User Guide

Power Sensor

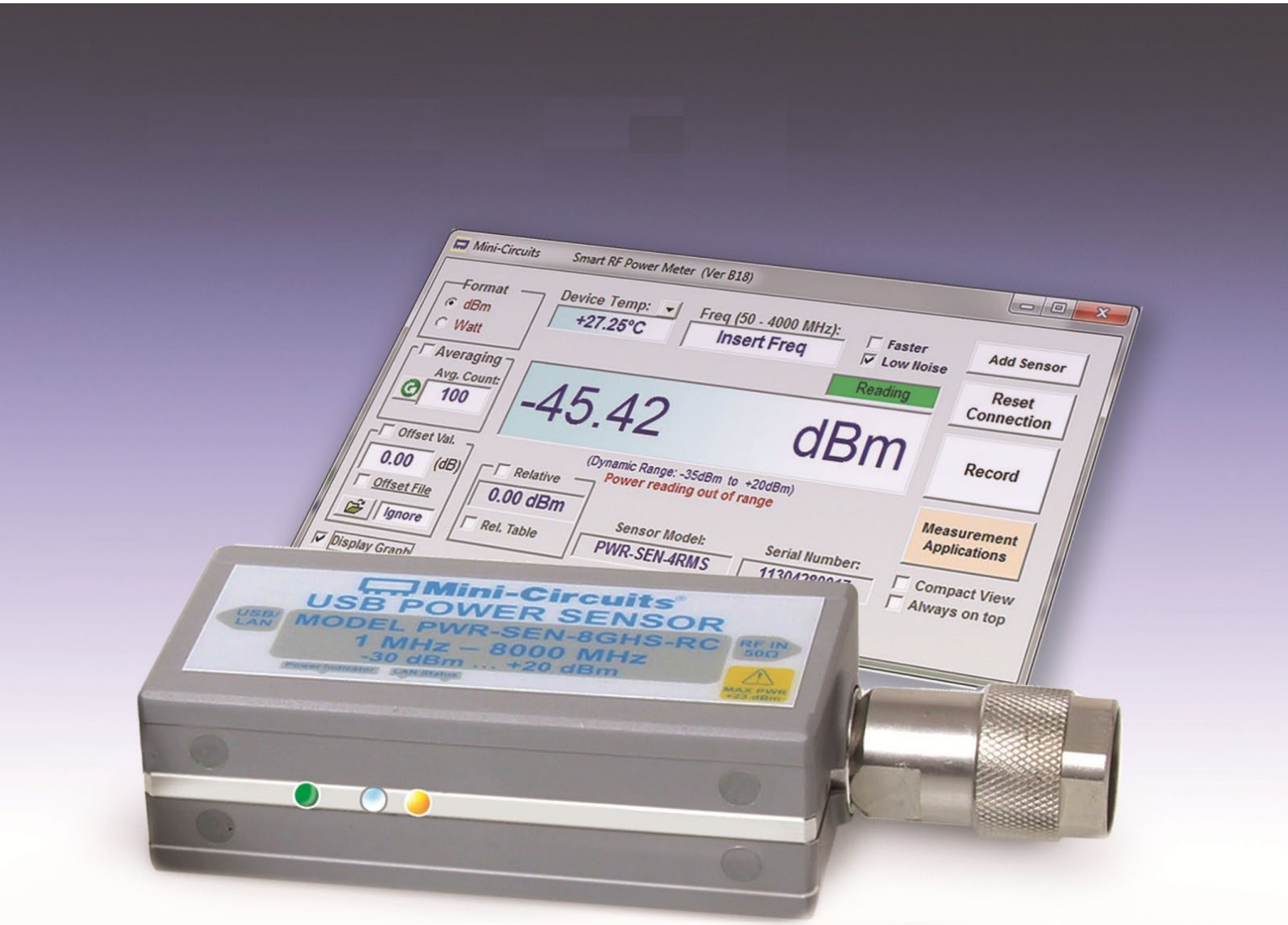


Table of Contents

1 General Information

1.1. User-Guide Scope

This user guide provides general introduction, installation instructions and operating information for Mini-Circuits' PWR series of USB and Ethernet smart power sensors.

1.2. Support Contacts

We are here to support you every step of the way. For technical support and assistance, please contact us at the email address below or refer to our website for your local support:

- testsolutions@minicircuits.com
- https://www.minicircuits.com/contact/worldwide_tech_support.html

1.3. Warranty & RMA Returns

Mini-Circuits provides a limited time warranty with all products. Please contact your account manager or refer to our website for full details: https://www.minicircuits.com/support/ordering.html

If you have any questions or concerns with your product, please contact us in the first instance through testsolutions@minicircuits.com. Our team will work with you promptly to understand and resolve any issues. As a software-controlled instrument, it is usually possible to resolve issues remotely without requiring the unit to be returned to the factory.

In the event that a return to the factory is necessary, Mini-Circuits will provide an RMA number and full return instructions.

1.4. End of Life

Please contact testsolutions@minicircuits.com to review environmentally friendly end of life disposal options.

1.5. Definitions

Note:

- A note advises on important information you may need to ensure proper operation of the equipment.
- There is no risk to either the equipment or the user.

Caution:

- A caution advises about a condition or procedure which can cause damage to the equipment.
- There is no danger to the user.

Warning:

- A warning alerts to a possible risk to the user and steps to avoid it.
- Do NOT proceed until you are sure you understand the warning.

2 About Mini-Circuits Smart Power Sensors

2.1. Introduction

Traditionally, when you wanted to measure signal power from electronic components or circuit boards, you'd have to connect them to a bulky and expensive bench-top power meter. Mini-Circuits PWR power sensors offer a more convenient approach, using a quick and simple USB or Ethernet connection to turn your Windows PC or laptop into an RF/Microwave power meter.

The PWR series offers a low-cost replacement solution for conventional RF/Microwave power meters, but goes even further by adding portability, easy data storage, advanced data-processing capabilities, and remote operation via Ethernet. Unlike most conventional bench-top instruments, they're self-calibrating and compensate automatically for temperature. They're quick and easy to use with plug and play functionality making them perfect for field or remote use.

2.2. Key Features

- Pocket-sized portability
- Automatic frequency calibration & temperature compensation
- Turns a laptop or PC into a low-cost replacement power meter
- Remote power measurement via Ethernet
- Effective, easy-to-use software:
    - User-friendly GUI for Windows® computers & direct programming support for Linux.
    - Multiple data display and output options, including Excel®
    - Data averaging
    - Relative measurements
    - Scheduled data recording with user defined spec limits
    - Multi-sensor support (up to 24), display options, and management tools
    - Measurement Applications suite to simplify many common test scenarios

For additional details, performance data and graphs, outline drawing, ordering information and environmental specifications, see our catalog at: https://www.minicircuits.com/WebStore/RF-Smart-Power-Sensors.html

2.3. Intended Applications

Mini-Circuits PWR series smart power sensors are intended for indoor use in:

- Lab and test equipment setups for both manual and automated measurements.
- Remote location monitoring.
- Automatic, scheduled data collection.
- Evaluation of high-power, multi-port devices with built-in virtual couplers/attenuators & other software tools

The power sensors can be used by anyone familiar with the basics of electronics measurements or electronic control systems.

2.4. Model Selection Guide

Model name	Frequency range		Sensor type	Video BW*** (MHz)	Input Power		Meas. Speed	Max DC Supply Current (mA)	Control protocols
	Min	Max			Min (dBm)	Max (dBm)			
PWR-2.5GHS-75 ‡	100 kHz	2.5 GHz	CW	N/A	-30	+20	30ms	70	USB
PWR-4GHS	9 kHz	4 GHz	CW	N/A	-30	+20	30ms	70	USB
PWR-6GHS	1 MHz	6 GHz	CW	N/A	-30	+20	30ms	70	USB
PWR-6LGHS	50 MHz	6 GHz	CW	N/A	-45	+10	30ms	110	USB
PWR-6LRMS-RC	50 MHz	6 GHz	RMS	N/A	-45	+10	30ms	300	USB, Ethernet
PWR-6RMS-RC	50 MHz	6 GHz	RMS	N/A	-35	+20	30ms	300	USB, Ethernet
PWR-8FS	1 MHz	8 GHz	CW	N/A	-30	+20	10ms	70	USB
PWR-8GHS	1 MHz	8 GHz	CW	N/A	-30	+20	30ms	70	USB
PWR-8GHS-RC	1 MHz	8 GHz	CW	N/A	-30	+20	30ms	250	USB, Ethernet
PWR-8P-RC	10 MHz	8 GHz	Peak & Avg	0.1	-60	+20	2µs	450*	USB, Ethernet
PWR-8PW-RC	10 MHz	8 GHz	Peak & Avg	10	-60	+20	50ns	500*	USB, Ethernet
PWR-40PW-RC	500 MHz	40 GHz	Peak & Avg	10	-20	+20	50ns	500**	USB, Ethernet

For additional details and ordering information, click on model P/N.

* With Ethernet disabled, increases to 650mA with Ethernet control enabled.

** With Ethernet disabled, increases to 700mA with Ethernet control enabled.

***Higher video bandwidth allows measuring modulated signals with greater information rate. RMS models can measure the average power of any signal regardless of the information rate.

‡ Model has impedance of 75Ω

2.5. Environmental Specifications

Mini-Circuits' PWR series smart power sensors are intended for operation in office, laboratory, or production test environments. Do not use in any condition which exceeds the published environmental specifications.

Condition	Specification
Operating temperature	0°C to +50°C
Humidity	5% to 85% RH (non-condensing)
Altitude	Up to 2000 m (6560 ft)
Pollution degree	2 - Normally only non-conductive pollution occurs (per IEC 61010)

2.6. Supported Software Environments

Mini-Circuits PWR series smart power sensors have been tested in the following operating systems:

- 32-bit systems: Windows 7 or later
- 64-bit systems: Windows 7 or later (GUI & API); Linux (direct programming only)

Custom automation programs can be created in most modern programming environments, including Python, C#, LabVIEW, MatLab and more.

For more information on programming the USB & Ethernet Power Sensors, refer to the programming manual.

2.7. Conformity

Mini-Circuits' PWR series smart power sensors conform to the following international standards:

Standard	Meaning
CE	Meets the requirements of the following applicable European directives and carries the CE marking accordingly: • Low Voltage – Directive 2014/35 • Electromagnetic Compatibility – Directive 2014/30/EU • Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) – Directive 2015/863
UKCA	Meets the requirements of the following applicable UK directives and carries the UKCA marking accordingly: • Electrical Equipment (Safety) Regulations 2016 • Electromagnetic Compatibility Regulations 2016 • The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012
FCC	This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.
USB 2.0	The model meets the specifications of the Universal Serial Bus version 2.0 communication standard as described by USB-IF.
USB HID	The model meets the requirements for Universal Serial Bus Human Interface Devices according to USB-IF's Device Class Definition for Human Interface Devices firmware revision 1.11.

2.8. Accessories and Options

The power sensors are supplied with a 6.6 ft (2.0 m) USB cable. Additionally, Peak & Average sensors are provided with an SMB-BNC cable for use in Trigger and Video out applications.

The following optional accessories are available:

- Various additional adaptors (see models' datasheet for details).
- For additional details and ordering information, see: https://www.minicircuits.com/WebStore/RF-Smart-Power-Sensors.html
- The full software package including GUI, API DLL files and programming instructions, can be downloaded from https://www.minicircuits.com/softwaredownload/pm.html

2.9. Service and Calibration

The only user-performed service possible for the PWR models is external cleaning of the case and connectors as needed. Do not use any detergents or spray cleaning solutions to clean the PWR unit. To clean the connectors, use an alcohol solution, and to clean the PWR case, a soft, damp cloth.

The recommended calibration cycle for Mini-Circuits PWR series smart power sensors is once a year. Calibration service is available from Mini-Circuits. For details see "Ordering, Pricing & Availability Information" link from individual model pages on the website.

2.10. Safety & Precautions

Mini-Circuits' PWR models contain no user serviceable parts and should not be opened. Discontinue use and contact Mini-Circuits in the event of visible damage to any parts.

Please observe the following safety precautions at all times when using Mini-Circuits USB & Ethernet power sensors:

Caution:

- Do not attempt to measure signals of greater power than the sensor is rated for in its datasheet.

Warning:

- Properly ground all equipment to reduce the risk of accidental electrical shock.

3 Software Setup

3.1. System Requirements

The minimum requirements for installation of the Mini-Circuits USB & Ethernet Power Sensors software package and API on the host PC are:

- Microsoft Windows 7 or later (32- or 64-bit).
- Intel i3 or equivalent (recommended).

3.2. Software Downloads & Resources

The full USB & Ethernet Power Sensors software package including GUI, API and documentation is available for download from:

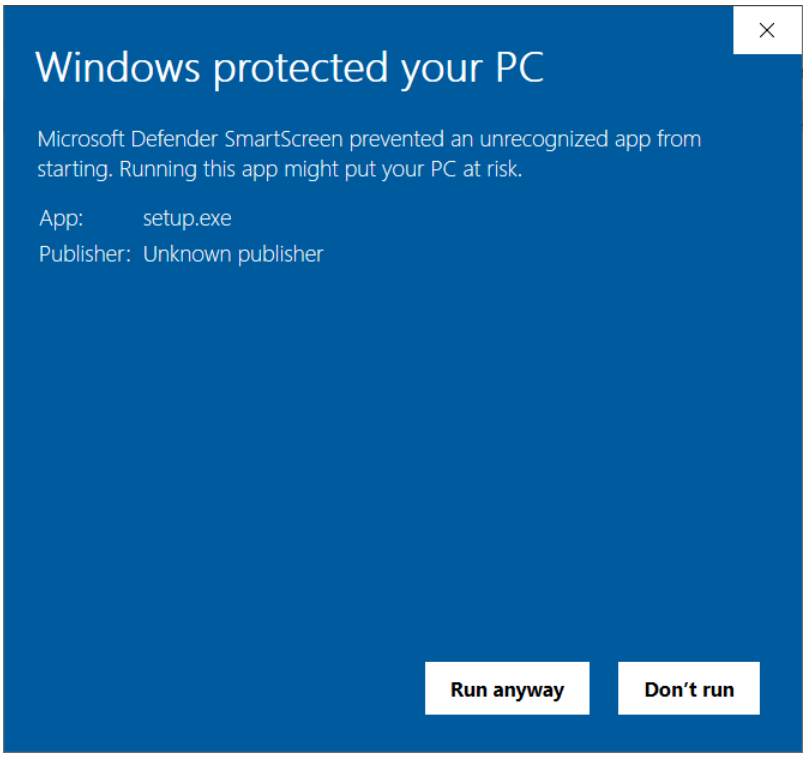
- https://www.minicircuits.com/softwaredownload/pm.html

You can download the GUI setup file directly from:

- https://www.minicircuits.com/softwaredownload/PowerMeter_Setup.zip

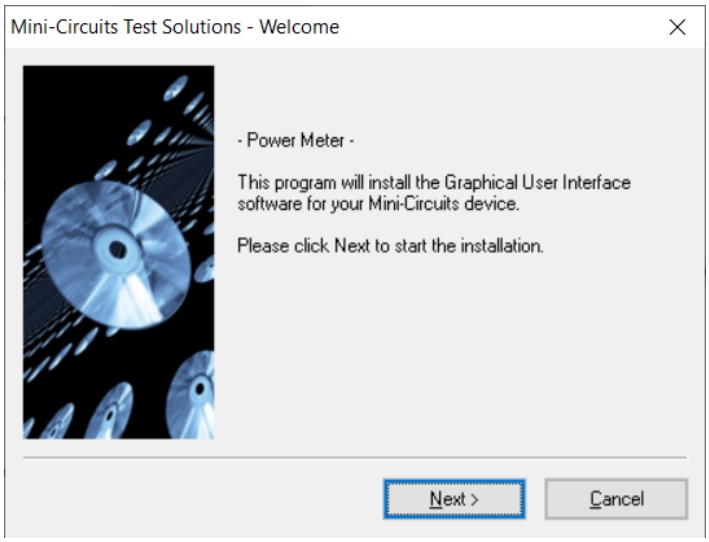
3.3. Software Installation

1. Save all work in progress and close any other programs that may be running.
2. Download the Power Sensors software from the Mini-Circuits website.
3. Extract the downloaded zip file and begin the installation process and double-click the **Setup.exe** icon.
4. If Microsoft Defender SmartScreen provides a warning about an unrecognized app, select **More Info** and then **Run Anyway**.

