

Instruction Manual

Automotive Protocols

Trigger, Decode and Measure

CANbus/CAN FDbus
LINbus
FlexRaybus



Automotive Protocols Trigger, Decode and Measure Instruction Manual

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924311 Rev B

July 2015

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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 how to use the following software:

- CANbus Serial Trigger, Decoder, and Measurements (optional Symbolic)
- CAN FDbus Serial Trigger, Decoder, and Measurements (optional Symbolic)
- LINbus Serial Trigger and Decoder
- FlexRaybus Serial Trigger, Decoder, and Physical Layer Tests

Assumptions

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.

Compatibility

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.

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 the oscilloscope 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

Add an optional set of serial data measurements to the oscilloscope's standard measurement capabilities and quickly plot the measurement results.

Measurement data can be viewed as a Histogram, Track, or Trend plot of the digitally encoded data values for a specific input versus time. These plots effectively perform a digital-to-analog conversion that can be viewed right next to the decoded waveform.

Measurements data can also 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.

About the CANbus and CAN FDbus Options

CAN is a vehicle bus designed specifically for automotive applications, but it is now found in other applications, as well. The various CAN specifications are maintained by the International Organization for Standards (ISO) and can be obtained at www.iso.org.

CANbus TD supports decoding standard CAN (11-bit and extended 29-bit).

CAN FDbus TD supports decoding standard CAN as well as the advanced features of CAN FD: bitrate increase for the Data segment and the extension of the possible Data payload from 8 bytes to 64 bytes. It also supports ISO and non-ISO frames.

Both options allow triggering on CAN messages, Frame IDs, serial data patterns, or errors. Frame-level and value-level filtering enable you to target the trigger to a certain type of CAN message, a single frame ID or data pattern, or to a range of data.

The TDM variants of these options add a set of CAN-specific measurement parameters and plots.

The TDM SYMBOLIC variants of these options add symbolic decoding, triggering, and measuring based on user-defined .DBC symbol files.

About the LINbus Option

LIN is a low-cost master/slave system designed for implementation in vehicles, typically in what is commonly referred to as body electronics. The LIN specification is maintained by the International Standards Organization (ISO) and can be obtained at www.iso.org.

The LINbus TD option allows triggering on specific LIN frames, data patterns, or errors. Other features include:

- Ability to trigger and decode LIN Version 1.3, 2.x, and SAE J2602 formats, even when LINbus traffic contains mixed versions.
- Triggering on Checksum, Header Parity, and Sync Byte Errors.

About the FlexRaybus Option

FlexRay is an automotive network communications protocol developed by the FlexRay Consortium to govern on-board automotive computing. The FlexRay consortium disbanded in 2009, and FlexRay is now defined in ISO standards 17458-1 to 17458-5.

The FlexRaybus TD option allows you to trigger and decode FlexRay protocol version 2.1 at 10 Mb/s, 5 Mb/s or 2.5 Mb/s. Features include:

- Ability to trigger on TSS, Frame characteristics, protocol Errors, or various Symbols (such as wakeup patterns).
- Frame triggers may be set on individual Frame IDs or ranges and be further conditionalized using Cycle Counts or Frame Qualifiers.

The FlexRay PHY option also provides special physical layer eye diagram tests as specified by the FlexRay standard and physical-layer measurement parameters.

Decoding

Serial Decode Technical Overview

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. 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, then run the decoder.

NOTE: See [Failure to Decode](#) for more information about the required acquisition settings.

4. Use the various decoder tools to verify that transitions are being correctly decoded. Tune the decoder settings as needed.
5. Once you know you are correctly decoding transitions in one mode, continue making small acquisitions 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.
6. Run the decoder on acquisitions of the desired length.

You can disable/enable the decoder as desired without having to repeat the set up and tuning provided the basic signal characteristics do not change.

Setting Up the Decoder

The main Serial Decode dialog allows you to preset up-to-four, independent decoders, Decode 1 to Decode 4. 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 Decode # buttons at the left of the Decode Setup dialog. You don't have to step back to the Serial Decode dialog. Controls with the same label on either dialog share the same function.

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 now. This will let you view the decoding on screen as soon as there is an acquisition, which helps to begin tuning. If you wish, you can wait until all settings are complete to enable the decoder.
 - Select the desired **Protocol** to use.
 - Select the **Data (Source)** to be decoded. This can be any signal input channel (Cx), memory (Mx), or math function (Fx).
3. Optionally, check [Link To Trigger](#) **On** to tie the decoder setup to a serial trigger setup.
4. Touch the **Setup** button (next to Search) to open the Decode Setup dialog. If you use this method rather than the tab, your settings will be correctly pre-selected on the Decode Setup dialog.
5. Go on to complete the settings on the right-hand dialogs next to the Decode Setup dialog.

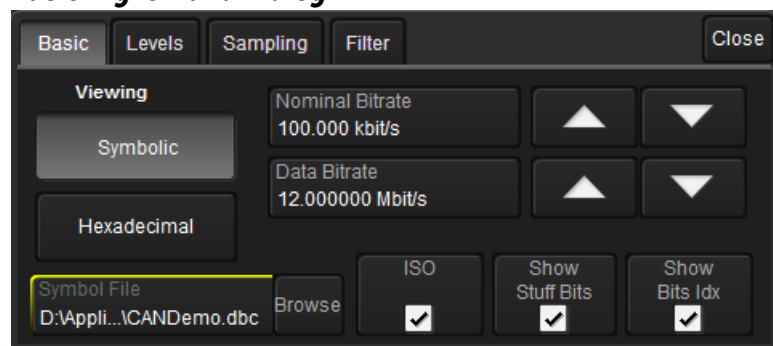
CAN/CAN FD Decoder Settings

Symbolic Decoding

If you have purchased the CAN TDM SYMBOLIC or CAN FD TDM SYMBOLIC options, some additional controls related to symbolic decoding will appear on the decoder set up dialogs.

The default symbol file is located in D:\Applications\<protocol>. You may copy your own symbol file to this directory and browse to it for easy selection. Symbol files must have the .dbc extension. We recommend that you copy and modify the default .dbc file to ensure the symbol file is properly formatted.

Basic Right-Hand Dialog



TDM SYMBOLIC users: choose to view the decoder results either in **Hexadecimal** or with **Symbolic** translation. If you choose Symbolic, touch **Browse** and select the **Symbol File** to use.

NOTE: These controls will not appear if your installation does not support symbolic decoding.

Enter the **Nominal Bitrate** (Arbitration bitrate) of the bus to which you are connected as precisely as you know it. 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 Up and Down arrow buttons to scroll a list of standard bitrates, or touch the field to enter the value using the Adjust knob or the numeric keypad.

TIP: If you are unsure of the bitrate, apply the Bit Rate measurement parameter to a short acquisition.

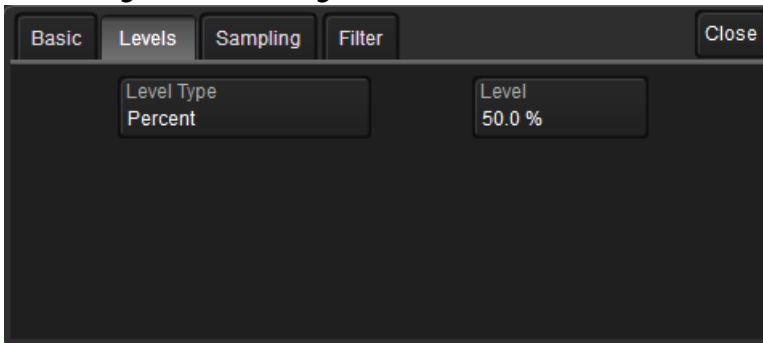
CAN FD users: also enter the **Data Bitrate**. The same precautions apply as for the Nominal Bitrate.

CAN FD users: check **ISO** if your signal supports ISO frames.

Check **Show Bits Idx** to display a bit index for each bit, which can assist with analysis or debugging of the decode. The bit index starts at 0 at the beginning of the message and increases monotonously to the end of the message. Note that the bit index skips the stuffbits.

Check **Show Stuff Bits** to display the stuff bits on each CAN message frame.

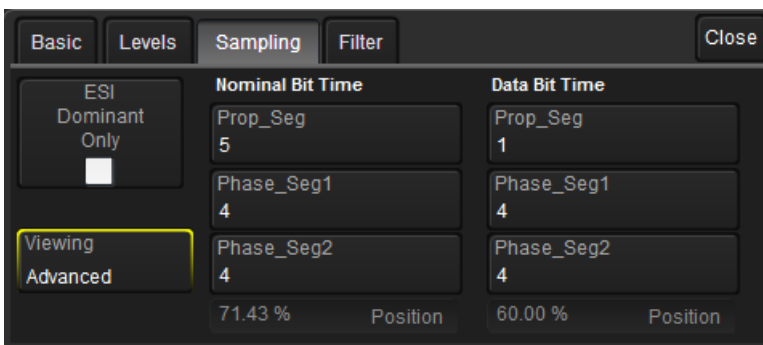
Levels Right-Hand Dialog



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

Sampling Right-Hand Dialog

This dialog only appears if your system supports CAN FD decoding.



By default, **ESI Dominant Only** is selected, which indicates the signal always contains an ESI bit set to dominant. This allows the decoder to operate in a mode where it doesn't need sampling point information. When it is possible that signal can contain a recessive ESI bit, then enter the sampling point information manually. Clear ESI Dominant Only to enable the Nominal Bit Time and Data Bit Time fields and set the sampling rates.

First, choose a **Viewing** style of either Basic (sampling position only) or Advanced (all fields).

For the Basic setup, enter the sampling point as a percent of amplitude in the **Requested Position** fields.

