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DATA SHEET

USB Software Package

for InfiniiVision X-Series Oscilloscopes

The USB Software Package for Keysight's InfiniiVision oscilloscopes enables USB 2.0 low-, full-, and hi-speed protocol triggering and decode, as well as USB PD (Power Delivery) trigger and decode. This package also enables other advanced analysis capabilities including USB 2.0 automated signal quality testing, jitter analysis, mask testing, and frequency response analysis (Bode plots) to help test and debug high-speed digital signals, such as USB 2.0.

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Introduction

The primary reason engineers use oscilloscopes to debug and characterize serial buses, such as USB 2.0 is because of an oscilloscope's inherent ability to characterize the analog quality of these signals. Performing analog characterization using an oscilloscope is often referred to as "physical layer" measurements. Table 1 lists the specific measurement capabilities that are enabled on each series with the USB Software Package for Keysight Technologies InfiniiVision X-Series oscilloscopes.

Table 1. USB Software Packages for InfiniiVision Oscilloscopes

InfiniiVision Series:		3000T	4000A	6000A
USB Package Model Number:		**D3000USBB**	**D4000USBB**	**D6000USBB**
Serial Trigger & Decode	USB 2.0 Low- & Full-speed	✓	✓	✓
	USB 2.0 Hi-speed[1]		✓	✓
	USB PD (Power Delivery)	✓	✓	✓
Advanced Analysis Capabilities	USB 2.0 Signal Quality Test[2]		✓	✓
	Jitter Analysis			✓
	Mask Limit Test	✓	✓	✓
	Measurement Limit Test	✓	✓	✓
	Frequency Response Analysis	✓	✓	✓

1. USB 2.0 hi-speed trigger & decode supported on ≥ 1-GHz bandwidth models only.
2. USB 2.0 hi-speed signal quality tests on ≥ 1.5-GHz bandwidth models only.

When licensed with the USB Software Package, Keysight’s InfiniiVision 3000T, 4000, and 6000 X-Series oscilloscopes can not only trigger on a broad range of USB 2.0 specific packet types (handshake, token, data, etc.) and errors, but the scope also provides a time-correlated decode trace of each packet below captured waveforms so that you can directly compare the quality of waveforms that produce each decoded byte. In addition, the scope can also display a tabular list of multiple and consecutively captured and decoded packets in the upper half of the scope’s display as shown in Figure 1.

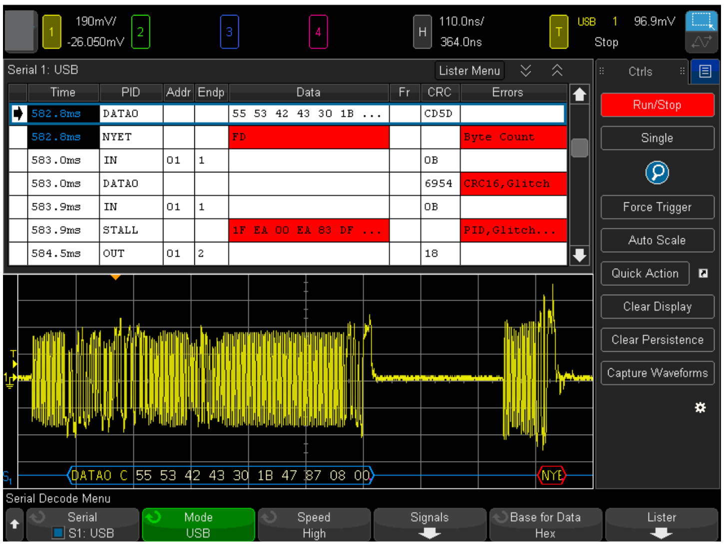

Figure 1. Hardware-based decoding quickly uncovers USB 2.0 hi-speed bus errors.

Keysight InfiniiVision X-Series oscilloscopes utilize hardware-based decoding as opposed to conventional oscilloscope software-based decoding. This means that the scope remains responsive and fast when decoding is turned on. And with a virtual real-time update of the USB decode trace, the scope has a much higher probability of detecting infrequent USB errors such as PID errors or CRC errors as compared to other oscilloscopes that utilize software-based decoding.

Serial Trigger and Decode

USB 2.0 Low- and Full-speed

Table 2: USB 2.0 Low- and Full-speed Performance Characteristics

Performance Characteristics	
USB input source (D+ & D-)	Analog channels 1, 2, 3 or 4
	Digital channels D0-D15
Speed	Low (1.5 Mb/s) and Full (12 Mb/s)
Triggering	Start of packet (SOP)
	End of packet (EOP)
	Suspend – when bus is idle for > 3 ms
	Resume – when exiting an idle state > 10 ms
	Reset – when SE0 is > 10 ms
	Token packet with specified content

