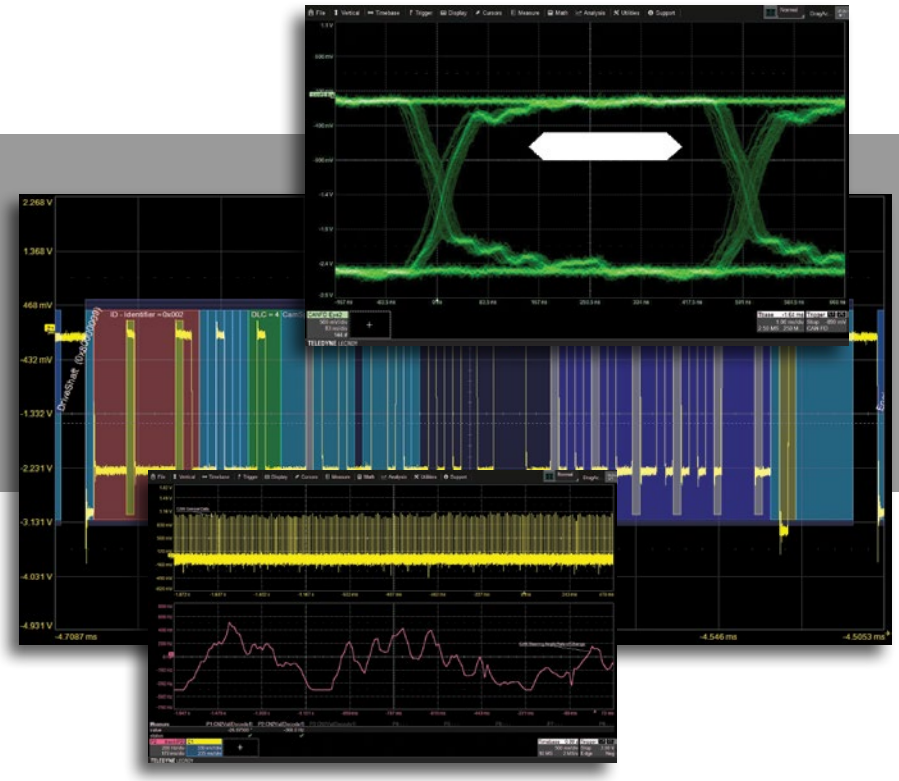
TELEDYNE LECROY
Everywhereyoulook™

Low-speed Serial Data Trigger, Decode, Measure/Graph, and Eye Diagrams



Teledyne LeCroy's Trigger (T), Decode (D), Measure/Graph (M or G) and Eye Diagram and Physical Layer (E or P) options are the best in the industry and nearly universally available across the entire Teledyne LeCroy oscilloscope product line.

Key Features

More than 20 supported standards:

- I²C, SPI, UART and RS-232
- 10Base-T1S, 100Base-T1/ BroadR-Reach
  CAN, CAN FD, CAN XL, and J1939
  FlexRay, LIN, SENT and SENT SPC
- ARINC 429, MIL-STD-1553, SPACEWIRE
- 10/100 Base-T Ethernet
- USB and USB-C Standards:
  USB 1.x, 2.0, USB 2.0 HSIC,
  USB Power Delivery (PD),
  USB4 Sideband (SB) Channel
- DisplayPort AUX Channel
- SMBus, PMBus, SPMI
- MIPI D-PHY, C-PHY, DigRF 3G, DigRF v4, I³C
- I²S, incl. LJ, RJ, TDM, Manchester and NRZ

Most powerful, flexible triggering capabilities

Intuitive, color-coded decode overlays

Single protocol results table supports up to four decoders at one time

Unique measure/graph capabilities:

- Automated timing measurements
- Serial DAC - extract digital data and plot it as a waveform
- Bus parameters

Physical layer eye diagrams

Highest Performance Triggers

Designed by people who know the standards, with the unique capabilities you want to isolate unusual events. Conditional data triggering permits maximum flexibility, and highly adaptable error frame triggering is available to isolate error conditions. Frame definition allows grouping of UART or SPI packets into message frames for customization.

The Best Serial Decoder

Decoded protocol information is color-coded to specific portions of the serial data waveform and transparently overlaid for an intuitive, easy-to-understand visual record. All decoded protocols are displayed in a single time-interleaved table. Touch a row in the interactive table to quickly zoom to a packet of interest and easily search through long records for specific protocol events using the built-in search feature.

Measure/Graph Tools for Validation Efficiency

Quickly validate cause and effect with automated timing measurements to or from an analog signal or another serial message. Make multiple measurements in a single long acquisition to quickly acquire statistics during corner-case testing. Serial (digital) data can be extracted to an analog value and graphed to monitor system performance over time, as if it was probed directly. Complete validation faster and gain better insight.

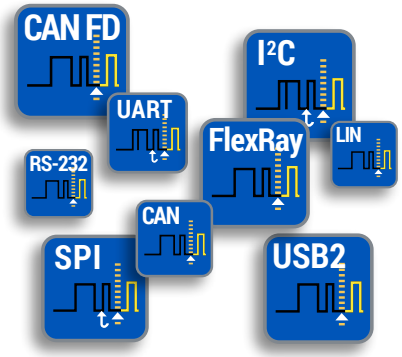
Eye Diagrams & Physical Layer

Rapidly display an eye diagram of your packetized low-speed serial data signal without additional setup time. Use eye parameters to quantify system performance and apply a standard or custom mask to identify anomalies. Mask failures can be indicated and can force the scope into Stop mode.

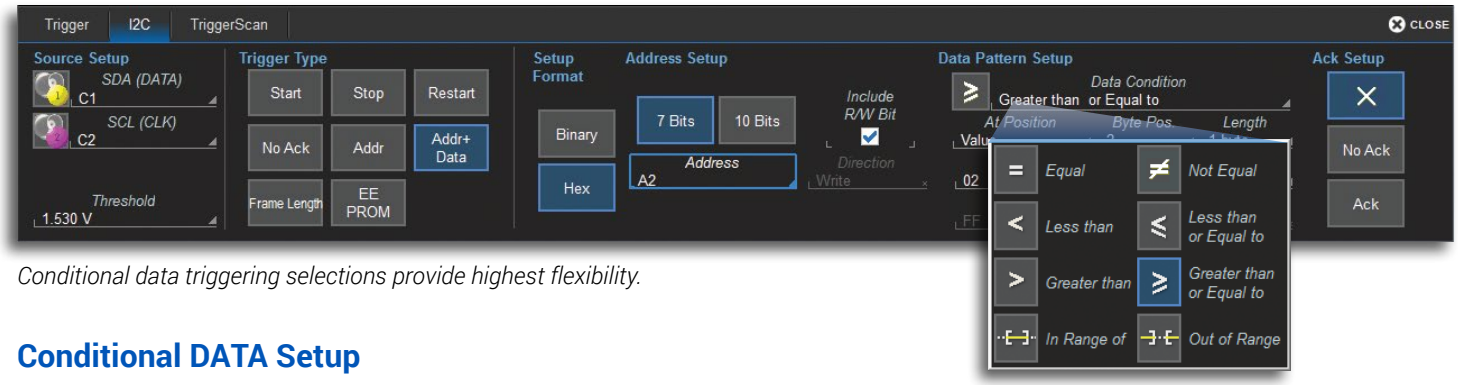
HIGHEST PERFORMANCE TRIGGERS

Every serial trigger we design exhibits deep knowledge of the standard. Most serial triggers work with digital (MSO) inputs, or the EXT input for the Clock line so as to conserve analog channels. Each serial trigger has some unique aspect for high performance, such as:

- **I²C trigger permits triggering on data in a specific location of an up to 2048 byte I²C EEPROM read or write.**
- **UART or SPI bytes can be combined into a single "message frame" - trigger on custom protocols based on UART or SPI byte blocks.**
- **UART supports 9-bit "address" or "wakeup" mode triggering.**
- **CAN, CAN FD, LIN, FlexRay and MIL-STD-1553 permit conditional ID/Address triggering.**
- **CAN and CAN FD permit triggering symbolically using a DBC or ARXML file.**
- **USB 2.0, USB-PD, USB4-SB, and MIL-STD-1553 triggers permits complex transaction definition and triggering.**



High performance triggers support a wide range of serial data standards.



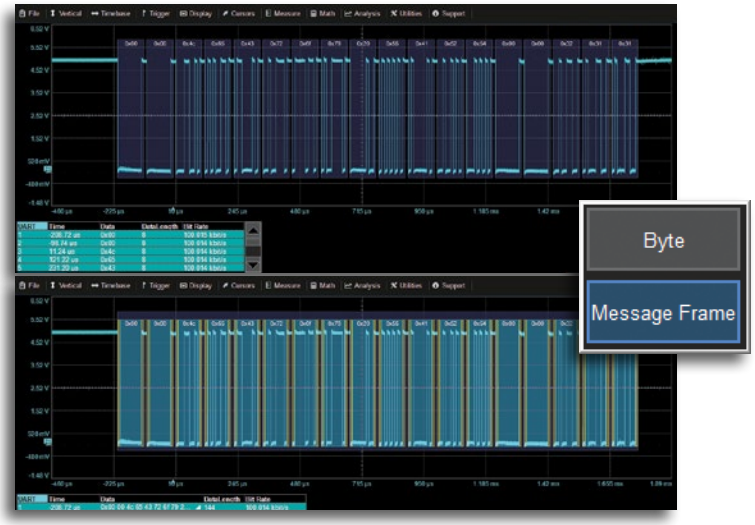
Conditional data triggering selections provide highest flexibility.

Conditional DATA Setup

Every Teledyne LeCroy low-speed serial trigger that incorporates DATA trigger permits a conditional (<. <=, =, >, >=, <>, inside a range, outside a range) setup for the DATA condition. This is especially useful in situations where abnormal events should be monitored, such as when a temperature sensor transmitting via I²C exceeds a maximum temperature, or a CAN node broadcasts a low or high engine RPM or coolant pressure. Furthermore, data for triggering can be specifically isolated in very long byte streams to specific bit locations, even those which span data bytes.

Support for Many Proprietary Protocols

Many proprietary serial protocols make use of the common UART (single Data line) or USART (Clock and Data lines, as in SPI) byte structures, with multiple bytes grouped into proprietary protocol definitions. Our highly flexible UART byte and SPI format definitions accommodate nearly any customer need, and the UART or SPI bytes can be defined to be part of a single "message frame" through use of our Interframe Setup. Then, the trigger pattern setup can isolate any byte value (e.g., an ID or DATA string value) that is part of your proprietary protocol message definition.



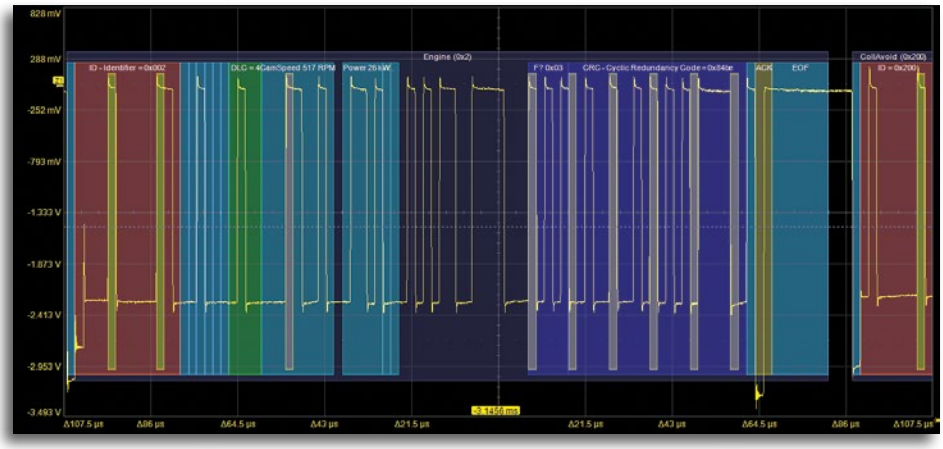
Byte mode (top) treats each byte uniquely. Message Frame mode (bottom) groups bytes into a single, long multi-byte message.

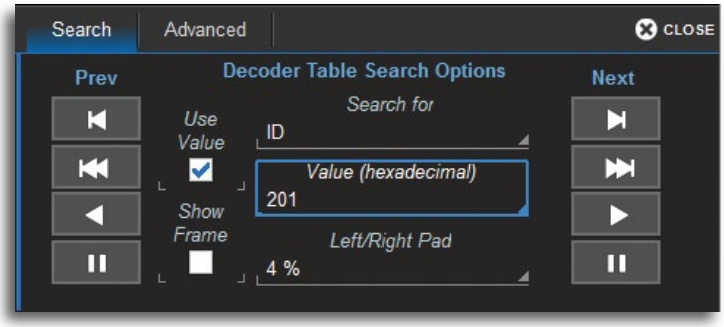
SIMPLY THE BEST SERIAL DECODER

Our serial decode, search and table tools work exactly the way you want. These tools are the industry standard for turning your oscilloscope into a protocol analyzer with fast and intuitive correlation of protocol data to the physical layer waveforms.

Intuitive, Color-Coded Overlays

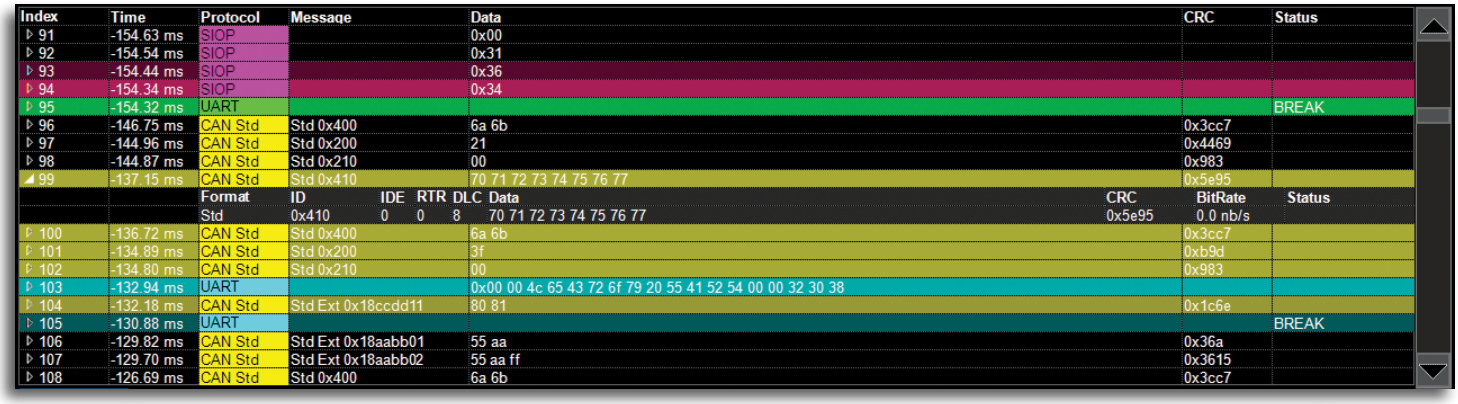
A transparent overlay with color-coding for specific portions of each protocol and the entire message frame makes it easy to understand your serial data information. Unlike other solutions, with protocol decode information away from the signal, our solution correlates the waveform and the protocol decode directly on the display. As the acquisition length is expanded or shortened, the decode overlay will adjust to show you just the right amount of information.





Pattern Search

All decoders provide the ability to search through a long record of decoded data by using a variety of search criteria, or values, or simply finding the next occurrence. Pattern Search automatically creates a zoom trace of the acquired waveform and displays the selected location complete with the transparent color-coded overlay.



Index	Time	Protocol	Message	Data	CRC	Status
91	-154.63 ms	SIOP		0x00		
92	-154.54 ms	SIOP		0x31		
93	-154.44 ms	SIOP		0x36		
94	-154.34 ms	SIOP		0x34		
95	-154.32 ms	UART				BREAK
96	-146.75 ms	CAN Std	Std 0x400	6a 6b	0x3cc7	
97	-144.96 ms	CAN Std	Std 0x200	21	0x4469	
98	-144.87 ms	CAN Std	Std 0x210	00	0x983	
99	-137.15 ms	CAN Std	Std 0x410	70 71 72 73 74 75 76 77	0x5e95	
		Format	ID	IDE RTR DLC Data	CRC	BitRate Status
		Std	0x410	0 0 8 70 71 72 73 74 75 76 77	0x5e95	0.0 nb/s
100	-136.72 ms	CAN Std	Std 0x400	6a 6b	0x3cc7	
101	-134.89 ms	CAN Std	Std 0x200	3f	0xb9d	
102	-134.80 ms	CAN Std	Std 0x210	00	0x983	
103	-132.94 ms	UART		0x00 00 4c 65 43 72 6f 79 20 55 41 52 54 00 00 32 30 38		
104	-132.18 ms	CAN Std	Std Ext 0x18ccdd11	80 81	0x1c6e	
105	-130.88 ms	UART				BREAK
106	-129.82 ms	CAN Std	Std Ext 0x18aabb01	55 aa	0x36a	
107	-129.70 ms	CAN Std	Std Ext 0x18aabb02	55 aa ff	0x3615	
108	-126.69 ms	CAN Std	Std 0x400	6a 6b	0x3cc7	

Interactive Table Summarizes Results

Turn the oscilloscope into a protocol analyzer with a tabular display of decoded information. Customize the table to show only the data of interest and touch a message in the table to automatically zoom to it and display it on the screen. Export the table for offline analysis. Up to four different decoded signals of any type may be simultaneously displayed in the table.

MEASUREMENT / GRAPHING - EXTEND YOUR KNOWLEDGE

Key Features

Timing measurements

- Serial Message to Analog Signal
- Analog Signal to Serial Message
- Serial Message to Serial Message

Serial DAC measurement/graphing

Bus status measurements

Automated – quickly gather statistics, display Histograms

Quickly correlate cause-effect timing relationships to other events

Conditional filtering

Supported for

- I^2C, SPI, UART and RS-232,
- 10Base-T1S, 100Base-T1/ BroadR-Reach
  CAN, CAN FD, CAN XL, and J1939
  FlexRay, LIN, SENT and SENT SPC
- ARINC 429, MIL-STD-1553, SPACEWIRE
- 10/100 Base-T Ethernet
- USB and USB-C Standards: USB 1.x, 2.0, USB 2.0 HSIC, USB Power Delivery (PD)
  USB4 Sideband (SB) Channel
- DisplayPort AUX Channel
- SMBus, PMBus, SPMI
- D-PHY, C-PHY, DigRF 3G, DigRF v4, I^3C
- I^2S, incl. LJ, RJ, TDM, Manchester and NRZ

The measurement and graphing capabilities significantly enhance our trigger and decode packages, and help you debug and validate faster.

Digital data can be extracted and rescaled to an analog value and graphed over time, time-correlated to other acquired data, as if you had probed it directly. It's a Serial Data DAC!

Automated cause-effect timing measurements can be made between analog signals and serial data messages, or two serial data messages. Use with serial triggering and long acquisitions to understand system behavior during stress or corner-case testing. A variety of bus status measurements are also available.

All measurements may be used with the rich set of standard Teledyne LeCroy standard parameter analysis tools, including automated pass/fail analysis with boolean test conditions, measurement gates, measurement accept, filtering, parameter math, and custom math.

Setup is easy in the Measure/Graph setup tab:

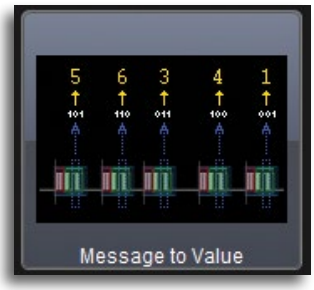
1. Choose the source
2. Choose the measurement
3. Select the destination parameter (e.g., P2)
4. Then apply and configure

Serial Data DAC and Graphing Tools

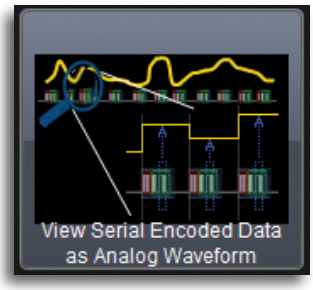
Digital data can be extracted from specific locations in the serial data message using the Message to Value measurement parameter - a serial data DAC. This information can then be displayed as a measurement parameter value(s), or it can be viewed as a time-correlated waveform displaying the measurement value over time - as if you were able to probe and acquire it directly. Use the long acquisition time of the oscilloscope to understand how the data changes over long periods of time, in conjunction with other system behaviors.

Some examples of the usefulness of this capability are:

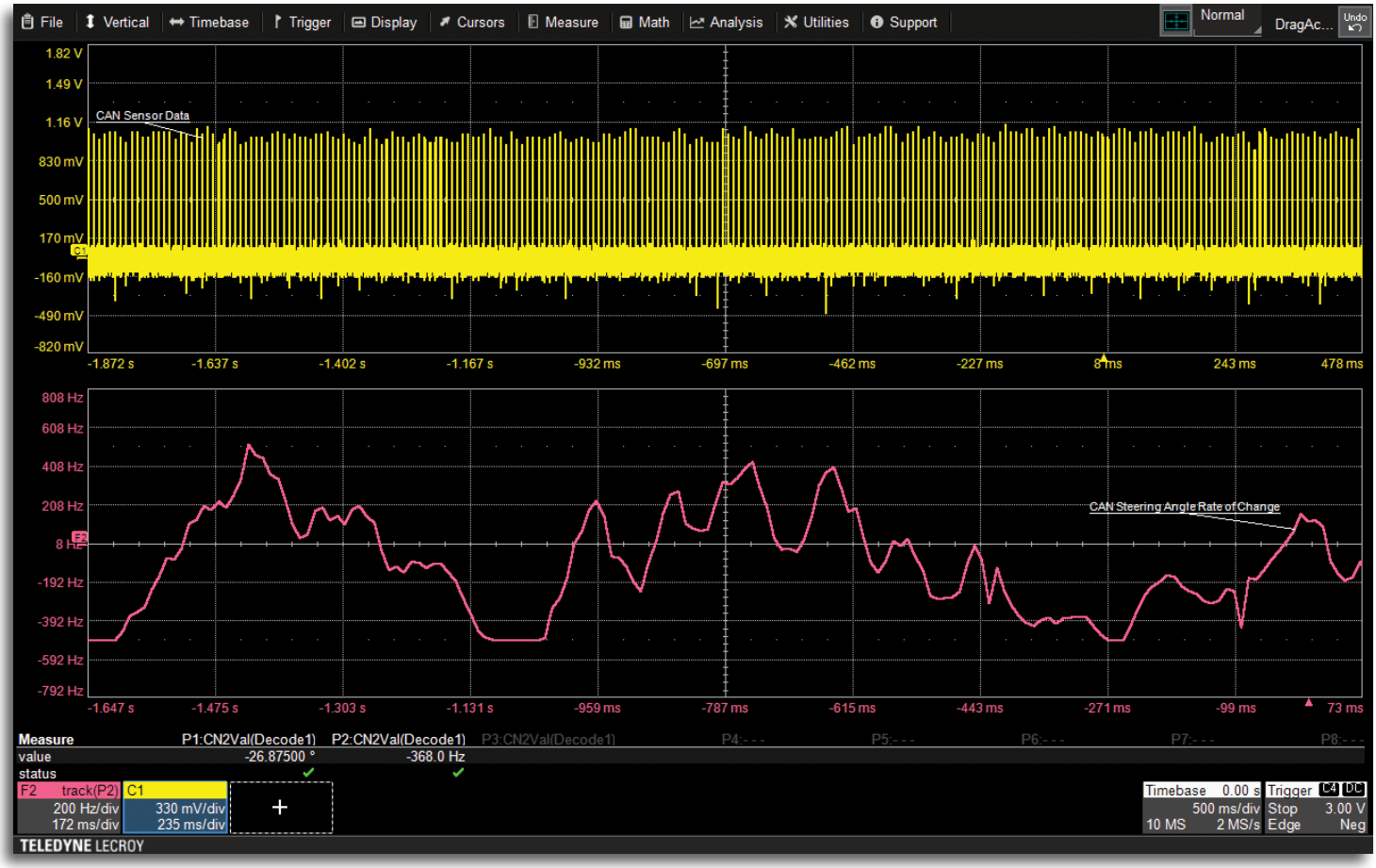
- Viewing I²C or SPI temperature sensor data
- Viewing DigRF 3G radio frequency I and Q modulated signals
- Viewing CAN wheel speed information used by an ABS
- Viewing reconstructed analog audio from serial I²S streams



Decoded data content of data payload of a protocol message meeting conditions.



