EE 5319 Nanoelectric Device, Circuit, and System

Project 2

Interconnect Repeater Insertion

Name/Class ID	Tasks Accomplished	Contribution to the Project (%)
Gopala Krishna M /11	A	25%
Srinivas Raghunandan M /10	B	25%
Siddarth Boge /2	C	25%
Suchitha Reddy C /4	D	25%

Consider an interconnect with the following parameters:

Parameters	Value
Technology Node (nm)	45
Wire Resistivity (μΩ·cm)	1.7
Wire capacitance (fF/um)	0.15
Wire Width (nm)	90
Aspect Ratio	2
Total Wire Length (mm)	2
Supply Voltage Vdd (V)	1
Minimum NMOS Width (nm)	50
Minimum PMOS Width (nm)	150
Channel Length (nm)	50

Please investigate the following questions and submit your findings, screenshots of measurement waveform/results, and conclusions to canvas. You may use the same report template from project 1.

$$AR = \frac{T}{W}$$

$$2 = \frac{T}{90\times10^{-9}} \qquad \boxed{T = 1.8\times10^{-9}}$$

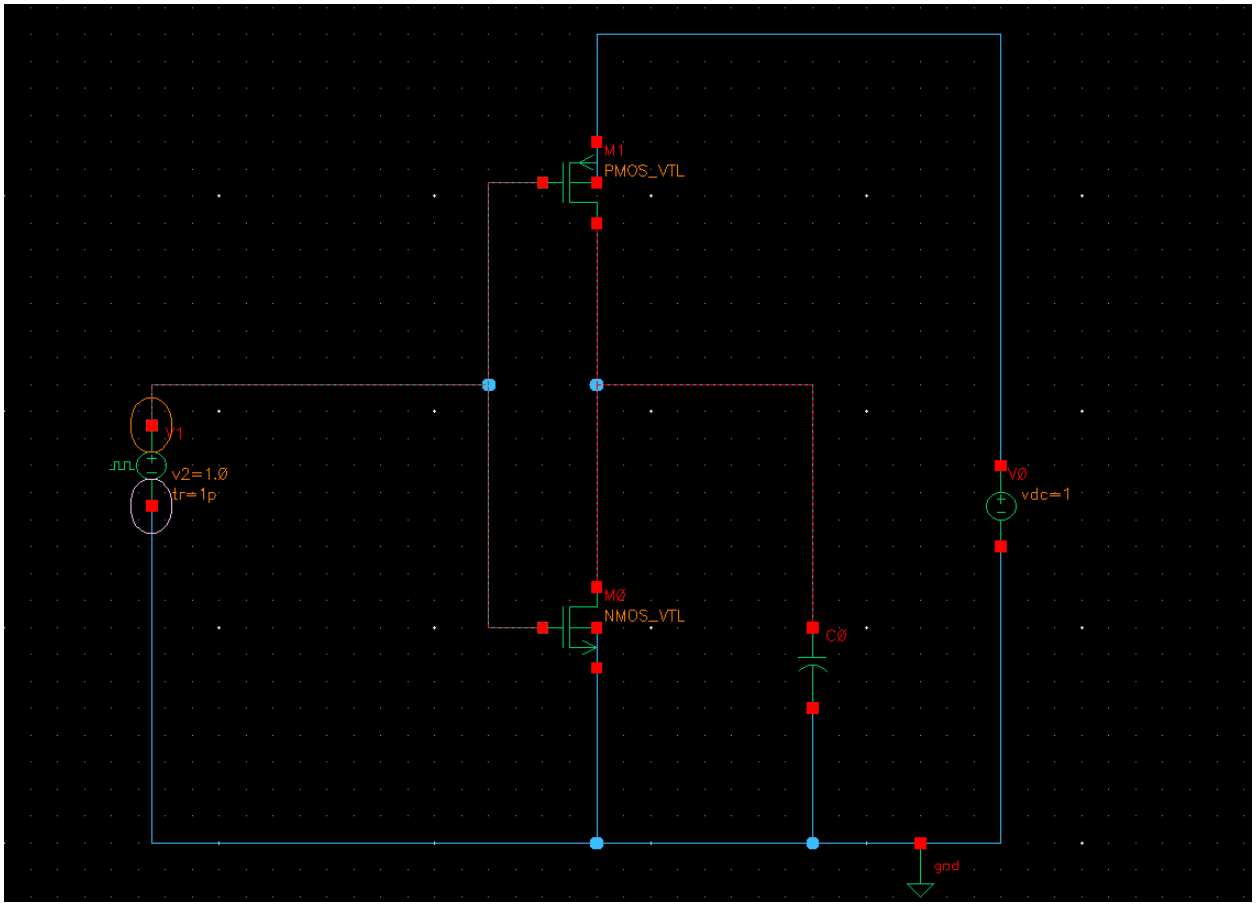
$$R = \frac{1.7\times10^{-8}\times2\times10^{-3}}{1.8\times10^{-7}\times90\times10^{-9}}$$

