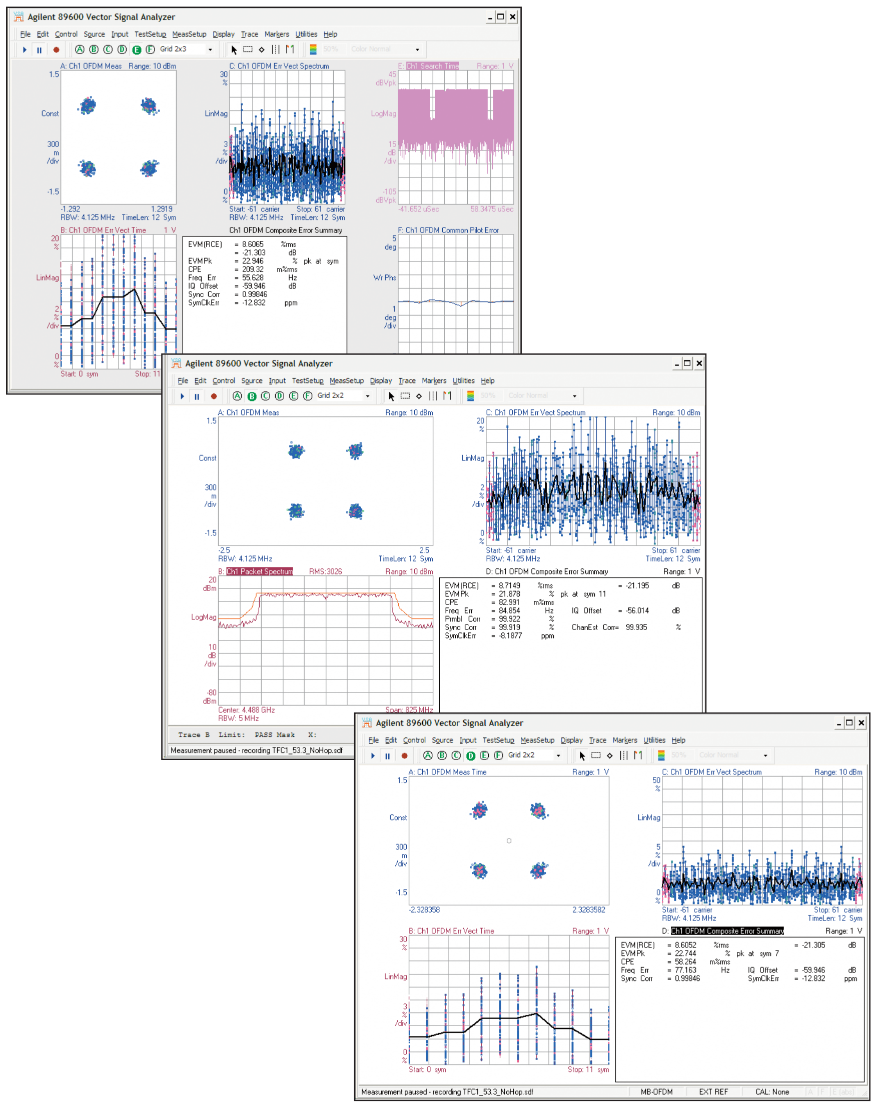
Beginning with release 16.0 of the 89600 VSA software, Option BHB (UWB Modulation Analysis) will be discontinued.

Option BHB Multiband-OFDM Modulation Analysis 89600 Vector Signal Analysis Software

Self-Guided Demonstration



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Agilent Technologies

WiMedia Alliance Ultra-Wideband Physical Layer Overview

The WiMedia® Alliance defines and supports the ultra-wideband (UWB) common radio platform, which is designed for use in wireless personal area networks (WPAN). The standard defined by the WiMedia Alliance defines the physical (PHY) and media access control (MAC) layers for the UWB common radio platform. The specification published by the WiMedia Alliance is the WiMedia PHY Test Specification. The ISO specifications that are based on the WiMedia Alliance specification are ECMA-368 and ECMA-369.

Certified Wireless USB is an extension to existing wired USB that uses the WiMedia UWB common radio platform. It will provide the functionality of existing USB but will do so without the need for wires, at target data rates of 480 Mb/s at 3 meters, and 110 Mb/s at 10 meters. Certified Wireless USB will initially be employed by consumer electronic devices, PC peripherals, and mobile devices.

The specification promoted by the WiMedia Alliance is based on Multiband Orthogonal Frequency Division Multiplexing (MB-OFDM). It is one of the two proposals that were presented to the IEEE working group 802.15, task group 3a (802.15.3a). The supporting organizations behind each of the two proposals now continue to promote them outside of the IEEE task group. This is done through the WiMedia Alliance, for MB-OFDM based UWB, and the UWB Forum, for Direct Sequence UWB (DS-UWB). This technical overview will focus on the PHY layer of MB-OFDM UWB.

The ECMA-368 standard specifies UWB operation in the frequency range of 3.10 to 10.60 GHz, for unlicensed operation. In this range are 14 bands, each 528 MHz wide. The lower (in frequency) 12 bands are grouped into four groups of three bands each, and the upper two of the 14 bands are grouped into a fifth group. The sixth band group consists of bands 9 to 11, which overlap band groups 3 and 4. For any one symbol transmitted, the

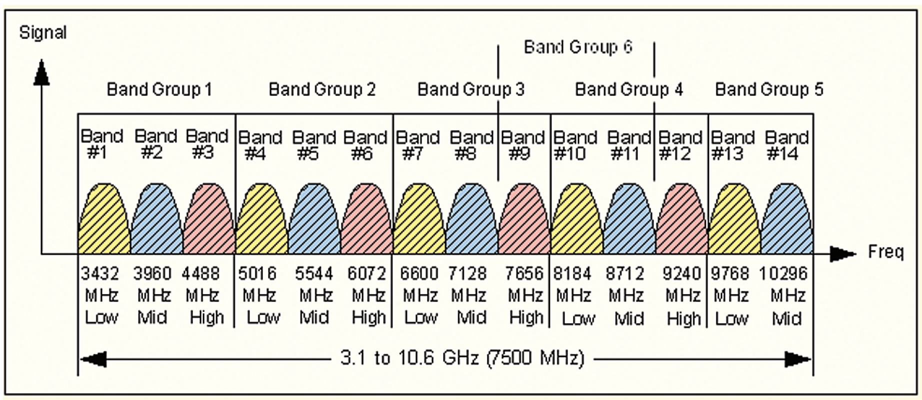

Figure 1. Frequency band plan for UWB band groups.

occupied bandwidth of the signal is nominally 528 MHz. However, the signal may hop in frequency according to predetermined patterns referred to as Time-Frequency Codes (TFCs). Certain TFCs have the signal hop to a different center frequency on every symbol. The data rates of devices that conform to the standard are from 53.3 Mb/s to 200 Mb/s, with data rates above 200 Mb/s being optional.

