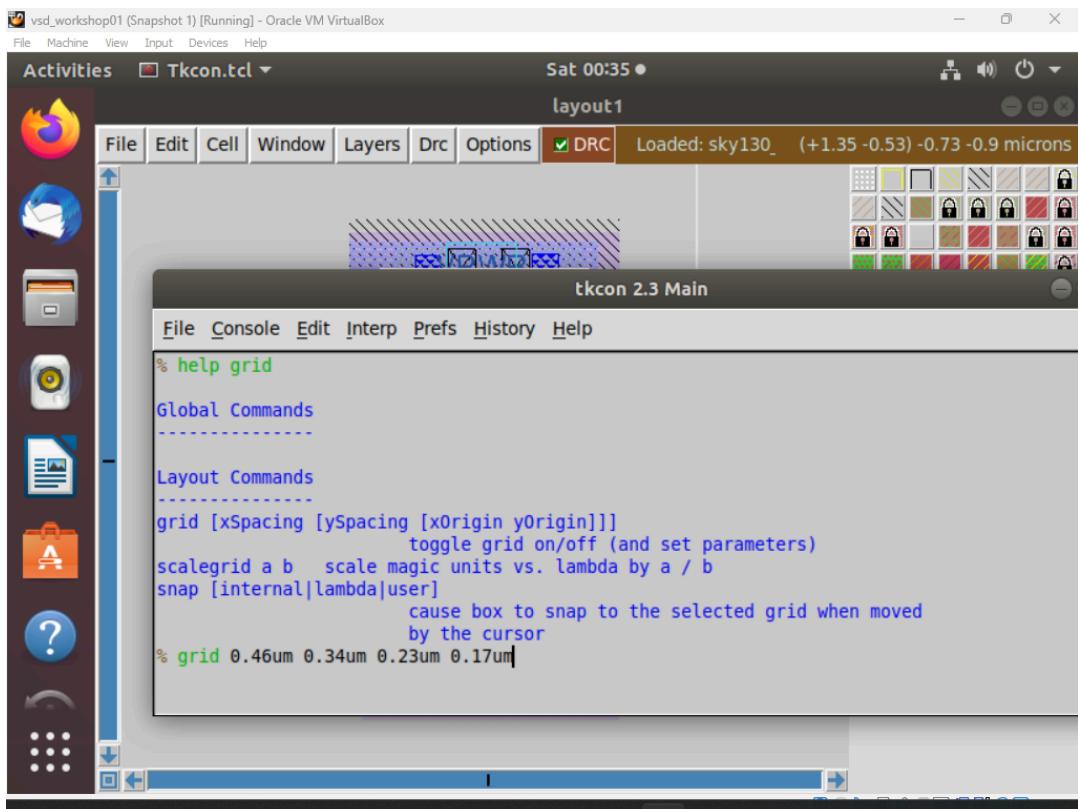
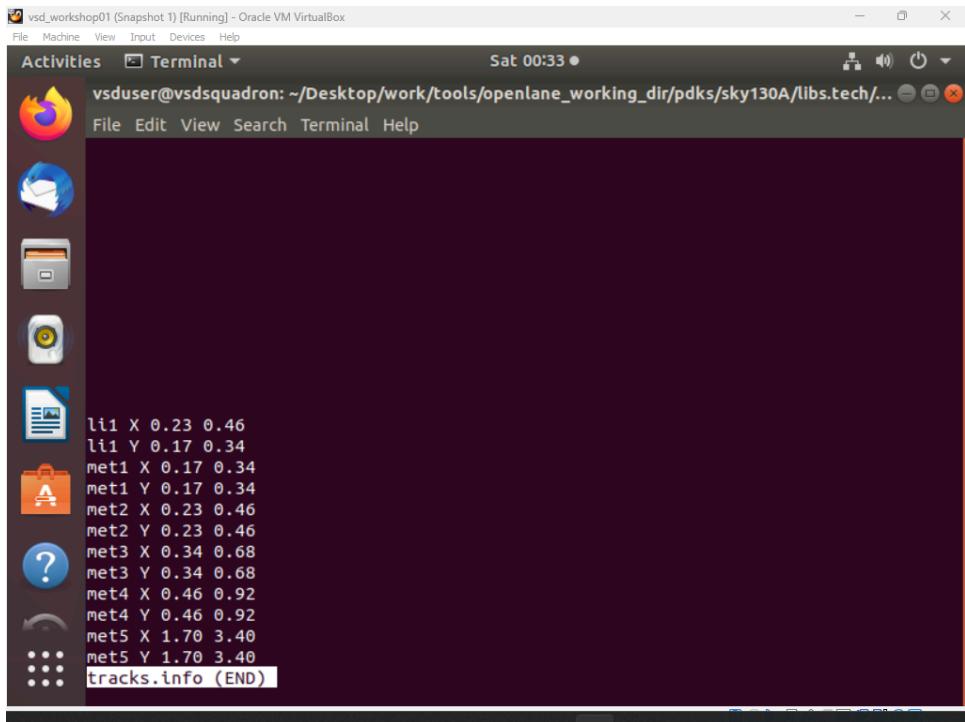
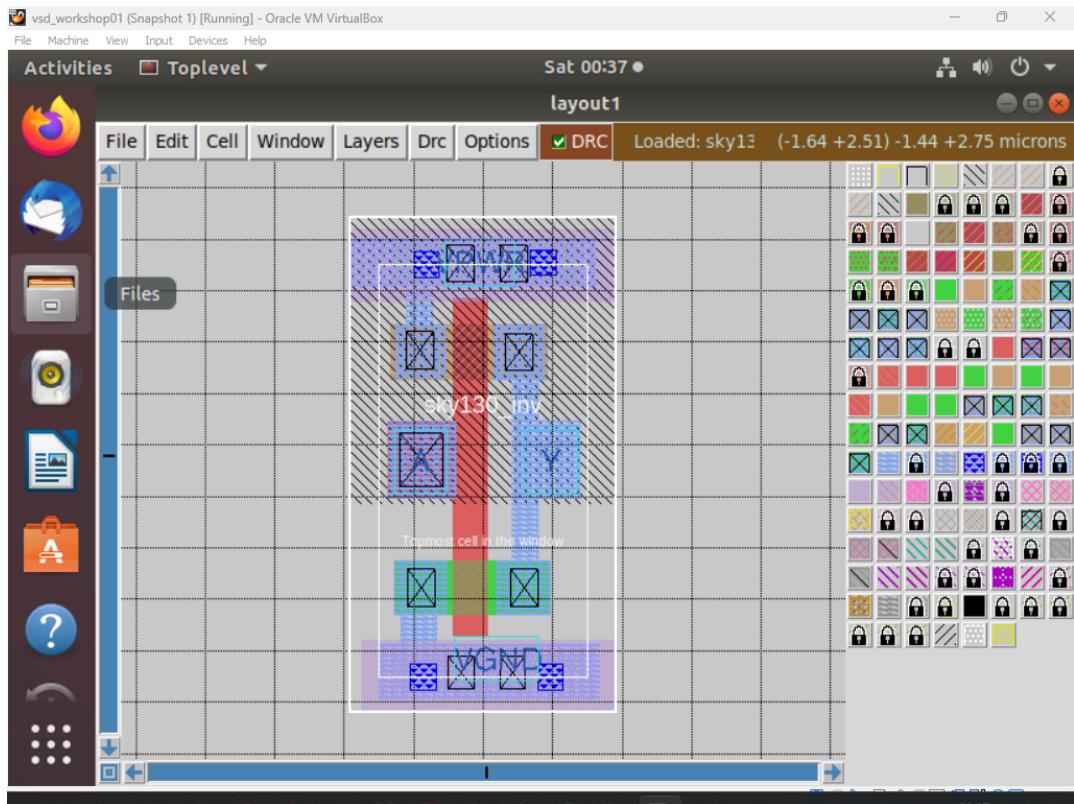
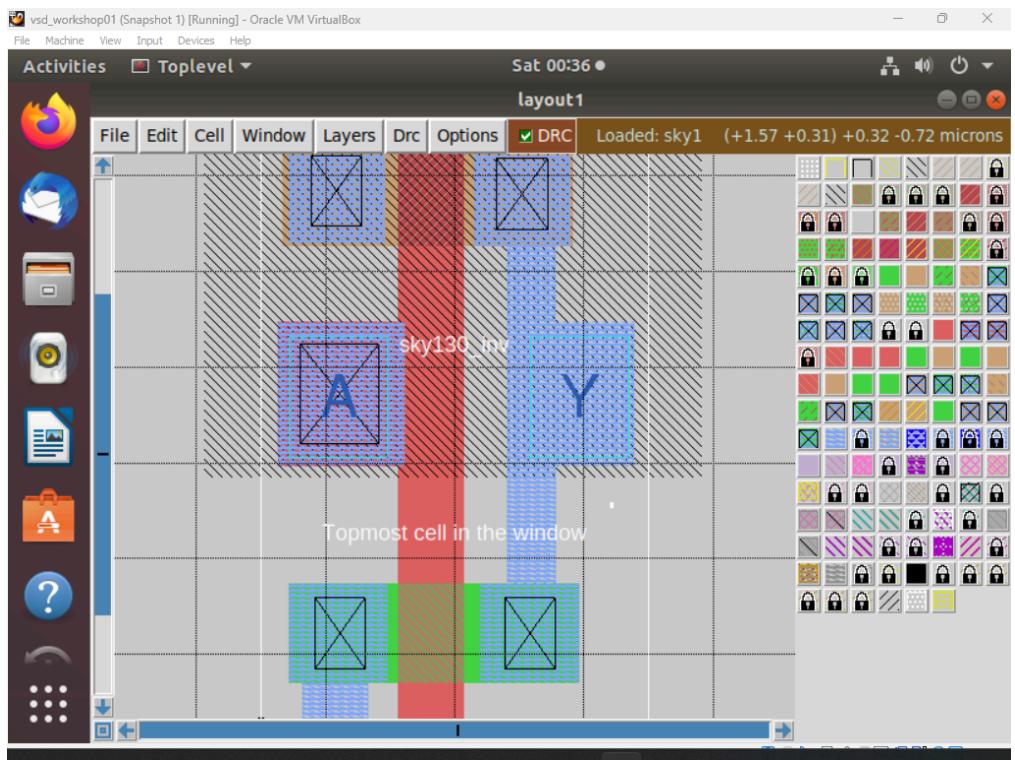


