

Inverter Chain Output Delay Difference

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1. Introduction

This report provides an examination of the 2-chain inverters' output delay difference. The implementation is completed with two oscilloscopes, a Tektronix 2-Series Mixed Signal Oscilloscope and a LeCroy WavePro 254 HD. Results are shown in the comparison table.

Figure 1 below shows the architecture of the design. The Output_A is connected to the CH1, and the Output_B is connected to the CH2 in both of the oscilloscopes (MSO2 and WP 254HD).

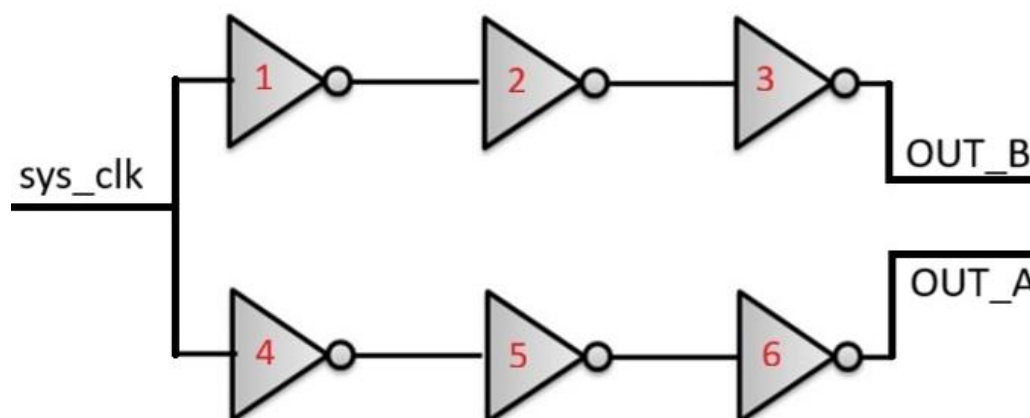


Figure 1

2. Section One: Output_A(top-left corner) and the Output_B(bottom-right corner)

2.1 Floorplanning

The floorplanning of the Output_A and the Output_B is shown in **Figure 2** below.