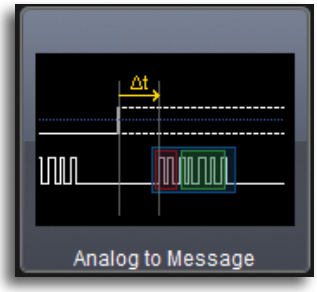
Applies a Track math operator to the Message to Value measurement to view Serial Encoded Data as an Analog Waveform.



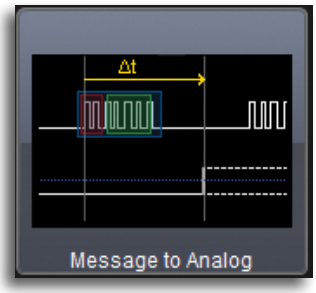
Shown above is a long acquisition of a CAN serial data signal (top waveform) that contains embedded digital data for steering wheel angle rate of change (deg/s, or Hz). The Message to Value parameter was configured to locate and extract the digital steering wheel angle range data from particular locations in specific CAN serial messages, and then converted from digital to analog form with proper re-scaling and physical units. The serial data DAC waveform (bottom waveform) is shown in the lower grid.

Automated Timing Measurements

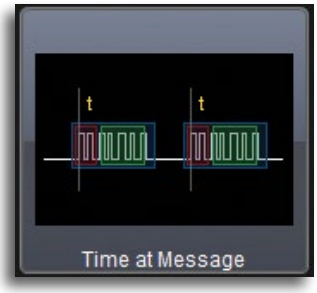
Utilize a serial trigger to isolate a specific message and then measure a cause-effect timing relationship with a subsequent analog signal, or vice versa. But instead of manually measuring the timing with cursors, use these tools to automate the measurement and return thousands of values quickly as your system undergoes stress testing. Automate the measurement and validation of gateway latency times from one serial message to another (e.g. CAN to LIN or low-speed CAN to high-speed CAN, or CAN to FlexRay) without having to manually use cursors or compare values and times in a protocol table. Quickly understand bus latency times or arbitration behaviors by measuring the difference between two messages on a single decoded waveform. Dramatically improve your validation efficiency and time to insight



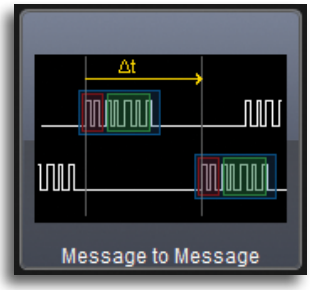
Analog to Message
Computes the time difference from a protocol message meeting specified conditions to the crossing of a threshold on an analog signal.



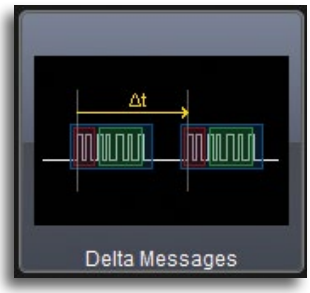
Message to Analog
Computes the time difference from a protocol message meeting specified conditions to the crossing of a threshold on an analog signal.



Time@Message
Time from Trigger to each protocol message meeting specified conditions.



Message to Message
Computes the time difference from a protocol message meeting specified conditions to another protocol message meeting specified conditions

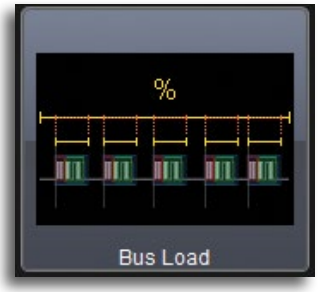


DeltaMessage Time
Computes the time difference between two messages on a single decoded line.

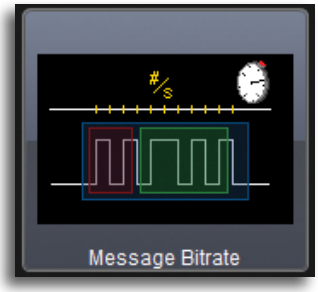
Use the Message to Analog measurement to find the time between an I²C data packet and a control signal on another channel. Multiple measurements in one or more triggers could be made to understand behaviors over time or under different operation conditions

Bus Status Measurements

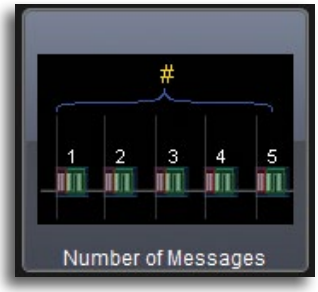
The bus status measurements Bus Load, Message Bitrate, and Number of Messages, give an overall status of the decode protocol to quickly learn if the bus is over utilized and to verify the bit rate matches expectations.



Message Bus Load %
Computes the load of user defined message in percent on the bus.



Message Bit Rate
Computes the bitrate of the user specified messages on the decoded trace.



Number of Messages
Computes the number of message matching user definition in a decoded trace.

The Perfect Oscilloscopes for the TDME Options

Teledyne LeCroy HDO, WavePro HD, and WaveRunner oscilloscopes are the perfect oscilloscope platforms to utilize the TD and TDME toolsets.

Teledyne LeCroy's 12-bit High Definition Oscilloscopes (HDOs), such as WaveRunner 8000HD, WavePro HD, HDO6000B, and WaveSurfer 4000HD provide 12-bit resolution and either 4 or 8 analog input channels up to 8 GHz with MSO digital input options. These oscilloscopes have powerful standard toolsets for debugging deeply embedded designs with analog, digital, serial data, and sensor signals. Their 12-bit resolution is ideal for measuring sensor signals and correlating them to other system activities. 8 analog input channels provides more ability to correlate more signals to each other.

Teledyne LeCroy 8-bit Oscilloscopes, such as the WaveRunner 9000 Series, are also extensively used for embedded system debug. Their standard toolsets complement the TDME packages extremely well.

EYE DIAGRAM AND PHYSICAL LAYER

Eye Diagrams are "bit-sliced" views of the physical layer serial data waveforms. They provide a fast, intuitive way to understand physical layer signal integrity. Eye Diagrams may be combined with masks and mask failure indications, and eye (opening) parameters. Protocols with challenging topologies (e.g. FlexRay) provide even more advanced measurement capabilities.

Key Features

Up to four simultaneous Eye Diagrams

Simple to set up - one button push

Include standard or custom masks - or create your own masks

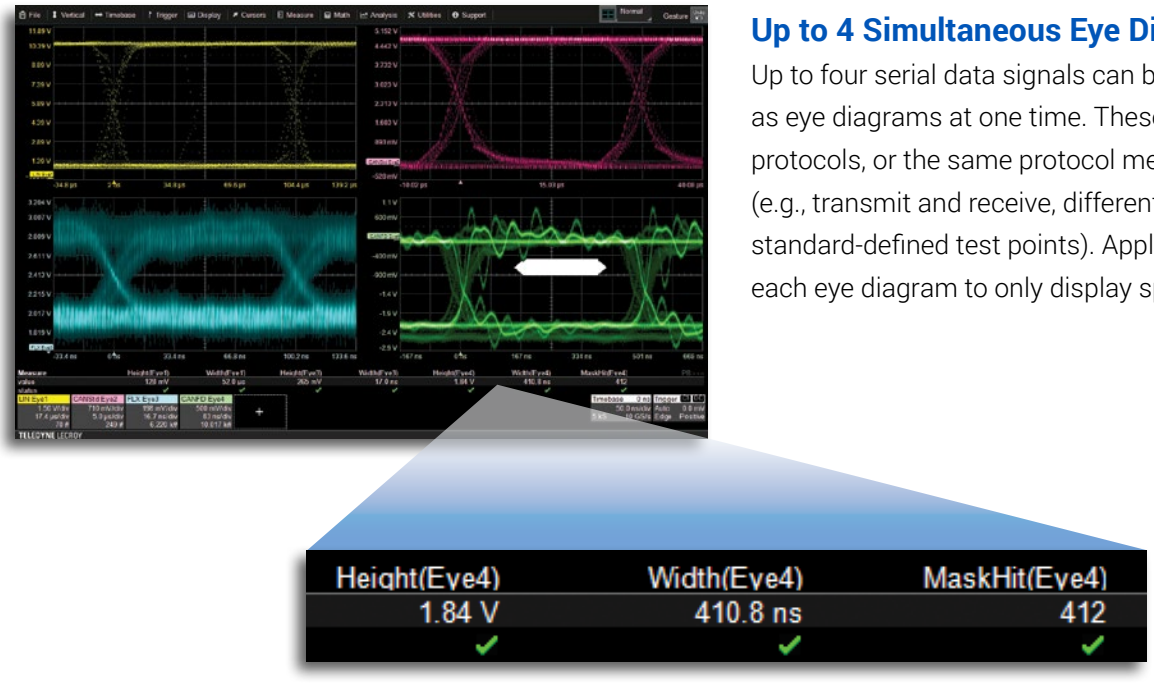
Eye parameters

Mask failure indication

Failure locator trace waveform

Pass/Fail with STOP on failure

Eye diagrams "slice" each bit and overlay them to get a consolidated view of signal quality. Intrusions into the eye opening or onto a mask indicate potential problems.



Up to 4 Simultaneous Eye Diagrams

Up to four serial data signals can be decoded and displayed as eye diagrams at one time. These can be different protocols, or the same protocol measured at different points (e.g., transmit and receive, different nodes, or different standard-defined test points). Apply a user-defined filter to each eye diagram to only display specific signals in the eye.

Eye Diagram Measurement Parameters

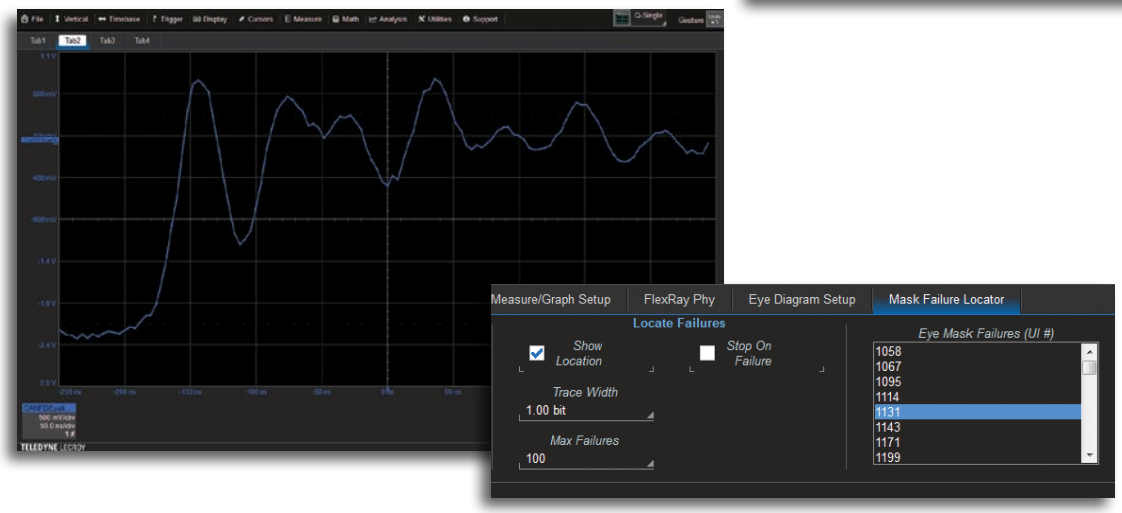
Quantify physical layer signal quality in the eye by applying parameters for Eye Height, Eye Width, and Number of Mask Failures. Some packages (e.g. FlexRay TDMP) go a step further and include additional measurements defined in the standard.

MASK AND MASK FAILURE INDICATION

E

Mask and Mask Failure Indication

A user-defined or pre-defined mask may be added to the eye diagram so as to objectively evaluate if the physical layer signal intrudes too far into the eye opening. Apply a filter to include or exclude specific messages from the Eye so as to determine failure source (e.g., messages from a specific node or with a specific ID). Mask failures are indicated with a red circle and can be displayed in a table. Touch the failure table to open a zoom of the failed area for further inspection.



PHYSICAL LAYER (EYE + ADVANCED MEASUREMENTS)

P

Some standards, due to their speed or complexity, provide specific guidance on what eye diagrams or measurements should be made and exactly how they should be performed. FlexRay, MIPI D-PHY, C-PHY, USB-PD, and DisplayPort AUX are examples. In these cases, the Eye Diagram ("E") capability is augmented with additional specialized "P" capability (for Physical Layer Measurements), per the standard. In these cases, the "E" capabilities previously described are also available.

Key Features

Set an ACK condition (ACK, NO ACK, Don't Care) in all frame trigger setups

Does not require clock trace to be displayed during decode

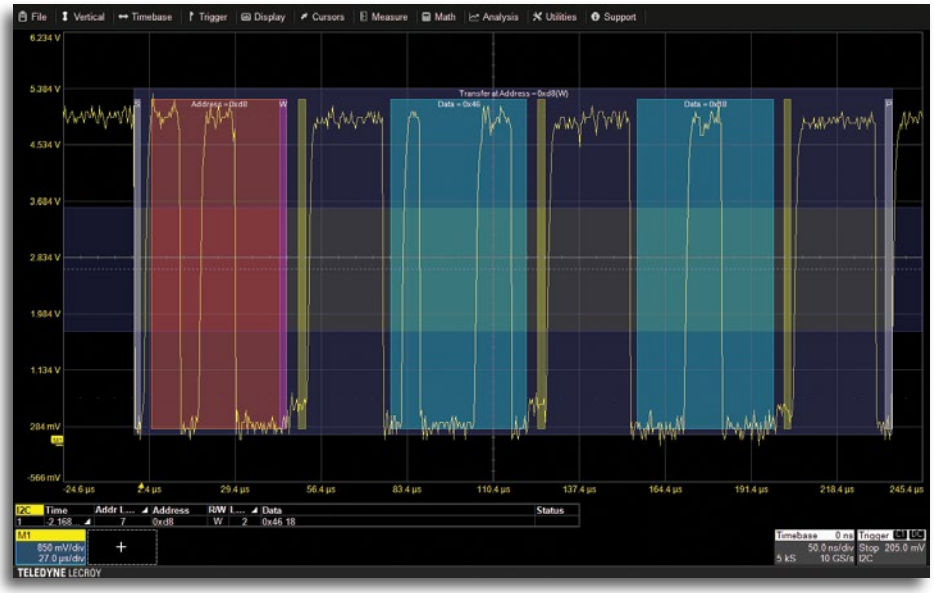
EEPROM read/write 2048 byte trigger capability

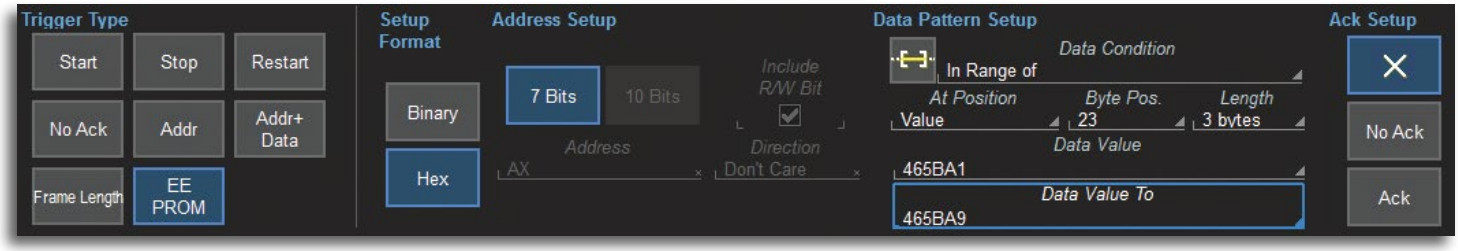
Frame Length trigger capability

Address can include a R/W bit, or define as Don't Care

Use analog or digital (MSO) inputs for acquisition and triggering

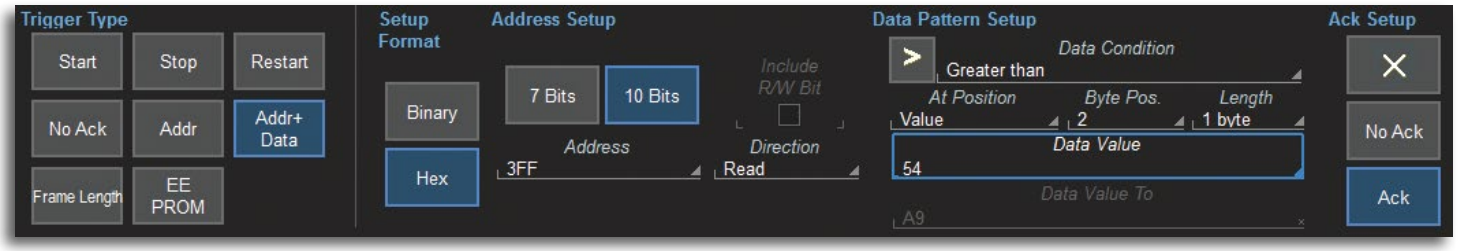
EXT input may be used for clock signal





More Trigger Choices

In addition to typical Start/Stop/ReStart, NoAck, Address and Address+Data triggers, Teledyne LeCroy provides triggering for EEPROM read/writes up to 2048 bytes long and for Frame Length. Address-based triggers permit an additional ACK condition (ACK present, NO ACK present, or DON'T CARE). and selection to include a R/W bit in a 7-bit trigger.



More Flexibility for Address-based Triggers

Address-based triggers permit an additional ACK condition (ACK present, NO ACK present, or DON'T CARE). and selection to define the transfer direction as a READ, WRITE or DON'T CARE (using R/W bit in a 7-bit trigger, or R/W Direction selection in a 10-bit trigger).

SPECIFICATIONS

I2Cbus TD and I2Cbus TDME	
Definition	
Source Setup	Select Source for Clock and Data.
Trigger Capability	
Format	Hexadecimal or Binary. ADDRESS and DATA can be set up with different formats.
Trigger Setup	Trigger on START, ReSTART, STOP, Missing ACK, ADDR, DATA, ADDR+DATA, ADDR+DATA FRAME LENGTH, EEPROM DATA TRANSFER
ADDRESS Setup	Specify one ADDRESS with condition of "=". 7 or 10 bit ADDRESS supported with full Read, Write, or R/W="Don't Care" selectability on both 7 and 10 bit ADDRESSes. Choose to Trigger on address values that include/don't include R/W bit in address value.
DATA Setup	ADDRESS+DATA Trigger Type: Hexadecimal: # Data Bytes = 0 to 12. Data can be defined by nibble. Binary: Any combination of 0,1, or X for 1-96 bits Data pattern can be set to start at any location in the 12 Byte / 96 bit sequence. ADDRESS+ DATA FRAME LENGTH Trigger Type: # Data Bytes = 0 to 2047. EEPROM DTA TRANSFER Trigger Type: # Data Bytes = 0 to 12. Data can be defined by nibble. Data pattern can be set to start at the beginning of any byte in an up to 2048 byte sequence.
DATA Conditions	<=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE.
ACK Conditions	For any ADDR, ADDR+DATA, ADDR+DATA FRAME LENGTH, or EEPROM DATA TRANSFER setup, select an ACK Condition of ACK, NO ACK, and DON'T CARE.
Bit Rates	Full range over I2C specification for Standard, Fast, Fast-Mode Plus, and High-Speed modes. Auto-detected.
Trigger Input	Any analog Channel or Digital input, or the EXT input. Clock may be input to EXT to conserve available analog Channels.
Decode + Search Capability	
Format	Hexadecimal, Binary, ASCII.
Decode Setup	Threshold definition required. Default is to Percent amplitude. Choose to Decode address values including/not including the R/W bit in address value.
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace. Clock channel may be turned OFF and data will still decode (reduces screen clutter)
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Visual Aid	Color Coding for FRAME, START/ReSTART bit, ADDR, R/W, DATA, ACK, NACK, and STOP bit. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search for Previous or Next ADDRESS, PACKET, or DATA in hexadecimal format.