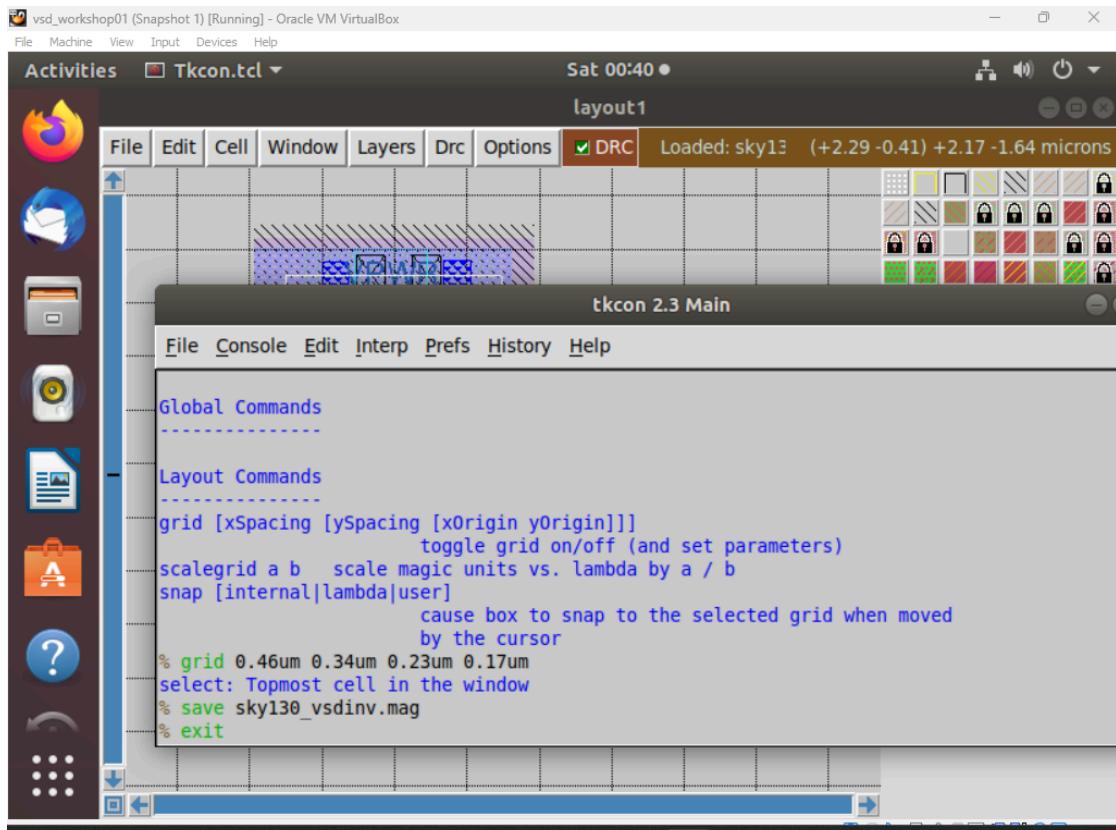
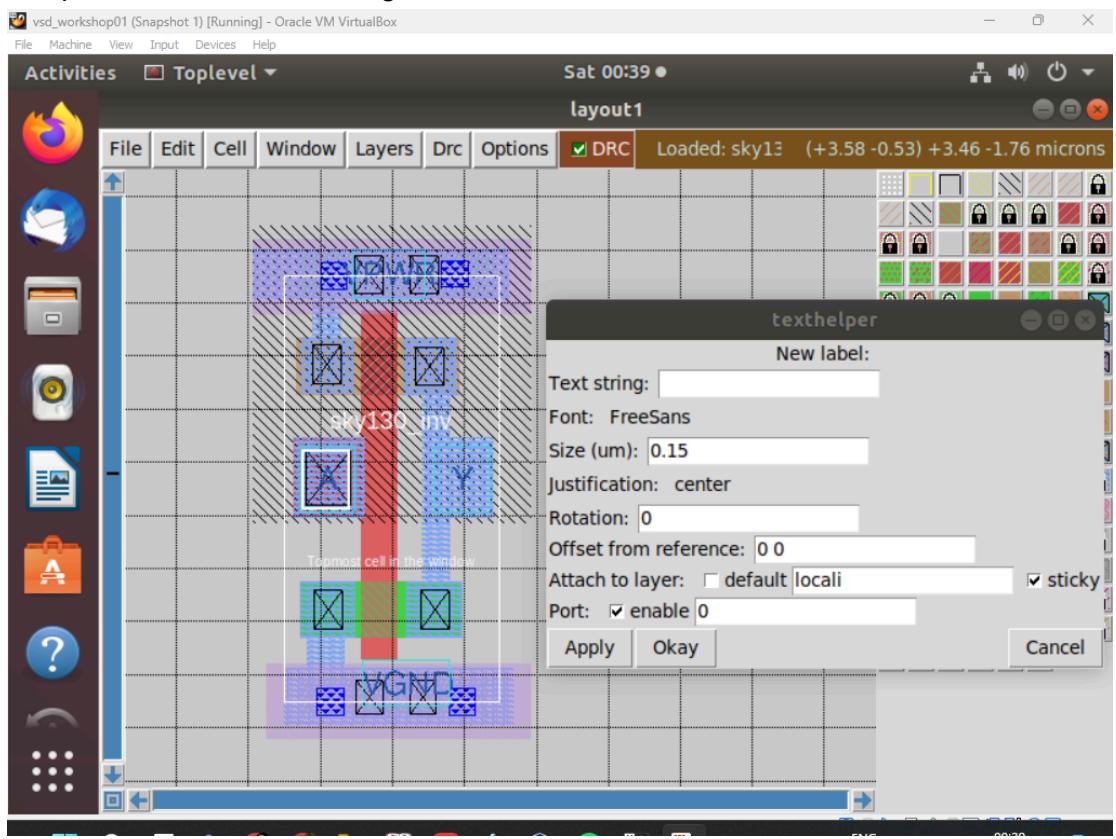
Day 4&5

