TELEDYNE LECROY
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Instruction Manual

AudioBus

Trigger, Decode, Graph

Contents

About This Manual

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

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

It is assumed that:

- You have purchased and activated 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 controllers.
- You have a basic understanding of how to use an oscilloscope, and specifically the Teledyne LeCroy oscilloscope on which the option is installed. Only features directly related to serial data triggering and decoding are explained in this manual.

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

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 AudioBus Options

AudioBus is a synchronous bus based on three wires which are used to pass multiple channels of audio data over a single line for use in connecting digital audio devices together.

NXP (formerly Philips Semiconductors) provides a full description of the I2S AudioBus variant in .pdf format at:

Decode

The Teledyne LeCroy AudioBus options apply software algorithms to extract audio-encoded serial data information from physical layer waveforms measured on your oscilloscope. The software decodes the Inter-IC Sound (I2S), Left Justified (LJ), Right-Justified (RJ), and Time Division Multiplexed (TDM) variants of the protocol. The extracted information is displayed over the actual physical layer waveforms, color-coded to provide fast, intuitive understanding of the relationship between AudioBus messages and other, time synchronous events.

Trigger

AudioBus TD implements a serial data trigger that is configurable for I^2S, LJ, and RJ variants. Triggers can be set on specific data patterns in any audio channel, or signal "errors" such as mutes, clips, and glitches.

Graph

The AudioBus TDG option (trigger, decode and graph) adds View Audio and Play Audio features to convert the digitally-encoded audio signal into an analog waveform that can be viewed or played aloud and saved to a playable (.WAV) format, providing intuitive understanding of events in the serial data signal.

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 Set Up

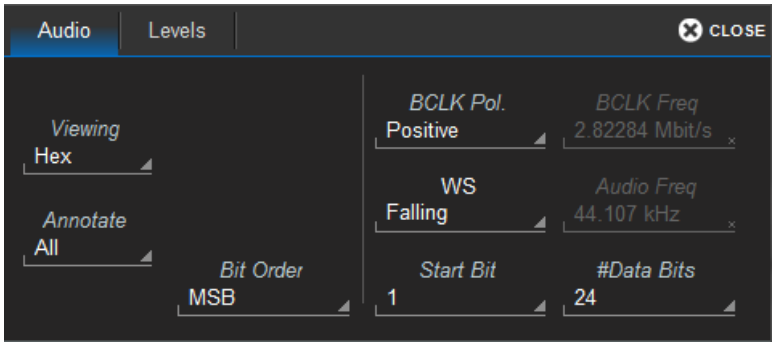
Use the Decode Setup dialog and its protocol-related subdialogs to preset decoders for future use. Each decoder can use different protocols and data sources, or have other variations, giving you maximum flexibility to compare different signals or view the same signal from multiple perspectives.

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. From the buttons at the left, select the **Decode #** to set up.
3. Select the **data source (Src 1)** to be decoded and the **Protocol** to decode.
4. If required by the protocol, also select the **Strobe** or **Clock** source. (These controls will simply not appear if not relevant.)
5. Define the bit- and protocol-level decoding on the subdialogs next to the Decode Setup dialog.

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 # .

AudioBus Decoder Settings

Audio Subdialog



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

Choose to **Annotate** (mark on the overlay) All, Left, or Right channels. When AudioBus TDM is the protocol, the options are All or channels Audio 1 through Audio 8 individually.

Choose to decode using MSB (Most Significant Bit) or LSB (Least Significant Bit) **Bit Order**. I2S data is usually transmitted with the most significant bit (MSB) first.

Choose the **BCLK Pol.** (bit clock polarity), Positive or Negative.

Choose a **WS** (word select) of Rising or Falling. (This field is FRS in AudioBus TDM.)

Enter the data **Start Bit** and **#Data Bits**.

The BCLK Freq. and Audio Freq. will be read from the signal as the decoding is in progress.

