentional. It allows for more averaging during the isolation measurement.

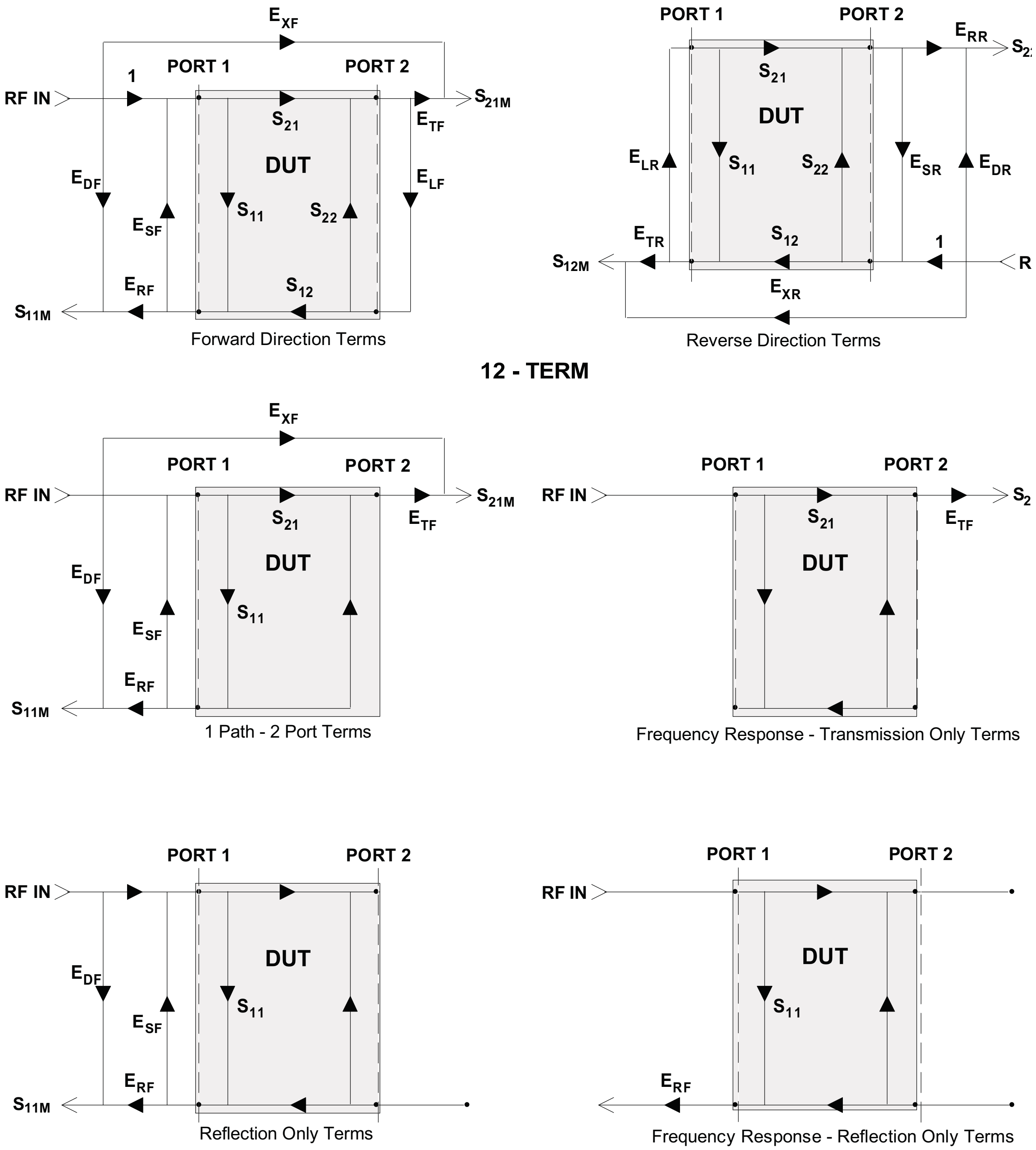


Figure 7-6. *Error Models*

Calibrating for a Measurement

CALIBRATING FOR A REFLECTION MEASUREMENT USES THREE STANDARDS:

- Short
- Open
- Termination

IDEAL TERMINATIONS

- Reflectionless
- Perfect Connector
- Infinite-Length, Dimensionally Exact, Reflectionless Transmission Line

PRACTICAL Zo TERMINATIONS

- Broadband Load
- Sliding Termination

Let us assume that we want to correct for three errors in the reflection measurement: source match, directivity, and tracking. We accomplish this using three standards.

Shorts are the easiest to visualize. They totally reflect all of the incident RF energy output at a precise phase. The terms zero-ohms impedance, voltage null, and 180° phase all define an RF Short.

Opens are similar to Shorts, but their response is more complex. The terms voltage maximum, infinite impedance, and 0° phase all define a perfect Open. A perfect Open, however, is only a concept. In reality Opens always have a small fringing capacitance.

To account for the fact that the Open will not predictably reflect impedance at an exact 0° phase reference, we alter its response using coefficients that accurately characterize the fringing capacitance. The coefficients are different for each coaxial line size, since each size has a different fringing capacitance. To maximize accuracy, ensure that these coefficients are installed prior to the calibration (Menu U3).

As Opens and Shorts provide two references for a full reflection, Z_0 terminations provide a zero-reflection reference.

Ideal Z_0 terminations must consist of two parts, a perfect connector and an infinite-length perfect transmission line that absorbs all of the RF energy that enters it (no reflections).

Infinite length transmission lines are unwieldy at best, so you must use less-than-ideal terminations. For calibration purposes there are two common types: broadband loads and sliding terminations.

BROADBAND LOAD

- Easy to Use
- Inexpensive
- Adequate for Most Applications

SLIDING LOAD

- Connector
- Long Transmission Line
- Movable Microwave Load

Broadband loads are widely used. An example is the Anritsu 28 Series Termination. These terminations are easy to use as calibration tools, and they are adequate for most applications.

Sliding Loads are the traditional vector network analyzer Z_0 calibration reference. They provide the best performance when the application requires high-precision return loss measurements. Sliding loads consist of a connector, a long section of precision transmission line, and a microwave load that is movable within the transmission line. One thing to remember with sliding loads is that they have a low-frequency limit and must be used with a fixed load below this cutoff frequency for full frequency coverage. Anritsu sliding loads cut off at 2 GHz. (V-connector sliding loads cut off at 4 GHz).

Pin depth—the relationship between the interface positions of the outer and center conductors—is the most critical parameter under your control in a sliding load. An example of its criticality is that an incorrect pin depth of 0.001 inch can cause a reflection return loss of 44 dB. And, since we are trying to calibrate to accurately measure a 40 dB return loss, correct pin depth makes a big difference!

Cables in the measurement system are another cause for concern. The main criteria for a cable are stability and repeatability. Anritsu offers two types of cables that meet these criteria: semi-rigid and flexible. Our semi-rigid cables provide maximum stability with limited flexibility of movement. Our flexible cables allow more freedom of movement and provide good phase stability.

Evaluating the Calibration

The 37XXXD provides an accurate representation of complex data. However, it can only provide accuracy to the extent of the supplied calibration data. For this reason, it is necessary to periodically verify the calibration data and the 37XXXD system performance.

Calibration verification reveals problems such as a poor contact with one of the calibration components, improper torquing, or a test port out of specification. Problems like these can easily occur during a calibration procedure. Anyone who has experienced one of these problems and stored bad data—after having performed a complete calibration procedure—knows the frustration it can cause. Additionally, it can be very costly to use incorrectly taken measurement data for design or quality assurance purposes.

The best way to confirm a calibration is to measure a precision, known-good device and confirm its specifications.

Verification Kits

Anritsu has developed several precision-component kits: for 3.5 mm connectors, for GPC-7 connectors, K Connectors® and V Connectors®. These are, respectively, the Models 3666, 3667, and 3668 and 3669 Verification Kits.

Each of the kits contain 20 dB and 50 dB attenuators, an airline, and a Beatty Standard. A Beatty Standard is a two-port mismatch similar to a beadless airline. It consists of a center conductor with a discontinuity in the middle providing the mismatch (Figure 7-7).

