

# 2016



## srsLTE installation

TENET  
TECHNETRONICS

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srsLTE is a free and open-source LTE library for SDR UE and eNodeB developed by SRS, licensed by AGPLv3 . The library is highly modular with minimum inter-module or external dependencies. It is entirely written in C and, if available in the system, uses the acceleration library VOLK distributed in GNURadio.

**Software support:** It supports PHY LTE for release 8. It is designed for maximum modularity and code reuse with minimal inter-module or external dependencies. The code is written in ANSI C and makes extensive use of Single Instruction Multiple Data (SIMD) operations, for maximum performance.

- LTE Release 8 compliant
- FDD configuration
- Tested bandwidths: 1.4, 3, 5, 10, 15 and 20 MHz
- Transmission mode 1 (single antenna) and 2 (transmit diversity)
- Cell search and synchronization procedure for the UE
- All DL channels/signals are supported for UE and eNodeB side: PSS, SSS, PBCH, PCFICH, PHICH, PDCCH, PDSCH
- All UL channels/signals are supported for UE side: PRACH, PUSCH, PUCCH, SRS
- Frequency-based ZF and MMSE
- Highly optimized Turbo Decoder available in Intel SSE4.1/AVX (+100 Mbps) and standard C (+25 Mbps)
- MATLAB and OCTAVE MEX library generation for many components
- UE receiver tested and verified with Amarisoft LTE 100 eNodeB and commercial LTE networks (Telefonica Spain, Three.ie and Eircom in Ireland).

**Hardware Capability:** The library deals with buffers of samples in system memory thus being able to work with any RF front-end. It currently provides interfaces to the Universal Hardware Driver (UHD), giving support to the Ettus USRP family of devices. The aim of the library is providing the tools to build LTE-based applications such as a complete eNodeB or UE. There is no sampling rate conversion, therefore the hardware should support 30.72 MHz clock in order to work correctly with LTE sampling frequencies and decode signals from live LTE base stations. Tested hardware supports:

- USRP B210
- USRP X300
- bladeRF.

### Installing srsLTE:

srsLTE is dependent on the GUI package provided by srs, i.e srsGUI. Thus before installing srsLTE, we need to install srsGUI.

**srsGUI:** srsGUI is a free and open-source graphics library for SDR using Qt and Qwt. It is licensed by GPLv3. The library provides a number of useful plots for graphing real and complex numbers. Each plot is designed to be frequently updated with new data.

### Current Features:

- Real plot - simple line plot.
- Complex plot - plot including real, imaginary, magnitude and phase values.
- Scatter plot - 2-D scatter plot for complex-valued data.
- Waterfall plot - includes a line plot and waterfall plot showing past values using a colour legend.

## Installing srsGUI:

Requirements boost, qt4, qwt packages. To install these run the following command in the terminal:

**sudo apt-get install libboost-system-dev libboost-test-dev libboost-thread-dev libqwt-dev libqt4-dev**

**Or**

**sudo aptitude install libboost-system-dev libboost-thread-dev libqwt-dev libqt4-dev**

**Or**

Install the boost packages from the website [www.boost.org](http://www.boost.org)

- Download the current release (Boost\_1\_60\_0)
- Unpack it using the following commands:
  - **xxx@ubuntu:~\$ cd Downloads**
  - **xxx@ubuntu/Downloads/:~\$ sudo tar -zxf boost\_1\_60\_0.tar.gz**
  - **xxx@ubuntu/Downloads/:~\$ cd boost\_1\_60\_0**
  - **xxx@ubuntu/Downloads/boost\_1\_60\_0/:~\$ sudo ./bootstrap.sh --prefix=/usr/local/**
  - **xxx@ubuntu/Downloads/boost\_1\_60\_0/:~\$ sudo ./b2**

```
kavya@ubuntu:~/Downloads/boost_1_60_0$ sudo ./b2
Performing configuration checks

- 32-bit : no (cached)
- 64-bit : yes (cached)
- arm : no (cached)
- mips1 : no (cached)
- power : no (cached)
- sparc : no (cached)
- x86 : yes (cached)
```

```
Building the Boost C++ Libraries.

- symlinks supported      : yes (cached)
- lockfree boost::atomic_flag : yes (cached)
- has_icu builds          : yes (cached)
warning: Graph library does not contain MPI-based parallel components.
note: to enable them, add "using mpi ;" to your user-config.jam
- zlib                      : yes (cached)
- iconv (libc)              : yes (cached)
- icu                       : yes (cached)
- compiler-supports-visibility : yes (cached)
- compiler-supports-sse3    : yes (cached)
- compiler-supports-avx2    : no  (cached)
- gcc visibility            : yes (cached)
- long double support       : yes (cached)
warning: skipping optional Message Passing Interface (MPI) library.
note: to enable MPI support, add "using mpi ;" to user-config.jam.
note: to suppress this message, pass "--without-mpi" to bjam.
note: otherwise, you can safely ignore this message.
- zlib                      : yes (cached)

Component configuration:

- atomic                  : building
- chrono                  : building
- container               : building
- context                 : building
- coroutine               : building
- coroutine2              : building
```

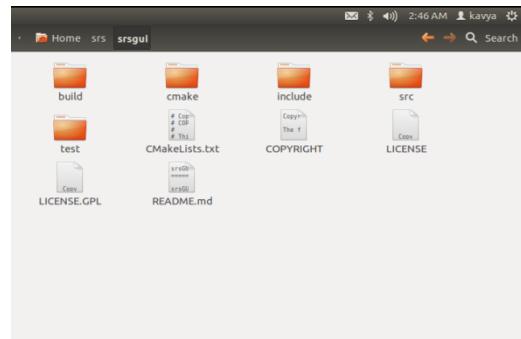
```
- random                  : building
- regex                   : building
- serialization           : building
- signals                 : building
- system                  : building
- test                     : building
- thread                  : building
- timer                   : building
- type_erasure            : building
- wave                     : building

...patience...
...patience...
...patience...
...patience...
...patience...
...patience...
...found 13808 targets...

The Boost C++ Libraries were successfully built!
The following directory should be added to compiler include paths:
  /home/kavya/Downloads/boost_1_60_0
The following directory should be added to linker library paths:
  /home/kavya/Downloads/boost_1_60_0/stage/lib
kavya@ubuntu:~/Downloads/boost_1_60_0$ █
```

To download and install srsGUI run the following commands in terminal

- git clone <http://github.com/suttonpd/srsgui.git>
- cd srsgui
- mkdir build



- cd build
- cmake ..
- make

```
kavya@ubuntu:~$ cd Downloads/srsgui/build
kavya@ubuntu:~/Downloads/srsgui/build$ cmake ../
--
-- Configuring Boost C++ Libraries...
-- Boost version: 104800
-- Boost include directories: /usr/include
-- Boost library directories: /usr/lib
-- Boost libraries: /usr/lib/libboost_thread-mt.so;/usr/lib/libboost_unit_test_framework-mt.so;/usr/lib/libboost_system-mt.so
-- srsGUI library will be installed.
-- Configuring done
-- Generating done
-- Build files have been written to: /home/kavya/Downloads/srsgui/build
kavya@ubuntu:~/Downloads/srsgui/build$
```

```
kavya@ubuntu:~/Downloads/srsgui/build$ make
[ 1%] Generating waterfallplot/moc_WaterfallplotWrapper.cxx
[ 3%] Generating __/include/srsgui/common/moc_Lineplot.cxx
[ 5%] Generating __/include/srsgui/common/moc_Pointplot.cxx
[ 7%] Generating __/include/srsgui/common/moc_Spectrogramplot.cxx
```

TECHNE TRONICS

```
t.c.o
Linking C executable complexplot_test_c
[ 86%] Built target complexplot_test_c
[ 88%] Building C object test/c/CMakeFiles/realplot_test_c.dir/realplot_test.c.o
Linking C executable realplot_test_c
[ 88%] Built target realplot_test_c
[ 90%] Building C object test/c/CMakeFiles/scatterplot_test_c.dir/scatterplot_tes
t.c.o
Linking C executable scatterplot_test_c
[ 90%] Built target scatterplot_test_c
[ 92%] Building C object test/c/CMakeFiles/waterfallplot_test_c.dir/waterfallplot_
test.c.o
Linking C executable waterfallplot_test_c
[ 92%] Built target waterfallplot_test_c
[ 94%] Building CXX object test/cxx/CMakeFiles/complexplot_test.dir/complexplot_t
est.cpp.o
Linking CXX executable complexplot_test
[ 94%] Built target complexplot_test
[ 96%] Building CXX object test/cxx/CMakeFiles/realplot_test.dir/realplot_test.cp
p.o
Linking CXX executable realplot_test
[ 96%] Built target realplot_test
[ 98%] Building CXX object test/cxx/CMakeFiles/scatterplot_test.dir/scatterplot_t
est.cpp.o
Linking CXX executable scatterplot_test
[ 98%] Built target scatterplot_test
[100%] Building CXX object test/cxx/CMakeFiles/waterfallplot_test.dir/waterfallpl
ot_test.cpp.o
Linking CXX executable waterfallplot_test
[100%] Built target waterfallplot_test
kavya@ubuntu:~/Downloads/srsgui/build$ █
```