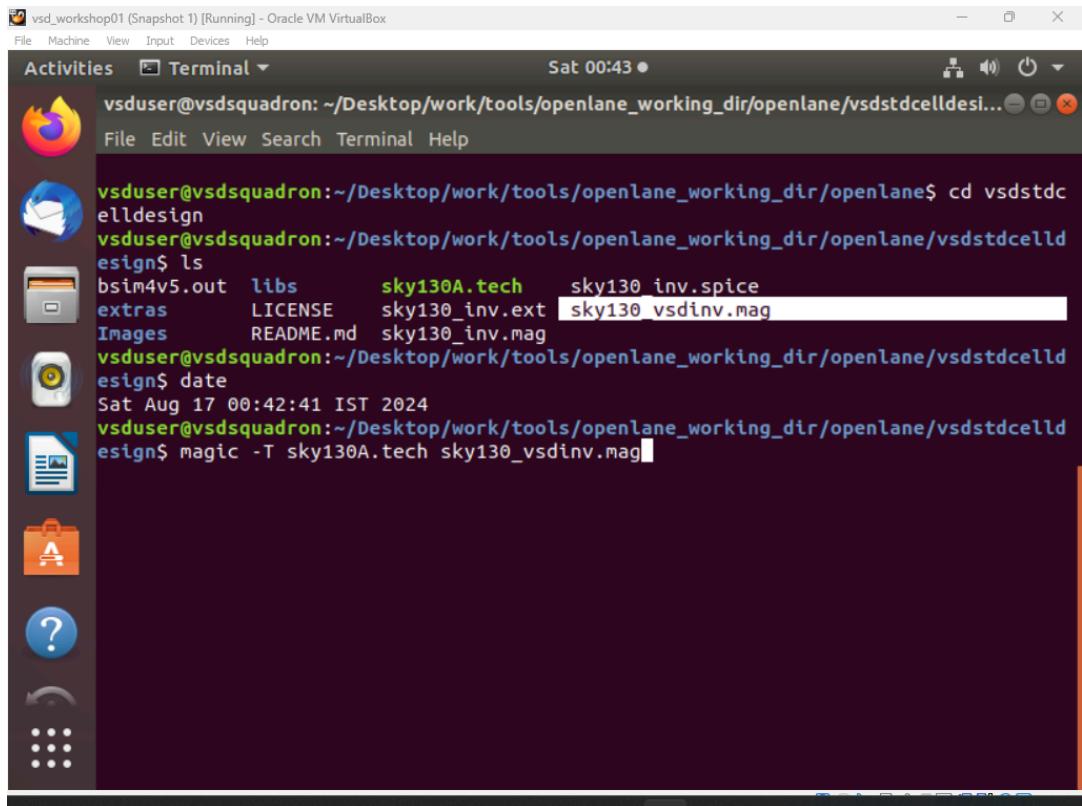


Grid in magic



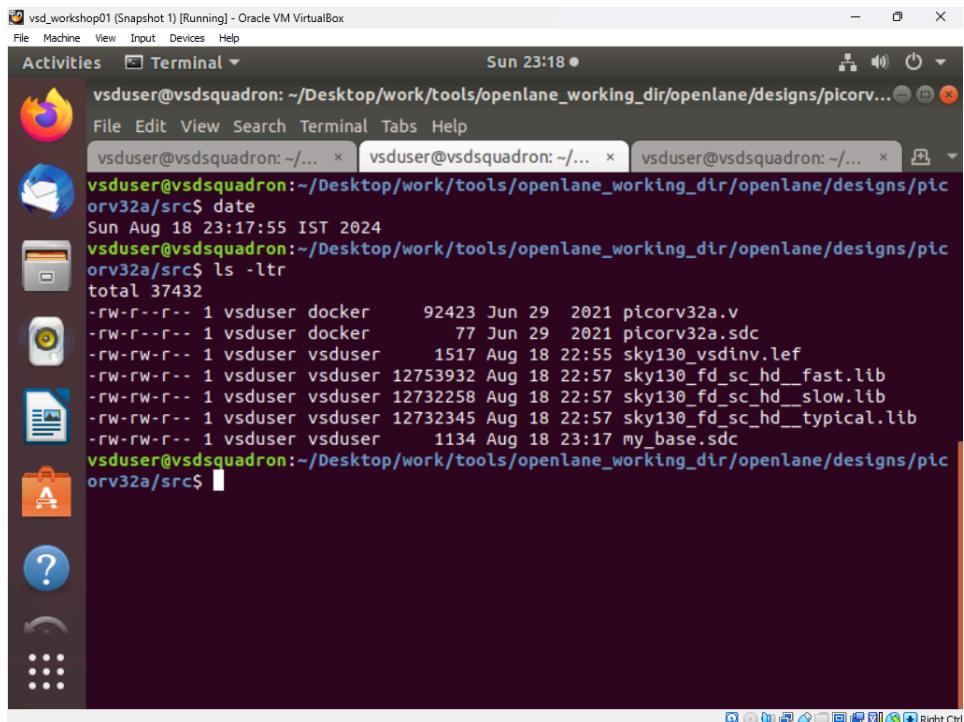
Edit port names/values in magic





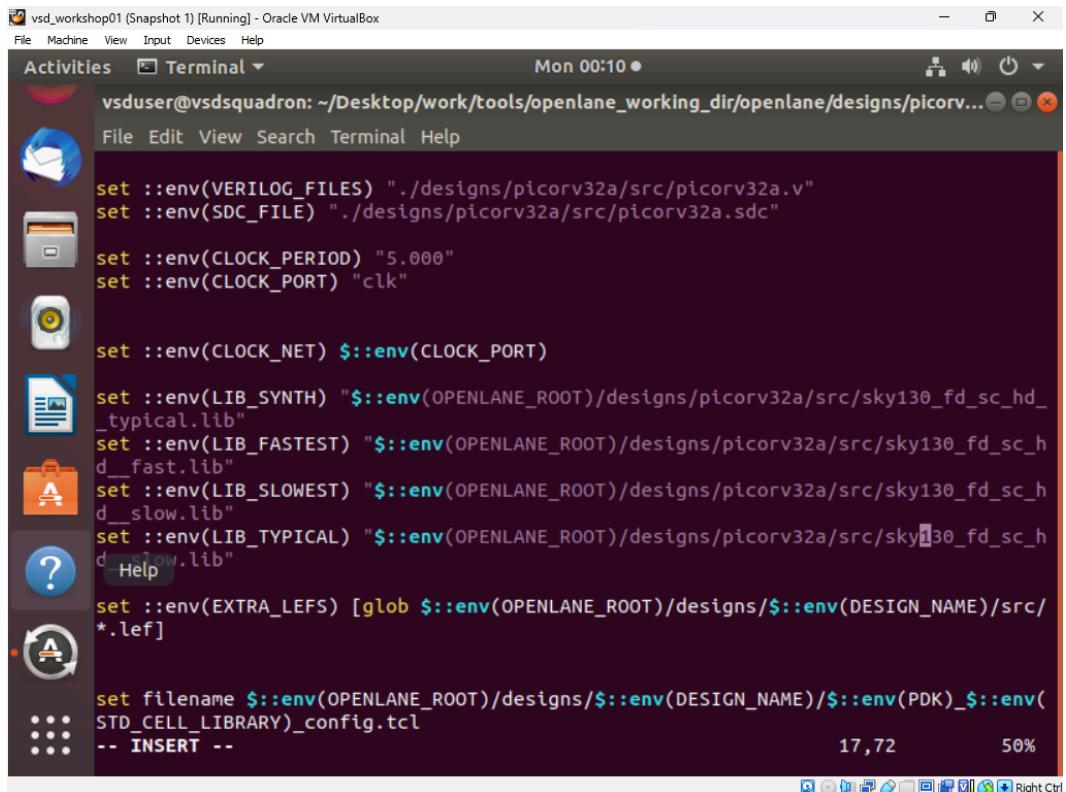
```
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane/vsdstdcelldesign$ ls
bsim4v5.out  libs      sky130A.tech    sky130_inv.spice
extras        LICENSE   sky130_inv.ext  sky130_vsdinv.mag
Images        README.md  sky130_inv.mag
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane/vsdstdcelldesign$ date
Sat Aug 17 00:42:41 IST 2024
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane/vsdstdcelldesign$ magic -T sky130A.tech sky130_vsdinv.mag
```

Copy the newly generated lef and associated required lib files to 'picorv32a' design 'src' directory



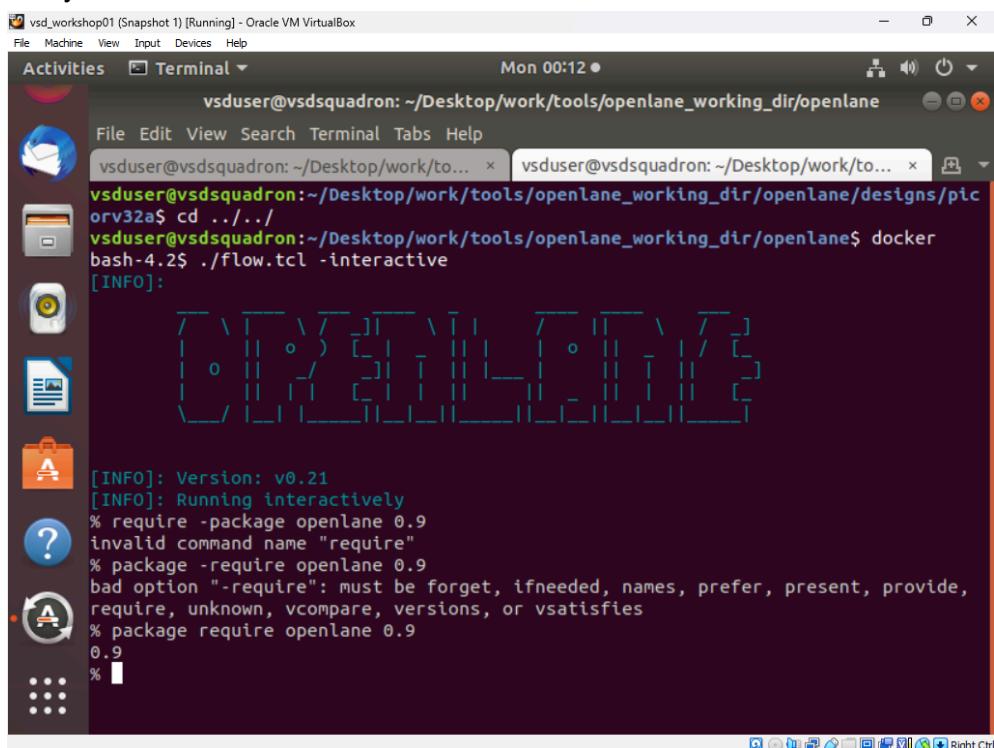
```
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane/designs/picorv32a/src$ date
Sun Aug 18 23:17:55 IST 2024
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane/designs/picorv32a/src$ ls -ltr
total 37432
-rw-r--r-- 1 vsduser docker 92423 Jun 29 2021 picorv32a.v
-rw-r--r-- 1 vsduser docker 77 Jun 29 2021 picorv32a.sdc
-rw-rw-r-- 1 vsduser vsduser 1517 Aug 18 22:55 sky130_vsdinv.lef
-rw-rw-r-- 1 vsduser vsduser 12753932 Aug 18 22:57 sky130_fd_sc_hd_fast.lib
-rw-rw-r-- 1 vsduser vsduser 12732258 Aug 18 22:57 sky130_fd_sc_hd_slow.lib
-rw-rw-r-- 1 vsduser vsduser 12732345 Aug 18 22:57 sky130_fd_sc_hd_typical.lib
-rw-rw-r-- 1 vsduser vsduser 1134 Aug 18 23:17 my_base.sdc
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane/designs/picorv32a/src$
```

Edit config.tcl as shown



```
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane/designs/picorv32a$ ./config.tcl
set ::env(VERILOG_FILES) "./designs/picorv32a/src/picorv32a.v"
set ::env(SDC_FILE) "./designs/picorv32a/src/picorv32a.sdc"
set ::env(CLOCK_PERIOD) "5.000"
set ::env(CLOCK_PORT) "clk"
set ::env(CLOCK_NET) $::env(CLOCK_PORT)
set ::env(LIB_SYNTH) "$::env(OPENLANE_ROOT)/designs/picorv32a/src/sky130_fd_sc_hd_typical.lib"
set ::env(LIB_FASTEST) "$::env(OPENLANE_ROOT)/designs/picorv32a/src/sky130_fd_sc_hd_fast.lib"
set ::env(LIB_SLOWEST) "$::env(OPENLANE_ROOT)/designs/picorv32a/src/sky130_fd_sc_hd_slow.lib"
set ::env(LIB_TYPICAL) "$::env(OPENLANE_ROOT)/designs/picorv32a/src/sky130_fd_sc_hd_low.lib"
set ::env(EXTRA_LEFS) [glob $::env(OPENLANE_ROOT)/designs/$::env(DESIGN_NAME)/src/*.lef]
set filename $::env(OPENLANE_ROOT)/designs/$::env(DESIGN_NAME)/$::env(PDK)_$::env(STD_CELL_LIBRARY)_config.tcl
-- INSERT --
```

