TELEDYNE LECROY
Everywhereyoulook™

Instruction Manual

Trigger, Decode, Measure/Graph, Eye Diagrams

for Embedded Protocols:

I2C
SPI
UART and RS-232

TELEDYNE LECROY
Everywhereyoulook™

Embedded Protocols TDME Instruction Manual

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Contents

About This Manual

Teledyne LeCroy offers a wide array of toolsets for decoding and debugging serial data streams. These toolsets may be purchased as optional software packages, or are provided standard with some oscilloscopes.

This manual explains the basic procedures for using serial data decoder and trigger software options. There are also sections pertaining to the measure and graphing capabilities and eye diagram tests.

This manual is presented with the assumption that:

- You have purchased and installed one of the serial data products described in this manual.
- You have a basic understanding of the serial data standard physical and protocol layer specifications, and know how these standards are used in embedded controllers.
- You have a basic understanding of how to use an oscilloscope, and specifically the Teledyne LeCroy oscilloscope on which the option is installed. Only features directly related to serial data triggering and decoding are explained in this manual.

Teledyne LeCroy is constantly expanding coverage of serial data standards and updating software. Some capabilities described in this documentation may only be available with the latest version of our firmware. You can download the free firmware update from:

teledynelecroy.com/support/softwaredownload

While some of the images in this manual may not exactly match what is on your oscilloscope display—or may show an example taken from another standard—be assured that the functionality is identical, as much functionality is shared. Product-specific exceptions will be noted in the text.

About the Options

Decode

Teledyne LeCroy decoders apply software algorithms to extract serial data information from physical layer waveforms measured on your oscilloscope. The extracted information is displayed over the actual physical layer waveforms, color-coded to provide fast, intuitive understanding of the relationship between message frames and other, time synchronous events.

Trigger

Trigger *and* decode (-TD) options enable you to trigger the oscilloscope acquisition upon finding specific message frames, data patterns, or errors in serial data streams. Conditional filtering at different levels enables you to target the trigger to a single message or a range of matching data.

Measure/Graph and Eye Diagrams

The installation of any -DME or -TDME option adds a set of measurements designed for serial data analysis and protocol-specific eye diagram tests to the standard trigger and decoder capabilities. See Measuring for instructions on using the measure and graphing capabilities. See Eye Diagram Tests for instructions on using the eye diagram tests.

About the I2Cbus Options

I2C is a standardized protocol created by Philips with a documented technical specification. NXP (formerly Philips Semiconductors) provides a full description of the standard at:

www.nxp.com/documents

The I2Cbus TD and TDME options enable triggering on a range of data bytes corresponding with reads or writes to specific sub-address memory blocks in the EEPROM. It can also aid in monitoring data outputs from I2C- based sensors, such as analog-to-digital converters, and triggering when data is outside a safe operating range. Other features include:

- Address conditions in binary and data conditions in hexadecimal to trigger on a range of addresses using "Don't Care" bits
- Frame length triggering
- EEPROM triggering on up to 96 bits (12 bytes) of data at any location within an I2C frame or at a user-defined location in a 2048 byte window
- All permutations of Read, Write, or R/W Don't Care trigger conditions for 7 and 10-bit addresses
- ACK response triggering

About the SPIbus Options

SPI was popularized by Motorola but is not a standard, per se. There are variants with differences characterized by how data is clocked, whether data is MSB or LSB format, and whether it is multislave or single-slave.

While SPI has no formal standard, information is often included in the technical documentation for the microprocessor supporting the protocol.

The "Simplified" SPI (SIOP, SSPI, and SPI-Custom) decoders do not require use of a Chip Select line. In its place is the ability to set a minimum Interframe Time. By eliminating the Chip Select line presence requirement, an additional oscilloscope channel is preserved for use with other analog signals.

The SPIbus TD and TDME options enable trigger on SPI messages, targeted to a specific data pattern or a range of data. As with the decoder, the serial data trigger can be configured for any of the many variants of SPI.

About the UART/RS-232bus Options

UART is a generic backbone for many proprietary serial data protocols, each with different physical layers. UART has no formal standard. The protocol evolved from mechanical rotating teletypewriter devices. Formats were formalized with the advent of the first electronic computers.

RS-232 is a special case of UART, with a more defined protocol and specific physical layer. The physical layer is defined in Electronic Industries Association (EIA) EIA-RS-232-C and Telecommunications Industry Association (TIA) TIA-232-F. Its protocol layer is not specified; however, UART is commonly implemented. Resources can be found at www.eia.org and www.tiaonline.org.

The UART/RS-232bus TD and TDME options feature:

- Ability to define the UART byte with 9-bit data, with the 9^{th} data bit functioning as an alert bit with a value setable to 0, 1, or X.
- Ability to define as few as 5 bits of data in the UART byte.
- Polarity configurable to either IdleLow or IdleHigh.
- Decoding in **Binary** or **Hex**(adecimal) formats

Triggers can be set on data patterns or Parity errors. Data triggers can be set to find values relative to ranges or individual values. Additional features include:

- Triggering on up to 12 bytes of data in a string up to 2048 bytes long.
- Ability to define the UART byte messages into a single long message packet.

Serial Decode

The algorithms described here at a high level are used by all Teledyne LeCroy serial decoders sold for oscilloscopes. They differ slightly between serial data signals that have a clock embedded in data and those with separate clock and data signals.

Bit-level Decoding

The first software algorithm examines the embedded clock for each message based on a default or user- specified vertical threshold level. Once the clock signal is extracted or known, the algorithm examines the corresponding data signal at the predetermined vertical level to determine whether a data bit is high or low. The default vertical level is set to 50% and is determined from a measurement of peak amplitude of the signals acquired by the oscilloscope. For most decoders, it can also be set to an absolute voltage level, if desired. The algorithm intelligently applies a hysteresis to the rising and falling edge of the serial data signal to minimize the chance of perturbations or ringing on the edge affecting the data bit decoding.

Note: Although the decoding algorithm is based on a clock extraction software algorithm using a vertical level, the results returned are the same as those from a traditional protocol analyzer using sampling point-based decode.

Logical Decoding

After determining individual data bit values, another algorithm performs a decoding of the serial data message after separation of the underlying data bits into logical groups specific to the protocol (Header/ID, Address Labels, Data Length Codes, Data, CRC, Parity Bits, Start Bits, Stop Bits, Delimiters, Idle Segments, etc.).

Message Decoding

Finally, another algorithm applies a color overlay with annotations to the decoded waveform to mark the transitions in the signal. Decoded message data is displayed in tabular form below the grid. Various compaction schemes are utilized to show the data during a long acquisition (many hundreds or thousands of serial data messages) or a short acquisition (one serial data message acquisition). In the case of the longest acquisition, only the most important information is highlighted, whereas in the case of the shortest acquisition, all information is displayed with additional highlighting of the complete message frame.

User Interaction

Your interaction with the software in many ways mirrors the order of the algorithms. You will:

- Assign a protocol/encoding scheme, an input source, and a clock source (if necessary) to one of the four decoder panels using the Serial Data and Decode Setup dialogs.
- Complete the remaining dialogs required by the protocol/encoding scheme.
- Work with the decoded waveform, result table, and measurements to analyze the decoding.

Decoding Workflow

We recommend the following workflow for effective decoding:

1. Connect your data and strobe/clock lines (if used) to the oscilloscope.
2. Set up the decoder using the lowest level decoding mode available (e.g., Bits).
3. Acquire a sufficient burst of relevant data. The data burst should be reasonably well centered on screen, in both directions, with generous idle segments on both sides.

   Note: See Failure to Decode for more information about the required acquisition settings. A burst might contain at most 100000 transitions, or 32000 bits/1000 words, whichever occurs first. This is more a safety limit for software engineering reasons than a limit based on any protocol. We recommend starting with much smaller bursts.

4. Stop the acquisition, then run the decoder.
5. Use the various decoder tools to verify that transitions are being correctly decoded. Tune the decoder settings as needed.
6. Once you know you are correctly decoding transitions in one mode, continue making small acquisitions of five to eight bursts and running the decoder in higher level modes (e.g., Words). The decoder settings you verify on a few bursts will be reused when handling many packets.
7. Run the decoder on acquisitions of the desired length.

When you are satisfied the decoder is working properly, you can disable/enable the decoder as desired without having to repeat this set up and tuning process, provided the basic signal characteristics do not change.

Decoder Setup

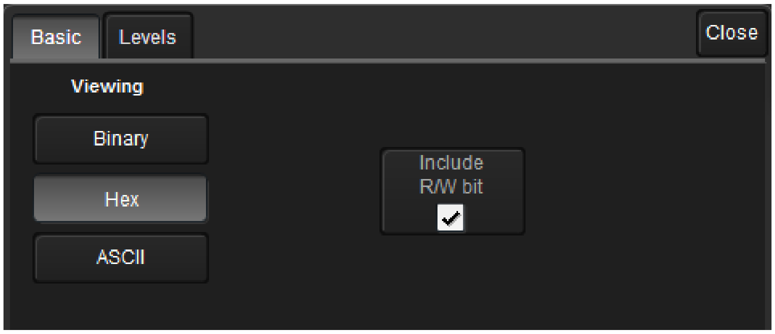
Use the Decode Setup dialog and its protocol-related subdialogs to preset decoders for future use. Each decoder can use different (or the same) protocols and data sources, or have other variations, giving you maximum flexibility to compare different signals or view the same signal from multiple perspectives.

Tip: After completing setup for one decoder, you can quickly start setup for the other decoders by using the buttons at the left of the Decode Setup dialog to change the Decode # .

1. Touch the **Front Panel Serial Decode button** (if available on your oscilloscope), or choose **Analysis > Serial Decode** from the oscilloscope menu bar. Open the **Decode Setup** dialog.
2. Select the **data source (Src 1)** to be decoded and the **Protocol** to decode.
3. If required by the protocol, also select the **Strobe** or **Clock** source. (These controls will simply not appear if not relevant.)
4. Define the bit- and protocol-level decoding on the subdialogs next to the Decode Setup dialog.