AudioBus I2S Variations

In addition to the above, enter the **Start Bit** to begin counting the decode, generally 0 or 1.

AudioBus TDM Variations

In addition to the above:

Enter the **#Bits in Ch**(annel).

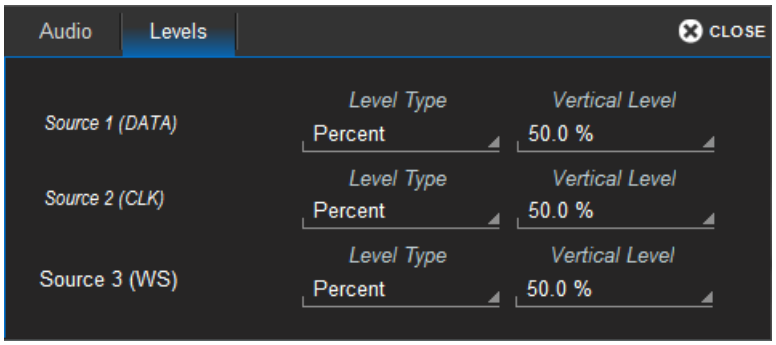
Choose an **FRS** (frame select) of Rising or Falling.

Enter the **Start Bit** to begin counting the decode, generally 0 or 1.

Display Fields

As the decode is run, the **Audio Freq**(uency) and **BCLK Freq**(uency) fields are populated for your reference.

Levels Subdialog



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

Note: When Muting a decoded signal or using a Mute Trigger, set your source level types to **Absolute**. Adjust the voltage level so it moves to a position above the muted trace on the display grid.

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 of the summary result table, instead of in the message bar as usual.

All decoders will test for the condition **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.

If the decoder incorporates a user-defined bit rate (usually these are protocols that do not utilize a dedicated clock/strobe line), the following two conditions are also tested:

- **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.

In all the above cases, 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. 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).

2. Optionally, modify the:

   - **Protocol** associated with the decoder.
   - **Data (Source)** to be decoded.

3. Check Link To Trigger **On** to tie this decoder setup to a serial trigger setup.

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

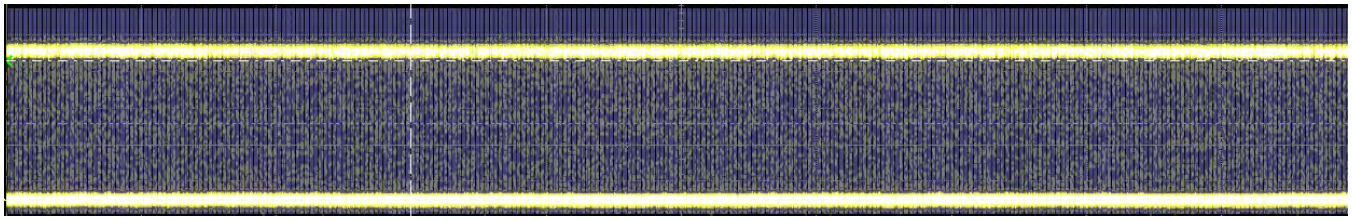
Reading Waveform Annotations

When a decoder is enabled, an annotated waveform appears on the oscilloscope display, allowing you to quickly see the relationship between the protocol decoding and the physical layer. A colored overlay marks significant bit-sequences in the source signal: 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 an AudioBus waveform or its Zoom trace to highlight key elements of the decoded signal (not all overlays shown on screen capture):

Annotation	Overlay Color
Message	Navy Blue (behind other fields)
Left Channel data or Audio 1 - Audio 8 data (TDM variant)	Aqua Blue
Right Channel data	Green



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

Zoom showing annotation details.

Serial Decode Result Table

When **View Decode** is checked on the Decode Setup Dialog *and* a source signal has been decoded using that protocol, a table summarizing the decoder results appears below the grids. This result table provides a view of data as decoded during the most recent acquisition, even when there are too many bursts for the waveform annotation to be legible.

