

OpenCPI
Rx App Guide
(PLUTO Supplement)

OpenCPI Release: v2.4.7

Revision History

Revision	Description of Change	Date
v1.7	Initial release. Resource Utilization Table removed	4/2020

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1 Document Scope

This document describes the receive demo application or “Rx App”. It includes a description of the RX App application and instructions on how to setup the various supported hardware platforms, build and execution of the application.

2 Description

For more information on this application, see `ocpi.assets`’s more in-depth version of the *RX_app* document.

3 Hardware Portability

This application is specific to the `pluto` platform.

4 Building the Application

4.1 Common Application Worker Dependencies

The following application workers, sorted by component library name, must be built prior to building the RX application assembly. See Appendix A for the parameter configurations used in the application, and see the individual component datasheets for more information.

- `ocpi.core`
 `file_write.rcc`
- `ocpi.assets.util_comps`
 `timestamp.hdl`
- `ocpi.assets.dsp_comps`
 `cic_dec.hdl`
 `complex_mixer.hdl`
 `iq_imbalance_fixer.hdl`
 `dc_offset_filter.hdl`

4.2 Hardware-Specific Worker Dependencies

The following workers, sorted by component library name, must be built prior to building RX app. See Appendix A for the parameter configurations used in the application, and see the individual component datasheets for more information and build instructions.

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- `ocpi.osp.pluto.device`
 `pluto_rx.rcc`

4.3 HDL Assembly and HDL Container

For more information on this application, see `ocpi.assets`'s more in-depth version of the *RX_app* document.

4.4 Performance and Resource Utilization

4.5 Executable

To build for the PLUTO (which runs the xilinx18_3 PetaLinux operating system), run the following command from the *rx_app* directory:

```
ocpidev build --rcc-platform pluto0.31
```

For more information on this application, see `ocpi.assets`'s more in-depth version of the *RX_app* document.

5 Testing the Application

5.1 Sample Test Setup

For more information on this application, see `ocpi.assets`'s more in-depth version of the *RX_app* document.

5.2 Artifacts

For more information on this application, see `ocpi.assets`'s more in-depth version of the *RX_app* document. Appendix B includes a list of the artifacts required for each platform and mode.

5.3 Arguments to executable

For more information on this application, see `ocpi.assets`'s more in-depth version of the *RX_app* document.

5.4 Library Path Requirements

Prior to running the application, the environment variable `OCPI_LIBRARY_PATH` must be configure, such that, all of the Rx application's run-time artifacts can be located. OpenCPI conveniently provides access to a project's run-time artifacts at the top-level of each project in a directory called `artifacts`. Reference the OpenCPI Application Development Guide for more about `OCPI_LIBRARY_PATH`.

Run "make show" in the application directory for a recommended `OCPI_LIBRARY_PATH`.

5.5 Expected results

A python script is included with the application for plotting the received data in both the time and frequency domain. Using the test setup shown above and the default settings for the GNUradio block diagram, run the application with the following arguments:

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```
# Usage is:
# ./target-pluto0_31/rx_app rf_tune_freq data_bw rf_bw rf_gain bb_bw bb_gain if_tune_freq runtime enable_timestamps frontend
./target-pluto0_31/rx_app 1000 0.512 -1 24 1 -1 0.256 1 1 pluto
```

The output file can then be plotted with the python script with the following syntax and the output can be seen below:

```
python ./scripts/plotAndFftAndTime.py odata/rx_app_raw.out complex 18000 256000 16352
```

Alternatively, the shortened file can be plotted which will ignore optionally unwanted startup data:

```
python ./scripts/plotAndFftAndTime.py odata/rx_app_shortened.out complex 18000 256000 16352
```

The default sample rate for the GNUradio block diagram is 512 kS/s. It is recommended that when using RX app with this input signal that a sample rate close to 512 kS/s be used. Higher sample rates are still valid, but may produce plots that look drastically different than those shown here.

Timestamps are embedded, optionally, in the output file, and in addition to plotting, the script parses out and prints the timestamps. An example output gathered using the syntax above:

```
Timestamp at index: 000000000 : 1.0728292 Seconds: 0x1 Fraction: 0x12a4eec4
Timestamp at index: 000008180 : 1.0887978 Seconds: 0x1 Fraction: 0x16bb73ba ('Delta: 0.0159686', 'Expected:', 0.0159688')
Timestamp at index: 000016360 : 1.1047664 Seconds: 0x1 Fraction: 0x1ad1f906 ('Delta: 0.0159686', 'Expected:', 0.0159688')
```

A small discrepancy (+/- 10) between Delta and Expected is typical. The difference is an artifact of the resolution of the fractional part of the timestamp applied in the timestamp HDL component. More information can be found in the timestamp component datasheet.

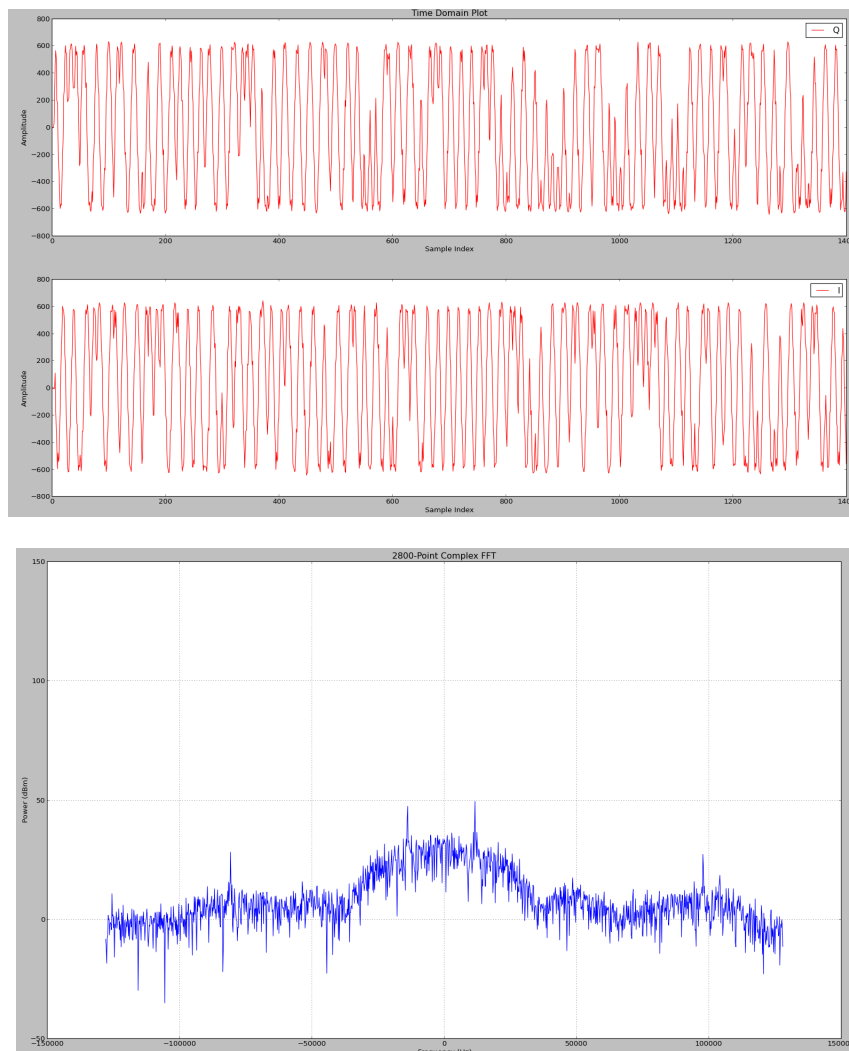


Figure 1: Output of RX app

5.6 Using a RF Signal Generator

An arbitrary RF signal generator can be used with RX app instead of the Ettus N210.

Hardware Setup

- Signal generator is set to 2400.8 MHz with an amplitude of -40 dBm.
- Signal generator is connected to the PLUTO RX1A SMA.

Example 1 - Execution (remote system)

An example run with an IF tune freq of 0.1 MHz would be as follows.

