Q3 Using the bilinear transformation, design a highpass filter, monotonic in passband with cutoff frequency of 1000 Hz & down 10 dB at 350 Hz. The sampling freq is 5000 Hz. Implement using basic building blocks. Show derivation for filter. Demonstrate filter's o/p for 5 diff. freq. ranging from 100 Hz to 10000 Hz. Choose these freq smartly to demonstrate the filter working

⇒ Given:

Passband atten. = α_p = 3 dB

Stopband atten. = α_s = 10 dB

Sampling freq = f_{sam} = 5000 Hz

$\therefore T_s = 1/5000 = 2 \times 10^{-4}$ s

f_p = 1000 Hz

f_s = 350 Hz

$$\therefore \Omega_p = \frac{2}{T} \tan \frac{\omega_p T_s}{2}$$

$$= \frac{2}{2 \times 10^{-4}} \tan \left[\frac{2\pi f_p T_s}{2} \right]$$

$$= 10^4 \tan \left[\frac{\pi \times 1000}{5000} \right]$$

$$= 10^4 \tan [0.2\pi] = 7265.4 \text{ rad/s}.$$

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$$\Omega_s = \frac{2}{T} \tan\left[\frac{\omega_s T_{sam}}{2}\right]$$

$$= 10^4 \tan[0.07\pi] = 2235.3 \text{ rad/s}$$

The order of Filter,

$$\epsilon = \sqrt{10^{0.1\alpha_p} - 1} = 1$$

$$\lambda = \sqrt{10^{0.1\alpha_s} - 1} = 3$$

$$\therefore N = \frac{\log(\lambda/\epsilon)}{\log(\Omega_s/\Omega_p)} = \frac{\log 3}{\log 3.25}$$

$$\therefore N = 0.932$$

For HPF,

$$\Omega_c = \Omega_p = 7265 \text{ rad/s}$$

$$\therefore H(s) = \frac{s}{s+7265}$$

Using BLT;

$$H(z) = H(s)\Big|_{\frac{10^4(1-z^{-1})}{(1+z^{-1})}}$$

$$\therefore H(z) = \frac{0.5792(1-z^{-1})}{1-0.1584z^{-1}} \quad \ldots$$

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