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**GWU Adam Lab**

**SKYWATER 130 PDK Complete Install Guide**

**SKYWATER 130 PDK Complete Install Guide + Basic  
Inverter: 2022**

## Purpose/Outline

This document will provide a detailed outline on how to get started using the [SkyWater PDK](#) and walk through the implementation of a CMOS inverter using the layout tool magic. Many other guides and videos exist on this topic, but this guide is specifically designed for those with limited Linux experience and those unfamiliar with using docker. The guide walks through installations on both Linux and Windows.

## Efabless Docker Image

SkyWater PDK relies on a variety of open-source tools that can be difficult to install individually. Thankfully, Efabless has created a docker image with all the needed tools preconfigured to work with SkyWater. This part of the guide is primarily useful for those unfamiliar with docker.

[Docker is a program designed to run applications in virtual environments](#) called “containers: and has a wide variety of applications. In this case, docker is being used to create a desktop environment with a suite of tools to work with SkyWater. Once the docker image is run, the environment is accessible through a web browser on the host machine.

## Linux Install Guide

### Installing Docker

The beauty of using a virtual environment is that even though these tools primarily run on Linux, docker can be hosted in most any environment. The rest of the guide will assume that the user is using a Linux machine as a host, but [docker can also be installed on Windows and Mac](#).

Note: docker cannot be installed simply using apt on Linux, below is the tutorial provided by [docs.docker.com](https://docs.docker.com):

#### **## Uninstall Old Versions of Docker ##**

```
$ sudo apt-get remove docker docker-engine docker.io containerd runc
```

#### **## Set Up the Repository ##**

```
$ sudo apt-get update
```

```
sudo apt-get install \
```

```
ca-certificates \
```

```
curl \
```

```
gnupg \
```

```
lsb-release
```

#### **## Add Docker's GPG Key ##**

```
$ curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo gpg --dearmor -o /usr/share/keyrings/docker-archive-keyring.gpg
```

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```
$ echo \  
"deb [arch=$(dpkg --print-architecture)  
signed-by=/usr/share/keyrings/docker-archive-keyring.gpg]  
https://download.docker.com/linux/ubuntu \  
$(lsb_release -cs) stable" | sudo tee /etc/apt/sources.list.d/docker.list > /dev/null  
  
## Complete The Install ##  
$ sudo apt-get update  
$ sudo apt-get install docker-ce docker-ce-cli containerd.io docker-compose-plugin  
  
## Run a Quick Test ##  
$ sudo docker run hello-world
```

### Downloading the FOSS-ASIC-TOOLS Image

Now that docker is successfully installed, the image containing all that is needed for SkyWater is ready to be downloaded and run.

The following mimics the install guide found on the ASIC tools [github here](#).

```
$ cd $HOME  
$ mkdir my-local-design-files  
$ export DESIGNS=$HOME/my-local-design-files
```

*\$HOME is simply an environment variable containing the path to the current user's home directory.*

*\$DESIGNS is setup as an environment variable for use in starting the docker in the next steps*

The directory my-local-design-files will reside on the hard disk of the host computer but will be mounted by the docker image at start-up. It will essentially act as a link between the host computer and the design environment.

Inside the environment, this directory will be mounted and appear as “/foss/designs”. Any files placed inside the directory can be accessed by both the host computer and the virtual docker environment. Any files placed outside this directory in the docker will be erased every time the docker is restarted.

Now all that's left is to pull the environment and spin it up. The files are large so these steps may take a bit.

```
$ docker pull efabless/foss-asic-tools:latest
```

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This last step will start the design environment (container) and automatically start a shell in the virtual machine. It automatically mounts the design files directory created earlier using the DESIGNS environment variable. In this example, the password to access the environment is set to “adamlab12” but this can be changed.

