EE577 Lab4 Report
Spring 2017

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Task1 find best number of fin.

```
************************
*  lab5 sample hspice (1bit 1T DRAM cell)
************************

.include './hp7nfet.pm'
.include './hp7pfet.pm'

*define parameters
.param vdd=0.7
.param vss=0
.param lg=11n
.param slope=10p
.param p_fin = 10
.param n_fin = 10
VSS Gnd 0 'vss'
VDD Vdd 0 'vdd'
.param LoadCap = 1f

*add transistors
*pfet is for the finfet nfet
mp1 Vdd A Z A pfet L=lg NFIN=p_fin
mn1 Z A Gnd A nfet L=lg NFIN=n_fin

*add cap
Cz Z Gnd 'LoadCap'

*add voltage sourse
VY A 0 PULSE Vdd 0 '1n' 'slope' 'slope' '1n-slope' '2n'



*do transient analysis
  *syntax: .TRAN tiner tstop START=stval
  *tiner - time step
  *tstop - final time
  *stval - initial time (default 0)
.tran 1p 6n

*print the V(Z) to waveform file *.tr0
.print V(Z)

*simulation options (you can modify this. Post is needed for .tran analysis)
.OPTION Post Brief NoMod probe measout

*measurement
.MEASURE TRAN risedelay TRIG V(A) VAL='vdd/2' FALL=2 TARG V(Z) VAL='vdd/2' RISE=2
.MEASURE TRAN falldelay TRIG V(A) VAL='vdd/2' RISE=2 TARG V(Z) VAL='vdd/2' FALL=2
.MEASURE TRAN risetime TRIG V(Z) VAL='vdd*0.2' RISE=2 TARG V(Z) VAL='vdd*0.8' RISE=2
.MEASURE TRAN falltime TRIG V(Z) VAL='vdd*0.8' FALL=2 TARG V(Z) VAL='vdd*0.2' FALL=2
.end
```

```
from subprocess import call
def replace_line(file_name, line_num, text):
    lines = open(file_name, 'r').readlines()
    lines[line_num] = text
    out = open(file_name, 'w')
    out.writelines(lines)
    out.close()
f = open("output.txt", 'w')
f.write("Name\tnP\tnN\trisedelay\tfalldelay\trisetime\tfalltime\trisefallratio\n")
def test(name):
    for i in range(1,11):
        replace_line(name+".sp",12,".param p_fin = "+str(i)+"\n")
        for j in range(1,11):
            f.write(name+"\t"+str(i)+"\t"+str(j)+"\t")
            replace_line(name+".sp",13,".param n_fin = "+str(j)+"\n")
            call(["hspice",name+".sp"])
            lines = open(name+".mt0", 'r').readlines()
            n=lines[4].split()
            print n
            f.write(n[0]+"\t"+n[1]+"\t"+n[2]+"\t"+n[3]+"\t"+str(float(n[0][:4])/float(n[1][:4]))+"\n")
test('inv')
test('nand')
test('nor')
f.close()
```

The result:

Name	nP	nN	risedelay	falldelay	risetime	falltime	risefallratio	
inv	7	6	2.73E-12	2.74E-12	2.75E-12	2.45E-12	0.996350365	0.00365
inv	8	7	2.51E-12	2.50E-12	2.40E-12	2.30E-12	1.004	0.004
nand	9	9	2.91E-12	2.92E-12	2.63E-12	2.71E-12	0.993150685	0.006849
nand	7	7	3.17E-12	3.20E-12	3.11E-12	2.72E-12	0.990595611	0.009404
nor	10	7	3.04E-12	3.07E-12	2.71E-12	3.04E-12	0.990196078	0.009804
nand	8	8	3.02E-12	3.07E-12	2.71E-12	2.74E-12	0.983660131	0.01634
nand	6	6	3.36E-12	3.43E-12	3.08E-12	2.91E-12	0.979591837	0.020408
nor	6	4	3.79E-12	3.70E-12	3.28E-12	3.26E-12	1.021621622	0.021622

The number I chose:

Inv nP=7 nN=6

Nand nP=7 nN=7

Nor nP=10 nN=7

Task2 The delay of 2x 4x inv nand nor

```
************************
*  lab5 sample hspice (1bit 1T DRAM cell)
************************

.include './hp7nfet.pm'
.include './hp7pfet.pm'

*define parameters
.param vdd=0.7
.param vss=0
.param lg=11n
.param slope=10p
.param p_fin = 10
.param n_fin = 10
VSS Gnd 0 'vss'
VDD Vdd 0 'vdd'
.param LoadCap = 1f

*add transistors
*pfet is for the finfet nfet
mp1 Vdd A Z A pfet L=lg NFIN=p_fin
mn1 Z A Gnd A nfet L=lg NFIN=n_fin

*add cap
Cz Z Gnd 'LoadCap'

*add voltage sourse
VY A 0 PULSE Vdd 0 '1n' 'slope' 'slope' '1n-slope' '2n'



*do transient analysis
  *syntax: .TRAN tiner tstop START=stval
  *tiner - time step
  *tstop - final time
  *stval - initial time (default 0)
.tran 1p 6n

*print the V(Z) to waveform file *.tr0
.print V(Z)

*simulation options (you can modify this. Post is needed for .tran analysis)
.OPTION Post Brief NoMod probe measout

*measurement
.MEASURE TRAN risedelay TRIG V(A) VAL='vdd/2' FALL=2 TARG V(Z) VAL='vdd/2' RISE=2
.MEASURE TRAN falldelay TRIG V(A) VAL='vdd/2' RISE=2 TARG V(Z) VAL='vdd/2' FALL=2
.MEASURE TRAN risetime TRIG V(Z) VAL='vdd*0.2' RISE=2 TARG V(Z) VAL='vdd*0.8' RISE=2
.MEASURE TRAN falltime TRIG V(Z) VAL='vdd*0.8' FALL=2 TARG V(Z) VAL='vdd*0.2' FALL=2
.end
```

```
from subprocess import call
def replace_line(file_name, line_num, text):
    lines = open(file_name, 'r').readlines()
    lines[line_num] = text
    out = open(file_name, 'w')
    out.writelines(lines)
    out.close()
f = open("output1.txt", 'w')
f.write("Name\tnP\tnN\trisedelay\tfalldelay\trisetime\tfalltime\trisefallratio\n")
def test(name,nP,nN):
    l=[1,2,4]
    for i in l:
        replace_line(name+".sp",12,".param p_fin = "+str(nP*i)+"\n")
        replace_line(name+".sp",13,".param n_fin = "+str(nN*i)+"\n")
        f.write(name+"\t"+str(nP*i)+"\t"+str(nN*i)+"\t")
        call(["hspice",name+".sp"])
        lines = open(name+".mt0", 'r').readlines()
        n=lines[4].split()
        print n
        f.write(n[0]+"\t"+n[1]+"\t"+n[2]+"\t"+n[3]+"\t"+str(float(n[0][:4])/float(n[1][:4]))+"\n")
test('inv',7,6)
test('nand',7,7)
test('nor',10,7)
f.close()
```

The result:

Name	nP	nN	risedelay	falldelay	risetime	falltime	risefallratio
inv	7	6	2.731e-12	2.743e-12	2.747e-12	2.452e-12	0.996350364964
inv	14	12	1.935e-12	1.996e-12	2.031e-12	1.982e-12	0.969849246231
inv	28	24	1.538e-12	1.534e-12	1.759e-12	1.627e-12	1.0
nand	7	7	3.165e-12	3.195e-12	3.112e-12	2.724e-12	0.990595611285
nand	14	14	2.558e-12	2.477e-12	2.291e-12	2.184e-12	1.03238866397
nand	28	28	2.106e-12	2.057e-12	2.033e-12	1.775e-12	1.0243902439
nor	10	7	3.039e-12	3.068e-12	2.710e-12	3.036e-12	0.990196078431
nor	20	14	2.312e-12	2.337e-12	2.038e-12	2.389e-12	0.991416309013
nor	40	28	1.981e-12	2.202e-12	1.893e-12	2.001e-12	0.9

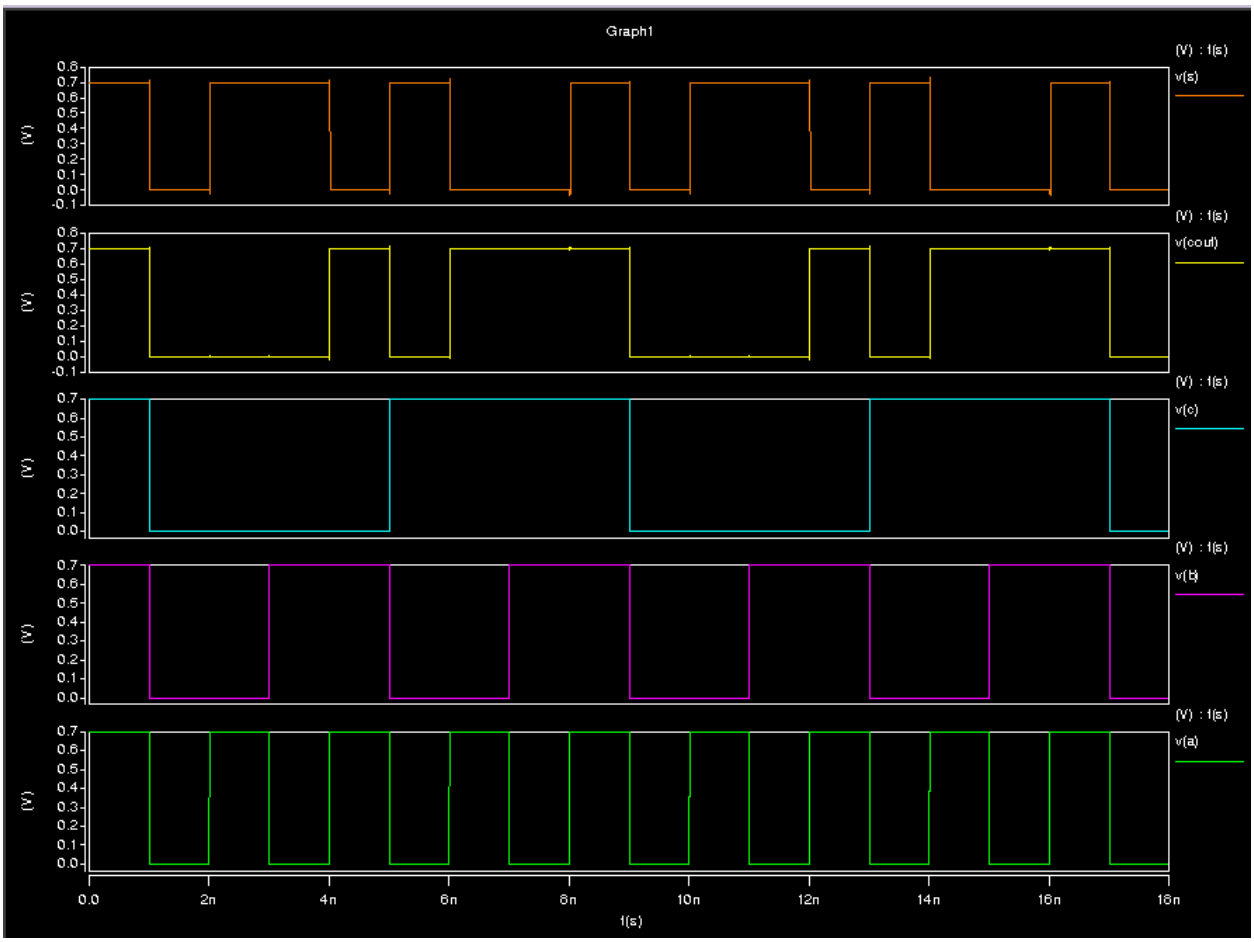
Task3 4 mode of nand nor design.

```
************************
*  lab5 sample hspice (1bit 1T DRAM cell)
************************

.include './hp7nfet.pm'
.include './hp7pfet.pm'

*define parameters
.param vdd=0.7
.param vss=0
.param lg=11n
.param slope=10p
.param p_fin = 7
.param n_fin = 7
VSS Gnd 0 'vss'
VDD Vdd 0 'vdd'
.param LoadCap = 1f

*add transistors
*pfet is for the finfet nfet
mp1 Vdd A Z A pfet L=lg NFIN=p_fin
mp2 Vdd Vdd Z Vdd pfet L=lg NFIN=p_fin
mn1 Z Vdd B Vdd nfet L=lg NFIN=n_fin
mn2 B A Gnd A nfet L=lg NFIN=n_fin
*add cap
Cz Z Gnd 'LoadCap'

*add voltage sourse
VY A 0 PULSE Vdd 0 '1n' 'slope' 'slope' '1n-slope' '2n'



*do transient analysis
  *syntax: .TRAN tiner tstop START=stval
  *tiner - time step
  *tstop - final time
  *stval - initial time (default 0)
.tran 1p 6n

*print the V(Z) to waveform file *.tr0
.print V(Z)

*simulation options (you can modify this. Post is needed for .tran analysis)
.OPTION Post Brief NoMod probe measout

*measurement
.MEASURE TRAN risedelay TRIG V(A) VAL='vdd/2' FALL=2 TARG V(Z) VAL='vdd/2' RISE=2
.MEASURE TRAN falldelay TRIG V(A) VAL='vdd/2' RISE=2 TARG V(Z) VAL='vdd/2' FALL=2
.MEASURE TRAN risetime TRIG V(Z) VAL='vdd*0.2' RISE=2 TARG V(Z) VAL='vdd*0.8' RISE=2
.MEASURE TRAN falltime TRIG V(Z) VAL='vdd*0.8' FALL=2 TARG V(Z) VAL='vdd*0.2' FALL=2
.MEASURE TRAN SwitchPower AVG P(mp1) FROM=0.5n TO=2.5n
.MEASURE TRAN LeakPower AVG P(mn2) FROM=2.2n TO=2.8n
.MEASURE TRAN SwitchEngergy Param='SwitchPower*2n'
.end
```

		rise delay	fall delay	rise time	fall time	switchpower	leakpower	switchenergy
Nand	SG	3.17E-12	3.20E-12	3.11E-12	2.72E-12	2.87E-07	5.26E-12	5.75E-16
	LP	3.17E-12	3.24E-12	2.86E-12	2.90E-12	2.87E-07	3.73E-11	5.745E-16
	IG	3.04E-12	3.08E-12	3.06E-12	2.63E-12	2.75E-07	1.81E-11	5.50E-16
	IG/LP	3.04E-12	3.08E-12	3.06E-12	2.63E-12	2.75E-07	1.81E-11	5.50E-16
Nor	SG	3.04E-12	3.07E-12	2.71E-12	3.04E-12	3.03E-07	1.97E-08	6.06E-16
	LP	3.00E-12	3.09E-12	2.44E-12	2.74E-12	3.03E-07	1.97E-08	6.06E-16
	IG	2.96E-12	2.85E-12	2.59E-12	3.09E-12	2.67E-07	1.97E-08	5.33E-16
	IG/LP	2.96E-12	2.85E-12	2.59E-12	3.09E-12	2.67E-07	1.97E-08	5.33E-16

Task4 Full Adder

```
.include './hp7nfet.pm'
.include './hp7pfet.pm'

*define parameters
.param vdd=0.7
.param vss=0
.param lg=11n
.param slope=10p
.param p_fin = 7
.param n_fin = 7
VSS Gnd 0 'vss'
VDD Vdd 0 'vdd'
.param LoadCap = 1f
.global Vdd
.global Gnd

.subckt nand A B Z
mp1 Vdd A Z A pfet L=lg NFIN=p_fin
mp2 Vdd B Z B pfet L=lg NFIN=p_fin
mn1 Z B C B nfet L=lg NFIN=n_fin
mn2 C A Gnd A nfet L=lg NFIN=n_fin
.ends
*add transistors
*pfet is for the finfet nfet
X1 A B Net1 nand
X2 A Net1 Net2 nand
X3 B Net1 Net3 nand
X4 Net2 Net3 Net4 nand
X5 Net4 C Net5 nand
X6 Net4 Net5 Net6 nand
X7 C Net5 Net7 nand
X8 Net6 Net7 S nand
X9 Net5 Net1 Cout nand
*add cap
Cs S Gnd 'LoadCap'
Ccout Cout Gnd 'LoadCap'
*add voltage sourse
VA A 0 PULSE Vdd 0 '1n' 'slope' 'slope' '1n-slope' '2n'
VB B 0 PULSE Vdd 0 '1n' 'slope' 'slope' '2n-slope' '4n'
VC C 0 PULSE Vdd 0 '1n' 'slope' 'slope' '4n-slope' '8n'

*do transient analysis
  *syntax: .TRAN tiner tstop START=stval
  *tiner - time step
  *tstop - final time
  *stval - initial time (default 0)
.tran 1p 18n

*print the V(Z) to waveform file *.tr0
.print V(A)
.print V(B)
.print V(C)
.print V(Cout)
.print V(S)
*simulation options (you can modify this. Post is needed for .tran analysis)
.OPTION Post Brief NoMod probe measout

*measurement
.MEASURE TRAN S_risedelay TRIG V(A) VAL='vdd/2' RISE=1 TARG V(S) VAL='vdd/2' RISE=1
.MEASURE TRAN S_falldelay TRIG V(A) VAL='vdd/2' RISE=2 TARG V(S) VAL='vdd/2' FALL=2
.MEASURE TRAN Cout_risedelay TRIG V(A) VAL='vdd/2' RISE=2 TARG V(Cout) VAL='vdd/2' RISE=1
.MEASURE TRAN Cout_falldelay TRIG V(A) VAL='vdd/2' FALL=1 TARG V(Cout) VAL='vdd/2' FALL=1
.end
```



s_risedelay	s_falldelay	cout_risedelay	cout_falldelay
8.861e-12	1.209e-11	5.912e-12	4.388e-12