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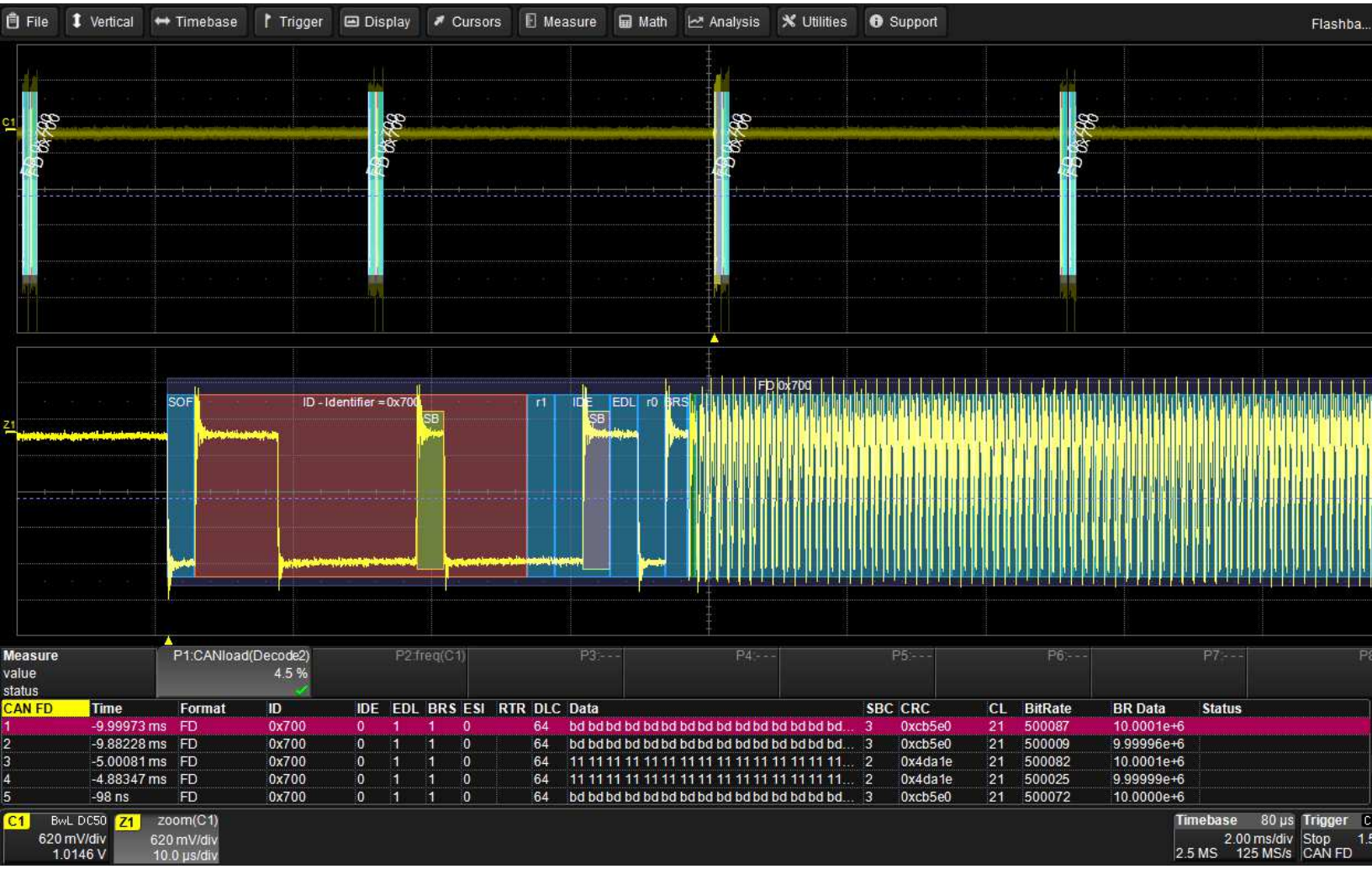

Instruction Manual

Automotive Protocols

Trigger, Decode and Measure

CANbus/CAN FDbus

LINbus

FlexRaybus

Automotive Protocols Trigger, Decode and Measure Instruction Manual

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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 oscillosocpe 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 (C*x*), memory (M*x*), or math function (F*x*).
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.

