Madan Mohan Malaviya University of Technology, Gorakhpur

Electronics and Communication Engineering Department

DIGITAL SIGNAL PROCESSING (BEC-303)

TUTORIAL - UNIT-III

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1. What is an FIR system? Compare an FIR system with an IIR system.
2. Define phase delay and group delay.
3. What is a linear phase filter? What conditions are to be satisfied by the impulse response of an FIR system in order to have a linear phase?
4. The transfer function of an linear phase FIR filter ($M = 7$) is $H(Z) = \sum_{n=0}^{M-1} h(n)z^{-n}$. Determine the magnitude response and show that the phase and group delays are constant
5. Obtain a general expression for the frequency response of linear phase FIR filters.
6. Explain the Fourier series method of designing an FIR filter.
7. Design a Finite Impulse Response low-pass filter with a cut-off frequency of $1kHz$ and sampling rate of $4kHz$ with eleven samples using Fourier series.
8. Design an ideal highpass filter with a frequency response

$$H_d(e^{j\omega}) = \begin{cases} 1, & \frac{\pi}{4} \leq |\omega| \leq \pi \\ 0, & |\omega| \leq \frac{\pi}{4} \end{cases}$$

   Determine $h(n)$ and $H(z)$ for $M = 11$ and plot the magnitude response.

9. Design an ideal bandpass filter with a frequency response

$$H_d(e^{j\omega}) = \begin{cases} 1, & \frac{\pi}{4} \leq |\omega| \leq \frac{3\pi}{4} \\ 0, & \text{otherwise} \end{cases}$$

   Determine $h(n)$ and $H(z)$ for $M = 11$ and plot the magnitude response.

10. What are the desirable features of the window functions? Further discuss the effect of windowing.
11. What are the different window functions used in designing FIR filters. Obtain their frequency-domain characteristics.
12. Compare the frequency-domain characteristics of the different types of window functions.
13. Design an ideal highpass filter with a frequency response

$$H_d(e^{j\omega}) = \begin{cases} 1, & \frac{\pi}{4} \leq |\omega| \leq \pi \\ 0, & |\omega| \leq \frac{\pi}{4} \end{cases}$$

   Find $h(n)$ and $H(z)$ for $M = 11$ using (a) Hamming Window (b) Hanning Window and plot the magnitude response.

14. Design a high pass filter using Hamming window with a cut-off frequency of $1.2rad$ and $M = 9$.
15. The desired response of a low-pass filter is

$$H_d(e^{j\omega}) = \begin{cases} e^{-j3\omega}, & -\frac{3\pi}{4} \leq \omega \leq \frac{3\pi}{4} \\ 0, & \frac{3\pi}{4} \leq |\omega| \leq \pi \end{cases}$$

   Determine $H(e^{jw})$ for $M = 7$ using a Hamming window.

16. Design an FIR digital filter to approximate an ideal low-pass filter with passband gain of unity, cut-off frequency of $850Hz$ and working at a sampling frequency of $f_s = 5000Hz$. The length of the impulse response should be 5. Use a rectangular window.
17. What is a Kaiser window? Why is it superior to other window functions? Explain the procedure for designing an FIR filter using the Kaiser window.

18. Design an FIR linear phase filter using Kaiser Window to meet the following specifications:

$$0.99 \leq |H_(e^{j\omega})| \leq 1.01, \text{ for } 0 \leq |\omega| \leq 0.19\pi$$
$$|H_(e^{j\omega})| \leq 0.01, \text{ for } 0.21\pi \leq |\omega| \leq \pi$$

19. Explain the Type-I Frequency sampling method of designing an FIR filter.

20. Determine the filter coefficients $h(n)$ obtained by Frequency sampling technique

$$H_d(e^{j\omega}) = \begin{cases} e^{-j(M-1)\omega/2}; & 0 \leq |\omega| \leq \frac{\pi}{2} \\ 0; & \frac{\pi}{2} \leq |\omega| \leq \pi \end{cases}$$

for $M = 7$