Performance Characteristics	
	Data packet with specified content
	Handshake packet with specified content
	Special packet with specified content
	All errors – any of the below error conditions
	PID error – if packet type field does not match check field
	CRC5 error – if 5-bit CRC error is detected
	CRC16 error – if 16-bit CRC error is detected
	Glitch error – if two transitions occur in half a bit time
	Bit stuff error – if >6 consecutive “ones” are detected
	SE1 error – if SE1 > 1 bit time
Hardware-based decode	
– Base format	Hex, Binary, ASCII or Decimal data decode
– Token packets (excluding SOF, 3 bytes)	PID (yellow, “OUT”, “IN”, “SETUP”, “PING”)
	PID Check (yellow when valid, red when error detected) – numeric value
	Address (blue, 7 bits)
	Endpoint (green, 4 bits)
	CRC (blue when valid, red when error detected, 5 bits)
– Token packets (SOF, 3 bytes)	PID (yellow, “SOF”)
	PID Check (yellow when valid, red when error detected, 5 bits)
	Frame (green, 11-bits) – the frame number
	CRC (blue when valid, red when error detected, 5 bits)
– Data packets (3 to 1027 bytes)	PID (yellow, “DATA0”, “DATA1”, DATA2”, “MDATA”)
	PID Check (yellow when valid, red when error detected, 16 bits)
– Handshake packets (1 byte)	PID (yellow, “ACK”, “NAK”, “STALL”, “NYET”, “PRE”, “ERR”)
	PID Check (yellow when valid, read when error detected) – numeric value
	Hub Addr (green, 7 bits)
	SC (blue, 1 bit)
	Port (green, 7 bits)
	S & E|U (blue, 2 bits)
	ET (green, 2 bits)
	CRC (blue when valid, red when error detected, 5 bits
– Multi-bus analysis	USB low-full-speed plus one other serial bus (including another USB bus)

USB 2.0 Hi Speed

Table 3: USB 2.0 Hi-speed Performance Characteristics (≥ 1-GHz bandwidth 4000 and 6000 X-Series models only)

Performance Characteristics	
USB differential input source	Analog channels 1, 2, 3 or 4 (using a differential active probe)
Speed	High (480 Mb/s)
Triggering	Token packet with specified content
	Data packet with specified content
	Handshake packet with specified content
	Special packet with specified content
	All errors – any of the below error conditions
	PID error – if packet type field does not match check field
	CRC5 error – if 5-bit CRC error is detected
	CRC16 error – if 16-bit CRC error is detected
	Glitch error – if two transitions occur in half a bit time
Hardware-based decode	
Base format	Hex, Binary, ASCII or Decimal data decode
Token packets (excluding SOF, 3 bytes)	PID (yellow, “OUT”, “IN”, “SETUP”, “PING”)
	PID check (yellow when valid, red when error detected) – numeric value
	Address (blue, 7 bits)
	Endpoint (green, 4 bits)
	CRC (blue when valid, red when error detected, 5 bits)
Token packets (SOF, 3 bytes)	PID (yellow, “SOF”)
	PID check (yellow when valid, red when error detected, 5 bits)
Data packets (3 to 1027 bytes)	Frame (green, 11-bits) – the frame number
	CRC (blue when valid, red when error detected, 5 bits)
	PID (yellow, “DATA0”, “DATA1”, DATA2”, “MDATA”)
	PID check (yellow when valid, red when error detected, 16 bits)
Handshake packets (1 byte)	PID (yellow, “ACK”, “NAK”, “STALL”, “NYET”, “PRE”, “ERR”)
	PID check (yellow when valid, read when error detected) – numeric value
	Hub Addr (green, 7 bits)
	SC (blue, 1 bit)
	Port (green, 7 bits)
	S & E|U (blue, 2 bits)
	ET (green, 2 bits)
	CRC (blue when valid, red when error detected, 5 bits
Multi-bus analysis	N/A

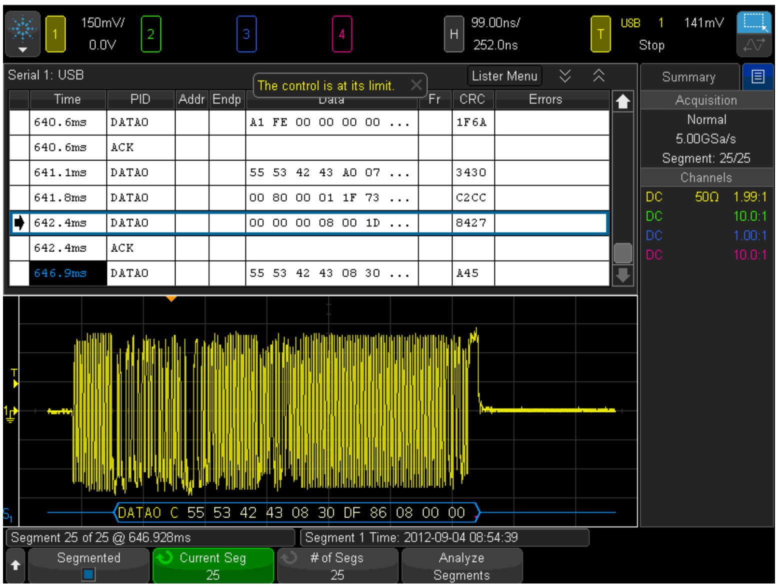

Figure 2. USB 2.0 hi-speed trigger and decode.

