TITLE:

CROSSTALK AND EYE DIAGRAM ANALYSIS OF GEN-X LRM CONNECTORS (10-507603 and 10-507702) USING ALL CONTACTS AS DIFFERENTIAL PAIRS

Purpose:

This report provides the results of SPICE modeling of the Gen-X LRM connector for use in a low speed LVDS application. All pins were configured as differential pairs, as shown in figure 1.

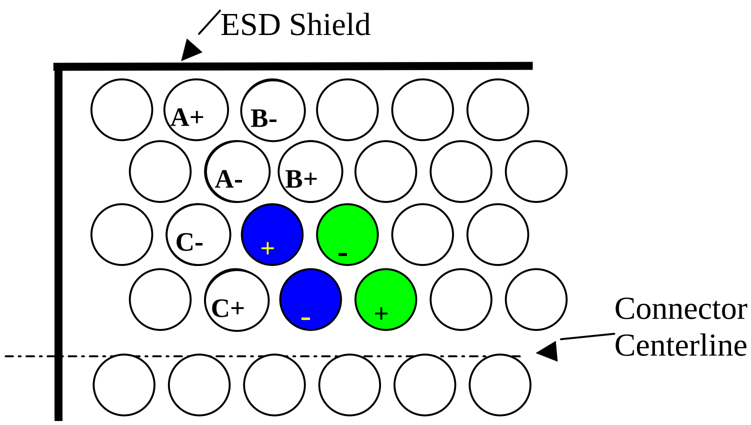

Figure 1. Differential Pair configuration. Each pair is a single color.

Method:

The SPICE parameters for the differential pairs of the Gen-X connector were obtained by use of an electromagnetic field solver. The connector was divided into a multitude geometrically-discrete cross-sections, and each geometry analyzed via the electromagnetic field solver (see report ER-8559 for additional details). It should be noted that the field of contacts actually analyzed was similar to that depicted in Figure 1, including the ESD shield. The L and C matrix used for the SPICE model was generated from a contact internal to the pattern, such as the positive blue contact. Previous work done has indicated that the contacts adjacent to the ESD shield will have negligible differences to those internal to the field of contacts.

TDR plots were simulated for a variety of conditions; single mated pair of connectors, pad/via capacitance, and two connectors connected by a loss-less transmission line. A single line of each differential pair was terminated to a 50 ohm loss-less transmission line for the simulations (see figure 12). In addition, two full differential pairs (each half/single line of each differential pair was terminated to a 50 ohm loss-less transmission line) were simulated, and driven differentially (see Figure 21). The single/half models permitted more transmission lines to be simultaneously analyzed, and the full differential pair models permitted insight into the true behavior of a differential system. Multiple risetimes were used to simulate multiple data rates.

In addition, eye-pattern simulation was conducted at various data rates, and various connector configurations. The technique for creating "eye" displays in Pspice was from Microsim Application Note titled "Creating Eye Displays Using Probe". This was originally published in *The Design Source Newsletter*, January, 1993. It is available online at http://www.pspice.com/online_help/appnotes.asp. The pseudorandom bit patterns used as the input signal are derived using a BASIC program defined in Microsim Application Note "Test Analog Circuits with Random Digital Data", also available at the above Web site.

Results:

Simulated TDR displays are shown for 35 ps, 350 ps, 700 ps, and 1.75 ns. These risetimes correspond (roughly) to data rates of 10 Gbps, 1 Gbps, 500 Mbps,and 200 Mbps respectfully. The crosstalk ranged from 13% to 2.6% over this range for the single/half differential pair model, as can be seen in Figures 3 through 6. In addition, Figures 14, 15, 17, and 18 depict the difference between one and two threat signals coupling into one victim transmission line for the single/half differential pair model.

Figure 20 shows the full differential pair model crosstalk between the Blue and Green differential pairs of Figure 1 to be approximately 1.3%, half of that predicted by the single/half differential pair model.

Eye sweep simulations are shown in Figures 7 through 13 for various data rates and connector configurations. As noted in Figure 12, these simulations were single-ended driven, not differentially.

Conclusion:

Based on the eye diagram for 1 Gbps (figure 11), the fully utilized Gen-X connector should be capable of supporting 187 Mbps. Unfortunately a 200 Mbps data rate eye pattern could not be simulated due to software limitations.

The crosstalk analysis for the 187 Mbps was much more complicated.

Crosstalk between two adjacent differential pairs such as the Blue and Green pairs in Figure 1 should not exceed 1.3%, as shown in Figure 20. The common mode rejection obtained from true differential signal processing was what yielded this advantage, and is why the true differential pair modeled data was used as opposed to the single/half differential pair derived data.

Crosstalk between two opposed differential pairs (such as the A pair and the Blue pair in Figure 1) should not exceed 2.6%, as depicted in Figure 7. In this case, the common mode rejection is not a factor, as the differential energy from the threat differential pair is primarily coupling into one half of the victim differential pair. That is why the single/half differential pair derived data has been used.

The crosstalk between multiple simultaneous threat differential pairs and one victim differential pair should not exceed 6%, as depicted Figure 15, but may in fact be much smaller than that depending on the position of the threat differential pairs relative to the victim differential pair. For instance, if the threat differential pairs were the C pair and Green pair, and the victim pair the Blue pair depicted in Figure 1, the crosstalk should not be greater than 2.6%, and may even be reduced to practically zero due to the differential nature of the signals. This would also be the case if the threat differential pairs were the A and B pair, and the victim the Blue pair depicted in Figure 1.

The actual geometric simulation was done with the pairs assigned along a horizontal row (not as shown in Figure 1). Since there is minimal difference between the geometry of the preferred method shown in Figure 2 and the horizontal row pairing, it has been assumed that the data found in this report also applies to the preferred method.

