Keysight FlexRay Compliance Test Application

KEYSIGHT TECHNOLOGIES

Methods of Implementation

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FlexRay Automated Testing—At a Glance

Overview

Keysight FlexRay Compliance Test Application software for Keysight InfiniiVision 3000 X-Series, 4000 X-Series, 6000 Series, and 7000 Series Oscilloscopes gives you a fast and easy way to verify and debug the physical layer characteristics of your FlexRay designs. The FlexRay Compliance Test Application lets you automatically run FlexRay conformance tests and displays the results in a flexible report format. In addition to the measurement data, the report provides margin analysis that shows how closely your device passed or failed each test.

The FlexRay Compliance Test Application:

- Lets you select individual or multiple tests to run.
- Lets you decide the type of hardware connection to use (single-ended or differential) and shows you how to make oscilloscope connections to the Device Under Test based on selected connection type.
- Automatically checks for proper Oscilloscope configuration.
- Automatically sets up the Oscilloscope for each test.
- Provides detailed information for each test that has been run and lets you specify the thresholds at which marginal or critical warnings appear.
- Creates a printable HTML report of the tests that have been run.

For more information, see:

- Chapter 1, “Prerequisites,” starting on page 7
  - "Required Equipment and Software" on page 8
  - "Installing Keysight IO Libraries Suite" on page 9
  - "Installing the Software" on page 13
  - "Licensing the FlexRay Test Application" on page 13
- Chapter 2, “About the Tests,” starting on page 15
  - "1.1 Eye Diagram Measurement" on page 16
  - "1.2 Amplitude Measurement" on page 22
  - "1.3 Transition Time Measurement" on page 28
  - "1.4 TSS Width Measurement" on page 34
  - "1.5 Mean Corrected Cycle Time" on page 38
  - "1.6 Signal Integrity Voting Tests" on page 42

For an HTML version to understand how to use the test application & its various features, click **Help>Contents...** within the FlexRay Compliance Test Application to see the *Keysight FlexRay Compliance Test Application Online Help*.

See Also

- The electrical and timing parameters are specified by *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E*.

Contents

1 Prerequisites

Before running the automated tests, you must acquire the required equipment and software and calibrate the Oscilloscope. After the Oscilloscope has been calibrated, you are ready to start the FlexRay Compliance Test Application and perform measurements.

Required Equipment and Software

In order to run the automated tests, you need the following equipment and software:

- One of the following InfiniiVision 4-channel oscilloscopes:
  - 4000 X-Series oscilloscope with:
    - FLEX license (order DSOX4FLEX).
    - MASK license (order DSOX4MASK).
  - 3000 X-Series oscilloscope with:
    - FLEX license (order DSOX3FLEX).
    - MASK license (order DSOX3MASK).
    - SGM license (order DSOX3SGM).
  - 6000 Series or 7000 Series oscilloscope with:
    - Software version 6.00 or greater.
    - Option FLX (N5432C) license, or Option FRS (N5432A) with N5432U upgrade license.
- Differential active probe. Keysight recommended probes include:
  - N2792A 200 MHz differential active probe.
  - N2793A 800 MHz differential active probe.
  - 113xA InfiniiMax differential active probe.
- FlexRay Physical Layer Conformance Test Application software.
- Keysight I/O libraries version 15.0 or greater.
- FlexRay device under test.

Controller PC Requirements

To ensure adequate performance, the FlexRay Physical Layer Conformance Test Application requires a controller PC with these characteristics:

- Processor: Intel Pentium 4 Processor 3 Ghz or better.
- RAM: 2 GB or better.
- Operating System: Windows XP 32-bit.

Installing Keysight IO Libraries Suite

The controller PC must have installed Keysight I/O libraries version 15.0 or greater.

The Keysight IO Libraries Suite software can be downloaded from the Keysight web site at: "www.keysight.com/find/iolib"

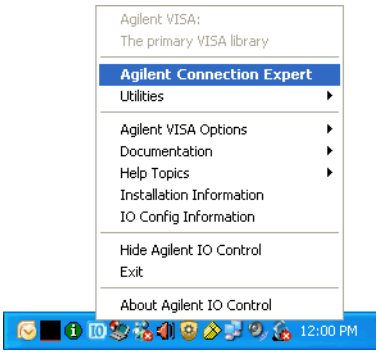
- "Adding Your Oscilloscope Using Keysight Connection Expert" on page 9

Adding Your Oscilloscope Using Keysight Connection Expert

This procedure only needs to be performed once for each oscilloscope used to perform FlexRay conformance measurements.

NOTE **The menus and dialogs shown here may differ slightly depending on the version of the Keysight IO Libraries Suite.**

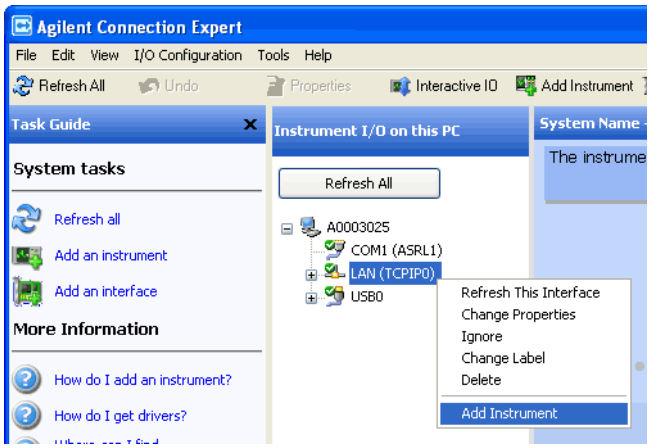
1 On the PC that will run the FlexRay Test Application, choose **Start > All Programs > Keysight IO Libraries Suite > Keysight Connection Expert** from the Windows Start menu. Or, click on the Keysight IO Control icon in the taskbar, and choose Keysight Connection Expert from the popup menu.



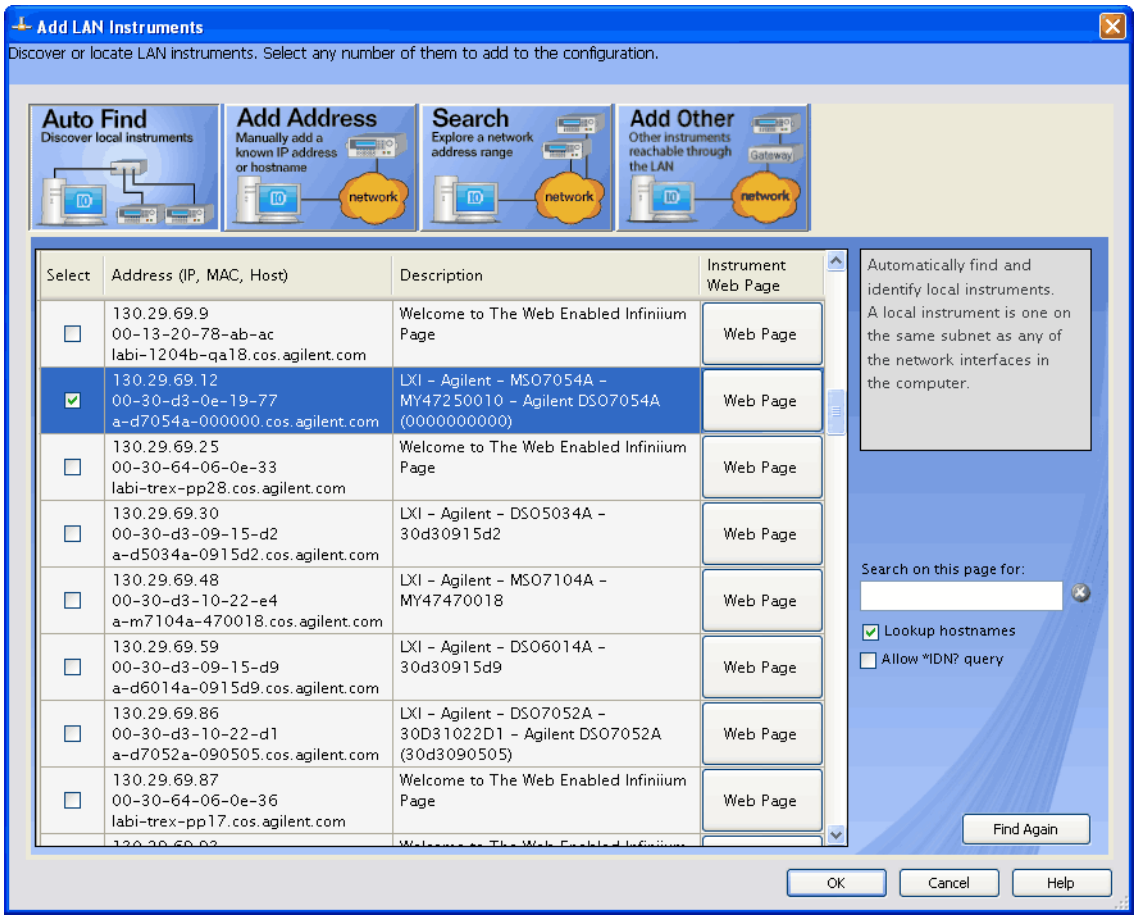
2 In the Keysight Connection Expert application, instruments connected to the controller's USB and GPIB interfaces should automatically appear. (You can click Refresh All to update the list of instruments on these interfaces.)

You must manually add instruments on LAN interfaces:

a Right-click on the LAN interface, choose **Add Instrument** from the popup menu, and click **OK** in the resulting dialog (because the desired interface is already selected).



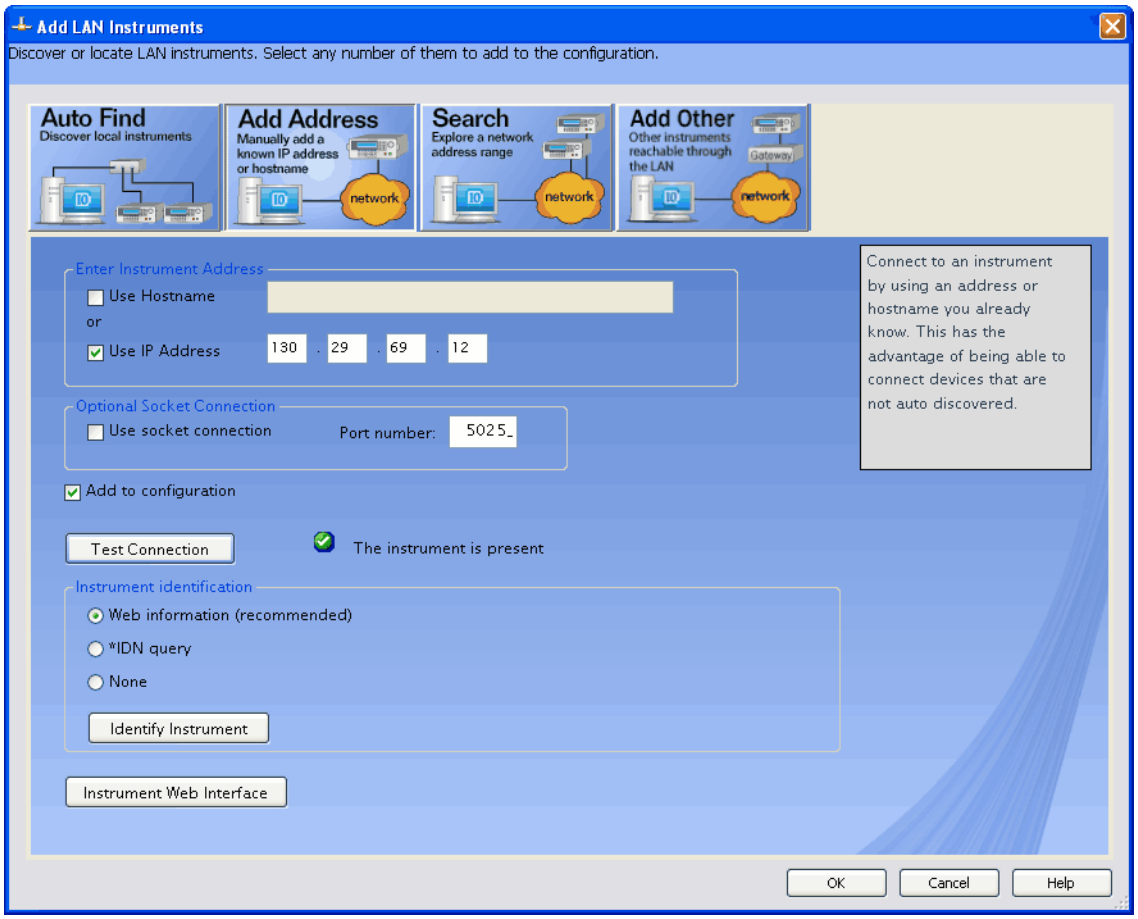
b If the oscilloscope is on the same subnet, select it and click **OK**.