USB PD (Power Delivery)

- Supports decoding and triggering on the USB PD protocol.
- Hardware-based decoding to capture random and infrequent errors quickly
- Supports dual-bus analysis with time-interleave lister display
- Trigger on Preamble, EOP, and Ordered sets (SOP, SOP’, SOP”, etc.)
- Trigger on Header content hexadecimally, or on symbolic messages including control message types, data message types, or extended message types

Table 4. USB PD Performance Characteristics

Performance Characteristics	
USB Type-C CC wire input source	Analog channels 1, 2, 3, or 4
Baud rate	300 kbps ± 10%
Triggering	Preamble start
	EOP
	Ordered sets:
	– SOP, SOP’, SOP”, SOP’ debug, SOP” debug, hard reset, cable reset
	Errors:
	– CRC error, Preamble error
	Header content (qualified on SOP, SOP’, SOP”, or none):
	– Control message (GoodCRC, Accept, Reject, Get_Source_Cap, etc. [1])
	– Data message (Source_Cap, Request, BIST, etc. [1])
	– Extended message (Source_Cap_Extended, Status, Battery_Cap, etc. [1])
	– Value (Hex – 4 nibbles)

Performance Characteristics	
Hardware-based decode (Time-correlated decode trace below waveform and protocol lister table above waveform)	Preamble (PRE in blue)
	Ordered set (symbolic name in blue)
	Header (Hex digits in yellow)
	Data (32-bit Hex objects in white)
	CRC (Hex in green)
	End of packet (EOP in blue)
	Symbolic:
	– Control messages
	– Data messages
	– Extended messages
	– Source capabilities (in Volts/Amps)
	– Sink capabilities (in Volts/Amps)
	– Structured vendor defined message commands
Multi-bus analysis	USB PD plus one other serial bus

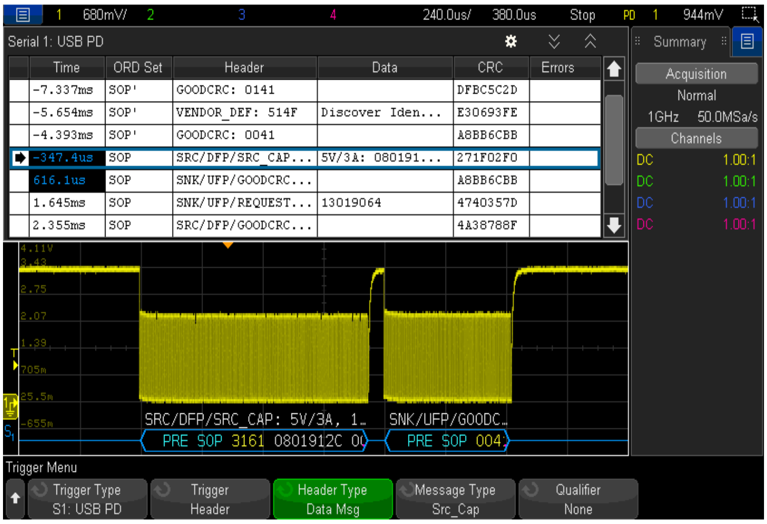

Figure 3. USB PD decode on an InfiniiVision X-Series oscilloscope.

Advanced Analysis

USB 2.0 Signal Quality Test

With Keysight's USB 2.0 signal quality test capability on InfiniiVision 4000 or 6000 X-Series oscilloscopes, engineers now have a more affordable pre-compliance test solution that can perform what many consider to be the most important series of USB 2.0 physical layer tests (signal quality) before running their final product through complete certification testing at a USB-IF designated workshop.

Features:

- Pass/fail test comparison standards based on low-speed, full-speed, hi-speed, far-end, near-end, host, and device specifications
- Real-time eye test
- Consecutive, paired JK, and paired KJ jitter
- Sync test
- Cross-over voltage (low- and full-speed only)
- EOP bit-width
- Signaling rate
- Edge monotonicity
- Rise/fall edge rate
- Edge rate match (low- and full-speed only)
- HTML pass/fail report generation

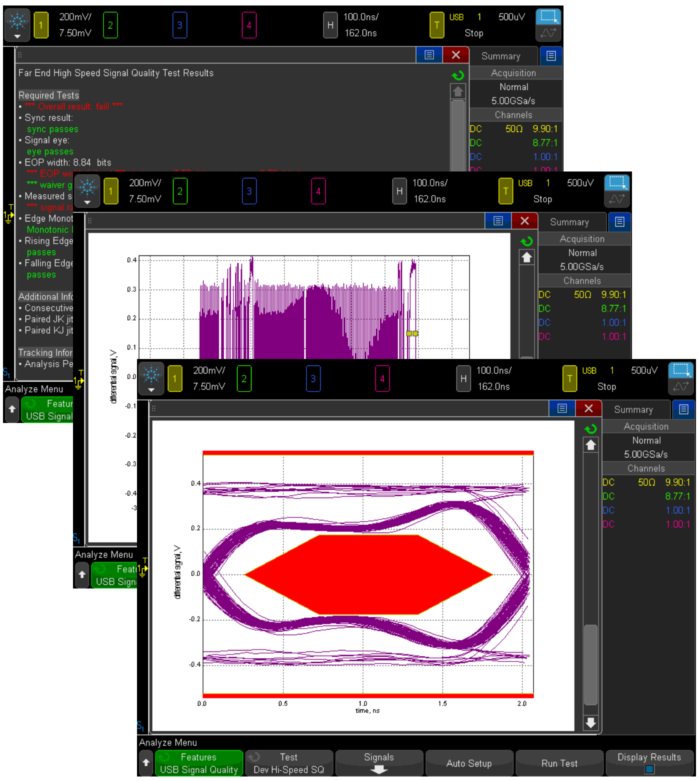

Figure 4. Scrollable on-screen signal quality test report.

