ECEN 714: Submission for LAB 10

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Contents (Logical Effort Calculations and optimization, Comparisons between old design and the optimized design.)

Transistor Level diagram of the 3-Bit Adder with Critical Path

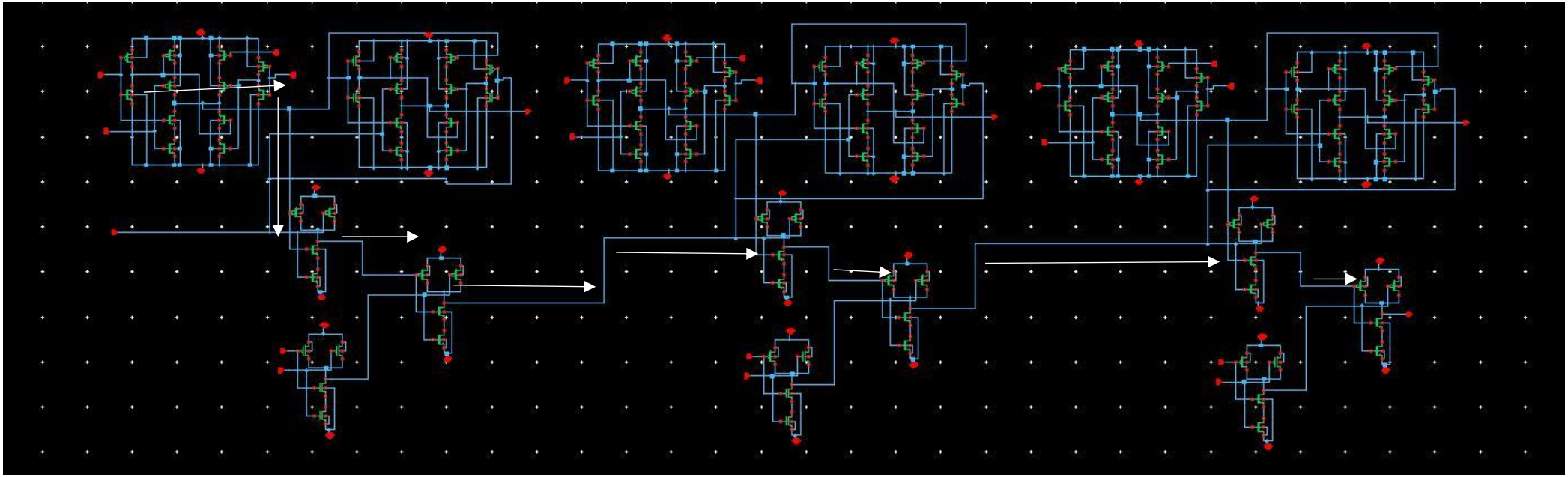


Figure 1: The White arrows show the critical path

Logic Effort Calculation(G):

$$G = \text{Path Logical Effort} = \prod g_i$$

$$g_{XOR} = \frac{C_{in}}{C_{in} \text{ of equivalent inverter}} = \frac{2Wp+2Wn}{\frac{Wp}{2}+\frac{Wn}{2}} = 4$$

$$g_{NAND} = \frac{C_{in}}{C_{in} \text{ of equivalent inverter}} = \frac{Wp+Wn}{Wp+\frac{Wn}{2}} = \frac{900+450}{900+450/2} = 1.2$$

$$G = 11.94$$

Branch Effort Calculation(B)

$$B = \prod b = \prod \frac{\left(C_{on-path} + C_{off-path}\right)}{\left(C_{on-path}\right)} = 30.52$$

b1= 3.125; b2 = 1; b3 = 3.125; b4=1; b5 = 3.125; b6 = 1; b7 = 1

Electrical Effort Calculation (H)

$$H = \frac{30fF}{C_{xor}} = \frac{30fF}{6.8fF} = 4.41$$

Path Effort Calculation (F)

$$F = GBH = 11.94 * 30.52 * 4.41 = 1607.04$$

$$f^{\sim} = F^{1/7} = 2.87$$

Resizing of Transistors

Resizing begins at output and moves towards the input. Hence starting at gate 7.

$$C_{in7} = g_{NAND} * \frac{30fF}{f^{\sim}} = 1.2 * \frac{30fF}{2.87} = 12.54fF$$

As this capacitance is not up to the specification this transistor needs to be resized.

$$W_{new_n} = \frac{12.54fF}{C_{gate}} * W_n = \frac{12.54fF}{3.2fF} * 450nm = 1763nm$$

$$W_{new_p} = \frac{12.54fF}{C_{gate}} * W_p = \frac{12.54fF}{3.2fF} * 900nm = 3526nm$$