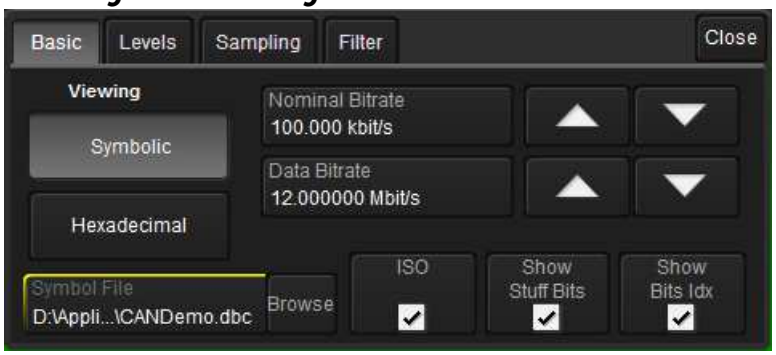
CAN/CAN FD Decoder Settings

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.

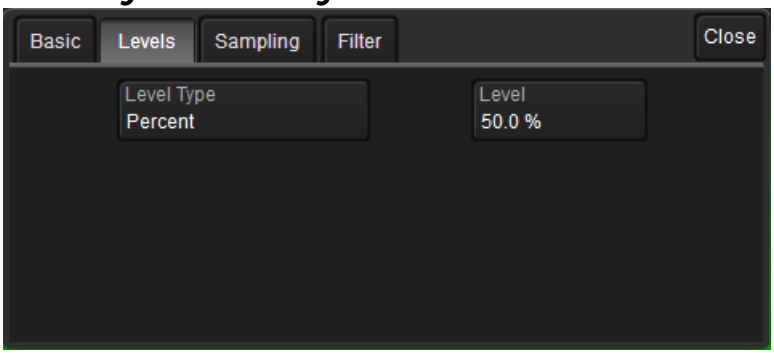
CAN FD users: also enter the **Data Bitrate**. The same precautions apply as for the Nominal Bitrate.

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.

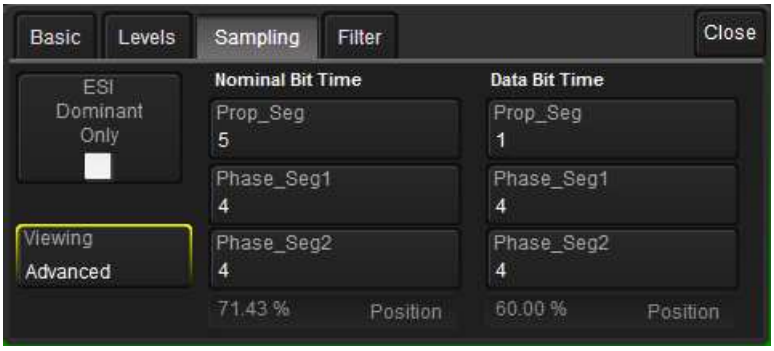
Levels Right-Hand Dialog



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.