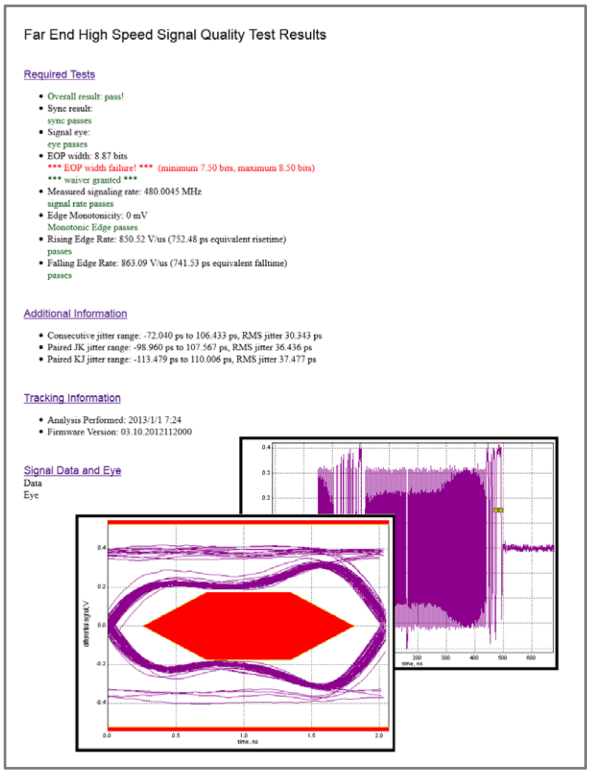

Figure 5. USB 2.0 signal quality test report in HTML format.

USB 2.0 Signal Quality Test Coverage

Table 5 summarizes the USB 2.0 signal quality test capabilities of the InfiniiVision 4000 and 6000 X-Series oscilloscopes when licensed with the USB Software Package. For complete USB 2.0 compliance testing (beyond just “signal quality” testing), Keysight recommends the Keysight Infiniium S-Series oscilloscope.

Table 5. USB 2.0 Test Coverage

USB measurement	USB 2.0 test coverage
EL_2 EL_4 EL_5 Data Eye and Mask Test High speed SQ	√
Consecutive, paired JK, and paired KJ jitter	√
Full and Low speed signal quality	√
Sync test	√
Cross-over voltage (low- and full-speed only)	√
EOP bit-width	√
Signaling rate	√
EL_6 Device Rise and Fall Time[1]	√
Edge rate match (low- and full-speed only)	√
HTML pass/fail report generation	√
EL_7 Device Non-Monotonic Edge Test	√
EL_22 Interpacket Gap Tests	X
EL_28 Chirp-K Latency	X
EL_29 Device CHIRP-K Duration	X
EL_31 Host Hi-Speed Terminations Enable and D+ Disconnect Time	X
EL_38 EL_39 Device Suspend Timing Response	X
EL_40 Device Resume Timing Response	X
EL_27 Device CHIRP Response to Reset from Hi-Speed Operation	X
EL_28 Device CHIRP Response to Reset from Suspend	X
EL_8 Device J Test	X
EL_8 Device K Test	X
EL_9 Device SE0_NAK Test	X
Inrush Current Test	X
Drop/Droop Vbus tests	X
VBus Backdrive tests	X

1. To accurately measure USB 2.0 rise and fall times with less than 10% error for sub 500 ps edges the measurement system bandwidth must be at least 2.5 GHz as required for official USB-IF compliance testing.

USB 2.0 Signal Quality Test Fixtures

For testing "live traffic" (non-compliance testing) using recommended probing, test fixtures are not required. For testing low- and full-speed products based on USB-IF compliance standards (pre-compliance signal quality testing), Keysight recommends using the E2646B "SQuIDD" test fixture shown in Figure 6. This test fixture provides easy-access probing test points for Keysight's N2800 Series 10:1 passive probes.

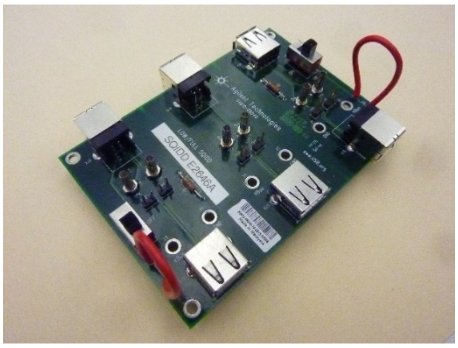

Figure 6. E2626B "SQuIDD" test fixture for testing USB 2.0 low- and full-speed products.

For testing a USB 2.0 hi-speed device based on USB-IF compliance standards (pre-compliance signal quality testing), Keysight recommends using the E2666B test fixture kit shown in Figure 7. Testing hi-speed devices using a programmed test pattern only requires that you connect the D+ and D- signals to the scope's input channels using SMA cabling along with the appropriate SMA-to-BNC adapters.

