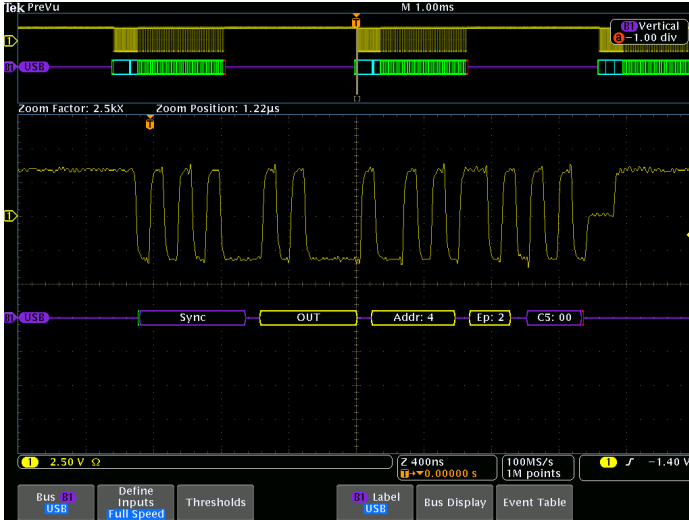


USB 2.0 Application Software

USB 2.0 Decoding, Triggering, and Compliance Testing Software



These applications provide comprehensive, integrated tools for engineers designing USB-based embedded systems and validating the physical-layer compliance to the USB 2.0 standards. The applications are supported on the DPO/DSA/MSO7000C/D/DX, DPO7000C, 5 Series MSO, MSO/DPO5000, MDO4000, and MDO3000 Series oscilloscopes.

Key features

- USB 2.0 Compliance Testing
 - Automated Compliance Testing for USB 2.0 Verification
 - Designed for use with MSO/DPO5000, DPO7000C, and DPO/DSA/MSO7000C/D/DX Series Oscilloscopes
- SR-USB USB Triggering and Analysis
 - Automated Trigger and Decode for USB 2.0 and 3.0
 - Designed for use with MSO/DPO5000, DPO7000C, and DPO/DSA/MSO7000C/D/DX Series Oscilloscopes
- 5-SRUSB2 USB Triggering and Analysis
 - Automated Trigger and Decode for USB 2.0
 - Designed for use with 5 Series MSO
- DPO4USB USB 2.0 Triggering and Analysis
 - Automated Trigger, Decode, and Search for USB 2.0
 - Designed for use with MDO4000 Series Oscilloscopes
- MDO3USB USB 2.0 Triggering and Analysis
 - Automated Trigger, Decode, and Search for USB 2.0
 - Designed for use with MDO3000 Series Oscilloscopes

Applications

- Low-speed USB 2.0
- Full-speed USB 2.0
- High-speed USB 2.0
- SuperSpeed USB 3.0 (trigger and analysis)

Product description

The Tektronix USB 2.0 compliance test application (Opt. USB2) and selected Tektronix oscilloscopes provide one-button compliance testing for USB 2.0 devices as specified by the USB-IF. The USB software automates the compliance testing and allows engineers to perform the required tests efficiently and reliably right on their bench.

The Tektronix MDO4000 Series oscilloscopes with the DPO4USB Serial Application Module, MDO3000 Series oscilloscopes with the MDO3USB Serial Application Module, 5 Series MSO with the 5-SRUSB2 application, and MSO/DPO5000, DPO7000C, and DPO/DSA/MSO7000C/D/DX Series oscilloscopes with the SR-USB application simplify analysis of USB 2.0 and 3.0 waveforms when validating and debugging USB-based embedded systems by providing trigger, decode, and search for low-speed, full-speed, high-speed, and SuperSpeed USB buses. MDO3USB offers automated decode and search for low-speed, full-speed, and high-speed USB buses, as well as triggering on low-speed and full-speed buses. DPO4USB offers automated trigger, decode, and search for low-speed, full-speed, and high-speed USB buses, enabling fast and efficient validation and debug.

USB2 – Automated USB 2.0 Physical Layer compliance testing

USB compliance testing has some unique measurement challenges:

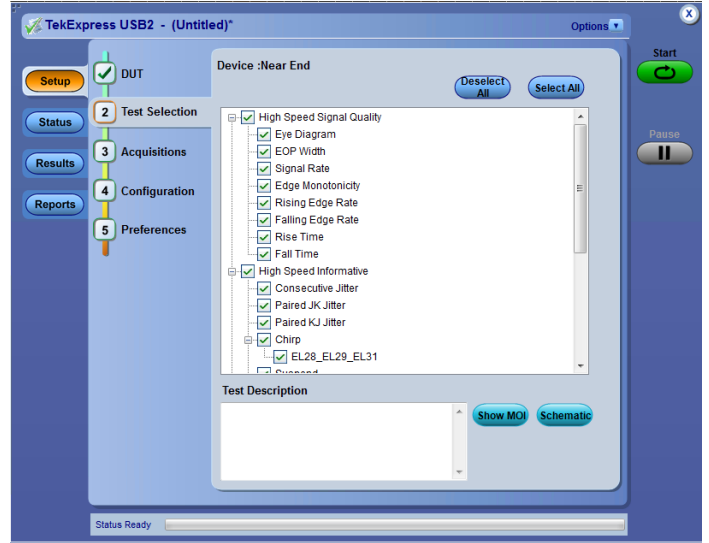
- Designers must quickly and accurately perform all compliance tests recommended by the USB Implementers Forum, Inc. (USB-IF) before they can use the “certified” USB-IF logo on their packaging
- Characterization of these electrical signals includes mask testing and parametric testing, for low-speed, full-speed, and high-speed hosts, devices, and hubs
- Signal speeds range from 1.5 Mb/s (low-speed) to 480 Mb/s (high-speed)

