Installation of CAD tools

This is a step-by-step guide to install tools and their dependencies from their respective git repositories on your system(Ubuntu 22.04). Before, that follow the steps below to download and install git on your system.

```
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop$ sudo add-apt-repository ppa:git-core/ppa
[sudo] password for sysad:
PPA publishes dbgsym, you may need to include 'main/debug' component
Repository: 'deb https://ppa.launchpadcontent.net/git-core/ppa/ubuntu/ jammy main'
Description:
The most current stable version of Git for Ubuntu.

For release candidates, go to https://launchpad.net/~git-core/+archive/candidate .
More info: https://launchpad.net/~git-core/+archive/ubuntu/ppa
Adding repository.
Press [ENTER] to continue or Ctrl-c to cancel.
Found existing deb entry in /etc/apt/sources.list.d/git-core-ubuntu-ppa-jammy.list
Adding deb entry to /etc/apt/sources.list.d/git-core-ubuntu-ppa-jammy.list
Found existing deb-src entry in /etc/apt/sources.list.d/git-core-ubuntu-ppa-jammy.list
Adding disabled deb-src entry to /etc/apt/sources.list.d/git-core-ubuntu-ppa-jammy.list
Adding key to /etc/apt/trusted.gpg.d/git-core-ubuntu-ppa.gpg with fingerprint E1DD270288B4E6030699E45FA1715D88E1DF1F24
Hit:1 http://in.archive.ubuntu.com/ubuntu jammy InRelease
Hit:2 http://security.ubuntu.com/ubuntu jammy-security InRelease
Hit:3 http://in.archive.ubuntu.com/ubuntu jammy-updates InRelease
Hit:4 http://in.archive.ubuntu.com/ubuntu jammy-backports InRelease
Hit:5 https://download.docker.com/linux/ubuntu jammy InRelease
Hit:6 https://ppa.launchpadcontent.net/git-core/ppa/ubuntu jammy InRelease
Reading package lists... Done
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop$ sudo apt update
Hit:1 https://download.docker.com/linux/ubuntu jammy InRelease
Hit:2 http://security.ubuntu.com/ubuntu jammy-security InRelease
Hit:3 http://in.archive.ubuntu.com/ubuntu jammy InRelease
Hit:4 http://in.archive.ubuntu.com/ubuntu jammy-updates InRelease
Hit:5 https://ppa.launchpadcontent.net/git-core/ppa/ubuntu jammy InRelease
Hit:6 http://in.archive.ubuntu.com/ubuntu jammy-backports InRelease
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
12 packages can be upgraded. Run 'apt list --upgradable' to see them.
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop$ sudo apt install git
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
git is already the newest version (1:2.43.0-0ppa1~ubuntu22.04.1).
The following packages were automatically installed and are no longer required:
  bridge-utils ubuntu-fan
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 12 not upgraded.
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop$
```

Analog design flow

List of tools that will be used in designing analog circuits : XSchem : for schematic capture, Ngpsice : for simulation, Magic : layout tool, netgen : to perform LVS. Follow the steps below to install all the tools listed above and their dependencies from git.

Xschem installation :

xschem dependencies :

```
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install libx11-6 -y >log
[sudo] password for sysad:
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install libxrender1  -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install libxcb1 -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install libcairo2 -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install tcl8.6 -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install tk8.6 -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install flex -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install libxpm4 -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install  libx11-dev -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install libxrender-dev -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install libx11-xcb-dev -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install libcairo2-dev -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install tcl8.6-dev -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install tk8.6-dev -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install bison -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install libxpm-dev -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ sudo apt-get install libjpeg-dev -y >log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$
```

XSchem installation :

Type "xschem" in the terminal and press ENTER, to verify installation of the tool.