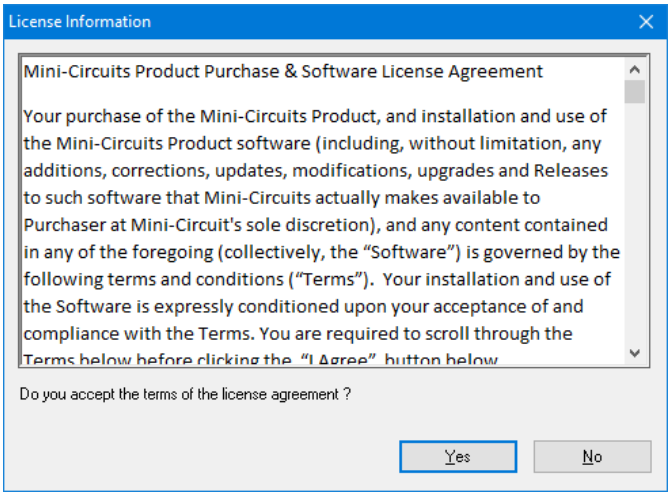


5. If prompted by Windows User Account Control, enter user credentials for an account allowing software installation.

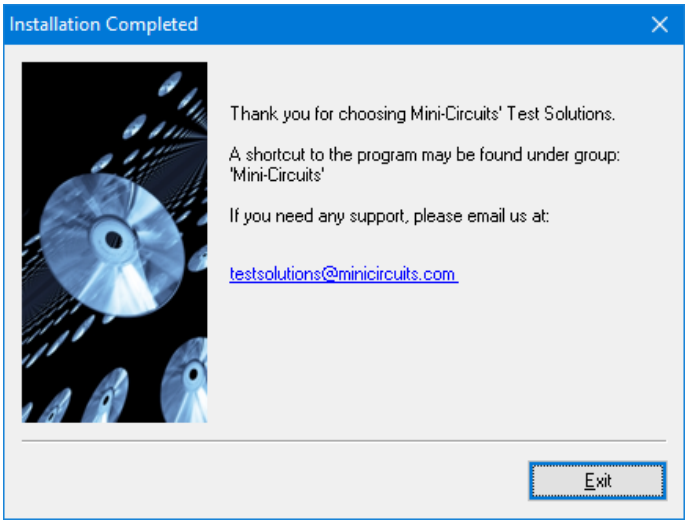
6. Click **Next** to begin the installation.



7. Click **Yes** to accept the license agreement.



8. Click **Exit** on the final window confirming that installation completed successfully.



In the event of any issues with installation, please contact testsolutions@minicircuits.com for support.

4 Power Sensor Setup

4.1. CW and RMS Models

Align the red dot at the Power Sensor USB connection with the one on the supplied cable and press in until you hear a 'click'.

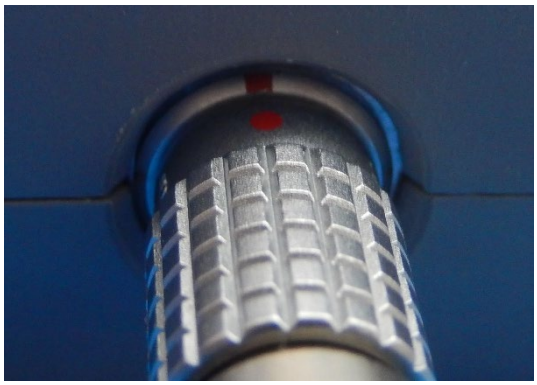


Figure 4.1: Plug cable into unit.

4.2. Peak Power Models

Simply connect the standard USB cable supplied to the USB port.

Caution:

- Note the maximum input power rating in the datasheet and the conditions specified for it.
- Exceeding these values may damage the model.
- Do not exceed the operational safe power levels for extended periods of time.

4.3. Warmup time

Mini-Circuits power meters include internal temperature sensing to provide accurate measurements. Rapid or significant variations in temperature can affect accuracy and repeatability of measurements so the sensor should be allowed to warmup to a settled temperature at the desired operating conditions before use.

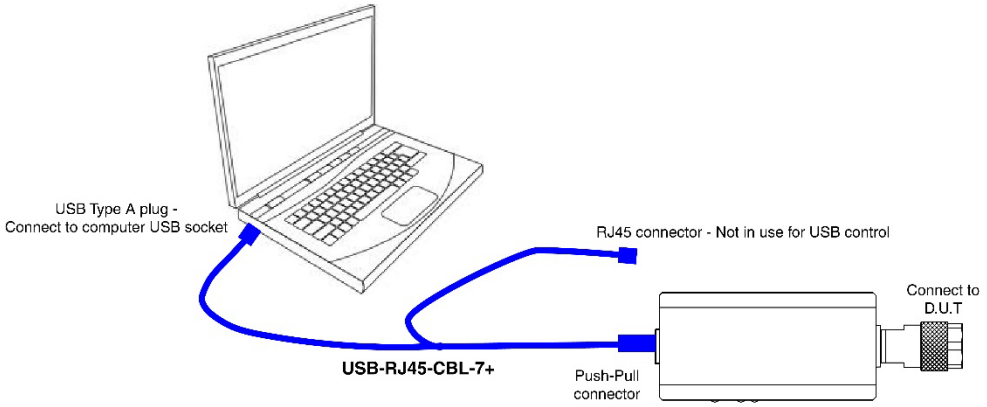
Model name	Sensor type	Warmup time (Minutes)
PWR-2.5GHS-75	CW	5
PWR-4GHS	CW	5
PWR-6GHS	CW	5
PWR-6LGHS	CW	5
PWR-6LRMS-RC	RMS	5
PWR-6RMS-RC	RMS	5
PWR-8FS	CW	5
PWR-8GHS	CW	5
PWR-8GHS-RC	CW	5
PWR-8P-RC	Peak & Avg	15
PWR-8PW-RC	Peak & Avg	30
PWR-40PW-RC	Peak & Avg	30

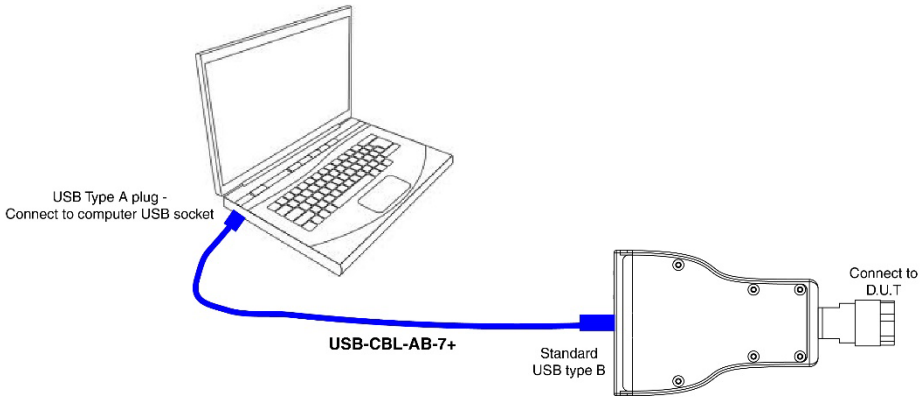
Note:

- Mini-Circuits' power sensors are tested at standard laboratory conditions in +25±3°C after the specified warmup time period.
- For peak & average power sensors, significant changes to the sample period may lead to a change in internal temperature of the sensor. For best accuracy, allow the internal temperature reading to stabilize after a change.

4.4. USB Control

Connect USB type A plug of the supplied cable to the computer USB port and begin testing. In RC models the RJ45 connector may remain disconnected for USB control.

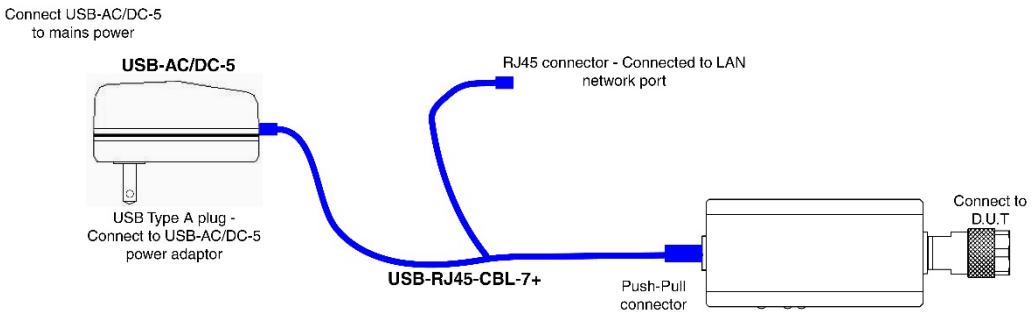




4.5. Ethernet Control using AC/DC adaptor (CW and RMS RC models only)

Connect the USB type A plug of the USB-RJ45-CBL-7+ cable to the provided power adaptor and plug it in to a mains power socket, note the power sensor's power indicator lights up.

Connect the Ethernet plug to a network port and note power sensor's Ethernet status indicators light up.



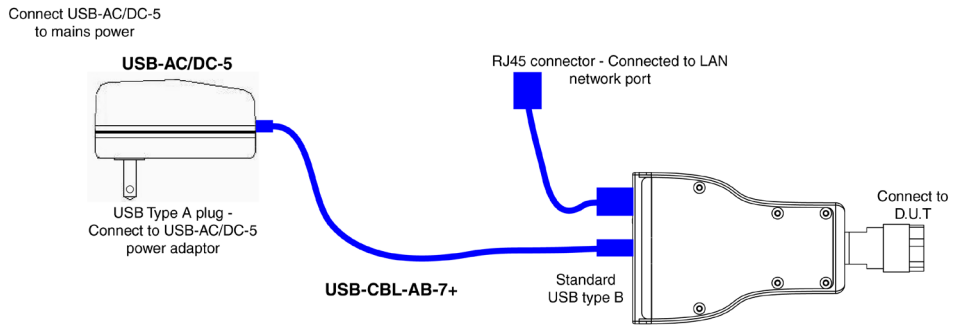
4.6. Ethernet Control using AC/DC adaptor (Peak & Avg models only)

Connect the provided USB cable to the power adaptor and plug it in to a mains power socket, note the power sensor's power indicator lights up.

Connect the Ethernet plug to a network port and note the indicators at the power sensor's Ethernet port light up.

Note:

- Before connecting the power sensor for the first time you will need to enable Ethernet control. If Ethernet control is not enabled the indicator lights on the sensor's Ethernet port will not light up



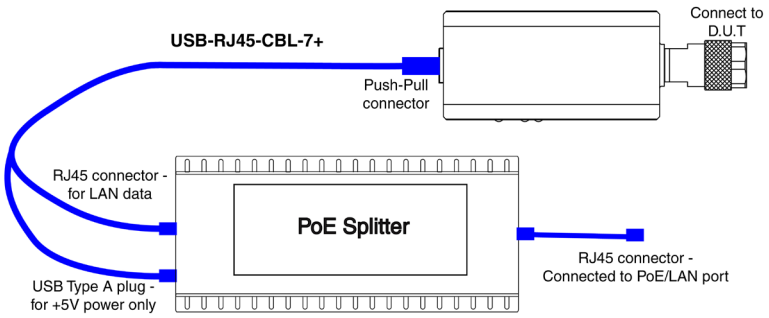
4.7. Ethernet Control using Power Over Ethernet (RC models only)

Mini-Circuits RC power sensor models do not directly support PoE but an external PoE splitter could be used to enable their use on a PoE network.

Follow the instructions from the supplier to connect the splitter's PoE interface into an Ethernet port supporting PoE.

Connect the power sensor's USB connection into the splitter's USB / DC supply port (an adapter may be required), ensuring the sensor's power indicator LED turns on.

Connect the power sensor's Ethernet connection into the splitter's RJ45 network port, the sensor's Ethernet data indicator LEDs should turn on.

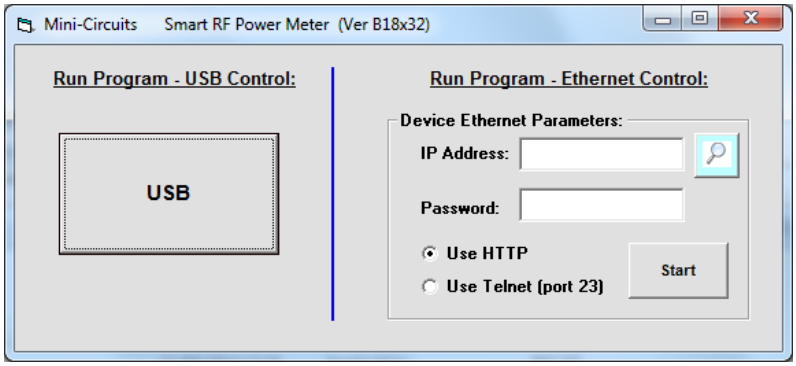


5 Using Mini-Circuits' GUI

5.1. USB Interface

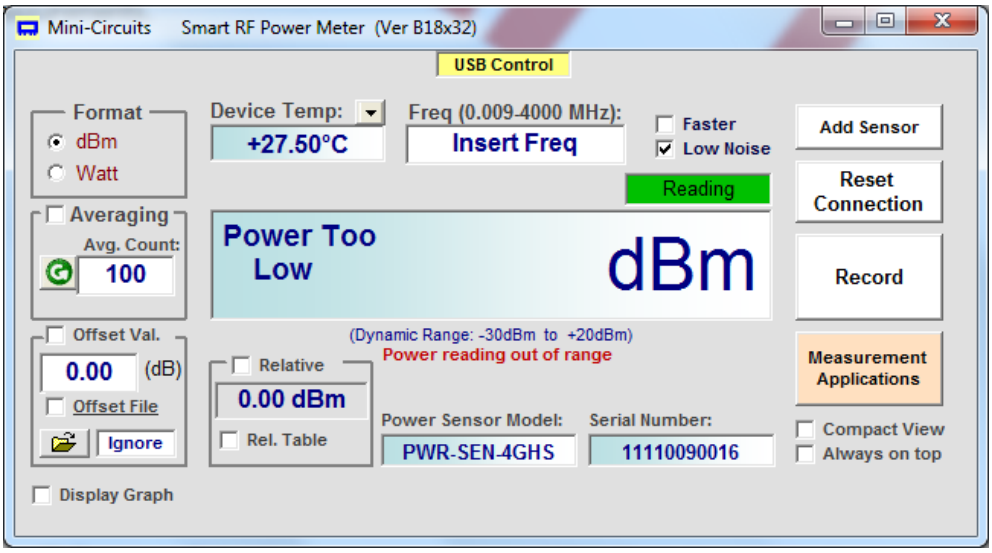
5.1.1. Getting Started

Launch the GUI from the Windows Start menu.

