OpenCPI
Tutorial 3: Developing an RCC Worker

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Revision History

Revision	Description of Change	Date
1.0	Creation	2019-12-12
2.0	Update for release 2.0	2020-09-12
2.2	Update for release 2.2 (remove makefile refs, change to XML files)	2021-07-03
2.3	Update for release 2.3 (complete makeless changes)	2021-08-15

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1 Overview

This tutorial introduces you to the RCC worker authoring model and the OpenCPI unit test capability for workers. Our example is the **`peak_detector`** component in the **`ocpi.tutorial`** project. We used this component, both its RCC and its HDL implementations, in our application and assemblies in Tutorial 2. In this tutorial, we'll step through the procedure used to create the component and its RCC worker implementation. We'll create a component specification for the **`peak_detector`** component and then design, build and test an RCC worker that implements its function.

The peak detector function is to calculate and report the signed maximum and minimum peaks in the I/Q data arriving at its input port and then pass this input data through unchanged to its output port. Given an input of complex numbers, the peak detector component finds the biggest I I or Q sample and the smallest I or Q sample. The process is as follows:

- current_biggest = max(current_biggest, max(I,Q))
- current_smallest = min(current_smallest, min(I,Q))
- Pass input complex samples to the output port

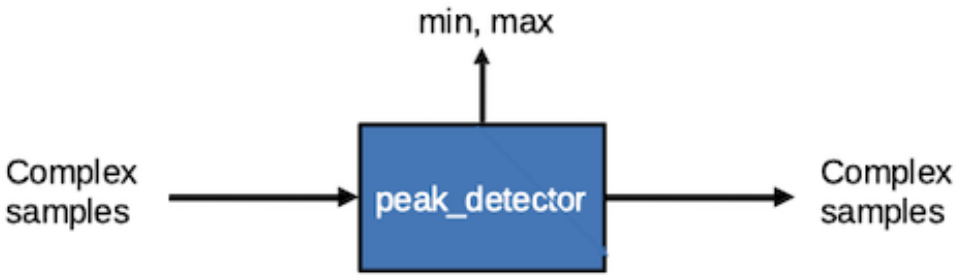


Figure 1: Peak Detector Component Function

1.1 Tutorial Objectives

The purpose of this tutorial is to demonstrate the design process for an RCC worker implementation, including how to use the OpenCPI unit test capability.

This tutorial shows you how to:

- Create the peak detector component specification (properties and ports).
- Create the peak detector worker C++ code and build the RCC worker for the target platform.
- Create, build and run the unit test for the RCC worker on the target platform.

It demonstrates how to use the RCC authoring model to:

- Use component spec (OCS) properties as worker-local variables
- Access worker data ports
- Create worker methods for initializing local variables and running worker code
- Use worker method result values to communicate worker states to the OpenCPI framework

After running this tutorial, you should understand the basics of the RCC authoring model and how to use the OpenCPI unit test suite on an RCC worker implementation of a simple OpenCPI component.

1.2 What's Provided for This Tutorial

The tutorial provides source code for the following tutorial items:

- The **`peak_detector`** worker, written according to the API for the RCC (C++ source code) authoring model.
- The unit test files **`generate.py`** and **`verify.py`**, written in Python
- The unit test **`bash`** shell script **`view.sh`**

This source code is available as text in the relevant sections of this document that you can copy and paste into the relevant files following the instructions given in the section.

The tutorial also provides the XML source for all of the assets used to build and run the example component, worker and tests, available as text in the relevant sections of the document.

You will also use the following script from the **`ocpi.tutorial`** project:

- The Python script code for plotting and viewing the output data, in **`scripts/PlotAndFft.py`**

1.3 Prerequisites to Using This Tutorial

Before you begin this tutorial, you should have successfully completed Tutorial 1, "Component-based Development" and Tutorial 2, "Designing Applications and HDL Assemblies".

We recommend reading the following briefings before getting started with the tutorial:

- Briefing 4, "Component and Worker Overview"
- Briefing 5, "Automated Test Suite – Introduction"
- Briefing 6, "OpenCPI RCC Development"

1.4 Documentation References

The documents listed in the following table provide detailed information about subjects discussed in this tutorial. The documents listed here are not required reading for this tutorial but will likely be of interest for more in-depth learning.