Run openlane by invoking docker and run synthesis by using additional commands to add the newly created lef file.



```
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane$ docker bash-4.2$ ./flow.tcl -interactive
[INFO]:
[INFO]: Version: v0.21
[INFO]: Running interactively
% require -package openlane 0.9
invalid command name "require"
% package -require openlane 0.9
bad option "-require": must be forget, ifneeded, names, prefer, present, provide,
require, unknown, vcompare, versions, or vsatisfies
% package require openlane 0.9
0.9
%
```

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

File Machine View Input Devices Help

Activities Terminal Mon 00:14

```
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
File Edit View Search Terminal Tabs Help
vsduser@vsdsquadron: ~/Desktop/work/to... x vsduser@vsdsquadron: ~/Desktop/work/to... x
mergeLef.py : Merging LEFs
sky130_fd_sc_hd.lef: SITEs matched found: 0
sky130_fd_sc_hd.lef: MACROs matched found: 437
sky130_ef_sc_hd_fill_12.lef: SITEs matched found: 0
sky130_ef_sc_hd_fill_12.lef: MACROs matched found: 1
sky130_ef_sc_hd_decap_12.lef: SITEs matched found: 0
sky130_ef_sc_hd_decap_12.lef: MACROs matched found: 1
sky130_ef_sc_hd_fakediode_2.lef: SITEs matched found: 0
sky130_ef_sc_hd_fakediode_2.lef: MACROs matched found: 1
mergeLef.py : Merging LEFs complete
mergeLef.py : Merging LEFs
sky130_vsdinv.lef: SITEs matched found: 0
sky130_vsdinv.lef: MACROs matched found: 1
mergeLef.py : Merging LEFs complete
[INFO]: Merging the following extra LEFs: /openLANE_flow/designs/picorv32a/src/sky130_vsdinv.lef
[INFO]: Trimming Liberty...
[INFO]: Generating Exclude List...
[INFO]: Storing configs into config.tcl ...
[INFO]: Preparation complete
% set lefs [glob $::env(DESIGN_DIR)/src/*.lef]
/openLANE_flow/designs/picorv32a/src/sky130_vsdinv.lef
% add_lefs -src $lefs
[INFO]: Merging /openLANE_flow/designs/picorv32a/src/sky130_vsdinv.lef
%
```

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

File Machine View Input Devices Help

Activities Terminal Mon 00:16

```
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
File Edit View Search Terminal Tabs Help
vsduser@vsdsquadron: ~/Desktop/work/to... x vsduser@vsdsquadron: ~/Desktop/work/to... x
puts "[INFO]: Setting input delay to: $input_delay_value"
[INFO]: Setting input delay to: 4.946000000000001
set_max_fanout $::env(SYNTH_MAX_FANOUT) [current_design]
set_clk_indx [lsearch [all_inputs] [get_port $::env(CLOCK_PORT)]]
#set_rst_indx [lsearch [all_inputs] [get_port resetn]]
set_all_inputs_wo_clk [lreplace [all_inputs] $clk_indx $rst_indx]
#set_all_inputs_wo_clk_rst [lreplace $all_inputs_wo_clk $rst_indx $rst_indx]
set_all_inputs_wo_clk_rst $all_inputs_wo_clk
# correct resetn
set_input_delay $input_delay_value -clock [get_clocks $::env(CLOCK_PORT)] $all_in
puts_wo_clk_rst
#set_input_delay 0.0 -clock [get_clocks $::env(CLOCK_PORT)] {resetn}
set_output_delay $output_delay_value -clock [get_clocks $::env(CLOCK_PORT)] [all_
outputs]
# TODO set this as parameter
set_driving_cell -lib_cell $::env(SYNTH_DRIVING_CELL) -pin $::env(SYNTH_DRIVING_CE
LL_PIN) [all_inputs]
set_cap_load [expr $::env(SYNTH_CAP_LOAD) / 1000.0]
puts "[INFO]: Setting load to: $cap_load"
[INFO]: Setting load to: 0.01765
set_load $cap_load [all_outputs]
tns -711.59
wns -23.89
[INFO]: Synthesis was successful
%
```

```

vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
File Edit View Search Terminal Tabs Help
vsduser@vsdsquadron: ~/Desktop/work/to... x vsduser@vsdsquadron: ~/Desktop/work/to... x
sky130_fd_sc_hd_o31a_2 19
sky130_fd_sc_hd_o31ai_2 1
sky130_fd_sc_hd_o32a_2 109
sky130_fd_sc_hd_o41a_2 2
sky130_fd_sc_hd_or2_2 1088
sky130_fd_sc_hd_or2b_2 25
sky130_fd_sc_hd_or3_2 68
sky130_fd_sc_hd_or3b_2 5
sky130_fd_sc_hd_or4_2 93
sky130_fd_sc_hd_or4b_2 6
sky130_fd_sc_hd_or4bb_2 2
sky130_vsdinv 1554

Chip area for module '\picorv32a': 147712.918400

29. Executing Verilog backend.
Dumping module '\picorv32a'.

Warnings: 307 unique messages, 307 total
End of script. Logfile hash: 70df4fcfc8e, CPU: user 17.11s system 0.16s, MEM: 95.98
MB peak
Yosys 0.9+3621 (git sha1 84e9fa7, gcc 8.3.1 -fPIC -Os)
Time spent: 48% 2x abc (15 sec), 15% 33x opt_expr (5 sec), ...
[INFO]: Changing netlist from 0 to /openLANE_flow/designs/picorv32a/runs/18-08_18-42/results/synthesis/picorv32a.synthesis.v

```

It can further be modified by setting parameters to improve timing.

```

vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane/configuration
File Edit View Search Terminal Tabs Help
vsduser@vsdsquadron: ~/... x vsduser@vsdsquadron: ~/... x vsduser@vsdsquadron: ~/... x
These variables are optional that can be specified in the design configuration file.

### Synthesis
| Variable | Description |
|-----|-----|
| `LIB_SYNTH` | The library used for synthesis by yosys. <br> (Default: '$::env(PDK_ROOT)/$::env(PDK)/libs.ref/$::env(STD_CELL_LIBRARY)/lib/sky130_fd_sc_hd_tt_025C_1v80.lib') |
| `SYNTH_BIN` | The yosys binary used in the flow. <br> (Default: 'yosys') |
| `SYNTH_DRIVING_CELL` | The cell to drive the input ports. <br> (Default: 'sky130_fd_sc_hd_inv_8') |
| `SYNTH_DRIVING_CELL_PIN` | The name of the SYNTH_DRIVING_CELL output pin. <br> (Default: 'Y') |
| `SYNTH_CAP_LOAD` | The capacitive load on the output ports in femtofarads. <br> (Default: '17.65' ff) |
| `SYNTH_MAX_FANOUT` | The max load that the output ports can drive. <br> (Default: '5' cells) |
| `SYNTH_MAX_TRAN` | The max transition time (slew) from high to low or low to high on cell inputs in ns. Used in synthesis <br> (Default: Calculated at runtime as '10%' of the provided clock period, unless this exceeds a set DEFAULT_MAX_TRAN, in which case it will be used as is). |
| `SYNTH_STRATEGY` | Strategies for abc logic synthesis and technology mapping <br> :

```

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

File Machine View Input Devices Help

Activities Terminal Mon 00:23

```
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
File Edit View Search Terminal Tabs Help
vsduser@vsdsquadron: ~/... x vsduser@vsdsquadron: ~/... x vsduser@vsdsquadron: ~/... x
set_output_delay $output_delay_value -clock [get_clocks $::env(CLOCK_PORT)] [all_outputs]
# TODO set this as parameter
set_driving_cell -lib_cell $::env(SYNTH_DRIVING_CELL) -pin $::env(SYNTH_DRIVING_CE_LL_PIN) [all_inputs]
set_cap_load [expr $::env(SYNTH_CAP_LOAD) / 1000.0]
puts "[INFO]: Setting load to: $cap_load"
[INFO]: Setting load to: 0.01765
set_load $cap_load [all_outputs]
tns -711.59
wns -23.89
[INFO]: Synthesis was successful
% echo $::env(SYNTH_STRATEGY)
AREA 0
% set ::env(SYNTH_STRATEGY) 1
1
% echo $::env(SYNTH_BUFFERING)
1
% echo $::env(SYNTH_SIZING)
0
% set ::env(SYNTH_SIZING) 1
1
% echo $::env(SYNTH_DRIVING_CELL)
sky130_fd_sc_hd_inv_8
% run_synthesis
```

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

File Machine View Input Devices Help

Activities Terminal Mon 00:27

```
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
File Edit View Search Terminal Tabs Help
vsduser@vsdsquadron: ~/... x vsduser@vsdsquadron: ~/... x vsduser@vsdsquadron: ~/... x
#set all_inputs_wo_clk_RST [lreplace $all_inputs_wo_clk $rst_indx $rst_indx]
set all_inputs_wo_clk_RST $all_inputs_wo_clk
# correct resetn
set_input_delay $input_delay_value -clock [get_clocks $::env(CLOCK_PORT)] $all_in
puts_wo_clk_RST
#set_input_delay 0.0 -clock [get_clocks $::env(CLOCK_PORT)] {resetn}
set_output_delay $output_delay_value -clock [get_clocks $::env(CLOCK_PORT)] [all_outputs]
# TODO set this as parameter
set_driving_cell -lib_cell $::env(SYNTH_DRIVING_CELL) -pin $::env(SYNTH_DRIVING_CE_LL_PIN) [all_inputs]
set_cap_load [expr $::env(SYNTH_CAP_LOAD) / 1000.0]
puts "[INFO]: Setting load to: $cap_load"
[INFO]: Setting load to: 0.01765
set_load $cap_load [all_outputs]
tns -711.59
wns -23.89
[INFO]: Synthesis was successful
% set ::env(SYNTH_SIZINIG) 1
can't read "::env(SYNTH_SIZINIG)": no such variable
% set ::env(SYNTH_SIZING) 1
1
% set ::env(SYNTH_STRATEGY) "DELAY 3"
DELAY 3
%
```

