User Guide

MA24104A
Inline High Power Sensor

Average Power, 600 MHz to 4 GHz

Anritsu

Anritsu Company
490 Jarvis Drive
Morgan Hill, CA 95037-2809
USA

PN: 10585-00016
Revision: A
Printed: February 2009

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印刷线路板 (PCA)	×	○	×	×	○	○
机壳、支架 (Chassis)	×	○	×	×	○	○
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Chapter 1 — General Information

1-1 Scope of Manual

This manual provides general information, installation, and operating information for the Anritsu MA24104A Inline High Power Sensor. Throughout this manual, the terms MA24104A, inline high power sensor, and power sensor will be used interchangeably to refer to the device. Manual organization is shown in the table of contents.

1-2 Introduction

This chapter contains general information about the MA24104A power sensor. It includes a general description of the device and information on its identification number, information on initial inspection, and preparation for storage and shipment.

1-3 Description

The MA24104A power sensor is a highly accurate, standalone instrument that communicates with a PC via USB. The MA24104A also communicates with many Anritsu handheld instruments, such as Spectrum Master, BTS Master, VNA Master, Cell Master, and Site Master (Option 19 required in these instruments). The power measurement capability of MA24104A is intended to mimic that of a traditional thermal (thermo-electric) power sensor. Therefore, it is ideal for measuring the average power of CW or modulated RF waveforms such as 3G, 4G, OFDM, and multi-tone signals. In other words, it measures true RMS power regardless of the type of input signal.

1-4 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 and the power sensor has been checked for mechanical and electrical operation. The following items are included with every MA24104A shipment:

- MA24104A, inline high power sensor
- 40-168-R, external power supply
- 2000-1566-R, USB 2.0A to Mini-B cable
- 800-441, RS232 cable
- 69747, AA Alkaline batteries (qty 3)
- 2300-525, CD containing required software and manuals

If the shipment is incomplete or if the power sensor is damaged mechanically or electrically, notify your local sales representative or Anritsu Customer Service. If the shipping container is damaged or shows signs of stress, notify the carrier as well as Anritsu. Keep the shipping materials for the carrier's inspection.

1-5 Identification Number

All Anritsu power sensors are assigned a unique seven digit serial number, such as “0701012”. 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 MA24104A power sensor, serial number: 0701012).

Customer Asset Tag Placement

When affixing an asset tag to the MA24104A, please use the area indicated below to insure that the asset tag is retained with the product during service.

Figure 1-1. Customer Asset Tag Placement

1-6 Preparation for Storage/Shipment

Preparing the power sensor 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:

- **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.
- **Address the Container:** If the instrument is being returned to Anritsu for service, mark the address of the appropriate Anritsu service center and your return address on the carton in one or more prominent locations.

Chapter 2 — Installation (PC Only)

2-1 Introduction

This chapter provides information and instructions on operating the MA24104A power sensor. It contains the following:

- Hardware and Software Requirements for the Anritsu Power Meter Application
- Driver Installation procedure for properly installing the driver for the sensor

2-2 Hardware and Software Requirements

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

- Intel® Pentium® III or equivalent processor
- Microsoft® Windows Vista® (32-bit only), Windows XP or Windows 2000
- 512 MB of RAM
- 100 MB of available hard-disk space
- 1024 × 768 display resolution
- PC or laptop with a USB port and CD-ROM drive

2-3 Driver Installation

The driver must be installed before the MA24104A power sensor can be used. Follow the steps below as a guide for proper installation:

1. Insert the installation CD in the drive of your computer. If the installation menu does not start automatically, open the file named **Startup.htm** located on the CD.

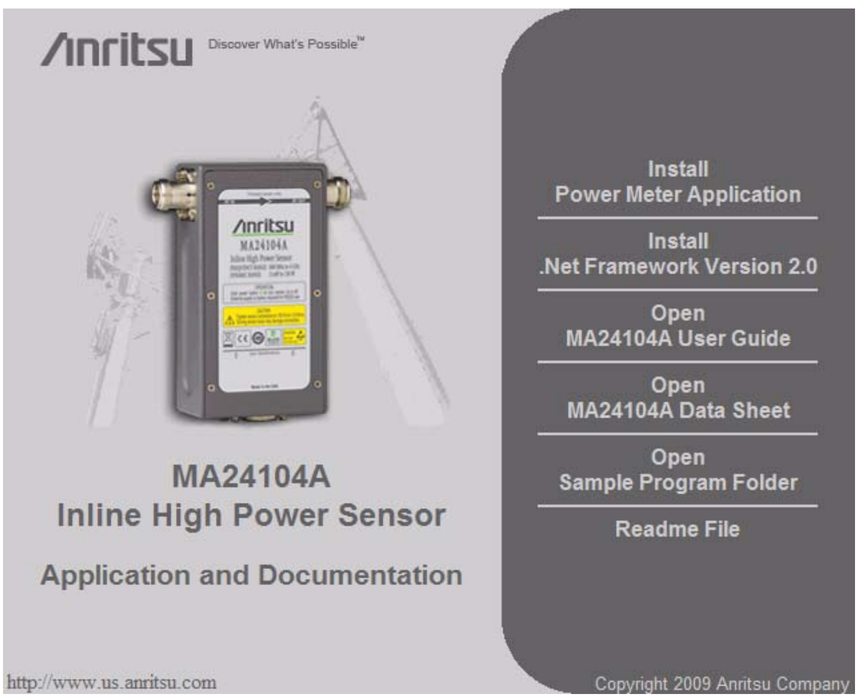


Figure 2-1. Anritsu Power Meter Installation Menu

> **Note:** If required, please install the Microsoft® .Net Framework, version 2.0.

2. Click **Install Power Meter Application** and select **Run** to start the installation.

3. Click **Next** in the following screen to begin the installation process.

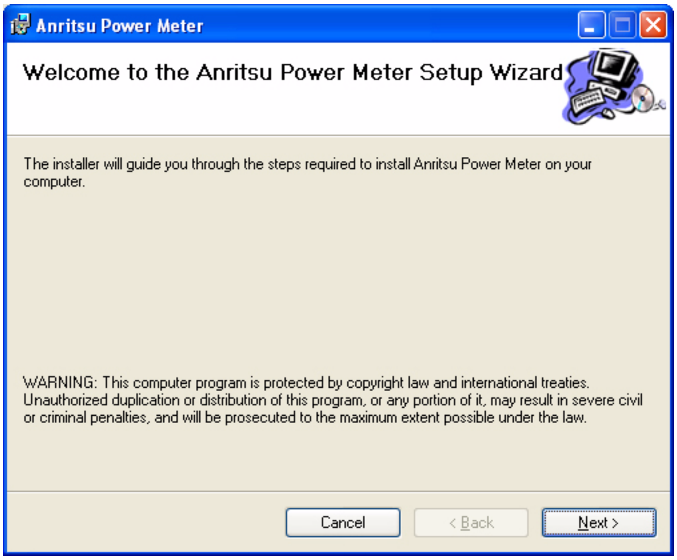


Figure 2-2. Anritsu Power Meter Installation

4. Browse for the installation folder, select the desired permissions, and then click **Next**. The default installation directory is: C:\Program Files\Anritsu\AnritsuPowerMeter

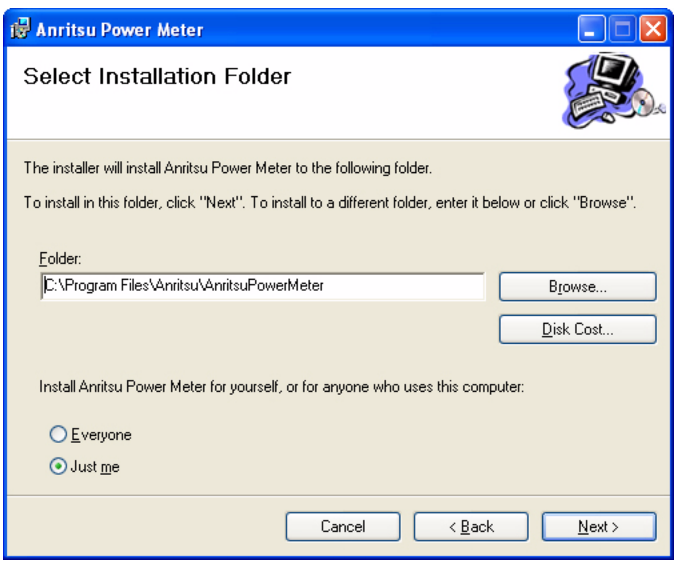


Figure 2-3. Anritsu Power Meter Installation

5. Select **I Agree** to the license agreement, and then click **Next**.

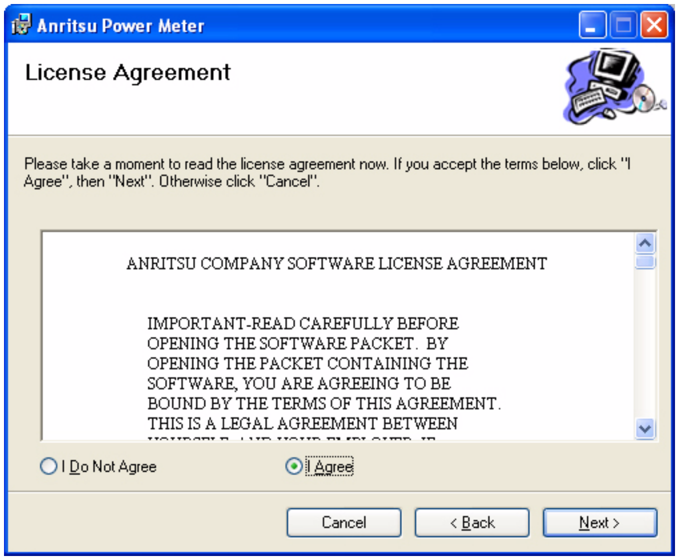


Figure 2-4. License Agreement

6. Select **Next** to continue with the software installation.

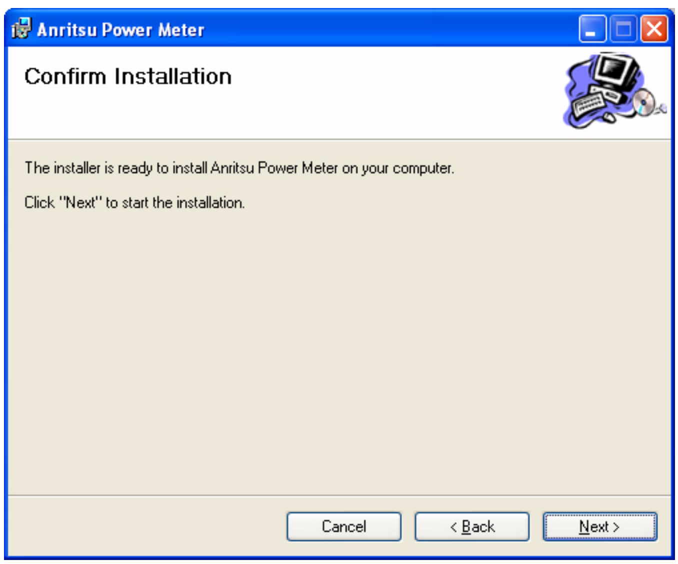


Figure 2-5. Confirm Installation

The software will then install to the selected location.