You can export result table data to a .CSV file. See also Automating the Decoder.

Tip: If any downstream processes such as measurements reference a decoder, the result table does not have to be visible in order for the decoder to function. Hiding the table can improve performance when your aim is to export data rather than view the decoding.

Table Rows

Each row of the table represents one index of data found within the acquisition, numbered sequentially. 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.

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 match the input source that resulted in that index.

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

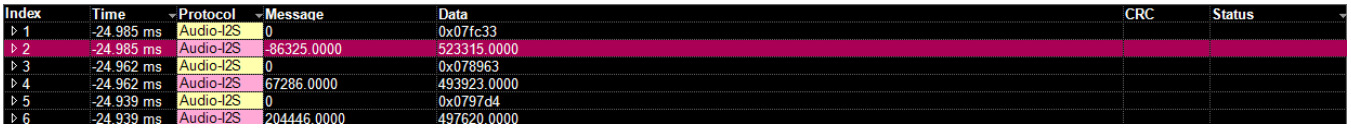
Swipe the table up/down or use the scrollbar at the far right to navigate the table. See Using the Result Table for more information about how to interact with the table rows to view the decoding.

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 selected columns.

A **summary result table** combining results from two decoders always shows these columns.

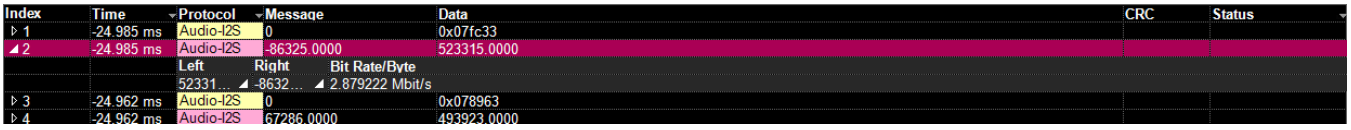
Column	Extracted or Computed Data
Index	Number of the line in the table
Time	Time elapsed from start of acquisition to start of message
Protocol	Protocol being decoded
Message	Message identifier bits
Data	Data payload
CRC	Cyclic Redundancy Check sequence bits
Status	Any decoder messages; content may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



Index	Time	Protocol	Message	Data	CRC	Status
1	-24.985 ms	Audio-I2S	0	0x07fc33		
2	-24.985 ms	Audio-I2S	-86325.0000	523315.0000		
3	-24.962 ms	Audio-I2S	0	0x078963		
4	-24.962 ms	Audio-I2S	67286.0000	493923.0000		
5	-24.939 ms	Audio-I2S	0	0x0797d4		
6	-24.939 ms	Audio-I2S	204446.0000	497620.0000		

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

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

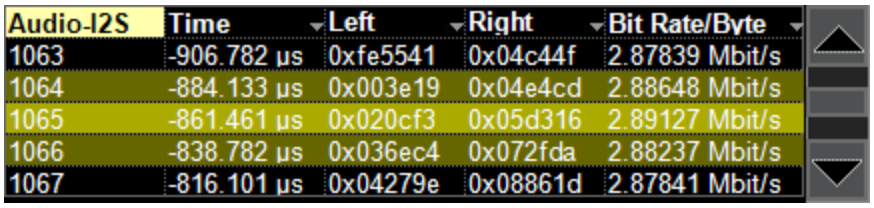


Index	Time	Protocol	Message	Data	CRC	Status
1	-24.985 ms	Audio-I2S	0	0x07fc33		
2	-24.985 ms	Audio-I2S	-86325.0000	523315.0000		
		Left	Right	Bit Rate/Byte		
		52331...	-8632...	2.879222 Mbit/s		
3	-24.962 ms	Audio-I2S	0	0x078963		
4	-24.962 ms	Audio-I2S	67286.0000	493923.0000		

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

This extracted audio signal data appears on the detailed result table. Columns can be hidden by customizing the result table.

