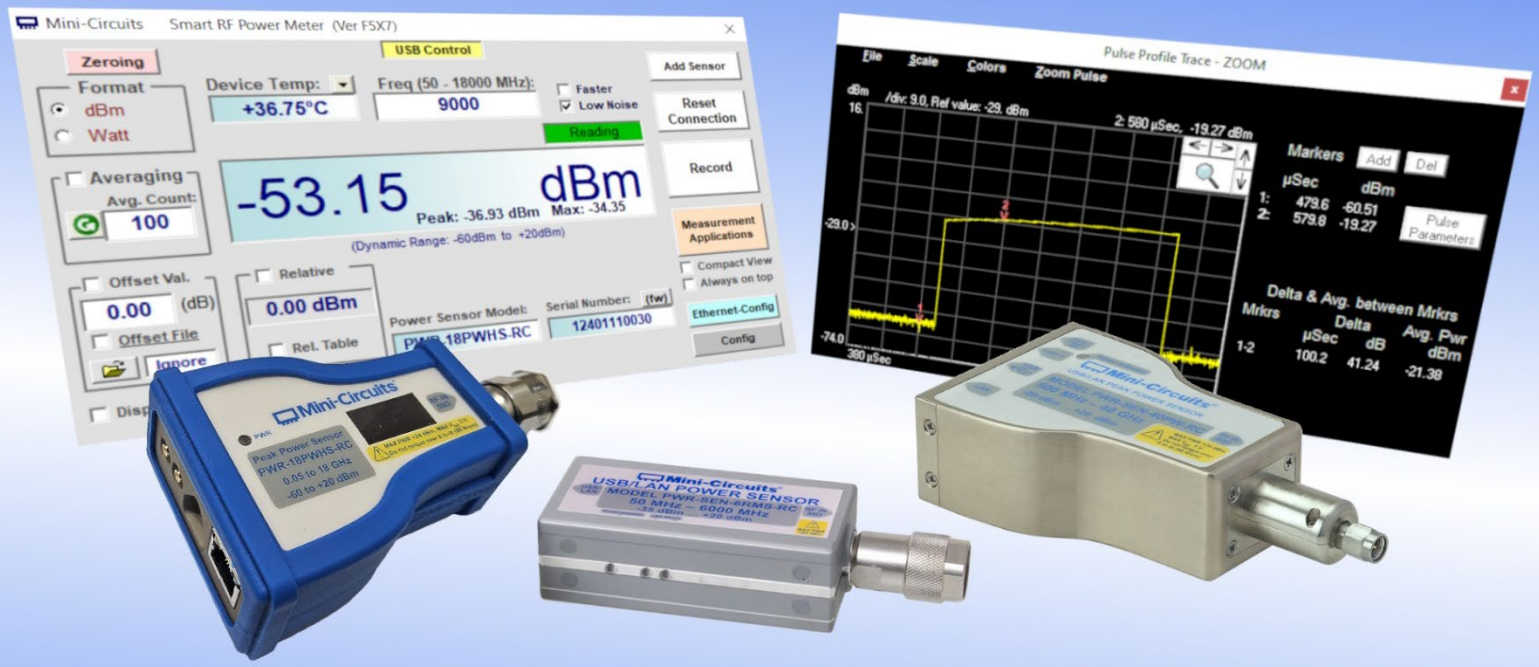
User Guide

smart Power Sensors



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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 series 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

Precise features vary between models, but Mini-Circuits' complete range includes options for all of the following:

- Power measurement up to 40 GHz.
- Wide input dynamic ranges, up to 80 dB.
- Peak & average power sensors for analysis of fast varying pulsed and modulated waveforms.
- RMS power sensors for RMS (average power) measurement of CW, pulsed and modulated signals.
- Cost effective CW power sensors for average power measurement of single tone signals.
- Pocket-sized portability.
- Automatic frequency calibration & temperature compensation.
- Turns a laptop or PC into a low-cost replacement power-meter.
- Integrated display showing important parameters directly on the power sensor.
- Remote power measurement via Ethernet.
- USB HID (Human Interface Device) for "plug & play" operation (no driver installation required).
- 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.
- Control systems.
- Automated switching of signal paths in a complex system.
- 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

For additional model information – performance graphs and data, outline drawing, environmental specifications, ordering details and more – please click on the model part number to view it on the Mini-Circuits website.

Model name	Frequency range (GHz)	Input power (dBm)	Sensor type	Resolut-ion	Video BW [1] (MHz)	Max DC supply current [2] (mA)	Control protocols
PWR-2.5GHS-75 [3]	100 kHz – 2.5 GHz	-30 to +20	CW	30 ms	–	70	USB
PWR-4GHS	9 kHz – 4 GHz	-30 to +20	CW	30 ms	–	70	USB
PWR-6GHS	1 MHz – 6 GHz	-30 to +20	CW	30 ms	–	70	USB
PWR-6LGHS	50 MHz – 6 GHz	-45 to +10	CW	30 ms	–	110	USB
PWR-8FS	1 MHz – 8 GHz	-30 to +20	CW	10 ms	–	70	USB
PWR-8GHS	1 MHz – 8 GHz	-30 to +20	CW	30 ms	–	70	USB
PWR-8GHS-RC	1 MHz – 8 GHz	-30 to +20	CW	30 ms	–	250	USB, Ethernet
PWR-6LRMS-RC	50 MHz – 6 GHz	-45 to +10	RMS	30 ms	–	300	USB, Ethernet
PWR-6RMS-RC	50 MHz – 6 GHz	-35 to +20	RMS	30 ms	–	300	USB, Ethernet
PWR-9RMS-RC	50 MHz – 9 GHz	-60 to +20	RMS	0.5 ms	100	500 (550)	USB, Ethernet
PWR-18RMS-RC	50 MHz – 18 GHz	-60 to +20	RMS	0.5 ms	100	500 (550)	USB, Ethernet
PWR-8P-RC	10 MHz – 8 GHz	-60 to +20	Peak & Avg	2 µs	0.1	450 (650)	USB, Ethernet
PWR-8PW-RC	10 MHz – 8 GHz	-60 to +20	Peak & Avg	50 ns	10	500 (650)	USB, Ethernet
PWR-9PWHS-RC	50 MHz – 9 GHz	-60 to +20	Peak & Avg	13 ns	30	700 (850)	USB, Ethernet
PWR-18PWHS-RC	50 MHz – 18 GHz	-60 to +20	Peak & Avg	13 ns	30	700 (850)	USB, Ethernet
PWR-40PW-RC	500 MHz – 40 GHz	-20 to +20	Peak & Avg	50 ns	10	500 (700)	USB, Ethernet

1. 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.
2. For models supporting an "Ethernet disable" function the maximum DC supply current is listed for both disabled and enabled Ethernet.
3. The model has an 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; Linux (no GUI support).

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

Refer to the programming manual for more information on power sensor programming.

2.7. Conformity

Mini-Circuits' 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.
TCP/IP	The **RC** suffix series Ethernet communication complies with the specifications of the Transmission Control Protocol (TCP) and Internet Protocol (IP) as defined in RFC 791 and RFC 793.
HTTP	The **RC** suffix series supports all requirements for communicating with the Hypertext Transfer Protocol (HTTP) as defined in RFC 1945**.**
Telnet	The **RC** suffix series supports all requirements for communicating with the Telnet protocol, as defined in RFC 854.

2.8. Accessories and Options

PWR series power sensor models come with a single control cable and an BNC-SMB trigger cable:

- USB control/data cable
- 5.0 ft (~1.5 m) Trigger cable: BNC (Male) to SMB (Female) (for sensors with external trigger port)

Additional ordering options are available (see models' datasheet for details):

- 5.0 ft (1.5 m) Ethernet cable: RJ45 (Male) to RJ45 (Male) Cat 5E cable
- Various connector adaptors:
    - 50Ω N-type (Female) to SMA (Female)
    - 50Ω N-type (Female) to SMA (Male)
    - 50Ω N-type (Female) to BNC (Male)
    - 1.85 mm (Female) to 2.92 mm (Female)
- 5V AC/DC power adaptor suitable for a wide selection of wall sockets

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. The case can be cleaned with a soft, slightly dampened cloth and the connectors with an alcohol solution. Do not allow any liquid ingress into the case or connectors.

The recommended calibration cycle for Mini-Circuits' PWR series models is once a year. Calibration service is available from Mini-Circuits. For details and links refer to individual models' datasheet.

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:

- Inputting a power which exceeds the sensor's operational or maximum power ratings (check datasheet for details) may damage it.
- To prevent potential damage to the sensor while evaluating a high-power device, use a calibrated setup containing an attenuator or a coupler as described in *section 0*.

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 Smart RF Power Meter” user interface program and API DLL on the host PC are:

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

Control method	Required support
USB control	USB HID
Ethernet control	Network connection

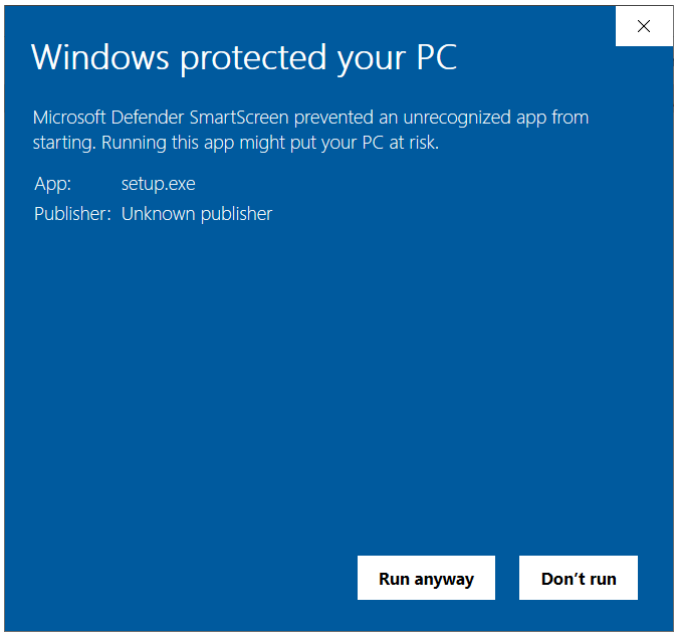
3.2. Software Downloads & Resources

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

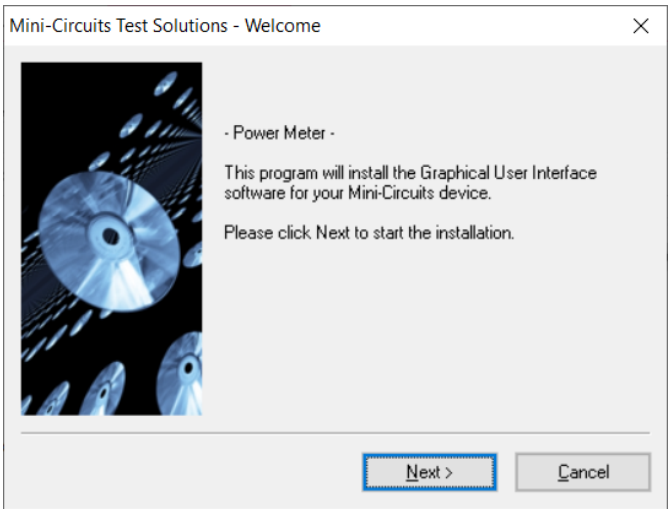
3.3. Software Installation

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

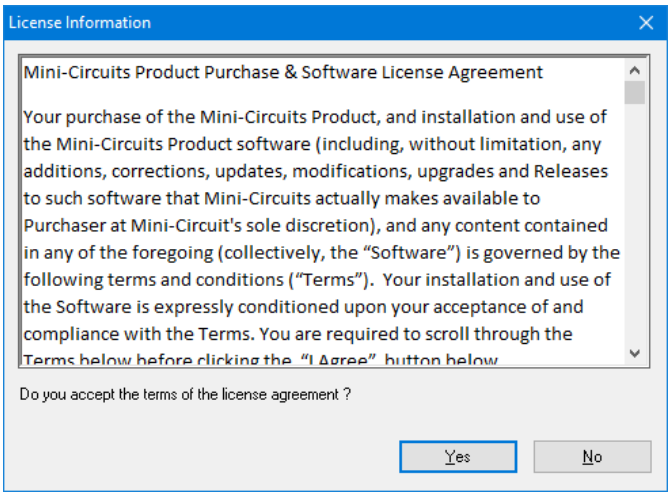


- If prompted by Windows User Account Control, enter user credentials for an account allowing software installation.

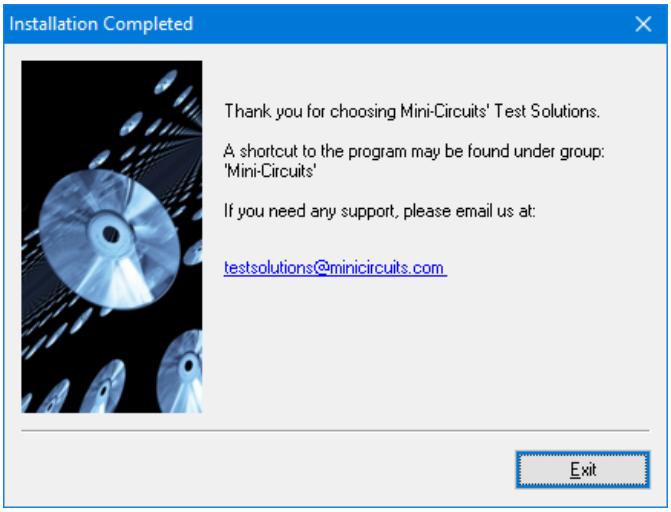
- Click **Next** to begin the installation.



