Maintenance Manual

ML2480B Series, ML2490A Series Wideband/Pulse Power Meter

ML2487A/B
Wideband Power Meter - Single Channel

ML2488A/B
Wideband Power Meter - Dual Channel

ML2495A
Pulse Power Meter - Single Channel

ML2496A
Pulse Power Meter - Dual Channel

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USA

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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, and possible loss related to equipment malfunction, if not performed properly.

Warning

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

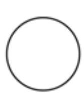
Caution

This indicates a hazardous procedure that could result in loss related to equipment malfunction if proper precautions are not taken.

Safety Symbols Used on Equipment and in Manuals

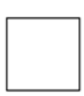
The following safety symbols are used inside or on the equipment near operation locations to provide information about safety items and operation precautions. Ensure that you clearly understand the meanings of the symbols and take the necessary precautions *before* operating the equipment. Some or all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

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

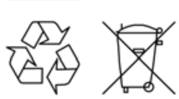


This indicates a compulsory safety precaution. The required operation is indicated symbolically in or near the circle.

This indicates a warning or caution. The contents are indicated symbolically in or near the triangle.



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



These indicate that the marked part should be recycled.

For Safety

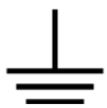
Warning

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

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.

Caution

Electrostatic Discharge (ESD) can damage the highly sensitive circuits in the instrument. ESD is most likely to occur as test devices are being connected to, or disconnected from, the instrument’s front and rear panel ports and connectors. You can protect the instrument and test devices by wearing a static-discharge wristband. Alternatively, you can ground yourself to discharge any static charge by touching the outer chassis of the grounded instrument before touching the instrument’s front and rear panel ports and connectors. Avoid touching the test port center conductors unless you are properly grounded and have eliminated the possibility of static discharge.

Repair of damage that is found to be caused by electrostatic discharge is not covered under warranty.

Table of Contents

Chapter 4—Adjustment

Chapter 5—Troubleshooting

Chapter 1 — General Information

1-1 Introduction

This manual provides service information for the ML2487/8A, ML2487/8B and ML2495/6A Wideband Peak Power Meter. The service information includes replaceable parts information, troubleshooting, performance verification tests, calibration procedures, functional circuit descriptions and block diagrams, and assembly/subassembly removal and replacement. Throughout this manual, the terms *ML248xx or ML249xA*, *Power Meter, or DUT (device under test)* are used to refer to the instrument. Manual organization is shown in the table of contents.

This chapter provides a general description of the *ML248xx and ML249xA* identification numbers, related manuals, and options. Information is included concerning level of maintenance, replaceable subassemblies and components, exchange assembly program, and preventive maintenance. Static-sensitive component handling precautions and lists of exchangeable subassemblies and recommended test equipment are also provided.

1-2 Description

This manual is applicable to the following power meters:

Table 1-1. Power Meter Model Descriptions

Model	Description	Frequency Range	Video BW	Input Channels
ML2487A	Wideband Power Meter, Single Input	100 kHz to 65 GHz	20 MHz	1
ML2487B	Wideband Power Meter, Single Input	100 kHz to 65 GHz	20 MHz	1
ML2488A	Wideband Power Meter, Dual Input	100 kHz to 65 GHz	20 MHz	2
ML2488B	Wideband Power Meter, Dual Input	100 kHz to 65 GHz	20 MHz	2
ML2495A	Pulse Power Meter, Single Input	100 kHz to 65 GHz	65 MHz	1
ML2496A	Pulse Power Meter, Dual Input	100 kHz to 65 GHz	65 MHz	2

A complete instrument description with performance specifications for each model can be found in the technical data sheet, Anritsu part number: 11410-00423, which is also available online. Updated versions of this manual and the technical data sheet may be downloaded from the Anritsu Internet site at: http://www.anritsu.com.

1-3 Documentation Conventions

The following conventions are used throughout this document:

Instrument Identification

Throughout this manual, the terms *ML248xx or ML249xA*, *Power Meter, or DUT (device under test)* are used to refer to the instrument. When required to identify a specific model, the specific model number is used, such as *ML2496A*. Manual organization is shown in the table of contents.

Hard Keys or Front Panel Keys

Front panel hard keys are denoted with a bold Sans Serif font such as “Press the front panel **Frequency** key.”

User Interface, Menus, and Soft Buttons

The ML248xx and ML249xA user interface consists of menus, button lists, sub-menus, toolbars, and dialog boxes. All of these elements are denoted with a special font, such as the Calibration menu or the AutoCal button.

User Interface Navigation Conventions

Navigation:

Elements in navigation shortcuts or paths (identified as "Navigation") are separated with the pipe symbol ("|"). Menu and dialog box names are distinctive Sans Serif font. Button names are in Title Case. For example, you would enter the power meter Service Mode by pressing the front panel keys in the following sequence:

System | Service **|** Diag **| 0 |** Enter

This string means: press the **System** hard key **|** press the Service soft key **|** press the Diag soft key **|** press the **0** keypad hard key **|** Press the Enter soft key.

User Input:

User input such as entering values or other information is denoted in a mono-spaced font such as:

`This font denotes a string of user input.`

For example:

Write `HCCFVAL <New Value>`

1-4 Identification Number

An Anritsu Power Meter ID number is affixed to the rear panel. Please use the complete ID number when ordering parts or corresponding with Anritsu Customer Service.

1-5 Online Manual

This manual is available on CD ROM as an Adobe Acrobat Portable Document Format (*.pdf) file. The file can be viewed using Acrobat Reader, a free program that is also included on the CD ROM. The file is "linked" such that the viewer can choose a topic to view from the displayed "bookmark" list and "jump" to the manual page on which the topic resides. The text can also be searched.

1-6 Related Manuals

This is one of a manual set that consists of the following:

Table 1-2. Related Manuals

Model	Title	Anritsu Part Number
ML2487/8A or ML2495/6A	Wideband Peak Power Meter Operation Manual	13000-00162
ML2487/8A or ML2495/6A	Wideband Peak Power Meter Remote Programming Manual	13000-00163
ML2487/8B or ML2495/6A	Wideband Peak Power Meter Operation Manual	13000-00238
ML2487/8B or ML2495/6A	Wideband Peak Power Meter Remote Programming Manual	13000-00239

1-7 Model Options and Accessories

ML248xA

The ML248xA Power Meter is no longer available and has been replaced by the ML248xB.

ML248xB

The ML248xB Power Meter is available with either one or two sensor inputs. Model numbers, options, and accessories are listed below.

Table 1-3. ML248xB Models

Number of Sensor Channels	Model Number
Single input	ML2487B
Dual input	ML2488B

Table 1-4. ML248xB Options and Accessories

Option Description	Option/Accessory Part Number
Rack Mount, single unit	2400-82
Rack Mount, side-by-side	2400-83
Front Bail Handle	ML2480B-005
(Front Bail Handle cannot be used with Rack Mount Kits)	
Rear Panel Mounted Input A	ML2480B-006
Rear Panel Mounted Input A and Reference	ML2480B -007
Rear Panel Mounted Inputs A, B, and Reference	ML2480B -008
Rear Panel Mounted Inputs A and B	ML2480B -009
1 GHz Reference	ML2480B-015
(Options -06 to -09 are mutually exclusive for any given ML248xB unit)	
Front Panel Cover (Cannot be used with rack-mounted units)	2000-1535
Spare 1.5m Sensor Cable	2000-1537-R
0.3m Sensor Cable	2000-1536-R
Bootload Serial Interface Cable	2000-1544

Table 1-5. ML248xB Accessories

Item Description	Part Number
Hard Sided Transit Case	760-209
Soft Sided Carry Case with shoulder strap	D41310

ML249xA

The ML249xA Power Meter is available with either one or two sensor inputs. Model numbers, options, and accessories are listed below.

Table 1-6. ML249xA Models

Number of Sensor Channels	Model Number
Single input	ML2495A
Dual input	ML2496A

Table 1-7. ML249xA Options and Accessories

Option Description	Option/Accessory Part Number
Rack Mount, single unit	2400-82
Rack Mount, side-by-side	2400-83
Front Bail Handle	ML2400A-05
(Front Bail Handle cannot be used with Rack Mount Kits)	
Rear Panel Mounted Input A	ML2490A-06
Rear Panel Mounted Input A and Reference	ML2490A-07
Rear Panel Mounted Inputs A, B, and Reference	ML2490A-08
Rear Panel Mounted Inputs A and B	ML2490A-09
(Options -06 to -09 are mutually exclusive for any given ML249xA unit)	
Front Panel Cover (Cannot be used with rack-mounted units)	2000-1535
Spare 1.5m Sensor Cable	2000-1537-R
0.3m Sensor Cable	2000-1536-R
Bootload Serial Interface Cable	2000-1544

Table 1-8. ML249xA Accessories

Item Description	Part Number
Hard Sided Transit Case	760-206
Soft Sided Carry Case with shoulder strap	D41310

1-8 Service Policy

The preferred power meter service policy is to return the unit to the local Service Center for the needed service. The Service Center will then perform the needed service or return to the factory if needed.

1-9 Replaceable Parts

The following spare parts are available for the power meter. Refer to Chapter 6 for removal and replacement procedures. Contact your nearest Anritsu Customer Service or Sales Center for price and availability information.

Table 1-9. ML248xA Spare Parts

Description ML248xA	Part No
PSU for ML248xA	ND61153
Measurement PCB assembly for ML2487A	ND61154
Measurement PCB assembly for ML2488A	ND61155
Control PCB for ML248xA	ND65070
Front panel assembly all cables and overlay fitted ML2487A.	ND61157
Front panel assembly all cables and overlay fitted ML2488A.	ND61158
Top Case with gaskets	ND50266
Bottom Case with gaskets	ND50267
Rear panel assembly for ML248xA	ND61159
1 GHz Calibrator Exchange Assy	ND69837
ML248xx/9xA RF 1 GHz Calibrator Cable	62212
ML248xx RF 50 MHz Calibrator Cable (without opt. 15)	3-B41256
ML2487A Single Channel Flexi Cable	ND68096
ML2488A Dual Channel Flexi Cable	ND68097

Table 1-10. ML248xB Spare Parts

Description ML248xB	Part No
PSU for ML248xB	ND61153
Measurement PCB assembly for ML2487B	ND69841
Measurement PCB assembly for ML2488B	ND69842
Control PCB for ML248xB	ND65070
Front panel assembly all cables and overlay fitted ML2487B.	ND69843
Front panel assembly all cables and overlay fitted ML2488B.	ND69844
Top Case with gaskets	ND50266
Bottom Case with gaskets	ND50267
Rear panel assembly for ML248xB	ND65073
ML248xx/9xA RF 1 GHz Calibrator Cable	62212
ML248xx RF 50 MHz Calibrator Cable (without opt. 15)	3-B41256
ML2487B Single Channel Flexi Cable	ND68098
ML2488B Dual Channel Flexi Cable	ND68099
ML248xB/9xA TCPIP Embedded Stack Assy	ND65074
1 GHz Calibrator Exchange Assy	ND69837

Table 1-11. ML249xA Spare Parts

Description ML249xA	Part No
PSU for ML249xA	ND61153
Measurement PCB assembly for ML2495A	ND65068
Measurement PCB assembly for ML2496A	ND65069
Control PCB for ML249xA	ND65070
Front panel assembly all cables and overlay fitted ML2495A.	ND65071
Front panel assembly all cables and overlay fitted ML2496A.	ND65072
Top Case with gaskets	ND50266
Bottom Case with gaskets	ND50267
Rear panel assembly for ML249xA	ND65073
TCPIP Embedded stack assembly	ND65074
1 GHz Calibrator Exchange Assy	ND69837
ML248xx/9xA RF 1 GHz Calibrator Cable	62212
ML2495A Single Channel Flexi Cable	ND68098
ML2496A Dual Channel Flexi Cable	ND68099

Note Other assemblies may be added if required.

1-10 Test Equipment List

Table 1-12 provides a list of recommended test equipment needed for the performance verification, calibration, and troubleshooting procedures presented in this manual. The test equipment setup is critical to making accurate measurements. In some cases, you may substitute test equipment having the same critical specifications as the test equipment indicated in the test equipment list (refer to “Measurement Uncertainty” on page 3-1).

Table 1-12. Test Equipment List (1 of 2)

Instrument	Critical Specification	Manufacturer/Model	Usage[a]
Range Calibrator	N/A	Anritsu ML2419A	C, P
Frequency Counter		Anritsu MF2412B	C, P
RF Cable: BNC male connector at one end and N-type male connector at other end	BNC(m) to N(m)	Any common source	C, P
RF Cable: N-type male connection at both ends	N(m) to N(m)	Any common source	C, P
BNC male to dual binding post adaptor	N/A	Any common source	P
Analog Power Meter	Functions with Agilent Nano Volt meter and Agilent 8478B	Agilent 432A	C, P
Power Meter	Functions with Agilent 8478B	Agilent N432A	P
S820E	VNA to measure VSWR at 50 MHz and 1 GHz	Anritsu	P
Nano Volt / Micro Ohm Meter or equivalent	Functions with Agilent 432A power meter.	Agilent 34420A	C, P

Table 1-12. Test Equipment List (2 of 2)

Instrument	Critical Specification	Manufacturer/Model	Usage[a]
Power Sensor		Agilent 8478B	C, P
Digital Voltmeter (DVM)	±0.0015 % basic 24 hour DCV accuracy	Agilent 34401A	C
Anritsu Power Sensor	Functions with Agilent 432A. Cal/zero at 50 MHz	Anritsu MA24xxA (not MA2411A)	C
Non-magnetic tuning wand with a screwdriver tip for 6-32 slotted cores	N/A	Any common source	C

a. P = Performance Verification Tests, C = Calibration, T = Troubleshooting

1-11 ESD Requirements

All electronic devices, components, and instruments can be damaged by electrostatic discharge. It is important to take preventive measures to protect the instrument and its internal subassemblies from electrostatic discharge.

An ESD safe work area and proper ESD handling procedures that conform to ANSI/ESD S20.20-1999 or ANSI/ESD S20.20-2007 is mandatory to avoid ESD damage when handling subassemblies or components found in Anritsu instruments.

Chapter 2 — Functional Description

2-1 Product Overview

The power meter is a lightweight, portable instrument featuring high accuracy and fast measurement speeds. The large front panel LCD provides simultaneous dual display channel readout with graphical display of pulse power measurements.

Sensor Inputs and Amplifiers

The ML2487x / ML2495A Power Meter features a single sensor input. The ML2488x / ML2496A Power Meters have an additional sensor input. Each sensor input has its own dedicated, low noise, high speed amplifier. The amplifier is split into five ranges to cover the power range from –70 dBm to +20 dBm. These are for CW measurements only. Ranges 1 and 2 are the DC coupled ranges and are used for the measurements over a dynamic range of approximately –30 dBm to +20 dBm. Ranges 3 to 5 are used for low level measurements. These are the AC ranges and are used in conjunction with a chopper located in the sensor. The use of a chopped signal provides extra measurement stability at low power levels.

There are also three high speed ranges which overlap each other. These are 7, 8 and 9 and are used for Pulse Modulated measurements over a dynamic range of approximately –30 dBm to +20 dBm, depending on which sensor is used.

Sensors

Two types of sensors are available: diode and thermal. Diode sensors provide fast response speed and a wide dynamic range (–70 dBm to +20 dBm for example). Thermal sensors provide high accuracy and stable averaged readings, with a dynamic range of –30 dBm to +20 dBm.

Internal Standard 50 MHz Reference (ML248xx only)

A high accuracy and stable 50 MHz reference is provided within the meter for convenient sensor calibration.

Option 15 Internal 50 MHz and 1 GHz Reference

A high accuracy and stable 50 MHz and 1 GHz reference is provided within the power meter for convenient sensor calibration. The 1 GHz reference is essential for correct calibration of MA2411A Power Sensors. All ML2495/6A power meters are fitted with the 50 MHz and 1 GHz reference. ML248xx power meters can have option 15 installed.

Measurement Modes

The power meter has been designed to operate in two main modes.

Pulsed/Modulated Mode

Pulsed/modulated mode activates the high speed data acquisition system and is used to measure all time variant signals such as GSM, CDMA, WLAN and radar signals. Results can either be displayed as a graph (profile) or as a number (readout). A selection of trigger modes and controls allow the user to set the precise time over which data is captured, measured and displayed in this mode.

CW Mode

CW mode activates the low bandwidth data acquisition system. This mode is used to measure CW and slowly varying signals. Results are displayed as a readout display.

2-2 General Operation

The power meter consists of several key blocks.

Input Amplifier

Each sensor input has its own dedicated, low noise, high speed amplifier. The CW amplifier is split into five ranges to cover the power range from –70 dBm to +20 dBm. Ranges 1 to 2 are DC coupled. Ranges 3 to 5 are used for low-level measurements. These are the AC ranges and are used in conjunction with a chopper located in the sensor.

Ranges 7, 8 and 9 are high speed ranges and split the signal into two paths; a wideband AC path and a DC low bandwidth path. The two sections are recombined before a high speed ADC for Pulse Mod measurements which samples at 64 Ms/s.

Signal Processing

The signal processing is split between two functional blocks; the dedicated FPGA, and the DSP.

FPGA

The FPGA controls the AD converters. Data is sampled at a rate determined by the capture time set for the measurement. The highest sample rate is 64 Ms/s. The data is stored in a 256K trace memory buffer. Internal and external triggers are handled by the FPGA.

Digital Signal Processor (DSP)

A dedicated processor is used to control all signal processing including measurement processing, sensor interface, internal channel calibration, zeroing, averaging, and communication to the main processor. The 256K trace buffer memory is dual port and is accessed by the DSP for signal processing. Results are then passed to the main processor that handles the display and remote interfaces. When the power meter is turned on, the main processor downloads the DSP operating program that runs a self-test and confirms all hardware is operational.

2-3 Interface

The power meter front panel has a 1/4 VGA LCD unit. The front panel has three sets of keys.

Numeric keypad	Used to scroll down menus, enter numeric values and move markers.
Hard keys	Used to select menus for the operation of the power meter.
Soft keys	Used to select dialog boxes and instrument settings.

2-4 GPIB Operation

The power meter GPIB operation is provided by a fully integrated National Instruments TNT 4882 IC. Most front panel functions are available by GPIB command. These commands are fully described in the Remote Programming Manual.

2-5 Case Construction

The power meter has a clamshell case structure. The top and bottom covers are of a rugged molded plastic construction. The top case has raised slots that align with the feet of the bottom case to allow unit stacking. The front and rear panels are fitted into slots in the top and bottom cases.

Front Panel

The front panel assembly is made up of a conductive contact rubber keypad sandwiched between the molded plastic front panel and the LCD PCB assembly. Depending upon the option configuration selected, the front panel may contain the signal channel input connectors and the RF calibrator reference output.

Rear Panel

The rear panel is made from sheet aluminum and contains the ground stud, line power input module, RS-232 I/O connector, GPIB connector, four BNC I/O connectors. The rear panel is attached to the main PCB and fits into slots in the top and bottom cases.

Handle and Rack Mount

An optional handle can be fitted using the two circular mounting points on each side of the unit. A special top and bottom case are available to provide rack mounting capability.

2-6 Internal Construction

The power meter contains the Measurement PCB, the Control PCB, and the Power Supply Unit (PSU).

Measurement PCB

The Measurement PCB is a multi-layer board with approximately 95 % surface mount components and with some components through-hole mounted.

Control PCB

The Control PCB is a multi-layer board with approximately 95 % surface mount components and with some components through-hole mounted. The board is mounted on six standoffs in the bottom case and secured by three screws.

Power Supply

The power supply unit is mounted under the control PCB using a metal support bracket. The PSU sits in a plastic cage to divert airflow to keep it cool. Line power is fed through an input filter module mounted on the rear panel.

2-7 Front Panel

The front panel consists of the following components:

LCD Display

The large front panel color liquid crystal display presents measurements and operations menus.

System Keys

The operation of the power meter is controlled by six hard keys: Ch1/Ch2, Channel, Sensor, Cal/Zero, System, and Preset. Each of these keys generates a soft key menu on the right side of the display.

Soft Keys

The six soft keys either apply functions directly, or access second or third level menus. Each key is related to the text displayed directly to the left.

Data Entry Keypad

The data entry keypad features the numbers 0 to 9 and all the letters of the alphabet. The keypad also allows the user to enter a positive or negative value and enter a decimal point. These keys are used to enter numeric data, such as a sensor cal factor frequency.

ON/Standby Key

The On/Standby key is used to turn the unit on from standby mode. The switch is a software control switch that indicates to the PSU control circuitry what state the unit should be in. The power meter is in standby mode when AC line power is applied.

2-8 Front Panel Connectors

This section describes the power meter front panel connectors.

Sensor Inputs

On standard model power meters, the signal channel A and B input connectors are mounted on the front panel. The connectors are 12-pin Hirose type. A sensor cable, provided with the meter, is used to connect an Anritsu power sensor to the signal channel. The connectors are snap push fit and require the outer body to be pulled to enable removal.

RF Reference Calibrator

The internal reference provides a high stability, high accuracy level for signal channel calibration. The output connector is a flange mounted female ‘N’ type. With the power sensor connected to the calibrator output, a “Zero/Cal” will automatically zero the signal channel and then perform a 0 dBm calibration. All measurements are then referenced to the 0 dBm level.

2-9 Rear Panel Connectors

This section describes the power meter rear panel connectors.

Line Power Input

The AC line power input module is mounted on the rear panel and the supplied line power cable connects to it. The module contains filtering elements to ensure immunity to external noise and reduce emissions. The power meter automatically senses the line level and internally configures itself accordingly. The specified line power requirement is 85 to 264V AC, 47 to 440 Hz, 80 VA maximum. An internally mounted 2.5A slow blow fuse provides fault protection.

Note The internally mounted 2.5 A slow blow fuse cannot be changed by the operator.

Ground Stud

A ground stud provides an additional grounding connection.

RS-232 Port

A PC standard 9-pin D connector provides connection to the serial port. The serial port can be used to update the power meter operating firmware, and control operation of the power meter from a PC or terminal. The hardware handshake lines RTS and CTS are used to control the flow of data.

GPIB

A standard General Purpose Interface Bus connector is used to connect through GPIB to other test equipment and a host computer. The power meter series is compatible with IEEE-488.1/2 requirements. Refer to the power meter Remote Programming Manual for information on using GPIB.

BNC I/O Ports

Output 1

Multi-purpose BNC connector is user-configurable for Analog Output 1 (volts/units), or Limits (pass/fail (TTL)). It supports pass/fail testing for channel 1. It Can be configured to output a real-time measurement signal from sensor Input A, which is suitable for levelling purposes.

Output 2

Multi-purpose BNC connector is user configurable for Analog Output 2 (volts/units), or Limits (pass/fail (TTL)). It supports pass/fail testing for Channel 2. It can be configured to output a real-time measurement signal from sensor Input B, suitable for levelling purposes.

Input 1 (Digital)

The External Trigger is a multi purpose BNC connector used as a TTL trigger input.

