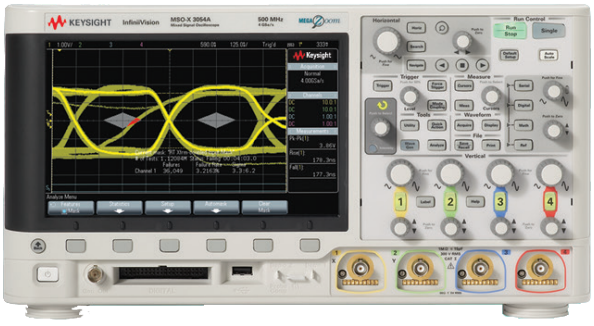
Keysight Technologies
Serial Bus Options for InfiniiVision X-Series Oscilloscopes

Data Sheet



KEYSIGHT TECHNOLOGIES

Unlocking Measurement Insights

Introduction

Serial buses are pervasive in today's digital designs and are used for a variety of purposes including on-board chip-to-chip communication, CPU to peripheral control, as well as for remote sensor data transfer and control.

Without intelligent oscilloscope serial bus triggering and protocol decode, it can be difficult to debug these buses and correlate data transfers with other mixed signal interactions in your system. Keysight Technologies, Inc. InfiniiVision X-Series oscilloscopes (DSOs) and mixed-signal oscilloscopes (MSOs) offer optional integrated serial bus triggering and hardware-based protocol decoding solutions that give you the tools you need to accelerate debug of your designs that include serial bus communication.

Supported serial protocols (trigger and decode)

- I^2C
- SPI
- CAN (with .dbc symbolic decoding)
- CAN FD (with .dbc symbolic decoding)
- LIN (with .ldf symbolic decoding)
- FlexRay (includes physical layer pre-compliance test software)
- SENT
- CXPI
- USB 2.0 (low-, full-, and hi-speed)
- USB 2.0 signal quality
- I^2S
- MIL-STD 1553
- ARINC 429
- User-definable Manchester
- User-definable NRZ

Refer to ordering information near the end of this document for specific oscilloscope model compatibility.

Features

- Hardware-based decoding
- Multi-bus analysis with interleaved lister display
- Automatic search and navigation
- Compatible with segmented memory acquisition
- Symbolic trigger and decode (CAN, CAN FD, and LIN)
- Eye-diagram mask testing (CAN, CAN FD, MIL-STD 1553, and ARINC 429)

Hardware-Based Decoding

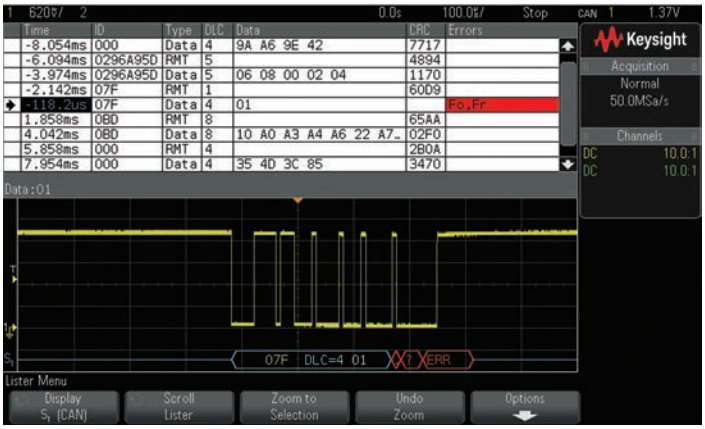


Figure 1. Hardware-based decoding quickly reveals serial communication errors.

Keysight's InfiniiVision Series oscilloscopes are the industry's only scopes to use hardware-based decoding. Most other vendor's scopes with serial bus triggering and protocol decode, use software post-processing techniques to decode serial packets/frames. With these software techniques, waveform- and decode-update rates tend to be slow (sometimes seconds per update.) That's especially true when using deep memory, which is often required to capture multiple packetized serial bus signals. And when analyzing multiple serial buses simultaneously, software techniques can make decode update rates even slower.

Faster decoding with hardware-based technology enhances scope usability and more importantly, the probability of capturing infrequent serial communication errors. Figure 1 shows an example of a Keysight InfiniiVision X-Series scope capturing a random and infrequent CAN error frame. The upper half of the scope's display shows the decoded data in a "Lister" format, along with a time-correlated decode trace shown below the waveform.

Symbolic Trigger and Decode

With the DSOXT3AUTO, DSOX4AUTO or DSOX6AUTO option licensed on a 3000T, 4000 or 6000 X-Series oscilloscope, you can import a .dbc file that defines your multi-node CAN network. The oscilloscope can then trigger on and decode the CAN bus symbolically as shown in Figure 2. LIN symbolic trigger and decode is also supported on the 3000T, 4000 and 6000 X-Series oscilloscopes by importing an industry-standard .ldf file.

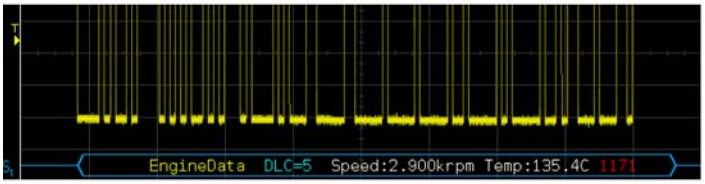


Figure 2. Symbolically decoding the CAN bus.

Automatic Search and Navigation

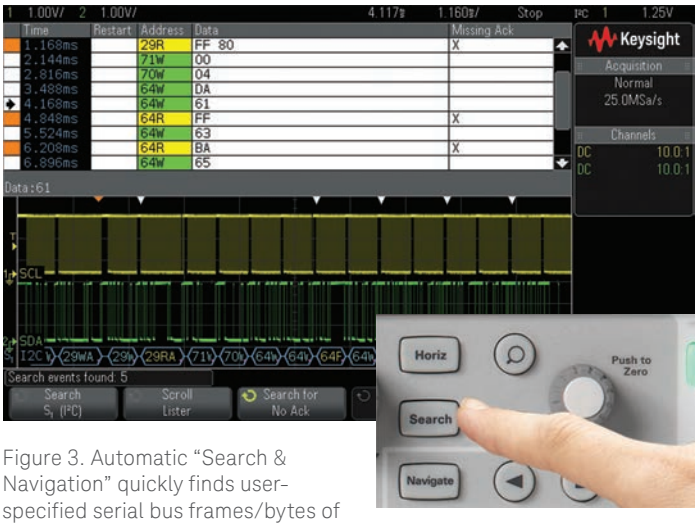


Figure 3. Automatic "Search & Navigation" quickly finds user-specified serial bus frames/bytes of interest.

After capturing a long record of serial bus communication using the InfiniiVision scope's MegaZoom deep memory, you can easily perform a search operation based on specific criteria that you enter. Then, you can quickly navigate to bytes/frames of serial data that satisfy the entered search criteria. Figure 3 shows an example of searching on captured I^2C data to find all occurrences of Read or Write operations with "No Ack." In this case, the scope found five occurrences of data transfers with "No Ack," and marked each occurrence with a white triangle to show where in time they happened relative to the captured waveform. Navigating and zooming-in on each marked byte/frame is quick and easy using the scope's front panel navigation keys. Search and Navigation not available for DSOXT3CXPI/DSOX4CXPI/DSOX6CXPI.

Multi-bus Analysis

Figure 4. An interleaved “Lister” makes it easier to time-correlate activity between two decoded serial buses.

Many of today’s designs include multiple serial buses. Sometimes it may be necessary to correlate data from one serial bus to another. Keysight’s InfiniiVision 3000, 4000 and 6000 X-Series oscilloscopes can decode two serial buses simultaneously using hardware-based decoding. Plus they are the only scopes on the market that can also display the captured data in a time-interleaved “Lister” display, as shown in Figure 4. In this particular example, the scope has simultaneously decoded and interleaved a CAN and LIN bus in an automotive system.

Using Segmented Memory to Capture Multiple Serial Bus

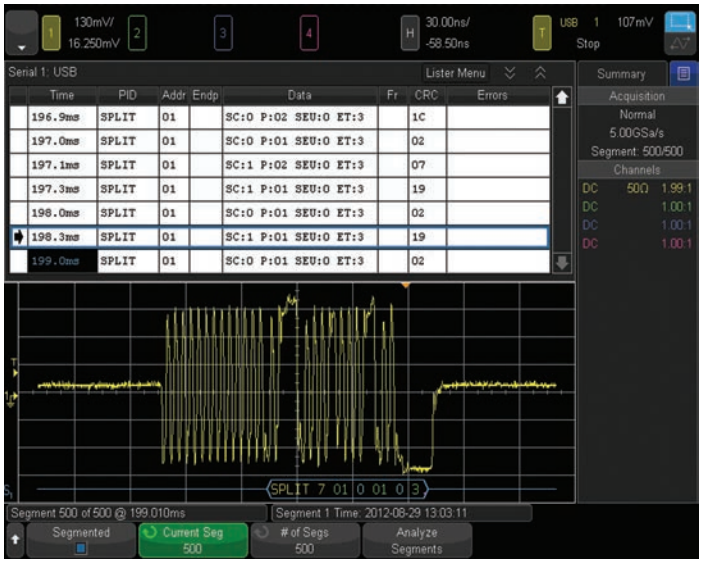


Figure 5. Segmented memory acquisition selectively captures more packets/bytes of serial bus activity.

Use segmented acquisition on Keysight’s InfiniiVision X-Series oscilloscopes to optimize your scope’s memory, letting you capture more packets/frames of serial bus activity. Segmented memory acquisition optimizes the number of packetized serial communication frames that can be captured consecutively. Segmented memory does this by capturing just the selective frames/bytes of interest while ignoring (not digitizing) idle time and other unimportant frames/bytes. Figure 5 shows an example of the oscilloscope capturing 500 consecutive hi-speed USB split packets for a total acquisition time of approximately 200 ms. Capturing this much data using conventional oscilloscope acquisition memory would require 1G bytes of memory.

