数字信号处理B

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HW9

Exercise 1

$$\omega_p = 0.2\pi, \omega_s = 0.5\pi, T_s = 10\mu s = 1 \times 10^{-5} s$$

$$\Omega_p = \frac{\omega_p}{T_s} = 2 \times 10^4 \pi, \Omega_s = \frac{\omega_s}{T_s} = 5 \times 10^4 \pi$$

$$\lambda_p = \frac{\Omega_p}{\Omega_p} = 1, \lambda_s = \frac{\Omega_s}{\Omega_p} = 2.5$$

$$\alpha_p = 3, \alpha_s = 30$$

$$C = \sqrt{10^{\alpha_p/10} - 1} = 1$$

$$a = \sqrt{\frac{10^{\alpha_s/10} - 1}{10^{\alpha_p/10} - 1}} = 31.68$$

$$n = \frac{\lg a}{\lg \lambda_s} = 3.77, N = 4$$

$$p_k = \exp\left(j\frac{2k + N - 1}{2N}\pi\right), k = 1 \ldots N$$

$$G(p) = \frac{1}{(p - p_1)(p - p_2)(p - p_3)(p - p_4)} = \frac{1}{(p^2 - 2p\cos\frac{5}{8}\pi + 1)(p^2 - 2p\cos\frac{7}{8}\pi + 1)}$$

$$G(s) = G(p = \frac{s}{\Omega_p}) = \frac{1}{(1 - \cos^2\frac{5}{8}\pi)(1 - \cos^2\frac{7}{8}\pi)} \cdot \frac{(1 - \cos^2\frac{5}{8}\pi)}{(p - \cos\frac{5}{8}\pi)^2 + (1 - \cos^2\frac{5}{8}\pi)} \cdot \frac{(1 - \cos^2\frac{7}{8}\pi)}{(p - \cos\frac{7}{8}\pi)^2 + (1 - \cos^2\frac{7}{8}\pi)}$$

$$G(s) = A\frac{\beta_1^2}{(s - \alpha_1)^2 + \beta_1^2} \cdot \frac{\beta_2^2}{(s - \alpha_2)^2 + \beta_2^2}$$

$$A = \frac{1}{(1 - \cos^2\frac{5}{8}\pi)(1 - \cos^2\frac{7}{8}\pi)}, \alpha_1 = \cos\frac{5}{8}\pi, \alpha_2 = \cos\frac{7}{8}\pi, \beta_1 = \sqrt{1 - \cos^2\frac{5}{8}\pi}, \beta_2 = \sqrt{1 - \cos^2\frac{7}{8}\pi}$$

$$H(z) = A \cdot \frac{zT_s e^{\alpha_1 T_s}\sin(\beta_1 T_s)}{z^2 - z2e^{\alpha_1 T_s}\cos(\beta_1 T_s) + e^{2\alpha_1 T_s}} \cdot \frac{zT_s e^{\alpha_2 T_s}\sin(\beta_2 T_s)}{z^2 - z2e^{\alpha_2 T_s}\cos(\beta_2 T_s) + e^{2\alpha_2 T_s}}$$

$$H(z) = \frac{0.0169z^{-1} + 0.0442z^{-2} + 0.075z^{-3}}{1 - 2.402z^{-1} + 2.3608z^{-2} - 1.0839z^{-3} + 0.1936z^{-4}}$$

Exercise 2

$$f_p = 400Hz, f_s = 300Hz, F_s = 1000Hz, \alpha_p = 3, \alpha_s = 35$$

$$\omega_p = 2\pi\frac{f_p}{F_s} = 0.8\pi, \omega_s = 2\pi\frac{f_s}{F_s} = 0.6\pi$$

$$\Omega_p = \tan(\frac{\omega_p}{2}) = 3.0777, \Omega_s = \tan(\frac{\omega_s}{2}) = 1.3764$$

$$\eta_p = \frac{\Omega_p}{\Omega_p} = 1, \eta_s = \frac{\Omega_s}{\Omega_p} = 0.4472$$

