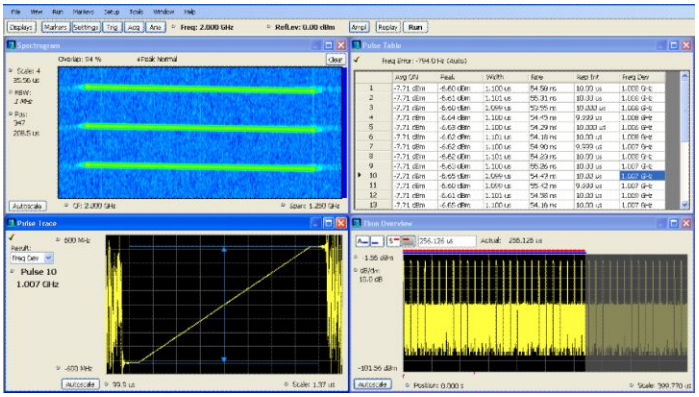
Vector Signal Analysis Software for Oscilloscopes

SignalVu™ Datasheet



SignalVu vector signal analysis software combines the signal analysis engine of the RSA5000 and RSA6000 Series real-time spectrum analyzer with that of the industry's widest bandwidth digital oscilloscopes, making it possible for designers to evaluate complex signals without an external down converter. You get the functionality of a vector signal analyzer, a spectrum analyzer, and the powerful trigger capabilities of a digital oscilloscope - all in a single package. You can use SignalVu with an MSO/DPO5000, DPO7000, or DPO/DSA/MSO70000 Series digital oscilloscope to easily validate wideband designs and characterize wideband spectral events. Whether your design validation needs include wideband radar, high data rate satellite links, wireless LAN, or frequency-hopping communications, SignalVu can speed your time-to-insight by showing you the time-variant behavior of these wideband signals.

Key features

- Trigger
  - Integrated RF signal analysis package lets you take full advantage of oscilloscope settings
  - Pinpoint™ triggering offers over 1400 combinations to address virtually any triggering situation
- Capture
  - Direct observation of microwave signals without need of an external down converter
  - All signals up to the analog bandwidth of oscilloscope are captured into memory
  - Customize oscilloscope acquisition parameters for effective use of capture memory
  - FastFrame segmented memory captures signal bursts without storing the signal's off time
  - Supports RF, I and Q, and differential I and Q signals using the oscilloscope's 4 analog inputs
- Analyze
  - Extensive time-correlated, multidomain displays connect problems in time, frequency, phase, and amplitude for quicker understanding of cause and effect when troubleshooting
  - Power measurements and signal statistics help you characterize components and systems: ACLR, Multicarrier ACLR, Power vs. Time, CCDF, OBW/EBW, and Spur Search
  - WLAN spectrum and modulation transmitter measurements based on IEEE 802.11 a/b/g/j/p/n/ac standards (Option SV23, SV24 and SV25)
  - AM/FM/PM Modulation and Audio Measurements (Opt. SVA) for characterization of analog transmitters and audio signals
  - Settling Time Measurements, Frequency, and Phase (Opt. SVT) for characterization of wideband frequency-agile oscillators
  - Advanced Signal Analysis Suite (Opt. SVP) - Automated pulse measurements including rise time, pulse width, and pulse-to-pulse phase provide deep insight into pulse train behavior
  - General Purpose Digital Modulation Analysis (Opt. SVM) provides vector signal analyzer functionality
  - Flexible OFDM analysis (Opt. SVO) with support for 802.11a/g/j and WiMAX 802.16-2004 signals
  - Frequency offset control for analyzing baseband signals with near-zero intermediate frequencies (IF)
  - Tektronix OpenChoice® makes for easy transfer to a variety of analysis programs such as Excel and Matlab

Applications

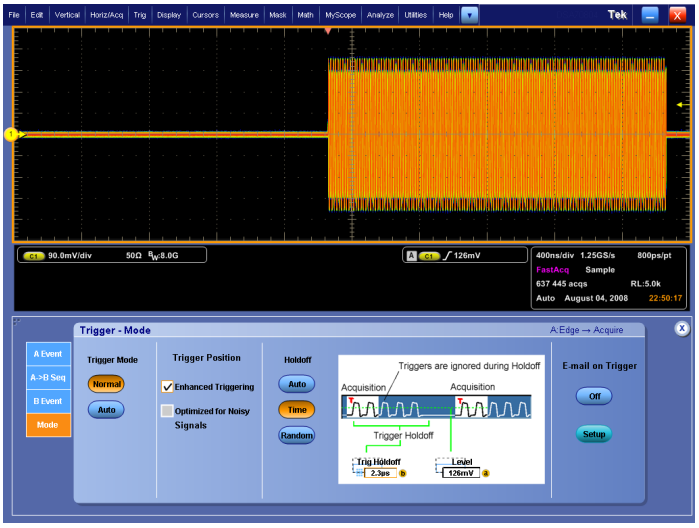
- Wideband radar and pulsed RF signals
- Frequency agile communications
- Broadband satellite and microwave backhaul links
- Wireless LAN

Wideband signal characterization

SignalVu helps you easily validate wideband designs and characterize wideband spectral events using an MSO/DPO5000, DPO7000, or DPO/DSA/MSO70000 Series digital oscilloscope. Users can easily switch between the SignalVu application and the oscilloscope's user interface to optimize the collection of wideband signals.

Trigger

SignalVu software works seamlessly with the oscilloscope allowing users to utilize all of its powerful triggering capabilities. The ability to trigger on time- and amplitude-varying events of interest is paramount in wideband system design, debug, and validation. The Tektronix oscilloscopes' trigger systems allow selection of virtually all trigger types on both A and B trigger events whether they be transition, state, time, or logic qualified triggers. Once triggered, SignalVu processes the acquisition for analysis in multiple domains.

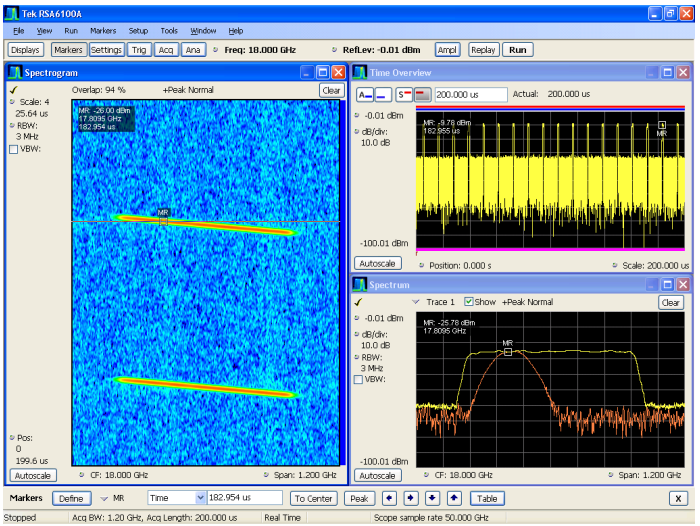


Powerful oscilloscope triggers allow the user to capture only the relevant portion of wideband signals. Pinpoint trigger functions such as combining A and B events with Edge with Holdoff can capture a pulse train during a specific transmitter mode of operation.

