



# FlexRay Measurements (Option FLX) for Agilent's InfiniiVision Series Oscilloscopes

## Data Sheet

**Debug the physical layer characteristics of your FlexRay bus faster**

### Introduction

Agilent Technologies InfiniiVision Series oscilloscopes offer integrated FlexRay serial bus triggering, hardware-based decoding, eye-diagram mask testing, and the most extensive FlexRay physical layer conformance test package in the oscilloscope industry. These FlexRay measurement tools, which all come standard with Option FLX, can help you more efficiently debug and characterize your FlexRay physical layer network.



### Features

- Hardware-based decoding helps find errors quicker
- Synchronize on multiplexed data with cycle-base and cycle-repetition triggering
- Perform hardware-based pass/fail FlexRay eye-diagram mask testing based on published standards
- Capture more consecutive decoded FlexRay frames using Segmented Memory acquisition
- Make physical layer measurements in the field with the only oscilloscope for FlexRay applications with optional battery operation
- Precision differential active probing of the FlexRay bus
- The most comprehensive and automated FlexRay physical layer conformance testing



**Agilent Technologies**

## Time-correlate FlexRay triggering and protocol decode with physical layer waveforms

With Option FLX on your Agilent InfiniiVision series oscilloscope (or N5432C for after-purchase upgrades), you can now trigger on and time-correlate FlexRay communication with your physical layer signals. And with Agilent's unique hardware-based decoding, not only are triggering and decoding of the FlexRay bus based on the same technology to insure consistency between triggering and decoding, but hardware-based decoding provides the fastest decode update rates in the industry.

Software-based decoding, which is used on all other vendor's oscilloscopes, tends to be slow. This is especially true when using deep memory, which is often required for today's FlexRay applications. The real benefit of Agilent's hardware-based FlexRay decoding is throughput. Not only does this enhance the usability of a scope, but most importantly it improves the scopes probability of capturing random and infrequent communication errors.

Figure 1 shows an example of the scope set up to trigger on frame ID:34 (decimal). The lower decode trace, which shows a header CRC error highlighted in red, is time-correlated with the physical layer signal (yellow trace) captured by the scope's channel-1 input. The upper half of the scope's display shows the scope's protocol "lister" display. This display shows the "big picture" of FlexRay communication that occurs both before and after the trigger event. And with Agilent's new 7000B series scopes, you can also easily Search & Navigate within the lister display to find particular events of interest with direct time-correlation to the waveform display.

