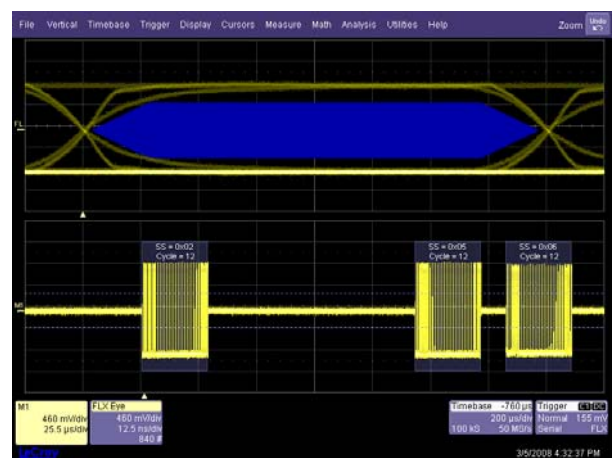# FLEXRAY
TRIGGER, DECODE, AND PHYSICAL LAYER TEST

Operator's Manual
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FlexRay-TDP-OM-E Rev B
916006 Rev A

TABLE OF CONTENTS

INTRODUCTION

Several communication protocol types are used in automotive applications. They are used to send data from sensors to electronic control units (ECUs) or from one ECU to another. These protocol types include **Controller Area Network** (CAN), **Local Interconnect Network** (LIN) and **FlexRay**. LIN is a low-cost master/slave system designed for low-cost implementation in vehicles, typically in what is commonly referred to as "body electronics." FlexRay is a time-triggered automotive communications bus designed for higher speeds and fault tolerance.

This manual focuses on the FlexRay **TDP**, **TD** and **D** products; LeCroy also has separate **CAN** and **LIN** products and manuals.

Overview

FlexRay bus TDP, TD and D options contain powerful software algorithms which extract serial data information from physical layer waveforms measured on your oscilloscope. The extracted information is overlaid (annotated) on the actual physical layer waveforms, and color-coded to provide fast, intuitive understanding.

This is especially helpful for FlexRay, an emerging standard many engineers are just starting to use.
The FlexRaybus TDP and TD options allow triggering on TSS (Start), Frame, Symbol or Errors. Frame triggering can be set conditionally to select a range of Frame ID values to trigger on, not just a single ID. Other powerful and user-friendly features included in FlexRaybus trigger include:

- Ability to trigger and decode FlexRay protocol version 2.1 at 10 Mb/s, 5 Mb/s or 2.5 Mb/s

- Ability to create powerful Frame triggers including Cycle Count and Frame Qualifiers

- Triggering on FSS, BSS, FES, Header CRC and Payload CRC errors as well as CID, CAS/MTS and Wakeup Pattern Symbols

The FlexRay TDP, TD and D Serial Data options are unique oscilloscope tools from LeCroy that greatly increase your ability to debug and analyze embedded controllers that use FlexRay. The D products are Serial Decode only, and the TD products include Serial Trigger and Decode. The TDP product is the superset of all capabilities and includes the Trigger, Decode and Physical layer test.

Physical layer test using the FlexRay TDP product consists of Eye Diagram Testing and Physical Layer Timing Measurements. The FlexRay trigger is integrated into the oscilloscope – no external hardware is used – and is selected through the normal oscilloscope trigger menus. FlexRay signals are sent to the oscilloscope using a differential probe like the ADP305 or AP033. Decoding is accessed from the Analysis pull-down menu. The decoding is overlaid on top of the appropriate channel, and is intuitively presented and color-coded for quick understanding. Physical layer test including eye diagrams and measurement parameters are accessed through the Physical Layer tab in the Decode Setup. All packages contain Search capability for specific IDs, Frames and Errors and a Table displays summarized protocol data underneath the oscilloscope grid.

COMPATIBILITY

The FlexRay TDP and TD options are available for WaveRunner Xi oscilloscopes. The FlexRay D option is available with WaveRunner 6000, WavePro 7000 and WaveMaster 8000 oscilloscopes.

The FlexRay specification is published by the FlexRay Consortium. As of the date of the printing of this manual the FlexRay protocol specification is currently at V2.1 Rev A, accompanying this specification is the V2.1 Rev A Errata V1 document. Separate specifications exist for the physical layer and data link layer.

ASSUMPTIONS

This manual assumes a basic understanding of the FlexRay standard physical layer and protocol layer specifications, and knowledge of how FlexRay is used. Also, a basic understanding of oscilloscope operation - specifically the LeCroy oscilloscope which the FlexRay trigger, decode, and physical layer option is used with – is assumed. Wherever practical or necessary, details on specific oscilloscope features have been included in this manual.

> **Note:** LeCroy has a policy of frequently updating software. It is possible that screen images in this manual may not exactly match what you see on your oscilloscope display. However, functionality is nearly identical.

The TDP Series Software

The TDP option adds the following capability to the LeCroy oscilloscope software user interface dialogs:

1. Serial Trigger Selection

   If this is the first serial trigger option you have installed on your scope, an additional icon appears in your trigger dialog box. It allows a serial trigger condition to be set from within the oscilloscope using an easy-to-understand interface.
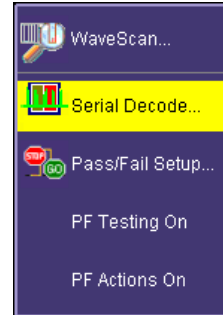
2. Serial Decode

   If this is the first serial decode option you have installed on your scope, an additional set of Serial Decode and Decode Setup dialog boxes are provided for setup of protocol format (as necessary) and decoding. These can be accessed from the Analysis menu.

3. Decode Protocol Selections

   FlexRay is one of several signal types that can be decoded by the oscilloscope. Other standards in I^2C, SPI, UART, RS-232, CAN and LIN.

4. Physical Layer Test

   Eye diagram and physical layer measurement parameters are accessed through the Serial Decode setup by selecting the Physical Layer Tab

![X-STREAM]

The TD Series Software

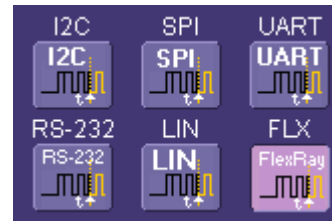The TD option adds the following capability to the LeCroy oscilloscope software user interface dialogs:

1. Serial Trigger Selection

   If this is the first serial trigger option you have installed on your scope, an additional icon appears in your trigger dialog box. It allows a serial trigger condition to be set from within the oscilloscope using an easy-to-understand interface.
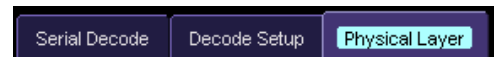

2. Serial Decode

   If this is the first serial decode option you have installed on your scope, an additional set of Serial Decode and Decode Setup dialog boxes are provided for setup of protocol format (as necessary) and decoding. These can be accessed from the Analysis menu.

3. Decode Protocol Selections

   FlexRay is one of several signal types that can be decoded by the oscilloscope. Other standards in I^{2}C, SPI, UART, RS-232, CAN and LIN.
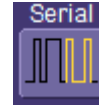
The D Series Software

The D option adds the following capability to the LeCroy oscilloscope software user interface dialogs:

1. Serial Decode
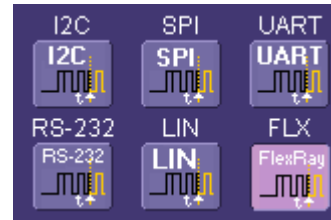
   If this is the first serial decode option you have installed on your scope, an additional set of Serial Decode and Decode Setup dialog boxes are provided for setup of protocol format (as necessary) and decoding.

2. Decode Protocol Selections

   FlexRay is one of several signal types that can be decoded by the oscilloscope. Other standards in I^{2}C, SPI, UART, RS-232, CAN and LIN.
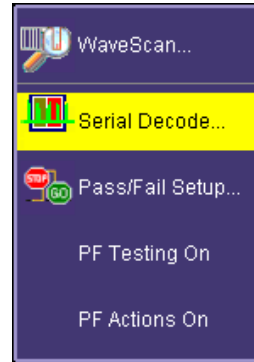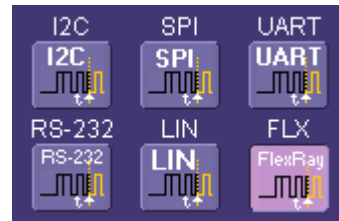
TECHNICAL OVERVIEW OF D, TD, AND TDP OPTIONS

LeCroy's offering of FlexRay trigger, decode and physical layer test options utilize advanced trigger circuitry and advanced software algorithms to provide powerful capability for serial data triggering and decoding.

FlexRay Trigger

FlexRay TDP and TD options contain advanced serial data triggering. This serial data triggering is implemented directly within the hardware of the oscilloscope acquisition system, and contains advanced algorithms to protocol decode, recognize, and trigger on user-defined serial data patterns. This allows a recognized serial data pattern to be used to trigger the oscilloscope at a pre-determined time, and other signals coincident with the desired serial data pattern can be captured simultaneously.

FlexRay Decode

FlexRay TDP, TD and D options contain powerful protocol decoding and annotation software algorithms. The software algorithm examines the embedded clock for each message based on a default (or user set) vertical levels. The algorithm is intelligent in that it applies a hysteresis to the rising and falling edge of the serial data signal to minimize the chance that perturbations or ringing on the edge affect the decoding. The default levels are set to 30% and 70% and are determined from a measurement of peak amplitude of the signals acquired by the oscilloscope. It can also be set to (absolute) voltage levels, if desired. The algorithm then performs an analysis of the serial data message to determine the nominal bit width.