Figure 7. E2666B hi-speed device test fixture.

For testing USB 2.0 hi-speed hosts based on USB-IF compliance standards (pre-compliance signal quality testing), Keysight recommends using the E2667B test fixture kit shown in Figure 8. Testing hi-speed hosts using a programmed test pattern only requires that you connect the D+ and D- signals to the scope's input channels using SMA cabling along with the appropriate SMA-to-BNC adapters.

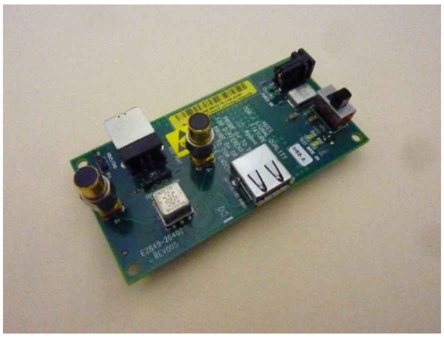

Figure 8. E2667B hi-speed host test fixture.

Jitter Analysis

With the USB Software Package licensed on the InfiniiVision 6000 X-Series oscilloscope, various types of jitter measurements with multiple views and quantization of jitter are enabled to provide you with valuable insight into the source of unwanted timing errors.

Features:

- Serial data TIE jitter measurements
- Clock jitter measurements including: clock TIE, N period, period to period, +width to +width, -width to -width, and duty cycle
- Various clock recovery algorithms including: constant/fixed clock, 1st order phase-locked loop (PLL) with loop bandwidth, and 2nd order PLL with loop bandwidth and damping factor
- Various views/plots of jitter including: jitter histogram, jitter trend, jitter spectrum, and jitter statistics
- Color- graded real-time eye with automatic eye-opening measurements

Jitter on clock signals can be measured either relative to a software-based recovered ideal clock or relative to selected cycles of the clock signal itself. Jitter measurements on serial data signals, which are sometimes referred to as Time Interval Error (TIE), can be performed relative to either an explicit reference clock or a software-based recovered clock.

Table 6 summarizes the various types of jitter measurements that can performed using the jitter analysis capability on an InfiniiVision 6000 X-Series oscilloscope licensed with the USB Software Package.

Table 6. Types of clock and serial data jitter measurements

Serial Data Jitter Measurements	
Data TIE	Measures timing error of all edges of the input serial data signal relative to either a recovered ideal clock or an explicit input clock signal.
Clock Jitter Measurements	
Clock TIE	Measures timing error of selected edges (rising, falling, or both) of the input clock signal relative to a recovered ideal clock.
N period	Measures the time-span of N consecutive periods of the clock based on the selected edge (rising or falling). Then, it shifts ahead by one period and measures the time-span of the next N consecutive periods, and so on. For example, if N = 3, then jitter = $(T_1 + T_2 + T_3)$, $(T_2 + T_3 + T_4)$, $(T_3 + T_4 + T_5)$, etc.
Period to period	Measures the time difference of successive periods (or groups of periods if N > 1) of the input clock signal on the selected edge (rising or falling). If N = 1, which is sometimes referred to as cycle-to-cycle jitter, then jitter = $T_2 – T_1$, $T_3 – T_2$, $T_4 – T_3$, etc. If N = 3, then jitter = $(T_4 + T_5 + T_6) – (T_1 + T_2 + T_3)$, $(T_5 + T_6 + T_7) – (T_2 + T_3 + T_4)$, etc.
+Width to +width	Measures the time difference of successive positive pulse widths of the input clock signal ($^{+}PW_{n+1} – {}^{+}PW_n$).
-Width to -width	Measures the time difference of successive negative pulse widths of the input clock signal ($^{-}PW_{n+1} – {}^{-}PW_n$).
+Duty cycle	Measures the duty cycle of every cycle of the input clock signal.
Serial data jitter measurements	
Data TIE	Measures timing error of all edges of the input serial data signal relative to either a recovered ideal clock or an explicit input clock signal.

Jitter Views

In addition to reporting numerical jitter results with statistics, jitter can viewed/plotted in various formats that can often help provide insight into the distribution and source of timing errors including the following:

- Jitter histogram
- Jitter trend
- Jitter spectrum
- Real-time eye

Figure 9 shows an example of a serial data TIE measurement with a jitter histogram plot and jitter trend plot. The histogram shows the probability distribution function (PDF) of accumulated timing errors along with numerical statistics of measured jitter. The jitter trend plot shows timing error of each serial data edge time-correlated to the input data signal (yellow trace) that is under test. In other words, the jitter trend waveform plots timing error on the vertical axis (sec/div) versus time on the horizontal axis.