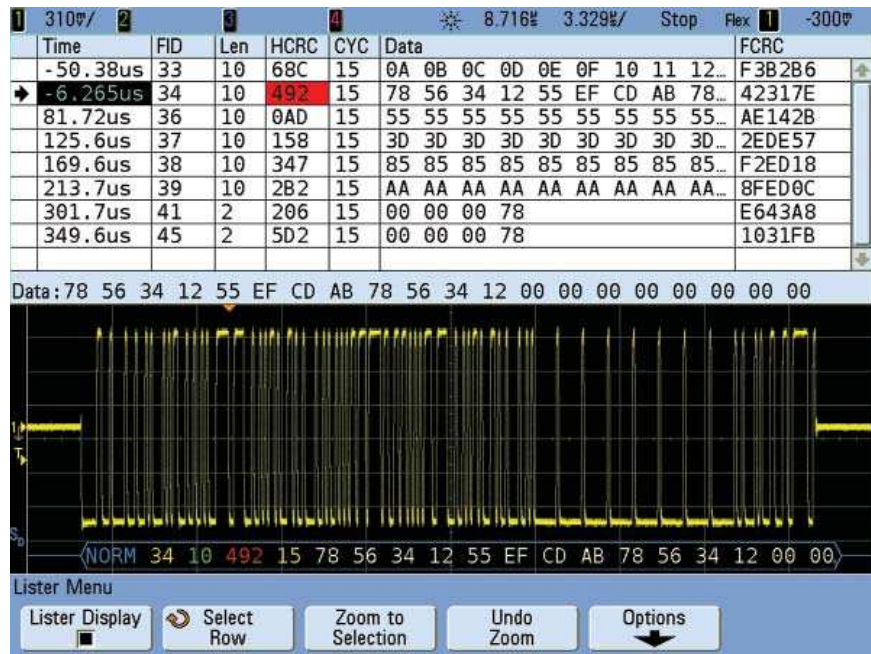


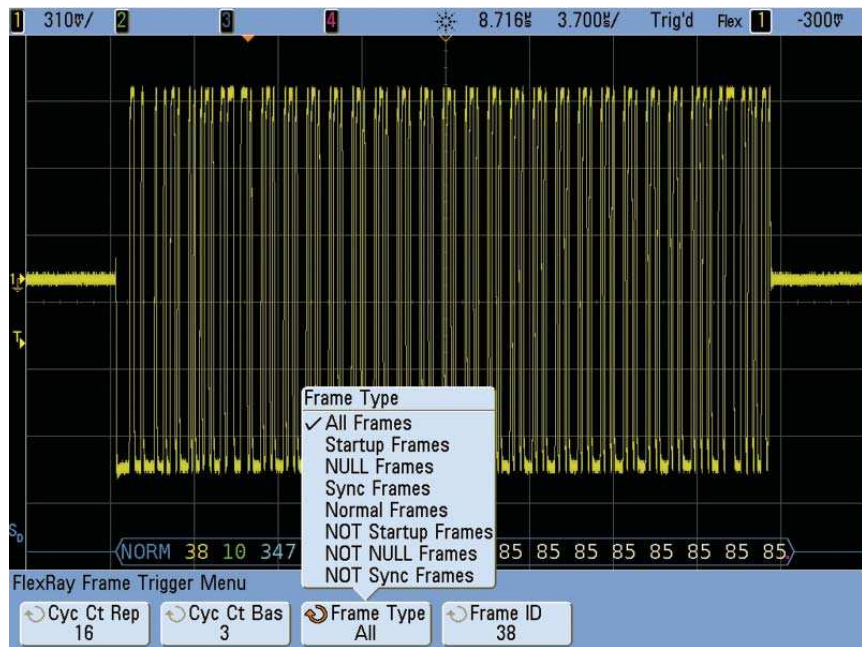
Figure 1: Time-correlated display of the FlexRay physical layer signal with protocol decoding.



## Capture multiplexed parameters with cycle-multiplexed triggering

Data contents within FlexRay frames are often multiplexed. For example, one particular frame may be used to transmit various engine diagnostic parameters. Temperature may be transmitted during a defined set of cycles within a particular frame, while oil pressure, as well as other engine parameters, may be transmitted during a different set of cycles within the same frame ID. Triggering the oscilloscope's acquisition to capture and lock-in on particular multiplexed parameters such as this requires cycle-multiplexed triggering. This is sometimes referred to as "base-rep" cycle triggering, which Agilent's InfiniiVision Series scopes support.

Figure 2 shows an example of the scope set up to trigger on frame ID:38 with a cycle-rep factor of 16 and cycle-base factor of 3. With this setup the scope only triggers on cycles #3, #19, #35, and #51 ( $3 + 16$ ,  $3 + 16 + 16$ ,  $3 + 16 + 16 + 16$ , etc.). Also note that Agilent's InfiniiVision Series oscilloscope with Option FLX can also trigger on and decode particular frame types symbolically, such as Startup frames, Null frames, Sync frames, etc., as well as Boolean NOT frame types.



**Figure 2: Cycle-multiplexed triggering using cycle-repetitive and cycle-base multiplexed factors.**

## Making FlexRay Eye-diagram Mask Tests

With Agilent's mask testing capability, you can also perform automatic pass/fail eye-diagram mask tests based on published FlexRay physical layer standards.

Figure 3 shows a mask test at the TP1 test plane. The reference for this particular test is based on triggering on alternating rising and falling edges at the output of a bus driver. In this example more than 3,500,000 bits were tested.

Figure 4 shows an eye-diagram mask test on a relatively noisy FlexRay signal at the TP4 receiver test plane. This eye-diagram test was generated by capturing and overlaying bits from all frames in a multi-node system. Since this test is performed at or near the input of a FlexRay receiver, this test is based on triggering on repetitive byte start sequence (BSS) events, which are the re-synchronizing events for a receiver's sampling.

