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Time Gated Measurements and Low-Signal-Level Triggering of Pulsed Signals

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Pulsed signals are prevalent in various RF technologies, ranging from classical applications such as radar and electronic warfare (EW) to modern digital communication formats utilizing time multiplexing. Although much more challenging than constant-amplitude signals, accurate characterization and measurement of pulsed signal power is critical to successful system development, production, and operation.

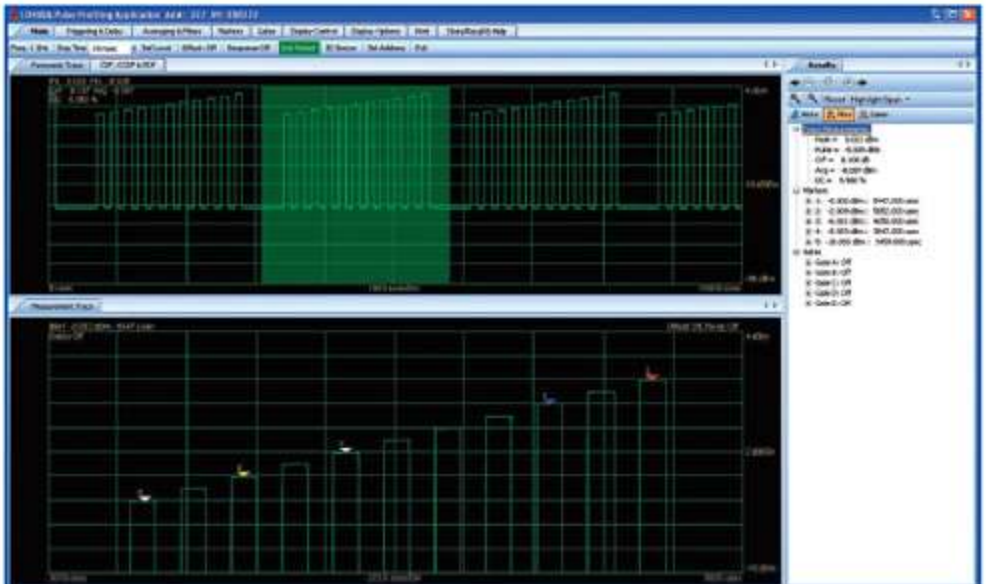

Figure 1: Stepped Pulse Train with 1 dB increments

Power sensors must include pulsed measurement capabilities and achieve performance specifications to meet the requirements needed for these applications. LadyBug Technologies provides this capability and performance in a compact USB power sensor: its LB480A Pulse Profiling USB PowerSensor+TM includes dedicated software with all the tools necessary for complete power characterization of pulsed and bursting signals.

Pulsed Radar and EW Signals

Vast improvements in jamming resistance, highly improved accuracy, and augmented information capabilities require increasingly complex radar and EW systems. Over the last several decades, simple rectangular and pulsed signals used solely for ranging have evolved to wideband phase-modulated pulses and pulsed patterns with varying pulse rates.

For rectangular pulses of a repetitive pulse train with constant amplitude, peak power can be calculated by dividing the average power by the duty cycle. This classical method is low in cost but clearly limited in its ability to fully characterize pulse waveforms. New sampling techniques enable measurement of the entire pulse envelope with a power meter providing complete parametric information as well as a graphical representation of the pulse profile.

Figure 2: WiMAX Downlink Burst with preamble and payload data segments

Parameters used in evaluating modern radar signals include peak power, pulse power, rise time, fall time, droop, crest factor, etc. These characterize pulse shape as well as signal strength. Measuring radar signals is a critical function of power sensors whether in the laboratory or on the flight line. Accurate measurements are required through the entire frequency band and over a wide range of temperatures.

Initially, high power RF pulsed waveforms are generated within the radar transmitter. At the transmitter output, the pulse shape is critical to system performance. Ideally, the waveforms should have a perfectly rectangular shape.

