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Week 11 Labs – Differential Pairs
2026-04-01

Lab 1:

The purpose of this lab is to learn how to create eye diagrams and analyze them using Hyperlynx by simulating a 100Ω differential pair. Then, I explored how adding skew to one side of a differential pair affected the eye.

To prevent reflections, I used T-terminations as shown in schematic (figure 1). The T-termination style terminates differential and common signals propagating down a differential pair. The driver used was MODvsEZIBIS CMOS, 3.3V, ULTRA, OUT. To make the eyes, a PRBS7 was used on a 12" differential pair with a bit width of 1 ns (1 GHz). Losses were enabled.

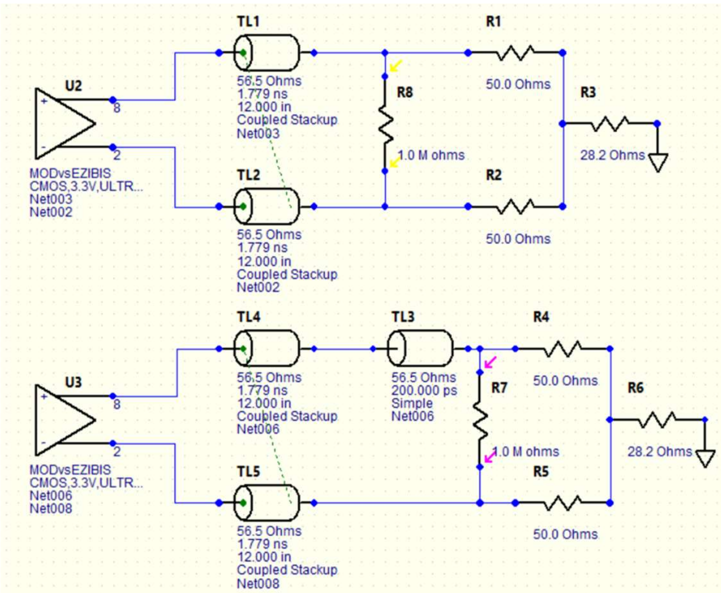

Figure 1: Schematic to experiment with skew. The additional T-line element in the lower circuit adds 0.2ns of delay to the signal on the p line.

Without any skew, the eye was measured to have a width of 977.878 ps and a height of 5.16V. With the skew, these values dropped to 953.053 ps and 4.92 V, respectively. These results are summarized in table 1, and the individual eyes independently and overlayed can be found in figures 2 through 4.

Experiment	**Eye width (ps)**	**Eye height (V)**
Without skew	977.878	5.16
With skew	953.053	4.92

Table 1: Eye sizes for a differential pair with and without 0.2 ns of skew.

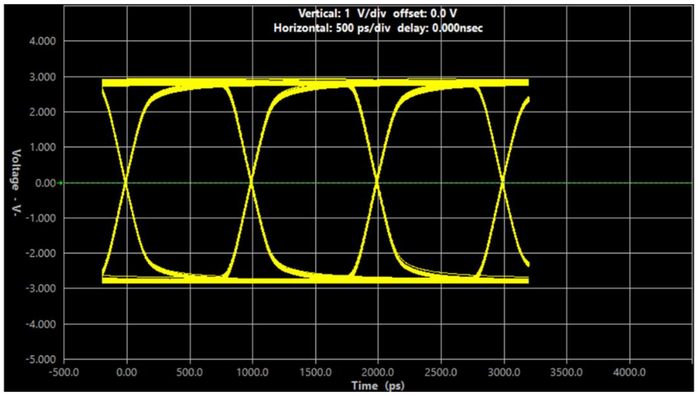

Figure 2: Eye diagram without skew.

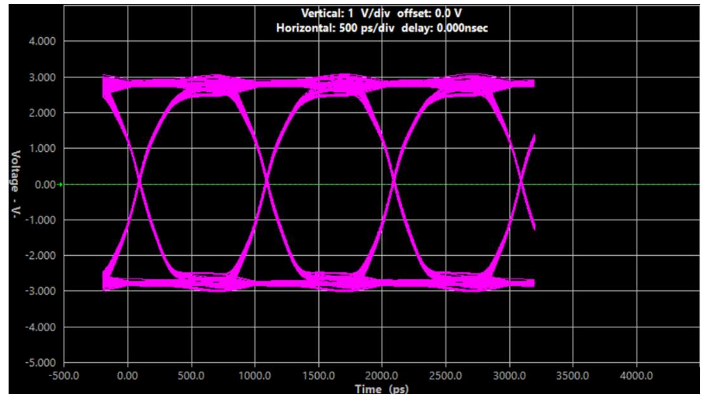

Figure 3: Eye diagram with skew.