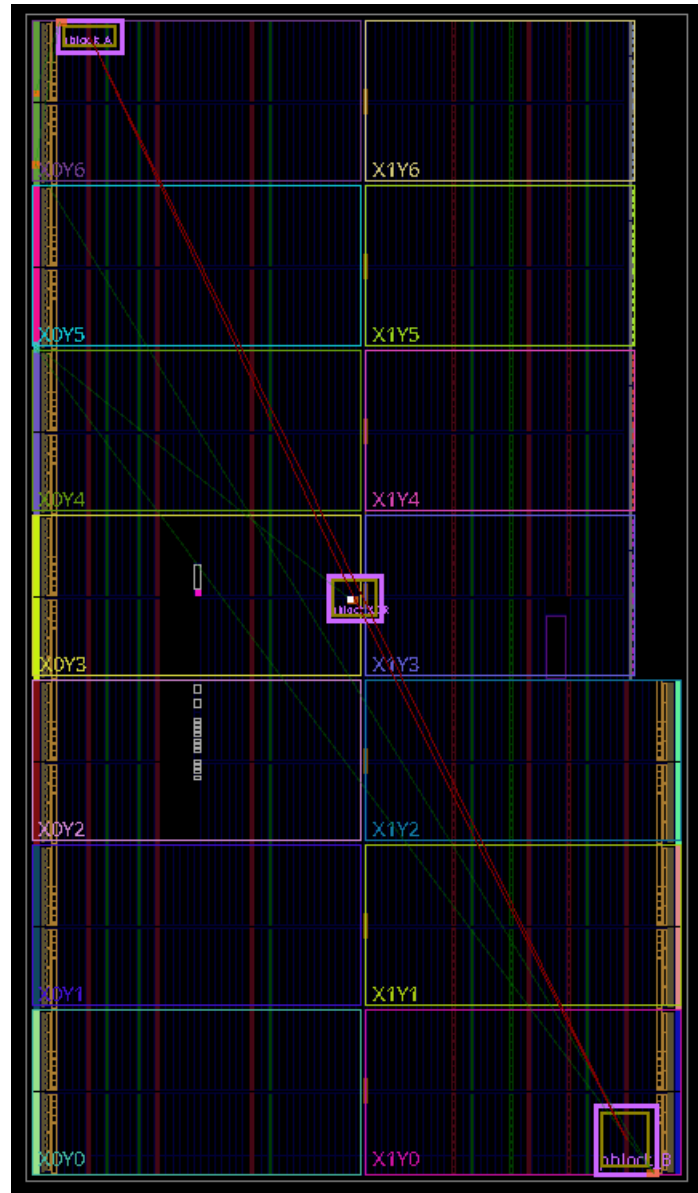


Figure 2: Output_A(top-left corner) and the Output_B(bottom-right corner)

2.2 MSO2 observation

The MSO2 has a built-in AFG (arbitrary function generator). The AFG and the oscilloscope settings are documented, and the output results are shown in Figure 3 below. In addition, the delay difference between the output_A and the output_B is found to be 1.418 ns by using the built-in measurement function. The methodology is shown in Figures 4 and 5.

Function Generator (AFG)

- **Waveform:** Square
- **Frequency:** 1 kHz
- **Amplitude:** 3.3 Vpp (High = 3.3 V, Low = 0 V)
- **Offset:** +1.65 V (so it swings 0...3.3 V)
- **Duty cycle:** 50 %
- **Load impedance:** High-Z

Channel 1 (output_A)

- **Probe:** 10×, DC coupling
- **Bandwidth:** 200 MHz limit enabled
- **Vertical scale:** 830 mV/div (enough to keep 3.3 V logic on-screen without clipping)
- **Vertical position:** 0
- **Trigger:** Rising edge, 50% threshold (~1.58 V)

Channel 2 (output_B)

- **Probe:** 10×, DC coupling
- **Bandwidth:** 200 MHz limit enabled
- **Vertical scale:** 850 mV/div (enough to keep 3.3 V logic on-screen without clipping)
- **Vertical position:** 0
- **Trigger:** Rising edge, 50% threshold (~1.58 V)



Figure 3: Ch1: output_A , and CH2: output_B (delay = 1.418 ns)

Figures 4 and 5 below show how to measure the delay difference.