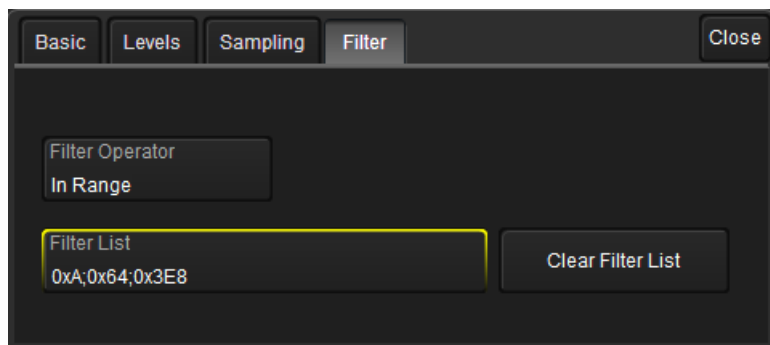
For the Advanced setup, manually enter values for:

- **Prop_Seg**, the part of the bit time used to compensate for the physical delay times within the network.
- **Phase_Seg1** Number of time quanta before the sampling point.
- **Phase_Seg2** Number of time quanta after the sampling point.

NOTE: All settings on this tab are ignored when decoding a Standard CAN frame.

Filter Right-Hand Dialog

Use the **Filter** dialog to include only certain symbols or hex values in the decoder results.



Choose a **Filter Operator** of:

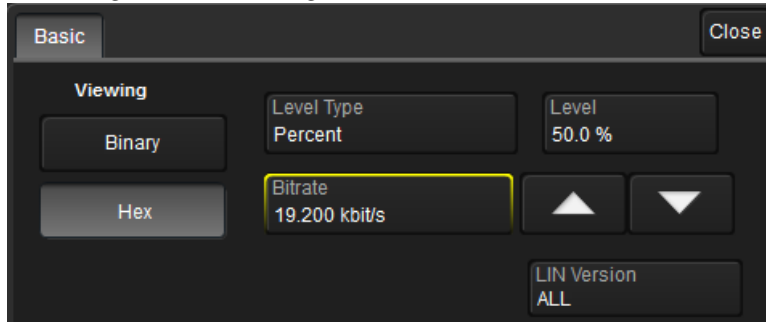
- **In Range** (include only those shown). In Range is very useful when working specifically on certain messages. It allows faster selection in the result table, as well as faster visual identification on the annotated trace and faster export to file. When working on messages that have a causal relationship (i.e., message 0xa6f is always expected sometime before message 0xb2c), filtering on *<first value>;<second value>* will help in studying this traffic.
- **Out Range** (include all but those shown). Out Range helps when analyzing traffic dominated by one or a few messages. For example, in an elevator, the traffic might be constituted at 97 % by the position messages of the cabin traveling up and down. An engineer interested in the messages generated by passengers calling the elevator on the floors could filter out the frequent position messages and see only the comparatively rare floor requests.
- **None** turns off filtering.

In **Filter List**, enter the list of symbols or hex values to include, separated by semi-colons.

Clear Filter List resets the list.

LIN Decoder Settings

Basic Right-Hand Dialog



Under **Viewing**, choose to view/enter data in either **Binary** or **Hex**(adecimal) formats.

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

Enter the **Bitrate** of the bus to which you are connected as precisely as you know it. 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 Up and Down arrows to scroll a list of standard bit rates, or enter any value between 1 and 20 kbit/s.

TIP: If you are unsure of the bitrate, apply the Bit Rate measurement parameter to a short acquisition.

Choose the **LIN Version** (standard) used to encode the input signal. If you are unsure or don't care, choose ALL.

FlexRay Decoder Settings

Basic Right-Hand Dialog

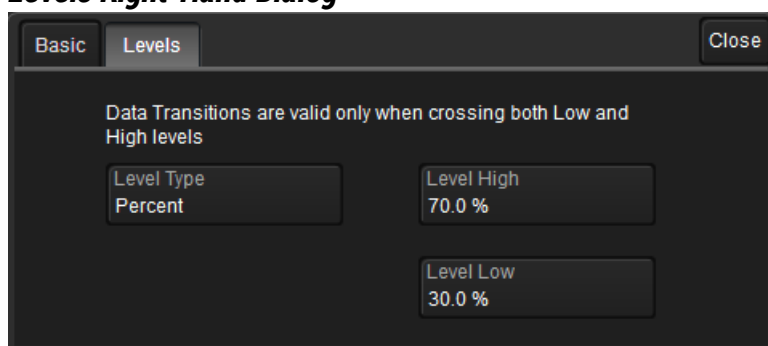


Adjust the **Bitrate** value to match the one on the bus to which you are connected. Touch the arrow buttons to scroll through standard bitrates (2.5, 5.0 or 10.0 Mb/s) and make a selection. Or, touch Bitrate and enter the value using the ADJUST knob or the pop-up keypad.

Select the appropriate **Channel** to decode, Channel A or Channel B of the FlexRay bus.

NOTE: Decoding will still occur when the wrong channel is selected, but results in CRC errors being shown on the overlay.

Levels Right-Hand Dialog



In **Level High** and **Level Low**, enter the signal crossing values. FlexRay is a tri-level signal and requires 2 levels for the oscilloscope to distinguish between 1 and 0. As indicated on the dialog, data transitions are valid only when crossing both Low and High levels. The set levels are shown by a dotted, horizontal line on the oscilloscope grid.

NOTE: If the initial decoding contains a number of error frames, ensure level is set to a reasonable value.

Level is normally entered as percent and defaults to 70% (of amplitude) for Level High and 30% for Level Low. You can alternatively enter Level as an absolute voltage value by changing the **Level Type** from Percent to Absolute.

Enabling/Disabling the Decoder

Once set up, the four decoders can be enabled simultaneously or separately, although this number may be limited depending on the type of source channels selected. Decoders can be easily disabled without disrupting the configuration.

To enable: press the **Front Panel Serial Decode button** (if available on your oscilloscope) or choose **Analysis > Serial Decode** to open the Serial Decode dialog, then check **Decode On** next to the respective decoder.

If **View Decode** is checked (default) for that decoder on the Decode Setup dialog, a [result table](#) and [decoded waveform](#) appear. The number of rows of data displayed on each table will depend on the **Table#Rows** setting. The default is one, which can be increased, but doing so will decrease the amount of the screen available to display traces.

To disable: deselect the **Decode On** box individually, or touch **Turn All Off**.

Failure to Decode

Three conditions in particular may cause the decoder to fail, in which case a failure message will appear in the first row of the decoder 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 too short to allow any meaningful 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, as well.

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.

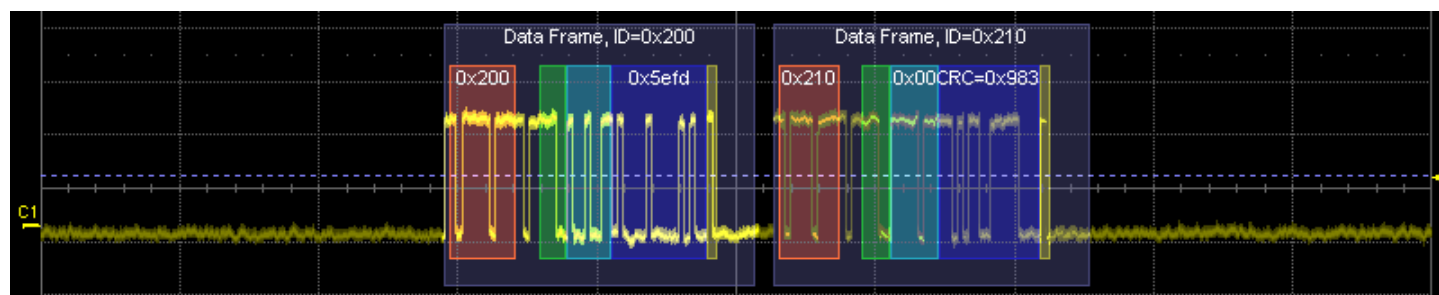
TIP: An easy way to zoom is to touch the row number column of the [result table](#).

CAN Waveform Annotations

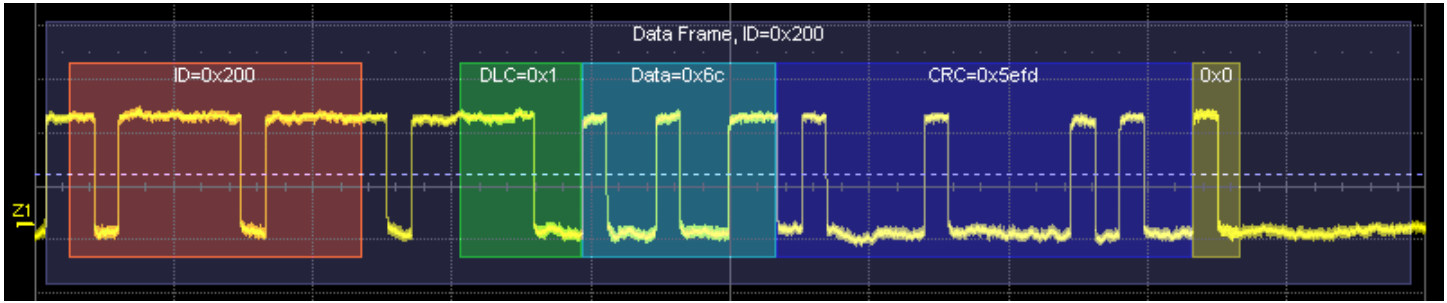
These overlays appear on a CAN waveform or its Zoom trace (some annotations are not shown on the screen-shot).

Annotation	Overlay Color (1) (2)	Overlay Text (3)
Frame ID	Navy Blue (behind other fields)	Data Frame, ID=<value>
IDE	Brick Red	ID=<value>
DLC	Green	DLC=<value>
Payload Data	Aqua Blue	Data=<value>
CRC	Royal Blue	CRC=<value>
ACK	Tan	<value>
Error	Bright Red (behind other fields)	Error=<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 symbolic or hexadecimal depending on your decoder selection.



Decoded waveform. At this resolution, little information appears on the overlay.



