The University of Texas at Dallas

Dept of Electrical Engineering

EECT 6325: VLSI Design
Project 3

INVERTER DESIGN AND LAYOUT

Done by:

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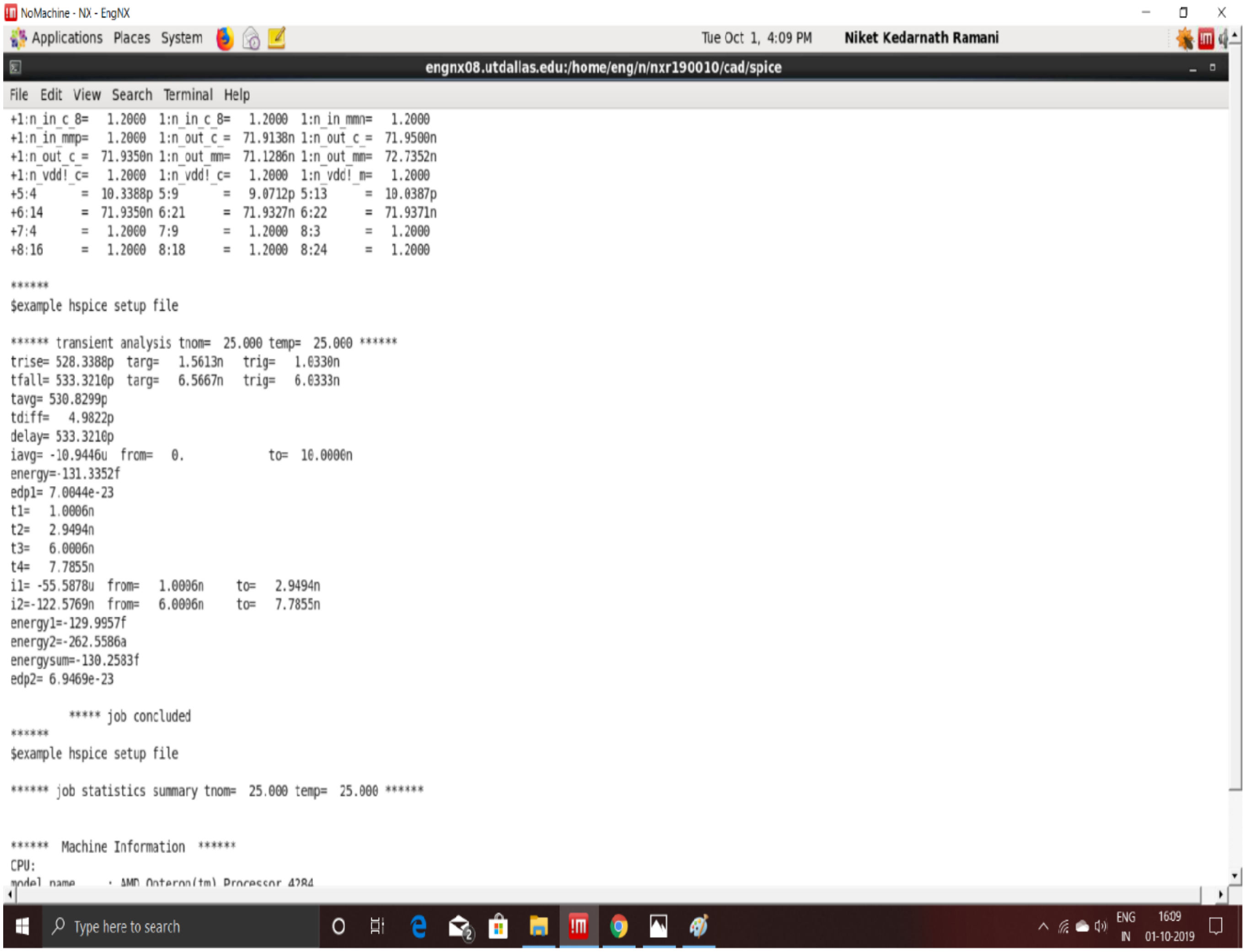
<u>Energy, Delay, Energy delay product and area measurements :</u>

