

Product Manual for the
POWER METER APPLICATION
MODELS LB478A/479A/480A/559A/579A/589A/679A/680A



Table of Contents

TABLE OF CONTENTS	2
NOTICES	3
1. GENERAL INFORMATION	4
INTRODUCTION	4
DESCRIPTION	4
USB CONSIDERATIONS	4
More information related to USB.....	5
How to identify the type of USB port	5
APPLICATIONS	6
ACCESSORIES SUPPLIED	6
SPECIFICATIONS	7
OPTIONS	8
WARRANTY	8
SERVICE	8
CALIBRATION CYCLE	8
CONTACT INFORMATION	8
2. INSTALLATION.....	9
INITIAL INSPECTION.....	9
SUPPORT CONTACT INFORMATION	9
OPERATING SYSTEM AND COMPUTER REQUIREMENTS	9
INSTALLATION PROCEDURE	9
Install the Software	9
3. BASIC OPERATING INSTRUCTIONS – GETTING STARTED	10
OPERATING PRECAUTIONS	10
PROGRAM START UP	10
CONFIGURING THE SENSOR.....	11
Measurement Update Rate.....	11
Addressing the Sensor	11
MAKING BASIC MEASUREMENTS	12
Zeroing and Reference Power Calibration	12
Setting the Center Frequency	12
Display Preferences and Measurement Units	13
Measurement Resolution.....	14
Instrument Preset	14
Making an Average Power (CW) Measurement.....	15
Making a Pulse Power Measurement	16
Alternate Pulse Measurement using Duty Cycle	17
4. DETAILED OPERATING INSTRUCTIONS.....	19
MEASUREMENT OVERVIEW AND EXAMPLES	19
The Power Meter Application.....	19
The Pulse Profiling Application	19
Pulse Measurement Criteria (LB4XXA models only)	20
Pulse Peak Criteria (LB4XXA models only)	21
Measurement Example: OFDM Pilot Tone (LB4XXA models only)	22
Measurement Example: GSM (LB4XXA models only)	25
GUI FUNCTIONS	26
The Menu Bar.....	26
The Toolbar	27
Averaging.....	29
Extended Averaging	29
Max Hold	29
Anti-alias Control	30
Offset Correction	31
Making a Relative Power Measurement.....	32
Frequency Response Correction	33
Impedance Matching	34
Triggering.....	35
Recorder	37
Data Logging.....	38
Limits Pass/Fail	40
MEASUREMENT ACCURACY	42

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Sensor Technology.....	43
Functional Block Diagram.....	44
5. ERROR MESSAGES	45
6. ERRATA AND USER UPDATES – BY DATE.....	45
REV DATE: 01/07/08.....	45
REV DATE: 03/24/08.....	45
REV DATE: 04/15/08.....	45
REV DATE: 06/16/08.....	45
REV DATE: 08/19/08.....	45
REV DATE: 11/20/08.....	45
REV DATE: 02/06/09.....	45
REV DATE: 02/24/09.....	45
REV DATE: 03/27/09.....	45
REV DATE: 04/09/09.....	46

NOTICES

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SAFETY

A **WARNING** indicates a potential hazard that could completely damage the product. Do not continue until you fully understand the meaning.

A **CAUTION** indicates a potential hazard that could partially damage the product. Do not continue until you fully understand the meaning.

A **NOTE** provides additional pertinent information related to the operation of the product.

CONFORMITY

WEEE Compliant
RoHS Compliant
USB 2.0 Compliant

DISCLAIMER

The information contained in this document is subject to change without notice. There is no guarantee as to the accuracy of the material presented or its application. Any errors of commission or omission will be corrected in subsequent revisions or made available by errata.

WARRANTY

See the warranty section of this document for details.

DOCUMENT NUMBER

Not Assigned (Reference LBXXXA Product Manual for the Power Meter Application).

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

1. General Information

Introduction

This manual provides information about the installation and operation of the LB478A/479A/480A/LB679A/LB680A and LB559A/579A/589A model USB power sensors when using the **Power Meter Application** software. The LB4XXA series (reference to models LB478A/79A/80A and LB679A/80A) of sensors make CW and pulse measurements. The LB5XXA series of microwave sensors make average - True RMS - (CW or modulated) measurements only. (The LB480A/LB680A sensors are also capable of making pulse profile measurements – refer to the Pulse Profile Application Quick Start Guide and Product Manual for the **Pulse Profiling Application**). This manual also contains information regarding product features and support, specifications, compatibility, and some measurement examples. Refer to the product Programming Guide for programming information. The Errata and User Update section at the end of this document reflects recent changes in product development.

Description

The LBXXXA Series USB Power Sensor features a highly compact power sensor body that connects directly to a desktop or laptop computer using a standard USB port and standard USB cable(s). A separate power meter is not required. The LBXXXA Series USB Power Sensors convert RF and microwave power into digital data at the point of measurement. The companion **Power Meter Application** software provides a front panel display, or Graphical User Interface (GUI), that allows the user to make typical CW and pulse (modulation) measurements. This application is the primary subject of this document. A programmatic interface is also supplied with the product.

Sensor zeroing and meter reference calibration are not required. This reduces setup time and simplifies programming. The unit features optional source Trigger IN/OUT or Recorder OUT connectors in addition to a variety of RF input connectors. Please refer to the Options section of this document for a complete listing of product options to include extended performance and support.

PowerSensor+™ products address key aspects of general purpose scalar measurements as well as CW, pulse, and other modulated power measurements. PowerSensor+™ products offer benefits in overall cost, accuracy, measurement speed, flexibility and test development time.

SPECIAL NOTE: The RF input connector is field replaceable if the connector type remains the same regardless of sex. For example: The user can replace an SMA female connector with an SMA male, however, an SMA connector cannot be replaced with Type-N. *Field replacement of the connector voids calibration and should only be done where calibration is not required.*

USB Considerations

The Universal Serial Bus (USB) provides adequate power for the sensor under normal circumstances. However, when using a longer cable (greater than 3-5 meters), or when some laptop or portable computers are used, an active or self-powered hub may be required. These are available at most computer stores and often sell for under \$20.00. The sensor is powered directly via the USB cable and typically draws 450 mA at a nominal 5 VDC. An active hub will compensate for the DC voltage drop beyond approximately 3-5 meters. The reason an active hub is recommended when using a portable computer is to conserve the battery life of the computer. PowerSensor+™ products are USB 2.0 compliant. The following information is provided for reference when selecting a hub:

Bus-powered hub: Draws a maximum of 100 mA at power up and 500 mA during normal operation.

Self-powered hub: Draws a maximum of 100 mA and *must* supply 500 mA to each port.

Low power, bus-powered functions: Draws a maximum of 100 mA (often applies to portable computers).

High power, bus-powered functions: Self-powered hubs: Draws a maximum of 100 mA and *must* supply 500 mA to each port.

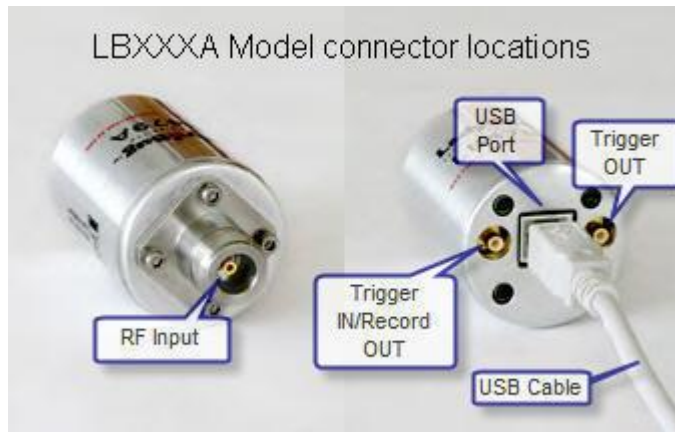
Suspended device: Draws a maximum of 0.5 mA

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

More information related to USB

1. Supplied voltage by a host or a powered hub port is between 4.75 V and 5.25 V.
2. Maximum voltage drop for bus-powered hubs is 0.35 V from its host or hub to the hub output port.
3. Normal operational voltage for functions is 4.75 V (minimum).



How to identify the type of USB port

The PowerSensor+™ requires your computer to have USB 2.0 port(s) for correct operation. You can identify what type of USB port you have using the following process:

Click **Start** and select **Control Panel**. Select the **Performance and Maintenance** category then pick the **System** icon. Click the **Hardware** tab and select **Device Manager** as shown below. Now expand the **Universal Serial Bus controllers** heading as shown and look for the word “Enhanced” or USB2 to indicate that USB 2.0 is present on your computer.



LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Applications

The PowerSensor+™ line of products is designed specifically for the following measurement applications:

- General Average and Pulse Power Measurements
- Power Measurements Requiring High Accuracy:
 - CW & Pulsed Signals
 - Narrow and Wide Band Signals: CDMA, W-CDMA, QAM, OFDM, GSM, TDMA, QPSK, FSK, AM, FM
 - Recorders, Power Monitoring, and ALC Loops
- Research & Development and Manufacturing
- Maintenance, Repair, Installation and Service
- Communications
- Radar, Wireless, Satellite, Radio Links

Accessories Supplied

The product is shipped with the following items:

1. A sensor with selected hardware and software options.
2. Standard or optional return to factory warranty.
3. 2-meter high speed USB cable.
4. Software CD or USB flash drive, includes the following:
 - Data sheet.
 - This product manual.
 - A user application (GUI) – provides a means of making measurements.
 - Drivers – several interfaces are available.
 - Programming Guide with sample code.
5. Quick Start Guide and Quick Start Card.
6. NIST traceable calibration certification.
7. Packing list and invoice.

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Specifications

Refer to the data sheet by individual model number for a complete listing of product specifications to include pulse profiling capability (LB480A/LB680A only). Data sheets are available on-line at the company website – see Contact Information.

Product Comparison Table:

Model Number and Description	SWR	Dynamic Range*	Avg Pk & Pulse	Pulse Profiling
LB478A CW PowerSensor+ .01 – 8.0 GHz (functional to 10 GHz)	1.15:1	-35 to +20 dBm	Yes	No
LB479A CW Wide Dynamic Range PowerSensor+ .01 – 8.0 GHz (functional to 10 GHz)	1.09:1	-60 to +20 dBm	Yes	No
LB480A Pulse Profiling Wide Dynamic Range PowerSensor+ .1 – 8.0 GHz (functional to 10 GHz)	1.09:1	-60 to +20 dBm	Yes	Yes
LB559A Microwave PowerSensor+ .01 – 12.5 GHz	1.20:1	-55 to +20 dBm	Avg	No
LB579A Microwave PowerSensor+ .01 – 18 GHz	1.20:1	-55 to +20 dBm	Avg	No
LB589A Microwave PowerSensor+ .01 – 26.5 GHz	1.20:1	-55 to +20 dBm	Avg	No
LB679A Microwave PowerSensor+ .05 – 20 GHz	1.20:1	-40 to +20 dBm	Yes	No
LB680A Pulse Profiling Microwave PowerSensor+ .05 – 20.0 GHz	1.20:1	-40 to +20 dBm	Yes	Yes

* **CAUTION:** Max Input = +20 dBm; Damage Level = +23 dBm (all models)

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Options

Refer to the order guide by individual model number for all product options. Order guides are available on-line at the company website – see Contact Information.

Warranty

The warranty on the LadyBug PowerSensor+™ series of products is one year, return to factory. Extended warranty and calibration service options are available. Please see the Order Guide for details.

SPECIAL NOTE: The RF input connector is field replaceable if the connector type remains the same, regardless of sex. For example, the user can replace an SMA female connector with an SMA male; however, an SMA connector cannot be replaced with Type-N. *Field replacement of the connector voids calibration and should only be done where calibration is not required.*

Service

There are no serviceable parts on the LadyBug PowerSensor+™ series of products. Recommended service is return to factory for repair. A high-quality connector saver (adapter) can be used on the RF input connector to extend the useful life of the factory installed connector.

Calibration Cycle

The recommended calibration cycle for the LadyBug PowerSensor+™ series of products is one year, return to factory. Extended warranty and calibration service options are available. Please see the Order Guide for details.

Contact Information

LadyBug Technologies LLC
3317 Chanate Rd. Suite 2F
Santa Rosa, CA 95404
Phone 707.546.1050
Fax 707.237.6724
www.ladybug-tech.com

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

2. Installation

Initial Inspection

Check the shipment for any damage to the shipping container or the components inside.

Support Contact Information

LadyBug Technologies LLC
3317 Chanate Rd. Suite 2F
Santa Rosa, CA 95404
Phone 707.546.1050
Fax 707.237.6724
www.ladybug-tech.com

Operating System and Computer Requirements

The PowerSensor+™ line of products is compatible with Windows 2000 (SP2 or greater), Windows XP, and Windows 7 operating systems with version 4.5 LB software. Support is available for various test development environments including MS Visual Basic 6.0; MS Visual Basic .NET; MS C# .NET; NI LabVIEW; NI LabWindows; and Agilent VEE.

Recommended PC configuration:

*Pentium D
1G RAM
1.0 GHz Processor
CD Drive
USB 2.0 Port**

* The USB port or hub *must* supply 500 mA @ 5 V for each power sensor operation. *Refer to the USB Considerations section of this manual to determine if your computer has a USB 2.0 port(s).*

Installation Procedure

Install the Software

Refer to the Quick Start Card (Windows XP or Windows 7) to install the version 4.5 software.

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

3. Basic Operating Instructions – Getting Started

Operating Precautions

Observe the cautions and warnings about maximum input power in the specifications section. Insure that the RF input connector on the sensor is clean and undamaged as well as the mating connector. The following procedures assume the software and hardware have been installed according to the installation process outlined in the preceding section of this manual.

Program Start Up

Starts the software if it is not currently running by clicking on the desktop icon labeled “Power Meter Application” or launch it from its program location (select *Start > All Programs > LB Technologies LLC > LB Power Meter Application*). Sensor(s) are selected by serial number if more than one sensor is connected to the computer. The serial number is stamped below the USB port on the sensor body. We will be using the LB480A user interface for demonstration purposes throughout this document. You may not have the LB480A sensor but the interface is common to all models in the power meter configuration.

The GUI comes up by default in the average power or CW mode of operation for all models; frequency is set to 1 GHz; averaging is set to 75 measurements; the measurement update rate is medium; offsets and frequency response are disabled. These parameters are accessible from the Measurement menu. The **Preset** button will return the interface to the default state. (There will be no Pulse Power mode of operation for the LB5XXXA CW power sensor). Refer to the GUI Functions section of this manual under *Detailed Operating Instructions* for more information about configuring the sensor.



A separate GUI with unit model, serial number and address will appear for each active device when you open a new instance of the **Power Meter Application**. The GUI allows identification of the individual sensor(s) by blinking the LED on the sensor body. Clicking the ID button shown above will cause the LED on the sensor to blink four times in quick succession. The ID and Preset functions are duplicated on the Measurement menu.

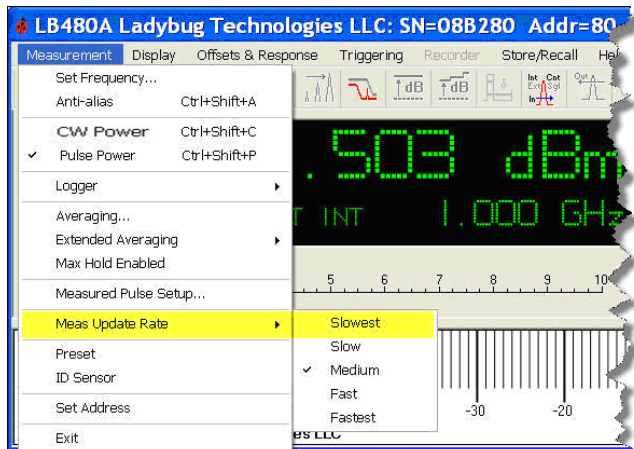
LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Configuring the Sensor

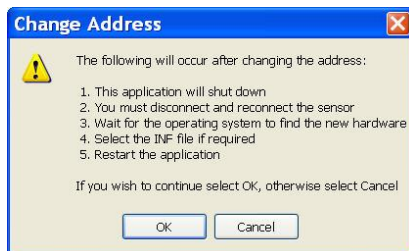
Measurement Update Rate

The measurement rate can be adjusted by selecting **Meas Update Rate** from the Measurement menu as shown below. Other items on the Measurement menu are explained in the GUI Functions section of this document. The application will take longer to respond to mouse clicks and data entry as the measurement rate is increased.



Addressing the Sensor

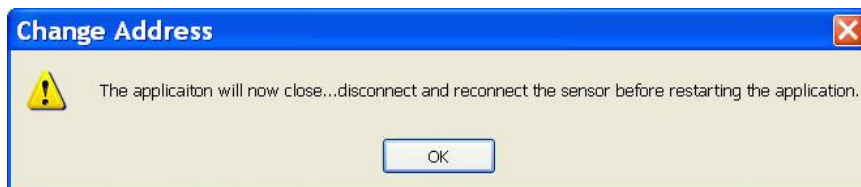
The **Set Address** facility allows the address of the sensor(s) to be assigned from 1 to 255. Changing the address requires an automatic re-start of the application. You will see the following sequence of windows when changing the address by selecting **Set Address** from the Measurement menu. Follow the instructions as stated to change the address and to disconnect and reconnect the sensor.



Change address Screen #1



Change address Screen #2



Change address Screen #3

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Making Basic Measurements

This manual applies to models LB478A, LB479A and LB480A as well as models LB559A, LB579A and LB589A. All sensors function identically for CW measurements. The significant difference between these sensors is the ability to make pulse measurements.

The sections of this manual that focus on pulse measurements apply only to models LB478A, LB479A and LB480A. These sensors will be collectively referred to as LB4XXA sensors throughout the remainder of this manual. The LB4XXA sensors can make both CW and pulse (modulation) measurements. The LB559A, LB579A and LB589A will be collectively referred to as LB5XXA sensors. The LB5XXA sensors can make broadband CW measurements only. These CW measurements are thermally compensated, true RMS measurements.