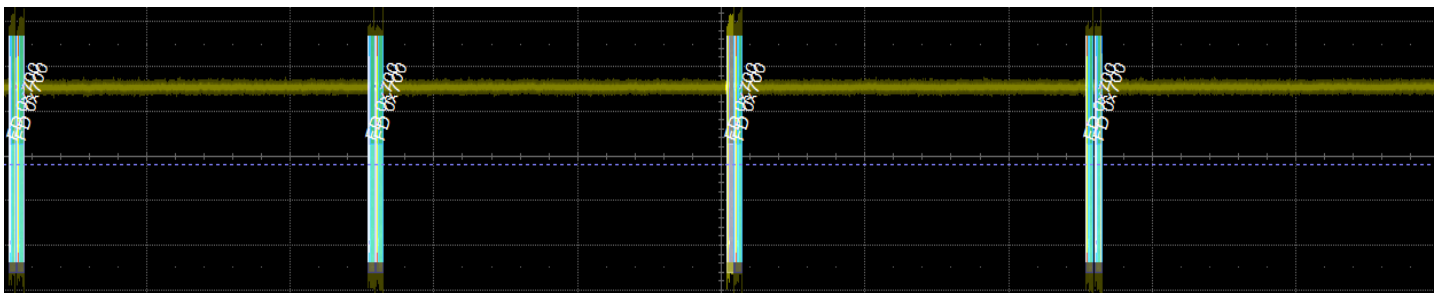
Zoom of frame 0x200 showing annotation details.

CAN FD Waveform Annotations

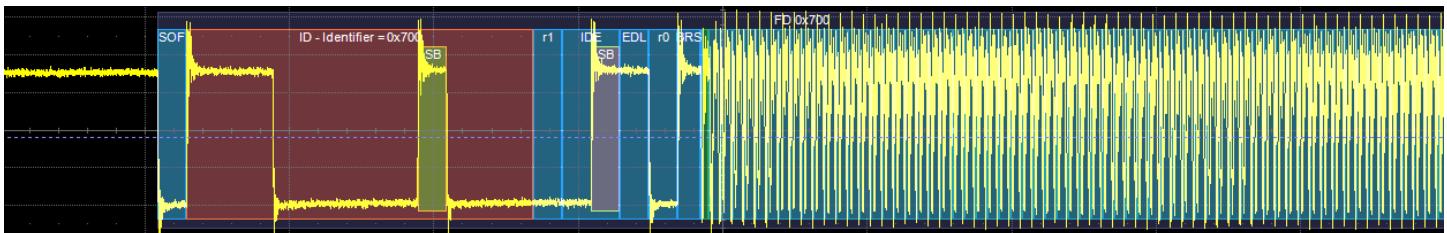
These overlays appear on a CAN FD waveform or its Zoom trace (some annotations are not shown on the screen-shot).

Annotation	Overlay Color (1)	Overlay Text (2) (3)
Frame ID	Navy Blue (behind other fields)	<Std FD> <value>
IDE	Brick Red	ID = <value>
DLC	Bright Green	<value>
Payload Data	Aqua Blue	<value>
CRC	Royal Blue	CRC = <value>
ACK	Tan	
EOF	Aqua Blue	EOF

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 symbolic or hexadecimal depending on your decoder selection.



Initial decoding.



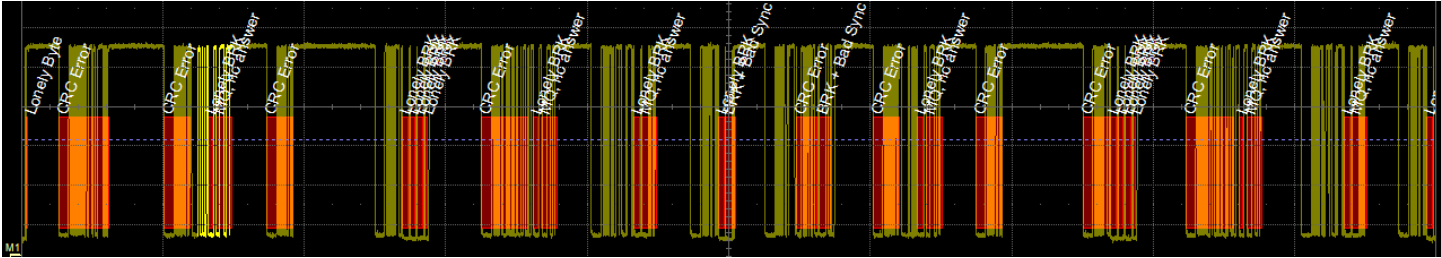
Zoom of frame 0x700 showing annotation details.

LIN Waveform Annotations

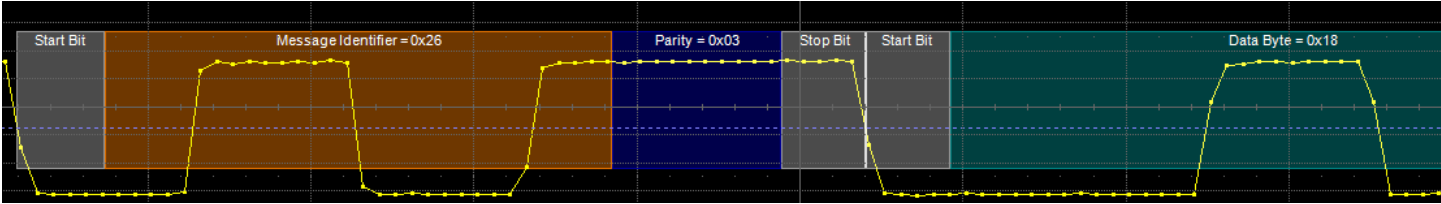
These overlays appear on a LIN waveform or its Zoom trace.

Annotation	Overlay Color (1)	Overlay Text (2) (3)
Message	Navy Blue (behind other fields)	
Protocol error	Bright Red (behind other fields)	<error type>
Breaks	Grey	Break
Start/Stop bits	Grey	<Start bit Stop bit>
Synch bits	Olive Green	Synch=<value>
Message ID	Brown	Message Identifier =<value>
Parity bits	Royal Blue	Parity=<value>
Payload data	Aqua Blue	Data=<value>
Checksum bits	Royal Blue	<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 or hexadecimal depending on your decoder selection.



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



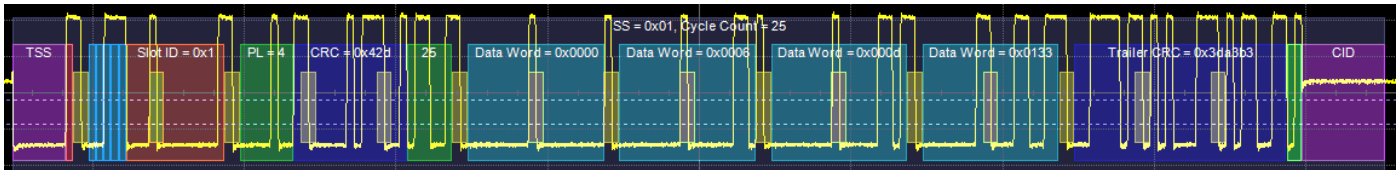
Zoom of message 0x26.

FlexRaybus Waveform Annotations

These overlays appear on a FlexRaybus waveform or its Zoom trace to highlight key elements of the decoded signal (some annotations are not shown on the screen-shot).

Annotation	Overlay Color (1)	Overlay Text (2)
Message frame	Navy (behind other fields)	<type> = <ID>, Cycle Count = <value>
Protocol error	Bright Red (behind other fields)	<error type>
Transmit Start Sequence (TSS) and Channel Idle Delimiter (CID)	Purple	<TSS CID>
Frame Start Sequence (FSS)	Orange	
Byte Start Sequence (BSS)	Tan	
Frame ID	Cyan Blue	
Payload data	Aqua Blue	Data Word = <value>
Slot ID	Brick Red	Slot ID = <value>
Payload Length (PL), Cycle Count (CC), and Frame End Sequence (FES)	Green	<PL CC FES> = <value>
Cyclic Redundancy Check (CRC)	Royal Blue	<Header Trailer> CRC = <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.



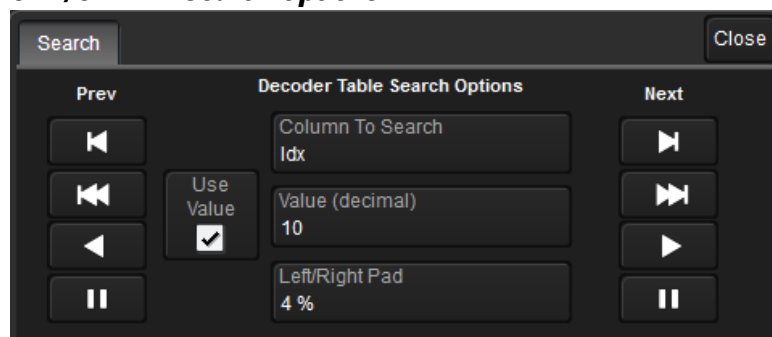
Decoded FlexRay waveform.

Searching Waveforms

Selecting the **Search** Action button on the Decode Setup dialog opens the decoder Search dialog, where you can enter criteria for finding events of interest in the waveform: various protocol elements, data values, errors, etc. **Prev** and **Next** buttons then navigate to matches found in the decoded waveform, simultaneously creating a zoom of each match.

The default zoom always shows the matching data (plus any padding) at the full width of the grid. Use the standard Zoom controls to rescale the zoom to the desired level of magnification.

CAN/CAN FD Search Options



Choose the [result table](#) **Column to Search** for matching data.

Enter the **Value** to find in that column. Check **Use Value** to enable this control.

Optionally, enter a **Left/Right Pad**, the percentage of horizontal division around matching data to display on the zoomed waveform.

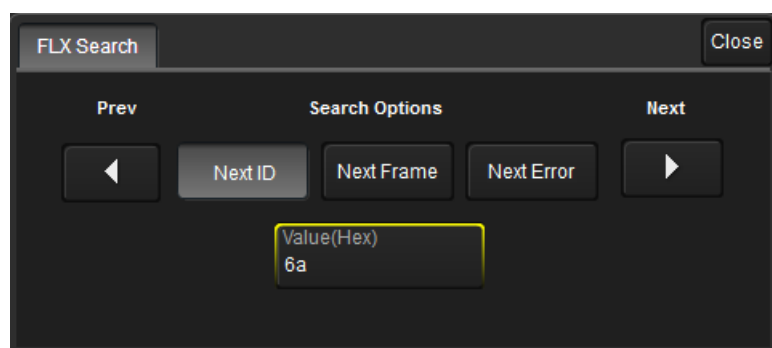
Use the **Prev** and **Next** buttons to view the search results.

