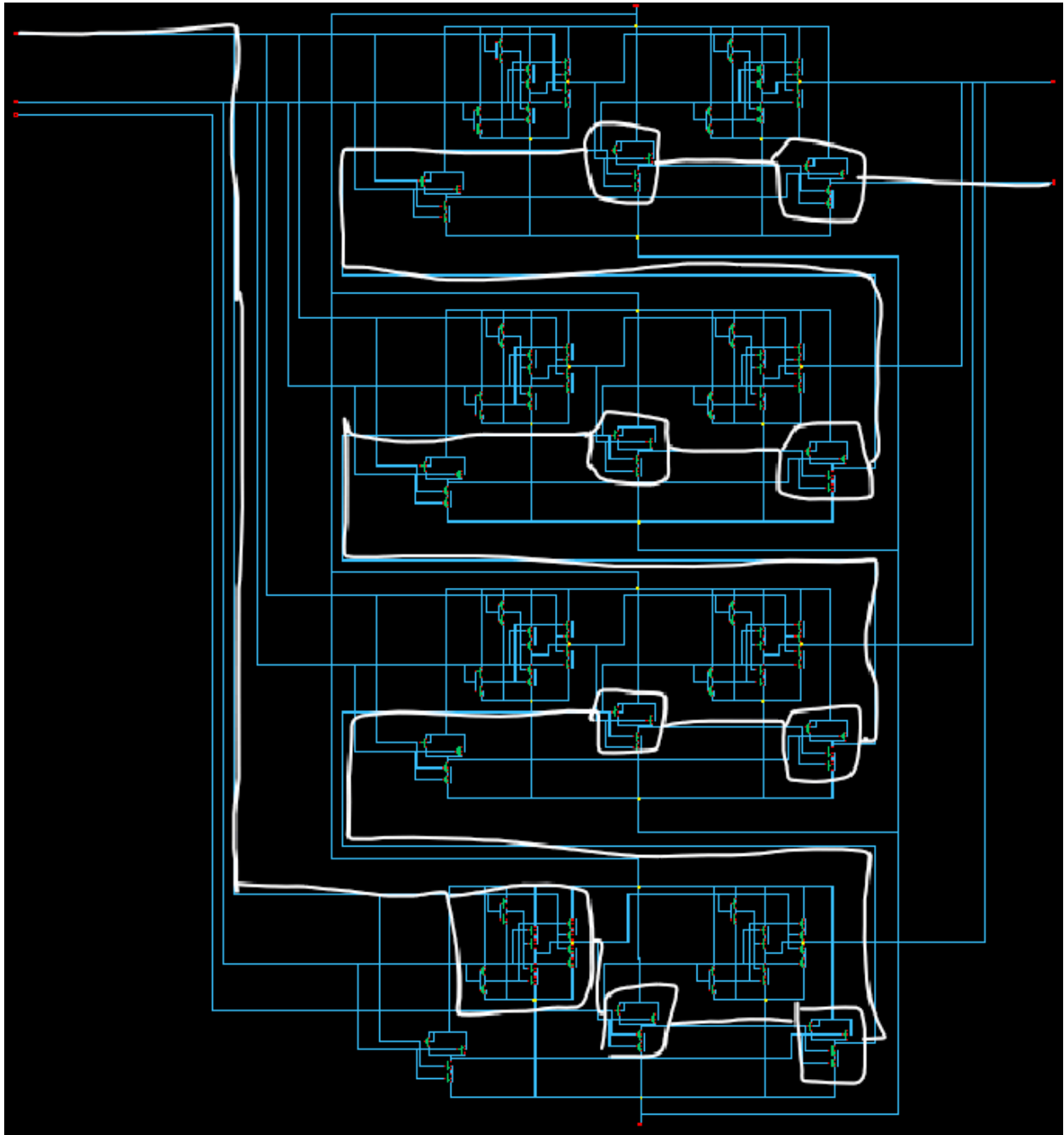


1) Circuit with critical path



2) Calculation of G, B, H

NAND:

$$C_{\text{nand}} = 2.308 \text{ fF}$$

$$W_p = 600\text{n}, W_n = 300\text{n}$$

XOR:

$$C_{\text{xor}} = 2.234 \text{ fF}$$

$$W_p = 1.2\mu, W_n = 300\text{n}$$

$$g_1 = g_{\text{xor}} = 4$$

$$g_{\text{nand}} = 4/3 = g_{2,3,\dots,9}$$

$$G = 4 * (4/3)^8 = 39.955$$

$$C_{\text{load}} = 30 \text{ fF}$$

$$H = C_{\text{load}}/C_{\text{xor}} = 30/2.234 = 13.429$$

$$b_1 = (C_{\text{xor}} + C_{\text{nand}}) / C_{\text{xor}} = 2.033$$

$$b_2 = b_4 = b_6 = b_8 = (C_{\text{xor}} + C_{\text{nand}}) / C_{\text{nand}} = 1.968$$

$$b_3 = b_5 = b_7 = b_9 = 1$$

$$B = 2.033 * (1.968)^4 * 1^4 = 30.494$$

$$F = G * B * H = 16361.3$$

$$f = F^{1/9} = 2.939$$

$$2.7 < f < 4$$

3) Resizing

$$C_{in} = g_i(C_{out,i}) / f$$

$$C_{out9} = 30 \text{ fF}$$

$$C_{in9} = ((4/3)*30) / 2.939 = 13.61 \text{ fF} > 2.308 \text{ fF (need resize)}$$

$$\text{Resize} = C_{in9}/C_{nand} = 13.61/2.308 = 5.897$$

$$w_p = 3.54 \mu\text{m}, w_n = 1.77 \mu\text{m}$$

$$C_{in8} = ((4/3)*13.61) / 2.939 = 6.174 \text{ fF} > 2.308 \text{ fF (need resize)}$$

$$\text{Resize} = C_{in9}/C_{nand} = 6.174/2.308 = 2.675$$

$$w_p = 1.61 \mu\text{m}, w_n = 802.5 \text{ nm}$$

$$C_{in7} = ((4/3)*6.174) / 2.939 = 2.801 \text{ fF} > 2.308 \text{ fF (need resize)}$$

$$\text{Resize} = C_{in9}/C_{nand} = 2.801/2.308 = 1.214$$

$$w_p = 728.4 \text{ nm}, w_n = 364.2 \text{ nm}$$

$$C_{in6} = ((4/3)*2.801) / 2.939 = 1.271 \text{ fF} < 2.308 \text{ fF (don't need resize)}$$

$$C_{in5} = ((4/3)*2.308) / 2.939 = 1.047 \text{ fF} < 2.308 \text{ fF (don't need resize)}$$

$$C_{in4} = ((4/3)*2.308) / 2.939 = 1.047 \text{ fF} < 2.308 \text{ fF (don't need resize)}$$

