

Day 3 Lab:

Commands used:

```
# Change directory to openlane
cd Desktop/work/tools/openlane_working_dir/openlane

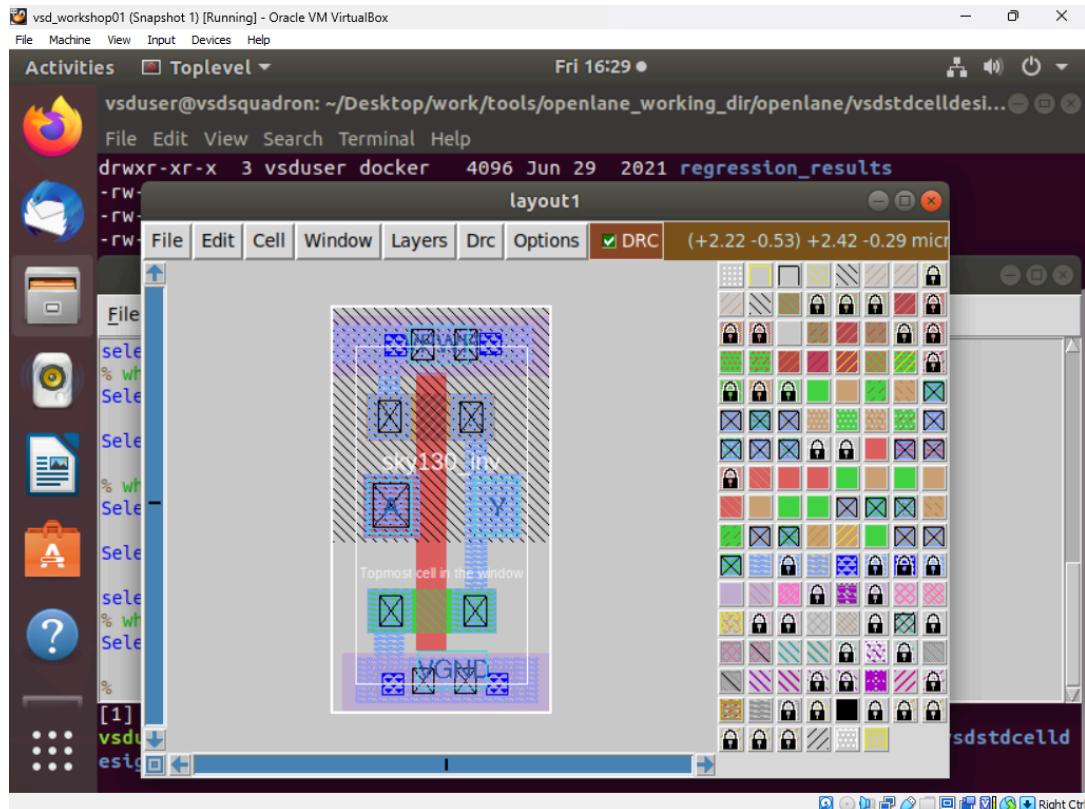
# Clone the repository with custom inverter design
git clone https://github.com/nickson-jose/vsdstdcelldesign

