ECE 580 PROJECT
Fall 2014

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Part I. Introduction

"The poles of a system (those closest to the imaginary axis in the s-plane) give rise to the longest lasting terms in the transient response of the system. Then those poles are called dominant poles. "

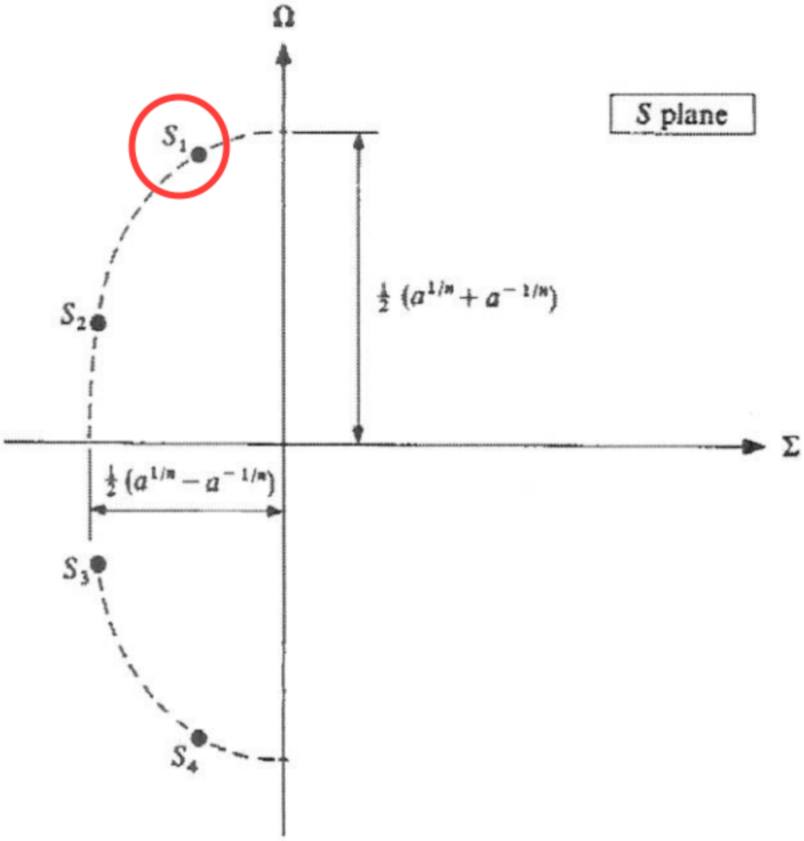

Figure 1. Natural modes of a Chebyshev filter for $n = 4$.

Figure 1 shows the natural modes of a 4th order Chebyshev filter. S_1 is the dominant pole. Some basic equations are showing below:

$$k_p = \sqrt{10^{\alpha_p/10} - 1} \text{ or } \alpha_p = 10\log(1 + k_p^2)$$

$$a = \frac{1}{k_p} + \sqrt{\frac{1}{k_p^2} + 1}$$

Then, for each pole, the real part is:

$$\Sigma_k = -\sin\left(\frac{2k-1}{n}\frac{\pi}{2}\right)\frac{1}{2}\left(a^{1/n} - a^{-1/n}\right) \qquad k = 1,2,\ldots,\square$$

and the imaginary part is:

$$\Omega_k = \cos\left(\frac{2k-1}{n}\frac{\pi}{2}\right)\frac{1}{2}\left(a^{1/n} + a^{-1/n}\right) \qquad k = 1,2,\ldots,\square$$

and then:

$$S_k = \Sigma_k + j\Omega_k \qquad k = 1,2,\ldots,\square$$

In this project, n equals to 5. Another useful equation is:

$$Q_p = \frac{|S_k|}{2 \times |Re\{S_k\}|} \qquad k = 1,2,\ldots,\square$$

Part II. Question 1—plot the pole Q (Q_p) of the dominant pole of a fifth-order Chebyshev filter as a function of α_p

