

TX FIR Equalizer – CML mode

12 Gbps

(Final Report)

Muhammad Aldacher

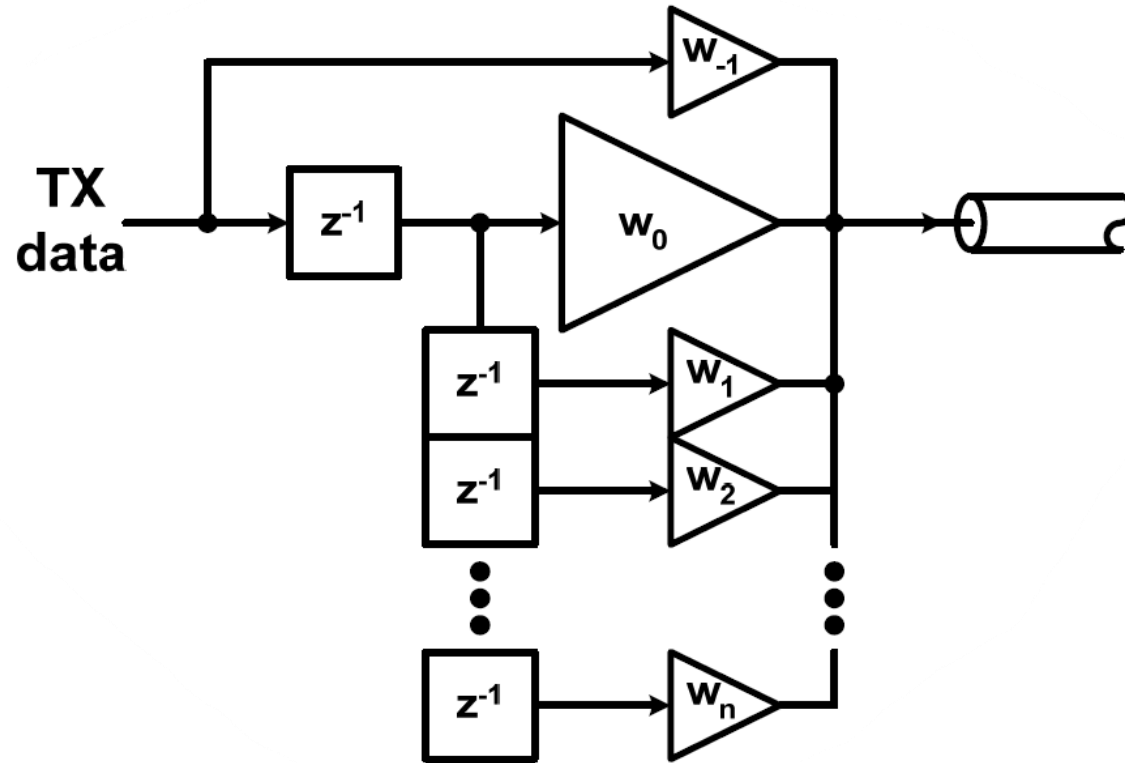
Outline

1. Background
2. Implementation
3. Schematics
4. Design Steps
5. Simulation Results
 - a) Pulse Response
 - b) Eye Diagram
 - c) Transient Waveforms

Background

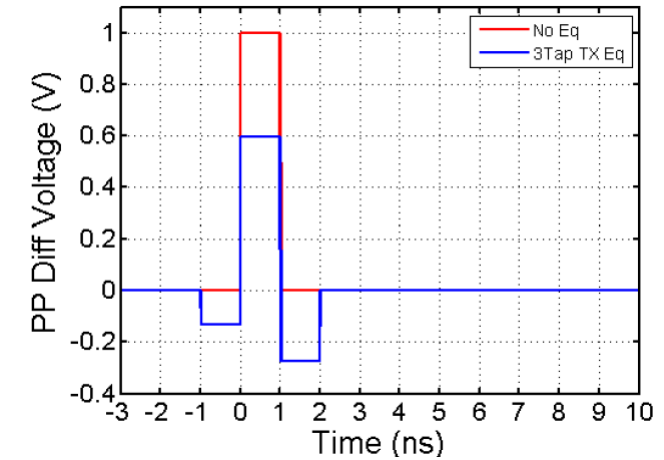
- "TX FIR equalization" is the technique in which a transmitter applies a Finite Impulse Response (FIR) filter to pre-distort the signal before sending it.
- This is to compensate for the distortions introduced by the transmission channel, thus improving signal quality at the receiver by mitigating intersymbol interference (ISI).