| Test Name | Details | Speed | Pass/Fail | Value | Margin | Comments |
|--------------------|------------------------|------------|-------------|--------------|-------------------------|----------|
| Falling Edge Rate | Falling Edge Rate | High Speed | Pass | 953.260 V/us | 1179.740 V/us | N.A |
| Paired KJ Jitter | Max KJ Jitter | High Speed | Informative | 37.461 ps | N.A | N.A |
| Paired KJ Jitter | Min KJ Jitter | High Speed | Informative | -31.774 ps | N.A | N.A |
| Paired KJ Jitter | RMS KJ Jitter | High Speed | Informative | 10.075 ps | N.A | N.A |
| Signal Rate | Signal Rate | High Speed | Pass | 480.022 Mbps | 0.262 Mbps & 0.218 Mbps | N.A |
| Rising Edge Rate | Rising Edge Rate | High Speed | Pass | 937.390 V/us | 1195.610 V/us | N.A |
| Edge Monotonicity | Edge Monotonicity | High Speed | Pass | 0.000 mV | 50.000 mV | N.A |
| EOP Width | EOP Width | High Speed | Pass | 8.0 bits | 0.480 bits & 0.520 bits | N.A |
| Eye Diagram | Mask Hits | High Speed | Pass | 0.000 | 0.000 & 1.000 | N.A |
| Rise Time | Rise Time | High Speed | Pass | 682.750 ps | 382.750 ps | N.A |
| Consecutive Jitter | Max Consecutive Jitter | High Speed | Informative | 58.905 ps | N.A | N.A |
| Consecutive Jitter | Min Consecutive Jitter | High Speed | Informative | -32.161 ps | N.A | N.A |
| Consecutive Jitter | RMS | High Speed | Informative | 22.983 ps | N.A | N.A |

USB compliance test results

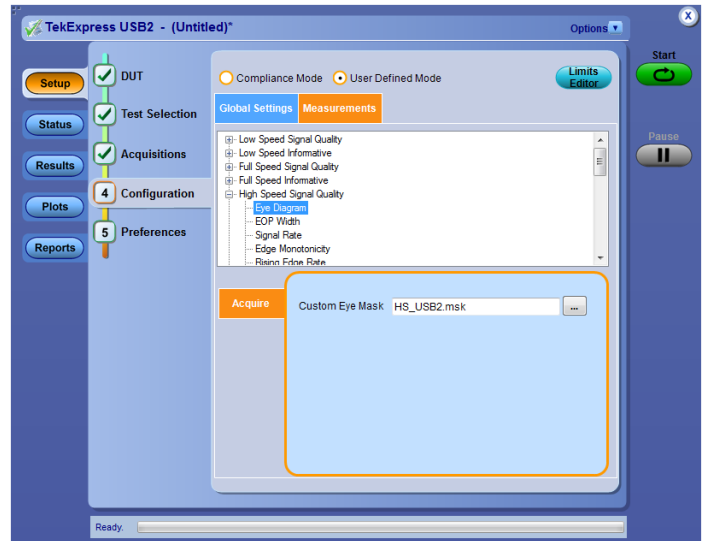
The USB2 application software provides automated compliance testing for USB 2.0 serial bus verification, including:

- Fully compliant with USB-IF tests for USB 2.0 compliance testing
- Automated eye diagram analysis verifies signal quality against standard USB-IF eye masks or custom masks
- Automated oscilloscope setups for various tests eliminate time-consuming manual setups
- Comprehensive test fixture enables quick setup and signal access for a wide range of tests
- High-speed tests: Signal Quality, Receiver Sensitivity, Chirp, Reset, Reset from High Speed, Reset from Suspend, Resume, Suspend, Packet Parameter, and Monotonicity tests
- Automatic signal generator control for receiver sensitivity simplifies testing
- Online help fully documents test procedures
- User-configurable measurement limits for tolerance testing

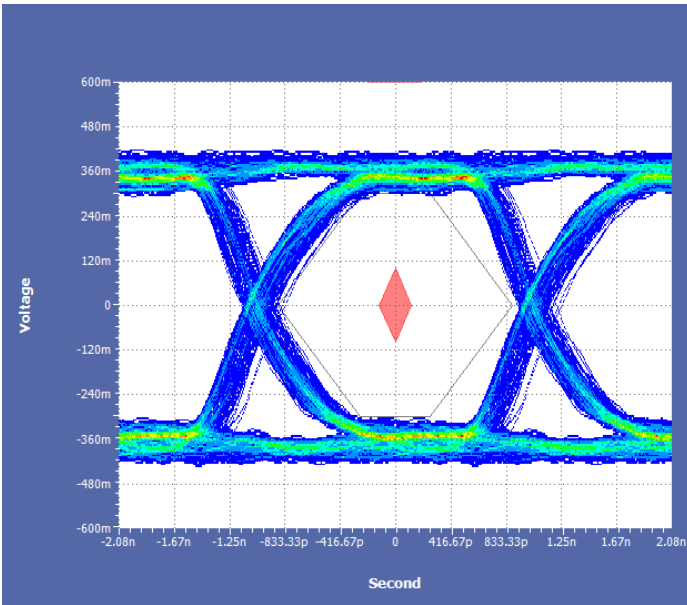


Measurement Select menu for the Signal Quality test suite

Quick Pass/Fail tests substantiated with results make the USB2 application the preferred solution for USB 2.0 physical-layer validation. In-depth analysis is possible with the statistical information about the tests performed. The user-defined measurement limits and custom mask testing also help to perform tolerance testing on a design.



Custom Mask Selection for High Speed Signal Quality



Custom Mask (red) with standard USB-IF mask (black) as reference

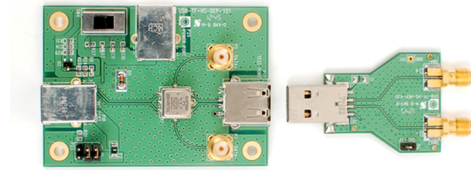
USB2 compliance test fixtures

The Tektronix TDSUSBF test fixture set provides a probing solution for the Low- and Full-speed Signal Quality, Inrush Current, Drop and Droop, Receiver Sensitivity, and Impedance Measurement test. The TDSUSBF test fixture set is ordered separately.