Otherwise, click **Add Address** (or if you have a version of the IO Libraries that doesn't have Auto Find, select the LAN interface and click **OK**).

c In the next dialog, select either **Hostname** or **IP address**, and enter the oscilloscope's hostname or IP address.

d Click **Test Connection**.



e If the instrument is successfully opened, click **OK** to close the dialog. If the instrument is not opened successfully, go back and verify the LAN connections and the oscilloscope setup.

3 In the Keysight Connection Expert application, choose **File > Exit** from the menu to exit the application.

Installing the FlexRay Physical Layer Conformance Test Application software

You must install the FlexRay Physical Layer Conformance Test Application on a controller PC that is connected to the InfiniiVision 3000 X-Series, 4000 X-Series, 6000 Series, or 7000 Series oscilloscope via LAN or USB.

- "Installing the Software" on page 13
- "Licensing the FlexRay Test Application" on page 13

Installing the Software

Install the FlexRay Test Application software from one of the following download web pages:

- "http://www.keysight.com/find/flexray3000" (for 3000 X-Series oscilloscopes)
- "http://www.keysight.com/find/flexray4000" (for 4000 X-Series oscilloscopes)
- "http://www.keysight.com/find/flexray" (for 6000 Series and 7000 Series oscilloscopes)

To install the software:

1. If you have an InfiniiVision 6000 Series or 7000 Series oscilloscope, make sure you have version 6.00 or higher of the oscilloscope firmware by choosing **[Utility] > Service > About Oscilloscope** from the front panel.
2. Download the FlexRay Physical Layer Conformance Test Application install package from the Keysight web site to your controller PC.
3. Run the install package executable file and follow its instructions.

   Be sure to accept the installation of the .NET Framework software; it is required in order to run the FlexRay Physical Layer Conformance Test Application.

Licensing the FlexRay Test Application

The FlexRay Physical Layer Conformance Test Application software comes standard with:

- DSOX3FLEX on 3000 X-Series oscilloscopes.
- DSOX4FLEX on 4000 X-Series oscilloscopes.
- Option FLX (N5432C) on 6000 Series and 7000 Series oscilloscopes, which automatically licenses Option FRC. Option FRC in the oscilloscope is the only requirement.

  Previous Option FRS (N5432A) customers can order the N5432U upgrade to get Option FRC.

Option FRC is an oscilloscope-locked license – this enables any FlexRay Physical Layer Conformance Test Application to connect to and use a licensed oscilloscope. This type of license permits multiple users to share an oscilloscope using a single license.

To install option licenses

On 3000 X-Series and 4000 X-Series oscilloscopes:

1. Follow the instructions on the Entitlement Certificate you received with your FlexRay option purchase.
2. Your license file will be delivered via e-mail.

   License files are loaded from a USB storage device using the oscilloscope's File Explorer.

On 6000 Series and 7000 Series oscilloscopes:

1. Follow the instructions on the Entitlement Certificate you received with your FlexRay option purchase.

   You will need the unique identifier for the oscilloscope. You can find the Instrument ID by choosing **[Utility] > Options > Licenses > Show license information** from the front panel.
2. Your license will be delivered via e-mail.

   The e-mail will contain an alphanumeric code. Enter this code directly into your instrument using the oscilloscope's interface (see the oscilloscope documentation for instructions on how to install feature licenses).

2 About the Tests

1.1 Eye Diagram Measurement

Test Overview

The purpose of this test is to verify that the DUT meets the specified eye template requirements as specified in Chapter 7, Figure 7-2 (TP1) and Figure 7-3 (TP4) of the *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E.*

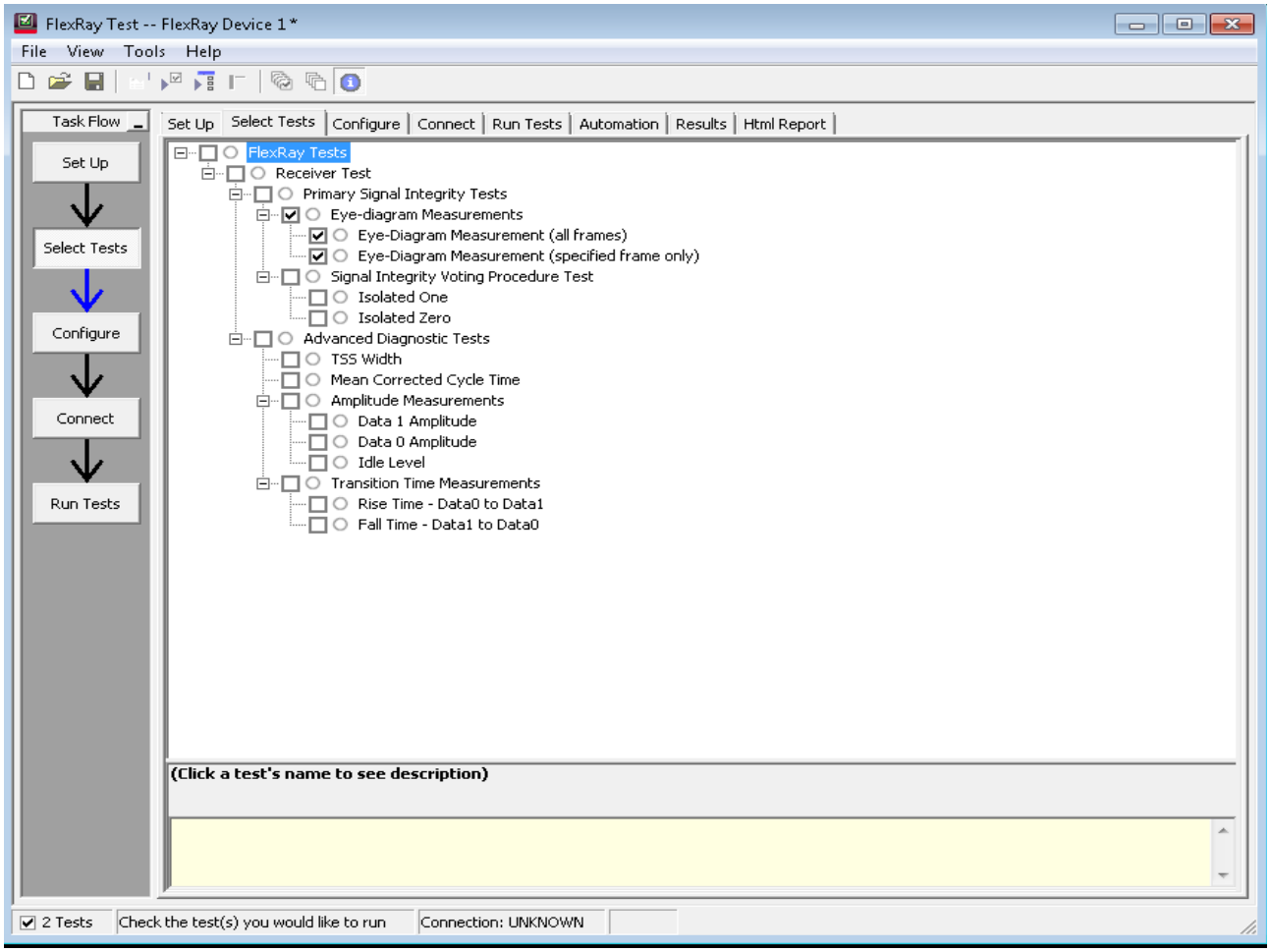


Figure 1 Selection of Eye Diagram Tests in the Compliance Test Application

TP1 Eye Diagram—A FlexRay bus driver shall meet the eye diagram requirements with test load defined in section 7.2.1 of the *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E*; a TxD signal with rise and fall times of 6ns (which is 20%-80% of V_{10}) and a perfect bit duration of 100ns.

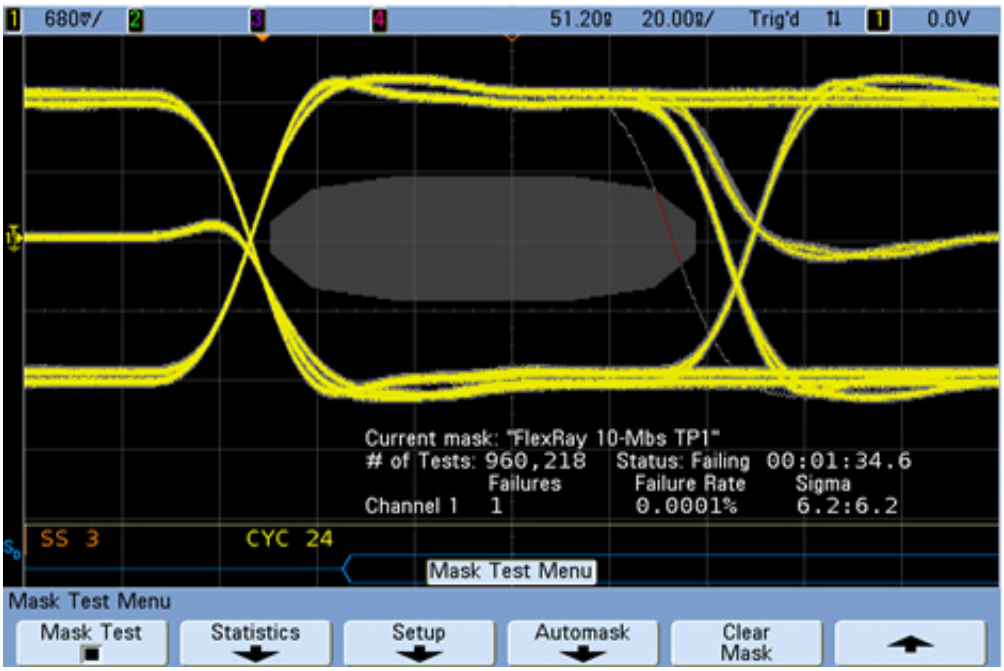


Figure 2TP1 FlexRay Mask

TP4 Eye Diagram—A prerequisite to successful decoding of the FlexRay communication element in the receiving communication controller is through a proper analog input signal at the receiving bus driver. You may assess this with the eye-diagrams defined in this test.