Keysight’s InfiniiVision X-Series oscilloscopes are the only scopes on the market today that can acquire segments on up to four analog channels of acquisition and time-correlated segments on digital channels (using an MSO model), along with automatic hardware-based serial bus decoding for each segment. In addition, you can use the scope’s Search and Navigation capability after a segmented memory acquisition has been performed.

Serial Bus Eye-diagram and Pulse Mask Testing

With the addition of the DSOX2MASK, DSOX3MASK, DSOX4MASK or DSOX6MASK mask test option, standard on DSOX1000, which can perform over 200,000 pass/fail tests (50,000 on 2000 X-Series) per second, you can perform eye-diagram and pulse mask testing on CAN signals on all InfiniiVision X-Series oscilloscopes. Eye-diagram mask testing on FlexRay, MIL-STD 1553 and ARINC 429 signals can be performed using an InfiniiVision 3000, 4000 or 6000 X-Series oscilloscope. Eye-diagram measurements provide a comprehensive signal quality test of the integrity of your transmitted and received signals. Keysight provides various mask files that you can download at no charge. The mask files are based on published industry mask standards and/or derived from physical layer/electrical specifications.

The following CAN mask files are available:

- 125 kbps – 400 meters
- 250 kbps – 200 meters
- 500 kbps – 10 meters
- 500 kbps – 80 meters
- 800 kbps – 40 meters
- 1000 kbps – 25 meters

Mask files for CAN FD are also available (3000, 4000 and 6000 X-Series only). CAN FD eye-diagrams are based on the first 10 bits of the FD phase from all frames.

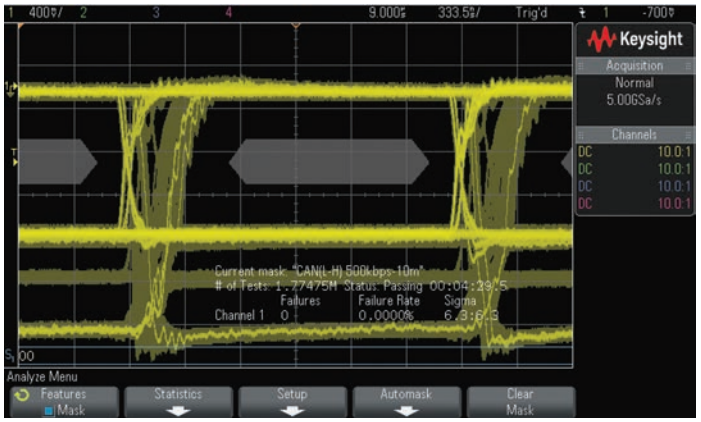


Figure 6. CAN 500 kbps mask test on 10 meter system.

The following FlexRay mask test files are available:

- TP1 standard voltage (10 Mbps only)
- TP1 increased voltage (10 Mbps only)
- TP11 standard voltage (10 Mbps only)
- TP11 increased voltage (10 Mbps only)
- TP4 10 Mbps
- TP4 5 Mbps
- TP4 2.5 Mbps

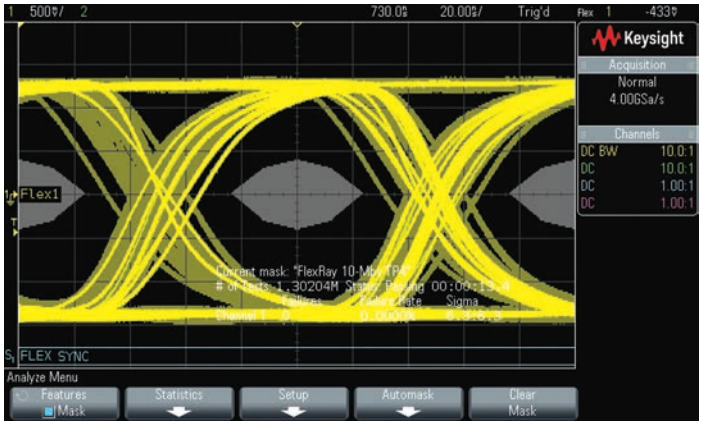


Figure 7. FlexRay TP4 eye-diagram mask test.

The following MIL-STD 1553 mask test files are available:

- System xfmr-coupled Input
- System direct-coupled Input
- BC xfmr-coupled Input
- BC direct-coupled Input
- RT xfmr-coupled Input
- RT direct-coupled Input

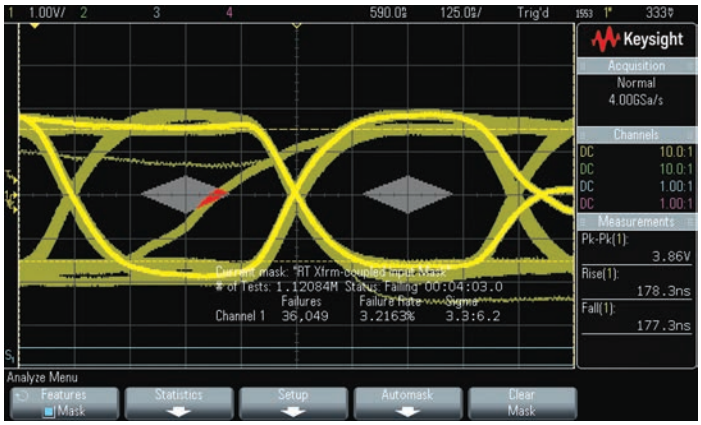


Figure 8. MIL-STD 1553 BC to RT xfrm-coupled input mask test reveals a shifted bit that violates the pass/fail mask.

Serial Bus Eye-diagram and Pulse Mask Testing

The following ARINC 429 mask/pulse test files are available:

- 100 kbps Eye Test
- 100 kbps 1's Pulse Test
- 100 kbps 0's Pulse Test
- 100 kbps Null Level Test
- 12.5 kbps Eye Test
- 12.5 kbps 1's Pulse Test
- 12.5 kbps 0's Pulse Test
- 12.5 kbps Null Level Test

For additional information about eye-diagram mask testing on CAN, FlexRay, MIL-STD 1553 and ARINC 429 signals, refer to the application notes listed at the end of this document.

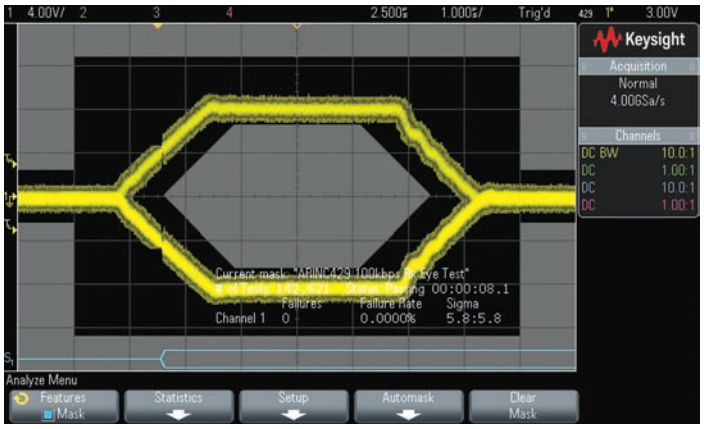


Figure 9. ARINC 429 100 kbps eye-diagram mask test.

Automated Physical Layer Conformance Testing

To perform USB 2.0 signal quality testing based on USB-IF compliance standards, Keysight offers the DSOX4USBSQ or DSOX6USBSQ options on InfiniiVision 4000 or 6000 X-Series oscilloscopes. Figure 10 shows an example of the USB 2.0 real-time eye test. Also included with this option is complete signal quality test report generation in HTML format. To see the complete list of supported tests, refer to the DSOX4USBSQ/ DSOX6USBSQ signal quality test option data sheet listed at the ended of this document.

To perform physical layer conformance testing on the differential FlexRay bus, Keysight provides a PC-based software package that you can download from Keysight's website at no additional charge. If the InfiniiVision X-Series scope is licensed with the FlexRay, mask test and segmented memory, you can perform automated physical layer tests at either receiver input or transmitter output test points. Figure 10 shows an example of the generated report from a signal integrity voting test on a 10-Mbs isolated "1" pulse. The test report includes comprehensive pass/ fail and margin analysis based on published specifications.

Refer to the tables in the Specifications/Characteristics section of this document on page 19 to see the entire list of 33 available FlexRay tests that can be selected and performed using the FlexRay physical layer conformance test software package.

Figure 10. USB 2.0 signal quality eye test based on USB-IF physical layer compliance standards.

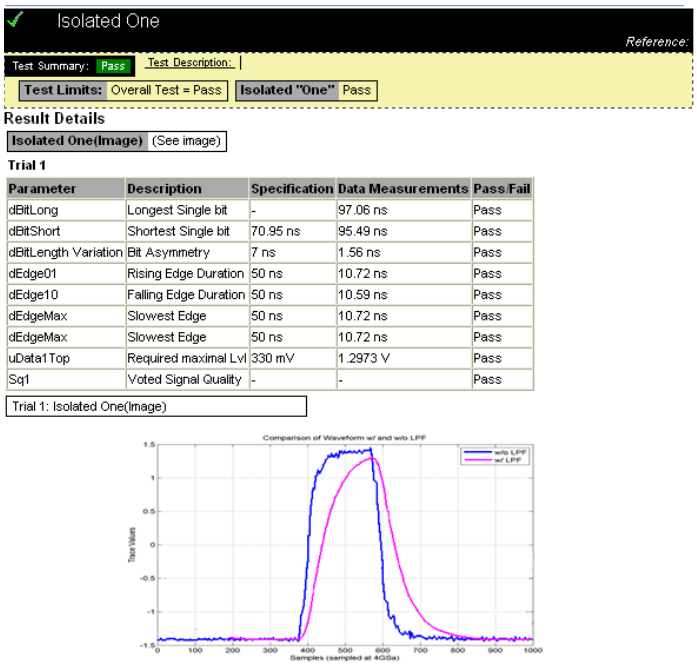


Figure 11. FlexRay signal integrity voting test performed on an isolated "1" bit.

