TECHNICAL BRIEF

Testing & Debugging Avionics Systems that Use ARINC 429 or MIL-STD-1553 Data Busses

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Summary

The data busses in aircraft and spacecraft require very high quality in transmission and reception since proper communication of commands and data are crucial to operation. The ARINC 429 standard used predominately in commercial aircraft and the MIL-STD-1553 bus used in military avionics and space vehicles (military and commercial) have some common characteristics as well as important differences. This paper will give useful examples of how to view, test and troubleshoot these busses using digital oscilloscopes.

Physical Characteristics

As with many serial data systems, both ARINC 429 and MIL-STD-1553 are differential busses. ARINC 429 is the simpler and less costly of the two. The physical connection is via twisted pair wires with balanced differential signals. It uses a self clocking, self synchronizing data bus. MIL-STD-1553 uses dual redundant balanced differential pairs. The peak to peak voltage allowed in the differential pair of an ARINC 429 system is 10 volts whereas the peak to peak output voltage of a transmitter on the MIL-STD-1553 bus is allowed to be as high as 18-27 volts. Both systems are designed for noise immunity and signal integrity. Among the plethora of modern serial data standards, both avionics busses are fairly low speed compared to PCI-Express, SAS or other standards which transport large amounts of data over short distances inside personal computers.

Capturing and Viewing Signals

Since the edge rates of signals and the command/data transmission rate of the busses is moderate, an engineer working on a system using ARINC 429 or MIL-STD-1553 does not need the type of very expensive oscilloscope used to capture signals sent on multi gigabit per second busses. The WaveSurfer and WaveRunner classes of oscilloscopes from LeCroy are well matched to this application. The images used in this paper to illustrate capturing, viewing, decoding and troubleshooting signals were gathered using those types of oscilloscopes. Figure 1 shows a typical example of serial data decoding. Though this particular image shows MIL-STD-1553, the decoding of many types of serial data looks very similar. Rather than the engineer spending a large amount of time peering at the shape of a serial data signal on his oscilloscope screen, counting highs/lows and decoding the data in his head the oscilloscope can highlight different portions of the signal content with different background colors, digitally decode the data and display the resulting digital interpretation along with the analog shape of the electrical waveform from the bus. This not only saves the engineer considerable time in developing a new product (or trouble shooting a problem), it also greatly reduces the chance of human error in “eyeball interpretation” of the signal shape. Note that in Figure 1 the upper trace is at longer time/division. It shows more signal length, but with less detail than the lower trace, which is a zoom of the upper trace.