Capture

Capture once - make multiple measurements without recapturing. All signals in an acquisition bandwidth are recorded into the oscilloscope's deep memory. Up to four channels can be captured simultaneously; each of which can be independently analyzed by SignalVu software. Channels can be RF, I and Q, or differential inputs. Users can also apply math functions to the acquisition prior to analysis by SignalVu. Acquisition lengths vary depending upon the selected capture bandwidth - up to 25 ms can be captured on a single channel with the MSO/DPO5000 Series, up to 12.5 ms can be acquired on a single channel with the DPO7000 Series, and up to 2.5 ms can be captured on a single channel with the DPO/DSA/MSO70000 Series. Significantly longer capture times can be realized with lower oscilloscope sample rates.

Using the FastFrame segmented memory feature in SignalVu enables you to capture events of interest, such as low duty cycle pulsed signals, while conserving acquisition memory. Using multiple trigger events, FastFrame captures and stores short-duration, bursty signals and passes them to SignalVu vector signal analysis functions. Capturing thousands of frames is possible, so long-term trends and changes in the bursty signal can be analyzed.



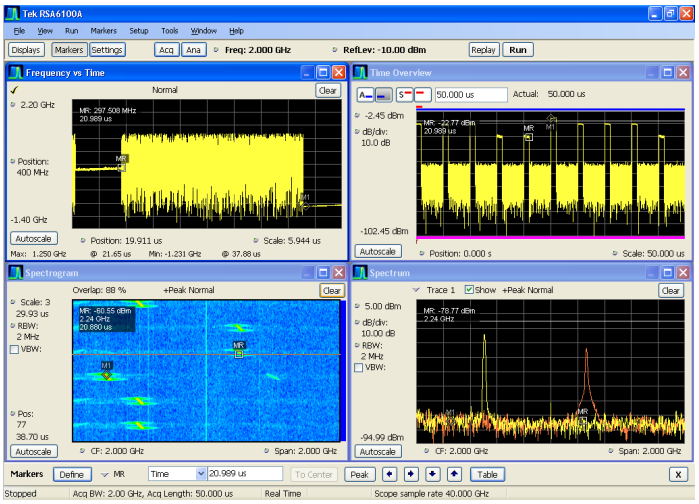
Once captured into memory, SignalVu provides detailed analysis in multiple domains. The spectrogram display (left panel) shows the frequency of an 800 MHz wide LFM pulse changing over time. By selecting the point in time in the spectrogram during the On time of the pulse, the chirp behavior can be seen as it sweeps from low to high (lower right panel).

Analyze

SignalVu vector signal analysis software utilizes the same analysis capabilities found in the RSA5000 and RSA6000 Series real-time spectrum analyzers. SignalVu advances productivity for engineers working on components or in wideband RF system design, integration, and performance verification, or operations engineers working in networks, or spectrum management. In addition to spectrum analysis, spectrograms display both frequency and amplitude changes over time. Time-correlated measurements can be made across the frequency, phase, amplitude, and modulation domains. This is ideal for signal analysis that includes frequency hopping, pulse characteristics, modulation switching, settling time, bandwidth changes, and intermittent signals.

SignalVu can process RF, I and Q, and differential I and Q signals from any one of the four available oscilloscope inputs. Math functions applied by the oscilloscope are also utilized by SignalVu allowing users to apply custom filtering prior to vector signal analysis.

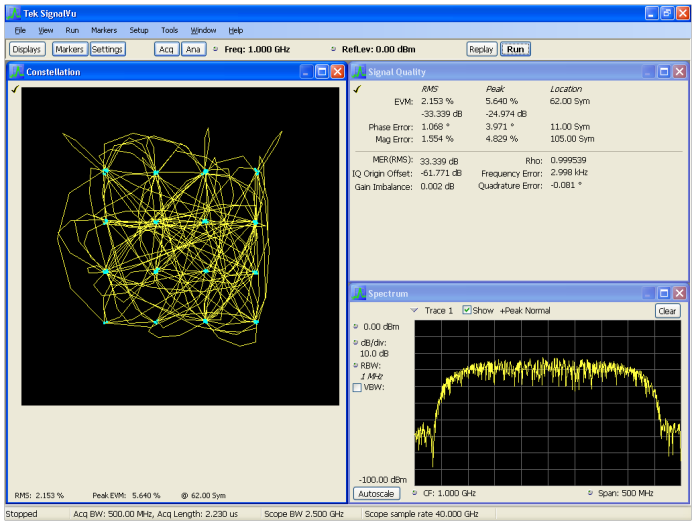
The Microsoft Windows environment makes this multidomain analysis even easier with an unlimited number of analysis windows, all time-correlated, to provide deeper insight into signal behavior. A user interface that adapts to your preferences (keyboard, front panel, touch screen, and mouse) makes learning SignalVu easy for both first-time users and experienced hands.



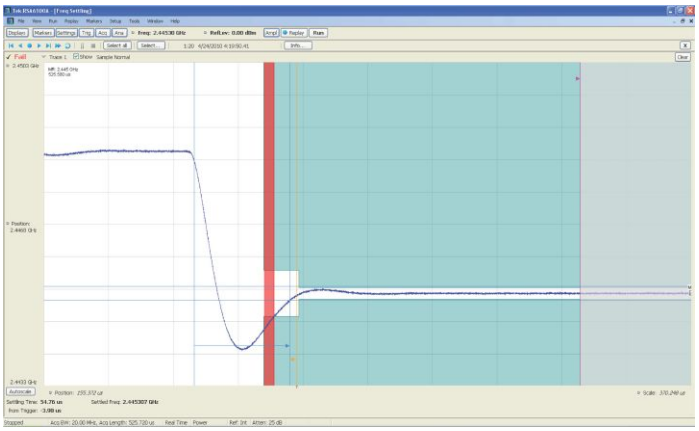
Time-correlated, multidomain view provides a new level of insight into design or operational problems not possible with conventional analysis solutions. Here, the hop patterns of a narrowband signal can be observed using Spectrogram (lower left) and its hop characteristics can be precisely measured with Frequency vs Time display (upper left). The time and frequency responses can be observed in the two right-hand views as the signal hops from one frequency to the next.

Options tailored for your wideband applications

SignalVu vector signal analysis software is available for all MSO/DPO5000, DPO7000, and DPO/DSA/MSO70000 Series oscilloscopes and offers options to meet your specific application, whether it be wideband radar characterization, broadband satellite, or spectrum management. SignalVu Essentials (Opt. SVE) provides the fundamental capability for all measurements and is required for pulse analysis (Opt. SVP), settling time (Opt. SVT), digital modulation analysis (Opt. SVM), flexible OFDM analysis (Opt. SVO), and AM/FM/PM Modulation and Audio Measurements (Opt. SVA).