Table 1 - OpenCPI Reference Documentation

Title	Published By	Public URL
OpenCPI User Guide	OpenCPI	https://opencpi.gitlab.io/releases/latest/docs/OpenCPI_User.pdf
OpenCPI Application Development Guide	OpenCPI	https://opencpi.gitlab.io/releases/latest/docs/OpenCPI_Application_Development.pdf
OpenCPI Component Development Guide	OpenCPI	https://opencpi.gitlab.io/releases/latest/docs/OpenCPI_Component_Development.pdf
OpenCPI HDL Development Guide	OpenCPI	https://opencpi.gitlab.io/releases/latest/docs/OpenCPI_HDL_Development.pdf
OpenCPI RCC Development Guide	OpenCPI	https://opencpi.gitlab.io/releases/latest/docs/OpenCPI_RCC_Development.pdf

2 Create New Project

We need to create a new, clean project for Tutorial 3; we'll call it **`DemoProject3`**. This project has the same requirements as the project we created for Tutorial 2.

To create the new project, use the following **`ocpidev`** command:

```
ocpidev -D ocpi.assets -D ocpi.tutorial create project DemoProject3
--register
```

We need to make the same modifications to the **`Project.xml`** file as we did in Tutorial 2. Open the **`Project.xml`** file with a text editor and add the following two lines after the **`ProjectDependencies`** attribute:

```
HdlLibraries='prims'
ComponentLibraries='util_comps'
```

and then save and close the file.

3 Create Component Library

Before we can create our component, we need to create a component library for it. We only need one component library, so we can use the top-level **`components`** directory as our library like we did in Tutorial 1. We just need to create this directory.

To create the **`components`** library with **`ocpidev`**, run the following command in the **`DemoProject3`** directory:

```
ocpidev create library components
```

4 Create Component

Now we need to create the OCS (OpenCPI Component Specification) for our peak detector function that defines its properties and ports.

4.1 Create Component Spec

We'll create our new **peak_detector** component spec in the **components** library we just created.

To create the component spec with **ocpidev**, run the following command in the **DemoProject3/components** directory:

```
ocpidev create component peak_detector
```

The command creates the component spec **peak_detector-spec.xml** in **components/specs**. We'll add properties and ports to the component spec in the next step.

4.2 Create Component Properties and Ports

The **peak_detector** component function requires two properties: a **max_peak** property that returns the most positive I or Q value and a **min_peak** property that returns the most negative I or Q value. The worker implementation of the component uses these properties to keep track of maximum and minimum peak amplitudes and will change their values during execution, so they should be declared as ***volatile*** properties.

The **peak_detector** component also requires one input port and one output port for communication with other components in an application; both ports will use the **iqstream** protocol.

To create the properties and ports from the command line, open **peak_detector-spec.xml** with a text editor and add the following XML between the **ComponentSpec** elements (highlighted in red):

```
<ComponentSpec>
  <Property Name="min_peak" Type="Short" Volatile="true"/>
  <Property Name="max_peak" Type="Short" Volatile="true"/>
  <Port Name="in" Protocol="iqstream_protocol"/>
  <Port Name="out" Protocol="iqstream_protocol" Producer="true"/>
</ComponentSpec>
```

5 Create Worker

We've defined the **`peak_detector`** component spec. Now we need to create the workers that implement them. In our case, we only need to create one implementation – an RCC implementation – which uses the RCC authoring model.

Recall from the ***OpenCPI User Guide*** and the introductory briefings that workers run on ***containers***, which provide the runtime environment for executing workers and manage their execution on a processor. An ***RCC worker*** implements worker methods called by the container and can also call container methods.

RCC workers use symbols, data types and ordinals defined in a header file that is generated for the worker when it is created. These elements are based on the component spec (OCS), protocol spec (OPS) and worker description (OWD) and include the implementation name, the control operations implemented, the properties that require notification, the static memory allocation requirements of the implementation code and the minimum number of buffers required at each port. The information in the OCS, OPS and OWD is used to drive the code generation and build process for the worker. An RCC worker can call a small subset of Posix and ISO-C runtime libraries that provide the minimal environment required of embedded systems. You can read more about these local services and about RCC worker OWD elements, the RCC worker interface and RCC worker code generation in the ***OpenCPI RCC Development Guide***.