LIN and FlexRay Search Options

Next (Frame) ID finds the next occurrence of the ID entered in **Value**.

Next Frame finds the start of the next frame.

Next Error finds the next FlexRay protocol error.



Use the **Prev** and **Next** buttons to view the search results.

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 message data as decoded during the most recent acquisition, even when messages are too compact to allow 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.

Selecting a number in the first (index) column of the table will display a zoom of the corresponding position in the decoded waveform.

You can [customize the result table](#), changing both the number of rows and the columns displayed. The default is one row. On a single-row table, touch the Down arrow at the far right to open a scrollbar that lets you display the previous or next row of data.



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

You can also [export result table data](#) to a .CSV file, and the table itself is useful for [measuring](#).

CAN Result Table

Column	Extracted or Computed Data
Index (always shown)	Number of the line in the table; also number of the message in the annotation overlay on the trace.
Time	Time elapsed from start of acquisition to Start of Frame.
ID	Standard or Extended Identifier bits (aka Frame ID).
RTR	Remote Transmission Request bits.
DLC	Real number of Data Length Code bytes (not the value encoded in the DLC).
Data	Data Field bytes.
CRC	Cyclic Redundancy Check sequence bits.
ACK	Acknowledge Field bit.
Bit Rate/Msg	Actual bitrate (BR) for this message, the average BR recomputed by dividing the entire Message time span by the total number of bits in the message.
ID Length	Number of bits in the ID of the CAN message, either 11 (Standard) or 29 (Extended).

CAN	Time	ID	RTR	DLC	Data	CRC	ACK	Bit Rate/Msg
1	-1.16786 ms	0x00a1	0	8	ffff ff 0f fe ffff 7f	0x21c3	0	100.005e+3
2	41.8257 μs	0x00a2	0	8	80 00 80 08 20 20 00 40	0x448b	0	99.799e+3
3	1.25409 ms	0x00a3	0	8	00 00 00 00 00 00 00 00	0x5608	0	99.858e+3

Section of typical CAN decoder result table.

CAN FD Result Table

Column	Extracted or Computed Data
Idx (always shown)	Number of the line in the table; also number of the message in the annotation overlay on the trace.
Time	Time elapsed from start of acquisition to Start of Frame.
Format	Number of ID bits, either 11 (Standard) or 29 (Extended).
ID	11 or 29-bit message ID (ID of the message also governs its priority on the bus, based on the CSMA/CD scheme).
IDE	Arbitration Field Identifier Extension; Dominant (0) = 11-bit, Recessive (1) = 29-bit.
EDL	Extended Data Length bits.
BRS	Bit Rate Switch when Arbitration Frame and Data Frame configured to have different bit rate; Dominant (0) = no bit rate change, Recessive (1) = change to higher bit rate.
ESI	Error State Indicator; Dominant (0) = node is error active, Recessive (1) = node is error passive.
RTR	Remote Transmission Request bit. Dominant (0) = Data Frame; Recessive (1) = Remote Frame. It is only used in Standard CAN, not in CAN FD, but listed in case Standard CAN frames are included in the signal. It will appear empty for CAN FD frames.
DLC	Data Length Code bits.
Data	Data Field bytes.
SBC	Stuff Bit Counter. This column only appears when ISO frames are supported and ISO is checked.
CRC	Cyclic Redundancy Check Sequence bits.
CL	CRC Length, depending on the number of bytes in the payload either 17 bits for data frames up to 16 bytes or 21 bits for data frames over 16 bytes.
BitRate	Computed transmission bit rate.
BR Data	Data bit rate dynamically recomputed for every message, similar to the nominal BR.
Status	Description of all the errors in this message detected by the decoder.

CAN FD	Time	Format	ID	IDE	EDL	BRS	ESI	RTR	DLC	Data	SBC	CRC	CL	BitRate	BR Data	Status
1	-9.99973 ms	FD	0x700	0	1	1	0		64	bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd...	3	0xcb5e0	21	500087	10.0001e+6	
2	-9.88228 ms	FD	0x700	0	1	1	0		64	bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd...	3	0xcb5e0	21	500009	9.99996e+6	
3	-5.00081 ms	FD	0x700	0	1	1	0		64	11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11...	2	0x4da1e	21	500082	10.0001e+6	
4	-4.88347 ms	FD	0x700	0	1	1	0		64	11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11...	2	0x4da1e	21	500025	9.99999e+6	
5	-98 ns	FD	0x700	0	1	1	0		64	bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd bd...	3	0xcb5e0	21	500072	10.0000e+6	

Section of CAN FD decoder result table.

LIN Result Table

Column	Extracted or Computed Data
Idx (always shown)	Number of the line in the table; also number of the message in the annotation overlay on the trace
Time	Time elapsed from start of acquisition to Start of Frame
Break	Break (inter-message) bits
Synch	Synch bits
ID	Frame ID
Parity	Parity bits
Data Length	Data field length
Data	Data field bytes
Checksum	Checksum bits
BitRate	Transmission bit rate
Symbol	Status of any LIN symbols found in the frame

LIN	Time	Break	Synch	ID	Parity	DataLength	Data	Checksum	Bit Rate	Symbol
5	3.27274 S	0							19.129 kbit/s	Lonely BRK
6	3.27388 S	0	e0	3e	03	0			19.113 kbit/s	MQ, no answer
7	3.28108 S	0	66	26	03	1	f8	86	19.177 kbit/s	CRC Error
8	3.29637 S	0	66	26	03	1	fe	e0	19.151 kbit/s	CRC Error

Section of typical LIN result table.

FlexRay Result Table

Column	Extracted or Computed Data
Index (always shown)	Number of the line in the table; also number of the message in the annotation overlay on the trace.
Time	Time elapsed from start of acquisition to Start of Frame.
Bit Rate/Msg	Actual bit rate (BR) for this message, the average BR recomputed by dividing the entire Message time span by the total number of bits in the message.
Frame ID	Frame identifier bits.
Payload Length	Number of words in data payload.
Header CRC	Cyclic Redundancy Check sequence bits.
Cycle Count	Cycle number.
Data	Data Field bytes.
Trailer CRC	Cyclic Redundancy Check sequence bits.
Symbol	Symbol type, if found: Wakeup Pattern (WUS), Channel Idle (CID), Collision Avoidance (CAS), or Media Access Test (MTS).

FLX	Time	Bit Rate/Msg	Frame...	Payl...	Header C...	Cy...	Data	Trailer C...	Symbol
1	-925.348 μ s	10.0001e+6							WUS
2	-900.348 μ s	10.0015e+6	0x12	2	0x776	12	0xee23 0x8c7e	0x90e786	

Section of typical FlexRay result table.

Customizing the Result Table

NUMBER OF COLUMNS

Follow these steps to change what data appears in the 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 in the table, clear any columns you wish to remove. Only those columns selected will appear on the oscilloscope display.
To return to the preset display, touch **Default**.
4. Touch the **Close** button when finished.

BIT RATE TOLERANCE

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 \pm tolerance) by coloring in red the Bitrate shown in the table.

NUMBER OF ROWS

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.

Zooming with the Result Table

Besides displaying the decoded serial data, the result table enables you to quickly Zoom regions of the decoded waveform and access other functionality.

Touching the **Index (row) number** in the first column opens a Zoom of the corresponding region in the decode trace. This is a quick way to navigate to events of interest in the acquisition.

The **Index column heading** (top, left-most cell of the table header) bears the name of the corresponding protocol, and the cell's fill color matches the color of the input source. Touching this cell opens the Decode Setup dialog if it has been closed.

Touching any other **data cell** in the table opens a pop-up menu with several choices of action:

- **Off** turns off the decode.
- **Zoom** creates a zoom of the region where the data appears (same as touching the row number).
- **Setup** opens the Decoder Setup dialog (same as touching the first column heading).
- **Export** exports the decode results table to a .CSV file.
- **Measure** displays a choice of [measurements](#) that can be made on the decoded signal.

Exporting Result Table Data

You can manually export the decoder 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.

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 **Decode#** as the source. Make other file format and storage selections as you wish.

Measuring

If you have installed any -TDM option or PROTObus MAG, these general 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: Depending on the protocol, measurements may appear in a sub-menu of the Measure Setup menu and may have slightly different names. For example, the CAN sub-menu has measurements for CANtoValue instead of Message to Value, etc. The measurements are the same.

Measurement	Description
View Serial Encoded Data as Analog Waveform	Automatically sets up a Message to Value parameter and then tracks the assigned measurement. In doing so, a Digital-to-Analog Conversion (DAC) of the embedded digital data is performed and the digital data is displayed as an analog waveform.
Message to Value	Extracts and converts a specific portion of the data/payload in the message and displays it as an analog value.
MsgToAnalog (Message to Analog)	Computes time from start of first message that meets conditions to crossing threshold on an analog signal. Result is negative if analog event precedes message. You must choose the digital input in Source1 and the analog input in Source 2 for this measurement to work properly.
AnalogToMsg (Analog to Message)	Computes time from crossing threshold on an analog signal to start of first message that meets conditions. Result is negative if message precedes analog event. You must choose the analog input in Source 1 and the digital input in Source 2 for this measurement to work properly.
MsgToMsg (Message to Message)	Computes time difference from start of first message that meets conditions to start of next message.
DeltaMsg (Delta Message)	Computes time difference between two messages on a single decoded line.
Time@Msg (Time at Message)	Computes time from trigger to start of each message that meets conditions.
BusLoad	Computes the load of user-defined messages on the bus (as a percent).
MsgBitrate	Computes the bitrate of user-specified messages on decoded traces.
NumMessages (Number of Messages)	Computes the total number of messages in the decoding that meet conditions.