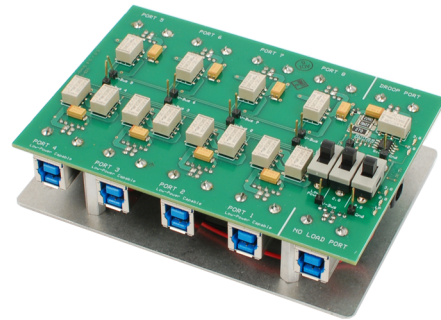
The USB-IF High-speed signal quality fixture set (USB2SIGQUAL) provides the necessary SMA-based connection for performing Eye Diagram and other signal quality measurements. The USB 2.0 / 3.0 Drop-Droop fixture (USB2/3_DD) from USB-IF provides sufficient loads for testing voltage drop and droop levels while testing Host or Hubs (downstream ports supplying VBUS).



TDSUSBF USB 2.0 test fixture set



USB2SIGQUAL High-speed Signal Quality test fixture set (available from USB-IF)



USB-IF Droop-Drop fixture (available from USB-IF)

SR-USB USB 2.0 and 3.0 triggering and analysis

Debugging USB-based embedded systems designs provides some complex measurement and analysis challenges:

- Capturing specific USB addresses and data
- Displaying the elements of the USB message in an understandable format, in a variety of formats, for a wide variety of engineers and technicians
- Time-correlating USB messages with analog and digital signals in the embedded system
- Capture long time windows of USB traffic and then find specific events within the acquired data

The optional SR-USB application software, installed in an MSO/DPO5000, DPO7000C, or DPO/DSA/MSO7000C/D/DX Series oscilloscope, provides a robust set of tools for debugging embedded systems with USB 2.0 and 3.0 serial buses, including:

- Automated serial triggering and decode for low-speed, full-speed, and high-speed USB 2.0 signals
- Serial triggering and decode for SuperSpeed USB 3.0 signals (8b/10b)
- Trigger on all the critical elements of a USB bus such as address, data, etc.
- Decode all the critical elements of each USB message. No more counting 1s and 0s!
- Search through long acquisitions using user-defined criteria to find specific messages
- Event table shows decoded serial bus activity in a tabular, time-stamped format for quick summary of system activity

USB serial triggering

Trigger on packet content such as sync, reset, suspend/resume, token (address) packets with specific address and endpoint, specific data content, handshake packets, special packets, and errors.



Triggering on a specific PID on a USB full-speed bus. A complete set of triggers, including triggers for specific token (address) and data packet content, ensures you quickly capture your event of interest.

USB serial decode

The SR-USB application provides a higher-level, combined view of the individual signals that make up the USB bus, making it easy to identify where packets begin and end and identify subpacket components such as sync, PID, data, CRC, errors, etc.



Color-coded decoded display of low-speed USB bus, showing Sync, PID, CRC, and Stop components of the serial signal



High-speed USB decoded display, automatically displaying bus content in any of several digital formats

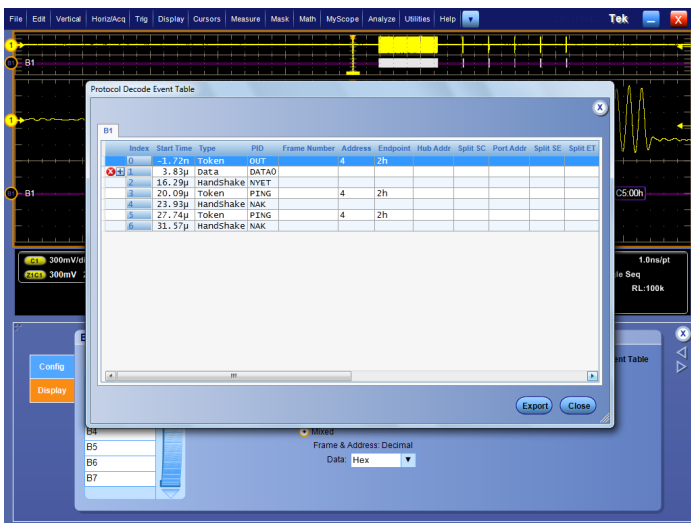


USB 3.0 bus display showing multiple layers simultaneously

Are you wasting time manually decoding the waveform? Tired of having to visually inspect the waveform to count clocks, determine if each bit is a 1 or a 0, combine bits into bytes, and determine the hex value? Let the oscilloscope with the SR-USB application do it for you! Once you've set up a USB bus, the MSO/DPO5000, DPO7000C, or DPO/DSA/MSO7000C/D/DX Series will decode each packet on the bus, and display the value in Hex, Binary, or ASCII in the bus waveform.

USB 2.0 Event table

In addition to seeing decoded packet data on the bus waveform itself, you can view all captured packets in a tabular view much like you would see in a software listing. Packets are time stamped and listed consecutively with columns for each component (Time, PID, Address, Payload, and Errors).



USB decoded Event table showing all packet information with time-stamp information

USB 2.0 search

USB packet content triggering is very useful for isolating the event of interest, but once you've captured it and need to analyze the surrounding data, what do you do? In the past, users had to manually scroll through the waveform counting and converting bits and looking for what caused the event. With the SR-USB application installed, you can enable the oscilloscope to automatically search through the acquired data for user-defined criteria including serial packet content. Each occurrence is highlighted by a search mark. Rapid navigation between marks is as simple as pressing the **Previous** (←) and **Next** (→) buttons on the oscilloscope front panel.

