SPACEWIRE MARGINS TESTER

Session: SpaceWire Test and Verification

Short Paper

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ABSTRACT

The subject of this presentation is a SpaceWire Margins Tester which is intended to simulate major parameters to give designers an idea about SpaceWire link voltage and timing margin. The operational principal uses a good SpaceWire signal from a known source and degrades it to a point where the SpaceWire link under test will start to experience receive errors. Methods for simulating and testing the margin ranges of SpaceWire physical layer are shown on attached Power Point slides [1].

1. Problem

A common question that occurs during SpaceWire link testing is: "OK, it works now in a lab – but what are the worst physical layer conditions that this link can tolerate for a desired error rate?" It is very important to take this into account as the communication speeds and distances between SpaceWire links are increasing and it is difficult to verify this especially if some of the commonly used SpaceWire hardware components, particularly MDM connectors and some cables, may negatively impact link performance. In addition, temperature and active radiation may also contribute to link degradation.

As a result, the engineer needs to simulate SpaceWire conditions for various communication speeds. The parameters include: Data and Strobe skew to satisfy setup and hold timing, LVDS skew for each individual differential pair, "eye pattern" opening span, and LVDS receiver bias.

SpaceWire margin simulations are hampered by SpaceWire protocol and physical layer difficulties.. There are no explicit provisions in the existing protocol standards to support error tests. The constant current used in LVDS links makes margin testing very cumbersome. Last, the different cable wire gauges and their lengths provide major impact on transmission quality.

2. Suggestion

The proposed SpaceWire Margins Tester or SWMT simulates most of SpaceWire physical layer parameters to allow the designer to determine each particular

SpaceWire link margins and predict possible performance degradations at worst anticipated conditions.

2.1 Methods and Assumptions

The SWMT receives the SpaceWire signal from a known source, degrades the margin in the SpaceWire signal by error injection, and retransmits the signal to the device under test (DUT) until a link error is detected. Link errors are detected when the link goes silent during a restart (clock dropout condition). The link restarts serve as substitutes of conventional bit error rates (BER). By knowing link protocol parameters, it is possible to translate resulting frame error rate (FER) to more commonly used BER.

It is important to note that only the DUT receiver is subjected to simulation. The DUT transmitter site is needed to respond with valid test results. It is intended that the distance between the SWMT and the DUT is minimal so that the DUT's transmitter will have minimal effect on the link's performance. As a result, the SWMT standalone instrument is designed to satisfy the above mentioned methodology. A more precise Complex SWMT is also possible and its specs are discussed in attached slides presentation [1].

3. Technical Characteristics

3.1 Simulated Parameters

Of all the SpaceWire parameters that can be simulated, only the three main parameters of skew, span, and bias are simulated.

3.1.1 Skew

Variable skew simulation between the Data and Strobe SpaceWire signals is needed to define minimal setup and hold time that the DUT can tolerate to have reliable clock extraction. Skew is simulated by using delay elements to slide one signal versus the other in both directions from nominal "0" timing point. As a result, the minimal time interval between Data and Strobe can be determined. The suggested range of signal sliding is ± 30 nS (60 nS of total covered interval) with around 1 nS resolution. This skew corresponds to an equivalent minimum communication speed of 16.6 Mbps. The SWMT will automatically select the skew range based on the operating frequency of the link. The SWMT supports links speeds of up to 310 Mbps (3 nS bit time). The maximum communication speed is set by the operator at the beginning of every test, starting from 10 Mbps and with step resolutions of 10 Mbps. Because of some implementation difficulties, differential pair skew is not tested in a current version of SWMT.

3.1.2 Span

Variable span is needed to simulate minimal voltage at receiver inputs. This is the trickiest parameter to simulate for the LVDS physical layer. The SWMT uses modulated high speed amplifiers with voltage outputs to adjust the span. The span is defined by loading the DUT's termination resistor so the differential voltage drop across resistor will correspond to LVDS DUT receiver allowable operating range. The maximum drop across the 100 Ω termination resistor is 700 mV p-p at 3.5 mA nominal current. The minimal drop is specified by LVDS specification document [2] at ± 100 mV, or 200 mV p-p. To have some extra margins, the SWMT will set its operational range from 180 to 720 mV p-p with programmable steps of 20 mV. To minimize signal loss across the cable between the DUT and SWMT, the shortest possible cable (0.5-1 m) with largest wire gauges (AWG 22-24) is required. This approach was successfully tested by NASA GSFC to troubleshoot one of its spacecraft electronic units.

3.1.3 Bias

Variable bias, which also can be referred to as common mode voltage (CMV), is rather simple to simulate. The LVDS specification document [2] defines receiver's nominal bias at around +1.2 V. The SWMT will set its simulation range as ± 1.2 V from nominal or 0 V to +2.4 V on absolute scale: all with programmable steps of 200 mV. The SWMT will also be able to detect ground fault condition when its pin 3 is shorted to overall shield or DUT chassis.

3.2 Simulation

The parameter's simulation can be either static, by manually changing one parameter at a time and monitoring result; or dynamic, by defining the working range of change of one or more of desired parameters and allow the SWMT to try all available combinations within range. In dynamic mode, only one parameter is changed at a time on a 1 ms time interval. At the end of an interval DUT generated clock dropout counter is assessed and if new value is detected it is immediately reported.

The longest time that it takes to run through all possible combinations at 10 Mbps communication speed is 23 seconds, but this time cycle may be greatly reduced if higher speeds and/or tighter allowable ranges are selected.

3.3 Connection Modes

Two connection modes are available: Pass mode – from external Source to DUT and Loop mode – from DUT transmitter back to DUT receiver; in this mode the DUT has to establish a self loopback data link. In Pass mode, the DUT transmission is passed to an external Source unaltered; in this case SWMT is connected in to a break between SpaceWire link source and DUT.

4.0 Control

There are two ways to control the SWMT.

4.1 Local

Local control is done through front panel buttons and dials and provides manual access to all of the simulated parameters. In addition, each SWMT contains up to 8 different profiles (combined set of simulated parameters) stored in non-volatile SWMT memory.

4.2 Remote

Remote control is optional and is provided from remote computer through an electrically isolated USB 2.0 port. Isolation is required to provide valid Bias simulations. Remote computer duplicates all local control operations and provides for a more automated option.

5. Telemetry

The main telemetry parameter is dropout counter value. Every second front panel display shows the accumulated number of occurred dropouts and current test elapsed time. The test duration can be as long as 99,999 seconds (in excess of 27 hours) and can show up to 99,999 link dropouts. Once started, a test can be terminated either by the operator, or by the timer or dropout counter overflow. The remote computer is able to track telemetry with 1 ms resolution (vs. 1 second for visual display) together with current profile's setup.

6. Future Developments

In addition to a Simple (or Coarse) tester, a Precision tester can be made. This requires changing the structure of existing SpaceWire IP cores by adding a module for testing. This change would allow performing BER detection inside IP (instead of FER) and report it on demand. Activation of this test mode could be done through a dedicated operational code from outside. Implementing this change allows an external tester not to inject errors in to the pre-existing data from some other source, but to generate its own test patterns and provide a much higher level of test fidelity especially in area of simulating Data and Strobe signals skew and differential pair skew. These new features can be discussed in greater details during the ISC-2008 meeting and the prototype could be ready for ISC-2009.

7. References

1. SpaceWire Physical Margins Tester – ISC-2008 presentation
2. ANSI TIA/EIA-644A [LVDS] Standard

8. Acknowledgments

The authors would like to thank Michael Pagen for his suggestions that helped to develop Simple SWMT concept.