Spring 2020

控制系統
Control Systems

Unit 6L
Compensation Characteristics and Design Considerations

Feng-Li Lian & Ming-Li Chiang

NTU-EE

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Summary of Compensation Characteristics

- PD Control
- Adds phase lead at all frequencies above the break point.
- If there is no change in gain on the low-frequency asymptotic,
- PD compensation will increase
  - the crossover frequency and
  - the speed of response.
- The increase in magnitude of the frequency response

at the higher frequencies

will increase the system’s sensitivity to noise

Summary of Compensation Characteristics

- Lead Compensation
- Adds phase lead at a frequency band

  between the two break points,

  which are usually selected to bracket the crossover frequency.
- If there is no change in gain on the low-frequency asymptotic,
- Lead compensation will increase
  - the crossover frequency and
  - the speed of response.

Summary of Compensation Characteristics

- PI Control
- Increases the frequency-response magnitude

  at frequencies below the break point,

  thereby decreasing steady-state error.
- It also contributes phase lag below the break point,

  which must be kept at a low enough frequency

  to avoid degrading the stability excessively

Summary of Compensation Characteristics

- Lag Compensation
- Increases the frequency-response magnitude

  at frequencies below the two break points,

  thereby decreasing steady-state error.
- Alternatively, with suitable adjustments in K,

  Lag Compensation can be used

  to decrease the frequency-response magnitude

  at frequencies above the two break points
- So that, ω_c yields an acceptable PM.

Summary of Compensation Characteristics

- Lag Compensation
- Lag Compensation also contributes phase lag between the two break points, which must be kept at frequencies low enough to keep the phase decrease from degrading the PM excessively
- The Lag Compensation will typically provide a slower response than using Lead Compensation.

Design Considerations

- Characteristics of the OL Bode Plot of the loop gain

  determine performance with respective to:

  steady-state error, low-frequency errors,

  and dynamic response, including stability margins.

- Other properties of feedback include:

  reducing the effects of sensor noise

  and parameter changes on the performance of system.

- Design for acceptable errors

  due to command inputs and disturbances

  can be thought of as placing a lower bound

  on the low-frequency gain of the OL system.

Design Considerations

- Another aspect of the sensitivity issue concerns the high-frequency portion of the system.
- To alleviate the effects of sensor noise, the high-frequency gain must be kept low.
- For example, a lead compensation of one pole, compared with pure derivative control, for reducing the effects of sensor noise at high frequencies.
- Or, add an extra pole in the compensation to introduce even more attenuation error reduction:

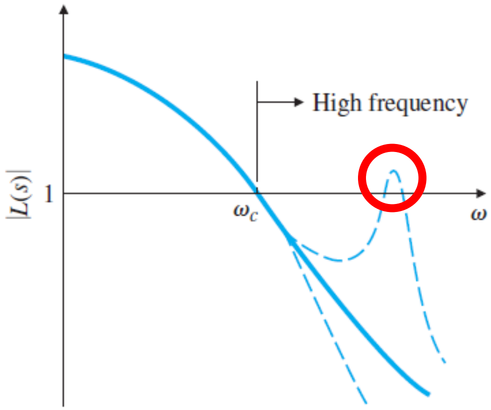
$$D_c(s) = \frac{T_D\, s + 1}{(\,\alpha\, T_D\, s + 1\,)^2}$$

Design Considerations

- Many systems have high-frequency dynamic phenomena (e.g., mechanical resonances, bridge vibration, etc.) that could have an impact on the stability of a system.

Design Considerations

- Design for unknown high-frequency dynamics is to keep the high-frequency gain low.
- An unknown high-frequency resonance causes the magnitude to rise above 1.



- Can be lowered by adding extra poles.
- Refer as Amplitude or Gain Stabilization.
- On the other hand,

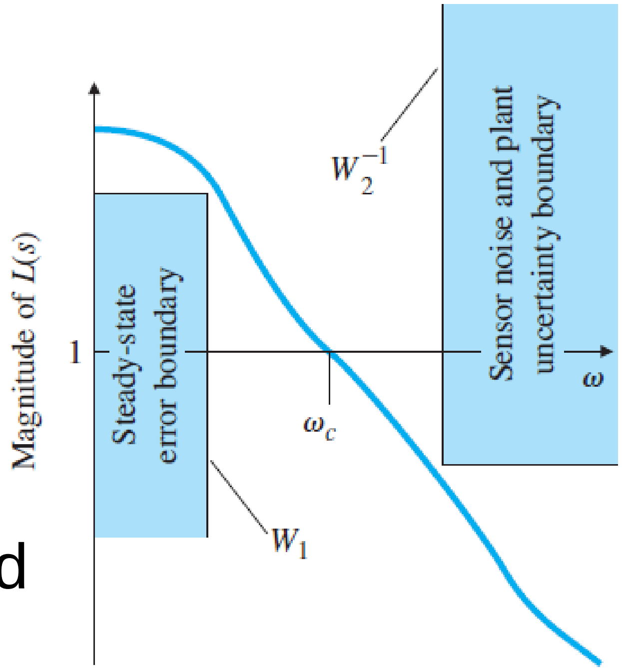
  to avoid encirclements of -1,

  by changing the phase at a specific frequency

  (e.g., notch compensation)

  is referred as Phase Stabilization.

Design Considerations



- The two aspects of sensitivity (high- and low-frequency behavior) can be depicted graphically.
- Minimum low-frequency gain allowable for
  - acceptable steady-state error and low-frequency error performance
- Maximum high-frequency gain allowable
  - for acceptable noise performance
  - for low probability of instability
    - caused by plant-model errors.