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

File Machine View Input Devices Help

Activities Terminal Mon 00:30 ●

File Edit View Search Terminal Tabs Help

vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane

```
This program is licensed under the BSD-3 license. See the LICENSE file for details.
.
Components of this program may be licensed under more restrictive licenses which must be honored.
Notice 0: Reading LEF file: /openLANE_flow/designs/picorv32a/runs/18-08_18-42/tmp/merged_unpadded.lef
Notice 0: Created 13 technology layers
Notice 0: Created 25 technology vias
Notice 0: Created 442 library cells
Notice 0: Finished LEF file: /openLANE_flow/designs/picorv32a/runs/18-08_18-42/tmp/merged_unpadded.lef
[INFO IFP-0001] Added 238 rows of 1412 sites.
[INFO] Extracting DIE_AREA and CORE_AREA from the floorplan
[INFO] Floorplanned on a die area of 0.0 0.0 660.685 671.405 (microns). Saving to /openLANE_flow/designs/picorv32a/runs/18-08_18-42/reports/floorplan/9-verilog2def.die_area.rpt.
[INFO] Floorplanned on a core area of 5.52 10.88 655.04 658.24 (microns). Saving to /openLANE_flow/designs/picorv32a/runs/18-08_18-42/reports/floorplan/9-verilog2def.core_area.rpt.
[INFO]: Core area width: 649.52
[INFO]: Core area height: 647.36
[INFO]: Changing layout from /openLANE_flow/designs/picorv32a/runs/18-08_18-42/tmp/placement/7-replace.def to /openLANE_flow/designs/picorv32a/runs/18-08_18-42/tmp/floorplan/9-verilog2def_openroad.def
%
```

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

File Machine View Input Devices Help

Activities Terminal Mon 00:35 ●

File Edit View Search Terminal Tabs Help

vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane

```
0.14 0.00 24.22 v _14208/_C1 (sky130_fd_sc_hd_o211a_2)
0.06 0.23 24.46 v _14208/_X (sky130_fd_sc_hd_o211a_2)
1 0.00 0.06 0.00 24.46 v _27600/_D (sky130_fd_sc_hd_dfxtp_2)
                           24.46 data arrival time

0.00 24.73 24.73 clock clk (rise edge)
0.00 24.73 24.73 clock network delay (ideal)
0.00 24.73 24.73 clock reconvergence pessimism
-0.29 24.44 24.73 ^ _27600/_CLK (sky130_fd_sc_hd_dfxtp_2)
                           library setup time
24.44 24.44 data required time
-----
```

24.44 data required time
-24.46 data arrival time

-0.02 slack (VIOLATED)

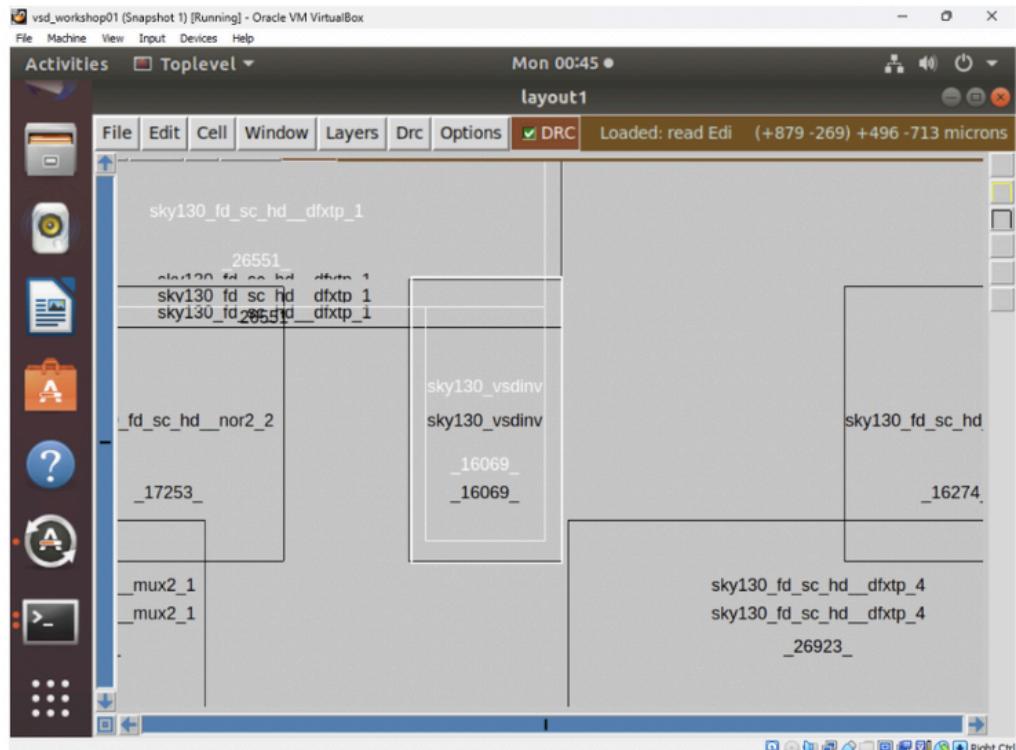
```
wns -25.17
tns -776.63
[INFO]: Global placement was successful
[INFO]: Changing layout from /openLANE_flow/designs/picorv32a/runs/18-08_18-42/results/floorplan/picorv32a.floorplan.def to /openLANE_flow/designs/picorv32a/runs/18-08_18-42/tmp/placement/12-replace.def
```

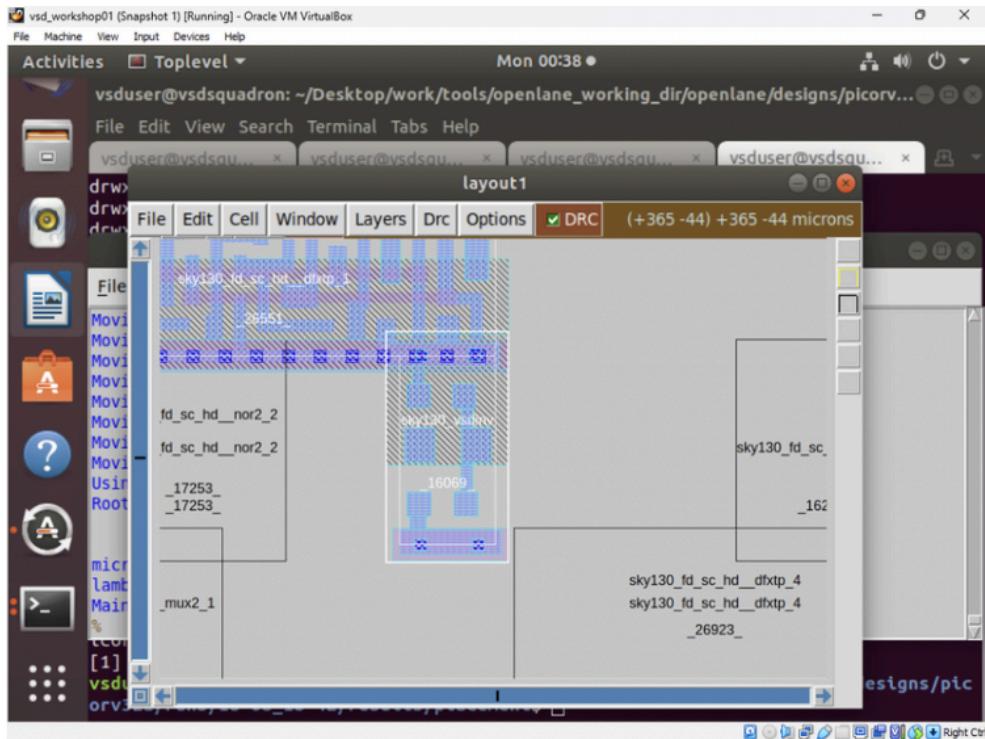
```

vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
[INFO DPL-0020] Mirrored 6226 instances
[INFO DPL-0021] HPWL before      769495.6 u
[INFO DPL-0022] HPWL after       756230.0 u
[INFO DPL-0023] HPWL delta        -1.7 %
[INFO]: Changing layout from /openLANE_flow/designs/picorv32a/runs/18-08_18-42/tmp
/placement/12-resizer.def to /openLANE_flow/designs/picorv32a/runs/18-08_18-42/res
ults/placement/picorv32a.placement.def
[INFO]: Changing layout from /openLANE_flow/designs/picorv32a/runs/18-08_18-42/res
ults/placement/picorv32a.placement.def to /openLANE_flow/designs/picorv32a/runs/18
-08_18-42/results/placement/picorv32a.placement.def
[INFO]: Taking a Screenshot of the Layout Using Klayout...
[INFO]: current step index: 16
Using Techfile: /home/vsduser/Desktop/work/tools/openlane_working_dir/pdks/sky130A
/libs.tech/klayout/sky130A.lyt
Using layout file: /openLANE_flow/designs/picorv32a/runs/18-08_18-42/results/place
ment/picorv32a.placement.def
[INFO] Reading tech file: /home/vsduser/Desktop/work/tools/openlane_working_dir/pd
ks/sky130A/libs.tech/klayout/sky130A.lyt
[INFO] Reading Layout file: /openLANE_flow/designs/picorv32a/runs/18-08_18-42/resu
lts/placement/picorv32a.placement.def
[INFO] Writing out PNG screenshot '/openLANE_flow/designs/picorv32a/runs/18-08_18-
42/results/placement/picorv32a.placement.def.png'
Done
[INFO]: Screenshot taken.
%

```

It can be seen that sky_vsdinv is added to the design by using the magic commands.