Energy (E)	**Delay (D)**	**Energy delay Product (EDP)**	**Area (A) (in)**
131.3352 f V	533.3210 ps	$7.0044*10^{-23}$	$8.228*10^{-14}$




```
+1:n_in_c_8=   1.2000  1:n_in_c_8=   1.2000  1:n_in_mmn=   1.2000
+1:n_in_mmp=   1.2000  1:n_out_c_=  71.9138n 1:n_out_c_=  71.9500n
+1:n_out_c_=  71.9350n 1:n_out_mm=  71.1286n 1:n_out_mm=  72.7352n
+1:n_vdd!_c=   1.2000  1:n_vdd!_c=   1.2000  1:n_vdd!_m=   1.2000
+5:4       =  10.3388p 5:9       =   9.0712p 5:13      =  10.0387p
+6:14      =  71.9350n 6:21      =  71.9327n 6:22      =  71.9371n
+7:4       =   1.2000  7:9       =   1.2000  8:3       =   1.2000
+8:16      =   1.2000  8:18      =   1.2000  8:24      =   1.2000

******
$example hspice setup file

****** transient analysis tnom=  25.000 temp=  25.000 ******
trise= 528.3388p  targ=   1.5613n   trig=   1.0330n
tfall= 533.3210p  targ=   6.5667n   trig=   6.0333n
tavg= 530.8299p
tdiff=   4.9822p
delay= 533.3210p
iavg= -10.9446u  from=   0.           to=  10.0000n
energy=-131.3352f
edp1= 7.0044e-23
t1=   1.0006n
t2=   2.9494n
t3=   6.0006n
t4=   7.7855n
i1= -55.5878u  from=   1.0006n     to=   2.9494n
i2=-122.5769n  from=   6.0006n     to=   7.7855n
energy1=-129.9957f
energy2=-262.5586a
energysum=-130.2583f
edp2= 6.9469e-23

         ***** job concluded
******
$example hspice setup file

****** job statistics summary tnom=  25.000 temp=  25.000 ******


******  Machine Information  ******
CPU:
model name      : AMD Opteron(tm) Processor 4284
```


Fig: Energy, delay and Energy delay product

Spice Test Setup File :

$example HSPICE setup file

$transistor model

.include
"/proj/cad/library/mosis/GF65_LPe/cmos10lpe_CDS_oa_dl064_11_20160415/models/YI-SM00030/Hspice/models/design.inc"

.include /home/eng/n/nxr190010/cad/gf65/inv1_LVS/inv1.pex.sp

.global vdd! gnd!