Probing Differential Serial Buses

Many of today's serial buses are based on differential signaling including USB, CAN, CAN FD, FlexRay, MIL-STD 1553 and ARINC 429. In addition, serial buses based on the RS232/UART protocol are often differential if implemented with RS422 or RS485 output drivers/transceivers. Keysight offers a wide range of differential active probes compatible with the InfiniiVision X-Series oscilloscopes for various bandwidth and dynamic range applications. Table 1 shows the differential probes that Keysight recommends for each of the listed differential serial buses.

Table 1. Recommended probes for differential buses

Differential bus (max bit rate)	N2791A (25-MHz bandwidth)	N2818A [1] (200-MHz bandwidth)	N2750A (1.5-GHz bandwidth)
CAN (1 Mbps)	X	X	
CAN FD (10 Mbps data phase)		X	
FlexRay (10 Mbps)		X	
MIL-STD 1553 (1 Mbps)	X	X	
ARINC 429 (100 kbps)	X	X	
RS422/RS485 (10 Mbps)	X	X	
Hi-speed USB (480 Mbps)			X

1. The N2818A differential probe is not compatible with Keysight's InfiniiVision 1000 X- and 2000 X-Series oscilloscopes.

If you need to connect to DB9-SubD connectors on your differential CAN, CAN FD and/or FlexRay bus, Keysight also offers the CAN/FlexRay DB9 probe head (part number 0960-2926) is shown in the inset picture of Figure 12.

When probing differential signals inside of environmental chambers at extreme temperatures, Keysight offers the N7013A extreme temperature extension kit shown in Figure 13. The N7013A is compatible with the N2791A and N2818A differential probes and can operate in temperatures ranging from –40 to +85 °C. To learn more about this probing solution, refer the Extreme Temperature Probing Solutions selection guide (publication number 5991-3504EN) listed at the end of this document.

The N2750A differential active probe shown in Figure 14, which is recommended for hi-speed USB 2.0 measurement applications, is based on Keysight's InfiniiMode technology. With the press of a button, you can quickly toggle between viewing the differential signal, high-side signal, low-side signal or the common mode signal on the USB 2.0 hi-speed bus without moving probe connections.

Figure 13. The N7013A extreme temperature probing kit for differential probes.

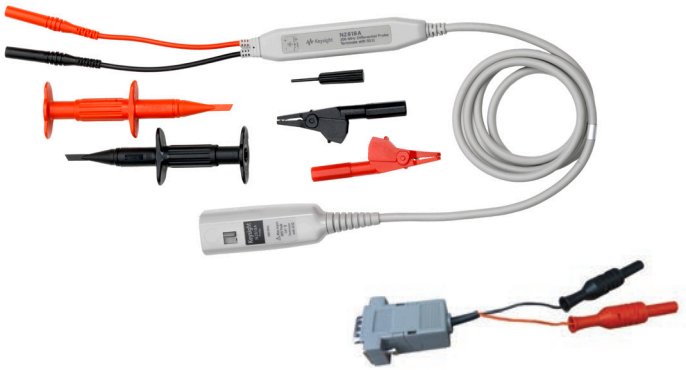
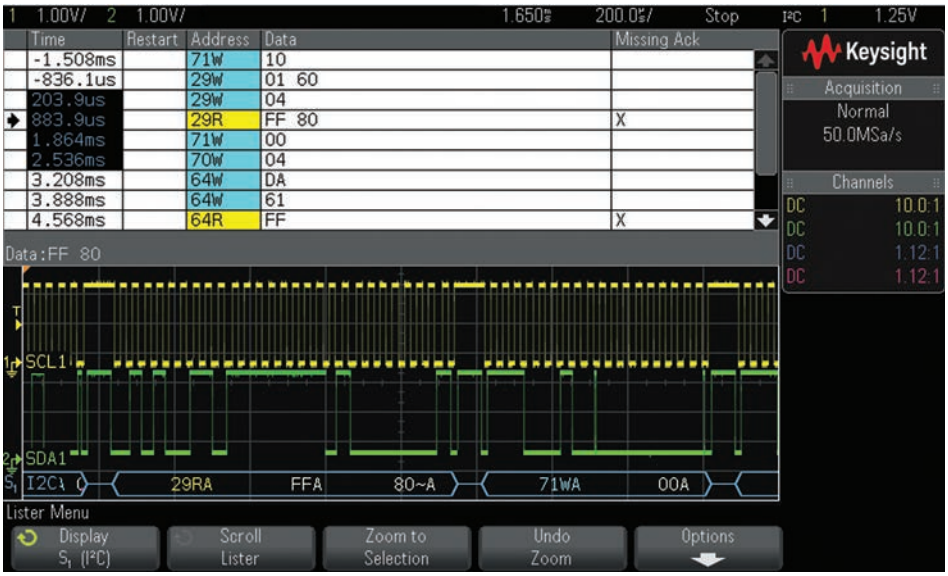


Figure 12. Keysight's N2818A 200-MHz differential active probe.

Figure 14. Keysight's N2750A 1.5-GHz InfiniiMode differential active probe.

Specifications/Characteristics

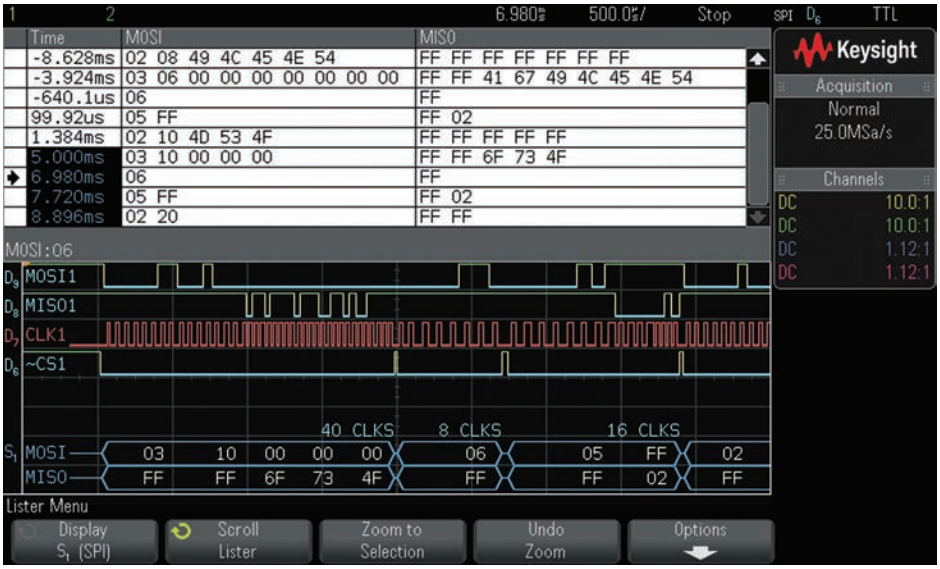
I²C specifications/characteristics	
Clock and data input source	Analog channels 1, 2, 3 or 4
	Digital channels D0 to D15 (3000, 4000 and 6000 X-Series only)
Max clock/data rate	Up to 3.4 Mbps
Triggering	Start condition
	Stop condition
	Missing acknowledge
	Address with no acknowledge
	Restart
	EEPROM data read
	Frame (Start:Addr7:Read:Ack:Data)
	Frame (Start:Addr7:Write:Ack:Data)
	Frame (Start:Addr7:Read:Ack:Data:Ack:Data2)
	Frame (Start:Addr7:Write:Ack:Data:Ack:Data2)
	10-bit write
Hardware-based decode	Data (HEX digits in white)
	Address decode size: 7 bits (excludes R/W bit) or 8 bits (includes R/W bit)
	Read address (HEX digits followed by “R” in yellow)
	Write address (HEX digits followed by “W” in light-blue)
	Restart addresses (“S” in green, followed by HEX digits, followed by “R” or “W”)
	Acknowledges (suffixes “A” or “~A” in the same color as the data or address preceding it)
	Idle bus (mid-level bus trace in dark blue)
	Active bus (bi-level bus trace in dark blue)
	Unknown/error bus (bi-level bus trace in red)
Multi-bus analysis	I²C plus one other serial bus, including another I²C bus. (3000, 4000 and 6000 X-Series only)



Tabular protocol lister display is not available on 1000 X-Series oscilloscopes.

Specifications/Characteristics (Continued)

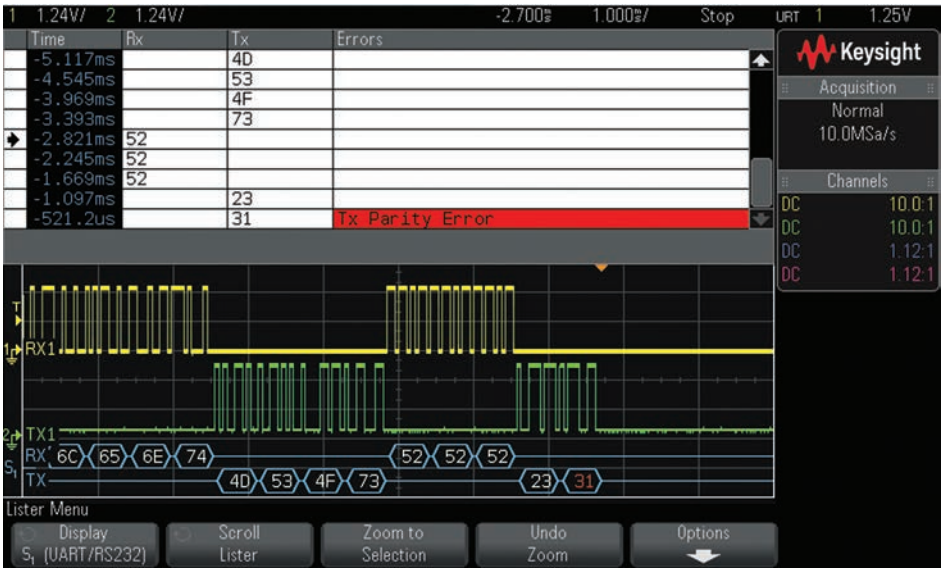
SPI specifications/characteristics	
MOSI, MISO, Clock and CS input source	Analog channels 1, 2, 3 or 4
	Digital channels D0 to D15 (3000, 4000 and 6000 X-Series only)
Max clock/data rate	Up to 25 Mb/s
Triggering	4- to 64-bit data pattern during a user-specified framing period
	Framing period can be a positive or negative chip select (CS or ~CS) or clock idle time (timeout)
Hardware-based decode	Number of decode traces: 2 independent traces (MISO and MOSI)
	Data (hex digits in white)
	Unknown/error bus (bi-level bus trace in red)
	Number of clocks/packet ("XX CLKS" in light-blue above data packet)
	Idle bus (mid-level bus trace in dark blue)
	Active bus (bi-level bus trace in dark blue)
Multi-bus analysis	SPI plus one other serial bus, excluding another SPI bus. (3000, 4000 and 6000 X-Series only)



Tabular protocol lister display is not available on 1000 X-Series oscilloscopes.