Typically, these verification kits will be used by calibration or metrology labs. Each of the kits contain several precision components, all of which have been characterized at specified frequencies. The data on these components is stored on a disk provided with the verification kit.

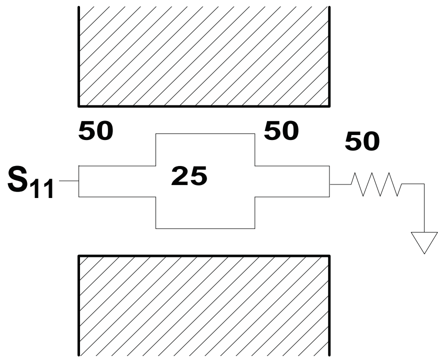


Figure 7-7. *The Beatty Standard*

The verification of the kit components is straight forward. The components are first measured with the 37XXXD, then they are compared with the data recorded on the disk. If the measured data compares favorably with the recorded data (taking tolerances into consideration), then the system is known to be operating properly and providing accurate data.

There is one caution that you need to observe when using Verification Kits. Because the verification components have been characterized, you must handle them carefully so that you do not change their known characteristics. Consequently, you should not have them available for daily use. Rather, you should only use them for the accuracy verification checks taken every 6-to-12 months (or at any other time the system's integrity is in doubt).

This completes the discussion on calibration. Refer to paragraph 7-3 for a procedure showing how to calibrate the sliding load.

7-3 SLIDING TERMINATION

Sliding terminations (loads) are the traditional Z_0 calibration-reference devices for vector network analyzer calibration. When correctly used and perfectly aligned, they can be more accurate than precision fixed loads. However, sliding terminations have a 2 GHz (4 GHz for V-Connector sliding loads) low-frequency limit and must be used with a fixed load for full frequency-range coverage.

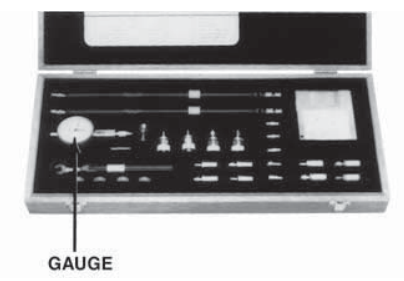
Sliding terminations consist of a connector, a long section of precision transmission line, and a microwave load that is movable within the transmission line. Pin depth—the relationship between the interface positions of the outer and center conductors—is the most critical parameter that you can control in a sliding termination. An example of its criticality is that an incorrect pin depth of 0.001 inch can cause a reflection return loss of 44 dB. Since you are usually calibrating to accurately measure a greater than 40 dB return loss, correct pin depth is essential.

Since setting an accurate pin depth is so important, this discussion centers on describing how to set the pin depth for male and female sliding terminations. Calibration with the sliding termination is essentially the same as described below for the broadband load.

The procedure below uses the Model 3652 Calibration Kit and its 17KF50 and 17K50 Sliding Terminations. Calibration is similar for the Model 3650 SMA/3.5mm, Model 3651 GPC-7 and Model 3654 V connector kits. For the 3651, the procedure is simpler because the GPC-7 connector is genderless, there are no male and female versions.

Procedure

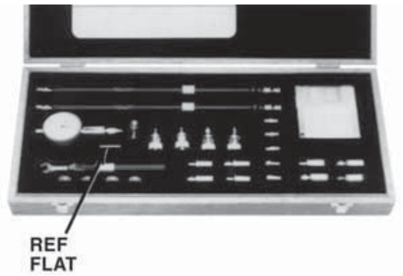
Step 1. Remove the Pin Depth Gauge from the kit, place it on the bench top.



NOTE

The gauge is convertible between male and female. The following procedure describes the zeroing process for the female fitting. The procedure for the male fitting begins with Step 16.

Step 2. Push the outer locking ring towards the gauge to expose the center pin.



Step 3. Take the 01-210 Ref Flat from the kit.

Step 4. While holding the gauge as shown, press the Ref Flat firmly against the end of the exposed center pin.

Step 5. While pressing the Ref Flat against the center pin, check that the pointer aligns with the “0” mark. If it does not, loosen the bezel lockscrew and rotate the bezel to align the pointer with the “0” mark. Tighten the bezel lock screw.

NOTE

Gently rock the Ref Flat against the center pin to ensure that it is fully depressed and you have accurately set the gauge for zero.

Step 6. Remove the sliding termination with the female-connector (17KF50, for this example) from the kit, and slide the load all the way toward the end closest to the connector.

Step 7. With either hand, pick up the sliding termination near its connector end.

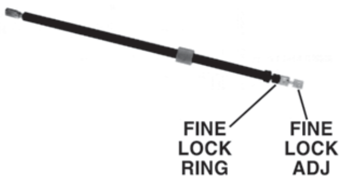
Step 8. Cup the sliding termination in your palm, and support the barrel between your body and crooked elbow.

Step 9. Remove the flush short by holding its body and unscrewing its connector.

Step 10. Install the gauge onto the end of the sliding termination.

Step 11. If the COARSE SET adjustment—which has been set at the factory—has not moved, the inner dial on the gauge will read "0." If it doesn't, perform the Coarse Set Adjustment in Step 15.

Step 12. Place the sliding termination, with the gauge attached, on the bench top.

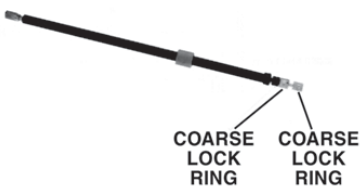


Step 13. Loosen the FINE LOCK ring and turn the FINE ADJ ring to position the gauge pointer 2-3 small divisions on the “–” side of zero.

Step 14. Turn the FINE LOCK ring clockwise to both tighten the adjustment and place the pointer exactly to “0.” The Sliding Termination is now ready to use.

NOTES

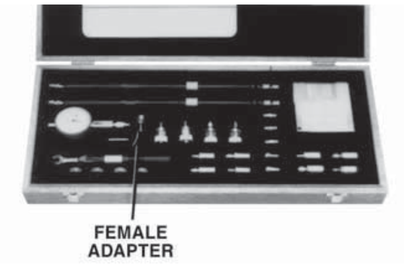
Ensure that the inner dial reads “0.”
The following step is not normally necessary. It needs to be done only if the adjustment has changed since it was set at the factory.



Step 15. With the 01-211 Flush Short installed, loosen the COARSE LOCK and gently push the COARSE SET adjustment rod in as far as it will go. This coarsely sets the center conductor to be flush against the attached short. Return to Step 2.

Step 16. The procedure for adjusting the male-connector sliding termination is essentially the same as that described above. The only difference is that you must install the female adapter on the end of the gauge shaft, over the center conductor. To install this adapter, proceed as follows:

- Zero-set the gauge as described in Steps 2 through 5.
- Push the outer locking ring back toward the gauge and turn it clockwise onto the exposed threads.
- Loosen the lock ring one turn in a counterclockwise direction.



Step 17. Remove the 01-223 Female Adapter ("F ADAPTER FOR PIN GAUGE") from the kit.

Step 18. Install the female adapter over the center pin and screw it into the locking ring, and tighten the outer ring until it is snug against the housing.

Step 19. Inspect the end of the adapter, you should see no more than two exposed threads. If so, repeat Steps 7 through 10.

Step 20. Connect the gauge to the sliding termination and zero set the center pin using the FINE ADJ as previously described in Steps 2 through 5.

7-4 SOLT CALIBRATION

The SOLT calibration for the 37XXXD Vector Network Analyzer system uses a Short, Open, Load, and a Thru line connection to categorize the inherent errors in the measurement system. These errors include those caused by connectors as well as internal system errors such as RF leakage, IF leakage, and component interaction. For maximum accuracy, install the capacitive coefficients (for the open device) using Menu U3.