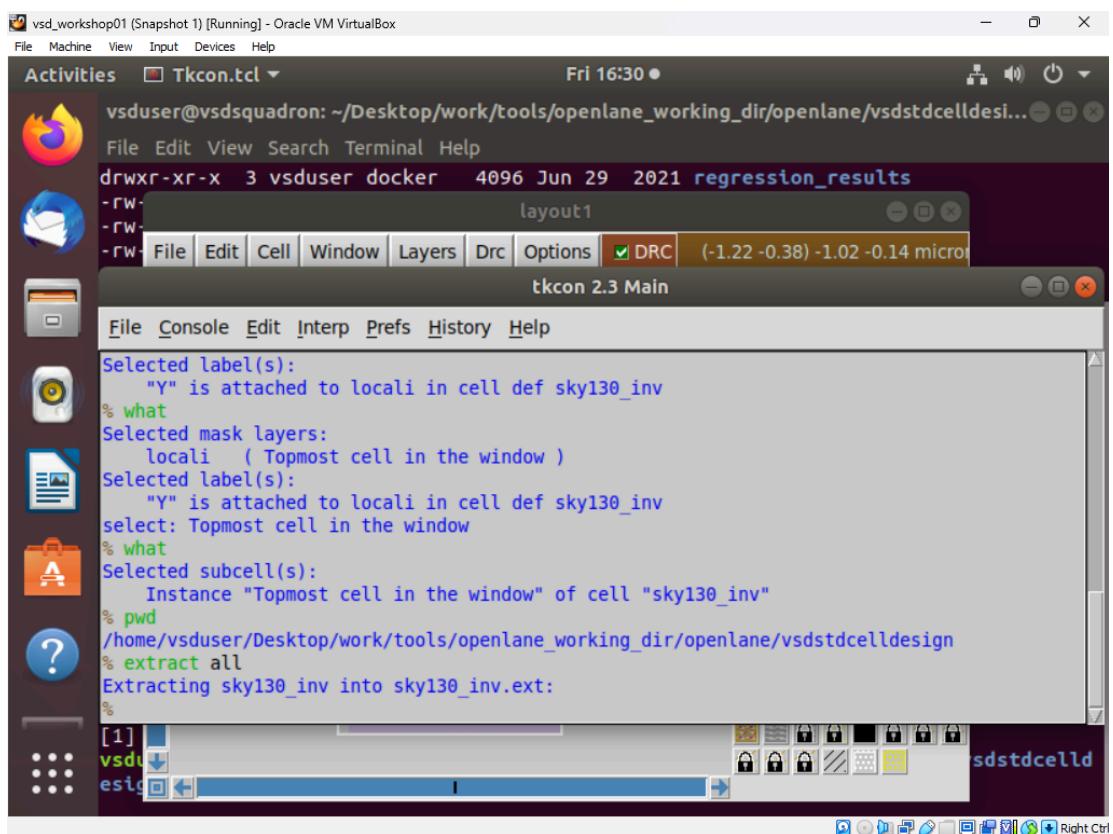
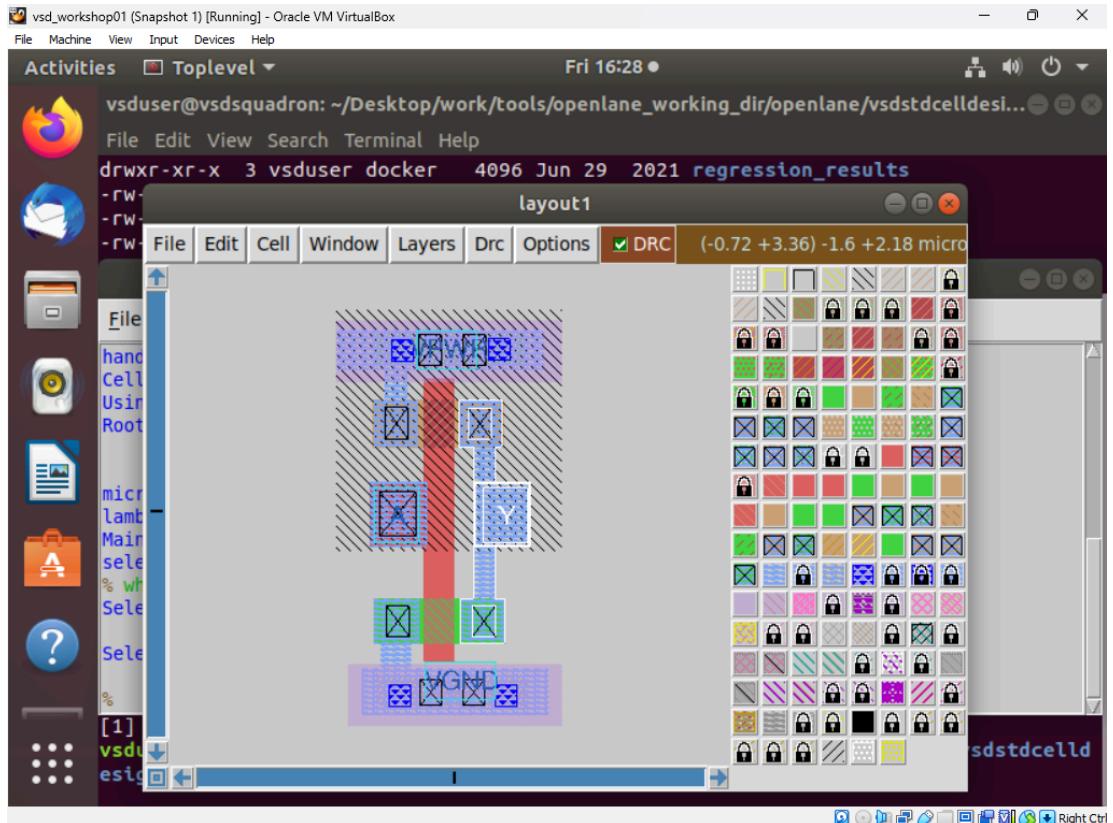
# Change into repository directory
cd vsdstdcelldesign

# Copy magic tech file to the repo directory for easy access
cp /home/vsduser/Desktop/work/tools/openlane_working_dir/pdk/sky130A/libs.tech/magic/sky130A.tech

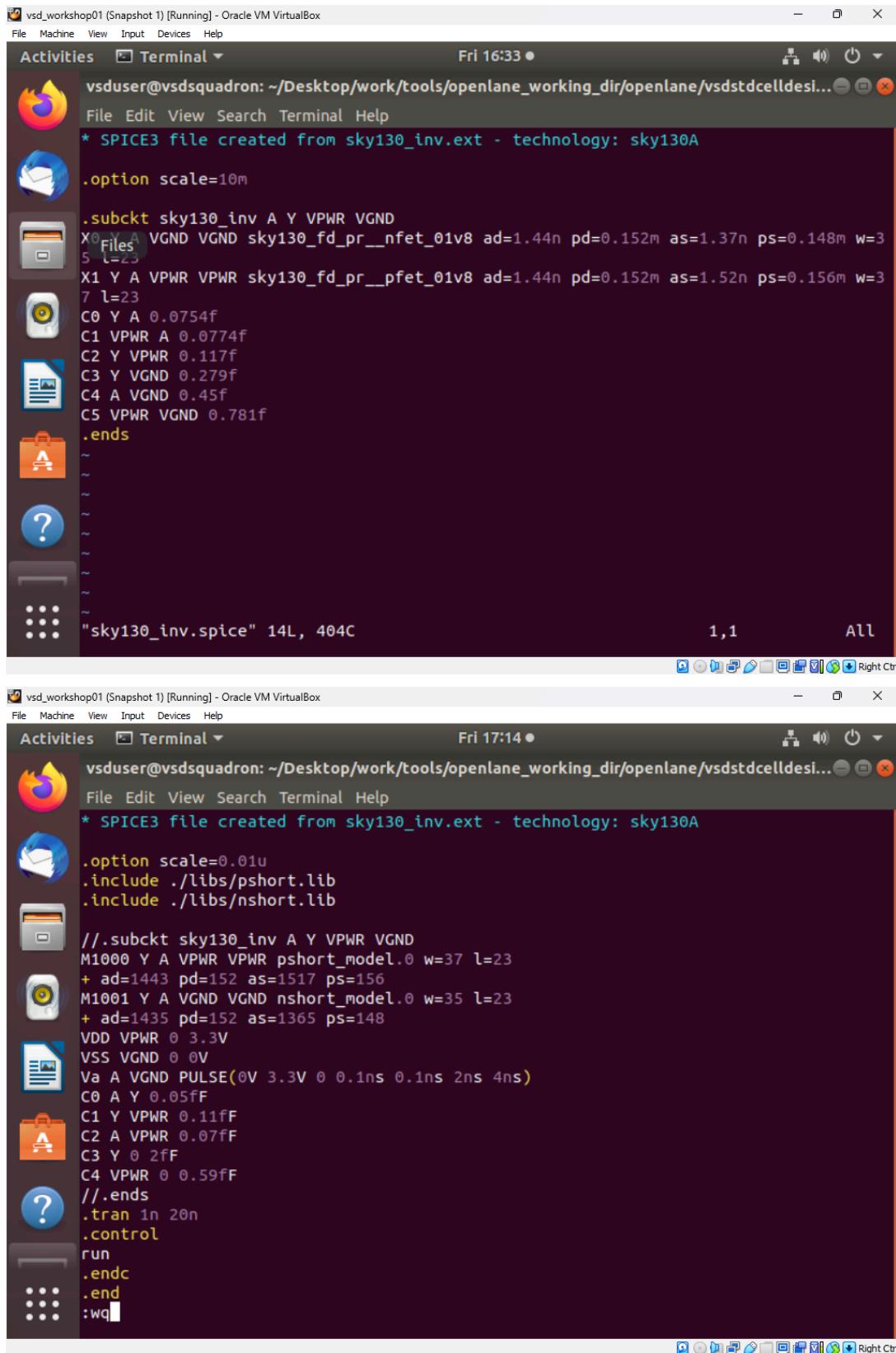
# Check contents whether everything is present
ls -ltr

# Command to open custom inverter layout in magic
magic -T sky130A.tech sky130_inv.mag &
```





