LeCroy

SDA-UWB
Software Option

Operator's Manual

August 2006

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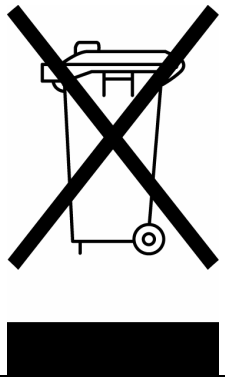

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UWB-OM-E Rev A
914492 Rev A

SIGNAL ACQUISITION REQUIREMENTS:

The UWB package requires that the oscilloscope sample rate be set to 20 GS/s or higher. It is designed to work at 20 GS/s, 40 GS/s, 60 GS/s, or 80 GS/s.

This software is designed for UWB signals as described by the WiMedia® Alliance.

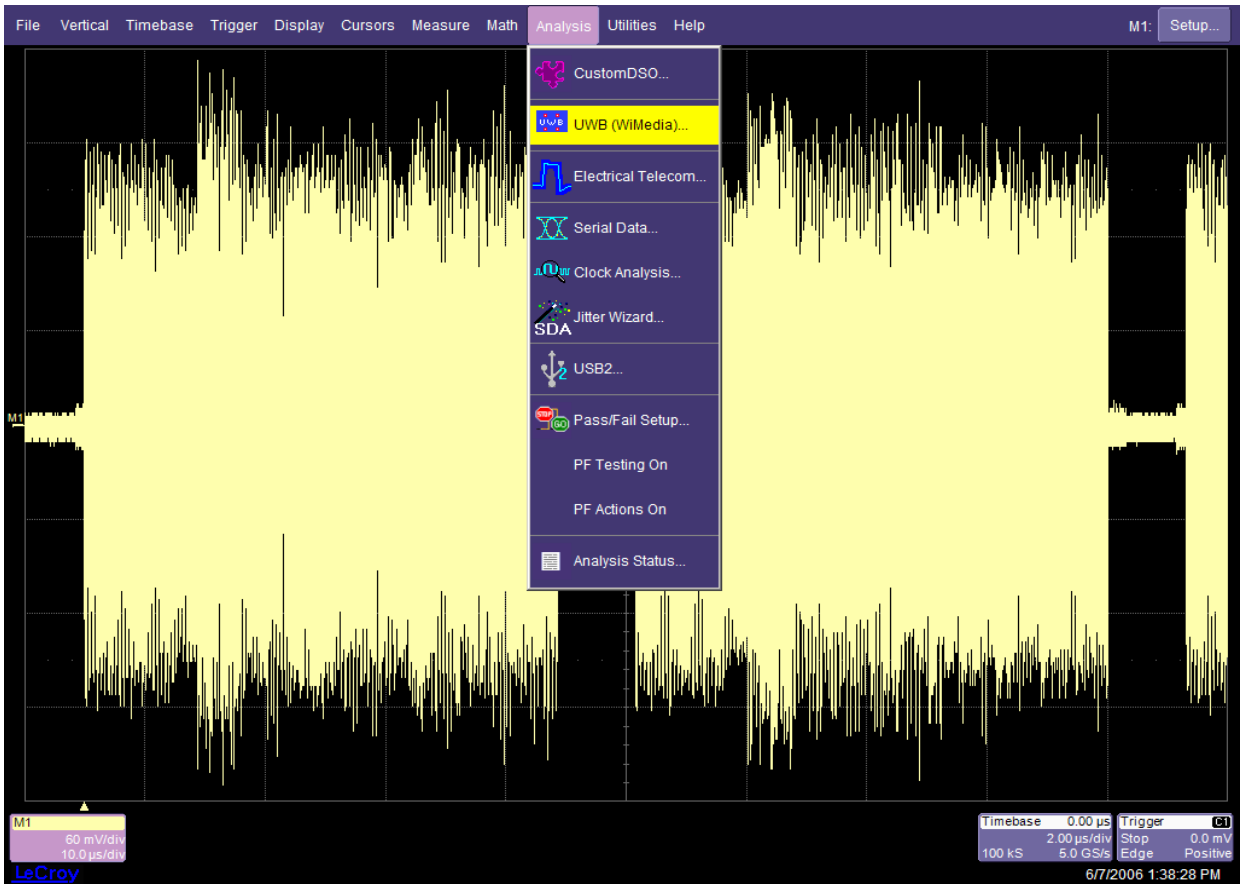
You must capture the beginning of a packet preceded by at least 200 ns of the inter-packet gap: just like a real receiver, the analysis software must see packet's preamble.