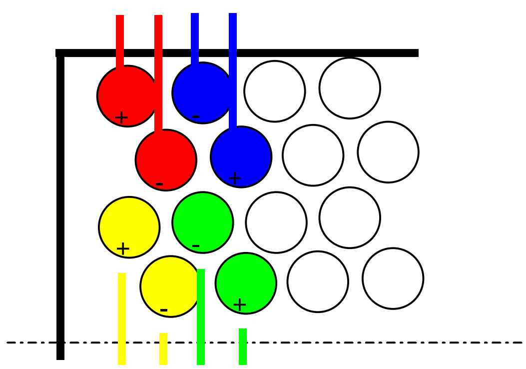

Figure 2. Preferred Differential Pairing of contacts. Colored lines represent surface mount tails.

Recommendations:

Verification testing should be conducted to confirm the validity of the simulation data provided in this report.

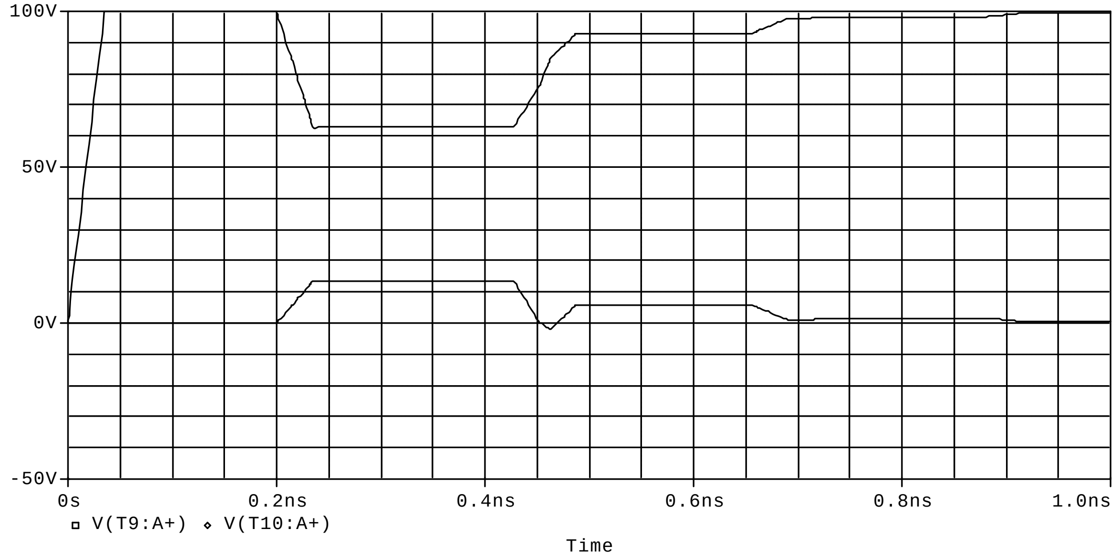

Figure 3. SPICE Output, simulated TDR, Zdiff = 63 ohms, Xtalk = 13.5% (35 ps input risetime, single connector mated pair, no via parasitic capacitance).

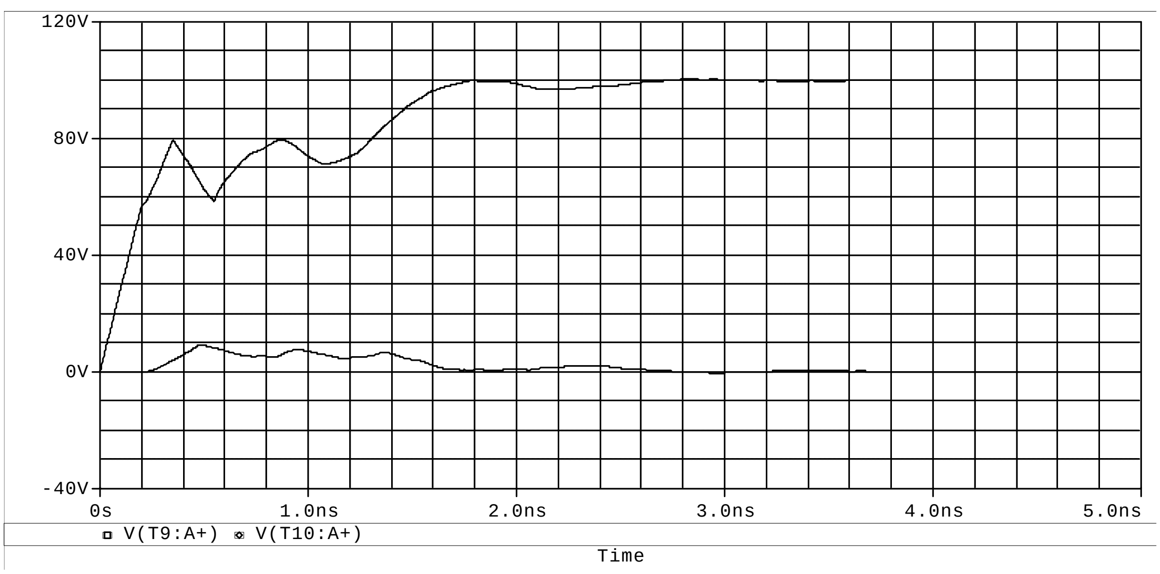

Figure 4. SPICE Output, simulated TDR, Zdiff = 70 ohms, Xtalk = 9% (350 ps input risetime, two connector mated pairs, with four 1.5 pF vias for each connector.)).