Wideband satellite and point-to-point microwave links can be directly observed with SignalVu analysis software. Here, General Purpose Digital Modulation Analysis (Opt. SVM) is demodulating a 16QAM backhaul link running at 312.5 MS/s.



Settling time measurements (Opt. SVT) are easy and automated. The user can select measurement bandwidth, tolerance bands, reference frequency (auto or manual), and establish up to 3 tolerance bands vs. time for Pass/Fail testing. Settling time may be referenced to external or internal trigger, and from the last settled frequency or phase. In the illustration, frequency settling time for a hopped oscillator is measured from an external trigger point from the device under test.

WLAN transmitter testing

With the WLAN measurement options, you can perform standards-based transmitter measurements in the time, frequency, and modulation domains.

- Option SV23 supports IEEE 802.11a, b, g, j and p signals
- Option SV24 supports IEEE 802.11n 20 MHz and 40 MHz SISO signals
- Option SV25 supports IEEE 802.11ac 20/40/80/160 MHz SISO signals

The table below described the modulation formats and frequency bands of IEEE 802.11 WLAN signals

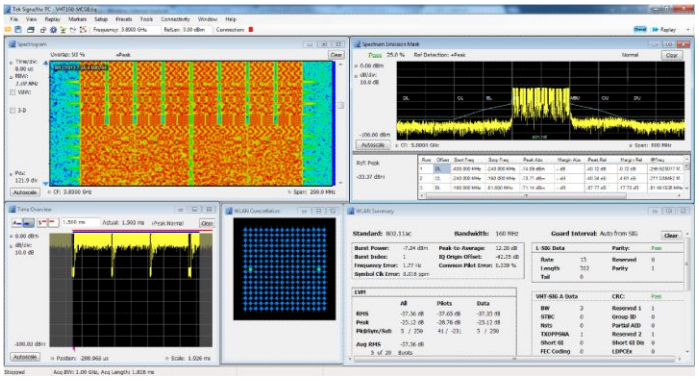
Standard	Std PHY	Freq band(s)	Signal	Modulation formats	Bandwidth (max)	802.11-2012 section
802.11b	DSSS HR/DSSS	2.4 GHz	DSSS/CCK 1 - 11 Mbps	DBSK, DQPSK CCK5.5M, CCK11M	20 MHz	16 & 17
802.11g	ERP	2.4 GHz	DSSS/CCK/PBCC 1 - 33 Mbps	BPSK DQPSK	20 MHz	17
802.11a	OFDM	5 GHz	OFDM 64 <54 Mbps	BPSK QPSK 16QAM 64QAM	20 MHz	18
802.11g		2.4 GHz			20 MHz	19
802.11j/p		5 GHz			5, 10, 20 MHz	18
802.11n	HT	2.4 GHz & 5 GHz	OFDM 64, 128 ≤ 150 Mbps	BPSK QPSK 16QAM 64QAM	20 , 40 MHz	20
802.11ac	VHT	5 GHz	OFDM 64, 128, 256, 512 ≤ 867 Mbps	BPSK QPSK 16QAM 64QAM 256QAM	20, 40, 80, 160 MHz	22

The Frequency Band (Freq Band(s)) provides the minimum requirement for the bandwidth of the oscilloscope to use.

Inside SignalVu, the WLAN presets make the EVM, Constellation and SEM measurements push-button. The WLAN RF transmitter measurements are defined by the IEEE 802.11- 2012 revision of the standard and listed below with the reference to the section and the limit to reach.

IEEE 802.11 RF layer test	IEEE reference 802.11-2012	Limit tested
Transmit power	16.4.7.2 (DSSS)	country dependent
	17.4.7.2 ("b")	country dependent
	18.3.9.2("a")	country dependent
	19.4.8.2 ("g")	country dependent
	20.3.20.3 ("n")	country dependent
Transmit Power On/Off Ramp	16.4.7.8 (DSSS)	(10%-90%) 2 usec
	17.4.7.7 ("b")	(10%-90%) 2 usec
Transmit Spectrum mask	16.4.7.5 (DSSS)	Std mask
	17.4.7.4 ("b")	Std mask
	18.3.9.3 ("a")	Std mask
	19.5.5 ("g")	Std mask
	20.3.20.1 ("n")	Std mask
	22.3.18.1 ("ac")	Std mask
RF Carrier suppression	16.4.7.9 ("DSSS")	-15dB
	17.4.7.8 ("b")	-15dB
Center frequency leakage	18.3.9.7.2 ("a")	-15 dBc or +2 dB w.r.t. average subcarrier power
	20.3.20.7.2 ("n")	20 MHz: follow 18.3.9.7.2
		40 MHz: -20 dBc or 0 dB w.r.t. average subcarrier power
Transmit Spectral flatness	18.3.9.7.3 ("a")	+/- 4 dB (SC = -16…16), +4/-6 dB (other)
	20.3.20.2 ("n")	+/- 4 dB, +4/-6 dB
	22.3.18.2 ("ac")	+/- 4 dB, +4/-6 dB (various BWs, 20-160 MHz)
Transmission spurious	18.3.9.4 ("a")	country dependent
Transmit Center frequency tolerance	16.4.7.6 ("DSSS")	+/-25 ppm
	17.4.7.5 ("b")	+/-25 ppm
	18.3.9.5 ("a")	+/-20 ppm (20 MHz and 10 MHz), +/-10 ppm (5 MHz)
	19.4.8.3 ("g")	+/-25 ppm
	20.3.20.4 ("n")	+/-20 ppm (5 GHz band), +/-25 ppm (2.4 GHz band)
	22.3.18.3 ("ac")	+/-20 ppm
Symbol clock frequency tolerance	16.4.7.7 ("DSSS")	+/-25 ppm
	17.4.7.6 ("b")	+/-25 ppm
	18.3.9.6 ("a")	+/-20 ppm (20 MHz and 10 MHz), +/-10 ppm (5 MHz)
	19.4.8.4 ("g")	+/-25 ppm
	20.3.20.6 ("n")	+/-20 ppm (5 GHz band), +/-25 ppm (2.4 GHz band)
	22.3.18.3 ("ac")	+/-20 ppm
Transmit Modulation accuracy	16.4.7.10 ("DSSS")	Peak EVM < 0.35
	17.4.7.9 ("b")	Peak EVM < 0.36