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



- 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. Hardware Setup

4.1. DC Supply Connection

The power sensors always draw the DC power supply through the USB interface. To get started, connect the supplied USB cable to the sensor.

For sensors with the proprietary push-pull round connector, align the red dot on the cable connector with the red dot on the sensor and push until a click is heard. Pull back the collar on the connector to release the connection.

For sensors with a lockable USB connector, push the USB securely in place before tightening the screw.

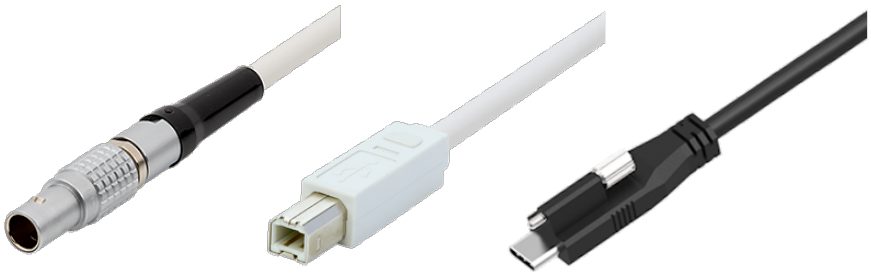


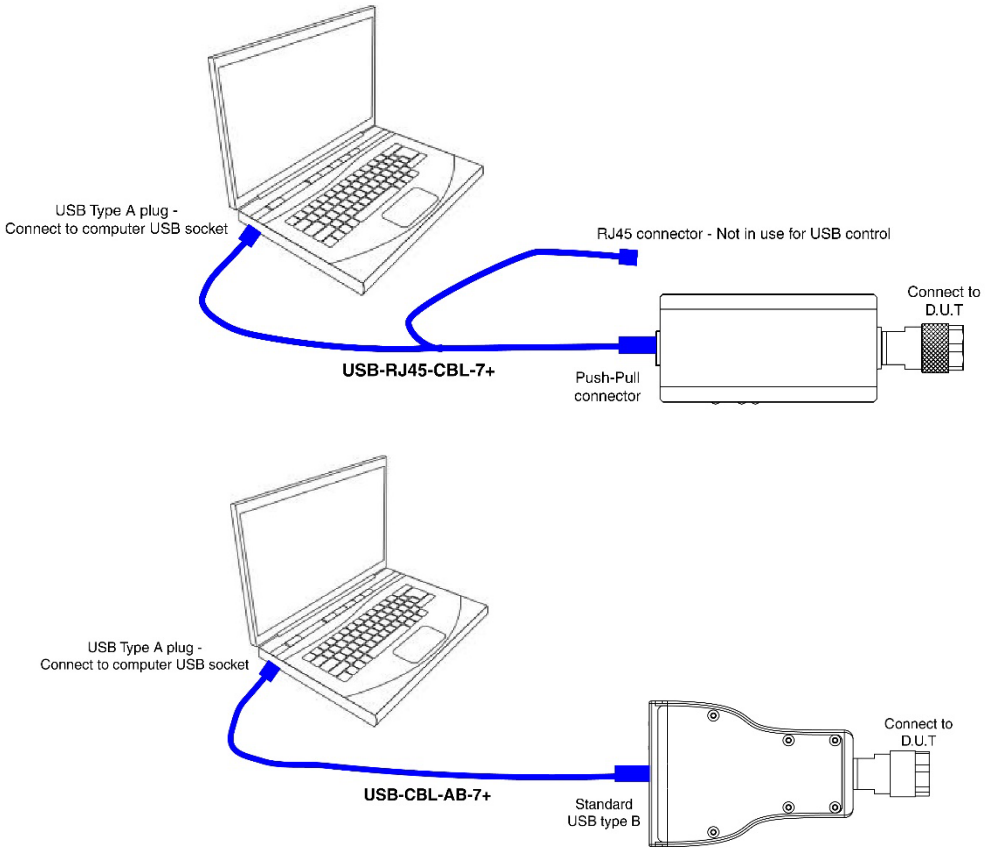
Figure 4.1: Different models' DC supply connector examples – push-pull, USB type B, and lockable USB type C connectors.

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.

4.2. USB Control

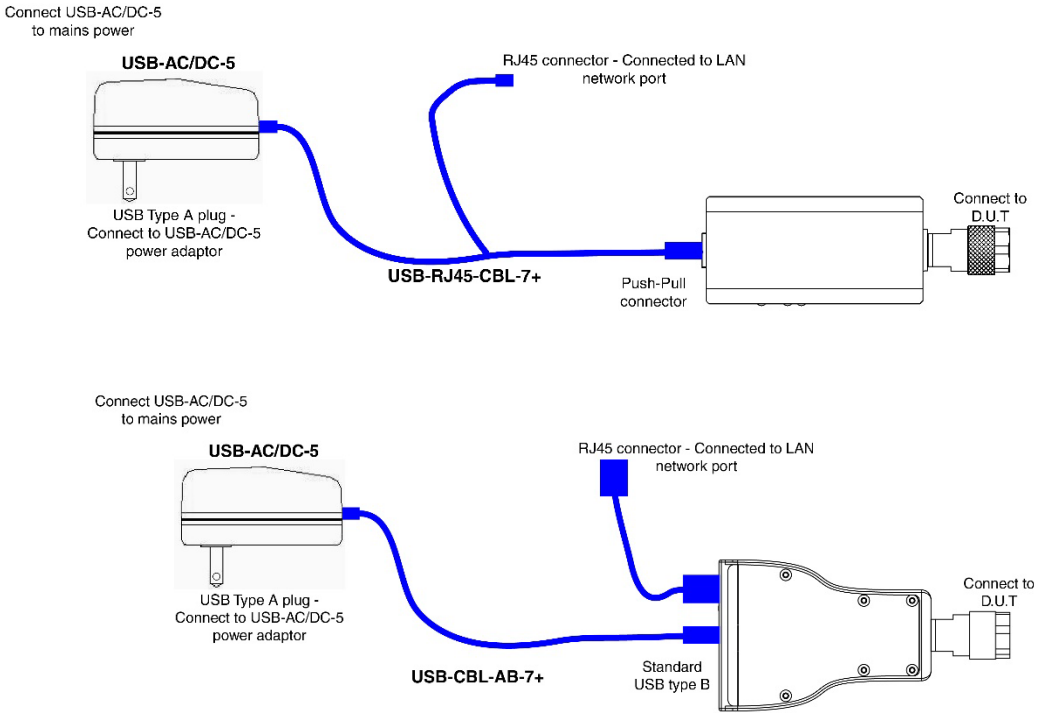
Connect the USB type A plug of the supplied cable to the computer USB port and begin testing. For models supplied with a “Y” cable with both USB and RJ45 connectors, the RJ45 connector may remain disconnected for USB control.



4.3. Ethernet Control using AC/DC adaptor

Connect the USB type A plug of the included control cable to the power adaptor and plug it into a mains power socket. Note the power sensor's power indicator lights up.

For models supplied with a “Y” cable, connect the RJ45 connector into a network port. For all other models, connect a standard network cable from the power sensor's RJ45 connector to a network port and note that the sensor's Ethernet status indicators light up.



Note:

- Before connecting the power sensor for the first time you may need to enable Ethernet control (depending on model), see *section 0* for details. If Ethernet control is not enabled the indicator lights on the sensor’s Ethernet port will not light up.

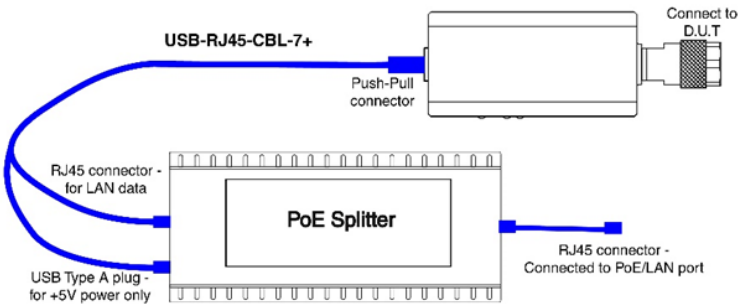
4.4. Ethernet Control using Power over Ethernet

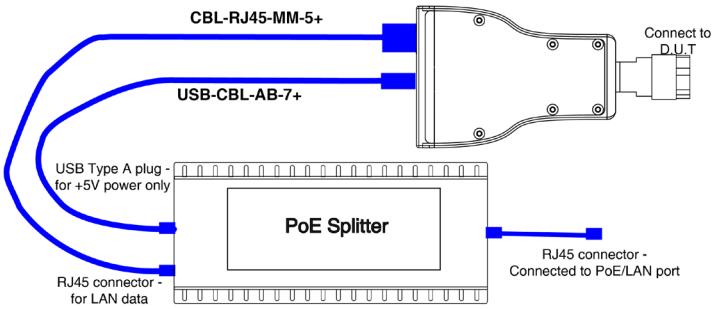
Mini-Circuits RC power sensor models do not directly support PoE (Power over Ethernet), but an external PoE splitter could be used to enable their use on a PoE network.

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 adaptor 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.

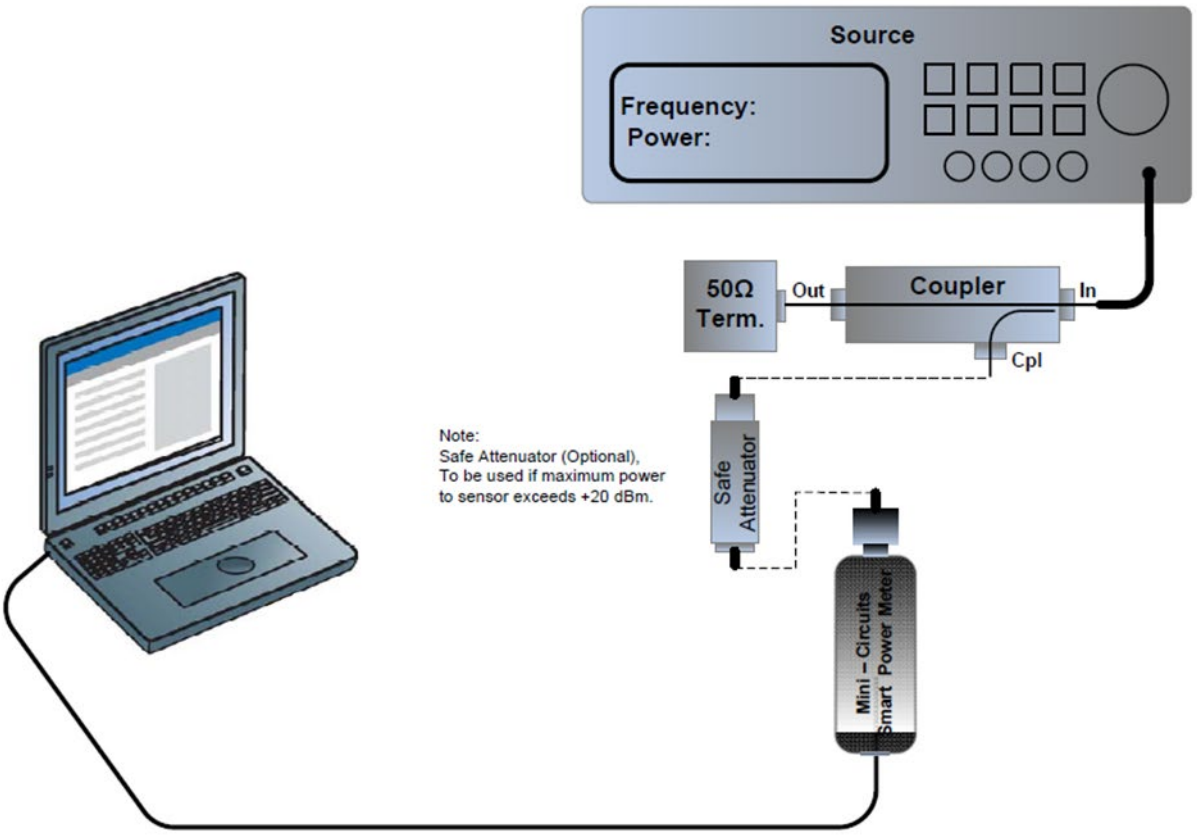




4.5. Testing a High-Power Source using a Coupler

When evaluating or monitoring a high-power device with the power sensor, it is required to attenuate the power from the source before it reaches the power sensor to avoid damaging it. This is commonly done using an attenuator or coupler connected to the power sensor. To avoid measurement errors due to inaccuracies in the coupler, it is recommended to calibrate the test setup at low power before testing by either manually creating a relative table per *section 6.7* or with the Measurement Applications.

After calibrating the coupler, it is possible to measure high power levels using the setup below as long as the actual power reaching the power sensor does not exceed its power limits (generally +20 dBm, see model's datasheet for details).



If monitoring a power, the 50Ω termination shown in the block diagram would be replaced with the device receiving the RF power.

4.6. Warm-up 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	Warmup time (Minutes)
PWR-2.5GHS-75	5
PWR-4GHS	5
PWR-6GHS	5
PWR-6LGHS	5
PWR-6LRMS-RC	5
PWR-6RMS-RC	5
PWR-8FS	5
PWR-8GHS	5
PWR-8GHS-RC	5
PWR-8P-RC	15
PWR-8PW-RC	30
PWR-9PWHS-RC	30
PWR-9RMS-RC	30
PWR-18PWHS-RC	30
PWR-18RMS-RC	30
PWR-40PW-RC	30

Note:

- Mini-Circuits' power sensors are tested at standard laboratory conditions in 25±5°C after the specified warmup 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.