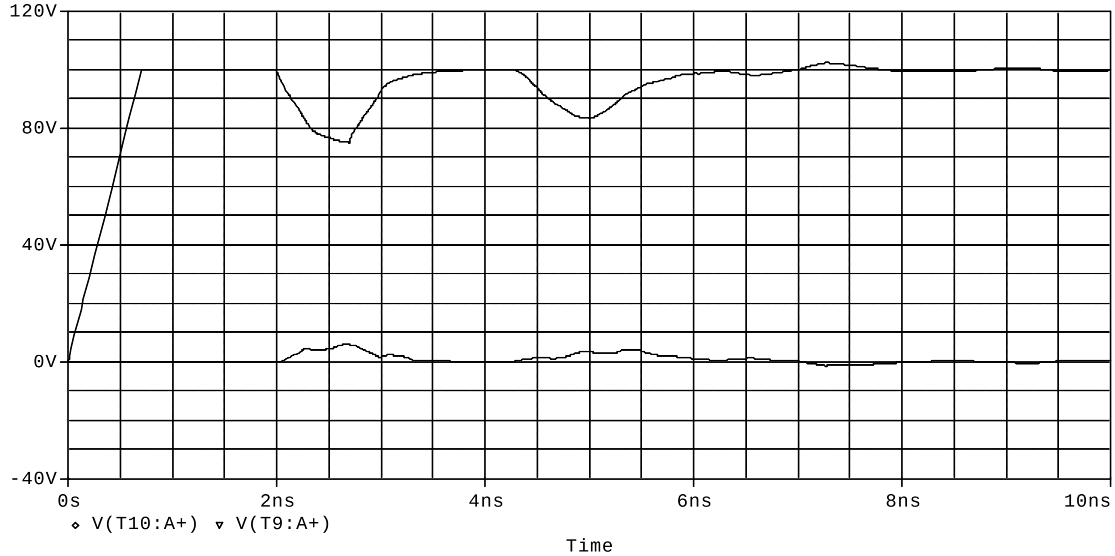

Figure 5. SPICE Output, simulated TDR, Zdiff = 76 ohms, Xtalk = 6% (700 ps input risetime, two connector mated pairs, with four 1.5 pF vias per connector).

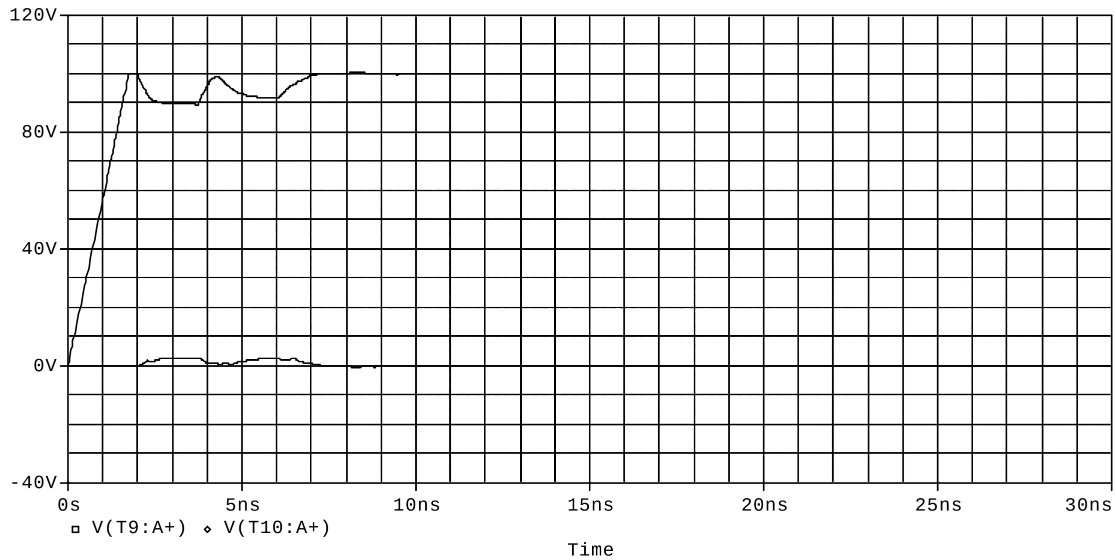

Figure 6. SPICE Output, simulated TDR, Zdiff = 90 ohms, Xtalk = 2.6% (1.75 ns input risetime, two connector mated pairs, with four 1.5 pF vias per connector).

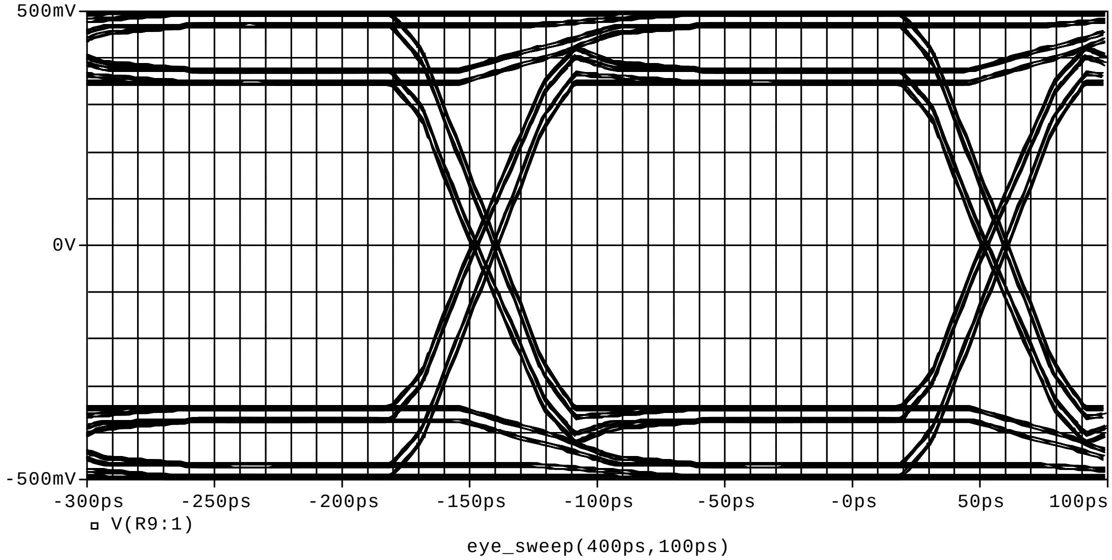

Figure 7. Simulated Eye Sweep at 5 Gbps for a single mated pair of connectors, without via/pad capacitance (based on same data used to create figure 3).