Background

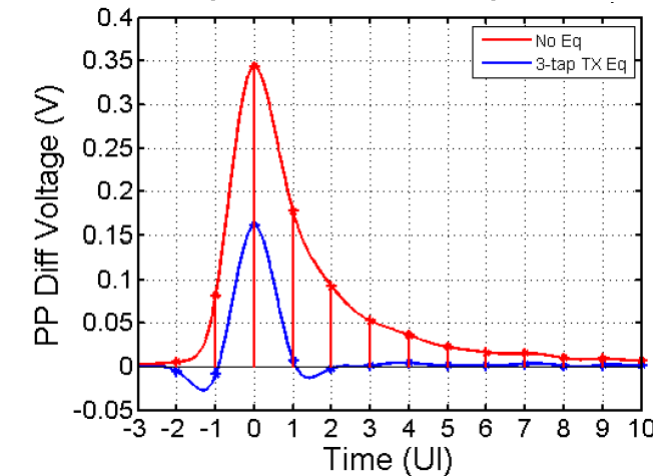


Time Domain

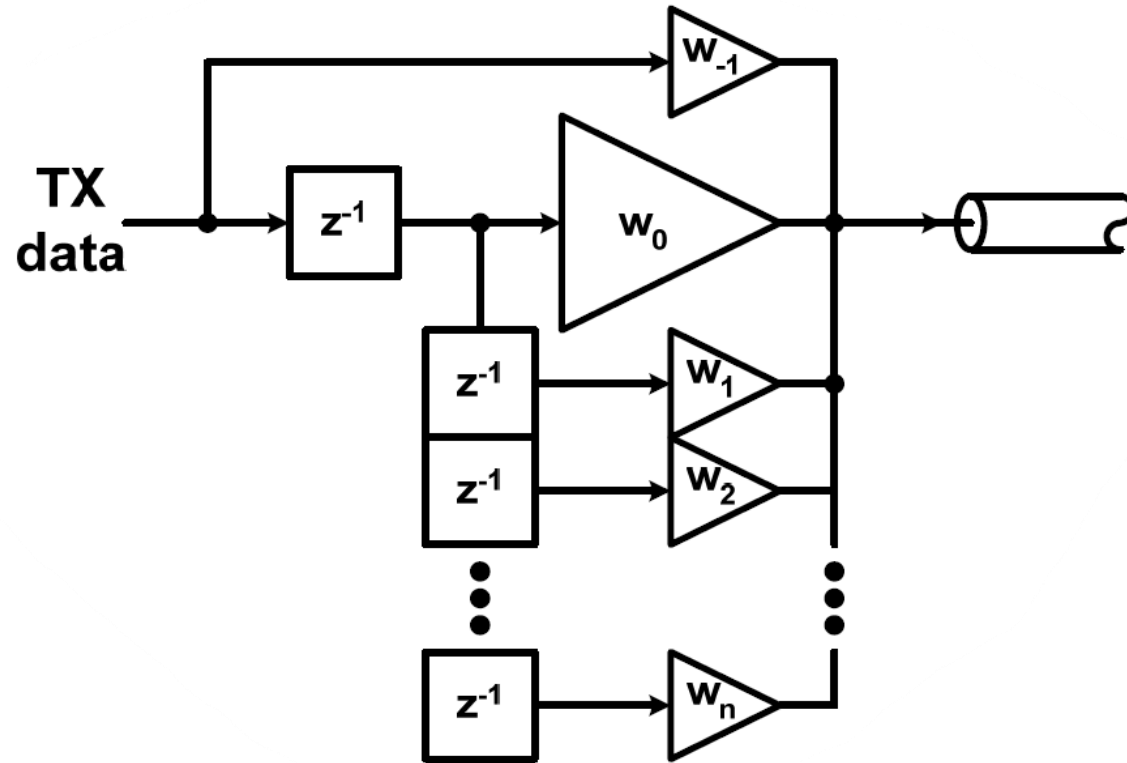
Input Pulse w/ 3-tap TX Eq



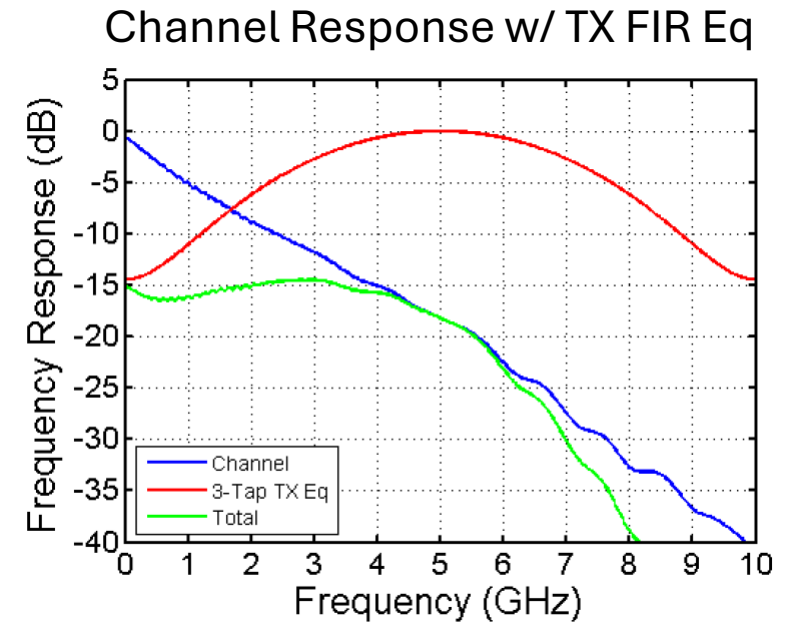
Output Pulse Response



Background

