CS-330 Assignment 2
Introduction:
Sampling, Nyquist frequency, Aliasing

Hard Deadline: 26 October 2023

Assinged: 19 October 2023

General Information

For each assignment some code examples with complete working flowgraphs or blocks are provided, but in some cases there are missing elements.
For every assignment you should provide screenshots of the execution of the flowgraph in your report! 📷

Exercise 1

The goal of this exercise is to help you become familiar with the Nyquist frequency.
Open the *lab2_1.grc*, using the **GNU Radio Companion** and execute the flowgraph.

1. Are the signals provided going to be properly transmitted without loss of information and why?

2. Perform the proper modifications to produce visually smoother signals, **without** changing the frequency of the signals. Compare the CPU usage between the previous run and the new one and *report* your findings. 📷

3. Which is the minimum possible sampling rate that you can use at the flowgraph and why?

4. Does the parameter *Sample Rate* of the *Throttle* block affect the signal? If no, what it is actually affects?

Exercise 2

The second exercise explores signal properties on the frequency domain. It will help you become familiar with the spectrum analysis graphical tool of GNU Radio and learn some basic properties of the Fourier Transform. Copy the flowgraph of the previous exercise as *lab2_2.grc*.

1. Drop the Time Sink and insert a Frequency Sink. At the **Spectrum Width** option select **Half**.

2. Instead of fixed parameters for the frequency and amplitude of the signals, use QT widgets to dynamically and graphically change their values. Which are the minimum and maximum values allowed?

3. Set the frequency of both signal A and B at 6 kHz.

   (a) What do you observe about the spectrum of signal A+B compared to the spectrum of signal A and B respectively?

   (b) Why the spectrum of signal A and signal B is the same regardless the fact that the first is a cosine and the second a sine?

Exercise 3

This exercise will help you understand the notion of signal phase and what happens when two signals are transmitted concurrently. Open the *lab2_3.grc* file. The flowgraph included is incomplete and you should perform some modifications.

1. Without adding any other block, try to produce a zeroed signal for the A+B signal. **You are not allowed to alter the signal sources parameters or the sampling rate.** 📷

2. Which is the value that you used for the parameter of the delay block? Why and how did you choose this value?

Exercise 4

The goal of this exercise is to present the insights of sampling, aliasing and filtering.

Open the *lab2_4.grc* file. The flowgraph provides a signal source block that operates on a sampling rate of 32 kHz. This signal is plotted using the Frequency Sink block of GNU Radio. In order to emulate properly a down sampled signal, the flowgraph utilizes the *Keep 1 in M* block which drops out 3 of every 4 samples and keeps only the first (down-sampling/decimation by a factor of 4). The resulting signal is also plotted together in the same Frequency Sink block.

1. Use the slider to change the frequency. What do you observe?

2. Which is the frequency range of the down-sampled signal? Why?

3. **Before** the down-sampling (keep 1 in M block), insert a proper filter block in order to cutoff the undesired aliasing effect. GNU Radio provides a variety of filter blocks under the category *Filters*. *Report* the type of the filter you chose, the parameters you applied, and the reasoning. 📷

4. What is f_{alias} frequency and how does it affect our signal in the frequency domain? Is there a way to calculate it?

Exercise 5

Open the lab2_5 flowgraph, without changing the type of the waveform or adding any other blocks, try to convert the sawtooth waveform to a triangle. 📷

1. What is a correct sampling rate for this signal and why? Hint: can we apply the nyquist theorem here?

About Submission

The submission of the Assignments will be done through the **turnin** process. If needed, more info will be sent to the list prior to the deadline. You can turnin this assignment until **Sunday 23/10 23:59**. Use the command below:

turnin assignment2@hy330 <dir>

You should provide a report as a **single pdf file**, containing your comments, screenshots or anything that you believe will be helpful for your grading. Also include any .grc files that you have created or changed.

About Oral Examination

All the students who have submitted their exercises are requested to attend the oral exam session, in order to present their solutions. A short quiz will also take place during that time. You will need to choose a timeslot for the oral exam using Doodle. More details will be sent to you via email.

Attention

- Each student will only be examined during the timeslot choosed.

- During this session both the Assignments 1 and 2 will be examined.

- Both the timely submission and the oral exam session will contribute to the grading of the assignment.