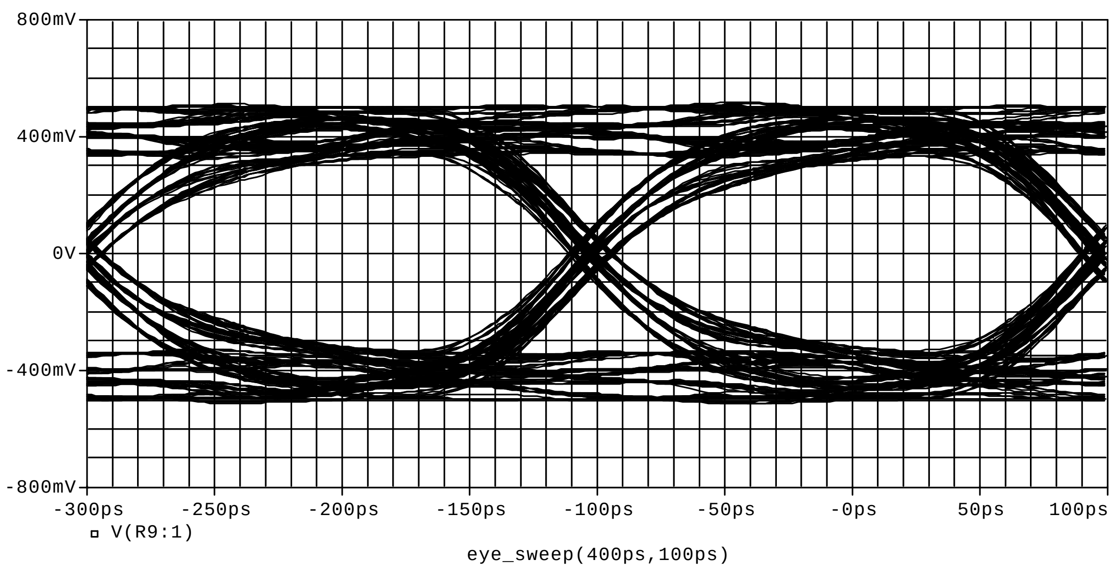

Figure 8. Simulated Eye Sweep at 5 Gbps for a single mated pair, with via capacitance (four vias @ 1.5 pF each).

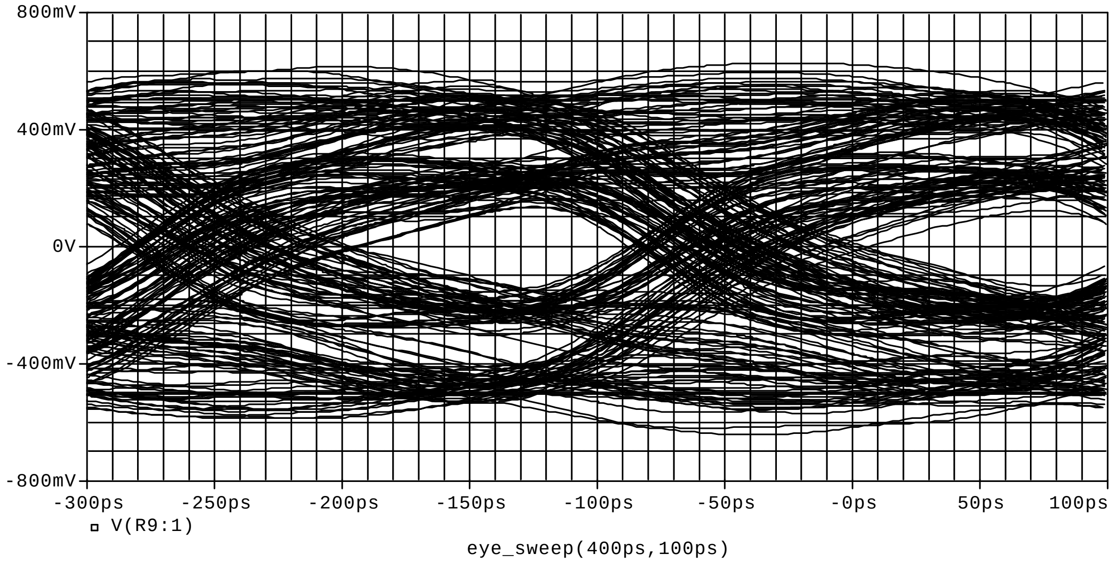

Figure 9. Simulated Eye Sweep at 5 Gbps for 2 mated pairs of connectors, plus via capacitance (4 vias @ 1.5 pF each per connector).

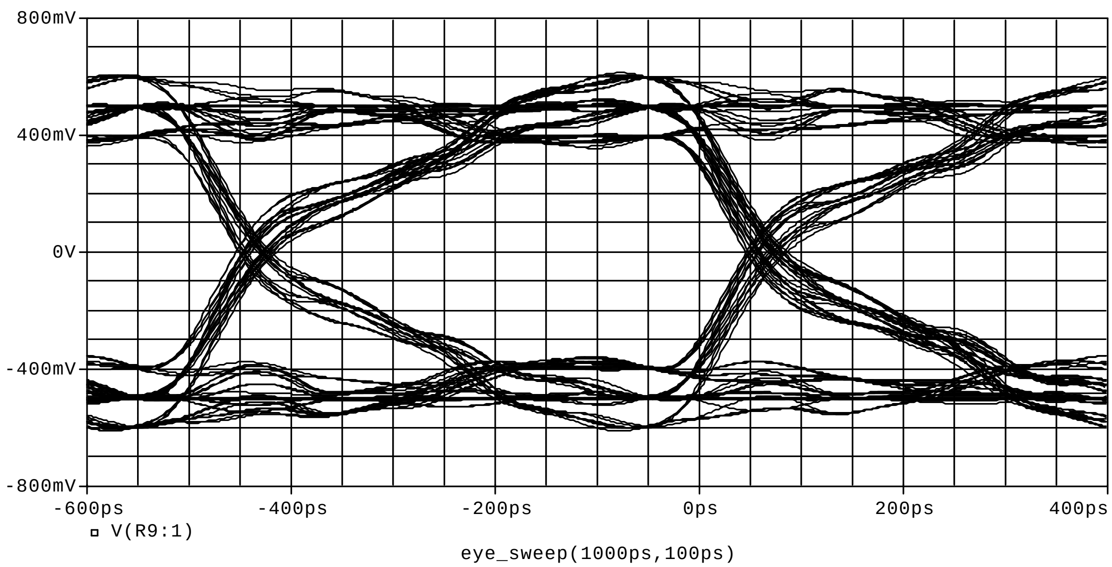

Figure 10. Simulated Eye Sweep at 2 Gbps for 2 mated pairs of connectors, plus via capacitance (4 vias @ 1.5 pF each per connector).

