WEEK:5

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OpenROAD Flow Setup and Floorplan + Placement

Objective

Set up the OpenROAD Flow Scripts environment and execute Floorplan and Placement stages of the physical design flow. This task demonstrates how logical RTL is translated into a physical layout on silicon, bridging the gap between transistor-level design and backend implementation.

Importance

Floorplanning and placement are key steps in VLSI physical design:

- Floorplan defines the die and core boundaries, macro locations, and I/O pin placement.
- Placement arranges standard cells within the core while respecting timing, congestion, and design constraints.
- Understanding these stages improves comprehension of area, delay, and manufacturability trade-offs.

Reference

OpenROAD Flow Scripts Reference: https://github.com/spatha0011/spatha_vsd-hdp/blob/main/Day14/README.md

Task Components

1. Install OpenROAD Flow Scripts

- Clone repository and build using Docker.

```
git clone --recursive https://github.com/The-OpenROAD-Project/OpenROAD-flow-scripts

cd OpenROAD-flow-scripts

./build_openroad.sh --threads 8
```

- Source environment:
  source ./env.sh
- Verify installation:
  docker run --rm -it -u $(id -u ${USER}):$(id -g ${USER}) -v $(pwd)/flow:/OpenROAD-flow-scripts/flow openroad/flow-ubuntu22.04-builder
  cd flow
  source ./env.sh
  yosys -help
- openroad -help

Problem encountered: GUI could not run outside Docker due to missing Qt plugins (xcb).
Solution: Used Docker with docker_shell gui_final to launch GUI with proper volume mounts and X11 support.

```
{
xhost +local:root
docker run -it --rm \
   -e DISPLAY=$DISPLAY \
   -v /tmp/.X11-unix:/tmp/.X11-unix \
   -v /home/srao/OpenROAD-flow-scripts:/OpenROAD-flow-scripts \
   openroad/flow-ubuntu22.04-builder bash
}
```

1. Run Floorplan and Placement Flow
   - Execute floorplan: run_floorplan target in flow.
   - Execute placement: run_placement target in flow.
     cd /OpenROAD-flow-scripts/flow
     make DESIGN_CONFIG=./designs/asap7/gcd/config.mk PLACE
     ls results/asap7/gcd/base/

Generated files in flow/results/asap7/gcd/base/:

- 2_floorplan.odb (floorplan database)
- 3_place.odb (placement database)

Problem encountered: Results folder initially missing when running OpenROAD outside Docker.
Solution: Mounted flow folder as a volume in Docker to persist output files.