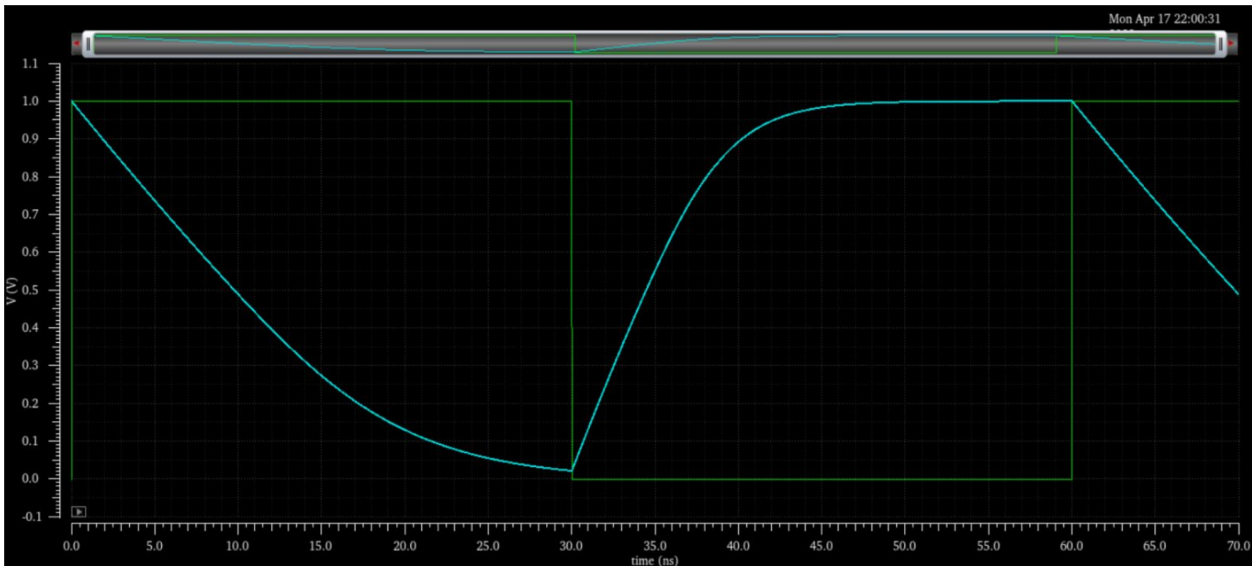
$$\boxed{R_W = 2.09\,k\Omega}$$

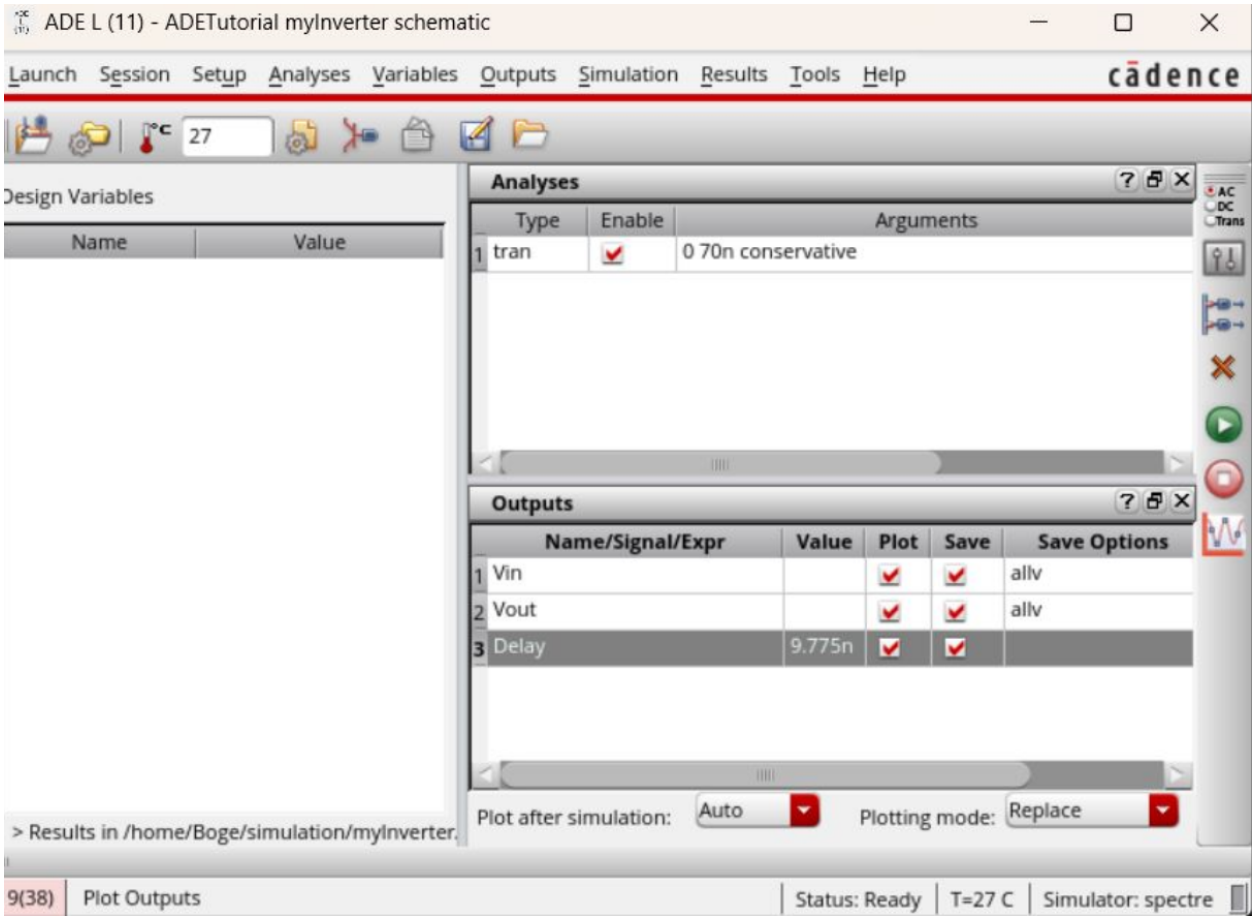
$$C = \frac{0.15\times10^{-15}}{10^{-16}}\times2\times10^{-3}$$

$$= 3\times10^{-13}$$

$$\boxed{C_W = 0.3\,pF}$$


M1
PMOS_VTL
V1
v2=1.0
tr=1p
V0
vdc=1
M0
NMOS_VTL
C0
gnd


Mon Apr 17 22:00:31
V (V)
time (ns)



