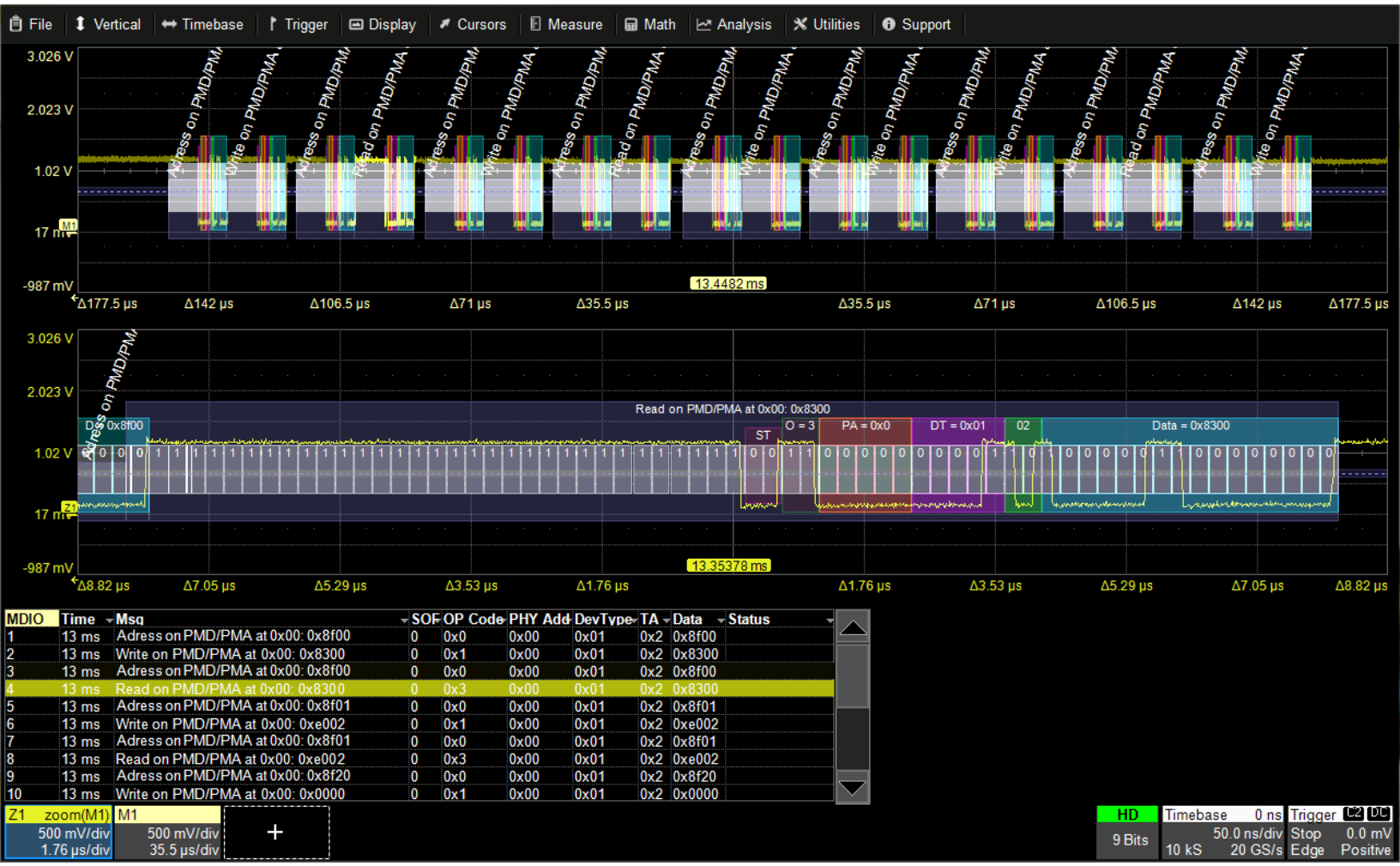
TELEDYNE LECROY
Everywhereyoulook™



MDIO	Time	Msg	SOF	OP Code	PHY Add	DevType	TA	Data	Status
1	13 ms	Adress on PMD/PMA at 0x00: 0x8f00	0	0x0	0x00	0x01	0x2	0x8f00	
2	13 ms	Write on PMD/PMA at 0x00: 0x8300	0	0x1	0x00	0x01	0x2	0x8300	
3	13 ms	Adress on PMD/PMA at 0x00: 0x8f00	0	0x0	0x00	0x01	0x2	0x8f00	
4	13 ms	Read on PMD/PMA at 0x00: 0x8300	0	0x3	0x00	0x01	0x2	0x8300	
5	13 ms	Adress on PMD/PMA at 0x00: 0x8f01	0	0x0	0x00	0x01	0x2	0x8f01	
6	13 ms	Write on PMD/PMA at 0x00: 0xe002	0	0x1	0x00	0x01	0x2	0xe002	
7	13 ms	Adress on PMD/PMA at 0x00: 0x8f01	0	0x0	0x00	0x01	0x2	0x8f01	
8	13 ms	Read on PMD/PMA at 0x00: 0xe002	0	0x3	0x00	0x01	0x2	0xe002	
9	13 ms	Adress on PMD/PMA at 0x00: 0x8f20	0	0x0	0x00	0x01	0x2	0x8f20	
10	13 ms	Write on PMD/PMA at 0x00: 0x0000	0	0x1	0x00	0x01	0x2	0x0000	

Instruction Manual

MDIObus Decoder

MDIObus Decoder Software Instruction Manual

927746 Rev A
January 2017

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.

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 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 MDIObus Option