Extract spice file and make modifications



```
* SPICE3 file created from sky130_inv.ext - technology: sky130A
.option scale=10m

.subckt sky130_inv A Y VPWR VGND
X0 Y A VGND VGND sky130_fd_pr_nfet_01v8 ad=1.44n pd=0.152m as=1.37n ps=0.148m w=3
5 l=23
X1 Y A VPWR VPWR sky130_fd_pr_pfet_01v8 ad=1.44n pd=0.152m as=1.52n ps=0.156m w=3
7 l=23
C0 Y A 0.0754f
C1 VPWR A 0.0774f
C2 Y VPWR 0.117f
C3 Y VGND 0.279f
C4 A VGND 0.45f
C5 VPWR VGND 0.781f
.ends

"sky130_inv.spice" 14L, 404C
```

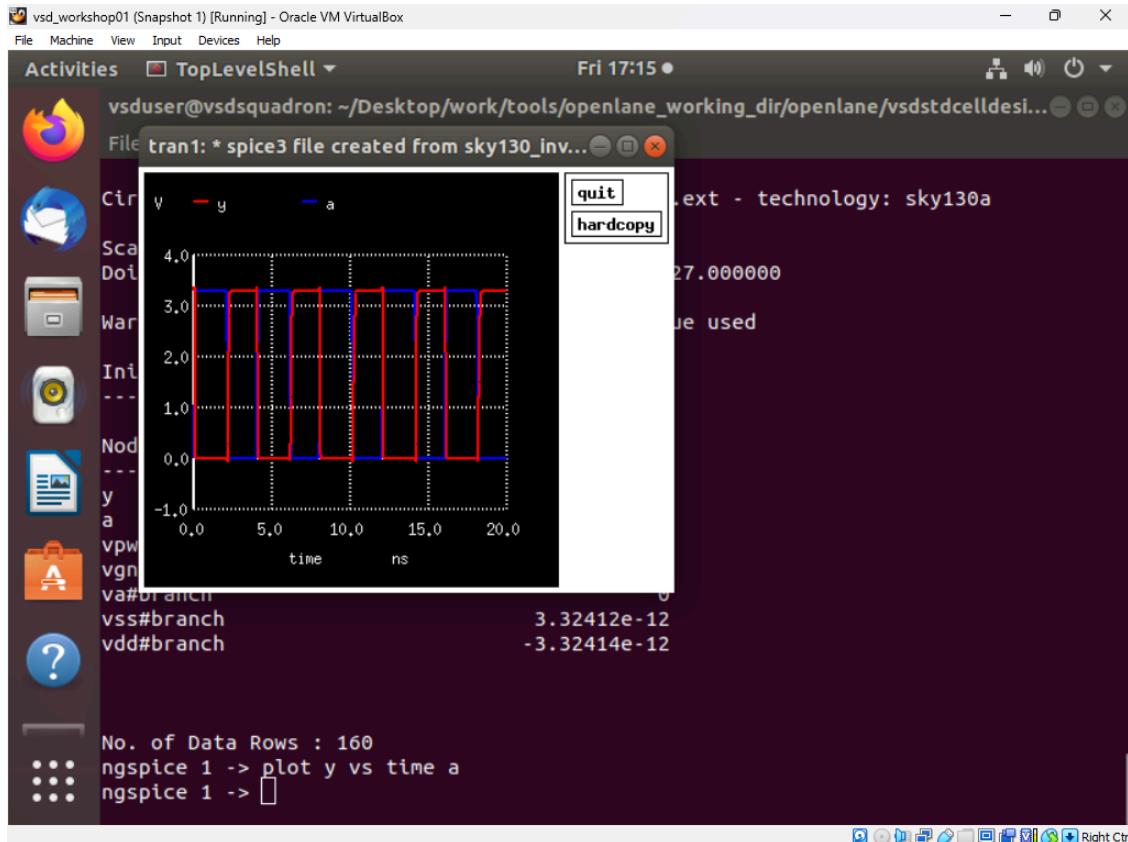


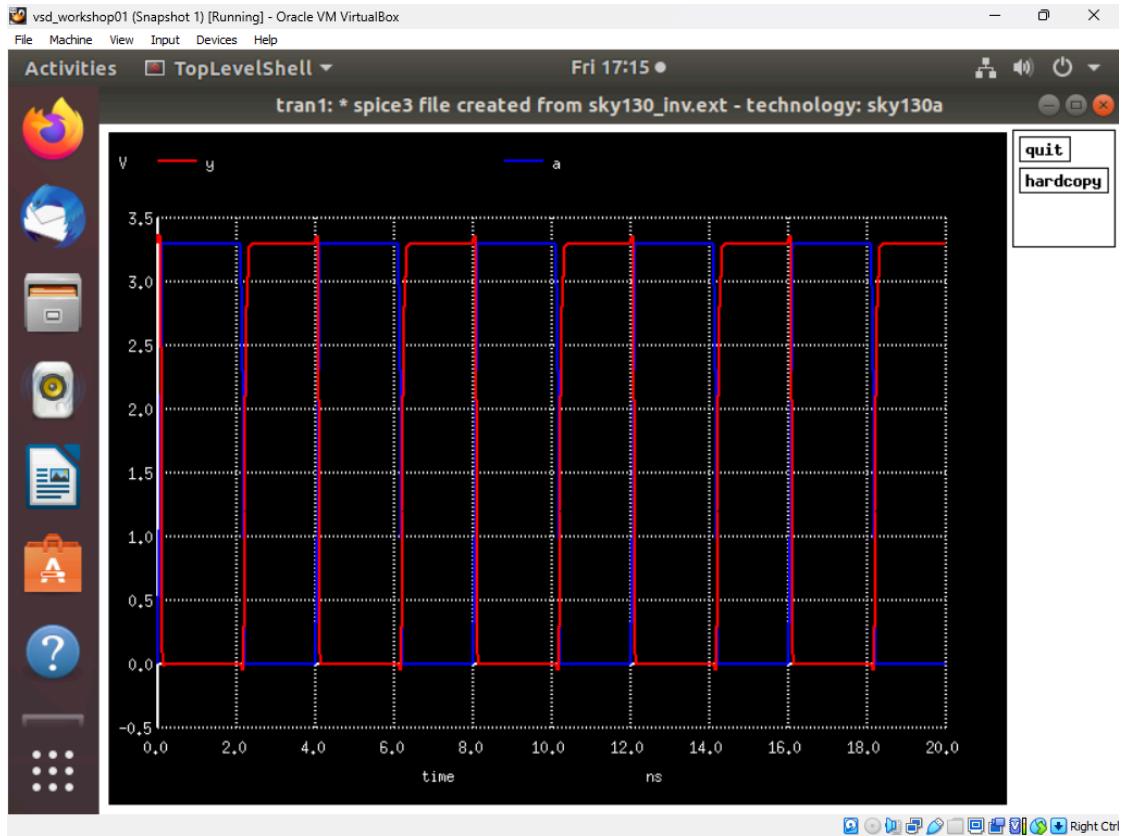
```
* SPICE3 file created from sky130_inv.ext - technology: sky130A
.option scale=0.01u
.include ./libs/pshort.lib
.include ./libs/nshort.lib

//.subckt sky130_inv A Y VPWR VGND
M1000 Y A VPWR VPWR pshort_model.0 w=37 l=23
+ ad=1443 pd=152 as=1517 ps=156
M1001 Y A VGND VGND nshort_model.0 w=35 l=23
+ ad=1435 pd=152 as=1365 ps=148
VDD VPWR 0 3.3V
VSS VGND 0 0V
Va A VGND PULSE(0V 3.3V 0 0.1ns 0.1ns 2ns 4ns)
C0 A Y 0.05ff
C1 Y VPWR 0.11ff
C2 A VPWR 0.07ff
C3 Y 0 2ff
C4 VPWR 0 0.59ff
//.ends
.tran 1n 20n
.control
run
.endc
.end
:wq
```

