

Instruction Manual

SpaceWirebus Decoder



SpaceWirebus Decoder Software Instruction Manual

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About This Manual

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

This manual explains 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 SpaceWirebus Option

The SpaceWirebus D option provides packet, character, and bit-level decoding of SpaceWire signals. The decoder is based on the ECSS-E-ST-50-12C 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 Setup

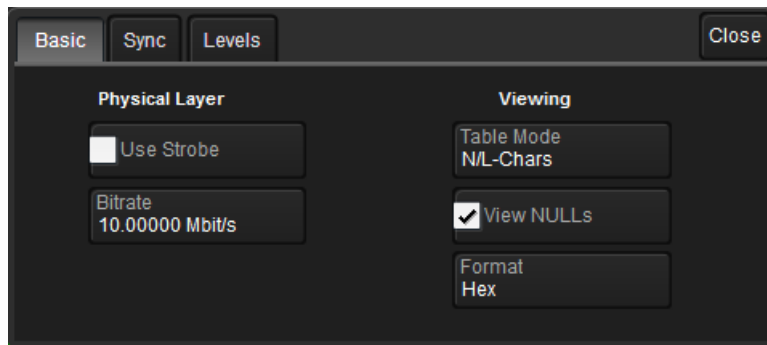
Use the Decode Setup dialog and its protocol-related subdialogs to preset decoders for future use. Each decoder can use different (or the same) protocols and data sources, or have other variations, giving you maximum flexibility to compare different signals or view the same signal from multiple perspectives.



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.

Basic Subdialog



Physical Layer

Choose a method for determining the bit transitions:

- Select **Use Strobe** to use the strobe line. This method is required if you are decoding signals with a variable bitrate. If you use this method, the Bitrate field is disabled and disregarded by the decoding algorithm.
- Alternatively, if the stream is running at a constant bitrate over the acquisition window, you can deselect Use Strobe, then touch **Bitrate** and enter the value. This method decodes the input as a normal, continuous NRZ signal, interpolating the non-transitional bits using the declared Bitrate. It has the advantage of freeing an oscilloscope channel that would otherwise be used for the strobe.

Viewing

Choose a **Table Mode**, which determines the level of the decoding that appears on the overlay and in the result table: Bits, N/L-Chars, or Packets.

Select **View NULLs** if you wish to display the NULL characters separating packets. By default, NULLs are not shown except for the two NULLs immediately preceding and following a packet. Omitting NULLs can sometimes improve decoder performance.

Choose the **Format** in which to view the decoded data: Hex(decimal), ASCII, or Decimal.



Tip: The Viewing parameters can be changed at any time during the decoding to gain better understanding of the signal.

Sync Subdialog

The Sync parameters govern the grouping of bits into N/L characters. They enable the decoder to determine where a Normal or Link character starts and ends by synchronizing the bit stream with the character stream.



Note: The Sync is not a trigger.

Basic Sync Levels Close

Synchronization

Sync Mode
Pattern

First Bit Offset(FBO)
1

Sync Pattern (NULL,EOP,ESC,FCT,HH,TCHH sep by ,)
NULL,NULL,0x5c

Choose one of the following **Sync Modes**:

- **Nulls** mode (default) synchronizes upon finding a bit pattern corresponding to the specified number of NULLs. When using this method, enter the number of **Consecutive NULLs** that indicate the start of a character. The default of 2 NULLs is not generally adequate unless there is sufficient redundancy in the data stream. The First Bit Offset (FBO) is computed by the Sync Scanner algorithm, so the FBO entry field is disabled.
- **Pattern** mode synchronizes upon finding a user-defined symbolic pattern that may be composed of NULLs, Data Characters, ESC, FCT and Time Codes. When using this method, enter the **Sync Pattern** as comma-delimited list of symbols, no spaces (see example above). Follow the syntax in the table below:

For Symbol	Use Syntax	Comments
NULL character	NULL null N n	
ESC code	ESC esc	
FCT code	FCT fct	
EOP code	EOP	
Data value	0x<HH>	0x followed by 2 Hex digits
Time code	TC<HH>	TC followed by 2 Hex digits

As with Nulls mode, the FBO is calculated, so the entry field is disabled.

- **Manual** mode synchronizes at the occurrence of the bit number entered into FBO.

Levels Subdialog

For both the Data line and Strobe line (if used):

- Enter the **Level Type** and **Level** used to determine the edge crossings of the SpaceWire signal. The default of 50% of amplitude is sufficient for most signals, but signals with a varying DC component or noisy signals may require the level to be set as an absolute voltage value.
- In **Hysteresis Type** and **Hysteresis**, enter the amount the signal may rise or fall without affecting bit transition as either a percentage of amplitude or absolute number of vertical grid divisions. This can help to stabilize the decoding on noisy signals.