In Tutorial 1, we created an RCC worker, which generated an **`rcc`** subdirectory with the worker's OWD XML file and a "skeleton" source code file in the C++ language that we updated to include the C++ code for the worker. We'll do the same thing here for our **`peak_detector`** worker.

5.1 Create RCC Worker OWD and Skeleton File

To create the worker with **ocpidev**, run the following command in the **DemoProject3/components** directory:

```
ocpidev create worker peak_detector.rcc
```

Recall from Tutorial 1 that the suffix of the worker's name - **.rcc** in this case - directs the tool to generate an RCC worker.

Run the **tree** command and you'll see that the **components** directory now has a subdirectory **peak_detector.rcc** with the files **peak_detector.xml** (the OWD) and **peak_detector.cc** (the skeleton file).

Recall from Tutorial 1 that an RCC worker's OWD does not usually need to be changed, so we don't need to do anything with **peak_detector.xml**. The **peak_detector.cc** skeleton file is the basis for writing the worker's execution code. We need to add the C++ code that implements our peak detector function to this file; we'll create this code in the next step.

In **peak_detector.rcc/gen**, you'll see the generated header file **peak_detector-worker.hh**. Do not edit this file. It contains the type definitions and declarations customized for this worker. You'll also see a **peak_detector-skel.cc** file in the **gen** subdirectory. This file exists as a backup copy of the skeleton file and should not be touched.

5.2 Write RCC Worker C++ Code

The **peak_detector** worker uses two local variables to keep track of the maximum and minimum peak amplitudes. To ensure that the peaks are detected correctly, the worker needs to initialize the variable that keeps track of the maximum peak to the most negative value represented in a signed 16-bit number (-32768) and initialize the variable that keeps track of the minimum peak to the most positive value represented in a signed 16-bit number (32767).

On completion, the **peak_detector** worker returns the most positive I or Q sample value with the **max_peak** property and the most negative with the **min_peak** property. This is not the value of the vector represented by I and Q, but simply the max/min value of the I and Q samples taken independently. The worker uses the OpenCPI **iqstream** protocol for both input and output ports (specified by the OPS **iqstream-protocol.xml** in the **opci.core** project). The **iqstream** protocol defines an interface of 16-bit complex signed samples. You can find the OPS for the **iqstream** protocol in **<*opencpi_install_path*>/projects/core/specs/iqstream-protocol.xml**.

To implement these functions, our **peak_detector** worker code needs to:

- Declare the persistent local variables **min_buff** and **max_buff** for the **min_peak** and **max_peak** properties.
- Provide a **start** method that initializes these local variables.
- Provide a **run** method that checks for end of input data, makes sure there is room on the output port for the output data, performs the necessary function for the component and advances the ports.

The next sections describe how to write this code for the **peak_detector** worker. For details on RCC worker methods and on developing RCC workers, see the ***OpenCPI RCC Development Guide***.

5.2.1 Write Initialization Code

We need to put the persistent local variables **min_buff** and **max_buff** into the body of the **Peak_detectorWorker** class, which exists in the generated skeleton file. These internal buffers should match the **short** type defined for the **min_peak** and **max_peak** properties in the OCS. We then initialize them in the **start** RCC worker method: **max_buff** to most negative (-32767) and **min_buff** to most positive (32768) values. We use the **start** method because we're initializing property values and so that initialization occurs both when the worker is first started and when it is resumed after being suspended. Write the following code:

```
class Peak_detectorWorker : public Peak_detectorWorkerBase {
  int16_t max_buff, min_buff;

 RCCResult start(){
    max_buff = -32768; // initialize max to most neg
    min_buff = 32767;  // initialize min to most pos
    return RCC_OK;
  }
```

Note the **RCCResult** return type declared in the **start** method. All worker methods use the **RCCResult** type as a return value to indicate to the container on which they're executing what to do when the worker method returns. Here, the **RCCResult** value **RCC_OK** indicates to the container that the worker has succeeded without error and that normal execution can continue.

5.2.2 Write Output Buffer Checking and Sizing Code

Our **run** RCC worker method also needs to make sure there is room on the output port for the outgoing I/Q data. Since it is passing data from input to output, it simply needs to make the output message the same size as the input message.

