Keysight Technologies
Debugging LIN, CAN, CAN FD, SENT and FlexRay Serial Buses

Application Brief

To help you accelerate debug of your automotive serial buses, the Keysight Technologies, Inc. InfiniiVision X-Series provide CAN, CAN FD, LIN, SENT, and FlexRay triggering and decoding as well as CAN and FlexRay eye-diagram mask testing capability.

KEYSIGHT TECHNOLOGIES

To improve efficiency of system communication and to reduce cost, all of today's automotive designs employ a variety of serial bus communication protocols. The I2C and SPI protocols are cost often used for chip-to-chip communication within electronic control units (ECUs). For longer distant serial communication and control between various automotive subsystems such as comfort control systems, anti-lock brakes, drive train, and engine control, the CAN, CAN FD, LIN, SENT, and FlexRay protocols are the most popular serial buses implemented in today's vehicles.

The LIN serial bus, which is based on a master-slave relationship, is primarily used in non-safety critical applications such as seat and mirror controls. The differential event-triggered CAN/CAN FD serial buses, which have higher noise immunity than the single-ended LIN bus, have been the vehicle's workhorse control bus for more than two decades now. The differential time-triggered FlexRay serial bus, which operates on a synchronous deterministic schedule, is an emerging serial bus technology used in some of today's higher-end automobiles for more performance-demanding and safety-critical systems. The SENT (single edge nibble transmission) bus is used to digitally transmit sensor data to automotive ECUs.

Unfortunately, serial bus communication is often susceptible to signal integrity problems caused by the naturally harsh environment found in automobiles, which can sometimes create errors during critical communication cycles. Although serial bus protocol analyzers are a great tool used to test and monitor the higher level protocol and application layer transfer of serial bus data, they tell you nothing about the integrity/quality of your automotive serial bus signals (physical layer). But some of today's mid-range and higher performance digital storage oscilloscopes (DSOs) offer LIN, CAN, CAN FD, SENT, and FlexRay bus decoding and triggering capabilities that provide the time-correlation link between the protocol layer and physical layer.

Figure 1 shows a Keysight InfiniiVision 4000 X-Series oscilloscope capturing and decoding a CAN bus symbolically while simultaneously capturing and decoding a LIN bus in HEX format. Time-correlated decode traces for each bus are shown at the bottom of the display. The top half of the scope's display shows the oscilloscope industry's only time-interleaved "lister" display.

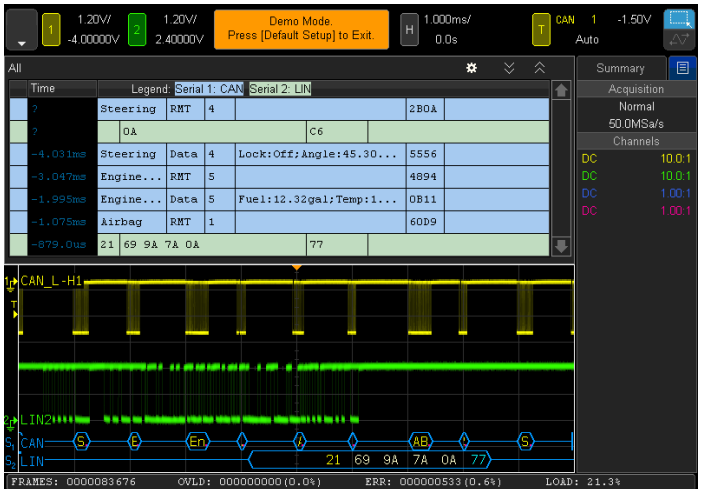

Figure 1: Capturing and decoding a CAN and LIN serial bus simultaneously on a Keysight InfiniiVision X-Series oscilloscope.

Also unique in Keysight's InfiniiVision Series oscilloscopes is hardware-based decoding. All other oscilloscopes on the market today utilize software-based decoding. Software-based decoding tends to be slow – especially when using a scope's deeper memory selections. Hardware-based decoding provides a virtual real-time update of serial bus activity – even when using deep memory. This enhances the scope's probability of capturing random and infrequent communication errors.

In addition to providing decoded words time-correlated to captured waveforms, another useful tool to verify the signal integrity of the higher-speed CAN and FlexRay buses is to perform an eye-diagram mask test. Eye-diagram testing is used in a broad range of today's serial bus applications. An eye-diagram is basically an overlay of all bits captured by the scope to show when bits are valid and not valid. This provides a composite picture of the overall quality of a system's physical layer characteristics, which includes amplitude variations possibly due to transmission line affects, reflections, system noise, over-shoot, ringing, signal edge timing, and jitter.