In the 528 MHz bandwidth signal, the OFDM structure is as follows. The signal has a total of 122 useful subcarriers, with a spacing of 4.125 MHz between each. Ten of the subcarriers are guard subcarriers; five are on the lower-frequency edge of the signal, and five are on the upper-frequency edge of the signal. The guard subcarriers are implemented to ensure compliance with regulatory conditions such as minimum occupied bandwidth, and their power levels are adjusted accordingly. Twelve pilot carriers are distributed in frequency within the signal. Their locations in the frequency domain are defined in the standard (see Figure 3) and do not change from symbol to symbol. The remaining 100 subcarriers are data-bearing.

Time-Frequency Codes (TFC)								
TFC	Band Group	Base Sequence Preamble	Band Hopping Sequence					
1	1	1	1	2	3	1	2	3
2		2	1	3	2	1	3	2
3		3	1	1	2	2	3	3
4		4	1	1	3	3	2	2
5		5	1	1	1	1	1	1
6		6	2	2	2	2	2	2
7		7	3	3	3	3	3	3
8		8	1	2	1	2	1	2
9		9	1	3	1	3	1	3
10		10	2	3	2	3	2	3
5	5	5*	13	13	13	13	13	13
6		6*	14	14	14	14	14	14
8		8*	13	14	13	14	13	14
* Only 5, 6 and 8 are defined.								
		Color codes:	Low		Mid		High	

Figure 2. Example TFC hopping sequences.

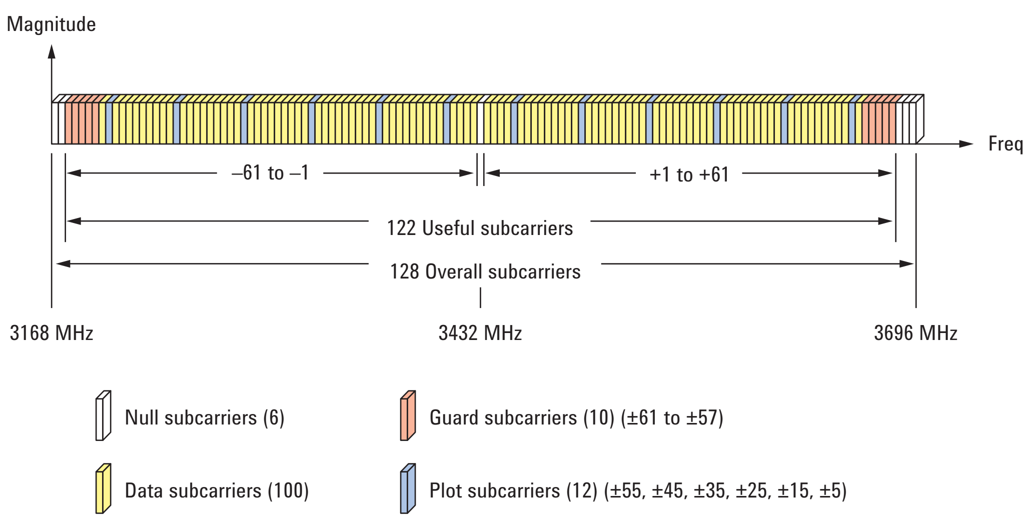

Figure 3. Frequency-domain structure of UWB OFDM signal.

The MB-OFDM standard allows for several modulation schemes to transmit data over the 100 data-bearing subcarriers. QPSK modulation is used on the subcarriers for data rates up to 200 Mb/s, with different coding rates used to achieve different data rates. For the 320 Mb/s, 400 Mb/s, and 480 Mb/s data rates, a dual-carrier modulation (DCM) scheme is employed. DCM is a technique where bits are organized into groups of four. Each group of 4 bits is then mapped onto two separate constellation maps. Their structure is very similar to a 16QAM constellation. Each 16QAM constellation is then modulated onto two subcarriers, with one subcarrier located 50 subcarriers away from the other. Since subcarriers with this separation are approximately 206 MHz apart, the probability that both points will suffer from fading simultaneously is reduced, and diversity loss is reduced.

As with many other OFDM-based technologies, UWB mitigates effects of multi-path interference through the use of padding and extending. Instead of using symbol padding, however, zero padding is used. The IFFT and FFT period of a symbol is 242.42 ns long, and the zero-padded suffix is 70.08 ns long. Thus, the total symbol length is 312.5 ns. In addition to minimizing the effects of multi-path interference, the zero-padded suffix allows the transmitter and receiver some time to switch between the hopped center frequencies of the TFC employed.

From a frame structure perspective, MB-OFDM UWB is similar to other wireless networking formats. The general physical layer frame contains a preamble, a header, and a payload (see the Timing Diagram on page 26). The preamble, or PLCP Preamble, provides timing synchronization and channel estimation. A standard preamble or a shorter burst preamble may be used. The header, or PLCP header, contains information such as the rate and length of the payload to follow, the MAC header, and tail and parity bits. The header is always sent at 39.4 Mb/s, regardless of the data rate of the payload. The payload, or PSDU, contains the frame payload, of variable length, and check and pad bits. Its data rate can vary among the values mentioned above.

The standard PLCP preamble is used by the receiver for packet/frame synchronization and channel estimation. Packet/frame synchronization provides coarse frequency estimation of the carrier and coarse symbol timing; the channel estimation portion of the preamble provides fine estimation of the carrier frequency, symbol timing, and frequency response of the channel. The burst preamble is used in a streaming mode, where bursts of packets are sent consecutively, separated only by a short time interval, known as the minimum inter-frame separation time (pMIFS). The structure of the burst preamble is identical to the structure of the standard preamble: a packet/frame synchronization part followed by a channel estimation part. The packet/frame estimation portion of the burst preamble is half as long as the equivalent portion in the standard preamble. The channel estimation portions of the burst and standard preambles are of the same length.

The MB-OFDM standard continues to evolve in consideration of new data rates and interference mitigation.

Adopting the Best Measurement Approach

The 89600 VSA software, with Multiband-OFDM Modulation Analysis, is ideal for the analysis and troubleshooting of the complex, wide-bandwidth, and time-varying nature of UWB MB-OFDM signals. Combined with Infiniium oscilloscopes, it covers all frequency ranges as defined by the WiMedia Alliance standard. It can also analyze and demodulate signals modulated with any of the ten possible TFCs over any of the band groups, with automatic or manual TFC detection. The mandatory data rates, as well as the optional higher data rates, are supported, allowing the designer to test the maximum throughput of the device, up to 480 Mb/s. For these higher data rates, modulation analysis of DCM and the use of burst preambles are supported. If the system or device under test is a non-hopping MB-OFDM signal, it can be examined by de-selecting Frequency Hopping Analysis on the Advanced tab of the DemodProperties dialog box. Other useful Advanced tab troubleshooting capabilities include analyzing time-scaled baseband signals that are hopped at final frequencies.

When measuring and troubleshooting digitally modulated systems, it is tempting to go directly to digital demodulation and the measurement tools. It is usually better to follow a measurement sequence: one that begins with basic spectrum measurements and continues with vector (combined frequency and time) measurements before switching to basic digital modulation analysis and finally to advanced and/or standard specific analysis. This sequence of measurements is especially useful because it reduces the chance that important signal problems will be missed.