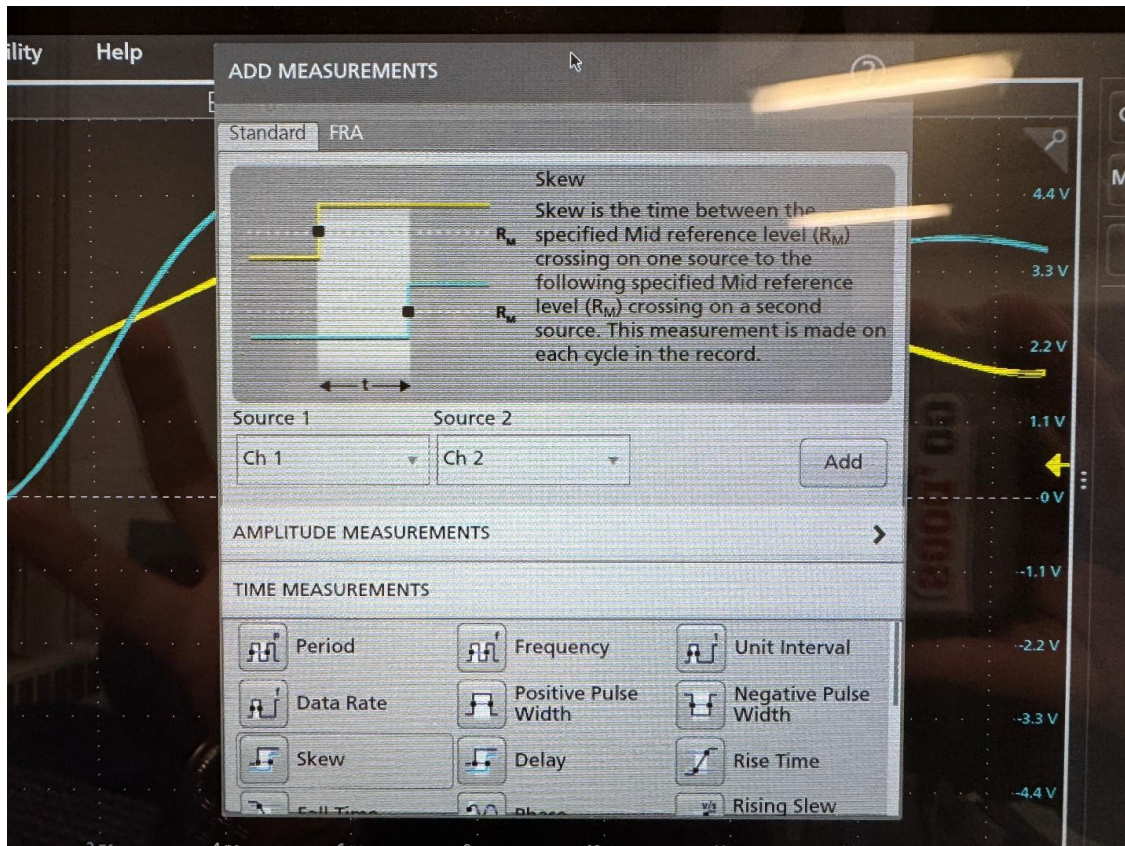


Figure 4

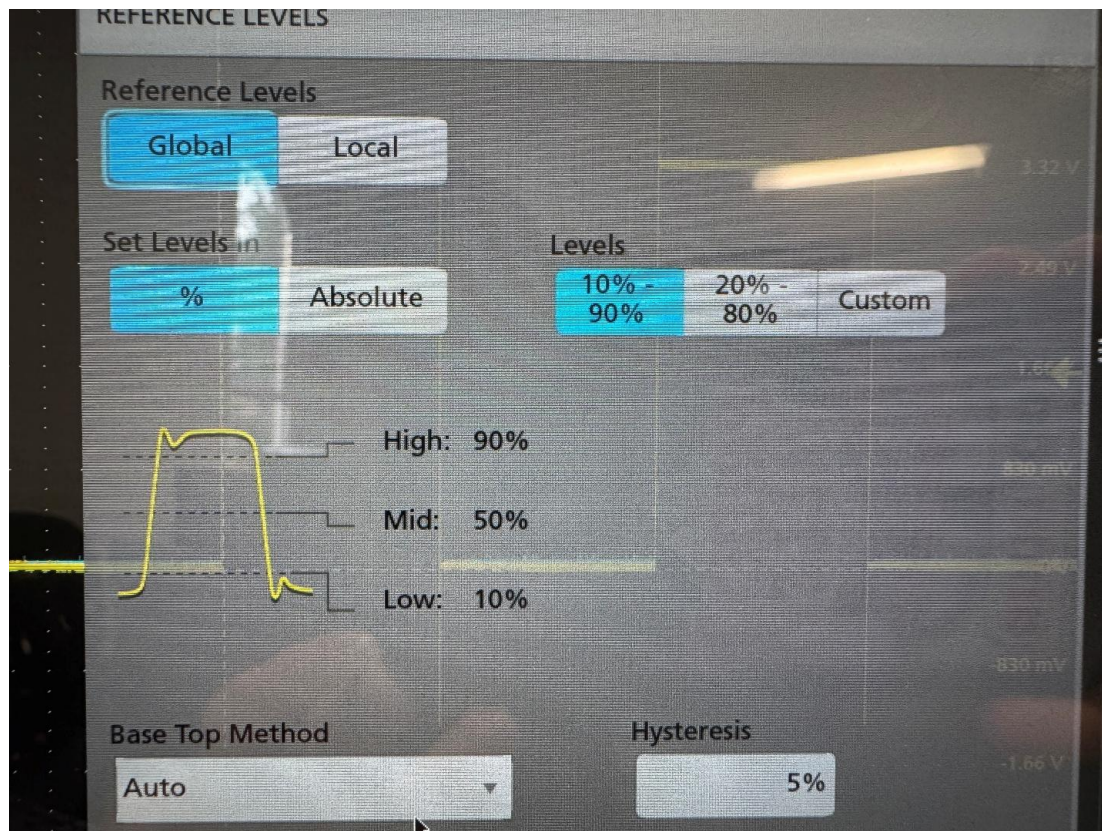


Figure 5: Reference Levels

2.3 WP 254HD observation

Tektronix AFG 3021B is used as a function generator, and the same values are set. The AFG and the oscilloscope settings are documented, and the output results are shown in Figure 6 below. In addition, the delay difference between the output_A and the output_B is found to be 1.819 ns by using the built-in measurement function. The methodology is shown in Figure 7.

Function Generator (AFG)

- **Waveform:** Square
- **Frequency:** 1 kHz
- **Amplitude:** 3.3 Vpp (High = 3.3 V, Low = 0 V)
- **Offset:** +1.65 V (so it swings 0...3.3 V)
- **Duty cycle:** 50 %
- **Load impedance:** High-Z

Channel 1 (output_A)

- **Probe:** 10×, DC coupling
- **Bandwidth:** full (2.5GHz)
- **Vertical scale:** 1 V/div (enough to keep 3.3 V logic on-screen without clipping)
- **Vertical position:** 0
- **Trigger:** Rising edge, 50% threshold (~1.58 V)

Channel 2 (output_B)

- **Probe:** 10×, DC coupling
- **Bandwidth:** full (2.5 GHz)
- **Vertical scale:** 1 V/div (enough to keep 3.3 V logic on-screen without clipping)
- **Vertical position:** 0
- **Trigger:** Rising edge, 50% threshold (~1.58 V)

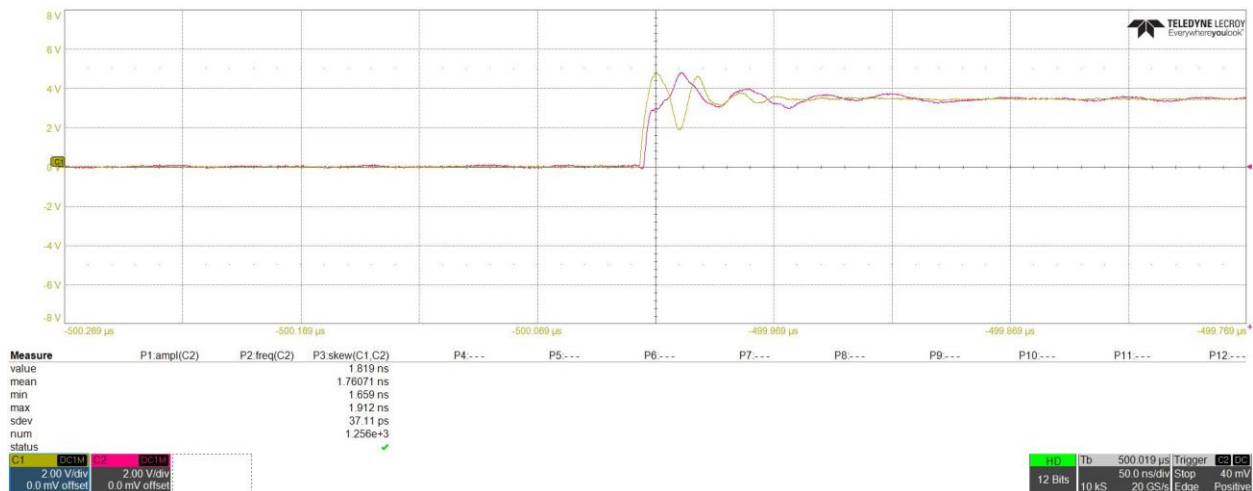












Figure 6: WP 254HD observation (1.819 ns)

	Phase Calculate the phase difference between two edges
	Rise 20-80% Duration of rising edge from 20-80%
	Rise time Duration of rising edge from 10-90%
	Rise@level Duration of rising edge from user defined transitions
rms	RMS Root mean square of the data
	Setup Time from the data edge to the clock edge
	Skew Time of clock1 edge minus time of nearest clock2 edge
	Slew rate Slew rate or local dv/dt in a transition zone
	Std dev Standard deviation of the data
	TIE@level Difference between the measured times of crossing a given slope and level and the ideal expected time
	Time@level

h Definition Oscilloscope

Figure 7: WP 254HD built-in delay difference measurement

3. Section Two: Output_A(top-left corner) and the Output_B(top-right corner)

3.1 Floorplanning

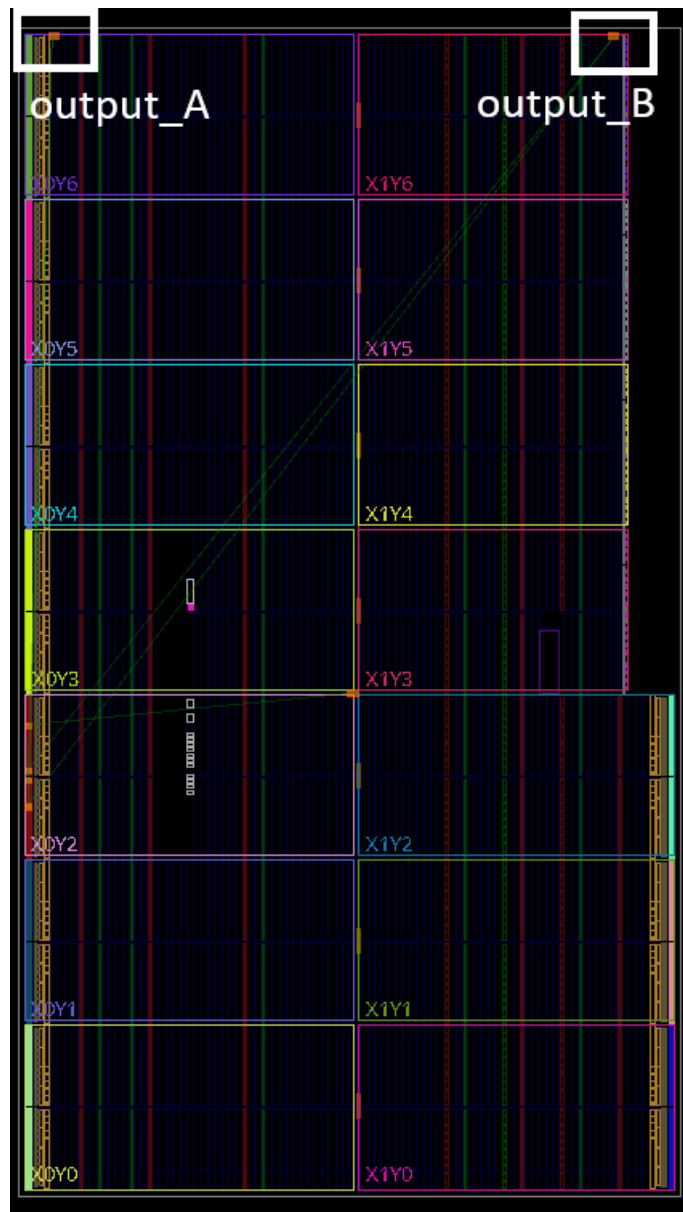


Figure 8: Floorplanning (output_A is at top-left and output_B is at top-right)

3.2 MSO2 observation

The Measurement Setup (Same values are used in the Tektronix MSO2)

Function Generator (AFG)

- Waveform: Square
- Frequency: 1 kHz
- Amplitude: 3.3 Vpp (High = 3.3 V, Low = 0 V)
- Offset: +1.65 V (so it swings 0...3.3 V)
- Duty cycle: 50 %
- Load impedance: High-Z

Channel 1 (output_A)

- Probe: 10×, DC coupling
- Bandwidth: 200 MHz limit enabled
- Vertical scale: 850 mV/div (enough to keep 3.3 V logic on-screen without clipping)
- Vertical position: 0
- Trigger: Rising edge, 50% threshold (~1.58 V)

Channel 2 (output_B)

- Probe: 10×, DC coupling
- Bandwidth: 200 MHz limit enabled
- Vertical scale: 850 mV/div (enough to keep 3.3 V logic on-screen without clipping)
- Vertical position: 0
- Trigger: Rising edge, 50% threshold (~1.58 V)

Horizontal / Acquisition

- Scale: 4 ns/div when zoomed in on one rising edge
- Record length: 25 pts
- Sample rate: 1.25 GS/s (maximum for two active channels)



Figure 9: Ch1: output_A , and CH2: output_B (delay = 2.111 ns)

The delay difference between the output_A and the output_B is found to be 2.111 ns by using the built-in measurement function that is shown in Figure 9 above.