{

cd /OpenROAD-flow-scripts/tools/install/OpenROAD/bin

./openroad -gui

}

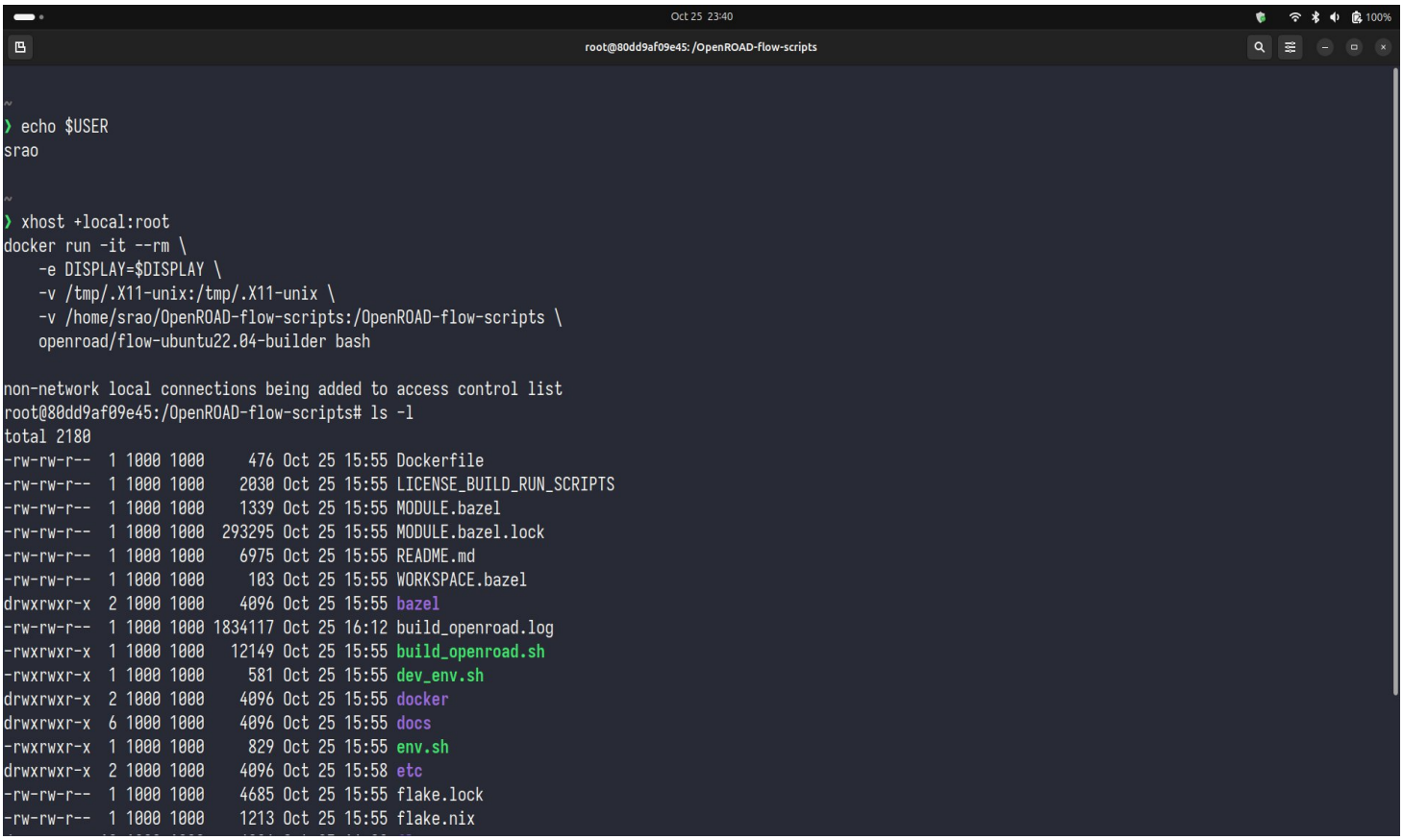
Analyze Floorplan (2_floorplan.odb) in OpenROAD GUI

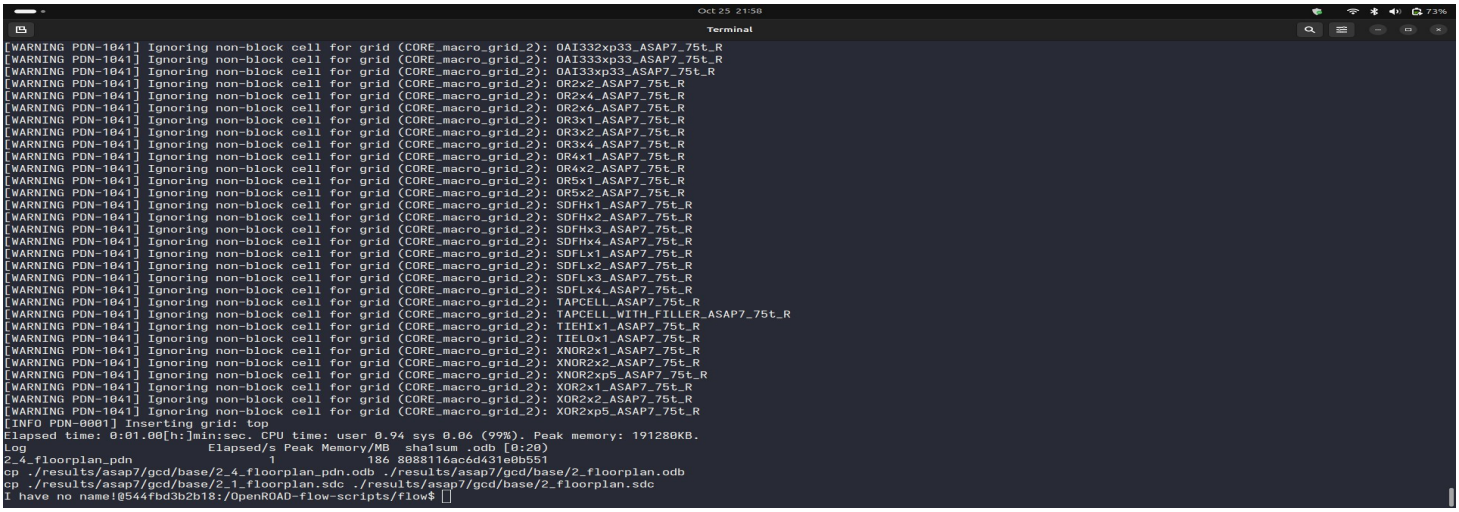
- Load floorplan database:
  read_db /OpenROAD-flow-scripts/flow/results/asap7/gcd/base/2_floorplan.odb
- Inspect design metrics:
  get_pins
- Visual verification: zoom and pan the GUI to confirm macro locations, die/core boundaries, and I/O placement.

