CSE4210 – Architecture and Hardware for DSP

Project Task 2

FIR Filter Design

Introduction

In this task, you will design an FIR filter based on given specifications.

Tasks

1. Design a half-band FIR filter using Matlab

Half-band filter is widely used in multi-rate signal processing applications for up-sampling or down-sampling by a factor of two. Half-band filters have three important characteristics, (1) it is an odd length filter, (2) the passband and stoppand ripples must be the same, and (3) the passband edge f_p and stopband edge f_s are equidistant from the halfband frequency, i.e. 0.25.

You are required to design a half-band filter that satisfies the following specifications:

Passband edge: f_p/f_{sample}=0.1875
Stopband edge: f_s/f_{sample}=0.3125
Passpand ripple: 0.01
Stopband attenuation: 40dB

Design the filter using Matlab and record your filter length and coefficients.

2. Filter coefficient quantization

In order to get rid of multipliers in filter implementation, you are required to quantize the filter coefficients into 8-bit binary (fractional bits) in the form of sum(or difference) of two terms of power-of-two (PoT), i.e. coefficient= $2^n \pm 2^m$, where *n* and *m* are positive or negative integers. For example: 0.625 and 0.375 can be expressed as:
$0.625=0.5+0.125=2^{-1}+2^{-3}$
$0.375=0.5-0.125=2^{-1}-2^{-3}$

The filter with quantized coefficients should have at 35dB stopband attenuation. To quantize the coefficients, follow the steps below.

Step 1: round all coefficients to the nearest two terms of PoT values.
Step 2: examine the frequency response of the filter.
Step 3: If the frequency response meets the design specifications, record the coefficients. Stop. Otherwise, goto Step 4.
Step 4: adjust the coefficient values and plot the frequency response. Goto Step 3. If your filter still does not meet the specifications after few iterations in Steps 3 and 4, goto Step 5.
Step5: increase the filter length and redesign the filter. Goto Step 1. (Note the maximum filter length should be less than or equal to 21).

With PoT coefficients, all multiplications can be implemented by shifter and adder. For example, D=0.625*A can be implemented as:

i. B=Shift A to right by 1
ii. C=Shift A to right by 3
iii. D=B+C

Note no shifter is required in the implementation. You can hardwire B and C (in above example) to the adder's inputs.

Report

Your report should include the following sections.

1. Introduction: A brief introduction of the theory about the project. A brief description of software tools used.
2. Task Management: A brief description on how your team is organized in performing this task, the role of each team member, the contributions of each team member.
3. Design Procedures: Detailed descriptions of the design procedures including filter design, coefficient quantization.
4. Discussion
5. Conclusion

Resource

1. FIR filter design using Matlab:
http://www.mathworks.com/help/dsp/examples/designing-low-pass-fir-filters.html