Project 3

INVERTER DESIGN AND LAYOUT

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1. Layout

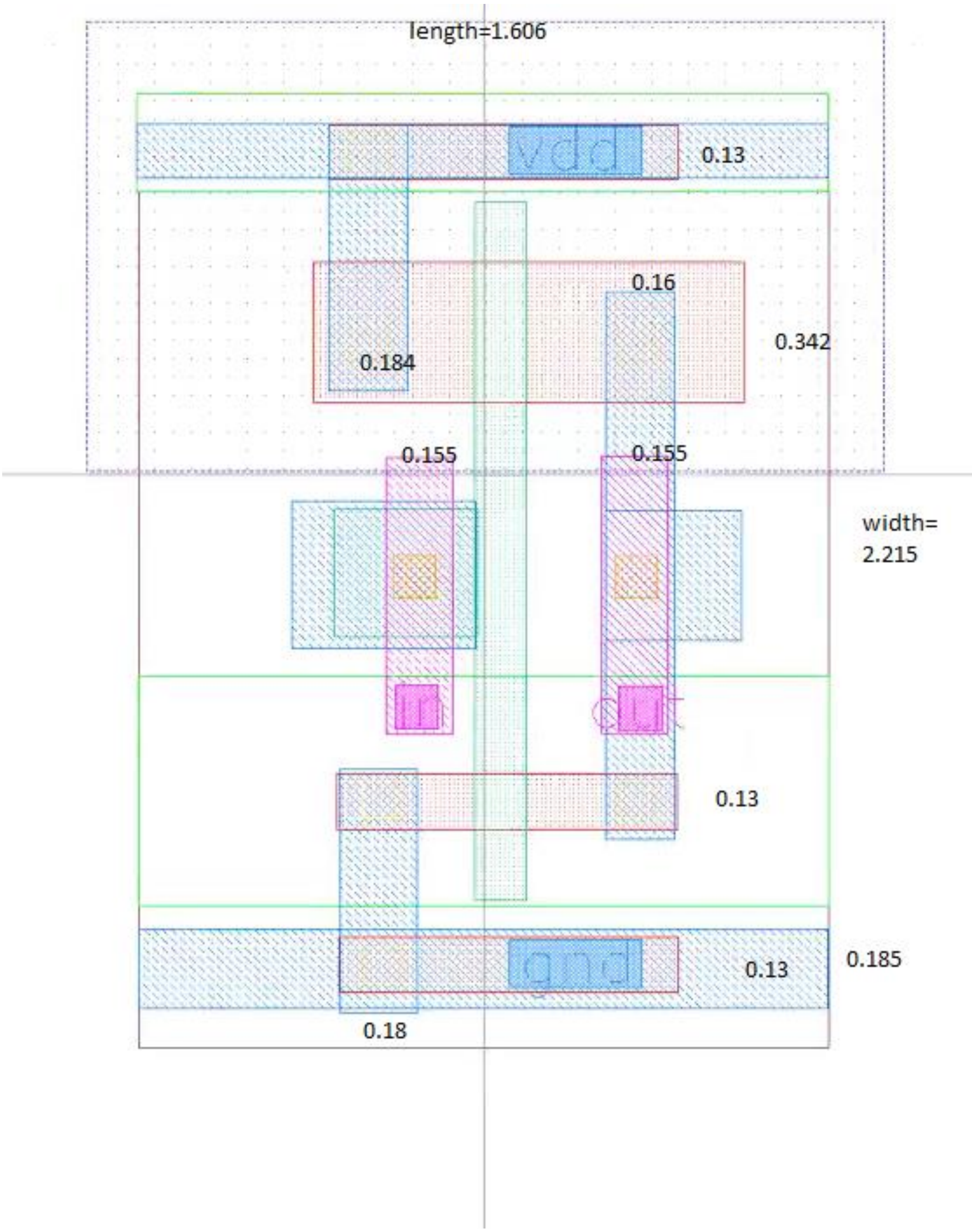

Figure 1 Inverter Layout

2. Schematic View

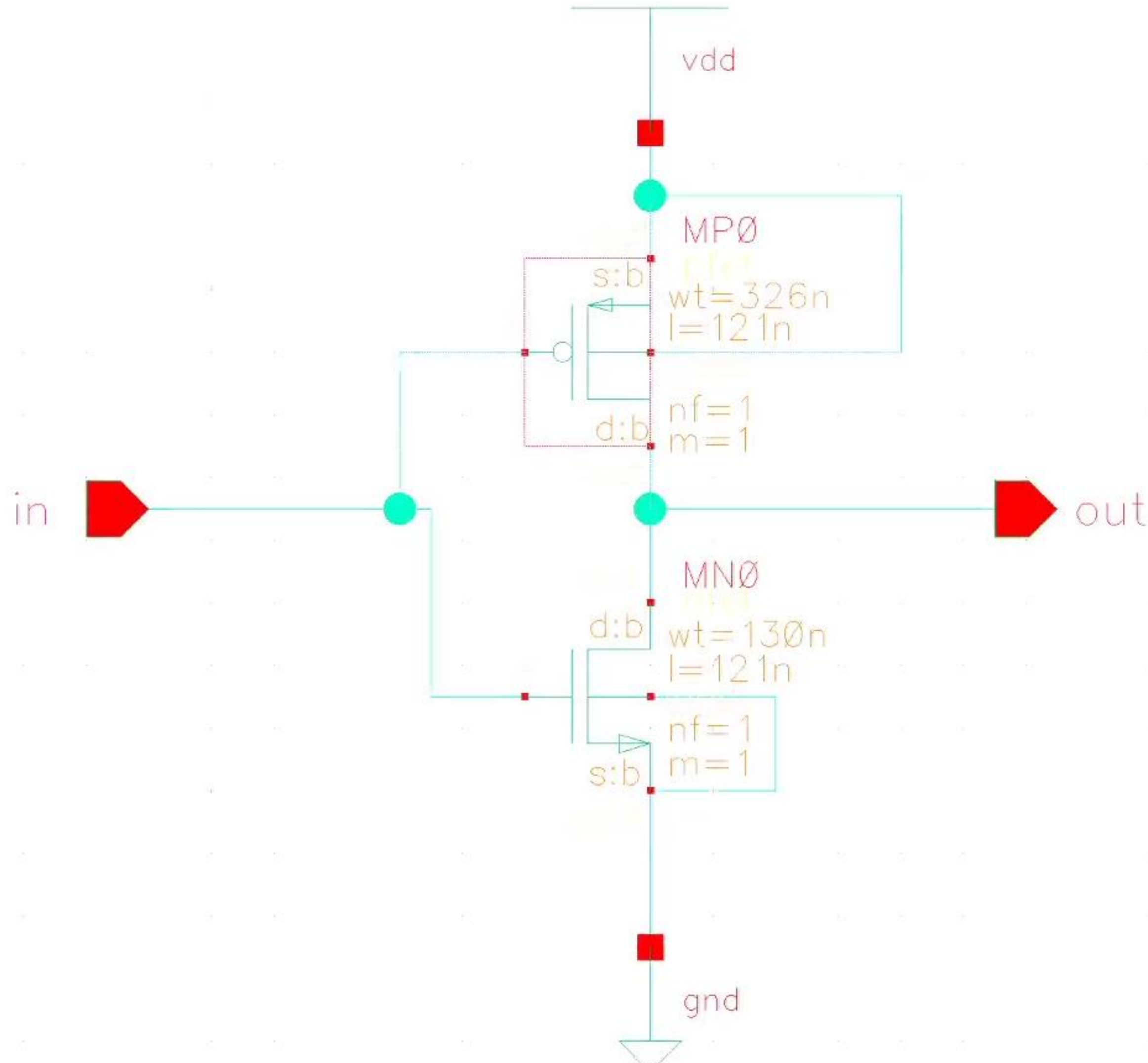

Figure 2 Schematic View

3. Simulation View

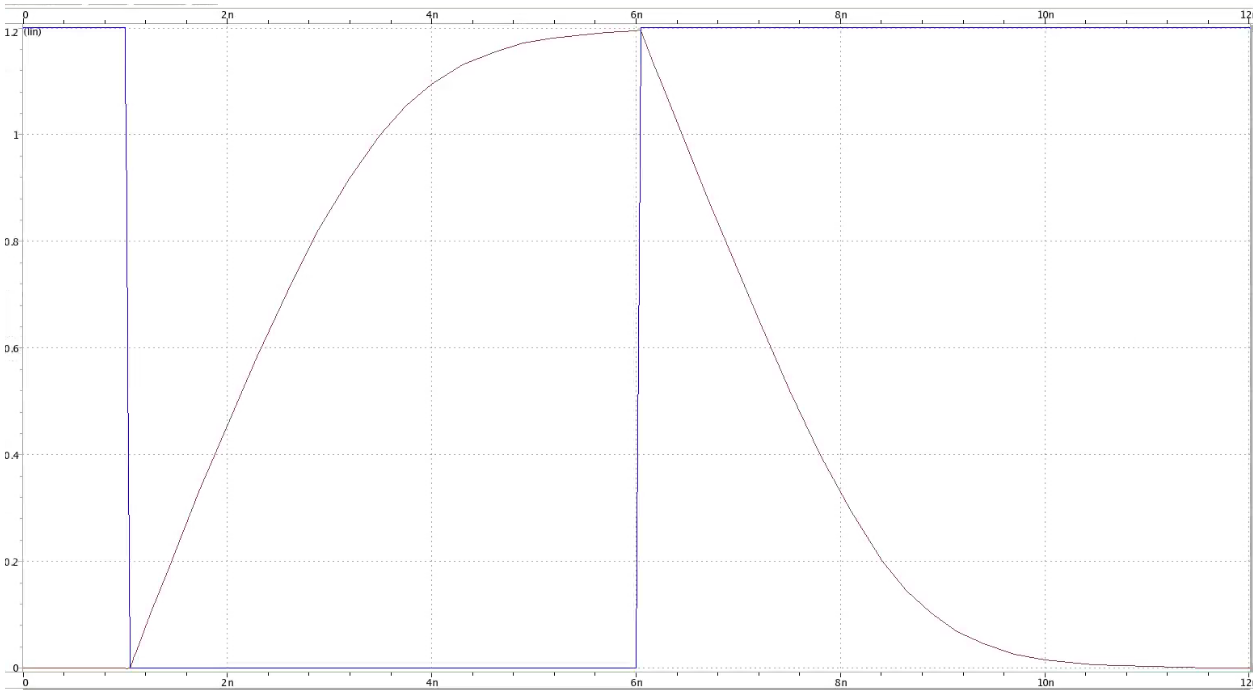

Figure 3 delay waveform

```
$DATA1 SOURCE='HSPICE' VERSION='L-2016.06-SP1-2 linux64' PARAM_COUNT=0
.TITLE '$example hspice setup file'
 trise           tfall           tavg            tdiff
 delay           iavg            energy          edp1
 t1              t2              t3              t4
