Filter Design Assignment

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Filter Number 23

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First Filter Specifications

1. Un-normalized Discrete Time Filter Specifications:
   - Sampling Frequency (f_s) = 140kHz
   - $B_L = 9.4kHz$
   - $B_H = 14.4kHz$
   - Monotonic Passband (Butterworth)
2. Normalized Digital Filter Specifications
   - $\omega_{p1} = \frac{9.4}{140}2\pi = 0.4219$
   - $\omega_{p2} = \frac{14.4}{140}2\pi = 0.6463$
   - $\omega_{s1} = \frac{8.4}{140}2\pi = 0.3770$
   - $\omega_{s2} = \frac{15.4}{140}2\pi = 0.6912$
3. Analog Filter Specifications
   - $\Omega_{p1} = tan(\frac{\omega_{p1}}{2}) = 0.2141$
   - $\Omega_{p2} = tan(\frac{\omega_{p2}}{2}) = 0.3349$
   - $\Omega_{s1} = tan(\frac{\omega_{s1}}{2}) = 0.1908$
   - $\Omega_{s2} = tan(\frac{\omega_{s2}}{2}) = 0.3600$
4. Frequency transformation to be employed

$$s_L = \frac{s^2 + \Omega_0^2}{Bs} \tag{1}$$

   with $B = \Omega_{p2} - \Omega_{p1} = 0.1208$ and $\Omega_0 = \sqrt{\Omega_{p1}\Omega_{p2}} = 0.2678$
   This translates to

$$\Omega_L = \frac{\Omega^2 - \Omega_0^2}{B\Omega} \tag{2}$$

5. Frequency transformed lowpass analog filter specifications
   From 2
   - $\Omega_{Lp} = 1$
   - $\Omega_{Ls} = min(\Omega_{Ls1}, \Omega_{Ls2}) = 1.3321$
6. The analog Low pass Transfer Function

$$H_{analog}(s_L) = \frac{1}{0.4533s^{11} + 3.423s^{10} + 12.92s^9 + 32.07s^8 + 57.98s^7 + 80.04s^6 + 86.01s^5 + 71.95s^4 + 45.95s^3 + 2}$$