I2Cbus TDME only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog**, **Analog to Message**, **Message to Message**, **ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger) measurement parameters. Serial Message may be defined by "ID =" (where applicable) and user-defined DATA condition of <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages**, **Message Bit Rate**, **Message Bus Load %**: Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

Key Features

Supports nearly any type of SPI, including simplified SPI with no Chip Select and SPI DDR

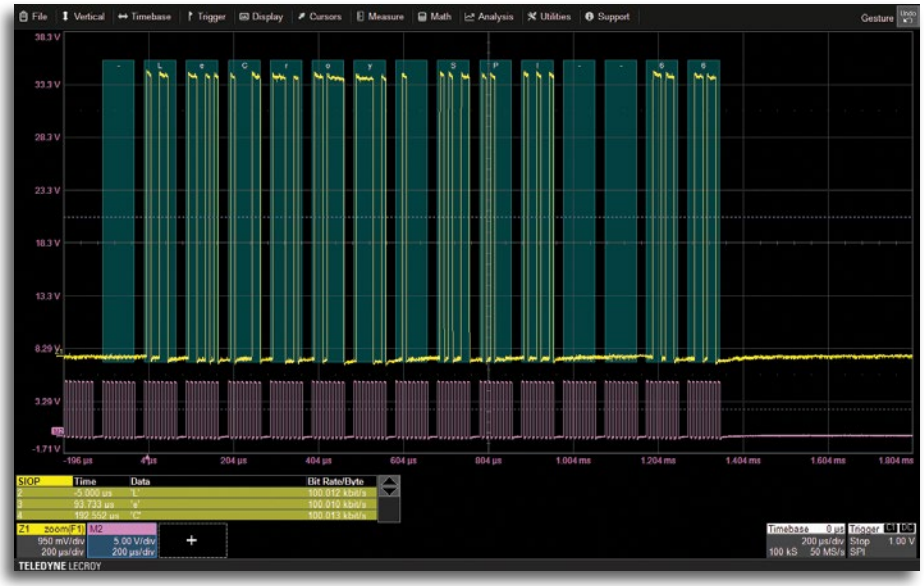
Interframe message time setup permits Frame definition for support of many proprietary USART-based protocols

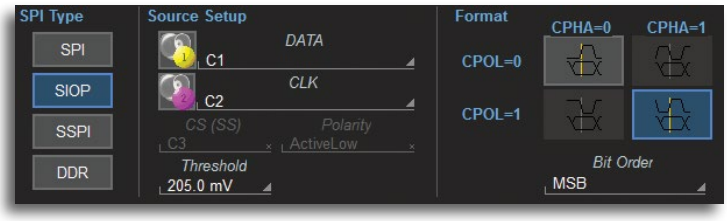
Flexible Bits/Word Decode Setup

Does not require clock trace to be displayed during decode

Use analog or digital (MSO) inputs for acquisition and triggering

EXT input may be used for clock signal



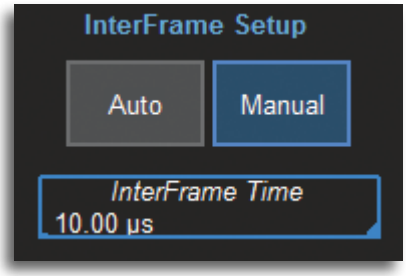


SPI Triggering When No Chip Select is Present

Most SPI triggers require that a Chip Select signal be present. However, simplified (single-master, single-slave) SPI (also referred to as SSPI or SIOP) has no Chip Select. Our solution still permits triggering on simplified SPI through use of an Interframe Setup time. In most cases, the AUTO default provides accurate results, but MANUAL selection is also available.

Interframe Message Time Setup for Proprietary USART-based Protocols

Two line (CLOCK and DATA) serial data signals with proprietary formats are sometimes used. This is commonly known as a USART. Given the flexibility of the setup of our trigger and decoder, it is often possible to use the Interframe Message Time Setup to "packetize" consecutive bytes into one Message Frame, and then trigger on serial data in a particular byte location in the complete multi-byte Frame. Then, SPI-CUSTOM may be used to decode information as a complete Frame instead of individual Bytes.



SPECIFICATIONS

SPIbus TD and SPIbus TDME	
Definition	
Source and Protocol Setup	Select Source for Clock, Data, and Chip/Slave Select (Chip/Slave Select not required for SIOP or SSPI types). Select SPI Type (SPI, SIOP, SSPI, or SPI-DDR). SPI Type CUSTOM is also available in the decoder. For SPI or SPI-Custom, select CPOL (Clock Polarity 0 or 1) and CPHA (DATA Polarity 0 or 1) (SIOP permits CPOL selection of 0 or 1, but CPHA =1; SSPI CPOL=1, CPHA=1; SPI-DDR does not have CPOL or CPHA selection). Select DATA = MSB or LSB. Select InterFrame Setup to Auto or Manual.
Trigger Capability	
Format	Hexadecimal or Binary
Trigger Setup	Trigger on DATA for any of the five SPI Modes with either MSB/LSB and with or without Slave Select. InterFrame Setup permits user-definition of expected maximum time between clock bits so as to permit triggering with CLOCK and DATA signals in the absence of a CHIP/SLAVE SELECT signal (SIOP or SSPI). Typically, the InterFrame AUTO default of 4x a bit length is sufficient, but this can be set to any value.
DATA Setup	Hexadecimal: # Data Bytes = 0 to 12. Data can be defined by nibble. Binary: Any combination of 0,1, or X for 1-96 bits Data pattern can be set to start at any location in the 12 Byte / 96 bit sequence. InterFrame Time Setup is available for SIOP, SSPI, and SPI-CUSTOM Types. This permits user-definition of expected maximum time between clock bits so as to permit decoding in the absence of a Chip/Slave Select signal. The InterFrame AUTO default of 4x a bit length is typically sufficient, but this can be set to any value up to 10 seconds. It also enables definition of multiple SPI (any Type) byte packets into a single long message package of multiple SPI Data bytes, over which up to 12 Data Bytes can be defined for triggering (as described above).
DATA Condition Setup	<=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE
Bit Rates	Any, up to 25 Mb/s (typical). Auto-detected from clock signal.
Trigger Input	Any analog Channel or Digital input, or the EXT input. Clock or Chip/Slave Select may be input to EXT to conserve available analog Channels.
Decode + Search Capability	
Format	Hexadecimal, Binary, ASCII
Decode Setup	Threshold definition required. Default is to Percent amplitude. Choose to Decode address values including/not including the R/W bit in address value.
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace. Clock channel may be turned OFF and data will still decode (reduces screen clutter)
# of Decoded Waveforms	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Visual Aid	Color Coding for FRAME, START/ReSTART bit, ADDR, R/W, DATA, ACK, NACK, and STOP bit. Decode information is intelligently annotated based on timebase setting.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search for Previous or Next MESSAGE or DATA Pattern in hexadecimal format.

SPIbus TDME only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger) Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages, Message Bit Rate, Message Bus Load %** Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

Key Features

Completely configurable UART-byte structure

Customizable Message Frame (multiple bytes in one Frame) for proprietary protocol triggering

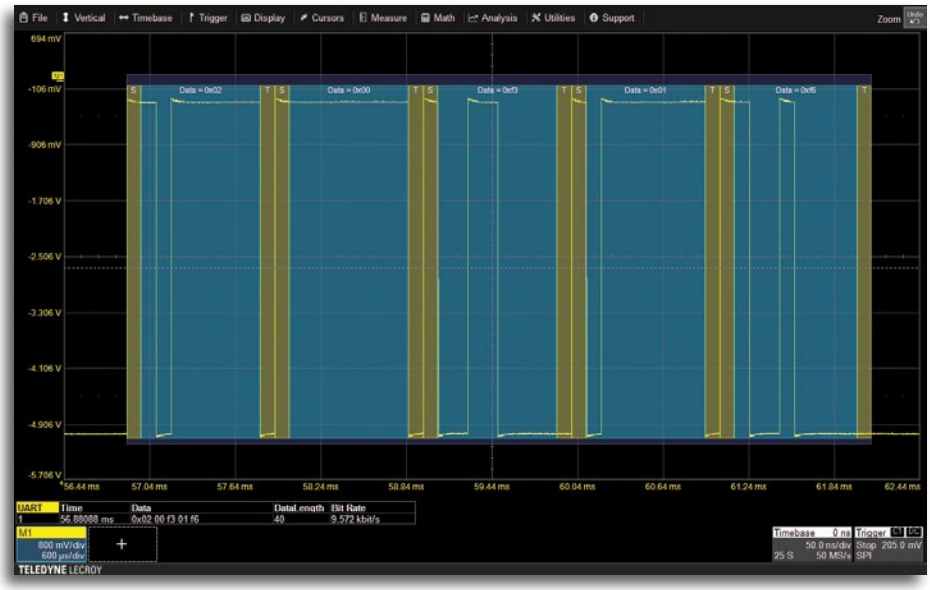
Supports 9-bit "address" or "wakeup" mode in byte definition (triggering and decoding)

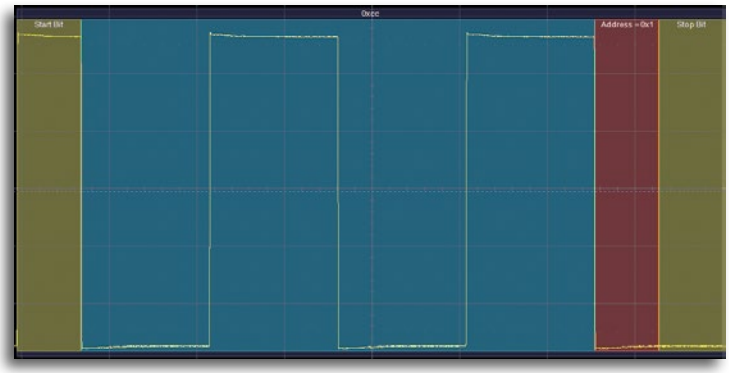
Supports up to 16-bit Data words for decoding

Binary, Hexadecimal, ASCII or Decimal decoding

Polarity either IdleLow or IdleHigh

Use analog or digital (MSO) inputs for acquisition and triggering



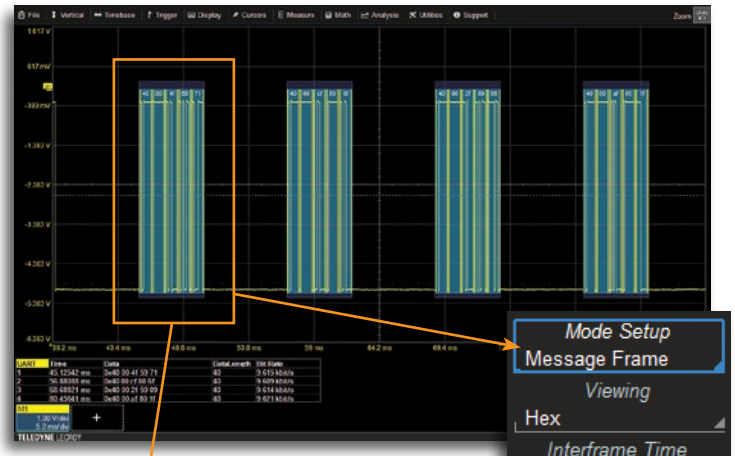


9-bit "Address" or "Wakeup" Triggering

Most UART triggers assume a maximum of 8 data bits (excluding stop/start and parity bits) in a single byte. However, our solution supports 9-bit data bytes for situations in which a UART protocol is utilized for Address, Wakeup or other communication to another peripheral, preceding the normal serial data byte transmission.

Interframe Message Time Setup for Proprietary UART-based Protocols

UART byte-based serial data signals with proprietary formats are often used. Given the flexibility of the setup of our trigger and decoder, it is often possible to use the Interframe Message Time Setup to "packetize" consecutive bytes into one Message Frame, and then trigger on in serial data in a particular byte location in the complete multi-byte Frame. Then, the UART decoder may be used to decode information as a complete Frame instead of individual Bytes.



UART	Time	Data	DataLength	Bit Rate
1	45.12542 ms	0x40 00 4f 59 71	40	9.615 kbit/s
2	56.88088 ms	0x40 00 cf 80 6f	40	9.609 kbit/s
3	68.68821 ms	0x40 00 2f 59 09	40	9.614 kbit/s
4	80.45641 ms	0x40 00 af 80 1f	40	9.621 kbit/s

SPECIFICATIONS

UART-RS232bus TD and UART-RS232bus TDME		
Definition		
Source and Protocol Setup	For UART: Select Source for Data Select BitRate Select # Data Bits (5-9) Select Parity (Odd, Even, None) Select # Stop Bits (1, 1.5, 2) Select Bit Order (MSB or LSB) Select Polarity (IdleLow or IdleHigh)	For RS-232: Select Source for Data Select BitRate Select # Data Bits (5-8) Select Parity (Odd, Even, None) Select # Stop Bits (1, 1.5, 2)
Trigger Capability		
Format	Hexadecimal or Binary	
Trigger Setup	Trigger on DATA or Parity Error	
DATA Setup	Hexadecimal: # Data Bytes = 0 to 12. Data can be defined by nibble. Binary: Any combination of 0,1, or X for 1-96 bits Data pattern can be set to start at any location in the 12 Byte / 96 bit sequence. "Frame" definition permits definition of UART byte packets into a single long message package through a user-defined "Interframe Time" value. In this mode, a 12-bit Data pattern can be defined anywhere in a 2048 UART byte message frame.	
DATA Condition Setup	<=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE	
Bit Rates	User-defined to any nominal value from 300 b/s to 10 Mb/s	
Decode + Search Capability		
Format	Hexadecimal, Binary, ASCII	
Decode Setup	Threshold definition required. Default is to Percent amplitude. Select BitRate, # Data Bits (5 to 16), Parity (NONE, ODD, EVEN), # Stop Bits (1 or 2), Bit Order (MSB or LSB), and Polarity (IDLE HIGH or IDLE LOW) (for RS-232, no Bit Order or Polarity setup). Frame definition permits definition of UART byte packets into a single long (decoded) message package through a user-defined "Interframe Time" value.	
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace.	
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).	
Visual Aid	Color Coding for START Bit, STOP Bit, PARITY Bit, and DATA bytes. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.	
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.	
Pattern Search	Search for Previous or Next ERROR or DATA Byte in hexadecimal format.	

UART-RS232bus TDME only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger) Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages, Message Bit Rate, Message Bus Load %** Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	"Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

Key Features

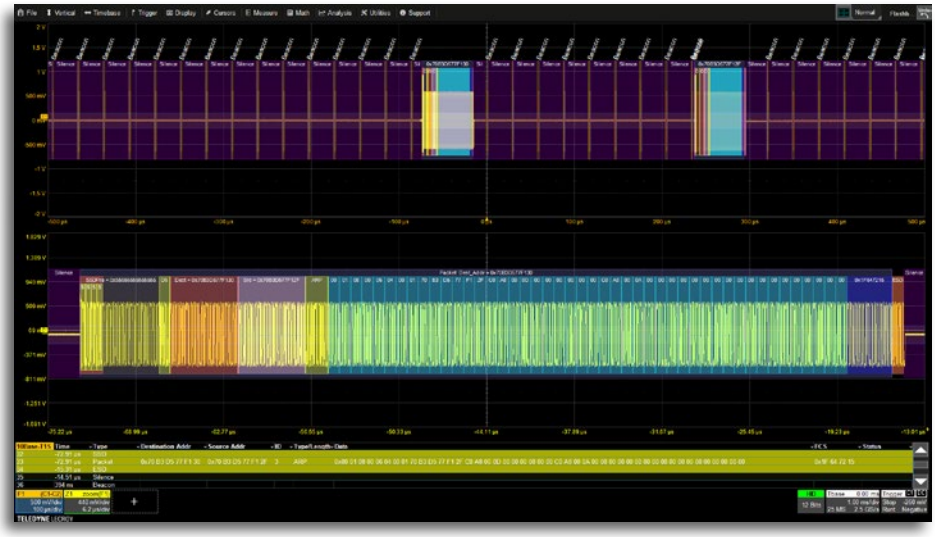
Trigger on Beacon, ID, ID + DATA, Commit/Sync, ESD and CRC-Error

Automatically identifying Node ID simplifies setting up the trigger / decoder

Filtering by node ID and Eye Diagrams identify physical layer issues

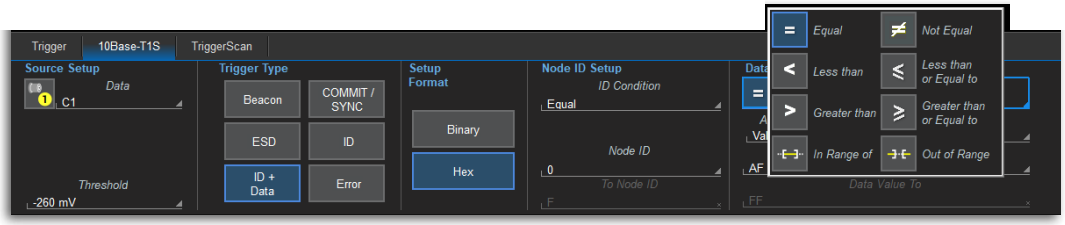
Unique measure/graph capabilities:

- Verify PLCA timing with automated measurements
- Serial DAC - extract digital data and plot it as a waveform



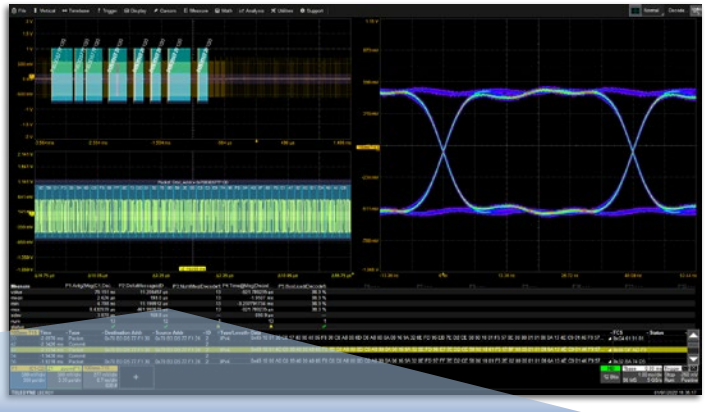
Comprehensive and Powerful 10Base-T1S Trigger

Capability is provided to permit triggering on Beacon, ID, ID + DATA, Commit/Sync, ESD and CRC-Error. Trigger on Data with full capability to define specific data values or ranges of data values up to 12bytes within the complete data field. The automatic assignment of note ID to MAC address based on analyzing the PLCA cycle simplifies the setting up of the trigger/decoder function.



Great tools for identifying physical layer issues

The possibility of filtering the decoded data by specific node ID together with the display of eye diagram and the bus specific timing measurements helps to identify problems on the physical layer and in the PLCA cycle.



Measure	P1:Anlg2Msg(C1,Dec...	P2:DeltaMessages(D...	P3:NumMsg(Decode1)	P4:Time@Msg(Decod...	P5:BusLoad(Decode1)
value	79.151 ns	11.208457 µs	13	-921.789235 µs	38.3 %
mean	2.626 µs	193.0 µs	13	-1.9507 ms	38.3 %
min	4.788 ns	11.199912 µs	13	-3.237791734 ms	38.3 %
max	8.432939 µs	461.992070 µs	13	-921.789235 µs	38.3 %
sdev	3.870 µs	168.8 µs	---	690.9 µs	---
num	13	12	1	13	1
status	✓	✓	⚠	⚠	✓

SPECIFICATIONS

10Base-T1S TD and 10Base-T1S TDME	
Definition	
Source and Protocol Setup	Select Source.
Trigger Capability	
Format	Hexadecimal or Binary.
Trigger Setup	Trigger on Beacon, COMMIT/SYNC, ESD (ESDOK, ESDERR, ESDJAB), ID, ID+DATA and Errors.
ADDRESS Setup	Specify Frame ID(s) in Hexadecimal or Binary with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE.
DATA Setup	Hexadecimal: # Data Bytes = 0 to 12. Binary: Any combination of 0,1, or X for 1-96 bits Data pattern can be up to 12byte (96bit) and can be set to start at any location in the data sequence.
DATA Condition Setup	<=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE.
Trigger Input	Any analog Channel or Digital input, or the EXT input. External MSO not supported.
Decode + Search Capability	
Format	Hexadecimal or Binary.
Decode Setup	Select Probing Type (Differential Probe, Single-ended Probes) Define level or use Auto Levels.
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace.
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Location	Overlaid on acquired waveform, on Grid.
Visual Aid	Color Coding for Beacon, COMMIT, Preamble, SFD, Destination Address, Source Address, Type/Length, Data, FCS, ESD and Idle. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search for previous or next: Index, Time, Type, Destination Address, Source Address, Type/Length, Data, FCS and Status.