Analyze Placement (3_place.odb) in OpenROAD GUI

- Load placed design database:
  read_db /OpenROAD-flow-scripts/flow/results/asap7/gcd/base/3_place.odb
- Check placement statistics:
  check_placement
  report_activity_annotation
  report_design_area
  get_nets
- Visual inspection: confirm standard cells are aligned within the core, ensure no cell overlaps, and macros remain fixed.

TERMINUS SCREENSHOTS:

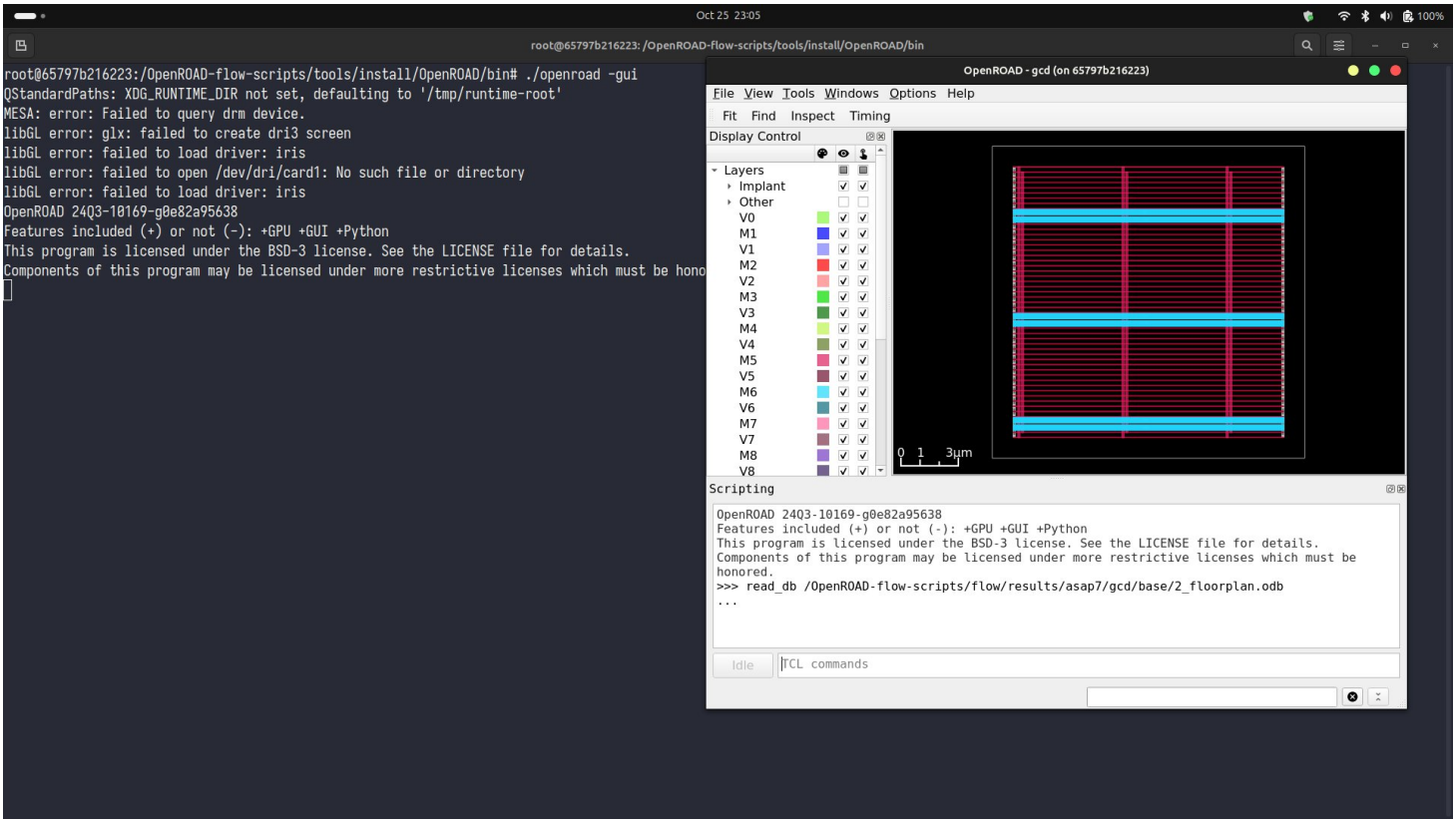


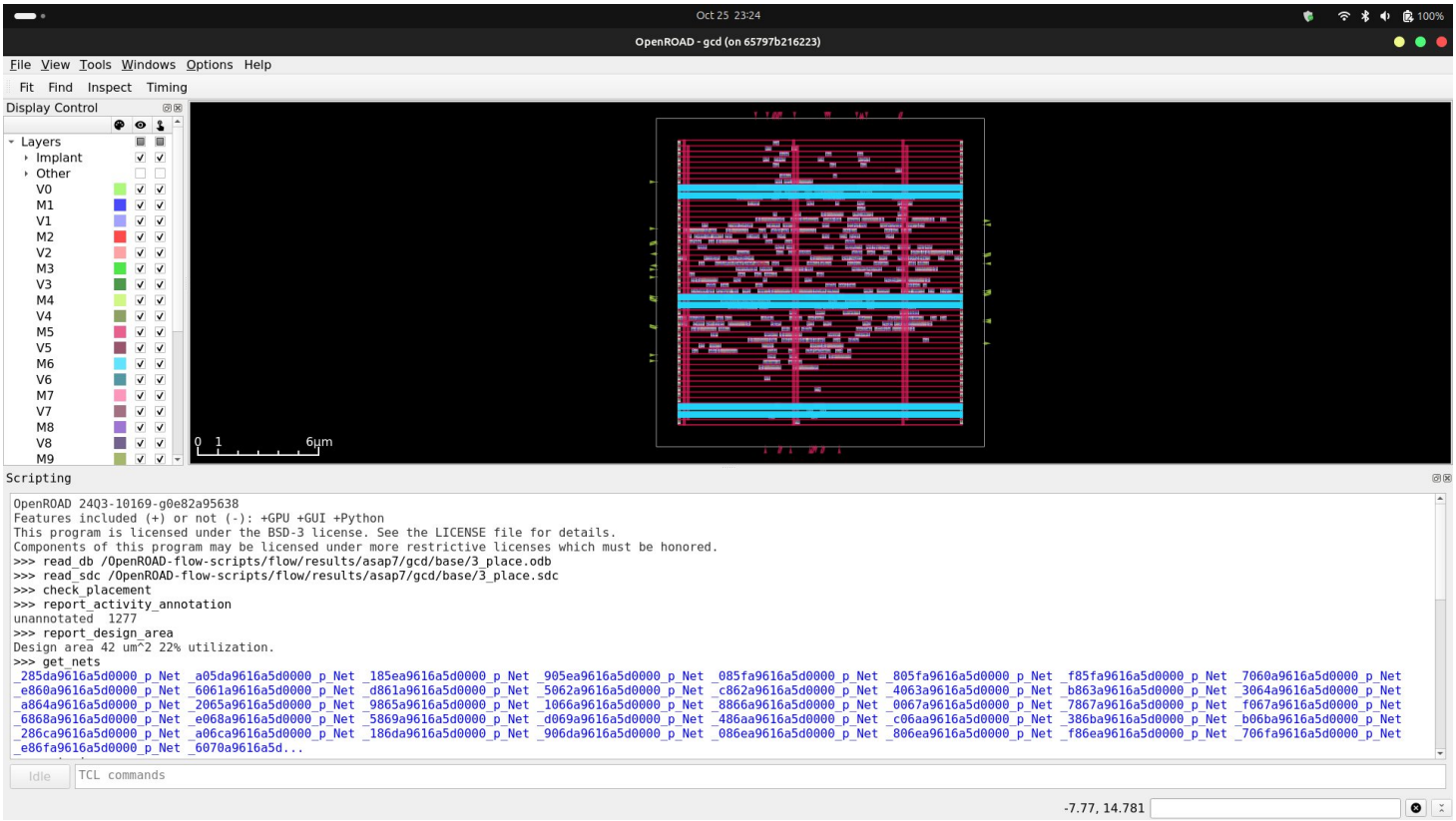


```
[INFO DPL-0332] End of pass, Generator random called 7280 times.
[INFO DPL-0335] Generator random, Cumulative attempts 14560, swaps 1032, moves  5744 since last reset.
[INFO DPL-0333] End of pass, Objective hpwl, Initial cost 8.511530e+05, Scratch cost 8.464360e+05, Incremental cost 8.464360e+05, Mismatch? N
[INFO DPL-0338] End of pass, Total cost is 8.464360e+05.
[INFO DPL-0327] Pass   2 of random improver; improvement in cost is 0.55 percent.
[INFO DPL-0328] End of random improver; improvement is 1.615305 percent.
[INFO DPL-0380] Cell flipping.
[INFO DPL-0382] Changed 0 cell orientations for row compatibility.
[INFO DPL-0383] Performed 115 cell flips.
[INFO DPL-0384] End of flipping; objective is 8.147430e+05, improvement is 3.74 percent.
[INFO DPL-0313] Found 0 cells in wrong regions.
[INFO DPL-0315] Found 0 row alignment problems.
[INFO DPL-0314] Found 0 site alignment problems.
[INFO DPL-0311] Found 0 overlaps between adjacent cells.
[INFO DPL-0312] Found 0 edge spacing violations and 0 padding violations.
Detailed Improvement Results
----------------------------------------
Original HPWL              884.3 u (     412.5,      471.8)
Final HPWL                 813.5 u (     367.0,      446.5)
Delta HPWL                  -8.0 % (     -11.0,       -5.4)

[INFO DPL-0020] Mirrored 34 instances
[INFO DPL-0021] HPWL before             813.5 u
[INFO DPL-0022] HPWL after              811.8 u