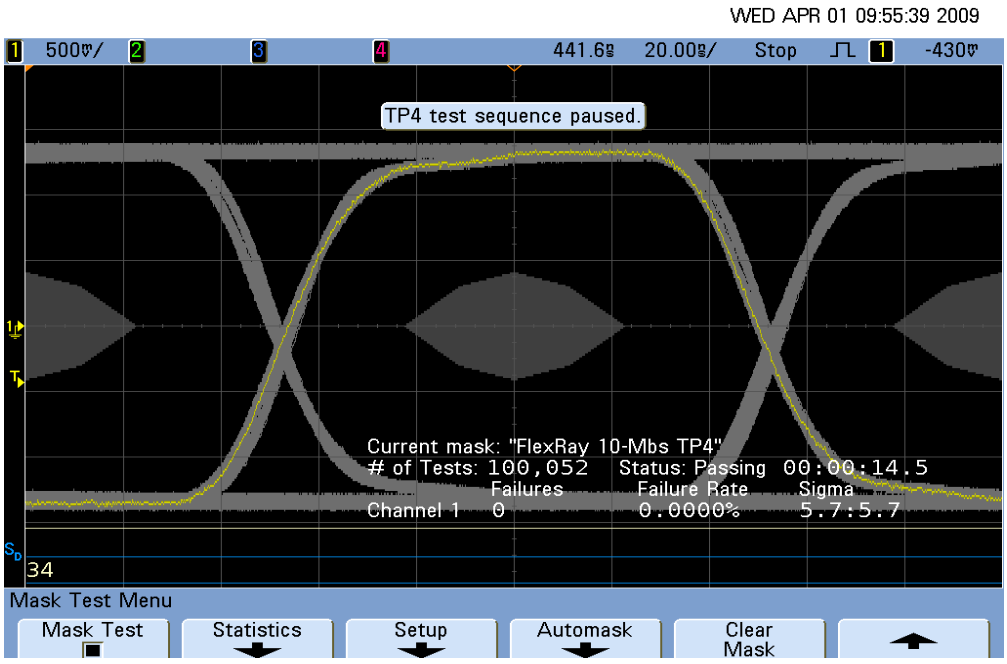


Figure 3TP4 FlexRay Mask

References

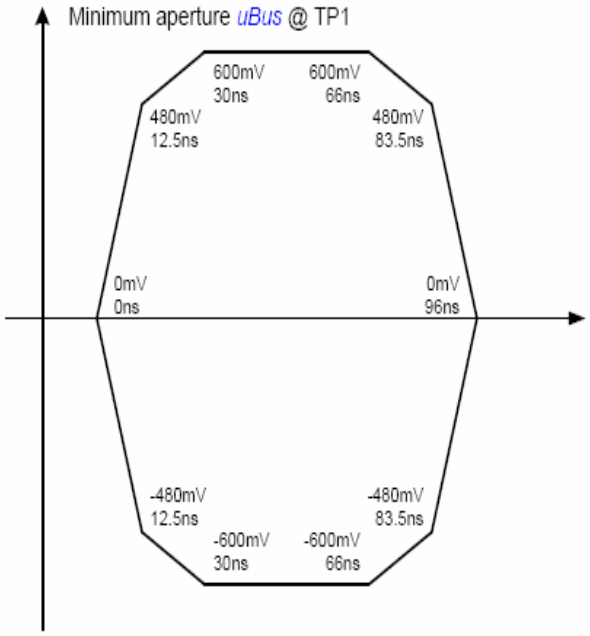


Figure 7-2: Required waveform at TP1.

Figure 4 Required Waveform at TP1

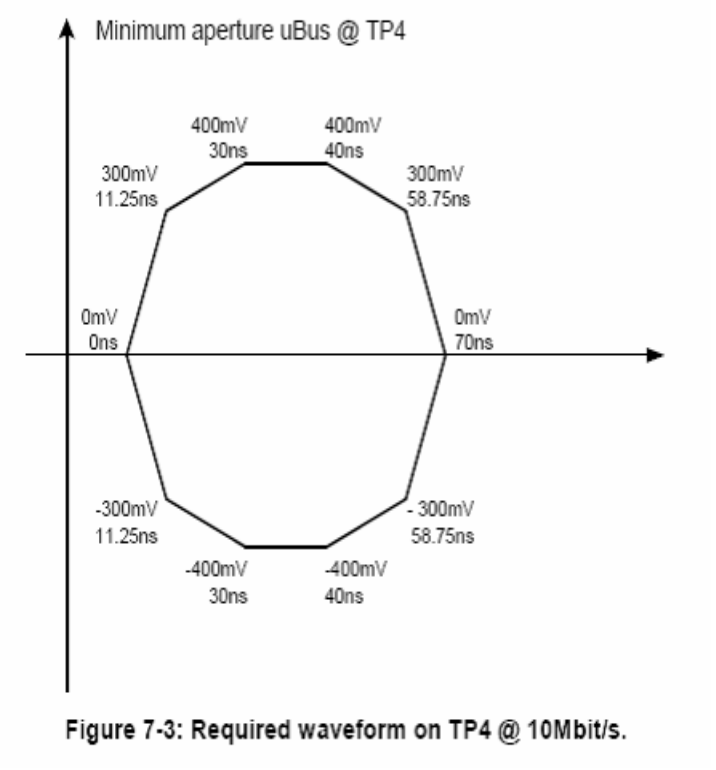


Figure 5 Required Waveform on TP4 at 10 Mbps

Eye Diagram Mask Test

Only for systems with a baud rate of 10 Mbps, the eye diagram has captures and overlays of multiple bits from ALL frames that are referenced to triggering on alternate rising and falling edges at the ideal 0.0 V crossing point at the selected test plane (which is either TP1 — output of a Bus Driver or TP11 — output of an Active Star). The eye diagram test runs for a default value of **100000** captured bits, which is set under **Number of Waveforms (Eye-diagram tests)**. You may modify this value in the **Configure** tab of the FlexRay Compliance Test Application. The measured results, which consists of number of failed bits and the overall Pass/Fail criteria, are compared against the appropriate specified mask, that is:

TP1—Standard Voltage Transmitter or Increased Voltage Transmitter

TP11—Standard Voltage Transmitter or Increased Voltage Transmitter

The *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E* specifies that the transmitter eye diagram mask test is primarily used to test differential outputs of Bus Driver and Active Star devices when the input for these devices is stimulated using a 10 Mbps pulse train from a signal generator source. When you perform measurements using frames

generated by a random FlexRay Communication Controller, the test results are considered as information-only and you must consider these results for physical layer conformance.

In addition, if you are testing a synchronous multi-node system, note that since the eye diagram test overlays bits from ALL frames, some of the captured bits (generated from frames of the other nodes/ECUs in the system) are actually "received" bits and not "transmitted" bits. If this test passes, it is an assurance that the quality of the signals from the transmitter under test also passes. However, if this test fails, the cause of failure could be the testing of attenuated signals that are generated from nodes/ECUs, which are remotely located from the transmitter under test.

Test Procedure

1. Configure the FlexRay DUT such that it acts as a source for FlexRay signal.
2. Reset the Oscilloscope.
3. Load either TP1 or TP4 mask file on the Oscilloscope.
4. Stop **Acquisitions**.
5. Clear the Oscilloscope Display.
6. Set the minimum number of acquisitions to **100K tests**.
7. Start the Mask Test.
8. Run the **Total Failure** query when the test is complete.
9. Transfer the Image.
10. Compare the test results with the compliance test limits.

Expected/Observable Results

For all eye diagram tests, the signal must not violate the eye mask specified in Figure 1.1.1 and Figure 1.1.2 of the *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E.*

1.2 Amplitude Measurement

Test Overview

The purpose of this test is to verify that the Amplitude (Data1, Data0 and Idle Level) of the Device Under Test (DUT) is within the conformance limits as specified in Figure 2.1.1 and Figure 2.1.2 of the *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E.*

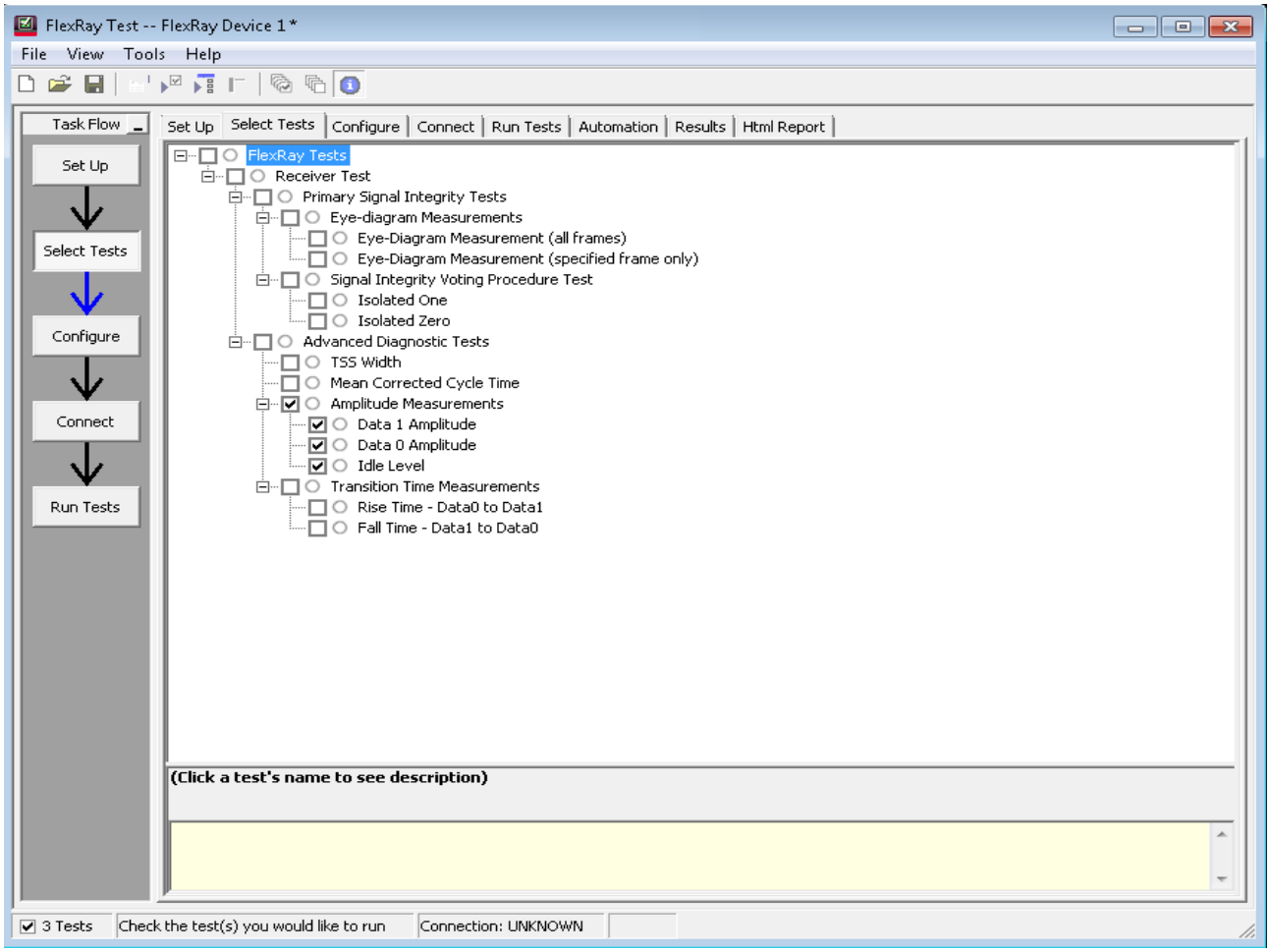


Figure 6 Selection of Amplitude Measurement Tests in the Compliance Test Application

Data1 Amplitude (+uBDTx-active): Measures the maximum steady-state level (V_{top}) of the differential Data1 (active high) signal within the specified frame at a transmitter test plane differential probing point. Compare the measured results against the specified test limits of 600mV < +uBDTx-active < 2.0V.

