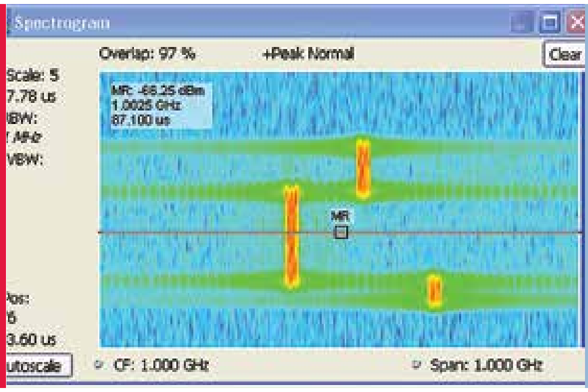

SignalVu-PC Demonstration Guide

Bringing the Benefits of Wideband Vector Signal Analysis to your PC

Demonstration Guide with Stored Signals

What You'll Need

- SignalVu-PC demonstration software and signals. The latest version can be downloaded at www.tektronix.com.

SignalVu-PC puts the analysis capability of Tektronix Real Time Signal Analyzers on your computer. Analysis in multiple domains can be performed on signals acquired from:

- MDO4000 Mixed-Domain Oscilloscopes RF channel
- Tektronix 3000 and 4000 series oscilloscopes
- All Windows-based real time oscilloscopes (5000, 7000, 70000 series)
- Real Time Signal Analyzers (RSA3000, RSA5000, RSA6000 series)
- Third-party files in MATLAB level-5 format

Tektronix®

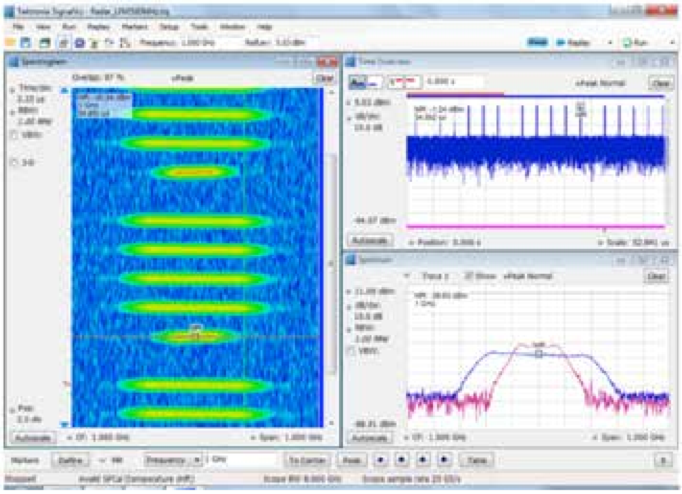

Figure 1. SignalVu-PC allows users to see the time-varying nature of complex signals. In this example, the Spectrogram shows four wideband radar chirps followed by a relatively narrow one. The Spectrum display in the lower right shows how the signal changes over time as the marker is moved through the time record.

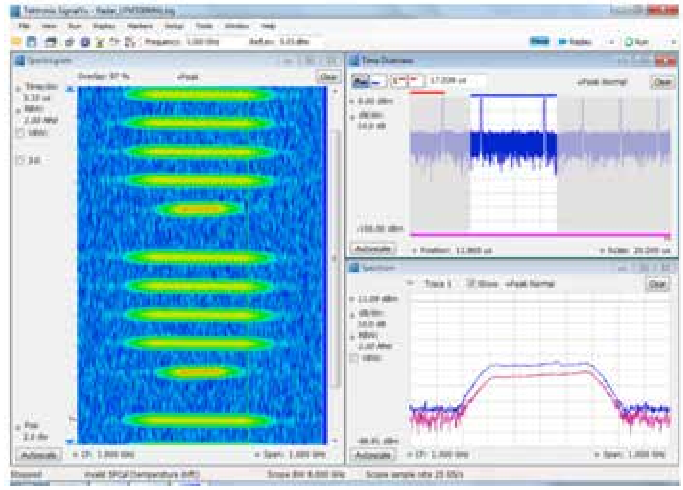

Figure 2. Easily select the portion of the acquisition to be analyzed using the analysis curtain. Simply drag the left and right edges of the curtain (shaded areas) to exclude acquisition time from the analysis.

This demonstration guide is designed to help you understand the benefits of SignalVu PC for analysis of waveforms captured by Tektronix DPO/DSA/MSO Series digital oscilloscopes, MDO4000 Multi-Domain Oscilloscopes and Tektronix Real Time Signal Analyzers. The guide is divided into eight application sections:

- CW Tone
- Wideband Radar
- Hopping Waveforms
- Wideband Modulation
- Multi-domain oscilloscope acquisitions
- AM/FM/PM/Audio Analysis
- Signal Monitoring with RTSA waveforms
- WLAN 802.11ac Signal Analysis

If you are already familiar with the above applications and the SignalVu-PC user interface, you may choose to focus only on the actions described in the Application Overview boxes. Feel free to explore other SignalVu-PC features as you work through these examples. If you prefer a more guided approach, you will want to read the surrounding discussion for each application. Though the demos may be performed in any order, you will gain the most insight into SignalVu-PC's value by working through each demo in order.

SignalVu-PC's user interface is based on the RSA Series Real-Time Signal Analyzer user interface. For those not familiar with the RSA, an introduction can be found in the RSAs Quick Reference. It describes the look and feel of the RSA and the many ways users can interact with this powerful user interface to make measurements most efficiently.

User Interface Conventions

The following conventions are used in this guide to help facilitate parameter entry from the PC keyboard and GUI:

- {Soft Key} entries refer to soft buttons and menu selections on the screen and are listed in brackets, such as {Settings}.
- Numeric Data Entry _ entries are italicized showing the value to be entered, such as *RBW _ 50 kHz*

You will see references to applying "focus" to measurement windows in each of the demonstrations. Applying focus refers to mouse clicking anywhere inside the measurement window so that the title bar is highlighted.