- sudo make install

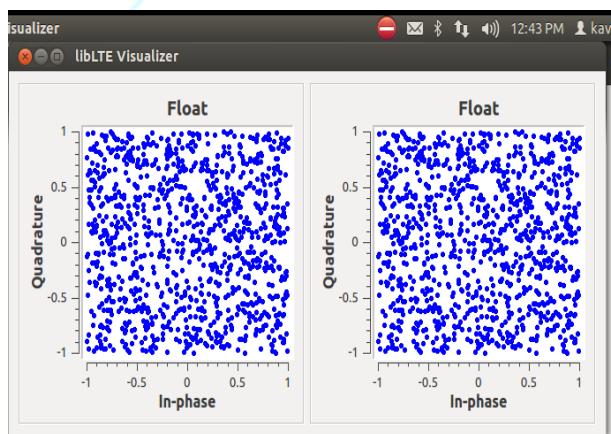
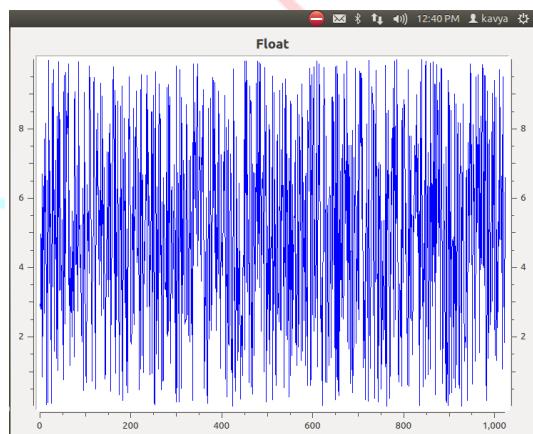
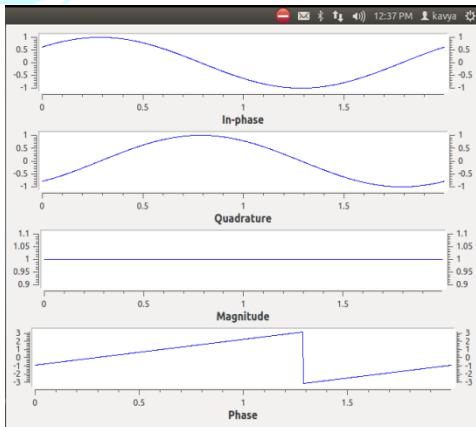
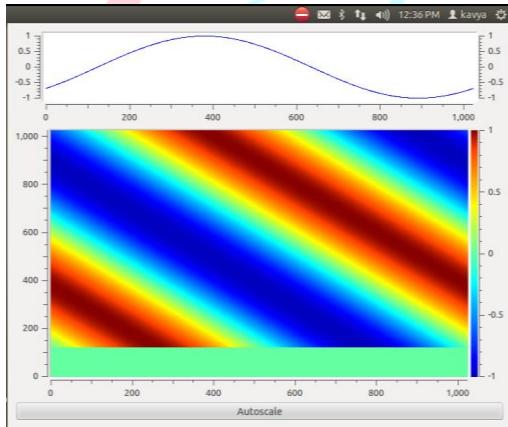
```
[ 84%] Built target srsgui
[ 86%] Built target complexplot_test_c
[ 88%] Built target realplot_test_c
[ 90%] Built target scatterplot_test_c
[ 92%] Built target waterfallplot_test_c
[ 94%] Built target complexplot_test
[ 96%] Built target realplot_test
[ 98%] Built target scatterplot_test
[100%] Built target waterfallplot_test
Install the project...
-- Install configuration: ""
-- Installing: /usr/local/include/srsgui
-- Installing: /usr/local/include/srsgui/plot
-- Installing: /usr/local/include/srsgui/plot/plot_waterfall.h
-- Installing: /usr/local/include/srsgui/plot/Complexplot.h
-- Installing: /usr/local/include/srsgui/plot/Scatterplot.h
-- Installing: /usr/local/include/srsgui/plot/Waterfallplot.h
-- Installing: /usr/local/include/srsgui/plot/plot_scatter.h
-- Installing: /usr/local/include/srsgui/plot/plot_real.h
-- Installing: /usr/local/include/srsgui/plot/Realplot.h
-- Installing: /usr/local/include/srsgui/plot/plot_complex.h
-- Installing: /usr/local/include/srsgui/srsgui.h
-- Installing: /usr/local/include/srsgui/common
-- Installing: /usr/local/include/srsgui/common/Spectrogramplot.h
-- Installing: /usr/local/include/srsgui/common/Pointplot.h
-- Installing: /usr/local/include/srsgui/common/WaterfallData.h
-- Installing: /usr/local/include/srsgui/common/Events.h
-- Installing: /usr/local/include/srsgui/common/Lineplot.h
-- Installing: /usr/local/include/srsgui/srsgui++.h
-- Installing: /usr/local/lib/libsrsgui.so
kavya@ubuntu:~/Downloads/srsgui/build$ █
```

- make test

```
kavya@ubuntu:~/Downloads/srsgui/build$ make test
Running tests...
Test project /home/kavya/Downloads/srsgui/build
  Start 1: waterfallplot_test_c
  1/8 Test #1: waterfallplot_test_c ..... Passed    11.29 sec
  Start 2: complexplot_test_c
  2/8 Test #2: complexplot_test_c ..... Passed    3.80 sec
  Start 3: realplot_test_c
  3/8 Test #3: realplot_test_c ..... Passed    4.53 sec
  Start 4: scatterplot_test_c
  4/8 Test #4: scatterplot_test_c ..... Passed    7.66 sec
  Start 5: waterfallplot_test
  5/8 Test #5: waterfallplot_test ..... Passed   13.10 sec
  Start 6: complexplot_test
  6/8 Test #6: complexplot_test ..... Passed    6.26 sec
  Start 7: realplot_test
  7/8 Test #7: realplot_test ..... Passed    2.20 sec
  Start 8: scatterplot_test
  8/8 Test #8: scatterplot_test ..... Passed    2.03 sec

100% tests passed, 0 tests failed out of 8

Total Test time (real) = 51.10 sec
kavya@ubuntu:~/Downloads/srsgui/build$
```



- After installing srsgui, we need to install libfftw from ubuntu package manager.  
This can be done by using the following command:

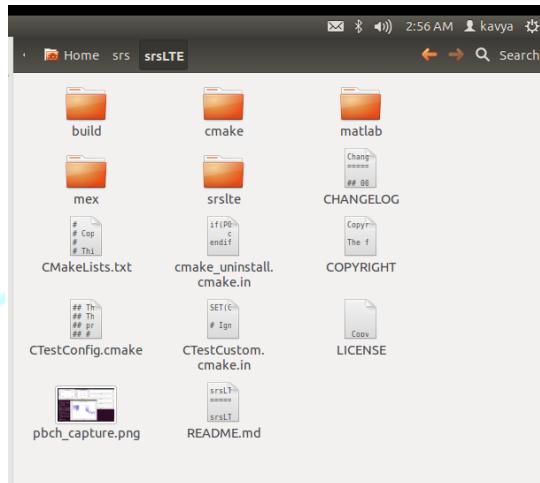
**Sudo apt-get install libfftw**

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## Steps to install srsLTE:

- git clone <http://github.com/srsLTE/srsLTE.git>
- cd srsLTE
- mkdir build



- cd build
- cmake ..
- make

```
kavya@ubuntu:~$ cd Downloads
kavya@ubuntu:~/Downloads$ cd srsLTE/build
kavya@ubuntu:~/Downloads/srsLTE/build$ cmake ../
-- Build type not specified: defaulting to Release.
-- SSE4.1 is enabled - target CPU must support it
-- AVX is enabled - target CPU must support it
-- Using install prefix: /usr/local
-- Building for version: 001.001.000
-- UHD LIBRARIES /usr/local/lib/libuhd.so
-- UHD INCLUDE DIRS /usr/local/include
-- checking for module 'libbladeRF'
-- package 'libbladeRF' not found
-- libbladeRF not found.
-- SRSGUI LIBRARIES /usr/local/lib/libsrsgui.so
-- SRSGUI INCLUDE DIRS /usr/local/include
-- Found SRSGUI: /usr/local/lib/libsrsgui.so
-- Could NOT find VOLK (missing: VOLK_LIBRARIES VOLK_INCLUDE_DIRS)
-- VOLK SIMD library NOT found. Using generic implementation.
-- SRSGUI LIBRARIES /usr/local/lib/libsrsgui.so
-- SRSGUI INCLUDE DIRS /usr/local/include
-- examples will be installed.
-- Configuring done
-- Generating done
-- Build files have been written to: /home/kavya/Downloads/srsLTE/build
kavya@ubuntu:~/Downloads/srsLTE/build$
```

```
kavya@ubuntu:~/Downloads/srsLTE/build$ make clean
kavya@ubuntu:~/Downloads/srsLTE/build$ make
[ 1%] Building C object srslte/lib/CMakeFiles/srslte.dir/ch_estimation/src/refsi
gnal_dl.c.o
[ 2%] Building C object srslte/lib/CMakeFiles/srslte.dir/ch_estimation/src/chest_
dl.c.o
[ 2%] Building C object srslte/lib/CMakeFiles/srslte.dir/ch_estimation/src/refsi
gnal_ul.c.o
[ 3%] Building C object srslte/lib/CMakeFiles/srslte.dir/utils/src/convolution.c
.o
[ 4%] Building C object srslte/lib/CMakeFiles/srslte.dir/utils/src/vector_simd.c
.o
[ 5%] Building C object srslte/lib/CMakeFiles/srslte.dir/utils/src/cexptab.c.o
[ 5%] Building C object srslte/lib/CMakeFiles/srslte.dir/utils/src/debug.c.o
[ 6%] Building C object srslte/lib/CMakeFiles/srslte.dir/utils/src/bit.c.o
[ 7%] Building C object srslte/lib/CMakeFiles/srslte.dir/utils/src/vector.c.o
[ 8%] Building C object srslte/lib/CMakeFiles/srslte.dir/io/src/filesource.c.o
[ 8%] Building C object srslte/lib/CMakeFiles/srslte.dir/io/src/netsource.c.o
[ 9%] Building C object srslte/lib/CMakeFiles/srslte.dir/io/src/netsink.c.o
[ 10%] Building C object srslte/lib/CMakeFiles/srslte.dir/io/src/filesink.c.o
[ 11%] Building C object srslte/lib/CMakeFiles/srslte.dir/io/src/binsource.c.o
[ 11%] Building C object srslte/lib/CMakeFiles/srslte.dir/modem/src/modem_table.c
.o
[ 12%] Building C object srslte/lib/CMakeFiles/srslte.dir/modem/src/hard_demod_lt
e.c.o
[ 13%] Building C object srslte/lib/CMakeFiles/srslte.dir/modem/src/demod_soft.c
.o
```

```
Linking C executable pdsch_ue
[ 95%] Built target pdsch_ue
Scanning dependencies of target synch_file
[ 96%] Building C object srslte/examples/CMakeFiles/synch_file.dir/synch_file.c.o
Linking C executable synch_file
[ 96%] Built target synch_file
Scanning dependencies of target usrp_capture
[ 97%] Building C object srslte/examples/CMakeFiles/usrp_capture.dir/usrp_capture
.c.o
Linking C executable usrp_capture
[ 97%] Built target usrp_capture
Scanning dependencies of target usrp_capture_sync
[ 98%] Building C object srslte/examples/CMakeFiles/usrp_capture_sync.dir/usrp_ca
ture_sync.c.o
Linking C executable usrp_capture_sync
[ 98%] Built target usrp_capture_sync
Scanning dependencies of target usrp_txrx
[ 99%] Building C object srslte/examples/CMakeFiles/usrp_txrx.dir/usrp_txrx.c.o
Linking C executable usrp_txrx
[ 99%] Built target usrp_txrx
Scanning dependencies of target pss
[100%] Building C object srslte/examples/tutorial_examples/CMakeFiles/pss.dir/pss
.c.o
Linking C executable pss
[100%] Built target pss
Scanning dependencies of target simple_tx
[100%] Building C object srslte/examples/tutorial_examples/CMakeFiles/simple_tx.d
ir/simple_tx.c.o
Linking C executable simple_tx
[100%] Built target simple_tx
kavya@ubuntu:~/Downloads/srsLTE/build$ █
```