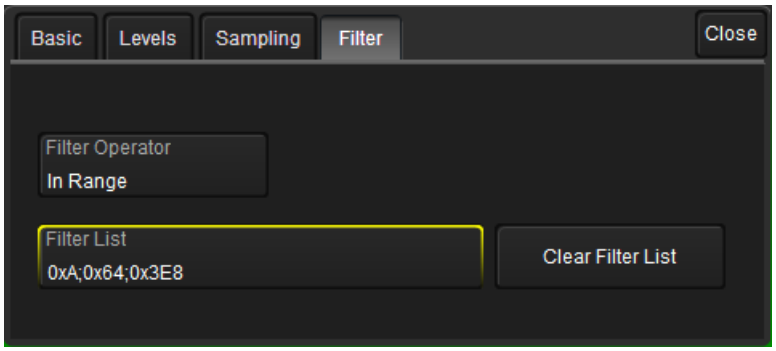
For the Advanced setup, manually enter values for:

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

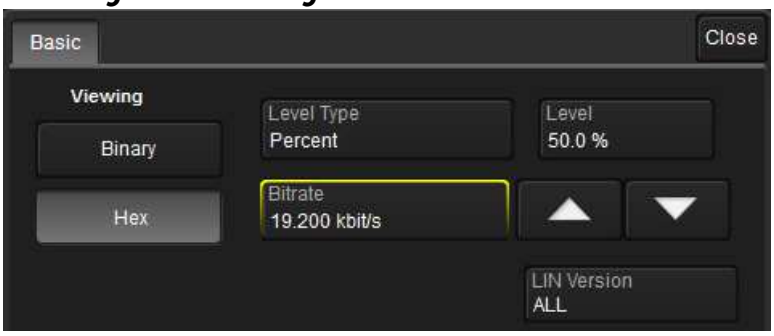
- **In Range** (include only those shown). In Range is very useful when working specifically on certain messages. It allows faster selection in the result table, as well as faster visual identification on the annotated trace and faster export to file. When working on messages that have a causal relationship (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 1and 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

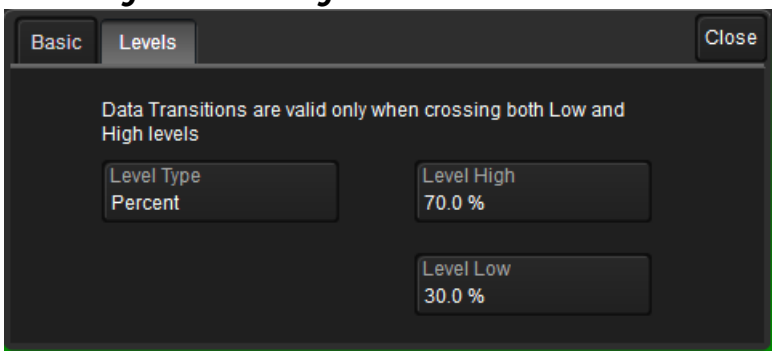
Basic Right-Hand Dialog

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 the 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 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, 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.

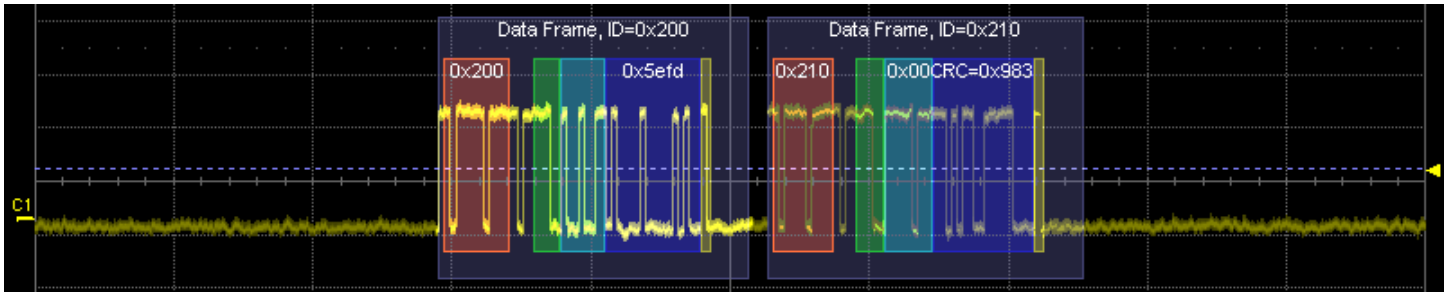
TIP: An easy way to zoom is to touch the row number column of the result table.

