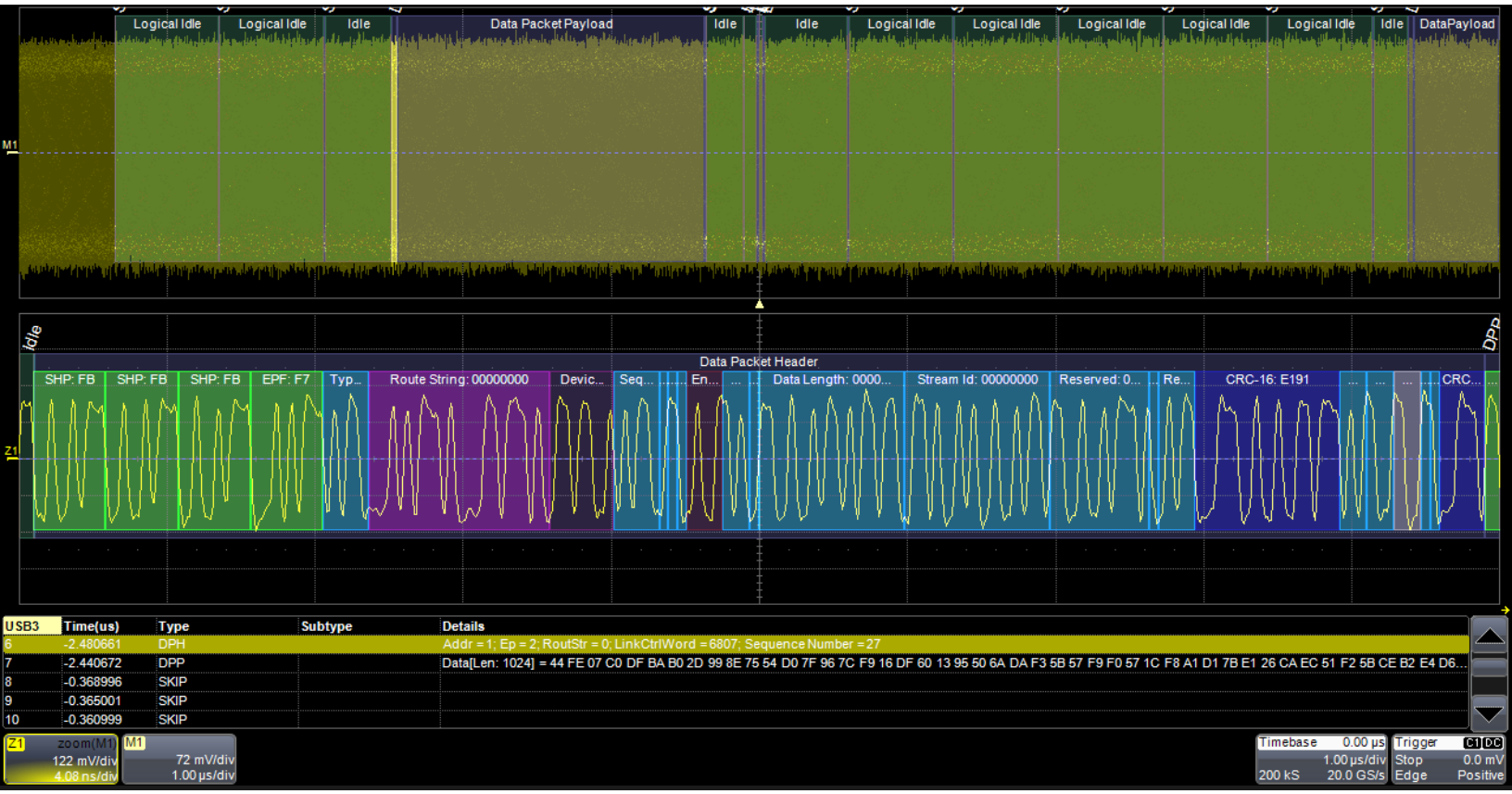
TELEDYNE LECROY
Everywhereyoulook™



Instruction Manual

USB3.0bus

Decoder Software

USB3.0bus Decoder Software Instruction Manual

926375 Rev B
April 2016

Contents

About This Manual

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

This manual explains the basic procedures for using serial data decoder software options.