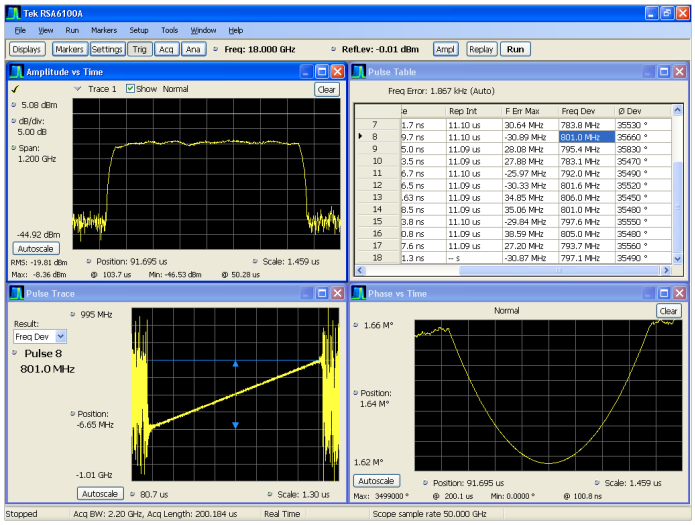
IEEE 802.11 WLAN transmitter test summary				
IEEE 802.11 RF layer test	IEEE reference 802.11-2012	Limit tested		
		Modulation	Coding rate (R	Relative constellation error (dB)
Transmitter Constellation Error	18.3.9.7.4 ("a")	BPSK	1/2	-5
		BPSK	3/4	-8
		QPSK	1/2	-10
		QPSK	3/4	-13
		16-QAM	1/2	-16
		16-QAM	3/4	-19
		64-QAM	2/3	-22
		64-QAM	3/4	-25
	20.3.20.7.3 ("n")	BPSK	1/2	–5
		QPSK	1/2	–10
		QPSK	3/4	–13
		16-QAM	1/2	–16
		16-QAM	3/4	–19
		64-QAM	2/3	–22
		64-QAM	3/4	–25
		64-QAM	5/6	–27
	22.3.18.4.3 ("ac")	BPSK	1/2	-5
		QPSK	1/2	-10
		QPSK	3/4	-13
		16-QAM	1/2	-16
		16-QAM	3/4	-19
		64-QAM	2/3	-22
		64-QAM	3/4	-25
		64-QAM	5/6	-27
		256-QAM	3/4	-30
		256-QAM	5/6	-32
Out-of-band spurious emission	16.4.6.6 ("DSSS")	country dependent		
	17.4.6.9 ("b")	country dependent		
	18.3.8.5 ("a")	country dependent		
	19.4.4 ("g")	country dependent		



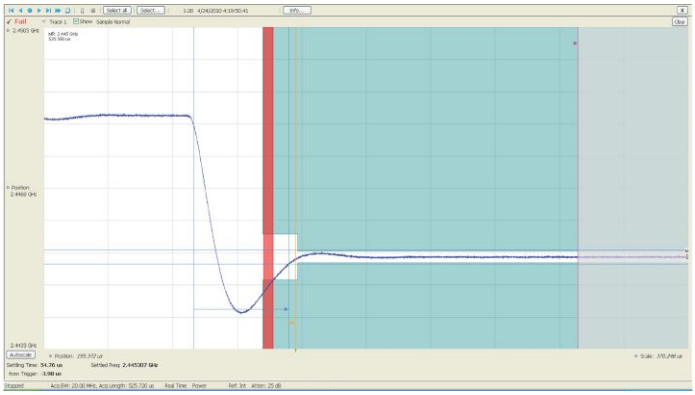
Measurement functions

Spectrum analyzer measurements (Opt. SVE)	Channel Power, Adjacent Channel Power, Multicarrier Adjacent Channel Power/Leakage Ratio, Occupied Bandwidth, xdB Down, dBm/Hz Marker, dBc/Hz Marker
Time domain and statistical measurements (Opt. SVE)	RF IQ vs. Time, Amplitude vs. Time, Power vs. Time, Frequency vs. Time, Phase vs. Time, CCDF, Peak-to-Average Ratio, Amplitude, Frequency, and Phase Modulation Analysis
Spur search measurements (Opt. SVE)	Up to 20 ranges, user-selected detectors (peak, average, CISPR peak), filters (RBW, CISPR, MIL) and VBW in each range. Linear or Log frequency scale. Measurements and violations in absolute power or relative to a carrier. Up to 999 violations identified in tabular form for export in CSV format
WLAN 802.11a/b/g/j/p measurement application (Opt. SV23) WLAN 802.11n measurement application (Opt. SV24) WLAN 802.11ac measurement application (Opt. SV25)	All of the RF transmitter measurements as defined in the IEEE standard, and a wide range of additional scalar measurements such as Carrier Frequency error, Symbol Timing error, Average/peak burst power, IQ Origin Offset, RMS/Peak EVM, and analysis displays, such as EVM and Phase/ Magnitude Error vs time/frequency or vs symbols/ subcarriers, as well as packet header decoded information and symbol table. Option SV23 requires Option SVE Option SV24 requires option SV23 Option SV25 requires option SV24
AM/FM/PM modulation and audio measurements (Opt. SVA)	Carrier Power, Frequency Error, Modulation Frequency, Modulation Parameters (±peak, peak-peak/2, RMS), SINAD, Modulation Distortion, S/N, THD, TNHD, Hum and Noise
Settling time (frequency and phase) (Opt. SVT)	Measured Frequency, Settling Time from last settled frequency, Settling Time from last settled phase, Settling Time from Trigger. Automatic or manual reference frequency selection. User-adjustable measurement bandwidth, averaging, and smoothing. Pass/Fail Mask Testing with 3 user-settable zones

Advanced signal analysis (Opt. SVP)	Average On Power, Peak Power, Average Transmitted Power, Pulse Width, Rise Time, Fall Time, Repetition Interval (seconds), Repetition Interval (Hz), Duty Factor (%), Duty Factor (ratio), Ripple (dB), Ripple (%), Droop (dB), Droop (%), Overshoot (dB), Overshoot (%), Pulse-Pulse Frequency Difference, Pulse-Pulse Phase Difference, RMS Frequency Error, Max Frequency Error, RMS Phase Error, Max Phase Error, Frequency Deviation, Phase Deviation, Impulse Response (dB), Impulse Response (time), Time Stamp
Flexible OFDM analysis (Opt. SVO)	OFDM analysis with support for WLAN 802.11a/g/j and WiMAX 802.16-2004. Constellation, Scalar Measurement Summary, EVM or Power vs. Carrier, Symbol Table (Binary or Hexadecimal)
General purpose digital modulation analysis (Opt. SVM)	Error Vector Magnitude (EVM) (RMS, Peak, EVM vs. Time), Modulation Error Ratio (MER), Magnitude Error (RMS, Peak, Mag Error vs. Time), Phase Error (RMS, Peak, Phase Error vs. Time), Origin Offset, Frequency Error, Gain Imbalance, Quadrature Error, Rho, Constellation, Symbol Table. FSK only: Frequency Deviation, Symbol Timing Error



The Advanced Signal Analysis package (Opt. SVP) provides 27 individual measurements to automatically characterize long pulse trains. An 800 MHz wide LFM chirp centered at 18 GHz is seen here with measurements for pulses 7 through 18 (upper right). The shape of the pulse can be seen in the Amplitude vs. Time plot shown in the upper left. Detailed views of pulse #8's frequency deviation and parabolic phase trajectory are shown in the lower two views.