According to the MultiBand OFDM Physical Layer Specification 1.1 (©2005 MultiBand OFDM Alliance and WiMedia Alliance), EVM is only computed on data symbols. With a Standard preamble, the first data (PSDU, payload) symbol is symbol 43. Although our software does not require it, you should acquire full packets. The WiMedia PHY Compliance and Interoperability Test Specification (v1. 0, September 1, 2006) says "EVM shall be computed over at least 3 packets with a payload of at least 96 symbols each. If the measured EVM is within 2 dB of the specified EVM maximum in absolute value, abs(measuredEVM – specEVM) < 2 dB, then the EVM should be remeasured over an average of 10 packets to ensure accuracy of the measurement." Please see the WiMedia PHY Compliance and Interoperability Test Specification for more details.

Scope Firmware Version: 4.9.2

ACCESSING SDA-UWB

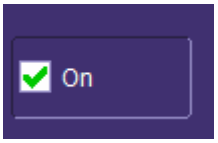
Once installed, SDA-UWB's math and parameter selections will appear in the Analysis menu.



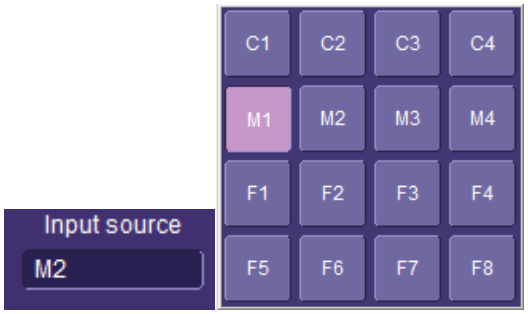
Click on the UWB selection to display the UWB user interface at the bottom of the scope screen:

SDA-UWB user interface

UWB ANALYSIS

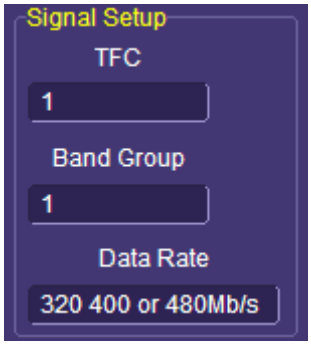


Select this checkbox to start the analysis of the selected **Input Source**.



Input Source is selectable between 4 input channels, 4 memory channels, 8 math functions.

SIGNAL SETUP



Time Frequency Channels

TFC values range from 1 to 7.

TFC1: symbol 1 = Lowest band, symbol 2= mid band, symbol 3 = high band and repeats 1,2,3…1,2,3

TFC2: 1, 3, 2….1, 3, 2….

TFC3: 11, 22, 33 … 11, 22, 33….

TFC4: 11, 33, 22….

TFC5, 6, 7: FFI mode (Fixed Frequency Interleave).

Note: When working in TFC 5, 6, or 7 there is only going to be 1 PSD mask. In fact there is no energy in the other bands.

Band Group

Each Band Group is composed of 3 Bands

Each Band Group has 7 possible TFC choices except Band Group 5, which has fewer choices.

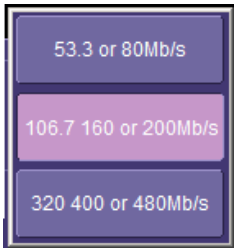
Each combination of Band Group and TFC is called a Channel

Channel number

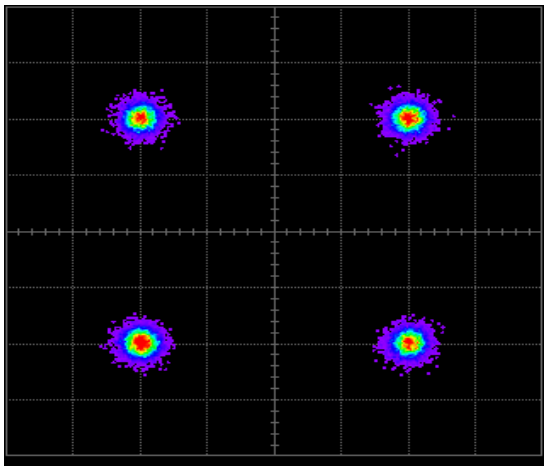
Channel numbers are determined as: 8 x Band Group + TFC

Data Rate

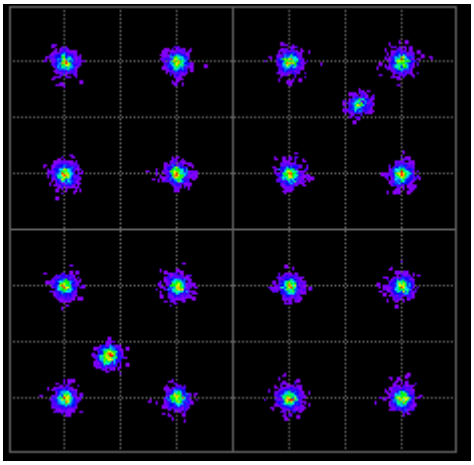
Transmission speed of the User Data Portion only of the packet:



Note: In the MB-OFDM signal, the data is modulated with a QPSK scheme for data rates up to 200 Mb/s. For user signals with higher data rates, the DCM modulation scheme is used (18 stars in the constellation display, 16 for data plus 2 for pilot tones).