Input 2 (Analog)

Multi purpose BNC V/GHz Input connector used for volts per GHz connection. It supports 0 V to +20 V nominal input voltage with software selectable scaling. V/GHz is used for automatic CAL FACTOR correction by applying an external voltage, scaled to frequency. The correct calibration factor for this frequency is automatically interpolated and applied when in V/GHz calibration factor mode. Different scaling may be applied to sensor A or B allowing for measurement of frequency translation devices. Available simultaneously with channel A and/or B data, the data rate is as set on the channel.

VGA Out

For video output to 1/4 VGA external display.

Ethernet – 10/100 Base T LAN Interface

2-10 Power Supply Operation

The power meter power supply is a switch mode type with three DC outputs at +5.8V, –5V, and +12V. The line power required for correct operation is 85 VAC to 264 VAC at 47 Hz to 440 Hz. When line power is applied, all three DC outputs will always be present. The main processor is always in operation when the line power is applied. Within the unit on the Control PCB and the Measurement PCB DC regulators control all internal DC supplies. Most of these supplies can be switched off in stand by mode by the main processor.

Chapter 3 — Performance Verification

3-1 Introduction

Performance of the Anritsu ML248xA, ML248xB and ML249xA Power Meters can be verified using the procedures in this chapter.

3-2 Test Conditions

The equipment used to verify the power meter is intended for use as calibration instruments, and as such must be operated under controlled conditions of temperature and humidity in order to meet its specified precision and stability.

All tests must be performed at a temperature of 25 °C ±10 °C (77 °F ±18 °F) and a relative humidity of less than 75 % at 25 °C (77° F), non-condensing. Prior to making any precision measurements, allow the range calibrator and the power meter to warm up for a period of 15 minutes from power on. If the power supply is interrupted for any reason, allow a similar settling period.

3-3 Measurement Uncertainty

All test records are provided with a measurement uncertainty, which consists of the type-B[1] components. The error contributions are measurement method, test equipment, standards, and other correction factors (for example, calibration factors and mismatch error) per the prescribed test procedure. The statement(s) of compliance with specification[2] is based on a 95 % coverage probability for the expanded uncertainty of the measurement results on which the decision of compliance is based. Other values of coverage probability for the expanded uncertainty may be reported, where practicable, for some of the measured values it is not possible to make a statement of compliance with specification[2].

3-4 Input Range Verification

The performance of the power meter's individual signal channel inputs are verified using the Anritsu ML2419A Range Calibrator. Ranges 1 through 5 are verified on the ML248xA power meter, while ranges 1 through 5, and 7 through 9 are verified on the ML248xB and ML249xA power meters. References in this procedure to sensor input B apply to model ML2488A, ML2488B or ML2496A (dual-channel) power meters only.

Required Equipment

- Anritsu ML2419A Range Calibrator

Measurement Procedure

1. Connect the range calibrator to the power meter using 1.5m sensor cables. The input(s) to be verified must be connected to the corresponding connector(s) on the range calibrator. Connect power meter connector A to range calibrator connector A, and power meter connector B to range calibrator connector B (ML2488A, ML2488B or ML2496A only).
2. On connection of the sensor cable(s), the meter automatically detects a range calibrator is present and displays the performance verification menus.

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1. BIPM JCGM 100:2008 Evaluation of measurement data–Guide to the expression of uncertainty in measurement
2. LAC–G8:03/2009: Guidelines on the Reporting of Compliance with Specification

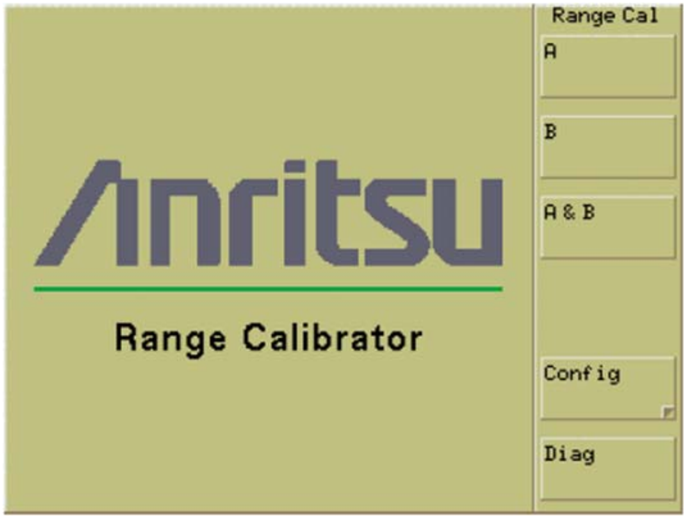


Figure 3-1. Range Calibrator

The performance verification tests will begin when the soft key for the sensor input to be verified is selected.

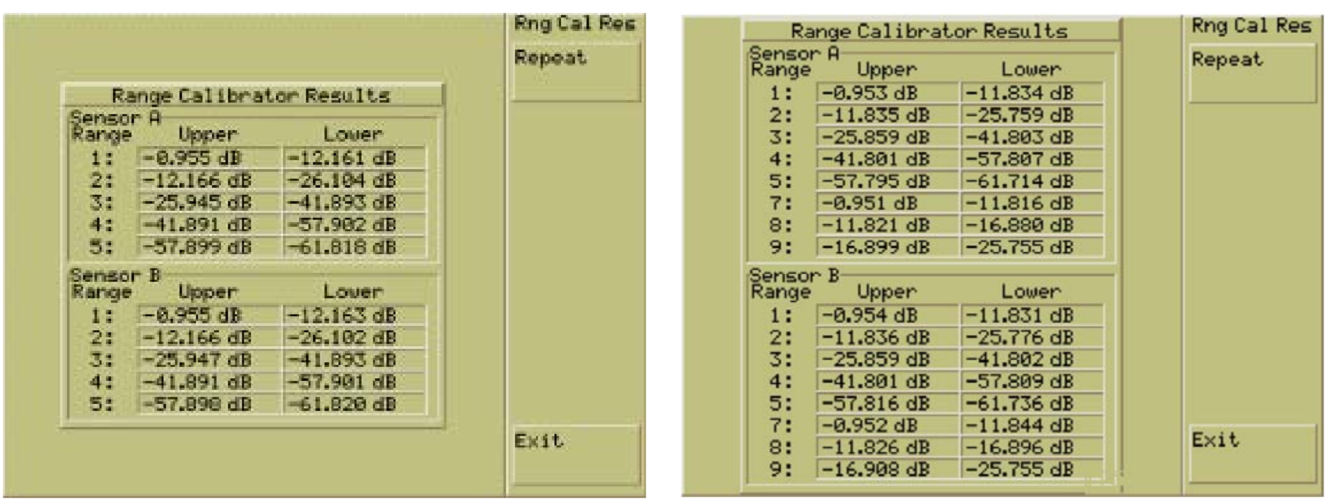
3. For single-channel power meters (ML2487A, ML2487B or ML2495A), press the A soft key.
4. For dual-channel models (ML2488A, ML2488B or ML2496A), press A, B, or A and B.

If the A and B soft key is selected, all measurements are first taken on sensor input A, then repeated for sensor input B. Performance verification tests for each sensor input are performed in the following sequence.

a. The signal channel input is zeroed.

b. The power meter signal channel(s) are checked at the upper and lower levels of each measurement range. A null is performed at each range setting prior to every measurement.

5. When all measurements have been performed on the selected inputs, the results are presented on the screen and soft keys are displayed as shown in Figure 3-2.



ML2487A/8A ML2487B/8B or ML2495A/6A

Figure 3-2. Range Measurement Results

Range Data Interpretation

The tabular data consists of the values read by the meter for each range, with one measurement taken at each end of each range. For each of these measurements, there is an expected value as shown in Table 3-1. The measured value is given a pass or fail depending on how close it is to the expected value. The limits for pass and fail are shown in Table 3-2.

Table 3-1. Range Data Expected Output Levels

Range	Abbreviation	Expected output levels
Range 1 Upper Level	**R1U**	–0.9540 dB
Range 1 Lower Level	**R1L**	–11.8342 dB
Range 2 Upper Level	**R2U**	–11.8342 dB
Range 2 Lower Level	**R2L**	–25.7741 dB
Range 3 Upper Level	**R3U**	–25.8606 dB
Range 3 Lower Level	**R3L**	–41.8031 dB
Range 4 Upper Level	**R4U**	–41.8031 dB
Range 4 Lower Level	**R4L**	–57.8139 dB
Range 5 Upper Level	**R5U**	–57.8139 dB
Range 5 Lower Level	**R5L**	–61.7260 dB
Range 7 Upper Level	**R7U**	–0.9540 dB (ML2487/8B and ML249xA only)
Range 7 Lower Level	**R7L**	–11.8342 dB (ML2487/8B and ML249xA only)
Range 8 Upper Level	**R8U**	–11.8342 dB (ML2487/8B and ML249xA only)
Range 8 Lower Level	**R8L**	–16.8965 dB (ML2487/8B and ML249xA only)
Range 9 Upper Level	**R9U**	–16.8965 dB (ML2487/8B and ML249xA only)
Range 9 Lower Level	**R9L**	–25.7741 dB (ML2487/8B and ML249xA only)

The Range Calibrator measures the “Zero” level, and the “Upper” and “Lower” limits of each of the ranges (both channels on a dual-channel meter). To calculate the dB Error Figure for each level, subtract the expected level from the measured level.

6. The Data from the power meter display can be entered into an excel spreadsheet (*.xls) to verify the measurements. The part number of this spreadsheet is 63153. Contact your nearest Anritsu Customer Service or Sales center for an electronic copy of this spreadsheet.

7. Record the data from the spreadsheet to the test record tables “Measurements and Calculated Error Figure” on page A-2 and “Error, Linearity and Range Change Calculations” on page A-3).

Note	If the spreadsheet is not available, calculate and record the data using the test records on pages A-2 and A-3.

8. To exit the range calibrator mode, disconnect the sensor cables. The power meter is reset to the default mode.

Pass/Fail Criteria

The meter should be accepted as PASSED if it meets the error and linearity statistics listed in Table 3-2.

Table 3-2. Pass/Fail Criteria

Range	Specifications (dB)
Range 1 Absolute Error	–0.020 ≤ R1U ≤ 0.020
Range 1 Linearity	–0.040 ≤ R1U–R1L ≤ 0.040
Ranges 1-2 Change	–0.030 ≤ R1L–R2U ≤ 0.030
Range 2 Linearity	–0.040 ≤ R2U–R2L ≤ 0.040
Ranges 2-3 Change	–0.030 ≤ R2L–R3U ≤ 0.030
Range 3 Absolute Error	–0.020 ≤ R3U ≤ 0.020
Range 3 Linearity	–0.040 ≤ R3U–R3L ≤ 0.040
Ranges 3-4 Change	–0.030 ≤ R3L–R4U ≤ 0.030
Range 4 Linearity	–0.040 ≤ R4U–R4L ≤ 0.040
Range 4-5 Change	–0.030 ≤ R4L–R5U ≤ 0.030
Range 5 Linearity	–0.040 ≤ R5U–R5L ≤ 0.040
Range 7 Absolute Error	–0.030 ≤ R7U ≤ 0.030
Range 8 Absolute Error	–0.030 ≤ R8U ≤ 0.030
Range 8 Linearity	–0.085 ≤ R8U–R8L ≤ 0.085
Range 9 Absolute Error	–0.050 ≤ R9U ≤ 0.050
Range 9 Linearity	–0.18 ≤ R9U–R9L ≤ 0.18

Absolute Error

The absolute error is the difference between the measured level and expected level. For example, from the readout shown in Figure 3-2, the calculated absolute error for Range 1 Upper (R1U) is:

$R1_{upper} - R1_{expected} = (-0.955) - (-0.9540) = -0.0010$ dB

The calculated absolute error in this case should be ≥ –0.020 dB and ≤ 0.020 dB which are the limits shown in Table 3-2.

Linearity

The linearity is the difference between the upper range error and the lower range error. For example, from the absolute error calculations above, the calculated linearity is:

Error R1U – Error R1L = (0.0010) – (0.0002) = 0.0008 dB

The calculated linearity in this case should fall between –0.040 and 0.040 dB as shown in Table 3-2.

Range Change

The range change error is the difference between the errors for the two dB levels at the overlap between any two ranges. This should be ≥ –0.030 dB and ≤ 0.030 dB as shown in Table 3-2. For example, the maximum range change error between R1L–R2U is:

$R1L_{error} - R2U_{error} = (0.0002) - (-0.0008) = 0.0010$ dB

3-5 50 MHz Calibrator Frequency (All Models)

The following procedure is used to measure the 50 MHz Calibrator output frequency of the ML248xx and ML249xA power meters.

Required Equipment

- Anritsu MF2412B Frequency Counter or equivalent
- RF Cable with BNC male connection at one end and N-type male connection at other end.

Procedure

1. Power on the power meter and frequency counter. Allow both to warm up for 15 minutes before taking measurements.
2. On the MF2412B:
   a. Press the **Preset** key.
   b. Press the **Input** key.
   c. Press the Left Arrow (**<**) key to highlight Input CH area.
   d. Press the **Enter** key until Input 2 is selected.
   e. Press the Right Arrow (**>**) key to highlight the Impd2 area.
   f. Press the **Enter** key until 50 Ohms is selected.
   g. Press the **Return to Meas** key.
3. Connect an RF cable from Input2 of the MF2412B to the Calibrator output of the power meter.
4. On the power meter, turn on the RF calibrator by pressing the **Cal / Zero** key, then the Calibrator soft key, and then the RF Calibrator soft key.
5. With the RF calibrator on, the MF2412B frequency counter should be reading the frequency of the calibrator output. Record the frequency below and in "Calibrator Frequency Uncertainty" on page A-4.

   F_{meas} = ____________________ Hz

Calibrator Frequency Uncertainty

The sources of uncertainties of the frequency counter measurement at 50 MHz include:

- One Count: Least significant digits (LSD) of the frequency counter
- Time base accuracy from either of the following:
  - GPS Disciplined Oscillator
  - MF2412B Frequency Counter
- Residual error of the frequency counter:
  - Normal Mode; Measurement Frequency / $1E^{10}$
  - Fast Mode; Measurement Frequency / $2E^{9}$

Use the following equation to determine the expanded measurement uncertainty (U_f) with coverage factor K = 2, 95 % level of confidence.

1. For the MF2412B, use the following numbers to determine U_f.
   - One count = 1
   - Time base accuracy (TBA) for the MF2412B:
     - TBA = $7.5E^{-8}$ with option 1
     - TBA = $4.5E^{-8}$ with option 2
     - TBA = $1.5E^{-8}$ with option 3

- Measurement Frequency:
  - F_{meas} = Frequency from the MF2412B (in Hz)
- Residual Error:

$$ERR_{Res} = \frac{F_{meas}}{1 \times 10^{10}}$$

$$U_f = \pm 2\sqrt{\left(\frac{1}{\sqrt{3}}\right)^2 + (ERR_{res})^2 + (F_{meas} \times TBA)^2}$$

$$U_f = \_\_\_\_\_\_\_\_ \text{ Hz}$$

2. Verify the frequency of the calibrator $F_{meas} \pm U_f$ is within the range of 50 MHz ±500 kHz.

3. If the frequency is outside the 50 MHz ±500 kHz limits, proceed to Section 4-6 “RF Calibrator 50 MHz Frequency (ML248xx without Option 15)” or Section 4-8 “RF Calibrator 50 MHz Frequency and 50 MHz/1 GHz Output Power” in Chapter 4, “Adjustment”.

3-6 1 GHz Calibrator Frequency (ML248xx-Option 15, ML249xA)

The following procedure is used to measure the 1 GHz Calibrator output frequency of the ML248xA and ML248xB power meters with option 15 and all ML249xA units.

Required Equipment

- Anritsu MF2412B Frequency Counter or equivalent
- RF Cable with N-type male connection at both ends

Procedure for 1 GHz Verification

1. Power on the power meter and frequency counter. Allow both to warm up for 15 minutes before taking measurements.
2. On the MF2412B, press the **Preset** key.
3. On the MF2412B, press the **Input** key.
4. Ensure the Input CH is set to Input 1.
5. On the MF2412B, press the Return to Meas key.
6. Connect an RF cable from Input 1 of the MF2412B to the Calibrator Output of the power meter.
7. On the power meter, turn on the 1 GHz RF calibrator by pressing the Cal / Zero key, then the Calibrator soft key. Ensure the 1 GHz button is selected and press the RF Calibrator soft key.
8. Now the power meter calibrator output should be turned on and the MF2412B frequency counter should be reading the frequency of the calibrator output. Record the frequency below and in Calibrator Frequency Uncertainty of Appendix A:

   F_{meas} = ____________________ Hz

Calibrator Frequency Uncertainty

The sources of uncertainties of the frequency counter measurement at 1 GHz include:

- One Count: Least significant digits (LSD) of the frequency counter
- Time base accuracy from either of the following:
  - GPS Disciplined Oscillator
  - MF2412B Frequency Counter
- •Residual error of the frequency counter:
  - Normal Mode; Measurement Frequency / $1E^{10}$
  - Fast Mode; Measurement Frequency / $2E^{9}$

Use the following equation to determine the expanded measurement uncertainty (U_f) with coverage factor K = 2, 95 % level of confidence.

1. For the MF2412B, use the following numbers to determine U_f.
   - One count = 1
   - Time base accuracy for the MF2412B:
     - TBA = $7.5E^{-8}$ with option 1
     - TBA = $4.5E^{-8}$ with option 2
     - TBA = $1.5E^{-8}$ with option 3

- Measurement Frequency:

  F_{meas} = Frequency from the MF2412B (in Hz)

- Residual Error:

$$ERR_{Res} = \frac{F_{meas}}{1 \times 10^{10}}$$

$$U_f = \pm 2\sqrt{\left(\frac{1}{\sqrt{3}}\right)^2 + (ERR_{res})^2 + (F_{meas} \times TBA)^2}$$

$$U_f = \_\_\_\_\_\_\_\_ \text{ Hz}$$

2. Verify the frequency of the calibrator $F_{meas} \pm U_f$ is within the range of 1 GHz ± 20 MHz.
3. If the frequency is outside the 1 GHz ±20 MHz limits, proceed to Section 4-8 "RF Calibrator 50 MHz Frequency and 50 MHz/1 GHz Output Power" in Chapter 4, "Adjustment".

3-7 50 MHz Calibrator Power Level (All Models)

The following procedure is used to measure the Calibrator output power level of the ML248xx and ML249xA power meters.

Required Equipment

- Agilent 432A Analog Power Meter
- Agilent 34420A Nano Volt / Micro Ohm Meter or equivalent
- Agilent 8478B Power Sensor

Recording Results

Record measurements and calculations from this section in "Pmeas Calculation" on page A-6.

Procedure

1. Connect the Agilent 34420A to the Agilent 432A using the 4-wire cable provided with the Agilent 34420A See Figure 3-3 for connection details.

   shows 4-wire cable provided with the Agilent 34420A, along with two BNC to binding post adapters needed to connect the four wires to the rear of the 432A power meter.
2. Attach the connector end to the input Agilent 34420A volt meter.
3. Attach the wires with the BNC to binding post adaptors as shown to the rear of the 432A power meter:
   - Green = V_{rf}
   - White = GND of V_{rf}
   - Red = V_{comp}
   - Black = GND of V_{comp}

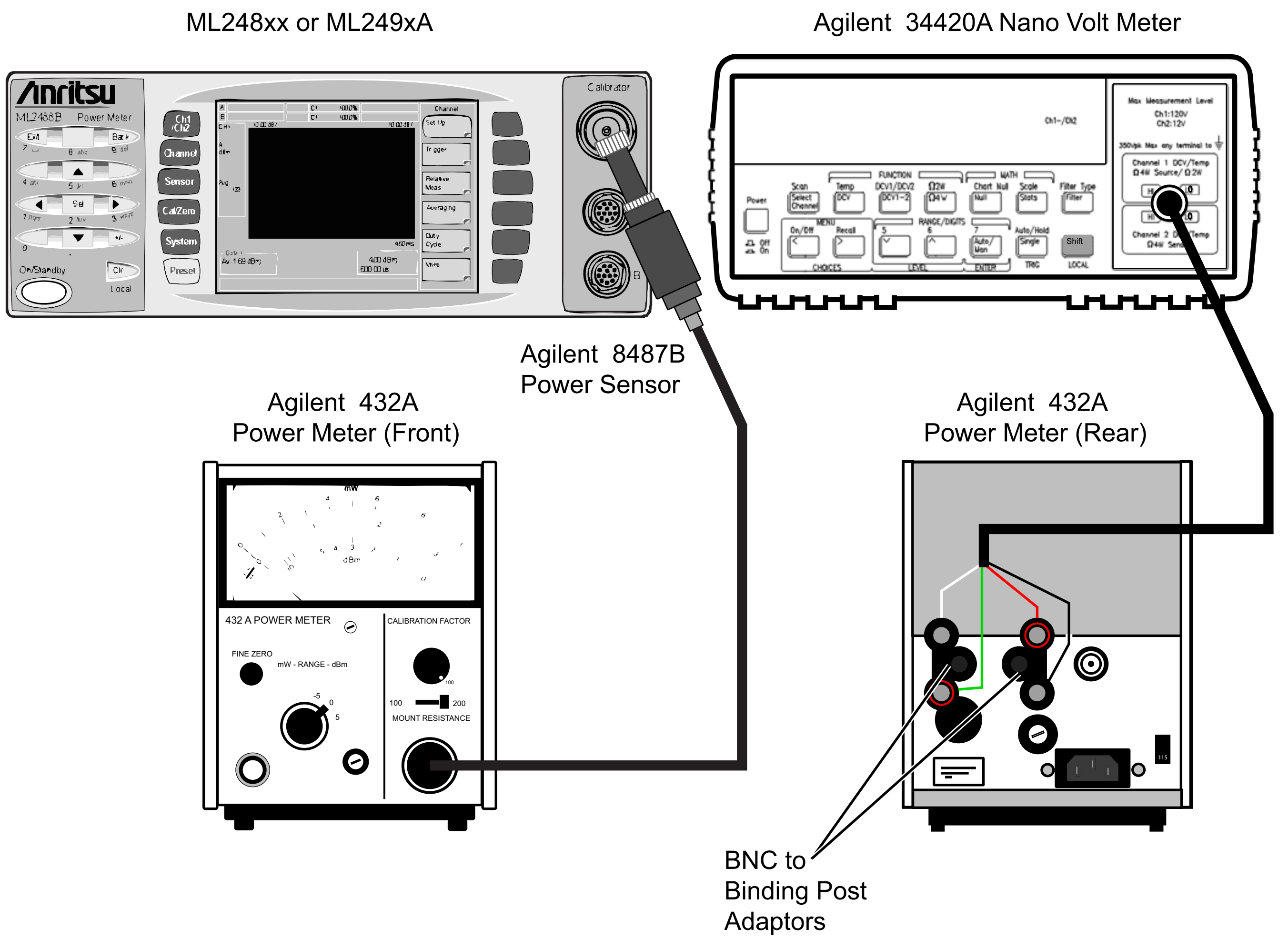


Figure 3-3. Equipment Connection for Calibrator Power Level Verification

4. Connect the Agilent Power Sensor 8478B to the Agilent 432A Power Meter.
5. Power on the 432A power meter and the 34420A voltmeter. Allow the units to warm up for 15 minutes before taking any measurements.
6. On the front panel of the 432A power meter, set the Mount Resistance to 200 ohms as shown in Figure 3-4.
7. On the front panel of the 432A power meter, set the Calibration Factor to 100.
8. After the 432A and 34420A have warmed up for 15 minutes, perform a zeroing of the 432A power meter according to the instructions listed in the 432A user manual.
9. On the front panel of the 432A power meter, set the Range to 0 dBm.
10. On the ML248xx or ML249xA, verify the RF Calibrator is off.
11. Connect the 8478B power sensor directly to the ML248xx or ML249xA calibrator.