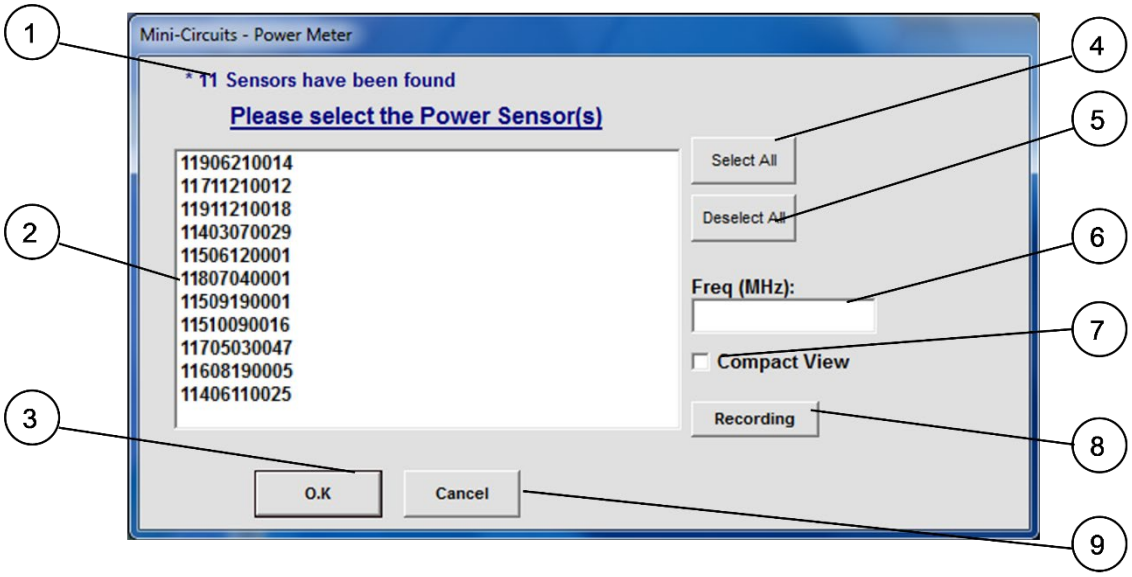


The startup window allows you to select the control method you wish to use for the PWR units, USB or Ethernet control. All models support USB control, only models with an 'RC' suffix such as PWR-8GHS-RC support Ethernet control. For USB control click on the USB button, for Ethernet control see section 5.2.

If a single PWR power sensor is connected to the computer via USB, the Smart RF Power meter screen will appear, already displaying your unit ready to start measurements.



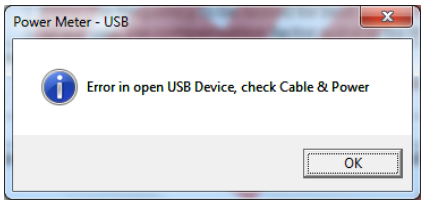
If multiple PWR power sensors are connected to the computer via USB, the initial screen will show a list of S/N for connected units. You can select a single unit, or multiple units you wish to start with – each opening in its own window. The program can handle up to 24 units connected simultaneously.



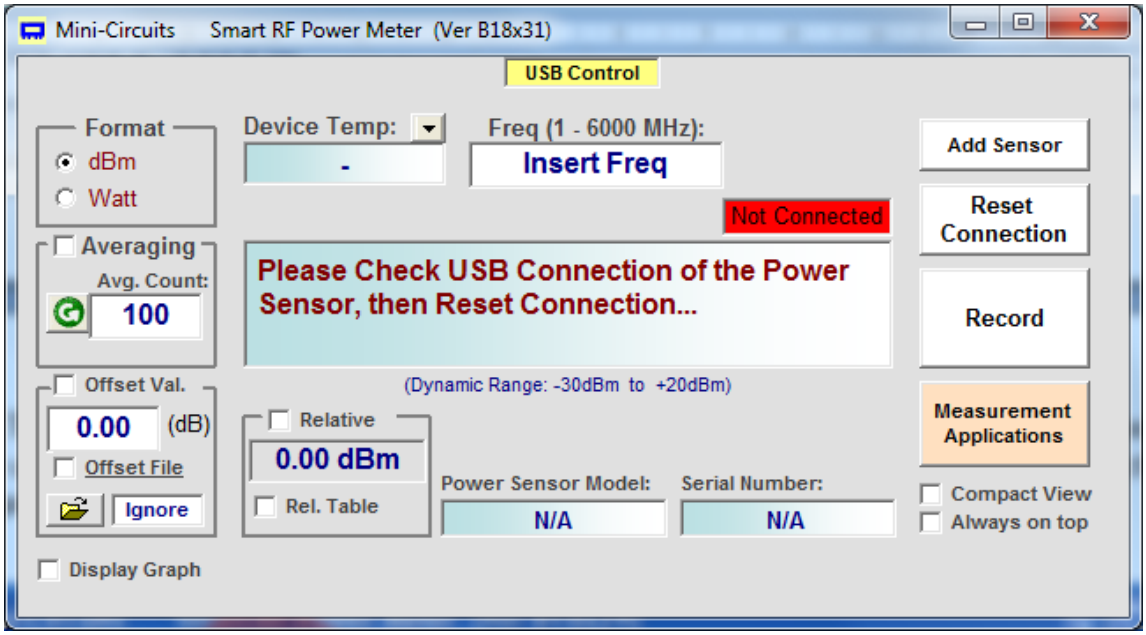
#	Name	Description
1	Number of sensors	Shows total number of power sensors detected
2	Sensor List	List, by serial number of all sensors detected
3	O.K.	Proceed with the sensors selected
4	Select All	Marks all sensors listed
5	Deselect All	Cancels selection of all sensors listed
6	Freq	Enter the compensation frequency to be set for all selected units.
7	Compact View	Open selected power sensors in compact view
8	Recording	Open data recording window to set data recording for one or more of the sensors
9	Cancel	Exit the program

5.1.2. Alerts on startup

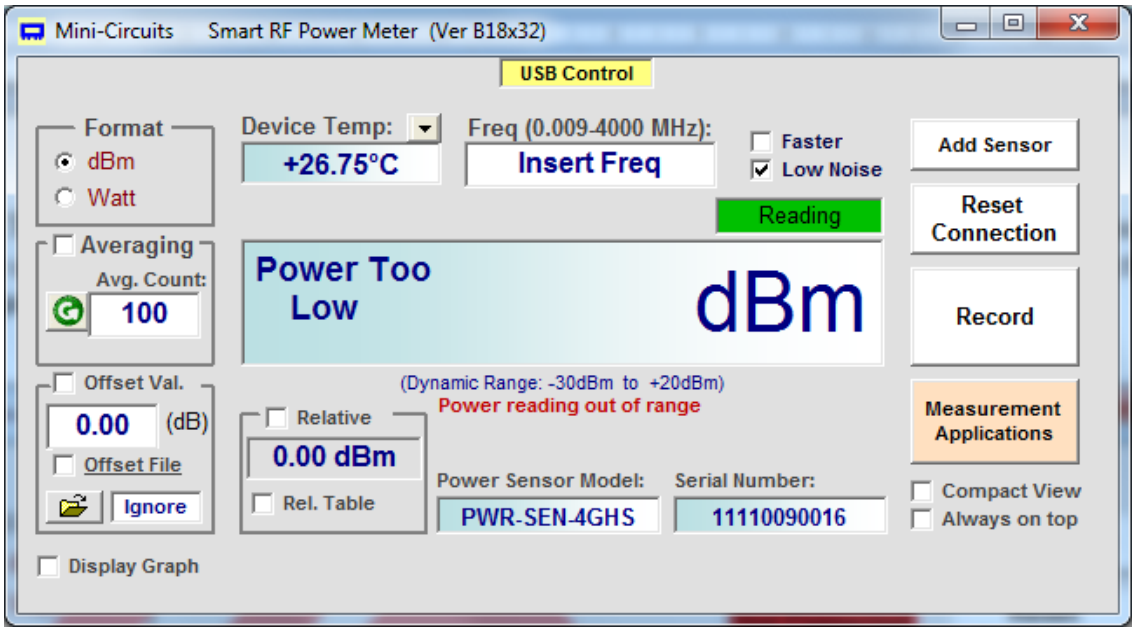
If no PWR power sensors are connected to the computer via USB or there is a problem with the USB connection selecting USB will cause the following alert will pop-up. Click OK and check the USB connections before clicking the 'reset connection' button.



After acknowledging the alert, the main measurement screen will appear with no unit selected and a 'Not Connected' notice. Click on 'reset connection' to try connecting again, or close the program.



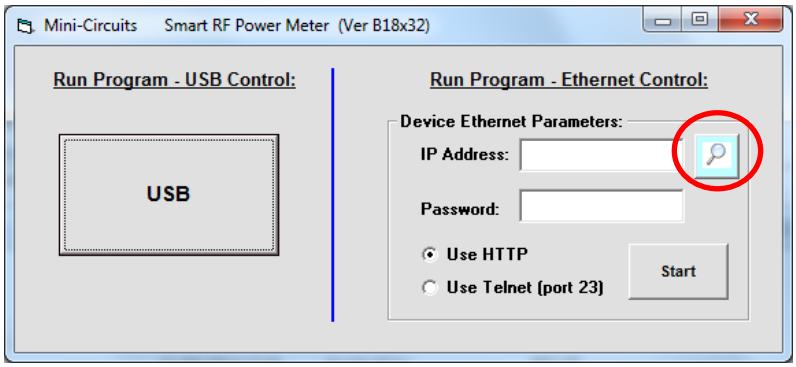
If there's a faulty DUT connection, no RF power or the power is below the sensors dynamic range a 'Power Too Low' notice will appear.



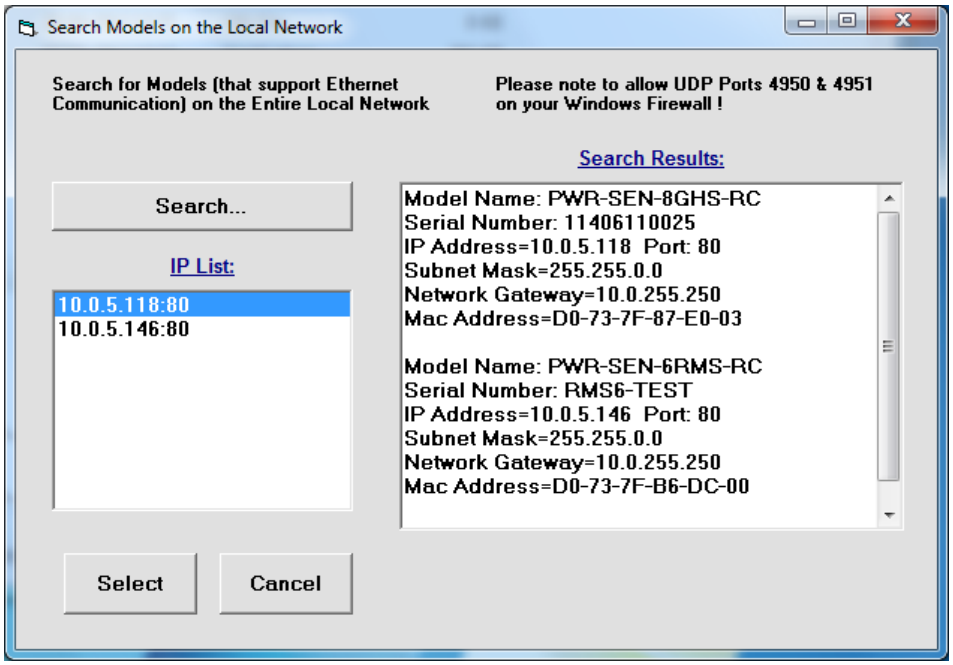
5.2. Ethernet Interface (RC suffix only)

5.2.1. Getting Started

After starting the GUI (section 5.1) you can select the control method you wish to use for the PWR, either USB or Ethernet control. All models support USB control, only models with the RC suffix (such as PWR-8GHS-RC) support Ethernet control. To start operation with USB see section 5.1. For Ethernet control either type the IP address and port of the power sensor, or click on the search icon.



After clicking on the search icon, the IP search will pop up with a list of smart power meter IP addresses found and their HTTP ports on the left side of the screen, and full details of each unit on the right. Mark the IP address you wish to use and click select. The search window will close, and the IP address and port will be entered in the IP address field of the initial screen automatically.



Notes:

1) To refresh the list of units found click on the Search button.
2) The search function uses ports UDP 4950 and UDP 4951 for communication, ensure your firewall allows access to these ports.

3) For Peak power sensor models you need to enable Ethernet control before using it for the first time see section 0 for details.

After entering the IP address, enter your password if you set one (see section 5.2 for details), select the communication protocol you wish to use (HTTP or Telnet) and click start, the unit's main screen will open.

Note:

- Changing Ethernet settings while in Ethernet control is only possible in PWR-40PW-RC & PWR-8PW-RC. In all other models changes in configuration must be done while in USB control.

Telnet or HTTP commands can also be used to control the power sensor without using the GUI. Just type in the command in the address field of your Internet browser, implement a Get/Post HTTP function in your selected application (for HTTP) or establish a Telnet connection (for Telnet). A full list of the commands available and their syntax is available in the PWR models programming handbook.

Note:

- Depending on the browser used and your network configuration you may need to disable the proxy server for your computer or add the smart power meter's IP address to the list of addresses in the proxy server.

5.3. Ethernet Configuration (RC suffix only)

5.3.1. Default IP Configuration

Mini-Circuits' power sensors ship from the factory with DHCP enabled by default so in most cases an IP address will be assigned automatically when the device is connected to the network. Once a valid IP address has been assigned and identified it can be re-configured via the Ethernet connection (for example, to set a static IP configuration) using our GUI, Ethernet configuration tool, or the programming API.

Note:

- Peak & Average power sensors ship with Ethernet disabled by default. These sensors must first be connected by USB in order to enable Ethernet control (see section 5.3.4).

5.3.2. Default Static / "Link-Local" IP Address

A default "link-local" IP address will be assumed when DHCP is enabled if the device does not receive a valid response from a DHCP server. This also applies when a power sensor with DHCP enabled is connected directly via an Ethernet cable to a PC (instead of via a network). The default static / link-local IP address for all Mini-Circuits devices with the relevant firmware is 169.254.10.10.

This can be used as a method to configure a specific static IP address for a new device straight out of the box, without resorting to a USB connection or even Mini-Circuits' GUI. Just connect the attenuator directly to the PC, open the HTML Ethernet configuration tool (see **section 5.3.5**), connect to the attenuator using the *169.254.10.10* default IP and proceed to set the new configuration as needed.

Consult the table below for which firmware revision is required for your unit to support this feature:

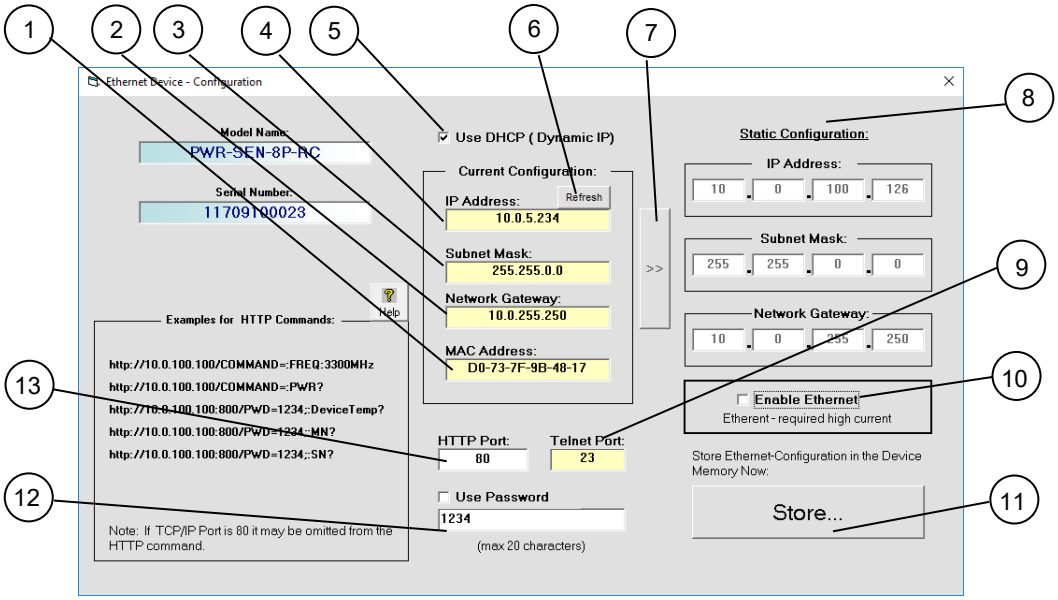
Model P/N	Firmware revision
PWR-8GHS-RC	A4 and newer
PWR-6LRMS-RC	A3 and newer
PWR-6RMS-RC	A3 and newer
PWR-8P-RC	A5 and newer
PWR-8PW-RC	All versions
PWR-40PW-RC	All versions

5.3.3. Recovery of IP Configuration via USB

If at any time an Ethernet connection cannot be established (for example, if the current IP address is not valid on the network) then the settings can always be reset by connecting to the device using USB and the GUI or programming API.

