Lab 7: Pulse shaping and end to end digital data transmission over ideal channel

Wadhwani Electronics Lab

Department of Electrical Engineering
Indian Institute of Technology, Bombay.

Aim of the experiment

- To introduce the basic concepts of pulse shaping and its importance for transmitting the signal using GNU Radio
- Understanding of different building blocks that are commonly used in pulse shaping and wireless digital communication system at transmitter end.
- To plot eye diagram and determine the sampling region and noise margin using eye diagram
- End to end transmission of data over noiseless channel using IQ modulation-demodulation scheme

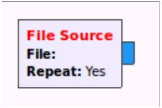
Lab Task 1: Pulse shaping of BPSK symbols generated for transmission

In this part, pulse shaping of the symbols generated is to be done

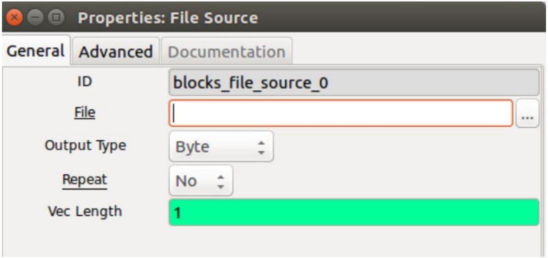
Instructions:

- Generation of symbol:-
  1. Use "File Source" block in repeat mode to read "Original_text.txt" with output in byte format.
  2. Use "Unpack K bits". After this you will have only two unique bytes at output which will represent "1" and "0".
  3. Use "Chunks to Symbol" block to maps "1" & "0" to "1" & "-1" and use "Time Sink" in **stem plot** mode to observe mapping done by "Chunks to Symbol" block.
- Interpolate output of "Chunks to Symbol" block using "Inerpolating FIR Filter block" and pass it to **Root Raised Cosine(RRC) Filter** for pulse shaping with the following specs:-
  - sps = 8 , Gain = 3, Num Taps=11*sps
  - Symbol rate = 10k, Sample rate = sps*Symbol rate
  - Alpha = Keep it variable to observe change in shape of eye w.r.t α
- After adding each block, check its output using Time and Frequency Sinks, before proceeding further (to observe the signals that are present at various points in the system).

File Source - Reads raw data values in binary format from the specified file.



Note : Give the path to the text file.
Output Type - Byte   Repeat - Yes



Unpack K Bits

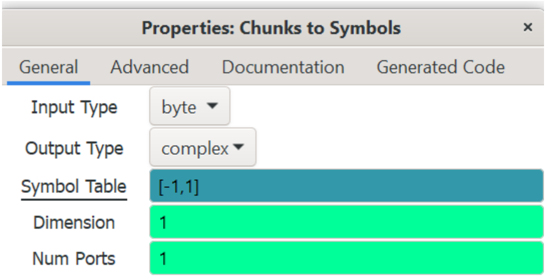
Unpack K Bits : Converts a byte with K relevant bits to K output bytes with 1 bit in LSB from packed byte.

Since a text file consists of ASCII characters (Each character is represented in 8 bits), we use this block to extract the bit stream corresponding to the text file.

If input to Unpack K Bits is 10000001 then output will be 00000001 00000000 00000000 00000000 00000000 00000000 00000000 00000001. So every output of Unpack K Bits will in byte format but will represent a single bit.

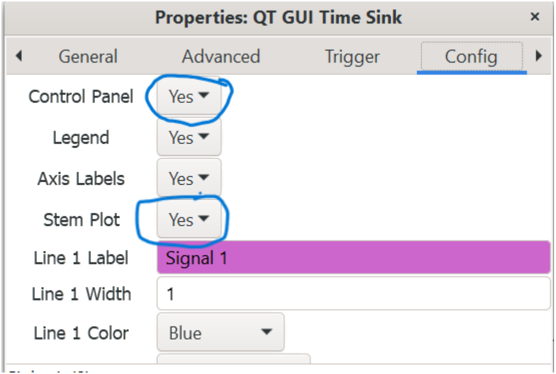
Note : $K = 8$

Chunks to Symbol



This block is used to map the input data to symbols necessary for transmission. For proper operation, input should have only as many unique values as the number of symbols specified in symbol table. Since symbols are 1 & -1 imaginery part of output will not carry any information.

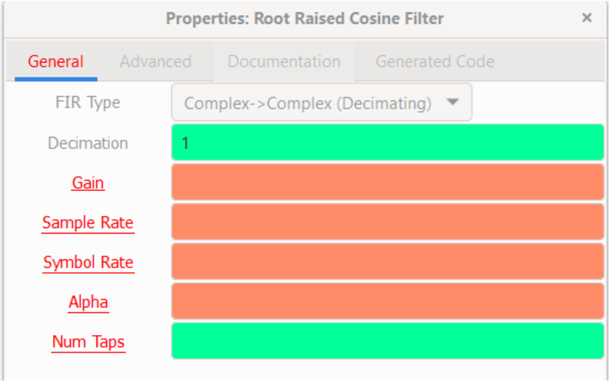
Time Sink



Use time sink with above-shown configuration to observe and compare **Symbol** generated from **Chunks**

Root Raised Cosine Filter

Set **variables** for root raised cosine filter



Note:

- Use Interpolating FIR filter of interpolation=sps for clear visualization of individual pulses before passing through root raised cosine filter
- Tap value for Interpolating FIR filter for zero padding is supposed to be 1

Lab Task 1 cont'd

- Observe the Impulse response of RRC filter
- Observe the output pulse shaped signal in both time and frequency domain, vary **alpha** of RRC filter and demonstrate it to your TA
- Think of other blocks which can replace Root Raised Cosine filter (can be used for pulse shaping)