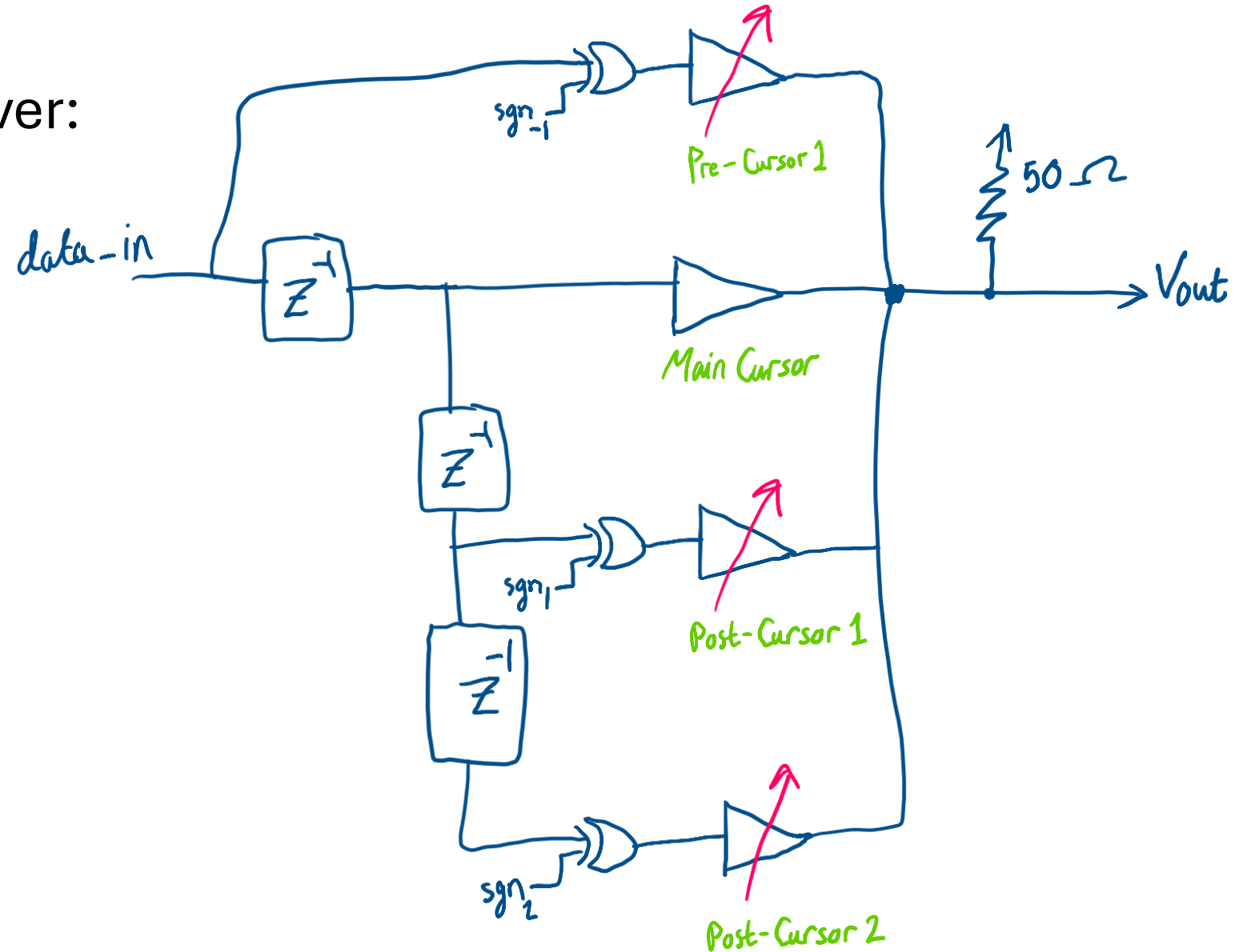


Freq Domain



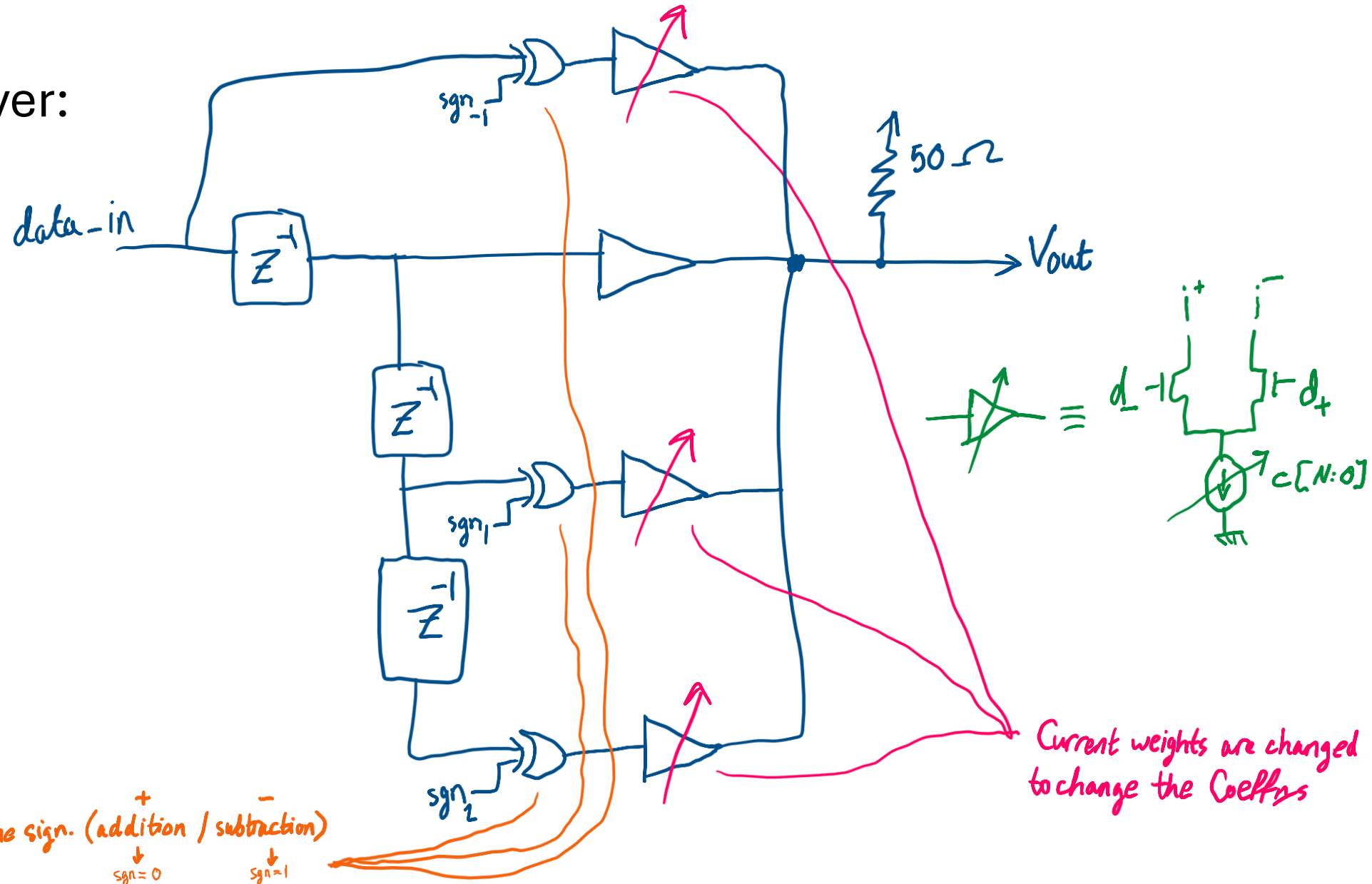
Implementation

- For CML driver:

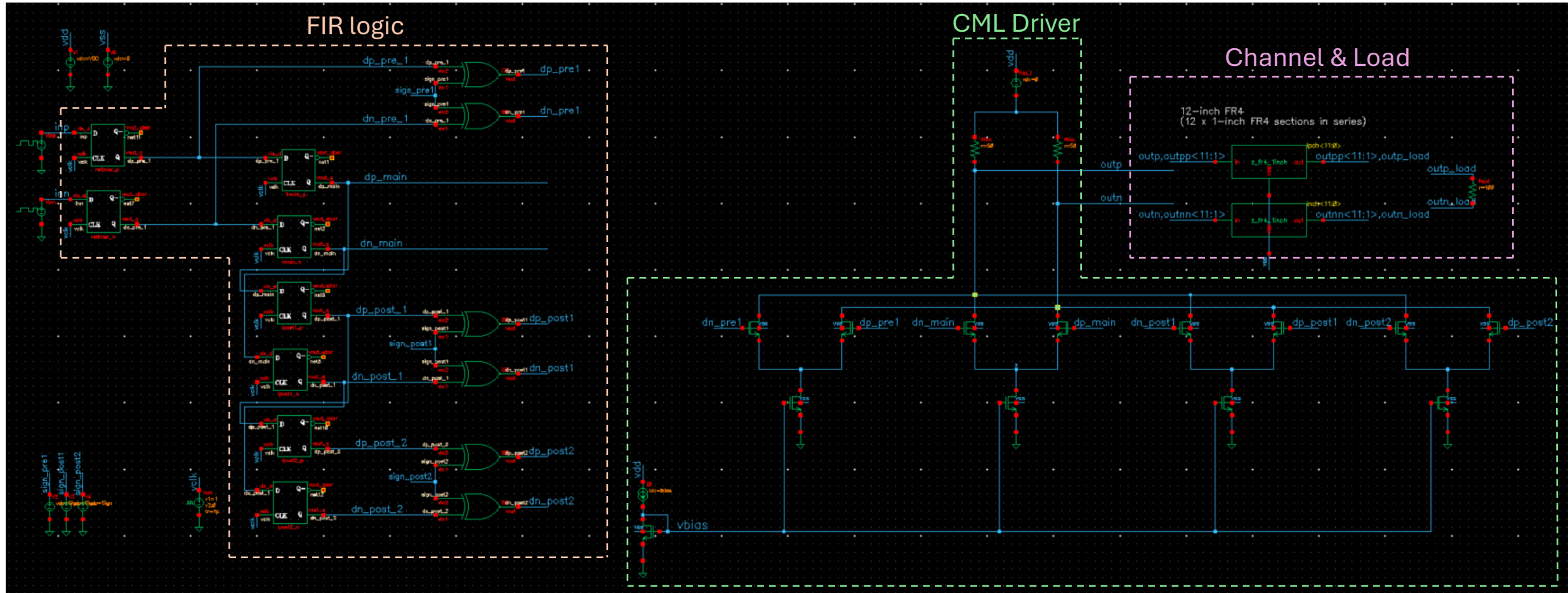


Implementation

- For CML driver:



Schematics

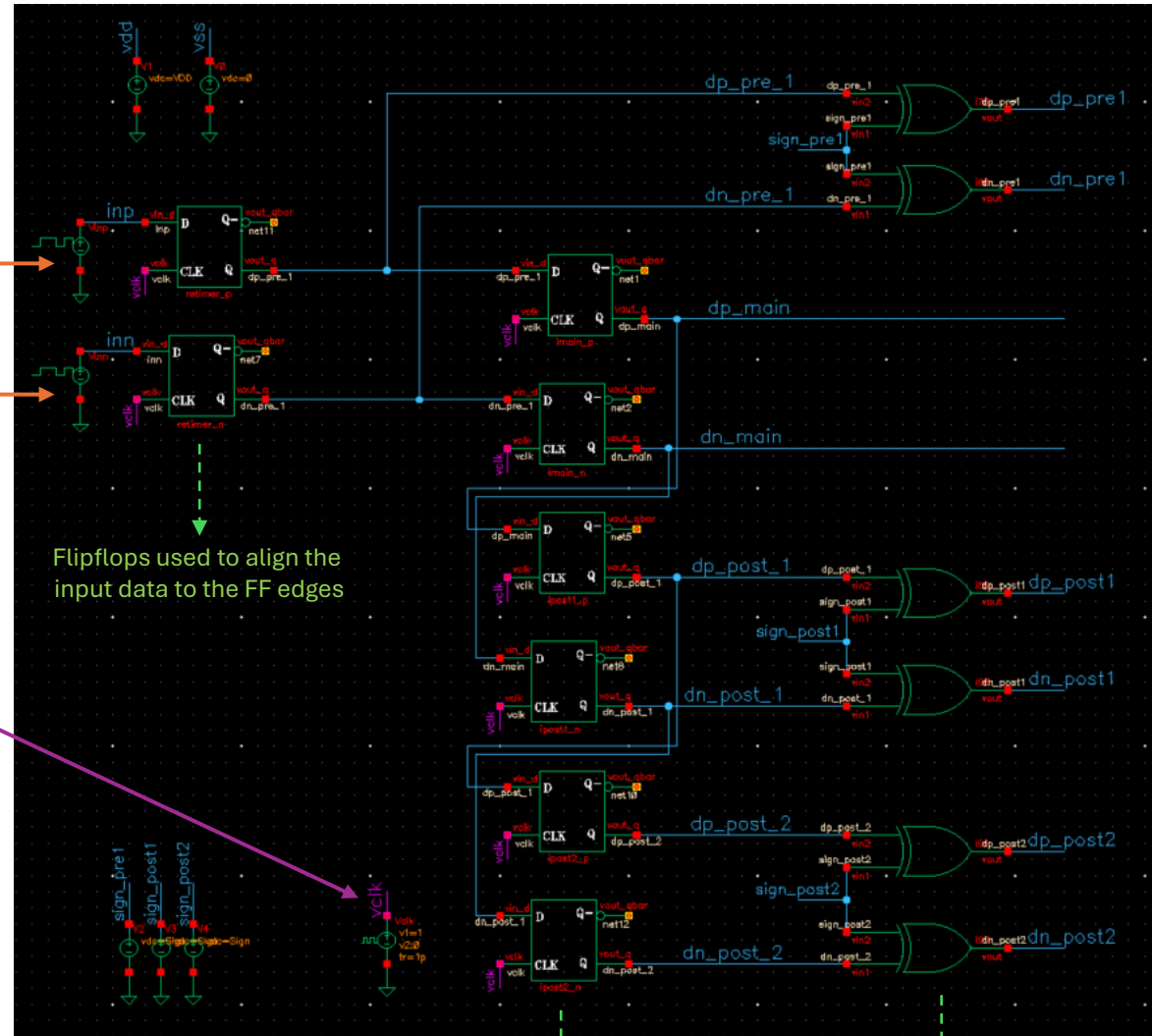


Schematics

A) FIR Logic:

12 Gb/s PRBS
Inputs

12 GHz Clock



Flipflops used to align the
input data to the FF edges

Flipflops used as delay cells

XOR gates used to apply the
sign to the cursor taps

Pre-Cursor 1

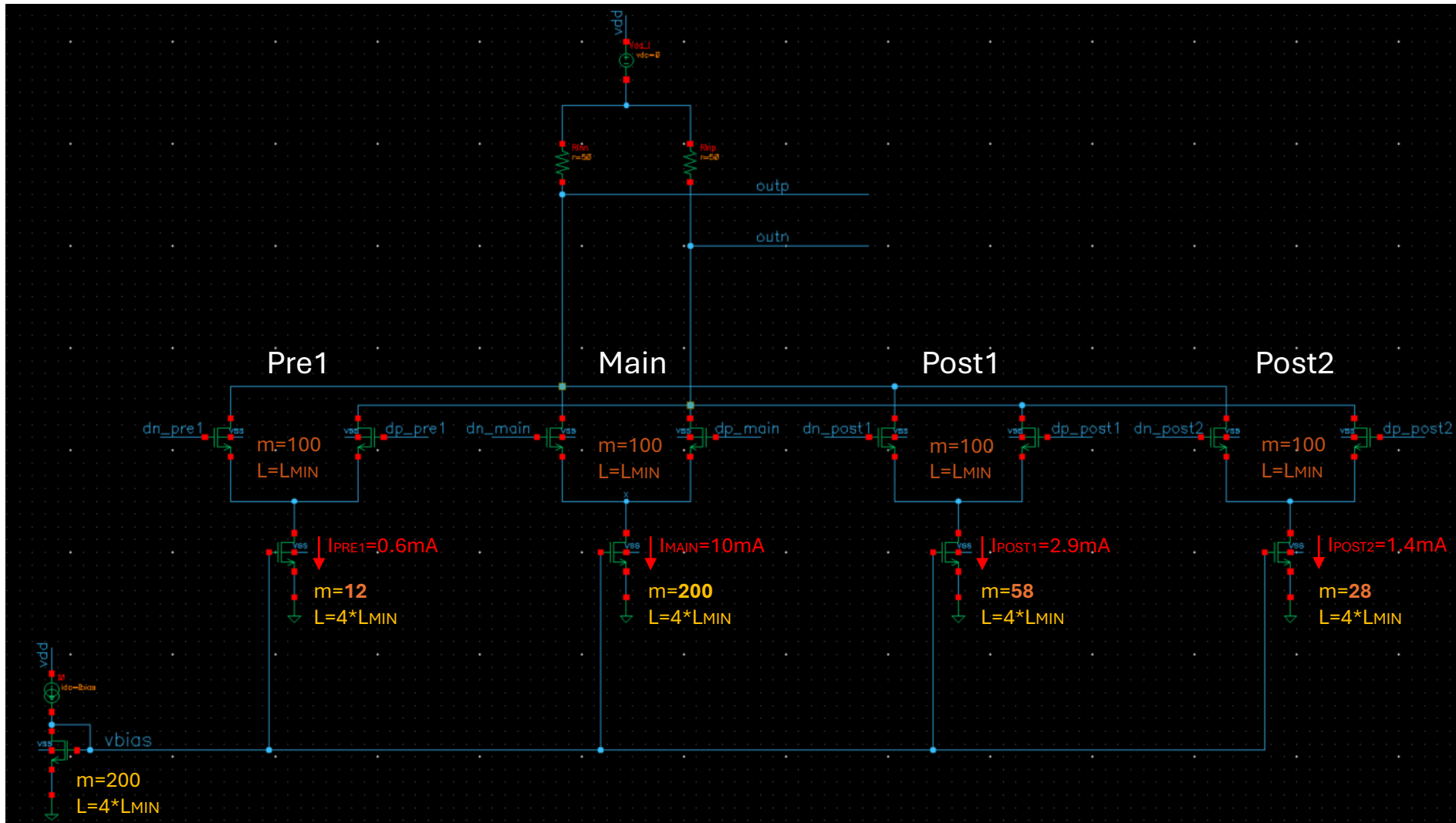
Main-Cursor

Post-Cursor 1

Post-Cursor 2

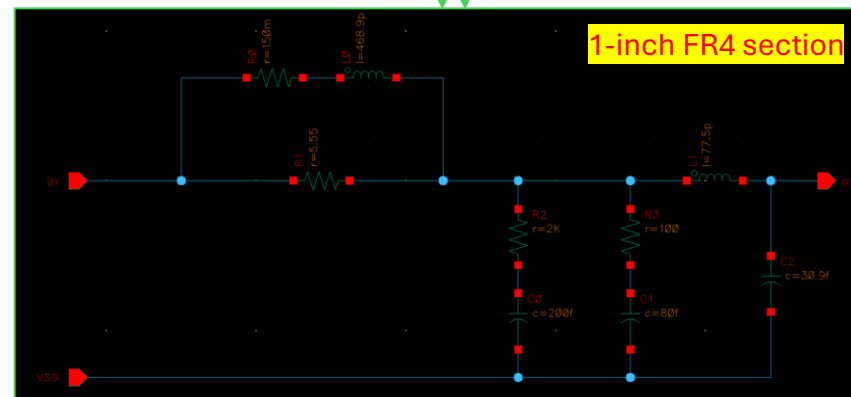
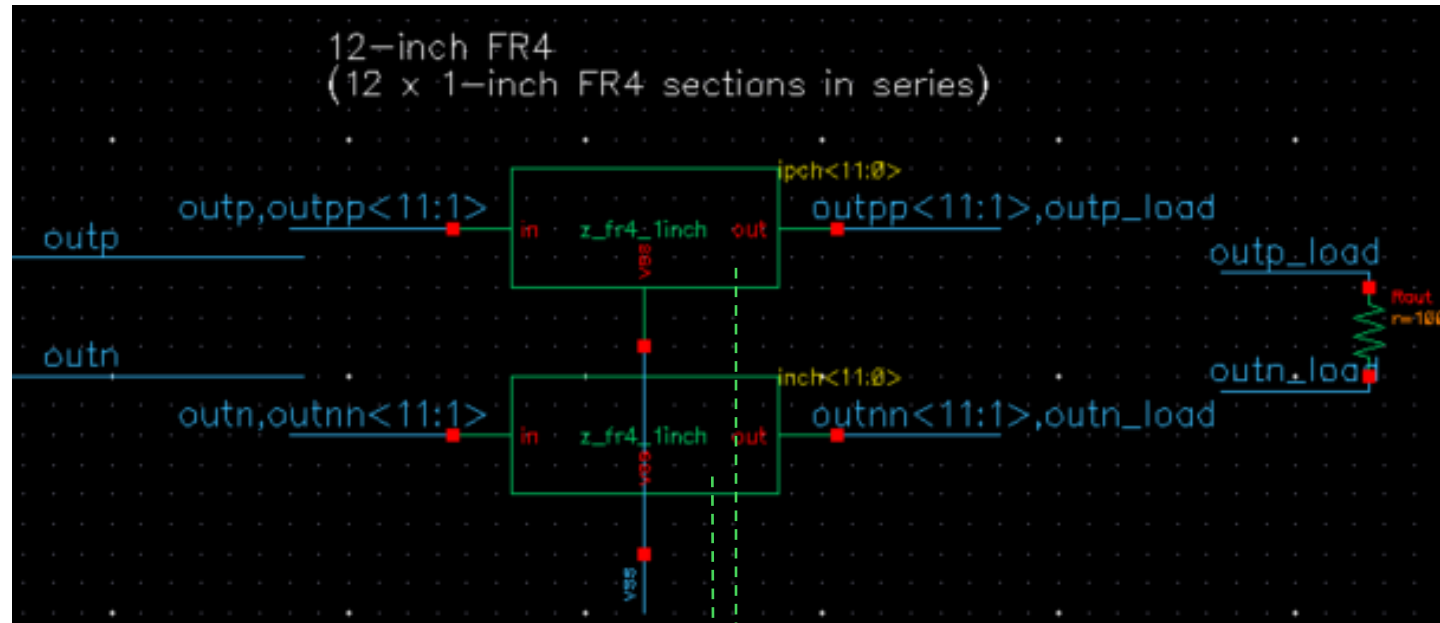
Schematics

