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 (MS02 and WP 254HD).

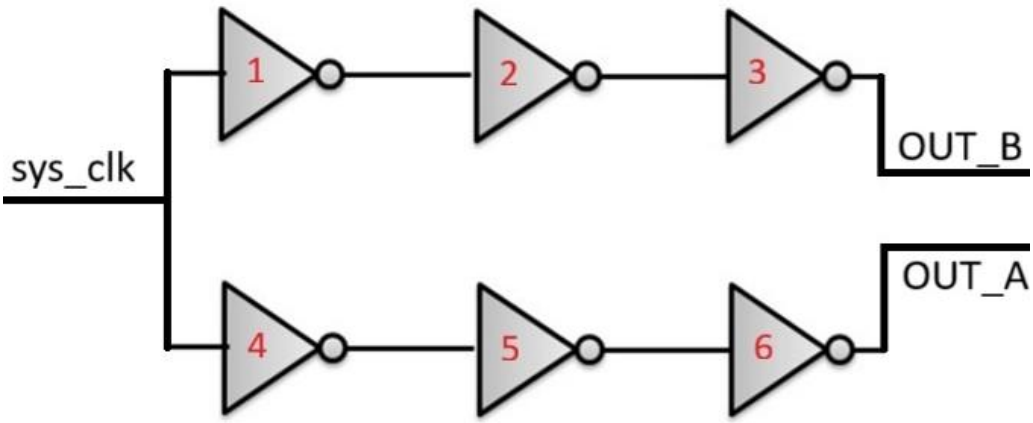

Figure 1

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.

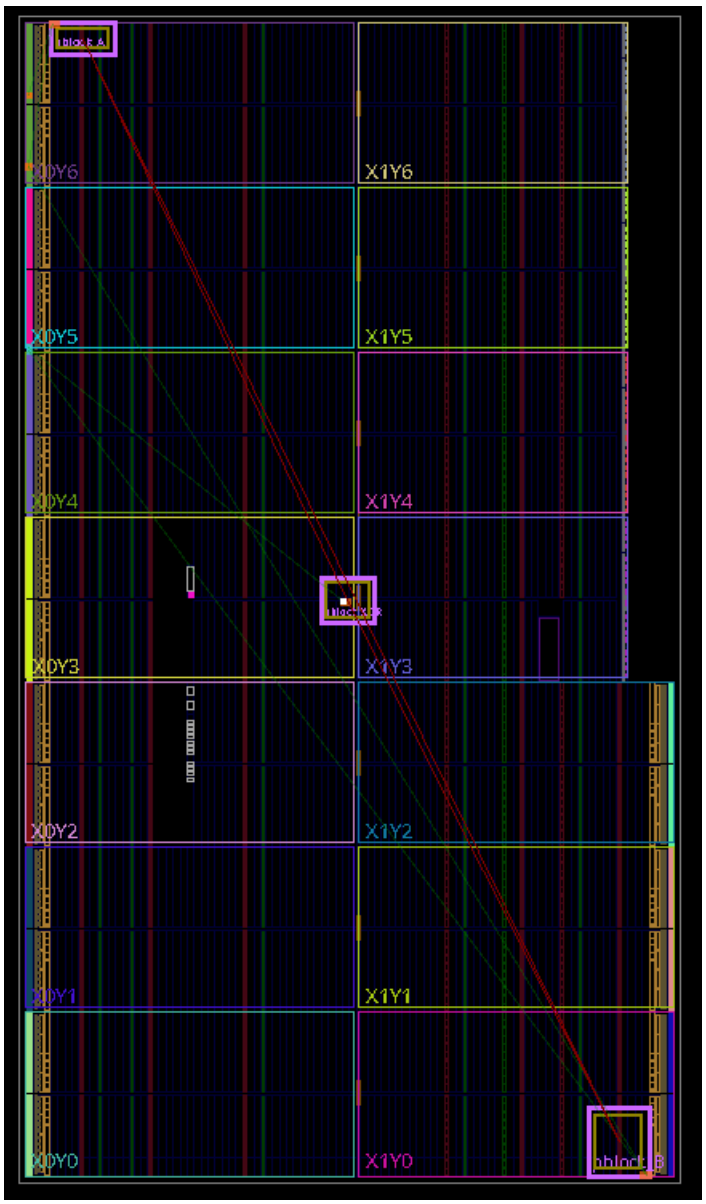

Figure 2: Output_A(top-left corner) and the Output_B(bottom-right corner)

