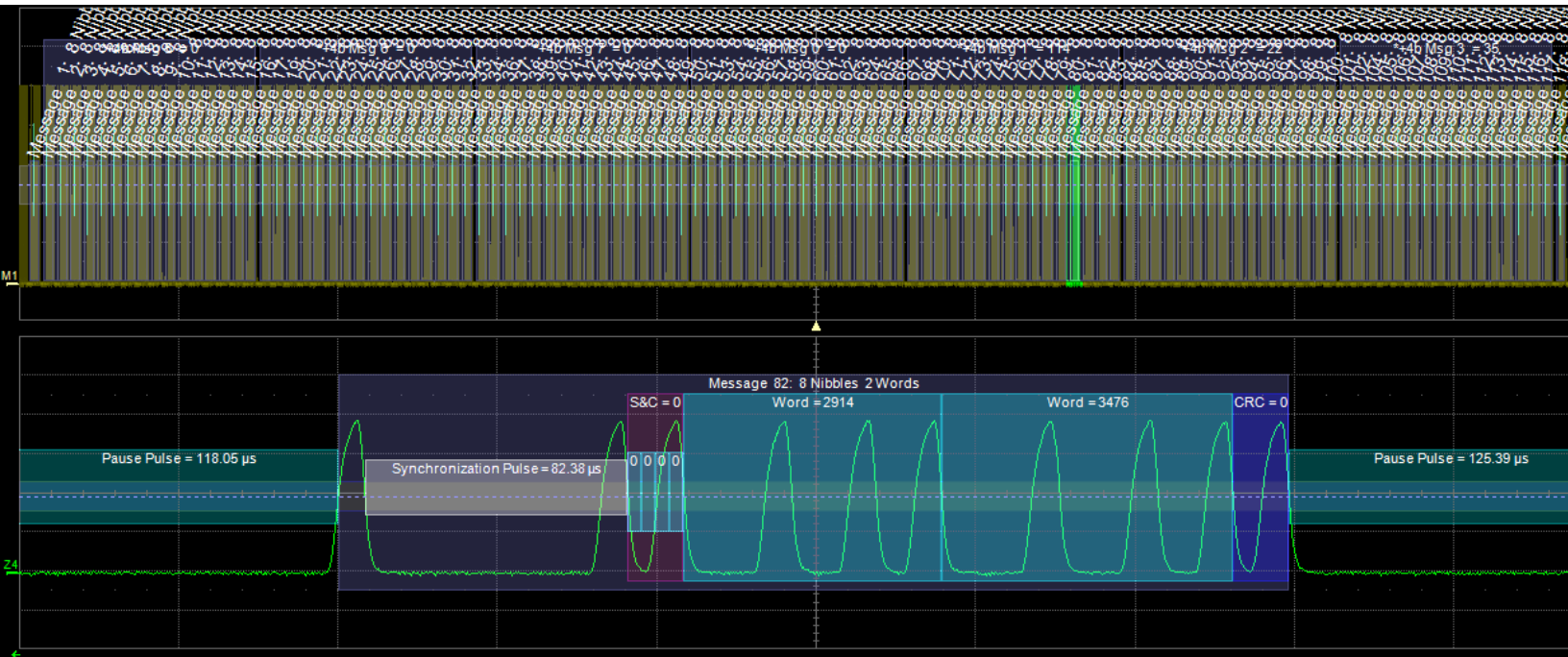
TELEDYNE LECROY
Everywhereyoulook™



SENT	Time	Sync	Tick	Msg	Stat	b0	b1	b2	b3	D0	D1	ID	Data	CRC	RMS	Pause P	$	Status
78	6.27011 ms	82.32 µs	1.47 µs	Message 78: 8 Nibbles 2 Words	0	0	0	0	0	2907	1188			15	34.3 ns	106.3 µs	0	
79	6.69357 ms	82.36 µs	1.47 µs	Message 79: 8 Nibbles 2 Words	0	0	0	0	0	2909	676			5	22.3 ns	103.2 µs	0	
80	7.11709 ms	82.34 µs	1.47 µs	Message 80: 8 Nibbles 2 Words	4	0	0	1	0	2911	164			3	20.1 ns	118.0 µs	0	
81	7.54063 ms	82.32 µs	1.47 µs	Message 81: 8 Nibbles 2 Words	0	0	0	0	0	2913	3732			5	23.6 ns	115.1 µs	0	
82	7.96420 ms	82.38 µs	1.47 µs	Message 82: 8 Nibbles 2 Words	0	0	0	0	0	2914	3476			0	26.7 ns	118.0 µs	0	
83	8.38777 ms	82.38 µs	1.47 µs	Message 83: 8 Nibbles 2 Words	4	0	0	1	0	2917	2708			9	20.5 ns	125.4 µs	0	
84	8.81129 ms	82.32 µs	1.47 µs	Message 84: 8 Nibbles 2 Words	4	0	0	1	0	2919	2196			15	23.5 ns	106.2 µs	0	
85	9.23485 ms	82.38 µs	1.47 µs	Message 85: 8 Nibbles 2 Words	4	0	0	1	0	2921	1684			0	22.7 ns	97.43 µs	0	
86	2.88189 ms			*+4b Msg 1 = 114								1	114	7				
87	9.65839 ms	82.34 µs	1.47 µs	Message 87: 8 Nibbles 2 Words	8	0	0	0	1	2923	1172			6	15.5 ns	119.5 µs	0	

Instruction Manual

SENT Decoder

SENT Decoder Instruction Manual

922664 Rev C
August 2015

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 how to use the SENT Decoder option.

Assumptions

This manual is presented with the assumption that:

- You have purchased and installed one of the serial data products described in this manual.
- You have a basic understanding of the serial data standard physical and protocol layer specifications, and know how these standards are used in embedded controllers.
- You have a basic understanding of how to use an oscilloscope, and specifically the Teledyne LeCroy oscilloscope on which the option is installed. Only features directly related to serial data decoding are explained in this manual.

Compatibility

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

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

About the Option

Decode

Teledyne LeCroy decoders apply software algorithms to extract serial data information from physical layer waveforms measured on your oscilloscope. The extracted information is displayed over the actual physical layer waveforms, color-coded to provide fast, intuitive understanding of the relationship between message frames and other, time synchronous events.

Measure

With the installation of PROTObus MAG, add a protocol-specific set of measurements to the oscilloscope's standard measurement capabilities and quickly plot the measurement results.

Graph Measurements

Measurement data can be viewed as a Histogram, Track, or Trend plot of the digitally encoded data values for a specific input versus time. These plots effectively perform a digital-to-analog conversion that can be viewed right next to the decoded waveform.

Filter and Gate Measurements

Measurements can be filtered to include only the specified frame types, IDs, or data patterns. As with all traces, you can set a gate to restrict measurements to a horizontal range of the grid corresponding to a specific time segment of the acquisition.

SENT Overview

SAE J2716 SENT (Single Edge Nibble Transmission) protocol is a point-to-point scheme for transmitting signal values from a sensor to a controller. It is intended to allow for high-resolution data transmission with a lower system cost than other available serial data solutions. Data is transmitted in units of 4 bits = 1 nibble for which the interval between two falling edges (single edge) of the modulated signal with a constant amplitude voltage is evaluated. A data frame contains 24 bits of data (each 3 nibbles for 2 channels, such as pressure and temperature), 4 bits = 1 nibble for error detection (CRC) and 4 bits = 1 nibble of status and communication, making a total of 8 nibbles. Optionally, data can be transferred in a 5-nibble frame, with 3 nibbles for a single measurement channel, 1 for CRC and 1 for the status/communication. (SENT Protocol, wikipedia.org, accessed 03-06-2013).

The Teledyne LeCroy SENT decoder option is a tool aimed at decoding SENT streams emitted by various sensors. This decoder supports both the 2008 and the 2010 SENT specification.

Decoding

Serial Decode Technical Overview

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

Bit-level Decoding

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

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

Logical Decoding

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

Message Decoding

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

User Interaction

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

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

Decoding Workflow

We recommend the following workflow for effective decoding:

1. Connect your data and strobe/clock lines (if used) to the oscilloscope.
2. Set up the decoder using the lowest level decoding mode available (e.g., Bits).
3. Acquire a sufficient burst of relevant data, then run the decoder.

