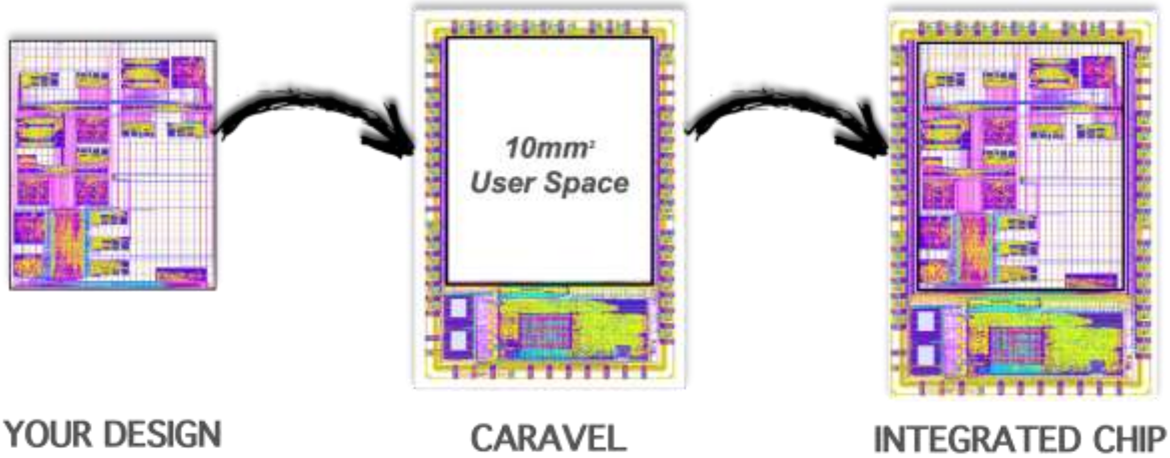
Technology and Design Flows

- **Technology**: SkyWater 130 nm open-source PDK.
- **Shuttle**: Efabless chipIgnite MPW shuttle, which provides:
  - 10 square mm area for the user design per project.
  - A standardized harness called caravel with a RISC-V CPU, RAM, and 38 general purpose I/Os.
  - 100 packaged ICs and 5 assembled boards post fabrication.



- **Analog design flow**: Using open-source analog design flow with the following tools (note that commercial analog design tools like Virtuoso and Calibre are not supported for this open PDK yet):
  - PDK files from skywater-pdk, open_pdks and xschem_sky130. All of these are necessary.
  - Schematic entry with xschem.
  - Simulation with ngspice.
  - Layout, extraction and DRC with magic.
  - LVS with netgen.
  - Manual routing of design using magic into the caravel analog user project. This user project is verified with precheck tool and submitted to the shuttle.

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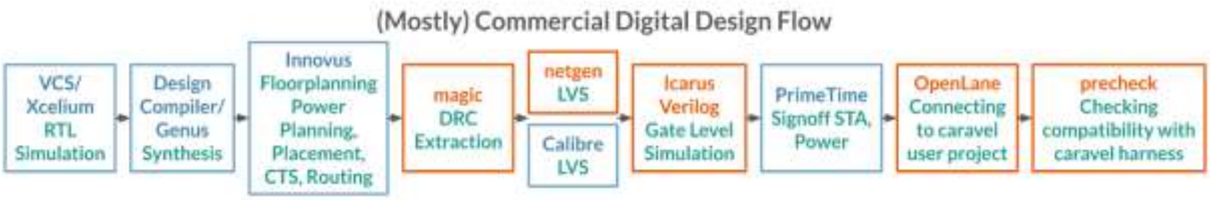
- **Digital design flow**: We use either an open-source digital design flow called OpenLane, or for advanced features, a (mostly) commercial digital design flow shown below composed using mflowgen. Note that since the open PDK does not have support for Calibre yet, we use a combination of magic and netgen for DRC, extraction and LVS for the digital designs as well. In either case, we perform the final integration of the user design into the caravel user project using OpenLane. This user project is verified with precheck tool and submitted to the shuttle.