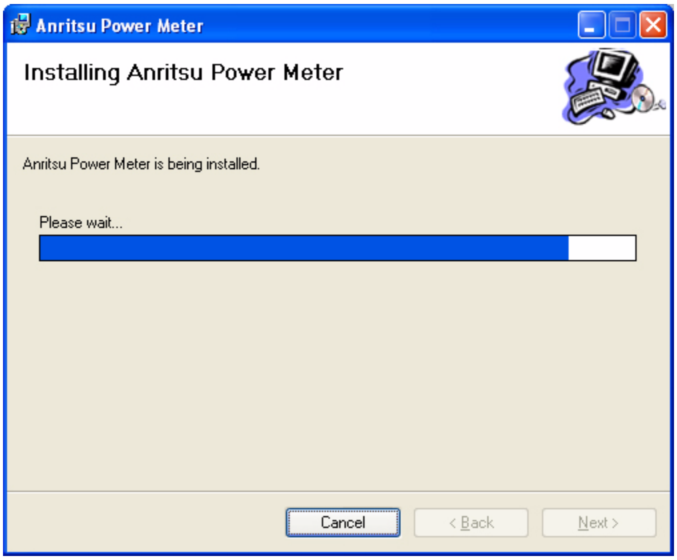


Figure 2-6. Installing Anritsu Power Meter Application

7. When the installation completes, click **Close**.

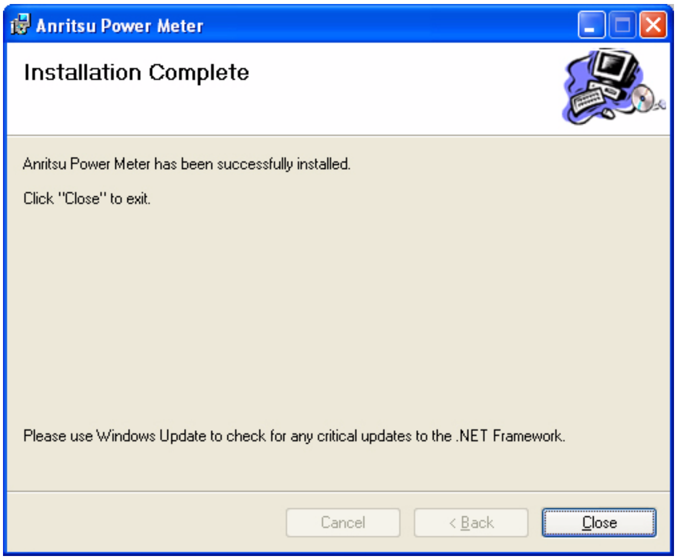


Figure 2-7. Application Installation Complete

8. Connect the MA24104A power sensor to the USB port of the PC with the supplied USB cable, then press and hold the **ON** button for one second. The status LED lights green indicating that the sensor is turned ON.

9. When the **Found New Hardware Wizard** installation screen appears, select **No, not this time** to search for software, and then click **Next**. If the Wizard does not start, refer to Appendix C, "Serial Port Compatibility" for troubleshooting information.

Figure 2-8. Found New Hardware Wizard

10. Select **Install from a list or specific location (Advanced)**, and then click **Next**.

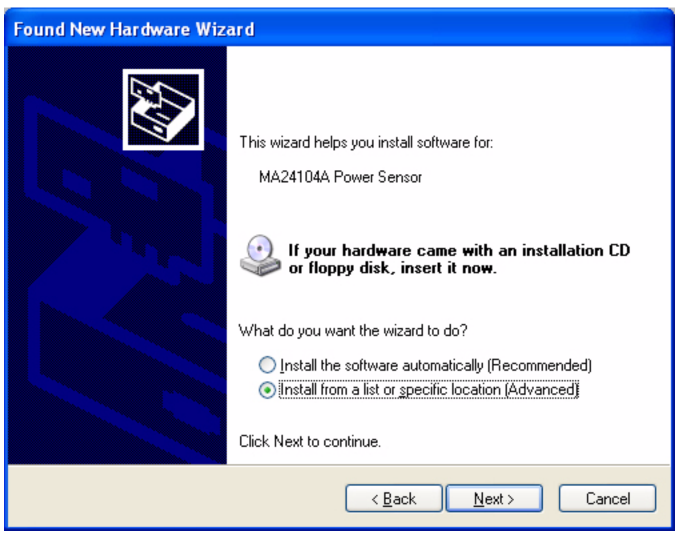


Figure 2-9. Found New Hardware Wizard

11. Select **Don't search. I will choose the driver to install**, and then click **Next**.

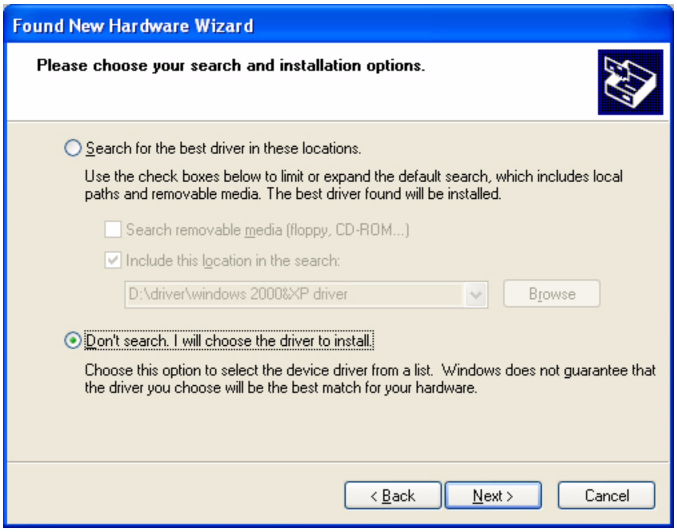


Figure 2-10. Found New Hardware Wizard

12. Select the hardware type **Computer**, and then click **Next**.

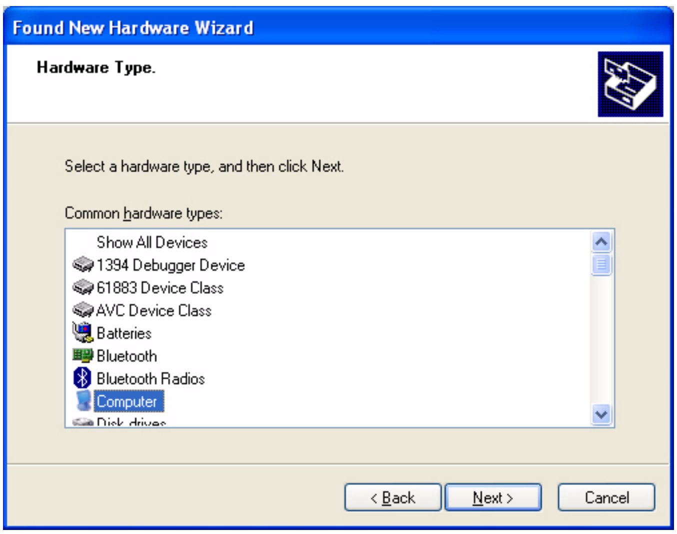


Figure 2-11. Found New Hardware Wizard

13. Click **Have Disk...**, and then click **Next**.

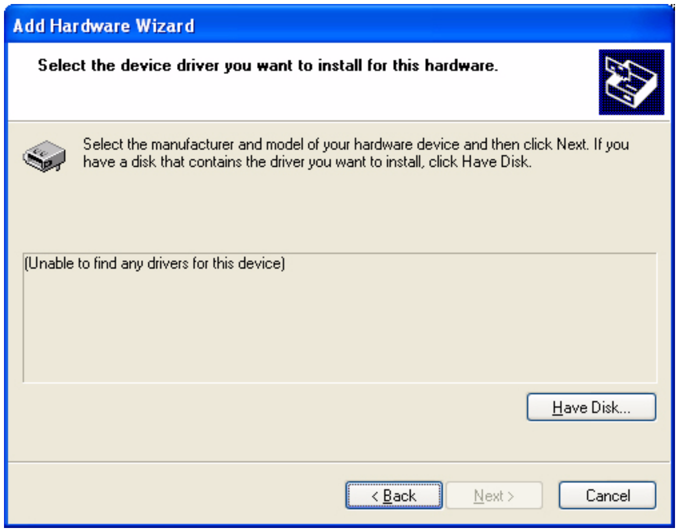


Figure 2-12. Found New Hardware Wizard

14. Browse to the location on your hard drive where you installed the program. If the default settings were chosen during the application installation, click **Browse...**, as shown below, and then select:

C:\Program Files\Anritsu\AnritsuInlinePowerMeter\AnritsuMA24104A.inf

15. Click **Open**, then click **OK**.

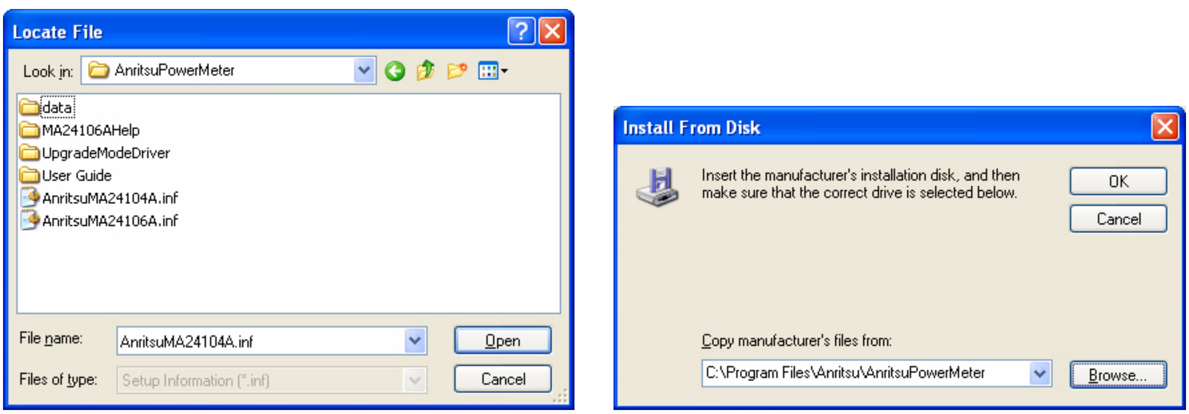


Figure 2-13. Install From Disk

16. Select **Anritsu MA24104A** from the list, and then click **Next** as shown below.

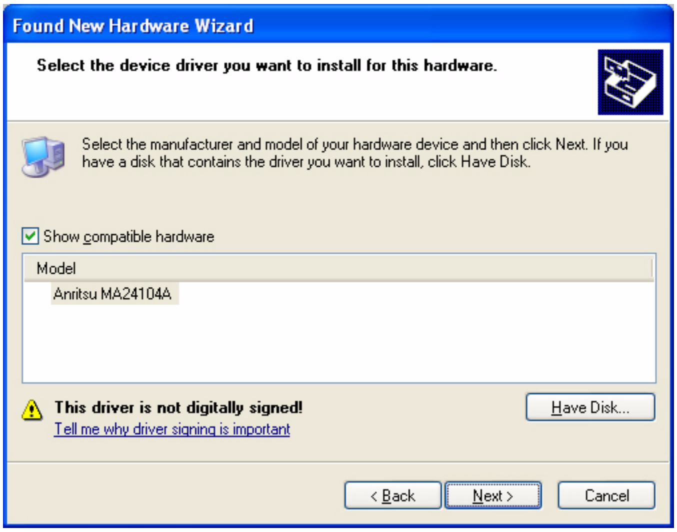


Figure 2-14. Found New Hardware Wizard

17. The Hardware Installation Warning dialog will appear as shown in Figure 2-15. Click **Continue Anyway**.

Figure 2-15. Hardware Installation

18. Click **Finish** to close the wizard.

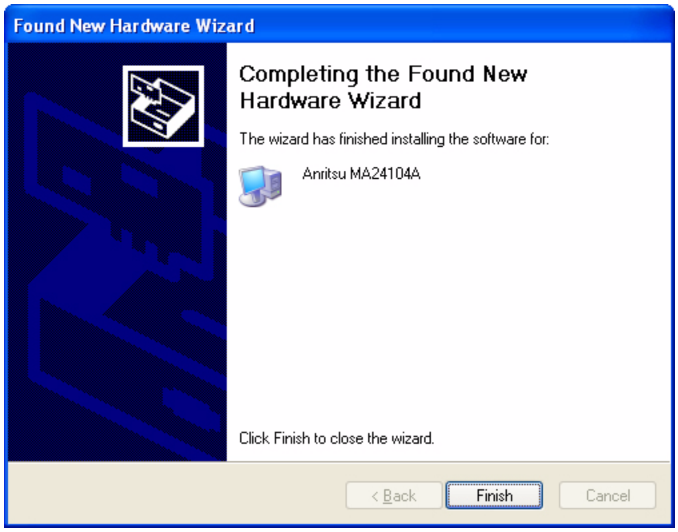


Figure 2-16. Found New Hardware Wizard

19. The MA24104A is now ready for use. Launch the Anritsu Power Meter application from the new desktop icon or from the Start | Programs menu. Refer to Chapter 3 for information about using the Anritsu Power Meter application.

