Design Procedure for IIR filters

→ Find order N & 3dB cut off freq Ω_{cn} using given specifications by using normalized filter.

(Let given specifications be Ω_p' & Ω_s', K_p & K_s.
& normalized filter parameters be $\Omega_p = 1$ rad/s, $\Omega_s = \frac{\Omega_s'}{\Omega_p'}$, K_p, K_s)

→

$$N = \log\left[\frac{10^{0.1K_p} - 1}{10^{0.1K_s} - 1}\right] \div 2\log\left(\frac{\Omega_p}{\Omega_s}\right)$$

$$\Omega_{cn} = \frac{\Omega_p}{\left(10^{-0.1K_p} - 1\right)^{\frac{1}{2N}}}$$

→ Find $H_N(s) = \frac{1}{B_N(s)}$ i.e TF of normalized filter.

→ Perform analog transformation

$H_p(s) = H_N(s)\Big|_{s=\frac{s}{\Omega_{cn}}}$ → Normalized prototype filter.

→ Perform $H_a(s) = H_p(s)\Big|_{s=\frac{s}{\Omega_p'}}$ for LP filter

$H_a(s) = H_p(s)\Big|_{s=\frac{\Omega_p'}{s}}$ for HP filter.

$H_a(s)$ is TF for given specifications.

For BP & BS filters.

→ Find normalized filter by using transformation of specifications.

$\Omega_p = 1$ rad/s & $\Omega_s = \min(|A|, |B|)$

→ Find order N using normalized filter

→ Find T.F. $H_N(s)$

→ Transform $H_N(s)$ to $H_a(s)$ by using following Table.

To find Ω_s we:

For BPF $\Rightarrow$ $A = \dfrac{-\Omega_1^2 + \Omega_0^2}{\Omega_1 (B_0)}$ & $B = \dfrac{+\Omega_2^2 - \Omega_0^2}{\Omega_2 (B_0)}$

$\Omega_0^2 = \Omega_1 \Omega$

$B_0 = (\Omega_2 - \Omega_1$

$\Omega_s = \min(|A|, |B|)$

For BSF BEF $A = \dfrac{\Omega_1 B_0}{-\Omega_1^2 + \Omega_0^2}$, $B = \dfrac{\Omega_2 B_0}{-\Omega_2^2 + \Omega_0^2}$

$\Omega_s = \min(|A|, |B|)$

Transformations

LP to BP $\Rightarrow$ $s \rightarrow \dfrac{s^2 + \Omega_0^2}{s B_0}$

LP to BS $\Rightarrow$ $s \rightarrow \dfrac{s B_0}{s^2 + \Omega_0^2}$

$\Omega_0^2 = \Omega_1 \Omega_2$

$B_0 = \Omega_2 - \Omega_1$