

Digital IC Design

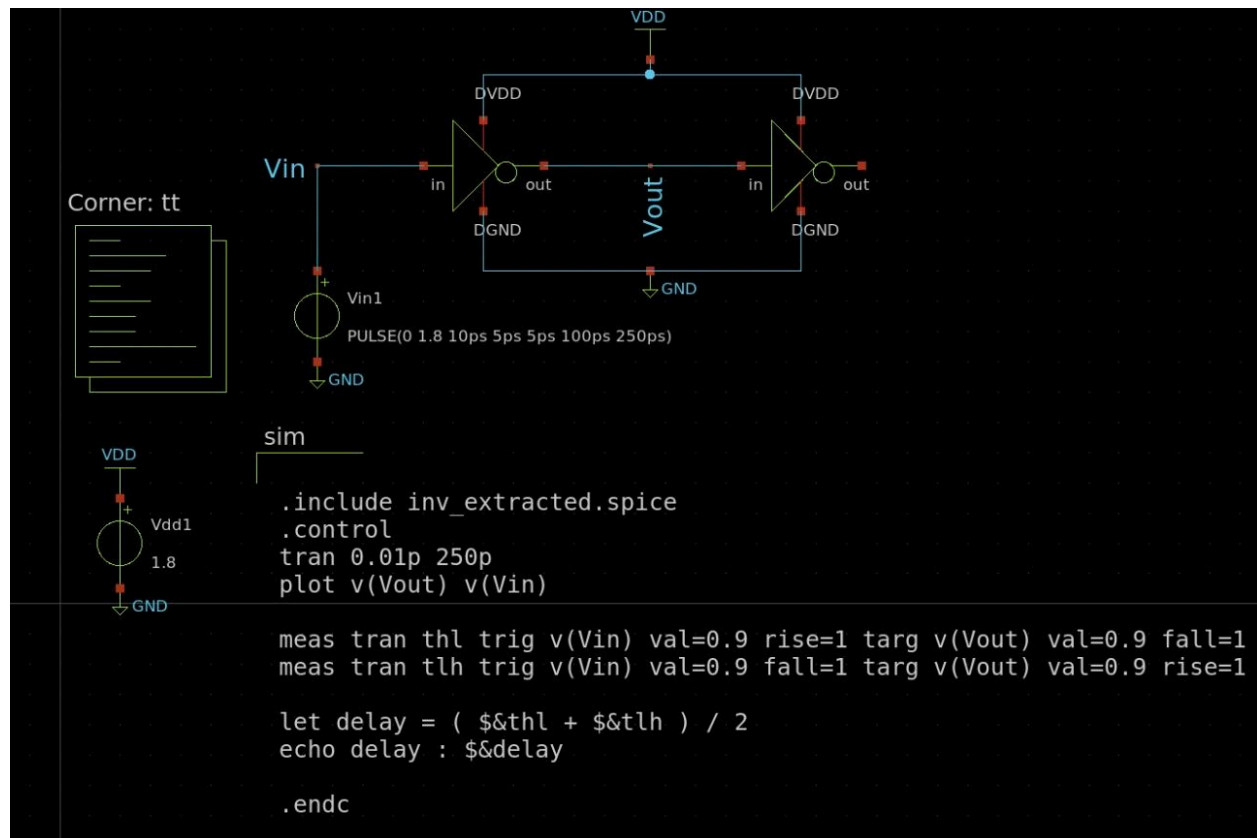
EE5311

Mourya Sai Sandeep
EE22B045

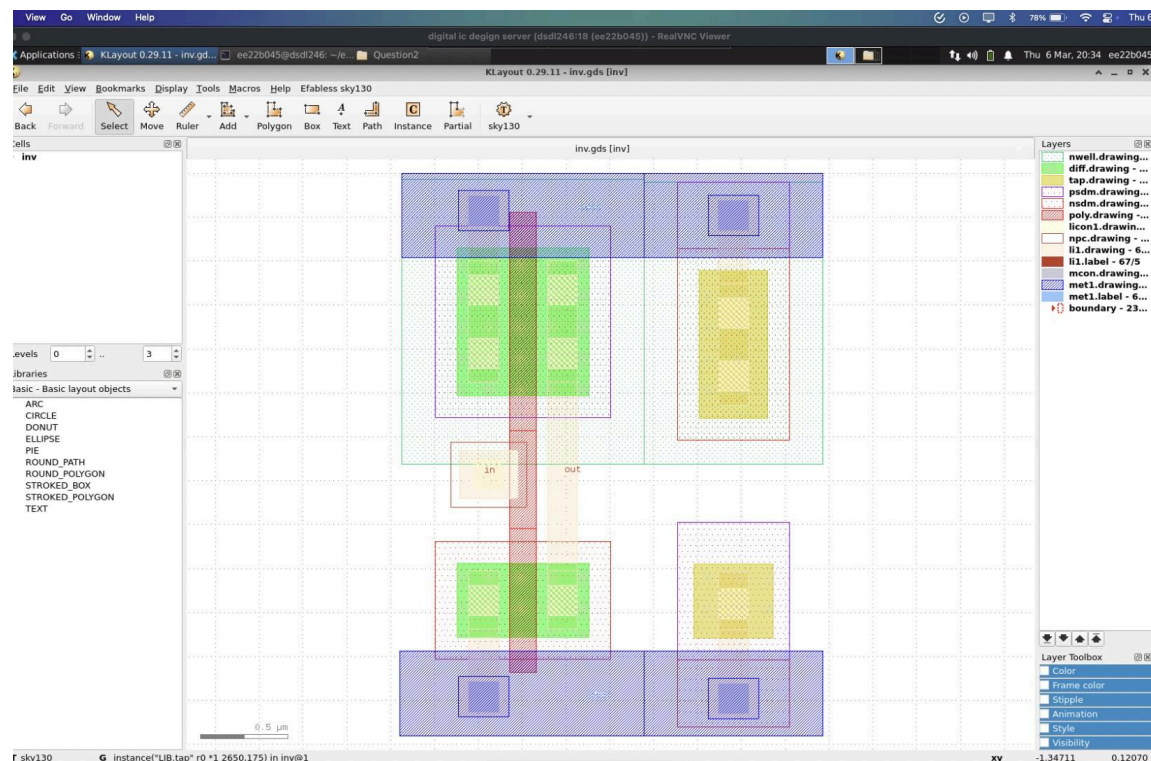