I2C Decoder Settings

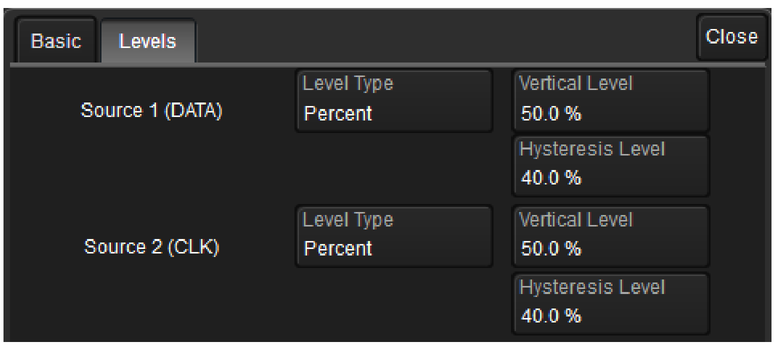
Basic Subdialog



Under **Viewing**, choose to view/enter data in **Binary**, **Hexadecimal**, or **ASCII** formats.

Some engineers consider the address pattern to include the R/W bit (i.e., 8-bits). If your signal utilizes 8-bit addresses, mark **include the R/W bit**.

Levels Subdialog



Enter the **Vertical Level** used to determine the edge crossings of the DATA and CLK (Clock) source signals. This value will be used to determine the bit-level decoding. Level is normally set as a Percent of amplitude and defaults to 50%. It can alternatively be set as an absolute voltage by changing the **Level Type** to Absolute. The set Vertical Level appears as a dotted horizontal line across the oscilloscope grid. If your initial decoding indicates that there are a number of error packets, make sure that the level is set to a reasonable value.

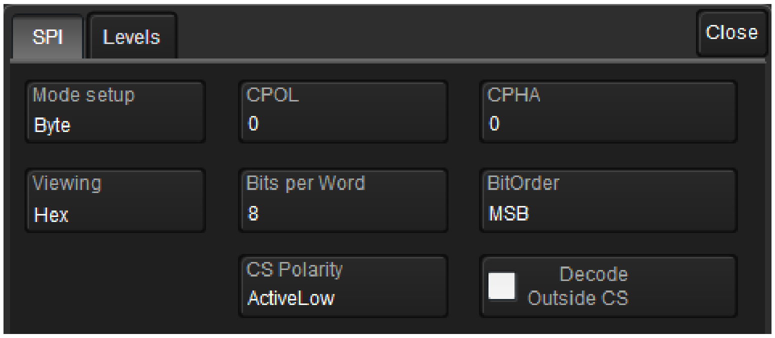
Note: Data and clock sources can be set to different levels, but they are typically the same level.

Enter a **Hysteresis Level** indicating the amount the signal may rise or fall without affecting bit transition; this helps to compensate for noisy signals. Hysteresis Level must be set in the same manner as you set the Vertical Level: either percent of amplitude or absolute number of grid divisions.

SPI Decoder Settings

SPI/Basic Subdialog

For SPI and SPI-DDR decoders, the top subdialog will be named after the protocol. For SIOP, SSPI, and SPI-Custom decoders, this dialog will be named Basic. They are the same except for Chip Select and InterFrame settings.



Mode setup - Choose to decode by Byte or Frame.

CPOL (Clock Polarity) and **CPHA** (Clock Phase) - SPI requires that selections be made for the clock polarity and phasing of the data to the clock. SPI microcontrollers and peripherals have settings for CPOL and CPHA that are published in the technical datasheets for those products. Enter those values in this section. SPI Mode 0 = CPOL 0 and CPHA 0. SPI Mode 1 = CPOL 0 and CPHA 1. SPI Mode 2 = CPOL 1 and CPHA 0. SPI Mode 3 = CPOL 1 and CPHA 1.

Note: Identical settings for Clock Polarity and Clock Phase are on the SPI serial trigger setup dialog. If you have chosen to link this decoder to the trigger, shared settings are copied from the trigger setup and dynamically updated in both locations.

In **Viewing**, choose to view/enter decoded values in Binary, Hexadecimal, ASCII, or Decimal format.

Bits per Word and **BitOrder** - Enter the number of bits per word and choose from MSB or LSB bit order format.

SPI and SPI-DDR Variations

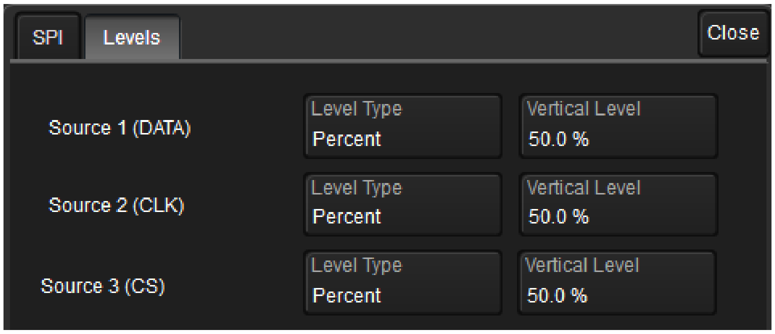
CS Polarity - Set Chip Select Polarity to either ActiveLow or ActiveHigh.

Decode Outside CS - Check if you want to decode all SPI bytes instead of only those active during the Chip Select.

SIOP and SPI-Custom Variations

SIOP, SSPI and SPI-Custom decoders do not use Chip Select. Instead, choose to set the InterFrame period **Auto**(matically) or **Manual**(ly). Auto sets a time that is is (typically) 4x a single bit time and less than the interframe time between different message packets. For a manual setting, enter the **InterFrame Time**.

Levels Subdialog



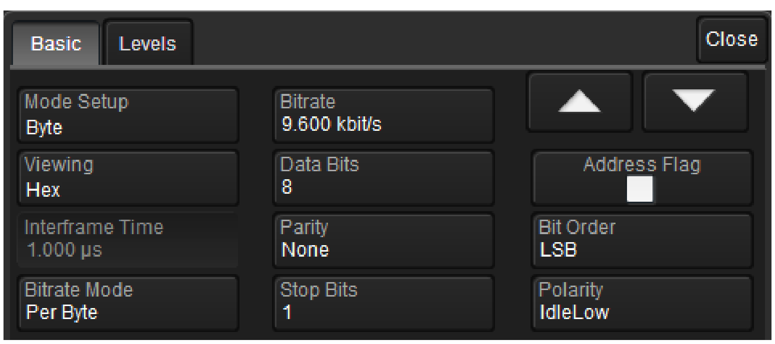
Enter the **Vertical Level** used to determine the edge crossings of the SPI source signals: Data, Clock, and Chip Select (SPI and SPI-DDR decoders only). This value will be used to determine the bit-level decoding. Level is normally set as a Percent of amplitude and defaults to 50%. It can alternatively be set as an absolute number of grid divisions (positive or negative) by changing the **Level Type** to Absolute.

The set Vertical Level appears as a dotted horizontal line across the oscilloscope grid. If your initial decoding indicates that there are a number of error packets, make sure that the level is set to a reasonable value.

UART/RS-232 Decoder Settings

Basic Subdialog

Use these controls to define the characteristics of the data signal.



In **Mode Setup**, choose to view the decoding per Byte or per Message frame. The result table will show one Byte or Message per line. If you are using Message mode, also enter the **InterFrame Time** between messages.

In **Viewing**, choose to view/enter values in Binary, Hexadecimal, ASCII, or Decimal format.

Choose a **Bitrate Mode** to determine how the bit rate is calculated:

- Per Byte computes bit rate for each byte separately, then takes the average of those to calculate bit rate of frame. This method of computing bit rate ensures that the gap between each byte is not included in the overall frame bit rate.

- Per Message computes bit rate using the full length of frame divided by total number of bits.

Enter the **Bitrate** of the bus to which you are connected. The value should be correct within 5%. A mismatched bit rate will cause various confusing side effects on the decoding, so it is best to take time to correctly adjust this fundamental value. Use the arrows to scroll a list of standard bit rates, or touch Bitrate and enter a value.

Tip: If you are not sure about the value, apply the Bit Rate measurement parameter to a short acquisition to determine the exact bit rate of your signal.

Enter the number of **Data Bits** per byte (not including the START, STOP, or PARITY bits).

Select the **Parity**. Parity must be Odd or Even to trigger on Parity Error.

Enter the number of **Stop Bits**.

Check **Address Flag** to decode the last bit before the STOP bit to determine if it is an address or data byte.

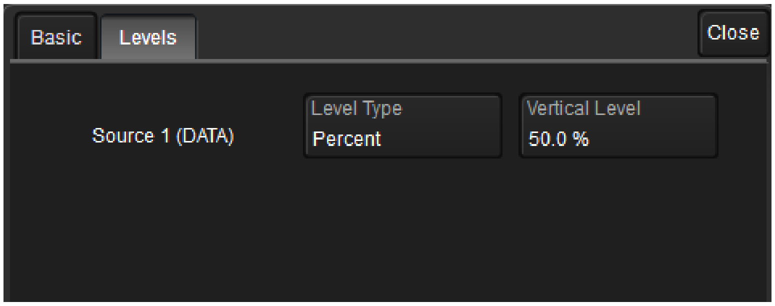
Choose either Most Significant Bit (MSB) or Least Significant Bit (LSB) **Bit Order**.

Note: On an RS-232 decoder, this field defaults to LSB and cannot be changed.

Select the **Polarity** of the UART signal, either **IdleLow** (Data 1 = High) or **IdleHigh** (Data 1 = Low).

Note: On an RS-232 decoder, this field defaults to IdleLow and cannot be changed.

Levels Subdialog



Enter the **Vertical Level** used to determine the edge crossings of the source signal. This value will be used to determine the bit-level decoding. Level is normally set as a Percent of amplitude and defaults to 50%. It can alternatively be set as an absolute voltage by changing the **Level Type** to Absolute. The set Vertical Level appears as a dotted horizontal line across the oscilloscope grid. If your initial decoding indicates that there are a number of error packets, make sure that the level is set to a reasonable value.

Failure to Decode

Three conditions in particular may cause a decoder to fail, in which case a failure message will appear in the first row the the summary result table, instead of in the message bar as usual:

- **Under sampled**. If the sampling rate (SR) is insufficient to resolve the signal adequately based on the bit rate (BR) setup or clock frequency, the message "Under Sampled" will appear. The minimum SR:BR ratio required is 4:1. It is suggested that you use a slightly higher SR:BR ratio if possible, and use significantly higher SR:BR ratios if you want to also view perturbations or other anomalies on your serial data analog signal.
- **Too short acquisition**. If the acquisition window is to short to allow any meaningfull decoding, the message “Too Short Acquisition” will appear. The minimum number of bits required varies from one protocol to another, but is usually between 5 and 50.
- **Too small amplitude**. If the signal’s amplitude is too small with respect to the full ADC range, the message “Decrease V/Div” will appear. The required amplitude to allow decoding is usually one vertical division.