Execute ngspice and plot y vs a

```
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane/vsdstdcelldesi... Fri 17:15 ●
Activities Terminal
File Edit View Search Terminal Help
*****
Circuit: * spice3 file created from sky130_inv.ext - technology: sky130a
Scale set
Doing analysis at TEMP = 27.000000 and TNOM = 27.000000
Warning: va: no DC value, transient time 0 value used
Initial Transient Solution
-----
Node          Voltage
-----
y            3.3
a            0
vpwr         3.3
vgnd         0
va#branch    0
vss#branch   3.32412e-12
vdd#branch   -3.32414e-12
No. of Data Rows : 160
ngspice 1 -> plot y vs time a
```





Characterization of the plot

Calculate:

1. Rise time

It is time taken to the output waveform to 20% value to 80% value.

```
x0 = 2.18191e-09, y0 = 0.660032
x0 = 2.2457e-09, y0 = 2.64
```

$$\text{Rise time} = (2.2457 - 2.1819)\text{e-09} = 63.8\text{psec}$$

2. Fall time

It is the time taken by output for transition from 80% to 20%.

```
x0 = 4.052e-09, y0 = 2.64019
x0 = 4.09451e-09, y0 = 0.66
```

$$\text{Fall time} = (4.09451 - 4.052)\text{e-09} = 42.51\text{psec}$$

3. Propagation delay

It is the time difference between the 50% of input and 50% of the output.

```
x0 = 2.14935e-09, y0 = 1.65032  
x0 = 2.21e-09, y0 = 1.65016
```

Propagation delay =(2.21 - 2.14935)e-09 = 60.65psec.

4. Cell rise delay

Time taken by output to rise to 50% and input to fall to 50%

```
x0 = 2.14992e-09, y0 = 1.65014  
x0 = 2.21078e-09, y0 = 1.65009
```

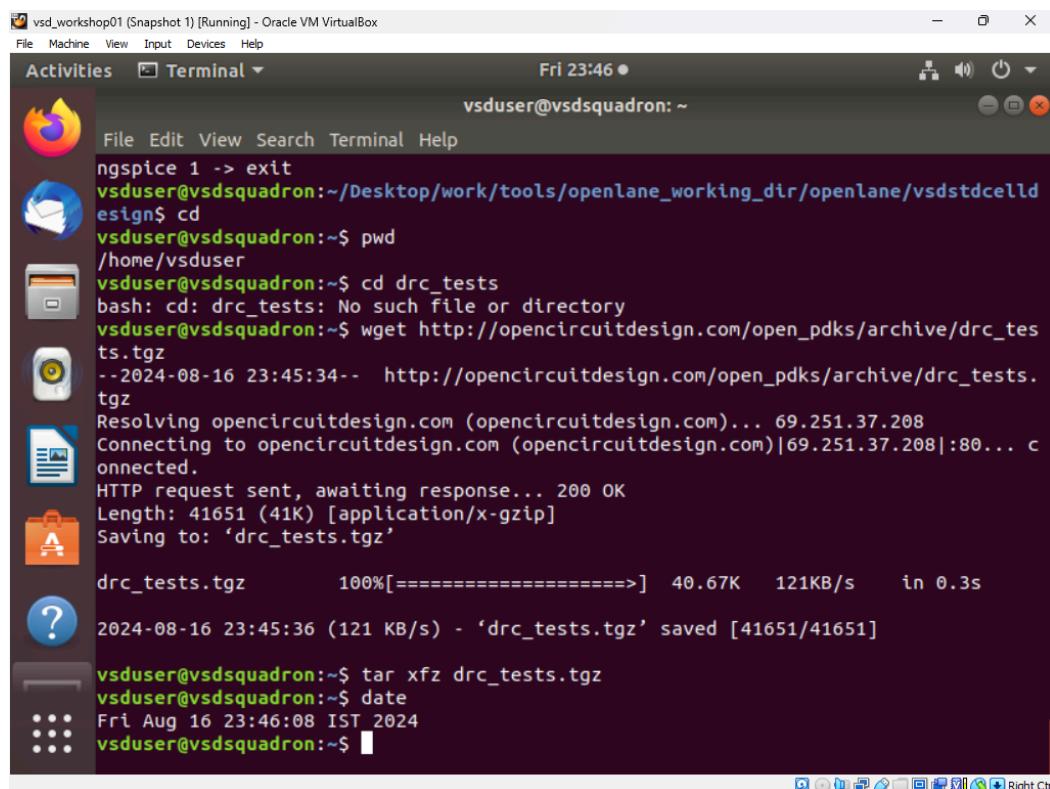
Cell rise delay=(2.21078-2.14992)e-09=60.86psec

5. Cell fall delay

Time taken by output to fall to 50% and input to rise to 50%

```
x0 = 4.05e-09, y0 = 1.65016  
x0 = 4.07725e-09, y0 = 1.65016
```

Cell fall delay=(4.07725-4.05)e-09 = 27.25psec



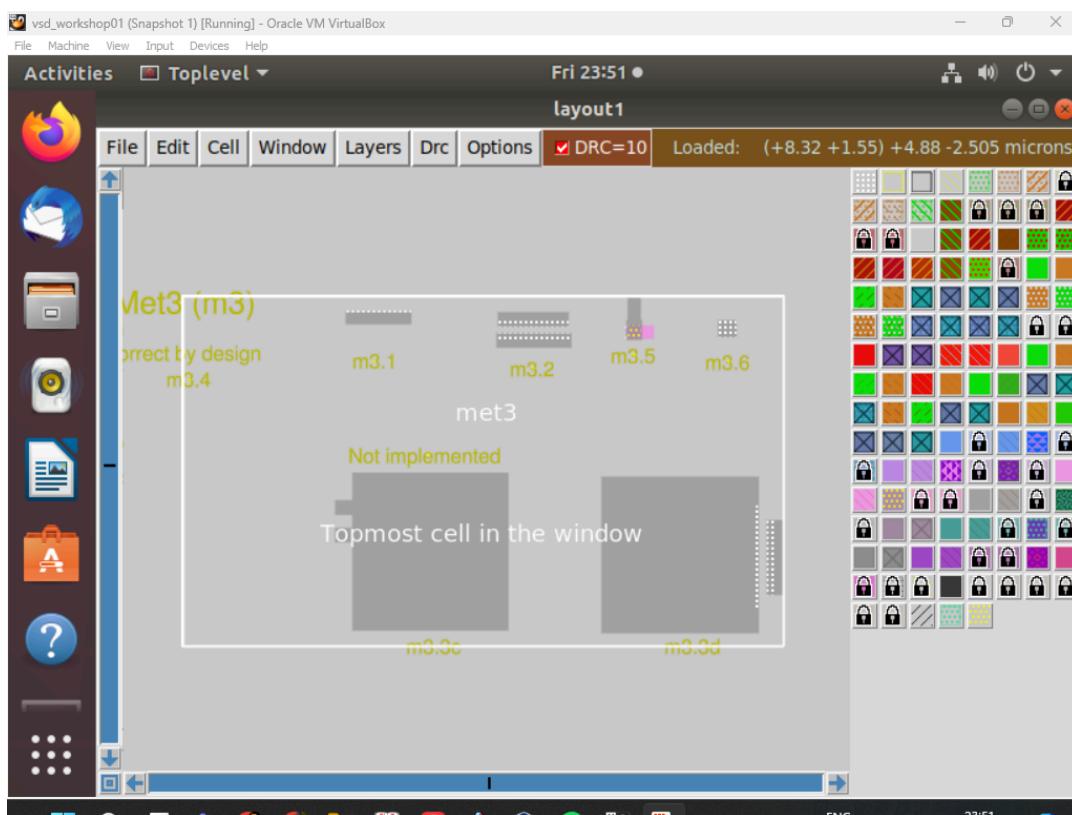
vsd_workshop01 (Snapshot 1) [Running] - Oracle VM VirtualBox