Data0 Amplitude (-uBDTx-active): Measures the minimum steady-state level (V_{base}) of the differential Data0 (active low) signal within the specified frame at a transmitter test plane differential probing point. Compare the measured results against the specified test limits of -2.0V < -uBDTx-active < -600mV.

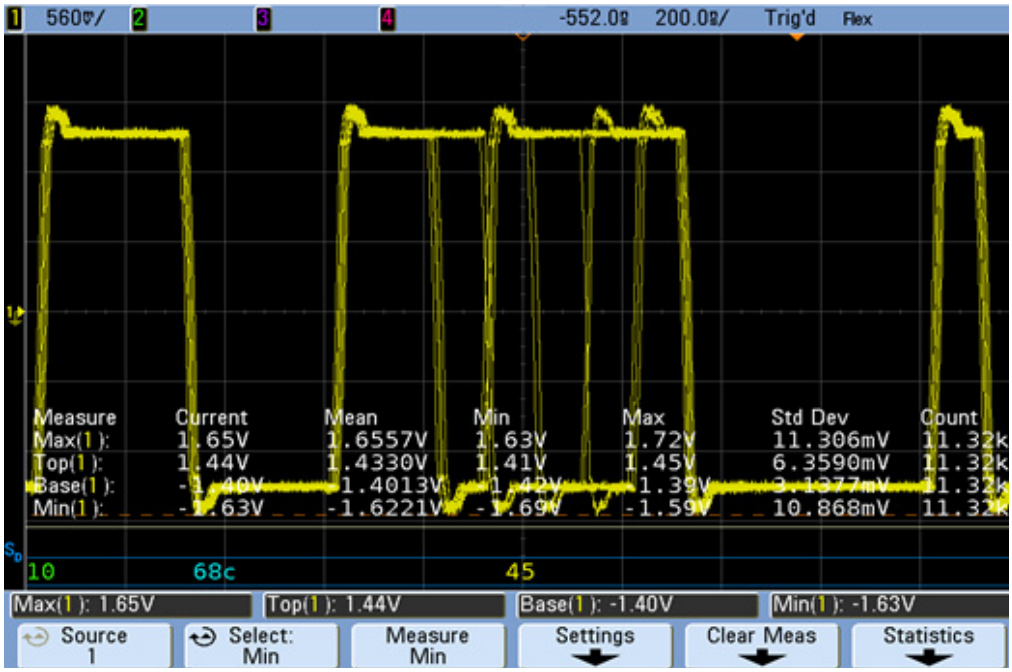


Figure 7 Measuring Data1 and Data0

Idle Level (uBDTx-Idle): Measures the average voltage level of the idle level signal prior to the occurrence of the TSS event of the specified frame at a transmitter test plane differential probing point. Compare the measured results against the specified limits of -30mV < uBDTx-Idle < +30 mV.

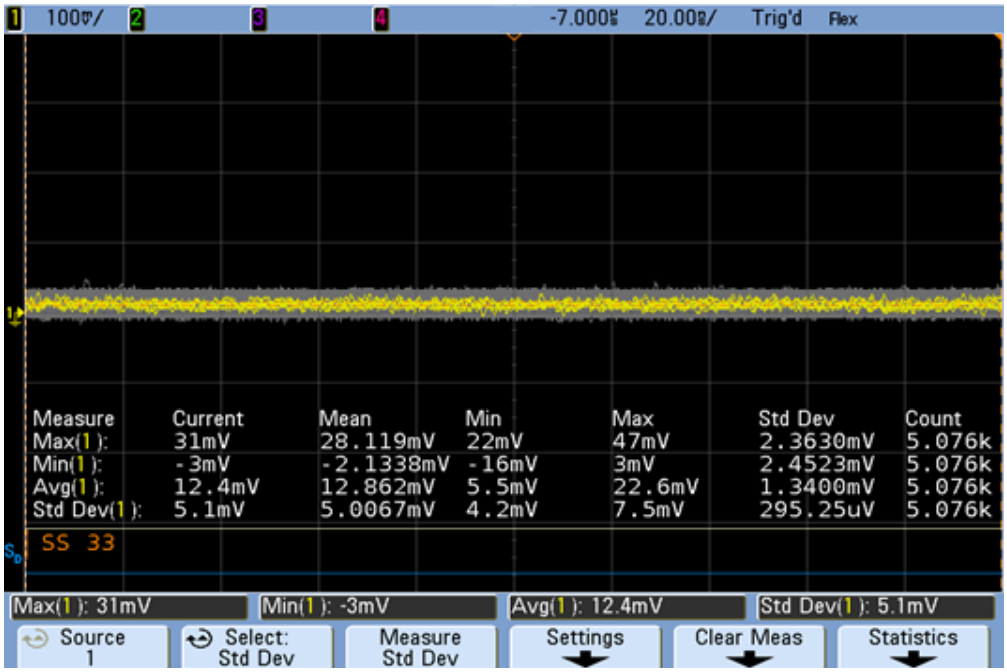


Figure 8 Measuring Idle Level

References

Table 1 Minimum and Maximum Data Values for Amplitude Measurement tests

Name	Description	Min	Max	Unit
uRx	uBus@TP4	400	3000	mV
dRxia	Transition time Idle=>Data_0	18	22	ns
dRxai	Transition time Data_0=>Idle	18	22	ns
dActive	Minimum time Data_0	590	610	ns
dIdle	Minimum time Idle	590	610	ns
uBDTxactive	Absolute value of uBus, while sending (*)	600	2000	mV
uBDTxidle	Absolute value of uBus, while Idle (*)	0	30	mV
dBDTx10	Transmitter delay, negative edge (***)	-	100	ns
dBDTx01	Transmitter delay, positive edge (***)	-	100	ns
dBDTxAsym	Transmitter delay mismatch (***) |dBDTx10 - dBDTx01|	-	5	ns

Table 1 Minimum and Maximum Data Values for Amplitude Measurement tests

Name	Description	Min	Max	Unit
dBDTxAsym2	Transmitter delay mismatch (****) |dBDTx10 - dBDTx01|	-	4	ns
dBusTx10	Fall time differential bus voltage (**) (80% to 20%)	6	18.75	ns
dBusTx01	Rise time differential bus voltage (**) (20% to 80%)	6	18.75	ns

Test Procedure

Initial Setup

1 Configure the FlexRay DUT such that it acts as a source for FlexRay signal.

2 On the Oscilloscope:

- **a** Set to Default Setup.
- **b** Set Triggered Mode as Normal.
- **c** Set the Initial V/div = 1V/div, Offset = 0V.
- **d** On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **Signal Generator Clock gated by T-Enable**:
  - Trigger = 50ns < +PW < 150ns
  - Trigger level = -300mV
  - Noise Reject = ON
  - Timebase = 20ns/div, Delay = 0.0s
- **e** On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:
  - Serial Decode = FlexRay = ON
  - VPT1000 mode = Synchronous or Asynchronous
  - Trigger Type = FlexRay, Mode = Frame
  - Frame ID = N, Cycle Rep = All
  - Delay = 0.0
  - If 10 Mbps, Timebase = 2.0us/div
  - If 5 Mbps, Timebase = 4.0us/div

- If 2.5 Mbps, Timebase = 8.0us/div

f Measure V_{pp} with stats.

g Perform Query measurement.

h Compute V/div-optimum = ~$V_{pp(max)}$/6

i Set selected Channel V/div = V/div-optimum

j On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:

- Measure “T@V” on first falling edge @ V = -300mV
- Result = dTSS (This value of time denotes the beginning of the frame relative to the trigger point you set. This value is used later for delay settings.)

k Clear measurement.

Data1 and Data0 Amplitude Measurement (+uBDTx-active, -uBDTx-active, +uRx-data, -uRx-data)

1 On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:

a On the Oscilloscope:

- (For Baud Rate 10Mbps) Set Timebase = 200ns/div, Delay = -550ns
- (For Baud Rate 5Mbps) Set Timebase = 400ns/div, Delay = -800ns
- (For Baud Rate 2.5 Mbps) Set Timebase = 800ns/div, Delay = -1.5us

b Measure with Stats:

- V_{max}
- V_{top} (+uBDTx-active or +uRx-data)
- V_{base} (-uBDTx-active or -uRx-data)
- V_{min}

c Stop Acquisition.

d Run a query for measurement stats

e Transfer image

f Compare the test results with the compliance test limits.

Idle Level Measurements (+uBDTx-idle, +uRx-idle)

1 On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:

a On the Oscilloscope:

- (For Baud Rate 10Mbps) Set Timebase = 20ns/div, Delay = dTSS-1us
- (For Baud Rate 5Mbps) Set Timebase = 40ns/div, Delay = dTSS-2us
- (For Baud Rate 2.5 Mbps) Set Timebase = 80ns/div, Delay = dTSS-4us

2 On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **Signal Generator Clock gated by T-Enable**:

   a On the Oscilloscope:

   - Trigger = +PW>200ns
   - Delay = -200ns

   b Infinite Persistence = ON

   c Measure Vmax, Vmin, Vaverage, Vstd-dev with stats

   d Clear Display

   e Query measurement with stats

   f Transfer image

   g Infinite Persistence = Off

   h Transfer image

Expected/Observable Results

The amplitude level must meet the following limits as per the *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E*:

- 600mV < uRx-active < 2000mV
- -600mV < -uRx-active < -2000mV
- -30mV < uRx-idle < 30mV

- 400mV < uBDTx-active < 3000mV
- -400mV < -uBDTx-active < -3000mV
- -30mV < uBDTx-idle < 30mV

1.3 Transition Time Measurement

Test Overview

The purpose of this test is to verify that the Transition Time (Data1 and Data0) of the Device Under Test (DUT) is within the conformance limits specified in Figure 2.1.1 and Figure 2.1.2 of the *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E.*