5.3.4. Ethernet Setting Screen

The Ethernet Configuration screen allows the settings to be reviewed and updated. The image below shows the factory default of the power sensor. If these settings fit your local network, you do not need to access the setup before connecting the power sensor to the network.



Note:

- If you are using a proxy server for your LAN connections you may need to define a name for the power sensor IP address, or disable the proxy server to connect to the power sensor via Ethernet.

The Ethernet Configuration settings are:

#	Name	Description
1	MAC Address	Media Access Control Address – a unique, unchanging identifier for the smart power meter unit.
2	Network Gateway	IP address of the network gateway. When DHCP is selected this is assigned by the server and will change according to the server.
3	Subnet Mask	The network's subnet mask. When DHCP is selected this is assigned by the server and will change according to the server.
4	IP Address	The IP address of the unit on the network. When DHCP is selected this is assigned by the server and will change according to the server.
5	Use DHCP	When selected the smart power meter will query the server for appropriate parameters with no input from the user and will disregard manually entered IP address, subnet mask and network gateway settings.
6	Refresh	Request IP address, gateway and subnet mask from the server.
7	Copy State	Copies current state of dynamic IP to static IP, not available when DHCP is selected.
8	Static Configuration	When DHCP is not selected the user must specify the values below and will not be changed by the server.
9	Telnet Port	Port to be used for Telnet communication. Cannot be changed by user
10	Ethernet Enable	For Peak and Average power sensors only, the Ethernet control circuitry needs to be specifically enabled before power sensor can be used via Ethernet by selecting the “Enable Ethernet” option shown below and clicking “Store”. Once Ethernet control is enabled you can proceed as described for other RC suffix models.
11	Store	After you've made all the changes you want to click on this button to save the settings.
12	Password	If you want to limit the users able to access the power sensor select "Use Password" and enter the desired password (up to 20 characters).
13	HTTP Port	Specify the port to use for HTTP communication with the network (default 80). Note port address does not get assigned by the server when DHCP is selected. Port 23 is reserved for Telnet communication and cannot be used.

After making the changes you want, click on "Store" and the changes will be saved to the smart power meter's memory. See section 5.2 for working with Ethernet control.

Note:

- For Peak & Average power sensors - when Ethernet is enabled some power sensors may draw over 500 mA. This may cause issues if attempting to power it from a USB 2.0 port.

5.3.5. Ethernet Configuration Tool

The Ethernet configuration can also be changed via Ethernet control. To make changing the Ethernet configuration easier for users operating in a non-Windows environment or otherwise can't use the provided GUI, Mini-Circuits created the Ethernet Configuration tool (see **table 0** for firmware requirements).

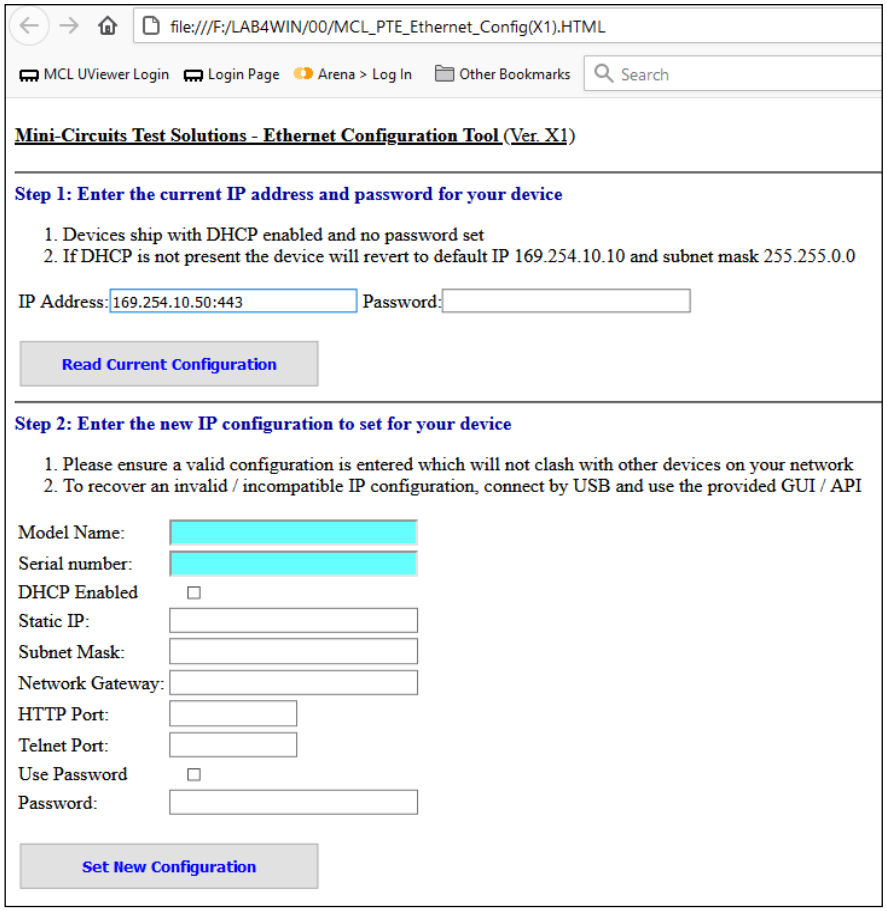
https://www.minicircuits.com/softwaredownload/MCL_PTE_Ethernet_Config.zip

Note:

- Javascript must be enabled in your browser to use the configuration tool.

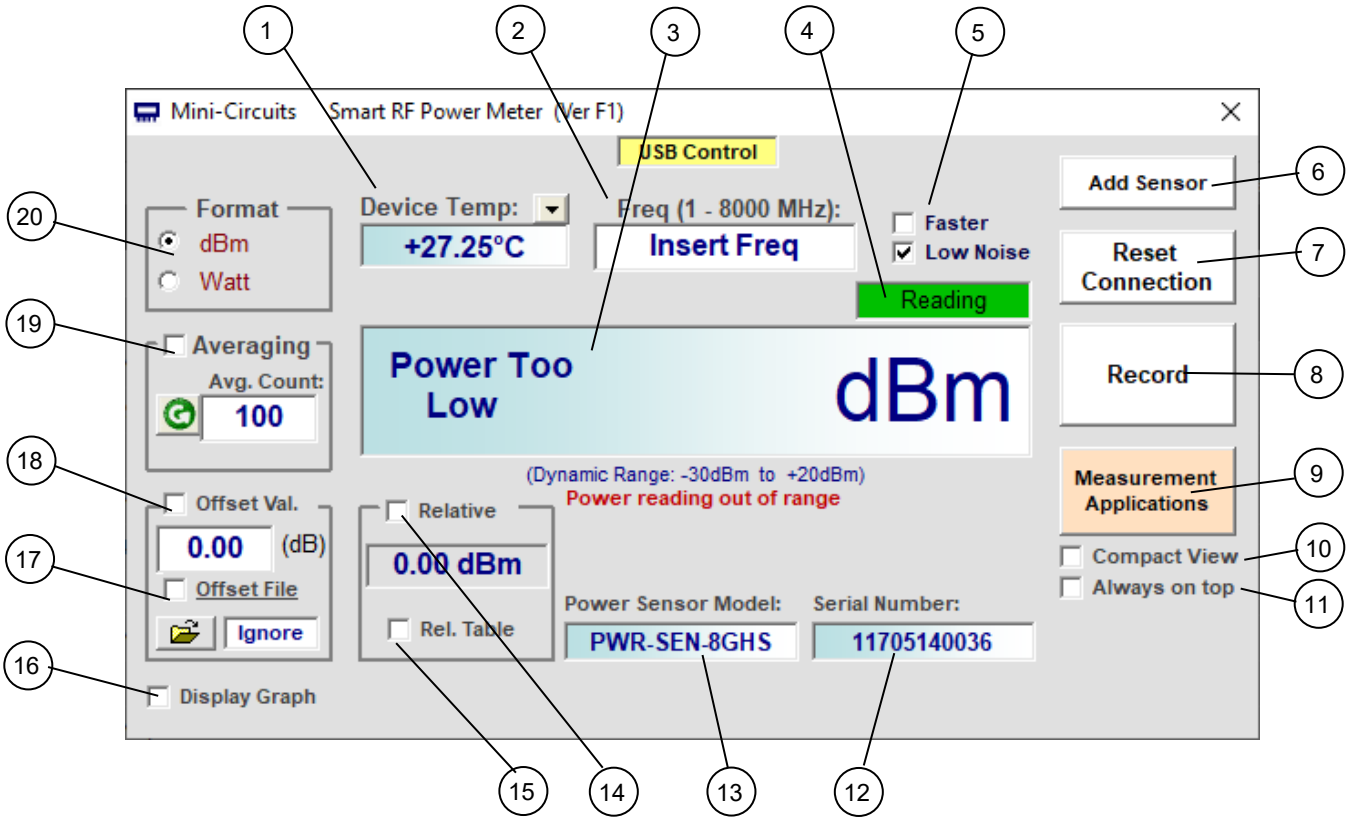
To use the configuration tool:

- Type the IP address in the field in step 1 (if you assigned a password for the unit type is as well).
- If you set the device to some port other than 80, enter the port as well in the same field, then click **Read Current Configuration**.
- The fields in step 2 will be populated with the current state of the device. Enter the updated information in the relevant fields.
- Click **Set New Configuration** to end the process.



5.4. Main Power Measurement Screen

The main screen provides a simple and easy-to-use interface for measuring RF power with the PWR power sensor (See Figure below).

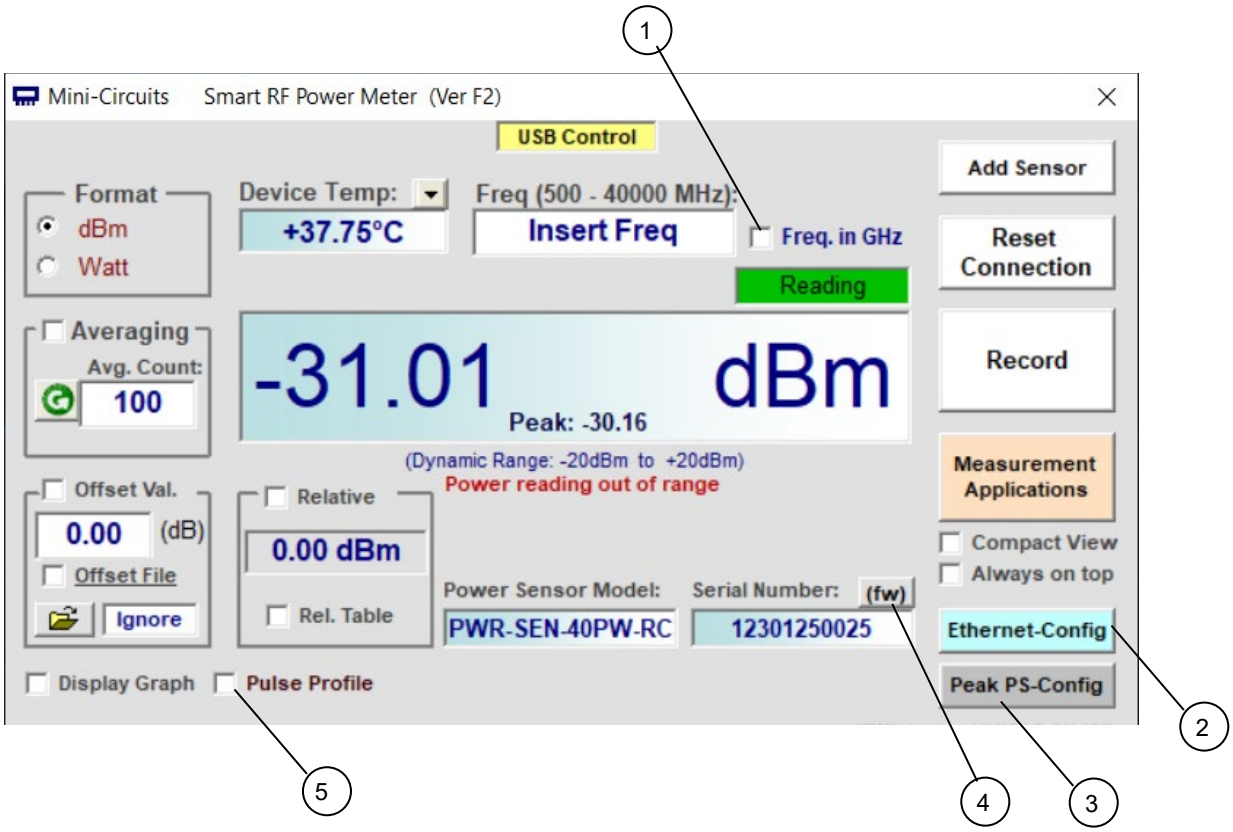


5.4.1. General functions

#	Name	Description
1	Device Temp.	Displays the power sensor's internal temperature. The PWR smart power sensors compensate automatically for any temperature variation in the 0-50°C (32-122°F) range. Click on the drop box to select Celsius or Fahrenheit display format.
2	Freq.	Displays the power sensor's specified frequency range and allows the user to enter the expected input frequency to use for the internally calculated frequency compensation. For best performance, enter the approximate signal frequency you wish to test.
3	Measured Power display	Displays the Average power measured over the sample period and below that the peak power. If sample period is not suitable for the signal or zoom track does not lock on the pulse the power shown will not be correct. **Note:** Peak power values are displayed for peak power sensors only.
4	Connection status	Displays the status of connection to the power sensor: "Reading" – good connection, "Searching" - attempting to reestablish connection, "Not connected" – Power sensor not found.
5	Meas. Speed	For CW & RMS models check the mode in which you wish to operate: "Low Noise" – 100ms typ, "Faster" – 30 ms typ, or "Fastest" – 10ms typ (available on PWR-8FS only). **Note:** Not available for peak power sensor models.
6	Add Sensor	Click to work with more than one sensor from the same computer. For more details, see **section 5.12**, "Multi-Sensor Setups".

#	Name	Description
7	Reset Connection	Click to return to initial control selection screen to reconnect a power sensor to your computer after it was disconnected, change control method or when replacing one sensor with another.
8	Record	Opens the data record window, for details see **section 5.8**.
9	Measurement Applications	Open advanced measurement applications window. See Measurement Applications Guide for details.
10	Compact View	Reduce size of window. This option is usually employed for multi-sensor setups. See **section 5.11** for details.
11	Always on Top	Click to keep your power sensor screens on top of other applications.
12	Serial Number	Displays serial number of power sensor currently connected.
13	Model	Displays model name of power sensor currently connected.
14	Relative	Check to save your current reading as a baseline value. From then until unchecked, measurements will show how DUT power varies from that baseline. In dBm format, relative results are given in dBc and in Watt format in %.
15	Rel. Table	Opens Relative Frequency points table. When the table is filled, entries in the table will supersede current reading for relative measurements. See **section 0** for details.
16	Display Graph	Check to activate real-time graph, see **section 5.5.1** for details.
17	Offset Val.	This feature allows the user to compensate for Loss or Gain in their DUT setup. A positive value compensates for a Loss, and a negative value for a Gain. Click on the check box and enter the appropriate value (in dB) in the window below.
18	Offset File	Check to get offset values from a saved file. Primarily used for advanced Measurement Applications, see **section 5.7** for details.
19	Averaging	Check the averaging box and enter the number of measurements you wish to average. When selected the power sensor will average the power reading over the number of measurements specified in Avg. Count and display the number of measurements averaged. Clicking on the button to the left of the average count window will clear the averaged values and reset the count.
20	Format	Select dBm or Watts format to display the data in.