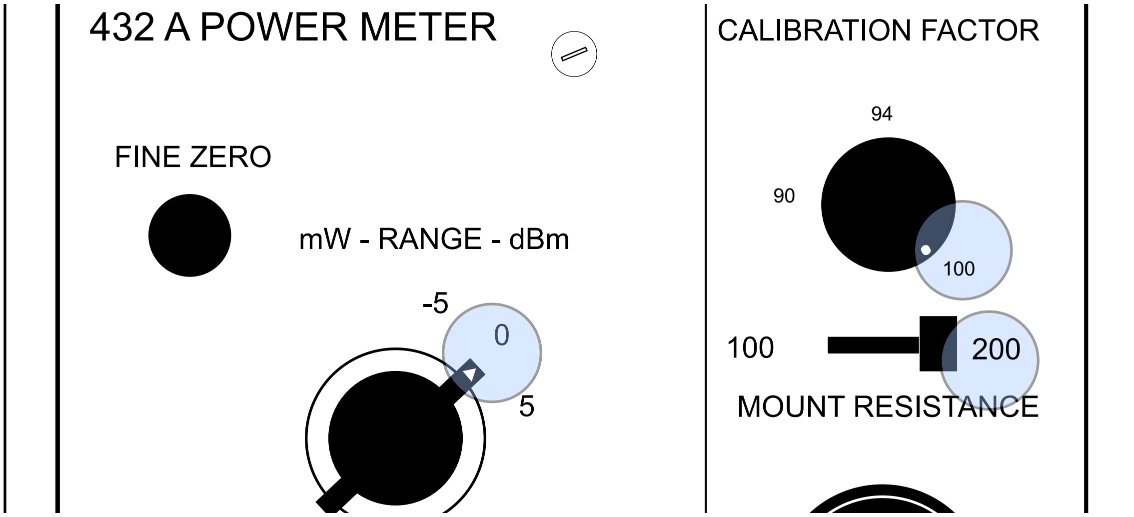


Figure 3-4. Power Meter Settings

12. Press **DCV 1-2** on the Agilent 34420A as shown in Figure 3-5.

    Record the number shown in the display of the 34420A as V0.

    V_0 = _______________ Volts

13. On the ML248xx or ML249xA power meter, turn on the RF calibrator by pressing the **Cal / Zero** key, then the Calibrator soft key, then the RF Calibrator soft key. (Ensure the 50 MHz calibrator is selected.)

14. Record the reading on the Agilent 34420A as V1.

    V_1 = _______________ Volts

15. While the RF is still on, press the **DCV** key on the 34420A and record this number as V_{comp}.

    V_{comp} = _______________ Volts

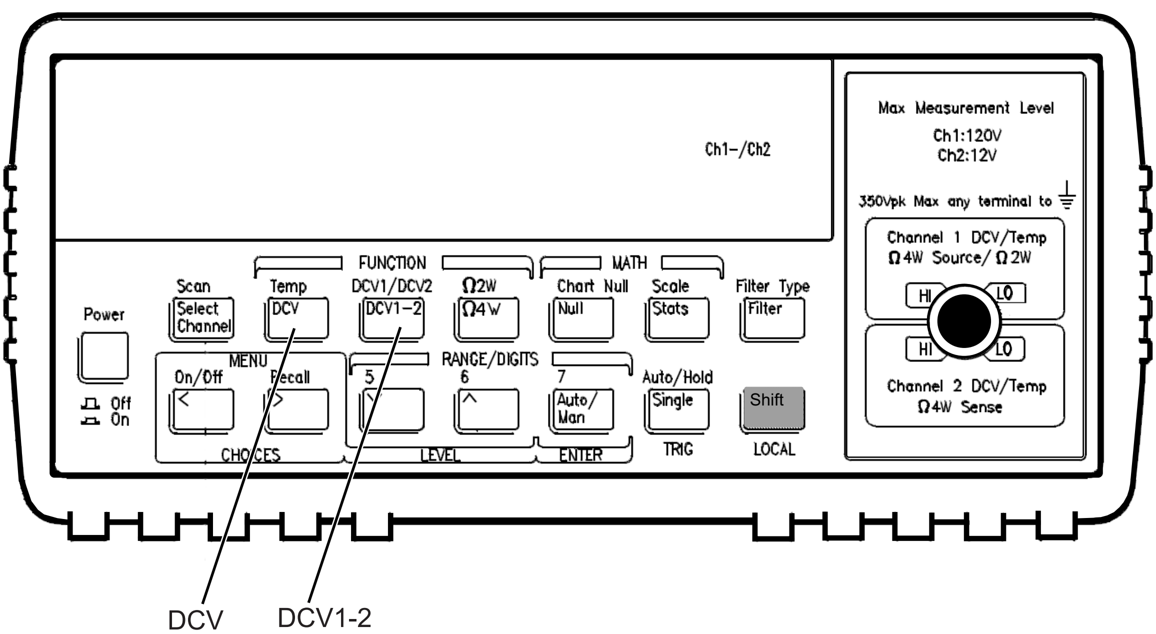


Figure 3-5. Measurement Sequence on Agilent 34420A

P_{meas} Calculation

1. Use the equation below to determine P_{meas} (the reference calibrator output power in Watts). Start by finding the Mismatch (M), then using this number, along with V0, V1, V_{comp}, R, and EE to solve for P_{meas}. Record values and calculations in "Pmeas Calculation" on page A-6.

$$P_{meas} = \left[\frac{2 \times V_{comp} \times (V_1 - V_0) + V_0^2 - V_1^2}{4 \times R \times EE \times M}\right]$$

$$M = \frac{1 - |\Gamma_d|^2}{|(1 \pm \Gamma_s \times \Gamma_d)^2|}$$

Where:

$M = \frac{1 - \lvert\Gamma_d\rvert^2}{\lvert(1 \pm \Gamma_s \times \Gamma_d)^2\rvert}$	Worst case value for M (should be used in the P_{meas} equation above)
Γ_d = ________	Reflection coefficient magnitude of the 8478B sensor (found in the 8478B calibration data)
EE = ________	Effective Efficiency of the 8478B sensor (found in the 8478B calibration data)
U_e = ________	Effective Efficiency uncertainty of the 8478B sensor (found in the 8478B calibration data; Needed for uncertainty calculation in Step 2 of this section)
Γ_s = 0.019	Reflection coefficient magnitude of the ML248xx and ML249xA Reference Calibrator output; (Needed for uncertainty calculation in Step 2 of this section)
R = ________	Mount Resistance of the 432A power meter
V_{comp} = _____	From Step 15, above
V_1 = ________	From Step 14, above
V_0 = ________	From Step 12, above
P_{meas} = ________	Calculated from the P_{meas} equation above

2. After P_{meas} is determined, the next step is to calculate the expanded uncertainty with coverage factor K = 2. This is done by using the equations below to get a value for the Expanded Uncertainty (K = 2).

Table 3-3 shows an uncertainty calculation of an ML248xxA reference calibrator power level. The table shows the resulting expanded uncertainty and each source of uncertainty.

Calibrator Power Level Uncertainty

The formula for standard uncertainty is:

$$\text{Standard Uncertainty } X_{unc} = \frac{1}{(Divisor)} \times (\text{Uncertainty}) \times (\text{Sensitivity}C_{ix})$$

The divisor of each source of uncertainty is determined by the type of probability distribution of each uncertainty source.

The uncertainty equations of V_0, V_1, V_{comp} and R are obtained from the Agilent 33420A multimeter accuracy specifications for 1 year, 23 °C ±5 °C as stated in the product's datasheet. The uncertainties of V_0, V_1, V_{comp} and R vary model to model of the multimeter used. The uncertainty of the Effective Efficiency, EE, is obtained from the thermistor mount 8478B calibration data. The uncertainty of Mismatch, M, is obtained by taking twice the product of the reflection coefficient magnitude of the 8478B, Γ_d, and the reflection coefficient magnitude of the ML24xxx Reference Calibrator, Γ_S. The uncertainty of connector repeatability, CR, is set to 0.1 % (for example, 60 dB for precision connectors).

The sensitivity, C_{ix} of each source of uncertainty, except for connector repeatability CR, is the first partial derivative of the P_{meas} equation with respect to the uncertainty source variable. The equation below shows how the sensitivity of V_{comp} and C_{iVcomp} is obtained:

$$C_{iV\text{comp}} = \frac{d}{dV_{comp}}[P_{meas}] = \frac{d}{dV_{comp}}\left[\frac{2 \times V_{comp} \times (V_1 - V_0) + V_0^{\;2} - V_1^{\;2}}{4 \times R \times EE \times M}\right] = \frac{2 \times (V_1 - V_0)}{4 \times R \times EE \times M}$$

Taking the partial first derivative of P_{meas} with respect to the variable uncertainty source needs to be done to obtain sensitivity C_{ix} for the rest of the sources of uncertainty, except for connector repeatability CR, which has a sensitivity set to 0.001 W.

Table 3-3. Uncertainty Calculation of an ML248xx Reference Calibrator Output Power Level

Sources of Uncertainty	Unit	Readings	Uncertainty	Units	Divisor	Sensitivity	Units	Standard Uncertainty (W)	Standard Uncertainty (μW)
V_{comp}	(V)	5.1627784	1.949×10^{-4}	(V)	1.732	1.950×10^{-4}	(V/Ohm)	2.194×10^{-8}	0.0219
V0	(V)	0.0009813	2.756×10^{-4}	(V)	1.732	-1.300×10^{-2}	(V/Ohm)	-2.068×10^{-6}	–2.0680
V1	(V)	0.0784392	2.756×10^{-4}	(V)	1.732	1.280×10^{-2}	(V/Ohm)	2.037×10^{-6}	2.0369
R	(Ω)	200	1.400×10^{-2}	(Ω)	1.732	-4.996×10^{-6}	(W/Ohm)	-4.038×10^{-8}	–0.0404
EE	-	0.993600	1.700×10^{-3}	-	1.000	1.006×10^{-3}	W	-1.709×10^{-6}	–1.7094
M	-	0.999345	9.728×10^{-4}	-	1.414	-9.998×10^{-4}	W	-6.877×10^{-7}	–0.6877
CR	-	0	1.000×10^{-3}	-	1.000	1.000×10^{-3}	W	1.000×10^{-6}	1.0000
Combined Uncertainty (μW)									3.5809
Expanded Uncertainty (K = 2) (mW)									0.00716
Expanded Uncertainty (K = 2) (%)									0.716

The standard uncertainty of each source of uncertainty in Table 3-3 is calculated as follows:

$$V_{comp}Unc = \frac{1}{\sqrt{3}} \times (0.00003 \times V_{comp} + 0.000004 \times 10V) \times \left(\frac{2(V_1 - V_0)}{4 \times R \times EE \times M}\right)$$

$$V_0Unc = \frac{1}{\sqrt{3}} \times (\sqrt{2 \times (0.00003 \times V_{comp} + 0.0000004 \times 10V)^2}) \times \left(\frac{-2(V_{comp} - V_0)}{4 \times R \times EE \times M}\right)$$

$$V_1Unc = \frac{1}{\sqrt{3}} \times (\sqrt{2(0.00003 \times V_{\mathrm{comp}} + 0.000004 \times 10V)^2}) \times \left(\frac{2(V_{comp} - V_1)}{(4 \times R \times EE \times M)}\right)$$

$$R_{Unc} = \frac{1}{\sqrt{3}} \times (0.00006 \times \mathrm{R} + 0.000002 \times (1000)) \times \left(\frac{-2V_{comp}(V_1 - V_0) - V_0{}^2 + V_1{}^2}{4 \times R^2 \times EE \times M}\right)$$

$$EE_{Unc} = \frac{1}{1} \times \left(\frac{U_e}{2}\right) \times \left(\frac{-2V_{comp}(V_1 - V_0) - V_0{}^2 + V_1{}^2}{4 \times R \times EE^2 \times M}\right)$$

$$M_{Unc} = \frac{1}{\sqrt{2}} \times (2 \times \Gamma_{\mathrm{s}} \times \Gamma_{\mathrm{d}}) \times \left(\frac{-2V_{comp}(V_1 - V_0) - \mathrm{V}_0{}^2 + \mathrm{V}_1{}^2}{4 \times \mathrm{R} \times EE \times M^2}\right)$$

$$CR_{Unc} = \frac{1}{1} \times (0.1\%) \times (0.001W) = 0.000001W$$

$$\text{Combined Uncertainty} = \sqrt{V_{comp}Unc^2 + V_1Unc^2 + V_0Unc^2 + R^2_{\mathrm{Unc}} + EE^2_{Unc} + M^2_{Unc} + CR^2_{Unc}}$$

$$(\mathrm{K} = 2) = 2 \times \text{Combined Uncertainty} \times 1000 \text{ (95\% level of confidence)}$$

Expanded Uncertainty (K = 2) = _______________ (mW) (determined from the above equations)

Now that you have P_{meas} and Expanded Uncertainty (K = 2), you can calculate lower and upper limits with the following equation:

$P_{actual} = P_{meas} \pm P_{meas}$ x Expanded Uncertainty (K = 2) (%)

P_{actual} Lower = _____________ mW

P_{actual} Upper = _____________ mW

The accuracy specification for the reference calibrator output power level is 1 mW ± 0.012 mW/mW per year. The maximum permissible error for the power output level, P_{actual} should be within the range of 1 mW ±0.0015 mW/mW (for example: 0.9985 mW to 1.0015 mW). If P_{actual} is outside of the 1 mW ±0.0015 mW/mW limit, perform Section 4-6 “RF Calibrator 50 MHz Frequency (ML248xx without Option 15)” in Chapter 4, “Adjustment”.

3-8 1 GHz Calibrator Power Level (ML248xx-Option 15, ML249xA)

Repeat the steps in Section 3-7, and ensure the 1 GHz calibrator is selected instead of the 50 MHz calibrator for Step 13.

Record measurements and calculations in “Pmeas Calculation” on page A-9.

3-9 50 MHz Calibrator VSWR Verification (All Models)

The following procedure is used to measure the VSWR of the RF Calibrator port when the 50 MHz Calibrator is selected on the ML248xx and ML249xA power meters. This procedure uses many calculations. It’s recommended to use a spreadsheet to enter the equations and calculate the results.

Required Equipment

- Agilent N432A Power Meter
- Agilent 8478B Power Sensor
- Agilent 34401A DMM or equivalent
- Anritsu S820E VNA or equivalent

Recording Results

Record measurements and calculations within this procedure, and record the final VSWR result within the Test Records on page A-11.

Procedure

1. Power off the N432A.
2. Connect the power sensor cable to the N432A without connecting the power sensor.
3. Refer to Figure 3-6. Measure the resistance from the Vrf BNC center conductor on the rear of the N432A to Pin 1 of the sensor cable.
4. Power on the N432A.
5. Go to the Channel Menu of the N432A and then scroll through the menu to select Bridge Resistance.
6. The internal N432A resistance can be changed between the 100, 200, 300 and 400 ohm settings. Select the 100 ohm setting.
7. Power off the N432A.
8. With a DMM, measure the resistance of the new Bridge Resistance setting.
9. Record the measurement below.

10. Repeat step 4 through 9 to measure and record the measurements for the 200, 300, 400 Ohm settings.

11. Record the 4 resistance measurements below:

R_{100} = ______________ (A value near 100 ohms)
R_{200} = ______________ (A value near 200 ohms)
R_{300} = ______________ (A value near 300 ohms)
R_{400} = ______________ (A value near 400 ohms)

Figure 3-6. 100, 200, 300 and 400 Ohm Bridge Resistance Measurement

12. Power off the N432A.

13. Attach the 8478B power sensor to the sensor cable.

14. Do not connect the power sensor to any source.

15. Power on the N432A.

16. Allow the N432A to zero the power sensor.

17. After zeroing is complete, attach the power sensor to the S820E or equivalent VNA.

18. Measure the VSWR at 50 MHz for each of the 4 resistance settings and record below:

$VSWR_{100}$ = ______________
$VSWR_{200}$ = ______________
$VSWR_{300}$ = ______________
$VSWR_{400}$ = ______________

19. Using the VSWR values from the previous step calculate the reflection coefficient, also known as Gamma (Γ) for each of the resistance values, using the following formula:

$$\Gamma = \frac{(VSWR - 1)}{(VSWR + 1)}$$

Γ_{100} = ______________ (should be a number near 0.33)

Γ_{200} = ______________ (should be a number near 0)

Γ_{300} = ______________ (should be a number near 0.2)

Γ_{400} = ______________ (should be a number near 0.33)

20. For each of the resistance settings, connect the 8478B to the RF Calibrator of the DUT,

21. On the N432A, toggle the front panel Display button so that menu 2 of 2 is displayed.

22. Set the N432A to Display Voltages.

23. Press the “Voltages Display” button.

24. Note the measured values “V_1” and “V_{comp1}” as shown in Figure 3-7.

25. Change the N432A Bridge Resistance to 100 ohms as described in steps 5 and 6.

26. Ensure the RF Calibrator on the DUT is turned off.

27. Record the V_1 and V_{comp1} values shown on the N432A into Table 3-4 as V_1 off and V_{comp1} off.

28. Turn on the RF Calibrator on the DUT and allow the measurements to settle for approximately 10 seconds.

29. Record the V_1 and V_{comp1} values on the N432A into Table 3-4, for V_1on and V_{comp1} on.

30. Turn off the RF Calibrator on the DUT.

31. When switching the RF Calibrator between On/Off and Off/On, allow the readings to settle for approximately 10 seconds before recording the results.

32. Repeat step 25 through 31 with the N432A Bridge Resistance set to 200, 300 and 400 ohms.

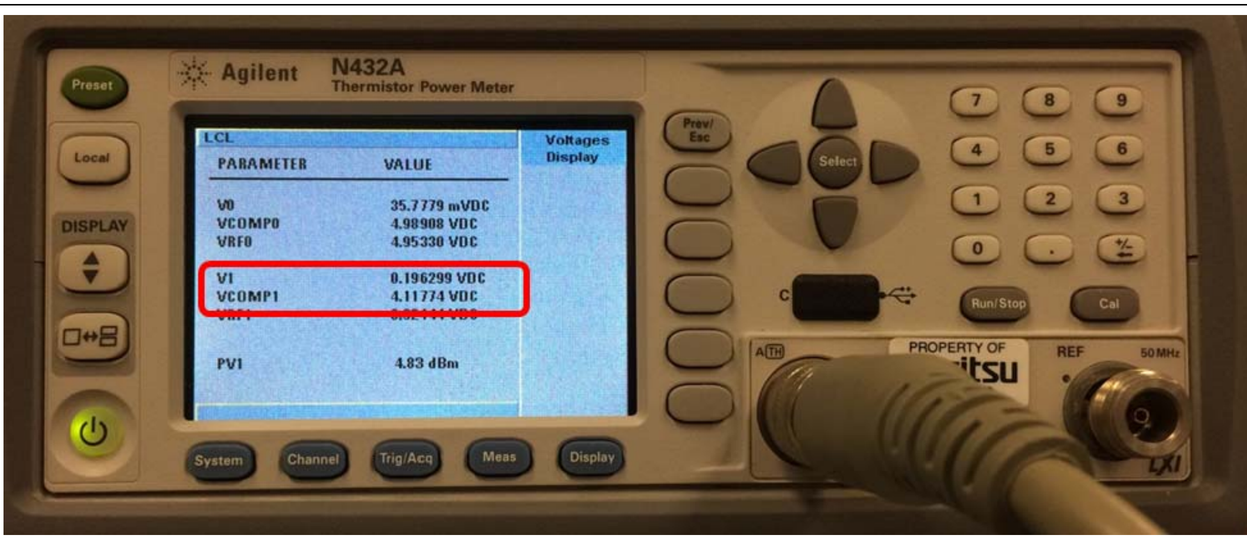


Figure 3-7. V_1 and V_{comp1} Values Shown on the N432A

Table 3-4. 50 MHz VSWR

Bridge Resistance	Calibrator Setting	V_1 / V_{COMP1} Setting	Measured Value
100 Ω	V_1 with RF Calibrator Off	V_1 off=	
	V_{COMP1} with RF Calibrator Off	V_{COMP1} off=	
	V_1 with RF Calibrator On	V_1 on=	
	V_{COMP1} with RF Calibrator On	V_{COMP1} on=	
200 Ω	V_1 with RF Calibrator Off	V_1 off=	
	V_{COMP1} with RF Calibrator Off	V_{COMP1} off=	
	V_1 with RF Calibrator On	V_1 on=	
	V_{COMP1} with RF Calibrator On	V_{COMP1} on=	
300 Ω	V_1 with RF Calibrator Off	V_1 off=	
	V_{COMP1} with RF Calibrator Off	V_{COMP1} off=	
	V_1 with RF Calibrator On	V_1 on=	
	V_{COMP1} with RF Calibrator On	V_{COMP1} on=	
400 Ω	V_1 with RF Calibrator Off	V_1 off=	
	V_{COMP1} with RF Calibrator Off	V_{COMP1} off=	
	V_1 with RF Calibrator On	V_1 on=	
	V_{COMP1} with RF Calibrator On	V_{COMP1} on=	

33. Calculate the power which will be used in the VSWR calculation (P_{vswr}) for each resistance using the resistance values from Step 11, the voltage values from Step 31 and the following equation:

$$Pvswr = \frac{2(V1on \times VCOMP1on - V1off \times VCOMP1off) + V1off^2 - V1on^2}{4 \times R}$$

P_{vswr} for 100 ohms, $P_{vswr100}$ = ______________ (should be a number near 1 mV, 0.001 volts)

P_{vswr} for 200 ohms, $P_{vswr200}$ = ______________ (should be a number near 1 mV, 0.001 volts)

P_{vswr} for 300 ohms, $P_{vswr300}$ = ______________ (should be a number near 1 mV, 0.001 volts)

P_{vswr} for 400 ohms, $P_{vswr400}$ = ______________ (should be a number near 1 mV, 0.001 volts)

34. Calculate the variable M for 100, 300 and 400 ohms using the Power values calculated from Step 33, the reflection coefficients from Step 19 and the following equations:

$$M100 = \frac{Pvswr200(1 - |\Gamma 100|^2)}{Pvswr100(1 - |\Gamma 200|^2)} = \_\_\_\_\_\_\_\_\_\_\_\_$$

$$M300 = \frac{Pvswr200(1 - |\Gamma 300|^2)}{Pvswr300(1 - |\Gamma 200|^2)} = \_\_\_\_\_\_\_\_\_\_\_\_$$

$$M400 = \frac{Pvswr200(1 - |\Gamma 400|^2)}{Pvswr400(1 - |\Gamma 200|^2)} = \_\_\_\_\_\_\_\_\_\_\_\_$$

35. Calculate the variable Gamma S (ΓS) for the 100, 300 and 400 resistance values using the M variables from Step 34, the Gamma values from Step 19 and following equations. Each equation will produce two numbers, record the number that is between -1 and +1, and discard the number outside of this range.

$$\Gamma S100 = \frac{2(\Gamma 200 \times M100 - \Gamma 100) \pm \sqrt{(2 \times \Gamma 100 - 2 \times \Gamma 200 \times M100)^2 - 4(\Gamma 200^2 \times M100 - \Gamma 100^2) \times (M100 - 1)}}{2(\Gamma 200^2 \times M100 - \Gamma 100^2)}$$

ΓS100 = ______________

$$\Gamma S300 = \frac{2(\Gamma 200 \times M300 - \Gamma 300) \pm \sqrt{(2 \times \Gamma 300 - 2 \times \Gamma 200 \times M300)^2 - 4(\Gamma 200^2 \times M300 - \Gamma 300^2) \times (M300 - 1)}}{2(\Gamma 200^2 \times M300 - \Gamma 300^2)}$$

ΓS300 = ______________

$$\Gamma S400 = \frac{2(\Gamma 200 \times M400 - \Gamma 400) \pm \sqrt{(2 \times \Gamma 400 - 2 \times \Gamma 200 \times M400)^2 - 4(\Gamma 200^2 \times M400 - \Gamma 400^2) \times (M400 - 1)}}{2(\Gamma 200^2 \times M400 - \Gamma 400^2)}$$

ΓS400 = ______________

36. With the three Gamma S (ΓS) values from Step 35, calculate three VSWR values for the 50 MHz RF Calibrator using the following equations. Record the value nearest to 1 as the VSWR value in the test record, on page A-11.

$$VSWR100 = \frac{(1 + |\Gamma S100|)}{(1 - |\Gamma S100|)}$$

$VSWR_{100}$ = ______________

$$VSWR300 = \frac{(1 + |\Gamma S300|)}{(1 - |\Gamma S300|)}$$

$VSWR_{300}$ = ______________

$$VSWR400 = \frac{(1 + |\Gamma S400|)}{(1 - |\Gamma S400|)}$$

$VSWR_{400}$ = ______________

3-10 1 GHz Calibrator VSWR Verification

(ML248xx-Option 15, ML249xA)

The following procedure is used to measure the VSWR of the RF Calibrator port when the 1 GHz Calibrator is selected on the ML248xx (with option 15) and ML249xA power meters. This procedure uses many calculations. It's recommended to use a spreadsheet to enter the equations and calculate the results.