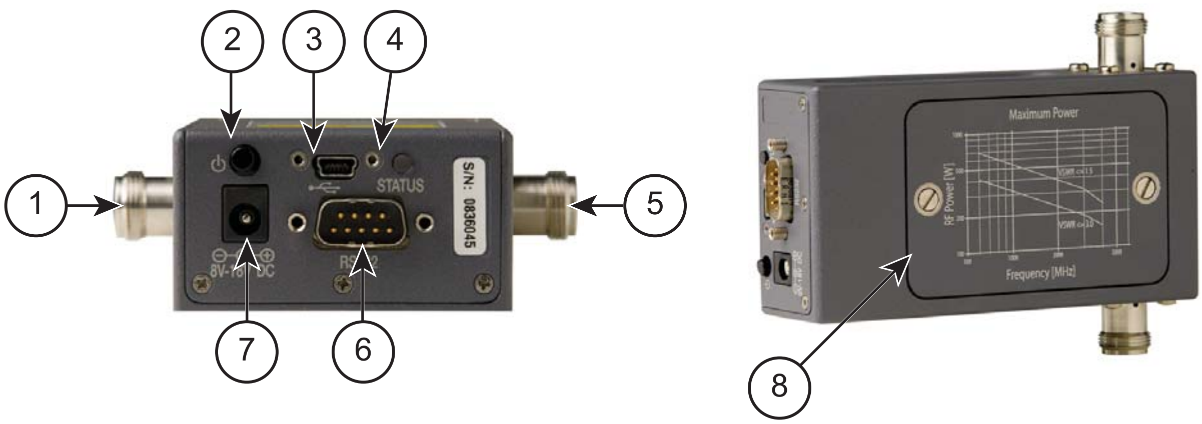
Chapter 3 — Using the Power Sensor

3-1 Introduction

This chapter provides information on using the Anritsu Power Meter application with the MA24104A inline high power sensor. It provides a description of the Graphical User Interface, various settings of the application, basic procedures for Making Measurements, as well as information about Uncertainty of a Measurement.

3-2 Sensor Overview

The power sensor's connectors are illustrated in the figure below:

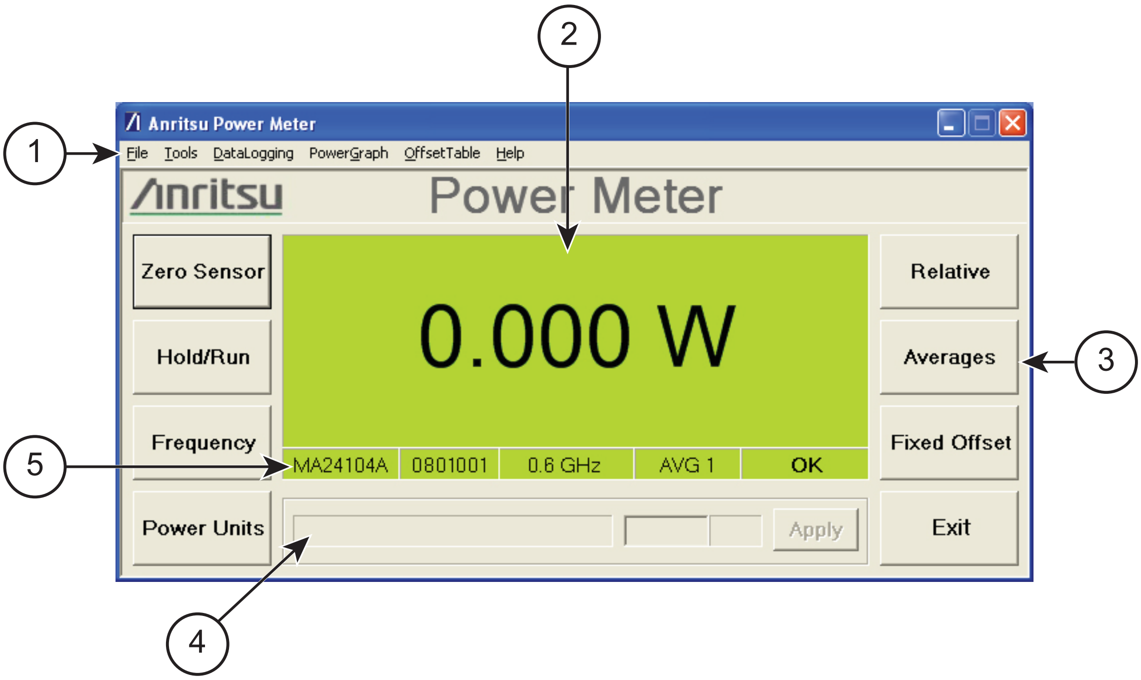


Index	Description
1	RF Input
2	Power ON/OFF
3	USB Mini-B Port (for connection with a PC or Anritsu Handheld instrument)
4	2-color LED (reports functional status of the sensor) **Green:** Sensor ON, Status OK **Amber:** Error Condition (see Table 3-5) **Blinking:** Low Battery
5	RF Output
6	RS232 Port (for connection with Anritsu handheld instruments)
7	DC Input (for RS232 use without batteries)
8	Battery Compartment (supports 3AA size batteries) **Note:** When using battery power with the RS232 interface, the MA24104A enables an auto shutdown (sleep) feature. If the RS232 bus is disconnected or becomes inactive, the power sensor shuts down (sleeps) to preserve battery power. The sensor automatically powers up (wakes up) when the host is reconnected or becomes active. Zeroing is then required before taking measurements.

Figure 3-1. MA24104A Sensor Overview

3-3 Graphical User Interface

The graphical user interface layout is divided into five sections as illustrated in the figure below:



Index	Description
1	Menu Bar
2	Display Window
3	Buttons
4	Data Entry Fields
5	Status Bar

Figure 3-2. Anritsu Power Meter Application Overview

The Anritsu Power Meter application always launches in the default state as described below:

- **Frequency:** 600 MHz
- **Power Units:** W
- **Averages:** 1
- **Fixed Offset:** 0 dB
- **Time Aperture:** Low (fast mode)

Communication with the sensor does not take place until the **Apply** button is clicked or the **Enter** key on the keyboard is pressed.

Buttons

There are nine buttons available on the user interface to perform the most common tasks as described below:

- **Zero:** Performs the Zero operation. Removes system noise from the measurement.
- **Hold/Run:** Holds the last reading. Run releases the hold.
- **Frequency:** Applies frequency correction to the measured power.
- **Power Units:** Displays units of power in linear or log scale.
- **Normal/Relative:** Displays power changes with respect to a desired reference value.
- **Averages:** Allows input of a custom averaging entry. The default number is 1.
- **Fixed Offset:** Applies an offset in dB. Input positive value for attenuation.
- **Apply:** Applies the current entry in the data entry field.
- **Exit:** Terminates the program.

Data Entry Fields

The data entry fields become active when clicking a button to accept an appropriate entry (see the example in Figure 3-3). Communication with the power sensor does not take place until the Apply button is clicked or the Enter key on the keyboard is pressed. The following list summarizes the entry fields:

- **Frequency Button:** Sets the Cal Factor Frequency in GHz
- **Power Units Button:** Sets the units of power to dBm, W, mW, or µW
- **Averages Button:** Sets the number of averages from 1 to 256 (see Table 3-1 for guidelines)
- **Fixed Offset Button:** Sets the offset from –100 dB to +100 dB

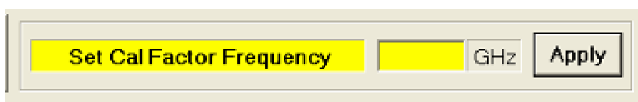


Figure 3-3. Example of an Active Entry Field

Display Window

The display window contains the following information (see Figure 3-4 and Figure 3-5):

- Measured Power
- Relative Power
- Units of Power
- Fixed Offset
- Offset Table

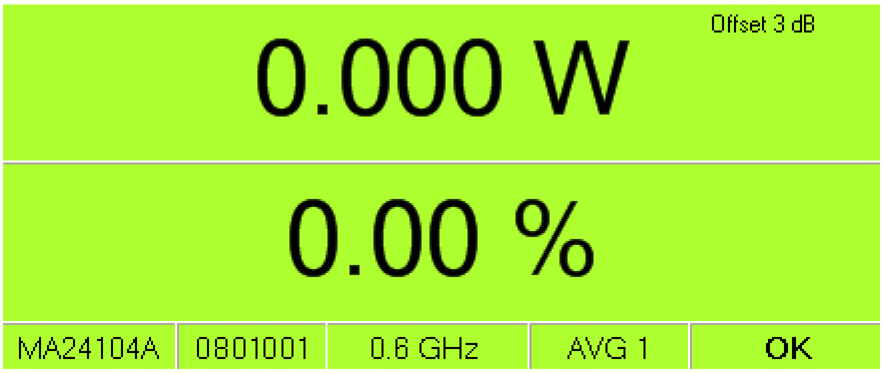


Figure 3-4. Display Window (Relative Mode with Fixed Offset On)

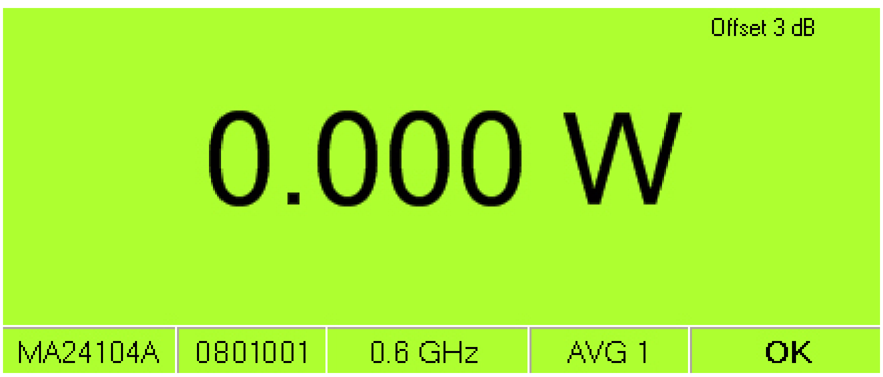


Figure 3-5. Display Window (Normal mode with Offset Table On)

Status Bar

The status bar displays the model number, serial number, cal factor frequency, averaging number, and operational status of the sensor (see Figure 3-6).

Figure 3-6. Status Bar

Menu Bar

The Menu Bar contains the following menus:

File Menu

The File menu contains the Exit command, which terminates the application.

Figure 3-7. File Menu

Tools Menu

The Tools menu contains:

- **Reset Averages:** Restarts the averaging.
- **Clear Fixed Offset:** Removes the offset value and displays the absolute power being measured at the sensor's RF input port.
- **High Aperture Time:** When High Aperture Time mode is selected, the 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.
- **Upgrade Firmware:** Launches the firmware upgrade sequence. Refer to Appendix C for a procedure on upgrading the firmware.
- **Connected to COM Port Number:** Displays the COM port number that is currently assigned to the power sensor.

