3. For the given specification, find the order of BW Filter.

$\alpha_p = 3$ dB, $\alpha_s = 18$ dB, $f_p = 1$ kHz, $f_s = 2$ kHz.

$f_p = 1$ kHz $\quad f_s = 2$ kHz $\quad \alpha_p = 3$ dB, $\alpha_s = 18$ dB

$\Omega_p = 2\pi \times 10^3 = 2000\pi$ rad/sec

$\Omega_s = 2\pi \times 2 \times 10^3 = 4000\pi$ rad/sec.

$$N \geq \frac{\log A}{\log 1/k}$$

$$A = \left[\frac{(10^{0.1\alpha_B} - 1)}{(10^{0.1\alpha_p} - 1)}\right]^{1/2} = \left(\frac{10^{0.1\times 18} - 1}{10^{0.1\times 3} - 1}\right)^{1/2} = \left[\frac{62.0957}{0.9952}\right]^{1/2}$$

$$A = 7.899$$

$$k = \frac{\Omega_p}{\Omega_s} = \frac{2000\pi}{4000\pi} = 0.5$$

$k = 0.5$ $\quad 1/k = 2$

$$N \geq \frac{\log A}{\log 1/k} = \frac{\log 7.899}{\log 2} = 2.98$$

$N = 3$

4. Design an analog BW filter: $\alpha_p = 0.5$ dB, $\alpha_s = 22$ dB $f_p = 10$ kHz, $f_s = 25$ kHz.

5. Find the pole locations of the 6th order B.W filter with $\Omega_c = 1$ rad/sec.

$\alpha_p = 0.5$ dB

$\alpha_s = 22$ dB

$\Omega_p = 2\pi \times 10 \times 10^3 = 20000\pi$

$\Omega_s = 2\pi \times 25 \times 10^3 = 50000\pi$

$$N \geq \frac{\log A}{\log 1/k}$$

$$A = \left(\frac{10^{0.1\alpha_s} - 1}{10^{0.1\alpha_p} - 1}\right)^{1/2} = \left(\frac{10^{0.1\times 22} - 1}{10^{0.1\times 0.5} - 1}\right)^{1/2}$$

$$= \left(\frac{157.49}{0.122}\right)^{1/2}$$

$$\boxed{A = 35.93}$$

$$k = \frac{\Omega_p}{\Omega_s} = \frac{20000\pi}{50000\pi} = \frac{2}{5} = 0.4$$

$$\boxed{\frac{1}{k} = 2.5}$$

$$N \geq \frac{\log A}{\log\left(\frac{1}{k}\right)} \geq \frac{\log 35.93}{\log 2.5}$$

$$N \geq 3.91$$

$$\boxed{N = 4}$$

$$H(s) = \frac{1}{(s^2 + 0.765378 + 1)(s^2 + 1.8477s + 1)}$$

$$\Omega_c = \frac{\Omega_p}{(10^{0.1\alpha_p} - 1)^{1/2N}} = \frac{20000\pi}{(10^{0.1\times 0.5} - 1)^{1/8}} = \frac{20000\pi}{0.7688}$$

$$= 81729.09$$

$$= 81,729.09 \text{ rad/sec}$$

$$H_a(s) = H(s)\Big|_{s \to \frac{s}{81729.09}}$$

$$= \frac{1}{\left[\left(\frac{s}{81729.09}\right)^2 + \left(\frac{0.76537s}{81729.09}\right) + 1\right]\left[\left(\frac{s}{81729.09}\right)^2 + \left(\frac{1.84778}{81729.09}\right) + 1\right]}$$

$$= \frac{1}{\left[\frac{s^2}{6.68\times10^9} + (9.36\times10^{-6})s + 1\right]\left[\frac{s^2}{6.68\times10^9} + (2.26\times10^{-5}) + 1\right]}$$

$$= \frac{(6.68\times10^9)^2}{\left[s^2 + (62.52\times10^3)s + (6.68\times10^9)\right]\left[s^2 + (15.1\times10^4)s + (6.68\times10^9)\right]}$$

$$H_a(s) = \frac{44.6224\times10^{18}}{\left[s^2 + (62.52\times10^3)s + (6.68\times10^9)\right]\left[s^2 + (15.1\times10^4)s + (6.68\times10^9)\right]}$$

5. $N = 6$

$\Omega_c = 1$ rad/sec

$N \to$ even $\therefore s_k = \Omega_c e^{j\left[\frac{(2k-1)\pi}{2N} + \frac{\pi}{2}\right]}$

$$s_k = e^{j\left[\frac{\pi}{2} + \frac{(2k-1)\pi}{2N}\right]}$$

$k = 1, 2, \ldots 6$

$$s_1 = e^{j\left[\frac{\pi}{2} + \frac{\pi}{12}\right]} = e^{j\frac{7\pi}{12}}$$

$$= -0.2588 + j0.9659$$

$$s_2 = e^{j\left[\frac{\pi}{2} + \frac{3\pi}{12}\right]} = e^{j\frac{9\pi}{12}}$$

$$= -0.707 + j0.707$$

$$s_3 = e^{j\left[\frac{\pi}{2} + \frac{5\pi}{12}\right]} = e^{j\frac{11\pi}{12}}$$

$$= -0.9659 + j0.2588$$

$$s_4 = e^{j\left[\frac{\pi}{2} + \frac{7\pi}{12}\right]} = e^{j\frac{13\pi}{12}}$$

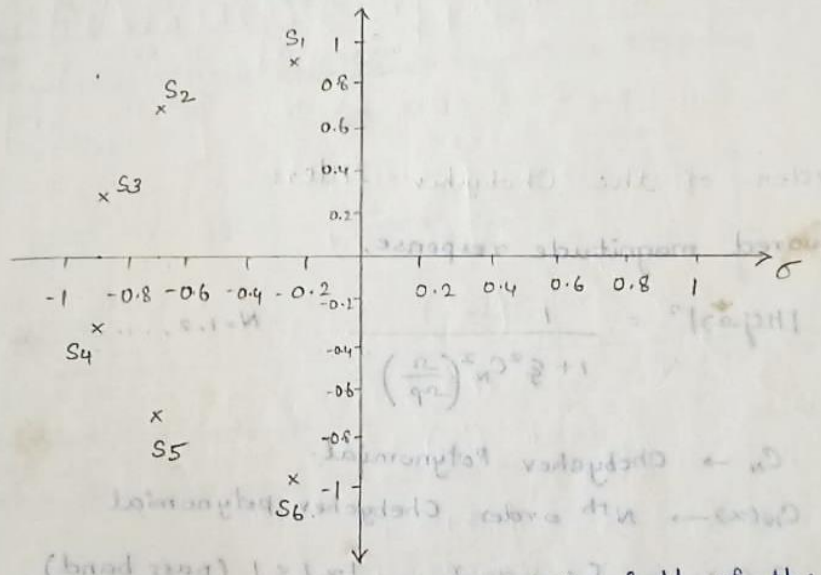
$$= -0.9659 - j0.2588$$

$$s_5 = e^{j\left[\frac{\pi}{2} + \frac{9\pi}{12}\right]} = e^{j\frac{15\pi}{12}}$$

$$= -0.707 - j0.707.$$

$$s_6 = e^{j\left[\pi/2 + 11\pi/12\right]} = e^{j17\pi/12}$$

$$= -0.2588 - j0.9659$$



All the 6 poles lie on the left half of the s-plane.