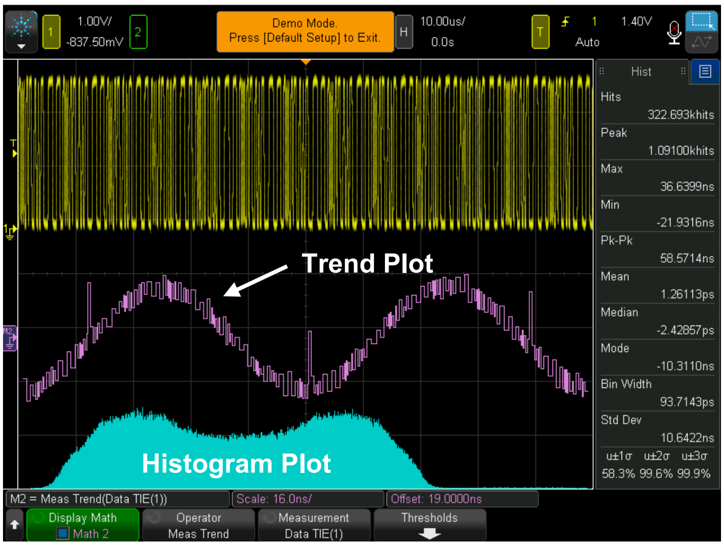

Figure 9. Jitter TIE analysis with the histogram and trend (error versus time) views of timing errors.

Figure 10 shows an example of a serial data TIE measurement with the jitter spectrum view along with a jitter trend plot. The jitter spec- trum is actually a Fast Fourier Transform (FFT) waveform math operation performed on the jit- ter trend waveform data. This view of jitter can often times help identify periodic components of jitter as illustrated in this jitter measurement example. Also available are frequency-domain search features to automatically identify peak frequencies.

Note that although they not shown, all three views of jitter analysis (histogram, trend, and spectrum) and can be selected and viewed simultaneously.

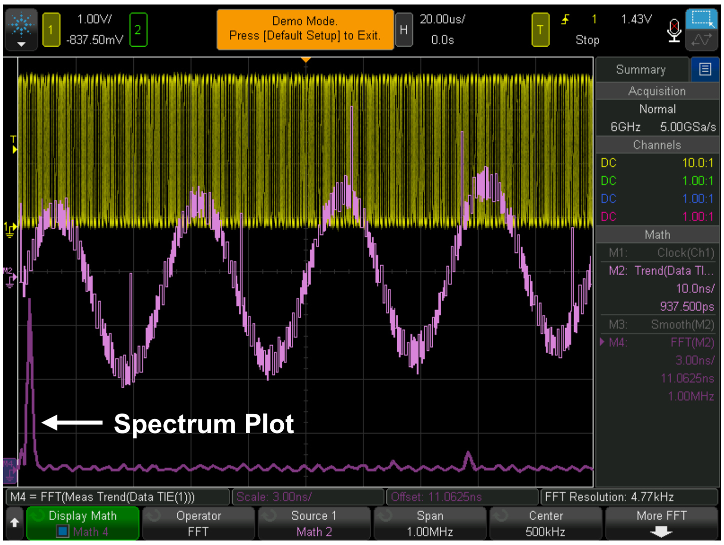

Figure 10. Jitter TIE analysis with the jitter spectrum (error versus frequency) and jitter trend views of timing errors.

In addition to viewing jitter in histogram, trend, and spectrum views, the InfiniiVision 6000 X-Series oscilloscopes can also display a color-graded Real-Time Eye (RTE) of serial data signals as shown in Figure 11. A real-time eye is an overlay of all bits to show worst-case timing (jitter) and worst-case noise relative to a recovered or explicit clock. With a real-time eye display, it is easy to observe the valid data window present at the input of receivers, along with automatic eye-opening measurements (eye height and eye width).

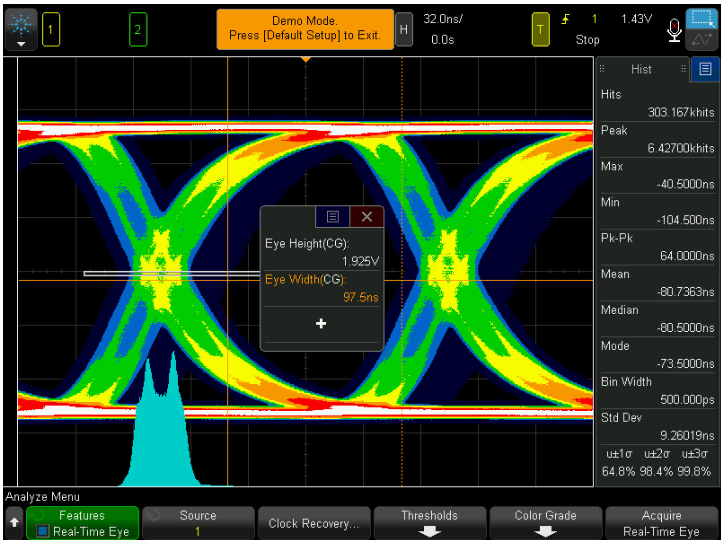

Figure 11. The color-graded real-time eye waveform shows worst-case data valid windows (eye-opening).

Clock Recovery for Jitter Analysis

Clock and serial data TIE jitter measurements are performed on all captured edges based on the selected transition(s) relative to either an explicit input reference clock signal or a software-based recovered clock (sometimes referred to as clock data recovery (CDR)).

Creating real-time eye displays also requires a recovered clock to use as a reference for slicing the captured serial data waveform into individual Unit Internals (UIs) for overlapping/folding. Since most of today's serial bus signals don't have explicit clocks (clocks are typically embedded in the data signal), software-based clock recovery is required to extract the clock from the data.