Column	Extracted or Computed Data
Index (always shown)	Number of the line in the table
Time	Time elapsed from start of acquisition to Start of Frame
Left	Left channel data
Right	Right channel data
Audio 1- Audio 8 (TDG option only)	Data for audio channels 1 through 8, instead of Left or Right
Bit Rate/Byte	Actual bitrate for this byte, the average BR recomputed by dividing the entire message time span by the total number of bytes in the message
Status	List of all errors found in the decoding



Audio-I2S	Time	Left	Right	Bit Rate/Byte
1063	-906.782 µs	0xfe5541	0x04c44f	2.87839 Mbit/s
1064	-884.133 µs	0x003e19	0x04e4cd	2.88648 Mbit/s
1065	-861.461 µs	0x020cf3	0x05d316	2.89127 Mbit/s
1066	-838.782 µs	0x036ec4	0x072fda	2.88237 Mbit/s
1067	-816.101 µs	0x04279e	0x08861d	2.87841 Mbit/s

Section of typical AudioBus 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 a summary table, 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 zoom scale, 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.

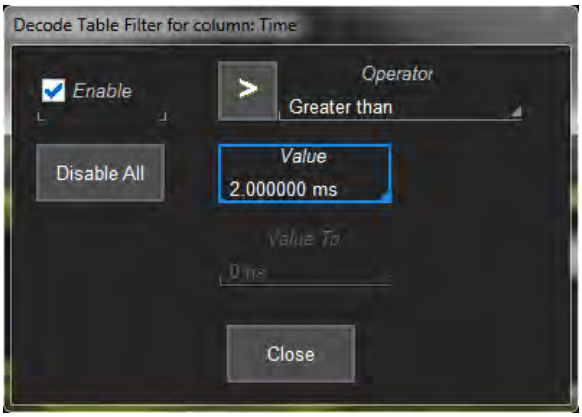
When there are multiple decoders running, each can have its own zoom of the decoding highlighted on the summary table at the same time.

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 zoom that is not yet turned on.

Filter Results

Those columns of data that have a drop-down arrow in the header cell can be filtered: 

Touch the **header cell** to open the Decode Table Filter dialog.



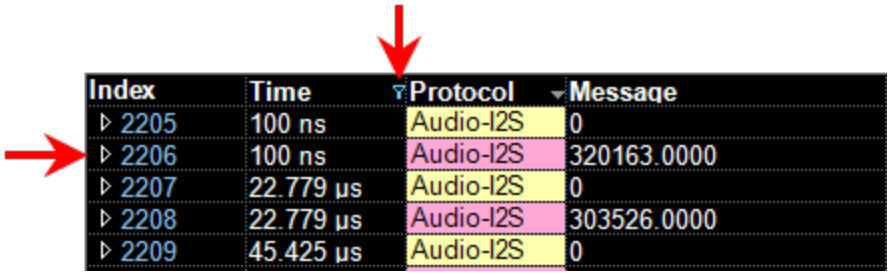
Select a filter **Operator** and enter a **Value** that satisfies the filter condition.

Operators	Data Types	Returns
=, ≠	Numeric or Text	Exact matches only
>, ≥, <, ≤	Numeric	All data that satisfies the operator
In Range, Out Range	Numeric	All data within/without range limits
Equals Any (on List), Does Not Equal Any (on List)	Text	All data that is/is not an exact match to any full value on the list. Enter a comma-delimited list of values, no spaces before or after the comma, although there may be spaces within the strings.
Contains, Does Not Contain	Text	All data that contains or does not contain the string

Note: Once the Operator is selected, the dialog shows the format that may be entered in Value for that column of data. Numeric values must be within .01% tolerance of a result to be considered a match. Text values are case-sensitive, including spaces within the string.

Select **Enable** to turn on the column filter; deselect it to turn off the filter. Use the **Disable All** button to quickly turn off multiple filters. The filter settings remain in place until changed and can be re-enabled on subsequent decodings.