```
$ docker pull efabless/foss-asic-tools:latest
$ sudo docker run -it -p 80:80 --user $(id -u):$(id -g) -v $DESIGNS:/foss/designs -e VNC_PW=adamlab12 -e VNC_RESOLUTION=1920x1080 efabless/foss-asic-tools:beta bash
```

Everything is ready, the last step is to use a remote access tool called VNC to access the environment. This is made easy through a web accessible version that should now be running and set up. All that’s left is to enter the loopback address into the web browser of the host machine. <http://127.0.0.1> (Note the use http, not https).

### **Windows Install Guide**

#### **Installing Docker**

Download the exe for Docker from here and install:

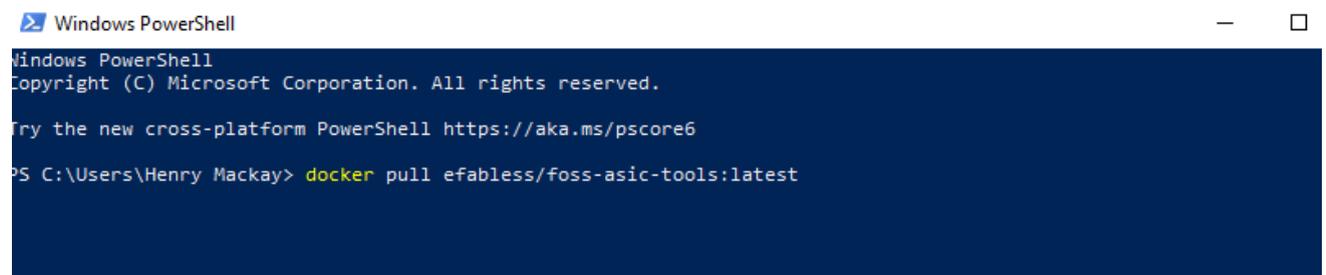
<http://docs.docker.com/desktop/windows/install>

Note: there is also a download available for Mac that is very similar.

#### **Downloading the FOSS-ASIC-TOOLS Image**

Open PowerShell in windows from the search bar and run the following command.