$$\lambda_p = \frac{1}{\eta_p} = 1, \lambda_s = \frac{1}{\eta_s} = 2.23605$$

$$\varepsilon = \sqrt{10^{\alpha_p/10} - 1} = 1$$

$$a = \sqrt{\frac{10^{\alpha_s/10} - 1}{10^{\alpha_p/10} - 1}} = 56.36$$

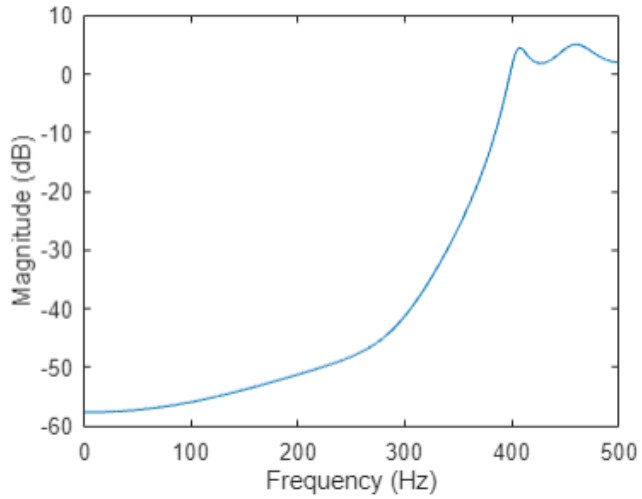
$$n = \frac{\cosh^{-1} a}{\cosh^{-1} \lambda_s} = 4$$

$$G(p) = \frac{1}{8(p^2 + 0.17p + 0.9029)(p^2 + 0.4104p + 0.1958)}$$

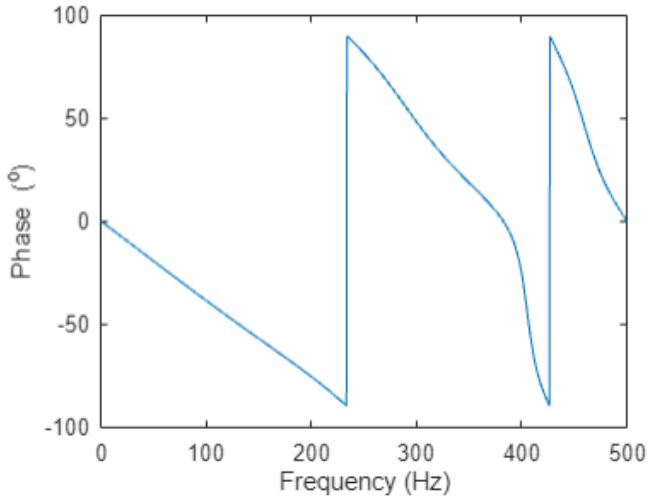
$$H(z) = G(p = \frac{\Omega_p}{s}, s = \frac{z+1}{z-1})$$

$$H(z) = \frac{0.00105(1 - 4z^{-1} + 6z^{-2} - 4z^{-3} + z^{-4})}{1 + 3.270z^{-1} + 4.342z^{-2} + 2.743z^{-3} + 0.695z^{-4}}$$

幅频响应：



相频响应：



Exercise 3

$$f_{pl} = 44Hz, f_{sl} = 47Hz, f_{sh} = 53Hz, f_{ph} = 56Hz$$

$$\omega = 2\pi\frac{f}{F_s}$$

$$\omega_{pl} = 0.27646, \omega_{sl} = 0.29531, \omega_{sh} = 0.33301, \omega_{ph} = 0.35186$$

$$\Omega = \tan\frac{\omega}{2}$$

$$\Omega_{pl} = 0.139117, \Omega_{sl} = 0.148737, \Omega_{sh} = 0.168060, \Omega_{ph} = 0.177767$$

$$\Omega_{BW} = \Omega_{ph} - \Omega_{pl} = 0.0386497, \Omega_0 = \sqrt{\Omega_{ph}\Omega_{pl}} = 0.157259$$

$$\eta = \Omega/\Omega_{BW}$$

$$\eta_{pl} = 3.599436, \eta_{sl} = 3.848340, \eta_{sh} = 4.348293, \eta_{ph} = 4.599436$$

$$\lambda_p = 1, \lambda_s = 1.84855$$

$$p = \frac{z^2 - 1}{26.5133z^2 - 50.4671z + 26.5133}$$

$$H(z) = \frac{1 - 11.11z^{-1} - 180.12z^{-2} - 595.81z^{-3} + 675.93z^{-4} - 568.80z^{-5} - 156.77z^{-6} - 8.83z^{-7} + 0.76z^{-8}}{0.61 - 6.95z^{-1} - 118.63z^{-2} - 412.34z^{-3} + 478.96z^{-4} - 412.34z^{-5} - 118.63z^{-6} - 6.95z^{-7} + 0.61z^{-8}}$$