   NOTE: See Failure to Decode for more information about the required acquisition settings.
4. Use the various decoder tools to verify that transitions are being correctly decoded. Tune the decoder settings as needed.
5. Once you know you are correctly decoding transitions in one mode, continue making small acquisitions and running the decoder in higher level modes (e.g., Words). The decoder settings you verify on a few bursts will be reused when handling many packets.
6. Run the decoder on acquisitions of the desired length.

You can disable/enable the decoder as desired without having to repeat the set up and tuning provided the basic signal characteristics do not change.

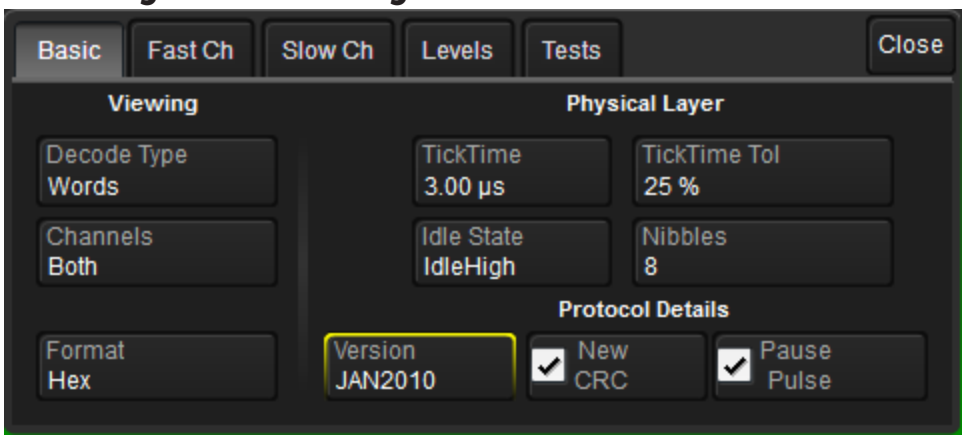
Setting Up the Decoder

The main Serial Decode dialog allows you to preset up-to-four, independent decoders, Decode 1 to Decode 4. Each decoder can use different (or the same) protocols and data sources, or have other variations, giving you maximum flexibility to compare different signals or view the same signal from multiple perspectives.

TIP: After completing setup for one decoder, you can quickly start setup for the other decoders by using the Decode # buttons at the left of the Decode Setup dialog. You don't have to step back to the Serial Decode dialog. Controls with the same label on either dialog share the same function.

1. Touch the **Front Panel Serial Decode button** (if available on your oscilloscope), or choose **Analysis > Serial Decode** from the oscilloscope menu bar to access the Serial Decode dialog.
2. On the same row as the **Decode #**:
   - Check **On** to enable the decoder now. This will let you view the decoding on screen as soon as there is an acquisition, which helps to begin tuning. If you wish, you can wait until all settings are complete to enable the decoder.
   - Select the desired **Protocol** to use.
   - Select the **Data (Source)** to be decoded. This can be any signal input channel (C*x*), memory (M*x*), or math function (F*x*).
3. Touch the **Setup** button (next to Search) to open the Decode Setup dialog. If you use this method rather than the tab, your settings will be correctly pre-selected on the Decode Setup dialog.
4. Go on to complete the settings on the right-hand dialogs next to the Decode Setup dialog.

Basic Right-Hand Dialog



Configure all settings on the Basic right-hand dialog:

Decode Type - Choose whether to decode Nibbles or Words in the source signal.

Channels - Choose to decode Fast Only, Slow Only, or Both channels.

Format - Choose to decode results in Hex(idecimal) or Dec(imal) format.

TickTime - Time in seconds between a nibble of value N and a nibble of value N+1.

TickTime Tol(erance) - Defines how the CAL pulse is filtered with respect to the Ticktime indicated by the user. i.e. if a tick Time of 3us is set, with a tolerance of 10% the CAL pulse is expected to be 56 * 3 us +- 10%, therefore 168 us +- 10%.

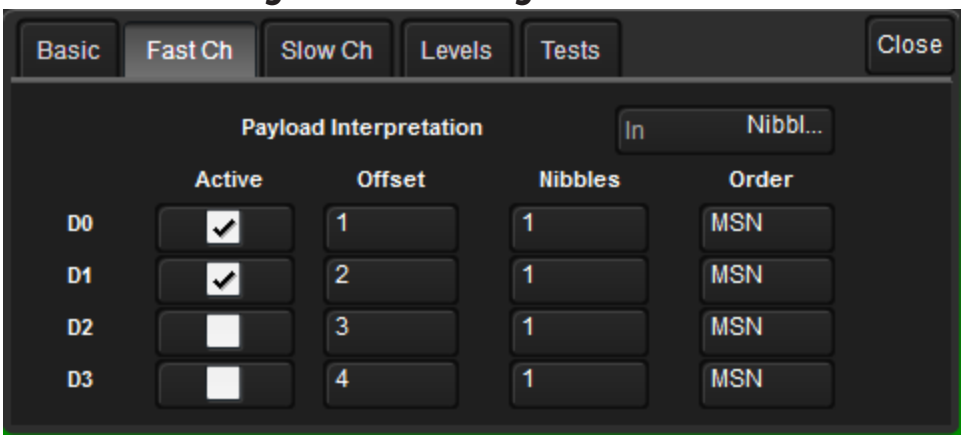
Idle State - Defines where the idle state lies, therefore opposite of pulse direction. Choose IdleLow or IdleHigh.

Nibbles - Enter the number of nibbles that make up a word. Choose from 5 to 8 (8 is the default).

Version - Choose the version of the protocol used in the decoded signal. If you are using the Jan 2010 version, also choose to enable or disable the following Protocol Details:

- **New CRC** - When checked, the CRC computation will be performed as per 2010 recommended implementation under 5.4.2.2. Otherwise it will follow the 2008 guidelines, under 5.4.2.1 (Legacy).
- **Pause Pulse** - When checked, algorithm expects a Pause pulse as per 2010 definition under 5.2.6. The Pause Pulse follows the CRC of message N and precedes the CAL pulse of message N+1.

Fast Channel Right-Hand Dialog



The Fast Channel dialog will appear if you selected a Decode Type of “Words” and Channels is set to either “Fast” or “Both.”

The SENT protocol specifies four user-defined data fields, D0 through D3. Each of these can be used to present the content of the message payload as it was programmed. Select each that you wish to decode. Then, enter the payload offset and how many nibbles are included in that field.

For each of the four data bits (D0-D3) that are in use, specify the payload interpretation.

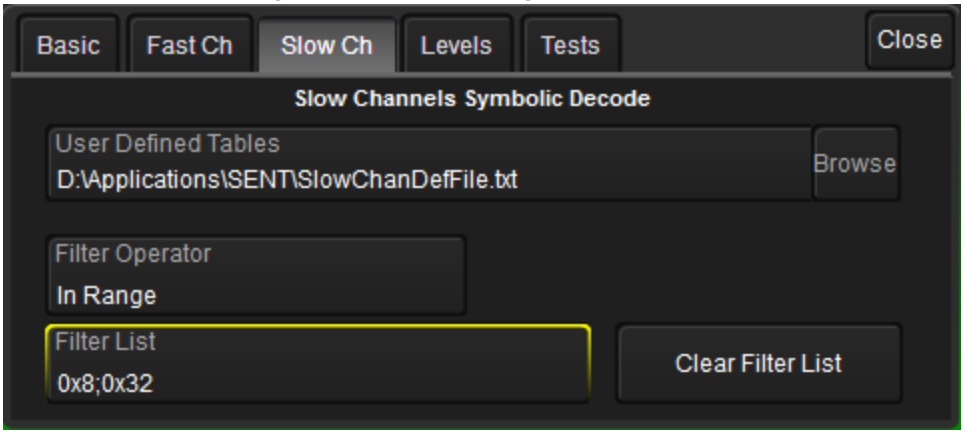
Active - check to activate the display showing payload content.

Offset - defines where in the payload you start including content.

Nibbles – number of nibbles included in the field.

Order – select whether data is presented in least-significant bit (LSN) or most-significant bit (MSN) order.