In each case, the decoding is turned off to protect you from incorrect data. Adjust your acquisition settings accordingly, then re-enable the decoder.

Note: It is possible that several conditions are present, but you will only see the first relevant message in the table. If you continue to experience failures, try adjusting the other settings.

Serial Decode Dialog

To first set up a decoder, go to the Decode Setup dialog. Once decoders have been configured, use the Serial Decode dialog to quickly turn on/off a decoder or make minor modifications to the settings.

To turn on decoders:

1. Touch the **Front Panel Serial Decode button** (if available on your oscilloscope), or choose **Analysis > Serial Decode** from the oscilloscope menu bar to access the Serial Decode dialog.
2. On the same row as the **Decode #**, check **On** to enable the decoder.

   As long as On is checked (and there is a valid acquisition), a result table and decoded waveform appear. The number of rows of data displayed will depend on the **Table#Rows** setting (on the Decode Setup dialog).
3. Optionally, modify the:
   - **Protocol** associated with the decoder.
   - **Data (Source)** to be decoded.
4. Check Link To Trigger **On** to tie this decoder setup to a serial trigger setup.

To turn off decoders: deselect the On boxes individually, or touch **Turn All Off**.

Reading Waveform Annotations

When a decoder is enabled, an annotated waveform appears on the oscilloscope display, allowing you to quickly read the results of the decoding. A colored overlay marks significant bit-sequences in the source signal. The overlay contains annotations corresponding to the Header/ID, Address, Labels, Data Length Codes, Data, CRC, Parity Bits, Start Bits, Stop Bits, Delimiters, Idle segments, etc. Annotations are customized to the protocol or encoding scheme.

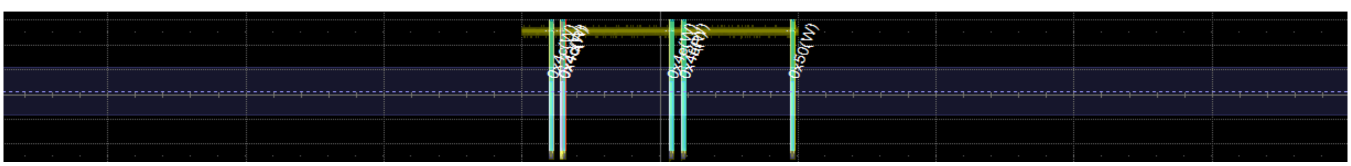
The amount of information shown on an annotation is affected by the width of the rectangles in the overlay, which is determined by the magnification (scale) of the trace and the length of the acquisition. Zooming a portion of the decoder trace will reveal the detailed annotations.

I2C Waveform Annotations

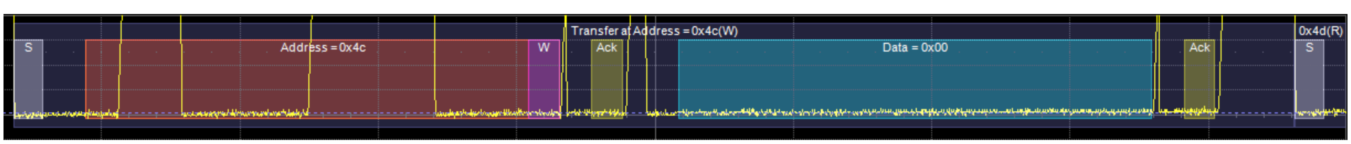
These overlays appear on an I2C waveform or its zoom trace:

Annotation	Overlay Color (1)	Text (2) (3)
Packet	Navy Blue (behind other fields)	<type> = <value> (< R | W >)
Start/Stop Bits	Grey	< S | P >
R/W Bits	Hot Pink	< R | W >
Address	Brick Red	Address = <value>
Acknowledge	Olive	ACK
No Acknowledge	Bright Red	NACK
Payload Data	Aqua Blue	Data = <bytes>
Protocol Error	Bright Red (behind other fields)	<error type>

1. Combined overlays affect the appearance of colors.
2. Text in brackets < > is variable. The amount of text shown depends on your zoom factors.
3. Payload data values shown in binary, hexadecimal, or ASCII depending on your decoder selection. Other values shown in hexadecimal only.



Initial decoding. At this resolution, little information appears on the overlay.



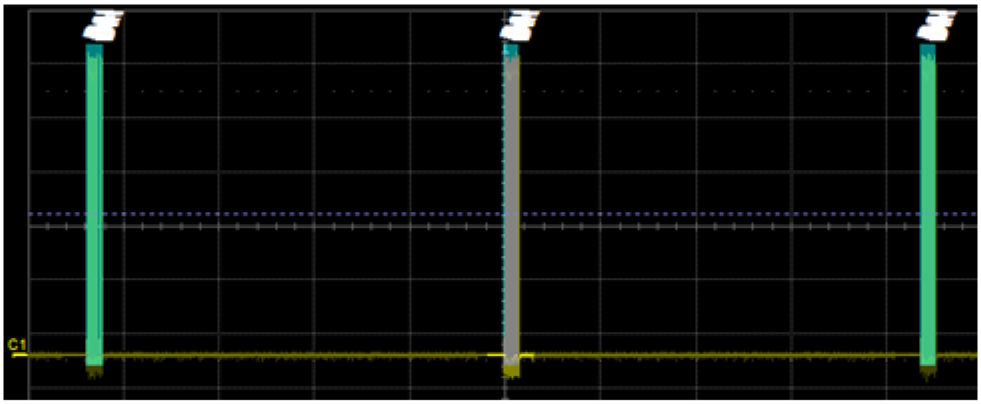
Zoom of single index showing annotation details.

SPI Waveform Annotations

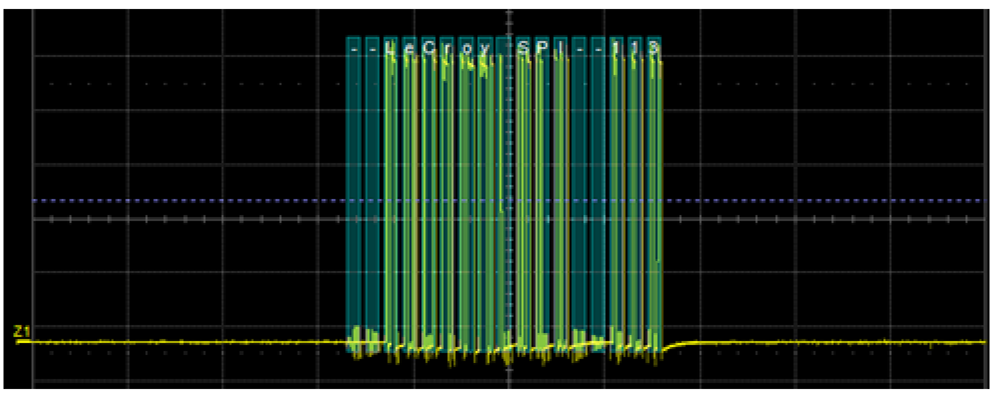
These overlays appear on a SPI waveform or its zoom trace:

Annotation	Overlay Color (1)	Text (2) (3)
Data byte	Green	<value>

1. Combined overlays affect the appearance of colors.
2. Text in brackets < > is variable. The amount of text shown depends on your zoom factors.
3. Data values are shown in binary, hexadecimal, ASCII, or decimal depending on your decoder selection.



Initial decoding of SIOP waveform.



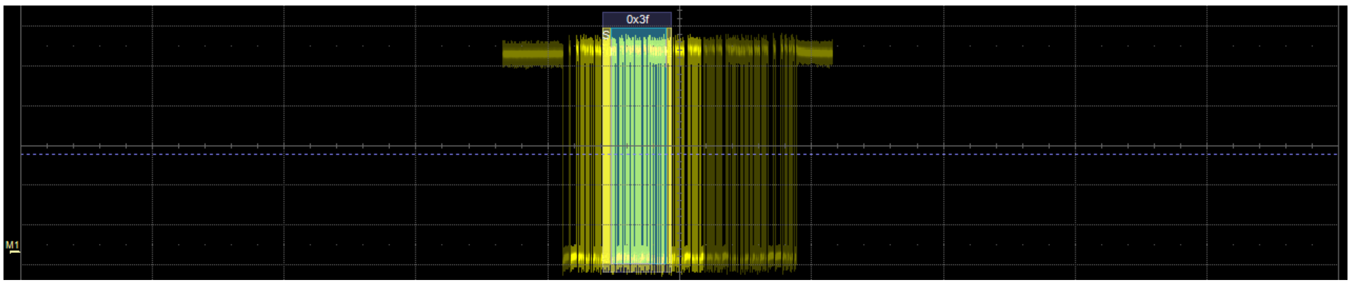
Zoomed SIOP waveform, showing detailed annotations.

UART/RS-232 Waveform Annotations

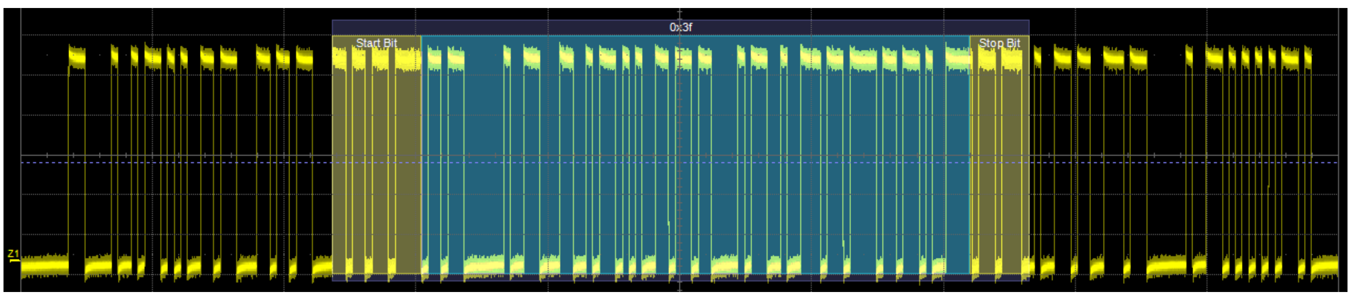
These overlays appear on decoded UART and RS-232 waveforms and their zoom traces.