Tutorial - 5
Report

Experiment - 1

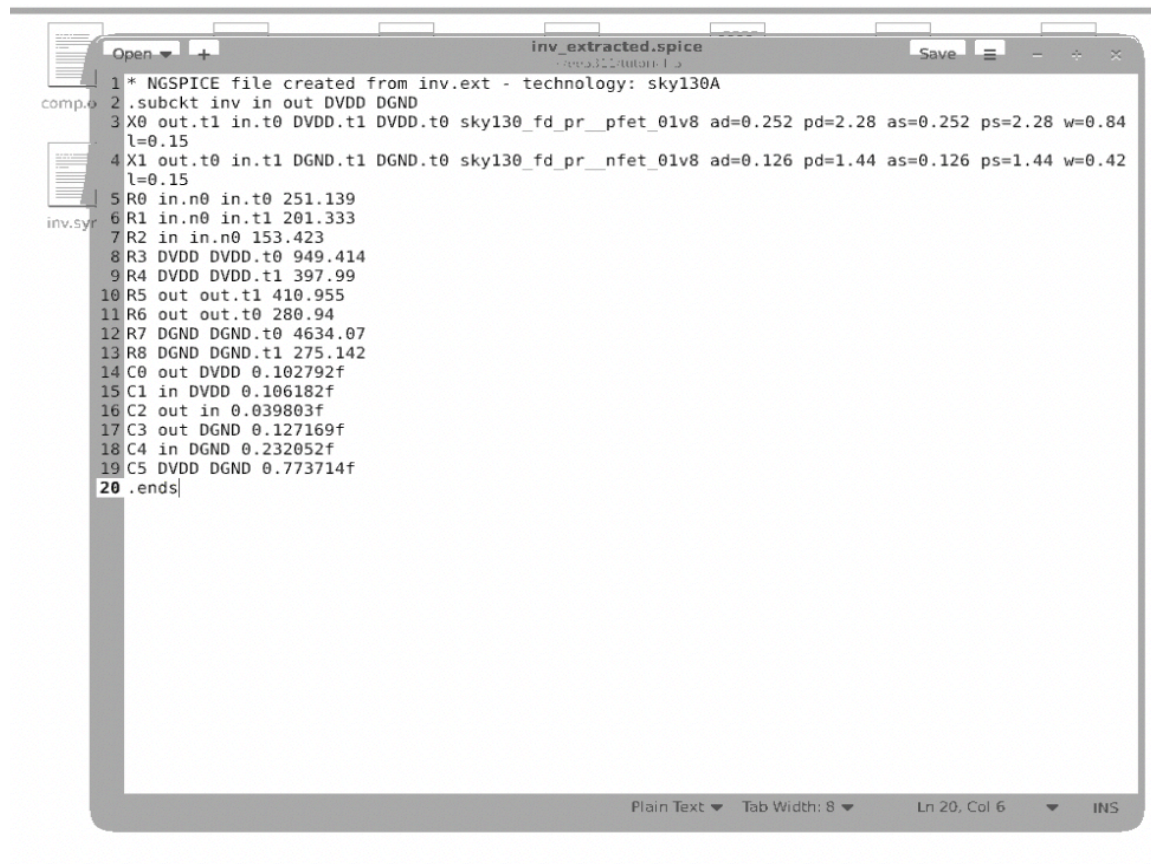
Schematic



KLayout for inverter:



Extracted Parasitics:



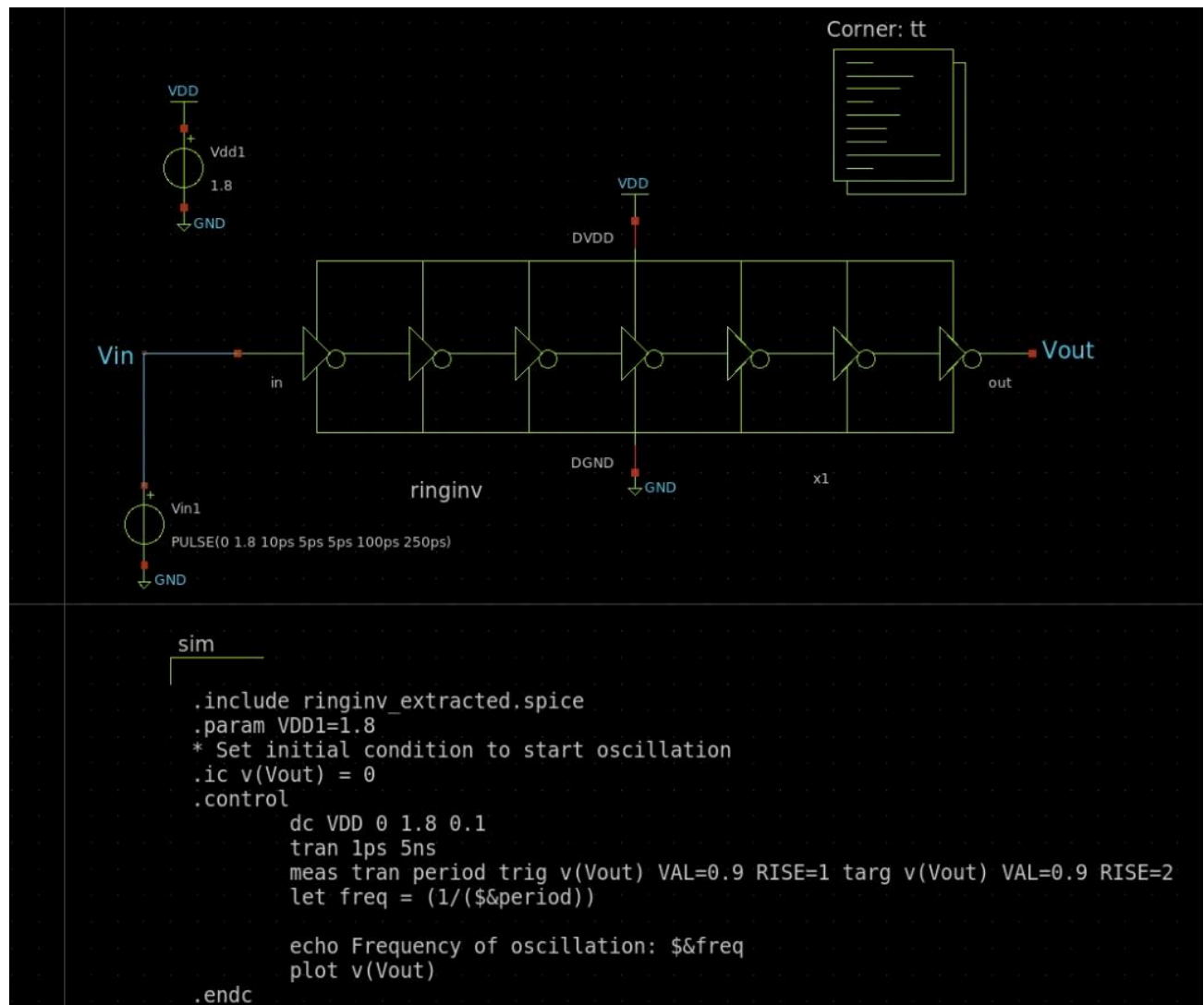
The image shows a text editor window titled "inv_extracted.spice" with a menu bar containing "Open", "Save", and a list icon. The editor displays a list of 20 lines of extracted parasitics for a circuit. The first line is a comment: "1 * NGSPICE file created from inv.ext - technology: sky130A". The second line is a subcircuit definition: "2 .subckt inv in out DVDD DGND". The third line is a transistor definition: "3 X0 out.t1 in.t0 DVDD.t1 DVDD.t0 sky130_fd_pr__pfet_01v8 ad=0.252 pd=2.28 as=0.252 ps=2.28 w=0.84 l=0.15". The fourth line is another transistor definition: "4 X1 out.t0 in.t1 DGND.t1 DGND.t0 sky130_fd_pr__nfet_01v8 ad=0.126 pd=1.44 as=0.126 ps=1.44 w=0.42 l=0.15". The remaining lines (5-19) are parasitic values for various nodes and components. The 20th line is ".ends". The status bar at the bottom indicates "Plain Text", "Tab Width: 8", "Ln 20, Col 6", and "INS".

```
1 * NGSPICE file created from inv.ext - technology: sky130A
2 .subckt inv in out DVDD DGND
3 X0 out.t1 in.t0 DVDD.t1 DVDD.t0 sky130_fd_pr__pfet_01v8 ad=0.252 pd=2.28 as=0.252 ps=2.28 w=0.84
  l=0.15
4 X1 out.t0 in.t1 DGND.t1 DGND.t0 sky130_fd_pr__nfet_01v8 ad=0.126 pd=1.44 as=0.126 ps=1.44 w=0.42
  l=0.15
5 R0 in.n0 in.t0 251.139
6 R1 in.n0 in.t1 201.333
7 R2 in in.n0 153.423
8 R3 DVDD DVDD.t0 949.414
9 R4 DVDD DVDD.t1 397.99
10 R5 out out.t1 410.955
11 R6 out out.t0 280.94
12 R7 DGND DGND.t0 4634.07
13 R8 DGND DGND.t1 275.142
14 C0 out DVDD 0.102792f
15 C1 in DVDD 0.106182f
16 C2 out in 0.039803f
17 C3 out DGND 0.127169f
18 C4 in DGND 0.232052f
19 C5 DVDD DGND 0.773714f
20 .ends
```