Figure 2 shows a FlexRay eye-diagram mask test based on a TP4-10Mbps standard. The triggering reference for the TP4 mask test is based on each Byte Start Sequence (BSS) event. This is the same reference signal that FlexRay receivers use to re-synchronize and recover clocks for sampling received data. The Keysight InfiniiVision series oscilloscopes utilize a unique repetitive hardware clock recovery technique to capture and overlay each bit of every byte in the synchronous FlexRay system. Note that it is also possible to "filter" the capture and overlay of FlexRay eye-diagram data based on specific frame IDs.

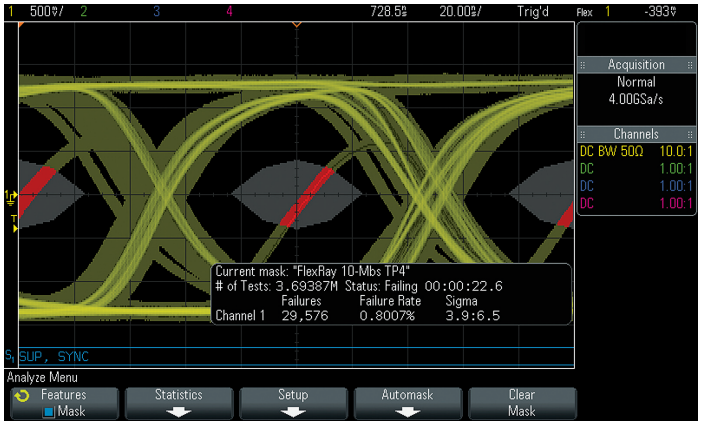

Figure 2: FlexRay "TP4" eye-diagram mask testing using a Keysight InfiniiVision 3000 X-Series oscilloscope.

FlexRay eye-diagram mask testing is possible on Keysight 3000, 4000, and 6000 X-Series oscilloscopes with the FlexRay option and the Mask Test option. Various FlexRay mask files based on baud rate and test plane (TP#) can be downloaded at no charge.

CAN eye-diagram mask testing is possible on all models of Keysight's InfiniiVision X-Series oscilloscopes with the CAN/LIN option and the Mask Test option. Various CAN mask files based on baud rate, probing polarity (dominant-bit high or dominant-bit low), and network length can be downloaded at no charge.

Keysight's InfiniiVision X-Series oscilloscopes

If you are in the market today to purchase your next oscilloscope for automotive serial bus applications, Keysight Technologies' InfiniiVision X-Series oscilloscopes come in various bandwidth models ranging from 70 MHz up to 6 GHz. These scopes come with a standard 3-year warranty, as well as an industry-first 2-year recommended calibration cycle.

For probing your differential CAN/CAN FD and FlexRay buses, Keysight recommends the 200-MHz N2818A differential active probe.

To learn more about Keysight's InfiniiVision 2000, 3000, 4000, and 6000 X-Series oscilloscopes and mixed signal oscilloscopes for automotive applications, go to www.keysight.com/find/infiniivision

Automotive Serial Bus Features	**InfiniiVision X-Series Availability**			
Description	**2000X**	**3000TX**	**4000X**	**6000X**
CAN decode and trigger	DSOX2AUTO	DSOXT3AUTO	DSOX4AUTO	DSOX6AUTO
CAN FD decode and trigger	N/A	DSOXT3AUTO	DSOX4AUTO	N/A
CAN-dbc symbolic decode and trigger	N/A	DSOXT3AUTO	DSOX4AUTO	DSOX6AUTO
CAN eye diagram mask testing	DSOX2AUTO + DSOX2 MASK	DSOXT3AUTO + DSOX3MASK	DSOX4AUTO + DSOX4MASK	DSOXAUTO + DSOX6MASK
LIN decode and trigger	DSOX2AUTO	DSOXT3AUTO	DSOX4AUTO	DSOX6AUTO
SENT decode and trigger	N/A	N/A	DSOX4SENSOR	N/A
FlexRay decode and trigger	N/A	DSOX3FLEX	DSOX4FLEX	DSOX6FLEX
FlexRay eye diagram mask testing	N/A	DSOX3FLEX + DSOX3MASK	DSOX4FLEX + DSOX4MASK	DSOX6FLEX + DSOX6MASK

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