Annotation	Overlay Color (1)	Text (2) (3)
Byte	Navy Blue (behind other fields)	<value>
Start/Stop Bits	Yellow	< S | P >
Payload Data	Aqua Blue	
Protocol Error	Bright Red (behind other fields)	<error type>

1. Combined overlays affect the appearance of colors.
2. Text in brackets < > is variable. The amount of text shown depends on your zoom factors.
3. Data values are shown in binary, hexadecimal, ASCII, or decimal depending on your decoder selection.



Initial decoding.



Zoom showing annotation details.

Serial Decode Result Table

By default, a table summarizing the decoder results appears below the grids whenever a decoder is enabled. The result table provides a view of data as decoded during the most recent acquisition, even when the number of bursts are too many to allow legible annotation on the waveform trace.

The table is displayed only when the **View Decode** checkbox is marked on the Decode Setup Dialog *and* a source signal has been decoded using that protocol.

You can export result table data to a .CSV file.

Table Rows

Each row of the table represents one index of data found within the acquisition. Exactly what this represents depends on the protocol and how you have chosen to "packetize" the data stream when configuring the decoder (frame, message, packet, etc.).

Note: For some decoders, it is even possible to turn off packetization, in which case all the decoded data appears on one row of the table.

See Using the Result Table for more information about how to interact with the table rows to view the decoding. Swipe the table up/down or use the scrollbar at the far right to navigate the table.

When multiple decoders are run at once, the index rows are combined in a summary table, ordered according to their acquisition time. The Protocol column is colorized to show which input source resulted in that index.

You can change the number of rows displayed on the table at one time. The default is five rows.

Table Columns

When a single decoder is enabled, the result table shows the protocol-specific details of the decoding. This **detailed result table** may be customized to show only those columns you want displayed.

Enabling two or more decoders switches the display to a combined table. A top-level **summary result table** (which cannot be changed) shows these columns of data for every decoding:

Column	Extracted or Computed Data
Index	Number of the line in the table
Time	Time elapsed from start of acquisition to start of message
Protocol	Protocol being decoded
Message	Message identifier bits
Data	Data payload
CRC	Cyclic Redundancy Check sequence bits
Status	Any decoder messages; content may vary by protocol

Index	Time	Protocol	Message	Data
9	2.62316 ms	I2C	'r'	
10	2.84000 ms	I2C	'r'	'eetings from LeCroy..9..Tw..n7i..1ni.g}.W.<")...L.Z.O*...f........ 8 ......
11	4.11914 ms	I2C	'L'	"
12	4.32165 ms	I2C	'M'	' LeCroy I2C 30'
13	43.6681 ms	I2C	'N'	' LeCroy I2C 31'

Example summary result table, with results from two decoders combined on one table.

When you select the Index number from the summary result table, the detailed results for that index drops-in below it.

Index	Time	Protocol	Message			Data	
10	2.84000 ms	I2C	'r'			'eetings from LeCroy..9..Tw..n7i..1ni.g}.W.<")...L.Z.O*...f........ 8	
		Addr Length	Address	R/W	Len...	Data	Status
		10	'r'	R	255	'eetings from LeCroy..9..Tw..n7i..1ni.g}....	
11	4.11914 ms	I2C	'L'			"	
12	4.32165 ms	I2C	'M'			' LeCroy I2C 30'	

Example summary result table showing drop-in detailed result table.

I2C Result Table

Column	Extracted or Computed Data
Index (always shown)	Number of the line in the table
Time	Time elapsed from start of acquisition to Start of Frame
Address Length	Number of Address field bits, either 7 or 10
Address	Extracted Address field bits, in either binary or hexadecimal
R/W	Extracted Read/Write field bits
Length	Number of Data field bytes
Data	Extracted Data field bytes
Status	I2C errors found in the decoding

I2C	Time	Addr Length	Address	R/W	Len...	Data	Status
1	-16.70...	7	0x4c	W	16	0x00 00 4c 65 43 72 6f 79 20 49 32 43 00 00 33 30	
2	4.119...	7	0x4c	W	1	0x00	
3	4.321...	7	0x4d	R	16	0x00 00 4c 65 43 72 6f 79 20 49 32 43 00 00 33 30	
4	43.66...	7	0x4e	W	16	0x00 00 4c 65 43 72 6f 79 20 49 32 43 00 00 33 31	
5	47.80...	7	0x4e	W	1	0x00	

Section of typical I2C detailed result table.

SPI Result Table

Column	Extracted or Computed Data
Index (always shown)	Number of the line in the table
Time	Time elapsed from start of acquisition to start of message
Data	Extracted data values
Bit Rate/Byte or Bit Rate/Msg	Bit Rate for corresponding byte or message of data, depending on your Mode Setup selection

SPI-DDR	Time	Data	Bit Rate/Byte
2062	-67.507 µs	0x55	1.249578 Gbit/s
2063	-67.501 µs	0x55	1.252629 Gbit/s
2064	-67.495 µs	0x55	1.252558 Gbit/s
2065	41.906 µs	0x2a	1.354154 Gbit/s

Section of typical SPI detailed result table.

UART/RS-232 Result Table

Column	Extracted or Computed Data
Index (always shown)	Number of the line in the table
Time	Time elapsed from start of acquisition to start of message
Data	Decoded data payload bytes
Data Length	Data field length
A/D	If the Address flag is checked, this column will show whether the byte is address or payload data
Parity	Parity bit
Bit Rate	Transmission bit rate per Byte or Message, depending on Mode Setup selection

UART	Time	Data	DataLength	A/D	Parity	Bit Rate
6	1.89960 ms		400			9.594 kbit/s
7	44.29363 ms	0xfe	8	1	1	9.244 kbit/s
8	45.48360 ms		401			9.594 kbit/s
9	87.98162 ms	0xfe	8	1	1	9.378 kbit/s

Section of typical UART detailed result table.

Using the Result Table

Besides displaying the decoded serial data, the result table helps you to inspect the acquisition.

Zoom & Search

Touching any cell of the table opens a zoom centered around the part of the waveform corresponding to the index. The Z*x* dialog opens to allow you to rescale the zoom, or to Search the acquisition. This is a quick way to navigate to events of interest in the acquisition.

Tip: When in combined table mode, touch any data cell *other than* Index and Protocol to zoom.

The table rows corresponding to the zoomed area are highlighted, as is the zoomed area of the source waveform; the highlight color reflects the zoom that it relates to (Z1 yellow, Z2 pink, etc.). As you adjust the scale of the zoom, the highlighted area may expand to several rows of the table, or fade to indicate that only a part of that Index is shown in the zoom.

When there are multiple decoders running, each can have its own zoom of the decoding highlighted on the combined table at the same time.

Note: The zoom number is no longer tied to the decoder number. The software tries to match the numbers, but if it cannot it uses the next empty zoom slot.

Index	Time	Protocol	Message	Data	CRC	Status
10	2.84000 ms	I2C	'r'	'eetings from LeCroy..9..Tw..n7i..1ni.g}.W.<")...L.Z.O*...f........ 8		
11	4.11914 ms	I2C	'L'	''		
12	4.32165 ms	I2C	'M'	' LeCroy I2C 30'		
13	43.6681 ms	I2C	'N'	' LeCroy I2C 31'		
14	47.8039 ms	I2C	'N'	''		

Example multi-decoder table, both zoomed indexes highlighted.

View Details

When viewing a combined table, touch the **Index number** in the first column to drop-in the detailed decoding of that record. Touch the Index cell again to hide the details.

If there is more data than can be displayed in a cell, the cell is marked with a white triangle in the lower-right corner. Touch this to open a pop-up showing the full decoding.

Navigate

In single table mode, touch the **Index column header** (top, left-most cell of the table) to open the Decode Setup dialog. This is especially helpful for adjusting the decoder during initial tuning.

When in combined table mode, the Index column header cell opens the Serial Decode dialog, where you can enable/disable all the decoders. Touch the **Protocol** cell to open the Decode Setup dialog for the decoder that produced that index of data.

Customizing the Result Table

Follow these steps to change what data appears on the detailed result table:

1. Press the Front Panel **Serial Decode button** or choose **Analysis > Serial Decode**, then open the **Decode Setup tab**.
2. Touch the **Configure Table** button.
3. On the **View Columns** pop-up dialog, mark the columns you want to appear and clear those you wish to remove. Only those columns selected will appear on the oscilloscope display.

   Note: If a selected column is not relevant to the decoding selections, the column will not appear in the table.

   To return to the preset display, touch **Default**.
4. Touch the **Close** button when finished.

On some decoders, you may also use the View Columns pop-up to set a **Bit Rate Tolerance** percentage. When implemented, the tolerance is used to flag out-of-tolerance messages (messages outside the user-defined bitrate +- tolerance) by colorizing in red the Bitrate shown in the table.

You may customize the size of the result table by changing the **Table # Rows** setting on the Decode Setup dialog. Keep in mind that the deeper the table, the more compressed the waveform display on the grid, especially if there are also measurements turned on.

Exporting Result Table Data

You can manually export the detailed result table data to a .CSV file:

1. Press the Front Panel **Serial Decode button**, or choose **Analysis > Serial Decode**, then open the **Decode Setup tab**.
2. Optionally, touch **Browse** and enter a new **File Name** and output folder.
3. Touch the **Export Table** button.

Export files are by default created in the D:\Applications\<protocol> folder, although you can choose any other folder on the oscilloscope or any external drive connected to a host USB port. The data will overwrite the last export file saved in the protocol directory, unless you enter a new filename.

Note: When a combined table is exported, a combined file is saved in D:\Applications\Serial Decode. Separate files for each decoder are saved in D:\Applications\<protocol>.

In addition, the oscilloscope Save Table feature will automatically create tabular data files with each acquisition trigger. The file names are automatically incremented so that data is not lost. Choose **File > Save Table** from the oscilloscope menu bar and select **Decodex** as the source. Make other file format and storage selections as you wish.

Searching Decoded Waveforms

Touching the Action toolbar **Search button** button on the Decode Setup dialog creates a 10:1 zoom of the center of the decoder source trace and opens the Search subdialog.

Touching the **any cell** of the result table similarly creates a zoom and opens Search, but of only that part of the waveform corresponding to the index (plus any padding).

Tip: In combined table mode, touch any cell *other than* Index and Protocol to create the zoom.

Basic Search

On the Search subdialog, select what type of data element to **Search for**. These basic criteria vary by protocol, but generally correspond to the columns of data displayed on the detailed decoder result table.

