Home Work #2

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1 Question 1

$$G(s) = \frac{50(s+0.5)}{(s+1)(s+1.5)^3(s+2)}$$

Steady state error:

$$e_{ss} = \lim_{s \to 0} s \times \frac{1}{G(s)+1} R(s)$$

When input is step $R(s)$ is $\frac{1}{s}$.

$$e_{ss} = \lim_{s \to 0} \frac{1}{G(s)+1}$$

1.1 lead compensation

$$G_c(s) = K_c \frac{s + \frac{1}{T}}{s + \frac{1}{\alpha T}}, \quad 0 < \alpha < 1$$

$$G_c(s) = K_c \alpha \frac{Ts+1}{\alpha Ts+1}$$

Define:

$$K_c \alpha = K$$

then:

$$G_c(s) = K \frac{Ts+1}{\alpha Ts+1}$$

The open-loop transfer function of the compensated system is:

$$G_c(s)G(s) = G_c(s) = K \frac{Ts+1}{\alpha Ts+1} G(s) = G_c(s) = \frac{Ts+1}{\alpha Ts+1} KG(s) = G_c(s) = \frac{Ts+1}{\alpha Ts+1} G_1(s)$$

Where:

$$KG(s) = G_1(s)$$

The amplitude ratio:

$$|G(j\omega)| = \frac{50\sqrt{\omega^2+0.5^2}}{\sqrt{\omega^2+1^2} \times (\sqrt{\omega^2+1.5^2})^3 \times \sqrt{\omega^2+2^2}}$$

Gain Crossover frequency:

$$|G(j\omega_g)| = 1$$

$$\frac{50\sqrt{\omega_g^2 + 0.5^2}}{\sqrt{\omega_g^2 + 1^2} \times (\sqrt{\omega_g^2 + 1.5^2})^3 \times \sqrt{\omega_g^2 + 2^2}} = 1$$

$$2500(\omega_g^2 + 0.25) = (\omega_g^2 + 1)(\omega_g^2 + 2.25)^3(\omega_g^2 + 4)$$

This equation solved with MATLAB and code has attacked (Q1_a.m).

$$\omega_g = 2.037$$

The phase angle:

$$\angle G(s) =$$

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