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 decoding are explained in this manual.

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

teledynelecroy.com/support/softwaredownload

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

About the USB3bus D Option

USB 3.0 (also referred to as SuperSpeed USB) extended the USB standard to a bus bit rate of 5 Gb/s. It is backward compatible with USB 2.0 and 1.0 and retains use with hubs and other related devices. So as to accommodate a very high bit rate and reduce bus turnaround time limitation, USB 3.0 defines separate dual simplex transmission and reception on differential lines. The additional lines are run parallel to the USB 2.0 lines for forward and backward compatibility.

The USB3bus D option applies software algorithms to extract link layer information from USB signals 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.

USB3bus D seamlessly decodes USB3.0, USB2.0, and USB1.0 packets. It is compatible with the ProtoSync™ option.

Serial Decode

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

Bit-level Decoding

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

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

Logical Decoding

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

Message Decoding

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

User Interaction

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

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

Decoding Workflow

We recommend the following workflow for effective decoding:

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

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

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

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

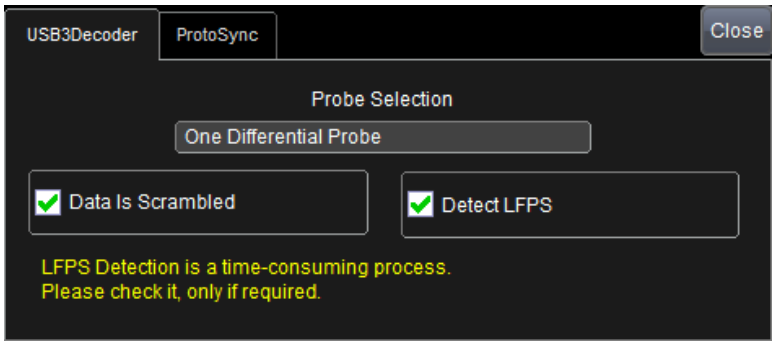
Decoder Setup

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

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

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

USB3 Decoder Subdialog



Configure the **Probe Selection** control based on whether you're using **One Differential Probe** or **Two Single Ended Probes**.

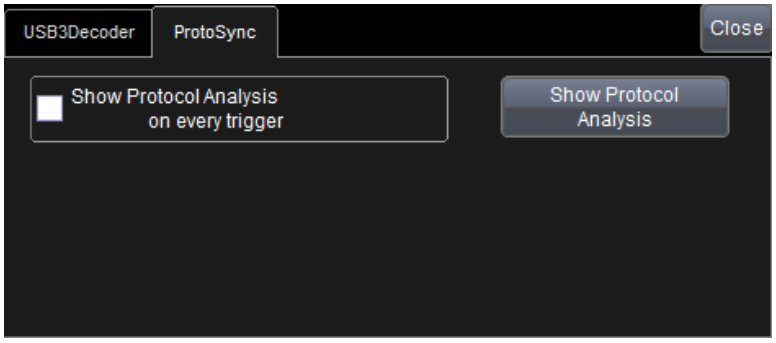
Note: The number of **Source Selectors** on the **Decode Setup** dialog changes to accommodate your probe selection. Be sure to select an input for each probe.

Select **Data Is Scrambled** if the source signal is scrambled.

Select **Detect LFPS** (Low Frequency Periodic Signaling) to mark these periods on the decoding overlay.

ProtoSync Subdialog

This dialog appears behind the decoder setup dialog if you have installed the ProtoSync option key *and* the USB ProtoSync Software on the instrument. Use it to display the decoded data in the format of a protocol analyzer. See ProtoSync.



