CS-330 Assignment 4
Modulation, GNU Radio Development

Deadline: 15/12/2025 23:59 via elearn

Assigned: 8/12/2025

General Information

The goal of this assignment is to become familiar with two basic modulation schemes, FSK and PSK. You will be also implement your first GNU Radio block.

Exercise 1

In this exercise you will improve the performance of the naive FM modulator.

1. Open the *simplified_fsk.grc* flowgraph located at **Example flowgraphs for GNU Radio** in here. Make all the proper modifications, in order the sampling rate to be 192 KSPS and the bitrate 1200.

2. Try to improve the RF performance of the FSK modulator (reduce spurious emissions) by applying pulse shaping and/or filtering. 📷

3. Compare the resulting bandwidth with the bandwidth of a proper FSK modulator, like GNU Radio provides (*frequency_mod* block). What do you observe? 📷

Exercise 2

In this exercise you will implement your first GNU Radio block, providing the implementation of a modulator that supports various modulation schemes (BPSK, QPSK, 16-QAM).

1. First, create a part of the flowgraph that reads data from a file and splits the byte stream into a stream of K bits per byte. K is the number of bits per constellation point, depending on the modulation scheme of the scenario. You can use the existing GNU Radio blocks for byte splitting.

2. Using the *gr_modtool* create a block with the name **constellation_mapping_yourAM**. This block has a byte input stream and a complex output stream. For every byte of K bits it produces a complex number that corresponds to a constellation point of the appropriate modulation scheme. The block takes as argument the number of K bits that each constellation point carries. This number can be used to identify the modulation scheme that should be used, depending on the table below.

K	Modulation
1	BPSK
2	QPSK
4	16-QAM

   The constellation points for every modulation scheme are depicted in Figures 1, 2 and 3.

   Using the QT Constellation sink, provide a screen-shot of the constellation for each modulation scheme. 📷

3. You may observe that the maximum IQ amplitude of each modulation scheme is different. This means that the mean energy of each modulation scheme is different. In general this is not desirable. For this reason, perform normalization at the constellation points of each modulation scheme. The normalization factors can be retrieved from the table below.

Modulation	**Normalization factor**
BPSK	1
QPSK	$1/\sqrt{2}$
16-QAM	$1/\sqrt{10}$

Again, provide a screen-shot that shows the constellation of each modulation scheme.

Discuss possible reasons for a system to have the same mean energy for all modulation schemes.

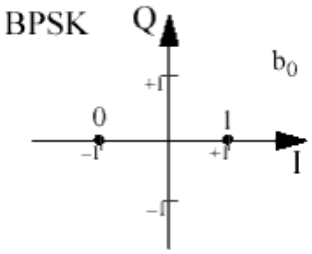

Figure 1: BPSK constellation points

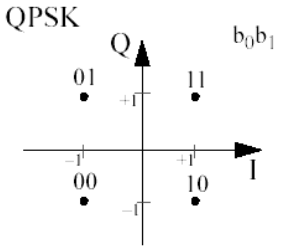

Figure 2: QPSK constellation points

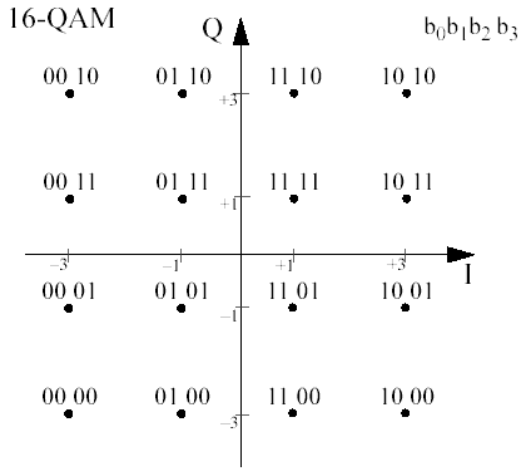

Figure 3: 16-QAM constellation points

About Submission

The submission of the Assignments will be done through the **elearn** platform. If needed, more info will be sent to the list prior to the deadline. You can turnin this assignment until **Monday 15/12 23:59**.

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. For the out of tree module you should submit the whole directory **gr-constellation_mapping_yourAM** without the build folder.

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 the Assignment 3, 4 and the project will be examined.
- Both the timely submission and the oral exam session will contribute to the grading of the assignment.