Management Data Input/Output, or MDIO, is a 2-wire serial bus used to manage physical layer devices (PHYs) in media access controllers (MACs) in Gigabit Ethernet equipment. MDIO was originally defined in Clause 22 of IEEE RFC802.3, with additions provided in Clause 45 of the IEEE RFC802.3ae specification to meet the expanding needs of 10-Gigabit Ethernet devices.

Information about the MDIO specification can be accessed at:

http://www.totalphase.com/support/articles/200349206-MDIO-Background

The Teledyne LeCroy MDIObus Decoder option supports decoding of both MDIO formats described by Clause 22 and Clause 45 of the specification.

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 packets and other, time synchronous events.

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.

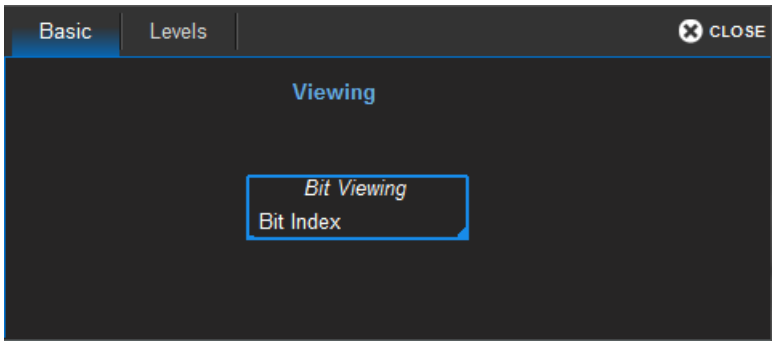
Decoder Set Up

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 # .

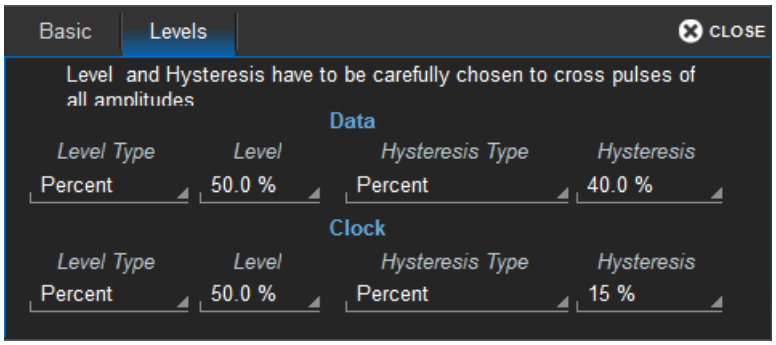
Basic Subdialog



Select a Bit Viewing mode:

- **None**—Fields marked on overlay, but not individual bit values
- **Bit Index**—Individual bits marked and labeled with index (number)
- **Bit State**—Individual bits marked and labeled with logical state (0 or 1)

Levels Subdialog



For both Data and Strobe lines, enter the vertical **Level** used to determine the edge crossings of the signal. This value will be used to determine the bit-level decoding.