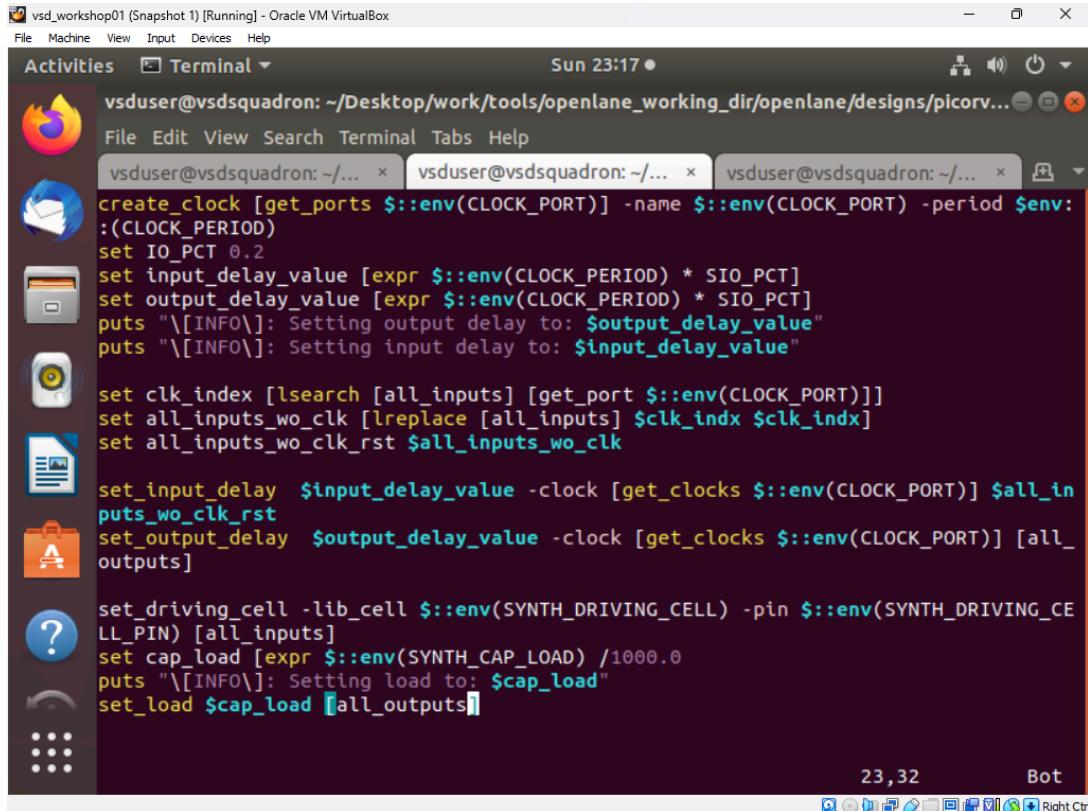
Post synthesis timing analysis with Opensta

```

vsd_workshop01 (Snapshot 1) [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal Mon 13:40 ●
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
File Edit View Terminal Tabs Help
vsduser@vs... x vsduser@vs... x vsduser@vs... x vsduser@vs... x vsduser@vs... x
puts "[INFO]: Setting input delay to: $input_delay_value"
[INFO]: Setting input delay to: 4.946000000000001
set_max_fanout $::env(SYNTH_MAX_FANOUT) [current_design]
set_clk_indx [lsearch [all_inputs] [get_port $::env(CLOCK_PORT)]]
#set_rst_indx [lsearch [all_inputs] [get_port resetn]]
set_all_inputs_wo_clk [lreplace [all_inputs] $clk_indx $clk_indx]
#set_all_inputs_wo_clk_rst [lreplace $all_inputs_wo_clk $rst_indx $rst_indx]
set_all_inputs_wo_clk_rst $all_inputs_wo_clk
# correct resetn
set_input_delay $input_delay_value -clock [get_clocks $::env(CLOCK_PORT)] $all_in
puts_wo_clk_rst
#set_input_delay 0.0 -clock [get_clocks $::env(CLOCK_PORT)] {resetn}
set_output_delay $output_delay_value -clock [get_clocks $::env(CLOCK_PORT)] [all_
outputs]
# TODO set this as parameter
set_driving_cell -lib_cell $::env(SYNTH_DRIVING_CELL) -pin $::env(SYNTH_DRIVING_CE
LL_PIN) [all_inputs]
set_cap_load [expr $::env(SYNTH_CAP_LOAD) / 1000.0]
puts "[INFO]: Setting load to: $cap_load"
[INFO]: Setting load to: 0.01765
set_load $cap_load [all_outputs]
tns -711.59
wns -23.89
[INFO]: Synthesis was successful
%
```

Create pre_sta.conf in openlane directory

My_base



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

File Machine View Input Devices Help

Activities Terminal Sun 23:17 ●

```
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane/designs/picorv... ~
```

File Edit View Search Terminal Tabs Help

```
create_clock [get_ports $::env(CLOCK_PORT)] -name $::env(CLOCK_PORT) -period $env:(CLOCK_PERIOD)
set IO_PCT 0.2
set input_delay_value [expr $::env(CLOCK_PERIOD) * SIO_PCT]
set output_delay_value [expr $::env(CLOCK_PERIOD) * SIO_PCT]
puts "[INFO]: Setting output delay to: $output_delay_value"
puts "[INFO]: Setting input delay to: $input_delay_value"

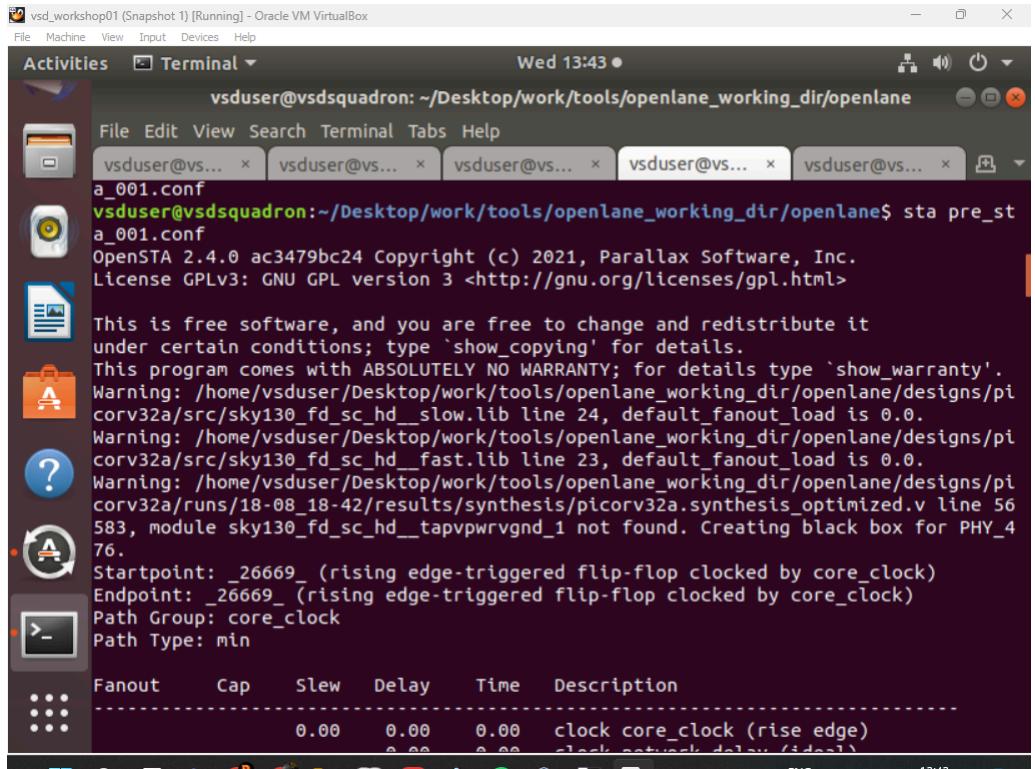
set clk_index [lsearch [all_inputs] [get_port $::env(CLOCK_PORT)]]
set all_inputs_wo_clk [lreplace [all_inputs] $clk_indx $clk_indx]
set all_inputs_wo_clk_rst $all_inputs_wo_clk

set_input_delay $input_delay_value -clock [get_clocks $::env(CLOCK_PORT)] $all_in
puts_wo_clk_rst
set_output_delay $output_delay_value -clock [get_clocks $::env(CLOCK_PORT)] [all_
outputs]

set_driving_cell -lib_cell $::env(SYNTH_DRIVING_CELL) -pin $::env(SYNTH_DRIVING_CE
LL_PIN) [all_inputs]
set_cap_load [expr $::env(SYNTH_CAP_LOAD) /1000.0
puts "[INFO]: Setting load to: $cap_load"
set_load $cap_load [all_outputs]
```