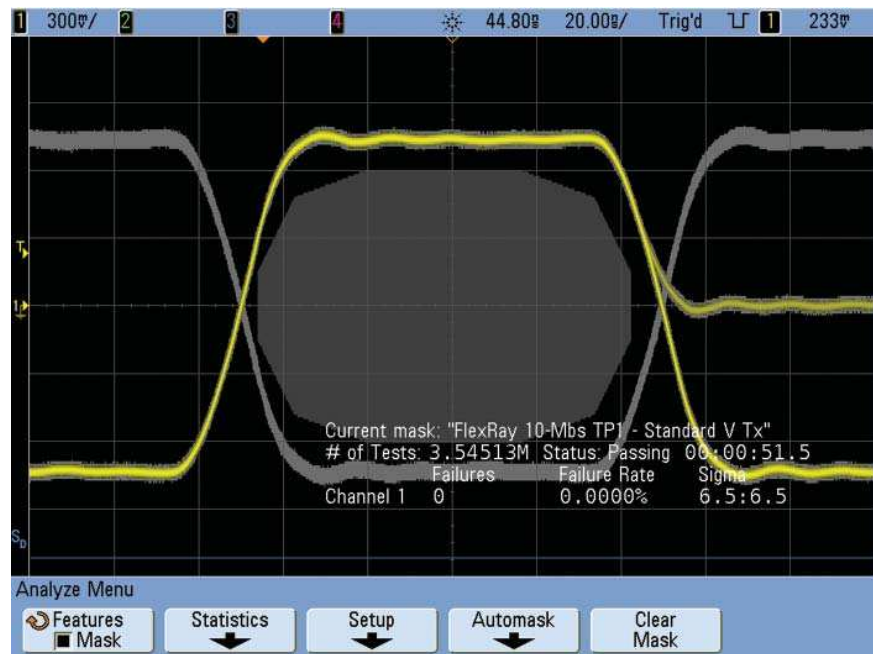


Figure 3. FlexRay TP1 mask test at the output of a bus driver.

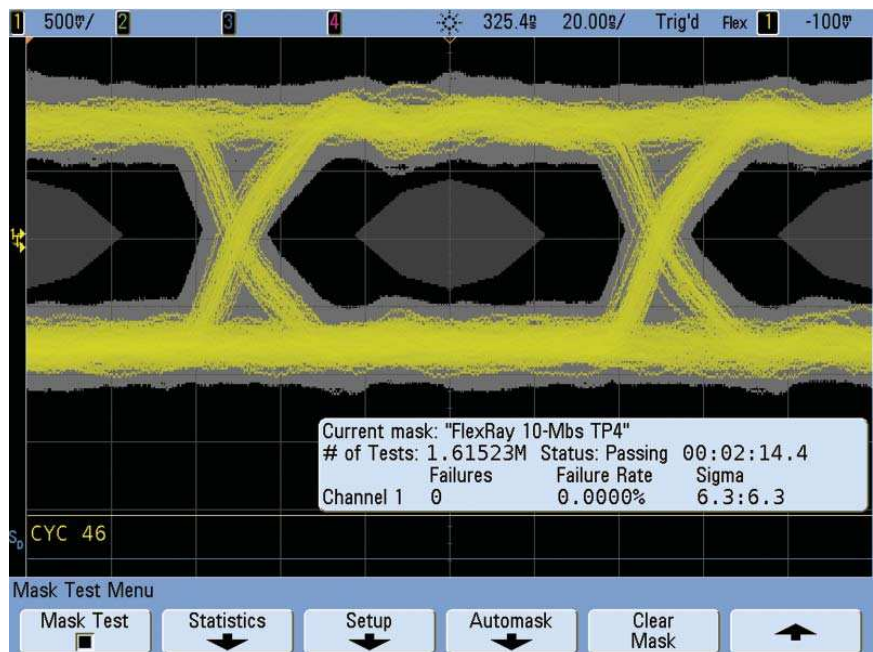


Figure 4. FlexRay TP4 mask test at the input of a FlexRay receiver.

## FlexRay mask test criteria and failure analysis

Agilent's InfiniiVision Series oscilloscope mask testing is the only hardware-based mask testing in the oscilloscopes industry. This produces the industry's fastest mask testing with test rates up to 100,000 waveforms tested per second. With test rates this fast the scope can quickly uncover very infrequent anomalies and provide detailed pass/fail statistics, including a Sigma quality report. In addition, you have the ability to customize your testing based on a variety of test criteria, including:

- Test continuously
- Test until 1st error detected
- Test until a user-specified number of tests has been satisfied
- Test until a user-specified test time has been satisfied
- Test until a user-specified potential Six Sigma quality has been satisfied

Figure 5 shows an example of a "stop-on-error" TP4 eye-diagram mask test based on the capture and overlay of bits from just frame ID:1. The first mask violation, which occurred after testing approximately 5000 bits, reveals a runt pulse with time shift.