Slow Channel Right-Hand Dialog



The Slow Channel dialog will appear if you selected a Decode Type of “Words” and Channels is set to either “Slow Only” or “Both.” The Slow Only option takes a single data value from each of 16 or 18 SENT message packets and builds a Slow Channel result, displayed on the decoder result table.

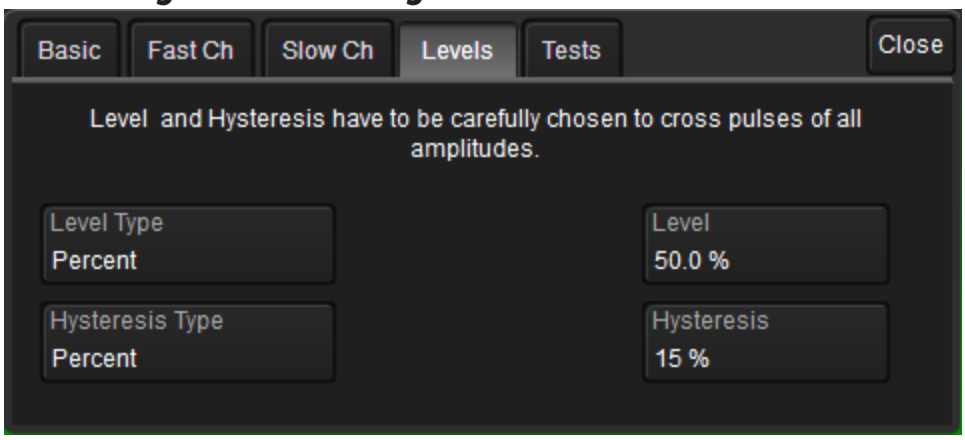
A plain text Slow Channel Definition File (SCDF) is used to decode this data into a more meaningful presentation of the assimilated slow channel data. For example, it is expected that different sensors will require different SCDF files. On the Slow Channel dialog, select the User Defined Tables field and Browse to the SCDF file to use for this purpose.

To upload a new SCDF file:

1. Connect a USB drive one of the oscilloscope host USB ports.
2. Touch **Browse**, then **Open Explorer Here**.
3. Use Windows Xplorer to copy the file to the directory D:\Applications\Sent.

Use the filter functionality to include only certain values in the decoding, such as dynamic temperature data, or to exclude other data that is undesirable. Choose a **Filter Operator** of In Range (include these) or Out Range (exclude these), then enter the message hexadecimal ID codes in the **Filter List**, separated by semi-colons. Do not include spaces.

Levels Right-Hand Dialog



The Levels dialog controls the levels used for determining the edge crossings of the SENT signal. The default settings of Level = 25% and Hysteresis = 0.5 divisions are usually appropriate for most signals.

Level Type - whether Level will be given as **Percentage** of amplitude or **Absolute** number of vertical divisions.

Level - percentage of amplitude or absolute voltage at which the crossing occurs.

Hysteresis Type - whether Hysteresis will be given as **Percentage** or absolute number of vertical **Divisions**.

Hysteresis - margin of error; amount signal may rise or fall without affecting bit transition.

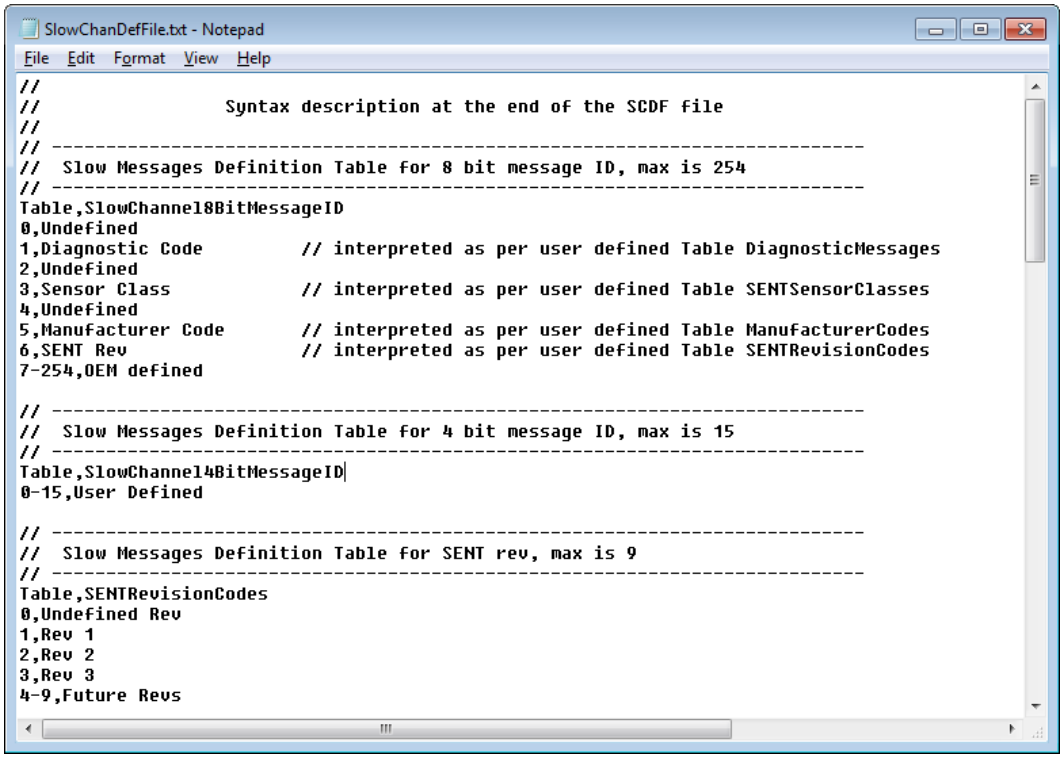
Tests Right-Hand Dialog

The Test dialog enables you to apply any of four SAE test criteria (the text on the dialog describes the test). Select each test to apply, then enter the value that completes the statement.

See Understanding SAE Test Results for more information.

SCDF File Structure

The mechanism used to translate SENT IDs and values is a simple TXT file containing table definitions. The beginning of the SCDF default file installed on every instrument is shown here in a text editor, which is enough to edit the file.



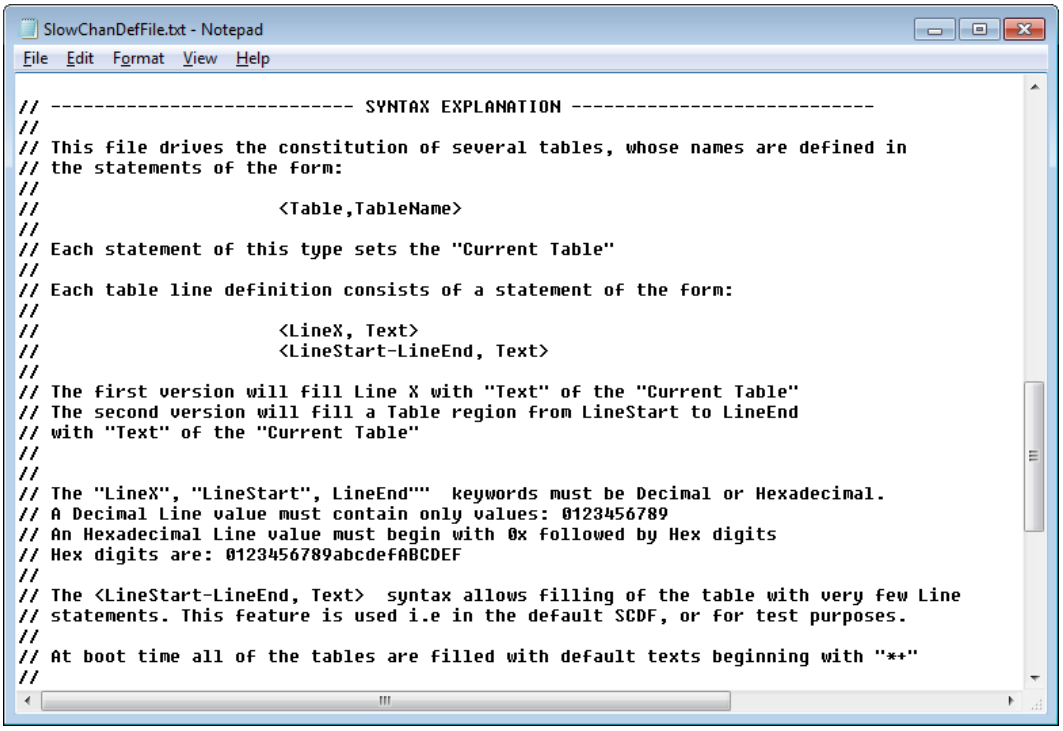
Reserved Names

The SCDF syntax defines several reserved names to identify the auxiliary tables used for:

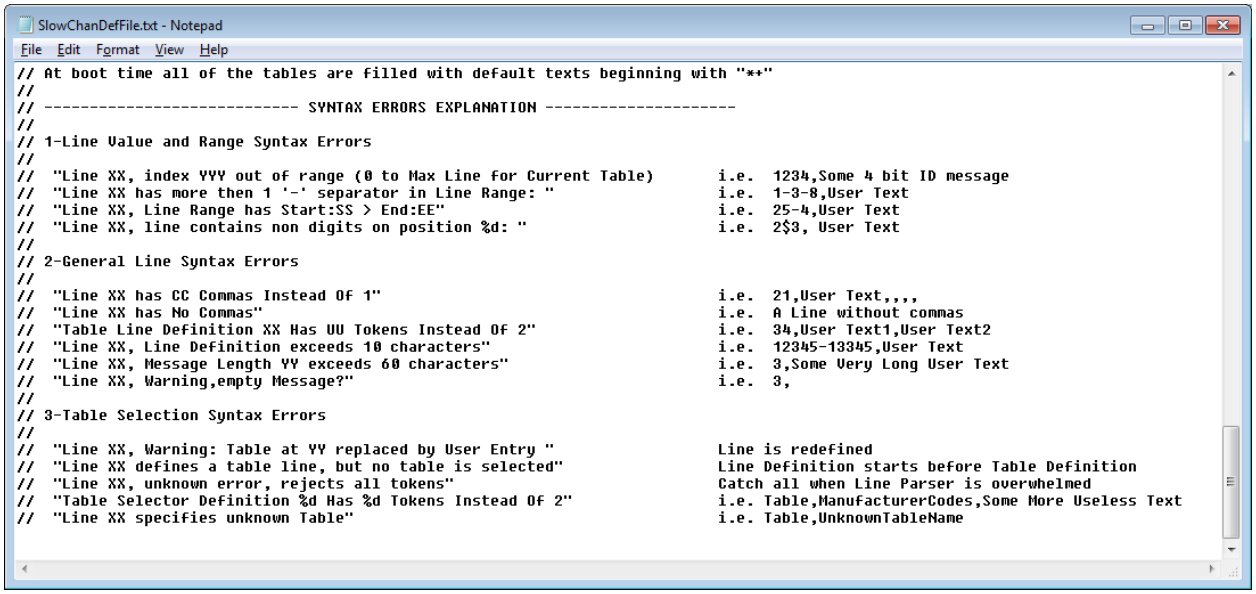
- Table, SlowChannel8BitMessageID, used to interpret the 8 bit message ID
- Table, SlowChannel4BitMessageID, used to interpret the 8 bit message ID
- Table, SENTRevisionCodes, used to interpret the value conveyed by message ID 6
- Table, SENTSensorClasses, used to interpret the value conveyed by message ID 3
- Table, DiagnosticMessages, used to interpret the value conveyed by message ID 1
- Table, ManufacturerCodes, used to interpret the value conveyed by message ID 5

Syntax Errors

The syntax is documented in the file itself as comments toward the end, as well as the syntax errors detected during the parsing.



Parsing errors are listed at the very end of the file. Note that the parsing errors are very useful when beginning to use the SCDF, in order to located syntax errors. The syntax is very strict, in order to keep the parser as simple as possible.



In addition to the SCDF file, parsing errors are always emitted at the bottom of the oscilloscope screen, with the last error overwriting the previous ones. It is therefore advisable to fix the errors as they occur, beginning with the last emitted error, then reload the file and see if any errors are left.

Failure to Decode

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

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

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

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

Enabling/Disabling the Decoder

Once set up, the four decoders can be enabled simultaneously or separately, although this number may be limited depending on the type of source channels selected. Decoders can be easily disabled without disrupting the configuration.

To enable: press the **Front Panel Serial Decode button** (if available on your oscilloscope) or choose **Analysis > Serial Decode** to open the Serial Decode dialog, then check **Decode On** next to the respective decoder.

If **View Decode** is checked (default) for that decoder on the Decode Setup dialog, a result table and decoded waveform appear. The number of rows of data displayed on each table will depend on the **Table#Rows** setting. The default is one, which can be increased, but doing so will decrease the amount of the screen available to display traces.

To disable: deselect the **Decode On** box individually, or touch **Turn All Off**.

Reading Waveform Annotations

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

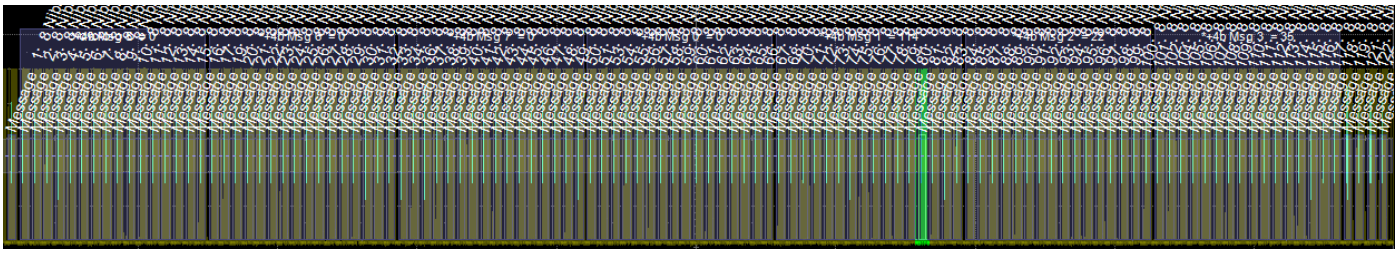
The amount of information shown on an annotation is affected by the width of the rectangles in the overlay, which is determined by the magnification (scale) of the trace and the length of the acquisition. Zooming a portion of the decoder trace will reveal the detailed annotations.

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

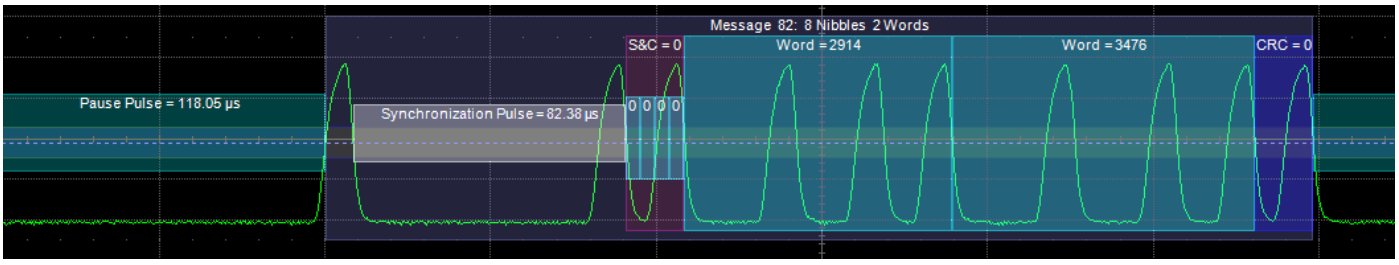
These overlays appear on a SENT trace, or its zoom, to highlight key portions of the decoded signal.

Annotation	Overlay Color	Text
Message burst	Navy Blue (behind data fields)	Message <ID>
Pause pulse	Dark Green	Pause Pulse = <time>
Syncronization pulse	Grey	Synchronization Pulse = <time>
Status & Communication Bits	Purple	S&C = <value>
Payload data	Aqua Blue	[Word | Nibble] = <value>

NOTE: Text in brackets < > is variable. Data bytes are shown in Nibbles or Words, depending on your Viewing selection.