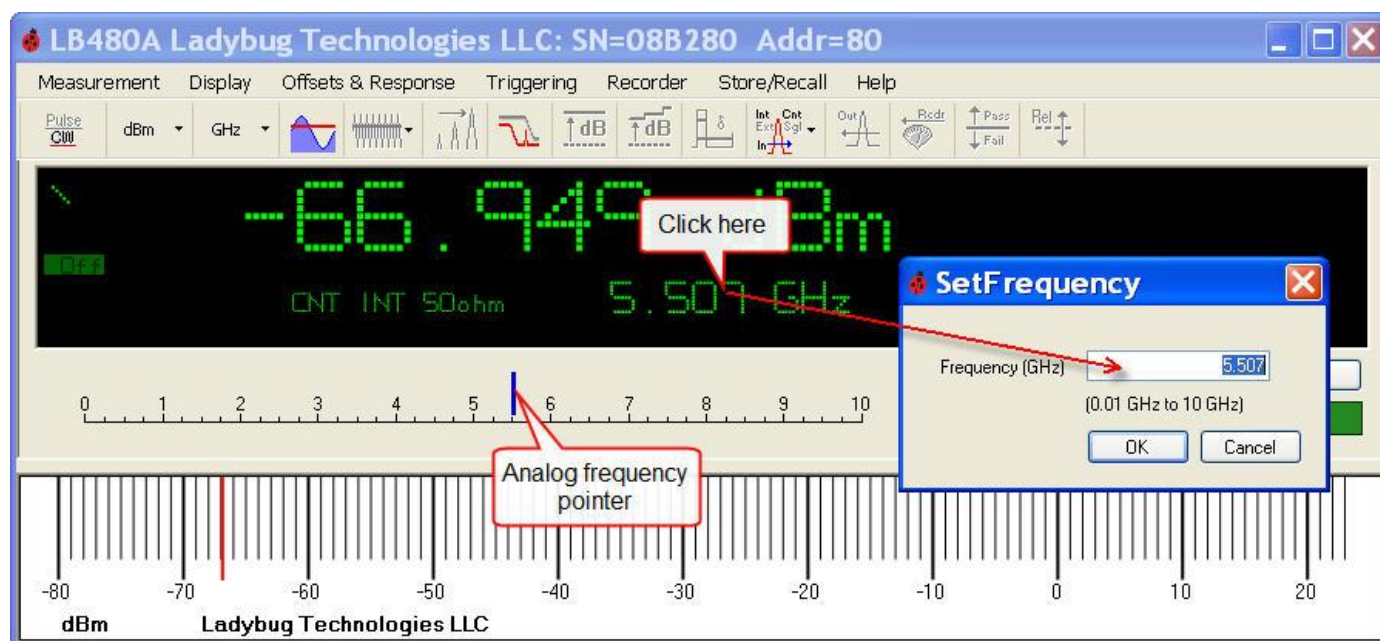
Zeroing and Reference Power Calibration

The design of the power sensor does not require zeroing or power calibration and there is no provision for zeroing or calibration.

NOTE: While zeroing is not required for any LadyBug sensor, the LB5XXA sensors require time to thermally stabilize. Little if any warm-up time is required for measurements above -40.0 dBm. However, to make accurate measurements below -40 dBm the LB5XXA sensor should be allowed to thermally stabilize for one hour.

Setting the Center Frequency

Set the center frequency (GHz) as shown below. The center frequency *must* be set whenever the incoming signal frequency changes. Measurement accuracy requires the frequency to be set and not doing so can be a significant source of error. The frequency can also be set by sliding the analog frequency scale pointer just below the active display. The pointer will change color from blue to red when the center frequency is beyond the measurement range of the sensor. The pointer is less accurate but more convenient than entering a frequency value. You can also set the frequency by selecting **Measurement > Set Frequency** from the menu bar (not shown).

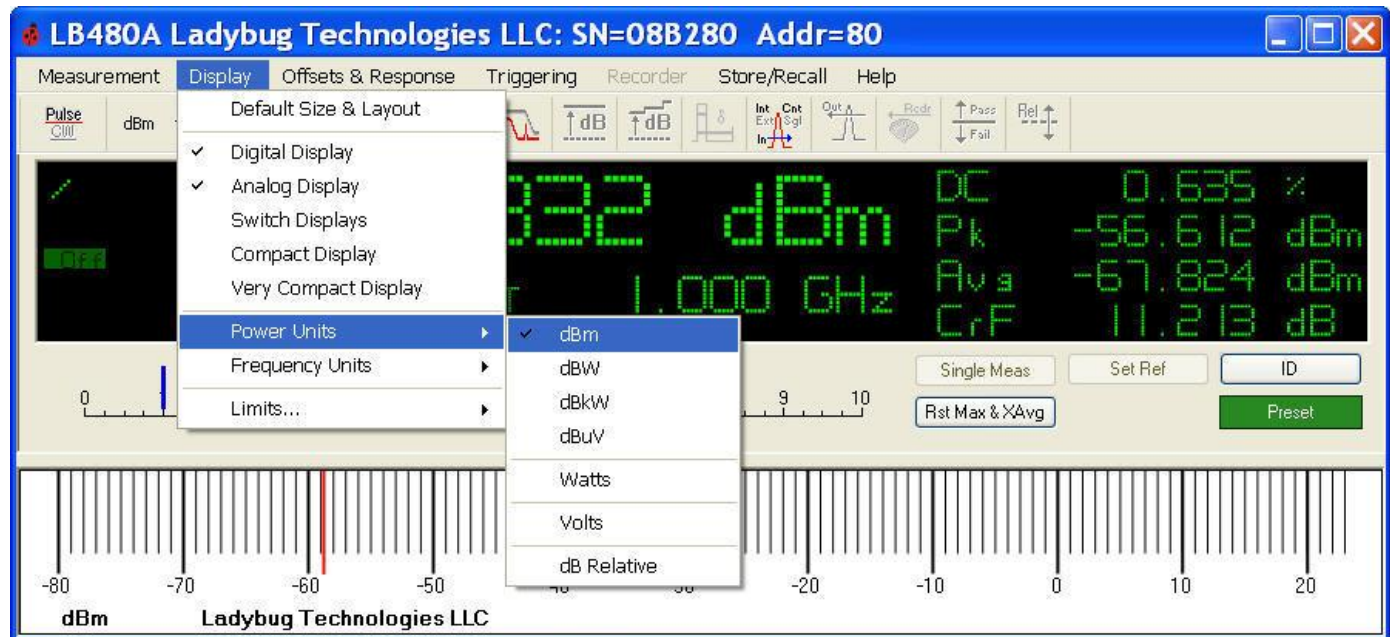


LBXXXX Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Display Preferences and Measurement Units

Select the display preferences and the measurement units (power and frequency) from the **Display** menu as shown below. There are selections for digital or analog presentations of frequency and power; an analog frequency scale; and an analog power scale. You can switch between displays and size the display as needed between compact and very compact. Refer to the GUI functions section of this manual for an explanation of Limits.



Default Size & Layout

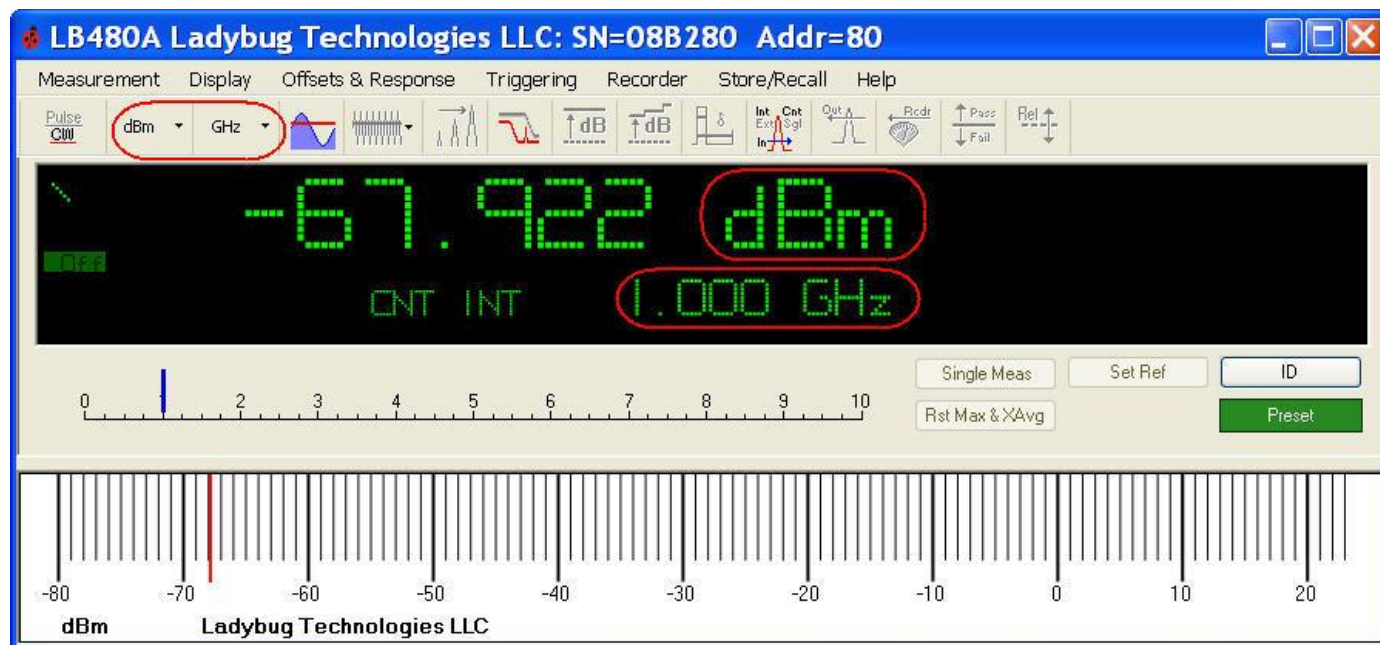


Compact Display

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

The power and frequency units are also selectable from the toolbar as shown below. Or you can change the power units by clicking on the units label to the right of the power reading itself. And you can change the center frequency by clicking anywhere on the frequency reading in the active display.



Measurement Resolution

The amplitude resolution is fixed to a thousandth of a measurement unit. Frequency is selectable in MHz or GHz ranges.

Instrument Preset

The **Preset** button returns the unit to the following default state:

Mode = CW
Frequency = 1 GHz
Frequency units = GHz
Power units = dBm
Averaging = 75
Measured Pulse Setup = 3 dB (See Pulse Peak Criteria for LB4XXX only)
Measurement Update Rate = medium
Display = default
Sweep Time = 1 msec
Offset = 0 dB, disabled
Response = 0 dB, disabled
Duty Cycle = 10%, disabled
Minimum Loss Pad (75 ohm) = not selected*
Trigger Mode = Internal Continuous
Trigger Out = disabled
Recorder = disabled

*Preset will not change the input impedance if checked (enabled). Application launch sets the input to 50 ohms.

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Making an Average Power (CW) Measurement

Complete the following steps to make a typical CW measurement (all models):

1. Using a signal generator or other appropriate source, provide a signal source with the following parameters:

CW Frequency: 1 GHz
Power Level: 0 dBm (1 mW)
Modulation: OFF
RF Power: OFF

WARNING: DO NOT EXCEED +23dBm, 200mW, or 3.15VRMS. Refer to the specifications in the product data sheet for maximum allowable limits by model number.

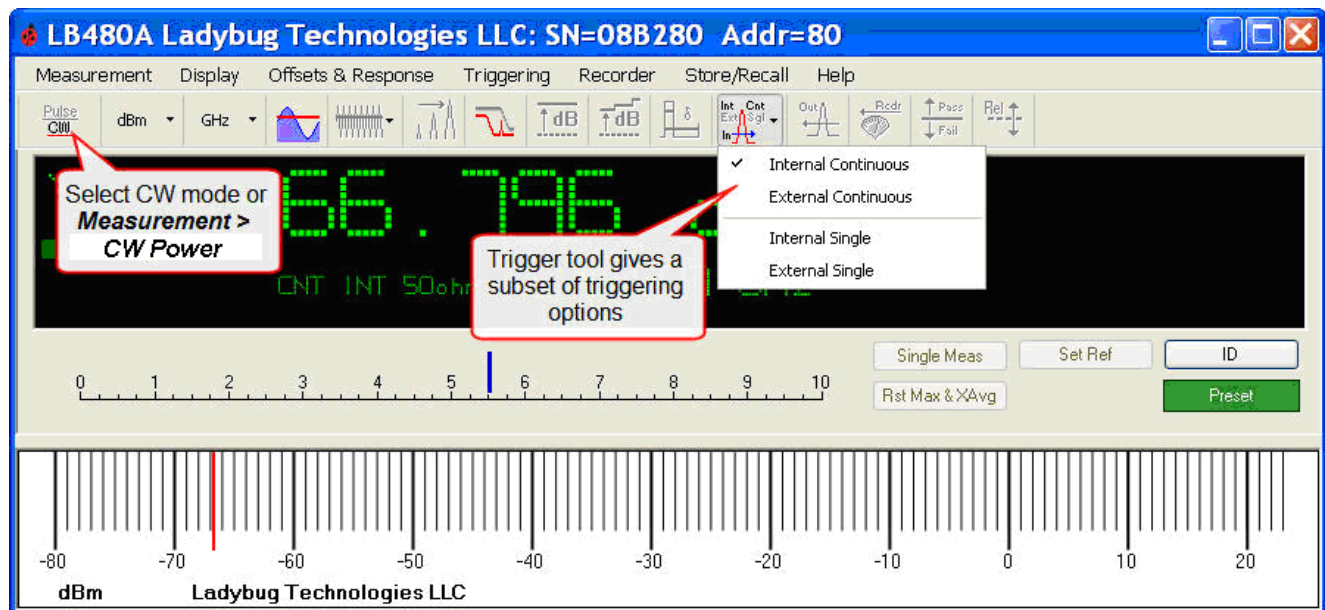
2. Setup the GUI to receive the RF source input as shown below including the power and frequency units. All parameters shown can be disabled for this example except for Triggering (option 003), which can be set to continuous and internal:

Select: *Measurement > CW Power* (or activate the CW button on the toolbar for LB4XXA models only). The application is always in the CW mode for LB5XXA models so the button is not present.

Select: *Measurement > Set Frequency*

Enter: 1 GHz

Select: (Optional) *Triggering > Continuous > Internal*



3. Connect the sensor to the RF source and turn the RF power on.
4. The GUI display should now indicate approximately ~0 dBm at 1 GHz.
5. Vary the source power to see if the GUI display tracks the source power.

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Making a Pulse Power Measurement

Complete the following steps to make a typical pulse power measurement (LB4XXA models only):

1. Using a signal generator or other appropriate source, set the RF source for a pulse modulated output as indicated below:

Power Level: 0 dBm (1 mW)
CW Frequency: 1 GHz
PRF: 10 kHz (or a PRI of 0.1 msec)
Pulse Modulation: 50% Duty Cycle (or a pulse width of 50 usec)
RF Power: OFF

WARNING: DO NOT EXCEED +23dBm, 200mW, or 3.15VRMS. Refer to the specifications in the product data sheet for maximum allowable limits by model number.

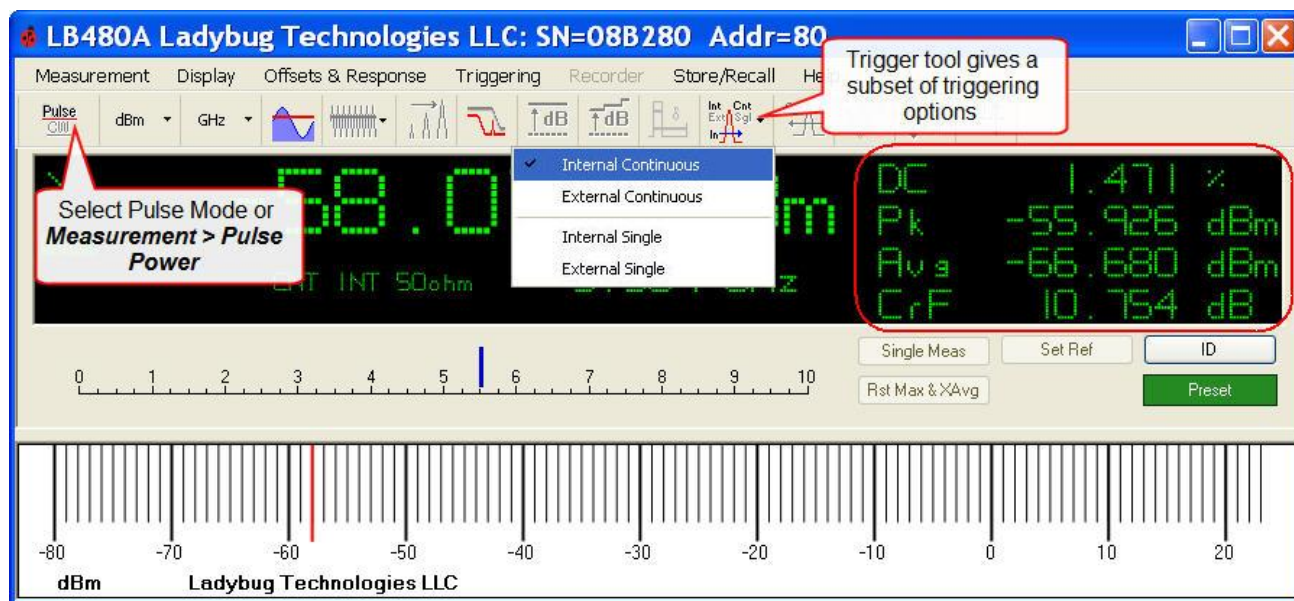
2. Setup the GUI to receive the RF source input as shown below including the power and frequency units. All parameters shown can be disabled for this example except for Triggering (option 003), which should be set to continuous and internal:

Select: *Measurement > Pulse Power* (or activate the Pulse button on the toolbar for LB4XXA models only)

Select: *Measurement > Set Frequency*

Enter: 1 GHz

Select: (Optional) *Triggering > Internal > Continuous*



The active display above indicates input Duty Cycle (DC); Peak power (Pk); Average power (Avg); and Crest Factor (CrF) when in the Pulse Power mode. The larger reading indicates the pulse power. The default setup is the automatic or 3 db points below peak power. This "dB below peak" value can be changed by de-selecting automatic and entering a different value if the specific pulse characteristics are known. Refer to the "Pulse Measurement Criteria" and "Pulse Peak Criteria" sections of this manual under *Detailed Operating Instructions* for further information.

