

Chapter 8 - Tapeout

Course authors (Git file)



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Section 1

Open-source Tapeout informations from IHP



Open-source Tapeout informations from IHP

This chapter provides information about the Tapeout at IHP. Please follow the links to tag along with the chapter.



IHP - Repositories structure

- The designs for the open-source Tapeouts are collected as the “Open DesignLib”.
- During the process of each Tapeout there are dedicated repositories by the names TO_monthyear.
- After Tapeout these designs shall be merged into the Open DesignLib repository.



PDK and Open DesignLib

- Open.source PDK:

<https://github.com/IHP-GmbH/IHP-Open-PDK>

- Open DesignLib:

<https://github.com/IHP-GmbH/IHP-Open-DesignLib>



TapeOut repositories (TO)

- Tapeout May 2024:

https://github.com/IHP-GmbH/TO_May2024

- Tapeout Nov 2024:

https://github.com/IHP-GmbH/TO_Nov2024

- Tapeout Dec 2024:

https://github.com/IHP-GmbH/TO_Dec2024



Section 2

READMEs



README file in TO repositories

Important notes:

- Always look for the most actual and stable information
- Tools and workflows change faast
- Design rules don't change fast (if ever)
- Most parts of the PDK are long term stable



Submission process

Screenshot from the **README TO_DEC2024**:

Submission process

To submit for our OpenMPW run you have to have a valid github account. Make a fork of this repository and then create a separate directory for your design next to the `ExampleDesign` (you can also make a copy and rename it). Structure your data according to our recommendations, update the documentation and push your files to your fork, then make a pull request.

⚠ Caution

On each PR a github action will be triggered to run a minimal DRC precheck (rejection test). Please consider it and do not upload many `gds` files.

Once you make a PR a github action will run a minimum set of DRC checks on each `gds` and `gds.zip` file. If the test passes it means that your design is manufacturable at our pilot line not ensuring the reliability. An example of a failure is shown on the following figure

Figure 1: Submission process



Physical constraints

Screenshot from the **README TO_DEC2024**:

Physical design constraint

1. Please align with the layout design rules which can be found [here](#)
2. The area granted to a community member is 2 mm² It includes the sealring.
3. The sealring can be found among KLayout PyCells.

Figure 2: Physical design constraints



Project structure

Screenshot from the **README TO_DEC2024**:

Directory structure

If you are a designer, we propose the following directory structure, which we and the community would appreciate you using. Please ensure that the design you submit is reproducible, meaning it should include all the information necessary to replicate the design.



```
<design_name>
├── design_data
│   ├── tool1/format1/step1
│   │   └── data
│   └── tool2/format2/setp2
│       └── data
├── doc
│   ├── specification
│   └── ...
└── val <- validation/verification >
```

The first segmentation separates the **design data** from a **documentation** and **verification/validation data**.

Figure 3: Directories in a project



Design data structure

Screenshot from the **README TO_DEC2024**:

Design data directory structure

The `design_data` should be structured using tool/format/step specific scheme.

Here you can find some examples:

Example1

```
└─ design_data
  └─ xschem
  └─ ngspice
  └─ klayout
  └─ drc
  └─ lvs
  └─ gds
```



Example2

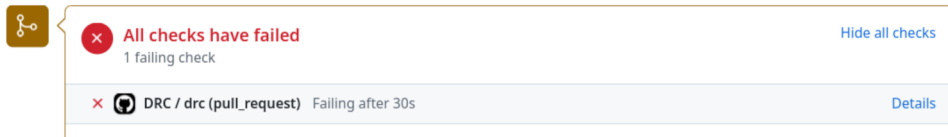
```
└─ design_data
  └─ verilog
  └─ sdc
  └─ lef
  └─ gds
  └─ lib
  └─ drc
  └─ lvs
  └─ reports
  └─ log
```



DRC

During a submission to a Tapeout the design gets checked with a DRC via Github Actions.

Once you make a PR a github action will run a minimum set of DRC checks on each `gds` and `gds.zip` file. If the test passes it means that your design is manufacturable at our pilot line not ensuring the reliability. An example of a failure is shown on the following figure



The detailed report can be downloaded from a link, which can be found at the end of the section `Details->Archive DRC Results` as show on the image:



Figure 5: DRC via Github actions



Section 3

Read-the-docs



Read-the-docs

- Open PDK Docu:

<https://ihp-open-pdk-docs.readthedocs.io/en/latest/index.html>

- Open DesignLib Docu:

<https://ihp-open-ip.readthedocs.io/en/latest/>



README versus Read-the-docs

- The README version is a extract of the full documentation (read-the-docs) for the DesignLib.
- The read-the-docs version contains the Tapeout calender and further info



Tapeout calendar

Welcome to IHP-Open-DesignLib documentation!