Optionally, enter a **Hysteresis** band value. Hysteresis represents the amount the signal may rise or fall from the crossing Level without affecting the bit transition.

Setting Level and Hysteresis

The default Level and Hysteresis values are sufficient for decoding most signals, but in some cases it can be beneficial to change them.

Level

The **Level** setting represents the logical level for bit transition, corresponding to the physical Low and High distinction. Level is normally set as 50% of waveform amplitude, but can alternatively be set as an absolute voltage (with reference to the waveform 0 level) by changing the **Level Type** to Absolute.

Percent mode is easy to set up because the software immediately determines the optimal threshold, but in some cases it might be beneficial to switch to Absolute mode:

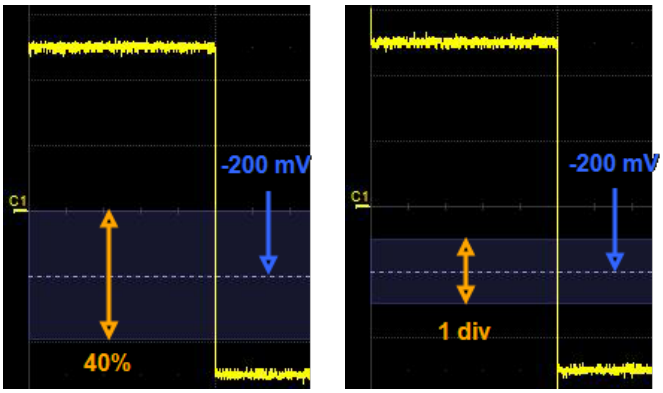
- On poor signals, where Percent mode can fail and lead to bad decodes
- On noisy signals or signals with a varying DC component
- On very long acquisitions, where Percent mode adds computational load

The transition 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 Level is set to a reasonable value.

Hysteresis

The optional **Hysteresis** setting imposes a limit above and below the measurement level that precludes measurements of noise or other perturbations within this band.

A blue marker around the Level line indicates the area of the hysteresis band. As with Level Type, **Hysteresis Type** may be either a percentage of amplitude or an absolute number of vertical grid divisions.



Hysteresis set as 40 percent of total waveform amplitude (left) and Hysteresis set as equivalent of 1 grid division (right) around an absolute -200mV Level setting.

Note: Usually, you can set the Level and Hysteresis in the same or different modes. For a few protocols, Hysteresis can only be set as a number of mV plus/minus the Level.

Observe the following when setting Hysteresis:

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

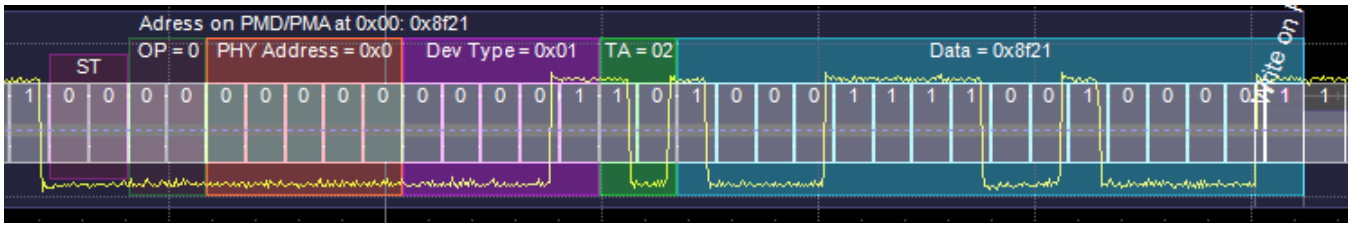
Verifying the Decoding

MDIO does not specify structural coherency checking such as CRC, parity bits or data length used by other protocols. Although a few coherency checks are applied to the individual fields by the decoder, a review of the initial results is necessary to be sure the decoded results can be trusted. Carefully inspect a few messages and verify their contents against known values sent by the microcontroller.