NOTE: Crest Factor is otherwise known as PAR (Peak to Average power Ratio).

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

3. Connect the sensor to the RF source and turn the RF power on.
4. The GUI display should now indicate the source power at 1 GHz: ~0 dBm pulse power; ~50% DC; ~0 dBm peak; ~-3 dBm average; and ~3 dB CrF (Crest Factor is the ratio between peak and average power or PAR).
5. Vary the source power and duty cycle to see if the GUI display tracks the source.

PowerSensor+™ measurements are real time presentations of power. They are not a type of calculated measurement made by most CW sensors. You will note a corresponding change in the duty cycle reported in the GUI if you change the duty cycle of your source. You will note a change in the pulse envelope power (the large display), peak power, and average power if you change the power level. The duty cycle will remain unchanged.

The LB479A can measure 350 nsec pulses at -55 dBm (and lower) with a PRF of 1 kHz (or lower). Such measurements require averaging to be set between 5000 and 10000.

Alternate Pulse Measurement using Duty Cycle

PowerSensor+™ sensors can make the more traditional pulse measurement using an assumed duty cycle as an adjustment to the indicated power. This type of measurement is less accurate and more prone to error because of the pulse shape factor; and because the duty cycle is assumed. However, this a useful measurement approach using the LB5XXA line of instruments.

The duty cycle correction is calculated as follows:

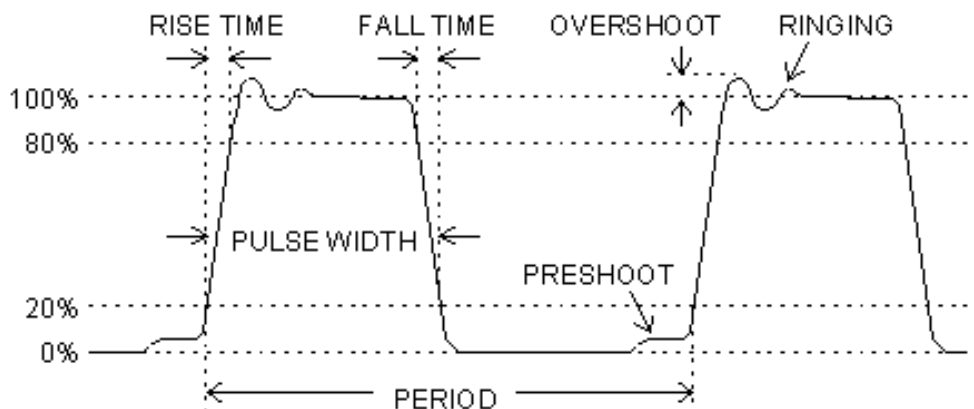
Pulse Power = Measured Power + Duty Cycle Adjustment

The duty cycle adjustment is: $-(10\log_{10}(\text{Duty Cycle}))$

For instance, if you measured an average power of -20 dBm and assumed a duty cycle of 10% (0.10) then the pulse power would be calculated as follows:

Pulse Power = -20 dBm + $-(10\log_{10}(\text{Duty Cycle}))$ = -20 dBm + (10 dB) = -10dBm

The sensor must be placed in CW Power mode to access this style of duty cycle measurement.



$$\text{PERIOD} = \frac{1}{\text{PRF}}, \text{ "PRF" = PULSE REPETITION FREQUENCY} \quad \text{DUTY CYCLE} = \frac{\text{PULSE WIDTH}}{\text{PERIOD}}$$

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Follow the steps below demonstrating this more traditional pulse measurement using duty cycle:

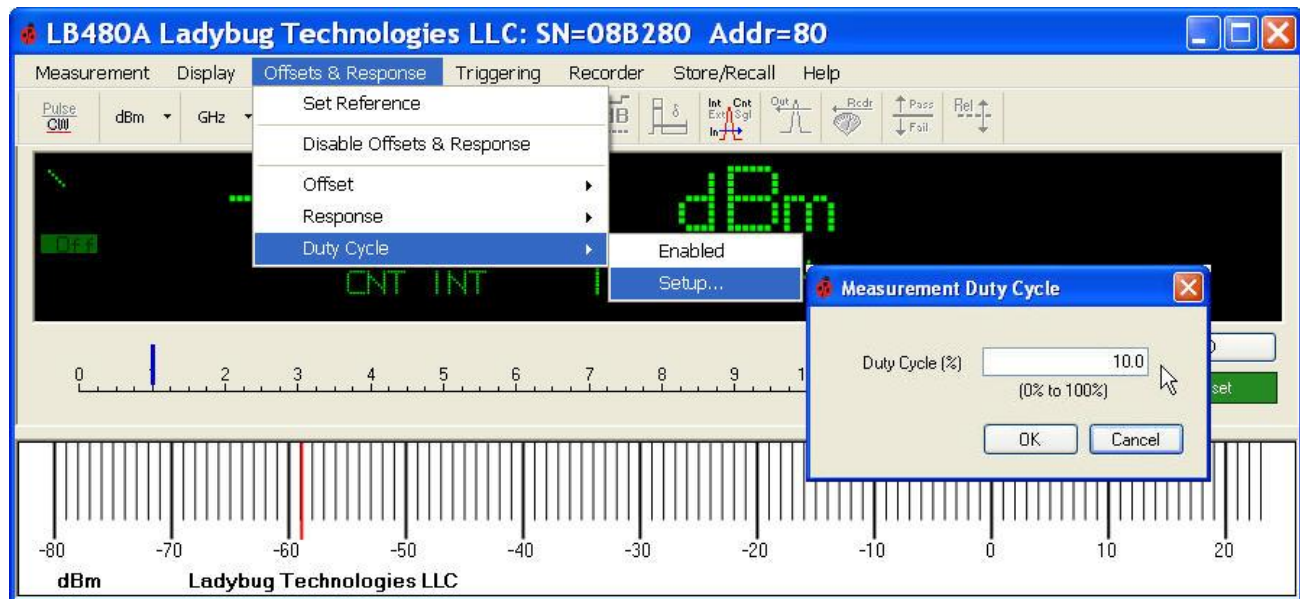
1. Setup the interface by selecting the following parameters as shown below.

Select: *Measurement > CW Power* (or activate the CW button on the toolbar - not required for LB5XXA)

Select: *Offsets & Response > Duty Cycle > Setup*

Enter: 10 (%)

Select: *Offsets & Response > Duty Cycle > Enabled* (or activate the DC icon  on the toolbar)



2. The display will report source pulse power in the CW configuration and the DC annunciator will activate. The duty cycle can be used down to about 0.1%.

4. Detailed Operating Instructions

Measurement Overview and Examples

The Power Meter Application

The LB4XXXA and LB6XXXA series of RF sensors makes Avg and pulse (modulation) measurements in a 10 MHz video bandwidth. The LB5XXXA series of microwave sensors makes CW or true average power measurements up to 26.5 GHz. (The LB480A and LB680A sensors are also capable of making pulse profile measurements – refer to the *Quick Start Guide and Product Manual for the Pulse Profiling Application*).

The pulse power mode of operation displays pulse power (average power in the pulse); pulse duty cycle; peak pulse power; average power; and Crest Factor (CrF) or the peak to average power ratio. This mode applies to the LB4XXXA sensors only. The LB4XXXA/LB6XXXA sensors are capable of more than 2000 settled readings per second.

There is provision for logging measurements to file and pass/fail limit checking on all models. Various trigger methods are available to allow the measurement of continuously modulated signals or single events.

Refer to the block diagram in the Measurement Accuracy section of this document for the following discussion: The incoming broadband RF/microwave energy is first conditioned and converted to digital format. The input power drives two measurement channels of differing sensitivity. The transition between these paths is typically between -30 and -20 dBm. Most LadyBug power sensors continually digitize both paths simultaneously and use a weighted average approach over the transition range. This approach to the measurement means that a seamless measurement transition between paths is possible. It also means that the full dynamic range of the sensor is available to all measurements all of the time.

By contrast, sensors produced by other manufacturers measure only one path at a time. This requires that the transition be managed *after* an errant measurement has been made. This makes the transition between any two ranges a point of potential discontinuity or hysteresis. As a result, minor differences in the calibration between the two paths can often result in constant and annoying switching between paths. Constant path switching can produce a noticeable jump in power level readings. Another and perhaps more detrimental effect is that this approach guarantees that the full dynamic range of the sensor is not available to any given measurement. Ladybug has resolved these range transition problems.

The LB4XXXA and LB6XXXA sensors are capable of making pulse (modulation) measurements. These pulse measurements are possible because the LB4XXXA sensors employ a 10 MHz video or modulation bandwidth. Discussions about bandwidth are generally accompanied by concerns about making an aliased measurement. Though uncommon in practice, aliasing can and does occur. LadyBug sensors can randomize the sampling in order to minimize or eliminate the possibility of making an aliased measurement. However, this sampling randomization is accompanied by a small performance penalty. Rather than penalize all measurements we allow the user to favor performance (speed of measurement), or guard against aliasing. This choice is presented on the user interface as an anti-aliasing option.

The display toolbar has an anti-aliasing control button that is used for CW and continuous pulse measurements only. It is generally useful for the LB4XXXA/LB6XXXA sensors where the video content is greater than 200 kHz. This feature guards against making aliased measurements for modulation bandwidths greater than 200 kHz. It actually determines the sampling method that is employed for the particular modulation bandwidth - either narrow or wide. The toolbar functions are explained in greater detail in the GUI Functions section of this manual.

The Pulse Profiling Application

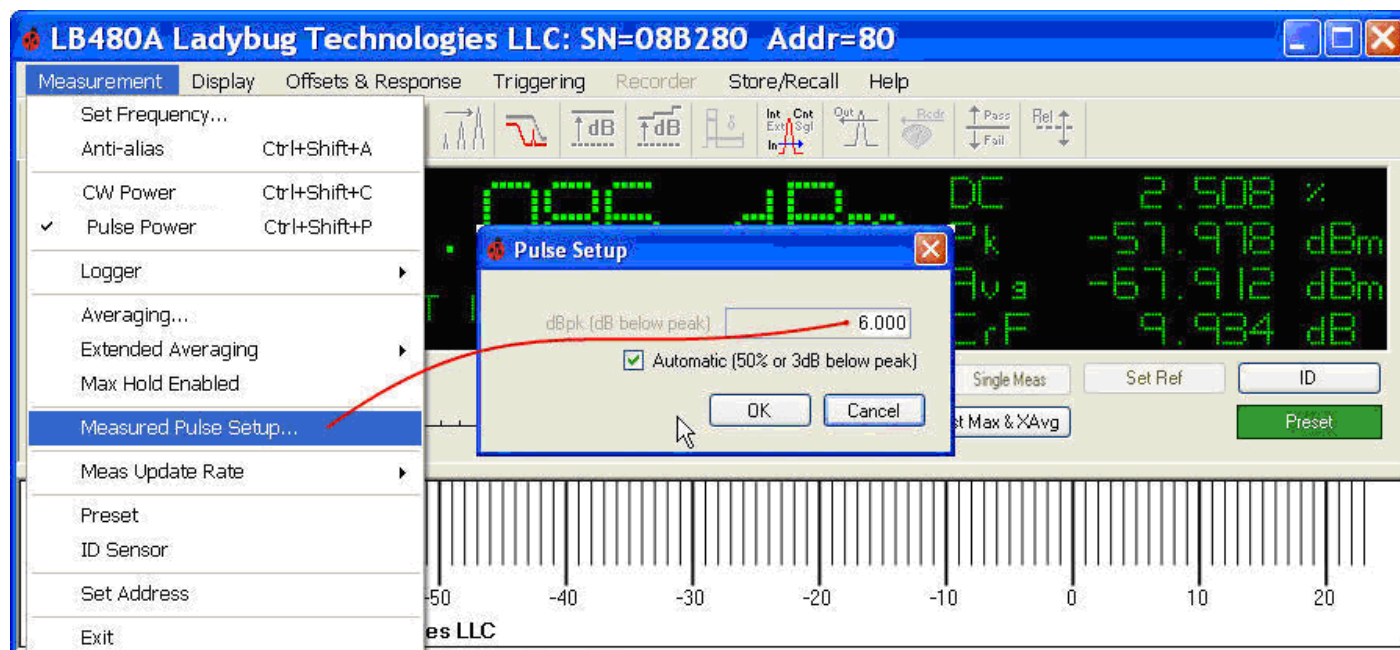
The LB480A/LB680A are specifically designed for those applications requiring a time domain analysis of pulse and other modulated signal formats. *Refer to the Quick Start Guide and Product Manual for the Pulse Profiling Application.*

LBXXXA Series USB PowerSensor+™

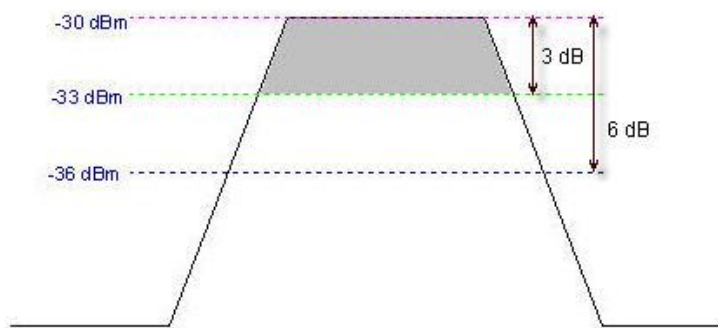
Product Manual PMA (Power Meter Application)

Pulse Measurement Criteria (LB4XXA/LB6XXA models only)

This value determines the portion of the pulse to be used to measure pulse power. Select **Measurement > Measured Pulse Setup** from the menu bar to access this facility as shown below. The default or automatic value is 3 dB below the measured peak value or the 50% down points. You can also set the criteria and leave the automatic feature on. Then by turning the auto feature on and off you can switch between the automatic value (dB) and the value you have chosen. For instance, if you set the criteria to 6 dB and turn the auto criteria on and off, you will be toggling between 3 dB and 6 dB below peak. This can also give you some sense of rise time or slope and the sensitivity to this criteria.



Pulse criteria is assumed to be specified as “dB below peak.” If the peak value is -30 dBm and the criteria is 3 dB, then the pulse criteria will be -33 dB during the measurement. Normally you will specify a positive value. Likewise, if you chose 6 dB you would be using -36 dB as the criteria. Provided overshoot is minimal and rise time is relatively steep, the automatic criteria is adequate for most applications. The diagrams below are intended to help clarify pulse criteria.

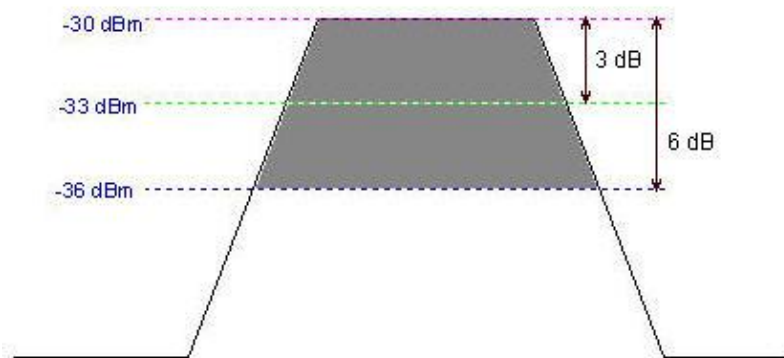


A. Three dB Pulse Criteria

In diagram A, the peak value is -30 dBm and the pulse criteria is 3 dB. The shaded area represents the portion of the pulse that will be used to determine pulse power and duty cycle.

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)



B. Six dB Pulse Criteria

In diagram B, the peak value remains -30 dBm and the darkly shaded area represents the portion of the pulse that will be used to determine pulse power and duty cycle using a 6 dB peak criteria. You can see that the average in diagram B will be lower than the average in diagram A.

Pulse Peak Criteria (LB4XXA/LB6XXA models only)

There are a number of parameters that can affect pulse measurements. One of particular concern is the pulse peak criteria. Pulse peak criteria is relative to the measured peak value and changes will affect the duty cycle and pulse power. The affects will be most pronounced for pulses that have sloped rising and falling edges.

While peak measurement results can be obtained as low as -60 dBm and at rates as fast as 3 MHz, with pulse widths less than 250 nsec, the best measurements require some care. For best results, you can make pulse measurements when the pulse power is about 6 dB above the peak noise with averages set from about 50 to 100.

The best method to determine peak noise is to make a peak measurement with the signal off and then examine the peak power reading.

Additionally, as the duty cycle decreases you may need to increase averaging; and as PRF increases you can decrease the number of averages. A good starting point is about 100 buffers or averages for a PRF of 10 kHz and a duty cycle of 10%. Adjust the averages inversely proportional to the PRF and duty cycle - so if the PRF doubles you might be able to cut the averages by half. As a rule of thumb, it is good practice to keep the number of averages above 50 unless you need the additional speed.

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Measurement Example: OFDM Pilot Tone (LB4XXXA/LB6XXXA models only)

Pilot tones for some wireless devices can operate at very low PRF (well below 100Hz); very low duty cycles (<0.05%); and at a variety of carrier frequencies. Making peak power or pulse power measurements under these circumstances can be difficult without expensive equipment. However, the LB4XXXA series of sensors are quite capable of making these measurements. In addition, the LB480A can present a time domain representation of the pulses. For this example (a wireless LAN) we will assume a frequency of 2.4 GHz; a PRF of about 10 Hz; and a signal level of 0dBm to 20dBm.