If you get error when you run **"make"** command, please run the command: **sudo apt install make**

```
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop$ cd /home/sysad/CAD_tools/
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$  git clone https://github.com/StefanSchippers/xschem.git xschem
Cloning into 'xschem'...
remote: Enumerating objects: 24927, done.
remote: Counting objects: 100% (7049/7049), done.
remote: Compressing objects: 100% (1534/1534), done.
remote: Total 24927 (delta 5610), reused 6945 (delta 5509), pack-reused 17878
Receiving objects: 100% (24927/24927), 46.68 MiB | 9.45 MiB/s, done.
Resolving deltas: 100% (19649/19649), done.
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ cd xschem/
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ ./configure
cc -DGENCALL -DRUNTIME -g  -DPLUGIN_SCRIPTS   -Isrc//tmpasm  -DPLUGIN_PARSGEN    -DPLUGIN_GUI     -Isrc//default   -c -o hooks.o h
cc -DGENCALL -DRUNTIME -g  -DPLUGIN_SCRIPTS   -Isrc//tmpasm  -DPLUGIN_PARSGEN    -DPLUGIN_GUI     -Isrc//default -c src//default/f
cc -DGENCALL -DRUNTIME -g  -DPLUGIN_SCRIPTS   -Isrc//tmpasm  -DPLUGIN_PARSGEN    -DPLUGIN_GUI     -Isrc//default -c src//default/l
```

```
Configuration complete, ready to compile.

sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/xschem$ make && make install
cd src && make
make[1]: Entering directory '/home/sysad/CAD_tools/xschem/src'
gcc -c -pipe -O2 -I/usr/include/cairo -I/usr/include/glib-2.0 -I/usr/lib/x86_64-linux-gnu/glib-2.0/inclu
include/libpng16 -I/usr/include/tcl8.6  -o icon.o icon.c
gcc -c -pipe -O2 -I/usr/include/cairo -I/usr/include/glib-2.0 -I/usr/lib/x86_64-linux-gnu/glib-2.0/inclu
include/libpng16 -I/usr/include/tcl8.6  -o callback.o callback.c
gcc -c -pipe -O2 -I/usr/include/cairo -I/usr/include/glib-2.0 -I/usr/lib/x86_64-linux-gnu/glib-2.0/inclu
```

Installation of NgSpice and dependencies :

Ngspice dependencies :

```
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop$ sudo apt-get install libtool -y > ngspice_log
[sudo] password for sysad:
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop$ sudo apt-get install autoconf -y > ngspice_log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop$ sudo apt-get install libxaw7-dev -y > ngspice_log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop$ sudo apt-get install libreadline-dev -y > ngspice_log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop$
```

Ngspice installation :

```
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ git clone https://git.code.sf.net/p/ngspice/ngspice ngspice
Cloning into 'ngspice'...
remote: Enumerating objects: 130302, done.
remote: Counting objects: 100% (130302/130302), done.
remote: Compressing objects: 100% (24583/24583), done.
remote: Total 130302 (delta 106189), reused 128411 (delta 104417)
Receiving objects: 100% (130302/130302), 41.67 MiB | 290.00 KiB/s, done.
Resolving deltas: 100% (106189/106189), done.
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ cd ngspice/
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/ngspice$ ./autogen.sh
Running libtoolize
libtoolize: putting auxiliary files in '.'.
libtoolize: copying file './ltmain.sh'
libtoolize: putting macros in AC_CONFIG_MACRO_DIRS, 'm4'.
libtoolize: copying file 'm4/libtool.m4'
libtoolize: copying file 'm4/ltoptions.m4'
libtoolize: copying file 'm4/ltsugar.m4'
libtoolize: copying file 'm4/ltversion.m4'
libtoolize: copying file 'm4/lt~obsolete.m4'
Running aclocal
Running autoheader
Running automake -Wall --copy --add-missing
configure.ac:46: installing './ar-lib'
configure.ac:42: installing './compile'
configure.ac:44: installing './config.guess'
configure.ac:44: installing './config.sub'
configure.ac:37: installing './install-sh'
configure.ac:37: installing './missing'
src/Makefile.am: installing './depcomp'
configure.ac: installing './ylwrap'
Running autoconf
configure.ac:967: warning: The macro `AC_TRY_LINK' is obsolete.
configure.ac:967: You should run autoupdate.
./lib/autoconf/general.m4:2920: AC_TRY_LINK is expanded from...
configure.ac:967: the top level
configure.ac:1099: warning: AC_PROG_LEX without either yywrap or noyywrap is obsolete
./lib/autoconf/programs.m4:716: _AC_PROG_LEX is expanded from...
./lib/autoconf/programs.m4:709: AC_PROG_LEX is expanded from...
configure.ac:1099: the top level
configure.ac:1330: warning: AC_CHECK_HEADERS($dir/include/readline/readline.h): you should use literals
./lib/autoconf/headers.m4:217: AC_CHECK_HEADERS is expanded from...
configure.ac:1330: the top level
configure.ac:1330: warning: AC_CHECK_HEADERS($dir/include/readline/history.h): you should use literals
./lib/autoconf/headers.m4:217: AC_CHECK_HEADERS is expanded from...
configure.ac:1330: the top level
Success.
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/ngspice$ mkdir release
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/ngspice$ cd release/
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/ngspice/release$ ../configure --with-x --enable-xspice --disable-debug --enal
able-osdi > ngspice_log
configure: WARNING: Removing debugging option!
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/ngspice/release$ make && sudo make install
Making all in src
```