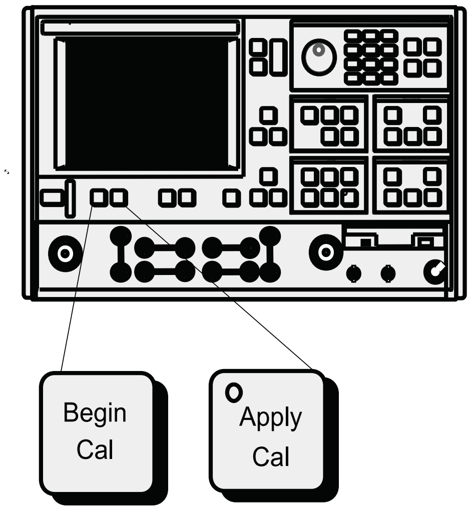
NOTE

The SOLT calibration, in conjuction with the SSST calibration, are merged to create a continuous, single sweep broadband calibration on the ME7808A system. Refer to Chapter 15 for details about the broadband mode of operation.

Calibration Procedure

A detailed, step-by-step procedure for performing a Short-Open-Load-Throughline calibration is given below.

Step 1. Press the Begin Cal key.



MENU C11

BEGIN CALIBRATION

KEEP EXISTING CAL DATA

REPEAT PREVIOUS CAL

AUTOCAL

CAL METHOD STANDARD

TRANSMISSION LINE TYPE: XXXXXXXX

CHANGE CAL METHOD AND LINE TYPE

NEXT CAL STEP

PRESS <ENTER> TO SELECT

Step 2. Select **CHANGE CAL METHOD AND LINE TYPE**, in menu C11 (left). (This assumes SOLT and COAXIAL are not presently shown in blue as being selected.)

MENU C11A

- CHANGE CAL METHOD AND LINE TYPE
- NEXT CAL STEP
- CAL METHOD
- SOLT (STANDARD)
- SSLT (DOUBLE OFFSET SHORT WITH LOAD)
- SSST (TRIPLE OFFSET SHORT)
- LRL/LRM
- TRM
- TRANSMISSION LINE TYPE
- COAXIAL
- WAVE GUIDE
- MICROSTRIP
- PRESS <ENTER> TO SELECT

Step 3. When menu C11A (left) appears, move the cursor to the following:

a. **SOLT (STANDARD)**, then press the Enter key. This selects Standard (SOLT) as the calibration method.

b. **COAXIAL**, then press the Enter key. This selects coaxial transmission line media.

c. **NEXT CAL STEP**, then press the Enter key. This causes menu C11 to return to the screen.

Step 4. When menu C11 reappears, confirm that the **SOLT** calibration method and **COAXIAL** line type have been selected. Select **NEXT CAL STEP** and press the Enter key to proceed. This brings up menu C5.

MENU C5

- CALIBRATION TYPE
- FULL 12-TERM
- 1 PATH 2 PORT
- TRANSMISSION FREQUENCY RESPONSE
- REFLECTION ONLY
- PRESS <ENTER> TO SELECT

Step 5. Menu C5 (left) lets you select the type of calibration. For this example, move the cursor to **FULL 12-TERM** and press the Enter key. This selection calibrates for all twelve error terms.

Step 6. The next menu, C5D, lets you choose whether to include or exclude the error terms associated with leakage between measurement channels. For a normal calibration, you would choose to include these error terms. Therefore, move the cursor to **INCLUDE ISOLATION (STANDARD)** and press the Enter key.

MENU C5D

- SELECT USE OF ISOLATION IN CALIBRATION
- INCLUDE ISOLATION (STANDARD)
- EXCLUDE ISOLATION
- PRESS <ENTER> TO SELECT

MENU C1

SELECT
CALIBRATION
DATA POINTS

NORMAL
(1601 POINTS
MAXIMUM)

C.W.
(1 POINT)

N-DISCRETE
FREQUENCIES
(2 TO 1601
POINTS)

TIME DOMAIN
(HARMONIC)

PRESS <ENTER>
TO SELECT

Step 7. Next, menu C1 appears. It lets you select the number of frequency points at which calibration data is to be taken. The choices are:

a. **NORMAL:** Data is taken at up to 1601 equally spaced frequencies across the calibration frequency range. *Use this selection for this example.*

b. **C.W.:** Data is taken at one point. This choice brings up menu C2B (below) that lets you select the single CW frequency point.

MENU C2B

SINGLE POINT
CALIBRATION

C.W. FREQ
XX.XXXX GHz

FINISHED
ENTRY, NEXT
CAL STEP

INPUT FREQ AND
PRESS <ENTER>
TO SELECT

c. **N-DISCRETE FREQUENCIES:** This selection lets you specify a discrete number of frequency points, from 2 to 1601.

d. **TIME DOMAIN:** This selection is the calibration mode for low-pass time-domain processing. It lets you select frequencies at integer (harmonic) multiples of the start frequency.

MENU C2

FREQ RANGE OF
CALIBRATION

START
0.0400000000GHz

STOP
20.000000000 GHz

201 DATA PTS
0.099800000 GHz
STEP SIZE

MAXIMUM NUMBER
OF DATA POINTS
1601 MAX PTS
801 MAX PTS
401 MAX PTS
201 MAX PTS
101 MAX PTS
51 MAX PTS

NEXT CAL STEP

PRESS <ENTER>
TO SELECT

Step 8. The next menu, C2 (left), lets you set your start and stop frequencies. For this example, move the cursor to **START,** press 40 on the keypad, and hit the MHz terminator key. Perform like operations for the **STOP** choice, except make entry read 20 GHz. After setting the frequencies, select **NEXT CAL STEP** and press the Enter key.

MENU C3
CONFIRM CALIBRATION PARAMETERS
PORT 1 CONN K CONN (M)
PORT 2 CONN SMA (M)
REFLECTION PAIRING MIXED
LOAD TYPE SLIDING
THROUGHLINE PARAMETERS
REFERENCE IMPEDANCE
TEST SIGNALS
START CAL
PRESS <ENTER> TO SELECT OR CHANGE

Step 9. When menu C3 (left) appears, if you want to change any of the parameters shown in blue letters, place the cursor on that parameter and press the Enter key. For this example, we will change them all, starting with the top one. Move the cursor to **PORT 1 CONN** and press the Enter key.

Step 10. In menu C4 (below), which appears next, move the cursor to **K CONN (M)** and then press the Enter key. This choice presumes that you have a K-Female connector on the device-under-test (DUT). Remember, in this menu you choose the connector type on the test port, or the connector type that *mates* with the DUT connector. When menu C3 returns, observe that **K CONN (M)** is now shown in blue for the **PORT 1 CONN** choice.

MENU C4
SELECT PORT 1 CONNECTOR TYPE
K-CONN (M)
K-CONN (F)
V-CONN (M)
V-CONN (F)
W1-CONN (M)
W1-CONN (F)
SMA (M)
SMA (F)
GPC-3.5 (M)
GPC-3.5 (F)
GPC-7
USER DEFINED
MORE
PRESS <ENTER> TO SELECT

MENU C3
CONFIRM CALIBRATION PARAMETERS
PORT 1 CONN K CONN (M)
PORT 2 CONN K CONN (M)
REFLECTION PAIRING MIXED
LOAD TYPE SLIDING
THROUGH PARAMETERS
REFERENCE IMPEDANCE
TEST SIGNALS
START CAL
PRESS <ENTER> TO SELECT OR CHANGE

Step 11. With menu C3 (left) displayed, move the cursor to **PORT 2 CONN** and press the Enter key. Following the procedure in Step 10, select **K CONN (M)** for the Port 2 connector.

Step 12. When menu C3 returns:

a. Observe that **PORT 2 CONN** now reflects **K CONN (M)**.

b. Move the cursor to **REFLECTION PARING** and press the Enter key. This brings up menu C13 (below).

MENU C13
SELECT REFLECTION PAIRING
MIXED (OPEN–SHORT SHORT–OPEN)
MATCHED (OPEN–OPEN SHORT–SHORT)
PRESS <ENTER> TO SELECT

Reflection Pairing lets you mix or match the Open and Short reflection devices in the Calibration Sequence menus. The **MIXED** choice lets you calibrate using first an Open on one port and a Short on the other, then a Short on one port and an Open on the other. Conversely, **MATCHED** lets you calibrate first using an Open on both ports then using a Short on both ports. For this example, choose **MIXED** and press the Enter key.