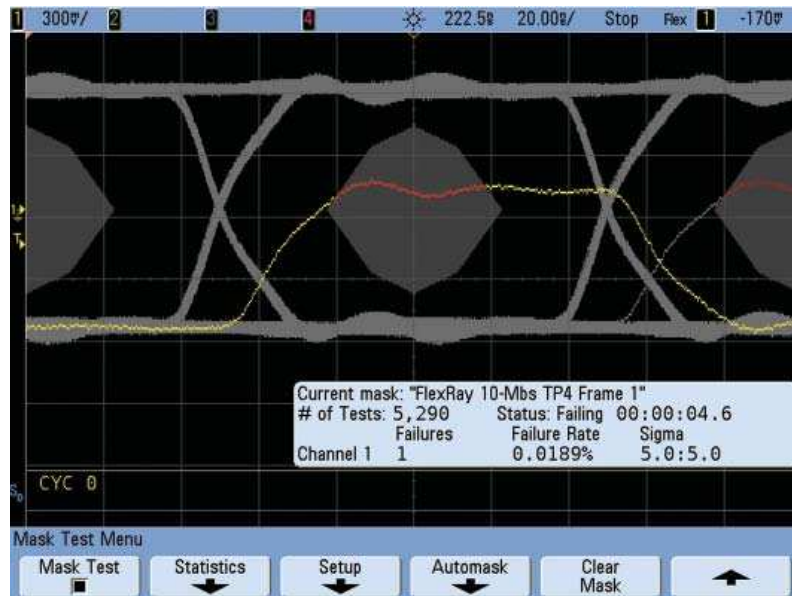
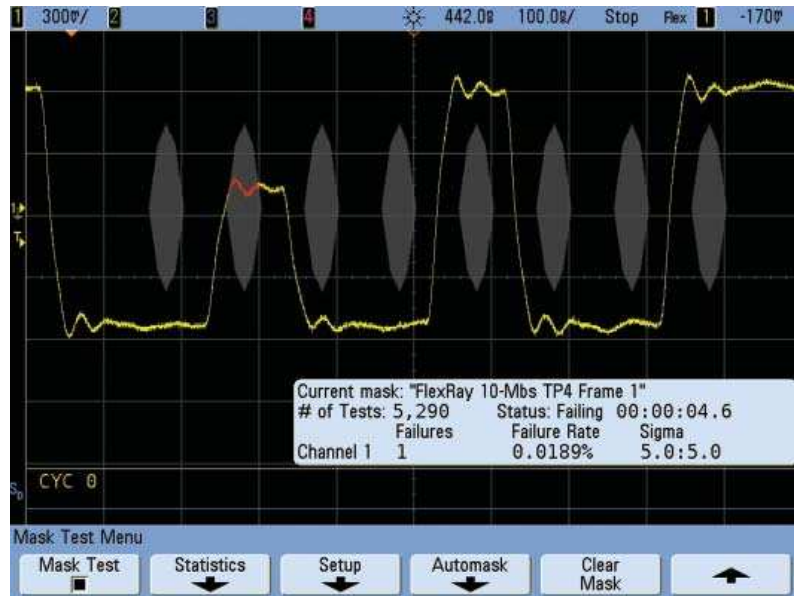


Figure 5. A "stop-on-error" TP4 eye-diagram mask test.

After acquisitions have been stopped due to this mask violation, we can then re-scale the timebase to effectively “unfold” the eye in order to discover more information about this failure as shown in Figure 6. This particular mask violation occurred during bit time #6.



**Figure 6. “Unfolding” the eye reveals the specific bit that produced the mask failure.**

### Available FlexRay Mask Files

Various mask test files based on different test planes, baud rates, and bus driver characteristics can be obtained from Agilent as free downloads including:

- TP1 standard voltage (10 Mbs only)
- TP1 increased voltage (10 Mbs only)
- TP11 standard voltage (10 Mbs only)
- TP11 increased voltage (10 Mbs only)
- TP4 10 Mbs
- TP4 5 Mbs
- TP4 2.5 Mbs

Note that the TP1 and TP11 masks are primarily used to test the output characteristics of a single bus driver or active star device using a 10 MHz signal generator clock source gated by T-Enable-low, regardless of whether the device will ultimately be used in 10 Mbs, 5 Mbs, or 2.5 Mbs FlexRay systems.

Although the TP4 (receiver) mask test files are initially configured to test all frames within a multi-node synchronous or asynchronous system, these files can be easily modified in order to “filter” mask testing on a particular frame.

For additional information on FlexRay eye-diagram mask testing, download Agilent’s applications note title, “FlexRay Physical Layer Eye-diagram Mask Testing” Publication number 5990-4923EN.