Specifications/Characteristics (Continued)

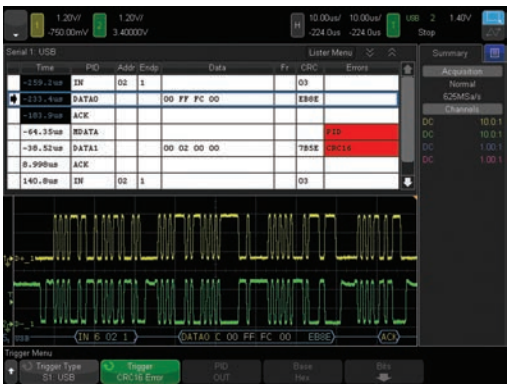
RS232/UART specifications/characteristics	
Tx and Rx input source	Analog channels 1, 2, 3 or 4
	Digital channels D0 to D15 (3000, 4000 and 6000 X-Series only)
Bus configuration	
– Baud rates	100 b/s up to 12 Mb/s (maximum 10 Mb/s on 1000X and 2000X)
– Number of bits	5 to 9
– Parity	None, odd or even
– Polarity	Idle low or idle high
– Bit order	LSB out first or MSB out first
Triggering	Rx start bit
	Rx stop bit
	Rx data
	Rx 1:data (9-bit format)
	Rx 0:data (9-bit format)
	Rx X:data (9-bit format)
	Rx or Tx parity error
	Tx start bit
	Tx stop bit
	Tx data
	Tx 1:data (9-bit format)
	Tx 0:data (9-bit format)
	Tx X:data (9-bit format)
	Burst (nth frame within burst defined by timeout)
Hardware-based decode	
– Number of decode traces	2 independent traces (Tx and Rx)
– Data format	Binary, hex or ASCII-code characters
– Data byte display	White characters if no parity error, red characters if parity or bus error
– Idle bus trace	Mid-level bus trace in blue
– Active bus trace	Bi-level trace in blue
Multi-bus analysis	RS232/UART plus one other serial bus, including another RS232/UART bus. (3000, 4000 and 6000 X-Series only)
Totalize/counter function	Total received frames
	Total transmitted frames
	Total parity error frames (with percentage)



Tabular protocol lister display is not available on 1000 X-Series oscilloscopes.

Specifications/Characteristics (Continued)

USB 2.0 low- and full-speed specifications/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
	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)

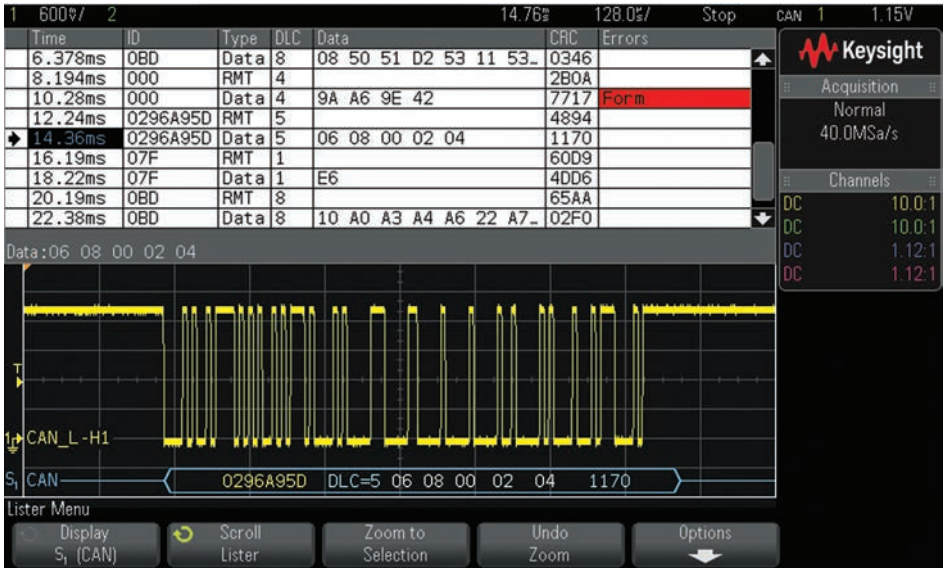


Specifications/Characteristics (Continued)

USB 2.0 high-speed specifications/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

Specifications/Characteristics (Continued)

CAN specifications/characteristics (1000 X-, 2000 X-, and 3000 X-Series only)	
CAN input source	Analog channels 1, 2, 3 or 4
	Digital channels D0 to D15 non-differential. (3000 X-Series only)
Signal types	Rx, Tx, CAN_L, CAN_H, Diff (L-H), Diff (H-L)
Baud rates	10 kb/s up to 5 Mb/s
Triggering	Start-of-frame (SOF)
	Remote frame ID (RMT)
	Data frame ID (~RMT)
	Remote or data frame ID
	Data frame ID and data
	Error frame
	All errors (includes protocol "form" errors that may not generate flagged error frames)
	Acknowledge errors
	Overload frames
	ID length: 11 bits or 29 bits (extended)
Hardware-based decode	Frame ID (hex digits in yellow)
	Remote frame (RMT in green)
	Data length code (DLC in blue)
	Data bytes (hex digits in white)
	CRC (hex digits in blue = valid, hex digits in red = error)
	Error frame (bi-level bus trace and ERR message in red)
	Form error (bi-level bus trace and "?" in red)
	Overload frame ("OVRLD" in blue)
	Idle bus (mid-level bus trace in dark blue)
	Active bus (bi-level bus trace in dark blue)
Multi-bus analysis	CAN plus one other serial bus, including another CAN bus. (3000 X-Series only)
Totalize function	Total frames, total overload frames, total error frames, bus utilization (bus load)
Eye-diagram mask testing (3000 X-Series only, requires DSOX3MASK)	Various downloadable mask files available based on differential probing polarity, baud rate and network length



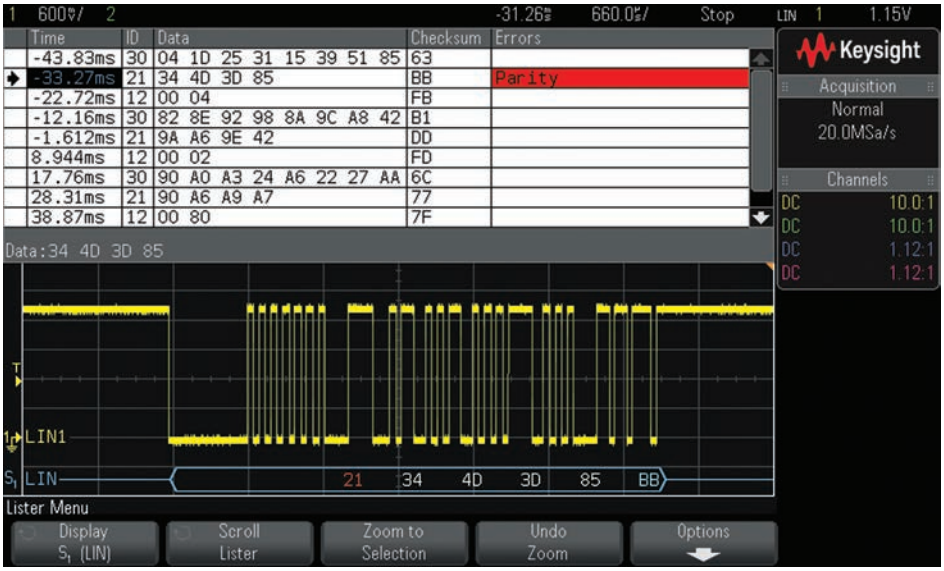
Tabular protocol lister display is not available on 1000 X-Series oscilloscopes.