Delay = 9.77ns

Using delay, we must find Ro. Period=100ns, Stop time=70ns, C=1pF

We got delay as 9.77ns, we can calculate Ro

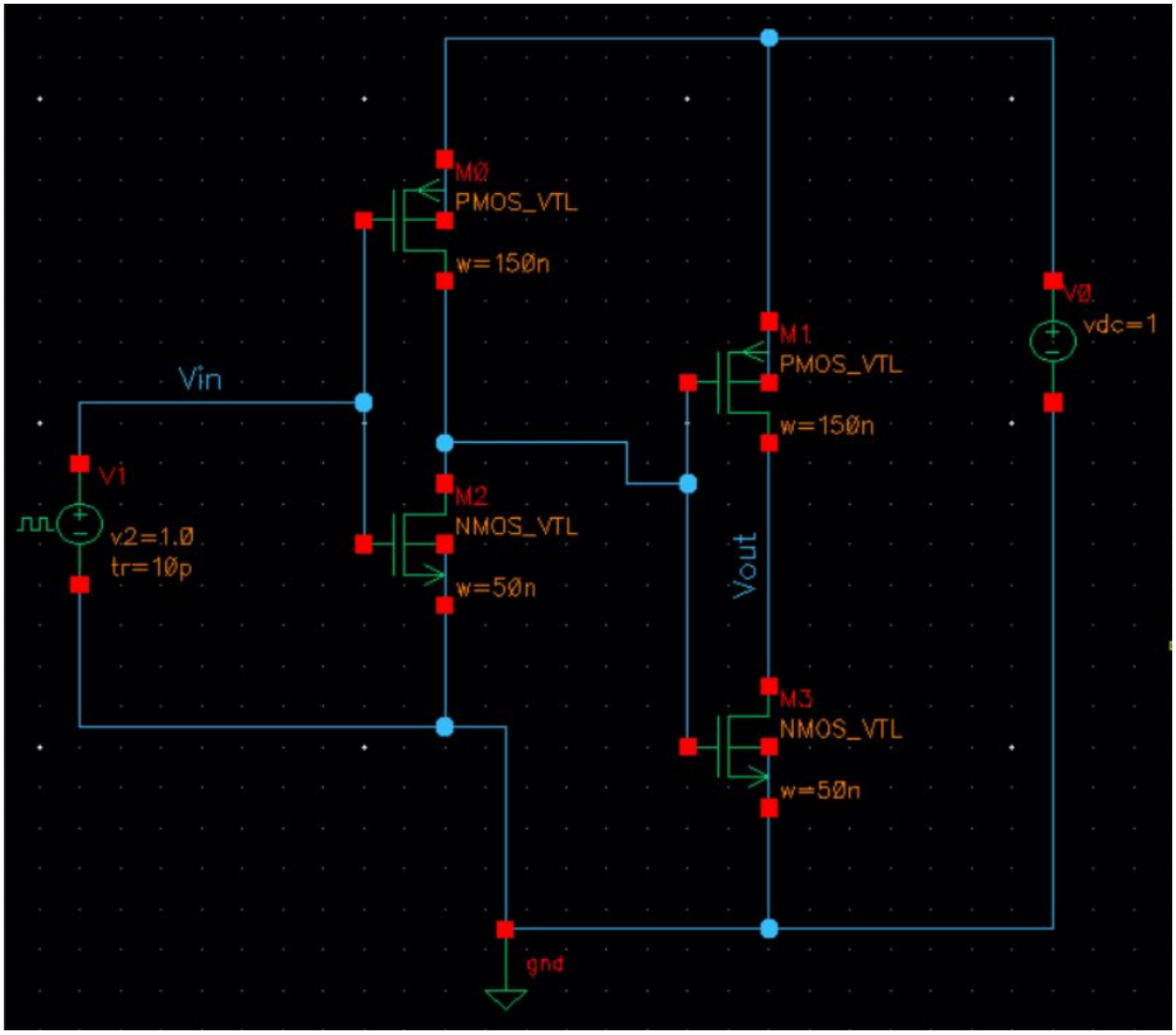
$$T_d = 0.7 R_o C_o$$

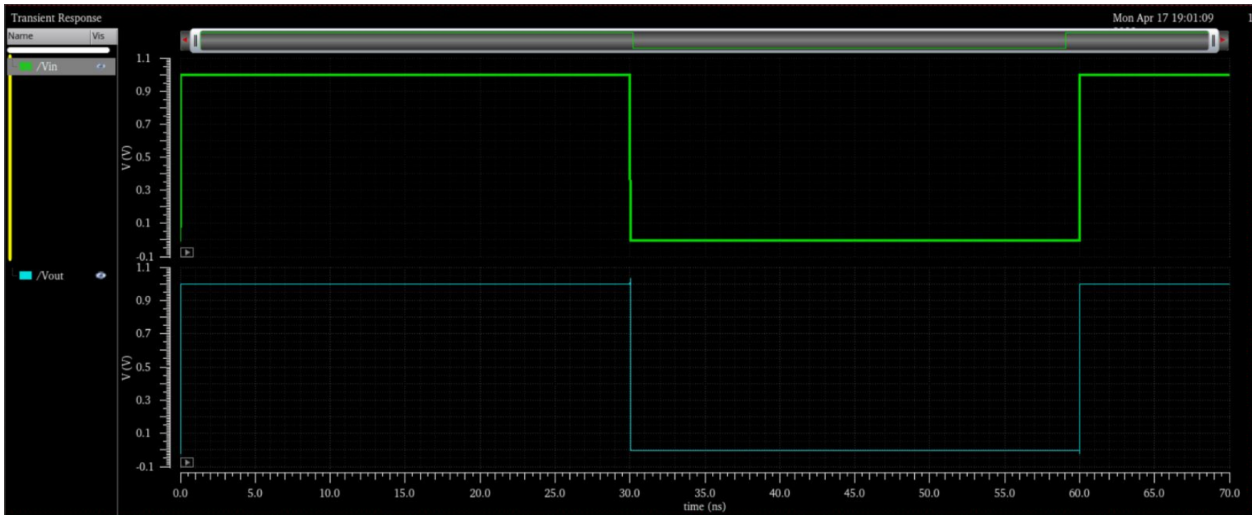
$$9.77 = 0.7 R_o \times 1 \times 10^{-12}$$