Assuming the power level is less than +20 dBm we can connect the sensor directly to the output of our device without fear of damage. If your device produces power levels greater than +20 dBm you will need to add a pad between the sensor and the output of your device. You may find it useful to enter offset or response correction if you add an attenuator.

Press the **Preset** button on the power panel and configure the sensor as follows:

Mode = Pulse
Frequency = 2.4 GHz
Averages = 75 (default)
Anti-aliasing = OFF (default)
Extended Averaging = OFF (default)
Max Hold = Off (default)
Triggering = Internal, Continuous (default)

We happen to know in our case that this pilot tone has a PRF of about 9.7 Hz and a duty cycle of less than 1%. With these settings the measurement is likely to be very unstable. It may bounce wildly between very low levels and very high levels. The reason for this is the following:

With a PRF of about 10 Hz we get a pulse about every 100 msec. However, we have the averaging set to 75. Since each average takes about 250 usec, a total of 75 averages results in a measurement time of about 20 msec. The probability of intercept (between measurement time and pulse) is about 20%.

This low probability of intercept causes the bouncing. This bouncing occurs because the number of samples (75) does not measure the signal over a long enough period of time. We could extend the averages to just enough to cover the period or about 375 averages. This will give us much more stable readings. However, they are just on the verge of being unstable. To resolve this problem we need to extend the averaging so that we get 10 entire cycles to measure for 1 second. A quick calculation yields:

$$\text{Averages} = (1 \text{ second} / 250 \text{ usec}) = 4000$$

You should see a dramatic stabilization of the readings. In our example we get the following readings:

Pulse (main reading): 16.9 dBm (+/-0.2 dB)
DC = 0.05% (+/-0.05%)
Pk = 18.4 dBm (+/-0.2 dB)
Avg = -14.4 dBm (+/-0.4 dBm)

While this is a dramatic improvement it is still not as stable as it could be. We can take two approaches to further stabilize the measurements. The first approach is to simply increase the averaging to 10000.

$$\text{Averages} = 10000$$

LBXXXX Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

This helped to stabilize the measurements. However, you have to wait several seconds between updates. Now try connecting and disconnecting the RF source. You will see that each reading is independent of the previous reading – so that when power is disconnected the meter responds appropriately. You just have to wait a few seconds between measurements.

We will take a different approach next. We will combine averaging with extended averaging. Extended averaging uses exponential averaging in addition to normal averaging. This provides frequent updates and more stable readings. To start we will set the averaging down to 2000

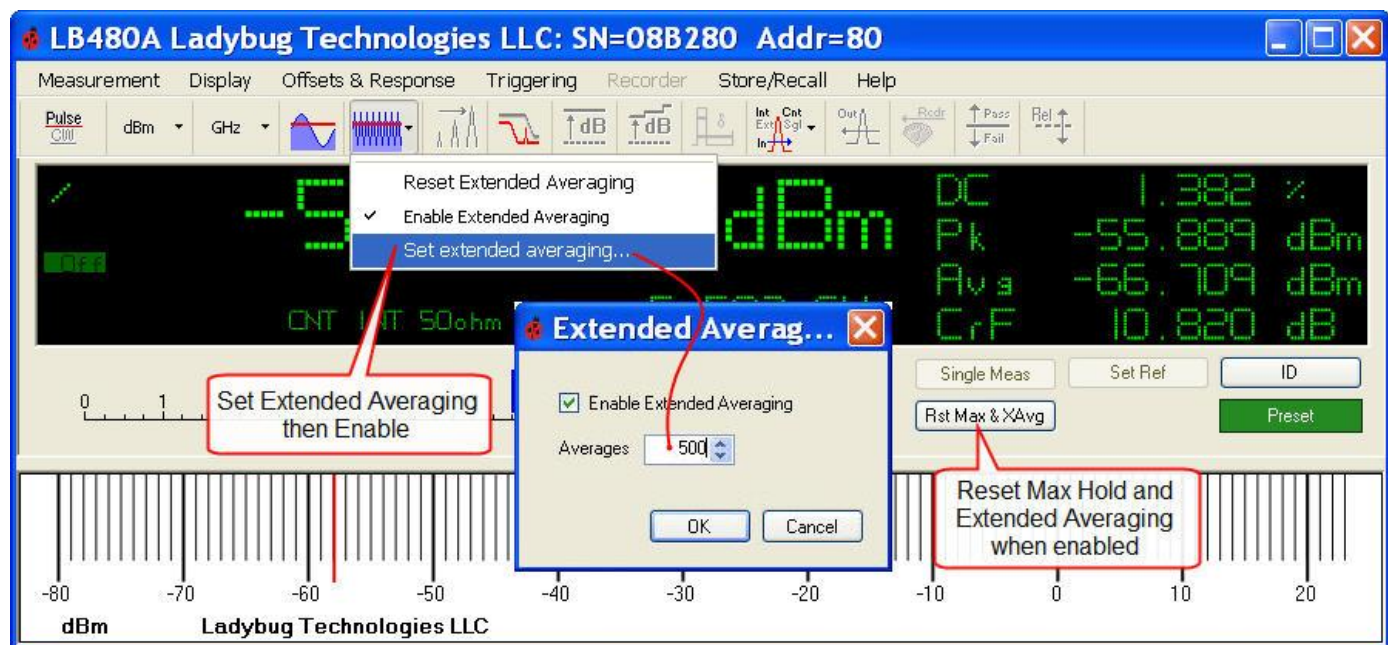
Averaging = 2000

Now setup extended averaging. To do this, click the arrow next to the extended averaging icon on the toolbar as shown below. A drop down menu will appear. Select **Set Extended Averaging**. When the dialog box appears perform the following:

Enable Extended Averaging = check box

Averages = enter 500

Click the OK button



After just a few measurements you should see the readings stabilize dramatically. This is what we wanted. Now we can try a few experiments: Disconnect the sensor from the source (remove the incoming RF signal). Instead of seeing a sharp decrease in power as we did with averaging set to 10000, the indicated power will drift downward slowly. This is because the extended averaging is a “running” average of the past several readings. If you were not aware of this fact this could be a very disconcerting result. Remember, we set the number of extended averages to 500 so the readings now reflect the effects of the last 500 readings.

Given the current settings we might have to wait 10 minutes for a reasonable result. The most immediate action we can take to resolve this action is to click the **Rst Max & XAvg** button on the front panel as shown above. When you do this the reading should show that you have no signal connected. Try it now by clicking the **Rst Max & XAvg** button.

Product Manual PMA (Power Meter Application)

Try resetting the extended averaging to 10 and then alternately connect and disconnect the RF signal. After a few connections and disconnections you get some sense of how long your signal takes to settle. With some experimentation you will find a combination of averaging and extended averaging and clicking the **Rst Max & XAvg** button that gives you an acceptable result. The following settings produced a reasonable result:

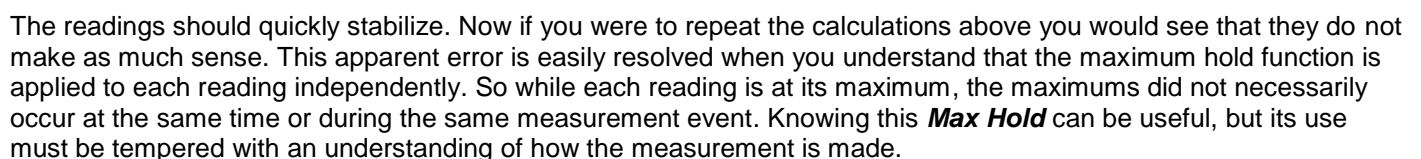
Even modest extended averaging helps the process along quite nicely.

Pulse = 16.7 dBm
DC = 0.033%
Pk = 18.2 dBm
Avg = -17.4 dBm

$$\text{Pulse Power (W)} = \text{Average Power (W)} / \text{Duty Cycle}$$

Average Power = -17.4 dBm or about 18.2 uW
Pulse Power (W) = 18.2 uW/0.033% = 18.2e-6/0.00033 = 55.14 mW
Pulse Power (dBm) = 10 * Log(55.14 mW/1 mW) = 17.4 dBm

Finally, we will examine the Max Hold function. Start by presetting the unit and select **Pulse Power** mode. This sets the averages back to 75 and disables the extended averaging. Our readings are bouncing around again. Now click the **Max Hold** button on the toolbar as shown below.



LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

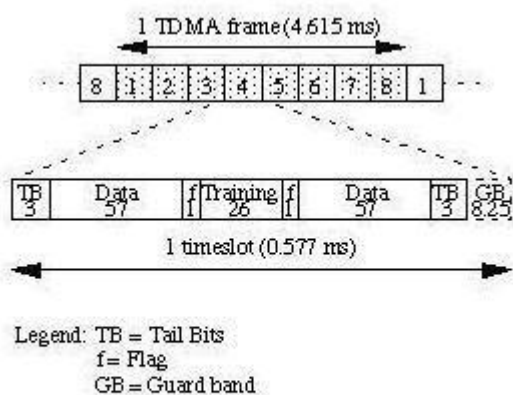
Measurement Example: GSM (LB4XXA models only)

GSM (Global System for Mobile Communication) is a TDMA (Time Division Multiple Access) world standard and the most widely used for mobile phones. The modulation technique is 0.3 GMSK (Gaussian Minimum Shift Keying) with a modulation data rate of 270.8 kb/s. Bit rate relates to amplitude modulation bandwidth, however, GSM transmission uses a constant signal envelope so average power can be measured.

The GSM TDMA structure is shown below with data shown in a single time slot per frame or 1/8 (12.5%) of the time. The transmitter synchronizes during 3 tail bits and is silent during 8.25 guard bits. That amounts to 11.25 bits of transmitter inactivity out of 156.25 bits total. The transmitter is then active or transferring data within 0.928 (92.8%) of a time slot:

$$(156.25 - 11.25) / 156.25 = 0.928 \text{ of a slot}$$

The duty cycle of the transmitter power is then $12.5\% \times 0.928 = 11.6\%$




GSM TDMA structure and normal burst. The number of bits per field is below the field legend.

Make the measurement by connecting the sensor and opening the application.

1. *Select: Measurement > Set Frequency*
2. *Enter: Carrier frequency, (select one) 850/900/1800/1900 MHz*
3. *Select: Measurement > Anti-alias (enable)*
4. *Select: Measurement > Pulse Power*
5. *Select: Triggering > Continuous > Internal*

The sensor can now measure the GSM power in the active time slot. Verify the sensor automatically reports the correct duty cycle.

Alternately, you can use the more traditional method previously described to compare the pulse power readings:

1. *Select: Measurement > Average Power (CW)*
2. *Select: Offsets & Response > Duty Cycle > Setup*
3. *Enter: 11.6 (%)*
4. *Select: Offsets & Response > Duty Cycle > Enabled (or activate the DC icon  on the toolbar)*

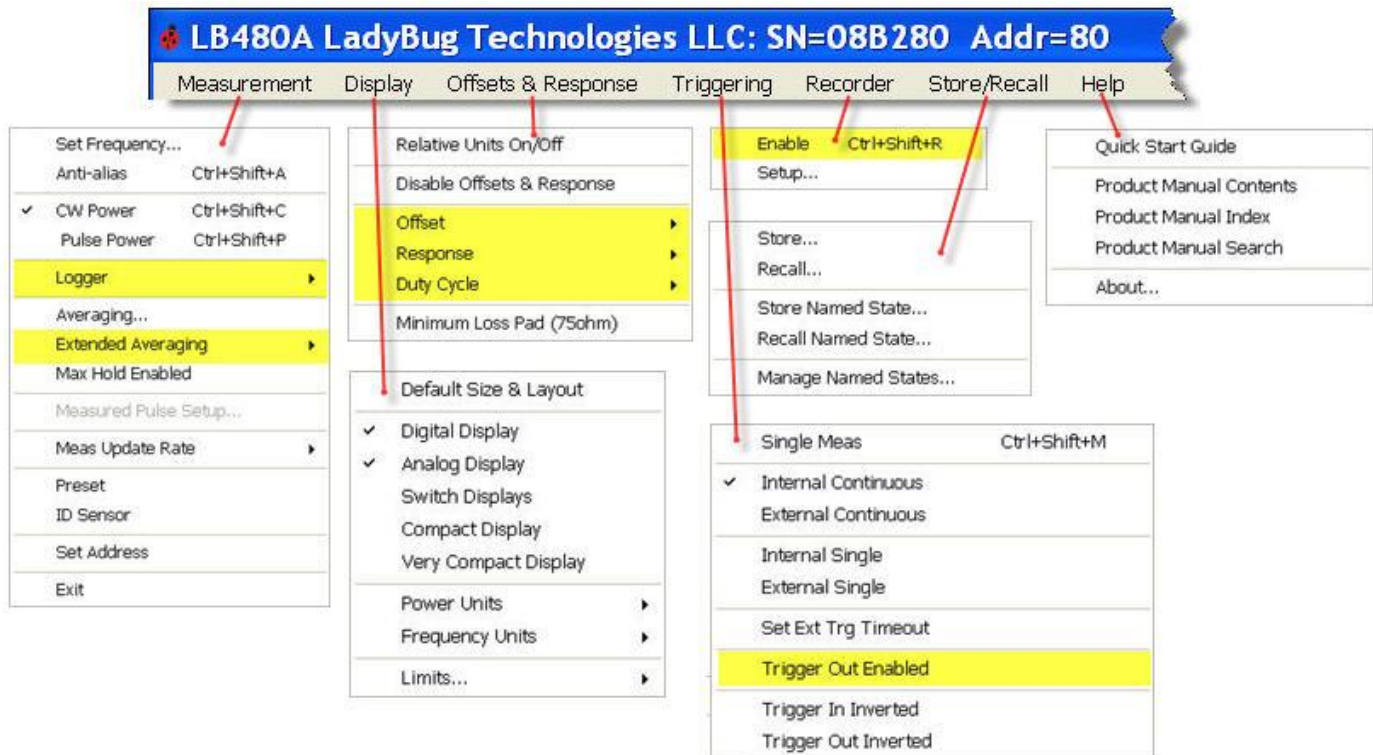
LBXXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

GUI Functions

The Menu Bar

The menu map below shows all the submenus for each functional heading. We have covered many of these functions in *section 3. Basic Operating Instructions*. Menus provide the configuration setups related to each functional heading and are directly linked to the toolbar buttons. The current sensor configuration is indicated by a check mark next to the menu item. The highlighted setups (Logger, Extended Averaging, Limits, Offset, Response, Duty Cycle, Trigger Out, Recorder) *must* be enabled for functionality from either the menu or the toolbar. Since most menu functions are also accessible from the toolbar we will proceed directly to an explanation of the toolbar buttons.



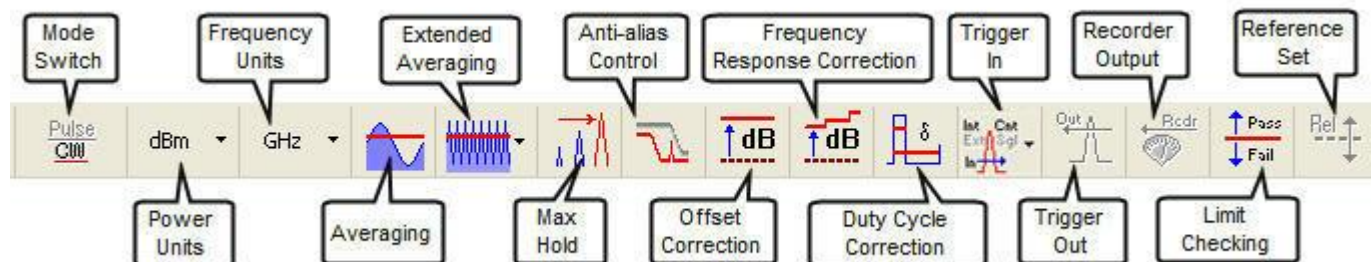
The **Store/Recall** and **Help** menus are not included on the toolbar. There are 20 **Store/Recall** registers and each register holds an entire state. However, the states are *not* held in the instrument but reside on the local PC in a basic text file. The files are named by model number and address and are retained in the Ladybug application directory. This means that saved states can be saved, copied or moved between PCs. Refer to the product Programming Guide for more information. The **Help** directory contains product documentation.

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

The Toolbar

The toolbar is shown below. Notice that each toolbar button has a label if you hover over it with the mouse cursor. The toolbar buttons are like hot keys that duplicate many of the menu selections or actions and make it easier to manipulate the meter settings. Each function is accessible from the menu bar and some toolbar buttons are simply switches.



More detailed descriptions of the toolbar buttons are listed below. Graphic examples of the toolbar functions follow in sequence after that starting with **Averaging**.

Mode: Switch between Average (CW) and Pulse Power modes of operation. This button is not present for LB5XXA.

Power: Select the power units (dBm, dBW, dBkW, dBuV, dBmV, dBV, W, V, dB Relative).

Frequency: Select the frequency units (MHz or GHz). The center frequency *must* be updated when the incoming signal frequency changes as this frequency setting is used to correct amplitude for frequency variation. The best measurement accuracy requires the frequency to be set and not doing so can be a significant source of error.

Averaging: Select averaging from 1 to 30000 measurements. The number of averages depends on signal stability and power level. More averaging may be required for low-level signals. Increasing the number of averages also increases the measurement time.

Extended Averaging: Set, enable, reset extended averaging from the drop down. Extended averaging should be seen as an adjunct to averaging. Extended averaging is an exponential average of the last n readings where n is the number of extended averages. This function is reset by the front panel button labeled **Rst Max & XAvg**. This button resets or restarts both the max hold and extended averaging functions.

Max Hold: Retains the maximum measured value until reset or deactivated. For pulse measurements, each reading (Pulse, Peak, CrF, Avg, DC) is held at its maximum value independent of the other readings. This function is reset by the front panel button labeled **Rst Max & XAvg**. This button resets or restarts both the max hold and extended averaging functions.

Anti-alias Control: The toolbar button is toggle on/off. Enable anti-alias control for input modulation bandwidths greater than 200 kHz. Disable it for modulation bandwidths less than 200 kHz.

