Application Note

SC2430 – Integration with GNU Radio

Number: SCT-AN3A21VC

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Revision History

Revision	Date	Author	Description
1.0	2023-Feb-14	K. Sumlak	First Release

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1. Introduction

This document details how to integrate the SCT SC2430 Signal Conditioning Module (SCM) with the GNU Radio Software Defined Radio (SDR) platform using Ettus USRP Hardware Driver (UHD).

1.1 Signal Conditioning Module

The SCM is an RF front-end solution that provides signal conditioning and amplification for Software Define Radio (SDR) systems. Four independent channels are available and capable of supporting Time Division Duplex (TDD) and Frequency Division Duplex (FDD) operations. For Frequency Division Duplex (FDD) applications, configure two channels for continuous TX and RX operation.

Figure 1 – SC2430 Signal Conditioning Module Front Panel

The signal conditioning and amplification of the SCM are designed specifically for 5G NR frequency bands. Additional RF performance details are described in the document *SCT-PS0A21VC – SC2430 Product Specification*. See Section 3.1 for additional information.

Figure 2 provides a high-level illustration of the functional blocks included with each of the SCM channels.

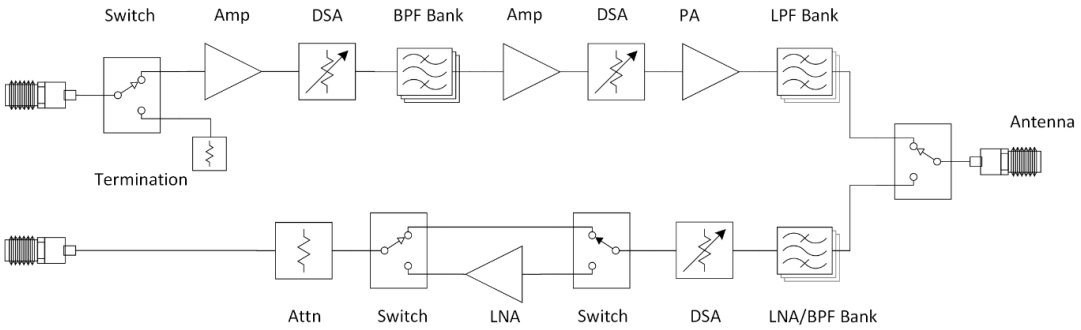

Figure 2 - SC2430 Channel Block Diagram

1.2 SDR Integration

The SCM was designed specifically for use with the NI Ettus-USRP X410, however, it's possible to integrate with other SDR types using either the Binary or Console Protocols as described in the document *SCT-SW0A21VC - SC2430 API Specification*. See Section 3.1 for additional information.

When paired with the Ettus X410 USRP, the SCM UHD Extension Library enables transparent integration with the Ettus USRP Hardware Driver (UHD). The SCM is controlled by UHD via the HDMI physical interface and Binary Protocol.

2. GNU Radio

GNU Radio is an open-source development toolkit that provides signal processing blocks to implement Software Defined Radio functionality. GNU Radio leverages the Ettus USRP Hardware Driver (UHD) to control the X410 SDR and SC2430 SCM.

2.1 Building and Installing

The following sections detail the procedure to install and configure UHD, the SC2430 UHD Extension, and GNU Radio on an Ubuntu 22.04 Linux system.

2.1.1 UHD

The Ettus USRP Hardware Driver (UHD) Version 4.3 or newer is required to support the SC2430 UHD Extension (Section 2.1.2). It's recommended to build and install UHD from source before installing GNU Radio. See the Ettus UHD documentation for complete instructions on how to build UHD from source, including the required dependencies.

The following example builds and installs UHD 4.3.

```
$ git clone --branch v4.3.0.0 https://github.com/EttusResearch/uhd.git
$ cd <workspace>/uhd/host
$ mkdir build && cd build
$ cmake ../
$ make -j$(nproc)
$ sudo make install
$ sudo ldconfig
$ cd <workspace>
```

2.1.2 UHD Extension

The SC2430 UHD Extension Library enables transparent integration with the Ettus USRP Hardware Driver and the X410 SDR. See Section 3.2 for additional information.

The following example builds and installs the SC2430 Extension into the UHD installation.

```
$ git clone https://github.com/SignalCraftTechnologies/SC2430-UHDExtension.git
$ cd <workspace>/SC2430-UHDExtension
$ mkdir build && cd build
$ cmake ../
$ make
$ sudo make install
$ cd <workspace>
```

2.1.3 GNU Radio

It is recommended to build and install GNU Radio from source. Prebuilt binaries may not include a version of UHD that is compatible with the SC2430 Extension. See the GNU Radio documentation for complete instructions to build and install from source, including the required dependencies.