Specifications/Characteristics (Continued)

CAN/CAN FD specifications/characteristics (3000T X-, 4000 X-, and 6000 X-Series and M924XA Series only)	
Note: "Classic" CAN 2.0 is a subset of CAN FD. CAN FD trigger and decode supports ISO and non-ISO CAN FD specifications. Both of these protocol standards are supported with the DSOXT3AUTO, DSOX4AUTO and DSOX6AUTO option in an InfiniiVision 3000T, 4000 and 6000 X-Series oscilloscope.	
CAN input source	Analog channels 1, 2, 3 or 4
	Digital channels D0 to D15 non-differential
Signal types	Rx, Tx, CAN_L, CAN_H, Diff (L-H), Diff (H-L)
Standard baud rates	10 kb/s up to 5 Mb/s
FD baud rates	10 kb/s up to 10 Mb/s
Triggering	SOF (Start-of-frame)
	EOF (End-of-frame, filtered by ID)
	Data frame ID (11 bits or 29 bits: Extended)
	Data frame ID and data – non FD
	Data frame ID and data - FD
	Remote frame ID (RTR)
	Remote or data frame ID
	Error frame (filtered by ID)
	Acknowledge error (filtered by ID)
	Form error (filtered by ID)
	Stuff error (filtered by ID)
	CRC error (filtered by ID)
	Spec error (includes Ack, Form, Stuff or CRC error; filter by ID)
	All errors (includes any Spec error or Error frame; filtered by ID)
	BRS bit (filtered by ID of FD frames only)
	CRC delimiter bit (filtered by ID of FD frames only)
	ESI bit active (filtered by ID of FD frames only)
	ESI bit passive (filtered by ID of FD frame only)
	Overload frames
Symbolic triggering (based on .dbc file)	Message names
	Message and signal values/encoded states (first 8 bytes)
Hardware-based decode	Frame ID (hex digits in yellow)
	Remote frame (RMT in green)
	Data length code (DLC = with decimal digits in blue)
	Data bytes (hex digits in white)
	ESI bit passive (frame type column in lister shaded yellow; FD frames only)
	Error frame (bi-level red bus trace with ERR FRAME in red)
	Stuff bit error (bi-level red bus trace with STUFF ERR in red)
	Form error (bi-level red bus trace with FORM ERR in red)
	Acknowledge error (bi-level red bus trace with ACK ERR in red)
	CRC (hex digits in blue = valid, hex digits in red = error)
	Overload frame ("OVRLD" in blue)
	Idle bus (mid-level dark blue bus trace)
	Active bus (bi-level dark blue bus trace with embedded decode within)
Symbolic decode (based on .dbc file)	Message names (alpha-numeric characters in yellow)
	Signal names, value/encoded state (first 8 bytes) and units (alpha-numeric characters in white)
Multi-bus analysis	CAN/CAN FD plus one other serial bus, including another CAN/CAN FD bus
Totalize function (real time)	Total frames, total error frames with %, total spec errors, bus load in %
CAN/CAN FD Eye-diagram mask testing (requires DSOX3MASK/DSOX4MASK/ DSOX6MASK)	Various downloadable mask files available based on differential probing polarity, baud rate and network length

Specifications/Characteristics (Continued)

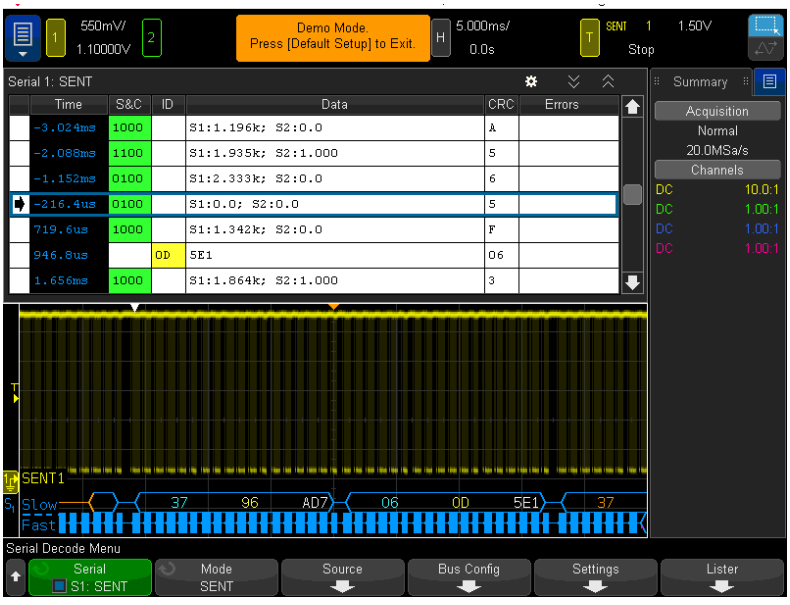
LIN specifications/characteristics	
LIN input source	Analog channels 1, 2, 3 or 4
	Digital channels D0 to D15 except 1000 and 2000 X-Series
LIN standards	LIN 1.3 or LIN 2.X
Baud rates	2400 b/s to 625 kb/s
Triggering	Sync break
	Frame ID (0X00HEX to 0X3FHEX)
	Frame ID and data
	Parity error
	Checksum error
Symbolic decode (except 1000X and 2000X) (based on .ldf file)	Message names (alpha-numeric characters in yellow)
	Signal names, value/encoded state and units (alpha-numeric characters in white)
Hardware-based decode	Frame ID (6-bit hex digits in yellow)
	Frame ID and optional parity bits (8-bit hex digits in yellow if valid, red if parity bit error)
	Data bytes (hex digits in white)
	Check sum (hex digits in blue = valid, hex digits in red = error)
	Sync error ("SYNC" in red)
	THeader-max ("THM" in red)
	TFrame-max ("TFM" in red)
	Parity error ("PAR" in red)
	LIN 1.3 wake-up error ("WUP" in red)
	Idle bus (mid-level bus trace in dark blue)
	Active bus (bi-level bus trace in dark blue)
Symbolic triggering (except 1000X and 2000X) (based on .dbc file)	Message names
	Message and signal values/encoded states
Multi-bus analysis	LIN plus one other serial bus, including another LIN bus. (except 1000X and 2000X)



Tabular protocol lister display is not available on 1000 X-Series oscilloscopes.

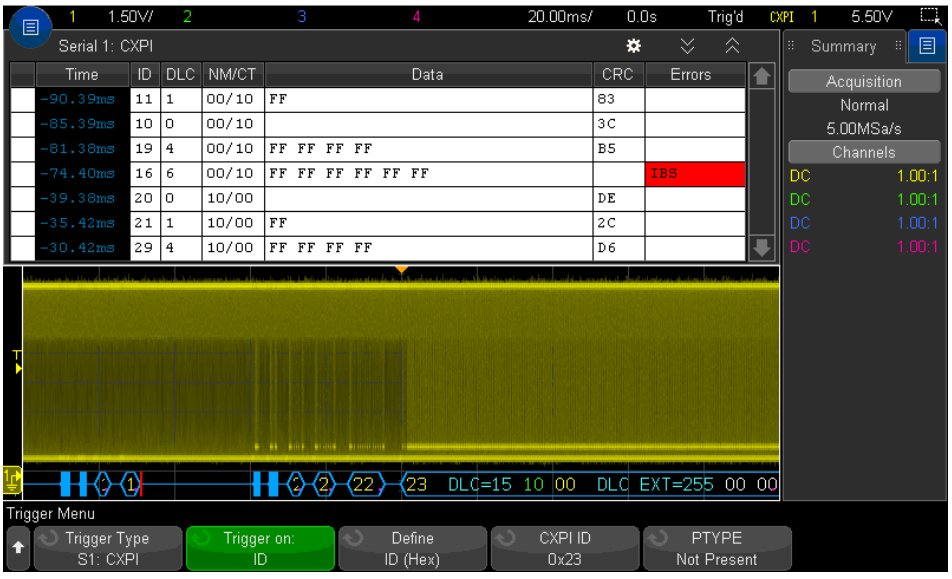
Specifications/Characteristics (Continued)

SENT specifications/characteristics	
CAN input source	Analog channels 1, 2, 3 or 4
	Digital channels D0 to D15 non-differential
Clock period	1 µs to 300 µs with user-defined tolerance setting from 3 to 30%
Number of nibbles	1 to 6
Idle state	High or low
CRC format	2008 or 2010 standards
Pause pulse	On/Off
Message format	Fast Nibbles (All)
	Fast Signals (only)
	Fast + Short Serial
	Fast + Enhanced Serial (automatically detects bit format: 12-bit data/8-bit ID or 16-bit data/4-bit ID)
	Short Serial (only)
	Enhanced Serial (only)
Number of defined signals	1 to 6 (each specified by start bit #, number of bits and nibble order)
Numerical format of signals	Hexadecimal, unsigned decimal or transfer function with user-defined multiplier and offset for each defined signal
Triggering	Start of fast channel message
	Start of slow channel message
	Fast channel status and communication nibble + data
	Slow channel message ID
	Slow channel message ID + data
	Tolerance violation (sync pulse width exceeds user-specified tolerance)
	Fast channel CRC error
	Slow channel CRC error
	All CRC errors
	Pulse period error (if nibbles are < 12 or > 27 ticks wide)
	Successive sync pulses error (if consecutive sync pulse widths are greater than 1/64 difference)
Fast channel decode	Status & communication nibble (binary digits in green)
	Data (hex, unsigned decimal or transfer function digits in white based on user-defined signal format)
	CRC error (hex digit in blue = valid, hex digit in red = error)
	Pulse period error (< or > in red)
Slow channel decode	Message ID (hex digits in yellow)
	Data (hex digits in white)
	CRC (hex digits in blue = valid, hex digits in red = error)
Multi-bus analysis	SENT plus one other serial bus, including another SENT bus



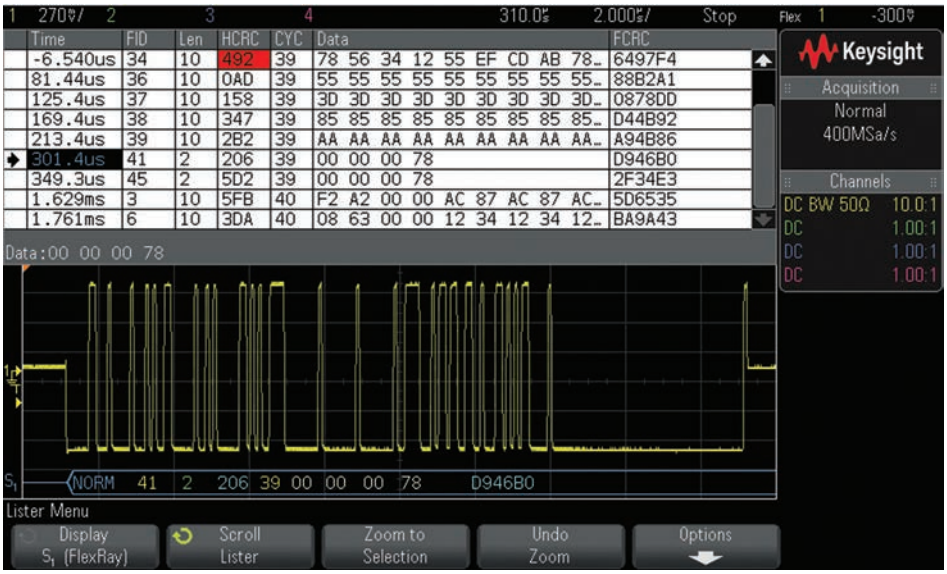
Specifications/Characteristics (Continued)