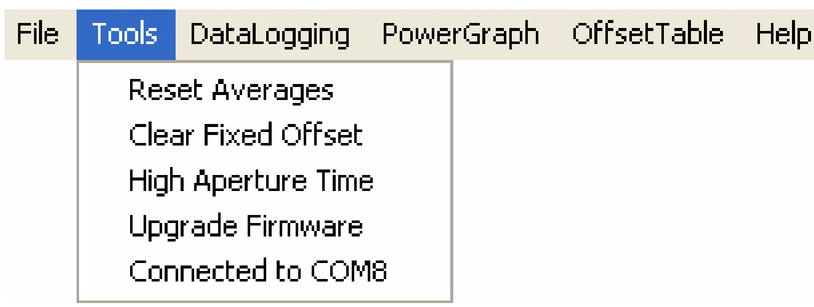


Figure 3-8. Tools Menu

Data Logging Menu

The Data Logging menu provides choices between Data Logging On or Data Logging Off.

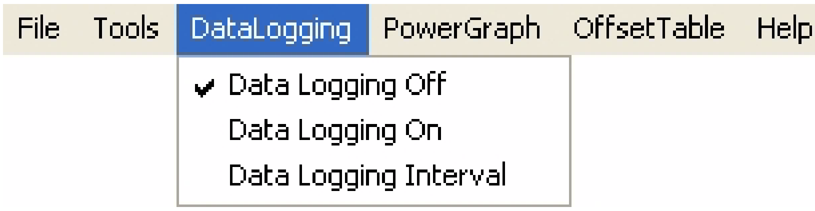


Figure 3-9. DataLogging Menu

- **Data Logging On:** Data is stored as comma separated value (.csv) files that can be directly opened in Microsoft Excel. The filenames have the following format:

  xxxxxxx_yyyy_mm_dd_hhmmss.csv

  where:

  xxxxxxx: Serial number of the power sensor
  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 filename and location can be selected or changed as desired.

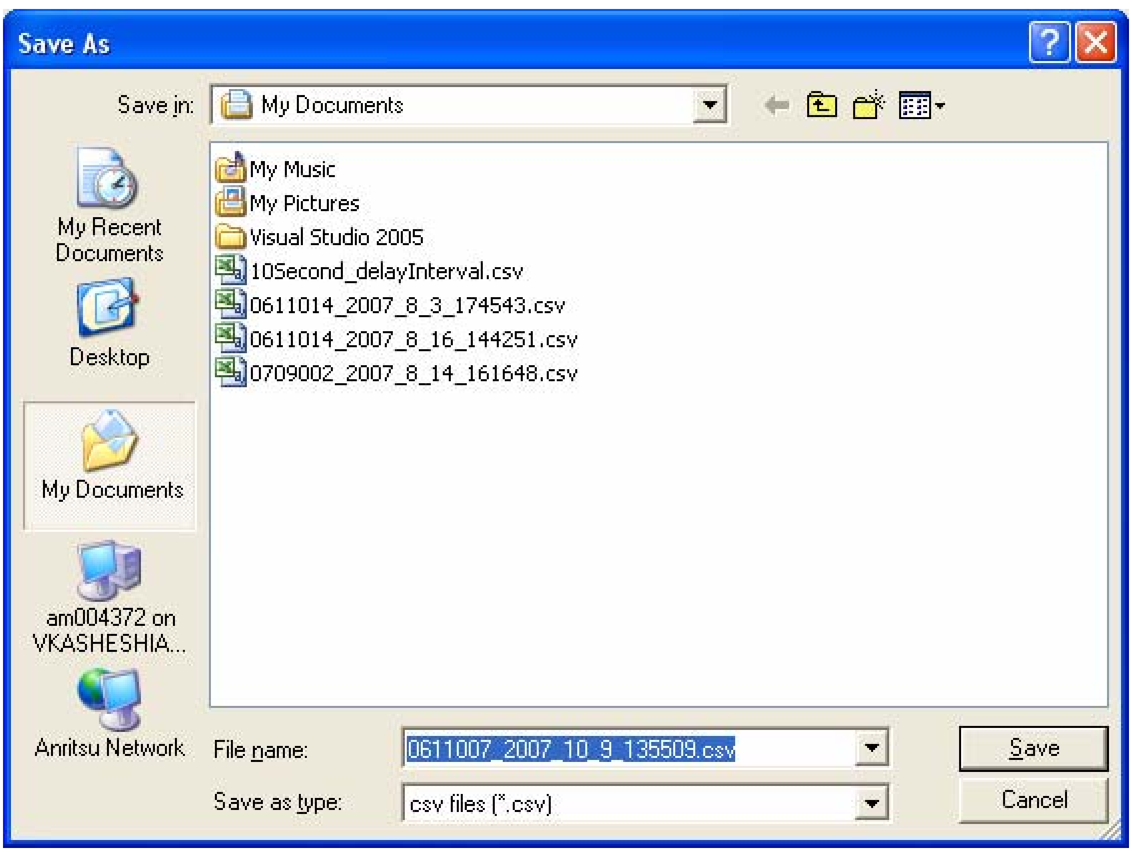


Figure 3-10. DataLogging Save Dialog

- **Data Logging Interval:** Sets full speed data logging (approximately 10 measurements per second) or fixed interval data logging (user defined logging interval).

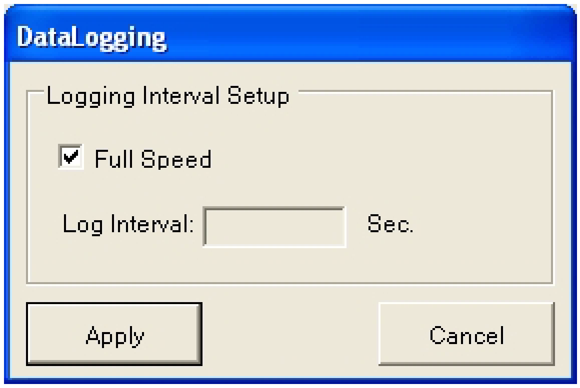


Figure 3-11. Data Logging

Power Graph

The Power Graph feature provides the ability to plot measured power with respect to time. This feature can be used for drift testing, tuning circuits, and for monitoring circuit behaviors to external stimuli. The graph is continuously updated in real time.

Figure 3-12. Power Graph Menu

Note: Unavailable selections become available after the Power Graph is started.

Clicking **Start** in the Power Graph menu opens the power versus time graph (Figure 3-13).

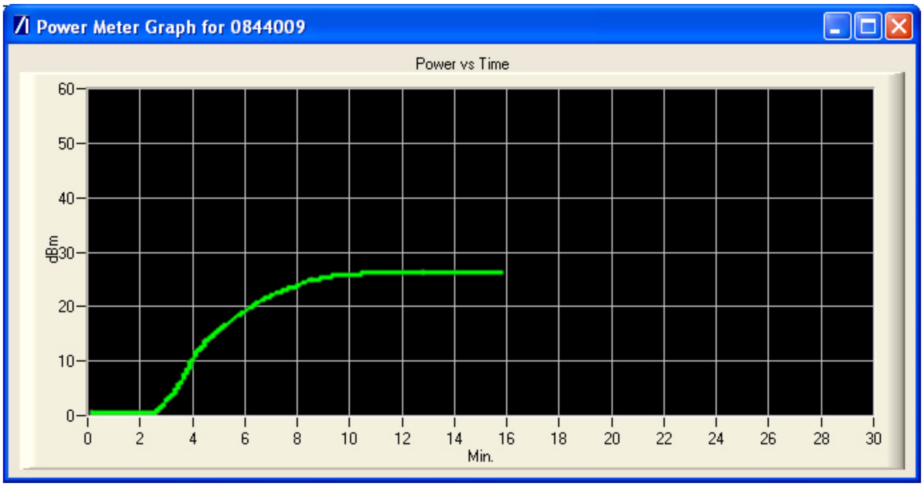


Figure 3-13. Power Graph Screen

The default settings of the graph are as follows:

- **Time, X-axis:** 30 minutes
- **Power, Y-axis:** 60 dBm (1000 Watts)

Clicking **Setup** opens the Graph Setup dialog (below) where the scales of time and power axes can be changed. Power is in dBm and time is in minutes.

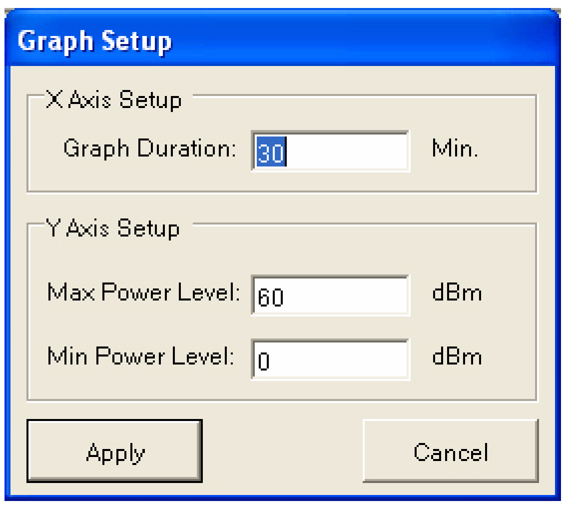


Figure 3-14. PowerGraph Setup Dialog

Offset Table

The Offset Table feature provides the ability to apply corrections to measurements when RF devices are used between the sensor and DUT. Offset Table is different from Fixed Offset as it provides the ability to enter different offset values at different frequencies for an RF device. The frequency response of that device needs to be known before it 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.

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

1. Click **OffsetTable** and select **Setup**.
2. In the resulting dialog (Figure 3-15), 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.

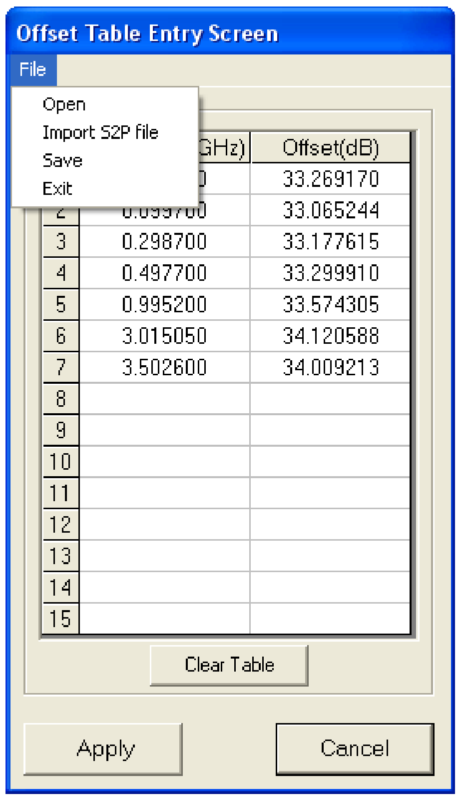


Figure 3-15. Offset Entry Screen

3. Click **Apply** in the Offset Entry screen to correct the measurement.

   The word Offset appears 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 Offset Table On selection in the OffsetTable 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 (see Figure 3-16). Any number of device responses can be stored. The files are stored as comma separated value files (.csv).