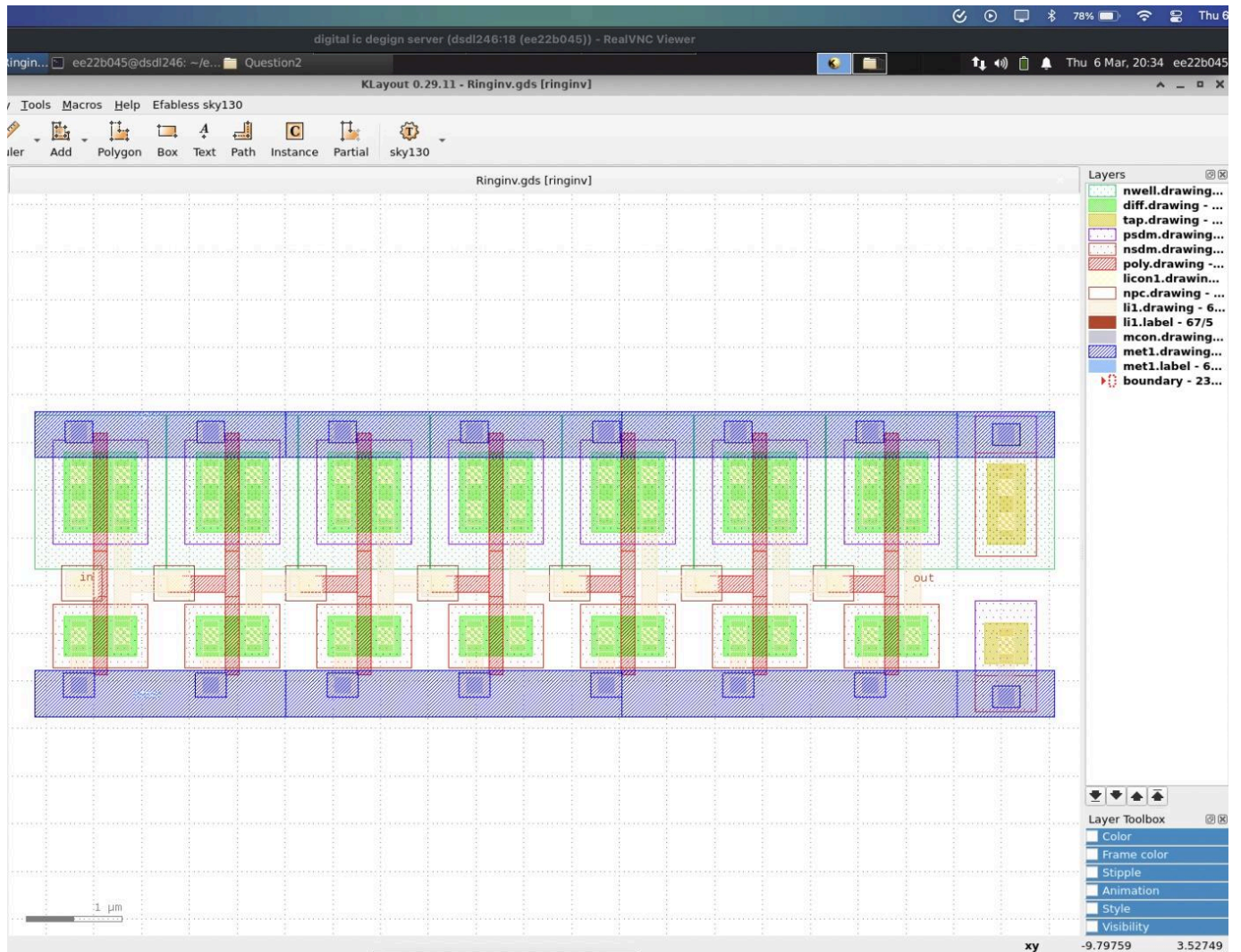
- A) The Delay of the Circuit(without the Parasitics) = 2.07×10^{-11} sec
- B) The Delay of the Circuit With Parasitics = 2.52×10^{-11} sec

Experiment - 2:

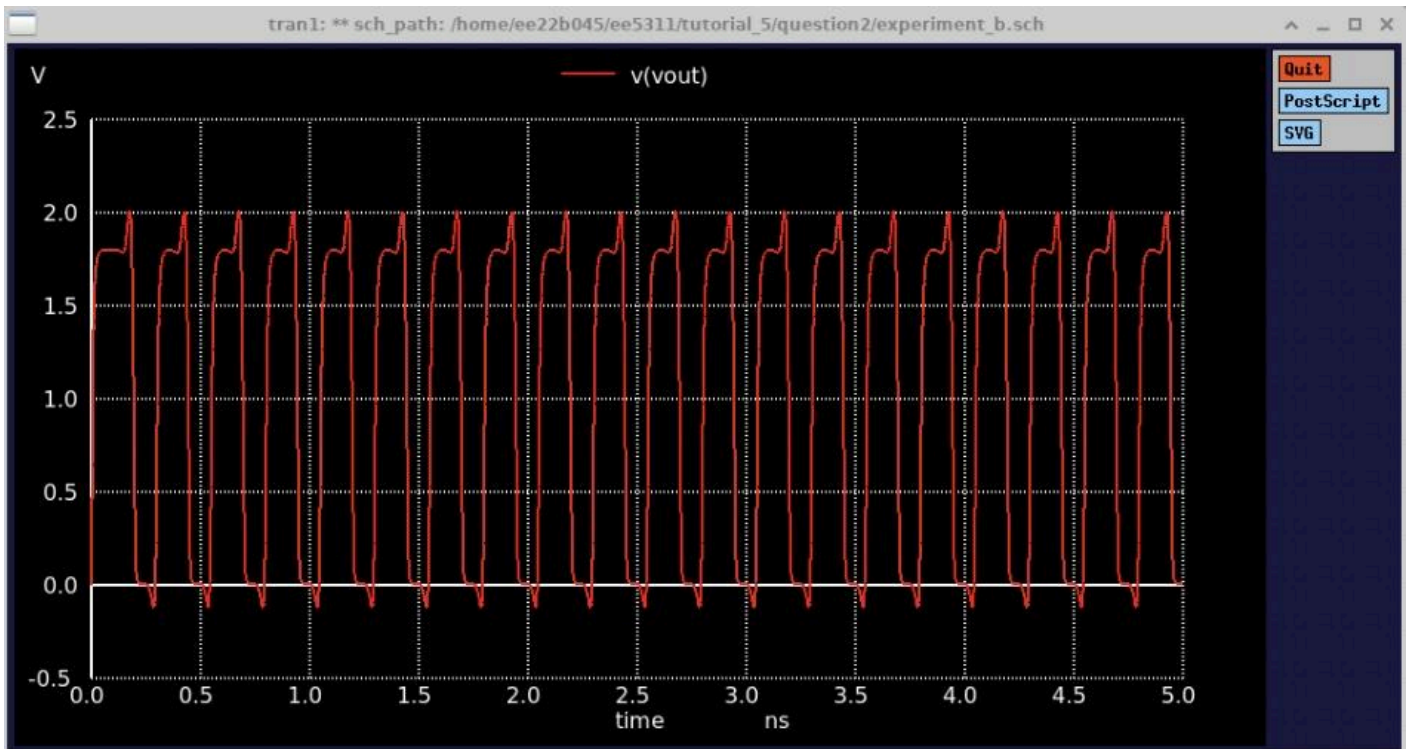
Schematic



Kayout of Ring Oscillator



c) When parasitics are not Included in the Schematic:



This graph shows the Oscillations without counting for the Parasitics
Frequency of oscillation : $3.37 \times 10^9 \text{ Hz}$ or 3.37GHz

```

Experiment_B.spice" -a || sh
Using SPARSE 1.3 as Direct Linear Solver

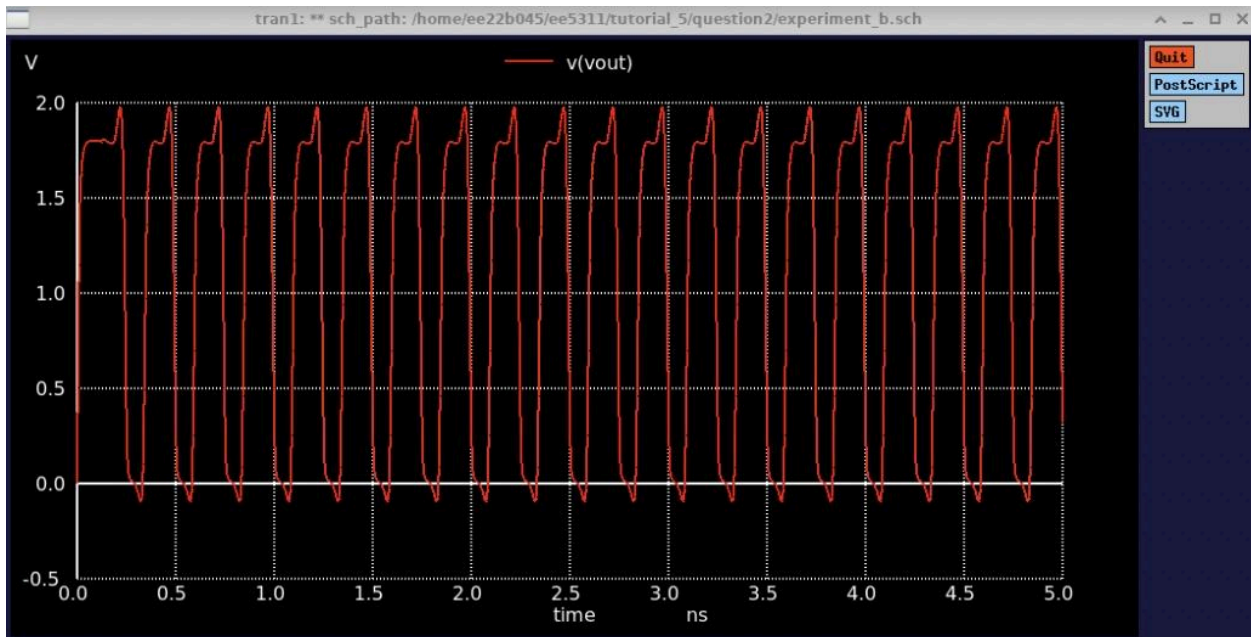
Initial Transient Solution
-----
Node                Voltage
-----
x1.net1              1.8
vin                  0
vdd                  1.8
x1.net2              6.71229e-07
x1.net3              1.8
x1.net4              6.71229e-07
x1.net5              1.8
x1.net6              6.71229e-07
vout                 0
vin1#branch          0
vdd1#branch          -0.000143287

Reference value : 3.37070e-09
No. of Data Rows : 5248
period              = 2.959575e-10 targ= 3.008172e-10 trig= 4.859678e-12
Frequency of oscillation: 3.37886E+09
ngspice 7 ->
  