B) CML Driver:



Schematics

C) Channel & Load:



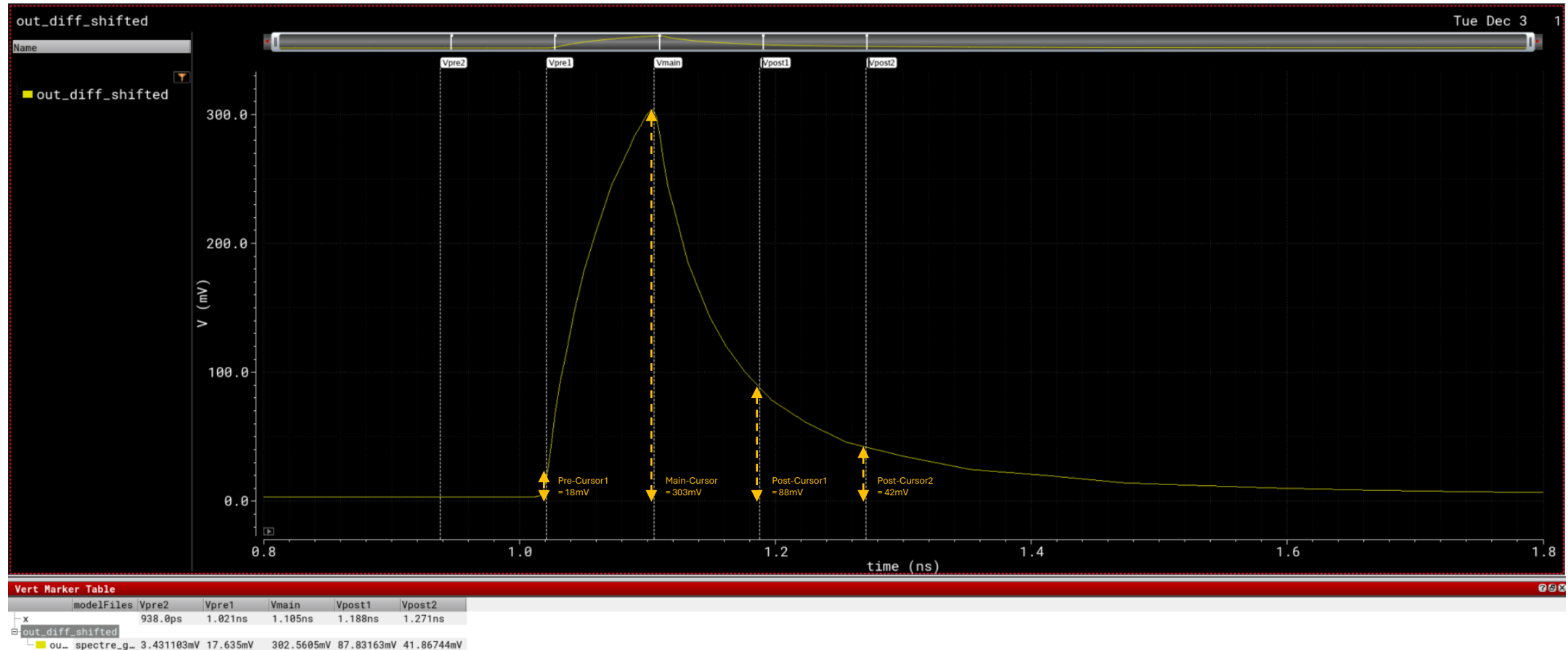
Design Steps

1. Design the **Tx-Driver** at a low data-rate & without equalization as shown in this project ([Tx-Driver Design](#))
2. Find the **pulse response** of this Tx-Driver at the desired data-rate.
3. Calculate the **pre & post cursors** from the pulse response.
4. Modify the Tx-Driver design by adding **weighted taps** based on the cursors' values.
5. Find the **eye diagram** to see how much the eye opening improved.

Simulation Results

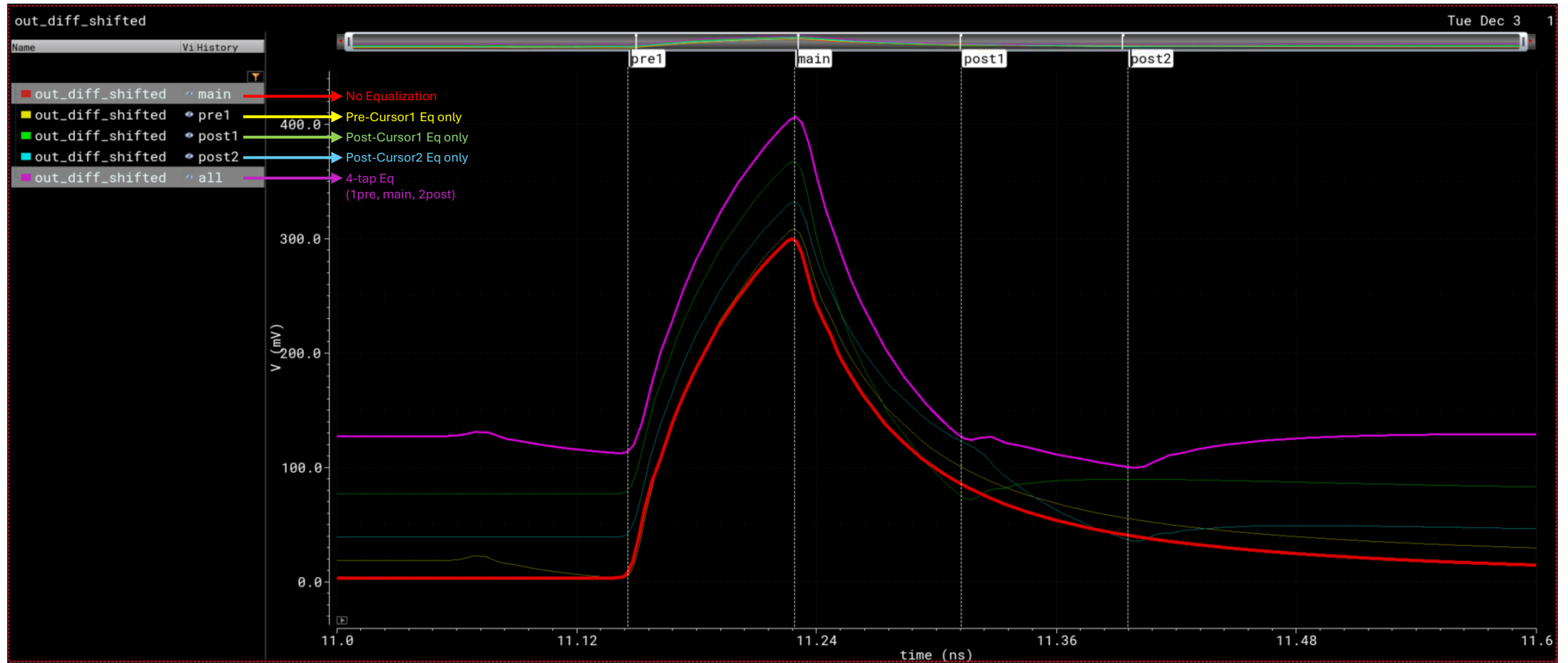
A) Pulse Response: (Without Equalization)