Optionally:

- Check **Use Value** and enter the **Value** to find in that column. If you do not enter a Value, Search goes to the beginning of the next data element of that type found in the acquisition.
- Enter a **Left/Right Pad**, the percentage of horizontal division around matching data to display on the zoom.
- Check **Show Frame** to mark on the overlay the frame in which the event was found.

After entering the Search criteria, use the **Prev** and **Next** buttons to navigate to the matching data in the table, simultaneously shifting the zoom to the portion of the waveform that corresponds to the match.

The touch screen message bar shows details about the table row and column where the matching data was found.

Advanced Search

Advanced Search allows you to create complex criteria by using Boolean AND/OR logic to combine up-to-three different searches. On the Advanced dialog, choose the **Col(umns) to Search 1 - 3** and the **Value** to find just as you would a basic search, then choose the **Operator(s)** that represent the relationship between them.

Serial Trigger

TD options provide advanced serial data triggering in addition to decoding. Serial data triggering is implemented directly within the hardware of the oscilloscope acquisition system. The serial data trigger scrutinises the data stream in real time to recognise "on-the-fly" the user-defined serial data conditions. When the desired pattern is recognised, the oscilloscope takes a real-time acquisition of all input signals as configured in the instrument's acquisition settings. This allows decode and analysis of the signal being triggered on, as well as concomittant data streams and analog signals.

The serial trigger supports fairly simple conditions, such as "trigger at the begining of any packet," but the conditions can be made more restrictive depending on the protocol and the available filters, such as "trigger on packets with ID = 0x456". The most complex triggers incorporate a double condition on the ID and data, for example "trigger on packets with ID = 0x456 and when data in position 27 exceeds 1000".

The trigger and decode systems are independant, although they are seamlessly coordinated in the user interface and the architecture. It is therefore possible to trigger without decoding and decode without triggering.

Requirements

Serial trigger options require the appropriate hardware (please consult support), an installed option key, and the latest firmware release.

Restrictions

The serial trigger only operates on one protocol at a time. It is therefore impossible to express a condition such as "trigger on CAN frames with ID = 0x456 followed by LIN packet with Adress 0xEBC."

Linking Trigger to Decoder

A quick way to set up a serial trigger is to link it to a decoder by checking the **Link to Trigger** ("On") box on the Serial Decode dialog. Linking decoder to trigger allows you to configure the trigger with the exact same values that are used for decoding the signal (in particular the bit rate), saving the extra effort needed to re-enter values on the serial trigger set up dialogs.

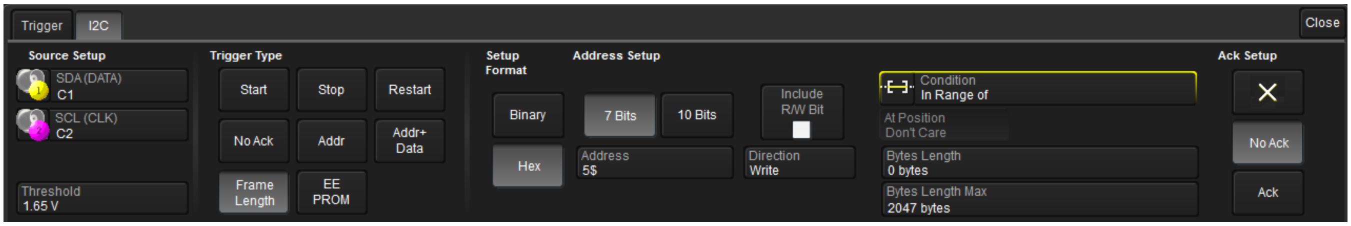
While the decoder and the trigger have distincts sets of controls, when the link is active, a change to the bit rate in the decoder will immediately propagate to the trigger and vice-versa.

I2C Trigger Setup

To access the serial trigger dialogs:

- Touch the Trigger descriptor box or choose **Trigger > Trigger Setup** from the Menu Bar.
- Touch the **Serial** Type button, and the **I2C** Standard button.

Then, working from left to right, make the desired selections from the I2C dialog.



Source Setup

In **DATA**, select the data source input channel.

In **CLK**, select the clock source input channel.

Use the **Threshold** control to adjust the vertical level for the trigger. This value is used for both data and clock signals.

Trigger Type

These buttons determine which frames/fields are included in the trigger search and which controls are activated on the Trigger setup dialog.

Start triggers upon finding the next Start Frame.

Stop triggers upon finding the next Stop Frame.

Restart triggers upon finding the next Restart.

No Ack triggers upon finding the next packet with no ACK field value.

Address triggers upon finding the next packet containing the specified address. Complete the Address Setup and Ack Setup fields described below.

Address+Data triggers upon finding matching Address field values *and* data patterns. Complete Address Setup, Data Pattern Setup, and Ack Setup fields described below.

Frame Length triggers upon finding packets that satisfy the frame length conditions. Complete the Condition and ByteLength fields under Data Pattern Setup.

EEPROM triggers upon finding matching EEPROM data patterns. Complete Data Pattern Setup and Ack Setup fields described below.

Setup Format

Choose to display/enter values in **Binary** or **Hex**(adecimal) format. The selection propagates throughout the entire I2C trigger setup. Toggling between formats does not result in loss of information, but will transform the appearance of values.

Address Setup

Choose whether the signal utilizes a **7-bit** or **10-bit** Address length.

Mark **Include R/W bit** if the Read/Write bit is included in the address value (i.e., 8-bit Address values).

Enter the **Address Value**. To use wildcards ("Don't Care" values) in any bit or nibble position, enter an X.

Note: When Hex values are converted to Binary, any non-nibble length wildcards are shown as $.

Choose a **Direction** of Read, Write, or Don't Care for the Address value. Address values are always MSB format.

Data Pattern Setup

Create a condition statement that describes the Data field pattern upon which to trigger. This condition is added to the Address condition.

Use **Data Condition** (Boolean operator) and **Data Value** together to specify the data patern upon which to fire the trigger. If less than 12 bytes of data is entered in Data Value, the data is assumed to begin at the 0 (i.e., first) data byte in the I2C message. If this is not desired, then add preceding or trailing wildcard (X) nibbles to the pattern. To use a range of values, choose In Range or Out Range.

When setting a range, enter the start value in Data Value and the stop value in **Data Value To**.

Note: When more than one data byte is entered, the data is treated as Most Significant Byte (MSB) First. In Hexadecimal format, data must be entered as full bytes even though the minimum acceptable entry is a nibble. If less than a full byte is entered, wildcards (XX) precede the pattern values entered.

Use **At Pos.** and **Byte Pos.** together to mark a specific position in the Data field the matching Data Value must occupy. You can select any position up to 2048, starting with Byte 0 (the first data byte).

Length defaults to the length, in bytes, of the pattern set in Data Value. If the length is changed to a lesser value, it truncates the beginning of the value. If the length is increased, wildcards (XX) are appended to the beginning of the value.

Note: This field appears as Bytes Length when using a Frame Length trigger. Specify a length from 0 (first byte only) to 2047 bytes (full frame), or to set a range, the **Bytes Length Max**.

Ack Setup

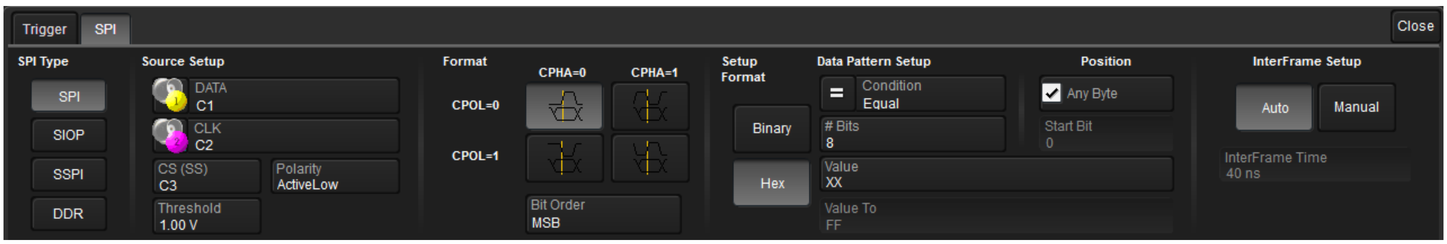
Choose whether to add an Acknowledge bit condition to the other trigger conditions: **X** (Don't Care), **No Ack** or **Ack**.

SPI Trigger Setup

To access the serial trigger dialogs:

- Touch the Trigger descriptor box or choose **Trigger > Trigger Setup** from the Menu Bar.
- Touch the **Serial** Type button, and the SPI Standard buttons:

Then, working from left to right, make the desired selections from the SPI dialog.



SPI Type

Choose the type of SPI encoding used on the input signal: **SPI**, **SIOP** , **SPI-DDR**, or **SSPI**.

Source Setup

In **DATA**, select the data source input channel.

In **CLK** (Clock), select the clock source input channel.

For SPI and SPI-DDR signals, enter the **CS (Chip Select)** input channel and **Polarity**.

Use the **Threshold** control to adjust the vertical level for the trigger. This threshold is used for all input channels.

Format

For SPI and SIOP signals, choose the **CPOL** (Clock Polarity) and **CPHA** (Clock Phase), the phasing of the data to the clock. SPI microcontrollers and peripherals have settings for CPOL and CPHA that are published in the technical datasheets for those products. Choose the button containing the graphic that corresponds with your needs: SPI Mode 0 = CPOL 0 and CPHA 0. SPI Mode 1 = CPOL 0 and CPHA 1. SPI Mode 2 = CPOL 1 and CPHA 0. SPI Mode 3 = CPOL 1 and CPHA 1.

Note: There is only one option for SSPI signals. These settings are not used by SPI-DDR.

Choose either MSB or LSB **Bit Order** format.

Setup Format

Setup format determines how you will view/enter the data pattern trigger criteria. Choose either **Binary** or **Hex**(adecimal) format.

Data Pattern Setup

Use **Condition** and **Value** together to describe the data pattern upon which to trigger. All values that meet the criteria will fire the trigger. Up to 12 bytes (96 bits) of data can be entered in Value. If using ranges, also enter the **To Value**.

In # **Bits**, enter the total bits in the trigger pattern (regardless of the data field length in the signal). If the Value entry is shorter than #Bits, it will be padded to this total number using "don't care" characters ("X" if the trigger condition is = or Not =, "O" otherwise).

Position

Check **Any Byte** to begin searching for the data pattern at any point in the message.