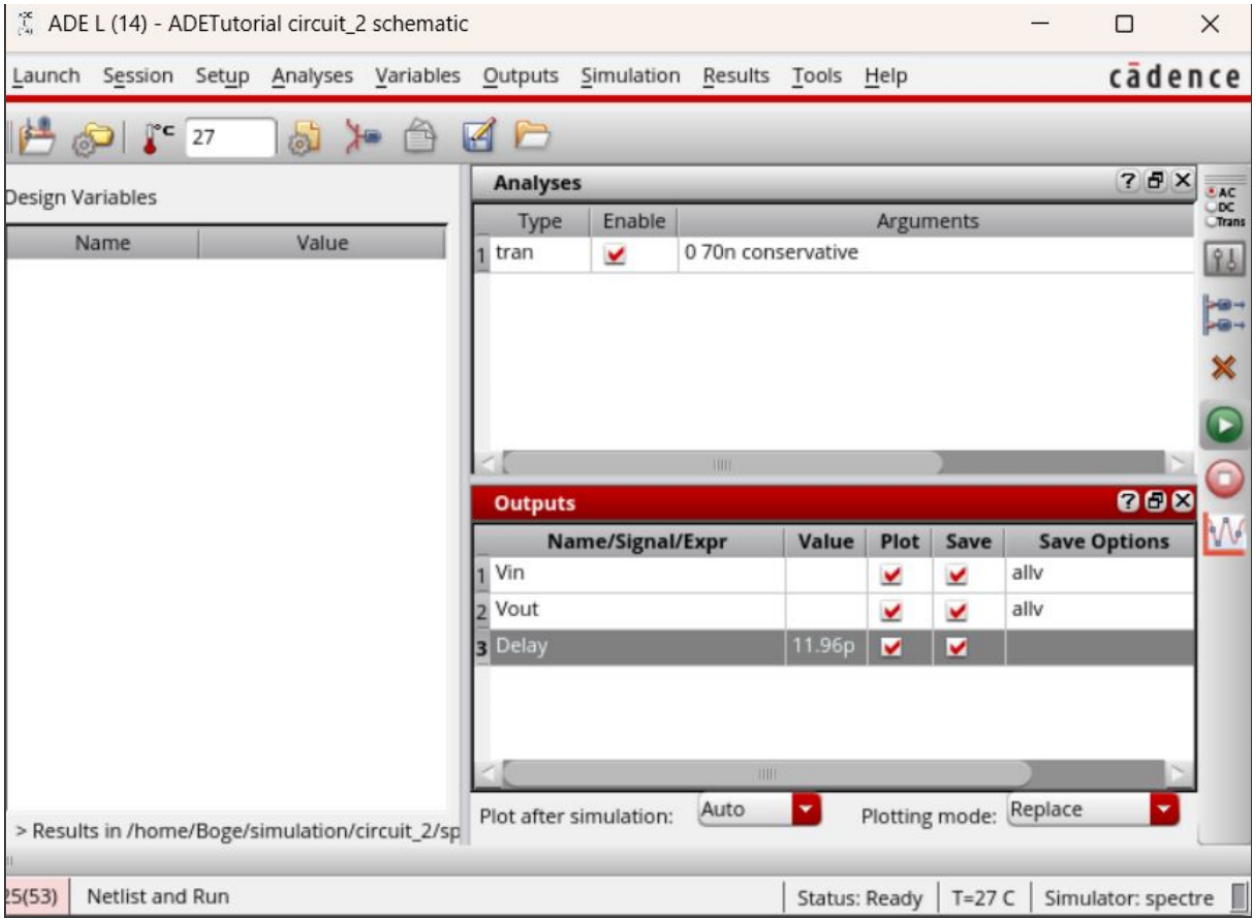
$$R_o = \frac{9.77 \times 10^{-9}}{0.7 \times 1 \times 10^{-12}}$$

$$\boxed{R_o = 13.96 K\Omega}$$

Find Co,


M0
PMOS_VTL
w=150n
M1
PMOS_VTL
w=150n
V0
vdc=1
Vin
V1
v2=1.0
tr=10p
M2
NMOS_VTL
w=50n
Vout
M3
NMOS_VTL
w=50n
gnd


Transient Response
Mon Apr 17 19:01:09
Name
Vis
/Vin
/Vout
V (V)
time (ns)



Using the same procedure of delay calculation,

Delay=11.96ps.