CAN Waveform Annotations

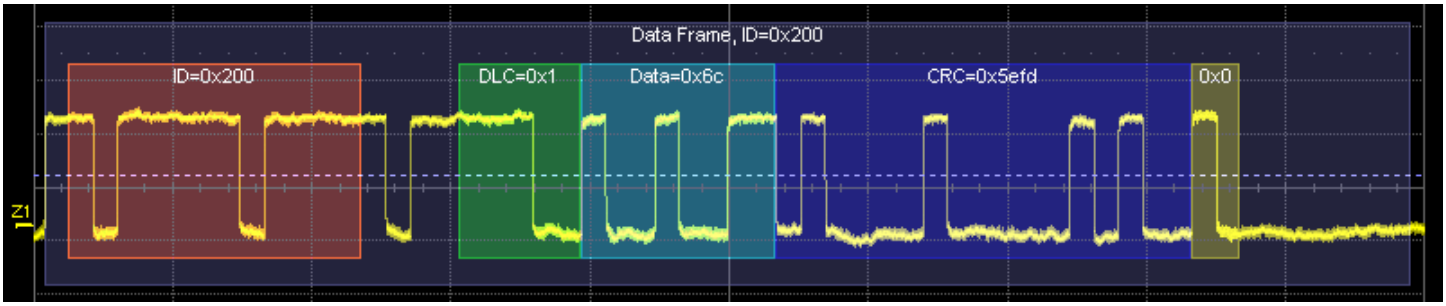
These overlays appear on a CAN waveform or its Zoom trace (some annotations are not shown on the screen-shot).

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.



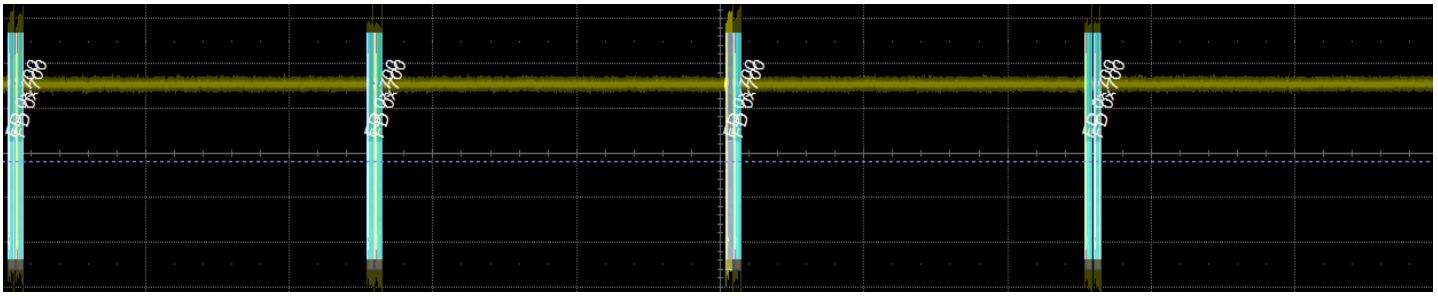
Zoom of frame 0x200 showing annotation details.