QPSK constellation display (4 stars)

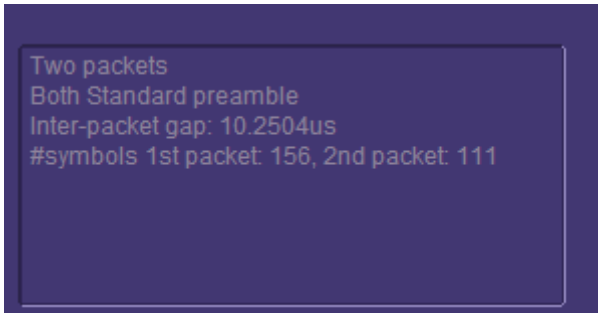


DCM constellation display (16 stars data + 2 stars for pilot tone)

Information Box

Outputs useful information on the signal being analyzed:

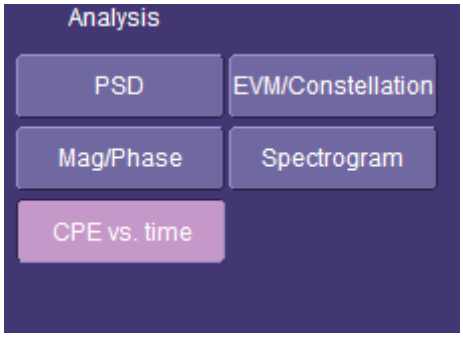
- Number of packets displayed
- Preamble information
- Inter-packet gap time
- Number of symbols contained in each packet displayed



Analysis

5 main selections:

- Power Spectral Density (PSD)
- Error Vector Magnitude (EVM) with Constellation display
- Magnitude and Phase plots (Mag/Phase)
- Spectrogram
- Common Phase Error (CPE) vs. time



POWER SPECTRAL DENSITY (PSD) SECTION

Symbol Selection

A symbol is a burst of energy occupying 500 MHz.

These controls are disabled when the **Use Defaults** checkbox is checked (default mode). To gain access to these 2 numerical selections, disable the **Use Defaults** checkbox.

Start Offset

This numerical control lets you modify the point in the gap (between symbols) when the RF radio transmitter actually turns on. The default value is 0 ns, which corresponds to the 5th sample before the nominal symbol start at the base sample rate (528 MS/s). The WiMedia PHY Compliance and Interoperability Test Specification (hereafter referred to as the C&I spec) allows the start value to be varied to find a time that minimizes local oscillator leakage or other issues, in order to pass the PSD mask and adjacent channel power ration (ACPR) tests. The same start position must be used for both tests.

Duration

The time interval between each symbol within a package. Default value is 303 ns.

The duration of each symbol plus the gap (between the symbols) is nominally 312.5 ns. The nominal duration of the symbol without the gap is 242.42 ns. (303 ns is 160 baseband sample times.)

The C&I spec does not allow the duration to be changed, for C&I testing the duration must be the default value, 303 ns.

Use Defaults Checkbox

This box is checked by default. Deselect this checkbox to gain control of the Symbol section ("Start offset" and "Duration" fields).

Show Control

Switches the display between the Mask pass/fail view and the ACPR values view

Mask Pass/Fail View

This view displays the power spectral density of the 3 bands in the selected Band Group and tests the limits against the specified masks. Test result passes if the 3 signals do not violate the 3 corresponding masks.

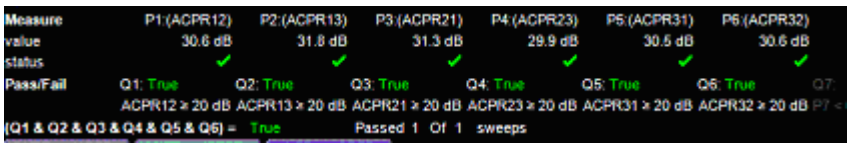
Example of the PSD Mask pass/fail testing view

Adjacent Channel Power Ratio (ACPR) View

Click on the ACPR Values to switch from the **Mask pass/fail** view to the **ACPR values** view

This view shows the pass/fail limit testing on the Adjacent Channel Power Ratio parameters. Each of the six displayed ACPR parameters measures the power ratio between the transmitting channel and the two adjacent channels. Test limit is the same for all six channels and equal to 20 dB.

The test passes when the transmission channel power is greater than or equal to each one of the adjacent channels by 20 dB.

