User Guide

Anritsu PowerXpert™

MA24105A, Inline Peak Power Sensor, 350 MHz to 4 GHz
MA24106A, True–RMS USB Power Sensors, 10 MHz to 6 GHz
MA24x08A, True–RMS USB Power Sensors, 10 MHz to 8 GHz
MA24x18A, True–RMS USB Power Sensors, 10 MHz to 18 GHz
MA24126A, True–RMS USB Power Sensors, 10 MHz to 26 GHz
MA24330A, Microwave CW USB Power Sensors, 10 MHz to 33 GHz
MA24340A, Microwave CW USB Power Sensors, 10 MHz to 40 GHz
MA24350A, Microwave CW USB Power Sensors, 10 MHz to 50 GHz
MA24507A, mmWave Power Master™ Analyzer, 9 kHz to 70 GHz
MA24510A, mmWave Power Master Analyzer, 9 kHz to 110 GHz

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Chapter 1 — General Information

1-1   Introduction

The purpose of this User Guide is to provide installation, operation, use of instruments, and programming information using the Anritsu USB Power Sensors and Power Master power analyzers with the Anritsu PowerXpert application.

This chapter contains general information about the Anritsu USB power sensors and Power Master power analyzers. Within the context of this User Guide, USB power sensors may also be referred to as power sensors and Power Master power analyzers may also be referred to as Power Master.

Contacting Anritsu for Sales and Service

To contact Anritsu, visit the following URL and select the services in your region.

http://www.anritsu.com/contact-us

Product Information, Compliance, and Safety

The Product Information, Compliance, and Safety manual provides important notices, warranty, safety, and regulatory compliance information for the Anritsu Power Meters, Power Masters, USB Power Sensors, Thermal Sensors, and Diode Sensors. Before operation, be sure to read these important notices located at the Anritsu product page Library tab of your instrument. Additional product information is located at the Anritsu Power Meters and Sensors product page. Visit the product page of your instrument listed below and select the Library tab.

https://www.anritsu.com/en-US/test-measurement/RF-Microwave/Power-Meters-and-Sensors

Additional Documentation

Additional product information is located at the Anritsu Power Meters and Sensors product page.

- https://www.anritsu.com/en-us/test-measurement/products/ma24105a
- https://www.anritsu.com/en-us/test-measurement/products/ma24106a
- https://www.anritsu.com/en-us/test-measurement/products/ma24108a
- https://www.anritsu.com/en-us/test-measurement/products/ma24118a
- https://www.anritsu.com/en-us/test-measurement/products/ma24126a
- https://www.anritsu.com/en-us/test-measurement/products/ma24208a
- https://www.anritsu.com/en-us/test-measurement/products/ma24218a
- https://www.anritsu.com/en-us/test-measurement/products/ma24330a
- https://www.anritsu.com/en-us/test-measurement/products/ma24340a
- https://www.anritsu.com/en-us/test-measurement/products/ma24350a
- https://www.anritsu.com/en-us/test-measurement/products/ma24507a
- https://www.anritsu.com/en-us/test-measurement/products/ma24510a

1-2   Instrument Description

The Anritsu USB power sensors and the Power Master are highly accurate, standalone devices that interface with the PowerXpert application installed on a PC through a USB cable connection. The power sensors and Power Master can be used with many Anritsu handheld instruments, such as Spectrum Master, BTS Master, VNA Master, Cell Master, and Site Master. The power sensors and Power Masters are ideal for measuring the average power of CW or modulated RF waveforms such as 3G, 4G, OFDM, and multitone signals. They measure true-RMS power regardless of the type of input signal.

The Anritsu Power Sensors and Power Masters covered in this User Guide are listed in Table 1-1.

Table 1-1.   USB Power Sensors and Power Master Power Analyzers

Model Number	Type	Frequency Range	Test Port Connectors
MA24105A	Inline Peak Power Sensor	350 MHz to 4 GHz	N(m) Connector
MA24106A	True–RMS USB Power Sensors	10 MHz to 6 GHz	N(m) Connector
MA24108A	True–RMS USB Power Sensors	10 MHz to 8 GHz	N(m) Connector
MA24118A	True–RMS USB Power Sensors	10 MHz to 18 GHz	N(m) Connector
MA24126A	True–RMS USB Power Sensors	10 MHz to 26 GHz	K(m) Connector
MA24208A	True–RMS USB Power Sensors	10 MHz to 8 GHz	K(m) Connector
MA24218A	True–RMS USB Power Sensors	10 MHz to 26 GHz	K(m) Connector
MA24330A	Microwave CW USB Power Sensors	10 MHz to 33 GHz	K(m) Connector
MA24340A	Microwave CW USB Power Sensors	10 MHz to 40 GHz	K(m) Connector
MA24350A	Microwave CW USB Power Sensors	10 MHz to 50 GHz	V(m) Connector
MA24507A	mmWave Power Master Power Analyzer	9 kHz to 70 GHz	V(m) Connector
MA24510A	mmWave Power Master Power Analyzer	9 kHz to 110 GHz	W1(m) Connector

Sensor Identification

All Anritsu power sensors and Power Masters are assigned a unique seven digit serial number, such as "1901012". The serial number is printed on a label that is affixed to the unit. When ordering parts or corresponding with Anritsu Customer Service, please use the correct serial number with reference to the specific instrument's model number (for example, model MA24126A power sensor, serial number: 0701012). When attaching an asset tag, locate an unobtrusive area on the power sensor or Power Master to affix the asset tag.

Interface Type

The power sensors and Power Masters interface types are listed below:

- The MA24106A has a USB Type Mini-B port interface.
- The MA24105A, MA24108A, MA24118A, and MA24126A have a USB Type Micro-B port interface. These power sensor models utilizes serial over USB communication for remote programming.
- The MA24208A and MA24218A have a USB Type Micro-B port interface. These power sensor models utilize USB 2.0 technology for remote programming.
- The MA24330A, MA24340A, and MA24350A have a USB Type Micro-B port interface. These power sensor models utilize USB 2.0 technology for remote programming.
- The MA245xxA Power Masters have a USB Type C Port interface with a PC or Anritsu handheld instrument. The Power Master utilizes a super speed USB 3.0 technology for remote programming.

1-3   Initial Inspection

Inspect the shipping container for damage. If the shipping container is damaged, retain it until the contents of the shipment have been checked against the packing list checked for mechanical and electrical operation. If the contents should need to be returned, see "Instrument Care and Preventive Maintenance" on page 1-4. The following items are included with every shipment:

MA24105A:

- MA24105A, Inline Peak Power Sensor
- Quick Start Guide
- 2000-1606-R, 1.8 meter USB A to Micro-B Cable with Latch
- Certificate of Calibration

MA24106A:

- MA24106A, USB Power Sensor
- Quick Start Guide
- 2000-1566-R, USB 2.0 A to Mini-B Cable
- Certificate of Calibration

MA24126A, MA24x08A, MA24x18A and MA243x0A:

- MA24x08A, MA24x18A, or MA24126A USB Power Sensor
- Quick Start Guide
- 2000-1605-R, 1.5 meter BNC(M) to MCX(M) Cable
- MA24108A, MA24118A, and MA24126A uses a USB 2.0 A to Mini-B cable with latch
- MA24208A, MA24218A, and MA243x0A uses a 1.83 meter USB-A to Micro-B Cable
- Certificate of Calibration

MA24507A, MA24510A:

- MA245xxA Power Master mmWave Power Analyzer
- Quick Start Guide
- 2000-1859-R 1.0 m USB A to C Port Cable
- Certificate of Calibration

1-4   Calibration and Verification

The power sensors and Power Masters comes fully calibrated from the factory and there are user-serviceable parts inside. Anritsu recommends annual calibration and performance verification by local Anritsu service centers. Accredited calibration to ISO17025 and ANSI/NCSL Z540-1 are available and can include a calibration certificate, test report, and uncertainty data.

Note	Contact your local Anritsu Service Center and return defective sensors with a detailed description of the observed problem.

1-5   Instrument Care and Preventive Maintenance

Instrument care and preventive maintenance consist occasional cleaning of the instrument, inspecting and cleaning the RF connectors and all accessories before use..

Caution	Do not operate or store the power measurement equipment in extreme environments. Refer to the instrument Technical Data Sheet for the specified operating and storage conditions,

Connector Care

Clean the instrument with a soft, lint-free cloth dampened with water or water with a mild cleaning solution. Clean the RF connectors and center pins with a cotton swab dampened with denatured alcohol. Visually inspect the connectors. The fingers of the female connectors and the pins of the male connectors should be unbroken and uniform in appearance. If you are unsure whether the connectors are undamaged, gauge the connectors to confirm that the dimensions are correct.

Visually inspect the test port cables. The test port cable should be uniform in appearance and not stretched, kinked, dented, or broken.

Visually inspect connectors for general wear, cleanliness, and for damage such as bent pins or connector rings. Repair or replace damaged connectors immediately. Dirty connectors can limit the accuracy of your measurements. Damaged connectors can harm the instrument. Connection of cables carrying an electrostatic potential, excess power, or excess voltage can damage the connector, the instrument, or both.

To prevent damage to your instrument, do not use pliers or wrenches to tighten connectors. Inadequate torque settings can affect measurement accuracy. Over-tightening connectors can cause damage to the connector or instrument, Refer to the connector type torque settings listed in Table 1-2 on page 1-5.

Connecting

Connect RF connectors as follows:

1. Carefully align the connectors. The male connector center pin must slip concentrically into the contact fingers of the female connector.

2. Align and push connectors straight together. Do not twist or screw them together. A slight resistance can usually be felt as the center conductors mate.

3. To tighten, turn the connector nut, not the connector body. Damage can occur to the center conductor and to the outer conductor if the connector body is twisted.

4. If you use a torque wrench, initially tighten by hand so that approximately 1/8 turn or 45 degrees of rotation remains for the final tightening with the torque wrench.

5. Relieve any side pressure on the connection (such as from long or heavy cables) in order to assure consistent torque.

6. Use an open-end wrench to keep the connector body from turning while tightening with the torque wrench.

Disconnecting

Disconnect RF connectors as follows:

1. If a wrench is needed, use an open-end wrench to keep the connector body from turning while loosening with a second wrench.

2. Complete the disconnection by hand, turning only the connector nut.

3. Pull the connectors straight apart without twisting or bending.

Torque Settings

The recommended torque settings for the USB power sensor and Power Master is listed in Table 1-2.

Table 1-2.   Connector Wrench Requirements – Torque Wrenches and Settings – Open End Wrenches

Connector Type	Torque Wrench Size	Torque Specification	Open End Wrench
N	19 mm (3/4 in)	12 lbf·in (1.35 N·m)	Twist-on connector version, therefore no torque setting. Align connectors, thread, and then twist on until finger tight. Do not use a wrench or pliers to tighten.
K (2.92 mm)	8 mm (5/16 in)	8 lbf·in (0.90 N·m)	5/16 in. or 8 mm
V (1.85 mm)	8 mm (5/16 in)	8 lbf·in (0.90 N·m)	5/16 in. or 8 mm
W1 (1 mm)	6 mm	0.45 N·m (4 lbf·in)	6 mm x 7 mm
0.8 (0.8 mm)	6 mm	0.45 N·m (4 lbf·in)	6 mm x 7 mm

Mechanical Shock

Handle power measurement devices with care. Avoid dropping, tossing, or allowing any form of mechanical shock that will compromise the power measurement accuracy.

ESD Caution

The power sensors and Power Master, like other high performance instruments, are susceptible to electrostatic discharge (ESD) damage. Coaxial cables and antennas often build up a static charge, which (if allowed to discharge by connecting directly to the instrument without discharging the static charge) may damage the PowerXpert input circuitry. Instrument operators must be aware of the potential for ESD damage and take all necessary precautions.

Operators should exercise practices outlined within industry standards such as JEDEC-625 (EIA-625), MIL-HDBK-263, and MIL-STD-1686, which pertain to ESD and ESDS devices, equipment, and practices. Because these apply to the PowerXpert, it is recommended that any static charges that may be present be dissipated before connecting coaxial cables or antennas to the instrument. This may be as simple as temporarily attaching a short or load device to the cable or antenna prior to attaching to the PowerXpert. It is important to remember that the operator may also carry a static charge that can cause damage. Following the practices outlined in the above standards will ensure a safe environment for both personnel and equipment.

1-6   Preparation for Storage/Shipment

Preparing the power sensor and Power Master for storage consists of cleaning the unit, packing the inside with moisture-absorbing desiccant crystals, and storing the unit in the recommended temperature environment. Please refer to the data sheet for storage temperature recommendations.

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

Note	Disconnect any USB sensor cables before packaging the power sensor.

- **Use a Suitable Container:** Obtain a corrugated cardboard carton. This carton should have inside dimensions of no less than 15 cm larger than the unit dimensions to allow for cushioning.
- **Protect the Instrument:** Surround the unit with polyethylene sheeting to protect the finish.
- **Cushion the Instrument:** Cushion the instrument on all sides by tightly packing urethane foam between the carton and the unit. Provide at least three inches of dunnage on all sides.
- **Seal the Container:** Seal the carton by using either shipping tape or an industrial stapler.

Chapter 2 — Installing PowerXpert

2-1 Introduction

This chapter provides information on installing the Anritsu PowerXpert application for the USB power sensors and Power Masters. To use the power sensors and Power Master, both the PowerXpert application and their drivers must be installed. Follow the steps below as a guide for proper installation.

- "PC Requirements"
- "Installing PowerXpert"
- "Installing Power Sensor Drivers"

2-2 PC Requirements

Please make sure that the following minimum requirements are met for installing and using the software:

- Intel® Pentium® III with 1 GB RAM or Intel® Pentium® IV with 512 MB RAM, or equivalent (Intel® Pentium® IV with 1 GB RAM recommended; a dual core processor with 2 GB RAM is recommended for use with the multisensor feature.)
- All versions of Microsoft® Windows 10, Windows 8, Windows 8.1, Windows 7 and Windows Vista®, Windows XP. Check the TDS of your power sensor to confirm the compatibility of your operating system.
- 100 MB hard-disk free space
- Display resolution 1024 × 768
- High speed USB 2.0 for MA242x8A and MA243x0A sensors
- Super speed USB 3.0 for MA245xxA Power Master power analyzers
- Microsoft® .NET Framework Version 4.0 or higher

Note	PowerXpert needs .Net Framework 4.0. The PowerXpert installation will detect whether or not this is already on your PC and will provide a message if it is not installed. This framework version is included in both Minimal & Full version of installers.

Note	Earlier versions of PowerXpert **and** the ATMEL SAM-BA software must first be uninstalled from the PC before installing PowerXpert. Earlier versions of the MA24108A, MA24118A, or MA24126A power sensors must be upgraded with firmware version 2.0 or later to use all of the features of PowerXpert (firmware must be upgraded using PowerXpert). Refer to Appendix B, "Upgrading Power Sensor Firmware – MA241xxA Series" for information about upgrading the power sensor firmware.

2-3   Installing PowerXpert

Both PowerXpert and the USB power sensor/analyzer drivers must be installed before using these devices. Follow the steps below as a guide for proper installation.

1. Download the latest PowerXpert Analysis and Control Software from the Anritsu Website:
   https://www.anritsu.com/en-us/test-measurement/support/downloads/software/dwl19095

2. Click **Install Anritsu PowerXpert.**

3. Select **Run** to start the installation.

4. Click through the installation screens.

5. When the installation is complete, PowerXpert becomes a User Interface for making Power Measurements..
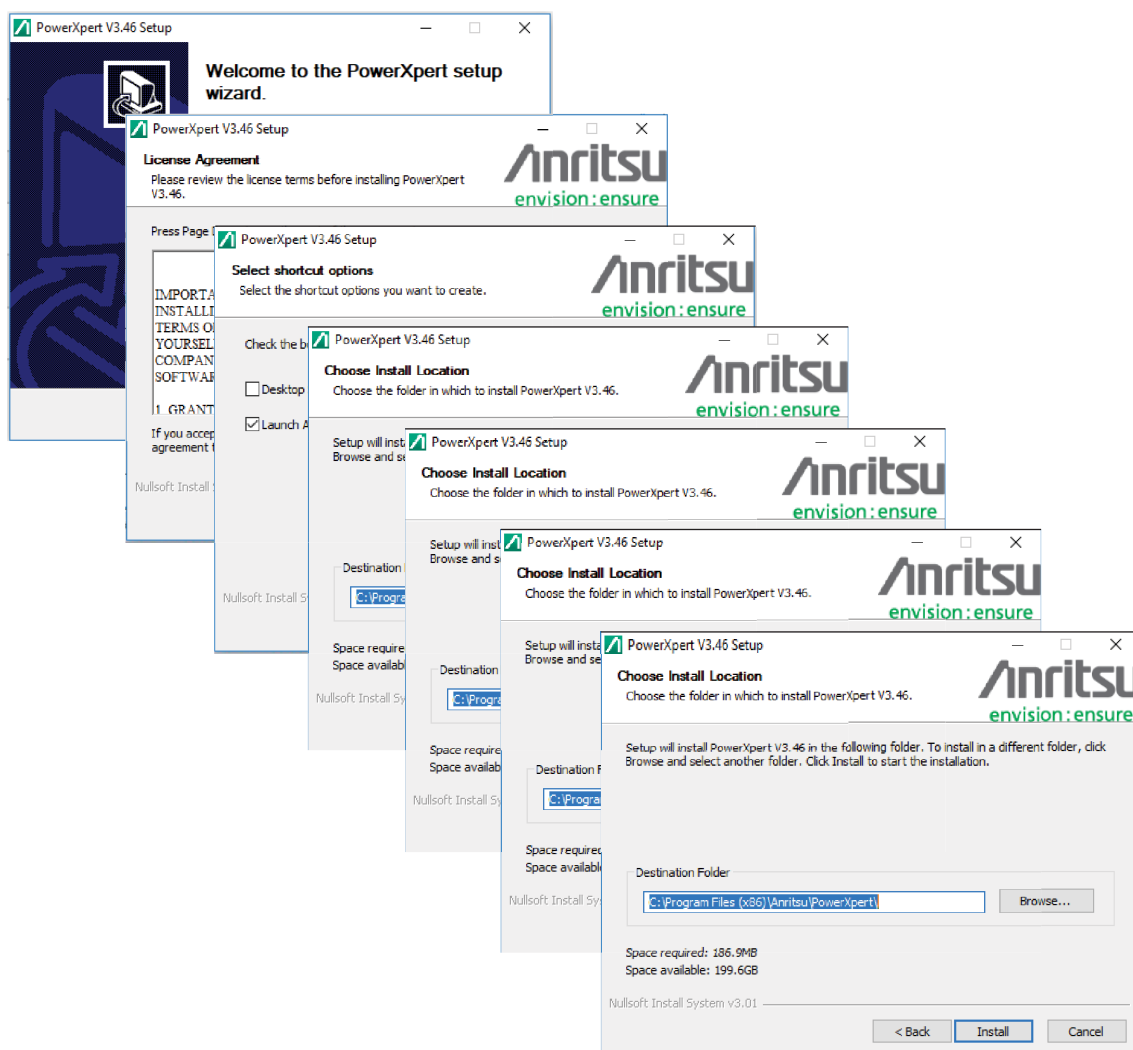
Figure 2-1.   PowerXpert Installation Screens

2-4   Setting PowerXpert to Run in Windows XP Compatibility Mode
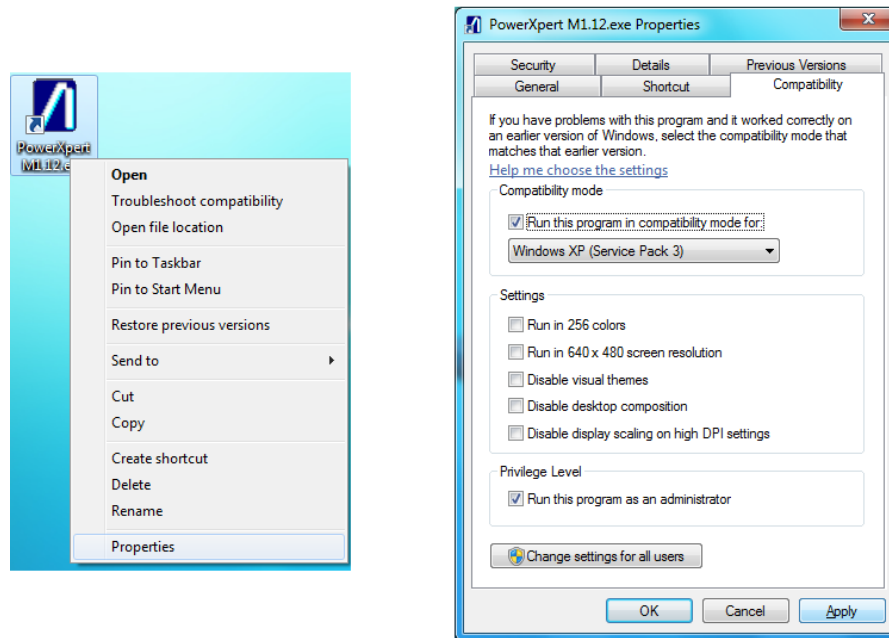
Figure 2-2.   Setting PowerXpert to Run in Windows XP Compatibility Mode

The PowerXpert application can be launched from the Windows Start menu from the Anritsu program group.

If you are installing a new power sensor driver, continue to the next section, "Installing Power Sensor Drivers".

Installing Power Sensor Drivers

1. Connect the power sensor to the USB port of the PC with the supplied USB cable.

2. When the Found New Hardware Wizard installation screen appears, select **No, not this time** to search for software, and then click **Next**.

Figure 2-3.   Found New Hardware Wizard

3. Select **Install the software automatically (Recommended)**, and then click **Next**.
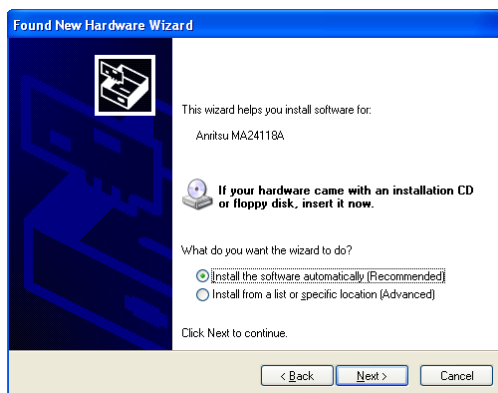
Figure 2-4.   Found New Hardware Wizard

4. Select the sensor being installed from the list, then click **Next** as shown below.
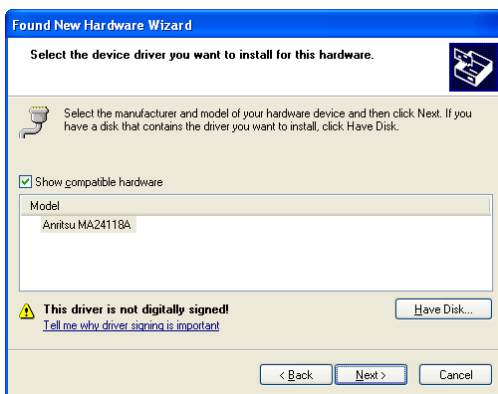
Figure 2-5.   Found New Hardware Wizard

5. The Hardware Installation warning dialog appears as shown below. Click **Continue Anyway**.

Figure 2-6.   Hardware Installation Warning

The hardware driver installs.
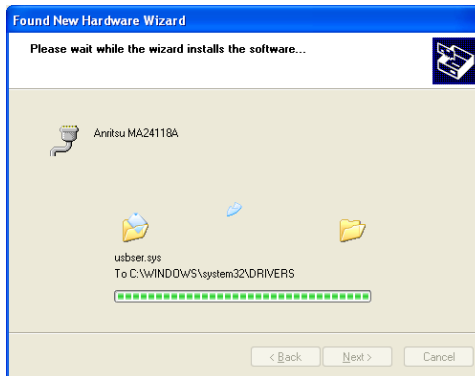
Figure 2-7.   Found New Hardware Wizard

6. When the installation is complete, click **Finish** to close the wizard.

For the MA241xxA series, the status LED should illuminate green indicating that the sensor is ready to use.

If the status LED illuminates amber color, refer to the "Error States" section in the "Using the MA241xxA" chapter for your sensor.

For the MA242x8A, MA243x0A and MA245xxA series, the status LED should be solid green indicating that the sensor is ready to use.

If the status LED blinks green, refer to the "Error States" section in the "Using the MA242x8A" chapter for your sensor.
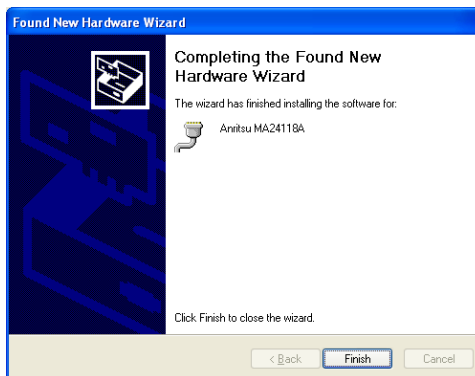
Figure 2-8.   Found New Hardware Wizard

7. The power sensor is now ready for use. Launch the Anritsu PowerXpert application from the new desktop icon or from the **Start** | Programs | Anritsu menu. Refer to Chapter 3, "Using USB Power Sensors with PowerXpert" for information about using the Anritsu PowerXpert application.

Chapter 3 — Using USB Power Sensors with PowerXpert

3-1   Introduction

This chapter provides information on using the Anritsu PowerXpert application, a data analysis, and control software for use with Anritsu's USB power sensors. If using a Power Master, see Chapter 12, "Using Power Master with PowerXpert".

PowerXpert provides a graphical user interface (GUI), making the PC appear like a traditional power meter that facilitates average power, time slot, and scope-like measurements. PowerXpert is operational with up to eight power sensors. Depending on which power sensors are connected to the PC, the PowerXpert application operates in four distinct modes as follows:

- "Continuous Mode" available with all power sensors
- "Time Slot Mode" available with the MA24x08A, MA24x18A, and MA24126A only
- "Scope Mode" available with the MA24x08A, MA24x18A, MA24126A and MA243x0A only
- "List Mode" available with the MA24208A, MA24218A and MA243x0A only

Note	When operating the MA245xxA Power Master, the MA241xxx Series, MA242xxx, and MA243xxx USB power sensors can be connected to make separate power measurements simultaneously in Continuous mode. For details, see "Show Multiple Sensor Display" on page 3-30.

For information about using your power sensor, refer to one of the following chapters for your power sensor:

- Chapter 4, "Using the MA24105A"
- Chapter 6, "Using the MA24106A"
- Chapter 8, "Using the MA24x08A, MA24x18A, and MA24126A"
- Chapter 10, "Using the MA243x0A"

The power sensors are also compatible with most Anritsu RF and microwave handheld analyzers. The power sensor easily connects to these instruments via a USB A to Mini-/Micro-B cable, turning them into a virtual power meter. Please refer to instrument-specific user guides for operation of the sensors.

3-2   Connect USB Power Sensor

Connect the USB connector side of the Power Sensor to the PC with a USB cable. PowerXpert detects and displays the sensor model number and serial number in PowerXpert as described in The power sensor measurement and status window displays the information shown in Figure 3-3 on page 3-6. This may take a few seconds for the connection to be detected and displayed. PowerXpert always starts up in the default state of the connected sensor. Upon disconnection, PowerXpert resets and after reconnection, restarts in the default state.

3-3   PowerXpert Settings with USB Power Sensors

Some features and settings offered by PowerXpert are only available with select power sensor models as displayed in Table 3-1.

Table 3-1.   PowerXpert Sensor Compatibility Table (1 of 2)

PowerXpert Features with USB Power Sensors		USB Power Sensors						
		MA24105A	MA24106A	MA24108A	MA24118A	MA24126A	MA242x8A	MA243x0A
Continuous Mode	Duty Cycle	x	-	x	x	x	x	x
	Relative Mode	x	x	x	x	x	x	x
	Units	x	x	x	x	x	x	x
	Aperture time	-	x	x	x	x	x	x
	Forward Power	x	x	x	x	x	x	x
	Reverse Power	x	-	-	-	-	-	-
	Peak Power	x	-	-	-	-	-	-
	Center Freq and Span	-	-	-	-	-	-	-
	Resolution	-	-	-	-	-	-	-
	Range	-	-	-	-	-	-	-
	Crest Factor	x	-	-	-	-	-	-
	CCDF	x	-	-	-	-	-	-
	Burst Average	-	-	-	-	-	-	-
	Reflection Coeff	x	-	-	-	-	-	-
	Return-loss	x	-	-	-	-	-	-
	VSWR	x	-	-	-	-	-	-
	Video BW	x	-	-	-	-	-	-
	Measurement Channel Power CW Max	-	-	-	-	-	-	-
	Measurement Hold	-	x	x	x	x	x	x
Time Slot Mode	Number of slots	-	-	x	x	x	x	-
	Slot width	-	-	x	x	x	x	-
	Start exclusion	-	-	x	x	x	x	-
	End exclusion	-	-	x	x	x	x	-
Scope Mode	Capture time	-	-	x	x	x	x	x
	Data points	-	-	x	x	x	x	x
	Gate start	-	-	x	x	x	x	x
	Gate end	-	-	x	x	x	x	x
	Fence start	-	-	x	x	x	x	x
	Fence end	-	-	x	x	x	x	x
List Mode	List file	-	-	-	-	-	x	x
	Output file	-	-	-	-	-	x	x

Table 3-1.   PowerXpert Sensor Compatibility Table (2 of 2)

PowerXpert Features with USB Power Sensors		USB Power Sensors						
		MA24105A	MA24106A	MA24108A	MA24118A	MA24126A	MA242x8A	MA243x0A
General Settings	Zero sensor	x	x	x	x	x	x	x
	Frequency	x	x	x	x	x	x	x
	Auto average	-	-	x	x	x	x	x
	Auto avgsrc	-	-	x	x	x	x	x
	Averaging method	-	-	x	x	x	x	x
	Averages	x	x	x	x	x	x	x
	Offset	x	x	x	x	x	x	x
	Step Detect	-	-	-	-	-	x	x
	Range	x	x	x	x	x	x	x
Trigger	Source	-	-	x	x	x	x	x
	Arm Type	-	-	x	x	x	x	x
	Level	-	-	x	x	x	x	x
	Edge	-	-	x	x	x	x	x
	Delay	-	-	x	x	x	x	x
	Noise Immunity	-	-	-	x	x	-	-
	Hold Off	-	-	-	-	-	x	x
	Hysteresis	-	-	-	-	-	x	x
More Settings	Modulation Type	x	-	-	-	-	-	-
Tools	Advanced Features	-	-	-	-	-	x	x
	Zero All Sensors	x	x	x	x	x	x	x
	Capture Screen	x	x	x	x	x	x	x
	Log data	x	x	x	x	x	x	x
	Show Multiple Sensor Display	x	x	x	x	x	x	x
	Offset Table	-	x	-	-	-	-	-
	Update Firmware	-	x	-	-	-	x	x
	View Summary	x	-	-	-	-	-	-
Settings	Save/Recall setup	-	-	x	x	x	x	x
	Reset to factory settings	-	-	x	x	x	x	x
	Set sensor timeout	-	-	x	x	x	x	x
	Secure Mode	-	-	x	x	x	x	x

3-4   PowerXpert Graphic User Interface

Using the USB Power sensors with PowerXpert provides a user interface as shown in Figure 3-1.

Index	Description
1	Toolbar - See "Toolbar" on page 3-5.
2	Sensor Information Area showing sensor model and serial number, communications port, and firmware version.
3	The measurement ans status window is described in Section "Measurement and Status Window" on page 3-6 (Note that the screen shown for MA24105A displays two values, forward and reverse).
4	**Graphical Display for each mode:** See "Continuous Mode" on page 3-7. See "Time Slot Mode" on page 3-11. See "Scope Mode" on page 3-13.
5	**Graphical Settings for each mode:** See "Continuous Mode" on page 3-7. See "Time Slot Mode" on page 3-11. See "Scope Mode" on page 3-13.
6	Trigger Settings is available with the MA24x08A, MA24x18A, MA24126A and MA243x0A only. See "Trigger Settings" on page 3-23. The **Arm Trigger** button must be clcked to apply any setting changes. **6a –** MA241xxA models only–Trigger setting includes "Noise Immunity". **6b –** MA242x8A and MA243x0A models only–Trigger setting includes "Hysteresis" around the trigger level and "Holdoff".
7	The **Apply above settings** button must be clicked to apply any setting changes. See "General Settings" on page 3-20.
8	The settings for the selected mode type (Continuous, Time Slot, Scope, or List mode) is displayed. The **Apply above settings** button must be clicked to apply any setting changes.

Figure 3-1.   Anritsu PowerXpert Application GUI Overview

3-5   Toolbar

The PowerXpert power sensor Tool Bar provides the following modes:

- "Continuous Mode" is available with all power sensors.
- "Time Slot Mode" is available with the MA24x08A, MA24x18A, and MA24126A only.
- "Scope Mode" is available with the MA24x08A, MA24x18A, MA24126A and MA243x0A only.
- "List Mode" is available with MA242x8A and MA243x0A only.

The Tool Bar consists of the following menus.

Tools: The "Tools Menu" on page 3-27 consists of the following commands listed below:

- "Zero All Sensors" on page 3-27
- "Capture Screen" on page 3-27
- "Log Data" on page 3-28
- "Show Multiple Sensor Display" on page 3-30
- "Offset Table" on page 3-31
- "Advanced Features" on page 3-33 (available in MS242x8A series only)
- "Update Firmware" on page 3-32

Settings: The "Settings Menu" on page 3-33 consists of the following commands:

- "Saving and Recalling Settings" on page 3-33
- "Resetting to Factory Settings" on page 3-34
- "Sensor TimeOut Setting" on page 3-34
- "Secure Mode" on page 3-35

Sensor Information

The Sensor Information window shows the model, serial number, connection port type, Firmware installed, and FPGA information as shown in Figure 3-2. When multiple sensor's are connected, the serial numbers display in the same Sensor Information window. Click a serial number to view the associated sensor parameters.
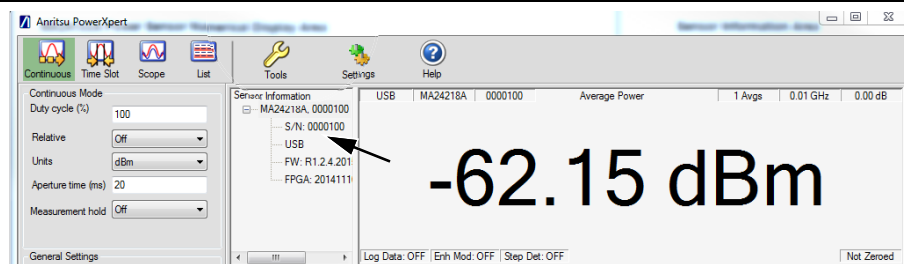
Figure 3-2.   View Sensor Parameters

Measurement and Status Window

The power sensor measurement and status window displays the information shown in Figure 3-3.
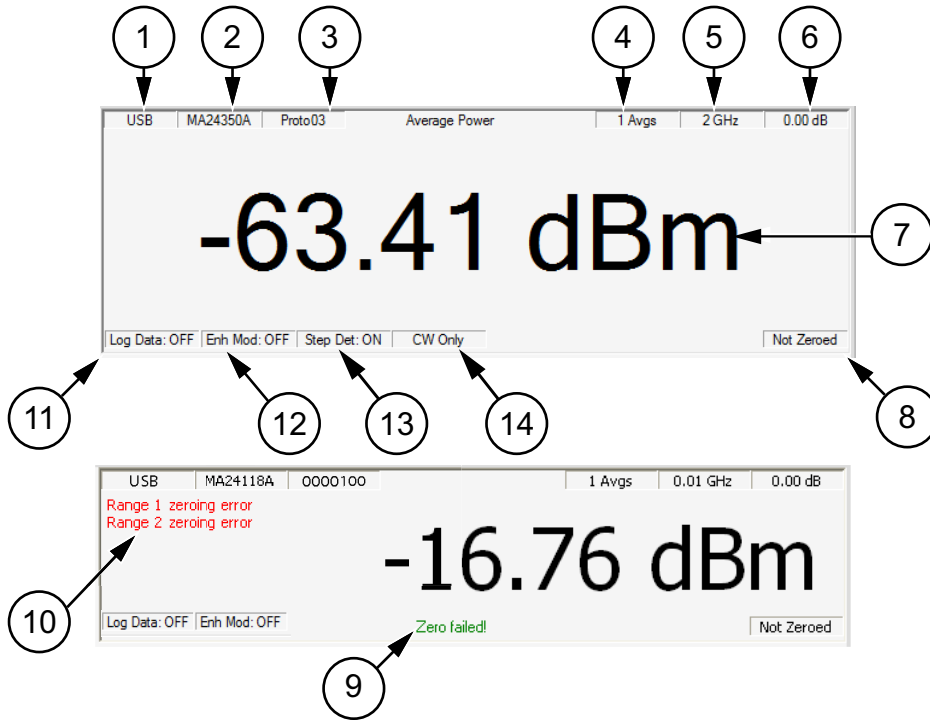
Index	Description
1	Communications port type used to connect the sensor
2	Model number of the connected power sensor.
3	Serial number of the connected power sensor.
4	Averaging count
5	Measurement frequency (Cal Factor)
6	Fixed offset value
7	Numerical reading with units of measure or task message displayed.
8	Sensor Zero status
9	Sensor status messages (displayed temporarily)
10	Sensor error messages indicator. Error messages displayed will vary depending on the sensor used.
11	Data Logging status
12	Enhanced Modulation status (feature available with MA242x8A sensors only)
13	Step Detect status
14	CW Status (feature available with MA243x0A sensors only)

Figure 3-3.   PowerXpert Measurement and Status Window

3-6   Continuous Mode

Continuous mode is available with all power sensors. This mode is user selectable from the toolbar and is the default mode of operation at startup. In this mode, the sensor is "continuously triggered", continuously collects data. and displays average power of the input signal.

Graphical Display Area

The following Power versus Time graph used in Continuous mode is shown in Figure 3-4.

Index	Description
1	The vertical scale displays the power level in dBm, regardless of the Units settings of dBm, μW, mW, or W from the Continuous settings area.
2	Graphical trace display showing the power level as a function of time.
3	Marker showing as a vertical blue line with an x on the marker point and numerical values for the time (in minutes) and power level (in dBm). The marker is available for reading power at an instant of time. It can be dragged with the mouse and can be centered in the display via the **Center Marker** button.
4	The horizontal scale displays the time in minutes and may be increased or decreased from the graticule settings area. This scale increases up to a maximum of 1440 minutes.
5	**Graticule settings area:** **Time Span (min):** Sets the current time span setting from 0.1 minutes up to a maximum of 1440 minutes. **Power Max (dBm):** Sets the upper power level for the vertical scale. **Power Min (dBm):** Sets the lower power level for the vertical scale. • **Power Max (dBm)** and **Power Min (dBm)** settings are not available when set to Automatic. **Scale Mode:** Sets the vertical scaling to Automatic or Manual. Changes to these settings are applied by pressing the **Enter** key.

Figure 3-4.   Continuous Mode Graphical Display Area

Settings

The description of the Continuous mode settings are shown in Figure 3-5.

Figure 3-5.   Continuous Mode Settings
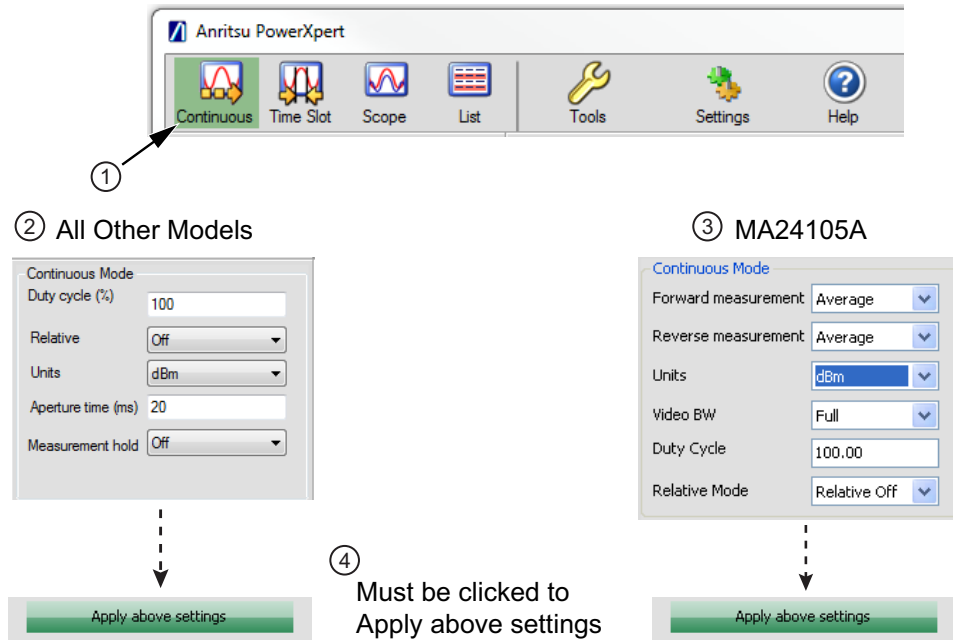
Index	Description
1	Continuous mode location on Task Bar.
2	All Models except MA24105A.
3	Model MA24105A Only
4	Apply above settings.

Duty Cycle

Duty cycle is available only with the MA24x08A, MA24x18A, MA24126A, and MA243x0A power sensors. Duty cycle correction is applied (as a percentage) to the measured average power of a pulse modulated signal to obtain the pulse power. The duty cycle correction is used to find the power during the pulse, given a measurement of the average power of a pulse modulated signal for which the duty cycle is known, and is calculated as follows:

Linear units: *Pulse power = Average power / (duty cycle % / 100)*

dBm: *Pulse power = Average power – 10 x Log (duty cycle % / 100)*

Note	On the MA24105A sensor, Duty Cycle is only used for dedicated burst average measurement.

Relative

When relative mode is turned on, relative measurement displays power changes with respect to the displayed power. To reset the power reference, turn relative mode Off, and then back on. This mode is particularly useful to study drift or measure (loss of) attenuator and (gain of) amplifiers.

Note	Relative measurement is a feature of PowerXpert and does not apply to Crest Factor, CCDF, Reflection Coefficient, Return Loss, and VSWR.

Units

Displays units of power in linear or log scale (dBm, μW, mW, or W).

Forward Measurement

Forward measurements listed below are available only with the MA24105A power sensor. Selectable forward measurement settings include:

- Average Power
- Crest Factor
- Burst Average User
- Peak Power
- Burst Average Auto
- CCDF

Reverse Measurement

Reverse measurements are available only with the MA24105A power sensor. Selectable reverse measurement settings include:

- Average Power
- Reflection Coefficient
- Return Loss
- VSWR

Video Bandwidth

Video Bandwidth settings are available only with the MA24105A power sensor. Selectable peak measurement video bandwidths include:

- Full
- 200 kHz
- 4 kHz

Aperture Time

The aperture time is the total time the sensor observes the input signal in order to make one power measurement. Settings vary depending on which power sensor is connected as follows:

MA24105A: Aperture time is not available

MA24106A: Two aperture time modes are available.

- **HAT (High Aperture Time):** When High Aperture Time mode is selected, the MA24106A power sensor provides more accurate measurements of TDMA signals. In this mode, the ADC acquisition time is increased and the display update rate is decreased. This mode can be useful when measuring low power, modulated signals and when changing between ranges. With HAT selected, signals with pulse repetition periods as long as 50 ms can usually be measured.

- **LAT (Low Aperture Time):** When Low Aperture Time mode is selected, the ADC acquisition time is decreased and the display update rate is increased. With LAT selected, the maximum recommended pulse repetition time is about 10 ms.

MA24x08A, MA24x18A, and MA24126A: If external averaging is selected, two or more of these measurements are averaged together to form the displayed power. PowerXpert automatically uses a default aperture time based upon the connected sensor. For example, when using MA24118A with a 20 ms aperture time, the sensor collects 2860 samples (with ~142 kHz sampling rate), and averages them together to compute the measurement value. Depending upon the measurement speed requirements or signal type, aperture time can be increased or decreased. For slow moving modulated signals, higher aperture time setting may be required to obtain stable readings. Refer to the "Measurement Factors" section of your power sensor chapter for more details.

Measurement Hold

Set to On: Holds the last sensor readings.

Set to Off: The sensor continues to sample measurements. Measurement hold is not used on the MA24105A.

Apply Above Settings Button

The **Apply Above Settings** button applies all changes made to the Continuous mode settings. Changes to these settings do not take effect until this button is clicked.

3-7   Time Slot Mode

Time Slot mode is available with power sensor models MA24x08A, MA24x18A, and MA24126A and is used for performing measurements on TDMA waveforms like GSM/EDGE. The Time Slot mode breaks up the measurement into equal time slots and displays the calculated average power reading for each individual slot as shown in Figure 3-6.

Index	Description
1	The vertical scale displays the power level in dBm.
2	Trigger Delay Time: Shows the current trigger delay position. The trigger delay is set via the Trigger Settings area. Note that the trigger marker will not be visible for positive trigger delays. See "Trigger Settings" on page 3-23.
3	Trigger Level Marker: Shows the current trigger level position. The trigger level is set via the Trigger Settings area. See "Trigger Settings" on page 3-23.
4	Graphical slot display showing the slot power level as a function of time slot number.
5	Marker showing as a vertical blue line with an x on the marker point and numerical values for the time slot number and power level (in dBm). The marker is available for reading power at an instant of time. It can be dragged with the mouse and can be centered in the display via the **Center marker** button.
6	The horizontal scale displays the time slots and may be increased or decreased from the Time Slot mode settings window.
7	Graticule Settings: **Number of Slots:** Displays the current number of slots setting. This setting is changed via the Time Slot mode settings area. **Power Max (dBm):** Sets the upper power level for the vertical scale. **Power Min (dBm):** Sets the lower power level for the vertical scale. • **Power Max (dBm)** and **Power Min (dBm)** settings are not available when set to Automatic. **Scale Mode:** Sets the vertical scaling to Automatic or Manual. Changes to these settings are applied by pressing the **Enter** key.

Figure 3-6.   Time Slot Mode Graphical Display Area

Settings

The measurements need to be triggered. Unwanted portions in the transition from one time slot to the next can be masked by user-definable exclusion periods. It is necessary that the waveform under test consists of equally spaced time slots and that the settings match the waveform. Time Slot mode settings are shown in Figure 3-7.
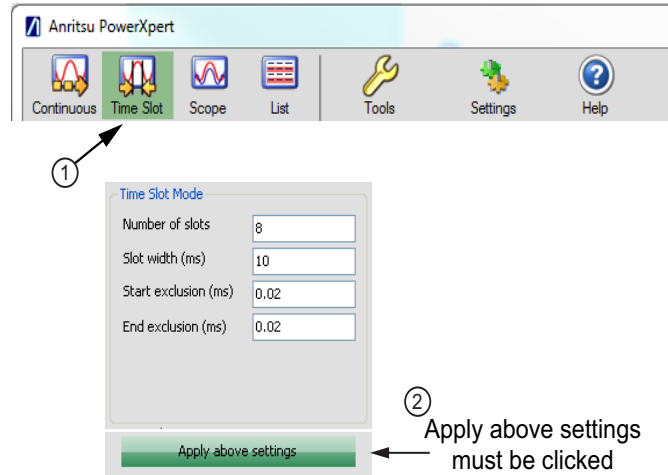
Index	Description
1	Continuous mode location on Task Bar
2	Apply above settings.

Figure 3-7.   Time Slot Mode Settings

Number of Slots

The number of time slots that make a single frame. PowerXpert can support up to 128 slots. A single marker can be set on a particular slot to read average power in that slot. The power reading is the average power of all the samples falling within that slot.

Slot Width

Slot width is the width of each slot in milliseconds. All slots in a single frame should have the same width.

Start and End Exclusion

Start exclusion is the time in milliseconds to be excluded from the beginning of each slot for power calculation. End exclusion is the time in milliseconds to be excluded at the end of each slot for power calculation. This feature is generally used to define spacing between slots, although it may not be evident from the Time Slot mode graph. the following are general guidelines for Time Slot mode settings:

- The exclusions should not eclipse the entire slot width:
  ```
  Start Exclusion + End exclusion < Slot width
  ```
- The maximum capture time is limited by the sensor:
  ```
  Slot width x Number of slots = Total capture time
  ```

Apply Above Settings Button

The **Apply above settings** button applies all changes made to the "Time Slot Mode" settings. Changes to these settings do not take effect until clicking this button.

3-8   Scope Mode

Scope mode is available with power sensor models MA24x08A, MA24x18A, MA24126A and MA243x0A. In Scope mode, the sensor acts similarly to an oscilloscope in that it can be used to measure power as a function of time. A Scope mode display is shown in Figure 3-8.

Index	Description
1	The vertical scale displays the power level in dBm.
2	Trigger Delay Time showing the current trigger delay position. The trigger delay is set in the Trigger Settings area. See "Trigger Settings" on page 3-23.
3	Trigger Level Marker showing the current trigger level position. The trigger level is set in the Trigger Settings area. See "Trigger Settings" on page 3-23.
4	Marker showing as a vertical blue line with an x on the marker point and numerical values for the time (ms) and power level (dBm). The marker is available for reading power at an instant of time. It can be dragged with the mouse and can be centered in the display via the **Center marker** button.
5	Graphical trace display showing the power level as a function of time.
6	The horizontal scale displays the total capture time (in milliseconds) and may be increased or decreased from the Scope mode settings area.
7	Graticule Settings: **Capture Time:** Displays the current capture time setting. This setting is changed in the Scope Mode settings window. **Power Max (dBm):** Sets the upper power level for the vertical scale. **Power Min (dBm):** Sets the lower power level for the vertical scale. • **Power Max (dBm)** and **Power Min (dBm)** settings are not available when set to Automatic. **Scale Mode:** Sets the vertical scaling to Automatic or Manual. Changes to these settings are applied by pressing the **Enter** key.
8	Gate Start (ms)
9	Fence Start (ms)
10	Fence End (ms)
11	Gate End (ms)

Figure 3-8.   Scope Mode Graphical Display Area

Settings

The Scope mode settings are shown in Figure 3-9.
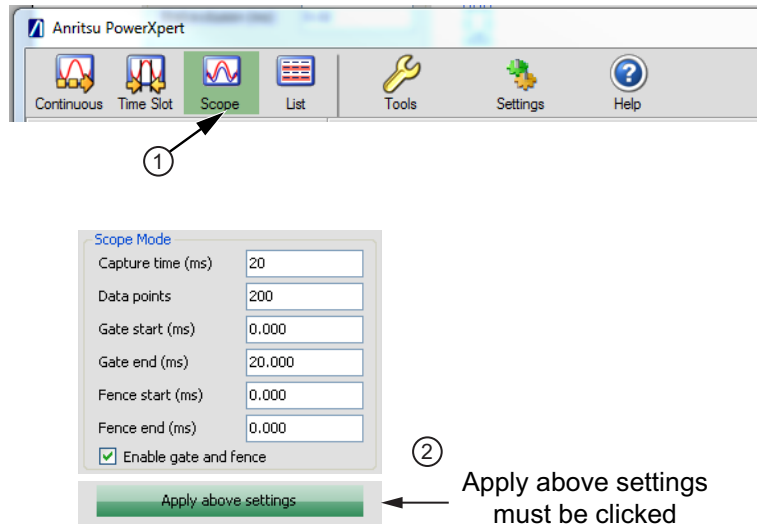
Index	Description
1	Scope mode location on Task Bar
2	Apply above settings.

Figure 3-9.   Scope Mode Settings

Parameters of Operation

There are two parameters needed to define the Scope mode operation:

- Capture time
- Number of data points.

The sensor first waits for a trigger. Upon receiving a trigger, the sensor starts collecting data at its sample rate for the duration of the capture time. This will typically result in a number of samples that exceed the number of displayed data points. In this case, individual samples are averaged together to display the requested number of data points.

Capture Time: The Capture Time represents the time displayed on the screen at any one time. If a positive delay is specified for the trigger delay item, the capture time will commence once the specified delay has been reached.

Data Points: Scope mode can be used to look at very fine structures of a signal. When using marker, gate, and fence, the power of any specific time can be accurately measured. To better observe these fine signal structures, a graph capture time can be reduced to get better resolution. However, as capture time shrinks, the time intervals between data points on the graph also decrease. The capture time can continue to shrink until it approaches the absolute resolution limit.

The sampling rate of the MA241xxA series power sensors is approximately 131 kS/s, or 7.6 µs per sample. The sampling rate of the MA242x8A and MA243x0A series power sensors is approximately 140.056 kS/s, or 7.14 µs per sample. When the capture time divided by the number of points is at 7 µs, the resolution has reached its maximum. Any more reduction in capture time must be accompanied by a reduction in the number of data points such that:

(capture time)/(data point) > 7 µs

For example, in case of a MA24118A with 20 ms of capture time, there are 2860 samples. If there were 10 data points, then each data point consists of an average of 286 samples. The number of data points should not be less than the total number of samples. For a given capture time, the lower the number of data points the more samples that are averaged per point, thus the lower the trace noise.

When there is a large number of points in a graph, the points are plotted at the beginning of the given time interval. For example, if a graph has a capture time of 100 ms and data points of 1000, then the first time interval is from time 0 µs to 100 µs (100 ms/1000). The power measured during this time interval is plotted as a point at time 0 µs. Subsequent intervals are plotted the same way until time interval 1000, where data is plotted as a point at time 99.9 ms. When there are many data points in a graph, not having a point at exactly 100 ms is not noticeable. However, when there are fewer points, then the graph seems incomplete (missing the last data point). One may perceive this as a time inaccuracy if not aware of how the graph is plotted.

When the number of points reaches 100, PowerXpert implements a different type of graphing that is more technically correct. Instead of plotting each time interval as a point, time intervals are plotted as a horizontal line between the start and the end of the time interval. For example, if a graph has a capture time of 1 ms and data points of 100, then the first time interval will be from 0 µs to 10 µs (1 ms/100). The power measured during this time interval is a horizontal line representing the measured power plotted between time 0 µs to 1 µs. Subsequent time intervals are plotted the same way until time interval 100, where a horizontal line is plotted between time 990 µs and 1 ms. See Figure 3-10. The resulting power graph will look different as seen in Figure 3-11.

Figure 3-10. Data Point Plot Difference Description
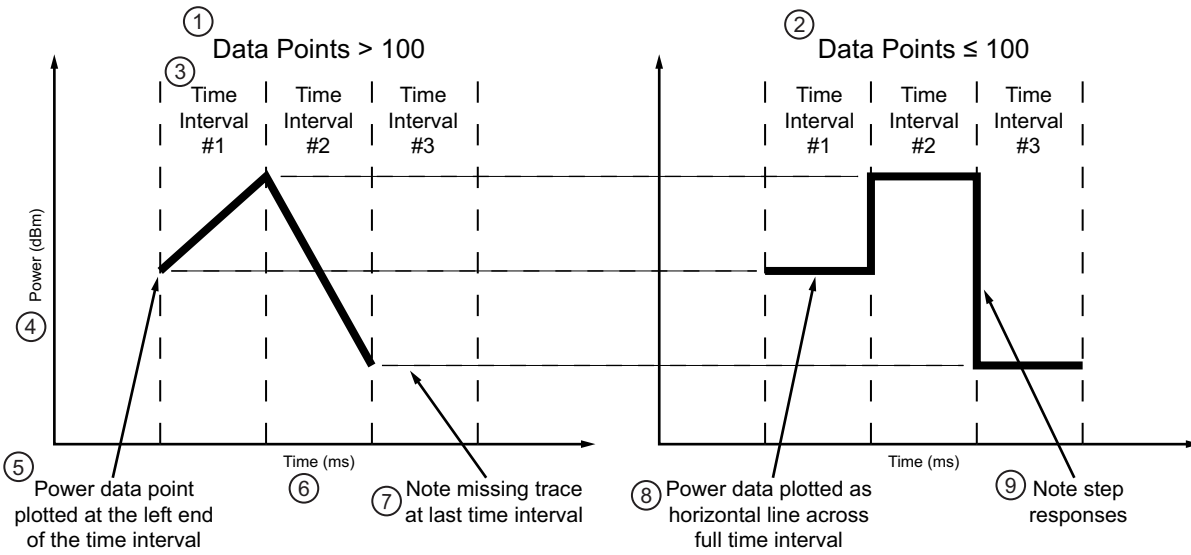
Index	Description
1	Data Points > 100
2	Data Points ≤ 100
3	Time Intervals (#1, #2, #3)
4	Power (dBm)
5	Power data point plotted at the left end of the time interval
6	Time (ms)
7	Note missing trace at last time interval
8	Power data plotted as horizontal line across full time interval
9	Note step responses
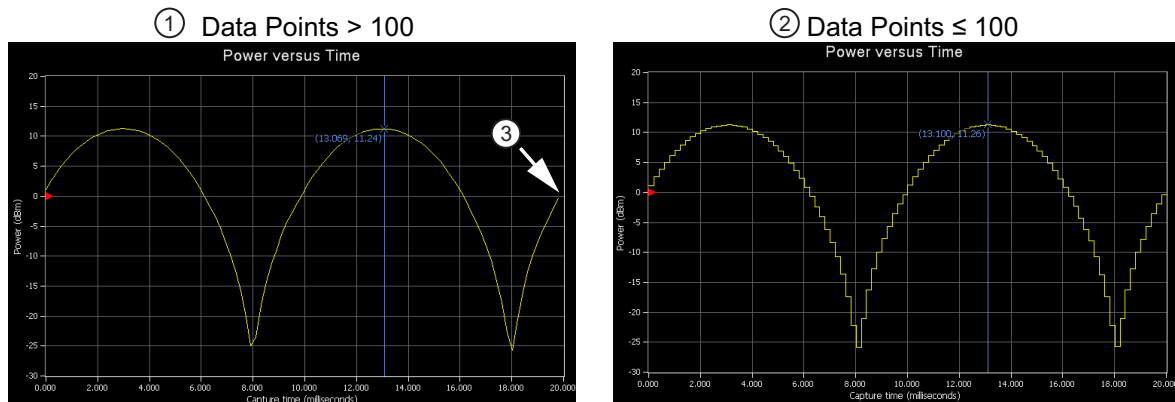
Index	Description
1	Data Points >100
2	Data Points ≤100
3	Note the missing trace at the last time interval in the plot on the left.

Figure 3-11. Data Points Plot Differences

Gate and Fence

The Gate and Fence feature enables measurement of the desired portion of the waveform. A Gate is a specification for extracting an averaged power reading measurement between two defined points on a pulsed waveform. A fence must be set up within the boundaries of a gate, unless the fence is disabled by setting the Fence start and end to zero, or to the same value. All data sampled between the fence start and end positions are excluded from the average power calculations for the gate. This is useful for purposes such as excluding a training sequence from an EDGE measurement.
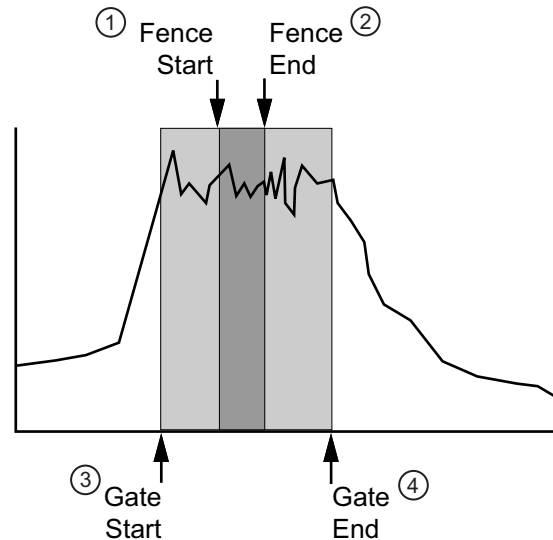
Index	Description
1	Fence Start
2	Fence End
3	Gate Start
4	Gate End

Figure 3-12. Gate and Fence Mode Settings

Checking the **Enable gate and fence** box enables the feature in PowerXpert. All of the gate and fence settings are relative to the triggering event (start of capture). The fence must reside entirely within the gate, unless the fence is disabled by setting the Fence start and Fence end to zero. The gate and fence start and end points can be dragged by the mouse or directly entered: (the **Apply above settings** button must be clicked to enable the changes to the gate and fence parameters, even when dragging them with the mouse).

Certain restrictions and conditions apply when setting up gating and fence settings as listed below:

- Gate start cannot be negative and it cannot exceed the capture time.
- Gate end value cannot be less than gate start and cannot exceed the capture time.
- Fence start should be between Gate start and Gate end.
- Fence end should be between Fence start and Gate end.
- If the Fence start and Fence end values are the same, then the fence is disabled.
- Fence is disabled if both fence start and fence end are set to zero.
- The Fence start and Fence end positions cannot be set outside of the area defined by the Gate start and Gate end positions.
- The Gate start and Gate end points are included in the measurement.
- The Fence start and Fence end points are excluded from the measurement and have priority over the Gate start and Gate end points if they coincide.

3-9   List Mode

List mode is only available with power sensor models MA242x8A and MA243x0A. In List mode, the sensor can take up to 1000 measurements with different settings defined for each measurement. The measurement settings are defined in a setup file which must be sent to the sensor before starting the measurement process. The sensor needs to be externally triggered to perform each measurement. After each measurement is complete, the sensor sends a trigger out signal to indicate its readiness for the next trigger. In this way, handshaking can occur to synchronize the sensor and the device-under-test. When all measurements are completed, the results will be displayed in a table. If any error occurred during a measurement, the table row of the corresponding measurement will be highlighted in red.

List Mode Setup File

In List mode, the correct settings for each measurement are specified in a text file which is sent to the sensor. A List Mode window is shown in Figure 3-13. To send a setup file to the sensor, browse to and select the file by clicking the button next to the List File text box, then click the "Upload Settings to Sensor" button. The user must load the sensor with a setup file containing a list of frequency (GHz), aperture time (ms), and average count settings using the LOADLIST command where each set of settings corresponds to one measurement setup. See "Setup File Example" on page 3-19. The file format of the setup file is specified below. It needs be a (.csv) file that contain a header followed by up to 1000 sets of settings, each on their own line. The file must end with a blank line. The file format is comma separated value (.csv). Once a setup file has been sent to the sensor, the "Start List Measurement" button will become available to start the measurement process. See "List Mode Output File" on page 3-19.
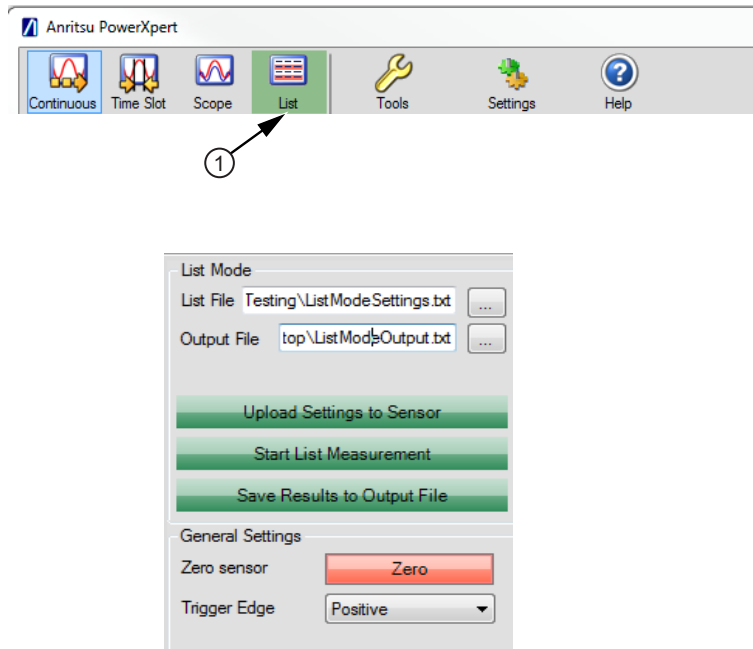
Index	Description
1	List Mode Settings

Figure 3-13. List Mode Settings

Setup File Example

```
Frequency (GHz), Aperture Time (ms), Average Count
2.0,1,1024
2.0,2,1024
2.0,3,1024
2.0,4,1024
…
2.0,200,10
<blank line>
```

Meas No.	Frequency (GHz)	Aperture time (ms)	Averages	Power (mW)
1	2.00000	1.00	10	-000.0000028
2	2.00000	2.00	10	-000.0000035
3	2.00000	3.00	10	-000.0000006
4	2.00000	4.00	10	-000.0000019
5	2.00000	5.00	10	-000.0000027
6	2.00000	6.00	10	-000.0000013
7	2.00000	7.00	10	-000.0000022
8	2.00000	8.00	10	-000.0000017
9	2.00000	9.00	10	-000.0000023
10	2.00000	10.00	10	-000.0000027

Figure 3-14. List Mode Data Display

List Mode Output File

The results from the List mode measurements can be saved to an output file. Browse to a location by clicking the button next to the Output File text box, enter the desired filename and click save. Once a List mode run has completed, the results can be saved to the output file by clicking the "Save Results to Output File" button.

3-10   General Settings

The General Settings settings shown in Figure 3-15 are common to all four modes and power sensors.

Apply above settings
must be clicked
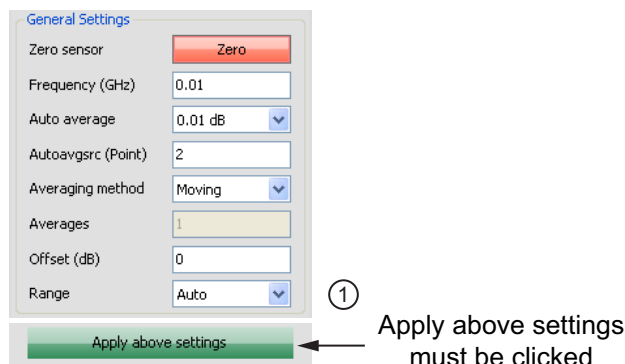
Index	Description
1	Button must be clicked to apply above settings

Figure 3-15.   General Settings

Zero Sensor

Zero the sensor before making power measurements. If frequent low-level measurements are being made, check the sensor zeroing often. Before zeroing the sensor, connect it to the DUT (device under test) test port and reduce RF power from the connection to a level 20 dB below the noise floor of the power sensor.

For the MA24105A power sensor, this level is less than –20 dBm. For the MA24106A power sensor, this level is less than –60 dBm. For the MA243x1A, this level is –67 dBm. For the MA24108A, MA24118A, MA24126A, and MA243x0A this level is less than –70 dBm. For the MA24208A, and MA24218A, this level is less than –70 dBm.

Leave the sensor connected to the DUT test port so that ground noise and thermal EMF (electro-magnetic fields) are zeroed out of the measurement. The sensor may also be connected to a grounded connector on the DUT or disconnected from any signal source.

Frequency

Entering the frequency of measurement applies frequency correction to the measured power. The power sensor has an internal EEPROM containing frequency calibration factors that were programmed into the sensor at the factory. The power sensor has an internal temperature sensor that reports its readings periodically to the microprocessor. The sensor makes all of the required calculations on the measurement once entering the measurement frequency.

Auto Average

Auto average is only available with the MA24x08A, MA24x18A, MA24126A and MA243x0A power sensors. Auto average sets the auto averaging status and count. When an auto averaging resolution is selected, the sensor chooses an averaging number that is a compromise between stabilizing the power reading and providing reasonable settling time. It does this by choosing an averaging number based on the power level currently being measured.

For most power levels, selecting auto averaging results in the power reading fluctuating by no more than twice the selected auto average resolution setting. However, near the low end of the measurement range, the power reading may fluctuate by more than this as the averaging number has been limited to maintain reasonable settling response time. Auto averaging only stabilizes the readings due to noise contributed by the power sensor electronics. Power variations that are the result of measuring modulated signals are not taken into account by the sensor in auto averaging. Setting Auto average to Off enables manual averaging.