IHP-Open-DesignLib is repository, which contains open source IC designs using IHP SG13G2 BiCMOS processes. It is also a central point for design fabrication under the concept of IHP Free MPW runs funded by a public German project [FMD-QNC \(16ME083\)](#). Project funds can be used exclusively to produce chip designs for non-commercial activities, such as university education, research projects, and others. In the project, a continuation for the provision of free area for the open source community is to be worked out.

| Tape In date | 10 May 2024 | 11 Nov 2024 | 22 Nov 2024 | 01 Mar 2025 | 09 May |
|-----------------------------------|-------------|-------------|-------------|-------------|--------|
| Technology | SG13G2 | SG13CMOS | SG13G2 | SG13G2 | SG13G2 |
| Area available [mm ²] | 10 | 220 | 20 | 140 | 30 |

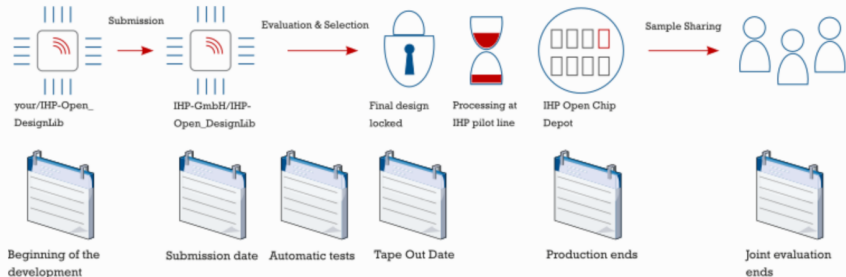
| 11 Nov 2024 | 22 Nov 2024 | 01 Mar 2025 | 09 May 2025 | 18 Jul 2025 | 15 Sep 2025 |
|-------------|-------------|-------------|-------------|-------------|-------------|
| SG13CMOS | SG13G2 | SG13G2 | SG13G2 | SG13G2 | SG13CMOS |
| 220 | 20 | 140 | 30 | 30 | 220 |

Figure 6: Open DesignLib Tapeout Calendar



More submission information

The overview of the submission process is shown on the following figure.



The submission process contains a few steps, where some of them are mandatory and crucial:

1. Project development phase. At the beginning specifications and criteria will be defined by PDK status, later specifications from sponsors might be possible

Figure 7: Submission process detailed



Section 4

The last steps to a successful Tapeout



The last steps to a successful Tapeout

A few words about the finish of a Tapeout-ready GDS:

- A successful Tapeout for a producible, correct and working microchip contains more steps and knowledge. It is out of scope of the course to explain and tutor these all details about this knowledge.
- Most of these steps will integrate into ORFS soon in a easy-to-use way eventually.



Topic to watch in design

Till then, here is a (not complete) list of important topics:

- Placement and instantiation of the Input-Outputs.
- Metall fills
- Sealing construction
- Automated DRC free



Github Actions

- Tapeout Nov 2024 Actions drc.yml:

https://github.com/IHP-GmbH/TO_Nov2024/blob/main/.github/workflows/drc.yml

- Tapeout Nov 2024 Actions runs:

https://github.com/IHP-GmbH/TO_Nov2024/actions



Active development in ORFS

Pull requests in ORFS with the search IHP in it:

<https://github.com/The-OpenROAD-Project/OpenROAD-flow-scripts/pulls?q=IHP+>

The screenshot shows the GitHub interface for the repository 'OpenROAD-flow-scripts'. The 'Pull requests' tab is selected, showing 53 requests. A search filter 'IHP' is applied. The results list several merged pull requests, including 'Reverted AT mods in config.mk's', 'update metrics for ppl fix', 'ibex autotuner updates for gf180, ihp-sg13g2 and sky130hd', 'update Yosys to version 0.49', 'AES AutoTuner updates', and 'flow: designs: ihp-sg13g2: i2c-gpio-expander: Fix missing IO pwr/gnd'.