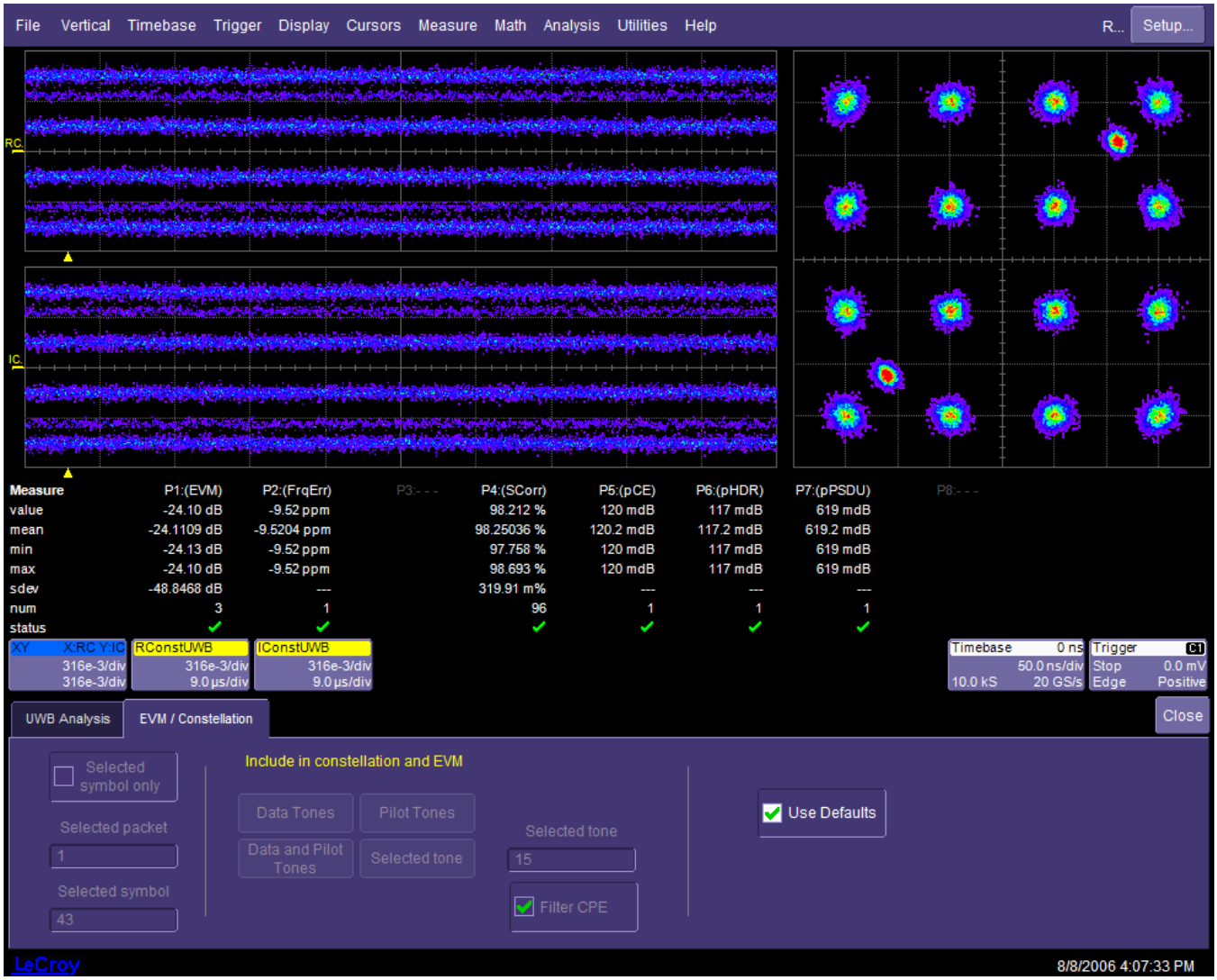


Example of the ACPR values view

ERROR VECTOR MEASUREMENT (EVM) & CONSTELLATION

This view offers a simultaneous display of:

- Real and Imaginary waveforms (I and Q components) of tones of all symbols analyzed
- Constellation display in X-Y grid
- Error Vector Magnitude Measurement (P1)
- Frequency Error Measurement (P2)
- Sync Correlation Measurement of preamble symbols (P4)
- Relative Power of Channel Estimation symbols (P5)
- Relative Power of Header symbols (P6)
- Relative Power of Payload symbols (P7)



Real and Imaginary Waveforms (I and Q components)

These two waveforms are the result of the discreet Fourier transform (DFT) processing, and display the Real and Imaginary components of all the tones contained in each symbol. The points in these traces are the same as the points in the constellation. These traces have horizontal axis units of time, but 112 points from each symbol are from the same symbol (the same time); i.e., the time scale is # symbols * symbol duration. This is sufficient to

deduce which packet, or approximately which symbol within a PSDU, caused a visible disturbance; but this time scale does match the acquisition's time scale, which of course includes inter-packet gaps, inter-symbol gaps, and preamble and header symbols that do not contribute to the constellation.

Error Vector Magnitude (EVM) Measurement Parameter

Error Vector Magnitude is the distance between the point where each tone, as magnitude and phase, actually fell and where it should have fallen. Ideally each tone should fall exactly on the constellation point but, in reality, each tone falls in the proximity of the ideal constellation points, creating a "cloud" around the ideal points of the constellation.