NOTE: there are possibilities for alternative to commercial tools

- **Memories**: For memories, there are two options:
    - OpenRAM SRAM compiler: While the support for SkyWater 130 nm technology is still being added to the OpenRAM compiler, there are pre-generated SRAM macros available here. The 1 KByte and 2 KByte macros are verified and can be used in projects.
    - DFFRAM compiler: This generates D flip-flop based memories. It is less dense than OpenRAM by a factor of 3, but more dense than what you would get by synthesizing to flip-flops using OpenLane.

- # Resources

  Documentation

    - SkyWater 130 nm PDK
    - Xschem
    - Ngspice
    - Magic
    - Netgen
    - OpenLane

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- Caravel
- Mflowgen
- Open Hardware Verification Tools

Tutorials and Examples

- Digital flow:

  commercial digital design flow composed using mflowgen, with two small examples: a GCD unit and a design with an SRAM.

- OpenLane tutorial.
- Analog flow:

  Xschem/ngspice tutorial for Monte Carlo simulation.

- Caravel:
  - Walkthrough of caravel user project and analog user project, and how to submit your design to the shuttle.
  - Caravel user project features --- What are the utilities provided by caravel to the user project?
  - Aboard caravel --- How to integrate your design with caravel?

Physical Design: RTL-to-GDSII using SKY130 technology and OpenLANE for EDA

A Tutorial made by Pritesh Shirsath on VSD Cloud platform, (same can be practiced on local Machine).

https://github.com/Ren-Ps/PD_RTL2GDS_SKY130_ps

As per OpenLane Documention, it have more capabilities and features, bit more than above tutorial covers. So, it's suggested to read the doc of it for further try.

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STEPS TO INSTALL OPENROAD

Run the below commands step-by-step:

```
cd
git clone --recursive https://github.com/The-OpenROAD-Project/OpenROAD.git
cd OpenROAD
./etc/DependencyInstaller.sh

cd
git clone --recursive https://github.com/The-OpenROAD-Project/OpenROAD-
flow-scripts
cd OpenROAD-flow-scripts
./build_openroad.sh –local

export OPENROAD=~/OpenROAD-flow-scripts/tools/OpenROAD
export PATH=~/OpenROAD-flow-scripts/tools/install/OpenROAD/bin:~/OpenROAD-
flow-scripts/tools/install/yosys/bin:~/OpenROAD-flow-
scripts/tools/install/LSOracle/bin:$PATH
```

VIEW LAYOUT

The final output of the flow is a GDSII file containing all of the ASIC geometry. We can view it with either Magic VLSI or kLayout. (Suggestion, install both)

kLayout

1. Install kLayout for your platform, by package manager or from source.
2. Set up the Skywater 130 technology in kLayout:
3. Go to **Tools** > **Manage Technologies**
4. Right click on the **Technologies** pane and select **Import Technology**
5. Navigate to `${PDK_ROOT}/sky130A/libs.tech/klayout` and select `sky130A.lyt`
6. This will create the EFS8A technology. Close the **Technology Manager** window and select **EFS8A** with the technology toolbar button (it's a big T in a circle).
7. Open the GDSII file `${LATEST_RUN}/results/magic/gcd.gds`.
8. Play with viewing different layers. (**NOTE:** Else go to Tools > Package Manager > Install New Packages tab > Select sky130 > Apply, to skip till step 6)

OpenLane

Prerequisites - At a minimum:

- GNU Make
- Python 3.6+ with pip and virtualenv
- Git 2.35+
- Docker 19.03.12+

On Ubuntu, that's...

```
apt install -y build-essential python3 python3-venv python3-pip
```

After installing above install Docker and follow post-docer installation steps
Linux **post-installation steps for Docker Engine**

To create the `docker` group and add your user:

1. Create the `docker` group.

   ```
   $ sudo groupadd docker
   ```

2. Add your user to the `docker` group.

   ```
   $ sudo usermod -aG docker $USER
   ```

3. Log out and log back in so that your group membership is re-evaluated.

   If you're running Linux in a virtual machine, it may be necessary to restart the virtual machine for changes to take effect.