MENU C3

CONFIRM
CALIBRATION
PARAMETERS

PORT 1 CONN
TYPE N (M)

PORT 2 CONN
TYPE N (F)

REFLECTION
PARING
MIXED

LOAD TYPE
BROADBAND

THROUGH
PARAMETERS

REFERENCE
IMPEDANCE

TEST SIGNALS

START CAL

PRESS <ENTER>
TO SELECT

Step 13. When menu C3 returns:

a. Observe that **REFLECTION PARING** now reflects **MIXED**.

b. Move cursor to **LOAD TYPE** and press the Enter key. This brings up menu C6 (below).

MENU C6

SELECT
TYPE OF LOAD

BROADBAND
FIXED LOAD

SLIDING LOAD
(MAY ALSO
REQUIRE
BROADBAND
FIXED LOAD)

PRESS <ENTER>
TO SELECT

This menu lets you select either of two load types, broadband or sliding. Broadband loads are adequate for all but the most demanding reflection measurements. They are easier to use and less expensive than sliding loads. If you choose a sliding load, refer to paragraph 7-3 for a procedure on setting pin depth.

For this example, select **BROADBAND LOAD** and press the Enter key.

MENU C6A

ENTER
BROADBAND LOAD
IMPEDANCE

BROADBAND
LOAD
IMPEDANCE
50.000 Ω

PRESS <ENTER>
TO SELECT

c. The next menu to appear, C6A (left), prompts you to enter an impedance value. For this example, use the rotary knob to change the displayed value to 50Ω. Alternatively, you can key in 50 ohms. That is, press 50 on the keypad and the X1 terminator key. If the value is 1 μΩ, key in .001 and press the 10^{-3} terminator key. Conversely, if the value is 1 MΩ, key in 1000 and press the 10^{3} terminator key.

MENU C20

ENTER
THROUGH LINE
PARAMETERS

OFFSET LENGTH
0.0000 mm

THROUGHLINE
IMPEDANCE
50.000 Ω

PRESS <ENTER>
WHEN COMPLETE

MENU C17

ENTER
REFERENCE
IMPEDANCE

REFERENCE
IMPEDANCE
50.000 Ω

PRESS <ENTER>
WHEN COMPLETE

Step 14. When menu C3 again returns:

a. Observe that **LOAD TYPE** now shows **BROADBAND**.

b. Move cursor to **THROUGH PARAMETERS** and press the Enter key.

Step 15. Menu C20 (left) appears next. It lets you define the length of the offset and the impedance of the throughline. For this example, enter 0 mm for length and 50 ohms for impedance.

Step 16. When menu C3 reappears, move the cursor to **REFERENCE IMPEDANCE** and press the Enter key. This brings up menu C17 (left).

Step 17. Move cursor to **REFERENCE IMPEDANCE** and use the rotary knob to change the displayed value to 50Ω.

Press the Enter key when you have completed your value entry.

MENU SU2

TEST SIGNALS

POWER CONTROL
0.0 dB
(0 TO -20)

PORT 1 ATTN
20 dB (0 - 70)

PORT 1 POWER
XX.XX dBm

PORT 2 ATTN
X0 dB (0-40)

CALIBRATE
FOR FLATNESS
(CAL EXISTS)

FLATNESS
CORRECTION
AT XX.X dBm

SOURCE 2 PWR
XX.X dBm

PREVIOUS MENU

PRESS <ENTER>
TO SELECT

Step 18. When menu C3 returns, select **TEST SIGNALS** to bring up menu SU2 (left).

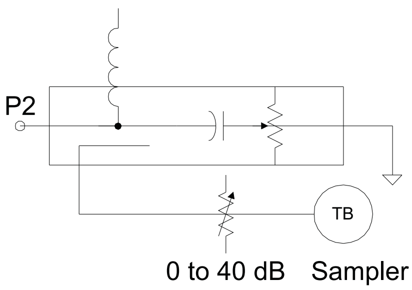
Step 19. Menu SU2 lets you define the power level of the signals at the two test ports. Power delivered to the DUT by the test set must be such that the measured signals are well above the noise floor but below the 0.1 dB compression level of the Test Set samplers. (Noise floor and maximum signal into Port 2 levels are specified in Appendix C.)

For measuring high power signals, a Port 2 attenuator in the forward transmission path allows up to 1 Watt of power (30 dBm) before 0.1 dB compression occurs.

Determine the required input power level and the expected output RF power level from the DUT. Ideally, the Port 2 step attenuator should be set so that the input to the test sampler (left) is less than –10 dBm. For example, if the input to the DUT is set for –20 dBm and the device gain is 40 dB, set the **PORT 2 ATTN** menu option for 20 dB.

(If you needed to calibrate the test port for power flatness, you would move the cursor to **FLATNESS CORRECTION** and press the Enter key.)

Finally, move the cursor to **PREVIOUS MENU** and press the Enter key. This returns you to menu SU1. When you get there, press the Enter key to return to menu C3.



MENU C3

CONFIRM
CALIBRATION
PARAMETERS

PORT 1 CONN
TYPE N (M)

PORT 2 CONN
SMA (M)

REFLECTION
PAIRING
MIXED

LOAD TYPE
SLIDING

THROUGH
PARAMETERS

REFERENCE
IMPEDANCE

TEST SIGNALS

START CAL

PRESS <ENTER>
TO SELECT
OR CHANGE

Step 20. When menu C3 reappears, select **START CAL** and press the Enter key to begin the calibration procedure.

Continue the calibration sequence by following the prompts as they appear. Connect the appropriate Isolation Devices, Broadband Loads, Opens, Shorts, and Throughlines, when requested in the calibration sequence.

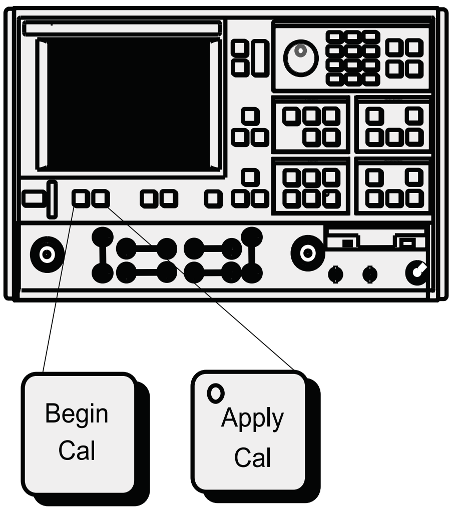
7-5 OFFSET-SHORT CALIBRATION (SSLT)

The Offset-Short calibration, now also referred to as the Double Offset-Short Calibration, is the standard technique for waveguide; however, this method can be used for the coaxial and microstrip line types as well. It uses two shorts, two loads, and a thru line to categorize the inherent errors in the waveguide measurement system. These errors include those caused by connectors as well as internal system errors such as RF leakage, IF leakage, and component interaction.

Calibration Procedure

A detailed, step-by-step procedure for performing an Offset-Short calibration for waveguide is given below.

Step 1. Press the Begin Cal key.



MENU C11

BEGIN CALIBRATION

KEEP EXISTING CAL DATA

REPEAT PREVIOUS CAL

AUTOCAL

CAL METHOD XXXXXXX

TRANSMISSION LINE TYPE: XXXXXXXX

CHANGE CAL METHOD AND LINE TYPE

NEXT CAL STEP

PRESS <ENTER> TO SELECT

Step 2. Select **CHANGE CAL METHOD AND LINE TYPE**, in menu C11 (left). (This assumes OFFSET SHORT and WAVEGUIDE are not presently shown in blue as being selected.)

MENU C11A

CHANGE CAL METHOD AND LINE TYPE

NEXT CAL STEP

CAL METHOD

SOLT (STANDARD)

SSLT (DOUBLE OFF-SET SHORT WITH LOAD)

SSST (TRIPLE OFFSET SHORT)

LRL/LRM

TRM

TRANSMISSION LINE TYPE

COAXIAL

WAVEGUIDE

MICROSTRIP

PRESS <ENTER> TO SELECT

Step 3. When menu C11A (left) appears, move cursor to the following:

a. **SSLT (DOUBLE OFFSET SHORT)**, then press the Enter key. This selects Offset Short as the calibration method.

b. **WAVEGUIDE**, then press the Enter key. This brings menu C5 (bottom left) to the screen.

c. **NEXT CAL STEP**, then press the Enter key. This causes menu C11 to return to the screen.

Step 4. When menu C11 reappears, confirm that the **OFFSET SHORT** calibration method and **WAVEGUIDE** line-type have been selected. Select **NEXT CAL STEP** and press the Enter key to proceed.