Also, to make this code not care about opcodes, it simply copies the opcode from input message to output.

The iq() accessor of the input and output ports comes from the definition of the IQ messages found in the **iqstream_protocol.xml** in the core built-in project (in **projects/core/specs/iqstream_protocol.xml**)

The RCC authoring model provides buffer management data members and methods. Here, the **opCode** method retrieves the opcode of the input buffer and the **setOpCode** method sets it in the output port. For details, see the ***OpenCPI RCC Development Guide***.

To implement this syntax for **peak_detector.cc**, write the following code for the **run** method:

```
const size_t num_of_elements = in.iq().data().size();
out.iq().data().resize(num_of_elements);
out.setOpCode(in.opCode());
```

5.2.3 Write Run Function Code

The **run** RCC worker method declares pointers for reading input data and writing output data. The syntax used here is:

```
const <ProtocolNameOpNameArgName> *idata =
  <PortInName>.<OpName>().<ArgName>().data();
<ProtocolNameOpNameArgName> * odata =
  <PortOutName>.<OpName>().<ArgName>().data();
```

To implement this syntax, add the following code to the **peak_detector.rcc run** method:

```
const IqstreamIqData *idata = in.iq().data().data();
IqstreamIqData *odata = out.iq().data().data();
```

Is the input a sequence or an array? If it is one of these structures, the **run** method for the RCC worker needs to iterate through the elements. Recall that **max_peak** is the greatest value of either I or Q and **min_peak** is the smallest value of either I or Q. Write the following code for the **peak_detector.cc run** method:

```
for ( ) { // decrement through num_of_elements
   // 1. determine max peak and min peak
    *odata++=*idata++ // 2. copy this message to output buffer
}
// 4. set properties().max_peak & set properties().min_peak
// to the calculated max_buff and min_buff
// 3. Do work
for (unsigned n = num_of_elements; n; --n) {
   max_buff = std::max(std::max(idata->I,idata->Q),max_buff);
   min_buff = std::min(std::min(idata->I,idata->Q),min_buff);
   *odata++ = *idata++; // copy this message to output buffer
}
properties().max_peak = max_buff;
properties().min_peak = min_buff;
```

Note that **peak_detector.rcc** must include the **algorithm** standard template library to use the **max** and **min** functions for sequences (highlighted in red in the code example above.) Be sure to include it at the start of your C++ code like this:

```
#include <algorithm>
```

5.2.4 Write Advance Port Code

Add the following code to the **peak_detector.cc run** method to signal the container to advance the ports:

```
return RCC_ADVANCE;
```

The **RCCResult** value **RCC_ADVANCE** tells the container to advance the ports that were ready when the run method was called, essentially consuming input and producing output.

Now we're ready to update the worker skeleton file with the C++ code we've written.

5.3 Update RCC Worker Skeleton File

Now we'll add the C++ source code we just created to the **`peak_detector.cc`** skeleton file.

Using a text editor, replace the code in the **`peak_detector.cc`** skeleton file in **`components/peak_detector.rcc/peak_detector.cc`** with the following C++ code:

```
#include <algorithm>
#include "peak_detector-worker.hh"

using namespace OCPI::RCC; // for easy access to RCC data types and
constants
using namespace Peak_detectorWorkerTypes;

class Peak_detectorWorker : public Peak_detectorWorkerBase {

  int16_t max_buff, min_buff;

  RCCResult start(){
    max_buff = -32768;
    min_buff = 32767;
    return RCC_OK;
  }

  RCCResult run(bool /*timedout*/) {

    // 1. Make sure there is room on the output port
    const size_t num_of_elements = in.iq().data().size();
    out.iq().data().resize(num_of_elements);
    out.setOpCode(in.opCode());

    // 2. Do work
    const IqstreamIqData *idata = in.iq().data().data();
    IqstreamIqData *odata = out.iq().data().data();
    for (unsigned n = num_of_elements; n; --n) {
      max_buff = std::max(std::max(idata->I,idata->Q),max_buff);
      min_buff = std::min(std::min(idata->I,idata->Q),min_buff);

      *odata++ = *idata++; // copy this message to output buffer
    }
    properties().max_peak = max_buff;
    properties().min_peak = min_buff;

    // 3. Advance ports
    return RCC_ADVANCE;
  }
};

PEAK_DETECTOR_START_INFO
// Insert any static info assignments here (memSize, memSizes,
portInfo)
// e.g.: info.memSize = sizeof(MyMemoryStruct);
PEAK_DETECTOR_END_INFO
```

5.4 Build RCC Worker

Now we need to compile the **peak_detector** worker for the platform on which we want to run it; for this tutorial, it's our development host. Although workers are normally built as part of building an entire component library or as part of an entire project, we'll build our **peak_detector** worker separately.

To build the worker with **ocpidev**, run the following command from the **DemoProject3** directory:

```
ocpidev build worker peak_detector.rcc
```

Navigate to **components/peak_detector.rcc**. There should be a new subdirectory **target-<*platform*>** that contains the artifacts needed to run the worker on this platform. Make sure the file **peak_detector.o** (highlighted in red in the output of the **ls -l** command below) exists in this subdirectory:

```
ls -l target-centos7
peak_detector_assy-art.xml
peak_detector_assy.xml
peak_detector_dispatch.c
peak_detector_dispatch.o
peak_detector_dispatch.o.deps
peak_detector.o
peak_detector.o.deps
peak_detector.so
```

Next, we'll create the unit test for **peak_detector** and then run it.

6 Create Unit Test

An OpenCPI ***unit test suite*** is a collection of test cases that allow functional testing of all workers that implement a component specification across all available platforms for which the workers have been built. A component's unit test suite is contained in a subdirectory named **`<component>.test`** in a component library. The test suite can be applied to all of the workers in the library that implement that component's OCS, regardless of authoring model and/or language.

For more information on the OpenCPI unit test suite feature and how to use it, see the ***OpenCPI Component Development Guide***.

We'll use the OpenCPI unit test capability to generate:

- Multiple application XMLs (OAS) that the OpenCPI framework can use to test the workers on different platforms
- Input test files

A unit test consists of the following phases:

- The ***generate*** phase, which creates the gen subdirectory and generates the input data, OASs, OHADs and case configuration(s)
- The ***build*** phase, which builds the HDL assemblies for the target platforms. This phase is only relevant for HDL workers and platforms
- The ***prepare*** phase, which creates the run subdirectory, examines the available built workers and available runtime platforms and creates the execution scripts
- The ***run*** phase, which executes the tests
- The ***verify*** phase, which verifies the results

We'll use combinations of these phases as we create, build and run our **`peak_detector`** unit test suite.

To create the unit test with **`ocpidev`**, run the following command in the **`DemoProject3/components`** directory:

```
ocpidev create test peak_detector
```

Now run the **`tree`** command to observe the files created:

```
peak_detector.test
├── generate.py
├── peak_detector-test.xml
├── verify.py
└── view.sh
```

The files of interest here are:

- **`peak_detector-test.xml`**. This is the test suite description file. It specifies the test cases and the defaults that apply to all test cases.

- **`generate.py`.** This is a stub file for an optional script that you can create to generate input test data for ports or property value files. There is one script for each input port.
- **`verify.py`**. This is a stub file for an optional script that you can create to verify output test data produced by output ports. There is one script for each output port..
- **`view.sh`**. This is a stub file for an optional script that you can create to view the results of a test execution; for example, a plot. This script may not be necessary or appropriate for many workers. It can work as a helpful aid in the development process, but it is not meant for long-term testing and re-testing.

We want to use the generate, verify and view scripts in this tutorial, so we'll need to edit the test suite description file to specify them and create the code for each script. The next sections describe these steps.

6.1 Edit Unit Test Description File

In this step, we'll edit the unit test description file **`peak_detector-test.xml`**. We need to add the generate and verify scripts with the sample size 32768 as parameters to the scripts. We'll also set up the test to use HDL file I/O. It's not applicable for testing our RCC worker, but we'll need it in a later tutorial, where we'll use this same test on an HDL implementation of the peak detector worker.

To edit the unit test description file on the command line, open the **`peak_detector-test.xml`** file with a text editor and make the following changes:

- Uncomment the Input and Output elements
- Edit the Input element to add the value **32768** as the sample size parameter to the **`generate.py`** script:

```
Script='generate.py 32768'
```

- Edit the Output element to add the value **32768** as the sample size parameter to the **`verify.py`** script:

```
Script='verify.py 32768'
```

Your **`peak_detector-test.xml`** file should now look like this:

```
<Tests UseHDLFileIo='true'>
<Input Port='in' Script='generate.py 32768'/>
<Output Port='out' Script='verify.py 32768' View='view.sh'/>
</Tests>
```

6.2 Edit Test Scripts

Now we need to create code for the empty **`generate.py`**, **`verify.py`** and **`view.sh`** scripts we created when we created the unit test. We'll use the code provided in the next sections for this purpose.

Note: Make sure your test scripts have read and execute permissions before using them to build and run the **`peak_detector`** unit test. For example:

```
chmod 777 generate.py
chmod 777 verify.py
chmod 777 view.sh
```

6.2.1 Edit generate.py Script

Open the **`generate.py`** script with a text editor and then copy and paste the following text into the file:

```
#!/usr/bin/env python3

"""Generate idata for Peak Detector (binary data file).

Generate args:
- amount to generate (number of complex signed 16-bit samples)
- target file

To test the Peak Detector, a binary data file is generated
containing complex signed 16-bit samples with a tone at 13 Hz.

The input data is passed through the worker, so the output file
should be identical to the input file. The worker measures
the minimum and maximum amplitudes found within the complex
data stream. These values, reported as properties, are compared
with min/max calculations performed within the script.

"""

import numpy as np, sys

def generate(argv):
    print ("*** Generate input (binary data file) ***")
    if len(argv) < 2:
        print("Exit: Enter number of input samples (int:1 to ?)")
        return
    elif len(argv) < 3:
        print("Exit: Enter an input filename")
        return

    filename = argv[2]
    num_samples = int(argv[1])

    # Create an input file with a single tone at 13 Hz; Fs=100 Hz
    Tone13 = 13
    Fs = 100
    Ts = 1.0/float(Fs)
    t = np.arange(0,num_samples*Ts,Ts,dtype=np.float)

    real = np.cos(Tone13*2*np.pi*t)
    imag = np.sin(Tone13*2*np.pi*t)
    out_data = np.array(np.zeros(num_samples),
dtype=np.dtype((np.uint32, {'real_idx':(np.int16,2), 'imag_idx':
(np.int16,0)})))

    # pick a gain at 95% max value - i.e. back off a little
    # to avoid file generation overflow. This results in
    # complex amplitudes that swing between +31k and -31k
    # within an int16. We must use the same gain on both rails to
    # avoid I/Q spectral image
    gain = 32768*0.95 / max(abs(real))
    out_data['real_idx'] = np.int16(real * gain)
```

```
        out_data['imag_idx'] = np.int16(imag * gain)

        # Save data file
        f = open(filename, 'wb')
        for i in range(0,num_samples):
            f.write(out_data[i])
        f.close()

        print ('Output filename: ', filename)
        print ('Number of samples: ', num_samples)
        print ('*** End of file generation ***\n')

    def main():
        print ("\n","*"*80)
        print ("*** Python: Peak Detector ***")
        generate(sys.argv)

    if __name__ == '__main__':
        main()
```

6.2.2 Edit verify.py Script

Open the **`verify.py`** script with a text editor and then copy and paste the following text into the file:

```
#!/usr/bin/env python3

"""Validate odata for Peak Detector (binary data file).

Validate args:
- amount to validate (number of complex signed 16-bit samples)
- target file

To test the Peak Detector, a binary data file is generated
containing complex signed 16-bit samples with a tone at 13 Hz.
The input data is passed through the worker, so the output file
should be identical to the input file. The worker measures
the minimum and maximum amplitudes found within the complex
data stream. These values, reported as properties, are compared
with min/max calculations performed within the script.

"""
import numpy as np, sys, os.path, re

class color:
    PURPLE = '\033[95m'
    CYAN = '\033[96m'
    DARKCYAN = '\033[36m'
    BLUE = '\033[94m'
    GREEN = '\033[92m'
    YELLOW = '\033[93m'
    RED = '\033[91m'
    BOLD = '\033[1m'
    UNDERLINE = '\033[4m'
    END = '\033[0m'

def validation(argv):
    print ("*** Validate output against expected data ***")
    if len(argv) < 2:
        print ("Exit: Need to know how many samples")
        return
    elif len(argv) < 3:
        print("Exit: Enter an output filename")
        return

    num_samples = int(argv[1])

    # strip off output extension and replace with 'log'
    # ('.out.out'=>'.log')

    logname = os.path.splitext(argv[2])[0]
    logname = os.path.splitext(logname)[0] + ".log"
    if not os.path.isfile(logname):
        logname = os.path.splitext(logname)[0] + ".remote_log"

    # Parse the logfile for the final values of max/min peaks
    # Normally, we would access these via environment variables:
```

```
    #   OCPI_TEST_max_peak, OCPI_TEST_min_peak
    # Due to an inconsistency in the unit test framework,
    # the final values of these properties are captured
    # correctly in the environment variables
    #   for RCC workers, but not HDL.

    min_peak=max_peak=None

    with open(logname, 'r') as log:
        for line in log:
            max_obj = re.search("Property \d+:
peak_detector.max_peak = \"(-?\d+)\".*", line)
            if max_obj: #max_obj[1]:
                max_peak = int(max_obj.group(1))
            min_obj = re.search("Property \d+:
peak_detector.min_peak = \"(-?\d+)\".*", line)
            if min_obj: #[1]:
                min_peak = int(min_obj.group(1))

    if not min_peak or not max_peak:
        print("Exit: log file does not contain max/min peak final
values")
        return

    #Read all of input data file as complex int16
    print ('File to validate: ', argv[2])

    ofile = open(argv[2], 'rb')
    dout = np.fromfile(ofile, dtype=np.dtype((np.uint32,
     {'real_idx':(np.int16,2), 'imag_idx':(np.int16,0)})), count=-1)
    ofile.close()

    #Ensure dout is not all zeros
    if all(dout == 0):
        print (color.RED + color.BOLD + 'FAILED, values are all
zero' + color.END)
        return

    #Ensure that dout is the expected amount of data
    if len(dout) != num_samples:
        print (color.RED + color.BOLD + 'FAILED, input file length
is unexpected' + color.END)
        print (color.RED + color.BOLD + 'Length dout = ', len(dout),
               'while expected length is = ' + color.END,
num_samples)
        return

   # Calculate the maximum in python for verification
    pymin = min(min(dout['real_idx']), min(dout['imag_idx']))
    pymax = max(max(dout['real_idx']), max(dout['imag_idx']))

    print ('uut_min_peak = ', min_peak)
```

```
    print ('uut_max_peak = ', max_peak)
    print ('file_min_peak = ', pymin)
    print ('file_max_peak = ', pymax)

    if (min_peak != pymin) or (max_peak != pymax):
        print (color.RED + color.BOLD + 'FAILED, min/max values do
not match' +
               color.END)
        return

    print ('Data matched expected results.')
    print (color.GREEN + color.BOLD + 'PASSED' + color.END)
    print ('*** End validation ***\n')

def main():
    print ("\n","*"*80)
    print ("*** Python: Peak Detector ***")
    validation(sys.argv)

if __name__ == '__main__':
    main()
```

6.2.3 Edit view.sh Script

Open the **`view.sh`** script with a text editor and then copy and paste the following lines at the end of the file (highlighted in red):

```
#!/bin/bash --noprofile
# Use this script to view your input and output data.
# Args: <list-of-user-defined-args> <input-file> <output-file>
$OCPI_ROOT_DIR/projects/tutorial/scripts/plotAndFft.py $2 complex
32768 100&
$OCPI_ROOT_DIR/projects/tutorial/scripts/plotAndFft.py $1 complex
32768 100&
```

6.3 Build Unit Test

Now we'll build the unit test suite for the target platform.

To generate and build the unit test with **`ocpidev`**, run the command:

```
ocpidev run test peak_detector.test --mode gen_build --rcc-platform
centos7
```

Navigate to **`peak_detector.test/gen/`** and observe the artifacts created. The following files and directories are of interest:

- **`cases.txt`**. This file is user-readable and lists various test configurations.
- **`cases.xml`**. This file is used by the OpenCPI framework to execute tests.
- **`cases.xml.deps`**. This file contains a list of dependent files.
- **`applications/`**. This directory contains OAS files and scripts used by the OpenCPI framework to execute applications.

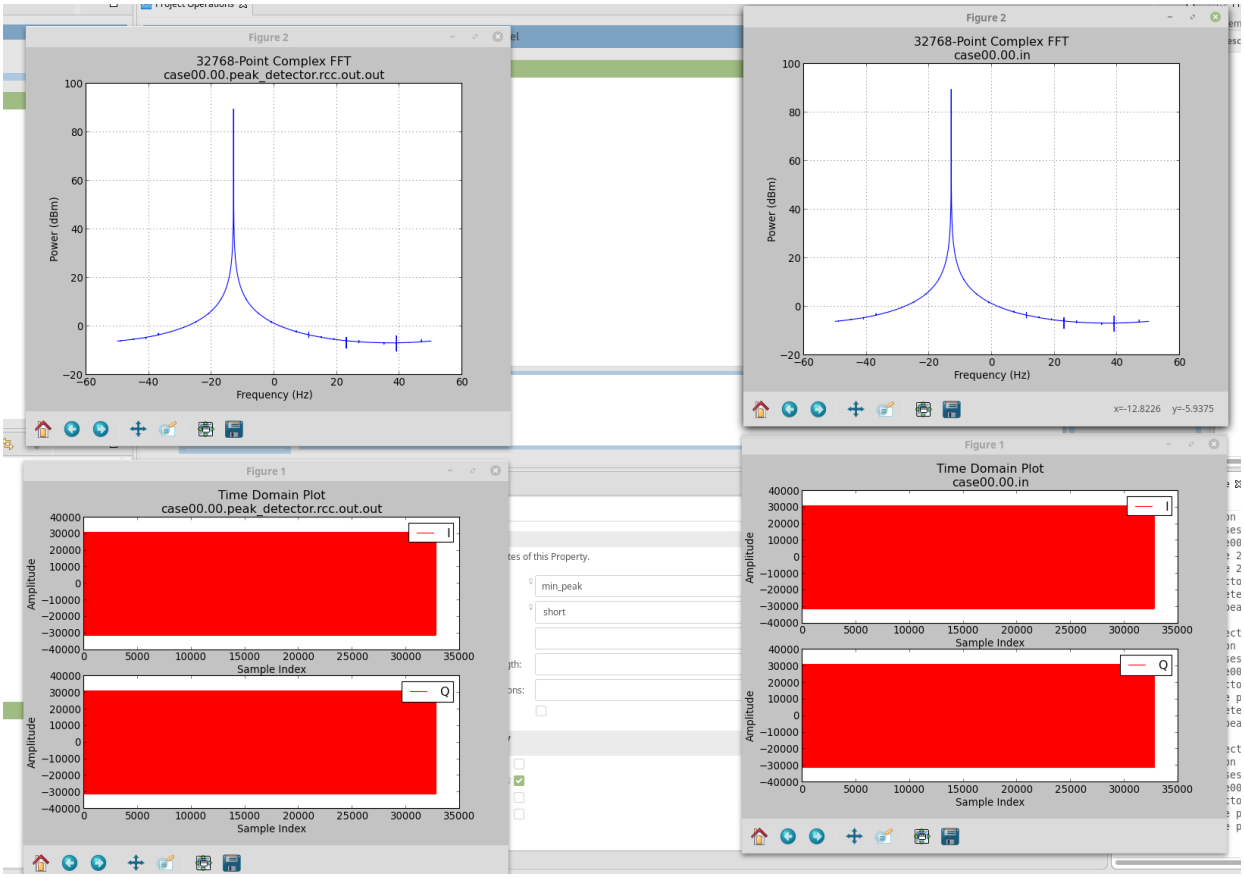
7 Run Unit Test

Now we'll run the unit test and view the results.

To run the test and view the output from the command line, run the following **`ocpidev`** command from the **`DemoProject3`** directory (you can also run it from the **`components`** directory or the **`peak_detector.test`** directory):

```
ocpidev run --mode prep_run_verify --only-platform centos7 --view
```

You should see this output:



8 Tutorial Summary

Now that you've completed this tutorial, you should be familiar with the basic concepts of the RCC authoring model and how to use it to develop an RCC worker and the OpenCPI unit test suite and how to use OpenCPI tools to perform unit testing on an RCC worker.