Type 11: Compensators

For Concept, refer to Control System K-Notes, Design of Control Systems

General Tip: *Memorize the formulas for maximum phase shift and frequency corresponding to maximum phase shift.*

Sample Problem:

The transfer functions of two compensators are given below:

$$C_1 = \frac{10(s+1)}{(s+10)} \quad , \quad C_2 = \frac{(s+10)}{10(s+1)}$$

Which one of the following statements is correct?

(A) C_1 is lead compensator and C_2 is a lag compensator

(B) C_1 is a lag compensator and C_2 is a lead compensator

(C) Both C_1 and C_2 are lead compensator

(D) Both C_1 and C_2 are lag compensator

Solution: (A) is correct option

For $C1$ Phase is given by

$$\theta_{C_1} = \tan^{-1}(\omega) - \tan^{-1}(\frac{\omega}{10})$$

$$\theta_{C_1} = \tan^{-1}\left[\frac{\omega - \frac{\omega}{10}}{1 + \frac{\omega^2}{10}}\right] = \tan^{-1}\left[\frac{9\omega}{10+\omega^2}\right] > 0 \ \text{(Phase lead)}$$

Similarly for C_2, phase is

$$\theta_{C_2} = \tan^{-1}(\frac{\omega}{10}) - \tan^{-1}(\omega)$$

$$\theta_{C_2} = \tan^{-1}\left[\frac{\frac{\omega}{10} - \omega}{1 + \frac{\omega^2}{10}}\right] = \tan^{-1}\left[\frac{-9\omega}{10+\omega^2}\right] < 0 \ \text{(Phase lag)}$$

Unsolved Problem:

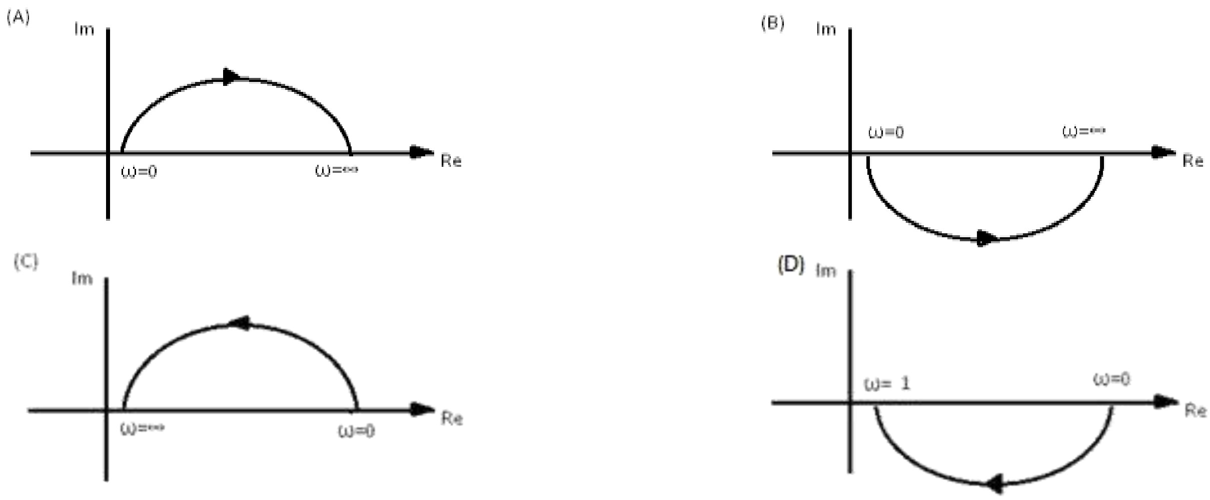
Q.1 Which of the following in the transfer function of a load compensation network.

(A) $\frac{(s+5)}{(s+8)}$ (B) $\frac{(s+8)}{(s+5)}$ (C) $\frac{s(s+5)}{(s+8)}$ (D) $\frac{(s+8)}{s(s+5)}$

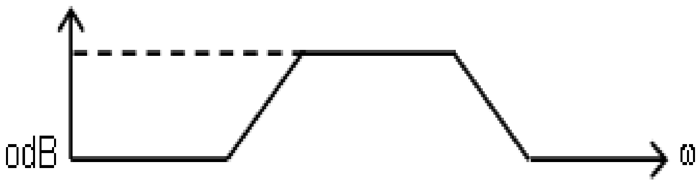
Q.2 Maximum phase lead of the compensator $D(s) = \dfrac{(0.5s+1)}{(0.05s+1)}$ is

(A) 52 at 4 rad/sec (B) 52 at 10 rad/sec (C) 55 at 12 rad/sec (D) None of the above

Q.3 Which one of the polar diagram corresponds to a lag network?



Q.4 The frequency response of controller is given below. The controller is



(A) Lead (B) Lag (C) Lead-lag (D) Lag-lead

Q.5 The controller of the form $G_c(s) = \dfrac{K(s+a)}{(s+b)}$. A first order compensator is designed for a plant with the transfer function $G(s) = \dfrac{1}{s(s+3)}$ such that the un-damped natural frequency and the damping ratio of the closed loop second order system are 2 rad/sec and 0.5 respectively. When the steady state error to a unit step input is zero then the controller parameters are

(A) K=4, a=3, b=2 (B) K=1, a=3, b=2 (C) K=4, a=2, b=3 (D) K=1, a=2, b=3