 i1              i2              energy1         energy2
 energysum       edp2            temper          alter#
  1.301e-09       1.296e-09       1.299e-09       4.727e-12
  1.301e-09      -1.088e-05      -1.305e-13       1.698e-22
  1.000e-09       5.656e-09       6.000e-09       1.032e-08
 -2.330e-05       1.018e-09      -1.302e-13       5.277e-18
 -1.301e-13       1.693e-22        25.0000        1
```

Figure 4.Mt0 file(EDP)

As figure 4, the delay difference between t_{LH} and t_{HL} are 5ps.

EDP (Energy Delay Product)= |Delay*Energy|=|1301ps*-130.1fJ|=1.6926*10^{-22} J·s

Area=length*width=1.606*2.215=3.579 μm^2

AEDP = Area*EDP = 3.579um2 *1.6926*10^{-22} J·s = 6.05*10^{-22}J·s·um2

4. Spice Test Setup File

```
$example HSPICE setup file

$transistor model
.include
"/proj/cad/library/mosis/GF65_LPe/cmos10lpe_CDS_oa_dl064_11_20160415/models/Y
I-SM00030/Hspice/models/design.inc"
.include inv1.pex.netlist

.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 1.05ns 0v 6ns 0v 6.05ns 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
inv1lvs.sp
$.tr 100ps 12ns sweep WP 1u 9u 0.5u

.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
```