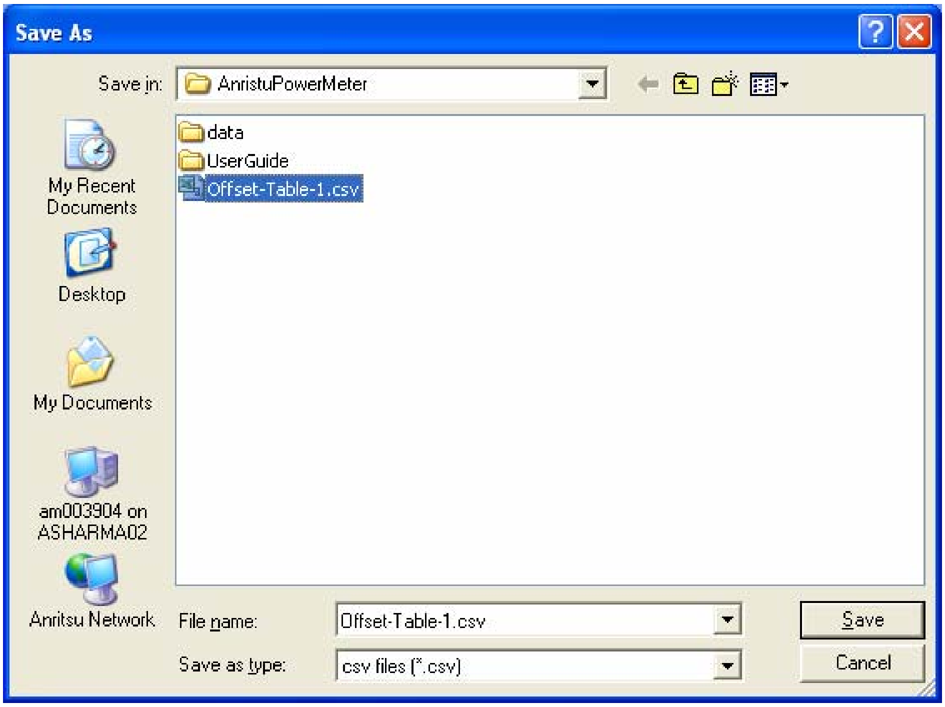


Figure 3-16. Save As Dialog

6. To recall a response, click **Open** in the Offset Entry screen, select the file, and then click **Apply**. Similarly, S2P files can be imported as shown below:

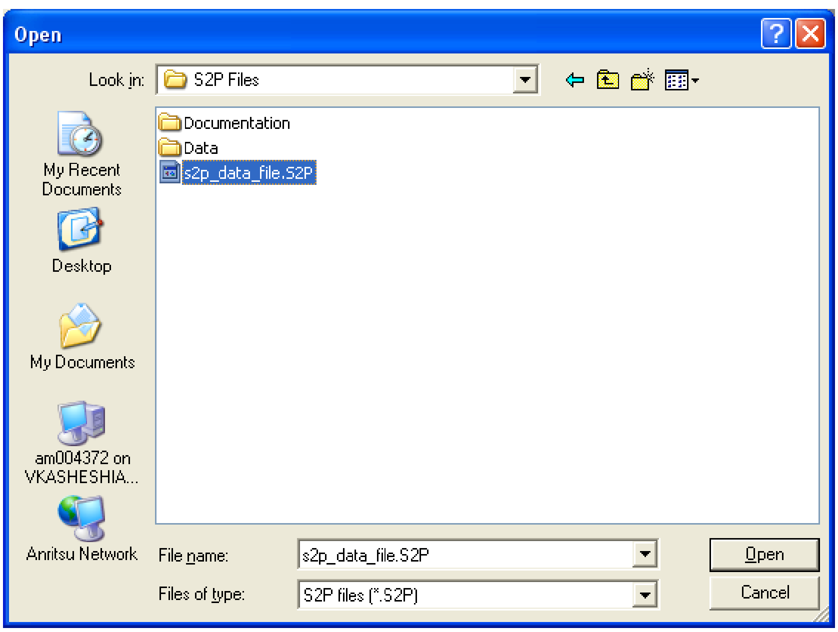


Figure 3-17. Open Dialog

7. To remove the Offset Table correction, click **Offset Table Off**. A check mark appears in front of Offset Table Off and the word Offset does not appear in the display window (see Figure 3-18).

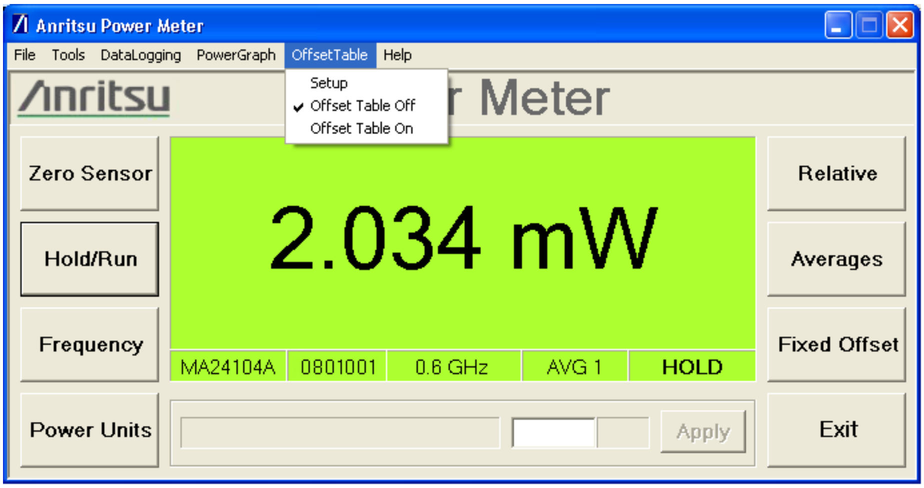


Figure 3-18. Offset Table Menu (Offset Table Off Status)

Session Restore

The Anritsu Power Meter application retains the set up information of a session, even if the inline high power sensor becomes disconnected from the PC. When the inline high power sensor is reconnected, the changed properties (if different from default) will be highlighted for five seconds as a reminder of the changed set up. The set up information is lost once the application is closed or a different model sensor is connected.

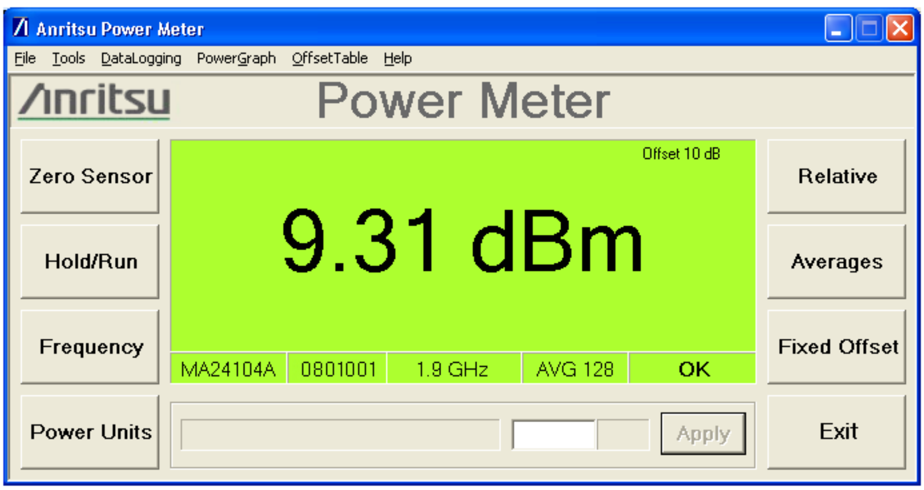


Figure 3-19. Session Restore

3-4 Making Measurements

This section presents common procedures for using the MA24104A power sensor with a PC. These procedures refer to the MA24104A sensor and Anritsu Power meter PC application buttons and menus that were previously described. Before attempting these procedures, you should be familiar with the Anritsu Power Meter PC application. If an Anritsu Master™ series instrument is being used, refer to the user documentation that came with the instrument for procedures on operating external power sensors.

Basic Power Measurement

1. Connect the sensor to a computer or Anritsu Master™ series instrument as shown in Figure 3-20 and turn the power sensor **ON** by pressing the sensor's power button for 1 second.

> **Note:** Operation with the RS232 port requires an external power supply or batteries installed in the sensor. A USB connection does not require an external power supply or batteries. When changing connection methods (USB/RS232), the sensor must be powered off and back on, and re-zeroed. If the sensor goes into sleep mode, the sensor must be re-zeroed before taking measurements.

2. Open the Anritsu Power Meter application.

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

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 Power Meter application window (power readings are continuous with the default setting).

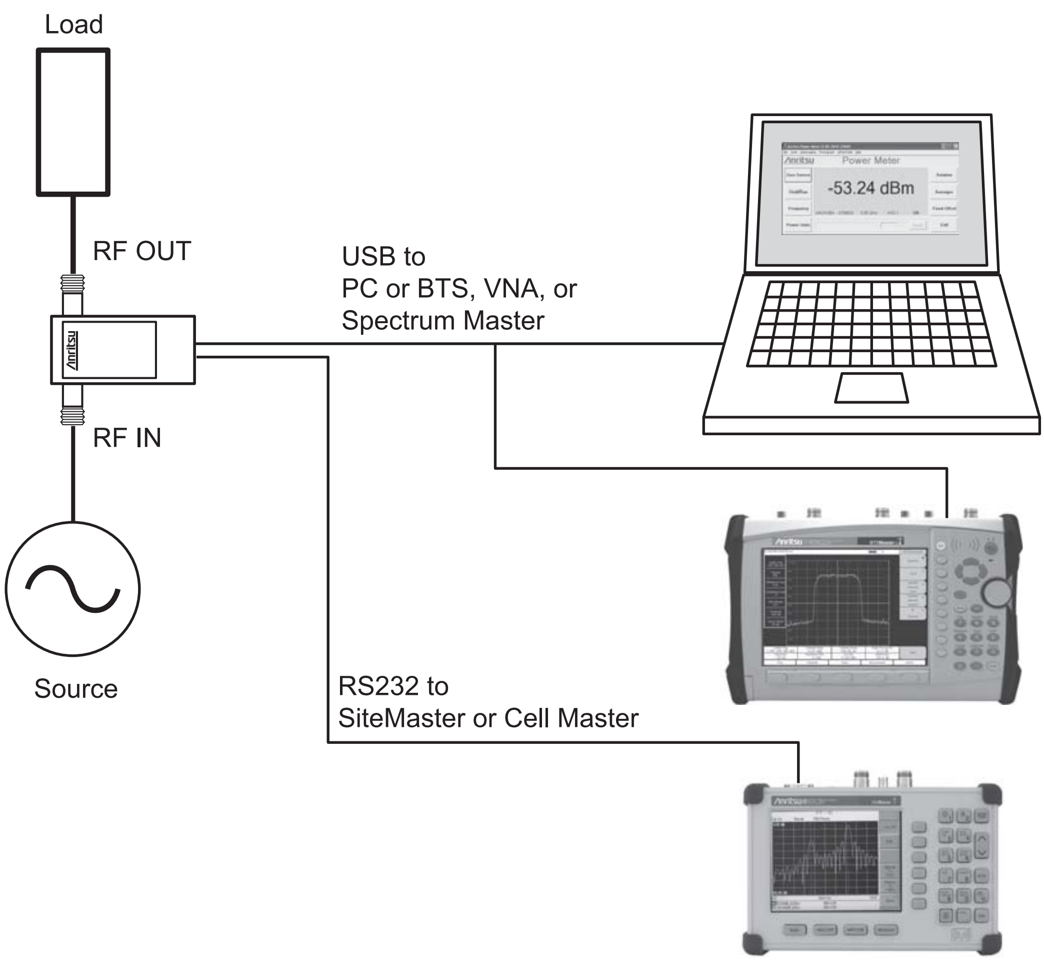


Figure 3-20. Measurement Setup

> **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.

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**.

> **Warning:** Do not connect the sensor backwards (**RF IN** and **RF OUT** reversed) or apply power outside of the MA24104A specifications or permanent damage may result.