CXPI specifications/characteristics	
CXPI input source	Analog channels 1, 2, 3 or 4
Baud rates	9.6 kb/s to 40 kb/s (20 kb/s typical) with tolerance setting
Triggering	SOF (Start-of-frame)
	EOF (End-of-frame)
	PTYPE
	Frame ID (PTPYE present or not present)
	Frame ID + info + data
	Frame ID + info + data (long frame)
	CRC field error (filtered by ID)
	Parity error
	Inter-byte space error (filtered by ID)
	Inter-frame space error (filtered by ID)
	Framing error (filtered by ID)
	Data length error (filtered by ID)
	Sample error
	All errors
	Sleep frame
	Wakeup pulse
Hardware-based decode	Frame ID (hex digits in yellow if valid or red if parity error)
	Data length code (DLC = with decimal digits in blue)
	Network management (NM) bits (binary digits in green)
	Counter (CT) bits (binary digits in yellow)
	Data (hex digits in white)
	CRC (hex digits in blue = valid, hex digits in red = error)
	Idle bus (mid-level dark blue bus trace)
	Active bus (bi-level dark blue bus trace with embedded decode within)
	Inter-byte space error (IBS ERR in red)
	Data length error (LEN ERR in red)
	Sleep mode (SLEEP MODE in orange within bi-level orange bus trace)
	Wakeup pulse (WAKEUP PULSE in blue with bi-level blue bus trace)
Multi-bus analysis	CXPI plus one other serial bus



Specifications/Characteristics (Continued)

FlexRay specifications/characteristics	
FlexRay input source	Channel 1, 2, 3 or 4 (using differential probe)
FlexRay channels	A or B
Baud rates	2.5 Mbps, 5.0 Mbps and 10 Mbps
Frame triggering	Frame type: Startup (SUP), not startup (~SUP), sync (SYNC), not sync (~SYNC), null (NULL), not null (~NULL), normal (NORM) and All
	Frame ID: 1 to 2047 (decimal format) and All
	Cycle
	Base: 0 to 63 (decimal format) and All
	Repetition: 1, 2, 4, 8, 16, 32, 64 (decimal format) and All
Error triggering	All errors
	Header CRC error
	Frame CRC error
Event triggering	Wake-up
	TSS (transmission start sequence)
	BSS (byte start sequence)
	FES/DTS (frame end or dynamic trailing sequence)
Frame decoding	Frame type (NORM, SYNC, SUP, NULL in blue)
	Frame ID (decimal digits in yellow)
	Payload-length (decimal number of words in green)
	Header CRC (hex digits in blue if valid or red digits if invalid)
	Cycle number (decimal digits in yellow)
	Data bytes (HEX digits in white)
	Frame CRC (hex digits in blue if valid or red digits
Totalize function	Total frames
	Total synchronization frames
	Total null frames
Eye-diagram mask testing (requires DSOX-3MASK mask test option plus downloadable mask files)	TP1 standard voltage (10 Mbps only)
	TP1 increased voltage (10 Mbps only)
	TP11 standard voltage (10 Mbps only)
	TP11 increased voltage (10 Mbps only)
	TP4 10 Mbps, TP4 5 Mbps and TP4 2.5 Mbps
Multi-bus analysis	FlexRay plus one other serial bus (including another FlexRay bus)



FlexRay Physical Layer Conformance Test Software

Requires FlexRay option (DSOX3FLEX/DSOX4FLEX/DSOX6FLEX)
Mask test option (DSOX3MASK/DSOX4MASK/DSOX6MASK)
Segmented memory option (DSOX3SGM or standard on 3000T, 4000 and 6000 X-Series)

Table 1. Receiver input tests

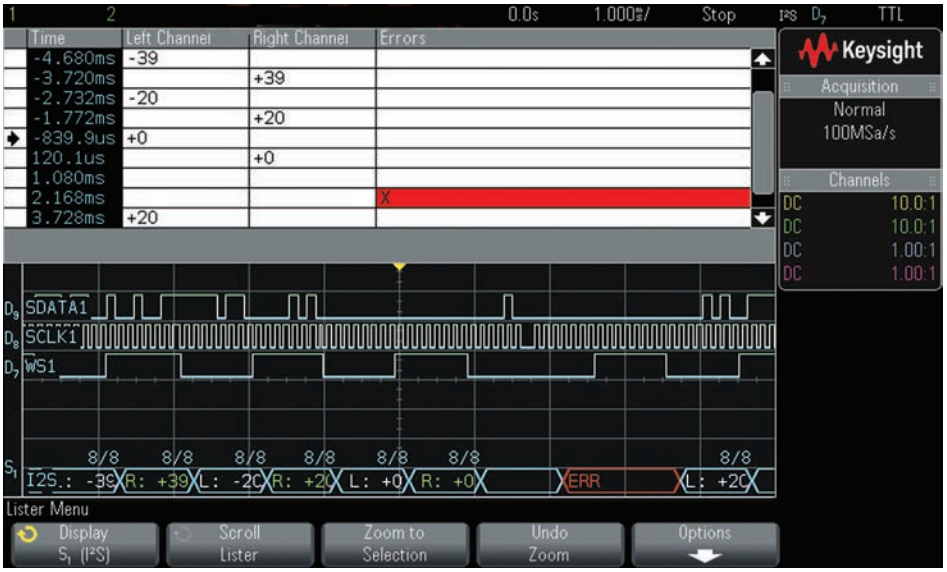
Parameter tested	Test description
Eye-diagram mask tests:	
– TP4 – All	Receiver mask test on all frames
– TP4 – ID	Receiver mask test on specified frame
Signal integrity voting tests on 13 MHz low-pass filtered Isolated "1":	
– uData1Top	Required maximal level
– dBitShort	Shortest single bit
– dBitLengthVariation	Bit asymmetry
– dEdge01	Rising edge duration (–300 mV to +300 mV)
– dEdge10	Falling edge duration (+300 mV to –300 mV)
– dEdgeMax	Slowest edge
– Sq1	Isolated "1" voted signal quality
Signal integrity voting tests on 13 MHz low-pass filtered Isolated "0":	
– uData0Top	Required minimal level
– dBitShort	Shortest single bit
– dBitLengthVariation	Bit asymmetry
– dEdge01	Rising edge duration (–300 mV to +300 mV)
– dEdge10	Falling edge duration (+300 mV to –300 mV)
– dEdgeMax	Slowest edge
– Sq0	Isolated "0" voted signal quality
Advanced diagnostic tests:	
– gdTSSTransmitter	Transmitted TSS width at receiver
– MCT	Mean corrected cycle time
– uBusRx-Data	Data 1 amplitude
– uBusRx-Data	Data 0 amplitude
– uRx-Idle	Mean idle level
– dBusRx01	Rise time Data0 to Data1 (–300 mV to +300 mV)
– dBusRx10	Fall time Data1 to Data0 (+300 mV to –300 mV)

Table 2. Transmitter output tests

Parameter tested	Test description
Eye-diagram mask tests (10 Mbs only):	
– TP1 – Std V	Mask test on standard voltage bus driver output
– TP1 – Incr V	Mask test on increased voltage bus driver output
– TP11 – Std V	Mask test on standard voltage active star output
– P11 – Incr V	Mask test on increased voltage active star output
Advanced diagnostic tests:	
– gdTSSTransmitter	Transmitted TSS width
– uBusTx-Data	Data 1 amplitude
– uBusTx-Data	Data 0 amplitude
– uRx-Idle	Mean idle level
– dBusTx01	Rise time Data0 to Data1 (20 to 80%)
– dBusTx10	Fall time Data1 to Data0 (80 to 20%)

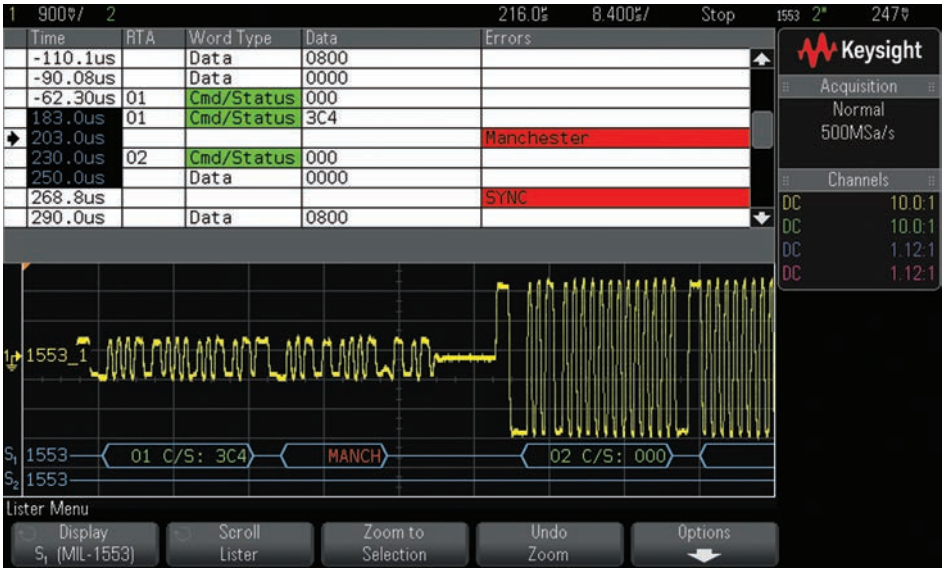
Specifications/Characteristics (Continued)