After determining bit width, a different algorithm performs a decoding of the serial data message into binary format after separation of the underlying data into logical groups (TSS, FSS, Frame Qualifiers, ID, Payload Length, CRC, Payload Length Code, Data, BSS, Data Length Codes, Data, FES, etc.). Finally, another algorithm provides the appropriate color coding of the message, and displays the protocol message data on the screen, as desired, overlaid on the source trace. 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 FlexRay frame acquisition). In the case of the longest acquisition, only the most important information is highlighted. In the case of the shortest acquisition, all information is displayed with additional highlighting of the complete message frame.

> **Note:** Although the decoding algorithm is based on a clock extraction software algorithm using vertical levels, the results returned are the same as those from a traditional protocol analyzer using sampling point-based decode. In addition, the clock extraction technique allows partial decoding of messages in the event of physical layer noise, in many cases, whereas a protocol analyzer usually cannot. This is a significant advantage for the LeCroy software algorithm.

If the sampling rate (SR) is insufficient to resolve the signal adequately based on the bit rate (BR) setup, then the protocol decoding is turned OFF to protect the operator from incorrect data. The minimum SR:BR ratio required is 4:1. It is suggested to use a slightly higher SR:BR ratio if possible, and significantly higher SR:BR ratios if you also want to view perturbations or other anomalies on your serial data analog signal.

FlexRay Physical Layer

FlexRay TDP contains a software algorithm which creates eye diagrams, performs mask testing and measures timing parameters as defined in the FlexRay specification. The algorithm creates eye diagrams by slicing up all the bits transmitted in the FlexRay signal and superimposing each bit on to an eye diagram. The signal is sliced based on measurements taken at the falling edge of the first Bytes Start Sequence (BSS) and the time between consecutive BSS symbols. These measurements allow the algorithm to compute the rate of the embedded clock and slice the FlexRay waveform in to sub-waveforms that are one bit in length. The clock uses a constant bitrate specified by the user and is resynchronized on every BSS. These sub-waveforms are then scaled to fill 8 horizontal divisions on the oscilloscope and represent 1 Unit Interval (UI) in the eye diagram and superimposed on top of each other.

Mask testing can be performed on the eye diagram with masks defined at TP1 and TP4. The mask is aligned horizontally by computing the time for a single UI and centering it on the display. The mask is centered vertically around 0V.

Along with eye diagrams and mask testing the TDP option adds 4 FlexRay specific measurements to the oscilloscope. These measurements are **Propagation Delay**, **Asymmetric Delay**, **Truncation**, and **Jitter**. They are measured as defined in the FlexRay specification. These measurements characterize timing properties of the propagation of signals along the communication channel.

# USING THE TRIGGER, DECODE AND PHYSICAL LAYER TOOLSETS

FlexRay Triggering

FlexRay triggering is easily accessible in a variety of ways. The TD and TDP options add an additional Serial selection to the Trigger Type in the Trigger dialog. These dialogs are shared by all the low-speed serial protocols LeCroy offers. This is why all serial trigger selections are grouped in a common section with nearly identical selection and setup procedures (if installed on the oscilloscope). These dialogs are conveniently accessed with just one or two touches of the screen.

If you are not familiar with or are just learning about FlexRay, begin by using the simplest trigger conditions (TSS, or Frame ID). Then, experiment with an ID + Count "Equal" to a specific value. Then, try a conditional ID + Cycle Count trigger (ID "Greater Than" or "In Range").
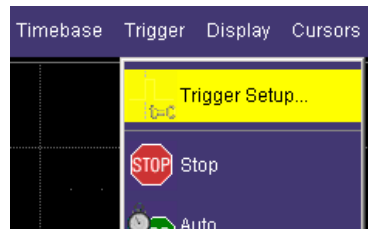
Accessing the FlexRay Trigger

The FlexRay serial trigger is accessed from the oscilloscope trigger dialog. This dialog can be accessed as follows:

1. Touch the **Trigger** Descriptor Box in the lower right corner of the oscilloscope display.
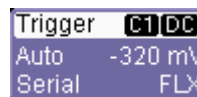
    Or

    Touch **Trigger** →**Trigger Setup** on the Menu Bar.

2. Touch **Serial** in the Type selection area.

3. Select the **FlexRay** trigger. The menu automatically changes to a different tab on the Trigger dialog. The tab is named after the serial trigger selected.

    The image shown here is from an oscilloscope with multiple serial data trigger options installed.

Creating a FlexRay Trigger Condition

The FlexRay Trigger dialog, with detail on some of the setup conditions, is shown on the following screen-shots.
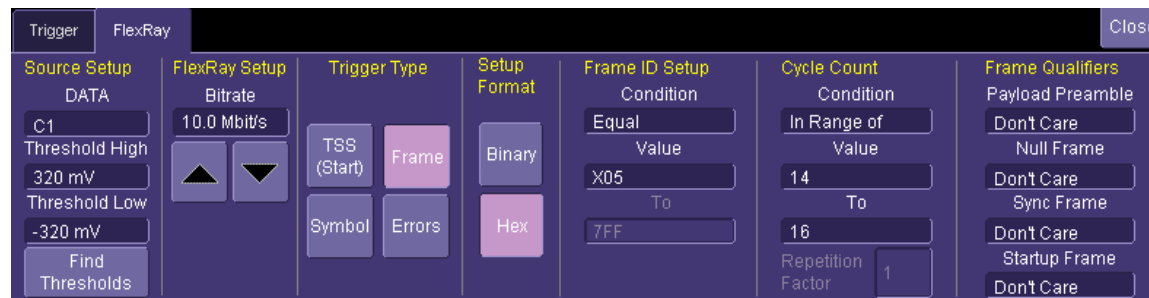
The Source Setup information must be defined. The datasheet for your part should contain the information you need to properly setup the FlexRay Trigger.

Selection of Trigger Type results in dynamic changes to the FlexRay Trigger dialog.
To select a value for any of the conditions, touch the existing value (using your finger, or use a mouse pointer) to open the pop-up dialog box with a list of choices, and select one of the choices.

Trigger Setup Detail

Source Setup

DATA – The pop-up dialog is used to select the appropriate channel or EXT input. Ensure these selections are made correctly for proper trigger functionality.

Threshold – Adjust the vertical level thresholds for the trigger. FlexRay is a tri-level signal and requires the user to set 2 voltage thresholds to enable the oscilloscope to distinguish between 1 and 0. Much like an Edge trigger, a user must specify the level used in order to process the incoming signals and determine whether the desired serial data pattern is meeting the set trigger condition. For simplicity, an automated **Find Threshold** function detects and sets appropriate thresholds.

FlexRay Bit Rate Setup

The FlexRay trigger can be configured to trigger on FlexRay signals at 2.5 Mb/s, 5 Mb/s and 10 Mb/s as defined in the FlexRay specification.

Trigger Type Selection

The FlexRay trigger can be configured to trigger on simple TSS (Start), FlexRay Frame (ID, Cycle Count, Frame Qualifiers) or FlexRay Symbols (CID, CAS/MTS and Wakeup Pattern). Error Frame triggering is also supported for FSS, BSS and FES, Header CRC and Payload CRC errors. Choose a Trigger Type and the dialog changes to correspond with your selection.

Setup Format

Select either **Binary** or **Hexadecimal** setup format. The format selected only affects the Frame ID. The cycle count trigger is always a Decimal value from 0 to 63; the Frame Qualifiers are always Binary with choices of 1, 0, or Don't Care.

Toggling back and forth between the formats does not result in loss of information (binary is used internally as the core format for all triggering and decoding operations), though use of don't care bits in a binary setup results in the display of an X (for a full nibble don't care) or a $ (for a partial nibble don't care).

Frame Trigger Setup

Frame ID – Enter the desired Frame ID in the field labeled **Value**, touching the field brings up the keypad for data entry. Entering X signifies Don't Care, the default ID is XXX.

The Frame ID **Condition** can be set many different ways. Possible conditions are <=, <, =, >, >=, not =, In Range of, or Out of Range. The default setting is Equal.

If ID condition is In Range of or Out of Range, a **To** value must also be given to specify the full ID range for the trigger.
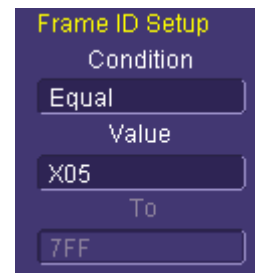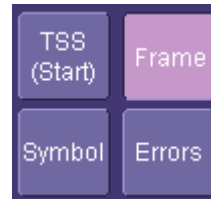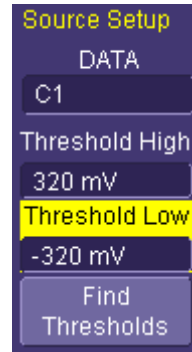
Cycle Count – The Cycle Count is combined with the Frame ID to enable powerful FlexRay triggering.

The Cycle Count is a decimal value between 0 and 63 and correlates to the FlexRay Cycle Count numbering system. The default Value is Cycle Count 0. If the cycle count is not intended to be part of the Frame triggering, the condition can be set differently to accommodate such scenarios. Possible conditions are <=, <, =, >, >=, not =, In Range of, or Out of Range. The default setting is Equal.