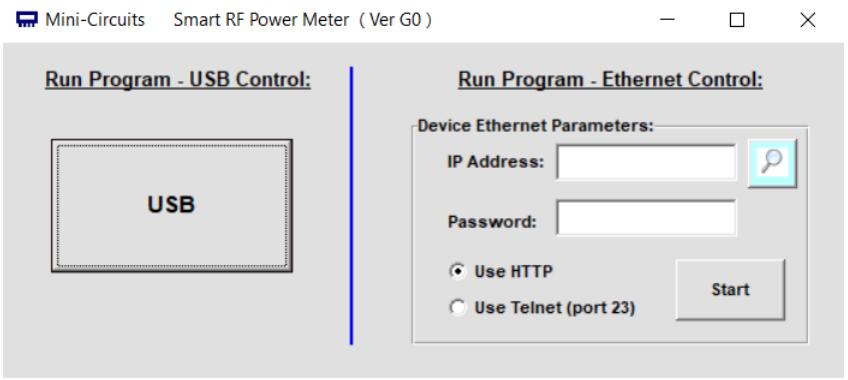
5. GUI: Getting Started

All USB & Ethernet power sensor models are supplied along with API programming objects (DLL files) to allow easy control by most common lab test software (see programming manual for details) and with a Windows GUI program to control the model manually.

5.1. Getting Started

To start the program, use the **Start** menu or navigate to the location the "Mini-Circuits Power Meter" software was installed in and run the program.

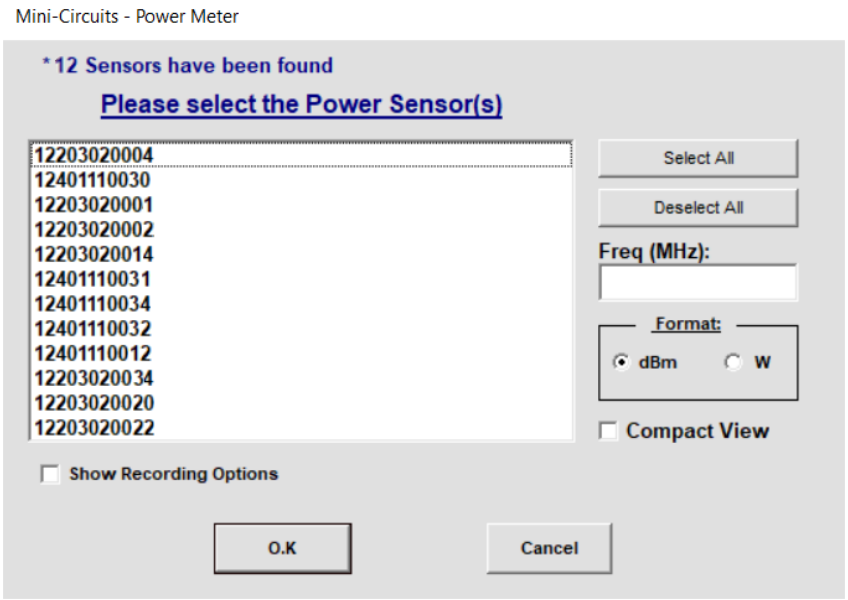
Once running, the user will be required to pick one of the available control modes: USB, HTTP, or Telnet control.



5.1.1. USB Control

Clicking the **USB** button in the startup screen will start the unit in USB control. In case the program does not detect a unit connected to the PC via USB or if there are no connected units then an alert will pop-up. If the alert persists even when a unit is connected, then check the unit's LED indicator or the USB cable's integrity.

The program can handle up to 24 units connected simultaneously. If multiple units are connected to the PC via USB, select the desired units' serial numbers from the provided list and click **O.K** to proceed. It is possible to set the starting conditions for all units from this screen (frequency, power display format, compact/normal program view and record options).



5.1.2. Ethernet Control

To use Ethernet control with a supported unit, click the **search icon** next to the **IP Address** field to find all Mini-Circuits power sensor models connected to the network.

A search window will pop up listing the power sensors' IP address and assigned ports on the left, with full network details on each unit to the right. Click the IP address of the desired unit and press **Select**. The search window will close, and the selected IP address will be automatically entered in the IP address field on the startup screen.

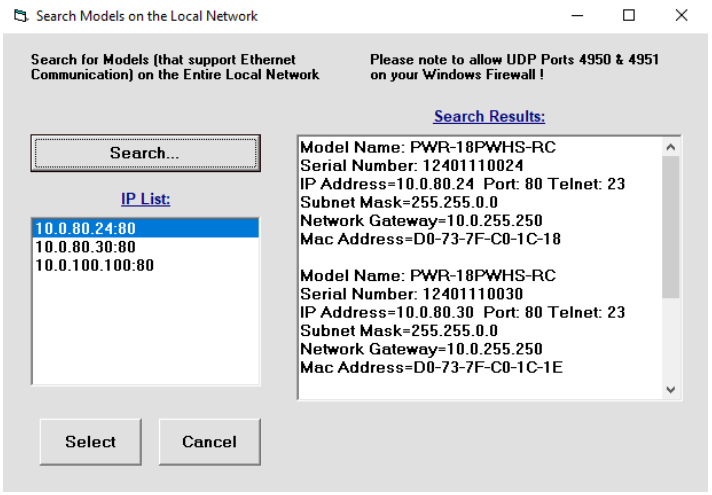


Figure 5.1.2: *Ethernet IP search window*

It is possible to skip the search window by manually inputting the IP address along with the HTTP/Telnet ports being used (required if using non-default ports).

Once the IP address has been entered, input the password if one has been set (see *section 5.2*). Proceed to select the desired communication protocol (HTTP or Telnet) and click on the **Start** button to begin.

Note:

- To refresh the list of connected units, click on the **Search…** button.
- The network search uses a UDP broadcast on ports 4950 and 4951; ensure these ports are enabled in your firewall.
- If it is not possible to locate connected devices beyond the local subnet; their IP address can be entered manually.
- Some models are shipped with Ethernet disabled by default. Refer to *section 5.2* for details.
- Depending on the browser used and your network configuration you may need to disable the proxy server for your computer or add the power sensor's IP address to the list of addresses in the proxy server.

In addition to the Mini-Circuits GUI, users can use Telnet or HTTP text commands over Ethernet to control the module.

This can be achieved in one of the ways below:

- Type the command in the address field of your internet browser.
- Implement a Get/Post HTTP function in your selected application (for HTTP).
- Establish a Telnet connection.

A full list of the possible commands and queries is available in the Mini-Circuits' Programming handbook.

5.2. Ethernet Configuration

Mini-Circuits' list of PWR models with Ethernet interface is summarized below along with the features / capabilities supported.

Model name	Default Ethernet State	Ethernet Configuration Options	Default IP Support
PWR-6LRMS-RC	Enabled	Via USB Only	Firmware A3 and newer
PWR-6RMS-RC	Enabled	Via USB Only	Firmware A3 and newer
PWR-8GHS-RC	Enabled	Via USB Only	Firmware A4 and newer
PWR-8P-RC	Disabled	Via USB or Ethernet	Firmware A5 and newer
PWR-8PW-RC	Disabled	Via USB or Ethernet	Yes
PWR-9PWHS-RC	Disabled	Via USB or Ethernet	Yes
PWR-9RMS-RC	Disabled	Via USB or Ethernet	Yes
PWR-18PWHS-RC	Disabled	Via USB or Ethernet	Yes
PWR-18RMS-RC	Disabled	Via USB or Ethernet	Yes
PWR-40PW-RC	Disabled	Via USB or Ethernet	Yes

5.2.1. Enabling Ethernet Control

Certain models ship with Ethernet disabled by default in order to reduce current consumption. The first connection for these models must therefore be via USB. Once a USB connection has been established, Ethernet control can be enabled via the GUI or the API.

For all other models, there is no option to disable Ethernet control so both USB and Ethernet connections are available from first use.

5.2.2. IP Configuration

Mini-Circuits' models ship from the factory with DHCP enabled by default using port 80 for HTTP and port 23 for Telnet.

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.

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 re-configured by connecting to via USB and the GUI.

5.2.3. Default "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 module with DHCP enabled is connected directly via an Ethernet cable to a PC (instead of via a network). The default "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 without resorting to a USB connection or even Mini-Circuits' GUI. Just connect the module directly to the PC, open the HTML Ethernet configuration tool (see *section 5.2.5*), connect to the module using the *169.254.10.10* default IP and proceed to set the new configuration as needed.

5.2.4. Ethernet Settings Screen

To change the Ethernet settings, click on the **Ethernet-Config** button in the GUI's main screen, or use Mini-Circuits' Ethernet configuration tool (see *section 5.2.5*).

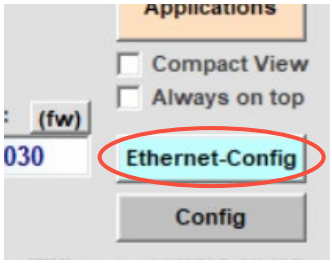


Figure 5.2.4a: *The "Ethernet-Config" button on the GUI's main screen*

On the first instance the screen is opened it will have the default factory settings (as shown in *Figure 5.2.4b*). If these are appropriate for your local network, **Enable Ethernet** control and proceed to access the model via Ethernet as described in *section 5.1.2*.

If changes are made, click on **Store** to save them to the model's memory and proceed to connect via Ethernet connection.

Note:

- It is not advised to set the HTTP, Telnet, and SSH ports to use the same port.
- 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.
- Some models require a USB connection in order to view and edit the Ethernet configuration. Refer to *section 5.2* for details.

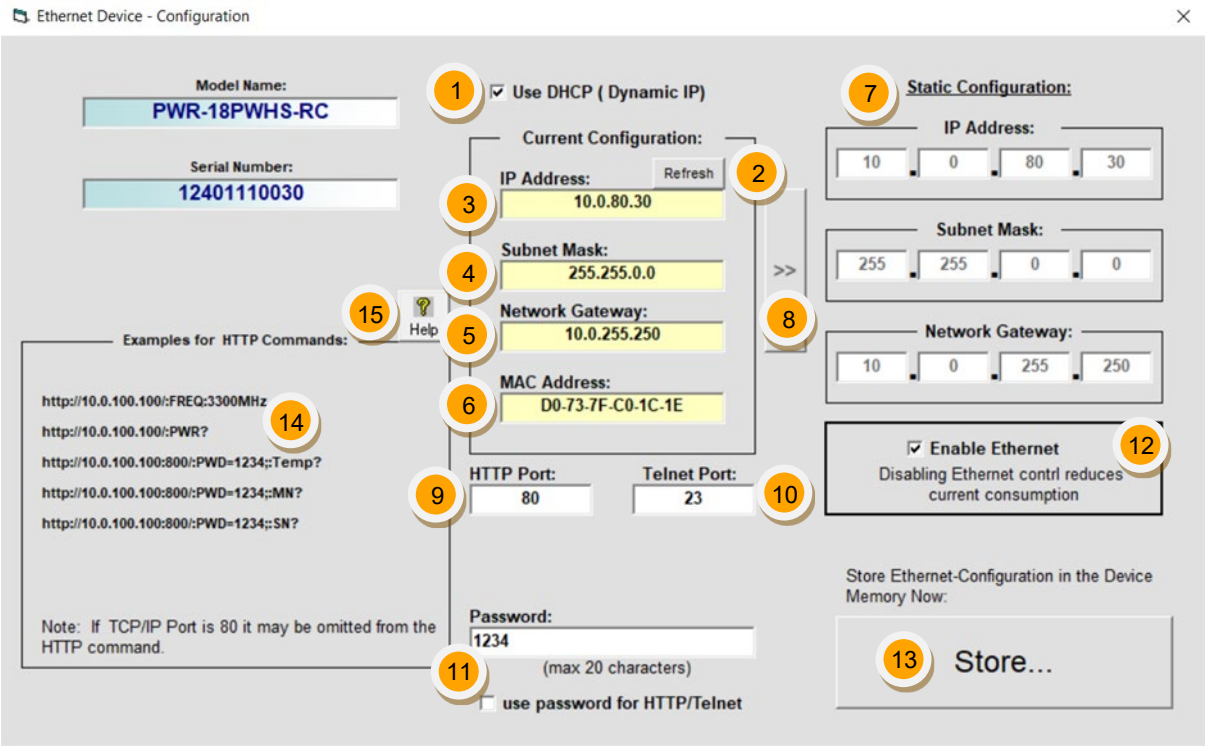


Figure 5.2.4b: *Ethernet Settings screen (at factory default state)*

#	Name	Descriptions
1	Use DHCP	When selected the attenuator will query the server for appropriate parameters with no input from the user.
2	Refresh	Request IP address, subnet mask and network gateway from the server.
3	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.
4	Subnet Mask	The network's subnet mask. When DHCP is selected this is assigned by the server and will change according to the server.
5	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.
6	MAC Address	Media Access Control address – a unique, unchanging identifier for the attenuator unit.
7	Static Configuration	When DHCP is not selected the user must specify the values below which will not be changed by the server.
8	Copy state	Copies current state of dynamic IP to static IP (not available when DHCP is enabled).
9	HTTP Port	Specify the port to use for HTTP communication on the network (default 80). Note that port address does not get assigned by the server when DHCP is selected. To disable the HTTP protocol set the port to 65535.
10	Telnet Port	Specify the port to use for Telnet communication on the network (default 23). To disable the Telnet protocol set the port to 65535.
11	Password	To restrict remote access to the unit in HTTP or Telnet mode, check **Use Password** and enter the desired password (up to 20 characters).
12	Enable/Disable Ethernet	Uncheck to disable Ethernet and reduce the sensor's current consumption (Refer to *section 5.2* for supported models).
13	Store	Saves the current Ethernet settings into the sensor's memory.
14	HTTP command examples	A short list of useful HTTP commands. For more programming help, refer to the programming manual.
15	Help	Short helpful information on the window and how to use it.

Note:

- Review the DC supply on the model datasheet when enabling Ethernet control and ensure the connected USB power source is capable of delivering sufficient current.