Calculate Co,

We got delay 11.96ps, we can calculate Co

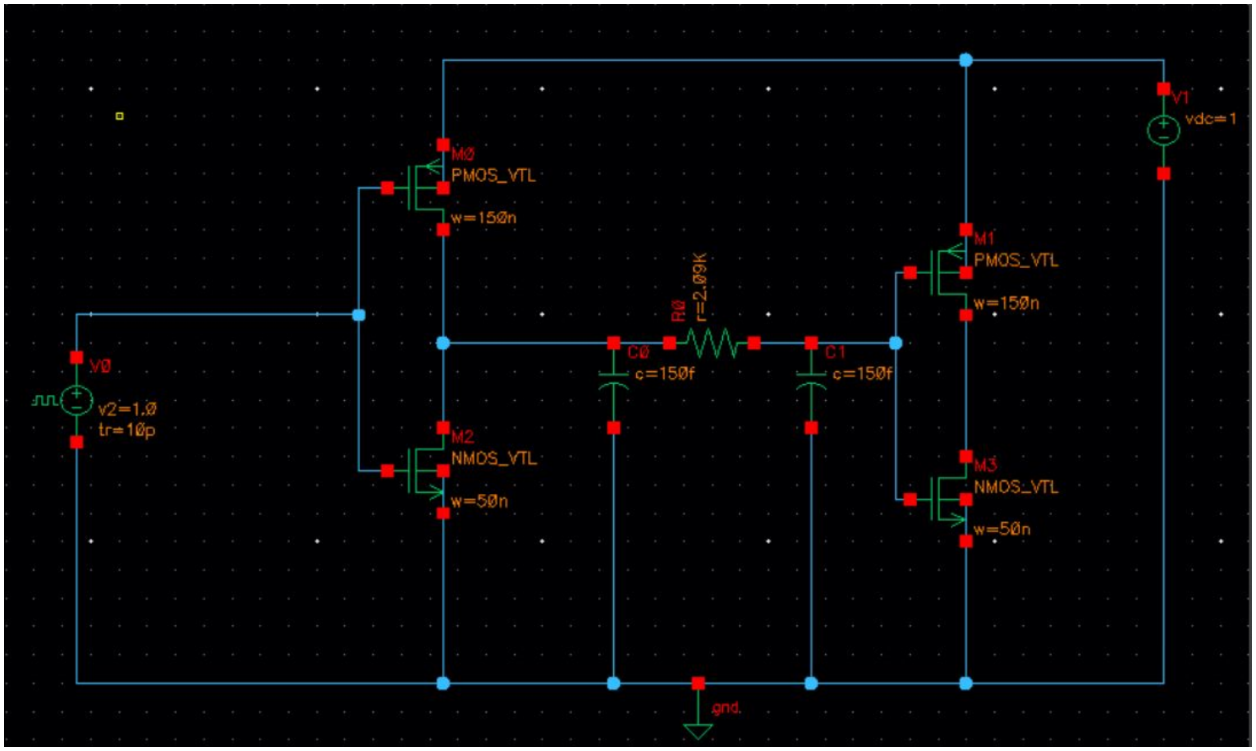
$$T_d = 0.7 R_o C_o$$

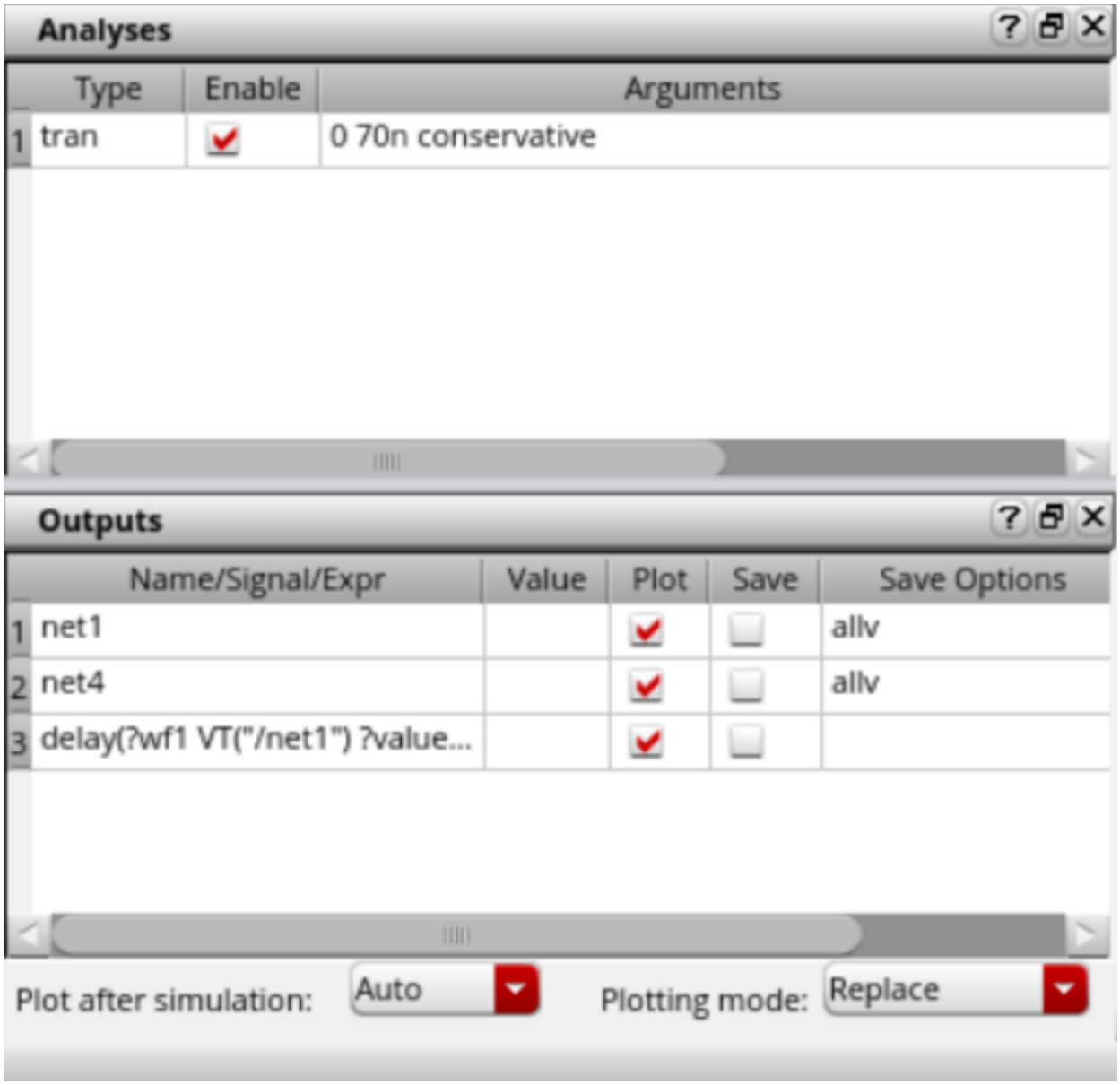
$$11.96 = 0.7 \times 13.96 \times 10^3 C_o$$

