DEPARTMENT OF COMPUTER ENGINEERING
CPEN 304 – Digital Signal Processing
Course Project

Issue date: 13th June*, 2024* Submission: **20th August**, 2024

Objective of this course project exercise

The objective of this laboratory exercise is to design and build a suitable digital filter (either FIR or IIR) to meet a given a set of specifications. As part of the work, you will learn how to derive the filter specifications from a given signal, design the filter using the derived specifications, and implement the filter on a chip (Arduino or PIC microcontroller or DSP chip) and test the performance of the filter in the Proteus environment.

1. Filter specification and design for course project

In the course project for the CPEN 301 course, you acquired a real-world or analog signal from a sensor and designed a pre-processing or front-end filter system to filter out noise. The output signal was to meet a maximum magnitude not exceeding 5V to serve as input to an Arduino or PIC microcontroller chip. In this course project, your task will be to design a digital filter (either FIR or IIR) using the signal information and implement the filter on Arduino chip or PIC microcontroller or DSP chip for digital processing of the signal. The following are the deliverables for the project:

(a) Pre-processing filter design:

Define the specification required for the design of the pre-processing filter system for your analog signal. Here, you are required to define the passband and stopband edge frequencies, peak passband gain and stopband attenuation information, type of filter response required for design (this is dependent on your signal properties), the sampling frequency for the design, and the filter design method for approximation of the ideal filter response. What is the frequency bandwidth of your signal (perform Fourier transform on the signal to determine the frequency range)? Ensure that your analog filter specifications will not produce pre-processing filter circuit with order not exceeding 3.

(b) Digital filter design:

Define the specification required to design the digital filter for implementation. Here, you are required to provide the specification for the frequency and passband peak gain and stopband attenuation information, sampling rate, type of filter response, type of digital filter (FIR or IIR), and the filter design method. Use the FDA tool to design the filter and provide the following information in your report:

(i) Filter design parameters;
(ii) Filter magnitude response of the filter;
(iii) Impulse response of the designed filter;
(iv) Frequency response of the filter;
(v) Information about the designed filter (check from the information icon on the filter design menu bar);

(c) Signal source and noise:

Practical analog signals that are acquired from sensors and transducers come along with background noise signal (white or gaussian or random noise) which are

introduced from different sources (external or internal from the electronics). Since the signal data that will be used for the work will be synthetic data (i.e., generated data) or acquired digital data (from the internet) which will not contain noise, you have to model a random noise with defined frequency and add the noise to your raw data. Here, you are required to determine the frequency bandwidth necessary for the noise signal. A good choice for the noise frequency range will be 10% or 20% more the maximum signal frequency content.

(d) Simulink model development of system:

Create a Simulink model of the entire system, including the input signal source, the noise signal, model of the sampling system, model of the pre-processing system, model of the digital filter system, model of the reconstruction filter system, and the output display system.

(e) Proteus implementation of digital filter:

Now, export your designed digital filter coefficients from the Matlab and implement the filter on an Arduino chip or PIC microcontroller using the Proteus environment. Test the functionality of your designed filter in the emulation platform. Submit your codes together with the Proteus model in your report.

(f) Report and presentation:

Prepare a power point presentation of the project work along with a technical report and submit the two documents for grading. Note that documents received after the stipulated submission deadline will not be considered for grading.