Auto Averaging Source

Auto averaging source is only available in "Scope Mode" (to specify which point to use) and in "Time Slot Mode" (to specify which slot number to use). Auto averaging source is only available with the MA24x08A, MA24x18A, MA24126A and MA243x0A power sensors. Auto averaging source sets which display point or slot number to use for auto averaging. The auto averaging algorithm can only use one averaging number at a time and this point or slot number must be specified when "Auto Average" is enabled.

Averaging Method

Averaging method is only available with the MA24x08A, MA24x18A, MA24126A and MA243x0A power sensors. The types of averaging methods are Moving and Repeat.

Moving: Averaging is continuously performed over the number of specified measurements. When the specified number is reached, the average is calculated. When the next measurement is finished the average is recalculated from the new start and end positions. Refer to the figure below that shows moving averaging performed over eight measurements.
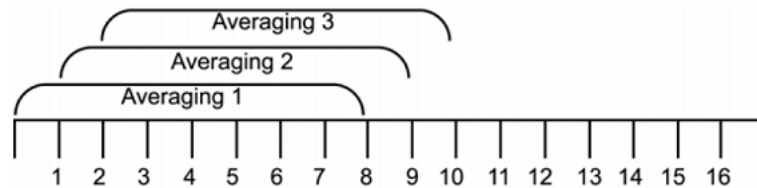
Figure 3-16. Moving Averaging

Repeat: Averaging is performed over the number of measurements specified. The displayed power is not updated until the next entire batch of measurements is complete. Refer to the figure below that shows repeat averaging performed over 8 measurements.
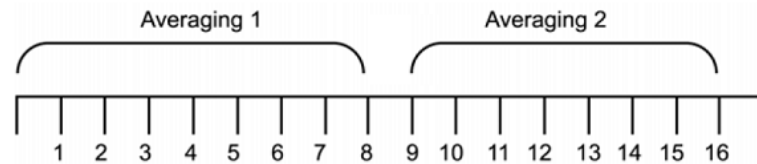
Figure 3-17. Repeat Averaging

Averages

The Averages setting allows you to specify the number of measurements that are averaged to calculate the displayed power. A setting of 1 disables averaging. This setting is only available when "Auto Average" is Off and applies equally to both forward and reverse measurements.

Offset

A fixed value (in dB) specified by the user is applied as a power offset to the sensor. A positive offset adds a value to the power readings and can be used to compensate for attenuators, couplers, limiters, and other lossy devices. A negative value subtracts a value from the power reading and can be used to compensate for amplification in the measurement path.

Range

Range allows the operating power range of the sensor to be set to the desired range. Setting to "Auto" means that sensor firmware determines the appropriate range for it to operate. Auto ranging is available only with MA24108A, MA24118A, MA24126A, MA24208A, MA24218A and MA243x0A power sensors.

Table 3-2.   Power Sensor Operating Power Range

\<det range\>	MA24105A	MA241xxA	MA242x8A	MA243x0A
0	Auto Range	Auto Range	Auto Range	Auto Range
1	Low power (+3 dBm to +38 dBm)	Channel A (+20 dBm to –7 dBm)	Channel A (+20 dBm to +4 dBm)	Channel A (+20 dBm to +4 dBm)
2	High power (+38 dBm to +51.76)	Channel B (<–7 dBm to –40 dBm)	Channel B (<+4 dBm to –16 dBm)	Channel B (+4 dBm to –16 dBm)
3	-	-	Chanel C (<–16 dBm to –60 dBm)	Chanel C (–16 dBm to –70 dBm)

In some instances, setting the range manually improves the measurement. For example, a low duty cycle, high crest factor signal, where average power may fall in one range and the peak power in another, may result in erroneous readings when the sensor is set to auto range. In this case, setting the range manually closer to the anticipated average power will increase the accuracy.

Apply Above Settings Button

The **Apply above settings** button applies all changes made to the "Scope Mode" settings. Changes to these settings do not take affect until clicking this button.

3-11   Trigger Settings

Trigger settings is only available in Time Slot Mode and Scope Mode with power sensor models MA24x08A, MA24x18A, and MA24126A. Trigger settings are available only in Scope mode with MA243x0A. Trigger is an event that initiates a measurement run. When the sensor is armed, it starts looking for the trigger. Once the trigger occurs, the sensor starts collecting data and measurement commences. Before arming the sensor, the sensor must be set up with the following trigger related parameters:
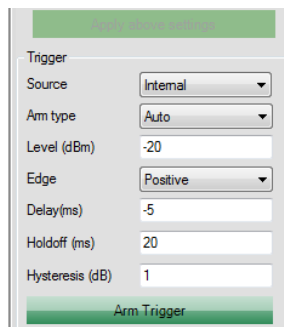
Figure 3-18. Trigger Settings

Trigger Source

- **Internal Trigger:** If internal trigger source is selected, the sensor triggers based on the signal level, edge/slope and noise immunity factor.

- **External Trigger:** When the sensor is setup with external trigger, it is triggered by the TTL/CMOS signal on the external trigger pin. In this trigger source, sensor can be set up to trigger at a particular edge of the TTL/CMOS signal. External trigger does not depend on any other trigger related parameter.

- **Continuous Trigger:** The sensor continuously collects data when the trigger source is set to continuous and does not look for any trigger event. Continuous trigger does not depend on any other trigger related parameters and these settings are unavailable for a Continuous trigger source.Trigger Arm Type

The trigger parameters are effective only if the sensor is armed. "Armed" is the state when the sensor is looking for a trigger. By default, the sensor is in Standby mode, it has to be armed before it starts looking for trigger. Trigger arming is effective only when the trigger source is set to internal or external. It does not play any role when the trigger source is continuous. An armed sensor returns the power automatically after a trigger has occurred and data has been collected and processed. The trigger can be armed in following ways:

- **StandBy:** This is the default arming state of the sensor. If the trigger source is internal or external, and the arm type is stand by, then the sensor will not make measurements or update the trace data. This is similar to the "stop" acquisition function of a digital oscilloscope. However, if the trigger source is continuous, then the sensor continuously collects and updates trace data.

- **Auto Arm:** In this state, the sensor rearms automatically after a trigger event has occurred and power is displayed. It is generally used to evaluate periodic waveforms. In other words, the sensor rearms after every measurement run. The power is displayed/updated automatically after every trigger event.

- **Single Arm:** The trigger is first armed and, once the trigger event occurs, the data is collected and the display updated, then the trigger is unarmed. Thus, only one measurement run and display update is performed. This mode is generally used to evaluate non-periodic waveforms. If averaging is selected, the results will not usually be very meaningful because all of the measurement runs commence with only the one trigger event and occur successively. The individual measurement runs are not synchronized to the input signal; therefore, averaging should not normally be used with the single arming type.

- **Multiarm:** Multiarming is used when averaging is needed, but continuous display updates are not needed. In this mode the trigger is armed, then once the trigger event occurs, the measurement data is taken and the display is updated (for the moving average method). Then the trigger is rearmed. This cycle repeats N times where N is the current averaging number. If the averaging method is *Moving*, then the display is updated after each trigger and measurement run. If the averaging method is *Repeat*, then the display is updated only after N triggers and measurement runs. Once N runs are complete, the trigger is unarmed.

Trigger Level

Sets the power level threshold of the waveform under test that, when crossed, triggers a measurement. It is used during internal triggering only.

Trigger Edge

It sets the trigger edge for internal and external trigger. Trigger edge can be set to positive or negative. For internal trigger, the sensor triggers only when the signal crosses the trigger level from high to low when set to negative edge; the sensor triggers only when the signal crosses the trigger level from low to high when set to positive. For external trigger, the sensor triggers when the TTL/CMOS signal on the external trigger pin falls from high to low when set to negative; the sensor triggers when the TTL/CMOS signal on the external trigger pin rises from low to high when set to positive.

Trigger Delay

A trigger delay allows a time lag (positive or negative) between the trigger event and the data displayed on the screen. An example of Trigger Delay with positive parameters is shown in Figure 3-19.

Specifying a positive delay has the effect of displaying data occurring some time after the trigger event. When the delay is positive, the sensor waits for the set delay time after a trigger before it starts taking readings. The sensor is unresponsive during the wait period and cannot be aborted. For example, for a capture time of 20 ms and a delay of 1 ms, the length of the capture would be from 1 ms to 21 ms given that the trigger occurs at time, t = 0. The capture time is unaffected by a positive trigger delay.
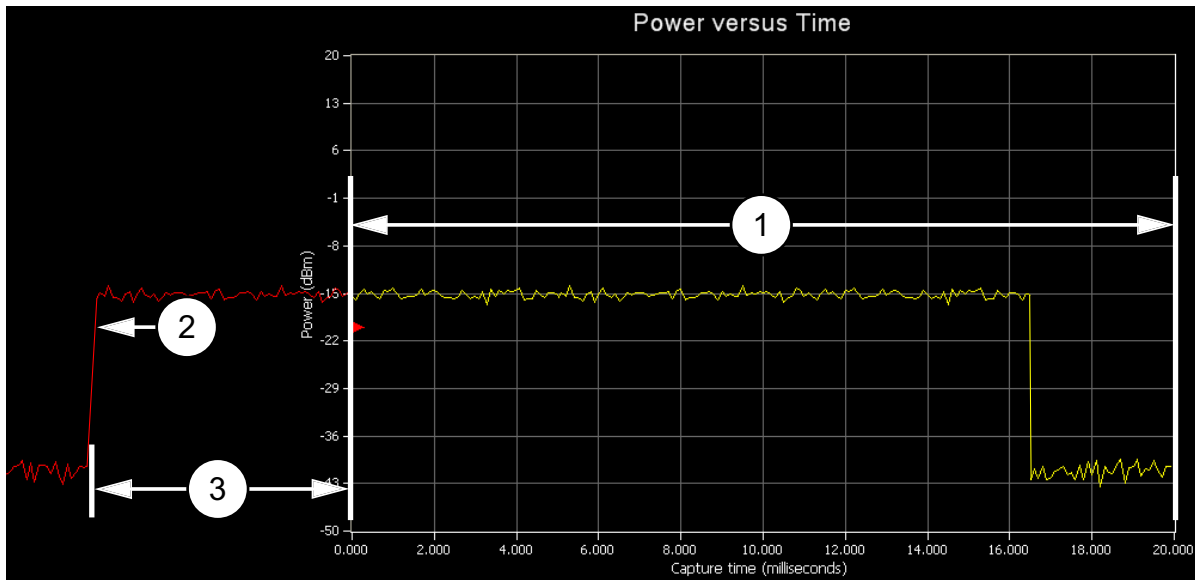
Index	Description
1	Capture Time (ms)
2	Trigger Level (dBm) and Positive Edge Trigger
3	Positive Trigger Delay Time (ms)

Figure 3-19. Trigger Delay Positive Parameters

Specifying a negative delay allows the user to display data occurring immediately before the trigger event. An example of Trigger Delay with positive parameters is shown in Figure 3-20. The negative delay cannot be greater than or equal to the capture time. If the capture time conflicts with the trigger delay, an error is generated.
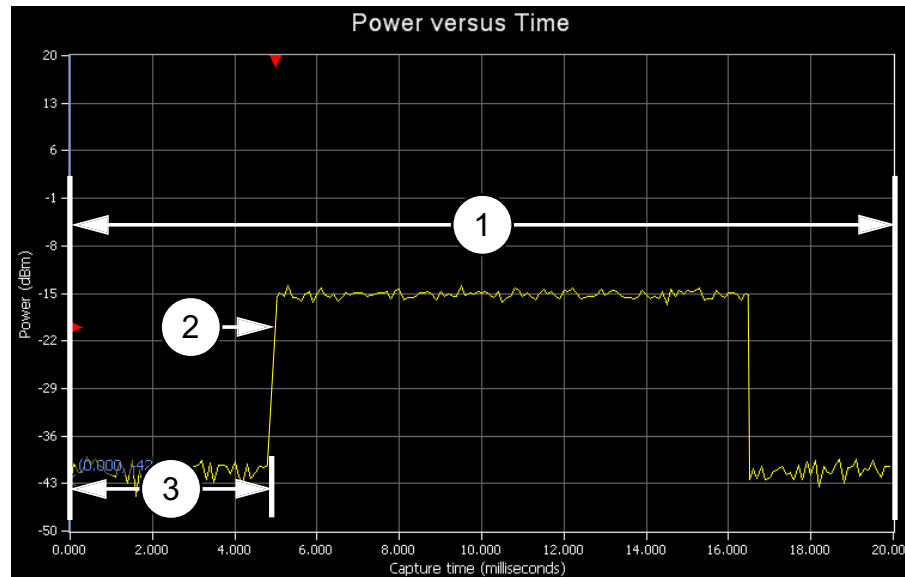
Index	Description
1	Capture Time (ms)
2	Trigger Level (dBm) and Positive Edge Trigger
3	Negative Trigger Delay Time (ms)

Figure 3-20. Trigger Delay Negative Parameters

Trigger Holdoff

Trigger Holdoff is available only in MA242x8A and MA243x0A models during internal or external triggering. It is intended to prevent problems arising from multi-triggering by suppressing triggers for a time after the first detection. When detecting noisy RF pulses, hysteresis and noise immunity may not be sufficient for reliably detecting the correct trigger event. A noisy burst might always drop below the lower hysteresis threshold and be missed entirely. Similarly, a noisy burst may not cross the noise immunity threshold enough times to cause a trigger detection. With hysteresis and noise immunity off, a trigger hold off duration slightly greater than the signal burst time will ensure a stable trigger capture.

Noise Immunity

Noise Immunity is available only in MA24108A, MA24118A, and MA24126A models. This feature is available during internal triggering and is intended to minimize the risk of triggering on an unintended edge. For very noisy signals, the sensor can trigger at an undesired point or edge. To provide immunity against such situations, the sensor can be set to wait for N number of samples to cross the trigger level before it triggers. Higher values of N result in increased noise immunity, but also increase the trigger latency. It is advised to use a negative trigger delay when using noise immunity. The negative delay required to reduce the trigger latency is the product of N and the sample duration of the power sensor (see sensor specifications), which is approximately 7 µs for the MA24108A and MA24118A. The default value for the trigger noise immunity factor is 1 (no immunity).

Hysteresis

Hysteresis is available in the MA242x8A and MA243x0A models. This feature is available during internal triggering and is intended to minimize the risk of triggering on an unintended edge. To minimize this potential, the sensor can be set to wait for the measured power to be beyond a hysteresis value of 0 to 10 dB from the trigger level before it is rearmed to trigger. The hysteresis value is applied differently depending on the Trigger Edge setting. If the Trigger Edge is positive, then the measured level must fall below the trigger level by the hysteresis amount before it is rearmed to trigger. For negative Trigger Edges, the measured value would need to rise above the trigger level plus the hysteresis value before the trigger is rearmed. The default value for the hysteresis level is +/– 0 dB (no hysteresis).

Arm Trigger Button

The **Arm trigger** button becomes available in "Time Slot Mode" or "Scope Mode" when the "Trigger Settings" have been changed. It may also become available in other conditions such as trigger timeout. Clicking the button applies the trigger settings and arms the trigger. PowerXpert may not be actively taking data and updating the graph when the **Arm trigger** button is available and has not been clicked.

3-12   Tools Menu

The Tools menu is shown in Figure 3-21.
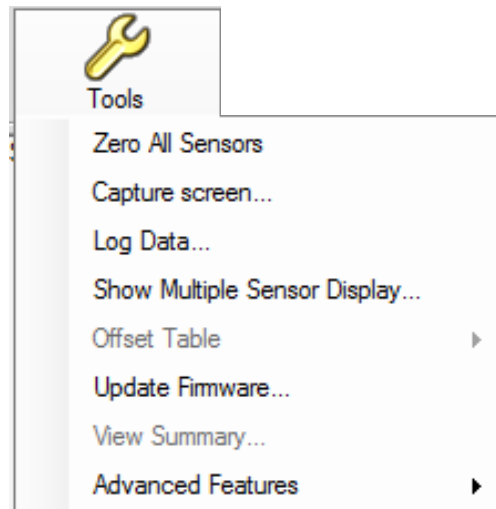
Figure 3-21. Tools Menu

Zero All Sensors

Zero All Sensors provides a convenient method of zeroing all connected sensors. Zero all sensors before making power measurements. If frequent low-level measurements are being made, it is advised to often check the sensor zeroing to assure accurate measurements. Before zeroing the sensor, connect it to the DUT (device under test) test port and remove RF power from the connection to a level 20 dB below the noise floor of the power sensor. For the MA24105A, this level is less than –20 dBm. For the MA24108A, MA24118A, MA24126A, MA24208A, MA24218A and MA243x0A, this level is less than –70 dBm. For the MA243x1A, this level is –67 dBm. Leave the sensor connected to the DUT test port so that ground noise and thermal EMF (electro-magnetic fields) are zeroed out of the measurement. The sensor may also be connected to a grounded connector on the DUT.

Capture Screen

The Capture Screen utility captures a PowerXpert screenshot and displays the Save image dialog that allows you to save the image in BMP, JPEG, PNG, or GIF file formats.
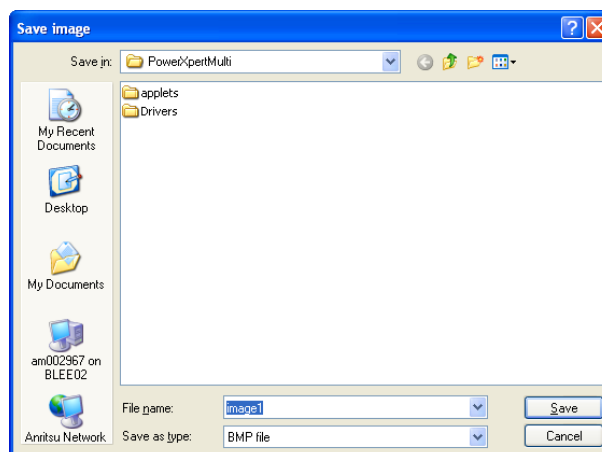
Figure 3-22. Save Image Dialog

Log Data

The Log Data feature provides the ability to record data in a comma separated value file and is accessed from the **Tools | Log Data** toolbar. This feature is available only when the application is in Continuous Average mode. Data logging is set up in the dialog below:
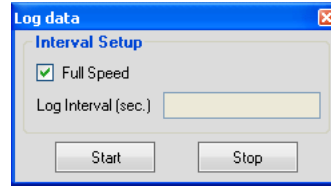
Figure 3-23. Log Data Dialog

- **Interval Setup:** Sets full speed data or fixed interval data logging (user defined logging interval). When Full Speed is selected, the user must manually start and stop the logging function.

- **Log Interval (sec.):** Type the time interval in which to log data when Full Speed is deselected.

Note	Log Interval should be set to reduce the number of data points when capturing long time periods as Microsoft Excel has a limitation of data records.

Data is stored as comma separated value (.csv) files that can be directly opened in Microsoft Excel. The filename and location can be selected or changed as desired. The default filenames have the following format:

```
Test_yyyy_mm_dd_hhmmss.csv
```

where:

- **yyyy:** Four-digit year
- **mm:** One- or two-digit month
- **dd:** One- or two-digit day
- **hhmmss:** Two digit hours (24-hour clock), minutes, and seconds

The Save As dialog is shown when the **Start** button is pressed.
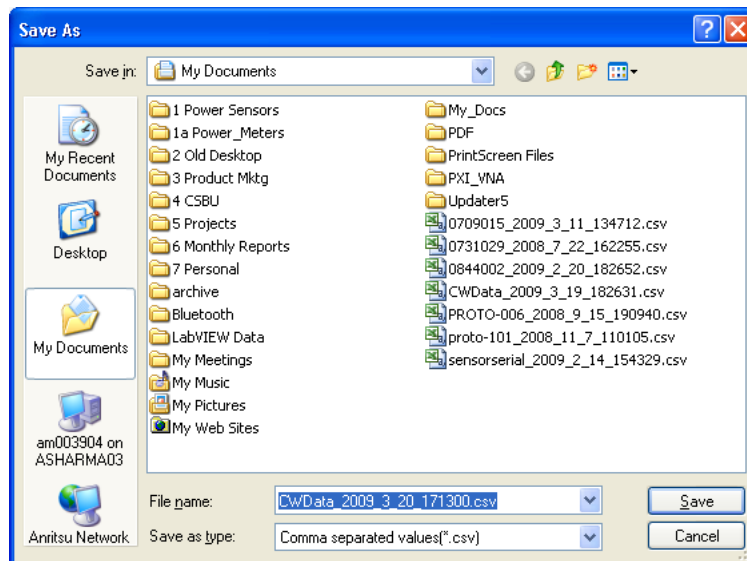
Figure 3-24. Log Data Save As Dialog

Sample log data is shown in a Microsoft Excel spreadsheet file below:

	A	B	C	D	E
1	Initial setup information				
2	Sensor Model	MA24218A			
3	Sensor Serial No	204			
4	Frequency	2	GHz		
5	Fixed Offset	0	dB		
6	Enhanced Modulation	ON			
7	Sample Interval	Full Speed			
8	Any setup information is not updated during data logging.				
9	15:55:11	-16.712	dBm		
10	15:55:11	-16.691	dBm		
11	15:55:11	-16.696	dBm		
12	15:55:11	-16.75	dBm		
13	15:55:11	-16.744	dBm		
14	15:55:11	-16.704	dBm		
15	15:55:11	-16.731	dBm		
16	15:55:11	-16.748	dBm		
17	15:55:11	-16.749	dBm		
18	15:55:11	-16.68	dBm		
19	15:55:12	-16.796	dBm		
20	15:55:12	-16.76	dBm		
21	15:55:12	-16.747	dBm		
22	15:55:12	-16.626	dBm		
23	15:55:12	-16.74	dBm		

Figure 3-25. Log Data Enhanced Modulation On

Data logging is stopped by accessing the **Tools | Log Data** toolbar and pressing **Stop** in the Log data dialog.

	A	B	C	D	E
1	Initial setup information				
2	Sensor Model	MA24218A			
3	Sensor Serial No	204			
4	Frequency	2	GHz		
5	Fixed Offset	0	dB		
6	Sample Interval	Full Speed			
7	Any setup information is not updated during data logging.				
8	15:54:19	-30.409	dBm		
9	15:54:19	-30.478	dBm		
10	15:54:19	-30.494	dBm		
11	15:54:19	-30.446	dBm		
12	15:54:19	-30.403	dBm		
13	15:54:19	-30.429	dBm		
14	15:54:19	-30.427	dBm		
15	15:54:19	-30.391	dBm		
16	15:54:19	-30.417	dBm		
17	15:54:20	-30.428	dBm		
18	15:54:20	-30.365	dBm		
19	15:54:23	-30.412	dBm		
20	15:54:24	-30.463	dBm		
21	15:54:24	-30.435	dBm		
22	15:54:24	-30.382	dBm		
23	15:54:24	-30.398	dBm		
24	15:54:24	-30.404	dBm		

Figure 3-26. Log Data Enhanced Modulation Off

Show Multiple Sensor Display

PowerXpert offers a Multiple Sensor Display screen that can show simultaneous measurements of up to eight sensors. This display is in addition to the normal PowerXpert display and is enabled by clicking Tools | Show Multiple Sensor Display. The measurements in the Multiple Sensor Display may differ from the measurements displayed in the numerical display area. The Multiple Sensor Display measurements are accomplished in a multi-threading process while the measurements in the numerical display area are performed.
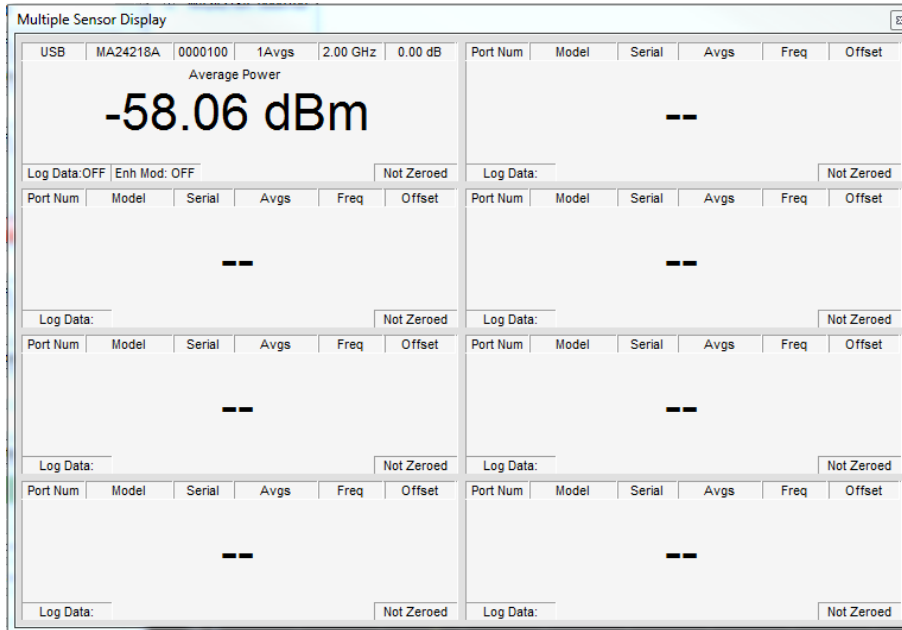
Figure 3-27. PowerXpert Multiple Sensor Display

When using multiple sensors, the sensor parameters are applied to the selected sensor in the Sensor Information area.
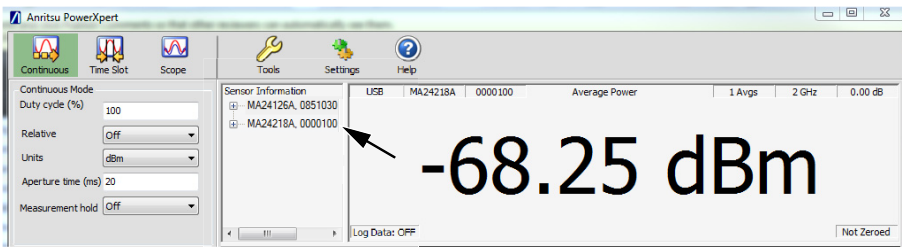
Figure 3-28. Selecting Sensor

Summary Display

For the MA24105A, PowerXpert shows a Summary Display screen as shown in Figure 3-29, that can show simultaneous forward and reverse measurements including:

- Forward Average Power
- Forward Crest Factor
- Forward Burst Average
- Forward Peak Power
- Reverse Average Power
- Reverse Refection Coefficient
- Reverse Return Loss
- Reverse VSWR.

This display, is enabled by clicking **Tools | View Summary**. The measurements in the Summary Display may differ from the measurements displayed in the numerical display area. The Summary Display measurements are accomplished in a multi-threading process while the measurements in the numerical display area are performed.
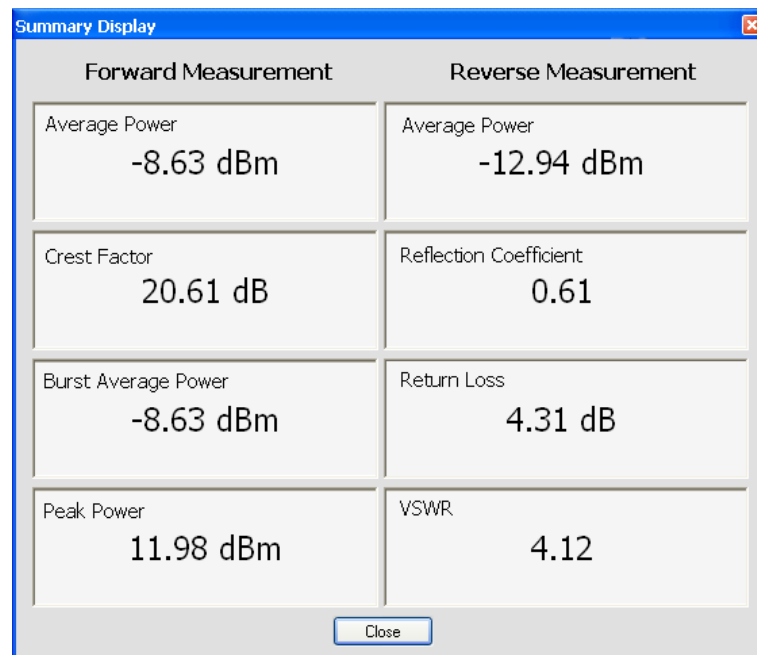
Figure 3-29. View Summary Screen

Offset Table

Offset Table feature is only available with the MA24106A power sensor. Offset table provides the ability to apply corrections to measurements when RF devices are used between the sensor and DUT. Different from Fixed Offset, Offset Tables allows you to enter different offset values at different frequencies for an RF device. The frequency response of that device needs to be known before the offset corrections can be entered. Offset Table employs linear interpolation to determine offset values for intermediate frequencies. In cases where the cal factor frequency is higher than the highest frequency in the offset table, then the offset for the highest frequency in the table is used. Similarly, when the cal factor frequency is lower than the lowest frequency in the offset table, then the offset for the lowest frequency in the offset table is used.

Offset Table Setup

The procedure for setting, saving, recalling, and applying the offset table is as follows:

1. Click **Tools | Offset Table | Setup**.

Figure 3-30. Offset Table

2. In the resulting dialog enter the frequency response of the RF device manually or by importing an S2P file used to measure the DUT.

Note	Positive values in dB are used for attenuation.

3. Click **Apply** in the Offset Entry screen to correct the measurement. "Offset table applied" appears briefly in the display window indicating that an offset table correction is applied to the current measurement. Also, a check mark is applied in front of the **Enable Offset Table** selection in the **Tools | Offset Table** menu.

4. To clear all of the entries in the table, click the **Clear Table** button.

5. Save the response of the device by clicking Save from the Offset Entry Screen and save as a file in the directory of your choice. Any number of device responses can be stored. The files are stored as comma separated value files (.csv).

6. To recall a response, click **File | Open** in the Offset Table dialog, select the file, and then click Apply. Similarly, .s2p files can be imported by selecting **File | Import .s2p file** in the Offset Table dialog.

7. To remove the offset table correction, click **Tools | Offset Table | Enable Offset Table**. to remove the check mark. "Offset table disabled" appears briefly in the display window indicating that an offset table correction is no longer applied to the current measurement.

Update Firmware

To Update the MA21xxA series, refer to Appendix B, "Upgrading Power Sensor Firmware – MA241xxA Series".

To Update the MA242x8A and MA243x0A Series, refer to Appendix C, "Updating Power Sensor Firmware - MA242x8A and MA243x0A Series".

3-13 Advanced Features

Advanced Features provides the Enhanced Modulation and Step Detect submenus.

Enhanced Modulation

This feature is active with the MA242x8A sensors only. The enhanced modulation has a different algorithm to compute the final power reading based on sampled voltages, and is available in all the modes supported. The crossover power between ranges are set 3 dB lower in enhanced modulation to allow for the modulated signal.

Step Detect

While using auto averaging, the step detect feature allows the sensor's power readings to jump quickly to the actual input power when a large change in power is detected. When viewing power versus time in Continuous Average mode in PowerXpert, the averaging count calculated by auto averaging can be high enough to cause a noticeable settling time in the power readings. When step detect is enabled the power readings will jump quickly to near the actual input power level. Step detect causes the plotted data to appear to reach the actual input power faster, but note that the actual settling time remains the same.

3-14 Settings Menu

The Settings menu is only available with the MA24126A, MA242x8A, and MA243x0A, and power sensors. The Settings menu shown in Figure 3-31 is used for saving and recalling PowerXpert setups, resetting PowerXpert, setting the sensor time out, and enabling secure mode.
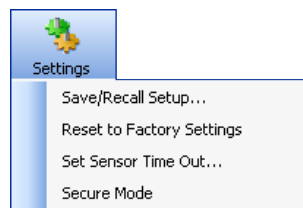
Figure 3-31. Settings Menu

Saving and Recalling Settings

The current settings can be saved to any one of ten non-volatile storage locations. If the storage location was already in use, the previously stored settings are automatically overwritten. Trigger Arm Type, Sensor Timeout, Scale Mode settings, Units, and a fixed Offset value are not stored as part of the saved setup and will not be recalled
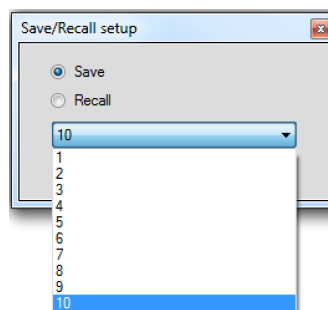
Figure 3-32. Save/Recall Setup Dialog

Resetting to Factory Settings

This selection resets PowerXpert and the power sensor to the default state.

Sensor TimeOut Setting

Sensor TimeOut is a PowerXpert feature. It is active during internal or external triggering only (Time Slot and Scope modes). It is provided for situations where a trigger event may not occur for a long period of time (greater than a default of 1 minute).
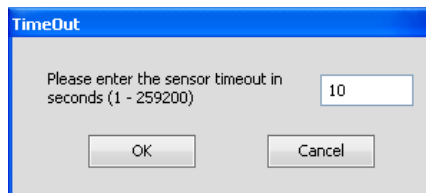
Figure 3-33. Sensor TimeOut Dialog

During triggering (internal or external), the sensor sends the data to the application after it receives a trigger. If the PowerXpert application does not receive any data from the sensor for the set timeout period, then the user is informed and is prompted to re-arm the sensor.
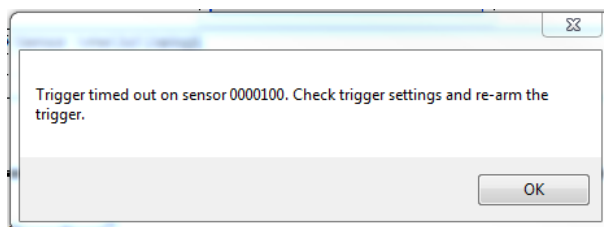
Figure 3-34. Trigger Timed Out Dialog

Secure Mode

The MA24106A is an secure device and can be moved in and out of the secure facilities as there are no user accessible locations in this sensor. In the MA24x08A, MA24x18A, MA24126A and MA243x0A, the user can store and retrieve instrument set ups in this memory. Memory is cleared using the secure mode procedure. The MA24105A does not use this feature because it is a secure device.The MA24106A USB power sensor has two different types of memory devices:

- Non-Volatile 32 kB FLASH memory within the PIC18F4550 micro-controller. This contains firmware for the sensor. This memory is not accessible by the user.

- Non-Volatile 8 kB EEPROM. This contains sensor factory calibration data and sensor information like Serial no, model no etc. This memory is not accessible by the user.

The MA24105A, MA24108A, MA24118A and MA24126A USB power sensors have three different types of memory devices:

- Non-Volatile 512 kB FLASH memory within the AT91SAM7SE512 micro-controller. This contains firmware for the sensor. User cannot write to or access this memory.

- Volatile 32 MB SDRAM. This contains program variables, buffers and calibration data information while sensor is in operation. This is initialized on power up and wiped clean when powered down. The user cannot write to this memory directly, and it is completely cleared during power down. This memory is not accessible by the user.

- Non-Volatile 4 MB Data FLASH. Contains sensor factory calibration data, user setups (user setups are not used on MA24105A) and sensor information like Serial no, Model no etc. The user cannot write to this memory directly.

The MA242x8A and MA243x0A USB power sensors have four different types of memory devices:

- Static memory 128 kB within FPGA. It is initialized during FPGA configuration with the bootloader code, which starts to execute after configuration is complete. This memory is not accessible by the user.

- Non-Volatile 64 kB FLASH memory. This contains boot flash for the FPGA and firmware for the sensor. This memory is not accessible by the user.

- Volatile 512 MB SDRAM. This acts as program and data storage while the sensor is in operation. It is initialized on power up and wiped clean when powered down. This memory is not accessible by the user.

- Non-Volatile 128 kB Data FLASH. This contains sensor factory calibration data, user instrument setups, and sensor information like Serial no, Model no etc.

3-15   No Sensor

The No Sensor message shown in is displayed:

- If there is no response from the sensor after re-arming of the trigger..

Figure 3-35. No Sensor Connected

- If the sensor detects that trigger arming is set, then there was no trigger and will again wait for the data. If the data still does not come, the cycle repeats.

- If the trigger event does not occur for a long time, then the length of the sensor's timeout needs to be increased or the trigger needs to be re-armed manually.

- If no trigger event is detected.

- If there is a communication problem with the sensor. In this case, close the application, disconnect sensor, and reopen application and reconnect the sensor. If the problem persists, contact an Anritsu service center.

Clearing the Non-Volatile Data Flash

Information such as a user-defined setup saved in the sensor needs to be removed from the USB power sensors if it is moved out of a secure facility. This can be accomplished by using the secure mode to completely wipe the non-volatile, 4 MB DATA FLASH of all user-saved information. The user sets the secure mode via PowerXpert. When PowerXpert is next started, the non-volatile flash is completely purged of all user-saved information. The power sensor then sets the factory defaults for the current settings.

Click **Settings** | Secure Mode. A warning dialog box appears.
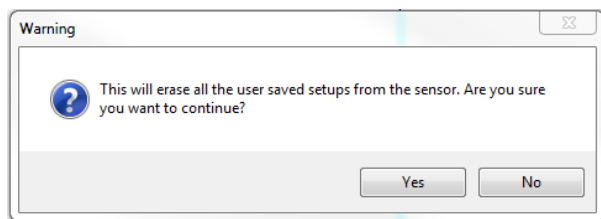
Figure 3-36. Secure Mode Warning

Click **OK**. Shut down and then restart PowerXpert. The power sensor now powers up with the non-volatile memory completely purged. The secure state can also be set over the USB using the "DELETE" remote command.

3-16   Help

The Help menu provides options to launch the online documentation and provides an informational About dialog.
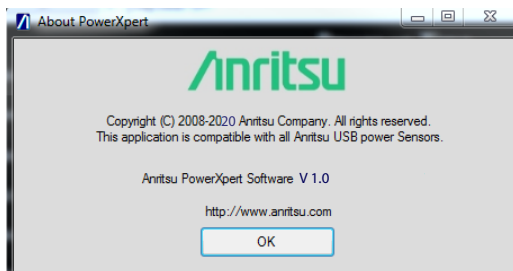
Figure 3-37. About PowerXpert

Chapter 4 — Using the MA24105A

4-1 Introduction

This chapter describes using the MA24105A USB power sensor and the PowerXpert PC buttons and menus described in Chapter 3, "Using USB Power Sensors with PowerXpert". If an Anritsu series handheld instrument is being used with the power sensor, refer to the user documentation that came with the handheld instrument for procedures on operating external power sensors.

4-2 Sensor Connector Overview

The MA24105A USB power sensor connectors are shown in Figure 4-1.
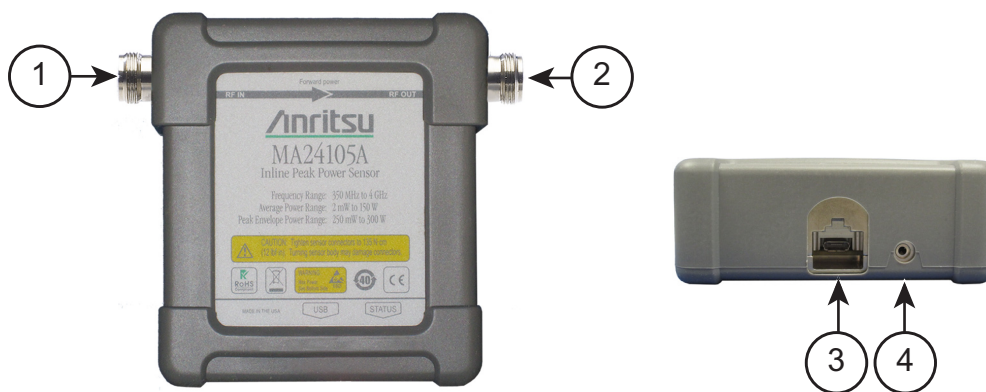
Index	Description
1	RF Input: N Type Connector (Torque connector at 12 lbf·in [1.35 N·m])
2	RF Output: N Type Connector (Torque connector at 12 lbf·in [1.35 N·m])
3	USB Micro-B Port (for connection with a PC or Anritsu Handheld instrument)
4	2-color LED (reports functional status of the sensor) **Green:** Sensor ON, Status OK **Amber:** Error Condition (see Table 4-6 on page 4-10)

Figure 4-1. MA24105A Sensor Connector Overview

4-3 Basic Power Measurement

This section provides steps and information to make basic power measurements with the MA24105A power sensor and PowerXpert. To perform a power measurement:

1. Connect the sensor to a computer or Anritsu Master™ series instrument as shown in Figure 4-2 on page 4-2.

2. Open the Anritsu PowerXpert application.

3. Zero the sensor as described below in "Zeroing the Sensor".

Caution	**Do not** apply power greater than the power sensor specifications or permanent damage may result. Connect a fixed attenuator to the output connector when power exceeds +20 dBm.

Caution	Before connecting the power sensor to a another device, read the "Instrument Care and Preventive Maintenance" on page 1-4.

4. Connect the load to the RF OUT port of the sensor. Connecting the load first protects the power sensor as well as the source/DUT from excessive mismatch.

5. Connect the RF source to the RF IN port of the power sensor.

6. Read the power measurement from the Anritsu PowerXpert application window (power readings are continuous with the default setting).
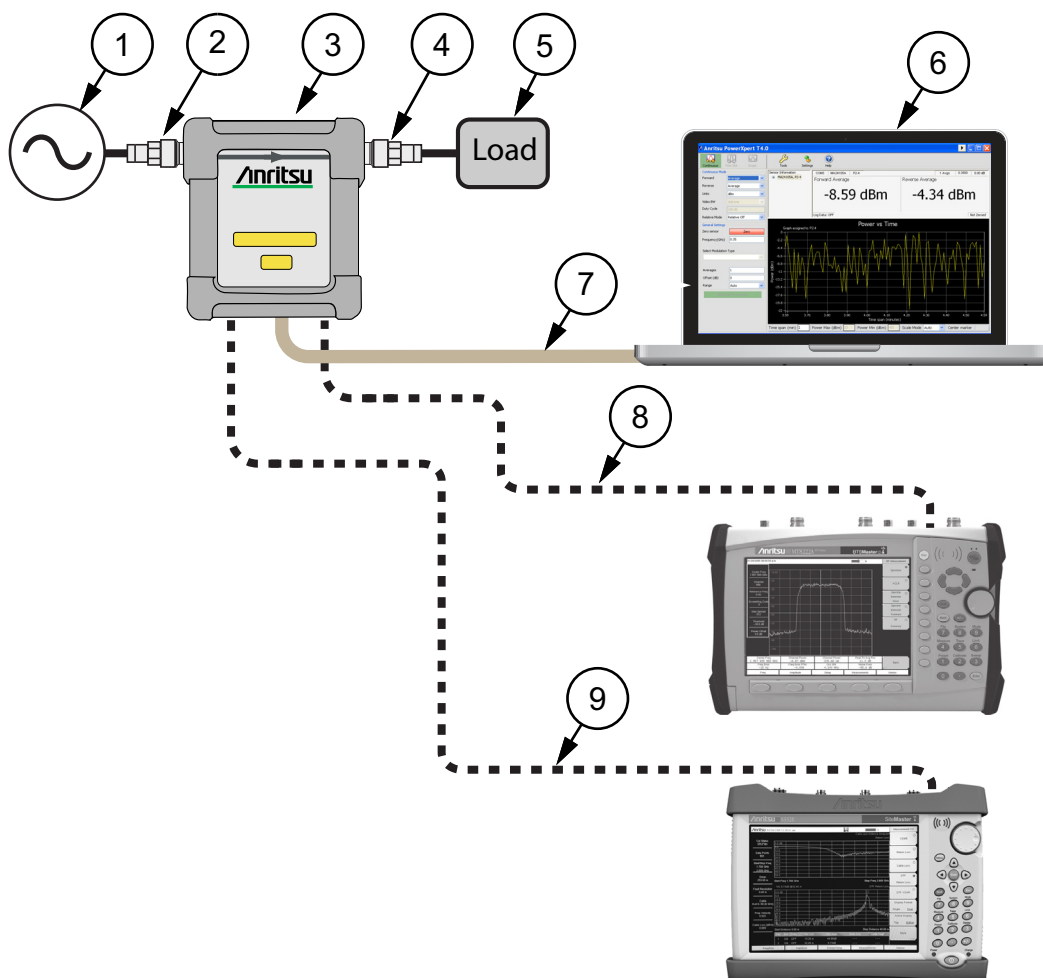
Index	Description
1	Source
2	RF In: N type Connector (Torque connector at 12 lbf·in [1.35 N·m])
3	MA24105A
4	RF Out: N type Connector (Torque connector at 12 lbf·in [1.35 N·m])
5	Load
6	PC with Anritsu PowerXpert Application
7	USB Cable to PC
8	USB to Spectrum Analyzer
9	USB to Spectrum Analyzer

Figure 4-2. Measurement Setup

Connecting the Sensor

RF signal connections are made to the Type N female RF connectors, which have a 50 Ω characteristic impedance. The input port is labeled RF IN and the output port is labeled RF OUT.

When connecting to the Type N female connector of the MA24105A to a Type N connector, observe the following proper practice for tightening the connection:

1. While holding the body of the N connector in one hand, turn the Type N Male connector nut to finger tighten the connection. **Do not** turn the body of the MA24105A as this will cause excessive wear to the connector.

2. Back off the connection by turning the connector nut counter clockwise ¼ turn.

3. Tighten the connection (clockwise) using a 12 in-lb torque wrench (Anritsu part number: 01-200).

Note	The Sensor has a USB 2.0 interface with a USB Type Micro-B port. The MA24105A can be remotely programmed over this USB interface. In addition to programming, the MA24105A is powered by the USB. The interface is USB 2.0 compatible, but with an interface speed of 12 Mbps.

Zeroing the Sensor

Zero the sensor before making power measurements. If frequent low-level measurements are being made, check the sensor zeroing often and repeat as necessary. If the sensor goes into sleep mode, the sensor must be re-zeroed before taking measurements. Before zeroing the sensor, connect it to the DUT (device under test) test port and remove RF power from the connection to a level 20 dB below the noise floor of the power sensor. For the MA24105A power sensor, this level is less than –20 dBm. Leave the sensor connected to the DUT test port so that ground noise and thermal EMF (electro-magnetic fields) are zeroed out of the measurement. The sensor may also be connected to a grounded connector on the DUT or disconnected from any signal source.

To zero the sensor, click the **Zero** button on the application. If the sensor fails the zeroing operation, the message box states "Sensor zero failed" and "ZERO_ERROR" will be displayed on the application screen until the problem is corrected. If RF is detected, a reminder message will pop up asking to remove the RF source.

Applying a Calibration Factor Correction

The MA24105A power sensor has an internal EEPROM containing correction and calibration factors that were programmed into the sensor at the factory. The power sensor has an internal temperature sensor that reports its readings periodically to the microprocessor. The sensor makes all of the required calculations on the measurement once the measurement frequency has been entered by the user.

The signal channel/analog signal acquisition hardware is integrated along with the RF front end of the power sensor. All of the necessary frequency and temperature corrections take place within the sensor. Therefore, there is no need for a reference calibration with the MA24105A.

4-4   Measurement Factors

The following measurement factors may apply.

Multitone Signals

The MA24105A is a True-RMS sensor that can measure very wide bandwidth modulation. The only limitation is the frequency flatness of the sensor. Because the sensor's sensitivity is not identical for all frequencies and when measuring multitone signals, the frequency entered into the sensor's application should be the average frequency of all significant tones.

The MA24105A has an error of 0.05 dB for every 100 MHz bandwidth at frequencies between 0.5 GHz and 4 GHz, and an error of 0.5 dB for every 100 MHz bandwidth at frequencies below 0.6 GHz.

Noise and Averaging

To achieve a required reading resolution, particularly at low power levels, averaging is often needed to reduce noise and steady the displayed power reading. Use the noise vs. resolution Table 4-1 and Table 4-2 on page 4-6 to determine the number of averages that will typically be required for a given resolution. Alternatively, determine the number of averages through calculation by using the noise specifications and the fact that noise will be proportional to the square root of N, where N is the number of averages.

For example, a CW tone at +25 dBm is to be measured to 0.01 dB resolution. Using Table 4-1, the required number of averages is seven averages when measuring average power in the forward direction.

Note	The set number of averages applies to both forward and reverse readings.

Settling Time

The MA24105A samples power continuously every 150 ms. The sensor's front end and digitizer settles completely to a step change in power in this amount of time. However, there is no way to synchronize the sensor's sampling to any other event, such as a power step or bus request for a measurement. Therefore, the first measurement requested from the sensor after a power step may not be fully settled. To ensure a fully settled measurement when operating the sensor over the bus, wait 150 ms after a power step before requesting the measurement from the sensor. Alternatively, request two measurements from the sensor and discard the first.

If averaging is required as described above, settling time increases by N × sample period, where N is the number of averages and the sample period is the time in milliseconds. The measurement sample period is 150 ms. When operating the sensor over the bus, request N+1 measurements from the sensor, discard the first, and then average the subsequent readings. The settling time is approximately (N+1) × sample period.

Maximum Power

The MA24105A is rated to meet all specifications up to an average input power level of 150 Watts. Although the average power of all signals should be kept at or below this level, time varying and burst signals having peak powers less than 300 W can be measured. To ensure accurate readings, the peak-to-average ratio (PAPR) of signals must be less than 12 dB.

Warning	Power in excess of that shown in Figure 4-3 on page 4-5 may damage the sensor.

MA24105A Maximum Power
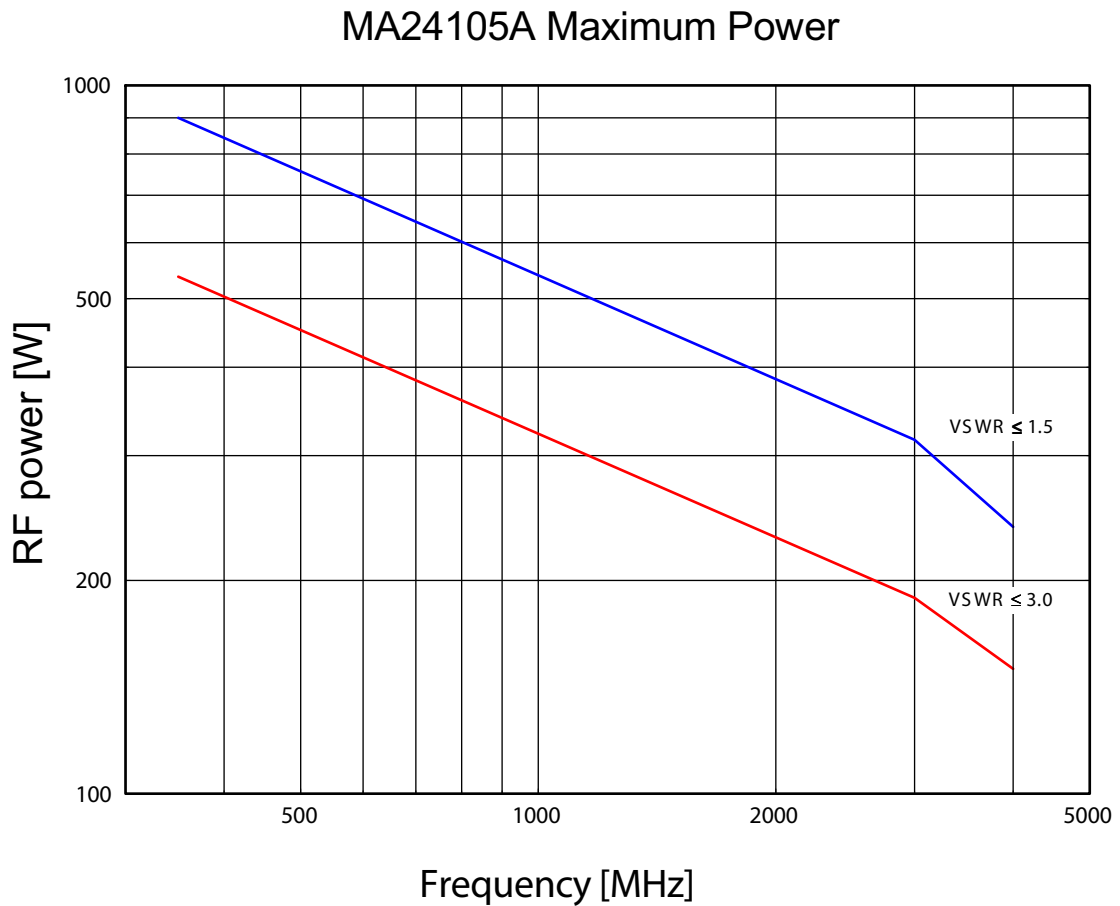
Figure 4-3.   Maximum Power Handling Capacity

4-5   Optimizing the Readings

This section presents information on how to get the fastest readings from the MA24105A power sensor when using the Anritsu PowerXpert application or operating under remote control (refer to Chapter 16 for specific remote programming command descriptions). Measurement speed depends greatly on the type of measurement, the power level, and stability of the signal. Stability of a measurement is influenced by noise and signal modulation. If high resolution is required, averaging must be increased.

Note	The values in the following tables are typical and should be used as a reference only.

Table 4-1 describes the number of averages needed to attain a certain noise level for a particular power level measurement when measuring forward average power.

Table 4-1.   MA24105A Averaging Table (Forward Average Power)

Input Power (dBm)	Input Power (W)	Number of Averages Needed for < ±0.20 dB Noise	Number of Averages Needed for < ±0.15 dB Noise	Number of Averages Needed for < ±0.10 dB Noise	Number of Averages Needed for < ±0.05 dB Noise	Number of Averages Needed for < ±0.01 dB Noise
50	100	1	1	1	1	1
45	31.6	1	1	1	1	1
40	10.0	1	1	1	1	1
35	3.16	1	1	1	1	1
30	1.00	1	1	1	1	1
25	0.316	1	1	1	1	7
20	0.100	1	1	1	3	69
15	0.0316	2	4	7	28	–
10	0.0100	18	32	70	276	–
5	0.00316	179	314	–	–	–

Table 4-2, describes the number of averages needed to attain a certain noise level for a particular power level measurement when measuring forward peak power.

Table 4-2.   MA24105A Averaging Table (Forward Peak Power)

Input Power (dBm)	Input Power (W)	Number of Averages Needed for < ±0.20 dB Noise	Number of Averages Needed for < ±0.15 dB Noise	Number of Averages Needed for < ±0.10 dB Noise	Number of Averages Needed for < ±0.05 dB Noise	Number of Averages Needed for < ±0.01 dB Noise
50	100	1	1	1	1	2
45	31.6	1	1	1	1	13
40	10.0	1	1	2	6	126
35	3.16	4	6	13	51	–

4-6   Uncertainty of a Measurement

Included at the Anritsu download center is a Microsoft Excel tool for calculating power uncertainty. It contains two tabs; one that provides measurement uncertainty for each sensor (selectable from a drop-down menu), and another tab that provides additional uncertainty components and calculated values for the power sensor.

https://www.anritsu.com/en-us/test-measurement/support/downloads/software/dwl003263

Power measurements have many component parts that affect overall measurement uncertainty when measuring power with the sensor:

- **Measurement Uncertainty:** Measurement uncertainty includes the uncertainty associated with the correction of frequency and the linearity response of the sensor over the entire dynamic range. Anritsu follows the industry standard condition of calibrating the power-sensing element at a reference power of 0 dBm (1 mW) and an ambient temperature of 25 °C.

- **Temperature Compensation:** Sensor Temperature Compensation describes the relative power level response over the dynamic range of the sensor. Temperature Compensation should be considered when operating the sensor at other than room temperature.

- **Noise, Zero Set, and Zero Drift:** These are factors within the sensor that impact measurement accuracy at the bottom of the power sensor's dynamic range.

- **Mismatch Uncertainty:** Mismatch uncertainty is typically the largest component of measurement uncertainty. The error is caused by the differing impedances between the power sensor and the devices to which the power sensor is connected. Mismatch uncertainty can be calculated as follows:

  - **Source Mismatch:**

    % Source Mismatch Uncertainty = $100[|1 + \Gamma_1\Gamma_2|^2 - 1]$

    dB Mismatch Uncertainty = $20\log|1 + \Gamma_1\Gamma_2|$

  - **Load Mismatch (not considering inline power sensor insertion loss):**

    % Load Mismatch Uncertainty = $100[|1 + \Gamma_2\Gamma_3|^2 - 1]$

    dB Load Mismatch Uncertainty = $20\log|1 + \Gamma_2\Gamma_3|$

  - **Load Mismatch (considering inline power sensor insertion loss):**

    % Load Mismatch Uncertainty = $100[|1 + t^2\Gamma_2\Gamma_3|^2 - 1]$

    dB Load Mismatch Uncertainty = $20\log|1 + t^2\Gamma_2\Gamma_3|$

- **Directivity Uncertainty:**

    % Uncertainty due to Finite Directivity = $100[(1 + \Gamma_3 / D)^2 - 1]$

where:

   D is the directivity of the inline power sensor expressed in linear units

   Γ_1 is the reflection coefficient of the inline power sensor

   Γ_2 is the reflection coefficient of the source

   Γ_3 is the reflection coefficient of the load

   t is the inline power sensor's transmission coefficient

   $t = 10^{(IL/20)}$

   IL = Insertion Loss of the inline power sensor

Uncertainty Examples

Noise Measurement Uncertainty is shown in Table 4-3.

Table 4-3.   Noise Measurement Uncertainty Calculations

Noise Calculations at 50 dBm (100 W):

Noise	1.9 mW/100 W = 0.0 %
Zero Set	3 mW/100 W = 0.0 %
Zero Drift	2.7 mW/100 W = 0.0 %

Noise Calculations at +10 dBm (10 mW):

Noise	170 μW/10 mW = 1.7 %
Zero Set	250 μW/10 mW = 2.5 %
Zero Drift	230 μW/10 mW = 2.3 %

Two measurement uncertainty calculations for the MA24105A are shown in Table 4-4. The MA24105A is used to measure the power of a 1 GHz, +50.0 dBm and +10 dBm CW signal from a signal source with a 1.5:1 VSWR and a load having a 1.2:1 VSWR. The example is based on 128 measurement averages.

Table 4-4.   Measurement Uncertainty Examples

Uncertainty Term	Uncertainty at +50 dBm(%)	Uncertainty at +10 dBm(%)	Probability Distribution	Divisor	Adjusted Uncertainty at +50 dBm (%)	Adjusted Uncertainty at +10 dBm (%)
Measurement Uncertainty	3.8	3.8	Normal at 2σ	2	1.9	1.9
Noise	0.0	1.7	Normal at 2σ	2	0.0	0.9
Zero Set	0.0	2.5	Rectangular	√3	0.0	1.4
Zero Drift	0.0	2.3	Normal at 2σ	2	0.0	1.3
Directivity Induced Uncertainty	0.6	0.6	Rectangular	√3	0.3	0.3
Source Mismatch Uncertainty	1.4	1.4	Rectangular	√3	0.8	0.8
Load Mismatch Uncertainty	3.7	3.7	Rectangular	√3	2.1	2.1
Effect of Digital Modulation	0	0	Rectangular	√3	0	0
Combined Uncertainty (RSS) Room Temperature					3.0	3.7
Expanded Uncertainty with K=2 Room Temperature					6.0	7.3
Temperature Compensation	1.9	1.9	Rectangular	√3	1.1	1.1
Combined Uncertainty (RSS, 0 to 50 °C)					3.2	3.8
Expanded Uncertainty with K=2 (RSS, 0 to 50 °C)					6.3	7.6

Table 4-5 shows another example measuring a pulse signal of +50 dBm at a repetition rate of 80/S with a duty cycle of 8 %.

Table 4-5.   Uncertainty Example - Pulse Signal (MA24105A)

PEP Uncertainty Components

Power Sensor	Uncertainty at +50 dBm (%)	Probability Distribution	Divisor	Adjusted Uncertainty at +50 dBm (%)
Base Unc (Average Power Uncertainty)	6.3	Normal	2	3.2
Peak Circuit Contribution	7.3	Rectangular	√3	4.2
Burst Repetition Rate	1.8	Rectangular	√3	1.0
Burst Width	0.0	Rectangular	√3	0.0
Burst Duty Cycle	0.1	Rectangular	√3	0.1
PEP Measurement Uncertainty				
Combined Uncertainty (%) (Base Unc + RSS)				7.5
Expanded Uncertainty (%) with K=2				15.0

4-7   Error Messages

Error messages are described in Table 4-6. The status LED will light amber when an error state occurs. In most cases, the error condition can be easily corrected. If not, note the error message and contact an Anritsu Service Center.

Table 4-6.   Error Messages

Message	Description	Resolution
Zero invalid as temperature changed by more than 10 Degrees C	The sensor's ambient temperature has changed by more than 10 ºC since the last zero operation.	Perform the zero operation again.
Temperature out of operating range	The sensor is operating outside of its specified range of 0 ºC to 55 ºC.	Operate the sensor within its specified range.
Sensor zero failed	This message box appears if the zero operation is unsuccessful. The reason could be the presence of RF power at the input of the sensor.	Turn off the RF input to the sensor or disconnect the sensor from the RF source and try the zero operation again.
ZERO_ERROR	This message appears on the application screen if the zero operation is unsuccessful. The reason could be the presence of RF power at the input of the sensor.	Turn off the RF input to the sensor or disconnect the sensor from the RF source and try the zero operation again.
ADC_TEMP_OVERRNGE	This message appears on the application screen if the sensor is being operated in extremely high temperatures and has overheated.	Remove the sensor from the USB connection and allow to cool to the operating range of the sensor: 0 ºC to 55 ºC

Chapter 5 — Verifying MA24105A Performance

5-1   Introduction

This chapter provides test procedures with measurement recording tables, test equipment setups, and verification tables to verify the measurement accuracy of the MA24105A USB power sensors. Test and verification is performed by comparing the sensor to a reference sensor with a specified cal factor and linearity performance or uncertainty. The reference sensor should be calibrated by a reputable standards laboratory using NIST instruments with low published measurement uncertainty values. Sensor test limits in these procedures are set appropriately to the specified comparison equipment. All tests must be performed at an ambient temperature of 20 ºC to 25 ºC to optimize the power sensor's performance.

Note	Refer to the instrument Technical Data Sheet for performance specifications.

5-2   Required Equipment

Table 5-1. Required Equipment

Equipment Description	Manufacturer and Model	Critical Specifications
Vector Network Analyzer (Pretest)	Anritsu MS4642B or equivalent	Reflection Coefficient Uncertainty ≤ 0.013, 350 MHz to 2 GHz Uncertainty ≤ 0.020, 2 GHz to 4 GHz
Synthesizer (Cal. Factor and Linearity Tests)	Anritsu MG3692B or equivalent	Output Power: ≥ +20 dBm 0.05 GHz to 4 GHz Output Power Setting Resolution: 0.01 dBm Harmonics: ≤ –40 dBc Source VSWR ≤ 2.00
Reference Power Meter (Cal. Factor and Linearity Tests)	Anritsu ML2438A or equivalent	Instrumentation Accuracy ≤ 0.5 %
Reference Power Sensor (Cal. Factor and Linearity Tests)	Anritsu MA24002A or equivalent	NIST Calibration or equivalent
10 dB N Attenuator (Linearity Test)	Aeroflex Model 1433	VSWR ≤ 1.15, 350 MHz to 4 GHz, 250 W min.
10 dB K Attenuator (Frequency Response and Linearity Tests)	Anritsu 41KC-10	VSWR ≤ 1.15, 350MHz to 4 GHz, 2 W min.
Low Power 30 dB N Attenuator (Linearity Tests)	42N50A-30	VSWR ≤ 1.2, 350 MHz to 4 GHz, 30 W min.
50 ohm Termination	Aeroflex Model 1433	VSWR ≤ 1.15, 350 MHz to 4 GHz, 250 W min.
Adapter N(f) to K(f) (Frequency Response and Linearity Tests)	Anritsu 34ANF50, 34AS50, 34AN50, and 34ASF50	VSWR ≤ 1.05, 350 MHz to 4 GHz
Power Coupler (Linearity Test)	MITEQ CD2-522-30N	350 MHz to 4.0 GHz, Coupling = 30 dB, 250 W min.
Amplifier (Directivity, Frequency Response and Linearity Tests)	Ophir 5163, 5125	350 MHz to 4.0 GHz, 250 W min. Harmonics/Spurious < –20 dBc
Personal Computer	Any	See Chapter 2

5-3   VSWR Pretest

The uncertainty of the VSWR test equipment will affect actual measurement values.

Test Procedure

Caution	**Do not** apply power greater than the power sensor specifications or permanent damage may result. Connect a fixed attenuator to the output connector when power exceeds +20 dBm.

Caution	Before connecting the power sensor to a another device, read the "Instrument Care and Preventive Maintenance" on page 1-4.

Using required equipment suggested in Table 5-1 on page 5-1, follow the manufacturer's S_{11} (or return loss) calibration procedure to perform calibration on a network analyzer. Connect the power sensor to the network analyzer test port and measure power sensor input match. Typically, matches are measured in terms of return loss in dB. Return loss and magnitude of the reflection coefficient conversion equations are as follows:

$\rho = 10^{-RL/20}$

$RL = -20\log\rho$

where

RL = Return Loss in dB

ρ = Magnitude of the Reflection Coefficient

VSWR and magnitude of the reflection coefficient conversion equations are as follows:

$VSWR = (1 + \rho) / (1 - \rho)$

$\rho = (VSWR - 1) / (VSWR + 1)$

where

VSWR = Voltage Standing Wave Ratio

ρ = Magnitude of the Reflection Coefficient

Record the measured data to Table 5-2 in the Actual Measurement column. The Actual Measurement should be smaller than the Maximum Reflection Coefficient. The Maximum Reflection Coefficient is the measurement system uncertainty added to the sensor's reflection coefficient specification. If the Actual Measurement reflection coefficient is larger than the Maximum Reflection Coefficient, then the power sensor may be defective. If the actual reflection coefficient is significantly larger than the maximum values in Table 5-2, then the sensor is damaged and it is not necessary to perform further testing.

Table 5-2.   Pretest Measurement Result

Frequency	MS4642B Reflection Coefficient Uncertainty	Maximum Reflection Coefficient	Actual Measurement
350 MHz to 3 GHz	0.013	0.033 + 0.013 = 0.046	
3 GHz to 4 GHz	0.020	0.047 + 0.020 = 0.067	

5-4   Directivity Test

Directivity tests an MA24105A for how selective the sensor is when measuring power in a given direction of travel and rejecting signals traveling in the opposite direction.

Test Procedure

The simplified equations below give the first order approximation of this parameter:

Directivity (dB) = Power Forward (dB) – Power Reverse (dB)

Directivity Coefficient = $10^{(-\text{Directivity (dB)} / 20)}$

Directivity (dB) = –20 × log(Directivity Coefficient)

Directivity (dB) = 10 × log(Power Forward / Power Reverse), where power is in watts.

In this test, the MA24105A is tested first with power in the forward direction and then with power in the reverse direction. See Figure 5-1 on page 5-4.

Note	Both forward and reverse readings are taken from the Forward Average Power window on the PowerXpert display as shown in Figure 5-2 on page 5-5.

The ratio of the two power readings are the directivity of the device assuming that both the termination and source are perfect 50 ohm matches. Since the termination and source are not perfect matches, residual effects from multiple reflections need to be accounted for by performing the following procedure.

1. Turn off the RF of the synthesizer. Connect the power amplifier to the synthesizer. Connect the output of the amplifier to the input of the MA24105A. Terminate the output of the MA24105A with the specified termination. See Figure 5-1.

2. With the RF off, zero the MA24105A.

3. Set the synthesizer to the first frequency in Table 5-3 on page 5-5 and to a very low power setting and slowly increase the power until the MA24105A displays +30 dBm. Allow the devices to warm up for 30 minutes.