## Capture more FlexRay frames with segmented memory acquisition

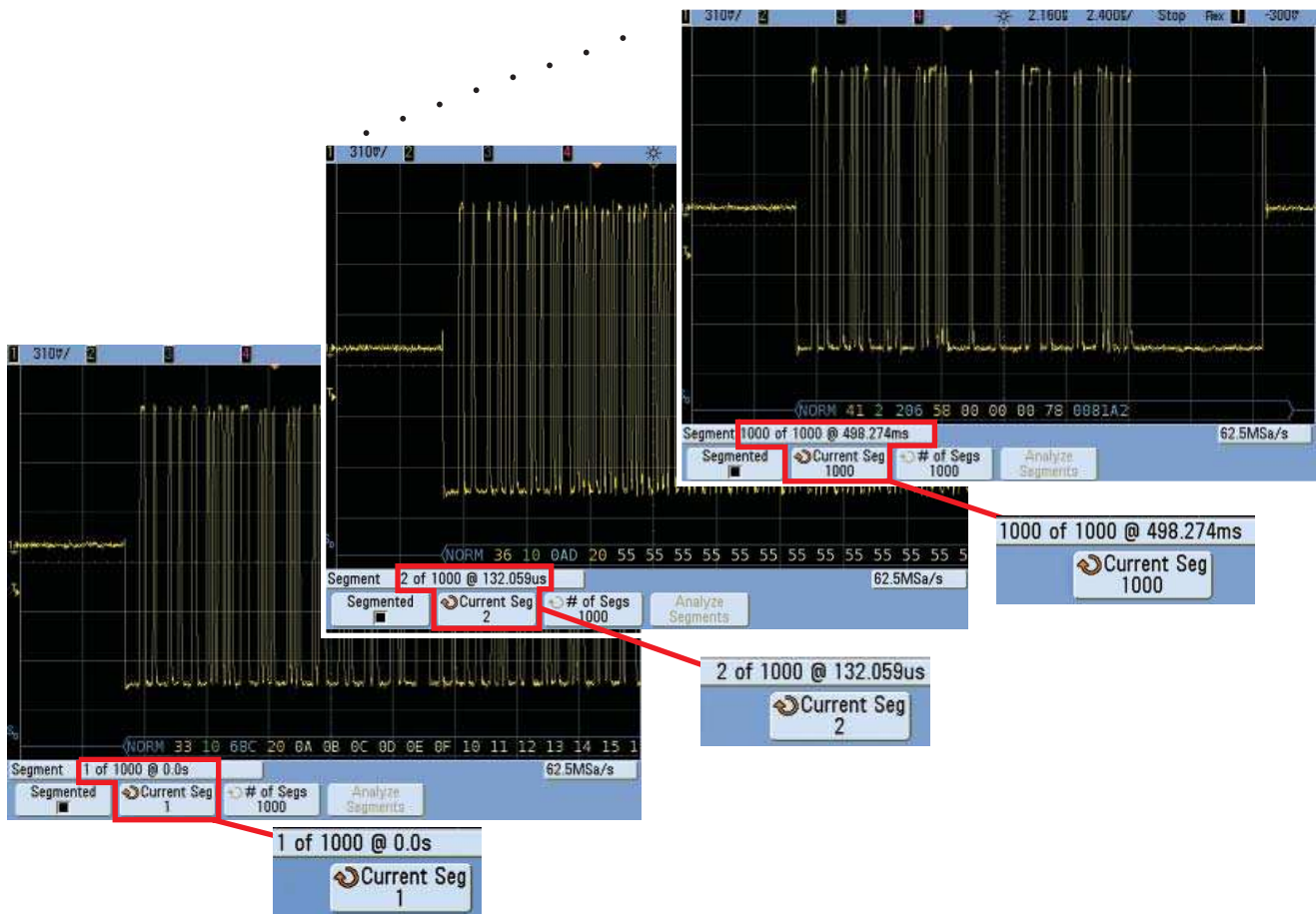
With the segmented memory acquisition mode, Agilent's InfiniiVision Series oscilloscopes can optimize your scope's acquisition memory allowing you to capture more FlexRay frames along with protocol decoding of each frame while using less oscilloscope acquisition memory. Segmented memory acquisition optimizes the number of FlexRay frames that can be captured consecutively by selectively ignoring (not digitizing) unimportant network idle time between frames. And

with a minimum 250 picoseconds time-tagging resolution, you will know the precise time between each frame.