5-SRUSB2 USB 2.0 triggering and analysis

Debugging USB-based embedded systems designs provides some complex measurement and analysis challenges:

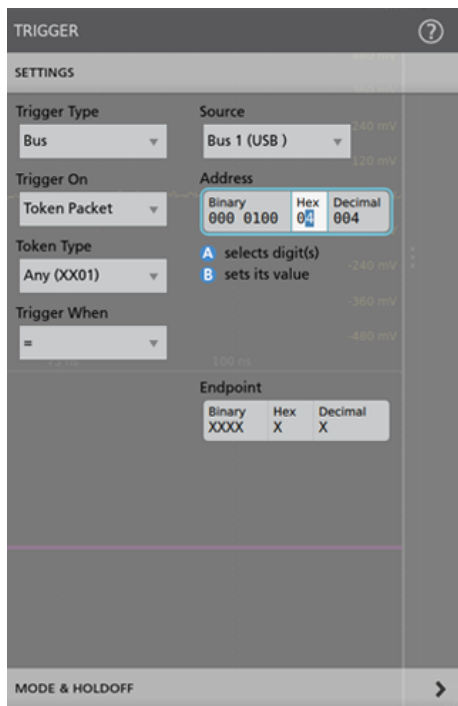
- Capturing specific USB addresses and data
- Displaying the elements of the USB message in an understandable format, in a variety of formats, for a wide variety of engineers and technicians
- Time-correlating USB messages with analog and digital signals in the embedded system
- Capture long time windows of USB traffic and then find specific events within the acquired data

The optional 5-SRUSB2 application software, installed in a 5 Series MSO, provides a robust set of tools for debugging embedded systems with USB 2.0 serial buses, including:

- Automated serial triggering and decode for low-speed, full-speed, and high-speed USB 2.0 signals
- Trigger on all the critical elements of a USB bus such as address, data, etc.
- Decode all the critical elements of each USB message. No more counting 1s and 0s!
- Search through long acquisitions using user-defined criteria to find specific messages
- Results table shows decoded serial bus activity in a tabular, time-stamped format for quick summary of system activity

USB serial triggering

Trigger on packet content such as sync, reset, suspend/resume, token (address) packets with specific address and endpoint, specific data content, handshake packets, special packets, and errors.



Trigger setup to capture a specific token (address) on a USB high-speed bus. A complete set of triggers, including triggers for specific token (address) and data packet content, ensures you quickly capture your event of interest.

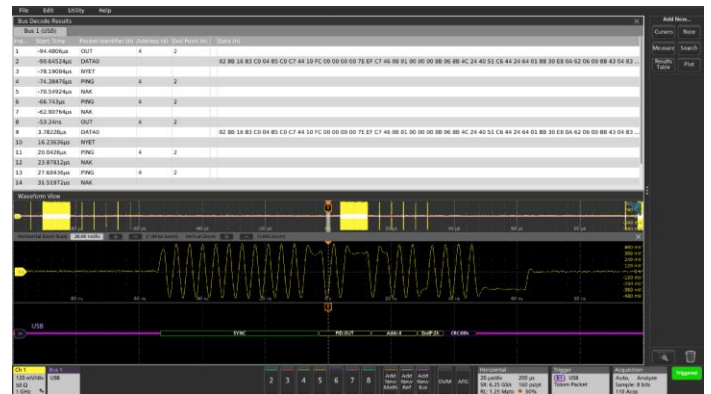
USB 2.0 serial decode

The 5-SRUSB2 application provides a higher-level, combined view of the individual signals that make up the USB bus, making it easy to identify where packets begin and end and identify sub-packet components such as sync, PID, data, CRC, errors, etc.

Tired of manually decoding the waveform? Let the oscilloscope with the 5-SRUSB2 application do it for you! Once you've set up a USB bus, the 5 Series MSO will decode each packet on the bus, and display the value in Hex, Binary, or ASCII in the bus waveform.

USB 2.0 Results Table

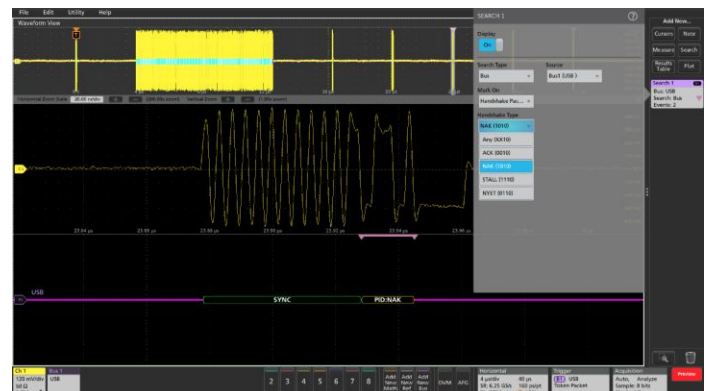
In addition to seeing decoded packet data on the bus waveform itself, you can view all captured packets in a tabular view much like you would see in a software listing. Packets are time stamped and listed consecutively with columns for each component (Time, PID, Address, Payload, and Errors).



Results table showing all USB HS packet information with time-stamp information

USB 2.0 search

USB packet content triggering is very useful for isolating the event of interest, but once you've captured it and need to analyze the surrounding data, what do you do? In the past, users had to manually scroll through the waveform counting and converting bits and looking for what caused the event. With the 5-SRUSB2 application installed, you can enable the oscilloscope to automatically search through the acquired data for user-defined criteria including serial packet content. Each occurrence is highlighted by a search mark. Rapid navigation between marks is as simple as pressing the **Previous** (←) and **Next** (→) buttons on the oscilloscope front panel.



Wave Inspector automated search finds all specified bus elements (in this case, NAK)

DPO4USB/MDO3USB - USB 2.0 triggering and analysis

Debugging USB-based embedded system designs provides some complex measurement and analysis challenges:

- Capturing specific USB addresses and data
- Displaying the elements of the USB message in an understandable format, in a variety of formats, for a wide variety of engineers and technicians
- Time-correlating USB messages with analog and digital signals in the embedded system
- Capture long time windows of USB traffic and then find specific events within the acquired data

The optional DPO4USB application module, installed in an MDO4000 Series oscilloscope, or the optional MDO3USB application module, installed in an MDO3000 Series oscilloscope, provides a robust set of tools for debugging embedded systems with USB 2.0 serial buses, including:

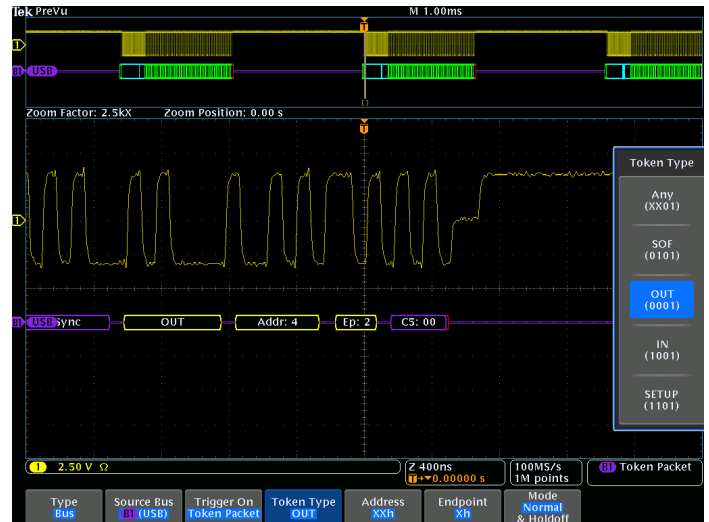
- Automated serial triggering for low-speed, full-speed, and high-speed (DPO4USB only) USB 2.0 signals
- Automated serial decode and search for low-speed, full-speed, and high-speed USB 2.0 signals
- Trigger on all the critical elements of a USB bus such as address, data, etc.
- Decode all the critical elements of each USB message. No more counting 1s and 0s!
- Search through long acquisitions using user-defined criteria to find specific messages
- Event table shows decoded serial bus activity in a tabular, time-stamped format for quick summary of system activity

USB 2.0 serial triggering

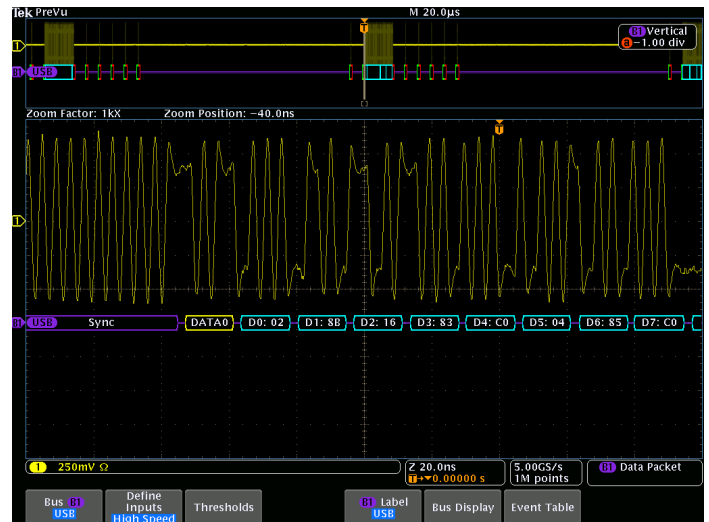
Trigger on packet content such as sync, reset, suspend/resume, token (address) packets with specific address and endpoint, specific data content, handshake packets, special packets, and errors.

USB 2.0 decode

The DPO4USB/MDO3USB USB Serial Application Module provides a higher-level, combined view of the individual signals that make up the USB bus, making it easy to identify where packets begin and end and identifying subpacket components such as sync, PID, data, CRC, errors, etc.



Triggering on a specific PID on an USB FS bus. A complete set of triggers, including triggers for specific Token (address) and data packet content, ensures you quickly capture your event of interest.



High-speed USB decoded display, automatically displaying bus content in any of several digital formats

Are you wasting time manually decoding the waveform? Tired of having to visually inspect the waveform to count clocks, determine if each bit is a 1 or a 0, combine bits into bytes, and determine the hex value? Let the oscilloscope with a USB Triggering and Analysis Application module do it for you! Once you've set up a USB bus, the MDO4000 or MDO3000 Series will decode each packet on the bus, and display the value in Hex, Binary, or ASCII in the bus waveform.

Specifications

USB2

| Instrument compatibility | Oscilloscope | Description |
|--------------------------|--|---|
| | MSO5034/B DPO5034/B MSO5054/B DPO5054/B MSO5104/B DPO5104/B DPO7054C DPO7104C | USB 2.0 Compliance: Low-speed and Full-speed USB |
| | MSO5204/B DPO5204/B DPO7254C DPO7354C All DPO/DSA/MSO70000C/D/DX models | USB 2.0 Compliance: Low-speed, Full-speed, and High-speed USB (High-speed Receiver Sensitivity testing not supported on MSO/DPO5000/B models) |

Testing options

| | |
|---------------------------------|---|
| USB tests | Host, hubs, and devices |
| Signal Quality tests | Eye Diagram Test, Jitter (JK, KJ, and Consecutive), Crossover Voltage Range, Signal Rate, End-of-Packet Width, Rising Edge Rate, Falling Edge Rate |
| High-speed tests | Receiver Sensitivity, Chirp, Reset, Resume, Reset from High Speed, Reset from Suspend, Packet Parameter, and Edge Monotonicity test (not supported on MSO/DPO5000/B models) |
| Inrush Current check | Data-sufficiency readout. Coulombs and capacitance listed across inrush regions |
| Droop test | Volts readout |
| Speed selection | Low-speed (LS), Full-speed (FS), and High-speed (HS) |
| Signal direction | Upstream and downstream |
| Test Point selection | Near End and Far End |
| Report Generation format | MHTML, PDF, and CSV formats |

SR-USB

| Instrument compatibility | Oscilloscope | Description |
|--------------------------|--|---|
| | MSO5034/B DPO5034/B MSO5054/B DPO5054/B DPO7054C | Trigger and Decode: Low-speed and Full-speed USB |
| | MSO5104/B DPO5104/B MSO5204/B DPO5204/B | Trigger and Decode: Low-speed, Full-speed, and High-speed USB |
| | DPO7104C DPO7254C DPO7354C | Decode: Low-speed, Full-speed, and High-speed USB Trigger: Low-speed and Full-speed USB |
| | All DPO/DSA/MSO70000C/D/DX models | Decode: Low-speed, Full-speed, and High-speed, and SuperSpeed (8b/10b) USB Trigger: Low-speed and Full-speed USB |

