Introductory Motion and Control
Characteristics of Phase-Lead and Phase-Lag Compensators

Phase-Lead Compensator (PD type compensation)

- $G_c(s) = \frac{p}{z}\left(\frac{s+z}{s+p}\right) \quad (p > z)$
- ***Increases system bandwidth*** which usually correlates to ***reduced rise*** and ***settling times*** and a ***susceptibility*** to ***high frequency noise***.
- ***Increases the phase*** of the forward-path transfer function near the zero-gain crossover frequency. This ***increases*** the ***phase margin*** of the closed-loop system and hence the relative stability.

Phase-Lag Compensator (PI type compensation)

- $G_c(s) = \frac{p}{z}\left(\frac{s+z}{s+p}\right) \quad (p < z)$
- ***Reduces the system bandwidth*** which usually correlates to ***increased rise*** and ***settling times*** and a ***lower susceptibility*** to ***high frequency noise***.
- ***Attenuates the magnitude*** of the forward-path transfer function near and above the zero-gain crossover frequency. This improves the system's relative stability, but usually slows it down.
- ***Reduces steady-state error***.

Lead-Lag Compensator (PID type compensation)

- $G_c(s) = \frac{p_1 p_2}{z_1 z_2}\left(\frac{s+z_1}{s+p_1}\right)\left(\frac{s+z_2}{s+p_2}\right) \quad (p_1 > z_1 \text{ and } p_2 < z_2)$.
- The ***phase-lead portion*** of the compensator can be used to ***increase*** the ***system bandwidth*** and achieve ***faster response*** at lower frequencies, and the ***phase-lag portion*** can be used to ***lower steady-state error*** and to ***reduce susceptibility*** to ***high frequency noise***.
- Either the phase-lead or the phase-lag portions can be designed first.