Type "ngspice" in the terminal and press ENTER, to verify installation of the tool.

PDK installation :

```
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ git clone git://opencircuitdesign.com/open_pdks sky_pdk
Cloning into 'sky_pdk'...
remote: Enumerating objects: 9155, done.
remote: Counting objects: 100% (9155/9155), done.
remote: Compressing objects: 100% (3012/3012), done.
remote: Total 9155 (delta 6173), reused 8194 (delta 5563), pack-reused 0
Receiving objects: 100% (9155/9155), 15.02 MiB | 1.93 MiB/s, done.
Resolving deltas: 100% (6173/6173), done.
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ cd sky_pdk/
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/sky_pdk$ ./configure --enable-sky130-pdk > skypdk_log
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/sky_pdk$ make && sudo make install
(cd sky130 && make -j all)
make[1]: Entering directory '/home/sysad/CAD_tools/sky_pdk/sky130'
if test "x" != "x"; then \
        FD_PR_COMMIT=`cat  | grep sky130_fd_pr | grep -v COMMIT | cut -d'"' -f4` ; \
fi
if test "x" != "x"; then \
        FD_IO_COMMIT=`cat  | grep sky130_fd_io | grep -v COMMIT | cut -d'"' -f4` ; \
fi
```

Installation of magic and dependencies :

Magic dependencies :

```
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/magic$
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/magic$
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/magic$ sudo apt-get install libgl-dev > magic_logs
[sudo] password for sysad:
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/magic$ sudo apt-get install libglu1-mesa-dev > magic_logs
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/magic$
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/magic$
```

Magic installation :

```
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ git clone https://github.com/RTimothyEdwards/magic
Cloning into 'magic'...
remote: Enumerating objects: 12430, done.
remote: Counting objects: 100% (12430/12430), done.
remote: Compressing objects: 100% (3690/3690), done.
remote: Total 12430 (delta 8097), reused 12344 (delta 8034), pack-reused 0
Receiving objects: 100% (12430/12430), 7.37 MiB | 4.95 MiB/s, done.
Resolving deltas: 100% (8097/8097), done.
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ cd magic/
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/magic$ ./configure
checking build system type... x86_64-pc-linux-gnu
checking host system type... x86_64-pc-linux-gnu
checking target system type... x86_64-pc-linux-gnu
checking for gcc... gcc
checking whether the C compiler works... yes
checking for C compiler default output file name... a.out
checking for suffix of executables...
checking whether we are cross compiling... no
checking for suffix of object files... o
checking whether we are using the GNU C compiler... yes
checking whether gcc accepts -g... yes
checking for gcc option to accept ISO C89... none needed
checking how to run the C preprocessor... gcc -E
checking for g++... g++
checking whether we are using the GNU C++ compiler... yes
checking whether g++ accepts -g... yes
checking for library containing strerror... none required



Configuration Summary (principle requirements):

X11:          yes
Python3:      yes
OpenGL:       yes
Vector fonts: yes
Cairo:        yes
Tcl/Tk:       yes
------------------------------------------------------------

Use 'make' to compile and 'make install' to install.

------------------------------------------------------------

sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/magic$ make @@ make install
make: *** No rule to make target '@@'.  Stop.
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/magic$ magic
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/magic$
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/magic$
```

Start designing : To create a new directory and start XSchem(or magic) , you can follow these steps using the command line.