Offset Correction: The toolbar button is toggle on/off. The **Offsets & Response** setup menu allows gain or loss offsets to be entered as part of the measurement setup.

Frequency Response Correction: The toolbar button is toggle on/off. The **Offsets & Response** setup menu allows frequency dependent gain or loss offsets to be entered as part of the measurement setup.

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Duty Cycle Correction: The toolbar button is toggle on/off and determines the pulse on/off time at a specified rate and duration when in average power or CW mode only. The button is inactive when in pulse power mode as the duty cycle is determined automatically. The duty cycle setup is accessible from the **Offsets & Response** menu and allows entry of pulse duty cycle from 1 to 100%.

Trigger In: (Standard and Optional) TTL compatible. Provision is made for various trigger sources from the drop down. The trigger menu and toolbar button will not appear for the LB478A/479A or LB5XXA if option 003 is not installed. See data sheet for parameters.

Trigger Out: (Standard and Optional) TTL compatible. The trigger menu and toolbar button will not appear for the LB478A/479A or LB5XXA if option 003 is not installed. See data sheet for parameters.

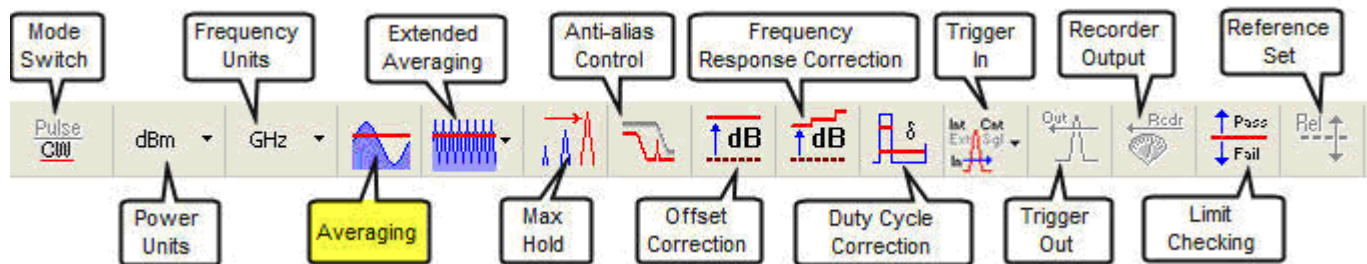
Recorder Output: (Optional) Shared with trigger input. Data output to Excel and other formats. Recorder is a 0 to 1 VDC output that is proportional to the measured power.

Limit Checking: Provision is made for setting measurement limit specifications with pass or fail (High/Low) annunciators shown on the display. The **Limits** setup is accessible from the **Display** menu.

Rel: The REL annunciator will show in the display when activated and the power units will change to “dB relative”. This tool works in conjunction with the **Set Ref** button on the front panel to set the reference value so that a subsequent power level can be measured relative to this reference level. (*See Making a Relative Power Measurement*).

Product Manual PMA (Power Meter Application)

Averaging sets the number of data buffers that are averaged. The default state is 75 averages and it takes about 0.25 msec to collect one buffer of data. The number of averages or buffers is settable from the **Measurement** menu shown below or alternately, by clicking the averaging button on the toolbar and entering a value from 1 to 30000.



This averaging should be seen as an adjunct to averaging. Extended averaging is a exponential average of the last n readings where n is the number of extended averages. This function is reset by the front panel button labeled **Rst Max & XAvg**. This button resets or restarts both max hold and extended averaging. You can set, reset and enable extended averaging from the drop down on the toolbar. *(For an example of extended averaging see section 4. Detailed Operating Instructions, Measurement Overview and Examples, Measurement Example: OFDM Pilot Tone).*

Retains the maximum measured value until reset or deactivated. For pulse measurements, each reading is held at its maximum value independent of the other readings. This function is reset by the front panel button labeled **Rst Max & XAvg**. This button resets or restarts both the max hold and extended averaging functions. (For an example of max hold see section 4. *Detailed Operating Instructions, Measurement Overview, Measurement Example: OFDM Pilot Tone*).

LBXXXX Series USB PowerSensor+™

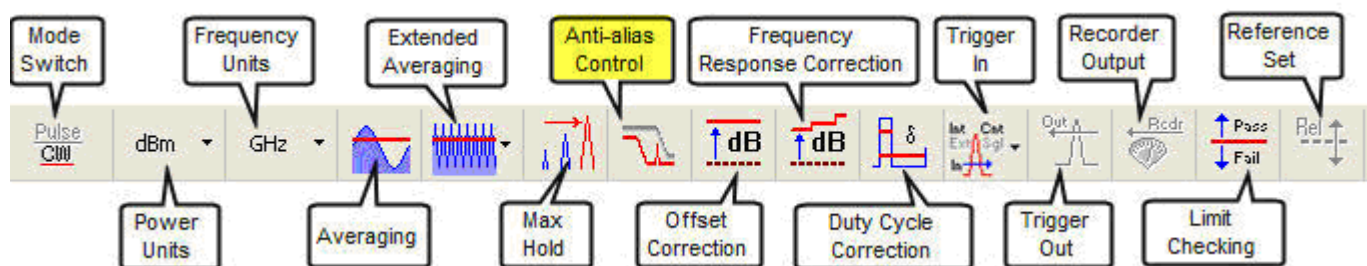
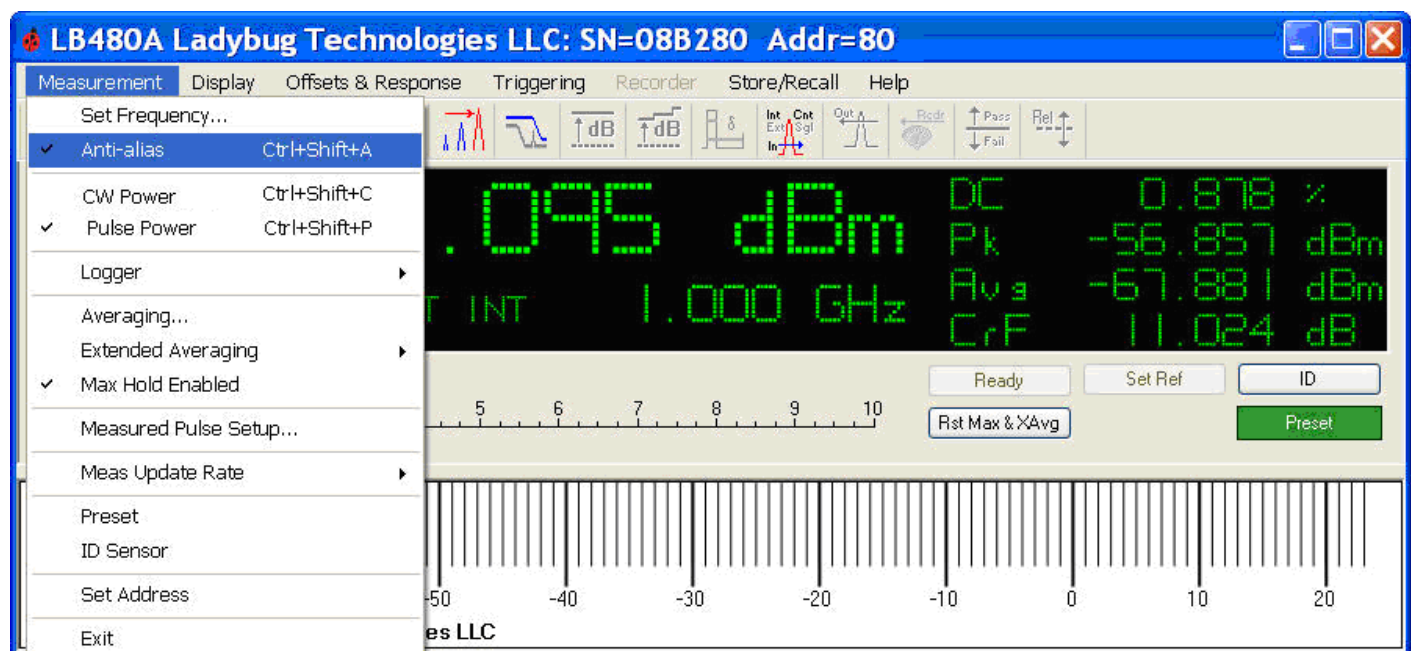
Product Manual PMA (Power Meter Application)

Anti-alias Control

The toolbar button is toggle on/off. Enable anti-alias control for input modulation bandwidths greater than 200 kHz. Disable it for modulation bandwidths less than 200 kHz. This button is used for CW and continuous pulse power measurements *only* to provide the greatest measurement accuracy. This control feature can best be described as a low/high pass filter switch and actually relates to the sampling method that is employed for the particular modulation bandwidth - either narrow or wide.

Normally the sampling is 500 kHz. As the baseband signals approach the Nyquist criteria (realistically about 200 kHz in this case) problems arise. There are several approaches that can be used to resolve this problem. We use an anti-aliasing capability that randomizes the sample period. This randomization does have some affect on the rapidity of acquiring the data.

As a result, the anti-aliasing algorithm is normally turned off. However, if you are measuring signals that have baseband content greater than about 200 kHz we recommend turning on the anti-aliasing feature.



Anti-alias control enabled (BW >200 kHz)

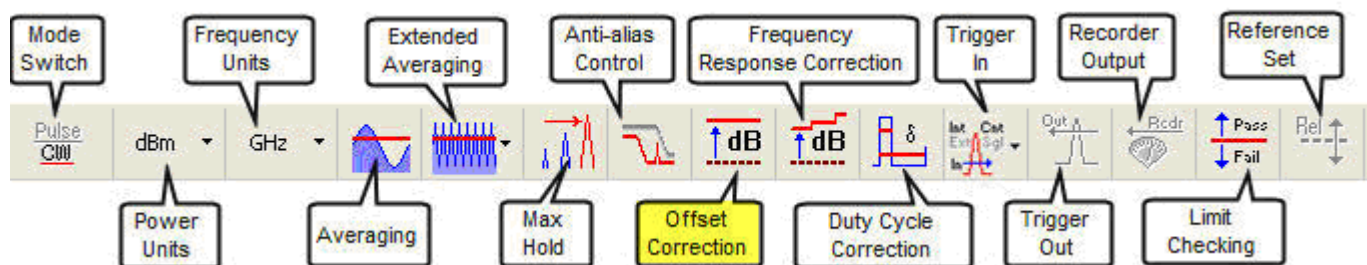
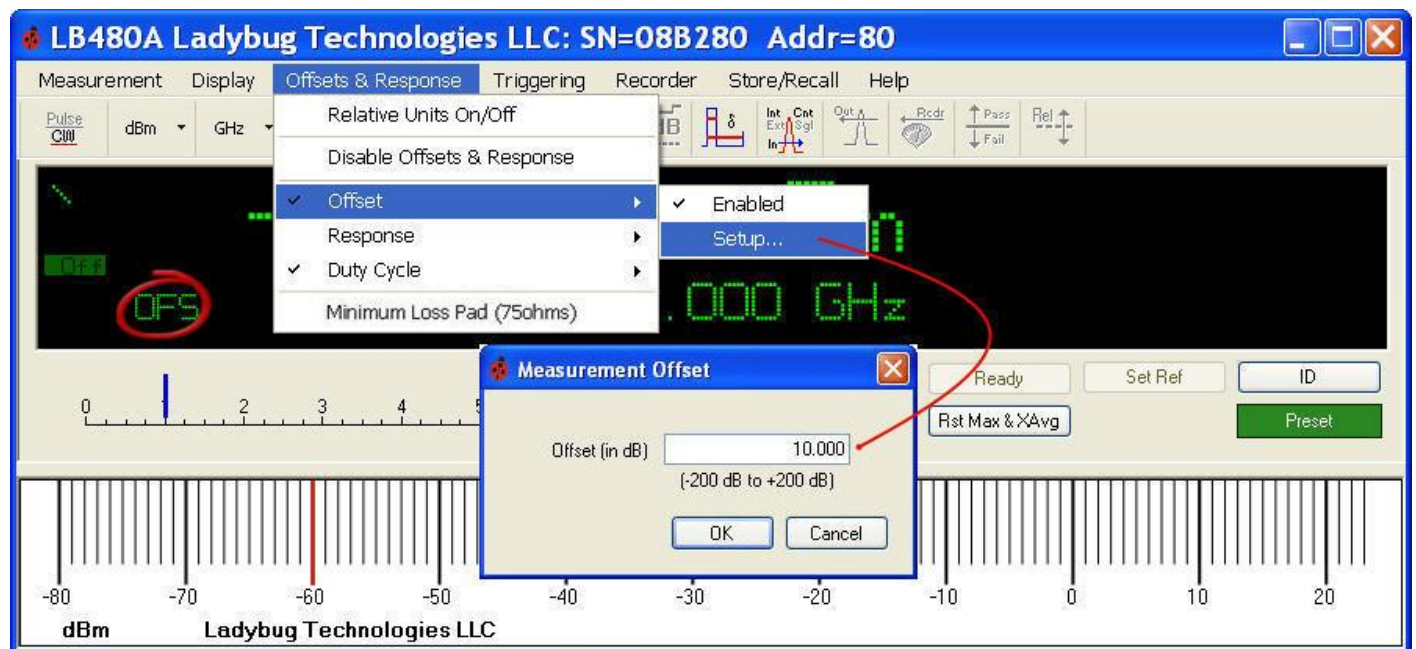



Anti-alias control disabled (BW <200 kHz)

Offset Correction

Offsets can compensate for signal loss or gain in the measurement path outside the sensor. For example, the offset function is helpful when an attenuator or amplifier is in front of the sensor. This offset is fixed and is not a function of frequency. If you need an offset that is a function of frequency use the response correction tool. (See *Frequency Response Correction* further on in this section). The following example uses an attenuator to demonstrate the offset feature:

1. Connect the sensor and start the application.
2. Set the frequency of interest.
3. Connect the attenuator to the sensor. The power reading will decrease by the value of attenuation.
4. As shown below select **Offsets & Response > Offset > Setup** and enter the attenuation value.




5. Enable the offset by activating the offset correction button  on the toolbar. Offset can also be enabled from the **Offsets & Response** menu.
6. The displayed power will increase by the value entered and the OFS annunciator will activate on the bottom-left of the display.

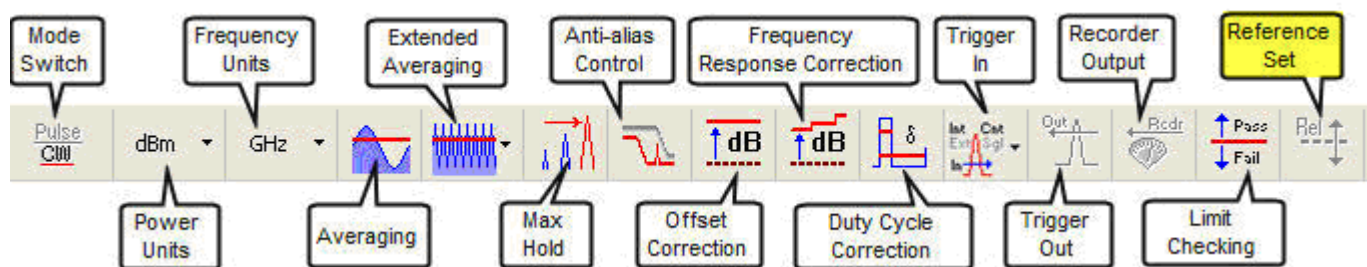
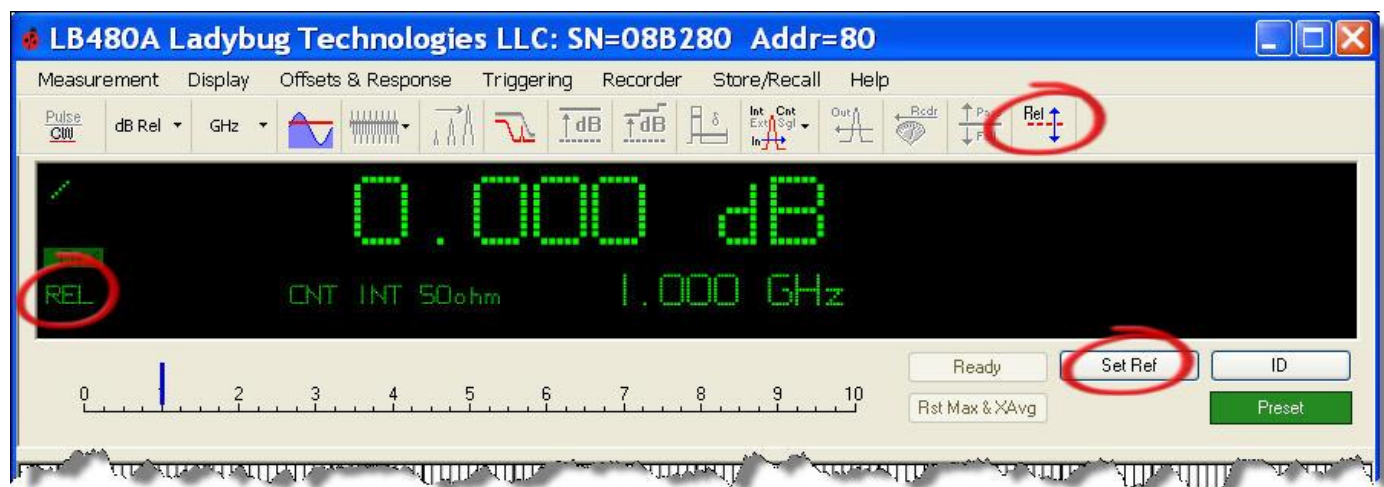
LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Making a Relative Power Measurement

The **Offsets & Response** menu allows comparison of an input to a reference value. The relative difference can be displayed in dB. Complete the following steps to set a reference value:

1. Make sure the sensor is connected to the measurement setup establishing the reference value.
2. Activate the **Rel(ative)** button  on the toolbar. The REL annunciator will appear and the power units will change to “dB relative” as shown below. Click the **Set Ref** button below the display to establish the 0 dB reference point.
3. You can change the reference level at any time by adjusting the source power then click the **Set Ref** button.
4. The display will now indicate power relative to this reference value in subsequent measurements and the REL annunciator will be active. Relative power can be disabled as needed by clicking the **Rel** button on the toolbar. Alternately, you can turn it on/off by selecting **Offsets & Response > Relative Units On/Off** from the menu.