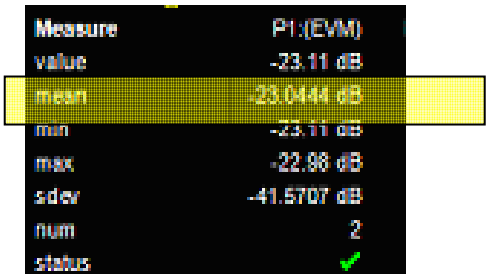
One Error Vector Magnitude (**EVM**) value is calculated for each packet (all the symbols contribute) by the root mean square calculation. From section 8.7 of the MultiBand OFDM Physical Layer Specification, EVM is calculated for each packet as follows, which is the square root of the mean squared distance from expected constellation points of all the data and all the pilot tones in each of the symbols after the packet header to the end of the packet:

$$\sqrt{\sum_{n = N_{sync} + N_{hdr}}^{N_{packet}} \left[\frac{\sum_{k=1}^{N_D} |R_{D,n}[k] - C_{D,n}[k]|^2 + \sum_{k=1}^{N_P} |R_{P,n}[k] - C_{P,n}[k]|^2}{(N_D + N_P) N_{frame} P_0} \right]}$$

The EVM value is then calculated by averaging the values from each packet:

$$RMS_{error} = \frac{1}{N_f} \sum_{i=1}^{N_f}$$

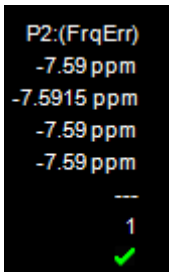
EVM is displayed with statistics on. The "value" is a number calculated for the most recently processed packet. The "value", "min" and "max" are EVM values from one packet. "Num" is the number of packets contributing to the "mean." The EVM result you should look at is the "mean" value, which is the result of averaging the values from each packet, as required.



The "sdev" value, because it is shown in the same units as all the values, requires a word of explanation. But first, please note that, in this measurement, there is not much value in considering sdev; the test does not require it. Linear units must be averaged to find the mean and the sdev. Then both are converted to dB. Sdev reflects the distribution of EVM values from different packets. It is expected to be much smaller than EVM, as shown. If sdev is larger, all else being unchanged, min and max will be farther apart.

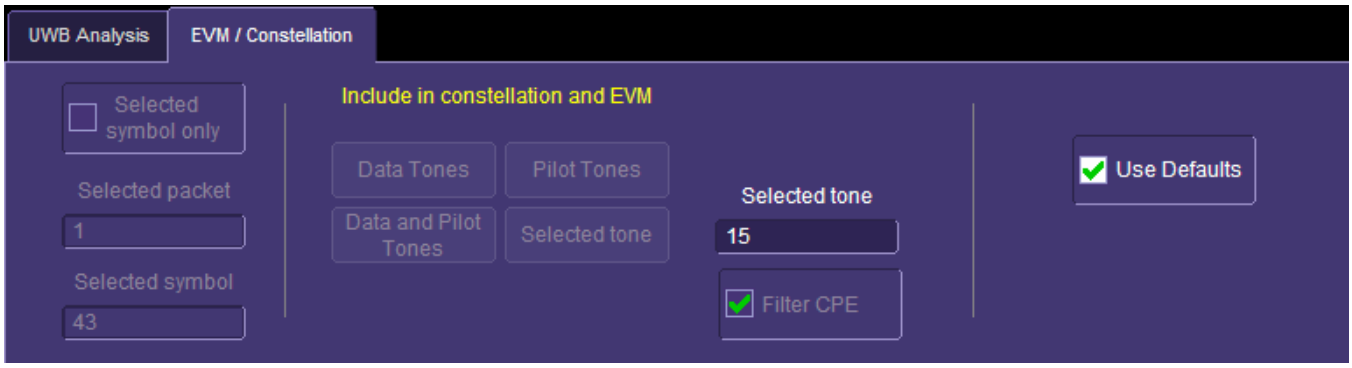
Frequency Error Measurement Parameter

This parameter measures the drift in the timing error that is due to a mismatch between the signal timing and what it should be, based on our timebase. The timing error is derived from Common Phase Error measurement. The drift between the first PSDU symbol and the end of the packet divided by the time gives a frequency mismatch between the signal and the ideal frequency. This is the frequency error, and it is represented in parts per million.