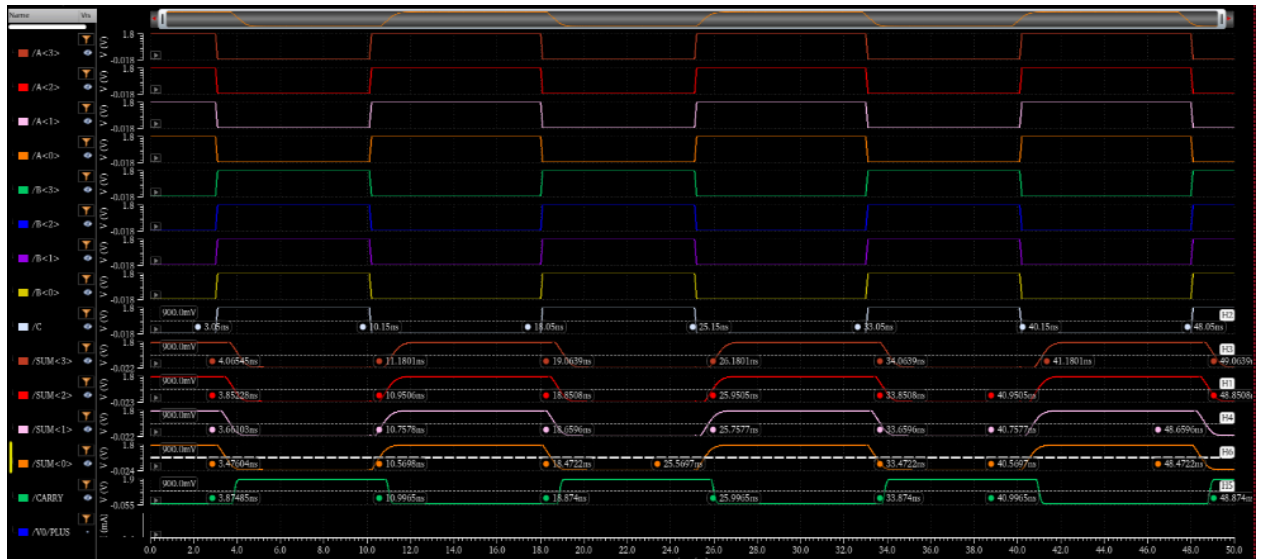
$$C_{in3} = ((4/3)*2.308) / 2.939 = 1.047 \text{ fF} < 2.308 \text{ fF (don't need resize)}$$

$$C_{in2} = ((4/3)*2.308) / 2.939 = 1.047 \text{ fF} < 2.308 \text{ fF (don't need resize)}$$

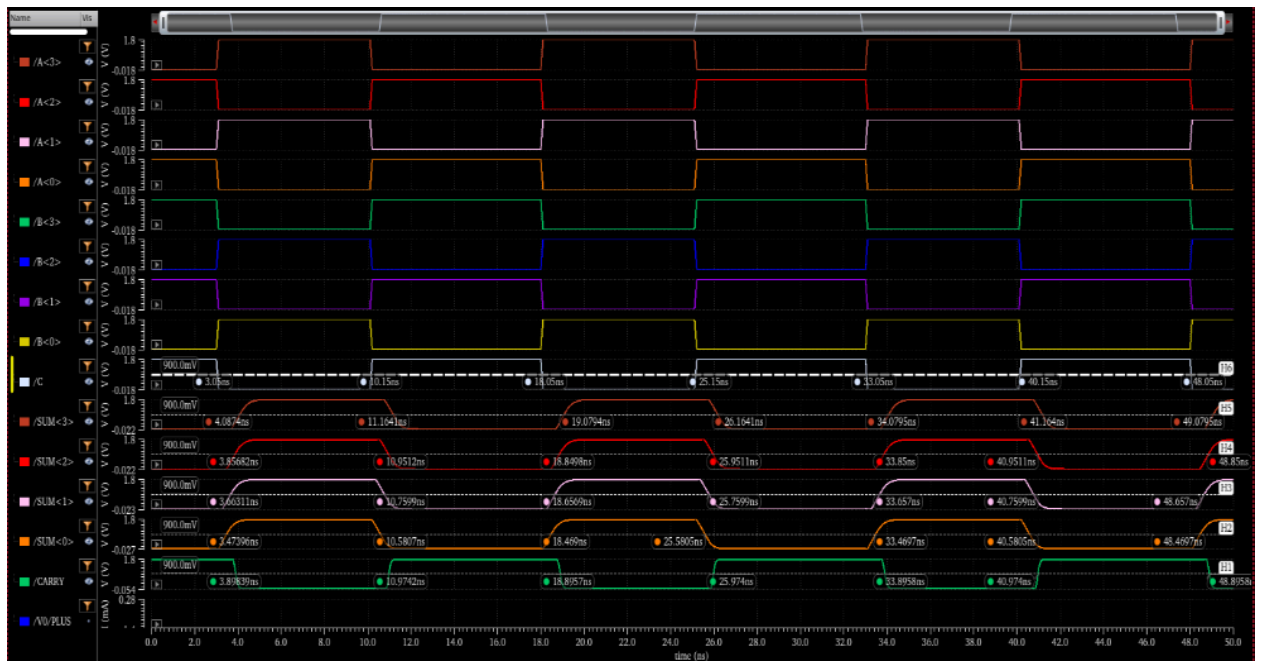
$$C_{in1} = ((4/3)*2.308) / 2.939 = 1.047 \text{ fF} < 2.308 \text{ fF (don't need resize)}$$