I²S specifications/characteristics	
SCLK, WS and SDATA input source	Analog channels 1, 2, 3 or 4
	Digital channels D0 to D15
Bus configuration:	
– Transmitted word size	4 to 32 bits (user selectable)
– Decoded/receiver word size	4 to 32 bits (user selectable)
– Alignment	Standard, left-justified or right-justified
– Word select - low	Left-channel or right-channel
– SCLK slope	Rising edge or falling edge
– Decoded base	Hex (2's complement) or signed decimal
Baud rates	2400 b/s to 625 kb/s
Triggering:	
– Audio channel	Audio left, audio right or either
– Trigger modes	= (Equal to entered data value)
	≠ (Not equal to entered data value)
	< (Less than entered data value)
	> (Greater than entered data value)
	>< (Within range of entered data values)
	<> (Out of range of entered data values)
	Increasing value that crosses armed (<=) and trigger (>=) entered data values
	Decreasing value that crosses armed (>=) and trigger (<=) entered data values
Hardware-based decode:	
– Left channel	L: "decoded value" in white
– Right channel	R: "decoded value" in green
– Error	ERR in red (mismatch between transmitted and received word size or invalid input signaling)
– Word size indicator	"# of TX / # of RX" CLKS in blue displayed above each decoded work
Multi-bus analysis	I²S plus one other serial bus (excluding another I²S bus)



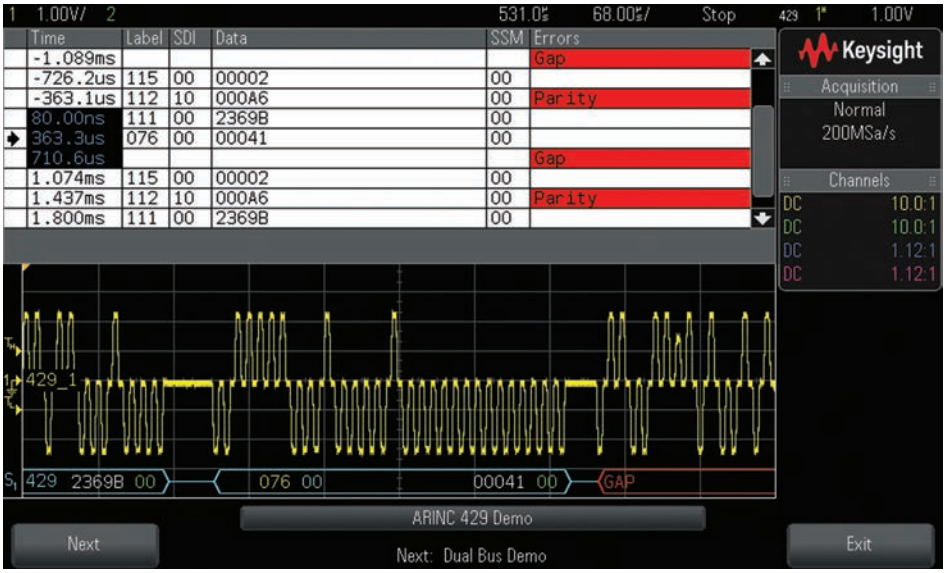
Specifications/Characteristics (Continued)

MIL-STD 1553 specifications/characteristics	
MIL-Std 1553 input source	Analog channels 1, 2, 3 or 4 (using a differential active probe)
Triggering	Data word start
	Data word stop
	Command/status word start
	Command/status word stop
	Remote terminal address (hex)
	Remote terminal address (hex) + 11 bits (binary)
	Parity error
	Sync error
	Manchester error
Color-coded, hardware-accelerated decode	Base: HEX or binary
	Command or status word (“C/S” in green)
	Remote terminal address (hex or binary digits in green)
	11 Bits following RTA (hex or binary digits in green)
	Data word (“D” in white)
	Data word bits (hex or binary digits in white)
	Parity error (all decoded text in red)
	Synchronization error (“Sync” in red)
	Manchester error (“Manch“ in red)
Eye-diagram mask testing (requires DSOX-3MASK mask test option plus downloadable mask files)	System xfmr-coupled input
	System direct-coupled input
	BC xfmr-coupled input
	BC direct-coupled input
	RT xfmr-coupled input
	RT xfmr-coupled input
Multi-bus analysis	MIL-STD 1553 plus one other serial bus, (including another MIL-STD 1553 bus)



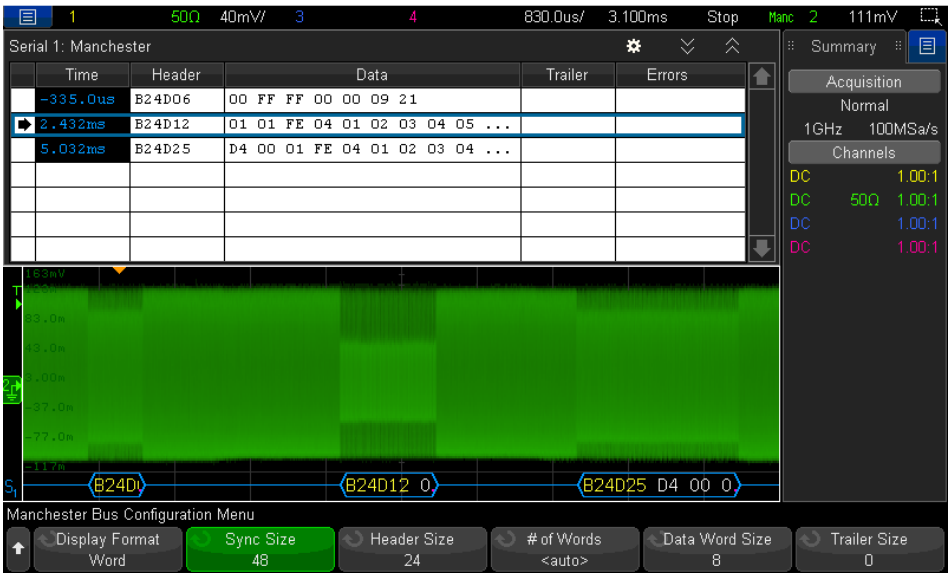
Specifications/Characteristics (Continued)

ARINC 429 specifications/characteristics	
ARINC 429 input source	Analog channels 1, 2, 3 or 4 (using a differential active probe)
	High (100 kbps)
Baud rates	Low (12.5 kbps)
Triggering	Word start
	Word stop
	Label (octal)
	Label (octal) + bits (binary)
	Label range (octal)
	Parity error
	Word error
	Gap error
	Word or gap error
	All errors
	All bits (useful for eye-diagram testing)
	All 0 bits
	All 1 bits
Color-coded, hardware-accelerated decode	Word format: Label/SDI/data/SSM or label/data/SSM or label/data
	Label (octal digits in yellow)
	SDI (binary digits in blue)
	Data (hex or binary digits in white)
	SSM (binary digits in green)
	Errors (text in red)
Totalize function	Total words
	Total errors
Eye-diagram and pulse mask testing (requires DSOX3MASK plus downloadable mask files)	100 kbps eye test
	100 kbps 1's test
	100 kbps 0's test
	100 kbps null test
	12.5 kbps eye test
	12.5 kbps 1's test
	12.5 kbps 0's test
	12.5 kbps null test
Multi-bus analysis	ARINC 429 plus one other bus (including another ARINC 429 bus)



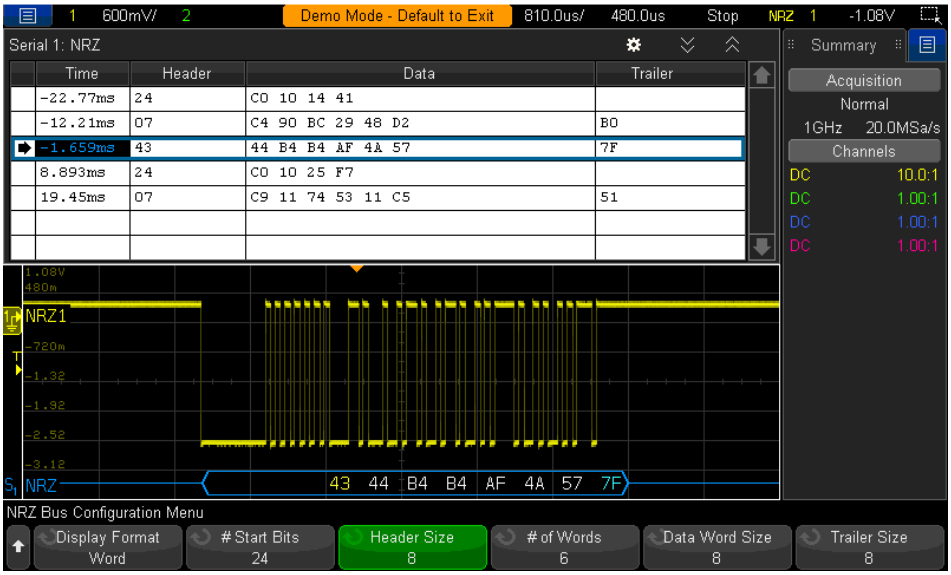
Specifications/Characteristics (Continued)

User-definable Manchester specifications/characteristics	
Input source	Analog channels 1, 2, 3 or 4
	Digital channels D0 to D15 non-differential
Baud rate	2 kbps to 5 Mbps
	Automatic RF demodulation at 212 kbps and 424 kbps (NFC-F)
Baud rate tolerance	5 to 30%
Display format	Word or bits
Polarity	Rising edge = 1 or falling edge = 1
Bit order	MSB or LSB (MSB only in binary display format)
Idle	1.5 to 32 bits
Sync size	0 to 255 bits
Header size (word format only)	0 to 32 bits
Number of words (word format only)	1 to 255 or auto
Data word size (word format only)	2 to 32 bits
Trailer size (word format only)	0 to 32 bits (0 if using “Auto” number of words)
Triggering	SOF (Start-of-frame)
	Value (first 4 to 128 bits entered in binary format)
	Manchester error
Decoding (word format)	Decode base (HEX, ASCII or unsigned decimal)
	Header field (all digits in yellow)
	Data field (all digits in white)
	Trailer (all digits in blue)
Decoding (bit format)	All binary digits in white
Multi-bus analysis	User-definable Manchester plus one other serial bus