The wideband radar and modulation demos refer to the "analysis curtain". This feature is simply the gray area on the left and right of the analysis area in the Time Overview display. The analysis curtain can be used to select that portion of the acquisition you wish to analyze. Adjust the end of the analysis period by dragging the left-hand portion of the curtain with the mouse. If the curtain is not visible, simply move your cursor to the left-hand edge of the Time Overview display and hold down the left mouse button. Then drag the curtain over to the desired start of the analysis area. The end of the analysis area can be set by dragging the right-hand curtain in a similar fashion.

Measuring a Simple CW Tone

A CW tone is a simple, but useful example to highlight some of the key benefits of the SignalVu-PC software. Most importantly, the SignalVu-PC user interface is familiar to users of both traditional spectrum analyzers and vector signal analyzers, alike. One of the biggest differences between a traditional spectrum analyzer and SignalVu-PC is the dramatic improvement in real-time bandwidth available when oscilloscopes are used as the acquisition engine. The acquisition used in this example is from an oscilloscope, performaing a 1 GHz wide analysis centered at 1 GHz. However, microwave measurements of multiple GHz bandwidth are now possible.

The CW tone example highlights how quickly you can setup and measure your signal of interest with just a few simple mouse clicks. After setting the basic measurement parameters, use the mouse right-click to move the trace so the peak and noise floor are both clearly visible on the display. Now, find the peak of the CW tone with another right-click selecting Marker to peak. Add another marker and either move the delta marker to the next highest peak or use the marker menu at the bottom of the display and choose the down arrow to find the next lower peak. Note the high spurious free dynamic range with this signal applied.

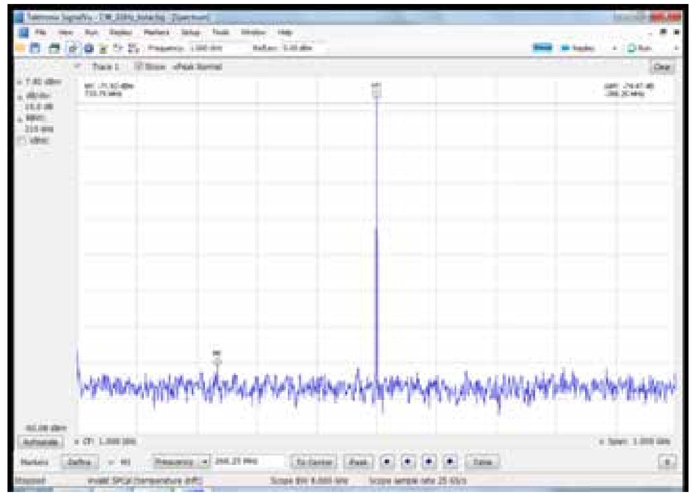

Figure 3. This simple example shows how markers and mouse right-clicks can be used to quickly measure the performance of a CW tone in a 1 GHz span.

Application Overview

Objective	**Keystrokes**
Setup SignalVu-PC to display a 1 GHz CW Tone	**SignalVu-PC** {Presets (Main)} *Freq _ 1GHz, Span _ 1GHz*
Recall a saved acquisition data file with a 1 GHz CW Tone	{File} {Recall} CW_1GHz_tone.tiq (Note: the Files of Type item should be set to "Acquisition data with setup (TIQ)") {Open} {Data only} {OK} Mouse right-click, {Pan} and move the trace down so the peak of the CW tone is visible
Observe Residual Spurs with Signal Applied	*RBW _ 210 kHz* Refresh the display by pressing {Replay} Mouse right-click, select {Marker to Peak} Mouse right-click, select {Add marker} Drag the M1 marker to next highest peak and observe the delta readout in the upper right hand corner of the display

Wideband Radar

SignaVu is ideally suited for designers and troubleshooters of wideband radar systems. Frequency coverage through Ka-band, automated pulse characterization and SignalVu-PC's numerous displays for showing the time-varying nature of these waveforms are just some of the benefits the radar engineer will enjoy. In addition, signals that vary in time or in amplitude can be captured by the oscilloscope's or RTSA's sophisticated triggers.

The radar signal in this demo consists of a series of 500 MHz wide linear FM (LFM) chirps followed by a chirp of narrower bandwidth and longer pulse repetition interval (PRI). You will have a chance to view these signals and their time varying nature.

Before starting this demonstration, let's discuss an important display for configuring and analyzing signal captures. The Time Overview is a display that shows the entire acquisition record and shows you how the spectrum time and analysis time fit within the acquisition record. This enables you to see how you can adjust the spectrum time and analysis time to measure portions of the data.

The Time Overview window shows the user the total power of the RF present during each sample period within the acquisition bandwidth. Time Overview can also be used to set the length of the analysis. The two blue buttons on the left are used to set the analysis offset relative to the trigger location (the left-most button) and total analysis length (right blue button). Similarly, the two red buttons set the spectrum offset (left red button) and length of the time used to compute the spectrum (right red button). In this demonstration, both the analysis length and spectrum length are set to 50 µs. The offset values are set to -40 µs relative to the trigger.

Application Overview

Objective	Keystrokes
Display spectrum of LFM chirps	**SignalVu-PC** {Presets (Main)} *Freq _ 1GHz, Span _ 1 GHz*
Recall a saved acquisition data file with a 500 MHz LFM chirp	{File} {Recall} Radar LFM500MHz.tiq (Note: the File of Type item should be set to "Acquisition data with setup (TIQ)") {Open} {Data only} {OK}
Set the analysis time	{Setup} {Displays} double click {Time Overview} {OK} *Analysis Start _ -35 µs* *Analysis Length _ 40 µs* *Spectrum Start _ -35 µs* *Spectrum Length _ 40 µs* Refresh the display by pressing {Replay}
View the spectrogram	{Setup} {Displays} double click {Spectrogram} {OK} Click the "Gear" icon {Settings} Time & Freq Scale tab Overlap: 95% Close the Spectrogram Settings menu Refresh the display by pressing {Replay}
Display pulse parameter details	{Setup} {Displays} double-click {Spectrogram} to remove Select {Pulsed RF} folder and double-click on {Pulse Table} and {Pulse Trace} {OK} Apply focus to Pulse Table window Click {Setup} {Settings} Params tab, {Measurement Filter} {No Filter} *Bandwidth 1 GHz* Select Measurements tab, check-box Rise Time and Frequency Deviation Select Frequency Estimation tab {Modulation Type} {Linear Chirp} Close the Pulse Table Settings menu Refresh the display by pressing {Replay} Apply focus to the Pulse Table. Click on the cell for Rise for pulse # 1. Click on the cell for Freq Dev for pulse # 1. Note how this affects the Pulse Trace display Click on Freq Dev for pulse # 5 Click on Freq Dev for pulse # 4
Display spectrum detail of long PRI chirp	Apply focus on Time Overview Set Time Overview Spectrum Length around only one of the long PRI pulses. First, push the Time Overview right red button (Spectrum Length). Then drag the left curtain, then the right curtain so only the 5th pulse is visible inside the curtain. Place the left and right edges of the curtain so that the pulse on-time is approximately in the center. Refresh the display by pressing {Replay}