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



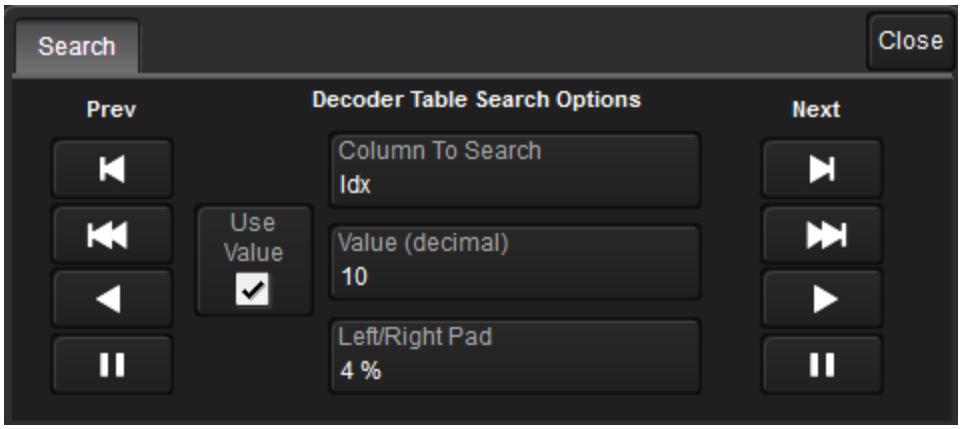
Zoomed waveform annotations, showing decoded data.

Searching Waveforms

Selecting the **Search** Action button on the Decode Setup dialog opens the decoder Search dialog, where you can enter criteria for finding events of interest in the waveform: various protocol elements, data values, errors, etc. **Prev** and **Next** buttons then navigate to matches found in the decoded waveform, simultaneously creating a zoom of each match.

The default zoom always shows the matching data (plus any padding) at the full width of the grid. Use the standard Zoom controls to rescale the zoom to the desired level of magnification.

Choose from the following options on the Search dialog to find matching occurrences in the decoded waveform.



Choose the result table **Column to Search** for matching data. Unless you enter a Value, search will go to the beginning of the next occurence of that data field in the acquisition.

Optionally:

- Enter the **Value** to find in that column. Check **Use Value** to enable this control.

  TIP: These controls will not appear when there is no capability to find a specific value in that column.

- Enter a **Left/Right Pad**, the percentage of horizontal division around matching data to display on the zoomed waveform.
- Check **Show Frame** to mark on the overlay the frame in which the event was found.

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

Serial Decode Result Table

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

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

Selecting a number in the first (index) column of the table will display a zoom of the corresponding position in the decoded waveform.

You can customize the result table, changing both the number of rows and the columns displayed. The default is one row. On a single-row table, touch the Down arrow at the far right to open a scrollbar that lets you display the previous or next row of data.

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

You can also export result table data to a .CSV file, and the table itself is useful for measuring.

Column	Extracted or Computed Data
Index (always shown)	Number of the line in the table; also number of the message in the annotation overlay on the trace.
Time(µs)	Time (in microseconds) of the beginning of the SENT burst, with respect to the trigger point of the record.
Sync	Real measured length of the synchronization pulse. The pulse width is measured between the two falling edges of the sync pulse, at the intersection of the signal and the Level selected on the Level dialog. Note that a large hysteresis will impact this value.
Tick	TickTime; value of the sync pulse divided by 56.
Msg (always shown)	Message summary, with the number of transitions, nibbles and words.
Stat	Value of the status and communication (S&C) nibbles. This value is split into its component bits in the next four columns to help interpret the contents. Component bits are chromacoded for quick reference to their result values in the ID, Data, and CRC columns.
b0-b1	Reserved for special applications.
b2	Message data bits (slow channels).
b3	Message start bits.
D0 - D3	Message data bits (fast channels).
ID	Result value of 8-bit ID.
Data	Result value of 12-bit data.
CRC (always shown)	Value of the CRC (error detection) nibble compared to values of the other nibbles of the message. If it does not match, an error appears in the Status column. It is normal that the first and last messages of a record, when truncated, generate a CRC error.
RMS	Root Mean Square value of the falling edge crossings, usually in nanoseconds.

Column	Extracted or Computed Data
Pause Pulse	Time ed from the end of a burst to the beginning of the next burst.
S	Boolean Status column. This column numerically reflects the contents of the Status column. The value is 0 when the Status is empty (no errors) and 1 when Status contains text (errors reported). The S column is the link to the Pass/Fail System of the oscilloscope when used for tests. The preferred method is to apply the MessageToValue parameter to the S column, then apply the Pass/Fail condition to the parameter.
Status	Reported errors and warnings.

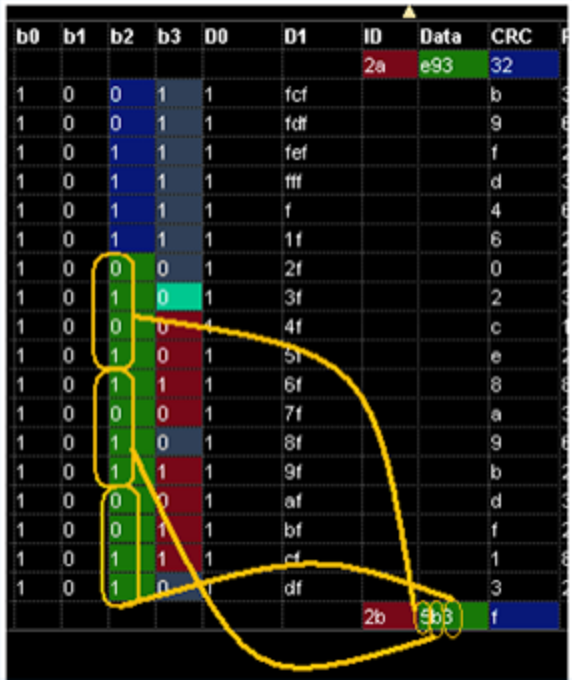
SENT	Time	Sync	Tick	Msg	Stat	b0	b1	b2	b3	D0	D1	ID	Data	CRC	RMS	Pause P	S	Status
78	6.27011 ms	82.32 µs	1.47 µs	Message 78: 8 Nibbles 2 Words	0	0	0	0	0	2907	1188			15	34.3 ns	106.3 µs	0	
79	6.69357 ms	82.36 µs	1.47 µs	Message 79: 8 Nibbles 2 Words	0	0	0	0	0	2909	676			5	22.3 ns	103.2 µs	0	
80	7.11709 ms	82.34 µs	1.47 µs	Message 80: 8 Nibbles 2 Words	4	0	0	1	0	2911	164			3	20.1 ns	118.0 µs	0	
81	7.54063 ms	82.32 µs	1.47 µs	Message 81: 8 Nibbles 2 Words	0	0	0	0	0	2913	3732			5	23.6 ns	115.1 µs	0	
82	7.96420 ms	82.38 µs	1.47 µs	Message 82: 8 Nibbles 2 Words	0	0	0	0	0	2914	3476			0	26.7 ns	118.0 µs	0	
83	8.38777 ms	82.38 µs	1.47 µs	Message 83: 8 Nibbles 2 Words	4	0	0	1	0	2917	2708			9	20.5 ns	125.4 µs	0	
84	8.81129 ms	82.32 µs	1.47 µs	Message 84: 8 Nibbles 2 Words	4	0	0	1	0	2919	2196			15	23.5 ns	106.2 µs	0	
85	9.23485 ms	82.38 µs	1.47 µs	Message 85: 8 Nibbles 2 Words	4	0	0	1	0	2921	1684			0	22.7 ns	97.43 µs	0	
86	2.88189 ms			*+4b Msg 1 = 114								1	114	7				

Section of typical SENT decoder result table.

Chromacoding of S&C Bits

In addition to the decoded bit values, the SENT result table displays color-coding of Status and Communication (S&C) bits so that it is easy to recognize how they are distributed over many Fast Messages (16 or 18). The resulting bit transmission is shown in the ID, Data, and CRC columns.

Bits	Color Code
Sync pattern	Grey
4-bit or 8-bit ID	Red
12-bit Data	Green
Control bit: When set to 0, ID is 8-bits and Data 12-bits wide When set to 1, ID is 4-bits and Data 16-bits wide	Turquoise
4-bit or 6-bit CRC	Blue



Enhanced Slow Message using color to show how Sync, ID, Data, and CRC bits are distributed over 18 Fast Messages.

