

Building and Installing the USRP Open-Source Toolchain (UHD and GNU Radio) on OS X

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This AN provides a comprehensive step-by-step guide for installing UHD (and GNU Radio) on *OSX* (Mac OS X / MacOS X 10.4 to 10.15) and *macOS 11 or newer* -- whether via a package manager or from source.

UHD 3.9, 3.15, and 4.0 have been compiled and installed on OSX 10.4 ("Tiger") and 10.5 ("Leopard") for PowerPC or Intel 32-bit, OSX 10.6 ("Snow Leopard") through the OSX 10.15 ("Catalina") for Intel 64-bit, as well as macOS 11 ("Big Sur") Intel or ARM 64-bit running any compatible version of Xcode on all recent and many older Macs. In general UHD performance varies greatly depending on the computer's OS, CPU, and networking stack and hardware for ethernet and USB. For Macs there is more consistency between hardware and OS versions because of Apple's tight coupling of hardware and software; hence the broad OSX and hardware support for UHD.

Primary support is for 64-bit Intel-based Macs, running OSX 10.9 or newer using Clang / libc++; secondary support is for OSX 10.6 through 10.8 64-bit Intel-based Macs using Xcode's default GCC / libstdc++ or specially-installed Clang / libc++ (e.g., via MacPorts); tertiary support is for OSX 10.4 and 10.5 Intel or PowerPC 32-bit using Xcode's default GCC / libstdc++ (as of early 2021, Clang does not yet build reliably for these older OSX). There is very little support for getting the background libraries and applications installed on OSX 10.4 or 10.5 (in general, and for 64-bit in specific), and for 32-bit Intel installs -- though any or all of these might be possible. MacPorts makes efforts to keep its ports working on all OSX from 10.4 through current, though some ports require an older version than current, or OS-specific patches. Hence, we recommend using MacPorts for older OSX installs as well as in general.

For the purposes of building and using UHD, you can use Apple's Terminal.app if you so choose, no matter how you install UHD. Other terminal applications such as *iTerm2* work well too.

That said, running almost any graphical user interface (GUI) will require downloading and installing X11/XQuartz first. Through OSX 10.8, Apple provided a means to install the X11.app directly, but XQuartz has always been more up to date. Starting in OSX 10.9, Apple no longer provided X11.app. Hence, just use XQuartz from the get-go. Note that unless you experiment with using the Quartz interface to various graphical toolkits (e.g., GTK), you *must* use X11 as the terminal interface for any GUI applications for UHD and GNU Radio.

Apple provides a full integrated development environment via *Xcode*, which can be downloaded either via the Mac App store or directly from Apple's Developer area depending on the version of OSX in use. Xcode provides the compilers and related development tools needed to build and execute UHD and its dependencies.

Once Xcode is installed, you must still install the *Command Line Tools*, which can be accomplished by executing the *Xcode.app*, then going to *Preferences...* -> *Downloads* and making sure Command Line Tools is selected/enabled [feel free to select other downloads too]. You might be able to install the Command Line Tools in a terminal using the command

```
xcode-select --install
```

but this command will not work with every OSX / Xcode combination (e.g., does not work with OSX 10.8 and Xcode 5, but does work with OSX 10.9 and Xcode 5). More recent OSX provides the Command Line Tools via the Mac App Store.

Once the Command Line Tools are installed, UHD and other projects can be installed either from source or, preferably, via a package manager such as MacPorts.

UHD can be installed via a package manager or from source. For installing via a package manager we cover just via [MacPorts](#); other package managers such as [Fink](#) or [HomeBrew](#) might provide a means for installed UHD similar to that found in MacPorts. MacPorts tends to be more up-to-date with respect to new releases, which can be both a blessing and a curse since sometimes new releases are untested and result in build or runtime errors. MacPorts, HomeBrew, and Fink offer thousands of ready-to-install libraries and applications, and hence they are highly recommended to use instead of installing from source / scratch.

NOTE: We highly recommended that you install all dependencies via the *same package manager!* When issues arise, the issues are much easier to track down, and updating UHD and any of its dependencies is also much easier.