Step 5. Menu C5 appears next. This menu (bottom left) lets you select the type of calibration. For this example, move the cursor to **FULL 12-TERM** and press the Enter key.

Step 6. The next menu, C5D (below), lets you choose whether to include or exclude the error terms associated with leakage between measurement channels. For a normal calibration, you would choose to include these error terms. Therefore, move the cursor to **INCLUDE ISOLATION (STANDARD)** and press the Enter key.

MENU C5

SELECT CALIBRATION TYPE

FULL 12-TERM

1 PATH 2 PORT

TRANSMISSION FREQUENCY RESPONSE

REFLECTION ONLY

PRESS <ENTER> TO SELECT

MENU C5D

SELECT USE OF ISOLATION IN CALIBRATION

INCLUDE ISOLATION (STANDARD)

EXCLUDE ISOLATION

PRESS <ENTER> TO SELECT

MENU C1

SELECT
CALIBRATION
DATA POINTS

NORMAL
(1601 POINTS
MAXIMUM)

C.W.
(1 POINT)

N-DISCRETE
FREQUENCIES
(2 TO 1601
POINTS)

TIME DOMAIN
(HARMONIC)

PRESS <ENTER>
TO SELECT

Step 7. Menu C1 (left), which appears next, lets you select the number of frequency points at which calibration data is to be taken. Of these choices, which were described in paragraph 7-4, choose **NORMAL (1601 POINTS MAXIMUM)** for this example.

Step 8. The next menu, C2 (below), lets you set your start and stop frequencies. For this example, move cursor to **START**, press 40 on keypad, and press the MHz terminator key. Perform like operations for the **STOP** choice, except make entry read 20 GHz. After setting the frequencies, select **NEXT CAL STEP** and press the Enter key.

MENU C2

FREQ RANGE OF
CALIBRATION

START
0.0400000000GHz

STOP
20.000000000 GHz

201 DATA PTS
0.099800000 GHz
STEP SIZE

MAXIMUM NUMBER
OF DATA POINTS
1601 MAX PTS
801 MAX PTS
401 MAX PTS
201 MAX PTS
101 MAX PTS
51 MAX PTS

NEXT CAL STEP

PRESS <ENTER>
TO SELECT

MENU C3B

CONFIRM
CALIBRATION
PARAMETERS

WAVEGUIDE
PARAMETERS
INSTALLED

REFLECTION
PAIRING
XXXXXXXX

LOAD TYPE
BROADBAND

THROUGH LINE
PARAMETERS

TEST SIGNALS

START CAL

PRESS <ENTER>
TO SELECT
OR CHANGE

Step 9. When menu C3B (bottom left) appears, if you want to change any of the parameters shown in blue letters, place the cursor on that parameter and press the Enter key. (These choices operate the same as was described for menu C3 in section 7-4.) For this example, we change the waveguide parameters. Move the cursor to **WAVEGUIDE PARAMETERS** and press the Enter key.

MENU C15

SELECT
WAVEGUIDE
KIT TO USE

–INSTALLED KIT—

IDENTIFIER
XXXX

CUTOFF FREQ:
XXX.XXXXXXXXX GHz

SHORT 1
XX.XXXX mm

SHORT 2
XX.XXXX mm

USE INSTALLED
WAVEGUIDE KIT

USER DEFINED

PRESS <ENTER>
TO SELECT

Step 10. When menu C15 (left) appears, move cursor to one of the two available choices and press the Enter key. These choices are described below.

a. **USE INSTALLED WAVEGUIDE KIT:** Selecting this choice uses the values shown in blue for IDENTIFIER, CUTOFF FREQ, SHORT 1, and SHORT 2. Select this choice, for this example.

b. **USER DEFINED:** Selecting this choice brings up menu C15A (below), which lets you specify waveguide parameters. After defining your waveguide parameters, you are returned to menu C3B.

MENU C15A

ENTER
WAVEGUIDE
PARAMETERS

WAVEGUIDE
CUTOFF FREQ:
XXX.XXXXXXXXX GHz

OFFSET LENGTH
OF SHORT 1
XX.XXXX mm

OFFSET LENGTH
OF SHORT 2
XX.XXXX mm

PRESS <ENTER>
WHEN COMPLETE

Step 11. Continue the calibration sequence by following the prompts as they appear. Connect the appropriate Isolation Devices, Broadband Loads, Shorts, and Throughlines, when requested in the calibration sequence.

7-6 TRIPLE OFFSET-SHORT CALIBRATION (SSST)

The Triple Offset-Short calibration method can be used in coax, waveguide, and microstrip line types, and is most accurate when used over narrower frequency ranges. As the name implies, this method uses three offset-shorts to categorize the inherent errors in the measurement system. These errors include those caused by connectors as well as internal system errors such as RF leakage, IF leakage, and component interaction.

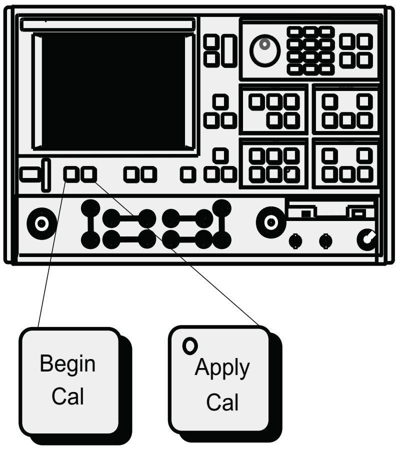
NOTE

A continuous single sweep bradband calibration from 40 MHz to 110 GHz can be created by merging a 40 MHz to 65 GHz SOLT calibration with a 65 GHz to 110 GHz SSST calibration. For more information, refer to section 7-9, Merge Cal Files, and to Chapter 15 for details about the broadband mode of operation.

Calibration Procedure

A detailed, step-by-step procedure for performing a Triple Offset-Short calibration is given below:

Step 1. Press the Begin Cal key.



Step 2. Select **CHANGE CAL METHOD AND LINE TYPE**, in menu C11 (left). (This assumes that OFFSET SHORT and WAVEGUIDE are not presently shown in blue as being selected.)

MENU C11
BEGIN CALIBRATION
KEEP EXISTING CAL DATA
REPEAT PREVIOUS CAL
AUTOCAL
CAL METHOD STANDARD
TRANSMISSION LINE TYPE: XXXXXXXX
CHANGE CAL METHOD AND LINE TYPE
NEXT CAL STEP
PRESS <ENTER> TO SELECT

Step 3. When menu C11A (left) appears, move cursor to the following:

a. **SSST (TRIPLE OFFSET SHORT)**, then press the Enter key. This selects Triple Offset-Short as the calibration method.

b. **COAXIAL**, then press the Enter key. This brings menu C5 (left) to the screen.

c. **NEXT CAL STEP**, then press the Enter key. This causes menu C11 to return to the screen.

MENU C11A
CHANGE CAL METHOD AND LINE TYPE
NEXT CAL STEP
CAL METHOD
SOLT (STANDARD)
SSLT (DOUBLE OFF-SET SHORT WITH LOAD)
SSST (TRIPLE OFFSET SHORT)
LRL/LRM
TRM
TRANSMISSION LINE TYPE
COAXIAL
WAVEGUIDE
MICROSTRIP
PRESS <ENTER> TO SELECT

Step 4. When menu C11 reappears, confirm that the SSST calibration method and COAXIAL line-type have been selected. Select **NEXT CAL STEP** and press the Enter key to proceed.

Step 5. Menu C5 appears next (lower left). This menu lets you select the type of calibration. For this example, move the cursor to **FULL 12-TERM** and press the Enter key.

Menu C5
CALIBRATION TYPE
FULL 12-TERM
1 PATH 2 PORT
TRANSMISSION FREQUENCY RESPONSE
REFLECTION ONLY
PRESS <ENTER> TO SELECT

Step 6. The next menu, C5D (below), lets you choose whether to include or exclude the error terms associated with leakage between measurement channels. For a normal calibration, you would choose to include these error terms. Therefore, move the cursor to **INCLUDE ISOLATION (STANDARD)** and press the Enter key.