```
> docker pull efabless/foss-asic-tools:latest
```

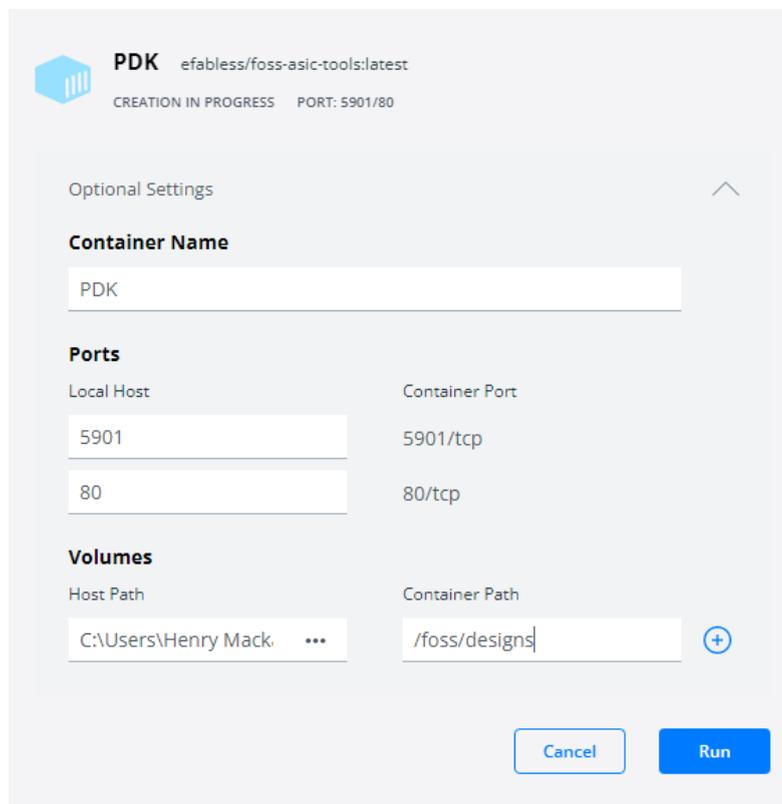


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Create a folder on the hard disk of the host computer that will be mounted by the docker image at start-up. It will essentially act as a link between the host computer and the design environment.

Inside the environment, this directory will be mounted and appear as “/foss/designs”. Any files placed inside the directory can be accessed by both the host computer and the virtual docker environment. Any files placed outside this directory in the docker will be erased every time the docker is restarted.

- Open the Docker GUI.
- Go to the images tab and select “Run” for efabless/foss-asic-tools.
- Use the following options and select the folder you just created for “Host Path”.



**PDK** efabless/foss-asic-tools:latest  
CREATION IN PROGRESS PORT: 5901/80

Optional Settings

**Container Name**

PDK

**Ports**

Local Host	Container Port
5901	5901/tcp
80	80/tcp

**Volumes**

Host Path	Container Path
C:\Users\Henry Mack	/foss/designs

Cancel Run