5.2.5. 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.

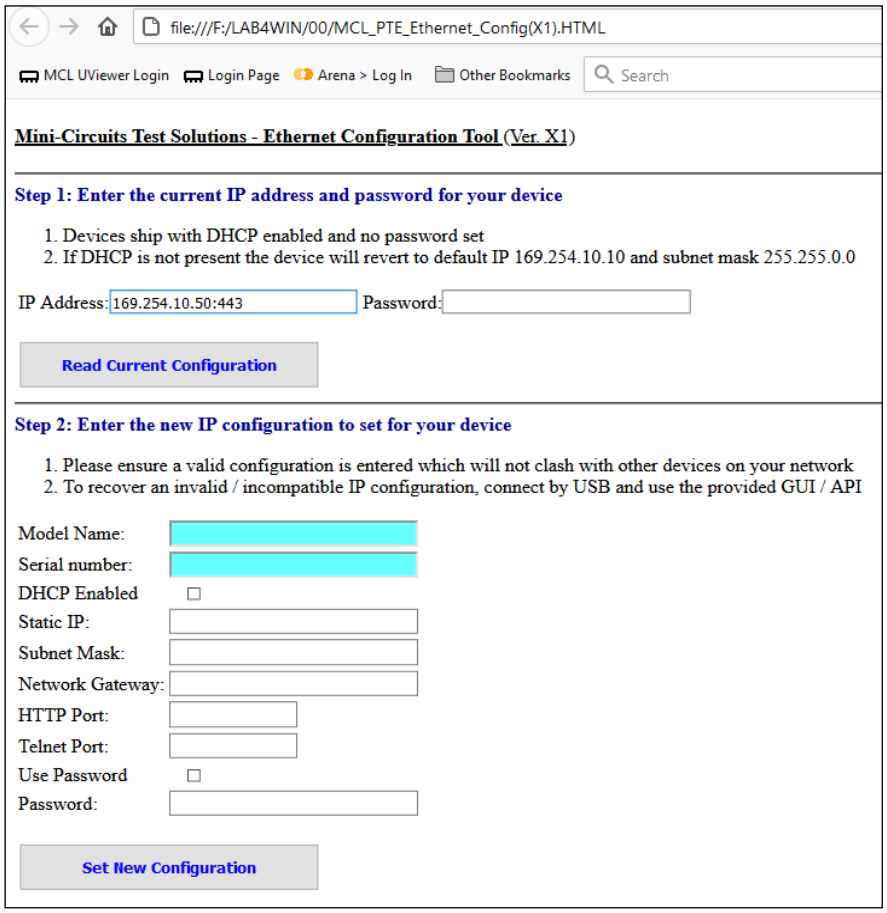
https://www.minicircuits.com/softwaredownload/MCL_PTE_Ethernet_Config.zip

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 it 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.



5.3. Firmware Update

All Mini-Circuits units 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.

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 5.4* for details).

5.3.1. Requirements

To update a unit's firmware, a Windows computer with an installation of Mini-Circuits' Power Meter software is required. Additionally, a suitable firmware file provided by Mini-Circuits' Test Solutions department needs to be available on hand.

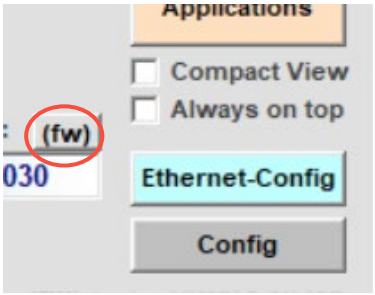
Note:

- Only Mini-Circuits' RC series (and PWR-6LGHS) models support the firmware update functionality.

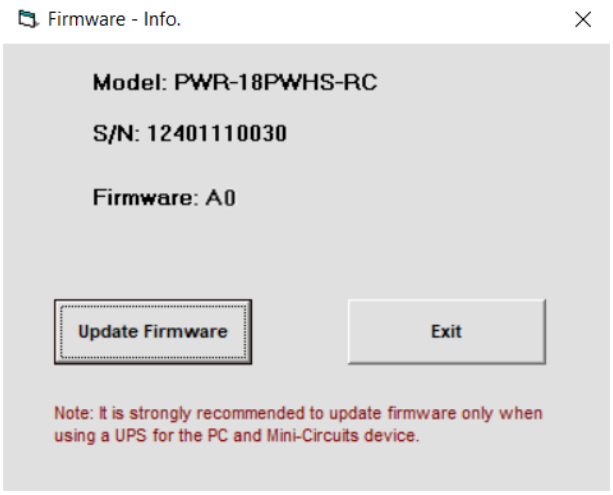
5.3.2. Process

The following firmware upgrade instructions apply to both current and legacy controller versions, but with some visual differences (as highlighted below):

- Connect only the unit to be upgraded to the PC via USB (see *section 5.1.1*) and start Mini-Circuits' Power Meter GUI program.
- After selecting **USB** connection, click the **(fw)** indicator on the main screen (next to the unit's serial number display).



- The “Firmware – Info” window note the firmware revision currently installed on the unit. Chose **Update Firmware** to proceed or **Exit** to cancel the process.



- Navigate to the location of the firmware *.hex* file you received from Mini-Circuits’ Test Solutions and chose it.

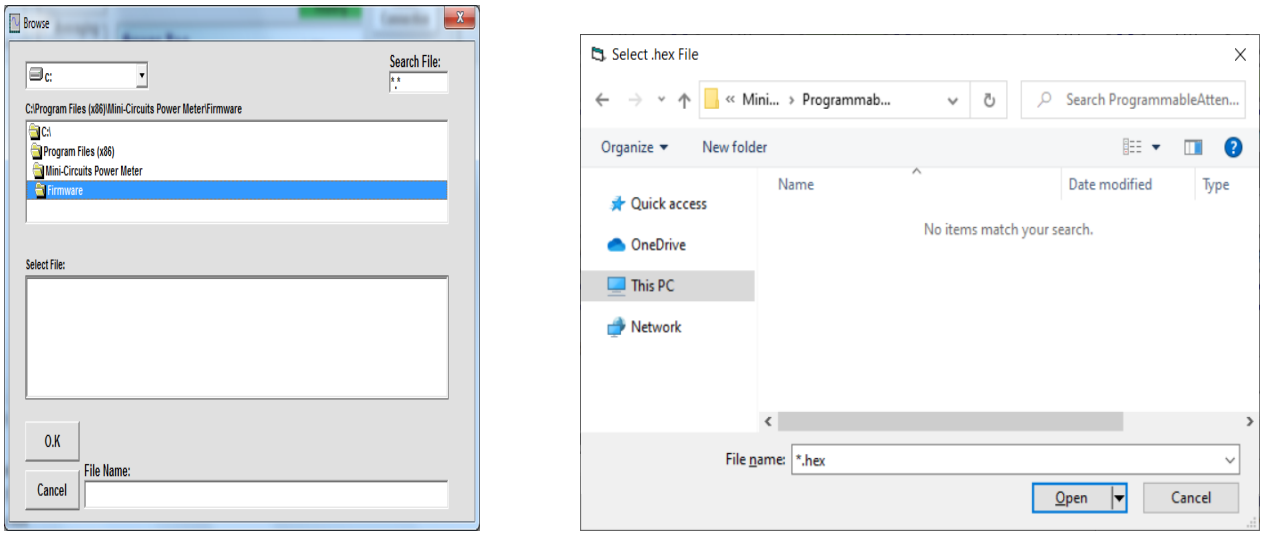


***Figure 5.3.2a**: Firmware - Browse window (Legacy – left, Current – right)*

- The selected file should then be installed on the unit with the process taking up to a minute.

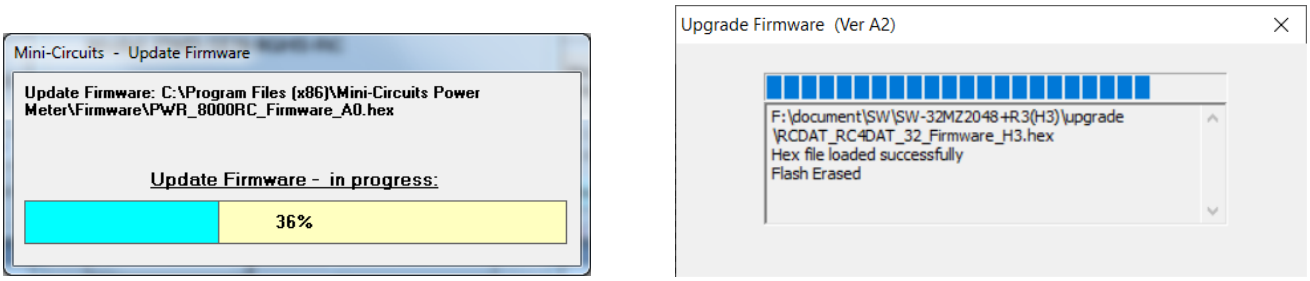


***Figure 5.3.2b**: Firmware - Progress Bar window (Legacy – left, Current – right)*

Caution:

- Do not disconnect the unit or shut down the program while the firmware is being updated. Doing so may damage the unit.
- Attempting to start a second GUI session while the firmware is being updated may cause the firmware to be corrupted. It is therefore recommended not to attempt to start any additional GUI sessions until after the firmware upgrade has been completed.

- After the firmware has been updated a confirmation alert will appear. Click **OK** to shut down the program and restart it.
- If the firmware upgrade was interrupted, this can result in a partial installation rendering the device inoperable. Refer to *section 5.4* to start the firmware recovery process.

5.4. Firmware Recovery

Mini-Circuits models feature a firmware recovery option for cases where the unit's firmware has become corrupted rendering it no longer accessible (for example, due to an interrupted firmware upgrade).

Caution:
- Ensure you have the firmware file ready before attempting a recovery process.
- Contact testsolutions@minicircuits.com if you do not have the *.hex* firmware file.

5.4.1. Recovery Steps (Current)

Follow the below recovery steps for the models listed below:

Model name	Sensor type
PWR-8PW-RC	Peak & Average
PWR-9PWHS-RC	Peak & Average
PWR-9RMS-RC	RMS
PWR-18PWHS-RC	Peak & Average
PWR-18RMS-RC	RMS
PWR-40PW-RC	Peak & Average

- Connect the unit to the PC via USB.
- Navigate to the directory where Mini-Circuits' Power Meter GUI has been installed.
- Locate and run the "UpgradeFirmware.exe" utility program.
- Click **Connect** / **Disconnect** and wait for the device to be connected.
- Click **Load Hex File** and navigate to the firmware's (file ending with *.hex*) location on your PC.
- Click **Upgrade Firmware** and wait for the program to finish.

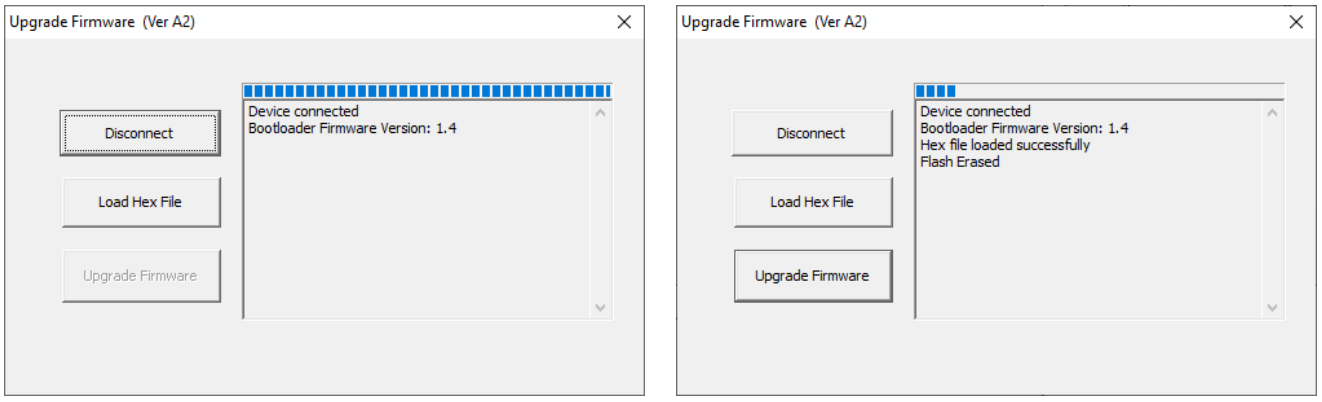


***Figure 5.4.1**: Left – Unit connection step; Right – Firmware upgrade step*

5.4.2. Recovery Steps (Legacy)

Follow the below recovery steps for the models listed below:

Model name	Sensor type
PWR-6LGHS	CW
PWR-6LRMS-RC	RMS
PWR-6RMS-RC	RMS
PWR-8GHS-RC	CW
PWR-8P-RC	Peak & Average

- Connect the unit to the PC via USB.
- Start Mini-Circuits' Power Meter GUI program and allow it time to attempt and establish a connection with the unit.
- If the connection attempt has failed, an alert would appear advising the user of a corrupt firmware.
- Click **Yes** to proceed with the firmware recovery and refer to *section 5.3.2* on how to proceed.