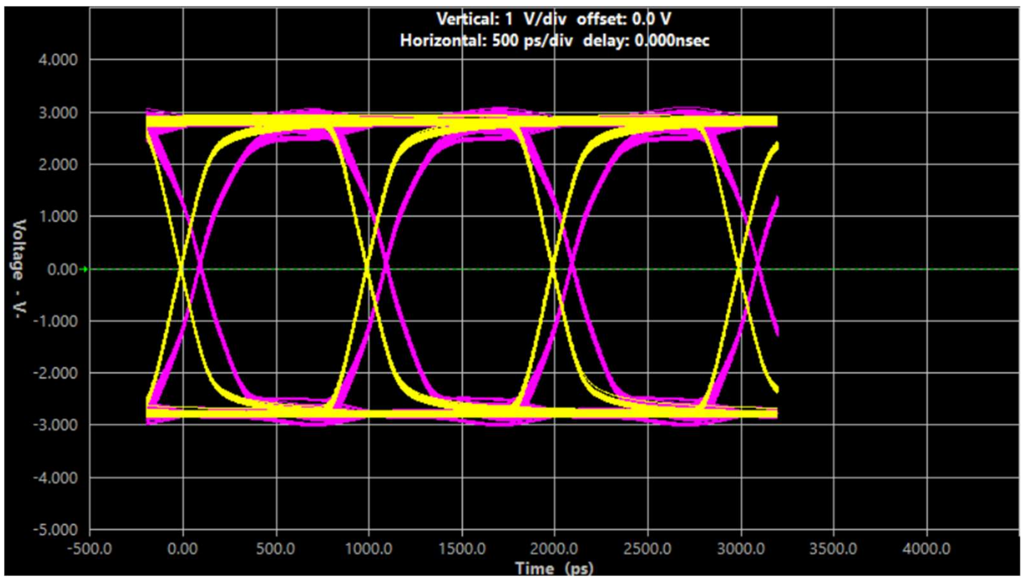

Figure 4: Overlay of eye diagrams with (pink) and without (yellow) skew.

So what:

The main learning from this lab is that skew closes the eye. It does this by shifting when the p and n signals reach the receiver, and by attenuating the signal with more delay due to the additional resistance of that line. This demonstrates the importance of keeping the length and resistance of each differential pair equal.

Lab 2:

The purpose of this lab is to explore the eye diagrams for different termination strategies for differential pairs. Then, I assesed what I would consider the maximum data rate for the differential termination strategy with a skew of 0.2 ns.

For this lab, I used Hyperlynx with a 100Ω differential pair, and the driver used was the MODvsEZIBIS CMOS, 3.3V, ULTRA, OUT. The bit width was 1 ns (1 GHz). Losses were enabled. The circuit diagram can be found in figure 1.

Four termination strategies were compared, and their eye widths and heights are compared in table 1. The eye diagrams for each termination can be found in figures 2 through 5.

An additional circuit with 0.2 ns of skew and a differential termination was also made to determine its maximum data rate. The eye diagram for this experiment can be found in figure 6.