Before starting xschem, copy xschemrc file.

```
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~$ mkdir designs
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~$ cd designs/
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/designs$ mkdir schematic
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/designs$ cd schematic/
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/designs/schematic$ cp /usr/local/share/pdk/sky130A/libs.tech/xschem/xschemrc .
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/designs/schematic$ ls
xschemrc
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/designs/schematic$ xschem
Warning: PDK_ROOT env. var. not found or empty, trying to find an open_pdks install
open_pdks installation: using /usr/local/share/pdk
SKYWATER_MODELS: /usr/local/share/pdk/sky130A/libs.tech/combined
SKYWATER_STDCELLS: /usr/local/share/pdk/sky130A/libs.ref/sky130_fd_sc_hd/spice
setup_tcp_bespice: success : listening to TCP port: 2022
[xschem [~/designs/schematic]
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/designs/schematic$ magic -rcfile /usr/local/share/pdk/sky130A/libs.tech/magic/sky130A.magicrc
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/designs/schematic$
```

Digital design flow :

iVerilog is used to verify the functionality of our design and OpenLane to generate GDS.

iVerilog installation :

```
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~$ cd CAD_tools/
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ git clone https://github.com/steveicarus/iverilog.git
Cloning into 'iverilog'...
remote: Enumerating objects: 71648, done.
remote: Counting objects: 100% (9052/9052), done.
remote: Compressing objects: 100% (934/934), done.
remote: Total 71648 (delta 8206), reused 8426 (delta 8108), pack-reused 62596
Receiving objects: 100% (71648/71648), 29.54 MiB | 3.55 MiB/s, done.
Resolving deltas: 100% (54592/54592), done.
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ cd iverilog/
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/iverilog$ sh ./autoconf.sh >iverilog_logs
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/iverilog$ ./configure >iverilog_logs
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools/iverilog$ make && sudo make install > iverilog_log
mkdir dep
Using git-describe for VERSION_TAG
g++ -DHAVE_CONFIG_H -I. -Ilibmisc  -Wall -Wextra -Wshadow   -g -O2 -std=c++11 -MD -c main.cc -o main.o
mv main.d dep/main.d
g++ -DHAVE_CONFIG_H -I. -Ilibmisc  -Wall -Wextra -Wshadow   -g -O2 -std=c++11 -MD -c async.cc -o async.o
mv async.d dep/async.d
g++ -DHAVE_CONFIG_H -I. -Ilibmisc  -Wall -Wextra -Wshadow   -g -O2 -std=c++11 -MD -c design_dump.cc -o design_dump.o
mv design_dump.d dep/design_dump.d
g++ -DHAVE_CONFIG_H -I. -Ilibmisc  -Wall -Wextra -Wshadow   -g -O2 -std=c++11 -MD -c discipline.cc -o discipline.o
mv discipline.d dep/discipline.d
g++ -DHAVE_CONFIG_H -I. -Ilibmisc  -Wall -Wextra -Wshadow   -g -O2 -std=c++11 -MD -c dup_expr.cc -o dup_expr.o
mv dup_expr.d dep/dup_expr.d
g++ -DHAVE_CONFIG_H -I. -Ilibmisc  -Wall -Wextra -Wshadow   -g -O2 -std=c++11 -MD -c elaborate.cc -o elaborate.o
mv elaborate.d dep/elaborate.d
g++ -DHAVE_CONFIG_H -I. -Ilibmisc  -Wall -Wextra -Wshadow   -g -O2 -std=c++11 -MD -c elab_expr.cc -o elab_expr.o
```