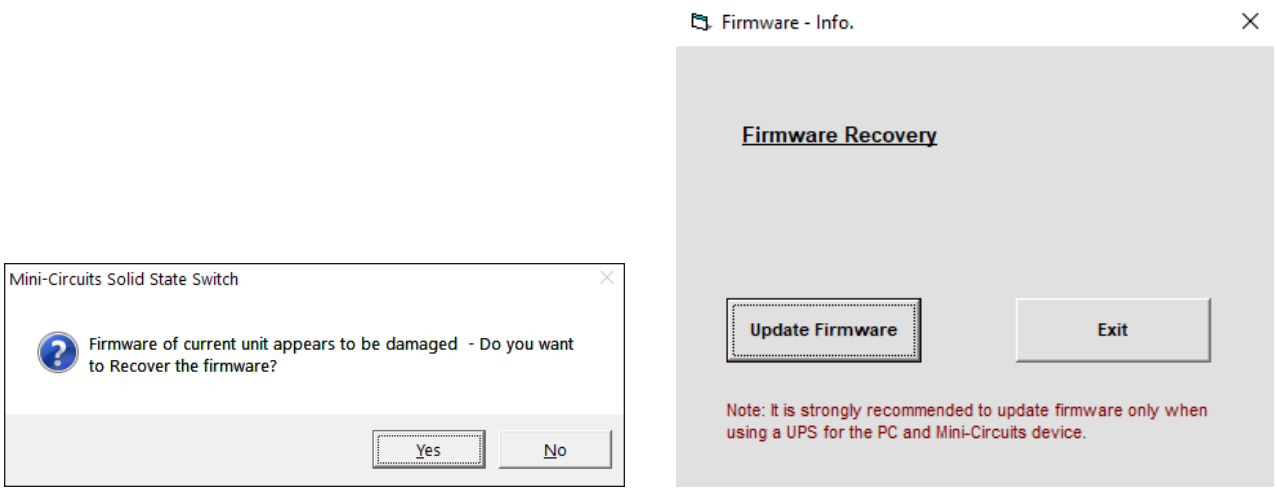
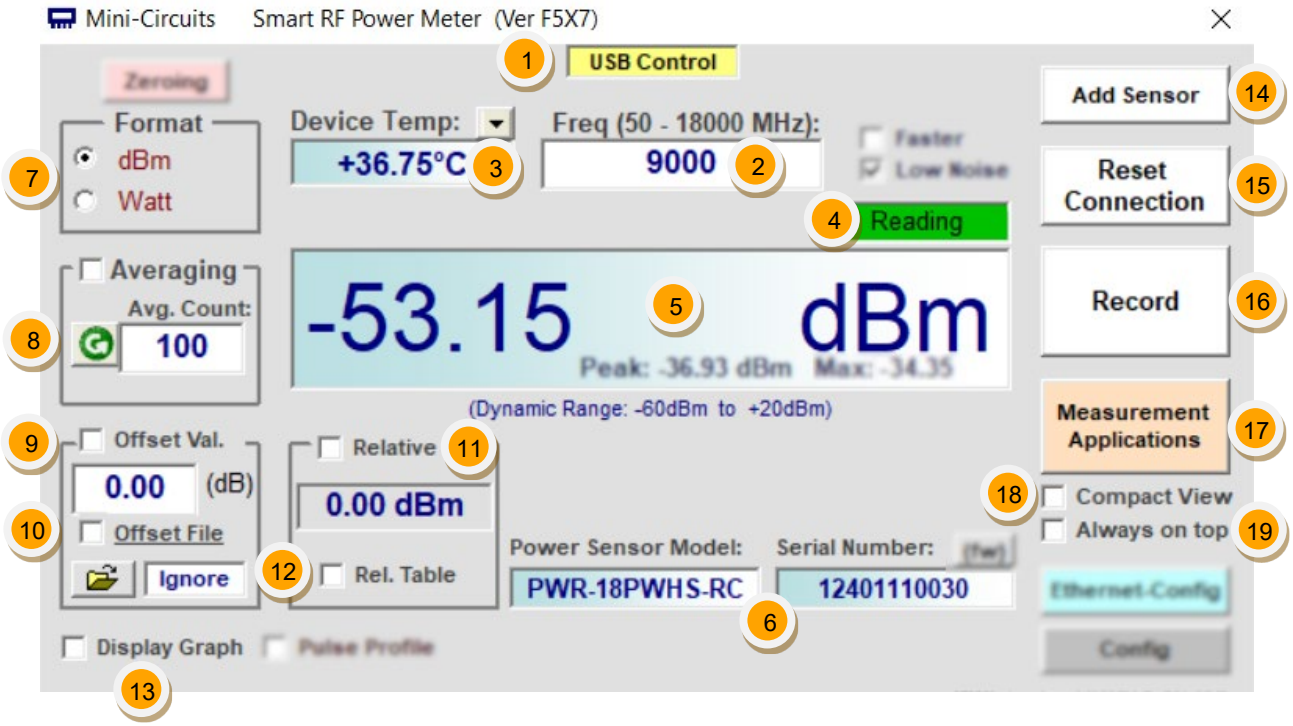


Figure 5.4.2: *A corrupted firmware alert (left) and firmware recovery window (right)*

6. GUI: Main Screen Functions

6.1. General Functions

Once the control method has been selected, the main screen of the GUI program will appear.



#	Name	Description
1	Control method	Displays the current control method status chosen to operate the unit.
2	Frequency	Allows the user to input the desired frequency (within the model's specified range) to test and be used for the internally calculated frequency compensation. On high frequency models, it is possible to change the display format from MHz to GHz.
3	Device Temp.	Displays the power sensor's internal temperature. Display format can be either Celsius or Fahrenheit. The power sensor compensates automatically for any temperature variation in the 0 - 50°C (32 - 122°F) range. For best accuracy ensure device temperature has stabilized before starting tests.
4	Connection status	Displays the status of connection to the power sensor: • **Reading** - Good connection (green background). • **Searching** - Attempting to re-establish connection (orange background). • **Not connected** - Power sensor not found (red background).
5	Measured Power display	Displays the average power measured over the sample period. On supported models, also displays peak power values (see *section 6.2*). **Note:** If the sample period is not suitable for the signal, the displayed power will be incorrect.
6	Model & Serial Number	Displays model name and serial number of the currently connected power sensor.
7	Power format	Select either dBm or Watt for power level display format. Changes to dB and % if **Relative** is checked.
8	Averaging	When checked, the unit runs a continues average of the power readings over the entered number of measurements (1 - 999). Clicking the **Restart** button will reset the continues average

#	Name	Description
9	Offset Value	Check to input a value (dB) to compensate for Loss or Gain in the DUT setup. A positive value compensates for a Loss, while a negative value compensates for a Gain.
10	Offset File	Check to get offset values from a saved file (primarily used for advanced Measurement Applications). See *section 6.7* for details.
11	Relative	Check to save the current power reading as a baseline value. From then until unchecked, measurements will show how the DUT power varies from that baseline. Relative results are given in dB (for dBm) and in % (for Watt).
12	Relative Table	Opens the "Relative Frequency Points" table. When it is filled, entries will supersede current reading for relative measurements. See *section 0* for details.
13	Display Graph	Check to activate real-time graph. See *section 0* for details.
14	Add Sensor	Click to work with more than one sensor from the same computer. See *section 6.9* for details.
15	Reset Connection	Reset the connection between the PC and the unit. Usually done after a unit disconnected, replaced with another, or the control method was changed.
16	Record	Opens the "Data Record" window. See *section 6.8* for details.
17	Measurement Applications	Open Advanced Measurement Applications window. See Measurement Applications Guide for details.
18	Compact View	Reduces the size of the GUI displaying only the unit's S/N, frequency, and power reading. This option is usually employed for multi-sensor setups. See *section 6.3* for details.
19	Always on Top	Check to keep the power sensor screen on top of other applications.

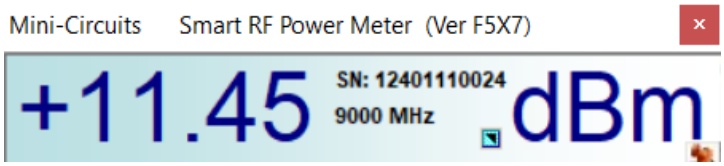
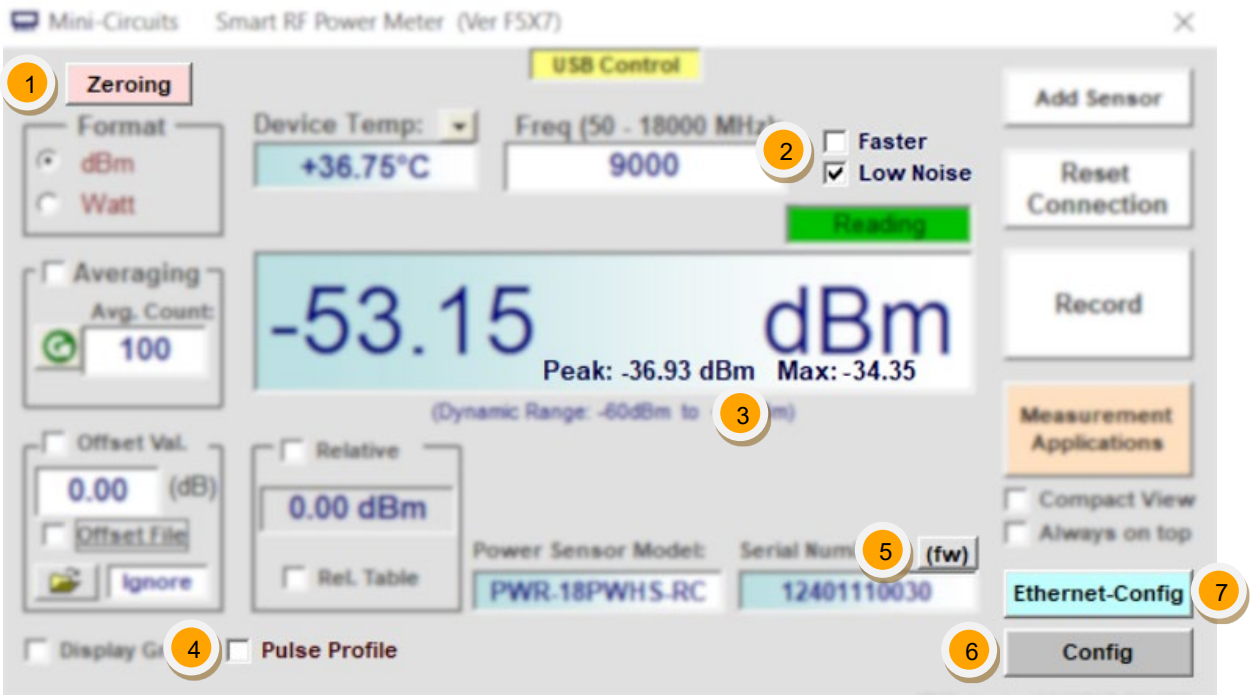


Figure 6.1: *Compact View mode displaying unit's S/N, frequency, and current power reading.*

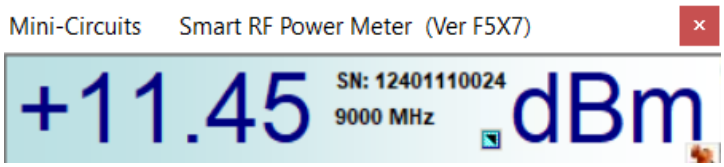
6.2. Model Specific Functions



#	Name	Description
1	Zeroing	When shown, click to zero the sensor for accurate low power measurements (refer to *section 0*). This button will not be shown for models which do not require zeroing.
2	Measurement Speed	On supporting models, click to switch between the supported measurement speeds: • Low Noise – 100 ms typ • Faster – 30 ms typ • Fastest – 10 ms typ (available on PWR-8FS only). **Note:** Mini-Circuits' latest sensors all operate at significantly faster rates than the settings above so these options will not be shown. Refer to the sample period settings under the Config button.
3	Peak Power	For Peak sensors only: Displays the momentary peak power value and the overall max peak power value (for **RT Max Peak** see *section 7.4.3*).
4	Pulse Profile	Opens the Pulse Profile Analysis windows (see *section 7.5*).
5	(fw)	On supporting models: Opens the firmware status check and upgrade window (see *section 5.3*).
6	Configuration	Mini-Circuits' latest sensors include advanced sampling and trigger options which can be configured as needed. Click the **Config** button to access these settings: • Setting sample period and trigger delays. • Set the trigger and operation modes, time and trigger mode (see *section 7).*
7	Ethernet configuration	For models with RC suffix only: Opens the dedicated Ethernet configuration screen (see *section 5.2).*

6.3. Compact View

Enabling **Compact View** from the main screen will reduce the GUI's display on the screen. To restore the regular main screen display, click anywhere on the compact screen display.



In compact view, the program displays the unit's serial number, the tested frequency and the current power reading and units. Any parameter change will require returning to the main screen first.

6.4. Sensor Zeroing

The below listed models have a zeroing feature to ensure accurate power measurements all the way to the bottom end of the sensor's specified input power range:

Model name	Sensor type
PWR-9PWHS-RC	Peak & Average
PWR-9RMS-RC	RMS
PWR-18PWHS-RC	Peak & Average
PWR-18RMS-RC	RMS
PWR-40PW-RC	Peak & Average

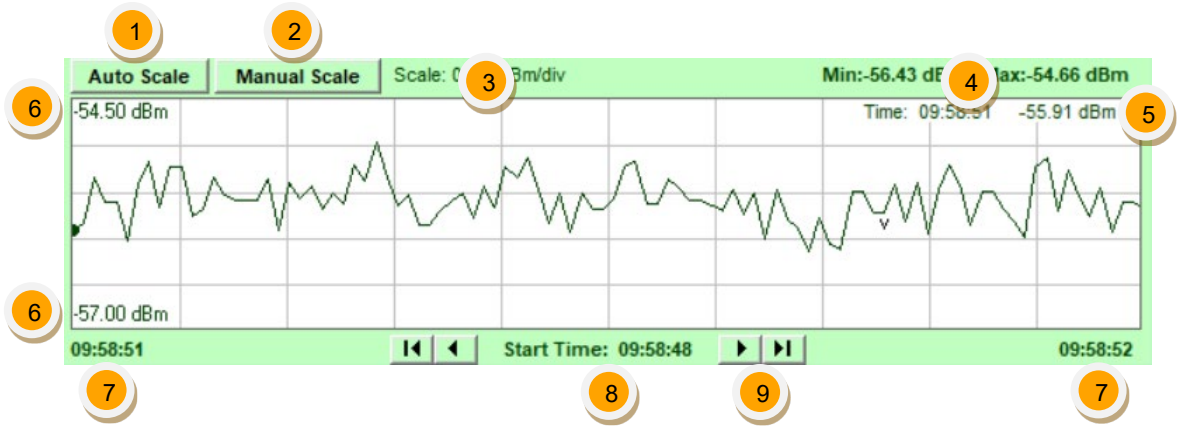
It is recommended to zero the sensor at the start of a measurement session or after a change of ±2°C in the ambient temperature – the button will turn red to highlight that the temperature has changed sufficiently to zero the sensor again.

