1. a) Discuss about the mapping of analog poles into the digital domain using Impulse Invariant Transformation. 12
b) For the analog transfer function

\[ H(s) = \frac{2}{(s+1)(s+2)} \]

derive \( H(z) \) using Impulse Invariant Transformation. 8

2. a) Derive the relevant formula associated with the Bilinear Transformation from the s-plane to the z-plane. 10
b) Justify the requirement for prewarping in Bilinear Transformation. 5
c) Determine \( H(z) \) using Bilinear Transformation if

\[ H(s) = \frac{1}{(s+1)^2} \text{ and } T = 0.1 \text{ Sec.} \] 5

3. a) Explain the magnitude response of analog low-pass Butterworth filter. 10
[ Turn over
b) Plot the normalized poles of Third order Butterworth filter and make suitable comments.

4. a) Show that in a Butterworth low-pass filter, \[ N \geq \frac{\log A}{\log k} \]
where the symbols have their usual significance.

b) Design an analog Butterworth filter having \(-2\)dB pass band attenuation at a frequency of 20 rad/sec and at least \(-10\)dB stopband attenuation at 30 rad/sec.

5. a) Differentiate between Type-I and Type-II chebyshev low-pass filters.

b) Explain how chebyshev polynomials can be generated by recursive equation.

c) Determine the analog transfer function of chebyshev low-pass filter using Bilinear Transformation having the following specifications:

\[ \alpha_p = 1 \text{dB} \text{ ripple in } 0 \leq w \leq 0.2\pi \]

\[ \alpha_s = 15 \text{dB} \text{ in } 0.3\pi \leq w \leq \pi \]

6. a) Derive the general equation for determining the zeros of linear phase FIR filter.

b) Based on the equation in Part ‘a’, determine the end-point zeros for all the possible cases with respect to impulse response and filter order.

c) Based on the determination in Part ‘b’ justify the potential application of the filter.

7. a) For an FIR filter of length \(M = 5\) having symmetric impulse response, derive the expression for the frequency response.

b) Repeat Part ‘a’ for \(M = 9\).

c) Based on the derivations in Part ‘a’ and Part ‘b’, derive the general expression for the magnitude and phase characteristics of the frequency response of the FIR filter.

d) Comment on the phase characteristics.

8. The desired frequency response of an ideal high-pass filter is

\[ H_d(jw) = \begin{cases} 
1 & \pi \geq |w| \geq \pi/3 \\
0 & \text{otherwise} 
\end{cases} \]

a) Determine the desired impulse response.

b) Determine the truncated impulse response with \(N = 9\).

c) Sketch the magnitude response of the designed filter.