Figure 7 shows a FlexRay bus measurement with the scope set up to trigger on every frame. Using this trigger condition with the segmented memory acquisition mode turned on, the scope easily captures 1000 consecutive FlexRay frames for a total acquisition time of 498 milliseconds. After acquiring the 1000 segments/

frames, you can then easily navigate through all frames individually to look for any anomalies or errors.

Agilent's InfiniiVision Series oscilloscopes are the only scopes available today that can acquire segments on up to four analog channels of acquisition and capture time-correlated segments on digital channels, and perform hardware-based serial bus decoding of each segment.



**Figure 7: Segmented Memory acquisition captures up to 2000 consecutive FlexRay frames with precise time-tagging between captured frames.**

# Automated FlexRay Physical Layer Conformance Testing

To perform FlexRay Physical Layer Conformance testing, Agilent provides a PC-based software package that you can download from Agilent's website at no additional charge. With this software package, you can perform automated tests at either receiver input or transmitter output test points.

Figure 8 shows an example of the generated report from a Signal Integrity Voting Test on a 10-Mbs isolated "1" pulse. The test report includes comprehensive pass/fail and margin analysis based on published specifications.

Table 1 and Table 2 show a list of the 33 available tests that can be selected and performed using the FlexRay Physical Layer Conformance Test software package.

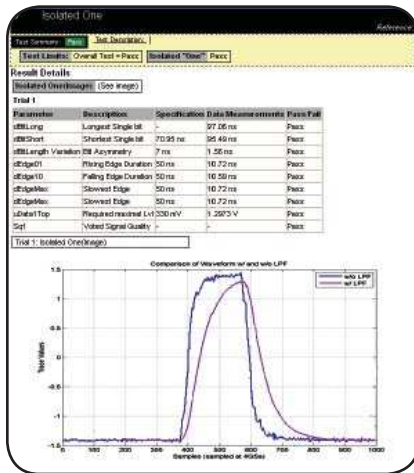


Figure 8: Signal Integrity Voting test performed on an isolated "1" bit.

## Receiver Input Tests

Parameter Tested	Test Description
<b>Eye-diagram Mask Tests:</b>	
TP4 – All	Receiver mask test on all frames
TP4 – ID	Receiver mask test on specified frame
<b>Signal Integrity Voting Tests on 14 MHz low-pass filtered Isolated "1":</b>	
uData1Top	Required maximal level
dBitShort	Shortest single bit
dBitLengthVariation	Bit Asymmetry
dEdge01	Rising Edge Duration (-300 mV to +300 mV)
dEdge10	Falling Edge Duration (+300 mV to -300 mV)
dEdgeMax	Slowest Edge
Sq1	Isolated "1" voted signal quality
<b>Signal Integrity Voting Tests on 14 MHz low-pass filtered Isolated "0":</b>	
uData0Top	Required minimal level
dBitShort	Shortest single bit
dBitLengthVariation	Bit Asymmetry
dEdge01	Rising Edge Duration (-300 mV to +300 mV)
dEdge10	Falling Edge Duration (+300 mV to -300 mV)
dEdgeMax	Slowest Edge
Sq0	Isolated "0" voted signal quality
<b>Advanced Diagnostic Tests:</b>	
gdTSSTransmitter	Transmitted TSS width @ receiver
MCT	Mean Corrected Cycle Time
uBusRx-Data	Data 1 Amplitude
-uBusRx-Data	Data 0 Amplitude
uRx-Idle	Mean Idle Level
dBusRx01	Rise Time Data0 to Data1 (-300 mV to +300 mV)
dBusRx10	Fall Time Data1 to Data0 (+300 mV to -300 mV)

Table 1: Receiver Input Tests

## Transmitter Output Tests

Parameter Tested	Test Description
<b>Eye-diagram Mask Tests (10 Mbs only):</b>	
TP1 – Std V	Mask test on standard voltage bus driver output
TP1 – Incr V	Mask test on increased voltage bus driver output
TP11 – Std V	Mask test on standard voltage active star output
TP11 – Incr V	Mask test on increased voltage active star output
<b>Advanced Diagnostic Tests:</b>	
gdTSSTransmitter	Transmitted TSS width
uBusTx-Data	Data 1 Amplitude
-uBusTx-Data	Data 0 Amplitude
uRx-Idle	Mean Idle Level
dBusTx01	Rise Time Data0 to Data1 (20% to 80%)
dBusTx10	Fall Time Data1 to Data0 (80% to 20%)