Required Equipment

- Agilent N432A Power Meter
- Agilent 8478B Power Sensor
- Agilent 34401A DMM or equivalent
- Anritsu S820E VNA, or equivalent

Recording Results

Record measurements and calculations within this procedure, and record the final VSWR result within the Test Records on page A-11.

Procedure

1. Power off the N432A.
2. Connect the power sensor cable to the N432A without connecting the power sensor.
3. Refer to Figure 3-8. Measure the resistance from the Vrf BNC center conductor on the rear of the N432A to Pin 1 of the sensor cable.
4. Power on the N432A.
5. Go to the Channel Menu of the N432A and then scroll through the menu to select Bridge Resistance.
6. The internal N432A resistance can be changed between the 100, 200, 300 and 400 ohm settings. Select the 100 ohm setting.
7. Power off the N432A.
8. With a DMM, measure the resistance of the new Bridge Resistance setting.
9. Record the measurement below.
10. Repeat step 4 through 9 to measure and record the measurements for the 200, 300, 400 Ohm settings.
11. Record the 4 resistance measurements below.

R_{100} = ______________ (A value near 100 ohms)

R_{200} = ______________ (A value near 200 ohms)

R_{300} = ______________ (A value near 300 ohms)

R_{400} = ______________ (A value near 400 ohms)

Figure 3-8. 100, 200, 300 and 400 Ohm Bridge Resistance Measurement

12. Power off the N432A.

13. Attach the 8478B power sensor to the sensor cable.

14. Do not connect the power sensor to any source.

15. Power on the N432A.

16. Allow the N432A to zero the power sensor.

17. After zeroing is complete, attach the power sensor to the S820E or equivalent VNA.

18. Measure the VSWR at 1 GHz for each of the 4 resistance settings and record below:

$VSWR_{100}$ = ______________

$VSWR_{200}$ = ______________

$VSWR_{300}$ = ______________

$VSWR_{400}$ = ______________

19. Using the VSWR values from Step 12 calculate the reflection coefficient, also known as Gamma (Γ) for each of the resistance values, using the following formula:

$$\Gamma = \frac{(VSWR - 1)}{(VSWR + 1)}$$

Γ_{100} = ______________ (should be a number near 0.33)

Γ_{200} = ______________ (should be a number near 0)

Γ_{300} = ______________ (should be a number near 0.2)

Γ_{400} = ______________ (should be a number near 0.33)

20. For each of the resistance settings, connect the 8478B to the RF Calibrator of the DUT,

21. On the N432A, toggle the front panel Display button so that menu 2 of 2 is displayed.

22. Set the N432A to Display Voltages.

23. Press the “Voltages Display” button.

24. Note the measured values “V_1” and “V_{comp1}” as shown in Figure 3-9.

25. Change the N432A Bridge Resistance to 100 ohms as described in steps 5 and 6.

26. Ensure the RF Calibrator on the DUT is turned off.

27. Record the V_1 and V_{comp1} values shown on the N432A into Table 3-5 as V_1 off and V_{comp1} off.

28. Turn on the RF Calibrator on the DUT and allow the measurements to settle for approximately 10 seconds.

29. Record the V_1 and V_{comp1} values on the N432A into Table 3-5, for V_1on and V_{comp1} on.

30. Turn off the RF Calibrator on the DUT.

31. When switching the RF Calibrator between On/Off and Off/On, allow the readings to settle for approximately 10 seconds before recording the results.

32. Repeat step 25 through 31 with the N432A Bridge Resistance set to 200, 300 and 400 ohms.

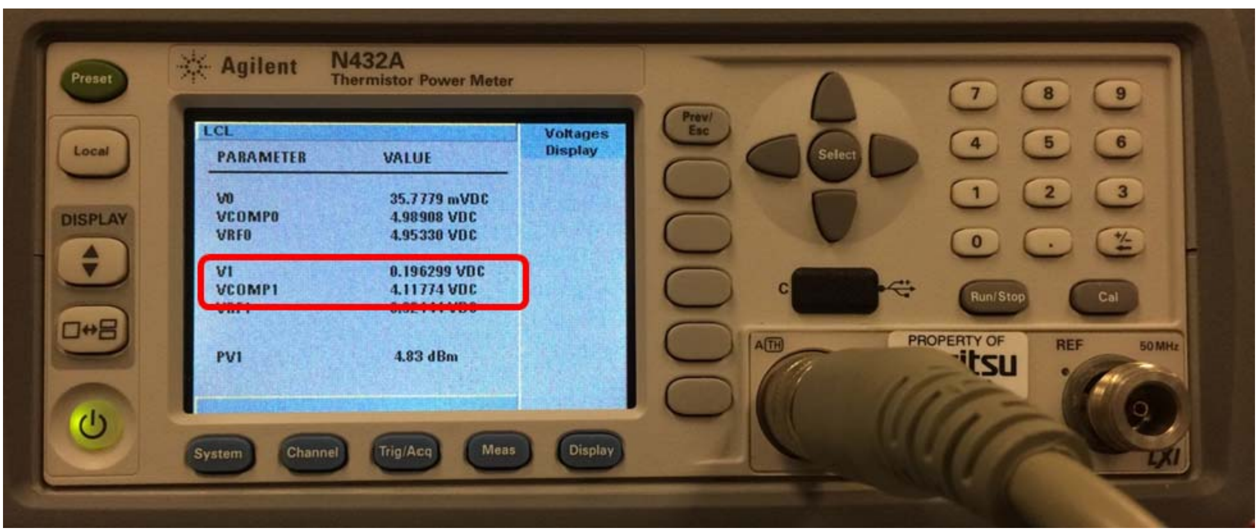


Figure 3-9. V_1 and V_{COMP1} Values Shown on the N432A

Table 3-5. 1 GHz VSWR

Bridge Resistance	Calibrator Setting	V_1 / V_{COMP1} Setting	Measured Value
100 Ω	V_1 with RF Calibrator Off	V_1 off=	
	V_{COMP1} with RF Calibrator Off	V_{COMP1} off=	
	V_1 with RF Calibrator On	V_1 on=	
	V_{COMP1} with RF Calibrator On	V_{COMP1} on=	
200 Ω	V_1 with RF Calibrator Off	V_1 off=	
	V_{COMP1} with RF Calibrator Off	V_{COMP1} off=	
	V_1 with RF Calibrator On	V_1 on=	
	V_{COMP1} with RF Calibrator On	V_{COMP1} on=	
300 Ω	V_1 with RF Calibrator Off	V_1 off=	
	V_{COMP1} with RF Calibrator Off	V_{COMP1} off=	
	V_1 with RF Calibrator On	V_1 on=	
	V_{COMP1} with RF Calibrator On	V_{COMP1} on=	
400 Ω	V_1 with RF Calibrator Off	V_1 off=	
	V_{COMP1} with RF Calibrator Off	V_{COMP1} off=	
	V_1 with RF Calibrator On	V_1 on=	
	V_{COMP1} with RF Calibrator On	V_{COMP1} on=	

33. Calculate the power which will be used in the VSWR calculation (Pvswr) for each resistance using the resistance values from Step 11, the voltage values from Step 27 and the following equation:

$$\text{Pvswr} = \frac{2(\text{V1on} \times \text{VCOMP1on} - \text{V1off} \times \text{VCOMP1off}) + \text{V1off}^2 - \text{V1on}^2}{4 \times \text{R}}$$

Pvswr for 100 ohms, Pvswr_{100} = ______________ (should be a number near 1 mV, 0.001 volts)

Pvswr for 200 ohms, Pvswr_{200} = ______________ (should be a number near 1 mV, 0.001 volts)

Pvswr for 300 ohms, Pvswr_{300} = ______________ (should be a number near 1 mV, 0.001 volts)

Pvswr for 400 ohms, Pvswr_{400} = ______________ (should be a number near 1 mV, 0.001 volts)

34. Calculate the variable M for 100, 300 and 400 ohms using the Power values calculated from Step 33, the reflection coefficients from Step 19 and the following equations:

$$\text{M100} = \frac{\text{Pvswr200}(1 - |\Gamma 100|^2)}{\text{Pvswr100}(1 - |\Gamma 200|^2)} = \underline{\hspace{3cm}}$$

$$\text{M300} = \frac{\text{Pvswr200}(1 - |\Gamma 300|^2)}{\text{Pvswr300}(1 - |\Gamma 200|^2)} = \underline{\hspace{3cm}}$$

$$\text{M400} = \frac{\text{Pvswr200}(1 - |\Gamma 400|^2)}{\text{Pvswr400}(1 - |\Gamma 200|^2)} = \underline{\hspace{3cm}}$$

35. Calculate the variable Gamma S (ΓS) for the 100, 300 and 400 resistance values using the M variables from Step 34, the Gamma values from Step 19 and following equations. Each equation will produce two numbers, record the number that is between -1 and +1, and discard the number outside of this range.

$$\Gamma S100 = \frac{2(\Gamma 200 \times M100 - \Gamma 100) \pm \sqrt{(2 \times \Gamma 100 - 2 \times \Gamma 200 \times M100)^2 - 4(\Gamma 200^2 \times M100 - \Gamma 100^2) \times (M100 - 1)}}{2(\Gamma 200^2 \times M100 - \Gamma 100^2)}$$

ΓS100 = ______________

$$\Gamma S300 = \frac{2(\Gamma 200 \times M300 - \Gamma 300) \pm \sqrt{(2 \times \Gamma 300 - 2 \times \Gamma 200 \times M300)^2 - 4(\Gamma 200^2 \times M300 - \Gamma 300^2) \times (M300 - 1)}}{2(\Gamma 200^2 \times M300 - \Gamma 300^2)}$$

ΓS300 = ______________

$$\Gamma S400 = \frac{2(\Gamma 200 \times M400 - \Gamma 400) \pm \sqrt{(2 \times \Gamma 400 - 2 \times \Gamma 200 \times M400)^2 - 4(\Gamma 200^2 \times M400 - \Gamma 400^2) \times (M400 - 1)}}{2(\Gamma 200^2 \times M400 - \Gamma 400^2)}$$

ΓS400 = ______________

36. With the three Gamma S (ΓS) values from Step 35, calculate three VSWR values for the 1 GHz RF Calibrator using the following equations. Record the value nearest to 1 as the VSWR value in the test record, on page A-11.

$$VSWR100 = \frac{(1 + |\Gamma S100|)}{(1 - |\Gamma S100|)}$$

$VSWR_{100}$ = ______________

$$VSWR300 = \frac{(1 + |\Gamma S300|)}{(1 - |\Gamma S300|)}$$

$VSWR_{300}$ = ______________

$$VSWR400 = \frac{(1 + |\Gamma S400|)}{(1 - |\Gamma S400|)}$$

$VSWR_{400}$ = ______________

Chapter 4 — Adjustment

4-1 Introduction

This chapter describes the process of calibrating the ML248xx and ML249xA Power Meter.

Note	Procedures in this section should be performed by qualified technical personnel only. These procedures require access to internal test points and adjustment potentiometers. Care should be taken to avoid contact with potentially hazardous voltages or damage to the equipment.

4-2 Required Test Equipment

The following test equipment is required to perform the procedures in this chapter.

- Digital Voltmeter (DVM) with ±0.0015 % basic 24 hour DCV accuracy
  Example: Agilent 34401A
- ML2419A Range Calibrator
- Frequency Counter
  Example: Anritsu MF2412A
- Anritsu MA24xxA Series Power Sensor (not MA2411A)
- Non-magnetic tuning wand with a screwdriver tip for 6-32 slotted cores
- Agilent Analog Power Meter 432A to be used in conjunction with:
  - Agilent Voltage Meter 34420A.
  - Agilent Power Sensor 8478B.

Note	Ensure all test equipment is within its calibration period.

4-3 Test Conditions

The power meter must be operated under controlled conditions of temperature and humidity in order to meet its specified precision and stability. All tests should ideally be performed at a temperature of 25 °C ±5 °C (77 °F ±7 °F) and a relative humidity of less than 75 % non-condensing.

4-4 Pre-Test Setup

1. With power disconnected, open the unit by loosening the six captive screws on the underside and separating the top half of the case from the base. Ensure that the front and rear panels remain firmly in place during this operation.
2. Apply power to the unit using the AC inlet on the rear panel and verify that the meter has completed the Power On Self Test (POST).
3. Prior to making any precision measurements, allow the power meter to warm up for a period of 15 minutes from power on. If the power supply is interrupted for any reason, allow a similar settling period.

4-5 DC Reference Calibration

To calibrate the DC Reference:

1. Enter the power meter Service Mode by pressing the front panel keys as follows:

   System | Service **|** Diag **| 0 |** Enter

2. Set the DSP cal number to 6 by pressing the front panel keys as follows:

   DSP Diag Commands **| Sel | 6 |** Enter **|** Send Command

3. Connect a DVM between ZTP17 (gnd) and ZTP205 (+V) on the Measurement PCB. See Figure 4-1 on page 4-3.

4. Measure and record the reading displayed on the DVM in mV. If the reading is a negative value, change the minus (–) to a plus (+).

   Example: If reading = –0.004 V, change to +0.004 V.

5. Subtract the positive reading from Step 4 from 1 V and record this result.

   Example: If reading from Step 4 = 0.004 V

   1.000 V – 0.004 V = 0.996 V

6. Set the DSP cal number to 5 by pressing the front panel keys as follows:

   Sel | 5 | Enter **|** Send Command

7. Connect a DVM between ZTP17 (gnd) and ZTP205 (+V) on the measurement PCB as shown in Figure 4-1.

8. Adjust pot R353 (ML2487/8A) or R82 (ML2495/6A and ML2487/8B) so the DVM reads the value calculated in Step 5, ± 2 mV.

9. Reset the unit by pressing the front panel keys as follows:

   Preset **| Sel**

10. Record results in Section 4-5: DC Reference Calibration of Appendix A, “Test Records”.

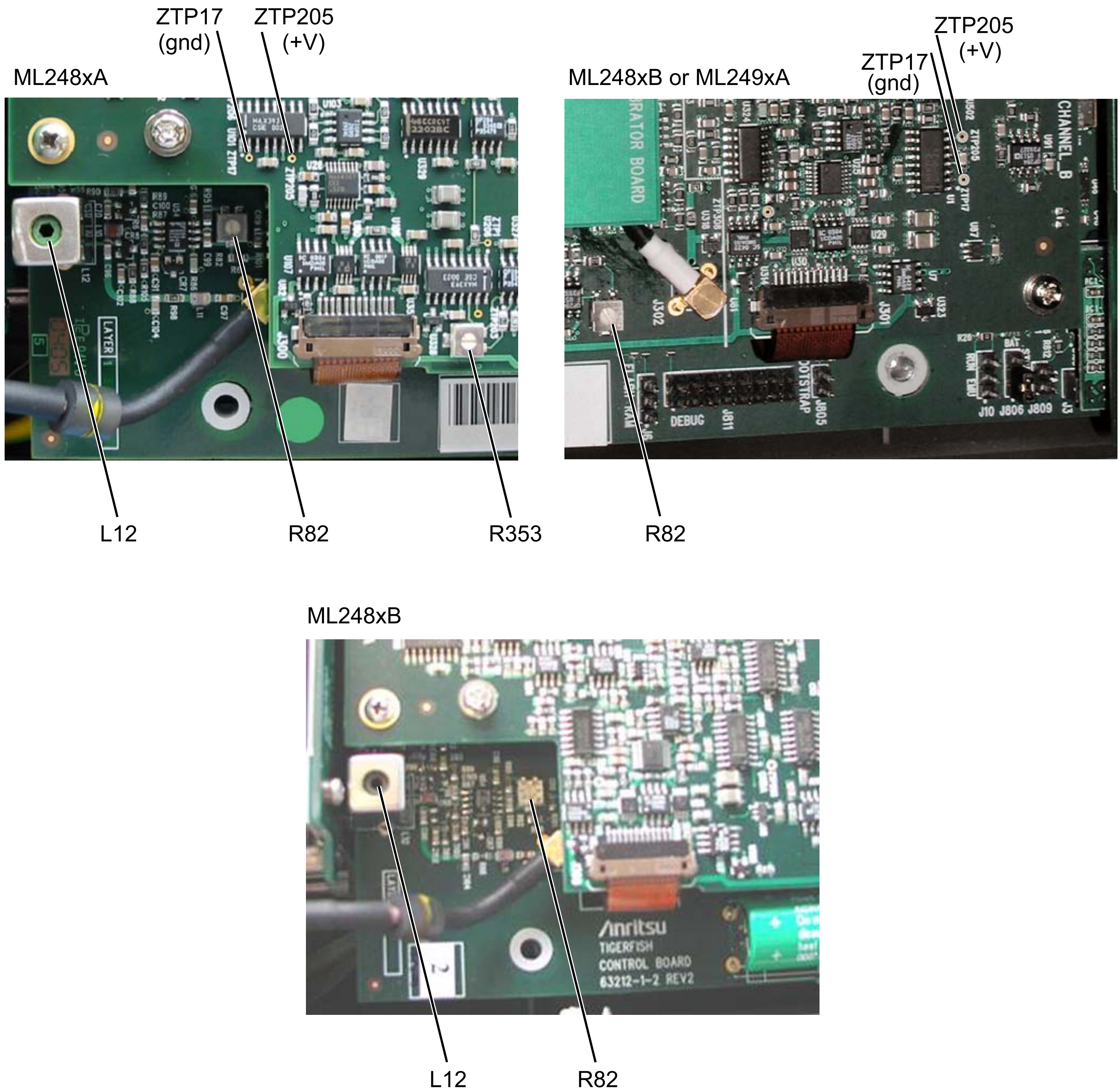


Figure 4-1. Calibration Test and Adjustment Points

4-6 RF Calibrator 50 MHz Frequency (ML248xx without Option 15)

(If the power meter is a ML2495/6A or ML248xx fitted with option 15 (1 GHz reference), go to Section 4-8.)

To calibrate the 50 MHz frequency of the reference:

1. Connect an RF frequency cable from the power meter RF calibrator output to an Anritsu MF2412B frequency counter.
2. Set the RF calibrator to ON at 0 dBm by pressing the front panel keys as follows:

   Call/Zero | Calibrator | Calibrator RF

   A bright green indicator is displayed in the button when the calibrator is switched on.
3. Adjust inductor core L12 with a non-metal adjustment tool for a frequency reading of 50 MHz ±500 kHz. See Figure 4-1 for inductor location.

Note	If a metal adjustment tool is used, it must be removed from inductor L12 before reading the counter, as the metal tool may affect the frequency.

4. Disconnect the frequency counter from the power meter.
5. Record results and calculations in Section 4-6: RF Calibrator 50 MHz Frequency Adjustment (ML248xx without Option 15) of Appendix A.

4-7 RF Calibrator Output Power (ML248xx without Option 15)

To adjust the RF Calibrator output power:

1. If the reference calibrator output power level is outside of the 1 mW ±0.0015 mW limits, adjust R82 and recalculate P_{actual} Upper and P_{actual} Lower with the new V_0, V_1, and V_{comp} numbers using the same equations as in Section 3-7 of Chapter 3.
2. Repeat Step 1 until P_{actual} Upper and P_{actual} Lower are both within specification.
3. Record results and calculations in Section 4-7: RF Calibrator Output Power Adjustment (ML248xx without Option 15) of Appendix A.

4-8 RF Calibrator 50 MHz Frequency and 50 MHz/1 GHz Output Power

Use the following steps to adjust and set the 50 MHz frequency and 50 MHz / 1 GHz Output Power Level on an ML249xA or an ML248xx with option 15 installed. The values are entered into an EPROM on the calibrator board and stored.

Required Equipment

- Frequency Counter: Anritsu MF2412B
- Power Meter: Agilent 432A
- Power Sensor: Agilent 8478B
- Voltmeter: Agilent 34420A Nano Volt, Micro-Ohm Meter

Preliminary Steps

1. Connect RF cable from calibrator to front panel of the MF2412B frequency counter.
2. Connect a GPIB cable from the PC to the unit under test.
3. Apply AC power to power meter and turn on.
4. Open Measurement & Automation Explorer on the PC desk top icon.
5. Navigate to GPIBO (PCI-GPIB) and search for Instrument0 as shown in Figure 4-2.