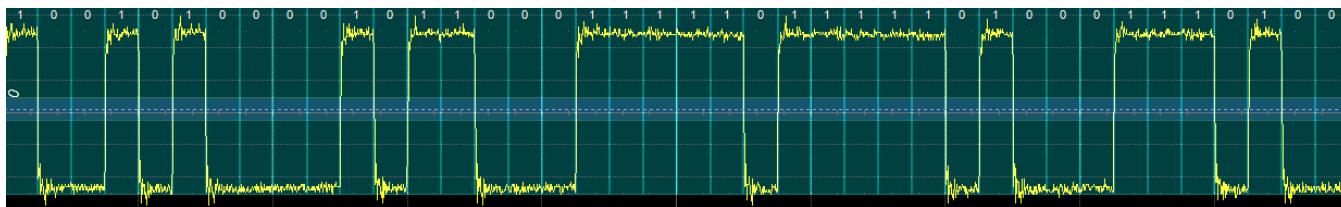
Verifying the Decode

The following examples show proper decodings of a SpaceWire signal. If your decodings do not resemble these, modify the decoder settings until they do.

Bit Level

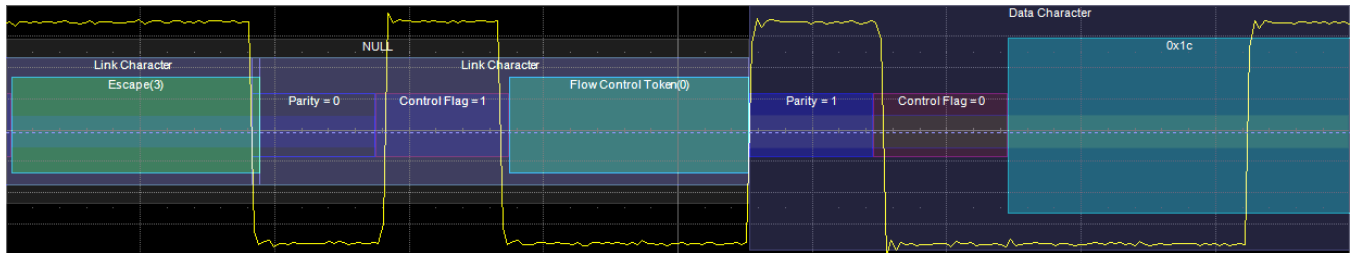
- Each signal plateau, low or high, divided into an integer number of bits
- Bit transitions aligned with signal transitions
- No gaps in the annotation and no overlaid annotations

The only tolerable exceptions would be the first and last bits shown, near the edges of the grid.



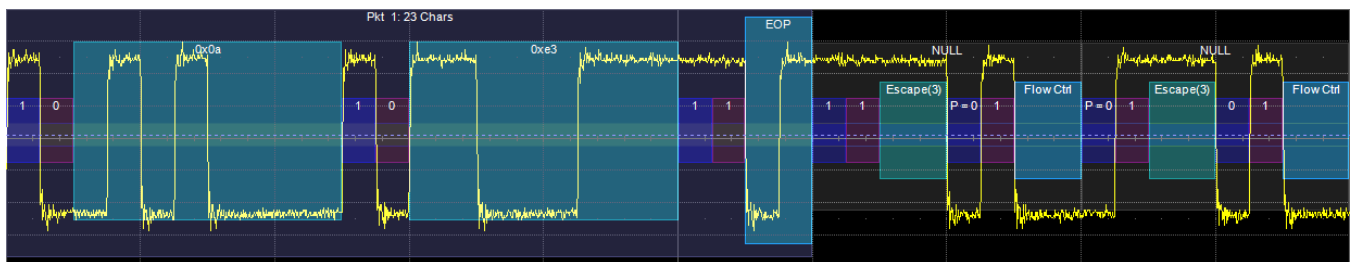
N/L-Char Level

- 8-bit NULLs
- 4-bit Link Characters (ESC, FCT, EOP) containing control bits



Packet Level

- Packets containing 8-bit Data Characters, each preceded by a Parity bit and a Control Flag bit, followed by an End of Packet
- NULLs containing control bits



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 too short to allow any meaningful decoding, the message "Too Short Acquisition" will appear. The minimum number of bits required varies from one protocol to another, but is usually between 5 and 50.
- **Too small amplitude.** If the signal's amplitude is too small with respect to the full ADC range, the message "Decrease V/Div" will appear. The required amplitude to allow decoding is usually one vertical division.

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



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

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

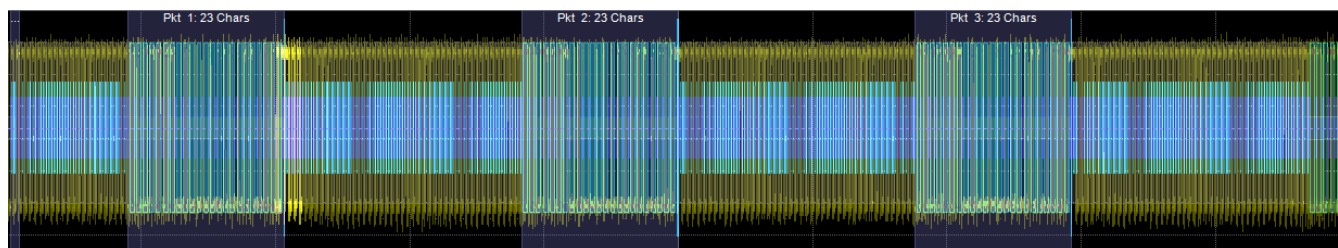
When a decoder is enabled, an annotated waveform appears on the oscilloscope display, allowing you to quickly read the results of the decoding. A colored overlay marks significant bit-sequences in the source signal. The overlay contains annotations corresponding to the Header/ID, Address, Labels, Data 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.