We recommend using MacPorts and actively support UHD development on OSX via this method. Using MacPorts, the correct hardware device images are automatically installed for you, and there are no post-install tasks. With a single command, you can be up and running in short order.

If you do not already have MacPorts installed, you will need to [install it first](#). If required (such as installing MacPorts from source), follow the [MacPorts shell environment changes](#) guide such that MacPorts-installed executables are found before all others. These are the only changes to the shell environment needed to execute any MacPorts-installed executable.

NOTE: Setting any DYLD environment variable (e.g., *DYLD_LIBRARY_PATH*) for general use is **highly discouraged**, because doing so, in our experience, leads to problems down the road that are very difficult to diagnose. OSX provides robust means for correcting DYLD-based issues even after dependencies are installed.

Once MacPorts is installed, UHD and all of its dependencies can be installed by executing

```
sudo port install uhd
```

This method of installing UHD is actively kept up to date by Ettus Research technical support, and hence is the recommended way to install GNU Radio on OSX. GNU Radio can similarly be installed via

```
sudo port install gnuradio
```

The latest developments in UHD and GNU Radio can be installed via

```
sudo port install uhd-devel
sudo port install gnuradio-devel
```

Please note that these *devel* ports, while tested for basic compilation and functionality, are not formal releases and hence should be considered beta software which might contain bugs or even major issues.

There are a number of background libraries and applications that must be installed from source or binary in order to compile or execute UHD; a full list is provided in the [UHD build guide](#). These can be obtained by using a package manager and/or from source.

Many UHD developers first install UHD using MacPorts in order to get all of the necessary background dependencies installed, then remove just UHD via

```
sudo port uninstall uhd
```

Installing UHD from source follows the [standard cmake method](#), with a few arguments to make sure *cmake* always finds the Python executable, library, and headers *from the same Python install*, and uses the desired compiler. First, download the source code either as a [release](#) or [via GIT](#).

NOTE: All of the PYTHON defines must point to the same install of Python, otherwise runtime errors are likely to occur.

For example, on OSX 10.14 or 10.15 using Xcode 11 (which provides the Clang compiler suite), MacPorts installed into */opt/local* (the default), and for Python 2.7 (as installed by MacPorts), issue the following commands from within the UHD source top-level directory:

```
$ mkdir build
$ cd build
$ CC=/usr/bin/clang CXX=/usr/bin/clang++ \
  cmake -DPYTHON_EXECUTABLE=/opt/local/bin/python2.7 \
  -DPYTHON_INCLUDE_DIR=/opt/local/Library/Frameworks/Python.framework/Versions/2.7/Headers \
  -DPYTHON_LIBRARY=/opt/local/Library/Frameworks/Python.framework/Versions/2.7/Python ../host
$ make
```

If *make* succeeds, then you can test the build for errors via

```
$ make test
```

To install the build, issue

```
$ sudo make install
```

and UHD will be installed into the default prefix, */usr/local*.

NOTE: To change the install prefix to */path/to/your/desired/prefix*, in the *cmake* command add the argument *-DCMAKE_INSTALL_PREFIX=/path/to/your/desired/prefix --* changing the actual path to that of the desired install prefix.

NOTE: If you want to test where the install will place files, you can set a destination directory that the install prefix is appended to via using the pre-argument *DESTDIR*. To verify that all files are installed and then uninstalled correctly, we often use the following command

```
$ DESTDIR=./tmp make install
```

and then look in the directory *./tmp* to verify that all of the desired files are installed into their final destination correctly, starting with the *CMAKE_INSTALL_PREFIX*. Then, issue the command

```
$ DESTDIR=./tmp make uninstall
```

to uninstall from the same directory. Then look in the directory *./tmp* to see if any files remain, and if so then fix the CMake scripts to both install and uninstall all of the desired files correctly.

NOTE: Selecting another compiler is as simple as changing the *CC* and *CXX* pre-arguments to the *cmake* command.

See the [GNU Radio OSX Install guide](#).