For gate 6;

$$C_{in6} = g_{NAND} * \frac{12.54fF}{f\sim} = 1.2 * \frac{12.54fF}{2.87} = 5.24fF$$

As this is still not upto specification we need to resize once again.

$$W_{new_n} = \frac{5.24fF}{C_{gate}} * W_n = \frac{5.24fF}{3.2fF} * 450nm = 736nm$$

$$W_{new_p} = \frac{5.24fF}{C_{gate}} * W_p = \frac{5.24fF}{3.2fF} * 900nm = 1473.75nm$$

For gate 5;

$$C_{in5} = g_{NAND} * \frac{5.24fF}{f\sim} = 1.2 * \frac{5.24fF}{2.87} = 2.19fF$$

As the capacitance is within specification we stop the resizing of transistors.

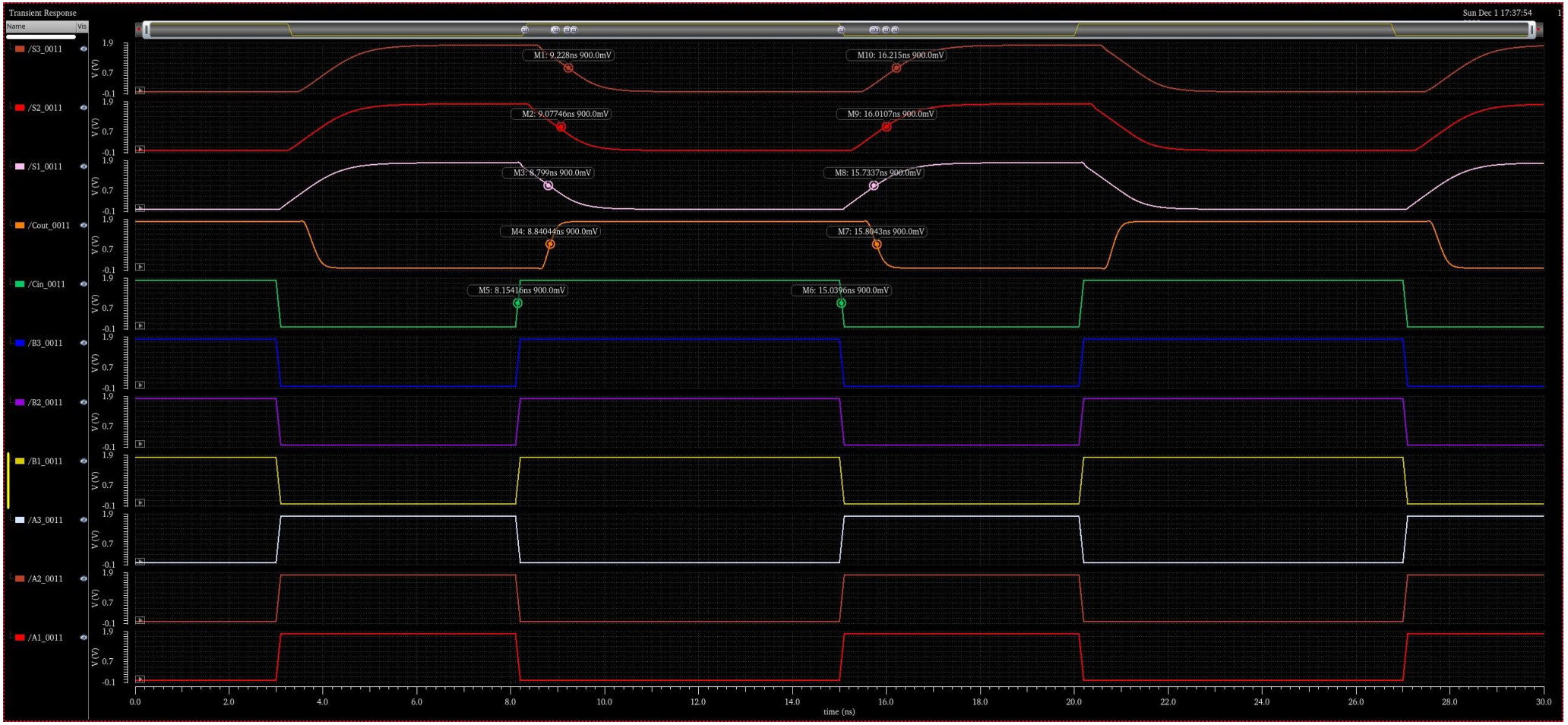
Delay Comparision

Old Values:

Vector 1 *A=000; B=111; Cin= 1*	**Cin**	**s1**	**s2**	**s3**	**Cout**
	8.1597	8.91764	8.91764	9.29052	9.03413
	15.0679	15.9126	16.093	16.093	15.786
Delay	**s1**	**s2**	**s3**	**Cout**	
Rising	0.75794	0.75794	1.13082	0.7181	
Falling	0.8447	1.0251	1.0251	0.87443	

Vector 1	Cin	s1	s2	s3	Cout
	8.15416	8.799	9.0774	9.228	8.84044
	15.0396	15.7337	16.01	16.215	15.8043
Delay	s1	s2	s3	cout	
rising	0.64484	0.92324	1.07384	0.7647	
falling	0.6941	0.9704	1.1754	0.68628	

New Values:

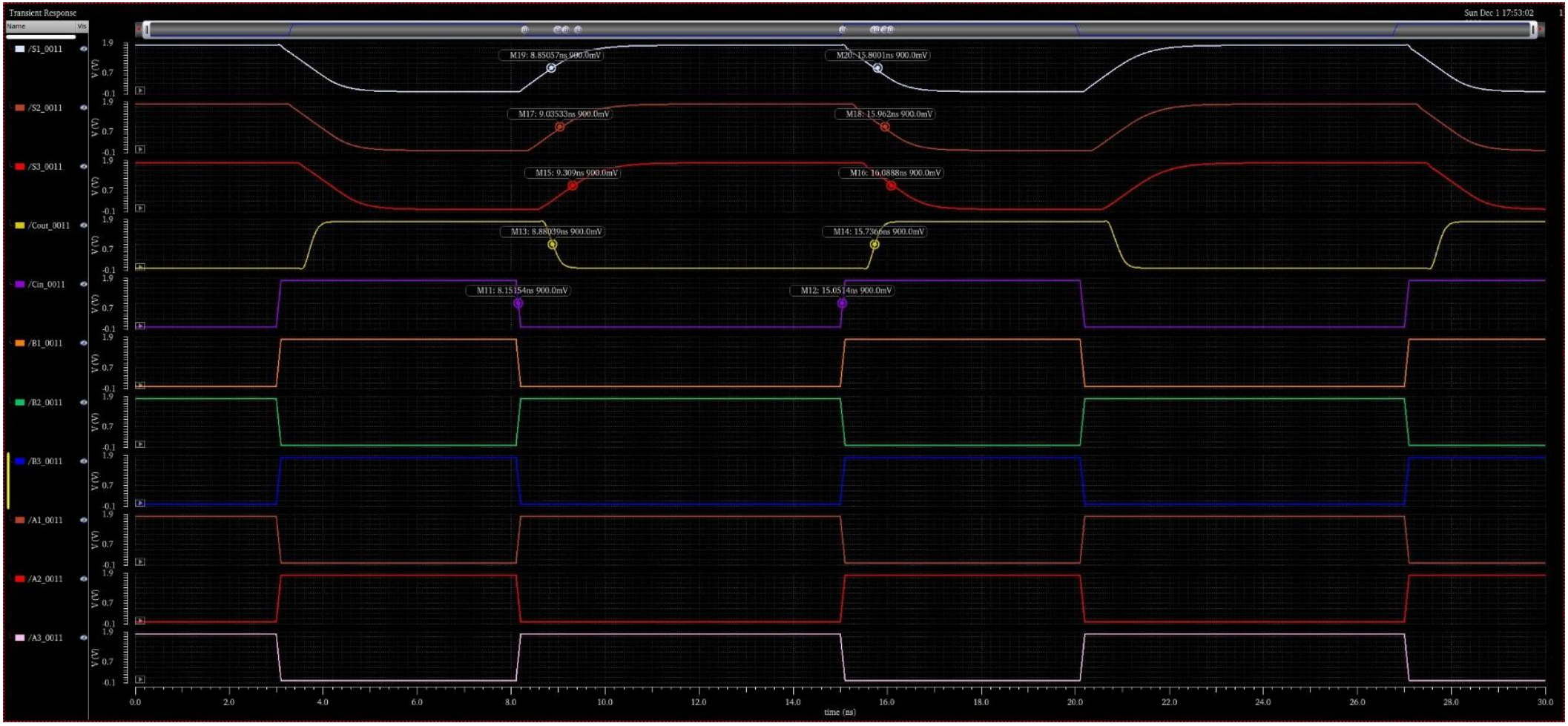

Transient Response
Sun Dec 1 17:37:54
Name
Vis
/S3_0011
/S2_0011
/S1_0011
/Cout_0011
/Cin_0011
/B3_0011
/B2_0011
/B1_0011
/A3_0011
/A2_0011
/A1_0011
M1: 9.228ns 900.0mV
M10: 16.215ns 900.0mV
M2: 9.07746ns 900.0mV
M9: 16.0107ns 900.0mV
M3: 8.799ns 900.0mV
M8: 15.7337ns 900.0mV
M4: 8.84044ns 900.0mV
M7: 15.8043ns 900.0mV
M5: 8.15416ns 900.0mV
M6: 15.0396ns 900.0mV
V (V)
1.9
0.7
-0.1
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
28.0
30.0
time (ns)

Old Values:

Vector 2 *A=101; B=010; Cin=0*	**Cin**	**s1**	**s2**	**s3**	**Cout**
	8.14765	8.9062	9.26074	9.47085	8.99078
	15.0565	15.8704	15.9068	16.008	15.9326
Delay	**s1**	**s2**	**s3**	**cout**	
Rising	0.75855	1.11309	1.3232	0.8761	
Falling	0.8139	0.8503	0.9515	0.84313	

New Values:

Vector 2	Cin	s1	s2	s3	Cout
	8.15154	8.85057	9.03533	9.309	8.88039
	15.0514	15.8001	15.962	16.088	15.7366
Delay	s1	s2	s3	cout	
rising	0.69903	0.88379	1.15746	0.6852	
falling	0.7487	0.9106	1.0366	0.72885	

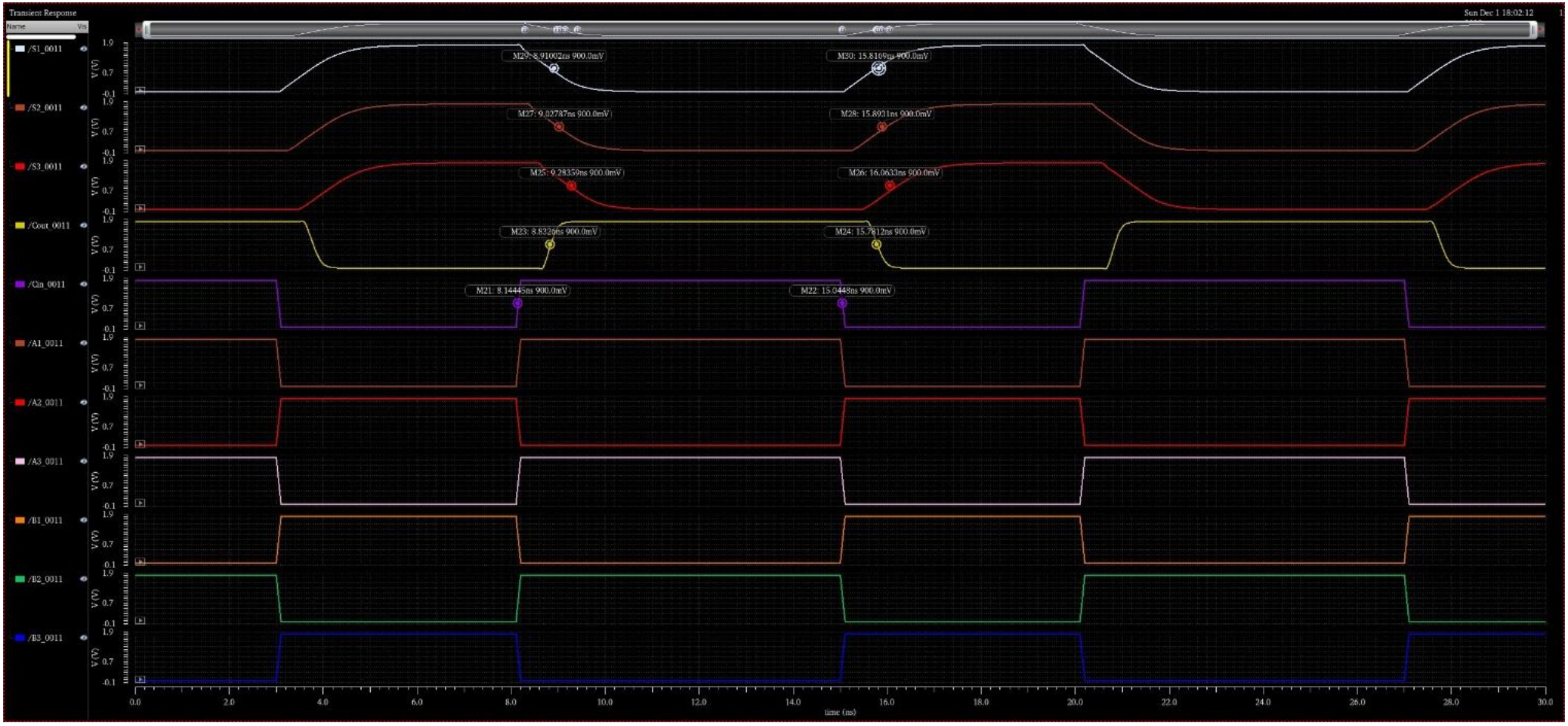

Transient Response
Sun Dec 1 17:53:02
Name
Vis
/S1_0011
/S2_0011
/S3_0011
/Cout_0011
/Cin_0011
/B1_0011
/B2_0011
/B3_0011
/A1_0011
/A2_0011
/A3_0011
M19: 8.85057ns 900.0mV
M20: 15.8001ns 900.0mV
M17: 9.03533ns 900.0mV
M18: 15.962ns 900.0mV
M15: 9.309ns 900.0mV
M16: 16.0888ns 900.0mV
M13: 8.88039ns 900.0mV
M14: 15.7306ns 900.0mV
M11: 8.15154ns 900.0mV
M12: 15.0514ns 900.0mV
1.9
0.7
-0.1
V (V)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
28.0
30.0
time (ns)

Old Values:

Vector 3 *A=101; B=010; Cin=1*	**Cin**	**s1**	**s2**	**s3**	**Cout**
	8.16413	8.82517	8.89457	9.25728	9.11594
	15.0537	15.913	16.0688	16.1686	15.8164
Delay	**s1**	**s2**	**s3**	**cout**	
Rising	0.8593	1.0151	1.1149	0.95181	
Falling	0.66104	0.73044	1.09315	0.7627	

New Values:

Vector 3	Cin	s1	s2	s3	Cout
	8.1444	8.91002	9.02787	9.2835	8.832
	15.0537	15.8169	15.8931	16.0633	15.7812
Delay	s1	s2	s3	cout	
rising	0.7632	0.8394	1.0096	0.6876	
falling	0.76562	0.88347	1.1391	0.7275	


Transient Response
Sun Dec 1 18:02:12
Name
Vis
/S1_0011
/S2_0011
/S3_0011
/Cout_0011
/Cin_0011
/A1_0011
/A2_0011
/A3_0011
/B1_0011
/B2_0011
/B3_0011
M29: 8.91002ns 900.0mV
M30: 15.8169ns 900.0mV
M27: 9.02787ns 900.0mV
M28: 15.8931ns 900.0mV
M25: 9.28359ns 900.0mV
M26: 16.0633ns 900.0mV
M23: 8.832ns 900.0mV
M24: 15.7812ns 900.0mV
M21: 8.14445ns 900.0mV
M22: 15.0448ns 900.0mV
1.9
0.7
-0.1
0.1
V (V)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
28.0
30.0
time (ns)

Old Values:

Vector 4 *A=110; B=101; Cin=0*	**Cin**	**s1**	**s2**	**s3**	**Cout**
	8.1518	8.79267	8.98721	9.13881	9.02989
	15.0521	15.7476	16.0412	16.2284	15.792
Delay	**s1**	**s2**	**s3**	**cout**	
Rising	0.64087	0.83541	0.98701	0.7399	
Falling	0.6955	0.9891	1.1763	0.87809	

New Values:

Vector 4	Cin	s1	s2	s3	Cout
	8.1368	8.8904	9.09531	9.22023	8.84359
	15.0432	15.81	15.9317	16.0438	15.757
Delay	s1	s2	s3	cout	
rising	0.7536	0.95851	1.08343	0.7138	
falling	0.7668	0.8885	1.0006	0.70679	


Transient Response
Sun Dec 1 18:18:54
Name
Vis
/S1_0011
/S2_0011
/S3_0011
/Cout_0011
/Cin_0011
/B1_0011
/B2_0011
/B3_0011
/A1_0011
/A2_0011
/A3_0011
M39: 8.8904ns 900.0mV
M40: 15.81ns 900.0mV
M37: 9.09531ns 900.0mV
M38: 15.9317ns 900.0mV
M35: 9.22023ns 900.0mV
M36: 16.0438ns 900.0mV
M33: 8.84359ns 900.0mV
M34: 15.757ns 900.0mV
M31: 8.13883ns 900.0mV
M32: 15.0453ns 900.0mV
1.9
0.7
-0.1
V (V)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
28.0
30.0
time (ns)

Power Comparision

	Old Power	New Power
Vector 1	-0.000176	-0.000184
Vector 2	-0.000150	-0.000163
Vector 3	-0.000173	-0.000192
Vector 4	-0.000172	-0.000186

Area Comparision

Area of the old design : 15.78 μm^2
Area of the new design: 17.94 μm^2