ThinkRF Device API Documentation

Release 0.3.0-dev

ThinkRF Corporation

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CHAPTER

ONE

REFERENCE

1.1 thinkrf.devices

class `thinkrf.devices.`**`WSA4000`**`(`*connector=<class 'thinkrf.connectors.PlainSocketConnector'>*`)`

Interface for WSA4000

Parameters **connector** – Connector class to use for SCPI/VRT connections

`connect()` must be called before other methods are used.

`ADC_DYNAMIC_RANGE` **= 72.5**

`antenna``(`**args*, ***kwargs*`)`

This command selects and queries the active antenna port.

Parameters **number** – 1 or 2 to set; None to query

Returns active antenna port

`capture``(`*spp*, *ppb*`)`

This command will start the single block capture and the return of *ppb* packets of *spp* samples each. The data within a single block capture trace is continuous from one packet to the other, but not necessary between successive block capture commands issued.

Parameters

- **spp** – the number of samples in a packet
- **ppb** – the number of packets in a capture

`connect``(`**args*, ***kwargs*`)`

connect to a wsa

Parameters **host** – the hostname or IP to connect to

`decimation``(`**args*, ***kwargs*`)`

This command sets or queries the rate of decimation of samples in a trace capture. This decimation method consists of cascaded integrator-comb (CIC) filters and at every *value* number of samples, one sample is captured. The supported rate is 4 - 1023. When the rate is set to 1, no decimation is performed on the trace capture.

Parameters **value** (*int*) – new decimation value (1 or 4 - 1023); None to query

Returns the decimation value

`disconnect``()`

close a connection to a wsa

eof()
Check if the VRT stream has closed.

Returns True if no more data, False if more data

flush()
Flush capture memory of sweep captures.

flush_captures()
Flush capture memory of sweep captures.

freq(**args*, ***kwargs*)
This command sets or queries the tuned center frequency of the WSA.

Parameters **freq** (*int*) – the new center frequency in Hz (0 - 10 GHz); None to query

Returns the frequency in Hz

fshift(**args*, ***kwargs*)
This command sets or queries the frequency shift value.

Parameters **freq** (*int*) – the new frequency shift in Hz (0 - 125 MHz); None to query

Returns the amount of frequency shift

gain(**args*, ***kwargs*)
This command sets or queries RFE quantized gain configuration. The RF front end (RFE) of the WSA4000 consists of multiple quantized gain stages. The gain corresponding to each user-selectable setting has been pre-calculated for either optimal sensitivity or linearity. The parameter defines the total quantized gain of the RFE.

Parameters **gain** – 'high', 'medium', 'low' or 'vlow' to set; None to query

Returns the RF gain value

has_data()
Check if there is VRT data to read.

Returns True if there is a packet to read, False if not

have_read_perm(**args*, ***kwargs*)
Check if we have permission to read data.

Returns True if allowed to read, False if not

id(**args*, ***kwargs*)
Returns the WSA4000's identification information string.

Returns "<Manufacturer>,<Model>,<Serial number>,<Firmware version>"

ifgain(**args*, ***kwargs*)
This command sets or queries variable IF gain stages of the RFE. The gain has a range of -10 to 34 dB. This stage of the gain is additive with the primary gain stages of the LNA that are described in `gain()`.

Parameters **gain** – float between -10 and 34 to set; None to query

Returns the ifgain in dB

locked(**args*, ***kwargs*)
This command queries the lock status of the RF VCO (Voltage Control Oscillator) in the Radio Front End (RFE) or the lock status of the PLL reference clock in the digital card.

Parameters **modulestr** – 'vco' for rf lock status, 'clkref' for mobo lock status

Returns True if locked

preselect_filter(**args*, ***kwargs*)
This command sets or queries the RFE preselect filter selection.

Parameters **enable** – True or False to set; None to query

Returns the RFE preselect filter selection state

raw_read(**args*, ***kwargs*)
Raw read of VRT socket data from the WSA.

Parameters **num** – the number of bytes to read

Returns bytes

read(**args*, ***kwargs*)
Read a single VRT packet from the WSA.

See `thinkrf.vrt.Stream.read_packet()`.

request_read_perm(**args*, ***kwargs*)
Aquire exclusive permission to read data from the WSA.

Returns True if allowed to read, False if not

reset()
Resets the WSA4000 to its default settings. It does not affect the registers or queues associated with the IEEE mandated commands.

scpiget(*cmd*)
Send a SCPI command and wait for the response.

This is the lowest-level interface provided. Please see the Programmer's Guide for information about the commands available.

Parameters **cmd** (*str*) – the command to send

Returns the response back from the box if any

scpiset(*cmd*)
Send a SCPI command.

This is the lowest-level interface provided. Please see the Programmer's Guide for information about the commands available.

Parameters **cmd** (*str*) – the command to send

sweep_add(*entry*)
Add an entry to the sweep list

Parameters **entry** (*thinkrf.config.SweepEntry*) – the sweep entry to add

sweep_clear()
Remove all entries from the sweep list.

sweep_read(**args*, ***kwargs*)
Read an entry from the sweep list.

Parameters **index** – the index of the entry to read

Returns sweep entry

Return type thinkrf.config.SweepEntry

sweep_start(*start_id=None*)
Start the sweep engine.

sweep_stop()
Stop the sweep engine.

trigger(**args*, ***kwargs*)
This command sets or queries the type of trigger event. Setting the trigger type to "NONE" is equivalent to disabling the trigger execution; setting to any other type will enable the trigger engine.

Parameters **settings** (*thinkrf.config.TriggerSettings*) – the new trigger settings; None to query

Returns the trigger settings

1.2 thinkrf.config

class thinkrf.config.**SweepEntry**(*fstart=2400000000*, *fstop=2400000000*, *fstep=100000000*, *fshift=0*, *decimation=0*, *antenna=1*, *gain='vlow'*, *ifgain=0*, *spp=1024*, *ppb=1*, *trigtype='none'*, *level_fstart=50000000*, *level_fstop=10000000000*, *level_amplitude=-100*)
Sweep entry for `thinkrf.devices.WSA4000.sweep_add()`

Parameters

- **fstart** – starting frequency in Hz
- **fstop** – ending frequency in Hz
- **shift** – the frequency shift in Hz
- **decimation** – the decimation value (0 or 4 - 1023)
- **antenna** – the antenna (1 or 2)
- **gain** – the RF gain value ('high', 'medium', 'low' or 'vlow')
- **ifgain** – the IF gain in dB (-10 - 34)
- **spp** – samples per packet
- **ppb** – packets per block
- **trigtype** – trigger type ('none' or 'level')
- **level_fstart** – level trigger starting frequency in Hz
- **level_fstop** – level trigger ending frequency in Hz
- **level_amplitude** – level trigger minimum in dBm

class thinkrf.config.**TriggerSettings**(*trigtype='NONE'*, *fstart=None*, *fstop=None*, *amplitude=None*)
Trigger settings for `thinkrf.devices.WSA4000.trigger()`.

Parameters

- **trigtype** – "LEVEL" or "NONE" to disable
- **fstart** – starting frequency in Hz
- **fstop** – ending frequency in Hz
- **amplitude** – minumum level for trigger in dBm

exception thinkrf.config.**TriggerSettingsError**

1.3 thinkrf.vrt

class `thinkrf.vrt.`**`ContextPacket`**(*pkt_type*, *word*, *socket*)

A Context Packet received from `thinkrf.vrt.Stream.read_packet()`

`fields`

a dict containing field names and values from the packet

`is_context_packet`(*ptype=None*)

Parameters **ptype** – "Receiver", "Digitizer" or None for any packet type

Returns True if this packet matches the type passed

`is_data_packet`()

Returns False

class `thinkrf.vrt.`**`DataPacket`**(*word*, *socket*)

A Data Packet received from `thinkrf.vrt.Stream.read_packet()`

`data`

a `thinkrf.vrt.IQData` object containing the packet data

`is_context_packet`(*ptype=None*)

Returns False

`is_data_packet`()

Returns True

class `thinkrf.vrt.`**`IQData`**(*binary_data*)

Data Packet values as a lazy collection of (I, Q) tuples read from *binary_data*.

This object behaves as an immutable python sequence, e.g. you may do any of the following:

```
points = len(iq_data)

i_and_q = iq_data[5]

for i, q in iq_data:
    print i, q
```

`numpy_array`()

Return a numpy array of I, Q values for this data similar to:

```
array([[ -44,    8],
       [ -40,   60],
       [ -12,   92],
       ...,
       [-132,   -8],
       [-124,   56],
       [ -44,   80]], dtype=int16)
```

exception `thinkrf.vrt.`**`InvalidDataReceived`**

class `thinkrf.vrt.`**`Stream`**(*socket*)

A VRT Packet Stream interface wrapping *socket*.

`has_data`()

Returns True if there is data waiting on *socket*.

read_packet()

Read a complete packet from *socket* and return either a `thinkrf.vrt.ContextPacket` or a `thinkrf.vrt.DataPacket`.

1.4 thinkrf.util

thinkrf.util.**read_data_and_reflevel**(*dut*, *points=1024*)

Wait for and capture a data packet and a reference level packet.

Returns (data_pkt, reflevel_pkt)

thinkrf.util.**socketread**(*socket*, *count*, *flags=None*)

Retry socket read until count data received, like reading from a file.

1.5 thinkrf.numpy_util

thinkrf.numpy_util.**compute_fft**(*dut*, *data_pkt*, *reflevel_pkt*)

Return an array of dBm values by computing the FFT of the passed data and reference level.

Parameters

- **dut** (*thinkrf.devices.WSA4000*) – WSA device
- **data_pkt** (*thinkrf.vrt.DataPacket*) – packet containing samples
- **reflevel_pkt** (*thinkrf.vrt.ContextPacket*) – packet containing 'reflevel' value

This function uses only *dut.ADC_DYNAMIC_RANGE*, *data_pkt.data* and *reflevel_pkt['reflevel']*.

Returns numpy array of dBm values as floats

CHAPTER

TWO

BASIC EXAMPLES

2.1 show_i_q.py

This example connects to a device specified on the command line, tunes it to a center frequency of 2.450 MHz then reads and displays one capture of 1024 i, q values.

```
#!/usr/bin/env python

import sys
from thinkrf.devices import WSA4000

# connect to wsa
dut = WSA4000()
dut.connect(sys.argv[1])

# setup test conditions
dut.reset()
dut.request_read_perm()
dut.ifgain(0)
dut.freq(2450e6)
dut.gain('low')
dut.fshift(0)
dut.decimation(0)

# capture 1 packet
dut.capture(1024, 1)

# read until I get 1 data packet
while not dut.eof():
    pkt = dut.read()

    if pkt.is_data_packet():
        break

# print I/Q data into i and q
for i, q in pkt.data:
    print "%d,%d" % (i, q)
```

Example output (truncated):

```
0,-20
-8,-16
0,-24
-8,-12
```

```
0,-32
24,-24
32,-16
-12,-24
-20,0
12,-32
32,-4
0,12
-20,-16
-48,16
-12,12
0,-36
4,-12
```

2.2 plot_fft.py

This example connects to a device specified on the command line, tunes it to a center frequency of 2.450 MHz and sets a trigger for a signal with an amplitude of -70 dBm or greater between 2.400 MHz and 2.480 MHz.

When the trigger is satisfied the data is captured and rendered as a spectrum display using NumPy and matplotlib.

```python
#!/usr/bin/env python

from thinkrf.devices import WSA4000
from thinkrf.config import TriggerSettings
from thinkrf.util import read_data_and_reflevel
from thinkrf.numpy_util import compute_fft

import sys
import time
import math

from matplotlib.pyplot import plot, figure, axis, xlabel, ylabel, show

# connect to wsa
dut = WSA4000()
dut.connect(sys.argv[1])

# setup test conditions
dut.reset()
dut.request_read_perm()
dut.ifgain(0)
dut.freq(2450e6)
dut.gain('high')
dut.fshift(0)
dut.decimation(0)
trigger = TriggerSettings(
    trigtype="LEVEL",
    fstart=2400e6,
    fstop=2480e6,
    amplitude=-70)
dut.trigger(trigger)

# capture 1 packet
data, reflevel = read_data_and_reflevel(dut, 1024)
```

```
# compute the fft of the complex data
powdata = compute_fft(dut, data, reflevel)

# setup my graph
fig = figure(1)
axis([0, 1024, -120, 20])

xlabel("Sample Index")
ylabel("Amplitude")

# plot something
plot(powdata, color='blue')

# show graph
show()
```

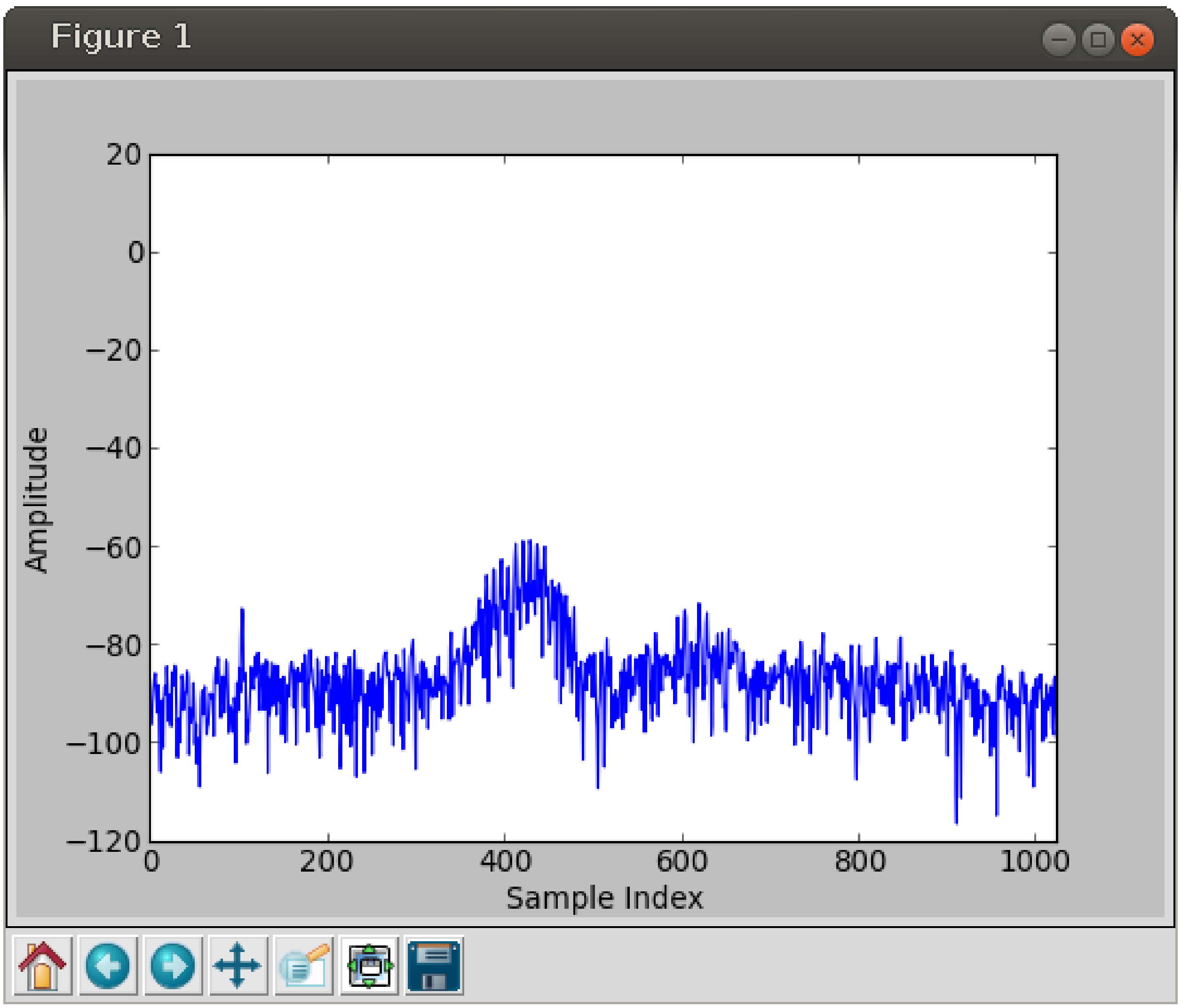


Figure 2.1: Example output of `plot_fft.py`

CHAPTER

THREE

GUI EXAMPLE: WSA4000DEMO

`wsa4000demo` is a cross-platform GUI application built with the Qt toolkit and PySide bindings for Python.

You may run application by launching the `wsa4000demo.py` script in the `examples/gui` directory.

You may specify a device on the command line or open a device after the GUI has launched. Adding `--reset` to the command line parameters will cause the device to be reset to defaults after connecting.

3.1 wsa4000demo.py

This is the script that launches the application.

```
#!/usr/bin/env python

import sys
from PySide import QtGui
from gui import MainWindow

app = QtGui.QApplication(sys.argv)
ex = MainWindow()
sys.exit(app.exec_())
```

3.2 gui.py

The main application window and GUI controls are created here.

`MainWindow` creates and handles the `File | Open Device` menu and wraps the `MainPanel` widget responsible for most of the interface.

All the buttons and controls and their callback functions are built in `MainPanel` and arranged on a grid. A `SpectrumView` is created and placed to left of the controls.

Note: This version calls `MainPanel.update_screen()` in a timer loop 20 times a second. This method makes a blocking call to capture the next packet and render it all in the same thread as the application. This can make the interface slow or completely unresponsive if you lose connection to the device.

The next release will move the blocking call and data processing into a separate process.

```
import sys
import socket

from PySide import QtGui, QtCore
from spectrum import SpectrumView
from util import frequency_text

from thinkrf.devices import WSA4000
from thinkrf.util import read_data_and_reflevel
from thinkrf.numpy_util import compute_fft

DEVICE_FULL_SPAN = 125e6
REFRESH_CHARTS = 0.05

class MainWindow(QtGui.QMainWindow):
    def __init__(self, name=None):
        super(MainWindow, self).__init__()
        self.initUI()

        self.dut = None
        if len(sys.argv) > 1:
            self.open_device(sys.argv[1])
        else:
            self.open_device_dialog()
        self.show()

        timer = QtCore.QTimer(self)
        timer.timeout.connect(self.update_charts)
        timer.start(REFRESH_CHARTS)

    def initUI(self):
        openAction = QtGui.QAction('&Open Device', self)
        openAction.triggered.connect(self.open_device_dialog)
        exitAction = QtGui.QAction('&Exit', self)
        exitAction.setShortcut('Ctrl+Q')
        exitAction.triggered.connect(self.close)
        menubar = self.menuBar()
        fileMenu = menubar.addMenu('&File')
        fileMenu.addAction(openAction)
        fileMenu.addAction(exitAction)

        self.setWindowTitle('ThinkRF WSA4000')

    def open_device_dialog(self):
        name, ok = QtGui.QInputDialog.getText(self, 'Open Device',
            'Enter a hostname or IP address:')
        while True:
            if not ok:
                return

            try:
                self.open_device(name)
                break
            except socket.error:
                name, ok = QtGui.QInputDialog.getText(self, 'Open Device',
                    'Connection Failed, please try again\n\n'
                    'Enter a hostname or IP address:')
```

```
    def open_device(self, name):
        dut = WSA4000()
        dut.connect(name)
        dut.request_read_perm()
        if '--reset' in sys.argv:
            dut.reset()

        self.dut = dut
        self.setCentralWidget(MainPanel(dut))
        self.setWindowTitle('ThinkRF WSA4000: %s' % name)

    def update_charts(self):
        if self.dut is None:
            return
        self.centralWidget().update_screen()


class MainPanel(QtGui.QWidget):

    def __init__(self, dut):
        super(MainPanel, self).__init__()
        self.dut = dut
        self.get_freq_mhz()
        self.get_decimation()
        self.decimation_points = None
        data, reflevel = read_data_and_reflevel(dut)
        self.screen = SpectrumView(
            compute_fft(dut, data, reflevel),
            self.center_freq,
            self.decimation_factor)
        self.initUI()

    def initUI(self):
        grid = QtGui.QGridLayout()
        grid.setSpacing(10)
        grid.addWidget(self.screen, 0, 0, 8, 1)
        grid.setColumnMinimumWidth(0, 400)

        y = 0
        grid.addWidget(self._antenna_control(), y, 1, 1, 2)
        grid.addWidget(self._bpf_control(), y, 3, 1, 2)
        y += 1
        grid.addWidget(self._gain_control(), y, 1, 1, 2)
        grid.addWidget(QtGui.QLabel('IF Gain:'), y, 3, 1, 1)
        grid.addWidget(self._ifgain_control(), y, 4, 1, 1)
        y += 1
        freq, steps, freq_plus, freq_minus = self._freq_controls()
        grid.addWidget(QtGui.QLabel('Center Freq:'), y, 1, 1, 1)
        grid.addWidget(freq, y, 2, 1, 2)
        grid.addWidget(QtGui.QLabel('MHz'), y, 4, 1, 1)
        y += 1
        grid.addWidget(steps, y, 2, 1, 2)
        grid.addWidget(freq_minus, y, 1, 1, 1)
        grid.addWidget(freq_plus, y, 4, 1, 1)
        y += 1
        span, rbw = self._span_rbw_controls()
        grid.addWidget(span, y, 1, 1, 2)
        grid.addWidget(rbw, y, 3, 1, 2)
```

```
        self.setLayout(grid)
        self.show()

    def _antenna_control(self):
        antenna = QtGui.QComboBox(self)
        antenna.addItem("Antenna 1")
        antenna.addItem("Antenna 2")
        antenna.setCurrentIndex(self.dut.antenna() - 1)
        def new_antenna():
            self.dut.antenna(int(antenna.currentText().split()[-1]))
        antenna.currentIndexChanged.connect(new_antenna)
        return antenna

    def _bpf_control(self):
        bpf = QtGui.QComboBox(self)
        bpf.addItem("BPF On")
        bpf.addItem("BPF Off")
        bpf.setCurrentIndex(0 if self.dut.preselect_filter() else 1)
        def new_bpf():
            self.dut.preselect_filter("On" in bpf.currentText())
        bpf.currentIndexChanged.connect(new_bpf)
        return bpf

    def _gain_control(self):
        gain = QtGui.QComboBox(self)
        gain_values = ['High', 'Med', 'Low', 'VLow']
        for g in gain_values:
            gain.addItem("RF Gain: %s" % g)
        gain_index = [g.lower() for g in gain_values].index(self.dut.gain())
        gain.setCurrentIndex(gain_index)
        def new_gain():
            self.dut.gain(gain.currentText().split()[-1].lower())
        gain.currentIndexChanged.connect(new_gain)
        return gain

    def _ifgain_control(self):
        ifgain = QtGui.QSpinBox(self)
        ifgain.setRange(-10, 34)
        ifgain.setSuffix(" dB")
        ifgain.setValue(int(self.dut.ifgain()))
        def new_ifgain():
            self.dut.ifgain(ifgain.value())
        ifgain.valueChanged.connect(new_ifgain)
        return ifgain

    def _freq_controls(self):
        freq = QtGui.QLineEdit("")
        def read_freq():
            freq.setText("%0.1f" % self.get_freq_mhz())
        read_freq()
        def write_freq():
            try:
                f = float(freq.text())
            except ValueError:
                return
            self.set_freq_mhz(f)
        freq.editingFinished.connect(write_freq)
```

```
        steps = QtGui.QComboBox(self)
        steps.addItem("Adjust: 1 MHz")
        steps.addItem("Adjust: 2.5 MHz")
        steps.addItem("Adjust: 10 MHz")
        steps.addItem("Adjust: 25 MHz")
        steps.addItem("Adjust: 100 MHz")
        steps.setCurrentIndex(2)
        def freq_step(factor):
            try:
                f = float(freq.text())
            except ValueError:
                return read_freq()
            delta = float(steps.currentText().split()[1]) * factor
            freq.setText("%0.1f" % (f + delta))
            write_freq()
        freq_minus = QtGui.QPushButton('-')
        freq_minus.clicked.connect(lambda: freq_step(-1))
        freq_plus = QtGui.QPushButton('+')
        freq_plus.clicked.connect(lambda: freq_step(1))

        return freq, steps, freq_plus, freq_minus

    def _span_rbw_controls(self):
        span = QtGui.QComboBox(self)
        decimation_values = [1] + [2 ** x for x in range(2, 10)]
        for d in decimation_values:
            span.addItem("Span: %s" % frequency_text(DEVICE_FULL_SPAN / d))
        span.setCurrentIndex(decimation_values.index(self.dut.decimation()))
        def new_span():
            self.set_decimation(decimation_values[span.currentIndex()])
            build_rbw()
        span.currentIndexChanged.connect(new_span)

        rbw = QtGui.QComboBox(self)
        points_values = [2 ** x for x in range(8, 16)]
        rbw.addItems([str(p) for p in points_values])
        def build_rbw():
            d = self.decimation_factor
            for i, p in enumerate(points_values):
                r = DEVICE_FULL_SPAN / d / p
                rbw.setItemText(i, "RBW: %s" % frequency_text(r))
                if self.decimation_points and self.decimation_points == d * p:
                    rbw.setCurrentIndex(i)
            self.points = points_values[rbw.currentIndex()]
        build_rbw()
        def new_rbw():
            self.points = points_values[rbw.currentIndex()]
            self.decimation_points = self.decimation_factor * self.points
        rbw.setCurrentIndex(points_values.index(1024))
        new_rbw()
        rbw.currentIndexChanged.connect(new_rbw)

        return span, rbw


    def update_screen(self):
        data, reflevel = read_data_and_reflevel(
            self.dut,
```

```
                self.points)
            self.screen.update_data(
                compute_fft(self.dut, data, reflevel),
                self.center_freq,
                self.decimation_factor)

    def get_freq_mhz(self):
        self.center_freq = self.dut.freq()
        return self.center_freq / 1e6

    def set_freq_mhz(self, f):
        self.center_freq = f * 1e6
        self.dut.freq(self.center_freq)

    def get_decimation(self):
        d = self.dut.decimation()
        self.decimation_factor = 1 if d == 0 else d

    def set_decimation(self, d):
        self.decimation_factor = 1 if d == 0 else d
        self.dut.decimation(d)
```

3.3 spectrum.py

The `SpectrumView` widget is divided into three parts:

- `SpectrumViewPlot` contains the plotted spectrum data.
- `SpectrumViewLeftAxis` displays the dBm axis along the left.
- `SpectrumViewBottomAxis` displays the MHz axis across the bottom.

The utility functions `dBm_labels` and `MHz_labels` compute the positions and labels for each axis.

```
import numpy
import itertools
from PySide import QtGui, QtCore

TOP_MARGIN = 20
RIGHT_MARGIN = 20
LEFT_AXIS_WIDTH = 70
BOTTOM_AXIS_HEIGHT = 40
AXIS_THICKNESS = 1

DBM_TOP = 20
DBM_BOTTOM = -140
DBM_STEPS = 9

class SpectrumView(QtGui.QWidget):
    """
    A complete spectrum view with left/bottom axis and plot
    """

    def __init__(self, powdata, center_freq, decimation_factor):
        super(SpectrumView, self).__init__()
        self.plot = SpectrumViewPlot(powdata, center_freq, decimation_factor)
        self.left = SpectrumViewLeftAxis()
```

```
        self.bottom = SpectrumViewBottomAxis()
        self.bottom.update_params(center_freq, decimation_factor)
        self.initUI()

    def initUI(self):
        grid = QtGui.QGridLayout()
        grid.setSpacing(0)
        grid.addWidget(self.left, 0, 0, 2, 1)
        grid.addWidget(self.plot, 0, 1, 1, 1)
        grid.addWidget(self.bottom, 1, 1, 1, 1)
        grid.setRowStretch(0, 1)
        grid.setColumnStretch(1, 1)
        grid.setColumnMinimumWidth(0, LEFT_AXIS_WIDTH)
        grid.setRowMinimumHeight(1, BOTTOM_AXIS_HEIGHT)

        grid.setContentsMargins(0, 0, 0, 0)
        self.setLayout(grid)

    def update_data(self, powdata, center_freq, decimation_factor):
        if (self.plot.center_freq, self.plot.decimation_factor) != (
                center_freq, decimation_factor):
            self.bottom.update_params(center_freq, decimation_factor)
        self.plot.update_data(powdata, center_freq, decimation_factor)


def dBm_labels(height):
    """
    return a list of (position, label_text) tuples where position
    is a value between 0 (top) and height (bottom).
    """
    # simple, fixed implementation for now
    dBm_labels = [str(d) for d in
        numpy.linspace(DBM_TOP, DBM_BOTTOM, DBM_STEPS)]
    y_values = numpy.linspace(0, height, DBM_STEPS)
    return zip(y_values, dBm_labels)

class SpectrumViewLeftAxis(QtGui.QWidget):
    """
    The left axis of a spectrum view showing dBm range

    This widget includes the space to the left of the bottom axis
    """
    def paintEvent(self, e):
        qp = QtGui.QPainter()
        qp.begin(self)
        size = self.size()
        self.drawAxis(qp, size.width(), size.height())
        qp.end()

    def drawAxis(self, qp, width, height):
        qp.fillRect(0, 0, width, height, QtCore.Qt.black)
        qp.setPen(QtCore.Qt.gray)
        qp.fillRect(
            width - AXIS_THICKNESS,
            TOP_MARGIN,
            AXIS_THICKNESS,
            height - BOTTOM_AXIS_HEIGHT + AXIS_THICKNESS - TOP_MARGIN,
            QtCore.Qt.gray)
```

```
        for y, txt in dBm_labels(height - BOTTOM_AXIS_HEIGHT - TOP_MARGIN):
            qp.drawText(
                0,
                y + TOP_MARGIN - 10,
                LEFT_AXIS_WIDTH - 5,
                20,
                QtCore.Qt.AlignRight | QtCore.Qt.AlignVCenter,
                txt)

def MHz_labels(width, center_freq, decimation_factor):
    """
    return a list of (position, label_text) tuples where position
    is a value between 0 (left) and width (right).
    """
    df = float(decimation_factor)
    # simple, fixed implementation for now
    offsets = (-50, -25, 0, 25, 50)
    freq_labels = [str(center_freq / 1e6 + d/df) for d in offsets]
    x_values = [(d + 62.5) * width / 125 for d in offsets]
    return zip(x_values, freq_labels)

class SpectrumViewBottomAxis(QtGui.QWidget):
    """
    The bottom axis of a spectrum view showing frequencies
    """
    def update_params(self, center_freq, decimation_factor):
        self.center_freq = center_freq
        self.decimation_factor = decimation_factor
        self.update()

    def paintEvent(self, e):
        qp = QtGui.QPainter()
        qp.begin(self)
        size = self.size()
        self.drawAxis(qp, size.width(), size.height())
        qp.end()

    def drawAxis(self, qp, width, height):
        qp.fillRect(0, 0, width, height, QtCore.Qt.black)
        qp.setPen(QtCore.Qt.gray)
        qp.fillRect(
            0,
            0,
            width - RIGHT_MARGIN,
            AXIS_THICKNESS,
            QtCore.Qt.gray)

        for x, txt in MHz_labels(
                width - RIGHT_MARGIN,
                self.center_freq,
                self.decimation_factor):
            qp.drawText(
                x - 40,
                5,
                80,
                BOTTOM_AXIS_HEIGHT - 10,
                QtCore.Qt.AlignTop | QtCore.Qt.AlignHCenter,
                txt)
```

```python
class SpectrumViewPlot(QtGui.QWidget):
    """
    The data plot of a spectrum view
    """
    def __init__(self, powdata, center_freq, decimation_factor):
        super(SpectrumViewPlot, self).__init__()
        self.powdata = powdata
        self.center_freq = center_freq
        self.decimation_factor = decimation_factor

    def update_data(self, powdata, center_freq, decimation_factor):
        self.powdata = powdata
        self.center_freq = center_freq
        self.decimation_factor = decimation_factor
        self.update()

    def paintEvent(self, e):
        qp = QtGui.QPainter()
        qp.begin(self)
        self.drawLines(qp)
        qp.end()

    def drawLines(self, qp):
        size = self.size()
        width = size.width()
        height = size.height()
        qp.fillRect(0, 0, width, height, QtCore.Qt.black)

        qp.setPen(QtGui.QPen(QtCore.Qt.gray, 1, QtCore.Qt.DotLine))
        for y, txt in dBm_labels(height - TOP_MARGIN):
            qp.drawLine(
                0,
                y + TOP_MARGIN,
                width - RIGHT_MARGIN - 1,
                y + TOP_MARGIN)
        for x, txt in MHz_labels(
                width - RIGHT_MARGIN,
                self.center_freq,
                self.decimation_factor):
            qp.drawLine(
                x,
                TOP_MARGIN,
                x,
                height - 1)

        qp.setPen(QtCore.Qt.green)

        y_values = height - 1 - (self.powdata - DBM_BOTTOM) * (
            float(height - TOP_MARGIN) / (DBM_TOP - DBM_BOTTOM))
        x_values = numpy.linspace(0, width - 1 - RIGHT_MARGIN,
            len(self.powdata))

        path = QtGui.QPainterPath()
        points = itertools.izip(x_values, y_values)
        path.moveTo(*next(points))
        for x,y in points:
```

```
            path.lineTo(x, y)
        qp.drawPath(path)
```

3.4 util.py

Pretty-print frequency values

```
def frequency_text(hz):
    """
    return hz as readable text in Hz, kHz, MHz or GHz
    """
    if hz < 1e3:
        return "%.3f Hz" % hz
    elif hz < 1e6:
        return "%.3f kHz" % (hz / 1e3)
    elif hz < 1e9:
        return "%.3f MHz" % (hz / 1e6)
    return "%.3f GHz" % (hz / 1e9)
```

CHAPTER

FOUR

PLANNED DEVELOPMENT

4.1 Blocking Sockets

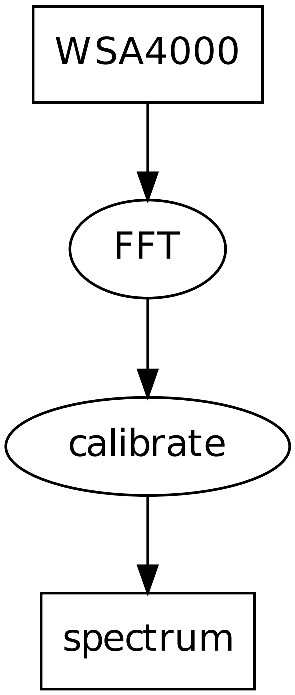
This library will continue to be usable in a simple blocking-socket manner the way the current GUI example does.

Simple data capture and processing needs can be accomplished with few lines of code.

4.2 Twisted and Async

The device API is being extended so that it can also work with a provided non-blocking Twisted API, or any other async library the user chooses to add support for.

The simplest Twisted use will have all processing blocks in the same process, much like the current GUI example but without the problem of the UI freezing when no data is arriving from the device. This mode is the simplest for the programmer and incurrs no cost for passing data from one processing block to the next.

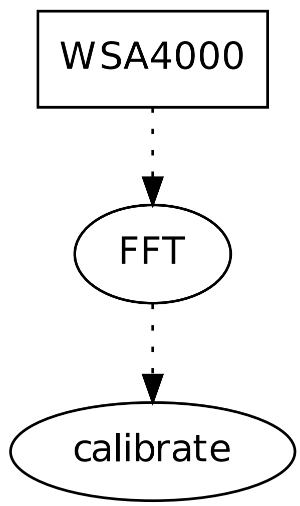



```
wsa = WSA4000(host)
fft = fft_block(wsa)
calibrate = calibrate_block(fft)
spectrum = spectrum_display(calibrate)
```

4.3 Processing Blocks

Processing blocks will use Python interfaces based on zope.interface to describe connections that may be made from consumer to producer.

Consumers will connect to their configured producers only if they are not producers (e.g. a graph renderer) or if all their required producer interfaces have consumers connected.

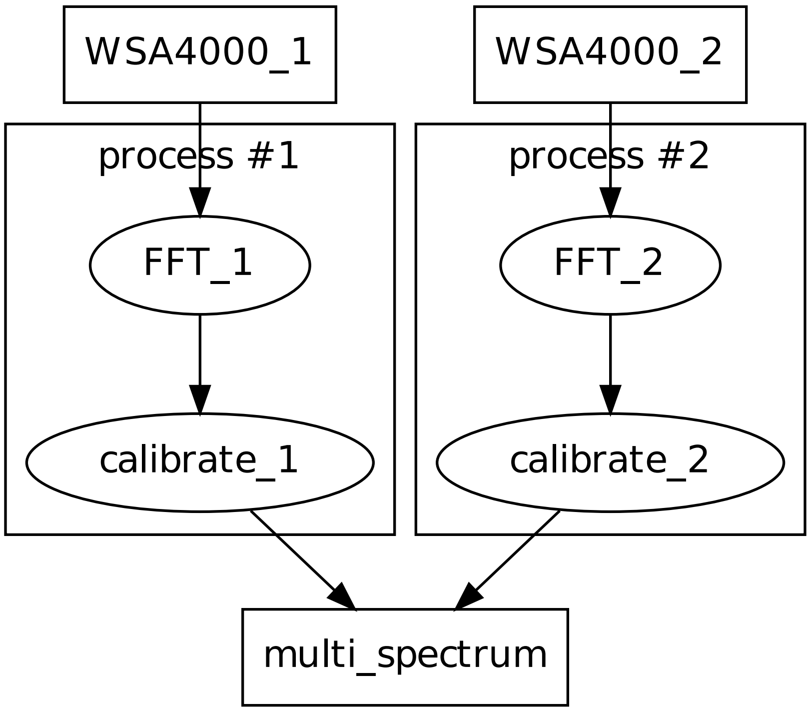



```
wsa = WSA4000(host)
fft = fft_block(wsa)
calibrate = calibrate_block(fft)
```

4.4 Multiprocess and HTTP

Using multiple cores for data processing will be accomplished by grouping some or all processing blocks into separate processes. These processes will pass data with long-polling HTTP requests at the boundaries.

HTTP Headers will be used to indicate the type of data/packet being sent. The body will contain the raw packet bytes.




```
process1 = process()
process2 = process()
wsa1 = WSA4000(host1)
fft1 = fft_block(wsa1, proc=process1)
calibrate1 = calibrate_block(fft1, proc=process1)
wsa2 = WSA4000(host2)
fft2 = fft_block(wsa2, proc=process2)
calibrate2 = calibrate_block(fft2, proc=process2)
multi_spectrum = multi_spectrum_display(calibrate1, calibrate2)
```

4.5 Distributed

HTTP servers work across different machines without modification. Setting up a distributed processing chain across separate machines will be possible to set up, but will require some more manual configuration than multiprocess configuration.

Authentication between machines is outside the scope of this library.

Extending the process block deployment across machines in an easier way (with ssh, for example) is a possible future enhancement.

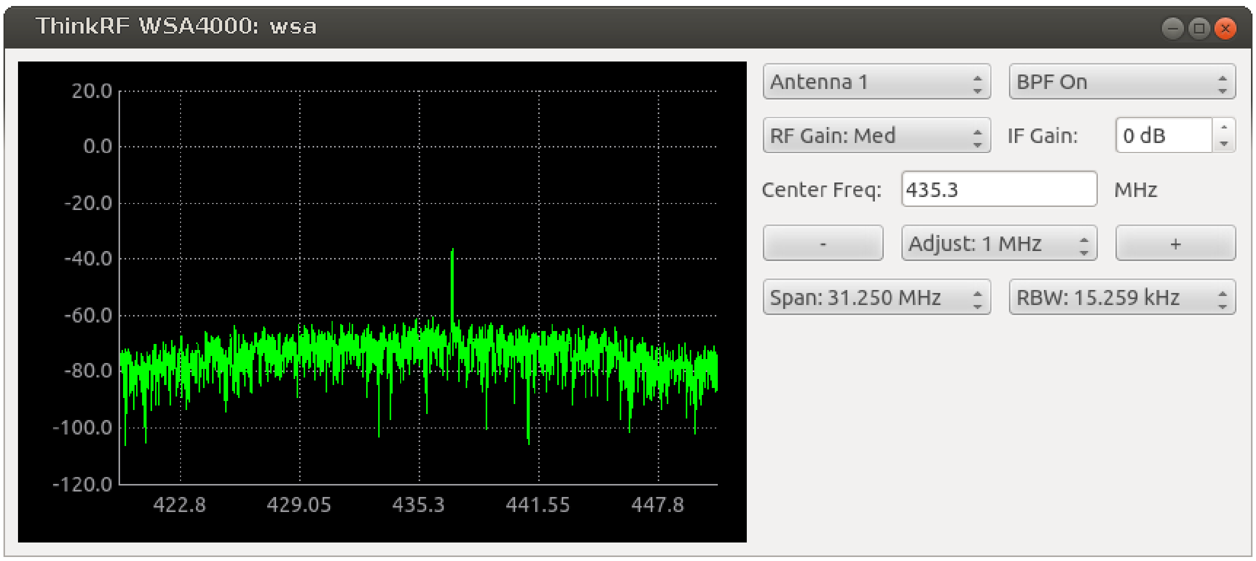


Figure 4.1: The *wsa4000demo GUI* application

CHAPTER

FIVE

INDICES AND TABLES

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- *search*

PYTHON MODULE INDEX

t