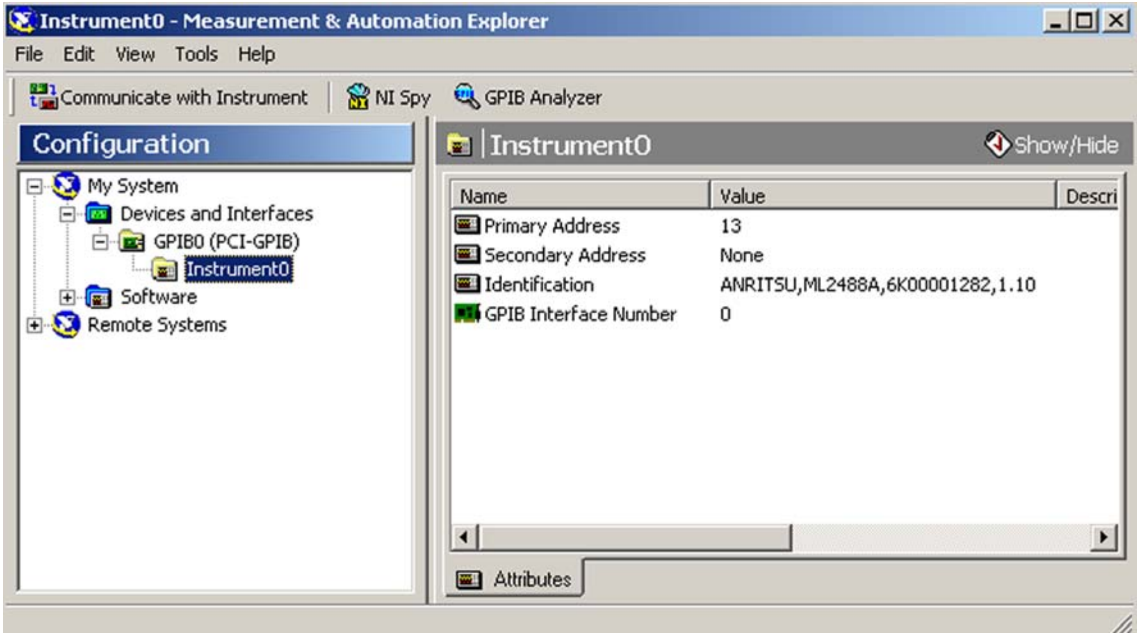


Figure 4-2. Measurement and Automation Explorer

6. Click Communicate with Instrument as shown in Figure 4-3.

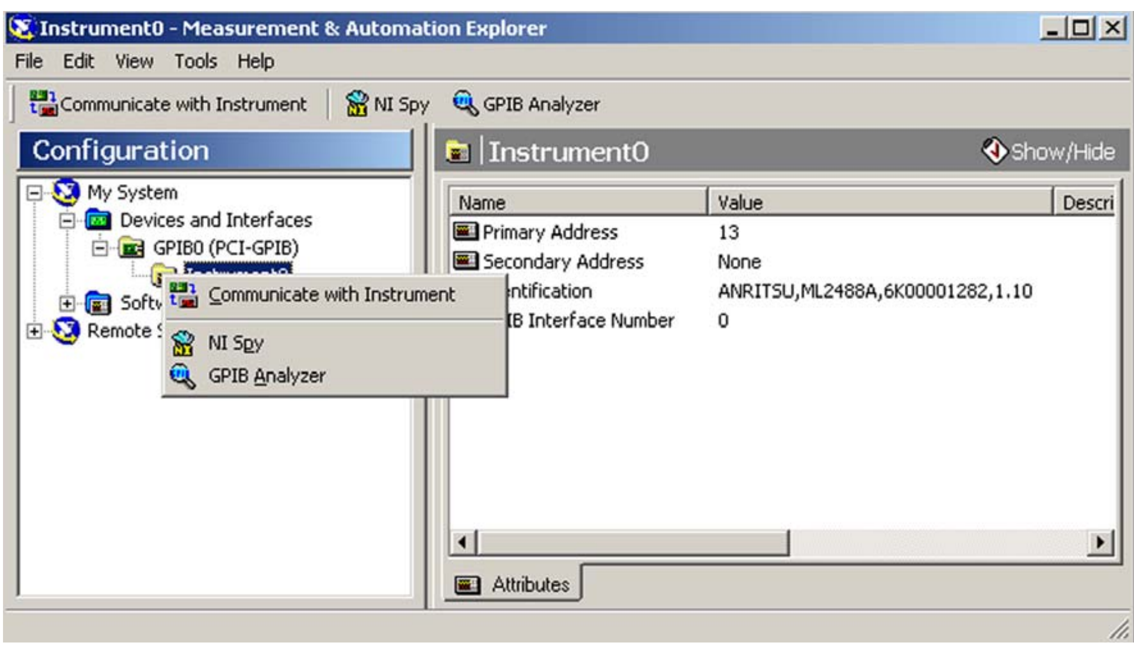


Figure 4-3. Communicate with Instrument

7. In the Send String box (Figure 4-4), type the commands listed below and use the Write or Query button to send and receive data to and from the power meter.

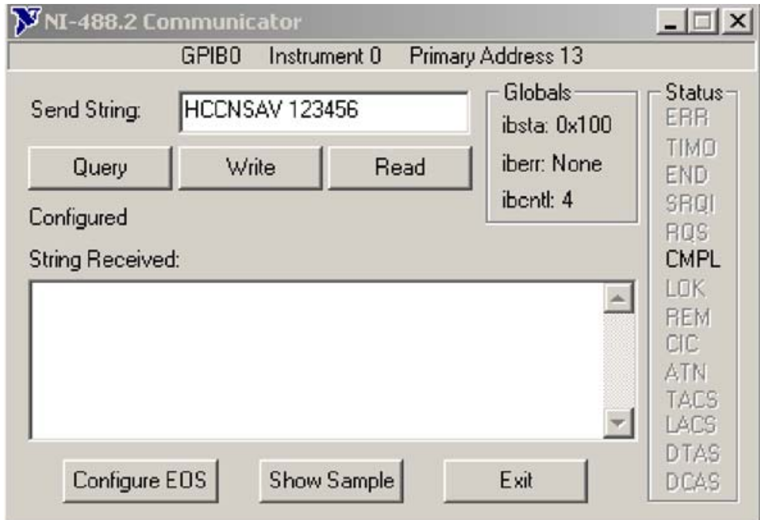


Figure 4-4. Send-Receive Dialogue

Setting up the 50 MHz Frequency

1. Write SNRFCAL ON (turns RF on).
2. Query SNCALF? (Ensure the response is 50 MHZ, if not Write SNCALF 50MHZ).
3. Query HCCFVAL? (Write down this value between 0 and 4095).
4. Note the frequency on the frequency counter and enter a new DAC value (higher than the original value to raise the frequency, or lower than the original value to lower the frequency). Use the following commands to write a new DAC value.
   a. Write HCCFVAL <New Value>

      Continue to adjust the DAC value until the frequency is within specification. Once the frequency is within specification, save the DAC value using the following command:

   b. Write HCCFSAV TRUE,<New Value>
5. To verify the frequency accuracy, repeat Section 3-5 “50 MHz Calibrator Frequency (All Models)” and Section 3-6 “1 GHz Calibrator Frequency (ML248xx-Option 15, ML249xA)”.

Setting up the 50 MHz and 1 GHz Levels

1. Write SNRFCAL ON (turns RF on)
2. Write SNCALF 50MHZ (selects 50 MHz)
3. Query HCCVAL? (Write down this value between 0 and 4095)
4. Write HCCVAL VALUE (Enter value between 0 and 4095 to adjust the 0 dBm level, then write down the new value).

   (This value will adjust the 50 MHz Level O/P. Write this value down as you will use it later)
5. Write SNCALF 1GHz (Select 1 GHz)
6. Write HCCVAL VALUE (Enter value between 0 and 4095)

   (This value will adjust the 1 GHz Level O/P. Note this value down as you will use it later)

7. Save the new 50 MHz and 1 GHz output level DAC values with the following command:

   Write HCCSAV<50MHz Level Value>,<1GHz Level Value>,<Calibration date in the form of MMDDYY>

Verifying Cal Data was Saved

1. To verify that calibration data is saved correctly, use the following command in the Send String box and use the Query button, as shown in Figure 4-5:

   Query HCCALDTO

2. The String Received should be:

   HCCALDTO <Board SN>,<New 50MHz DAC value>,<New 1GHz DAC value>,<date>,<Freq value>

3. Perform Section 3-7 “50 MHz Calibrator Power Level (All Models)” in Chapter 3 to verify the output power is within specification.

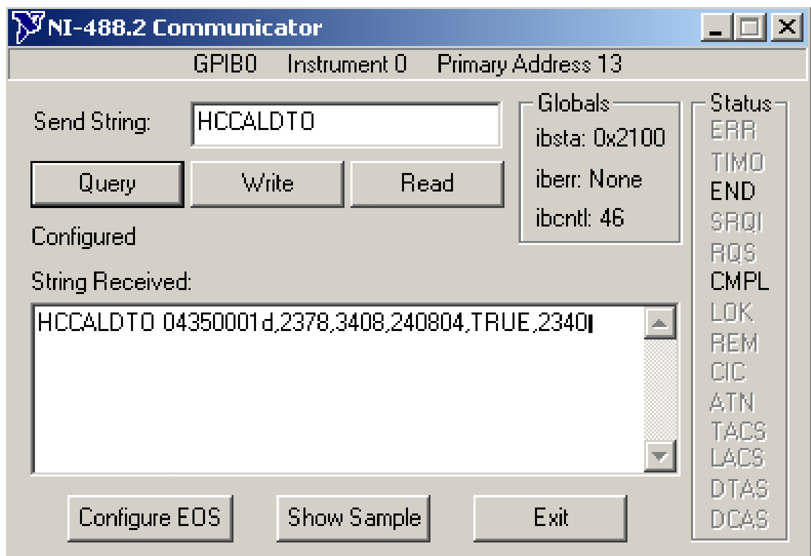


Figure 4-5. Verifying Cal Data Saved Using Query

4. Record results and calculations in Pmeas Calculation of Appendix A, “Test Records”.

Chapter 5 — Troubleshooting

5-1 Introduction

Anristu strongly recommends that power meter repair be performed by qualified technical personnel only. The preferred service policy is exchange of the defective unit. This policy ensures minimum downtime for the customer. Only when unit exchange is not possible should the fault finding and repair work detailed below be used. Refer to Section 1-9 in Chapter 1 for a listing of spare parts mentioned in this chapter. Contact your nearest Anritsu Customer Service or Sales center for price and availability information.

The procedures in this chapter suggest the most likely remedies in a logical order of severity. It is best to follow the steps as presented in order to properly isolate the fault. Refer to the power meter Operation Manual for the specific operating instructions referred to in these procedures. Refer to Chapter 6 for specific module removal and replacement instructions.

5-2 Front Panel and Display

The following procedures refer to possible faults with the power meter front panel and display.

Fault: No Display

Description

With the line power cable connected and the front panel on/off key pressed, there is no display on the unit.

Recommended Action

1. Use the bootload method to load new software to the control PCB. Refer to Chapter 7, “Firmware Updates” for instructions.
2. If the software will not load, replace the control PCB.
3. If the software will load but the front panel still does not operate, replace the front panel assembly.
4. If all the above does not fix the fault, replace the control PCB.

Fault: Keys Inoperable: Display On

Description

With the line power cable connected and the front panel on/off key pressed, there is a display on the unit but the keys do not operate.

Recommended Action

Replace the front panel assembly

Fault: One or More Keys Inoperable: Display On and Operating

Description

Front panel display is working, but the buttons are not working. The front panel LCD operates normally during start up and displays a normal measurement display, but one or all of the front panel buttons do not work.

Recommended Action

1. Reprogram the power meter using the bootload method described in Section 7-3 of Chapter 7, "Firmware Updates".
2. Replace the front panel assembly.
3. Replace the control PCB assembly.

Fault: Measurement Problems with Input A or Input B.

Description

Problems are encountered when calibrating, zeroing, or making power measurements with the power meter on Input A or B.

Recommended Action

1. Remove the top cover and confirm the two flexible cables are correctly seated in J300 and J301 on the right hand side of the measurement PCB.
2. Confirm that the flexible cable has not become disconnected from the front panel Input A and B connectors.
3. If the display indicates Sensor A or B are not fitted when sensors are connected to the front panel Inputs A or B, replace the front panel assembly including the flexible signal channel cable.
4. If both inputs A and B perform a sensor zero, but will not perform a 0 dBm calibration, connect the sensor to another 0 dBm, 50 MHz source and verify proper operation.
5. For all other measurement problems with Input A and B, replace the front panel assembly.
6. If replacing the front panel assembly does not fix the problem, replace the measurement PCB assembly.

Fault: RF Calibrator

Description

The frequency or power level is out of specification or the RF level is not present at all.

Recommended Action

1. If the RF calibrator is ON, yet no power is present at the calibrator connector, replace the N–type connector cable assembly from the control PCB to the front panel.
2. Calibrate the RF reference and output power according to Section 4-6 and Section 4-7. If calibration is not possible, replace the control PCB.

5-3 Rear Panel

The following procedures refer to possible faults with the power meter rear panel.

Fault: Power Meter Will Not Load Firmware.

Description:

It is not possible to load a firmware update or bootload firmware into the unit.

Recommended Action

1. Check that the PC configuration is correct for firmware transfer (refer to Chapter 7).
2. Confirm that the serial cable is correctly wired and not damaged.

3. Replace the control PCB.

Fault: No GPIB Communication

Description:

No GPIB communication occurs when connected to a compatible GPIB controller.

Recommended Action

1. Reset the unit to factory defaults and try again.
2. Replace the control PCB.

Fault: Incorrect Operation of BNC Inputs or Outputs

Description:

One or more of the rear panel BNC connectors fail to operate correctly.

Recommended Action

1. Visually inspect all of the BNC connectors. If any physical damage is observed, replace the control PCB.
2. If there is no physical damage, yet the BNC Inputs or Outputs do not work correctly, replace the control PCB.

5-4 General Faults

The following procedures refer to general system faults.

Fault: Power Meter Loses Non-volatile Memory.

Description:

The power meter loses all non-volatile memory (stored setups, cal factors, cal factor tables, etc.) when powered off for more than two minutes.

Recommended Action

1. Confirm the jumper is fitted to J806 on pins 1 and 2. These are the two pins nearest the outer edge of the control PCB (the STORE ON position, as silk-screened on the PCB).
2. Measure the DC voltage of the lithium battery mounted to the center of the control PCB. This can be measured across pin 1 of J806 and the ground stud on the rear panel. This battery should measure 3.2 V. If the voltage is less than 2.8 V, replace the battery or the control PCB.

Fault: Alarm Buzzer Does Not Sound

Description:

The noise generator does not make any sound or the sound is too low.

Recommended Action

1. Reset the unit to the factory defaults and try again.
2. Replace the control PCB.

Chapter 6 — Removal and Replacement Procedures

6-1 Introduction

Anritsu strongly recommends that power meter repair be performed by qualified technical personnel only. The preferred power meter service policy is the replacement of major sub assemblies or complete unit exchange program.

Always verify the need for a component replacement using the troubleshooting guidelines presented in Chapter 5. Repair or replacement in the field to a level beyond the subassemblies listed in this chapter is not recommended. Refer to Section 1-9 in Chapter 1 for a list of replaceable parts mentioned in this chapter. Contact your nearest Anritsu Customer Service or Sales Center for price and availability information.

Caution	The procedures in this chapter should be performed by qualified technical personnel only. These procedures may require access to internal components, and care should be taken to avoid contact with potentially hazardous voltages or damage from static electricity.

6-2 Power Meter Disassembly

This procedure provides instructions for disassembling the complete power meter unit to its main sub assemblies. When a repair requires an assembly to be replaced, use part or all of the procedure to replace the defective part.

Tools Required

- Phillips screwdriver
- Slotted screwdriver
- 3/16 nut driver
- 5/16 nut driver
- 9/16 deep socket

Measurement PCB Removal (ML2487/8A)

1. Remove the AC power cord.
2. Remove the six captive screws from the underside of the unit and remove the top cover. Ensure that the front and rear panels remain firmly in place during this operation.
3. Remove the six screws and washers that mount the measurement PCB to its support standoffs. See Figure 6-1.

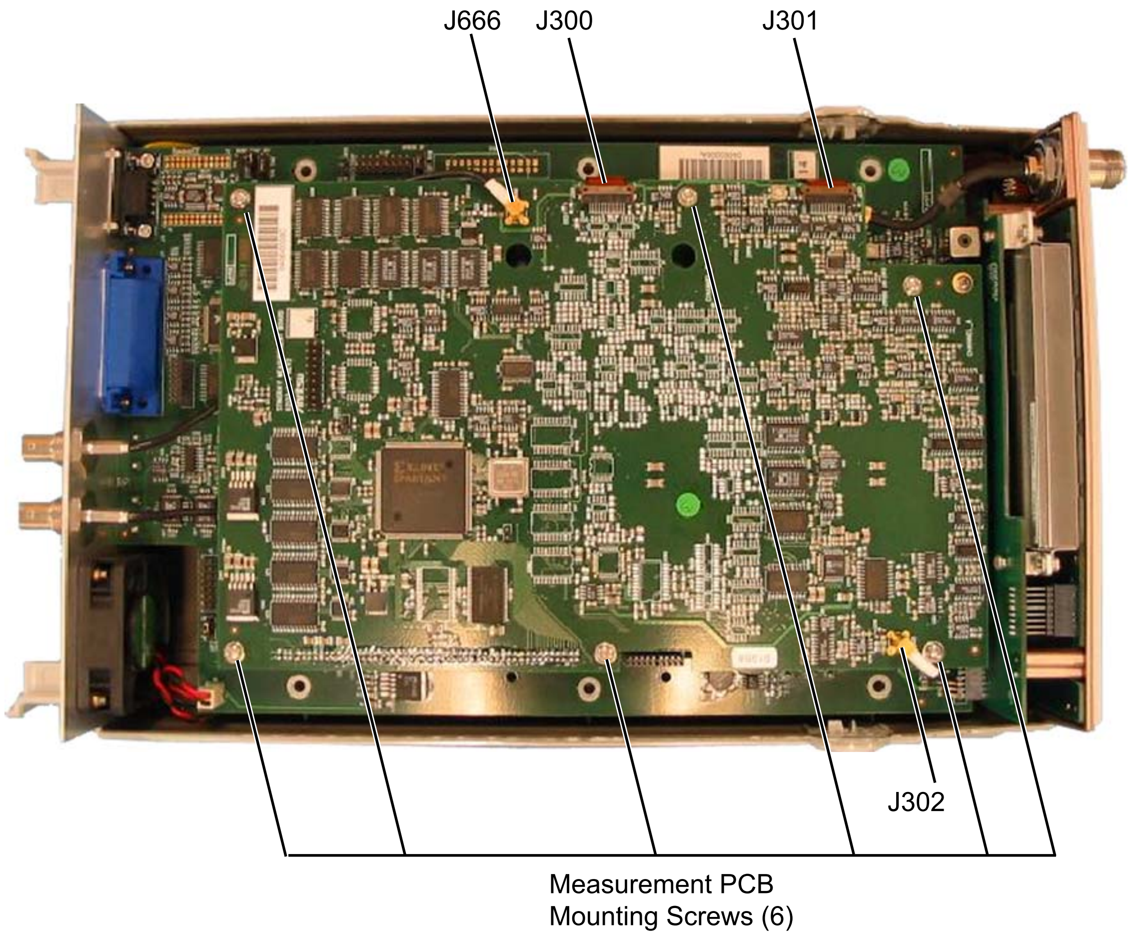


Figure 6-1. Measurement PCB Removal - ML2487/8A

4. Disconnect the MCX connectors from J302 and J666 on the measurement PCB. See Figure 6-1.
5. Disconnect the flexi cable from J300 and J301 on the measurement PCB.

   Pull back the locking tabs first to release the cable. See Figure 6-1.
6. Remove the measurement PCB from the Control PCB, by gently prying apart the two PCBs at the main 100-way PCB-PCB connector. Place the PCB in a safe location.

1GHz Calibrator PCB Removal

1. Remove the AC power cord.
2. Remove the six captive screws on the underside of the unit and remove the top cover. Ensure that the front and rear panels remain firmly in place during this operation.
3. Remove the four screws and washers that mount the calibrator PCB to its support standoffs, then remove the SMA connector. See Figure 6-2.

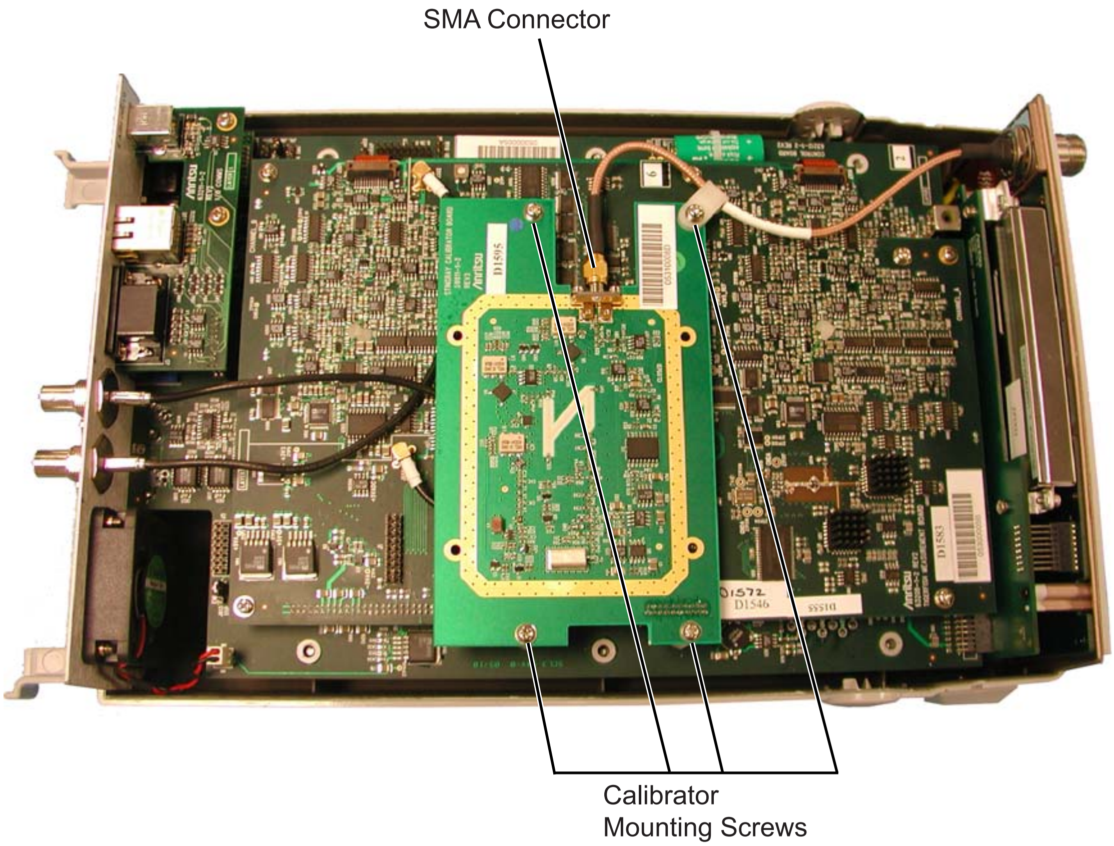


Figure 6-2. 1 GHz Calibrator Removal

Measurement PCB Removal (ML248xB and ML249xA)

1. Remove the six screws and washers that mount the measurement PCB to its support standoffs as shown in Figure 6-3.
2. Disconnect the MCX connectors from J302 and J666 on the measurement PCB.
3. Disconnect the flexi cable from J300 and J301 on the measurement PCB. Pull back the locking tabs first to release the cable.
4. Remove the measurement PCB from the control PCB, by gently prying the two PCBs apart at the main 100-way PCB-PCB connector. Place the PCB in a safe location.