3.3. WP 254HD observation

Tektronix AFG 3021B is used as a function generator, and the same values as before are set-see details below. The AFG and the oscilloscope settings are documented, and the output results are shown in Figure 10 below. In addition, the delay difference between the output_A and the output_B is found to be 2.502 ns by using the built-in measurement function.

Function Generator (AFG)

- **Waveform:** Square
- **Frequency:** 1 kHz
- **Amplitude:** 3.3 Vpp (High = 3.3 V, Low = 0 V)
- **Offset:** +1.65 V (so it swings 0...3.3 V)
- **Duty cycle:** 50 %
- **Load impedance:** High-Z

Channel 1 (output_A)

- **Probe:** 10×, DC coupling
- **Bandwidth:** full (2.5GHz)
- **Vertical scale:** 1 V/div (enough to keep 3.3 V logic on-screen without clipping)
- **Vertical position:** 0
- **Trigger:** Rising edge, 50% threshold (~1.58 V)

Channel 2 (output_B)

- **Probe:** 10×, DC coupling
- **Bandwidth:** full (2.5 GHz)
- **Vertical scale:** 1 V/div (enough to keep 3.3 V logic on-screen without clipping)
- **Vertical position:** 0
- **Trigger:** Rising edge, 50% threshold (~1.58 V)

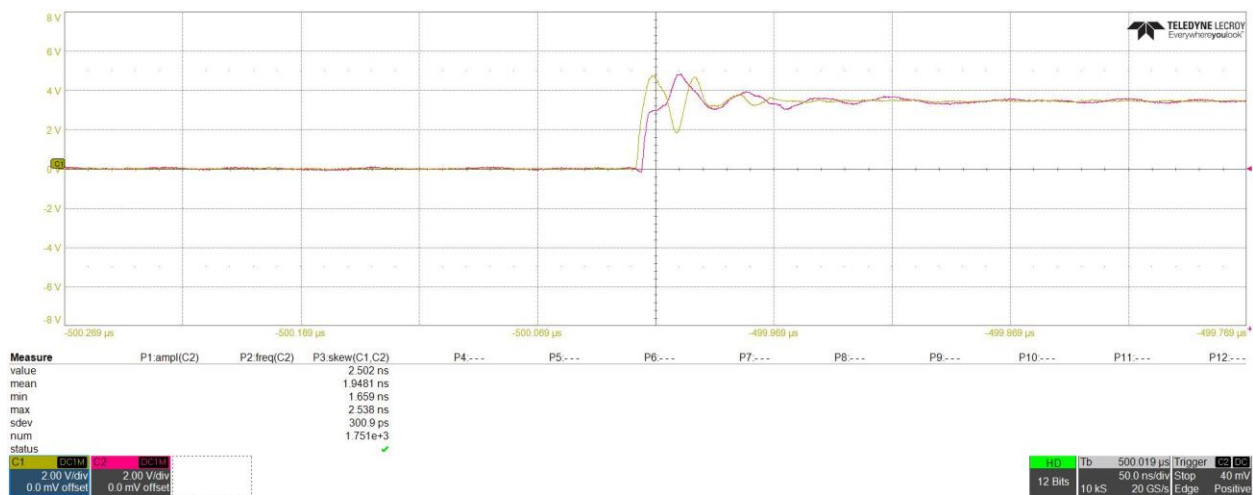


Figure 10: WP 254HD observation (2.502 ns)

4. Section Three: Results

This section presents results, supported by a comparison table.

Function Generator Settings (same for all)	Oscilloscope Settings	Delay Measurement CH1: output_A (top_left corner) CH2: output_B (bottom_right corner)	Delay Measurement CH1: output_A (top_left corner) CH2: output_B (top_right corner)
Square Wave, 1 kHz, 3.3 Vpp, High Z, 50% Duty Cycle	Tektronix MSO2 Bandwidth: 100 MHz	1.418 ns	2.111 ns
Square Wave, 1kHz, 3.3 Vpp, High Z, 50% Duty Cycle	LeCroy WavePro 254HD Bandwidth: 2.5 GHz	1.819 ns	2.502 ns

Table 1

5. Conclusion

The report highlights key findings, supported by figures and comparative data.