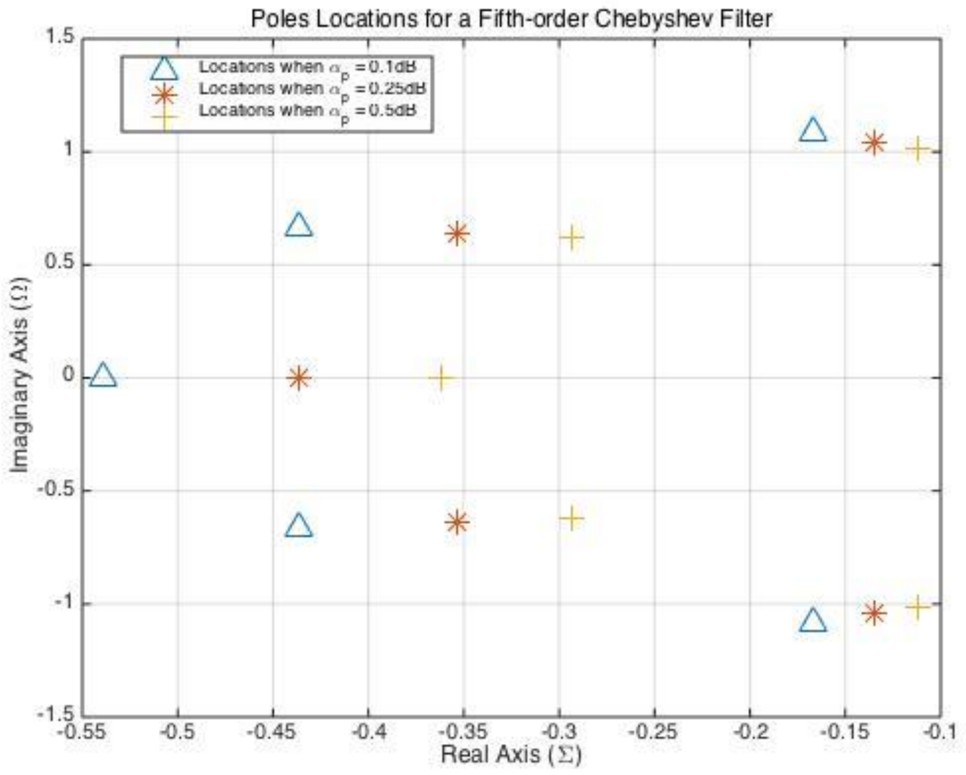

Figure 2. Poles locations.

Figure 2 shows the poles locations if we let passband loss equals to 0.1, 0.25, and 0.5dB. From this figure we can see, larger passband loss, the locations are closer to the origin.

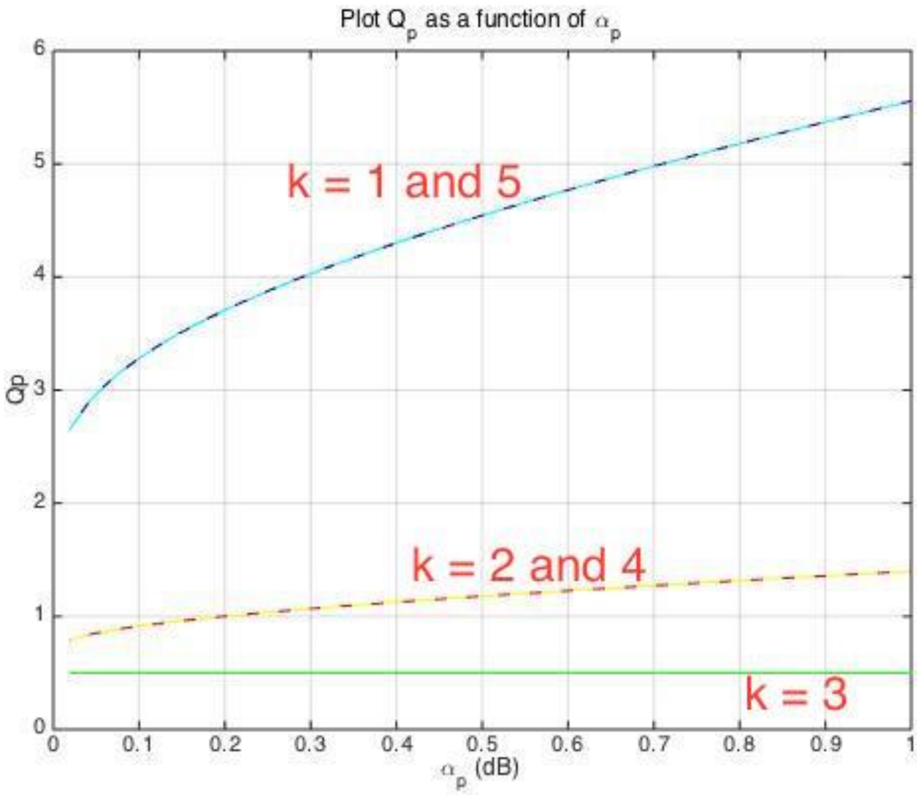

Figure 3. Q_p vs. α_p for k equals to 1, 2, 3, 4, and 5.