Those columns of data that have been filtered will have a funnel icon (similar to Excel) in the header cell, and the index numbers will be colorized.



Index	Time	Protocol	Message
2205	100 ns	Audio-I2S	0
2206	100 ns	Audio-I2S	320163.0000
2207	22.779 µs	Audio-I2S	0
2208	22.779 µs	Audio-I2S	303526.0000
2209	45.425 µs	Audio-I2S	0

Example filtered decoder table.

On summary tables, only the Time, Protocol, and Status columns can be filtered.

If you apply filters to a single decoder table, the annotation is applied to only that portion of the waveform corresponding to the filtered results, so you can quickly see where those results occurred. Annotations are not affected when a summary table is filtered.

View Details

When viewing a summary 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 a single decoder table, 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 a summary table, 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

Performance may be enhanced if you reduce the number of columns in the result table to only those you need to see. It is also especially helpful if you plan to export the data.

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 column is not relevant to the decoder as configured, it will not appear.

   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, unless you enter a new filename.

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

The 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.

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 summary 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.

Decoding in Sequence Mode

Decoders can be applied to Sequence Mode acquisitions. In this case, the index numbers on the result table are followed by the segment in which the index was found and the number of the sample within that segment: *index* (*segment-sample*).

CAN Std	Time	Format	ID	IDE	RTR	DLC	Data
2 (2-1)	9.72882 ms	Std	0x400	0	0	2	6a 6b
3 (3-1)	19.7527 ms	Std	0x400	0	0	2	6a 6b
4 (4-1)	30.2558 ms	Std	0x400	0	0	2	6a 6b
5 (5-1)	40.1663 ms	Std	0x400	0	0	2	6a 6b
6 (6-1)	49.8284 ms	Std	0x400	0	0	2	6a 6b
7 (7-1)	59.8595 ms	Std	0x400	0	0	2	6a 6b
8 (8-1)	69.8913 ms	Std	0x400	0	0	2	6a 6b
9 (9-1)	80.4032 ms	Std	0x400	0	0	2	6a 6b
10 (10-1)	89.9384 ms	Std	0x400	0	0	2	6a 6b
11 (11-1)	99.9688 ms	Std	0x400	0	0	2	6a 6b

Example filtered result table for a sequence mode acquisition.

In the example above, each segment was triggered on the occurrence of ID 0x400, which occurred only once per segment, so there is only one sample per segment. The Time shown for each index in a Sequence acquisition is absolute time from the first segment trigger to the beginning of the sample segment.

Otherwise, the results are the same as for other types of acquisitions and can be zoomed, filtered, searched, or used to navigate. When a Sequence Mode table is filtered, the waveform annotation appears on only those segments and samples corresponding to the filtered results.

Note: Waveform annotations can only be shown when the Sequence Display Mode is Adjacent. Annotations are not adjusted when a Sequence Mode summary table is filtered, only the table data.

Multiple decoders can be run on Sequence Mode acquisitions, but in a summary table, each decoder will have a first segment, second segment, etc., and there may be any number of samples in each. As in any summary table, the samples will be interleaved and indexed according to their actual acquisition time. So, you may find (3-2) of one decoder before (1-1) of another. Filter on the Protocol column to see the sequential results for only one decoder.

View and Play Audio

The View Audio and Play Audio functions (enabled with the TDG option) convert the digitally-encoded audio signal into an analog waveform that can be viewed or played aloud. This provides an intuitive way to understand circuit problems causing clipping, glitches, and other anomalies in the audio. It also helps show the effects of the audio signal before Digital Signal Processing (DSP).

View Audio

View Audio can be performed for up to four audio channels for conventional Left/Right audio, or home cinema applications (enabled by time division multiplexed audio buses).

On the **Audio Track Wizard**, set up Math traces for the audio channel you wish to view on the display grid.