Set Bit Viewing to Bit Index. With a decoding visible, select cells from the Index (first) column of the result table to zoom the packet. Confirm that you see:

- 2-bit Start of Frame (ST)
- 2-bit OP code
- 5-bit PHY Address
- 5-bit Device Type (Clause 45) or Register Address (Clause 22)
- 2-bit Turnaround time
- 16-bit Address or Data field

Switch Bit Viewing to Bit State. Confirm ST is 00 for Clause 45 and 01 for Clause 22.



Correctly decoded Clause 45 packet.

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.

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

Reading Waveform Annotations

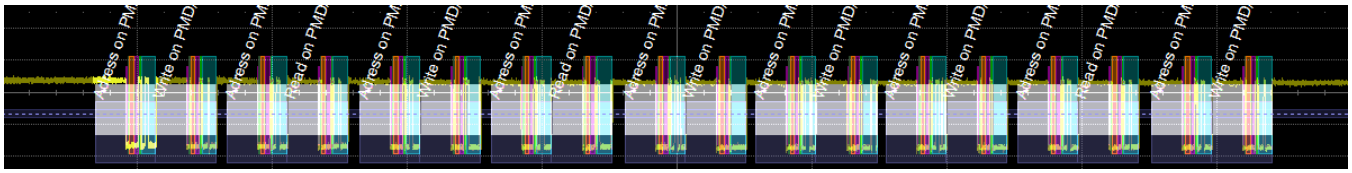
When a decoder is enabled, an annotated waveform appears on the oscilloscope display, allowing you to quickly see the relationship between the protocol decoding and the physical layer. A colored overlay marks significant bit-sequences in the source signal: Header/ID, Address, Labels, Data Length Codes, 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 a decoded MDIO waveform or its Zoom trace to highlight key elements of the decoded signal.

View Mode	Annotation	Overlay Color (1)	Text (2)
Bit Index & Bit State	Bits	Grey	*<0 to 63>* <0 | 1>
All	Packet	Navy Blue	<*OP*> on <*DEV*> at <*PHY*>:<*Data*>
	Start of Frame	Purple	Start of Frame | ST = <00 | 01>
	Operation Code	Dark Green (appears Burgundy)	Operation Code | OP Code | OP = <*value*>
	Physical Address	Brick Red	PHY Address | PA = <*value*>
	Device Type (Clause 45) Register Addr. (Clause 22)	Bright Purple	Device Type | DEV Type | DT = <*value*> Register Address | REG Addr. | RA = <*value*>
	Turnaround Time	Bright Green	Turn Around | T Around | TA = <*value*>
	Data (payload)	Aqua Blue	Data = <*value*>
	Errors	Red	<*Error Message*>

1. Combined overlays and zoom factor will affect the appearance of colors.
2. Text in brackets < > is variable. The amount of text shown depends on your zoom factors.



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.

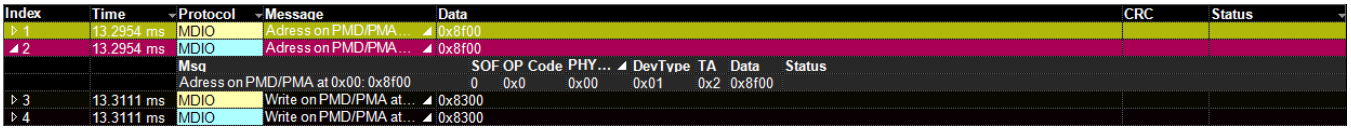
A **summary result table** combining results from two decoders always shows these columns.