- sudo make install

```
-- Up-to-date: /usr/local/include/srslte/fec/rm_conv.h
-- Up-to-date: /usr/local/include/srslte/fec/rm_turbo.h
-- Up-to-date: /usr/local/include/srslte/fec/turbodecoder_sse.h
-- Installing: /usr/local/include/srslte/channel
-- Up-to-date: /usr/local/include/srslte/channel/ch_awgn.h
-- Installing: /usr/local/include/srslte/sync
-- Up-to-date: /usr/local/include/srslte/sync/cfo.h
-- Up-to-date: /usr/local/include/srslte/sync/sync.h
-- Up-to-date: /usr/local/include/srslte/sync/cp.h
-- Up-to-date: /usr/local/include/srslte/sync/ssb.h
-- Up-to-date: /usr/local/include/srslte/sync/pss.h
-- Up-to-date: /usr/local/include/srslte/sync/sfo.h
-- Installing: /usr/local/include/srslte/agc
-- Up-to-date: /usr/local/include/srslte/agc/agc.h
-- Installing: /usr/local/include/srslte/rf
-- Up-to-date: /usr/local/include/srslte/rf/rf_utils.h
-- Up-to-date: /usr/local/include/srslte/rf/rf.h
-- Installing: /usr/local/include/srslte/resampling
-- Up-to-date: /usr/local/include/srslte/resampling/interp.h
-- Up-to-date: /usr/local/include/srslte/resampling/resample_arb.h
-- Up-to-date: /usr/local/include/srslte/resampling/decim.h
-- Installing: /usr/local/include/srslte/mimo
-- Up-to-date: /usr/local/include/srslte/mimo/precoding.h
-- Up-to-date: /usr/local/include/srslte/mimo/layermap.h
-- Installing: /usr/local/lib/libsrslte_rf.so.001.001
-- Up-to-date: /usr/local/lib/libsrslte_rf.so
-- Removed runtime path from "/usr/local/lib/libsrslte_rf.so.001.001"
-- Installing: /usr/local/lib/libsrslte.so.001.001
-- Up-to-date: /usr/local/lib/libsrslte.so
-- Up-to-date: /usr/local/include/srslte/version.h
kavya@ubuntu:~/Downloads/srsLTE/build$
```

- make test

```
Start 116: layermap_multiplex_16 ..... Passed 0.00 sec
116/128 Test #116: layermap_multiplex_16 ..... Passed 0.00 sec
Start 117: layermap_multiplex_17 ..... Passed 0.00 sec
117/128 Test #117: layermap_multiplex_17 ..... Passed 0.00 sec
Start 118: layermap_multiplex_18 ..... Passed 0.00 sec
118/128 Test #118: layermap_multiplex_18 ..... Passed 0.00 sec
Start 119: layermap_multiplex_22 ..... Passed 0.00 sec
119/128 Test #119: layermap_multiplex_22 ..... Passed 0.00 sec
Start 120: layermap_multiplex_23 ..... Passed 0.00 sec
120/128 Test #120: layermap_multiplex_23 ..... Passed 0.00 sec
Start 121: layermap_multiplex_24 ..... Passed 0.00 sec
121/128 Test #121: layermap_multiplex_24 ..... Passed 0.00 sec
Start 122: layermap_multiplex_25 ..... Passed 0.00 sec
122/128 Test #122: layermap_multiplex_25 ..... Passed 0.00 sec
Start 123: layermap_multiplex_26 ..... Passed 0.00 sec
123/128 Test #123: layermap_multiplex_26 ..... Passed 0.00 sec
Start 124: layermap_multiplex_27 ..... Passed 0.00 sec
124/128 Test #124: layermap_multiplex_27 ..... Passed 0.00 sec
Start 125: layermap_multiplex_28 ..... Passed 0.00 sec
125/128 Test #125: layermap_multiplex_28 ..... Passed 0.00 sec
Start 126: precoding_single ..... Passed 0.00 sec
126/128 Test #126: precoding_single ..... Passed 0.00 sec
Start 127: precoding_diversity2 ..... Passed 0.00 sec
127/128 Test #127: precoding_diversity2 ..... Passed 0.00 sec
Start 128: precoding_diversity4 ..... Passed 0.00 sec
128/128 Test #128: precoding_diversity4 ..... Passed 0.00 sec

100% tests passed, 0 tests failed out of 128

Total Test time (real) = 32.92 sec
kavya@ubuntu:~/Downloads/srsLTE/build$
```

## srsUE:



srsUE is a software radio LTE UE. It is written in C++ and builds upon the srsLTE library.

Running on an Intel Core i7-4790, srsUE achieves up to 60Mbps DL with a 20 Mhz bandwidth SISO configuration. srsUE is released under the AGPLv3 license.

srsUE is a software radio LTE UE covering all layers of the network stack from PHY to IP. It is written in C++ and builds upon the srsLTE library which provides the PHY layer processing. For some security functions and RRC/NAS message parsing, it uses some functions from the

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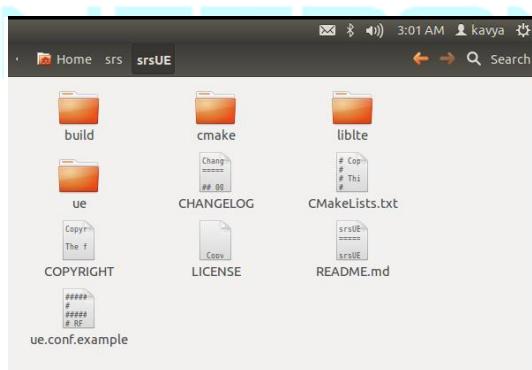
Email: info@tenettech.com, Phone: 080 - 26722726

openLTE project. Running on an Intel Core i7-4790, srsUE achieves more than 60 Mbps downlink with a 20 MHz bandwidth SISO configuration, when tested against an Amarisoft LTE 100 eNodeB. Apart from the features listed above for the srsLTE library, srsUE provides the following additional features:

- MAC, RLC, PDCP, RRC, NAS and GW layers;
- Soft USIM supporting Milenage and XOR authentication;
- Detailed log system with per-layer log levels and hex dumps;
- MAC layer Wireshark packet capture;
- Command-line trace metrics;
- Detailed input configuration file; *and*
- Virtual network interface (i.e. *tun/tap* device) created upon network attach.

#### Steps to download srsUE:

- First we need some dependencies to be installed prior to installing srsUE
  - srsLTE: <https://github.com/srslte/srslte>
  - UHD: <https://github.com/EttusResearch/uhd>
  - Polarssl:  
**sudo apt-get install libpolarssl-dev**
- git clone <https://github.com/srsLTE/srsUE.git>
- cd srsUE
- mkdir build



- cd build

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- cmake ..
- make

If error appears saying polarssl/compat not found. Then download polarssl 1.3 versions from <http://packages.ubuntu.com/trusty/libpolarssl-dev>. Supporting package libpolarssl5 should be installed. To install .deb files run the below command in terminal:

- sudo dpkg -i <package-name>.deb

If you get a make error, do the following changes in codes.

- Open the code in /srsUE/ue(hdr/common/buffer\_pool.h)
- Make the below line as comment line :  

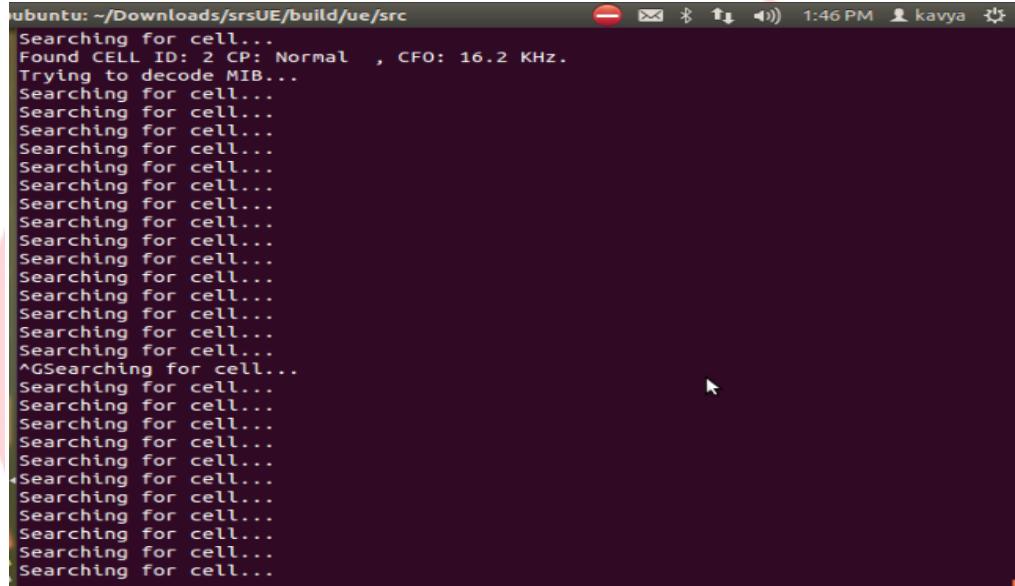
```
#include <boost/thread/lock_guard.hpp>
```
- Save and close
- Open the code in /srsUE/ue(hdr/common/log\_stdout.h)
- Add the line #include <stdio.h> after #define LOGSTDOUT\_H
- Save and close
- Again make

```
hd.so.003, may conflict with libboost_date_time.so.1.46.1
/usr/bin/ld: warning: libboost_thread.so.1.48.0, needed by /usr/local/lib/libuhd.
so.003, may conflict with libboost_thread.so.1.46.1
[ 78%] Built target ue
[ 80%] Built target log_filter_test
[ 82%] Built target logger_test
[ 83%] Built target msg_queue_test
[ 85%] Built target timeout_test
Linking CXX executable ue_itf_test_prach
/usr/bin/ld: warning: libboost_date_time.so.1.48.0, needed by /usr/local/lib/libu
hd.so.003, may conflict with libboost_date_time.so.1.46.1
[ 87%] Built target ue_itf_test_prach
Linking CXX executable ue_itf_test_sib1
/usr/bin/ld: warning: libboost_date_time.so.1.48.0, needed by /usr/local/lib/libu
hd.so.003, may conflict with libboost_date_time.so.1.46.1
[ 89%] Built target ue_itf_test_sib1
Linking CXX executable mac_test
/usr/bin/ld: warning: libboost_date_time.so.1.48.0, needed by /usr/local/lib/libu
hd.so.003, may conflict with libboost_date_time.so.1.46.1
[ 91%] Built target mac_test
Linking CXX executable rlc_am_control_test
[ 92%] Built target rlc_am_control_test
Linking CXX executable rlc_am_data_test
[ 94%] Built target rlc_am_data_test
Linking CXX executable rlc_am_test
[ 96%] Built target rlc_am_test
Linking CXX executable rlc_um_data_test
[ 98%] Built target rlc_um_data_test
Linking CXX executable rlc_um_test
[100%] Built target rlc_um_test
kavya@ubuntu:~/Downloads/srsUE/build$
```