Lab Task 2 : Interpretation of Eye plot

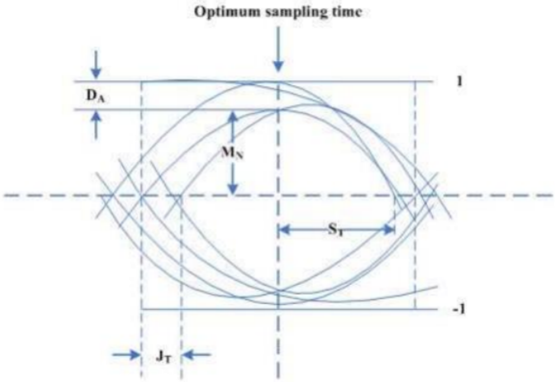


Figure: Eye Diagram

where

D_A is a measure of distortion caused by intersymbol interference (ISI)

J_T is a measure of the timing jitter

M_N is a measure of noise margin

S_T is a measure of sensitivity-to-timing error

Lab Task 2 cont'd

Q.Explain how the following paramters vary with alpha of RRC filter to your TA:-

- Margin of Noise
- Total Jitter range
- Eye width
- Sampling region range

- Upconvert the baseband signal to passband, by multiplying it with a 100 kHz carrier signal.
- Before upconversion use of Rational Resampler to increase sampling rate by factor of 5.
- Observe the obtained signal (which represents a practical modulated signal that one can actually transmit from the antenna).

Q. What should be the sampling rate of carrier signal?

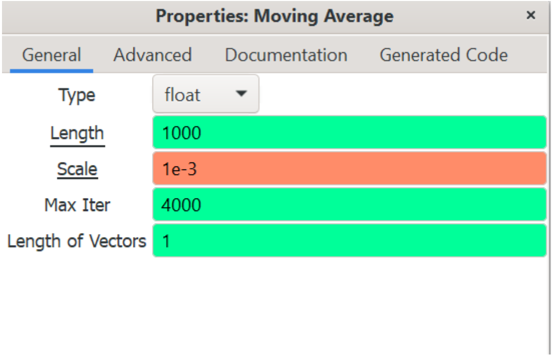
Lab Task 3: Optimal Sampling to recover digital data

- Demodulate the modulated signal and bring it to the appropriate sampling rate
- To determine the optimal sampling instance of pulse shaped data as shown in Eye Diagram:-
  1. Use a "delay" block to control the sampling instance of pulse shaped data
  2. Use a "Decimating FIR Filter" block with decimation = sps to sample the pulse shaped data
  3. Pass the sampled data to "Moving Average" block via a "abs" block to filter out ripples in sampled data and pass it to time sink.
  4. Adjust delay based on output of moving average filter

Q. On what basis should you adjust the delay to sample pulse shaped data at optimal sampling instance?

Q. What is sampling rate of data just after demodulation ?

Moving Average



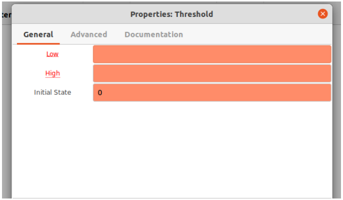
This block will produce average of last 1000 inputs with above shown configuration

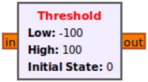
Lab Task 3 cont'd : Receive Data

- Once delay is finalized, pass output of "Decimating FIR Filter" block to a "Threshold" block with appropriate low and high threshold followed by "Float to Uchar" block to get binary data.
- Next you are required to packs bits again to form byte, but before packing use "Skip Head" block to remove some garbage values
- Use "Pack K bits" block to recover the ASCII value which was unpacked at transmission end
- Store the result using the "File Sink" block to a text file. If you are sampling in "sampling region", then you will be able to receive text exactly.

Threshold

Threshold: Output a 1 or zero based on a threshold value.
Test the incoming signal against a threshold. If the signal exceeds the High value, it will change its output to 1, and if the signal falls below the Low value, it will change its output to 0.



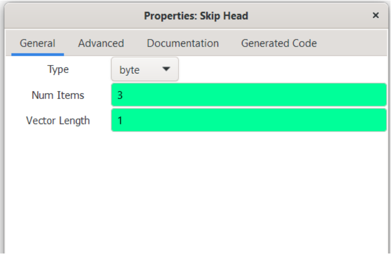


Float To UChar

To Change the format of data stream from float to UChar (Byte Format)

Skip Head

Skips the first N data items received. Useful when there garbage values at the start. Filters and Resamplers in GNU Radio introduce some garbage values which can lead to packing of wrong set of bits to form a byte(ASCII value) while text transmission.



Note : Since the number of junk bits added depends on your flow and the modulation scheme, you need to do iterative trial to get the correct value.

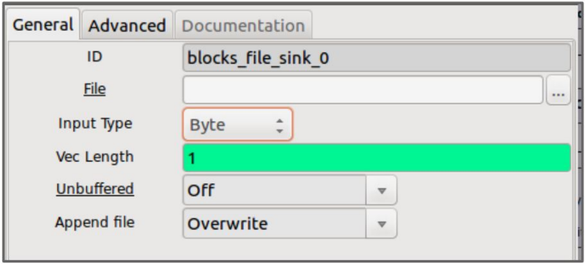
Pack K bits

Pack K Bits : Converts a vector of bytes with 1 bit in the LSB to a byte with K relevant bits.

After processing the data in bit format, to read whether we performed modulation and demodulation correctly we need to pack this bits into a byte. ($K = 8$)

File Sink

File Sink : Outputs raw data values in binary format to the specified file.



Note : Save file with .txt format