If Cycle Count condition is In Range of or Out of Range, a **To** value must also be given to specify the full ID range for the trigger.

If the Cycle Count condition is set to Equal the Repetition Factor can be set to a value of 1, 2, 4, 8, 16, 32 or 64 to allow for triggering when Cycle multiplexing is being used.

Condition – The condition for Frame ID and Cycle Count can be set many different ways. Possible conditions are <=, <, =, >, >=, not =, in a range, out of a range, or don't care.

Frame Qualifiers – The final aspect of Frame trigger setup is the Frame Qualifiers which are defined in the FlexRay specification. Frame Qualifiers provide an additional level of complexity for creating powerful FlexRay triggers. The default setting for each of the Qualifiers is Don't Care; each can be set to One, Zero or Don't Care as independent variables in the trigger setup.

Symbol Trigger Setup

If Symbol is selected as the trigger type, then this set of checkboxes is shown. The FlexRay specification calls out several symbols included in the FlexRay protocol. The symbol trigger allows for triggering on any Frame that includes one or more of these symbols.

- Channel Idle Delimiter (CID)
- Collision Avoidance Symbol (CAS) Media Access Test Symbol (MTS)
- Wakeup Pattern (WUP)

Check or uncheck to include or exclude Symbols as desired. Selecting more than one symbol sets the oscilloscope to trigger on any of the Symbols selected.

Error Trigger Setup

This set of checkboxes are shown if Error is selected as the trigger type. The errors are broken in to 2 categories, Protocol Errors and CRC Errors.

Protocol Errors:

- Frame Start Sequence (FSS)
- Byte Start Sequence (BSS)
- Frame End Sequence (FES)

CRC Errors:

- Header CRC
- Payload CRC
- The correct channel must be selected when triggering on CRC errors
- Check or uncheck each one, as desired, to include or not include that specific type of error in the trigger.
- For convenience Select and Deselect All buttons are available when using Error triggering.
- Detailed description of the Error Triggers is found in Appendix C.
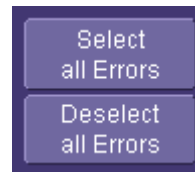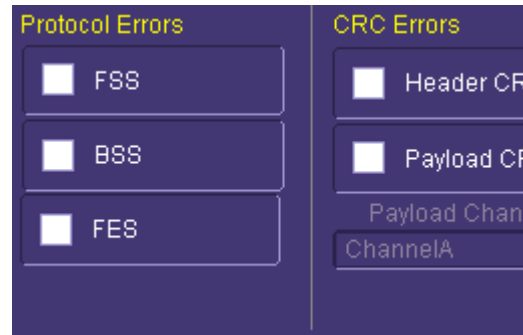
FlexRay Decoding

FlexRay decoding tools are easily accessible in a variety of ways. The D, TD and TDP options add a new set of dialogs for Decode setup. These dialogs are shared by all the low-speed serial protocols that LeCroy offers, so all serial trigger and serial decoding selections are grouped in a common selection with nearly identical selection and setup. These dialogs are conveniently accessed with just one or two touches of the screen.

Decode and Decode Setup

These dialogs provide the ability to set the oscilloscope up for FlexRay decoding, with display of the protocol data overlaid on the signal. They also allow quick and easy access to oscilloscope zooming, searching, table display, and table export.

The serial decode and decode setup dialogs are accessed in the following ways:

1. Touch **Analysis** → **Serial Decode** from the menu bar. The Serial Decode Summary dialog is shown which provides access to Decode Setup.

2. Touch the **Channel** or **Memory** Descriptor Box to open the respective dialog box, and touch the **Decode** button on the bottom toolbar.
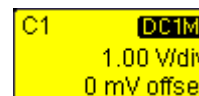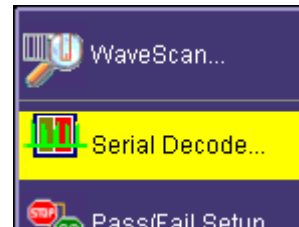
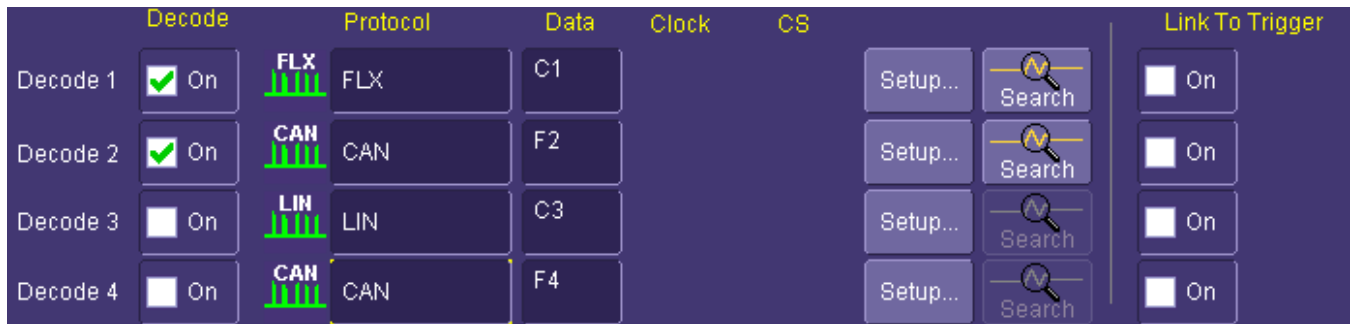3. Touch a Channel, Memory, or Math trace to open a pop-up dialog that displays a shortcut to the Decode Setup dialog box
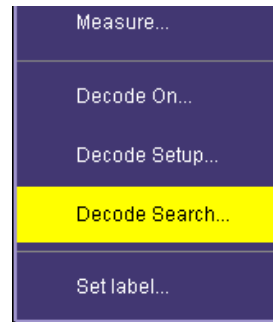

Serial Decode (Summary) Dialog Box

The Serial Decode dialog box is a summary page of which decoders are ON, and how they are set up. In addition, there are shortcuts to Decode Setup and Search.

There are four independent decoders. A user can operate up to four at a single time, though the limitation may be on the number of channels that can be accommodated at one time. Each of the 4 decoders can be configured to different FlexRay busses or any combination of serial data busses such as I^2C, SPI, UART, RS-232, CAN or LIN if the appropriate options are installed. Practically speaking, if a user was decoding signals with a clock and data line (and perhaps also a chip select or other third line), then two simultaneous decodes is the maximum number using the LeCroy oscilloscope analog channels. Addition of the MS-250 or MS-500 Mixed Signal Oscilloscope options allows usage of digital lines for trigger and decoding, which preserves analog channels for other uses. Contact LeCroy for more information about this option.

The detail of the Serial Decode dialog box is described as follows:

Decoder # - There are four independent decoders, each can be set up a different way for a different protocol.
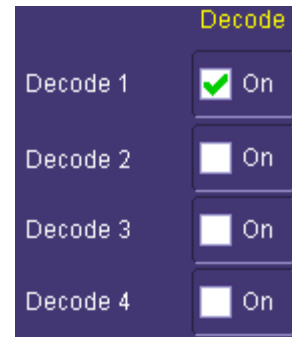


Decode ON Checkbox – If checked, the decoder is turned ON and set to decode (provided the protocol is correctly setup in the Decode Setup dialog box).

Protocol – This pop-up dialog allows selection of a specific serial protocol. If FlexRay is the only option installed on the oscilloscope, it is the only choice; if additional options are installed they appear on this dialog as well.

Data Selection – This pop-up dialog allows you select the channel or other source for decoding.
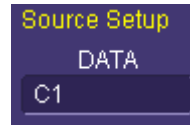
Decode Setup Shortcut Button – This provides quick access to the second tab (Decode Setup) where there are quick buttons for Search, and Table (Configure Table and Export Table). If you have already defined the trigger, then the trigger setup settings copy over into the decode setup.
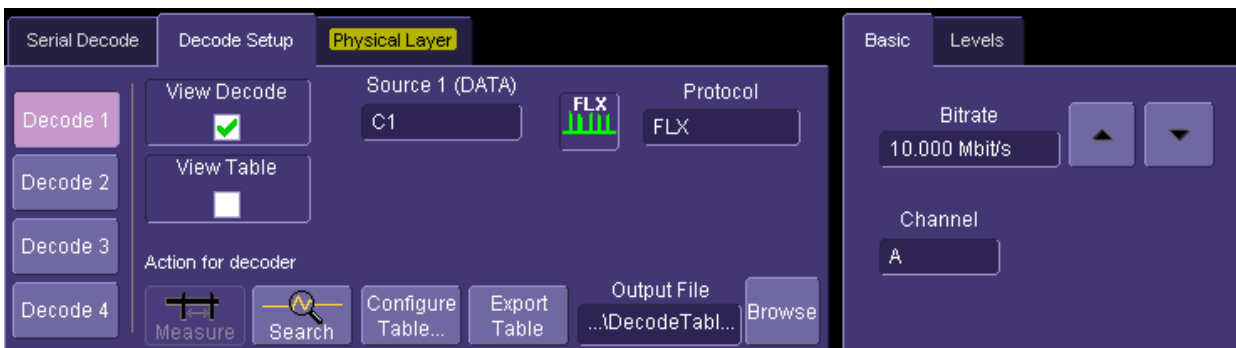
Search – Push this button to open a Zoom (Zx trace) that has, as its source, the corresponding Channel (Cx trace). In addition, the right hand dialog in the Zoom trace has Search options specific to the FlexRay protocol.