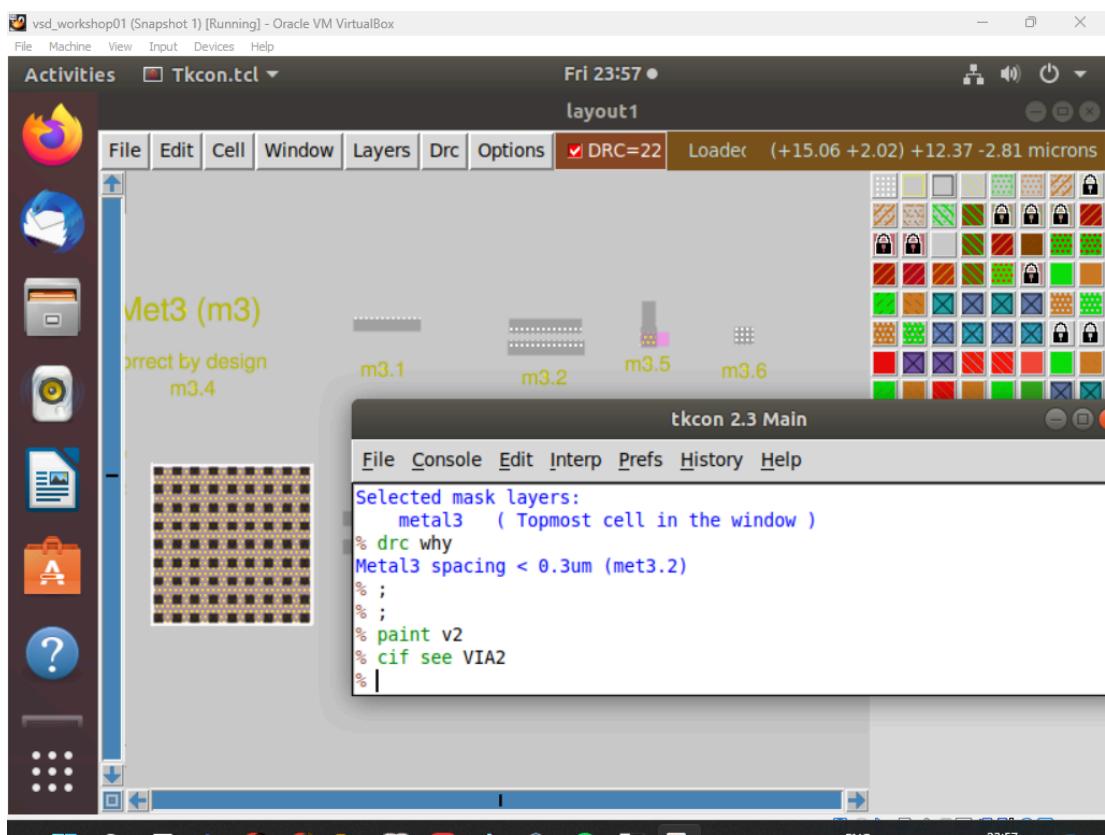
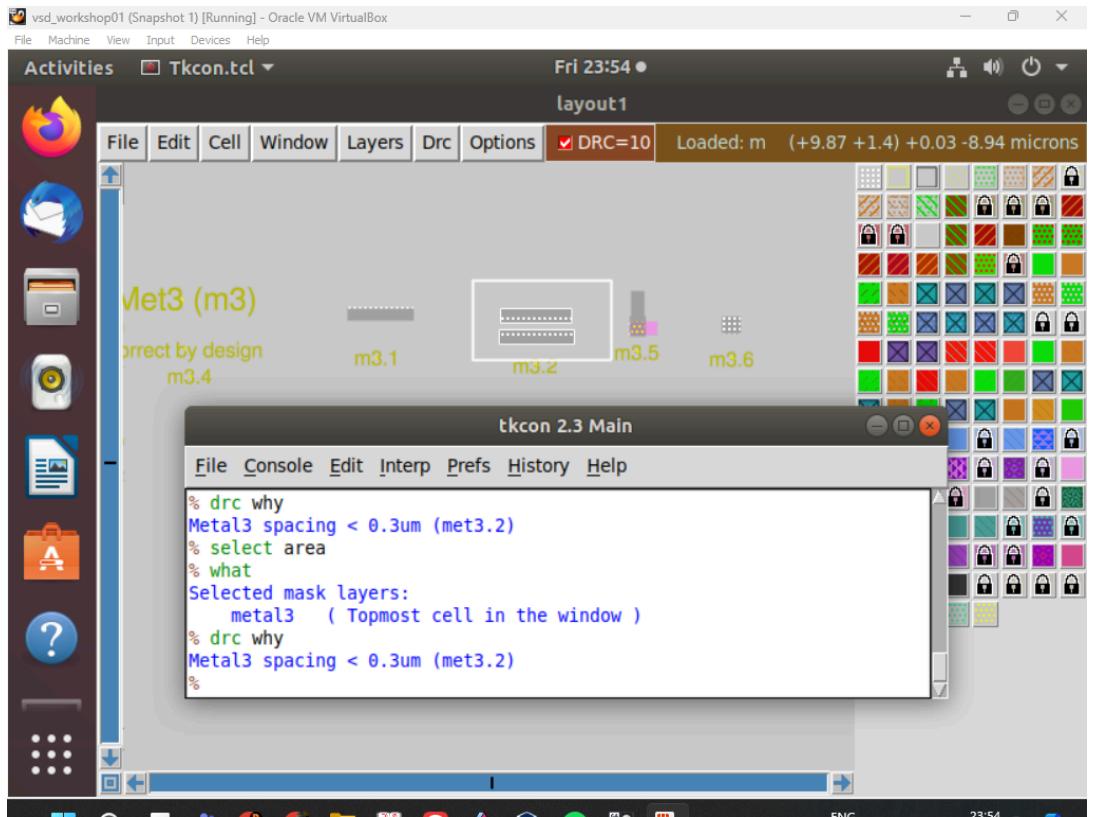
File Machine View Input Devices Help

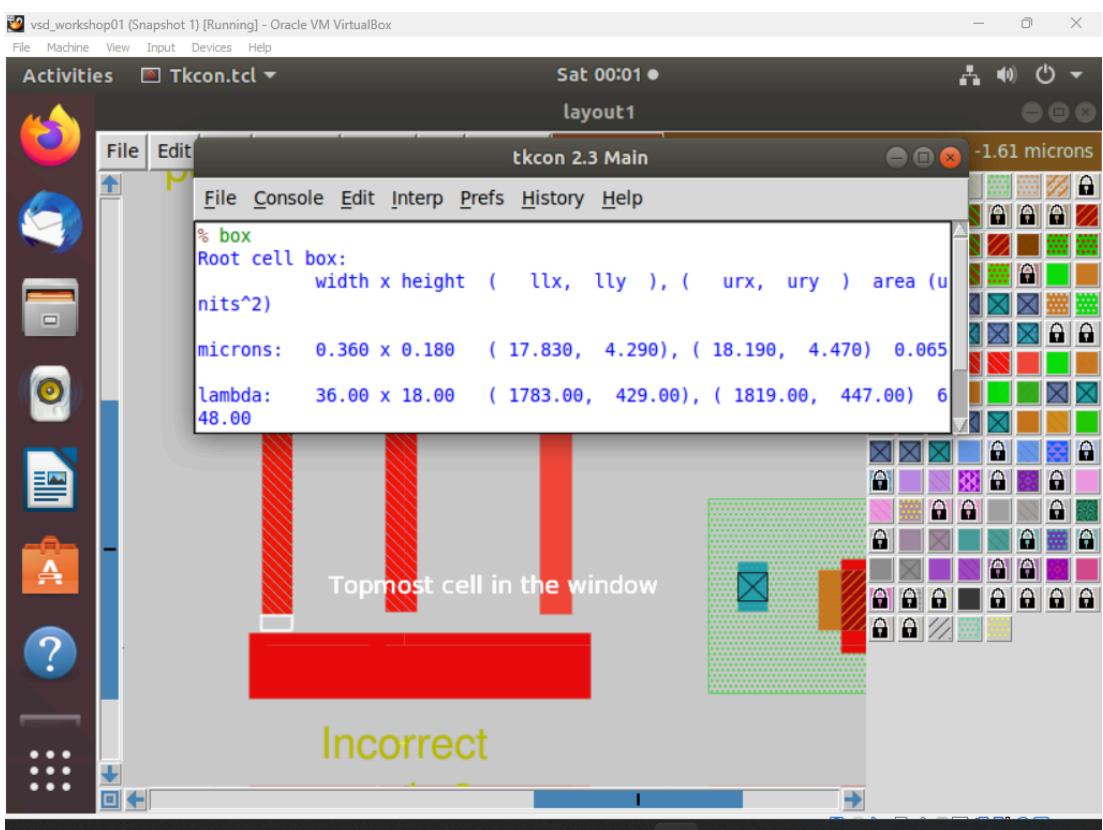
Activities Terminal Fri 23:48 •

vsduser@vsdsquadron: ~/drc_tests

```
-rw-rw-r-- 1 vsduser vsduser 11586 Sep 15 2020 licon.mag
-rw-rw-r-- 1 vsduser vsduser 1480 Sep 15 2020 li.mag
-rw-rw-r-- 1 vsduser vsduser 4648 Sep 15 2020 lvtm.mag
-rw-rw-r-- 1 vsduser vsduser 2565 Sep 15 2020 .magicrc
-rw-rw-r-- 1 vsduser vsduser 1198 Sep 15 2020 mcon.mag
-rw-rw-r-- 1 vsduser vsduser 2103 Sep 15 2020 met1.mag
-rw-rw-r-- 1 vsduser vsduser 1799 Sep 15 2020 met2.mag
-rw-rw-r-- 1 vsduser vsduser 1500 Sep 16 2020 met3.mag
-rw-rw-r-- 1 vsduser vsduser 1114 Sep 16 2020 met4.mag
-rw-rw-r-- 1 vsduser vsduser 757 Sep 15 2020 met5.mag
-rw-rw-r-- 1 vsduser vsduser 1948 Sep 15 2020 npc.mag
-rw-rw-r-- 1 vsduser vsduser 2497 Sep 15 2020 nsd.mag
-rw-rw-r-- 1 vsduser vsduser 1351 Sep 16 2020 nwell.mag
-rw-rw-r-- 1 vsduser vsduser 536 Sep 15 2020 pad.mag
-rw-rw-r-- 1 vsduser vsduser 5588 Sep 16 2020 poly.mag
-rw-rw-r-- 1 vsduser vsduser 2565 Sep 15 2020 psd.mag
-rw-rw-r-- 1 vsduser vsduser 3025 Sep 15 2020 rpm.mag
-rw-rw-r-- 1 vsduser vsduser 135962 Sep 16 2020 sky130A.tech
-rw-rw-r-- 1 vsduser vsduser 2476 Sep 16 2020 tunn.mag
-rw-rw-r-- 1 vsduser vsduser 4114 Sep 16 2020 varac.mag
-rw-rw-r-- 1 vsduser vsduser 1271 Sep 15 2020 via2.mag
-rw-rw-r-- 1 vsduser vsduser 1267 Sep 15 2020 via3.mag
-rw-rw-r-- 1 vsduser vsduser 966 Sep 15 2020 via4.mag
-rw-rw-r-- 1 vsduser vsduser 955 Sep 15 2020 via.mag
vsduser@vsdsquadron:~/drc_tests$ gvim .magicrc
vsduser@vsdsquadron:~/drc_tests$ magic -d XR 8
```







vsd_workshop01 (Snapshot 1) [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal

Sat 00:14 •

vsduser@vsdsquadron: ~/drc_tests

```
#-----
# width xhrpoly 350 "xhrpoly resistor width < %d (P+ poly.1a)"
# NOTE: xhrpoly resistor requires choice of discrete widths 0.35, 0.69, ... up to 1.27.

#-----
# uehrpoly (P+ poly resistor, 2kOhm/sq)
#-----

width uehrpoly 350 "uehrpoly resistor width < %d"
spacing xhrpoly,uehrpoly,xpc alldiff 480 touching_illegal \
    "xhrpoly/uehrpoly resistor spacing to diffusion < %d (poly.9)"
spacing xhrpoly,uehrpoly,xpc allpolynonres 480 touching_illegal \
    "xhrpoly/uehrpoly resistor spacing to allpolynonres < %d (poly.9)"

#-----
# MOS Varactor device rules
#-----
```

overhang *nsd var,varhvt 250 \
 "N-Tap overhang of Varactor < %d (var.4)"

overhang *mvnsd mvvar 250 \
-- INSERT --

5187,2 87%