   You can also run the following command to activate the changes to groups:

   ```
   $ newgrp docker
   ```

4. Verify that you can run `docker` commands without `sudo`.

   ```
   $ docker run hello-world
   ```

   This command downloads a test image and runs it in a container. When the container runs, it prints a message and exits.

   If you initially ran Docker CLI commands using `sudo` before adding your user to the `docker` group, you may see the following error:

   ```
   WARNING: Error loading config file: /home/user/.docker/config.json -
   stat /home/user/.docker/config.json: permission denied
   ```

This error indicates that the permission settings for the `~/.docker/` directory are incorrect, due to having used the `sudo` command earlier.
To fix this problem, either remove the `~/.docker/` directory (it’s recreated automatically, but any custom settings are lost), or change its ownership and permissions using the following commands:

```
$ sudo chown "$USER":"$USER" /home/"$USER"/.docker -R
$ sudo chmod g+rwx "$HOME/.docker" -R
```

On success of docker post installation, set up the Sky130 PDK and OpenLane by running:

```
    git clone https://github.com/The-OpenROAD-Project/OpenLane.git
    cd OpenLane/
    make
    make test # This a ~5 minute test that verifies that the flow and the
pdk were properly installed
```

Simple 3D viewer for GDS2 files (Visit: gds3xtrude)

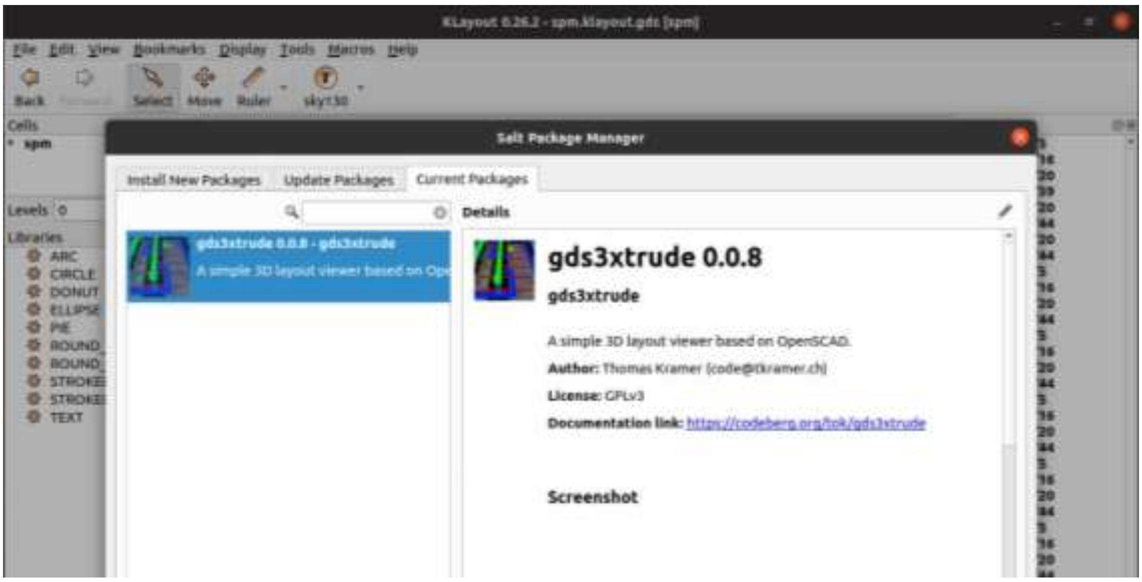
However, the easy way for the same is,

Open KLayout > Tools > Manage Packages

In Install New Packages Tab Search for gds3xtrude

Double click on it > Apply > New window appears as Ready for Installation, Click OK.

Done.!



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