Product Manual for the

PULSE PROFILING APPLICATION

MODELS LB480A/LB680A

Lady Bug
TECHNOLOGIES LLC

Models LB480A/LB680A USB PowerSensor+™

Product Manual PPA (Pulse Profiling Application)

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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 LB480A Product Manual for the Pulse Profiling Application).

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1. General Information

Introduction

This manual provides information about how to install and operate the LB480A/LB680A models for USB Pulse Profiling PowerSensor+™. Information about product features, specifications, and support is also included. Use the electronic bookmarks shown below (or the table of contents) to reference product features that include all of the toolbar functions. 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.
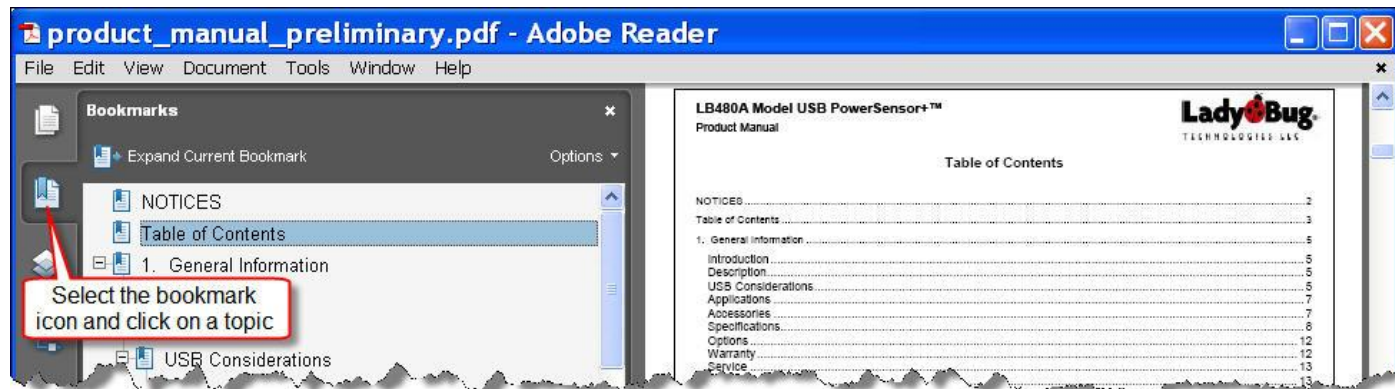
It is highly recommended that you begin with the LB480A Quick Start Guide for the *Pulse Profiling Application* to quickly learn the basics of instrument operation. Alternately, if you want to use the sensor simply as a CW and pulse power meter, refer to the LBXXXA Quick Start Guide and Product Manual for the *Power Meter Application*.

Description

The LB480A USB PowerSensor+™ features a compact power sensor body that connects directly to a desktop or laptop computer using a standard USB port. A separate power meter is not required. The companion *Pulse Profile Application* software provides a front panel display, or Graphical User Interface (GUI**)**, that allows the user to make typical CW and pulse (modulation) measurements. A programmatic interface is also available for the product.

The LB480A power sensor allows for the complete characterization of RF and microwave signals from 100 MHz to 8 GHz with a dynamic range of -60 to +20 dBm. The LB480A is specifically designed for those applications requiring a time domain analysis of pulse and other modulated signal formats.

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 5 VDC(nominal). 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

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

LBXXXA Model connector locations

How to identify the type of USB port
The PowerSensor+™ requires your computer to have USB 2.0 for correct operation. You can identify what port you have using the following method or similar depending on your operating system, either Windows 2000 or XP:

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 and look for the word "Enhanced" or USB2 to indicate that USB 2.0 is present on your computer.

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Applications

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

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

Accessories

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, 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.

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Specifications

NOTE: Refer to the current data sheet for each model for specifications.

Options

Model No. and Options	Description
LB480A	Pulse Profiling Wide Dynamic Range PowerSensor+™ (0.1 – 8 GHz)
LB680A	Pulse Profiling PowerSensor+™ (0.05 – 20 GHz)
Select one connector option:	
+0SM	SMA male
+0SF	SMA female
+0NM	N male
+0NF	N female
Additional Options:	
+20M	Additional male connector[1]
+20F	Additional female connector[1]
+001	Add recorder out (not available with 0W2)
+003	External Trigger – included with the product
+004	Add 100 kHz, 200 kHz, 300 kHz, 500 kHz, 1 MHz, 2 MHz, 3 MHz, 5 MHz, 10 MHz
+0W2	Wideband Video Out (50 ohms) (not available with 001)
+CW3	Three year extended warranty and calibration service
+W03	Three year extended warranty
+C03	Three year extended calibration service

[1] Additional connectors are provided for convenience to allow the user to switch between connector sexes.

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.*

Warranty

The warranty on the 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.

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 PowerSensor+™. 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 input connector.

Calibration Cycle

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

Contact Information

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2. Installing the Software and the Sensor

Initial Inspection

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

Support Contact Information

LadyBug Technologies LLC
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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. 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 product manual to determine if your computer has a USB 2.0 port(s).*

Installation Procedure
Install the Software

You will need the sensor with USB cable (supplied); a compatible computer with available USB 2.0 port; and the software CDs (Qty 2). (Alternately, the application may be supplied on a USB flash drive).

Refer to the Quick Start Card (Windows XP or Windows 7) for the version 4.5 sw installation procedures.

3. Pulse Profiling Overview

Quick Start Guide and Additional Documentation

It is highly recommended that you start with the Quick Start Guide for the *Pulse Profiling Application* to quickly learn the basics of instrument operation. This product manual can then be used as a comprehensive reference for additional information. *(Alternately, if you want to use the sensor simply as a CW or pulse power meter, refer to the LBXXXA Quick Start Guide and Product Manual for the Power Meter Application).*

Measurement Capability

The LB480A/LB680A are specifically designed for those applications requiring a time domain analysis of pulse and other modulated signal formats. Both models use a repetitive under-sampling technique to reconstruct the input signal. This results in an effective sample rate of up to 48 MS/s. Signals with modulation bandwidths up to 10 MHz can be measured with a high degree of accuracy

The differences between the two models are frequency range coverage and noise floor. The LB480A is specified from 100 MHz to 8 GHz with a noise floor < -60 dBm for frequencies < 6 GHz. The LB680A is specified from 50 MHz to 20 GHz (18.6 GHz with Type N connectors) and has a noise floor of -40 to -45 dBm.

The application provides five (5) pairs of markers and five (5) pairs of time gates that are used to take measurements. The time gates allow characterization of the pulse signal to include the following parameters. There is also an automatic measurement feature that allows all of these measurements to be made with a click of a button:

1. Rise time (RT)
2. Fall time (FT)
3. Pulse width (PW)
4. Pulse repetition time (PRT)
5. Pulse repetition frequency (PRF)
6. Duty cycle (DC)
7. Pulse power (Pls)
8. Peak power (Pk)
9. Average power (Avg)
10. Crest factor (CF or CrF)
11. Overshoot (OvSh)
12. Droop (Droop)
13. On/Off ratio

The gates also provide three groups of canned measurements:

1. Power Set (peak power, pulse power and crest factor)
2. Time & Frequency Set (pulse width, pulse repetition time, pulse repetition frequency)
3. Mixed Set (peak power, crest factor, pulse width, pulse repetition frequency)

Zeroing and Reference Power Calibration

The innovative design (patent pending) of the PowerSensor+™ does not require zeroing or power calibration before use and there is no provision for zeroing or calibration.

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4. The Elements of the Display Panel

Sensor Information

Toolbars

The main elements of the default display are shown below with no signal applied to the sensor. We will demonstrate the features and functionality of the user interface in the following section of this manual entitled "The Toolbar Functions". The main elements of the display are:

- The Banner with sensor information
- The Toolbars
- The Dockable Windows (Panoramic Trace; Measurement Trace; Auto Measure; Results; CDF, CCDF & PDF)

The Banner at the top of the user interface indicates the model number of the power sensor, the unit address, and the unit serial number. The Toolbars allow you to configure the sensor for any given measurement and provide for housekeeping tasks. The Dockable Windows or panes give a visual presentation of the input signal to the sensor: The top graph is called the **Panoramic Trace** and the bottom graph is called the **Measurement Trace**. You can highlight a portion of the Panorama by clicking and dragging the cursor directly on the Panorama View. This highlighted time segment will then appear in the Measurement View. This allows for a more detailed examination of the signal using time markers and time gates. The **Auto Measure** pane allows you to make a comprehensive list of measurements with a click of a button. The **Results** pane (inlay) allows you to manually setup the markers and gates for a given measurement as we will demonstrate. The **Results** pane shows the measurement readings that include the current trace values and the marker and gate values. The current trace values are also listed above the grid in the Panorama View (circled). The **Results** pane provides convenient access to the tools needed to manipulate the signal display in the Measurement view. You can scroll left and right; zoom in and out; reset or highlight the span; and select the pointer mode. The **CDF, CCDF & PDF** pane gives you some tools for statistical analysis - *see Section 6. Statistics.*
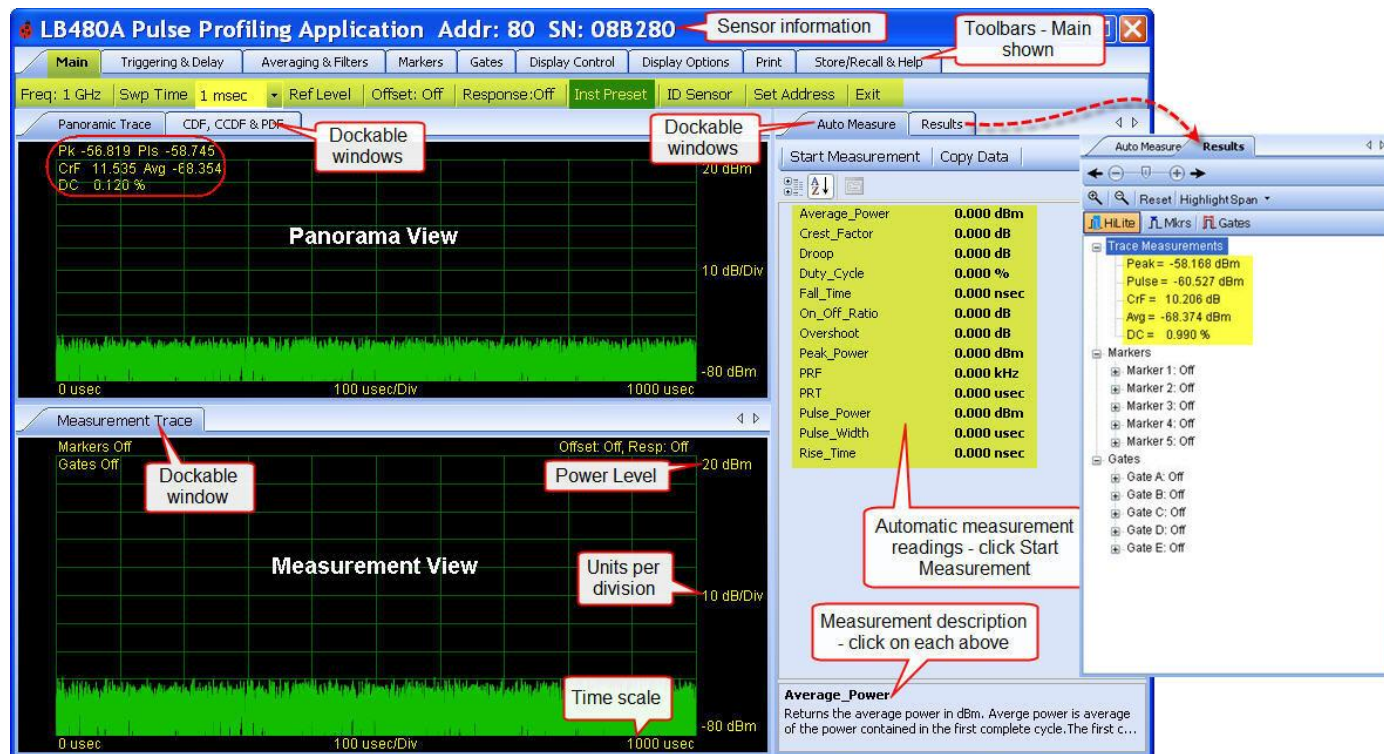
The Dockable Windows can be repositioned to maximize the display areas. We will explain the docking features next to allow you to manage the display presentation to your liking.
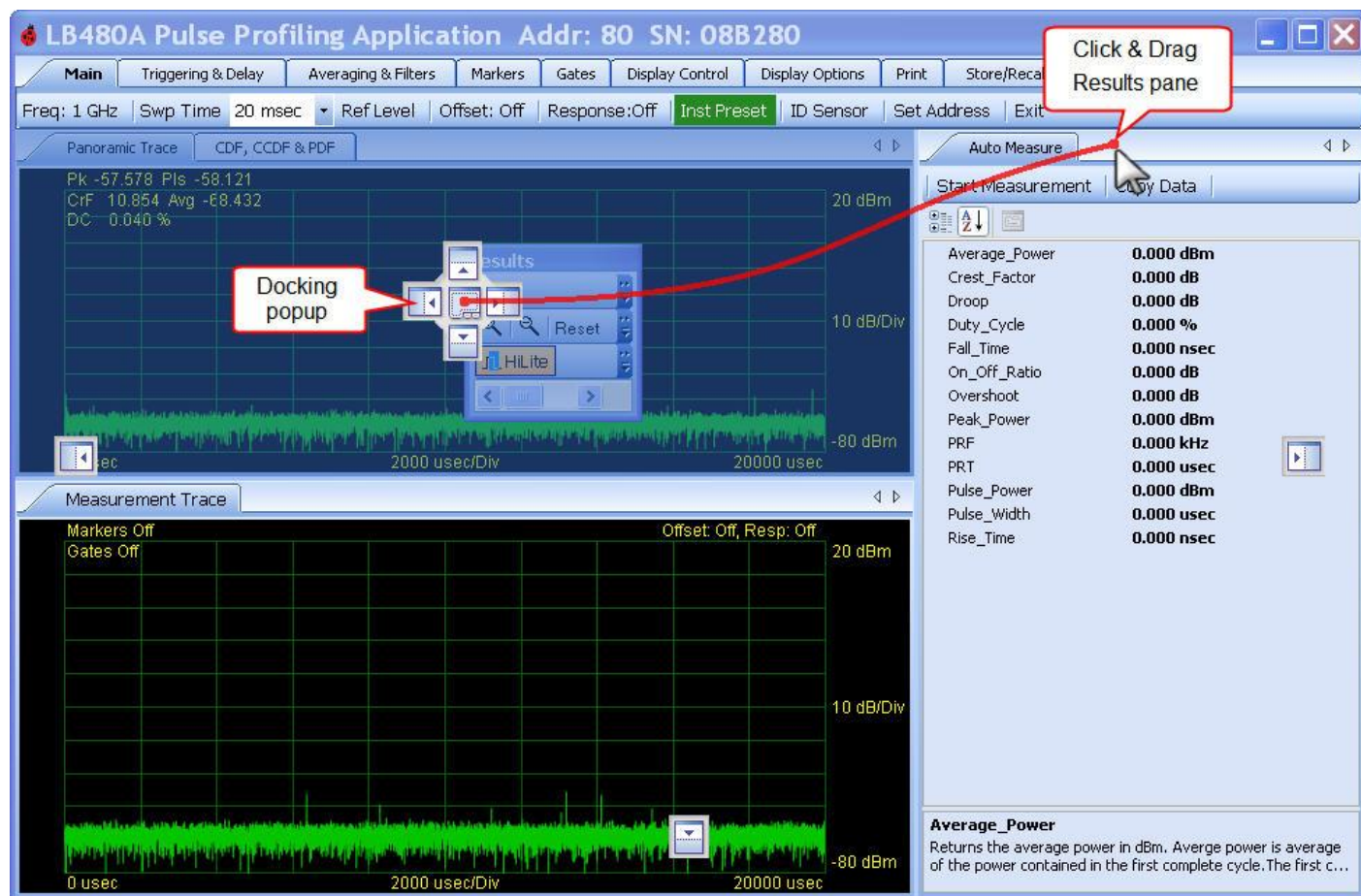
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Dockable Windows

You can position any of the five dockable windows (or panes) anywhere on the panel using the docking feature. You can also auto-hide a pane(s). We will demonstrate both in the following sequence. To activate the docking popup click and drag the cursor from one of the dockable window tabs. Then select a position (top, bottom, center, right, left) on the popup to place that display or pane on the panel.

We will demonstrate moving the **Results** pane over the **Panoramic Trace** in the next three screen shots: First, drag the **Results** tab over the **Panoramic Trace** and hold until the docking popup appears as shown below. See how the drop zone becomes highlighted. Now release the mouse on the center overlay position on the **Panoramic Trace**. Do the same thing with the **Auto Measure** pane.

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You will see the following two screens with the **Auto Measure** pane first on top. Now click the **Panoramic Trace** tab to put it on top and to see one way to expand the viewing area of the signal.
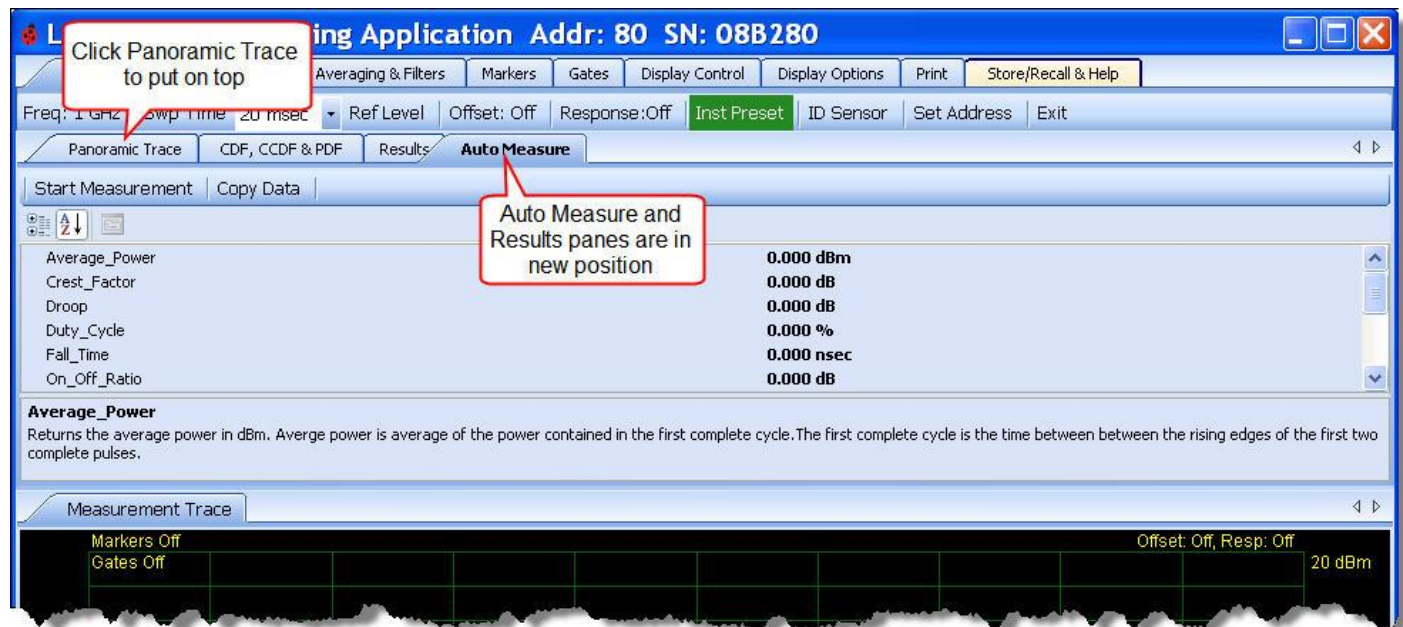
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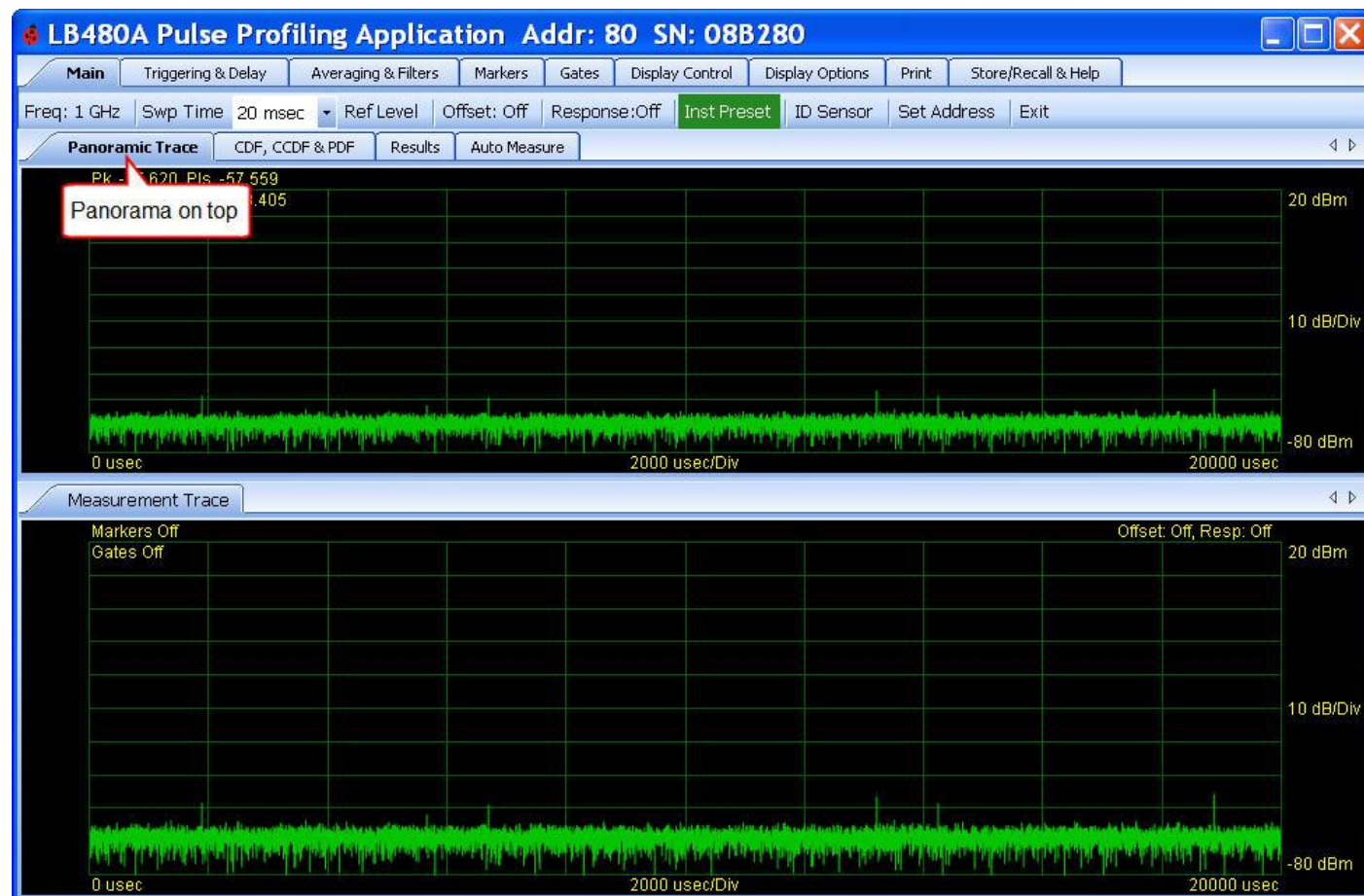Product Manual PPA (Pulse Profiling Application)