4. Turn off the RF of the synthesizer and zero the MA24105A again.

5. Turn on the RF and adjust the synthesizer until the MA24105A displays approximately +44 dBm. Confirm that the reading is stable and record this value as Power Forward in Table 5-3.

6. Turn off the RF on the synthesizer.

7. Reverse the MA24105A connections to the termination and the amplifier. Confirm that the MA24105A output is now connected to the amplifier and that the input is connected to the termination. See Figure 5-1.

8. Turn on the RF. Change the MA24105A averages if necessary to see a steady reading. Record the value as Power Reverse in Table 5-3.

9. Calculate the Actual Directivity in dB by subtracting Power Reverse from Power Forward. If the power is in watts, use the formula noted above to calculate the Actual Directivity in dB.

10. If the actual directivity is larger than the minimum allowable directivity in Table 5-3, contact Anritsu customer service.

11. Repeat the steps above for the next frequency in Table 5-3.
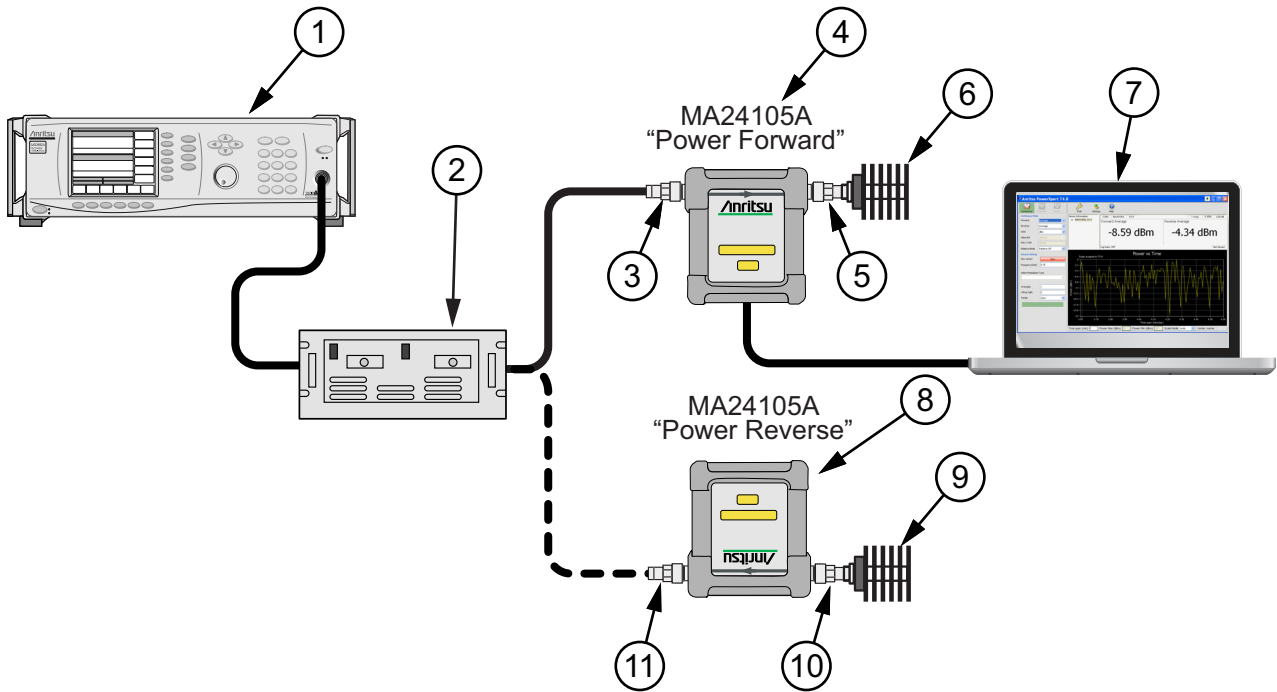
Index	Description
1	Synthesizer
2	Amplifier
3	RF In: N Type Connector (Torque connector at 12 lbf·in [1.35 N·m])
4	MA24105A "Power Forward" Measurement
5	RF Out: N Type Connector (Torque connector at 12 lbf·in [1.35 N·m])
6	50 ohm Termination
7	PC with Anritsu PowerXpert Application
8	MA24105A "Power Reverse" Measurement
9	50 ohm Termination
10	RF In
11	RF Out

Figure 5-1.   Directivity Test Set Up for Power Forward and Power Reverse
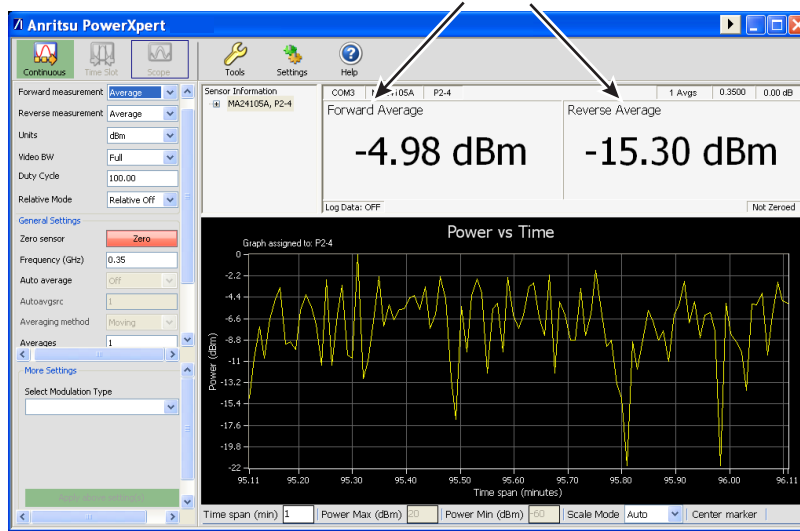
Figure 5-2.   Forward and Reverse Power Reading Location

Table 5-3.   Directivity Test Measured Results

Frequency (GHz)	Reflective Coefficient of Termination	Maximum Directivity Coefficient	A Power Forward (dB)	B Power Reverse (dB)	A – B Actual Directivity (dB)	Minimum Allowable Directivity (dB)
0.35	0.071	0.040				19.1
1.0	0.071	0.032				19.7
1.5	0.071	0.032				19.7
2.0	0.071	0.032				19.7
2.5	0.071	0.032				19.7
3.0	0.071	0.032				19.7
3.5	0.071	0.040				19.1
4.0	0.071	0.040				19.1

5-5   Frequency Response Test

In this test the frequency response of the sensor is tested at one low power level against a reference sensor of known measurement uncertainty. The reference sensor should be calibrated by a reputable standards laboratory using instruments with low published measurement uncertainty values. To perform the comparison, both sensors are used to measure the output power of a synthesizer with a high quality attenuator, such as the 41KC-10, on the output. The attenuator improves the source match of the synthesizer by lowering the mismatch ripples, thereby lowering the uncertainty in the comparison.

Test Procedure

1. Set up the equipment as shown in Figure 5-3.

    a. Connect the reference power sensor to the reference power meter using the appropriate cables.

    b. Connect the USB cable between the personal computer with the PowerXpert application installed and the MA24105A power sensor under test.

    c. Launch the PowerXpert application.

    d. Turn the power on to all of the instruments and allow them to warm up for the amount of time specified in their respective manuals.

    e. Reset or Preset all of the instruments.

    f. Configure the reference meter and sensor to measure a CW signal.

    g. Perform a sensor Zero and a 1 mW reference calibration on the reference sensor and meter per the manufacturer's instructions.

    h. Perform a low-level Zero of the MA24105A by disconnecting the MA24105A from the synthesizer, clicking the **Zero** button on the PowerXpert application, and waiting for the Zeroing message to close.

    i. Connect the synthesizer to the amplifier input. Connect the attenuator to the amplifier output, then connect the appropriate adapter to the output of the attenuator.

    j. Set the synthesizer to 350 MHz and a very low power output

.
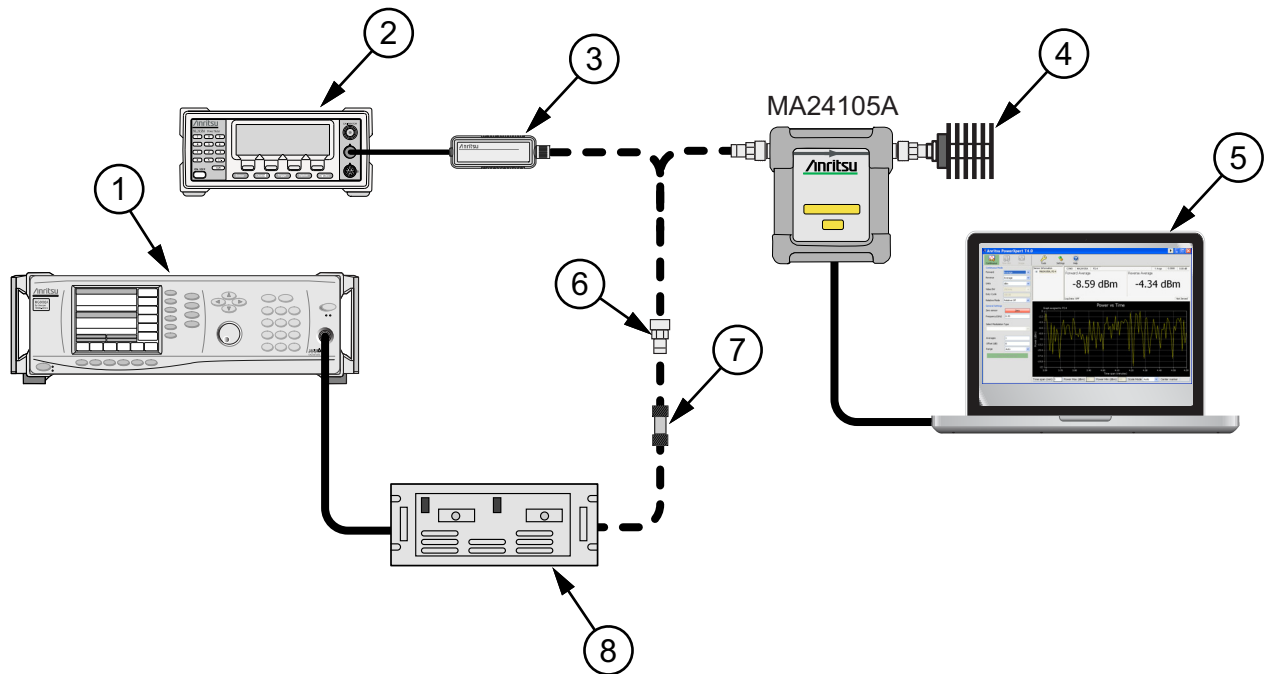
Index	Description
1	Synthesizer
2	Reference Power Meter
3	Reference Power Sensor
4	50 ohm Termination
5	PC with Anritsu PowerXpert Application
6	K to N Adapter
7	Attenuator
8	Amplifier

Figure 5-3.   Frequency Response Test Set Up

2. Connect the reference sensor to the amplifier with the appropriate adapter and attenuator in-line. See Figure 5-3.

3. Apply the Cal factor to the reference sensor per the manufacturer's instruction.

4. Adjust the synthesizer power until the reference displays +15 dBm.

5. Record the power indicated by the reference meter in Table 5-4.

6. Disconnect the reference sensor from the synthesizer output and connect the MA24105A power sensor with the appropriate adapter and attenuator in-line. See Figure 5-3.

7. Apply the Cal factor to the MA24105A by entering the frequency (in GHz) in the PowerXpert application, and then click **Apply above settings**.

8. Record the power indicated by the MA24105A in Table 5-4.

9. Set the synthesizer frequency to the next frequency in Table 5-4.

10. Repeat Step 2 through Step 9 until all of the frequencies in Table 5-4 have been measured.

11. For each row in Table 5-4, calculate the absolute value of the difference between the recorded Reference power measurement and the recorded MA24105A measurement, and record the result in Table 5-4.

12. For each frequency, compare the power difference to the maximum allowed difference specified in Table 5-4. If the difference is higher than the maximum allowed difference, contact Anritsu customer service.

Table 5-4. Test Measurement Results

Frequency (GHz)	A Reference Power Measurement (dBm)	B MA24105A Measurement (dBm)	|A-B| Absolute Value of Difference in Power Measurements (dB)	Maximum Allowed Difference (dB)
0.35				0.33
1.0				0.33
1.5				0.33
2.0				0.33
2.5				0.36
3.0				0.36
3.5				0.37
4.0				0.37

5-6   Linearity Test

The linearity correction of the MA24105A is compared to a thermal power sensor, which has very good inherent linearity over a power range of about –20 dBm to +10 dBm. For this reason, the MA24105A will be compared to the thermal sensor in two *ranges*, keeping the power levels to the thermal sensor in the range of –17 dBm to +5 dBm, while the power to the MA24105A will vary from about –26 dBm to about +14 dBm.

Test Procedure

1. Set up the equipment as follows (refer to for an illustration):

   a. Connect the reference power sensor to the reference power meter using the appropriate cables.

   b. Connect the USB cable between the personal computer with the PowerXpert application installed and the MA24105A power sensor under test.

   c. Launch the PowerXpert application.

   d. Turn the power on to all of the instruments and allow them to warm up for the amount of time specified in the instrument's respective manuals.

   e. Reset or Preset all of the instruments.

   f. Configure the reference meter and sensor to measure a CW signal.

   g. Perform a sensor Zero and a 1 mW reference calibration on the reference sensor and meter per the manufacturer's instructions.

   h. Perform a low-level Zero of the MA24105A by disconnecting the sensor from the synthesizer, click the **Zero** button in the PowerXpert application, and wait for the Zeroing message to close.

   i. Connect the power coupler to the output of the synthesizer and connect the 10 dB K attenuator using an adapter to the coupler's coupling output.

   j. Connect the low power 30 dB N attenuator to the other coupling output.

   k. Connect the reference sensor to the 10 dB K attenuator using an adapter.

   l. Connect the MA24105A to the output of the coupler.

   m. Set the synthesizer to 350 MHz and a very low power level.

   n. Increase averaging by entering "16" in the PowerXpert application, and then click **Apply above settings**.
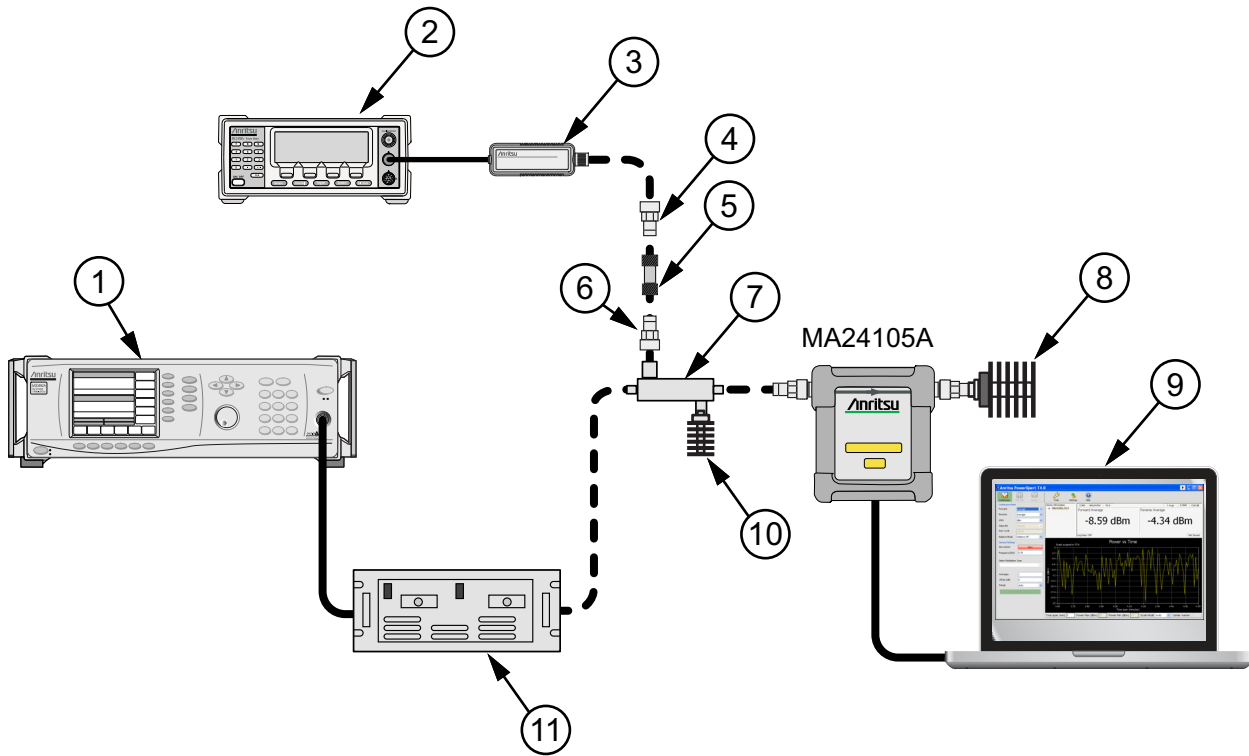
Index	Description
1	Synthesizer
2	Reference Power Meter
3	Reference Power Sensor
4	K to N Adapter
5	10 dB Attenuator N Type
6	K to N Adapter
7	Power Coupler
8	50 ohm Termination
9	PC with Anritsu PowerXpert Application
10	30 dB N Attenuator
11	Amplifier

Figure 5-4.   Linearity Test Setup 1

2. Apply the Cal factor to the reference sensor per the manufacturer's procedure.

3. Apply the Cal factor to the MA24105A by entering the frequency (in GHz) in the PowerXpert application, and then click **Apply above settings**.

4. Turn Off the synthesizer's RF output and perform a low-level Zero of both the Reference sensor and the MA24105A.

5. Turn On the synthesizer's RF output.

6. Adjust the synthesizer's power until the MA24105A is reading approximately +45 dBm.

7. Record data for the first 20 dB range as follows:

   a. Record the power reading by the reference meter in Table 5-5.

   b. Record the power reading by the MA24105A in Table 5-5.

   c. Reduce synthesizer power by 5 dB. The Amplifier output and the MA24105A should be about +40 dBm.

   d. Record the reference meter and the MA24105A power sensor readings in Table 5-5.

   e. Repeat the measurement for amplifier output levels of +35 dBm, +30 dBm, and +25 dBm. The MA24105A power measured at +25 dBm will be used in Step 8e,

8. Set up the test for the second 20 dB range as follows:

   a. Remove the 10 dB K attenuator from in between the reference sensor and coupler, then connect the reference sensor directly to the coupler's coupling port.

   b. Remove the MA24105A from the coupler and connect the 10 dB N attenuator between the coupler and the MA24105A power sensor. See Figure 5-5.

   c. Turn off the synthesizer RF output and perform a low-level Zero of both the Reference sensor and the MA24105A.

   d. Turn on the synthesizer RF output.
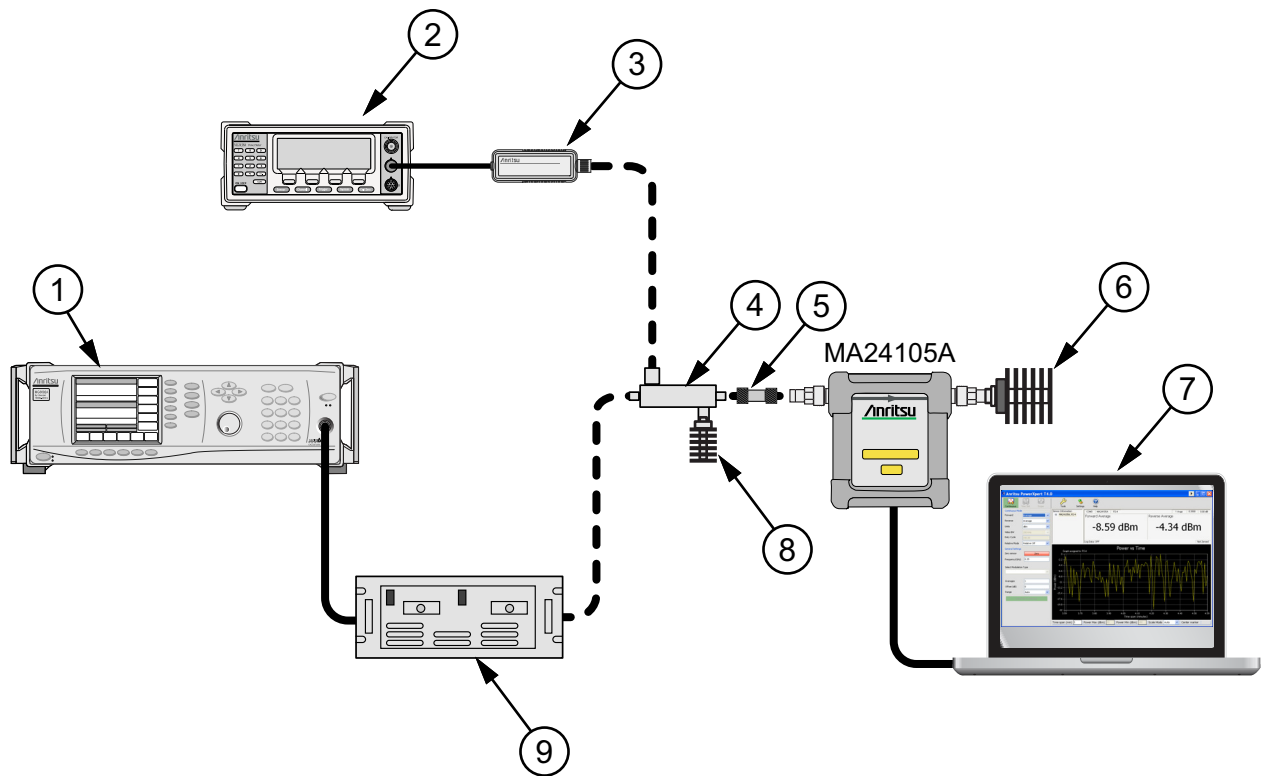
Index	Description
1	Synthesizer
2	Reference Power Meter
3	Reference Power Sensor
4	Power Coupler
5	10 dB N Attenuator
6	50 ohm Termination
7	PC with Anritsu PowerXpert Application
8	30 dB N Attenuator
9	Amplifier

Figure 5-5. Linearity Test Setup 2

    e. Set the amplifier output level to approximately 5 dB higher and then adjust the output level until the MA24105A reads as close as possible to the value obtained in Step 7e.

9. Record data for the next 20 dB range:

    a. Read and record the power indicated by the reference meter in Table 5-5.

    b. Lower the output power level of the amplifier by 5 dB. The amplifier output should be about +30 dBm and the MA24105A should be about +20 dBm.

    c. Record the reference meter and the MA24105A power sensor readings in Table 5-5.

    d. Repeat the measurement for amplifier output levels of +25, +20, and +15 dBm.

Table 5-5.   Measurement Results (350 MHz)

Row #	Approx. Output Power of the Amplifier (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6 – A5) Correction (dB)	C = (A + B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24105A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	45	10				0		
2	40	10				0		
3	35	10				0		
4	30	10				0		
5	25	10				0		
6	adjust per Step 8e	0		0		10		
7	30	0		0		10		
8	25	0		0		10		
9	20	0		0		10		
10	15	0		0		10		
11							Max:	
12							Min:	
13						Delta (E11 – E12):		

10. Perform the calculations and operational check as follows:

    a. Subtract the Reference Power Measurement of row 5 from the Reference Power Measurement of row 6. Record this value in the Correction column of rows 1 through 5.

> **Note**   The Correction column of rows 1 through 5 should all have the same value.
> The Correction column of rows 6 through 10 have values of 0.

    b. Add the Reference Power Measurement and Correction values of row 1 and record the result in the Corrected Reference Power Measurement column of row 1.

    c. Repeat Step 10b for rows 2 through 10.

    d. Subtract the MA24105A Measurement of row 1 from the Corrected Reference Power Measurement of row 1 and record the result in the Difference Calculation column of row 1.

    e. Repeat Step 10d for rows 2 through 10.

    f. Find the largest (most positive) value in the Difference Calculation column and record this value next to the word Max in row 11.

    g. Find the smallest (least positive or most negative) value in the Difference Calculation column and record this value next to the word Min in row 12.

    h. Subtract the Min value from Step 10g from the Max value from Step 10f and record the result next to the word Delta in row 13.

    i. The Delta result should be less than 0.3 dB. If it is larger, contact Anritsu customer service.

11. Repeat the entire measurement and calculations with synthesizer frequency settings of 2 GHz and 4 GHz.

Table 5-6. Measurement Results (2 GHz)

Row #	Approx. Output Power of the Amplifier (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24105A Measurement (dBm)	C–D Difference Calculation (dB)
1	45	10				0		
2	40	10				0		
3	35	10				0		
4	30	10				0		
5	25	10				0		
6	adjust per Step 8e	0		0		10		
7	30	0		0		10		
8	25	0		0		10		
9	20	0		0		10		
10	15	0		0		10		
11							Max:	
12							Min:	
13						Delta (E11 – E12):		

Table 5-7.   Measurement Results (4 GHz)

Row #	Approx. Output Power of the Amplifier (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24105A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	45	10				0		
2	40	10				0		
3	35	10				0		
4	30	10				0		
5	25	10				0		
6	adjust per Step 8e	0		0		10		
7	30	0		0		10		
8	25	0		0		10		
9	20	0		0		10		
10	15	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 – E12):	

Chapter 6 — Using the MA24106A

6-1 Introduction

This chapter describes using the MA24106A USB power sensor and the PowerXpert PC buttons and menus described in Chapter 3, "Using USB Power Sensors with PowerXpert". If an Anritsu series handheld instrument is being used with the power sensor, refer to the user documentation that came with the handheld instrument for procedures on operating external power sensors.

6-2 Sensor Connector Overview

The MA24106A power sensor connectors are shown in Figure 6-1.

Index	Description
1	RF Input: N Type Connector (Torque connector at 12 lbf·in [1.35 N·m])
2	2-color LED (reports functional status of the sensor) **Green:** Sensor ON, Status OK **Amber:** Error or Programming Condition
3	USB Mini-B Port (for connection with a PC or Anritsu handheld instrument)

Figure 6-1. MA24106A Sensor Connector Overview

6-3 Basic Power Measurement

This section provides steps and information to make basic power measurements with the MA24106A power sensor and PowerXpert.

Caution	The supplied USB cable with the screw-in connector should be securely fastened to the sensor to avoid damage to the mini-USB connector.

To perform a power measurement:

1. Connect the sensor to a computer as shown in Figure 6-2.

2. Open the Anritsu PowerXpert application.

3. Zero the sensor as described below in "Zeroing the Sensor" on page 6-2.

.

Caution	**Do not** apply power greater than the power sensor specifications or permanent damage may result. Connect a fixed attenuator to the output connector when power exceeds +20 dBm.

Caution	Before connecting the power sensor to a another device, read the "Instrument Care and Preventive Maintenance" on page 1-4.
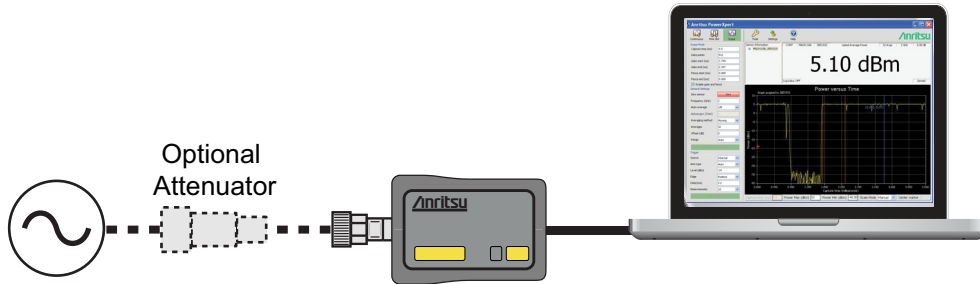
Figure 6-2.   Measurement Setup

4. Connect the power sensor to an RF source.

5. Read the power measurement from the Anritsu PowerXpert application window (power readings are continuous with the default setting).

Connecting the DUT

When connecting to the Type N connector of the MA24106A to a Type N female connector, observe the following proper practice for tightening the connection:

1. While holding the body of the sensor in one hand, turn the Type N Male connector nut to finger tighten the connection. Do not turn the body of the MA24106A as this will cause excessive wear to the connector.

2. Back off the connection by turning the connector nut counter clockwise ¼ turn.

3. Tighten the connection (clockwise) using a 12 in-lb torque wrench (Anritsu part number: 01-200).

Note	The Sensor has a USB 2.0 interface with a USB Type Mini-B port. The MA24106A can be remotely programmed over this USB interface. In addition to programming, the MA24106A is powered by the USB. The interface is USB 2.0 compatible, but with an interface speed of 12 Mbps.

Zeroing the Sensor

Zero the sensor before making power measurements, particularly when operating within the lower 20 dB dynamic range of the power sensor. If frequent low-level measurements are being made, check the sensor zeroing often and repeat as necessary. Before zeroing the sensor, connect the sensor to the DUT (device under test) test port and remove RF power from the connection to a level 20 dB below the noise floor of the power sensor. For the MA24106A power sensor, this level is less than –60 dBm. Leave the sensor connected to the DUT test port so that ground noise and thermal EMF (electro-magnetic fields) are zeroed out of the measurement. The sensor may also be connected to a grounded connector on the DUT or disconnected from any signal source.

To zero the sensor, click the **Zero** button on the application. If the sensor fails the zeroing operation, the message box states "Sensor zero failed" and "ZERO_ERROR" will be displayed on the application screen until the problem is corrected. If RF is detected, a reminder message will pop up asking to remove the RF source.

Calibrating the Sensor

The signal channel/analog signal acquisition hardware is integrated along with the RF front end of the power sensor. All of the necessary frequency and temperature corrections take place within the sensor. Therefore, there is no need for a reference calibration (at 50 MHz and 1 mW) with the MA24106A.

Applying a Calibration Factor Correction

The MA24106A power sensor has an internal EEPROM containing correction and calibration factors that were programmed into the sensor at the factory. The power sensor has an internal temperature sensor that reports its readings periodically to the microprocessor. The sensor makes all of the required calculations on the measurement once the measurement frequency has been entered by the user.

6-4   Measurement Factors

The following measurement factors may apply.

Time Varying Signals

Case 1: Modulated signals with pulse or pattern repetition times $\leq$ 1 ms (PRF $\geq$ 1 kHz)

If you obtain a steady power reading of a modulated signal (no significant fluctuations of the displayed power) with no averaging, then it is likely that the pulse or pattern repetition rate is greater than 1 kHz. In this case, most of the averaging of the envelope power is performed in the front end of the sensor (before being digitized). When this is the case, the MA24106A will provide an accurate indication of the average power with no special considerations.

Case 2: Modulated signals with pulse or pattern repetition times between 1 ms and 50 ms (100 Hz < PRF < 1 kHz)

In this case, the signal is varying too slowly to be averaged in the front end of the sensor, so averaging must be performed after digitalization by increasing the averaging number in the power meter application (or calculating the average of several measurements if controlling the sensor over the bus). A large amount of averaging must be used for some pulse/pattern repetition frequencies to get a steady reading. If Low Aperture Time (LAT) mode is selected, the maximum recommended pulse repetition time is about 10 ms. If High Aperture Time (HAT) mode is selected, signals with pulse repetition periods as long as 50 ms can usually be measured.

Case 3: Modulated signals with pulse or pattern repetition times greater than 50 ms

In this case, it can be difficult to get an accurate average power reading even by averaging many readings. The sample rate of the sensor and the pulse repetition rate of the signal may be close enough that they can "beat" together resulting in low frequency modulation of the power indication. If averages are not calculated over many of these beats, or an integer number of beats, errors can result. This is not unique to the MA24106A and can be an issue with any power sensor/meter and any sampled data system.

High Crest Factor Signals (peak to average ratio)

High crest factor signals such as PAPR as high as 10dB. To ensure the most accurate power measurement, the average power of the signal should not exceed +20dBm. For example the peak power of the signal should not exceed +30dBm if its PAPR is 10dB. A sensor's linearity graph of a WCDMA (TestModel_5_8HSPDSCH) signal with PAPR of 10 dB is shown below:

2GHz WCDMA Linearity
TestModel_5_8HSPDSCH

Variance (dB) vs *Input Power (dBm)*
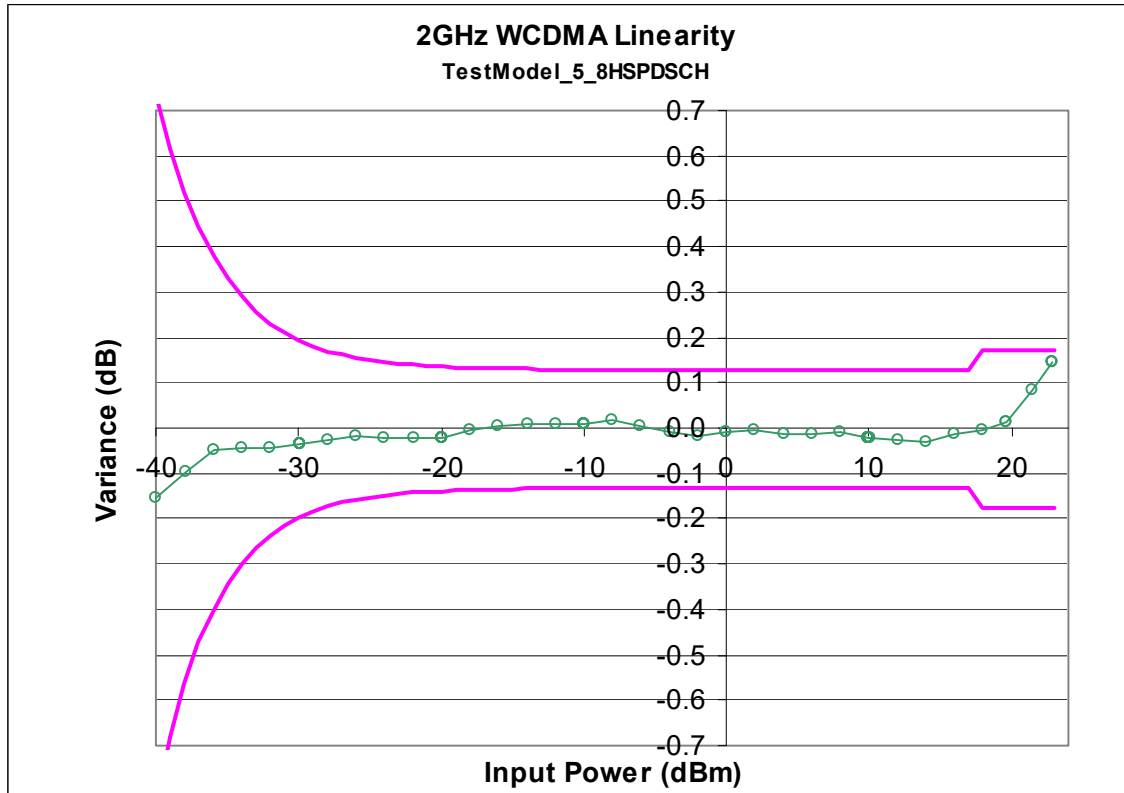
Figure 6-3.   Sensor Linearity Graph

Multitone Signals

The MA24106A is a True-RMS sensor that can measure very wide bandwidth modulation without much restriction. The only limitation is the frequency flatness of the sensor. Because the sensor's sensitivity is not identical for all frequencies and when measuring multitone signals, the frequency entered into the sensor's application should be the average frequency of all significant tones. The MA24106A has an error of 0.01 dB for every 100 MHz bandwidth at frequencies below 3 GHz, and an error of 0.03 dB for every 100 MHz bandwidth at frequencies above 3 GHz.

For example, a dual tone signal of 2.0 GHz and 2.2 GHz may have an additional measurement error of 0.02 dB (0.01 dB × 2) when the application frequency is set to 2.1 GHz.

Noise and Averaging

To achieve a required reading resolution, particularly at low power levels, averaging is often needed to reduce noise and steady the displayed power reading. Use the noise vs. resolution table in Table 6-1 and Table 6-2 on page 6-6 to determine the number of averages that will typically be required for a given resolution. Alternatively, determine the number of averages through calculation by using the noise specifications and the fact that noise will be proportional to the square root of N, where N is the number of averages.

For example, a CW tone at –30 dBm is to be measured to 0.01 dB resolution. Using the table in the sensor manual, the required number of averages is 38 averages using High Aperture Time mode (the same measurement would require more than 256 averages in Low Aperture Time mode).

Settling Time

The MA24106A samples power continuously every 70 ms in the Low Aperture Time (LAT) mode and 700 ms in the High Aperture Time (HAT) mode. The sensor's front end and digitizer settles completely to a step change in power in this amount of time. However, there is no way to synchronize the sensor's sampling to any other event, such as a power step or bus request for a measurement. Therefore, the first measurement requested from the sensor after a power step may not be fully settled. To ensure a fully settled measurement when operating the sensor over the bus, wait 70 ms (700 ms if in HAT) after a power step before requesting the measurement from the sensor. Alternatively, request two measurements from the sensor and discard the first.

If averaging is required as described above, settling time increases by N × sample period, where N is the number of averages and the sample period is the time is milliseconds. The measurement sample period is 70 ms for LAT and 700 ms for HAT. When operating the sensor over the bus, request N+1 measurements from the sensor, discard the first, and then average the subsequent readings. The settling time is approximately (N+1) × sample period.

6-5   Optimizing the Readings

This section presents information on how to get the fastest readings from the MA24106A power sensor when using the Anritsu PowerXpert application or operating under remote control (refer to Chapter 16 for specific remote programming command descriptions). Measurement speed depends greatly on the type of measurement, the power level, and stability of the signal. Stability of a measurement is influenced by noise and signal modulation. If high resolution is required, averaging must be increased.

Note	The values in the following tables are typical and should be used as a reference only.

Table 6-1 describes the number of averages needed to attain a certain noise level for a particular power level measurement with the Low Aperture Time mode setting.

Table 6-1.   MA24106A Averaging Table (Low Aperture Time, Default Mode)

Input Power (dBm)	Input Power (mW)	Number of Averages Needed for < ±0.20 dB Noise	Number of Averages Needed for < ±0.15 dB Noise	Number of Averages Needed for < ±0.10 dB Noise	Number of Averages Needed for < ±0.05 dB Noise	Number of Averages Needed for < ±0.01 dB Noise
20	100	1	1	1	1	1
15	31.6	1	1	1	1	1
10	10.0	1	1	1	1	1
5	3.16	1	1	1	1	2
0	1.00	1	1	1	4	16
−5	0.316	1	1	1	20	78
−10	0.100	1	1	1	1	1
−15	0.0316	1	1	1	1	1
−20	0.0100	1	1	1	1	7
−25	0.00316	1	1	1	3	61
−30	0.00100	2	3	7	25	−
−35	0.000316	16	28	62	245	−
−40	0.000100	158	−	−	−	−

Table 6-2, describes the number of averages needed to attain a certain noise level for a particular power level measurement with the High Aperture Time mode setting.

Table 6-2.   MA24106A Averaging Table (High Aperture Time)

Input Power (dBm)	Input Power (mW)	Number of Averages Needed for < ±0.20 dB Noise	Number of Averages Needed for < ±0.15 dB Noise	Number of Averages Needed for < ±0.10 dB Noise	Number of Averages Needed for < ±0.05 dB Noise	Number of Averages Needed for < ±0.01 dB Noise
20	100	1	1	1	1	1
15	31.6	1	1	1	1	1
10	10.0	1	1	1	1	1
5	3.16	1	1	1	1	1
0	1.00	1	1	1	1	1
−5	0.316	1	1	1	2	5
−10	0.100	1	1	1	1	1
−15	0.0316	1	1	1	1	1
−20	0.0100	1	1	1	1	1
−25	0.00316	1	1	1	1	4
−30	0.00100	1	1	1	2	38
−35	0.000316	1	2	4	16	−
−40	0.000100	10	18	39	153	−

6-6   Uncertainty of a Measurement

Measurement Uncertainty Calculator

Included at the Anritsu download center is a Microsoft Excel tool for calculating power uncertainty. It contains two tabs; one that provides measurement uncertainty for each sensor (selectable from a drop-down menu), and another tab that provides additional uncertainty components and calculated values for the power sensor.

https://www.anritsu.com/en-us/test-measurement/support/downloads/software/dwl003263

Uncertainty Components

Power measurements have many component parts that affect overall measurement uncertainty when measuring power with the sensor:

- **Sensor Linearity and Temperature Compensation:** Sensor Linearity and Temperature Compensation describe the relative power level response over the dynamic range of the sensor. Temperature Compensation should be considered when operating the sensor at other than room temperature.

- **Noise, Zero Set, and Zero Drift:** These are factors within the sensor that impact measurement accuracy at the bottom of the power sensor's dynamic range.

- **Mismatch Uncertainty:** Mismatch uncertainty is typically the largest component of measurement uncertainty. The error is caused by differing impedances between the power sensor and the device to which the power sensor is connected. Mismatch uncertainty can be calculated as follows:

    % Mismatch Uncertainty $= 100[|1 + \Gamma_1\Gamma_2|^2 - 1]$

    dB Mismatch Uncertainty $= 10\log|1 + \Gamma_1\Gamma_2|$

    where

    Γ_1 and Γ_2 are the reflection coefficients of the power sensor and the device under test

- **Sensor Calibration Factor Uncertainty:** Sensor Calibration Factor Uncertainty is defined as the accuracy of the sensor calibrated at a standard calibration condition. Anritsu follows the industry standard condition of calibration at a reference power of 0 dBm (1 mW) and an ambient temperature of 25 °C.

Uncertainty Example

Two measurement uncertainty calculations for Low Aperture Time mode are shown for the MA24106A in Table 6-3. The MA24106A is used to measure the power of a 3 GHz, +12.0 dBm and –35 dBm CW signal from a signal source with 1.5:1 VSWR. The example is based on 128 measurement averages.

Table 6-3.   Measurement Uncertainty Example

Uncertainty Term	Uncertainty Specification at +12 dBm (%)	Uncertainty Specification at –35 dBm (%)	Probability Distribution	Divisor	Adjusted Uncertainty at +12 dBm (%)	Adjusted Uncertainty at –35 dBm (%)
Sensor Linearity (<+18 dBm)	3.0	3.0	Rectangular	$\sqrt{3}$	1.8	1.8
Noise	0.0	0.8	Normal at 2σ	2	0.0	0.4
Zero Set	0.0	3.2	Rectangular	$\sqrt{3}$	0.0	1.8
Zero Drift	0.0	0.9	Normal at 2σ	2	0.0	0.6
Calibration Factor Uncertainty	1.4	1.4	Normal at 2σ	2	0.7	0.7
Mismatch Uncertainty	4.0	4.0	Rectangular	$\sqrt{3}$	2.3	2.3
Combined Uncertainty (RSS), Room Temperature					3.0	3.6
Expanded Uncertainty with K=2, Room Temperature					6.0	7.2
Temperature Compensation	1.4	1.4	Rectangular	$\sqrt{3}$	0.8	0.8
Combined Uncertainty (RSS, 0 to 50 °C)					3.1	3.7
Expanded Uncertainty with K=2 (RSS, 0 to 50 °C)					6.2	7.4

Table 6-4.   Noise Measurement Uncertainty Calculations

Noise Calculations at 12 dBm (16 mW):

Noise	400 nW/16 mW = 0.0 %
Zero Set	1700 nW/16 mW = 0.0 %
Zero Drift	500 nW/16 mW = 0.0 %

Noise Calculations at –35 dBm (316 nW):

Noise	2.5 nW/316 nW = 0.8 %
Zero Set	10 nW/316 nW = 3.2 %
Zero Drift	3 nW/316 nW = 0.9 %

6-7   Error Messages

Error messages are described in Table 6-5. The status LED will illuminate amber color when an error state occurs. In most cases, the error condition can be easily corrected. If not, note the error message and contact an Anritsu Service Center.

Table 6-5.   Error Messages

Message	Description	Resolution
Zero invalid as temperature changed by more than 10 Degrees C	The sensor's ambient temperature has changed by more than 10 ºC since the last zero operation.	Perform the zero operation again.
Temperature out of operating range	Operating range of the sensor is 0 ºC to 55 ºC.	Re-examine the ambient conditions.
Sensor zero failed	This message box appears if the zero operation is unsuccessful. The reason could be the presence of RF power at the input of the sensor.	Turn off the RF input to the sensor or disconnect the sensor from the RF source and try the zero operation again.
ZERO_ERROR	This message appears on the application screen if the zero operation is unsuccessful. The reason could be the presence of RF power at the input of the sensor.	Turn off the RF input to the sensor or disconnect the sensor from the RF source and try the zero operation again.
ADC_TEMP_OVERRNGE	This message appears on the application screen if the sensor is being operated in extremely high temperatures and has overheated.	Remove the sensor from the USB connection and allow to cool to the operating range of the sensor: 0 ºC to 55 ºC

Chapter 7 — Verifying MA24106A Performance

7-1 Introduction

This chapter provides test procedures with measurement recording tables, test equipment setups, and verification tables to verify the measurement accuracy of the MA24106A USB power sensors. Test and verification is performed by comparing the sensor to a reference sensor with a specified cal factor and linearity performance or uncertainty. The reference sensor should be calibrated by a reputable standards laboratory using NIST instruments with low published measurement uncertainty values. Sensor test limits in these procedures are set appropriately to the specified comparison equipment. All tests must be performed at an ambient temperature of 20 ºC to 25 ºC to optimize the power sensor's performance.

Note	Refer to the instrument Technical Data Sheet for performance specifications.

7-2 Required Equipment

Table 7-1. Required Equipment

Equipment Description	Manufacturer and Model	Critical Specifications
Vector Network Analyzer (Pretest)	Anritsu MS4642B or equivalent	Reflection Coefficient Uncertainty ≤0.013, 10 MHz to 2 GHz Uncertainty ≤0.020, 2 GHz to 6 GHz
Synthesizer (Cal. Factor and Linearity Tests)	Anritsu MG3692C or equivalent	Output Power: >+18 dBm, 50 MHz to 6 GHz Output Power Setting Resolution: 0.01 dBm Harmonics: ≤–40 dBc Source VSWR ≤ 2.00
Reference Power Meter (Cal. Factor and Linearity Tests)	Anritsu ML2438 or equivalent	Instrumentation Accuracy ≤ 0.5 %
Reference Power Sensor (Cal. Factor and Linearity Tests)	Anritsu MA24002A or equivalent	NIST Calibration or equivalent
10 dB K Attenuator (Linearity Test)	Anritsu 41KC-10	VSWR ≤ 1.15, 10 MHz to 6 GHz
6 dB K Attenuator (Cal. Factor Test)	Anritsu 41KC-6	VSWR ≤ 1.15, 10 MHz to 6 GHz
Adapter N(f) to K(f) (Cal. Factor and Linearity Tests)	Anritsu 34ANF50 and 34AS50	VSWR ≤ 1.05, 10 MHz to 6 GHz
Power Splitter (Linearity Tests)	Anritsu K241B	Effective Output VSWR < 1.45, 10 MHz to 6 GHz
Personal Computer	Any	See Chapter 2

7-3   VSWR Pretest

The uncertainty of the VSWR test equipment will affect actual measurement values.

Test Procedure

Caution	**Do not** apply power greater than the power sensor specifications or permanent damage may result. Connect a fixed attenuator to the output connector when power exceeds +20 dBm.

Caution	Before connecting the power sensor to a another device, read the "Instrument Care and Preventive Maintenance" on page 1-4.

Using required equipment suggested in Table 7-1 on page 7-1, follow the manufacturer's S_{11} (or return loss) calibration procedure to perform calibration on a network analyzer. Connect the power sensor to the network analyzer test port and measure power sensor input match. Typically, matches are measured in terms of return loss in dB. Return loss and magnitude of the reflection coefficient conversion equations are as follows:

$\rho = 10^{-RL/20}$

$RL = -20\log\rho$

where

RL = Return Loss in dB

ρ = Magnitude of the Reflection Coefficient

VSWR and magnitude of the reflection coefficient conversion equations are as follows:

$VSWR = (1 + \rho) / (1 - \rho)$

$\rho = (VSWR - 1) / (VSWR + 1)$

where

VSWR = Voltage Standing Wave Ratio

ρ = Magnitude of the Reflection Coefficient

Record the measured data into Table 7-2 under the Actual Measurement column. The Actual Measurement should be smaller than the Maximum Reflection coefficient. The Maximum Reflection Coefficient is equal to the measurement system uncertainty added to the sensor's reflection coefficient specification. If the Actual Measurement reflection coefficient is larger than the Maximum Reflection Coefficient, then the power sensor may be defective. If the actual reflection coefficient is significantly larger than the maximum values in Table 7-2, then the sensor is damaged and it is not necessary to perform further testing.

Table 7-2.   Pretest Measurement Result

Frequency	MS4642B Reflection Coefficient Uncertainty	Maximum Reflection Coefficient	Actual Measurement
50 MHz to 2 GHz	0.013	0.050 + 0.013 = 0.063	
2 GHz to 6 GHz	0.020	0.100 + 0.020 = 0.120	

7-4 Frequency Response Test

In this test, the frequency response of the sensor is tested at one low power level against a reference sensor of known measurement uncertainty. The reference sensor should be calibrated by a reputable standards laboratory using instruments with low published measurement uncertainty values. To perform the comparison, both sensors are used to measure the output power of a synthesizer with a high quality attenuator, such as the 41KC-6, on the output. The attenuator improves the source match of the synthesizer by lowering the mismatch ripples, thereby lowering the uncertainty in the comparison.

Test Procedure

1. Set up the equipment as follows (refer to Figure 7-1 for an illustration):

   a. Connect the reference power sensor to the reference power meter using the appropriate cables.

   b. Connect the MA24106A USB cable between the personal computer with the PowerXpert application installed and the MA24106A power sensor under test.

   c. Launch the PowerXpert application.

   d. Turn the power on to all of the instruments and allow them to warm up for the amount of time specified in their respective manuals.

   e. Reset or Preset all of the instruments.

   f. Configure the reference meter and sensor to measure a CW signal.

   g. Perform a sensor Zero and a 1 mW reference calibration on the reference sensor and meter per the manufacturer's instructions.

   h. Perform a low-level Zero of the MA24106A by disconnecting the MA24106A from the synthesizer, clicking the **Zero** button on the PowerXpert GUI, and waiting for the **Zeroing** message to close.

   i. Connect the attenuator to the output of the synthesizer, then connect the appropriate adapter to the output of the attenuator.

   j. Set the synthesizer to +6 dBm and 50 MHz.
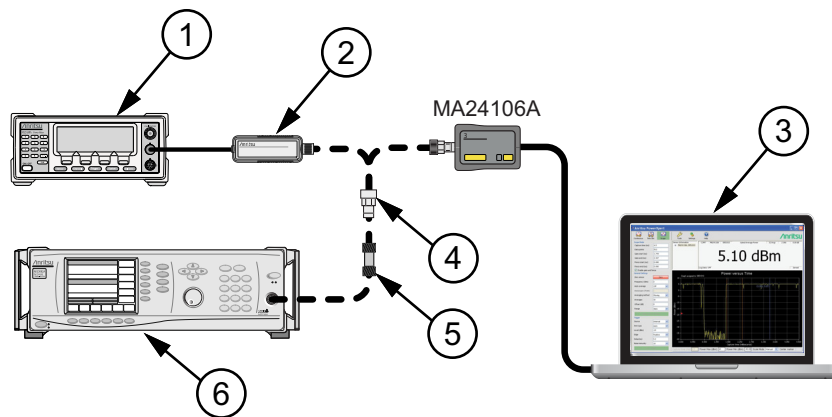
Index	Description
1	Reference Power Meter
2	Reference Power Sensor
3	PC with Anritsu PowerXpert Application
4	K to N Adapter
5	Attenuator
6	Synthesizer

Figure 7-1. Cal Factor Test Set Up

2. Connect the reference sensor to the synthesizer with the appropriate adapter and attenuator in-line. See Figure 7-1.

3. Apply the Cal factor to the reference sensor per the manufacturer's instruction.

4. Record the power indicated by the reference meter in Table 7-3.

5. Disconnect the reference sensor from the synthesizer output and connect the MA24106A power sensor with the appropriate adapter and attenuator in-line. See Figure 7-1.

6. Apply the Cal factor to the MA24106A by entering the frequency (in GHz) in the PowerXpert application, and then click **Apply above settings**.

7. Record the power indicated by the MA24106A in Table 7-3.

8. Set the synthesizer frequency to the next frequency in Table 7-3.

9. Repeat Step 2 through Step 8 until all of the frequencies in Table 7-3 have been measured.

10. For each row in Table 7-3, calculate the absolute value of the difference between the recorded Reference power measurement and the recorded MA24106A measurement, and record the result in Table 7-3.

11. For each frequency, compare the power difference to the maximum allowed difference specified in Table 7-3. If the difference is higher than the maximum allowed difference, contact Anritsu customer service.

Table 7-3. Test Measurement Results

Frequency (GHz)	A Reference Power Measurement (dBm)	B MA24106A Measurement (dBm)	|A-B| Absolute Value of Difference in Power Measurements (dB)	Maximum Allowed Difference (dB)
0.05				0.26
0.1				0.26
0.3				0.26
0.5				0.26
1.0				0.26
2.0				0.31
3.0				0.31
4.0				0.31
5.0				0.33
6.0				0.33

7-5   Linearity Test

The linearity correction of the MA24106A is compared to a thermal power sensor, which has very good inherent linearity over a power range of about –20 to +10 dBm. For this reason, the MA24106A will be compared to the thermal sensor in two *ranges*, keeping the power levels to the thermal sensor in the range of –17 dBm to +5 dBm, while the power to the MA24106A will vary from about –26 dBm to about +14 dBm.

Test Procedure

1. Set up the equipment as follows (refer to Figure 7-2 for an illustration):

  a. Connect the reference power sensor to the reference power meter using the appropriate cables.

  b. Connect the USB cable between the personal computer with the PowerXpert application installed and the MA24106A power sensor under test.

  c. Launch the PowerXpert application.

  d. Turn the power on to all of the instruments and allow them to warm up for the amount of time specified in the instrument's respective manuals.

  e. Reset or Preset all of the instruments.

  f. Configure the reference meter and sensor to measure a CW signal.

  g. Perform a sensor Zero and a 1 mW reference calibration on the reference sensor and meter per the manufacturer's instructions.

  h. Perform a low-level Zero of the MA24106A by disconnecting the sensor from the synthesizer, click the **Zero** button in the PowerXpert application, and wait for the Zeroing message to close.

  i. Connect the power splitter to the output of the synthesizer and connect the 10 dB attenuator to one of the splitter outputs.

  j. Connect an N(f) to K adapter to each power sensor.

  k. Connect the reference sensor and adapter to the 10 dB attenuator.

  l. Connect the MA24106A and adapter to the other splitter output.

  m. Set the synthesizer to 50 MHz and +20 dBm.

  n. Increase averaging by entering "16" in the PowerXpert application, and then click **Apply above settings**.
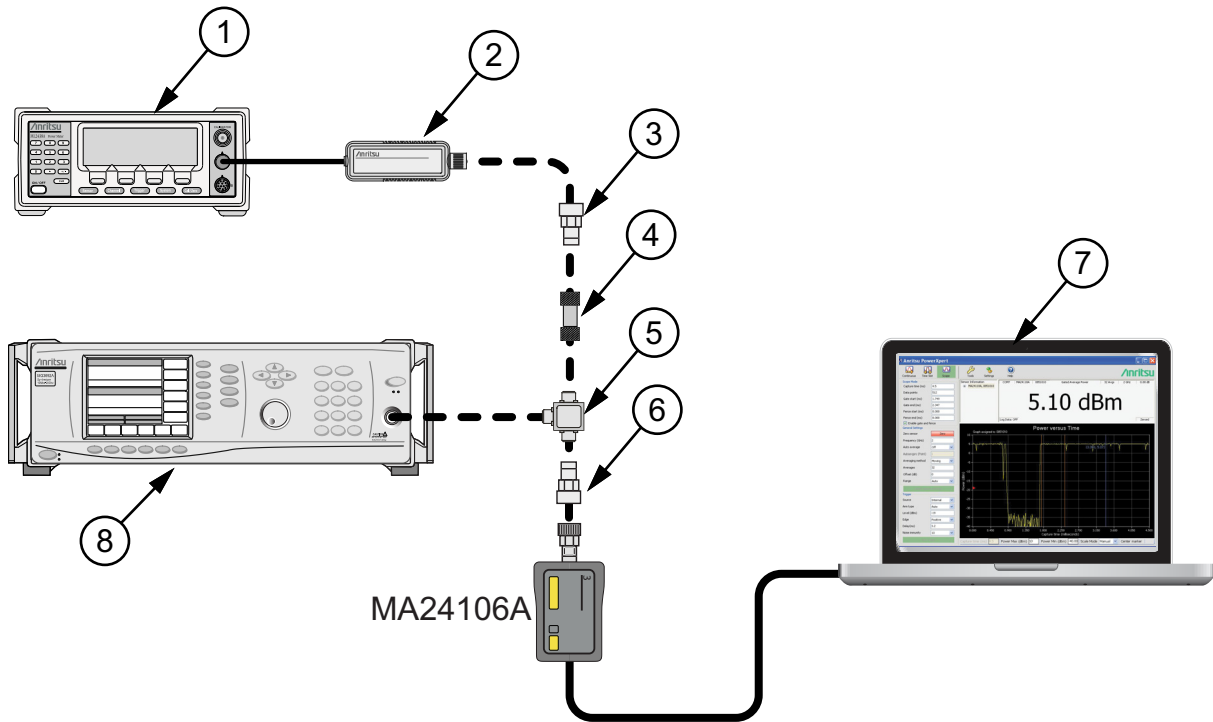
Index	Description
1	Reference Power Meter
2	Reference Power Sensor
3	K to N Adapter (if required)
4	Attenuator
5	Power Splitter
6	K to N Adapter (if required)
7	PC with Anritsu PowerXpert Application
8	Synthesizer

Figure 7-2.   Linearity Test Setup 1

2. Apply the Cal factor to the reference sensor per the manufacturer's procedure.

3. Apply the Cal factor to the MA24106A by entering the frequency (in GHz) in the PowerXpert application, and then click **Apply above settings**.

4. Turn Off the synthesizer's RF output and perform a low-level Zero of both the Reference sensor and the MA24106A.

5. Turn On the synthesizer's RF output.

6. Record data for the first 20 dB range as follows:

    a. Record the power reading by the reference meter in Table 7-4 on page 7-8.

    b. Record the power reading by the MA24106A in Table 7-4.

    c. Set the synthesizer power to +15 dBm.

    d. Record the reference meter and the MA24106A power sensor readings in Table 7-4.

    e. Repeat the measurement for synthesizer output levels of +10, +5, and 0 dBm.

Note	The MA24106A power measured at 0 dBm will be used in Step 7e, below.

7. Set up the test for the second 20 dB range as follows:

  a. Remove the 10 dB attenuator from in between the reference sensor and splitter and connect the reference sensor directly to the splitter.

  b. Remove the MA24106A from the splitter and connect the 10 dB attenuator between the splitter and the MA24106A power sensor (see Figure 7-3).

  c. Turn Off the synthesizer's RF output and perform a low-level Zero of both the Reference sensor and the MA24106A.

  d. Turn On the synthesizer's RF output.
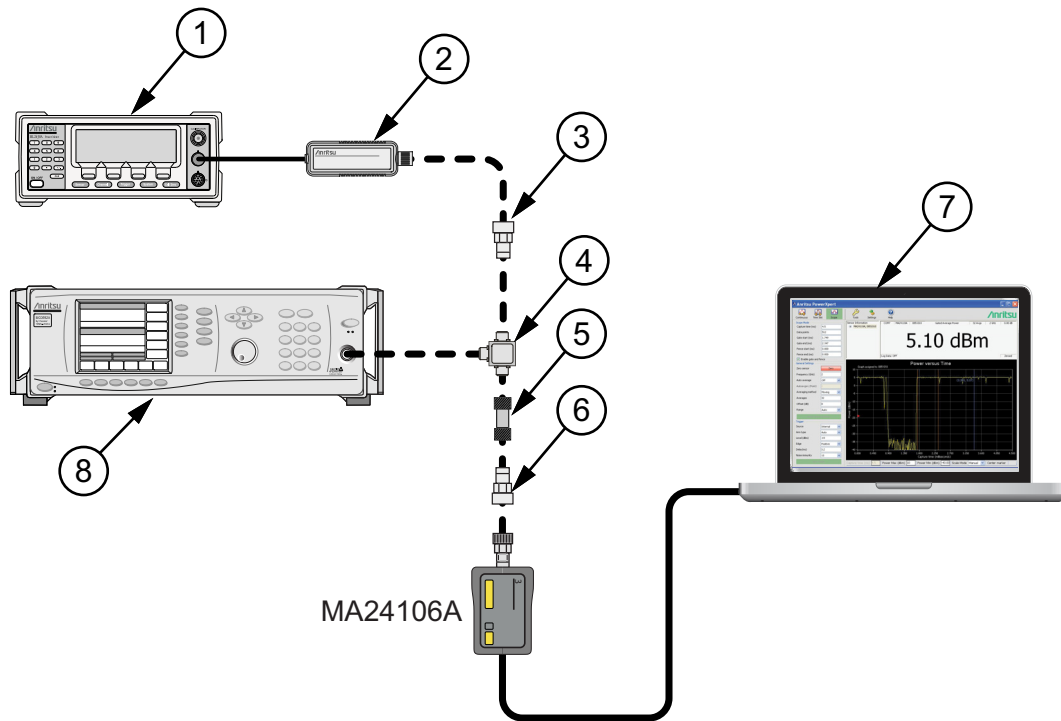
Index	Description
1	Reference Power Meter
2	Reference Power Sensor
3	K to N Adapter (if required)
4	Power Splitter
5	Attenuator
6	K to N Adapter (if required)
7	PC with Anritsu PowerXpert Application
8	Synthesizer

Figure 7-3. Linearity Test Setup 2

  e. Set the synthesizer output level to +10 dBm and then adjust it until the sensor/meter under test reads as close as possible to the value obtained above in Step 6e.

8. Record data for the next 20 dB range

  a. Read and record the power indicated by the reference meter in Table 7-4.

    b. Lower the output power level of the synthesizer to +5 dBm.

    c. Record the reference meter and the MA24106A power sensor readings in Table 7-4.

    d. Repeat the measurement for synthesizer output levels of 0, –5, and –10 dBm.

Table 7-4.   Measurement Results (50 MHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24106A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	–5	0		0		10		
10	–10	0		0		10		
11							Max:	
12							Min:	
13						Delta (E11 – E12):		

9. Perform the calculations and operation check as follows:

    a. Subtract the Reference Power Measurement of row 5 from the Reference Power Measurement of row 6. Record this value in the Correction column of rows 1 through 5.

> | Note | The Correction column of rows 1 through 5 should all have the same value.
The Correction column of rows 6 through 10 have values of 0. |
> |---|---|

    b. Add the Reference Power Measurement and Correction values of row 1 and record the result in the Corrected Reference Power Measurement column of row 1.

    c. Repeat Step 9b for rows 2 through 10.

    d. Subtract the MA24106A Measurement of row 1 from the Corrected Reference Power Measurement of row 1 and record the result in the Difference Calculation column of row 1.

    e. Repeat Step 9d for rows 2 through 10.

    f. Find the largest (most positive) value in the Difference Calculation column and record this value next to the word Max in row 11.

    g. Find the smallest (least positive or most negative) value in the Difference Calculation column and record this value next to the word Min in row 12.

    h. Subtract the Min value from Step 9g from the Max value from Step 9f and record the result next to the word Delta in row 13.

    i. The Delta result should be less than 0.3 dB. If it is larger, contact Anritsu customer service.

10. Repeat the entire measurement and calculations with synthesizer frequency settings of 2 GHz, 4 GHz, and 6 GHz.

Table 7-5. Measurement Results (2 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24106A Measurement (dBm)	C–D Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	–5	0		0		10		
10	–10	0		0		10		
11							Max:	
12							Min:	
13						Delta (E11 – E12):		

Table 7-6. Measurement Results (4 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24106A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	–5	0		0		10		
10	–10	0		0		10		
11							Max:	
12							Min:	
13						Delta (E11 – E12):		

Table 7-7.   Measurement Results (6 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24106A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	−5	0		0		10		
10	−10	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 – E12):	

Chapter 8 — Using the MA24x08A, MA24x18A, and MA24126A

8-1 Introduction

This chapter describes using the MA24108A, MA24118A, and MA24126A USB power sensors with the Anritsu PowerXpert PC application buttons and menus described in Chapter 3, "Using USB Power Sensors with PowerXpert". If an Anritsu series handheld instrument is being used with the power sensor, refer to the user documentation that came with the handheld instrument for procedures on operating external power sensors.

8-2 Sensor Connector Overview

The MA24x08A, MA24x18A, and MA24126A power sensor connectors are shown in Figure 8-1

MA24108A, MA24118A
MA24126A

Index	Description
MA24108A, MA24118A, MA24126A	
1	(MA24108A, MA24118A): RF Input: N Type Connector (Torque connector at 12 lbf·in [1.35 N·m]) (MA24126A) RF Input K Type Connector (Torque connector at 8 lbf·in [0.90 N·m])
2	2-color LED (reports functional status of the sensor) **Green:** Sensor ON, Status OK **Amber:** Error or Programming Condition
3	USB Micro-B Port (for connection with a PC or Anritsu handheld instrument)
4	External Trigger Input (TTL/CMOS)

Figure 8-1. MA24108A, MA24118A, MA24126A Sensor Connectors Overview

The MA24208A and MA24218A power sensor is shown in the figure below.

MA24208A, MA24218A

Index	Description
	MA24208A, MA24218A
1	(MA24208A, MA24218A) RF Input: N Type Connector (Torque connector at 12 lbf·in [1.35 N·m]) RF Input: N
2	**LED Solid Green:** Sensor ON, Status OK **Blinks Green:** Error or Programming Condition
3	Trigger Out (For Future Use)
4	USB Micro-B Port (for connection with a PC or Anritsu handheld instrument)
5	External Trigger Input (TTL/CMOS)

Figure 8-2.   MA242x8A Series, Side View and Rear Connection View

8-3   Basic Power Measurement

This section provides steps and information to make basic power measurements with the MA24108A, MA24118A, and MA24126A power sensor and PowerXpert. To perform a power measurement:

1. Connect the sensor to a computer as shown in Figure 8-3.

2. Open the Anritsu PowerXpert application.

3. Zero the sensor as described below in "Zeroing the Sensor".

Caution	**Do not** apply power greater than the power sensor specifications or permanent damage may result. Connect a fixed attenuator to the output connector when power exceeds +20 dBm.

Caution	Before connecting the power sensor to a another device, read the "Instrument Care and Preventive Maintenance" on page 1-4.
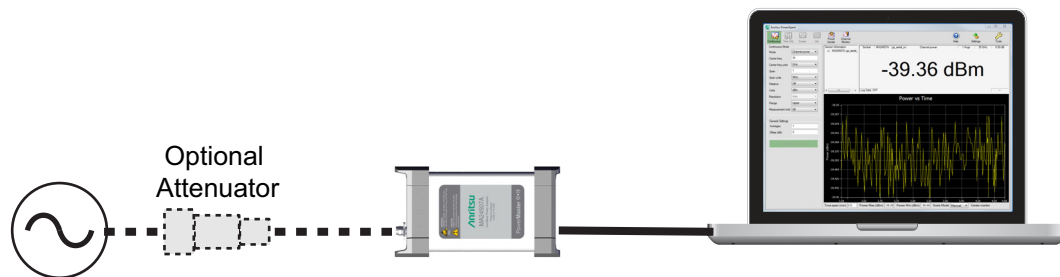
Figure 8-3.   Measurement Setup

4. Connect the RF source to the RF IN port of the power sensor. Read the power measurement from the Anritsu PowerXpert application window (power readings are continuous with the default setting).

