Shiv Nadar University

Department of Electrical Engineering-(SoE)

EED305: Digital Signal Processing **Lab-09** **Instructor:** Prof. Vijay Kumar Chakka

Topics: Design of window based linear phase FIR filter

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1. The $61-$ length rectangular windowed ideal low pass filter with a cut off frequency $w_c = \frac{\pi}{4}$, whose impulse response is given below

$$h_1[n] = \begin{cases} \frac{w_c}{\pi} & for\ n = 0 \\ \frac{w_c}{\pi}\left(\frac{\sin(w_c n)}{w_c n}\right) & for\ |n| \leq 30 \\ 0 & otherwise. \end{cases}$$

   a. Plot the impulse response $h_1[n]$
   b. Calculate and plot the 512 point frequency response of the above system (Type-1 (Even order Even symmetry) linear phase FIR filter having generalized frequency response is given below)

$$H\left(e^{jw}\right) = e^{-\frac{jNW}{2}} \sum_{n=0}^{\frac{N}{2}-1} 2h\left(\frac{N}{2} - n\right)\cos(nw)\,.$$

   c. Plot the frequency response by using the MATLAB built in function (**Hint:** $freqz(h_1[n])$). Write your observation.

2. Plot the following windows with N=61

   i. Rectangular window

$$w_1[n] = \begin{cases} 1 & for\ 0 \leq n \leq N-1 \\ 0 & otherwise \end{cases}$$

   ii. Generalized Hamming window

$$w_2[n] = \alpha - (1-\alpha)\cos\left(\frac{2\pi n}{N-1}\right),$$
$$where\ 0 \leq n \leq N-1, and\ \ \alpha \geq 0.5$$

   iii. Hamming window is Generalized Hamming window with $\alpha = 0.54$
   iv. Hanning window is Generalized Hamming window with $\alpha = 0.5$
   v. Bartlet window is defined below

$$w_3[n] = \begin{cases} \dfrac{2n}{N-1} & for, \quad 0 \le n \le \dfrac{N-1}{2} \\ 2 - \dfrac{2n}{N-1} & for, \dfrac{N-1}{2} \le n \le N-1 \end{cases}$$

vi. Blackman window

$$w_4[n] = 0.42 - 0.5\cos\left(\frac{2\pi n}{N-1}\right) + 0.08\cos\left(\frac{4\pi n}{N-1}\right),$$
$$where\ 0 \le n \le N-1$$

a. Plot the frequency response of above window functions.