5.4.2. Model specific functions

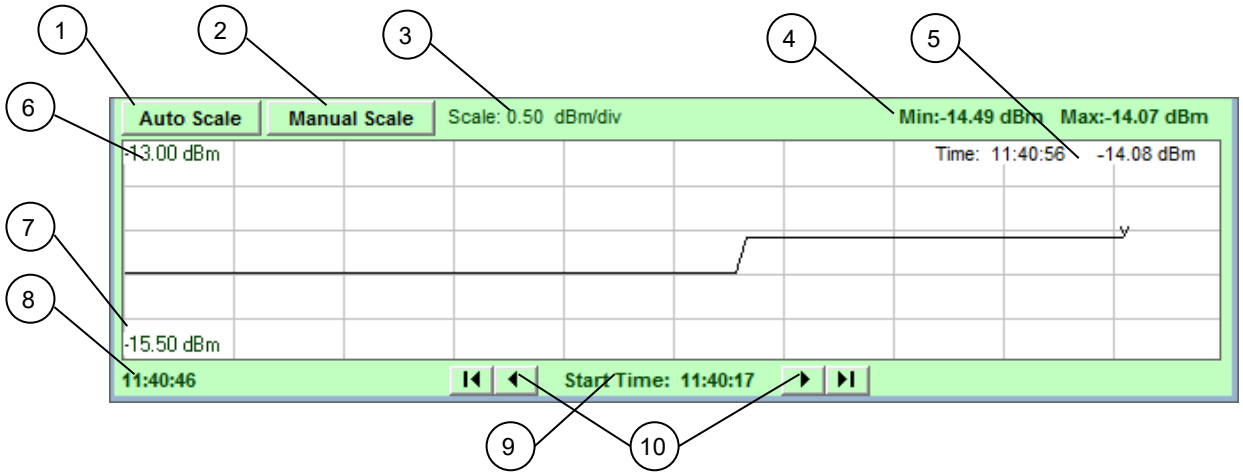


#	Name	Description
1	Freq. in GHz	For PWR-40PW-RC only: Changes the unit for the Frequency from MHz to GHz.
2	Ethernet-Config	For models with RC suffix only: Opens the Ethernet configuration window to change the current configuration. See **section 5.3.1** for details.
3	Peak PS config	For Peak & Average sensors only: Changes central section of screen to Peak Power Sensor configuration screen to allow setting sample time and trigger mode. See **chapter 6** for details.
4	(fw)	For models with RC suffix only: Opens the Firmware info window to allow upgrading the firmware of the connected sensor. See **section 0** for details and supported models.
5	Peak PS config	For Peak & Average sensors only: Changes central section of screen to Peak Power Sensor configuration screen to allow setting sample time and trigger mode. See **chapter 0** for details.

5.5. Real Time Graph

Checking the 'Display Graph' box in the lower left corner of the main screen will cause a graph window to open below the main screen showing power over time.

For Peak &Average Power sensors only the average power is displayed in this graph, for other parameters see Pulse Profile option (**section 6.3**).

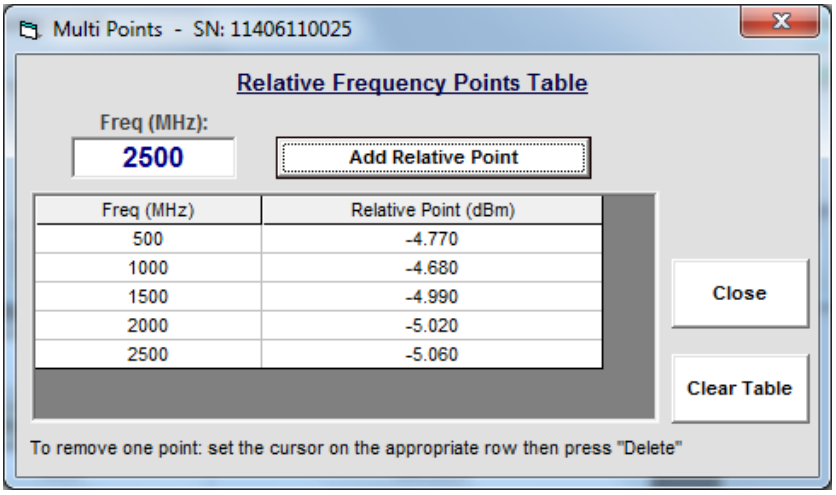


5.5.1. Real-Time Graph Indicators and Functions

#	Name	Description
1	Auto Scale	Set Y-axis automatically to best display current data.
2	Manual Scale	Opens a small window to allow setting the Max value and value per div. of the Y-axis. The values shown will be in the same units as those specified in the Main screen format field. Clicking on the button a second time will close the Manual Scale window.
3	Scale	Current value per division of Y-axis
4	Min/Max values	Minimum and Maximum values currently displayed in graph
5	Current reading	Current time and power reading
6	Max scale	Max value of Y-axis
7	Min scale	Min value of Y-axis
8	Time	Start time of currently displayed graph
9	Start Time	Time at which real-time graph was started
10	Arrows	Use arrows to scroll back and forth in graph.

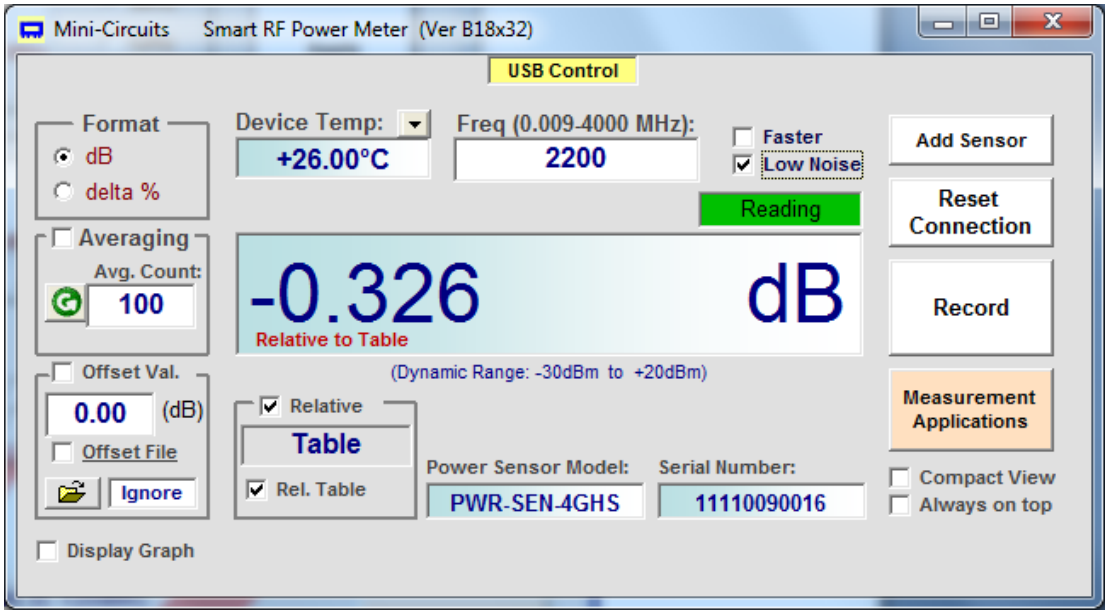
5.6. Relative Frequency Points Table

Checking the 'Rel. Table' check box will open the relative frequency points table shown below. This table allows specifying multiple points for relative measurements. To add a point to the table, enter the relevant frequency and click on 'Add Relative Point' – the current power reading will be added to the table.



To delete a point click on the row you wish to delete to select it, then press the 'Delete' key. To delete all values from the table click on the 'Clear Table' button.

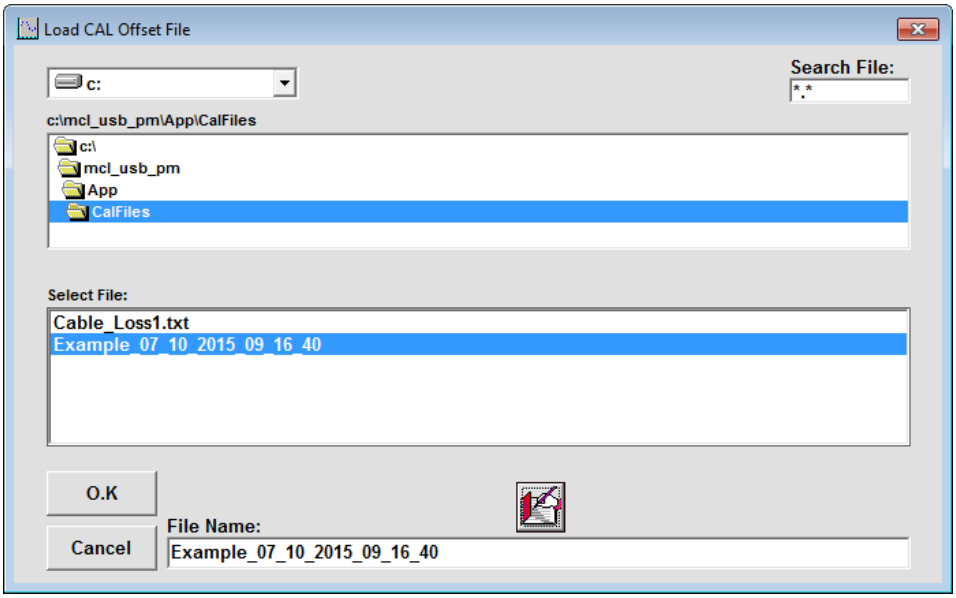
Once you're satisfied with the entries close the table, the main screen will now show 'TABLE' in relative measurement field. Checking the 'Relative' checkbox will change all measurements into relative measurements referenced to the values in the table. If a frequency not listed in the table is specified for measurement the smart power meter program will calculate the correct reference value based on interpolation of existing data points.



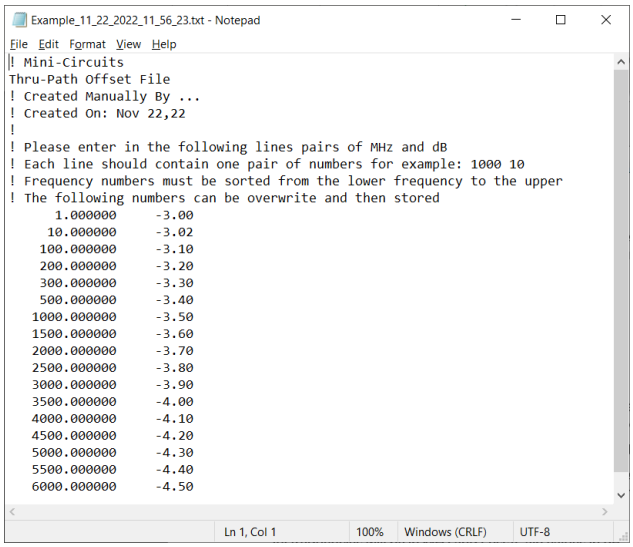
5.7. Creating and Using Offset Files

An offset file is useful for compensating for loss/gain in the system which are not constant over frequency. For example if you need to compensate for the loss of a transmission line between the power sensor and the DUT. Measurement Applications #10, Calibrating Thru-Path described in chapter 13 of the Measurement Applications Guide allows you to measure the gain/loss of the system between the power sensor and the DUT and automatically creates an offset file for that system.

Clicking on the folder icon below the 'Offset File' check box will open a browse window. If you have an offset file ready, select it and click OK.



To create an offset file manually click on the edit icon over the file name window and a sample offset file will be created. Replace the values in the sample file with the values you need and save the file. There is no requirement for any specific file name or suffix, however as the file is a simple text file saving it with a txt suffix to simplify future editing is recommended.



When creating an offset file observe the following rules:

Any line containing an exclamation mark character (!)will be ignored. This is useful for adding notes to the file, or temporarily skipping certain points in the offset file.

The first line in the file (other than notes) shall be "Thru-Path Offset File" (Not case sensitive).

There shall be at least one space character between the frequency value and the loss/gain value and only a single pair of values in a line (Separator character between pairs is line feed carriage return).

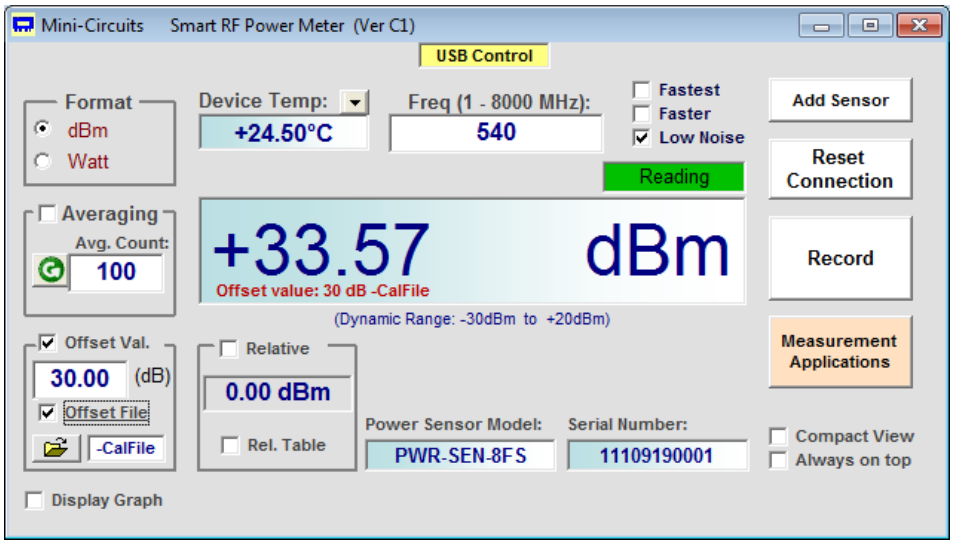
Values will be sorted by frequency from low to high.

All frequencies will be in MHz and Loss/Gain values in dB.

Note:

- When reading frequencies between two sets of values the PWR sensor software will use linear interpolation to calculate the required offset. When reading a frequency outside the range covered by the offset file the closest value will be used. Thus when using the example shown in above, the offset value for 5750 MHz will be -4.45 dB and for all frequencies 6000 MHz or greater will be -4.5 dB.

When the 'Offset File' option is checked an "Offset value: Cal file" notice will appear and the value calculated from the offset file for the frequency tested will be subtracted from the reading. If needed, a fixed offset can be added by checking the 'Offset Value' check box and specifying an attenuation value.