Connecting the DUT

RF signal connections are made to the male RF connector, which has a 50 ohm characteristic impedance. When connecting to the male connector of the sensor, observe the following practice for tightening the connection:

1. While holding the body of the sensor in one hand, turn the male connector nut to finger tighten the connection. **Do not** turn the body of the sensor as this will cause excessive wear to the connector.

2. Back off the connection by turning the connector nut counter clockwise 1/4 turn.

3. Tighten the connection (clockwise) using a 12 in-lb torque wrench (Anritsu part number: 01-200).

Zeroing the Sensor

Zero the sensor before making power measurements. If frequent low-level measurements are being made, check the sensor zeroing often and repeat as necessary. If the sensor goes into sleep mode, the sensor must be re-zeroed before taking measurements. Before zeroing the sensor, connect it to the DUT (device under test) test port and remove RF power from the connection to a level 20 dB below the noise floor of the power sensor. For the MA24108A, MA24118A, MA24126A, MA24208A, and MA24218A this level is less than −70 dBm. Leave the sensor connected to the DUT test port so that ground noise and thermal EMF (electro-magnetic fields) are zeroed out of the measurement. The sensor may also be connected to a grounded connector on the DUT or disconnected from any signal source.

To zero the sensor MA241xxA series power sensor, click the **Zero** button on the application. If the sensor fails the zeroing operation, the messages "Range 1 zeroing error" and/or "Range 2 zeroing error" is displayed on the application screen until the problem is corrected.

To zero the sensor MA242x8A series power sensor, click the **Zero** button on the application. If the sensor fails the zeroing operation, remove power from the sensor and Zero again.

Calibrating the Sensor

The signal channel/analog signal acquisition hardware is integrated along with the RF front end of the power sensor. All calibration factors, as well as linearity and temperature corrections, are stored in the sensor. Therefore, there is no need for a reference calibration with the sensor.

Applying a Calibration Factor Correction

The power sensor has an internal EEPROM containing correction and calibration factors that were programmed into the sensor at the factory. The power sensor has an internal temperature sensor that reports its readings periodically to the microprocessor. The sensor makes all of the required calculations on the measurement once the measurement frequency has been entered in the "General Settings" area.

8-4   Measurement Factors

The following measurement factors may apply.

High Crest Factor Signals (peak to average ratio)

High crest factor signals, such as CDMA/WCDMA, may have PAPR (Peak-to-Average Power Ratio) as high as 10dB. To ensure the most accurate power measurement, the average power of the signal should not exceed +20dBm. For example the peak power of the signal should not exceed +30dBm if its PAPR is 10dB.

A MA241xxA series sensor's linearity graph of a WCDMA (TestModel_5_8HSPDSCH) signal with 10 dB PAPR is shown below:
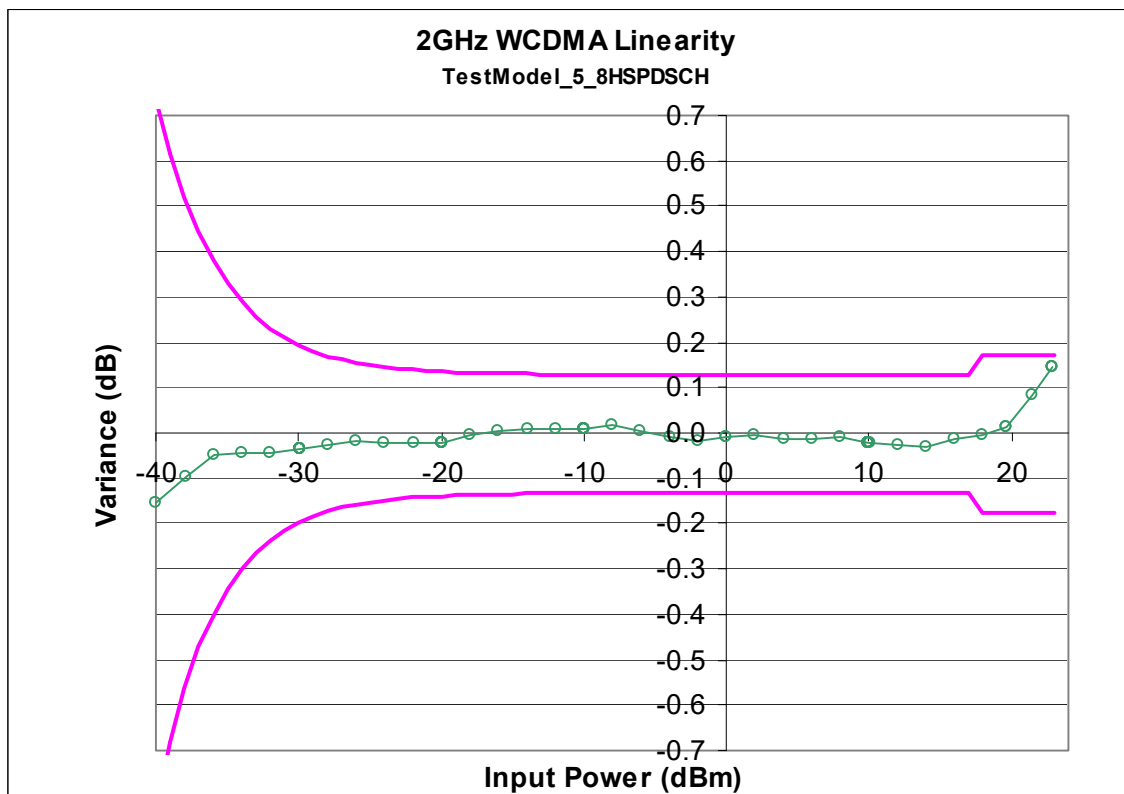
Figure 8-4.   Sensor Linearity Graph

Multitone Signals

The sensor is a True-RMS sensor that can measure very wide bandwidth modulation without much restriction. The only limitation is the frequency flatness of the sensor. Because the sensor's sensitivity is not identical for all frequencies and when measuring multitone signals, the frequency entered into the sensor's application should be the average frequency of all significant tones. The sensor has an additional uncertainty of 0.05 dB for every 1 GHz tone separation when measuring multitone signals.

For example, a dual tone signal of 2 GHz and 4 GHz may have an additional measurement error of 0.1 dB (0.05 dB × 2) when the application frequency is set to 3 GHz.

Advanced Features / Enhanced Modulation

Enhanced Modulation is available with the MA242x8A sensors only. Enhanced modulation can be enabled under Tools/Advanced Features menu. It is recommended to measure pulse modulated signal with period shorter than 30 µs and crest factor up to 10 dB. The user can also examine the signal in Scope mode set to one sample per point with and without Enhanced modulation, and choose the setting that yields a better defined waveform.

The enhanced modulation has a different algorithm to compute the final power reading based on sampled voltages, and is available in all the modes supported. The crossover power between ranges are set 3 dB lower in enhanced modulation to allow for the modulated signal.

Noise and Averaging

To achieve a required reading resolution, particularly at low power levels, averaging is often needed to reduce noise and steady the displayed power reading. Use the noise vs. resolution table in Table 8-1 and Table 8-2 on page 8-9 to determine the number of averages that will typically be required for a given resolution. Alternatively, determine the number of averages through calculation by using the noise specifications and the fact that noise will be inversely proportional to the square root of N, where N is the number of averages. For example, a CW tone at –25 dBm is to be measured to 0.05 dB resolution. Using Table 8-2 the required number of averages is 2 averages. The same measurement to 0.01 dB resolution would require 31 averages.

Average Value of Time Varying Signals

When measuring the average power of a time varying or modulated signal with a modulation bandwidth (BW) which is much greater than the signal channel of the sensor, averaging of the power is performed in the sensor hardware (detectors and or preamplifiers). For the case of the MA24x08A, MA24x18A and MA24126A; the signal channel BW is 50 kHz. Signals modulated at MHz rates will be averaged in the hardware and no special considerations are required.

When measuring signals with modulation frequency components near, or below, the signal channel bandwidth, average power readings may be seen to fluctuate over time. This fluctuation may be reduced through careful selection of the aperture time and averaging number. Ideally, the aperture time should be chosen to be an integer multiple of the modulation frequency. If this can be done, then the average power reading will be stable for each measurement update. For modulations with multiple frequencies present, or with significant modulation components with periods longer than the maximum aperture time (300 ms for MA24108A, MA24118A, MA24126A and 1 s for MA242x8A), averaging will have to be increased to obtain a stable reading. If the measurement update rate is very close to the period of the modulation, a low frequency "beat note" can result. If the frequencies are very close, the beat note can be very low in frequency, and therefore require very long averaging times to remove. In this case it is suggested that the aperture time be changed to result in a higher frequency beat which is easier to average out.

Settling Time

The signal channel bandwidth of the MA241xxA series and MA242x8A series power sensor supports a rise time of about 8 µs. The ADC sample period is approximately 7.6 µs. Thus it will take more than one ADC sample for the signal channel hardware to completely settle in response to a step change in input power. The hardware settling time for the MA241xxA series power sensor can be estimated by assuming a single pole response with 50 kHz bandwidth:

$$Settling time = -\left[\tau \times \ln\left(\frac{SP}{100} \right) \right]$$

where:

$$\tau = \frac{0.35}{(50e-3)} = 7e-6 \; seconds$$

$$SP = Desired \; Settling \, \%$$

For small settling percentages, it is quite likely that the noise per ADC sample will be larger than the desired settling percentage, thus averaging or decimation of ADC samples will have to be used to reduce the noise. Averaging will, of course, increase the settling time of the measurement in direct proportion to the averaging number used.

It is important to note that the settling time described above strictly applies only to increasing power steps (rise time). Settling to decreasing power steps is typically slower. For settling decreasing power steps to 1 % or 0.1 %, the settling will typically be within a factor of 2 or 3 of the calculation above. Settling to 0.01 % or less may take considerably longer.

Noise and Time Resolution in Scope Mode

In Scope mode (and in all other modes), the MA24x08A, MA24x18A and MA24126A is sampling at full speed, which is approximately once every 7 µs. When the period chosen for Scope mode exceeds the number of data points times this period, then multiple ADC samples are averaged to form each data point. Therefore there is a trade-off between time resolution (many data points) and trace noise. To minimize trace noise, choose less data points. Of course for recurrent waveforms, trace averaging can always be used to reduce trace noise if a large number of points is desired. This would however tend to increase the over-all measurement time.

Optimizing Internal Triggering

Sometimes it can be difficult to obtain consistent triggering in scope or Time Slot mode. Here are some points to consider when choosing triggering parameters:

- It is more difficult to trigger on signals which are slowly varying with time. Noise in the signal channel can result in false triggers. In this case, try setting the trigger level at powers away from the bottoms of the measurement ranges. The trigger crossover power for the MA24105A, MA24106A, MA24108A, MA24118A, and MA24126A is about +2 dBm. Thus it can be advantageous to avoid setting the trigger at powers just above +2 dBm, and powers just above –20 dBm where the trigger signal is noisy. The trigger crossover power for the MA24208A and MA24218A is about +4 dBm. Thus it can be advantageous to avoid setting the trigger at powers just above +4 dBm, and powers just above –16 dBm where the trigger signal is noisy.

- Modulated signals can appear "noisy" and also result in false triggers. In this case, adjusting the trigger level may not help. Sometimes there may be a portion of the signal with less modulation, or less "noise-like" modulation which can be triggered on with more success. Try using a different trigger point and adjusting the trigger delay to shift the waveform in time to see the desired section.

- False triggers due to either noise or noise-like modulation can be reduced by increasing the trigger noise immunity parameter for the MA24108A, MA24118A, and MA24126A and invoking hysteresis for the MA242x8A. Using noise immunity will result in a slight positive trigger delay, but this can be made up for by introducing a negative trigger delay with the trigger delay parameter.

- The trigger settings should always be optimized before trace averaging is applied. If trace averaging is used when the trigger is not stabilized, the displayed waveform will not be an accurate representation of the signal. First optimize the trigger, then apply trace averaging.

Noise Floor in Scope Mode

The noise level or "floor" displayed in scope or Time Slot mode in PowerXpert when using low averaging may seem to be higher than what would be expected. This is due to the way noise is dealt with when converting power into dBm for display. With no input power, the values of the ADC samples vary about some value which corresponds to zero power. Ideally there are equal number of samples above and below this value. The samples which are below this value correspond to "negative" power. This is non-physical, and does not truly mean there is negative power flow to the sensor, it is simply a by product of noise in the signal channel. If these samples are displayed in linear power units such as mW, then the noise floor will be as expected. However there is a problem when converting to logarithmic units such as dB. Because taking the logarithm of negative numbers is not generally allowed, the absolute value of the samples is usually taken before taking the logarithm. This has the drawback of increasing the average value of the samples, artificially increasing the apparent noise floor. When the averaging is increased, the noise floor will go down. The apparent noise floor can be estimated using:

$NF = 0.8 \times noise$

where:

NF = the average linear power or noise floor due to taking absolute value of power samples

$noise$ = the noise power in linear units on a 1 sigma basis

8-5　Optimizing the Readings

This section presents information on how to get the fastest readings from the power sensor when using the Anritsu PowerXpert application or operating under remote control (refer to Chapter 16 for specific remote programming command descriptions). Measurement speed depends greatly on the type of measurement, the power level, and stability of the signal. Stability of a measurement is influenced by noise and signal modulation. If high resolution is required, averaging must be increased.

Table 8-1 on page 8-8 describes the number of averages needed for the MA241xxA sensors to attain a certain noise level for a particular power level measurement.

Table 8-2 on page 8-9 describes the number of averages needed for the MA242x8A sensors to attain a certain noise level for a particular power level measurement.

Note	The values in the following table are typical and should be used as reference only.

Table 8-1.   MA24108A, MA24118A, MA24126A Sensor Averaging Table (continuous mode, default settings, 20 ms aperture time)

Input Power (dBm)	Input Power (mW)	Number of Averages Needed for < ±0.20 dB Noise	Number of Averages Needed for < ±0.15 dB Noise	Number of Averages Needed for < ±0.10 dB Noise	Number of Averages Needed for < ±0.05 dB Noise	Number of Averages Needed for < ±0.01 dB Noise
20	100.000	1	1	1	1	1
15	31.623	1	1	1	1	1
10	10.000	1	1	1	1	1
5	3.162	1	1	1	1	2
0	1.000	1	1	1	1	13
−5	3.162E−01	1	1	2	5	121
−10	1.000E−01	1	1	1	1	1
−15	3.162E−02	1	1	1	1	1
−20	1.000E−02	1	1	1	1	4
−25	3.162E−03	1	1	1	2	31
−30	1.000E−03	1	2	4	13	303
−35	3.162E−04	8	14	31	123	3025
−40	1.000E−04	79	139	309	1222	30248

Noise Calculations:

$$20 dBm \geq Power \geq -7 dBm$$

$$\pm noise(dB) = 10\log\left[1 - \left(\frac{8 \times 10^{-3}}{10^{(Power/10)}}\right)\left(\frac{20 \times Points}{Time \times N}\right)^{1/2}\right]$$

$$-40 dBm \leq Power < -7 dBm$$

$$\pm noise(dB) = 10\log\left[1 - \left(\frac{40 \times 10^{-6}}{10^{(Power/10)}}\right)\left(\frac{20 \times Points}{Time \times N}\right)^{1/2}\right]$$

where:

Continuous Average Mode:

Power = Power level being measured in dBm
Points = 1
Time = Aperture time in milliseconds
N = Number of averages

Scope Mode:

Power = Power level being measured in dBm
Points = The number of data points on the scope graph
Time = Capture time in milliseconds
N = Number of averages

Note	The values in the following table are typical and should be used as a reference only.

Table 8-2.   MA242x8A Sensor Averaging Table (continuous mode, default settings, 20 ms aperture time)

Input Power (dBm)	Input Power (mW)	Number of Averages Needed for < ±0.20 dB Noise	Number of Averages Needed for < ±0.15 dB Noise	Number of Averages Needed for < ±0.10 dB Noise	Number of Averages Needed for < ±0.05 dB Noise	Number of Averages Needed for < ±0.01 dB Noise
20	100.000	1	1	1	1	1
15	31.623	1	1	1	1	1
10	10.000	1	1	1	1	1
5	3.162	1	1	1	1	8
0	1.000	1	1	1	1	1
−5	3.162E−01	1	1	1	1	1
−10	1.000E−01	1	1	1	1	1
−15	3.162E−02	1	1	1	1	10
−20	1.000E−02	1	1	1	1	1
−25	3.162E−03	1	1	1	1	1
−30	1.000E−03	1	1	1	1	2
−35	3.162E−04	1	1	1	1	15
−40	1.000E−04	1	1	2	6	147
−45	3.162E−05	4	7	15	60	1465
−50	1.000E−05	39	68	150	592	14644
−55	3.162E−06	383	673	1495	5912	146437
−60	1.000E−06	3824	6721	14950	59116	1464363

Noise Calculations:

2 sigma noise

$$20dBm \geq Power \geq 4dBm$$

$$\pm noise(dB) = 10\log\left[1 - \left(\frac{8.56 \times 10^{-4}}{10^{(Power/10)}}\right)\left(\frac{10240 \times Points}{Time \times N}\right)^{1/2}\right]$$

2 sigma noise

$$4dBm > Power \geq -16dBm$$

$$\pm noise(dB) = 10\log\left[1 - \left(\frac{1.01 \times 10^{-5}}{10^{(Power/10)}}\right)\left(\frac{10240 \times Points}{Time \times N}\right)^{1/2}\right]$$

2 sigma noise

$$-16dBm > Power \geq -60dBm$$

$$\pm noise(dB) = 10\log\left[1 - \left(\frac{1023 \times 10^{-7}}{10^{(Power/10)}}\right)\left(\frac{10240 \times Points}{Time \times N}\right)^{1/2}\right]$$

where:

Continuous Average Mode:

Power = Power level being measured in dBm
Points = 1
Time = Aperture time in milliseconds
N = Number of averages

Scope Mode:

Power = Power level being measured in dBm
Points = The number of data points on the scope graph
Time = Capture time in milliseconds
N = Number of averages

8-6   Uncertainty of a Measurement

Measurement Uncertainty Calculator

Included at the Anritsu download center is a Microsoft Excel tool for calculating power uncertainty. It contains two tabs; one that provides measurement uncertainty for each sensor (selectable from a drop-down menu), and another tab that provides additional uncertainty components and calculated values for the power sensor.

https://www.anritsu.com/en-us/test-measurement/support/downloads/software/dwl003263

Uncertainty Components

Power measurements have many component parts that affect overall measurement uncertainty when measuring power with the sensor:

- **Measurement Uncertainty:** Measurement uncertainty includes the uncertainty associated with the correction of frequency and the linearity response of the sensor over the entire dynamic range. Anritsu follows the industry standard condition of calibrating the power-sensing element at a reference power of 0 dBm (1 mW) and an ambient temperature of 25 °C.

- **Temperature Compensation:** Sensor Temperature Compensation describes the relative power level response over the dynamic range of the sensor. Temperature Compensation should be considered when operating the sensor at other than room temperature.

- **Noise, Zero Set, and Zero Drift:** These are factors within the sensor that impact measurement accuracy at the bottom of the power sensor's dynamic range.

- **Mismatch Uncertainty:** Mismatch uncertainty is typically the largest component of measurement uncertainty. The error is caused by the differing impedances between the power sensor and the devices to which the power sensor is connected. Mismatch uncertainty can be calculated as follows:

  $$\% \text{ Mismatch Uncertainty} = 100\left[|1 + \Gamma_1\Gamma_2|^2 - 1\right]$$

  $$\text{dB Mismatch Uncertainty} = 20\log|1 + \Gamma_1\Gamma_2|$$

  where:

  Γ_1 is the reflection coefficient of the power sensor

  Γ_2 is the reflection coefficient of the device

Uncertainty examples are shown in Table 8-3 on page 8-12 and Table 8-4 on page 8-13.

Uncertainty Examples

Two measurement uncertainty calculations are shown for the MA24108A and MA24118A sensors in Table 8-3. The power sensor is used to measure the power of a 3 GHz, +12.0 dBm and –35 dBm CW signal from a signal source with a 1.5:1 VSWR. The example is based on an aperture time of 20 ms and 64 measurement averages.

Table 8-3.   MA24108A and MA24118A Measurement Uncertainty Example

Uncertainty Term	Uncertainty Specification at +12 dBm (%)	Uncertainty Specification at –35 dBm (%)	Probability Distribution	Divisor	Adjusted Uncertainty at +12 dBm (%)	Adjusted Uncertainty at –35 dBm (%)
Sensor Linearity (<+18 dBm)	3.0	3.0	Rectangular	$\sqrt{3}$	1.7	1.7
Noise	0.0	1.6	Normal at 2σ	2	0.0	0.8
Zero Set	0.0	3.2	Rectangular	$\sqrt{3}$	0.0	1.8
Zero Drift	0.0	0.9	Normal at 2σ	2	0.0	0.6
Calibration Factor Uncertainty	1.5	1.5	Normal at 2σ	2	0.8	0.8
Mismatch Uncertainty	4.0	4.0	Rectangular	$\sqrt{3}$	2.3	2.3
Combined Uncertainty (RSS), Room Temperature					3.0	3.6
Expanded Uncertainty with K=2, Room Temperature					6.0	7.3
Temperature Compensation	1.4	1.4	Rectangular	$\sqrt{3}$	0.8	0.8
Combined Uncertainty (RSS, 0 to 50 °C)					3.1	3.6
Expanded Uncertainty with K=2 (RSS, 0 to 50 °C)					6.2	7.5

Two measurement uncertainty calculations are shown for the MA24126A sensor in Table 8-4. The power sensor is used to measure the power of a 3 GHz, +12.0 dBm and –35 dBm CW signal from a signal source with a 1.5:1 VSWR. The example is based on an aperture time of 20 ms and 64 measurement averages.

Table 8-4.   MA24126A Measurement Uncertainty Example

Uncertainty Term	Uncertainty Specification at +12 dBm (%)	Uncertainty Specification at –35 dBm (%)	Probability Distribution	Divisor	Adjusted Uncertainty at +12 dBm (%)	Adjusted Uncertainty at –35 dBm (%)
Sensor Linearity (<+18 dBm)	3.0	3.0	Rectangular	$\sqrt{3}$	1.7	1.7
Noise	0.0	1.6	Normal at 2σ	2	0.0	0.8
Zero Set	0.0	3.2	Rectangular	$\sqrt{3}$	0.0	1.8
Zero Drift	0.0	0.9	Normal at 2σ	2	0.0	0.6
Calibration Factor Uncertainty	2.5	2.5	Normal at 2σ	2	1.25	1.25
Mismatch Uncertainty	4.0	4.0	Rectangular	$\sqrt{3}$	2.3	2.3
Combined Uncertainty (RSS), Room Temperature					3.2	3.8
Expanded Uncertainty with K=2, Room Temperature					6.3	7.6
Temperature Compensation	1.4	1.4	Rectangular	$\sqrt{3}$	0.8	0.8
Combined Uncertainty (RSS, 0 to 50 °C)					3.3	3.9
Expanded Uncertainty with K=2 (RSS, 0 to 50 °C)					6.5	7.7

Table 8-5.   Noise Measurement Uncertainty Calculations for the MA24108A, MA24118A, MA24126A

Noise Calculations at 12 dBm (16 mW):

Noise	1 μW/16 mW = 0.0 %
Zero Set	1 μW/16 mW = 0.0 %
Zero Drift	0.5 μW/16 mW = 0.0 %

Noise Calculations at –35 dBm (316 nW):

Noise	5 nW/316 nW = 1.6 %
Zero Set	10 nW/316 nW = 3.2 %
Zero Drift	3 nW/316 nW = 0.9 %

Two measurement uncertainty calculations are shown for the MA242x8A sensor in Table 8-6. The power sensor is used to measure the power of a 3 GHz, +12.0 dBm and –35 dBm CW signal from a signal source with a 1.5:1 VSWR. The example is based on an aperture time of 20 ms and 64 measurement averages.

Table 8-6.   MA24208A and MA24218A Measurement Uncertainty Example

Uncertainty Term	Uncertainty Specification at +12 dBm (%)	Uncertainty Specification at –35 dBm (%)	Probability Distribution	Divisor	Adjusted Uncertainty at +12 dBm (%)	Adjusted Uncertainty at –35 dBm (%)
Linearity and Calibration Factor	2.33	3.16	Normal at 2σ	2	1.16	1.58
Noise	0.02	0.11	Normal at 2σ	2	0.01	0.05
Zero Set	0.01	0.11	Rectangular	√3	0.00	0.06
Zero Drift	0.01	0.11	Normal at 2σ	2	0.00	0.05
Mismatch	4	4	Rectangular	√3	2.31	2.31
Combined Uncertainty (RSS), 20 °C to 30 °C					2.59	2.80
Expanded Uncertainty with K=2, 20 °C to 30 °C					5.18	5.60

Table 8-7.   Noise Measurement Uncertainty Calculations for the MA24208A and MA24218A senors

Noise Calculations at 12 dBm (16 mW):

Noise	2.41 μW/15.85 mW = 0.01%
Zero Set	1.07 μW/15.85 mW = 0.01%
Zero Drift	1 μW/15.85 mW = 0.01%

Noise Calculations at –35 dBm (316.2 nW):

Noise	0.346 nW/316.2 nW = 0.11%
Zero Set	0.332 nW/316.2 nW = 0.11%
Zero Drift	0.343 nW/316.2 nW = 0.11%

8-7   Error Messages

Error messages are described in Table 8-8 for the MA241xxA power sensor. The status LED will illuminate amber color for MA241xxA models when an error state occurs. The status LED for MA242x8A models will blink green when an error state occurs. In most cases, the error condition can be easily corrected. If the error condition cannot be corrected, note the error message and contact an Anritsu Service Center.

Table 8-8.   MA241xxA Error Messages

Message	Description	Resolution
Temp change > 10 °C	The sensor's ambient temperature has changed by more than 10 ºC since the last zero operation.	Perform the zero operation again.
Temperature over range	The sensor is operating outside of its specified range of 0 ºC to 55 ºC.	Operate the sensor within its specified range.
Range 1 zero failure or Range 2 zero failure	This message appears if the zero operation is unsuccessful. The reason could be the presence of RF power at the input of the sensor.	Turn off the RF input to the sensor or disconnect the sensor from the RF source and try the zero operation again.
Range 1 over range	This message appears on the application screen if excess power is applied to the sensor.	Reduce the input power to the sensor to within acceptable limits (< 20 dBm).

Error messages are described in Table 8-9 for the MA241xxA power sensor.

Table 8-9.   MA242x8A Error Messages

Message	Description	Resolution
"Temp Change > 10 ºC after Last Zero, Zero Again"	The sensor's ambient temperature has changed by more than 10 ºC since the last zero operation.	Perform the zero operation again.
Temp Out of Range	The sensor is operating outside of its specified range of 0 ºC to 50 ºC.	Operate the sensor within its specified range.
Remove Power from Sensor, Zero Again	This message appears if the zero operation is unsuccessful. The reason could be the presence of RF power at the input of the sensor.	Turn off the RF input to the sensor or disconnect the sensor from the RF source and try the zero operation again.
REDUCE POWER, Max Power Exceeded	This message appears on the application screen if excess power is applied to the sensor.	Reduce the input power to the sensor to within acceptable limits (< 20 dBm).

Chapter 9 — Verifying MA241xxA, MA242x8A Performance

9-1 Introduction

This chapter provides test procedures with measurement recording tables, test equipment setups, and verification tables to verify the measurement accuracy of the MA241xxA and MA242x8A USB power sensors. Test and verification is performed by comparing the sensor to a reference sensor with a specified cal factor and linearity performance or uncertainty. The reference sensor should be calibrated by a reputable standards laboratory using NIST instruments with low published measurement uncertainty values. Sensor test limits in these procedures are set appropriately to the specified comparison equipment. All tests must be performed at an ambient temperature of 20 ºC to 25 ºC to optimize the power sensor's performance.

Note	Refer to the instrument Technical Data Sheet for performance specifications.

9-2 Required Equipment

Table 9-1. Required Equipment for MA24108A, MA24118A, MA24126A

Equipment Description	Manufacturer and Model	Critical Specifications
Vector Network Analyzer (Pretest)	Anritsu 37369D Anritsu MS4642B or MS4644B (for MA24126A) or equivalent	Reflection Coefficient Uncertainty $\leq$ 0.013, 10 MHz to 2 GHz Uncertainty $\leq$ 0.020, 2 GHz to 18 GHz Uncertainty $\leq$ 0.025, 18 GHz to 26 GHz
Synthesizer (Freq Response and Linearity Tests)	Anritsu MG3693C or equivalent	Output Power: > +10 dBm, 50 MHz to 26 GHz Output Power Setting Resolution: 0.01 dBm Harmonics: $\leq$ –40 dBc Source VSWR $\leq$ 2.00
Reference Power Meter (Freq Response and Linearity Tests)	Anritsu ML2438A or equivalent	Instrumentation Accuracy $\leq$ 0.5 %
Reference Power Sensor (Freq Response and Linearity Tests)	Anritsu MA24002A or equivalent, or Anritsu MA24004A or equivalent (for MA24126A)	NIST Calibration or equivalent
10 dB K Attenuator (Linearity Test)	Anritsu 41KC-10	VSWR $\leq$ 1.15, 10 MHz to 12 GHz VSWR $\leq$ 1.20, 12 GHz to 18 GHz VSWR $\leq$ 1.30, 18 GHz to 26 GHz
6 dB K Attenuator (Cal. Factor Test)	Anritsu 41KC-6	VSWR $\leq$ 1.15, 10 MHz to 12 GHz VSWR $\leq$ 1.20, 12 GHz to 18 GHz VSWR $\leq$ 1.30, 18 GHz to 26 GHz
Adapter N(f) to K(f) (Freq Response and Linearity Tests)	Anritsu 34ANF50 and 34AK50	VSWR $\leq$ 1.10, 10 MHz to 18 GHz VSWR $\leq$ 1.17, 18 GHz to 26 GHz
Power Divider (Linearity Tests)	Anritsu K241B	Effective Output VSWR < 1.45, 10 MHz to 26 GHz
Personal Computer	Any	See Chapter 2

9-3   VSWR Pretest

The uncertainty of the VSWR test equipment will affect actual measurement values.

Test Procedure

Caution	**Do not** apply power greater than the power sensor specifications or permanent damage may result. Connect a fixed attenuator to the output connector when power exceeds +20 dBm.

Caution	Before connecting the power sensor to a another device, read the "Instrument Care and Preventive Maintenance" on page 1-4.

Using required equipment suggested in Table 9-1 on page 9-1, follow the manufacturer's S11 (input return loss) calibration procedure to perform calibration on the network analyzer. Connect the power sensor to the network analyzer test port and measure power sensor input match. Typically, return loss are expressed in dB, which can be interconverted to Reflection coefficient and VSWR as follows:

$\rho = 10^{-RL/20}$

$RL = -20\log\rho$

$VSWR = (1 + \rho) / (1 - \rho)$

$\rho = (VSWR - 1) / (VSWR + 1)$

where

RL = Return Loss in dB

ρ = Magnitude of the Reflection Coefficient

VSWR = Voltage Standing Wave Ratio

Record the measured data into Table 9-2 under the Actual Measurement column. The Actual Measurement should be smaller than the Maximum Reflection coefficient. The Maximum Reflection Coefficient is equal to the measurement system uncertainty added to the sensor's reflection coefficient specification. If the Actual Measurement reflection coefficient is larger than the Maximum Reflection Coefficient, then the power sensor may be defective. If the actual reflection coefficient is significantly larger than the maximum values in Table 9-2, then the sensor is damaged and it is not necessary to perform further testing.

Table 9-2.   VSWR Pretest Measurement Result

Frequency	Reflection Coefficient Uncertainty	Maximum Reflection Coefficient	Actual Measurement
10 MHz to 50 MHz	0.013	0.310 + 0.013 = 0.323	
50 MHz to 150 MHz	0.013	0.078 + 0.013 = 0.091	
150 MHz to 2 GHz	0.013	0.057 + 0.013 = 0.070	
2 GHz to 12 GHz	0.020	0.099 + 0.020 = 0.119	
12 GHz to 18 GHz	0.020	0.111 + 0.020 = 0.131	
18 GHz to 26 GHz	0.025	0.149 + 0.025 = 0.174	

9-4   Frequency Response Test

In this test the frequency response of the sensor is tested at one low power level against a reference sensor of known measurement uncertainty. The reference sensor should be calibrated by a reputable standards laboratory using instruments with low published measurement uncertainty values. To perform the comparison, both sensors are used to measure the output power of a synthesizer with a high quality power divider and an attenuator, such as the 41KC-6, on the output. The attenuator improves the source match of the synthesizer by lowering the mismatch ripples, thereby lowering the uncertainty in the comparison.

Test Procedure for MA24108A, MA24118A, MA24126A

1. Set up the equipment as follows (refer to Figure 9-1 for an illustration and Table 9-1 for the required equipment):

    a. Set the synthesizer output power to +6 dBm and start frequency to 10 MHz per Table 9-3 on page 9-5

    b. Connect the reference power sensor to the reference power meter using the appropriate cables.

    c. Connect the USB cable between the personal computer with the PowerXpert application installed and the MA24108A, MA24118A, or MA24126A power sensor under test.

    d. Launch the PowerXpert application.

    e. Turn the power on to all of the instruments and allow them to warm up for the amount of time specified in their respective manuals.

    f. Reset or Preset all of the instruments.

    g. Configure the reference meter and sensor to measure a CW signal.

    h. Perform a sensor Zero and a 1 mW reference calibration on the reference sensor and meter per the manufacturer's instructions.

    i. Perform a low-level Zero of the MA24108A, MA24118A, or MA24126A power sensor by disconnecting it from the synthesizer, clicking the **Zero** button on the PowerXpert application, and waiting for the Zeroing message to close.

    j. Connect the attenuator to the output of the synthesizer with the appropriate adapter (if required) to the output of the attenuator.

    k. Set the synthesizer output power to +6 dBm and start frequency to 50 MHz.
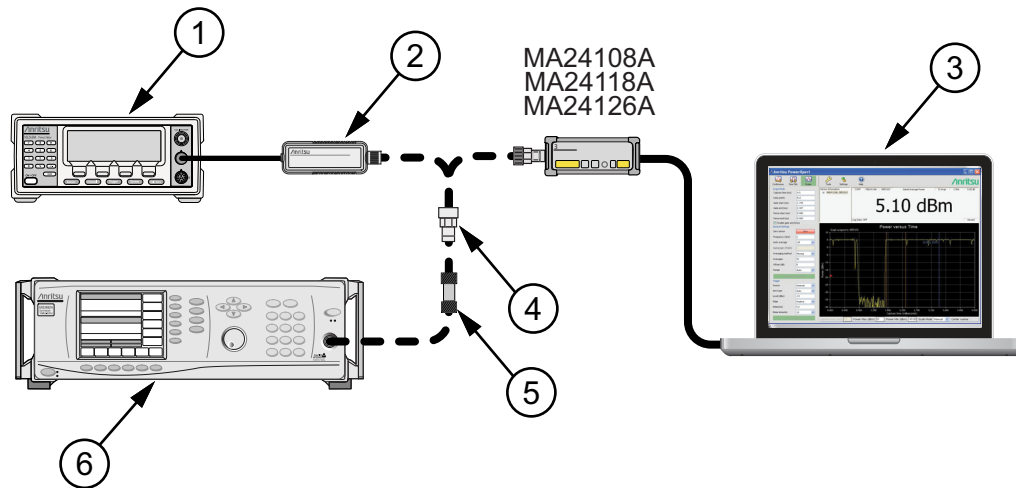
Index	Description
1	Reference Power Meter
2	Reference Power Sensor
3	PC with Anritsu PowerXpert Application
4	K to N Adapter (if required)
5	6 dB Fixed Attenuator
6	Synthesizer

Figure 9-1.   MA24108A, MA24118A, or MA24126A Frequency Response Setup

2. Connect the reference sensor to the synthesizer with the appropriate adapter (if required) and attenuator in-line. See Figure 9-1.

3. Apply the Cal factor to the reference sensor per the manufacturer's instruction.

4. Record the power indicated by the reference meter in Table 9-3.

5. Disconnect the reference sensor from the synthesizer output and connect the MA24108A, MA24118A, or MA24126A power sensor with the appropriate adapter (if required) and attenuator in-line. See Figure 9-1.

6. Apply the Cal factor to the MA24108A, MA24118A, or MA24126A by entering the frequency of the measurement in GHz.

7. In the General Settings, set Averages to 4.

8. Record the power indicated by the MA24108A, MA24118A, or MA24126A in Table 9-3.

9. Set the synthesizer frequency to the next frequency in Table 9-3.

10. Repeat Step 2 through Step 9 until all of the frequencies in Table 9-3 have been measured.

11. For each row in Table 9-3, calculate the absolute value of the difference between the recorded Reference power measurement and the recorded MA24108A, MA24118A, or MA24126A measurement, and record the result in Table 9-3.

12. For each frequency, compare the power difference to the maximum allowed difference specified in Table 9-3. If the difference is higher than the maximum allowed difference, contact Anritsu customer service.

Table 9-3.   MA24108, MA24118A, MA24126A Test Measurement Results

Frequency (GHz)	A Reference Power Measurement (dBm)	B MA241xxA Measurement (dBm)	|A-B| Absolute Value of Difference in Power Measurements (dB)	MA24108A and MA24118A Maximum Allowed Difference (dB)	MA24126A Maximum Allowed Difference (dB)
0.01				0.51	0.55
0.05				0.29	0.31
0.1				0.29	0.31
0.3				0.27	0.29
0.5				0.27	0.29
1.0				0.27	0.29
2.0				0.27	0.29
3.0				0.30	0.33
4.0				0.30	0.33
5.0				0.30	0.33
6.0				0.30	0.33
7.0				0.32	0.35
8.0				0.32	0.35
9.0				0.32	0.37
10.0				0.32	0.37
11.0				0.32	0.37
12.0				0.32	0.37
13.0				0.34	0.38
14.0				0.34	0.38
15.0				0.34	0.38
16.0				0.34	0.41
17.0				0.34	0.41
18.0				0.34	0.41
19.0				-	0.62
20.0				-	0.62
21.0				-	0.62
22.0				-	0.62
23.0				-	0.62
24.0				-	0.62
25.0				-	0.62
26.0				-	0.62

Test Procedure for MA242x8A

1. Set up the equipment as follows (refer to Figure 9-2 for illustration and Table 9-1 for the required equipment):

    a. Connect the reference power sensor to the power meter. Connect the USB sensor to the computer with supplied USB cable.

    b. Connect the synthesizer and power divider to both sensors (No cable between synthesizer and attenuator).

    c. Power up and reset all test instruments. Warm up for the period specified in their respective manuals.

    d. Launch the PowerXpert application and configure both sensors to measure CW signal.

    e. Turn off synthesizer RF output. Perform a sensor Zero and a 1mW Ref Cal on the reference sensor.

    f. Perform Zeroing on the USB sensor by clicking Zero on the PowerXpert.
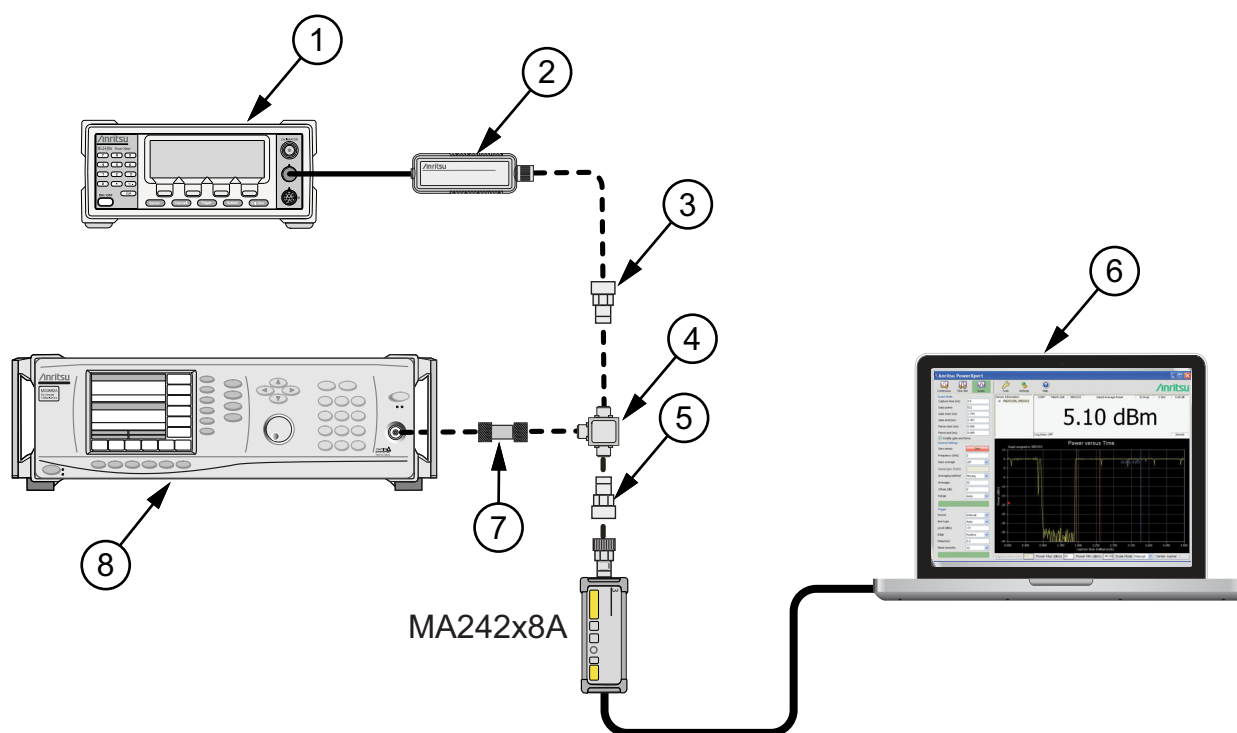
Index	Description
1	Reference Power Meter
2	Reference Power Sensor
3	N(f) to K(m) Adapter
4	Power Divider
5	N(f) to K(m) Adapter
6	PC with Anritsu PowerXpert Application
7	6dB Attenuator Steps 3 and 9 or 3dB Attenuator Step 10
8	Synthesizer

Figure 9-2.   MA242x8A or MA243x0A Frequency Response Setup

2. Set Aperture Time to 20ms and Averages to 10 on PowerXpert.

3. Connect the 6dB fixed attenuator between Synthesizer and Power Divider. Set synthesizer output to +6dBm and 10MHz. Adjust output if necessary so the Ref sensor reads –6 ±0.2 dBm at 10MHz.

4. Apply Cal factor to both sensors by entering either the measured frequency or CF value.

5. Record the power reading of both sensors in Table 9-4.

6. Set the synthesizer frequency to the next value without changing the power. Repeat steps 4 through 5 to measure all listed frequencies.

7. Calculate the absolute value of the difference between the sensors and compare to the maximum allowed difference at each frequency.

8. Flip the power divider outputs and repeat the measurement If any difference is higher than the maximum allowed value. Average the measurements before and after the flip on both sensors and re-compute their difference. Contact Anritsu if the difference is still higher than the maximum allowed value.

9. Set synthesizer output to –6dBm and 10MHz. Adjust output if necessary so the Ref sensor reads –18 ±0.2 dBm at 10MHz. Repeat steps 4 through 8.

10. Change fixed attenuator from 6dB to 3dB. Set synthesizer output to +16dBm and 10MHz. Adjust output if necessary so the Ref sensor reads +7 ±0.2 dBm at 10MHz. Repeat steps 4 through 8.

Table 9-4.   MA24208 and MA24218A Test Measurement Results

Freq GHz	A Reference Power Measurement (dBm)			B MA242x8A, MA243x0A Measurement (dBm)			|A–B| Absolute Value of Difference in Power Measurements (dB)			Max Allowed Diff (dB)
	–18 dBm	–6 dBm	+7 dBm	–18 dBm	–6 dBm	+7 dBm	–18 dBm	–6 dBm	+7 dBm	
0.01										0.41
0.05										0.31
0.1										0.31
0.3										0.31
0.5										0.31
1.0										0.31
2.0										0.31
3.0										0.32
4.0										0.32
5.0										0.32
6.0										0.32
7.0										0.34
8.0										0.34
9.0										0.34
10.0										0.34
11.0										0.34
12.0										0.34
13.0										0.35
14.0										0.35
15.0										0.35
16.0										0.35
17.0										0.35
18.0										0.35

9-5   Linearity Test for MA24108A/118A/126A

The linearity correction of the MA24108A, MA24118A, or MA24126A is compared to a thermal power sensor, which has very good inherent linearity over a power range of about –20 dBm to +10 dBm. For this reason, the MA24108A, MA24118A, or MA24126A is compared to the thermal sensor in two *ranges*, keeping the power levels to the thermal sensor in the range of –17 dBm to +5 dBm, while the power to the MA24108A, MA24118A, or MA24126A varies from about –26 dBm to about +14 dBm.

Test Procedure

1. Set up the equipment as follows (refer to Figure 9-3 for an illustration and Table 9-1 for the required equipment):

    a. Connect the reference power sensor to the reference power meter using the appropriate cables.

    b. Connect the USB cable between the personal computer with the PowerXpert application installed and the MA24108A, MA24118A, or MA24126A power sensor under test.

    c. Launch the PowerXpert application.

    d. Turn the power on to all of the instruments and allow them to warm up for the amount of time specified in the instrument's respective manuals.

    e. Reset or Preset all of the instruments.

    f. Configure the reference meter and sensor to measure a CW signal.

    g. Perform a sensor Zero and a 1 mW reference calibration on the reference sensor and meter per the manufacturer's instructions.

    h. Perform a low-level Zero of the MA24108A, MA24118A, or MA24126A by disconnecting the it from the synthesizer, clicking the Zero button on the PowerXpert application, and waiting for the Zeroing message to close.

    i. Connect the power splitter to the output of the synthesizer, and connect the 10 dB attenuator to the reference arm of the splitter output.

    j. Connect an N(f) to K adapter (if required) to each power sensor.

    k. Connect the reference sensor and adapter to the 10 dB attenuator.

    l. Connect the MA24108A, MA24118A, or MA24126A and adapter (if required) to the other splitter output.

    m. Set the synthesizer CW frequency to 50 MHz.

    n. Set the synthesizer leveled output power to +20 dBm or highest leveled power available (do not exceed +20 dBm).

    o. Increase averaging of the DUT sensor by entering "16" in the PowerXpert application, and then click **Apply above settings**.
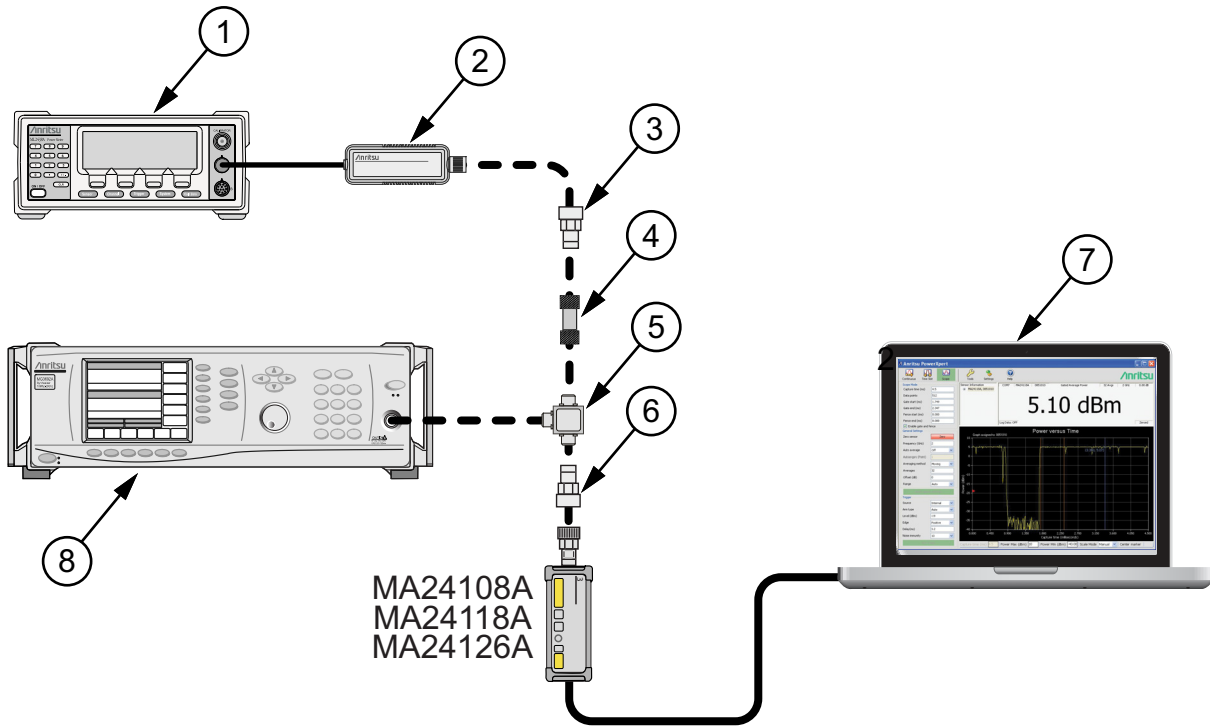
Index	Description
1	Reference Power Meter
2	Reference Power Sensor
3	K to N Adapter (if required)
4	10 dB Attenuator
5	Power Splitter
6	K to N Adapter (if required)
7	PC with Anritsu PowerXpert Application
8	Synthesizer

Figure 9-3.   Linearity Test Setup 1

2. Apply the Cal factor to the reference sensor per the manufacturer's procedure.

3. Apply the Cal factor by entering the frequency of the measurement in GHz.

4. Turn Off the synthesizer's RF output and perform a low-level Zero of both the Reference sensor and the MA24108A, MA24118A, or MA24126A.

5. Turn On the synthesizer's RF output.

6. Record data for the first 20 dB range as follows:

    a. Record the power reading by the reference meter in column A of Table 9-5 on page 9-12.

    b. Record the power reading by the MA24108A, MA24118A, or MA24126A in column of Table 9-5.

    c. Set the synthesizer power to +15 dBm.

    d. Record the reference meter and the MA24108A, MA24118A, or MA24126A power sensor readings in Table 9-5.

    e. Repeat the measurement of Step 6 for synthesizer output levels of +10, +5, and 0 dBm.

Note	The MA24108A, MA24118A, or MA24126A power measured at 0 dBm will be used in Step 7e, below.

7. Set up the test for the second 20 dB range as follows:

   a. Remove the 10 dB attenuator from in between the reference sensor and splitter and connect the reference sensor (with adapter, if required) directly to the splitter.

   b. Remove the MA24108A, MA24118A, or MA24126A from the splitter and connect the 10 dB attenuator between the splitter and the power sensor. See Figure 9-4.

   c. Turn Off the synthesizer's RF output and perform a low-level Zero of both the Reference sensor and the MA24108A, MA24118A, or MA24126A.

   d. Turn On the synthesizer's RF output.

   e. Set the synthesizer output level to +10 dBm, then adjust its power level until the sensor/meter under test reads as close as possible to the 0 dBm value obtained above in Step 6.
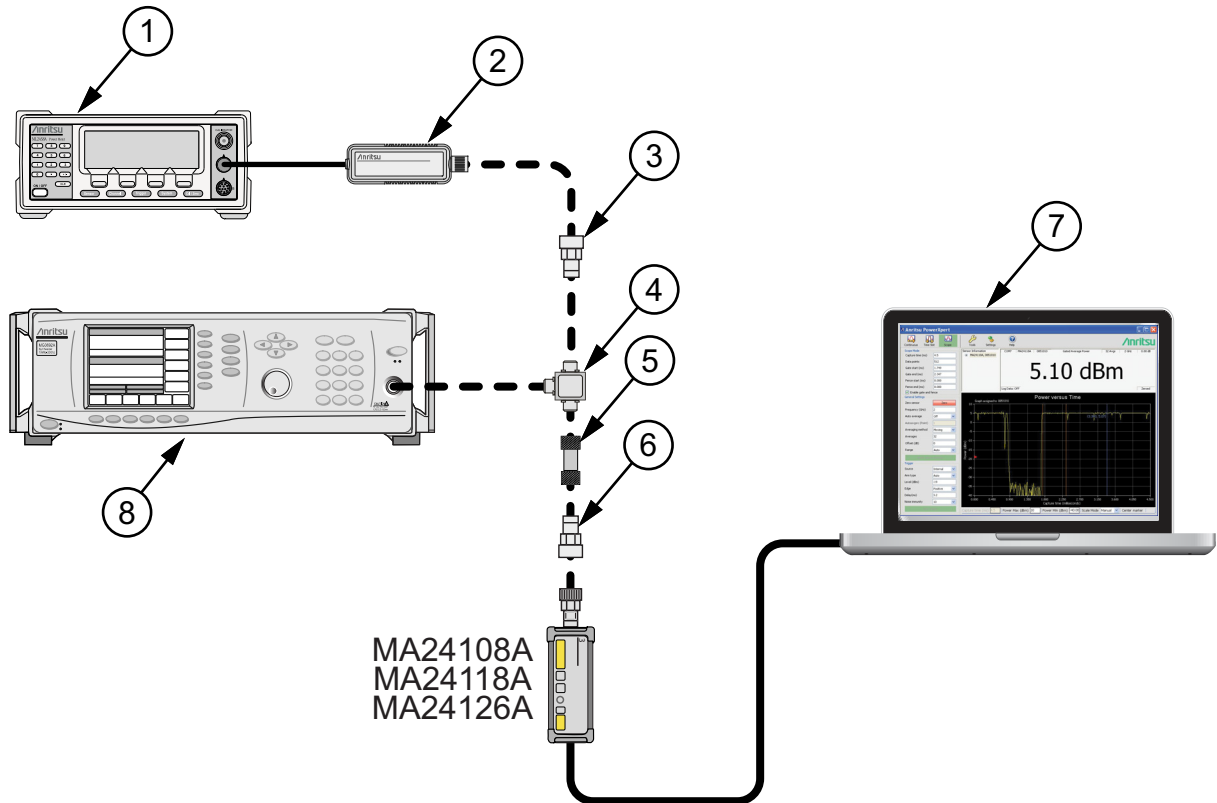
Index	Description
1	Reference Power Meter
2	Reference Power Sensor
3	K to N Adapter (if required)
4	Power Splitter
5	10 dB Attenuator
6	K to N Adapter (if required)
7	PC with Anritsu PowerXpert Application
8	Synthesizer

Figure 9-4.   Linearity Test Setup 2

8. Record data for the next 20 dB range:

  a. Read and record the power indicated by the reference meter in Table 9-5.

  b. Lower the output power level of the synthesizer to +5 dBm.

  c. Record the reference meter and the MA24108A, MA24118A, or MA24126A power sensor readings in Table 9-5, columns A and B respectively.

  d. Repeat the measurements of step 8 for synthesizer output levels of 0, –5, and –10 dBm.

Table 9-5.   Measurement Results (50 MHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24108A, MA24118A, or MA24126A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	–5	0		0		10		
10	–10	0		0		10		
11							Max:	
12							Min:	
13						Delta (E11 – E12):		

9. Perform the calculations and operation check as follows:

  a. Subtract the Reference Power Measurement of row 5 from the Reference Power Measurement of row 6. Record this value in the Correction column of rows 1 through 5.

Note	The Correction column of rows 1 through 5 should all have the same value. The Correction column of rows 6 through 10 have values of 0.

  b. Add the Reference Power Measurement and Correction values of row 1 and record the result in the Corrected Reference Power Measurement column of row 1.

  c. Repeat Step 9b for rows 2 through 10.

  d. Subtract the MA24108A, MA24118A, or MA24126A Measurement of row 1 from the Corrected Reference Power Measurement of row 1 and record the result in the Difference Calculation column of row 1.

  e. Repeat Step 9d for rows 2 through 10.

  f. Find the largest (most positive) value in the Difference Calculation column and record this value next to the word Max in row 11.

  g. Find the smallest (least positive or most negative) value in the Difference Calculation column and record this value next to the word Min in row 12.

     h. Subtract the Min value from Step 9g from the Max value from Step 9f and record the result next to the word Delta in row 13.

     i. The Delta result should be less than 0.3 dB. If it is larger, contact Anritsu customer service.

10. Repeat the entire measurement and calculations with synthesizer frequency settings of 2 GHz, 4 GHz, 6 GHz, 10 GHz, 12 GHz, 14 GHz, 16 GHz, 18 GHz, 20 GHz, 22 GHz, 24 GHz, and 26 GHz.

Refer to Section 9-6 for the MA24208A and MA24218A power sensor linearity testing.

Table 9-6.   Measurement Results (2 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24108A, MA24118A, or MA24126A Measurement (dBm)	C–D Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	−5	0		0		10		
10	−10	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 − E12):	

Table 9-7.   Measurement Results (4 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24108A, MA24118A, or MA24126A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	−5	0		0		10		
10	−10	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 − E12):	

Table 9-8.   Measurement Results (6 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24108A, MA24118A, or MA24126A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	–5	0		0		10		
10	–10	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 – E12):	

Table 9-9.   Measurement Results (8 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24108A, MA24118A, or MA24126A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	–5	0		0		10		
10	–10	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 – E12):	

Table 9-10. Measurement Results (10 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24118A, MA24126A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	−5	0		0		10		
10	−10	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 − E12):	

Table 9-11. Measurement Results (12 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24118A, MA24126A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	−5	0		0		10		
10	−10	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 − E12):	

Table 9-12. Measurement Results (14 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24118A, MA24126A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	–5	0		0		10		
10	–10	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 – E12):	

Table 9-13. Measurement Results (16 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24118A, MA24126A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	–5	0		0		10		
10	–10	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 – E12):	

Table 9-14. Measurement Results (18 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24118A, MA24126A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	−5	0		0		10		
10	−10	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 − E12):	

Table 9-15. Measurement Results (20 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24126A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	−5	0		0		10		
10	−10	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 − E12):	

Table 9-16. Measurement Results (22 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24126A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	–5	0		0		10		
10	–10	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 – E12):	

Table 9-17. Measurement Results (24 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24126A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	–5	0		0		10		
10	–10	0		0		10		
11							Max:	
12							Min:	
13							Delta (E11 – E12):	

Table 9-18. Measurement Results (26 GHz)

Row #	Synthesizer Power Level Setting (dBm)	Attenuation in Reference Arm (dB)	A Reference Power Measurement (dBm)	B = (A6–A5) Correction (dB)	C = (A+B) Corrected Reference Power Measurement (dB)	Attenuation in Test Arm (dB)	D MA24126A Measurement (dBm)	E = (C–D) Difference Calculation (dB)
1	+20	10				0		
2	+15	10				0		
3	+10	10				0		
4	+5	10				0		
5	0	10				0		
6	adjust per Step 7e	0		0		10		
7	+5	0		0		10		
8	0	0		0		10		
9	−5	0		0		10		
10	−10	0		0		10		
11							Max:	
12							Min:	
13						Delta (E11 − E12):		

9-6   Linearity Test MA24208A and MA24218A

The linearity correction of the MA24208A and MA24218A is compared to a thermal power sensor, which has very good inherent linearity over a power range of about –17 dBm to +4 dBm. For this reason, the MA24208A and MA24218A is compared to the thermal sensor in three *ranges*, keeping the power levels to the thermal sensor in the range of –17 dBm to +4 dBm, while the power to the MA24208A and MA24218A varies from about –37 dBm to about +14 dBm.

Test Procedure

1. Set up the equipment as follows (refer to Figure 9-5 for an illustration and Table 9-1 for the required equipment):

    a. Connect the reference power sensor to the reference power meter using the appropriate cables.

    b. Connect the USB cable between the personal computer with the PowerXpert application installed and the MA24208A and MA24218A power sensor under test.

    c. Launch the PowerXpert application.

    d. Turn the power on to all of the instruments and allow them to warm up for the amount of time specified in the instrument's respective manuals.

    e. Reset or Preset all of the instruments.

    f. Configure the reference meter and sensor to measure a CW signal.

    g. Perform a sensor Zero and a 1 mW reference calibration on the reference sensor and meter per the manufacturer's instructions.

    h. Connect the power splitter to the output of the synthesizer, and connect the 10 dB attenuator to the reference arm of the splitter output.

    i. Connect an N(f) to K adapter (if required) to each power sensor.

    j. Connect the reference sensor and adapter to the 10 dB attenuator.

    k. Connect theMA24208A and MA24218A and adapter (if required) to the other splitter output.

    l. Set the synthesizer CW frequency to 50 MHz.

    m. Set the synthesizer leveled output power to +20 dBm or highest leveled power available (do not exceed +20 dBm).

    n. Increase averaging of the DUT sensor by entering "16" in the PowerXpert application, and then click **Apply above settings**.
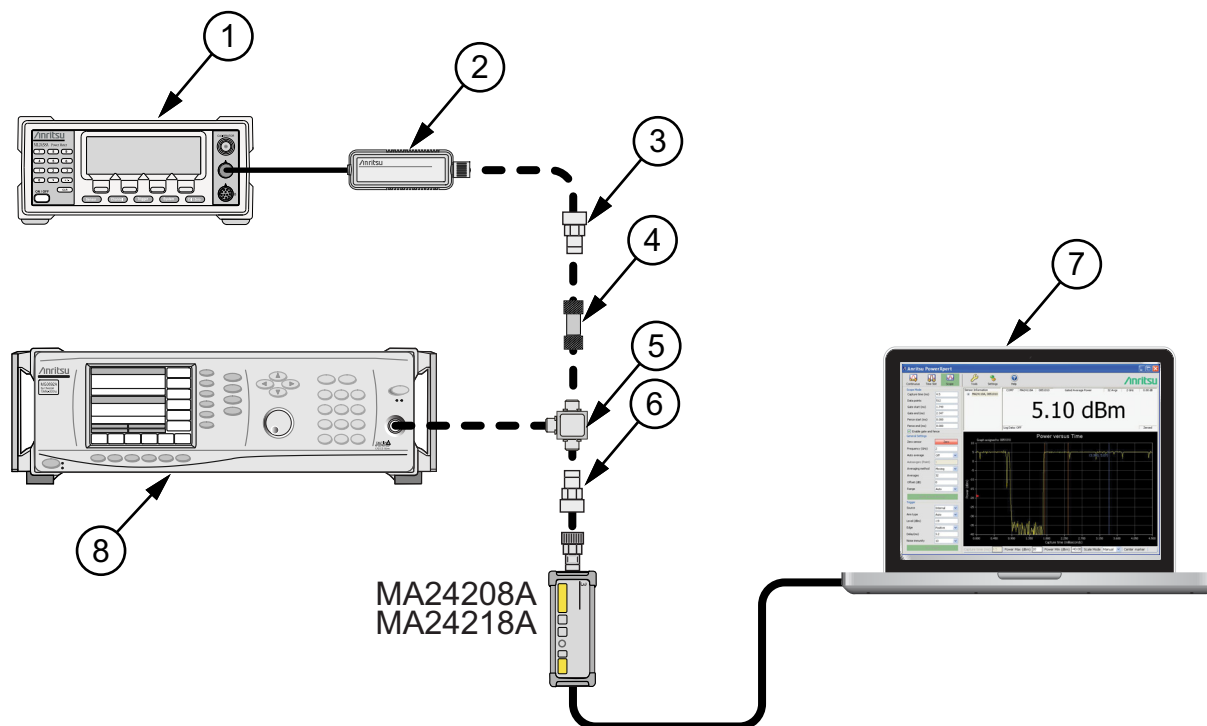
Index	Description
1	Reference Power Meter
2	Reference Power Sensor
3	K to N Adapter (if required)
4	10 dB Fixed Attenuator
5	Power Splitter
6	K to N Adapter (if required)
7	PC with Anritsu PowerXpert Application
8	Synthesizer

Figure 9-5.   Linearity Test Setup 3

2. Apply the Cal factor to the reference sensor per the manufacturer's procedure.

3. Apply the Cal factor by entering the frequency of the measurement in GHz.

4. Turn Off the synthesizer's RF output and perform a low-level Zero of both the Reference sensor and the MA24208A and MA24218A.

5. Turn On the synthesizer's RF output.

6. Record data for the first 20 dB range as follows:

    a. Record the power reading by the reference meter in column A of Table 9-19 on page 9-24.

    b. Record the power reading by the MA24208A and MA24218A in column B of Table 9-19.

    c. Set the synthesizer power to +15 dBm.

    d. Repeat the measurement of step 6 for synthesizer output levels of +10, +5, and 0 dBm.

Note	The MA24208A and MA24218A power measured at 0 dBm will be used in Step 7e, below.

7. Set up the test for the second 20 dB range as follows:

   a. Remove the 10 dB attenuator from in between the reference sensor and splitter and connect the reference sensor (with adapter, if required) directly to the splitter.

   b. Remove the MA24208A and MA24218A from the splitter and connect the 10 dB attenuator between the splitter and the power sensor (see Figure 9-6).

   c. Turn Off the synthesizer's RF output and perform a low-level Zero of both the Reference sensor and the MA24208A and MA24218A.

   d. Turn On the synthesizer's RF output.

   e. Set the synthesizer output level to +10 dBm, then adjust its power level until the sensor/meter under test reads as close as possible to the 0 dBm value recorded in column B row 5. Record the resulting power level in column B, row 6 of Table 9-19.

   f. Record the power indicated by the reference meter in column A of row 6.
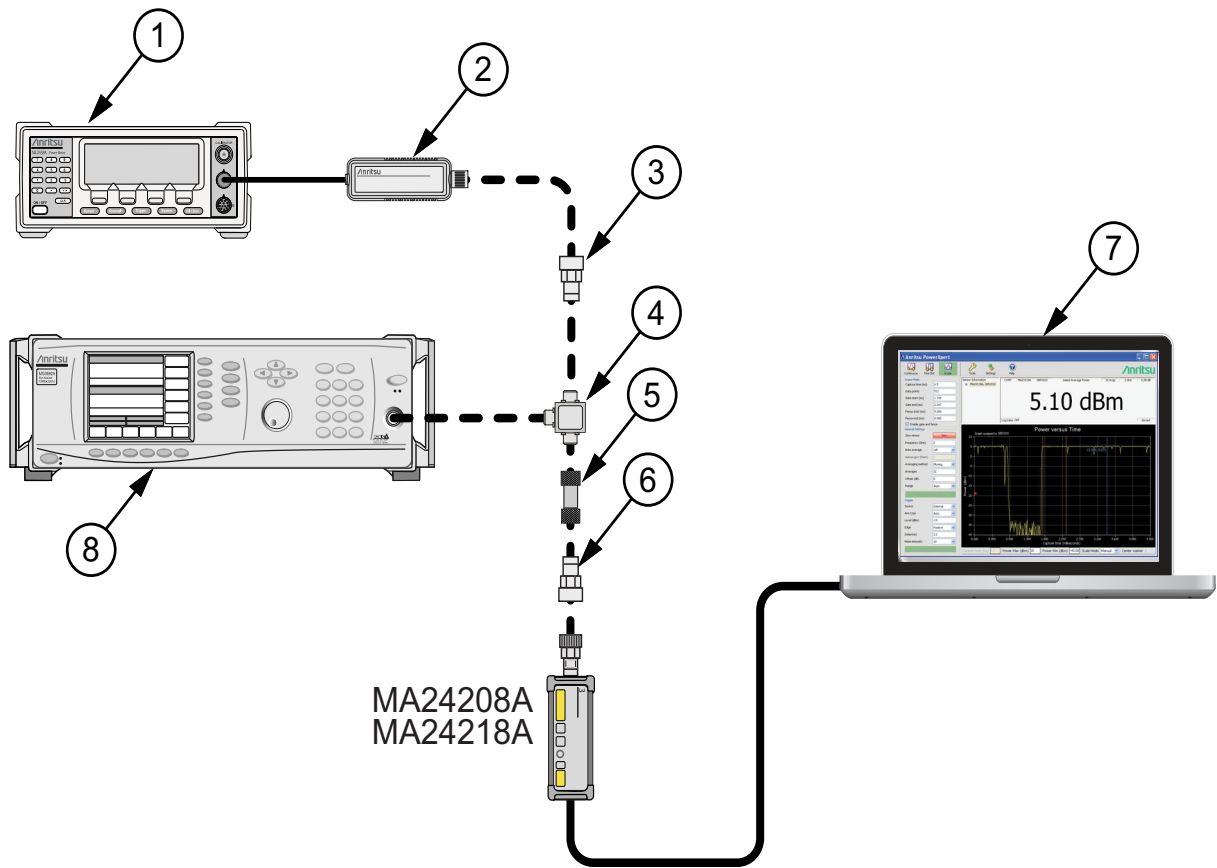
Index	Description
1	Reference Power Meter
2	Reference Power Sensor
3	K to N Adapter (if required)
4	Power Splitter
5	10 dB or 20 dB Fixed Attenuator Step 9
6	K to N Adapter (if required)
7	PC with Anritsu PowerXpert Application
8	Synthesizer

Figure 9-6.   Linearity Test Setup 4

8. Record data for the next 20 dB range

    a. Lower the output power level of the synthesizer to +5 dBm.

    b. Record the reference meter and the MA24208A and MA24218A power sensor readings in Table 9-19, columns A and B respectively.

    c. Repeat the measurements of step 8 for synthesizer output levels of 0 dBm, –5 dBm, and –10 dBm.