Table 2: Transmitter Output Tests

## Probe FlexRay signals with precision – even in environmental chambers

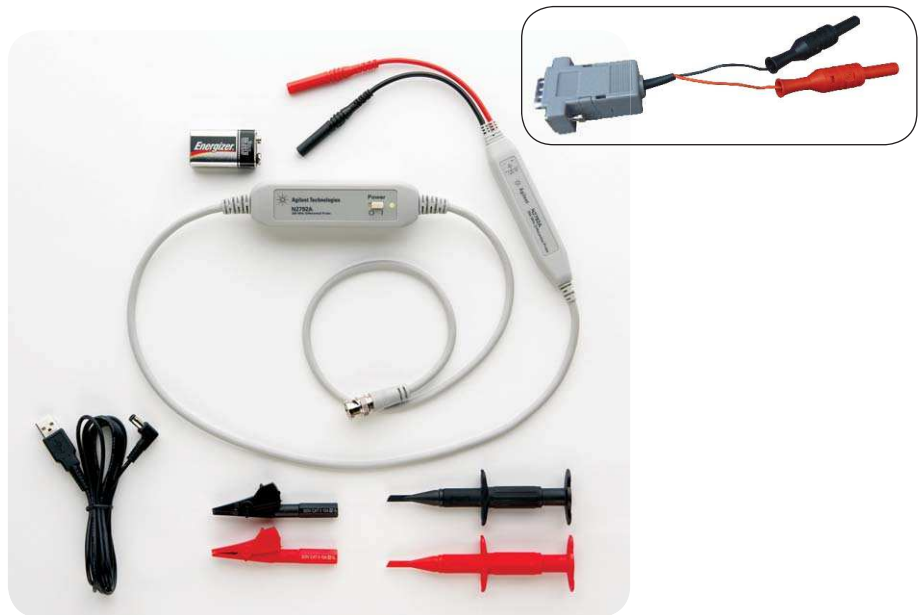
Signal integrity measurements on differential FlexRay signals require precision differential active probing. Agilent offers a wide range of differential active probes for various bandwidths and dynamic range applications.

For testing differential FlexRay signals on the bench or in the field, Agilent recommends either the N2792A, which is a 200-MHz, 1-M $\Omega$  differential active probe, or the N2793A, which is an 800-MHz, 200-k $\Omega$  differential active probe. Both of these probes have a 10:1 attenuation factor and are designed to be terminated into the scope's 50- $\Omega$  input.

If you need to connect to DB9-SubD connectors on your differential FlexRay bus, Agilent also offers CAN/FlexRay DB9 probe heads. These differential probe heads, which are shown in the insert of Figure 9, are compatible with N2791A (order part number 0960-2926) and the N2792A (order part number 0960-2927) differential active probes and allows you to easily connect to your FlexRay differential bus.

In addition to testing within controlled environments, automotive designs based on FlexRay technology are often tested under simulated extreme conditions in environmental chambers. These extreme conditions may include testing ECUs and differential serial buses at temperatures exceeding 150 ° Celsius. Unfortunately, most differential active probes are not rated to operate at these extreme temperatures.

For extreme temperature testing applications, Agilent recommends the InfiniiMax 1130A Series differential active probe. With the unique electrical and physical architecture of the InfiniiMax 1130A series, the N5450A extreme temperature cable extensive kit can be used to extend and displace the probe's active amplifier to be outside the environmental chamber (see Figure 10). With this configuration, the InfiniiMax' passive probe heads can be connected to test points within the chamber with temperatures ranging from -55 to +155 ° C.



*Figure 9. Agilent's N2792A and N2793A differential active probes are recommended for FlexRay applications.*



*Figure 10. The extreme temperature cable extension kit (N5450A) allows differential active probing within environmental chambers at extreme temperatures.*

## Make FlexRay tests in the field with battery operation

Although FlexRay systems should be thoroughly tested on the bench and under simulated environmental conditions, they should also be tested under real-world conditions. This requires in-car testing under various extreme driving conditions. Evaluating FlexRay bus signal fidelity with an “un-tethered” oscilloscope requires a scope that performs FlexRay measurements under battery operation. Agilent’s InfiniiVision 6000 Series oscilloscopes are the only battery-operated oscilloscopes on the market today that also support CAN, LIN, and FlexRay measurements. In addition to direct internal battery operation, the Agilent 6000 Series oscilloscopes can also be powered from an automobile’s 12-V battery using an optional power adapter.