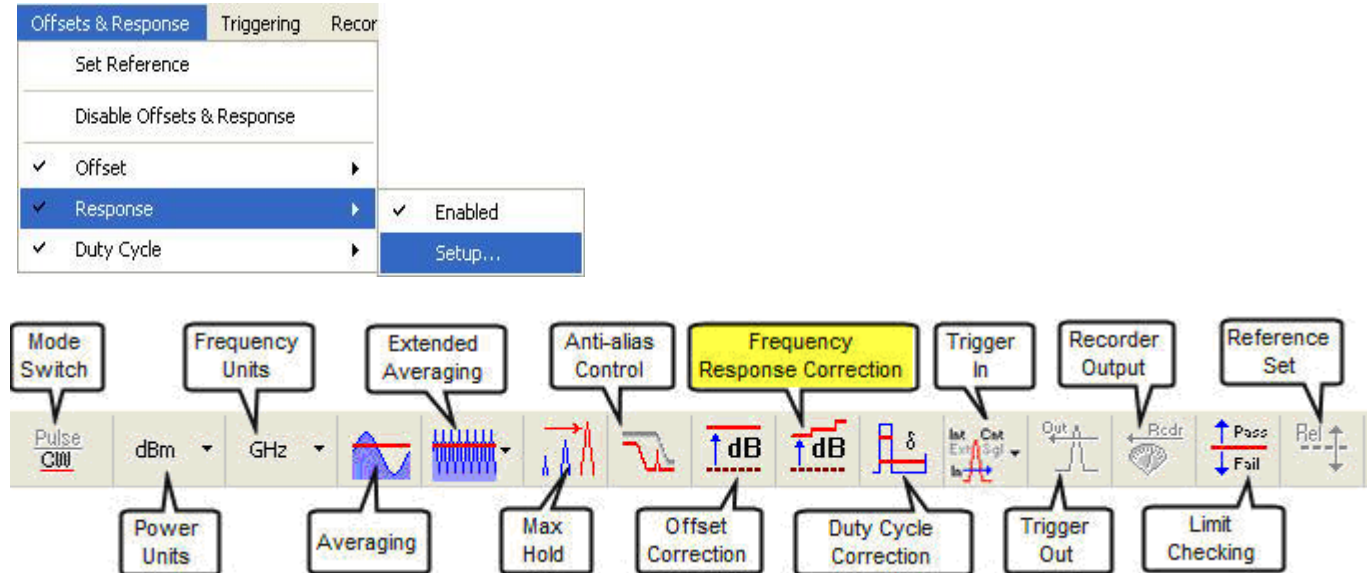


LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Frequency Response Correction

The **Response** setup menu shown below allows frequency dependent gain or loss offsets to be entered as part of the measurement setup. **Response** is a frequency sensitive offset so as you change the measurement frequency the response changes accordingly. **Response** amplitude is always expressed in dB and the frequency is expressed in Hz. The interpolation is linear with respect to frequency and dB. The **Response** setup allows up to 201 points to be entered. The response points are frequency and amplitude pairs. Setting the response is independent of enabling or disabling the feature. The toolbar button turns correction on or off.



Click **Setup** and enter the frequency and corresponding offset in the table shown below. Click **Add** after each frequency and offset entry to build the table. Select **Show Graph** to get a graphical presentation of the frequency offsets that were entered in the table.

The 'Frequency Response Offset' dialog box has a title bar with a close button. It contains two input fields: 'Frequency (GHz)' with the value '3' and 'Offset (dB)' with the value '2'. Below these are 'Add' and 'Clear All' buttons. A table lists frequency and offset values:

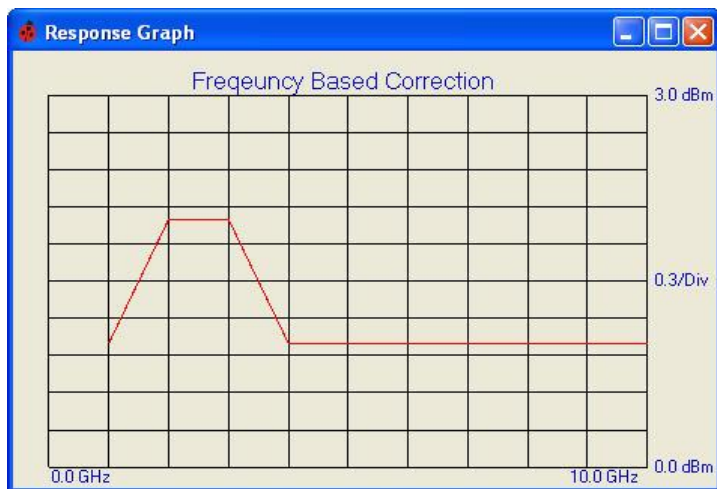
Frequency (GHz)	Offset (dB)
1.000	1.000
2.000	2.000
3.000	2.000
4.000	1.000
5.000	1.000
6.000	1.000
7.000	1.000
8.000	1.000
9.000	1.000
10.000	1.000

At the bottom are 'Show Graph', 'OK', and 'Cancel' buttons.

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Graph of frequency response below.



The frequency response (RSP) annunciator will appear when response correction is on as shown below. The frequency response correction button on the toolbar can be toggled on/off. The response feature can also be enabled from the **Offsets & Response** menu.



Impedance Matching

The sensor normally provides a 50-ohm impedance match at the input (default). However, you can switch to the 75-ohm MLP (minimum loss pad) from the **Offsets & Response** menu shown below. The display will indicate "75ohm-MLP" if selected.



LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

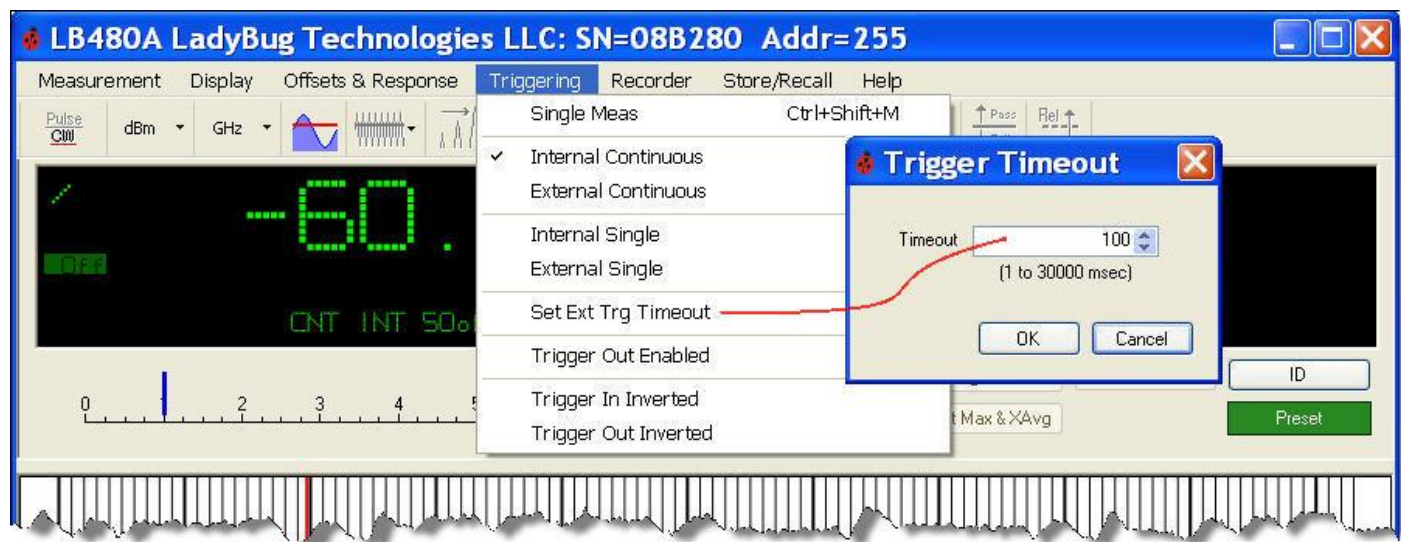
Triggering

The **Triggering** menu (standard and option 003) allows for a number of triggering capabilities as shown below. The single input trigger is controlled by the **Single Meas** button on the display. Trigger In and Recorder Out share a bi-directional connector labeled TI/RO on the sensor body and their operation is mutually exclusive. Refer to the trigger specifications on the data sheet for electrical parameters.

The trigger-in features are available on sensors with the option present. The trigger is assumed to be a TTL level and positive edge triggered. The trigger-in can be enabled, disabled or inverted.

The trigger-in defines or controls the start of a measurement cycle. After the trigger is detected the measurement will commence and will continue for the specified number of averages. Once a measurement is requested the system will monitor the trigger-in port. If a trigger is not detected in the allotted time, the system will time out and return an invalid measurement.

The trigger may be inverted: When the trigger-in is inverted the system will look for a negative edge (instead of a positive edge) and begin the measurement when a negative edge is detected. There is provision for setting a timeout period for an external trigger input (up to 30 seconds) as shown.



The trigger-out is compatible with TTL levels. It can be enabled, disabled and inverted (or normal). The trigger-out occurs at the beginning of a measurement. This means that if the measurement is untriggered (i.e. trigger-in is disabled) and trigger-out is enabled, a trigger will be produced each time a measurement is made. If the trigger-in is enabled then the trigger will be passed through when it is received.

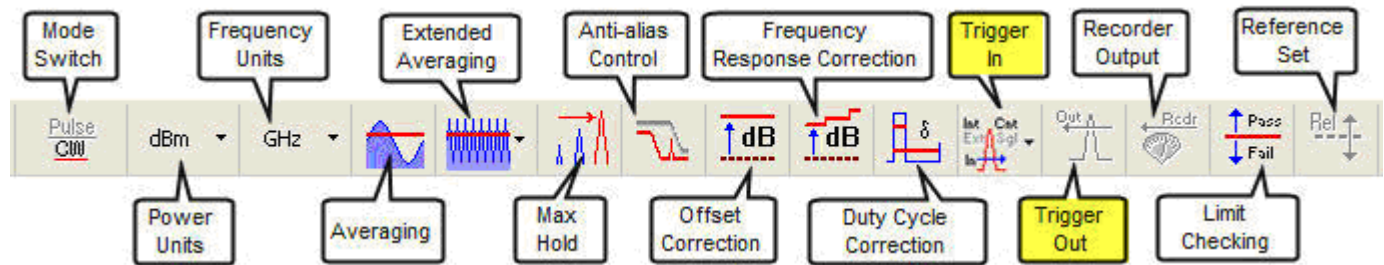
A trigger output is normally low. When a trigger is produced it begins with a positive-going edge and stays at a TTL level for a few microseconds then returns to ground potential. If the trigger-out is inverted it will transition from a high to a low TTL level. When a trigger is produced a negative edge will be produced going to a TTL low. Then after a few microseconds it will return to a TTL high.

NOTE: The application software handles the trigger condition for each sensor in serial fashion. When multiple sensors are running, the absence of a trigger in one instance will force a wait state and cause the other sensors to update at a slower rate. This would occur if a sensor lost its external trigger source for example.

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

The toolbar trigger drop down shown below works in conjunction with the triggering configurations just described. It allows the user to conveniently switch between internal/external continuous trigger and internal/external single sweep trigger.

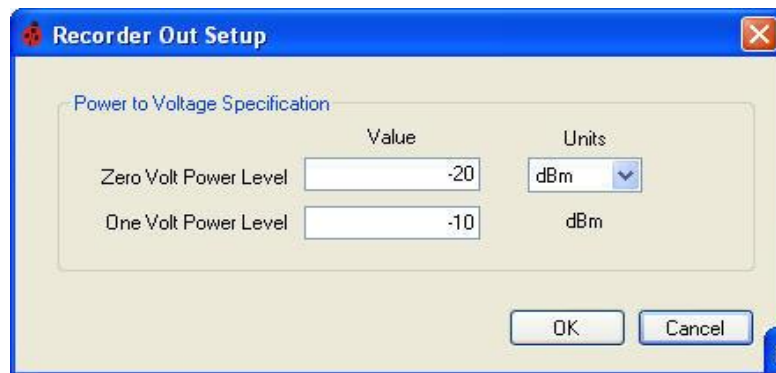
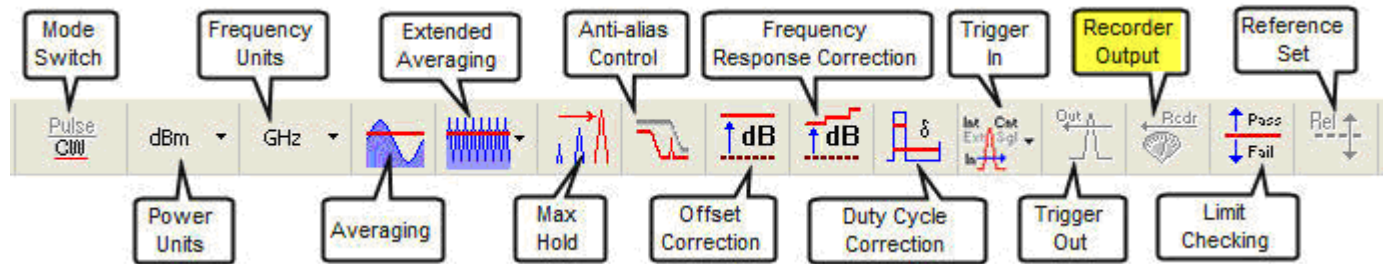


LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Recorder

The **Recorder** output function (option 001) is a 0 – 1 VDC settable output that is proportional to the measured RF input power. **Recorder** only works in CW mode. A window will appear to indicate the meter is in record mode if enabled. The meter display will be inaccessible until you exit this function. Recorder Out and Trigger In share a bi-directional connector labeled TI/RO and their operation is mutually exclusive. Setting up the recorder output is independent of enabling or disabling the feature.



The setup for the **Recorder Out** is straightforward: You need to specify a power level for the Zero Volt Level; specify a power level for the One Volt Level; and specify the units of measure. Units of measure serve to specify the power levels and they are used to specify the scale for interpolation. That is, if the units are logarithmic (dBm, dBuV, etc.), the interpolation between 0 VDC and 1 VDC will be with respect to that scale. Likewise, if the units are power (Watts or Volts), the interpolation will be with respect to that scale.

For example, if you set the 0 VDC level to -30 dBm and the 1 VDC level to -20 dBm then -25 dBm would produce 0.5 VDC. And if you set the 0 VDC level to 1 mW and the 1 VDC level to 7 mW, then a reading of 4 mW would produce 0.5 VDC.

The relationship of the limits and power levels are determined by the user. The recorder output passes through a 10 Hz hardware filter and the output is updated each time the power is measured so that the rate of update is tied to your rate of measurement. Perform the following to increase the rate of update:

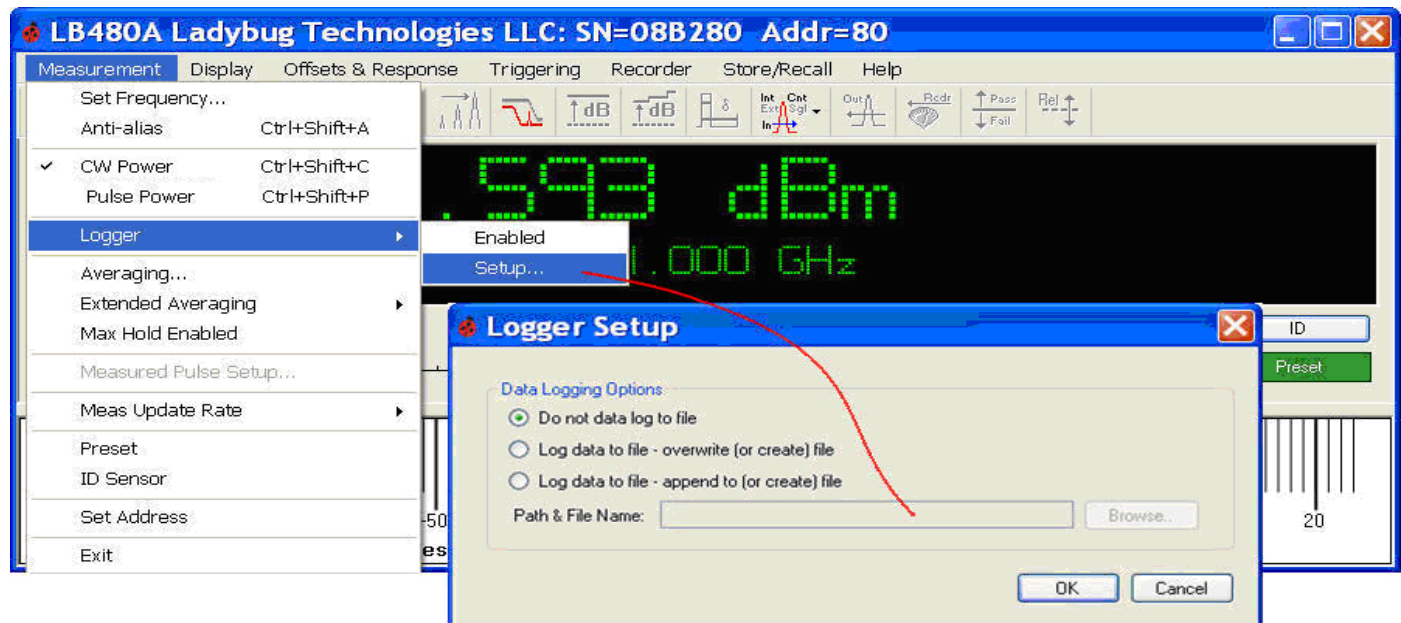
1. Reduce the number of averages.
2. Increase your rate of measurement.
3. Run as few processes as possible on the PC that is being used.
4. Minimize other tasks.