Table 9-19. Measurement Results (50 MHz)

Row #	Synth nominal level (dBm)	Atten in Ref Arm (dB)	Atten in Test Arm (dB)	A Ref Power (dBm)	B DUT Power (dBm)	C1 A6–A5 (dB)	C2 A10 –A11 (dB)	C3 B6–B5 (dB)	C4 B11 –B10 (dB)	D A+C (dBm)	E B5-D5 (dB)	F (D-B)+E Diff (dB)
1	20	10	0									
2	15	10	0									
3	10	10	0									
4	5	10	0									
5	0	10	0									
6	10	0	10									
7	5	0	10									
8	0	0	10									
9	–5	0	10									
10	–10	0	10									
11	0	0	20									
12	–5	0	20									
13	–10	0	20									
14											max	
15											min	
16											delta	

9. Set up the test for the next 15 dB range as follows:

    a. Remove the 10 dB attenuator from in between the splitter and DUT sensor and replace it with a 20 dB attenuator.

    b. Turn Off the synthesizer's RF output and perform a low-level Zero of both the Reference sensor and the MA24208A and MA24218A.

    c. Turn On the synthesizer's RF output.

    d. Set the synthesizer output level to 0 dBm (per Table 9-19), then adjust its power level until the sensor/meter under test reads as close as possible to the value in row10 column B. Record the resulting power level in column B, row 11 of Table 9-19.

    e. Read and record the power indicated by the reference meter in row 11 column A of Table 9-19.

10. Record data for the next 15 dB range.

    a. Lower the output power level of the synthesizer to –5 dBm.

    b. Record the reference meter and the MA24208A and MA24218A power sensor readings in Table 9-19, columns A and B respectively.

    c. Repeat the measurements of step 10 for synthesizer output levels of –10 dBm.

11. Perform the calculations as follows:

    a. Subtract the Reference Power Measurement of row 5, column A from the Reference Power Measurement of row 6, column A. Record this value in the column C1, rows 1 through 5.

Note	Column C1, rows 1 through 5 should all have the same value. The correction column rows 6 through 13 have values of 0.

    b. Subtract the DUT power of row 11 column A from that of Row 10 Column A and record in column C2, rows 11 through 13.

    c. Subtract the value in row 5 column B from that in row 6 column B. Copy the result into rows 6 through 10 of column C3.

    d. Subtract the value of row 10 column B from that in row 11 column B and copy it into rows 11 through 13 column C4.

    e. For each row in column D, add the values of the same row of column A and columns C1 through C4 (a blank has value 0 dB).

    f. Subtract the value of row 5 column D from that of row 5 column B. Record this values in column E rows 1 thorough 13.

    g. For each row in column F compute the value by subtracting the value of column B from that in column D and then adding the value from column E.

    h. Find the largest (most positive) value in the column F, rows 1 through 13, and record this value next to the word Max in row14.

    i. Find the smallest value in column F, rows 1 through 13, and record this value next to the word Min in row 15.

    j. Subtract the Min value from Step 11i from the Max value from Step 11h and record the result next to the word Delta in row 16.

    k. The Delta result should be less than 0.3 dB. If it is larger, contact Anritsu customer service.

12. Repeat the entire measurement and calculations with synthesizer frequency settings of 2 GHz, 4 GHz, 6 GHz, 8 GHz, 10 GHz, 12 GHz, 14 GHz, 16 GHz, and 18 GHz.

Table 9-20. Measurement Results (2 GHz)

Row #	Synth nominal level (dBm)	Atten in Ref Arm (dB)	Atten in Test Arm (dB)	A Ref Power (dBm)	B DUT Power (dBm)	C1 A6–A5 (dB)	C2 A10 –A11 (dB)	C3 B6–B5 (dB)	C4 B11 –B10 (dB)	D A+C (dBm)	E B5-D5 (dB)	F (D-B)+E Diff (dB)
1	20	10	0									
2	15	10	0									
3	10	10	0									
4	5	10	0									
5	0	10	0									
6	10	0	10									
7	5	0	10									
8	0	0	10									
9	−5	0	10									
10	−10	0	10									
11	0	0	20									
12	−5	0	20									
13	−10	0	20									
14											max	
15											min	
16											delta	

Table 9-21. Measurement Results (4 GHz)

Row #	Synth nominal level (dBm)	Atten in Ref Arm (dB)	Atten in Test Arm (dB)	A Ref Power (dBm)	B DUT Power (dBm)	C1 A6–A5 (dB)	C2 A10 –A11 (dB)	C3 B6–B5 (dB)	C4 B11 –B10 (dB)	D A+C (dBm)	E B5-D5 (dB)	F (D-B)+E Diff (dB)
1	20	10	0									
2	15	10	0									
3	10	10	0									
4	5	10	0									
5	0	10	0									
6	10	0	10									
7	5	0	10									
8	0	0	10									
9	–5	0	10									
10	–10	0	10									
11	0	0	20									
12	–5	0	20									
13	–10	0	20									
14											max	
15											min	
16											delta	

Table 9-22. Measurement Results (6 GHz)

Row #	Synth nominal level (dBm)	Atten in Ref Arm (dB)	Atten in Test Arm (dB)	A Ref Power (dBm)	B DUT Power (dBm)	C1 A6–A5 (dB)	C2 A10 –A11 (dB)	C3 B6–B5 (dB)	C4 B11 –B10 (dB)	D A+C (dBm)	E B5-D5 (dB)	F (D-B)+E Diff (dB)
1	20	10	0									
2	15	10	0									
3	10	10	0									
4	5	10	0									
5	0	10	0									
6	10	0	10									
7	5	0	10									
8	0	0	10									
9	−5	0	10									
10	−10	0	10									
11	0	0	20									
12	−5	0	20									
13	−10	0	20									
14											max	
15											min	
16											delta	

Table 9-23. Measurement Results (8 GHz)

Row #	Synth nominal level (dBm)	Atten in Ref Arm (dB)	Atten in Test Arm (dB)	A Ref Power (dBm)	B DUT Power (dBm)	C1 A6–A5 (dB)	C2 A10 –A11 (dB)	C3 B6–B5 (dB)	C4 B11 –B10 (dB)	D A+C (dBm)	E B5-D5 (dB)	F (D-B)+E Diff (dB)
1	20	10	0									
2	15	10	0									
3	10	10	0									
4	5	10	0									
5	0	10	0									
6	10	0	10									
7	5	0	10									
8	0	0	10									
9	–5	0	10									
10	–10	0	10									
11	0	0	20									
12	–5	0	20									
13	–10	0	20									
14											max	
15											min	
16											delta	

Table 9-24. Measurement Results (10 GHz)

Row #	Synth nominal level (dBm)	Atten in Ref Arm (dB)	Atten in Test Arm (dB)	A Ref Power (dBm)	B DUT Power (dBm)	C1 A6–A5 (dB)	C2 A10 –A11 (dB)	C3 B6–B5 (dB)	C4 B11 –B10 (dB)	D A+C (dBm)	E B5-D5 (dB)	F (D-B)+E Diff (dB)
1	20	10	0									
2	15	10	0									
3	10	10	0									
4	5	10	0									
5	0	10	0									
6	10	0	10									
7	5	0	10									
8	0	0	10									
9	−5	0	10									
10	−10	0	10									
11	0	0	20									
12	−5	0	20									
13	−10	0	20									
14											max	
15											min	
16											delta	

Table 9-25. Measurement Results (12 GHz)

Row #	Synth nominal level (dBm)	Atten in Ref Arm (dB)	Atten in Test Arm (dB)	A Ref Power (dBm)	B DUT Power (dBm)	C1 A6–A5 (dB)	C2 A10 –A11 (dB)	C3 B6–B5 (dB)	C4 B11 –B10 (dB)	D A+C (dBm)	E B5-D5 (dB)	F (D-B)+E Diff (dB)
1	20	10	0									
2	15	10	0									
3	10	10	0									
4	5	10	0									
5	0	10	0									
6	10	0	10									
7	5	0	10									
8	0	0	10									
9	–5	0	10									
10	–10	0	10									
11	0	0	20									
12	–5	0	20									
13	–10	0	20									
14											max	
15											min	
16											delta	

Table 9-26. Measurement Results (14 GHz)

Row #	Synth nominal level (dBm)	Atten in Ref Arm (dB)	Atten in Test Arm (dB)	A Ref Power (dBm)	B DUT Power (dBm)	C1 A6–A5 (dB)	C2 A10 –A11 (dB)	C3 B6–B5 (dB)	C4 B11 –B10 (dB)	D A+C (dBm)	E B5-D5 (dB)	F (D-B)+E Diff (dB)
1	20	10	0									
2	15	10	0									
3	10	10	0									
4	5	10	0									
5	0	10	0									
6	10	0	10									
7	5	0	10									
8	0	0	10									
9	−5	0	10									
10	−10	0	10									
11	0	0	20									
12	−5	0	20									
13	−10	0	20									
14											max	
15											min	
16											delta	

Table 9-27. Measurement Results (16 GHz)

Row #	Synth nominal level (dBm)	Atten in Ref Arm (dB)	Atten in Test Arm (dB)	A Ref Power (dBm)	B DUT Power (dBm)	C1 A6–A5 (dB)	C2 A10 –A11 (dB)	C3 B6–B5 (dB)	C4 B11 –B10 (dB)	D A+C (dBm)	E B5-D5 (dB)	F (D-B)+E Diff (dB)
1	20	10	0									
2	15	10	0									
3	10	10	0									
4	5	10	0									
5	0	10	0									
6	10	0	10									
7	5	0	10									
8	0	0	10									
9	–5	0	10									
10	–10	0	10									
11	0	0	20									
12	–5	0	20									
13	–10	0	20									
14											max	
15											min	
16											delta	

Table 9-28. Measurement Results (18 GHz)

Row #	Synth nominal level (dBm)	Atten in Ref Arm (dB)	Atten in Test Arm (dB)	A Ref Power (dBm)	B DUT Power (dBm)	C1 A6–A5 (dB)	C2 A10 −A11 (dB)	C3 B6–B5 (dB)	C4 B11 −B10 (dB)	D A+C (dBm)	E B5-D5 (dB)	F (D-B)+E Diff (dB)
1	20	10	0									
2	15	10	0									
3	10	10	0									
4	5	10	0									
5	0	10	0									
6	10	0	10									
7	5	0	10									
8	0	0	10									
9	−5	0	10									
10	−10	0	10									
11	0	0	20									
12	−5	0	20									
13	−10	0	20									
14											max	
15											min	
16											delta	

Chapter 10 — Using the MA243x0A

10-1 Introduction

This chapter describes using the MA243x0A USB power sensor and the Anritsu PowerXpert PC application buttons and menus described in Chapter 3, "Using USB Power Sensors with PowerXpert". If an Anritsu series handheld instrument is being used with the power sensor, refer to the user documentation that came with the handheld instrument for procedures on operating external power sensors.

10-2 Sensor Connector Overview

The MA243x0A power sensor connectors are shown in Figure 10-1.

Index	Description
	MA243x0A
1	MA24330A, MA24340A RF input: K male (Torque connector at 8lbf-in [0.9 N.m]). MA24350A RF input: V male (Torque connector at 8lbf-in [0.9 N.m]).
2	**LED Solid Green:** Sensor ON, Status OK **Blinks Green:** Error or Programming Condition
3	Trigger Out (For Future Use)
4	USB Micro-B Port (for connection with a PC or Anritsu handheld instrument)
5	External Trigger Input (TTL/CMOS)

Figure 10-1. MA243x0A Sensor Connectors Overview

10-3   Basic Power Measurement

This section provides steps and information to make basic power measurements with the MA243x0A power sensor and PowerXpert. To perform a power measurement:

1. Connect the sensor to a computer as shown in Figure 10-2.

2. Open the Anritsu PowerXpert application.

3. Zero the sensor as described below in "Zeroing the Sensor".

Caution	**Do not** apply power greater than the power sensor specifications or permanent damage may result. Connect a fixed attenuator to the output connector when power exceeds +20 dBm.

Caution	Before connecting the power sensor to a another device, read the "Instrument Care and Preventive Maintenance" on page 1-4.

Figure 10-2. Measurement Setup

4. Connect the RF source to the **RF IN** port of the power sensor. Read the power measurement from the Anritsu PowerXpert application window (power readings are continuous with the default setting).

Connecting the DUT

RF signal connections are made to the male RF connector, which has a 50 ohm characteristic impedance. When connecting to the male connector of the sensor, observe the following practice for tightening the connection:

1. While holding the body of the sensor in one hand, turn the male connector nut to finger tighten the connection. **Do not** turn the body of the sensor as this will cause excessive wear to the connector.

2. Back off the connection by turning the connector nut counter clockwise 1/4 turn.

3. Tighten the connection (clockwise) using a 8 in-lb torque wrench (Anritsu part number: 01-201).

Zeroing the Sensor

Zero the sensor before making power measurements. If frequent low-level measurements are being made, check the sensor zeroing often and repeat as necessary. If the sensor goes into sleep mode, the sensor must be re-zeroed before taking measurements. Before zeroing the sensor, connect it to the DUT (device under test) test port and remove RF power from the connection to a level 20 dB below the noise floor of the power sensor. For the MA243x0A this level is less than -70 dBm. Leave the sensor connected to the DUT test port so that ground noise and thermal EMF (electro-magnetic fields) are zeroed out of the measurement. The sensor may also be connected to a grounded connector on the DUT or disconnected from any signal source.

To zero the sensor MA243x0A series power sensor, click the **Zero** button on the PowerXpert application. If the sensor fails the zeroing operation, remove power from the sensor and Zero again.

Calibrating the Sensor

The signal channel/analog signal acquisition hardware is integrated along with the RF front end of the power sensor. All calibration factors, as well as linearity and temperature corrections, are stored in the sensor. Therefore, there is no need for a reference calibration with the sensor.

Applying a Calibration Factor Correction

The power sensor has an internal EEPROM containing correction and calibration factors that were programmed into the sensor at the factory. The power sensor has an internal temperature sensor that reports its readings periodically to the microprocessor. The sensor makes all of the required calculations on the measurement once the measurement frequency has been entered in the "General Settings" area.

10-4   Measurement Factors

The following measurement factors may apply.

Noise and Averaging

To achieve a required reading resolution, particularly at low power levels, averaging is often needed to reduce noise and steady the displayed power reading. Use the noise vs. resolution table in Table 10-1 and Table 10-2 on page 10-9 to determine the number of averages that will typically be required for a given resolution. Alternatively, determine the number of averages through calculation by using the noise specifications and the fact that noise will be inversely proportional to the square root of N, where N is the number of averages. For example, a CW tone at −45 dBm is to be measured to 0.05 dB resolution. Using Table 10-1 the required number of averages is 1. The same measurement to 0.01 dB resolution would require 121 averages.

Average Value of Time Varying Signals

When measuring the average power of a time varying or modulated signal with a modulation bandwidth (BW) which is much greater than the signal channel of the sensor, averaging of the power is performed in the sensor hardware (detectors and or preamplifiers). For the case of the MA243x0A the signal channel BW is 50 kHz. Signals modulated at MHz rates will be averaged in the hardware and no special considerations are required.

When measuring signals with modulation frequency components near or below the signal channel bandwidth, average power readings may be seen to fluctuate over time. This fluctuation may be reduced through careful selection of the aperture time and averaging number. Ideally, the aperture time should be chosen to be an integer multiple of the modulation frequency. If this can be done, then the average power reading will be stable for each measurement update. For modulations with multiple frequencies present, or with significant modulation components with periods longer than the maximum aperture time (1 sec for MA243x0A) averaging will have to be increased to obtain a stable reading. If the measurement update rate is very close to the period of the modulation, a low frequency "beat note" can result. If the frequencies are very close, the beat note can be very low in frequency, and therefore require very long averaging times to remove. In this case it is suggested that the aperture time be changed to result in a higher frequency beat which is easier to average out.

Settling Time

The signal channel bandwidth of the MA243x0A series power sensor supports a rise time of about 8 µs. The ADC sample period is approximately 7.14 µs. Thus it will take more than one ADC sample for the signal channel hardware to completely settle in response to a step change in input power. The hardware settling time for the MA243x0A series power sensor can be estimated by assuming a single pole response with 50 kHz bandwidth:

$$Settling time = -\left[\tau \times \ln\left(\frac{SP}{100} \right) \right]$$

where:

$$\tau = \frac{0.35}{(50e-3)} = 7e-6 \; seconds$$

$$SP = Desired \; Settling\%$$

For small settling percentages, it is quite likely that the noise per ADC sample will be larger than the desired settling percentage, thus averaging or decimation of ADC samples will have to be used to reduce the noise. Averaging will, of course, increase the settling time of the measurement in direct proportion to the averaging number used.

It is important to note that the settling time described above strictly applies only to increasing power steps (rise time). Settling to decreasing power steps is typically slower. For settling decreasing power steps to 1 % or 0.1 %, the settling will typically be within a factor of 2 or 3 of the calculation above. Settling to 0.01 % or less may take considerably longer.

Noise and Time Resolution in Scope Mode

In Scope mode (and in all other modes), the MA243x0A is sampling at full speed, which is approximately once every 7 µs. When the period chosen for Scope mode exceeds the number of data points times this period, then multiple ADC samples are averaged to form each data point. Therefore there is a trade-off between time resolution (many data points) and trace noise. To minimize trace noise, choose less data points. Of course for recurrent waveforms, trace averaging can always be used to reduce trace noise if a large number of points is desired. This would however tend to increase the over-all measurement time.

Optimizing Internal Triggering

Sometimes it can be difficult to obtain consistent triggering in Scope mode. Here are some points to consider when choosing triggering parameters:

- It is more difficult to trigger on signals which are slowly varying with time. Noise in the signal channel can result in false triggers. In this case, try setting the trigger level at powers away from the bottoms of the measurement ranges. The range crossover power for the MA243x0A is 0 dBm nominal between MP and HP and 20 dBm nominal between LP and MP. Thus it can be advantageous to avoid setting the trigger at powers just above +2 dBm, and powers just above –18 dBm where the trigger signal is noisy.

- Modulated signals can appear "noisy" and also result in false triggers. In this case, adjusting the trigger level may not help. Sometimes there may be a portion of the signal with less modulation, or less "noise-like" modulation which can be triggered on with more success. Try using a different trigger point and adjusting the trigger delay to shift the waveform in time to see the desired section.

- False triggers due to either noise or noise-like modulation can be reduced by increasing the trigger noise immunity parameter and invoking hysteresis for the MA243x0A. Using noise immunity will result in a slight positive trigger delay, but this can be made up for by introducing a negative trigger delay with the trigger delay parameter.

- The trigger settings should always be optimized before trace averaging is applied. If trace averaging is used when the trigger is not stabilized, the displayed waveform will not be an accurate representation of the signal. First optimize the trigger, then apply trace averaging.

Noise Floor in Scope Mode

The noise level or "floor" displayed in Scope mode in PowerXpert when using low averaging may seem to be higher than what would be expected. This is due to the way noise is dealt with when converting power into dBm for display. With no input power, the values of the ADC samples vary about some value which corresponds to zero power. Ideally there are equal number of samples above and below this value. The samples which are below this value correspond to "negative" power. This is non-physical, and does not truly mean there is negative power flow to the sensor, it is simply a by product of noise in the signal channel. If these samples are displayed in linear power units such as mW, then the noise floor will be as expected. However there is a problem when converting to logarithmic units such as dB. Because taking the logarithm of negative numbers is not generally allowed, the absolute value of the samples is usually taken before taking the logarithm. This has the drawback of increasing the average value of the samples, artificially increasing the apparent noise floor. When the averaging is increased, the noise floor will go down. The apparent noise floor can be estimated using:

$NF = 0.8 \times noise$

where:

NF = the average linear power or noise floor due to taking absolute value of power samples

$noise$ = the noise power in linear units on a 1 sigma basis

10-5   Optimizing the Readings

This section presents information on how to get the fastest readings from the power sensor when using the Anritsu PowerXpert application or operating under remote control (refer to Chapter 16 for specific remote programming command descriptions). Measurement speed depends greatly on the type of measurement, the power level, and stability of the signal. Stability of a measurement is influenced by noise and signal modulation. If high resolution is required, averaging must be increased.

For the MA243x0A sensors, Table 10-1 describes the number of averages needed to attain a certain noise level for a particular power level measurement.

Note	The values in the following table are typical and should be used as a reference only.

Table 10-1.   MA243x0A Sensor Averaging Table ("Continuous Mode", default settings, 20 ms aperture time)

Input Power (dBm)	Input Power (mW)	Number of Averages Needed for < ±0.20 dB Noise	Number of Averages Needed for < ±0.15 dB Noise	Number of Averages Needed for < ±0.10 dB Noise	Number of Averages Needed for < ±0.05 dB Noise	Number of Averages Needed for < ±0.01 dB Noise
20	100.000	1	1	1	1	1
15	31.623	1	1	1	1	1
10	10.000	1	1	1	1	1
5	3.162	1	1	1	1	1
2	1.585	1	1	1	1	1
−5	3.162E−01	1	1	1	1	1
−10	1.000E−01	1	1	1	1	1
−15	3.162E−02	1	1	1	1	1
−18	1.585E−02	1	1	1	1	1
−25	3.162E−03	1	1	1	1	1
−30	1.000E−03	1	1	1	1	1
−35	3.162E−04	1	1	1	1	1
−40	1.000E−04	1	1	1	1	12
−45	3.162E−05	1	1	1	5	121
−50	1.000E−05	3	6	12	49	1206
−55	3.162E−06	31	55	123	487	12061
−60	1.000E−06	315	554	1231	4869	120611

Noise Calculations:

2 sigma noise

$$20dBm \geq Power \geq -0dBm$$

$$\pm noise(dB) = -10\log\left[1 - \left(\frac{6.30 \times 10^{-7}}{10^{(Power/10)}}\right)\left(\frac{10240 \times Points}{Time \times N}\right)^{1/2}\right]$$

2 sigma noise

$$0dBm > Power \geq -20dBm$$

$$\pm noise(dB) = -10\log\left[1 - \left(\frac{6.51 \times 10^{-8}}{10^{(Power/10)}}\right)\left(\frac{10240 \times Points}{Time \times N}\right)^{1/2}\right]$$

2 sigma noise

$$-20dBm > Power \geq -70dBm$$

$$\pm noise(dB) = -10\log\left[1 - \left(\frac{3.53 \times 10^{-8}}{10^{(Power/10)}}\right)\left(\frac{10240 \times Points}{Time \times N}\right)^{1/2}\right]$$

where:

Continuous Average Mode:

Power = Power level being measured in dBm
Points = 1
Time = Aperture time in milliseconds
N = Number of averages

Scope Mode:

Power = Power level being measured in dBm
Points = The number of data points on the scope graph
Time = Capture time in milliseconds
N = Number of averages

10-6   Uncertainty of a Measurement

Measurement Uncertainty Calculator

Included at the Anritsu download center is a Microsoft Excel tool for calculating power uncertainty. It contains two tabs; one that provides measurement uncertainty for each sensor (selectable from a drop-down menu), and another tab that provides additional uncertainty components and calculated values for the power sensor.

https://www.anritsu.com/en-us/test-measurement/support/downloads/software/dwl003263

Uncertainty Components

Power measurements have many component parts that affect overall measurement uncertainty when measuring power with the sensor:

- **Measurement Uncertainty:** Measurement uncertainty includes the uncertainty associated with the correction of frequency and the linearity response of the sensor over the entire dynamic range. Anritsu follows the industry standard condition of calibrating the power-sensing element at a reference power of 0 dBm (1 mW) and an ambient temperature of 25 °C.

- **Temperature Compensation:** Sensor Temperature Compensation describes the relative power level response over the dynamic range of the sensor. Temperature Compensation should be considered when operating the sensor at other than room temperature.

- **Noise, Zero Set, and Zero Drift:** These are factors within the sensor that impact measurement accuracy at the bottom of the power sensor's dynamic range.

- **Mismatch Uncertainty:** Mismatch uncertainty is typically the largest component of measurement uncertainty. The error is caused by the differing impedances between the power sensor and the devices to which the power sensor is connected. Mismatch uncertainty can be calculated as follows:

  % Mismatch Uncertainty = $100[|1 + \Gamma_1\Gamma_2|^2 - 1]$

  dB Mismatch Uncertainty = $20\log|1 + \Gamma_1\Gamma_2|$

  where:

  Γ_1 is the reflection coefficient of the power sensor

  Γ_2 is the reflection coefficient of the device

Uncertainty examples are shown in .

Uncertainty Examples

Two measurement uncertainty calculations are shown for the MA243x0A sensor in Table 10-2. The power
sensor is used to measure the power of a 3 GHz, +10.0 dBm and –50 dBm CW signal from a signal source with
a 1.3:1 VSWR. The example is based on an aperture time of 20 ms and 64 measurement averages.

Table 10-2. MA243x0A Measurement Uncertainty Example

Uncertainty Term	Uncertainty Specification at +10 dBm (%)	Uncertainty Specification at –50 dBm (%)	Probability Distribution	Divisor	Adjusted Uncertainty at +10 dBm (%)	Adjusted Uncertainty at –50 dBm (%)
Linearity and Calibration Factor	2.80	2.80	Normal at 2σ	2	1.40	1.40
Noise	0	1.00	Normal at 2σ	2	0.50	0.16
Zero Set	0	0.97	Rectangular	√3	0.56	0.18
Zero Drift	0	0.89	Normal at 2σ	2	0.45	0.14
Mismatch	1.94	1.94	Rectangular	√3	1.12	1.12
Combined Uncertainty (RSS), 30 °C					1.79	1.99
Expanded Uncertainty with K=2, 30 °C					3.59	3.99

Table 10-3. Noise Measurement Uncertainty Calculations for the MA243x0A senors

Noise Calculations at 10 dBm (10 mW):

Noise	1.78 nW/10 mW = 0%
Zero Set	15.6 nW/10 mW = 0%
Zero Drift	17.2 nW/10 mW = 0%

Noise Calculations at –50 dBm (10 nW)

Noise	99.8 pW/10 nW = 1.00%
Zero Set	96.8 pW/10 nW = 0.97%
Zero Drift	89 pW/10 nW = 0.89%

10-7   Error Messages

Error messages are described in Table 10-4. The status LED for MA243x0A models will blink green when an error state occurs. In most cases, the error condition can be easily corrected. If the error condition cannot be corrected, note the error message and contact an Anritsu Service Center.

Table 10-4. MA243x0A Error Messages

Message	Description	Resolution
"Temp Change > 10 ºC after Last Zero, Zero Again"	The sensor's ambient temperature has changed by more than 10 ºC since the last zero operation.	Perform the zero operation again.
Temp Out of Range	The sensor is operating outside of its specified range of 0 ºC to 50 ºC.	Operate the sensor within its specified range.
Remove Power from Sensor, Zero Again	This message appears if the zero operation is unsuccessful. The reason could be the presence of RF power at the input of the sensor.	Turn off the RF input to the sensor or disconnect the sensor from the RF source and try the zero operation again.
REDUCE POWER, Max Power Exceeded	This message appears on the application screen if excess power is applied to the sensor.	Reduce the input power to the sensor to within acceptable limits (< 20 dBm).

Chapter 11 — Verifying MA243x0A Performance

11-1 Introduction

This chapter provides test procedures with measurement recording tables, test equipment setups, and verification tables to verify the measurement accuracy of the MA24330A, MA24340A, and MA24350A Power Sensors. Test and verification is performed by comparing the sensor to a reference sensor with a specified cal factor and linearity performance or uncertainty. The reference sensor should be calibrated by a reputable standards laboratory using NIST instruments with low published measurement uncertainty values. Sensor test limits in these procedures are set appropriately to the specified comparison equipment. All tests must be performed at an ambient temperature of 20 ºC to 25 ºC to optimize the power sensor's performance.

Note	Refer to the instrument Technical Data Sheet for performance specifications.

11-2 Required Equipment

Table 11-1. Required Equipment for MA243x0A

Equipment Description	Manufacturer and Model	Critical Specifications
Vector Network Analyzer	Anritsu MS4644B (40GHz) MS4645B (50GHz)	Reflection Coefficient UNC $\leq$ 0.015, 10MHz to 50MHz UNC $\leq$ 0.012, 50MHz to 18GHz UNC $\leq$ 0.016, 18 to 33GHz UNC $\leq$ 0.021, 33 to 40GHz UNC $\leq$ 0.024, 40 to 50GHz
Synthesizer	Anritsu MG3694C (40GHz) MG3695C (50GHz)	Output Power $\geq$ +15 dBm, 50 MHz to 40 GHz Output Power Setting Resolution: 0.01dBm Harmonics $\leq$–40 dBc Source VSWR $\leq$ 2.0
Reference Power Meter	Anritsu ML2438A	Instrumentation Accuracy $\leq$ 0.5 %
Reference Power Sensor	Anritsu MA24004A (40GHz) MA24005A (50GHz)	NIST Calibration or equivalent
10 dB Attenuator	Anritsu 41KC-10 (40GHz) 41V-10 (50GHz)	VSWR $\leq$ 1.10, 10 MHz to 12 GHz VSWR $\leq$ 1.15, > 12 GHz to 18 GHz VSWR $\leq$ 1.18, > 18 GHz to 26.5 GHz VSWR $\leq$ 1.28, > 26.5 GHz to 40 GHz
Power Splitter	Anritsu K241C (40GHz V241C (50GHz)	Effective Output VSWR < 2.0, DC to 18 GHz Effective Output VSWR < 2.3, 18 GHz to 40 GHz Effective Output VSWR < 2.6, 40 GHz to 50 GHz
Personal Computer	Any	See Chapter 2
Type V Calibration Kit	Anritsu 3654D	

11-3   VSWR Pretest

The uncertainty of the VSWR test equipment will affect actual measurement values.

Test Procedure

Caution	**Do not** apply power greater than the power sensor specifications or permanent damage may result. Connect a fixed attenuator to the output connector when power exceeds +20 dBm.

Caution	Before connecting the power sensor to a another device, read the "Instrument Care and Preventive Maintenance" on page 1-4.

Using required equipment suggested in Table 11-1 on page 11-1, follow the manufacturer's S11 (input return loss) calibration procedure to perform calibration on the network analyzer. Connect the power sensor to the network analyzer test port and measure power sensor input match. Typically, return loss are expressed in dB, which can be interconverted to Reflection Coefficient and VSWR as follows:

$\rho = 10^{-RL/20}$

$RL = -20\log\rho$

$VSWR = (1 + \rho) / (1 - \rho)$

$\rho = (VSWR - 1) / (VSWR + 1)$

where

RL = Return Loss in dB

ρ = Magnitude of the Reflection Coefficient

VSWR = Voltage Standing Wave Ratio

Record the measured data into Table 11-2 under the Actual Measurement column. The Actual Measurement should be smaller than the Maximum Reflection coefficient. The Maximum Reflection Coefficient is equal to the measurement system uncertainty added to the sensor's reflection coefficient specification. If the Actual Measurement reflection coefficient is larger than the Maximum Reflection Coefficient, then the power sensor may be defective. If the actual reflection coefficient is significantly larger than the maximum values in Table 11-2, then the sensor is damaged and it is not necessary to perform further testing

Table 11-2. VSWR Pretest Measurement Result

Frequency	Reflection Coefficient Uncertainty	Maximum Reflection Coefficient	Actual Measurement
10 MHz to 50 MHz	0.015	0.310+0.015 = 0.325	
50 MHz to 150 MHz	0.013	0.078+0.013 = 0.092	
150 MHz to 2 GHz	0.012	0.038+0.012 = 0.050	
2 GHz to 6 GHz	0.011	0.074+0.011 = 0.085	
6 GHz to 18 GHz	0.011	0.095+0.011 = 0.106	
18 GHz to 33 GHz	0.016	0.127+0.016 = 0.143	
33 GHz to 40 GHz	0.021	0.180+0.021 = 0.201	
40 GHz to 50 GHz	0.024	0.200+0.024 = 0.224	

11-4   Frequency Response Test

In this test the frequency response of the sensor is tested at one low power level against a reference sensor of known measurement uncertainty. The reference sensor should be calibrated by a reputable standards laboratory using instruments with low published measurement uncertainty values. To perform the comparison, both sensors are used to measure the output power of a synthesizer with a high quality attenuator at the output. The attenuator improves the source match of the synthesizer by lowering the mismatch ripples, thereby lowering the uncertainty in the comparison.

Test Procedure for MA243x0A

1. Set up the equipment as follows (refer to Figure 11-1 for an illustration and Table 11-1 for the required equipment):

   a. Preset all test equipment.

   b. Connect the sensor cable between the reference power sensor and power meter.

   c. Connect the USB cable between the computer and MA243x0A.

   d. Launch the PowerXpert application.

   e. Power up all test equipment for the amount of time specified in their manuals.

   f. Connect the attenuator to the synthesizer with appropriate adapter (if required)

   g. Connect the reference sensor to the attenuator. Turn Off synthesizer RF output.

.
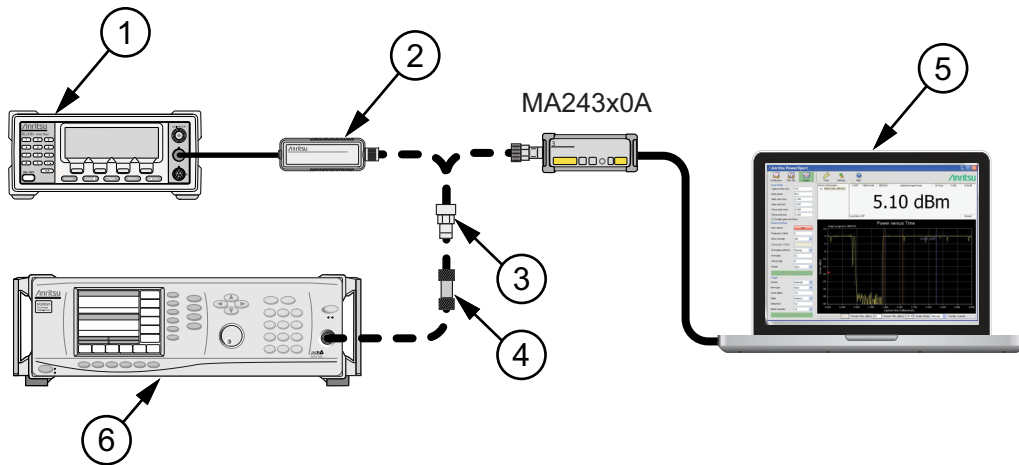
Index	Description
1	Reference Power Meter
2	Reference Power Sensor
3	Adapter
4	10 dB Attenuator
5	PC with Anritsu PowerXpert Application
6	Synthesizer

Figure 11-1. MA243x0A Frequency Response Setup

2. Perform a power sensor Zero and a 1mW reference calibration on the reference sensor and meter.

3. Set synthesizer power to 5dBm and frequency to 50MHz CW. Turn On RF output.

4. Apply the Cal Factor to the reference sensor.

5. Record the power indicated by the reference meter in Table 11-3.

6. Set synthesizer frequency to the next frequency in Table 11-3.

7. Repeat Steps 4 through 6 until all frequencies are measured.

8. Turn Off RF output. Disconnect the reference sensor and connect MA243x0A to the attenuator.

9. Perform a low-level Zero of MA243x0A by clicking the Zero button on PowerXpert.

10. Set synthesizer frequency to 50MHz CW. Turn On RF output.

11. Set Averages to 64 on PowerXpert.

12. Enter test frequency in GHz on PowerXpert.

13. Record the power indicated by the MA243x0A.

14. Set synthesizer frequency to the next frequency.

15. Repeat Steps 12 through 14 until all frequencies are measured

16. Calculate the absolute difference between the Reference power and MA243x0A measurement.

17. Compare the power difference to the maximum allowed difference specified. If the difference exceeds the maximum allowed difference, contact Anritsu Customer Service.

Table 11-3. MA243x0A Test Measurement Results

Frequency (GHz)	A Reference Power Measurement (dBm)	B MA243x0A Measurement (dBm)	|A-B| Absolute Value of Difference in Power Measurements (dB)	MA243x0A Maximum Allowed Difference (dB)
0.05				0.31
1.0				0.29
5.0				0.33
10.0				0.37
15.0				0.38
20.0				0.62
25.0				0.62
30.0				0.62
35.0				0.62
40.0				0.62
45.0				0.62
50.0				0.62

11-5 Linearity Test MA243x0A

The linearity correction of the MA243x0A is compared to a thermal power sensor, which has very good inherent linearity over a power range of about –17 dBm to +4 dBm. For this reason, the MA243x0A is compared to the thermal sensor in two ranges, keeping the power levels to the thermal sensor in the range of –17 to +4 dBm, while the power to the MA243x0A varies from about –28 to about +14 dBm.

Test Procedure

1. Set up the equipment as follows (refer to Figure 11-2 for an illustration and Table 11-1 for the required equipment):

a. Preset all test equipment.

b. Connect the sensor cable between the reference power sensor and power meter.

c. Connect the USB cable between the computer and MA243x0A.

d. Launch the PowerXpert application.

e. Power up all test equipment for the amount of time specified in their manuals.

f. Connect the power splitter to the synthesizer, and the 10 dB attenuator to the reference arm of the splitter output.

g. Connect the reference sensor and adapter (if required) to the 10 dB attenuator.

h. Connect the MA243x0A and adapter (if required) to the other splitter output.

i. Turn Off synthesizer RF output.
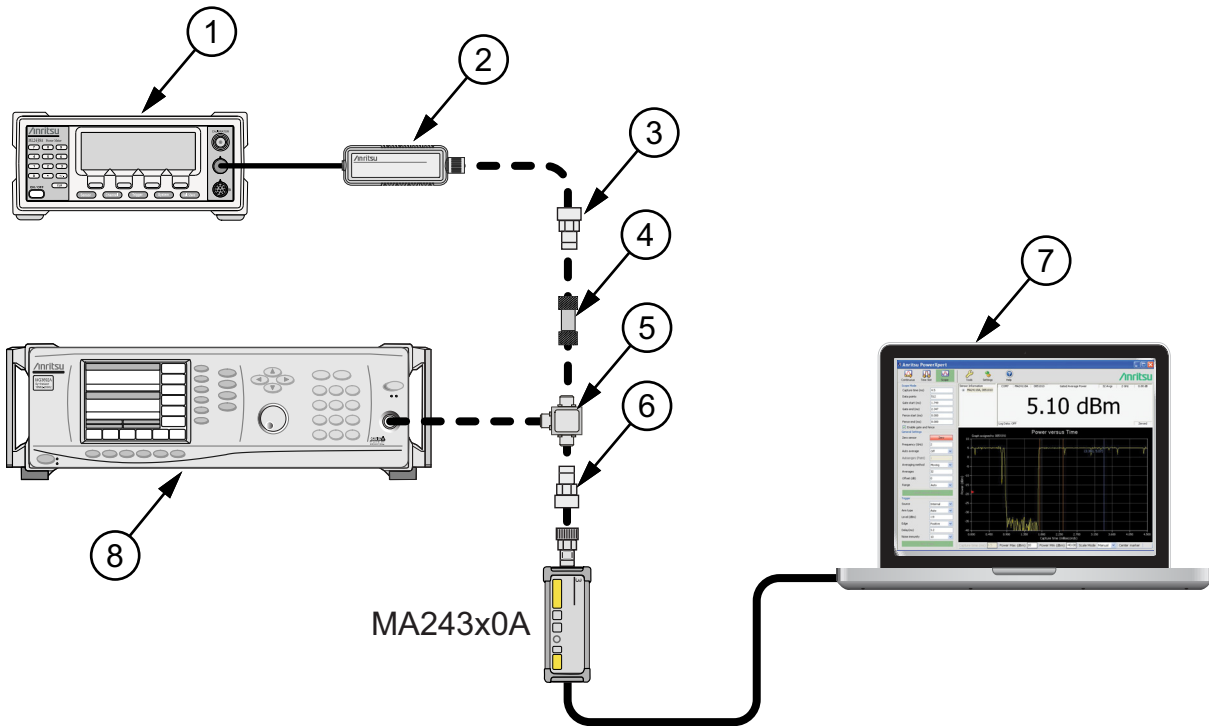
Index	Description
1	Reference Power Meter
2	Reference Power Sensor
3	Adapter (if required)
4	10 dB Attenuator
5	Power Splitter
6	Adapter (if required)
7	PC with Anritsu PowerXpert Application
8	Synthesizer

Figure 11-2. Linearity Test Setup 1

2. Perform a power sensor Zero and a 1mW reference calibration on the reference sensor and meter.

3. Perform a low-level Zero of MA243x0A by clicking the Zero button on PowerXpert.

4. Set synthesizer power to +20dBm (or highest leveled power < +20dBm) and frequency to 50MHz CW. Turn On RF output.

5. Apply Cal factor to the reference sensor.

6. Set Averages to 64 and enter test frequency in GHz on PowerXpert.

7. Record data for the first 20 dB range as follows:

    a. Record the power reading by the reference meter in column A of Table 11-4

    b. Record the power reading by the MA243x0A in column B of Table 11-4

    c. Repeat the measurement at synthesizer output level of +15, +10, +5, and 0 dBm.

8. Turn Off Synthesizer RF output

Note	The MA243x0A power measured at 0 dBm will be used in Step 9d, below.

9. Set up the test for the second 20 dB range as follows:

    a. Remove the 10 dB attenuator from in between the reference sensor directly to the splitter.

    b. Remove the MA243x0A from the splitter and connect the 10 dB attenuator between the splitter and the power sensor (see Figure 11-3).

    c. Turn On the synthesizer's RF output.

    d. Set the synthesizer output level to +10 dBm, then adjust its power level until MA243x0A reads as close as possible to the value recorded in column B row 5. Record the resulting power level in column B, row 6 of Table 11-4.

    e. Record the power indicated by the reference meter in column A of row 6.

    f. Repeat the measurement at synthesizer output level of +5, 0, −5 and −10dBm.
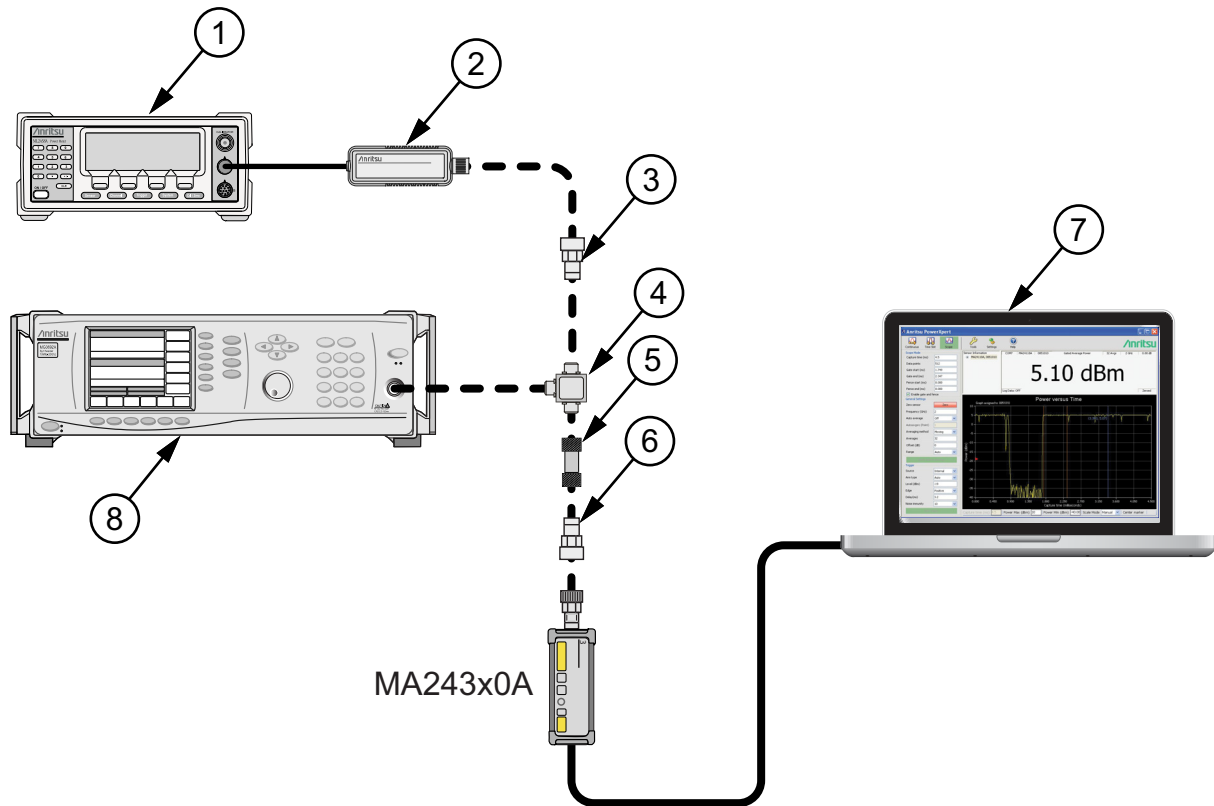
.

Index	Description
1	Reference Power Meter
2	Reference Power Sensor
3	Adapter (if required)
4	Power Splitter
5	10 dB Attenuator
6	Adapter (if required)
7	PC with Anritsu PowerXpert Application
8	Synthesizer

Figure 11-3. Linearity Test Setup 2

Table 11-4. Measurement Results (50 MHz)

Row #	Synth nominal level (dBm)	Atten in Ref Arm (dB)	Atten in Test Arm (dB)	A Ref Power (dBm)	B DUT Power (dBm)	C1 A6–A5 (dB)	C2 B6–B5 (dB)	D A+C (dBm)	E B5-D5 (dB)	F (D-B)+E Diff (dB)
1	20	10	0							
2	15	10	0							
3	10	10	0							
4	5	10	0							
5	0	10	0							
6	10	0	10							
7	5	0	10							
8	0	0	10							
9	–5	0	10							
10	–10	0	10							
11									max	
12									min	
13									delta	

10. Perform the calculations as follows:

   a. Subtract the Reference Power Measurement of row 5, column A from the Reference Power Measurement of row 6, column A. Record this value in the column C1, rows 1 through 5.

> **Note**   Column C1, rows 1 through 5 should all have the same value. The correction column rows 6 through 10 have values of 0.

   b. Subtract the value in row 5 column B from that in row 6 column B. Copy the result into rows 6 through 10 of column C2.

   c. For each row in column D, add the values of the same row of column A and columns C1 through C2 (a blank has value 0 dB).

   d. Subtract the value of row 5 column D from that of row 5 column B. Record this values in column E rows 1 thorough 10.

   e. For each row in column F compute the value by subtracting the value of column B from that in column D and then adding the value from column E.

   f. Find the largest (most positive) value in the column F, rows 1 through 10, and record this value next to the word Max in row11.

   g. Find the smallest value in column F, rows 1 through 10, and record this value next to the word Min in row 12.

   h. Subtract the Min value from the Max value and record the result next to the word Delta in row 13. The Delta result should be less than 0.3 dB. If it is larger, contact Anritsu Customer Service.

11. Repeat the entire measurement and calculation with synthesizer frequency at 1 GHz, 5 to 50GHz in 5GHz step.

Chapter 12 — Using Power Master with PowerXpert

12-1 Introduction

This chapter refers to using the Anritsu MA245xxA Power Master power analyzer with PowerXpert. If using USB Power Sensors, see Chapter 3, "Using USB Power Sensors with PowerXpert".

PowerXpert is a data analysis and control software for use with Anritsu's USB power sensors and Power Masters. PowerXpert provides a graphical user interface (GUI), making the PC appear like a traditional power meter. Using PowerXpert, the MA245xxA Power Master operates in three modes:

- "Continuous Mode" on page 12-6
- "Power Hunter Mode" on page 12-9
- "Channel Monitor Mode" on page 12-13

Note	When operating the MA245xxA Power Master, the MA241xxx Series, MA242xxx and MA243xxx USB power sensors can be connected to make separate power measurements simultaneously in Continuous Mode. For details, see "Multiple Sensor Display" on page 12-22.

12-2 Connect Power Master

Connect the USB connector side of the Power Master to the PC with a USB cable. PowerXpert detects and displays the sensor model number and serial number in PowerXpert as described in "Zero Sensor" on page 12-18. This may take a few seconds for the connection to be detected and displayed. PowerXpert always starts up in the default state of the connected sensor. Upon disconnection from PowerXpert, the Power Master resets and after reconnection, restarts in the default state.

12-3 PowerXpert Settings with Power Master

PowerXpert always starts up in the default state of the connected sensor. Upon disconnection from PowerXpert, the Power Master resets. When reconnected, PowerXpert starts in the default state. The PowerXpert features and settings with Power Master models are displayed in Table 12-1.

Table 12-1. PowerXpert with Power Master Compatibility Table (1 of 2)

PowerXpert Features with Power Master		Power Master Analyzers	
		MA24507A	MA24510A
Continuous Mode	Duty Cycle	-	-
	Relative Mode	x	x
	Units	x	x
	Aperture time	-	-
	Forward Power	-	-
	Reverse Power	-	-
	Peak Power	-	-
	Center Freq and Span	x	x
	Resolution	x	x
	Range	x	x
	Crest Factor	-	-
	CCDF	-	-
	Burst Average	-	-
	Reflection Coeff	-	-
	Return-loss	-	-
	VSWR	-	-
	Video BW	-	-
	Measurement Channel Power CW Max	x	x
	Measurement Hold	x	x
Time Slot Mode	Number of slots	-	-
	Slot width	-	-
	Start exclusion	-	-
	End exclusion	-	-
Scope Mode	Capture time	-	-
	Data points	-	-
	Gate start	-	-
	Gate end	-	-
	Fence start	-	-
	Fence end	-	-
List Mode	List file	-	-
	Output file	-	-

Table 12-1. PowerXpert with Power Master Compatibility Table (2 of 2)

PowerXpert Features with Power Master		Power Master Analyzers	
		MA24507A	MA24510A
General Settings	Zero sensor	-	-
	Frequency	-	-
	Auto average	-	-
	Auto avgsrc	-	-
	Averaging method	-	-
	Averages	x	x
	Offset	x	x
	Step Detect	-	-
	Range	-	-
Trigger	Source	-	-
	Arm Type	-	-
	Level	-	-
	Edge	-	-
	Delay	-	-
	Noise Immunity	-	-
	Hold Off	-	-
	Hysteresis	-	-
More Settings	Modulation Type	-	-
Tools	Advanced Features	-	-
	Zero All Sensors	-	-
	Capture Screen	x	x
	Log data	x	x
	Show Multiple Sensor Display	x	x
	Offset Table	-	-
	Update Firmware	-	-
	View Summary	-	-
Settings	Save/Recall setup	-	-
	Reset to factory settings	x	x
	Set sensor timeout	-	-
	Secure Mode	-	-

12-4   PowerXpert Overview

Using the MA245xxA Power Master with PowerXpert provides a user interface as shown in Figure 12-1.

Figure 12-1.   Anritsu PowerXpert Application GUI Overview

Index	Description
1	Toolbar - See "Toolbar" on page 12-5.
2	Power sensor / analyzer information area showing model and serial number, communications port, and firmware version,"Zero Sensor".
3	Displays setup and measurement readout area. The readouts displayed are mode dependent. "Continuous Mode Numerical Display Area" on page 12-8, "Power Hunter Status Window" on page 12-11, "" on page 12-14.
4	The display graticule provides power versus time representation of the power measurement waveform,"Graticule Settings and Graphical Display Area".
5	These lower task bar parameter settings are available to select and change manually. Changes to these settings are applied by pressing the **Enter** key. (The lower task bar parameter settings are used in Continuous mode only.)
6	Click **Apply above settings** to apply the user selected settings changes. Changes to the settings will not take effect until after clicking this bar.
7	This side panel displays the settings for the mode of operation selected.

12-5 Toolbar

The PowerXpert power sensor Tool Bar provides the following modes:

The Tool Bar consists of the following menus.

12-6 Sensor Information

When using multiple power sensors along with the Power Master, the parameters and numerical and graphical displays are associated with the selected sensor from the Sensor Information area. See Figure 12-2. When multiple sensor's serial numbers are displayed, click on the serial number to view. When removing a Power Master or power sensor, disconnect the device's USB connection at the Computer USB port. The Power Master and other power sensors will remain active until they are removed in the same way.

Note	A MA245xxA Power Master can be connected at the same time as a MA242xxA and MA243xxA USB power sensor, see "Multiple Sensor Display" on page 12-22, but multiple MA245xxA Power Masters on the same PC is currently not supported.
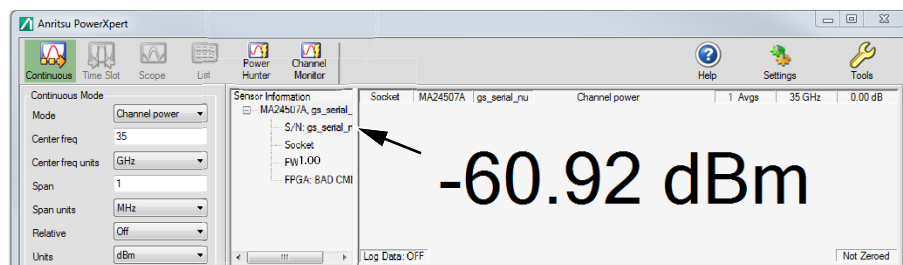
Figure 12-2. Selecting an analyzer or power sensor

12-7   Continuous Mode

Continuous Mode is the default mode in which the MA245xxA Power Master starts and displays the peak or average power of the input signal. In this mode, the Power Master is "continuously triggered" and collects data at all times. The Continuous Mode window below contains the following information.
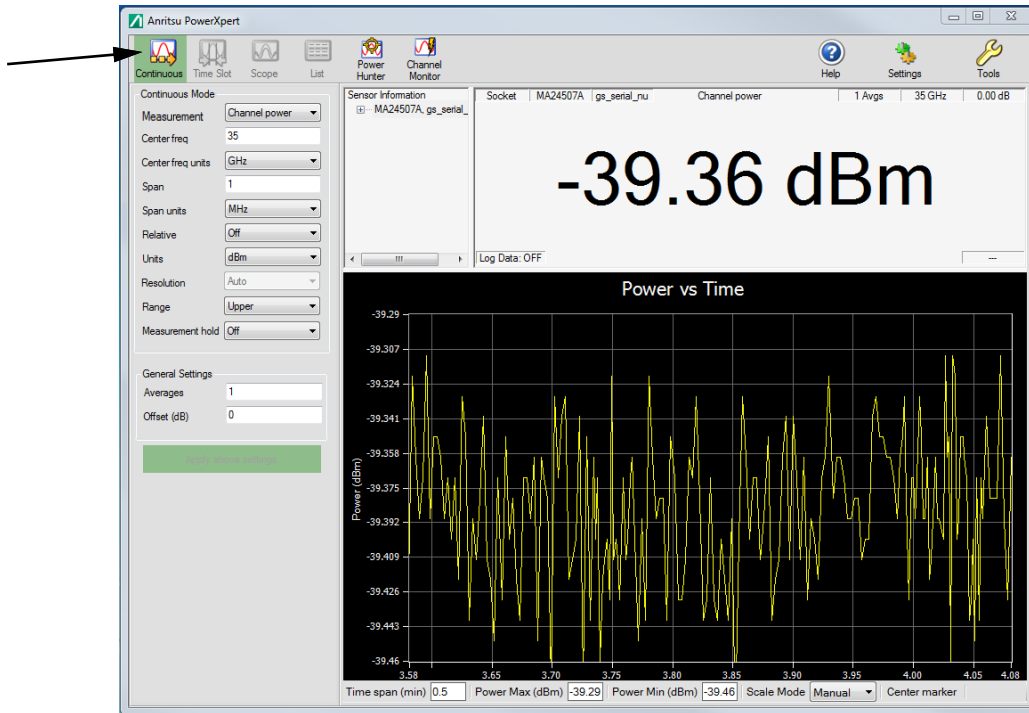
Continuous Mode Setting	Options/Range
Measurement	Channel Power / CW Max
Center Frequency (MA24507A)	9.5 kHz to 70 GHz - 500 Hz
Center Frequency (MA24510A)	9.5 kHz to 110 GHz - 500 Hz
Center freq units	kHz, MHz, GHz
Span	30 kHz to 2 GHz (Channel power), 30 kHz to Full span (CW max)
Span units	kHz, MHz, GHz
Relative	Off, On
Units	dBm, nW, µW, mW, W
Resolution	Low, Medium, High (Available in CW max mode)
Range	Upper, Lower
Measurement hold	Off, On
General Settings	
Averages	1 to 1000
Offset (dB)	−100 to +150
Apply Above Settings	Select Activates Settings

Figure 12-3. Continuous Mode User Interface Screen

12-8   Continuous Mode Settings

Changing the settings in Continuous Mode requires that the "Apply Above Settings Button" to be selected to activate any changed settings.

Measurement – CW/Channel Power

The CW/Channel mode pull down lets you select between Channel Power and CW Max mode. In Channel Power mode, the sensor will calculate the average integrated power across the entire user-defined span. Channel Power mode should be used when measuring average power of modulated signals.

In CW Max mode, the sensor will return the highest CW "peak" amplitude value within the user-defined channel. Note that the "peak" amplitude returned by the sensor is not necessarily at the user-defined center frequency. It is the highest average CW amplitude within the range of center frequency ± span/2.

There are two measurement ranges in the Power Master: upper and lower. The range can be set manually to either the range via PowerXpert or remote commands.

Table 12-2. Power Master Operating Power Range

det range	MA245xxA Power Master
Upper	High power (> –10 dBm)
Lower	Low power ($\leq$ –10 dBm)

Center Freq and Span

Center frequency and span combine to define the frequency channel in which power will be measured. The channel will begin at Center freq - Span/2 and end at Center freq + Span/2. Center freq can be any value as long as Center freq - Span/2 $\geq$ 9 kHz and Center freq + Span/2 $\leq$ 70 GHz for the MA24507A and Center freq - Span/2 $\geq$ 9 kHz and Center freq + Span/2 $\leq$ 110 GHz for the MA24510A. In Channel Power mode, span is limited to 2 GHz, but can be as wide as full span in CW Max mode.

Relative

Relative measurements power changes with respect to the displayed power when relative mode is turned on. To reset the power reference, turn relative mode Off, and then back On. This mode is particularly useful to study drift or measure (loss of) attenuator and (gain of) amplifiers.

Note	Relative measurement is a feature of PowerXpert and does not apply to Crest Factor, CCDF, Reflection Coefficient, Return Loss, and VSWR.

Units

Displays units of power in linear or log scale (dBm, nW, µW, mW, W).

Resolution

Resolution is available when measurement setting is set to CW max. Resolution allows the user to choose between optimizing speed or lowering the noise floor. When Resolution is set to "Low", the sensor will make more readings per second, but have a higher noise floor. Conversely, setting Resolution to "High" will lower the noise floor, but the sensor will make fewer readings per second.

Measurement Hold

When set to On, the measurement holds the last sensor readings. When set to Off, the sensor continues to sample measurements.

Continuous Mode Display Settings

The parameter settings available below the display screen provide control of the graticule power vs time settings. See Figure 12-4

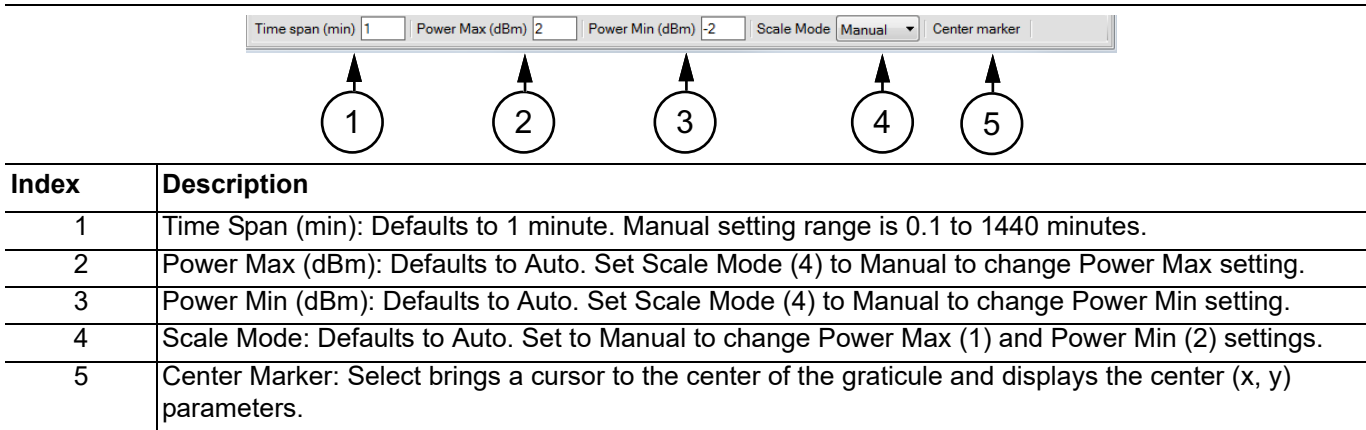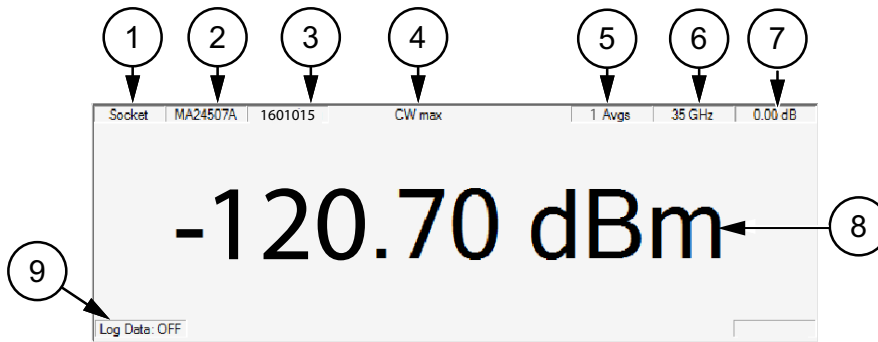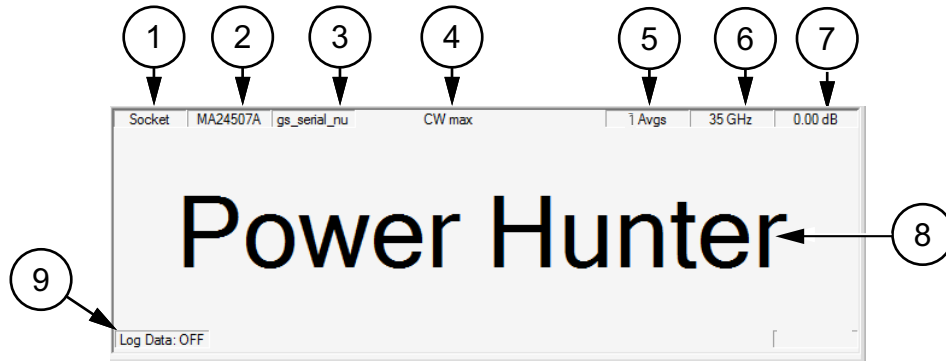| Index	Description
1	Time Span (min): Defaults to 1 minute. Manual setting range is 0.1 to 1440 minutes.
2	Power Max (dBm): Defaults to Auto. Set Scale Mode (4) to Manual to change Power Max setting.
3	Power Min (dBm): Defaults to Auto. Set Scale Mode (4) to Manual to change Power Min setting.
4	Scale Mode: Defaults to Auto. Set to Manual to change Power Max (1) and Power Min (2) settings.
5	Center Marker: Select brings a cursor to the center of the graticule and displays the center (x, y) parameters.

Figure 12-4. Graticule Power Vs Time Settings

Continuous Mode Numerical Display Area

The Continuous Mode numerical display window contains the following information:

Index	Description
1	Communications port type used to connect the sensor.
2	Model number of the connected power sensor.
3	Serial number of the connected power sensor.
4	Channel power or CW max mode
5	Averaging count
6	Center frequency
7	Fixed offset value
8	Numerical reading with units of measure or task message displayed.
9	Data Logging status

Figure 12-5. PowerXpert Numerical Display Area

12-9 Power Hunter Mode

Power Hunter Mode allows the user to search for up to six CW amplitude peaks within a user-defined frequency span. The Power Hunter Mode display window contains the following information.
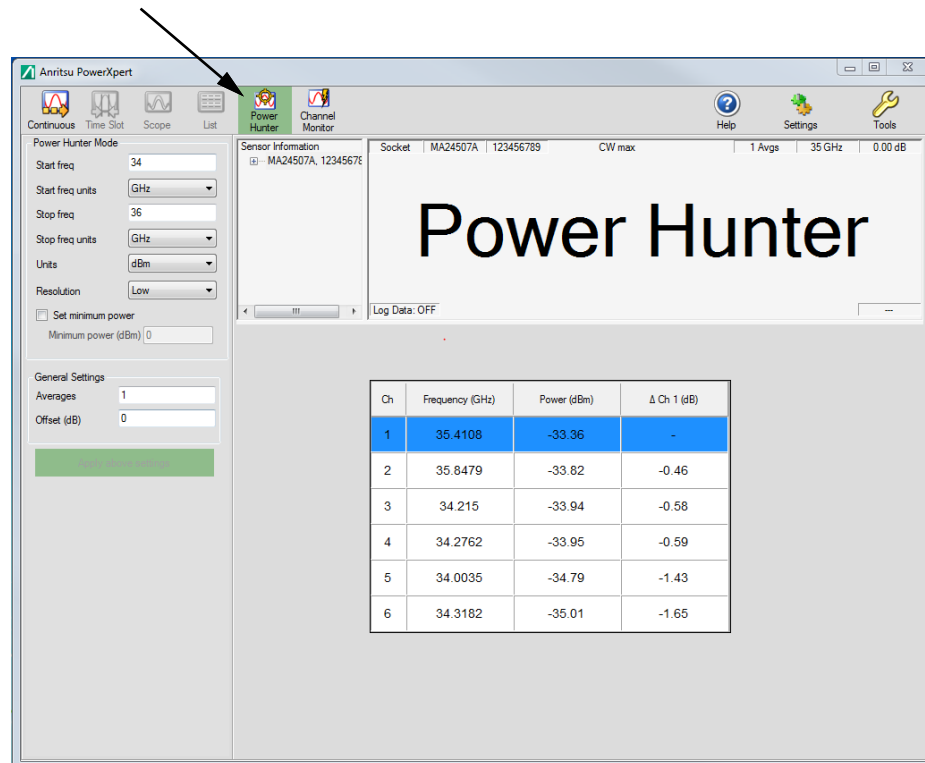
Power Hunter Mode Setting	Options/Range
Start frequency (MA24507A)	9.5 kHz to 70 GHz - 1 kHz
Start frequency (MA24510A)	9.5 kHz to 110 GHz - 1 kHz
Stop frequency (MA24507A)	70 GHz
Stop frequency (MA24510A)	110 GHz
Start / stop freq units	kHz, MHz, GHz
Units	dBm, nW, µW, mW, W
Resolution	Low, Medium, High
Set minimum power	Selected or not
Minimum power	−130 to 0 dBm
General Settings	
Averages	1 to 1000
Offset (dB)	−100 to +150
Apply Above Settings	Select Activates Settings

Figure 12-6. Power Hunter Mode User Interface Screen

12-10 Power Hunter Settings

Power Hunter mode only supports CW max mode.