When connecting to the Type N female connector of the MA24104A 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 MA24104A 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 MA24104A can be remotely programmed over this USB interface. In addition to programming, the MA24104A 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, it is advised to 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 MA24104A power sensor, this level is less than –20 dBm. It is preferable to 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, press 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 with the MA24104A.

Applying a Calibration Factor Correction

The MA24104A 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.

Optimizing the Readings

This section presents information on how to get the fastest readings from the MA24104A power sensor when using the Anritsu Power Meter application or operating under remote control (refer to Chapter 4 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 3-1, 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 3-1. MA24104A Averaging Table (Low Aperture Time, Default Mode)

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	4	16
40	10.0	1	1	1	20	78
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	61
15	0.0316	2	3	7	25	–
10	0.0100	16	28	62	245	–
5	0.00316	158	–	–	–	–

Table 3-2, 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 3-2. MA24104A Averaging Table (High Aperture Time)

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	2	5
35	3.16	1	1	1	1	1
30	1.00	1	1	1	1	1
25	0.316	1	1	1	1	1
20	0.100	1	1	1	1	4
15	0.0316	1	1	1	2	38
10	0.0100	1	2	4	16	–
5	0.00316	10	18	39	153	–

3-5 Measurement Considerations

Time Varying Signals

Case 1: Modulated signals with pulse or pattern repetition times ≤ 1 ms (PRF ≥ 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 MA24104A 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 MA24104A and can be an issue with any power sensor/meter and any sampled data system.

Multitone Signals

The MA24104A 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 multi-tone signals, the frequency entered into the sensor’s application should be the average frequency of all significant tones. The MA24104A has an error of 0.1 dB for every 100 MHz bandwidth at frequencies between 1 GHz and 3 GHz, and an error of 0.5 dB for every 100 MHz bandwidth at frequencies below 1 GHz and above 3 GHz.

Noise and Averaging

When there is a need 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 the sensor manual (Using the Power Sensor | Making Measurements | Optimizing the Readings) 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 +40 dBm is to be measured to 0.01 dB resolution. Using Table 3-1 and Table 3-2, the required number of averages is 5 averages using High Aperture Time mode (the same measurement would require more than 78 averages in Low Aperture Time mode).

Settling Time

The MA24104A 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.

Maximum Power

The MA24104A 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 the limits shown in the figure below can be measured. To ensure accurate readings, the peak-to-average ratio (crest factor) of signals must be less than 12 dB.

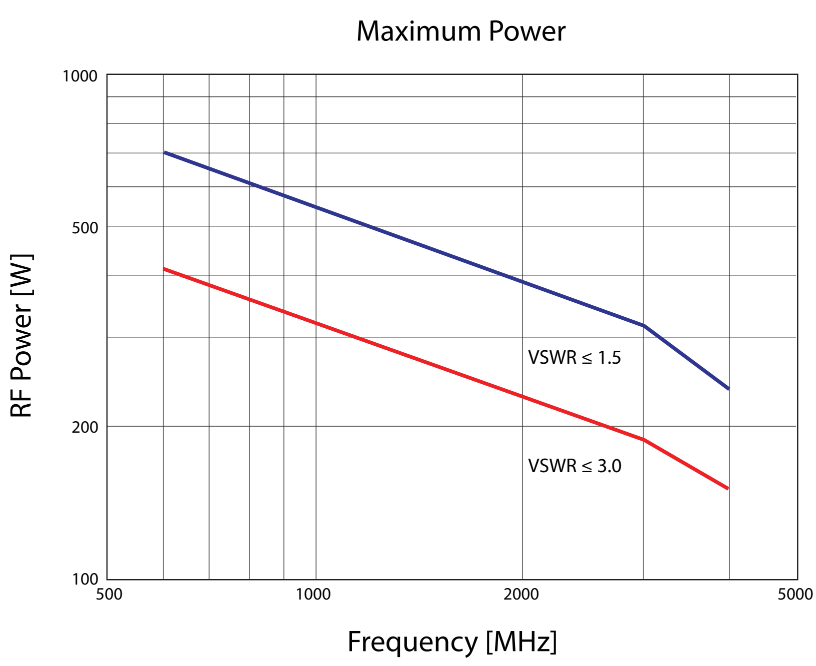


Figure 3-21. Maximum Power Handling Capacity (with Load VSWR less than 1.5:1 and 3.0:1)

3-6 Uncertainty of a Measurement

Power measurements have many component parts that affect overall measurement uncertainty when measuring power with the MA24104A 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:**

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

    $\text{dB Mismatch Uncertainty} = 20\log\left|1 + \Gamma_1\Gamma_2\right|$
  - **Load Mismatch (not considering inline power sensor insertion loss):**

    $\%\ \text{Load Mismatch Uncertainty} = 100\left[\left|1 + \Gamma_2\Gamma_3\right|^2 - 1\right]$

    $\text{dB Load Mismatch Uncertainty} = 20\log\left|1 + \Gamma_2\Gamma_3\right|$
  - **Load Mismatch (considering inline power sensor insertion loss):**

    $\%\ \text{Load Mismatch Uncertainty} = 100\left[\left|1 + \mathbf{t}^2\Gamma_2\Gamma_3\right|^2 - 1\right]$

    $\text{dB Load Mismatch Uncertainty} = 20\log\left|1 + \mathbf{t}^2\Gamma_2\Gamma_3\right|$
- **Directivity Uncertainty:**

  $\%\ \text{Uncertainty due to Finite Directivity} = 100\left[(1 + \Gamma_3/\mathbf{D})^2 - 1\right]$

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

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

IL = Insertion Loss of the inline power sensor

Uncertainty Examples

Two measurement uncertainty calculations for Low Aperture Time mode are shown for the MA24104A in Table 3-3. The MA24104A 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 3-3. 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	1.0	Normal at 2σ	2	0.0	0.5
Zero Set	0.1	4.0	Rectangular	$\sqrt{3}$	0.0	2.3
Zero Drift	0.0	1.2	Normal at 2σ	2	0.0	0.6
Directivity Induced Uncertainty	0.6	0.6	Rectangular	$\sqrt{3}$	0.3	0.3
Source Mismatch Uncertainty	1.3	1.3	Rectangular	$\sqrt{3}$	0.8	0.8
Load Mismatch Uncertainty	3.7	3.7	Rectangular	$\sqrt{3}$	2.1	2.1
Effect of Digital Modulation	0	0	Rectangular	$\sqrt{3}$	0	0
Combined Uncertainty (RSS) Room Temperature					2.9	3.8
Expanded Uncertainty with K=2 Room Temperature					5.9	7.6
Temperature Compensation	1.4	1.4	Rectangular	$\sqrt{3}$	0.8	0.8
Combined Uncertainty (RSS, 0 to 50 °C)					3.1	3.9
Expanded Uncertainty with K=2 (RSS, 0 to 50 °C)					6.1	7.8

Table 3-4. Noise Measurement Uncertainty Calculations

Noise Calculations at 50 dBm (100 W):	
Noise	24 mW/100 W = 0.0%
Zero Set	68 mW/100 W = 0.1%
Zero Drift	20 mW/100 W = 0.0%
Noise Calculations at +10 dBm (10 mW):	
Noise	100 μW/10 mW = 1.0%
Zero Set	398 μW/10 mW = 4.0%
Zero Drift	119 μW/10 mW = 1.2%

3-7 Error States

This section details some of the error messages that may appear on the application screen. In most cases, the error condition can be easily corrected. The status LED will light amber when an error state occurs. If not, note the error message and contact an Anritsu Service Center.

Table 3-5. 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	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 4 — Remote Operation

4-1 Introduction

Once connected to a PC using a USB cable, the MA24104A shows up as an RS-232 Serial COM port on the PC. You can check the COM port number from the Tools drop-down menu or by using the Windows control panel. The COM port number and following settings are needed in order to control the sensor remotely:

- **Baud Rate:** 115200
- **Data Bits:** 8
- **Parity:** None
- **Stop Bits:** 1

When the power sensor is connected to a PC using a USB cable, it will be configured in idle mode. While in idle mode, the sensor is waiting for a **START** command from the host application. The application developer must send the **START** command to put the sensor in measurement mode. Once the sensor is in measurement mode, various commands can be sent to communicate with the power sensor. When the application is being closed, the **STOP** command should be sent to put sensor in idle mode.

Note: In Low Aperture Time mode, the sensor takes about 70 milliseconds to respond to all commands with the exception of the **ZERO** command, which takes about 19 seconds.

In High Aperture Time mode, the sensor takes about 700 milliseconds to respond to all commands with the exception of the **ZERO** command, which takes about 19 seconds.

4-2 Remote Operation Commands Summary

The following is a list of commands available to control the MA24104A:

Table 4-1. Remote Operation Commands

Command	Description
START	Puts the power sensor in measurement mode
STOP	Stops the measurement mode and puts the sensor in idle mode
IDN?	Gets identification information from the sensor
PWR?	Gets the power reading from the power sensor
NPWR?	Gets a new power reading from the sensor
FREQ?	Gets the current cal factor frequency value from the sensor
FREQ	Sets the cal factor frequency value
ZERO	Zeros the power sensor
TMP?	Gets the current temperature from the sensor
STATUS?	Gets the error status byte from the sensor
HAT	Sets High Aperture Time mode
LAT	Sets Low Aperture Time mode
ASDON	Sets auto shutdown mode on
ASDOFF	Sets auto shutdown mode off

4-3 Remote Operation Command Details

Each command needs to be followed by a Line Feed (0x0A, ASCII 10) termination character. Response from the sensor will have a Line Feed (0x0A, ASCII 10) termination character attached at the end.

START

Description: Puts the power sensor in measurement mode.

Syntax: START + LF

Return Value: None for the first time, OK for any subsequent command sent.

Remarks: This command does not return anything when sent the first time. For any subsequent START commands, the sensor will return OK. This is helpful, if the user wants to know if the sensor is in measurement mode.

STOP

Description: Stops the measurement mode and puts the sensor in idle mode.

Syntax: STOP + LF

Return Value: OK or ERR

Remarks: This command should be sent before exiting the user application.

IDN?

Description: Gets identification information from the sensor.

Syntax: IDN? + LF

Return Value: ANRITSU, Model #, Serial #, Module Serial #, firmware version

PWR?

Description: Gets the power reading from the power sensor.

Syntax: PWR? + LF

Return Value: Power value in dBm

Remarks: If an error condition exists, the returned power reading values are pre-tagged with the letter “E” and the sensor’s LED turns yellow. The STATUS? command can then be issued to find details about the error.

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 yellow. The STATUS? command can then be issued to find details about the error.

Note: This command is only available in sensor firmware versions 1.01 and later.

FREQ?

Description: Gets the current cal factor frequency value from the sensor.

Syntax: FREQ? + LF

Return Value: Current cal factor frequency in GHz

FREQ

Description: Sets the current cal factor frequency value for the sensor.

Syntax: FREQ fghz + LF

Return Value: OK or ERR

Remarks: “fghz” is the cal factor frequency value in GHz. “fghz” must be between 0.6 GHz to 4 GHz. Available resolution is 3 digits after the decimal point.

ZERO

Description: Zeros the power sensor.

Syntax: ZERO + LF

Return Value: OK if successful and ERR if zeroing failed.

Remarks: In case of zero failure, the STATUS? command can be used to retrieve more detail about the error. See the STATUS? command for more detail. It takes 19 seconds to zero a sensor, please wait at least this long to get a response from the sensor.

TMP?

Description: Gets the current temperature reading from the sensor.

Syntax: TMP? + LF

Return Value: Current temperature in degrees C.

STATUS?

Description: Get error status byte from the sensor.

Syntax: STATUS? + LF

Return Value: Error status byte

Remarks: Error status byte information:

```
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
```

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.

LAT

Description: Sets the low aperture time mode.

Syntax: HAT + 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.