.option post runlvl=5

xi GND! OUT VDD! IN inv1

vdd vdd! gnd! 1.2v

vin in gnd! pwl(0ns 1.2v 1ns 1.2v 1.066ns 0v 6ns 0v 6.06666ns 1.2v 12ns

1.2v) cout out gnd! 90f

$transient analysis

.tr 100ps 12ns

$example of parameter sweep, replace numeric value W of pfet with WP in

invlvs.sp $.tr 100ps 12ns sweep WP 4.0400e-07 4.0405e-07 0.00005e-07

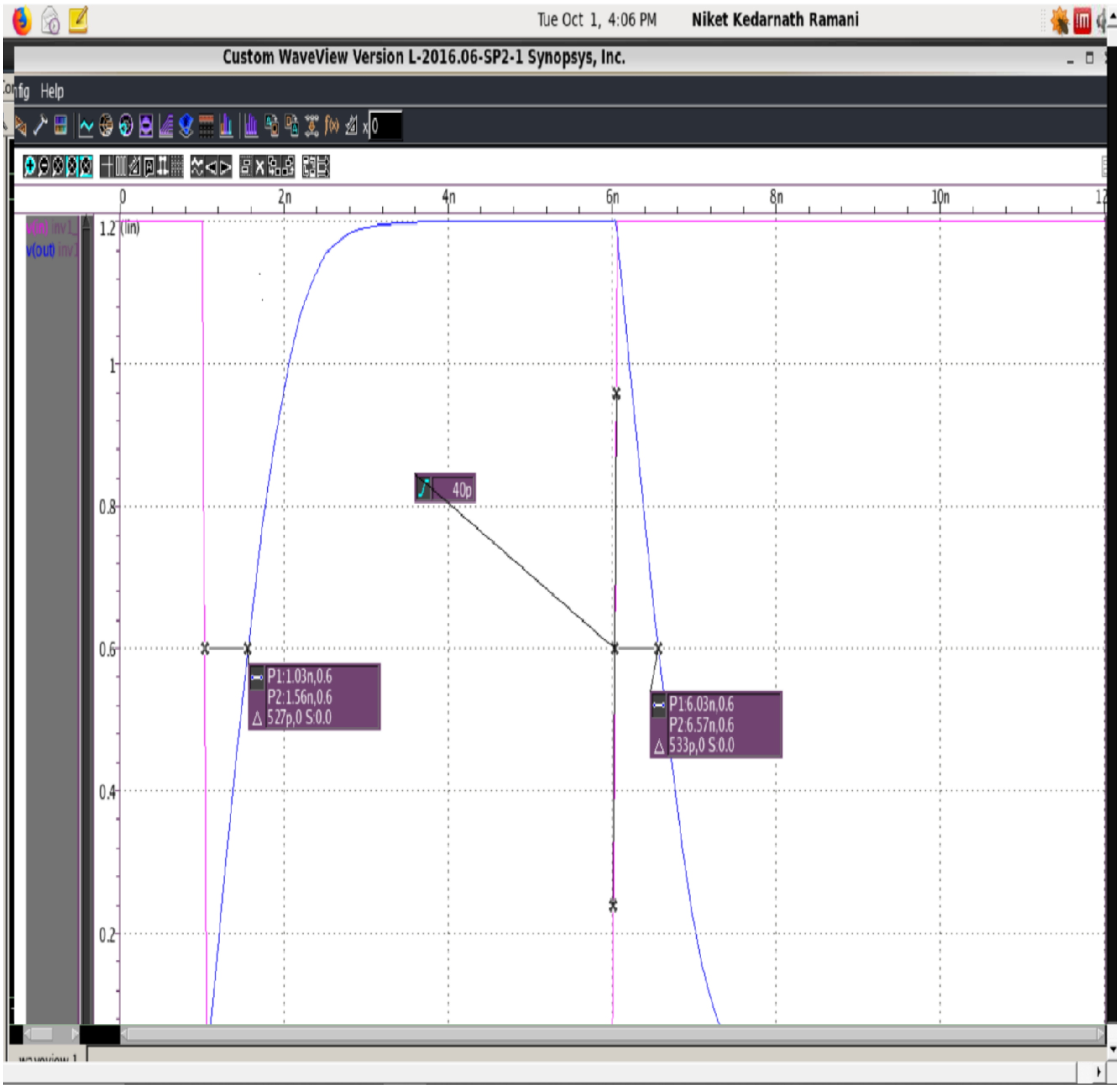
.measure tran trise trig v(in) val=0.6v fall=1 targ v(out) val=0.6v rise=1 $measure tlh at 0.6v

```
.measure tran tfall trig v(in) val=0.6v rise=1 targ v(out) val=0.6v fall=1 $measure tpl at 0.6v

.measure tavg param = '(trise+tfall)/2' $calculate average delay

.measure tdiff param='abs(trise-tfall)' $calculate delay difference

.measure delay param='max(trise,tfall)' $calculate worst case delay


$ method 1

.measure tran iavg avg i(vdd) from=0 to=10n $average current in one clock cycle

.measure energy param='1.2*iavg*10n' $calculate energy in one clock cycle

.measure edp1 param='abs(delay*energy)'


$ method 2

.measure tran t1 when v(in)=1.19 fall=1

.measure tran t2 when v(out)=1.19 rise=1

.measure tran t3 when v(in)=0.01 rise=1

.measure tran t4 when v(out)=0.01 fall=1

.measure tran i1 avg i(vdd) from=t1 to=t2 $average current when output rise

.measure tran i2 avg i(vdd) from=t3 to=t4 $average current when output fall

.measure energy1 param='1.2*i1*(t2-t1)' $calculate energy when output rise

.measure energy2 param='1.2*i2*(t4-t3)' $calculate energy when output fall

.measure energysum param='energy1+energy2'

.measure edp2 param='abs(delay*energysum)'


.end
```

Minimum EDP :

We achieved the minimum Energy density product (EDP) by keeping the width of nmos constant and by changing the width of the pmos and then doing a parameter sweep until we get the time difference (t diff) less than 5 picoseconds (5ps). We should also satisfy the condition that width of pmos is 3 times that of nmos (Wp =3Wn). We should observe that the energy density product (EDP) is directly proportional to the width.