To zero the sensor, disconnect the RF input and then click the **Zeroing** button. The process should be completed within a few seconds and then the RF input can be reconnected again.

6.5. Real Time Graph

Checking the **Display Graph** check box on the main screen will open a graph window below the main screen showing power over time.

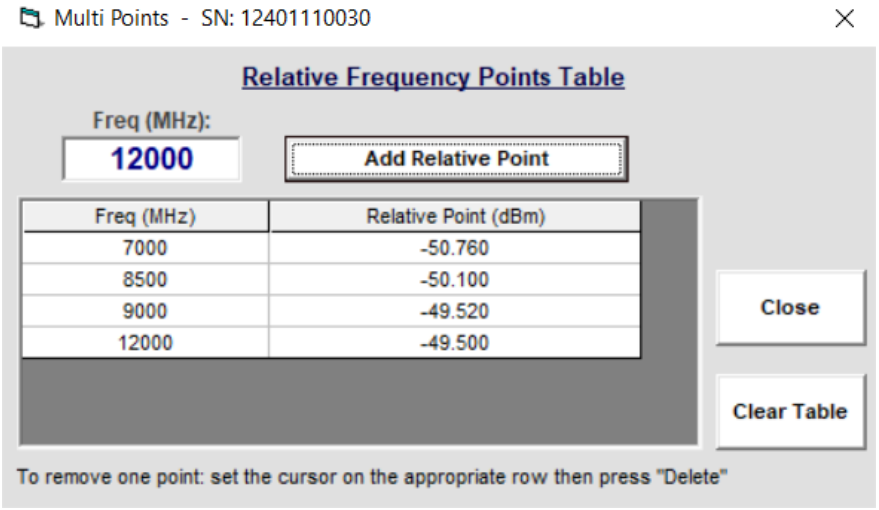
For Peak & Average Power sensors, only the average power is displayed in this graph. For other parameters, check the adjacent **Pulse Profile** box option (see *section 7.5*).



#	Name	Description
1	Auto Scale	Set Y-axis automatically to best display current data.
2	Manual Scale	Opens (and closes) a window to input the max value and per division value for the Y-axis. (Value units follow the format chosen on the main window).
3	Scale	Current value per division of Y-axis.
4	Min/Max values	Minimum and Maximum values appearing since the graph started.
5	Marker reading	Time and power reading of the marker on the graph.
6	Power (Y-axis)	Upper and lower power values of Y-axis.
7	Time (X-axis)	Starting and ending time of the currently displayed graph section (X-axis).
8	Start Time	Starting time of the current graph session
9	Arrows	Use arrows to scroll back and forth in graph.

6.6. Relative Frequency Points Table

Checking the **Relative 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** – and the current power reading will be added to the table.
- To delete a point from the table, click on the row you wish to delete and press the **Delete** key on the keyboard.
- Alternatively, to delete all points from the table, click on the **Clear Table** button.
- Once all desired entries have been added, proceed to **Close** the table. The main screen should now display “Table” under the relative measurement field.
- Check the **Relative** check box to change all measurements into relative measurements referenced to the values in the table.

Note:

- 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.

6.7. Using Offset Value and Offset File

An offset is useful for compensation of loss/gain within the system. The power sensor GUI allows the use of specifying a fixed offset value via the **Offset Value** check box and/or opting for a variable offset over frequency value via the **Offset File** option.

If desired, both offset value and offset file options can be applied simultaneously.

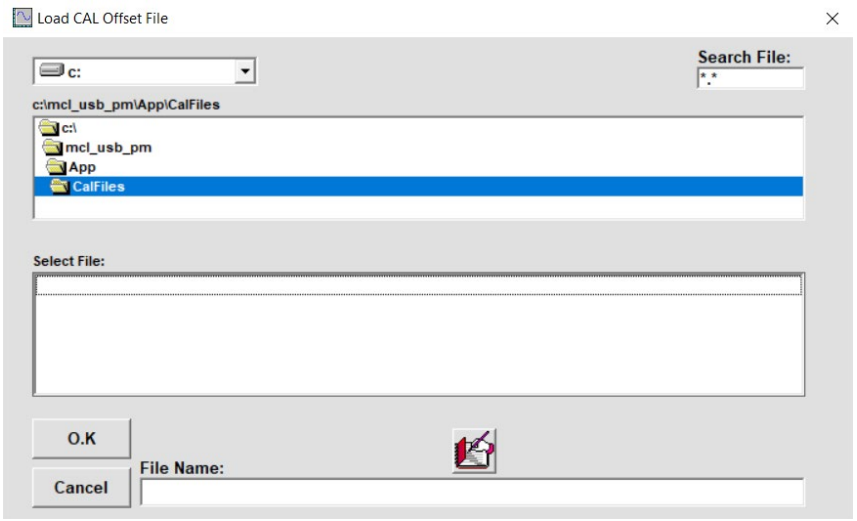
Note:

- Values in **Offset Value** are added, while values in the **Offset File** are subtracted.

6.7.1. Creating an Offset File

An offset file is useful for compensation of a variable loss/gain over frequency within the system. For example, if a compensation needs to be applied for the loss of a transmission line between the power sensor and the DUT.

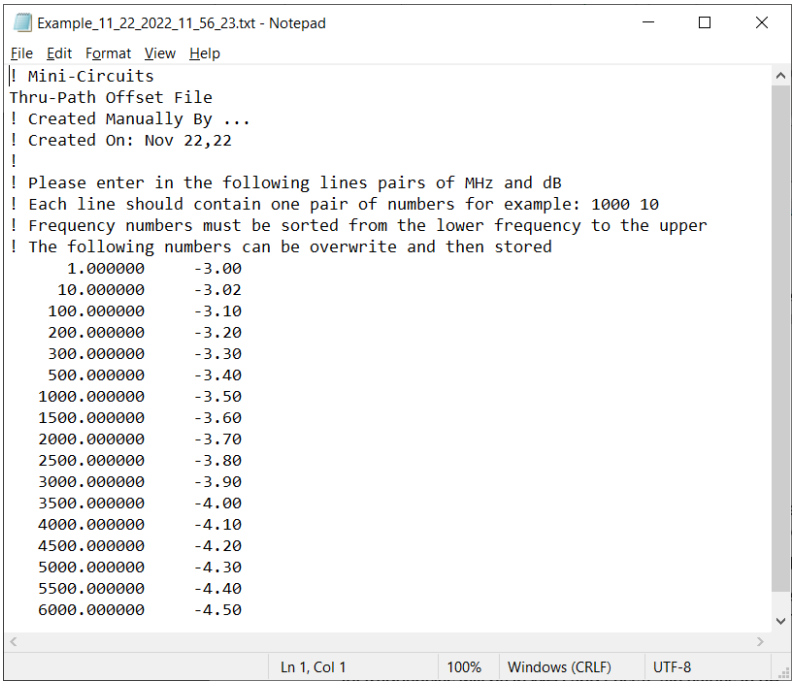
If an offset file is already available, it can be selected by clicking the **Folder icon** below the **Offset File** check box and navigate to its location in the opened browser window.



For automatic file creation, users may reference chapter 13 of the Measurement Applications Guide ("Measurement Applications #10 - Calibrating Thru-Path"). The chapter allows to measure the gain/loss of the system between the power sensor and the DUT and automatically creates an offset file for that system.

Alternatively, to create an offset file manually:

- Click on the **Edit** icon (above the file name window) to create a sample offset file
- Replace the values in the sample file with the desired values.
- Save the file as a simple text file (not a requirement, however, it will simplify any future editing).



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.

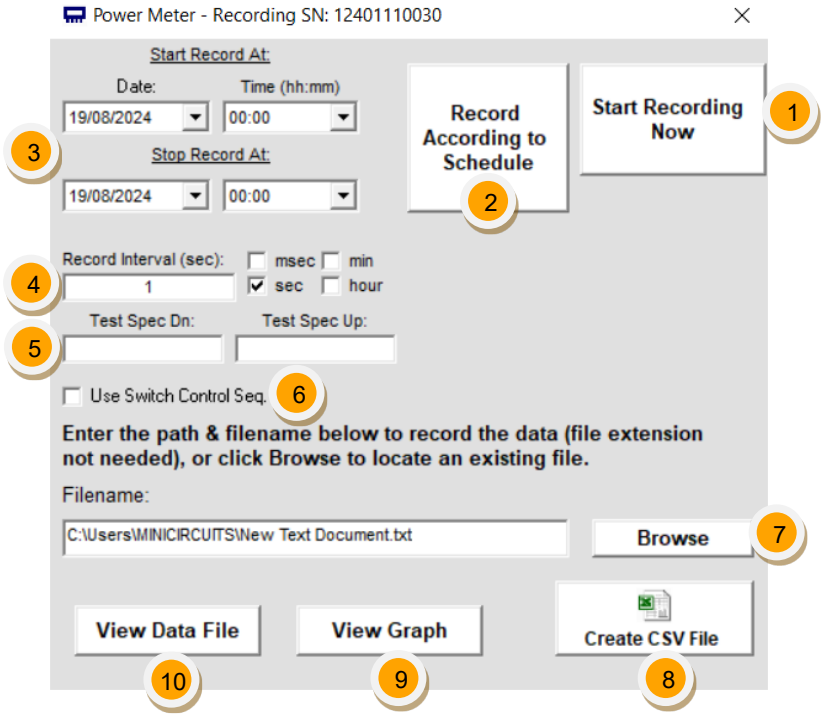
Note:

- 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. For example, when using the example shown above, the offset value for 5750 MHz will be -4.45 dB and the offset for frequencies over 6000 MHz 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 tested frequency will be subtracted from the reading.

6.8. Data Recording Window

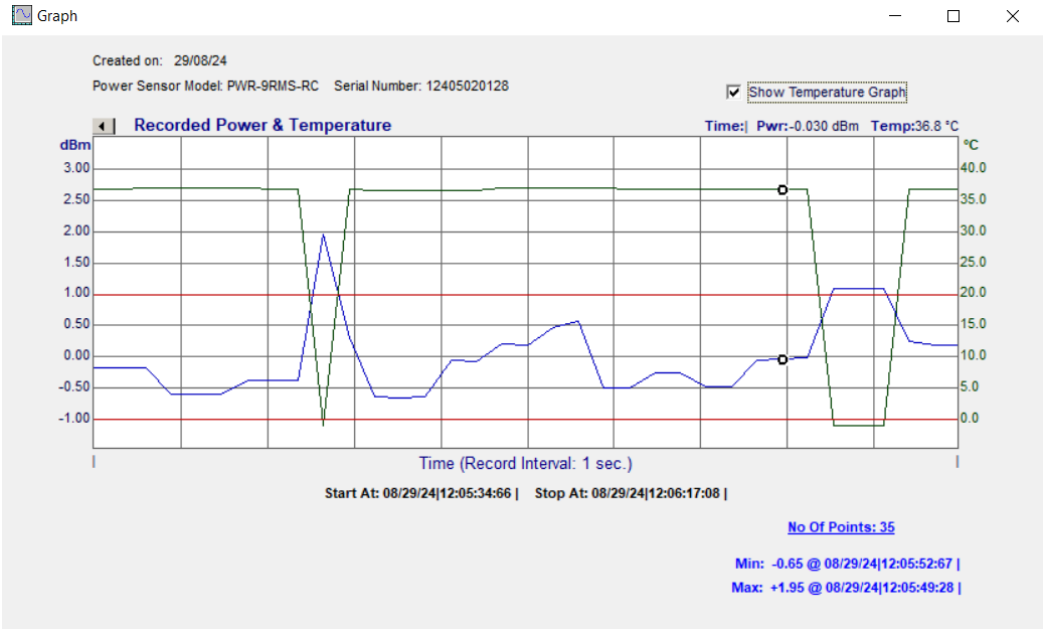
The data record screen can be accessed through the **Record** button on the main screen (right sidebar). The opened screen will list the serial number of the connected power sensor at the header of the window (for recording of multiple units, see *section 6.9*).



#	Name	Description
1	Start Recording Now	Closes the record window and saves the current settings. Data recording starts immediately.
2	Record According to Schedule	Closes the record window, saves the current settings and set schedule. Data recording will start according to the specified schedule.
3	Start/Stop Record at	Specify date and time at which to start/stop recording for scheduled tests.
4	Record Interval	Specify the interval at which data points will be recorded, from every 1 ms to 999999 hours. (Make sure the measurement speed is less than the record interval.)
5	Test Spec Down/Up	Input specification limits to mark data points exceeding them (either above or below) with an asterisk (*).
6	Switch Control Sequence	Using MCL's mechanical switch boxes, set up a switch sequence to access and record multiple power sensors (see *section 6.8.4*).
7	Browse	Opens a browse window to select an existing file or navigate to the desired path to save the file.
8	Create CSV File	Exports data in the selected file to a CSV file format and opens it in Excel (the program needs to be installed in the system).
9	View Graph	Opens a graphical presentation of the data stored in the selected file (see *section 6.8.1*).
10	View Data File	Opens the selected data file (read-only format).