```

Extracted Parasitics:

```
Question2
ringinv_extracted.spice
Save
1 * NGSPICE file created from ringinv.ext - technology: sky130A
2 .subckt ringinv DVDD in out DGND
3 X0 a_n1219_52# a_n1495_52# DGND.t13 DGND.t12 sky130_fd_pr_nfet_01v8 ad=0.126 pd=1.44 as=0.126
  ps=1.44 w=0.42 l=0.15
4 X1 a_n943_52# a_n1219_52# DVDD.t1 DVDD.t0 sky130_fd_pr_pfet_01v8 ad=0.252 pd=2.28 as=0.252
  ps=2.28 w=0.84 l=0.15
5 X2 a_n1771_52# in.t0 DGND.t9 DGND.t8 sky130_fd_pr_nfet_01v8 ad=0.126 pd=1.44 as=0.126 ps=1.44
  w=0.42 l=0.15
6 X3 a_n1495_52# a_n1771_52# DGND.t3 DGND.t2 sky130_fd_pr_nfet_01v8 ad=0.126 pd=1.44 as=0.126
  ps=1.44 w=0.42 l=0.15
7 X4 a_n667_52# a_n943_52# DGND.t5 DGND.t4 sky130_fd_pr_nfet_01v8 ad=0.126 pd=1.44 as=0.126
  ps=1.44 w=0.42 l=0.15
8 X5 a_n943_52# a_n1219_52# DGND.t1 DGND.t0 sky130_fd_pr_nfet_01v8 ad=0.126 pd=1.44 as=0.126
  ps=1.44 w=0.42 l=0.15
9 X6 a_n667_52# a_n943_52# DVDD.t5 DVDD.t4 sky130_fd_pr_pfet_01v8 ad=0.252 pd=2.28 as=0.252
  ps=2.28 w=0.84 l=0.15
10 X7 a_n391_52# a_n667_52# DVDD.t9 DVDD.t8 sky130_fd_pr_pfet_01v8 ad=0.252 pd=2.28 as=0.252
  ps=2.28 w=0.84 l=0.15
11 X8 out.t0 a_n391_52# DVDD.t7 DVDD.t6 sky130_fd_pr_pfet_01v8 ad=0.252 pd=2.28 as=0.252 ps=2.28
  w=0.84 l=0.15
12 X9 out.t1 a_n391_52# DGND.t7 DGND.t6 sky130_fd_pr_nfet_01v8 ad=0.126 pd=1.44 as=0.126 ps=1.44
  w=0.42 l=0.15
13 X10 a_n391_52# a_n667_52# DGND.t11 DGND.t10 sky130_fd_pr_nfet_01v8 ad=0.126 pd=1.44 as=0.126
  ps=1.44 w=0.42 l=0.15
14 X11 a_n1771_52# in.t1 DVDD.t11 DVDD.t10 sky130_fd_pr_pfet_01v8 ad=0.252 pd=2.28 as=0.252
  ps=2.28 w=0.84 l=0.15
15 X12 a_n1495_52# a_n1771_52# DVDD.t3 DVDD.t2 sky130_fd_pr_pfet_01v8 ad=0.252 pd=2.28 as=0.252
  ps=2.28 w=0.84 l=0.15
16 X13 a_n1219_52# a_n1495_52# DVDD.t13 DVDD.t12 sky130_fd_pr_pfet_01v8 ad=0.252 pd=2.28 as=0.252
  ps=2.28 w=0.84 l=0.15
17 R0 DGND.n0 DGND.t6 4634.22
18 R1 DGND.t6 DGND.t10 3930.1
19 R2 DGND.t10 DGND.t4 3930.1
20 R3 DGND.t4 DGND.t0 3930.1
21 R4 DGND.t0 DGND.t12 3930.1
22 R5 DGND.t12 DGND.t2 3930.1
23 R6 DGND.t2 DGND.t8 3930.1
24 R7 DGND DGND.t9 271.493
25 R8 DGND.n5 DGND.t3 271.346
26 R9 DGND.n4 DGND.t13 271.346
27 R10 DGND.n3 DGND.t1 271.346
28 R11 DGND.n2 DGND.t5 271.346
29 R12 DGND.n1 DGND.t11 271.346
30 R13 DGND.n0 DGND.t7 271.346
31 R14 DGND.n1 DGND.n0 0.359875
32 R15 DGND.n2 DGND.n1 0.359875
33 R16 DGND.n3 DGND.n2 0.359875
34 R17 DGND.n4 DGND.n3 0.359875
35 R18 DGND.n5 DGND.n4 0.359875
36 R19 DGND DGND.n5 0.21274
Plain Text Tab Width: 8 Ln 19, Col 27 INS
```