CAN FD Waveform Annotations

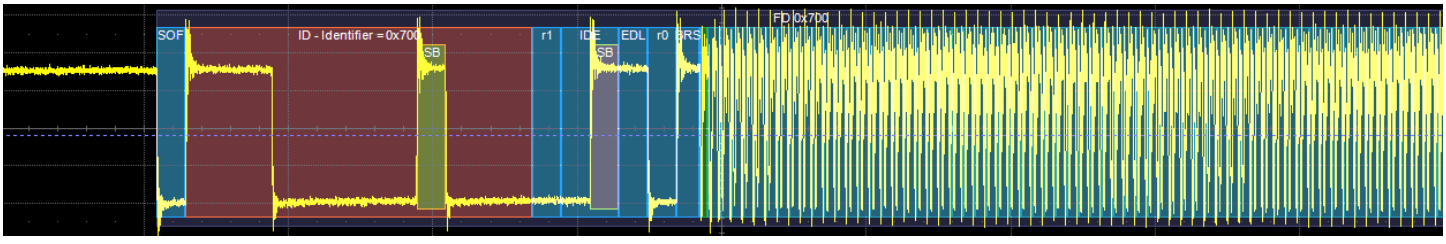
These overlays appear on a CAN FD waveform or its Zoom trace (some annotations are not shown on the screen-shot).

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.



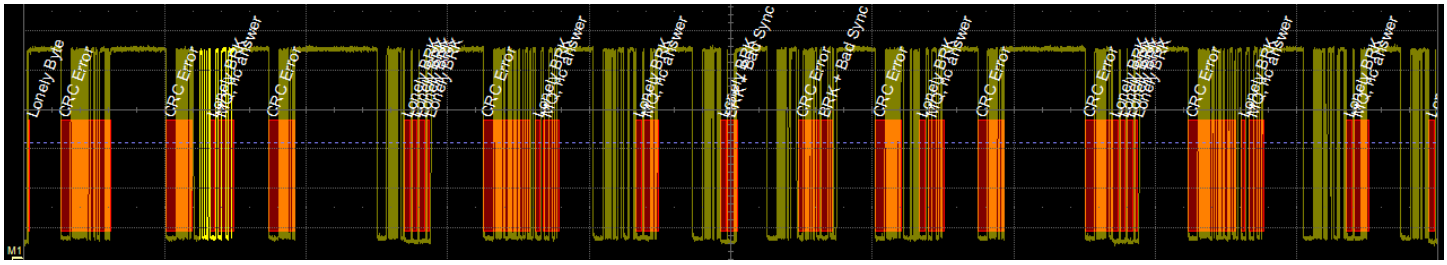
Zoom of frame 0x700 showing annotation details.

LIN Waveform Annotations

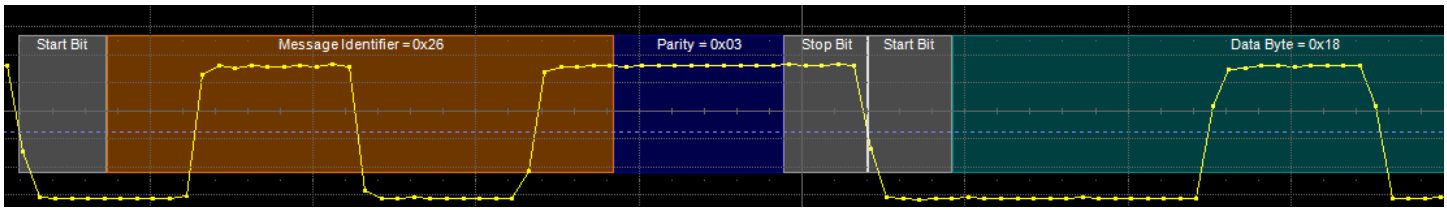
These overlays appear on a LIN waveform or its Zoom trace.

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.



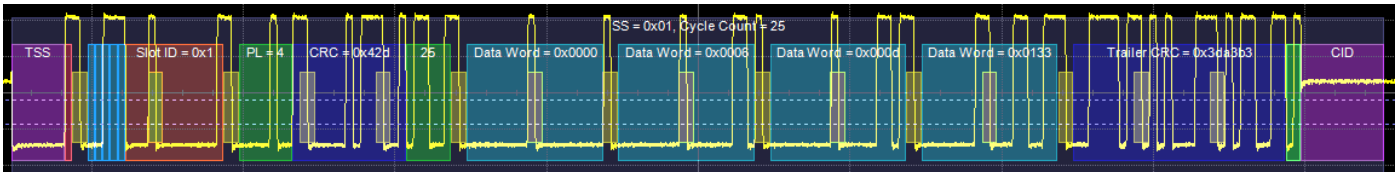
Zoom of message 0x26.