1 **Spectrum and time domain measurements**
Get basics right, find major problems

2 **Basic digital demodulation**
Signal quality numbers, constellation, basic error vector measurement

3 **Advanced digital demodulation**
Find specific problems and causes

Figure 4. Measurement and troubleshooting sequence used in this guide.

Step 1: Spectrum and time domain measurements

These measurements evaluate the basic parameters of the signal, the parameters that must be correct for demodulation to take place. Parameters such as center frequency, bandwidth, symbol timing, power, and spectral characteristics are investigated.

Step 2: Basic digital demodulation

These measurements evaluate the quality of the constellation. Along with a display of the constellation, they include static parameters such as: EVM, I/Q offset, frequency error, and symbol clock error.

Step 3: Advanced digital demodulation

These measurements are used to investigate the causes of errors uncovered in the basic modulation parameters, particularly EVM errors. These include dynamic parameters such as: Error vector frequency, error vector time, and pilot phase error.

Setting Up the Demonstration

Table 1. System requirements

The 89600 VSA software requires a PC connected via USB, GPIB or LAN I/O to a supported Agilent platform, including oscilloscopes, logic analyzers, and simulation software. For a list of supported platforms, see the *Hardware Measurement Platforms Data Sheet*, 5989-1753EN. To run the demonstration, either a laptop or desktop PC may be used as long as it meets or exceeds the following minimum requirements. In addition, you may run this demonstration in the supported oscilloscope itself: [1]

Operating system	Microsoft® Windows® XP Professional, Service Pack 2	Microsoft® Windows® Vista Business, Enterprise, or Ultimate
CPU	> 1700 MHz Pentium® or AMD-K6® > 2 GHz recommended	1 GHz 32-bit (x86) > 2 GHz recommended
RAM	512 MB 1 GB recommended for oscilloscopes with optional memory	1 GB 2 GB recommended for oscilloscopes with optional memory
Video RAM	4 MB (16 MB recommended)	125 MB (512 MB recommended)
Hard disk space	512 MB available	512 MB available
Additional drive	CDROM to load the software; license transfer requires 3.5-inch floppy drive, network access, or USB memory stick	CDROM to load the software; license transfer requires 3.5-inch floppy drive, network access, or USB memory stick
Interface support	LAN, GPIB, or USB	LAN, GPIB, or USB

1 For best immunity from electrostatic discharge (ESD), use a desktop PC.

Table 2. Software requirements

Version	89600 v10.0 required for full functionality described
Options - 200 - 300 - BHB	(89601A, 89601AN only) Basic vector signal analysis Hardware connectivity (required only if measurement hardware will be used) Multiband-OFDM modulation analysis

Setting Up the Demonstration (continued)

Table 3. Frequency and time domain setup

Instructions	Navigation
Preset the analyzer	Click **File > Preset > Preset All** Note: Using **Preset All** will cause all saved user state information to be lost. If this is a concern, save the current state before using **Preset All**. Click **File > Save > Setup** Note: The Menu/Toolbars, Display Appearance, and User Color Map may also be saved in a similar way.
Recall the simulated UWB MB-OFDM signal MBOFDM_TFC6_480Mbs.sdf	Click **File > Recall > Recall Recording** Navigate to the directory which contains the signal **C:\Program Files\Agilent\89600 VSA\Help\ Signals\ MBOFDM_TFC6_480Mbs.sdf**
Begin replay of the recording	Click **Control > Restart** Or, alternatively, click ▶ *(toolbar, left side)*

Notes

The size of the display window can be changed as desired. It may be useful to enlarge the display window (click and drag, as with any standard window) to see fine structure in a time domain or frequency domain display.

Start the measurement	Click **Restart** *(▶ toolbar, left side)* ...the analyzer will playback and measure the signal, starting at the beginning of the recording each time **Restart** is clicked. Note: The analyzer defaults to the span used to record the signal, and an overlap (governs the speed of signal playback) of 90%.
Temporarily halt playback	Click **Pause** *(❚❚ toolbar, left side)* Click it again to resume playback from the point where it was paused

If you wish to see what portion of the recording is currently selected for analysis, you can bring up the player window by selecting **Control > Player**. This window provides both a graphical and numeric indication of the current analysis location in the recording.

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The analyzer defaults to a stacked 2-trace display where the top trace is a spectrum measurement and the bottom trace is a time domain measurement, as shown in Figure 5. The default for the bottom trace is a vertical axis indicating logarithmic signal magnitude (envelope of the signal). The RF bursts in this signal can be seen as the recording is played back. The triggering defaults to the free run mode, so the signal will simply play back as it was originally recorded. The signal is centered at 3.96 GHz, and the 1.6 GHz span clearly shows the entire 528 MHz-wide signal.

Triggering properly gives the user a stable signal to work with, and once the signal is properly centered on screen, and properly triggered, accurate and repeatable measurements can be made.

Table 4. Setting the trigger

Instructions	Navigation
Select the trigger type	Click **Input > Playback Trigger** Select **Channel** from the **Type** drop-down menu Note: The playback is limited to recorded signals. To trigger live signals, use an external trigger or pulse search. The pulse search is the most robust method when the input is from hardware rather than from a recorded signal.
Set the trigger level	Type **70** mV in the **Level** field Click **OK** to accept ...a dotted line will appear on the trace at the programmed trigger level
Set the hold-off style	Select **Below Level** Note: Below Level hold-off style is the appropriate trigger type for high duty cycle bursts. For live signals, its applicability may be limited by the specific hardware you are using to make measurements
Set the hold-off time	Type **2** µsec in the **Hold-off** field Click **OK** to accept
Set the trigger delay value	Type –**10** µsec in the **Delay** field Click **OK** to accept

To increase the resolution of the traces, increase the number of points in the record to increase the time record length.

Table 5. Changing the number of frequency points

Instructions	Navigation
Select a larger number of frequency points	Click **MeasSetup > ResBW** Select **102401** from the **Frequency Points** drop-down menu Note: Increasing the number of frequency points increases the time record length while maintaining the frequency span; for more information on time record go to **Help > Content > Index** and type Time Record Length.
Set resolution bandwidth to 100 kHz	Type **100 kHz** in ResBW field

The signal may be easier to see clearly if auto-scale is used on the spectrum trace. Activate auto-scale by right-clicking the upper trace and selecting **Y Auto Scale** with either mouse button. Do this for both trace A and trace B.