Graphing Measurements

Measure and graph options 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

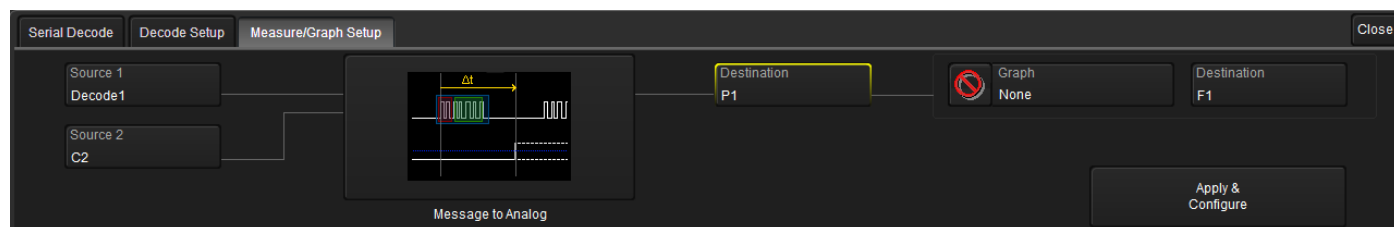
compare them to a corresponding analog signal, or to observe changes in timing. A parameter tracked over a long acquisition could provide information about the modulation of the parameter.

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, so also select a function location (Fx) in which to draw the plot. The plot will open along side the decoding in a separate grid.

Using the Measure/Graph Dialog

The Measure/Graph dialog, which appears behind the Decode Setup dialog when measurements are supported, is a quick way to apply parameters specifically designed for serial data measurement and simultaneously graph the results.



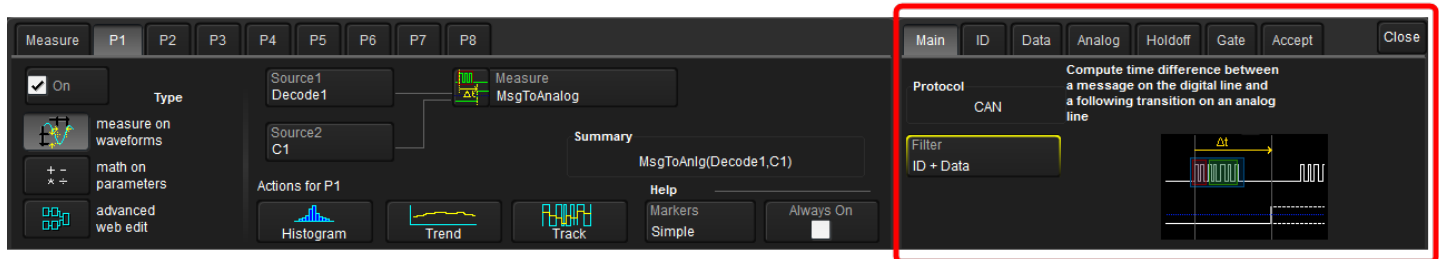
1. Select the **Measurement** to apply and the **Destination** parameter location (Px) in which to open it.
2. The **Source 1** decode is preselected; change it if necessary. If the measurement requires it, also select Source 2.
3. Optionally, choose a **Graph** format and the **Destination** math function location (Fx) in which to open it.
4. Optionally, set a measurement gate or filter. Touch **Apply & Configure** and make all required settings on the Measure right-hand dialogs that appear.

NOTE: The Serial Decode measurements are also available from the standard Measure setup menu. You can use the that functionality to set up as many measurements as your instrument has parameters.

Filtering Serial Decode Measurements

After applying a measurement to the decoded waveform on the Measure/Graph dialog, set filter conditions on the right-hand dialogs that appear next to the Px dialogs.

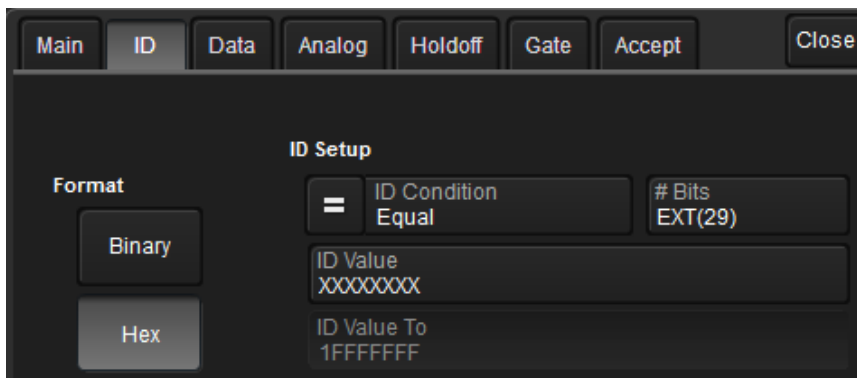
NOTE: Not all protocols or measurements support all filter types.



Frame ID Filter

This filter restricts the measurement to only frames with a specific ID value.

1. On the Main dialog, in **Filter** choose ID or ID+Data.
2. Open the **ID** tab that appears.



3. Choose to enter the frame ID value in **Binary** or **Hex**(adecimal) format.
4. Select the **# Bits** used to define the frame ID. (This will change the ID Value field length.) For CAN, choose from standard 11-bit or extended 29-bit.
5. 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**. On the pop-up dialog that appears when you touch ID Value:
 - Use the Left and Right arrows 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 dialog.

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.

The screenshot shows the 'Data Pattern Setup' dialog box. At the top, there are tabs for 'Main', 'ID', 'Data', 'Analog', 'Holdoff', 'Gate', 'Accept', and 'Close'. The 'Data' tab is selected. Below the tabs, the 'Data Pattern Setup' section contains a 'Data Condition' dropdown menu set to 'Equal'. To the left, under the 'Format' section, there are two buttons: 'Binary' and 'Hex'. Below these, there are two input fields: 'Start Position' with the value '0' and '# Bits' with the value '8'. At the bottom, there are two more input fields: 'Data Value' with the value 'XX' and 'Data Value To' with the value 'FF'.

Analog Filter

This filter applies only to parameters that measure the decoded waveform relative to an analog signal: AnalogtoMsg and MsgtoAnalog. It allows you to set the crossing level and slope of the Analog signal 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 signal mean.

The screenshot shows the 'Analog Filter' dialog box. At the top, there are tabs for 'Main', 'ID', 'Data', 'Analog', 'Holdoff', 'Gate', 'Accept', and 'Close'. The 'Analog' tab is selected. Below the tabs, the dialog title is 'Time from trigger (t=0) to crossing at a specified level.'. Below the title, there are two rows of controls. The first row has a 'Level is' dropdown set to 'Percent', a 'Percent level' input field set to '50 %', and a 'Find Level' button. The second row has a 'Slope' dropdown set to 'Pos' and a 'Hysteresis' input field set to '500 mdiv'.

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.

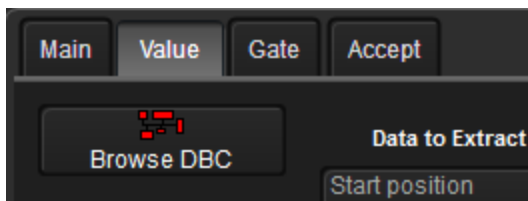
Observe the following when using Hysteresis:

- 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. CAN and CAN FD Symbolic Users: touch **Browse DBC**. Expand the .dbc file, then click on the desired symbol to filter on occurrences of that symbol.



NOTE: This button will not appear if your installation does not support symbolic decoding.

2. Under Data to Extract, begin by entering the **Start position** and the **# Bits** to extract.
3. Choose the **Encoding** type if the signal uses encoding, otherwise leave it Unsigned.
4. Under Conversion, enter the **a. Coefficient** and **b. Term** that satisfy the formula:
 $Value = Coefficient * Raw Value + Term$.
5. 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 Measure set up dialogs 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* or *Getting Started Manual* for more information.

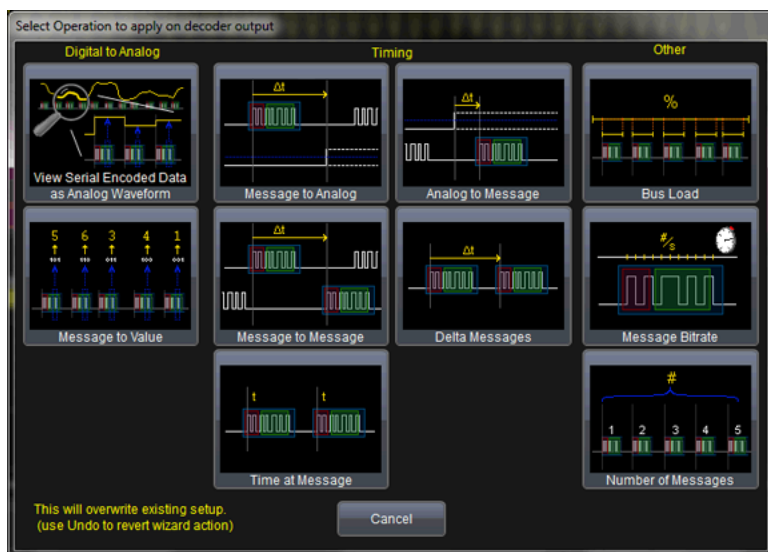
Using the Result Table

To quickly apply serial data measurements when the serial data setup dialogs are closed:

1. Touch any **data cell** of the decode result table.

NOTE: If running more than one decoder simultaneously, be sure to select a cell from the correct table. The measurement source will be the waveform belonging to the table you touch.

2. From the pop-up menu, select **Measure** to display the Select Operation... dialog.

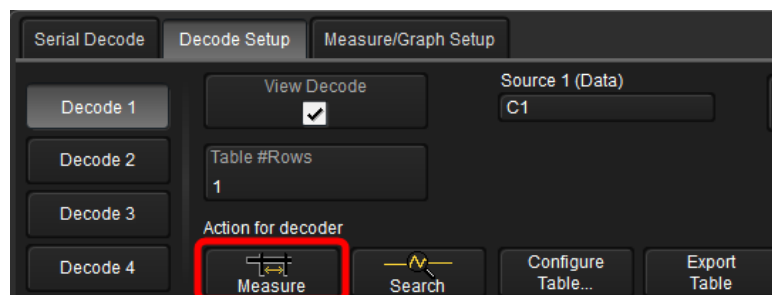


3. Touch any measurement operation to select it.
4. On the next dialog, choose a **parameter** location (P1-Px) in which to run the measurement.