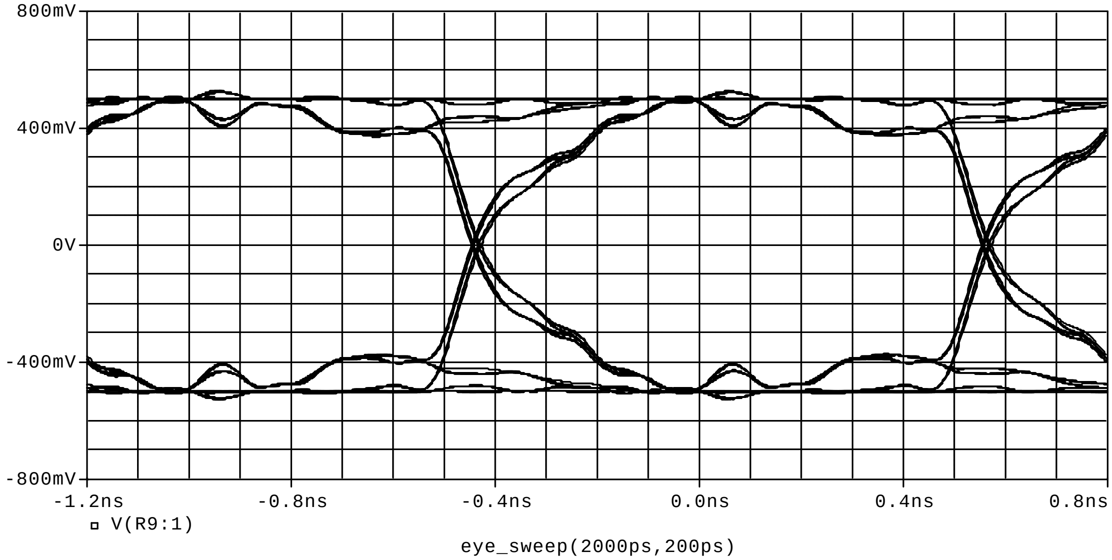

Figure 11. Simulated Eye Sweep at 1 Gbps for 2 mated pairs of connectors, plus via capacitance (4 vias @ 1.5 pF each per connector).

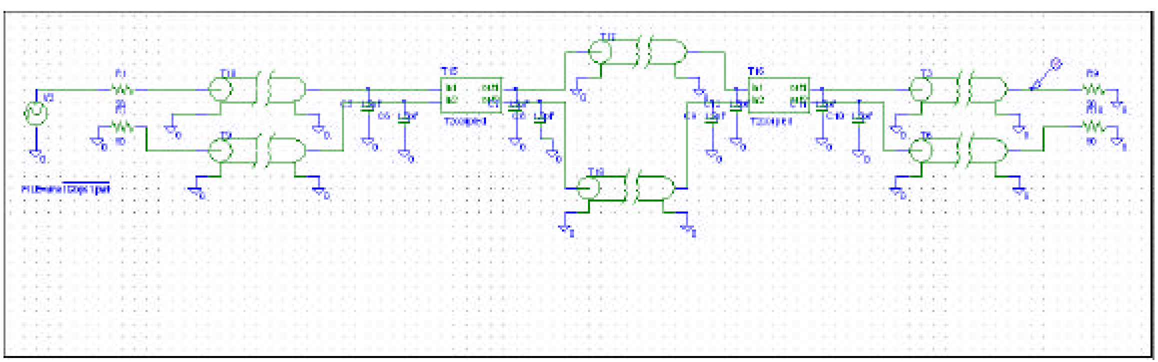

Figure 12. SPICE schematic used to produce the results shown in Figure 11.

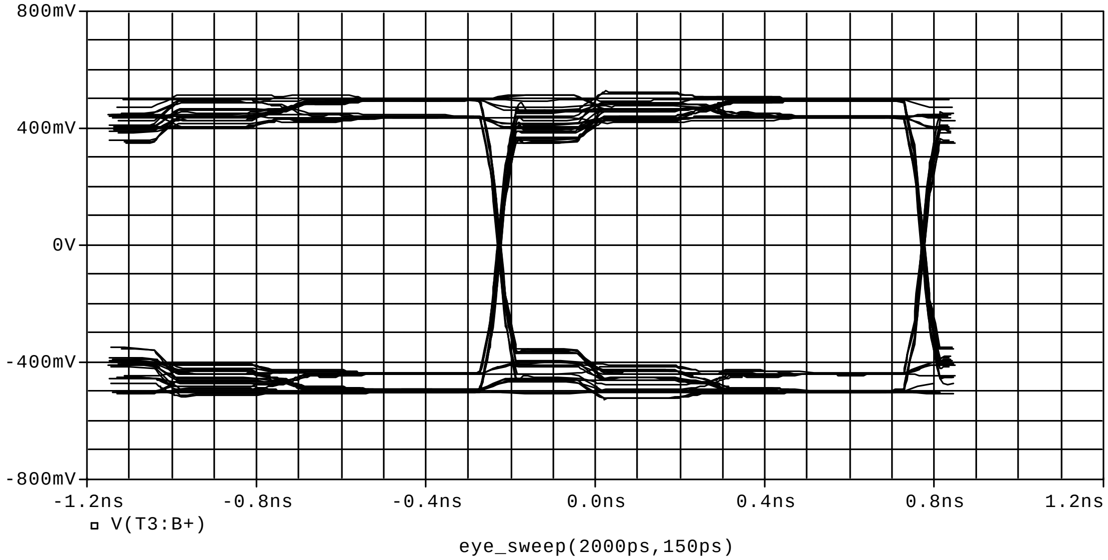

Figure 13. Simulated Eye Sweep at 1 Gbps for 2 mated pairs of connectors, w/o via capacitance. (Included for clarification of via influence. Compare to Figure 11.)