Settling time measurements (Opt. SVT) are easy and automated. The user can select measurement bandwidth, tolerance bands, reference frequency (auto or manual), and establish up to 3 tolerance bands vs. time for Pass/Fail testing. Settling time may be referenced to external or internal trigger, and from the last settled frequency or phase. In the illustration, frequency settling time for a hopped oscillator is measured from an external trigger point from the device under test.

Specifications

Performance (typical)

The following is typical performance of SignalVu™ running on any MSO/DPO5000, DPO7000, or DPO/DSA/MSO70000 Series oscilloscopes.

Frequency-related

Frequency range	See appropriate oscilloscope data sheet
Initial center frequency setting accuracy	Equal to time-base accuracy of oscilloscope
Center frequency setting resolution	0.1 Hz
Frequency offset range	0 Hz to the maximum bandwidth of the oscilloscope
Frequency marker readout accuracy	±(Reference Frequency Error × Marker Frequency + 0.001 × Span + 2) Hz
Span accuracy	±0.3%
Reference frequency error	Equal to oscilloscope reference frequency accuracy, aging, and drift. Refer to appropriate DPO/DSA/MSO data sheet.

3rd order inter-modulation distortion [1]

Center frequency	MSO/DPO5000	DPO7000	DPO/DSA/MSO70000
2 GHz	-38 dBc	-40 dBc	-55 dBc
10 GHz	--	--	-48 dBc
18 GHz	--	--	-50 dBc

Residual responses [2]

DPO/DSA/ MSO70000 series (all spans)	–60 dBm
DPO7000 series (all spans)	–65 dBm
MSO/DPO5000 series (all spans)	–70 dBm

Displayed average noise level [3]

Span	MSO/DPO5000	DPO7000	DPO/DSA/MSO70000
DC - 500 MHz	-94 dBm	-100 dBm	-103 dBm
>500 MHz - 3.5 GHz	-	-102 dBm	-103 dBm
>3.5 GHz - 14 GHz	-	-	-101 dBm
>14 GHz - 20 GHz	-	-	-88 dBm
>20 GHz - 25 GHz	-	-	-87 dBm
>25 GHz - 33 GHz	-	-	-85 dBm

Input-related

Number of inputs [4]	4
Input signal types	RF, I and Q (single ended), I and Q (differential)
Maximum input level	+26 dBm for 50 Ω input (5 V_{RMS})

1 Conditions: Each signal level -5 dBm, reference level 0 dBm, 1 MHz tone separation. Math traces off. DPO7054/7104 and MSO/DPO5034/5054/5104 performance not listed.

2 Conditions: RF input terminated, reference level 0 dBm, measurements made after specified oscilloscope warm-up and SPC calibration. Does not include zero Hz spur.

3 Conditions: RF input terminated, 10 kHz RBW, 100 averages, reference level -10 dBm, trace detection average. Measurements made after specified oscilloscope warm-up and SPC calibration. MSO/DPO5034 and MSO/DPO5054 performance not listed.

4 SignalVu can process acquisitions from any one of the oscilloscope channels. Users can also apply custom math and filter functions to each of the oscilloscope's acquisition channels. The resulting Math channel can then be selected by SignalVu for signal processing.

Performance (typical)

Trigger-related

Trigger modes

Free Run and Triggered. Trigger sensitivity and characteristics can be found in the appropriate oscilloscope data sheet.

Acquisition-related

SignalVu provides long acquisitions of waveform captures with high time and frequency resolution. Maximum acquisition time will vary based on the oscilloscope's available memory and analog bandwidth. The following table highlights each model's single-channel capabilities given its maximum available memory configuration.

Model [5]	Max span	Max acquisition time at max sample rate	Min RBW at max sample rate	Min IQ time resolution	Max number of FastFrames [6]
DPO/DSA73304D	33 GHz	2.5 ms	1.2 kHz	20 ps	65,535
DPO/DSA72504D	25 GHz				
DPO/DSA/ MSO72004C	20 GHz				
DPO/DSA/ MSO71604C	16 GHz				
DPO/DSA/ MSO71254C	12.5 GHz				
DPO/DSA/ MSO70804C	8 GHz	5 ms	600 Hz	80 ps	
DPO/DSA/ MSO70604C	6 GHz				
DPO/DSA/ MSO70404C	4 GHz				
DPO7354C	3.5 GHz	12.5 ms	300 Hz	50 ps	
DPO7254C	2.5 GHz				
DPO7104C	1 GHz			100 ps	
DPO7054C	500 MHz				
MSO/DPO5204	2 GHz	25 ms	100 Hz	200 ps	
MSO/DPO5104	1 GHz				
MSO/DPO5054	500 MHz			400 ps	
MSO/DPO5034	350 MHz				

5 With maximum available record length option and maximum sample rate.

6 Maximum number of frames available will depend upon the oscilloscope's record length, sample rate, and the acquisition length settings.

Performance (typical)

Analysis-related

Frequency (Opt. SVE)	Spectrum (Amplitude vs. Linear or Log Frequency)
	Spectrogram (Amplitude vs. Frequency over Time)
	Spurious (Amplitude vs. Linear or Log Frequency)
Time and statistics (Opt. SVE)	Amplitude vs. Time
	Frequency vs. Time
	Phase vs. Time
	Amplitude Modulation vs. Time
	Frequency Modulation vs. Time
	Phase Modulation vs. Time
	RF IQ vs. Time
	Time Overview
	CCDF
	Peak-to-Average Ratio
Settling time, frequency, and phase (Opt. SVT)	Frequency Settling vs. Time
	Phase Settling vs. Time
Advanced measurements suite (Opt. SVP)	Pulse results Table
	Pulse trace (Selectable by pulse number)
	Pulse statistics (Trend of pulse results, FFT of trend, and histogram)
Digital demod (Opt. SVM)	Constellation diagram
	EVM vs. Time
	Symbol table (binary or hexadecimal)
	Magnitude and Phase Error vs. Time, and Signal Quality
	Demodulated IQ vs. Time
	Eye diagram
	Trellis diagram
	Frequency Deviation vs. Time
Flexible OFDM (Opt. SVO)	EVM vs. Symbol, vs. Subcarrier Subcarrier Power vs. Symbol, vs. Subcarrier Subcarrier constellation Symbol data table Mag Error vs. Symbol, vs. Subcarrier Phase Error vs. Symbol, vs. Subcarrier Channel frequency response
Supported file formats	SignalVu can recall saved acquisitions from MSO/DPO5000, DPO7000, DPO/DSA/MSO70000, RSA5000, and RSA6000 Series instruments. Both WFM and TIQ file extensions can be recalled for postprocessing by SignalVu.