Docker installation : First step, install and run docker. Also, verify using "Hello world" example as shown.

```
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ sudo apt-get update
[sudo] password for sysad:
Hit:1 http://in.archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Get:3 http://in.archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Hit:4 http://in.archive.ubuntu.com/ubuntu jammy-backports InRelease
Get:5 http://in.archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [1,366 kB]
Get:6 http://in.archive.ubuntu.com/ubuntu jammy-updates/main i386 Packages [567 kB]
Get:7 http://in.archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1,044 kB]
Hit:8 https://ppa.launchpadcontent.net/git-core/ppa/ubuntu jammy InRelease
Get:9 https://download.docker.com/linux/ubuntu jammy InRelease [48.8 kB]
Fetched 3,255 kB in 6s (512 kB/s)
Reading package lists... Done
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ sudo apt-get install ca-certificates curl
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
ca-certificates is already the newest version (20230311ubuntu0.22.04.1).
curl is already the newest version (7.81.0-1ubuntu1.15).
The following packages were automatically installed and are no longer required:
  bridge-utils ubuntu-fan
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 12 not upgraded.
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ sudo install -m 0755 -d /etc/apt/keyrings
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ sudo curl -fsSL https://download.docker.com/linux/ubuntu/gpg -o /etc/apt/keyrings/docker.asc
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ sudo chmod a+r /etc/apt/keyrings/docker.asc
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ echo \
  "deb [arch=$(dpkg --print-architecture) signed-by=/etc/apt/keyrings/docker.asc] https://download.docker.com/linux/ubuntu \
  $(. /etc/os-release && echo "$VERSION_CODENAME") stable" | \
  sudo tee /etc/apt/sources.list.d/docker.list > /dev/null
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ sudo apt-get update
Hit:1 http://security.ubuntu.com/ubuntu jammy-security InRelease
Hit:2 http://in.archive.ubuntu.com/ubuntu jammy InRelease
Hit:3 http://in.archive.ubuntu.com/ubuntu jammy-updates InRelease
Hit:4 http://in.archive.ubuntu.com/ubuntu jammy-backports InRelease
Hit:5 https://ppa.launchpadcontent.net/git-core/ppa/ubuntu jammy InRelease
Hit:6 https://download.docker.com/linux/ubuntu jammy InRelease
Reading package lists... Done
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/CAD_tools$ sudo docker run hello-world

Hello from Docker!
This message shows that your installation appears to be working correctly.

To generate this message, Docker took the following steps:
 1. The Docker client contacted the Docker daemon.
 2. The Docker daemon pulled the "hello-world" image from the Docker Hub.
    (amd64)
 3. The Docker daemon created a new container from that image which runs the
    executable that produces the output you are currently reading.
 4. The Docker daemon streamed that output to the Docker client, which sent it
    to your terminal.

To try something more ambitious, you can run an Ubuntu container with:
 $ docker run -it ubuntu bash
```

OpenLane installation : Now, download and install OpenLane using git repository.

```
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~$ git clone --depth 1 https://github.com/The-OpenROAD-Project/OpenLane.git
Cloning into 'OpenLane'...
remote: Enumerating objects: 508, done.
remote: Counting objects: 100% (508/508), done.
remote: Compressing objects: 100% (430/430), done.
remote: Total 508 (delta 82), reused 295 (delta 33), pack-reused 0
Receiving objects: 100% (508/508), 8.33 MiB | 1.95 MiB/s, done.
Resolving deltas: 100% (82/82), done.
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~$ cd OpenLane/
```

```
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/OpenLane$ sudo make
make[1]: Entering directory '/home/sysad/CAD_tools/OpenLane'
9dbd8b5ea2bd891bed4dcc97df5c7439083f0368: Pulling from efabless/openlane
Digest: sha256:dd3a76f5bf9752b228dba569368d70d7c32c79da83aaf4e2a871c88fc9be2481
Status: Image is up to date for efabless/openlane:9dbd8b5ea2bd891bed4dcc97df5c7439083f0368
docker.io/efabless/openlane:9dbd8b5ea2bd891bed4dcc97df5c7439083f0368
make[1]: Leaving directory '/home/sysad/CAD_tools/OpenLane'
PYTHONPATH= ./venv/bin/python3 -m pip install --upgrade --no-cache-dir 'volare>=0.12.3'
Collecting volare>=0.12.3
  Downloading volare-0.16.0-py3-none-any.whl.metadata (7.7 kB)
Requirement already satisfied: click<9,>=8.0.0 in ./venv/lib/python3.10/site-packages (from volare>=0.12.3) (8.1.7)
```