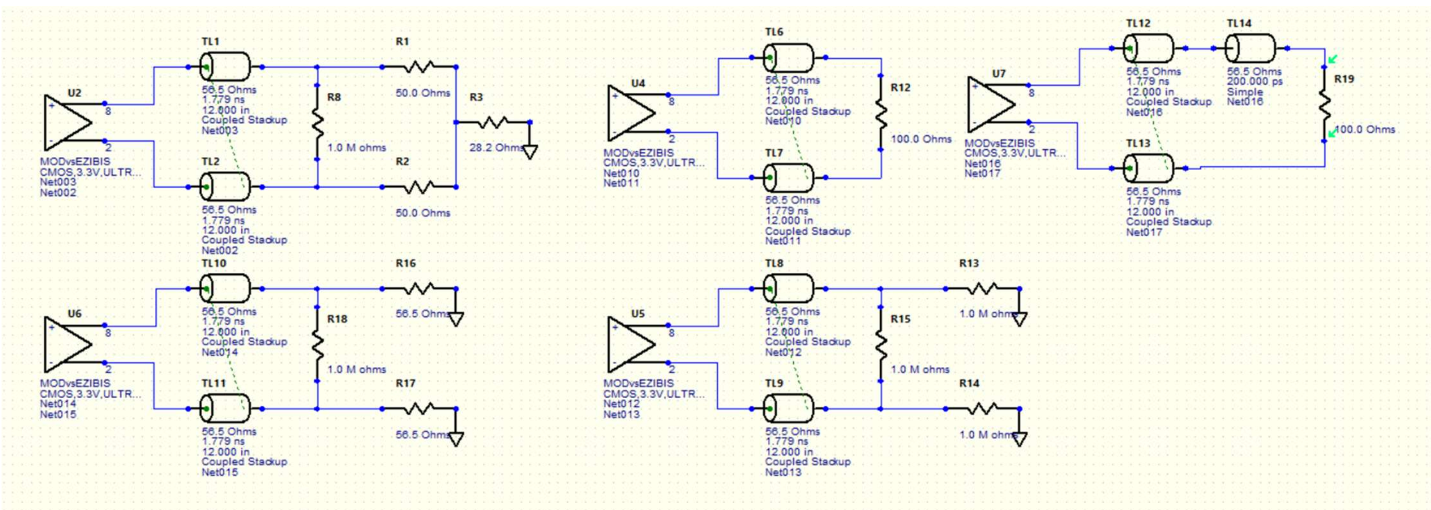

Figure 1: Circuits used in this lab. Clockwise, from the top left: T-termination, differential termination, differential termination with skew, no termination, and single-ended termination.

Termination style	Eye width (ps)	Eye height (V)
T termination	989.061	6.05
100Ω differential termination	977.995	5.21
50Ω single-ended termination	984.934	5.12
No termination	123.871	0.8929

Table 1: Compilation of eye charictaristics for different termination styles.

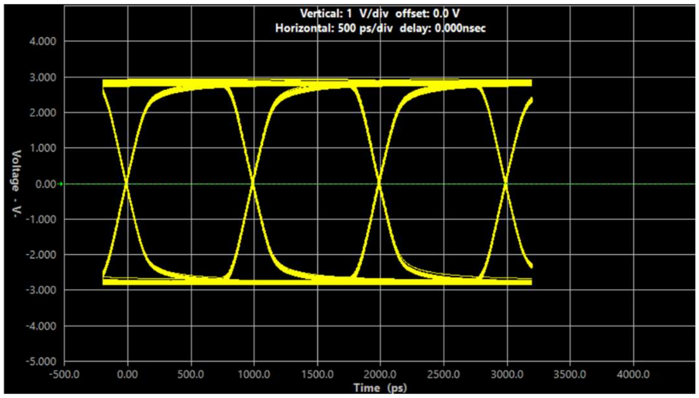

Figure 2: Eye for T-termination.

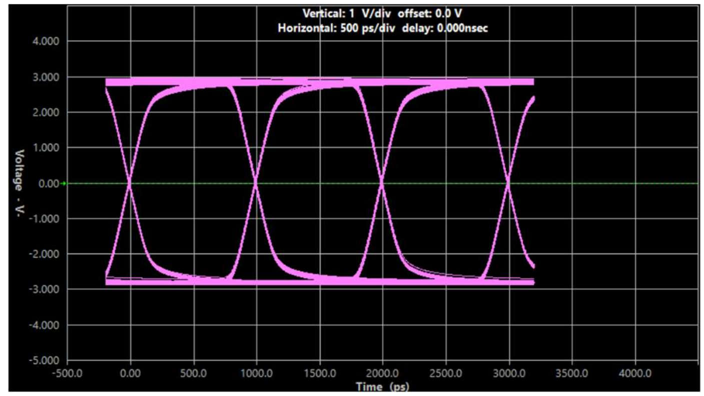

Figure 3: Eye for differential termination.