RF and spectrum analysis performance

Resolution bandwidth

Resolution bandwidth (spectrum analysis)	1, 2, 3, 5 sequence, auto-coupled, or user selected (arbitrary)
Resolution bandwidth shape	Approximately Gaussian, shape factor 4.1:1 (60:3 dB) ±10%, typical
Resolution bandwidth accuracy	±1% (auto-coupled RBW mode)
Alternative resolution bandwidth types	Kaiser window (RBW), –6 dB Mil, CISPR, Blackman-Harris 4B window, Uniform window (none), flat-top window (CW ampl.), Hanning window

RF and spectrum analysis performance

Video bandwidth

Video bandwidth range	Dependent on oscilloscope record length setting. approximately 500 Hz to 5 MHz
RBW/VBW maximum	10,000:1
RBW/VBW minimum	1:1
Resolution	5% of entered value
Accuracy (typical)	±10%

Time domain bandwidth (amplitude vs. time display)

Time domain bandwidth range	At least 1/2 to 1/10,000 of acquisition bandwidth
Time domain bandwidth shape	Approximately Gaussian, shape factor 4.1:1(60:3 dB), ±10% typical Shape factor <2.5:1 (60:3 dB) typical for all bandwidths
Time domain bandwidth accuracy	±10%

Spectrum display traces, detectors, and functions

Traces	Three traces + 1 math trace + 1 trace from spectrogram for spectrum display
Detector	Peak, –peak, average, CISPR peak
Trace functions	Normal, Average, Max Hold, Min Hold
Spectrum trace length	801, 2401, 4001, 8001, or 10401 points

AM/FM/PM modulation and audio measurements (Opt. SVA) [7]

Analog demodulation [8]

Carrier frequency range	1 kHz or (1/2 × audio analysis bandwidth) to maximum input frequency
Maximum audio frequency span	10 MHz

Audio filters

Low pass (kHz)	0.3, 3, 15, 30, 80, 300, and user-entered up to 0.9 × audio bandwidth
High pass (Hz)	20, 50, 300, 400, and user-entered up to 0.9 × audio bandwidth
Standard	CCITT, C-Message
De-emphasis (µs)	25, 50, 75, 750, and user-entered
File	User-supplied .TXT or .CSV file of amplitude/frequency pairs. Maximum 1000 pairs.

FM modulation analysis

FM measurements,	Carrier power, carrier frequency error, audio frequency, deviation (+peak, –peak, peak-peak/2, RMS), SINAD, modulation distortion, S/N, total harmonic distortion, total non-harmonic distortion, hum and noise
FM deviation accuracy	±1.5% of deviation
FM rate accuracy	±1.0 Hz
Carrier frequency accuracy	±1 Hz + (transmitter frequency × reference frequency error)

7 All published performance based on conditions of Input Signal: 0 dBm, Input Frequency: 100 MHz, RBW: Auto, Averaging: Off, Filters: Off. Sampling and input parameters optimized for best results.

8 Sampling rates of the oscilloscope are recommended to be adjusted to no more than 10X the audio carrier frequency for modulated signals, and 10X the audio analysis bandwidth for direct input audio. This reduces the length of acquisition required for narrow-band audio analysis.

AM/FM/PM modulation and audio measurements (Opt. SVA)

Residuals (FM) (rate: 1 kHz to 10 kHz, deviation: 5 kHz)

THD	0.2% (MSO/DPO7000, 70000 Series)
	1.0% (MSO/DPO5000 Series)
SINAD	44 dB (MSO/DPO7000, 70000 Series)
	38 dB (MSO/DPO5000 Series)

AM modulation analysis

AM measurements	Carrier power, audio frequency, modulation depth (+peak, –peak, peak-peak/2), RMS, SINAD, modulation distortion, S/N, total harmonic distortion, total non-harmonic distortion, hum and noise
AM depth accuracy (rate: 1 kHz, depth: 50%)	±1% + 0.01 × measured value
AM rate accuracy (rate: 1 kHz, depth: 50%)	±1.0 Hz

Residuals (AM)

THD	0.3% (MSO/DPO7000, 70000 Series)
	1.0% (MSO/DPO5000 Series)
SINAD	48 dB (MSO/DPO7000, 70000 Series)
	43 dB (MSO/DPO5000 Series)

PM modulation analysis

PM measurement	Carrier power, carrier frequency error, audio frequency, deviation (+peak, –peak, peak-peak/2, RMS), SINAD, modulation distortion, S/N, total harmonic distortion, total non-harmonic distortion, hum and noise
PM deviation accuracy (rate: 1 kHz, deviation: 0.628 rad)	±100% × (0.01 + (rate / 1 MHz))
PM rate accuracy (rate: 1 kHz, deviation: 0.628 rad)	±1 Hz

Residuals (PM)

THD	0.1% (MSO/DPO7000, 70000 Series)
	0.5% (MSO/DPO5000 Series)
SINAD	48 dB (MSO/DPO7000, 70000 Series)
	43 dB (MSO/DPO5000 Series)

Direct audio input

Audio measurements	Signal power, audio frequency (+peak, –peak, peak-peak/2, RMS), SINAD, modulation distortion, S/N, total harmonic distortion, total non-harmonic distortion, hum and noise
Direct input frequency range (for audio measurements only)	1 Hz to 10 MHz
Maximum audio frequency span	10 MHz
Audio frequency accuracy	±1 Hz

Residuals (PM)

THD	1.5%
SINAD	38 dB

AM/FM/PM modulation and audio measurements (Opt. SVA)

Minimum audio analysis bandwidth and RBW vs. oscilloscope memory and sample rate

Model	Sample rate: 1 GS/s				Sample rate: maximum			
	Standard memory		Maximum memory		Standard memory		Maximum memory	
	Min. Aud. BW	RBW (Auto)	Min. Aud. BW	RBW (Auto)	Min. Aud. BW	RBW (Auto)	Min. Aud. BW	RBW (Auto)
MSO/ DPO 5034 MSO/DPO 5054	200 kHz	400 Hz	20 kHz	40 Hz	1 MHz	2 kHz	100 kHz	200 hz
MSO/DPO 5104 MSO/DPO 5204	100 kHz	200 Hz	10 kHz	20 hz	1 MHz	2 kHz	100 kHz	200 Hz
DPO 7000	50 kHz	100 Hz	50 kHz	100 Hz	2 MHz	4 kHz	2 MHz	4 kHz
DPO/DSA/ MSO 70000 ≥12.5 GHz BW	200 kHz	400 Hz	10 kHz	20 Hz	not recom-mended	>4 kHz	1 MHz	2 kHz
DPO/DSA/ MSO 70000 <12.5 GHz BW	200 kHz	400 Hz	20 kHz	40 Hz	not recom-mended	>4 kHz	500 kHz	1 kHz