LBXXXA Series USB PowerSensor+™

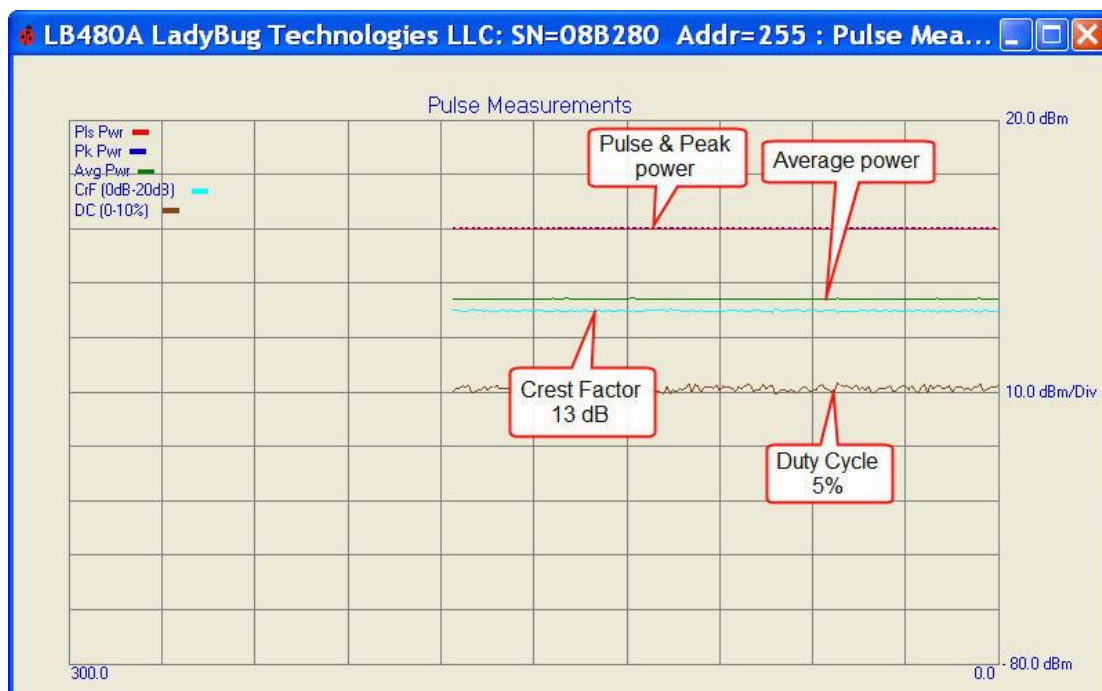
Product Manual PMA (Power Meter Application)

Data Logging

Select **Measurement > Logger > Setup** to display and record data to file as shown below. Browse to and enter a path and file name to log data. There is provision to overwrite an existing file or append data to file by checking the appropriate box.



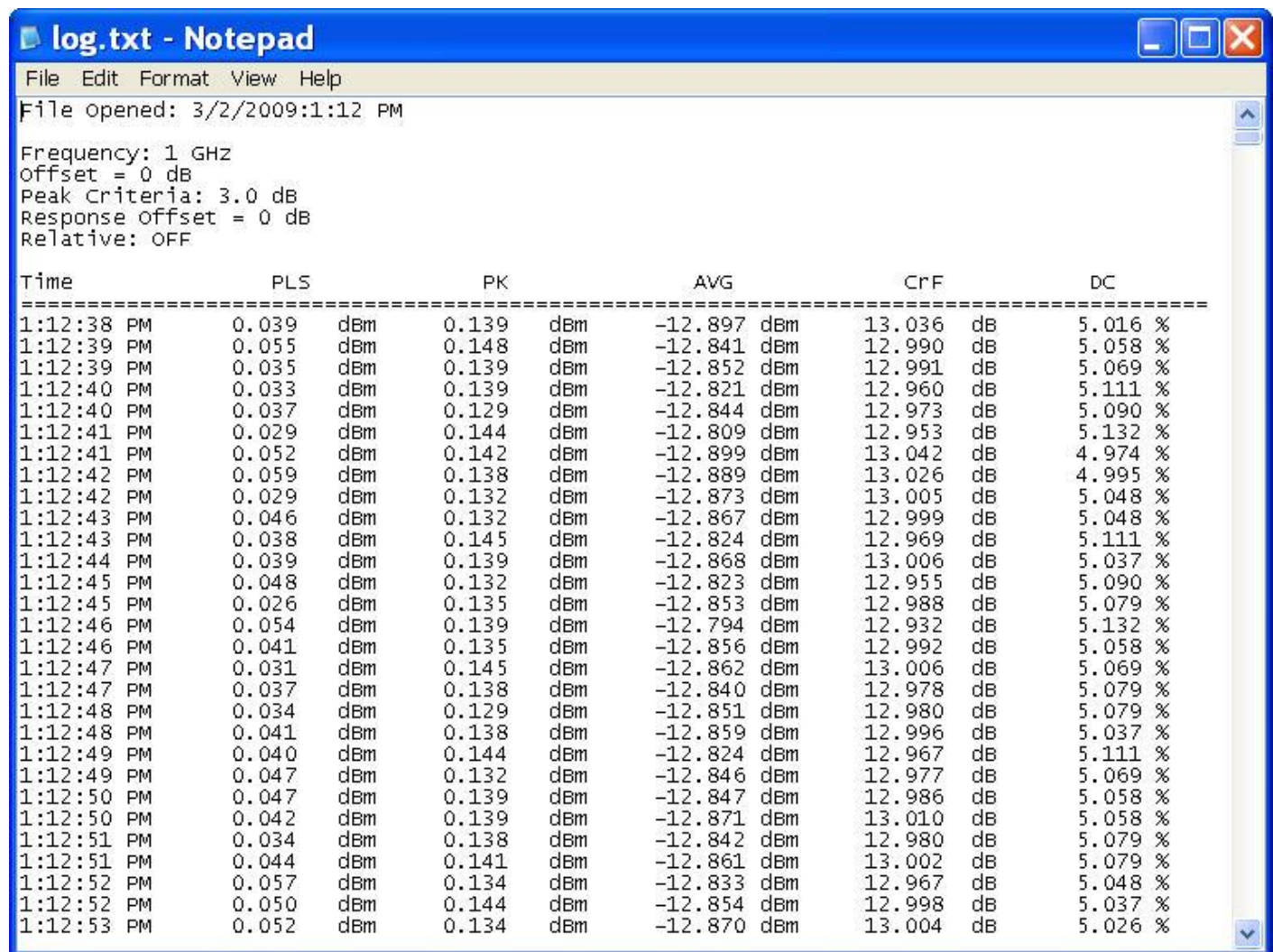
Once a valid path/file has been established, select **Measurement > Logger > Enabled** to start logging data. The recorder will start graphing from 0 to 300 readings (bottom scale, right to left). The duty cycle is scaled vertically from 0 to 10% (1% per division). Crest Factor is scaled vertically from 0 to 20 dB (2 dB per division). The graph below shows a duty cycle of 5% (center line); peak and pulse power are approximately 0 dBm; and Crest Factor is approximately 13 dBm.



LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

An example of tabular data saved to file is shown below when in pulse power mode. The file will indicate date/time, frequency, and offsets in addition to the measured values with time stamp.



log.txt - Notepad

File Edit Format View Help

File opened: 3/2/2009:1:12 PM

Frequency: 1 GHz
offset = 0 dB
Peak Criteria: 3.0 dB
Response offset = 0 dB
Relative: OFF

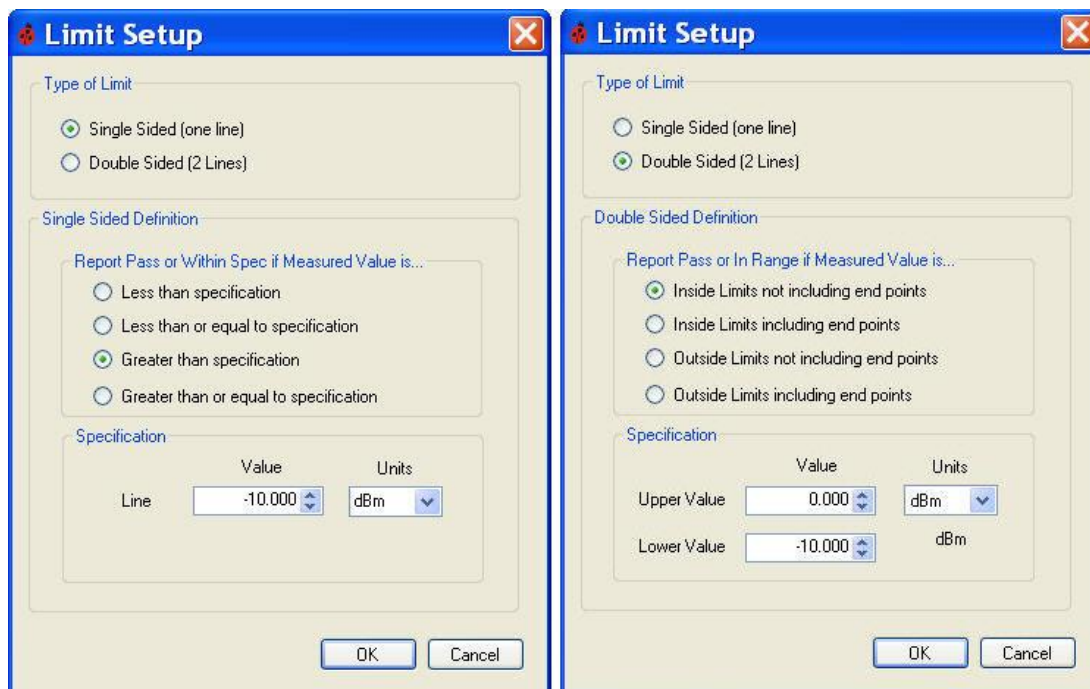
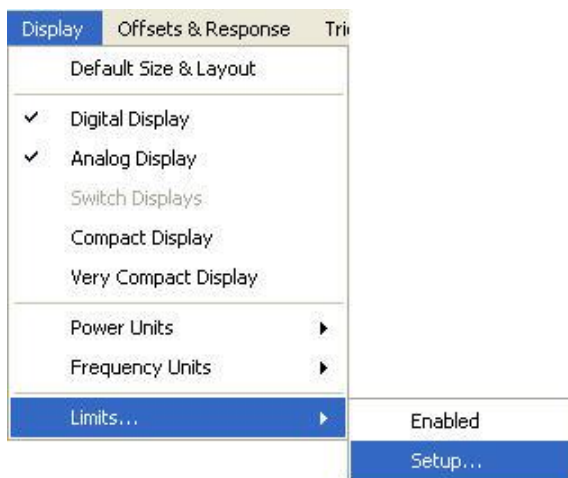
Time	PLS	PK	AVG	CrF	DC
1:12:38 PM	0.039 dBm	0.139 dBm	-12.897 dBm	13.036 dB	5.016 %
1:12:39 PM	0.055 dBm	0.148 dBm	-12.841 dBm	12.990 dB	5.058 %
1:12:39 PM	0.035 dBm	0.139 dBm	-12.852 dBm	12.991 dB	5.069 %
1:12:40 PM	0.033 dBm	0.139 dBm	-12.821 dBm	12.960 dB	5.111 %
1:12:40 PM	0.037 dBm	0.129 dBm	-12.844 dBm	12.973 dB	5.090 %
1:12:41 PM	0.029 dBm	0.144 dBm	-12.809 dBm	12.953 dB	5.132 %
1:12:41 PM	0.052 dBm	0.142 dBm	-12.899 dBm	13.042 dB	4.974 %
1:12:42 PM	0.059 dBm	0.138 dBm	-12.889 dBm	13.026 dB	4.995 %
1:12:42 PM	0.029 dBm	0.132 dBm	-12.873 dBm	13.005 dB	5.048 %
1:12:43 PM	0.046 dBm	0.132 dBm	-12.867 dBm	12.999 dB	5.048 %
1:12:43 PM	0.038 dBm	0.145 dBm	-12.824 dBm	12.969 dB	5.111 %
1:12:44 PM	0.039 dBm	0.139 dBm	-12.868 dBm	13.006 dB	5.037 %
1:12:45 PM	0.048 dBm	0.132 dBm	-12.823 dBm	12.955 dB	5.090 %
1:12:45 PM	0.026 dBm	0.135 dBm	-12.853 dBm	12.988 dB	5.079 %
1:12:46 PM	0.054 dBm	0.139 dBm	-12.794 dBm	12.932 dB	5.132 %
1:12:46 PM	0.041 dBm	0.135 dBm	-12.856 dBm	12.992 dB	5.058 %
1:12:47 PM	0.031 dBm	0.145 dBm	-12.862 dBm	13.006 dB	5.069 %
1:12:47 PM	0.037 dBm	0.138 dBm	-12.840 dBm	12.978 dB	5.079 %
1:12:48 PM	0.034 dBm	0.129 dBm	-12.851 dBm	12.980 dB	5.079 %
1:12:48 PM	0.041 dBm	0.138 dBm	-12.859 dBm	12.996 dB	5.037 %
1:12:49 PM	0.040 dBm	0.144 dBm	-12.824 dBm	12.967 dB	5.111 %
1:12:49 PM	0.047 dBm	0.132 dBm	-12.846 dBm	12.977 dB	5.069 %
1:12:50 PM	0.047 dBm	0.139 dBm	-12.847 dBm	12.986 dB	5.058 %
1:12:50 PM	0.042 dBm	0.139 dBm	-12.871 dBm	13.010 dB	5.058 %
1:12:51 PM	0.034 dBm	0.138 dBm	-12.842 dBm	12.980 dB	5.079 %
1:12:51 PM	0.044 dBm	0.141 dBm	-12.861 dBm	13.002 dB	5.079 %
1:12:52 PM	0.057 dBm	0.134 dBm	-12.833 dBm	12.967 dB	5.048 %
1:12:52 PM	0.050 dBm	0.144 dBm	-12.854 dBm	12.998 dB	5.037 %
1:12:53 PM	0.052 dBm	0.134 dBm	-12.870 dBm	13.004 dB	5.026 %

NOTE: There is a separate High Speed Logger application available for the LB4XXA series PowerSensor+™. See the website for information.

Limits Pass/Fail

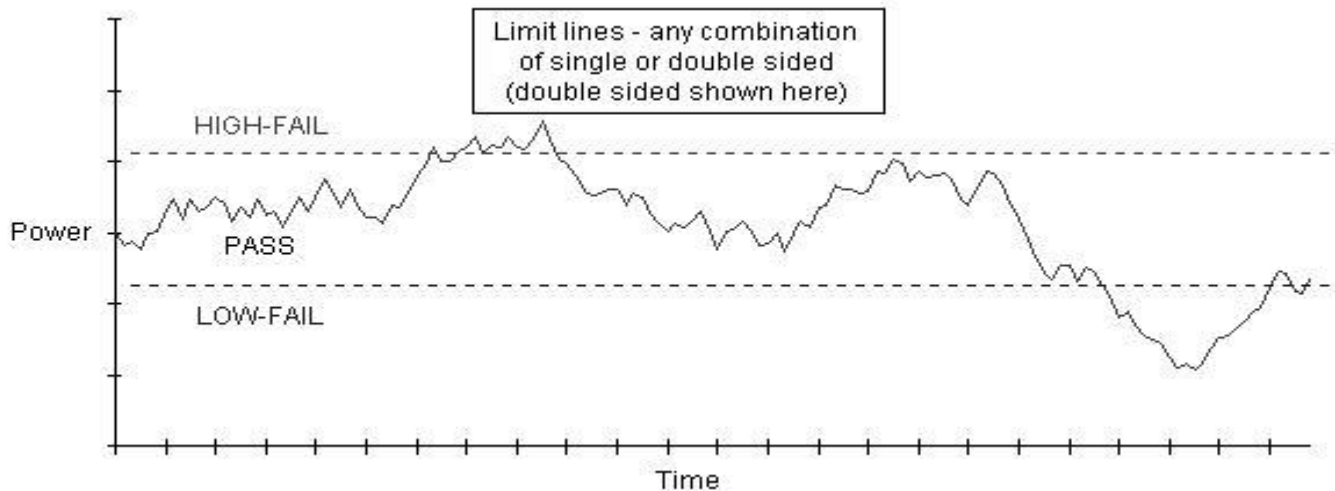
Select **Display > Limits > Setup** to establish test limit lines, either single or double sided as shown below. Limits are fixed values against which a measured value is compared, then an evaluation is expressed as pass or fail. This evaluation is done during a measurement and the limits come in two types. The first type is a single line. The value can be below, equal to, or above this line and you may specify any of these conditions as pass or fail. The second type of limit is a double line. The value can be equal outside the lines, equal between the lines, or equal to one of the lines. Any condition may be specified as pass or fail. The following is required when specifying the limit:

1. Type of limit.
2. Boundary conditions (one for single-sided, two for double-sided).
3. Units for the boundary conditions.
4. The rule of how to evaluate a pass or fail (we specify pass). The rules are different for single and double-sided limits. See **Limit Setup** windows below.