Menu C5D
SELECT USE OF ISLOATION IN CALIBRATION
INCLUDE ISOLATION (STANDARD)
EXCLUDE ISOLATION
PRESS <ENTER> TO SELECT

Step 7. Menu C1 appears next (left) and lets you select the number of frequency points for which calibration data is to be taken. Select **NORMAL (1601 POINTS MAXIMUM)** (refer to section 7-4 for a description).

MENU C1
SELECT CALIBRATION DATA POINTS
NORMAL (1601 POINTS MAXIMUM)
C.W. (1 POINT)
N-DISCRETE FREQUENCIES (2 TO 1601 POINTS)
TIME DOMAIN (HARMONIC)
PRESS <ENTER> TO SELECT

Step 8. The next menu, C2 (below), lets you set your start and stop frequencies. For this example, move the cursor to **START**, press 65 on the keypad, then press the GHz terminator key. Perform like operations for the **STOP** choice, except make the entry read 110 GHz. After setting the frequencies, select **NEXT CAL STEP** and press the Enter key.

MENU C2
FREQ RANGE OF CALIBRATION
START 0.0400000000GHz
STOP 20.000000000 GHz
201 DATA PTS 0.099800000 GHz STEP SIZE
MAXIMUM NUMBER OF DATA POINTS 1601 MAX PTS 801 MAX PTS 401 MAX PTS **201 MAX PTS** 101 MAX PTS 51 MAX PTS
NEXT CAL STEP
PRESS <ENTER> TO SELECT

Step 9. This brings up the Menu C14 (lower left) for selecting the connector types on ports 1 and 2. Select the **W1-CONN** connectors with the appropriate sex for a W1 (1mm) calibration.

Menu C14
SELECT PORT n OFFSET SHORT CONNECTOR TYPE
W1-CONN (M) W1-CONN (F)
SPECIAL A (M) SPECIAL A (F)
SPECIAL B (M) SPECIAL B (F)
SPECIAL C (M) SPECIAL C (F)
USER DEFINED
PRESS <ENTER> TO SELECT

MENU C3B

CONFIRM CALIBRATION PARAMETERS

WAVEGUIDE PARAMETERS INSTALLED

REFLECTION PAIRING MIXED

LOAD TYPE BROADBAND

THROUGH LINE PARAMETERS

TEST SIGNALS

START CAL

PRESS <ENTER> TO SELECT OR CHANGE

MENU C3

CONFIRM CALIBRATION PARAMETERS

PORT 1 CONN W1-CONN (M)

PORT 2 CONN W1-CONN (M)

REFLECTION PAIRING XXXXXXXX

LOAD TYPE BROADBAND

THROUGH LINE PARAMETERS

REFERENCE IMPEDANCE

TEST SIGNALS

START CAL

PRESS <ENTER> TO SELECT OR CHANGE

Step 10. When menu C3B (left) appears, if you want to change any of the parameters shown in blue letters, place the cursor on that parameter and press the Enter key.

Step 11. When menu C3 (lower left) returns:

a. Observe that PORT 1 CONN and PORT 2 CONN now reflects W1 CONN (M).

b. Move the cursor to **REFLECTION PARING** and press the Enter key. This brings up menu C13 (below).

MENU C13

SELECT REFLECTION PAIRING

MIXED (SHORT1-SHORT2, SHORT2-SHORT3, SHORT3-SHORT1)

MATCHED (SHORT1-SHORT1, SHORT2-SHORT2, SHORT3-SHORT3)

PRESS <ENTER> TO SELECT OR CHANGE

Step 12. Reflection Pairing lets you mix or match Offset Short devices in the Calibration Sequence menus, as per the kit available. Generally, on-wafer calibration substrates have matched components; however, it is more convenient, on a coaxial calibration, to use MIXED pairing in the case of the same connector types on both ports. The MIXED choice lets you calibrate using different offset shorts on the two ports. Conversely, MATCHED pairing lets you calibrate in sequence using one offset short type in each step. For this example, choose **MIXED** and press the Enter key.

Step 13. When menu C3 reappears, confirm the calibration parameters selected for the calibration, then select **START CAL** and continue the calibration sequence by following the prompts as they appear.

Step 14. Connect the appropriate Isolation Devices, the three Offset Shorts, and the Throughlines when requested in the calibration sequence.

7-7 LRL/LRM CALIBRATION

The LRL/LRM (line-reflect-line/line-reflect-match) calibration* feature provides an enhanced capability for error compensation when making measurements in coaxial, microstrip and waveguide transmission media. Instead of using the standard Open, Short, and Load, the LRL/LRM calibration method uses two lines and a reflection or match. The difference in length between line 1 and line 2 creates the measurements necessary for the error solutions.

The LRL/LRM calibration technique uses the characteristic impedance of a length of transmission line or a precision match as the calibration standard. A full LRL/LRM calibration consists of two transmission line measurements, a high reflection measurement, and an isolation measurement. Using this technique full 12-term error correction can be performed with the 37XXXD.

Three-line LRL/LRM calibration can also be selected. In a two-line LRL measurement, the difference in length between line one and line two is necessary for calibration but limits the frequency range to a 9:1 span. The use of three lines in the calibration extends the frequency range to an 81:1 span. A combination of LRL and LRM can accomodate any broadband measurement.

1. Through the use of LRL/LRM calibration and an external computer, in conjunction with ANACAT software, multiple-level de-embedding is possible. This calibration allows you to make semi-conductor chip measurements up to 40 GHz with a single test fixture.

2. In addition, any non-coaxial transmission media, including mixed media interconnects, can be accommodated. For example, a test device with a waveguide input and a coplanar microstrip output can be measured. Software automatically compensates for the microstrip dispersion.

A detailed procedure for calibrating for a measurement using the LRL/LRM method is provided in the following pages.

*LRM Calibration Method of Rhode & Scharwz, Germany

LRL/LRM Calibration (Microstrip)

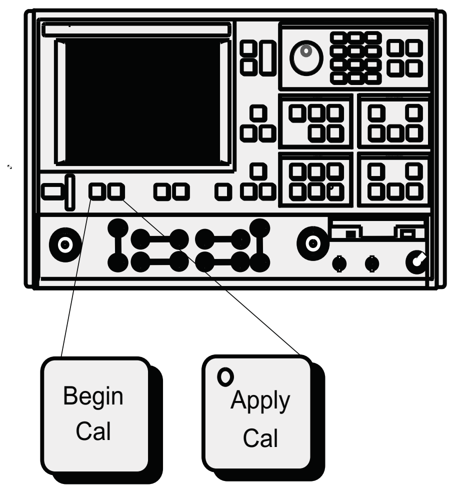
Microstrip is a dispersive media. The 37XXXD applies dispersion compensation during calibration for microstrip measurements. Because the 37XXXD must know the specific microstrip parameters, during the calibration procedure menus are available for entering the:

- width of the strip
- thickness of the substrate
- substrate dielectric constant
- effective dielectric constant Zc
- characteristic impedance (reference)

When testing microstrip devices it is necessary to launch from coax to microstrip. In production testing this launching must be temporary, so that the device can easily be installed in and be removed from the fixture. The requirement for launching to 65 GHz is met by the Anritsu Universal Test Fixture (UTF). The UTF provides accurate, repeatable launch to substrates from 5 to 70 mils thick, and from 0.15 to 2 inches long. Offset connections and right angles can be configured. DC bias probes can be mounted to the UTF to inject bias onto the substrate. UTF calibration/verification kits are available for alumina in 10 mil, 15 mil, and 25 mil microstrip, and for 25 mil coplanar waveguide. Although a UTF is not essential, the following calibration procedures presume its use.

Step 1. Select the desired LRL line substrates from the appropriate microstrip calibration kit. When called for in the calibration sequence, mount the LRL line substrates on the UTF following the procedure given in the 3680 OMM.

Step 2. Press the Begin Cal key.



MENU C11

BEGIN CALIBRATION
KEEP EXISTING CAL DATA
REPEAT PREVIOUS CAL
AUTOCAL
CAL METHOD XXXXXXXX
TRANSMISSION LINE TYPE: XXXXXXXX
CHANGE CAL METHOD AND LINE TYPE
NEXT CAL STEP
PRESS <ENTER> TO SELECT

Step 3. Select **CHANGE CAL METHOD AND LINE TYPE**, in menu C11 (left). (This assumes LRL and MICROSTRIP are not presently shown in blue as being selected.)

Step 4. When menu C11A (bottom left) appears, highlight the following selections.

a. **LRL/LRM** and press the Enter key.

b. **MICROSTRIP** and press the Enter key.

c. **NEXT CAL STEP** and press the Enter key.

Step 5. When menu C11 reappears, confirm that the **LRL/LRM** calibration method and **MICROSTRIP** line-type have been selected. Select **NEXT CAL STEP** and press the Enter key to proceed.

Step 6. Continue through the calibration sequence, and make the following selections from the menus that appear:

INCLUDE ISOLATION (STANDARD) (Menu C5D)
NORMAL (1601 POINTS MAXIMUM) (Menu C1)
START (Your start frequency) (Menu C2)
STOP (Your stop frequency) (Menu C2)

MENU C11A

CHANGE CAL METHOD AND LINE TYPE
NEXT CAL STEP
CAL METHOD
SOLT (STANDARD)
SSLT (DOUBLE OFF-SET SHORT WITH LOAD)
SSST (TRIPLE OFF-SET SHORT)
LRL/LRM
TRM
TRANSMISSION LINE TYPE
COAXIAL
WAVEGUIDE
MICROSTRIP
PRESS <ENTER> TO SELECT

MENU C5D

SELECT USE OF ISOLATION IN CALIBRATION
INCLUDE ISOLATION (STANDARD)
EXCLUDE ISOLATION
PRESS <ENTER> TO SELECT

MENU C1

SELECT CALIBRATION DATA POINTS
NORMAL (1601 POINTS MAXIMUM)
C.W. (1 POINT)
N-DISCRETE FREQUENCIES (2 TO 1601 POINTS)
TIME DOMAIN (HARMONIC)
PRESS <ENTER> TO SELECT

MENU C2

FREQ RANGE OF CALIBRATION
START 0.0400000000GHz
STOP 20.000000000 GHz
201 DATA PTS 0.099800000 GHz STEP SIZE
MAXIMUM NUMBER OF DATA POINTS
1601 MAX PTS
801 MAX PTS
401 MAX PTS
201 MAX PTS
101 MAX PTS
51 MAX PTS
NEXT CAL STEP
PRESS <ENTER> TO SELECT

MENU C3G

CONFIRM
CALIBRATION
PARAMETERS

LRL/LRM
PARAMETERS

MICROSTRIP
PARAMETERS
USER DEFINED

TEST SIGNALS

START CAL

PRESS <ENTER>
TO SELECT
OR CHANGE

Step 7. When menu C3G appears, if you want to change microstrip parameters to be different from those shown in blue, place the cursor on **MICROSTRIP PARAMETERS** and press the Enter key.

Step 8. When menu C16 (left) appears, move the cursor to the Anritsu 3680 UTF calibration kit you wish to use or to **USER DEFINED**; then press the Enter key.

The calibration kit selections shown in menu C16 are for the following 3680 Connection Substrate Kits:
10 MIL KIT — 36804B-10M
15 MIL KIT — 36804B-15M
25 MIL KIT — 36804B-25M

If you choose **USER DEFINED**, the next menu that appears (C16A), lets you characterize your parameters. Move the cursor to each selection, key in a value, then press the Enter key to return to menu C16.

MENU C16

SELECT
MICROSTRIP
KIT TO USE

10 MIL KIT

15 MIL KIT

25 MIL KIT

USER DEFINED

PRESS <ENTER>
WHEN COMPLETE

MENU C16A

ENTER
MICROSTRIP
PARAMETERS

WIDTH OF
STRIP
XX.XXXX mm

THICKNESS OF
SUBSTRATE
XXXX.XXXX mm

Zc
XXX.XXX pΩ

SUBSTRATE
DIELECTRIC
XX.XX

EFFECTIVE
DIELECTRIC
XX.XX
(RECOMMENDED
0.00)

PRESS <ENTER>
WHEN COMPLETE

MENU C3G

CONFIRM CALIBRATION PARAMETERS

LRL/LRM PARAMETERS

CHANGE MICROSTRIP PARAMETERS XXXXXXXXX

START CAL

PRESS <ENTER> TO SELECT

Step 9. Select **LRL/LRM PARAMETERS**, when menu C3G returns.

Step 10. When menu C18 appears, you have two choices to make: whether your calibration is to be two-line or three-line, and where you want to have your reference plane.

a. *Select the reference plane*: Highlight **MIDDLE OF LINE 1 (REF)** or **ENDS OF LINE 1 (REF)** and press the Enter key.

b. *Select the type of LRL/LRM calibration*: Highlight **ONE BAND** for a two-line calibration or **TWO BANDS** for a three-line calibration.

As mentioned earlier in a two-line measurement, the difference in length between line 1 and line 2 is necessary for calibration, but limits the frequency range to a 9:1 span. By using three lines in the calibration, you extend the frequency range to an 81:1 span.

If you select **TWO BANDS**, skip to Step 12.

MENU C18

CHANGE LRL/LRM PARAMETERS

NEXT CAL STEP

NUMBER OF BANDS USED

ONE BAND

TWO BANDS

LOCATION OF REFERENCE PLANES

MIDDLE OF LINE 1 (REF)

ENDS OF LINE 1 (REF)

PRESS <ENTER> TO SELECT

MENU C18A
CHANGE LRL/LRM PARAMETERS
NEXT CAL STEP
CHARACTERIZE CAL DEVICES
DEVICE 1 LINE 1 (REF) X.XXXX mm
DEVICE 2 LINE /MATCH X.XXXX mm
PRESS <ENTER> TO SELECT OR SWITCH

Step 11. When menu C18A (left) appears, make the following selections (for 2-line):

a. Move the cursor to **DEVICE 1 LINE 1 (REF)** and key in the value.

b. Move the cursor to **DEVICE 2 LINE/MATCH**. Here you have another decision to make: whether your calibration is to be LRL or LRM. For this selection, the Enter key acts as a toggle.

c. If you toggle such that **LINE** turns red, then key in the value for line 2. This value depends on your frequency range.

d. If you toggle **MATCH** red, observe that **FULLBAND** appears. This indicates that your reflective device covers the full calibration range.

e. When you have made both selections, move the cursor to **NEXT CAL STEP** and press the Enter key to produce the next menu. Skip to Step 13.

MENU C18B
CHANGE LRL/LRM PARAMETERS
NEXT CAL STEP
CHARACTERIZE CAL DEVICES
DEVICE 1 LINE 1 (REF) XX.XXXX
DEVICE 2 LINE/MATCH XX.XXXX/LOWBAND
DEVICE 3 LINE/MATCH XX.XXXX/HIGHBAND
FREQ AFTER WHICH THE USE OF DEVICE 2 AND DEVICE 3 IS EXCHANGED
BREAKPOINT XXX.XXXXXXXXXGHZ
PRESS <ENTER> TO SELECT OR SWITCH

Step 12. When menu C18B (left) appears, make the following selections (for 3-line):

a. Move the cursor to **DEVICE 1 LINE 1 (REF)** and key in the value (typically 1.00 cm). Press the Enter key to select.

b. Move the cursor to **DEVICE 2 LINE/MATCH**. Both here, and for the next choice, you have another decision to make: whether your calibration is to be LRL or LRM. For this selection, the Enter key acts as a toggle.

c. If you toggle such that **LINE** turns red, then key in the value for line 2. This value depends on your frequency range.

d. If you toggle **MATCH** red, observe that **LOWBAND** appears. This indicates that your reflection device is a low-band load. This load must have a passband such that it passes all frequencies from the start to the breakpoint (see below).

e. Move the cursor to **DEVICE 3 LINE/MATCH**. If device 3 is a line, key in the value. If it is a match, the term **HIGHBAND** will appear. This indicates that your match is a high-band load. This load must have a passband such that it passes all frequencies from the breakpoint to the stop frequency.

f. Move the cursor to **BREAKPOINT** and enter your breakpoint frequency. For two-line LRL calibrations, select a breakpoint equal to the upper frequency of the low frequency LRL line. For a combined LRL and LRM calibration, select a breakpoint equal to the top frequency of the calibration divided by six; for instance, to cover the frequency range 0.04 to 60 GHz, select 10 GHz as the breakpoint.

g. When you have made all selections, move the cursor to **NEXT CAL STEP** and press Enter to produce the next menu.

MENU C19

CHANGE LRL/LRM PARAMETERS

NEXT CAL STEP

REFLECTION OFFSET LENGTH +XXX.XXXX mm

REFLECTION TYPE

GREATER THAN Zo

LESS THAN Zo

MATCH PARAMETERS

MATCH IMPEDANCE +XXX.XXX Ω

MATCH INDUCTANCE +XXXX.XXXX pH

PRESS <ENTER> TO SELECT

Step 13. The next menu, C19, gives you choices for your reflective device.

a. Move the cursor to **REFLECTION OFFSET LENGTH** and key in a value (typically 0.0000 mm).

b. Move the cursor to **GREATER THAN Z_0** or **LESS THAN Z_0**, depending on whether your reflective device is an Open or a Short. Press the Enter key to select.

NOTE

Choose **GREATER THAN Z_0** for an Open and **LESS THAN Z_0** for a Short.

c. When you complete your choices, move the cursor to **NEXT CAL STEP** and press the Enter key.

MENU C3G

CONFIRM CALIBRATION PARAMETERS

CHANGE LRL/LRM PARAMETERS

CHANGE MICROSTRIP PARAMETERS XXXXXXXXX

START CAL

PRESS <ENTER> TO SELECT

Step 14. When menu C3G reappears, move cursor to **START CAL** and press Enter.

Step 15. Continue the calibration sequence by following the prompts as they appear. Mount the appropriate LRL line substrates when requested in the calibration sequence.

For the **REFLECTIVE DEVICE** and **BROADBAND LOAD** prompts, remove all substrates from the UTF and allow the lower jaws to short the center conductor. Separate the connector blocks by at least an inch. (The BROADBAND LOAD prompt only appears if you selected to include isolation in menu C5B.)

Step 16. Store the calibration.

LRL/LRM Calibration (Coaxial)

An LRL cal kit is necessary to perform the coaxial calibration. Calibration kits for GPC-7 are available from Maury Microwave and Hewlett Packard.

Two line lengths are used as the impedance standard. The calibration frequency range is limited by the difference in the lengths of the two lines. Their length must be different by approximately 90 degrees at the mid-band frequency. A good calibration can be achieved over the range of 18 degrees to 162 degrees making it possible to calibrate LRL over a 9:1 frequency range.

LRL calibration is very sensitive to uncalibrated source match. If some padding is placed at the test ports, the directivity and source match will be improved. If the goal is high level measurements, then padding should be included. If low level measurements are being performed, then the padding must be left out.

MENU C3E

CONFIRM
CALIBRATION
PARAMETERS

LRL/LRM
PARAMETERS

REFERENCE
IMPEDANCE

TEST SIGNALS

START CAL

PRESS <ENTER>
TO SELECT
OR CHANGE

Step 1. Same as Steps 1 through 6 in the Microstrip procedure, except choose **COAXIAL** in menu C11A.

Step 2. When menu C3E (left) appears, if you want to change line impedance, place cursor on **REFERENCE IMPEDANCE** and press the Enter key.

Step 3. When menu C17 (left) appears, move cursor to **REFERENCE IMPEDANCE**, key in the value, then press the Enter key.

MENU C17

ENTER
REFERENCE
IMPEDANCE

REFERENCE
IMPEDANCE
50.000 Ω

PRESS <ENTER>
WHEN COMPLETE

Step 4. Same as Steps 9 through 16 in the microstrip procedure.

In the coaxial, three-line calibration there are factors you need to be aware of. Note that it is the line length *differences* that are important to the LRL calibration, namely (L2–L1) and (L3–L1) where L1 is the length of line 1, L2 is the length of line 2, and L3 is the length of line 3.

Longer length differences are used for longer wavelengths (lower frequencies). For frequencies up to and including the breakpoint frequency, the larger absolute value of the (L2–L1) and (L3–L1) differences is used. At frequencies above the breakpoint, the smaller absolute value of the (L2–L1) and (L3–L1) differences is used.

Consideration must also be given to selecting the breakpoint frequency. Divide the frequency range to satisfy the 9:1 rule for any given pair of lines. The range is thus divided by the frequency breakpoint into the intervals [f1, f2] and [f2, f3]. Based on these intervals, next determine the appropriate length differences; the longer difference is associated with the lower interval [f1, f2]. Note that if the differences are equal to each other, concurrent frequency ranges are implied and only two lines need be used.

Select a line 1 reference (L1) around which to place these two differences. Use any combination of positive or negative differences around line 1. The software selects which interval is associated with either of line 2 or line 3 by comparing the absolute values of the differences with line 1. Data from the two lines, which make up the larger absolute difference, are used for the interval [f1, f2]. Data from the two lines, which make up the smaller absolute difference, are used for the interval [f2, f3].

LRL/LRM Calibration (Waveguide)

The waveguide procedure is very similar to the coaxial and microstrip procedures already described.

MENU C3F
CONFIRM CALIBRATION PARAMETERS
LRL/LRM PARAMETERS
WAVEGUIDE CUTOFF FREQ
TEST SIGNALS
START CAL
PRESS <ENTER> TO SELECT OR CHANGE

Step 1. Follow Steps 1 through 6 in the Microstrip procedure, page 7-37, except choose **WAVEGUIDE** in menu C11A.

The only difference is with menu C3F (left). For a waveguide calibration, move the cursor to **WAVEGUIDE CUTOFF FREQ** and press Enter. This action calls menu C15B, which lets you enter the waveguide cutoff frequency. After doing so, you are returned to menu C3F.

MENU C15B
ENTER WAVEGUIDE CUTOFF FREQUENCY
WAVEGUIDE CUTOFF FREQ XX.XXXX GHz
PRESS <ENTER> WHEN COMPLETE

Step 2. When menu C3F reappears, place cursor on **CHANGE LRL/LRM PARAMETERS** and press the Enter key.

Step 3. Follow Steps 9 through 13, page 7-40, in the Microstrip procedure.

7-8 *TRM CALIBRATION*

The TRM Calibration procedure is the same as the LRL/LRM procedure, previous page, except that certain parameters have been set by default so that the calibration is simpler to perform (e.g., the L-parameter in the LRM calibration has been set to equal a length of 0 mm for a through, and the R-parameter is set for a short).

7-9 MERGE CAL FILES APPLICATION

The Merge Cal Files application allows the user to combine two or more calibrations that were performed on the VNA, but having differing frequency ranges. This is of particular importance when a wide band RF calibration cannot be performed because wide band calibration components, such as loads and shorts, are not available. Such a case exists when using Anritsu's 37X97D wideband VNAs. Here, the preferred calibration method would be to perform a standard method (SOLT) coaxial calibration in the 0.04 to 65 GHz bands, a triple offset-short (SSST) coaxial calibration in the 65 to 110 GHz band, then combine the calibrations to yield a wideband 0.04 to 110 GHz calibration that can be saved and recalled.

The resultant calibration file setup will be the first calibration file setup except that the frequency points and RF correction values of the second calibration file will be intermingled with the frequency points and RF correction values of the first.The start and stop frequencies will be adjusted to reflect the lowest and highest frequencies in the intermingling. If there are frequency points in common, then the correction values of the first file will be used and that frequency and data point in the second file will be discarded.

Both RF calibration files must be the same type, that is, full 12 Term, 1 Path 2 Port Forward, 1 Path 2 Port Reverse, etc., and the total number of frequency points of the first and second files added together cannot exceed 1601.

In most cases, it doesn't matter which calibration file is chosen as the first calibration file; however, if the VNA is a 37397C used in a Broadband setup that crosses the 65 GHz switchpoint, it is advised that the first calibration data be from the lower frequency band and the second calibration data be from the higher frequency band. Additionally, if the higher frequency band calibration starts at 65.0 GHz, the lower frequency band calibration must end at 65.0 GHz. This will prevent a spike at the 65.0 GHz band switch point.

NOTE

Refer to Appendix A, Front Panel Menus, for descriptions of menus MRG1, EXT_MRG1, MRG2, and MRG3 that relate to this application.