Settling time, frequency, and phase (Opt. SVT) [9]

Settled frequency uncertainty,

Measurement frequency: 1 GHz

Averages	Frequency uncertainty at stated measurement bandwidth			
	1 GHz	100 MHz	10 MHz	1 MHz
Single measurement	20 kHz	2 kHz	500 Hz	100 Hz
100 averages	10 kHz	500 Hz	200 Hz	50 Hz
1000 averages	2 kHz	200 Hz	50 Hz	10 Hz

Measurement frequency: 9 GHz

Averages	Frequency uncertainty at stated measurement bandwidth			
	1 GHz	100 MHz	10 MHz	1 MHz
Single Measurement	20 kHz	5 kHz	2 kHz	200 Hz
100 Averages	10 kHz	2 kHz	500 Hz	50 Hz
1000 Averages	2 kHz	500 Hz	200 Hz	20 Hz

9 Settled Frequency or Phase at the measurement frequency. Measured signal level > -20 dBm, Attenuator: Auto.

Settling time, frequency, and phase (Opt. SVT)

Settled phase uncertainty,

Measurement frequency: 1 GHz

Averages	Phase uncertainty at stated measurement bandwidth			
	1 GHz	100 MHz	10 MHz	1 MHz
Single measurement	2°	2°	2°	2°
100 averages	0.5°	0.5°	0.5°	0.5°
1000 averages	0.2°	0.2°	0.2°	0.2°

Measurement frequency: 9 GHz

Averages	Phase uncertainty at stated measurement bandwidth			
	1 GHz	100 MHz	10 MHz	1 MHz
Single measurement	5°	5°	5°	5°
100 averages	2°	2°	2°	2°
1000 averages	0.5°	0.5°	0.5°	0.5°

Advanced measurement suite (Opt. SVP)

General characteristics

Measurements

Average On Power, Peak Power, Average Transmitted Power, Pulse Width, Rise Time, Fall Time, Repetition Interval (seconds), Repetition Interval (Hz), Duty Factor (%), Duty Factor (ratio), Ripple (dB), Ripple (%), Droop (dB), Droop (%), Overshoot (dB), Overshoot (%), Pulse-Pulse Frequency Difference, Pulse-Pulse Phase Difference, RMS Frequency Error, Max Frequency Error, RMS Phase Error, Max Phase Error, Frequency Deviation, Phase Deviation, Impulse Response (dB), Impulse Response (time), Time Stamp

Number of pulses

1 to 10,000

System rise time (typical)

Equal to oscilloscope rise time

Minimum pulse width for detection [10]

Model	Minimum PW
DPO/DSA72004B MSO72004	400 ps
DPO/DSA71604B MSO71604	500 ps
DPO/DSA71254B MSO71254	640 ps
DPO/DSA70804B MSO70804	1 ns
DPO/DSA70604B MSO70604	1.3 ns
DPO/DSA70404B MSO70404	2 ns
DPO7354	2.25 ns
DPO7254	3 ns
DPO7104	8 ns
DPO7054	16 ns
MSO/DPO5204	4 ns
MSO/DPO5104	8 ns
MSO/DPO5054	16 ns
MSO/DPO5034	25 ns

10 Conditions: Approximately equal to 10/(IQ sampling rate). IQ sampling rate is the final sample rate after digital down conversion from the oscilloscope. Pulse measurement filter set to max bandwidth.

Advanced measurement suite (Opt. SVP)

Pulse measurement accuracy (typical) [11]

Average on power	±0.3 dB + Absolute Amplitude Accuracy of oscilloscope
Average transmitted power	±0.4 dB + Absolute Amplitude Accuracy of oscilloscope
Peak power	±0.4 dB + Absolute Amplitude Accuracy of oscilloscope
Pulse width	±(3% of reading + 0.5 × sample period)
Pulse repetition rate	±(3% of reading + 0.5 × sample period)

Digital modulation analysis (Opt. SVM)

Modulation formats	π/2DBPSK, BPSK, SBPSK, QPSK, DQPSK, π/4DQPSK, D8PSK, 8PSK, OQPSK, SOQPSK, CPM, 16/32/64/128/256QAM, MSK, GMSK, GFSK, 2-FSK, 4-FSK, 8-FSK, 16-FSK, C4FM
Analysis period	Up to 80,000 samples
Measurement filters	Square-root raised cosine, raised cosine, Gaussian, rectangular, IS-95, IS-95 EQ, C4FM-P25, half-sine, None, User Defined
Reference filters	Raised cosine, Gaussian, rectangular, IS-95, SBPSK-MIL, SOQPSK-MIL, SOQPSK-ARTM, None, User Defined
Alpha/B x T range	0.001 to 1, 0.001 step
	Constellation, Error vector magnitude (EVM) vs time, Modulation error ratio (MER), Magnitude error vs time, Phase error vs time, Signal quality, Symbol table rhoFSK only: Frequency deviation, Symbol timing error
Symbol rate range	1 kS/s to (0.4 * Sample Rate) GS/s (modulated signal must be contained entirely within the acquisition bandwidth)

Adaptive equalizer

Type	Linear, decision-directed, feed-forward (FIR) equalizer with coefficient adaptation and adjustable convergence rate
Modulation types supported	BPSK, QPSK, OQPSK π/2 DQPSK, π/4 DQPSK, 8PSK, D8PSK, D16PSK, 16/32/64/128/256QAM
Reference filters for all modulation types except OQPSK	Raised cosine, Rectangular, None
Reference filters for OQPSK	Raised cosine, Half sine
Filter length	1-128 taps
Taps/symbol: raised cosine, half sine, no filter	1, 2, 4, 8
Taps/symbol: rectangular filter	1
Equalizer controls	Off, Train, Hold, Reset

16QAM Residual EVM (typical) for DPO7000 and DPO/DSA/MSO70000 series [12]

Symbol Rate	RF	IQ
100 MS/s	<2.0%	<2.0%
312.5 MS/s	<3.0%	<3.0%

11 Conditions: Pulse Width > 450 ns, S/N Ratio ≥30 dB, Duty Cycle 0.5 to 0.001, Temperature 18 °C to 28 °C.

12 CF = 1 GHz, Measurement Filter = root raised cosine, Reference Filter = raised cosine, Analysis Length = 200 symbols.

Digital modulation analysis (Opt. SVM)

16QAM Residual EVM (typical) for MSO/DPO5000 series[13]

Symbol Rate	RF	IQ
10 MS/s	1.5%	1.0%
100 MS/s	4.0%	2.0%

OFDM residual EVM, 802.11g Signal at 2.4 GHz, input level optimized for best performance

DPO7000 Series	–33 dB
DPO/DSA/MSO70000 Series	–38 dB

WLAN IEEE802.11a/b/g/j/p (Opt. SV23)