Everything is ready, the last step is to use a remote access tool called VNC to access the environment. This is made easy through a web accessible version that should now be running and set up. All that's left is to enter the loopback address into the web browser of the host machine. <http://127.0.0.1> (Note the use of http, not https).

## Design Environment

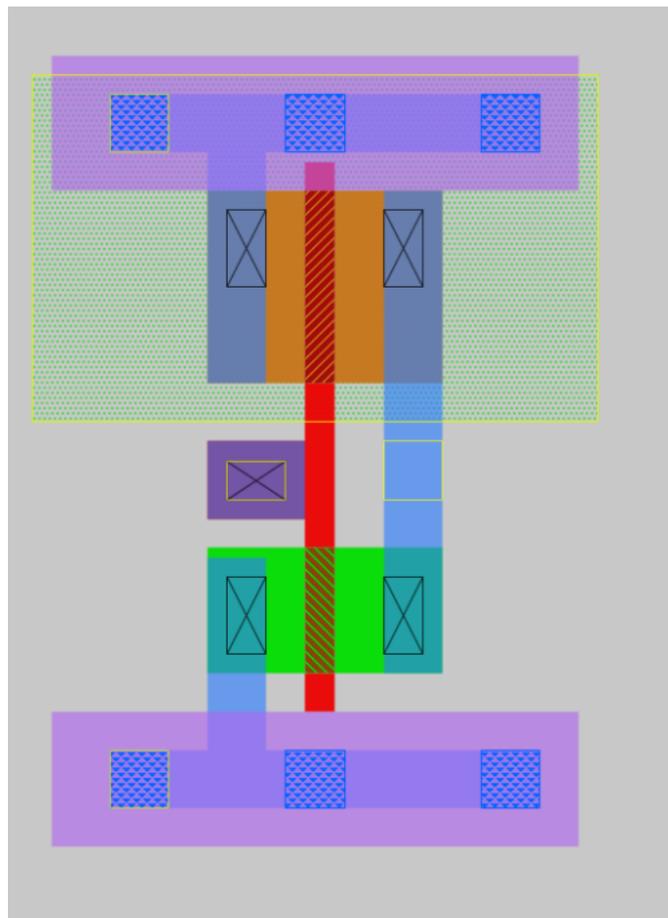
This new environment accessible via a web browser has a few key features

- The shared directory used for storing design files is: /foss/designs
- The directory storing open source tools is: /foss/tools
- The directory storing the skywater pdk is: /foss/pdk

## Inverter Implementation

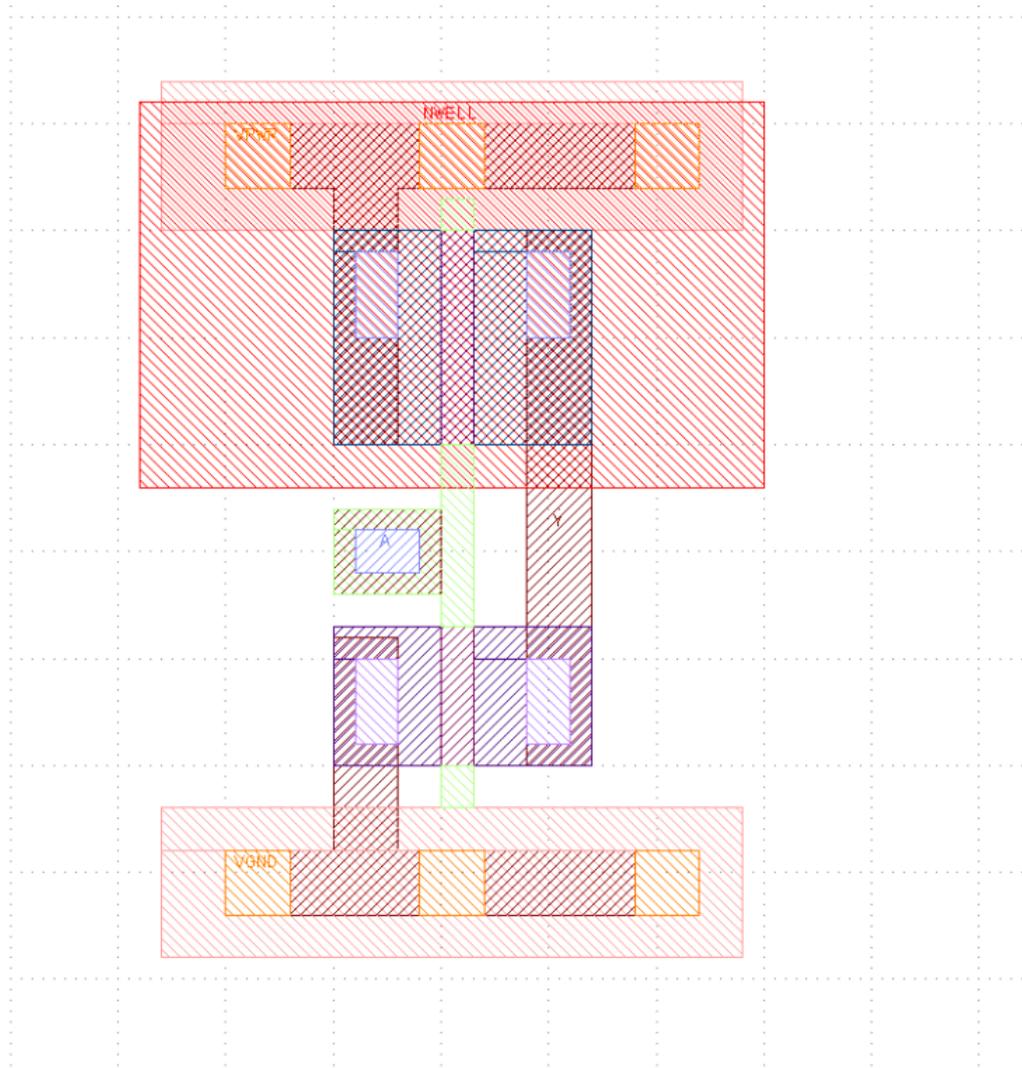
Mathew Venn is an electronic engineer that has several videos on YouTube documenting design using the SkyWater PDK. This is the inverter he implemented in magic from this [YouTube video](#). His channel is a good overall resource for information on SkyWater.

[Klayout](#) is another popular open source layout tool that is compatible with magic files. For demonstration purposes, the same inverter is displayed below in both magic and klayout.



Inverter Layout in Magic

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Same Inverter Layout in klayout

Below is the spice simulation from the inverter layout from output from magic.