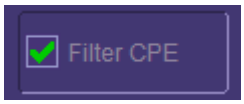


Include in Constellation and EVM

The default setting for this view is as shown in the figure below:



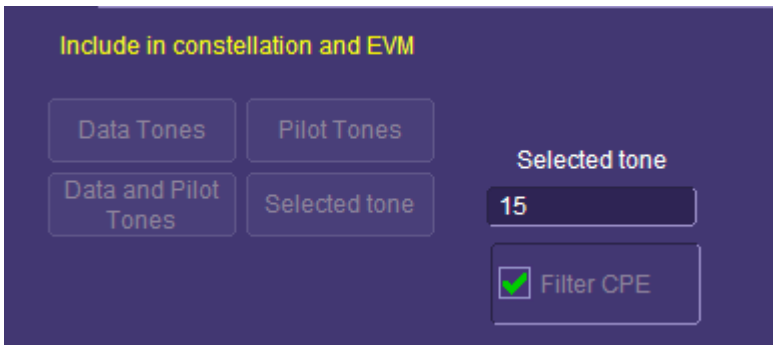
In this mode, the Constellation display includes data from both Data and Pilot tones for all the symbols of every packet that is included in the waveform under analysis.



The WiMedia PHY Compliance and Interoperability Test Specification v1.0 specifies in section 3.5 that “The EVM Rx shall compute and correct for common phase error (CPE) after a CPE filter has been applied as described in Section 3.5.1.” The intent of the filter is to cause relatively rapid and/or large fluctuations in the carrier frequency (that is, phase noise) to degrade EVM. The filter -3 dB bandwidth is approximately 266 kHz. When “Filter CPE” is checked, the required filter is applied. When “Filter CPE” is not checked, we completely correct for CPE on a symbol-by-symbol basis; that means phase noise will not degrade EVM up to a much higher frequency. The difference observed reflects how much EVM is degraded by fluctuation of the carrier frequency, that is, phase noise. C&I Testing requires “Filter CPE” to be checked.

When EVM is computed, the frequency of the signal has been matched; that is, the overall slope of CPE from start to end of each PSDU has been eliminated. Therefore it is only variation of CPE from symbol to symbol that is filtered and causes degradation of EVM values.

The inclusion choices are:



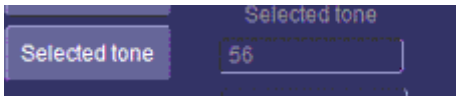
For compliance testing the appropriate choice is **Data and Pilot Tones**.

Selected Tone

In each symbol, there are (-61, + 61) tones. Tones +/- 5, 15, 25, 35, 45, 55 are pilot tones. If any pilot tone is selected, the constellation display will show only one point in the constellation. The pilot tone position never varies.

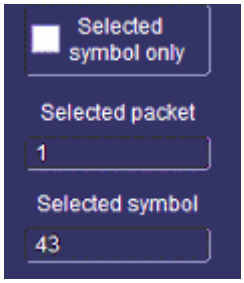
Any data tone selected will be displayed in any one of the four points of the constellation (QPSK). Data tones are distributed across the possible four points of the constellation.

In this mode of operation, you can select a specific tone among the available tones (12 pilot tones and 100 data tones) in each symbol.



Selected Packets and Selected Symbol

The two control boxes below allow you to select packets and a specific symbol within the selected packet.

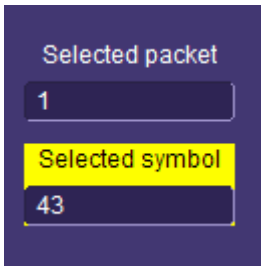


MAGNITUDE/PHASE (MAG/PHASE)

This view displays the Real and Imaginary components (Magnitude and Phase) that result from the DFT processing of the UWB signal after down-converting it to baseband:

Selected Packets

You can select a specific packet and the symbol of interest within one specific packet. The default value is packet 1, symbol 43 (beginning of User data) within the packet.



Note on symbols within a packet:

Preamble: 24 symbols (1 to 24)

Preamble: 6 symbols (channel estimation symbols 25 to 30). These symbols are used for channel equalization.

Header: 12 symbols transmitted at low data rates

User Data: from symbol 43 to end of packet. These are the only symbols transmitted at the “Data Rate.”

Show Tones

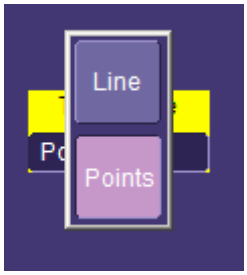
Pilots Only (Magnitude and Phase Traces)

There are 12 pilot tones in each symbol (located at ± 5, 15, 25, 35, 45, 55 of the DC center point). When **Pilot only** is selected, each one of the traces (Magnitude and Phase) displays one data point on each pilot tone.

Since the pilot tones are the reference for decoding, Magnitude and Phase are set values: magnitude is set at 1 and the phase of each tone varies between 45° and -135°.