10Base-T1S TDME only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value measurement parameter** extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger). Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages, Message Bit Rate, Message Bus Load %** Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Apply to Zoom, Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits, Failure Location.
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

Key Features

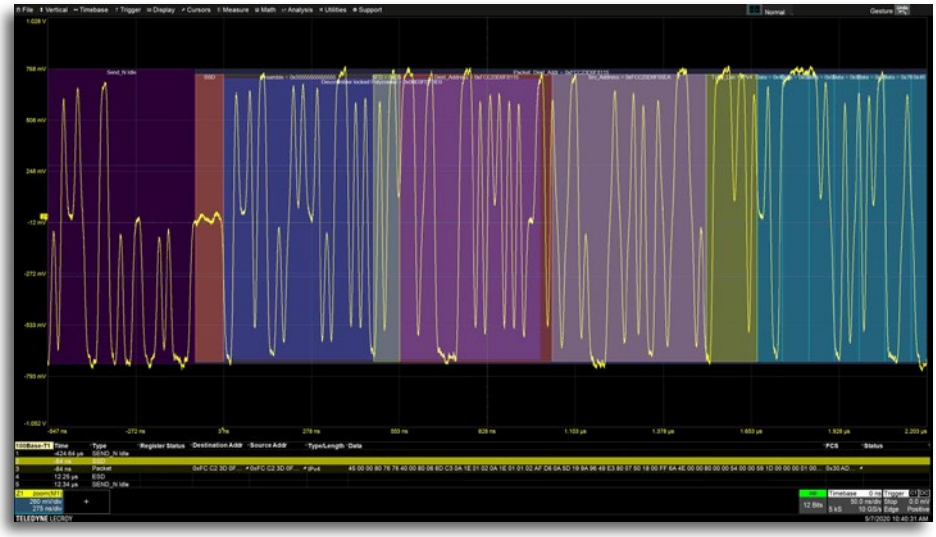
Trigger on Link Startup

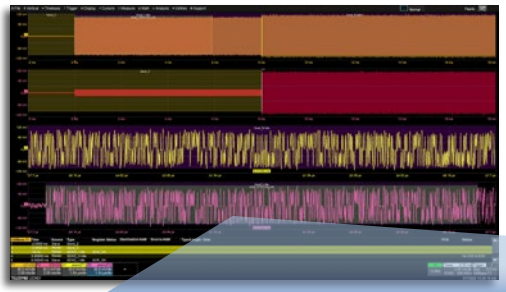
Debug Link Startup Handshaking

Descramble Data Packets

Enhanced Signal Separation

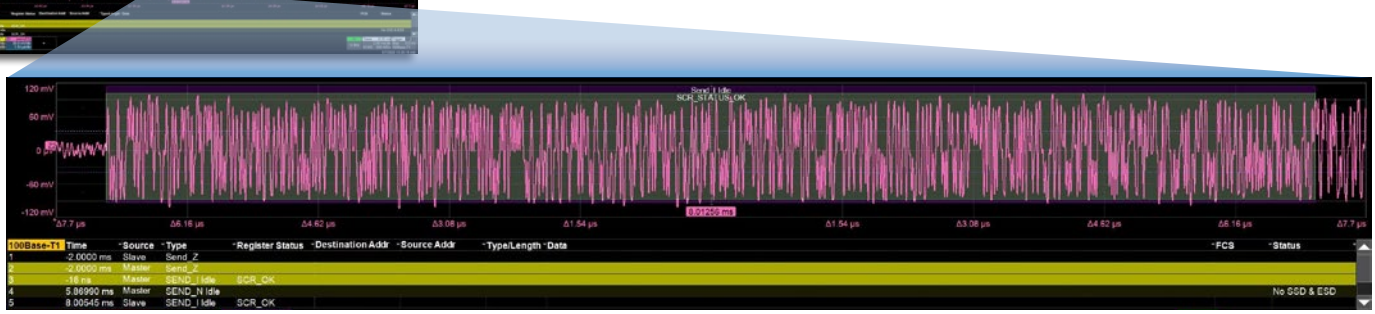
Identify Link Startup and Packet Errors





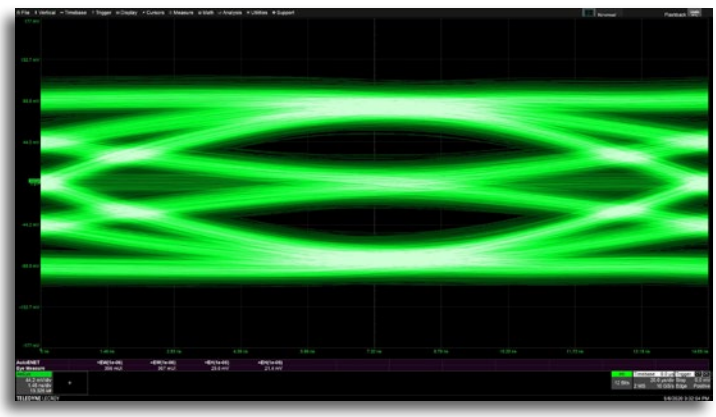
Debug Link Startup

Trigger on and decode the link startup handshaking between the Master and Slave. Track where the devices are in the handshaking sequence to determine the cause of a proper link not being established.

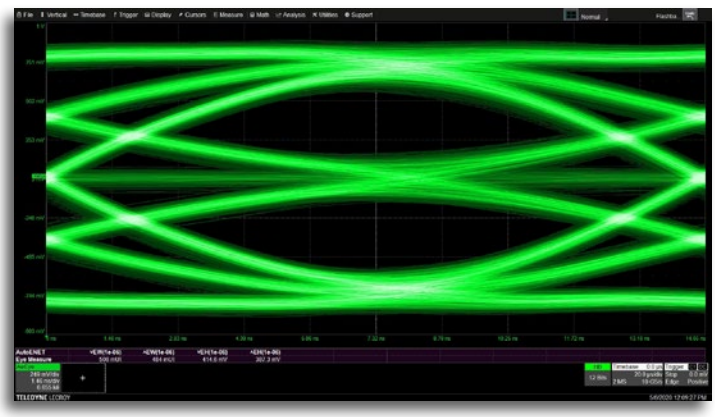


Enhanced Signal Separation

The TF-AUTO-ENET separates bi-directional link traffic to independently view signals from the Master and Slave. The software enhances the directivity of the directional couplers in real time, providing superior signal fidelity compared to other directional coupler approaches.



Before



After software enhancement to improve the directivity.

SPECIFICATIONS

100Base-T1 TD and 100Base-T1 TDME	
Definition	
Source and Protocol Setup	Select Source(s) for Master and/or Slave.
Trigger Capability	
Trigger Setup	Trigger on Master or Slave Start-up Sequence.
Trigger Input	Any analog Channel or the EXT input.
Trigger Design	Internal to oscilloscope, settable like any other oscilloscope trigger.
Decode + Search Capability	
Format	Ternary symbols or Descrambled bits (Hexadecimal).
Decode Setup	Select Probing Type (Differential Probe, Single-ended Probes). Define High and Low levels for each selected direction or use Auto Levels.
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace.
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Location	Overlaid on acquired waveform, on Grid.
Visual Aid	Color Coding for Packet, SSD, ESD, Preamble, SFD, Destination Address, Source Address, Type/Length, Data, FCS, Descrambler Locked Polynomial, and Idle. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search for previous or next: Index, Time, and Type.

100Base-T1 TDME only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger). Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages, Message Bit Rate, Message Bus Load %.** Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits.
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

Key Features

Symbolic trigger setup, decode, and data extraction and graph setup using (customer-supplied) DBC or ARXML file

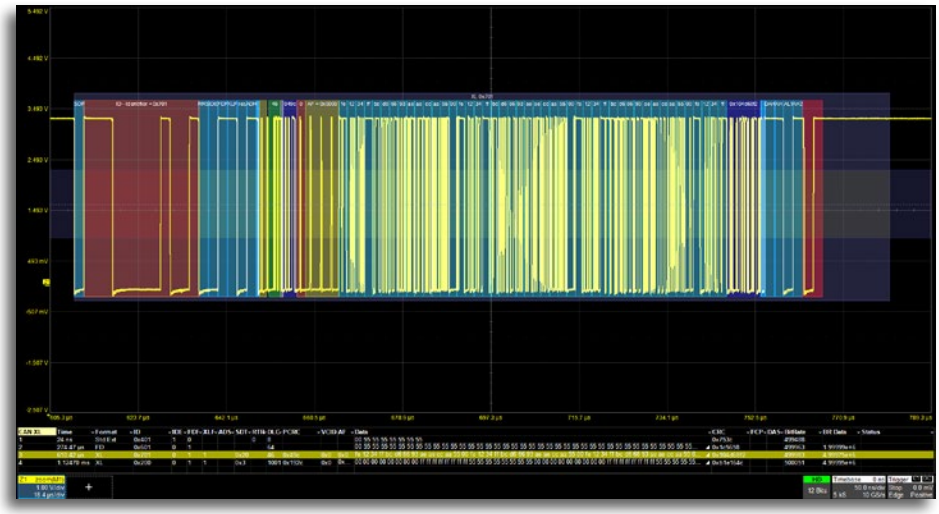
Error-frame red color decode highlight

DATA trigger pattern setup can be less than full bytes/nibbles and can be spread across bytes

Conditional ID definition (<, <=, =, >, >=, <>, IN RANGE, OUT of RANGE)

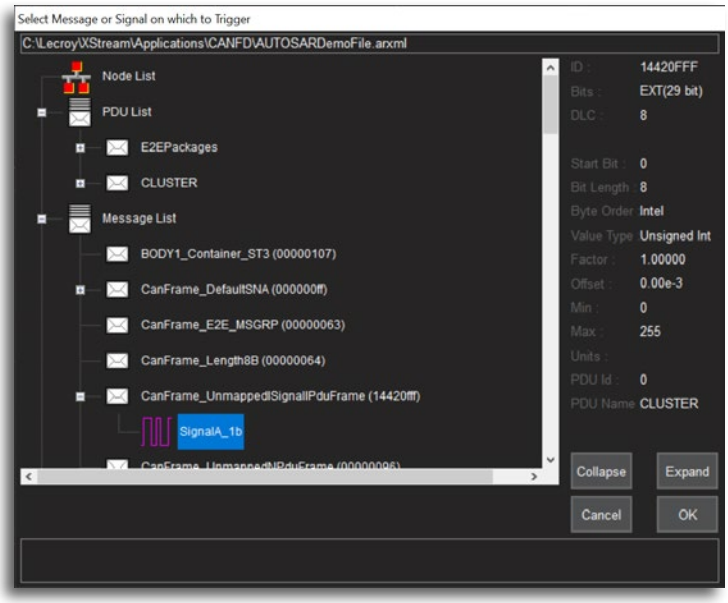
Supports 29-bit GM CAN Priority ID, Source ID, Parameter ID trigger and decode

Supports CAN XL SIC and FAST mode up to 20Mb/s



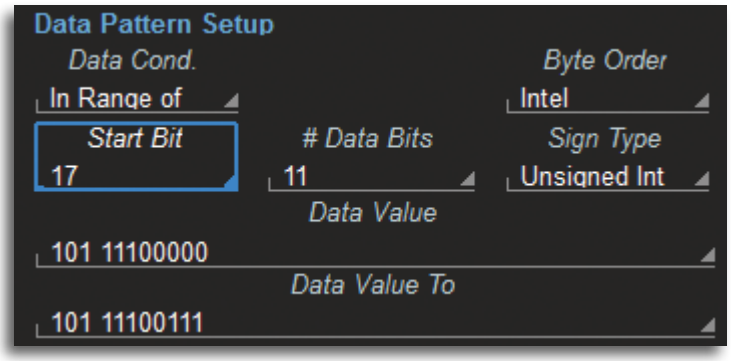
Symbolic (DBC & ARXML) File Support

CAN, CAN FD and CAN-XL decode options support use of a customer-supplied DBC or ARXML file for signal selection for triggering and CAN to Value serial data DAC setup. Additionally, the decode annotation is in Symbolic format as well, with complete message and signal structures described.



Trigger Flexibly Across Data Bytes

CAN remains the most used vehicle serial data bus. Many vehicle bus software architectures are very message dense, and data for a single message is spread across multiple data bytes. The hexadecimal and measurement toolsets permit isolation of specific bit-level data patterns in one or more data bytes, e.g., data location in bits 17-28 in data bytes 3, 4, and 5. This provides significant advantages in isolating the exact information or behavior you need. Symbolic message/signal setup is even simpler.



SPECIFICATIONS

	CAN FDbus TD CAN XL TD	CAN FDbus TDME Symbolic CAN XL TDME Symbolic
Definition		
Protocol Setup	CAN FDbus and CAN XL Select Source. Select Nominal BitRate for CAN FDbus and CAN XL select Data BitRate. **CAN FDbus:** Select Frame Type (EDL) Any(X), CAN Standard (0), or CAN FD (1). Select ISO FRAME, and BR Select (BRS) Any(X), Normal(0), or FD(1). **CAN XL:** Select Frame Type Any, CAN Std, CAN FD or CAN XL. Select CAN-XL FAST and BR Select (BRS) Any(X), Normal (0), FD(1).	
Trigger Capability		
Format	**CAN FDbus:** Hexadecimal or Binary for ID and Data **CAN XL:** Hexadecimal or Binary for ID, Data and VICD.	**CAN FDbus:** Symbolic, Hexadecimal or Binary for ID and Data **CAN XL:** Symbolic, Hexadecimal or Binary for ID, Data and VICD .
Trigger Setup	**CAN FDbus:** Trigger on ID, ID+DATA, REMOTE, ERROR or ALL (Data, Remote, or Error Frame) frames. **CAN XL**: Trigger on ID, ID+DATA, REMOTE, ERROR, SDT, VCID or ALL (Data, Remote, or Error Frame) frames. Set Requested (Bit) Sampling Point from 20 to 90% (Basic) or set values for Prop Seg, Phase_Seg1, Phase_Seg2, and SJW for (Advanced) independently for Nominal Bit TIme, FD Bit Time and XL Bit Time.	
ID Setup	**Hexadecimal or Binary:** Specify STD (11-bit), EXT (29-bit) or Any; ID(s) with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE. Supports triggering when both 11-bit and 29-bit IDs are present on the bus.	**Symbolic:** Specify a Message to trigger on using customer supplied DBC or ARXML database file. Choose from list sorted by Node, Message, or Signal. **Hexadecimal or Binary:** Specify STD (11-bit) or EXT (29-bit) ID(s) with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE. Supports triggering when both 11-bit and 29-bit IDs are present on the bus.
DATA Setup	**Hexadecimal:** # Data Bytes = 0 to 24 Data bytes can be defined by nibble. **Binary:** Any combination of 0,1, or X for 1-96bits. Data pattern can be any length and can be set to start at any location in the up to 512 (CAN & CAN FD) or 16384(CAN XL) bit sequence. Byte Order Intel or Motorola format, Signed or Unsigned Data.	**Symbolic:** Message+Signal with Signal value set in scaled units as defined in customer supplied DBC/ARXML database file. **Hexadecimal:** # Data Bytes = 0 to 24 Data bytes can be defined by nibble. **Binary:** Any combination of 0,1, or X for 1-96bits. Data pattern can be any length and can be set to start at any location in the up to 512 (CAN & CAN FD) or 16384(CAN XL) bit sequence. Byte Order Intel or Motorola format, Signed or Unsigned Data.
DATA Cond. Setup	<=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE (not available for bitrates >15Mb/s).	
Error Frame Setup	Select any combination of All Error Frames, Stuff Bit Errors, CRC Mismatch Errors, Stuffbit Counter Error, or Stuffbit Counter Parity Error CAN XL : Form, Ack, PCRC Preface, FCP Fomat and FCRC Frame CRC (not available for bitrates >15Mb/s).	
Remote Frame Setup	Supported for ID. Capability identical to ID Condition Setup (not available for bitrates >15Mb/s).	
Bit Rates	**Nominal Bit Rate:** 10, 25, 33.333, 50, 83.333, 100, 125, 250, 500 kb/s, or 1 Mb/s pre-defined nominal values, or user-defined to any nominal value from 10 kb/s to 1 Mb/s. **Data Bit Rate FD:** 0.5, 1.0, 1.5, 2.0, 5.0, 8.0, or 10 Mb/s pre-defined nominal values, or user-defined to any nominal value from 0.5 to 10 Mb/s. **Data Bit Rate XL:** 0.5, 1.0, 1.5, 2.0, 5.0, 8.0, 10, 12, or 20 Mb/s pre-defined nominal values, or user-defined to any nominal value from 0.5 to 20 Mb/s.	
Trigger Input	Any analog Channel or Digital input, or the EXT input.	
Decode + Search Capability		
Format	Hexadecimal.	Symbolic (Message and Signal level) or Hexadecimal. Symbolic decode requires user-provided DBC orARXML database file.
Decode Setup	Threshold definition required. Default is to Percent amplitude.	
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace.	
# of Decode Wfms	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).	
Location	Overlaid on acquired waveform, on Grid.	
Visual Aid	**Hexadecimal:** Color Coding for FRAME, ID, IDE, RTR, SRR, RRS, FDF, XLF,Res/ Res-XL, BRS, ESI/ADS, SDT, SEC, DLC, SBC, PCRC, VCID, AF, DATA, CRC, PCRC, FCP, DAS, ACK, STUFF BITS, BIT INDEX and ERRORs. Error Frames are decoded whenever possible, with uncorrupted portions decoded to Identify Type. In all cases, decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.	**Symbolic:** Color Coding for FRAME, ID, IDE, RTR, SRR, RRS, FDF, XLF,Res/ Res-XL, BRS, ESI/ADS, SDT, SEC, DLC, SBC, PCRC, VCID, AF, DATA, CRC, PCRC, FCP, DAS, ACK, STUFF BITS, BIT INDEX and ERRORs. Includes textual Message name, physical Signal value with units, and decode ARXML PDU ID and name. Error Frames are decoded whenever possible, with uncorrupted portions decoded to Identify Type. **Hexadecimal:** Color Coding for FRAME, ID, IDE, RTR, SRR, RRS, FDF, XLF,Res/ Res-XL, BRS, ESI/ADS, SDT, SEC, DLC, SBC, PCRC, VCID, AF, DATA, CRC, PCRC, FCP, DAS, ACK, STUFF BITS, BIT INDEX and ERRORs. Error Frames are decoded whenever possible, with uncorrupted portions decoded to Identify Type. In all cases, decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.	
Pattern Search	CAN FDbus: Search for Previous or Next Index, ID, IDE, DLC, DATA, and STATUS CAN XL: Search for Previous or Next Index, Idx, ID, IDE, FDF, XLF, ADS, SDT, BRS, ESI, DLC, PCRC, VCID, AF, CRC, FCP, DAS, CL, or STATUS.	
	CAN FDbus Symbolic, CAN XL Symbolic only	
Measure / Graph Capability		
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value measurement parameter** extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.	
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message (**time from trigger) Serial Message may be defined by "'ID ='" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.	
Bus Status Measurements	**Number of Messages, Message Bit Rate, Message Bus Load %** Serial Message may be defined by "'ID ='" (where applicable) and user-defined "'DATA <=, <, =, >, >=, <>, in range, out of range'" in any location in up to 2048 bits of data.	
Eye Diagram Capability		
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%. Apply to Zoom, Auto Scale.	
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits.	
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use. A variety of standard CAN masks are also provided.	
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.	

Key Features

The most comprehensive oscilloscope-based FlexRay solution

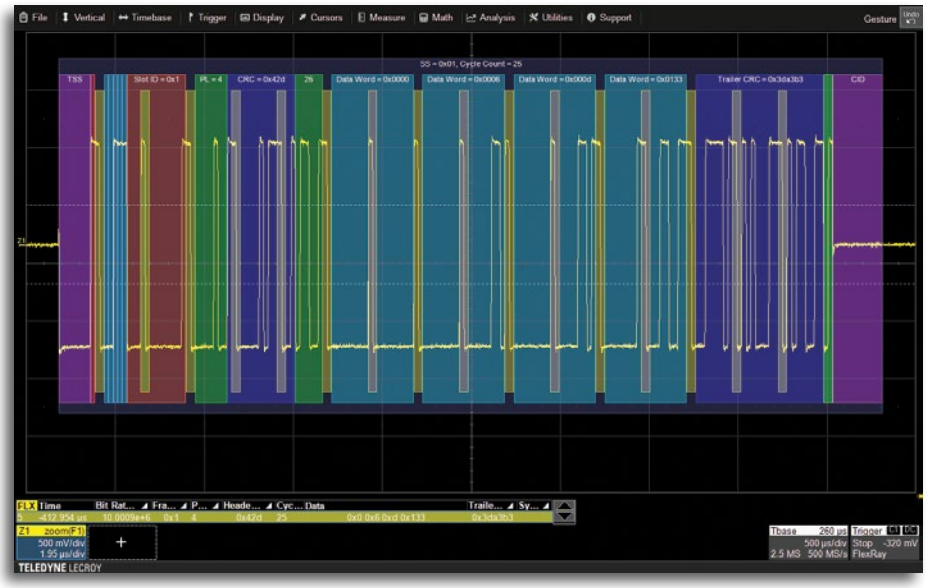
Supports triggering for:

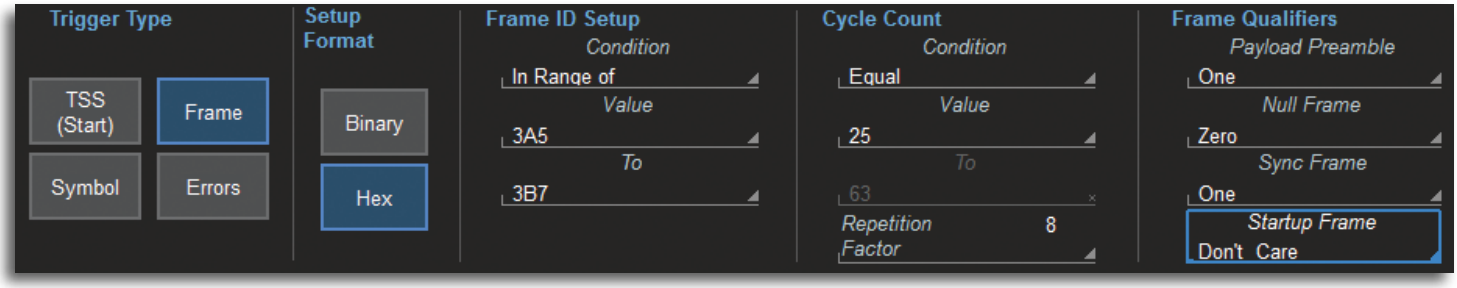
- Frame ID (Static and Dynamic)
- Frame Cycle Count
- Frame Qualifiers
- Symbols
- Errors

Physical Layer Measurements

- Propagation Delay
- Asymmetric Delay
- Truncation
- Jitter
- SI Voting

Supports 2.5, 5 and 10 Mb/s signals



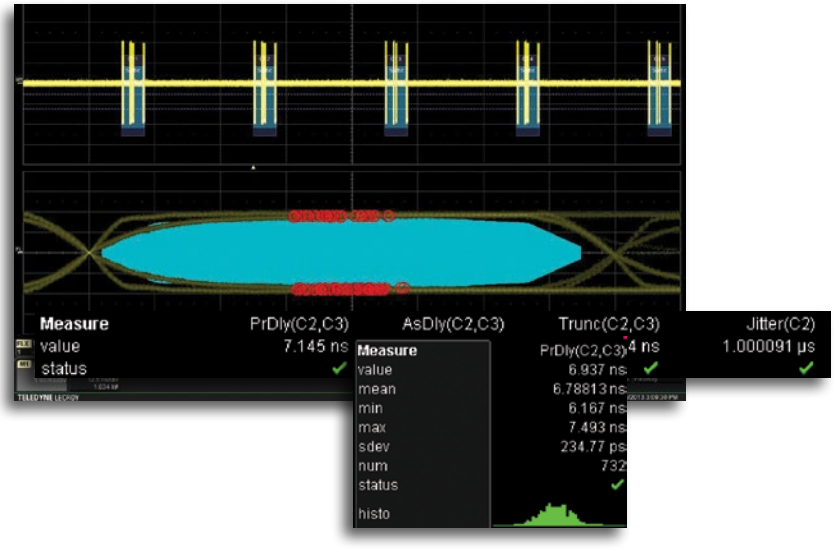


Extensive Triggering Capabilities

Triggering on the complex FlexRay protocol is made easy. Set up a simple TSS (Start) symbol trigger with a single button press or trigger on any part of a FlexRay frame including ID, Cycle Count, Cycle Repetition Factor, and Frame Qualifier. FlexRay defined Symbols and Errors can also be incorporated into the trigger making it as simple or advanced as necessary. Conditional triggering can be set to trigger on any range of Frame IDs or Cycles.