Decode Setup Dialog Box

The Decode Setup dialog box is where the details of the FlexRay protocol decode are entered. It appears as follows:

This is a single tab with an indicator on the left side that describes which of the four decoders the setup information pertains to. The left hand side of this dialog box is described below (the right hand side is described in the protocol specific chapters):

Decoder # Buttons – This describes which of the four decoders the currently entered information pertains to.
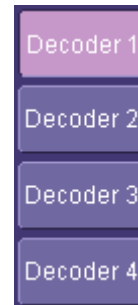
View Decode Checkbox – Touch this box to check or uncheck whether you want decoding turned ON. Decoding ON provides a highlight of each message frame, with color-coded highlighting and decoding of the various portions of the protocol message. Note that for very long acquisitions with hundreds or thousands of messages, decoding of the entire acquisition takes longer.
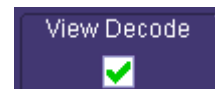
View Table Checkbox – Checking this box turns the Table ON. Unchecking it turns the Table OFF.

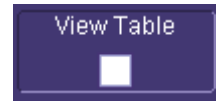**Note:** If the View Decode checkbox is not checked (i.e. decode is not ON), then the View Table checkbox is grayed out. The Table cannot display unless decode is occurring.

When the Table is displayed, it appears similar to that shown to the right. More details on the table can be found in the Protocol Table section of this manual

Source Setup – Touch these selections to open a pop-up dialog box which allows for selection of sources for the FlexRay data

This source can be either a Channel (C1 – C4), a Memory Trace (M1 – M4), or a Math Function (F1 – F4).
A Channel would be used for a new, real-time acquisition. A Memory would be used if you had saved data from a previous acquisition and were recalling it to do further analysis. Reference the oscilloscope's on-line Help for information about how to Store and Recall Waveforms.

Protocol Selection – This pop-up dialog allows selection of a specific serial protocol. If FlexRay is the only option installed on the oscilloscope, it is the only choice; if additional options are installed they appear on this dialog as well.

Action for Decoder Toolbar – Various buttons on this toolbar provide context sensitive shortcuts for decoding.

- **Search** allows quick creation of a zoom trace and changes the dialog box to the zoom/search dialog box. Acquire long records of message data, and use Search to look through the record for a particular message. Upon finding a message that meets the search criteria, the complete message is displayed with the Zoom Trace. Touch the arrow buttons to advance to the next message, or revert to the previous message. Unsuccessful searches are noted in a text line.

- **Configure Table** displays a pop-up dialog box specific to a particular protocol. The pop-up dialog contains checkboxes for various columns in the table. Check or uncheck the checkboxes to display or not display that particular column in the table.

- **Export Table** exports the complete protocol table data to a user-defined file. The output file name and directory can be selected by the user using the controls to the right.
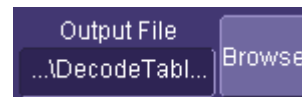
Decode Setup Detail

The FlexRay Decode Setup Right-Hand Dialogs (which are contained in the Decode Setup dialog box when FlexRay is selected as the Protocol to decode), with detail on the setup conditions, is shown in the images that follow:
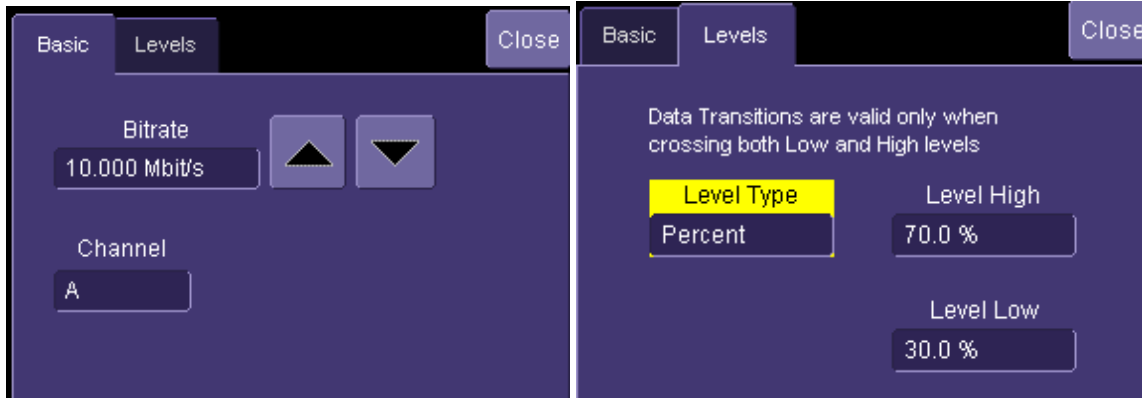
BitRate – Adjust the bit rate value here to match the bit rate on the bus you are connected to. This bit rate selection is dynamically linked to the decoding bit rate (they are always the same value). Use the arrows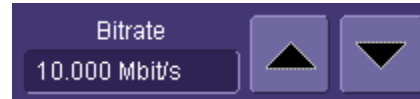 to move through standard bit rates (2.5, 5.0 or 10.0 Mb/s) and make a selection. Or, touch the number twice (with a finger, or using a mouse) and open a pop-up keypad and enter the value directly.

Channel – Select the appropriate channel to decode depending if signal being decoded is coming from Channel A or Channel B of the FlexRay bus. The channel selection only drives the CRC computation. If the wrong channel is selected, the decode still works, but exhibits CRC errors. In this case simply switching the channel fixes the decoding.
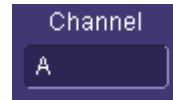
Level Type and **Level** - The message decoding algorithm setup is performed here. FlexRay is a tri-level signal and requires 2 levels for the oscilloscope to distinguish between 1 and 0. The level is normally set up in %, and defaults to 70% and 30%. To adjust the level, touch inside the number area to highlight the box title in yellow and then use the oscilloscope front panel Adjust knob to adjust. Or touch inside the number area twice and select a value using the pop-up numeric keypad. Switching the level type to Absolute allows for entry of voltage levels instead of percentages
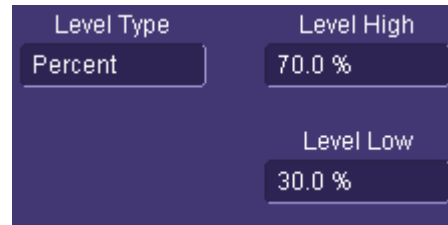
The set Level appears as a dotted horizontal line across the oscilloscope grid.

If initial decoding indicates a number of error frames, make sure that the level is set to a reasonable value.

Protocol Results Table

The protocol results table provides a quick and easy way to understand all of your FlexRay data as decoded by the oscilloscope, even when messages are too compacted to allow annotation on the display. In addition, the table provides a quick and easy method to look at decode results, and quickly zoom to a specific message. When displayed, the protocol results table appears under the waveform grid.

Idx	Time	Bit Rate/Msg	Frame ID	Header CRC	Cycle ...	Data	Trailer CRC	
52	3.22594 mS	9.9980869e+6	30	1597	15	0x696e 0x100 0x302 0x504 0x706 0x908	172708	▲
52	3.30131 mS	9.9899355e+6	33	954	15	0x696e 0x100 0x302 0x504 0x706 0x908	3323532	
52	3.32594 mS	9.9979330e+6	34	421	15	0x696e 0x100 0x302 0x504 0x706 0x908	16649522	
52	3.40131 mS	9.9898094e+6	37	1134	15	0x696e 0x100 0x1 0x504 0x706 0x908	9410881	
52	3.42594 mS	9.9979356e+6	38	1649	15	0x696e 0x100 0x302 0x504 0x706 0x908	7987688	
52	3.50131 mS	9.9902692e+6	41	1943	15	0x696e 0x100 0x302 0x504 0x706 0x908	15236328	
52	3.52593 mS	9.9985595e+6	42	1416	15	0x696e 0x100 0x302 0x504 0x706 0x908	2410326	
52	3.60130 mS	9.9898831e+6	45	67	15	0x696e 0x100 0x302 0x504 0x706 0x908	7311410	▼
53	3.62593 mS	9.9978341e+6	46	604	15	0x696e 0x100 0x302 0x504 0x706 0x908	10693516	

The slider bar on the right can be used to navigate through the protocol table. If the slider bar is yellow, then you can use the Adjust knob on the oscilloscope front panel to move the slider bar.