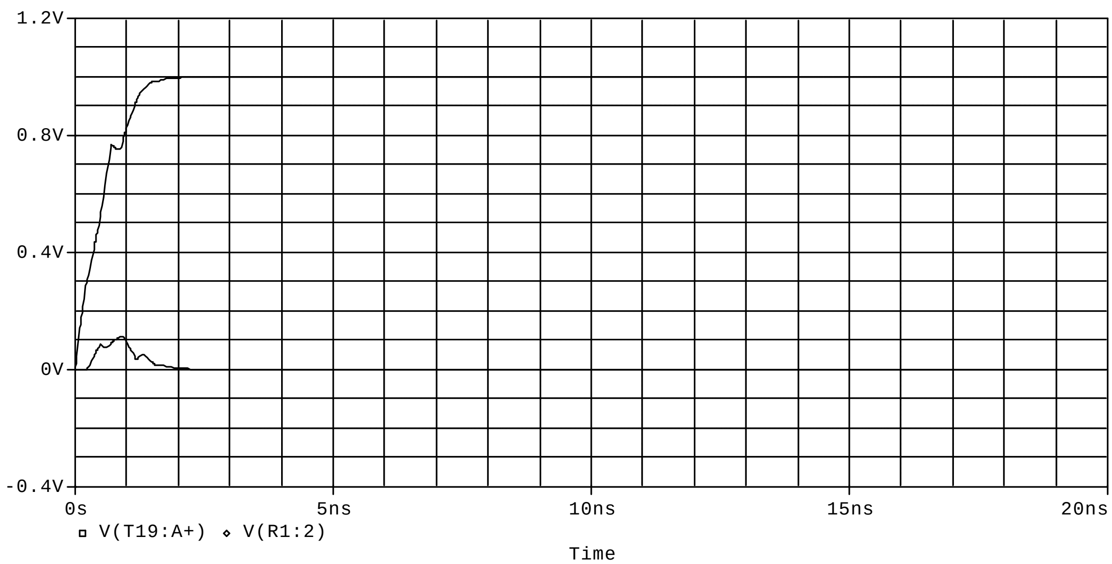

Figure 14. SPICE Output, simulated TDR, Zdiff = 76 ohms, Xtalk = 11.5% (700 ps input risetime, single connector pair, with vias, 2 adjacent lines driven.)

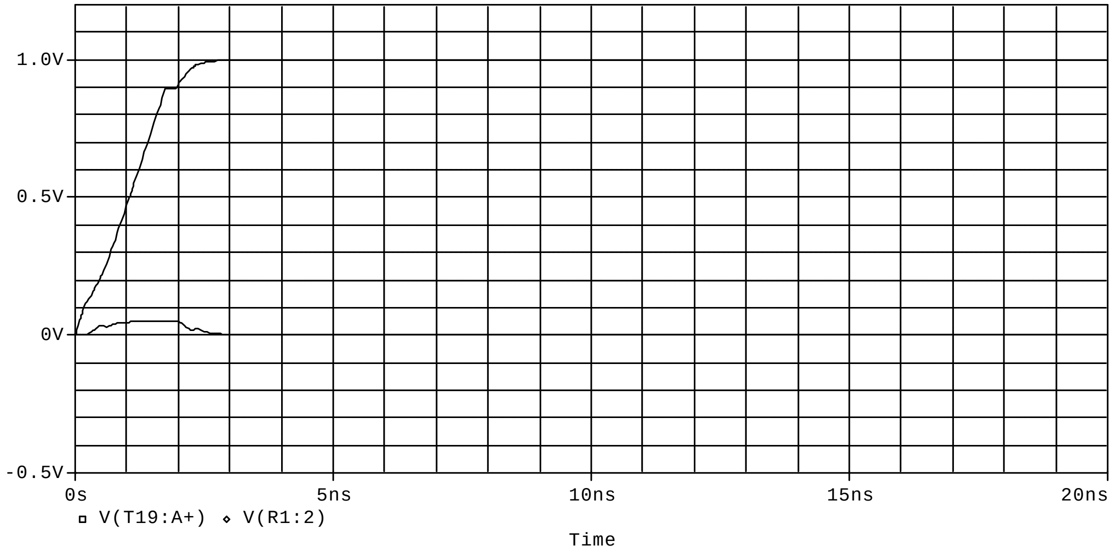

Figure 15. SPICE Output, simulated TDR, Zdiff = 90 ohms, Xtalk = 6.0 % (1.75 ns input risetime, single connector mated pair, with vias, 2 adjacent lines driven.)

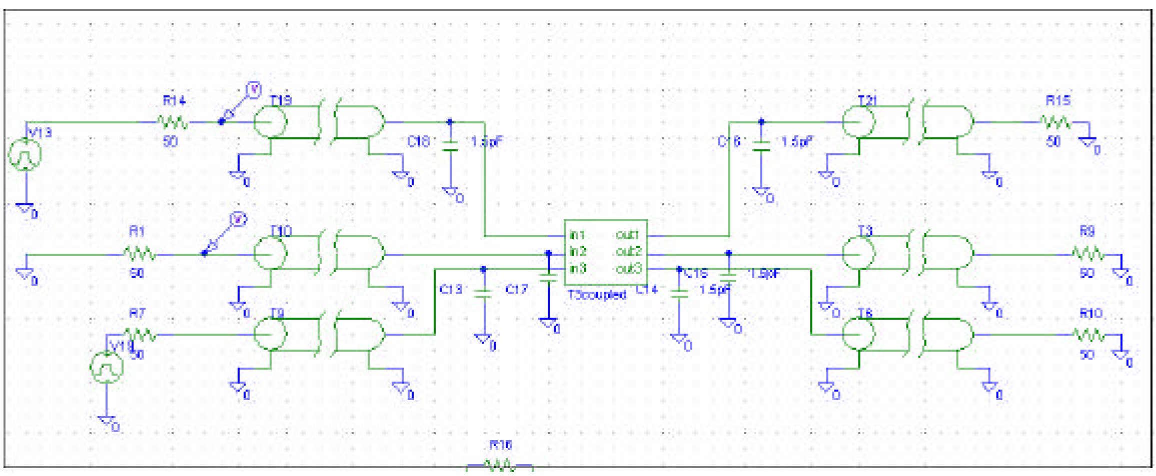

Figure 16. SPICE schematic used to produce the results shown in Figures 14 and 15.