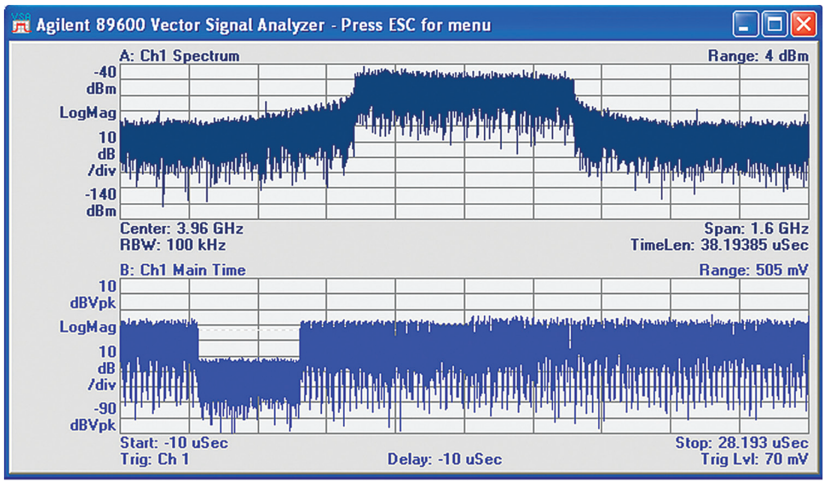

Figure 5. A properly triggered signal shows the spectrum and time displays of the signal, including the on-time and off-time.

Spectrum and time domain measurements

Spectrum measurements

The signal is centered at 3.96 GHz with an actual bandwidth of 507.4 MHz (122 x 4.125 MHz + 4.125 MHz for carrier 0). The occupied bandwidth (OBW) marker calculates these values from the spectrum trace. The bottom of the window will show the results of the OBW marker: the occupied bandwidth, centroid, and offset from trace center frequency.

The power in the occupied band is calculated by the band power marker. Once the measurement is enabled, a shaded portion of the spectrum will indicate the region used to calculate the band power. The measurement result, in dBm, will be displayed in the marker annotation area at the bottom of the screen. Note that the bandpower marker power should match the power listed in the summary OBW table in trace B.

To deactivate the OBW measurements, simply right-click the spectrum trace and clear the OBW marker. Using the trace B trace title hot-spot, return trace B to Main Time. Hot-spots exist anywhere on the display that a cursor changes to a hand icon. To use them, double click the parameter you want to change while this cursor is displayed.

Table 6. Measuring the occupied bandwidth and band power

Instructions	Navigation
Enable the OBW measurement on the trace of interest	Right-click trace A Select **Show OBW**
Display the power of the occupied bandwidth	Select trace B by left-clicking anywhere in the trace Select **Trace > Data > Marker > Obw Summary TrcA** on trace B
Select the center point of the band power measurement	Right-click trace A Select **Show Band Power** ...this readies the cursor to select the center of the band power measurement Click a point at the center frequency of the signal in trace A
Stretch the width of the region of the band power measurement so that it overlaps the shaded region of the OBW measurement	Click and drag either of the two vertical bars on the edge of band power region and stretch it so it overlaps the shaded OBW region
Once finished with the measurement, turn off the OBW and band power measurements	Right-click trace A Clear **Show OBW** Right-click trace A Clear **Show Band Power**
Display the time trace again	Left-click on trace B Select **Trace > Data > Main Time**

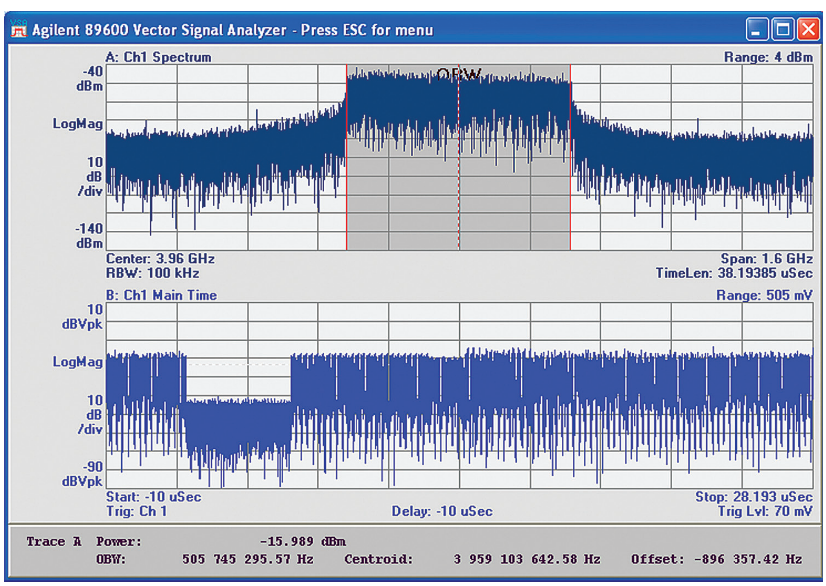

Figure 6. The occupied bandwidth marker's results are shown at the bottom of the window.

Self-Guided Demonstration (continued)

Spectrum and time domain measurements

Measuring the symbol time

Time-domain measurements help verify transmitter characteristics such as on and off times, rise and fall times, and other parameters. Changing the time length allows the user to zoom in the time-domain to areas of interest.

The symbol time can be measured with markers. The symbol time is measured by placing a marker on the rising edge of a symbol, and an offset marker on the rising edge of the symbol immediately following it. The marker readout at the bottom of the screen will show the differences in time and amplitude between the two markers, and, in this case, will report the total symbol time for one symbol, also referred to as T_{SYM}.

Table 7. Changing the time length

Instructions	Navigation
Change the time length to a smaller value to see details in the time domain	Click **MeasSetup > Time** Type **1** µsec in the **Main Time Length** field ...the main time display shows approximately three symbols

Table 8. Measuring the symbol time

Instructions	Navigation
Pause the recording to more easily make the measurement	Click **II** at the top left corner of the window
Place a marker on the main time trace	Right-click the main time measurement (trace B) Select **Show Offset** ...this places a marker and an offset in the display
Place the marker on the rising edge of a symbol	Click a portion of the trace that shows the rising edge of a symbol
Move the offset marker to the location of the reference marker	Right-click the screen Select **Move Offset to Mkr**
Place the marker on the adjacent symbol's rising edge	Click the rising edge of the next symbol on the trace ...the offset marker will remain where it is Note: The offset marker data is shown in the marker annotation area at the bottom of the window.
Once finished with the measurement, turn off the markers	Right-click trace B Clear **Show Marker**
Resume playing the recording	Click ▶ to resume replay

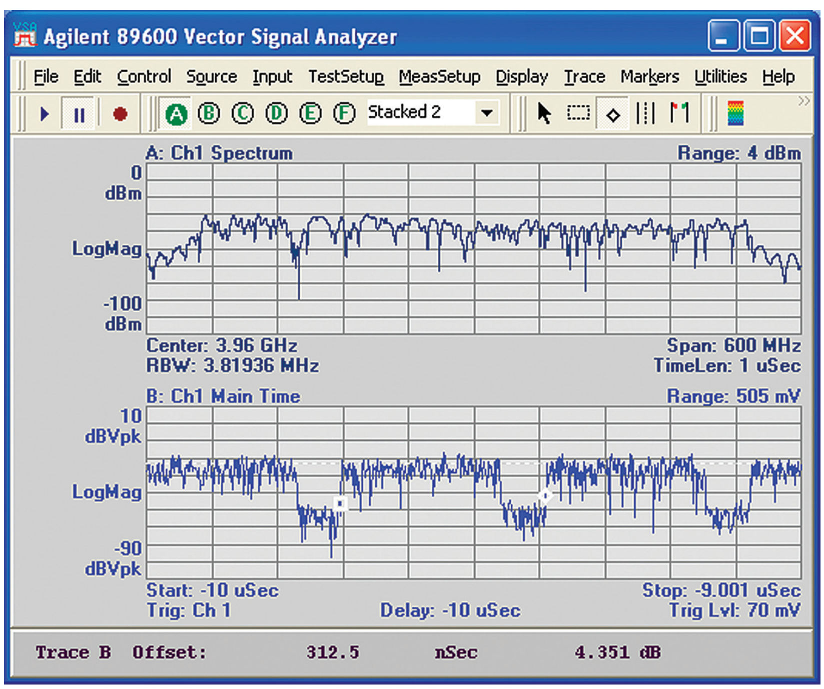

Figure 7. Measurement of one symbol-time using markers.

