APPLICATION NOTE

Measurement Tools for Quick Automotive Serial Bus Debugging

Using the HD3 Series oscilloscopes

KEYSIGHT

Introduction

An oscilloscope has an inherent ability to characterize the analog quality of automotive serial buses such as Controller Area Network (CAN), CAN FD, and Local Interconnect Network (LIN). That is why engineers often use oscilloscopes to debug and characterize these signals. Performing analog characterization using an oscilloscope is known as taking physical-layer measurements.

When analyzing the physical layer, the oscilloscope must operate at its fastest speed so you can see any infrequent errors on your buses that could cause serious defects. You can only see these infrequent errors if your oscilloscope is doing serial decoding in hardware. Software decoding causes an oscilloscope to run too slowly to catch any rare events.

Many oscilloscopes on the market offer automotive-focused options. However, the Keysight InfiniiVision HD3 Series oscilloscopes offer unique hardware-based measurement capabilities for debugging and characterizing the physical layer of automotive serial buses.

Figure 1. The InfiniiVision HD3 Series is the offers hardware-based serial decoding, which allows you to see infrequent errors

This application note explores the unique automotive measurement capabilities and advanced analysis features on InfiniiVision HD3 Series oscilloscopes to help you quickly debug and characterize the physical layer of automotive serial buses.

Those capabilities include the following:

- Hardware-based decoding for responsiveness.
- Dual-bus time-interleaved lister display.
- Decoding of all frames captured using segmented memory.
- Zone trigger to isolate occurrences of CAN bus arbitration.

Fast Oscilloscope Waveform Update Rate

Waveform update rates can be extremely slow when using deep memory on other vendor's oscilloscopes. Not only does this make the scope difficult to use, but it decreases the probability of finding an infrequent glitch.

In contrast, the HD3 Series oscilloscopes can update over 1.3 million waveforms per second with Keysight's exclusive custom ASIC technology. HD3 oscilloscopes can capture long waveforms while using automatic deep acquisition memory (100 Mpts per channel), which automotive serial bus applications often require. Figure 2 shows that a responsive scope enhances the instrument's usability and the probability of capturing elusive events that may be problematic in automotive designs.

Figure 2. An update rate of 1.3 million waveforms per second easily captures infrequent glitches and jitter

Hardware-Based Decoding

HD3 Series oscilloscopes use hardware-based decoding of CAN, CAN FD, LIN, and all other supported serial buses. Hardware-based decoding provides a real-time update of the decode trace. This capability increases the scope's probability of capturing and displaying infrequent serial bus communication errors, such as error frames and form, acknowledge errors, cyclic redundancy check (CRC), and bit stuffing errors, as shown in Figure 3.

Figure 3. Hardware-based decoding captures and displays an infrequent CAN bit stuffing error followed by an error frame

Dual-Bus Time-Interleaved Protocol Lister Display

Most oscilloscopes with serial bus options can display decoded data in two formats. One format shows one or more decode traces time-correlated to the captured waveform. This decode trace is useful when the scope's time base is set up to view a single frame. The time-correlated decode trace appears near the bottom of the scope's display (below the waveforms) on HD3 Series oscilloscopes. The second decode format is what Keysight calls the lister display. The lister display shows a tabular list of decoded data with column labels based on the fields for the specific protocol.

Automobiles use multiple buses for control and monitoring, including CAN, CAN FD, and LIN. Data sometimes needs to pass from one bus to another. Automotive vendors use chips known as gateways to interchange data between buses. InfiniiVision HD3 Series oscilloscopes can display time-interleaved decoded data from two buses in the same lister table, as shown in Figure 4. In this example, the LIN bus frames are green, and the CAN bus frames are yellow. The time-interleaved lister display makes it easy to trace data that passes from one bus to another.

Figure 4. Dual-bus time-interleaved lister display makes it easier to track data through CAN-to-LIN gateways

Segmented Memory Acquisition with Frame Decoding in a Lister Display

Automotive engineers often need to capture multiple and consecutive — yet selective — frames of serial data. For example, they may want to capture each consecutive occurrence of errors without capturing everything in between. Without segmented memory acquisition, the alternative is to use a scope with extremely deep memory and then wade through all that memory after capturing a long record that includes all frames (not just selected frames). This process is time-consuming and laborious.

Engineers can set up the HD3 Series oscilloscopes to capture segments with precise time-tagging between each frame. Then, they can review the segments individually with automatic decoding (time-correlated decode trace and lister). This process makes it easier to measure the time between occurrences of a particular error. It also enables engineers to track the sensor output data each time the system transmits an error, as shown in Figure 5.

Figure 5. Segmented memory acquisition with automatic decoding selectively captures CAN packets with precise time-tagging between each occurrence

Segmented memory acquisition in the HD3 Series oscilloscopes automatically decodes frames. HD3 oscilloscopes display all decoded frames from segmented acquisitions in the protocol lister display.