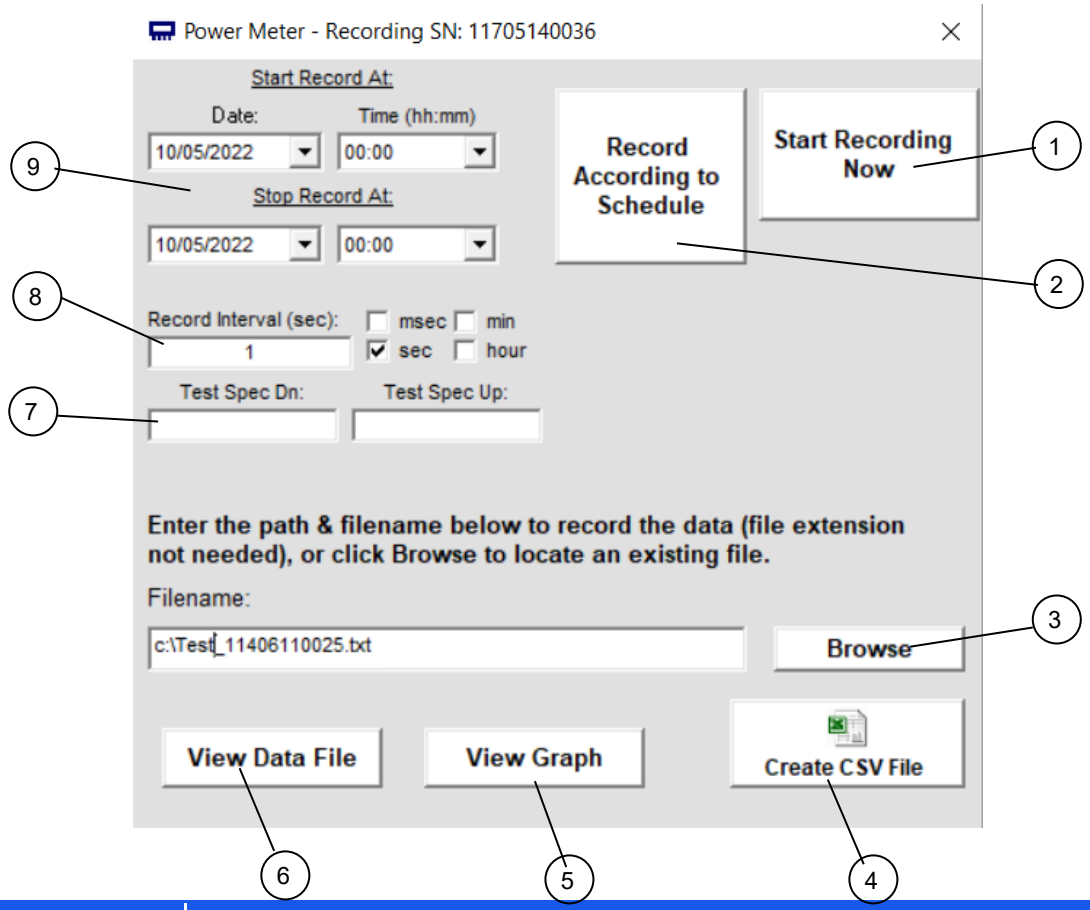


Note:

- Values in the offset file are subtracted, while values in offset value are added.

5.8. Data Recording Window

Get started by clicking the Record button on the right side of the Main Screen. The Power Meter Recording Screen will open, with the serial number of the sensor being recorded at the top:



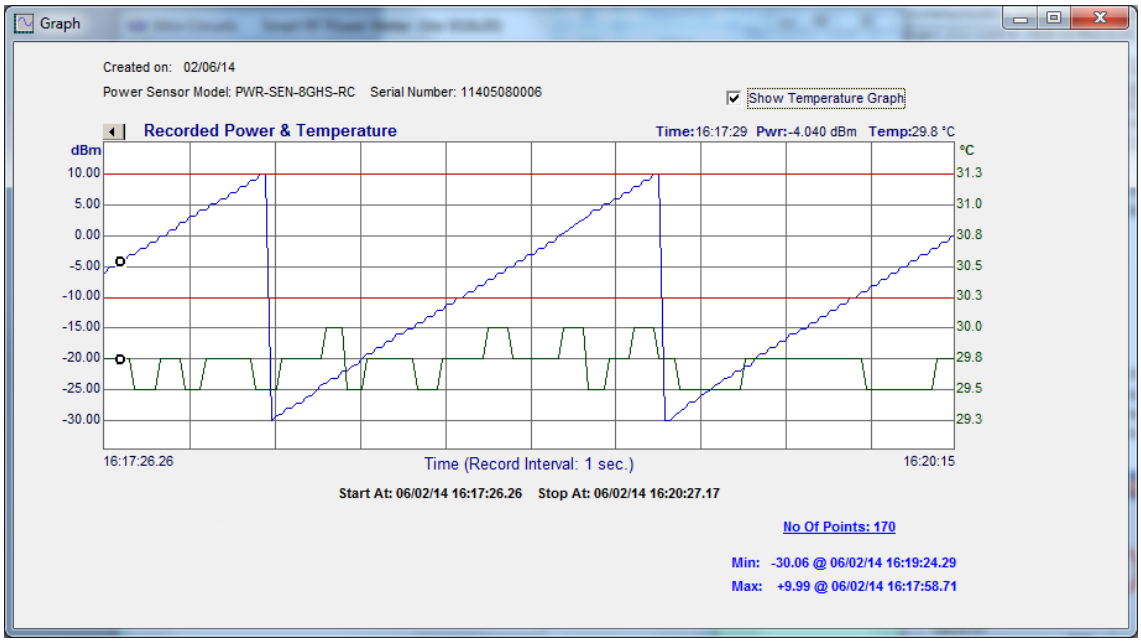
#	Name	Description
1	Start Recording Now	Close record window, saving current settings. Data recording will start immediately
2	Record According to Schedule	Close record window, saving current settings and schedule. Data recording will start according to the schedule specified.
3	Browse	Open a browse window to select an existing file or navigate to the desired path.
4	Create CSV File	Export data in selected file to CSV file format and opens it in Excel (program needs to be installed in the system).
5	View Graph	Open a graphical presentation of the data stored in the selected file.
6	View Data File	Open the data file selected (read only presentation).
7	Test Spec Dn/Up	If you enter specification limits in these fields data points which exceed these limits (either above or below) will be marked in the data by an asterisk (*).
8	Record Interval	Specify the interval at which data points will be recorded, from every 10ms, to 9999 hours. Make sure the measurement speed is less than the record interval.
9	Start/Stop Record at:	Specify date and time at which to start/stop recording, for scheduled tests.

Note:

- For starting recording of multiple units at once see 5.12.3 Data Recording for Multiple Sensors

5.8.1. View Graph

Clicking on the 'View Graph' button in the data record window will open a graphical presentation of the recorded data. Default presentation is of average power only, using the same units as the data was recorded in, but user can select to present both average power and temperature by checking 'Show temperature graph' or change the power units by clicking on the arrow next to the graph title.



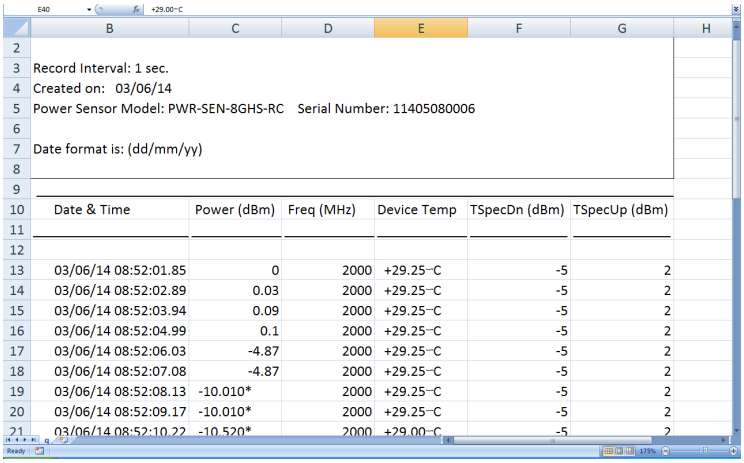
5.8.2. View Data File

Data recorded is saved to a text file in the format shown below

```
USB Power Meter Record File, Created By Mini-Circuits

Record Interval: 1 sec.
Created on:   03/06/14
Power Sensor Model: PWR-SEN-8GHS-RC    Serial Number: 11405080006

Date format is: (dd/mm/yy)

|      Date & Time     | Power (dBm)| Freq (MHz) |Device Temp |TSpecDn (dBm)|TSpecUp (dBm)|
|06/03/14 08:52:01.85 |    0.000   |  2000.00   |  +29.25°C  |    -5.000   |    2.000    |
|06/03/14 08:52:02.89 |    0.030   |  2000.00   |  +29.25°C  |    -5.000   |    2.000    |
|06/03/14 08:52:03.94 |    0.090   |  2000.00   |  +29.25°C  |    -5.000   |    2.000    |
|06/03/14 08:52:04.99 |    0.100   |  2000.00   |  +29.25°C  |    -5.000   |    2.000    |
|06/03/14 08:52:06.03 |   -4.870   |  2000.00   |  +29.25°C  |    -5.000   |    2.000    |
|06/03/14 08:52:07.08 |   -4.870   |  2000.00   |  +29.25°C  |    -5.000   |    2.000    |
|06/03/14 08:52:08.13 |  -10.010*  |  2000.00   |  +29.25°C  |    -5.000   |    2.000    |
|06/03/14 08:52:09.17 |  -10.010*  |  2000.00   |  +29.25°C  |    -5.000   |    2.000    |
```

5.8.3. Create CSV

When exporting data to a CSV file, it will open in Excel with the data being in the format shown below.



Record Interval: 1 sec.
Created on: 03/06/14
Power Sensor Model: PWR-SEN-8GHS-RC Serial Number: 11405080006

Date format is: (dd/mm/yy)

Date & Time	Power (dBm)	Freq (MHz)	Device Temp	TSpecDn (dBm)	TSpecUp (dBm)
03/06/14 08:52:01.85	0	2000	+29.25°C	-5	2
03/06/14 08:52:02.89	0.03	2000	+29.25°C	-5	2
03/06/14 08:52:03.94	0.09	2000	+29.25°C	-5	2
03/06/14 08:52:04.99	0.1	2000	+29.25°C	-5	2
03/06/14 08:52:06.03	-4.87	2000	+29.25°C	-5	2
03/06/14 08:52:07.08	-4.87	2000	+29.25°C	-5	2
03/06/14 08:52:08.13	-10.010*	2000	+29.25°C	-5	2
03/06/14 08:52:09.17	-10.010*	2000	+29.25°C	-5	2
03/06/14 08:52:10.22	-10.520*	2000	+29.00°C	-5	2

5.9. Firmware Update (Supported models only)

All power sensors are shipped with the latest available firmware and an update is usually not required. Mini-Circuits occasionally makes firmware update files available as a courtesy to add additional features or correct known issues. Please contact testsolutions@minicircuits.com for details.

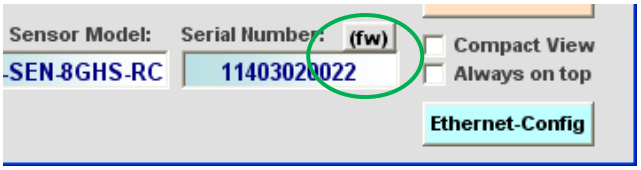
5.9.1. Models supporting firmware upgrade:

The following firmware upgrade instructions apply to all power sensor controller versions, but with some visual differences (for PWR-40PW-RC & PWR-8PW-RC) highlighted below.

Check the list below for models which support firmware upgrade:

- PWR-8GHS-RC
- PWR-6RMS-RC
- PWR-6LRMS-RC
- PWR-6LGHS
- PWR-8P-RC
- PWR-8PW-RC
- PWR-40PW-RC

The smart RF Power Meter GUI must be started in USB control (See section 0) to allow Firmware upgrade. When in USB control, you will note an (fw) indicator over the serial number field in the power sensor's main screen.

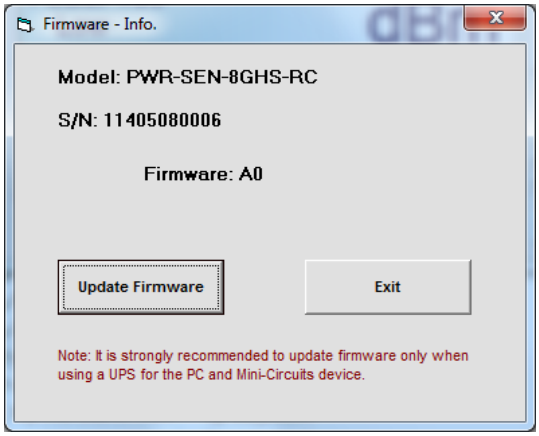


Firmware indicator on main screen

Caution:

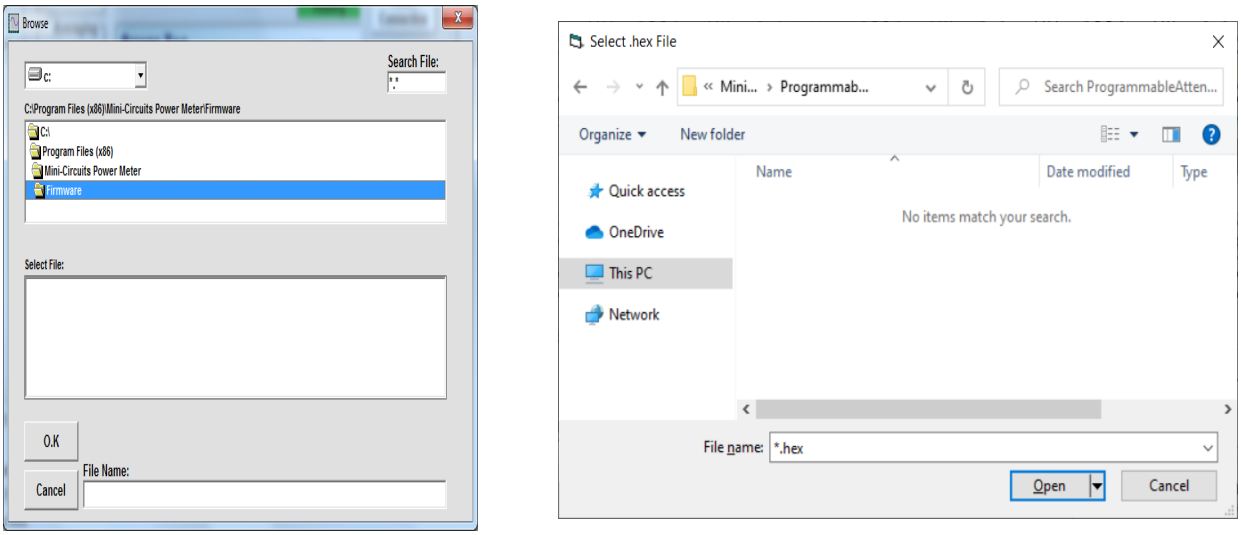
- The firmware update process has the potential to render the device inoperable in the event of communication failure. Updates should only be carried out with a stable PC and USB connection, and in-line with Mini-Circuits' guidelines.
- A recovery option is available to restore units rendered inoperable by an incorrect upgrade process (see *section 5.10* for details).

Click on the '(fw)' indicator, this will cause the firmware - info window to open (See below). The 'Firmware' listed is the version of the firmware installed in your smart power meter. Click on "Update Firmware" to select a new firmware version to install or click 'Exit' to close the firmware – info window.



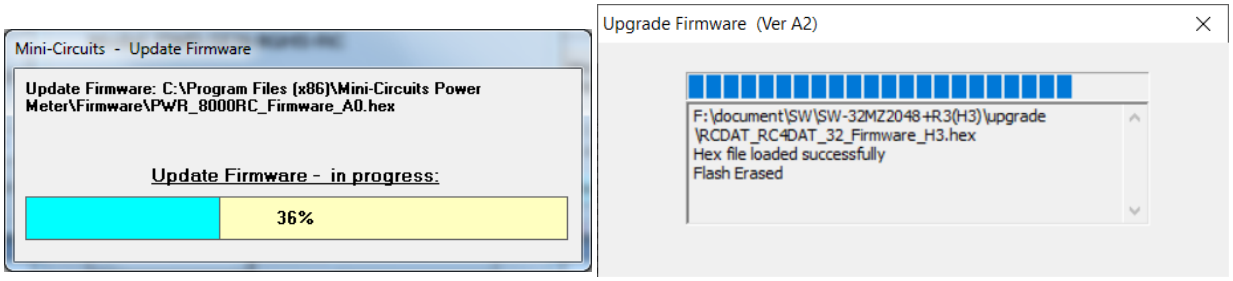
Firmware Information Window

A browse window will open to the firmware directory under the path you selected when installing the GUI program. Navigate to where you saved your firmware file, select the firmware version you wish to install and proceed.



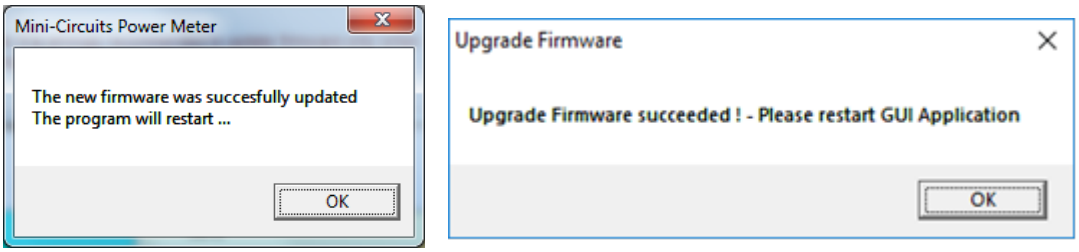
Firmware - Browse Window (Right – PWR-40PW-RC & PWR-8PW-RC, Left – other models)

The selected file will be installed in the power sensor. The process will take up to a minute.