	Pre-Cursor1	Main-Cursor	Post-Cursor1	Post-Cursor2
Adjusted VSWING(PK2PK)	$(18 / 303) * 500 \text{ mV} = 29.7 \text{ mV}$	$(303 / 303) * 500 \text{ mV} = 500 \text{ mV}$	$(88 / 303) * 500 \text{ mV} = 145.2 \text{ mV}$	$(42 / 303) * 500 \text{ mV} = 69.3 \text{ mV}$
Equivalent IBIAS	$29.7 \text{ mV} / 50 \text{ Ohms} = 0.6 \text{ mA}$	$500 \text{ mV} / 50 \text{ Ohms} = 10 \text{ mA}$	$145.2 \text{ mV} / 50 \text{ Ohms} = 2.9 \text{ mA}$	$69.3 \text{ mV} / 50 \text{ Ohms} = 1.4 \text{ mA}$
# of fingers	(m = 12)	(m = 200)	(m = 58)	(m = 28)



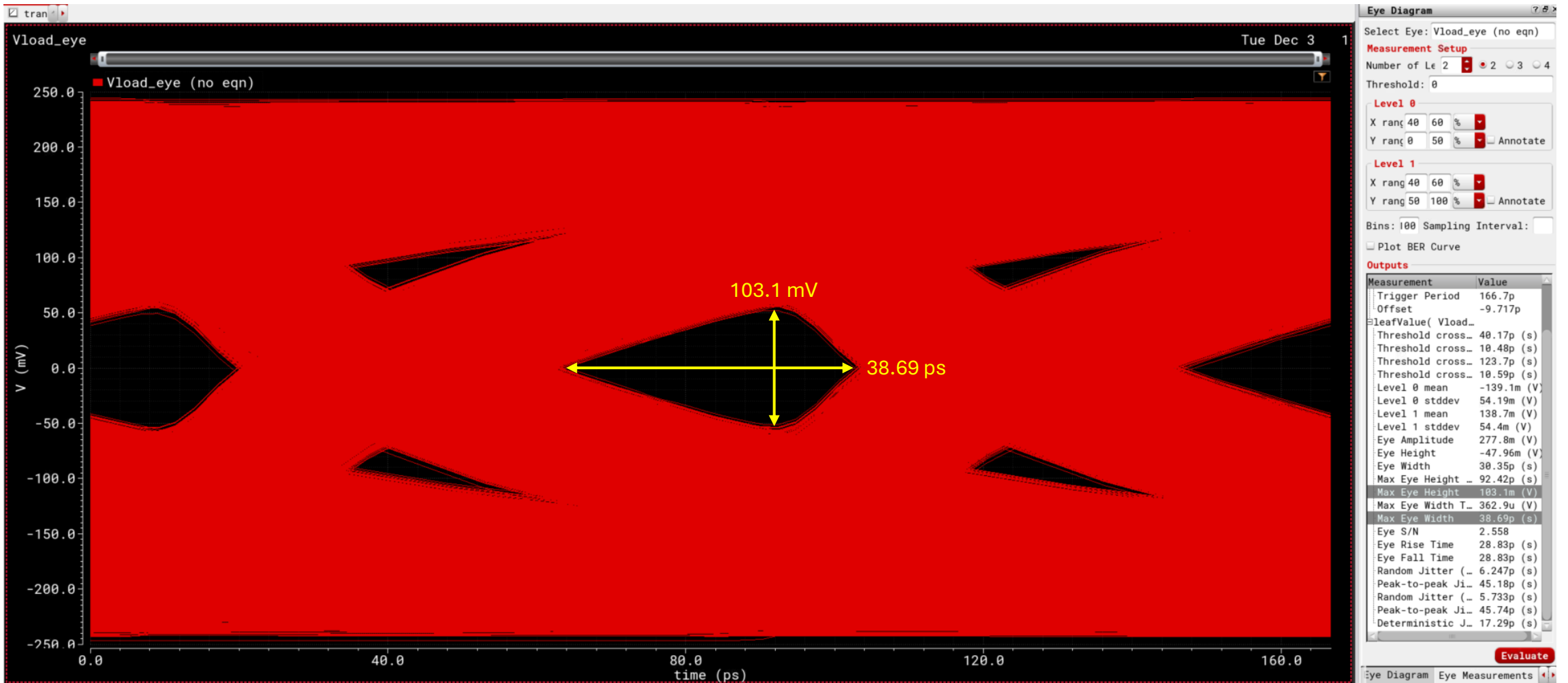
Simulation Results

A) Pulse Response: (With Equalization)