If you touch a row, a decoded zoom trace is created and displays that message trace in a zoom.
The table is only shown if the View Table checkbox is checked and decode has occurred on the trace. Only one protocol table can be viewed at a time. As described in the preceding section, the protocol table can be configured or exported. If you press the Configure Table button in the Decode Setup dialog box, a pop-up dialog similar to the one as follows is shown.
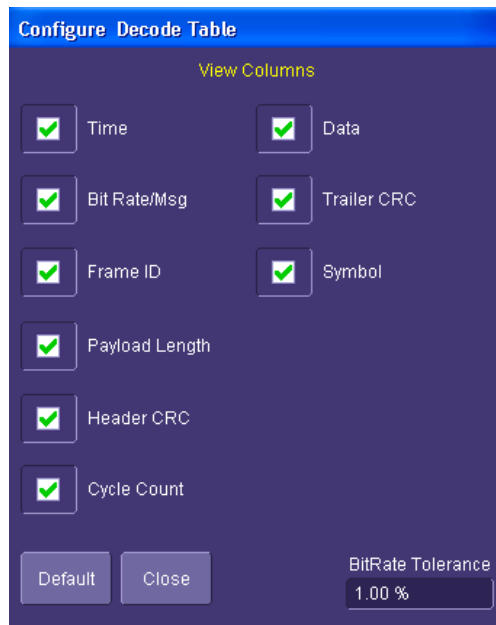
Default – Press the Default button to return to the default state of the table for that particular protocol.

Checkboxes – If you wish the item to be present as a column in the table for that particular protocol, touch the item to check the box.

BitRate Tolerance –This can be set to any value from 0.01% to 10%. If the bit rate is outside the tolerance range set, then the calculated bit rate appears as red text in the table

Searching for Messages

There are several ways to search for specific messages.

1. Touch the decoded waveform to open a pop-up dialog

    OR
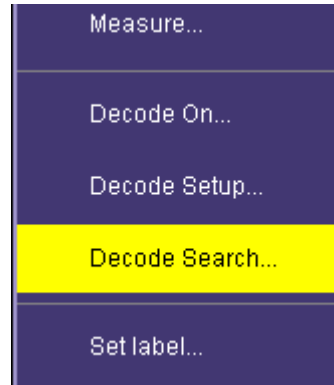
2. Touch the Search button in the Serial Decode Summary dialog box or the Decode Setup dialog box

    OR

3. From the File Menu, go to Math, and choose Zoom Setup to turn a Zoom ON, define its source, and search directly.
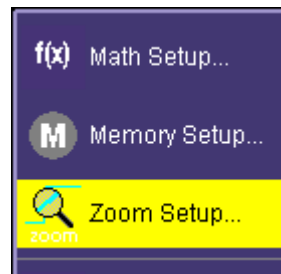
Any of the previous three steps take you to a Zoom dialog box with Search functionality in its own dialog box section at the right.
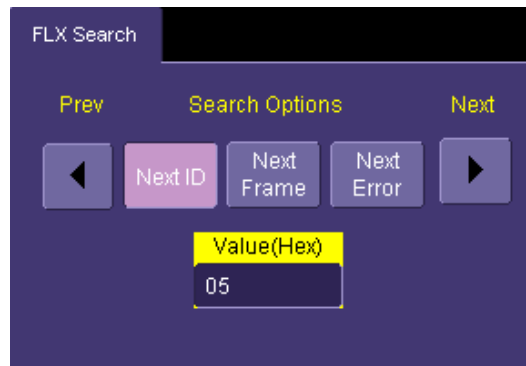
Use the Search Options buttons to define the type of Search you want, enter a value in Hexadecimal format, and use the left and right arrows to move your way from one message to the next.

Eye Diagram and Mask Test Setup Detail

The Left Hand side of the FlexRay Physical Layer tab has all the settings for Eye Diagram Mask testing as seen below.

Input Signal Setup

Source – The pop-up dialog is used to select the channel, math or memory waveform to use for the eye diagram creation

Bitrate – The eye diagram can be created from FlexRay waveforms with bitrates of 2.5 Mb/s, 5 Mb/s and 10 Mb/s as defined in the FlexRay specification. The value can be entered by using the arrow keys or touching the field and entering a value.
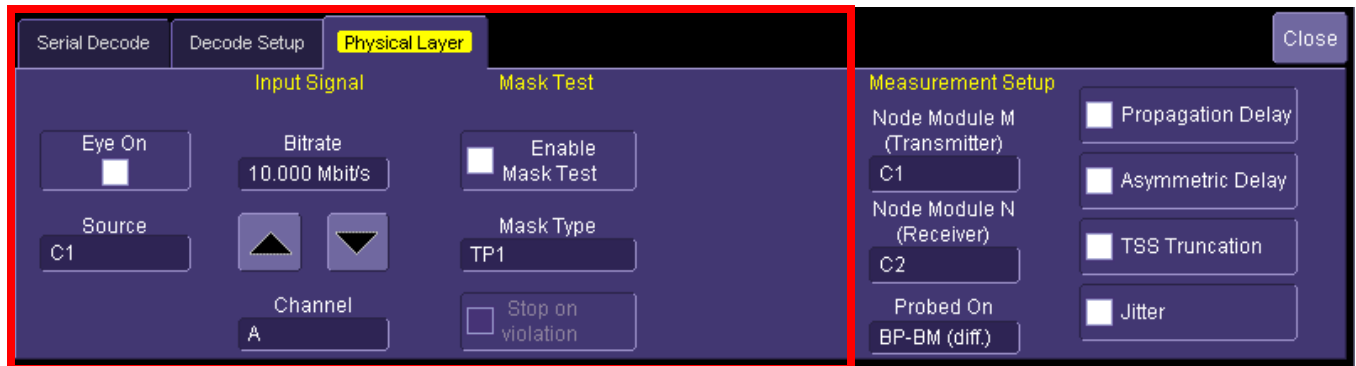

Channel – Select the appropriate FlexRay channel if the signal being used for the eye diagram is from Channel A or Channel B of the FlexRay bus.
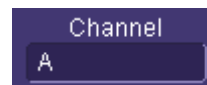
Eye On/Off – Toggle this button on and off to turn the eye diagram on and off

Note: The time required to build an eye diagram of long memory waveforms is longer than if short memory was used

Mask Test Setup

Mask Type – Select the desired mask for testing. Choices include TP1 and TP4, these are the only masks defined in the FlexRay specifications

Mask Test On/Off – Toggle mask testing on and off to perform the test. Mask violations appear with red failure indicators
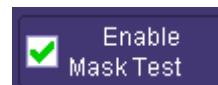
Testing Action – Select the Stop on Action capability to stop the oscilloscope from triggering once a failure occurs to understand where the failure occurred.

Mask Test Display

The FlexRay TDP option allows you to verify signal integrity of the communication channel and corresponding protocol data simultaneously as seen below. Points where the FlexRay signal intersects the mask are indicated with red failure marks.
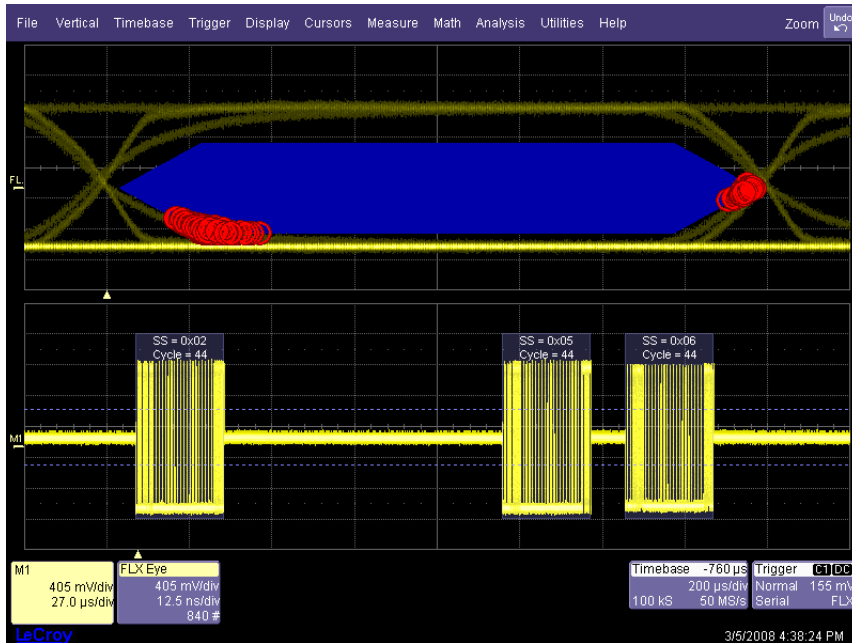
10 Mb/s FlexRay signal being tested on a TP1 mask

Physical Layer Measurement Parameters

The FlexRay TDP option provides four measurement parameters that are defined in the FlexRay physical layer specification. These measurements characterize timing properties of the signal along the communication channel.

Propagation Delay   This measurement is made on two points along the communication channel from the emitter node module to the receiver node module. Propagation Delay characterizes the propagation time of the signal using the first transition of the Bye Start Sequence (BSS).

Asymmetric Delay   This measurement is made on two points along the communication channel from the emitter node module to the receiver node module. Asymmetric delay characterizes the difference in delay between rising and falling edges.

Truncation   This measurement is made on two points along the communication channel from the emitter node module to the receiver node module. Truncation measures the change in width of the TSS.

Jitter   This measurement is made at on point, usually the receiving node Jitter measures the change of length between the last BSS and the FSS. This should usually be $1\mu s$.