Use Zone Triggering to Isolate and Characterize CAN Bus Arbitration

Identifying CAN bus arbitration is simple if the oscilloscope's waveform update rate is fast. Triggering on occurrences of arbitration based on specific CAN messages is challenging with most scopes. But the InfiniiVision oscilloscope's zone trigger capability lets you establish a zone where arbitration occurs (first few bits of each frame) while also qualifying the trigger condition on a specific frame ID (or symbolic message name), as shown in Figure 6. You can then use the oscilloscope's segmented memory acquisition to capture consecutive occurrences of arbitration to characterize how often it occurs.

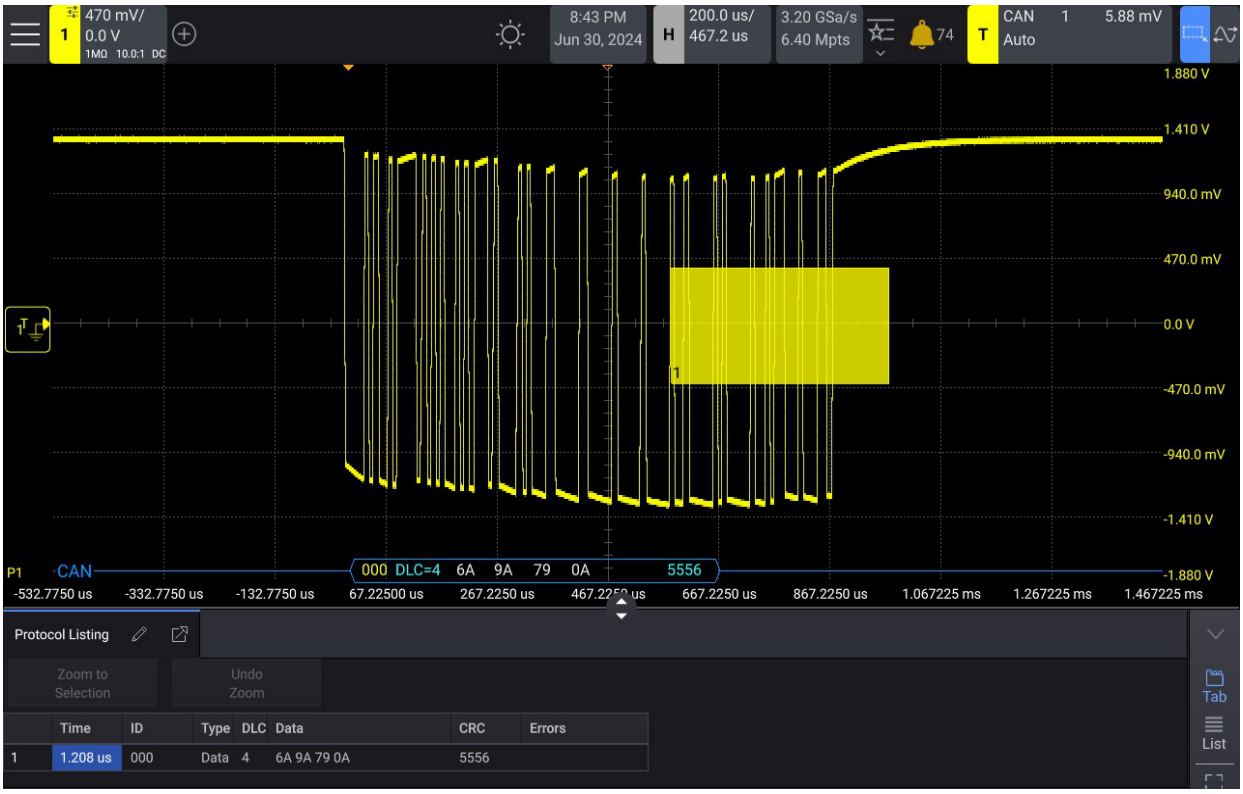

Figure 6. Characterization CAN bus arbitration using the oscilloscope's zone-triggering capability

Conclusion

All of today's major oscilloscope vendors offer options for triggering on, decoding, and searching data on CAN, LIN, CAN FD, and all other major serial buses. The InfiniiVision HD3 Series offers hardware-based decoding to ensure that you do not miss any rare events that can cause defects in your design. This, combined with the other unique capabilities of Keysight's HD3 scopes, like the lister display, will help you characterize and debug the physical layer of automotive serial buses quickly and with four times more vertical accuracy than other general-purpose oscilloscopes.

See What You've Been Missing

Get four times the resolution and half the noise.

The InfiniiVision HD3 Series oscilloscopes enable you to capture small signals accurately with its low-noise front end and 14-bit ADC, giving you four times more vertical resolution than other 12-bit general-purpose oscilloscopes. Combine this with an uncompromised waveform update rate and powerful features such as Keysight Fault Hunter, deep memory, and hardware accelerated testing, and the HD3 Series oscilloscopes are well-suited for your applications.

Learn more about the portable precision of the HD3 Series.

Figure 7. The all-new HD3 Series, built with completely custom components optimized specifically for oscilloscope measurements