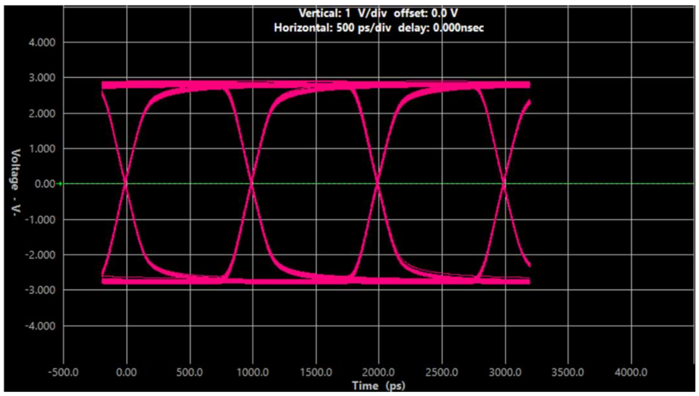

Figure 4: Eye for single-ended termination.

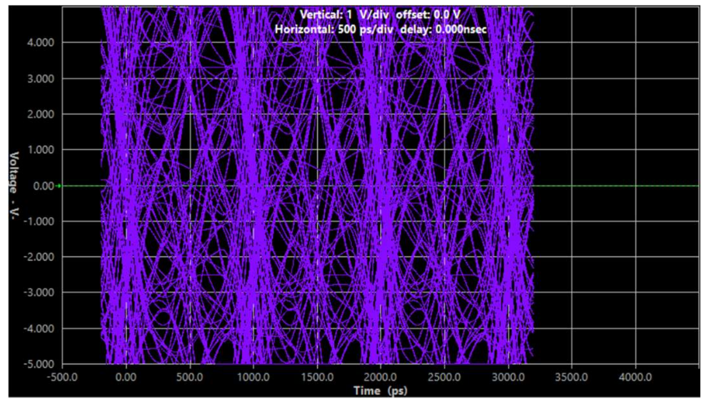

Figure 5: "Eye" without termination.

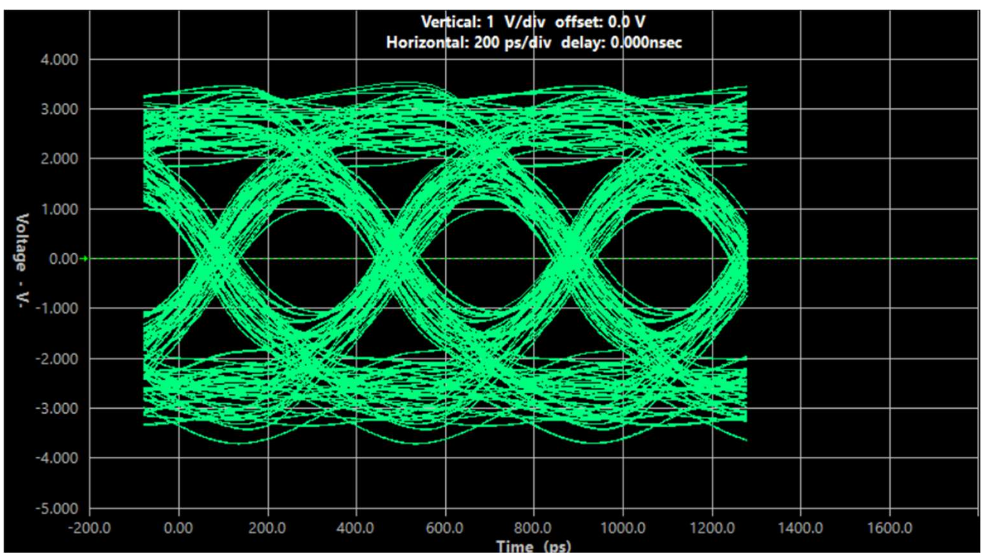

Figure 6: Eye diagram for a differential pair with 0.2 ns of skew with a 0.4 ns bit width (2.5 GHz data rate) and a differential termination style.

So what:

From the differential pair termination results, it’s clear that a termination strategy is needed since the simulation without a termination stradegy has crazy results. The T-termination worked best since it had terminations for both the differential and common signals. The diffential termination only terminated the differential signal and the single-ended termination relies on the coupling to terminate the differential signal.

After testing the termination types, I tried to get the maximum data rate for a differential pair with a skew on one line of 0.2ns. The actual maximum data rate will vary between receivers due to their setup time, hold time, and voltage level requirements. To me, it seems like this 20% skew begins to be too much around 2.5 GHz, or a 0.4 ns bit width. At that point, the skew is half of each bit, so the received signal is always transitioning, so the hold time is effectively 0 ps. The eye width at this bit rate is 289.975 ps and the eye height is 2.03V.