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	13.2954 ms	MDIO	Adress on PMD/PMA...	0x8f00		
2	13.2954 ms	MDIO	Adress on PMD/PMA...	0x8f00		
3	13.3111 ms	MDIO	Write on PMD/PMA at...	0x8300		
4	13.3111 ms	MDIO	Write on PMD/PMA at...	0x8300		
5	13.3299 ms	MDIO	Adress on PMD/PMA...	0x8f00		
6	13.3299 ms	MDIO	Adress on PMD/PMA...	0x8f00		

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.

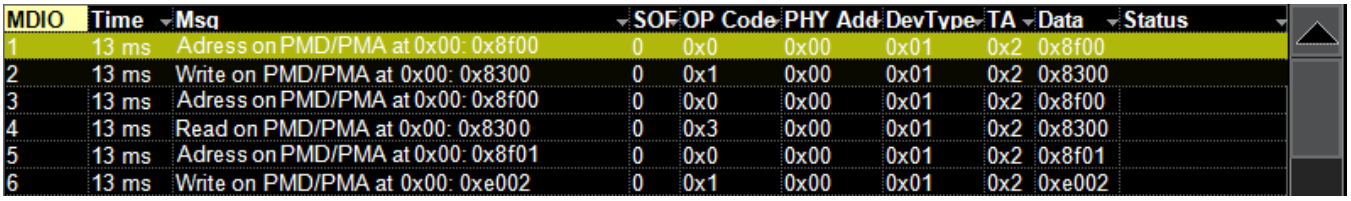


Index	Time	Protocol	Message	Data	CRC	Status
1	13.2954 ms	MDIO	Adress on PMD/PMA...	0x8f00		
2	13.2954 ms	MDIO	Adress on PMD/PMA...	0x8f00		
	Msg	SOF	OP Code	PHY...	DevType	TA	Data	Status
	Adress on PMD/PMA at 0x00: 0x8f00	0	0x0	0x00	0x01	0x2	0x8f00	
3	13.3111 ms	MDIO	Write on PMD/PMA at...	0x8300		
4	13.3111 ms	MDIO	Write on PMD/PMA at...	0x8300		

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

Each line of the MDIO result table shows the decoding of a single message within the acquisition. Columns can be shown or hidden by customizing the result table.

Column	Extracted or Computed Data
Idx (MDIO)	Number of the line in the table.
Time	Time elapsed from acquisition trigger to start of first bit in message.
Msg	Textual description of the message.
SOF	Start of Frame value: 0 for Clause 45, 1 for Clause 22.
OP Code	Message OP code.
PHY Add	Physical address for which the message is intended.
DevType	Device type.
TA	2-bit turnaround time delay.
Data	Payload data.
Status	Any errors or other processing messages.



MDIO	Time	Msg	SOF	OP Code	PHY Add	DevType	TA	Data	Status
1	13 ms	Adress on PMD/PMA at 0x00: 0x8f00	0	0x0	0x00	0x01	0x2	0x8f00	
2	13 ms	Write on PMD/PMA at 0x00: 0x8300	0	0x1	0x00	0x01	0x2	0x8300	
3	13 ms	Adress on PMD/PMA at 0x00: 0x8f00	0	0x0	0x00	0x01	0x2	0x8f00	
4	13 ms	Read on PMD/PMA at 0x00: 0x8300	0	0x3	0x00	0x01	0x2	0x8300	
5	13 ms	Adress on PMD/PMA at 0x00: 0x8f01	0	0x0	0x00	0x01	0x2	0x8f01	
6	13 ms	Write on PMD/PMA at 0x00: 0xe002	0	0x1	0x00	0x01	0x2	0xe002	

Section of typical MDIO result table.

The following error messages may appear in the Status column:

- **"Must be Clause 22 or 45!"**—SOF accepts only 0 (Clause 45) or 1 (Clause 22).
- **"OP code must be 1 or 2"**—OP Code accepts only 1 or 2 for Clause 22 messages. For Clause 45, any value is acceptable, and this check is not performed.