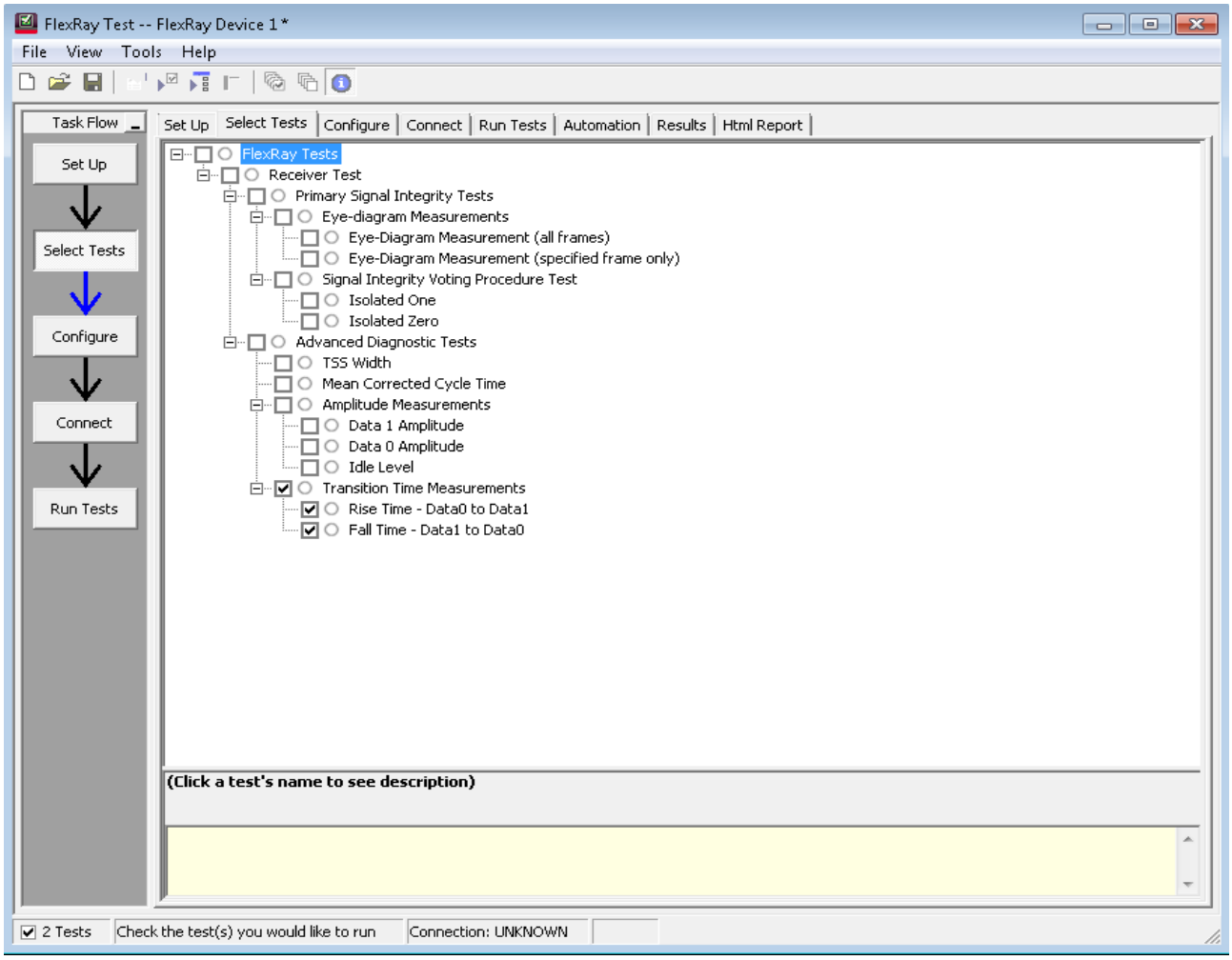


Figure 9 Selection of Transition Time Measurement Tests in the Compliance Test Application

Rise Time—Data0 to Data1 (dBusTx01): Measures the rising edge transition time of a FlexRay pulse within the specified frame at a transmitter test plane probing point based on a 20% to 80% measurement threshold level criteria. Compare the measured results against the specified limits of 6.0ns < dBusTx01 < 18.75ns.

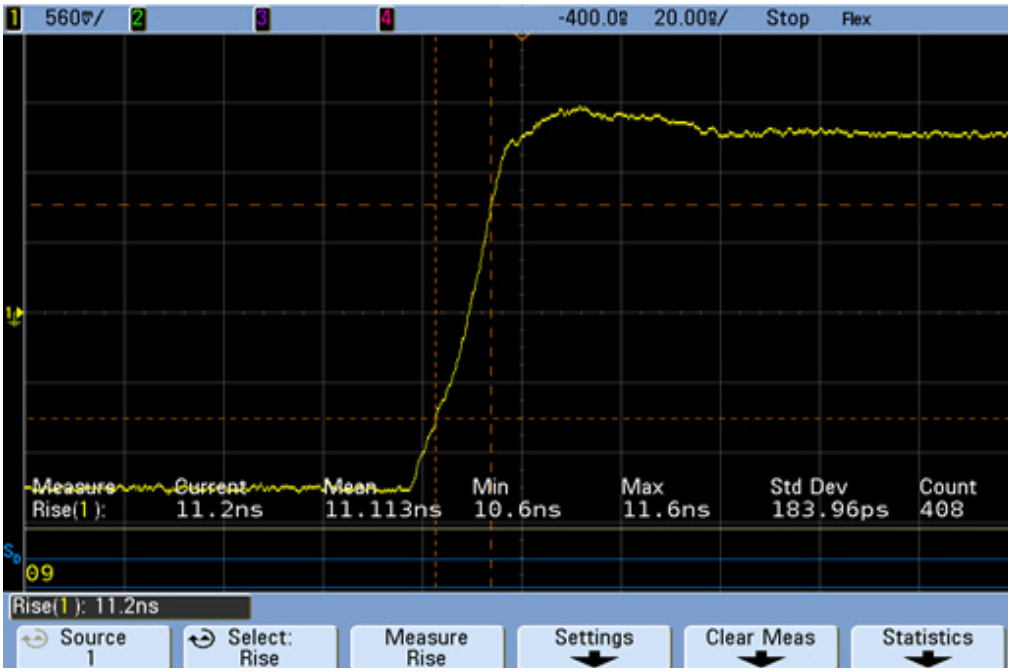


Figure 10 Rise Time Measurement on Data0 to Data1 Transition

Fall Time—Data1 to Data0 (dBusTx10): Measures the falling edge transition time of a FlexRay pulse within the specified frame at a transmitter test plane probing point based on 80% to 20% measurement threshold level criteria. Compare the measured results against the specified limits of 6.0ns < dBusTx01 < 18.75ns.

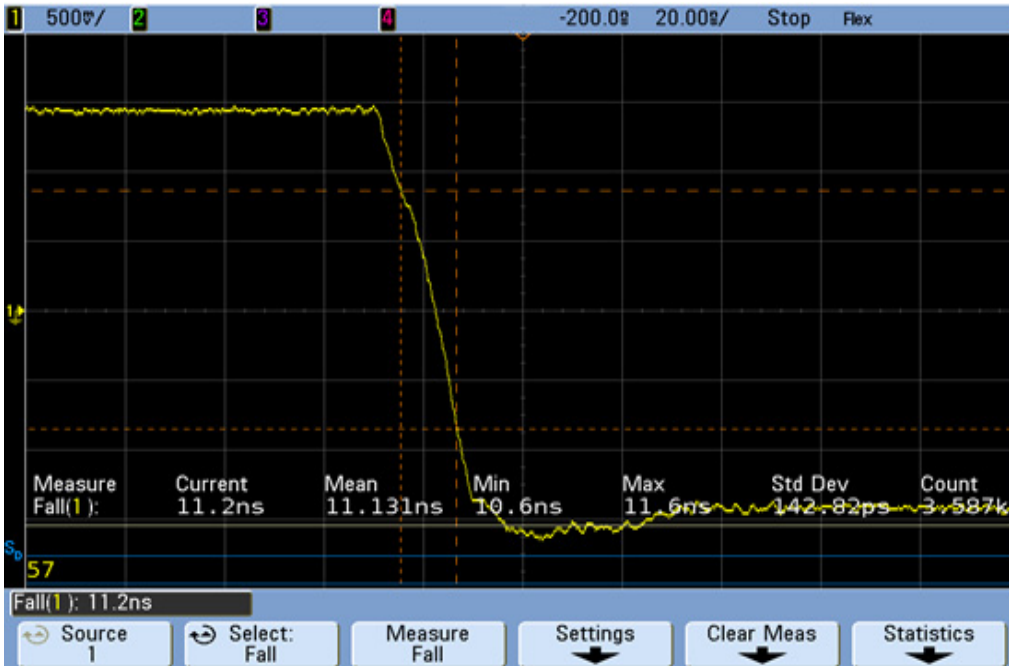


Figure 11 Fall Time Measurement on Data1 to Data0 Transition

References

Table 2 Minimum and Maximum Data Values for Transition Time Measurement tests

Name	Description	Min	Max	Unit
uRx	*uBus*@TP4	400	3000	mV
dRxia	Transition time *Idle=>Data_0*	18	22	ns
dRxai	Transition time *Data_0=>Idle*	18	22	ns
dActive	Minimum time *Data_0*	590	610	ns
dIdle	Minimum time *Idle*	590	610	ns
uBDTxactive	Absolute value of *uBus*, while sending (*)	600	2000	mV
uBDTxidle	Absolute value of *uBus*, while Idle (*)	0	30	mV
dBDTx10	Transmitter delay, negative edge (***)	-	100	ns
dBDTx01	Transmitter delay, positive edge (***)	-	100	ns
dBDTxAsym	Transmitter delay mismatch (***) |*dBDTx10 - dBDTx01*|	-	5	ns

Table 2 Minimum and Maximum Data Values for Transition Time Measurement tests

Name	Description	Min	Max	Unit
dBDTxAsym2	Transmitter delay mismatch (****) $\|dBDTx10 - dBDTx01\|$	-	4	ns
dBusTx10	Fall time differential bus voltage (**) (80% to 20%)	6	18.75	ns
dBusTx01	Rise time differential bus voltage (**) (20% to 80%)	6	18.75	ns

Test Procedure

Initial Setup

1 Configure the FlexRay DUT such that it acts as a source for FlexRay signal.

2 On the Oscilloscope:

a Set to Default Setup.

b Set Triggered Mode as Normal.

c Set the Initial V/div = 1V/div, Offset = 0V.

d On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **Signal Generator Clock gated by T-Enable**:

- Trigger = 50ns < +PW < 150ns
- Trigger level = -300mV
- Noise Reject = ON
- Timebase = 20ns/div, Delay = 0.0s

e On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:

- Serial Decode = FlexRay = ON
- VPT1000 mode = Synchronous or Asynchronous
- Trigger Type = FlexRay, Mode = Frame
- Frame ID = N, Cycle Rep = All
- Delay = 0.0
- If 10 Mbps, Timebase = 2.0us/div
- If 5 Mbps, Timebase = 4.0us/div

- If 2.5 Mbps, Timebase = 8.0us/div

f Measure V_{pp} with stats.

g Perform Query measurement.

h Compute V/div-optimum = ~$V_{pp(max)}$/6

i Set selected Channel V/div = V/div-optimum

j On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:

- Measure “T@V” on first falling edge @ V = -300mV
- Result = dTSS (This value of time denotes the beginning of the frame relative to the trigger point you set. This value is used later for delay settings.)

k Clear measurement.

Rise Time—Data1 and Data0 (dRx01 & dBusTx01)

1 Run the tests on the FlexRay Compliance Test Application.

2 On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **Signal Generator Clock gated by T-Enable**:

a On the Oscilloscope:

- Trigger = 50ns < -PW < 150ns
- Timebase = 20ns/div, Delay = 0.0s

b On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:

- Cycle Rep = 8, Cycle Base = 1
- Timebase = 20ns/div
- (For Baud Rate 10Mbps) Delay = -400ns
- (For Baud Rate 5Mbps) Delay = -500ns
- (For Baud Rate 2.5 Mbps) Delay = -670ns

c For Receiver Tests:

- Upper Threshold = +300mV
- Lower Threshold = -300mV

d For Transmitter Tests:

- Upper Threshold = 80%

- Lower Threshold = 20%

e Measure Rise Time with stat.

f Stop **Acquisition**.

g Run a query for measurement stats.

h Transfer image.

i Compare the test results with the compliance test limits.

Fall Time—Data1 and Data0 (dRx10 & dBusTx10)

1 Run the tests on the FlexRay Compliance Test Application.

2 On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **Signal Generator Clock gated by T-Enable**:

a On the Oscilloscope:

- Trigger = 50ns < +PW < 150ns
- Timebase = 20ns/div, Delay = 0.0s

b On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:

- Cycle Rep = 8, Cycle Base = 1
- Timebase = 20ns/div
- (For Baud Rate 10Mbps) Delay = -200ns
- (For Baud Rate 5Mbps) Delay = -100ns
- (For Baud Rate 2.5 Mbps) Delay = -125ns

c Measure Rise Time with stat.

d Stop **Acquisition**.

e Run a query for measurement stats.

f Transfer image.

g Compare the test results with the compliance test limits.