Failure to Decode

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

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

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

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

Serial Decode Dialog

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

To turn on decoders:

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

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

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

Reading Waveform Annotations

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

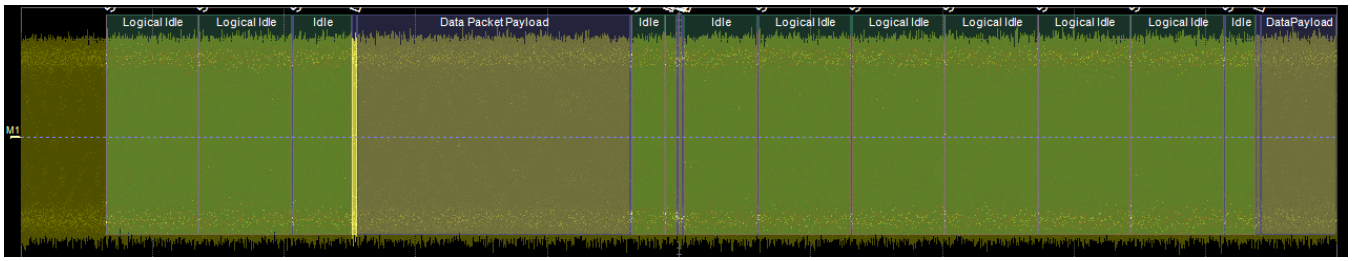
The amount of information shown on an annotation is affected by the width of the rectangles in the overlay, which is determined by the magnification (scale) of the trace and the length of the acquisition. Zooming a portion of the decoder trace will reveal the detailed annotations.

These overlays appear on a decoded USB3 waveform:

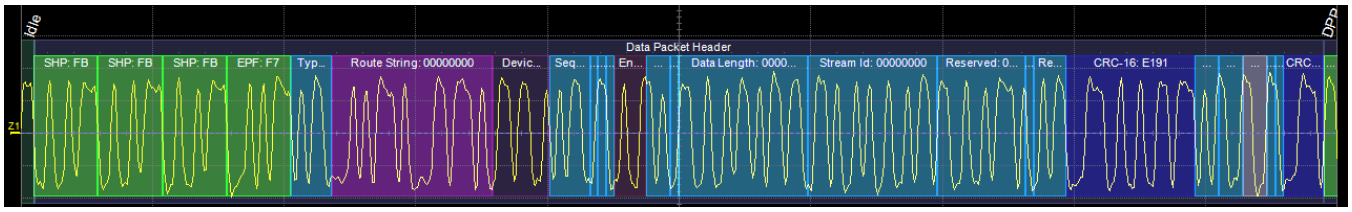
Decoding Level	Annotation	Overlay Color (1)	Text (2)
All	Logical Idle (period of one or more symbol times when no information is being transmitted)	Dark Green (behind physical layer waveform)	Logical Idle
	Protocol Error (a stored or transmitted result is compared to a CRC calculated from the data to determine if an error has occurred)	Red	Protocol Error
Link and Data	Link Command Transition Packet (TP)	Navy Blue (behind other fields)	<subtype> (e.g., LGOOD_4, ACK)
	Data Packet Header (DPH) Data Packet Payload (DPP)	Navy Blue (behind other fields)	<annotation>
	Skip	Navy Blue (behind SKP fields)	SKP Order Set
	Link Command Information	Aqua Blue	Link Command Information:<code>
	Controls	Bright Green	<control type>:<code> (e.g., EPF:F7, SKP: 3C)
	Cyclic Redundancy Check	Royal Blue	CRC-<code>
	Sub-Type	Bright Green	Sub-Type <symbol>
	Route String	Bright Pruple	Route String <symbol>
	Device Address	Dark Pruple	Device Address <symbol>
	Endpoint Number	Burgundy	Endpoint Number <symbol>
	Hub Depth Index	Gray	Hub Depth Index:<symbol>
	LC, TP, or DPH: End of Burst Type Reserved Retry Data Packet Direction	Aqua Blue	<annotation>:<symbol>

Decoding Level	Annotation	Overlay Color (1)	Text (2)
	Host Error Number of Packets Sequence Number Stream ID Packets Pending Header Sequence Number Delayed Deferred		
	Data Payload	Aqua Blue	DPP:<hex bytes>
Polling and Burst (3)	Low Frequency Periodic Signaling	Navy Blue (behind other fields)	LFPS
	Burst	Aqua Blue	Burst
	Electrical Idle (during LFPS)	Aqua Blue	E.Idle

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. In Burst, zoom is set to show only the burst period. In Polling, zoom shows both burst and electrical idle within the LFPS.