If we assume that the range of passband loss is 0 to 1dB, then, we can draw Q_p as a function of α_p for every pole. As shown in figure 3, the green curve is when k equals to 3, which refers to the pole most far away from the origin. The red and yellow curve represent when k equals to 2 and 4 respectively. The reason why these two curves are the same is the locations for pole S_2 and S_4 are symmetrical with respect to the Σ axis. Same conditions for S_1 (blue curve) and S_5 (cyan curve).

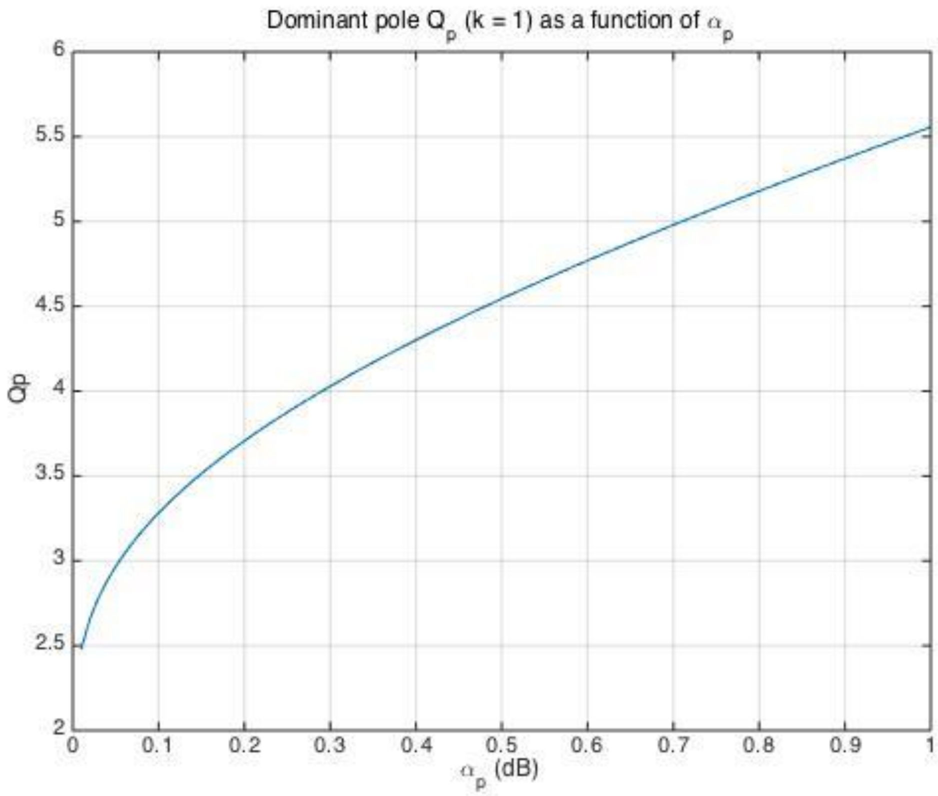

Figure 4. Plot the dominant pole as a function of α_p*.*

Figure 4 indicates Q_p as a function of α_p for the dominant pole. Again, in this figure, it is assuming that the range for α_p is from 0 to 1dB.

Part III. Question 2—find the largest passband loss if $Q_p < 5$, $Q_p < 3$, and $Q_p < 1$

- If $Q_p < 5$ **hold, the largest** $\alpha_p = 0.7dB$**.**
- If $Q_p < 3$ **hold, the largest** $\alpha_p = 0.05dB$**.**
- If $Q_p < 1$ **hold, there is no valid value for** α_p**.**

In this project, I assumed α_p is varying from 0 to 1dB, and the changing step was 0.01dB. If I use smaller changing step, the result could be more accurate.