Expected/Observable Results

The transition time must meet the following limits as per the *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E*:

- dRx10 < 22.5ns
- 6ns < dRx01 < 22.5ns

- 6ns < dBusTx10 < 18.75ns
- 6ns < dBusTx01< 18.75ns

1.4 TSS Width Measurement

Test Overview

The purpose of this test is to verify that the width of the Transmission Start Sequence of the Device Under Test (DUT) is within the conformance limits specified in the *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E*.

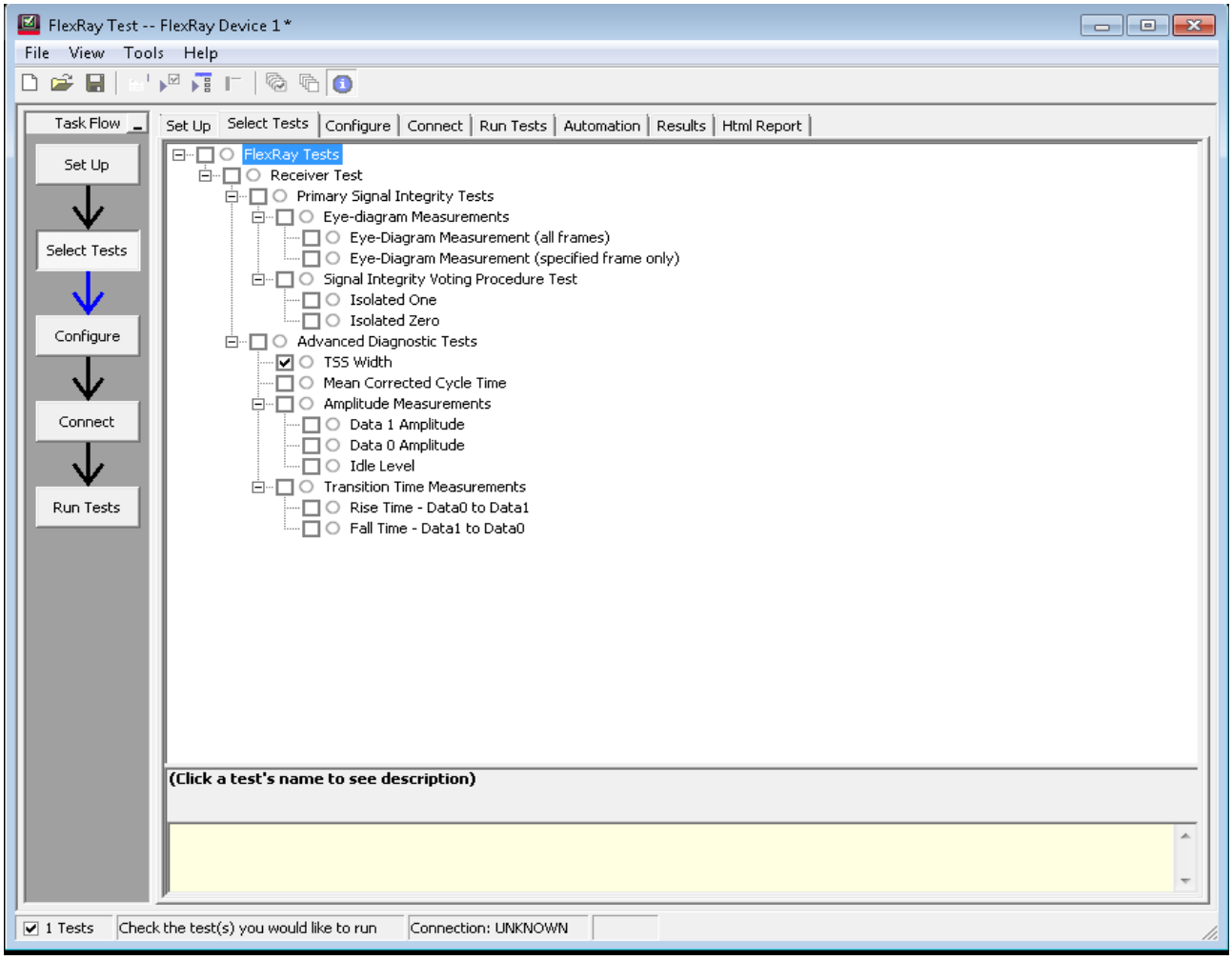


Figure 12 Selection of TSS Width Measurement Test in the Compliance Test Application

TSS-width (gdTSSTransmitter)—Measures the width of the Transmission Start Sequence (TSS) low pulse of the specified frame at a transmitter test plane differential probing point. Compare the measured results against the specified limits of:

(For Baud Rate 10Mbps) 6gdBit (590ns) < gdTSSTransmitter < 15gdBit (1.51us)

(For Baud Rate 5Mbps) 4gdBit (780ns) < gdTSSTransmitter < 8gdBit (1.62us)

(For Baud Rate 2.5 Mbps) 3gdBit (1.16us) < gdTSSTransmitter < 5gdBit (2.04us)

These test limits are based on absolute maximum and minimum possible TSS widths and also include Oscilloscope measurement resolution margin of +/- 10ns for a baud rate of 10Mbps, +/-20ns for a baud rate of 5Mbps or +/-40ns for a baud rate of 2.5Mbps. Note that you may run tests by manually entering precise test limits in the FlexRay Compliance Test Application based on the FlexRay system's specified gdTSSTransmitter timing parameter, gdBit and possible truncation.

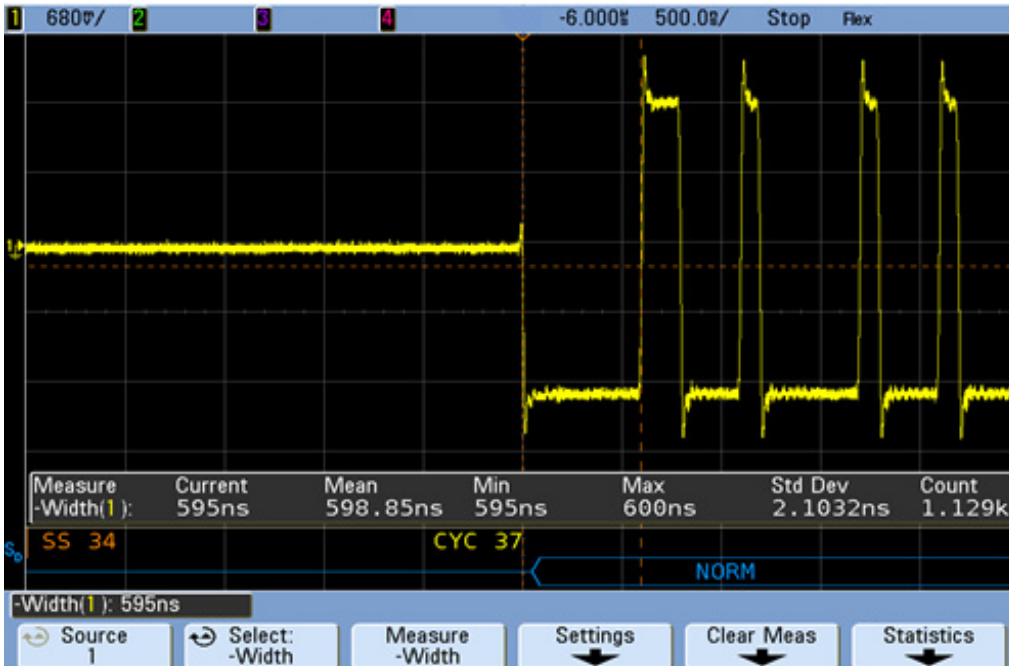


Figure 13 Measuring -width of TSS pulse

Test Procedure

Initial Setup

1 Configure the FlexRay DUT such that it acts as a source for FlexRay signal.

2 On the Oscilloscope:

- **a** Set to Default Setup.
- **b** Set Triggered Mode as Normal.
- **c** Set the Initial V/div = 1V/div, Offset = 0V.
- **d** On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **Signal Generator Clock gated by T-Enable**:
  - Trigger = 50ns < +PW < 150ns

- Trigger level = -300mV
- Noise Reject = ON
- Timebase = 20ns/div, Delay = 0.0s

e On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:

- Serial Decode = FlexRay = ON
- VPT1000 mode = Synchronous or Asynchronous
- Trigger Type = FlexRay, Mode = Frame
- Frame ID = N, Cycle Rep = All
- Delay = 0.0
- If 10 Mbps, Timebase = 2.0us/div
- If 5 Mbps, Timebase = 4.0us/div
- If 2.5 Mbps, Timebase = 8.0us/div

f Measure V_{pp} with stats.

g Perform Query measurement.

h Compute V/div-optimum = ~$V_{pp(max)}$/6

i Set selected Channel V/div = V/div-optimum

j On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:

- Measure “T@V” on first falling edge @ V = -300mV
- Result = dTSS (This value of time denotes the beginning of the frame relative to the trigger point you set. This value is used later for delay settings.)

k Clear measurement.

TSS Width Measurement

1. Skip this measurement if you select **Transmitter Signal Source** as **Signal Generator Clock gated by T-Enable**
2. Run the tests on the FlexRay Compliance Test Application.
3. Set Serial Decode = FlexRay to ON.
4. Set VPT1000 mode to Synchronous or Asynchronous, based on selection in the **Set Up** tab.
5. Set Trigger = FlexRay Frame ID = N, Cycle Rep = All
6. Set Timebase as:
   - 500ns/div, for Baud Rate 10Mbps
   - 1us/div, for Baud Rate 5Mbps
   - 2us/div, for Baud Rate 2.5 Mbps

7 Set Delay as the measurement of time at the voltage on the first falling edge, which is at V=-0.3V.

8 Set the Upper Threshold to -280mV.

9 Set Lower Threshold to -300mV.

10 Set Middle Threshold to -320mV.

11 Measure -Width with stats.

12 Stop **Acquisition**.

13 Run a query for measurement stats.

14 Transfer image.

15 Compare the test results with the compliance test limits.

Expected/Observable Results

The signal obtained from the test must meet the following limits as per the *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E*:

(For Baud Rate 10Mbps) 6gdBit (590ns) < gdTSSTransmitter < 15gdBit (1.51us)

(For Baud Rate 5Mbps) 4gdBit (780ns) < gdTSSTransmitter < 8gdBit (1.62us)

(For Baud Rate 2.5 Mbps) 3gdBit (1.16us) < gdTSSTransmitter < 5gdBit (2.04us)

1.5 Mean Corrected Cycle Time

Test Overview

The purpose of this test is to verify that the average value of the cycle time of the Device Under Test (DUT) is within the conformance limits specified in the *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E.*