Specifications/Characteristics (Continued)

User-definable NRZ specifications/characteristics	
Input source	Analog channels 1, 2, 3 or 4
	Digital channels D0 to D15 non-differential
Baud rate	5 kbps to 5 Mbps
Display format	Word or bits
Polarity	High = 1 or low = 1
Bit order	MSB or LSB (MSB only in binary display format)
Idle	1.5 to 32 bits
Idle state	High or low
Number of start bits	0 to 255 bits
Header size (word format only)	0 to 32 bits
Number of words (word format only)	1 to 255
Data word size (word format only)	2 to 32 bits
Trailer size (word format only)	0 to 32 bits
Triggering	SOF (Start-of-frame)
	Value (first 4 to 128 bits entered in binary format)
Decoding (word format)	Decode base (HEX, ASCII or unsigned decimal)
	Header field (all digits in yellow)
	Data field (all digits in white)
	Trailer (all digits in blue)
Decoding (bit format)	All binary digits in white
Multi-bus analysis	User-definable NRZ plus one other serial bus



Ordering Information

InfiniiVision 1000 X-Series

Licensed option	InfiniiVision 1000 X-Series (EDUX1002A and EDUX1002G)	InfiniiVision 1000 X-Series (DSOX1102A and DSOX1102G)
I²C/UART	EDUX1EMBD	
I²C/SPI/UART		DSOX1EMBD
CAN/LIN		DSOX1AUTO

InfiniiVision 2000 X-, 3000T X-, 4000 X-, 6000 X-Series and M924XA PXIe modular oscilloscopes

Licensed option [1]	InfiniiVision 2000 X-Series	InfiniiVision 3000T X-Series	InfiniiVision 4000 X-Series	InfiniiVision 6000 X-Series	InfiniiVision M924XA PXIe modular
I²C/SPI	DSOX2EMBD	DSOX3EMBD	DSOX4EMBD	DSOX6EMBD	M9240EMBA [7]
RS-232/UART	DSOX2COMP	DSOX3COMP	DSOX4COMP	DSOX6COMP	M9240CMPA
CAN/CAN FD/LIN (with symbolic decoding)	DSOX2AUTO [2]	DSOXT3AUTO	DSOX4AUTO	DSOX6AUTO	M9240ATOA
SENT		DSOXT3SENSOR	DSOX4SENSOR	DSOX6SENSOR	M9240SNSA
FlexRay (includes conformance test software)		DSOX3FLEX	DSOX4FLEX	DSOX4FLEX	
CXPI		DSOXT3CXPI	DSOX4CXPI	DSOX6CXPI	M9240CXPA
I²S		DSOX3AUDIO	DSOX4AUDIO	DSOX6AUDIO	
MIL-STD 1553/ARINC 429		DSOX3AERO	DSOX4AERO	DSOX6AERO	M9240AROA
Low-/full-speed USB 2.0			DSOX4USBFL	DSOX6USBFL	
Hi-speed USB 2.0			DSOX4USBH [3]	DSOX6USBH [3]	
USB 2.0 signal quality pre-compliance test			DSOX4USBSQ	DSOX6USBSQ	
User-definable Manchester/NRZ		DSOXT3NRZ	DSOX4NRZ	DSOX6NRZ	M9240NRZA
Segmented memory	DSOX2SGM	Standard	Standard	Standard	Standard
Mask test	DSOX2MASK	DSOX3MASK	DSOX4MASK	DSOX6MASK	M9240MSKA
Application bundle (all serial options plus more)	DSOX2APPBNDL	DSOX4APPBNDL	DSOX4APPBNDL	DSOX6APPBNDL	

Serial bus differential probing solutions [4]	Model number
25 MHz differential active probe	N2791A
200 MHz differential active probe	N2818A [5]
1.5 GHz differential active probe	N2750A [5]
Extreme temperature probing kit	N7013A [6]
DB9 probe head adapter (for CAN, CAN FD and FlexRay buses)	0960-2926 [6]

1. Additional licensed options available.
2. CAN FD and symbolic not available on InfiniiVision 2000 X-Series.
3. Hi-speed USB 2.0 trigger and decode options (DSOX4USBH and DSOX6USBH) available only on 1-GHz and higher bandwidth models.
4. Additional differential probing solutions available.
5. Not compatible with the InfiniiVision 2000 X-Series.
6. The N7013A extreme temperature probing kit and the 0960-2926 DB9 probe head adapter are compatible with the N2791A and N2818A differential active probes.
7. M9240EMBA supports I²C only.

Related Keysight Literature

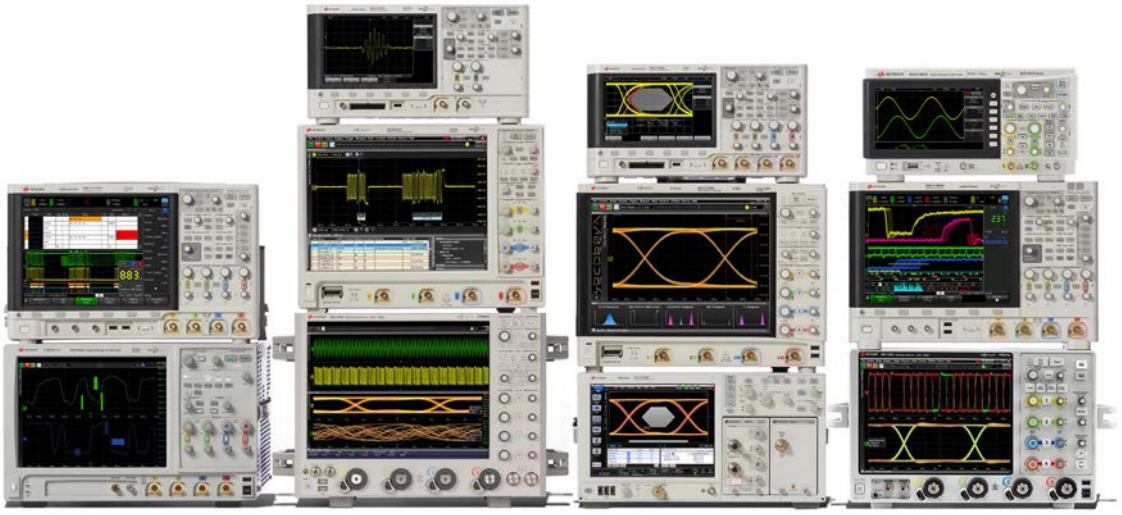
Publication title	Publication number
InfiniiVision 1000 X-Series Oscilloscopes - Data Sheet	5992-1965EN
InfiniiVision 2000 X-Series Oscilloscopes - Data Sheet	5990-6618EN
InfiniiVision 3000T X-Series Oscilloscopes - Data Sheet	5992-0140EN
InfiniiVision 4000 X-Series Oscilloscopes - Data Sheet	5991-1103EN
InfiniiVision 6000 X-Series Oscilloscopes - Data Sheet	5991-4087EN
M924XA InfiniiVision PXIe Modular Oscilloscopes - Data Sheet	5992-2003EN
InfiniiVision Oscilloscope Probes and Accessories - Selection Guide	5968-8153EN
Extreme Temperature Probing Solutions for Oscilloscope Measurements - Data Sheet	5990-3504EN
N2792A/N2818A 200 MHz and N2793A/N2819A 800 MHz Differential Probes - Data Sheet	5990-4753EN
N2750A/51A/52A InfiniiMode Differential Active Probes - Data Sheet	5991-0560EN
DSOX4USBSQ and DSOX6USBSQ USB 2.0 Signal Quality Test Option for 4000 and 6000 X-Series - Data Sheet	5991-1762EN
Using Oscilloscope Segmented Memory for Serial Bus Applications - Application Note	5990-5817EN
Characterizing Hi-Speed USB 2.0 Serial Buses In Embedded Designs - Data Sheet	5991-1148EN
Debug Automotive Designs Faster with CAN-dbc Symbolic Trigger and Decode - Application Note	5991-2847EN
CAN Eye-Diagram Mask Testing - Application Note	5991-0484EN
CAN FD Eye-Diagram Mask Testing - Application Note	5992-0437EN
Characterizing CAN Bus Arbitration Using InfiniiVision 4000/6000 X-Series Oscilloscope - Application Note	5991-4166EN
FlexRay Physical Layer Eye-diagram Mask Testing - Application Note	5990-4923EN
MIL-STD 1553 Eye-diagram Mask Testing – Application Note	5990-9324EN
ARINC 429 Eye-diagram and Pulse-shape Mask Testing – Application Note	5990-9325EN
Decoding Automotive Key Fob Communication based on Manchester-encoded ASK Modulation - Application Note	5992-2260EN
Triggering On and Decoding the PSI5 Sensor Serial Bus Using Oscilloscopes - Application Note	5992-2269EN

To download these documents, insert the publication number in the URL:
http://literature.cdn.keysight.com/litweb/pdf/XXXX-XXXXEN.pdf

Product web site

For the most up-to-date and complete application and product information, please visit our product Web sites at:

- **www.keysight.com/find/1000X-Series**
- **www.keysight.com/find/2000X-Series**
- **www.keysight.com/find/3000TX-Series**
- **www.keysight.com/find/4000X-Series**
- **www.keysight.com/find/6000X-Series**



Keysight Oscilloscopes

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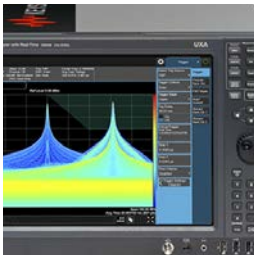


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