The spectrogram is a three-dimensional display that shows the changes in signal spectrum over time. It is particularly useful when analyzing signals that are bursted or frequency hopping, as are UWB signals. Features of signal transients, OFDM signal structure, and spectral splatter can all be identified with this display.

Table 9. Changing the time length

Instructions	Navigation
Select a smaller number of frequency points	Click **MeasSetup > ResBW** Select **6401** from the **Frequency Points** drop-down menu Note: Reducing the number of frequency points will reduce the processing needed to display the spectrogram.
Switch to a single display format	Click **Display > Layout > Single** ...this will allow the spectrogram display to fill the entire usable portion of the window
Ensure trace A is active and shows the spectrum display	If not, click **Display > Active Trace > Active A** Then click **Trace > Data > Spectrum**
Change the trigger to Free Run	Click **Input > Playback Trigger** Select **Free Run** in **Type** drop-down menu
Set the time length to 100 nsec	Click **MeasSetup > Time** Type **100** nsec in the **Main Time Length** field
Set Max Overlap to 95%	Click **MeasSetup > Time** Type **95%** in the **Max Overlap (Avg Off)** field
Enable the spectrogram display	Right-click trace A Select **Show Spectrogram** Note: You may need to adjust the scale by auto-scaling the trace or by adjusting the parameters on the **Trace > Y Scale** menu.
Once finished with the spectrogram measurement, disable it	Right-click trace A Clear **Show Spectrogram**

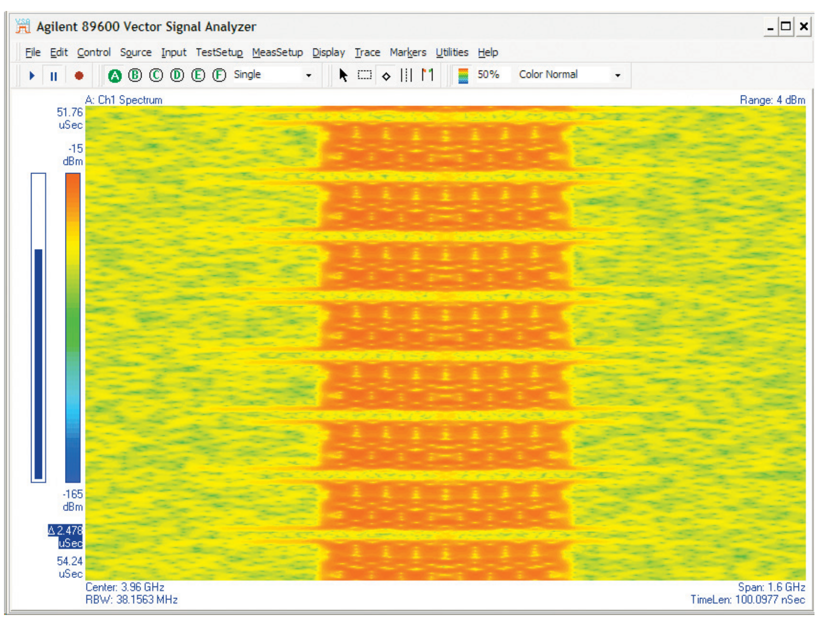

Figure 8. Spectrogram display of a non-hopped MB-OFDM signal. Notice the slight splatter at the beginning and end of each symbol.

Self-Guided Demonstration (continued)

Spectrum and time domain measurements

Figure 9 is an example spectrogram of a hopped signal that uses TFC 1. The vertical color bar on the left side of the spectrogram trace shows the color assignment for signal power. The highest power is red. This display allows the user to quickly identify spectral problems such as out of band spur and splatter that may occur at symbol transition points when the signal hops from one center frequency to another.

Figure 9. Spectrum of an MB-OFDM signal hopped over three center frequencies.

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3 **Advanced digital demodulation**
Find specific problems and causes

Once the RF and timing parameters have been investigated as described above, basic signal demodulation may begin. The MB-OFDM demodulator's settings are controlled using the demodulator properties.

Table 10. Turning on the demodulator and viewing the demodulator properties

Instructions	Navigation
View a stacked 2 display	Click **Display > Layout > Stacked 2**
Open the demodulator	Click **MeasSetup > Demodulator > Ultra-Wideband > MB-OFDM**

Basic digital demodulation

The default demod properties must be changed in order to properly demodulate the signal that was recalled in this example. The data rate of this signal is 480 Mb/s – this value can be changed in the drop-down menu. The recorded signal used here has a standard PLCP preamble, not a burst preamble. It uses Time Frequency Code (TFC) 6, so this needs to be set. Because this signal uses TFC 6, it is not, in fact, frequency-hopped. Therefore, frequency hopping analysis is automatically disabled. Otherwise, if the signal being tested used a different TFC, but was not actually hopped, frequency hopping analysis would have to be disabled. This is useful when troubleshooting a system, particularly in the early development phases, as designers can verify all parameters prior to actually hopping the signal. After performing these steps, the signal will be demodulated properly. The first indication of this will be the proper constellations in trace A.

Figure 10 shows the OFDM composite error summary in the bottom display. To view this, simply change the bottom display to show trace D.

Table 11. Selecting the correct data rate and TFC

Instructions	Navigation
Select TFC 6 and data rate	Click **MeasSetup > DemodProperties** On Format tab select **Preset to Standard > Band group 1 > TFC 6 ch 14** Select **Data Rate > 480 Mb/s**
Show the error summary table	Click **Display > Active Trace > Active B** Or, click trace B title (hot-spot) Select **Channel 1 Comp > Errs**

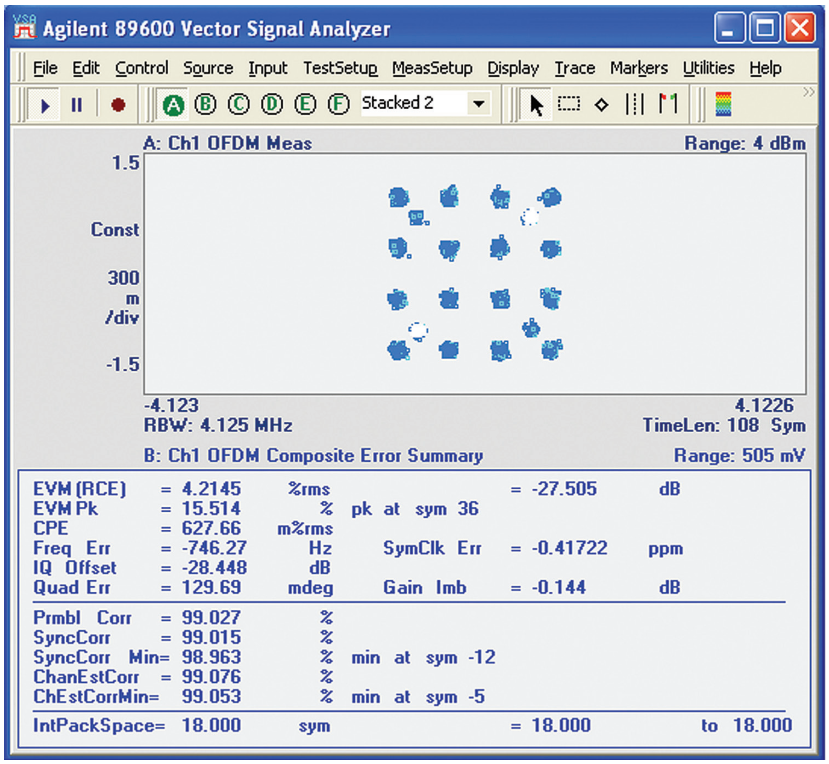

Figure 10. Basic demodulation of UWB signal showing constellations with header, payload, and pilots plus error summary table.

Table 12. Viewing the OFDM composite error summary in the bottom display

Instructions	Navigation
Change the bottom display to show the OFDM composite error summary	Click trace B On the toolbar, click **D**
Return bottom trace to spectrum	Click trace D (bottom) On the toolbar, click **B**

Self-Guided Demonstration (continued)
Basic digital demodulation

The OFDM composite error summary display shows modulation quality metrics such as Error Vector Magnitude (EVM) or Relative Constellation Error (RCE). This number summarizes the modulation quality of the signal over the measurement time (also called the measurement interval). Other metrics, such as the common pilot error (CPE) and IQ offset are also shown.

The flexibility of the 89600 VSA software allows the user to view multiple result displays simultaneously. This will show a screen with the following traces, clockwise from the upper-left display: the constellation, OFDM error vector spectrum, OFDM composite error summary displays, and spectrum. On any display with a trace, the user may right-click the display and select **Y Auto Scale** to automatically scale for proper viewing of the entire result.

Closer examination of the constellation will reveal the color-coded constellation points that are part of the display. For the MB-OFDM signal, data points are shown in red, and pilot points are shown in white (using the default display appearance colors which are different than those shown here). The blue points correspond to the points from the 10 guard subcarriers that are on either side of the signal in the frequency domain. This same color-coding scheme applies to the other displays as well, for example, in the error vector spectrum display.

Table 13. Viewing four displays simultaneously

Instructions	Navigation
Set the layout of the displays to show four displays in a 2x2 grid format	Click **Display > Layout > Grid 2x2** or select **Grid 2x2** from the drop-down menu in the tool bar (currently displaying **Stacked 2**)

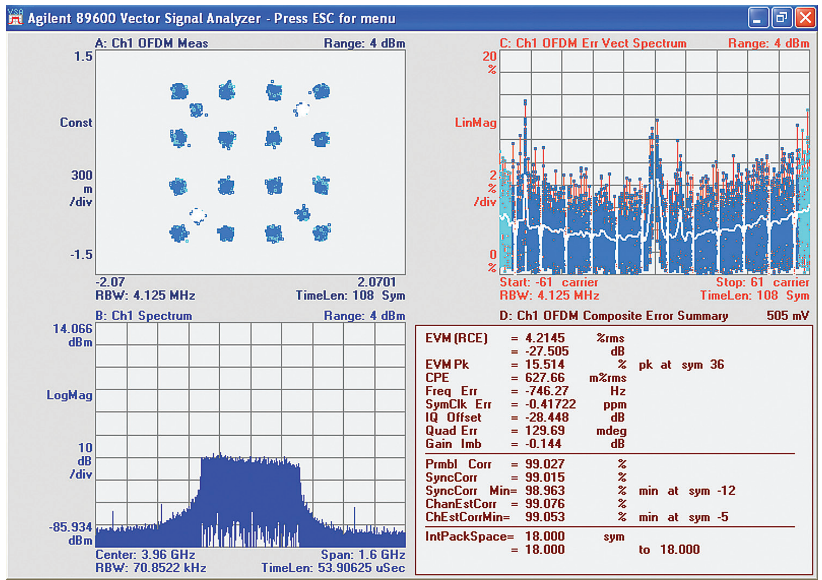

Figure 11. 2x2 configuration showing constellation, error vector spectrum, spectrum, and error summary displays.

The spectrum mask measurement ensures that the power level of the UWB signal is within limits and compliant to regulatory standards. A swept-tuned spectrum analyzer could be used to make this measurement, but the 89600 VSA can perform the same measurement and eliminates the need to set up a spectrum analyzer.

The error vector spectrum display shows the spectrum of the error vector as a function of time (error vector time display). Viewing the error vector spectrum can give added insight into the nature and origin of these error signals. Notice in this display there are white points, which correspond to pilot symbols, and a solid line that runs horizontally through the trace. This line is the rms average of the EVM spectrum across the frequency axis shown.

The error vector spectrum display shows the EVM (also relative constellation error or RCE) by carrier. The white carriers are the pilot tones and the blue carriers are the guard tones. Each dot on a carrier is the EVM (RCE) of that carrier for a particular symbol time.

Table 14. Enabling the spectral mask measurement

Instructions	Navigation
Ensure the spectrum display is the active trace	Click **Display** > **Active Trace** > **Active B** Note: In this case Trace B is the spectrum display.
Change the display to packet spectrum	Click **Trace** > **Data** > **Ch 1 Comp** > **Packet Spectrum**
Recall the limit tests	Click **Utilities** > **Limit Tests** > **Recall** Navigate to the Limits directory: (C:\Program Files\Agilent\89600 VSA\Examples\Limits) Load the file “WiMediaPSDMaskHigh.lims,” and do the same for the files “WiMediaPSDMaskMid.lims” and “WiMediaPSDMaskLow.lims” Click **Close**
Open the limits menu	Click **Markers** > **Limits**
Enable the spectral mask limit lines	Select the **Limit Test** check box Select “WiMediaPSDMaskMid” from the **Name** drop-down menu Note: We are using this limit test because our signal only occupies the Mid-band, however, if you had a hopping signal, you could make measurements on any of the bands.
Once finished with the measurement, turn off the limit lines	Click **Markers** > **Limits** Clear the **Limit Test** check box