Firmware - Progress Bar Window (Right – PWR-40PW-RC & PWR-8PW-RC, Left – other models)

After the firmware has updated an alert will appear. Click 'OK' to shut down the smart power meter program and then restart it normally.



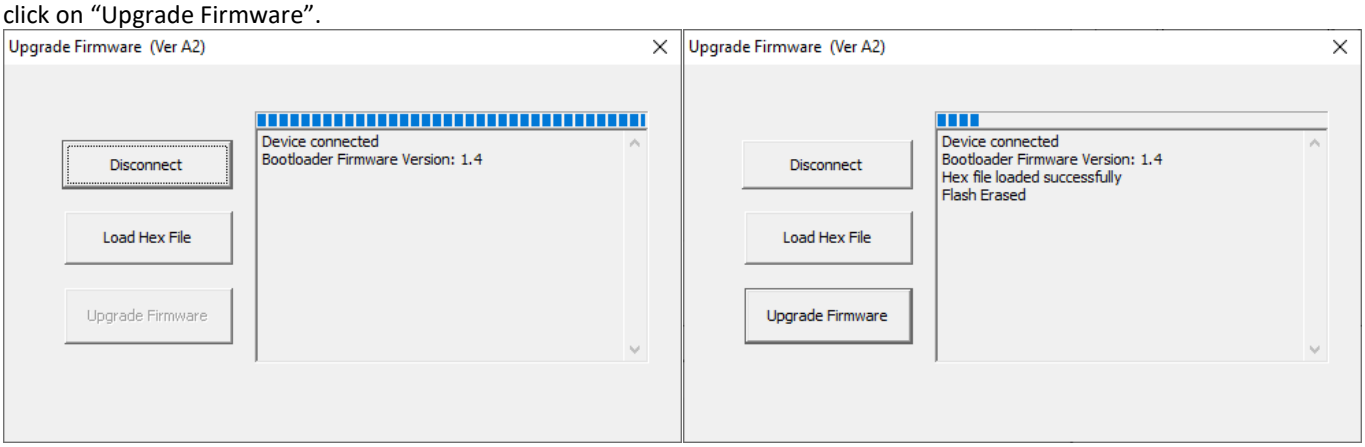
Firmware - Successful Update (Right – PWR-40PW-RC & PWR-8PW-RC, Left – other models)

5.10. Firmware Recovery

If your device has corrupted firmware and is no longer accessible (for example due to an interrupted firmware upgrade), you can follow the below steps to recover. Refer to section 5.9.1 for the list of models which support this function.

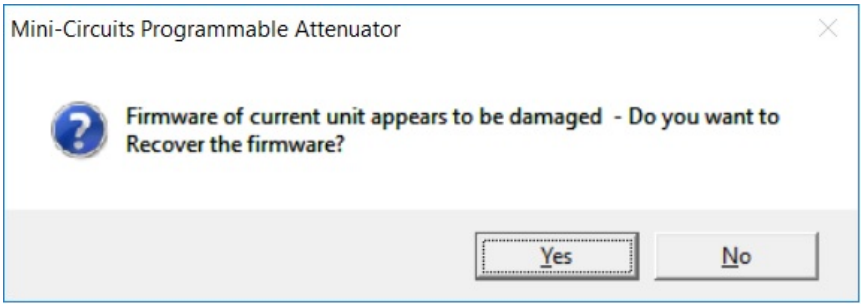
Please contact testsolutions@minicircuits.com if you do not have the ".hex" firmware file.

For PWR-40PW-RC & PWR-8PW-RC power sensors, navigate to the directory where you installed the GUI and run "UpgradeFirmware.exe". In the new window click the "Connect/ Disconnect" button. After a connection has been made proceed to click on "Load Hex File" button for a browse window to open. Navigate to where you saved the upgrade file and select it, then click on "Upgrade Firmware".



Firmware Upgrade App for PWR-40PW-RC & PWR-8PW-RC. (Connection step – left, Upgrade step – right)

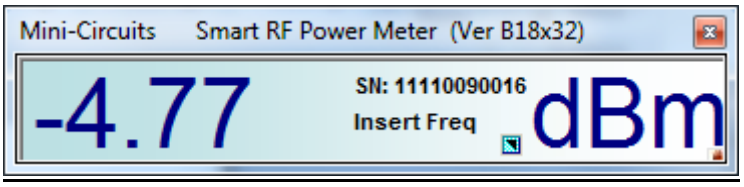
For all other power sensors (except PWR-40PW-RC or PWR-8PW-RC), open the GUI and attempt to establish a USB connection. An alert should appear advising that the corrupted unit has been identified, click 'Yes' to proceed and refer to section 0 above, or 'No' to cancel.



Firmware – recovery option (except PWR-40PW-RC or PWR-8PW-RC)

5.11. Compact View

Checking 'Compact View' in the bottom right corner of the main screen will cause the screen to shrink to the compact view display.

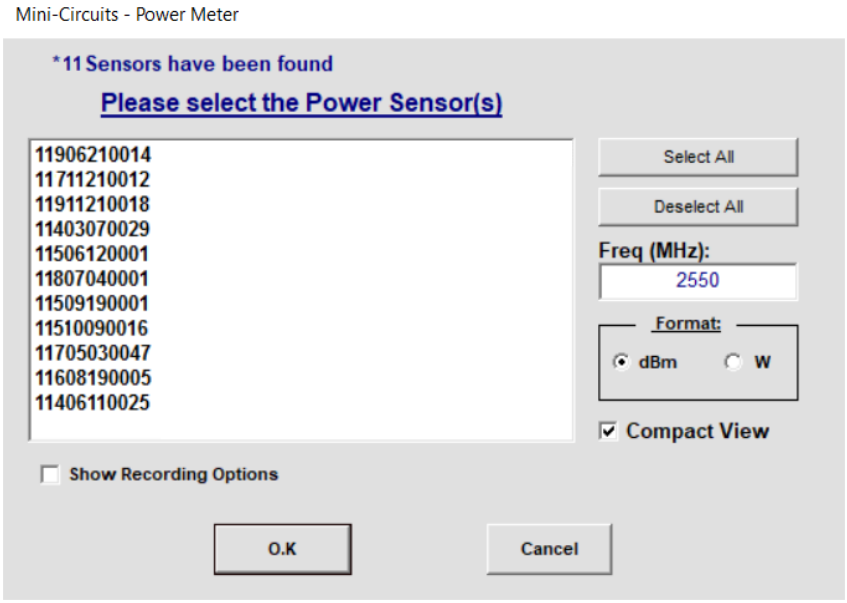


Clicking on any spot in the 'Compact View' screen will cause the program to return to the main screen. In compact view the program displays power measurement, measurement units, Power sensor S/N, and the frequency entered but you must return to main screen to change any parameters.

5.12. Working with Multiple Sensors

5.12.1. Starting with Multiple Power Sensors

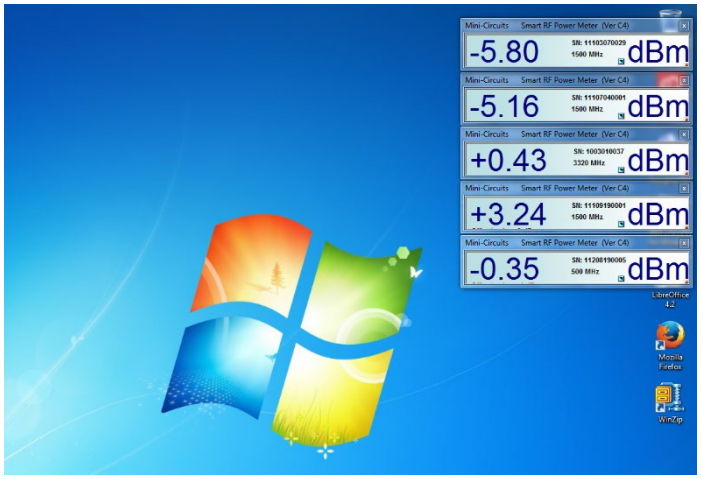
When the smart power meter detects multiple power sensors on startup, the power sensor selection window will appear. Select the sensors you wish to work with, or click 'Select all' for all sensors.



Power Sensor selection window

5.12.2. Specifying frequency and Compact view

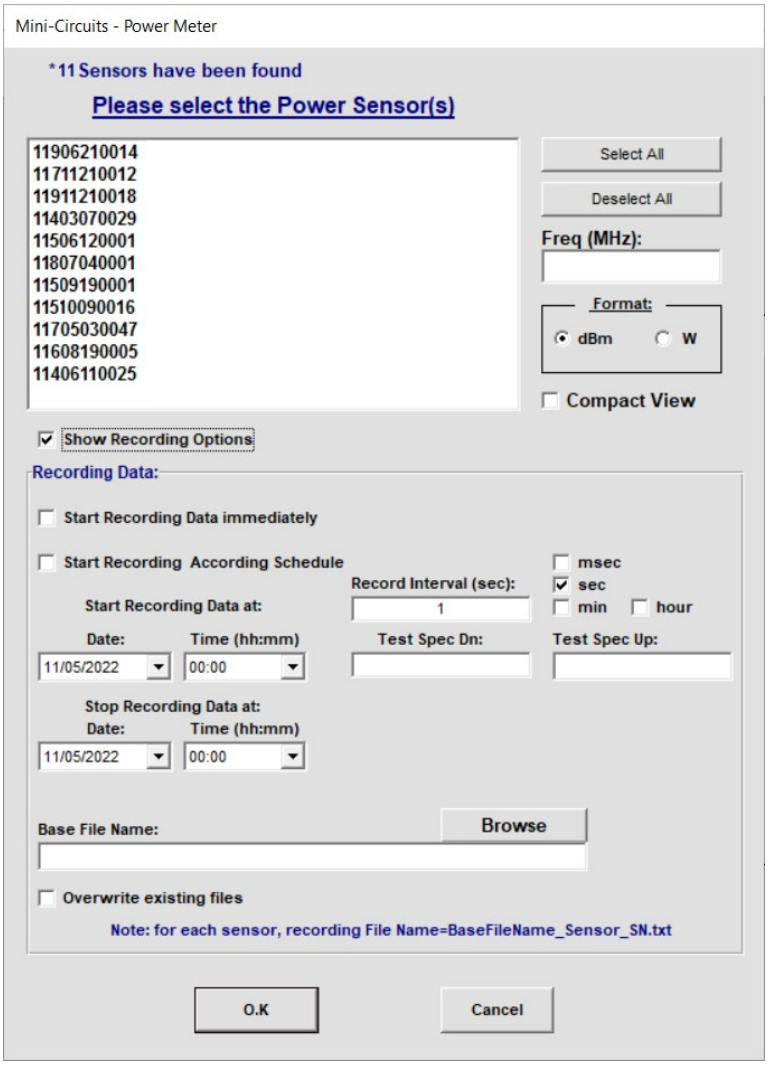
If all the sensors you are working with are testing the same frequency you may enter the frequency in frequency field of the power sensor selection screen, instead of individually for each sensor. When working with many power sensors simultaneously, it is recommended to check the compact view box before starting them so as to have all sensors open initially in compact view and only expand them when you need to modify the settings.



Multiple power sensor windows

5.12.3. Data Recording for Multiple Sensors

Clicking on the 'Recording' button in the bottom right corner of the screen will cause the data recording section of the window to expand below the initial power section selection window (See below). Recording data settings in this window will apply to all power sensors selected. For description of data recording settings see section 0.



Recording Multiple power sensors

Note:

- File names for multiple power sensor data recording are always in the format of "[path]_[model S/N].txt". Thus, if the path entered is "C:\test", the data for power sensor with serial number 11405080006 will be saved to file "C:\test_11405080006.txt".

5.12.4. Add Sensor

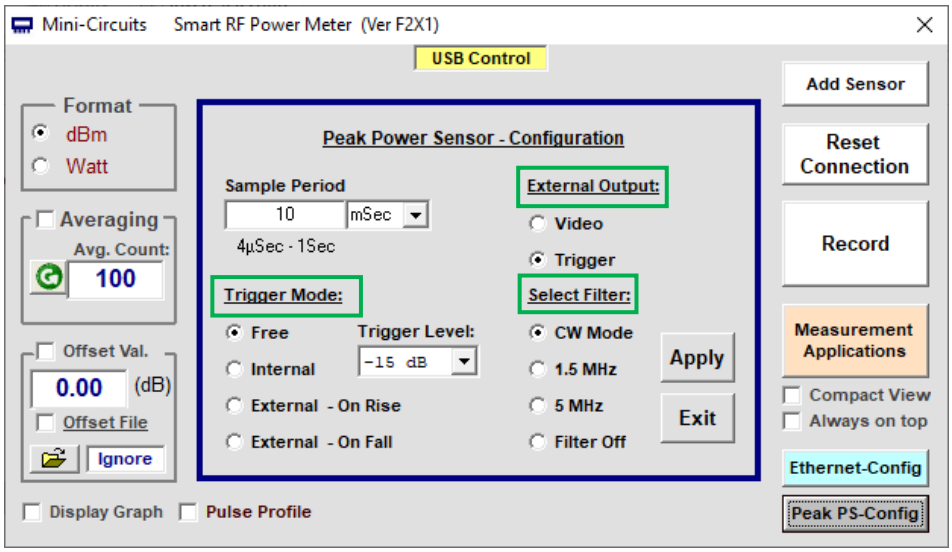
If you have already started working with a PWR power sensor and wish to start a second sensor you can click on the 'Add sensor' button in the main screen. This will open a second startup screen, as shown in section 0 & 5.2, select the communication protocol to use and it will show the additional sensors available. If only two sensors are connected via USB when clicking on USB it will automatically open the second sensor, without displaying the power sensor selection screen.

6 Peak Power and Pulse Profiling

This chapter explains how to use the peak and average power analysis functions of peak power sensors.

6.1. Sample Period

Clicking on the ‘Peak PS-Config' button in the main screen will cause the central section of the main screen to change to a configuration view. Click the ‘Peak PS-Config' button again or ‘Exit’ to return to measurement mode.



Sample Period & Trigger Config. window (not all options available to all models)

Note:

- Sample period should be greater than expected cycle of RF signal.
- After changing the settings click “Apply” to save them before exiting configuration mode.

6.1.1. Selecting a sample period

Refer to the relevant model datasheet to identify the maximum sample period for the sensor's ‘Full Sampling rate’. For sample periods less than or equal to this maximum period, the sampling rate remains constant and so the main consideration in selecting sample period is viewing convenience – you may wish to reduce the sample period to only slightly longer than the period of the signal to focus on it, or increase it to multiple pulse cycles to examine variation between the cycles and average the pulse parameters measured over those multiple cycles.

For signals with long periods, sample times greater than the sensor’s max ‘Full Sampling rate’ may be required. At this point the sensor begins to reduce the sampling rate, alternating between two sampling periods:

- The specified sample period with the sample points distributed linearly over the specified sample period.
- The ‘zoom’ period, showing only the timeframe from the ‘zoom on pulse’ portion of the sample period (see section 0-6.3.4 for details).

For best resolution use sample time only slightly greater than the RF signal’s period.

6.2. Trigger modes

6.2.1. Input Trigger Modes

Free	No Trigger used. A new sample period starts as soon as the data packet of the old is transmitted with minimal interrupt.
Internal	After a defined sample period ends the sensor will wait until it identifies a suitable RF signal to start the next sample period. See section 0 for details
External – On Rise	Sample period will start at rising edge of trigger at Trigger Input port of sensor.
External – On Fall	Sample period will start at falling edge of trigger at Trigger Input port of sensor.