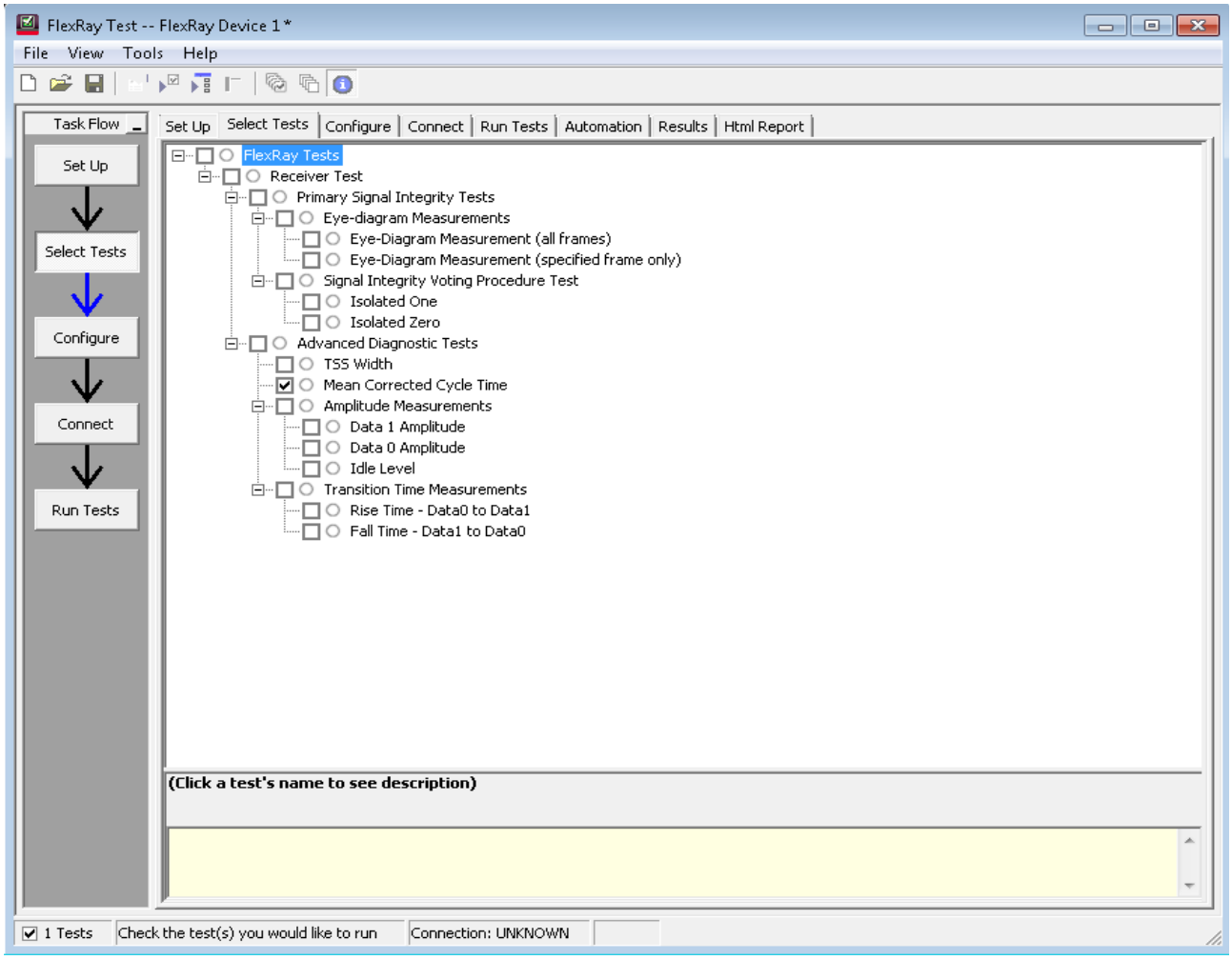


Figure 14 Selection of Mean Corrected Cycle Time Test in the Compliance Test Application

Mean Corrected Cycle Time—Uses the Oscilloscope's Segmented Memory Acquisition mode to capture 1001 consecutive frames of the specified ID with precise time-tagging between each frame. The FlexRay Compliance Test

Application computes the average cycle time at a transmitter test plane differential probing point. The results are for “information-only” and must not be compared against any specified or non-specified test limits.

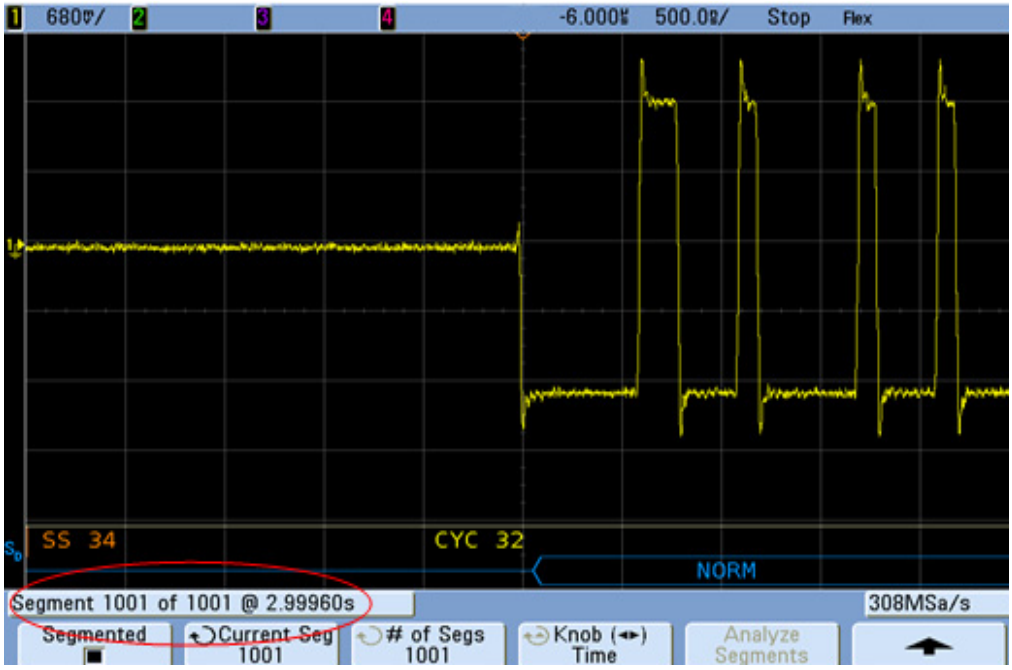


Figure 15 Cycle Time and Timebase Accuracy Test using Segmented Memory Acquisition

Test Procedure

Initial Setup

1 Configure the FlexRay DUT such that it acts as a source for FlexRay signal.

2 On the Oscilloscope:

- **a** Set to Default Setup.
- **b** Set Triggered Mode as Normal.
- **c** Set the Initial V/div = 1V/div, Offset = 0V.
- **d** On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **Signal Generator Clock gated by T-Enable**:
  - Trigger = 50ns < +PW < 150ns
  - Trigger level = -300mV
  - Noise Reject = ON
  - Timebase = 20ns/div, Delay = 0.0s
- **e** On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:

- Serial Decode = FlexRay = ON
- VPT1000 mode = Synchronous or Asynchronous
- Trigger Type = FlexRay, Mode = Frame
- Frame ID = N, Cycle Rep = All
- Delay = 0.0
- If 10 Mbps, Timebase = 2.0us/div
- If 5 Mbps, Timebase = 4.0us/div
- If 2.5 Mbps, Timebase = 8.0us/div

f Measure V_{pp} with stats.

g Perform Query measurement.

h Compute V/div-optimum = ~$V_{pp(max)}$/6

i Set selected Channel V/div = V/div-optimum

j On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:

- Measure “T@V” on first falling edge @ V = -300mV
- Result = dTSS (This value of time denotes the beginning of the frame relative to the trigger point you set. This value is used later for delay settings.)

k Clear measurement.

Mean Corrected Cycle Time

1. Skip this measurement if you select **Transmitter Signal Source** as **Signal Generator Clock gated by T-Enable**
2. Run the tests on the FlexRay Compliance Test Application.
3. Set Delay as the measurement of time at the voltage on the first falling edge, which is at V=-0.3V.
4. Set Timebase as:
   - 500ns/div, for Baud Rate 10Mbps
   - 1us/div, for Baud Rate 5Mbps
   - 2us/div, for Baud Rate 2.5 Mbps
5. Stop the test run.
6. Initiate the Transfer protocol.
7. Note the Frame type (NORM, SUYNC, SUP, NULL).
8. Set Acquisition Mode as Segmented Memory.
9. Set # of segments as 1001.
10. Set Segmented = ON.
11. Run the tests.

12 Record the time-tag of segment#1001.

13 Transfer Image.

Expected/Observable Results

The results are for “information-only” purposes and must not be compared against any specified or non-specified test limits.

1.6 Signal Integrity Voting Tests

Test Overview

The purpose of this test is to verify that the signal from the Device Under Test (DUT) meets the minimal signal shape requirement according to the *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E.*

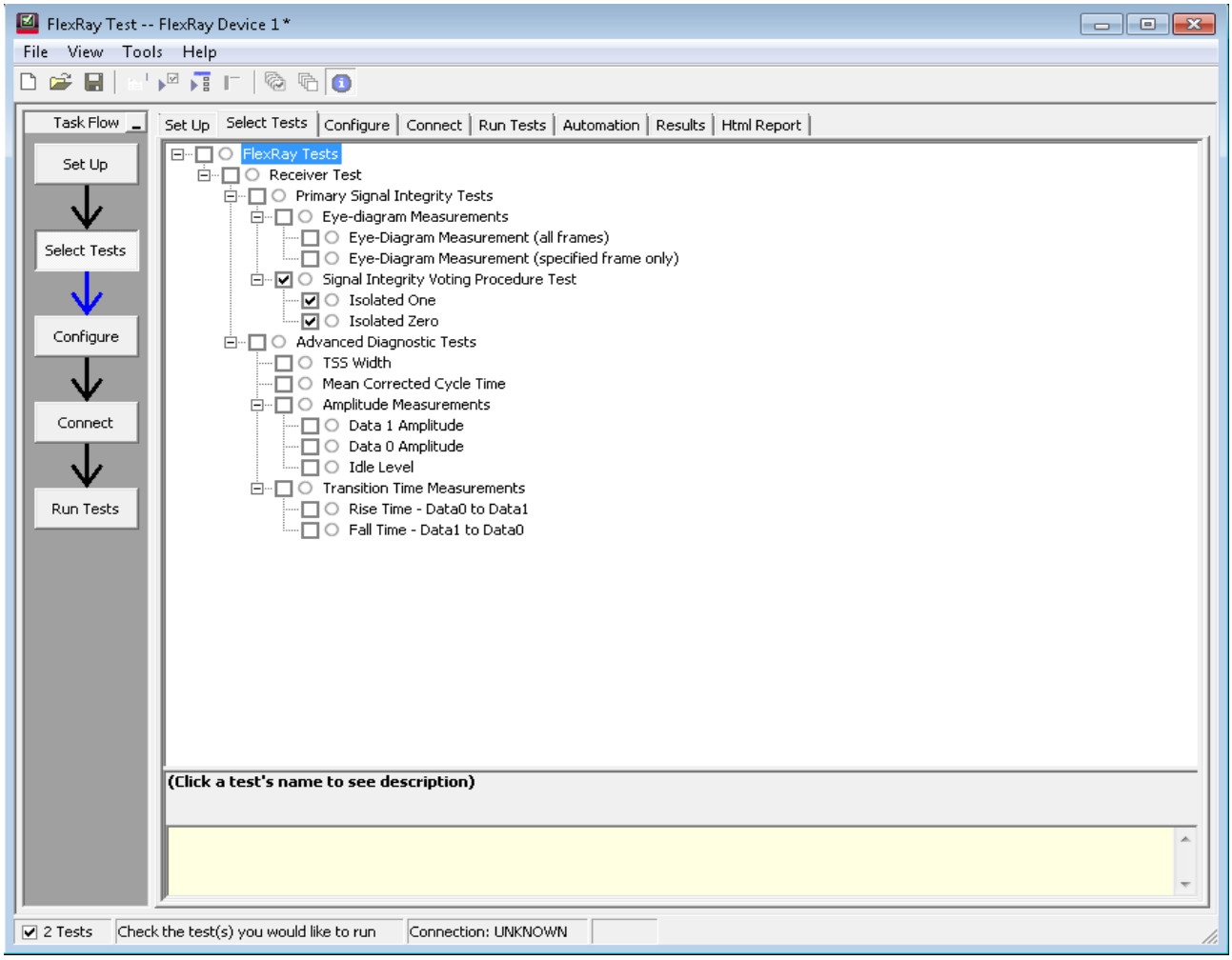


Figure 16 Selection of Signal Integrity Voting Procedure Test in the Compliance Test Application

Signal Integrity Voting—This is a procedure given by the BD properties and its robustness against disturbances. The procedure detects whether a FlexRay topology is operable or not. You must take into account the differential bus signal

shapes measured at any position. This procedure involves mathematical calculation. This procedure must meet the following conditions for the test to Pass:

- The differential voltage level must be high enough.
- The shortest detectable duration of one bit must be long enough.
- The asymmetry of the measured bit must be less than the defined limit.
- Idle detection between frames must be avoided.