Powerful Physical Layer Test

FlexRay eye diagram mask test overlays all the bits on FlexRay signal in an eye diagram with user-selected masks. Trigger on a specific Frame ID or range of IDs, or filter one long acquisition specific IDs, and show only those messages in the eye diagram. Supports SI Voting. Key timing parameters like Propagation Delay, Asymmetric Delay, Truncation and Jitter help you understand how signals propagate along the channel. Use statistics and histicons for deeper insight.



SPECIFICATIONS

FLEXRAYbus TD and FLEXRAYbus TDMP	
Definition	
Source and Protocol Setup	Select Source. Select BitRate. Select FlexRay Channel A or Channel B.
Trigger Capability	
Format	Hexadecimal or Binary for Frame ID. Decimal for Cycle Count.
Trigger Setup	Trigger on TSS (Start), Frame ID, Cycle Count, Symbols, and Errors
FRAME Setup	Specify Frame ID(s) in Hexadecimal or Binary with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE. Specify Cycle Count from 0 to 63 with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE. Specify Repetition Factor as 1, 2, 4, 8, 16, 32, or 64. Specify various Frame Qualifiers (Payload Preamble, Null Frame, Sync Frame, and Startup Frame) as 0, 1, or X (don't care).
DATA Setup	Hexadecimal: # Data Bytes = 0 to 8. Data can be defined by nibble. Binary: Any combination of 0,1, or X for 1-64 bits Data pattern can be any length and can be set to start at any location in the up to 8 Byte / 64 bit sequence.
Error Setup	Trigger on any combination of the following errors: Frame Start Sequence (FSS) Error – triggers when the logic high time between the TSS and the first byte is too long. Byte Start Sequence (BSS) Error – triggers anytime the BSS pattern is not seen between bytes where expected. Frame End Sequence (FES) Error – triggers when the FS is not seen after the last byte. Header CRC Error, Payload CRC Error (select Payload Channel A or B).
Symbol Trigger	Trigger on any combination of the following: Channel Idle Delimiter (CID) Symbol, Collision Avoidance Symbol (CAS) and/or Media Access Test Symbol (MTS), or Wakeup Pattern (WUP)
Bit Rates	2.5, 5, or 10 Mb/s pre-defined nominal values, or user-defined nominal values in 1 Mb/s increments
Trigger Input	Any analog Channel or the EXT input.
Decode + Search Capability	
Format	Hexadecimal, excepting Cycle Count (Decimal)
Decode Setup	Threshold definition required for High and Low levels. Default is to Absolute (in volts) amplitude. Select Channel (A or B).
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace.
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Visual Aid	Color Coding for FRAME, TSS, CID, FSS, Frame Qualifiers, Slot ID, Payload Length, Header CRC, Cycle Count, Data, BSS, Payload CRC and FES. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search by Previous or Next Frame, Next ID (hexadecimal format), or Next Error Frame.

FLEXRAYbus TDMP only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger). Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages, Message Bit Rate, Message Bus Load %.** Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	FlexRay PHY: Supports SI Voting (ON or OFF). With SI Voting ON, with voting selection for Positive Bit Length, Negative Bit Length (or both), and Filtered Input is possible. With SI Voting OFF, Any combination of Propagation Delay, Asymmetric Delay, Frame TSS Length Change, or Jitter. Eye Diagram: Eye Height, Eye Width, (Number of) Mask Hits
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use. Standard FlexRay TP1, TP1 Bus Driver, TP11, and TP11 Active Star are also provided.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

Key Features

LIN 1.3, 2.x and J2602 support

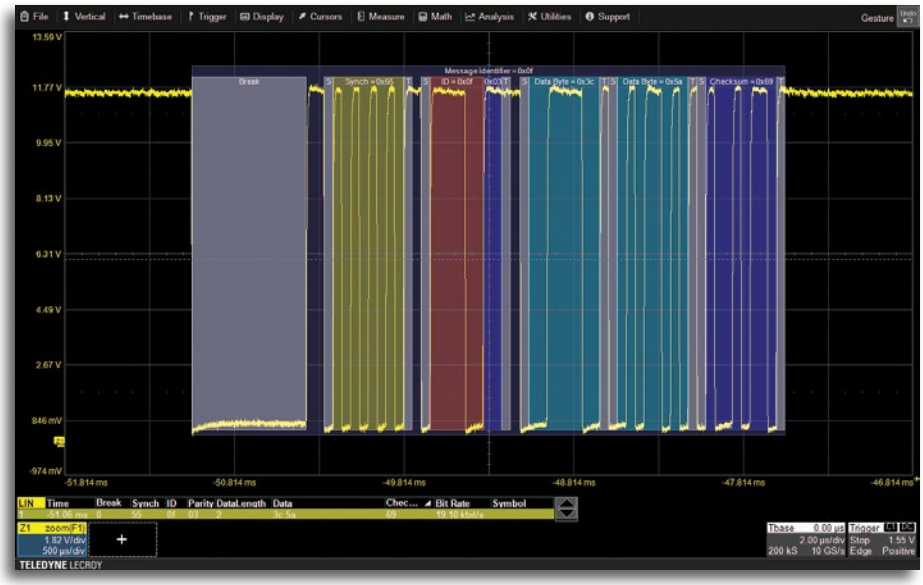
Break (Start of Message), ID, ID+DATA, and Error Frame triggers

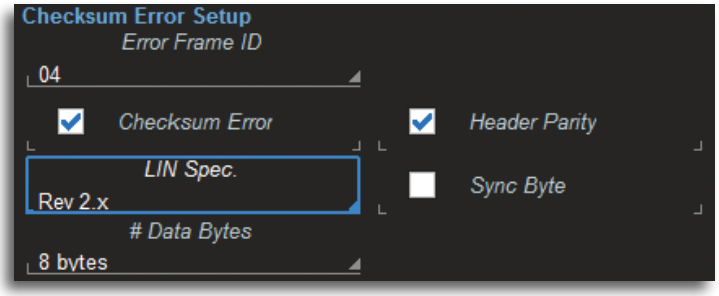
Error-frame red color decode highlight

Error-frame trigger can include some or all of Checksum, Header Parity, or Sync Byte types.

Conditional ID definition (<, <=, =, >, >=, <>, IN RANGE, OUT of RANGE)

Supports decode of buses with mixed LIN version traffic



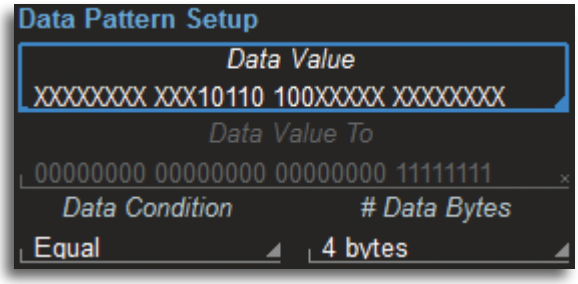


Flexible Error Frame Trigger

Select to trigger on any combination of Checksum, Header Parity, or Sync Byte error frame types. Additional, Checksum Error allows further definition for Frame ID, LIN Version, and Number of Data Bytes.

Trigger Flexibly Across Data Bytes

Many vehicle bus software architectures are very message dense, and data for a single message is spread across multiple data bytes. Our LIN trigger and measurement toolsets permit isolation of specific bit-level data patterns in one or more data bytes, e.g., data location in bits 18-26 in data bytes 2 and 3. This provides significant advantages in isolating the exact information or behavior you need.



SPECIFICATIONS

LINbus TD and LINbus TDME	
Definition	
Source and Protocol Setup	Select Source. Select BitRate.
Trigger Capability	
Format	Hexadecimal or Binary
Trigger Setup	Trigger on (Sync) Break (Start of Message), Frame ID, Frame ID+DATA, Error Frame (Any combination of Checksum, Header Parity, or Sync Byte error frames)
ADDRESS Setup	Specify one ADDRESS with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE.
DATA Setup	Hexadecimal: # Data Bytes = 0 to 8. Data can be defined by nibble. Binary: Any combination of 0,1, or X for 1-64 bits Data pattern can be any length and can be set to start at any location in the up to 8 Byte / 64 bit sequence.
DATA Condition Setup	<=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE
Error Setup	Select any combination of Checksum Error, Header Parity, or Sync Byte types. Checksum Error Setup for Frame ID, LIN version, and # Data Bytes
Bit Rates	1.2, 2.4, 4.8, 9.6, 10.417, 19.2 kb/s pre-defined nominal values, or user-defined to any nominal value from 300 b/s - 40 kb/s.
Trigger Input	Any analog Channel or Digital input, or the EXT input.
Decode + Search Capability	
Format	Hexadecimal, Binary
Decode Setup	Threshold definition required. Default is to Percent amplitude. Select BitRate. Select LIN version (1.3, 2.x, J2602, ALL). Decodes LIN messages on busses with mixed LIN versions
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace.
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Visual Aid	Color Coding for FRAME, BREAK, START/STOP bits, SYNCH bits, ID, ID Parity, DATA, CRC. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search by Previous or Next Frame, Next ID (hexadecimal format), or Next Error Frame.

LINbus TDME only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger) Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages, Message Bit Rate, Message Bus Load %** Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

SENT

Key Features

Supports SENT and SENT SPC

Decodes Frames as Nibbles or Words

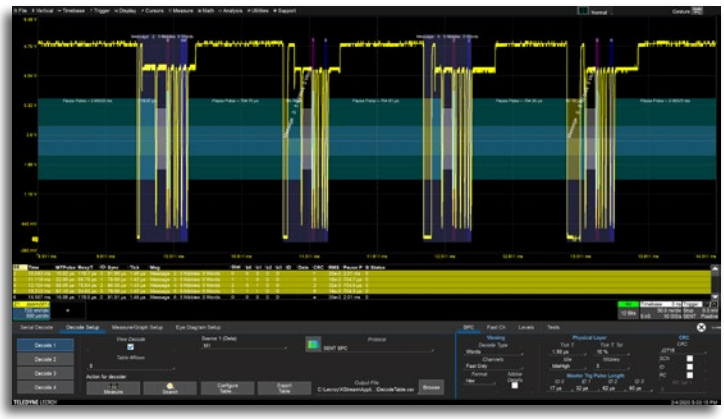
Supports Fast and Slow Channel Decode and Analysis

Extract and plot embedded SENT data

SAE Compliance Test Support

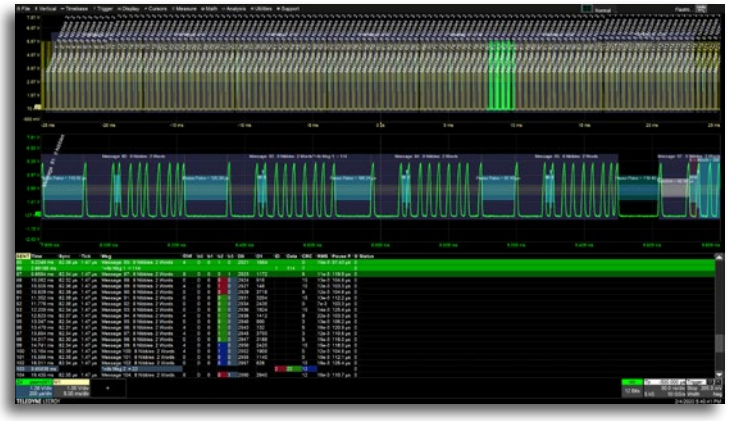
Debug and Characterize SENT SPC

Define up to 4 MTP lengths to analyze up-to-four “slave” sensors on the same wire. Use the column to value parameter to verify the stability of the MTP over time and correlate sensor activity to other signals in the system.



Fast and Slow Channels

Define up to 4 fast channels, specifying the numbers of nibbles and offset of each data word independently. The color-coded decode table shows how slow channel bits are distributed over the Fast Messages.



SENTbus TD and SENTbus TDME	
Definition	
Source and Protocol Setup	Select Source. SENT: Select SENT FEB 2008, JAN 2010, and APR 2016 versions or SENT SPC.
Trigger Capability	
Format	Hexadecimal or Binary.
Trigger Setup	Trigger on Start of Frame (Any, Slow Channel Message, or Fast Channel Message), Slow Channel ID+DATA (Any, Short Serial Message, or Enhanced Serial Message), Fast Channel ID+DATA, or Error (Any combination of Successive Calibration Pulse Error, Pulse Period Error, Fast Channel CRC Error, Slow Channel CRC Error, All CRC Error).
Slow Channel ID	Specify one Slow Channel ID 4 or 8 bit ID in Hexadecimal or Binary.
DATA Setup	Data Value: Data can be defined in Hexadecimal (any combination of 0-F for defined number of nibbles or selected message type) or Binary (any combination of Any combination of 0,1, or X for defined number of nibbles or selected message type) Fast Channel: Define nibble length (up to 6 nibbles) and nibble position (from 0 to 5).
DATA Condition Setup	<=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE.
Trigger Input	Any analog Channel or Digital input, or the EXT input. External MSO not supported.
Trigger Design	Internal to oscilloscope, settable like any other oscilloscope trigger.
Decode + Search Capability	
Format	Hexadecimal or Decimal.
Decode Setup	**SENT and SENT SPC:** Viewing: Decode Type (Nibbles or Words), Nibble Details (On/Off); Physical Layer: Tick Time (400 nsec to 3 msec), Tick Time Tolerance (1% to 50%), Idle State (High or Low), Nibbles (3 to 9); Protocol Details: SENT Version (FEB 2008, JAN 2010, or APR2016), New CRC (On/Off), Pause Pulse (On/Off); Channel Selection: Fast Only, Slow Only or Both; Levels and Hystersis: Percent or Absolute; For decode in "Words", "Fast Channels" has four fields available for Payload Interpretation (D0, D1, D2, or D3), includes controls to define Offset, Nibble and Order (MSB or LSB). For decode in "Words", "Slow Channels" has control for User Defined Tables, entered via a TXT file, allowing symbolic decode on Slow Channels. **SENT SPC:** Master Trigger Pulse Length: Define Length for up to four IDs (4 to 500 us); CRC: Version (J2716, Infineon, Method O, Method E), include Status and Communication Nibbles (SCN), ID, and Rolling Counter (RC).
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace.
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Visual Aid	**SENT and SENT SPC:** Color Coding for overall SENT Packet, Synchronization Pulse, Status and Communication Nibble, Reserved for Application Status, Serial Data Message Bits, Data Nibbles, CRC, and Pause Pulse. For Slow Channels, Bit Level Annotation. **SENT SPC:** Color Coding for Master Trigger Pulse and Sensor Response Time. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	**SENT and SENT SPC** When decoder set for "Nibbles", search for any of the following: Idx, Time, Sync, Tick Time, Message, Nibbles, RMS, Pause Pulse, and Status. When decoder set for "Words", search for Idx, Time, Sync, Tick, Message, Stat, b0, b1, b2, b3, D0, D1, D2, D3, CRC, RMS, ID, Data, Pause Pulse, and Status. **SENT SPC** When decoder set for "Nibbles" or "Words", search for any of the following: Master Trigger Pulse, Response Time, and ID Mux.

SENTbus TDME only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger). Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages, Message Bit Rate, Message Bus Load %.** Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

Key Features

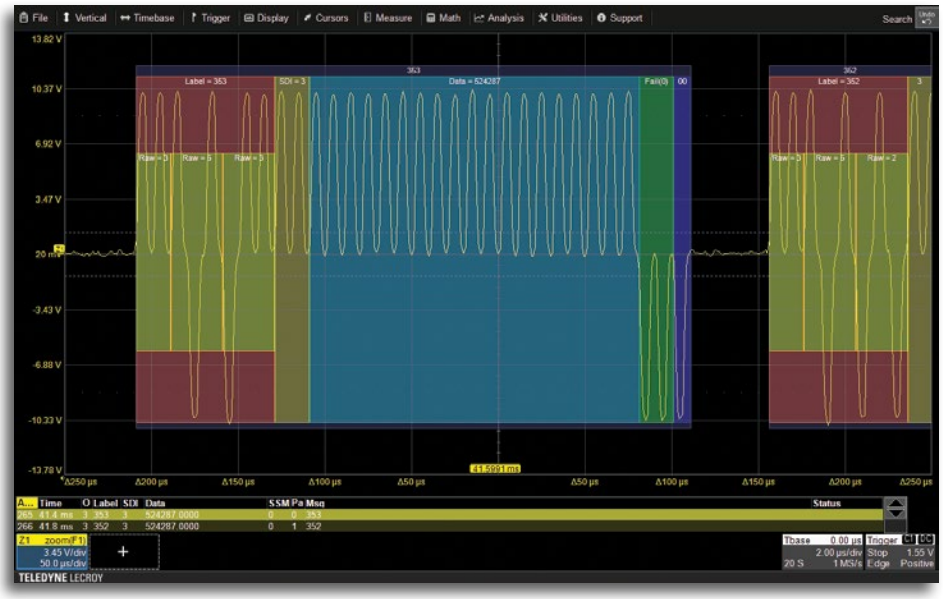
Symbolic decode with user-provided ULDF database file

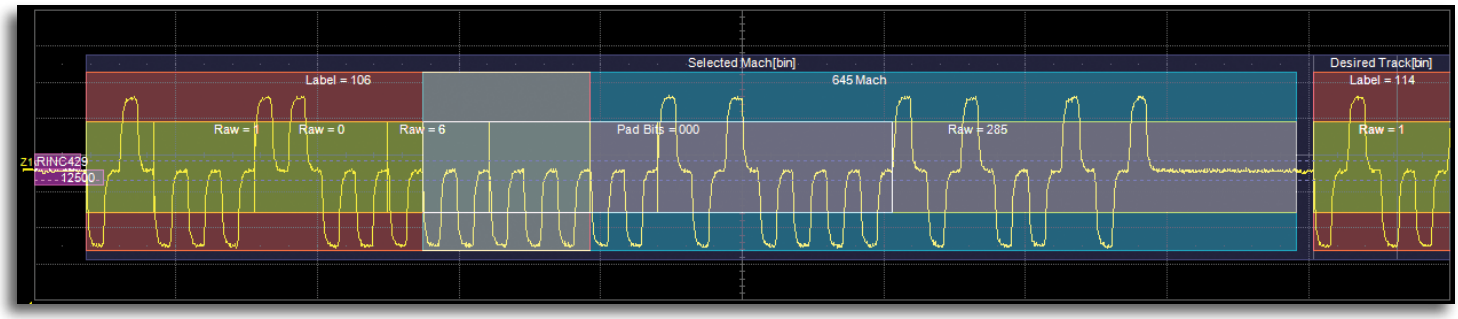
Decode Viewing Control Selection

- 8+24
- 8+2+19+2+1
- User-defined

Decode Annotation includes:

- Frame
- ID
- Label
- Raw Bits
- SDI
- Data
- SSM
- Parity
- Symbolic Message and Symbols





Symbolic Decode Transparent Overlay

A unique and powerful way to view decoded data. Using a user-provided ULDF file, the label and equipment ID fields can be displayed in an intuitive and easy to interpret way. The ULDF Label file is a Comma Separated Variable (CSV) file that contains the ARINC429 token definitions. Any text editor can be used to create or modify the Label file, and there is no limitation as to how many signals can be defined for a given Label. Here, the specified converted data is Selected Mach = 645 Mach.

Symbolic Decode Protocol Table

Symbol data is then displayed in the protocol table. Quickly view valuable information for each ARINC 429 word, such as Label, SDI, Data, SSM, Parity, and Symbolic Message.

Data	SSM	Pa	Msg	Symbols	Bits/Resol...	Pad
645 Mach				Selected Mach[bin]	12 / 1.000000	0
17.6 Degrees				Desired Track[bin]	12 / 0.050000	13
550 mDegrees				VS/FPA Val[bin]	12 / 0.050000	6
96 None				TACAN Control[bin]	12 / 1.000000	0
0.0 m				Metric Altitude[bcd]	4 / 0.250000	0
30.0 kg/m2				Appr Loc[bcd]	4 / 0.250000	0
5.0 kg/m2				DD5[bcd]	4 / 0.250000	0
1.01e+3				Spare[bin]	10 / 1.000000	464
63 ---				Spare[bin]	10 / 1.000000	507

ARINC429Bus DSYMBOLIC and ARINC429Bus DMESYMBOLIC	
Definition	
Source and Protocol Setup	Select Source. Select BitRate.
Decode + Search Capability	
Format	Hexadecimal or Symbolic+Hexadecimal. Symbolic decode requires user-provided ULDF database file
Decode Setup	Threshold definition required for High and Low levels. Default is to Absolute (in volts) amplitude. Select Viewing Control (8+24, 8+2+19+2+1, or User-defined).
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace.
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Visual Aid	Color coding for Frame, ID, Label, Raw Bits, SDI, Data, SSM, Parity. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search for Previous or Next IDX, Time, OctalDigits, Label, SDI, Data, SSM, Parity, Msg, or Status

ARINC429Bus DMESYMBOLIC only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger) Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages, Message Bit Rate, Message Bus Load %** Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

Key Features

Most comprehensive MIL-STD-1553 oscilloscope trigger available

- Transfers
- Command Words
- Data Words
- Status Words
- Error Words
- Response Times
- Intermessage Gap Times

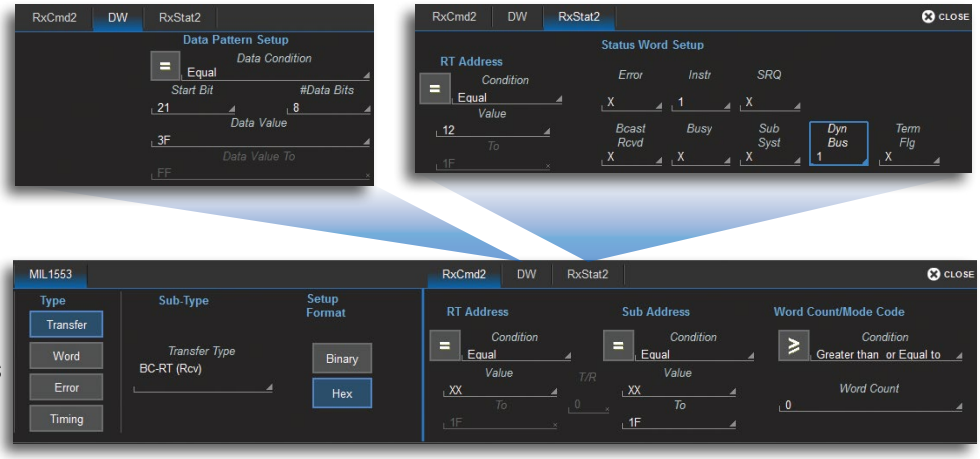
Conditional ADDRESS definition (<, <=, =, >, >=, <>, IN RANGE, OUT of RANGE)

Completely isolate a specific RT Address, Sub Address, Data Value, and Mode Code

Support for MIL-STD-1553 versions A and B

Highly Flexible and Powerful Triggering

The MIL-STD-1553 trigger can be configured at the transfer or word level to provide the right level of triggering. In addition, error triggers are able to locate the cause of protocol errors at either the transfer or word level. Word level triggering allows conditional RT Address and Sub Address entry.