Physical Layer Measurement Setup Detail

The Right Hand side of the FlexRay Physical Layer tab has the settings for physical layer measurements.
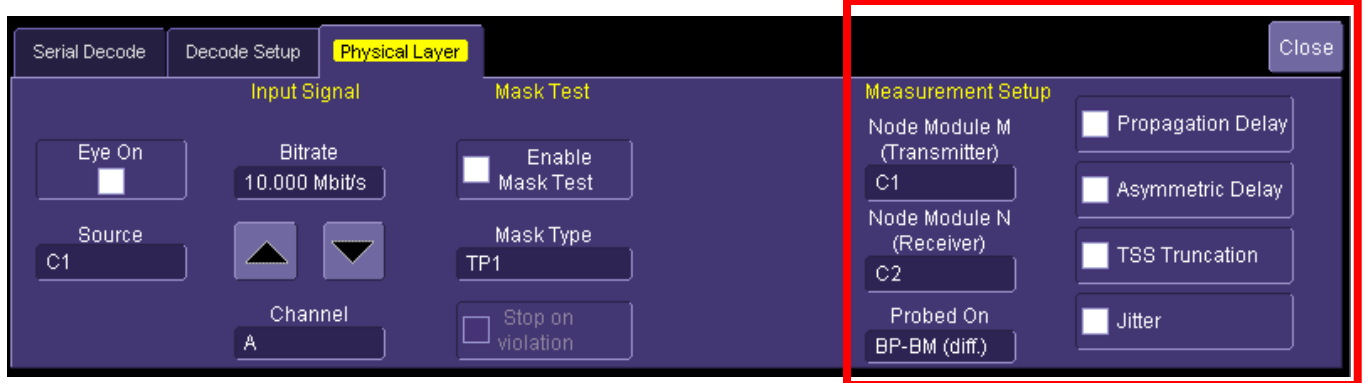
Measurement Parameter Setup

Source – Select the emitting and receiving nodes on the FlexRay channel where Propagation Delay, Asymmetric Delay and Truncation are being measured. Jitter is measured on a single channel.
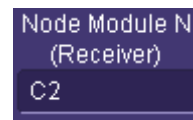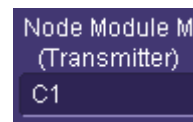
Measurements – Select one of the 4 FlexRay physical layer measurements. As the boxes are checked the measurement values are shown.
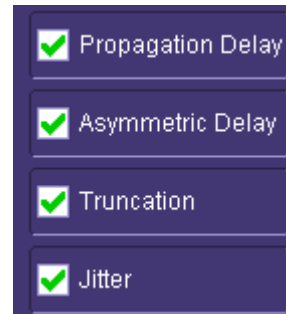
Probing point – Select the type of line you are probing on:
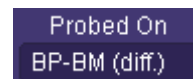
BP-BM (diff.) if the signal is a differential signal on the communication channel

RxD-TxD (dig.) if the signal is the two level digital signal of the communication controller interface

Viewing the Physical Layer Measurements

FlexRay physical layer measurements appear in the Measurement Table just as any other measurements would, directly under the waveform grid.

Measure	PrDly(C2,C3)	AsDly(C2,C3)	Trunc(C2,C3)	Jitter(C2)
value	7.145 ns	-66 ps	1.044 ns	1.000091 µs
status	✔	✔	✔	✔

Just like other measurement parameters statistical information can be displayed and the results can be shown visually in a histicon directly below the measured values.
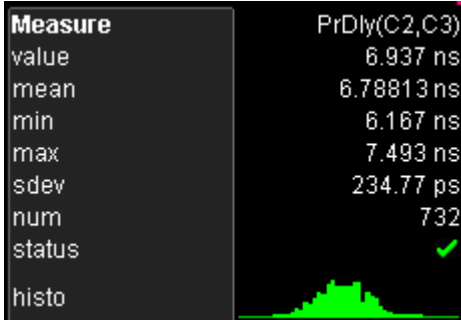
FlexRay measurements can be selected as the source for track, trend or histogram functions. More detail on these functions is described in a different section of this manual.

USING THE FLEXRAY PACKAGES: CHARACTERIZING EMBEDDED CONTROLLER PERFORMANCE

Overview

The standard oscilloscope contains a number of built-in tools, such as cursors, measurement parameters, and statistical analysis. These can be used to characterize performance for serial data signals just as they would be used to characterize performance on any other signals. You may want to use cursors for making single-shot timing measurements, and measurement parameters when you need to accumulate statistical data over many different acquisitions. In addition, measurement parameters are also helpful to determine the underlying integrity of the FlexRay physical signals.

FlexRay TDP, TD and D packages provide basic tools to characterize embedded controller performance. These tools can be used on the decoded channels, memories, zooms, functions, etc. just like they are used on any undecoded channels, memories, zooms, functions, etc. In addition, you can use normal Edge or SMART Triggers on an analog channel input to trigger the oscilloscope when a certain analog signal occurs, and then measure to a particular FlexRay frame using the decoded info as your guide.

Note: The examples shown below are using CAN bus messages, but the included oscilloscope tools described in the following sections can be applied in the same way.

For instance, take the example below of an analog signal creating a burst of CAN messages.
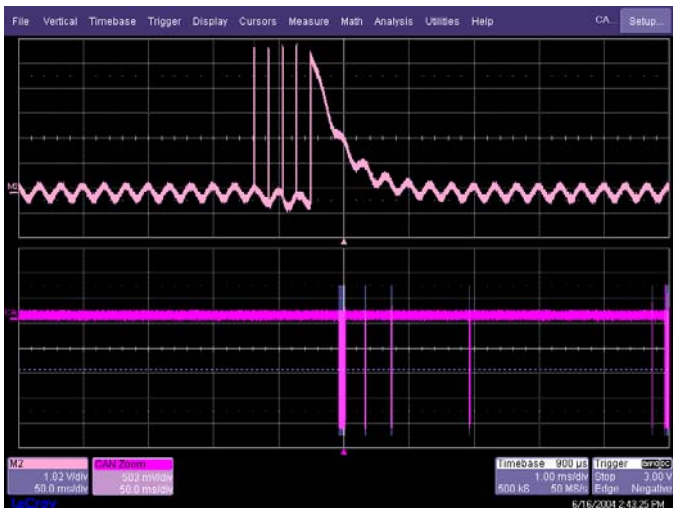
This data was acquired over a 500 ms duration. It is likely that you want to understand whether the analog signal input to your electronic control unit (ECU) is creating the desired CAN message output from the ECU. There are a number of ways that this could be done.

Using Cursors

Use horizontal cursors to mark locations on the waveform where the time measurement should be done, then read the cursor values to establish the measurement. As necessary, adjust the timebase or create zooms of the decoded trace(s) so as to be able to view the signal with enough detail. This is a good method for single-shot / single measurements.
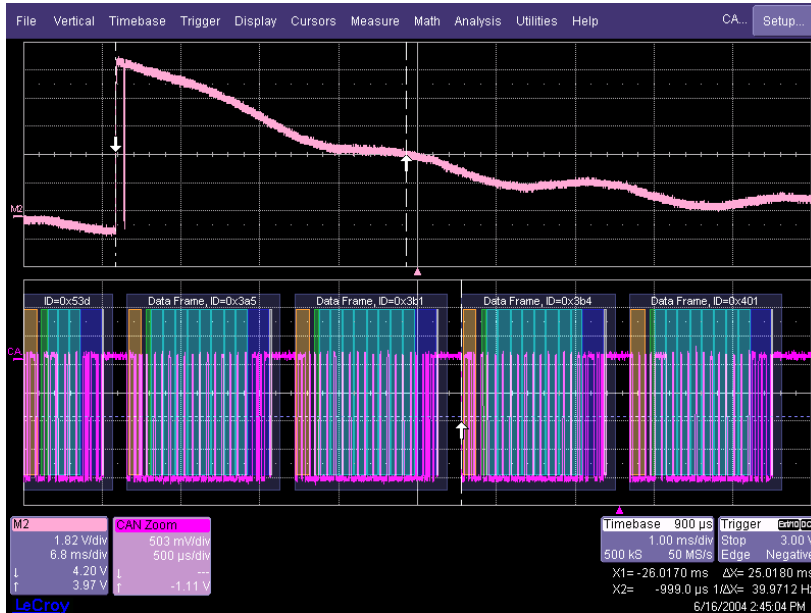
Using Measurement Parameters

Measurement parameters can be used to make signal integrity or timing measurements of your serial data signals. Basic parameters, such as Amplitude, Rise, Fall, Overshoot, etc. are ideal for signal integrity checks. Timing parameters, such as Delay, Delta Delay, Delta Time @ Level, etc., are ideal for measuring timing from trigger to other signals (such as from an I^2C or SPI Trigger to an analog signal). Delta Trig Time is ideal for measuring the time between segments of a Sequence Mode acquisition (Reference the chapter on Isolating and Analyzing Serial Bus Activity for more information on Sequence mode).

Amplitude – Noise and overshoot resistant measurement of the amplitude of the signal (measurement of amplitude from Top to Base).

Base – Value of the lowermost state in a bi-modal waveform

Delay – Time from the trigger to the first transition at the 50% amplitude crossing.

Delta Delay – Time between the 50% crossing of the first transition of two waveforms.

Delta Time @ Level – Time between selectable levels of two waveforms.

Delta Trig Time – The time from last trigger to this trigger (usually used in Sequence mode).

Fall (90-10), Fall 80-20, Fall@Level – Transition time on the falling edge. Three selections are available for the user to determine at which vertical level the measurement is made.

Maximum – Highest value in the input waveform.

Mean – Average of all data values.

Minimum – Lowest value in the input waveform.

Overshoot Negative – Overshoot following a falling edge.

Overshoot Positive – Overshoot following a rising edge.

Peak to Peak – Difference between the Maximum and Minimum data values.