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)

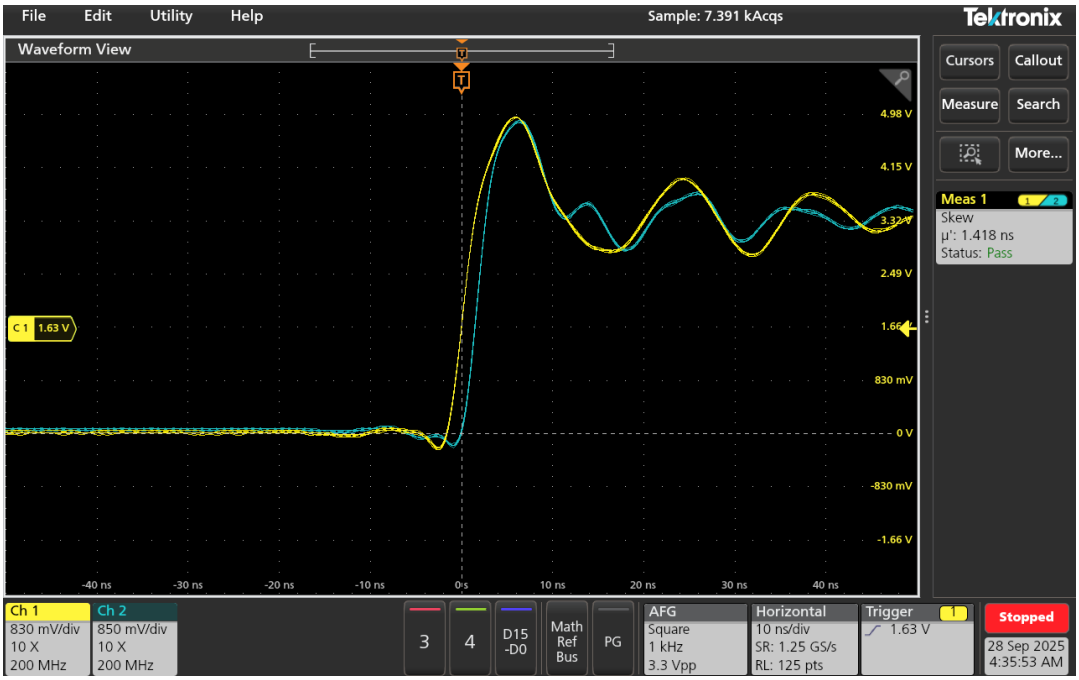

Figure 3: Ch1: output_A , and CH2: output_B (delay = 1.418 ns)