Bus Setup options

| | |
|--------------------------|--|
| USB compatibility | <p>Low-speed and Full-speed: All MSO/DPO5000, DPO7000C, and DPO/DSA/MSO70000C/D/DX Series models</p> <p>High-speed: MSO/DPO5204/B, MSO/DPO5104/B, DPO7354C, DPO7254C, DPO7104C, and DPO/DSA/MSO70000C/D/DX models only</p> <p>SuperSpeed: DPO/DSA/MSO70000C/D/DX models only</p> |
|--------------------------|--|

Sources

| | |
|---------------------|---|
| Single-ended | <p>Analog channels 1-4</p> <p>Math channels 1-4</p> <p>Digital channels D0-D15 (MSO5000 and MSO70000C/DX Series only)</p> |
| Differential | <p>Analog channels 1-4</p> <p>Math channels 1-4</p> |

| | |
|----------------------------|--|
| Recommended probing | <p>Low-speed and Full-speed: Single-ended or differential</p> <p>High-speed/SuperSpeed: Differential</p> |
|----------------------------|--|

| | |
|---------------------------------------|---|
| Address/Data formats available | <p>Hex, Binary, Decimal</p> <p>Decimal: Frame and Address</p> <p>Hex or ASCII: Data</p> |
|---------------------------------------|---|

Display modes

| | |
|--------------------------|---|
| Bus | Bus only |
| Bus and waveforms | Simultaneous display of bus and digital waveforms |
| Event table | Decoded packet data in a tabular view |

Bus Trigger options

Trigger and/or search on

Low-speed

Trigger/Search on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error

| Packet type | Description |
|------------------|---|
| Token packet | Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits. |
| Data packet | Any data type, DATA0, DATA1; Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range |
| Handshake packet | Any handshake type, ACK, NAK, STALL |
| Special packet | Any special type, Reserved |
| Error | PID Check, CRC5, CRC16, Bit Stuffing |

Full-speed

Trigger/Search on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error

| Packet type | Description |
|------------------|---|
| Token packet | Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits. |
| Data packet | Any data type, DATA0, DATA1; Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range |
| Handshake packet | Any handshake type, ACK, NAK, STALL |
| Special packet | Any special type, PRE, Reserved. |
| Error | PID Check, CRC5, CRC16, Bit Stuffing |

High-speed

Trigger/Search on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error

| Packet type | Description |
|------------------|--|
| Token packet | Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits. |
| Data packet | Any data type, DATA0, DATA1, DATA2, MDATA; Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range. |
| Handshake packet | Any handshake type, ACK, NAK, STALL, NYET |
| Special packet | Any special type, ERR, SPLIT, PING, Reserved. SPLIT packet components that can be specified include: Hub Address Start/Complete – Don't Care, Start (SSPLIT), Complete (CSPLIT) Port Address Start and End bits – Don't Care, Control/Bulk/Interrupt (Full-speed Device, Low-speed Device), Isochronous (Data is Middle, Data is End, Data is Start, Data is All) Endpoint Type – Don't Care, Control, Isochronous, Bulk, Interrupt |
| Error | PID Check, CRC5, CRC16, Any |

SuperSpeed

Trigger/Search on Ordered Set, Character, Symbol, Error

| Packet type | Description |
|-------------|---|
| Ordered Set | SKP, DPPSTART, DPPEND, DPPABORT |
| Character | K28.1 (SKP), K28.5 (COM) or other user-defined (8b/10b) |
| Symbol | User-defined with positive, negative, or either disparity |
| Error | Character or Disparity |

Bus decode

USB Data rates
 Low-speed: 1.5 Mb/s
 Full-speed: 12 Mb/s
 High-speed: 480 Mb/s
 SuperSpeed: 5 Gb/s

Decode display
 Start (green bar)
 PID (yellow packet)
 Data (cyan packet)
 CRC (purple packet)
 Stop (red bar)

5-SRUSB2

| Instrument compatibility | Oscilloscope | Description |
|--------------------------|--|---|
| | MSO54 opt. 5-BW-350 MSO54 opt. 5-BW-500 MSO56 opt. 5-BW-350 MSO56 opt. 5-BW-500 MSO58 opt. 5-BW-350 MSO58 opt. 5-BW-500 | Trigger and Decode: Low-speed and Full-speed USB |
| | MSO54 opt. 5-BW-1000 MSO54 opt. 5-BW-2000 MSO56 opt. 5-BW-1000 MSO56 opt. 5-BW-2000 MSO58 opt. 5-BW-1000 MSO58 opt. 5-BW-2000 | Trigger and Decode: Low-speed, Full-speed, and High-speed USB |

Bus Setup options

USB compatibility
 Low-speed and Full-speed: All 5 Series MSO models with 350 MHz or 500 MHz bandwidth
 High-speed: All 5 Series MSO models with 1 GHz or 2 GHz bandwidth

Sources

Single-ended
 Analog channels
 Digital channels
 Active Math channels
 Active Reference waveforms

Differential
 Analog channels
 Active Math channels
 Active Reference waveforms

Recommended probing
 Low-speed and Full-speed: Single-ended or differential
 High-speed: Differential

Address/Data formats available
 Hex, Binary, Decimal
 Decimal: Frame and Address
 Hex or ASCII: Data

Bus Setup options

Display modes

| | |
|-------------------|---|
| Bus | Bus only |
| Bus and waveforms | Simultaneous display of bus and digital waveforms |
| Results table | Decoded packet data in a tabular view |

Bus Trigger options

Trigger and/or search on

Low-speed

Trigger/Search on Sync, Handshake Packet, Special Packet, Error, Token (Address) Packet, Data Packet, Reset, Suspend, Resume, End of Packet.

| Packet type | Description |
|------------------|---|
| Token packet | Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits. |
| Data packet | Any data type, DATA0, DATA1; 1 – 16 bytes of Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range. |
| Handshake packet | Any handshake type, ACK, NAK, STALL |
| Special packet | Any special type, PRE, Reserved |
| Error | PID Check bits, Token CRC5, Data CRC16, Bit Stuffing |