Waveform :


Tue Oct 1, 4:06 PM
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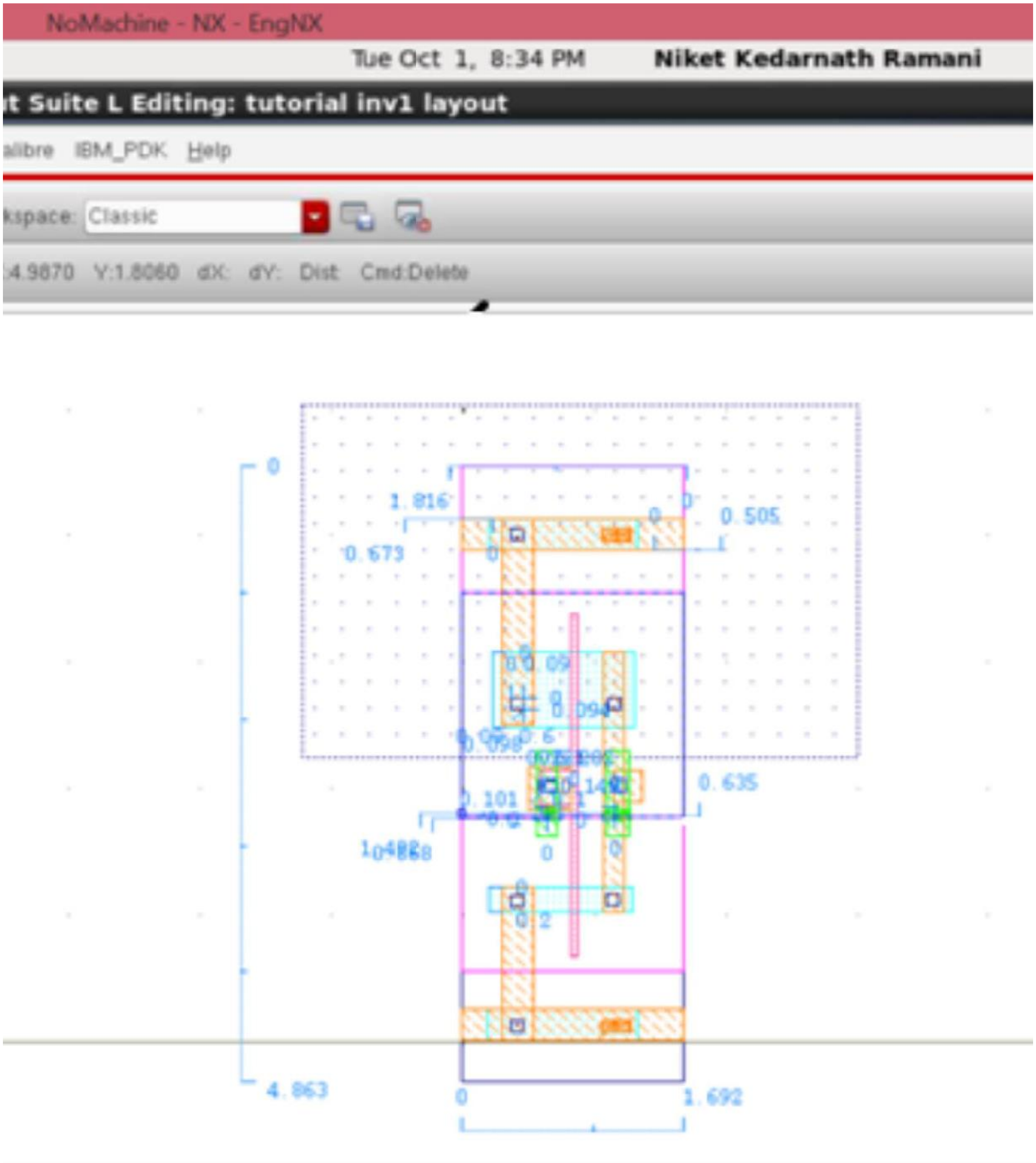
Custom WaveView Version L-2016.06-SP2-1 Synopsys, Inc.
Config Help
0
2n
4n
6n
8n
10n
1.2
1
0.8
0.6
0.4
0.2
(lin)
v(in)
v(out)
40p
P1:1.03n,0.6
P2:1.56n,0.6
△ 527p,0 S:0.0
P1:6.03n,0.6
P2:6.57n,0.6
△ 533p,0 S:0.0

Layout :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0.673
0.505
0.635
4.863
1.692