SignalVu-PC can calculate up to twenty-one measurements on every pulse acquired, up to a limit of 10,000 pulses, to help engineers validate the radar is operating within designed parameters. In this example, you are only calculating a few parameters, but the results clearly show that the 5th pulse is unique. Besides its longer PRI, the pulse table indicates the total frequency deviation to be approximately 240 MHz, chirping from a high frequency down to a low frequency. The other pulses are nearly 500 MHz wide and chirp from a low frequency to high.

The controls in Time Overview allow you to customize not only which portion of the acquisition is to be analyzed in the Pulse Table, they also allow you to precisely set the spectrum length to be used to compute the spectrum. In this case, the Spectrum time has been offset so that only the spectrum of the 5th pulse is now calculated. The Spectrum time can also be extended to the limits of the acquisition to view the composite spectrum of all pulses.

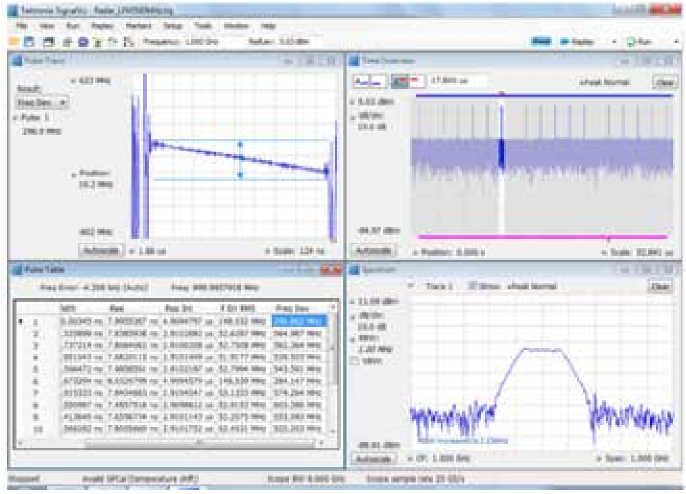

Figure 4. Automated pulse parameter measurements are included in SignalVu-PC SVP. The pulse trace in the upper left highlights the deviation a linear FM chirp of pulse number 1 in the table in the lower left. The lower right display shows the spectrum of a single pulse defined by the acquisition in the upper right.

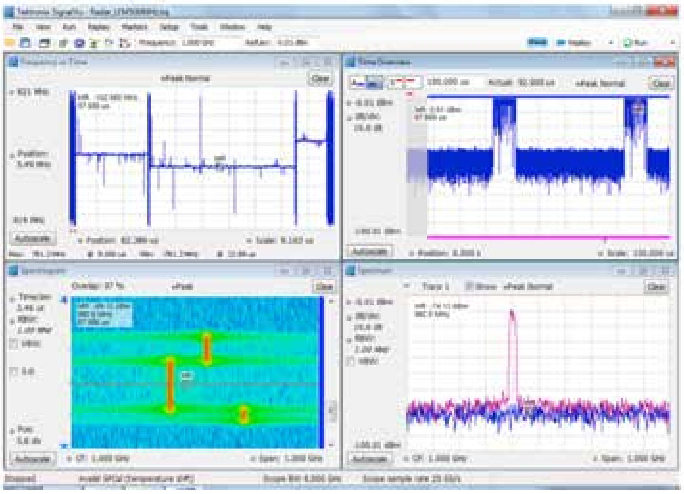

Figure 5. Correlated markers track the signal in all displays.

Hopping Waveforms

While the Spectrogram display is not new to the wideband engineer, they have not always had sufficient time and frequency resolution to precisely measure signal hop characteristics. In this demonstration, the Frequency vs. Time display is used to precisely measure the hop distance within a single burst, as well as the hop distances between bursts. This demonstration will also show you how markers are correlated between different measurement displays.

First, observe the hopping nature of the signal. Be sure to drag the marker through the Spectrogram to observe the hop characteristics in the Spectrum display. The bottom of the Spectrogram's display shows the most recently acquired data. Adding a marker in one display adds the same marker in all displays. Watch how the Spectrum replays the event and how the marker tracks frequency and time movements in all displays. Such correlated behavior is also available using SignalVu-PC's additional markers.

Pan and Zoom are right-click mouse features that allow the user to rapidly find a specific portion of the signal. Because modern oscilloscopes offer sampling rates up to 100 GSample/sec, extreme timing resolution is possible. The Pan feature allows the user to move the position of the trace in both the horizontal and vertical dimensions without having to rescale axes or change acquisition settings.

Application Overview

Objective	Keystrokes
Recall a saved aquisition data file with Hopping Waveform	{File} {Recall} Hopping_Waveform.tiq (Note: the Files of Type item should be set to “Acquisition data with setup (TIQ)”) {Open} {Data and Setup} {OK}
Zoom in on the Spectrogram of the 3 consecutive bursts	Apply focus to Spectrogram Right-click {Pan} drag mouse to position the 3 hops clearly on-screen (if needed) Right-click {Zoom} drag mouse vertically to display the 3 hops clearly Right-click {Add marker} and drag the MR marker slowly through the Spectrogram of each burst. Note that the line selected with the marker in the spectrogram is automatically displayed in the spectrum display.
Measure the hop distance within a single burst	Apply focus to Frequency vs Time Right-click {Zoom} drag mouse to right over the center of the hopping signal. Right-click {Pan} drag display to right to recenter it on the display. Repeat {Zoom} if needed, so the 3 hops dominate the display Drag the MR (marker reference) to the start of the first hop. Use the keyboard up and down arrow keys to precisely position the marker at the start of the first hop Right-click {Add marker} and drag M1 to the end of the third hop (about 8.6 μs and 160 MHz away) Repeat this process to see the hop distance (time and frequency) for the second hop
Measure hop distances between bursts	{Autoscale} Move M1 to the start of the next burst. {Zoom} on the start of the second burst and reposition M1 until it is precisely located at the start of the burst (about 50 μs away).

Wideband Modulation

Communications links for satellite and other point-to-point systems can frequently exceed the bandwidth available in conventional signal analyzers. Wideband digital oscilloscopes are a useful tool to characterize these transmissions because of their high analog bandwidths.

This demonstration will highlight how wideband digitally modulated signals can be reliably demodulated with SignalVu-PC.

Application Overview

Objective	Keystrokes
Recall a 16QAM Signal	{File} {Recall} 16QAM.tiq (Note: the Files of Type item should be set to "Acquisition data with setup (TIQ)") {Open} {Data and Setup} {OK}
Display Modulation Quality of 16QAM Signal	Apply focus to EVM vs Time {Autoscale} Right-click {Add marker}. Use the mouse or up/down arrow keys to move the marker from symbol to symbol
Analyze a different portion of the time acquisition	Move the marker in EVM vs Time to the right hand side of the display. Apply focus to the Time Overview display Grab the left hand side of the analysis time curtain and move it right approximately one full analysis length (~409ns). Press {Replay} to re-analyze the new portion of the acquisition.

Figure 6. Wideband point-to-point microwave links can be easily demodulated with SignalVu-PC's option SVM. Shown is a 16QAM signal operating at 312.5 Msymbols per second. Note the RMS EVM of less than 3%.

As in the other displays, correlated markers are useful in measuring changes from symbol to symbol. In this demonstration a 16QAM signal occupying nearly 500 MHz of spectrum (created by a Tektronix Arbitrary Waveform Generator) is used to illustrate that the AWG and digital oscilloscope can be used to create and measure relatively low EVM values. In this case, the RMS EVM value for this signal operating at 312.5 MS/sec is less than 3%.

Once the measurement is configured, try moving the marker from within any of the displays. Notice that whether the marker is moved within the symbol table or EVM vs. Time or Constellation, it tracks in the other displays allowing the user to understand how EVM changes on a symbol-by-symbol basis, including the trajectory the symbol makes.

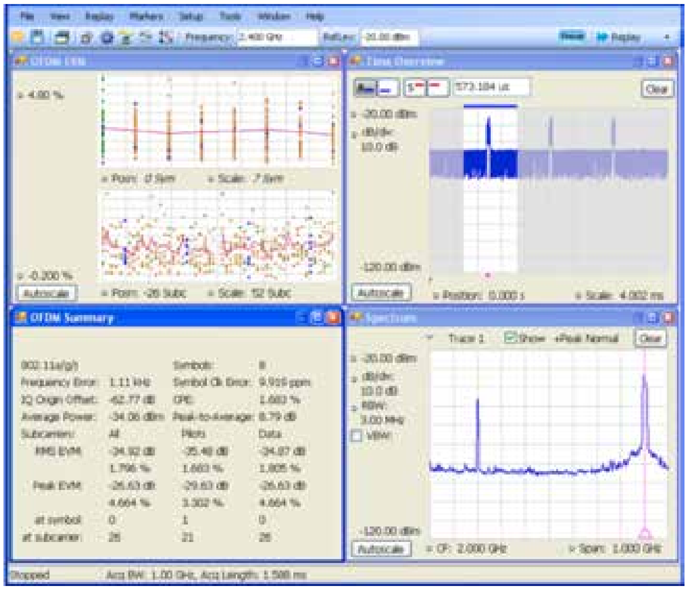

Figure 7a. This figure concentrates on the second signal present within Figure 7a. The signal shown is an 802.11g signal at 2.4 GHz along with a 1Msym/s QPSK signal operating at 1700 MHz. These signals were captured within the bandwidth of a Tektronix MDO Oscilloscope and the .TIQ file was saved. “Offset analysis frequency” was set to analyze the OFDM signal.

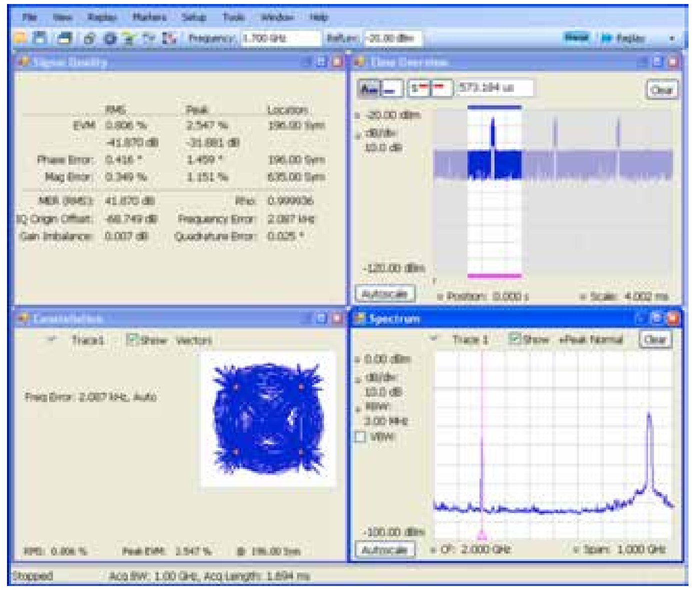

Figure 7b. SignalVu-PC allows users to view Tektronix MDO signals with ease. Shown is a 1Msym/s QPSK signal operating at 1700 MHz along with an 802.11g signal at 2.4 GHz. These signals were captured within the bandwidth of a Tektronix MDO Oscilloscope and the .TIQ file was saved. “Offset analysis frequency” was changed to 1.7 GHz to analyze the QPSK.

Wideband Capture Mixed-Domain Oscilloscope

The Tektronix Mixed-Domain Oscilloscope is able to capture I and Q data of 1.25 GHz bandwidth throughout its operating frequency range. This unprecedented capture bandwidth makes possible new types of analysis including signals that are widely separated in frequency. The example waveform contains two signals separated by 700 MHz, captured within a 1 GHz acquisition bandwidth. The higher frequency signal is an OFDM WLAN signal, and the lower frequency signal is a QPSK signal. Using SignalVu-PC we can perform modulation analysis on each signal from a single acquisition.

Following the Application Overview procedure, open the demonstration file MDO OFDM.tiq. You will see a display consisting of the following four panels:

- Spectrum
- OFDM Summary (modulation quality)
- OFDM EVM (Error Vector Magnitude vs. Carrier and Symbol Plots)
- Time Overview

Analyze a different portion of the time acquisition by following the Application Overview procedure. Adjusting the analysis period in the Time Overview, you can choose which packet of OFDM to analyze. Drag the analysis curtain to contain just the 2nd burst in the packet and press “Replay”, and a new analysis of that packet will appear in the OFDM analysis windows.

In the spectrum display, you will see a vertical magenta line over the OFDM signal. This is the indicator that the modulation analysis is being performed at a frequency offset from the center of the screen. Moving the magenta line can be accomplished by either: grabbing it with the mouse and dragging the line, or by entering a new frequency in the measurement frequency box at the top of the SignalVu-PC display.

To analyze the QPSK signal, continue to follow the Application Overview procedure, changing the analysis frequency, displays and modulation parameters. Now, SignalVu-PC has modified the analysis frequency and applied the new measurement settings for QPSK. To see this analysis quickly without making adjustments manually, just recall MDO QPSK.tiq.

Application Overview

Objective	Keystrokes
Display Modulation Analysis of OFDM Signal within MDO Acquisition Signal	**SignalVu-PC** {Presets (Main)} {File} {Recall…} MDO OFDM.tiq {Data and setup} {OK}
Analyze a different portion of the time acquisition	Apply focus to the Time Overview display Grab the left hand side of the analysis time curtain and move it to the right to contain the 2nd burst in the packet. Press {Replay} to re-analyze the new portion of the acquisition.

Objective	Keystrokes
Display Modulation Analysis of QPSK Signal within MDO Acquisition Signal	Change Frequency setting: Type *1.7 GHz* Press Enter {Setup} {Displays} double click {OFDM EVM} and {OFDM Summary} to remove. {GP Digital Modulation} double click {Signal Quality} and {Constellation} to add {OK} Apply focus to the Constellation display Click on "Gear" icon to open "Constellation Settings". *Modulation type: QPSK* *Symbol Rate: 1M* *Filter Parameter: 0.35* *Refresh the display by pressing {Replay}* Alternately, to see this analysis quickly without making adjustments manually, follow these steps: {Presets (Main)} {File} {Recall} MDO QPSK.tiq {Data and setup} {OK}

Figure 8. Powerful and convenient modulation and audio measurements are easily produced with RTSAs (Option 10) and SignalVu-PC for oscilloscopes. Shown is an audio waveform captured in “fast frame” mode. RF spectrum is on the right. Audio spectrum measurements are on the left.

Figure 9. The SignalVu-PC’s suite of powerful measurements and features makes analyzing audio signals efficient and easy. Users can employ audio filtering to affect the results. Multiple measurements, including Occupied Bandwidth, can be easily displayed so the user can monitor a greater number of signal characteristics at the same time. Shown is the same audio waveform as in Figure 8, but filtered with a 3 kHz Low Pass Filter. Audio spectrum is shown in the lower left. Occupied Bandwidth is shown in the upper left.

AM/FM/PM Audio Analysis

SignalVu-PC SVA enables modulation and audio measurements for AM, FM, PM, and direct-input audio. This demonstration will point out the highlights of the measurement package.

Following the Application Overview procedure, recall the FM Audio Analysis.tiq. This waveform was captured in “fast-frame” mode of the RTSA, so that several acquisitions are analyzed when the data is replayed. Select “Loop” from the replay control so that the acquisitions continuously re-analyze as you make changes to the analysis.

SignalVu-PC displays the RF spectrum, demodulated audio spectrum and modulation quality measurements. The spectrum analyzer RBW is set to 500 Hz. Vary the RBW of the spectrum analyzer from 100 kHz down to 100 Hz and observe the effect on the display. Variations in the settings can only be performed within the limits of the acquired data. Some settings cannot be achieved. To see this effect, set the RBW to 50 Hz. You will get a notification on the spectrum display that says, “RBW set to 63.5 Hz.” This is because the acquisition length of the data is not long enough to accommodate a 50 Hz RBW, and the instrument has set the lowest possible RBW available from the acquired data. Set the RBW back to 500 Hz when you are done.

Vary the Audio Spectrum controls and observe the results. Change the dB/div control to 20 dB/div to give you a better view of the noise. Change the horizontal scale (bottom left of the Audio Spectrum display) to 50 kHz to improve the view of spectrum details in the lower frequency range.

Now use the settings control for Audio Spectrum (push the “gear” icon to access the menus) to change what is displayed on the display. The current display shows the measurement of the fundamental and 12 harmonics, with a table of each components of frequency and amplitude. In the Params2 menu, vary “No. of Harmonics” from 5 to 18. As this number changes, the number of identified harmonics on the display and in the table changes as well. The THD result in the audio results panel also changes, from 0.016% when 5 harmonics are considered, to 0.24% when 18 harmonics are included in the measurement.

Select the “Audio Filters” tab from the Audio Spectrum Settings menus. Filtering the audio measurement will dramatically change the results in the spectrum and audio measurements panels. To see this, select LPF (Low Pass Filter) and vary the filter value from 15 kHz down to 3 kHz. Observe the improvement in SINAD as the filter bandwidth cutoff value is decreased.

Add a new measurement: Add the Occupied Bandwidth measurement from the select displays menu. A message will appear in the OBW display, “Acq BW too small for current setup”. This is because the default span for the OBW measurement is 11 MHz, but our acquired data is limited to 500 kHz bandwidth. To clear this, follow the Application Overview procedure to set the OBW measurement bandwidth to 500 kHz. The measurement will now proceed normally, and displays an OBW of 207 kHz.

Application Overview

Objective	Keystrokes
Display Modulation and Audio Measurements of FM waveform.	**SignalVu-PC** {Presets (Main)} {File} {Recall...} FM Audio Analysis.tiq {Data and setup} {OK} Click arrow to the right of the Replay button located in the upper right. Select "Loop" from the replay control so that the acquisitions continuously re-analyze as you make changes to analysis.
Adjust RBW and Observe Effects	Apply focus to the Spectrum display *RBW _ 100 kHz* Vary the RBW from 100 kHz down to 100 Hz. Note how this affects the Spectrum display. *RBW _ 50 Hz* Note that display indicates, "RBW set to 63.5 Hz". This is because the acquisition length is not long enough to accommodate a 50 Hz RBW. *RBW _ 500 Hz* Apply focus to the Audio Spectrum display *dB/div _ 20 dB*
Adjust Number of Harmonics and Observe Effects	{Setup} {Settings} {Params2} *No. of Harmonics _ 5* Note that the number of identified harmonics changes to 5. The THD measurement (found in upper right Audio Summary - FM panel) changes to approximately 0.016%. Vary the No. of Harmonics from 5 to 18. Note how this affects the THD measurement and the Audio Spectrum panel.
Observe Effects of Audio Filters	{Audio Filters} (This is the third tab of the Audio Spectrum Settings panels, to the right of Params2.) Click LPF. *LPF _ 15 kHz* Note the change in the Audio Spectrum panel. Vary the LPF from 15 kHz down to 3 kHz and note the improvement in the SINAD measurement (found in Audio Summary - FM panel).
Add Occupied Bandwidth Measurement	{Setup} {Displays} {RF Measurements} Double click {Occupied Bandwidth} to add {OK} Apply focus to the Occupied BW & x dB BW display {Setup} {Settings} {Parameters} *Measurement BW _ 500 kHz* Close the Occupied BW settings menu

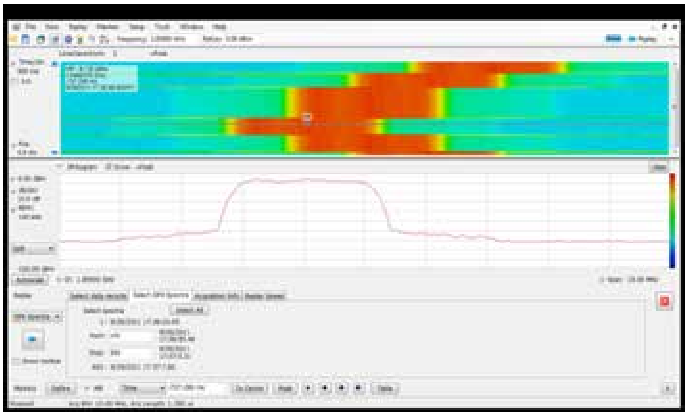

Figure 10. Maximize your testing efficiency by adjusting the DPX Spectral acquisition data to reduce the range of analyzed spectra. In the figure above, the DPX spectrogram is on top, while the spectrum is below. The spectrum corresponds to the precise location of the marker in the spectrogram, allowing you to analyze what is happening in the spectrum at the point that matters most to you.

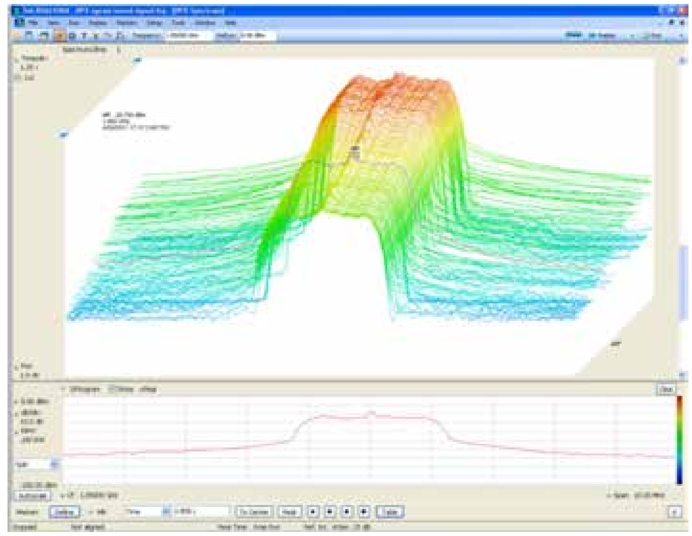

Figure 11. Speed up your problem solving efforts and find transient, infrequent signals in the presence of large signals by using the 3-D representation of the Tektronix DPX Spectrogram. Shown is a WLAN signal changing power over time, as seen by the color-graded amplitude scale of the spectrogram. The selected spectrum display from the spectrogram is seen in a contrasting color.

Signal Monitoring with RTSA Waveforms

Signal Monitoring: Reviewing captured signals with DPX Spectrogram

Signal monitoring may involve hours of data capture during a test or monitoring mission, and many more hours reviewing and analyzing signals after the events have passed. The DPX spectrogram available in Tektronix Real Time Signal Analyzers is ideally suited to monitoring events that last from seconds to days with varying time resolution.