Play Audio

1. Connect external speakers or headphones to your instrument.
2. On the Decode Setup dialog, touch **Play Audio**.

Saving .WAV Files

To save the converted audio data to a .WAV file for future listening:

1. From the menu bar, choose **File > Save Waveform**.
2. On the Save Waveform dialog, touch **Data Format** and select Audio.

Improving Decoder Performance

Digital oscilloscopes repeatedly capture "windows in time". Between captures, the oscilloscope is processing the previous acquisition.

The following suggestions can improve decoder performance and enable you to better exploit the long memories of Teledyne LeCroy oscilloscopes.

Decode Sequence Mode acquisitions. By using Sequence mode, you can take many shorter acquisitions over a longer period of time, so that memory is targeted on events of interest.

Parallel test using multiple oscilloscope channels. Up-to-four decoders can run simultaneously, each using different data or clock input sources. This approach is statistically interesting because multi-channel acquisitions occur in parallel. The processing is serialized, but the decoding of each input only requires 20% additional time, which can lessen overall time for production validation testing, etc.

Avoid oversampling. Too many samples slow the processing chain.

Optimize for analysis, not display. The oscilloscope has a preference setting (Utilities > Preference Setup > Preferences) to control how CPU time is allocated. If you are primarily concerned with quickly processing data for export to other systems (such as Automated Test Equipment) rather than viewing it personally, it can help to switch the Optimize For: setting to Analysis.

Turn off tables, annotations, and waveform traces. As long as downstream processes such as measurements or Pass/Fail tests reference a decoder, the decoder can function without actually displaying results. If you do not need to see the results but only need the exported data, you can deselect View Decode, or minimize the number of lines in a table. Closing input traces also helps.

Decrease the number of columns in tables. Only the result table rows and columns shown are exported. It is best to reduce tables to only the essential columns if the data is to be exported, as export time is proportional to the amount of data exchanged.

Automating the Decoder

As with all other oscilloscope settings, decoder features such as result table configuration and export can be configured remotely.

Configuring the Decoder

The object path to the decoder Control Variables (CVARs) is:

app.SerialDecode.Decode*n*

Where *n* is the decoder number, 1 to 4. All relevant decoder objects will be nested under this. Use the XStreamBrowser utility (installed on the oscilloscope desktop) to view the entire object hierarchy.

The CVAR app.SerialDecode.Decode*n*.Decode.ColumnState contains a pipe-delimited list of all the table columns that are selected for display. For example:

app.SerialDecode.Decode1.Decode.ColumnState = "Idx=On|Time=On|Data=On|..."

If you wish to hide or display columns, send the full string with the state changed from "on" to "off", or vice versa, rather than remove any column from the list.

Timebase, Trigger, and input Channel objects are found under app.Acquisition.

Accessing the Result Table

The data in the decoder Result Table can be accessed using the Automation object:

app.SerialDecode.Decode*n*.Out.Result.CellValue(*line index*, *column index*)(*item index*, *depth index*)

n:= 1 to 4

line index:= 1 to K

column index:= 1 to L

item index:= {0, 1, 2} where 0=Value, 1=StartTime, 2=StopTime

depth index:= 1 to M

Serial Trigger

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

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

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

Requirements

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

Restrictions

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

Linking Trigger and 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 trigger and decoder 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.