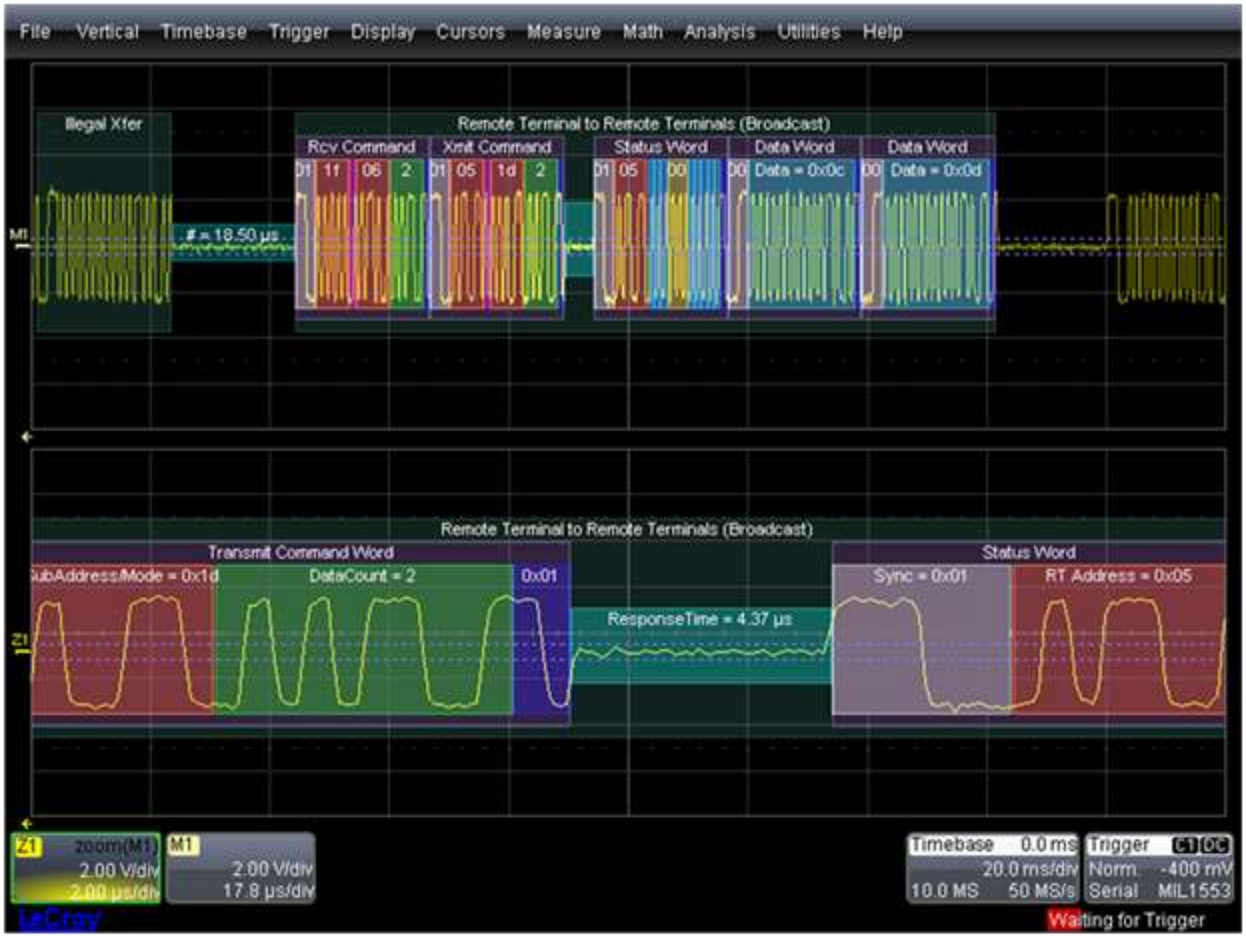

***Figure 1**: A MIL-STD-1553 signal is viewed and decoded on the upper trace. The lower trace shows a zoomed portion of the upper signal. Note the zoom has a more detailed level of decoding*

In addition to seeing the voltage vs time trace in more detail in the zoom view, the oscilloscope also shows more details of the decoding of the signal. This type of zooming to get more detail is particularly useful in modern digital oscilloscopes which have long data acquisition memory lengths and hence have the ability to capture more signal details than will conveniently fit onto the pixels of a typical flat panel display.

Using the Decoded Signal

Sometimes the engineer can get all the information he needs to confirm proper operation of a circuit or device by viewing the decoded signal. But more often the engineer needs to examine a long signal acquisition or even many acquisitions in order to spot problems or to characterize correct device operation. Figure 2 is an example of the view and decode of an ARINC 429 signal. It is somewhat similar to Figure 1; the upper trace shows one second of signal shape (10 divisions of the oscilloscope screen at 100 msec/div) and the lower trace is a zoom detail of that data. As with Figure 1 the zoom trace shows more detail of the voltage vs time trace and also more detail of the decoding of the data. There is a further feature at the bottom of Figure 2 – a table which lists important attributes of the serial data stream. The table can inform the oscilloscope user of important characteristics of the whole signal without him needing to zoom in and look at each piece of the signal in detail. By examining the table the user can find the pieces of the signal that are of the most interest, click on the entry in the table and the scope will automatically zoom to that portion of the signal.

Figure 2: *The capture of an ARINC 429 signal on the upper trace, a zoomed portion on the same signal on the lower trace and a table showing key signal characteristics*

Identifying and Trouble Shooting Problems

At the R&D stage every project suffers from some sorts of problems. In an avionics system it is particularly important to identify any potential pitfalls either in the data/command transmission system or in the devices which communicate via that system. The ARINC 429 option from LeCroy allows an oscilloscope user to search a captured signal record using a choice of 14 selectable criteria. These include the time of occurrence of a portion of the captured signal, data value, parity, message, status and other signal attributes. The MIL-STD-1553 option goes one step further and allows the scope user to set up a trigger to capture and decode exactly the portion of the signal in which the user is interested. Figure 3 shows the trigger setup menu where the user can choose the type (transfer, word, error and timing), subtype (command, data, status, any), format (binary, hex) and command. The oscilloscope will then monitor the live signal coming into the specified channel of the scope and trigger on the desired type of signal. As examples, being able to trigger on a specific command or being able to monitor the signal and trigger on any error are very powerful ways of testing and debugging problems.

Figure 3: *Setting up a trigger for MIL-STD-1553. The User can select the type, subtype, format and command*

Summary

Modern digital oscilloscopes can greatly speed product development time and minimize the possibility of glitches in aerospace systems. In addition to capturing and decoding avionics specific signals such as ARINC 429 and MIL-STD-1553 it is also possible to do the same sort signal acquisition, decode and trouble shooting on ubiquitous signals such as USB, RS232, UARTs, and a wide variety of other types of serial data.