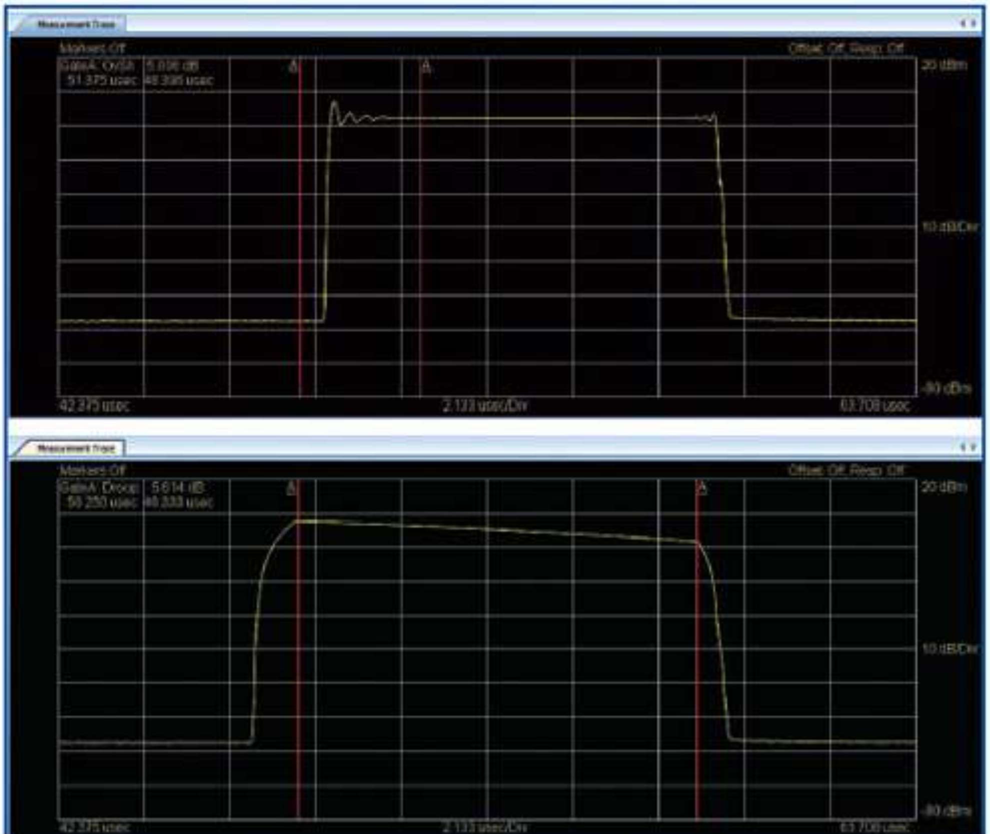

Figure 3: Pulse Profiling Application Overshoot and Droop Measurements (numerical results appear in upper left-hand corner)

In general, receiver testing requires a dynamic range of 80 dB or greater. Radar receiver measurements also include peak power and pulse shape characterization. Typical pulse shape measurements include droop and overshoot. Also of interest is the sensitivity, sometimes referred to as Minimum Discernable Signal (MDS). Sensitivity is measured under different conditions with various forms of interference.

One of the critical parameters when analyzing pulses is the dynamic range of the instrument: the range of signal power over which the instrument can accurately measure. The dynamic range can be degraded by excessively wide bandwidth of the measuring receiver due to the presence of broadband noise or other interfering signals.
When the radar receiver operates over a wide bandwidth, the received pulses are subject to additional noise. Depending on the signal-to-noise characteristics of the waveform, proper setting of the filter bandwidth can enhance the dynamic range of the power sensor measurement.

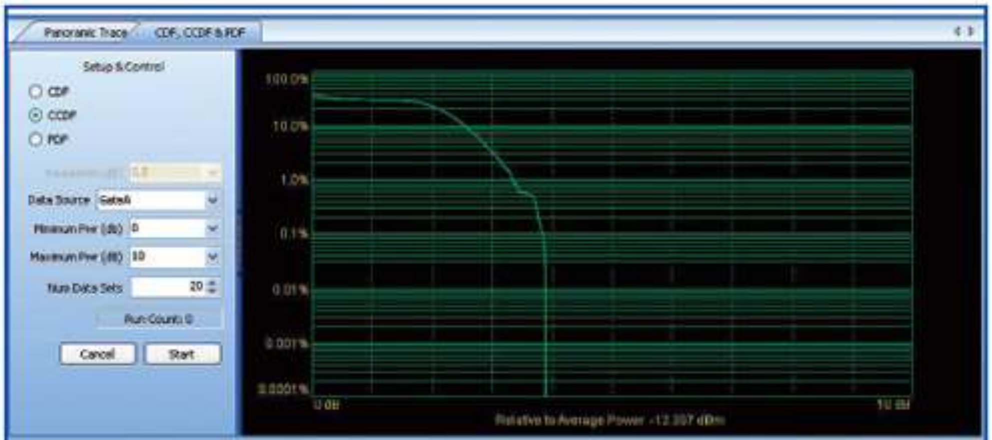

Figure 4: CCDF curve of the WiMAX burst from the Pulse Profiling Application

These requirements drive the development of power sensors with additional capabilities. Key features include:

- dynamic range
- total measurement error
- insensitivity to wide temperature variations
- graphical displays of measured values

Bursting Communications Signals

Digital communications standards use a variety of multiplexing and modulation methods to improve capacity as much as possible. Time Division Multiple Access (TDMA) enables users to share the same frequency by allocating slots of time for each to transmit or receive a burst of data. A TDMA waveform includes multiple RF bursts, each carrying the data for a specific user. Time slots are organized into data frames, with different types using different modulation techniques at different times. Power levels during a frame can vary widely, even dropping to no power at all. Capture and analysis of the specific segment of interest require time-gated power measurements.

Time gating enables accurate frame power and subframe power measurements by calculating the average power within the gate boundaries. Burst turn-on and turn-off ramps can also be characterized. LadyBug's Pulse Profiling Application software also provides a graphical representation of the burst shape.

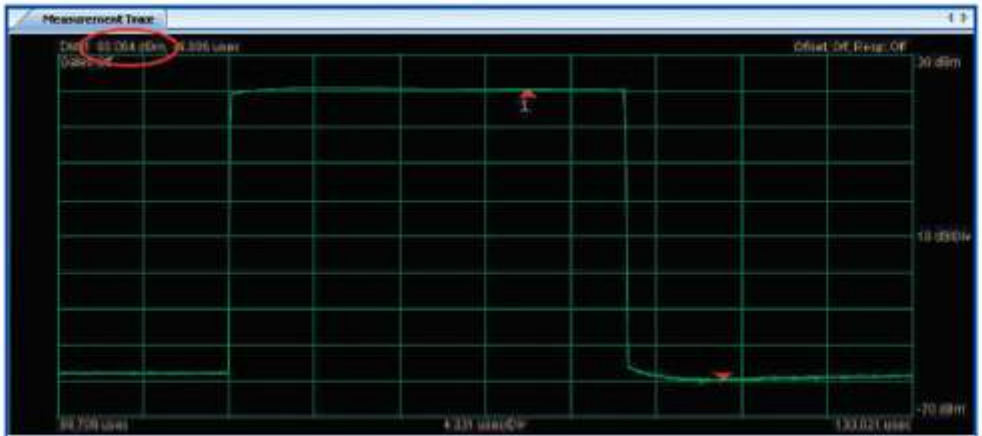

Figure 5: LadyBug LB480A PowerSensor+ measurement of 80 dB on/off ratio

New commercial wireless technologies such as Long Term Evolution (LTE) and WiMAX use Quadrature Amplitude Modulation (QAM) and higher-order modulation techniques that change the waveform amplitude between symbols. They also employ Offset Frequency Division Multiplexing (OFDM) to spread the signal spectrum, incorporating many subcarriers, each of which may carry different symbol information at various power levels. These signals can move quite slowly, resulting in measurement fluctuations. Accurate measurements can be made with the LadyBug Power Sensor+ by setting the measurement filter sufficiently wide and by increasing averaging. Measurement accuracy will degrade as signal content beyond the 10 MHz sensor bandwidth increases.

LB480A Pulse Profiling PowerSensor+

LadyBug Technologies' model LB480A PowerSensor+ is a USB pulse profiling power sensor designed for full-envelope characterization of pulsed waveforms. It has a dynamic range of -60 to +20 dBm, larger than most other comparable sensors. The LB480A provides the optional feature of a settable video bandwidth of up to 10 MHz. This enables the capture of all frequency elements required to accurately evaluate pulses with a wide video bandwidth.

In many cases, it can match or outperform expensive signal analyzers or oscilloscopes, which may also be too large or too sensitive to temperature fluctuations.

Figure 6: Triggering on a low level pulsed signal at -55 dBm

USB power sensors from LadyBug Technologies require no zeroing and no calibration prior to each use. They undergo the most robust factory calibration in the industry, including calibration across the full operational temperature range. The sensor continually monitors the temperature and adjusts each power reading, employing a patented technique that makes LadyBug USB power sensors virtually immune to temperature changes.

The Pulse Profiling application from LadyBug Technologies provides all needed capabilities for complete evaluation of pulsed signals. Included are: time gated measurements for peak and average pulse power, overshoot, rise time, fall time, pulse width, pulse repetition frequency, duty cycle, and crest factor. Additional statistical tools include Cumulative Distribution Function (CDF) and Complementary Cumulative Distribution Function (CCDF) plots that provide a graphical representation of peak power characteristics. Up to five unique time gates are available for a variety of simultaneous pulse parameter measurements. Additionally, as many as five markers provide differential or absolute power information versus time.

