1. (a) Find the cutoff frequency of an analog filter if the digital filter to be designed, make use of bilinear transformation and has a cutoff frequency of 450 Hz and sampling frequency of 1200 Hz. **20**

(b) Find the pole location of a normalized third order butterworth filter and show their pole location.

(c) Show that in the linear phase FIR filter with Antisymmetric Coefficients Impulse response and even length will have compulsory zero location at $Z = 1$ and $Z = -1$.

(d) Explain the method of Matched Z – Transform technique in IIR digital filter design.

(e) Describe and explain characteristics of Blackman and Bartlett window function used in FIR filter design.

2. (a) Design a butterworth first order digital filter having cutoff frequency of 200 Hz with sampling frequency of 1200 Hz using – **14**

(i) Impulse Invariance Technique

(ii) Bilinear Transformation Technique.

(b) Find Transfer Function H(z) of a filter using Impulse invariant technique from an analog domain filter – **6**

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

when sampling frequency is 500 Hz.

3. (a) Design an analog butterworth filter transfer function that satisfy following constraints :– **14**

$$0.75 \leq \left| H(e^{j\Omega}) \right| \leq 1 \text{ for } 0 \leq \Omega \leq 0.2\pi$$

$$\left| H(1^{j\Omega}) \right| \leq 0.25 \text{ for } 0.4\pi \leq \Omega \leq \pi$$

(b) Derive an expression to obtain the relation between digital frequency and analog frequency while designing a digital filter. **6**

4. (a) Design a fourth order FIR high pass filter using window function – **14**

$$W(n) = 0{\cdot}5\left[1 - \text{Cos}\left(\frac{2\pi n}{M-1}\right)\right] \text{ for } 0 \le n \le M-1$$

$$= 0 \quad \text{otherwise}$$

with cutoff frequency 0·20 KHz and sampling frequency 1 KHz. Also plot the magnitude response of this filter and verify that designed filter is a highpass filter.

(b) Why a 'window function' is needed while designing a FIR filter ? What is the criterion for selection of a proper window ? **6**

5. (a) Determine the coefficients of a linear phase FIR filter which has symmetric unit sample response and DFT samples are given by – **12**

$$H\left(\frac{2\pi K}{10}\right) = \{1, 1, 0, 0, 0, 0, 0, 0, 1, 1\}$$

(b) Explain design steps for FIR filter design using Kaiser window. **8**

6. (a) For a fifth order linear phase FIR filter with antisymmetric coefficients if one of the zeros is at $0{\cdot}25\, e^{\left(j\frac{\pi}{3}\right)}$ find the location of other zeros. Draw pole – zero diagram and find the impulse response h(n) of a filter. **8**

(b) Find the stopband attenuation in dB for a fourth order butterworth filter at frequency 7·5 KHz. The passband edge of the filter is located at 3 KHz with attenuation not less than 1 dB in the passband. **6**

(c) Compare butterworth, chebyshev and elliptic filter. **6**

7. (a) Explain cascade and parallel realization in Digital IIR function with examples. **20**

(b) Discuss design procedure for elliptic filter design.

(c) Discuss the merits of optimal linear phase FIR filter over other FIR filter design methods.

(d) Explain zero-input and overflow limit cycle oscillations due to quantization in digital filters.

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