Rise (10-90), Rise (20-80), Rise@Level –Transition time on the rising edge. Three selections are available for the user to determine at which vertical level the measurement is made.

Top – Value of the uppermost state in a bi-modal waveform

Measurement Gating

Gating is available on each standard parameter to allow you to set a measurement window that the parameter should be active in. This allows you to eliminate unwanted portions of the acquisition from your measurement.

Select gating from the Measure dialog by selecting the tab for the appropriate measurement (P1, P2, etc.) and then setting the start and stop for the gate. Reference the oscilloscope's on-line Help for more information on how to set gating.
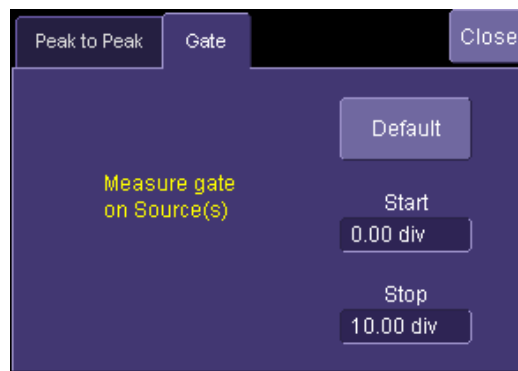
Using Statistics and Graphing

Statistics and Histicons are included with nearly every LeCroy oscilloscope They allow you to gather numerical and visual information on the distribution of your various measurements. You can turn on Statistics and Histicons separately in the Measure dialog. Simply touch the appropriate box to checkmark it and turn it ON, or touch it again to turn it OFF.

In addition, some optional LeCroy programs (such as JTA2) add capability to produce larger histograms, trends, and tracks of your measurement parameters. If you have this capability, then you can access it through the Measurement Parameter setup dialog (the Px tab).

24
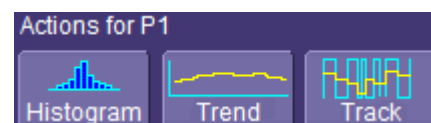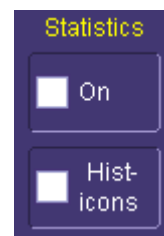
Pass/Fail Analysis with Measurement Parameters

Pass/Fail analysis using measurement parameters is quite simple to set up and quite powerful. For instance, you can define a timing measurement, define the limits for the timing measurement, and then run the oscilloscope in a Normal trigger mode, capturing thousands of measurement events. Then, for example, Pass/Fail can be used to save the Waveform in the event of a Fail, or send an email in the event of a fail.
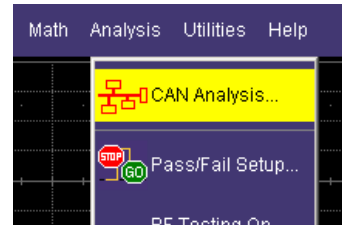
Set up Pass/Fail conditions by touching Analysis in the menu bar, then selecting Pass/Fail Setup. Reference the oscilloscope's on-line Help for more detail on pass/fail setup.

ISOLATE AND ANALYZE SERIAL BUS ACTIVITY

The combination of Serial Data Triggering, Decoding, and normal oscilloscope features is a powerful combination of tools that can make it very easy to find latent Serial Data HW or SW problems in your circuit. No longer is the oscilloscope a tool just for the hardware engineer. Now the software engineer can also easily visualize the Serial Data signals and relate it to programming code and operation. The TD options can enable the HW Engineer and SW Engineer to "speak the same language" when it comes to system debugging and performance checking. Some common Serial Data analysis needs and methods are discussed below:

Capture Long Pre-Trigger Time

LeCroy oscilloscopes are available with optional very long acquisition memory. For instance, the WaveRunner Xi Series oscilloscopes can capture up to 12.5 Mpts on 4 channels, or 25 Mpts on 2 channels. If your Serial Data signals are 1 Mb/s, and you sample at the minimum required and available sample rate (5 MS/s, you would be able to capture 5 seconds of Serial Data traffic. If you wish, this can be 100% pre-trigger, 100% post-trigger, or something in between.

1. Adjust Pre-Trigger and Post-Trigger time by adjusting the Delay knob on the oscilloscope's front panel.
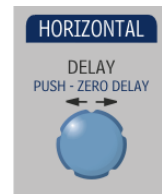
2. Optimize your Sample Rate or Memory Length by accessing the Horizontal Dialog in your oscilloscope and selecting either Set Max Memory mode or Fixed Sample Rate mode.

3. **Set Max Memory** can be used to decrease the memory usage in order to not sample at rates you specify as being too high (high sample rates can slow down the decoding algorithm). Then adjust your time timebase setting to the length needed to capture the event.
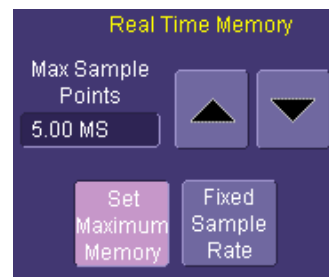
Note: Make sure your combined timebase and memory length settings do not result in too low of a sample rate. Otherwise, adequate capture and decode is not performed.

4. It's common to fix the sample rate to a specified value so you have the necessary oversampling to capture your Serial Data messages (at least 4X the bit rate). This also allows for a high enough sample rate to capture transients you may want to see on your Serial Data and analog signals (at least 2X the frequency of any expected transients, preferably 10X).

Reference your oscilloscope's Online help for more information on these common settings.

Trigger Repeatedly, Save Data to a Hard Drive

You may wish to set up your oscilloscope to capture a short or long memory acquisition for a certain trigger condition, then save data to a hard drive or memory stick whenever the trigger condition is met. This can be easily done in most LeCroy oscilloscopes. However, you must realize that there is significant trigger "dead time" when using this method. To minimize dead time, use the method described under Trigger Repeatedly, Store all Triggers (Sequence Mode).

1. First, set up your desired serial data (or other) trigger condition.

2. Then, choose **File → Save Waveform** from the menu bar. A dialog is shown where you can set Save Waveform conditions.

   You can set Save Waveform conditions as follows:

- **OFF** - No Auto Saving occurs

- **WRAP** - Auto Save occurs until the hard drive is filled, then discards the oldest data to write the newest data

- **FILL** - Auto Save occurs until the hard drive is filled

3. Be sure to choose a **Binary file format** if you wish to recall the traces into a LeCroy oscilloscope for later analysis.
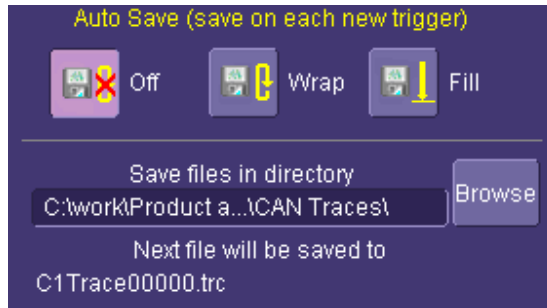
Even though the LeCroy oscilloscope hard drives are very large, it is a good idea to make sure that your trigger condition is set correctly before beginning your acquisitions.

> **Note:** This method is not guaranteed to capture all of your trigger events, since there is a large amount of "dead time" between triggers as the acquisition is captured, displayed, and stored to the hard drive before the scope is re-armed for a new trigger. Minimize dead time by using Sequence Mode.

Trigger Repeatedly, Store all Triggers (Sequence Mode)

LeCroy oscilloscope's have a powerful capability called Sequence Mode that allows you to store all triggered events by minimizing the dead time between triggers to < 800 nanoseconds. This is ideal for finding repetitive causes of problems on your serial data buses or associated signals. (Not available in WaveSurfer Series). Sequence Mode uses long acquisition memory that is divided into "segments." As triggered events are acquired, they are stored in acquisition "segments" to be recalled at a later date. The length of each sequence mode acquisition segment and the total number of segments allowed is roughly determined by the total acquisition memory in the oscilloscope. For instance, a WaveRunner Xi with VL memory can acquire 10,000 segments each a maximum of 625 samples long or 10 segments each a maximum of 1.25 megasamples long, or something in between. Different acquisition memory lengths have different ranges of segments and segment lengths. You can define any number of segments from 2 to the maximum for that memory length (reference your oscilloscope's on-line Help), and any length of segment (as long as there is sufficient acquisition memory). After acquisition of all segments is complete, you can recall them one-by-one and view them in decoded format on the oscilloscope screen.

Acquisition dead time is kept to a minimum because there are no operations performed during the acquisition. All data for each triggered event is written only into high-speed acquisition memory. Until the entire sequence is completed, there is no updating of the oscilloscope display, or other operations that cause unnecessary dead time. This is ideal for situations when you cannot take a chance on losing data.

In the example shown below, we have only acquired Channel 1 (the CAN signal) in sequence mode. We could also acquire additional analog or other signals as desired or as necessary to do a proper analysis.

1. Touch the **Timebase** descriptor box to open the Timebase dialog.
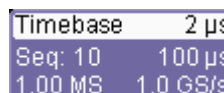
2. In the **Sampling Mode** area, select Sequence Mode. Touch the **Sequence** tab (now showing next to the Timebase tab).
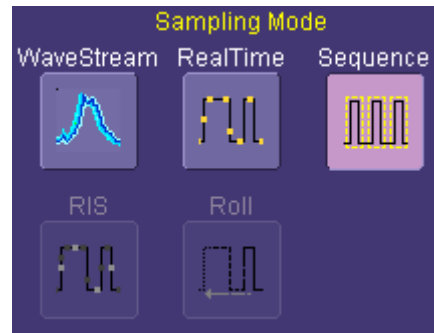
3. On the Sequence tab, select the **Display Mode**. Select the **Number of Segments Displayed** at one time.