## Executing srsUE example:

- Copy and rename the provided configuration file ue.conf.example
- Paste it in /srsUE/build/ue/src
- Connect PC to USRP B210
- Run the following command at the terminal

Sudo ./ue ue.conf.example



```
ubuntu: ~/Downloads/srsUE/build/ue/src
Searching for cell...
Found CELL ID: 2 CP: Normal , CFO: 16.2 KHz.
Trying to decode MIB...
Searching for cell...
```

## Executing srsLTE example:

- Go to the directory /srsLTE/build/srslte/examples
- Connect PC to USRP B210
- Run this command in terminal : ./pdsch\_ue -f 1800000000

```
x kavya@ubuntu: ~/Downloads/srsLTE/build/srslte/examples
Cell not found after 3 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
000000000000000000000000Could not find any cell in this frequency
Cell not found after 4 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
000000000000000000000000Could not find any cell in this frequency
Cell not found after 5 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
000000000000000000000000Could not find any cell in this frequency
Cell not found after 6 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
000000000000000000000000Could not find any cell in this frequency
Cell not found after 7 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
000000000000000000000000*Found Cell_id:  0 CP: Normal , DetectRatio=67% PSR=10.29, Power=-90.8 dBm
    Found Cell_id:  0 CP: Normal , DetectRatio= 0% PSR=0.00, Power=-inf dBm
    Found Cell_id:  0 CP: Normal , DetectRatio= 0% PSR=0.00, Power=-inf dBm
Decoding PBCH for cell 0 (N_id_2=0)
00Cell not found after 8 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
000000000000000000000000Could not find any cell in this frequency
Cell not found after 9 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
```

After this command, it displays the identified cell iD, cell priority, Detection Ratio, PSR and power in dBm.

eNodeB to UE Downlink transmission test

- Go to the directory /srsLTE/build/srslte/examples
  - Connect PC to USRP B210
  - Run this command in terminal : `./pdsch_enodeb -f 2400000000`

At the transmitter console, it is possible to change the Modulation and Coding Scheme (MCS) by typing a new number (between 0 and 28) and pressing Enter.

Here for example :

- MCS value entered is 13
  - No:of PRBs =25
  - Srs type =1
  - Then we get transport block size =5736
  - Modulation type =16QAM

This can be verified at online calculator of transport block size. ([https://www.rohde-schwarz.com/rsLTEResourceAllocation/index.php?toolID=TransportBlockSize\\_DL](https://www.rohde-schwarz.com/rsLTEResourceAllocation/index.php?toolID=TransportBlockSize_DL))

← → C Rohde & Schwarz GmbH & Co. KG [DE] https://www.rohde-schwarz.com/rsLTEResourceAllocation/index.php?toolID=TransportBlockSize\_DL&calcFunction=1&numRB\_value=25

- › [Introduction](#)
- › [Resource Allocation Type 2 Downlink \(RB to RIV\)](#)
- › [Resource Allocation Type 2 Uplink \(RIV to RB\)](#)
- › [Resource Allocation Type 2 Downlink / Uplink \(RIV to RB\)](#)
- › [Transport Block Size Downlink](#)
- › [Transport Block Size Uplink](#)
- › [Search Space](#)
- › [UCI over PUSCH](#)

### Transport Block Size Downlink

Enter the number of resource blocks and the modulation coding scheme value, as well as the number of antennas and the number of PDCCH symbols.

The transport block size, the code rate and the modulation scheme will be determined by clicking "Calculate!".

Number of Resource Blocks	<input type="text" value="25"/>
MCS Value [0, ..., 28]	<input type="text" value="13"/>
Number of Antennas	<input type="text" value="1"/>
Number of PDCCH symbols	<input type="text" value="2"/>

### Results

Transport Block Size	<b>5738</b>
Code Rate	<b>0.417</b>
Modulation Scheme	<b>16-QAM</b>

### Downlink Data transmission:

The following setup shows the practical setup for the enodeb and UE. This requires two systems and 2 USRP boards.

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At the transmitter side run the following code

`./pdsch_enodeb -f (frequency in Hz)`

**Transmitter setup**



We can change the modulation techniques by changing the MCS value from 0- 31 representing BPSK to 64 QAM. The following table represents the relation between MCS and modulation technique.

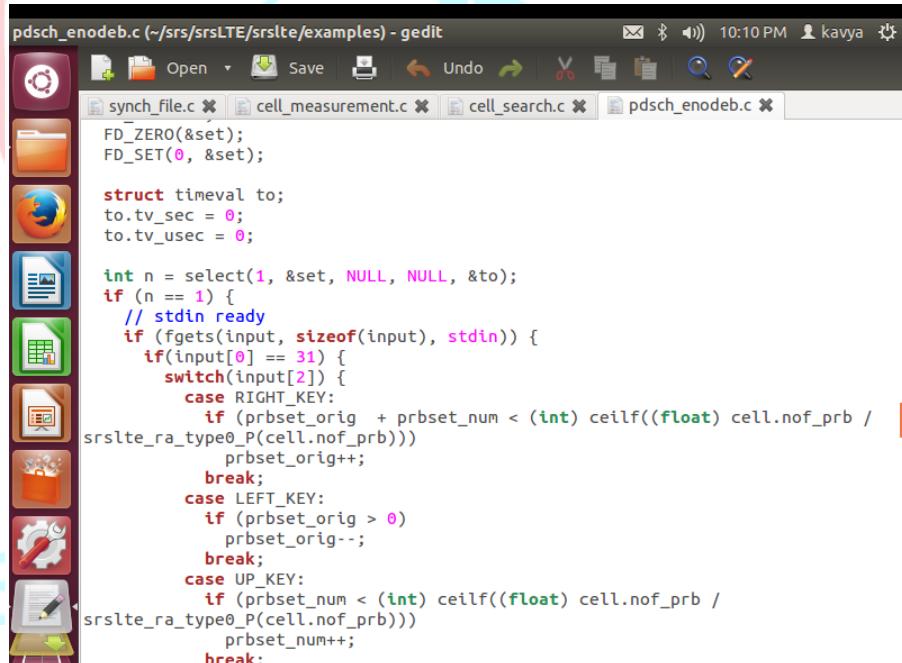
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---

MCS index	Spatial streams	Modulation type
0	1	BPSK
1	1	QPSK
2	1	QPSK
3	1	16-QAM
4	1	16-QAM
5	1	64-QAM
6	1	64-QAM
7	1	64-QAM
8	2	BPSK
9	2	QPSK
10	2	QPSK
11	2	16-QAM
12	2	16-QAM
13	2	64-QAM
14	2	64-QAM
15	2	64-QAM
16	3	BPSK
17	3	QPSK
18	3	QPSK
19	3	16-QAM
20	3	16-QAM
21	3	64-QAM
22	3	64-QAM
23	3	64-QAM
24	4	BPSK
25	4	QPSK
26	4	QPSK
27	4	16-QAM
28	4	16-QAM
29	4	64-QAM
30	4	64-QAM
31	4	64-QAM

The value of input[0] == 27 is replaced by 31 so that we can use 64 qam, in the pdsch\_enodeb program.



```

FD_ZERO(&set);
FD_SET(0, &set);

struct timeval to;
to.tv_sec = 0;
to.tv_usec = 0;

int n = select(1, &set, NULL, NULL, &to);
if (n == 1) {
    // stdin ready
    if (fgets(input, sizeof(input), stdin)) {
        if (input[0] == 31) {
            switch (input[2]) {
                case RIGHT_KEY:
                    if (prbset_orig + prbset_num < (int) ceilf((float) cell.nof_prb /
srslte_ra_type0_P(cell.nof_prb)))
                        prbset_orig++;
                    break;
                case LEFT_KEY:
                    if (prbset_orig > 0)
                        prbset_orig--;
                    break;
                case UP_KEY:
                    if (prbset_num < (int) ceilf((float) cell.nof_prb /
srslte_ra_type0_P(cell.nof_prb)))
                        prbset_num++;
                    break;
            }
        }
    }
}

```

Initial cell parameters are set in the enodeb program.

pdsch\_enodeb.c (~/srs/srsLTE/srslte/examples) - gedit

```
#define DOWN_KEY 66

srslte_cell_t cell = {
    25,           // nof_prb
    1,            // nof_ports
    0,            // bw_idx
    0,            // cell_id
    SRSLTE_CP_NORM,        // cyclic prefix
    SRSLTE_PHICH_R_1,      // PHICH resources
    SRSLTE_PHICH_NORM      // PHICH length
};

int net_port = -1; // -1 generates random dataThat means there is some problem
// sending samples to the device

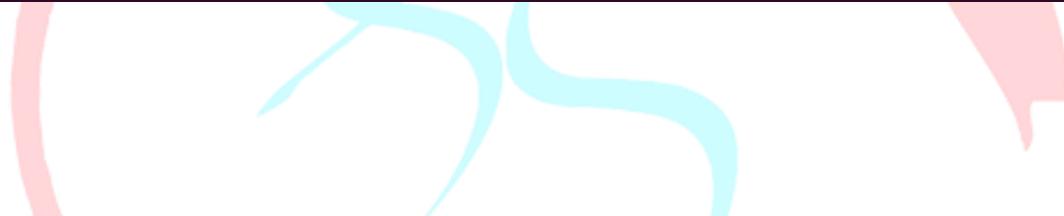
uint32_t cfi=2;
uint32_t mcs_idx = 1, last_mcs_idx = 1;
int nof_frames = -1;

char *rf_args = "";
float rf_amp = 0.8, rf_gain = 70.0, rf_freq = 2400000000;
bool null_file_sink=false;
srslte_filesink_t fsink;
srslte_ofdm_t ifft;
srslte_pbch_t pbch;
srslte_pcfcfh_t pcfcfh;
```

Outputs of the enodeb:

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## At the receiver

## Physical Setup



Run the following commands

**./pdsch\_ue - r 1234 - f (frequency in Hz)**

\*the frequency here should be same as that of transmitter (eNodeB).

