Oscilloscopes in Aerospace/Defense

Debugging MIL-STD 1553 serial buses

Agilent's InfiniiVision 3000 X-Series oscilloscopes provide MIL-STD 1553 triggering and decoding, as well as eye-diagram mask test capability to help you debug your MIL-STD 1553 buses faster.

The differential 1-Mbps MIL-STD 1553 serial bus is widely used today in a broad range of aerospace/defense systems including aircraft avionics equipment, space-based systems, as well as many ground-based military vehicles. Due to the harsh electrical environment of military equipment, testing the quality of received and transmitted signals is very important. The primary measurement tool that engineers and technicians use today to test the signal integrity of serial buses is an oscilloscope. But capturing and measuring the electrical characteristics of MIL-STD 1553 signals have been a difficult and tedious process using conventional analog or digital oscilloscopes. Setting up a scope to trigger and synchronize on specific transmitted or received words often requires an external synchronization signal or guessing at a specific trigger hold-off setting. And then to determine the message information of captured and displayed communication packets/words requires a commonly used visual "bit-counting" technique, which is slow and prone to errors.

Although MIL-STD 1553 bus monitors/protocol analyzers can provide the high-level protocol layer information regarding transfer of data, they tell you nothing about signal integrity. The answer to this dilemma (scope versus bus monitor) is to use a scope that is also able to intelligently trigger on and decode MIL-STD 1553 signals.

Figure 1 shows the display of an Agilent InfiniiVision X-Series scope capturing and decoding a MIL-STD 1553 RT-to-RT message transfer. All Command, Status, and Data Words are decoded and displayed in a time-correlated trace below the captured waveform. In addition, the scope displays a tabular list of decoded data in the upper half of the scope's display.

The differential probing point for this particular measurement was at the input of Remote Terminal #2. As expected, words received from the Bus Controller (BC) have reduced amplitudes due to transformer coupling. In addition, the shapes of each receive bit from the BC have been distorted — probably due a long and lossy transmission line within the aircraft. In this case, the scope revealed a Manchester encoding error (indicated by MANCH text color-coded in red) that occurred during the 2nd Command Word transmitted by the BC. With this information provided by the scope, it should now be much easier for the avionics engineer or technician to troubleshoot the root cause of this error.

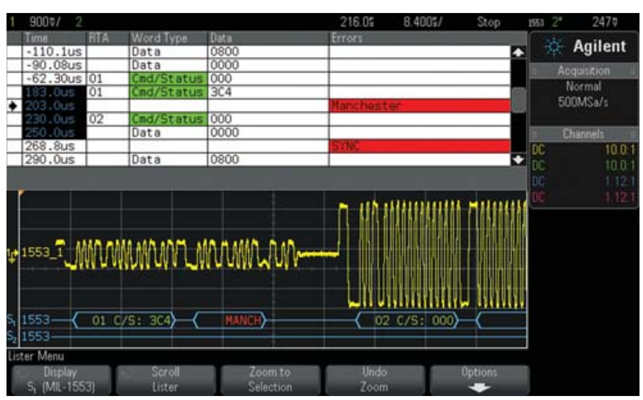

Figure 1: Decoding an RT-to-RT message on an Agilent InfiniiVision 3000 X-Series oscilloscope.

In addition to providing decoded words time-correlated to captured waveforms, another useful tool to verify the signal integrity of a MIL-STD 1553 bus 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 MIL-STD 1553 eye-diagram mask test at the input of a remote terminal. The scope repetitively captures and overlays all 17 Manchester-encoded bits of every Command Word transmitted by the Bus Controller. Note that since the 3-bit sync field of each word does not adhere to Manchester encoding, these bits are not included in the eye-diagram display.

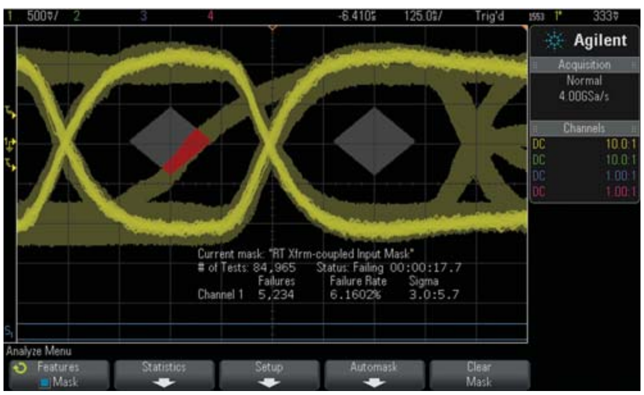

Figure 2: Testing the signal integrity of a differential MIL-STD 1553 serial bus using eye-diagram mask testing.

Although a typical eye-diagram based on NRZ encoded data consists of just one "eye", a MIL-STD 1553 eye-diagram is quite unique in that it actually consists of two "eyes"; one for each half of every Manchester encoded bit. A proper MIL-STD 1553 eye-diagram should show just rising and falling transitions in the middle of each bit (center-screen). But in this example we can see that the scope captured a shifted half-bit with a slow rising edge that crossed through the "keep-out" mask region causing mask test failures. This is most likely the bit that induced the decoded Manchester encoding error shown earlier in Figure 1.

The diamond-shaped masks that define the waveform "keep-out" area of the MIL-STD 1553 mask shown in Figure 2 are based on published MIL-STD 1553 minimum input amplitude and zero-crossing distortion specifications for a transformer-coupled system.

Agilent's InfiniiVision 3000 X-Series Oscilloscopes

If you are in the market today to purchase your next oscilloscope, Agilent Technologies' 3000 X-Series oscilloscopes come in various bandwidth models ranging from 100 MHz up to 500 MHz. These scopes come with a standard 3-year warranty, as well as an industry-first 2-year recommended calibration cycle. When purchased with the DSOX3AERO option, these scopes provide MIL-STD 1553 and ARINC 429 serial triggering and decoding. Eye-diagram mask testing of your MIL-STD 1553 bus is also available with the DSOX3MASK mask test option. Agilent provides various MIL-STD 1553 mask files that can be downloaded at no charge for testing both transformer-coupled systems as well as direct-coupled systems. For probing your differential MIL-STD 1553 bus, Agilent recommends the N2791A 25-MHz differential active probe.

To learn more about Agilent's InfiniiVision 2000 & 3000 X-Series oscilloscopes and mixed signal oscilloscopes, go to: www.agilent.com/find/morescope

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