NOTE: If the location already stores a measurement, this selection will overwrite that setup.
5. To [filter or gate the parameter](#), touch the Px cell of the readout table and make the desired settings on the right-hand dialogs that appear.

Using the Decode Setup Dialog

You can also access serial data measurements by touching the **Measure** button on the Decode Setup dialog. When using this button, measurements are set on the source of whichever Decoder (1-4) is currently selected on the Decode Setup dialog.



Triggering

Serial Trigger Technical Overview

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 imposible 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.

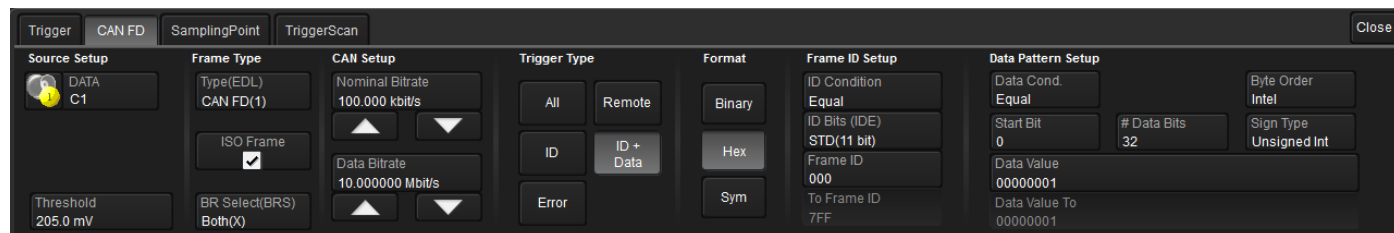
While the decoder and the trigger have distincts sets of controls, when the link is active, a change to the bit rate in the decoder will immediatly propagate to the trigger and vice-versa.

CAN/CAN FD Serial Trigger Setup

To access the trigger setup dialog:

- Touch the **Trigger descriptor box** or choose **Trigger > Trigger Setup** from the Menu Bar.
- On the Trigger dialog, touch the **Serial Type** button, then the **CAN Std** or **CAN FD Standard** button.

Working from left to right, make the desired selections from the CAN/CAN FD dialog.



Source Setup

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

Use the **Threshold** control to adjust the vertical level for the trigger. Much like an Edge trigger, you must specify the level at which to process the incoming signal to determine whether the serial data pattern meets the trigger condition.

TIP: One way to test that the threshold is set correctly is to initially set the Trigger Type to All. If you see a decoded message appear each time the oscilloscope triggers, the level is correct.

Frame Type

These controls appear only for CAN FD triggers. They allow you to specify information about the frame types to be found in the data stream.

Choose whether the EDL bit **Type** is Both (X), CAN Std (0) only, or CAN FD (1) only. Both enables triggering on streams with mixed legacy and extended frame types.

If using CAN FD Type, also:

- Check **ISO Frame** if the stream supports ISO frames.
- Choose a **BR Select** of Both (X), Normal (0), or FD (1). Both examines frames with or without a bit rate switch. Normal and FD examine only frames with the respective BRS bit values.

CAN Setup

If you have not linked the trigger to a pre-set decoder, enter the **Nominal Bitrate** used during the Arbitration sequence.

NOTE: When the trigger is linked, this value is dynamically linked to the decoding bitrate; they are always the same.

Use the Up and Down arrows to scroll the list of standard bit rates and make a selection, or touch Bitrate and use the Adjust knob or the pop-up keypad to enter the value.

CAN FD users: also enter the **Data Bitrate** used during the Data sequence.

Trigger Type

These buttons determine which frames/fields are included in the trigger search:

All triggers upon finding the first CAN frame.

Remote triggers upon finding matching Frame ID values in Remote frames (only). Complete the Frame ID Setup described below.

ID triggers upon finding matching Frame ID values in any type of frame. Complete the Frame ID Setup described below.

ID+Data triggers upon finding matching Frame ID values *and* data patterns. Complete both the Frame ID Setup and Data Pattern Setup described below.

Error triggers when a protocol error occurs. Select all the errors that can fire the trigger from below **Error Type**.

Setup Format

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

NOTE: SYMBOLIC users, follow the Symbolic Setup for Remote, ID, and ID+Data triggers instead of Frame ID Setup and Data Pattern Setup.

Frame ID Setup

Frame ID Setup is used to trigger upon encountering either a specific ID value or any value relative to a reference ID value (e.g., greater than x). Use these controls to create a condition statement that describes the trigger criteria.

Choose the **ID Condition** (Boolean operator) that describes the relationship to the Frame ID value. To use a range of values, choose In Range or Out Range.

In **ID Bits**, choose to trigger on 11-bit (Standard CAN) messages, 29-bit (Extended CAN) messages, or ALL.

Enter the reference **Frame ID** value. When setting a range, enter the start Frame ID.

When setting a range, enter the stop value in **To Frame ID**.

Data Pattern Setup

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

Choose the **Data Condition** (Boolean operator) that describes the relationship to the reference Data Value. To use a range of values, choose In Range or Out Range.

Set **DLC** (Data Length Code) to any integer value from 0 to 8. It should match the DLC of the CAN message(s) on which to trigger.

Choose from either Motorola (default) or Intel **Byte Order**.

Use **Start Bit** and **# Data Bits** together to define a string of up-to-64 contiguous data bits (8 data bytes) starting from any location in the CAN message data field (it is not limited to the start of a full byte or a nibble). The Start Bit can be any value from 0 to 63. The Start Bit value is always in LSB format (the bit number as shown on the decoded waveform, with bit 0 being at the far left and bit 63 being at the far right of the data string). Remember that the 1st data byte is bits 0-7, the 2nd data byte is bits 8-15, etc. Also, make sure the Start Bit value makes sense in relation to the DLC value (e.g., a Start Bit value of 32 with a DLC Value of 4 is not going to result in a successful trigger). The total # Bits can be any value from 1 to 64.

Choose a **Sign Type** of signed or unsigned integer format.

Enter the reference **Data Value**. When using a range, enter the start Data Value. For Hexadecimal format values, if desired, you can precede the ID value with **0x**, but this is not necessary. Be sure to enter a Data Value that matches the DLC Value.

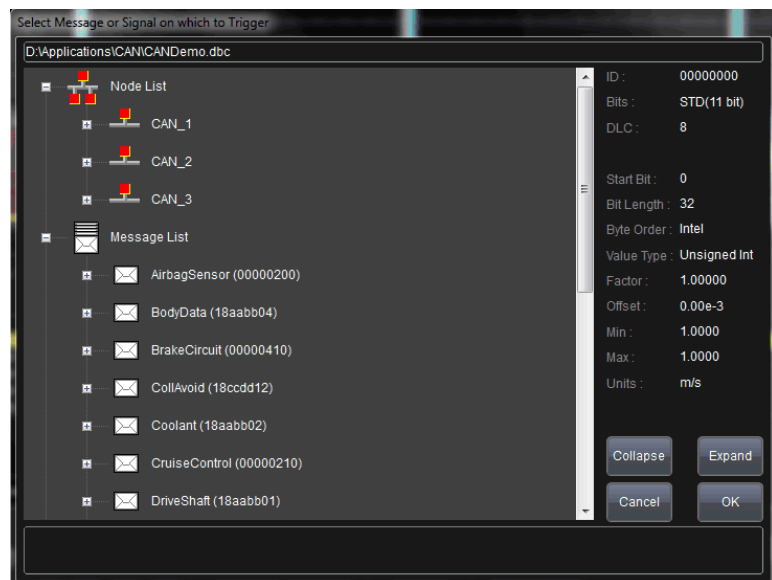
When using a range, enter the stop value in **Data Value To**.

Symbolic Setup

Symbolic triggering sets the trigger conditions on values defined in a symbol file.

Browse to and select the **Symbol File**.

Touch the **DBC** button to view the selected symbol file. A pop-up dialog displays a hierarchy of Nodes, Messages, and Signals. Expand the list to see the values defined for each.

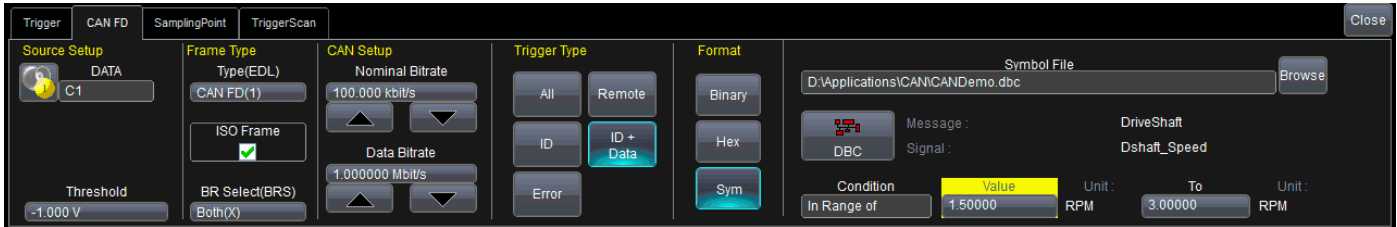


Select the element on which to trigger, then touch **OK**.

If you are setting up a symbolic ID+Data trigger, also create a condition statement that describes the data value upon which to trigger. All values that meet the condition will fire the trigger.

- Choose the **Condition** (Boolean operator) that describes the relationship to the reference value, then enter the **Value**.
- To use a range of values, choose In Range or Out Range and also enter the **To** value.