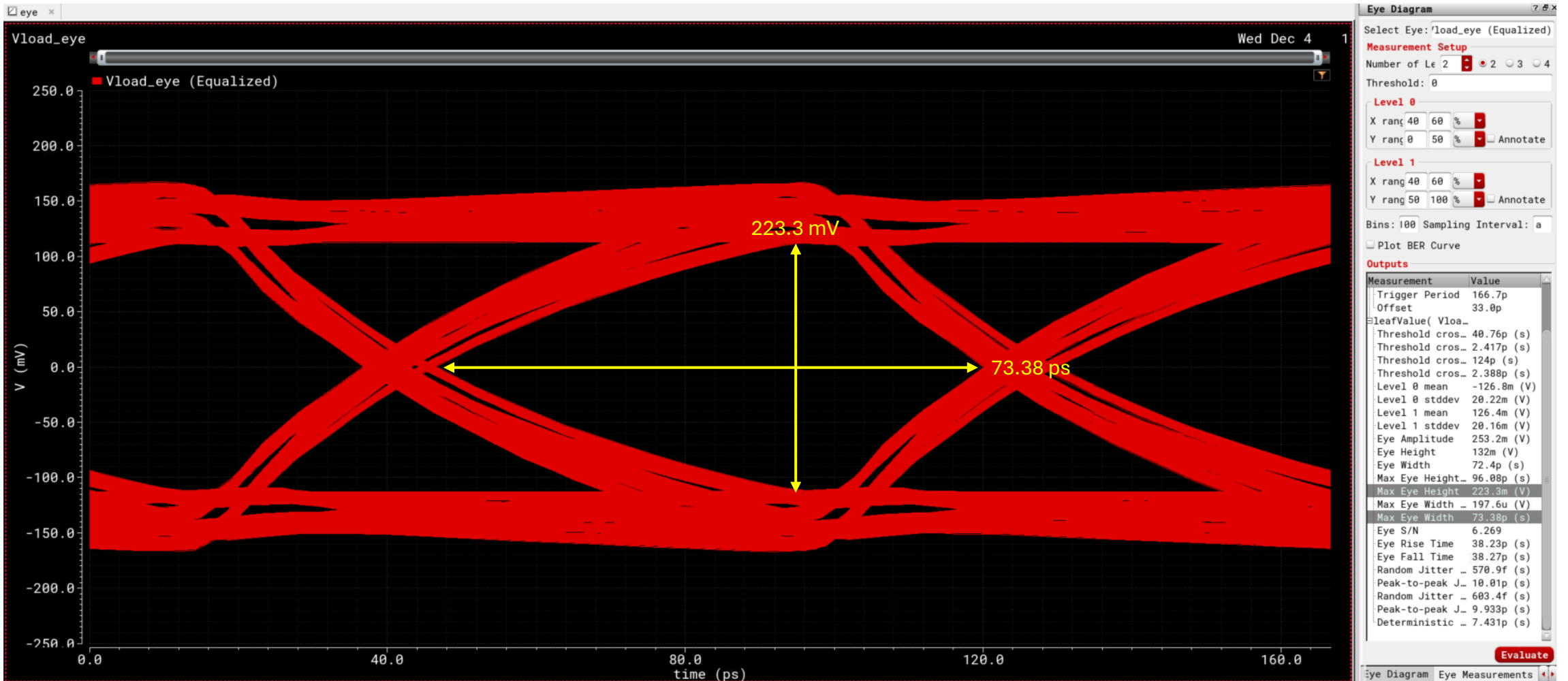
Simulation Results

B) Eye Diagram: (Without Equalization)



Simulation Results

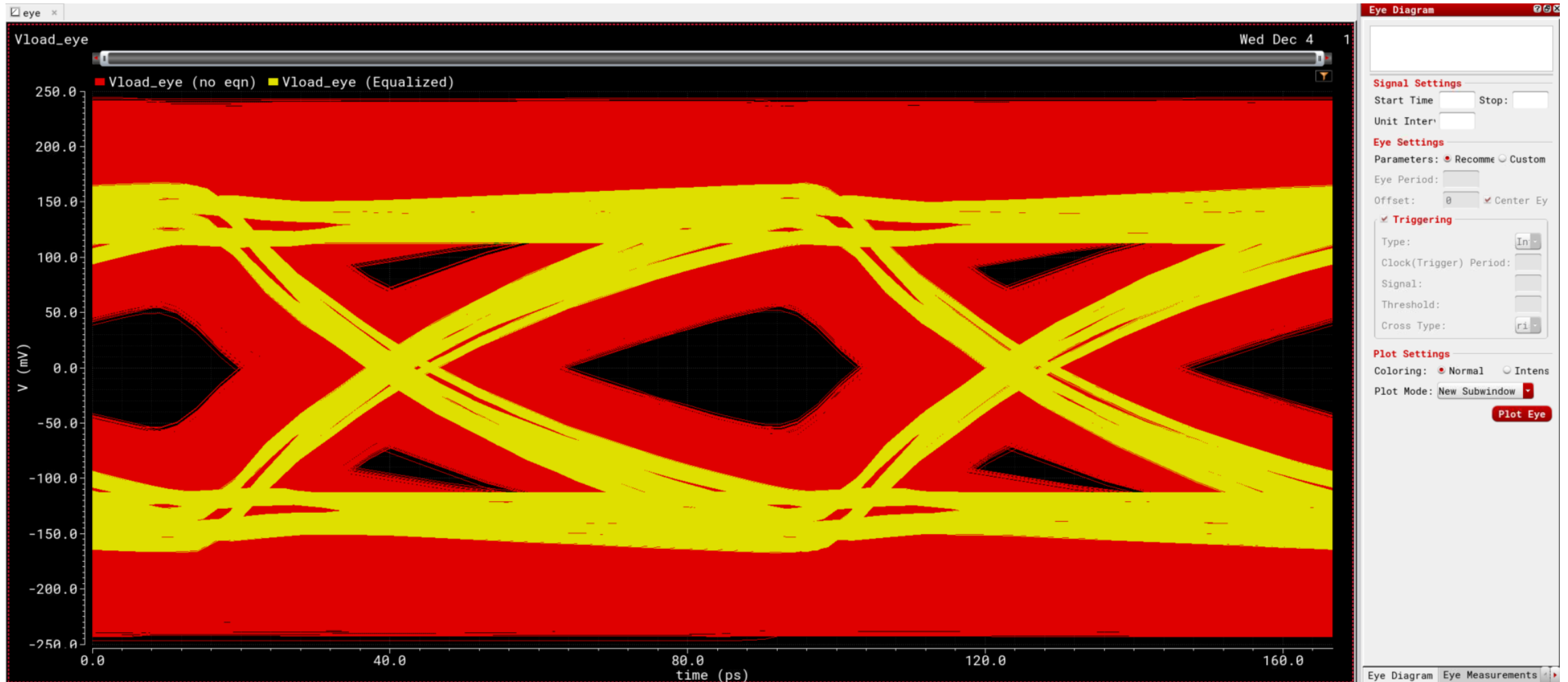
B) Eye Diagram: (With Equalization)



Simulation Results

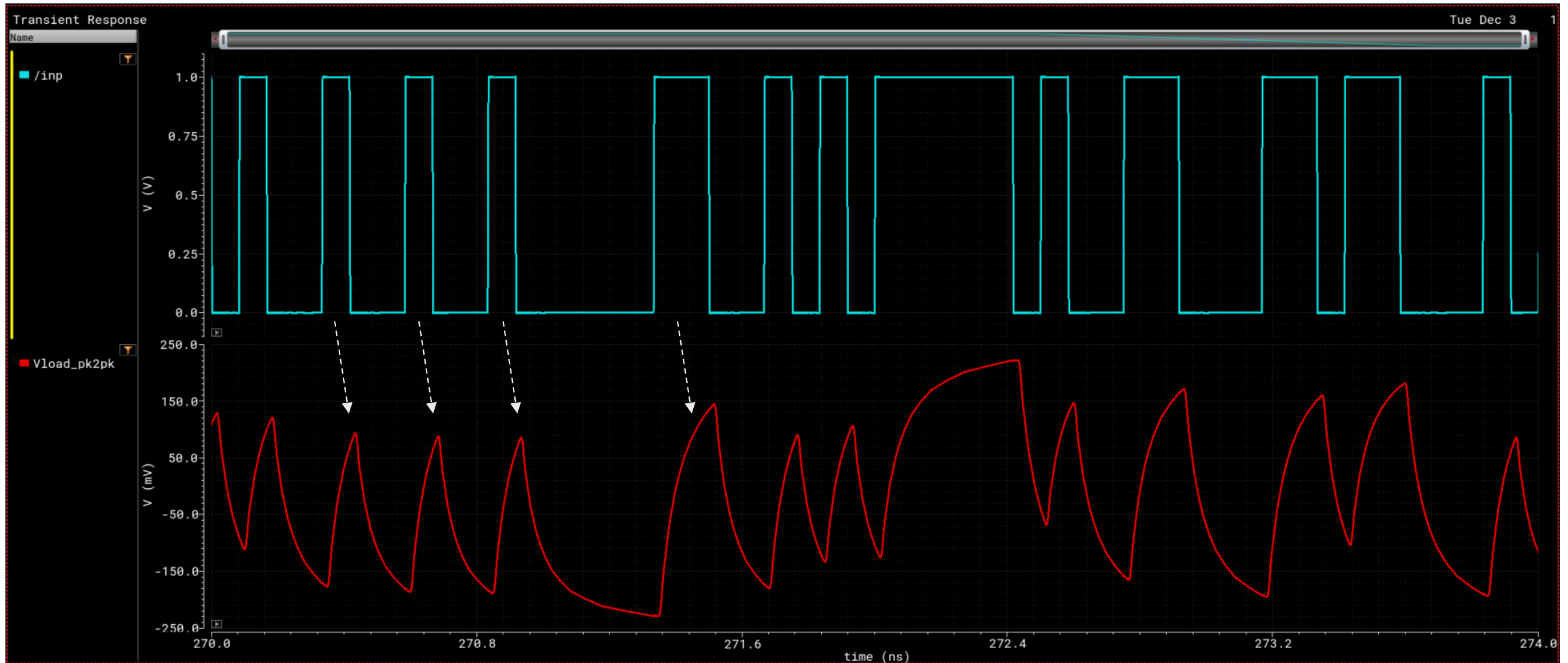
B) Eye Diagram:

	No Equalization	With Equalization (4-tap)
Eye Height (Max)	103.1 mV	223.3 mV
Eye Width (Max)	38.69 ps	73.38 ps
Swing (PK2PK)	500 mV (-250mV ~ +250mV)	328 mV (-164mV ~ +164mV)



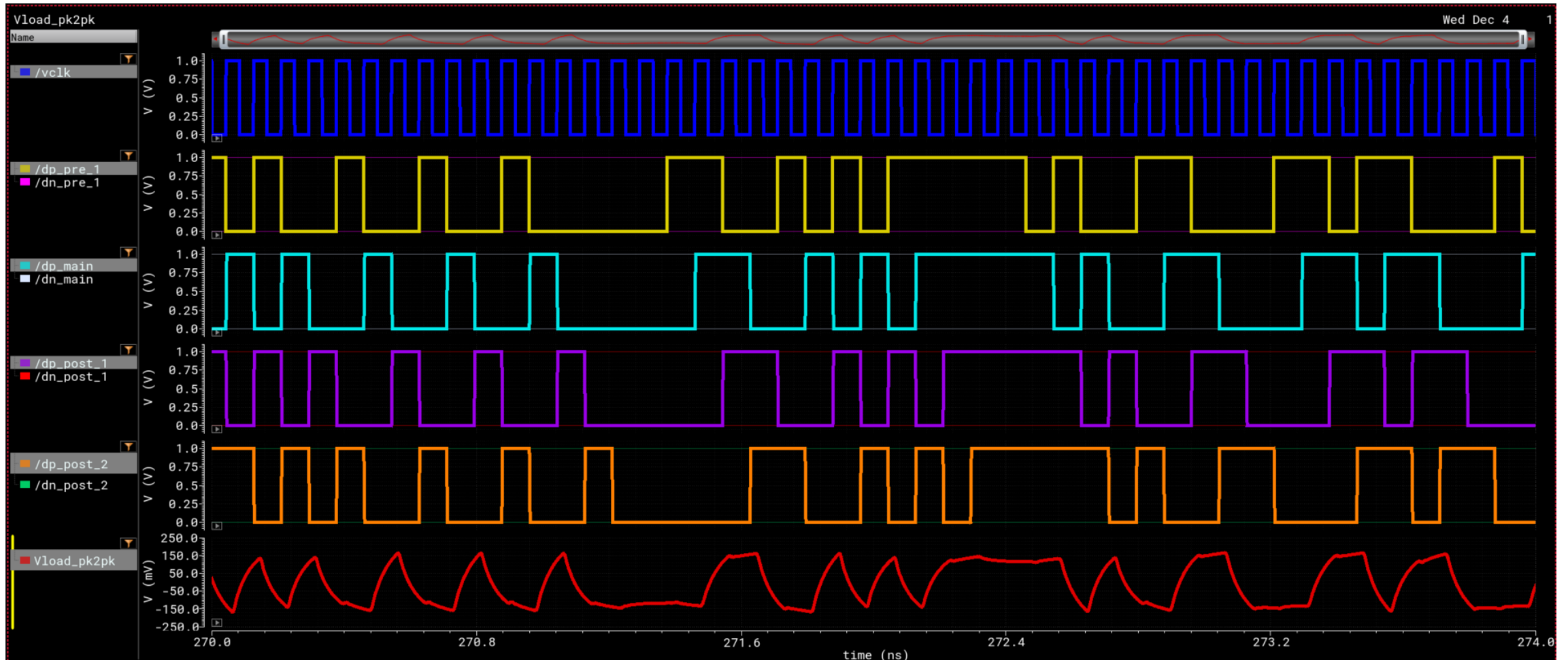
Simulation Results

C) Transient Waveforms: (Without Equalization)



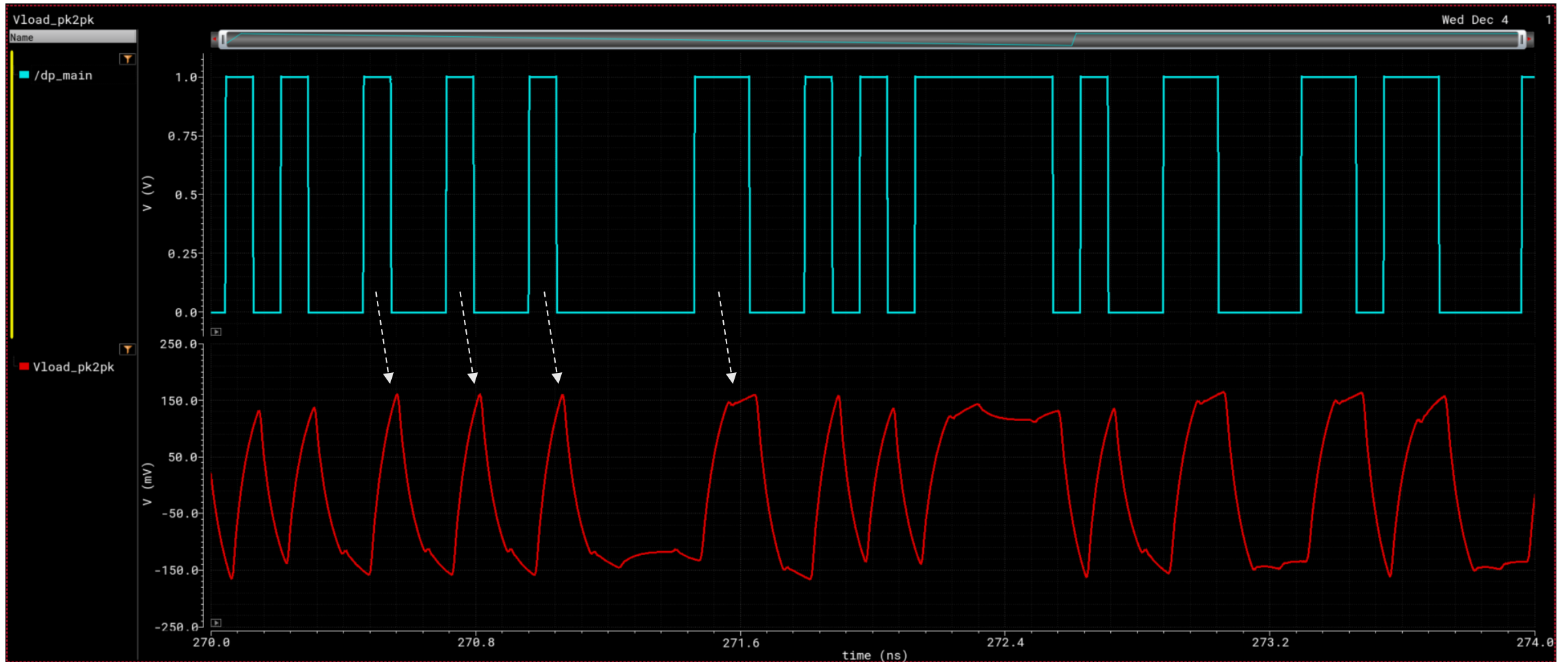
Simulation Results

C) Transient Waveforms: (With Equalization)



Simulation Results

C) Transient Waveforms: (With Equalization)



Conclusion

- This project shows the design procedure of a TX FIR Equalizer for a 12 Gb/s input & a channel of 12-inch FR4.
- It also shows how the equalization improves the eye opening of the output, while paying the price of lower swing amplitude & increased latency.