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.

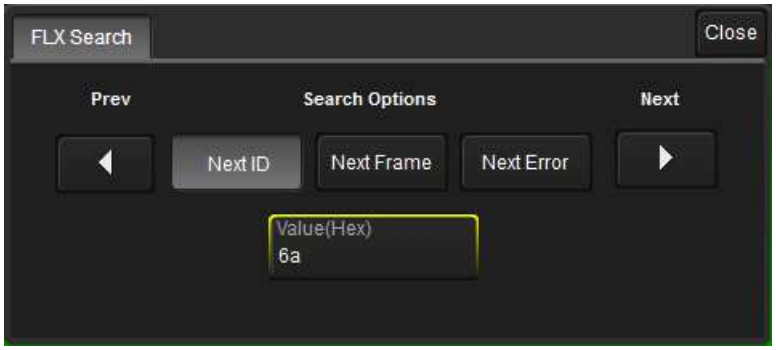
Use the **Prev** and **Next** buttons to view the search results.

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	ff ff ff 0f fe ff ff 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

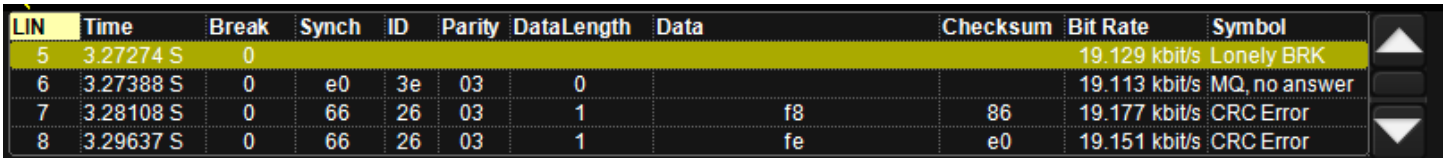
Column	Extracted or Computed Data
Idx (always shown)	Number of the line in the table; also number of the message in the annotation overlay on the trace.
Time	Time elapsed from start of acquisition to Start of Frame.
Format	Number of ID bits, either 11 (Standard) or 29 (Extended).
ID	11 or 29-bit message 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...	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...	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...	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...	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...	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

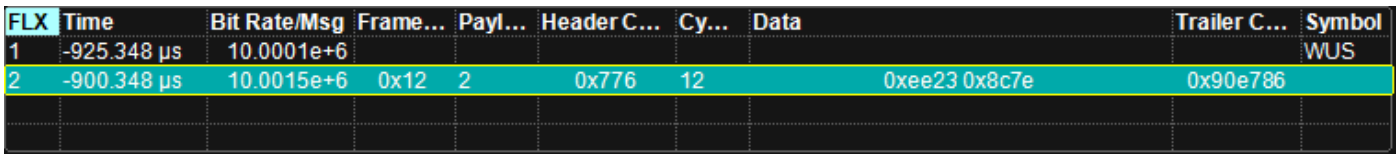


LIN	Time	Break	Synch	ID	Parity	DataLength	Data	Checksum	Bit Rate	Symbol
5	3.27274 S	0							19.129 kbit/s	Lonely BRK
6	3.27388 S	0	e0	3e	03	0			19.113 kbit/s	MQ, no answer
7	3.28108 S	0	66	26	03	1	f8	86	19.177 kbit/s	CRC Error
8	3.29637 S	0	66	26	03	1	fe	e0	19.151 kbit/s	CRC Error

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 diving 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 µs	10.0001e+6							WUS
2	-900.348 µs	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 +- tolerance) by colorizing 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.