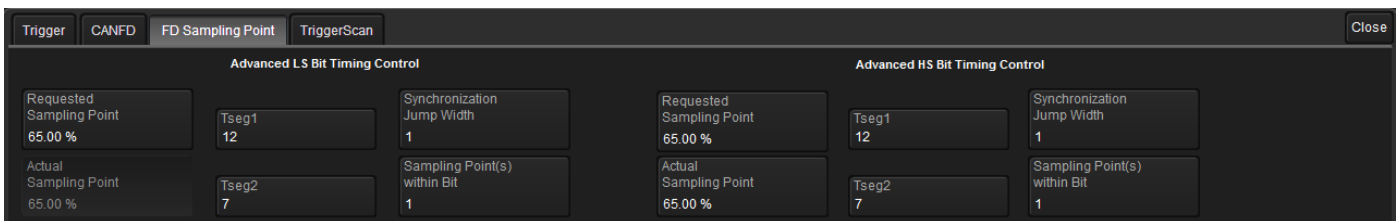
NOTE: The Units assigned to the values are taken directly from the symbol file.



Sampling Point

This dialog appears behind the trigger dialog in CAN FD options. Use it to manually set the sampling point levels for the Nominal Bit Time and the Data Bit Time in cases where there may be a recessive ESI bit.

NOTE: If the trigger is linked to a CAN FD decoder, these fields will already reflect the entries on the decoder Sampling right-hand dialog. Changing values here will also change the decoder.



First, choose to use either Basic or Advanced **Menu Format**.

In the Basic format, you need only set:

- The **Requested Sampling Point** position within the bit, expressed in %. Prop_Seg is forced to zero, while Phase_Seg1 and Phase_Seg2 are computed automatically.
- **SJW** (Synchronization Jump Width)

The Advanced format disables the Requested Sampling Point and instead enables all the fields on the dialog for manually entering Timing SJW as well as:

- **Prop_Seg**, the part of the bit time used to compensate for the physical delay times within the network.
- **Phase_Seg1**, number of time quanta before the sampling point.
- **Phase_Seg2**, number of time quanta after the sampling point.

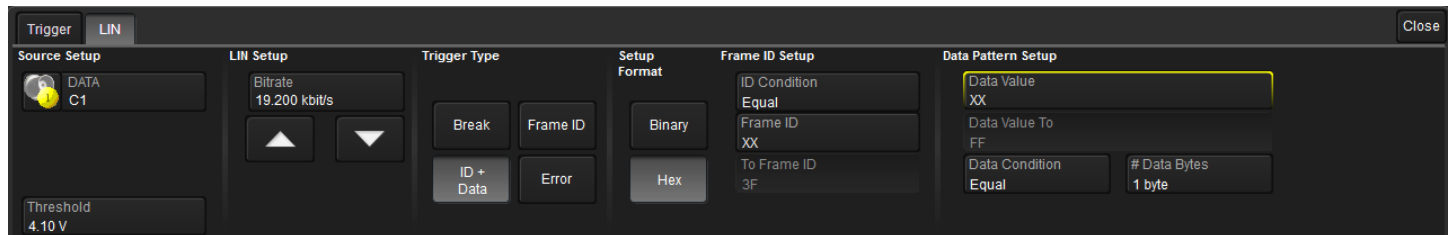
In Advanced format, the **Actual Sampling Point** levels measured are displayed on the dialog when the trigger is enabled.

LIN Serial Trigger Setup

To access the serial trigger dialog:

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

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



Source Setup

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

Use the **Threshold** control to adjust the vertical level for the trigger. Much like an Edge trigger, you must specify the level at which to process the incoming signal to determine whether the serial data pattern is meeting the set trigger condition.

LIN Setup

If you have not linked the trigger to a pre-set decoder, enter the **Bitrate** of the bus to which you are connected. This bit rate selection is dynamically linked to the decoding bit rate (they are always the same value). Use the Up or Down arrows to scroll the list of standard bit rates and make a selection, or touch the control and enter the value as close as possible to the actual bus rate.

Trigger Type

The LIN trigger can be configured to fire upon simple Start of Frame (**Break**), a Frame ID value, a combination of Frame ID values and Data patterns, or LIN error. Choose the desired Trigger Type and complete the remaining fields required to set the trigger condition:

- **Error**, complete the Checksum Error Setup below.
- **Frame ID**, complete the Frame ID Setup below.
- **ID + Data**, complete both Frame ID Setup and Data Pattern Setup below.

Setup Format

Choose to display/enter 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.

Frame ID Setup

Frame ID Setup is used to trigger upon encountering either a specific ID value or any value relative to a reference ID value (e.g., greater than x). Use these controls to create a condition statement that describes the trigger criteria.

Choose the **ID Condition** (Boolean operator) that describes the relationship to the Frame ID value. To use a range of values, choose In Range or Out Range.

Enter the reference **Frame ID** value. When setting a range, enter the start Frame ID.

When setting a range, enter the stop value in **To Frame ID**.

Data Pattern Setup

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

Choose the **Data Condition** (Boolean operator) that describes the relationship to the reference Data Value. To use a range of values, choose In Range or Out Range.

Enter the reference **Data Value**. When using a range, enter the start Data Value. In Hexadecimal format, data must be entered as full bytes even though the minimum required acceptable entry is a nibble. If less than a full byte is entered, then a "don't care" (wildcard) X precedes the pattern values entered. Up to 8 bytes of data can be entered as a pattern value. If less than 8 bytes of data is entered for the pattern value, the data is assumed to begin at Data Byte 1 in the LIN message. If this is not desired, then add preceding or trailing X nibbles to the pattern value.

When using a range, enter the stop value in **Data Value To**.

Data Bytes defaults to the length, in bytes, of the pattern set in the Data Value. If you change the length to be less than this value, it would truncate the beginning of the pattern value. If you were to increase the pattern length, it would add "don't care" XX byte values to the beginning of the pattern value. The maximum number of data bytes is 8, per the LIN standard.

Checksum Error Setup

Enter the **Error Frame ID** to search.

Check all the error types on which to trigger: **Checksum Error**, **Header Parity**, or **Sync Byte**.

If Checksum Error is selected, also enter the **LIN Spec.** (standard) used to encode the data and the # **Data Bytes** in a message.

FlexRay Trigger Setup

To access the serial trigger dialog:

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

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

Source Setup

These controls are use by all trigger types.

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

Use the **Threshold** controls to set the High and Low vertical level for the trigger. Much like an Edge trigger, you must specify the level at which to process the incoming signal to determine whether the serial data pattern is meeting the set trigger condition. FlexRay is a tri-level signal and requires two voltage threshold settings which enable the oscilloscope to distinguish between 1 and 0.

If desired, use the **Find Threshold** button to set appropriate thresholds based on the input signal characteristics.

FlexRay Setup

If you have not linked the trigger to a pre-set decoder, enter the **Bitrate** of the bus to which you are connected. This value is dynamically linked to the decoding bitrate; they are always the same. Touch the arrow buttons to scroll through standard bitrates (2.5, 5.0 or 10.0 Mb/s), or touch Bitrate and enter the value using the Adjust knob or the pop-up keypad.

Trigger Type

The LIN trigger can be configured to fire upon the occurrence of a simple Transmit Start Sequence (TSS), a Symbol, various Frame characteristics (ID, Cycle Count, or Qualifiers), or a FlexRay error. Choose the desired Trigger Type and complete the remaining fields required to set the trigger condition:

- **TSS**, complete Setup Format below.
- **Frame**, complete Setup Format and Frame Trigger below.
- **Symbol**, complete the Symbol Trigger below.
- **Error**, complete Error Trigger below.

Setup Format

Choose to display/enter 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.

Frame Trigger Setup

The screenshot shows the 'Frame Trigger Setup' window with the following configuration:

- Source Setup:** DATA C1, Threshold High 205.0 mV, Threshold Low -205.0 mV, Find Thresholds.
- FlexRay Setup:** Bitrate 10.0 Mbit/s.
- Trigger Type:** TSS (Start), Frame, Symbol, Errors.
- Setup Format:** Binary, Hex.
- Frame ID Setup (highlighted):** Condition In Range of, Value 06A, To 7FF.
- Cycle Count:** Condition Equal, Value 0, To 63, Repetition Factor 1.
- Frame Qualifiers:** Payload Preamble One, Null Frame Don't Care, Sync Frame Don't Care, Startup Frame Don't Care.

FRAME ID

Frame ID Setup is used to trigger upon encountering either a specific ID value or any value relative to a reference ID value (e.g., greater than x). Use these controls to create a condition statement that describes the Frame ID criteria.

Choose the **Condition** (Boolean operator) that describes the relationship to the Frame ID value. To use a range of values, choose In Range or Out Range.

Enter the reference **Value**. When setting a range, enter the start Frame ID in Value and the stop Frame ID value in **To**.

TIP: Use X as a wildcard ("Don't Care") in any position. To effectively exclude the Frame ID as a trigger condition, choose the Equal condition and the default value of all Xs.

CYCLE COUNT

The Cycle Count is a decimal value between 0 and 63 correlating to the FlexRay Cycle Count numbering system. The default Cycle Count is 0. You may also specify a Repetition Factor to allow for triggering when Cycle multiplexing is being used. This condition is added to any Frame ID conditions.

As with Frame ID, create a Boolean statement describing the Cycle Count criteria. Omit the Cycle Count criteria by selecting Condition "Don't Care".

When the Cycle Count condition is set to Equal, set a **Repetition Factor** of 1, 2, 4, 8, 16, 32 or 64.

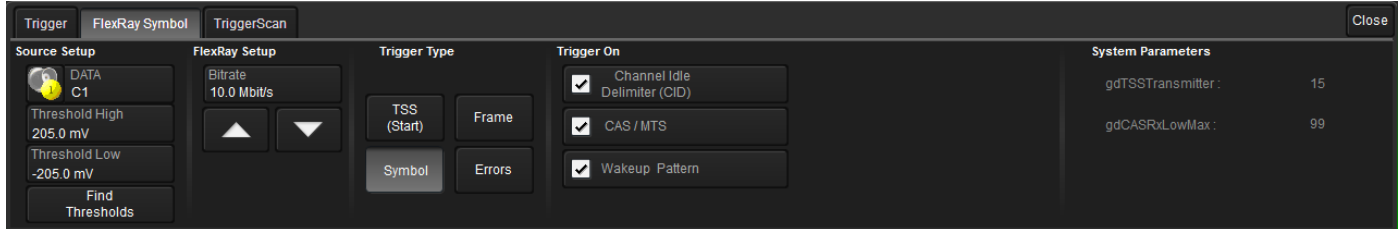
FRAME QUALIFIERS

Defined in the FlexRay specification, the occurrence of **Payload Preamble**, **Null Frame**, **Sync Frame**, or **Startup Frame** bits may be set as trigger conditions. These conditions are added to any Frame ID or Cycle Count conditions.

