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Q. Using BLT, design High-pass filter, monotonic in passband with cutt-off frequency of 1000 Hz and down 10 dB at 350 Hz. The sampling freq is 5000 Hz. Implement using basic building blocks. Shows derivation for this filter. Demonstrate filter output for 5 different freq. ranging from 100 Hz to 10000 Hz

Ans

Given:

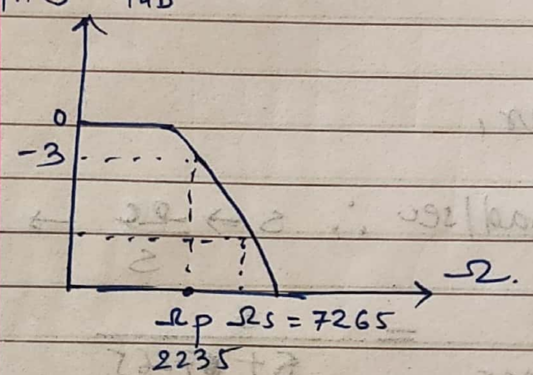
$\alpha_p = 3\,dB$, $\omega_c = \omega_p = 2\pi * 1000 = 2000\pi$ rad/s

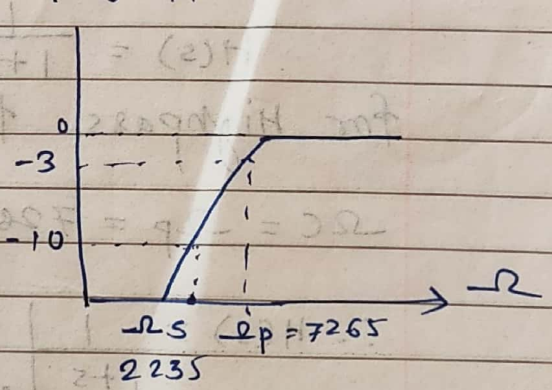
$\alpha_s = 10\,dB$, $\omega_s = 2\pi \times 350 = 700\pi$ rad/sec

$f_s = 5000$ Hz.

$T = \frac{1}{f_s} = \frac{1}{5000} = 2\times 10^{-4}$ sec.

Frequency Responce:





As we know,

Passpand freq. (H.P.F) = Stopband freq. (L.P.F)

& Stopband freq (H.P.F) = Passband freq (L.P.F)

& monotonic filter = Butterworth. filter.

$\therefore \Omega p = \frac{2}{T} \tan \frac{\omega_p T}{2}$

$= \frac{2}{2\times 10^{-4}} \tan\left(\frac{2000\pi \times 2\times 10^{-4}}{2}\right)$

$= 10^4 \tan(0.2\pi)$

$= 7265$ rad/sec

$$\Omega_s = \frac{2}{T} \tan \frac{\omega_s T}{2}$$

$$= \frac{2}{2\times10^{-4}} \tan\left(\frac{700\pi \times 2\times10^{-4}}{2}\right)$$

$$= 10^4 \tan(0.07\pi)$$

$$= 2235 \text{ rad/sec}$$

The order of filter,

$$N = \frac{\log\sqrt{\dfrac{10^{0.1\alpha_s}-1}{10^{0.1\alpha_p}-1}}}{\log\dfrac{\Omega_s}{\Omega_p}} = \frac{\log\sqrt{\dfrac{10^{0.1(60)}-1}{10^{0.1(3)}-1}}}{\log\dfrac{7265}{2235}} = \frac{\log 3}{\log 3.25}$$

$$= 0.932.$$

$\therefore$ if $N=1$ then $\Omega_c = 1$ rad/sec. for buttowarth filter

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

for Highpass filter,

$\Omega_C = \Omega_p = 7265$ rad/sec $\therefore$ $s \rightarrow \frac{\Omega_c}{s} \rightarrow \frac{7265}{s}$

$$\therefore H(s) = \frac{1}{1+s}\Bigg|_{s=\frac{7265}{s}} = \frac{s}{s+7265}$$

using BLT,

$$H(z) = H(s)\Bigg|_{s=\frac{2}{T}\left[\frac{1-z^{-1}}{1+z^{-1}}\right]}$$

$$= \frac{s}{s+7265}\Bigg|_{s=\frac{2}{2\times10^{-4}}\left[\frac{1-z^{-1}}{1+z^{-1}}\right]} = \frac{1000\,(1-z^{-1}/1+z^{-1})}{1000\left[\frac{1-z^{-1}}{1+z^{-1}}\right]+7265}$$

$$H(z) = \frac{0.5792\,(1-z^{-1})}{1-0.1584\,z^{-1}}$$