

ECE521 Experiment # 3: On Digital Filters Design
(Issued Tuesday 6/26, Due Tuesday 7/10)

The purpose of this experiment is the following:

1. Studying the frequency response of common window functions, and
2. Designing a general purpose FIR digital filter based on the windowing method.

1 Spectral Analysis of Windows

The purpose of this part is to study the frequency spectrum of window functions. These windows are to reduce the leakage effect, and as a result improve the accuracy of the frequency spectrum. Common window functions are in the textbook, Chap. 7. We are interested in four windows: the rectangular window, the Bartlett (triangular) window, the Hamming window, and the Kaiser window. The algorithm to evaluate the function $I_0(\cdot)$ can be found in Chap. 7. Using a window length $L = 256$, obtain the sequence $w[n]$ of the four windows and evaluate the function $W(f_d)$. Plot one period for $-0.5 \leq f_d \leq 0.5$ for all windows on the same scale with the amplitude in dB. Compare the width of the main lobe for all windows and the stop band (side lobes) attenuation.

2 FIR Digital Filter Design

In this part we will design a general purpose FIR digital filter using the windowing method. We will consider only the four windows of Part 1 (Rectangular, Bartlett, Hamming, and Kaiser) with the number of samples N even or odd. The program should be interactive with prompts for the following:

A. Filter type

- (A.1) filter type: lowpass, highpass, bandpass, and bandstop;
- (A.2) window type: rectangular, Bartlett, Hamming, and Kaiser; and
- (A.3) window length N (N is odd for highpass and bandpass filters).

B. Filter specifications

- (B.1) Cutoff frequency c (we consider only one period of f_d and the positive frequency range, i.e., $c \in [0, 0.5]$) for the two bands c_l and c_h ; and
- (B.2) Attenuation in the stopband. See Chap. 7 of the textbook for how to relate the window length with stopband attenuation to get the parameter β for the Kaiser window.

C. Output format

- (C.1) An option to print the impulse response $w[n]$ if desired;
- (C.2) An option to print the frequency response $W(f_d)$ in dB if desired;
- (C.3) An option to print the frequency response $W(f_d)$ in complex form if desired;
- (C.4) An option to print the sampled frequency response $w[k]$, $k/N = f_d$ in complex form if desired; and
- (C.5) An option to loop again to the design process and/or to exit the program.

Test your program using the test problems and tables in the text and the notes and print out a sample result.

Note: Write a neat report. All figures should have meaningful captions, properly labeled, and referred to in the text. Refrain from using any handwritten symbols, equations, etc. in your report, use a word-processor