6.8.1. View Graph

The **View Graph** button opens a graphical presentation of the recorded data. The presentation is of average power only, but the user may opt to add the temperature graph via the related checkbox above the graph (right side). The power graph units' can be changed via the arrow above the graph (left side).



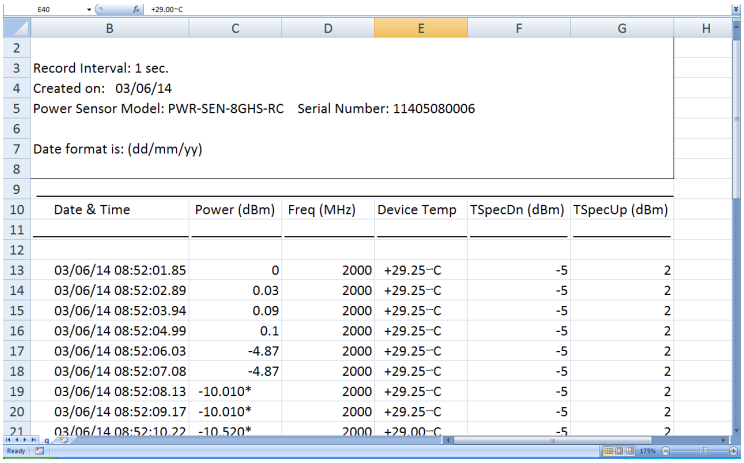
6.8.2. View Data File

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    |
|06/03/14 08:52:10.22 |  -10.520*  |  2000.00   |  +29.00°C  |    -5.000   |    2.000    |
```

6.8.3. Create CSV

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



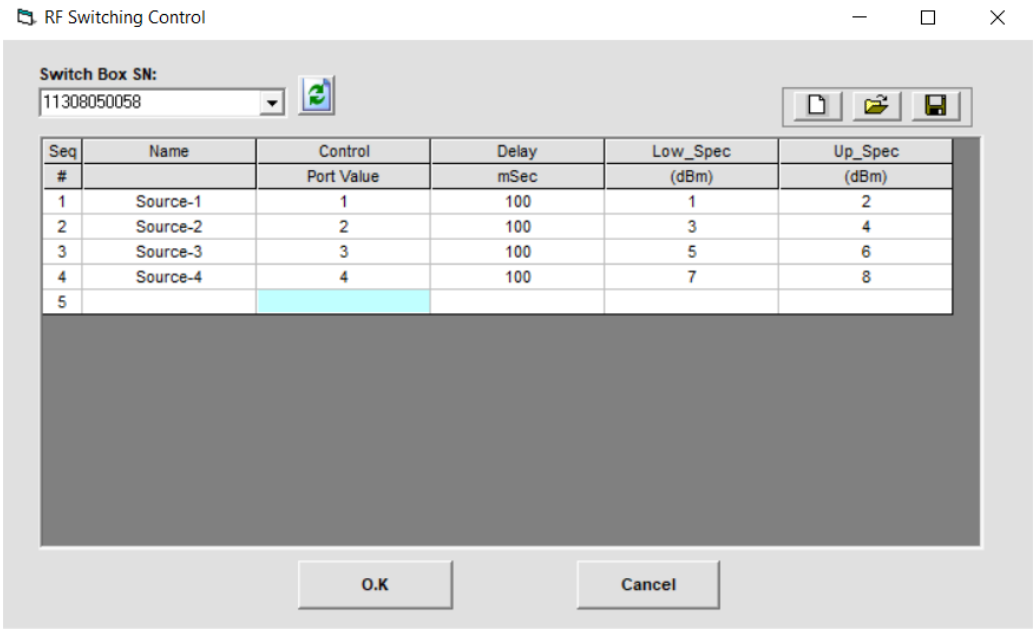
Record Interval: 1 sec.
Created on: 03/06/14
Power Sensor Model: PWR-SEN-8GHS-RC Serial Number: 11405080006

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

6.8.4. Switch Control Sequence

The **Switch Control Sequence** checkbox opens a window which allows recording multiple power sensors' data connected via mechanical switch boxes. The user can select which power sensor to access, for how long, and define high/low specs for them.



6.9. Working with Multi-Sensor Setups

In multiple power sensor setups, the GUI will open a selection screen of all the power sensor serial numbers which are connected in the chosen communication protocol.

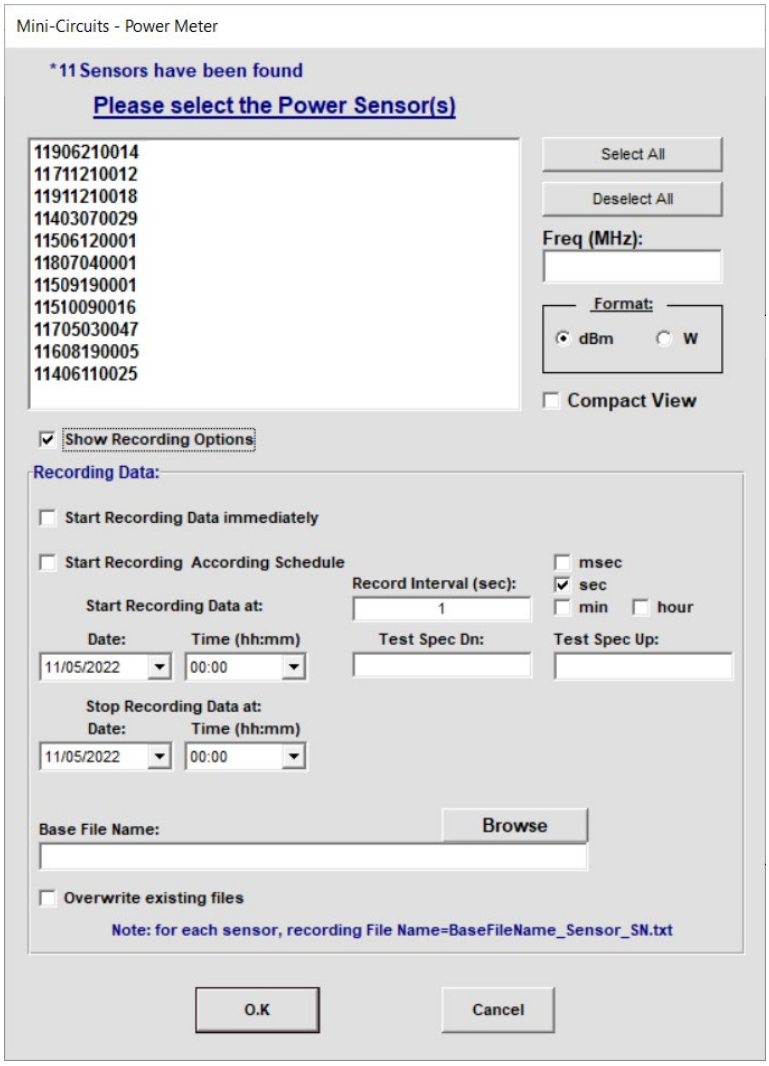


Figure 6.9a: *The recording section is hidden (unchecked) by default*

Users may **Select All** units or pick specific sensors to work with – it is possible to add additional sensors to work later via a 2nd instance of the GUI program or the **Add Sensor** button on the main screen (If only two sensors are connected via USB, it will automatically open the second sensor, without displaying the selection screen).

If all selected sensors are testing the same frequency users can input it in the designated field along with the power level's display format.

Checking the **Show Recording Options** will expand the screen with data recording section which will apply its settings to all the selected power sensors (see *section 6.8* for details on data recording options).

Note:

- In multi-sensor setups, data recording file naming will follow the format of "[path]_[model S/N].txt". For example, a power sensor with a 11405080006 S/N being saved in the folder "C:\test" will be named "test_11405080006.txt".

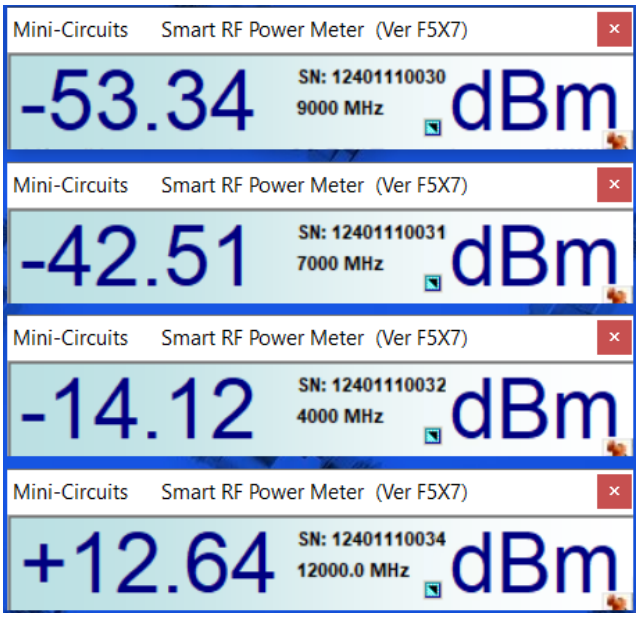


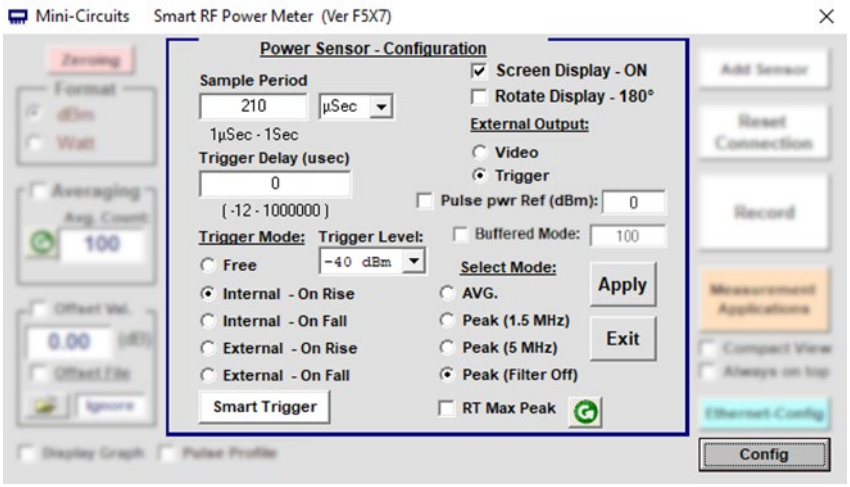
Figure 6.9b: *Multiple power sensors open in compact view*

Note:

- When working with multiple power sensors simultaneously, it is recommended to enable **Compact View** for them and only expand the specific power sensor which requires modifying.

7. GUI: Power Analysis Settings & Functions

The **Config** button is shown for supported models and provides access to sample time, trigger options and additional settings. The available settings vary between models. Refer to the model datasheet for details of which features are supported.



Note:

- After changing the settings, click **Apply** to save them before exiting configuration mode.

7.1. 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 7.5.2*).

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

Note:

- The sample period should be greater than the RF signal's expected cycle.

7.2. Input Trigger Modes

The range of supported trigger input options varies between models (refer to model datasheets for details), and includes the following:

#	Name	Description
1	Free	No trigger is used. A new sample period starts as soon as the data packet of the old period is transmitted with minimal interruption.
2	Internal – On Rise/Fall	The sample period starts when a rising/falling edge is detected which meets the trigger threshold conditions (see *section 7.2.1*).
3	External – On Rise/Fall	The sample period starts when a rising/falling edge of an external TTL signal is detected on the Trigger Input port.
4	Smart Trigger	The sample period starts once a pulse with a width meeting the specified rule is detected. This option is applied on top of the user defined trigger level.

Note:

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

7.2.1. Internal Trigger

The sample period will begin once the sensor detects a rising or falling edge in the RF input which meets the trigger threshold condition:

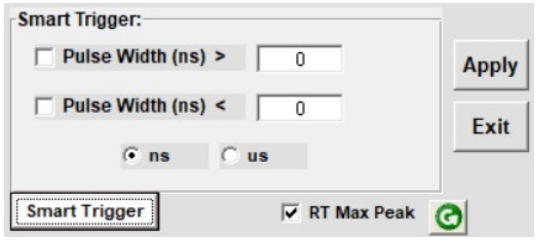
- For PWR-8P-RC and PWR-8PW-RC, the trigger threshold is a 3 dB rise or fall in the RF signal. This setting cannot be adjusted by the user for these models.
- For all other peak & average power sensors, the user can set a specific trigger threshold level in 1 dB increments.

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

7.2.2. Smart Trigger

On supported models, an additional pulse width criteria can be added to the trigger threshold condition.

Users may define a pulse width greater or smaller than a specific value, or even a combination of the two (for example, a pulse width between "Value X < **Width** < Value Y").



7.3. 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.

The below table summarises the trigger out behaviour of the listed models (refer to model datasheets for more details):

Model name	Trigger In mode	Trigger Out start	Trigger Out end
PWR-8P-RC	Any [1]	Rising edge	Falling edge
PWR-8PW-RC	Free [1, 2] Internal [1, 2] External [1]	Rising edge	Falling edge
PWR-9PWHS-RC	Internal (on Rise/Fall)	Rising/Falling edge of first pulse in sample period	Rising/Falling edge of second pulse in sample period, or end of sample period (whichever comes first)
PWR-18PWHS-RC	Internal on (Rise/Fall)	Rising/Falling edge of first pulse in sample	Rising/Falling edge of second pulse in sample period, or end of sample period (whichever comes first)
PWR-40PW-RC	Any	Rising edge	Falling edge
PWR-9RMS-RC	Any	End of sample period	After ~7 µs
PWR-18RMS-RC	Any	End of sample period	After ~7 µs

Note:

- Trigger out of PWR-8P-RC and PWR-8PW-RC follows the RF signal changing state when there is a change of 3 dB.
- In Free and Internal trigger in modes, the PWR-8PW-RC's trigger out is not always active. It starts at the start of the sample period and follows the RF signal for a time equal or greater than the sample period then stops.

7.3.1. Video Filter Selection

The peak and average power sensors have several different modulation bandwidth filters, selectable by the user (not supported by PWR-8P-RC). To reduce measurement noise, it is recommended to select the narrowest filter that will fit your signal BW.