| Filters | Q IHP | Labels (44) | Milestones (0) | New pull request |
|--|-------|-------------|----------------|------------------|
| Clear current search query, filters, and sorts | | | | |
| 3 Open ✓ 39 Closed Author ▾ Label ▾ Projects ▾ Milestones ▾ Reviews ▾ Assignee ▾ Sort ▾ | | | | |
| Reverted AT mods in config.mk's ✓ 7 #2744 by jeffng-or was merged 3 days ago • Approved | | | | |
| update metrics for ppl fix ✓ #2730 by eder-matheus was merged 4 days ago • Approved | | | | |
| ibex autotuner updates for gf180, ihp-sg13g2 and sky130hd ✓ 2 #2726 by jeffng-or was merged 5 days ago • Approved | | | | |
| update Yosys to version 0.49 ✓ 9 #2723 by openroad-ci was merged 4 days ago • Approved | | | | |
| AES AutoTuner updates ✓ 6 #2722 by jeffng-or was merged 5 days ago • Approved | | | | |
| flow: designs: ihp-sg13g2: i2c-gpio-expander: Fix missing IO pwr/gnd ✓ #2721 by dnlr was merged last week • Approved | | | | |



Issues in ORFS (open and IHP in it):

<https://github.com/The-OpenROAD-Project/OpenROAD-flow-scripts/issues?q=is%3Aissue%20state%3Aopen%20IHP>

The screenshot shows the GitHub interface for the repository 'The-OpenROAD-Project / OpenROAD-flow-scripts'. The search bar contains the query 'is:issue state:open IHP'. The results show a list of 6 open issues, all with the 'waiting on op' label. The issues are:

- [ERROR] LEF Cell 'spi_DEF_FILL' has no matching GDS/OAS cell. Cell will be empty when running ihp-sg13g2 examples** (waiting on op) - #2616 · hpretl opened on Dec 8, 2024 - 9 comments
- Min metal area ignored by ORFS (DRC error)** (drt, waiting on op) - #2574 · alpamps opened on Nov 19, 2024 - 3 comments
- Honor Cell Footprint in sky130hd, sky130hs and ihp** (fsl) - #2553 · Ackoucher opened on Nov 6, 2024 - 1 comment
- Change CI to only run relevant checks** - #2536 · Syndace opened on Oct 31, 2024 - 2 comments
- make command fails inside the docker during detail routing** - #2473 · vijayank88 opened on Oct 17, 2024 - 11 comments
- Bug in ihp-sg13g2 jpeg flow** - #1953 · luarss opened on Apr 20, 2024 - 14 comments

Figure 9: ORFS issues, open and IHP in it



Workarounds (example masked_aes)

The README of the design example from earlier (masked_aes) gives some basic, but sufficient information about the actual state and the workarounds.

<https://github.com/HEP-Alliance/masked-aes-tapeout/blob/main/README.md>

The ASIC

To build the ASIC, set up OpenROAD-flow-scripts, clone this repository as `<ORFS-Root>/flow/designs/ihp-sg13g2/masked_aes` and run the build like any other ORFS design.

Sealring

The sealring was generated using a script included with IHP's open PDK.

Clone the PDK and set up the technology in KLayout. The following command creates the sealring:

```
$ klayout -n sg13g2 -zz -r <IHP-repo-root>/ihp-sg13g2/libs.tech/klayout/tech/scripts/sealring.py -rd width=1065.0 -rc
```

The generated sealring has to be moved by -60 in both directions, which can be done in KLayout.

Caveats

Information on steps that are not fully automated yet as well as known issues.

Metal Fill

Metal fill has to be performed on the output GDS using a KLayout script provided as part of the IHP PDK. The script is currently work-in-progress here: [IHP-GmbH/IHP-Open-PDK#229](#)

DRC Violations

The final DRC design rule document shows a selection of violations that you have to correct here. The issues are listed here:



Before your Tapeout

If you plan to do a Tapeout with open-source to a Shuttlerun at IHP:

- Get in touch with the people at IHP before submitting a GDS.
- Inform yourself about the actual changes in the tools, the PDK and the submission repositories.
- Look for recent examples from the CoreExpert Group.



Section 5

Contribute to open-source



Contributing with Git

If you want to start contributing to open-source (maybe to this course?):

- Create a Git account
- Join a discussion about an issue.
- When you discover an error, write an issue yourself.

It is really not much more than a ticket-system via email.



The Feedback to this course

Your feedback will become issues in the course repository. Join in the discussion if you want to contribute:

<https://github.com/OS-EDA/Course/issues?q=is%3Aissue>

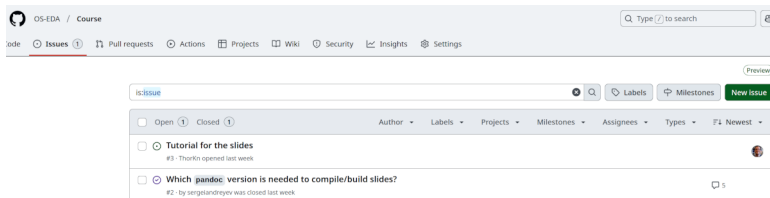


Figure 11: Issue tracking in the course repository

