

ME 4710 Motion and Control

Characteristics of Phase-Lead and Phase-Lag Compensators

Phase-Lead Compensator (PD type compensation)

- $G_c(s) = \frac{p}{z} \left(\frac{s+z}{s+p} \right)$ ($p > z$)
- **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)

- $G_c(s) = \frac{p}{z} \left(\frac{s+z}{s+p} \right)$ ($p < z$)
- **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)

- $G_c(s) = \frac{p_1 p_2}{z_1 z_2} \left(\frac{s+z_1}{s+p_1} \right) \left(\frac{s+z_2}{s+p_2} \right)$ ($p_1 > z_1$ 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.