Full-speed

Trigger/Search on Sync, Handshake Packet, Special Packet, Error, Token (Address) Packet, Data Packet, Reset, Suspend, Resume, End of Packet

| Packet type | Description |
|------------------|---|
| Token packet | Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits. |
| Data packet | Any data type, DATA0, DATA1; 1 – 16 bytes of Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range. |
| Handshake packet | Any handshake type, ACK, NAK, STALL |
| Special packet | Any special type, PRE, Reserved. |
| Error | PID Check bits, Token CRC5, Data CRC16, Bit Stuffing |

Bus Trigger options

High-speed

Trigger/Search on Sync, Handshake Packet, Special Packet, Error, Token (Address) Packet, Data Packet, Reset, Suspend, Resume, End of Packet

| Packet type | Description |
|------------------|---|
| Token packet | Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits. |
| Data packet | Any data type, DATA0, DATA1, DATA2, MDATA; 1 – 16 bytes of Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range. |
| Handshake packet | Any handshake type, ACK, NAK, STALL, NYET |
| Special packet | Any special type, ERR, SPLIT, PING, Reserved. SPLIT packet components that can be specified include: Hub Address Start/Complete – Don't Care, Start (SSPLIT), Complete (CSPLIT) Port Address Start and End bits – Don't Care, Control/Bulk/Interrupt (Full-speed Device, Low-speed Device), Isochronous (Data is Middle, Data is End, Data is Start, Data is All) Endpoint Type – Don't Care, Control, Isochronous, Bulk, Interrupt |
| Error | PID Check, CRC5, CRC16, Any |

Decode display

Start (green bar)
PID (yellow packet)
Data (cyan packet)
CRC (purple packet)
Stop (red bar)

DPO4USB

Instrument compatibility

| Oscilloscope | Description |
|---|--|
| All 100 MHz, 200 MHz, 350 MHz, 500 MHz MDO4000/B, MSO4000/B, and DPO4000 ¹ /B/C Series | Trigger and Decode: Low-speed and Full-speed |
| MSO4104 DPO4104 ¹ | Trigger: Low-speed and Full-speed Decode: Low-speed, Full-speed, and High-speed |
| All 1 GHz models of MSO/DPO4000B and MDO4000/B/C Series | Trigger and Decode: Low Speed, Full Speed, and High Speed |

Bus Setup options

USB 2.0 compatibility

Low-speed and Full-speed: All MDO/MSO/DPO4000 Series models
High-speed: Models with 1 GHz analog channel bandwidth

Sources

Single-ended

Analog channels 1-4
Digital channels D0-D15 (MDO and MSO Series only)

Differential

Analog channels 1-4
Math channel
Reference channels 1-4

¹ For DPO4000 (non-B) Series products with serial numbers lower than C020000 and no serial triggering hardware update installed, USB triggering is not supported.

Bus Setup options

| | |
|---------------------------------------|--|
| Recommended probing | Low-speed and Full-speed: Single-ended or differential High-speed: Differential |
| Threshold presets | Low-speed and Full-speed: Single-ended (D+: 1.4 V; D-: -1.4 V), Differential (High: 1.4 V; Low: -1.4 V) High-speed: Differential (High: 100 mV; Low: -100 mV) |
| Address/Data formats available | Hex, Binary, Decimal Decimal: Frame and Address Hex or ASCII: Data |
| Display modes | |
| Bus | Bus only |
| Bus and waveforms | Simultaneous display of bus and digital waveforms |
| Event table | Decoded packet data in a tabular view |

Bus Trigger options

Trigger and/or search on

Low-speed

Trigger/Search on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error

| Packet type | Description |
|------------------|---|
| Token packet | Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits. |
| Data packet | Any data type, DATA0, DATA1; Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range. |
| Handshake packet | Any handshake type, ACK, NAK, STALL |
| Special packet | Any special type, Reserved |
| Error | PID Check, CRC5, CRC16, Bit Stuffing |

Full-speed

Trigger/Search on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error

| Packet type | Description |
|------------------|---|
| Token packet | Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits. |
| Data packet | Any data type, DATA0, DATA1; Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range. |
| Handshake packet | Any handshake type, ACK, NAK, STALL |
| Special packet | Any special type, PRE, Reserved. |
| Error | PID Check, CRC5, CRC16, Bit Stuffing |

High-speed

Trigger/Search on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error

| Packet type | Description |
|------------------|--|
| Token packet | Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits. |
| Data packet | Any data type, DATA0, DATA1, DATA2, MDATA; Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range. |
| Handshake packet | Any handshake type, ACK, NAK, STALL, NYET |
| Special packet | Any special type, ERR, SPLIT, PING, Reserved. SPLIT packet components that can be specified include: Hub Address Start/Complete – Don't Care, Start (SSPLIT), Complete (CSPLIT) Port Address Start and End bits – Don't Care, Control/Bulk/Interrupt (Full-speed Device, Low-speed Device), Isochronous (Data is Middle, Data is End, Data is Start, Data is All) Endpoint Type – Don't Care, Control, Isochronous, Bulk, Interrupt |
| Error | PID Check, CRC5, CRC16 |

Bus decode

USB Data rates
 Low-speed: 1.5 Mb/s
 Full-speed: 12 Mb/s
 High-speed: 480 Mb/s

Decode display
 Start (green bar)
 PID (yellow packet)
 Data (cyan packet)
 CRC (purple packet)
 Stop (red bar)

MDO3USB

| Instrument compatibility | Oscilloscope | Description |
|--------------------------|---|--|
| | All 100 MHz, 200 MHz, 350 MHz, 500 MHz MDO3000 Series | Trigger and Decode: Low-speed and Full-speed |
| | All 1 GHz MDO3000 Series | Trigger: Low-speed and Full-speed Decode: Low-speed, Full-speed, and High-speed |

Bus Setup options

USB 2.0 compatibility
 Low-speed and Full-speed: All MDO3000 Series models
 High-speed: Models with 1 GHz analog channel bandwidth

Sources

Single-ended
 Analog channels 1-4
 Digital channels D0-D15 (models with MSO options only)

Differential
 Analog channels 1-4
 Math channel
 Reference channels 1-4

Recommended probing
 Low-speed and Full-speed: Single-ended or differential
 High-speed: Differential

