OFDM Spectrum

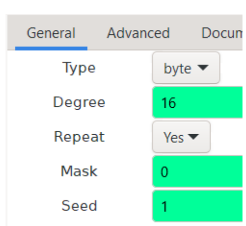
Introduction

In this lab you will create an OFDM transmitter using GNU Radio Companion . You will then measure the effect of changing various parameters on the power spectrum of the OFDM signal.

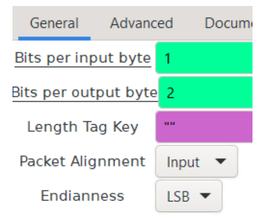
Create an OFDM Transmitter

The OFDM transmitter is shown in Figure 1 and is composed of the blocks described below. For each block you can click on the link in the Documentation tab to get more information on the block.

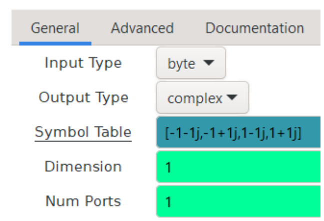
- The block contains four **Variable** blocks to configure the flowgraph:
  - `samp_rate` the sample rate, initially set to 1 MHz
  - `fft_len` the OFDM symbol length in samples, initially 128
  - `ncarrier` the number of data subcarriers placed in each OFDM symbol, initially 32
  - `cp_len` the length of the cyclic prefix added to each OFDM symbol, set to 16
- the **GLFSR**[1] Source block generates random 0/1 values (bits). The period of the sequence is $2^{\text{Degree}} - 1$. In this case the sequence will repeat after 65535 bits.



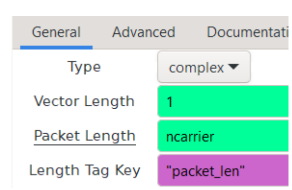
- the **Repack Bits** block groups/ungroups bits. In this case it collects two one-bit samples and creates one two-bit value (i.e. value between 0 and 3).



- the **Chunks to Symbols** block is configured to map 2-bit numbers into a complex value representing one of four QPSK constellation points. The array with the four possible complex values must be in Python syntax. Imaginary values are indicated with a `j` suffix.



- the **Stream to Tagged Stream** block adds a “tag” object to the sample stream. Here the tag is being used indicate the length of a group of samples that should be processed together. In this case the number of subcarriers to be placed in each OFDM symbol (`ncarrier`) is placed in a tag labelled `packet_len`.



- the **Throttle** block reduces the real-time sampling rate. Since there is no actual sink or source to set the sampling rate, the flowgraph will process samples as quickly as it can. This uses up all of the CPU time and makes the computer unresponsive. A typical PC should be able to compute at a sample rate of 10 k samples per second as configured in the flow graph in Figure 1.

[1] Galois linear feedback shift register

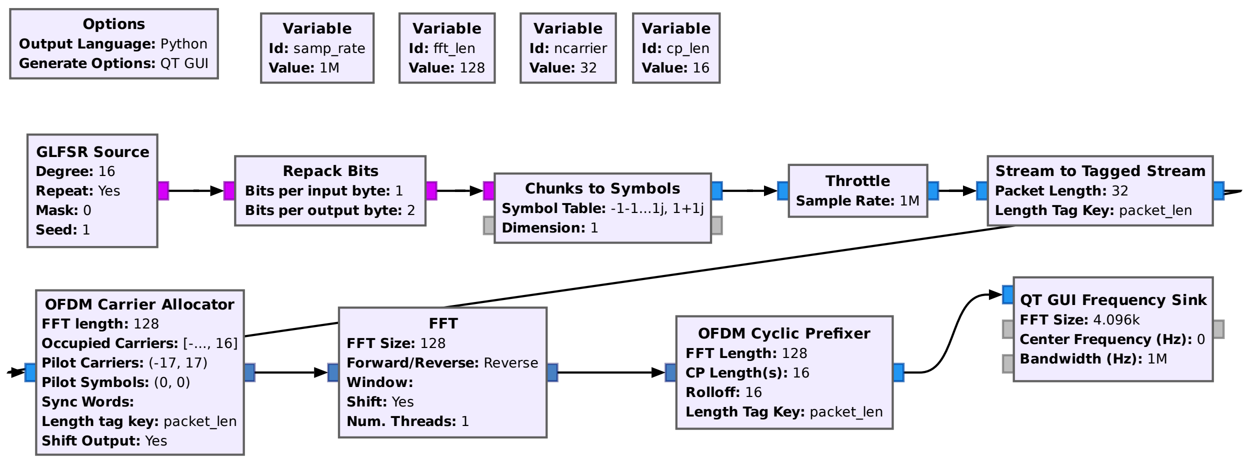
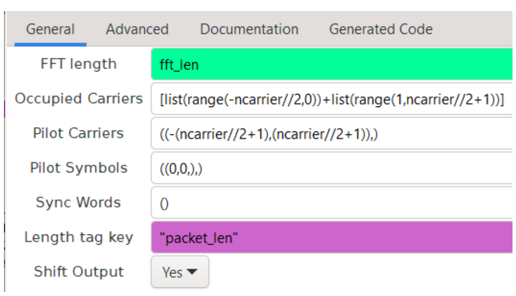