General characteristics

Modulation formats	DBPSK (DSSS1M), DQPSK (DSSS2M), CCK5.5M, CCK11M , OFDM (BPSK, QPSK, 16 or 64QAM)
Measurements	RMS and Peak EVM for Pilots/Data, Peak EVM located per symbol and subcarrier
	Packet header format information
	Average power and RMS EVM per section of the header
	WLAN power vs time, WLAN symbol table, WLAN constellation
	Spectrum Emission Mask, Spurious
	Error vector magnitude (EVM) vs symbol (or time), vs subcarrier (or frequency)
	Mag error vs symbol (or time), vs subcarrier (or frequency)
	Phase error vs symbol (or time), vs subcarrier (or frequency)
	WLAN channel frequency response vs symbol (or time), vs subcarrier (or frequency)
	WLAN spectral flatness vs symbol (or time), vs subcarrier (or frequency)

WLAN IEEE802.11n (Opt. SV24)

General characteristics

Modulation formats	OFDM (BPSK, QPSK, 16 or 64 QAM), SISO
Measurements	Burst index, Burst power, Peak to average burst power, IQ origin offset, Frequency error, Common pilot error, Symbol clock error
	RMS and peak EVM for Pilots/Data, peak EVM located per symbol and subcarrier
	Packet header format information
	Average power and RMS EVM per section of the header
	WLAN power vs time, WLAN symbol table, WLAN constellation
	Spectrum emission mask, spurious
	Error vector magnitude (EVM) vs symbol (or time), vs subcarrier (or frequency)
	Mag error vs symbol (or time), vs subcarrier (or frequency)
	Phase error vs symbol (or time), vs subcarrier (or frequency)
	WLAN channel frequency response vs symbol (or time), vs subcarrier (or frequency)
	WLAN spectral flatness vs symbol (or time), vs subcarrier (or frequency)

13 Carrier frequency 700 MHz. MSO/DPO5054 and MSO/DPO5034 performance not listed. Use of external reference will degrade EVM performance.

WLAN IEEE802.11ac (Opt. SV25)

General characteristics

Modulation formats	OFDM (BPSK, QPSK, 16 QAM, 64 QAM, 256 QAM), SISO
Measurements	Burst index, Burst power, Peak to average burst power, IQ origin offset,Frequency error, Common pilot error, Symbol clock error
	RMS and peak EVM for Pilots/Data, Peak EVM located per symbol and subcarrier
	Packet header format information
	Average power and RMS EVM per section of the header
	WLAN Power vs time, WLAN symbol table, WLAN constellation
	Spectrum emission mask, spurious
	Error vector magnitude (EVM) vs symbol (or time), vs subcarrier (or frequency)
	Mag error vs symbol (or time), vs subcarrier (or frequency)
	Phase error vs symbol (or time), vs subcarrier (or frequency)
	WLAN channel frequency response vs symbol (or time), vs subcarrier (or frequency)
	WLAN spectral flatness vs symbol (or time), vs subcarrier (or frequency)

General characteristics

GPIB	SCPI-compatible, see programmer manual for exceptions

Ordering information

SignalVu™ Vector Signal Analysis software is compatible with all DPO/MSO5000 Series digital oscilloscopes with firmware version 6.1.1 and DPO7000, DPO/DSA/MSO70000 Series digital oscilloscopes with firmware version V5.1.0 or higher. SignalVu Essentials (Opt. SVE) provides basic vector signal analysis and is required for all other analysis options.

Options

Opt. SVE	SignalVu Essentials - Vector Signal Analysis Software
Opt. SV23	WLAN 802.11a/b/g/j/p measurement application (requires opt. SVE, requires oscilloscope of bandwidth of 2.5 GHz or above)
Opt. SV24	WLAN 802.11n measurement application (requires opt SV23, requires oscilloscope of bandwidth of 2.5 GHz or above)
Opt. SV25	WLAN 802.11ac measurement application (requires opt SV24, requires oscilloscope of bandwidth of 6.0 GHz or above)
Opt. SVP	Advanced Signal Analysis, including pulse measurements (requires opt. SVE)
Opt. SVM	General Purpose Digital Modulation Analysis (requires opt. SVE)
Opt. SVT	Settling Time, Frequency, and Phase (requires opt. SVE)
Opt. SVO	Flexible OFDM with support for 802.11a/j/g and 802.16-2044 (fixed WiMAX) modulation types. Not available on the MSO/DPO5000 Series (requires instruments with Windows 7 operating system)
Opt. SVA	AM/FM/PM Modulation and Audio Measurements. Requires Opt. SVE (requires instruments with Windows 7 operating system)

SignalVu ordering and upgrade guide for new and existing instruments

Option ordering nomenclature for all oscilloscopes. Option SVE is required for all other options listed. Option SVO is not available on MSO/DPO5000 models.

For information on analysis software that runs on your personal computer, please see the SignalVu-PC data sheet 37W-26988.

New and existing models

Model	Ordering on new instrument	Upgrade existing instrument
MSO/DPO5000 Series	Opt. SVE (Essentials)	DPO-UP Opt. SVEE
DPO7000 Series	Opt. SVE (Essentials)	DPO-UP Opt. SVEM
DPO/DSA/MSO70000 Series ≤8 GHz	Opt. SVE (Essentials)	DPO-UP Opt. SVEH
DPO/DSA/MSO70000 Series >8 GHz	Opt. SVE (Essentials)	DPO-UP Opt. SVEU
Option SVE required for all other options listed	Opt. SVT (Settling time)	DPO-UP Opt. SVT
	Opt. SVP (Pulse measurements)	DPO-UP Opt. SVP
	Opt. SVM (GP modulation analysis)	DPO-UP Opt. SVM
	Opt. SVO (OFDM)	DPO-UP Opt. SVO
	Opt. SVA (AM/FM/PM Audio)	DPO-UP Opt. SVA
	Opt. SV23 (IEEE802.11a/b/g/j/p)	DPO-UP Opt. SV23
Option SV23 required for SV24	Opt. SV24 (IEEE802.11n)	DPO-UP Opt .SV24
Option SV24 required for SV25	Opt. SV25 (IEEE802.11ac)	DPO-UP Opt. SV25

Legacy models

DPO7000 Series, DPO/DSA/MSO70000 Series

Earlier DPO7000 and DPO/DSA/MSO70000 Series oscilloscopes may be retrofitted with SignalVu. These instruments use a Microsoft Windows XP operating system, have oscilloscope firmware version 5.1 or above, and are compatible with SignalVu version 2.3.0072. See upgrade nomenclature table above for ordering information. Option SVO (OFDM) and Option SVA (AM/FM/PM Audio) are not available on instruments with Microsoft Windows XP.

Standard accessories

- Quick-start manual (Printed)
- Printable Online Help file
- Programmer manual (on CD)

Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.

Product(s) complies with IEEE Standard 488.1-1987, RS-232-C, and with Tektronix Standard Codes and Formats.

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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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