Bulleworth

L.P

Bilenear T

given A_p A_s

w_p w_s

$$\Omega_p = \frac{2}{T}\tan\left(\frac{w_p}{2}\right)$$

$$\Omega_s = \frac{2}{T}\tan\left(\frac{w_s}{2}\right)$$

$$A_p = \frac{1}{\sqrt{1+\epsilon^2}}$$

$$A_s = \frac{1}{\sqrt{1+\lambda^2}}$$

$$N = \frac{\log(\lambda/\epsilon)}{\log\left(\frac{\Omega_s}{\Omega_p}\right)}$$

$$\Omega_c = \frac{1}{2}\left(\frac{\Omega_p}{\left(\frac{1}{A_p^2}-1\right)^{1/2N}} + \frac{\Omega_s}{\left(\frac{1}{A_s^2}-1\right)^{1/2N}}\right)$$

$$P_k = \pm\,\Omega_c\, e^{(2k+N+1)\frac{j}{2\pi}}$$

P_1

P_2

$$H(s) = \frac{(\Omega_c)^N}{(s-P_1)(s-P_2)}$$

$$s = \frac{2}{T}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)$$

Bulleworth

L.P

Impulse invariant

A_p A_s

w_p w_s

$$\Omega_p = \frac{w_p}{T} \qquad \Omega_s = \frac{w_s}{T}$$

$$N = \frac{\log(\lambda/\epsilon)}{\log\left(\frac{\Omega_s}{\Omega_p}\right)}$$

$$\Omega_c = \frac{1}{2}\left(\frac{\Omega_p}{\left(\frac{1}{A_p}-1\right)^{1/2N}} + \frac{\Omega_s}{\left(\frac{1}{A_s}-1\right)^{1/2N}}\right)$$

$$P_k = (\Omega_c)\, e^{\frac{j(2k+N+1)}{2\pi}}$$

$$H(s) = \frac{(\Omega_c)^N}{(s-P_1)(s-P_2)}$$

$$\frac{c_k}{s-P_k} = \boxed{\frac{c_k}{1-e^{P_k T}z^{-1}}}$$

High pass

Bineal

swap ~~ωs, ωp~~

$$\Omega s = \frac{2}{T}\tan\left(\frac{\omega s}{2}\right)$$

$$\Omega p = \frac{2}{T}\tan\left(\frac{\omega p}{2}\right)$$

$\Omega s \leftrightarrow \Omega p$

$$N = \frac{\log(\lambda/\varepsilon)}{\log\left(\frac{\Omega s}{\Omega p}\right)}$$

$$H(s) = \frac{1}{s^2+\sqrt{2}s+1}$$

$$s = \frac{\Omega c}{s} = \frac{\Omega p}{s}$$

$$H(s) = \frac{1}{\left(\frac{\Omega p}{s}\right)^2 + \sqrt{2}\left(\frac{\Omega p}{s}\right)}$$

$$s = \frac{2}{T}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)$$

Chebyshev

Bilinear

$$\Omega s = \frac{2}{T}\tan\left(\frac{\omega s}{2}\right)$$

$$\Omega p = \frac{2}{T}\tan\left(\frac{\omega p}{2}\right)$$

$$N = \frac{\cosh^{-1}\left(\frac{\lambda}{\varepsilon}\right)}{\cosh^{-1}\left(\frac{\Omega s}{\Omega p}\right)}$$

$$A_p = \frac{1}{\sqrt{1+\varepsilon^2}} \qquad A_s = \frac{1}{\sqrt{1+\lambda^2}}$$

$$P_k = \sigma_k + j\Omega_k$$

$$\sigma_k = a\cos\phi_k$$

$$\Omega_k = b\sin\phi_k$$

$$a = \Omega p\left(\frac{\mu^{1/N} - \mu^{-1/N}}{2}\right)$$

$$b = \Omega p\left(\frac{\mu^{1/N} + \mu^{-1/N}}{2}\right)$$

$$\mu = \frac{1+\sqrt{1+\varepsilon^2}}{\varepsilon}$$

$$\phi_k = \frac{\pi}{2N}(2k+N+1)$$

$$H(s) = \frac{K}{(s-p_1)(s-p_2)\cdots}$$

if N ⇒ odd

$K = b_0$

N even $K = \frac{b_0}{\sqrt{1+\varepsilon^2}}$

$$s = \frac{2}{T}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)$$

$$\frac{1}{s-p_k} = \left(\frac{1}{1-e^{p_k T} z^{-1}}\right)$$

impulse inv

$$\Omega_s = \left(\frac{\omega_s}{T}\right) \quad \Omega_p = \frac{\omega_p}{T}$$

$$N = \frac{\cosh^{-1}(\lambda/\varepsilon)}{\cosh^{-1}\left(\frac{\Omega_s}{\Omega_p}\right)}$$

$$A_p = \frac{1}{\sqrt{1+\varepsilon^2}} \quad A_s = \frac{1}{\sqrt{1+\lambda^2}}$$

$$p_k = \sigma_k + j\Omega_k$$

$$\sigma_k = a\cos\phi_k$$

$$\Omega_k = b\sin\phi_k$$

$$a = \Omega_p\left(\frac{\mu^{1/N} - \mu^{-1/N}}{2}\right)$$

$$b = \Omega_p\left(\frac{\mu^{1/N} + \mu^{-1/N}}{2}\right)$$

$$\mu = \frac{1+\sqrt{1+\varepsilon^2}}{\varepsilon}$$

$$\phi_k = \frac{\pi}{2N}(2k+N+1)$$

$$H(s) = \frac{K}{(\quad)}$$

$$K = b_0$$

$$K = \frac{b}{\sqrt{1+\varepsilon^2}}$$