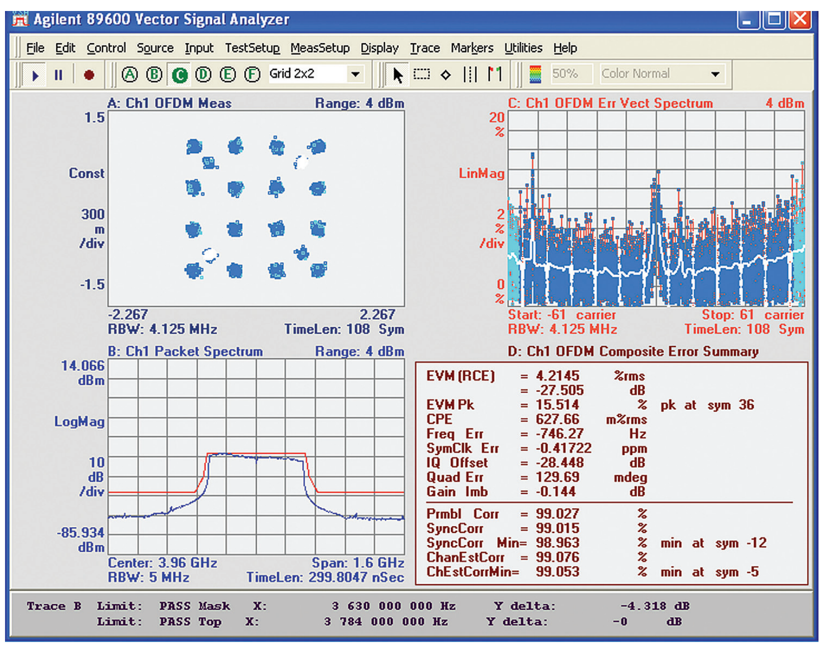

Figure 12. Spectrum mask measurement performed over the packet spectrum trace.

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More advanced troubleshooting and investigation into signal characteristics and signal quality can be made by viewing other displays. Two additional displays will then be shown – in this case the search time and OFDM common pilot error displays.

Table 15. Viewing six displays simultaneously

Instructions	Navigation
Set the layout of the displays to show six displays in a 2x3 grid format	Click **Display > Layout > Grid 2x3**

Self-Guided Demonstration (continued)
Advanced digital demodulation

Any of these displays can be changed to show a different trace or result. For example, you can change trace B to show error vector time. The error vector time display is similar to the EVM spectrum display, except that it displays EVM (RCE) using the time-domain as the reference axis, so that the progression of errors over time (symbols) can be seen.

Table 16. Showing the error vector time display

Instructions	Navigation
Make trace B the active trace	Click **Display > Active Trace > Active B**
Change trace B to show error vector time	Click **Trace > Data >Chan 1 Comp > Error Vector Time**

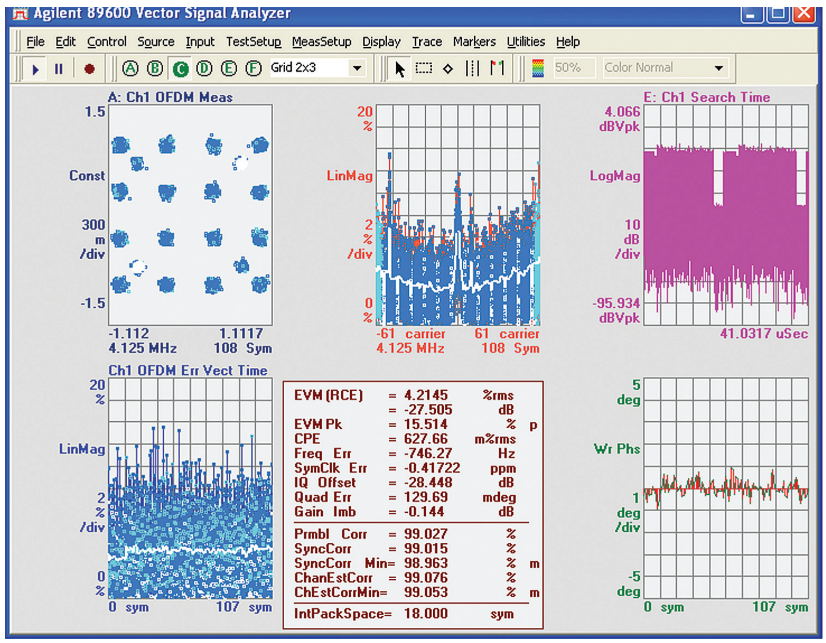


Figure 13. 2x3 configuration allows the user to view multiple results and traces simultaneously.

Self-Guided Demonstration (continued)

Advanced digital demodulation

Markers are mandatory for accurate measurement of specific points in the time, frequency, and modulation traces. Markers can be displayed on individual traces by selecting the marker icon in the toolbar, and then left-clicking a display, or by right-clicking a display and selecting **Show Marker**. Additional markers can be placed on other displays at the same time.

Coupled markers can be used to identify errors and then pinpoint their precise location from different perspectives, in order to more quickly and accurately find their source. The bottom of the window will report the marker readout of the first marker placed, as well as the readout from the markers in the other displays.

Table 17. Enabling multiple, coupled markers

Instructions	Navigation
Place a marker in the OFDM RMS Error Vector Time display	Right-click trace B (OFDM RMS Err Vect Time) Select **Show Marker**
Enable markers on the other displays	Click **Markers > Couple Markers** ...this will place markers in the other displays and couple them Note: You can experiment with this function by selecting the constellation display (or other) and using the right arrow key –> to move the marker to its next position. Clear markers by selecting each trace with a right-click and clearing **Show Marker** or by going to the menu and clicking on **Markers >Show Marker** to toggle the markers off.

A very useful display for MB-OFDM signals is the preamble phase error display. This result shows the error present in the phase of the preamble, which is used for timing synchronization and channel estimation. Problems in the preamble will generally result in poor sync correlation.

Table 18. View the preamble phase error display

Instructions	Navigation
Change trace E to show the preamble phase error display	Double-click the Trace Data hot-spot located on the title of the display, **E: Ch1 Search Time** Select **Channel 1 Comp** in the **Type** (left column) dialog box Select **Preamble Phase Err** in the **Data** (right column) dialog box Click **OK** to accept

Self-Guided Demonstration (continued)

Advanced digital demodulation

MB-OFDM signals at 480 Mb/s use DCM modulation in the payload. This portion of the signal can be analyzed simply by setting the measurement interval and offset appropriately.

These two parameters can be adjusted to show measurement points anywhere within the maximum result length measured.

In this instance, we will delay the start of the measurement for 12 symbol-times to avoid measuring the QPSK header. By decreasing the number of symbol-times you look at, you can perform more detailed analysis if needed.