Initial data-level decoding of USB3 waveform.



Zoom of decoding showing annotation details. The bottom image corresponds to the yellow bar in the initial decoding.

Serial Decode Result Table

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

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

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

Table Rows

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

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

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

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

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

Table Columns

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

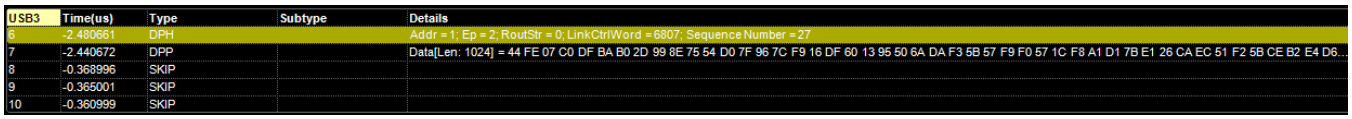
Enabling two or more decoders switches the display to a combined table. A top-level **summary result table** (which cannot be changed) shows these columns of data for every decoding:

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

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

USB3 Result Table

Column	Extracted or Computed Data
Index (always shown)	Number of the line in the table
Time	Time elapsed from start of acquisition to start of transmission
Type	Transmission type (e.g., Idle, Electrical Idle, SKIP, Link Command, TP, LFPS, Data Packet Header, Data Packet Payload)
Subtype	Where relevant (e.g., TP, Link Command), the transmission subtype (e.g., LGOOD_5)
Details	For DPH, the decoded address, routing, and priority codes; for DPP, the decoded payload in hexa-decimal



USB3	Time(us)	Type	Subtype	Details
6	-2.480661	DPH		Addr = 1; Ep = 2; RoutStr = 0; LinkCtrlWord = 6807; Sequence Number = 27
7	-2.440672	DPP		Data[Len: 1024] = 44 FE 07 C0 DF BA B0 2D 99 8E 75 54 D0 7F 96 7C F9 16 DF 60 13 95 50 6A DA F3 5B 57 F9 F0 57 1C F8 A1 D1 7B E1 26 CA EC 51 F2 5B CE B2 E4 D6...
8	-0.368996	SKIP		
9	-0.365001	SKIP		
10	-0.360999	SKIP		

Section of typical USB3 detailed result table.

Using the Result Table

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

Zoom & Search

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

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

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

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

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

View Details

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

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

Navigate

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

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

Customizing the Result Table

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

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

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

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

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

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

Exporting Result Table Data

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

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

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

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

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

Searching Decoded Waveforms

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

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

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

Basic Search

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

Optionally:

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

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

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

Advanced Search

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

ProtoSync

ProtoSync™ adds many of the same algorithms used by the Teledyne LeCroy hardware protocol analyzers to your decoder, enabling you to view the logic layer display of a protocol analyzer in sync with the physical layer display of an oscilloscope. There is no need to export the decoded data to another device, and the integrated graphical user interface makes it easy to switch between the views, or to arrange them side by side on the screen. Changing the decoder on the oscilloscope updates ProtoSync in real time for comprehensive physical and protocol layer debug and analysis.

Note: ProtoSync requires the installation of both the option key and the USB ProtoSync software. The ProtoSync software is available as a free download from teledynelecroy.com. After installing the software, go to the Start/Programs/LeCroy/USB Protocol Suite folder to find more extensive documentation for understanding the Protocol Analyzer.

ProtoSync Dialog

When the ProtoSync option is installed, the ProtoSync subdialog appears behind the protocol-specific decoder subdialogs. Use it to display the decoded data in Protocol View.

