Madan Mohan Malaviya University Of Technology, Gorakhpur

Electronics and Communication Engineering Department

DIGITAL SIGNAL PROCESSING (BEC-303)

TUTORIAL - UNIT-II

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1. What is an IIR filter?
2. For a bilinear transformation method, discuss the warping effect. Explain the design steps of IIR filter by the bilinear transformation method.
3. Explain the design steps of IIR filter by the implules invariance method?
4. Explain design of IIR filters using approximation of derivatives.
5. Obtain the mapping formula for the approximation of derivatives method using backward difference. Also discuss the limitation of approximation of derivatives method.
6. Obtain the mapping formula for the impulse invariant transformation. Also discuss the disadvantages of impulse invariant transformation.
7. Obtain the transformation formula for the bilinear transformation.
8. What are the different types of frequency transformations for designing IIR filters.
9. Use the backward difference for the derivative to convert the following analog filter with system function

   (a) $H(s) = \frac{1}{s+2}$ (b) $H(s) = \frac{1}{s^2+16}$ (c) $H(s) = \frac{1}{(s+0.1)^2+9}$

10. Convert the analog filter into a digital filter whose system function is

$$H(S) = \frac{s+0.2}{(s+0.2)^2+9}$$

   Use the impulse invariant technique. Assume $T = 1s$.

11. For the analog transfer function

$$H(S) = \frac{1}{(s+1)(s+2)}$$

   determine $H(z)$ using impulse invariant technique. Assume $T = 1s$.

12. Determine $H(z)$ using the impulse invariant technique for the analog system function

$$H(S) = \frac{1}{(s+5)(s^2+0.5s+2)}$$

13. The transfer function of an analog LPF is

$$H(S) = \frac{1}{s+1}$$

   with a bandwidth of $1rad/s$. Use bilinear transform to design a digital filter with a bandwidth of $20Hz$ at a sampling frequency of $60Hz$.

14. Convert the analog filter with system function

$$H(S) = \frac{s+0.1}{(s+0.1)^2+9}$$

   into a digital IIR filter using bilinear transformation. The digital filter should have a resonant frequency of $\omega_r = \frac{\pi}{4}$.

15. Apply bilinear transformation to

$$H(S) = \frac{2}{(s+1)(s+3)}$$

with $T = 0.1s$

16. A digital filter with a $3dB$ bandwidth of 0.25π is to be designed from the analog filter whose system response is

$$H(S) = \frac{\Omega_c}{s + \Omega_c}$$

Use bilinear transformation and obtain $H(z)$.

17. Obtain the system functions of normalised Butterworth filters for order $N = 1, 2, 3, 4$.

18. Use bilinear transform to design a first-order Butterworth LPF with 3 dB cut-off frequency of 0.2π.

19. Design a highpass filter for the given specifications, $\alpha_p = 3dB$ dB, $\alpha_s = 15dB$, $\Omega_p = 100\ rad/sec$ and $\Omega_s = 500\ rad/sec$.

20. Determine H(z) for a Butterworth filter satisfying the following constraints

$$\begin{aligned} \sqrt{05} \leq |H(e^{j\omega})| \leq 1 \qquad & 0 \leq \omega \leq \pi/2 \\ |H(e^{j\omega})| \leq 0.2 \qquad & 3\pi/4 \leq \omega \leq \pi \end{aligned}$$

with $T = 1s$. Apply impulse invariant transformation.

21. Design a digital Butterworth filter that satisfies the following constraint using bilinear transformation. Assume $T = 1s$.

$$\begin{aligned} 0.9 \leq |H(e^{j\omega})| \leq 1 \qquad & 0 \leq \omega \leq \pi/2 \\ |H(e^{j\omega})| \leq 0.2 \qquad & 3\pi/4 \leq \omega \leq \pi \end{aligned}$$

22. Discuss the method of determination of Chebyshev Polynomials and their properties.

23. Design a Chebyshev filter with a maximum passband attenuation of 2.5 dB at $\Omega_p = 20\ rad/sec$ and the stopband attenuation of 30 sdB at $\Omega_s = 80\ rad/sec$.