Start/Stop Frequency

Start and stop frequencies define the frequency window in which Power Master will search for CW "peaks". If six sensors are connected, PowerXpert will return the six highest CW values and the associated frequencies.

Start / Stop Freq Units

Select either kHz, MHz, or GHz.

Units

Displays units of power in linear or log scale (dBm, nW, μW, mW, W).

Resolution

Resolution allows the user to choose between optimizing speed or lowering the noise floor. When Resolution is set to "Low", the sensor will make more readings per second, but have a higher noise floor. Conversely, setting Resolution to "High" will lower the noise floor, but the sensor will make fewer readings per second.

Set Minimum Power

Power Hunter allows the user to set a minimum to the power values returned by the sensor. When a minimum power is defined, Power Hunter will only display the CW peaks above that minimum threshold. In the case where there are fewer than six CW peaks, the extra lines will remain blank.

Minimum Power

Provides means to enter in minimum power point. Range is 0 to –130 dBm.

Power Hunter Status Window

The Power Hunter mode numerical display window contains the following information:

Index	Description
1	Communications port type used to connect the sensor.
2	Model number of the connected power sensor.
3	Serial number of the connected power sensor.
4	CW mode setting (always CW max in Power Hunter mode)
5	Averaging count
6	Center frequency ([stop freq + start freq]/2)
7	Fixed offset value
8	Indicates that PowerXpert is in Power Hunter mode.
9	Data Logging status (not available in Power Hunter mode)

Figure 12-7. Power Hunter Numerical Display Area

Power Reading Display

The power reading window displays the frequency and power for each of the six highest CW peaks within the start and stop frequency range. The delta channel 1 column displays the power difference in dB between each channel and channel 1. The example below displays the six highest peaks detected from a start frequency of 15 GHz swept through to a stop frequency of 19 GHz. Channel (1) detects the highest peak and channels (2) through (6) detects the next highest peaks. The last column displays the measurement delta calculated when referenced to channel (1).

Ch	Frequency (GHz)	Power (dBm)	Δ Ch 1 (dB)
1	17.332	6.74	-
2	16.501	4.08	2.66
3	16.666	3.82	2.92
4	16.167	2.13	4.61
5	15.502	-2.01	8.75
6	15.334	-2.13	8.87

Figure 12-8. Power Hunter Mode Measurement Display Area

12-11 Channel Monitor Mode

Channel Monitor Mode allows the user to enter up to six different frequencies and monitor power at those frequencies simultaneously. The Channel Monitor display window contains the following information.
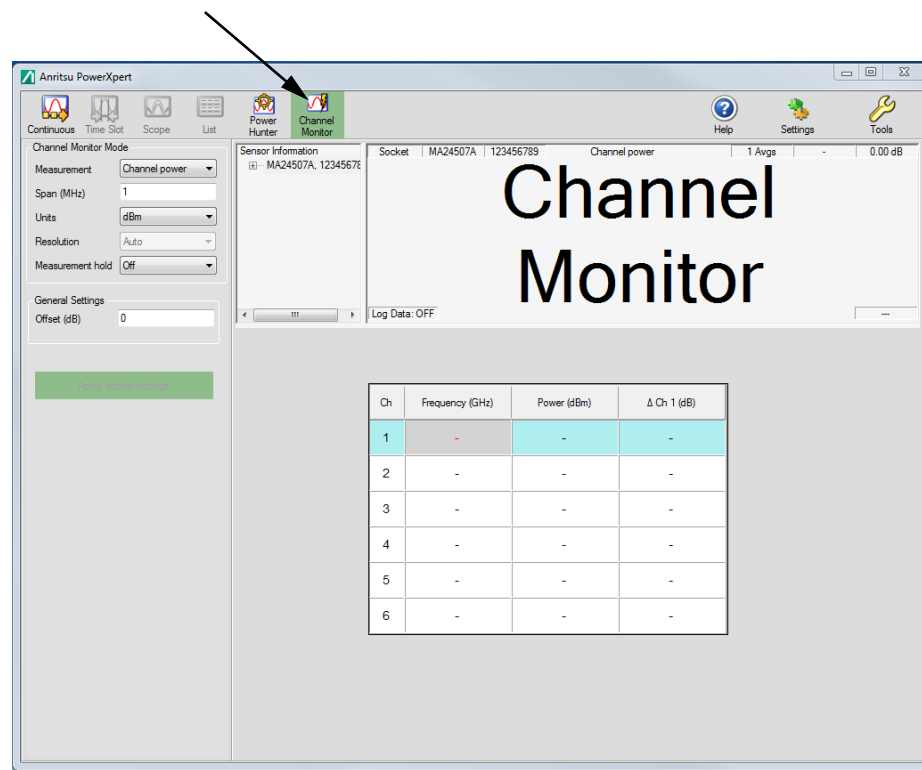
Channel Monitor Mode Setting	Options/Range
Measurement	Channel power / CW max
Span	1 kHz to 20 MHz
Units	dBm, nW, μW, mW, W
Resolution	Low, Medium, High (Available in CW max mode)
Measurement Hold	Off, On
General Settings	
Offset (dB)	−100 to +150
Apply Above Settings	Select Activates Settings

Figure 12-9. Channel Monitor Mode User Interface Screen

12-12 Channel Monitor Mode Settings

Measurement – CW/Channel Mode

The CW/Channel mode pull down lets you select between Channel Power and CW Max mode. In Channel Power mode, the sensor will calculate the average integrated power across the entire user-defined span. Channel Power mode should be used when measuring average power of modulated signals.

In CW Max mode, the sensor will return the highest CW "peak" amplitude value within the user-defined channel. Note that the "peak" amplitude returned by the sensor is not necessarily at the user-defined center frequency. It is the highest average CW amplitude within the range of center frequency ± span/2.

Span

In Channel Monitor mode, Span works with the frequencies defined in the power reading display area in the same way as it does with the center frequency in Continuous mode. The difference in Channel Monitor mode is that Span is limited to 20 MHz for each frequency channel.

Units

Displays units of power in linear or log scale (dBm, nW, μW, mW, W).

Resolution

Resolution is available when measurement setting is set to CW max. Resolution allows the user to choose between optimizing speed or lowering the noise floor. When Resolution is set to "Low", the sensor will make more readings per second, but have a higher noise floor. Conversely, setting Resolution to "High" will lower the noise floor, but the sensor will make fewer readings per second.

Measurement Hold

When set to On, holds the last sensor readings. When set to Off, the sensor continues to sample measurements.

Channel Monitor Mode Display Area

The Channel Monitor mode numerical display window contains the following information:
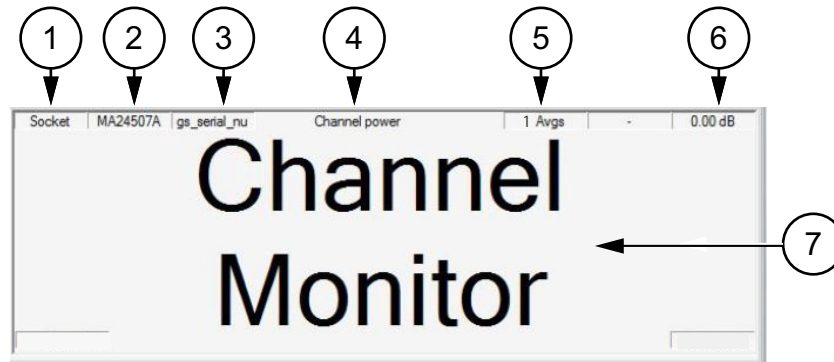
Index	Description
1	Communications port type used to connect the sensor.
2	Model number of the connected power sensor.
3	Serial number of the connected power sensor.
4	Channel/CW mode setting
5	Averaging count
6	Fixed offset value
7	Indicates that PowerXpert is in Channel Monitor mode.

Figure 12-10. Channel Monitor Numerical Display Area

Channel Monitor Display

The Channel Monitor readings display window is where the user enters the center frequencies. To monitor a frequency, simply click on one of the channels, type in the center frequency in GHz, and press enter or click out of the channel. The power will be displayed in the "Power (Units)" column. The user can enter up to six different frequencies. The same span and mode (defined in the left hand menu) will be applied to all channels. The delta channel (1) column displays the calculated difference between each channel to the referenced-channel (1).

Ch	Frequency (GHz)	Power (dBm)	Δ Ch 1 (dB)
1	15	0.03	-
2	16	-0.07	-0.10
3	17	-0.04	-0.07
4	18	-0.03	-0.06
5	19	-0.27	-0.30
6	20	-0.37	-0.40

Figure 12-11. Channel Monitor Mode Measurement Display Area

12-13 Graticule Settings and Graphical Display Area

This section provides a brief overview of the graticule settings and graphical display areas that are presented in the different operating modes of PowerXpert. The Power versus Time graph is used in all modes and provides the ability to plot measured power with respect to time (or time slots). This feature can be used for drift testing, tuning circuits, and for monitoring circuit behaviors to external stimuli. The graph starts automatically and updates continuously in real time.

The following Power versus Time graph is used in "Continuous Mode":

Index	Description
1	The vertical scale displays the power level in dBm, regardless of the Units settings of dBm, μW, mW, or W from the "Continuous Mode" settings area.
2	Graphical trace display showing the power level as a function of time.
3	Marker showing as a vertical blue line with an x on the marker point and numerical values for the time (in minutes) and power level (in dBm). The marker is available for reading power at an instant of time. It can be dragged with the mouse and can be centered in the display via the **Center marker** button.
4	The horizontal scale displays the time in minutes and may be increased or decreased from the graticule settings area. This scale increases up to a maximum of 1440 minutes.
5	Graticule settings area: **Time Span (min):** Sets the current time span setting from 0.1 minutes up to a maximum of 1440 minutes. **Power Max (dBm):** Sets the upper power level for the vertical scale. **Power Min (dBm):** Sets the lower power level for the vertical scale. • **Power Max (dBm)** and **Power Min (dBm)** settings are not available when set to Automatic. **Scale Mode:** Sets the vertical scaling to Automatic or Manual.

Figure 12-12. PowerXpert Graphical Display Area (Continuous Average Mode)

Zero Sensor

Zeroing is not necessary for the MA245xxA Power Master. When selecting Multiple Analyzer Display, see "Multiple Sensor Display" on page 12-22 from the Tools menu, "Tools Menu" on page 12-19 it will be necessary to Zero the MA24208A, MA24218A, MA24330A, MA24340A, and the MA24350A USB power sensors before making measurements.

Averages

The Averages setting allows you to specify the number of measurements that are averaged to calculate the displayed power. A setting of 1 disables averaging.

Offset

A fixed value (in dB) specified by the user is applied as a power offset to the sensor. A positive offset adds a value to the power readings and can be used to compensate for attenuators, couplers, limiters, and other lossy devices. A negative value subtracts a value from the power reading and can be used to compensate for amplification in the measurement path.

Apply Above Settings Button

The Apply Above Settings button applies all changes made to the settings. Changes to these settings do not take affect until clicking this button.

12-14 Tools Menu

The Tools menu provides the option of zeroing all sensors, capturing the PowerXpert screen display, enabling the log data. The grayed out selections are not available with the MA245xxA Power Master, but become available when a MA24208A, MA24218A, MA24330A, MA24340A, or MA24350A power sensor is connected and selected.
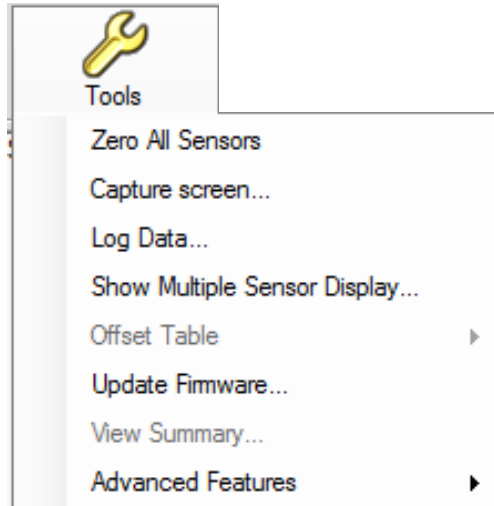
Figure 12-13. Tools Menu

Zero All Sensors

Note	The MA245xxA Power Master does not require to be Zeroed; therefore, Zero All Sensors is grayed out. But when the MA24208A, MA24218A, MA24330A, MA24340A, and the MA24350A USB power sensors are connected, the Zero All Sensors feature will become active. See "Zero Sensor" on page 12-18

Zero All Sensors provides a convenient method of zeroing all connected power sensors. Zero the MA24208A, MA24218A, MA24330A, MA24340A, and the MA24350A sensors before making power measurements. Zero All Sensors becomes active when a MA24208A, MA24218A, MA24330A, MA24340A, and / or a MA24350A is connected and selected from the "Zero Sensor" on page 12-18 or "Multiple Sensor Display" on page 12-22.

If frequent low-level measurements are being made, it is advised to often check the sensor zeroing to assure accurate measurements. Before zeroing the sensor, connect it to the DUT (device under test) test port and remove RF power from the connection to a level 20 dB below the noise floor of the power sensor. Leave the sensor connected to the DUT test port so that ground noise and thermal EMF (electro-magnetic fields) are zeroed out of the measurement. The sensor may also be connected to a grounded connector on the DUT.

Capture Screen

The Capture Screen utility captures a PowerXpert screenshot and displays the Save image dialog. Save the image in BMP, JPEG, PNG, or GIF file formats.
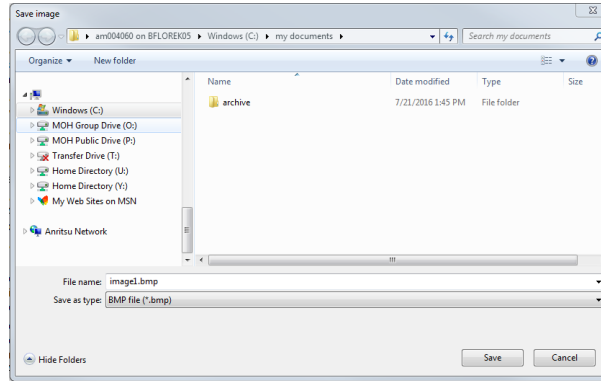
Figure 12-14. Save Image Dialog

Log Data

The Log Data feature records data in a comma separated value file and is accessed from the **Tools | Log Data** toolbar. This feature is available only when the application is in Continuous Average mode. Data logging is set up in the dialog below:
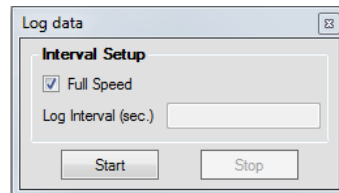
Figure 12-15. Log Data Dialog

- **Interval Setup:** Sets full speed data or fixed interval data logging (user defined logging interval). When Full Speed is selected, the user must manually start and stop the logging function.
- **Log Interval (sec.):** Sets the time interval in which to log data and is available when Full Speed is deselected.

Note	Log Interval should be set to reduce the number of data points when capturing long time periods as Microsoft Excel has a limitation of data records.

Data is stored as comma separated value (.csv) files that can be directly opened in Microsoft Excel. The filename and location can be selected or changed as desired. The default filenames have the following format:

```
Test_yyyy_mm_dd_hhmmss.csv
```

where:

- **yyyy:** Four-digit year
- **mm:** One- or two-digit month
- **dd:** One- or two-digit day
- **hhmmss:** Two digit hours (24-hour clock), minutes, and seconds

Sample log data is shown in a Microsoft Excel spreadsheet file below:

	A	B	C	D	E
1	Initial setup information				
2	Sensor Model	MA24218A			
3	Sensor Serial No	204			
4	Frequency	2	GHz		
5	Fixed Offset	0	dB		
6	Enhanced Modulation	ON			
7	Sample Interval	Full Speed			
8	Any setup information is not updated during data logging.				
9	15:55:11	-16.712	dBm		
10	15:55:11	-16.691	dBm		
11	15:55:11	-16.696	dBm		
12	15:55:11	-16.75	dBm		
13	15:55:11	-16.744	dBm		
14	15:55:11	-16.704	dBm		
15	15:55:11	-16.731	dBm		
16	15:55:11	-16.748	dBm		
17	15:55:11	-16.749	dBm		
18	15:55:11	-16.68	dBm		
19	15:55:12	-16.796	dBm		
20	15:55:12	-16.76	dBm		
21	15:55:12	-16.747	dBm		
22	15:55:12	-16.626	dBm		
23	15:55:12	-16.74	dBm		

Figure 12-16. Log Data Enhanced Modulation On

Data logging is stopped by accessing the **Tools | Log Data** toolbar and pressing **Stop** in the Log data dialog.

	A	B	C	D	E
1	Initial setup information				
2	Sensor Model	MA24218A			
3	Sensor Serial No	204			
4	Frequency	2	GHz		
5	Fixed Offset	0	dB		
6	Sample Interval	Full Speed			
7	Any setup information is not updated during data logging.				
8	15:54:19	-30.409	dBm		
9	15:54:19	-30.478	dBm		
10	15:54:19	-30.494	dBm		
11	15:54:19	-30.446	dBm		
12	15:54:19	-30.403	dBm		
13	15:54:19	-30.429	dBm		
14	15:54:19	-30.427	dBm		
15	15:54:19	-30.391	dBm		
16	15:54:19	-30.417	dBm		
17	15:54:20	-30.428	dBm		
18	15:54:20	-30.365	dBm		
19	15:54:23	-30.412	dBm		
20	15:54:24	-30.463	dBm		
21	15:54:24	-30.435	dBm		
22	15:54:24	-30.382	dBm		
23	15:54:24	-30.398	dBm		
24	15:54:24	-30.404	dBm		

Figure 12-17. Log Data Enhanced Modulation Off

Multiple Sensor Display

PowerXpert provides a Multiple Sensor Display screen that shows simultaneous measurements of up to eight sensors. This display is in addition to the normal PowerXpert display and is enabled by clicking **Tools | Show Multiple Sensor Display**. Average power measurements are displayed when in Continuous Mode for the MA245xxA Power Master and the MA241xxA, MA242xxA and MA243xxA USB power sensors.

Note	Only one MA245xxA Power Master can be connected to a PC at a time, but one MA245xxA Power Master can be used with multiple other Anritsu USB power sensors, such as the MA241xxA, MA242xxA and MA243xxA USB power sensors.

The Multiple Sensor Display provides an active sensor status. See Figure 12-18. This display shows three devices connected. The top display shows a MA24118A power sensor is connected and is in Scope Mode, (Not available for the MA245xxA Power Master). The next two readouts show the average power measurements when in Continuous Mode by a MA245xxA and the MA24350A.
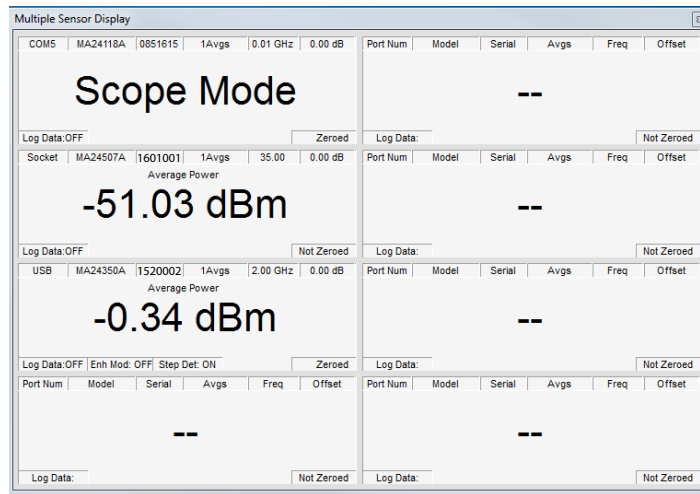
Figure 12-18. Multiple Sensor Display

The settings displayed in each measurement window apply to that power sensor or Power Master. To change a device's settings, access that power sensor or Power Master by going to the Sensor Information menu and select the sensor serial number of the device. Refer to Figure 12-19.
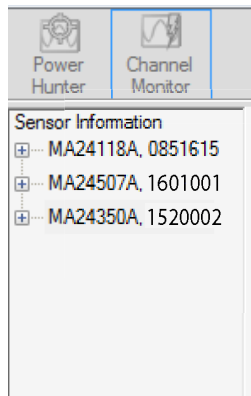
Figure 12-19. Sensor Information Menu

12-15 Settings Menu

The Settings menu provides Reset to Factory Settings. The Save/Recall Setup, Set Sensor Time Out, and Secure Mode are inactive at this time and will appear grayed out. The grayed out selections are not available with the MA245xxA Power Master, but become available when a MA24208A, MA24218A, MA24330A, MA24340A, or MA24350A power sensor is connected from "Multiple Sensor Display" on page 12-22.
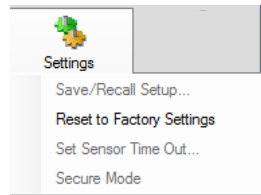
Figure 12-20. Settings Menu

Resetting to Factory Settings

This selection resets the PowerXpert settings to the default state.

No Sensor Display

Figure 12-21. No Sensor Connected

A No Sensor message will display when PowerXpert does not detect the Power Master or sensor connection. If this occurs:

1. Close the application and disconnect the Power Master or power sensor.

2. Open the PowerXpert application and reconnect the Power Master or power sensor.

3. If the problem persists, contact an Anritsu service center.

12-16 Help

The Help menu provides options to launch the online documentation and provides an informational About PowerXpert dialog.
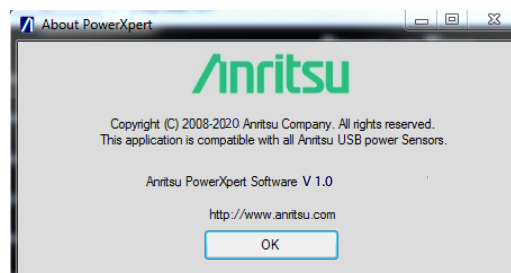
Figure 12-22. About PowerXpert

Chapter 13 — Using Power Master

13-1   Introduction

This chapter describes using the MA245xxA Power Master power analyzer with the Anritsu PowerXpert PC application buttons and menus described in Chapter 12, "Using Power Master with PowerXpert". If an Anritsu series handheld instrument is being used with the MA245xxA Power Master, refer to the user documentation that came with the handheld instrument for procedures on operating external power sensors.

Power Master Connector Overview

The MA245xxA Power Master connectors are shown in Figure 13-1.

MA245xxA

Index	Description
MA245xxA Power Master	
1	RF input: V male RF input: W1 male
2	Trigger Port (Inactive)
3	Status LED
4	USB Type C Port (for connection with a PC or Anritsu handheld instrument)
5	Reference Port (for service only)

Figure 13-1. MA245xxA Power Master Connectors Overview

13-2   Basic Power Measurement

This section provides steps and information to make basic power measurements with the Power Master and PowerXpert. To perform a power measurement:

1. Connect the Power Master to a computer as shown in Figure 13-2.

2. Open the Anritsu PowerXpert application.

Caution	**Do not** apply power greater than the power sensor specifications or permanent damage may result. Connect a fixed attenuator to the output connector when power exceeds +20 dBm.

Caution	Before connecting the power sensor to a another device, read the "Instrument Care and Preventive Maintenance" on page 1-4.
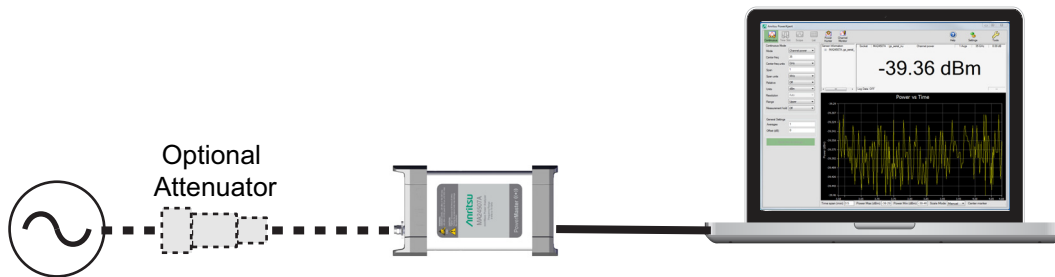
Figure 13-2. Measurement Setup

3. Connect the RF source to the RF IN port of the Power Master. Read the power measurement from the Anritsu PowerXpert application window (power readings are continuous with the default setting).

Connecting the DUT

RF signal connections are made to the male RF connector, which has a 50 ohm characteristic impedance. When connecting to the male connector of the Power Master, observe the following practice for tightening the connection:

1. While holding the body of the Power Master in one hand, turn the male connector nut to finger-tighten the connection. **Do not** turn the body of the Power Master as this will cause excessive wear to the connector.

2. Back off the connection by turning the connector nut counter clockwise 1/4 turn.

3. Tighten the connection (clockwise) using a 8 in-lb torque wrench (Anritsu part number: 01-201).

Zeroing the Power Master

Zeroing the MA245xxA Power Master is not required. All calibration factors, as well as temperature corrections, are stored in the Power Master. Therefore, there is no need for a reference calibration with the Power Master.

13-3   Error Messages

Error messages are described in Table 13-1. The status LED for MA245xxA Power Master will blink green when an error state occurs. In most cases, the error condition can be easily corrected. If the error condition cannot be corrected, note the error message and contact an Anritsu Service Center.

Table 13-1. MA245xxA Power Master Error Messages

Message	Description	Resolution
Temp Out of Range	The Power Master is operating outside of its specified range of 0 ºC to 50 ºC.	Operate the Power Master within its specified range.
REDUCE POWER, Max Power Exceeded	This message appears on the application screen if excess power is applied to the Power Master.	The maximum input power damage level is +30 dBm. Reduce the input power to the Power Master to within acceptable limits (< 20 dBm).

Chapter 14 — Verifying MA245xxA Performance

14-1 Introduction

This chapter provides test procedures with measurement recording tables, test equipment setups, and verification tables to verify the measurement accuracy of the MA245xxA Power Master power analyzer. Test and verification is performed by comparing the Power Master to a reference power sensor or Power Master with a specified cal factor and uncertainty. The reference sensor should be calibrated by a reputable standards laboratory using NIST instruments with low published measurement uncertainty values. Sensor test limits in these procedures are set appropriately to the specified comparison equipment. All tests must be performed at an ambient temperature of 20 ºC to 25 ºC to optimize the power sensor's performance.

Note	Refer to the instrument Technical Data Sheet for performance specifications.

14-2 Required Equipment

Required Equipment for MA24507A Power Master is listed in Table 14-1. Required Equipment for MA24510A Power Master is listed in Table 14-2.

Table 14-1. Required Equipment for MA24507A Power Master

Equipment Description	Manufacturer and Model	Critical Specifications
Vector Network Analyzer	Anritsu MS4647B (70 GHz)	Reflection Coefficient UNC ≤ 0.012, 50 MHz to 26.5 GHz UNC ≤ 0.018, 26.5 to 40 GHz UNC ≤ 0.026, 40 to 50 GHz UNC ≤ 0.034, 50 to 67 GHz
Synthesizer	Anritsu MG3697C (70 GHz)	Frequency range 50 MHz to 67 GHz Output power +5 dBm Output SWR <2.0
Reference Power Meter	Rhode Schwarz NRP2	Instrumentation Accuracy ≤ 0.5 %
Reference Power Sensor	Rhode Schwarz NRP-Z57 (67 GHz)	NIST Calibration or equivalent
10 dB Attenuator	Anritsu 41V-10 (60 GHz)	VSWR ≤1.15, DC to 12 GHz VSWR ≤1.20, > 12 to 18 GHz VSWR ≤1.25, > 18 to 26.5 GHz VSWR ≤1.40, > 26.5 to 40 GHz VSWR ≤1.90, > 40 to 60 GHz
Personal Computer	Any	See Chapter 2
Type V Calibration Kit	Anritsu 3654D	

Table 14-2. Required Equipment for MA24510A Power Master

Equipment Description	Manufacturer and Model	Critical Specifications
Vector Network Analyzer	Anritsu ME7838A (110 GHz)	Reflection Coefficient UNC $\leq$ 0.015, 50 MHz to 26.5 GHz UNC $\leq$ 0.016, 26.5 to 40 GHz UNC $\leq$ 0.017, 40 to 50 GHz UNC $\leq$ 0.020, 50 to 67 GHz UNC $\leq$ 0.028 67 to 110 GHz
Synthesizer	Anritsu MG3697C (70 GHz)	Frequency range 50 MHz to 67 GHz Output power +5 dBm Output SWR <2.0
Multiplier (used with synthesizer)	Norden ND75110G0P0 Keysight E3631A Flann 27373-WF60	Output Frequency 75 to 110 GHz 12 VDC Output (supply for multiplier) Adapter inlineWR10 to 1mm female (adapter for multiplier output)
Reference Power Sensor	Rhode Schwarz NRP-Z58 (110 GHz)	NIST Calibration or equivalent
Adapter	Anritsu 34WFV50	For testing MA24510A below 75 GHz.
Type W1 Calibration Kit	Anritsu 3656B	
Personal Computer	Any	See Chapter 2

14-3   VSWR Verification

The uncertainty of the VSWR test equipment will affect actual measurement values.

Test Procedure

Caution	**Do not** apply power greater than the power sensor specifications or permanent damage may result. Connect a fixed attenuator to the output connector when power exceeds +20 dBm.

Caution	Before connecting the power sensor to a another device, read the "Instrument Care and Preventive Maintenance" on page 1-4.

Using required equipment suggested in Table 14-1 on page 14-1, follow the manufacturer's S11 (input return loss) calibration procedure to perform calibration on the vector network analyzer. Connect the Power Master to the vector network analyzer test port and measure the Power Master input match. Typically, return loss are expressed in dB, which can be interconverted to Reflection Coefficient and VSWR as follows:

$$\rho = 10^{-RL/20}$$

$$RL = -20\log\rho$$

$$VSWR = (1 + \rho) / (1 - \rho)$$

$$\rho = (VSWR - 1) / (VSWR + 1)$$

where

RL = Return Loss in dB

ρ = Magnitude of the Reflection Coefficient

VSWR = Voltage Standing Wave Ratio

For the MA24507A, record the measured data into Table 14-3 under the Actual Measurement column. For the MA24510A, record the measured data into Table 14-4 under the Actual Measurement column. The Actual Measurement should be smaller than the Maximum Reflection Coefficient. The Maximum Reflection Coefficient is equal to the measurement system uncertainty added to the Power Master's reflection coefficient specification. If the Actual Measurement reflection coefficient is larger than the Maximum Reflection Coefficient, then the Power Master may be defective. If the actual reflection coefficient is significantly larger than the maximum values recorded, then the Power Master is damaged and it is not necessary to perform further testing.

Table 14-3. MA24507A Reflection Coefficient Measurement Result

Frequency	Reflection Coefficient Uncertainty	Maximum Reflection Coefficient (Typical)	Actual Measurement
50 MHz to 12.4 GHz	0.012	0.126+0.012 = 0.138	
12.4 to 26.5 GHz	0.012	0.16+0.012 = 0.172	
26.5 to 40 GHz	0.018	0.2+0.018 = 0.218	
40 to 50 GHz	0.026	0.251+0.026 = 0.277	
50 to 67 GHz	0.034	0.355+0.034 = 0.389	

Table 14-4. MA24510A Reflection Coefficient Measurement Result

Frequency	Reflection Coefficient Uncertainty	Maximum Reflection Coefficient (Typical)	Actual Measurement
50 MHz to 12.4 GHz	0.015	0.126+0.015=0.141	
>12.4 to 26.5 GHz	0.015	0.251+0.015=0.266	
>26.5 to 40 GHz	0.016	0.251+0.016=0.257	
>40 to 50 GHz	0.017	0.251+0.017=0.268	
>50 to 67 GHz	0.020	0.355+0.020=0.375	
>67 to 110 GHz	0.028	0.355+0.028=0.383	

14-4   Frequency Response Test

The frequency response of the Power Master is tested at one low power level against a reference power sensor or Power Master of known measurement uncertainty. The reference power sensor or Power Master should be calibrated by a reputable standards laboratory using instruments with low published measurement uncertainty values. To perform the comparison, both power sensors or Power Masters are used to measure the output power of a synthesizer with a high quality attenuator at the output. The attenuator improves the source match of the synthesizer by lowering the mismatch ripples, thereby lowering the uncertainty in the comparison.

Test Procedure

1. Set up the equipment as follows (refer to Figure 14-1 for an illustration and Table 14-1 for the required equipment):

   a. Preset all test equipment.

   b. Reference power sensor and power meter (if needed). Not shown in the Figure 14-1.

   c. Connect the USB cable between the computer and MA245xxA Power Master.

   d. Launch the PowerXpert application.

   e. Power up all test equipment for the amount of time specified in their manuals.

   f. Connect the attenuator to the synthesizer with appropriate adapter (if required).

   g. Connect the reference sensor to the attenuator.

   h. Turn Off synthesizer RF output.

.
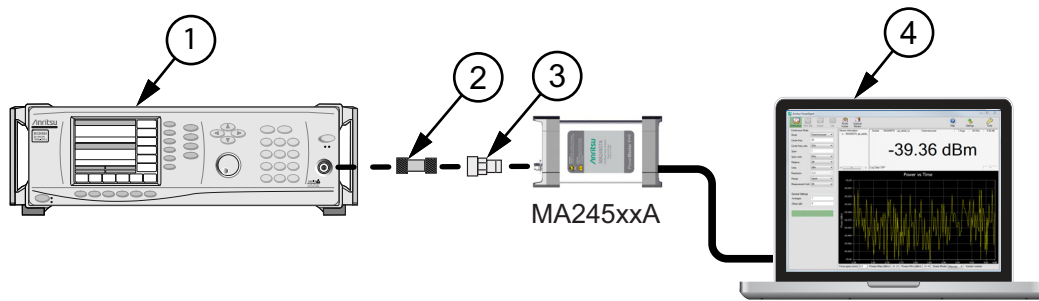
Index	Description
1	Synthesizer
2	10 dB Attenuator
3	Adapter
4	PC with Anritsu PowerXpert Application

Figure 14-1. MA245xxA Power Master < 67 GHz Frequency Response Setup

.
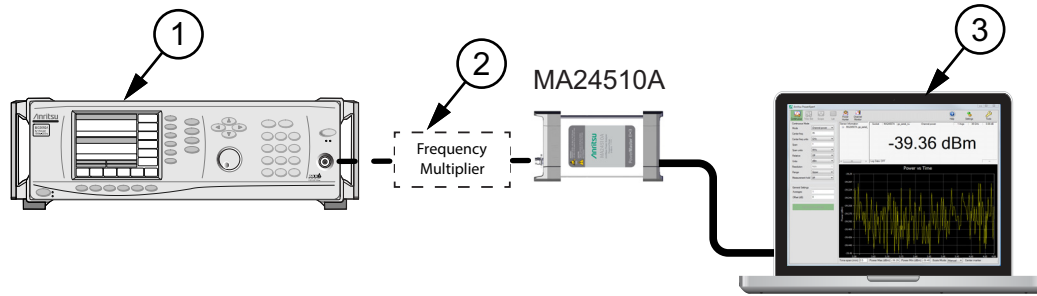
Index	Description
1	Synthesizer
2	Frequency Multiplier
3	PC with Anritsu PowerXpert Application

Figure 14-2. MA24510A Power Master 71 to 110 GHz Frequency Response Setup

2. Set synthesizer power to 5 dBm and frequency to 50 MHz CW. Turn On RF output.

3. Apply the Cal Factor to the reference sensor.

4. Record the power indicated by the reference meter or virtual power meter software in Table 14-5.

5. Set synthesizer frequency to the next frequency in Table 14-5.

6. Repeat Steps 3 through 6 until all frequencies are measured.

7. Turn Off RF output. Disconnect the reference sensor and connect MA245xxA Power Master to the attenuator.

8. Set synthesizer frequency to 50 MHz CW. Turn On RF output.

9. Set to Continuous Mode: Mode = Channel power, Span = 1MHz, Units =dBm, Range = Upper, Averages = 64

10. Enter test frequency in GHz on PowerXpert.

11. Record the power indicated by the MA245xxA Power Master.

12. Set synthesizer frequency to the next frequency.

- Note: The frequency multiplier doubles the frequency, so the synthesizer frequency must be set to 1/2 the test frequency with the 71 to 110 GHz setup.

13. Repeat Steps 10 through 13 until all frequencies are measured.

14. Calculate the absolute difference between the Reference power and MA245xxA Power Master measurement.

15. Compare the power difference to the maximum allowed difference specified. If the difference exceeds the maximum allowed difference, contact Anritsu Customer Service.

Table 14-5. MA245xxA Power Master Test Measurement Results

Frequency (GHz)	A Reference Power Measurement (dBm)	B MA245xxA Measurement (dBm)	|A-B| Absolute Value of Difference in Power Measurements (dB)	MA245xxA Maximum Allowed Difference (dB)
0.05				1.3
1.0				1.8
5.0				1.8
10.0				1.8
20.0				1.8
30.0				1.8
40.0				1.8
50.0				2.0
60.0				2.0
67.0				2.0
71.0				2.2
89.0				2.2
109.0				2.5

Chapter 15 — Programming Commands for USB Power Sensors

15-1   Introduction

This chapter describes the supported remote programming commands for each power sensor model. Programming commands are classified into three main groups with the following functions and modes:

Section 15-5 "General Purpose Commands"

Section 15-6 "Mode Commands"

- "Continuous Average Mode (CA Mode)"
- "Time Slot Mode"
- "Scope Mode"
- "List Mode"

Section 15-7 "Trigger Commands"

- "Trigger Source"
- "Trigger Level"
- "Trigger Edge"
- "Trigger Delay"
- "Trigger Noise Immunity"
- "Trigger Arming"

The MA241xxA series sensor default start up in the HOLD mode (the START command is sent to put the sensor in RUN mode).

The MA242x8A and MA243x0A series sensor default start-up state is RUN mode (the CHOLD command is sent to put the sensor in RUN mode).

15-2   Remote Operation Command Summary

Table 15-1 provides a summary of the power sensor and command compatibility.

Table 15-1. Remote Command Summary

Command	MA24105A	MA24106A	MA24108A	MA24118A	MA24126A	MA24208A	MA24218A	MA243x0A
General Commands								
AUTOAVG	-	-	x	x	x	x	x	x
AUTOAVG?	-	-	x	x	x	x	x	x
AUTOAVGRES	-	-	x	x	x	x	x	x
AUTOAVGRES?	-	-	x	x	x	x	x	x
AUTOAVGSRC	-	-	x	x	x	x	x	x
AUTOAVGSRC?	-	-	x	x	x	x	x	x
AVGCNT	x	-	x	x	x	x	x	x

Table 15-1. Remote Command Summary

Command	MA24105A	MA24106A	MA24108A	MA24118A	MA24126A	MA24208A	MA24218A	MA243x0A
AVGCNT?	x	-	x	x	x	x	x	x
AVGRST	x	-	x	x	x	x	x	x
AVGTYP	-	-	x	x	x	x	x	x
AVGTYP?	-	-	x	x	x	x	x	x
BUFFER_READ_FULL	-	-	-	-	-	x	x	x
BUFFER_SIZE	-	-	-	-	-	x	x	x
BUFFER_SIZE?	-	-	-	-	-	x	x	x
BUFFER_STATE	-	-	-	-	-	x	x	x
BUFFER_STATE?	-	-	-	-	-	x	x	x
CALDATE	x	-	x	x	x	x	x	x
CALREV?	-	-	-	-	-	x	x	x
CCDFTHRESH	x	-	-	-	-	-	-	-
CCDFTHRESH?	x	-	-	-	-	-	-	-
CHOLD	x	-	x	x	x	x	x	x
CHOLD?	x	-	x	x	x	x	x	x
CWDUTY	x	-	x	x	x	x	x	x
CWDUTY?	x	-	x	x	x	x	x	x
CWREL	-	-	x	x	x	x	x	x
CWREL?	-	-	x	x	x	x	x	x
DELETE	-	-	x	x	x	x	x	x
ENHMOD	-	-	-	-	-	x	x	x
ENHMOD?	-	-	-	-	-	x	x	x
FORWARD	x	-	-	-	-	-	-	-
FORWARD?	x	-	-	-	-	-	-	-
FREQ	x	x	x	x	x	x	x	x
FREQ?	x	x	x	x	x	x	x	x
FULLBUF	-	-	x	x	x	-	-	-
HAT	-	x	-	-	-	-	-	-
IDN?	x	x	x	x	x	x	x	x
*IDN?	-	-	-	-	-	x	x	x
IDNFPGA?	-	-	-	-	-	x	x	x
LAT	-	x	-	-	-	-	-	-
LOADLIST	-	-	-	-	-	x	x	x
LISTSTART	-	-	-	-	-	x	x	x
MODTYPE	x	-	-	-	-	-	-	-
MODTYPE?	x	-	-	-	-	-	-	-
NPWR?	-	x	-	-	-	-	-	-

Table 15-1. Remote Command Summary

Command	MA24105A	MA24106A	MA24108A	MA24118A	MA24126A	MA24208A	MA24218A	MA243x0A
PWR?	x	x	x	x	x	x	x	x
PWRALL	x	-	-	-	-	-	-	-
RDBUF	-	-	-	-	x	x	x	x
RECALL	-	-	x	x	x	x	x	x
REVERSE	x	-	-	-	-	-	-	-
REVERSE?	x	-	-	-	-	-	-	-
RST	x	-	x	x	x	x	x	x
SAVE	x	-	x	x	x	x	x	x
SETRNG	x	-	x	x	x	x	x	x
SETRNG?	x	-	x	x	x	x	x	x
START	x	x	x	x	x	x	x	x
STATUS?	x	x	x	x	x	x	x	x
STOP	x	x	x	x	x	x	x	x
TMP?	x	x	x	x	x	x	x	x
VIDEOBW	x	-	-	-	-	-	-	-
VIDEOBW?	x	-	-	-	-	-	-	-
ZERO	x	x	x	x	x	x	x	x
Mode Commands								
CHAPERT	-	-	x	x	x	x	x	x
CHAPERT?	-	-	x	x	x	x	x	x
CHMOD	-	-	x	x	x	x	x	x
CHMOD?	-	-	x	x	x	x	x	x
GATEPARAMS	-	-	x	x	x	x	x	x
GATEPARAMS?	-	-	x	x	x	x	x	x
GATEVALUES?	-	-	x	x	x	x	x	x
GENABLE	-	-	x	x	x	x	x	x
GENABLE?	-	-	x	x	x	x	x	x
SCOPEPARAMS	-	-	x	x	x	x	x	x
SCOPEPARAMS?	-	-	x	x	x	x	x	x
STEPDETECT	-	-	-	-	-	x	x	x
STEPDETECT?	-	-	-	-	-	x	x	x
TRGARMTYP	-	-	x	x	x	x	x	x
TRGARMTYP?	-	-	x	x	x	x	x	x
TRGDLY	-	-	x	x	x	x	x	x
TRGDLY?	-	-	x	x	x	x	x	x
TRGEDG	-	-	x	x	x	x	x	x
TRGEDG?	-	-	x	x	x	x	x	x

Table 15-1. Remote Command Summary

Command	MA24105A	MA24106A	MA24108A	MA24118A	MA24126A	MA24208A	MA24218A	MA243x0A
TRGHOLDDLY	-	-	-	-	-	x	x	x
TRGHOLDDLY?	-	-	-	-	-	x	x	x
TRGHYST	-	-	-	-	-	x	x	x
TRGHYST	-	-	-	-	-	x	x	x
TRGHYST?	-	-	-	-	-	x	x	x
TRGIMM	-	-	x	x	x	x	x	x
TRGLVL	-	-	x	x	x	x	x	x
TRGLVL?	-	-	x	x	x	x	x	x
TRGNOISE	-	-	x	x	x	-	-	-
TRGNOISE?	-	-	x	x	x	-	-	-
TRGSRC	-	-	x	x	x	x	x	x
TRGSRC?	-	-	x	x	x	x	x	x
TSLTPARAMS	-	-	x	x	x	x	x	x
TSLTPARAMS?	-	-	x	x	x	x	x	x

15-3   System Setup

Device Driver for MS Window

The power sensor device drivers, .inf file, should be installed in Microsoft Windows. The device driver contains the device specific configuration or settings, such as USB Vendor ID (VID) and Product ID (PID), to bring the senor online. The device driver can be installed manually, or automatically installed by the PowerXpert installation. To install manually, the device driver files are located in PowerXpert's default installation driver folder, which can be found in C:\Program Files (x86)\Anritsu\PowerXpert\Drivers, or user selected installation path: \and MA243x0A.

Remote Programming Interface

The MA241xxA power sensors utilize Serial over USB communication, so remote commands can be sent to power sensor manually or using standard serial port connection. For manual command operation, a serial port terminal application, such as Windows XP HyperTerminal can be used. For automated command operation, an application such as PowerXpert, can connect to the power sensor using a standard serial port connection. Information on a demo application and its source code can be found in "MA241xxA Series Demo Application" on page A-1.

The MA241xxA Series Power Sensors are also compatible with National Instruments VISA through serial connection.

The MA242x8A and MA243x0A power sensors utilize USB 2.0 technology for speed, which requires applications to use USB application programming interface (API) to communicate with power sensor. PowerXpert utilizes the Anritsu Sensor Driver. Information on an Anritsu Sensor Driver demo application and its source code can be found in "Using the MA242x8A, MA243x0A Series Demo Application" on page A-2.

The MA242x8A and MA243x0A Series Power Sensors can also be controlled remotely using National Instruments VISA using USB raw mode.

Model Comparison for Remote Programming

Table 15-2. Model Comparison

	MA24105A	MA24106A	MA24108A	MA24118A	MA24126A	MA24208A	MA24218A	MA243x0A
Serial	x	x	x	x	x	-	-	-
USB 2.0	-	-	-	-	-	x	x	x
USB PID	FF80	FFC9	FFCE	FFCB	FFCF	FF82	FF82	FF82

15-4   Programming the Sensor

Send and Receive Format

Every communication with the power sensor must be suffixed with the line feed (*LF*) character (ASCII 0x0A). Every response from the sensor is also suffixed with the same character (except when using Microsoft HyperTerminal, which uses a carriage return as the identifier). The sensor rejects any command without the line feed character with a NO TERM response. All commands and responses mentioned in this document are assumed to be suffixed with a new line character. The following considerations must also be observed:

- Command arguments presented in this document are enclosed in angle brackets: <argument>. The angle brackets are not included as part of the actual argument.
- Floating point numbers are truncated to integers by commands that only use integers as input. For example, if the number of averages is set as 2000.937, the firmware truncates the number to 2000.
- For the MA24x08A, MA24x18A, MA24126A and MA243x0A sensors, use only two digits after the decimal in floating point arguments (except FREQ, which uses four digits after the decimal, and gate parameters, which allow three digits after decimal).

HyperTerminal

Only the MA24105A, MA24x08A, MA24x18A, MA24126A and MA243x0A sensors are compatible with Windows HyperTerminal. When programming the sensor with HyperTerminal, the carriage return is used as the termination character instead of a new line. The HyperTerminal port should be configured with a baud rate of 9600 bits per second. To properly format the commands and responses for HyperTerminal, the following check boxes should be checked in Properties | Settings | ASCII Setup:

- Send line ends with line feeds
- Echo typed characters locally
- Append line feeds to incoming line ends

Time Resolution

The maximum time resolution of the sensor is 10 μs, hence all of the time arguments have a 10 μs resolution. This does not apply to the MA24105A sensor.

Sampling Rate

The MA24108A, MA24118A, and MA24126A sensors have two sampling rates. For "Continuous Mode" on page 3-7 and Internal "Trigger Source" on page 3-23, the sensor has a sampling time of 6.8288 µs or a sampling frequency of 146.438 kHz. External "Trigger Source" has a sampling time of 7.3347 µs, or a sampling frequency of 136.338 kHz.

The MA242x8A sensors have 1 sample rate for all modes including Continuous Average, Scope, Time Slot, and internal / external trigger modes. The sensor has a sampling time of 7.14 µs or a sampling frequency of 140.056 kHz.

The MA243x0A sensors have 1 sample rate for all modes including Continuous Average, Scope, and internal / external trigger modes. The sensor has a sampling time of 7.14 µs or a sampling frequency of 140.056 kHz.

Error Responses

Any unrecognized command is rejected by the sensor with a `BAD CMD` message. A valid command coupled with an invalid command is rejected by the sensor with an `ERR` message. A command failure is also indicated by the sensor with an `ERR` message.

Default Sensor Settings

The sensor settings in Table 15-3 apply to the MA24105A.

Table 15-3. General Default Sensor Settings, MA24105A

Setting	Command	Default Value
Mode of Operation	FORWARD REVERSE	Continuous Forward Mode Continuous Reverse Mode
Measurement Frequency	FREQ	0.35 GHz
Number of Averages	AVGCNT	1
Range	SETRNG	Auto range (0)

The sensor settings in Table 15-4, Table 15-5 and Table 15-7 apply to the MA24x08A, MA24x18A, MA24126A, MA243x0A.

Table 15-4. General Default Sensor Settings, MA24x08A, MA24x18A, MA24126A, MA243x0A

Setting	Command	Default Value
Mode of Operation	CHMOD	"Continuous Average Mode (CA Mode)" (0)
Measurement Frequency	FREQ	0.010 GHz (MA24108A, MA24118A, MA24126A) 2 GHz (MA24208A, MA24218A. MA243x0A)
Averaging Algorithm	AVGTYP	Moving (0)
Number of Averages	AVGCNT	1
Auto Averaging	AUTOAVG	Off (0)
Auto Averaging Source	AUTOAVGSRC	1
Auto Average Resolution	AUTOAVGRES	0.01 (2)
Range	SETRNG	Auto range (0)
Step Detect	STEPDETECT	On (1)

Table 15-5. Continuous Average Mode Default Sensor Settings, MA24x08A, MA24x18A, MA24126A, MA243x0A

Setting	Command	Default Value
Aperture Time	CHAPERT	20 ms
Duty Cycle Correction	CWDUTY	100 %
Relative Mode	CWREL	Off (0)

Table 15-6. Default buffer command settings (Continuous mode only for MA24x08A, MA24x18A, MA24126A, MA243x0A

Setting	Command	Default Value
Buffer Size continuous mode	BUFFER_SIZE	8192
Sensor Hold State	CHOLD	0 (RUN)
Enhancement Modulation	ENHMOD	OFF

Table 15-7. Time Slot Mode Default Sensor Settings, MA24x08A, MA24x18A, MA24126A

Setting	Command	Default Value
Number of Slots	TSLTPARAMS	8
Slot Width	TSLTPARAMS	10 ms
Start Exclusion	TSLTPARAMS	0.02 ms
End Exclusion	TSLTPARAMS	0.02 ms

Table 15-8. Scope Mode Default Sensor Settings, MA24x08A, MA24x18A, MA24126A, MA243x0A

Setting	Command	Default Value
Capture Time	SCOPEPARAMS	20 ms
Number of Points	SCOPEPARAMS	200
Gate	GENABLE	Disabled (0)
Gate Start	GATEPARAMS	0 ms
Gate End	GATEPARAMS	20 ms
Fence Start	GATEPARAMS	0 ms
Fence End	GATEPARAMS	0 ms

Table 15-9. Trigger Default Sensor Settings, MA24x08A, MA24x18A, MA24126A, MA243x0A

Setting	Command	Default Value
Trigger Source	TRGSRC	Continuous (0)
Trigger Arm Type	TRGARMTYP	Standby (3)
Trigger Level	TRGLVL	0 dBm
Trigger Edge	TRGEDG	Positive (0)
Trigger Delay	TRGDLY	0 ms
Trigger Hold Delay	TRGHOLDDLY	0 ms
Trigger Noise Parameter (Only for MA24108A, MA24118A, and MA24126A)	TRGNOISE	1
Hysteresis (for MA242x8A and MA243x0A)	TRGHYST	0 dB

15-5   General Purpose Commands

General purpose commands are used to set/read the general settings of the sensor. These commands are not mode or trigger dependent. All of the commands for the MA24105A and MA24106A sensors are confined to this section. Most of the commands in this section are compatible with the MA24x08A, MA24x18A, MA24126A and MA243x0A sensors.

Note	For successful remote operations ensure:
	• Usage of Remote commands are performed in correct sequence, modes based on the 'Description.
	• Read the 'Return Value' completely from the power sensor.
	Example some commands expect user to read 'ok' or data from a query command or the complete buffer, based on the data size set (e.g. RDBUF, BUFFER_READ_FULL).

START

Description: Sets the sensor to measurement mode from the idle mode.

Syntax: START *+LF*

Return Value: OK

Remarks: This command starts a MA241xxA sensor measuring, if it is in HOLD mode. The MA241xxA sensors default setting is HOLD mode. Therefore, the first command sent to the sensor is typically START. If the sensor is already in RUN mode, then no change will occur when using the START command - although an OK response will still be sent.

The MA242x8A and MA243x0A sensors' default setting is RUN mode. If the sensors are in HOLD mode, START is not the command to change the mode to RUN. This is accomplished using the CHOLD command. The START command will be accepted, but no action will be taken.

Note: MA242x8A and MA243x0A sensors do not need START command to start as they start in run mode by default. Sending command to MA242x8A and MA243x0A doesn't do anything but returns OK for compatibility reasons and not break existing programs. If MA242x8A and MA243x0A is in HOLD mode it will still stay in HOLD mode. To change MA242x8A and MA243x0A sensors from HOLD to RUN mode, CHOLD command should be used.

Compatible Sensor: MA24105A, MA24106A, MA24x08A, MA24x18A, MA24126A, MA243x0A

STOP

Description: Sets the power sensor to idle mode.

Syntax: STOP *+LF*

Return Value: OK

Remarks: This command should be sent before exiting the application. MA242x8A and MA243x0A models do not change the power sensor to Idle Mode, this can be achieved using CHMOD command. MA242x8A and MA243x0A does not change the mode to HOLD, this can be achieved using CHOLD command.

Compatible Sensor: MA24105A, MA24106A, MA24x08A, MA24x18A, MA24126A, MA243x0A

IDN?

Description: Gets the identification information from the sensor.

Syntax: IDN? *+LF*

Return Value: ANRITSU, Model #, Serial #, Module Serial #, firmware version.

Compatible Sensor: MA24105A, MA24106A, MA24x08A, MA24x18A, MA24126A, MA243x0A

*IDN?

Description: Gets the identification information from the sensor

Syntax: *IDN? *+LF*

Return Value: ANRITSU, Model #, Serial #, firmware version.

Compatible Sensor: MA24208A, MA24218A, MA243x0A

IDNFPGA?

Description: Gets FPGA Version from the sensor

Syntax: *IDNFPGA? +LF*

Return Value: yyyymmdd_HHMMSS

Compatible Sensor: MA24208A, MA24218A. MA243x0A

CALDATE

Description: Returns the last calibration date of the sensor.

Syntax: *CALDATE +LF*

Return Value: MA241xxA Calibration date format of the sensor in mm/dd/yyyy format.

MA242x8A and MA243x0A Calibration date format of the sensor mm/dd/yyyy hh:mm:ss

Remark: The MA242xxA sensors also include a time in the CALDATE response

Compatible Sensor: MA24105A, MA24x08A, MA24x18A, MA24126A, MA243x0A

CALREV?

Description: Returns the version number of the calibration file in the sensor.

Syntax: *CALREV? +LF*

Return Value: Version number of the calibration file in #.# format

Compatible Sensor: MA242xxA, MA243x0A

PWR?

Description: Gets the current power reading (in dBm) from the sensor output buffer in the Continuous Average mode.

Syntax: PWR? *+LF*

Return Value: Power value in dBm or ERR

On the MA24105A, two values (Forward and Reverse power value in dBm) are returned. The return value for this reading is a comma separated value (for example; return value "2.55,–0.228" means the forward power is +2.55 dBm and the reverse power is – 0.228 dBm).

Remarks: If an error condition exists, "e" precedes the output and the sensor's LED turns amber color. For the MA242x8A and MA243x0A models, if an error condition exists, "e" precedes the output and the sensor's LED blinks green. Use the STATUS? command for details about the error.

This command returns an error ("ERR") if used in Slot or Scope modes.

This command returns "busy" if used in repeat average mode with immediate trigger (if the sensor has not completed the averaging cycle).

In simple repeat average mode, it will echo the latest value from the buffer. The buffer will update only when the averaging cycle is complete.

In moving average mode, it will return the current power reading in the buffer.

Compatible Sensor: MA24105A, MA24106A, MA24x08A, MA24x18A, MA24126A, MA243x0A

PWRALL

Description: Gets all the measurements shown in Return Value

Syntax: PWRALL *+LF*

Return Value: Forward average power, Crest Factor, Burst Average Manual, Peak Envelope Power, Reverse Average Power, Reflection Coefficient, Return Loss, Standing Wave Ratio

Remarks: Returns comma separated values in the sequence shown in the return value above.

Compatible Sensor: MA24105A

NPWR?

Description: Gets a new power reading from the power sensor.

Syntax: NPWR? *+LF*

Return Value: Current Power value in dBm

Remarks: After receiving this command, the power sensor discards the existing data that is stored in the sensor's buffer. A new measurement of the current power is initiated to get a new power reading. If an error condition exists, the returned power reading values are pre-tagged with the letter "E" and the sensor's LED turns amber color. The STATUS? command can then be issued to find details about the error.

Compatible Sensor: MA24106A

FREQ

Description:	Sets the current calibration factor frequency value for the power sensor.
Syntax:	FREQ <freq> *+LF*
Return Value:	OK or ERR
Remarks:	The frequency <freq> value is in GHz and must be within the operating limits of the power sensor.

For the MA24105A, resolution is 0.0001 GHz (100 kHz) between 0.350 GHz and 4 GHz.

For the MA24106A, resolution is 0.000001 GHz (1 kHz) between 0.050 GHz and 6 GHz.

For the MA24108A, resolution is 0.0001 GHz (100 kHz) between 0.010 GHz and 8 GHz.

For the MA24118A, resolution is 0.0001 GHz (100 kHz) between 0.010 GHz and 18 GHz.

For the MA24126A, resolution is 0.0001 GHz (100 kHz) between 0.010 GHz and 26 GHz.

For the MA24208A, resolution is 0.000001 GHz (1 kHz) between 0.01 GHz and 8 GHz.

For the MA24218A, resolution is 0.000001 GHz (1 kHz) between 0.01 GHz and 18 GHz.

For the MA243x0A, resolution is 0.000001 GHz (1 kHz) between 0.01 GHz and 50 GHz.

Compatible Sensor: MA24105A, MA24106A, MA24x08A, MA24x18A, MA24126A, MA243x0A

FREQ?

Description:	Gets the current calibration factor frequency value of the power sensor.
Syntax:	FREQ? *+LF*
Return Value:	Current calibration factor frequency in GHz.
Compatible Sensor:	MA24105A, MA24106A, MA24x08A, MA24x18A, MA24126A, MA243x0A

ZERO

Description:	Zeros the power sensor.
Syntax:	ZERO *+LF*
Return Value:	OK if zero is successful or ERR if zero fails.
Remarks:	Zeroing the sensor is essential for taking accurate readings as it cancels any offsets in the preamplifiers and channel noise. The sensor should be zeroed without any input RF power. In case of zero failure, the STATUS? command can be used to retrieve more detail about the error.

For the MA24105A, zeroing the sensor takes approximately 75 seconds to complete and will take at least this long to get a response from the sensor.

For all other models, zeroing the sensor takes approximately 25 seconds to complete and will take at least this long to get a response from the sensor.

Compatible Sensor: MA24105A, MA24106A, MA24x08A, MA24x18A, MA24126A, MA243x0A

TMP?

Description: Gets the current temperature reading from the sensor.
The MA24105A, acquires the current temperature reading from both forward and reverse temperature sensors. The return value for this reading is a comma separated value (for example; 25,28).

MA24106A, MA24x08A, MA24x18A, MA24126A and MA243x0A return value for this reading is a single decimal value (for example 30.62).

Syntax: TMP? *+LF*

Return Value: Current temperature reading of the sensor in degrees Celsius.
On the MA24105A, current temperature reading of Forward and Reverse in degrees Celsius. The return value for this reading is a comma separated value (for example; return value "25,28" means the forward temperature is 25 degrees Celsius and the reverse temperature is 28 degrees Celsius).

Compatible Sensor: MA24105A, MA24106A, MA24x08A, MA24x18A, MA24126A, MA243x0A

STATUS?

For the MA241xxA Models

Description: Gets the current error status codes from the sensor.

Syntax: STATUS? *+LF*

Return Value: 0 (No errors) or error codes.

Remarks: For the MA24106A, the error status codes are as follows:
Status.b0: ZERO_TEMP_ERROR (Temperature changed more than allowable limit after zeroing sensor)
Status.b1: Not Used
Status.b2: ADC_CH2_OR (Temperature over range)
Status.b3: ADC_CH3_OR (Detector A over ranged)
Status.b4: ZERO_ERROR_DET_A
Status.b5: ZERO_ERROR_DET_B
Status.b6: TEMP_ERROR (Temperature beyond operating range)
Status.b7: Not Used

For the MA24105A, the error status codes are 16-bit numbers, each bit of which represents an error:
Bit 0: Temperature change of more than 10 °C after zeroing
Bit 1: Operating temperature over range < 0 °C or > 60 °C
Bit 2: Forward low zeroing error
Bit 3: Forward high zeroing error
Bit 4: Reverse zeroing error
Bit 5: PEP zeroing error
Bit 6: CCDF zeroing error
Bit 7: Forward high over range
Bit 8: Reverse over range
Bit 9: PEP over range
Bit 10: Flash Data Error

For the MA24108, MA24118A, MA24126A, the error status codes are 16-bit numbers, each bit of which represents an error:
Bit 0: Temperature change of more than 10 °C after zeroing
Bit 1: Operating temperature over range < 0 °C or > 60 °C
Bit 2: Detector A zeroing error
Bit 3: Detector B zeroing error
Bit 4: Detector A over range

Compatible Sensor: MA24105A, MMA24106A, MA24108A, MA24118A, MA24126A

For the MA242x8A and MA243x0A Models

Description: Gets the current error status codes from the sensor.

Syntax: STATUS? *+LF*

Return Value: Error status codes.

Bit 0: Temperature change of more than 10 °C after zeroing
Bit 1: Operating temperature over range < 0 °C or > 60 °C
Bit 2: High Power Detector zeroing error
Bit 3: Mid Power Detector zeroing error
Bit 4: High Power Detector over range
Bit 5: Low Power Detector zeroing error

Compatible Sensor: MA24208A, MA24218A, MA243x0A

HAT

Description: Sets the high aperture time mode.

Syntax: HAT *+LF*

Return Value: OK or ERR

Remarks: This command will put the sensor in high aperture time mode. In this mode, the A to D converter integration time is about 160 milliseconds.

Compatible Sensor: MA24106A

LAT

Description: Sets the low aperture time mode.

Syntax: LAT *+LF*

Return Value: OK or ERR

Remarks: This command will put the sensor in low aperture time mode. In this mode, the A to D converter integration time is about 10 milliseconds. This mode is the default mode for the sensor when powered up.

Compatible Sensor: MA24106A

RST

Description: Resets the sensor to factory default settings.

Note: RST does not set FULLBUF to factory defaults for models MA24108A, MA2418A, MA24126A.

Syntax: RST *+LF*

Return Value: OK

Compatible Sensor: MA24105A, MA24x08A, MA24x18A, MA24126A, MA243x0A

CHOLD

Description: Sets the current power sensor state.

Syntax: CHOLD <state> *+LF*

Return Value: OK or ERR

Remarks: <state> is an integer value that represents a specific mode:

0 – Run
1 – Hold

Compatible Sensor: MA24105A, MA24x08A, MA24x18A, MA24126A, MA243x0A

CHOLD?

Description: Gets the current power sensor state.

Syntax: CHOLD? *+LF*

Return Value: An integer value.

Remarks: This command queries the sensor state. Returned value can be:
0 – Run
1 – Hold

Compatible Sensor: MA24105A, MA24x08A, MA24x18A, MA24126A, MA243x0A

SETRNG

Description: Sets the detector range of the sensor.

Syntax: `SETRNG <det_range> +LF`

Return Value: `OK` or `ERR`

Remarks: <det_range> is an integer with the following values:

For MA24105A, <det_range> is an integer with the following values:
0 – Auto Range
1 – Low Power (covers the power range from +3 dBm to +38 dBm)
2 – High Power (covers the power range from >+38 dBm to +51.76 dBm)
3 – N/A

For MA241xxA, <det_range> is an integer with the following values:
0 – Auto Range
1 – Channel A (covers the power range from +20 dBm to +7 dBm)
2 – Channel B (covers the power range from <–7 dBm to –40 dBm)
3 – N/A

For MA242x8A, <det_range> is an integer with the following values:
0 – Auto Range
1 – Channel A (covers the power range from +20 dBm to +4 dBm)
2 – Channel B (covers the power range from <+4 dBm to –16 dBm)
3 – Channel C (covers the power range from <–16 dBm to –60 dBm).

For MA243x0A, <det_range> is an integer with the following values:
0 – Auto Range
1 – Channel A (covers the power range from +20 dBm to +4 dBm)
2 – Channel B (covers the power range from <+4 dBm to –16 dBm)
3 – Channel C (covers the power range from <–16 dBm to –70 dBm).

Compatible Sensor: MA24105A, MA24x08A, MA24x18A, MA24126A, MA243x0A

SETRNG?

Description: Gets the detector range setting of the sensor.

Syntax: SETRNG? *+LF*

Return Value: An integer with the following values:
For MA24105A, <det_range> is an integer with the following values:
0 – Auto Range
1 – Low Power (covers the power range from +3 dBm to +38 dBm)
2 – High Power (covers the power range from >+38 dBm to +51.76 dBm)
3 – N/A

For MA241xxA, <det_range> is an integer with the following values:
0 – Auto Range
1 – Channel A (covers the power range from +20 dBm to +7 dBm)
2 – Channel B (covers the power range from <–7 dBm to –40 dBm)
3 – N/A

For MA242x8A, <det_range> is an integer with the following values:
0 – Auto Range
1 – Channel A (covers the power range from +20 dBm to +4 dBm)
2 – Channel B (covers the power range from <+4 dBm to –16 dBm)
3 – Channel C (covers the power range from <–16 dBm to –60 dBm).

For MA243x0A, <det_range> is an integer with the following values:
0 – Auto Range
1 – Channel A (covers the power range from +20 dBm to +4 dBm)
2 – Channel B (covers the power range from <+4 dBm to –16 dBm)
3 – Channel C (covers the power range from <–16 dBm to –70 dBm).

Compatible Sensor: MA24105A, MA24x08A, MA24x18A, MA24126A, MA243x0A

SAVE

Description: Saves a user defined setup to the power sensor.

Syntax: SAVE <setup> +LF

Return Value: OK or ERR

Remarks: <setup> is an integer from 1 to 10 that is translated into a storage location. Therefore, there are 10 presets the user can store.ERR is returned if <setup> is out of range.