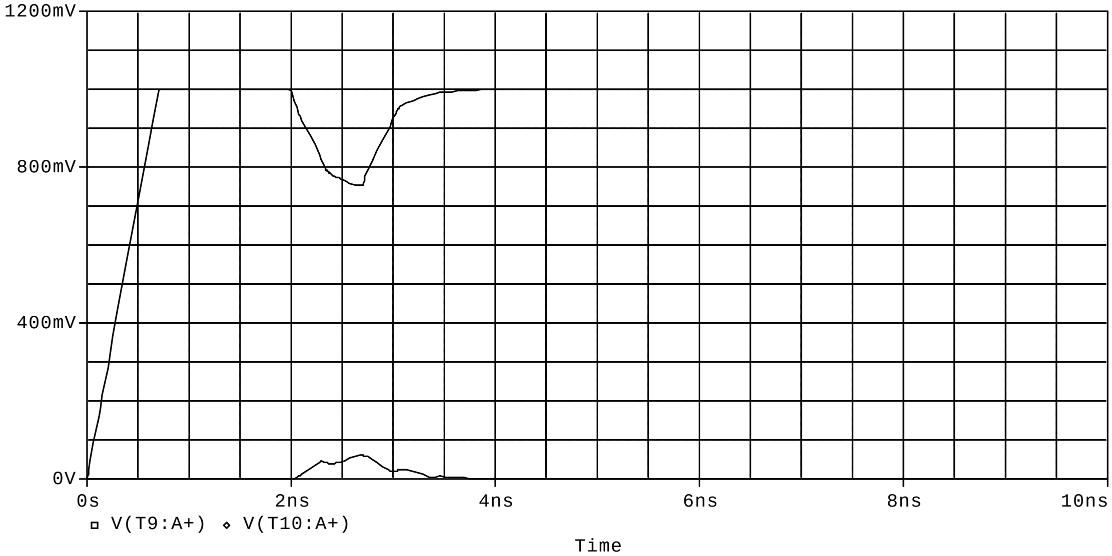

Figure 17. SPICE Output, simulated TDR, Zdiff = 76 ohms, Xtalk = 6% (700 ps input risetime, single connector mated pair, with vias, 1 adjacent line driven.) Similar to Figure 5, which was for two connector mated pairs.

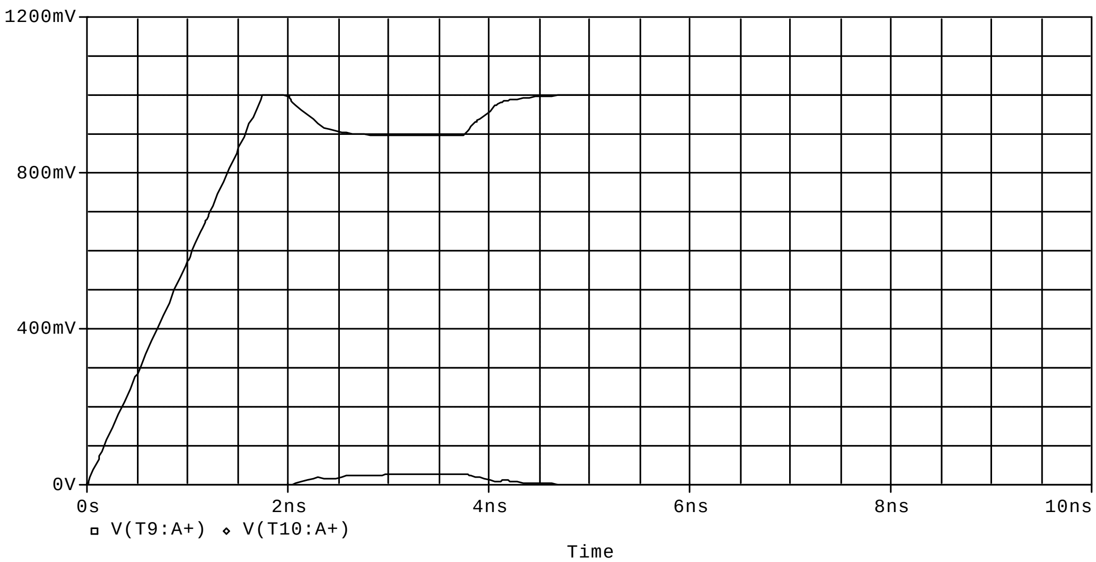

Figure 18. SPICE Output, simulated TDR, Zdiff = 76 ohms, Xtalk = 2.6% (1.75 ns input risetime, single connector mated pair, with vias, 1 adjacent line driven.) Similar to Figure 6, which was for two connector mated pairs.

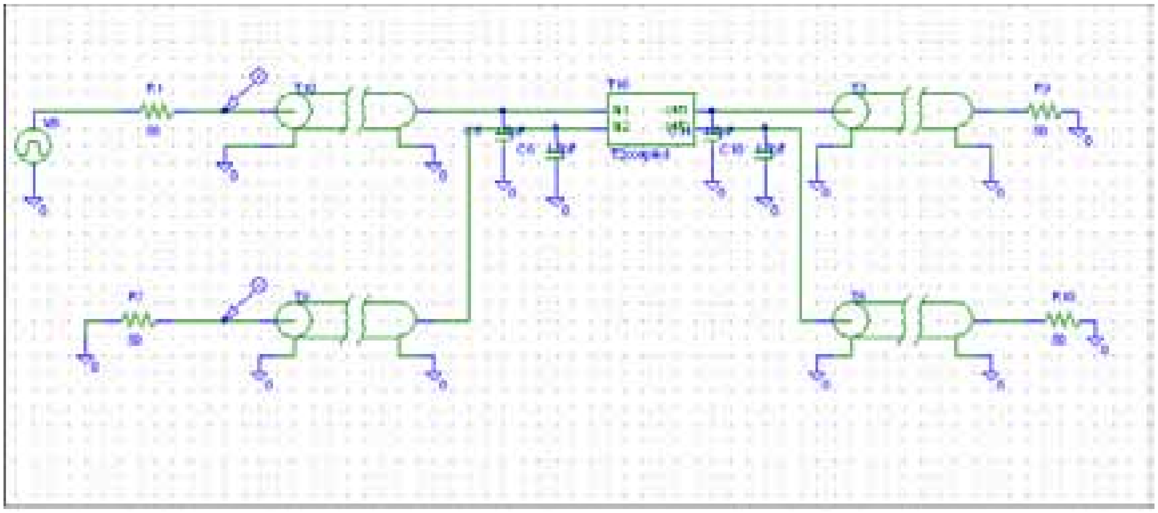

Figure 19. SPICE schematic used to produce the results shown in Figures 17 & 18.

