



The Principles of Automatic Control Lab #3 (online)

Department of Automation Dec, 2022







Frequency-Response Analysis Review

- Definition of System Frequency-Response
- Bode Diagrams

Control Systems Design by Frequency Response

- Lead Compensators
- Lag Compensators
- Lead-Lag Compensators





CB1: Inverted Adder

CB2: Inverted Amplifier #1

CB3: Inverted 1st-Order Delay #1

CB4: Inverted 1st-Order Delay #2

CB5: Compensator CB6: Inverted Amplifier #2 CB7: User-Defined Network CB8: Inverted Integrator



 V_{ref} Signal Source Scheme AD2-SCOPE CH1+ is fixedly connected to V_{ref}



SW9:

CB9: Inverter (Always Active)

 $V_{fdbk} = TP8$

OFF:

Output Signal Observation Scheme AD2-SCOPE CH2+ can be selectively switched

TP9



PID Parameters Tuning

When you are designing a PID controller for a given system, follow the steps shown below to obtain a desired response.

- 1. Obtain an open-loop response and determine what needs to be improved
- 2. Add a proportional control to improve the rise time
- 3. Add a derivative control to reduce the overshoot

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- 4. Add an integral control to reduce the steady-state error
- 5. Adjust each of the gains K_p , K_i , and K_d until you obtain a desired overall response.



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How to Draw the Bode Diagram for a Relatively Complex System

Traw the Bode diagram for the following TF:

$$G(j\omega) = \frac{10(j\omega + 3)}{(j\omega)(j\omega + 2)[(j\omega)^2 + j\omega + 2]}$$





Bode Diagram Features

- Relationship between system type and logmagnitude curve
 - Type 0, Type 1, Type 2
 - Kp, Kv, Ka







Control Systems Design by Frequency Response

Basic characteristics of different compensation

- Lead compensation (b)
- Lag compensation
- Lag-lead compensation



(C)

(d)







Characteristics of lead compensators



Lag Compensation



Characteristics of lag compensators

1)

$$G_c(s) = K_c \beta \frac{Ts+1}{\beta Ts+1} = K_c \frac{s+\frac{1}{T}}{s+\frac{1}{\beta T}} \qquad (\beta > 1)$$











Lead-Lag Compensation

Characteristics of lead-lag compensators







NOTE: the gain at high frequency!



Lead compensator (ACLab3.m, Krp3=10)





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Lead compensator (CB5+CB9, Krp3=10)

DON'T run into saturation!



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Lead compensator (CB5+CB9, Krp3=10)

Un-compensated Dynamic Response



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Un-compensated (Krp1=10, Krp4=8)

Un-compensated Response by Matlab 上海交通大學 i Jiao Tong University

1.6 System: sys2 Peak amplitude: 1.57 Overshoot (%): 56.8 1.4 At time (seconds): 0.221 1.2 System: sys2 Settling time (seconds): 1.42 Amplitude 0.6 0.4 0.2 0 0.5 1.5 2 2.5 0 1 Time (seconds)

Step Response

Un-compensated (ACLab3.m, Krp1=10, Krp4=8)



OL Bode plots by Matlab Un-compensated





Un-compensated (ACLab3.m, Krp1=10, Krp4=8)

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Compensated Dynamic Response

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Lead compensated (Krp3=10, Krp4=8)

Compensated Response by Matlab

Step Response 1.2 0.8 Amplitude 0.4 0.2 0 0 0.1 0.2 0.3 0.4 0.5 0.6 Time (seconds)

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Lead compensated (ACLab3.m, Krp3=10, Krp4=8)



OL Bode plots by Matlab compensated







Alternative Krp3 Values





Compensated Response by Matlab with Krp3=2

Lead Compensated (ACLab3.m, Krp3=2, Krp4=8)

Compensated Response with Krp3=2

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Lead Compensated (Krp3=2, Krp4=8)





Q&A