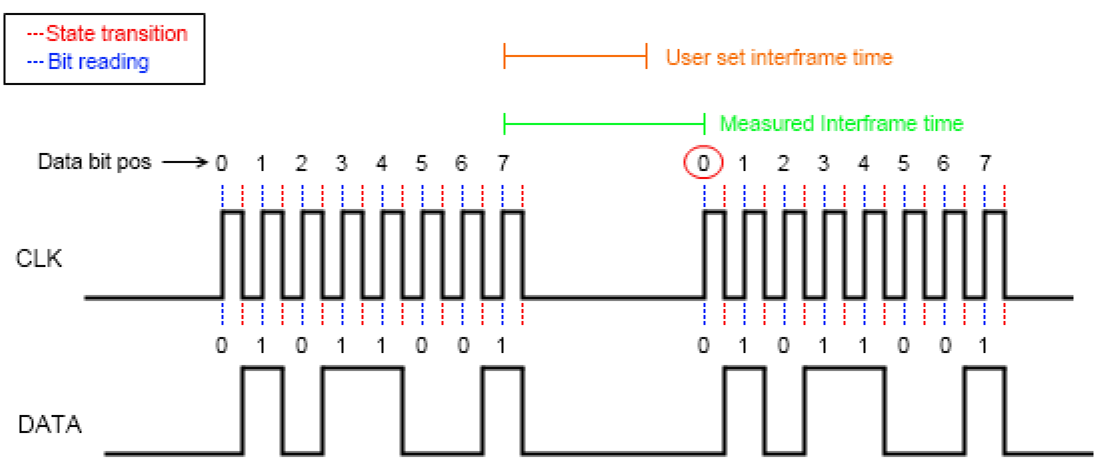
Otherwise, clear Any Byte and enter the **Start Bit** to begin searching for the pattern.

InterFrame Setup

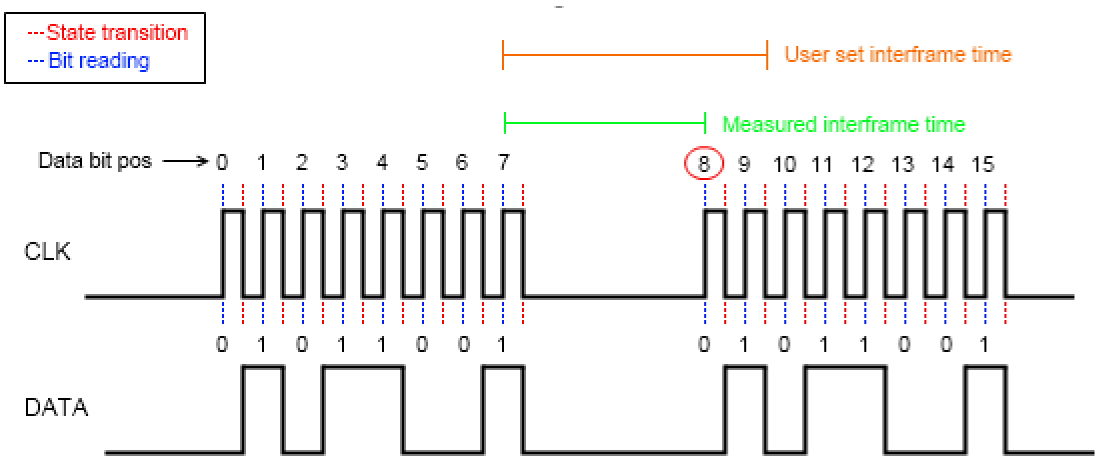
InterFrame Setup is used to determine the position of data in SPI packets. Since packets can include several words, and sometimes a signal is encoded over several words, it's important to establish a bit numbering scheme with a 0 point where counting begins.

Choose **Auto** or **Manual** mode. Manual enables the **InterFrame Time** field where you can provide a specific value. Auto mode sets the InterFrame time to four times the length of a bit.

In Manual mode, the time between each bit reading transition on the CLK signal is read. Inside a word, this time is equal to the length of a bit. At the end of a word, the time until the next transition can be bigger than a bit length. This specific time separation length (i.e., InterFrame Time) defines how the bits are numbered. When the read InterFrame Time is greater than the one you provided, the bit counter is reset to 0 (as shown in the following image).



When the read InterFrame Time is smaller than the one you provided, subsequent bits are considered part of the same packet and continue to accrue sequentially.

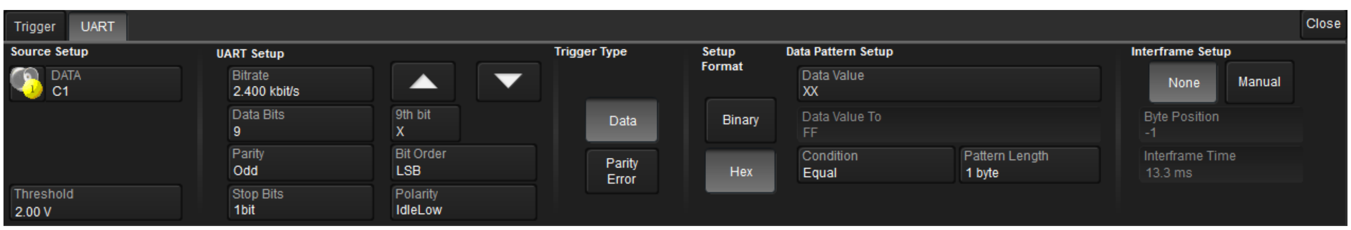


UART Trigger Setup

To access the serial trigger dialogs:

- Touch the Trigger descriptor box or choose **Trigger > Trigger Setup** from the Menu Bar.
- Touch the **Serial** Type button, and the **UART** Standard button.

Then, working from left to right, make the desired selections from the UART dialog.



Source Setup

In **DATA**, select the data source input channel.

Use the **Threshold** control to adjust the vertical level for the trigger.

UART Setup

Use these controls to define the characteristics of the data signal.

Enter the **Bitrate** of the bus to which you are connected. This bitrate selection is dynamically linked to the decoding bitrate (they are always the same value). Use the arrows to scroll a list of standard bit rates, or touch Bitrate and enter a value.

Enter the number of **Data Bits** per byte (not including the START, STOP, or PARITY bits). To trigger on UART messages with a 9^{th} DATA bit used as an Alert, enter 9 in Data Bits, then specify whether the 9^{th} **Alert** bit is a 0, 1, or X (don't care).

Select the **Parity**. Parity must be Odd or Even to trigger on Parity Error.

Enter the number of **Stop Bits**.

Choose either Most Significant Bit (MSB) or Least Significant Bit (LSB) **Bit Order**.

Select the **Polarity** of the UART signal, either **IdleLow** (Data 1 = High) or **IdleHigh** (Data 1 = Low).

Trigger Type

Choose to trigger on a user-defined **Data** pattern or a **Parity Error**.

Setup Format

Choose to display/enter data values in **Binary** or **Hex**(adecimal) format. The selection propagates throughout the entire trigger setup. Toggling between formats does not result in loss of information, but will transform the appearance of values.

Data Pattern

Use **Data Condition** and **Data Value** together to describe the Data field pattern upon which to trigger. To use a range of values, choose In Range or Out Range. When using a range, also enter the **Data Value To**.

Enter the data **Pattern Length**. This value defaults to the length, in bytes, of the Data Value entry. If the length is changed to a lesser value, it truncates the beginning of the value. If the length is increased, "don't care" bytes are appended to the beginning of the data pattern.

InterFrame Setup

InterFrame Setup is used to define the position of data in UART packets. Choose **None** or **Manual** mode. Manual enables the **Byte Position** and **InterFrame Time** fields for you to enter the values.

RS-232 Trigger Setup

To access the serial trigger dialogs:

- Touch the Trigger descriptor box or choose **Trigger > Trigger Setup** from the Menu Bar.
- Touch the **Serial** Type button, and the **RS-232** Standard button.

Then, working from left to right, make the desired selections from the RS-232 dialog.

Source Setup

In **DATA**, select the data source input channel.

Use the **Threshold** control to adjust the vertical level for the trigger.

RS-232 Setup

Use these controls to define the characteristics of the data signal.

Enter the **Bitrate** of the bus to which you are connected. This bitrate selection is dynamically linked to the decoding bitrate (they are always the same value). Use the arrows to scroll a list of standard bit rates, or touch Bitrate and enter a value.

Enter the number of **Data Bits** per byte (not including the START, STOP, or PARITY bits). To trigger on UART messages with a 9^{th} DATA bit used as an Alert, enter 9 in Data Bits, then specify whether the 9^{th} **Alert** bit is a 0, 1, or X (don't care).

Select the **Parity**. Parity must be Odd or Even to trigger on Parity Error.

Enter the number of **Stop Bits**.

Choose either Most Significant Bit (MSB) or Least Significant Bit (LSB) **Bit Order**.

Note: This field defaults to LSB and cannot be changed on an RS-232 trigger.

Select the **Polarity** of the UART signal, either **IdleLow** (Data 1 = High) or **IdleHigh** (Data 1 = Low).

Note: This field defaults to IdleLow and cannot be changed on an RS-232 trigger.

Trigger Type

Choose to trigger on a user-defined **Data** pattern or a **Parity Error**.

Setup Format

Choose to display/enter data values in **Binary** or **Hex**(adecimal) format. The selection propagates throughout the entire trigger setup. Toggling between formats does not result in loss of information, but will transform the appearance of values.

Data Pattern

Use **Data Condition** and **Data Value** together to describe the Data field pattern upon which to trigger. To use a range of values, choose In Range or Out Range. When using a range, also enter the **Data Value To**.

Enter the data **Pattern Length**. This value defaults to the length, in bytes, of the Data Value entry. If the length is changed to a lesser value, it truncates the beginning of the value. If the length is increased, "don't care" bytes are appended to the beginning of the data pattern.

InterFrame Setup

InterFrame Setup is used to define the position of data in RS-232 packets. Choose **None** or **Manual** mode. Manual enables the **Byte Position** and **InterFrame Time** fields for you to enter the values.

Using the Decoder with the Trigger

A key feature of Teledyne LeCroy trigger and decode options is the integration of the decoder functionality with the trigger. While you may not be interested in the decoded data per se, using the decoded waveform can help with understanding and tuning the trigger.

Stop and Look

Decoding with repetitive triggers can be very dynamic. Stop the acquisition and use the decoder tools such as Search, or oscilloscope tools such as TriggerScan, to inspect the waveform for events of interest. Touch and drag the paused trace to show time pre- or post-trigger.