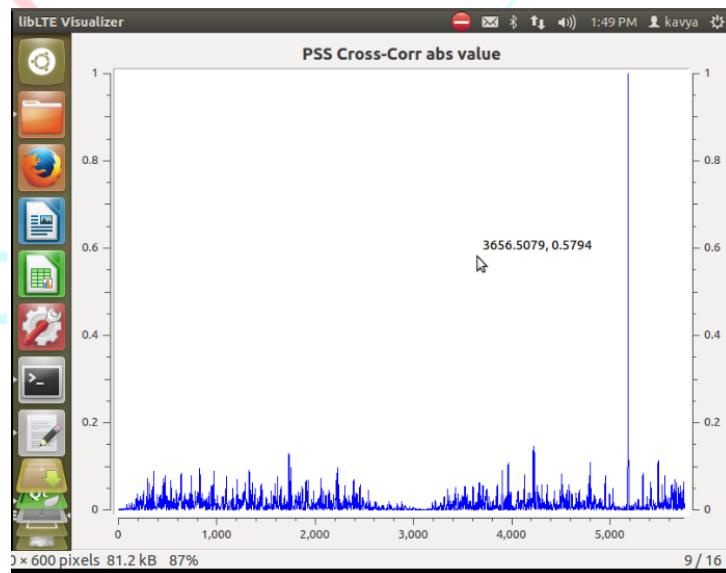
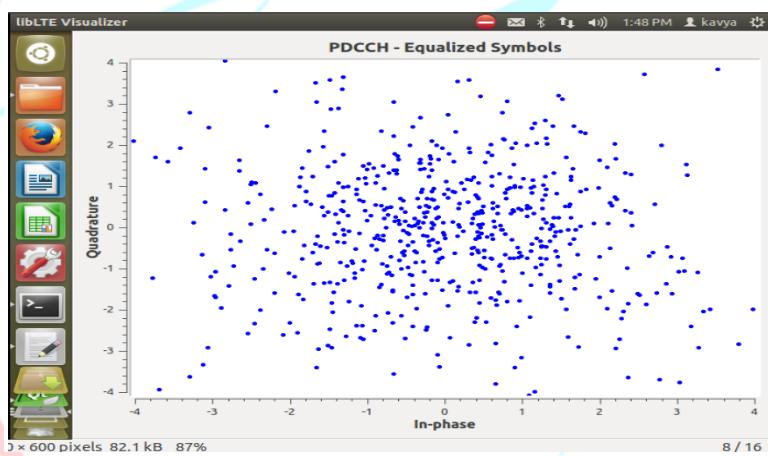
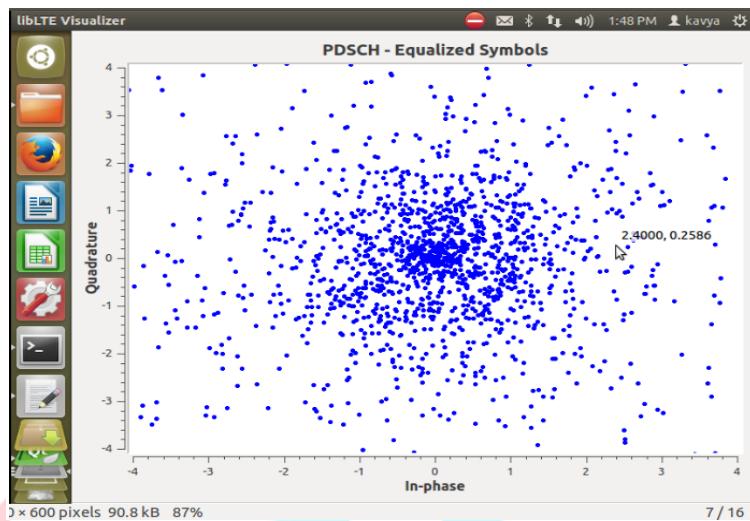
This command will detect the transmitted data and detect the cell ID.

## Case 1: 16QAM transmission

```
Terminal kavya@ubuntu: ~/Downloads/srsLTE/build/srslte/examples
Searching for cell...
00000000Could not find any cell in this frequency
Cell not found after 1 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
00000000000000000000000000000000Could not find any cell in this frequency
cell not found after 2 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
000*Found Cell_id: 0 CP: Normal , DetectRatio=61% PSR=11.39, Power=20.0 dBm
  Found Cell_id: 0 CP: Normal , DetectRatio= 0% PSR=0.00, Power=-inf dBm
  Found Cell_id: 0 CP: Normal , DetectRatio= 0% PSR=0.00, Power=-inf dBm
Decoding PBCH for cell 0 (N_id_2=0)
000000-- Asking for clock rate 23.040000 MHz...
-- Actually got clock rate 23.040000 MHz.
-- Performing timer loopback test... pass
Setting sampling rate 5.76 MHz
- Cell ID:          0        4.0, FrameCnt: 0, State: 10 00 0 00 0
- Nof ports:       1
- CP:              Normal
- PRB:             25
- PHICH Length:   Normal
- PHICH Resources: 1
- SFN:             632
Decoded MIB. SFN: 632, offset: 3
OF0: +0.62 KHz, SNR: -5.6 dB, PDCCH-Miss: 98.26%, PDSCH-BLER: 40.06%%%
```

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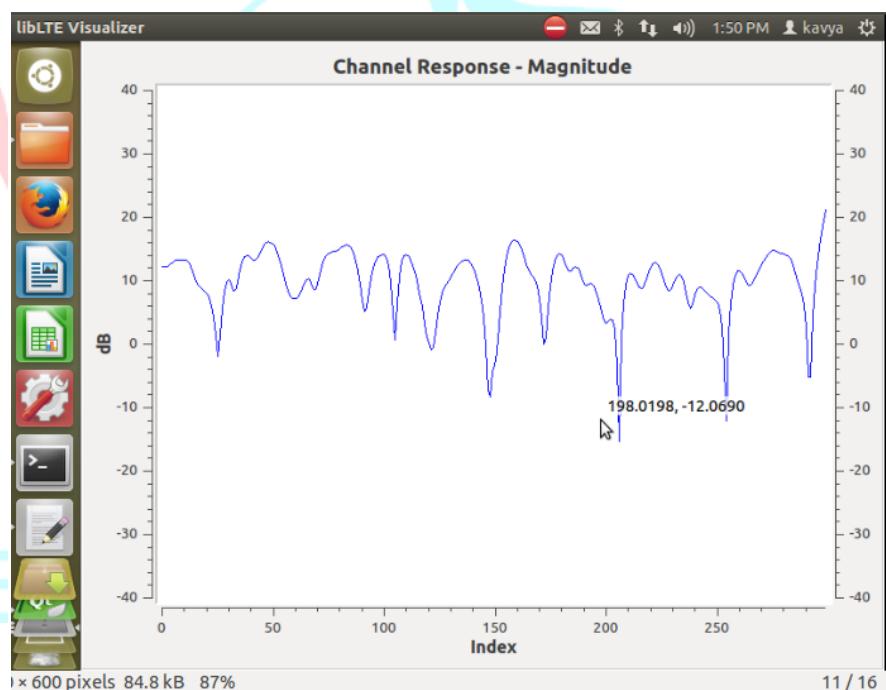
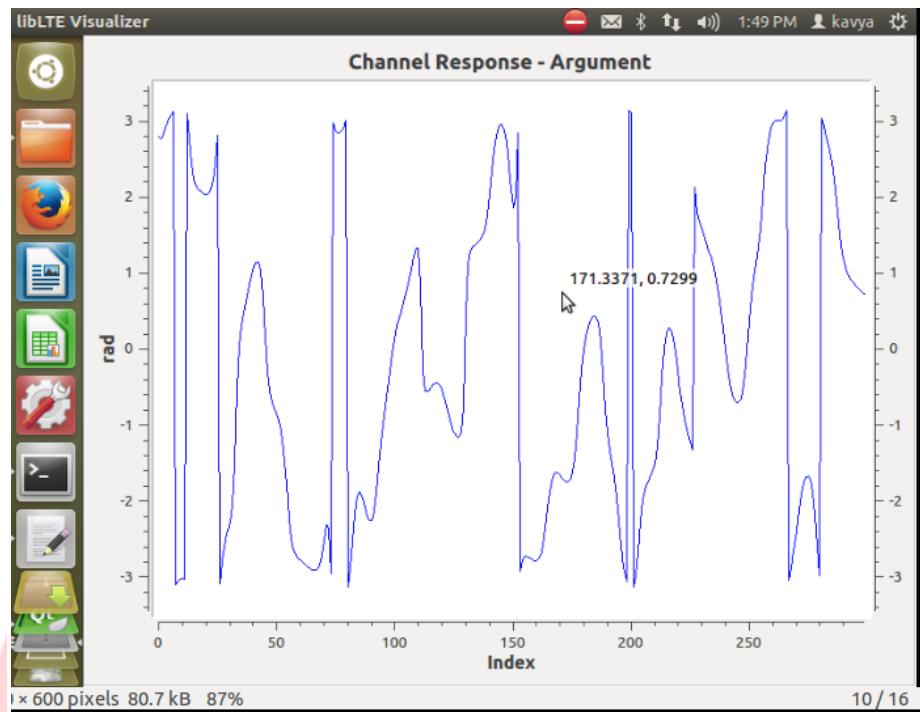
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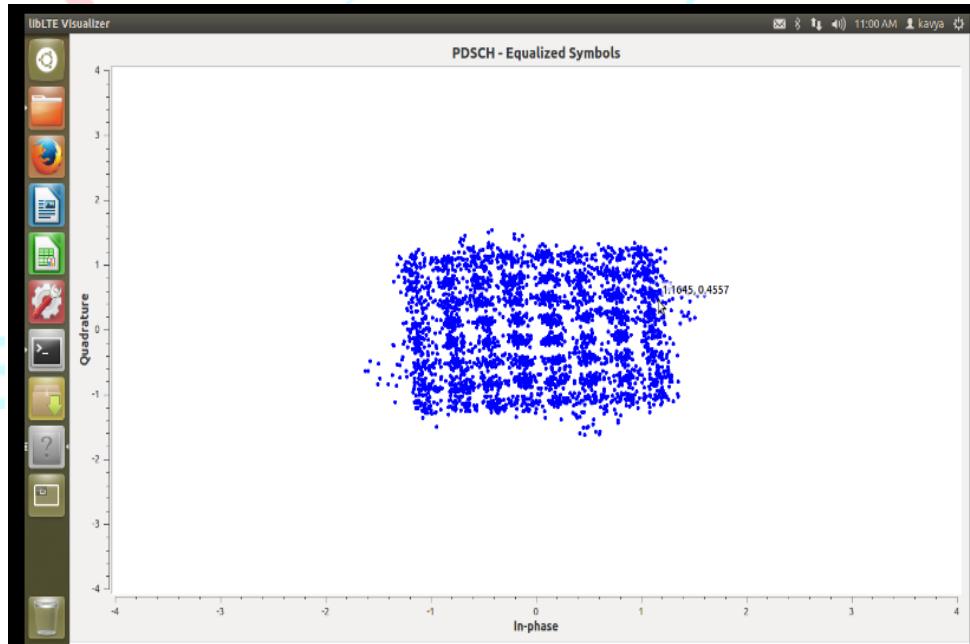


