

# Oscilloscope Measurement Tools to Debug Automotive Serial Buses Quickly

Using the HD3 Series Oscilloscope

# Introduction

An oscilloscope has an inherent ability to characterize the analog quality of automotive serial buses such as CAN, CAN FD, LIN and so many more. 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, it is critical the oscilloscope is still operating at its fastest speeds 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, Keysight's 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 ONLY oscilloscope in this class that offers hardware-based serial decoding.

This application note explores the unique automotive measurement capabilities and advanced analysis features on InfiniiVision X-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

## Fastest Oscilloscope Waveform Update Rate

The HD3 Series oscilloscopes can update over 1.3 million waveforms per second with Keysight's exclusive custom ASIC technology. HD3 oscilloscopes remain responsive even when capturing 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 usability of the instrument, as well as its probability of capturing elusive events that may be problematic in automotive designs.

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.



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

# Hardware-Based Decoding

HD3 Series oscilloscopes are the only oscilloscopes on the market that 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 enhances the scope's probability of capturing and displaying infrequent serial bus communication errors, such as error frames and form, acknowledge, CRC, and stuff bit errors, as shown in Figure 3.



**Figure 3.** Hardware-based decoding captures and displays an infrequent CAN stuff bit 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 the CAN, CAN FD, LIN, and other buses. 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. The LIN bus frames are green, and the CAN bus frames are blue in this example. The time-interleaved lister display makes it easy to trace data that passes from one bus to another.

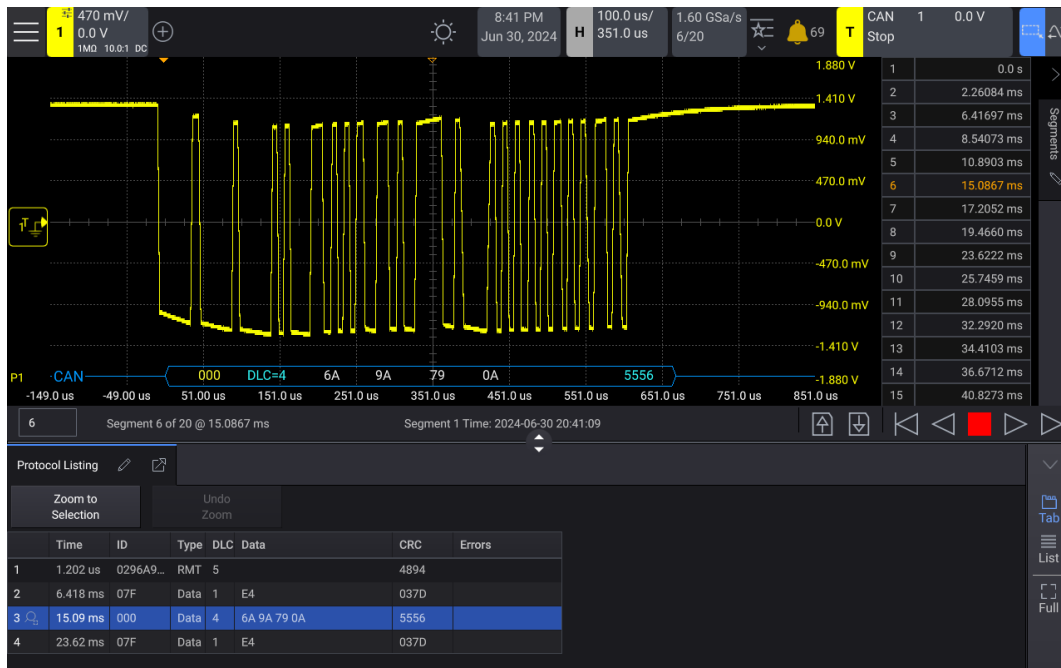


**Figure 4.** Dual-bus time-interleaved lister display makes it easier to track data through CAN-to-LIN gateways

# 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 selective frames). This process can take a really long time.

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

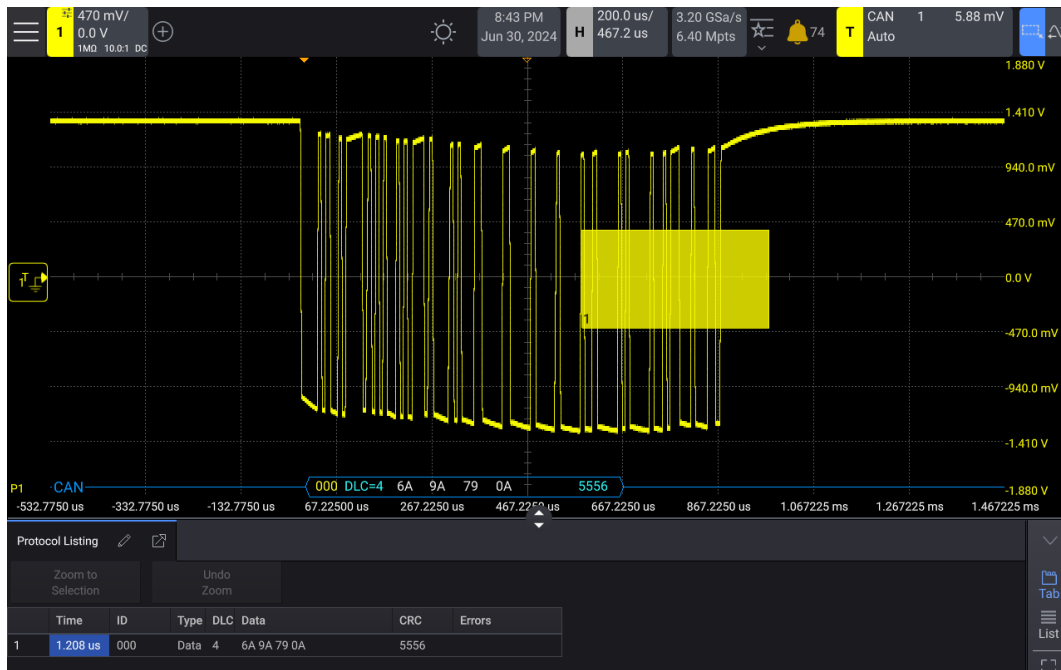


**Figure 5.** Segmented memory acquisition with automatic decoding selectively captures CAN packets with precise time-tagging between each occurrence

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

# Use Zone Triggering to Isolate and Characterize CAN Bus Arbitration

Identifying when CAN bus arbitration is occurring is easy if the oscilloscope's waveform update rate is fast. Triggering on occurrences of arbitration based on specific CAN messages is not so easy 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

## Summary

All of today's major oscilloscope vendors offer options for triggering on, decoding, and searching data on the CAN, LIN, CAN FD, and all other major serial buses. However, only the Keysight HD3 Series offers hardware-based decoding to ensure you don't 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 fastest with the most accuracy.

## See What You've Been Missing

4x the resolution and up to 10x less noise

The HD3 Series brings Keysight's industry-leading capabilities from high-performance scopes to the high-volume level, making precision portable from 200 MHz to 1 GHz. Leveraging custom hardware technology from the UXR Series, the HD3 boasts the most impressive resolution on the market with 4x the vertical accuracy and up to 10x less noise than the competition. Paired with our fast, uncompromised waveform update rate and 25x more memory, the HD3 Series is truly set apart from other oscilloscopes in this class.

Learn more about the portable precision of the HD3 at [keysight.com/find/HD3](https://keysight.com/find/HD3)



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

Keysight enables innovators to push the boundaries of engineering by quickly solving design, emulation, and test challenges to create the best product experiences. Start your innovation journey at [www.keysight.com](https://www.keysight.com).



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