[INFO DPL-0023] HPWL delta               -0.2 %
[INFO FLW-0012] Placement violations .
Report metrics stage 3, detailed place...

================================================================================
detailed place report_design_area
--------------------------------------------------------------------------------
Design area 42 um^2 22% utilization.
Elapsed time: 0:01.19[h:]min:sec. CPU time: user 1.19 sys 0.08 (106%). Peak memory: 195312KB.
Log                     Elapsed/s Peak Memory/MB  sha1sum .odb [0:20)
3_5_place_dp                    1            190 32bb6de56618c70b6989
cp ./results/asap7/gcd/base/3_5_place_dp.odb ./results/asap7/gcd/base/3_place.odb
cp ./results/asap7/gcd/base/2_floorplan.sdc ./results/asap7/gcd/base/3_place.sdc
I have no name!@544fbd3b2b18:/OpenROAD-flow-scripts/flow$
```

```
I have no name!@544fbd3b2b18:/OpenROAD-flow-scripts/flow/results/asap7/gcd/base$ ls -l
total 9596
-rw-r--r-- 1 1000 1000 760474 Oct 25 16:28 1_1_yosys_canonicalize.rtlil
-rw-r--r-- 1 1000 1000  46646 Oct 25 16:28 1_2_yosys.v
-rw-r--r-- 1 1000 1000    417 Oct 25 16:28 1_synth.sdc
-rw-r--r-- 1 1000 1000  46646 Oct 25 16:28 1_synth.v
-rw-r--r-- 1 1000 1000 732432 Oct 25 16:28 2_1_floorplan.odb
-rw-r--r-- 1 1000 1000   5773 Oct 25 16:28 2_1_floorplan.sdc
-rw-r--r-- 1 1000 1000 732432 Oct 25 16:28 2_2_floorplan_macro.odb
-rw-r--r-- 1 1000 1000      1 Oct 25 16:28 2_2_floorplan_macro.tcl
-rw-r--r-- 1 1000 1000 753862 Oct 25 16:28 2_3_floorplan_tapcell.odb
-rw-r--r-- 1 1000 1000 808860 Oct 25 16:28 2_4_floorplan_pdn.odb
-rw-r--r-- 1 1000 1000 808860 Oct 25 16:28 2_floorplan.odb
-rw-r--r-- 1 1000 1000   5773 Oct 25 16:28 2_floorplan.sdc
-rw-r--r-- 1 1000 1000 808860 Oct 25 16:28 3_1_place_gp_skip_io.odb
-rw-r--r-- 1 1000 1000 811236 Oct 25 16:28 3_2_place_iop.odb
-rw-r--r-- 1 1000 1000   4850 Oct 25 16:28 3_2_place_iop.tcl