MIL-STD-1553 TD and MIL-STD-1553 TDME	
Definition	
Source Setup	Select Source
Trigger Capability	
Format	Hexadecimal or Binary (Decimal for Word Count).
Trigger Setup	Trigger on ANY TRANSFER; a COMMAND WORD, STATUS WORD, DATA WORD, or ALL WORDS; an ERROR, a RESPONSE TIME, or an INTERMESSAGE GAP TIME. TRANSFERS may be further qualified by selecting the message type BC-RT, RT-BC, RT-RT, MODE COMMAND, MODE COMMAND & DATA (XMIT), MODE COMMAND AND DATA (RCV), various BROADCASTS (BC-RT(S), RT-RT(S), MODE COMMAND, and MODE COMMAND AND DATA)
Address Setup	For COMMAND WORD trigger specify 5-bit Remote Terminal (RT) Address ID(s) or Sub Address(es) with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE; specify Transmit/Receive bit setting of 0, 1, or X (don't care). For STATUS WORD trigger, specify 5- bit RT Address(es) ID(s) with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE; Specify Status Word bits as 0, 1, or X (don't care) for Message Error, Instrumentation, Service Request, Broadcast Command Received, Busy, Subsystem Flag, Dynamic Bus Control Acceptance, or Terminal Flag. For any TRANSFER containing an RT Address or Sub Address, setup is identical to that specified above. Settable in Hexadecimal or Binary format in all cases.

SPECIFICATIONS

MIL-STD-1553 TD and MIL-STD-1553 TDME (Cont'd)	
DATA Setup	Data Word Count: In any TRANSFER, specify Data Word Count in decimal format up 32 data words. DATA WORD or TRANSFER Data Setup (Hexadecimal): # Data Bytes = up to 2 (one Data Word) byte length, settable by nibble. DATA WORD or TRANSFER Data Setup (Binary): Any combination of 0,1, or X for 1-16 bits. Data pattern can be set to start at any location in an up to 2 Byte / 16 bit sequence (in a DATA WORD) or an up to 64 Byte / 512 bit sequence (in a TRANSFER)
DATA Condition Setup	Data Word Count: <=, <, =, >, >=, or <> Data Setup: <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE
Mode Command Setup	TRANSFER MODE COMMANDS and COMMAND WORDS may be qualified by selecting a Mode Code (0 to 31, with description) with a Mode Code condition of <=, <, =, >, >=, or <>.
Status Setup	In any TRANSFER or STATUS WORD, select 0, 1, or X (don't care) for various Status Word bits. Select for: Message Error, Instrumentation, Service Request, Broadcast Command Received, Busy, Subsystem Flag, Dynamic Bus Acceptance, and Terminal Flag
Error Setup	Select one or more Word Level or Transfer Level errors using a check box. Word Level error selection: Invalid Sync, Manchester Error, Idle Error, Parity Error. Transfer Level error selection: Bad Word Count, Address Mismatch, Non-contiguous Data, Sync Error.
Other Setups	Response Time Setup: Conditional Setup <, >, in range, out of range; Value Setup: 0 to 32.752 microseconds. Intermessage Gap Setup: Conditional Setup <, >, in range, out of range; Value Setup: 0 to 32.752 microseconds.
Bit Rates	1 Mb/s, pre-defined nominal value
Trigger Input	Any analog Channel or the EXT input.
Decode + Search Capability	
Format	Hexadecimal, Binary, Decimal (Binary not available for Address).
Decode Setup	Threshold definition required for High and Low levels. Default is to Absolute (in volts) amplitude. Select Table (Display) Mode (WORD or TRANSFER). Define Response Time and InterMessage Gap Time limits.
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace.
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Visual Aid	Color Coding for Message, Word, Sync bits, RTA Address and SubAddress bits, Receive/Transmit bit, Data Count bits, Data (Payload) bytes and Single-bit Condition Codes, Reserved bits, Response Time Check and Inter-Message Gap Time, and Word and Transfer Level Error Codes. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search for Previous or Next Index, Time, Message, Transaction, Type, Summary, Sync, RT Address, T/R, SubAddress, Count, ModeCode, Parity, Response Time, RT Address ACK, Message Error, Inst, SRQ, Reserved, Broadcase Rx, Busy, SubSystem Flag, Dynamic Bus Access, Terminal Flag, Data, IMG, or Status

MIL-STD-1553 TDME only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger). Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages, Message Bit Rate, Message Bus Load %**. Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	"Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

Key Features

Supports USB 2.0 Low, Full, or High speeds (1.x and 2.0)

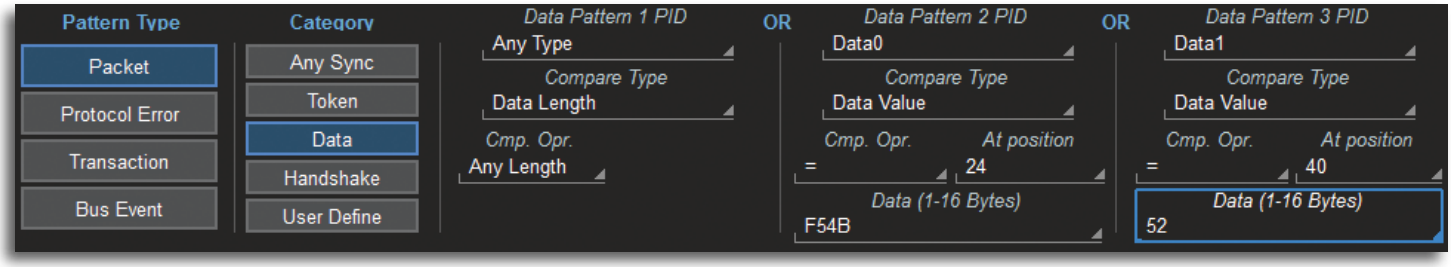
Trigger on USB packet types:

- Token
- Data
- Handshake
- User-defined

Transaction triggering support

Comprehensive Protocol Error and Bus Event triggering

Comprehensive Search by Events, Packets, Transactions or Errors

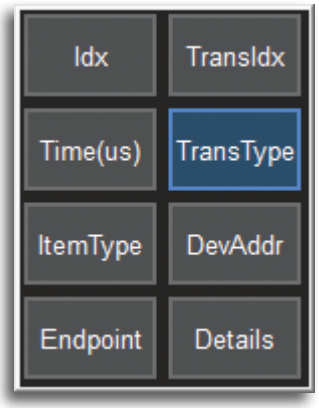


The Most Comprehensive USB Trigger

Full support is provided for triggering on any type of Packet, even User-Defined Packets, with complete flexibility for address, endpoint, split type, hub, port, etc. Trigger on specific Data payloads in specific locations. OR any three Packets in a single trigger condition. Create a USB Transaction trigger with any allowed combination of Token, Data, Handshake, and User-Defined packets. Advanced capability like this is usually only found in a dedicated protocol analyzer!

Search and Zoom

The powerful search engine of the USB 1.x/2.0 decode package can quickly find an Event, Packet, Transaction, or Protocol Error. Search through a long record of decoded data by entering any of the 45 available search criteria by entering a value or simply finding the next occurrence. For example, search through a long record to find a glitch that is frequently occurring after each EOP.



SPECIFICATIONS

	USB2bus TD and USB2bus TDME
Definition	
Source and Protocol Setup	Select for USB Low, Full, or High Speeds (1.x and 2.0). Select Source(s) (one or more, depending on Speed and probing system used). Select D+ and D- Voltage Levels (Low and Full Speeds only)
Trigger Capability	
Format	Hexadecimal or Binary
Trigger Setup	Trigger on Packet Type (Any, Token, Data, Handshake, or User-Defined), Protocol Error, Transaction (combine any allowable set of Token, Data, Handshake or User-defined Packet together in a Transaction), or Bus Event
PACKET Setup	**Any Packet:** Trigger on ANY SYNCH pattern. **Token Packet:** Trigger on ANY Token Packet. Select PREAMBLE/ERR Token Packet. Select SOF Token Packet with specific Frame Number. Select OUT, IN, SETUP, or PING Token Packet with a specific Address and Endpoint, or "don't care." Select SPLIT Special Token Packet with a specific SPLIT TYPE, HUB ADDR, PORT, S(speed/start), E(nd), and ET (for SPLIT type). Select USER-DEFINED. Trigger on any of three Token Packets of any type and trigger on them with an "OR" condition. **Data Packet:** Trigger on ANY Data Packet. Trigger on a single DATA0, DATA1, DATA2, or MDATA Data packet, with settings for Data Payload or Data Length, or trigger on any of up to three Data Packets of any type in an OR condition, with independent setup of Data Payload value or Data Length values. **Handshake Packet:** Trigger on ANY Handshake Packet. Trigger on a specific ACK, NAK, NYET, STALL or ERR Handshake Packet. **Transaction Packet:** Trigger on any USB Transaction - combine any allowable set of Token, Data, Handshake or User-Defined Packet together in a Transaction, and trigger when that set is detected
DATA Setup	In any DATA PACKET define up to three data conditions with OR logic. Data conditions may be Data Payload Pattern or Data Length for Any, DATA0, DATA1, DATA2, or MDATA types. Data Payload Pattern Setup (Hexadecimal): # Data Bytes = 1 to 16. Data can be defined by nibble. Data Payload Pattern Setup (Binary): Any combination of 0,1, or X for 1-128 bits. Data Payload Pattern start at any location in an up to 128 Byte / 1024 bit sequence. Data Length Setup: Hexadecimal; # Data Bytes = 0 to 1024.
DATA Cond. Setup	Data Payload: =, <>, or DON'T CARE. Data Length: <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or ANY LENGTH
Error Setup	Trigger on any ORed combination of PID/Check Error, CRC5 Error, CRC16 Error, Frame Length Error, Bad Data Toggle Error, or PID0 Error
Bus Event Setup	Trigger on any ORed combination of Reset, Resume, Suspend, or Chirp
Bit Rates	Low, Full or High-speed pre-defined values.
Trigger Input	USB 1.x and USB 2.0 (Low and Full Speed): Requires two inputs, using any analog Channels or the EXT input USB 2.0 (High Speed): Pre-defined channel, specific to each oscilloscope product line. Input must be with a suitable differential probe.
Decode + Search Capability	
Format	Hexadecimal USB 2.0 Link and Data Layer Protocol Decode
Decode Setup	Select Bus Speed (Low, Full, High). Select Probing Type (One Single-ended Probe, Two Single-ended Probes, Differential Probe).
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace.
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Visual Aid	Color Coding for Transaction, Packet (Handshake, Token, or Data), Control Sequences (Synch bits, PID bits, Check bits, or EOP bits), Device Address, Endpoint, Data Payload, CRC5 o CRC7, Inter-packet Idle, Inter-transaction Idle. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search for Event, Token Packet, Data Packet, Handshake Packet, Transaction Packet, or Protocol Error (45 unique conditions)

	USB2bus TDME only
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger). Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages, Message Bit Rate, Message Bus Load %.** Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

USB-PD (USB POWER DELIVERY)

Key Features

The most comprehensive oscilloscope-based USB-PD solution

Supports USB-PD 3.1 - EPR (Extended Power Range) and SPR (Standard Power Range)

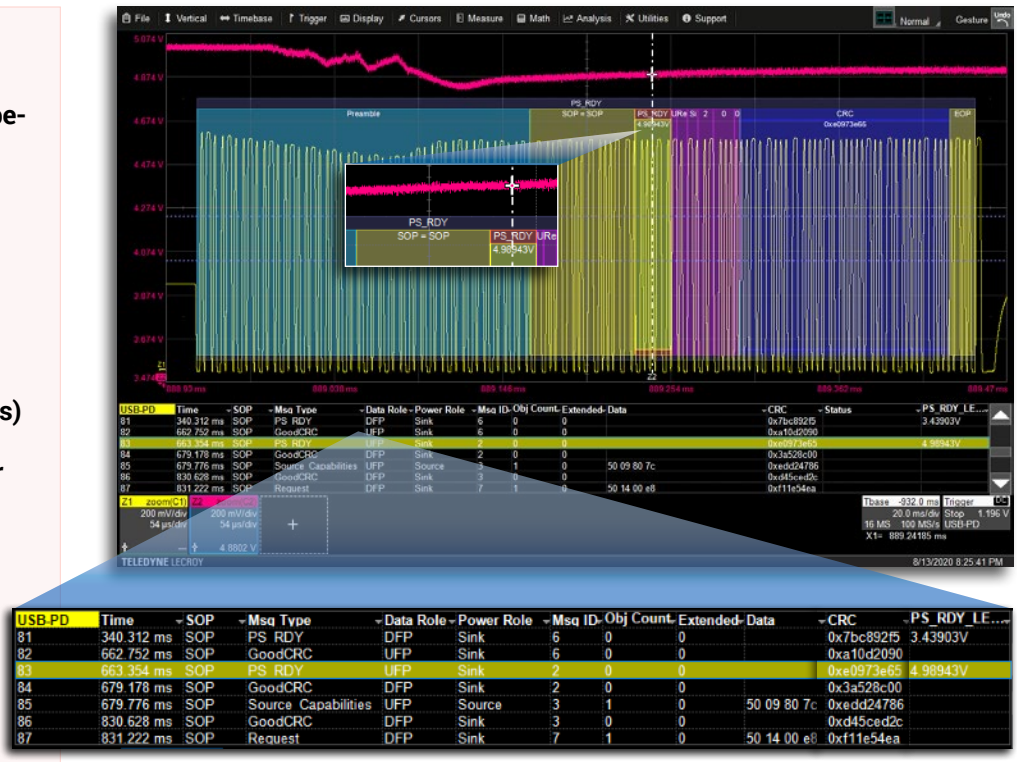
USB-PD Message Triggering

Decode Power Delivery Objects (PDOs)

BMC Eye Diagram and Physical Layer Measurements

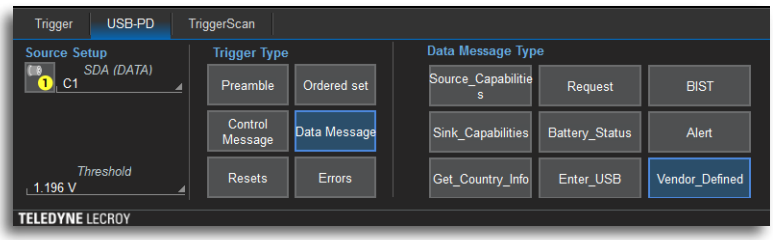
Time Correlate USB-PD with other USB Type-C® connector protocols

Enables USB-PD power supply validation and debug by correlating CC, V_{BUS}, and I_{LOAD} signals



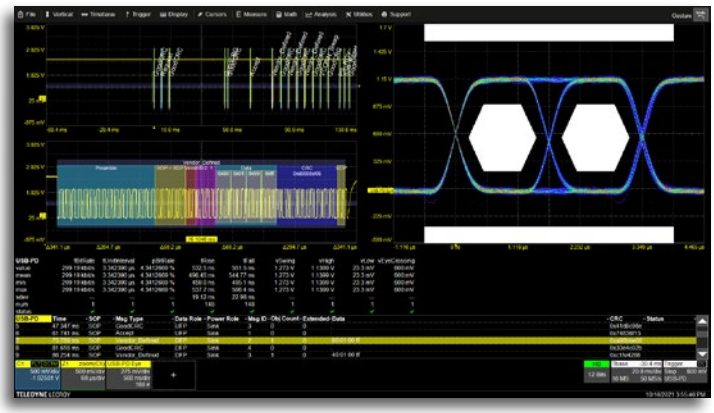
Comprehensive USB-PD Triggering

Debug power delivery compliance failures by using the same trigger selection types (Preamble, Ordered Set, Control Message, Data Message, Resets, and Errors) as found in the Teledyne LeCroy Voyager USB-PD compliance tester.



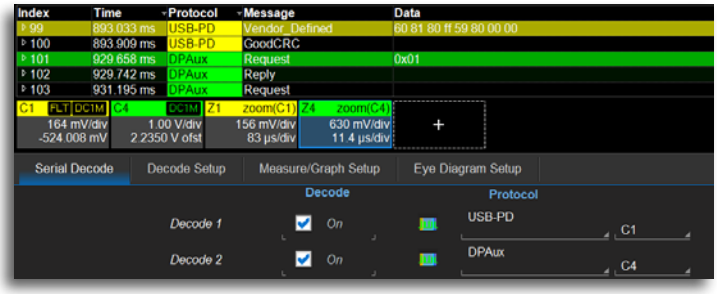
Eye Diagram and Physical Layer measurements

Debug USB-PD BMC (biphase mark coded) physical layer issues with comprehensive USB-PD Analysis. Select the packet of interest from the decode table, and USB-PD TDMP automatically makes measurements performs transmitter and receiver eye diagram mask testing.



Time Correlate USB Type-C Protocols

Debug USB Type-C system issues by time correlating USB-PD messages along with other USB Type-C signals such as DP-AUX or USB4-SBU sidebands.



	USB-PD TD and USB-PD TDMP
Definition	
Source and Protocol Setup	Select Channel Source for CC1/CC2 Signals.
Trigger Capability	
Format	Set Source and Threshold voltage for CC1/CC2.
Trigger Setup	**Comprehensive Trigger selections equivalent to the Teledyne LeCroy Voyager USB PD Compliance Tester for debugging compliance failures:** Trigger on Preamble, Ordered Set, Control Message, Data Message, Resets, or Errors with selections for each as follows: **Ordered Sets:** SOP, SOP', SOP", SOP'_Debug, or SOP"_Debug. **Control Messages:** GoodCRC, PS-RDY, VCONN_Swap, Not_Supported, Get_Country_Codes, GotoMin, Get_Source_Cap, Wait, Get_Source_Cap_Extended, Get_Sink_Cap_Extended, Accept, Get_Sink_Cap, Soft_Reset, Get_Status, Reject, DR_Swap, Data_Reset, FR_Swap, Ping, PR_Swap, Data_Reset_Complete, or Get_PPS_Status. **Data Message:** Source_Capabilities, Sink_Capabilities, Get_Country_Info, Request, Battery_Status, Enter_USB, BIST, Alert, Vendor Defined **Resets:** Soft Reset, Data Reset, or Cable Reset. **Errors:** 5b Symbol Error, Ordered Set Error, CRC Error, EOP Error, Reserved Message Error, Invalid Message Error, or Packet Length Error.
Trigger Design	Internal to oscilloscope, settable like any other oscilloscope trigger.
Decode + Search Capability	
Format	Hexadecimal or Binary.
Decode Setup	Source Setup for CC1/CC2.
Decode Input	Any analog Channel, Memory, Math, or Digital trace.
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Location	Overlaid on acquired DATA waveform, on Grid.
Visual Aid	Color Coding of Message Type, Preamble, SOP, Data Role (UFP/DFP), Power Role (Source/Sink), EPR/SPR (Source/Sink) Capabilities, Msg ID, Obj Count, Extended, Data, CRC, and EOP. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to four different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search for previous or next: Index, Time, SOP, Msg Type, Data Role, Power Role, Msg ID, Obj Count, Extended, Data, CRC, Status. Advanced search of a combination of up to the three Table Columns using AND/OR operation and specified Values.

	USB-PD TDMP Only
Definition	
Source and Protocol Setup	Typical Setup for USB-PD Specific Measurments: Select Channel Source for CC1 or CC2 Signals (required) Select Channel Source for Vbus Signal (required for VBUS@PS_RDY Measurements) Select Channel Source for Iload Signal (optional) Select Channel for other side band protocols such as DP-AUX , USB4-SBU (UART), or other Alt Modes (required if time correlating with USB-PD).
Measure / Graph Capability	
USB-PD Specific Measurements	PS_RDY_Level - Measures VBUS@PS_RDY.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), Time@Message (time from trigger). Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Eye Diagram and Physical Layer Test Capability	
Physical Layer Setup	USB-PD Analyis is selected (and enabled) from the Oscilloscope's Analsyis menu. Links to USB-PD serial decoder, performs Physical Layer and BMC Eye Diagram tests. Eye and Measurements made on selected Zoom packet in decoder or on full acquisition.
Selectable Physical Layer Measurements	**Measurements defined by the USB-PD Specification:** BMC Common Parameters: fBitRate, tUnitInterval BMC Transmitter: pBitRate, tRise, tFall, vHigh, vLow, vSwing, SymblEncod BMC Eye: vEyeCrossing Vbus: PS_RDY_LEVEL
VBUS@PS_RDY Measurement	Appears in Measurements as PS_RDY_LEVEL is enabled in Decode Setup menu. It Measures Vbus on a separate channel when PS_RDY message occurs on the CC line. Result is displayed in Measurement Table, Decode Overlay, and Decode Table.
Eye Diagram Setup	Select BMC Eye (ONE, ZERO, or BOTH). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Automatic measurement of Unit Interval (tUnitInterval) for Eye Diagram clock recovery and Eye Mask Hits.
Eye Mask	**USB-PD Standard or Custom Mask Selection:** USB-PD Standard: BMC Transmitter Mask, BMC Reciever Masks (Neutral, Sourcing, Sinking) Custom: Modify standard maks or create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

USB4 SIDEBAND (SB) CHANNEL

Key Features

Trigger on USB4® Thunderbolt™ Sideband Link Management Events

Decode Link (LT), Admin (AT), and Re-timer (RT) Transactions on SB-TX and SB-RX

Use standalone or with USB4bus DME for USB4 PHY-Logic Layer Debug

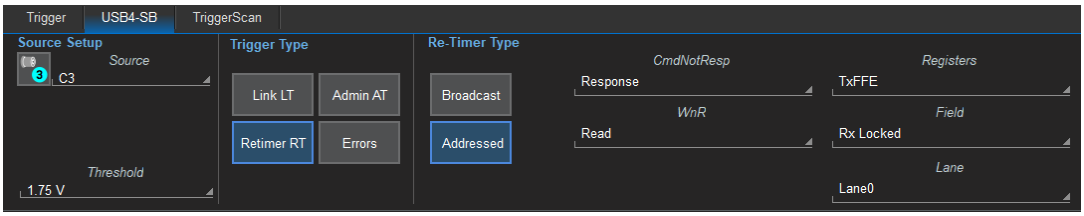
USB4 and Thunderbolt Sideband PHY Compliance Measurements

Analyze SB-Tx and SB-Rx using Interactive Protocol Table

Simply click on the USB4-SB packet of interest in the protocol table to create a zoom window of the waveform with color coded overlay showing the packet type, command, register address, and message details.