$$C_o = \frac{11.96 \times 10^{-12}}{0.7 \times 13.96 \times 10^3}$$

$$\boxed{C_o = 1.22 fF}$$

Schematic of pi model and do analysis,





Theoretical calculation of delay,

$$delay = 0.7R_oC_o + 0.7R_oC_w + 0.4R_wC_w + 0.7R_wC_o$$

we get 3.183

Delay=2.73ns

Theoretical delay = 3.18ns

The difference between theoretical and practical values is 0.453ns.

2. What is the delay improvement with optimal number (k) and size (h) of repeaters compared to the baseline when k and h are 1? Please report the optimal k and h in your design.

Calculation of Kopt and Hopt Values:

$$K_{opt} = \sqrt{\frac{0.4 R_w C_w}{0.7 R_o C_o}}$$

$$= \sqrt{\frac{0.4 \times 2.09 \times 0.3P}{0.7 \times 13.96 \times 1.22f}}$$

$$\boxed{K_{opt} = 4.586}$$

$$h_{opt} = \sqrt{\frac{R_o C_w}{R_w C_o}}$$

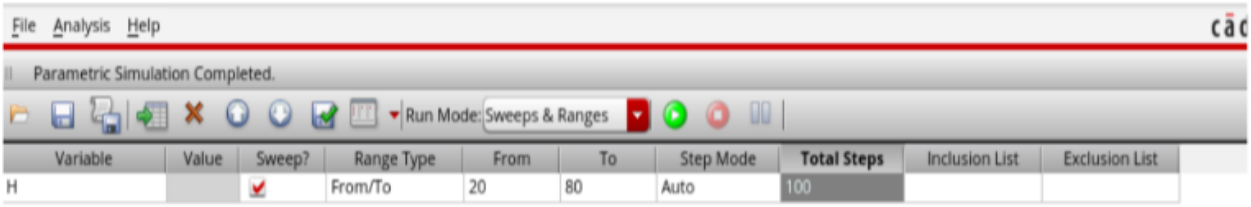
$$= \sqrt{\frac{13.96 \times 0.3P}{2.09 \times 1.22f}}$$

$$\boxed{h_{opt} = 40.52}$$

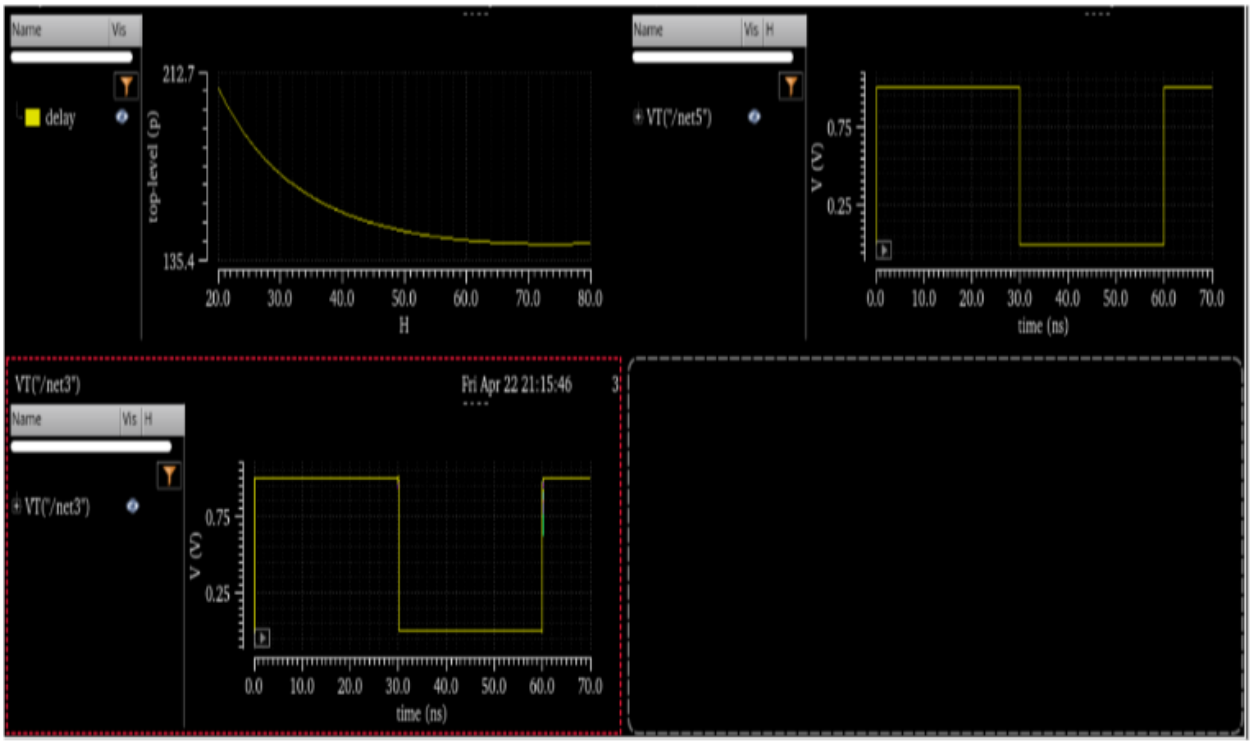
We need to sweep K, For that parametric analysis needs to be done