Jitter analysis provides the following software-based clock recovery algorithms:

- Constant/fixed clock
- 1st order PLL clock with user-specified loop bandwidth/cut-off frequency
- 2nd order PLL clock with user-specified loop bandwidth and damping factor
- Explicit clock (captured/not recovered)

Mask Test

If you need to validate the quality and stability of your electronic components and systems, the InfiniiVision oscilloscope's mask/waveform limit testing capability, which is enabled with the USB Software Package, can save you time and provide pass/fail statistics almost instantly. Mask testing offers a fast and easy way to test your signals to specified standards, as well as the ability to uncover unexpected signal anomalies, such as glitches. Mask testing on other oscilloscopes is usually based on software-intensive processing technology, which tends to be slow.

The InfiniiVision scope's mask testing is based on hardware-based technology, meaning that they can perform up to 270,000 real-time waveform pass/fail tests per second. This makes your testing throughput orders of magnitude faster than you can achieve on other oscilloscope mask test solutions.

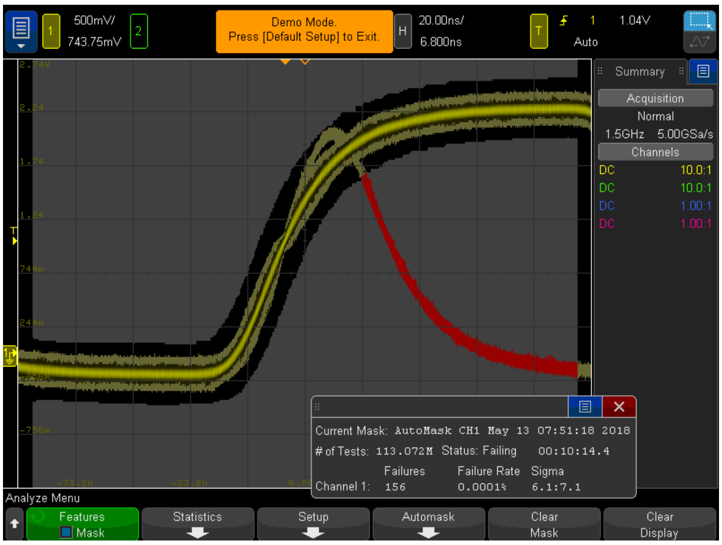

Figure 12. Frequency response of a bandpass filter.

Features

- Test up to 270,000 waveforms per second with the industry's fastest hardware-accelerated mask testing technology
- Automatic mask creation using input standard
- Easily download multi-region masks and setups based on industry standards
- Detailed pass/fail statistics
- Test to high-quality standards based on sigma
- Multiple user-selectable test criteria

Table 7. Mask Test Performance Characteristics

Performance Characteristics	
Mask test source	Analog channels 1, 2, 3, or 4
Maximum test rate	2000 X-Series: Up to 50,000 waveforms tested per second
	3000 and 4000 X-Series: Up to 270,000 waveforms tested per second
	6000 X-Series: Up to 130,000 waveforms tested per second
Acquisition modes	Real-time sampling–non-averaged, Real-time sampling–averaged
Mask creation	
• Automask-divisions	± X divisions, ± Y divisions
• Automask-absolute	± X seconds, ± Y volts
• Mask file import	Up to 8 failure regions (created in text editor)
Mask scaling	Source lock on (mask automatically re-scales with scope settings)
	Source lock off (mask scaling fixed relative to display when loaded or created)
Test criteria	Run until forever, Minimum number of tests, Minimum time, Minimum sigma
Action on error	Stop acquisitions, save image, print, perform measurements
Trigger output	On failure
Statistics display	Number of tests, Number of failures (for each channel tested), Failure rate (for each channel tested), Test time (hours – minutes – seconds), Sigma (actual versus maximum without failures)
Display formats	Mask – translucent gray, Failing waveform segments – red, Passing waveform segments – channel color
Save/recall	4 non-volatile internal registers (.msk format), USB memory stick (.msk format)

Frequency Response Analysis (Bode gain & phase plots)

Frequency Response Analysis (FRA) is often a critical measurement used to characterize the frequency response (gain and phase versus frequency) of a variety of today's electronic designs, including passive filters, amplifier circuits, and negative feedback networks of switch mode power supplies (loop response). FRA capability is included in the USB Software Package. This frequency-domain measurement capability is achieved with a swept gain and phase measurement versus frequency (Bode plot). The InfiniiVision oscilloscope uses the scope's built-in waveform generator (WaveGen) to stimulate the circuit under test at various frequency settings and then captures the input and output signals using two channels of the oscilloscope. At each test frequency, the scope measures, computes, plots gain ($20LogV_{OUT}/V_{IN}$) logarithmically and phase linearly.