4. If you have acquired more segments than you can display at one time, you can choose which segment at which to start the display.

5. As described previously in this manual, set up the Serial Trigger to capture the event you desire. For instance, for instance, you might want to trigger on a specific address or data value, and capture long pre-trigger time to determine what precedes that message. In this example, we've used a simple I^{2}C Start trigger. To begin the sequence mode acquisition, press the front panel SINGLE trigger button. Each time the trigger condition is met, the TRIG'D light on the front panel flashes. When you've acquired the set number of segments, the trigger STOPS and the following display is shown (this is a 50 segment acquisition in Mosaic display mode).
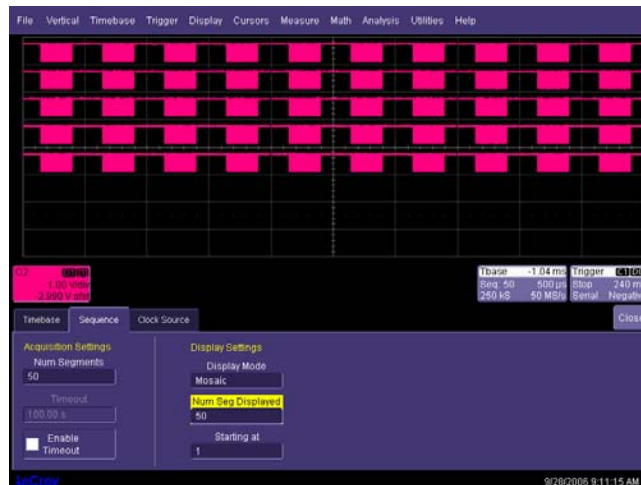
6. Display an individual segment separately from the main channel display by selecting **Math → Math Setup** from the menu bar. Now, choose a math trace to define as a **Segment** (here we're defining F1 as a Segment of C2).
    Use the channel the serial data was acquired on as a source (in this case Channel 2). Check the **TRACE ON** checkbox to display the trace. Select a segment to view by touching the **Select** tab and use either the pop-up keypad or the front panel adjust knob.

7. Set up the Decode to use the Math trace as the source for Data in order to view decoded data on the individual segment (in this case F4 is the source).

    To change the decoded segment, just select a new segment from the Math trace dialog (as shown in the preceding step).
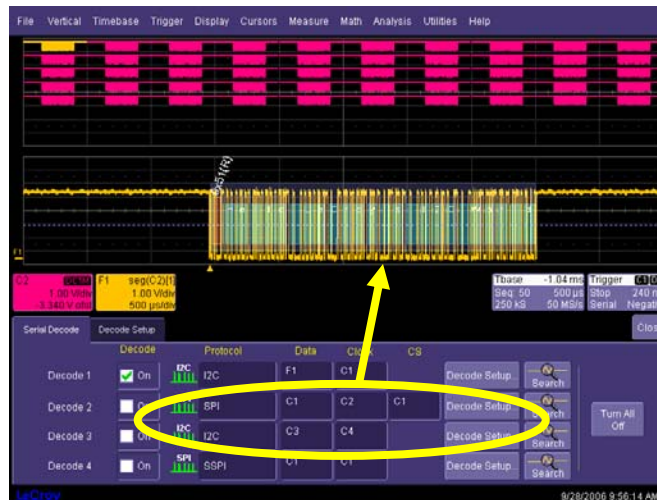
8. Conserve display space, by turning off the Channel and selecting only the segment you wish to view.
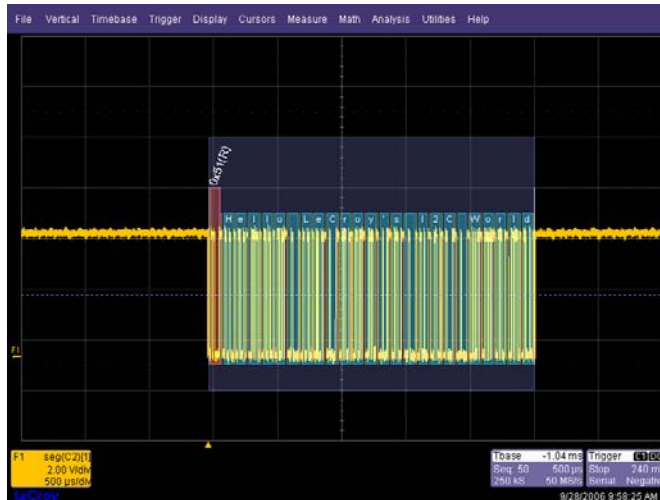

9. View the timestamps for each segment by selecting **Vertical → Channels Status** on the menu bar. On the **Show Status** portion of the dialog, select **Time** (shown right). A display of timestamp information for each segment in the sequence acquisition is then shown (as follows).

Seg	Time	since Segment 1	between Segment
1)	16-June-2004 11:53:35		
2)	16-June-2004 11:53:37	1.617166812 s	1.617166812 s
3)	16-June-2004 11:53:37	1.718687863 s	101.521050 ms
4)	16-June-2004 11:53:37	1.919879959 s	201.192096 ms
5)	16-June-2004 11:53:37	2.423745193 s	503.865234 ms
6)	16-June-2004 11:53:38	3.333904655 s	910.159462 ms
7)	16-June-2004 11:53:40	5.247904552 s	1.913999897 s
8)	16-June-2004 11:53:40	5.347525592 s	99.621040 ms
9)	16-June-2004 11:53:42	7.263465499 s	1.915939907 s
10)	16-June-2004 11:53:43	7.566198649 s	302.733150 ms
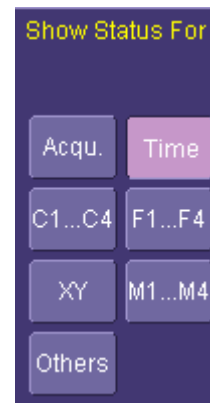
10. Ten timestamps fit on the display at a time. You can choose which 10 to display by using the **Select Segment** control. You can also page through the segments one at a time by using the **Adjust** knob on the front panel.

APPENDIX A – FLEXRAYBUS TDP AND TD SPECIFICATIONS

FlexRaybus TDP	
Definition	
Protocol Setup	Select BitRate (2.5, 5 or 10 Mb/s) Select FlexRay Channel A or Channel B
Decode Capability	
Format	All decoding is hexadecimal except for Cycle Count which is decoded using a decimal format
Decode Setup	Two threshold definitions required. Default is to Percent amplitude. Select BitRate. Select FlexRay Chanel A or Channel B
Decode Input	Any analog Channel, Memory or Math trace.
# of Decoded Waveforms	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).
Location	Overlaid over DATA waveform, on Grid. (Note: Use multi-grid if there is more than one decoder ON)
Visual Aid	Color Coding for TSS, FSS, Frame Qualifiers, Slot ID, Payload Length, Header CRC, Cycle Count, Data, BSS, Payload CRC and FES Decode information is intelligently annotated based on timebase setting.

Trigger Capability	
Format	Hexadecimal or Binary for Frame ID Decimal for Cycle Count
Trigger Setup	Trigger on TSS (Start), Frame ID, Cycle Count, Symbols and Errors Symbols: Channel Idle Delimiter (CID) Symbol, Collision Avoidance Symbol (CAS), Media Access Test Symbol (MTS), Wakeup Pattern (WUP) Errors: Frame Start Sequence (FSS) Error – triggers when the logic high time between the TSS and the first byte is too long Byte Start Sequence (BSS) Error – triggers anytime the BSS pattern is not seen between bytes where expected Frame End Sequence (FES) Error – triggers when the FS is not seen after the last byte
Frame ID and Cycle Count Condition Setup	<=, <, =, >, >=, <>, in range, out of range, don't care.
DATA Setup	Hexadecimal: # Data Bytes = 0 to 8. Data can be defined by nibble. Triggers on that data pattern regardless of position or in user settable location. Binary: Any combination of 0,1, or X for 1-64 bits. Triggers on that data pattern regardless of position or in user settable location.
Bit Rates	2.5, 5.0 or 10 Mb/s selectable.
Trigger Input	Any analog Channel or the EXT input.
Trigger Design	Internal to oscilloscope, settable like any other oscilloscope trigger
Physical Layer Test	
Eye Diagram	Eye diagram creation with mask testing at TP1 and TP4. Mask testing allows for 'Stop on Failure'
Measurements	Propagation Delay, Asymmetric Delay, Truncation, Jitter
Search Capability	
Pattern Search	Search by Next ID, Next Frame, or Next Error in Hexadecimal formats
Other	
Compatible With…	TDP (Trigger, Decode & Physical) and TD (Trigger & Decode) Option fully compatible with WRXi (retrofit kits available and required for some WRXi oscilloscopes) D (Decode) Option fully compatible with WR6000, WP7000, and WM8000 Series.

FlexRaybus TD

Definition	
Protocol Setup	Includes all Decode, Trigger and Search functionality described in FlexRaybus TDP, no Physical Layer Test included