ProtoSync Protocol View

The Protocol View displays data packets in a format consistent with hardware protocol analyzers:

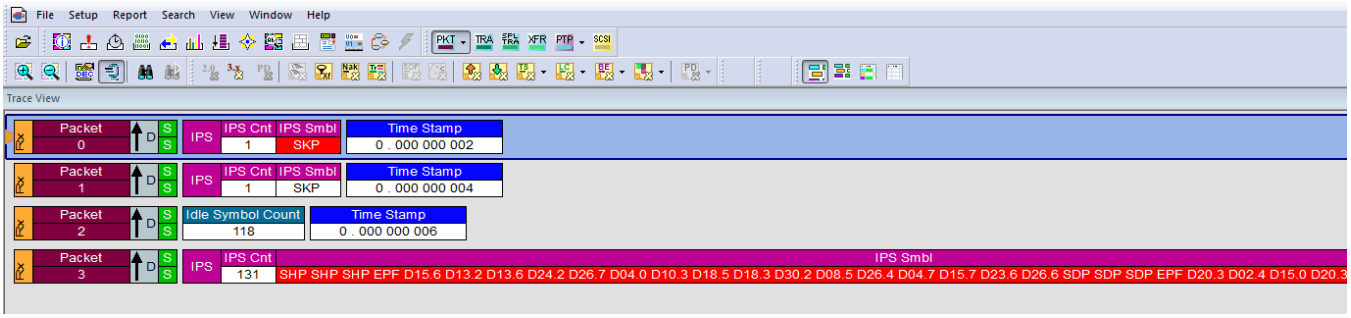
- Each row represents the decoded bits from one transaction/packet, with each cell color-coded to indicate different data types.
- Transactions are shown as either upstream or downstream.

Selecting any row in the Protocol View table will simultaneously zoom to that portion of the waveform in the decoder window.

To display the decoding in Protocol View, open the ProtoSync dialog and either:

- Touch **Show Protocol Analysis** to manually launch ProtoSync
- Select **Show Protocol Analysis on every trigger**. This option repeatedly sends data to ProtoSync.

This action will launch a display similar to that below:



Decoding shown in Protocol View display.

Service Centers

Our regional service centers are:

World Wide Corporate Office
Teledyne LeCroy
700 Chestnut Ridge Road
Chestnut Ridge, NY, 10977, USA
teledynelecroy.com
Sales and Service:
Ph: 800-553-2769 / 845-425-2000
FAX: 845-578-5985
contact.corp@teledynelecroy.com
Support:
Ph: 800-553-2769
support@teledynelecroy.com

US Protocol Solutions Group
Teledyne LeCroy
3385 Scott Boulevard
Santa Clara, CA, 95054, USA
teledynelecroy.com
Sales and Service:
Ph: 800-909-7211 / 408-727-6600
FAX: 408-727-0800
protocolsales@teledynelecroy.com
Support:
Ph: 800-909-7112 / 408-653-1260
psgsupport@teledynelecroy.com

European Headquarters
Teledyne LeCroy SA
4, Rue Moïse Marcinhes
Case postale 341
1217 Meyrin 1
Geneva, Switzerland
teledynelecroy.com/europe
Ph: + 41 22 719 2111
FAX: + 41 22 719 2230
contact.sa@teledynelecroy.com

China
LeCroy Corporation Beijing
Rm. 2001, Unit A, Horizon Plaza
No. 6, Zhichun Road, Haidian Dist.
Beijing 100088, China
www.lecroy.com.cn
Sales:
Ph: 86-10-82800318/0319/0320
FAX:86-10-82800316
Marketing.China@teledynelecroy.com
Service:
Rm. 2002
Ph: 86-10-82800245
Service.China@teledynelecroy.com

Korea
Teledyne LeCroy Korea
10th fl. 333 Yeongdong-daero
Gangnam-gu
Seoul 135-280, Korea
teledynelecroy.com/korea
Ph: ++ 82 2 3452 0400
FAX: ++ 82 2 3452 0490

Japan
Teledyne LeCroy Japan
3F, Houbunshafuchu Bldg.
3-11-5, Midori-cho, Fuchu-Shi
Tokyo 183-0006, Japan
teledynelecroy.com/japan
Ph: + 81-42-402-9400
FAX: + 81-42-402-9586

For a complete list of offices by country, including our sales & distribution partners, visit teledynelecroy.com/support/contact.

700 Chestnut Ridge Road
Chestnut Ridge, NY 10977
USA

teledynelecroy.com