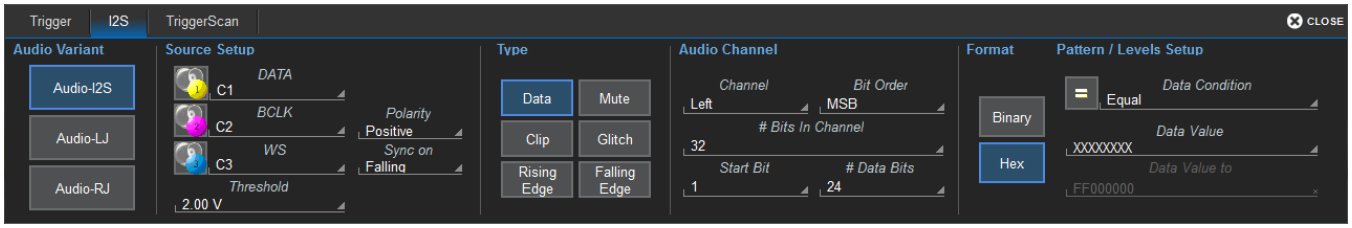
While the decoder and the trigger have distinct sets of controls, when the link is active, a change to the bit rate in the decoder will immediately propagate to the trigger and vice-versa.

AudioBus Trigger Setup

To access the serial trigger dialogs:

- Touch the Trigger descriptor box or choose **Trigger > Trigger Setup** from the Menu Bar.
- Touch the **Serial** Type button, and the **I2S** Standard button.

Then, working from left to right, make the desired selections from the I2S dialog.



Audio Variant

From the buttons at the left, select the variant of the AudioBus standard in use.

Source Setup

Each variant has a bus consisting of at least 3 lines: one multiplexed data line (**DATA**), one bit clock (**BCLK**), and one word select line (**WS**). Enter the source channel for each line.

Enter the **Polarity** of the DATA signal.

Choose to **Sync on** the Falling or Rising edge of the signal.

In **Threshold**, adjust the vertical level for the trigger (even if you have linked the trigger to a pre-set decoder, this is useful for tuning the trigger to improve the bit-level decoding). The same value is used for DATA, BCLOCK, and WS signals.

Type

The type of trigger selected determines the remainder of the trigger setup. The setup for each type is described separately in the following sections. All trigger types require completion of the Audio Channel setup, as well as the trigger Pattern/Level setup.

Audio Channel

Use these controls to define the audio channel characteristics upon which to base the trigger.

Choose Left or Right **Channel**.

Choose to use MSB (most-significant bit) or LSB (least-significant bit) **Bit Order**.

Enter the total **# Bits In Channel**.

Enter the **Start Bit** from which to begin the count.

Note: This field is disabled for the Audio-RJ variant. The default Start Bit is 8.

Enter the **# Data Bits**counted from the Start Bit (you entered) to include in the trigger condition.

Mute Trigger

Mute triggers when the data level is below a specified noise floor for a specified number of frames.

Choose to enter/view data in **Dec**(imal) or **dB** (decibel) format.

Enter the **Mute Noise Floor** below which the data signal must fall and the **Duration (# Frames)** it must remain there to produce a trigger.

Clip Trigger

Clip triggers when the data level exceeds a specified clip level for a specified number of frames.

Choose to enter/view data in **Dec**(imal) or **dB** (decibel) format.

Enter the **Clip Level** above which the signal must rise and the **Duration (# Frames)** it must remain there to produce a trigger.

Glitch Trigger

Glitch triggers when the rise time between two adjacent audio samples exceeds the specified threshold.

Choose to enter/view data in **Dec**(imal) or **dB** (decibel) format.

In **Threshhold**, enter the maximum allowable delta between adjacent audio samples.

Rising/Falling Edge Trigger

Rising Edge and **Falling Edge** trigger when the data level is either rising or falling at the specified threshold.

Choose to enter/view data in **Dec**(imal) or **dB** (decibel) format.

Enter the crossing level in **Threshhold**.

Data Trigger Setup

Data triggers upon a specific data pattern in the specified audio channel.

Choose to enter/view data in **Binary** or **Hex**(adecimal) format.

In Pattern/Levels setup, use **Data Condition** and **Data Value** together to create a condition statement that describes the trigger data pattern. To use a range of values, choose the In Range or Out Range condition and also enter the **Data Value To**.

Using the Decoder with the Trigger

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

Stop and Look

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

Optimize the Grid

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

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

Use Zoom

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

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

Saving Trigger Data

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

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

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