-rw-r--r-- 1 1000 1000 842546 Oct 25 16:28 3_3_place_gp.odb
-rw-r--r-- 1 1000 1000 842546 Oct 25 16:28 3_4_place_resized.odb
-rw-r--r-- 1 1000 1000 842546 Oct 25 16:28 3_5_place_dp.odb
-rw-r--r-- 1 1000 1000 842546 Oct 25 16:28 3_place.odb
-rw-r--r-- 1 1000 1000   5773 Oct 25 16:28 3_place.sdc
-rw-r--r-- 1 1000 1000      4 Oct 25 16:28 clock_period.txt
-rw-r--r-- 1 1000 1000  72058 Oct 25 16:28 mem.json
```

```
       -rd in_def=./results/asap7/gcd/base/6_final.def \
       -rd in_files="/OpenROAD-flow-scripts/flow/platforms/asap7/gds/asap7sc7p5t_28_R_220121a.gds  " \
       -rd seal_file="" \
       -rd out_file=./results/asap7/gcd/base/6_1_merged.gds \
       -rd tech_file=./objects/asap7/gcd/base/klayout.lyt \
       -rd layer_map= \
       -r /OpenROAD-flow-scripts/flow/util/def2stream.py) 2>&1 | tee /OpenROAD-flow-scripts/flow/logs/asap7/gcd/base/6_1_merge.log
KLayout 0.30.3
Warning: DEF UNITS does not match reader DBU (DEF UNITS is 1000 and corresponds to a DBU of 0.001, but reader DBU is set to 0.00025) (line=5, cell=, file=6_final.def)
[INFO] Reporting cells prior to loading DEF ...
       /OpenROAD-flow-scripts/flow/platforms/asap7/gds/asap7sc7p5t_28_R_220121a.gds
[INFO] GDS_ALLOW_EMPTY=fakeram.*
[INFO] All LEF cells have matching GDS/OAS cells
[INFO] No orphan cells in the final layout
Elapsed time: 0:01.09[h:]min:sec. CPU time: user 0.96 sys 0.11 (97%). Peak memory: 433860KB.
cp results/asap7/gcd/base/6_1_merged.gds results/asap7/gcd/base/6_final.gds
./logs/asap7/gcd/base
Log                        Elapsed/s Peak Memory/MB  sha1sum .odb [0:20)
1_1_yosys_canonicalize             0            79 65676087d9484a6a7b56
1_2_yosys                          1           145 85d1fe274549339acf41
2_1_floorplan                      1           209 017765b2615fdd1367b6
2_2_floorplan_macro                0           185 017765b2615fdd1367b6