**Figure 12: Making remote FlexRay measurements with Agilent’s battery option for InfiniiVision Series scopes**

## FlexRay specifications/characteristics (N5432C or Option FLX)

FlexRay input source	Channel 1, 2, 3, or 4 (using differential probe)
FlexRay Channels	A or B
Baud rates	2.5 Mbps, 5.0 Mbps, and 10 Mbps (user-selectable)
Frame triggering	<ul style="list-style-type: none"> <li>• Frame type: startup (SUP), not startup (~SUP), sync (SYNC), not sync (~SYNC), null (NULL), not null (~NULL), normal (NORM), and All</li> <li>• Frame ID: 1 to 2047 (decimal format), and All</li> <li>• Cycle - Base: 0 to 63 (decimal format), and All Repetition: 1, 2, 4, 8, 16, 32, 64 (decimal format), and All</li> </ul>
Error triggering	<ul style="list-style-type: none"> <li>• All errors</li> <li>• Header CRC error</li> <li>• Frame CRC error</li> </ul>
Event Triggering	<ul style="list-style-type: none"> <li>• Wake-up</li> <li>• TSS (transmission start sequence)</li> <li>• BSS (byte start sequence)</li> <li>• FES/DTS (frame end or dynamic trailing sequence)</li> </ul>
Frame decoding	<ul style="list-style-type: none"> <li>• Frame type (NORM, SYNC, SUP, NULL in blue)</li> <li>• Frame ID (decimal digits in yellow)</li> <li>• Payload-length (decimal number of words in green)</li> <li>• Header CRC (hex digits in blue if valid, or red digits if invalid)</li> <li>• Cycle number (decimal digits in yellow)</li> <li>• Data bytes (HEX digits in white)</li> <li>• Frame CRC (hex digits in blue if valid, or red digits if invalid)</li> </ul>
Totalize function	<ul style="list-style-type: none"> <li>• Total received frames</li> <li>• Total synchronization frames</li> <li>• Total null frames</li> </ul>

### Ordering information

Option FLX includes everything you need for FlexRay physical layer measurements on InfiniiVision Series oscilloscopes including licensed firmware that enables FlexRay triggering and decoding, mask testing,

segmented memory acquisition and physical layer conformance test software. If you already own an Agilent InfiniiVision Series oscilloscope and would like to upgrade your scope to support FlexRay measurements, order

the N5432C FlexRay after-purchase upgrade kit. Option FLX (or N5432C) is only compatible with 4-channel 5000, 6000, and 7000 Series DSO and MSOs with available bandwidth models ranging from 100 MHz up to 1 GHz.

Factory-installed option number	User-installed model number	Description
Option FLX	N5432C	FlexRay triggering and decode (4-channel DSO and MSO models only) , mask testing, segmented memory acquisition, and physical layer conformance test software
Option AMS	N5424A	CAN/LIN triggering and decode (4 and 4+16 channel models only)
Option LSS	N5423A	I <sup>2</sup> C/SPI serial decode option (4 and 4+16 channel models only)
Option 232	N5457A	RS-232/UART triggering and decode (4 and 4+16 channel models only)
	N2792A	200 MHz differential active probe
	N2793A	800 MHz differential active probe
	0960-2926	CAN/FlexRay probe head (compatible with N2792A)
	0960-2927	CAN/FlexRay probe head (compatible with N2793A)
	1130A	InfiniiMax 1.5 GHz differential active probe (probe heads ordered separately)
	N5450A	Extreme Temperature Cable Extension Kit for 1130A InfiniiMax probes

Note that additional options and accessories are available for Agilent InfiniiVision Series oscilloscopes. Refer to the appropriate 5000, 6000, or 7000 Series data sheet for ordering information about these additional options and accessories, as well as ordering information for specific oscilloscope models.

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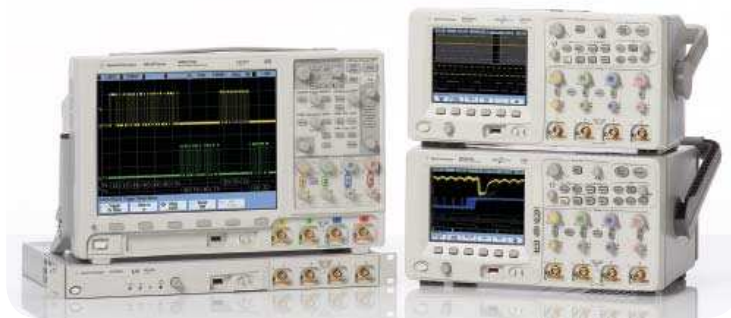
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