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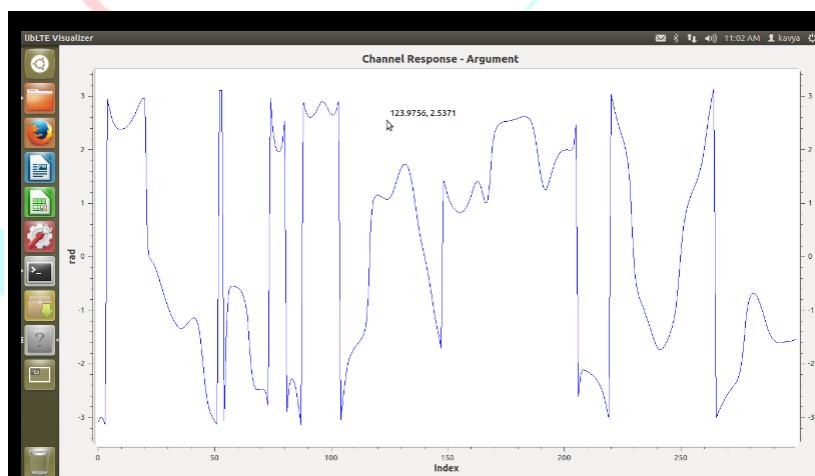
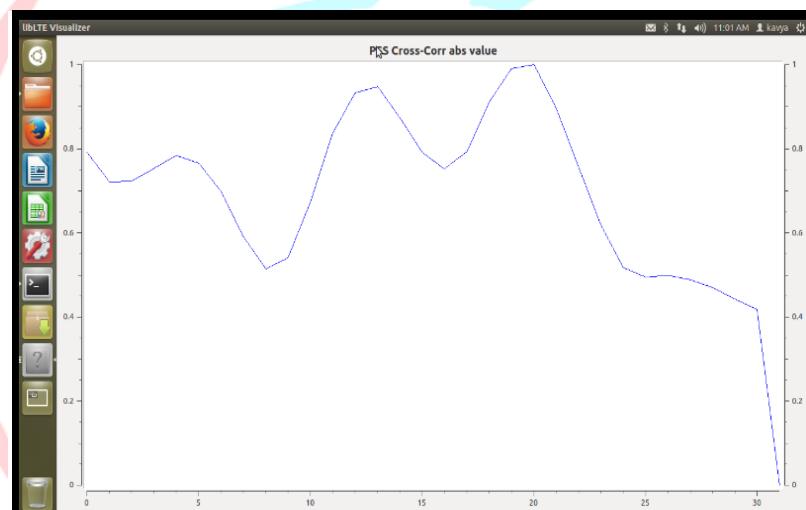
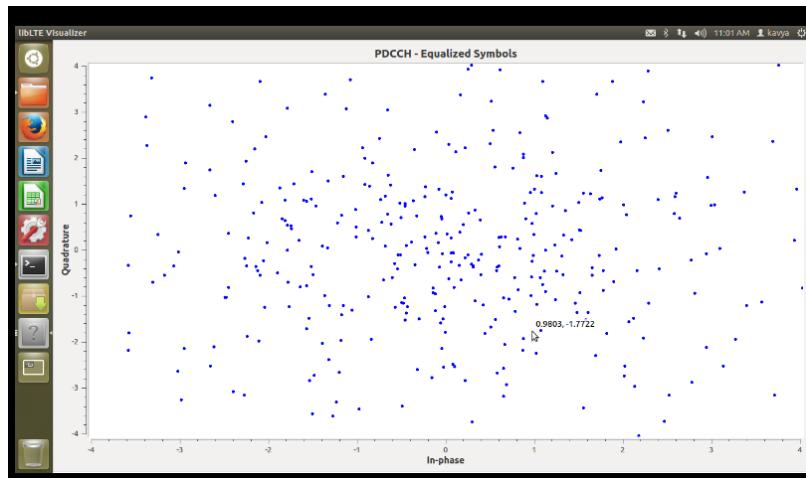
## Case 2: 64 QAM

```
kavya@ubuntu: ~/Downloads/srsLTE/build/srslte/examples
Starting AGC thread...
-- Asking for clock rate 30.720000 MHz...
-- Actually got clock rate 30.720000 MHz.
-- Performing timer loopback test... pass
Tuning receiver to 1800.000 MHz
Searching for cell...
00000000000000000000000000000000 Could not find any cell in this frequency
Cell not found after 0 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
00000000000000000000000000000000 Could not find any cell in this frequency
Cell not found after 1 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
00000000000000000000000000000000 Could not find any cell in this frequency
Cell not found after 2 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
00000000000000000000000000000000 Found Cell_id: 0 CP: Extended, DetectRatio=74% PSR=10.44, Power=-14.7 dBm
Found Cell_id: 0 CP: Normal , DetectRatio= 0% PSR=0.00, Power=-inf dBm
Found Cell_id: 0 CP: Normal , DetectRatio= 0% PSR=0.00, Power=-inf dBm
Decoding PBCH for cell 0 (N_id_2=0)
00000000000000000000000000000000 Cell not found after 3 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
00000000000000000000000000000000 Could not find any cell in this frequency
Cell not found after 4 trials. Trying again (Press Ctrl+C to exit)
Searching for cell...
00000000000000000000000000000000 Found Cell_id: 0 CP: Normal , DetectRatio=67% PSR=10.42, Power=-23.6 dBm
Found Cell_id: 0 CP: Normal , DetectRatio= 0% PSR=0.00, Power=-inf dBm
Found Cell_id: 0 CP: Normal , DetectRatio= 0% PSR=0.00, Power=-inf dBm
Decoding PBCH for cell 0 (N_id_2=0)
-- Asking for clock rate 23.040000 MHz...
-- Actually got clock rate 23.040000 MHz.
-- Performing timer loopback test... pass
Setting sampling rate 5.76 MHz
- Cell ID: 0 1.1, FrameCnt: 0, State: 1
- Nof ports: 1
- CP: Normal
- PRB: 25
- PHICH Length: Normal
- PHICH Resources: 1
- SFN: 840
Decoded MIB. SFN: 840, offset: 1
OFO: -0.60 KHz, SNR: -6.9 dB, PDCCH-MIst: 94.60%, PDSCH-BLER: 100.00%XXXX
```



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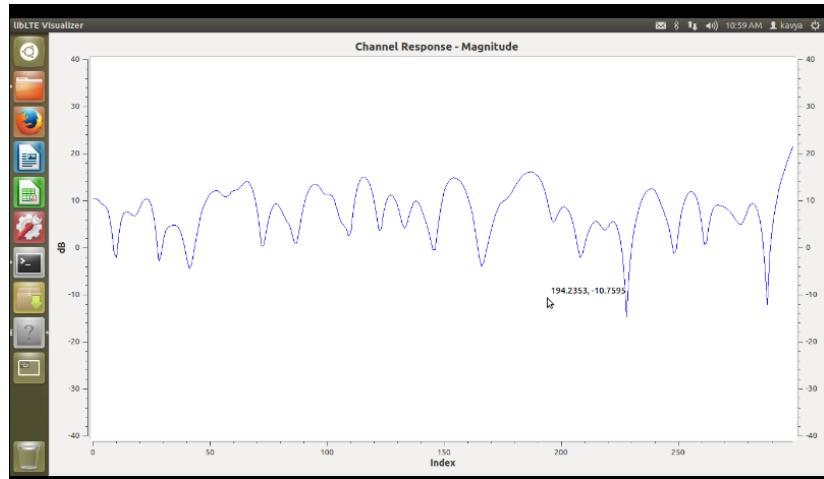
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TECS

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### Video streaming over Downlink (eNodeB to UE)