23,32 Bot

Now run sta pre_sta.conf in openlane

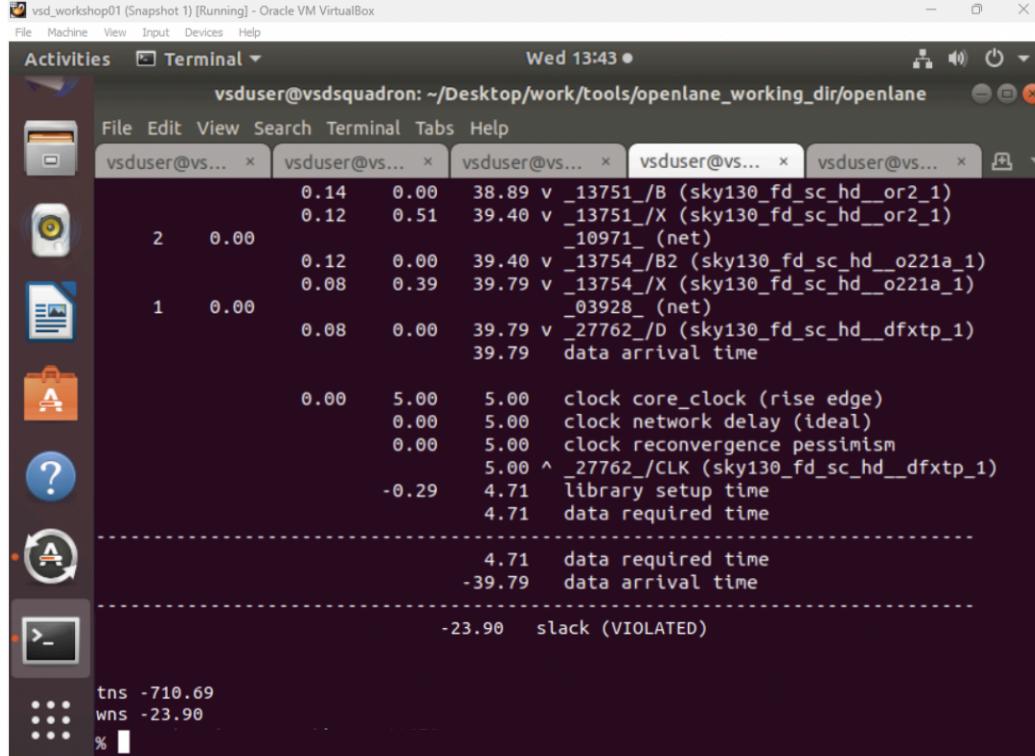


vsd_workshop01 (Snapshot 1) [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal • Wed 13:43 •
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
File Edit View Search Terminal Tabs Help
a_001.conf
vsduser@vsdsquadron:~/Desktop/work/tools/openlane_working_dir/openlane\$ sta pre_st
a_001.conf
OpenSTA 2.4.0 ac3479bc24 Copyright (c) 2021, Parallax Software, Inc.
License GPLv3: GNU GPL version 3 <http://gnu.org/licenses/gpl.html>

This is free software, and you are free to change and redistribute it
under certain conditions; type `show_copyright` for details.
This program comes with ABSOLUTELY NO WARRANTY; for details type `show_warranty`.
Warning: /home/vsduser/Desktop/work/tools/openlane_working_dir/openlane/designs/pi
corv32a/src/sky130_fd_sc_hd__slow.lib line 24, default_fanout_load is 0.0.
Warning: /home/vsduser/Desktop/work/tools/openlane_working_dir/openlane/designs/pi
corv32a/src/sky130_fd_sc_hd__fast.lib line 23, default_fanout_load is 0.0.
Warning: /home/vsduser/Desktop/work/tools/openlane_working_dir/openlane/designs/pi
corv32a/runs/18-08_18-42/results/synthesis/picorv32a.synthesis_optimized.v line 56
583, module sky130_fd_sc_hd__tapvpwrvgnd_1 not found. Creating black box for PHY_4
76.
Startpoint: _26669_ (rising edge-triggered flip-flop clocked by core_clock)
Endpoint: _26669_ (rising edge-triggered flip-flop clocked by core_clock)
Path Group: core_clock
Path Type: min

Fanout Cap Slew Delay Time Description

0.00 0.00 0.00 clock core_clock (rise edge)
0.00 0.00 clock network delay (ideal)


vsd_workshop01 (Snapshot 1) [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal • Wed 13:43 •
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
File Edit View Search Terminal Tabs Help
vsduser@vs... x vsduser@vs... x vsduser@vs... x vsduser@vs... x vsduser@vs... x
0.14 0.00 38.89 v _13751_/B (sky130_fd_sc_hd__or2_1)
0.12 0.51 39.40 v _13751_/X (sky130_fd_sc_hd__or2_1)
2 0.00 0.00 0.00 0.00 _10971_ (net)
0.12 0.00 39.40 v _13754_/B2 (sky130_fd_sc_hd__o221a_1)
0.08 0.39 39.79 v _13754_/X (sky130_fd_sc_hd__o221a_1)
1 0.00 0.00 0.00 0.00 _03928_ (net)
0.08 0.00 39.79 v _27762_/D (sky130_fd_sc_hd__dfxtip_1)
39.79 data arrival time

0.00 5.00 5.00 clock core_clock (rise edge)
0.00 5.00 clock network delay (ideal)
0.00 5.00 clock reconvergence pessimism
-0.29 5.00 ^ _27762_/CLK (sky130_fd_sc_hd__dfxtip_1)
4.71 library setup time
4.71 data required time

4.71 data required time
-39.79 data arrival time

-23.90 slack (VIOLATED)

tns -710.69
wns -23.90
%

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

File Machine View Input Devices Help

Activities Terminal • Wed 13:44

vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane

```

File Edit View Search Terminal Tabs Help
vsduser@vs... x vsduser@vs... x vsduser@vs... x vsduser@vs... x vsduser@vs... x
  0.00  0.00  0.00  0.00  0.00
  4   0.01    0.06  0.58  0.58 v _29052_/_CLK (sky130_fd_sc_hd__dfxtp_2)
        0.06  0.00  0.58 v _14460_/_A (sky130_vsdinv)
        0.19  0.17  0.75 ^ _14460_/_Y (sky130_vsdinv)
  3   0.01    0.19  0.00  0.75 ^ _14461_/_B2 (sky130_fd_sc_hd__o22ai_2)
        0.09  0.14  0.89 v _14461_/_Y (sky130_fd_sc_hd__o22ai_2)
  1   0.00    0.09  0.00  0.89 v _14462_/_C1 (sky130_fd_sc_hd__a221o_2)
        0.08  0.55  1.44 v _14462_/_X (sky130_fd_sc_hd__a221o_2)
  1   0.00    0.08  0.00  1.44 v _14481_/_A (sky130_fd_sc_hd__or4_2)
        0.21  1.53  2.97 v _14481_/_X (sky130_fd_sc_hd__or4_2)
  1   0.00    0.21  0.00  2.97 v _14509_/_A1 (sky130_fd_sc_hd__o2111a_2)
        0.07  0.54  3.51 v _14509_/_X (sky130_fd_sc_hd__o2111a_2)
  2   0.00    0.07  0.00  3.51 v _14510_/_C (sky130_fd_sc_hd__or3_2)
        0.21  1.04  4.55 v _14510_/_X (sky130_fd_sc_hd__or3_2)
  4   0.01    0.21  0.00  4.55 v _14513_/_A (sky130_fd_sc_hd__or2_2)
        0.11  0.71  5.26 v _14513_/_X (sky130_fd_sc_hd__or2_2)
  2   0.00    0.11  0.00  5.26 v _14514_/_C (sky130_fd_sc_hd__or3_2)
        0.20  1.03  6.29 v _14514_/_X (sky130_fd_sc_hd__or3_2)
  4   0.01    0.20  0.00  6.29 v _14517_/_A (sky130_fd_sc_hd__or2_2)
        0.00  0.00  6.29 v _14517_/_X (sky130_fd_sc_hd__or2_2)

```

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

File Machine View Input Devices Help

Activities Terminal • Wed 13:47

vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane

```

File Edit View Search Terminal Tabs Help
vsduser@vs... x vsduser@vs... x vsduser@vs... x vsduser@vs... x vsduser@vs... x
  4.71  data required time
-----
  4.71  data required time
  -39.79 data arrival time
-----
-23.90 slack (VIOLATED)

tns -710.69
wns -23.90
% report_net -connections _13158_
Error: net _13158_ not found.
% report_net -connections _11668_
Net _11668_
Driver pins
_15183_/_X output (sky130_fd_sc_hd__buf_2)
Load pins
_15184_/_B1 input (sky130_fd_sc_hd__a220_1)
_15697_/_B1 input (sky130_fd_sc_hd__a220_1)
_15743_/_B1 input (sky130_fd_sc_hd__a220_1)
_15833_/_B1 input (sky130_fd_sc_hd__a220_1)
_15879_/_B1 input (sky130_fd_sc_hd__a220_1)
_15957_/_B1 input (sky130_fd_sc_hd__a220_1)

```

```

vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
File Edit View Search Terminal Tabs Help
vsduser@vs... vsduser@vs... vsduser@vs... vsduser@vs... vsduser@vs...
47.9453 data arrival time

    0.0000  24.7300  24.7300  clock clk (rise edge)
    0.0000  24.7300  24.7300  clock network delay (ideal)
    0.0000  24.7300  24.7300  clock reconvergence pessimism
    24.7300 ^ _30440/_CLK (sky130_fd_sc_hd__dfxtp_2)
-0.2939  24.4361  24.4361  library setup time
    24.4361  data required time
    24.4361  data arrival time
    24.4361  data required time
-47.9453  data arrival time
-----+
-23.5092  slack (VIOLATED)

% report_net -connections _11675_
Net _11675_
Driver pins
_14514/_X output (sky130_fd_sc_hd__or3_2)

Load pins
_14515/_A input (sky130_vsdinv)
_14521/_B2 input (sky130_fd_sc_hd__o221a_2)
_14662/_B input (sky130_fd_sc_hd__or2_2)
_15166/_B input (sky130_fd_sc_hd__or2_2)

% replace_cell _14514_ sky130_fd_sc_hd__or3_4
1
% report_checks -fields Snet can show input pin(s) didn't