Delay = 179.8ps

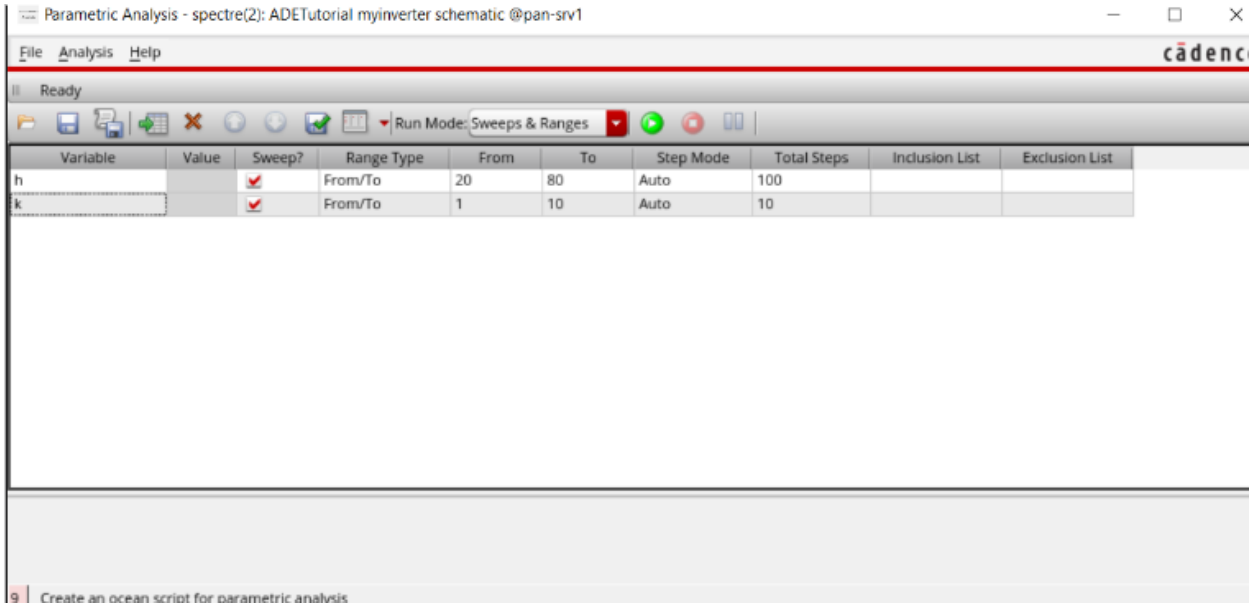
Use Parametric Analysis and Sweep H,

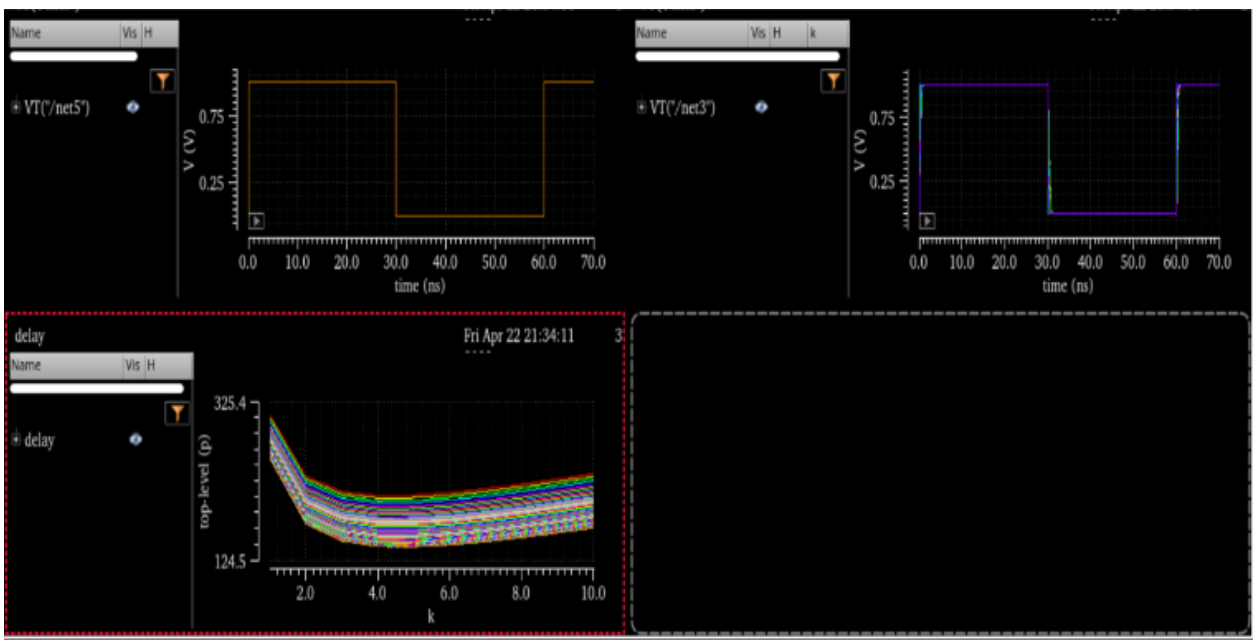


Variable	Value	Sweep?	Range Type	From	To	Step Mode	Total Steps	Inclusion List	Exclusion List
H		✓	From/To	20	80	Auto	100		



delay = 145.2ps, we get H=75.