ASDON

Description: Turns on auto shutdown mode

Syntax: ASDON + LF

Return Value: OK or ERR

Remarks: This command applies when RS232 connectivity is used with battery power. This is the default mode at power up. In this mode, the sensor will automatically go into sleep mode to conserve battery power if the RS-232 serial port cable is disconnected from the host. The sensor will wake up when an active host is reconnected and must be zeroed before taking measurements.

ASDOFF

Description: Turns off auto shutdown mode

Syntax: ASDOFF + LF

Return Value: OK or ERR

Remarks: This command applies when RS232 connectivity is used with battery power. In this mode, the sensor will not go into sleep mode if the RS-232 serial port cable is disconnected from the host.

Appendix A — Connector Care and Handling

Anritsu MA24104A Power Sensors are high-quality precision laboratory instruments and should receive the same care and respect afforded to such instruments. Follow the precautions listed below when handling or connecting these devices. Complying with these precautions will guarantee longer component life and less equipment down time due to connector or device failure. Also, such compliance will ensure that Power Sensor failures are not due to misuse or abuse – two failure modes not covered under the Anritsu warranty.

Beware of destructive pin depth mating connectors

Destructive pin depth of mating connectors is the major cause of failure in the field. When an RF component is mated with a connector having a destructive pin depth, damage will usually occur to the RF component connector. A destructive pin depth is one that is too long with respect to the reference plane of the connector (Figure A-1, left).

The pin depth of DUT connectors should be measured to assure compatibility before attempting to mate them with Power Sensor connectors. An Anritsu Pin Depth Gauge or equivalent can be used for this purpose (Figure A-1, right)

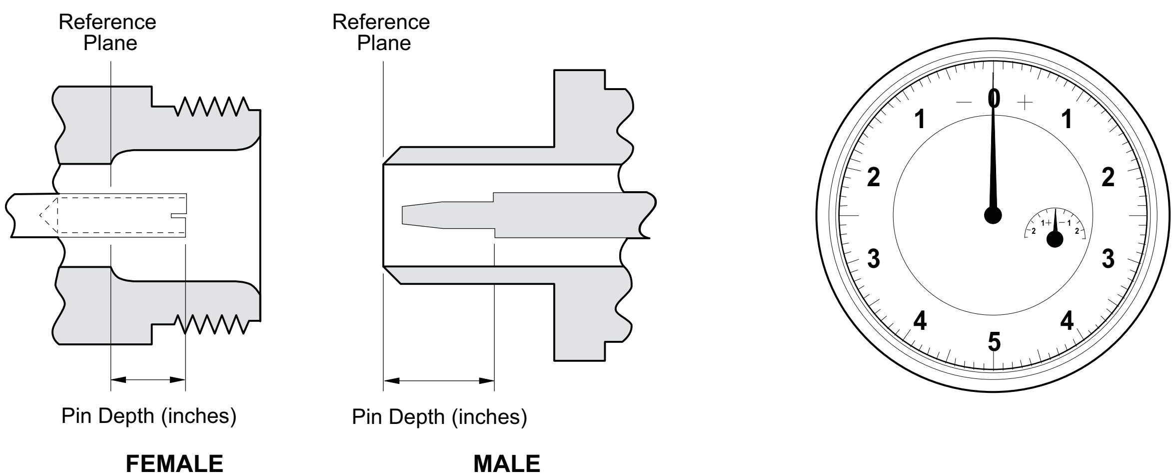


Figure A-1. Pin Depth

If the measured connector is out of tolerance in the "+" region, the center pin is too long (see Table A-1, below). Mating under this condition will likely damage the precision RF component connector. If the test device connector measures out of tolerance in the "–" region, the center pin is too short. This should not cause damage, but it could result in a poor connection and a consequent degradation in performance.

Table A-1. Allowable DUT Connector Pin Depth

Connector Type	Pin Depth Gage Model #	Pin Depth (inches)	Pin Depth Gage Readout
N-Male	SC3825	0.207 +0.030 –0.000	0.207 +0.000 –0.030
N-Female	SC3825	0.207 +0.000 –0.030	0.207 +0.000 –0.030

Avoid over torquing connectors

Over torquing connectors is destructive; it may damage the connector center pin. Always use a connector torque wrench when tightening connectors. Never use pliers to tighten connectors.

Avoid mechanical shock

Connectors are designed to withstand years of normal bench handling. However, do not drop or otherwise treat them roughly. Mechanical shock will significantly reduce their service life.

Avoid applying excessive power

The MA24104A sensor is rated at 150 W maximum continuous input power given a load VSWR of 3:1 or less. Exceeding the maximum input power level may permanently damage the internal components, rendering the power sensor useless. Refer to “Measurement Considerations” on page 3-15 for more details.

Cleaning connectors

The precise geometry that makes the RF component's high performance possible can easily be disturbed by dirt and other contamination adhering to the connector interfaces. When not in use, keep the connectors covered. To clean the connector interfaces, use a clean cotton swab that has been dampened with denatured alcohol.

The following are some important tips on connector care:

- Use only isopropyl alcohol as a cleaning solvent. Do not use excessive amounts of alcohol as prolonged drying of the connector may be required.
- Never put lateral pressure on the center pin of the connector.
- Verify that no cotton or other foreign material remains in the connector after cleaning.
- If available, use compressed air to remove foreign particles and to dry the connector.
- After cleaning, verify that the center pin has not been bent or damaged.
- Avoid touching connector mating planes with bare hands. Natural skin oils and microscopic dirt particles and very hard to remove.
- Always check the pin depth of DUT connectors before use to determine if they are out of spec. One bad connector can damage many.
- Always use an appropriate torque wrench.
- Put dust caps on the connector after use.

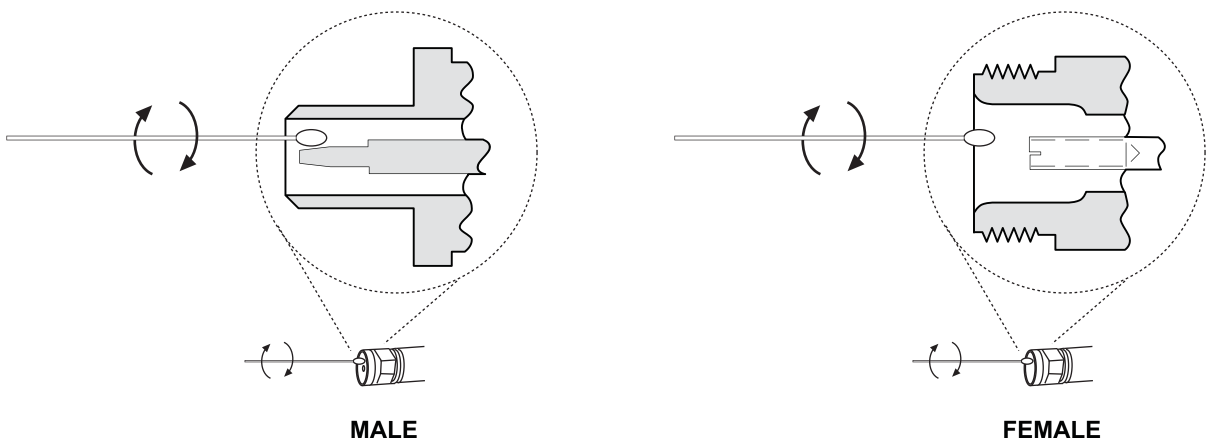


Figure A-2. Cleaning Connectors

Appendix B — Sample Visual Basic Code

B-1 Demo Application

The MA24104A CD contains a demo application that allows you to interface with the power sensor using the remote programming protocol. The sample code is written in Microsoft® Visual Basic® 6.0 and is given at the end of this appendix. The complete project, DempApp.vbp, is available on the CD that shipped with the sensor. The Demo Application's main form is shown below:

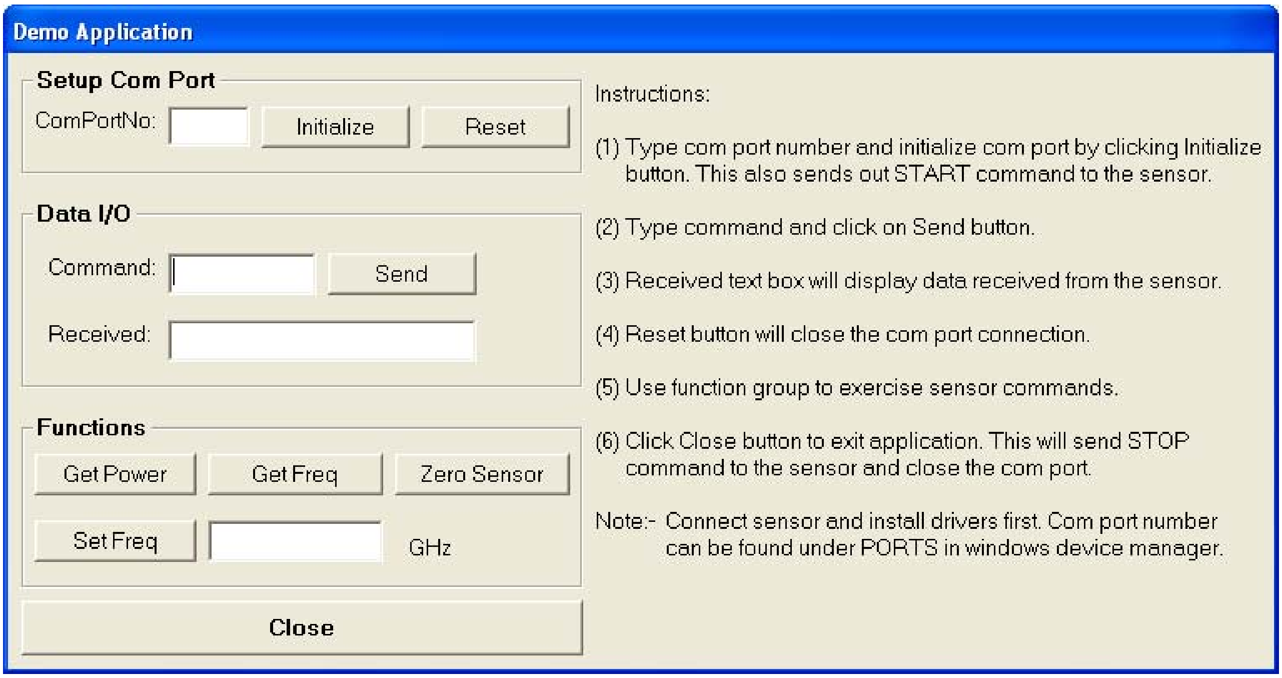


Figure B-1. Demo Application

It is recommended to use the source code and project available on the CD that shipped with the sensor to minimize typing errors. You may need to add Microsoft® Comm Control 6.0 manually, which can be added from Visual Basic® 6.0 IDE by navigating to: Project | Components.

B-2 Using the Demo Application

Once connected to the PC using the USB cable, the MA24104A shows up as a Serial port device on the PC. You can check the COM port number using the device manager in the Windows® control panel.

Type the COM port number in the ComPortNo: text box and click **Initialize**. Once the COM port is initialized, you can type commands in the Command text box, and then click the **Send** button. Any responses from the sensor will be displayed in the Received text box. You can use the Functions group buttons to exercise the sensor for power readings, frequency readings and settings, and for zeroing sensor.