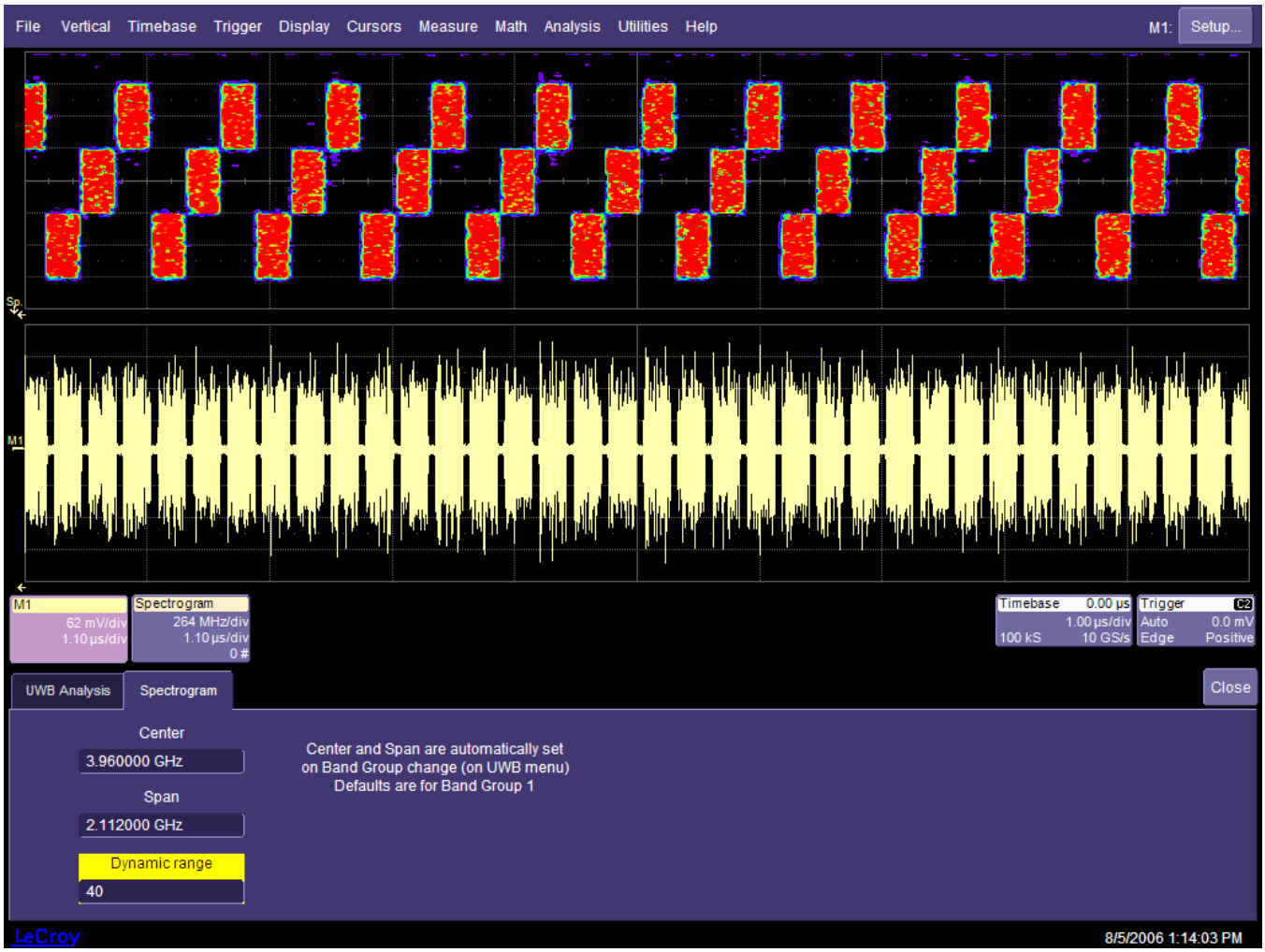
Trace Style

This control sets the style of the Real and Imaginary plots as either points only (default) or line (straight line interpolation between points).



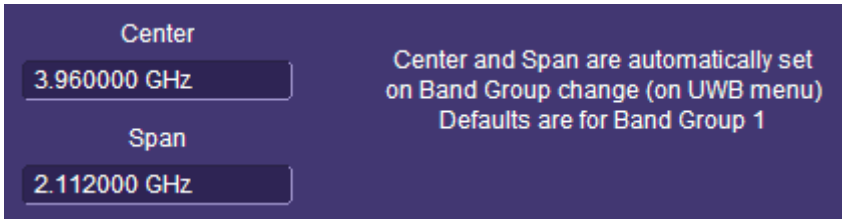
SPECTROGRAM

This view displays the spectrogram of the 3 frequency sub-bands. Forming a spectrogram does not require UWB processing, so you can zoom in on the source (as shown below) to any part of a packet.



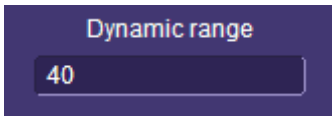
Center and Span

Center frequency and frequency span of the spectrogram.



Dynamic Range

Dynamic range of the signal displayed in the Spectrogram. Values range from 32 to 48. Default value is 40.