Next, drag the **Measurement Trace** tab over the **Panoramic Trace** and drop it in the center of the docking popup like we just demonstrated. You will see the screen below with the **Measurement Trace** expanded even more with no stimulus applied to the sensor.
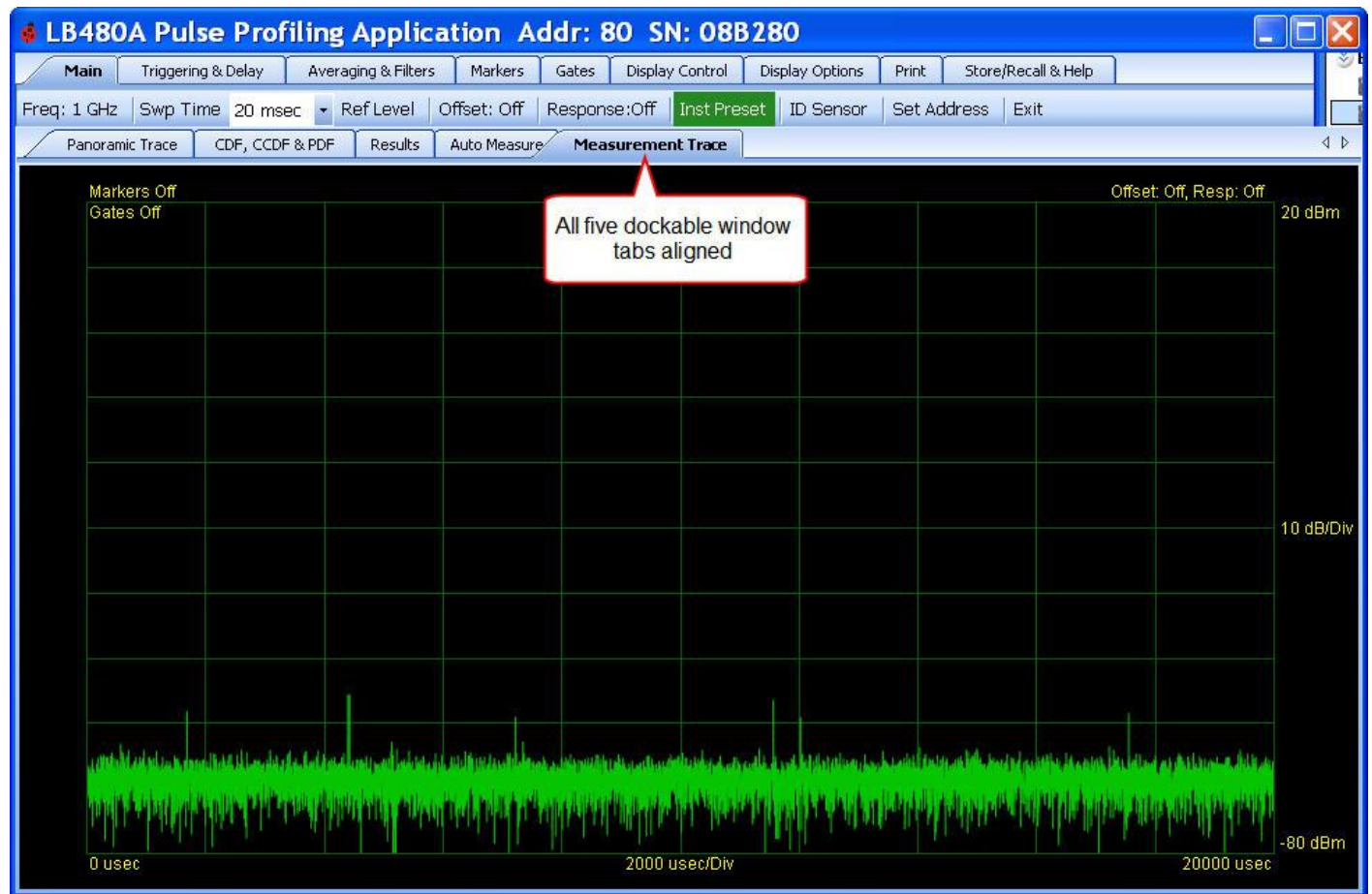
NOTE: You can also drag a docking tab onto the desktop (not shown). Double click on it or drag it back on the panel, then position it as previously described. You can adjust the size of each pane by clicking and dragging along the border areas as is typically done.
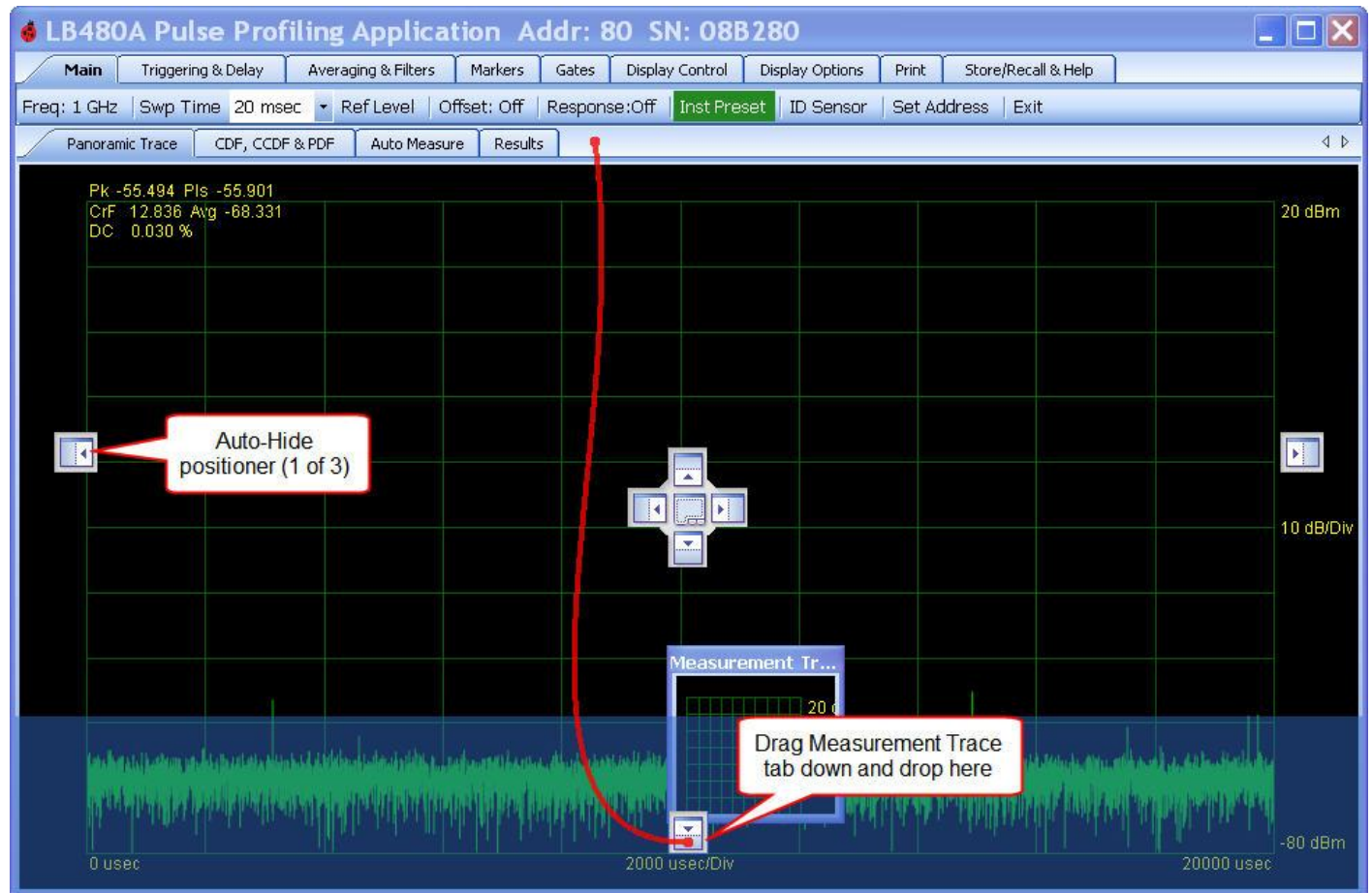
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Lastly, we demonstrate the Auto-Hide feature of dockable windows from the previous screen. Drag the **Measurement Trace** tab down until the docking popup appears and drop it on the bottom Auto-Hide positioner as shown below.

The **Measurement Trace** will move to the position indicated with Auto-Hide active as shown below. This means the display is not pinned to the panel and you must point to the Measurement Trace tab to view it. Toggle the Auto-Hide icon to turn this feature off or to pin the pane to the panel for continuous viewing.
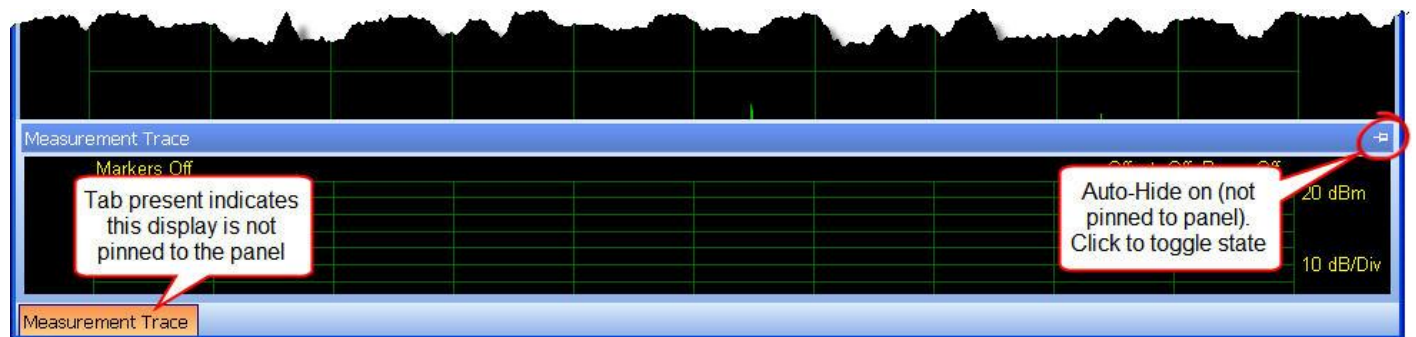
NOTE: A docking tab must be pinned or, in other words, Auto-Hide must be off in order to move it to another location.

The next section of this manual covers the toolbar functions.The toolbars comprise the largest section of this manual.

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5. The Toolbar Functions

Display Control Toolbar (Pointer Control)

Results Pane
Zoom
Reset
Highlight (Mode)
Markers (Mode)
Gates (Mode)

The Pulse Profile Application is designed to be highly interactive using the mouse. The mouse pointer has three modes of operation: **Highlight**, **Markers** and **Gates** . The Pointer Control (highlighted in yellow below) shows what mode is active for cursor control. The default mode is **Highlight**. These controls are available from the **Display Control** toolbar and in the **Results** pane for easy access. The screen below shows an arbitrary input to the sensor. The mouse pointer is in **Highlight** mode and a section of the span on the **Panoramic Trace** has been highlighted. This highlighted time seqment appears as the bottom **Measurement Trace** to allow for closer examination. Again, the **Display Control** toolbar mimics the same controls in the **Results** pane so you can readily tell what mode is active. **Highlight** is used in conjunction with **Markers** and **Gates** to take measurements. These measurements will then be displayed in the **Results** pane. The **Trace Measurements** in the **Results** pane will always indicate the Peak, Pulse, CrF (Crest Factor), Average (power in the pulse), and Duty Cycle. You can expand or collapse the individual headers in the **Results** pane. Notice that there is a short discription of each toolbar function when you hover over it with the cursor.
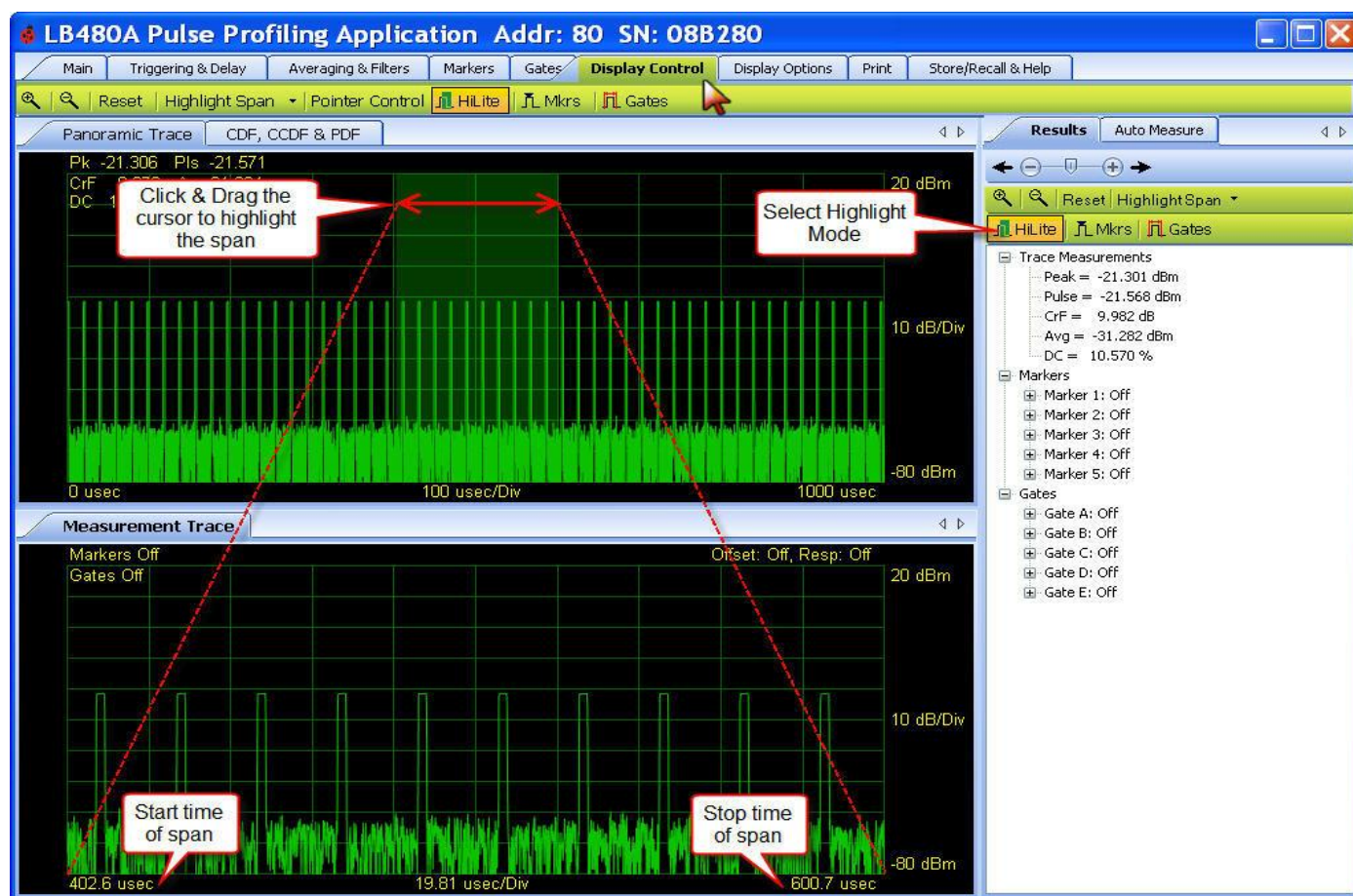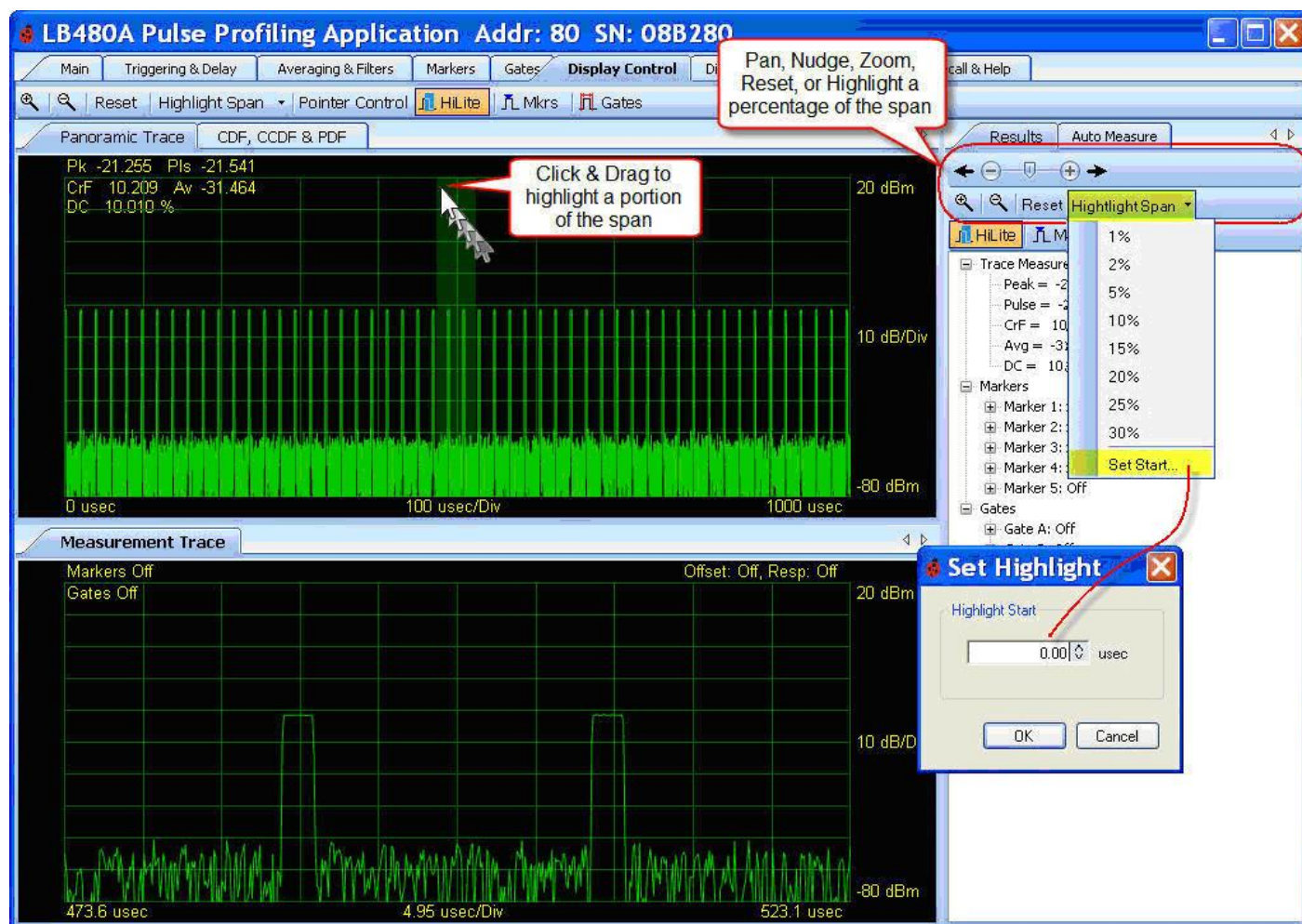
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The screen shots in this document use the following input to the LB480A sensor for demonstration purposes:

- Carrier Frequency = 1 GHz
- Modulation = ~50 kHz Pulse
- Duty Cycle = ~10%
- Pulse Width = ~2 usec
- Power = ~-20 dBm
- Sweep Time = 1 msec

Highlight Span

The **Panoramic Trace** and the **Measurement Trace** are designed to work in tandem to help the user identify and investigate areas of interest easily and quickly. To view a portion of the **Panoramic Trace** in more detail you need only select or highlight the portion of the trace in which you are interested. Refer to the screen shot below for the following discussion. After selecting **Highlight** mode, you can select a span in either the Panorama or Measurement views by dragging the cursor over the display. You can scroll, nudge or zoom in and out across the span or **Reset** it. You can also highlight a specified percentage of the span from the **Highlight Span** drop down. **Highlight Span** allows you to highlight a specified percentage of the sweep instead of pointing and clicking the cursor over the span. You can precisely set the point in time to start the highlighted percentage of the trace using the **Set Start** menu selection.

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You can highlight or select a portion of the trace using the following techniques:

1. Click and drag the mouse over a portion of the **Panoramic Trace** – only the portion selected by the mouse movement will be viewed in the **Measurement Trace**.

2. Click and drag the mouse over a portion of the **Measurement Trace** – only the portion selected by the mouse movement will be viewed in the **Measurement Trace**. This technique allows you to sequentially zoom in on a small portion of the trace. The mouse pointer *must* be in **Highlight** mode.

3. Click the **Highlight Span** drop down on the **Results** pane (or **Display Control** toolbar) and then select the percentage of interest. The selected portion will be viewable in the **Measurement Trace** understanding that:

    a. If a portion of the trace is currently being viewed the highlight of the selected percentage will be centered on the current area of interest.
    b. If a portion of the trace is not selected then the percentage will be centered around the middle of the current panorama trace.

4. To select a precise portion of the trace click the **Highlight Span** drop down and then select **Set Start**. Enter the beginning of the measurement trace in microseconds. Doing this in conjunction with the previous option allows you to select a very precise portion of the trace.

5. Click the **Zoom In** or **Zoom Out** buttons. These buttons double or halve the current viewing area. These buttons are available in the **Results** pane and in the **Display Control** toolbar.

6. Click the **Reset** button – this causes the entire **Panoramic Trace** to be made viewable in the **Measurement Trace** window. In other words, resetting selects the entire **Panoramic Trace**.

7. Use the scroll and nudge controls in the **Results** pane. These controls allow you to scroll the area of interest left or right. The nudge controls move the area one small step at a time.

Once you configure the input to your sensor it is helpful to practice using the highlight and the scroll/zoom/nudge controls to see the effect.
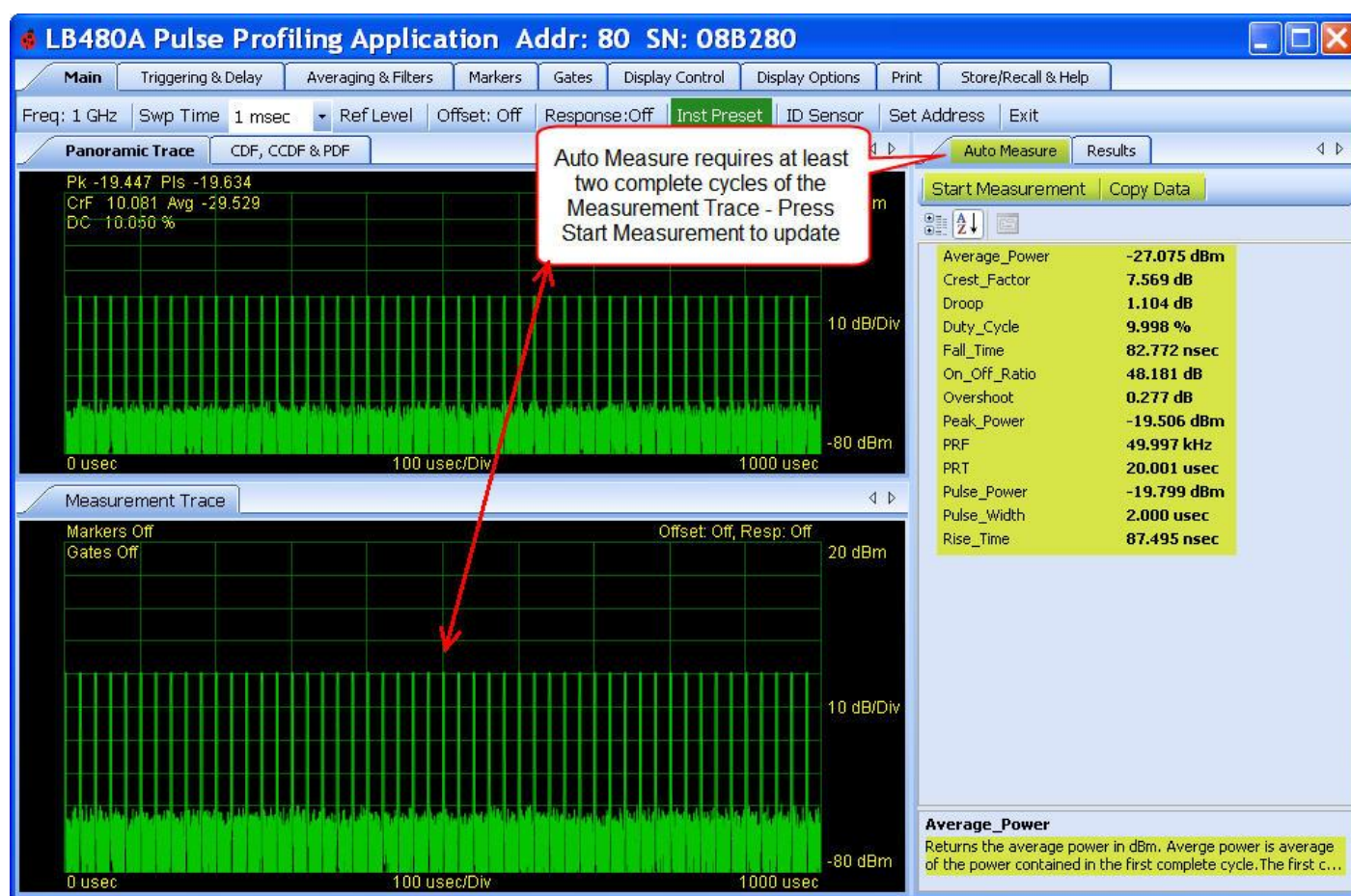
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Auto Measure Pane
Start Measurement
Copy Data

The **Auto Measure** feature requires at least two complete cycles of the pulse to be viewable in the **Measurement Trace** window in order to make an accurate measurement. Otherwise, you will see indeterminate numbers for the measured values. The **Auto Measure** pane or window comes up by default next to the **Results** pane and is one of the dockable windows which can be placed anywhere on the panel. Shown below is an example of an automatic measurement using our example input. The automatic measurement feature is very convenient and gives a complete characterization of the pulse with a click of a button based on the selected sweep time. Click **Start Measurement** to capture the instantaneous values shown below. The readings will not continuously update but will make a single sweep of the trace. You must click **Start Measurement** each time to update the measured readings. A description of each measurement is shown at the bottom of the pane when you click on the measurement label. Click **Copy Data** to copy the measurement results to the clipboard then paste it to your document of choice.

NOTE: The **Auto Measure** feature requires at least two complete cycles of the pulse to be viewable in the **Measurement Trace** window.

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Main Toolbar
Frequency
Sweep Time
Reference Level
Offset
Response

The **Main** toolbar shown below allows setting of the measurement **Frequency**; **Sweep Time**; **Reference Level** and **Resolution**; **Offset** and (frequency) **Response**. Again, the measurement frequency should correspond to the incoming signal frequency.
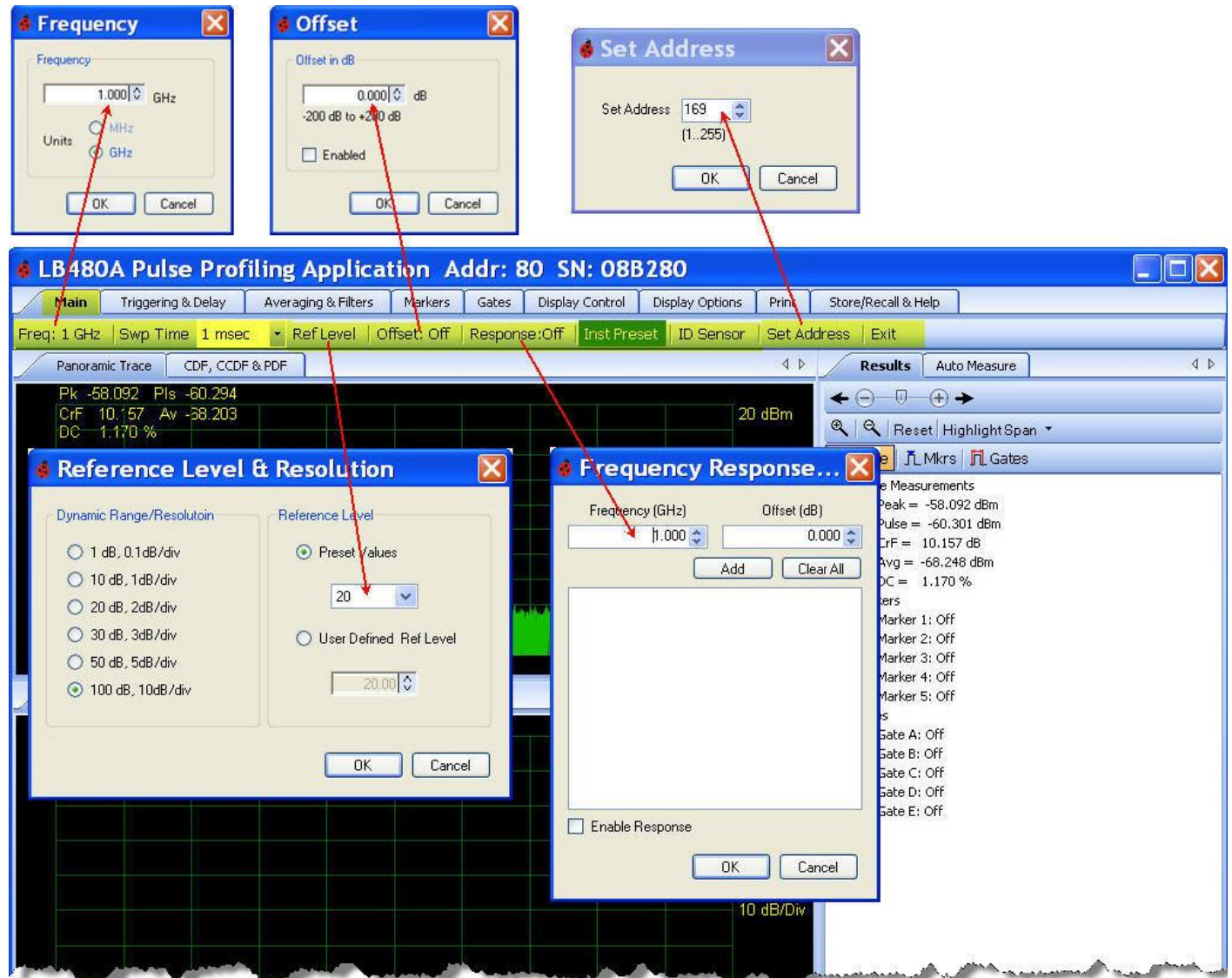
NOTE: The reference level and resolution settings change the formatting of the data that is presented whereas offset and response modifies the measured values.

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Setting the **Frequency** is essential to making accurate measurements. As with all power sensors, LadyBug corrects the readings based on a known incoming frequency. In the past this has been referred to as calibration factors or simply cal factors. Large errors can occur without setting the **Frequency** especially at the upper end of operation. Therefore, the **Frequency** setting must correspond to the input to achieve the most accurate measurements.

The following table shows the relationship between **Sweep Time**, sample rate, and total number of samples. Notice that the resolution of most computer displays is limited to somewhere between 1000 and 2000 points. This is a physical limitation of all displays. However, the measured data has substantially more resolution. Accordingly, you must zoom in to see maximum detail on a 10000 point trace. By providing a panoramic view, and a second potentially more detailed measurement view, LadyBug enables you to see both the forest and the trees.

The resolution of the trace changes with the **Sweep Time** as shown in the table below. Normally this resolution would be a serious and perhaps unacceptable limitation. However, LadyBug provides a delayed measurement capability. This enables you to see small portions of data in greater detail long after a trigger has been acquired.

Sweep Time	Time Between Samples	Length of Trace
10 usec	0.0208 usec	480 points
20 usec	0.0208 usec	960 points
50 usec	0.0208 usec	2400 points
100 usec	0.0208 usec	4800 points
200 usec	0.0208 usec	9600 points
500 usec	0.05 usec	10000 points
1000 usec	0.1 usec	10000 points
2000 usec	0.2 usec	10000 points
5000 usec	0.5 usec	10000 points
10000 usec	1.0 usec	10000 points
20000 usec	2.0 usec	10000 points
50000 usec	5.0 usec	10000 points

The **Reference Level** shifts the viewing area and it does not affect the measured values. When you click the reference level button the dialog box allows you to select a **Resolution** coupled with a viewable dynamic range (due to a fixed number of vertical divisions). The **Panoramic Trace** and **Measurement Trace** panes always display 10 vertical and 10 horizontal divisions. The **Reference Level** can be set using one of the preset values or a user defined value.

The **Reference Level** selections apply to both the Measurement view and the Panorama view. The **Resolution** setting apply only to the Measurement view. There is provision for offsetting the input over the range shown. Select **Offset** to enter a value and to enable/disable this functionality. The **Offset** and **Response** annunciators are visible above and to the right of the measurement grid.

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Offset provides a single valued offset to all measured data. **Offset** shifts the actual values of the measured data (not the viewing area). Simple offsets can be useful but they are limited in that they are not sensitive to frequency. If there is a frequency sensitive device in the measurement path, offset becomes very cumbersome since every frequency change must be accompanied by a change in offset.

To solve this problem use the **Response** tool. It is ideal for correcting measurements through devices like directional couplers. The **Response** function allows you to enter a set of amplitude and frequency pairs. As the user changes the frequency of measurement, the application automatically adjusts the offset based on the frequency selected by the user.

Both **Offset** and **Response** can be enabled and disabled without changing the data. This allows you to setup a response and enable and disable it without removing the data.

Instrument Preset

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

Frequency = 1 GHz
Sweep Time = 1 msec
Reference Level & Resolution = 20 dBm, 10 db/Div
Offset = 0 dB, disabled
Response = 0 dB, disabled
Trigger Source = Internal Auto
Trigger Level = -35 dBm
Trigger Edge = Positive
Trigger Mode = Continuous
Delay = 0 usec, disabled
Trigger Out = Off, Non-inverted
Averaging = 10, Off
Filter = 10 MHz with Option 004; 100 kHz without Option 004
Poles = 4 with option 004;1 with Optoin 004
Markers = All Off
Measurement Threshold = -55 dBm, On
Pulse Criteria = 6 dB (see Markers toolbar)
Gates = All Off
Display Font = Arial, 8 pts
Theme = Green
Grid = On
Results pane font = Arial, 9 pts
Auto Measure pane (not applicable)
Measurement Trace notation = Arial, 9 pts
Panoramic Trace notation = Arial, 9 pts
Measurement Trace is reset

ID Sensor
Set Address
Exit

The **ID Sensor** button causes the green LED on the back of the sensor to blink. This allows you to quickly associate a particular sensor with a particular window. It is especially useful if you have more than one sensor attached to the computer. The **Set Address** tool allows you to change the sensor address (1 to 255). Changing the unit address will cause the application to close. You must then re-start the application to initialize the sensor. The **Exit** button allows you to close the application.

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Markers Toolbar
Normal Markers

Markers are used to make measurements at a particular point (**Normal Markers**) or measure the difference between two points (**Delta Markers**). Markers are only available in the Measurement view. The value of each marker is displayed in the **Results** pane. The value of the active marker is displayed in the upper left portion of the Measurement view unless it is turned off – see the **Meas Notation On/Off** button under the **Display Options** toolbar.
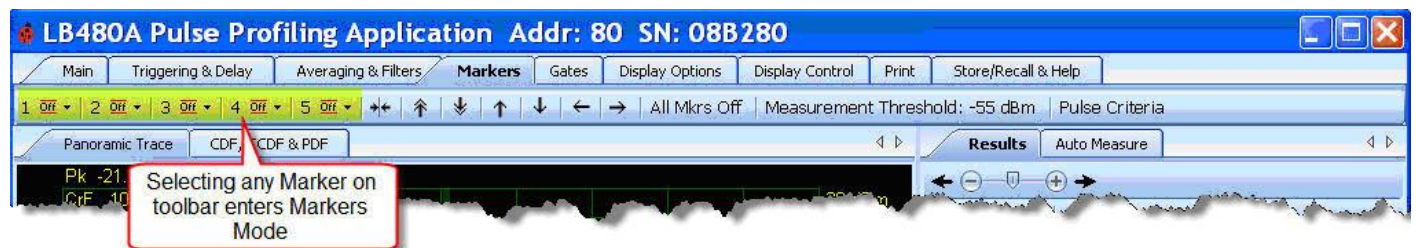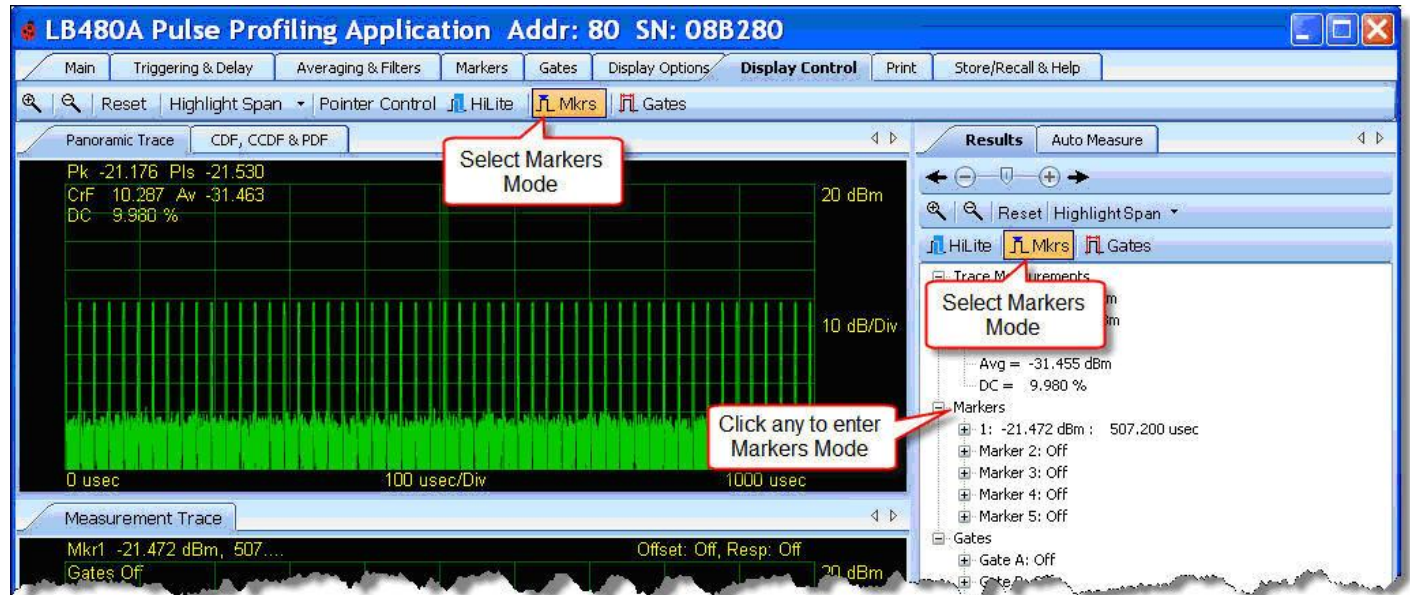
To manipulate (move or place) a particular marker the mouse pointer must be in the **Markers** mode. Because pointer modes are changed quite often there are a number of ways to change modes as shown above. You can select the **Markers** mode in four ways:

1. In the **Results** pane select the **Markers** mode icon.
2. In the **Results** pane click on any marker node. For instance, click the node labeled "Marker 1" to set the pointer mode to **Markers**.
3. Under the **Display Control** toolbar select the **Markers** mode icon
4. Select the **Markers** toolbar and select any numbered marker button.

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Now select the **Markers** tab on the toolbar and click the down arrow on marker 1 to enter the setup as shown below.

There are five marker pairs (1-5) on the **Markers** toolbar. These same markers are available from the **Results** pane. Each pair consists of a **Normal Marker** and a **Delta Marker**. **Normal Marker** is a single data point and appears above the measurement trace. **Delta Marker** gives the differential value and appears below the trace. **Markers** are activated by clicking on the number in the toolbar.

Set Position

You can set the marker position precisely in time by selecting **Set Position** from the marker drop down and entering a specific value as shown below.
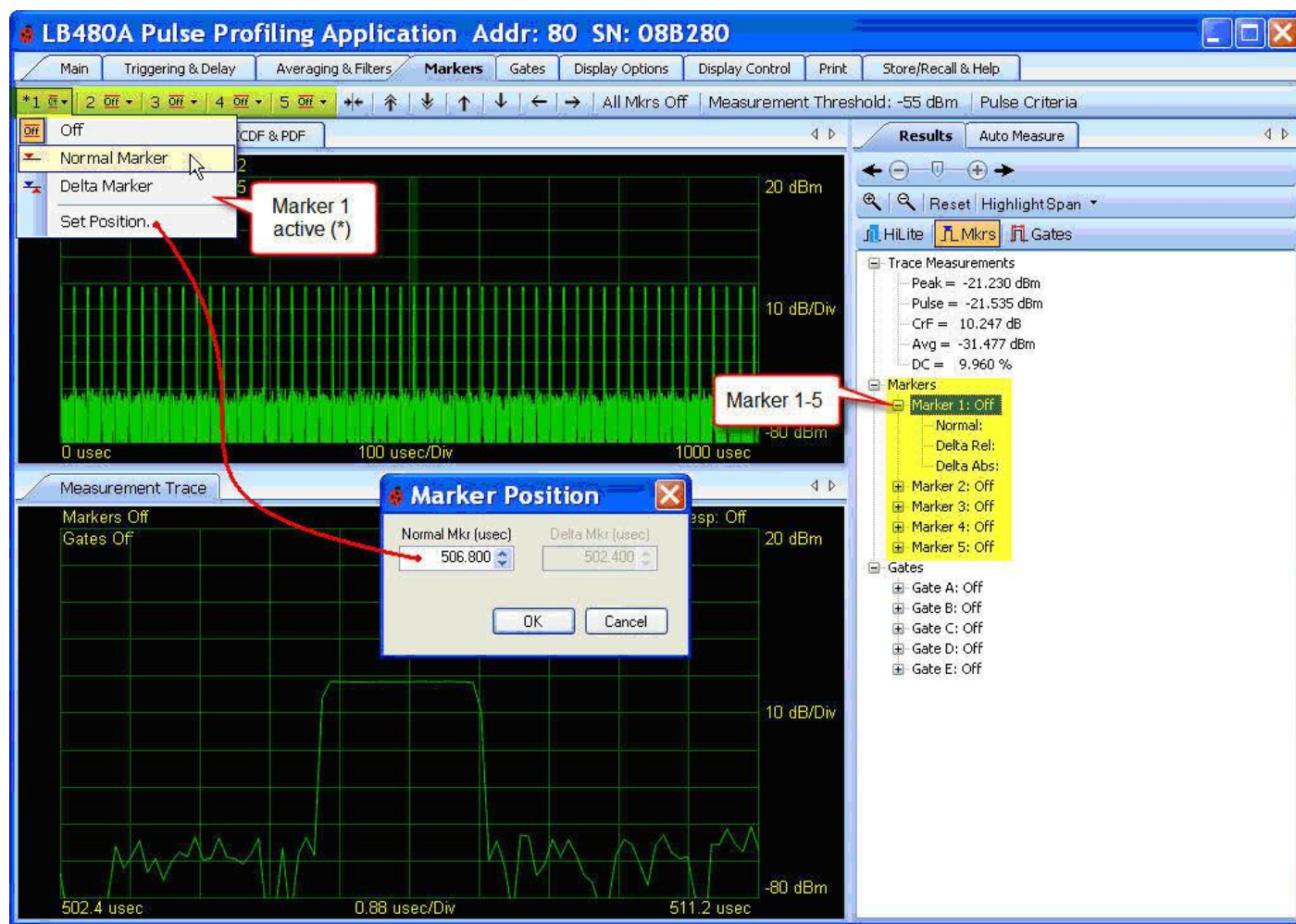
Only one marker can be active at a time although all five markers (or marker pairs) can be displayed simultaneously. The active marker will have an asterisk (*) next to its number in the toolbar and the marker number will be underlined and appear slightly larger in the display.

Once a marker is turned on (Normal or Delta) and the pointer mode is set to **Markers**, you click or click and drag on the measurement area to position the marker. As you move the marker the notation in the upper left corner of the measurement grid will be updated. The x value (time) is determined by the position of the cursor. The y value (magnitude) is determined by the value of the trace closest to that point in time.
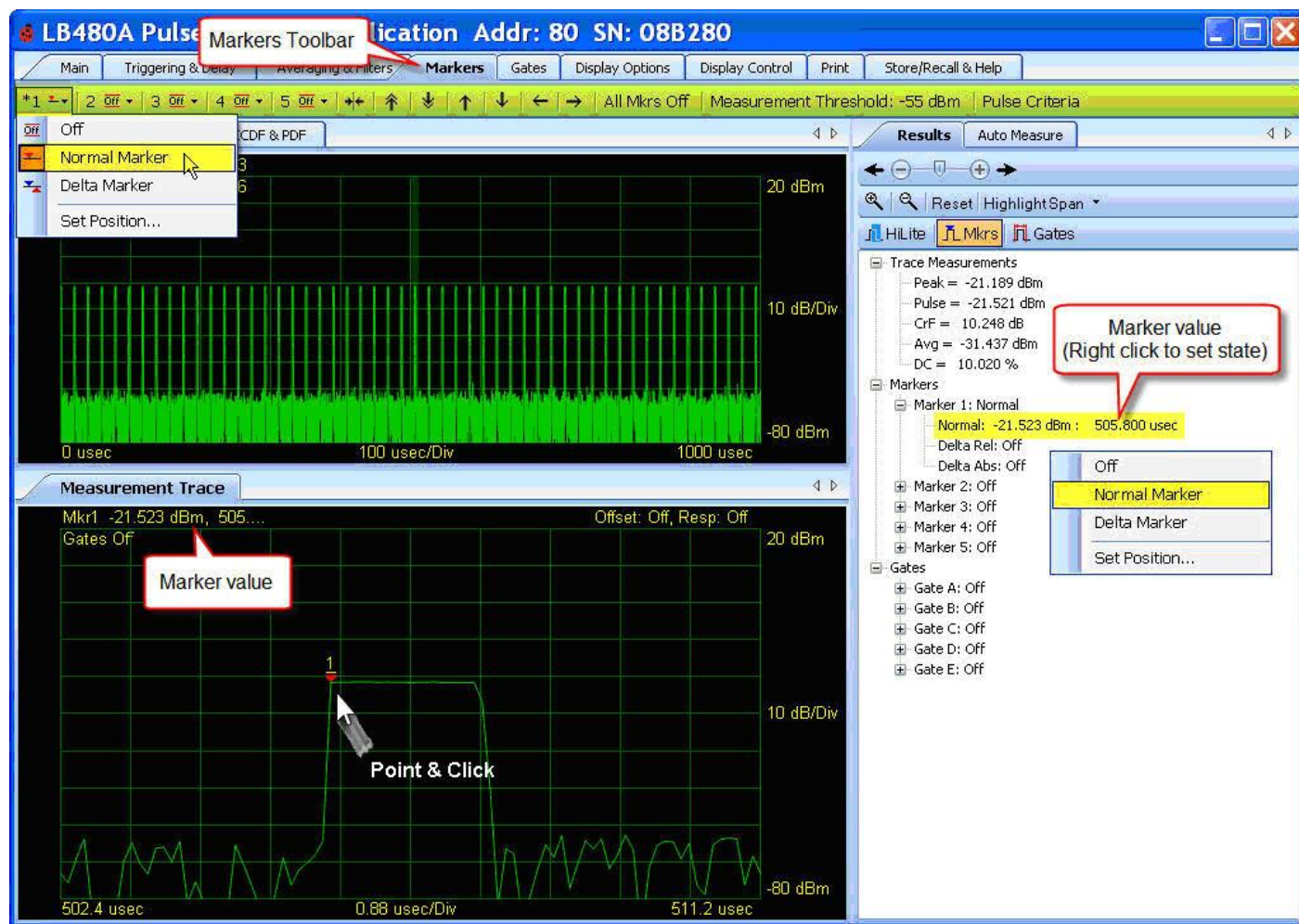
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Delta Markers

To use the delta function you position the **Normal Marker** at the desired point then select **Delta Marker**. You set the **Delta Marker** (using the mouse pointer) in a manner similar to positioning the **Normal Marker**. **Zoom** and **Scroll** can be used to more precisely locate the markers. The following two screen shots demonstrate first the **Normal Marker** and then the **Delta Marker** functions.

First, **Highlight** a single pulse in the panorama as previously described. Next, select the **Markers** tab on the toolbar and select **Normal Marker** from the **Markers 1** drop down as shown. You can also right click on the marker tree in the **Results** pane to access this drop down for each individual marker. **Marker 1** will appear at center graticule in the Measurement view. Expand the markers tree if it is not visible. Now click anywhere on the trace (the rising edge in this example) to set the marker position. Notice that the marker value (power and time) is visible in the **Results** pane and above the grid in the Measurement view (Mkr1).

NOTE: Only one marker can be active at a time. The active marker will have an asterisk (*) before its number in the Markers toolbar. The marker tree in the **Results** pane will not show the active marker.

The **Delta Marker** function is demonstrated next from this same screen shot.

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Now select **Delta Marker** from the **Markers 1** drop down shown below and click anywhere on the trace (the falling edge in this example) to position the second element of the marker pair. The annotation in the **Results** pane will now indicate the differential marker 1(**Delta Rel**ative) value in time and magnitude as well as its absolute value (**Delta Abs**olute). Also, the relative marker value will appear above the grid on the measurement view (DMk1). Follow this same process to setup the other markers. You can setup all the markers in either mode (Normal or Delta) but only one marker can be active at a time. Simply click on the marker to activate and read its value. You can also read the measured value in the **Results** pane. While the **Delta Marker** is convenient for measuring the time between two points (pulse repetition time, pulse width, etc.) it can also be used to measure frequency. As the delta marker is moved you will notice in the **Results** pane the inverse of the time (frequency) is also reported: So if you placed the normal marker on one pulse and the delta marker on the next adjacent pulse you could read the PRF (pulse repetition frequency).
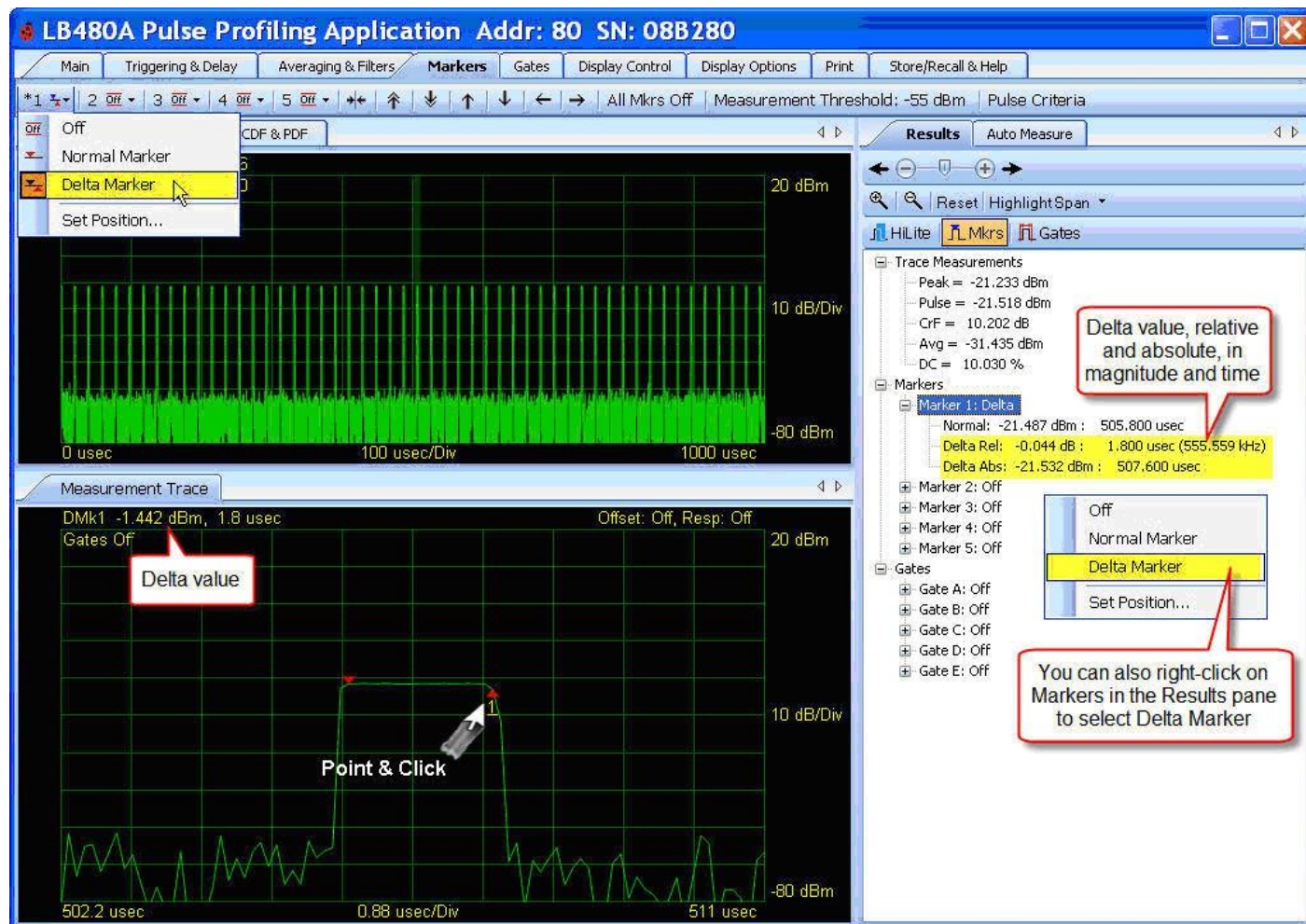
NOTE: You can highlight in the Panorama view without switching modes. However, if you attempt to highlight in the Measurement view while in a different mode (**Markers** or **Gates**) you will affect the positioning of the individual markers or gates.
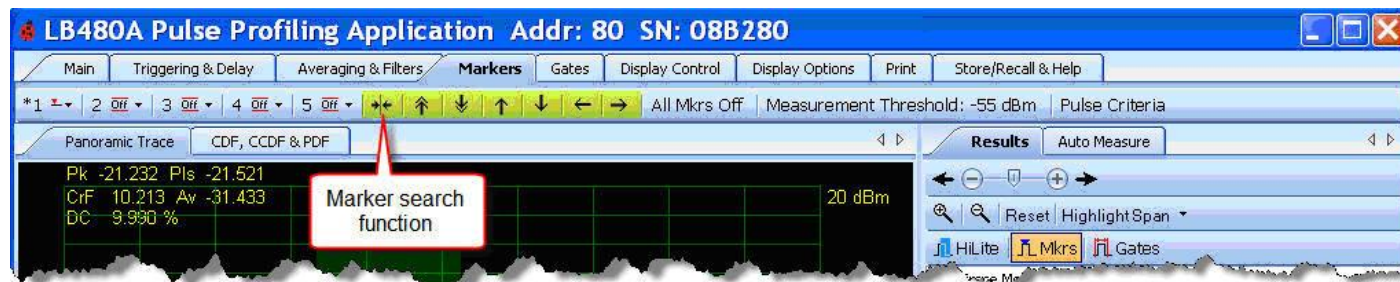
The marker search feature is covered next in additon to the remaining toolbar controls.
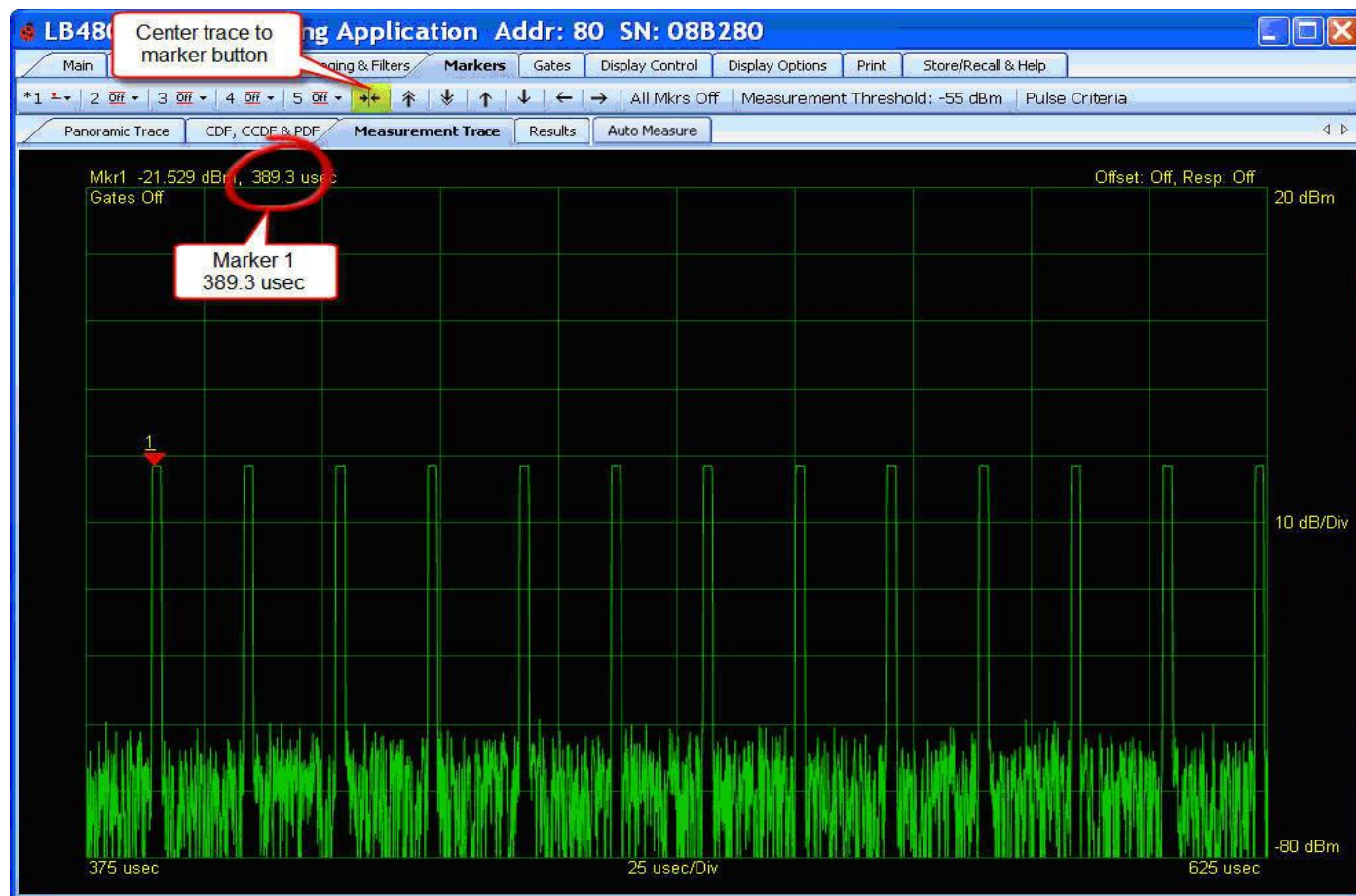
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Marker Search

The marker search tool shown below allows the active **Normal Marker** to automatically jump to minimum or maximum peak value or directional peak value. Also, the center of the measurement display can move to the active marker position. Hover over the arrows for a description of each action.

EXAMPLE: We have moved the dockable **Measurement Trace** pane for better viewing in the next screen shot to demonstrate the **Center trace on marker** function. Notice the marker 1 position in time before we click the corresponding button.


NOTE: The marker search will be affected by continuous waveforms whose pulse characteristics vary in amplitude so as to cause the search to jitter on instantaneous peaks. You can stablize the trace may switching to single trigger. Refer to the **Triggering & Delay** toolbar for setting the trigger source.

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Now click **Center trace on marker** on the toolbar and look at the screen below to see the result. Notice the time scale has shifted and the marker is at center graticule on the display.
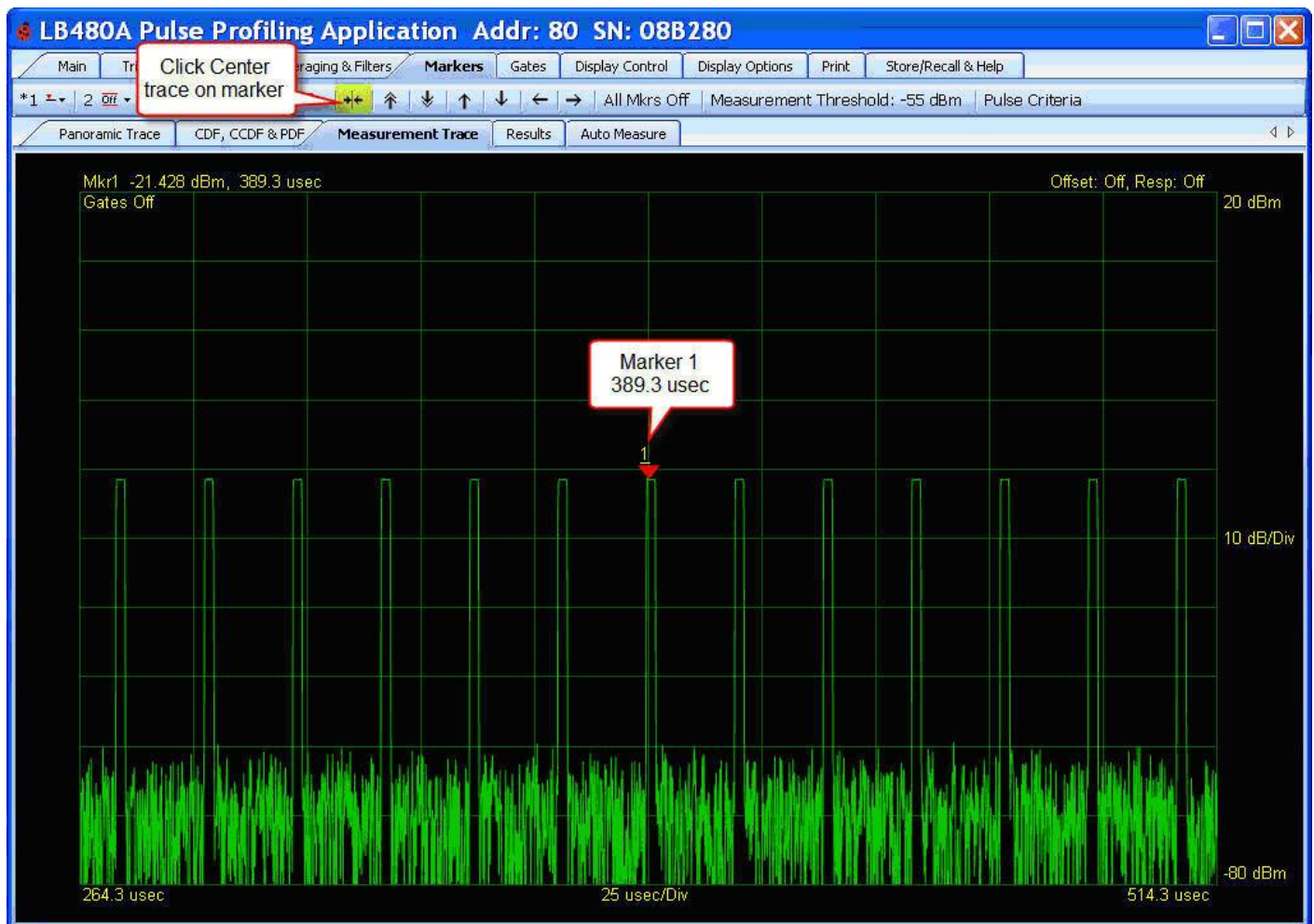
All Markers Off

The **All Mkrs Off** button on the toolbar does just that and resets all the markers 1-5. You will lose marker positioning if you click this button.
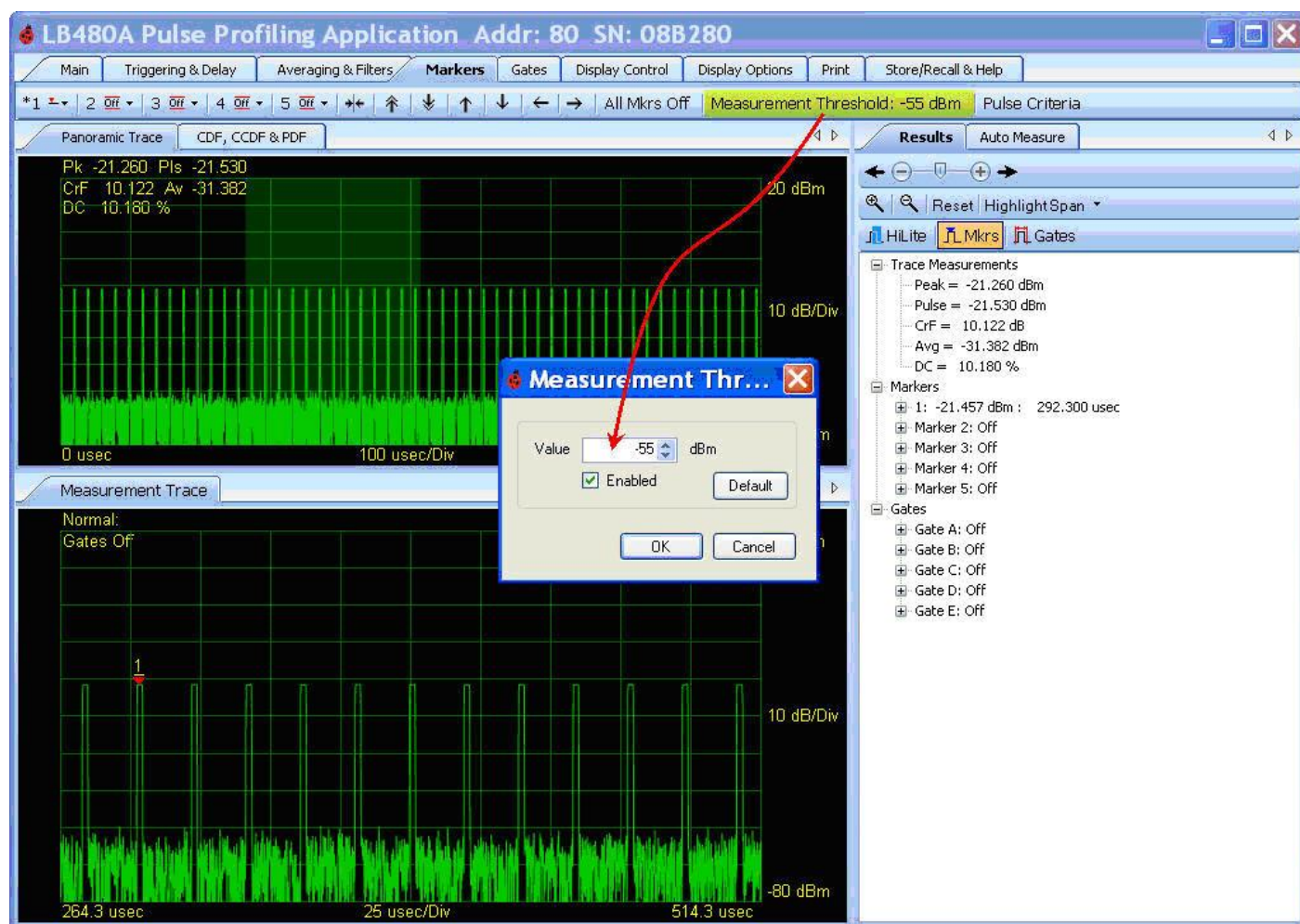
Measurement Threshold

The marker search tool works in conjuction with the **Measurement Threshold** function shown below. The **Measurement Threshold** sets the minimum value of the peaks considered by the marker and gate search algorithms. The **Measurement Threshold** is adjustable across the limits of the dynamic range of the instrument. The default setting is -55 dBm and the function must be enabled/disabled from the dialog box.

NOTE: The **Measurement Threshold** function is also used to set the lower limit of data used in gated measurements.

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EXAMPLE: Set **Measurement Threshold** to -20 dBm. Setup a normal marker on top of the pulse. Click **Marker to next peak right** and notice the active normal marker requires the threshold value to be met before it will search for the next peak. Since our signal is below -20 dBm it will not move. Set the marker threshold back to the default value (-55 dBm).
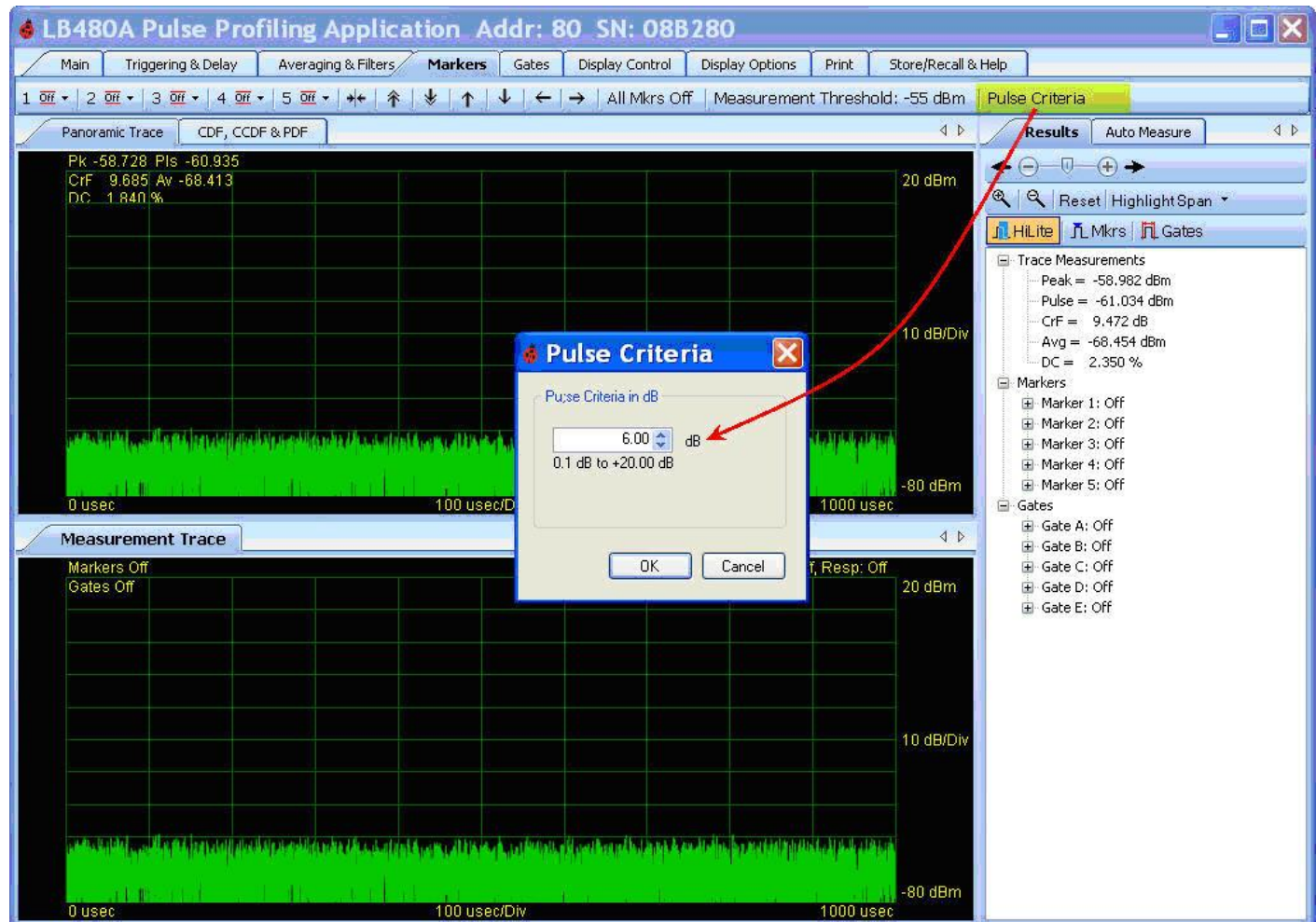
Pulse Criteria

Pulse Criteria is used to define the beginning and the end of a pulse. More precisely, pulse criteria defines the edges of the positive portion of the entire pulse. The pulse criteria is relative (or added) to the measurement threshold if threshold is enabled. The pulse criteria is relative to the noise floor if threshold is disabled: For example, if the threshold is -55dBm (default) and the pulse criteria is 6 dB, then the resultant level is -49 dBm. This means that the signal level must exceed -49 dBm before the start of a pulse is considered to have occurred. It also means that the level must subsequently fall below -49 dBm to define the end of a pulse. The area between the rising edge and the falling edge defines the outer edges of a pulse.

Pulse Criteria is used to define that portion of the total trace that is to be considered part of a pulse. While this measurement is useful and necessary it is not sufficient to make pulse measurements. We still have to analyze the pulse to define the pulse top. For this we must discover the points on the rising and falling edges that are 3 dB down from the pulse top.

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With these additional calculations we now have sufficient information to make proper pulse measurements. We can calculate the peak, droop, pulse power, and pulse width. These pulse measurements often represent a starting point for other measurements such as PRFand PRT. The Pulse Criteria dialog box is shown below with the default value of 6 dB.

NOTE: The **Pulse Criteria** definition stated above applies to data used in both marker and time gated measurements.

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Gates Toolbar
Measurement Description

Time gates allow the complete characterization of the incoming signal. Five time gate pairs (A-E) are available and each gate pair has its own toolbar. Just as the manipulation of markers required the pointer mode to be in **Markers** mode, the manipulation of gates requires that the pointer be in **Gates** mode. Just like markers, a gate must be active for you to move, relocate or measure using that gate. Click close to one end point then you can move it over the entire span. The sensitivity of the LB480A is such that it can measure a 325 nsec pulse at -55 dBm (or lower) with a PRF up to 250 kHz.

Below is a general gate positioning diagram that shows where to place the gates for the various measurement types.
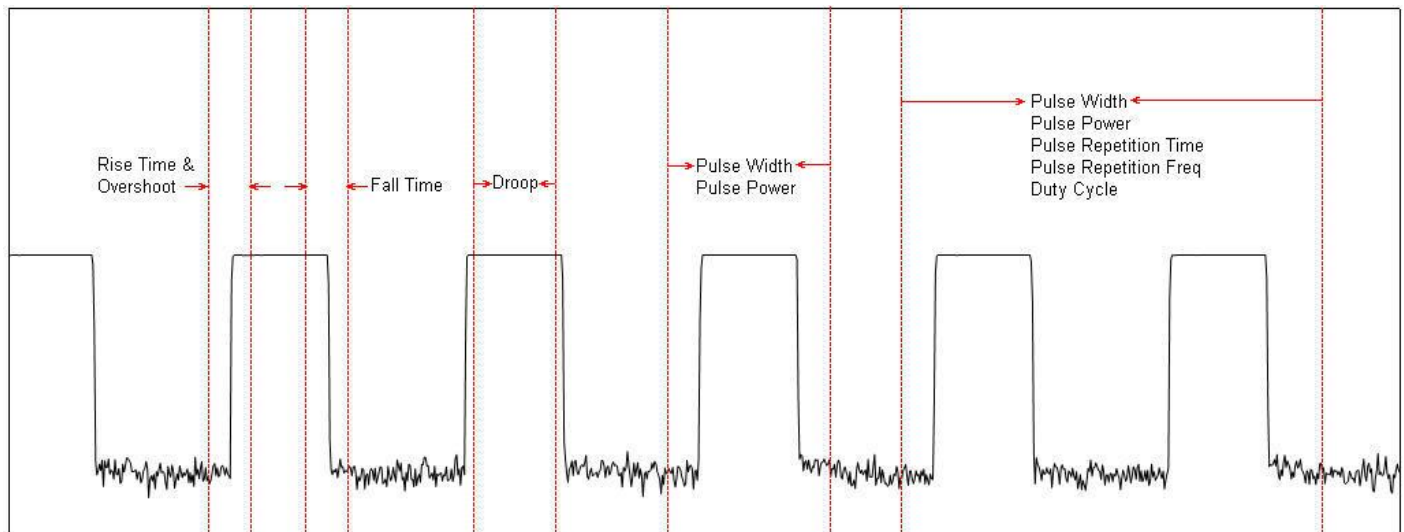
Notice that if several pulses are within a gate (pulse width, pulse power, PRT, PRF and duty cycle for example) the measurements will consider only the first pulse period. Rise time, fall time, and droop measurements are very sensitive to the position of the gates. These measurements use the position of the gates as starting and end points for the measurement. When making a rise time measurement the right gate marks the measurement peak. This also applies for fall time measurements except the left gate determines the peak. When measuring pulse droop, the 5% immediately following the left gate and the 5% immediately preceding the right gate are used for the measurement. For other measurements, the algorithm searches for the pulse (starting with the right gate) and then eliminates non-essential data.

A brief description of every measurement follows. After the list of measurements there are some measurement examples that guide you through the gate setups.

Rise Time

Returns the time required for the signal to rise from the 10% level to 90% level. The left gate determines the start of data. The right gate marks the highest point to be considered. The resultant measurement is the time required to increase in amplitude from 10% to 90% of the amplitude defined by the right-most gate.

Fall Time

Returns the time required for the signal to decrease from a 90% level to a 10% level as defined by the placement of the left-most gate. The right gate defines the end of data for this measurement.

Pulse Width

Returns the width of the pulse. The width of the pulse is the time for a signal to rise to within 3 dB of the top of the pulse then fall 3 dB below the top of the pulse. The left-most gate defines the start of data and the right-most gate defines the end of data. The gates must be positioned as described below:

- o   The left-most gate must follow a positive going edge
- o   The right-most gate must be preceded by one or more subsequent falling edges

The measurement first finds the first rising edge. The measurement then finds the first falling edge following the rising edge. The measurement then determines the time between the first rising edge and the subsequent falling edge. All other data is ignored.

Pulse Repetition Time and Pulse Repetition Time

PRF and PRT are the inverse or reciprocal of one another. Taking the reciprocal then of PRT is sufficient for determining PRF. PRT starts much like the pulse width measurement by searching for a rising edge except that the gates for a PRF (and PRT) measurement must include at least one complete, uninterrupted cycle. Therefore:

- o   The left-most gate must follow a positive going edge
- o   The right-most gate must follow one or more subsequent falling edges and at least one rising edge

Specifically, if the left-most gate intersects the top of a pulse, the data used to make the measurement will commence with the subsequent rising edge. The PRT is the time between the first rising edge and the second rising edge.

Duty Cycle

This measurement returns the percentage of on time during a selected cycle. The gates for a duty cycle measurement must be positioned with exactly the same restrictions as the PRT and PRF measurements. The measurement then proceeds to sort all samples into one of two bins. One bin is the "ON" bin and the other bin is the "OFF" bin. All points within 3 dB of the pulse top are placed in the "ON" bin. All other samples are placed in the "OFF" bin. Then a simple calculation is done:

DC (Duty Cycle) = #ON samples / (#ON samples + #OFF samples)

Pulse Power

This measurement reports the average power of all samples between the rising and falling edges. In this case the gate must be positioned exactly like Pulse Width measurements. The average of all samples between the rising and falling edges is reported.

Peak Power

This measurement reports the highest power level between two gates. There is no requirement for a rising or falling edge anywhere within the measurement window as defined by the gates.

Average Power

This measurement reports the average of all power between two gates. There is no requirement for a rising or falling

edge anywhere within the measurement window as defined by the gates.

Crest Factor

Crest factor is the difference between the peak power and the average power in any measurement window defined by gate edges. This measurement proceeds by first taking a peak power measurement, then an average power measurement. Then the measurement takes the difference between the two measurements and reports the result.

Droop

Measures the slope of the top of a pulse. The measurement is very sensitive to gate positions. Droop calculates the average power of the first 5% the samples following the left gate then takes the average of 5% of the samples immediately preceding the right gate. The difference between the two is droop in dB.

Overshoot

Reports the difference between the highest point between a rising edge and a pulse top. The position of the gate for overshoot measurements are identical to the positioning of the gate for rise time measurements.

Power Set

Returns a series of three measurements. These measurements are pulse power, peak power and crest factor for a selected gate.

Time & Frequency Set

Returns a pulse width, PRT and PRF measurement for a selected gate.

Mixed Set

Returns a peak power, crest factor, pulse width and PRF measurement for a a selected gate.

Set Position

The **Set Position** selection on the measurement list shown below allows you to precisely set the gate end points – just like for markers. Here we access the list from the **Results** pane and not the gates toolbar.

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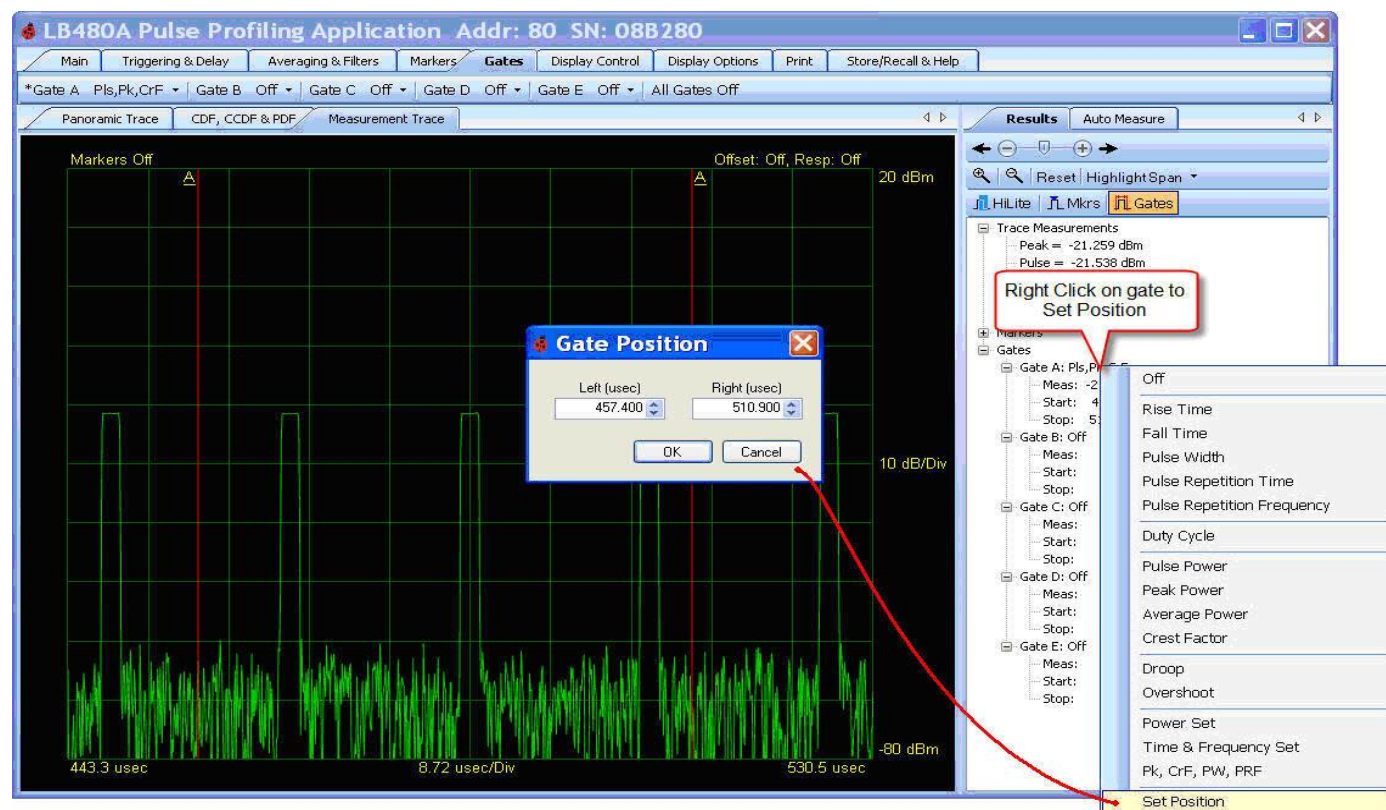
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Making a Gated Measurement

The following sequence of instructions demonstrates how to setup the gate(s) based on the example input used for markers:

First, **Highlight** a single pulse in the panorama as previously described. Zoom in and scroll left/right to get the pulse centered as shown below. Select **Gates** on the toolbar. All gates (A-E) should be off. Left-click on the Gate A drop down in the toolbar to show the list of measurements and pick **Pulse Width**. Alternately, you can right-click on the gate in the **Results** pane and make the measurement selection.

The gate pair will appear at center graticule in the Measurement view as shown below. An active gate will have an asterisk (*) in the toolbar and it will be underlined and appear slightly larger in the display.
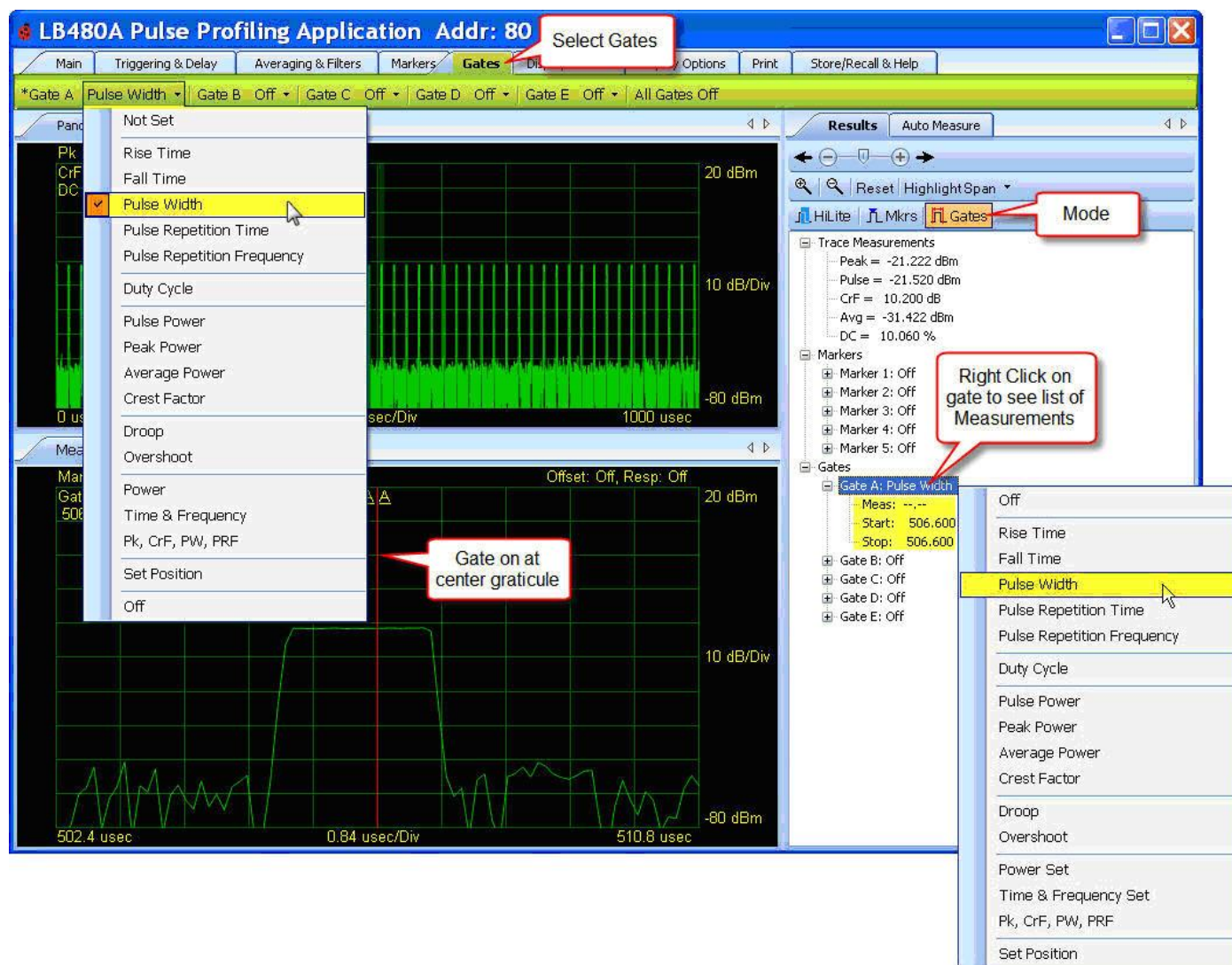

NOTE: You can always highlight the span if you drag the cursor over the Panorama view (or select a highlight span percentage and start time) even if you are in markers or gates mode. To highlight in the Measurement view you must be in the highlight mode. If you do not switch to highlight mode before clicking/dragging in the Measurement view you may inadvertently reposition markers or gates.

Now click to the left and right of the gate pair to set the gate end points as shown below. The measured value will appear in the **Results** pane under the gate and above the grid in the Measurement view. Notice that if the gate is not expanded you will see a measurement summary next to the gate node. You click on a gate to make it active. An asterisk (*) indicates the active gate and only one gate can be active at a time. The drop down menu on each gate shows the selection of measurements that can be made or, right-click on the gate in the **Results** pane. A dashed line (--.--) will appear if the gate cannot take a measurement or is not set. Adjust the gate end points accordingly to get a reading. A complete cycle of the incoming signal must be gated for periodic measurements such as duty cycle and frequency; and pulse width measurements must be at or below the 3 dB points (see the measurement description above). Notice that the measurement result does not change as long as an entire pulse is selected. That is, if you move the left gate closer to the left edge of the display the measurement result remains unchanged.
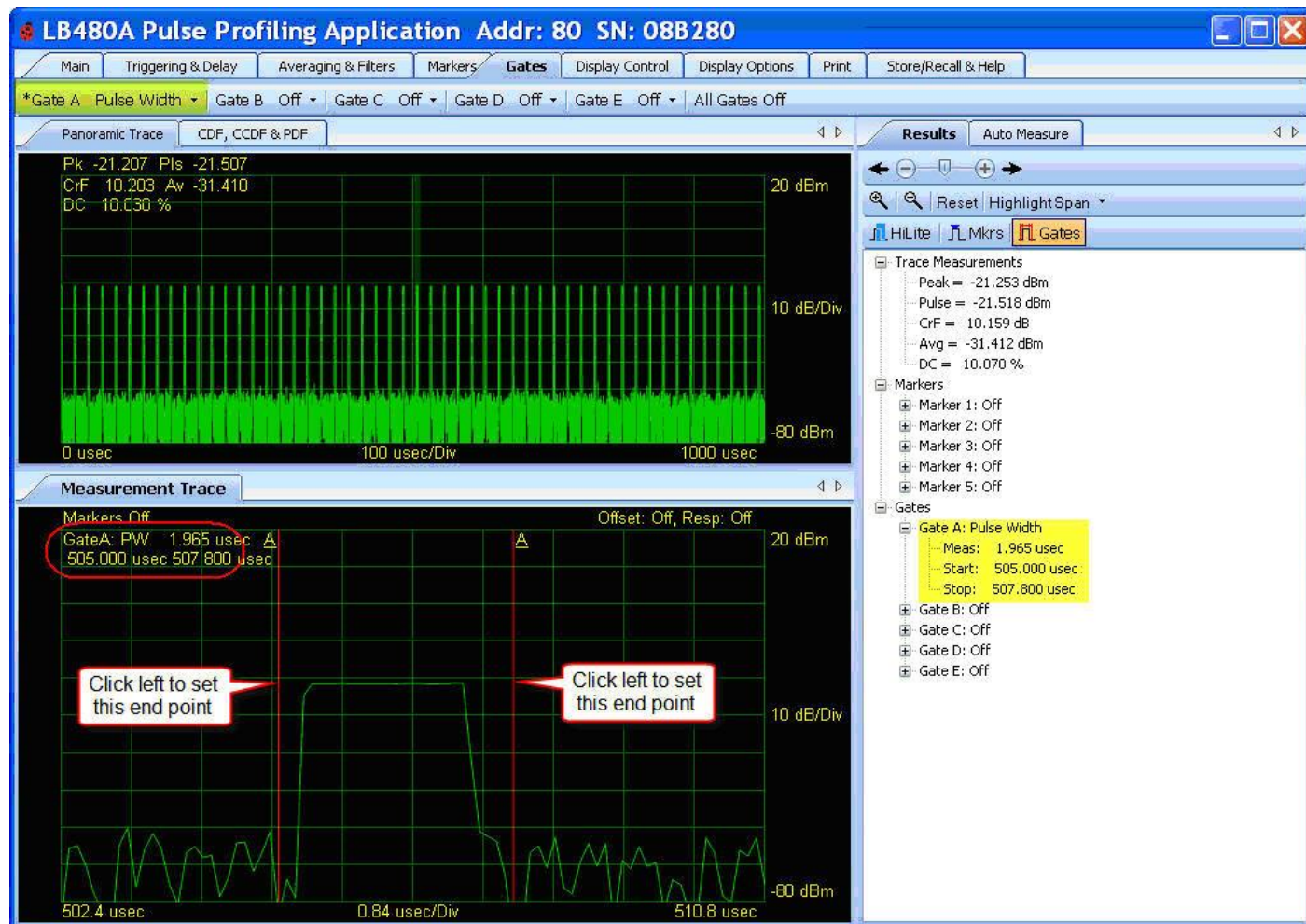
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Pictured below is an example of all gates on and each taking a measurement: Peak Power, Pulse Width, PRF, Droop, and Duty Cycle. Again, you activate a gate by clicking on it then setting its position as previously described. Finally, you can switch between these two modes of operation (gates and markers) to position markers within gates and gates within markers.

You can compare these manual measurements with an automatic measurement. Be sure that there are at least two pulse cylces in the Measurement view. Now select the **Auto Measure** pane and click **Start Measurement**.
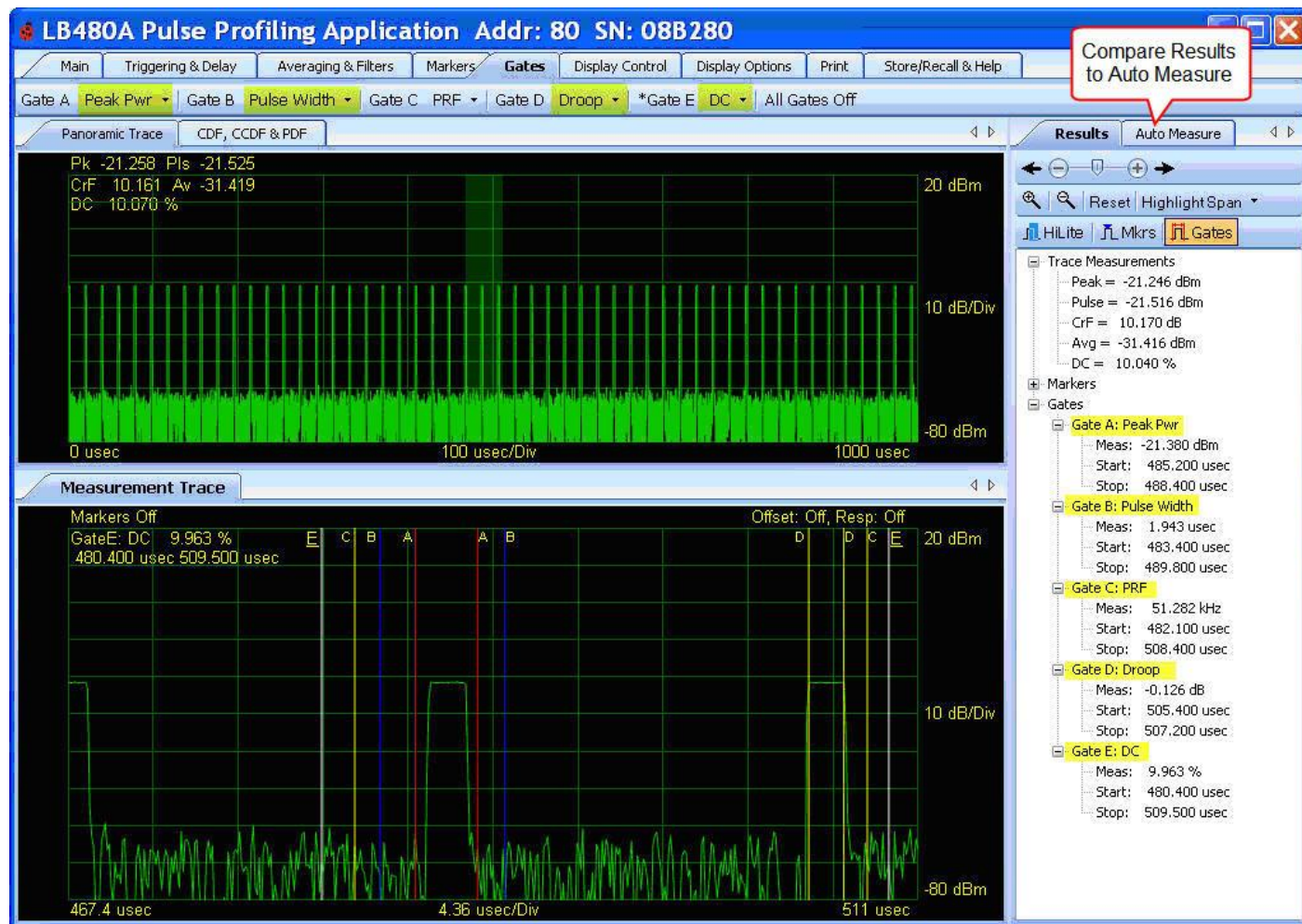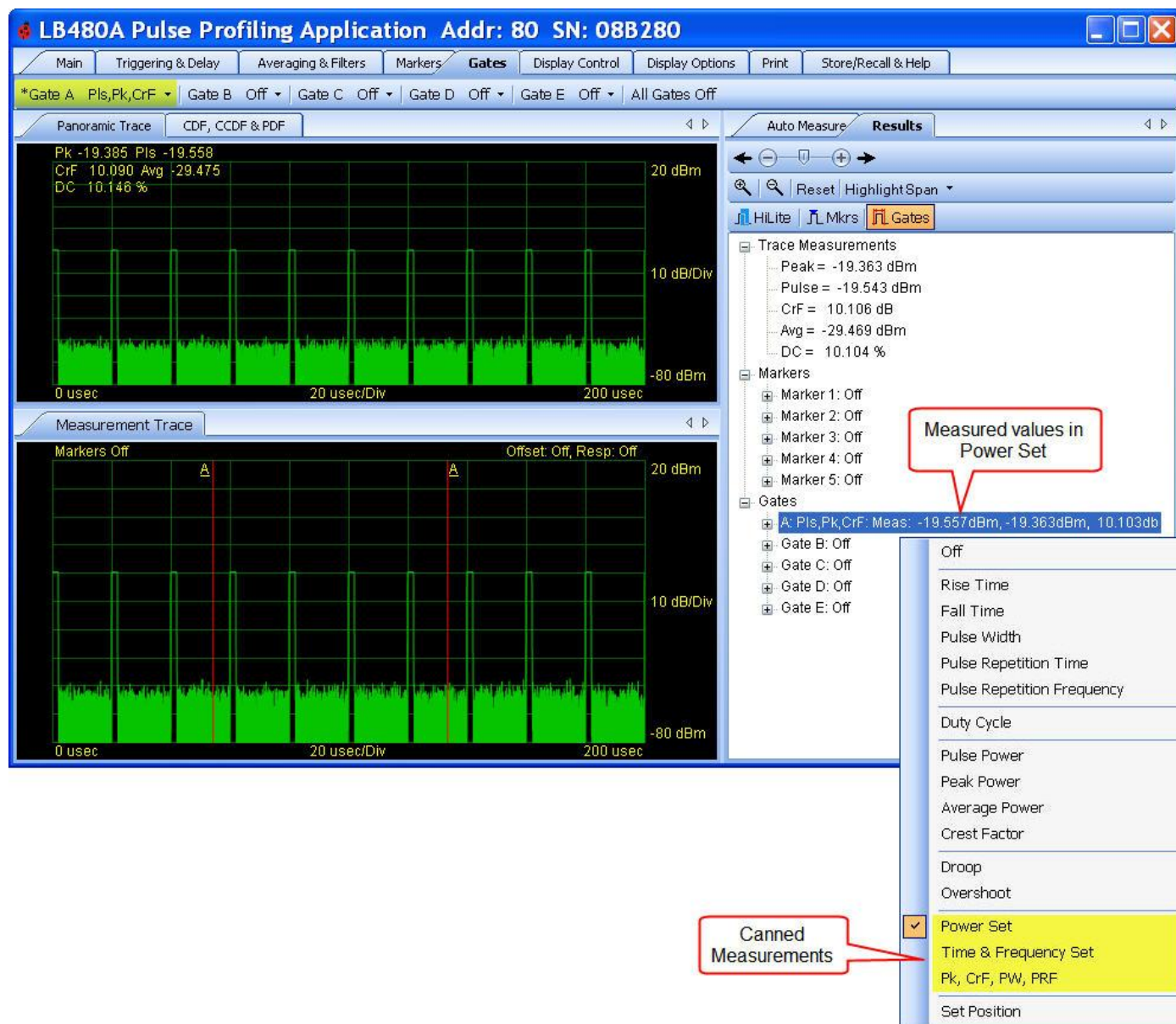

NOTE: You can always highlight the span if you drag the cursor over the Panorama view (or select a highlight span percentage and start time) even if you are in markers or gates mode. To highlight in the Measurement view you must be in the highlight mode. If you do not switch to highlight mode before clicking/dragging in the Measurement view you may inadvertently reposition markers or gates.

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Canned Measurement Example

Shown below is Gate A measuring Pulse power, Peak power and Crest Factor by clicking on the **Power Set** from the choice of three canned or group measurements. Right-click on the gate to see the measurement list or click the down arrow on the toolbar.

NOTE: You can always highlight the span if you drag the cursor over the Panorama view (or select a highlight span percentage and start time) even if you are in markers or gates mode. To highlight in the Measurement view you must be in the highlight mode. If you do not switch to highlight mode before clicking/dragging in the Measurement view you may inadvertently reposition markers or gates.

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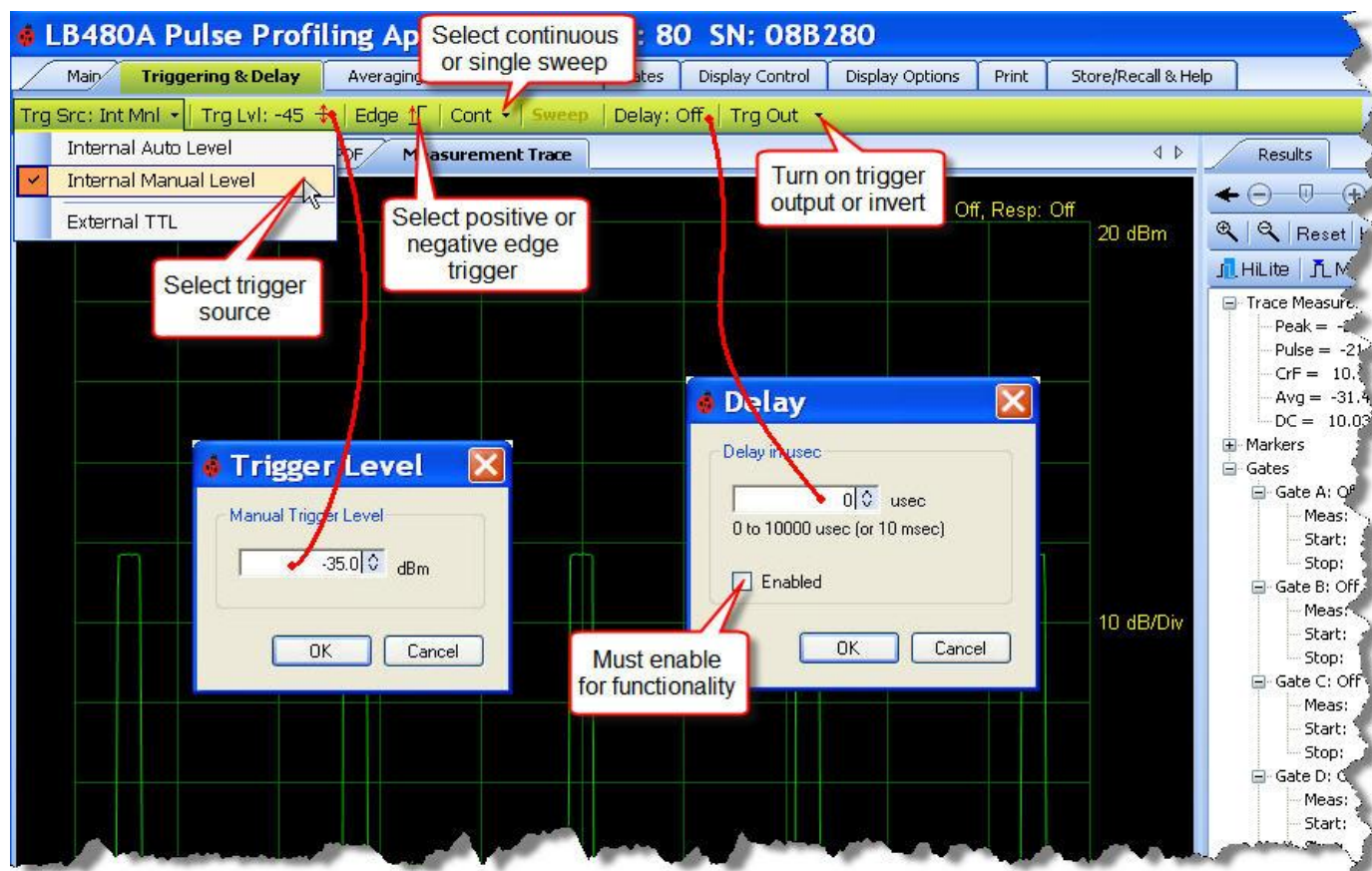Product Manual PPA (Pulse Profiling Application)

Triggering & Delay Toolbar
Internal Auto Level Trigger

Various triggering methods are provided from this toolbar. The **Internal Auto Level** trigger is determined by sampling the incoming signal. The general algorithm is as follows:

- Sample the incoming signal
- Examine the data for maximums and minimums
- Set the trigger level between the maximum and minimum (favoring the maximum)
- Take a trace using the standard process (same as manual trigger)

The **Internal Auto Level** is set for each trace so as the input varies the auto trigger level will be adjusted accordingly. Therefore, while the **Internal Auto Level** is more convenient (and quite reliable) it also can be somewhat less responsive. The **Internal Auto Level** trigger source is not recommended when peak input levels fall below approximately -50dBm (See **Internal Manual Level** trigger for inputs below -50 dBm).

All trigger modes can use positive or negative **Edge** triggering as well as **Cont** (continuous) or **Sngl** (single) sweep. The trigger **Delay** function (up to 10 msec) must be enabled/disabled from the delay window as shown below. The standard LB480A power sensor has **External TTL** input/output connectors labeled TI/TO (SMB-male). See the trigger limits in the specifications section of this document (or the LB480A data sheet) to employ the **External TTL** trigger capability utilizing the trigger connectors on the sensor body.

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The **Internal Auto Level** trigger mode always returns a trace and triggers off the incoming signal. However, if a signal is not present it will return a noise trace. Shown below is an example of a complex waveform being measured using internal triggering (AM = 90%, 1 kHz).
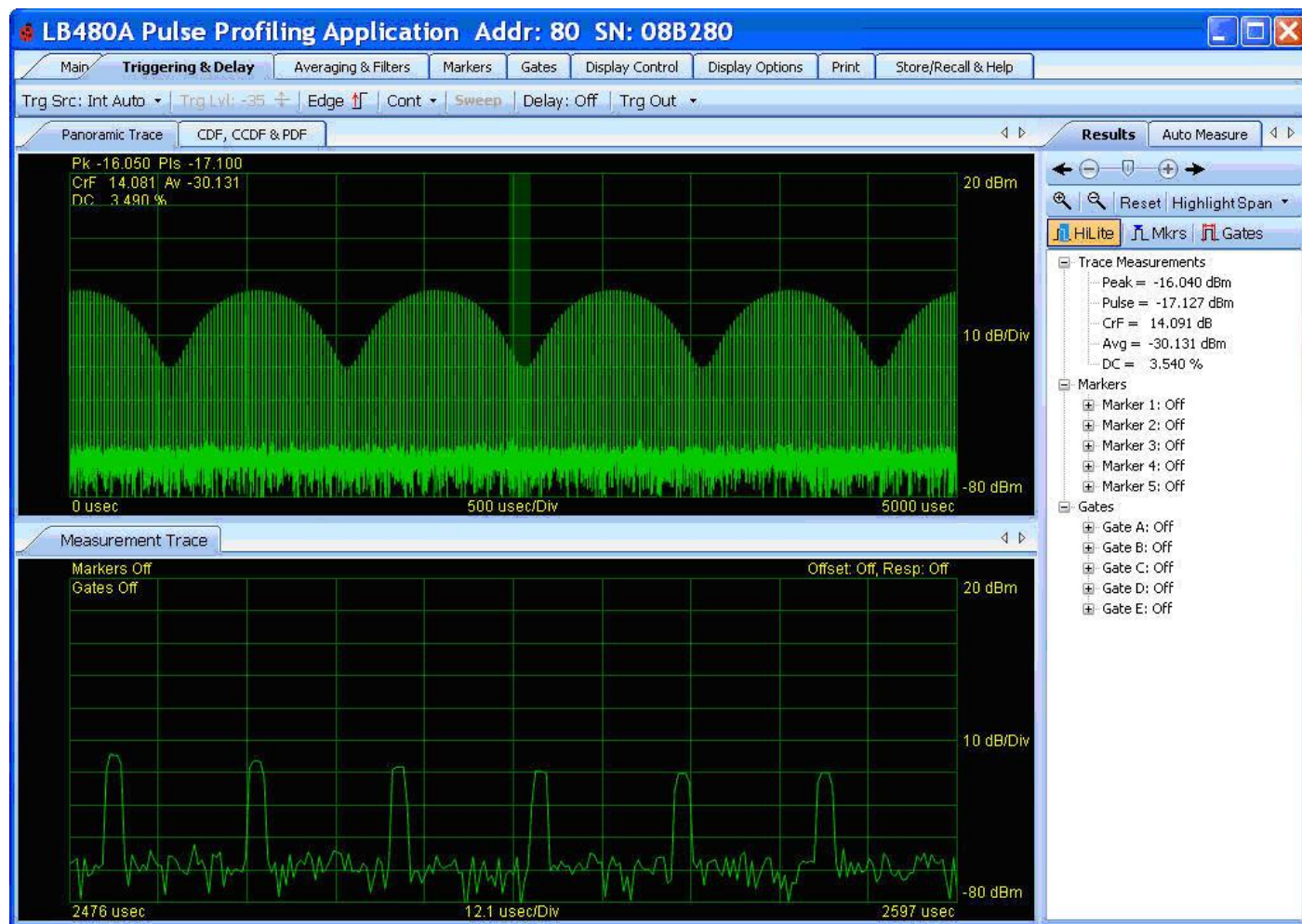
NOTE: An incoming pulse must be on at least 0.20 usec followed by at least 1 usec of off time for the sensor to properly trigger.
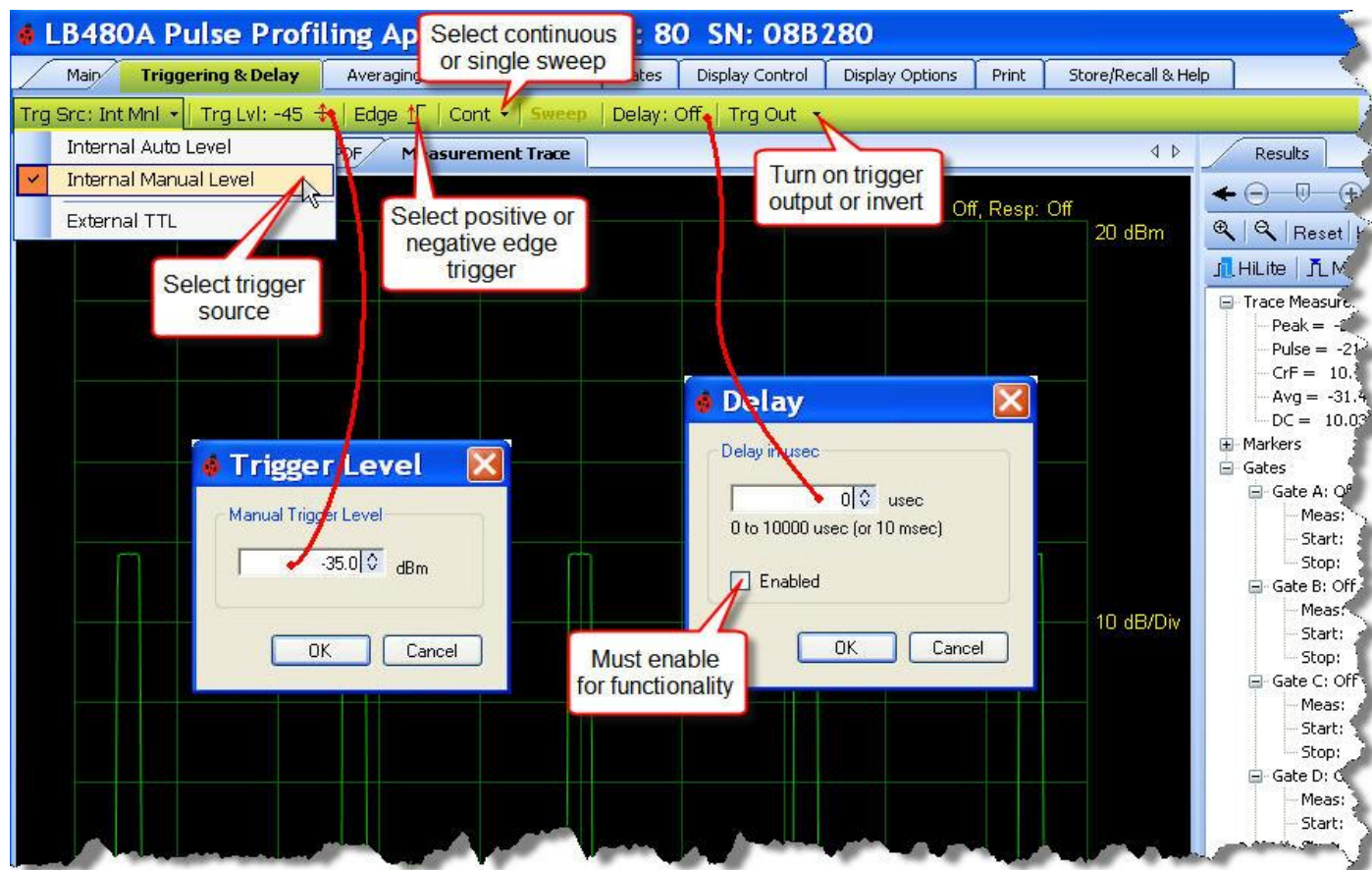
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Internal Manual Level Trigger

The sensor is capable of triggering on the incoming signal from about -55dBm to +20dBm when **Internal Manual Level** is selected and a value is entered as shown below. This trigger mode requires that you set the trigger level manually. If you set the trigger level too high you will not get a trace. Instead you will get a "Trigger?" message in the middle top of the measurement grid. This message indicates that a trigger was not found. If the trigger is set too low then the system will trigger on noise and you will get a noise trace.

All trigger modes can use positive or negative **Edge** triggering as well as **Cont** (continuous) or **Sngl** (single) sweep. The trigger **Delay** function (up to 10 msec) must be enabled/disabled from the delay window as shown below. The standard LB480A power sensor has **External TTL** input/output connectors labeled TI/TO (SMB-male). See the trigger limits in the specifications section of this document (or the LB480A data sheet) to employ the **External TTL** trigger capability utilizing the trigger connectors on the sensor body.

NOTE: An incoming pulse must be on at least 0.20 usec followed by at least 1 usec of off time for the sensor to properly trigger.
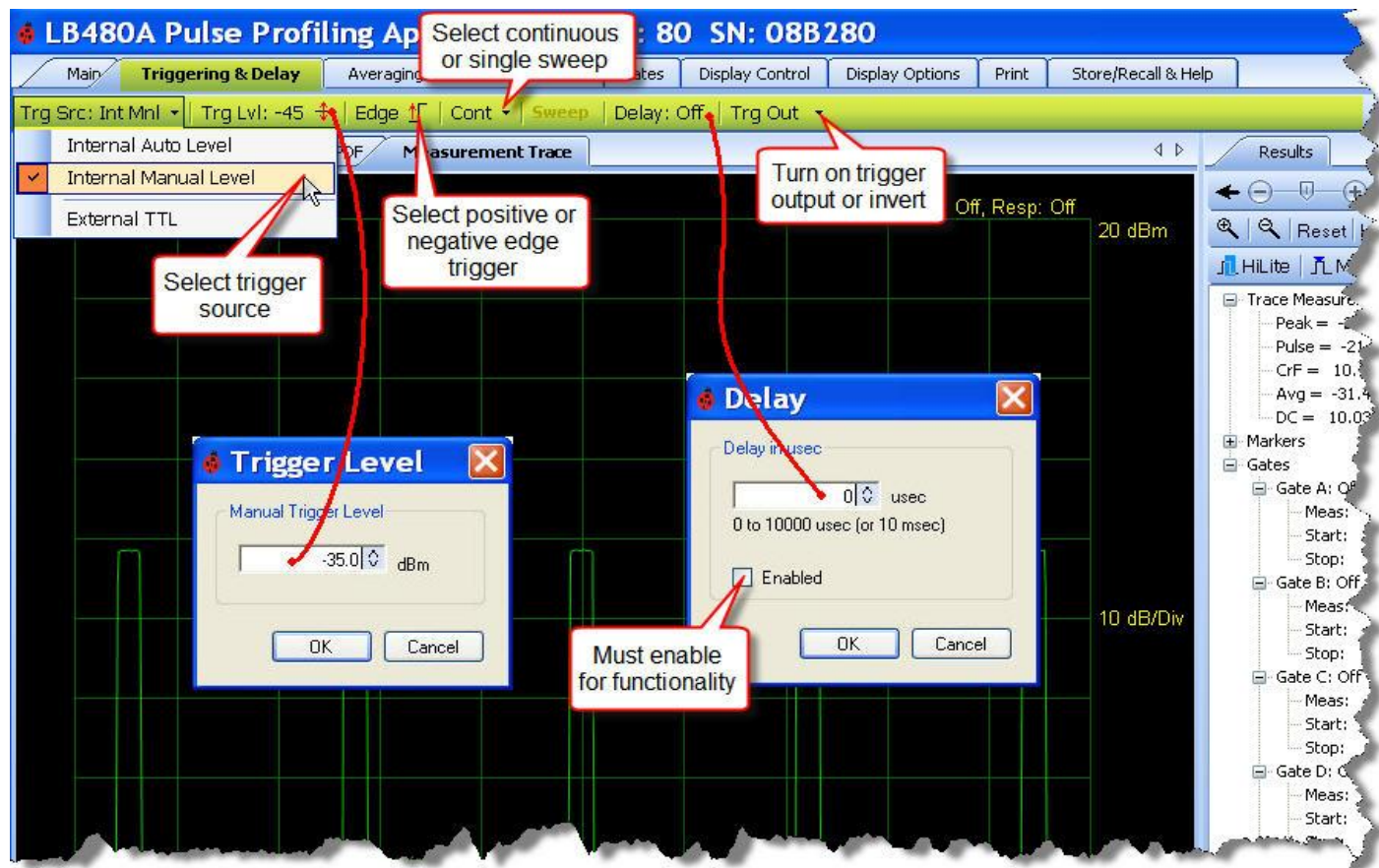
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External TTL Trigger

The external TTL trigger mode requires the user to connect an external SMB cable with an incoming TTL signal. Use this capability to trigger on an input that is not level dependent or for very low signal levels approaching the noise floor of the sensor. See the **Averaging & Filters** Toolbar section for more information on measuring low level signals.

All trigger modes can use positive or negative **Edge** triggering as well as **Cont** (continuous) or **Sngl** (single) sweep. The trigger **Delay** function (up to 10 msec) must be enabled/disabled from the delay window as shown below. The standard LB480A power sensor has **External TTL** input/output connectors labeled TI/TO (SMB-male). See the trigger limits in the specifications section of this document (or the LB480A data sheet) to employ the **External TTL** trigger capability utilizing the trigger connectors on the sensor body.

NOTE: An incoming pulse must be on at least 0.20 usec followed by at least 1 usec of off time for the sensor to properly trigger.

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Edge Trigger
Allows the user to trigger on the positive or negative edge as required for best viewing.

Continuous Sweep
Causes the sensor to continuously deliver new traces.

Single Sweep
Delivers one new sweep each time it is pressed with the exception of the first time. Occasionally the first sweep requires two button clicks.

Delay Trigger
Allows the user to delay the beginning of the trace from the trigger for up to 10 msec. This feature allows the user to acquire high resolution traces long after the trigger has occurred.

Trigger Out
If this feature is enabled it causes a trigger to be passed to the trigger out port on the sensor (labeled TO). The trigger out occurs somewhat differently for internal triggering than for External TTL triggering. When triggering internally (manual or automatic) a trigger is sent out each time a sweep starts. When triggering on an external TTL trigger the trigger is passed through to the trigger out port. The trigger out can also be inverted.
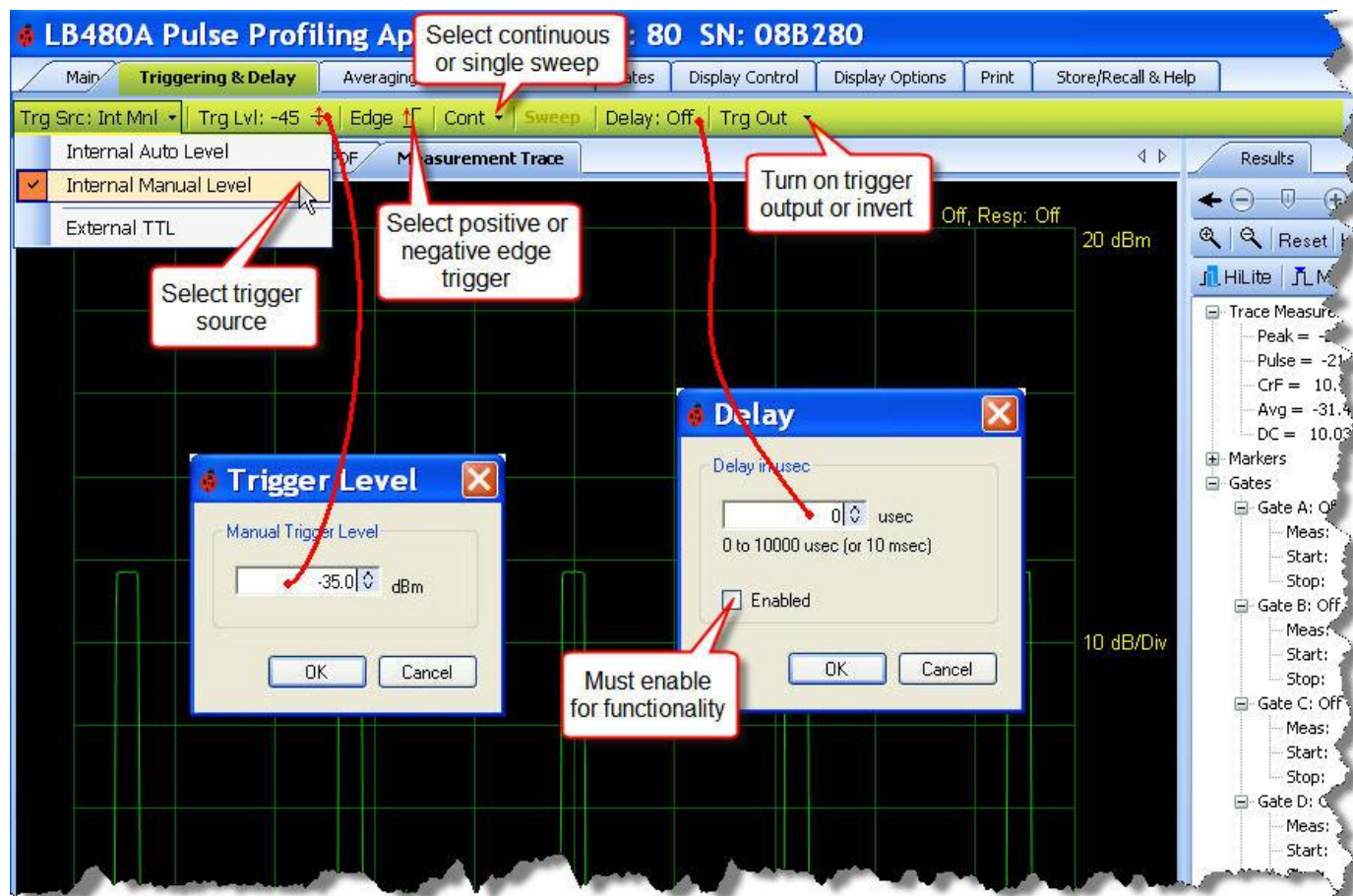
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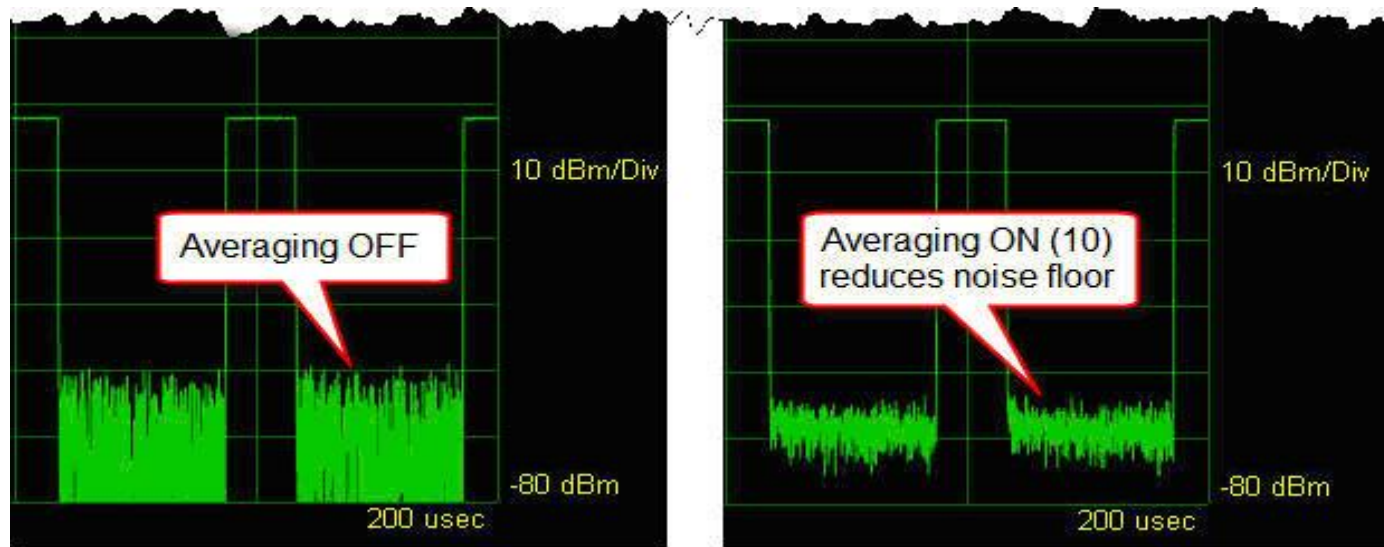Product Manual PPA (Pulse Profiling Application)

Averaging & Filters Toolbar
Auto Reset
Manual Reset

Averaging refers to trace averaging and this tool is used to set the number of traces that are averaged from 1 to 100. The default state is 10 averages with automatic reset enabled. It takes 0.3 – 1.0 msec to collect one buffer of data. The number of averages or buffers is selected from the drop down shown below. There is provision for automatic or manual averaging reset.

Auto Reset triggers an averaging restart when the trace changes are pronounced (it assumes a new signal is being examined). **Manual Reset** makes this function discretionary for the user. Shown below is an example of averaging OFF compared to averaging set to 10 and the effect. Increasing the number of averages increases the measurement time.

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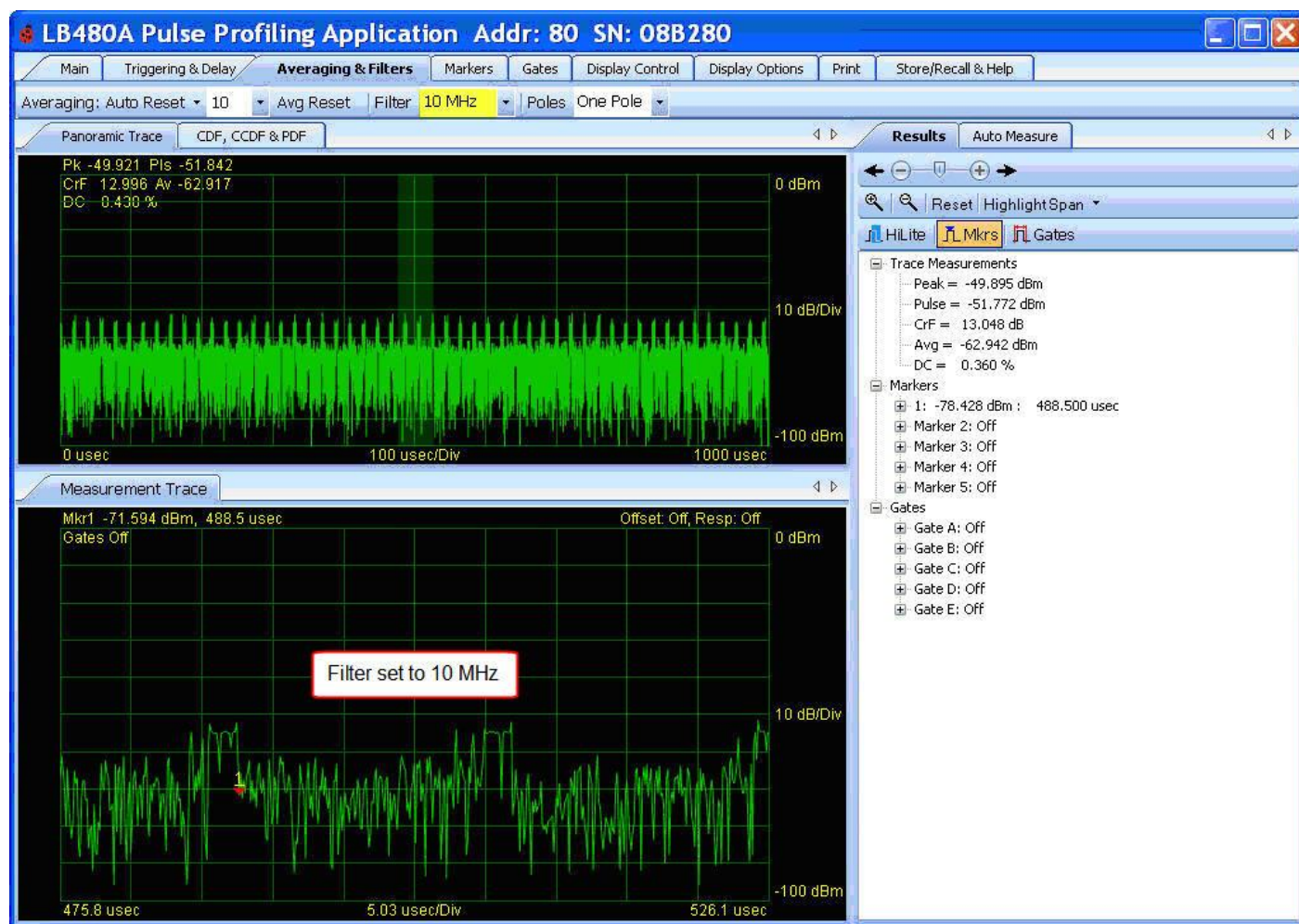
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Filter

The **Filter** drop down allows you to select an appropriate video bandwidth depending on your measurement needs. The default value is 10 MHz if you have option 004. If you do not have option 004 then the default (and only value) is 100 kHz. (Filter selection: 100 kHz, 200 kHz, 300 kHz, 500 kHz, 1 MHz, 2 MHz, 3 MHz, 5 MHz, 10 MHz).

Both averaging and filtering help reduce the noise floor. Below about -53 dBm you may need to use a combination of averaging, filtering (Option 004), and the standard external triggering capability to get satisfactory measurements. External triggering has the advantage of triggering on demand and is not level dependent.

There are trade-offs involved when using averaging. Increasing the number of averages maintains wave shape but decreases responsiveness or how quickly the trace is updated. Likewise, a lower **Filter** setting will provide faster trace updating but affects the wave shape. This results in a rounded pulse shape because as the filter is narrowed the high frequency component of the signal is decreased.

The following grahics illustrate measuring a low level signal with **Filter** set first to 10 MHz and then the same signal with **Filter** set to 200 kHz; in both cases averaging is set to 10. Notice the pulse becomes more discernable from the noise when the **Filter** setting is reduced in this instance.

Models LB480A/LB680A USB PowerSensor+™
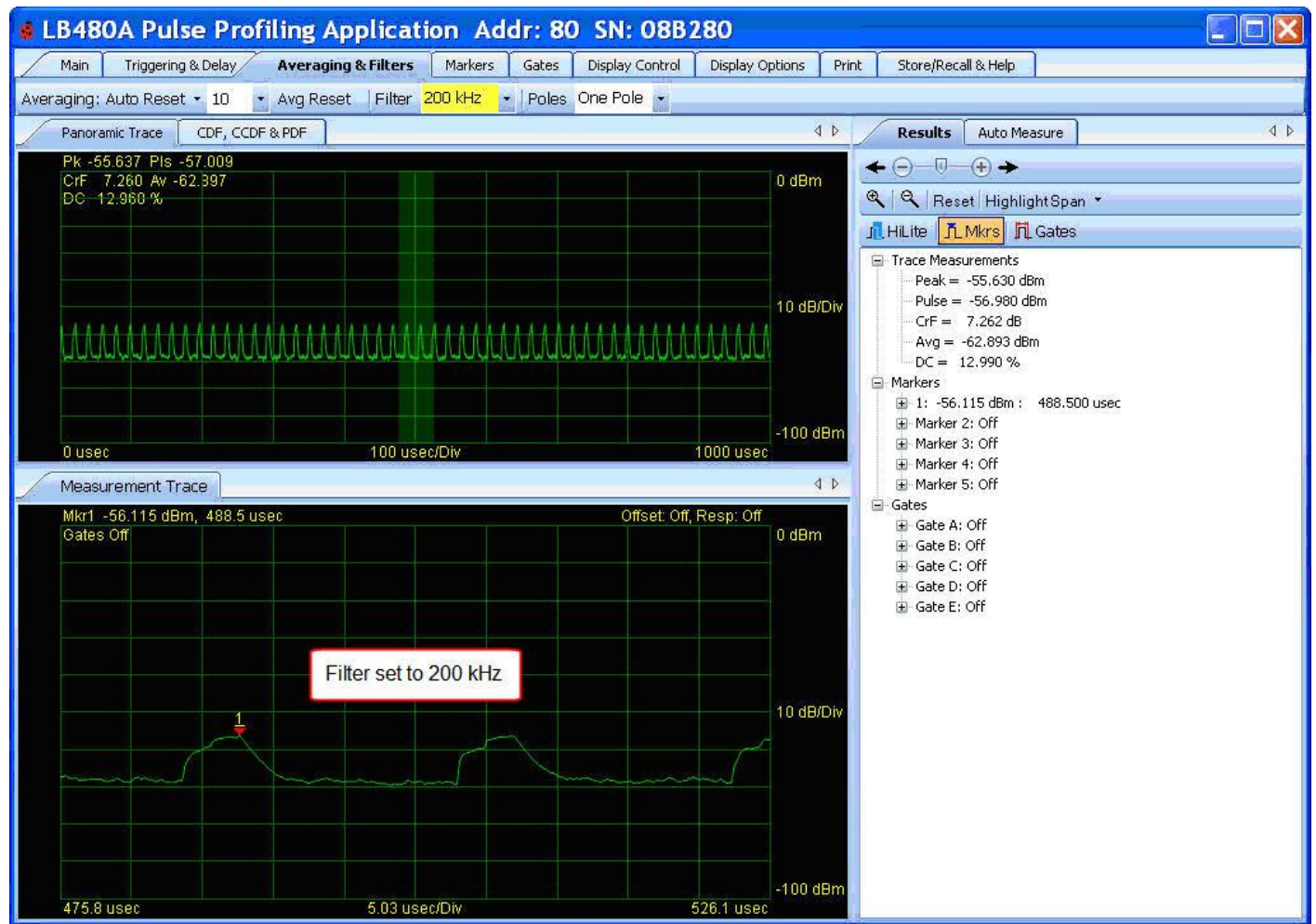
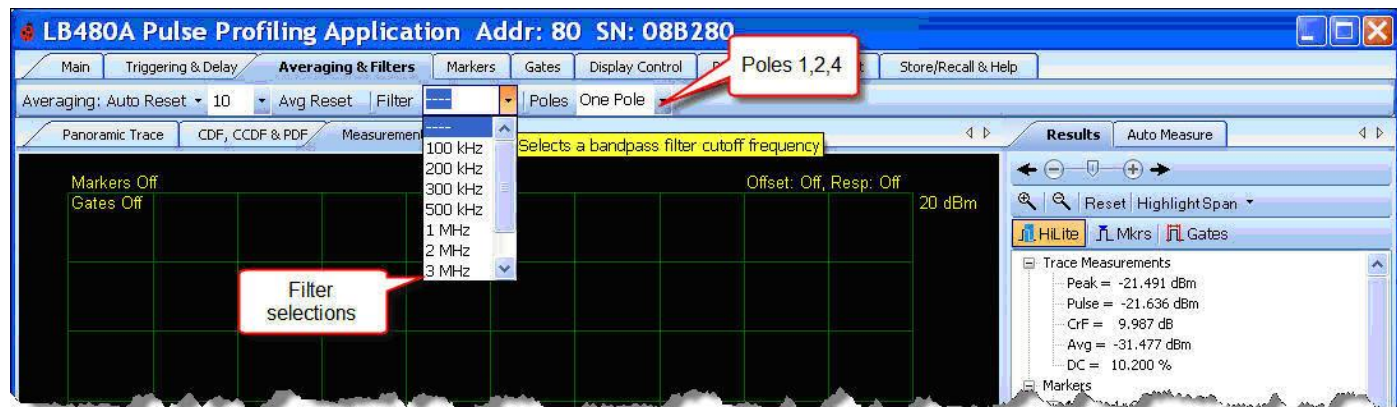Product Manual PPA (Pulse Profiling Application)

NOTE: The Filter and Poles selections are only active with LB480A Option 004. Otherwise the selections will be inactive and set to 100 kHz and one pole.

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Poles

The **Poles** drop down allows selection of one, two or four filter poles as shown below. The default value is four poles with option 004 and one pole without option 004.


The number of **Poles** has the effect of determining the sharpness of the frequency roll off depending on the filter selection. The greater the number of **Poles** the steeper the roll off and again, the reduction in the high frequency component of the signal. More **Poles** then decrease roll off but have the affect of increasing both the rise and fall times of the displayed signal (as time relates inversely to frequency).

NOTE: The Filter and Poles selections are only active with LB480A Option 004. Otherwise the selections will be inactive and set to 100 kHz and one pole.

Uncalibrated Measurement Message

You will see the popup below if the measurement becomes uncalibrated due to the filter, poles or sweep time settings. Also, an "Uncal Meas" label will appear on both the Panorama and Measurement view grids. Adjust the settings accordingly until the error message stops.

Revision: 08/02/11
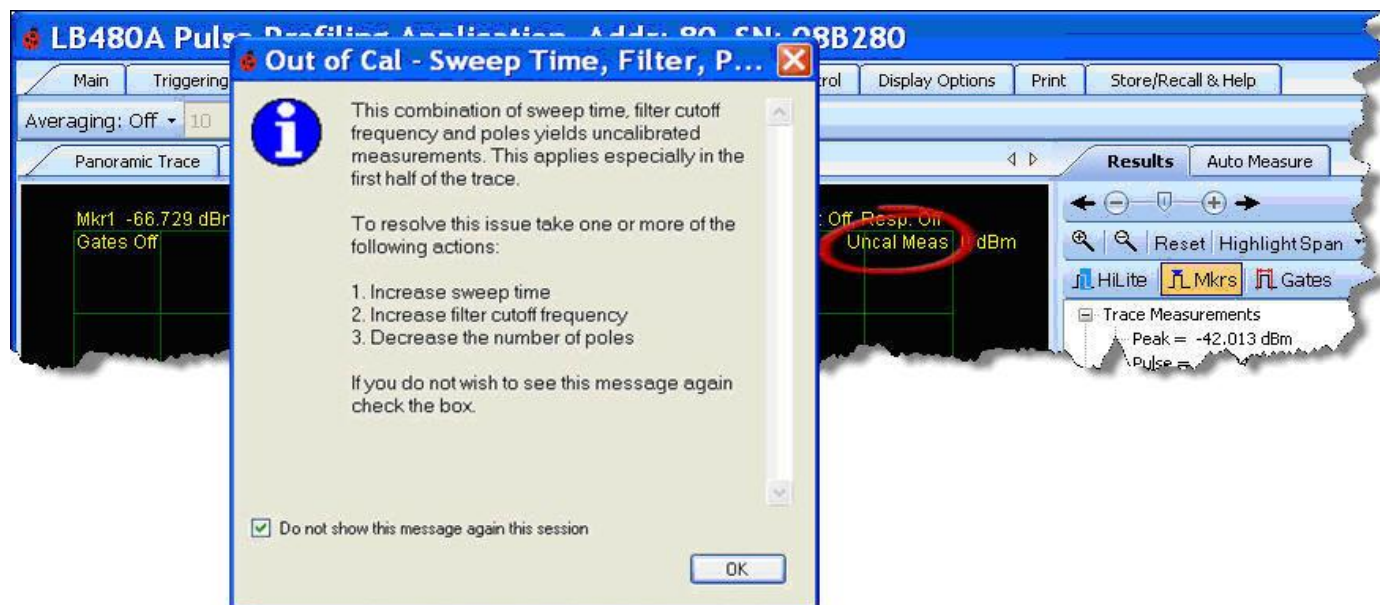
Models LB480A/LB680A USB PowerSensor+™

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Display Options Toolbar
Marker Color & Size
Gate Color & Size
Display Font
Results Font
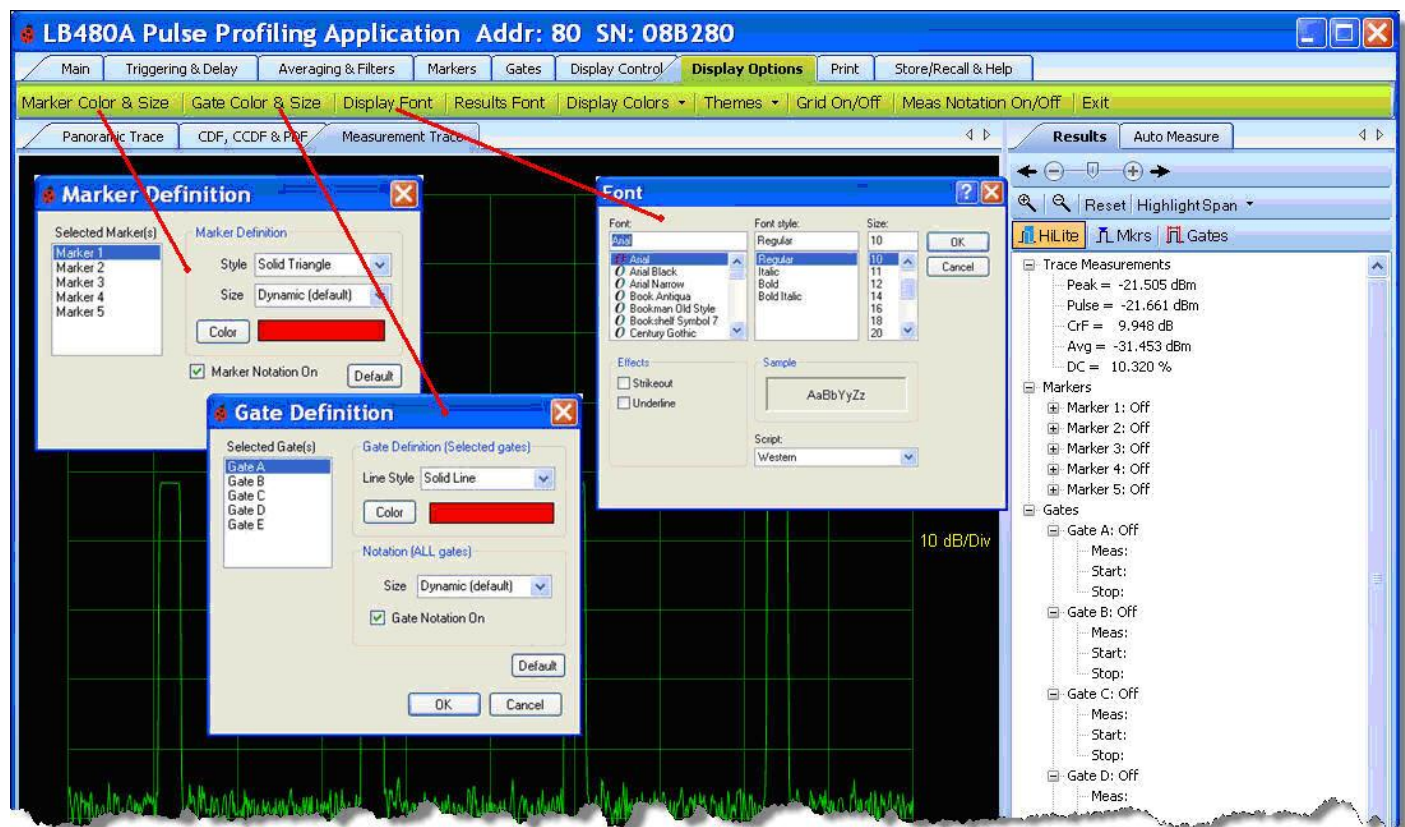**Display Colors**
Themes
Grid On/Off
Meas Notation On/Off
Exit

Select the display preferences from this toolbar as shown below – color, size, opacity, theme, etc. You can adjust the visual presentation as well as turn the grid and measurement notation on and off. You can also **Exit** the application from this toolbar.

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Print Toolbar
**Panorama Display**
Measure Display
CDF, CCDF and PDF Display
Print Black & White

The **Print** toolbar allows you to print either the **Panorama Display**, **Measure Display** or the statistical displays separately as shown below. The printout will include all the marker and gate values. You can select full color or black and white by checking the box.

Below is an example of the **Measure Display** printout which includes all the marker and gate values.
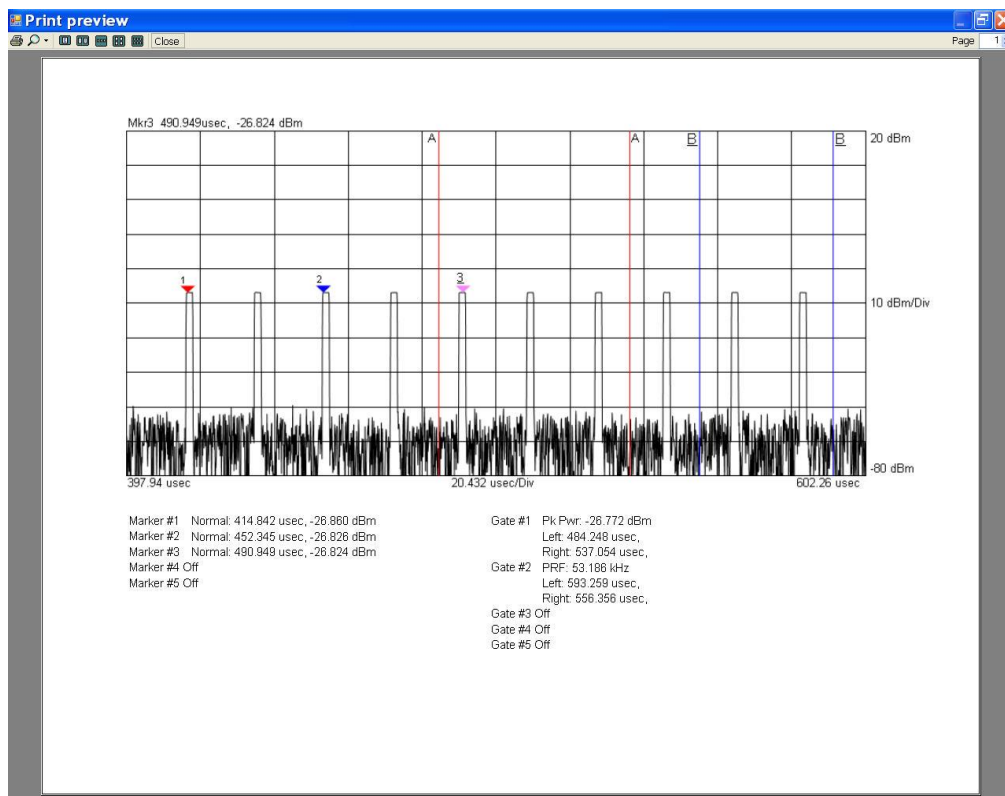
Models LB480A/LB680A USB PowerSensor+™

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Store/Recall & Help Toolbar
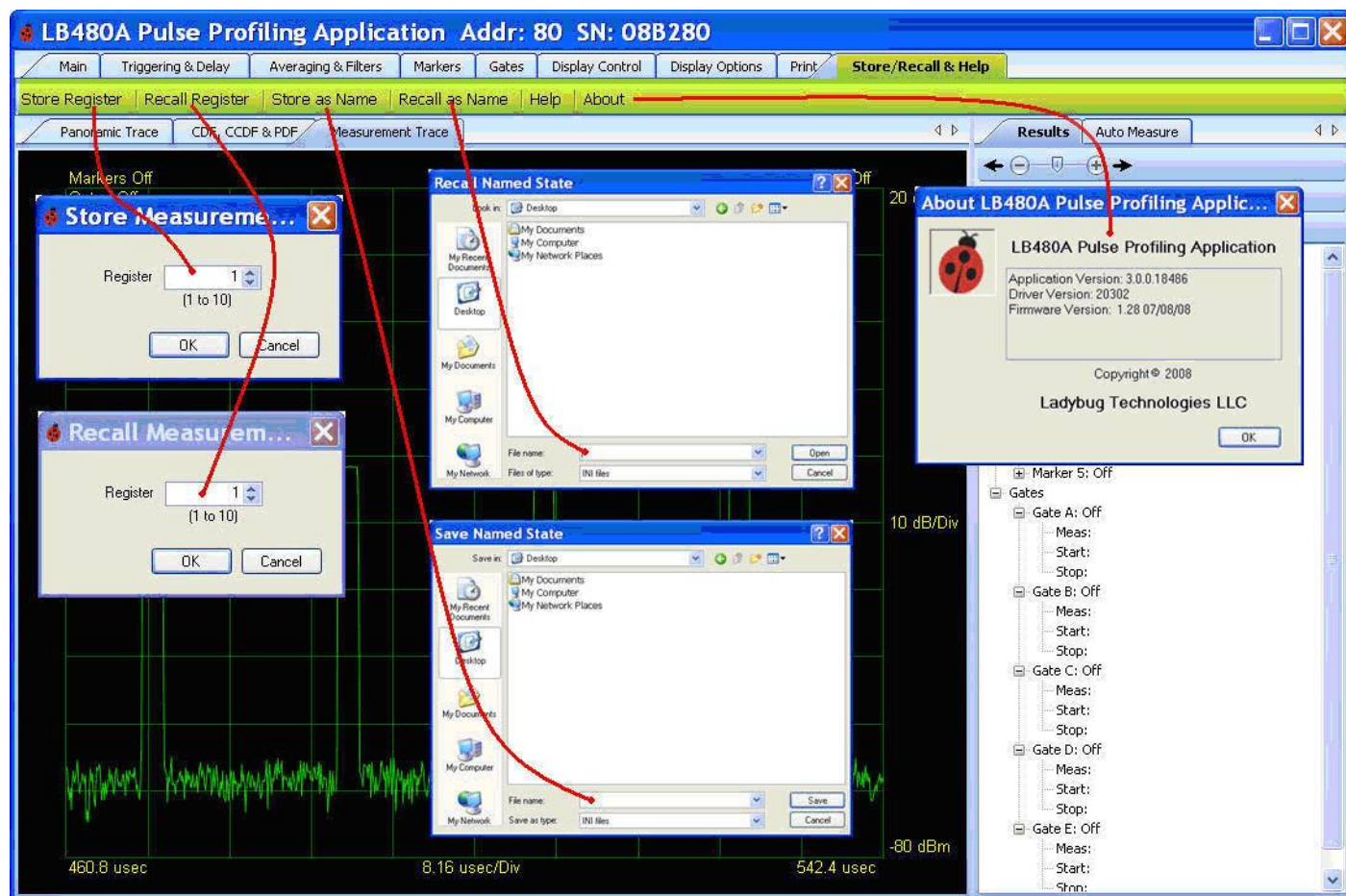**Store Register**
Recall Register
Store as Name
Recall as Name
Help
About

The **Store/Recall & Help** toolbar allows you to store and recall up to 10 measurement states as shown below. Additionally, you can store/recall to file by name. The **Help** tab will provide product documentation. The **About** tab will show the software, driver and firmware revisions.

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6. Statistics

Setup & Control
CDF
CCDF
PDF

The tab shown below provides a dockable window for the statisitical analysis of the signal trace. The tool allows for three presentations from the **Setup & Control** dialog box: The **CDF** (Cumulative Distribution Function) display shows the probability that a signal is below the average power level.
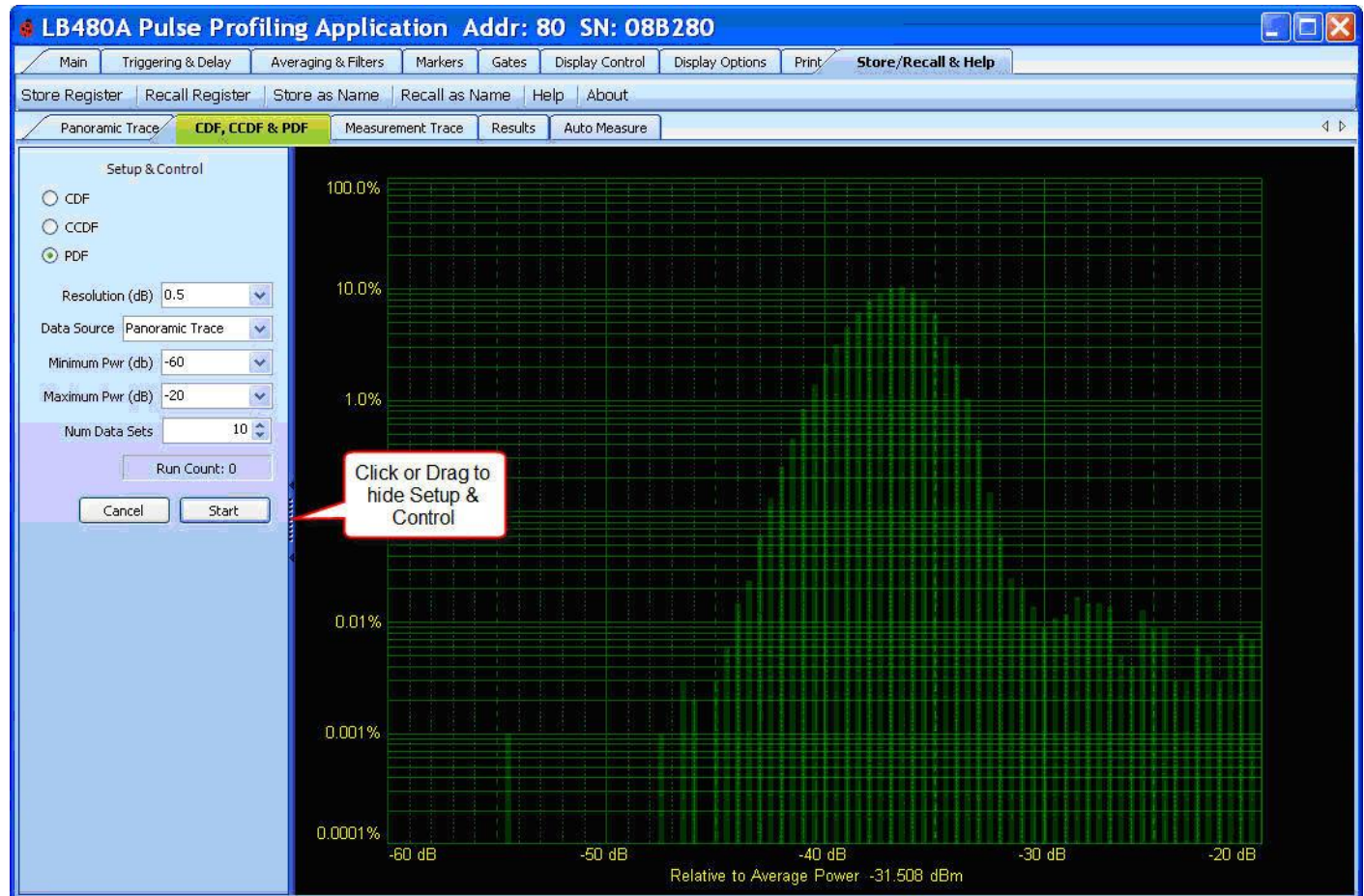
The **CCDF** (Complementary Cumulative Distribution Function) display shows how much time the signal spends at or above the average power level. The power level is expressed in dB relative to the average power. The percentage of time the signal spends at or above each line defines the probability for that particular power level. A CCDF curve is a plot of relative power levels versus probability. The **PDF** (Probability Density Function) is shown above from our prior demonstration with a specified input to the sensor. There is provision for entering the resolution; data source (trace or gates); minimum and maximum power; and number of data sets or runs with counter.

NOTE: Power (**CCDF**) curves provide critical information about the signals encountered in 3G systems. These curves also provide the peak-to-average power (crest factor) data needed by component designers.

7. 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: 02/05/09

1. Update all graphics and feature content to current design (Application Version: 3.1.0.34470).

Rev Date: 02/09/2011

1. Add LB680A and update graphics and feature content to current design (Application Version: xxxxxx)

Rev Date: 08/02/2011

1. Add reference to version 4.5 software and Windows 7 support.