Trigger Arm Type, Sensor Timeout, Scale Mode settings, Units, and a fixed Offset value will not be stored as part of the saved setup and therefore will not be recalled.

Compatible Sensor: MA24105A, MA24x08A, MA24x18A, MA24126A, MA243x0A

DELETE

Description: Deletes all user defined setups in the power sensor.

Syntax: DELETE *+LF*

Return Value: OK or ERR

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

RECALL

Description: Recalls one of the 10 user defined setups from the power sensor.

Syntax: `RECALL <setup> +LF`

Return Value: OK or ERR

Remarks: <setup> is an integer from 1 to 10 that is translated into a storage location. Hence, there are 10 presets the user can recall from. ERR is returned if <setup> is out of range.

Trigger Arm Type, Sensor Timeout, Scale Mode settings, Units, and a fixed Offset value are not stored as part of the saved setup and therefore will not be recalled.

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

RDBUF

Description: Reads the buffer in Scope and Time Slot modes.

Syntax: `RDBUF +LF`

Return Value: Returned power values are separated by a comma (,) and the buffer is prefixed and suffixed by $(the dollar sign) to mark the beginning and end of the buffer.

Remarks: This command is used to read out the entire array of points for the recent measurement run from the sensor output buffer. The output buffer contains readings from Scope and Time Slot modes for the MA242x8A power sensor and Scope mode only for the MA243x0A power sensor. Time Slot mode is not applicable to the MA243x0A.

The power readings are in mW. For the MA241xxA power sensors, each power reading has six digits after the decimal point (0.000001 mW). For the MA242x8A and MA243x0A power sensors, each power reading has seven digits after the decimal point (0.0000001 mW)

In case of an error, "e" precedes the output. Use the STATUS? command for details about the error. If the gate (discussed in "Scope Mode") is enabled, then the gate average power is also suffixed at the end of the output. For example, for four points with gate enabled, the RDBUF response is:
`$,<P1>,<P2>,<P3>,<P4>,$,<GP>`

Time Slot mode with 4 slots will send out the buffer as:
`$,-3.233454,0.124355,0.233443,0.223456,$`

Compatible Sensor: MA24x08A, MA24x18A, MA24126A
MA243x0A for Scope mode only. Time Slot mode does is not applicable for the MA243x0A.

FULLBUF

Description: Sets the full sensor enable.

Syntax: `FULLBUF <n> +LF`

Return Value: OK or ERR

Remarks: <n> is an integer value that represents a specific mode:
0 – Off
1 – On

This command has effect only if the sensor is internally or externally triggered. If full buffer is turned ON, the sensor will return the full buffer in triggered mode (default operation). If full buffer is turned OFF, the sensor only returns the gated average power value enclosed in the $(dollar sign). For example: `$,3.54546,$`

If the sensor is in Slot mode or the gates are turned off, the sensor returns:
`$,Sensor triggered, output is disabled,$`

In case of an error, "`e`" followed by the error code precedes the output. For example:
`e25$,2.565677,$`
or
`e25$,Sensor triggered, output is disabled,$`

Compatible Sensor: MA24108A, MA24118A, MA24126A

BUFFER_READ_FULL

Description: This command will work in Continuous Mode only. Waits for full buffer before returning.

Syntax: `BUFFER_READ_FULL +LF`

Return value: Comma separated power values

Remarks: Comma separated power values; For example, four power measurements will be returned as below in mW:<P1>,<P2>,<P3>,<P4>. Continuous Average mode will send out the buffer as: –000.0000176, –000.0000166, –000.0000164, –000.0000169. Command BUFFER_STATE and BUFFER_SIZE need to be set before using this command.

Compatible sensor: MA242x8A, MA243x0A

BUFFER_SIZE

Description: Sets buffer size

Syntax: `BUFFER_SIZE <size>`

Return Value: OK or ERR

Remarks: <size>1 to 8192

Default: 8192

Compatible sensor: MA242x8A, MA243x0A

BUFFER_SIZE?

Description: Returns current buffer size

Syntax: `BUFFER_SIZE? +LF`

Return Value: An integer value

Remarks: Integer value from 1 to 8192

Compatible sensor: MA242x8A, MA243x0A

BUFFER_STATE

Description: Set buffer state

Syntax: *BUFFER_STATE <state>*

Return Value: OK or ERR

Remarks: <state> is an integer

0 – OFF

1 – ON

Compatible sensor: MA242x8A, MA243x0A

BUFFER_STATE?

Description: Returns current buffer state

Syntax: *BUFFER_STATE? +LF*

Return Value: 0 or 1

Remarks: 0 – OFF

1 – ON

Compatible sensor: MA242x8A, MA243x0A

CWDUTY

Description: Sets the duty cycle correction.

Syntax: CWDUTY <duty_correction> +LF

Return Value: OK or ERR

Remarks: <duty_correction> is the duty cycle correction percentage from 0.01 to 100.

For the MA24105A, this correction applies only to Burst Average Manual measurement.

Compatible Sensor: MA24105A, MA24x08A, MA24x18A, MA24126A, MA243x0A

CWDUTY?

Description: Gets the duty cycle correction value.

Syntax: CWDUTY? *+LF*

Return Value: A float value

Remarks: Duty cycle correction percentage

Compatible Sensor: MA24105A, MA24x08A, MA24x18A, MA24126A, MA243x0A

CWREL

Description: Sets the CA relative power mode status ON or OFF.

Syntax: CWREL <relative> *+LF*

Return Value: OK or ERR

Remarks: In the relative power mode, the power is calculated relative to the current power value when the command is sent. <relative> is an integer with the following values:
0 – Relative mode OFF
1 – Relative mode ON

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

CWREL?

Description: Gets the CA relative mode status ON or OFF.

Syntax: CWREL? *+LF*

Return Value: 0 or 1

Remarks: In the relative power mode, the power is calculated relative to the current power value when the command is sent. <relative> is an integer with the following values:
0 – Relative mode OFF
1 – Relative mode ON

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

AVGTYP

Description: Sets the power sensor's averaging type of Moving or Repeat.

Syntax: AVTYP <average_type> *+LF*

Return Value: OK or ERR

Remarks: <average_type> is an integer with the following values:
0 – Moving
1 – Repeat

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

AVGTYP?

Description: Gets the current power sensor's averaging type of Moving or Repeat.

Syntax: AVTYP? *+LF*

Return Value: 0 or 1

Remarks: An integer with the following values:
0 – Moving
1 – Repeat

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

AVGCNT

Description: Sets the number of averages in the Continuous Average, Time Slot, or Scope modes for MA24x08A, MA24x18A and MA24126A.

Sets the number of averages in the Continuous Average or Scope modes for MA243x0A. Time Slot mode is not applicable to the MA243x0A.

Syntax: AVGCNT <num_avgs> *+LF*

Return Value: OK or ERR

Remarks: Average count is the number of measurements used to calculate the average power stored in the output buffer of the sensor. For MA24208A, MA24218A and MA243x0A: Max averaging number is 65536.

For the MA24105A: Max Averaging Number = 512 / points; the set number of averages applies to both forward and reverse readings.

In the Auto Average mode, this command is ineffective as the number is set automatically depending on the power level and resolution required. (There is no Auto Average for MA24105A).

Compatible Sensor: MA24105A, MA24x08A, MA24x18A, MA24126A.
MA243x0A in Continuous Average or Scope modes only.

AVGCNT?

Description: Gets the number of averages in the Continuous Average, Time Slot, or Scope modes.

Syntax: AVGCNT? *+LF*

Return Value: For MA24108A, MA24118A, MA24126A, an integer value between 1 and 40,000.
For MA24105A, an integer value between 1 and 512.

For MA24208A and MA24218A an integer value between 1 and 65536 is returned.
For MA243x0A an integer value between 1 and 65536 is returned in Continuous and Scope modes only.

Remarks: The command can also be used in the auto-average mode.

Time Slot and Scope modes applicable only to MA24x08A, MA24x18A, MA24126A. Scope modes applicable to MA243x0A. Time Slot mode is not applicable for the MA243x0A sensor.

Compatible Sensor: MA24105A, MA24x08A, MA24x18A, MA24126A
MA243x0A in Continuous and Scope mode only. Time Slot mode is not applicable for MA243x0A.

AUTOAVG

Description: Sets the Auto Average mode to ON, OFF or AUTO ONCE.

Syntax: AUTOAVG <average_mode> *+LF*

Return Value: OK or ERR

Remarks: The Auto Average mode depends on three factors, Auto Average Resolution, Capture Time, and the Auto Average Source, which are set by their own commands as explained later. <average_mode> is an integer with the following values:
0 – OFF
1 – ON
2 – AUTO ONCE (ON for one iteration only and is turned OFF automatically once the averaging number is set)

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

AUTOAVG?

Description: Gets the Auto Average mode of ON, OFF or AUTO ONCE.

Syntax: AUTOAVG? *+LF*

Return Value: An integer with the following values:
0 – OFF
1 – ON
2 – AUTO ONCE (ON for one iteration only and automatically OFF once the averaging number is set)

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

AUTOAVGSRC

Description: Sets the Auto Average Source value for Time Slot and Scope modes.

Syntax: AUTOAVGSRC <average_source> *+LF*

Return Value: OK or ERR

Remarks: The <average_source> number is calculated from the average power of only one Time Slot or Scope Point. If the <average_source> value is set out of bounds, auto averaging is ineffective. For auto averaging to be effective, the auto average source must be set less than the number of points in Scope mode, or set less than the number of slots in Time Slot mode. AUTOAVGSRC is disabled in CA mode.

Compatible Sensor: MA24x08A, MA24x18A, MA24126A
MA243x0A in Scope mode only. Time Slot mode is not applicable to the MA243x0A sensors.

AUTOAVGSRC?

Description: Gets the Auto Average Source value for Time Slot or Scope mode.

Syntax: AUTOAVGSRC? *+LF*

Return Value: An integer with the auto averaging source value.

Compatible Sensor: MA24x08A, MA24x18A, MA24126A
MA243x0A in Scope mode only. Time Slot mode is not applicable to the MA243x0A sensors.

AUTOAVGRES

Description: Sets the Auto Average resolution (digits after decimal point).

Syntax: AUTOAVGRES <average_resolution> *+LF*

Return Value: OK or ERR

Remarks: The <average_resolution> number is set according to the desired resolution. Higher resolution results in more averaging and slower throughput of data.
<average_resolution> must range from 0 to 3:

0 = 1.0 dB resolution 1 = 0.1 dB resolution, 2 = 0.01 dB resolution, 3 = 0.001 dB resolution

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

AUTOAVGRES?

Description: Gets the Auto Average resolution.

Syntax: AUTOAVGRES? *+LF*

Return Value: Integer from 0 to 3

Remarks: The Auto Averaging number is set according to the desired resolution. Higher resolution results in more averaging and slower throughput of data.

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

AVGRST

Description: Resets the averaging count and clears the averaging buffers.

Syntax: AVGRST *+LF*

Return Value: OK

Remarks: Note that "averaging count" is not referring to the AVGCNT command.

Compatible Sensor: MA24105A, MA24x08A, MA24x18A, MA24126A, MA243x0A

STEPDETECT

Description: Sets the step detect feature ON or OFF

Syntax: *STEPDETECT <state> +LF*

Return Value: OK or ERR

Remarks: <state> is an integer value

0 - OFF

1 - ON

Compatible Sensor: MA242x8A, MA243x0A

STEPDETECT?

Description: Gets the step detect feature ON or OFF

Syntax: *STEPDETECT? <state> +LF*

Return Value: integer value 0 or 1

Remarks: 0 - OFF

1 - ON

Compatible Sensor: MA242x8A, MA243x0A

FORWARD

Description: Sets the forward measurement mode.

Syntax: FORWARD *<num> +LF*

Details: num = 1 to 6

Return Value: OK or ERR

Remarks: 1 – Forward Average
2 – Crest Factor
3 – Burst Average Manual
4 – Peak Envelope Power
5 – Burst Average Auto
6 – CCDF

Compatible Sensor: MA24105A

FORWARD?

Description: Gets the forward measurement mode.

Syntax: FORWARD? *+LF*

Return Value: num = 1 to 6

Remarks: 1 – Forward Average
2 – Crest Factor
3 – Burst Average Manual
4 – Peak Envelope Power
5 – Burst Average Auto
6 – CCDF

Compatible Sensor: MA24105A

REVERSE

Description: Sets the reverse measurement mode

Syntax: REVERSE *<num> +LF*

Details: num = 1 to 4

Remarks: 1 – Reverse Average
2 – Reflection Coefficient
3 – Return Loss
4 – Standing Wave Ratio (VSWR)

Compatible Sensor: MA24105A

REVERSE?

Description: Gets the reverse measurement mode

Syntax: REVERSE? *+LF*

Return Value: num = 1 to 4

Remarks: 1 – Reverse Average
2 – Reflection Coefficient
3 – Return Loss
4 – Standing Wave Ratio (VSWR)

Compatible Sensor: MA24105A

VIDEOBW

Description: Sets the video BW

Syntax: VIDEOBW *<num> +LF*

Details: num = 0 to 2

Return Value: OK or ERR

Remarks: 0 – Full
1 – 4 kHz
2 – 200 kHz

Compatible Sensor: MA24105A

VIDEOBW?

Description: Gets the video BW

Syntax: VIDEOBW? *+LF*

Return Value: num = 0 to 2

Remarks: 0 – Full
1 – 4 kHz
2 – 200 kHz

Compatible Sensor: MA24105A

MODTYPE

Description: Sets the modulation type

Syntax: MODTYPE *<num> +LF*

Details: num = 0 to 5

Return Value: OK or ERR

Remarks: 0 – NONE
1 – GSM_GPRS_EDGE
2 – WCDMA_HSPA_SINGLE_CARRIER
3 – WCDMA_HSPA_MULTI_CARRIER
4 – ISDB_T
5 – CDMA_IS95_2000_EVDO

Compatible Sensor: MA24105A

MODTYPE?

Description: Gets the modulation type

Syntax: MODTYPE? *+LF*

Return Value: 0 to 5

Remarks: 0 – NONE
1 – GSM_GPRS_EDGE
2 – WCDMA_HSPA_SINGLE_CARRIER
3 – WCDMA_HSPA_MULTI_CARRIER
4 – ISDB_T
5 – CDMA_IS95_2000_EVDO

Compatible Sensor: MA24105A

ENHMOD

Description: Changes range crossover values for better accuracy with specific signal modulation conditions.

Syntax: *ENHMOD <state>*

Return Value: OK or ERR

Remarks: <state> is an integer value
0 – OFF
1 – ON

Compatible Sensor: MA242x8A, MA243x0A

ENHMOD?

Description: Get enhance modulation state

Syntax: *ENHMOD? +LF*

Return Value: integer value 0 to 1

Remarks: 0 – OFF
1 – ON

Compatible Sensor: MA242x8A, MA243x0A

CCDFTHRESH

Description: Sets the threshold for CCDF

Syntax: CCDFTHRESH *<num>* *+LF*

Return Value: OK or ERR

Remarks: <num> is a value in dBm. The range of CCDF threshold values that can be entered is 3 dBm to 54.77 dBm.

Compatible Sensor: MA24105A

CCDFTHRESH?

Description: Gets the threshold for CCDF

Syntax: CCDFTHRESH *<num>* *+LF*

Return Value: Last threshold value

Compatible Sensor: MA24105A

15-6   Mode Commands

The PowerXpert application operates in four distinct modes as follows:

- "Continuous Average Mode (CA Mode)" available with all power sensors
- "Time Slot Mode" available with the MA24x08A, MA24x18A, and MA24126A only.
- "Scope Mode" available with the MA24x08A, MA24x18A, MA24126A and MA243x0A only
- "List Mode" available with the MA24208A, MA24218A and MA243x0A only

The power sensor starts up in the "Continuous Average Mode (CA Mode)" mode after the "START" command is issued and continuously reads power, except MA242x8A and MA243x0A, which on startup is in RUN state. The "CHMOD" command is issued to change the sensor's mode of operation. Mode-specific commands can be issued when the sensor is in any other mode, but will only affect the sensor operation if the sensor is in the mode for which the command is issued. When the sensor mode is changed, the parameters/settings get updated automatically.

CHMOD

Description: Sets the current power sensor mode and loads related settings except, MA242x8A and MA243x0A, which on startup is in RUN state.

Syntax: `CHMOD <mode>` *+LF*

Return Value: OK or ERR

Remarks: <mode> is an integer value as follows:
0 – Continuous Average Mode
1 – Time Slot Mode
2 – Scope Mode
3 – Idle Mode
4 – List Mode

Compatible Sensor: MA24x08A, MA24x18A, MA24126A
MA243x0A does not accept 1–Time Slot mode

CHMOD?

Description: Gets the current power sensor mode.

Syntax: `CHMOD?` *+LF*

Return Value: Integer value as follows:
0 – Continuous Average Mode
1 – Time Slot Mode
2 – Scope Mode
3 – Idle Mode
4 – List Mode

Compatible Sensor: MA24x08A, MA24x18A, MA24126A
MA243x0A does not accept 1–Time Slot mode

Continuous Average Mode (CA Mode)

CA mode is the default mode of operation. In CA mode, the sensor is continuously triggered and collects data at all times. Capture time is the only parameter associated with CA mode. The sensor calculates one average power averaged over the entire capture time. For example, the MA241xxA sensor for 20 ms of capture time, the sensor collects 2860 samples (with an approximate 142 kHz sampling rate). The CA power is the average of the 2860 samples for each 20 ms time frame. The power can be read using the "PWR?" command. The related CA mode commands are listed below. For MA242x8A and MA243x0A sensors, the approximate sampling rate is 140 kHz. For 20ms capture time, the sensor collects 2801 samples.

CHAPERT

Description: Sets the effective capture time (aperture time) for average power measurements.

Syntax: CHAPERT >capture_time> *+LF*

Return Value: OK or ERR

Remarks: <capture_time>

0.01 to 300 ms (MA241xxA)
0.01 to 1000 ms (MA242x8A)
0.01 to 1000 ms (MA243x0A)

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

CHAPERT?

Description: Gets the effective capture time (aperture time) for average power measurements.

Syntax: CHAPERT? *+LF*

Return Value: A float value

Return Value: An aperture time for CA mode in ms.

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

Time Slot Mode

Time Slot mode operation is generally useful when doing measurement on slotted TDMA signals like GSM. The Time Slot mode breaks up the measurement in time slots and calculates the average power reading for each individual slot. The Time Slot mode measurement can be continuously triggered, but more often it is internally or externally triggered. Triggering is discussed in Section 15-7. To set up the sensor in Time Slot mode operation, the following four parameters must be set:

- **Number of Slots:** The number of slots is the number of time slots in the measurement. There is one power reading for each slot, the power reading being the averaged power of all the samples falling within that slot. The maximum number of slots is 128.

- **Slot Width:** Slot width is the width of each slot in milliseconds. The minimum slot width is 0.01 ms (approximately one sample) and the maximum slot width is 100 ms.

- **Start Exclusion:** Start exclusion is the time in milliseconds that is excluded from the beginning of each slot for power calculation.

- **End Exclusion:** End exclusion is the time in milliseconds that is excluded at the end of each slot for power calculation.

Note	Slot Width x Number of Slots = Total Capture Time. Total Capture Time cannot exceed 300 ms for MA24108A, MA24118A, and MA24126A sensors. Total Capture Time cannot exceed 1000 ms for MA24208A, and MA24218A sensors.
	The exclusions should not eclipse the entire slot width. Start Exclusion + End Exclusion must be less than the slot width.
	MA243x0A sensors will accept Time Slot mode command and parameter, but will not change anything.

The "TSLTPARAMS" command sends all of the above parameters at once. The "TSLTPARAMS?" command receives all of the above parameters at once.

TSLTPARAMS

Description: Sets all of the Time Slot mode parameters.

Syntax: TSLTPARAMS <num1,num2,num3,num4> *+LF*

Return Value: OK or ERR

Remarks: The input parameters are comma separated values and must be sent in the correct order as follows:
num1: Number of Slots
num2: Slot Width
num3: Start Exclusion Time
num4: End Exclusion Time
An asterisk "*" can be used instead of a value if the parameter is not to be changed. For example, TSLTPARAMS 8,20,*,1 updates the Number of Slots to 8, the Slot Width to 20 ms, the Exclusion End Time to 1 ms. The Exclusion Start Time remains unchanged. Returns ERR if the input values are out of range.

Compatible Sensor: MA24x08A, MA24x18A, MA24126A
MA243x0A sensors will accept Time Slot mode command and parameter, but will not change anything.

TSLTPARAMS?

Description: Sets all of the Time Slot mode parameters.

Syntax: TSLTPARAMS? *+LF*

Return Value: Comma separated string with the following four values:
num1: Number of Slots
num2: Slot Width
num3: Start Exclusion Time
num4: End Exclusion Time

Compatible Sensor: MA24x08A, MA24x18A, MA24126A
MA243x0A will return all zero parameters

Scope Mode

In Scope mode, the sensor acts similarly to an oscilloscope in that it can be used to measure power as a function of time. Two parameters are needed to define the Scope mode operation: the collection period and the number of data points. In Scope mode, the sensor first waits for a trigger. Once a trigger is received, the MA241xxA series power sensor collects data at its sample rate of approximately 140 kS/s for the duration of the capture time. For the MA242x8A and MA243x0A series power sensor, the sample rate is 140 kS/s. This typically results in a number of samples that exceeds the number of data points requested, and individual samples are then averaged together to reduce the data set to the requested number of data points.

Gate and Fence

A gate and a fence can be set up to compute the average power of all the points within the gate. The fence is used to mask the unwanted portion of the gate, but a fence remains entirely within the gate. Any points falling within the fence are rejected for the average gate power calculation. Setting the fence start and fence end to zero disables the fence. The gate can be enabled or disabled as desired by using the gate enable "GENABLE" command. If the gate is enabled, the average power, maximum power, minimum power and crest within the gate can be queried by using the gate power "GATEVALUES?" query. All values are based on data points and NOT on the individual raw sample packets in the gate.

Capture Time

The capture time is the total time in milliseconds captured by the sensor in a single run. The maximum capture time is 300 ms for MA24108A, MA24118A, and MA24126A and 1 s for MA242x8A and MA243x0A sensors. The capture time can not be made equal to or less than the negative trigger delay. In case of a conflict between trigger delay and capture time, an error is returned when setting scope parameters.

Number of Data Points

The number of data points can never be set less than the total number of samples. For a given capture time, the lower the number of data points, the more samples that are averaged per point, thus the lower the trace noise. The sensor supports a maximum of 1024 data points for the MA241xxA power sensors if there are enough samples. For example, 20 ms of capture time results in 2860 samples (~142 kHz sampling frequency for MA24108A, MA24118A, and MA24126A and 140 kHz sampling frequency for MA242x8A and MA243x0A sensors.). If there are 10 data points, then each data point contains the averaged data of 286 samples. The entire data point array is read out by the "RDBUF" command as explained in the previous section. Hence, "RDBUF" reads out 10 data point values separated by a comma (,).

Gate Start

Gate start marks the start of the gate in milliseconds with respect to the trigger (start of capture). The Gate start value can not be negative and it can not exceed the capture time.

Gate End

Gate end marks the end of the gate in milliseconds with respect to the trigger. The Gate end value can not be less than the Gate start value and it can not exceed the capture time.

Fence Start

Fence start marks the beginning of the fence in milliseconds with respect to the trigger. The fence start must always be inside the gate (unless the fence is disabled by setting both the fence start and the fence end to zero).

Fence End

Fence end marks the end of the fence in milliseconds with respect to the trigger. The fence end must always be between fence start and the Gate end (unless the fence is disabled by setting both the fence start and the fence end to zero). If the fence start value and the fence end value are the same, then the fence is ineffective.

SCOPEPARAMS

Description:	Sets the Scope mode parameters.
Syntax:	SCOPEPARAMS <num1,num2> +LF
Return Value:	OK or ERR
Remarks:	The input parameters are comma separated values and must be sent in the correct order as follows: **num1:** Data Capture Time; MA24108A, MA24118A, MA24126A maximum 300 ms, MA242x8A and MA243x0A maximum 1000 ms **num2:** Number of Points An asterisk "*" can be used instead of a value if the parameter is not to be changed. For example, SCOPEPARAMS *,4 updates the number of points to 4, while the data capture time is unchanged. A space is treated as a zero. Returns ERR if the input values are out of range.
Compatible Sensor:	MA24x08A, MA24x18A, MA24126A, MA243x0A

SCOPEPARAMS?

Description:	Gets the Scope mode parameters.
Syntax:	SCOPEPARAMS? +LF
Return Value:	Comma separated string with the following two values: **num1:** Data Capture Time **num2:** Number of Points
Compatible Sensor:	MA24x08A, MA24x18A, MA24126A, MA243x0A

GATEPARAMS

	This command sets the gate parameters. The parameters are comma separated in the order: gate start, gate end, fence start, fence end. An asterisk (*) can be used instead of a value if the user does not want to change that parameter.
Description:	Sets the gate parameters.
Syntax:	GATEPARAMS <num1,num2,num3,num4> +LF
Return Value:	OK or ERR
Remarks:	The input parameters are comma separated values (in ms) and must be sent in the correct order as follows: **num1:** Gate Start **num2:** Gate End **num3:** Fence Start **num4:** Fence End For example, GATEPARAMS 0,20,5,15 updates the Gate Start to 0 ms, the Gate End to 20 ms, the Fence Start to 5 ms, and the Fence End to 15 ms. An asterisk "*" can be used instead of a value if the parameter is not to be changed. Returns ERR if the input values are out of range.
Compatible Sensor:	MA24x08A, MA24x18A, MA24126A, MA243x0A

GATEPARAMS?

Description:	Gets the gate parameters.
Syntax:	GATEPARAMS? *+LF*
Return Value:	Comma separated string with the following four values: **num1:** Gate Start **num2:** Gate End **num3:** Fence Start **num4:** Fence End
Compatible Sensor:	MA24x08A, MA24x18A, MA24126A, MA243x0A

GENABLE

Description:	Enables or disables the gate.
Syntax:	GENABLE <gate> *+LF*
Return Value:	OK or ERR
Remarks:	<gate> is an integer with the following values: 0 – Disable 1 – Enable Returns ERR if <gate> is out of range or if the gate is improperly set up.
Compatible Sensor:	MA24x08A, MA24x18A, MA24126A, MA243x0A

GENABLE?

Description:	Gets the gate enable/disable status.
Syntax:	GENABLE?
Return Value:	0 – Disable 1 – Enabled
Compatible Sensor:	MA24x08A, MA24x18A, MA24126A, MA243x0A

GATEVALUES?

Description:	Gets the gate average power, peak power, minimum power, and crest for the most recent scope measurement run (with gate enabled).
Syntax:	GATEVALUES?
Return Value:	Comma separated string with the following four values: **num1:** Average Power (in dBm) **num2:** Peak Power (in dBm) **num3:** Minimum Power (in dBm) **num4:** Crest Power (in dB)
Remarks:	All return values are based on data points and NOT on the individual raw sample packets in the gate. In case of an error, "e" precedes the output. For example: "e2.453,3.456,5.234,2.435"
Compatible Sensor:	MA24x08A, MA24x18A, MA24126A, MA243x0A

List Mode

List mode provides the ability to make measurements for a large number of different setups without having to update the sensor settings each time. The user must load the sensor with a setup file containing a list of frequency (GHz), aperture time (ms), and average count settings using the LOADLIST command where each set of settings corresponds to one measurement setup. The sensor and device-under-test (DUT) are synchronized between setups by handshaking with triggers. Once the process is started with the LISTSTART command, the sensor performs power measurements using the settings defined in the setup file and outputs the results automatically once done. The process can be aborted with any command after sending the LISTSTART command and before the process completes.

LOADLIST

Description: Initiates the process of loading a setup file for List mode.

Syntax: *LOADLIST <num bytes> +LF*

Return Value: OK or ERR

Remarks: The sensor must be in List mode (CHMOD 4) for this command to be accepted. Once the LOADLIST command is received, the sensor will expect a handshake to take place. The handshake involves sending the "READY?" command to the sensor to which it will reply "READY". Once the handshake is complete, the sensor will expect <num bytes> of raw file data in 512 byte strings. The sensor will reply OK after receiving each 512 byte chunk. After processing <num bytes> of file data, the sensor will expect another handshake using the same commands as before.

User can download Demo Application from website to obtain source code and find how to upload list mode data into ListMode. User can find sample programming steps to upload measurement list into ListMode in MA242x8A Driver and Demo Application source code. Refer "Using the MA242x8A, MA243x0A Series Demo Application" on page A-2 and "Anritsu recommends that you use the source code and project available on the Anritsu website to get the latest version." on page A-2.

Compatible Sensor: MA242x8A, MA243x0A

LISTSTART

Description: Initiates the List mode process.

Syntax: *LISTSTART +LF*

Return Value: OK or ERR

Remarks: The sensor must be in List mode and have had a setup file loaded using the LOADLIST command in order for the LISTSTART command to be accepted. Once the process is started with the LISTSTART command, the sensor sets the frequency, aperture time, and average count settings defined for the first measurement in the setup file and then waits for a trigger from the DUT. When the sensor receives an external trigger, it performs a power measurement and then sends a trigger out signal to indicate its readiness for the next trigger. This cycle continues until all the measurements have been taken. The power values of all measurements are output automatically at the end of the process. The process can be aborted with any command after sending the LISTSTART command and before the process completes.

Compatible Sensor: MA242x8A, MA243x0A

15-7   Trigger Commands

Trigger is an event that initiates a measurement. When the sensor is armed, it waits for a trigger. Once the trigger occurs, the sensor starts data collection, calculation, and averaging to complete a measurement.

Trigger commands must be sent after general setup of the power sensor as the general settings impact the trigger setup. Before arming the sensor for a trigger, the sensor must be set up with the following trigger related parameters:

- "Trigger Source"
- "Trigger Level"
- "Trigger Edge"
- "Trigger Delay"
- "Trigger Noise Immunity"
- "Trigger Arming"

"Trigger Arming" commands should be sent to the sensor last and just before triggering because any other type of command aborts the armed state and places the sensor in standby mode. For Time Slot and Scope modes, the sensor's default arming state is standby.

Trigger Source

The power sensor supports four different types of triggers (trigger sources):

Continuous Trigger

When the trigger source is set to continuous, the sensor is continuously collecting data. It does not look for a trigger and is triggered all the time. Because the sensor is always collecting data, it does not depend on any other trigger related parameters.

Internal Trigger

If internal trigger source is set, the sensor triggers based on the signal power, edge and noise immunity factor set in the sensor. These parameters can be set with their respective commands as discussed later.

External Trigger

When the sensor is setup with external trigger, it is triggered by the TTL/CMOS signal on the external trigger pin. In this trigger source, sensor can be set up to trigger at a particular edge of the TTL/CMOS signal. External trigger does not depend on any other trigger related parameter.

Bus Trigger

Bus trigger is a manual trigger that allows the user to manually control the trigger by sending the "TRGIMM" command. The bus trigger is command based and is not set up like the other trigger sources, and it does not depend on any trigger-related parameters.

All of the trigger sources (except Bus Trigger) work in conjunction with the trigger arm types discussed later. A trigger setup is incomplete if the sensor is not armed. The trigger source can be set and read with the following commands:

TRGSRC

Description: Sets the trigger source.

Syntax: `TRGSRC <trigger_source>` *+LF*

Return Value: `OK` or `ERR`

Remarks: <trigger_source> is an integer with the following values:
0 – Continuous
1 – Internal
2 – External

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

TRGSRC?

Description: Gets the trigger source.

Syntax: `TRGSRC?` *+LF*

Return Value: An integer with the following values:
0 – Continuous
1 – Internal
2 – External

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

TRGIMM

Description: Triggers the sensor immediately and starts taking new readings.

Syntax: `TRGIMM` *+LF*

Return Value: Power reading in dBm or BUSY.

In Continuous mode, 1 power reading in dBm.

In scope/ Time Slot mode: $,<P1>,<P2>....,$

Remarks: Once the sensor receives this command, the sensor starts collecting data for the capture time defined by the sensor's mode. Once all data collection, calculation, and averaging is complete, the sensor automatically outputs the power reading and returns to the previous state (before `TRGIMM` was received). Upon receiving the TRGIMM command. the firmware automatically starts using repeat averaging type, irrespective of the type of average type set in the sensor.

Upon completion, if the sensor is in continuous mode, it outputs one power reading in dBm (same as the "PWR?" command) and if the sensor is in Scope or Time Slot mode, it sends the entire buffer out (like RDBUF command). If the power is requested (by sending "PWR?" or "RDBUF" commands) before the sensor is done with averaging, the sensor returns `BUSY`. In this case, the sensor will not send out the power value(s) automatically and will expect the user to continue requesting power. There is no need to arm the trigger when using bus trigger.

The sensor will not return anything when requesting power with TRGIMM while it's on hold (CHOLD 1), but it will continue to respond to power requests with BUSY until hold is turned off.

Compatible Sensor: MA24x08A, MA24x18A, MA24126A

MA243x0A is not applicable with Time Slot mode

Trigger Level

Trigger level is the power value that triggers the sensor when it is crossed. This parameter has no effect in continuous, external or bus trigger setups.

TRGLVL

         Description: Sets the trigger level in dBm.

              Syntax: TRGLVL <trigger_level> *+LF*

        Return Value: A float value

            Remarks: <trigger_level> For MA24108A, MA2418A, MA24126A must be from –20 dBm to +20 dBm in 0.01 dB steps.

                     <trigger_level> For MA24208A, MA24218A and MA243x0A must be from –35 dBm to +20 dBm in 0.01 dB steps.

  Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

TRGLVL?

         Description: Gets the trigger level in dBm.

              Syntax: TRGLVL? *+LF*

        Return Value: Trigger level in dBm

  Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

Trigger Edge

Sets the trigger edge for internal and external trigger. Trigger edge can be set to positive or negative.

For internal trigger, the sensor triggers only when the signal crosses the trigger level from high to low when set to negative; the sensor triggers only when the signal crosses the trigger level from low to high when set to positive.

For external trigger, the sensor triggers when the TTL/CMOS signal on the external trigger pin falls from high to low when set to negative; the sensor triggers when the TTL/CMOS signal on the external trigger pin rises from low to high when set to positive.

TRGEDG

         Description: Sets the trigger edge.

              Syntax: TRGEDG <trigger_edge> *+LF*

        Return Value: OK or ERR

            Remarks: <trigger_edge> is an integer with the following values:
                     0 – Positive
                     1 – Negative

  Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

TRGEDG?

Description: Gets the trigger edge setting.

Syntax: TRGEDG? *+LF*

Return Value: An integer with the following values:
0 – Positive
1 – Negative

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

Trigger Delay

Trigger delay is the time in milliseconds between the trigger event and when the sensor starts taking readings. The trigger delay can be either positive or negative. The trigger delay can be set from –5 ms to 10,000 ms with a resolution of 0.01 ms.

If the delay is negative, the sensor starts taking the readings before the trigger occurs and the total capture time includes the negative delay time. For example, for a capture time of 20 ms and a delay of –1 ms, the length of the capture would be from –1 ms to 19 ms, given the trigger occurs at time, t = 0. The negative delay can not be greater than or equal to the capture time. If the capture time conflicts with the trigger delay, the trigger delay command returns an error.

If the delay is positive, the sensor waits for the set delay time after a trigger before it starts taking readings. The sensor is unresponsive during the wait period and can not be aborted. The capture time is unaffected by a positive trigger delay.

TRGDLY

Description: Sets the trigger delay in msec

Syntax: TRGDLY <trigger_delay> +LF

Return Value: OK or ERR

Remarks: <trigger_delay> is the trigger delay value in msec and must range from –5 ms to 10,000 ms with a resolution of 0.01 ms.

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

TRGDLY?

Description: Gets the trigger delay in msec

Syntax: TRGDLY? +LF

Return Value: A float value

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

Trigger Hold Off

Trigger hold off is the duration in which trigger detection is suppressed after detecting the first trigger event. The hold off duration can be set from 0 ms (off) to 10,000 ms with a resolution of 0.01 ms. Trigger delay must be positive or off in order to use trigger hold off. Trigger hold off is applicable to Scope and Time Slot modes.

The limitation of hold off is mode dependent and can be determined as the following (All time units are in msec):

- In Scope mode, hold off - delay> (1.645 * capture time) + (0.042 * data points) + 0.24.

- In Slot mode, hold off - delay> (1.625 * slot width * number of slots) + (0.064 * number of slots) + 0.29.

- For MA243x0A; In Scope mode, hold off - delay> (8.238 * capture time) + (0.038 * data points) + 0.289. Time Slot mode is not applicable for the MA243x0A sensors.

TRGHOLDDLY

Description:	Sets the trigger hold off duration in msec.
Syntax:	TRGHOLDDLY <hold_off_duration> +LF
Return Value:	OK or ERR
Remarks:	<hold_off_duration> is the trigger hold off duration in msec and must range from 0 ms to 10,000 ms with a resolution of 0.01 ms.
Compatible Sensor:	MA24208A, MA24218A, MA243x0A

TRGHOLDDLY?

Description:	Gets the trigger hold off duration in msec.
Syntax:	TRGHOLDDLY? +LF
Return Value:	A float value
Compatible Sensor:	MA24208A, MA24218A, MA243x0A

Trigger Noise Immunity

When internally triggering on very noisy signals, the sensor can trigger at an undesired point or edge. To provide immunity against such situations, the sensor can be set to wait for N number of samples to cross the trigger level before it triggers.

The value of N is the trigger noise immunity factor and is set by the "TRGNOISE" command, where N is a value from 1 to 10. Higher values of N result in increased noise immunity, but also increase the trigger latency. It is advised to use a negative trigger delay when using noise immunity. The negative delay required to reduce the trigger latency is the product of N and the sample duration of the power sensor, which is approximately 7 µs.

TRGNOISE

Description:	Sets the trigger noise immunity factor.
Syntax:	TRGNOISE <noise> *+LF*
Return Value:	OK
Remarks:	<noise> is an integer from 1 to 10. Higher values of <noise> result in increased noise immunity, but also increase the trigger latency.
	Note: MA242x8A and MA243x0A always returns Ok (The MA242x8A and MA243x0A sensors are added for compatibility and do not support trigger noise immunity.)
Compatible Sensor:	MA24x08A, MA24x18A, MA24126A, MA243x0A MA242x8A and MA243x0A are added for compatibility and do not support trigger noise immunity.

TRGNOISE?

Description:	Gets the trigger noise immunity factor.
Syntax:	TRGNOISE? *+LF*
Return Value:	An integer from 1 to 10 for MA24108A, MA24118A, MA24126A
	1 for MA24208A, MA24218A, MA243x0A
Compatible Sensor:	MA24x08A, MA24x18A, MA24126A, MA243x0A MA242x8A and MA243x0A are added for compatibility and do not support trigger noise immunity.

Hysteresis

This feature is available during internal triggering. For very noisy signals, the sensor can trigger at an undesired point or edge. To minimize this potential, the sensor can be set to wait for the measured power to be beyond a hysteresis value of +/– X dB from the trigger level before it is rearmed to trigger. The default value for the hysteresis level is +/– 0 dB (no hysteresis).

TRGHYST

Description:	Sets trigger hysteresis value, 0 to 10 dB with 0.1 dB of precision
Syntax:	TRGHYST <value>
Details:	<value> is an integer from 1 to 10
Return Value:	OK or ERR
Compatible Sensor:	MA24208A, MA24218A, MA243x0A

TRGHYST?

Description:	Reads the hysteresis value
Syntax:	TRGHYST? *+LF*
Return Value:	An integer from 1 to 10
Compatible Sensor:	MA24208A, MA24218A, MA243x0A

Trigger Arming

The trigger parameters are effective only if the sensor is *armed*. Armed is the state when the sensor is waiting for a trigger. By default, the sensor is in *Standby* mode and must be armed before it can be triggered. "Trigger Arming" should be the last command sent to the sensor before triggering as any other type of command aborts the armed state and places the sensor in standby mode.

When the sensor is armed, it waits for a trigger indefinitely. Once the trigger occurs, the sensor starts data collection, calculation, and averaging to complete a measurement. The measurement result is sent in dBm (in CA mode) or in mW (in Time Slot and Scope modes). After setting up the sensor, the sensor can be armed as follows:

Auto Armed

In this arming state, the sensor is automatically rearmed after one trigger has occurred and the measurement has been output. Auto Armed is generally used in Time Slot and Scope modes to continuously monitor the signal.

Single Armed

In this arming state, the sensor is armed only once before the trigger. Once triggered, the sensor performs the measurement, outputs the result, and returns to the standby mode. The sensor makes N number of measurement runs and outputs the average power on completion of averaging the N measurements. N is the averaging number set in the sensor. However, in moving average mode, the intermediate moving average power is also sent after each measurement run, the last one being the most accurate as it has the effect of all of the N measurements. The sensor triggers only once and all of the measurements follow.

Multiarmed

In this arming state, the sensor is automatically rearmed for N number of times after each of N trigger events, and then the sensor outputs one measurement result at the completion of all triggered events. N is the number of averages set in the sensor prior to arming (set with the "AVGCNT" command). If there are N averages set in the sensor, the sensor will look for N triggers, make N measurements and send out one averaged power for all of the N triggered measurements. However, in moving average mode, the intermediate, moving average power is also sent after each triggered measurement, the last one being the most accurate as it has the average of all of the N measurements. For multiarmed triggering, at least N triggers must occur for the sensor to complete the entire measurement. The sensor is rearmed until it has received all N number of triggers. Once the measurements are complete, the sensor is set to the Standby mode.

Standby

In standby mode, the sensor is not waiting for a trigger and is UNARMED.

Trigger arming is effective only in the Internal and External trigger modes. Arming has no effect when the sensor is continuously triggered.

`TRGARMTYP`

Description: Sets the trigger arming state.

Syntax: `TRGARMTYP <arm_type>` *+LF*

Return Value: `OK` followed by measurement results, or `ERR`

Note: If user issues any command while the sensor is waiting for trigger, the sensor will return "Aborted" and will set TRGARMTYP to (3) – Standby state.

Remarks: <arm_type> is an integer with the following values:
0 – "Auto Armed"
1 – "Single Armed"
2 – "Multiarmed"
3 – "Standby"

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

`TRGARMTYP?`

Description: Gets the trigger arming state.

Syntax: `TRGARMTYP?` *+LF*

Return Value: An integer with the following values:
0 – "Auto Armed"
1 – "Single Armed"
2 – "Multiarmed"
3 – "Standby"

Compatible Sensor: MA24x08A, MA24x18A, MA24126A, MA243x0A

Chapter 16 — Programming Commands for Power Master

16-1   Introduction

This chapter describes the remote programming for the MA245xxA Power Master. This chapter contains all of the SCPI commands (required and native) that are implemented in the instrument. The SCPI commands are grouped by their respective subsystems. For each subsystem, the commands described in detail in the listing. The notation corresponds to one of the SCPI standards to a large extent.

Device Driver for MS Windows

The Power Master device driver .inf file should be installed in Microsoft Windows. The device driver contains the device specific configuration or settings, such as USB Vendor ID (VID) and Product ID (PID), to bring the Power Master online. The device driver is installed automatically by the PowerXpert installation. To install manually:

1. Open Windows Device Manager by clicking Start and typing "Device Manager", then opening the first result.

2. If the drivers are not already installed, when connected to the PC, the device may show in the Device Manager as "Westbridge" or "Unknown Device". Locate the Power Master in the Device Manager tree by finding the new entry that is added when the device gets connected to the PC.

3. Right click the device in Windows Device Manager and select Update Driver Software...

4. Click "Browse my computer for driver software".

5. Click "Let me pick from a list of device drivers on my computer".

6. Click "Have Disk..."

7. Browse to and select the device driver appropriate for your PC.

8. Click "Next".

9. Allow the driver to finish installing. Windows User Account Control may ask if you want to install the driver.

10. Click yes.

11. Run Anritsu Device Monitor to automatically load the firmware. You will see a Windows error message stating that the backend loader is incomplete. This is to be expected. At this point, the device will re-enumerate as a different device. The drivers will need to be installed again for this new device. Repeat Step 2 through Step 9

The Device Monitor appears in the system tray and provides the MA245xxA Power Master details.
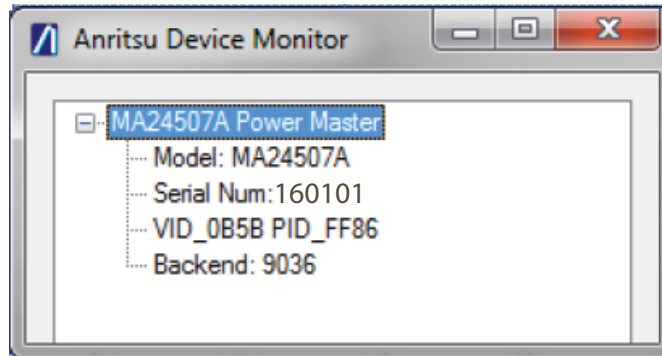
Figure 16-1. Device Monitor

Remote Programming Interface

The MA245xxA Power Master utilizes Super Speed USB 3.0 technology for speed and power and communicates using SCPI commands. In order to provide the SCPI interface via TCPIP socket, the Anritsu Device Monitor must be running on the PC where the device is connected. The Anritsu Device Monitor will recognize when the device is plugged in and launch the necessary background software automatically.

Applications may handle the network socket communication themselves and control the MA245xxA Power Master using the SCPI command set. The IP address of the instrument is the IP address of the PC to which the Power Master is physically connected. If the software is running on the same PC, then the address would be "localhost" or 127.0.0.1, and the network socket port number used by MA245xxA Power Master is 9001. If using a newer version of Windows 10, then the network socket port number used by MA245xxA Power Master is 59001. The MA245xxA Power Master can also be controlled remotely using National Instruments VISA using TCPIP mode.

16-2 IEEE 488.2 Commands

The IEEE-488.2 commands are defined in the IEEE-488.2 standard and must be implemented by all SCPI compatible instruments. The mandated commands listed in Table 16-1 are identified by the asterisk (*) at the beginning of the command keyword. These commands are used to control instrument status registers, status reporting, synchronization, and other common functions.

Table 16-1. IEEE 488.2 Mandated Commands

*CLS	*IDN?	*RST	STB?
*ESE	*OPC	*SRE*	*WAI
*ESE?	*OPC?	SRE?	
*ESR?			

16-3 Command Requirements

Query Commands

All commands, unless specifically noted in the commands syntax descriptions, have a query form. As defined in IEEE-488.2, a query is a command with a question mark symbol appended: (examples: `*IDN?`)
When a query form of a command is received, the current setting associated with the comm and is placed in the output buffer. Query commands always return the short form of the parameter unless otherwise specified. Boolean values are returned as `1` or `0`, even when they can be set as `on` or `off`.

Data Parameters

Data parameters, referred to simply as "parameters," are the quantitative values used as arguments for the command keywords. The parameter type associated with a particular SCPI command is determined by the type of information required to control the particular instrument function. For example, Boolean (ON | OFF) type parameters are used with commands that control switch functions.

Some command descriptions specify the type of data parameter to be used with each command. The most commonly used parameter types are numeric, extended numeric, discrete, and Boolean.

Numeric

Numeric parameters comprise integer numbers or any number in decimal or scientific notation, and may include polarity signs. This includes <NR1>, <NR2>, and <NR3> numeric data as defined in "Data Parameter Notations" below.

Extended Numeric

Extended numeric parameters include values such as MAXimum and MINimum.

Discrete

Discrete parameters, such as INTernal and EXTernal, are used to control program settings to a predetermined finite value or condition.

Boolean

Boolean parameters represent binary conditions and may be expressed as ON, OFF or 1, 0.

Data Parameter Notations

The following syntax conventions are used for data parameter descriptions in this manual:

Table 16-2. Parameter Notations

<arg>	::=a generic command argument consisting of one or more of the other data types
<bNR1>	::=boolean values in <NR1> format; numeric 1 or 0
<boolean>	::=ON | OFF. Can also be represented as 1 or 0, where 1 means ON and 0 means OFF Boolean parameters are always returned as 1 or 0 in <NR1> format by query commands
<integer>	::=an unsigned integer without a decimal point (implied radix point)
<NR1>	::=a signed integer without a decimal point (implied radix point)
<NR2>	::=a signed number with an explicit radix point
<NR3>	::=a scaled explicit decimal point numeric value with and exponent (e.g., floating point number)
<NRf>	::=<NR1>|<NR2>|<NR3>
<numeric_value>	::=SCPI numeric value: <NRf>|MINimum|MAXimum|UP|DOWN|DEFault|NAN (Not A Number)|INFinity|NINFinity (Negative Infinity) or other types
<char>	::=<CHARACTER PROGRAM DATA> Examples: CW, FIXed, UP, and DOWN
<string>	::=<STRING PROGRAM DATA> ASCII characters enclosed by double quotes. For example: "OFF"
<block>	::=IEEE-488.2 block data format
<NA>	::=Not Applicable

Unit Suffixes

Unit suffixes are not required for data parameters, provided the values are scaled for the global default units. The instrument SCPI default units are:

- Hz (Hertz) for frequency related parameters
- s (seconds) for time related parameters
- m (meters) for distance related parameters
- dB relative power value
- dBm absolute power value

16-4   Notational Conventions

The SCPI interface standardizes command syntax and style that simplifies the task of programming across a wide range of instrumentation. As with any programming language, the exact command keywords and command syntax must be used. Unrecognized commands or improper syntax will not function.

Table 16-3. Notational Conventions

:	A colon links command keywords together to form commands. The colon is not an actual part of the keyword, but is a signal to the SCPI interface parser. A colon must precede a root keyword immediately following a semicolon.
;	A semicolon separates commands if multiple commands are placed on a single program line.
[ ]	Square brackets enclose one or more optional keywords.
{ }	Braces enclose one or more keyword or command parameters that may be included one or more times.
|	A vertical bar indicates "or" and is used to separate alternative parameter options. Example: ON | OFF is the same as ON or OFF.
< >	Angle brackets enclose parameter descriptions.
::=	Means "is defined as" For example: <a>::=<b><c> indicates that <b><c> can replace <a>.
sp	Space, referred to as *white space*, must be used to separate keywords from their associated data parameters. It must not be used between keywords or inside keywords.
XXX	Indicates a root command name

For further information about SCPI command syntax and style, refer to the Standard Commands for Programmable Instruments (SCPI) 1999.0 document.

16-5   Programming the MA245xxA Power Master

Send and Receive Format

Every network socket communication with the Power Master must be suffixed with the line feed (*LF*) character (ASCII 0x0A). Every response from the Power Master is also suffixed with the same character (except when using Microsoft HyperTerminal, which uses a carriage return as the identifier). The Power Master will not respond to any commands until it receives a line feed character. All commands and responses mentioned in this document are assumed to be suffixed with a new line character. The following considerations must also be observed:

- Command arguments presented in this document are enclosed in angle brackets: <argument>. The angle brackets are not included as part of the actual argument.
- Floating point numbers are truncated to integers by commands that only use integers as input. For example, if the number of averages is set as 2000.937, the value is truncated to 2000.

Error Responses

When using network socket communication and SCPI commands, any unrecognized command will be ignored and a message will be added to the error queue. Error messages can be read and removed from the queue using the SYST:ERR? query.

Default Power Master Settings

The Power Master settings in Table 16-4 apply to the MA245xxA Power Master.

Table 16-4. General Default Settings

Setting	Command	Default Value
Average Count	`[:SENSe]:AVERage:COUNt`	10
Average State	`[:SENSe]:AVERage:STATe`	0
Center Frequency	`[:SENSe]:FREQuency:CENTer`	35,000,004,500
Channel Power State	`[:SENSe]:CHPower:STATe`	0
Channel Width	`[:SENSe]:FREQuency:CHWidth`	69,999,991,000
CW Max Count	`:CALCulate:CWMax:COUNt`	1
CW Max Threshold Level	`:CALCulate:CWMax:THReshold`	0
CW Max Threshold State	`:CALCulate:CWMax:THReshold:STATe`	0
Preamp State	`[:SENSe]:POWer:RF:GAIN:STATe`	0
Relative Mode	`[:SENSe]:POWer:RELative`	0
Resolution	`[:SENSe]:RESolution[?]`	LOW
Sweep Type	`:INITiate:CONTinuous`	1

16-6   Common Commands

The set of system common commands are primarily used to control the state of the instrument for system diagnostics, hardware calibration, and troubleshooting.

*CLS

Title:	Clear Status Command
Description:	This command clears all status data structures in the device (registers and error queue) and forces the Operation Complete state to Idle.

*ESE <NR1>
*ESE?

Title:	Standard Event Status Enable
Description:	This command provides access the Standard Event Status Enable Register. Refer to IEEE 488.2 for more information on the contents of this register.
Parameters:	<NR1>
Query Output:	<NR1>
Range:	0 to 255

*ESR?

Title:	Standard Event Status
Description:	This command queries the Standard Event Status Register. Refer to IEEE 488.2 for more information on the contents of this register.

*IDN?

Title:	Identification Query
Description:	This command returns the following information in <string> format separated by commas: manufacturer name ("Anritsu"), model number, serial number, firmware package number. The model number and options are separated by a "/" and each option is separated by a "/".

*OPC <NR1>
*OPC?

Title:	Operation Complete
Description:	The *OPC command causes the device to set the OPC bit of the Standard Event Status Register on the next transition of the No Operation Pending flag from false to true. The *OPC? command returns 1 in the response whenever the No Operation Pending Flag is true.
Parameters:	N/A
Query Output:	<NR1>

*RST

Title: Reset

Description: This command restores most application and system settings to their factory default value. System settings affected by this command are Ethernet configuration. Note that the unit will power-cycle after this command is executed. After executing this command communication will be lost. Wait a minimum of 30 seconds before re-establishing communication.

*SRE <NR1>
*SRE?

Title: Service Request Enable

Description: Service Request Enable. The command sets the Service Request Enable Register bits. A zero value in the command resets the register. The query returns the value of the Service Request Enable Register in <NR1> format. Bit 6 is always zero.

Parameters: <integer>

Query Output: <NR1> Returns the value of the Service Request Enable Register

Range: 0 to 255

*STB?

Title: Status Byte Query

Description: This command queries the Status Byte Register. Refer to IEEE 488.2 for more information on the contents of this register.

Query Output: <NR1>

*WAI

Title: Wait-to-Continue Command

Description: This command causes the device to execute no further commands or queries until the No Operation Pending flag is TRUE.

16-7   System Commands

System commands control instrument functions and some general purpose functions.These commands affect instrument functionality that does not directly relate to data collection, display or transfer.

:SYSTem:ERRor[:NEXT]?

Title: System Error Queue

Description: If an error occurs, the error number and message are placed in the error queue, which can be read by this query command. Errors are cleared by reading them.

- Error code 0, is "No error".
- Error codes from –100 to –199 belongs to the Command error category and sets bit 5 of the standard ESR register.
- Error codes from –200 to –299 belongs to the Command error category and sets bit 4 of the standard ESR register.
- Error codes from –400 to –499 belongs to the Query error category and sets bit 2 of the standard ESR register.
- Error codes from –300 to –399 and 1 to 32767 belongs to the Device-specific error and sets bit 3 of the standard ESR register.

Negative error numbers (command error, execution error, device-dependent error, query error) are standard SCPI errors.

Positive error numbers are device specific errors, not standard SCPI errors.

The error queue is also cleared by *CLS, *RST, and when power is turned on. If more errors have occurred than can fit in the buffer, the last error stored in the queue (the most recent error) is replaced with –350, Queue overflow. No additional errors are stored until removing errors from the queue. If no errors have occurred when reading the error queue, the instrument responds with 0, No error.

:SYSTem:PRESet

Title: Preset

Description: This command presets parameters in the current application to their factory default values.

16-8   MA245xxA Power Master Commands

General purpose commands for the MA245xxA Power Master are used to set/read the general settings of the Power Master. These commands are not mode or trigger dependent. The following considerations must also be observed:

- Command arguments presented in this document are enclosed in angle brackets: <argument>. The angle brackets are not included as part of the actual argument.
- Only SCPI commands that contain a question mark (?) called queries will return a value. No response should be expected for non-query commands.

:ABORt

Title: Abort

Description: Resets the trigger system. This has the effect of aborting the sweep or any measurement that is currently in progress. Additionally, any pending operation flags that were set by initiation of the trigger system will be set to false. If :INITiate:CONTinuous is OFF (i.e. the instrument is in single sweep mode), send the command :INITiate[:IMMediate] to trigger the next sweep. If :INITiate:CONTinuous is ON (i.e. the instrument is in continuous sweep mode) a new sweep will start immediately.

:CALCulate:CWMax:COUNt <integer>
:CALCulate:CWMax:COUNt?

Title: Peak Count.

Description: The desired number of measured signals to be reported by :FETC:CWMax? query.

Parameters: <integer>

Query Output: <integer>

Default Value: 1

Range: 1 to 6

:CALCulate:CWMax:THReshold <numeric_value>{DBM}
:CALCulate:CWMax:THReshold?

Title: CW Max Threshold Level

Description: Sets the threshold level which measured power must exceed to be reported by :FETC:CWMax? query.

Parameters: <numeric_value> {DBM}

Query Output: <NR2> Returns value in dBm

Default Value: 0 dBm

Default unit: dBm

Range: −150 dBm to 30 dBm

`:CALCulate:CWMax:THReshold:STATe <0|1|ON|OFF>`
`:CALCulate:CWMax:THReshold:STATe?`

Title: CW Max Threshold State

Description: Turn ON|OFF the threshold that the power must exceed to be reported by a :FETch:CWMax? query.

Parameters: <0|1|ON|OFF>

Query Output: 0|1

Default Value: OFF

`:FETCh:CWMax?`

Title: Fetch CW Max Power

Description: Returns the most recent CW max power measurement result. If the instrument is not sweeping and the current data is not valid, it will return error –230. This could occur if there was a *RST immediately before the :FETChCWMax? or if a measurement parameter was changed without an :INITiate, and the query will return the string "nan".

Parameters: N/A

Query Output: <NR2> returns a comma-delimited list of CW Max power measurement result pairs as <frequency in Hz, power in dBm>

Default Value: 0

`:FETCh:POWer?`

Title: Fetch Channel Power

Description: Returns the most recent integrated power measurement result. If the instrument is measuring, it will not return until the measurement is complete. If the instrument is not measuring and the current data is not valid it will return error –230. This could occur if there was a *RST immediately before the :FETCh? or if a measurement parameter was changed without an :INITiate. If the measurement is not enabled with [:SENSe]:CHPower:STATe then, the instrument will indicate error –400 and return the string "nan"

Parameters: N/A

Query Output: <NR2> Returns the most recent integrated power measurement result in dBm.

:INITiate:CONTinuous <0|1|ON|OFF>
:INITiate:CONTinuous?

Title:	Sweep Type
Description:	Specifies whether the sweep/measurement is triggered continuously. If the value is set to ON or 1, another sweep/measurement is triggered as soon as the current one completes. If continuous is set to OFF or 0, the instrument remains initiated until the current sweep/measurement completes, then enters the "idle" state and waits for the :INITiate[:IMMediate] command or for :INITiate:CONTinuous ON.

If :INITiate:CONTinuous is changed to ON before the current sweep/measurement completes, a new sweep/measurement will be continuously triggered as soon as the current sweep/measurement completes. If :INITiate[:IMMediate] is received before the current sweep/measurement completes, it will be ignored. Clients must either wait for the current sweep/measurement to complete before triggering a 'single sweep', or :ABORt the sweep/measurement after setting :INITiate:CONTinuous to OFF (which will cause the instrument to immediately enter the idle state where it can accept new triggers).

The default value is ON. That is, sending :INIT:CONT is equivalent to sending :INIT:CONT ON. The query version of the command returns a 1 if the instrument is continuously sweeping/measuring and returns a 0 if the instrument is in single sweep/measurement mode.

Parameters:	<0|1|ON|OFF>
Query Output:	0|1
Default Value:	ON

:INITiate[:IMMediate]

Title:	Initiate measurement
Description:	Triggers a measurement

:STATus:OPERation[:EVENt]?

Title: Get Operation Status

Description: This command requests information about the current status of the instrument. Each bit of the return value represents some operation. Only a subset of the bits are implemented for each application. The number returned is the decimal representation of the bit-wise OR of the enabled bits:

Bit	Decimal	Value Description
0	1	Not implemented
1	2	Not implemented
2	4	Not implemented
3	8	Not implemented
4	16	Not implemented
5	32	Not implemented
6	64	Not implemented
7	128	Not implemented
8	256	Sweep Complete

The Sweep Complete bit is set to 0 when the command :INITiate[:IMMediate] is sent to trigger a sweep. It will have a value of 1 when the sweep has completed.

Query Output: <NR1> Returns value 0 to 256

[:SENSe]:AVERage:COUNt <numeric_value>
[:SENSe]:AVERage:COUNt?

Title:	Sense Average Count
Description:	Sets the effective number of averages.
Parameters:	<numeric_value>
Query Output:	<NR2>
Default Value:	10
Range:	2 to 1000

[:SENSe]:AVERage:STATe <0|1|ON|OFF>
[:SENSe]:AVERage:STATe?

Title:	Sense Average State
Description:	Specifies whether successive power readings are averaged or not. Turning average state to ON will cause the measured power value to be the average of the last <integer> measured values where <integer> is set by [:SENSe]:AVERage:COUNt. This setting only applies when the [:SENSe]:CHPower:STATe is also ON.
Parameters:	<0|1|ON|OFF>
Query Output:	0|1
Default Value:	OFF

[:SENSe]:CHPower:STATe <0|1|ON|OFF>
[:SENSe]:CHPower:STATe?

Title:	Channel Power State
Description:	Sets the state of the channel power measurement, ON or OFF.
Parameters:	<0|1|ON|OFF>
Query Output:	0|1
Default Value:	OFF

[:SENSe]:FREQuency:CENTer <numeric_value>{HZ|KHZ|MHZ|GHZ}
[:SENSe]:FREQuency:CENTer?

Title:	Center Frequency
Description:	Sets the center frequency. Note that changing the value of the center frequency will change the value of the coupled parameters Start Frequency and Stop Frequency. It may also change the value of the span.
Parameters:	<numeric_value> HZ|KHZ|MHZ|GHZ
Query Output:	<NR2> Returns frequency value in Hz
Default Value:	35000004500
Default Unit:	Hz
Range:	9500 Hz to 69999999500 Hz (MA24507A)
Range:	9500 Hz to 110999999500 Hz (MA24510A)

[:SENSe]:FREQuency:CHWidth <numeric_value>{HZ|KHZ|MHZ|GHZ}
[:SENSe]:FREQuency:CHWidth?

Title:	Channel Width
Description:	Sets the channel width for power measurements. The measured channel is centered around the [:SENSe]:FREQuency:CENTer value. The center frequency plus half the channel width may not exceed the maximum measuring frequency of the instrument.
Parameters:	<numeric_value> HZ|KHZ|MHZ|GHZ
Query Output:	<NR2> Returns frequency value in Hz
Default Value:	69999991000
Default Unit:	Hz
Range:	1000 Hz to 69999991000 Hz

[:SENSe]:POWer:RELative <0|1|ON|OFF>
[:SENSe]:POWer:RELative?

Title:	Relative Power Mode
Description:	When the user enables Relative Mode the software begins to give power readings relative to the most recent power read before the command was sent. When Relative Power Mode is ON, all results returned by the :FETCh:POWer? and :FETCh:CWMax? queries are in units of dB as opposed to dBm.
Parameters:	<0|1|ON|OFF>
Query Output:	0|1
Default Value:	OFF

[:SENSe]:POWer:RF:GAIN:STATe <0|1|ON|OFF>
[:SENSe]:POWer:RF:GAIN:STATe?

Title:	Preamp
Description:	Sets the state of the internal amplifier for improved accuracy when measuring low-power signals.
Parameters:	<0|1|ON|OFF>
Query Output:	0|1
Default Value:	OFF

[:SENSe]:RESolution HIGH|MEDium|LOW
[:SENSe]:RESolution?

Title:	Power Resolution Mode
Description:	Specifies the resolution of the power measurement in CW max mode only. The resolution determines the relative precision of the frequency reported when getting the CW max power results with the :FETCh:CWMax? query. There is a trade-off between measurement speed and resolution so HIGH resolution will produce fewer measurements per unit time than LOW resolution.
Parameters:	HIGH|MEDium|LOW
Query Output:	LOW, MED, or HIGH
Default Value:	LOW

Appendix A — Using Demo Application

A-1   MA241xxA Series Demo Application

The demo application for MA241xxA series USB power sensors allows you to interface with the sensor using the remote programming protocol. To download the drivers and demo application, go to the "Library" section of the product page for your sensor at: http://www.anritsu.com. The Demo Application's interface is shown in Figure 1-A below:
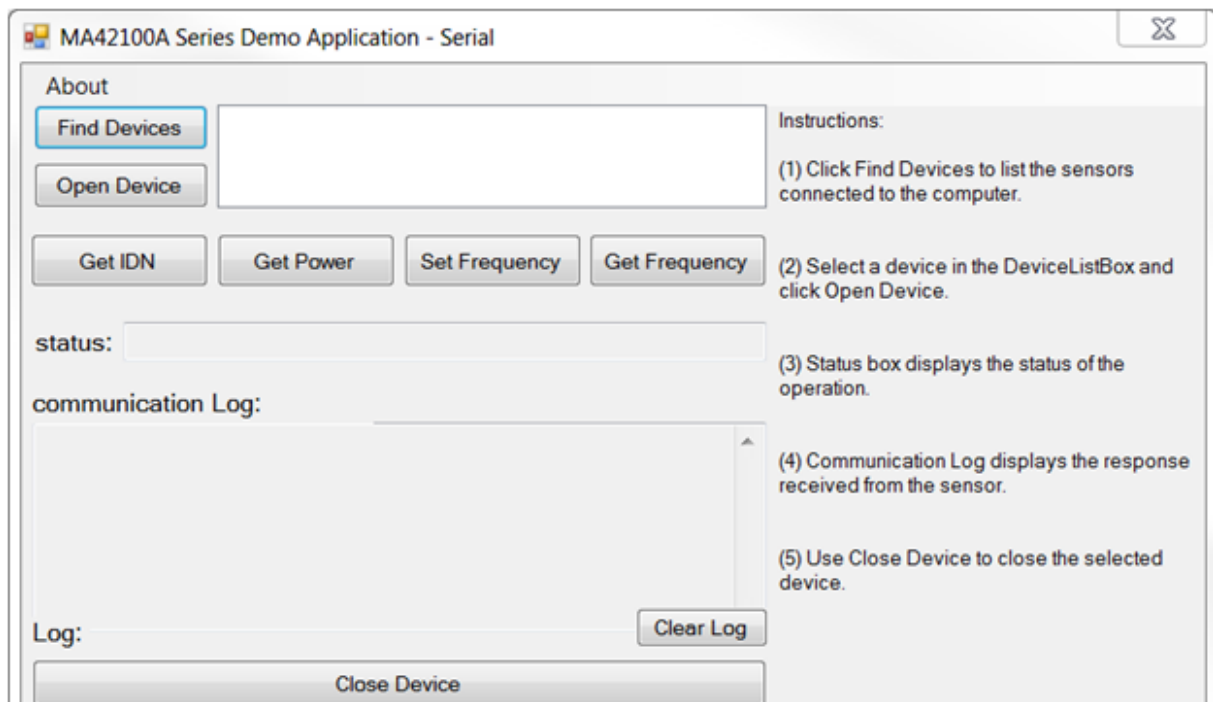
Figure A-1.   Demo Application

Anritsu recommends that you use the source code and project available on the Anritsu website to get the latest version.

Launch the Demo Application:

1. User must close all applications which communicate with power sensors prior to running the Demo Application. The driver and demo app folder on anritsu.com provides the Overview, Getting Started Instructions and Sample Code to launch the Demo Application. Double click on **DemoApp.exe**. The application screen shown in Figure A-1 will appear.