The available bandwidths are: CW, 1.5 MHz, 5 MHz and OFF (max pulse profiling BW, see model datasheets for details).

See below block diagram of PWR-18PWHS-RC illustrating the use of the filter modes.

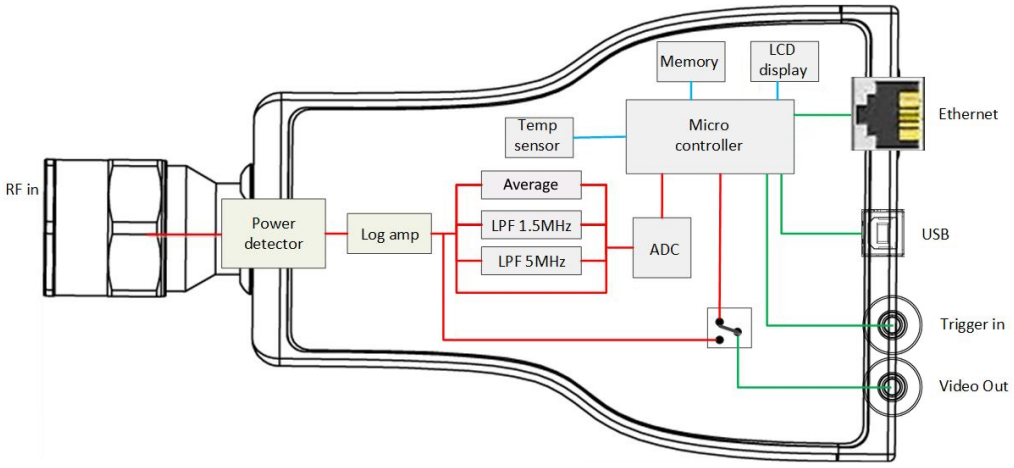


Figure 7.3.1: *PWR-18PWHS-RC functional block diagram*

7.4. Advanced Calculation Modes

The functions below are currently available only to the PWR-9RMS-RC & PWR-18RMS-RC (and their PWHS variant) models only.

7.4.1. Buffered Mode

Buffered mode is used to eliminate the typical USB communication delays between the PC and the sensor by capturing multiple sequential measurements within the sensor for later retrieval/analysis (see programming manual for details).

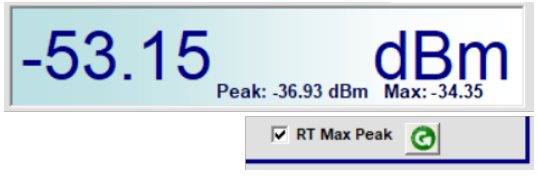
7.4.2. Pulse Power Reference

When enabled, input a power threshold which the sensor then uses to calculate the average power by ignoring any readings below this threshold. This is useful when measuring burst signals such as Wi-Fi.

7.4.3. Real Time Max Peak

When enabled, the function displays a continues reading of the maximum peak power on the main screen enabling users to detect momentary sudden spikes.

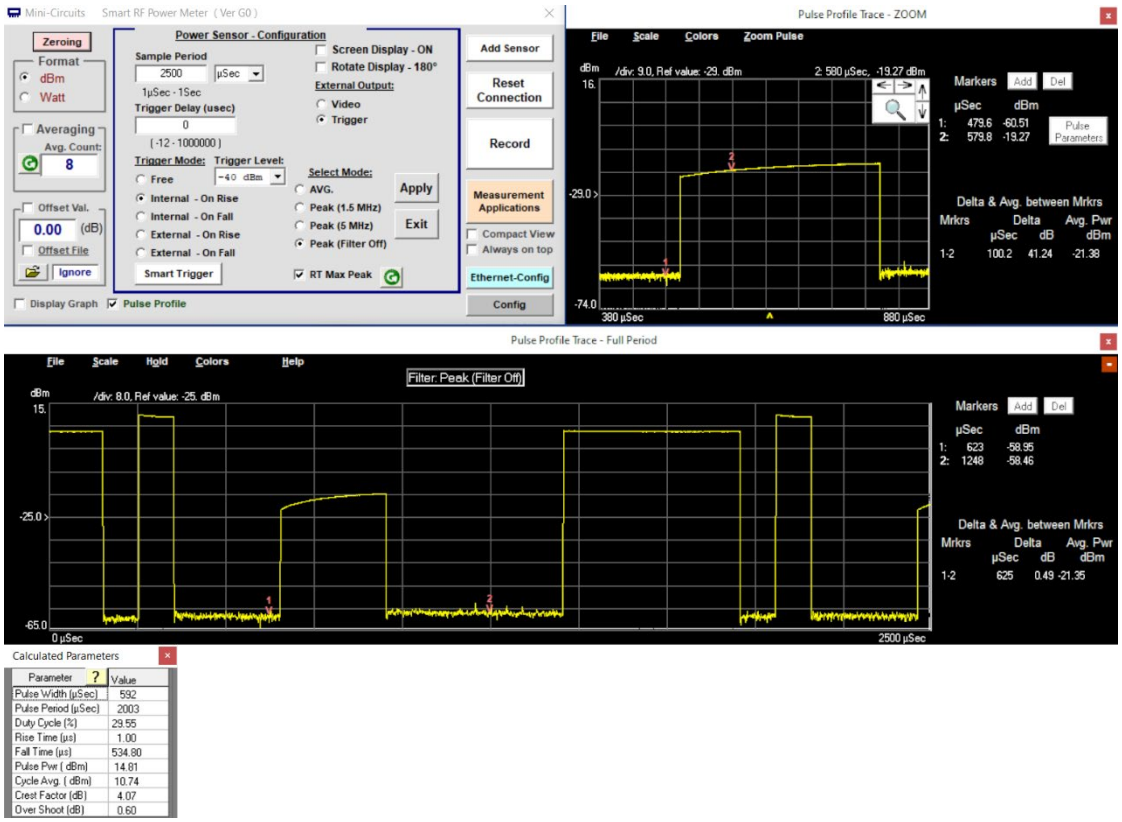
The reading is taken over frames utilizing the full sampling rate (see models' datasheet for details). The value is reset if either the **Reset** button is clicked or the function is unchecked (see programming manual for details).



7.5. Pulse Profile Analysis

Checking the **Pulse Profile** box on the main GUI screen will open 3 new screens used for pulse profile analysis:

- 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.



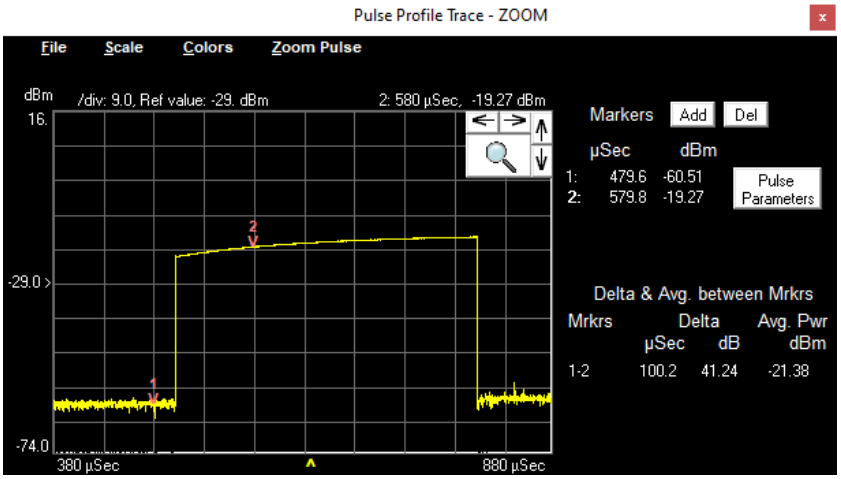
7.5.1. Pulse Profile Trace Options

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

#	Name	Description
1	File	Select to save the graph image as a **jpg file** or copy to the **clipboard**. This can be applied to either the selected graph or to all open windows.
2	Scale	Select **Auto** to reset the y-axis (power) to display the full signal being measured, or **Manual** to set the y-axis’s max power level and the power per division values.
3	Continue / Hold	Click to toggle between continuous live measurements and hold, to freeze the display and all measured parameters.
4	Colors	Select from a list of alternative color combinations for the background and signal traces.
5	Help (at Trace Full)	Accessible on the full pulse profile display. Displays the help file with a summary of all window functions.
6	Zoom on 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 7.5.3*).

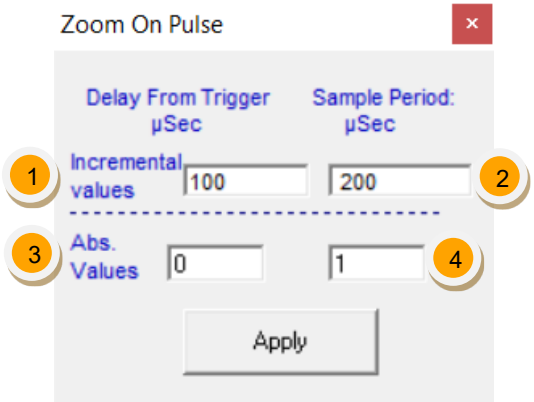
7.5.2. Zoom on Pulse Screen

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 several ways:



- When the display is first opened, the trace will center on the first pulse detected. If 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/Right arrow – Decreases/Increases the time delay between the start of the full pulse profile display and the start of the zoom display.
    - Down/Up arrow – Decreases/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.

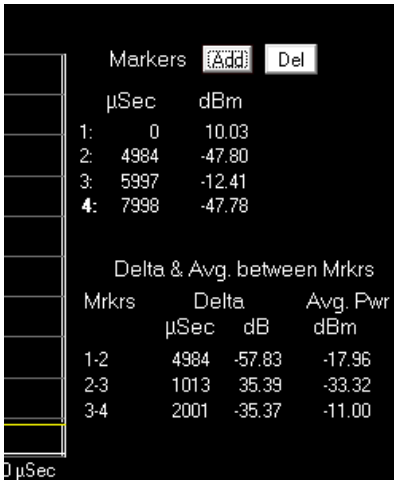
7.5.3. Zoom on Pulse Config Window



#	Name	Description
1	Increment values	Set increment value in µs for Left/Right arrow icons.
2	Delay from trigger	Set increment value in µs for Up/Down arrow icons.
3	Absolute values	Set start of zoom span in µs.
4	Sample Period	Set width of zoom span in µs.

7.5.4. Graphs Markers

The marker area of each graph is located to its right. It may contain up to 4 independently placed markers (but no less than 2). The currently selected marker's number will be in bold.



The markers list their timestamp (in µs or ms) from the start of the sample period and their power level (in dBm). Just below this list is located the "Delta and Average between Markers" list. It displays the delta in time and power between adjacent markers, and the average power over the period between the two markers.

The markers can be added or removed using the **Add** and **Delete** buttons respectively. Once added, the user can click on its number and place it manually within the graph (the marker location can be further adjusted using the keyboard's left and right arrows). A single marker can be set to the highest peak visible in the trace by double-clicking its number.

Note:

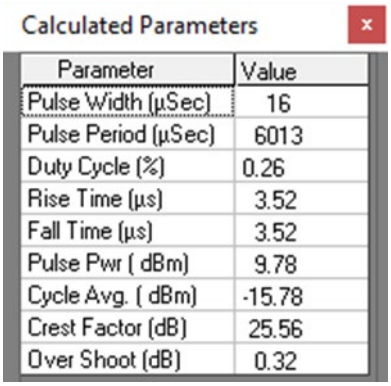
- It is not possible to delete all markers. A minimum of 2 markers will always remain.

7.5.5. 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 *section 7.5.2*), or use an external trigger to ensure the pulse signal is captured correctly.



#	Name	Description
1	Pulse Width	Time from 50% of the pulse rising edge to 50% of the pulse falling edge, calculated in µs.
2	Pulse Period	Time from 50% of the first pulse rising edge, to 50% of the next pulse rising edge, calculated in µs.
3	Duty Cycle	Ratio of the pulse width from the pulse period, calculated as a percentage.
4	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.
5	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.
6	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.
7	Cycle Average	Average power for the complete period of the “zoom on pulse” display, measured in dBm.
8	Crest Factor	Ratio of the pulse power to average power of the signal (Pulse Power - Average Power), in dB.
9	Overshoot	Ratio of the absolute peak power to pulse power of the signal (Peak Power - Pulse Power), in dB.

8. 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 files manually.

Revision D (Dec 22, 2015):

- Added model: PWR-6RMS-RC.
- Updated “Firmware Update” section.

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 sections: “Conformity”, and “Supported Software Environments”.
- Updated chapter: “Installation Guide”.
- Restructured and updated sections: “Main Screen” and “Data Recording Window”.
- Added sections: “Firmware Recovery”, “Internal Trigger” and “Filter Selection”.

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.
- Added model: PWR-8PW-RC.
- Added table of warm-up times per model.

Revision K (Jul 15, 2025):

- Added models: PWR-9PWHS-RC, PWR-9RMS-RC, PWR-18PWHS-RC, and PWR-18RMS-RC.
- Added sections: “Sensor Zeroing”, “Smart Trigger”, “Buffered Mode”, “Pulse Power Reference” and “Real Time Max Peak”.
- Restructured and rewrote existing sections.

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