Optimize the Grid

The initial decoding may be very compressed and impossible to read. Try the following:

- Increase the height of the trace by *decreasing* the gain setting (V/Div) of the decoder source channel. This causes the trace to occupy more of the available grid.
- Change your Display settings to turn off unnecessary grids. The Auto Grid feature automatically closes unused grids. On many oscilloscopes, you can manually move traces to consolidate grids.
- Close setup dialogs.

Use Zoom

The default trigger point is at zero (center), marked by a small triangle of the same color as the input channel at the bottom of the grid. Zoom small areas around the trigger point. The zoom will automatically expand to fit the width of the screen on a new grid. This will help you to see that your trigger is occurring on the bits you specified.

If you drag a trace too far left or right of the trigger point, the message decoding may disappear from the grid. You can prevent "losing" the decode by creating a zoom of whatever portion of the decode interests you. The zoom trace will not disappear when dragged and will show much more detail.

Saving Trigger Data

The message decoding and the result table are dynamic and will continue to change as long as there are new trigger events. As there may be many trigger events in long acquisitions or repetitive waveforms, it can be difficult (if not impossible) to actually read the results on screen unless you stop the acquisition. You can preserve data concurrent with the trigger by using the **AutoSave** feature.

- AutoSave Waveform creates a .trc file that copies the waveform at each trigger point. These files can be recalled to the oscilloscope for later viewing. Choose **File > Save Waveform** and an Auto Save setting of **Wrap** (overwrite when drive full) or **Fill** (stop when drive full). The files are saved in D:\Waveforms.
- AutoSave Table creates a .csv file of the result table data at each trigger point. Choose **File > Save Table** and an Auto Save setting of **Wrap** or **Fill**. The files are saved in D:\Tables.

Caution: If you have frequent triggers, it is possible you will eventually run out of hard drive space. Choose Wrap only if you're not concerned about files persisting on the instrument. If you choose Fill, plan to periodically delete or move files out of the directory.

Measure/Graph

The installation of the Measure/Graph package (included with any -DME or -TDME option) adds a set of measurements and plots designed for serial data analysis to the oscilloscope's standard measurement capabilities. Measurements can be quickly applied without having to leave the waveform or tabular views of the decoding.

Note: This functionality was formerly offered as part of -TDM options and the PROTObus MAG software option. The features described in this section should be present If you have either of these installed on your oscilloscope.

Serial Data Measurements

These measurements designed for debugging serial data streams can be applied to the decoded waveform. Measurements appear in a tabular readout below the grid (the same as for any other measurements) and are in addition to the result table that shows the decoded data. You can set up as many measurements as your oscilloscope has parameter locations.

Note: Measurements appear in the Serial Decode sub-menu of the Measure Setup menu and may have slightly different names. The measurements are the same.

Measurement	Description
AnalogToMsg	Computes time from crossing threshold on an analog signal to start of first message that meets conditions. If the message condition precedes the analog condition, no measurement is performed.
BusLoad	Computes the load of user-defined messages on the bus (as a percent).
DeltaMsg	Computes time difference between two messages on a single decoded line.
MsgBitrate	Computes the bitrate of user-specified messages on decoded traces.
MsgToAnalog	Computes time from start of first message that meets conditions to crossing threshold on an analog signal. If the analog condition precedes the message condition, no measurement is performed.
MsgToMsg	Computes time difference from start of first message that meets conditions to start of next message.
MsgToValue	Extracts and converts a specific portion of the data/payload in the message and displays it as an analog value.
NumMessages	Computes the total number of messages in the decoding that meet conditions.
Time@Msg	Computes time from trigger to start of each message that meets conditions.

Graphing Measurements

The Measure/Graph package include simplified methods for plotting measurement values as:

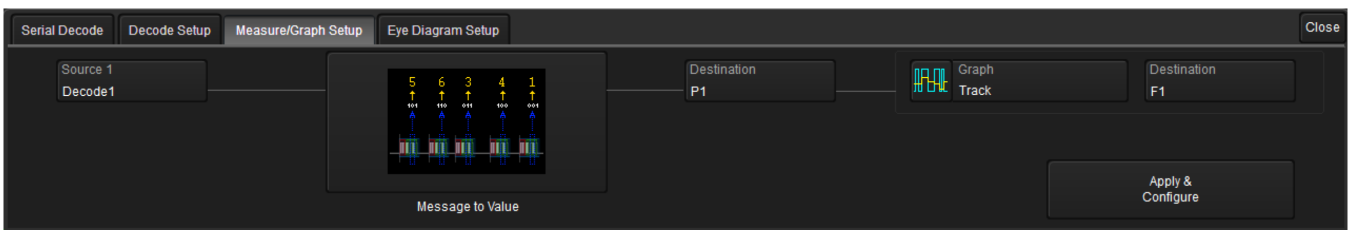
- **Histogram** - a bar chart of the number of data points that fall into statistically significant intervals or bins. Bar height relates to the frequency at which data points fall into each interval/bin. Histogram is helpful to understand the modality of a parameter and to debug excessive variation.
- **Trend** - a plot of the evolution of a parameter over time. The graph's vertical axis is the value of the parameter; its horizontal axis is the order in which the values were acquired. Trending data can be accumulated over many acquisitions. It is analogous to a chart recorder.
- **Track** - a time-correlated accumulation of values for a single acquisition. Tracks are time synchronous and clear with each new acquisition. Track can be used to plot data values and compare them to a corresponding analog signal, or to observe changes in timing. A parameter tracked over a long acquisition could provide information about the modulation of the parameter.

These plots effectively perform a digital-to-analog conversion that can be viewed right next to the decoded waveform.

To graph a measurement, just select the plot type from the Measure/Graph dialog when setting up the measurement. All plots are created as Math functions that open along side the deocoding in a separate grid.

Measure/Graph Setup Dialog

Use the Measure/Graph Setup dialog, which appears behind the Decode Setup dialog when measurements are supported, to apply serial data measurement parameters and simultaneously graph the results.



1. Select the **Measurement** to apply and the **Destination** parameter location (P*x*) in which to open it.
2. The active decoder is preselected in **Source 1**, indicating the measurement will be applied to the decoder results; change it if necessary. If the measurement requires it, also select an appropriate Source 2 (e.g., an analog waveform for comparison).
3. Optionally:
   - Touch Graph to select a plot type. Also select a **Destination** function (F*x*) for the plot.
   - Touch **Apply & Configure** to set a measurement filter or gate.

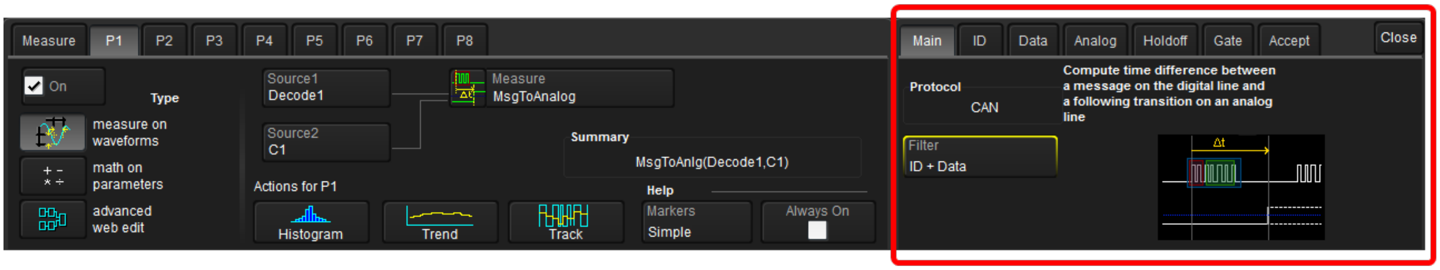
Filtering Serial Decode Measurements

For certain protocols, measurements can be filtered to include only the specified frame types, IDs, or data patterns. As with all traces, you can set a gate to restrict measurements to a horizontal range of the grid corresponding to a specific time segment of the acquisition.

Note: Not all measurements support all filter types.

After creating a measurement on the Measure/Graph Setup dialog, touch **Apply&Configure**. The touch screen display will switch to the standard Measure setup dialogs for the parameter you selected.

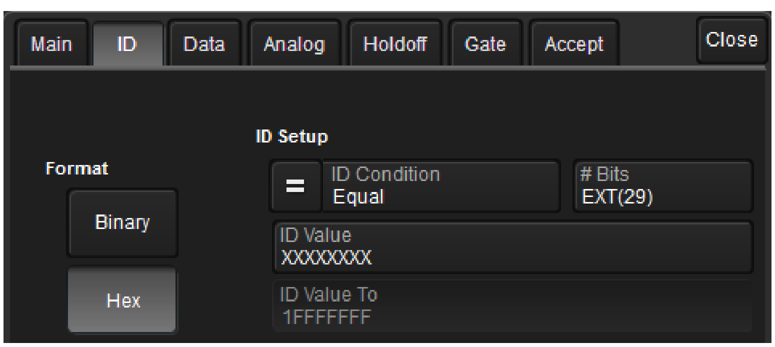
Set filter conditions on the right-hand subdialogs that appear next to the P*x* dialogs.



Frame ID Filter

This filter restricts the measurement to only frames with a specific ID value. Settings on this dialog may change depending on the protocol.

1. On the Main subdialog, in **Filter** choose ID or ID+Data.
2. Open the **ID tab** that appears and choose to enter the ID value in **Binary** or **Hex**(adecimal) format.



3. Using the **ID Condition** and **ID Value** controls, create a condition statement that describes the IDs you want included in the measurement. To set a range of values, also enter the **ID Value To**.

Tip: On the value entry pop-up: use the arrow keys to position the cursor; use Back to clear the previous character (like Backspace); use Clear to clear all characters.

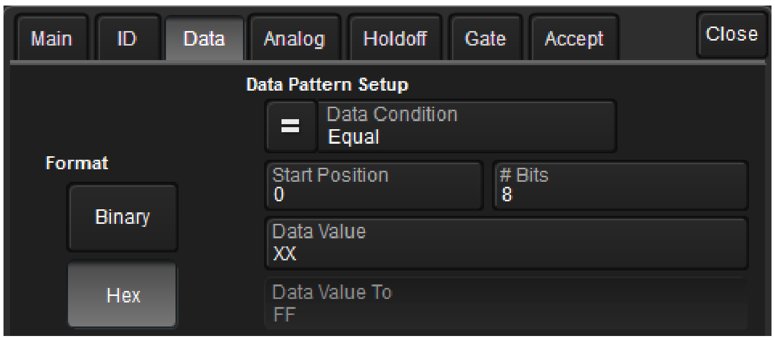
Data Filter

This restricts measurements to only frames containing extracted data that matches the filter condition. It can be combined with a Frame ID filter by choosing ID+Data on the Main subdialog.