> **Note:** The Demo Application uses Microsoft Comm Control, which limits COM Port number usage to less than 16 (COM3 to COM16).

```
*************************************************************************
// This sample program shows how to control Anritsu MA24104A inline high power sensor
using
//Microsoft Visual basic 6.0

Option Explicit
Public gstrInputBuffer As String

'Event handler for InitializeComPort button
Private Sub btnInitializeComPort_Click()
    Call SetCommPort(Val(Trim(txtCOMPORTNo.Text)))
End Sub

'Subroutine to set the com port
Public Sub SetCommPort(portNo As Integer)
    On Error GoTo errHndler
        'Setup MSComm control
        MSComm1.Settings = "115200,n,8,1"
        MSComm1.CommPort = Trim(txtCOMPORTNo.Text)
        MSComm1.PortOpen = True
        MSComm1.RThreshold = 1
        MSComm1.SThreshold = 1
        '
        'Wait for half a second before sending START command
        Delay (0.5)
        'Arm sensor to start making measurements
        txtCommand.Text = "START"
        Call btnSend_Click
        '
        Exit Sub

errHndler:
        MsgBox ("ERROR: " & Err.Description)
End Sub

'Event handler for ResetComPort button
Private Sub btnResetComPort_Click()
    'Close com port
    If MSComm1.PortOpen = True Then
       MSComm1.PortOpen = False
    End If
End Sub

'Event handler for Send button
Private Sub btnSend_Click()
  Dim strResult As String
    'Clear buffer & receive text window before sending command
    gstrInputBuffer = ""
    txtReceived.Text = ""
    'Send command and appead Termination character, 0x0A(10)with it.
    MSComm1.Output = UCase(txtCommand.Text) & Chr(10)
    'Display received result on the Received text box
    txtReceived.Text = strResult
    '
End Sub
```

```
'
'Event handler for MSComm1 event
Private Sub MSComm1_OnComm()
    'Get data from Input buffer
    gstrInputBuffer = MSComm1.Input
    'Display received result on the Received text box
    txtReceived.Text = gstrInputBuffer
End Sub

'Event handler for GetFreq button
Private Sub btnGetFreq_Click()
    txtCommand.Text = "FREQ?"
    Call btnSend_Click
End Sub

'Event handler for GetPower button
Private Sub btnGetPower_Click()
    txtCommand.Text = "PWR?"
    Call btnSend_Click
End Sub

'Event handler for SetFreq button
Private Sub btnSetFreq_Click()
    txtCommand.Text = "FREQ " & txtFreq.Text
    Call btnSend_Click
End Sub

'Event handler for ZeroSensor button
Private Sub btnZeroSensor_Click()
    txtCommand.Text = "ZERO"
    Call btnSend_Click
    'Sensor will return OK after about 19 Seconds
End Sub

'Event handler for Close button
Private Sub btnClose_Click()
'
    'Make sure we close the com port before we exit the app
    If MSComm1.PortOpen = True Then
        'Stop sensor from making measurements
        txtCommand.Text = "STOP"
        Call btnSend_Click
        '
        'Wait for half a second after sending START command
        Delay (0.5)
        '
        MSComm1.PortOpen = False
    End If
    'Close the app
    End
End Sub
```

```
'Delay routine
Public Sub Delay(ByVal Seconds As Single)
    '
    Dim fStartTimer As Single
    Dim fFinish     As Single
    '
    fStartTimer = Timer
    '
    Do
        DoEvents
        fFinish = Timer
        If Abs(fFinish - fStartTimer) > Seconds Then
            Exit Do
        End If
    Loop
    '
End Sub
************************************************************************
```

Appendix C — Upgrading the Firmware

The Anritsu Power Meter application provides the necessary software to upgrade the MA24104A power sensor's firmware. The current sensor firmware can be determined from the Help | About menu in the Anritsu Power Meter application. To upgrade the firmware, proceed as follows:

1. Download the latest firmware upgrade files from http://www.us.anritsu.com and save them in a recoverable location.
2. Launch the firmware upgrade utility from the Tools menu in the Anritsu Power Meter application and follow the on-screen instructions.
3. Disconnect and reconnect the USB cable from the power sensor. Push the sensor's power button for three seconds to turn the sensor On (note that the LED will illuminate) and then click **OK**.

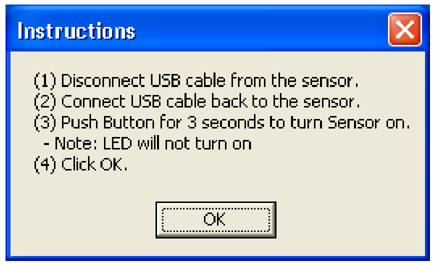


Figure C-1. Firmware Upgrade Dialog

Note: If this is the first time that you are upgrading the sensor's firmware, you will need to install the MA24104A upgrade driver. Follow the driver installation procedure as outlined in Section 2-3, starting with step 9, and select the **MA24104A Upgrade Mode** driver when prompted from: C:\Program Files\Anritsu\AnritsuPowerMeter\UpgradeModeDriver\AnritsuMA24104AUpgradeMode.inf

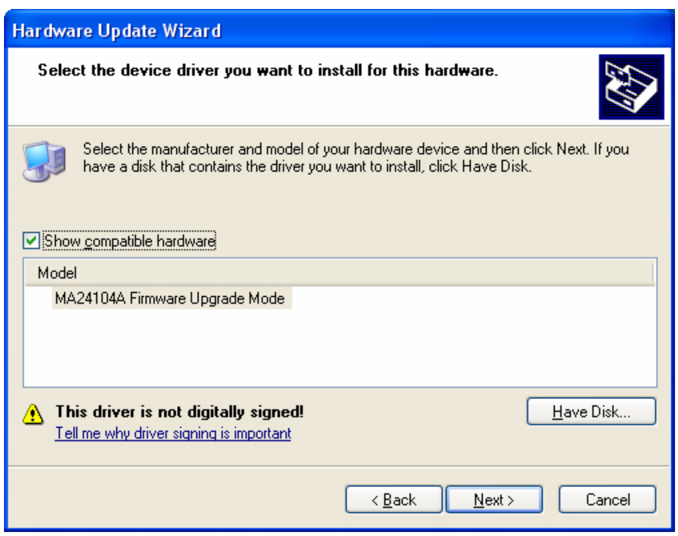


Figure C-2. Upgrade Firmware Driver

4. Once the upgrade driver has been installed, click **OK** on the dialog below.

Figure C-3. Firmware Upgrade Dialog

5. Select the power sensor that you intend to upgrade from the drop-down list box.

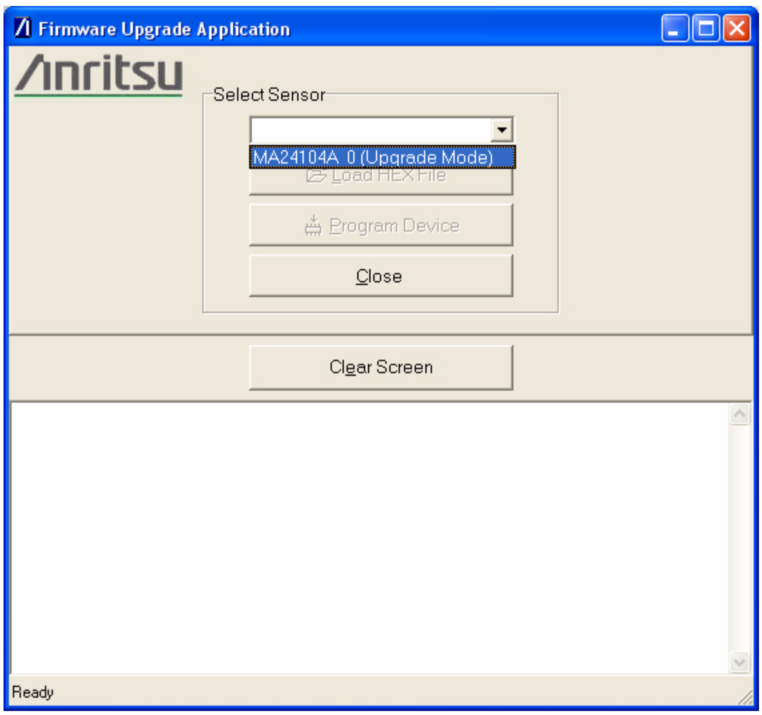


Figure C-4. Firmware Upgrade Application

6. Click **Load Hex File** and select the HEX file from the directory in which it was saved.

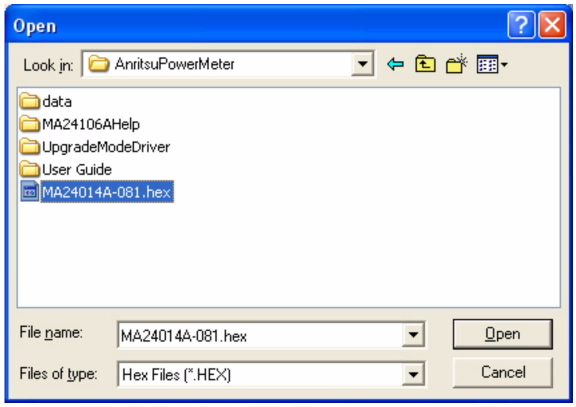


Figure C-5. Open File Dialog

Warning: Do Not disconnect the MA24104A power sensor from the USB port or interrupt the firmware write sequence as this will cause an unrecoverable programming error.

7. Click **Program Device**. The following messages will be displayed during the program operation:

```
MESSAGE - Programming FLASH Completed
MESSAGE - Erasing and Programming FLASH...
```

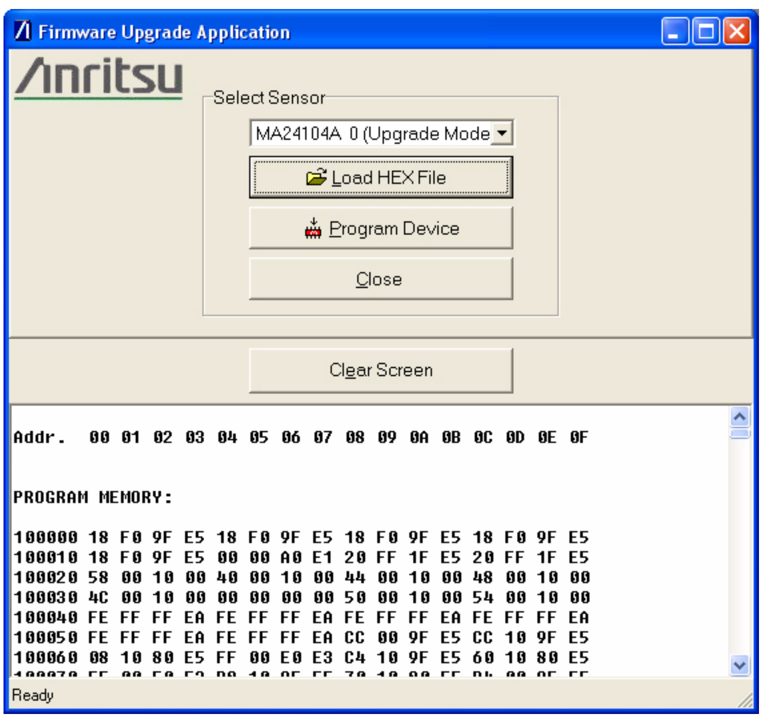


Figure C-6. Firmware Upgrade Application

8. Disconnect and reconnect the USB cable from the power sensor. Push the sensor's power button for three seconds to turn the sensor On (note that the LED will illuminate). Click **OK** to complete the firmware upgrade procedure.

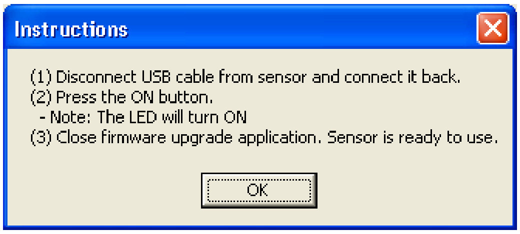


Figure C-7. Firmware Upgrade Dialog

9. Launch the Anritsu Power Meter application to begin using the upgraded sensor.

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