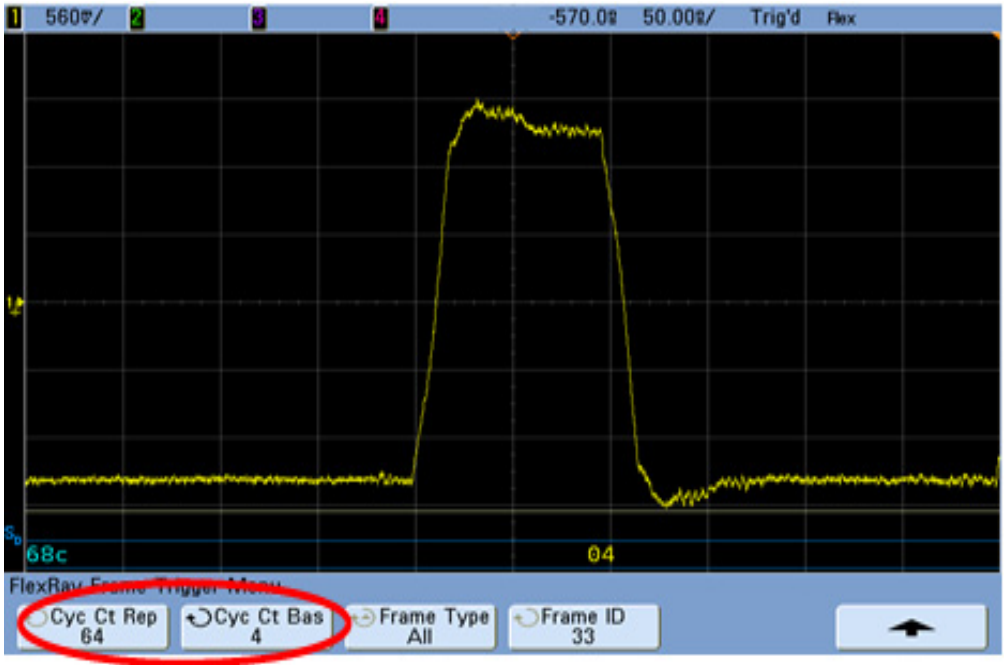


Figure 17 Capturing an isolated “one” by triggering on cycle#4

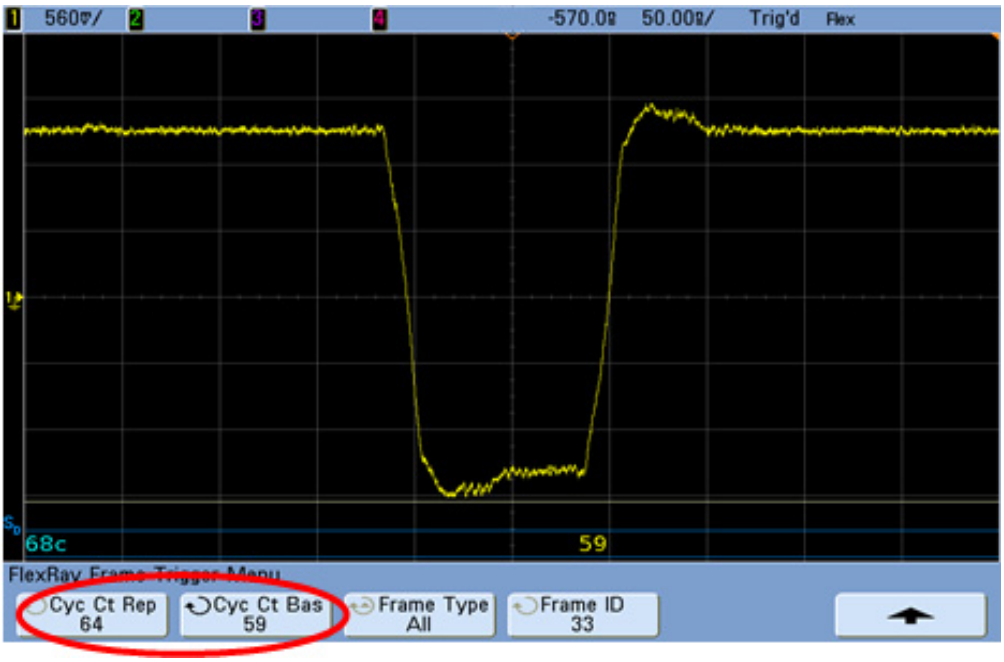


Figure 18 Capturing an isolated “zero” by triggering on cycle#59

References

Table 3 Signal Voting – Parameter list

Signal Voting	Parameter Name	Description
IN	$uBUS_{TPx'}$	Filtered differential voltage
	dBitShort	Shortest detectable duration of one bit
	dBitLong	Longest detectable duration of one bit
	dEdgeMax	Duration of the slowest edge
OUT	Sq	Voted signal quality
PARAMETER	dAsymmetricDelayMax	Required maximal asymmetric delay –passive star: 7ns (***) –terminated point-to-point: 3ns (**) –passive bus: 3ns (**)
	dBitMin	Required minimum duration of the shortest bit at TP4_BDi: 67ns [=70ns (*) - 3ns (**)]
	uData0Top	Required minimal level (Top): -330mV
	uData1Top	Required maximal level (Top): 330mV
	dIdleDetectionMin	Minimal Timeout to detect *Idle*: 50ns

(*) shortest bit that has to be sent by a BD on the bus (minimum of dRx0 and dRx1, see Figure 8-6 in the *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E*.

(**) maximal allowed asymmetry of the receiving BD (point-to-point or passive bus and virtually measured: TP4 to TP4-BDi).

(***) 3ns (**) + 4ns for the passive star.

Table 4 Signal Voting Procedure – Calculation Method

BEHAVIOR	IF *dAsymmetricDelay* <= *dAsymMax* AND $uBus_{TPx'}$ >= *uData1Top* AND *dBitShort* >= *dBitMin* AND *dEdgeMax* <= *dIdleDetectionMin* THEN *Sq* = *"pass"* ELSE *Sq* = *"fail"*	IF *dAsymmetricDelay* <= *dAsymMax* AND $uBus_{TPx'}$ <= *uData0Top* AND *dBitShort* >= *dBitMin* AND *dEdgeMax* <= *dIdleDetectionMin* THEN *Sq* = *"pass"* ELSE *Sq* = *"fail"*

The result is coded in the value *Sq*:

pass – the differential signal meets the minimal signal shape requirements (level and delay)

fail – the differential signal does not the minimal signal shape requirements (level or delay)

Test Procedure

Initial Setup

1 Configure the FlexRay DUT such that it acts as a source for FlexRay signal.

2 On the Oscilloscope:

a Set to Default Setup.

b Set Triggered Mode as Normal.

c Set the Initial V/div = 1V/div, Offset = 0V.

d On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **Signal Generator Clock gated by T-Enable**:

- Trigger = 50ns < +PW < 150ns
- Trigger level = -300mV
- Noise Reject = ON
- Timebase = 20ns/div, Delay = 0.0s

e On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:

- Serial Decode = FlexRay = ON
- VPT1000 mode = Synchronous or Asynchronous
- Trigger Type = FlexRay, Mode = Frame
- Frame ID = N, Cycle Rep = All
- Delay = 0.0
- If 10 Mbps, Timebase = 2.0us/div
- If 5 Mbps, Timebase = 4.0us/div
- If 2.5 Mbps, Timebase = 8.0us/div

f Measure V_{pp} with stats.

g Perform Query measurement.

h Compute V/div-optimum = ~$V_{pp(max)}$/6

i Set selected Channel V/div = V/div-optimum

j On the FlexRay Compliance Test Application, if you select **Transmitter Signal Source** as **FlexRay Communication Controller generated traffic**:

- Measure “T@V” on first falling edge @ V = -300mV
- Result = dTSS (This value of time denotes the beginning of the frame relative to the trigger point you set. This value is used later for delay settings.)

k Clear measurement.

Isolated One

1. Set Time Ref as Center.
2. Set Timebase as:
   - 50ns/div, Delay = -570ns for Baud Rate 10Mbps
   - 100ns/div, Delay = -800ns for Baud Rate 5Mbps
   - 200ns/div, Delay = -1.3us for Baud Rate 2.5 Mbps
3. Offset = 0V.
4. Set Serial Decode as FlexRay = ON.
5. VPT1000 mode = Synchronous or Asynchronous.
6. Trigger = FlexRay, Mode = Frame.
7. Cycle Rep = 64, Cycle Base = 4.
8. Frame ID = N.
9. Single.
10. Transfer the waveform data to MATLAB function.
11. Compute results as:
    - uData1Top = Vtop
    - dEdgeMax = RTmax or FTmax
    - dBitlong = PWmax
    - dBitShort = PWmin
    - dBitLengthVariation = dBitLong - dBitShort
12. Determine Pass/Fail criteria for isolated “one” (Data1):

    If dBitLengthVariation-Data1 <= 7ns

    AND uData1Top >= 300mV

    AND dBitShort-Data1 > 69.95ns for 10Mbps

    (OR) dBitShort-Data1 > 133.40ns for 5Mbps

    (OR) dBitShort-Data1 > 260.30ns for 2.5Mbps

    AND dEdgeMax-Data1 <= 50ns

    THEN *PASS* for Signal Quality (Sq-Data1) test#1

Isolated Zero

1. Cycle Base = 59.
2. Single.
3. Transfer the waveform data to MATLAB function.
4. Compute results as:

- uData0Top = Vbase
- dEdgeMax = RTmax or FTmax
- dBitlong = -PWmax
- dBitShort = -PWmin
- dBitLengthVariation = dBitLong - dBitShort

5 Determine Pass/Fail criteria for isolated “zero” (Data0):

If dBitLengthVariation-Data0 <= 7ns

AND uData0Top >= -300mV

AND dBitShort-Data0 > 69.95ns for 10Mbps

(OR) dBitShort-Data0 > 133.40ns for 5Mbps

(OR) dBitShort-Data0 > 260.30ns for 2.5Mbps

AND dEdgeMax-Data0 <= 50ns

THEN *PASS* for Signal Quality (Sq-Data0) test#1

If any of the above conditions fail, THEN *FAIL* for Signal Quality (Sq-Data0) test#1

MATLAB Function

1 Filter both Isolated “One” and “Zero” waveforms with a 14MHz low pass single pole filter.

2 Measure RT (-300mV to 300mV) and FT (-300mV to 300mV).

3 Vtop for isolated “One” and Vbase for isolated “Zero”.

4 +PW on isolated “One” filtered waveform at 16 distinct upper/lower threshold settings specified in the table.

5 -PW on isolated “Zero” filtered waveform at 16 distinct upper/lower threshold settings specified in the table.

Expected/Observable Results

The results obtained must meet the PASS condition as specified in the *FlexRay Communications System Electrical Physical Layer Specification, Version 2.1, Revision E.*

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