The following example builds and installs GNU Radio Volk, a dependency of GNU Radio.

```
$ git clone --recursive https://github.com/gnuradio/volk.git
$ cd <workspace>/volk
$ mkdir build && cd build
$ cmake -DCMAKE_BUILD_TYPE=Release -DPYTHON_EXECUTABLE=/usr/bin/python3 ../
$ make -j$(nproc)
$ sudo make install
```

```
$ sudo ldconfig
$ cd <workspace>
```

The following example builds and installs GNU Radio.

```
$ git clone https://github.com/gnuradio/gnuradio.git
$ cd <workspace>/gnuradio
$ mkdir build && cd build
$ cmake -DCMAKE_BUILD_TYPE=Release -DPYTHON_EXECUTABLE=/usr/bin/python3 ../
$ make -j$(nproc)
$ sudo make install
$ sudo ldconfig
$ volk_profile
$ cd <workspace>
```

2.2 Application Usage

When using the GNU Radio Companion, applications are described at a high level using the block diagram and GR blocks. The Output Language generated from the GNU Radio block diagram can be either Python or C++, as configured in the *Options* block shown in the top-left corner of Figure 3

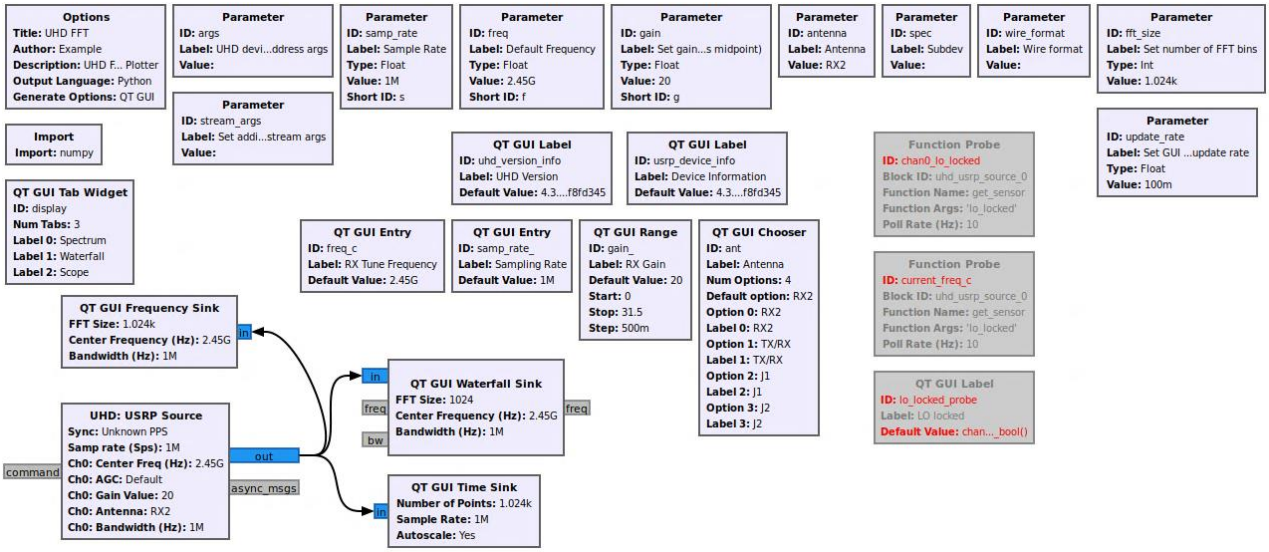

Figure 3 – GNU Radio Block Diagram, uhd_fft example

2.2.1 Python Output

When executing a Python application with UHD Extensions installed, it is required to pre-load the extension libraries before execution. See the UHD Extension Documentation for additional detail.

The following example demonstrates how to start the GNU Radio Companion with the SC2430 UHD Extension installed.

```
$ export LD_PRELOAD=/usr/local/lib/libuhd.so:/usr/local/lib/libsc2430.so:${LD_PRELOAD}
$ gnuradio-companion &
```

2.2.2 UHD Extension

The SC2430 UHD Extension is enabled by specifying the UHD argument *extension=sc2430*. From the GNU Radio block diagram, UHD arguments are provided to the *USRP Sink* and *USRP Source* blocks. UHD arguments are often specified as parameters as shown in Figure 4.

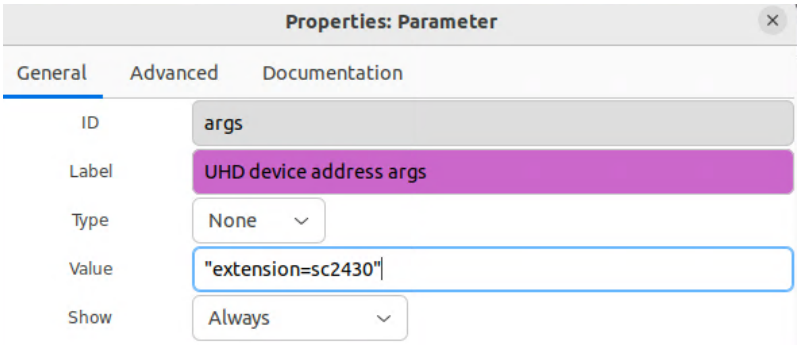

Figure 4 – GNU Radio UHD Device Arguments

Prebuilt applications which utilize the Parameter block for UHD arguments are inherently compatible with UHD Extensions. For example, to run the GNU Radio example *uhd_siggen_gui* with the SC2430 Extension use the following commands:

```
$ export LD_PRELOAD=/usr/local/lib/libuhd.so:/usr/local/lib/libsc2430.so:${LD_PRELOAD}
$ uhd_siggen_gui -f 2.35e9 --args extension=sc2430
```

3. Additional Resources

3.1 SCT Support

The following supporting documents are available from the SCT Support Portal[1]:

- SCT-UM0A21VC – Getting Started Guide
- SCT-PS0A21VC – Product Specification
- SCT-SW0A21VC – API Specification
- SCT-MD1A21VC – Mechanical Dimension

3.2 GitHub

See the SC2430-UHDExtension[2] repository for the UHD Extension Library source code and supporting documentation.

[1] https://www.signalcraft.com/support/support-microwave/
[2] https://github.com/SignalCraftTechnologies/SC2430-UHDExtension