Status Messages

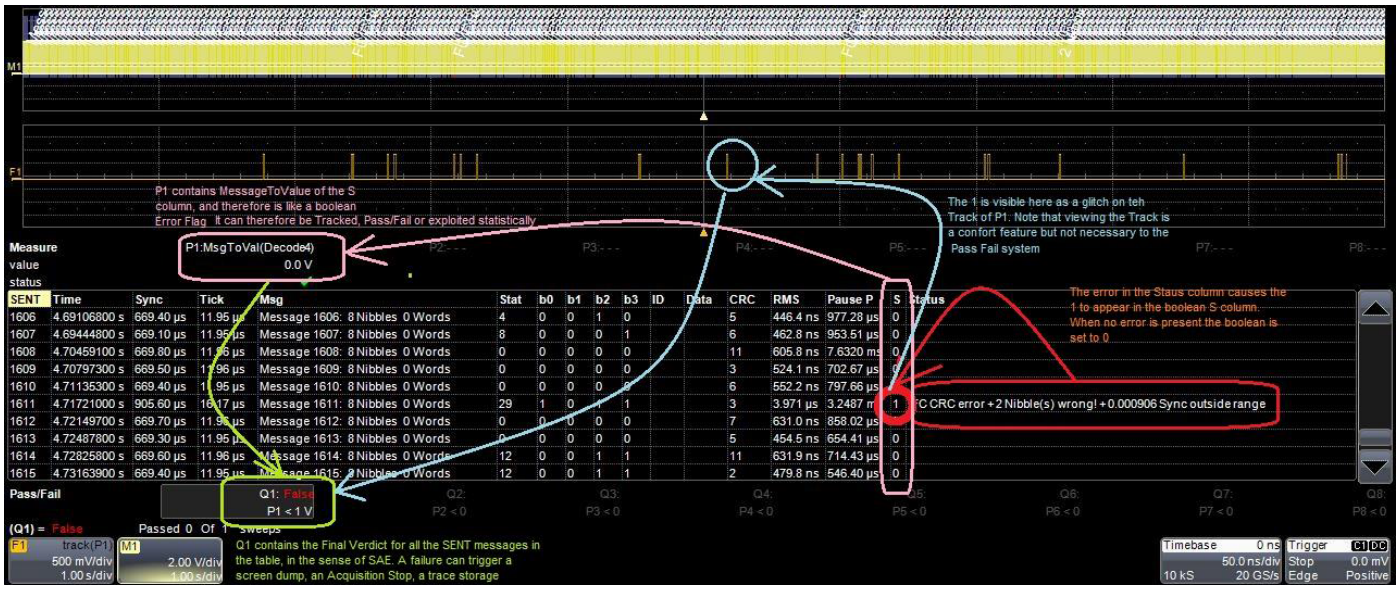
These messages may appear in the Status column of the SENT decoder result table:

Channel	Error	Message
Fast	Nibble value outside range 0-15	%d Nibble(s) wrong!
Fast	Sync outside range ± 25% of Sync computed as 56 * user TickTime	%f Sync outside range
Fast	Fast channel CRC error	FC CRC error
Slow	In enhanced Slow Message, bit 7, 13 or 18 is not 0	B [7|13|18] != 0!
Slow	Enhanced Slow Message CRC error	SC(18) CRC Error
Slow	Legacy Slow Message CRC error	SC(16) CRC Error

Understanding SAE Test Results

The results of SAE tests are populated to the **Status** and **S** columns of the result table:

- **Status** shows a description of the error
- **S** shows a 0 if there is no error, or 1 when an error appears, making it a Boolean error flag that can be tracked statistically or exploited for measurements and Pass/Fail testing.



SENT	Time	Sync	Tick	Msg	Stat	b0	b1	b2	b3	ID	Data	CRC	RMS	Pause P	S	Status
1606	4.69106800 s	669.40 µs	11.95 µs	Message 1606: 8 Nibbles 0 Words	4	0	0	1	0			5	446.4 ns	977.28 µs	0	
1607	4.69444800 s	669.10 µs	11.95 µs	Message 1607: 8 Nibbles 0 Words	8	0	0	0	1			6	462.8 ns	953.51 µs	0	
1608	4.70459100 s	669.80 µs	11.96 µs	Message 1608: 8 Nibbles 0 Words	0	0	0	0	0			11	605.8 ns	7.6320 ms	0	
1609	4.70797300 s	669.50 µs	11.96 µs	Message 1609: 8 Nibbles 0 Words	0	0	0	0	0			3	524.1 ns	702.67 µs	0	
1610	4.71135300 s	669.40 µs	11.95 µs	Message 1610: 8 Nibbles 0 Words	0	0	0	0	0			6	552.2 ns	797.66 µs	0	
1611	4.71721000 s	905.60 µs	16.17 µs	Message 1611: 8 Nibbles 0 Words	29	1	0	1	1			3	3.971 µs	3.2487 m	1	C CRC error +2 Nibble(s) wrong! +0.000906 Sync outside range
1612	4.72149700 s	669.70 µs	11.96 µs	Message 1612: 8 Nibbles 0 Words	0	0	0	0	0			7	631.0 ns	858.02 µs	0	
1613	4.72487800 s	669.30 µs	11.95 µs	Message 1613: 8 Nibbles 0 Words	0	0	0	0	0			5	454.5 ns	654.41 µs	0	
1614	4.72825800 s	669.60 µs	11.96 µs	Message 1614: 8 Nibbles 0 Words	12	0	0	1	1			11	631.9 ns	714.43 µs	0	
1615	4.73163900 s	669.40 µs	11.95 µs	Message 1615: 8 Nibbles 0 Words	12	0	0	1	1			2	479.8 ns	546.40 µs	0	

In the example above:

- A glitch in record 1611 appears as 1 in the S column.
- Parameter 1 (P1) is configured with MessageToValue set on column S, functioning as a "pass thru" of the S value so that it can be made available to other oscilloscope functions that utilize measurement parameters as sources, such as Pass/Fail testing or Math on Parameters.
- A Pass/Fail test is set up so that Q1 fails whenever P1 is *not* less than 1 (P1 < 1 = False), meaning 0. The "fail" could in turn be set up to trigger any number of other actions, such as stopping the acquisition or taking a capture of the screen to show what caused the failure.

  NOTE: It is not necessary to display the trace in order for the SAE test results to be used this way, that is simply another way to understand the cause of the error.

Customizing the Result Table

Number Of Columns

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

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

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

Bit Rate Tolerance

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

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

Number Of Rows

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

Zooming with the Result Table

Besides displaying the decoded serial data, the result table enables you to quickly Zoom regions of the decoded waveform and access other functionality.

Touching the **Index (row) number** in the first column opens a Zoom of the corresponding region in the decode trace. This is a quick way to navigate to events of interest in the acquisition.

The **Index column heading** (top, left-most cell of the table header) bears the name of the corresponding protocol, and the cell's fill color matches the color of the input source. Touching this cell opens the Decode Setup dialog if it has been closed.

Touching any other **data cell** in the table opens a pop-up menu with several choices of action:

- **Off** turns off the decode.
- **Zoom** creates a zoom of the region where the data appears (same as touching the row number).
- **Setup** opens the Decoder Setup dialog (same as touching the first column heading).
- **Export** exports the decode results table to a .CSV file.
- **Measure** displays a choice of measurements that can be made on the decoded signal.

Exporting Result Table Data

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

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

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

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

Measuring

If you have installed any -TDM option or PROTObus MAG, these general measurements designed for debugging serial data streams can be applied to the decoded waveform. Measurements appear in a tabular readout below the grid (the same as for any other measurements) and are in addition to the result table that shows the decoded data. You can set up as many measurements as your oscilloscope has parameter locations.

NOTE: Depending on the protocol, measurements may appear in a sub-menu of the Measure Setup menu and may have slightly different names. For example, the CAN sub-menu has measurements for CANtoValue instead of Message to Value, etc. The measurements are the same.