- Dynamic range: > 80 dB (typical)
- Frequency range: 10 Hz to 20 MHz
- Sweep or single frequency test modes
- Fixed test amplitude or custom Amplitude Profile
- 60 to 1000 points across Start/Stop sweep range
- Two pair of tracking gain and phase markers
- Plots gain and phase and tabular view of test results
- Easily export and/or save measurement results in .csv format for offline analysis

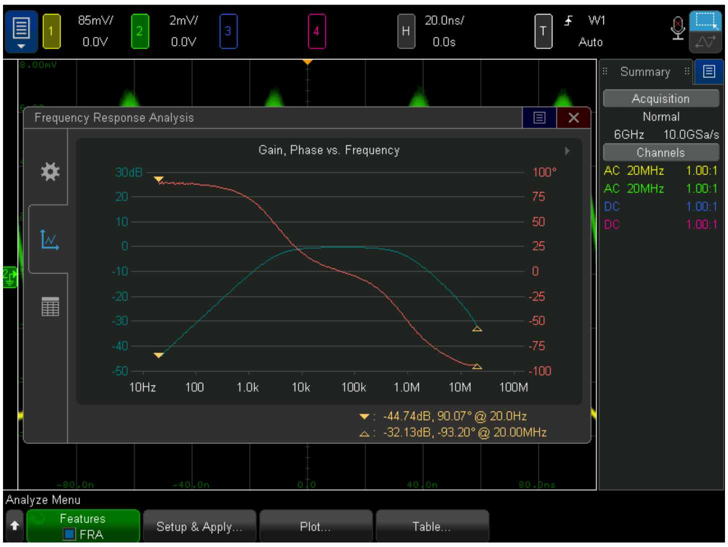

Figure 13. Frequency response analysis (gain & phase) on a bandpass filter.

Table 8. Frequency Response Analysis Performance Characteristics

Frequency Response Analysis		
Frequency mode	Sweep or single	
Frequency range	10 Hz to 20 MHz	
Test amplitude modes	Fixed or amplitude profile	
Test amplitude range	3000T:	10 mVpp to 2.5 Vpp into 50-Ω load
		20 mVpp to 5.0 Vpp into high impedance load
	4000A/6000A:	10 mVpp to 5 Vpp in 50-Ω load
		20 mVpp to 10.0 Vpp into high impedance load
Input and output sources	Channel 1, 2, 3, and 4	
Number of test points	60 to 1000 points across Start/Stop sweep range	
Test results	Overlaid gain and phase plot and tabular view	
Dynamic range	> 80 dB (typical) based on 0 dBm (630 mVpp) input into 50-Ω load	
Measurements	Dual pair of tracking gain and phase markers	
Plot scaling	Auto-scaled during test and manual setting after test	

Probing the USB 2.0 Differential Bus

To test USB 2.0 low- and full-speed designs, the only probes required are two 10:1 passive probes, which are shipped as standard accessories with every Keysight InfiniiVision X-Series oscilloscope.

To test USB 2.0 hi-speed designs based on pre-compliance standards with the appropriate device or host test fixture, 50-Ω SMA cables with SMA-to-BNC adapters are all that is required. For this use-model of testing, the test fixture is programmed to generate a specific test pattern.

During the design and debug phase of product development, engineers often need to test “live traffic” in their hi-speed designs (non-compliance testing). In this case, a test fixture is not required, but a differential active probe with sufficient bandwidth is required. For this use-model of testing, Keysight recommends an InfiniiMode N2750A Series differential active probe shown in Figure 3.

The N2750A Series probe is more than just a differential probe. With the press of the InfiniiMode button on the probe, you can quickly toggle between viewing the differential signal, high-side (D+) relative to ground, low-side (D-) relative to ground, or the common-mode signal. Although ultimately it is the quality of the differential signal that really matters, if signal integrity issues do exist on the differential bus, they can often be caused by issues such as system noise coupling into just one side of the bus (or perhaps improper PC board layout and termination related to just one side of the bus).

Figure 13. Keysight’s InfiniiMode N2750A Series differential active probe.

Related Literature

Table 9. Related literature

Publication title	Publication number
Jitter Analysis using Keysight's InfiniiVision 6000 X-Series and Infiniium Series Oscilloscopes, Application Note	5991-4087EN
Finding Sources of Jitter with Real-time Jitter Analysis, Application Note	5988-9740EN
Physical Layer Testing of the USB 2.0 Serial Bus, Application Note	5991-4167EN
Segmented Memory for Serial Bus Applications, Application Note	5990-5817EN
InfiniiVision 3000T X-Series Oscilloscopes, Data Sheet	5992-0140EN
InfiniiVision 4000 X-Series Oscilloscopes - Data Sheet	5991-1103EN
InfiniiVision 6000 X-Series Oscilloscopes - Data Sheet	5991-4087EN
N2750A/N2751A/N2752A InfiniiMode Differential Active Probes - Data Sheet	5991-0560EN

Ordering Information

Table 10. USB Software Package model numbers

InfiniiVision Series	USB Software Package
3000T X-Series	D3000USBB
4000 X-Series	D4000USBB
6000 X-Series	D6000USBB

Table 11. Recommended differential active probes (for hi-speed USB 2.0)

Recommended differential probing solutions	Model number
InfiniiMode 1.5 GHz differential active probe	N2750A
InfiniiMode 3.5 GHz differential active probe	N2751A
InfiniiMode 6.0 GHz differential active probe	N2752A

Table 12. Recommended test fixtures for USB 2.0 signal quality testing

Test fixture description	Model number
USB 2.0 low- and full-speed test fixture (SQuIDD)	E2646B
USB 2.0 hi-speed "device" test fixture kit	E2666B
USB 2.0 hi-speed "host" test fixture kit	E2667B