- **"DEVTYPE > 5!"**—Dev Type accepts only 1 to 5 for Clause 45 messages. For Clause 22, any value is acceptable, and this check is not performed.
- "**NumBits !=64"**—Messages must be 64-bits long.

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.

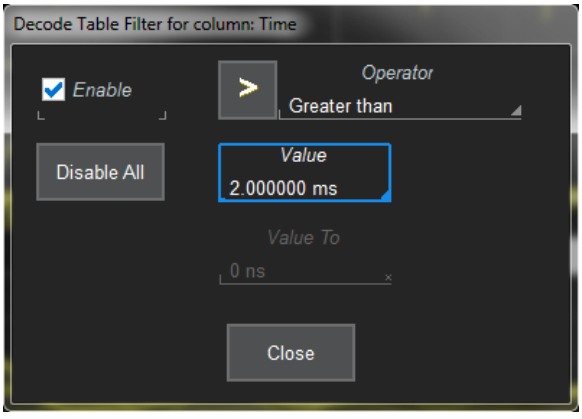
Index	Time	Protocol	Message	Data	CRC	Status
1	13.2954 ms	MDIO	Adress on PMD/PMA...	0x8f00		
2	13.2954 ms	MDIO	Adress on PMD/PMA...	0x8f00		
3	13.3111 ms	MDIO	Write on PMD/PMA at...	0x8300		
4	13.3111 ms	MDIO	Write on PMD/PMA at...	0x8300		
5	13.3299 ms	MDIO	Adress on PMD/PMA...	0x8f00		
6	13.3299 ms	MDIO	Adress on PMD/PMA...	0x8f00		

Example multi-decoder summary table, both zoomed indexes highlighted.

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.



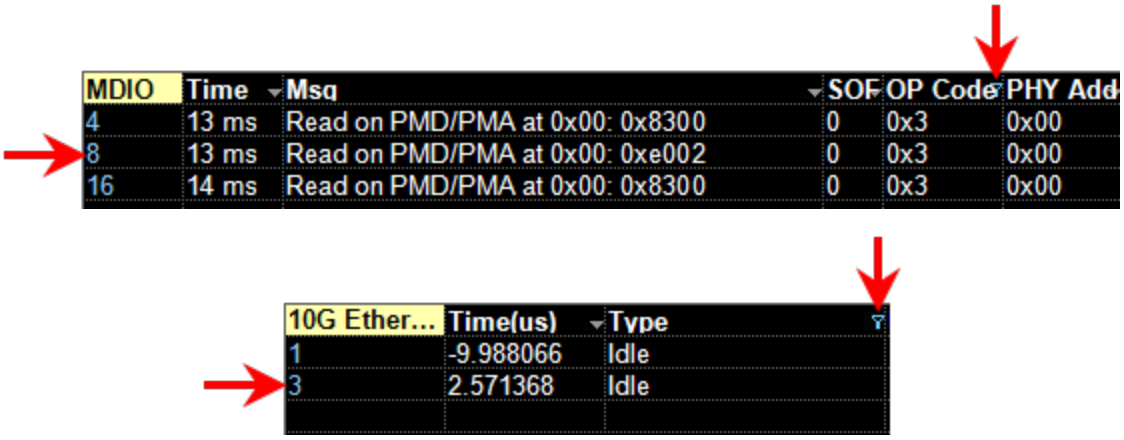
Select a filter **Operator** and enter a **Value** that satisfies the filter condition.

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.



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.

The MDIO decoder does not utilize the Bit Rate Tolerance setting.

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.

Improving Decoder Performance

Digital oscilloscopes repeatedly capture "windows in time". Between captures, the oscilloscope is processing the previous acquisition. The MDIO decoder generally captures 20 to 70% of signal time.

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. For MDIO, 20 to 50 samples per pulse are sufficient.

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

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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
customersupport@teledynelecroy.com

700 Chestnut Ridge Road
Chestnut Ridge, NY 10977
USA

teledynelecroy.com