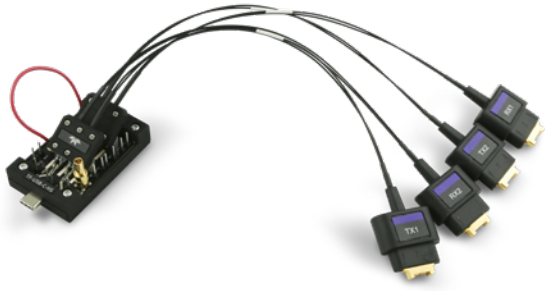
Trigger and Decode USB4 the Sideband

Setup the USB4-SB trigger to capture specific events during link training and the decode table to validate sideband link management transactions between devices are conformant to the USB4 specification.



Use standalone or with USB4bus DME software for PHY Logic Layer Debug

Use TF-USB-C USB High-speed and Sideband Test Coupon Fixtures with a wide range of oscilloscopes to capture USB4 sideband Tx and Rx signals using passive probes or with DH Series differential probes to capture the full USB4 bus including sideband signals and high-speed data. The TF-USB-C enables the only solution to trigger on USB4-SB signals and simultaneously capture high-speed data up to 20Gb/s on a live link, allowing the user to validate PHY link layer training on USB4 and Thunderbolt Transmitters, Re-timers, or Active Cables.



TF-USB-C-HS USB4 High Speed and Sideband Test Coupon

USB4-SB TD and TDMP	
Definition	
Source and Protocol Setup	Select Source(s).
Trigger Capability	
Format	Set Source and Threshold voltage for SBU4-SB Trigger Source.
Trigger Setup	**Comprehensive Trigger selections for debugging link training failures**: **Trigger Types:** Link (LT), Address (AT) and Retimer (RT) Transactions, with selectable Register values: **Link (LT)**: LSE Symbol (Resume, Fail, Lroff, Gen2, Gen3, Resume2, or Any), Lane (Lane0, Lane1, Any) **Admin (AT):** CmdNotResp (Command, Response, Any); **Command/Response:** (Read, Write, Any), **Read:** (Vendor ID, Product ID, Opcode, Metadata, Link Config, TxFEE, SB Chan Ver, Data, Any); **Write: (**Opcode, Metadata, TxFEE, Data, Any); **TxFFE Field:** (Request Done, Tx Active, Any; **Lane:** (Lane0, Lane1, Any) **Retimer** (RT): (Broadcast, Addressed); **Broadcast; Addressed: CmdNotResp** (Command, Response, Any); **Command/Response:** (Read, Write, Any); **Read:** (Vendor ID, Product ID, Opcode, Metadata, Link Config, TxFEE, SB Chan Ver, Data, Any); **Write:** (Opcode, Metadata, TxFEE, Data, Any); **TxFFE Field:** (Request Done, Tx Active, Any): **Lane:** (Lane0, Lane1, Any).
Trigger Input	Any analog Channel or Digital input, or the EXT input. External MSO not supported.
Decode + Search Capability	
Format	Hexadecimal or Binary (Decode of register values listed in Trigger Setup above).
Decode Setup	Define Source as: SBTX, SBRX, or 'SBTX and SBRX'.
Decode Input	Any analog Channel, Memory, Math, or Digital trace.
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Location	Overlaid on acquired DATA waveform, on Grid.
Visual Aid	Color Coding of Message Type, Preamble, SOP, Data Role (UFP/DFP), Power Role (Source/Sink), Msg ID, Obj Count, Extended, Data, CRC, and EOP. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search for previous or next: Index, Time, SOP, Msg Type, Data Role, Power Role, Msg ID, Obj Count, Extended, Data, CRC, Status. Advanced search of a combination of up to the three Table Columns using AND/OR operation and specified Values.

USB4-SB TDMP Only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger). Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Eye Diagram and Physical Layer Test Capability	
Physical Layer Setup	USB4-SB Analyis is selected (and enabled) from the Oscilloscope's Analsyis menu. Links to USB4-SB serial decoder, performs USB4 and Thunderbolt Physical Layer measurements. Measurements made on selected Zoom packet in decoder or on full acquisition.
Selectable Physical Layer Measurements	**USB4 and Thunderbolt Physcal Layer Tx Measurements:** VHigh, VLow, Rise Time, Fall Time, Amplitude, Bitrate, Burst Duration.
Eye Diagram and Mask Testing	**Eye Parameters:** Eye Height, Eye Width, (Number of) Mask Hits. Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use. Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

DP-AUX (DISPLAYPORT™ AUX CHANNEL)

Key Features

The most comprehensive oscilloscope-based DP-AUX solution

DisplayPort 2.0, 1.4, and eDP (embedded DisplayPort) Standards

Decodes DisplayPort AUX Reads and Writes

Native and I²C AUX Channel Transactions

DP-AUX Eye Diagram and Physical Layer Measurements

Use Standalone or with USB-PD TDME for DisplayPort over USB-C® testing

Interactive Protocol Table

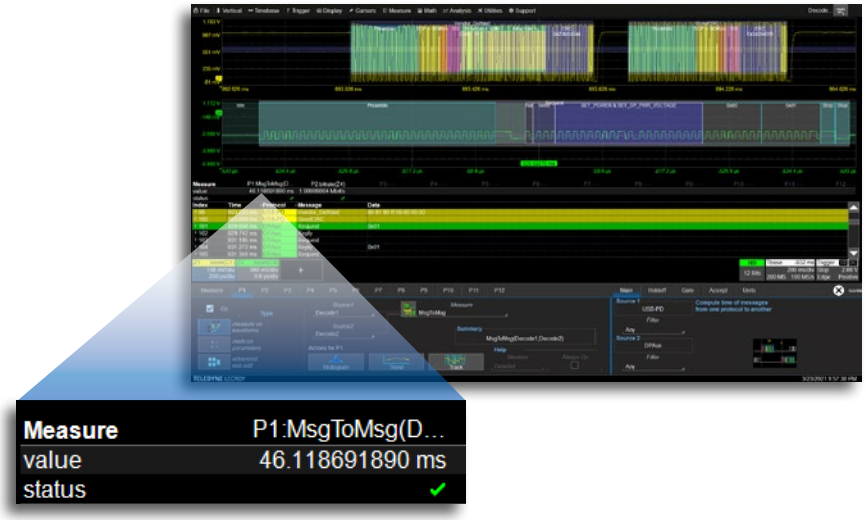
Simply click on the DP-AUX packet of interest in the protocol table to create a zoom window of the waveform with color coded overlay showing the packet type, command, AUX register address, and message details.

Eye Diagram and Physical Layer measurements

Perform DP-AUX EYE and Measurement testing consistent with the DisplayPort PHY Specification. Click on the packet of interest from the protocol table, and DP-AUX analysis software automatically makes measurements and performs transmitter or receiver eye diagram mask testing.

Use with USB-PD TDMP for DisplayPort over USB Type-C®

DP-AUX DMP can be used as standalone for Standard DP connector or eDP designs; or along with USB-PD TDMP to analyze timing between the DisplayPort AUX (SBU lines) and USB-PD (CC lines) in a DisplayPort over USB-C design. Msg-Msg timing measurements can be used to debug system interoperability issues caused by improper timing between USB-PD Alt Mode transactions and DisplayPort AUX link training.



	DP-AUX D and DP-AUX DMP
Definition	
Source and Protocol Setup	Select Source (Decode Input), Protocol (DPAux).
Trigger Capability	
Format	No Triggering on DisplayPort AUX. If used with USB-PD, use USB-PD Triggering to trigger on DisplayPort 'Alt Mode' transactions.
Decode + Search Capability	
Format	Hexadecimal or Symbolic DisplayPort AUX Transaction Decode.
Decode Setup	Select Source, View (Hexidecimal or Symbolic), Probing (AUX-P, AUX-N, or Differential), Reply Timeout, and Decode Threshold Levels.
Decode Input	Any analog Channel, Memory, Math, or Digital trace.
# of Decodes	Up to four buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Location	Overlaid on acquired DATA waveform, on Grid.
Visual Aid	Color Coding of Idle, Preamble, Packet Type, Command Type (Read/Write), DP Configuration Registor or I2C Address, and Command Register Data, Stop.
Table Configure, Export Table	Display up to 20 rows of decoded information for up to four different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search for previous or next: Index, Packet Type, Command Type, Command, DPCConfigReg/I2C Address.

	DP-AUX DMP Only
Measure / Graph Capability	
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), Time@Message (time from trigger). Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Eye Diagram and Physical Layer Test Capability	
Physical Layer Setup	DP-AUX Analyis is selected (and enabled) from the Oscilloscope's Analsyis menu. Links to DP-AUX serial decoder, performs AUX EYE Physical Layer tests. Eye and Measurements made on selected Zoom packet in decoder or on full acquisition.
Selectable Physical Layer Measurements	**Measurements defined by the DisplayPort Specification:** BitRate, Unit Interval, Common Mode Voltage, Slew Rate, Vpk-Pk.
Eye Diagram Setup	Select AUX EYE. Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%
Eye Parameters	Automatic measurement of BaudRate (2 x BitRate) for Eye Diagram clock recovery and Eye Mask Hits.
Eye Mask	**DP-AUX Standard or Custom Mask Selection:** DP-AUX Standard: AUX EYE (Transmitter and Reciever) Custom: Modify standard maks or create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

Key Features

Supports triggers on standard SMBus Command Protocols with or without PEC

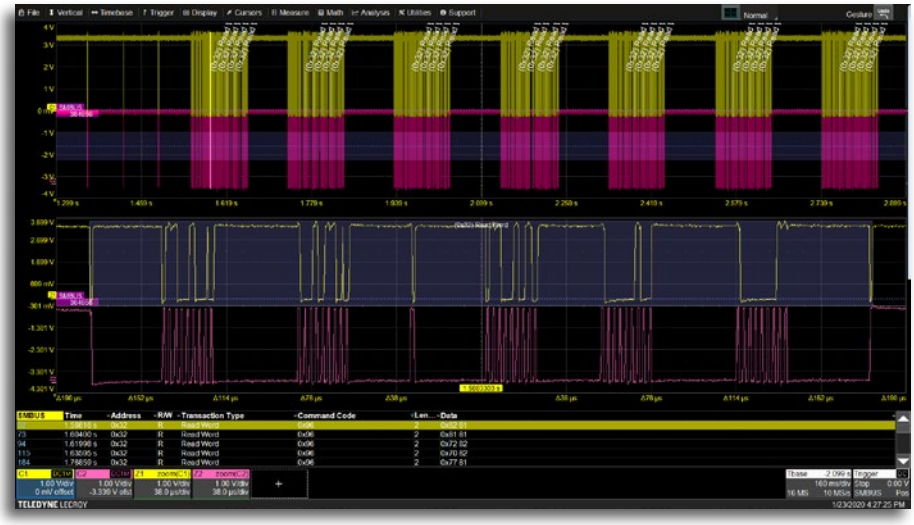
Trigger support for ARP, SMBALERT#, and PEC errors

Trigger and Decode unaffected by Clock Stretching

Provides for complex triggering with defined Address, R/W (direction), Command Code, and Data.

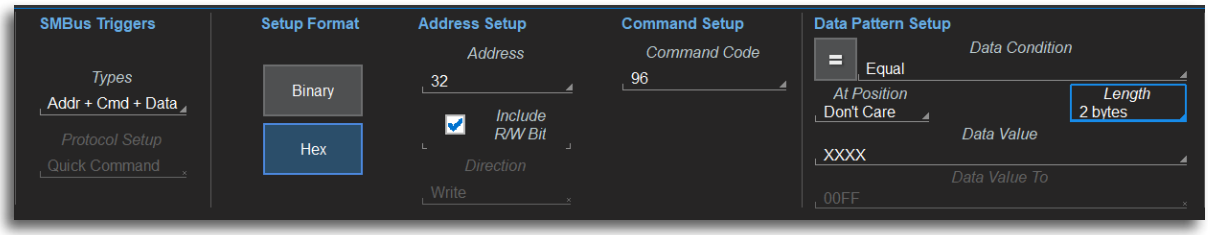
Conditional data definition (<, <=, =, >, >=, <>, INRANGE, OUT of RANGE).

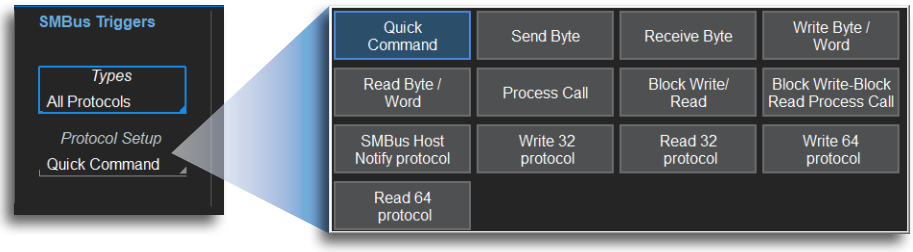
Use analog or digital (MSO) inputs for acquisition and triggering.



Comprehensive and Powerful SMBus Trigger

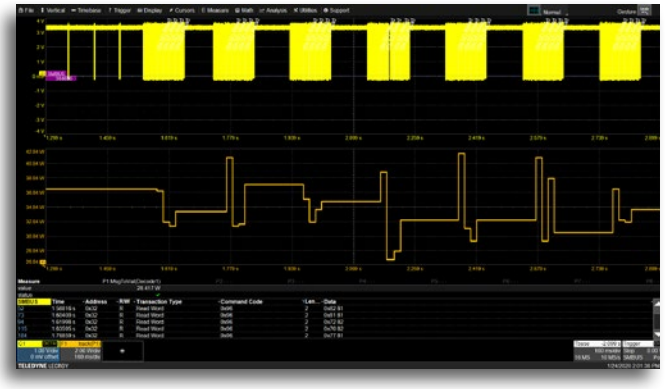
Capability is provided to trigger on any standard SMBus Command Protocol, ARP Command, and also on user-defined command protocols, with full capability to define specific data values or ranges of data values.





Extract Data from user-defined Command Code readouts and Plot it as a Waveform

SMBus data readouts are difficult to understand by reviewing hexadecimal values in a table. The SMBus TDME option provides ability to extract digital data from a defined data location in specific messages and convert them to analog values that are then plotted to resemble an analog waveform.



SMBus TD and SMBus TDME	
Definition	
Source and Protocol Setup	Select Source for Clock and Data
Trigger Capability	
Format	Hexadecimal or Binary. ADDRESS and DATA can be set up with different formats.
Trigger Setup	Trigger on START, STOP, RESTART, No ACK, Read Protocols, Write Protocols, Quick Command, Send Byte, Receive Byte, Write Byte/Word, Read Byte/Word, Process Call, Block Write/Read, Block Write-Block Read Process Call, SMBus Host Notify protocol, Write 32 protocol, Read 32 protocol, Write 64 protocol, Read 64 protocol, ARP, ADDR, ADDR+CMD+DATA, SMBALERT#, PEC Error
ADDRESS Setup	Specify one ADDRESS with condition of ""="". 7 bit ADDRESS supported with full Read, Write, or R/W=""Don't Care"" selectability on 7 bit ADDRESSes. Choose to Trigger on address values that include/don't include R/W bit in address value.
DATA Setup	Custom Trigger Type: Hexadecimal: # Data Bytes = 0 to 12. Data can be defined by nibble. Binary: Any combination of 0,1, or X for 1-96 bits. Data pattern can be set to start at any location in the 12 Byte / 96 bit sequence.
DATA Conditions	<=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE.
ACK Conditions	For any ADDR or ADDR+CMD+DATA setup, select an ACK Condition of ACK, NO ACK, and DON'T CARE.
Bit Rates	Full range over SMBus specification for 100 kHz Class, 400 kHz Class, and 1 MHz Class SMBus. Auto-detected.
Trigger Input	Any analog Channel or Digital input, or the EXT input. External MSO not supported.
Decode + Search Capability	
Format	Hexadecimal, Binary
Decode Setup	Threshold definition required. Default is to Percent amplitude. Choose to Decode address values including/not including the R/W bit in address value.
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace. Clock channel may be turned OFF and data will still decode (reduces screen clutter).
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Visual Aid	Color Coding for Command Protocols as well as START/ReSTART, ADDR, R/W, DATA, ACK, NACK, and STOP bits. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search for previous or next: Index, Time, Address, R/W, Command Code, Length, Data in hexadecimal format.

SMBus TDME only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger). Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages**, **Message Bit Rate**, **Message Bus Load %**: Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits.
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

Key Features

Support for SMBus and PMBus

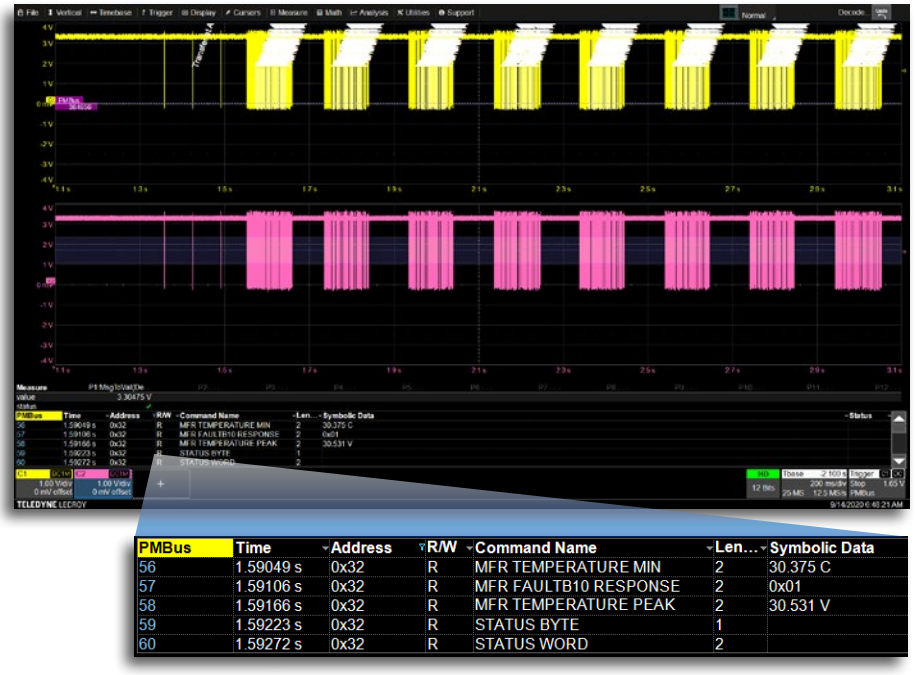
Select command categories and auto-fill numeric data formats

Trigger on hex or analog values (i.e., 5 V)

Custom configuration file

Conditional data definition (<, <=, =, >, >=, <>, In Range of, Out of Range)

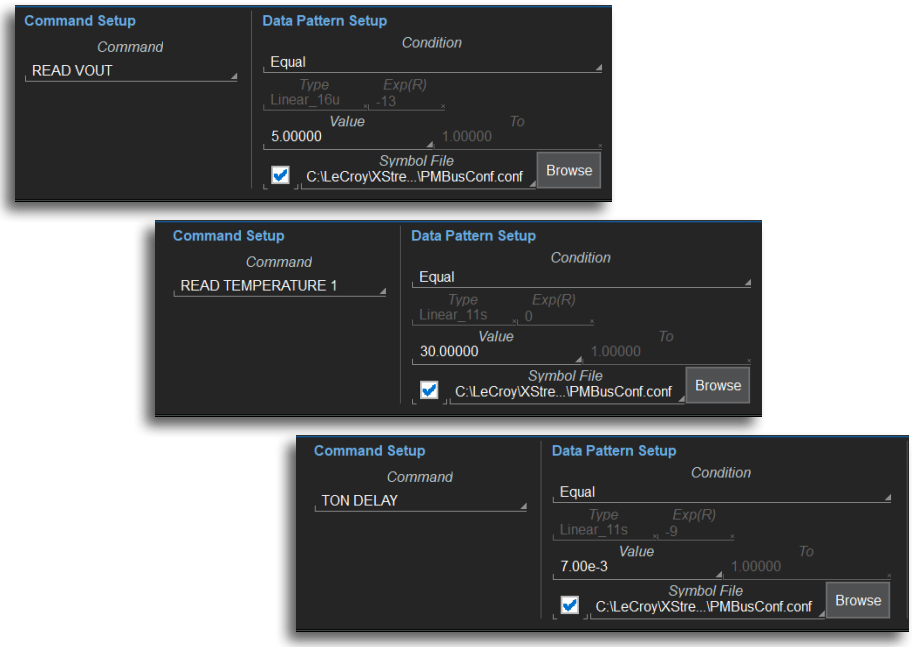
Use analog or digital (MSO) inputs for acquisition and triggering



PMBus	Time	Address	R/W	Command Name	Len...	Symbolic Data
56	1.59049 s	0x32	R	MFR TEMPERATURE MIN	2	30.375 C
57	1.59106 s	0x32	R	MFR FAULTB10 RESPONSE	2	0x01
58	1.59166 s	0x32	R	MFR TEMPERATURE PEAK	2	30.531 V
59	1.59223 s	0x32	R	STATUS BYTE	1	
60	1.59272 s	0x32	R	STATUS WORD	2	

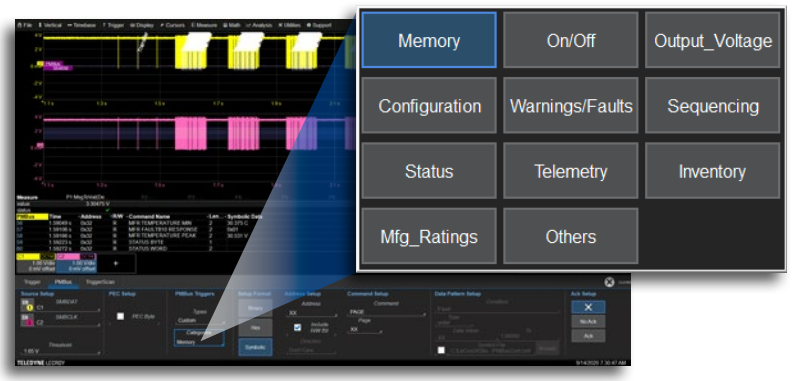
Trigger on Extracted Analog Values

Whether you want to trigger when the output voltage is 5 V, device temperature is 30°C, or it's 7 ms after a pin enables, enter the analog value and let the software do the rest. Also supports all standard SMBus trigger types.