Measurement	Description
View Serial Encoded Data as Analog Waveform	Automatically sets up a Message to Value parameter and then tracks the assigned measurement. In doing so, a Digital-to-Analog Conversion (DAC) of the embedded digital data is performed and the digital data is displayed as an analog waveform.
Message to Value	Extracts and converts a specific portion of the data/payload in the message and displays it as an analog value.
Column to Value	Extracts the data in a single column of the result table to a measurement parameter result location, with no transformation of value.
MsgToAnalog (Message to Analog)	Computes time from start of first message that meets conditions to crossing threshold on an analog signal. Result is negative if analog event precedes message. You must choose the digital input in Source1 and the analog input in Source 2 for this measurement to work properly.
AnalogToMsg (Analog to Message)	Computes time from crossing threshold on an analog signal to start of first message that meets conditions. Result is negative if message precedes analog event. You must choose the analog input in Source 1 and the digital input in Source 2 for this measurement to work properly.
MsgToMsg (Message to Message)	Computes time difference from start of first message that meets conditions to start of next message.
DeltaMsg (Delta Message)	Computes time difference between two messages on a single decoded line.
Time@Msg (Time at Message)	Computes time from trigger to start of each message that meets conditions.
BusLoad	Computes the load of user-defined messages on the bus (as a percent).
MsgBitrate	Computes the bitrate of user-specified messages on decoded traces.
NumMessages (Number of Messages)	Computes the total number of messages in the decoding that meet conditions.

Graphing Measurements

Measure and graph options include simplified methods for plotting measurement values as:

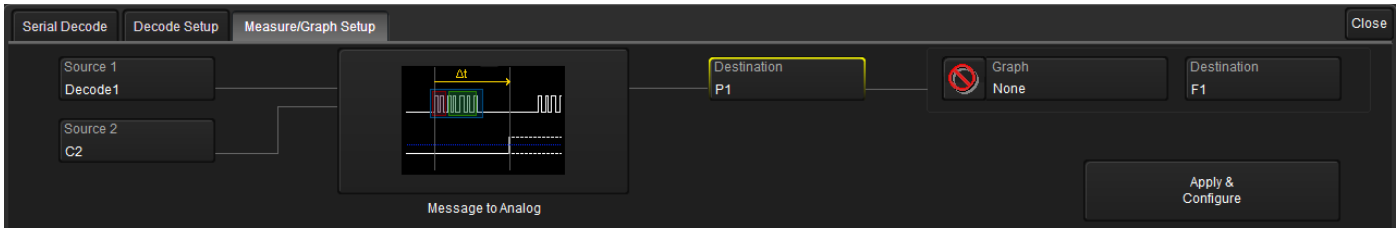
- **Histogram** - a bar chart of the number of data points that fall into statistically significant intervals or bins. Bar height relates to the frequency at which data points fall into each interval/bin. Histogram is helpful to understand the modality of a parameter and to debug excessive variation.
- **Trend** - a plot of the evolution of a parameter over time. The graph's vertical axis is the value of the parameter; its horizontal axis is the order in which the values were acquired. Trending data can be accumulated over many acquisitions. It is analogous to a chart recorder.
- **Track** - a time-correlated accumulation of values for a single acquisition. Tracks are time synchronous and clear with each new acquisition. Track can be used to plot data values and compare them to a corresponding analog signal, or to observe changes in timing. A parameter tracked over a long acquisition could provide information about the modulation of the parameter.

To graph a measurement, just select the plot type from the Measure/Graph dialog when setting up the measurement.

All plots are created as Math functions, so also select a function location (Fx) in which to draw the plot. The plot will open along side the deocoding in a separate grid.

Using the Measure/Graph Dialog

The Measure/Graph dialog, which appears behind the Decode Setup dialog when measurements are supported, is a quick way to apply parameters specifically designed for serial data measurement and simultaneously graph the results.



1. Select the **Measurement** to apply and the **Destination** parameter location (Px) in which to open it.
2. The **Source 1** decode is preselected; change it if necessary. If the measurement requires it, also select Source 2.
3. Optionally, choose a **Graph** format and the **Destination** math function location (Fx) in which to open it.
4. Optionally, set a measurement gate or filter. Touch **Apply & Configure** and make all required settings on the Measure right-hand dialogs that appear.

NOTE: The Serial Decode measurements are also available from the standard Measure setup menu. You can use the that functionality to set up as many measurements as your instrument has parameters.

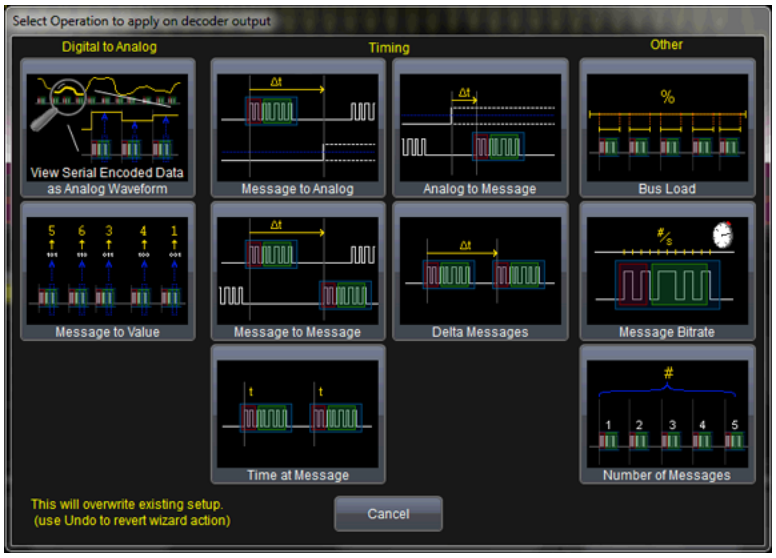
Using the Result Table

To quickly apply serial data measurements when the serial data setup dialogs are closed:

1. Touch any **data cell** of the decode result table.

   NOTE: If running more than one decoder simultaneously, be sure to select a cell from the correct table. The measurement source will be the waveform belonging to the table you touch.

2. From the pop-up menu, select **Measure** to display the Select Operation... dialog.



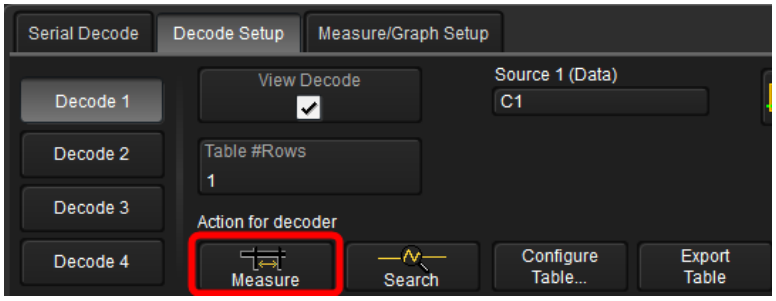
3. Touch any measurement operation to select it.
4. On the next dialog, choose a **parameter** location (P1-Px) in which to run the measurement.

   NOTE: If the location already stores a measurement, this selection will overwrite that setup.

5. To filter or gate the parameter, touch the Px cell of the readout table and make the desired settings on the right-hand dialogs that appear.

Using the Decode Setup Dialog

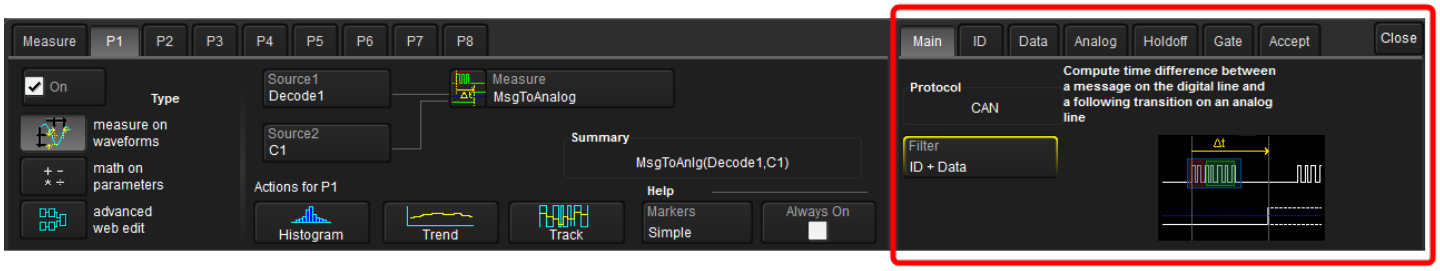
You can also access serial data measurements by touching the **Measure button** on the Decode Setup dialog. When using this button, measurements are set on the source of whichever Decoder (1-4) is currently selected on the Decode Setup dialog.