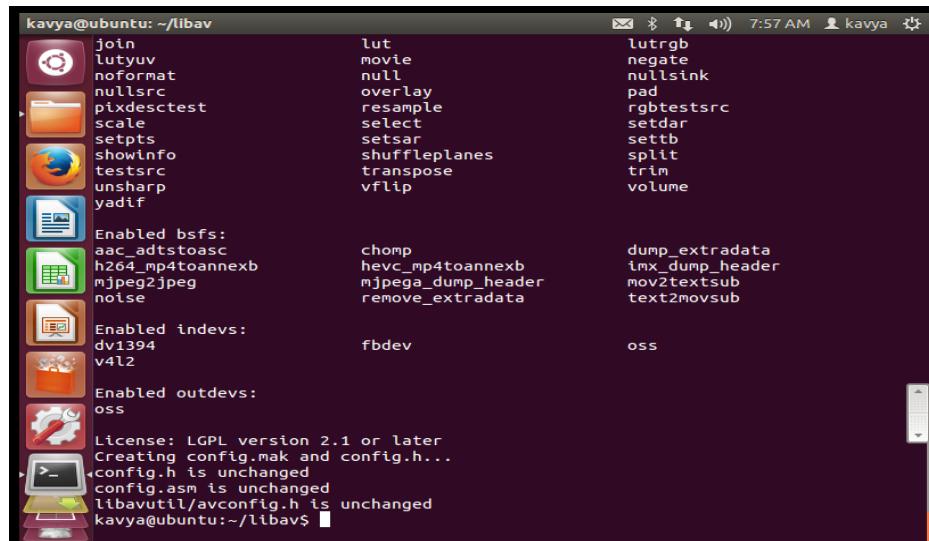
Before doing video streaming first we need to install libav-tools

- **Sudo apt-get install libav-tools**
- **Sudo apt-get install yasm**
- **git clone git://git.libav.org/libav.git**
- **cd libav**
- **./configure**

Or

```
kavya@ubuntu: ~/libav
kavya@ubuntu:~$ cd libav
kavya@ubuntu:~/libav$ sudo ./configure
```

TECHNE TRONICS



```
kavya@ubuntu: ~/libav
join lut lutrgb
lutyuv movie negate
noformat null nullsink
nullsrc overlay pad
pixdesc test resample rgbtessrc
scale select setdar
setpts setsar settb
showinfo shuffleplanes split
tests src transpose trim
unsharp vad volume

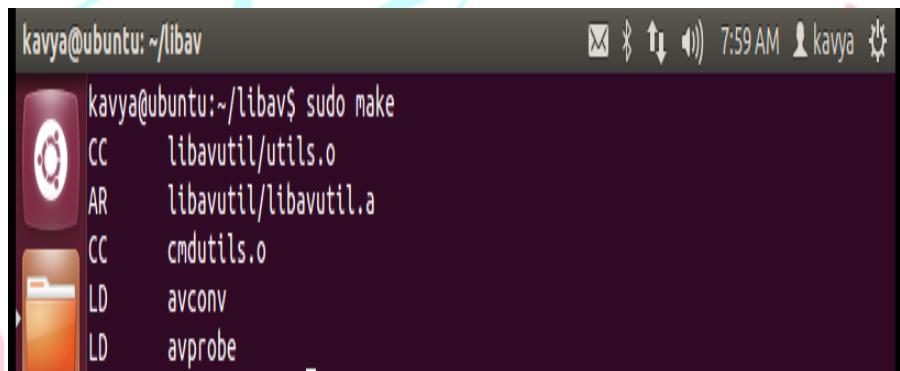
Enabled bsfs:
aac_adtstoasc chomp dump_extradata
h264_mp4toannexb hevc_mp4toannexb ttx_dump_header
mjpeg2jpeg mjpeg_dump_header mov2textsub
noise remove_extradata text2movsub

Enabled indevs:
dv1394 fbdev oss
v4l2

Enabled outdevs:
oss

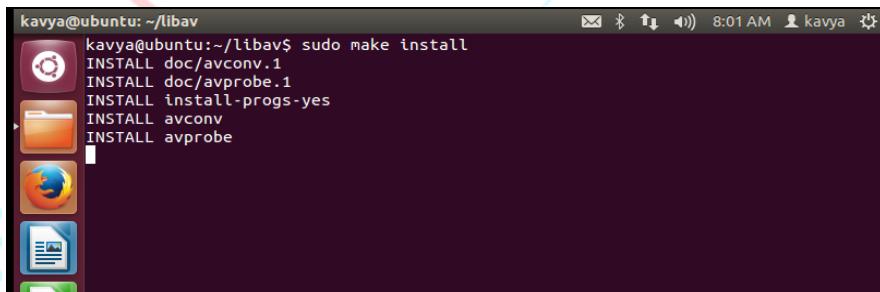
License: LGPL version 2.1 or later
Creating config.mak and config.h...
config.h is unchanged
config.asm is unchanged
libavutil/avconfig.h is unchanged
kavya@ubuntu:~/libav$
```

- **Make**



```
kavya@ubuntu: ~/libav
kavya@ubuntu:~/libav$ sudo make
CC libavutil/utils.o
AR libavutil/libavutil.a
CC cmdutils.o
LD avconv
LD avprobe
```

- **sudo make install**



```
kavya@ubuntu: ~/libav
kavya@ubuntu:~/libav$ sudo make install
INSTALL doc/avconv.1
INSTALL doc/avprobe.1
INSTALL install-progs-yes
INSTALL avconv
INSTALL avprobe
```

```

kavya@ubuntu: ~/libav
INSTALL libavutil/hwcontext.h
INSTALL libavutil/hwcontext_cuda.h
INSTALL libavutil/hwcontext_vaapi.h
INSTALL libavutil/hwcontext_vdpau.h
INSTALL libavutil/imgutils.h
INSTALL libavutil/intfloat.h
INSTALL libavutil/intreadwrite.h
INSTALL libavutil/lfg.h
INSTALL libavutil/log.h
INSTALL libavutil/macros.h
INSTALL libavutil/mathematics.h
INSTALL libavutil/nds.h
INSTALL libavutil/mem.h
INSTALL libavutil/dict.h
INSTALL libavutil/opt.h
INSTALL libavutil/parseutils.h
INSTALL libavutil/pixdesc.h
INSTALL libavutil/pixfmt.h
INSTALL libavutil/random_seed.h
INSTALL libavutil/replaygain.h
INSTALL libavutil/rational.h
INSTALL libavutil/samplefmt.h
INSTALL libavutil/sha.h
INSTALL libavutil/stereo3d.h
INSTALL libavutil/time.h
INSTALL libavutil/verston.h
INSTALL libavutil/xtea.h
INSTALL libavutil/zzo.h
INSTALL libavutil/avconfig.h
INSTALL libavutil/libavutil.pc
kavya@ubuntu:~/libav$ 

```

At transmitter run:

- **cd srsLTE/build/srslte/examples**
- **./pdsch\_enodeb -f (frequency in Hz) -u 2000**

Here -u 2000 will open port 2000 for listening for TCP connections.

To check whether the TCP connection is established or not. Run the following command

- **netstat -t -n | head -15**

```

tenetsdr@tenetsdr:~/Downloads/srs/srsLTE/build/srslte/examples$ netstat -t -n | head -15
(Not all processes could be identified, non-owned process info
 will not be shown, you would have to be root to see it all.)
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address          Foreign Address        State      PID/Program name
tcp        0      0 0.0.0.0:2000           0.0.0.0:*              LISTEN     29904/pdsch_enodeb
tcp        0      0 0.0.0.0:2001           0.0.0.0:*              LISTEN     30564/pdsch_enodeb
tcp        0      0 192.168.0.124:53       0.0.0.0:*              LISTEN     .
tcp        0      0 127.0.0.1:53            0.0.0.0:*              LISTEN     .
tcp        0      0 127.0.0.1:631           0.0.0.0:*              LISTEN     .
tcp        0      0 127.0.0.1:953           0.0.0.0:*              LISTEN     .
tcp6       0      0 ::1:53                ::*:*                  LISTEN     .
tcp6       0      0 ::1:631               ::*:*                  LISTEN     .
tcp6       0      0 ::1:953               ::*:*                  LISTEN     .
tenetsdr@tenetsdr:~/Downloads/srs/srsLTE/build/srslte/examples$ 

```

At receiver check for the established TCP connection

- **cd srsLTE/build/srslte/examples**

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- **./pdsch\_ue -r 1234 -u 2001 -u 127.0.0.1 -f (frequency in Hz)**

Here -u 2001 -u 127.0.0.1 will forward data that is injected at eNodeB to address port.

- To check the TCP connection

```
netstat -tapn | head -15
```

```
kavya@ubuntu: ~/Downloads/srsLTE/build/srsLTE/examples
tcp        0      0 0.0.0.0:40090          0.0.0.0:*          LISTEN      3
718/avplay
tcp        0      0 0.0.0.0:51470          0.0.0.0:*          LISTEN      3
783/avplay
tcp        0      0 0.0.0.0:54513          0.0.0.0:*          LISTEN      3
654/avplay
tcp        0      0 127.0.0.1:2001        0.0.0.0:*          LISTEN      3
616/avplay
tcp6       0      0 ::1:631              ::*:*                LISTEN      -

```

Run at transmitter:

- **avconv -f video4linux2 -i /dev/video0 -f mpegts tcp://127.0.0.1:2000**  
This command captures the live video using the web camera.
- **avconv -f x11grab -r 25 -i :0.0 -f mpegts tcp://127.0.0.1:2000 \$Home/output.avi**  
This command will capture the desktop video. The output can also be viewed at transmitter by using
- **avplay \$Home/output.avi**
- **press ctrl + c to stop video capturing.**