Automatically set up device commands and numeric data formats

Your power management device can support all of the 256 PMBus commands or a subset. Select a custom configuration file and numeric data formats are pre-filled, no complex calculations required. Everything is decoded and presented in an easy-to-read format.



SPECIFICATIONS

PMBus TD and PMBus TDME	
Definition	
Source and Protocol Setup	Select Source for Clock and Data
Trigger Capability	
Format	Hexadecimal or Binary. ADDRESS and DATA can be set up with different formats.
Trigger Setup	Trigger on value being monitored (Volts, temperature, time, etc.) by selecting specific command set (Memory, On/Off, Output Voltage, Configuration, Warning/Faults, Sequencing, Status, Telemetry, Inventory, Mfg Ratings, Others). Numeric data format gets automatically filled from configuration file. Trigger on any SMBus packet - START, STOP, RESTART, No ACK, Read Protocols, Write Protocols, Quick Command, Send Byte, Receive Byte, Write Byte/Word, Read Byte/Word, Process Call, Block Write/Read, Block Write-Block Read Process Call, SMBus Host Notify protocol, Write 32 protocol, Read 32 protocol, Write 64 protocol, Read 64 protocol, ARP, ADDR, ADDR+CMD+DATA, SMBALERT#, PEC Error
ADDRESS Setup	Specify one ADDRESS with condition of "=". 7 bit ADDRESS supported with full Read, Write, or R/W="Don't Care" selectability on 7 bit ADDRESSes. Choose to Trigger on address values that include/don't include R/W bit in address value.
Command Setup	Specify one 8-bit COMMAND with condition of ""="". 8-bit value can be in Binary, Hexadecimal, or Symbolic. Symbolic command can be default or defined in customer configuration file.
DATA Setup	Custom Trigger Type: Symbolic: Enter value being monitored (voltage, temperature, time, etc.) in decimal. Numeric data format gets automatically filled from configuration file. Hexadecimal: # Data Bytes = 0 to 12. Data can be defined by nibble. Binary: Any combination of 0,1, or X for 1-96 bits. Data pattern can be set to start at any location in the 12 Byte / 96 bit sequence.
DATA Conditions	<=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE. Selection options vary based off command category chosen.
ACK Conditions	For any ADDR or Custom setup, select an ACK Condition of ACK, NO ACK, and DON'T CARE.
Bit Rates	Full range over SMBus specification for 100 kHz Class, 400 kHz Class, and 1 MHz Class PMBus. Auto-detected.
Trigger Input	Any analog Channel or Digital input, or the EXT input. External MSO not supported. Clock may be input to EXT to conserve available analog Channels.
Decode + Search Capability	
Format	Hexadecimal, Symbolic
Decode Setup	Threshold definition required. Default is to Percent amplitude. Choose to Decode address values including/not including the R/W bit in address value.
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace. Clock channel may be turned OFF and data will still decode (reduces screen clutter)
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Visual Aid	Color Coding for START/ReSTART, ADDR, R/W, DATA, ACK, NACK, and STOP bits. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search for previous or next: Index, Time, Address, R/W, Command Code, Length, Data in hexadecimal format.

PMBus TDME only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger) Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages**, **Message Bit Rate**, **Message Bus Load %**: Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits.
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

Key Features

Trigger and Decode Commands, Command Sequences and Error Frames

User-defined Command Frame/ Sequence – trigger on non-standard frames.

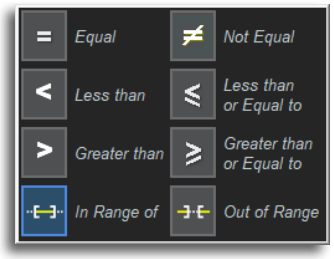
Conditional data definition (<, <=, =, >, >=, <>, INRANGE, OUT of RANGE).

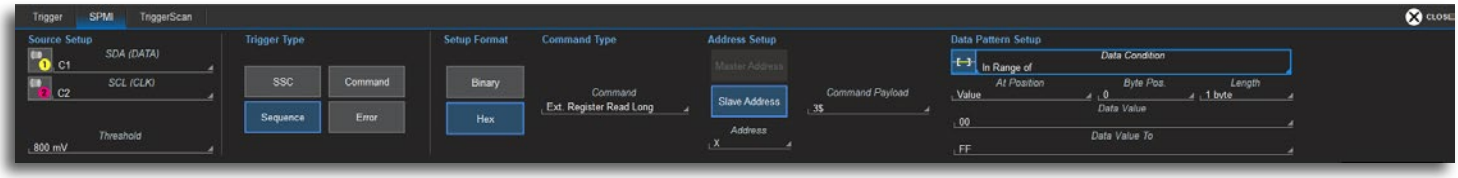
Use analog or digital (MSO) inputs for acquisition and triggering.

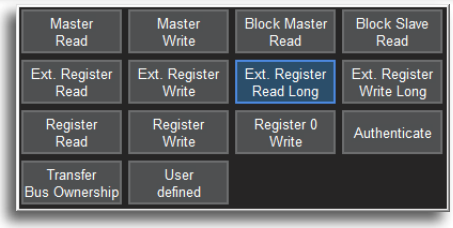
Full arbitration sequence support and for all sequences with pauses.

Comprehensive and Powerful SPMI Trigger

Capability is provided to permit triggering on any MIPI-defined allowable command sequence, and also on user-defined command sequences, with full capability to define specific data values or ranges of data values.

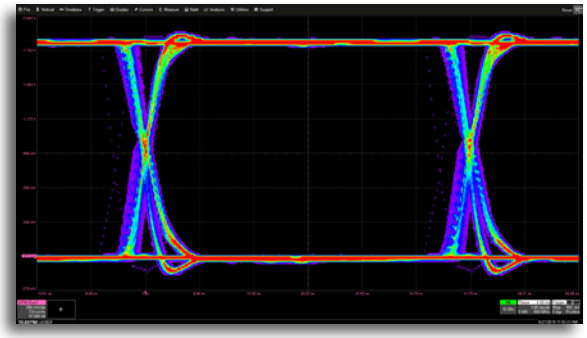






Eye Diagrams Identify Physical Layer Issues

Quickly create an eye diagram to intuitively show bit transitions and physical layer signal quality. In this 10 ms acquisition, it is easy to assess the signal quality and find the irregular bit transitions (faint purple lines).



SPMIbus TD and SPMIbus TDME	
Definition	
Source and Protocol Setup	Select Source for Clock and Data.
Trigger Capability	
Format	Hexadecimal or Binary
Trigger Setup	Trigger on SSC, Command (Reset, Sleep, Shutdown, Wakeup), Command Sequence (Master Read, Master Write, Block Master Read, Block Slave Read, Extended Register Read, Extended Register Write, Extended Register Read Long, Extended Register Write Long, Register Read, Register Write, Register 0 Write, Authenticate, Transfer Bus Ownership, User-defined), or Errors (OR any combination of Command Parity Error, Acknowledgement Error, Data Parity Error, Frames Error).
DATA Setup	Command Sequence Trigger Type: Hexadecimal: # Data Bytes = 0 to 16. Data can be defined by nibble. Binary: Any combination of 0,1, or X for 1-128 bits"
DATA Condition Setup	<=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE
Bit Rates	Any, up to 26 Mb/s. Auto-detected from clock signal.
Trigger Input	Any analog Channel or Digital input, or the EXT input. External MSO not supported
Decode + Search Capability	
Format	Hexadecimal, with selection for Bit Viewing (Index or State).
Decode Setup	Threshold definition required. Default is to Percent amplitude. Choose to Decode address values including/not including the R/W bit in address value.
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace. Clock channel may be turned OFF and data will still decode (reduces screen clutter).
# of Decoded Waveforms	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Visual Aid	Color Coding for FRAME, ARBITRATION SEQUENCE, COMMAND SEQUENCE, ARBITRATION/COMMAND BITS, SEQUENCE START CONDITION (SSC), SLAVE ADDRESS, COMMAND, BYTE COUNT CODE (BC), REGISTER ADDRESS, PAYLOAD DATA, PARITY BITS, BUS PARK CYCLE, ACK/NACK, and PROTOCOL ERROR Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Basic search for Previous or Next INDEX, TIME, MESSAGE (value), SSC, SLAVE (id), COMMAND, BYTE COUNT CODE, REGISTER, DATA (value), NBITS, or STATUS. Advanced search allows complex criteria using boolean and/or logic to combine up to three different searches.

SPMIbus TDME only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger) Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages, Message Bit Rate, Message Bus Load %** Serial Message may be defined by ""ID ="" (where applicable) and user-defined ""DATA <=, <, =, >, >=, <>, in range, out of range"" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits.
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

Key Features

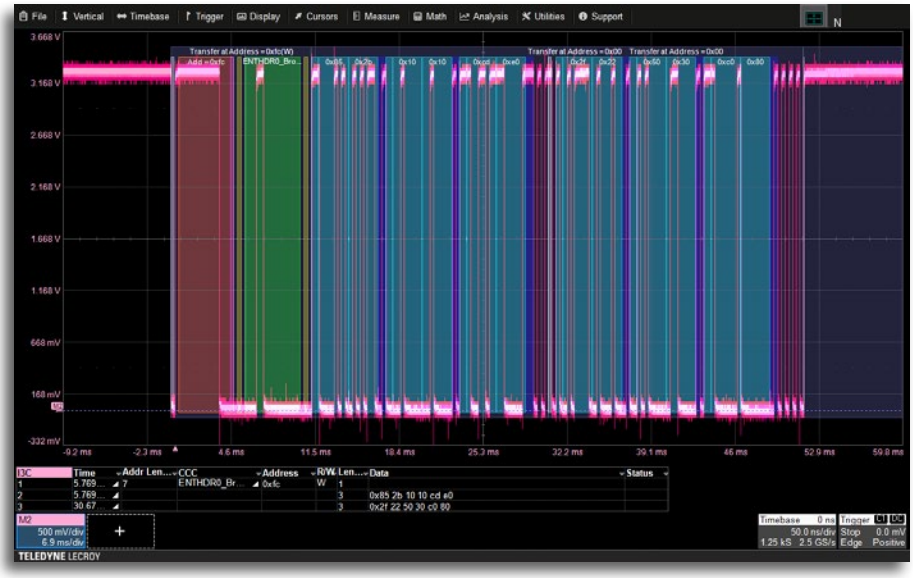
Supports triggers in SDR, HDR-DDR, and Legacy I2C operating modes

Provides triggering in "ANY" supported operating mode

Provides for complex triggering with defined Address, R/W (direction), Common Command Code, and Data.

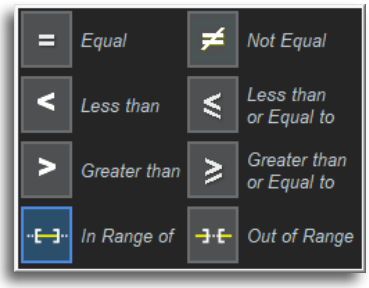
Conditional data definition (<, <=, =, >, >=, <>, INRANGE, OUT of RANGE).

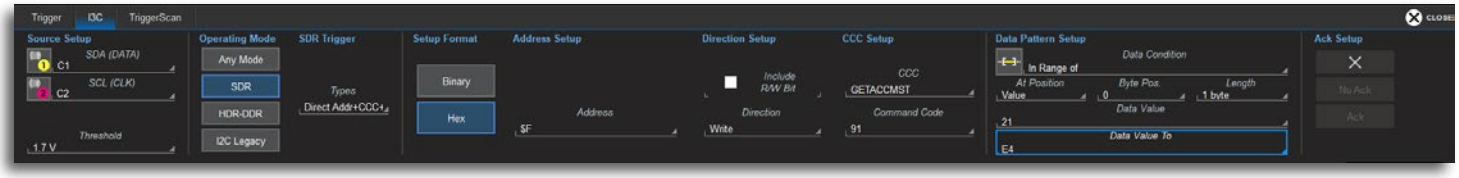
Use analog or digital (MSO) inputs for acquisition and triggering.



Comprehensive and Powerful I3C Trigger

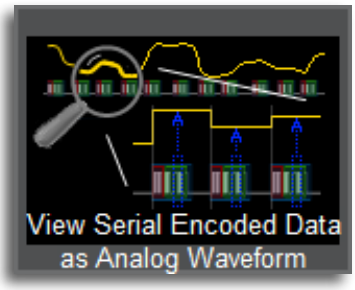
Capability is provided to permit triggering on any MIPI-defined allowable command sequence, and also on user-defined command sequences, with full capability to define specific data values or ranges of data values.





Extract Digital Sensor Data and Plot it as a Waveform

Embedded digital sensor data can be difficult to understand by reviewing hexadecimal values in a table. The I3Cbus TDME option provides ability to extract digital data from a defined data location in specific I3C messages and convert them to analog values that are then plotted to resemble an analog waveform.



I3Cbus TD and I3Cbus TDME	
Definition	
Source Setup	Select Source for Clock and Data.
Trigger Capability	
Format	Hexadecimal or Binary. ADDRESS and DATA can be set up with different formats.
Trigger Setup	Select from operating modes to trigger on the following: SDR: Start (S), Stop (P), Restart (SR), Direct Frame, Broadcast Frame, SDR Frame Length, Direct Address + CCC + Data, Broadcast Address + CCC + Data, SDR Errors HDR-DDR: Enter, Exit, Restart, Frame Length, Address + Cmd + Data, Preamble, Errors I2C Legacy: START, ReSTART, STOP, Missing ACK, ADDR, DATA, ADDR+DATA, ADDR+DATA FRAME LENGTH, EEPROM DATA TRANSFER Any Mode: Start (S), Stop (P), Restart(SR), Frame Length, Any Address + Data, Any Errors
ADDRESS Setup	Specify one ADDRESS with condition of "=". 7 or 10 bit ADDRESS supported with full Read, Write, or R/W="Don't Care" selectability on both 7 and 10 bit ADDRESSes. Choose to Trigger on address values that include/don't include R/W bit in address value.
DATA Setup	Direct Address + CCC + Data, Broadcast Address + CCC + Data, ADDRESS+DATA, Any Address + Data, and HDR-DDR Address + Cmd + Data Trigger Types: Hexadecimal: # Data Bytes = 0 to 12. Data can be defined by nibble. Binary: Any combination of 0,1, or X for 1-96 bits Data pattern can be set to start at any location in the 12 Byte / 96 bit sequence.
DATA Conditions	<=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE
ACK Conditions	For any Direct Address + CCC + Data, Broadcast Address + CCC + Data, HDR-DDR + Cmd + Data, Addr + Data, or Any Addr + Data setup, select an ACK Condition of ACK, NO ACK, and DON'T CARE.
Bit Rates	Full range of speeds for I3C specification for SDR, HDR-DDR, and I2C legacy operation modes.
Trigger Input	Any analog Channel or Digital input, or the EXT input. External MSO not supported.
Decode + Search Capability	
Format	Hexadecimal, Binary, ASCII
Decode Setup	Threshold definition required. Defavult is to Percent amplitude. Choose to Decode address values including/not including the R/W bit in address value.
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace. Clock channel may be turned OFF and data will still decode (reduces screen clutter).
# of Decodes	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Visual Aid	Color Coding for FRAME, START/ReSTART bit, ADDR, R/W, DATA, ACK, NACK, and STOP bit. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.
Pattern Search	Search for Previous or Next ADDRESS, PACKET, or DATA in hexadecimal format.

I3Cbus TDME only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger) Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages**, **Message Bit Rate**, **Message Bus Load %**: Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits.
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.

COMPATIBILITY

		WaveSurfer 3000z	WaveSurfer 4000HD	HDO4000A	WaveRunner 8000HD WaveRunner 9000
Embedded Computing	I²C	EMB bundle	EMB bundle	TD	TD, TDME
	SPI			TD	TD, TDME
	UART-RS232			TD	TD, TDME
	USB 2.0 HSIC	–	–	D	D
	EMB bundle (I²C, SPI, UART-RS232)	TD	TD	TD	TD, TDME
Automotive + Industrial	10Base-T1S	–	–	TD	TD, TDME
	100Base-T1/BroadR-Reach	–	–	TD	TD, TDME
	CAN[7]	AUTO bundle	AUTO bundle	TD	TD, TDME Symbolic
	CAN FD[5]	TD		TD	TD, TDME Symbolic
	CAN XL[6v]	–	–	TD	TD, TDME Symbolic
	FlexRay	TD	AUTO bundle	TD	TD, TDMP
	LIN	AUTO bundle		TD	TD, TDME
	SENT	–	–	TD	TD, TDME
	AUTO bundle	TD[3]	TD	TD[3]	-
Avionics	ARINC 429	–	–	D Symbolic	D Symbolic, DME Symbolic
	MIL-STD-1553	–	–	TD	TD, TDME
	SpaceWire	–	–	D	D
Peripherals	Ethernet (10/100Base-T)	–	–	D	D
	USB 2.0	–	–	D	TD, TDME
	USB-PD (Power Delivery)	–	–	TD	TD, TDMP
	USB4-SB (Sideband)			TD	TD, TDMP
	DisplayPort AUX	–	–	D	D, DMP
Power Mgmt	SMBus	–	–	TD	TD, TDME
	PMBus	–	–	TD	TD, TDME
	SPMI	–	–	TD	TD, TDME
MIPI	C-PHY	–	–	–	D, DP[4]
	D-PHY	–	–	D	D, DP[4]
	DigRF 3G	–	–	D	D
	DigRF v4	–	–	D	D
	I³C	–	–	TD	TD, TDME
Other	Audio (I²S, LJ, RJ, TDM)	TD	TD	TD	TD, TDG
	Manchester	–	–	D	D
	NRZ	–	–	D	D, TD[2]

Notes

1 – DME, DME Symbolic, DMP, and DG packages are available for these models through the Teledyne LeCroy Service Department - consult factory.
2 – Trigger and Decode are available through separately orderable options - consult factory.
3 – AUTO bundle contains CAN and LIN trigger and decode ("TD") when purchased with WaveSurfer 3000z, and contains CAN, LIN and FlexRay trigger and decode ("TD") when purchased with WaveSurfer 10, and HDO4000A.
4 – Available on some bandwidth models only.
5 – CAN FDbus options support both CAN FD and the legacy CAN protocol.
6 – CAN XL contain CAN and CAN FD
7 – CAN is included in CAN FD and CAN XL option

		HDO6000B	WavePro HD	WaveMaster 8 Zi-B	LabMaster 10 Zi-A
Embedded Computing	I²C	TD, TDME	TD, TDME	TD, TDME	D, DME[1]
	SPI	TD, TDME	TD, TDME	TD, TDME	D, DME[1]
	UART-RS232	TD, TDME	TD, TDME	TD, TDME	D, DME[1]
	USB 2.0 HSIC	D	D	D	D
	EMB bundle (I²C, SPI, UART-RS232)	TD, TDME	TD, TDME	TD, TDME	D, DME[1]
Automotive + Industrial	10Base-T1S	TD, TDME	TD, TDME	TD, TDME	–
	100Base-T1/BroadR-Reach	TD, TDME	TD, TDME	TD, TDME	–
	CAN[7]	TD, TDME Symbolic	TD, TDME Symbolic	TD, TDME Symbolic	D, DME Symbolic[1]
	CAN FD[5]	TD, TDME Symbolic	TD, TDME Symbolic	TD, TDME Symbolic	D, DME Symbolic[1]
	CAN XL[6]	TD, TDME Symbolic	TD, TDME Symbolic	–	–
	FlexRay	TD, TDMP	TD, TDMP	TD, TDMP	D, DMP[1]
	LIN	TD, TDME	TD, TDME	TD, TDME	D, DME[1]
	SENT	TD, TDME	TD, TDME	D	D
	AUTO bundle	–	–	–	–
Avionics	ARINC 429	D Symbolic, DME Symbolic	D Symbolic, DME Symbolic	D Symbolic, DME Symbolic	D Symbolic, DME Symbolic[1]
	MIL-STD-1553	TD, TDME	TD, TDME	TD, TDME	D, DME[1]
	SpaceWire	D	D	D	D
Peripherals	Ethernet (10/100Base-T)	D	D	D	D
	USB 2.0	TD, TDME	TD, TDME	D, DME	D, DME[1]
	USB-PD (Power Delivery)	TD, TDMP	TD, TDMP	TD, TDMP	DMP
	USB4-SB (Sideband)	TD, TDMP	TD, TDMP	TD, TDMP	DMP
	DisplayPort AUX	D, DMP	D, DMP	D, DMP	D, DMP
Power Mgmt	SMBus	TD, TDME	TD, TDME	–	–
	PMBus	TD, TDME	TD, TDME	–	–
	SPMI	TD, TDME	TD, TDME	D, DME	D, DME[1]
MIPI	C-PHY	–	D, DP[4]	D, DP	D, DP
	D-PHY	D	D, DP[4]	D, DP[5]	D, DP
	DigRF 3G	D	D	D	D
	DigRF v4	D	D	D	D
	I³C	TD, TDME	TD, TDME	D, DME	D, DME
Other	Audio (I²S, LJ, RJ, TDM)	TD, TDG	TD, TDG	TD, TDG	D, DG[1]
	Manchester	D	D	D	D
	NRZ	D	D, TD²	D, TD²	TD²

Notes

1 – DME, DME Symbolic, DMP, and DG packages are available for these models through the Teledyne LeCroy Service Department - consult factory.
2 – Trigger and Decode are available through separately orderable options - consult factory.
3 – AUTO bundle contains CAN and LIN trigger and decode ("TD") when purchased with WaveSurfer 3000z, and contains CAN, LIN and FlexRay trigger and decode ("TD") when purchased with WaveSurfer 10 and HDO4000A.
4 – Available on some bandwidth models only.
5 – CAN FDbus options support both CAN FD and the legacy CAN protocol.
6 – CAN XL contain CAN and CAN FD
7 – CAN is included in CAN FD and CAN XL option

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Customer Service

Teledyne LeCroy oscilloscopes and probes are designed, built, and tested to ensure high reliability. In the unlikely event you experience difficulties, our digital oscilloscopes are fully warranted for three years and our probes are warranted for one year. This warranty includes:

- No charge for return shipping
- Long-term 7-year support
- Upgrade to latest software at no charge

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1-800-5-LeCroy
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Local sales offices are located throughout the world.
Visit our website to find the most convenient location.

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