Joseph Nguyen

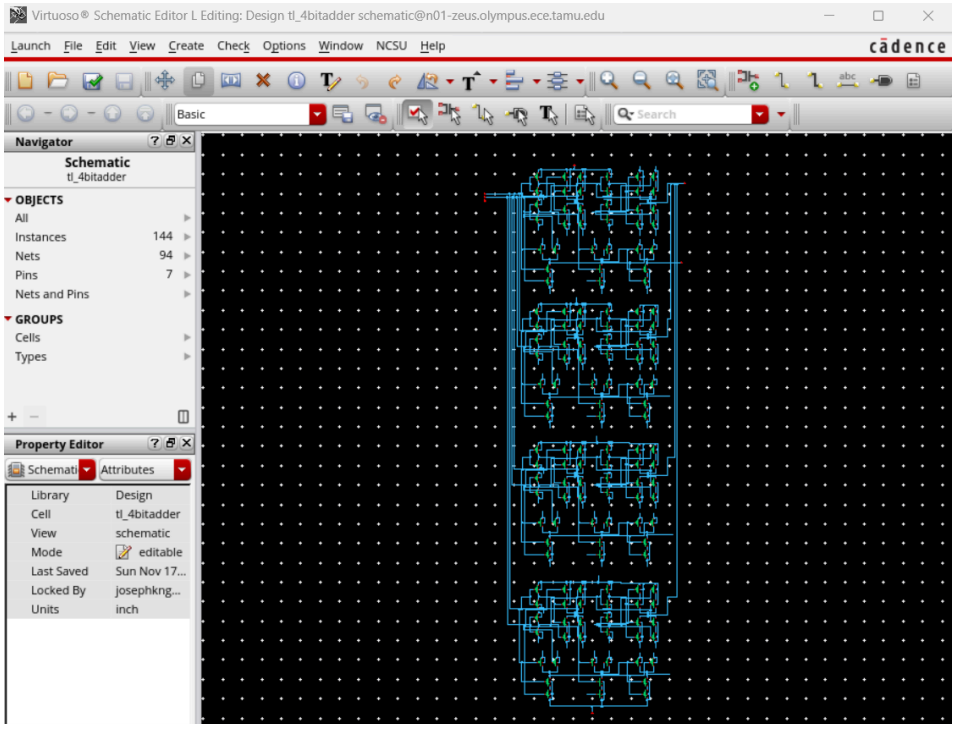
ECEN 454 Section 510

Lab date: 7 November 2024

Due date: 17 November 2024

Lab 9: Optimization using Logical Effort

Schematics:


Virtuoso® Schematic Editor L Editing: Design tl_4bitadder schematic@n01-zeus.olympus.ece.tamu.edu
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Pins 7
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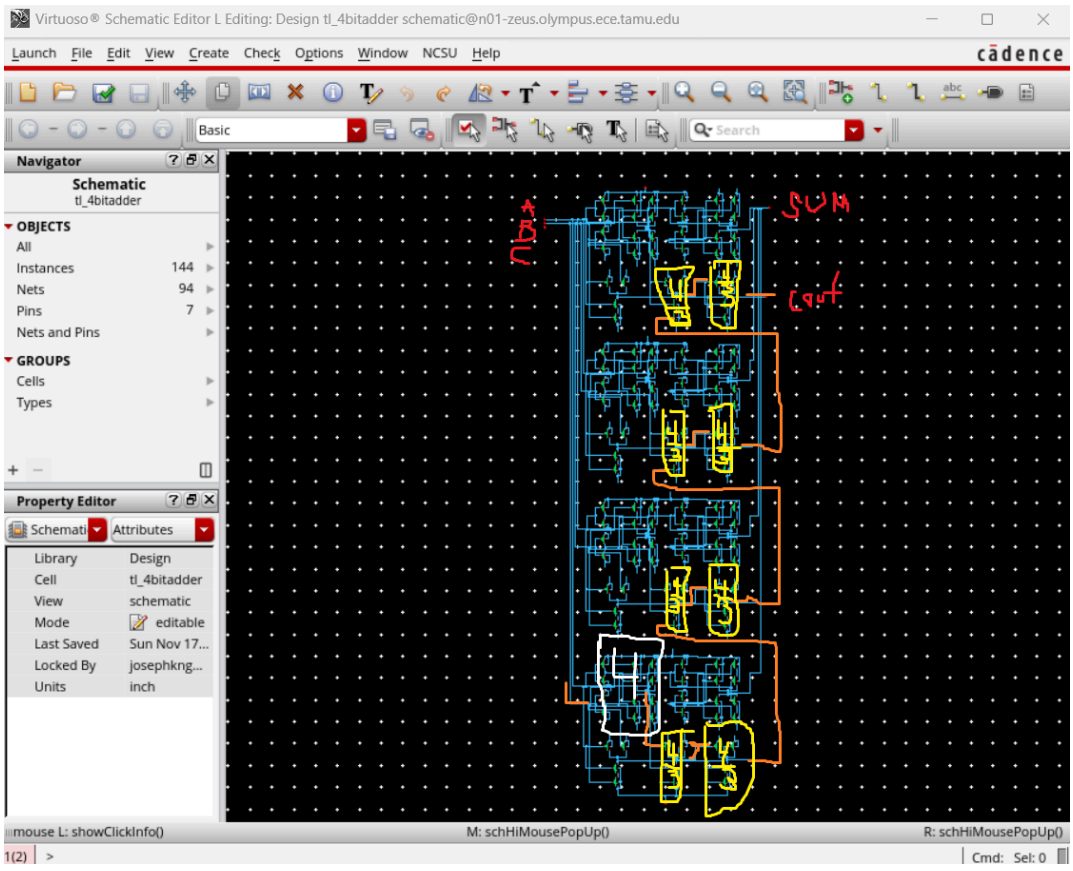
Virtuoso® Schematic Editor L Editing: Design tl_4bitadder schematic@n01-zeus.olympus.ece.tamu.edu
Launch File Edit View Create Check Options Window NCSU Help
cadence
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OBJECTS
All
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Nets 94
Pins 7
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R: schHiMousePopUp()
1(2)
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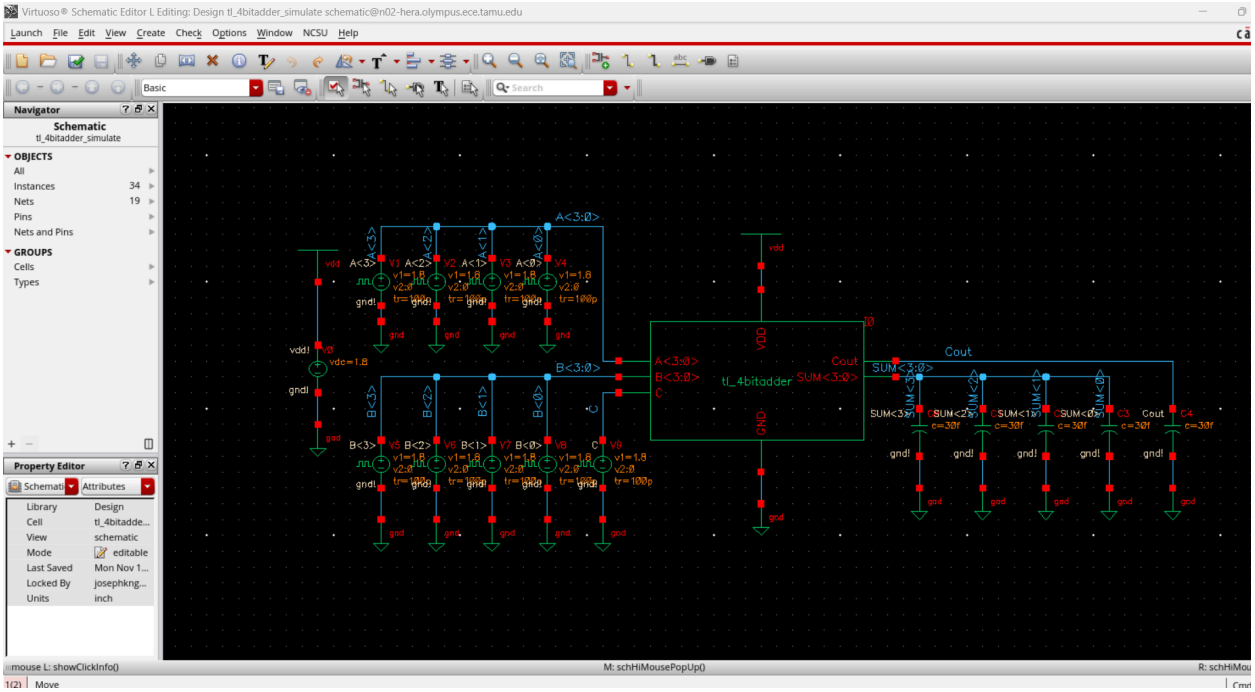


Logical Effort & Resizing Calculations:

Logical Effort

$C_{20f} = 8.53216\ fF$

$C_{nand2} = 4.10163\ fF$

$G = \prod g_i \ (i = 1,2,3,\dots,9)$

$g_1 = 4, \quad g_{2,3,\dots 9} = \frac{4}{3} \Rightarrow \boxed{G = 39.95 \approx 40}$

$H = \frac{30\ fF}{8.53216\ fF} = \boxed{3.5161}$

$B = \prod b_i \ (i = 1,2,3,\dots,9)$

$b_1 = \frac{8.53216 + 4.10163}{8.53216} = 1.48$

$b_{2,4,6,8} = \frac{8.53216 + 4.10163}{4.10163} = 3.08$

$b_{3,5,7,9} = 1 \Rightarrow \boxed{B = 133.29}$

$\boxed{F = GBH = 18723} \qquad \boxed{\hat{f} = F^{\left(\frac{1}{9}\right)} = 2.9834}$

Resizing

$C_{in,i} = g_i C_{out,i} / \hat{f}$ for $i = 9,8,7,\dots 1$

$C_{in,9} = \frac{4}{3}(30\ fF)/2.9834 = 13.41\ fF > 4.10163\ fF$

New size = $\frac{13.41}{4.10163}\left(\frac{900n}{200n}\right) = \frac{2.94\mu}{200n}$ PMOS $\quad \frac{13.41}{4.10163}\left(\frac{400n}{200n}\right) = \frac{1.309\mu}{200n}$ NMOS

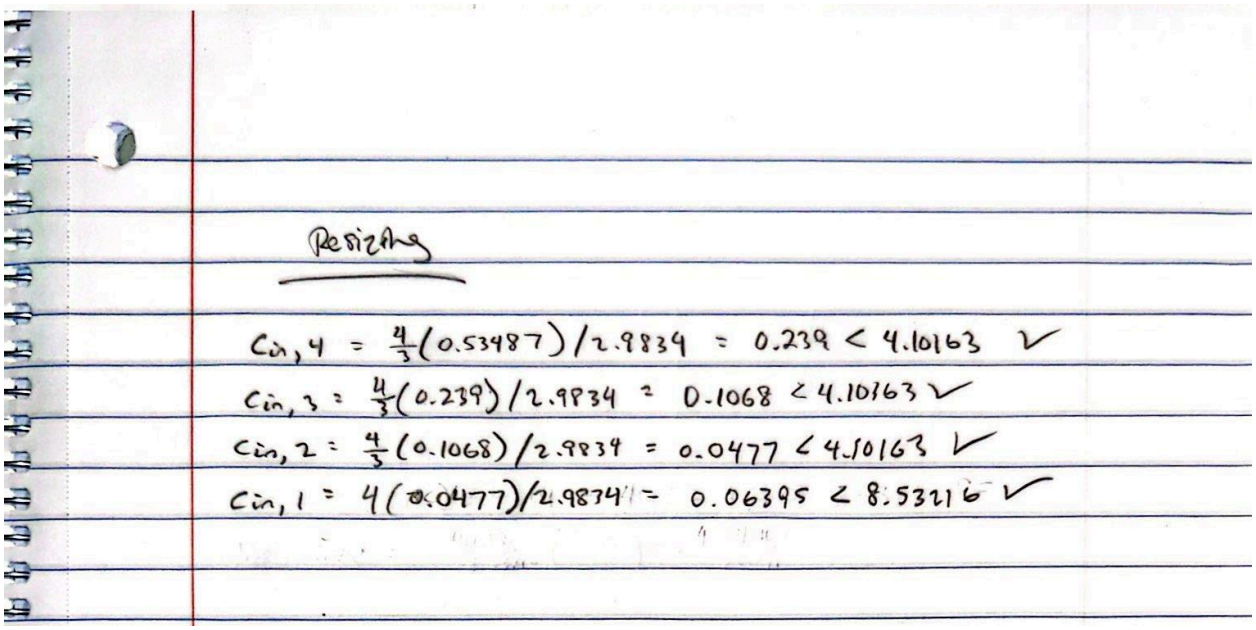
$C_{in,8} = \frac{4}{3}(13.41)/2.9834 = 5.992\ fF > 4.10163\ fF$

New size = $\frac{5.992}{4.10163}\left(\frac{900n}{200n}\right) = \frac{1.315\mu}{200n}$ PMOS $\quad \frac{5.992}{4.10163}\left(\frac{400n}{200n}\right) = \frac{584.4n}{200n}$ NMOS

$C_{in,7} = \frac{4}{3}(5.992)/2.9834 = 2.6779\ fF < 4.10163\ fF$ ✓

$C_{in,6} = \frac{4}{3}(2.6779)/2.9834 = 1.1968\ fF < 4.10163\ fF$ ✓

$C_{in,5} = \frac{4}{3}(1.1968)/2.9834 = 0.53487\ fF < 4.10163\ fF$ ✓



Non-optimized waveforms:


Virtuoso (R) Visualization & Analysis XL@n02-hera.olympus.ece.tamu.edu
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cadence
Transient Response
Mon Nov 18 19:40:12
Name Vis bit
/Cout
/SUM<3:0>
/C
/B<3:0>
/A<3:0>
3.94366ns
23.9721ns
43.9423ns
900.0mV
43.6151ns
44.0235ns
3.42256ns
4.02962ns
23.5913ns
23.9587ns
3.82459ns
3.62015ns
23.4155ns
23.775ns
3.05ns
23.15ns
43.05ns
H1
H2
H3
time (ns)


Virtuoso (R) Visualization & Analysis XL@n02-hera.olympus.ece.tamu.edu
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cadence
Transient Response
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24.1247ns
43.4867ns
43.8537ns
3.67401ns
3.48977ns
23.5189ns
23.9204ns
43.6699ns
3.8723ns
24.0436ns
43.8671ns
900.0mV
H1
H2
H3
time (ns)


Virtuoso (R) Visualization & Analysis XL@n02-hera.olympus.ece.tamu.edu
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cadence
Design tl_4bitadder_simulate sche...
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Vis
bit
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/C
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V (V)
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1.5
0.9
0.3
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23.9388ns
43.534ns
43.7104ns
H1
900.0mV
3.59494ns
23.4032ns
23.5968ns
43.589ns
43.4195ns
3.53553ns
3.32382ns
23.4032ns
43.3234ns
H2
900.0mV
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 32.0 34.0 36.0 38.0 40.0 42.0 44.0 46.0 48.0 50.0
time (ns)
mouse L:
M:
R:
18(48)
Trace: /Cout; Context: /home/ugrads/j/josephknguyen02/cadence/simulation/tl_4bitadder_simulate/spectre/schematic/psf; Dataset: tran-tran

Optimized Waveforms:


Virtuoso (R) Visualization & Analysis XL@n02-hera.olympus.ece.tamu.edu
File Edit View Graph Axis Trace Marker Measurements Tools Window Browser Help
cadence
Design tl_4bitadder_simulate sche...
Transient Response
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/C
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/SUM<2> /SUM<2>
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/Cout
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23.717ns
23.9207ns
43.6699ns
43.303ns
3.48977ns
3.83455ns
23.9997ns
43.8292ns
900.0mV
H1
H2
time (ns)
mouse L: M: R:
32(86) Trace: /Cout; Context: /home/ugrads/j/josephknguyen02/cadence/simulation/tl_4bitadder_simulate/spectre/schematic/psf; Dataset: tran-tran


Virtuoso (R) Visualization & Analysis XL@n02-hera.olympus.ece.tamu.edu
File Edit View Graph Axis Trace Marker Measurements Tools Window Browser Help
cadence
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Transient Response
Mon Nov 18 21:34:29
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/B<3:0>
/C
/SUM<3:0>
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/SUM<2> /SUM<2>
/SUM<1> /SUM<1>
/SUM<0> /SUM<0>
/Cout
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3.72426ns
23.4032ns
23.9466ns
43.534ns
43.7213ns
900.0mV
3.53556ns
3.59493ns
23.7429ns
23.5968ns
43.589ns
43.4195ns
23.3382ns
43.2927ns
900.0mV
3.29339ns
H1
H2
time (ns)
mouse L: M: R:
35(96) Trace: /Cout; Context: /home/ugrads/j/josephknguyen02/cadence/simulation/tl_4bitadder_simulate/spectre/schematic/psf; Dataset: tran-tran

Delay Table:

		Non-optimized (ps)		Optimized (ps)	
Case	**pin**	**falling delay**	**rising delay**	**falling delay**	**rising delay**
A=1111; B=0000;C=1	SUM3	974.6	808.4	985.7	820.42
	SUM2	770.3	623.8	770.1	623.6
	SUM1	566.3	439.1	566.1	439.13
	SUM0	369.4	256.6	368.8	256.61
	CARRY	893.5	822	849.1	784.21
A=1010; B=0101;C=0	SUM3	808.7	979.62	820.9	990.72
	SUM2	625	774.59	625.8	774.59
	SUM1	441.3	570.15	441.5	570.16
	SUM0	265.5	372.56	265.9	372.56
	CARRY	822.1	893.66	784.4	849.67
A=1010; B=0101;C=1	SUM3	974.7	808.8	986.3	820.84
	SUM2	770.4	624.01	770.7	624.03
	SUM1	566.8	439.77	567	439.77
	SUM0	368.9	256.61	369.4	256.61
	CARRY	993.6	822.3	849.7	784.55
A=1100; B=1000;C=0	SUM3	788.8	663.35	796.6	674.26
	SUM2	446.8	544.94	446.8	544.93
	SUM1	592.9	48553	592.9	485.56
	SUM0	253.2	373.3	253.2	373.29
	CARRY	253.2	273.82	188	243.39

Power Consumption Table:

Case	Non-optimized (uW)	Optimized (uW)
A=1111; B=0000;C=1	-35.5	-38.31
A=1010; B=0101;C=0	-42.27	-44.55
A=1010; B=0101;C=1	-36.2	-38.62
A=1100; B=1000;C=0	-40.75	-43.12

Area Table:

Non-optimized (um)^2	Optimized (um)^2
18.72	20.14