Assignment - 1

Tapered Inverter

EE 671 - VLSI Design

Name: **Sanchit Gupta**

Roll number: **23M1114**

Program: M.tech (EE5 - Electronic System)

Department: Electrical Engineering

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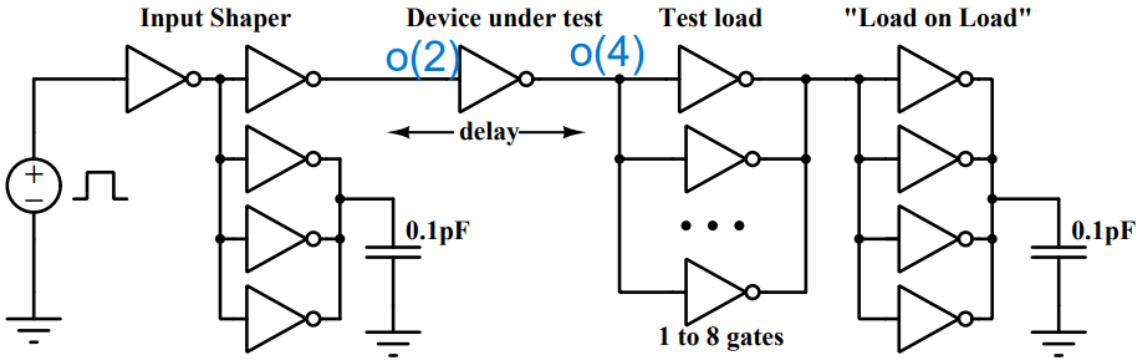
Q. 1 Simulate the circuit above with different number of inverters (from 1 to 8) as load on the inverter under test. Make sure you give a short enough time step in your .tran statement (≤ 1ps) so that you can evaluate delays of the order of tens of ps accurately.

As mentioned earlier, the delay here is the average of delays observed for input falling/output rising and input rising /output falling. Plot the delay of the inverter-under-test versus fan out, fit a straight line to this data and Find the slope and intercept of this line. Using the 2 slope and intercept, find the values for τ and pinv. Also, report the value of γ, the ratio of the width of p and n channel transistors required to give equal rise and fall times. (This was done in assignment-1).



Ans: NGSpice code for above program is given below:

.include models-180nm

.param Wp = 1.7936U

.param Wn = 0.6188U

.param L = 0.18U

*Unit Inverter

.subckt inv supply Inp Output

MP1 Output Inp Supply Supply cmosp

+ L = L W = Wp AD = (2*L*Wp) AS = (2*L*Wp) PD = (2*((2*L) + Wp)) PS = (2*((2*L) + Wp))

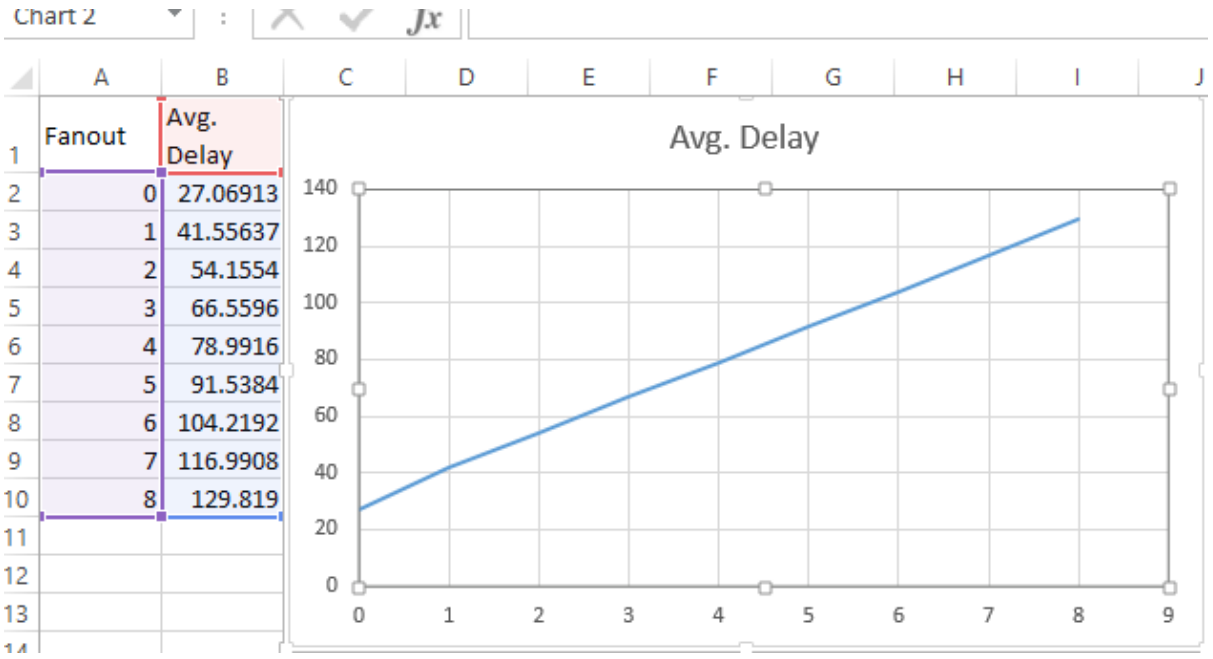
MN1 Output Inp 0 0 cmosn

+ L = L W = Wn AD = (2*L*Wn) AS = (2*L*Wn) PD = (2*((2*L) + Wn)) PS = (2*((2*L) + Wn))

.ends

```
vdd supply 0 dc 1.8

*Input shaper stage
Xinv1 supply ck o1 inv
Xinv2 supply o1 o2 inv
Xinv3 supply o1 o3 inv
Xinv4 supply o1 o3 inv
Xinv5 supply o1 o3 inv
c1 o3 o 0.1p

*Design under test stage
Xinv6 supply o2 o4 inv

*Test load stage
Xinv7 supply o4 o5 inv
Xinv8 supply o4 o5 inv
Xinv9 supply o4 o5 inv
Xinv10 supply o4 o5 inv
Xinv11 supply o4 o5 inv
Xinv12 supply o4 o5 inv
Xinv13 supply o4 o5 inv
Xinv14 supply o4 o5 inv

*Load on Load stage
Xinv15 supply o5 o6 inv
Xinv16 supply o5 o6 inv
Xinv17 supply o5 o6 inv
Xinv18 supply o5 o6 inv
c2 o6 o 0.1p
```

```
.param Trep= 5n
.param Trf = {Trep/20.0}
.param Tw = {Trep/2.0 - Trf}
.param hival=1.8
.param loval=0.0
Vpulse ck 0 DC 0 PULSE({loval} {hival} {Tw} {Trf} {Trf} {Tw} {Trep})
.tran 0.5pS {3*Trep} 0nS

.control
run
meas tran invdelay1 TRIG v(o2) VAL=0.9 RISE=2 TARG v(o4) VAL=0.9 FALL=2
meas tran invdelay2 TRIG v(o2) VAL=0.9 FALL=2 TARG v(o4) VAL=0.9 RISE=2
let avg_delay = ((invdelay1 + invdelay2)/2)
print avg_delay
.endc
.end
```



Avg. Delay(psec) vs Fanout

From the above graph,

Slope is given by: 12.59903 = τ

At fanout of 0, we have h = 0; => $(d)_0 = (p_{inv})\,\tau$

On solving above two equations, we have τ = 12.59903 psec and $p_{inv.}$ = 2.148

Also, γ = Wp / Wn which is equal to 2.89851