```
* instantiate the inverter
```

```
Xinv Y A VPWR VGND VGND VPWR inverter
```

```
.subckt inverter Y A NWELL VSUBS VGND VPWR
```

```
* NGSPICE file created from inverter.ext - technology: sky130A
```

```
* Top level circuit inverter
```

```
X0 Y A VPWR NWELL sky130_fd_pr__pfet_01v8 w=1e+06u l=150000u
```

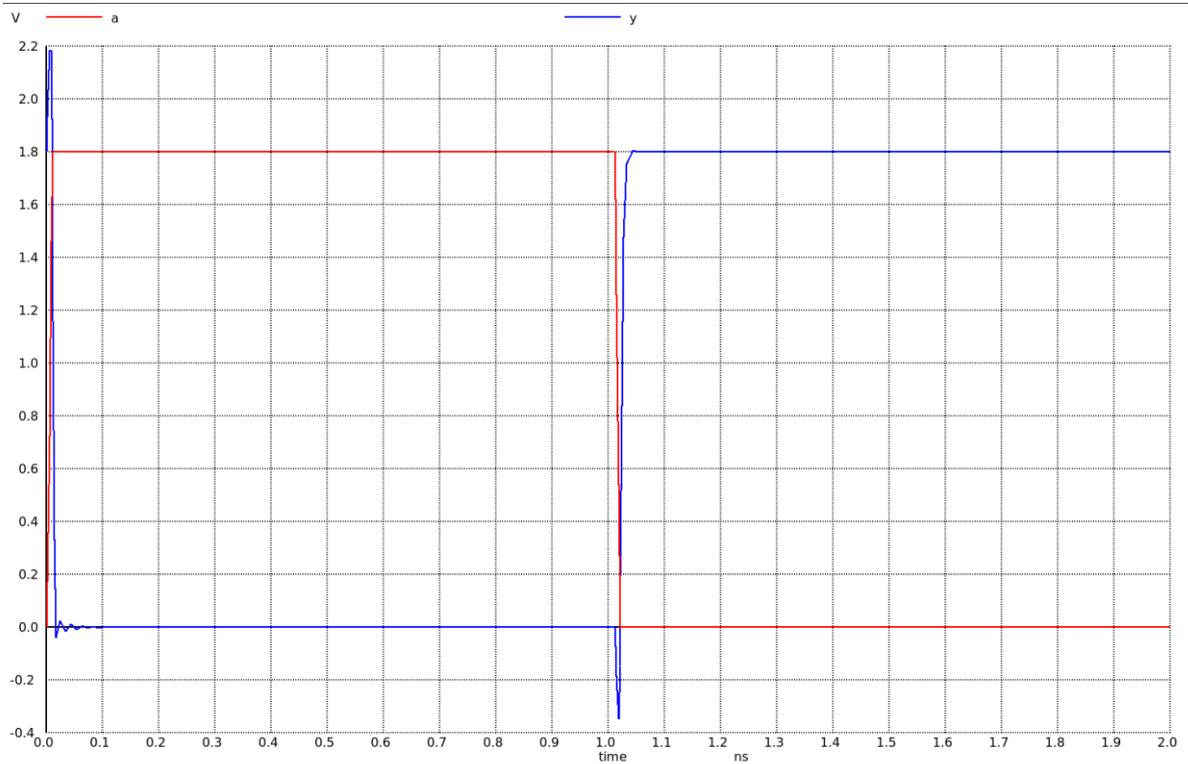
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```
X1 Y A VGND VSUBS sky130_fd_pr__nfet_01v8 w=650000u l=150000u
.ends
* set gnd and power
Vgnd VGND 0 0
Vdd VPWR VGND 1.8

* create pulse
Vin A VGND pulse(0 1.8 1p 10p 10p 1n 2n)
.tran 10e-12 2e-09 0e-00

.control
run
set color0 = white
set color1 = black
plot A Y
plot i(Vdd)
.endc

.end
```



Inverter Spice I-V Curve (does not take parasitics into account)

# SKYWATER 130 PDK Complete Install Guide with Efabless

## Sources/Documentation

Source	Link
Official SkyWater Documentation	<a href="https://skywater-pdk.readthedocs.io/en/main/">https://skywater-pdk.readthedocs.io/en/main/</a>
FOSS ASIC Tools	<a href="https://github.com/efabless/foss-asic-tools">https://github.com/efabless/foss-asic-tools</a>
Docker Documentation	<a href="https://docs.docker.com/get-started/overview/">https://docs.docker.com/get-started/overview/</a>
Inverter in Magic from Matthew Venn	<a href="https://github.com/mattvenn/magic-inverter">https://github.com/mattvenn/magic-inverter</a>
Matthew Venn's Youtube Channel	<a href="https://www.youtube.com/channel/UCZOxcsrjzGz0uDQSLTWPU7w">https://www.youtube.com/channel/UCZOxcsrjzGz0uDQSLTWPU7w</a>
Matthew Venn's Website	<a href="https://www.mattvenn.net/">https://www.mattvenn.net/</a>
Klayout Documentation	<a href="https://www.klayout.de/doc-qt5/manual/">https://www.klayout.de/doc-qt5/manual/</a>
Klayout Inverter with LVS	<a href="https://www.klayout.de/doc-qt5/manual/lvs_intro.html#h2-12">https://www.klayout.de/doc-qt5/manual/lvs_intro.html#h2-12</a>