Use the same procedure as above to create a condition describing the **Data Value(s)** to include in the measurement. Use "X" as a wild card ("Don't Care") in any position where the value doesn't matter.

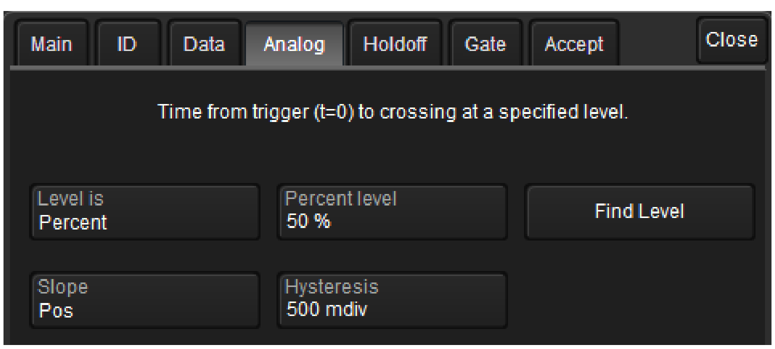
Optionally, enter a **Start Position** within the data field byte to begin seeking the pattern, and the **# Bits** in the data pattern. The remaining data fields positions will autofill with "X".

Note: For MsgtoMsg measurements, the data condition is entered twice: first for the Start Message and then for the End Message. The measurement computes the time to find a match to each set of conditions.



Analog Filter

This filter applies only to parameters that measure the decoded serial data signal relative to an analog waveform: AnalogtoMsg and MsgtoAnalog. It allows you to set the crossing level and slope of the Analog waveform event that is to be used in the measurement. Level may be set as a percentage of amplitude (default), or as an absolute voltage level by changing **Level Is** to Absolute. You can also use **Find Level** to allow the oscilloscope to set the level to the mean top-base amplitude.



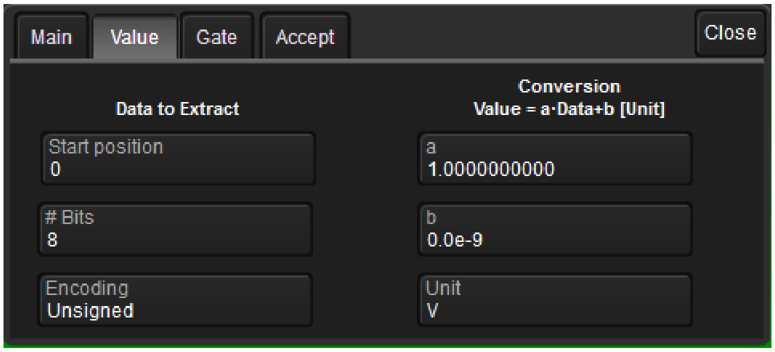
The optional **Hysteresis** setting imposes a limit above and below the measurement level, which precludes measurements of noise or other perturbations within this band. The width of the band is specified in milli-divisions.

Observe the following when using Hysteresis:

- Hysteresis must be larger than the maximum noise spike you wish to ignore.
- The largest usable hysteresis value must be less than the distance from the level to the closest extreme value of the waveform.

Value Conversion Filter

This filter applies only to the MsgtoValue parameter. It enables you to apply a value conversion to extracted data. The converted values appear in the result table.



1. Under Data to Extract, begin by entering the **Start position** and the **# Bits** to extract.
2. Choose the **Encoding** type if the signal uses encoding, otherwise leave it Unsigned.
3. Under Conversion, enter the **a. Coefficient** and **b. Term** that satisfy the formula:
   *Value = Coefficient * Raw Value + Term*.
4. Optionally, enter a **Unit** for the extracted decimal value.

Holdoff, Gate, and Accept

Certain measurements support holdoff, gating, or additional qualifiers (Accept). You will see the tab appear among the parameter subdialogs when the function is supported. When applied to serial data measurement, these functions work exactly as they do elsewhere in the oscilloscope:

- **Holdoff** specifies the amount of time or number of events to wait before starting the measurement.
- **Gate** specifies the Start Div and Stop Div that bound the portion of the acquisition to include in the measurement.
- **Accept** allows you to set qualifiers based on waveform state, either the measurement source or a second "gating" waveform, or to only accept measurement values that fall within pre-defined ranges.

See the oscilloscope *Operator's Manual* for more information.

Eye Diagram Tests

The -DME and -TDME options provide easy eye diagram setup and eye mask testing.

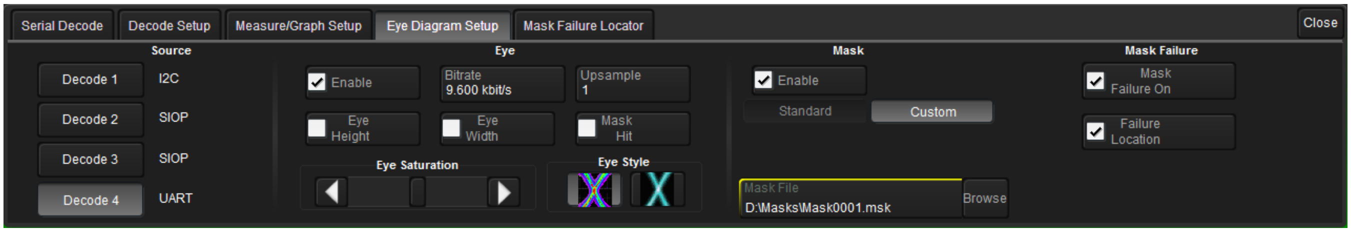
Eye diagrams are a key component of serial data analysis. They are used both quantitatively and qualitatively to understand the quality of the signal communications path. Signal integrity effects such as intersymbol interference, loss, crosstalk and EMI can be identified by viewing eye diagrams, such that the eye is typically viewed prior to performing any further analysis.

Each pixel in the eye takes on a color that indicates how frequently a signal has passed through the time and voltage specified for that pixel. The eye diagram shows all values a digital signal takes on during a bit period. A bit period (also referred to as unit interval, or UI) is defined by the data clock, whether explicit or extrapolated depending on the protocol.

Eye diagrams show the acquired signal that is currently being shown in the decoder. They are not persistent, as are eye diagrams generated in some other serial data analysis software, the eye will change from one acquisition to the next. Our recommended approach for using the eye diagrams is to:

- Make single shot acquisitions with decoder and eye diagram enabled to check that both are working correctly.
- Run a normal acquisition with Mask Testing and Stop On Failure enabled in the Mask Failure Locator, or with a Pass/Fail test set on one of the eye parameters.

Eye Diagram Setup Dialog



Create Eye Diagram

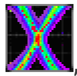
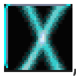
Open the **Eye Diagram Setup** dialog and select the **Decode** for which to create an eye diagram.

Under Eye, check **Enable** to display the eye diagram.

The **Bitrate** is automatically read from the decoder setup. This value is linked to the decoder bit rate setting, and changing it in either place will update both settings.

The **Upsample** factor increases the number of sample points used to compose the eye diagram. Increase from 1 to a higher number (e.g. 5) to fill in gaps. Gaps can occur when the bitrate is extremely close to a submultiple of the sampling rate, such that the sampling of the waveform does not move throughout the entire unit interval. Gaps can also occur when using a record length that does not sample a sufficiently large number of unit intervals.

The **Eye Style** may utilize color-graded or analog persistence:

- With **color-graded** persistence , pixels are given a color based on the pixel's relative population and the selected Eye Saturation. The color palette ranges from violet to red.
- With **analog** persistence , the color used mimicks the relative intensity that would be seen on an analog oscilloscope.

Use the **Eye Saturation** slider to adjust the color grading or intensity. Slide to the left to reduce the threshold required to reach saturation.

Choose to display the **Eye Height**, **Eye Width**, or **Mask Hit(s)** measurement parameters. These are added to the Measure table in the first open parameter slots.

Eye Mask Test

Under Mask, check **Enable** to turn on eye mask testing.

Select to use either a **Standard** or **Custom** mask, then either select the **Standard Mask** or **Browse** to and select your custom **Mask File**.

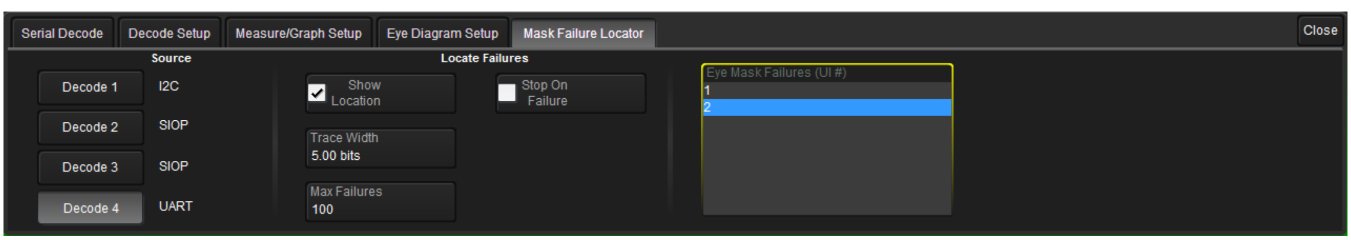
Tip: Masks previously created on the instrument are stored in D:\Masks. For ease of selection, copy other .msk files to this location.

Check **Mask Failure On** to mark the parts of the eye diagram that fail the mask test. Mask violations appear as red failure indicators where the eye diagram intersects the mask.

Check **Failure Location** to display the Mask Failure Locator dialog.

Mask Failure Locator Dialog

Use this dialog to quickly search the acquisition for eye diagram mask test failures.



In **Trace Width**, enter the number of UIs surrounding the mask violation to display as "padding."

Check **Stop On Failure** to stop acquisition whenever an eye mask failure occurs.

Enter the **Max Failures** to retain in the Eye Mask Failure list.

Select from the **Eye Mask Failure** list to mark and zoom to the location of that failure. Yellow circles appear over the red failure indicators to show the location of the failure.

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