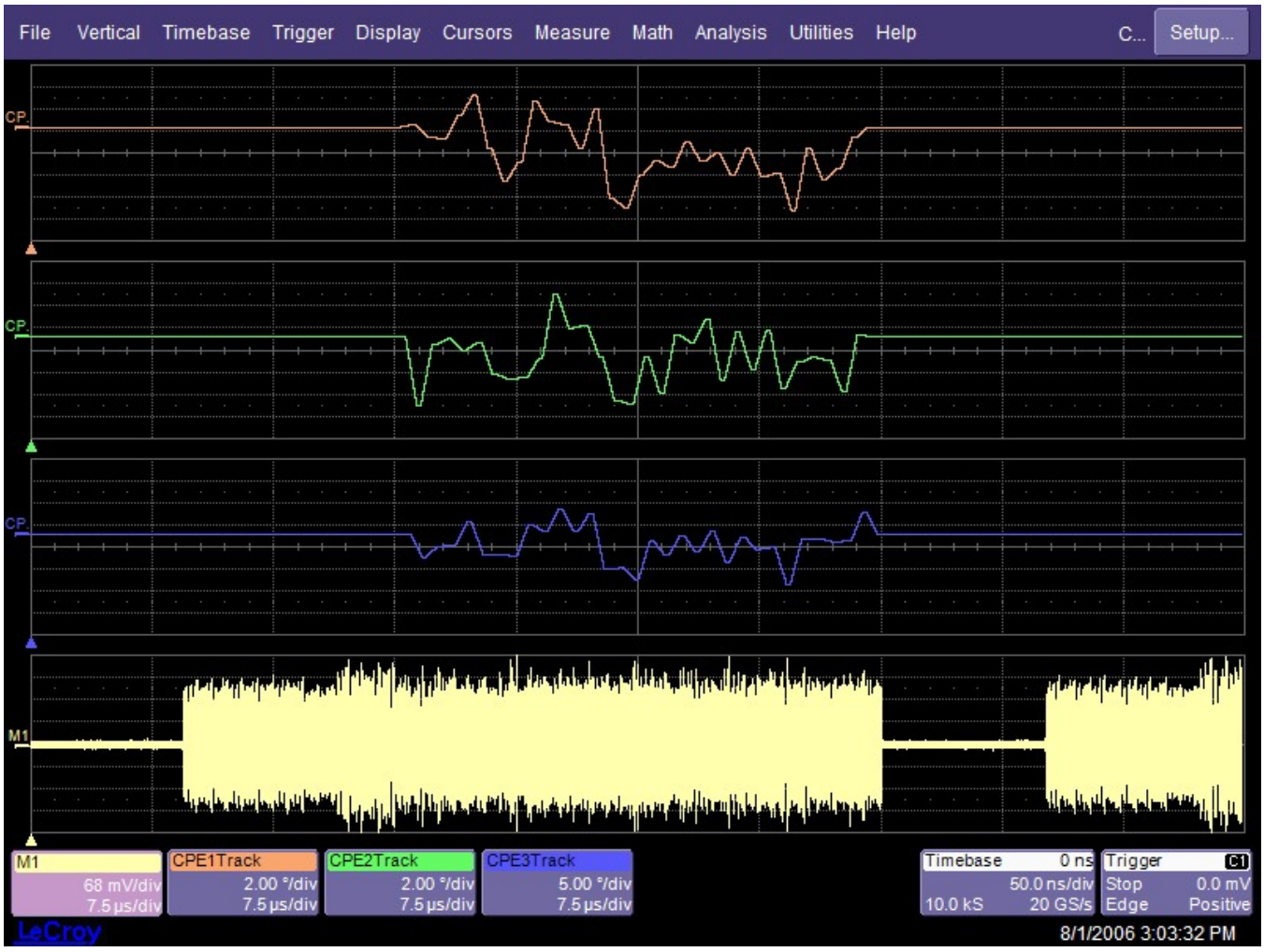
Note: The spectrogram display appearance is affected by the **Display**, **Persistence, Saturation** setting. If Saturation is set to 100%, there will be very little red, and the color scale is linearly distributed over the dynamic range. If Saturation is set to 50% (the default), then anything in the top half of the dynamic range will be red and the color scale is linearly distributed over the lower 50%. The UWB software does not change the Saturation setting.

COMMON PHASE ERROR (CPE) VS. TIME

This view shows how the Common Phase Error of the carrier frequency of each sub-band varies over time, over the PSDU. This view does require UWB processing to be done, so an entire packet (starting from the beginning) must be seen. The vertical scale of each track is automatically set to use most of the height of the grid, so it is important to look at the vertical scale-per-division in the trace descriptors, below the grids. In the figure below two of the tracks are at 2 degrees/div and the third is at 5 degrees/div. These variations are small.

Although it may not be clearly visible, the track is flat from start to end of each symbol time over which CPE was measured. A slanted line just connects measured values.

CPE of the first symbol of the PSDU is zero by definition. Because matching frequency eliminates the slope of CPE across the PSDU, the CPE track will also end at zero; only the variations from symbol to symbol are shown.



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