Parametric Analysis - spectre(2): ADETutorial myinverter schematic @pan-srv1
File Analysis Help
cadenc
Ready
Run Mode: Sweeps & Ranges
Variable | Value | Sweep? | Range Type | From | To | Step Mode | Total Steps | Inclusion List | Exclusion List
h | | ✓ | From/To | 20 | 80 | Auto | 100
k | | ✓ | From/To | 1 | 10 | Auto | 10
Create an ocean script for parametric analysis


Name Vis H
VT("/net5")
V (V)
0.75
0.25
0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0
time (ns)
Name Vis H k
VT("/net3")
V (V)
0.75
0.25
0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0
time (ns)
delay
Fri Apr 22 21:34:11
Name Vis H
delay
top-level (p)
325.4
124.5
2.0 4.0 6.0 8.0 10.0
k

Design Variables
Name | Value
h | 100
k | 10
Analyses
Type | Enable | Arguments
tran | ✓ | 0 70n
Outputs
Name/Signal/Expr | Value | Plot | Save | Save Options
VT("/net5") | wave | ✓
VT("/net3") | wave | ✓
delay | 169.5p | ✓

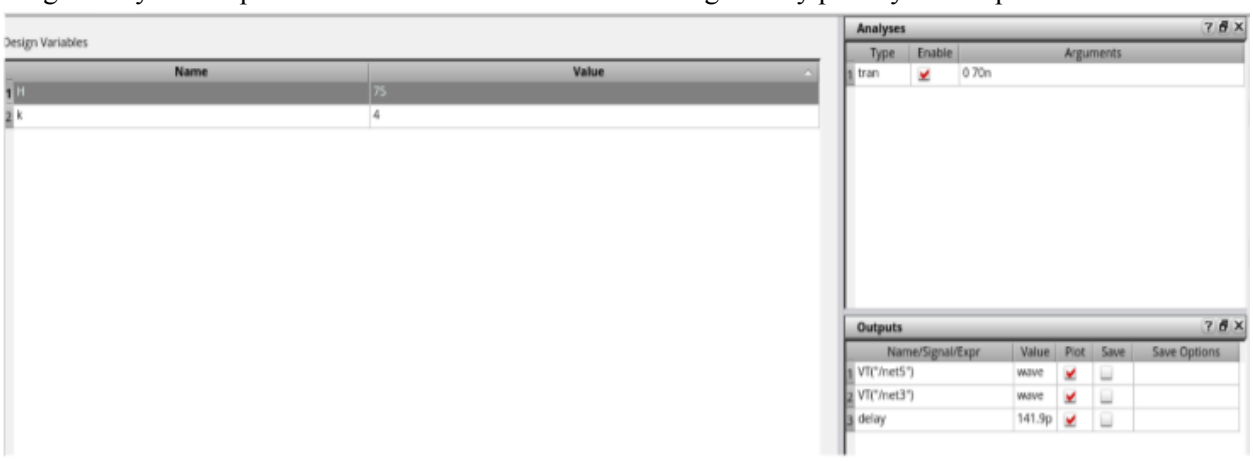
Delay = 169.5ps

3. If you use half of the optimal number of inverters, what is the delay penalty compared to the optimal number of inverters? You may assume h is always the optimal value.

Assign H=40, k=4. We get delay= 154.9ps

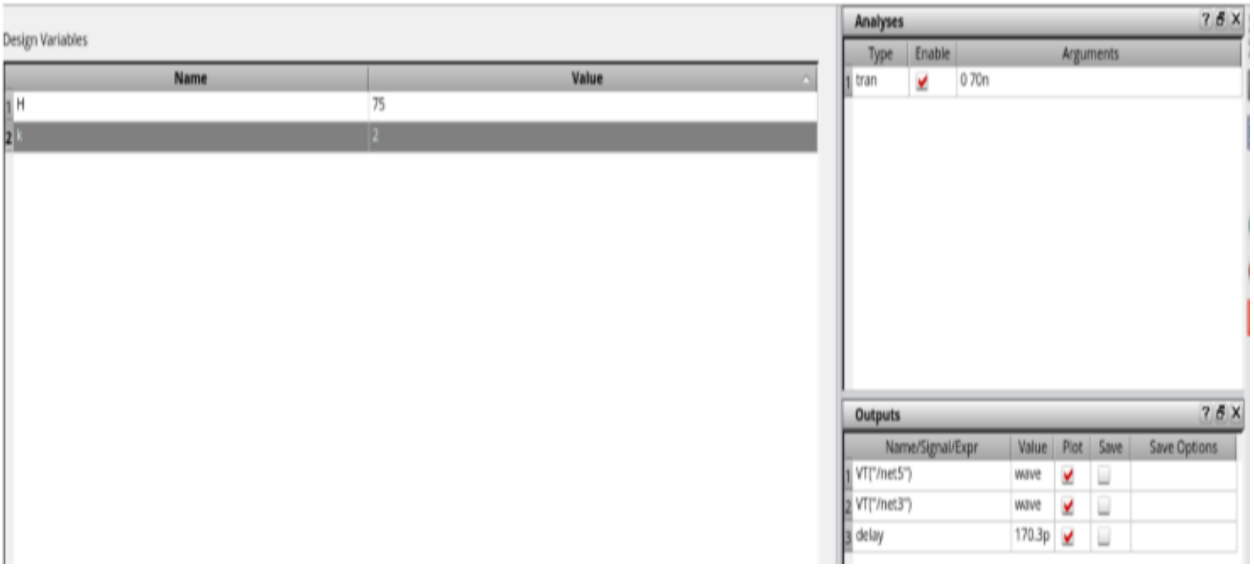
Reduce the size of inverters by 2 and H=40.

We get delay= 181.6ps. Reduce the size of inverters and we get delay penalty of 26.7ps



Assign H=75 and k=4. We get delay = 141.9ps

Reduce the size of inverter to 2 and H=75.



We get delay=170.3ps. Reduce the size of inverters, we get delay penalty =28.4ps

4. Do you see any differences between theory and experiments? If so, please give possible explanations.

The theoretical and experimental values show a significant disparity, with a delay difference of 0.453ns and a substantial difference in H value. It was assumed that Co is 1pF, but when the formula was used to calculate the value of Co, it was determined to be 1.22fF, which represents a difference of 99.8pF.