```
SAMP_RATE_MHZ=2.5
RF_TUNE_FREQ_MHZ=2400
IF_TUNE_FREQ_MHZ=0.1
./<target>/rx_app $RF_TUNE_FREQ_MHZ $SAMP_RATE_MHZ -1 24 2.5 -1 $IF_TUNE_FREQ_MHZ 1 1 pluto
```

Example 1 - Verification (development system)

Verify that the signal generator tone exists at 700,000 Hz in the plotted baseband signal FFT (calculated as signal generator frequency - RF tune frequency - IF tune frequency = 2400.8 MHz - 2400 MHz - 0.1 MHz = 700,000 Hz).

```
SAMP_RATE_HZ=2500000
python ./scripts/plotAndFftAndTime.py odata/rx_app_shortened.out complex 65536 $SAMP_RATE_HZ 16352 &
```

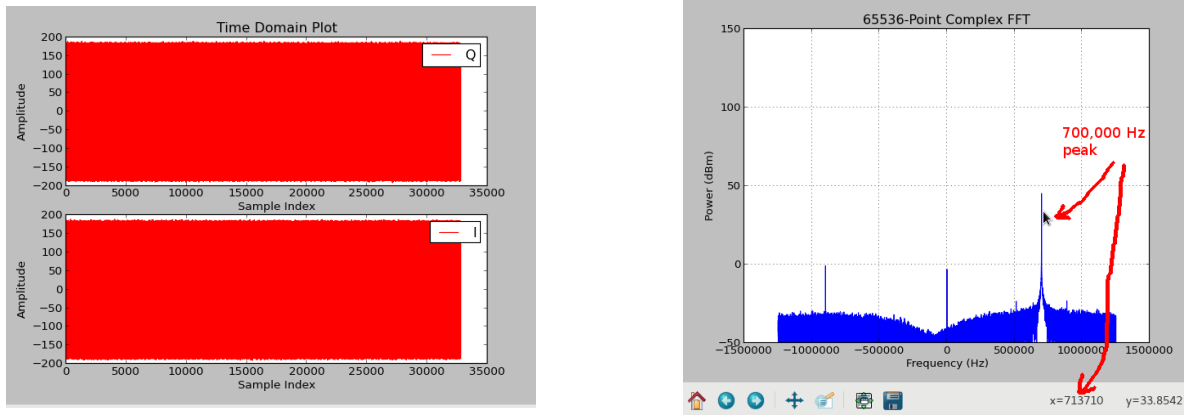


Figure 2: Output of RX app

Example 2 - Execution (remote system)

An example run with an IF tune freq of 0 MHz would be as follows.

```
SAMP_RATE_MHZ=2.5
RF_TUNE_FREQ_MHZ=2400
IF_TUNE_FREQ_MHZ=0
./<target>/rx_app $RF_TUNE_FREQ_MHZ $SAMP_RATE_MHZ -1 24 2.5 -1 $IF_TUNE_FREQ_MHZ 1 1 pluto
```

Example 2 - Verification (development system)

Verify that the signal generator tone exists at 800,000 Hz in the plotted baseband signal FFT (calculated as signal generator frequency - RF tune frequency - IF tune frequency = 2400.8 MHz - 2400 MHz - 0 MHz = 800,000 Hz).