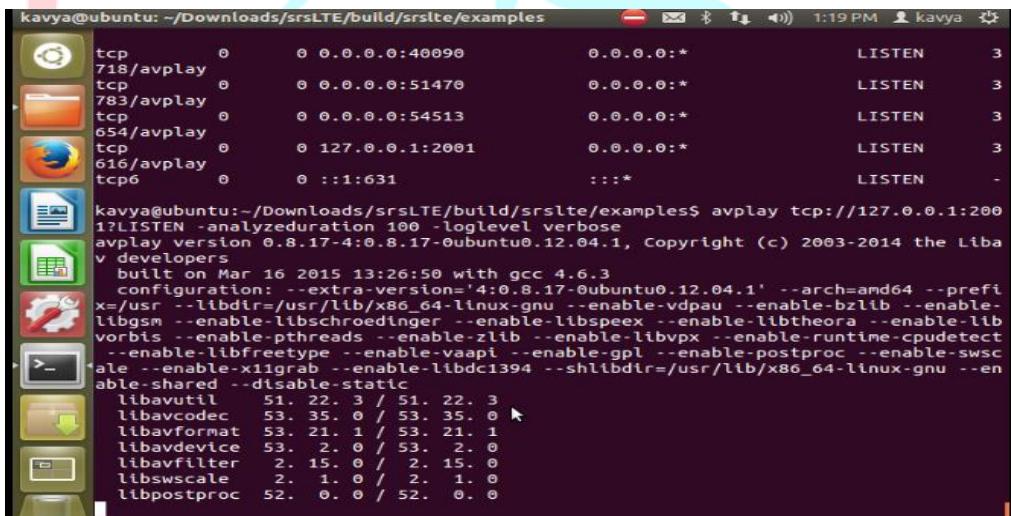
```

tenetsdr@tenetsdr:~/Downloads/srs/srsLTE/build/srslte/examples$ avconv -f video4linux2 -i /dev/video0 -f mpegts tcp://127.0.0.1:2000
avconv version 0.8.17-4:0.8.17-0ubuntu0.12.04.1, Copyright (c) 2000-2014 the Libav developers
built on Mar 16 2015 13:28:23 with gcc 4.6.3
[video4linux2 @ 0x9aceb0] Estimating duration from bitrate, this may be inaccurate
Input #0, video4linux2, from '/dev/video0':
  Duration: N/A, start: 3978.179893, bitrate: 147456 kb/s
    Stream #0.0: Video: rawvideo, yuyv422, 640x480, 147456 kb/s, 30 tbr, 1000k tbn, 30 tbc
      Incompatible pixel format 'yuyv422' for codec 'mpeg2video', auto-selecting format 'yuv420p'
      [buffer @ 0x9acfd80] w:640 h:480 pixfmt:yuyv422
      [avsink @ 0x9acff60] auto-inserting filter 'auto-inserted scaler 0' between the filter 'src' and the filter 'out'
      [scale @ 0x9ad03a0] w:640 h:480 fmt:yuyv422 -> w:640 h:480 fmt:yuv420p flags:0x4
      [mpegts @ 0x9acf240] muxrate VBR, pcr every 3 pkts, sdt every 200, pat/pmt every 40 pkts
Output #0, mpegts, to 'tcp://127.0.0.1:2000':
  Metadata:
    encoder : Lavf53.21.1
  Stream #0.0: Video: mpeg2video, yuv420p, 640x480, q=2-31, 200 kb/s, 90k tbn, 30 tbc
Stream mapping:
  Stream #0:0 -> #0:0 (rawvideo -> mpeg2video)
Press ctrl-c to stop encoding
frame= 506 fps= 30 q=31.0 size= 836kB time=16.83 bitrate= 406.9kbits/s dup=205 drop=0

```

At receiver run:

- **avplay tcp://127.0.0.1:2001**



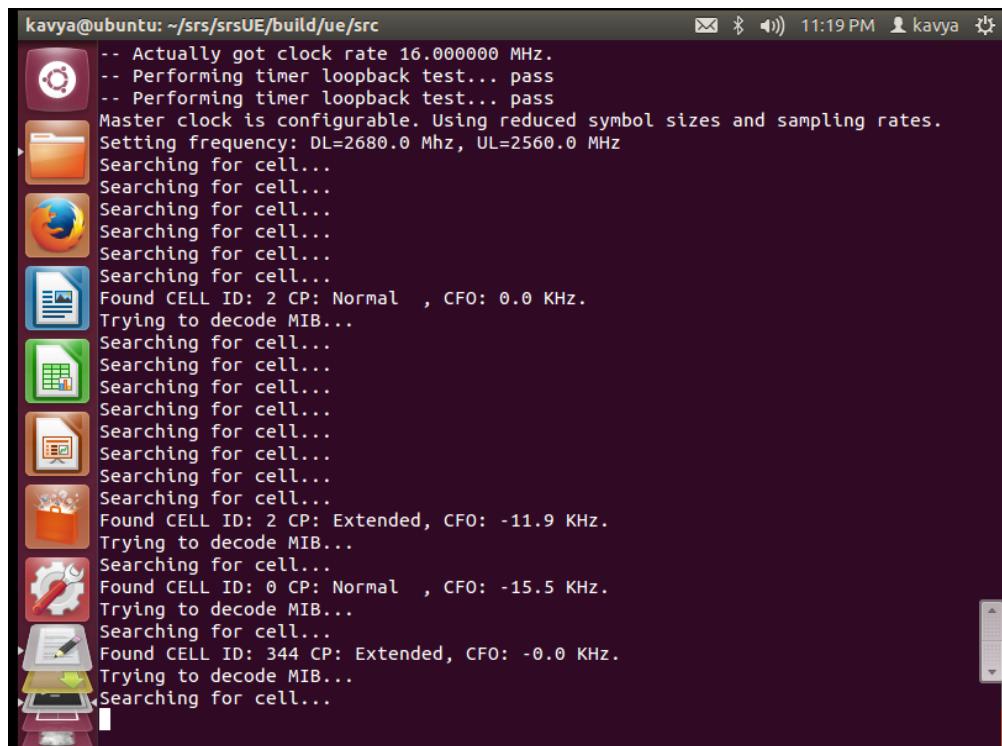
```

kavya@ubuntu: ~/Downloads/srsLTE/build/srslte/examples$ netstat -an | grep 127.0.0.1:2001
tcp        0      0 127.0.0.1:2001          0.0.0.0:*               LISTEN      3
kavya@ubuntu:~/Downloads/srsLTE/build/srslte/examples$ avplay tcp://127.0.0.1:2001
avplay version 0.8.17-4:0.8.17-0ubuntu0.12.04.1, Copyright (c) 2003-2014 the Libav developers
built on Mar 16 2015 13:26:50 with gcc 4.6.3
configuration: --extra-version='4:0.8.17-0ubuntu0.12.04.1' --arch=amd64 --prefix=/usr --libdir=/usr/lib/x86_64-linux-gnu --enable-vdpau --enable-bzlib --enable-libgsm --enable-libschroedinger --enable-libspeex --enable-libtheora --enable-libvorbis --enable-pthreads --enable-zlib --enable-libvpx --enable-runtime-cpudetect --enable-libfreetype --enable-vaapi --enable-gpl --enable-postproc --enable-swscale --enable-xiigrab --enable-libdc1394 --shlibdir=/usr/lib/x86_64-linux-gnu --enable-shared --disable-static
libavutil      51. 22. 3 / 51. 22. 3
libavcodec     53. 35. 0 / 53. 35. 0
libavformat    53. 21. 1 / 53. 21. 1
libavdevice    53.  2. 0 / 53.  2. 0
libavfilter     2. 15. 0 / 2. 15. 0
libswscale      2.  1. 0 / 2.  1. 0
libpostproc    52.  0. 0 / 52.  0. 0

```

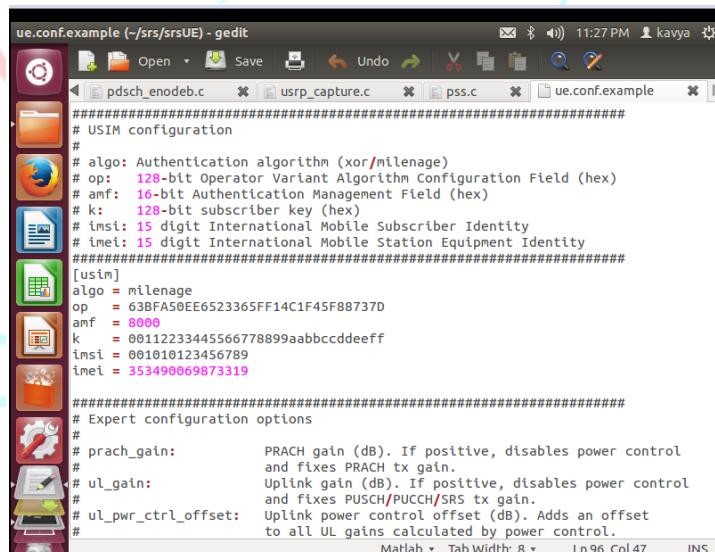
**TECHNETRONICS**

./ue ue.conf.example output



```
kavya@ubuntu: ~/srs/srsUE/build/ue/src
-- Actually got clock rate 16.000000 MHz.
-- Performing timer loopback test... pass
-- Performing timer loopback test... pass
Master clock is configurable. Using reduced symbol sizes and sampling rates.
Setting frequency: DL=2680.0 Mhz, UL=2560.0 MHz
Searching for cell...
Found CELL ID: 2 CP: Normal , CFO: 0.0 KHz.
Trying to decode MIB...
Searching for cell...
Found CELL ID: 2 CP: Extended, CFO: -11.9 KHz.
Trying to decode MIB...
Searching for cell...
Found CELL ID: 0 CP: Normal , CFO: -15.5 KHz.
Trying to decode MIB...
Searching for cell...
Found CELL ID: 344 CP: Extended, CFO: -0.0 KHz.
Trying to decode MIB...
Searching for cell...
```

Usim configuration



```
ue.conf.example (~/srs/srsUE) - gedit
pdch_enodeb.c  usrp_capture.c  pss.c  ue.conf.example
#####
# USIM configuration
#
# algo: Authentication algorithm (xor/milenage)
# op: 128-bit Operator Variant Algorithm Configuration Field (hex)
# amf: 16-bit Authentication Management Field (hex)
# k: 128-bit subscriber key (hex)
# imsi: 15 digit International Mobile Subscriber Identity
# imei: 15 digit International Mobile Station Equipment Identity
#####[usim]
algo = milenage
op  = 63BFA50EE6523365FF14C1F45F88737D
amf = 8000
k   = 00112233445566778899aabcccddeeff
imsi = 001010123456789
imei = 353490069873319
#####
# Expert configuration options
#
# prach_gain: PRACH gain (dB). If positive, disables power control
# and fixes PRACH tx gain.
# ul_gain: Uplink gain (dB). If positive, disables power control
# and fixes PUSCH/PUCCH/SRS tx gain.
# ul_pwr_ctrl_offset: Uplink power control offset (dB). Adds an offset
# to all UL gains calculated by power_control.
```

For more information please visit: [www.tenettech.com](http://www.tenettech.com) For technical query please send an e-mail: [info@tenettech.com](mailto:info@tenettech.com)

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