4) Optimized Waveforms

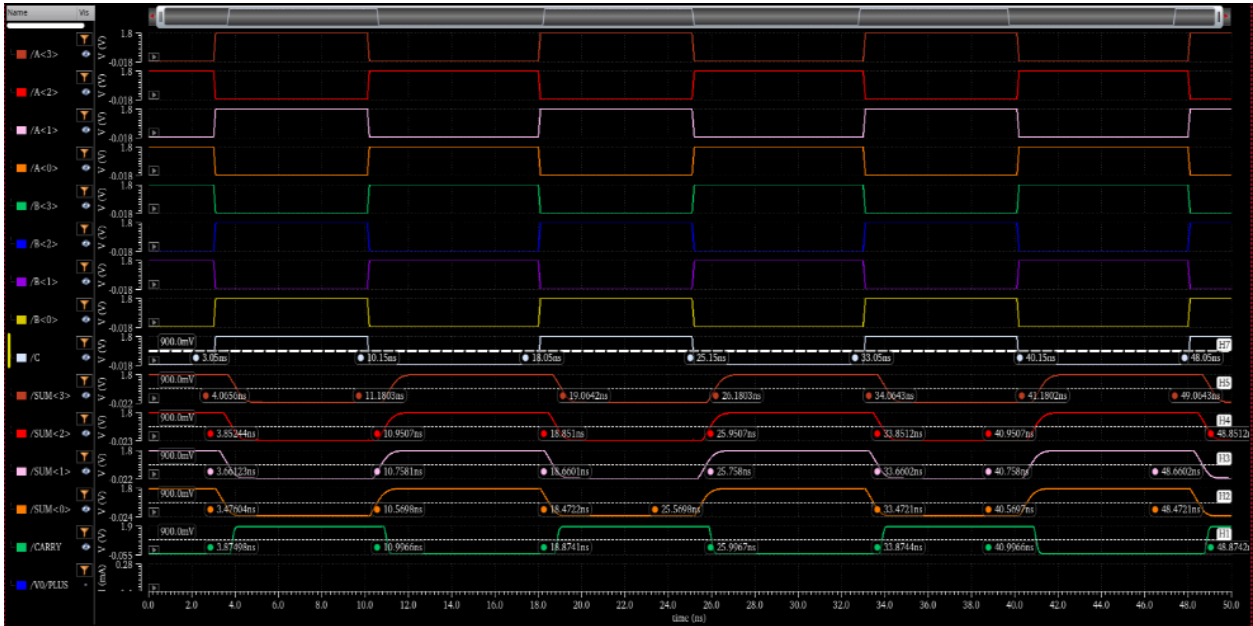
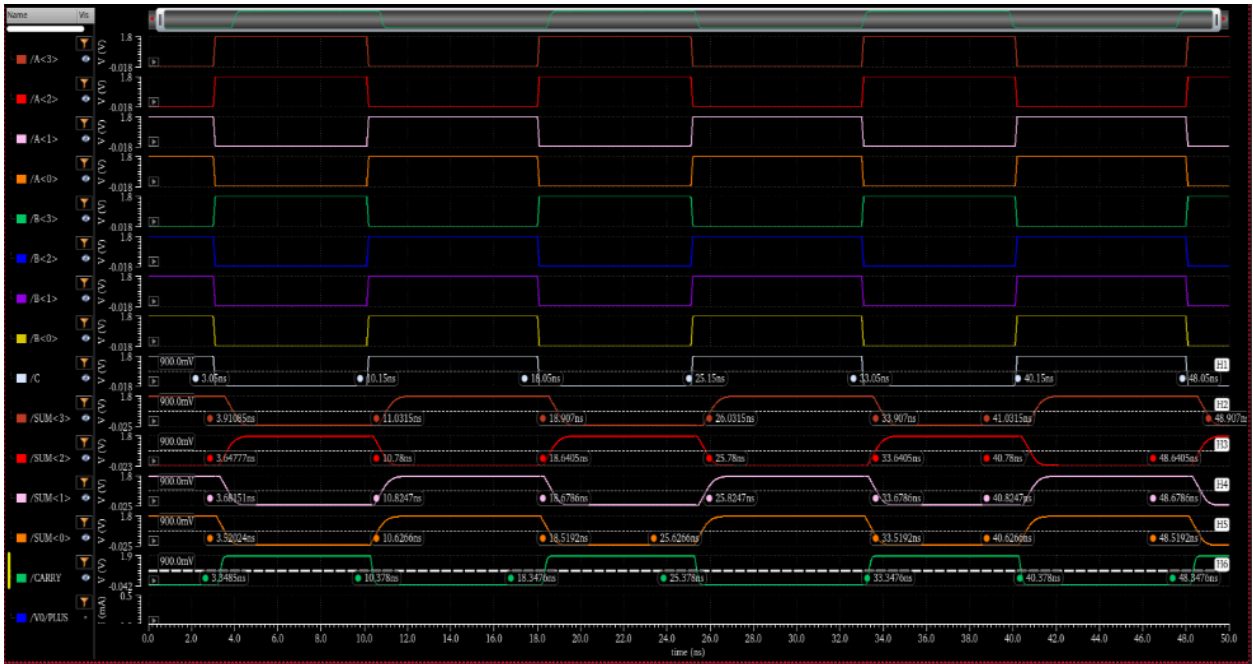
A = 0000, B = 1111, C = 1



A = 1010, B = 0101, C = 0



$A = 1010, B = 0101, C = 1$


$$A = 1100, B = 1000, C = 1$$


5) Table comparing delays and VDD power consumption

Delays:

Case	Pin	Non-optimized (ps)	Optimized (ps)
A = 0000	SUM <0>	426	426.04
B = 1111	SUM <1>	611	611.03
C = 1	SUM <2>	802.4	802.28
	SUM <3>	994	1015.45
	CARRY	1008.2	824.85
A = 1010	SUM <0>	423.96	423.96
B = 0101	SUM <1>	613.1	613.11
C = 0	SUM <2>	806.96	806.82
	SUM <3>	1001.19	1037.4
	CARRY	999.73	848.39
A = 1010	SUM <0>	426.06	426.04
B = 0101	SUM <1>	611.23	611.23
C = 1	SUM <2>	802.56	802.44
	SUM <3>	994.11	1015.6
	CARRY	1008.37	824.98
A = 1100	SUM <0>	470.24	470.24
B = 1000	SUM <1>	631.49	631.51
C = 0	SUM <2>	598	597.77
	SUM <3>	831.35	860.85
	CARRY	450.31	297.55

Power Consumption:

Case	Non-optimized (uW)	Optimized (uW)
A = 0000	-104.5	-114.2
B = 1111		
C = 1		
A = 1010	-114.3	-124.2
B = 0101		
C = 0		
A = 1010	-104.7	-114.4
B = 0101		
C = 1		
A = 1100	-112.3	-121.4
B = 1000		
C = 0		

6) Table Comparing Area

Optimized (u^2m^2)	Non-Optimized (u^2m^2)
20.2	17.76