```

Thus, on repeating this process several times as required, overall, the slack is reduced as shown below

```

vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
File Edit View Search Terminal Tabs Help
vsduser@vs... vsduser@vs... vsduser@vs... vsduser@vs... vsduser@vs...
3  0.0079   0.1421  0.0000  44.6237 v _12206_(net)
        0.1162  0.6492  45.2729 v _15225/_B (sky130_fd_sc_hd__or2_2)
        0.1162  0.0000  45.2729 v _15225/_X (sky130_fd_sc_hd__or2_2)
2  0.0035   0.1421  0.0000  45.2729 v _15226/_B (sky130_fd_sc_hd__or2_2)
        0.1421  0.6813  45.9542 v _15226/_X (sky130_fd_sc_hd__or2_2)
3  0.0079   0.1421  0.0000  45.9542 v _15227/_B (sky130_fd_sc_hd__or2_2)
        0.1228  0.6610  46.6153 v _15227/_X (sky130_fd_sc_hd__or2_2)
2  0.0044   0.1228  0.0000  46.6153 v _15230/_B2 (sky130_fd_sc_hd__o221a_2)
        0.0713  0.4381  47.0534 v _15230/_X (sky130_fd_sc_hd__o221a_2)
1  0.0016   0.0713  0.0000  47.0534 v _03928_(net)
        0.0713  0.0000  47.0534 v _30440/_D (sky130_fd_sc_hd__dfxtp_2)
        47.0534  data arrival time

    0.0000  24.7300  24.7300  clock clk (rise edge)
    0.0000  24.7300  24.7300  clock network delay (ideal)
    0.0000  24.7300  24.7300  clock reconvergence pessimism
    24.7300 ^ _30440/_CLK (sky130_fd_sc_hd__dfxtp_2)
-0.2939  24.4361  24.4361  library setup time
    24.4361  data required time
    24.4361  data arrival time
    24.4361  data required time
-47.0534  data arrival time
-----+
-22.6173  slack (VIOLATED)


```

Lab steps to run CTS using triton

The image shows two terminal windows in an Oracle VM VirtualBox environment. Both windows are titled "Activities Terminal".

Top Terminal Window:

```
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane/designs/picorv32a/runs/18-08_18-42/results/synthesis$ ls
merged_unpadded.lef  picorv32a.synthesis_optimized.v  picorv32a.synthesis.v
vsduser@vsdsquadron:~/Desktop/work/tools/openlane_working_dir/openlane/designs/picorv32a/runs/18-08_18-42/results/synthesis$ cp picorv32a.synthesis.v picorv32a.synthesis.old.v
vsduser@vsdsquadron:~/Desktop/work/tools/openlane_working_dir/openlane/designs/picorv32a/runs/18-08_18-42/results/synthesis$ ls
merged_unpadded.lef      picorv32a.synthesis_optimized.v
picorv32a.synthesis_old.v  picorv32a.synthesis.v
vsduser@vsdsquadron:~/Desktop/work/tools/openlane_working_dir/openlane/designs/picorv32a/runs/18-08_18-42/results/synthesis$
```

Bottom Terminal Window:

```
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
File Edit View Search Terminal Tabs Help
vsduser@vsdsqu... x vsduser@vsdsqu... x vsduser@vsdsqu... x vsduser@vsdsqu... x
0.0000    5.0000    5.0000  clock core_clock (rise edge)
          0.0000    5.0000  clock network delay (ideal)
          0.0000    5.0000  clock reconvergence pessimism
          5.0000 ^ _27762_/CLK (sky130_fd_sc_hd_dfx
tp_1
          -0.2921   4.7079  library setup time
          4.7079  data required time
-----
          -24.4361  data required time
          -47.0534  data arrival time
-----
          -22.6173  slack (VIOLATED)

% help write_verilog
write_verilog [-sort] [-include_pwr_gnd] [-remove_cells cells] filename
% write_verilog /home/vsduser/Desktop/work/tools/open_lane_working_dir/openlane/designs/picorv32a/runs/18-08_18-42/results/synthesis/picorv32a.synthesis.v
%
```

After running synthesis, floorplan and placement, run_cts.

```
vsd_workshop01 (Snapshot 1) [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal ▾ Wed 14:13 •
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
File Edit View Search Terminal Tabs Help
vsduser@vsdsqu... x vsduser@vsdsqu... x vsduser@vsdsqu... x vsduser@vsdsqu... x
ults/placement/picorv32a.placement.def to /openLANE_flow/designs/picorv32a/runs/21-08_07-42/results/placement/picorv32a.placement.def
[INFO]: Taking a Screenshot of the Layout Using Klayout...
[INFO]: current step index: 18
Using Techfile: /home/vsduser/Desktop/work/tools/openlane_working_dir/pdks/sky130A/libs.tech/klayout/sky130A.lyt
Using layout file: /openLANE_flow/designs/picorv32a/runs/21-08_07-42/results/placement/picorv32a.placement.def
[INFO] Reading tech file: /home/vsduser/Desktop/work/tools/openlane_working_dir/pdks/sky130A/libs.tech/klayout/sky130A.lyt
[INFO] Reading Layout file: /openLANE_flow/designs/picorv32a/runs/21-08_07-42/results/placement/picorv32a.placement.def
[INFO] Writing out PNG screenshot '/openLANE_flow/designs/picorv32a/runs/21-08_07-42/results/placement/picorv32a.placement.def.png'
Done
[INFO]: Screenshot taken.
% run_cts
[INFO]: Running TritonCTS...
[INFO]: current step index: 19
[INFO]: Trimming Liberty...
[INFO]: Generating Exclude List...
OpenROAD 0.9.0 1415572a73
This program is licensed under the BSD-3 license. See the LICENSE file for details
.
Components of this program may be licensed under more restrictive licenses which m
```

```
vsd_workshop01 (Snapshot 1) [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal ▾ Wed 14:20 •
vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane
File Edit View Search Terminal Tabs Help
vsduser@vsdsqu... x vsduser@vsdsqu... x vsduser@vsdsqu... x vsduser@vsdsqu... x
ks/sky130A/libs.tech/klayout/sky130A.lyt
[INFO] Reading Layout file: /openLANE_flow/designs/picorv32a/runs/21-08_07-42/results/cts/picorv32a.cts.def
[INFO] Writing out PNG screenshot '/openLANE_flow/designs/picorv32a/runs/21-08_07-42/results/cts/picorv32a.cts.def.png'
Done
[INFO]: Screenshot taken.
% gen_pdn
[INFO]: Generating PDN...
[INFO]: current step index: 22
OpenROAD 0.9.0 1415572a73
This program is licensed under the BSD-3 license. See the LICENSE file for details
.
Components of this program may be licensed under more restrictive licenses which m
ust be honored.
Notice 0: Reading LEF file: /openLANE_flow/designs/picorv32a/runs/21-08_07-42/tmp/merged_unpadded.lef
Notice 0: Created 13 technology layers
Notice 0: Created 25 technology vias
Notice 0: Created 441 library cells
Notice 0: Finished LEF file: /openLANE_flow/designs/picorv32a/runs/21-08_07-42/tmp/merged_unpadded.lef
Notice 0:
Reading DEF file: /openLANE_flow/designs/picorv32a/runs/21-08_07-42/results/cts/picorv32a.cts.def
```

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

File Machine View Input Devices Help

Activities Terminal •

Wed 14:20

vsduser@vsdsquadron: ~/Desktop/work/tools/openlane_working_dir/openlane

```
File Edit View Search Terminal Tabs Help
vsduser@vsdsqu... x vsduser@vsdsqu... x vsduser@vsdsqu... x vsduser@vsdsqu... x +
```

```
not located on a power stripe. Moving to closest stripe at (567.000um, 257.060um).
[WARNING PSM-0030] Vsrc location at (5.520um, 430.880um) and size =10.000um, is not located on a power stripe. Moving to closest stripe at (5.400um, 410.240um).
[WARNING PSM-0030] Vsrc location at (145.520um, 430.880um) and size =10.000um, is not located on a power stripe. Moving to closest stripe at (145.800um, 410.240um).
[WARNING PSM-0030] Vsrc location at (285.520um, 430.880um) and size =10.000um, is not located on a power stripe. Moving to closest stripe at (286.200um, 410.240um).
[WARNING PSM-0030] Vsrc location at (425.520um, 430.880um) and size =10.000um, is not located on a power stripe. Moving to closest stripe at (426.600um, 410.240um).
[WARNING PSM-0030] Vsrc location at (565.520um, 430.880um) and size =10.000um, is not located on a power stripe. Moving to closest stripe at (567.000um, 410.240um).
[WARNING PSM-0030] Vsrc location at (285.520um, 570.880um) and size =10.000um, is not located on a power stripe. Moving to closest stripe at (286.200um, 563.420um).
[WARNING PSM-0030] Vsrc location at (425.520um, 570.880um) and size =10.000um, is not located on a power stripe. Moving to closest stripe at (426.600um, 563.420um).
[WARNING PSM-0030] Vsrc location at (565.520um, 570.880um) and size =10.000um, is not located on a power stripe. Moving to closest stripe at (567.000um, 563.420um).
[INFO PSM-0031] Number of nodes on net VGND = 19223.
[INFO PSM-0037] G matrix created sucessfully.
[INFO PSM-0040] Connection between all PDN nodes established in net VGND.
[INFO]: PDN generation was successful.
[INFO]: Changing layout from /openLANE_flow/designs/picorv32a/runs/21-08_07-42/results/cts/picorv32a.cts.def to /openLANE_flow/designs/picorv32a/runs/21-08_07-42/tmp/floorplan/22-pdn.def
```

