Shiv Nadar University

Department of Electrical Engineering-(SoE)

EED305: Digital Signal Processing **Lab-10** **Instructor:** Prof. Vijay Kumar Chakka

Topics: Simple IIR filter design

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1. Design a first order LPF with a 3-dB cutoff frequency of $w_c = \frac{\pi}{4}$
   a. Plot it's magnitude and phase response
   b. Plot the magnitude and phase response of first order low pass filter for $\alpha = 0.5, 0.7, 0.8$ and calculate respective 3-dB cut-off frequency

First-order Low pass IIR digital filter:

Transfer function, $H_{LP}(z) = \frac{1-\alpha}{2}\left[\frac{1+z^{-1}}{1-\alpha z^{-1}}\right], |\alpha| < 1$

Where, $\alpha = \frac{1-\sin(w_c)}{\cos(w_c)}, \cos(w_c) = \frac{2\alpha}{1+\alpha^2}$ and w_c is the cutoff frequency

2. Repeat the question (1) for designing a HPF with 3-dB cutoff frequency of $w_c = \frac{\pi}{4}$

First-order High pass IIR digital filter:

Transfer function, $H_{HP}(z) = \frac{1+\alpha}{2}\left[\frac{1-z^{-1}}{1-\alpha z^{-1}}\right], |\alpha| < 1$

Where, $\alpha = \frac{1-\sin(w_c)}{\cos(w_c)}, \cos(w_c) = \frac{2\alpha}{1+\alpha^2}$ and w_c is the cutoff frequencies

3. Design a second-order Band pass filter with center frequency at 0.4π and a 3-dB bandwidth of 0.1π.
   a. Plot its magnitude and phase response
   b. For $\alpha = 0.2, 0.5, 0.8$ by keeping$\beta = 0.5$. Calculate their respective 3-dB bandwidths

c. Measure the Quality factor [Q = Center frequency/ 3-dB bandwidth]

d. Plot the magnitude and phase response of second order band pass filter Choose $\beta = 0.1,0.5,0.8$ and $\alpha = 0.6$ Calculate their respective center frequencies and Q factors

Second-order Band pass IIR digital filter:

$$\text{Transfer function, } H_{BP}(z) = \frac{1-\alpha}{2}\left[\frac{1-z^{-2}}{1-\beta(\alpha+1)z^{-1}+\alpha z^{-2}}\right], |\alpha| < 1$$

$$\text{With center frequency } w_o = \cos^{-1}(\beta) \text{ and}$$

$$\text{3-dB bandwidth } \Delta w_{3dB} = w_{c_2} - w_{c_1} = \cos^{-1}\left(\frac{2\alpha}{1+\alpha^2}\right)$$

4. Repeat the question (3) for designing a BSF with center frequency at 0.4π and a 3-dB bandwidth of 0.1π.

Second-order Band stop IIR digital filter:

$$\text{Transfer function, } H_{BS}(z) = \frac{1+\alpha}{2}\left[\frac{1-2\beta z^{-1}+z^{-2}}{1-\beta(\alpha+1)z^{-1}+\alpha z^{-2}}\right], |\alpha| < 1$$

$$\text{With center frequency } w_o = \cos^{-1}(\beta) \text{ and}$$

$$\text{3-dB bandwidth } \Delta w_{3dB} = w_{c_2} - w_{c_1} = \cos^{-1}\left(\frac{2\alpha}{1+\alpha^2}\right)$$