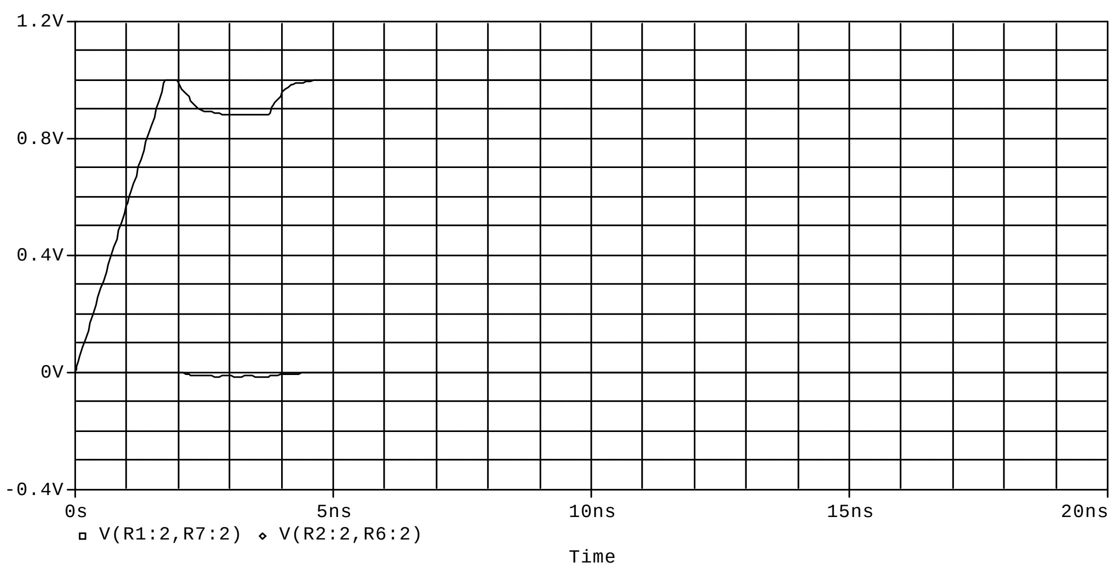

Figure 20. SPICE Output, simulated TDR, Zdiff = 76 ohms, Xtalk = 1.3%. 1.75 ns input risetime, single conn pair, with vias, 1 adjacent line driven. Full differential pair model. Compare to Figure 17, which is a "half differential pair" (single – ended) model.

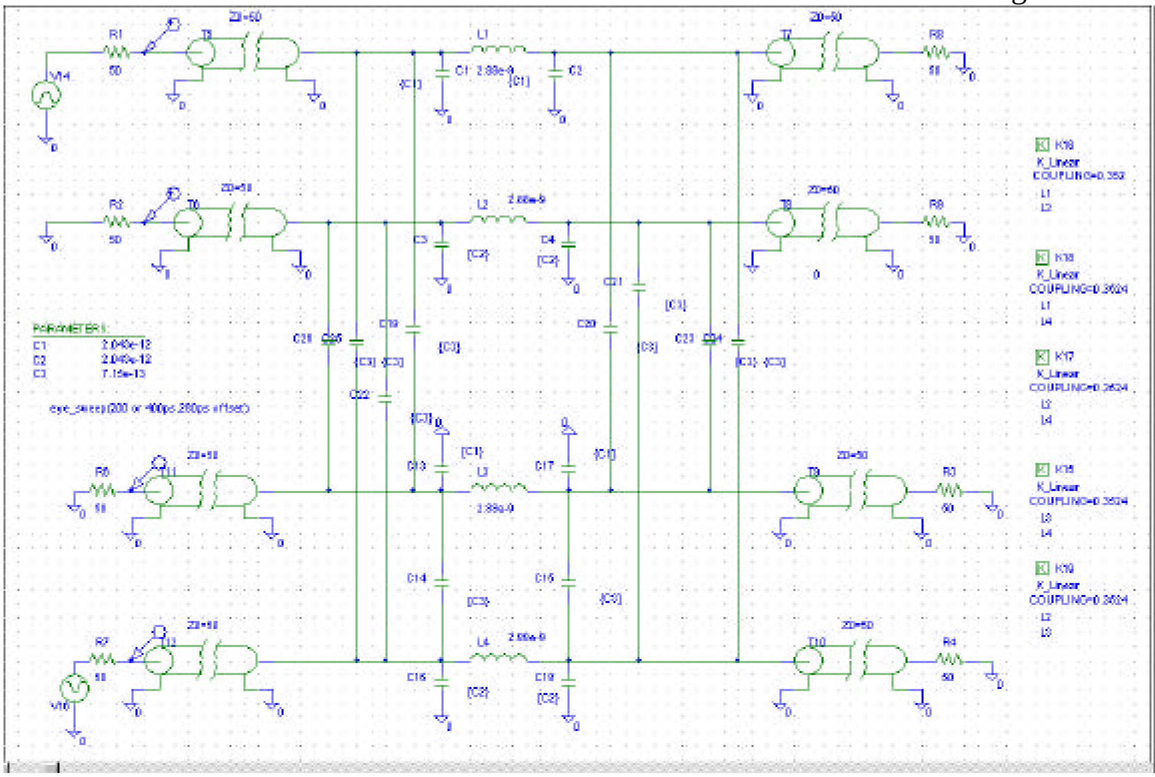

Figure 21. Two full-differential pair transmission line SPICE schematic used to produce the results shown in Figure 20.