Verify OpenLane installation by running **"sudo make test"**. **"Basic test passed"** verifies right installation of the tool.

```
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 61.6/61.6 kB 147.8 MB/s eta 0:00:00
Downloading certifi-2024.2.2-py3-none-any.whl (163 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 163.8/163.8 kB 197.1 MB/s eta 0:00:00
Downloading exceptiongroup-1.2.0-py3-none-any.whl (16 kB)
Downloading typing_extensions-4.9.0-py3-none-any.whl (32 kB)
Installing collected packages: pcpp, zstandard, typing-extensions, sniffio, pygments, mdurl, idna, h11, exceptiongroup, certifi, markdown-it-
Successfully installed anyio-4.2.0 certifi-2024.2.2 exceptiongroup-1.2.0 h11-0.14.0 httpcore-1.0.2 httpx-0.26.0 idna-3.6 markdown-it-py-3.0.0
h-13.7.0 sniffio-1.3.0 typing-extensions-4.9.0 volare-0.16.0 zstandard-0.22.0
./venv/bin/volare enable --pdk sky130
Version cd1748bb197f9b7af62a54507de6624e30363943 enabled for the sky130 PDK.
sysad@sysad-HP-Elite-Tower-600-G9-Desktop-PC:~/OpenLane$ sudo make test
cd /home/sysad/CAD_tools/OpenLane && \
        docker run --rm -v /root:/root -v /home/sysad/CAD_tools/OpenLane:/openlane -v /empty:/openlane/install -v /root/.volare:/root/.volare
 --user 0:0 -e DISPLAY=:0 -v /tmp/.X11-unix:/tmp/.X11-unix -v /root/.Xauthority:/.Xauthority --network host --security-opt seccomp=unconfined
7df5c7439083f0368-amd64 sh -c "./flow.tcl -design spm -tag openlane_test -overwrite"
OpenLane 9dbd8b5ea2bd891bed4dcc97df5c7439083f0368
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[INFO]: Using configuration in 'designs/spm/config.json'...
[INFO]: PDK Root: /root/.volare
[INFO]: Process Design Kit: sky130A
[INFO]: Standard Cell Library: sky130_fd_sc_hd
[INFO]: Optimization Standard Cell Library: sky130_fd_sc_hd
[INFO]: Run Directory: /openlane/designs/spm/runs/openlane_test
[INFO]: Saving runtime environment...
[INFO]: Preparing LEF files for the nom corner...
[INFO]: Preparing LEF files for the min corner...
[INFO]: Preparing LEF files for the max corner...
[INFO]: Running linter (Verilator) (log: designs/spm/runs/openlane_test/logs/synthesis/linter.log)...
[INFO]: 0 errors found by linter
[INFO]: 0 warnings found by linter
[STEP 1]
[INFO]: Running Synthesis (log: designs/spm/runs/openlane_test/logs/synthesis/1-synthesis.log)...
[STEP 2]
[INFO]: Running Single-Corner Static Timing Analysis (log: designs/spm/runs/openlane_test/logs/synthesis/2-sta.log)...
[STEP 3]
[INFO]: Running Initial Floorplanning (log: designs/spm/runs/openlane_test/logs/floorplan/3-initial_fp.log)...
```

Designing using iVerilog and openlane :

Verify design using iVerilog commands as given below:

iverilog -o counter counter_tb.v counter.v

vvp counter

Complied results are stored in "counter" file, which can used to verify the results. This is one of the ways of compiling.

OpenLane : Commands to add new design and run the flow script as shown below: