OREGON STATE UNIVERSITY
SCHOOL OF ELECTRICAL ENGINEERING & COMPUTER SCIENCE

ECE 464/564 **DIGITAL SIGNAL PROCESSING** October 26, 2022

COMPUTER PROJECT #2

Due: 11:59 p.m., November 9, 2022

Goal

This is the second in a series of three computing assignments that, together, will take you through the process of developing a simulation system for studying quadrature phase shift keying (QPSK) transmission and digital receivers for QPSK signals. In this part, you will work with and demonstrate your knowledge of

1. Band pass filtering.
2. Subsampling (decimation) to effectively reduce the carrier frequency.
3. Demodulation of the signal at the intermediate frequency (IF) stage.
4. Extraction of the baseband component by a lowpass filter.

Project Description

Receiver Design

We will implement a highly simplified receiver in this project. The block diagram for the receiver is shown in Figure 1. In this assignment, you will work on blocks up to the point marked **B** in Figure 1. The rest of the receiver design and overall performance evaluation of the communication system will comprise the third computing assignment.

Bandpass Filtering

The objective of this filter is to eliminate the noise from outside the signal band, and to prepare the signal for the A/D conversion. (In our implementation, we already have a discrete-time signal at the input, and the A/D is simulated through a simple sub-sampling process.) Design a linear phase, FIR bandpass filter whose passband is the bandwidth of the signal of interest. (You must decide on the specifications. Explain your thinking process in the report. You should write your own program to perform the filter design using the window method. Specifically, do not use the routines available in MATLAB for the filter design. Explain your choices during the design process in your report.)

Simulation of A/D Conversion Through Sub-Sampling

Choose a sub-sampling rate such that the resulting sampling rate is eight times the symbol rate. What is the center (effective carrier) frequency of the sub-sampled signal? You can think of this

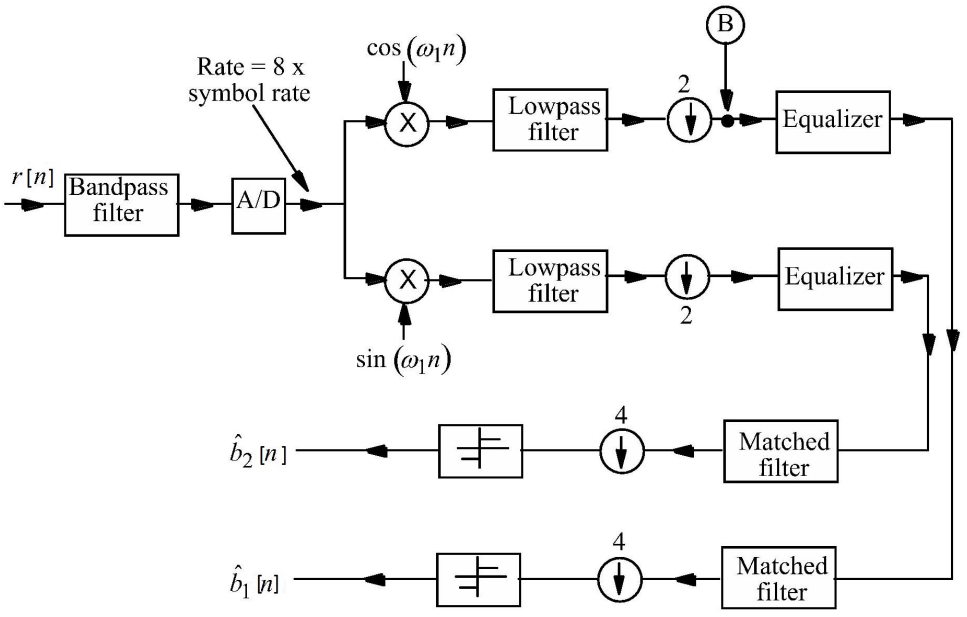

Figure 1: Block diagram of the receiver.

part as the intermediate frequency (IF) stage of the receiver. Is there any aliasing problems that cannot be resolved?

Demodulation

The demodulation frequency ω_1 should be the center frequency of the sub-sampled signal. Using cosine and sine function will allow us to separate the components resulting from the two "bits" $b_1[n]$ and $b_2[n]$. Multiplication with sinusoids will result in a high frequency component that must be eliminated through the use of an appropriately designed lowpass filter. Use a linear phase FIR filter and design the filter on your own. Be sure to explain your design considerations and the filter specifications you chose. After the lowpass filtering operation, sub-sample the output by a factor of 2 so that the data rates at the point marked **A** in Figure 2 of the first computing assignment and the point marked **B** in Figure 1 above are identical.

Comment in your report on the initial phase of the demodulating sinusoids. In practice, will zero phase as shown in the figure work? How will you find the right phase for the demodulating sine wave? Even though it is not true in practice, in this assignment, you can assume that you know the initial phase and time of the transmitted signal.

Project Report

Your report must be formally written and must not exceed 8 pages including figures, appendices, and the cover page for each module. (Do use a readable font size!) You should also upload any code you wrote to Canvas so that the TA can validate the code while grading your report. Make sure that instructions to run the code is included at the beginning of your code. The report should

contain at least the following components:

1. An introduction describing the problem (be sure to set the context up from the perspective of the overall goals of the three-part series of computer projects), your goals, and a summary of the results.

2. A section on methods that describes the details of your designs and calculations.

3. A section on performance evaluation describing your experimental techniques, the results of the experiments and a critical discussion of the results.

4. A concluding section that summarizes your work and makes your observations. Make sure that you include your thoughts about why the system performed in the way it did. Include a paragraph that describes all the concepts you learned and used to do this project, as well as things you could have done to make your work better.