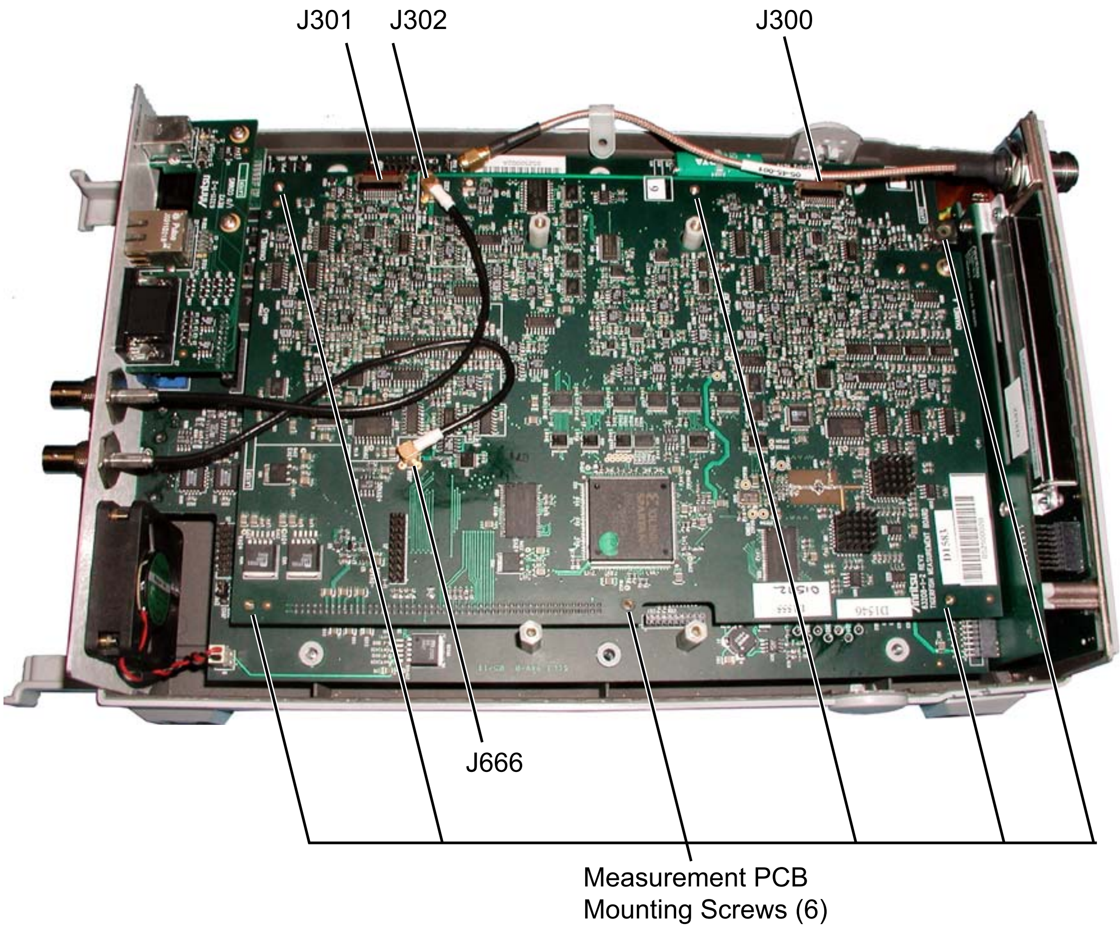


Figure 6-3. Measurement PCB Removal – ML248xB and ML249xA

Main Control PCB Removal

1. Remove the three screws that secure the control PCB to the lower case as shown in Figure 6-4

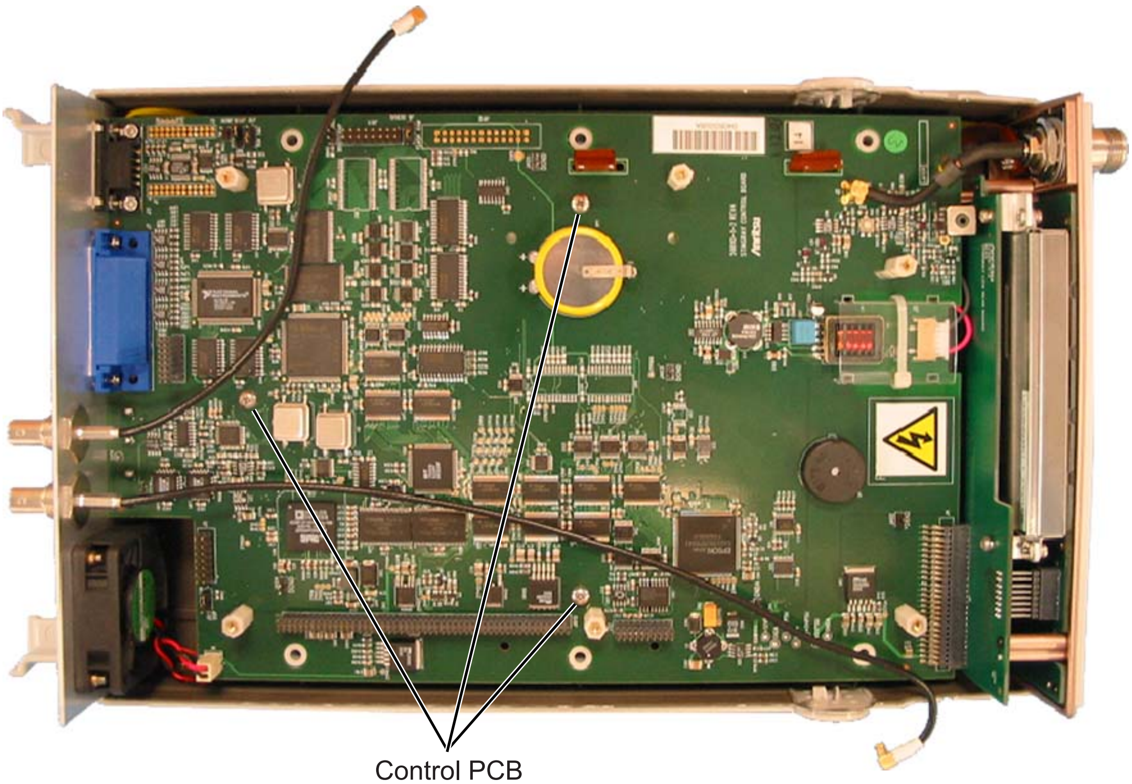


Figure 6-4. Main Control PCB Screw Removal

2. Turn the unit over so that it rests on the front panel and the rear panel. Press down on the rear panel BNC connectors and lift up the lower case. This will break the rear panel free from the lower case. DO NOT attempt to remove the PCB yet.
3. Press down on the front panel from the lower case. DO NOT attempt to remove the front panel yet.

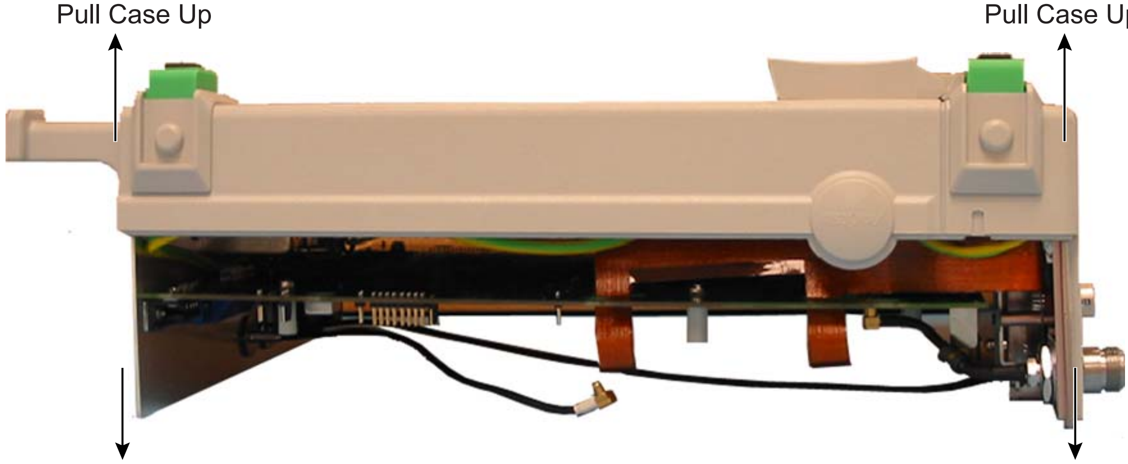


Figure 6-5. Separating Rear Panel From Lower Case

4. Turn the unit over and rest it on its lower case feet.
5. As shown in Figure 6-6 and Figure 6-7, gently lift up the main control PCB and disconnect the line power cable at the PSU connector P1, which connects the rear panel to the PSU.
6. Disconnect the DC supply cable at the PSU connector P2, which connects the PSU to the main control PCB. Lift the rear panel, control PCB and front panel assembly out of the lower case.

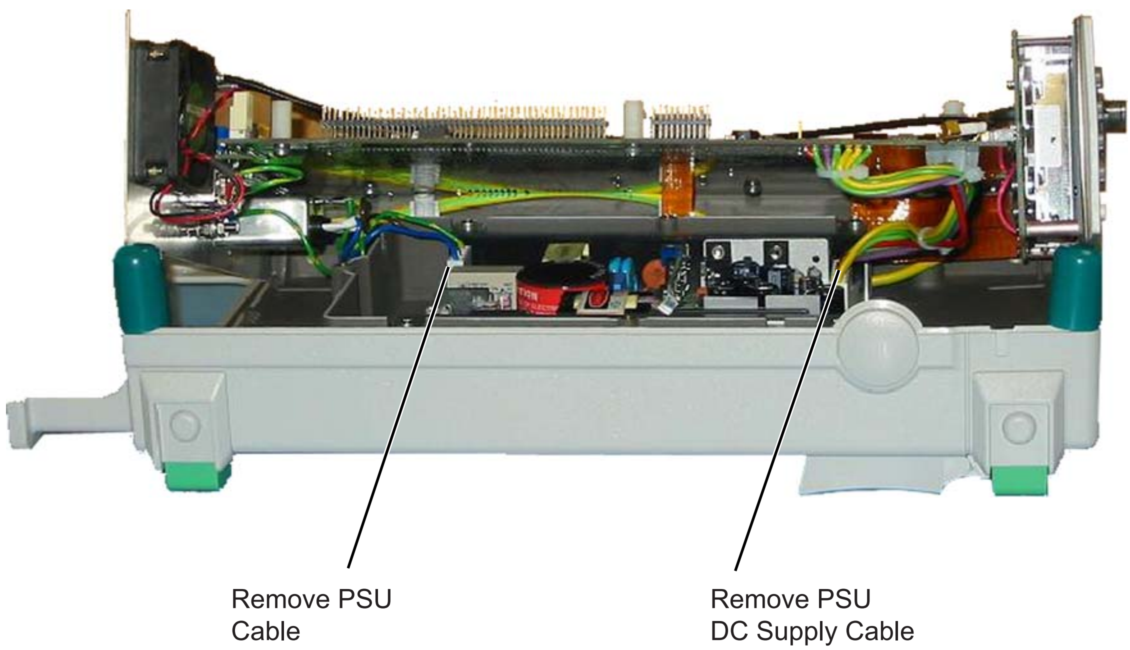


Figure 6-6. PSU Cable Removal

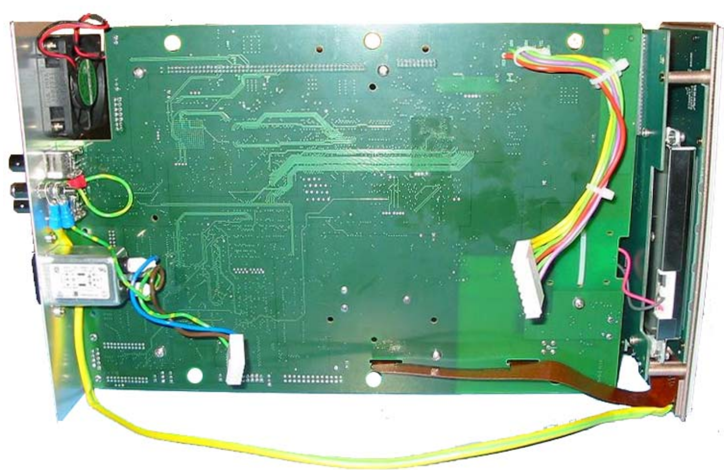


Figure 6-7. Main Control PCB Removed

Front Panel Removal

The front panel assembly is removed from the control PCB. See Figure 6-8 and Figure 6-9.

1. Disconnect the LCD backlight cable from J8 on the control PCB.
2. Disconnect the RF calibrator cable assembly from J2 on the control PCB (not applicable for ML249xA).
3. Remove the front panel PCB from the control PCB, by gently prying the two PCBs apart at the 50-way PCB-PCB connector at J4 on the control PCB.

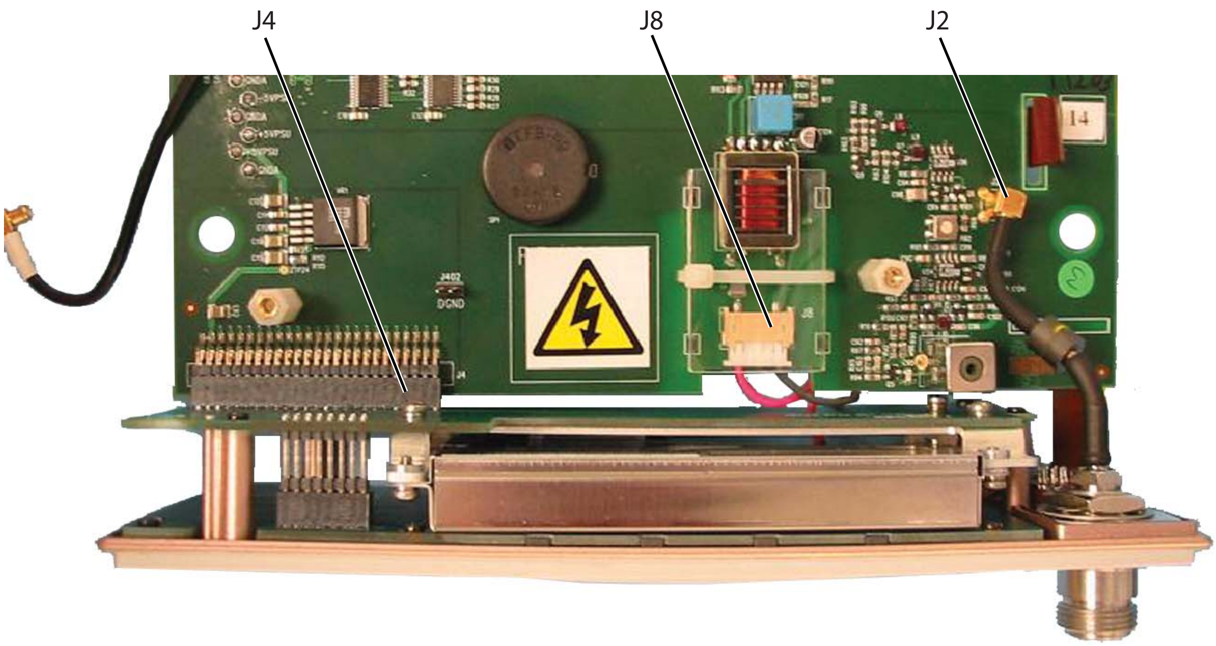


Figure 6-8. Front Panel Removal

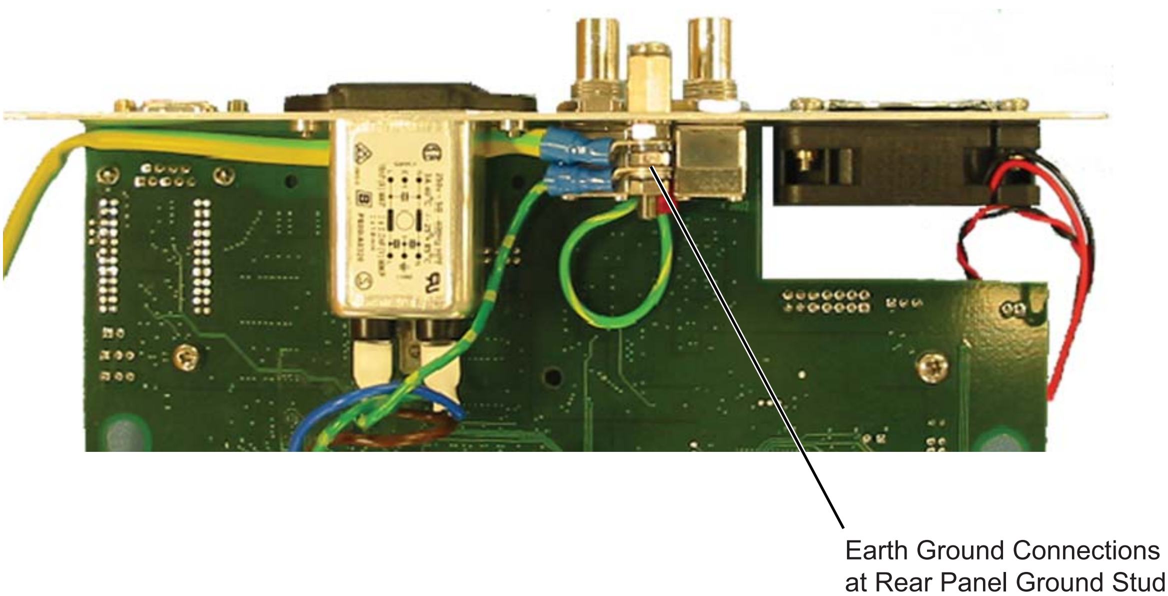


Figure 6-9. Front Panel Ground Removal

4. Undo the locking nuts on the rear panel grounding stud to release the ground cable that connects to the front panel assembly. The front panel assembly is now free.

Rear Panel Removal

The rear panel is removed from the main control PCB. See Figure 6-10 or Figure 6-11, depending on model.

1. Remove the two screws that hold the line power input module to the rear panel. Undo the nut that secures the earth cable to the rear panel stud. Remove the module.
2. Remove the fan cable from J400 on the control PCB assembly.
3. Remove the lock nuts from BNC Output 1 and BNC Output 2. Remove the lock washers.
4. Remove the two screws and washers from the GPIB connector. Remove the two nuts from the connector on the main PCB.
5. Remove the two screws and washers from the RS-232 connector. The rear panel is now free.
6. Remove the screws and nuts at the locations shown below.

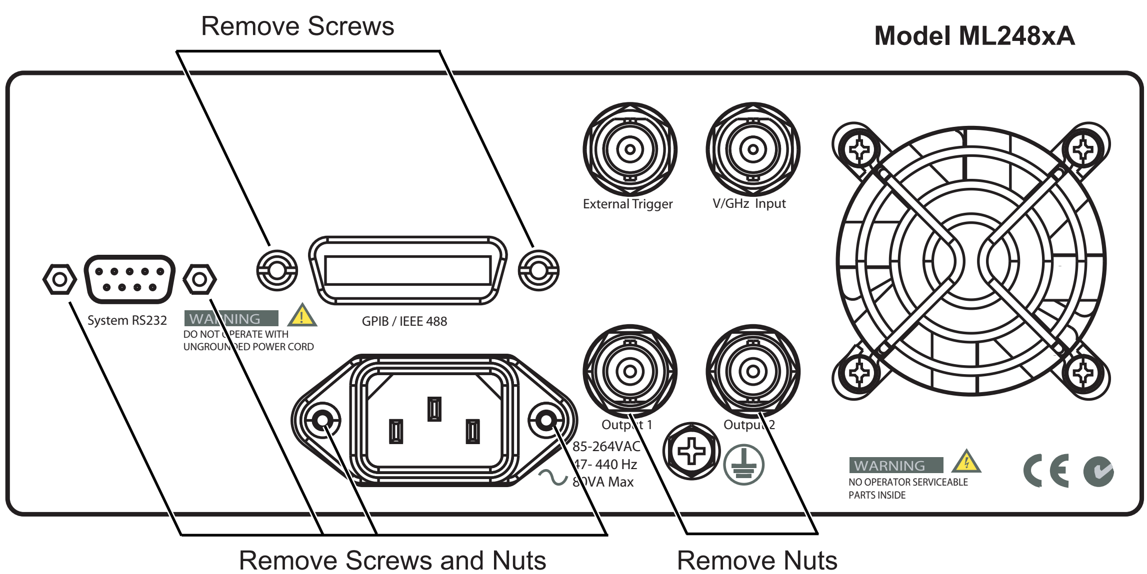


Figure 6-10. Rear Panel Removal (ML248xA)

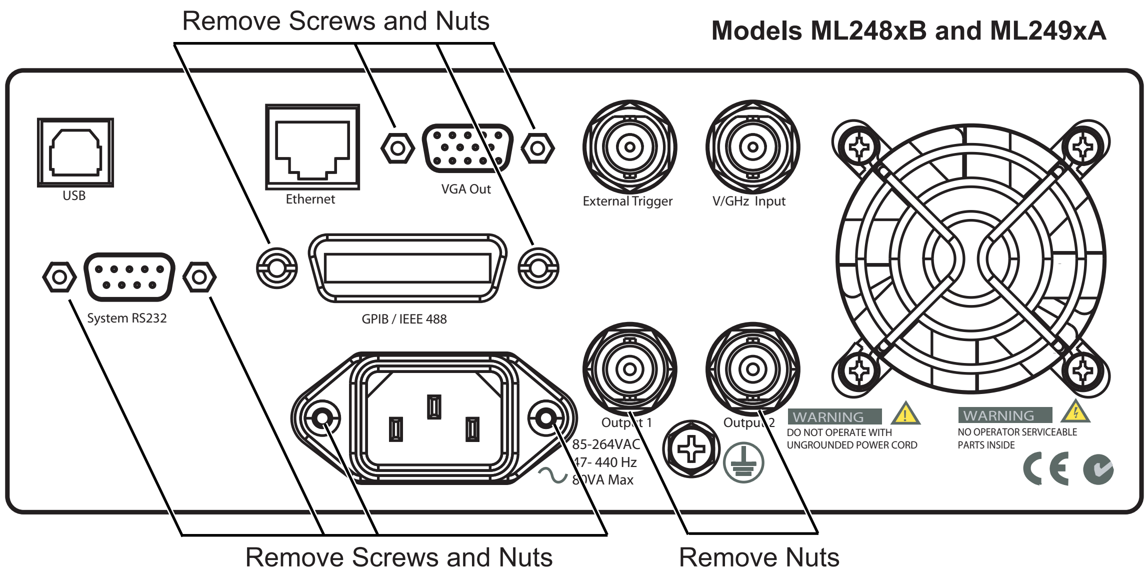


Figure 6-11. Rear Panel Removal (ML248xB and ML249xA))

PSU Assembly Removal

1. Remove the four screws that hold the PSU mounting bracket in the lower case as shown in Figure 6-12. Lift the PSU out of the lower case.
2. Remove the four mounting screws that hold the PSU in the PSU mounting bracket. The PSU is now free.

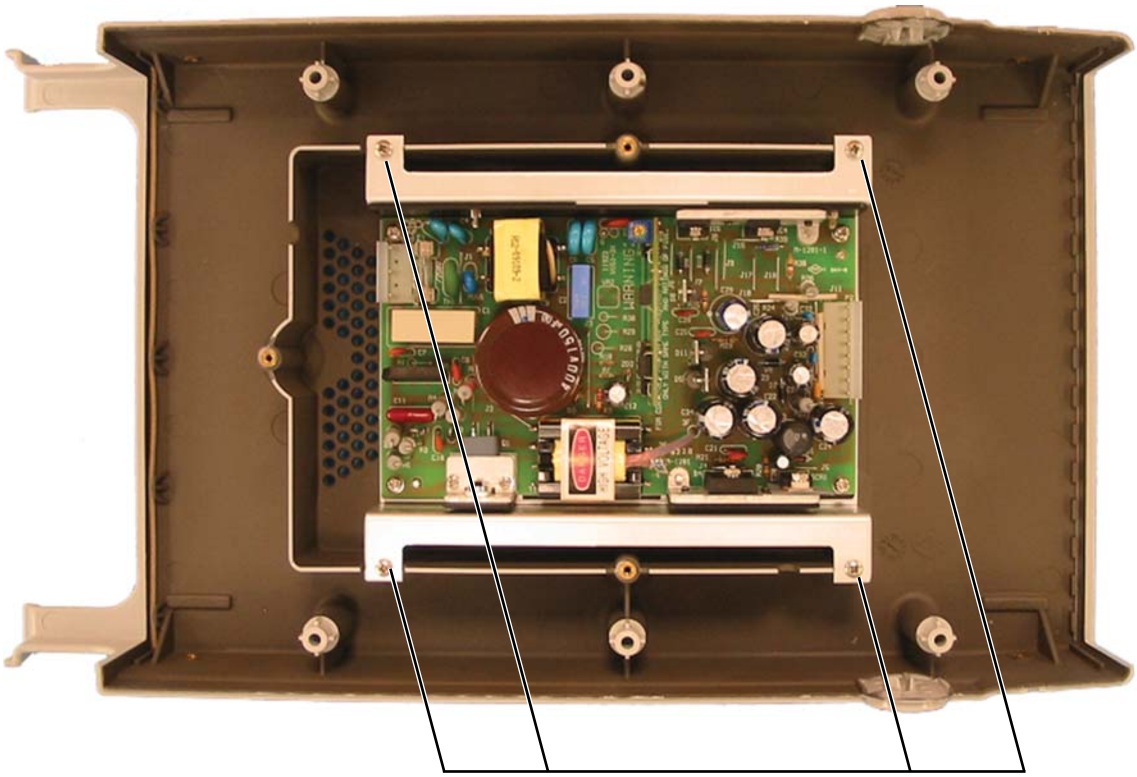


Figure 6-12. PSU Removal

6-3 Power Meter Reassembly

Installation of any assembly is the reverse of the disassembly procedure listed above.

Caution	When rebuilding the meter, pay special attention the location and routing of the AC power cable that connects from the PSU at P1 to the rear panel, and the DC supply cable that connects from the PSU at P2 to the control PCB. These cables can become trapped and pinched if incorrectly positioned. See Figure 6-13 below for the correct position.

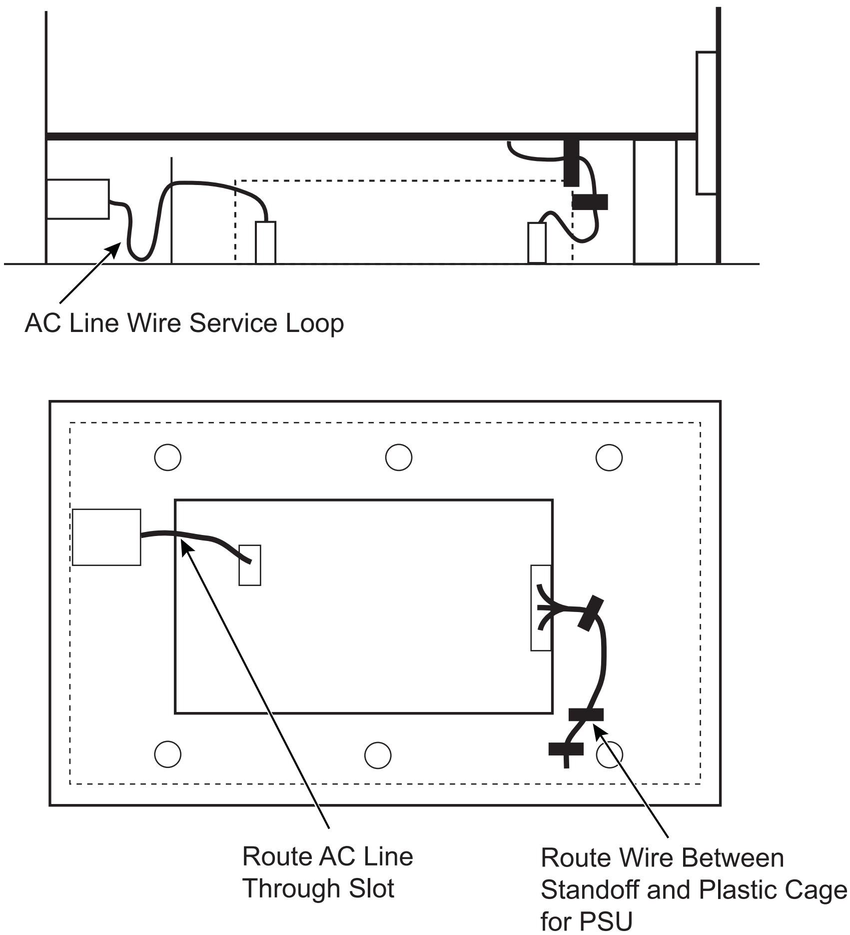


Figure 6-13. Correct AC and DC Line Wiring

Chapter 7 — Firmware Updates

7-1 Introduction

The power meter uses a flash EPROM to store the operating program. New versions of the operating program can be installed using a personal computer connected through the serial interface. Firmware updates are available from your nearest Anritsu Customer Service Centre.

This chapter describes the use of the Code Loader Program and the configuration of the required RS-232 cable. Also described is the procedure to change the serial number of the unit. This will allow a new control PCB to be fitted and then the unit serial number to be programmed in to the new PCB.

7-2 Code Loader Program

The Code Loader Program is a DOS based program used to transfer updated firmware into the Flash Memory.

Program Installation

1. Extract the contents of the zip file into an empty directory on the hard drive of your computer.
2. The installation on the computer is now complete.

Running the Program

Caution	Disable Windows screen savers before attempting to run the code loader program. Do not interrupt the downloading process as corruption of the EPROM program may result (refer to Section 7-3).

1. Connect the computer serial COM port to the power meter back panel RS-232 serial connector, using the Anritsu Serial Interface cable (P/N: B41323) or equivalent (refer to Section 7-4).
2. Apply power to the power meter and allow it to complete the POST (Power On Self Test). Power sensors need not be connected at this time.
3. On the power meter front panel, press:
   a. **System |** Service **|** Upgrade

      A message displays prompting the user to ensure that the serial cable is connected.

   b. Check the cable and press Continue when ready.

      A message displays to notify the user that software is being downloaded.
4. If the bootload cable is connected to port 1 of your personal computer, double click on the shortcut icon boot1. (This is in the directory to which that the zip file was extracted). If connected to port 2, use boot2.

   The program will proceed to download the new operating system to the power meter.

   The program takes about 10 minutes to complete the update, during which time the power meter LCD screen will be dark. When the downloading is complete, the power meter will reboot and be ready for normal use.
5. Disconnect the serial interface cable from the computer and the power meter.
6. Verify that the new firmware version was successfully installed by pressing:

   System | Services **|** Identity
7. The new firmware version will be displayed on the front panel.

7-3 Bootload Mode

If power is lost during programming or the EPROM has been corrupted in some way, the power meter can be forced into a special "bootload" mode and reprogrammed. See Figure 7-1 for jumper location.

Caution	The procedure in this section should be performed by qualified technical personnel only. This procedure requires access to internal components and care should be taken to avoid contact with potentially hazardous voltages.

1. With AC power disconnected, open the unit by loosening the six captive screws on the underside and separating the top half of the case from the base. Ensure that the front and rear panels remain firmly in place during this step.
2. Connect the computer serial COM port to the power meter back panel RS-232 serial connector, using the Anritsu Serial Interface cable (Anritsu P/N: B41323) or equivalent (see Section 7-4).
3. Install a jumper (Anritsu P/N: 551-577) to J805 (BOOTSTRAP) located to the rear right hand side of the Control PCB board. This will force the power meter into the bootload mode when power is applied.
4. Apply AC power to the power meter.
5. Go to Step 4 of "Running the Program" on page 7-1 and load the program as described.
6. Remove power from the meter and remove the jumper.
7. Replace the top cover, taking care not to over tighten the captive screws (50Ncm).

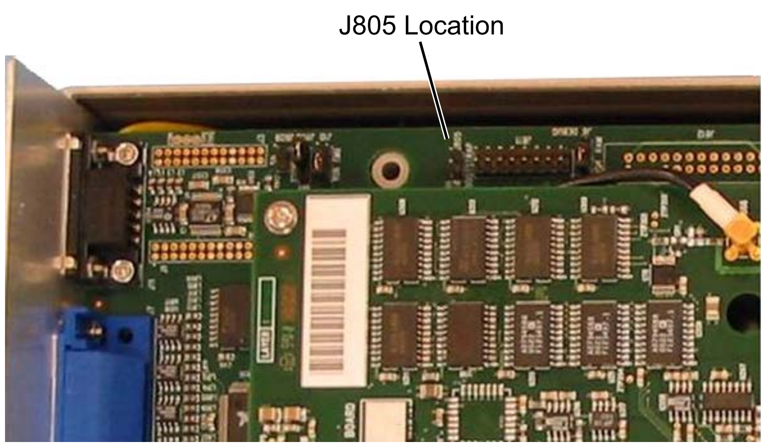


Figure 7-1. Location of J805

7-4 Serial Interface Cable

The 9-pin null-modem serial interface cable necessary for upgrading the power meter firmware is available from the Anritsu Customer Service department.

Order Anritsu part number 2000-1544.

The cable can also be assembled from the following readily available components:

- 2 meters of 8-conductor cable (Anritsu P/N: 800-365).
- 2 each, 9-pin female D-connectors.

Assemble the cable according to the following connection diagram and description.

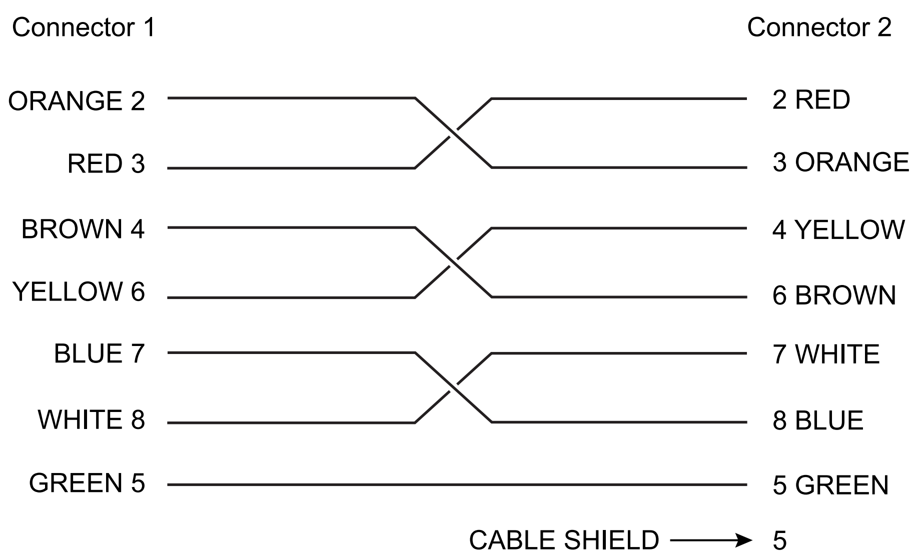


Figure 7-2. Serial Interface Cable Connections

Table 7-1. Serial Interface Cable Connections

D-Connector Number 1 Pin	To	D-Connector Number 2 Pin
2	**Connect To:**	3
3		2
4		6
5		5
6		4
7		8
8		7
–		Pin 5 to Cable shield

Appendix A — Test Records

A-1 Introduction

This appendix provides tables for recording the results of the performance verification tests (Chapter 3) and the calibration procedures (Chapter 4). They jointly provide the means for maintaining an accurate and complete record of instrument performance.

Some test records are customized to cover particular ML248xA, ML248xB and ML249xA options. These records contain references to frequency parameters and power levels that are applicable to the instrument with that option. When a test record is customized, it is labeled with the specific option that it covers. Test records which are not customized do not specify an option list.

A-2 Measurement Uncertainty

All test records are provided with a measurement uncertainty, which consists of the type-B[1] components. The error contributions are measurement method, test equipment, standards, and other correction factors (for example, calibration factors and mismatch error) per the prescribed test procedure. The statement(s) of compliance with specification[2] is based on a 95 % coverage probability for the expanded uncertainty of the measurement results on which the decision of compliance is based. Other values of coverage probability for the expanded uncertainty may be reported, where practicable, for some of the measured values it is not possible to make a statement of compliance with specification[2].

A-3 Test Records

We recommend that you make a copy of the test record pages each time a test procedure is performed. By dating each test record copy, a detailed history of the instrument's performance can be accumulated.

1. BIPM JCGM 100:2008 Evaluation of measurement data–Guide to the expression of uncertainty in measurement.
2. LAC–G8:03/2009: Guidelines on the Reporting of Compliance with Specification.

ML248xx, ML249xA	Firmware Revision:	Operator:
Serial Number:	Date:	Options:

Section 3-4: Input Range Verification

Measurements and Calculated Error Figure

Range	Measured (dB) Channel A	Measured (dB) Channel B	Expected Level	Error (dB) (Meas–Expected) CH A	Error (dB) (Meas–Expected) CH B
Range 1 Upper Level			–0.9540 dB		
Range 1 Lower Level			–11.8342 dB		
Range 2 Upper Level			–11.8342 dB		
Range 2 Lower Level			–25.7741 dB		
Range 3 Upper Level			–25.8606 dB		
Range 3 Lower Level			–41.8031 dB		
Range 4 Upper Level			–41.8031 dB		
Range 4 Lower Level			–57.8139 dB		
Range 5 Upper Level			–57.8139 dB		
Range 5 Lower Level			–61.7260 dB		
Range 7 Upper Level (ML2487/8B & ML249xA)			–0.9540 dB		
Range 7 Lower Level (ML2487/8B & ML249xA)			–11.8342 dB		
Range 8 Upper Level (ML2487/8B & ML249xA)			–11.8342 dB		
Range 8 Lower Level (ML2487/8B & ML249xA)			–16.8965 dB		
Range 9 Upper Level (ML2487/8B & ML249xA)			–16.8965 dB		
Range 9 Lower Level (ML2487/8B & ML249xA)			–25.7741 dB		

RF Calibrator Output 0 dBm

Specification	Level	Error	Pass/Fail	
± 0.03 dBm				

ML248xx, ML249xA	Firmware Revision:		Operator:
Serial Number:		Date:	Options:

Error, Linearity and Range Change Calculations

From Error Measurements in Above Table	Calculated (dB)		Specification (dB)	Results (Pass/Fail)	
	CH A	CH B	CH A & CH B	CH A	CH B
Range 1 Abs Error (R1U Meas–Expected Lvl)			–0.020 ≤ R1U ≤ 0.020		
Range 1 Linearity (R1U Error–R1L Error)			–0.040 ≤ R1U–R1L ≤ 0.040		
Ranges 1-2 Change (R1L Error–R2U Error)			–0.030 ≤ R1L–R2U ≤ 0.030		
Range 2 Linearity (R2U Error–R2L Error)			–0.040 ≤ 2RU–R2L ≤ 0.040		
Ranges 2-3 Change (R2L Error–R3U Error)			–0.030 ≤ R2L–R3U ≤ 0.030		
Range 3 Abs Error (R3U Meas–Expected Lvl)			–0.020 ≤ R3U ≤ 0.020		
Range 3 Linearity (R3U Error–R3L Error)			–0.040 ≤ R3U–R3L ≤ 0.040		
Ranges 3-4 Change (R3L Error–R4U Error)			–0.030 ≤ R3L–R4U ≤ 0.030		
Range 4 Linearity (R4U Error–R4L Error)			–0.040 ≤ R4U–R4L ≤ 0.040		
Range 4-5 Change (R4L Error–R5U Error)			–0.030 ≤ R4L–R5U ≤ 0.030		
Range 5 Linearity (R5U Error–R5L Error)			–0.040 ≤ R5U–R5L ≤ 0.040		
Range 7 Abs Error (R7U Meas–Expected Lvl)			–0.030 ≤ R7U ≤ 0.030		
Range 8 Abs Error (R8U Meas–Expected Lvl)			–0.030 ≤ R8U ≤ 0.030		
Range 8 Linearity (R8U Error–R8L Error)			–0.085 ≤ R8U–R8L ≤ 0.085		
Range 9 Abs Error (R9U Meas–Expected Lvl)			–0.050 ≤ R9U ≤ 0.050		
Range 9 Linearity (9U Error–R9L Error)			–0.18 ≤ R9U–R9L ≤ 0.18		

ML248xx, ML249xA	Firmware Revision:		Operator:
Serial Number:		Date:	Options:

Section 3-5: 50 MHz Calibrator Frequency Verification (All Models)

Calibrator Frequency Uncertainty

F_{meas} = ________________ Hz

Residual Error:

$$ERR_{Res} = \frac{F_{meas}}{1 \times 10^{10}}$$

$$U_f = \pm 2\sqrt{\left(\frac{1}{\sqrt{3}}\right)^2 + (ERR_{res})^2 + (F_{meas} \times TBA)^2}$$

$$U_f = \_\_\_\_\_\_\_\_ \text{ Hz}$$

Specification = $F_{meas} \pm U_f$ is within the range of 50 MHz ± 500 kHz

ML248xx, ML249xA	Firmware Revision:		Operator:
Serial Number:		Date:	Options:

Section 3-6: 1 GHz Calibrator Frequency Verification (ML248xx-Option 15, ML249xA)

Calibrator Frequency Uncertainty

F_{meas} = ___________________ Hz

Residual Error:

$$ERR_{Res} = \frac{F_{meas}}{1 \times 10^{10}}$$

$$U_f = \pm 2\sqrt{\left(\frac{1}{\sqrt{3}}\right)^2 + (ERR_{res})^2 + (F_{meas} \times TBA)^2}$$

$$U_f = \_\_\_\_\_\_\_\_ \text{ Hz}$$

Specification = $F_{meas} \pm U_f$ is within the range of 1 GHz ± 20 MHz

ML248xx, ML249xA	Firmware Revision:		Operator:
Serial Number:		Date:	Options:

Section 3-7: 50 MHz Calibrator Power Level Verification (All Models)

Pmeas Calculation

Measured: V_0 = ___________ V V_1 = ___________ V V_{comp} = ___________ V	Calculated: P_{meas} = ___________ V

Calculated:

$$P_{meas} = \left[\frac{2 \times V_{comp} \times (V_1 - V_0) + V_0^2 - V_1^2}{4 \times R \times EE \times M}\right]$$

$$M = \frac{1 - |\Gamma_d|^2}{|(1 \pm \Gamma_s \times \Gamma_d)^2|}$$

Where:	
$M = \frac{1 - \|\Gamma_d\|^2}{\|(1 \pm \Gamma_s \times \Gamma_d)^2\|}$	Worst case value for M (should be used in the P_{meas} equation above)
Γ_d = _________	Reflection coefficient magnitude of the 8478B sensor (found in the 8478B calibration data)
EE = _________	Effective Efficiency of the 8478B sensor (found in the 8478B calibration data)
U_e = _________	Effective Efficiency uncertainty of the 8478B sensor found in the 8478B calibration data; needed for Uncertainty calculation in Step 2 of Section 3-7)
$\Gamma_s = 0.019$	Reflection coefficient magnitude of the ML248xx and ML249xA Reference Calibrator output.(needed for uncertainty calculation in Step 2 of Section 3-7)
R = _________	Mount Resistance of the 432A Power Meter
V_{comp} = ______	From Step 15, of Section 3-7.
V_1 = _________	From Step 14, of Section 3-7
V_0 = _________	From Step 12, of Section 3-7
P_{meas} = _________	Calculated from the P_{meas} equation, above

ML248xx, ML249xA	Firmware Revision:		Operator:
Serial Number:		Date:	Options:

Calibrator Power Level Uncertainty

Equations for Uncertainty Calculations

Standard Uncertainty Calculation

$$\text{Standard Uncertainty } X_{unc} = \frac{1}{(Divisor)} \times (\text{Uncertainty}) \times (\text{SensitivityC}_{ix})$$

Source Uncertainty Calculations

$$V_{comp}Unc = \frac{1}{\sqrt{3}} \times (0.00003 \times V_{comp} + 0.000004 \times 10V) \times \left(\frac{2(V_1 - V_0)}{4 \times R \times EE \times M}\right)$$

$$V_0Unc = \frac{1}{\sqrt{3}} \times \left(\sqrt{2 \times (0.00003 \times V_{comp} + 0.0000004 \times 10V)^2}\right) \times \left(\frac{-2(V_{comp} - V_0)}{4 \times R \times EE \times M}\right)$$

$$V_1Unc = \frac{1}{\sqrt{3}} \times \left(\sqrt{2(0.00003 \times V_{\text{comp}} + 0.000004 \times 10V)^2}\right) \times \left(\frac{2(V_{comp} - V_1)}{(4 \times R \times EE \times M)}\right)$$

$$R_{Unc} = \frac{1}{\sqrt{3}} \times (0.00006 \times \text{R} + 0.000002 \times (1000)) \times \left(\frac{-2V_{comp}(V_1 - V_0) - V_0{}^2 + V_1{}^2}{4 \times R^2 \times EE \times M}\right)$$

$$EE_{Unc} = \frac{1}{1} \times \left(\frac{U_e}{2}\right) \times \left(\frac{-2V_{comp}(V_1 - V_0) - V_0{}^2 + V_1{}^2}{4 \times R \times EE^2 \times M}\right)$$

$$M_{Unc} = \frac{1}{\sqrt{2}} \times (2 \times \Gamma_{\text{s}} \times \Gamma_{\text{d}}) \times \left(\frac{-2V_{comp}(V_1 - V_0) - \text{V}_0{}^2 + \text{V}_1{}^2}{4 \times \text{R} \times EE \times M^2}\right)$$

$$CR_{Unc} = \frac{1}{1} \times (0.1\%) \times (0.001W) = 0.000001W$$

$$\text{Combined Uncertainty} = \sqrt{V_{comp}Unc^2 + V_1Unc^2 + V_0Unc^2 + R^2_{\text{Unc}} + EE^2_{Unc} + M^2_{Unc} + CR^2_{Unc}}$$

$$(\text{K} = 2) = 2 \times \text{Combined Uncertainty} \times 1000 \text{ (95\% level of confidence)}$$

Uncertainty Results: ML24xxx Reference Calibrator Output Power Level

Sources of Uncertainty	Unit	Readings	Uncertainty	Units	Divisor	Sensitivity	Units	Standard Uncertainty (W)	Standard Uncertainty (μW)
V_{comp}	(V)			(V)			(V/Ohm)		
V0	(V)			(V)			(V/Ohm)		
V1	(V)			(V)			(V/Ohm)		
R	(Ω)			(Ω)			(W/Ohm)		
EE	-			-			W		
M	-			-			W		
CR	-			-			W		
								Combined Uncertainty (μW)	
								Expanded Uncertainty (K = 2) (mW)	
								Expanded Uncertainty (K = 2) (%)	

Expanded Uncertainty, P_{actual} Lower, P_{actual} Upper

Expanded Uncertainty (K = 2) = _______________(mW) (determined from the above equations)

$P_{actual} = P_{meas} \pm P_{meas}$ x Expanded Uncertainty (K = 2) (%)

P_{actual} Lower = _____________mW

P_{actual} Upper = _____________mW

ML248xx, ML249xA	Firmware Revision:		Operator:
Serial Number:		Date:	Options:

Section 3-8: 1 GHz Calibrator Power Level Verification (ML248xx-Option 15, ML249xA)

Pmeas Calculation

Measured:	Calculated:
V_0 = ____________ V V_1 = ____________ V V_{comp} = ____________ V	P_{meas} = ____________ V

Calculated:

$$P_{meas} = \left[\frac{2 \times V_{comp} \times (V_1 - V_0) + V_0^{\ 2} - V_1^{\ 2}}{4 \times R \times EE \times M}\right]$$

$$M = \frac{1 - |\Gamma_d|^2}{|(1 \pm \Gamma_s \times \Gamma_d)^2|}$$

Where:	
$M = \frac{1 - \lvert\Gamma_d\rvert^2}{\lvert(1 \pm \Gamma_s \times \Gamma_d)^2\rvert}$	Worst case value for M (should be used in the P_{meas} equation above)
Γ_d = ________	Reflection coefficient magnitude of the 8478B sensor (found in the 8478B calibration data)
EE = ________	Effective Efficiency of the 8478B sensor (found in the 8478B calibration data)
U_e = ________	Effective Efficiency uncertainty of the 8478B sensor found in the 8478B calibration data; needed for Uncertainty calculation in Step 2 of Section 3-7)
$\Gamma_s = 0.019$	Reflection coefficient magnitude of the ML248xx and ML249xA Reference Calibrator output.(needed for Uncertainty calculation in Step 2 of Section 3-7)
R = ________	Mount Resistance of the 432A Power Meter
V_{comp} = _____	From Step 15, of Section 3-7.
V_1 = ________	From Step 14, of Section 3-7
V_0 = ________	From Step 12, of Section 3-7
P_{meas} = ________	Calculated from the P_{meas} equation, above

ML248xx, ML249xA	Firmware Revision:		Operator:
Serial Number:		Date:	Options:

Calibrator Power Level Uncertainty

Equations for Uncertainty Calculations

Standard Uncertainty Calculation

$$\text{Standard Uncertainty } X_{unc} = \frac{1}{(Divisor)} \times (\text{Uncertainty}) \times (\text{SensitivityC}_{ix})$$

Source Uncertainty Calculations

$$V_{comp}Unc = \frac{1}{\sqrt{3}} \times (0.00003 \times V_{comp} + 0.000004 \times 10V) \times \left(\frac{2(V_1 - V_0)}{4 \times R \times EE \times M}\right)$$

$$V_0Unc = \frac{1}{\sqrt{3}} \times \left(\sqrt{2 \times (0.00003 \times V_{comp} + 0.0000004 \times 10V)^2}\right) \times \left(\frac{-2(V_{comp} - V_0)}{4 \times R \times EE \times M}\right)$$

$$V_1Unc = \frac{1}{\sqrt{3}} \times \left(\sqrt{2(0.00003 \times V_{\text{comp}} + 0.000004 \times 10V)^2}\right) \times \left(\frac{2(V_{comp} - V_1)}{(4 \times R \times EE \times M)}\right)$$

$$R_{Unc} = \frac{1}{\sqrt{3}} \times (0.00006 \times \text{R} + 0.000002 \times (1000)) \times \left(\frac{-2V_{comp}(V_1 - V_0) - {V_0}^2 + {V_1}^2}{4 \times R^2 \times EE \times M}\right)$$

$$EE_{Unc} = \frac{1}{1} \times \left(\frac{U_e}{2}\right) \times \left(\frac{-2V_{comp}(V_1 - V_0) - {V_0}^2 + {V_1}^2}{4 \times R \times EE^2 \times M}\right)$$

$$M_{Unc} = \frac{1}{\sqrt{2}} \times (2 \times \Gamma_{\text{s}} \times \Gamma_{\text{d}}) \times \left(\frac{-2V_{comp}(V_1 - V_0) - {\text{V}_0}^2 + {\text{V}_1}^2}{4 \times \text{R} \times EE \times M^2}\right)$$

$$CR_{Unc} = \frac{1}{1} \times (0.1\%) \times (0.001W) = 0.000001W$$

$$\text{Combined Uncertainty} = \sqrt{V_{comp}Unc^2 + V_1Unc^2 + V_0Unc^2 + R^2_{\text{Unc}} + EE^2_{Unc} + M^2_{Unc} + CR^2_{Unc}}$$

$$(\text{K} = 2) = 2 \times \text{Combined Uncertainty} \times 1000 \text{ (95\% level of confidence)}$$

ML248xx, ML249xA	Firmware Revision:		Operator:
Serial Number:		**Date:**	**Options:**

Uncertainty Results: ML24xxx Reference Calibrator Output Power Level

Sources of Uncertainty	Unit	Readings	Uncertainty	Units	Divisor	Sensitivity	Units	Standard Uncertainty (W)	Standard Uncertainty (μW)
V_{comp}	(V)			(V)			(V/Ohm)		
V0	(V)			(V)			(V/Ohm)		
V1	(V)			(V)			(V/Ohm)		
R	(Ω)			(Ω)			(W/Ohm)		
EE	-			-			W		
M	-			-			W		
CR	-			-			W		
Combined Uncertainty (μW)									
Expanded Uncertainty (K = 2) (mW)									
Expanded Uncertainty (K = 2) (%)									

Expanded Uncertainty, P_{actual} Lower, P_{actual} Upper

Expanded Uncertainty (K = 2) = ________________(mW) (determined from the above equations)

$P_{actual} = P_{meas} \pm P_{meas}$ x Expanded Uncertainty (K = 2) (%)

P_{actual} Lower = ______________mW

P_{actual} Upper = ______________mW

Section 3-9:50 MHz Calibrator VSWR Verification (All Models)

Measured VSWR, 50 MHz RF Calibrator	Specification
______________	Less than 1.12

Section 3-10:1 GHz Calibrator VSWR Verification (ML248xx with Opt. 15 and ML249xA)

Measured VSWR, 1 GHz RF Calibrator	Specification
______________	Less than 1.20

ML248xx, ML249xA	Firmware Revision:		Operator:
Serial Number:		Date:	Options:

Section 4-5: DC Reference Calibration

Voltage Test Points	DSP Cal 6 Measurement	DSP Cal 5 Measurement After Adjustment	Specification
ZTP17 (gnd) and ZTP205 (+V)	______________VDC	______________VDC	DSP6 = DSP5 ± 2mV

Section 4-6: RF Calibrator 50 MHz Frequency Adjustment (ML248xx without Option 15)

	Measured (After Adjustment of L12)	Specification
Frequency	______________MHz	50 MHz ± 500 kHz

Section 4-7: RF Calibrator Output Power Adjustment (ML248xx without Option 15)

Measured	Specification
P_{actual} Lower = ______________mW P_{actual} Upper = ______________mW	1 mW ± 0.0015 mW

Appendix B — Specifications

B-1 ML2487/8A, ML2487/8B and ML2495/6A Technical Data Sheet

The latest version of the Technical Data Sheet (Anritsu PN: 11410-00423) for the ML2487/8A, ML2487/8B and ML2495/6A Wideband Peak Power Meter, can be downloaded from the Anritsu Internet site:

http://www.anritsu.com

The data sheet provides performance specifications for the various models in the ML24xxx series.

Appendix C — Connector Care

C-1 Introduction

This appendix provides instructions and discussion on the care and use of precision RF connectors.

C-2 Connector Do's and Don'ts

- These are high frequency connectors so be gentle and handle them with care.
- Avoid touching connector mating planes with bare hands. Natural skin oils and microscopic dirt particles are very hard to remove.
- Keep connectors clean.
- When using cotton swabs to clean connectors, make sure that you don't damage the center conductor.
- Always check the pin depth of a new connector before use to determine if they are out of spec. One bad connector can damage many.
- The connector can be damaged by turning in the wrong direction. Turning right tightens and turning left loosens. If you have trouble remembering, use the mnemonic "righty tighty, lefty loosely".
- Always use an appropriate torque wrench.
- Put dust caps on the connector after use.
- Never store adapters loose in a box, in a desk, or in a drawer.
- Calibration kit components are a unique set. Keep them together.

C-3 Coaxial Connector Care

Most coax connectors are assembled into a system and forgotten, but some, especially on test equipment are used almost continuously. The care and cleaning of these connectors is critical to accurate and reliable performance. Remember that all connectors have a limited life time and usually a maximum connect/disconnect specification, typically about 5,000 connections. Most will last well beyond this number, but poor usage and poor care can destroy a connector well before that number. Good connector performance can be achieved with the following:

- Periodic visual inspection
- Cleaning
- Proper connection and disconnection techniques using torque wrench
- Appropriate gauging techniques

C-4 Visual Inspection

To ensure a long and reliable connector life, careful visual inspection should be performed on the connectors before they are used on a particular job at a minimum of once per day when the item is being used. A “good” connector may get damaged if it is mated with a “bad” one.

The minimum magnification for connector inspection for damage varies with the connector:

- 7X for K and V connectors
- 2X for N connectors
- 10X for W1 connectors

Any connector with the following defects should be repaired or discarded:

- Plating
  - Deep scratches showing bare metal on the mating plane
  - Bubbles and blisters
  - The connectors may lose some gloss over time due to usage. Light scratches, marks and other cosmetic imperfections can be found on the mating plane surfaces. These should be of no cause for concern.
- Threads
  - Damaged threads. Don’t force the connectors to mate with each other.
- Center conductors
  - Bent, broken or damaged contacts.

C-5 Connector Pin Depth Precautions

A connector should be checked before it is used at a minimum of once per day when in use. If the connector is to be used on another item of equipment, the connector on the equipment to be tested should also be gauged.

Connectors should never be forced together when making a connection since forcing often indicates incorrectness and incompatibility. There are some dimensions that are critical for the mechanical integrity, non-destructive mating and electrical performance of the connector. Connector gauge kits are available for many connector types. Please refer to Anritsu Application Note 10200-00040. The mechanical gauging of coaxial connectors will detect and prevent the following problems:

Positive Pin Depth

Positive pin depth can result in buckling of the fingers of the female center conductor or damage to the internal structure of a device due to the axial forces generated.

Negative Pin Depth

Negative pin depth can result in poor return loss, possibly unreliable connections, and could even cause breakdown under peak power conditions.

Checking Pin Depth Gage

Pin depth gages should be checked for cleanliness before they are used at a minimum of once per month. Connector cleaning procedures (refer to Section C-6) can also be used to clean the pin depth gauges.

Pin Depth Dimensions

Before mating, measure the pin depth of the device that will mate with the RF component. The dimensions to measure are shown below in Figure C-1.

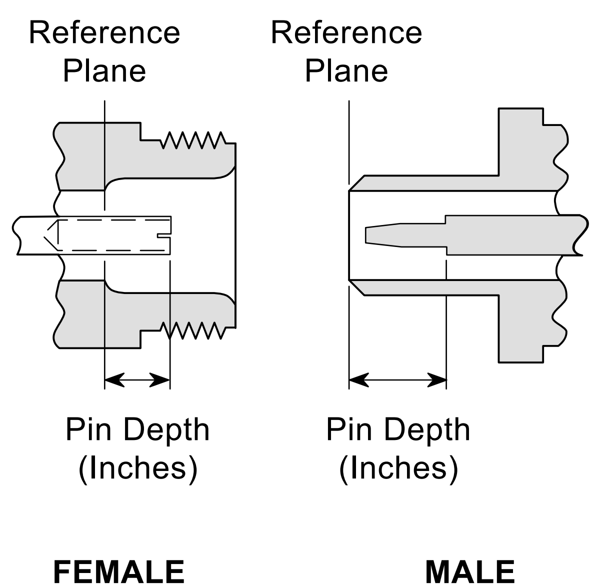
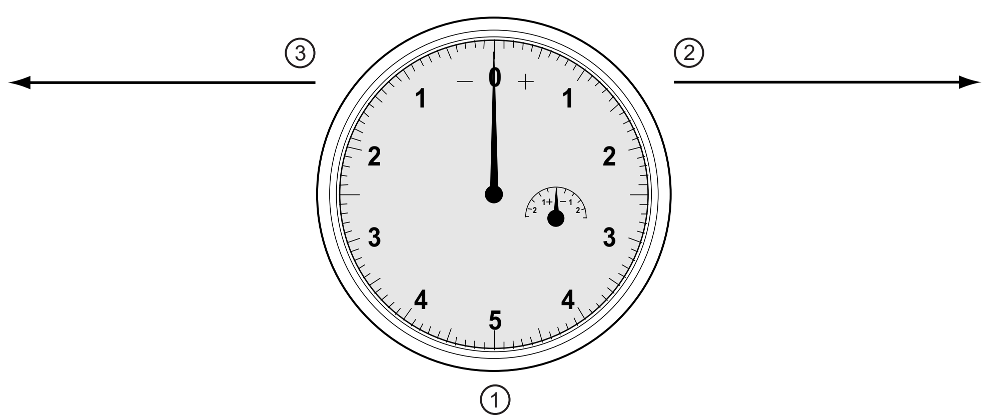


Figure C-1. N Connector Pin Depth

Pin Depth Gauge

Use an Anritsu Pin Depth Gauge or equivalent as shown below in Figure C-2 to accurately measure pin depths.



1 – Pin Depth Gauge with needle setting at zero.
2 – Positive needle direction clockwise to right.
3 – Negative needle direction counter-clockwise to left.

Figure C-2. Pin Depth Gauge

Based on RF components returned for repair, destructive pin depth of mating connectors is the major cause of failure in the field. When an RF component is mated with a connector having a destructive pin depth, damage will likely occur to the RF component connector.

Note	A destructive pin depth has a center pin that is too long in respect to the connector's reference plane.

Pin Depth Tolerances

The center pin of RF component connectors has a precision tolerance measured in "mils" which is equal to 1/1000 inch (0.001") or approximately 0.02540 mm.

V connectors have a higher precision tolerance measured in "tenths" or 1/10,000 inch (0.0001") or approximately 0.00254 mm.

Connectors on test devices that mate with RF components may not be precision types and may not have the proper depth. They must be measured before mating to ensure suitability and to avoid connector damage.

When gauging pin depth, if the test device connector measures out of tolerance (see Table C-1 on page C-4 below) in the "+" region of the gauge (see Figure C-2 on page C-3), the center pin is too long. Mating under this condition will likely damage the termination connector.

On the other hand, if the test device connector measures out of tolerance in the "–" region, the center pin is too short. While this will not cause any damage, it will result in a poor connection and a consequent degradation in performance.

Table C-1. Pin Depth Tolerances and Gauge Settings

Connector Type	Pin Depth (Inches)	Anritsu Gauge Setting
GPC-7	+0.000 –0.003	Same as pin depth
N Male	0.207 +0.003 / 0.000	0.207 +0.000 / –0.003
N Female	0.207 +0.000 / –0.003	0.207 +0.000 / –0.003
WSMA Male	–0.0025	Same as pin depth
WSMA Female	–0.0035	
K Male	+0.000	Same as pin depth
K Female	–0.003	
V Male	+0.000	Same as pin depth
V Female	–0.002	

Over Torquing Connectors

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

Teflon Tuning Washers

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

Mechanical Shock

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

C-6 Connector Cleaning Instructions

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

Isopropyl alcohol is the recommended solvent. Figure C-3 on page C-6 illustrates the cleaning procedures for male and female connectors.

Note	Most cotton swabs are too large to fit into the ends of the smaller connector types. In these cases it is necessary to peel off most of the cotton and then twist the remaining cotton tight. Be sure that the remaining cotton does not get stuck in the connector.

With continuous use, the outer conductor mating interface will build up a layer of dirt and metal chips that can severely degrade connector electrical and mechanical performance. It also tends to increase the coupling torque which then can damage the mating interface. Cleaning of connectors is essential for maintaining good electrical performance. Therefore, connectors should be checked for cleanliness before making any measurements (or calibration).

Cleaning Items Required

- Low pressure compressed air (solvent free)
- Cotton swabs
- Isopropyl alcohol (IPA)
- Microscope

Important Cleaning Tips

The following are some important tips on cleaning connectors:

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

Cleaning Procedure

1. Remove loose particles on the mating surfaces, threads, and similar surfaces using low-pressure compressed air.
2. The threads of the connector should be cleaned with cotton swab. When connector threads are clean, the connections can be hand-tightened to within approximately one-half turn of the proper torque.
3. Clean mating plane surfaces using alcohol on cotton swabs (Figure C-3).
   - Make sure that the cotton swab is not too large.
   - Use only enough solvent to clean the surface.
   - Use the least possible pressure to avoid damaging connector surfaces.
   - Do not spray solvents directly on to connector surfaces
4. After cleaning with swabs, again use low-pressure compressed air to remove any remaining small particles and to dry the connector surfaces.

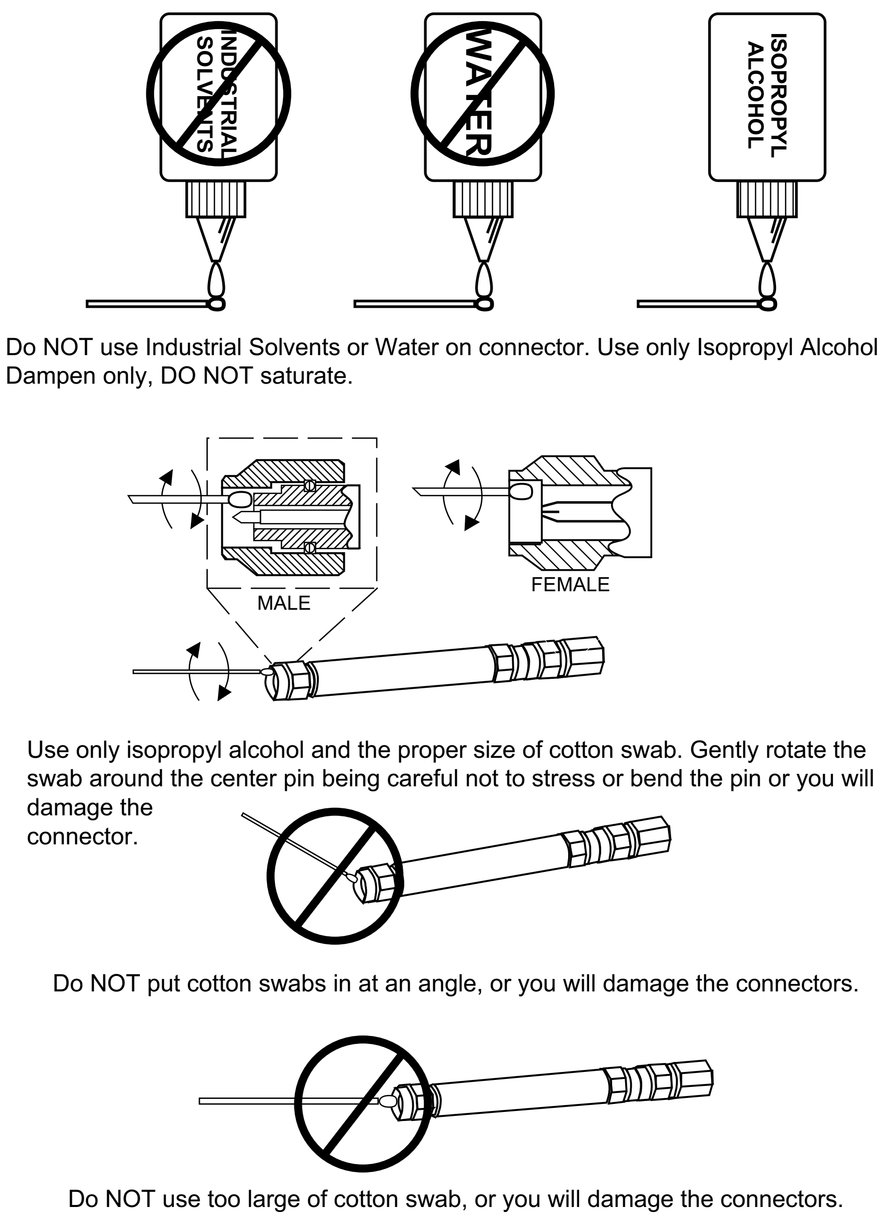


Figure C-3. Cleaning Connectors

C-7 Connection and Disconnection Techniques

Connection Procedure

1. Visually inspect the connectors (see “Visual Inspection” on page C-2).
2. If necessary, clean the connectors (see Figure C-3 on page C-6 and “Connector Cleaning Instructions” on page C-5).
3. Carefully align the connectors. The male connector center pin must slip concentrically into the contact fingers of the female connector.
4. Push connectors straight together. Do not twist or screw them together. As the center conductors mate, there is usually a slight resistance.
5. Do not turn the connector body, turn the connector nut instead. Major damage to the center conductor and the outer conductor can occur if the connector body is twisted.
6. Initial tightening can be done by hand.
7. Relieve any side pressure on the connection from long or heavy devices or cables. This assures consistent torque.
8. *Do not* pre-tighten so much that there is no rotation of the nut with the torque wrench. Leave about 1/8 turn or 45 degrees of rotation for the final tightening with the torque wrench.

   Table C-2 below lists the Anritsu Company torque wrench and open end wrench part numbers for different connectors.

Table C-2. Connector Wrench Requirements – Torque Wrenches and Settings – Open End Wrenches

Connector Type	Torque Wrench Model Number	Torque Specification	Open End Wrench
3.5mm/SMA	01-201	8 in-lbs	01-204
K	01-201	8 in-lbs	01-204
V	01-201	8 in-lbs	01-204

9. Hold torque wrench at the end.

Caution	Holding the torque wrench elsewhere applies an unknown amount of torque and could damage contacts and/or connectors.

10. Rotate *only* the connector nut when you tighten the connector. Use an open–end wrench to keep the body of the connector from turning.
11. Using two wrenches with an angle greater than 90° causes the connector devices to lift up and tends to misalign the devices and stress the connectors. This becomes more of a problem when there are several devices connected to each other.
12. Breaking the handle fully can cause the wrench to kick back and may loosen the connection.

C-8 Disconnection Procedure

1. Use an open end wrench to prevent the connector body from turning.
2. Use another wrench to loosen the connector nut.
3. Complete the disconnection by hand, turning *only* the connector nut.
4. Pull the connectors straight apart without twisting or bending.

Index

13000-00164 K

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