Threshold presets
 Low-speed and Full-speed: Single-ended (D+: 1.4 V; D-: -1.4 V), Differential (High: 1.4 V; Low: -1.4 V)
 High-speed: Differential (High: 100 mV; Low: -100 mV)

Address/Data formats available
 Hex, Binary, Decimal
 Decimal: Frame and Address
 Hex or ASCII: Data

Display modes

Bus
 Bus only

Bus and waveforms
 Simultaneous display of bus and digital waveforms

Event table
 Decoded packet data in a tabular view

Bus Trigger options

Trigger and/or search on

Low-speed

Trigger/Search on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error

| Packet type | Description |
|------------------|---|
| Token packet | Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits. |
| Data packet | Any data type, DATA0, DATA1; Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range. |
| Handshake packet | Any handshake type, ACK, NAK, STALL |
| Special packet | Any special type, Reserved |
| Error | PID Check, CRC5, CRC16, Bit Stuffing |

Full-speed

Trigger/Search on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error

| Packet type | Description |
|------------------|---|
| Token packet | Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits. |
| Data packet | Any data type, DATA0, DATA1; Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range. |
| Handshake packet | Any handshake type, ACK, NAK, STALL |
| Special packet | Any special type, PRE, Reserved. |
| Error | PID Check, CRC5, CRC16, Bit Stuffing |

High-speed

Trigger/Search on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error

| Packet type | Description |
|------------------|--|
| Token packet | Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits. |
| Data packet | Any data type, DATA0, DATA1, DATA2, MDATA; Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range. |
| Handshake packet | Any handshake type, ACK, NAK, STALL, NYET |
| Special packet | Any special type, ERR, SPLIT, PING, Reserved. SPLIT packet components that can be specified include: Hub Address Start/Complete – Don't Care, Start (SSPLIT), Complete (CSPLIT) Port Address Start and End bits – Don't Care, Control/Bulk/Interrupt (Full-speed Device, Low-speed Device), Isochronous (Data is Middle, Data is End, Data is Start, Data is All) Endpoint Type – Don't Care, Control, Isochronous, Bulk, Interrupt |
| Error | PID Check, CRC5, CRC16 |

Bus decode

USB Data rates

Low-speed: 1.5 Mb/s

Full-speed: 12 Mb/s

High-speed: 480 Mb/s

Decode display

Start (green bar)

PID (yellow packet)

Data (cyan packet)

CRC (purple packet)

Stop (red bar)

Ordering information

USB2

USB 2.0 Physical-layer Compliance Test Application

| Model | New instrument orders | Product upgrades | Floating licenses |
|-------------------------------|-----------------------|-------------------|-------------------|
| MSO/DPO5000 Series | Opt. USB2 | DPO-UP, Opt. USB2 | DPOFL-USB2 |
| DPO7000C Series | Opt. USB2 | DPO-UP, Opt. USB2 | DPOFL-USB2 |
| DPO/DSA/MSO70000C/D/DX Series | Opt. USB2 | DPO-UP, Opt. USB2 | DPOFL-USB2 |

SR-USB

USB Triggering and Analysis Application

| Model | New instrument orders | Product upgrades | Floating licenses |
|-------------------------------|-----------------------|--------------------|-------------------|
| MSO/DPO5000 Series | Opt. SR-USB | DPO-UP Opt. SR-USB | DPOFL-SR-USB |
| DPO7000C Series | Opt. SR-USB | DPO-UP Opt. SR-USB | DPOFL-SR-USB |
| DPO/DSA/MSO70000C/D/DX Series | Opt. SR-USB | DPO-UP Opt. SR-USB | DPOFL-SR-USB |

5-SRUSB2

USB 2.0 Triggering and Analysis Application

| Model | New instrument orders | Product upgrades | Floating licenses |
|--------------|-----------------------|------------------|-------------------|
| 5 Series MSO | Opt. 5-SRUSB2 | SUP5-SRUSB2 | - |

DPO4USB

USB 2.0 Triggering and Analysis Application

| Model | New instrument orders | Product upgrades | Floating licenses |
|----------------|-----------------------|------------------|-------------------|
| MDO4000 Series | DPO4USB | DPO4USB | - |

MDO3USB

USB 2.0 Triggering and Analysis Application

| Model | New instrument orders | Product upgrades | Floating licenses |
|----------------|-----------------------|------------------|-------------------|
| MDO3000 Series | MDO3USB | MDO3USB | - |

Recommended accessories

The P6248, P6330, TDP1500, and TDP3500 differential probes and P6245, TAP1500, and TAP2500 single-ended probes are approved for compliance testing. Higher-performance active or differential probes may be used for design applications. It is recommended to use a probe with 1X attenuation for best results. Please refer to www.tektronix.com/probes for further information on the recommended models of probes and any necessary probe adapters.

Accessories

| | |
|-----------------------------|---|
| TDSUSBF | USB 2.0 test fixture set |
| AWG5000C or AWG7000C series | Arbitrary waveform generator, signal source for receiver sensitivity tests. 5X attenuators are required |
| USB2SIGQUAL | USB-IF High-speed Signal Quality test fixture set (sold through USB-IF, please see USB.org) |
| USB2/3_DD | USB-IF Droop-Drop fixture (sold through USB-IF, please see USB.org) |

SR-USB

Please refer to www.tektronix.com/probes for further information on the recommended models of probes and any necessary probe adapters.

5-SRUSB2

Please refer to www.tektronix.com/probes for further information on the recommended models of probes and any necessary probe adapters.

DPO4USB

Please refer to www.tektronix.com/probes for further information on the recommended models of probes and any necessary probe adapters.

MDO3USB

Please refer to www.tektronix.com/probes for further information on the recommended models of probes and any necessary probe adapters.

Additional information

Tektronix offers a range of solutions for USB testing, including HSIC (High Speed Inter Connect) and USB 3.0. To see a comprehensive listing, and download the latest resources, visit www.tektronix.com/USB.

USB solution updates and up-to-date instrument software upgrades are available at www.tektronix.com/downloads.



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