2. Connect the power sensor to the PC using the USB cable and click Find Devices.

3. Select the desired sensor from the device list and click Open Device

4. Once the device is opened successfully, you can use the function buttons provided for power readings, frequency readings and settings. Find the Code C# link in your downloaded folder as well.

A-2   Using the MA242x8A, MA243x0A Series Demo Application

The demo application for MA242x8A and MA243x0A series USB power sensors allows you to interface with the power sensor using the remote programming protocol. The sample code is available on the Anritsu Website at: http://www.anritsu.com. Simply search for your sensor, open the product page, and find the drivers and demo app download in the "Library" section, or click here: Drivers Software Downloads. The Anritsu Sensor Driver DLL provides.NET 4.0 based API that can be used within the application to connect to and interact with a USB power sensor. The Demo Application's interface is shown below:
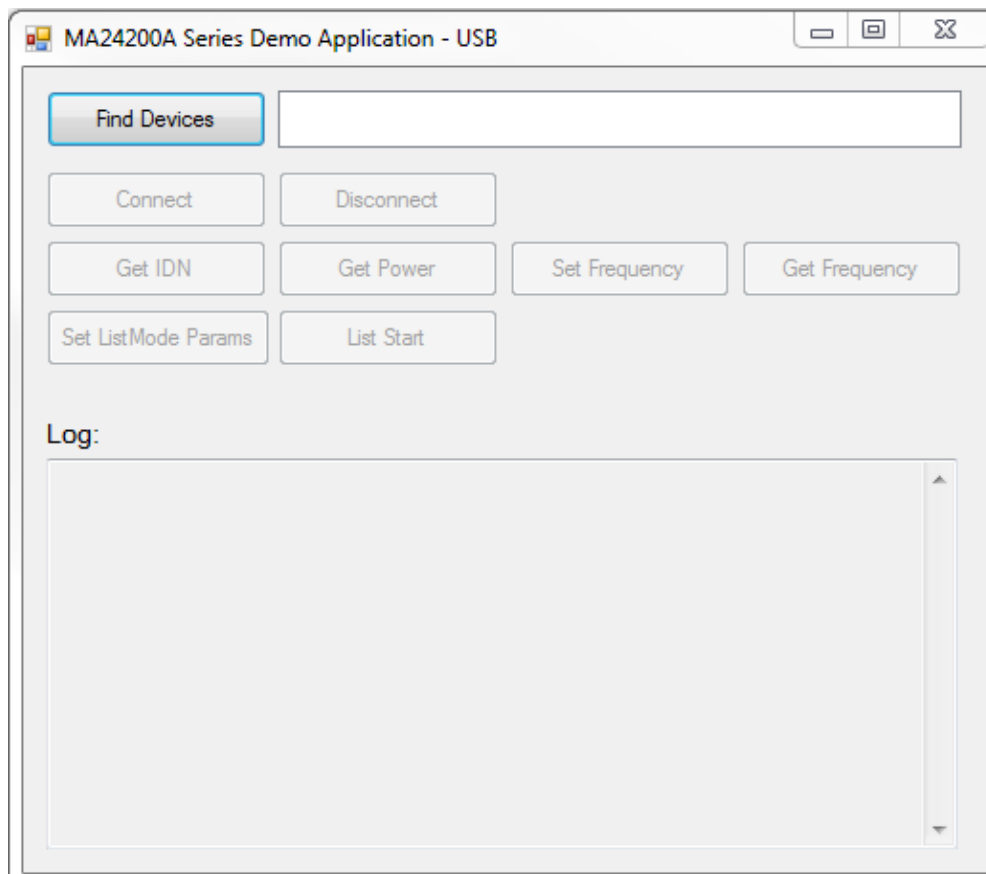
Figure A-2.   Demo Application

Anritsu recommends that you use the source code and project available on the Anritsu website to get the latest version.

Launch the Demo Application:

1. User must close all applications which communicate with power sensors prior to running the Demo Application. The Anritsu Sensor Driver Reference Guide downloaded from the web provides the Overview, Getting Started Instructions and Sample Code to launch the Demo Application. Double click on **BBSensorDriverDemo.exe**. The application screen shown in Figure A-2 will appear.

2. Connect the power sensor to the PC using the USB cable and click Find Devices.

3. Select the desired sensor from the device list and click Open Device

   Once the device is opened successfully you can use the function buttons provided for power readings, frequency readings and settings, Set List Mode Parameters and List Start. Find the Code C# link in your download folder as well.

Appendix B — Upgrading Power Sensor Firmware – MA241xxA Series

B-1   Introduction

Upgrade the Anritsu MA241xxA power sensor's firmware using PowerXpert. Follow the applicable procedure for your sensor model as described in the following sections:

- Section B-2 "MA24106A Firmware Upgrade"
- Section B-3 "MA24105A, MA24108A, MA24118A, and MA24126A Firmware Upgrade"

The current sensor firmware can be determined by expanding the Sensor Information list in PowerXpert.
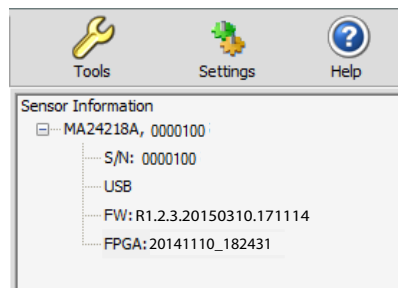
Figure B-1.   Checking Current Firmware Version

B-2   MA24106A Firmware Upgrade

Warning	Before launching the firmware upgrade utility, make sure that you have the firmware file available. Failure to complete the firmware installation will render the power sensor inoperable.

1. Download the latest firmware upgrade file for your sensor model from http://www.anritsu.com and save it to C:\Program Files (x86)\Anritsu\PowerXpert\Drivers.

2. Launch the Update Firmware command from the **Tools** menu. See Figure B-2.
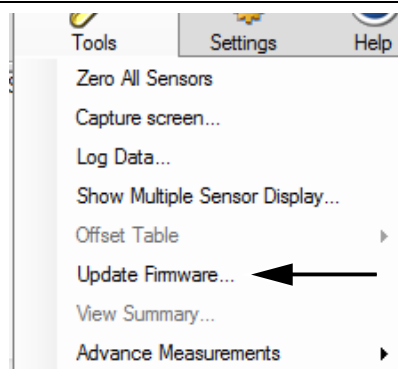
Figure B-2.   Update Firmware

---

3. Click through and following the on-screen instructions.
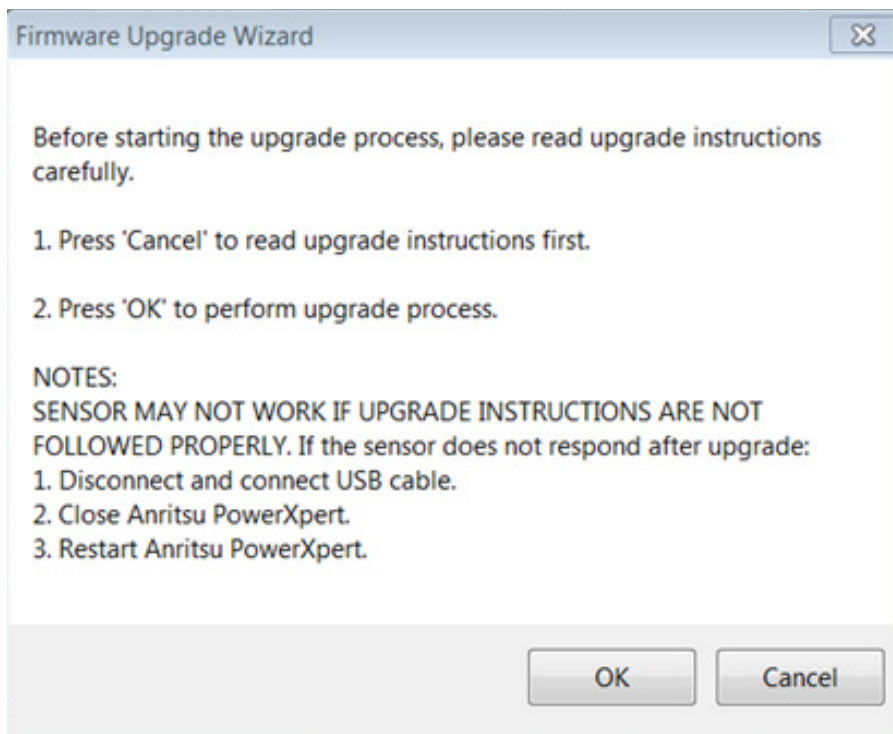
Figure B-3.   Firmware Installation Dialog Screen 1

4. Continue to the next screen as shown below.
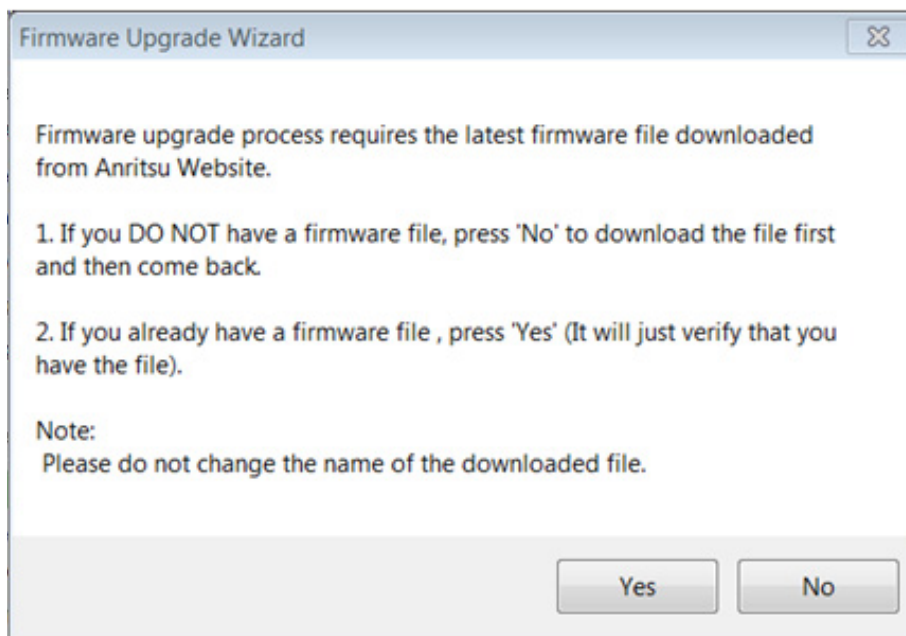
Figure B-4.   Firmware Installation Dialog Screen 2

5. Initiate the update process as follows:
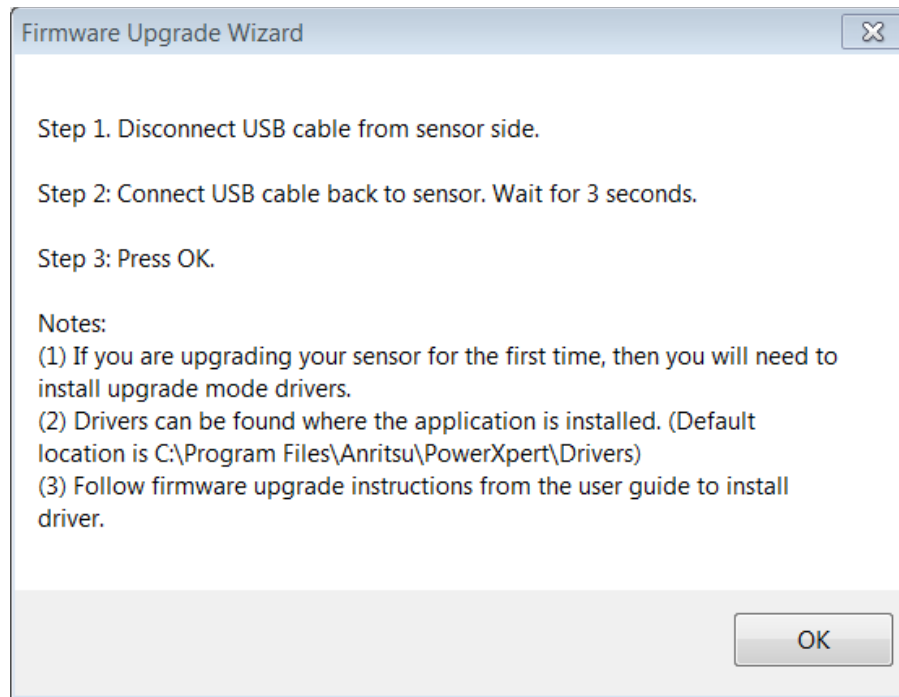
Figure B-5.   Firmware Installation Dialog Screen 3

6. Click Open after selecting the file.
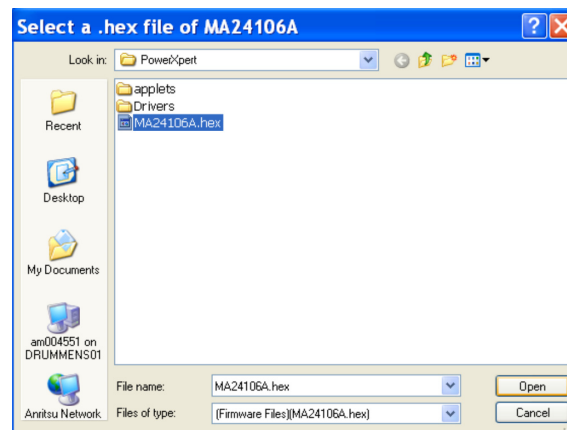
Figure B-6.   Verifying Location of Firmware File

7. If this is the first time you are upgrading the sensor's firmware, the power sensor upgrade driver must be installed. In this case, the Windows Found New Hardware wizard automatically starts so the driver can be installed before the firmware upgrade can continue. If the upgrade driver has already been installed, go to Step 9 to continue firmware installation.

8. The power sensor upgrade driver installation is similar to the power sensor driver installation detailed in "Installing Power Sensor Drivers" on page 2-3. During the upgrade driver installation, Windows will ask for the path to the driver file to install mchpusb.sys (mchpusb64.sys for 64-bit systems). During this step, browse to the program installation directory:
C:\Program Files (x86)\Anritsu\PowerXpert\Drivers
Select the file and complete the upgrade driver installation.
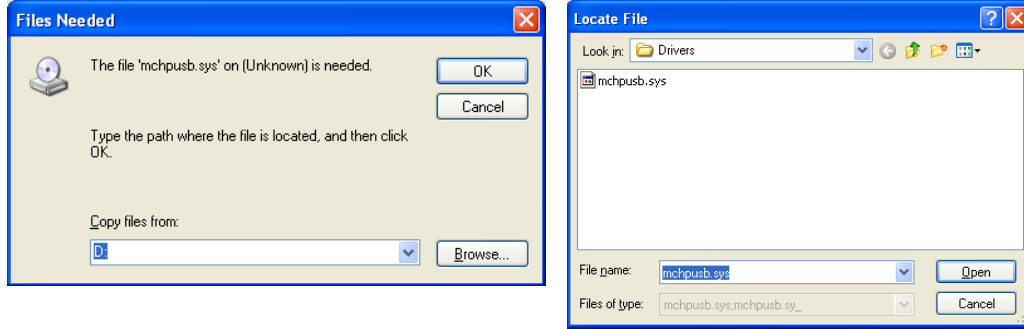
Figure B-7.   Windows Locate File Dialog

9. If the upgrade driver is installed, click **OK** (Figure B-8) to continue with the firmware upgrade. The Firmware Upgrade Application shown in Figure B-9 appears.
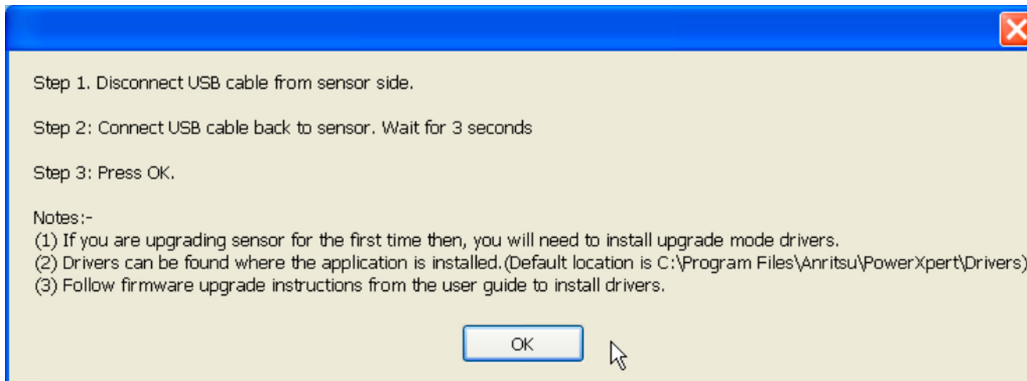
Figure B-8.   Continuing with Firmware Update

10. Select the power sensor that you intend to upgrade from the drop-down list field.

Figure B-9.   Firmware Upgrade Application

11. Click **Load HEX File** and select the HEX file from the directory in which it was saved.

A navigation dialog will open so you can find and select the hex file (Figure B-10).

12. Select the hex file for your sensor and click Open.

The Firmware Upgrade Application reappears (Figure B-11).
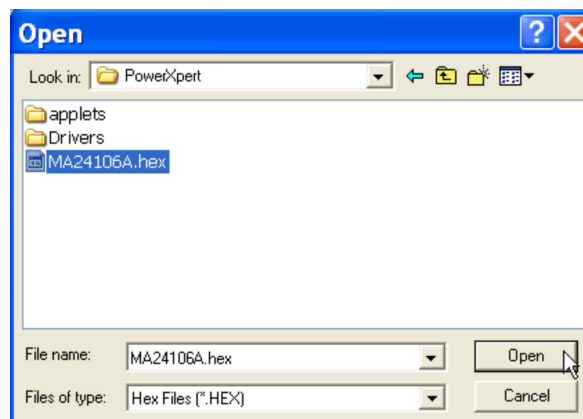
Figure B-10. Select Hex File Dialog

Warning	Do not disconnect the power sensor from the USB port or interrupt the firmware write sequence as this will cause an unrecoverable programming error and render the power sensor inoperable.

13. Click **Program Device**. The following messages will be displayed during the program operation:

```
MESSAGE - Programming FLASH Completed

MESSAGE - Erasing and Programming FLASH...
```
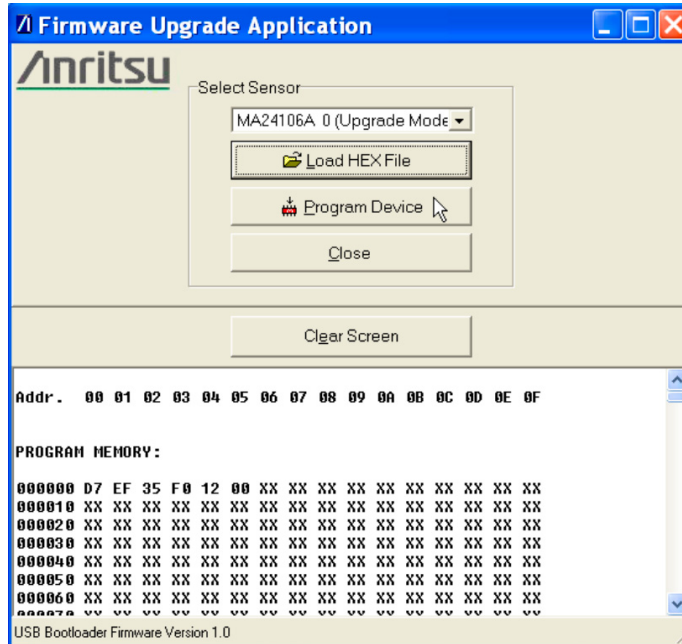

Figure B-11. Firmware Upgrade Application

14. Disconnect the USB cable from the power sensor and then reconnect it.

15. Close the Firmware Upgrade Application.
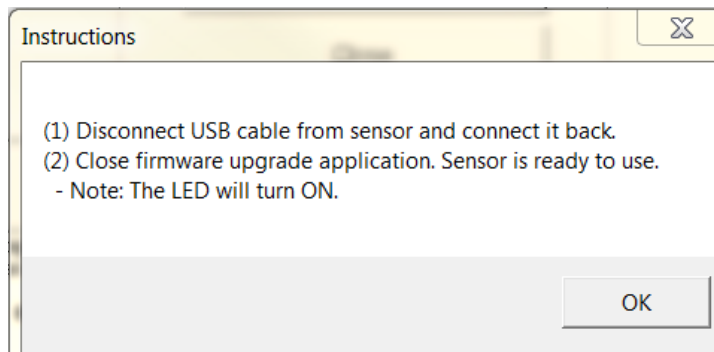
Figure B-12.

The sensor should be ready to use.

16. If the status LED on the power sensor is green, the sensor is programmed successfully and the Anritsu PowerXpert application should automatically detect the upgraded sensor.

B-3   MA24105A, MA24108A, MA24118A, and MA24126A Firmware Upgrade

1. Download the appropriate firmware upgrade file for your sensor model number from http://www.anritsu.com and save it to C:\Program Files\Anritsu\PowerXpert\.

Warning	Before launching the firmware upgrade utility, make sure that you have the sensor firmware file available. Failure to complete the firmware installation will render the power sensor inoperable. Earlier versions of the MA24108A and MA24118A power sensors used an Atmel upgrade driver. This driver must first be uninstalled from the USB devices listed in Windows Device Manager **before** upgrading the firmware. See "Removing Old Upgrade Driver" on page B-11.

Note	If for any reason the sensor becomes stuck in upgrade mode, the message "**Found a sensor in Upgrade mode, click here to Upgrade or Restore**." (Figure B-13) appears on the PowerXpert window. Click on the message to continue the upgrade or to restore the sensor to its original firmware state. Follow the instructions below starting at Step 7.
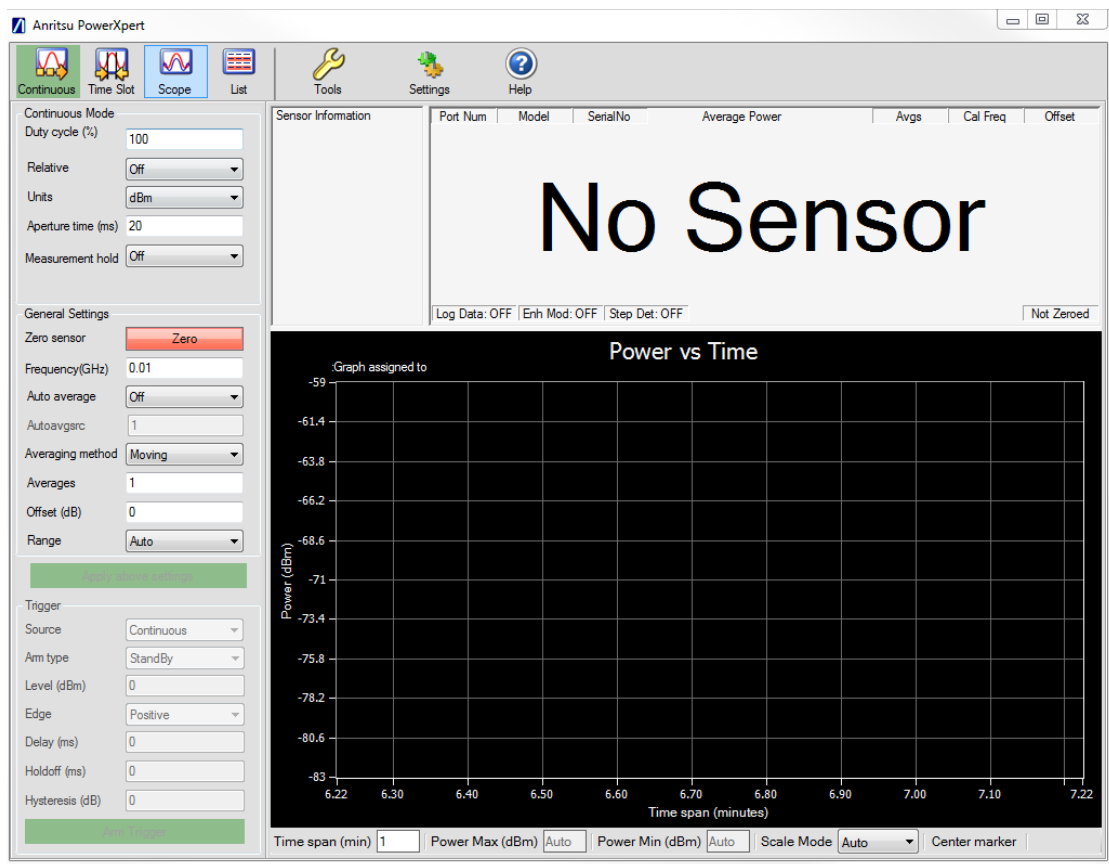
Figure B-13. Sensor in Upgrade Mode Indication

2. Launch PowerXpert.

3. Launch the Update Firmware command from the **Tools** menu.

4. Follow the on-screen instructions and refer to the following detailed instructions as needed.

5. First the upgrade wizard verifies the firmware upgrade file is on your computer. A navigation window (Figure B-14 on page B-8) automatically opens to the default location: C:\Program Files\Antritsu\PowerXpert\. If this is not the location to which you downloaded the file, you will need to navigate to its download location.
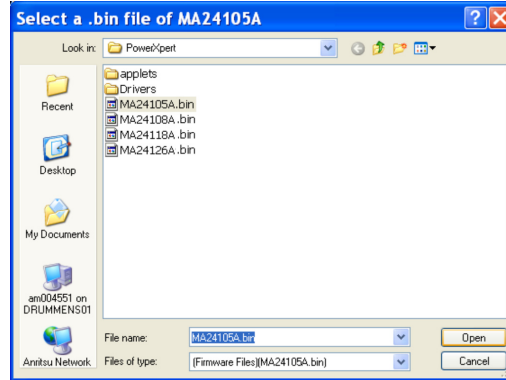
Figure B-14. Firmware File Access Verification

6. Select the appropriate file name for your sensor and click Open.

When this command is sent, the message shown in Figure B-15 appears, the sensor goes into upgrade mode, and the sensor status LED turns amber color. The LED must turn green before continuing.
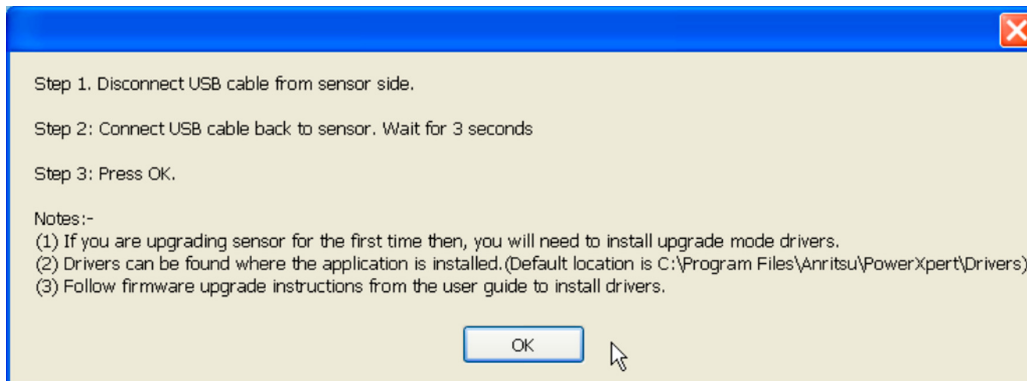
Figure B-15. Firmware Upgrade Dialog

Note	If this is the first time you are upgrading the sensor's firmware, the power sensor upgrade driver must first be installed. In this case, the Windows Found New Hardware wizard automatically starts so the driver can be installed *before* the firmware upgrade continues.
	Install the driver *before* clicking **OK** in the dialog box shown above in Figure B-15. If **OK** is clicked before the driver is installed, the COM port of the sensor will not be enumerated in the upgrade utility and the upgrade cannot proceed. When this happens, disconnect the USB cable from the sensor, close and restart the PowerXpert application, then reconnect the sensor. The message shown in Figure B-13 on page B-7 will appear. Follow the instructions in the message to resume the upgrade.
	The power sensor upgrade driver installation is similar to the power sensor driver installation detailed in "Installing Power Sensor Drivers" on page 2-3 except that the sensor will be identified as "Anritsu Sensor Upgrade Driver". The system should automatically find the driver and install it after a warning.
	Windows 7 operating system: the "Anritsu Sensor Upgrade Driver" is referred to as "GPS camera detect" by the OS because of a conflict in the driver. The SAM-BA functionality remains unaffected.
	If the upgrade driver has already been installed, go to Step 7 to continue firmware upgrade.

7. If the upgrade driver is installed, continue with the firmware upgrade by following the on-screen steps shown in Figure B-15. The same steps are listed below:

    a. Disconnect the USB cable at the sensor end.

    b. Reconnect the USB cable at the sensor. Wait a few seconds.

    c. Click OK.

Note	If the SAM-BA firmware upgrade utility does not start automatically, start it from: C:\Program Files\Anritsu\PowerXpert**SensorUpgradeUtility.exe**

8. The SAM-BA connection dialog appears as shown in Figure B-16. Select the connection and board as follows:

    a. Select or type the connection: **COMX**, where X is the COM port number to which the upgrade mode sensor is connected.

        The COM port number can be checked from the Windows Device Manager. If you do not see the sensor listed in the **Device Manager | Ports**, see "Removing Old Upgrade Driver" on page B-11.

    b. Select your board: **USB_POWER_SENSOR**

Note	The SAM-BA firmware upgrade utility requires that the serial ports between COM2 and COM49 be used. You can find out the COM port number by going to: Start | Settings | Control Panel | System | Hardware | Device Manager | Ports (COM & LPT). If the assigned COM port for the "Anritsu Sensor Upgrade Driver" is COM50 or greater, then the COM port number must be reassigned to less than COM50 and the SAM-BA firmware upgrade utility must be relaunched from C:\Program Files\Anritsu\PowerXpert\SensorUpgradeUtility.exe. Refer to Appendix D for additional information.

Figure B-16. SAM-BA Configuration Dialog

   9. Click **Connect** to proceed.

      The External RAM init. dialog then appears.

10. Click **Yes** on the External RAM init. dialog.
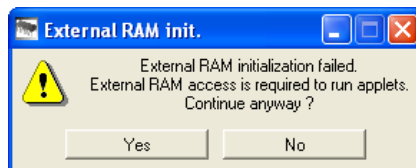
Figure B-17. External RAM init. Dialog

Note	If the sensor is stuck in the Upgrade mode and you are returning it to its original firmware state, in the next step click on the "Execute" button only.

11. When the SAM-BA firmware upgrade utility shown in Figure B-18 appears, do the following:

   a. In the Send File Name field, browse for the latest firmware file downloaded from the Anritsu Web site (MA24105A.bin, MA24108A.bin, MA24118A.bin, or MA24126A.bin).

   b. Click **Send File** (a Sending File status message should pop up).

   c. After the bin file is sent, click **No** in the Lock region(s) to lock pop-up dialog.

   d. In the scripts group field, select Boot from flash (GPNVM 2), and then click **Execute**.
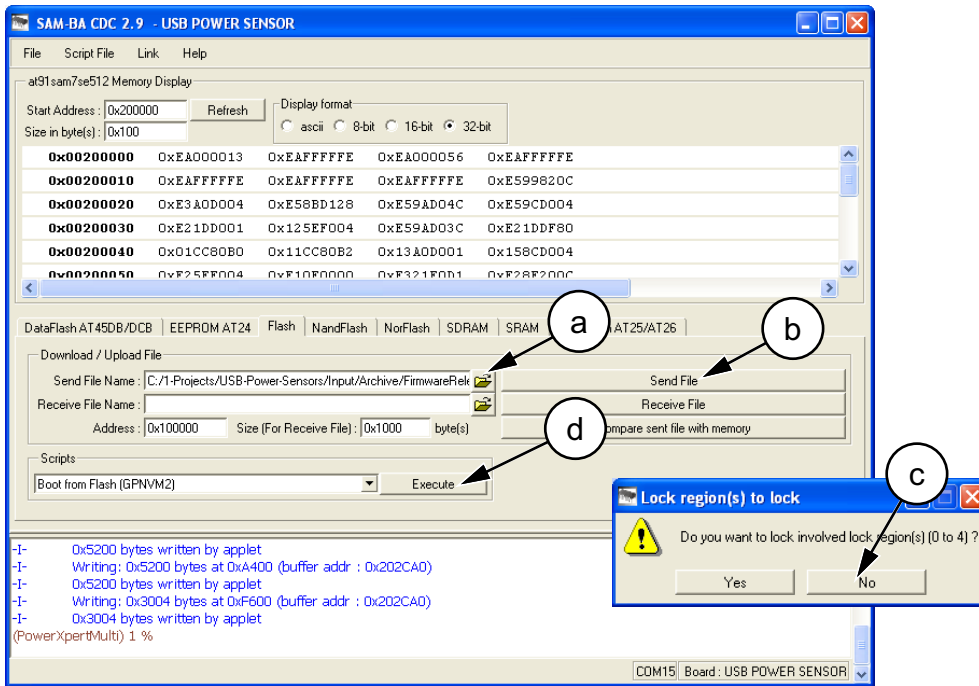
Figure B-18. SAM-BA Firmware Upgrade Utility

12. Close the SAM-BA interface and disconnect the sensor from the USB cable.

13. Reconnect the sensor.

   If the status light is green, the sensor is programmed successfully and the Anritsu PowerXpert application automatically detects the upgraded sensor.

B-4   Recovering a Sensor Stuck in Firmware Upgrade Mode

If for any reason the sensor becomes stuck in firmware upgrade mode, the message "**Found a sensor in Upgrade mode, Click here to Upgrade or Restore.**" appears on the PowerXpert window (see Figure B-13 on page B-7). To recover the sensor:

1. Click on the message to begin the restore process.

2. Perform Step 7 through Step 10 in Section B-3.

3. When the SAM-BA utility screen appears, click the Execute button **only** to restore the original sensor firmware.

4. Close the SAM-BA interface and disconnect the sensor from the USB cable.

5. Reconnect the sensor.

6. If the status light is green, the sensor is restored successfully and the Anritsu PowerXpert application automatically detects the sensor.

B-5   Removing Old Upgrade Driver

Earlier versions of the MA24108A and MA24118A power sensors used an Atmel upgrade driver. This driver must first be uninstalled from the USB devices listed in Windows Device Manager before upgrading the firmware. Use the following steps to check for and remove the old driver.

1. To find out if your sensor uses the Atmel upgrade driver, start Update Firmware and follow the instructions including disconnecting and reconnecting the USB cable.

   The sensor should show up as Anritsu Sensor Upgrade Driver in **Device Manager | Ports**. If it **does not** show up in the list and does not ask for a driver, perform the remaining steps to remove the old driver and install the new one.

2. The old driver can be seen in **Device Manager | Universal Device Controllers** listed as atm6124.sys ATMEL AT91xxxxx Test Board when you connect a sensor in upgrade mode. Right-click this item and select **Uninstall** to remove this driver.

3. Disconnect and reconnect the USB cable at the sensor. The system should look for a driver and start the Windows Found New Hardware wizard .

4. Follow the wizard instructions to complete the driver installation. You should now see the sensor listed as Anritsu Sensor Upgrade Driver in **Device Manager | Ports** and be able to complete the sensor firmware upgrade.

Appendix C — Updating Power Sensor Firmware - MA242x8A and MA243x0A Series

C-1 Introduction

Upgrade the Anritsu MA242x8A and MA243x0A power sensor's firmware using PowerXpert. The current sensor firmware can be determined by expanding the Sensor Information list in PowerXpert Figure C-1.
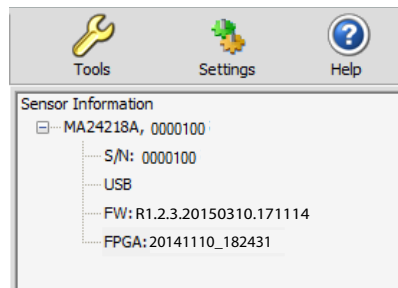
Figure C-1. Checking Current Firmware Version

C-2 MA242x8A, MA243x0A Update Firmware

1. Download the latest firmware update file for your sensor model from http://www.anritsu.com and save it to C:\Program Files\Anritsu\PowerXpert\.

2. Launch the Update Firmware command from the **Tools** menu. See Figure C-2.
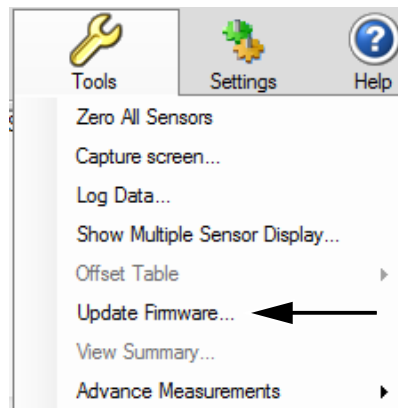
Figure C-2. Update Firmware
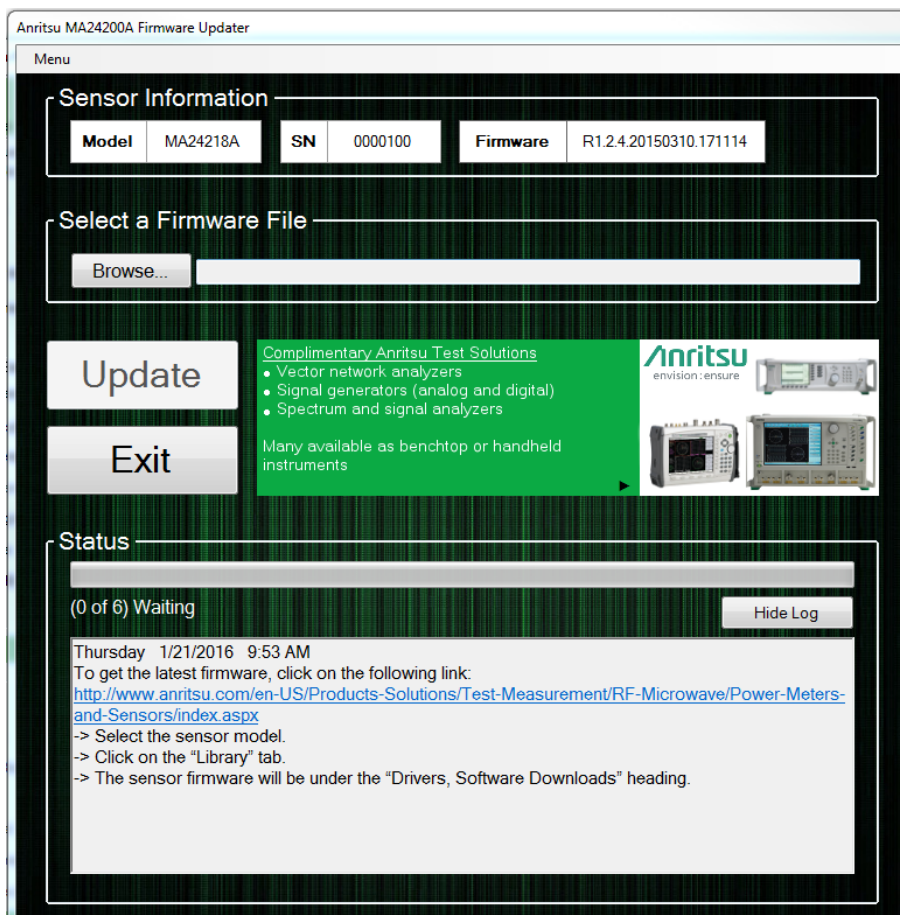
Figure C-3. Firmware Update Screen

3. Select Browse on the Firmware Updater Screen. Refer to Figure C-3.
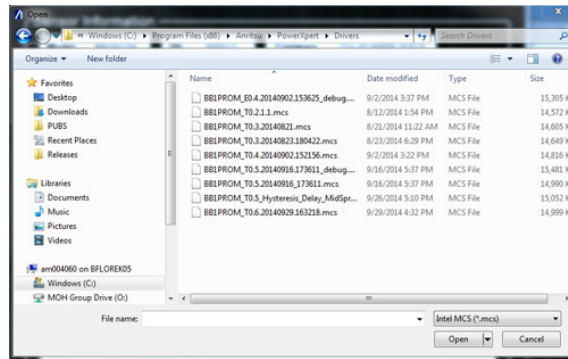
Figure C-4.   Verifying Location of Firmware File

4. Select the .mcs file that you want to load into the Browse text box. Figure C-4.
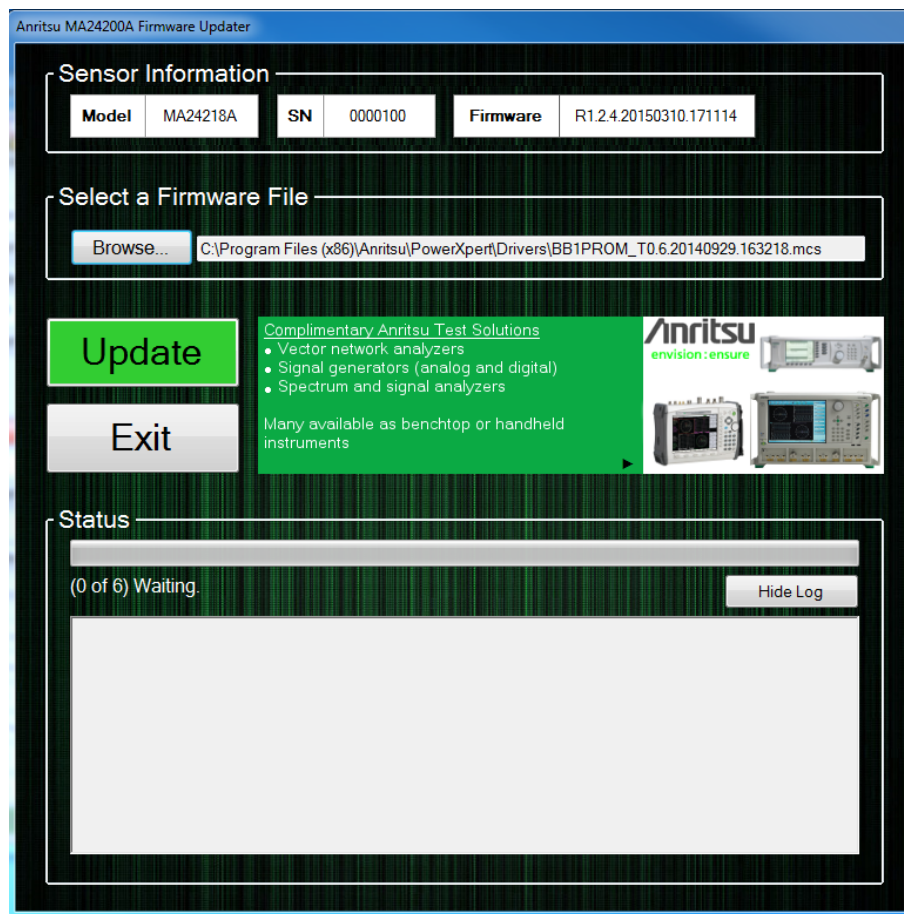
Figure C-5.   Firmware Installation Update Screen

5. Click the flashing Update button. The update process will be displayed on the Firmware Updater screen Figure C-6.
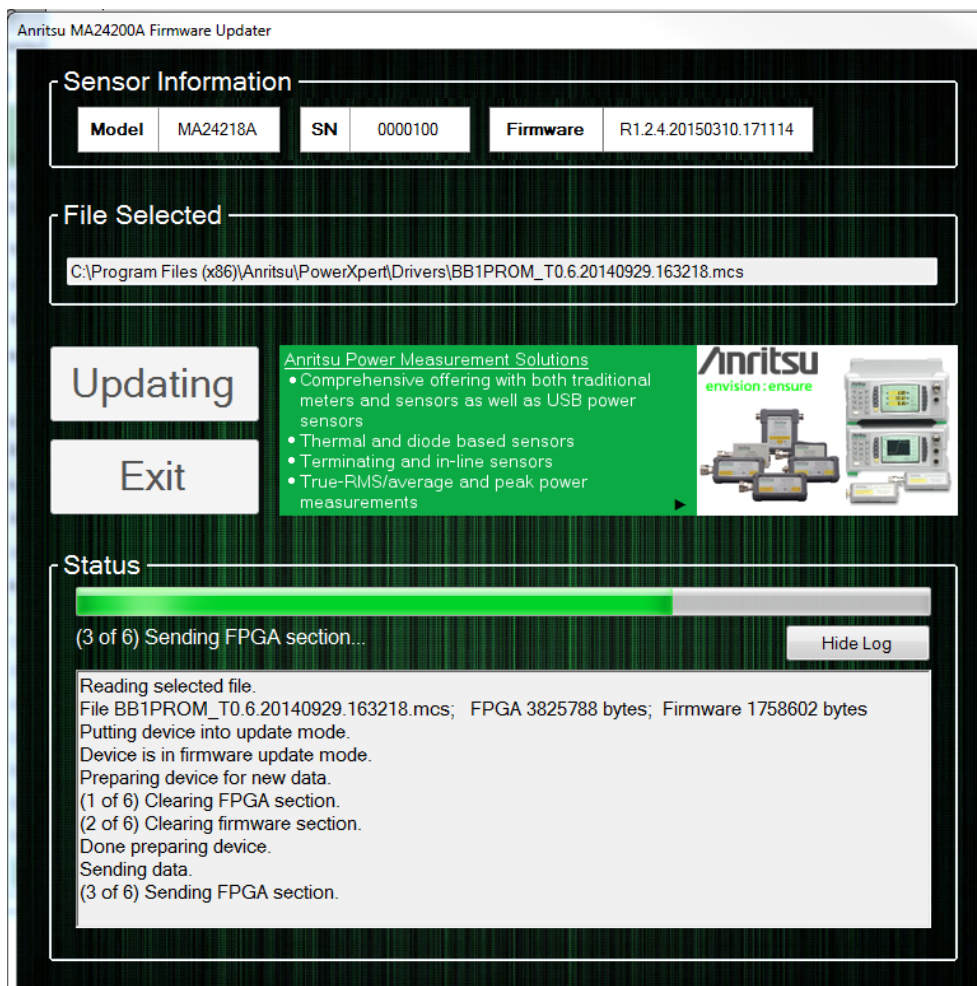
Figure C-6. Updating Firmware Screen

6. The Exit button highlights when the firmware update process is complete. Figure C-7.
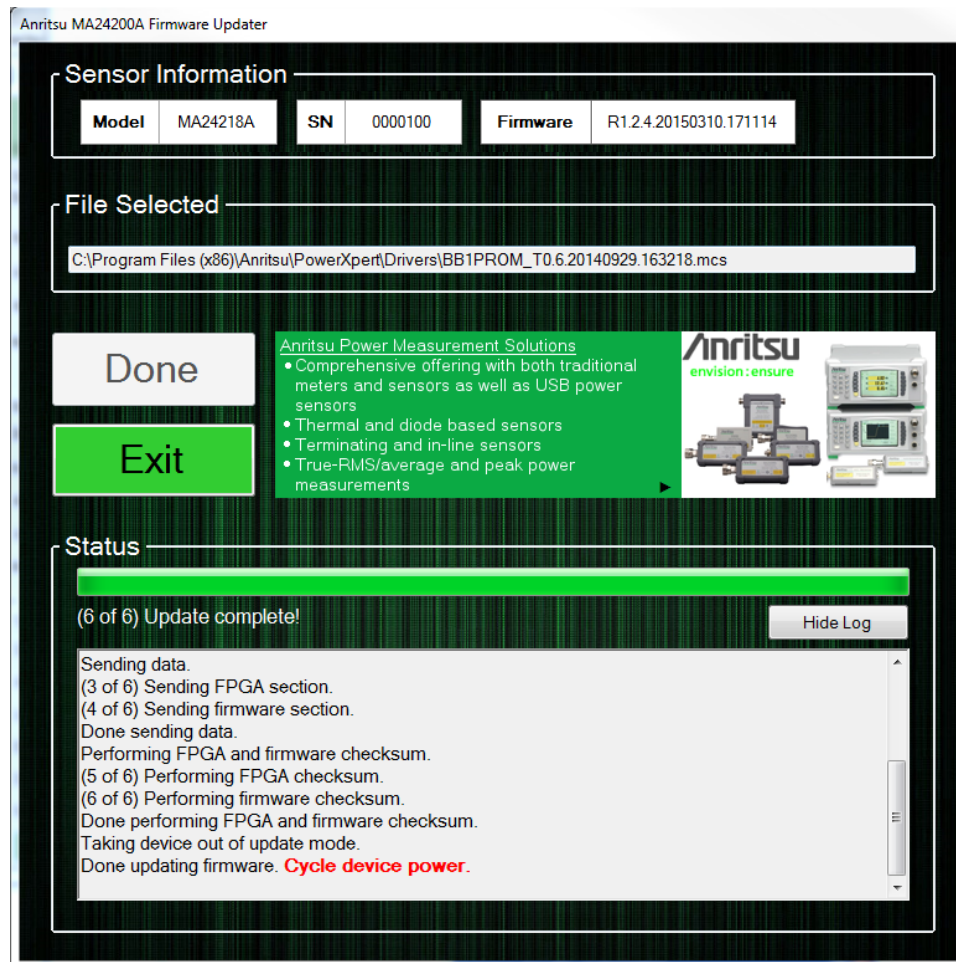
Figure C-7.   Firmware Updater Complete Screen

7. Close the Anritsu firmware update application by clicking on Exit button and power cycle the sensor by disconnecting USB cable and connecting it back to the PC USB port.

C-3   Recovering From an Unsuccessful Firmware Update

If the firmware update fails or is interrupted for any reason, the next time the sensor boots up it will use the permanent backup firmware. To recover from an unsuccessful firmware update, simply disconnect and reconnect the sensor to the PC and try again. When the displayed firmware version starts with "UPDATE_ME" it means the sensor is running the backup firmware and will not be fully functional until a successful firmware update occurs. The message "Update Firmware" will be displayed as shown in Figure C-8.
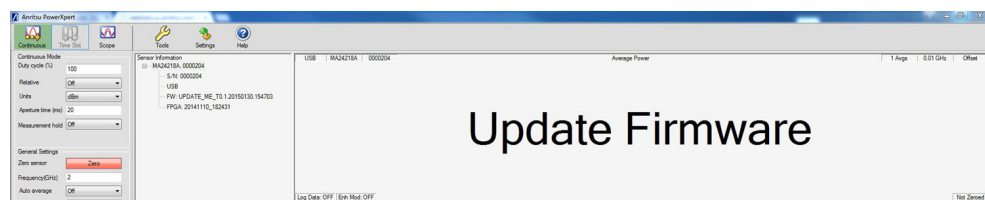
Figure C-8.   Update Firmware

No Sensor Connected

A power sensor must be connected to update the firmware. The No Sensor screen Figure C-9. indicates that:

- The USB connection has failed.
- The power sensor is not compatible with the current file being installed.
- No power sensor is connected into a USB connector.
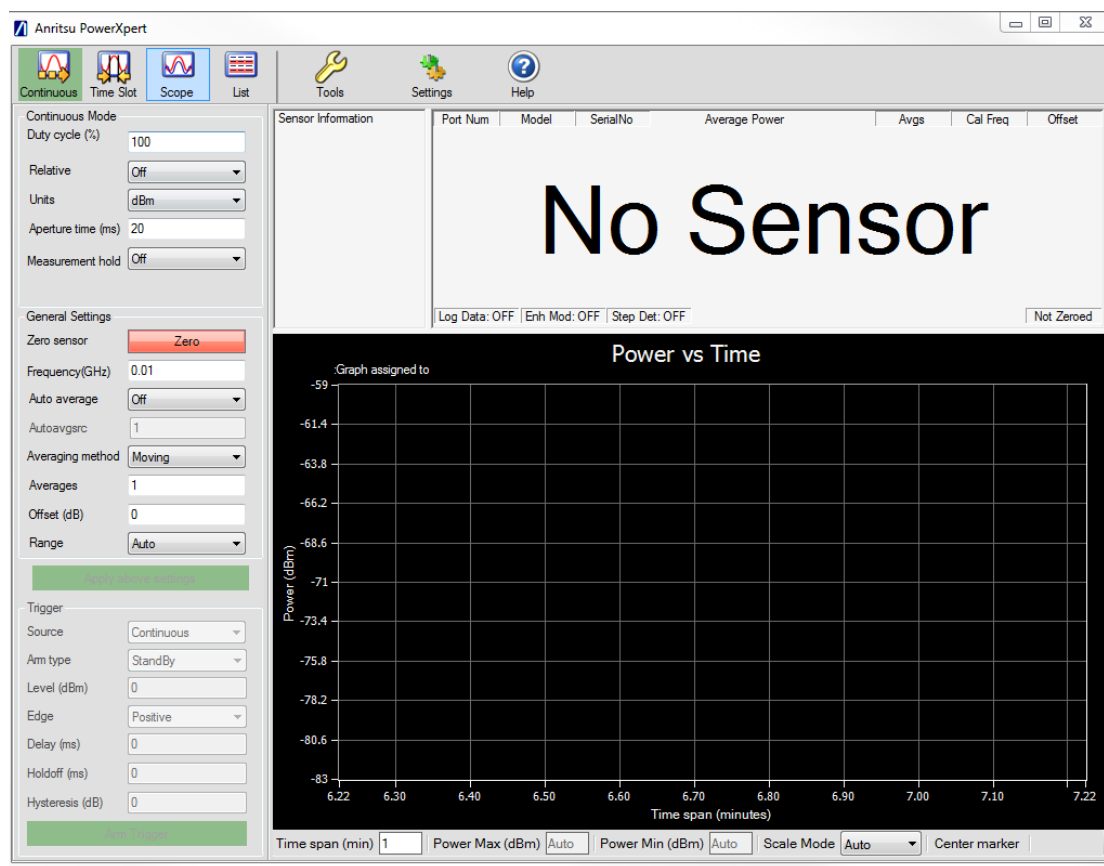
Figure C-9.   No Sensor Displayed

Appendix D — USB/Serial Port Compatibility

D-1   Introduction

The SAM-BA upgrade utility is used with the MA241xxA models only. The SAM-BA upgrade utility requires that the serial ports between COM2 and COM49 are used. You can find out the COM port number by going to **Start | Settings | Control Panel | System | Hardware | Device Manager | Ports (COM & LPT)**. Disconnect and reconnect the power sensor's USB cable from the computer and notice the new COM port number that appears in the Ports list.
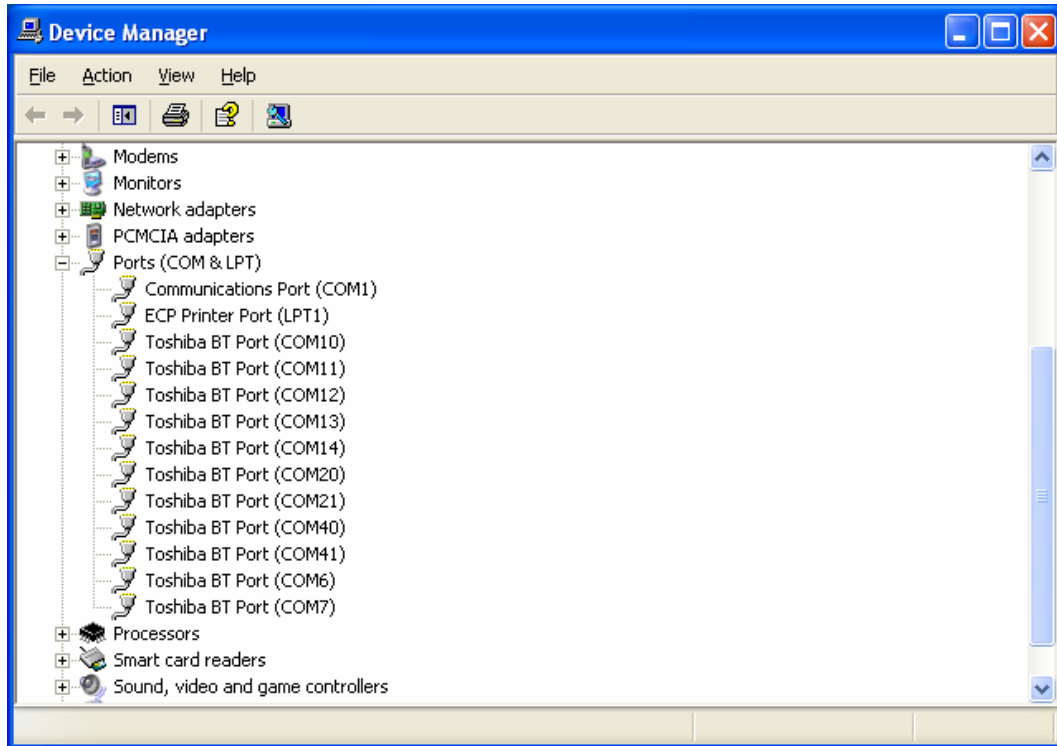
Figure D-1.   Device Manager

If this number is less than 49, then the PC application will work fine. However, if Windows maps your serial port to a port number greater than 49, such as COM51 or COM52 depending on which USB port that is being used, follow one of the three options outlined below. Whichever method you use, you should only need to perform the procedure once.

- Method 1–Download Updated Software
- Method 2–Trying a Different USB Port
- Method 3–Remapping a Serial Port

D-2   Method 1–Download Updated Software

The preferred method for resolving serial port compatibility issues is to download software updates for your product from www.anritsu.com.

D-3   Method 2–Trying a Different USB Port

1. Disconnect the USB end of your power sensor from your computer (or USB hub).

2. Connect the USB power sensor to a different USB port on your computer. Connecting to a USB hub tends to increase the port numbers, so connecting directly to the computer's USB port usually provides the best result.

3. Open the Device manager to see if the new port assignment is between COM2 and COM49. If it is NOT, return to step 1 and connect to a different USB port. If the port assignment is between COM2 and COM49, the problem has been resolved and no further action is required.

D-4   Method 3–Remapping a Serial Port

A serial port may be remapped to a different number, such as changing a serial port from COM19 to COM5. This may be needed if the methods above do not result in a serial port assignment between COM2 and COM49 or if you prefer to use a USB hub or a specific USB port on your computer.

1. Open the System Properties by going to **Start | Settings | Control Panel | System**, or simultaneously pressing the **Windows** and **Pause** keys.

2. Select the **Hardware** tab and click the **Device Manager** button to open the Device Manager.
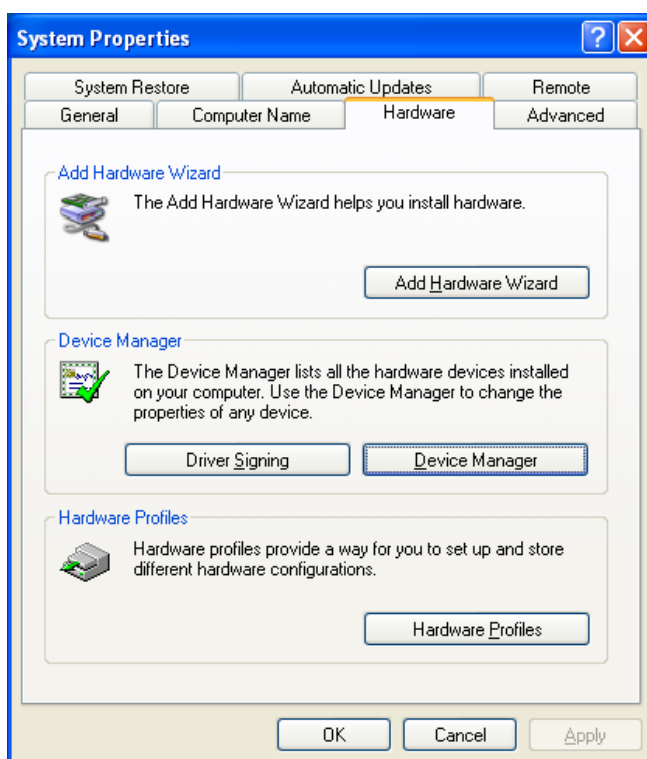
Figure D-2.   System Properties

3. Click the **+** box next to Ports (COM & LPT) to expand the installed ports list.
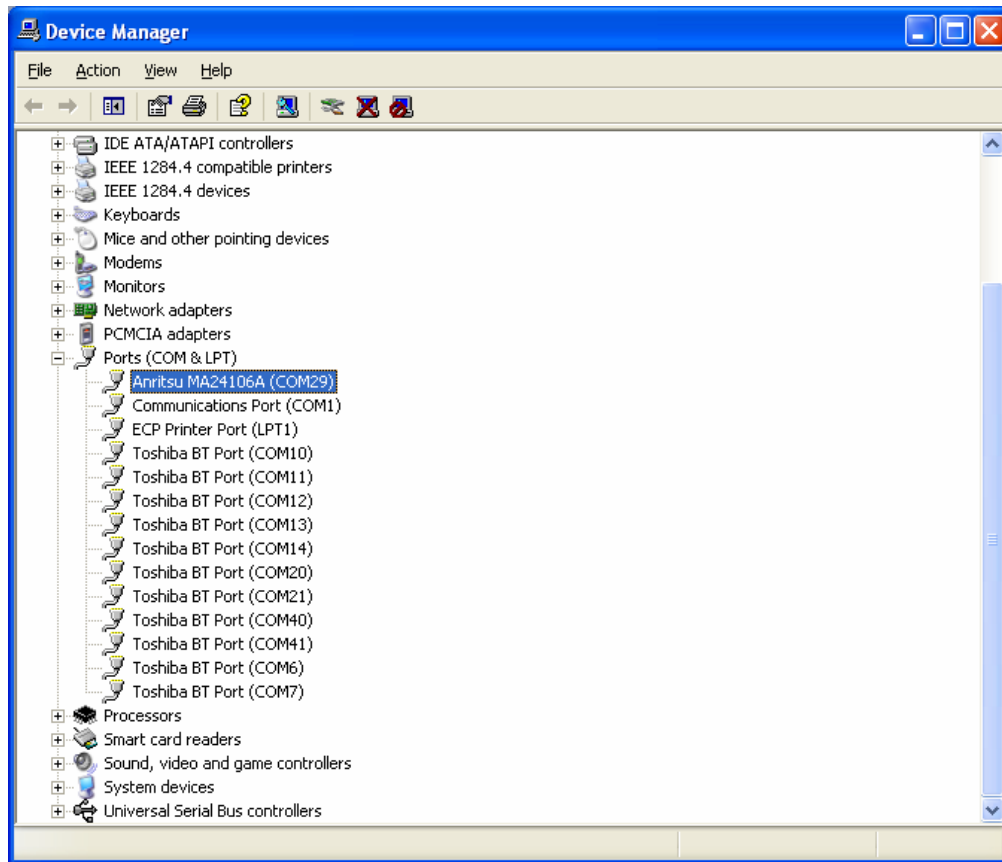
Figure D-3.   Device Manager

4. Select the port that is assigned to the power sensor. Disconnect and reconnect the sensor and notice the new COM port number that appears. The new port is the current port assignment for the power sensor.

5. Right-click on the new port assigned in step 4 above and select **Properties** from the pop-up menu to display the properties for that port.

6. Click the **Port Settings** tab of the properties window.

7. Click the **Advanced** button to show the advanced property settings for the port.
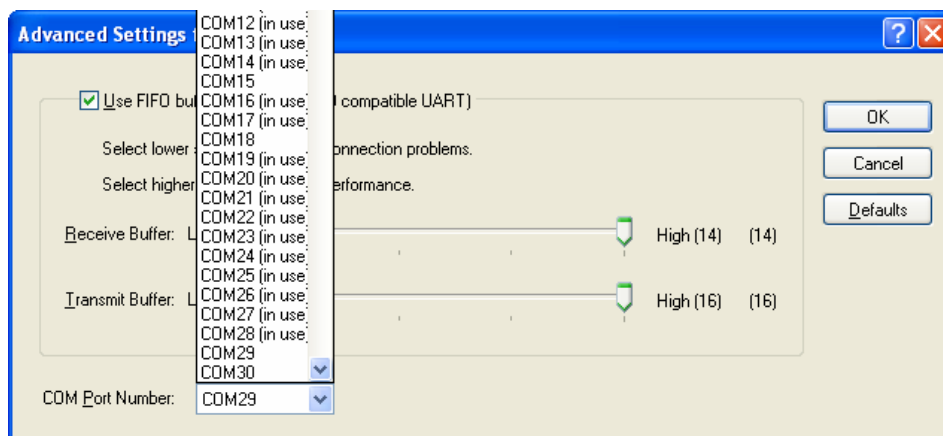
Figure D-4.   Advanced Settings for COM Port

8. Select a COM Port Number in the range of 1 through 16. If possible, select a port which is NOT marked as "in use" in the COM Port Number list. If all of the ports are marked as being in use, select port number 16 unless you know for sure that something is actually using COM16.

9. You will get an alert when you close the window telling you that the COM port number may be in use by another device and asking if you want to continue. Click **Yes** to continue.
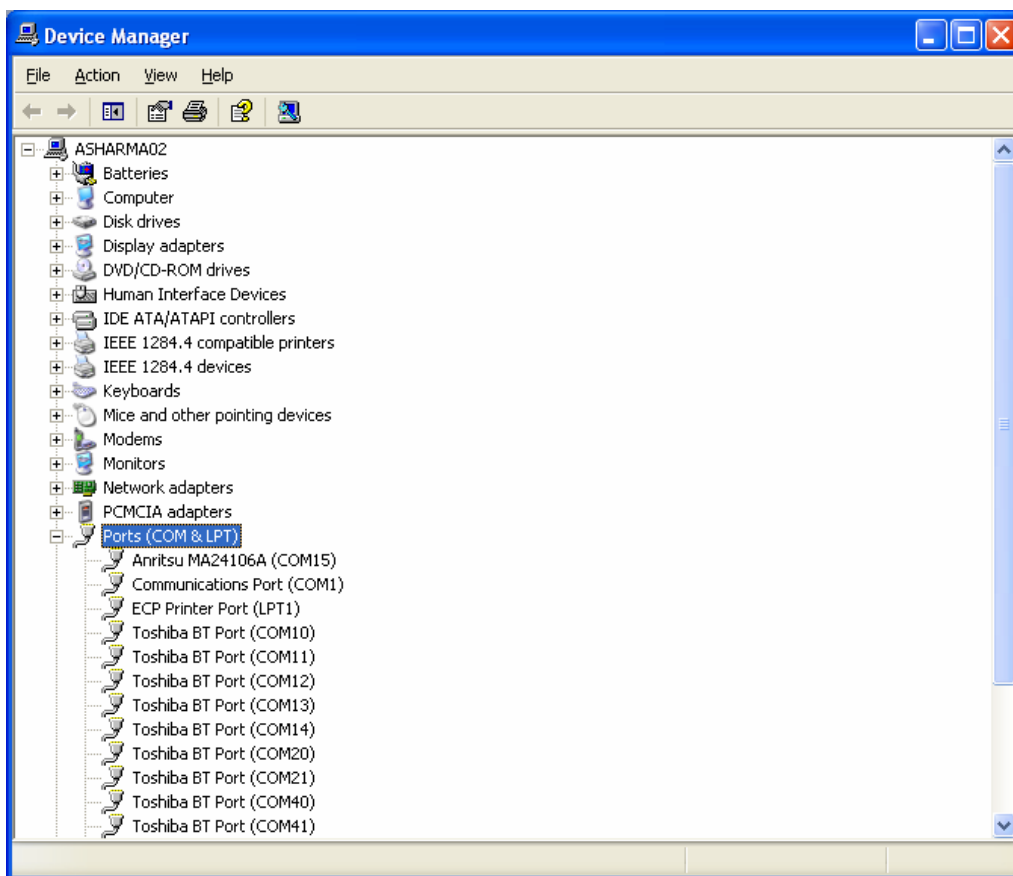
Figure D-5.   Device Manager

10. Close all open windows.

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