Note:

- Triggers received in the middle of a sample period will be ignored.

6.2.2. Output Trigger Modes

The Peak Power sensor's Trigger/Video Out can be set as either a negative video output, showing the modulating signal of the RF signal (up to the model's video bandwidth), or as a TTL trigger with falling edge corresponding to the start of a pulse.

When set as video output the output bypasses the sensor's analysis and filtering, allowing signals with even Wider BW to be examined using an Oscilloscope.

6.2.3. Internal Trigger

When the 'Trigger In' is set to 'Internal Trigger' the sample period will only start once the PWR detects an RF signal meeting the specified conditions.

For PWR-40PW-RC, the internal trigger threshold can be set by the user in 1 dB steps. The default threshold is -15 dBm. The sample period will start when a rising signal passing the specified input trigger threshold is detected in the RF input signal by the trigger detect block (shown in the block diagram in section 06.2.4 below).

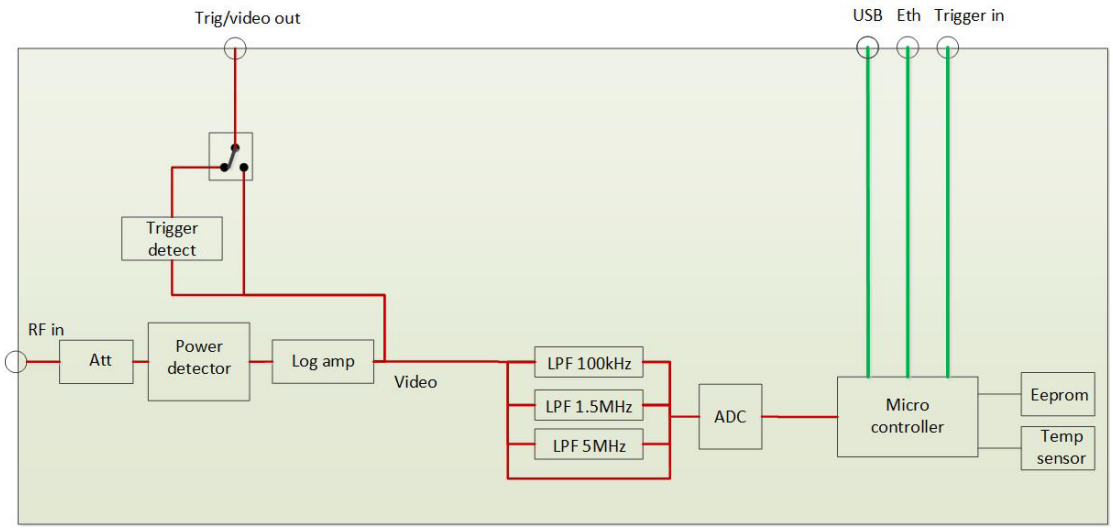
For PWR-8P-RC & PWR-8PW-RC, the trigger threshold is automatic, and an internal trigger event will be registered for the rising edge of any significant RF input signal.

Refer to the model datasheets for the minimum detectable internal trigger levels.

6.2.4. Video filter selection (Not supported by PWR-8P-RC)

The Peak & Average power sensors have several different modulation bandwidth filters, selectable by user. To reduce measurement noise it is recommended to select the narrowest filter that will fit your signal BW.

Available bandwidths are: CW, 1.5 MHz, 5 MHz and OFF (max pulse profiling BW, typically 10 MHz for PWR-8PW-RC & PWR-40PW-RC) See below block diagram of PWR-40PW-RC illustrating the use of the filter modes.



PWR-40PW-RC functional block diagram

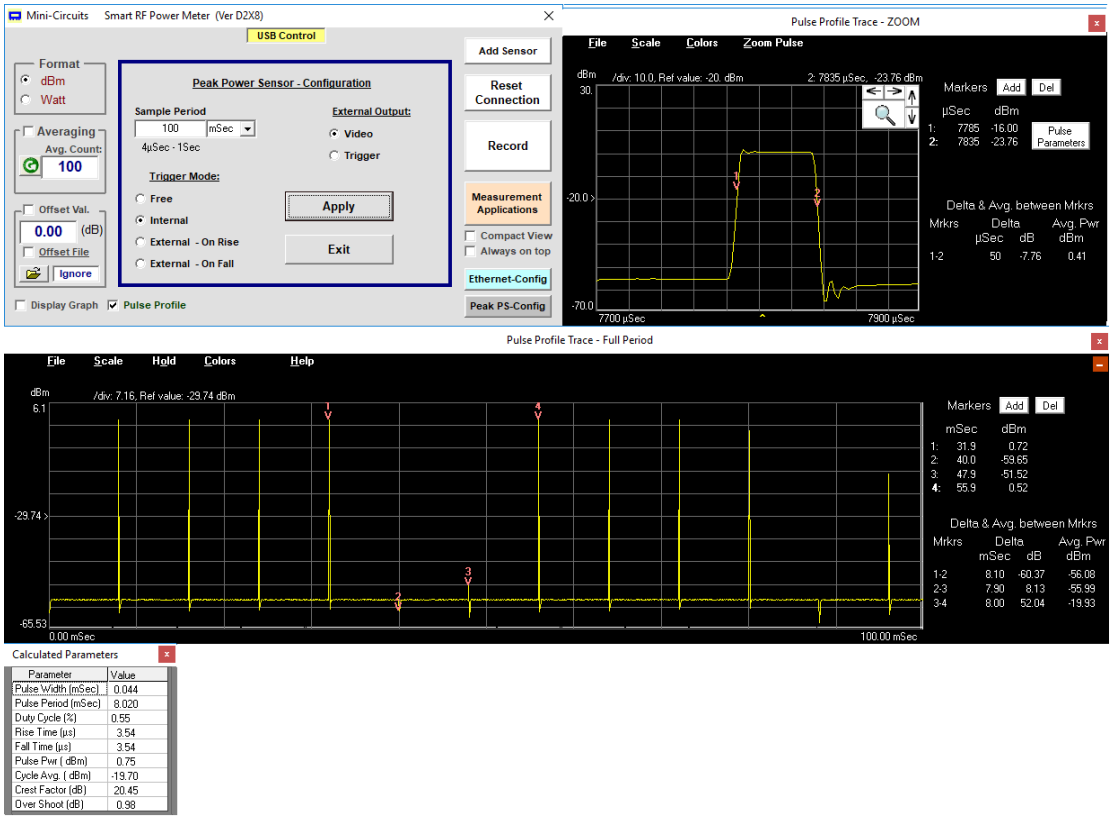
6.3. Pulse Profile Analysis

Select the "Pulse Profile" check box on the main GUI screen to open the pulse profile analysis screens. Three new windows will appear:

Full pulse profile display - Captures the full sample period of the sensor

"Zoom on pulse" display - Allows any portion of the signal to be focused on / expanded in a second graphical display.

Calculated parameters display - Summary of the measured and calculated parameters of the signal captured in the “zoom on pulse” display



Pulse Profiling Windows

6.3.1. Pulse Profiling Display Options

The menus at the top of the pulse profile displays provide the following options:

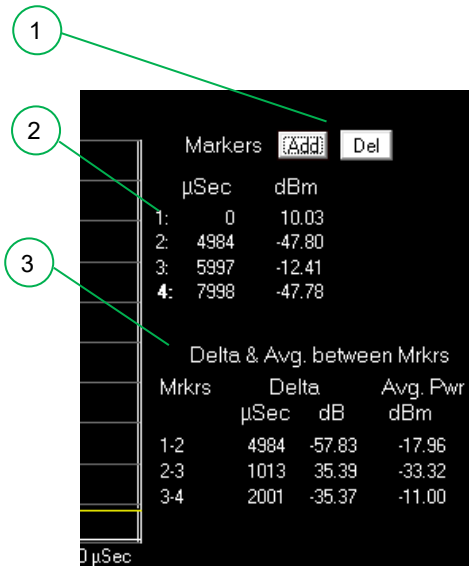
Screenshot	Select “File” from the menu to save the graph image as a jpg file or copy to the clipboard (either the selected graph or all open windows).
Scale	Select “Auto” to reset the y-axis (power) to display the full signal being measured, or “Manual” to open the configuration window where the max level and dB / div settings can be customized.
Continue / Hold	Click to toggle between continuous live measurements and hold, to freeze the display and all measured parameters.
Colors	Select from a list of alternative color combinations for the background and signal traces.

Help (at full trace)	Accessible on the full pulse profile display. Displays the help file with a summary of all window functions.
Zoom Pulse (at zoom trace)	Accessible on the “zoom on pulse” display. Select “Auto” to center the zoom on the first identified pulse, or “Config” to manually set the zoom display parameters (see section 6.3.4).

6.3.2. Markers for Graphs

To the right of each graph is a Markers table showing up to four markers with the time from the start of the sample period (in µs or ms), and the power level in dBm.

To add or delete markers click on the Add and Del buttons at the top of each table.
To place the marker automatically at the highest signal peak visible in the trace, double click on the marker number.
To manually place the marker, select the marker by clicking once on the marker number (number will become bold indicating it was selected) and then click in the graph at the location you wish to place the marker, or use the keyboard left and right arrow buttons to adjust the marker location.
Markers are placed independently in each graph.



Marker table

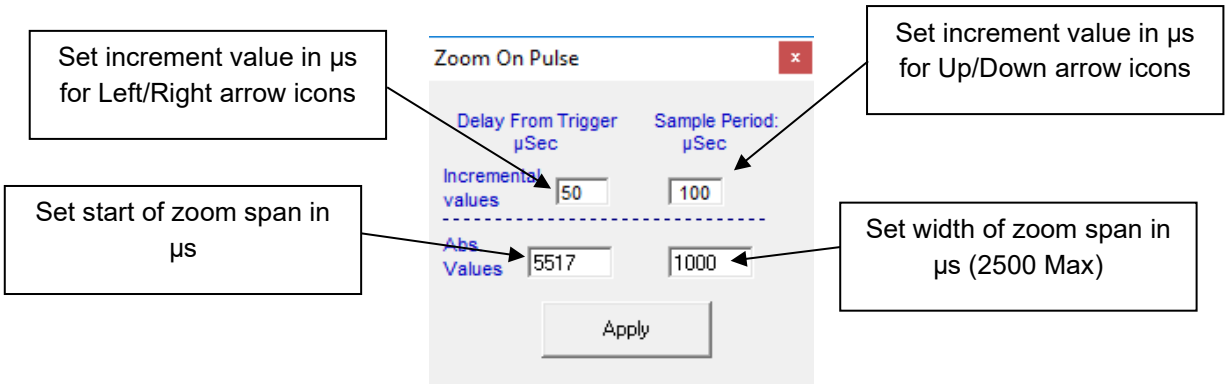
#	Name	Description
1	Add & Del	Add and delete markers. Clicking on Delete will remove the highest numbered marker currently active.
2	Marker list	Shows list of currently active markers, with selected marker in bold. Each marker shows the time from the start of the sample period and power level at that point.
3	Delta & Avg	List of deltas between adjacent markers. List shows delta in time and power, and average power over the period between the two markers.

6.3.3. Zoom Graph Configuration

The zoom display allows any portion of the pulse profile from the main display to be focused on and analyzed more closely. The zoomed section can be configured in a number of ways:

- When the display is first opened, the trace will center on the first pulse detected. As long as the pulse is wider than the time between two sample points, the zoom on pulse should identify the pulse automatically. For narrower pulses you will need to adjust the zoom manually as described below.
- Any portion of the main pulse profile display (showing the full sample capture period) can be selected for the zoom display by right-clicking in the main display, keeping the right mouse button depressed, and dragging a rectangle around the relevant section. Release the right mouse button to update the zoom display.
- The arrow buttons around the magnifying glass icon allow the time span and time delay of the zoomed display to be adjusted in small increments:
    - Left arrow – Decreases the time delay between the start of the full pulse profile display and the start of the zoom display.
    - Right arrow – Increases the time delay between the start of the full pulse profile display and the start of the zoom display.
    - Down arrow – Decreases the time span of the zoomed display around the same center point.
    - Up arrow – Increases the time span of the zoomed display around the same center point.
- Select "Config" from the "Zoom Pulse" menu to manually set the time delay and time span parameters.
- To re-center the zoom display automatically select "Auto" from the "Zoom Pulse" menu or click on the magnifying glass icon.

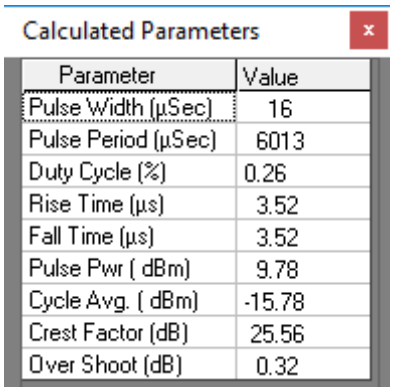
6.3.4. Zoom on Pulse Config Window



Zoom on pulse parameters

6.3.5. Calculated Parameters

The calculated parameters table provides measured and calculated details of the signal from the entire sample period. For long sample periods the calculation uses the combined data of two periods – the full sample period selected by user and the zoom section for improved resolution. For extreme duty cycles (over 99.8% or less than 0.2%) it may be necessary to adjust the zoom configuration manually (see sections 0 & 6.3.4) , or use an external trigger to ensure the pulse signal is captured correctly.



Pulse width Time from 50% of the pulse rising edge to 50% of the pulse falling edge, calculated in µs.

Pulse Period Time from 50% of the first pulse rising edge, to 50% of the next pulse rising edge, calculated in µs.

Duty Cycle Ratio of the pulse width from the pulse period, calculated as a percentage.

Rise Time Time taken for the pulse rising edge to reach 90% of its final value, from 10% of its final value, calculated in µs.

Fall time Time taken for the pulse falling edge to reach 10% of its initial value, from 90% of its initial value, calculated in µs.

Pulse Power Average power of the pulse, measured in dBm. This is an indication of the steady peak power level, averaging out any initial overshoot on the pulse rising edge.

Average Power Average power for the complete period of the “zoom on pulse” display, measured in dBm.

Crest Factor Ratio of the pulse power to average power of the signal (Pulse Power - Average Power), in dB.

Overshoot Ratio of the absolute peak power to pulse power of the signal (Peak Power - Pulse Power), in dB

7 Revision History

Revision OR (Nov. 10, 2014):

- Initial revision of the user guide.

Revision A (Dec. 12, 2014):

- Updated legal disclaimer.

Revision B (Jun 18, 2015):

- Updated legal disclaimer.

Revision C (Aug 16, 2015):

- Added instructions to create offset file manually.

Revision D (Dec. 22, 2015):

- Added model: PWR-6RMS-RC.
- Updated firmware upgrade instructions.

Revision E (May 30, 2016):

- Added models: PWR-6LRMS-RC, and PWR-6LGHS.
- Updated cover page.
- Rewrote “Model selection guide” section.
- Removed references to only PWR-xxx–RC models supporting firmware upgrade.

Revision F (Jan. 30, 2018):

- Added model: PWR-8P-RC
- Added general Peak & Average power sensor function descriptions.

Revision G (Apr. 12, 2018):

- Fixed errors in table of contents.

Revision H (May 10, 2022):

- Added model: PWR-40PW-RC.
- Changed MCL logo (front page) and footer.
- Updated “Conformity” section (section 1.8.3).
- Updated “Supported software environments” section (section 1.8.4)
- Updated “Installation guide” (chapter 2).
- Restructured and updated “Main Screen” (section 3.3) and “Data Recording Window” (section 3.7).
- Added “Firmware Recovery” section (section 3.9).
- Added “Internal trigger” (section 4.1.2) and “Filter selection” (section 4.1.4).

Revision J (May 30, 2023):

- Updated user-guide format: Re-written and restructured sections to support format update.
- Updated Conformity section with CE, UKCA and FCC compliance notes (section 2.7).
- Added model PWR-8PW-RC
- Added table of warmup times per model (section 4.3)

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