Filtering Serial Decode Measurements

After applying a measurement to the decoded waveform on the Measure/Graph dialog, set filter conditions on the right-hand dialogs that appear next to the P*x* dialogs.

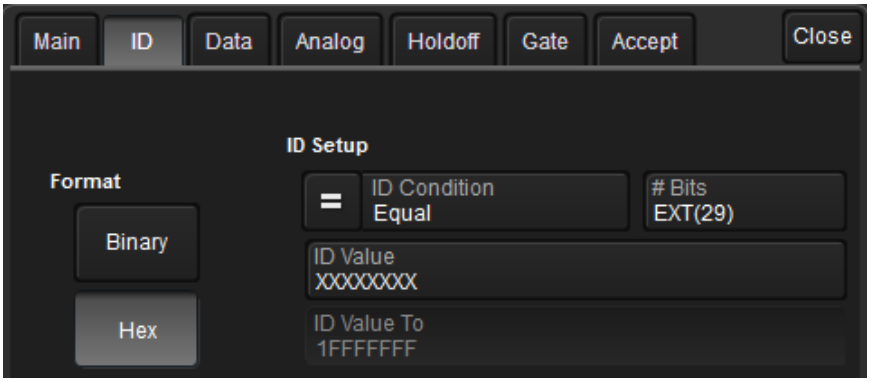
NOTE: Not all protocols or measurements support all filter types.



Frame ID Filter

This filter restricts the measurement to only frames with a specific ID value.

1. On the Main dialog, in **Filter** choose ID or ID+Data.
2. Open the **ID tab** that appears.



3. Choose to enter the frame ID value in **Binary** or **Hex**(adecimal) format.

4. Using the **ID Condition** and **ID Value** controls, create a condition statement that describes the IDs you want included in the measurement. To set a range of values, also enter the **ID Value To**. On the pop-up dialog that appears when you touch ID Value:
    - Use the Left and Right arrows to position the cursor.
    - Use Back to clear the previous character (like Backspace), Use Clear to clear all characters.

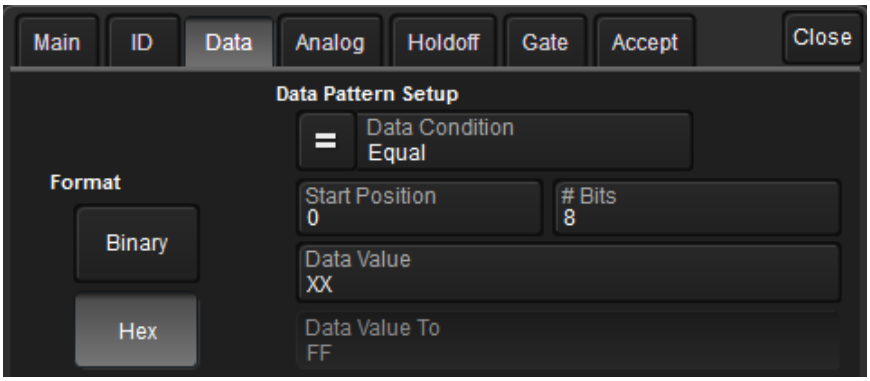
Data Filter

This restricts measurements to only frames containing extracted data that matches the filter condition. It can be combined with a Frame ID filter by choosing ID+Data on the Main dialog.

Use the same procedure as above to create a condition describing the **Data Value(s)** to include in the measurement. Use "X" as a wild card ("Don't Care") in any position where the value doesn't matter.

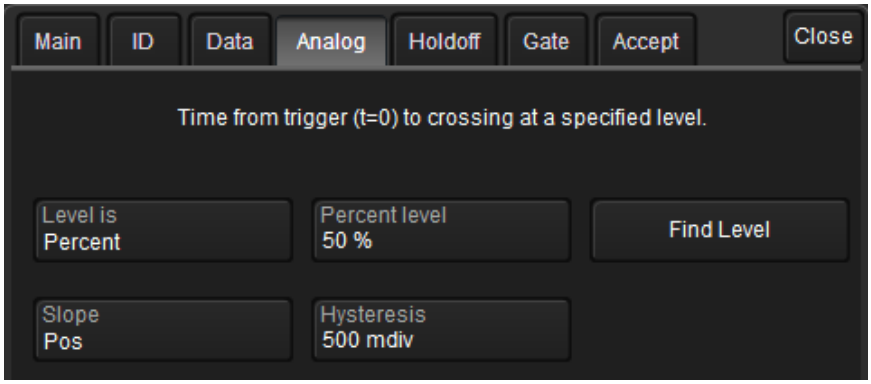
Optionally, enter a **Start Position** within the data field byte to begin seeking the pattern, and the **# Bits** in the data pattern. The remaining data fields positions will autofill with "X".

NOTE: For MsgtoMsg measurements, the data condition is entered twice: first for the Start Message and then for the End Message. The measurement computes the time to find a match to each set of conditions.



Analog Filter

This filter applies only to parameters that measure the decoded waveform relative to an analog signal: AnalogtoMsg and MsgtoAnalog. It allows you to set the crossing level and slope of the Analog signal event that is to be used in the measurement. Level may be set as a percentage of amplitude (default), or as an absolute voltage level by changing Level Is to Absolute. You can also use Find Level to allow the oscilloscope to set the level to the signal mean.



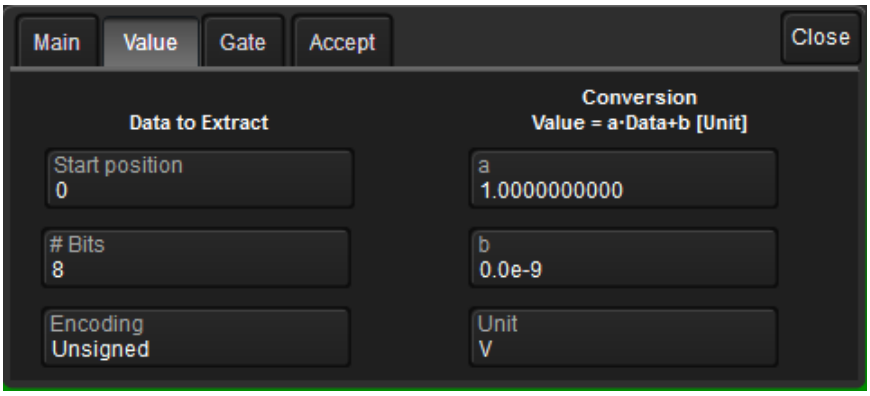
The optional Hysteresis setting imposes a limit above and below the measurement Level, which precludes measurements of noise or other perturbations within this band. The width of the band is specified in milli-divisions.

Observe the following when using 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.

Value Conversion Filter

This filter applies only to the MsgtoValue parameter. It enables you to apply a value conversion to extracted data. The converted values appear in the result table.



1. Under Data to Extract, begin by entering the **Start position** and the **# Bits** to extract.
2. Choose the **Encoding** type if the signal uses encoding, otherwise leave it Unsigned.
3. Under Conversion, enter the **a. Coefficient** and **b. Term** that satisfy the formula: *Value = Coefficient * Raw Value + Term*.
4. Optionally, enter a **Unit** for the extracted decimal value.

Holdoff, Gate, and Accept

Certain measurements support holdoff, gating, or additional qualifiers (Accept). You will see the tab appear among the Measure set up dialogs when the function is supported. When applied to serial data measurement, these functions work exactly as they do elsewhere in the oscilloscope:

- **Holdoff** specifies the amount of time or number of events to wait before starting the measurement.
- **Gate** specifies the Start Div and Stop Div that bound the portion of the acquisition to include in the measurement.
- **Accept** allows you to set qualifiers based on waveform state, either the measurement source or a second "gating" waveform, or to only accept measurement values that fall within pre-defined ranges.

See the oscilloscope *Operator's Manual* or *Getting Started Manual* for more information.

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