Table 19. Analyze DCM modulation

Instructions	Navigation
Change the measurement interval	Click **MeasSetup > Demod Properties** Select **Time** tab On the **Time** Tab, type **24 symbol-times** in the measurement interval field
Change the offset to view the DCM modulated portion of the signal	Type **12 symbol-times** for **Measurement Offset**

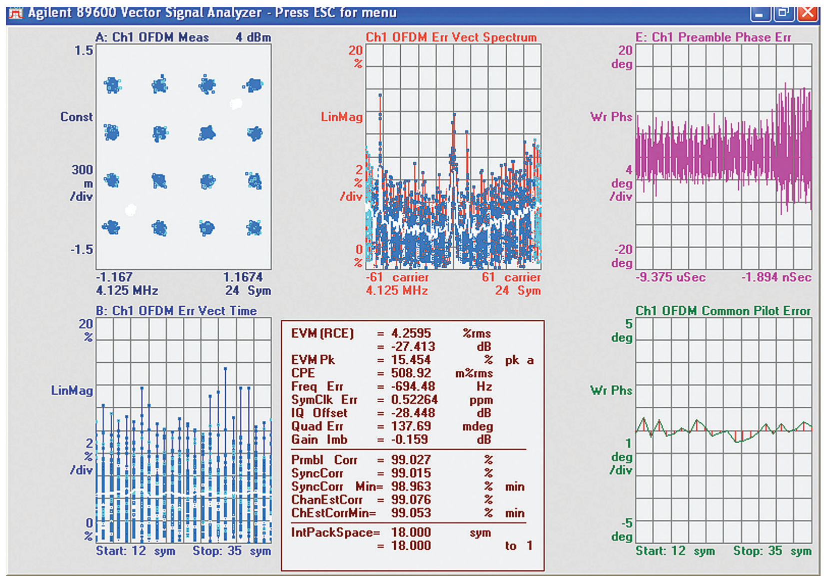


Figure 14. Demodulation of dual-carrier modulated UWB signal (Note: constellation in upper left).

Additional advanced analysis

The 89600 VSA software offers additional advanced displays and measurements. Essentially, it can act as a receiver allowing measurement of HCS and RS errors along with actual decode and checking of FCS. Change your measurement data type to **Composite Header Info/Data** and **OFDM Composite PSDU Info/Data** and check the **Help** text for more information.

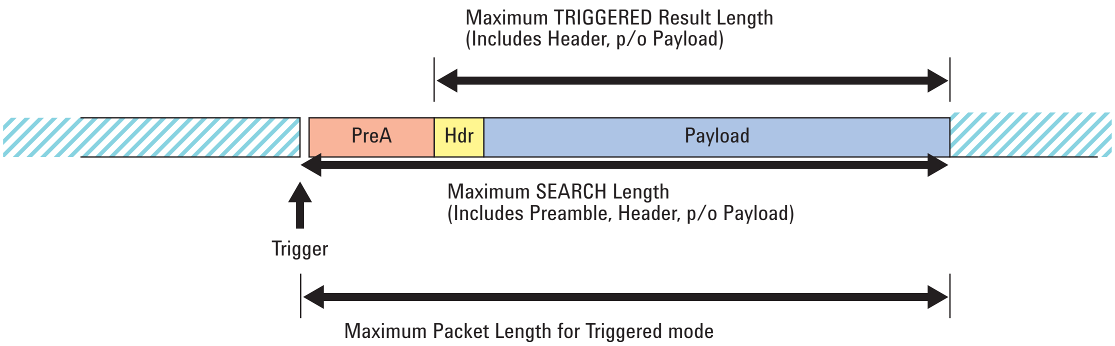
Summary

The complexities and challenges inherent in MB-OFDM signals are not trivial. Low power, very high data rates, high carrier frequencies, short symbol times, frequency hopping patterns, and other properties all increase the need for an advanced tool that can troubleshoot and determine the root cause among many possibilities. The Agilent 89600 VSA software with Multiband-OFDM modulation analysis dissects signals in powerful ways that help designers and developers get their product to market quickly. Its available presets, multiple-results screen, coupled markers, and specific displays such as preamble phase error allow the user to concentrate on the signal under test, and not the test equipment itself.

Timing Diagram

Triggered measurement:

Packet may be > maximum search length
Result length limited to maximum results length



Pulse search measurement:

Packet time must be < 0.5 * (maximum search length – 1.875 µs)
Payload limited to 96 or 48 symbols (see table)

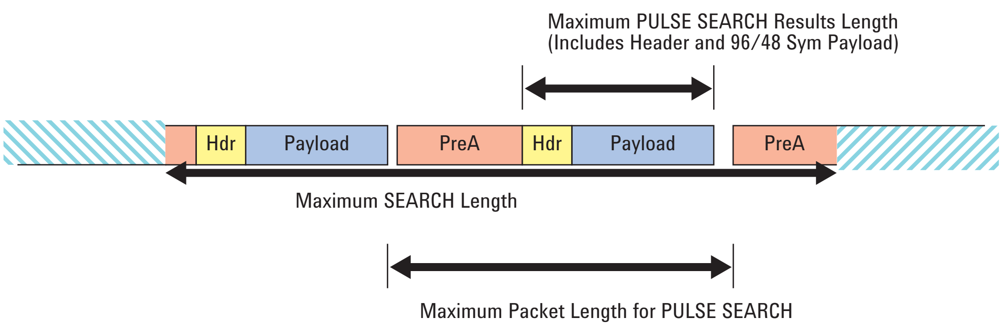


Figure 14. Timing diagram showing the relationship between triggered and pulse search measurements with respect to frame structure.

Glossary

CPE Common Pilot Error

DCM Dual Carrier Modulation

DS-UWB Direct-Sequence Ultra Wideband

EVM Error Vector Magnitude

FFT Fast Fourier Transform

IFFT Inverse Fast Fourier Transform

MAC Media Access Control

MBOA Multiband OFDM

MB-OFDM Multi-band Orthogonal Frequency Division Multiplexing

MIFS Minimum Inter-Frame Separation

OBW Occupied Bandwidth

PDSU PHY Service Data Unit

PHY Physical

PLCP Physical Layer Convergence Protocol

QPSK Quadrature Phase Shift Keying

RCE Relative Constellation Error

TFC Time-Frequency Code

TFC Time-Frequency Codes

UWB Ultra Wideband

WPAN Wireless Personal Area Network

ZPS Zero-padded Suffix

References

WiMedia Alliance (http://www.wimedia.org/)

Multiband OFDM Physical Layer Specification Release 1.1

ECMA International Standard ECMA-368 and Standard ECMA-369

Related Literature

Publication Title	Publication Type	Publication Number
89600 Series Vector Signal Analysis	Technical Overview	5989-1679EN
89600 Series Vector Signal Analysis 89601A/89601AN/89601N12	Data Sheet	5989-1786EN
89600S Vector Signal Analysis Software	CD	5980-1989E
Ultra-Wideband Communication RF Measurements	Application Note 1488	5989-0506EN
Agilent Technologies Solutions for Ultra-Wideband	Application Note	5989-5280EN
Agilent Infiniium Oscilloscopes Performance Guide Using the 89600 VSA Software	Application Note	5988-4096EN

Web Resources

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