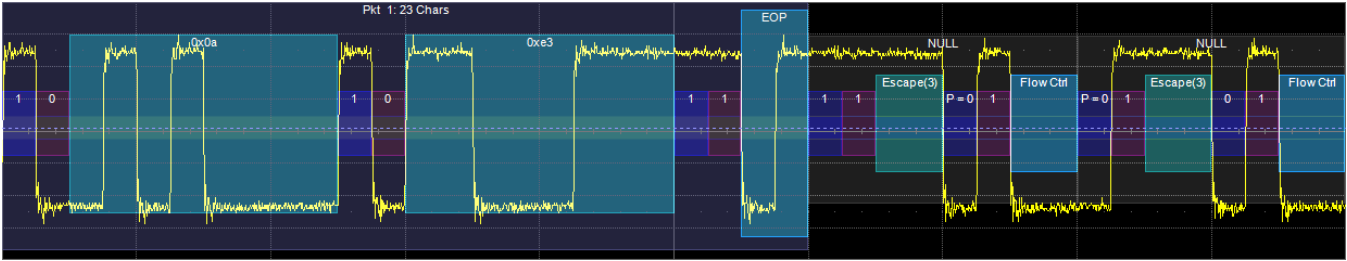
These overlays appear on a SpaceWire decoder waveform or its Zoom trace to highlight key elements of the decoded signal.

Table Mode	Annotation	Overlay Color (1)	Text (2) (3)
Bits only	Bits	Dark Green	<0 1>
N/L-Chars only	Normal and Link characters	Navy Blue behind Data Blue-Grey behind Link	< <i>type</i> > Character
	Time codes	Dark Grey behind characters	Time Code = <n>
N/L Chars and Packets	Sync	Navy Blue behind other fields	NULL <pattern>
	Data (payload) bytes	Aqua Blue	<value>
	Parity bits	Royal Blue (may appear purple in Link)	Parity = <0 1>
	Control flag bits	Purple	Control Flag = <0 1>
	Nulls	Dark Grey behind other fields	NULL
	Flow control tokens	Bright Green-Blue	Flow Control Token (<n>)
	Escape codes	Bright Green	Escape (<n>)
	End of packet bits	Bright Blue	End of Packet
	Errors	Red behind other fields	<Error Message>
Packets only	Packets	Navy Blue behind characters	Packet <n>:<n> Chars

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.
3. Values appear in hex, ASCII, or decimal, depending on your Viewing Format selection.



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



Zoom showing annotation details.

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.

SpaceWire Result Table

Depending on your Table Mode selection, each line of the SpaceWire result table shows the decoding of a single character or packet within the acquisition.

Columns can be shown or hidden by [customizing the result table](#).

Column	Extracted or Computed Data
Idx (SpW)	Number of the line in the table. When showing NULLs, the number is offset by one, since the NULLs occupy the first row of the table.
Time	Time elapsed from acquisition trigger to start of bit, character, or packet
Msg	Only appears in N/L-Chars and Packets table modes: In N/L-Char mode, it shows the Sync pattern in the first line, followed by a code distinguishing N-chars from L-chars. In packet Mode, it shows the Sync pattern in the first line, followed by the message describing the packet (e.g., "Pkt 7, 56 Chars").
TC	Time codes present in the record. Only appears in N/L-Chars and Packets table modes
P(arity)	Character parity bit value, 0 or 1. Only appears in N/L-Chars and Packets table modes. In Packet mode, all parities of character and packet are stacked in the same cell, making them invisible to the user.
F(lag)	Type of character, Control or Data. Only appears in N/L-Chars and Packets table modes.
Data	Raw value of data characters (0 to 255). Data decoded in Packet mode will likely be cut off except in cases of very short packets.
Ctrl	Raw value of control characters (0 to 3)
Status	Any errors or other processing messages

SpW	Time	Msg	TC	P	F	Data	Ctrl	Status
3	-3.3067 μ s	1	0	1			0	
4	-2.9067 μ s	1	0	1			3	
5	-2.5067 μ s	1	0	1			0	
6	-2.1066 μ s	0	1	0	1c			
7	-1.0991 μ s	0	0	0	ff			

Section of typical SpaceWire result table.

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 **Decodex** 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.



Idx = 15 (decimal) found at Row 55 Column 0 going Left

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.

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