```
SAMP_RATE_HZ=2500000
python ./scripts/plotAndFftAndTime.py odata/rx_app_shortened.out complex 65536 $SAMP_RATE_HZ 16352 &
```

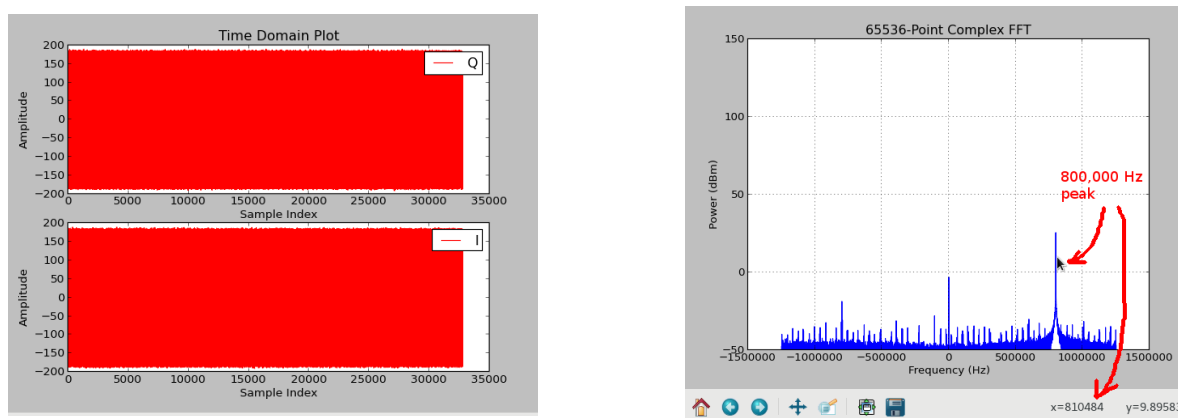


Figure 3: Output of RX app

5.7 Known Issues

- If the path `/var/volatile` does not exist or requires root permission to write to, you will need to modify the ACI and the application XML to use a different directory for writing data. This involves simply finding and replacing `/var/volatile` with a different directory in the `.cxx` and `.xml` files. Failing to make this change when necessary may result in a segmentation fault error at application runtime.

6 Appendix A: Worker Parameters

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- cic_dec.hdl
 - N = 3
 - M = 1
 - R = 8
 - DIN_WIDTH = 16
 - ACC_WIDTH = 25
 - DOUT_WIDTH = 16
- complex_mixer.hdl
 - NCO_DATA_WIDTH_p = 12
 - INPUT_DATA_WIDTH_p = 12
 - CORDIC_STAGES_p = 16
 - PEAK_MONITOR_p = true
- iq_imbalance_fixer.hdl
 - DATA_WIDTH_p = 16
 - ACC_PREC_p = 34
 - PEAK_MONITOR_p = true
- dc_offset_filter.hdl
 - DATA_WIDTH_p = 16
 - PEAK_MONITOR_p = true
- ad9361_spi.hdl
 - CP_CLK_FREQ_HZ_p = 100e6
- ad9361_data_sub.hdl
 - LVDS_p = false
 - HALF_DUPLEX_p = false
 - SINGLE_PORT_p = true
 - SWAP_PORTS_p = false
 - DATA_CLK_Delay = 11
 - RX_Data_Delay = 0
 - FB_CLK_DELAY = 12
 - TX_DATA_DELAY = 0
- ad9361_adc_sub
 - LVDS_p = false
 - HALF_DUPLEX_p = false
 - SINGLE_PORT_p = true
- ad9361_dac_sub
 - LVDS_p = false
 - HALF_DUPLEX_p = false
 - SINGLE_PORT_p = true

7 Appendix B: Artifacts

7.1 PLUTO

- dc_offset_iq_imbalance_mixer_cic_dec_timestamper_cfg_lrx_ltx_mode_2_cmos_cnt_lrx_ltx_thruasm_mode_2_cmos_pluto.bitz
- target-xilinx18.3/file_write.s.so
- target-xilinx18.3/pluto_rx.s.so
- target-xilinx18.3/ad9361_config_proxy.s.so