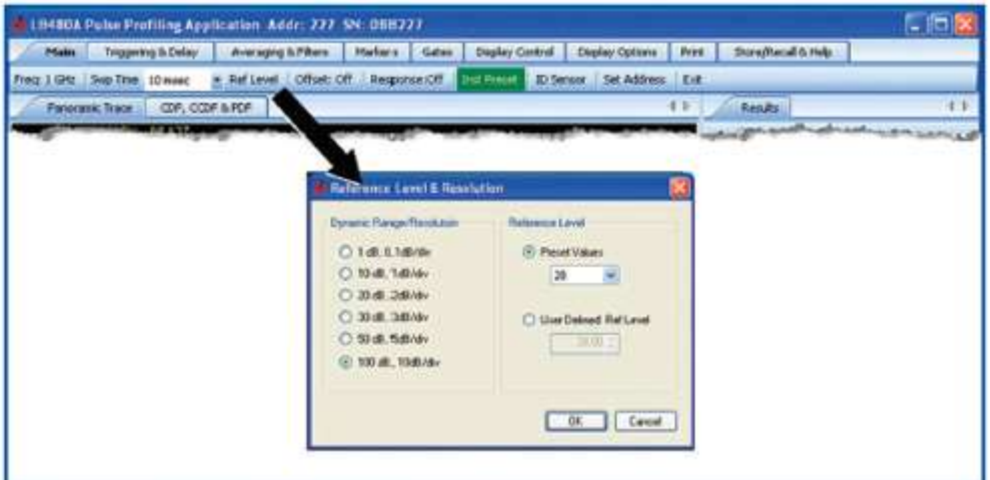

Figure 7: Making high dynamic range measurements using the LadyBug Pulse Profiling Application

Measurements of Signals with High Dynamic Range
Example: Measurement of an 80 dB Dynamic Range Pulse (-60 dBm to +20 dBm)

The ability to measure and analyze pulsed signals with a large on/off ratio is a requirement of power sensors used in radar and EW applications. The LB480A USB power sensor has this capability, as shown in **Figure 5**.

To make this high dynamic range measurement using the LadyBug Pulse Profiling application (see **Figure 7**):

• The maximum pulse power of the LB480A is +20 dBm and damage level is +23 dBm. Ensure the input signal does not exceed +20 dBm.
• Ensure the Frequency setting on the Main Tab is set to the RF carrier frequency of the pulsed signal. Use a Sweep Time, Reference Level and Dynamic Range Resolution that will capture the entire pulse envelope.
• On the Averaging & Filters Tab, turn Averaging on and use enough measurements to remove random noise and accurately measure the noise floor.
• On the Markers Tab, enable a delta marker to obtain the measurement.

Triggering with Low Level Signals
Example: Triggering with a -55 dBm Pulse

The capture of a specific event within an RF signal for analysis requires the ability to trigger the instrument at the event time. For signals input to a radio receiver, the desired segment of the signal may have a relatively low level.

The LB480A sensor is capable of triggering on a signal level between -55 and +20 dBm. Internal Manual Level must be selected. External triggering can synchronize the measurement to an event within the waveform.

To make a triggered measurement of a low-level signal using the LadyBug Pulse Profiling application:

• Set the Frequency on the Main Tab to the RF carrier frequency of the pulsed signal. Use a Sweep Time, Reference Level and Dynamic Range Resolution that will capture the pulse envelope with sufficient resolution to view the signal.

• On the Triggering and Delay Tab, set the Trigger Source to Internal Manual and the Trigger Level to -55 dBm as shown in **Figure 6**.
For best results, with very low-level rectangular signals trigger on the Falling Edge.

Conclusion
The capabilities and value of the LadyBug LB480A Pulse Profiling PowerSensor+ elevate it far above any other sensor in its class. It is an ideal choice for pulsed radar, EW, and bursting communications measurements. High dynamic range, low-level triggering, and extensive measurement capabilities are just a few of the many features of this unique sensor.

A data sheet for the LB480A can be found at:
http://www.ladybug-tech.com/downloads/salesliterature/lb480A/data_sheet_480A.pdf

Additional documentation and application software (including the Pulse Profiling Application) can be found at: http://www.ladybug-tech.com/downloads.html

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