Each qualifier can be set to one or zero, or omitted by selecting "Don't Care". The trigger will be restricted to frames with matching values in the respective field.

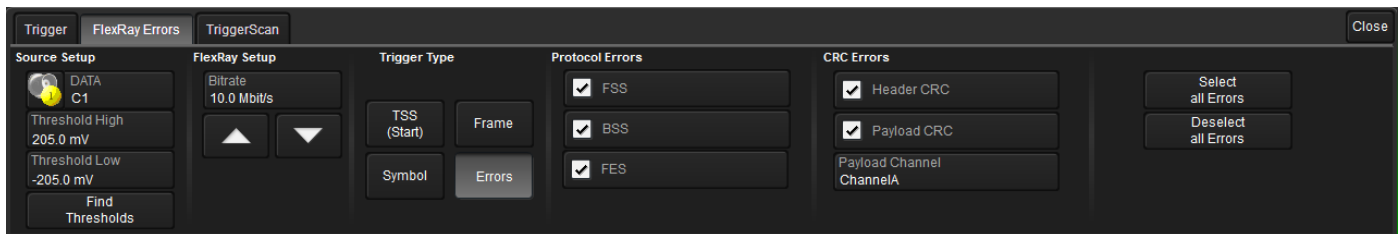
Symbol Trigger Setup

A Symbol trigger fires upon finding any frame that includes any one of the selected symbols. Mark all the desired symbol types.



Error Trigger Setup

An Error trigger fires upon the occurrence of any FlexRay protocol or CRC error. Mark all the desired error types. If you choose Payload CRC, also select the Payload input channel.



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 view 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 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 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 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.

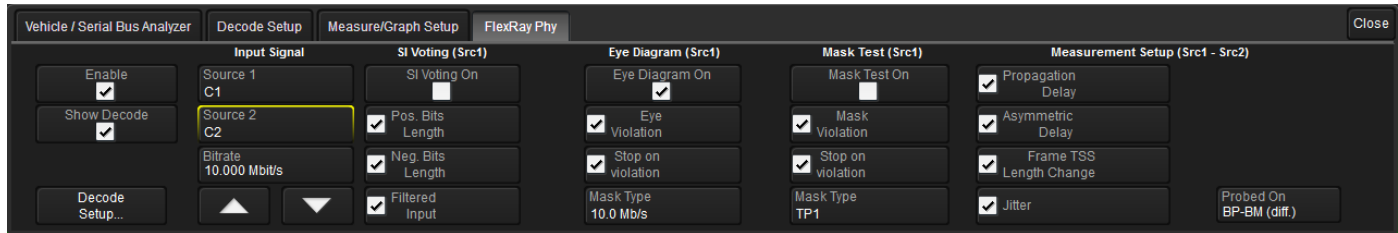
- AutoSave waveform creates a .trc file that copies the waveform at each trigger point. These files can be recalled to the oscilloscope for later viewing. Choose **File > Save Waveform** and an Auto Save setting of **Wrap** (overwrite when drive full) or **Fill** (stop when drive full). The files are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

FlexRay Physical Layer Testing

The FlexRaybus PHY option include physical layer tests specified by the FlexRay standard. When these options are activated, an additional FlexRay Phy dialog appears following the Measure/Graph Setup tab.



The dialog contains selections for SI Voting, Eye Diagram, Mask Testing, and Measurement Setup to quickly align signals to the FlexRay specification. These tests can be run simultaneously with the protocol-level decoding to quickly identify where errors and anomalies occur.

General Settings

Mark **Enable** to enable physical layer testing.

Mark **Show Decode** to display the signal decoding during the physical layer test. The current FlexRay decoder settings from the Decode Setup dialogs will apply.

The **Decode Setup** button provides quick access to the Decode Setup dialog.

Input Setup

Touch **Source 1** and choose the transmitter test signal.

NOTE: The **Source 1** signal is used for **SI Voting**, **Eye Diagram**, and **Mask Test** functions. **Source 1** and **2** are both used for the **Measurement** function.

Optionally, touch **Source 2** and choose the receiver test signal for Physical Layer Measurements.

Enter the **Bitrate** as close as possible to the the bitrate of the bus to which you are connected. Use the arrows to scroll through the standard bitrates (2.5 Mb/s, 5 Mb/s and 10 Mb/s) and make a selection, or touch the field to enter the value using the ADJUST knob or the keypad.

NOTE: Eye diagrams can be created from FlexRay waveforms with bitrates of 2.5 Mb/s, 5 Mb/s and 10 Mb/s as defined in the FlexRay standard.

SI Voting Setup

SI Voting was developed as an alternative for users who found eye diagrams and masks to result in failed tests on signals which would actually pass in practice. SI Voting filters every bit pattern of the form 00010 and 11101 (i.e., all single-bit pulses), then measures the bit-length between a point on the first edge and a symmetrical point on the second edge, providing a set of time deltas between the two edges. The result is then tested against the specification constraints on shortest and longest acceptable bit-length, maximum acceptable bit-length variation, longest acceptable edge time, and top and base levels.



NOTE: SI Voting disables the application and display of FlexRay physical layer measurements.

Mark **SI Voting On** to enable voting.

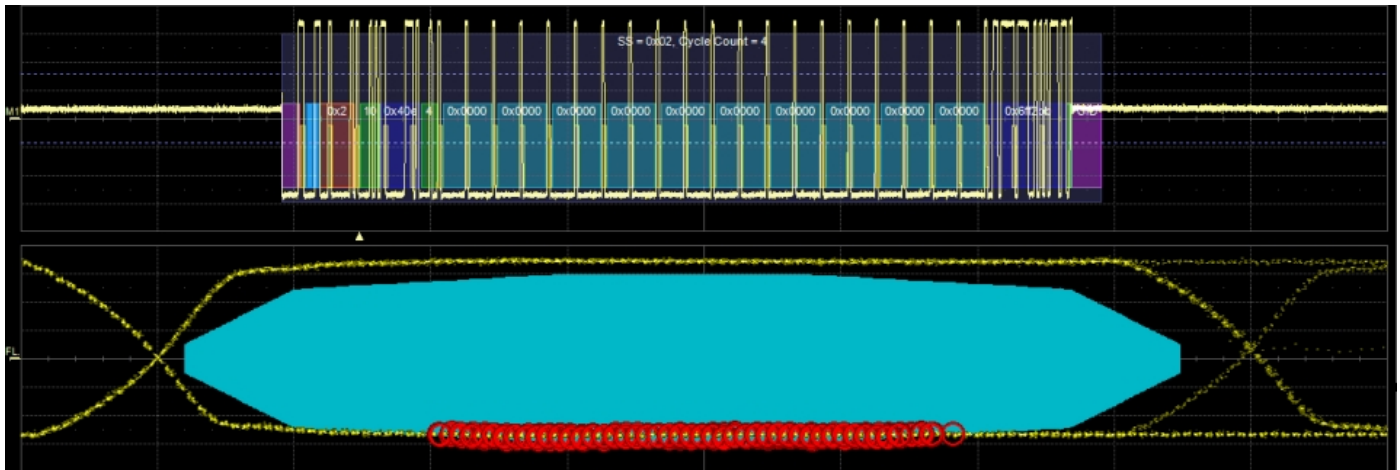
Mark each item on which to vote:

- **Pos. Bits Length**
- **Neg. Bits Length**
- **Filtered Input**

Mask Test Setup

Mask testing can be performed on the eye diagram with masks defined at TP1 and TP11. The mask is aligned horizontally by computing the time for a single UI and centering it on the display. The mask is centered vertically around 0V.

As explained in the FlexRay Electrical Physical Layer Specification, Chapter 7, the mask test makes an eye of the bits following any transition (rising and falling) with no clock recovery. Only a 10 Mb/s mask is defined in the specification, but assuming a controller passing at 10 Mb/s also passes at other bitrates, other masks are provided for different test points and setup configurations.



Mark **Mask Test On** to enable the mask test.

Mark **Mask Violation** to show violations on the display. Mask violations appear as red failure indicators where the eye diagram intersects the mask.

Mark **Stop on violation** to stop the acquisition whenever a mask violation occurs. This will allow time to examine the decoding compared to the mask violation and understand exactly where the violation occurred.

Touch **Mask Type** and choose from:

- TP1
- TP1 Bus Driver
- TP11
- TP11 Active Star

Physical Layer Measurement Setup

You can apply four measurements defined in the FlexRay physical layer specification to characterize the timing properties of the signal along the communication channel. Results appear in the measurement readout table below the grid.

Clear **SI Voting On** to enable measurement selection.

Mark each measurement you wish to apply to the test signal:

- **Propagation Delay**, measured on two points along the communication channel from the emitter node module to the receiver node module. Propagation Delay characterizes the propagation time of the signal using the first transition of the Byte Start Sequence (BSS).
- **Assymetric Delay**, measured on two points along the communication channel from the emitter node module to the receiver node module. Assymetric Delay characterizes the difference in delay between rising and falling edges.
- **Frame TSS Length Change**, measured on two points along the communication channel from the emitter node module to the receiver node module. Frame TSS Length Change measures the change in width of the Transition Start Sequence (TSS).
- **Jitter**, measured on a single point, usually the receiving node. Jitter measures the change of length between the last BSS and the FSS. This should usually be 1 μ s.

Touch **Probed On** and choose the type of line you are measuring:

- **BP-BM (diff)** - a differential signal on the communication channel
- **RxD-TxD (dig.)** - a two-level digital signal in the communication controller interface.

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