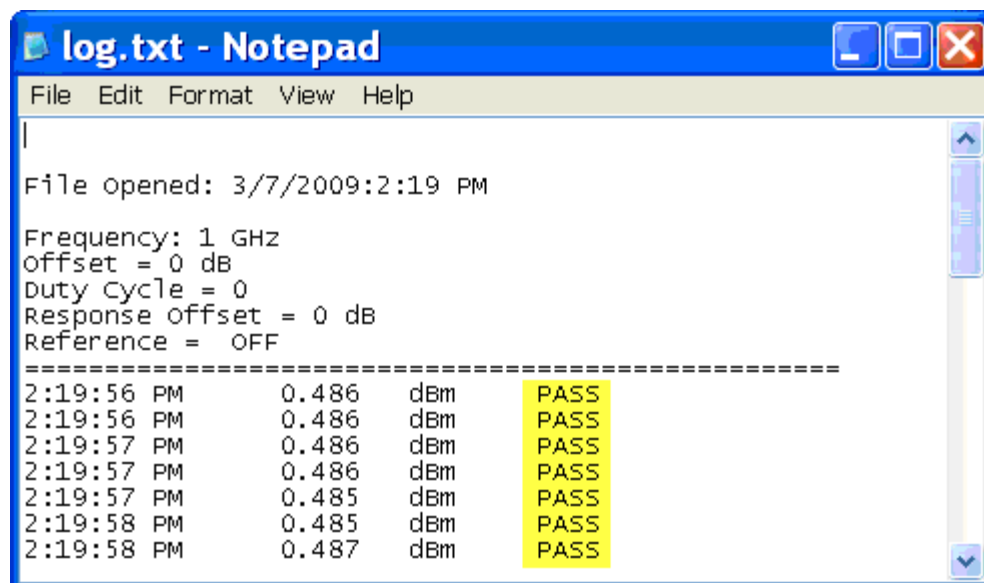
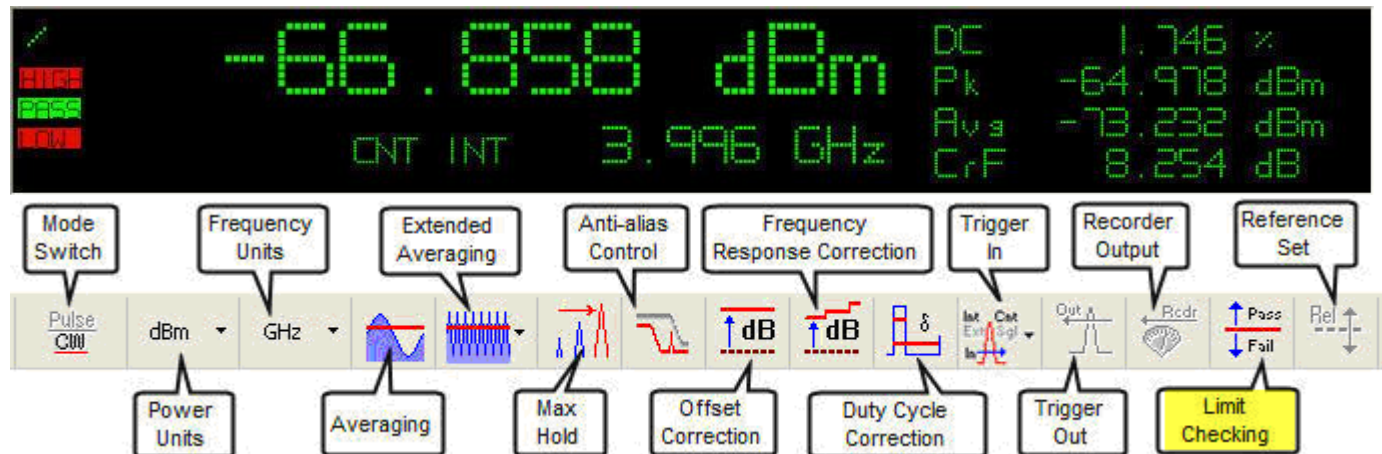


LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)



The appropriate PASS/HIGH/LOW annunciator will appear in the active display below when the measurement limits have been enabled. The annunciator will be "OFF" when not enabled, and if the limits are indeterminate the annunciator will indicate "Ind". Select **Display > Limits > Enabled** to activate or click the **Pass/Fail** toolbar button. Also notice the Logger file data will indicate PASS or FAIL if limits are enabled (example shown below).



LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

NOTE: Selecting dB Relative as the units of measurement will disable limits. The Limits Setup dialog box does not include a dB Relative selection.

Measurement Accuracy

The sources of measurement uncertainty associated with the LB series of power sensors consist of the following error terms:

1. Mismatch
2. Calibration factor
3. Linearity
4. Noise
5. Temperature
6. Zero Offset

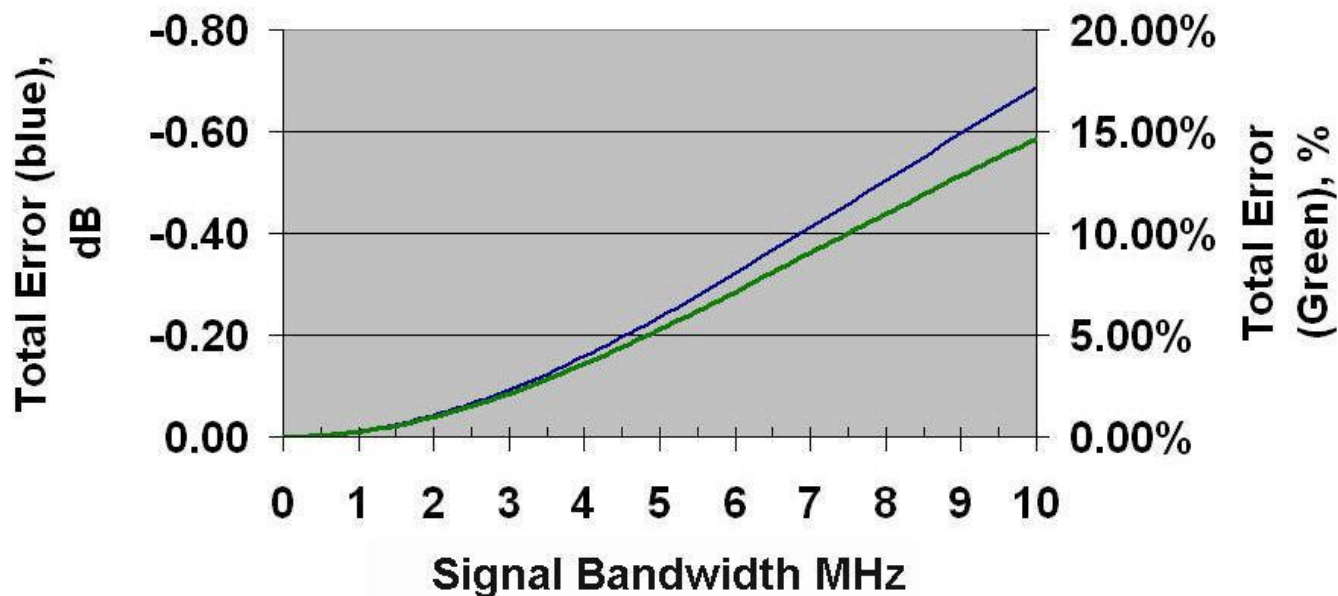
A root-sum-of-the-squares (RSS) uncertainty computation of these error terms yields an overall measurement accuracy of $\pm 1.95\%$. This is based on a well matched DUT where source match and calibration factor are the dominant contributors to uncertainty.

$$\text{RSS} = \sqrt{(\text{Mm}^2 + \text{CF}^2 + \text{L}^2 + \text{N}^2 + \text{T}^2 + \text{Z}^2)}$$

$$+1.95\% = 10 \log (1+0.0195) = +0.084 \text{ dB}$$

$$-1.95\% = 10 \log (1-0.0195) = -0.086 \text{ dB}$$

The plot below represents the total uncertainty relative to the input bandwidth for the PowerSensor+™ line of products.



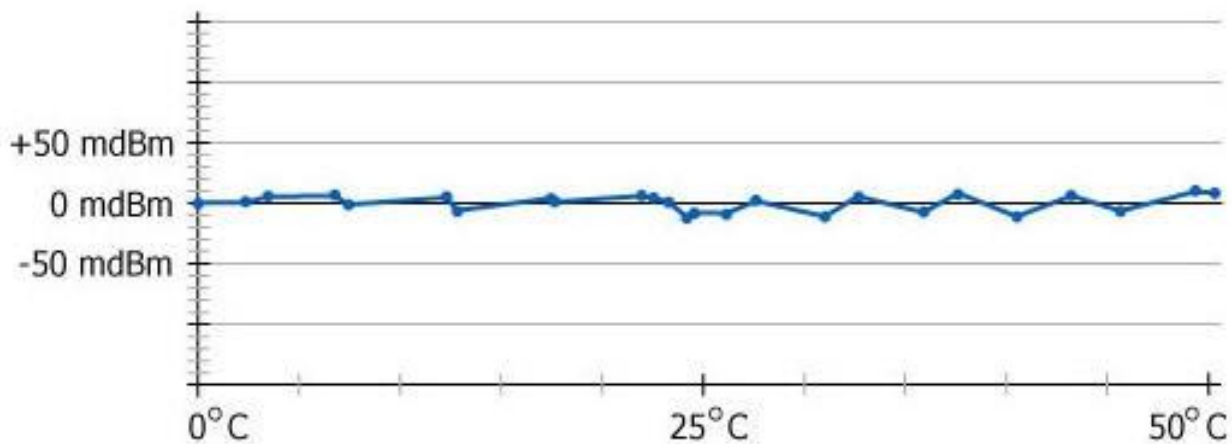
LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

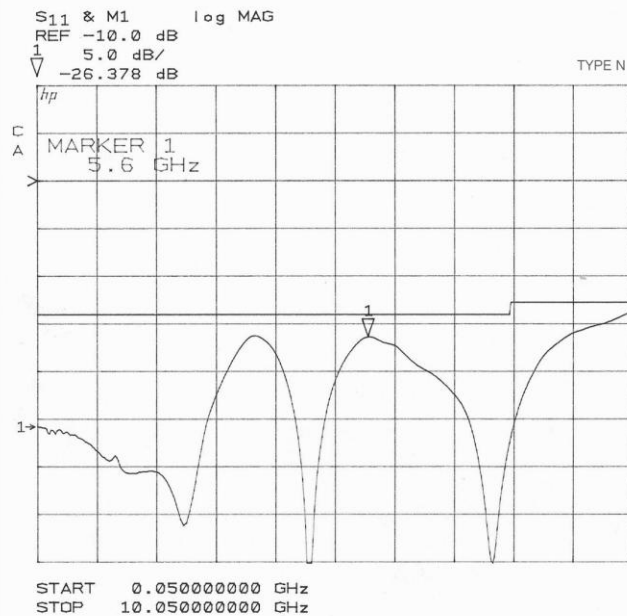
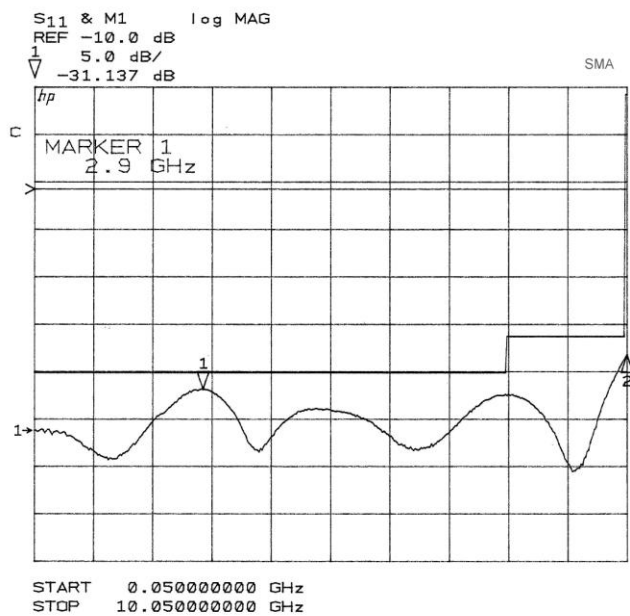
Sensor Technology

The (patent pending) design of the PowerSensor+™ allows for internal error correction and eliminates the need to zero the sensor. Additionally, no separate power reference calibration is required which reduces system errors and increases overall accuracy. A high degree of temperature stability is achieved for a given input power level as shown in the graph below:

LB479A PowerSensor+
Measured Power over Temperature at 1 GHz



Typical plots of sensor match are shown below with both SMA and Type N input connectors.



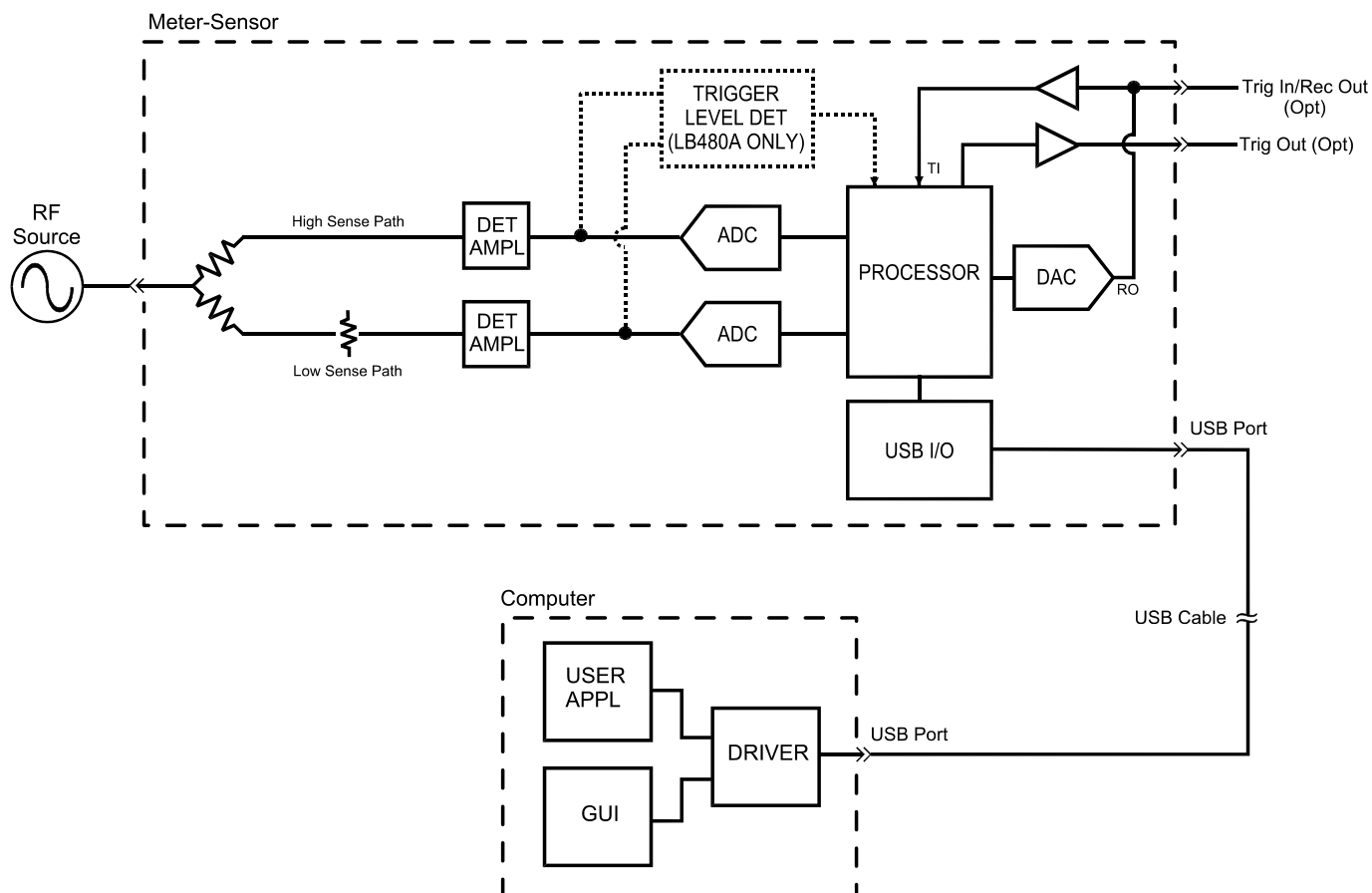
LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Functional Block Diagram

A block diagram is shown below and is representative of the PowerSensor+™ line of products. Notice that the Trigger Input and Recorder Output options are mutually exclusive and share a connector. Refer to the product Order Guide for a complete listing of available options.

LB Series PowerSensor+ Block Diagram



5. Error Messages

Various error windows will appear if there is a hardware or software problem or conflict. Follow the message instructions to correct the problem.

6. Errata and User Updates – by date

Subsequent revisions to the user interface and other product changes are listed in this section by date. Periodically these changes will be incorporated into the body of the manual by revision date (MM/DD/YY). Meanwhile, you can check for any interim updates by downloading the product manual from the website. The latest software and documentation are available for download from the company website - see the Contact Information section of this manual.

Rev Date: 01/07/08

1. Change supplied USB cable length from 3-meter to 2-meter in General Information/Accessories section, pg 6.
2. Add Programming Guide and Quick Start Card to accessories supplied with shipment in same section.

Rev Date: 03/24/08

1. Modify cover page title.
2. Add reference to LB480A Quick Start Guide for the Pulse Profile Application under Measurements Specific to the LB480A.

Rev Date: 04/15/08

1. Style change to headings.
2. Correct install procedure step 22.

Rev Date: 06/16/08

1. Add check to determine if customer has USB2.0 under USB Considerations section.
2. Add initial install procedure.

Rev Date: 08/19/08

1. Delete VBW specification for PAR (crest factor).

Rev Date: 11/20/08

1. Delete document tracking by alphanumeric revision code and use date only to conform with all other company documentation.

Rev Date: 02/06/09

1. Combine all sensor models LB4XXA/5XXA in one Product Manual and Quick Start Guide for the Power Meter Application.
2. Remove specifications and options by model number and replace with data sheet and order guide reference.
3. Update all graphics and feature content to current design (Software Version A.2.5.0.0).

Rev Date: 02/24/09

1. Update graphics for addressing the sensor to current design; add default instrument state.
2. Update measurement and triggering menus and logger setup to current design.
3. Note application may be supplied on USB flash drive in installation section.

Rev Date: 03/27/09

1. Update limits setup and store/recall menu to current design (Software Version 2.6.0.0).

LBXXXA Series USB PowerSensor+™

Product Manual PMA (Power Meter Application)

Rev Date: 04/09/09

1. Change "Average Power" to "CW Power" when referenced in the measurement setups that were not corrected previously.
2. Add Zero Offset error term to Measurement Accuracy section (as per data sheets).

Rev Date: 08/02/11

1. Add reference to software version 4.5, Windows 7, and LB6XX series sensors.