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

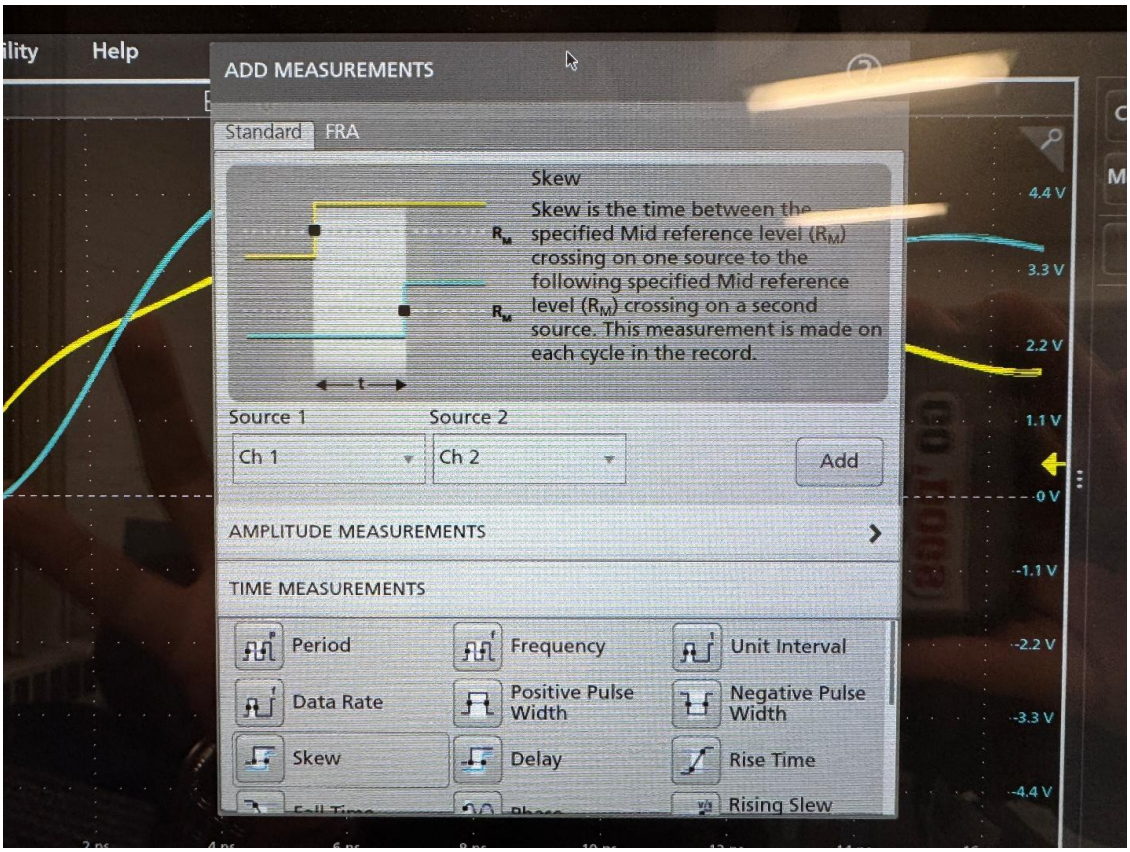

Figure 4

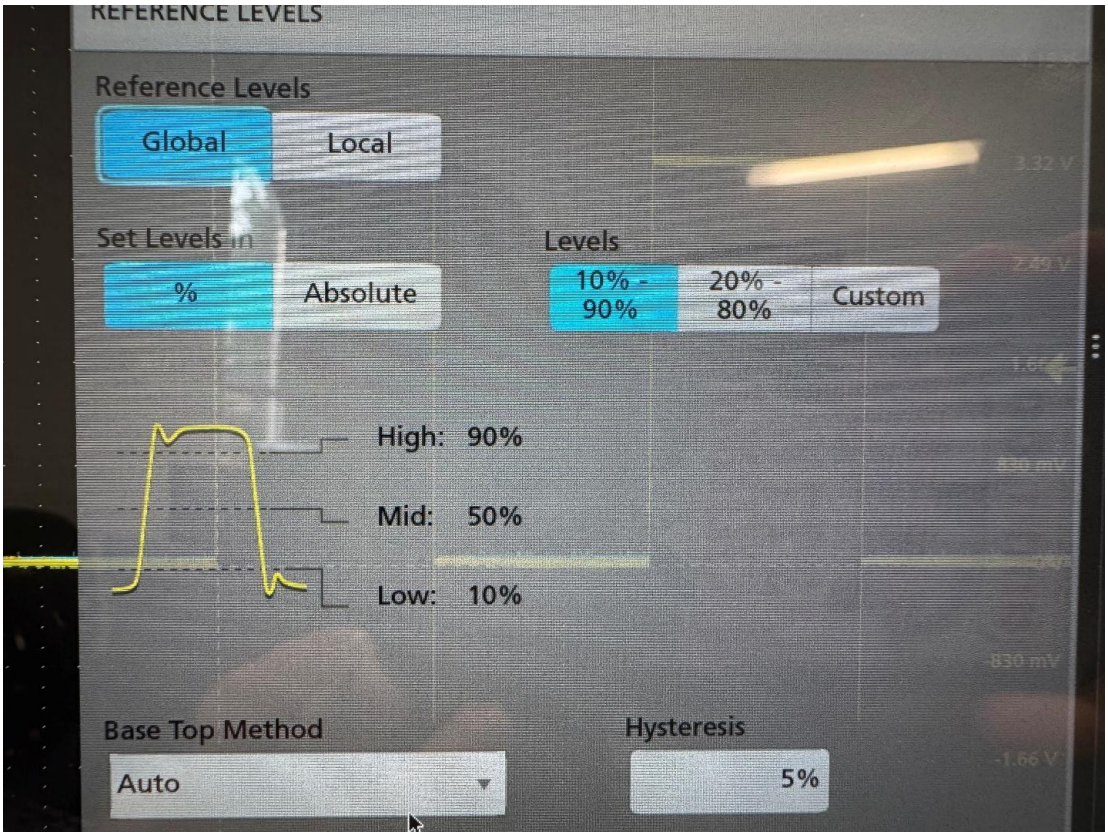

Figure 5: Reference Levels

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)

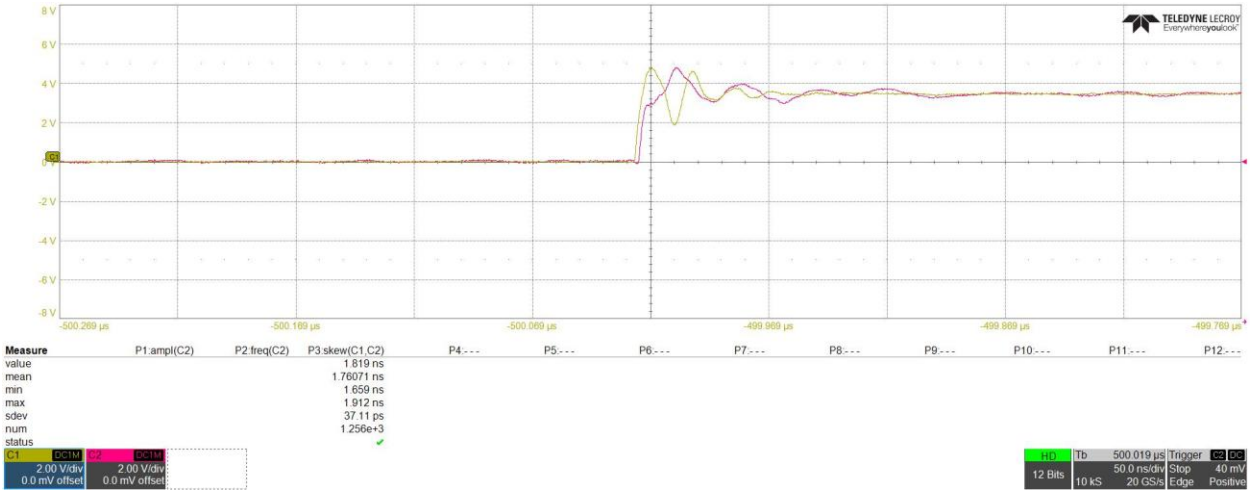

Figure 6: WP 254HD observation (1.819 ns)

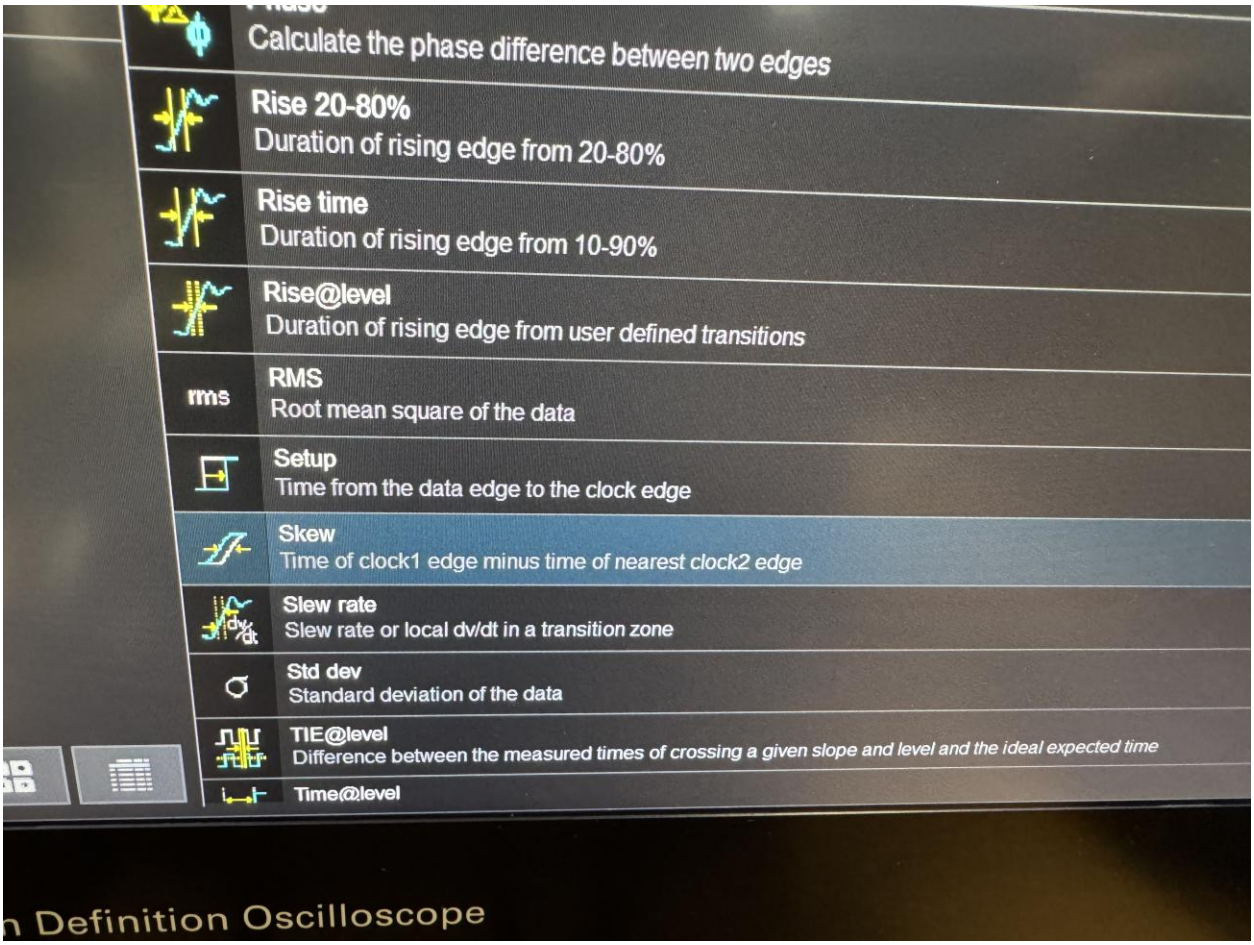

Figure 7: WP 254HD built-in delay difference measurement

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

3.1 Floorplanning

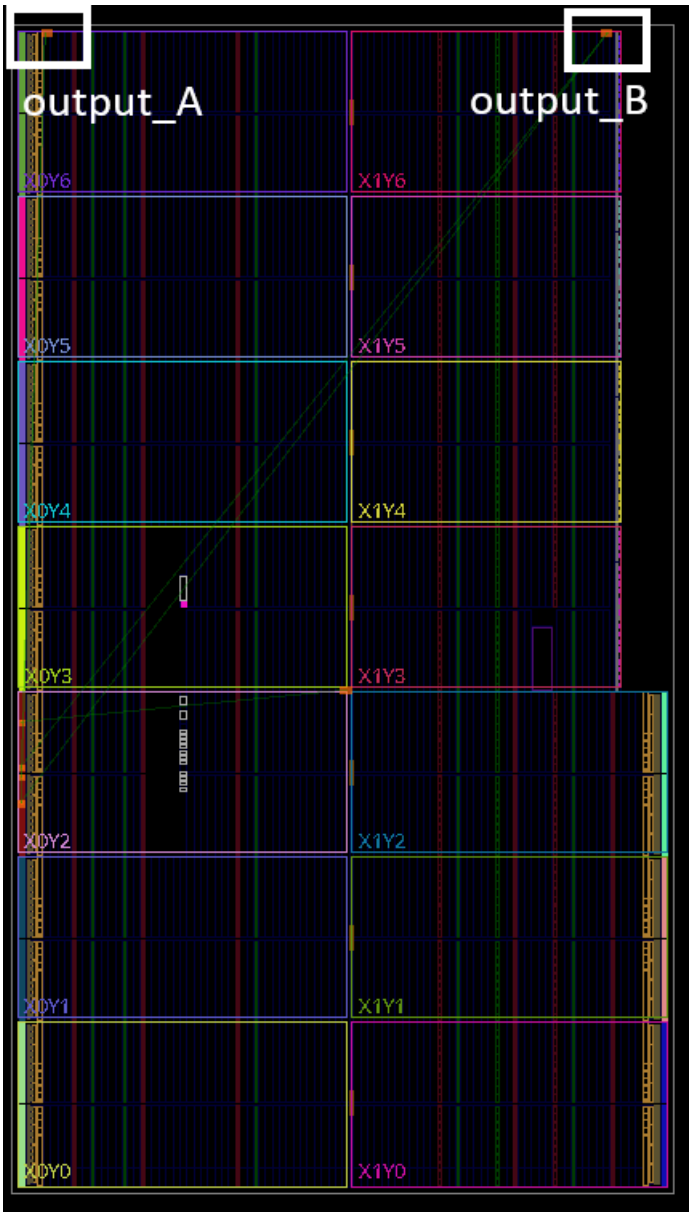

Figure 8: Floorplanning (output_A is at top-left and output_B is at top-right)

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)

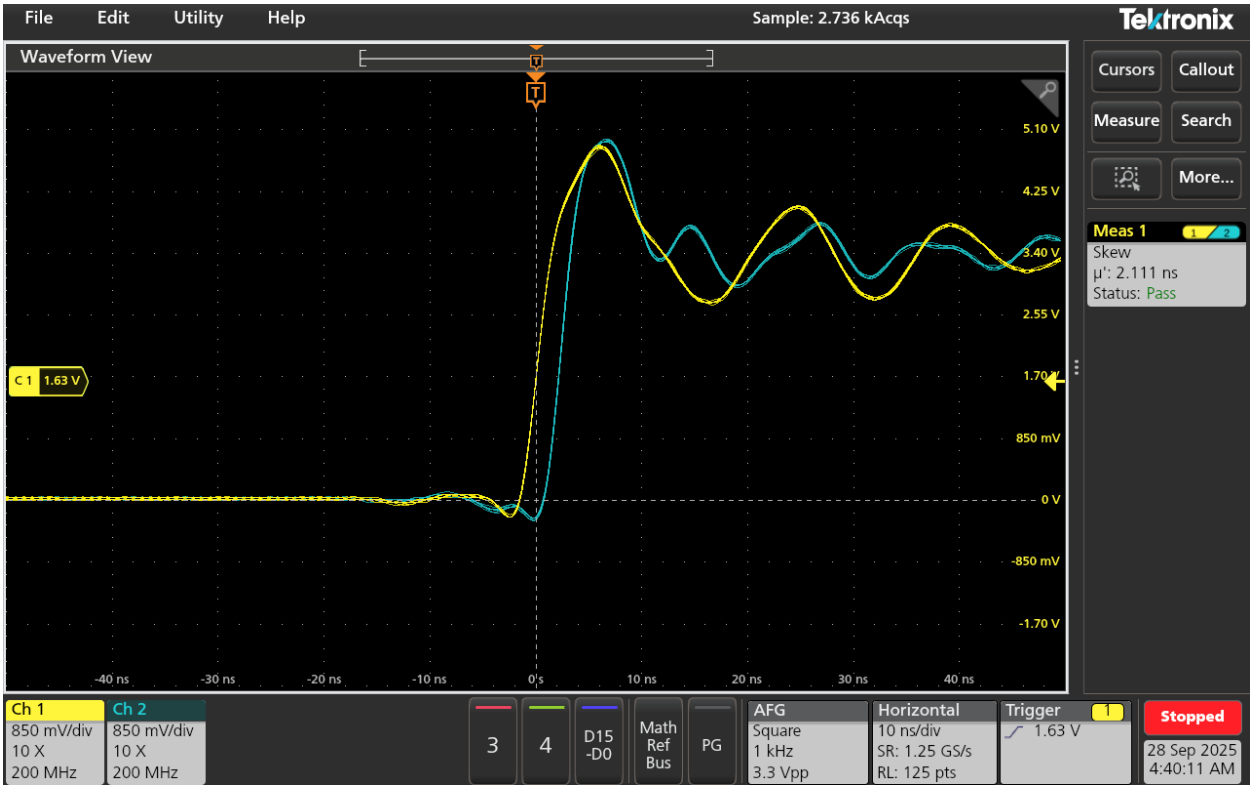

Figure 9: Ch1: output_A , and CH2: output_B (delay = 2.111 ns)

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)

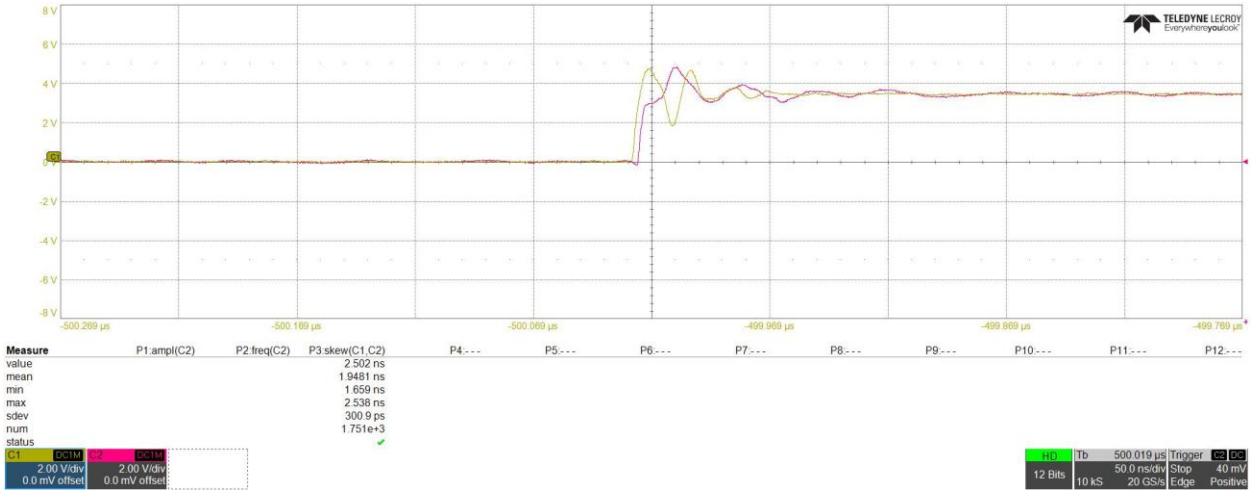

Figure 10: WP 254HD observation (2.502 ns)

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.