2_3_floorplan_tapcell              1           184 0a90b132b18de83d4370
2_4_floorplan_pdn                  1           187 8088116ac6d431e0b551
3_1_place_gp_skip_io               1           186 290907e127091b7a8bba
3_2_place_iop                      0           185 77ff42d6182d64c57cda
3_3_place_gp                       1           278 775b774928fe143ca272
3_4_place_resized                  1           205 775b774928fe143ca272
3_5_place_dp                       1           190 32bb6de56618c70b6989
4_1_cts                            2           227 590687a2eee1e7ee40ad
5_1_grt                            2           292 7e89ff1c7b614ff95864
5_2_route                         24          4303 2cb620caec2f6a200796
5_3_fillcell                       0           187 d4618073c43334d342e0
6_1_fill                           0           186 d4618073c43334d342e0
6_1_merge                          1           423                  N/A
6_report                           2           313                  N/A
Total                             39          4303
root@65797b216223:/OpenROAD-flow-scripts/flow#
```





- **Deliverables**

1. Terminal Screenshots
   - Commands executed
   - Visible Linux username
   - OpenROAD installation messages
   - Floorplan and placement completion logs
1. GUI Images
   - Floorplan view (2_floorplan.odb)

- Placement layout (3_place.odb)

1. Short Summary

- Installed OpenROAD Flow Scripts using Docker.
- Executed floorplan and placement stages for ASAP7 GCD design.
- Verified core area, die dimensions, macro positions, and standard cell placement using OpenROAD GUI.
- Resolved GUI Qt plugin issues by launching GUI inside Docker with proper volume mounts.

Outcome

By completing this task:

- OpenROAD Flow Scripts were successfully installed.
- Floorplan and placement stages executed and verified.

Visual and logged evidence of working environment was produced.