The supplied file contains a spectrogram of a signal that varies in frequency. The spectrogram has been created by the DPX engine in real time, and can be re-played by the SignalVu-PC software. This is different from the standard spectrogram that works on stored IQ data. The difference is in the length of time over which gapless spectrograms can be produced. When using DPX spectrograms, up to 60,000 spectrograms can be produced, and the length of time associated with the spectrogram is variable from 110 us to 6,400 seconds. This yields recording times from 6.4 seconds to 4,444 days. In contrast, spectrograms produced from acquisition data are limited by the maximum acquisition memory of the instrument and the acquisition bandwidth; this limitation means that no more than 7.15 seconds of gapless analysis can be performed at 85 MHz bandwidth.

Follow the Application Overview procedure to see how SignalVu-PC's powerful DPX Spectrogram makes reviewing captured signals quick and easy.

After learning how to analyze individual spectra using markers, observe the "Spectrums/line" readout in the upper left corner of the spectrogram. It currently reads "Spectrum/line: 4 +Peak". This means that each line shown on the spectrogram is the peak-detected result of 4 spectrums in the underlying data set. To see this change, vary the Time/Div control in the upper left of the display. It is currently set to 5 sec/div. Vary it from 10 sec/div to 500 ms/div and see the Spectrum/line readout change from 8 Spectrums/line to 2 Lines/Spectrum. At the 500 msec/div setting, each spectrum in the data set is spread over 2 lines in the spectrogram display.

In the demo waveform, approximately 14 seconds of spectral data have been recorded. To see details about the acquisition continue to follow the Application Overview procedure. Information on number of spectra and the time and date of the acquisition can be found in the "Select DPX Spectra" menu. If you have a large number of spectra saved, reducing the range for replay provides more efficient analysis. The replay range can also be set graphically, using the blue arrows on the left side of the spectrogram display.

The viewing aspect of the spectrogram can be changed from a flat X-Y format to a 3-D format. This may make is easier to find small or infrequent signals in the presence of large signals. To see the 3-D display, click on the 3-D box, located to the left of the spectrogram display and press "Replay". The 3-D representation will scroll upward on the spectrogram display.

To see the most detail in the spectrogram, the spectrum display can be shut off. To the left of the spectrum display is a drop-down box with "Split" selected. Select "DPXOgram" from this drop-down, and the Spectrogram will be show full-screen.

Application Overview

Objective	Keystrokes
Review Captured Signals with DPX Spectrogram.	**SignalVu-PC** {Presets (Main)} {File} {Recall...} DPX Spectrogram Demo.tiq {Data and setup} {OK} Refresh the display by pressing {Replay} The replay control allows you to view the currently selected spectrum, move to the next or previous spectrum, replay all spectra, or continuously loop through the record to view signals repeatedly. Select {All} from the replay menu
Analyze Individual Spectra Using Markers	Wait until spectrogram has filled the panel Right click in the spectrogram and select "Add marker" Move the marker vertically in the spectrogram and observe how the selected spectrum appears in the spectrum display. Time and date information for the selected spectrogram appears in the upper left corner of the spectrogram.

Objective	Keystrokes
Vary Time/Div Control and Observe Results	Apply focus to spectrogram *Time/div _ 10s* Note how Spectrums/line changed to 8 *Time/div _ 500 ms* Note how Spectrums/line changed to 2
Improve Efficiency by Reducing Spectra Range	{File} {Acquisition data info} {Select DPX Spectra} Reduce the range for replay for more efficient analysis by making the following setting changes: *Start _ 100* *Stop _ 500* Replay acquisition with smaller set of spectra by clinking the box with the blue arrows. Close the Acquisition data info settings menu
Maximize Your Viewing Capabilities: 3-D DPX	Using a 3-D viewing format may make it easier to find small or infrequent signals in the presence of large ones. Click on the 3-D box located to the left of the DPX spectrogram display. Refresh the display by pressing {Replay} To observe more detail in the spectrogram, shut off the spectrum by: Clicking box located in the lower left of the display with "Split" selected and select {DPXOgram}. You can allocate different sized windows to the spectrum and spectrogram display by dragging the separator bar between the two displays.

WLAN 802.11ac Signal Analysis

The Tektronix Mixed-Domain Oscilloscope is able to capture wideband signals such as the newest IEEE 802.11ac WLAN signals with 160 MHz bandwidth. With its unprecedented capture bandwidth and its WLAN transmitter measurement capability, SignalVu-PC lets you perform spectral emission mask (SEM), constellation diagram, and Error Vector Magnitude (EVM) measurement in the push of a few buttons. SignalVu-PC offers additional measurements needed to determine the quality of the signal captured as well as information about the packet.

There are two ways to start, either you can analyze the 802.11ac signal step by step, for that please follow the first two steps of the Application Overview procedure — or you can open the demonstration file ac_160MHz_256QAM_CF5250.tiq with data and setup and then bypass the first steps of identification of the signal. Once you apply the presets or load the setup from the file, you will see a display consisting of the following four panels:

- Time Overview shows the bursts of signal that were captured in the entire acquisition record as well as controls the window of time during which SignalVu-PC performs its analysis on the signal
- Spectrum Emission Mask (SEM) shows the spectrum at some point in the record compared to a mask defined by IEEE 802.11 standard. Please read more details in the Application Overview
- WLAN Summary packs a lot of information about the signal quality such as Error Vector Measurement (the key measurement). It also provides the packet CRC to detect any data encoding transmission issues. More details are provided in the Application Overview
- WLAN Constellation shows the I/Q plot representation of the demodulated signal. More details are provided in the Application Overview

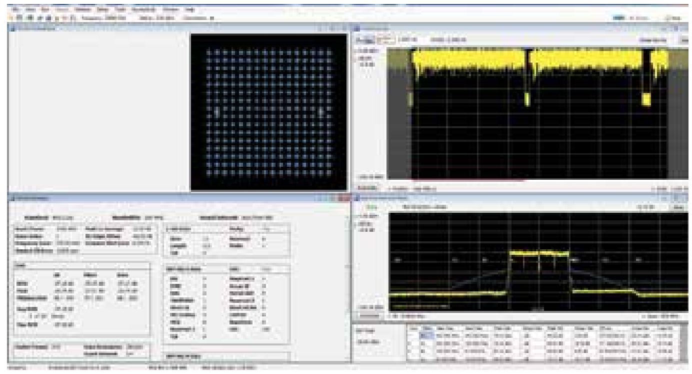

Figure 12. SignalVu-PC allows users to perform IEEE 802.11a/b/g/j/p/n/ac transmitter measurements for SISO configuration. Measurements in time, spectral and vector domains can be performed at the same time. Results can be cross-referenced thanks to the markers.

Application Overview

Objective	Keystrokes
Display WLAN 802.11ac spectrum – Show the OFDM shape of the spectrum and measure its bandwidth -> you know it is ac at 160MHz	**SignalVu-PC** {Presets (Main)} {File} {Recall} ac_160MHz_256QAM_CF5250.tiq Note: the File of Type item should be set to "Acquisition data with setup (TIQ)" {Open} {Data only} {OK} *Frequency_ 5.25 GHz, Span_800MHz* *{Replay}*
Use the Preset for the 802.11ac and 160MHz	{Presets} {Standards} {WLAN} {Standard_802.11ac} {Bandwidth_160MHz} {OK} {Replay} Now you should see 4 panels: WLAN Summary, Time Overview, WLAN Constellation, Spectrum Emission Mask The signal is coming from the MDO4000B connected to SignalVu-PC, the industry's widest Vector Signal Analyzer. Capturing 160 MHz of signal bandwidth and demodulating at the same time is not a problem with this combination of products. Other Vector Signal Analyzer cannot provide spectrum and modulation analysis at the same time during acquisition.

Application Overview

Objective	Keystrokes
Determine the type of modulation from the WLAN Constellation display	Take a look at the WLAN Constellation. There is a dense area of blue dots in this I/Q chart. The modulation used to transmit the data is 256-QAM. This is the new modulation format specified for 802.11ac to pack even more information. The plan for the 802.11ac data rate to go beyond 1 Gb/s and reach up to almost 7Gb/s when used in MIMO with 8 spatial streams. The yellow dots represent the pilot symbols that are used by the receiver for channel estimation of phase shift, phase noise and potential frequency offsets in the transmission. They use the simpler BPSK modulation scheme.
Review the EVM information provided in the WLAN Summary display	Apply focus to the WLAN Summary display The first piece of information, a user is looking for is the Avg RMS EVM measurement. By default averaging is not turned on. To turn it on, {Setup} {Settings} Select tab {EVM}, check "Count", and then {Replay} (left top corner of the application) You should see how many bursts have been averaged. 20 is the target total number provided by default, you can change this value in the Settings under "Max Bursts to Avg:" Other EVM values provided are Peak values and at which Symbol and Subcarrier the peak values reside. This information is needed to understand where transmitter issues may be.

Objective	Keystrokes
Review the Packet information provided in the WLAN Summary display	The packet format is VHT for "Very High Throughput", the packet structure includes L-STF, L-LTF, and L-SIG so the sent information can be understood by a legacy 802.11 receiver; and VHT-SIGA, VHT-STF and LTF that provides the actual configuration of the 802.11ac data. The right section of the Summary gives some of the key signal (SIG) header information, such as: ■ the rate of the modulation and the encoding, ■ a CRC that checks the validity of the transmission, ■ the length of the data being transmitted in that particular burst ■ Nsts indicates the number of spatial streams (minus 1) when in a MIMO configuration.
Review the Spectrum Emission Mask display	Apply focus to the Spectrum Emission Mask This shows the spectrum of the signal and the mask within which the signal needs to stay to pass both US FCC regulations and Wi-Fi compliance. The mask will need to be edited for other country regulations. The mask has several segments that are described in the table below the display (from DL to DU). To edit the mask, please refer to the User Manual. On the top left corner of the display there is a green Pass or a red Fail to provide a quick visual overview result. In case of Fail, the table below would highlight the segment that failed and in the display there would be a visible vertical red zone to pinpoint the issue. Note that SEM tests way beyond the bandwidth of the signal, so for WLAN 802.11a/n/ac signals that are in the upper band of the 5GHz, the acquisition instrument may not have enough bandwidth to test the upper section. In real life, issues are around the knee or elbow, when the frequency transitions.

Application Overview

Objective	Keystrokes
Let's bring more measurements	{Setup} {Displays} {Folders=WLAN Analysis} Here are the additional measurements: WLAN Channel Response WLAN EVM WLAN Mag Error (Mag = Magnitude) WLAN Phase Error WLAN Flatness WLAN Pwr vs. Time (Pwr = Power) WLAN Symb Table (Sym= Symbol) Double click on all of them {Replay}
Let's examine WLAN Power vs. Time – Show Power-on ramp time and power-down ramp time for 802.11b	Apply focus to the WLAN Power vs. Time {Autoscale} This display represents the burst that is being analyzed (the one highlighted in the Time Overview with the pink bar). It gives Power and Width measurements for the burst. The same information that was provided at the beginning of the WLAN Summary There are 2 more views provided under {View: Full Burst}, a detailed view of the rising edge {View: Rising Edge} and a view of the falling edge {View: Falling Edge} – make sure to {Autoscale} when showing these displays. For 802.11b, we provide power-on ramp time and power-down ramp time, measurements required by the standard. {Setup} {Settings} {Standard-802.11b} You can now see these measurements under the display. Don't forget to reselect {Standard-802.11ac} {Bandwidth-160 MHz} before moving to the next step.

Objective	Keystrokes
Cross correlate results between Symbols, EVM values, Mag and Phase Error values using Markers	Remove all displays except: WLAN constellation WLAN Symbol Table WLAN EVM WLAN Mag Error WLAN Phase Error Press {Autoscale} in all displays {Replay} Add a marker in the WLAN constellation display by right clicking in the graph and selecting "Add marker". Note that markers are added to all the displays Grab the marker and move it to another constellation point. Note that all markers move in all the displays. Now go to the WLAN Symbol table and click one of the symbols. Again note that the markers highlight the EVM, Mag Error and Phase Error for that same symbol (by reading the marker readouts)

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For Further Information
Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit **www.tektronix.com**

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