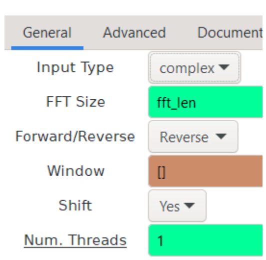
Figure 1: GRC flowgraph for an OFDM transmitter.

- the **OFDM Carrier Allocator** block places the data and pilot values into the correct subcarrier locations in an array of `fft_len` values (with zeros elsewhere). The data values are placed on the subcarriers nearest the carrier but not on the carrier frequency itself (index 0).

  Pilots subcarriers are not needed since we are not implementing a receiver. However, the block does not work properly without them so zero-value pilots are added on either side of the data subcarriers.

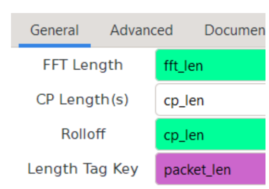


- the **FFT** block performs an inverse FFT on `fft_len` frequency-domain values (the complex subcarrier values) to generate `fft_len` complex time-domain samples

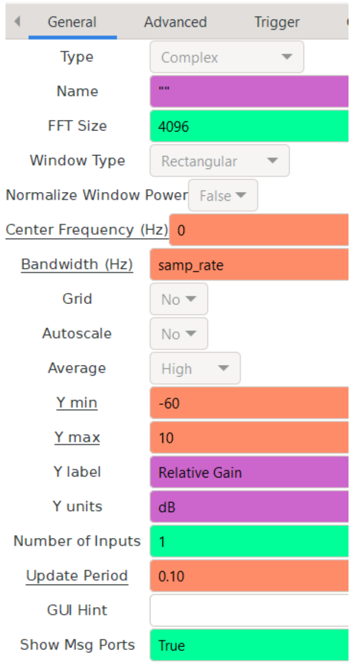


  The Shift parameter sets the middle of the frequency-domain input as the zero frequency. This makes negative indices correspond to frequencies below the carrier.

- the **OFDM Cyclic Prefix** block adds a cyclic prefix of `cp_len` samples to each OFDM symbol



- a **QT GUI Frequency Sink** block that displays the baseband spectrum of the signal. In the control panel you may be able to increase the averaging.



Change Parameters

Create a table with the following columns:

- sample rate,
- sample period,
- samples per OFDM symbol,
- OFDM symbol period,
- subcarrier spacing,
- number of subcarriers, and
- bandwidth.

Calculate the expected values for subcarrier spacing and bandwidth for the default parameters (above) and the following three additional test conditions (make the following changes relative to the first measurement rather than cumulative):

- change **`fft_len`** from 128 to 256
- change **`ncarrier`** from 32 to 64
- change **`samp_rate`** from 1 MHz to 2 MHz

Change each of the parameters and observe the effect on the spectrum. Capture the spectrum in each case. By the end of the lab you should have a screen capture of your flowgraph and four frequency sink files for your report.

Lab Report

Your lab report, in addition to the usual identification information, should contain:

- a screen capture of your Gnu Radio Companion flow graph
- the frequency sink screen captures for the four conditions listed above
- brief explanations of the shape of the initial spectrum and how each change affected the observed spectrum.