A)When Parasitics are included in the schematic:

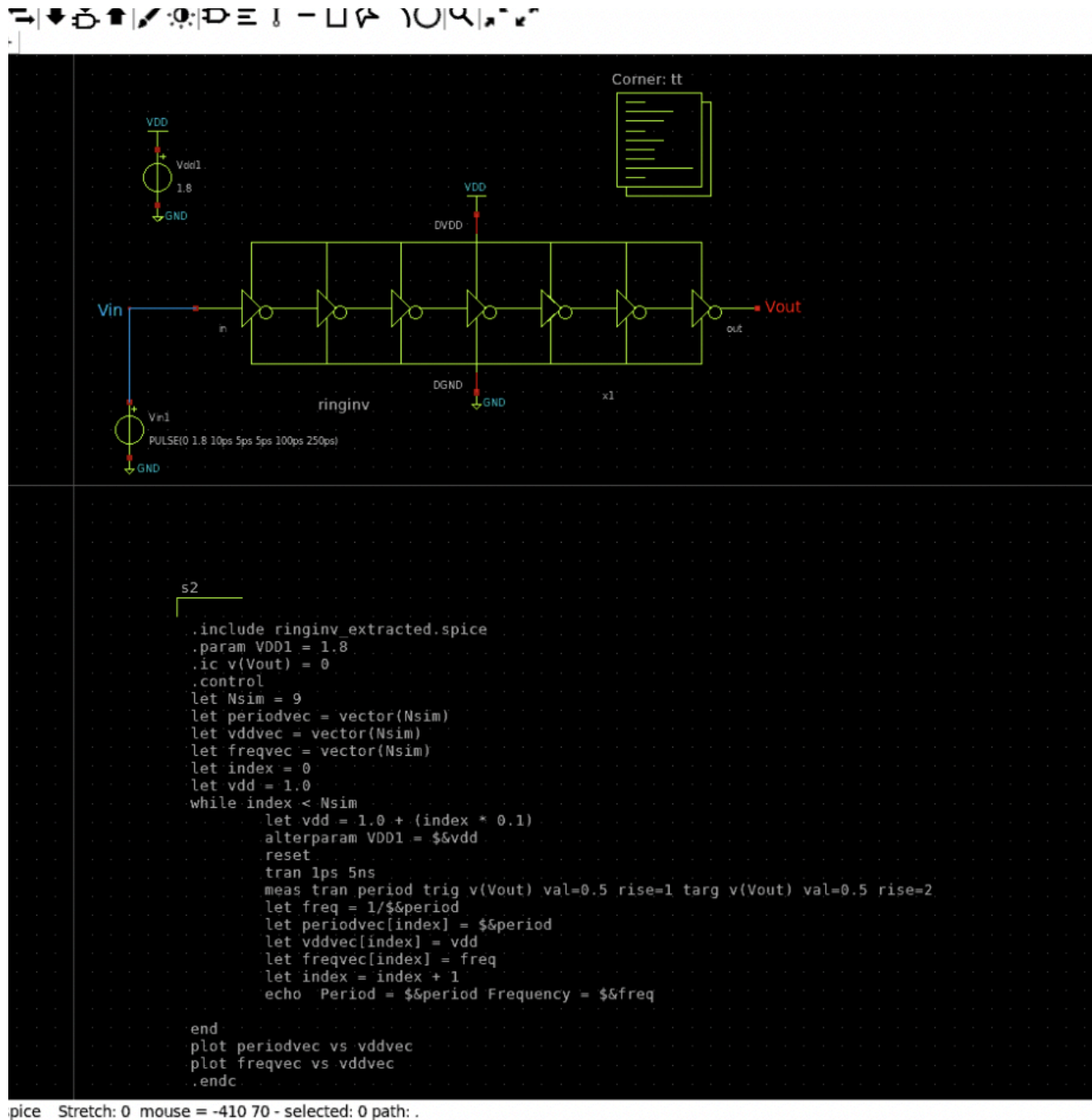


This graph shows the Oscillations without counting for the Parasitics
Frequency of oscillation : $2.97 \times 10^9 \text{Hz}$ or 2.97GHz

```
Experiment_B.spice" -a || sh
x1.dgnd,n0      6.86543e-10
x1.dgnd,n5      1.55376e-10
x1.dgnd,n4      3.31166e-10
x1.dgnd,n3      5.06945e-10
x1.dgnd,n2      5.95778e-10
x1.dgnd,n1      6.84599e-10
x1.dvdd,n0      1.79972
vdd             1.8
x1.dvdd,n5      1.79997
x1.dvdd,n4      1.79992
x1.dvdd,n3      1.79987
x1.dvdd,n2      1.79982
x1.dvdd,n1      1.79977
x1.in,n0        0
vin             0
vout            0
vin1#branch     0
vdd1#branch     -0.000141195

Reference value : 4.44150e-09
No. of Data Rows : 5248
period          = 3.389173e-10 targ= 3.455911e-10 trig= 6.673829e-12
Frequency of oscillation: 2.95057E+09
ngspice 7 -> █
```


B) Code and Schematic:

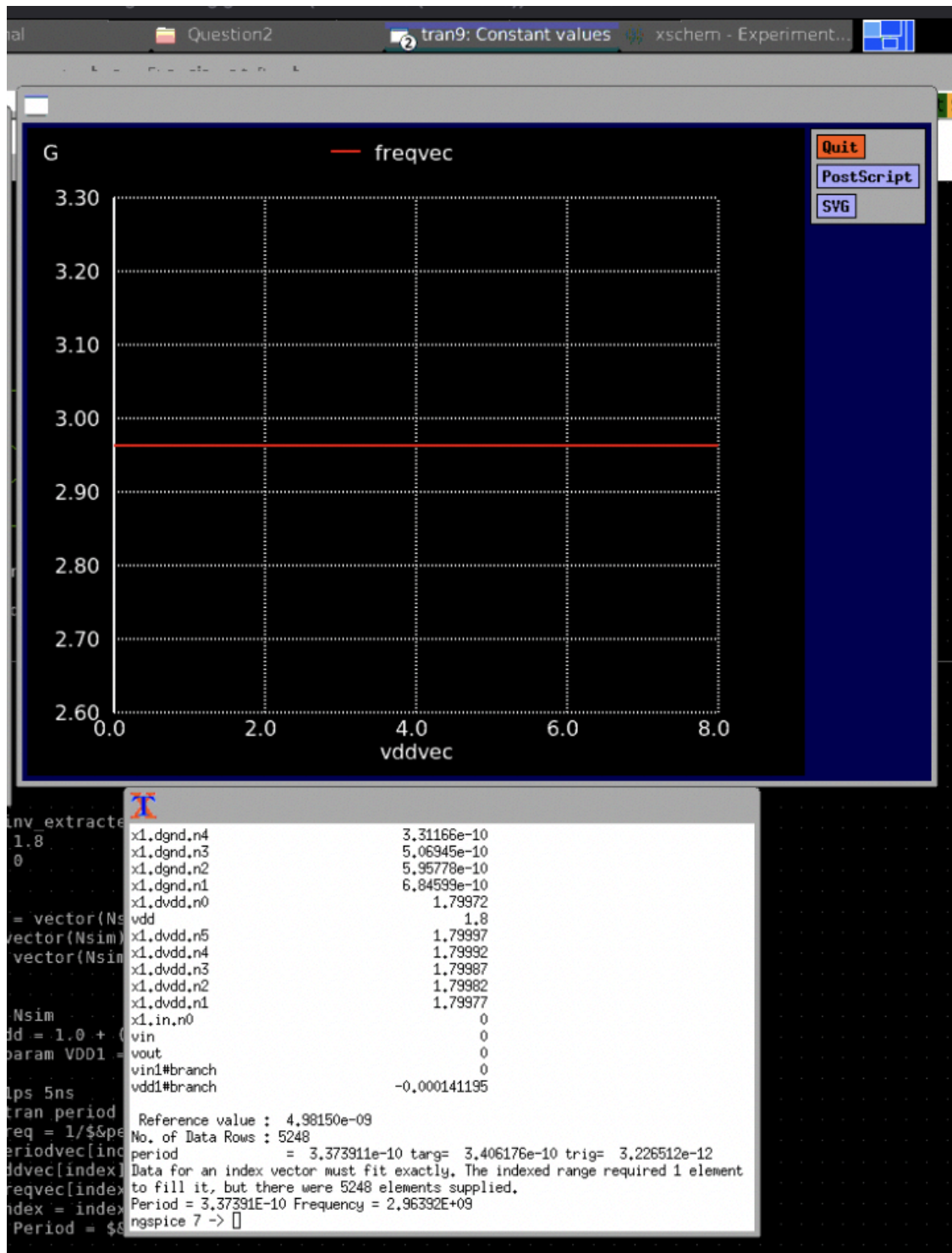


Observation:

Pre-layout frequency (no parasitics): Higher

Post-layout frequency (with parasitics): Lower

Frequency vs VDD response



- The End -

