Control Systems

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Contents

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***Abstract*—This manual is an introduction to control systems based on GATE problems.Links to sample Python codes are available in the text.**

Download python codes using

```
svn co https://github.com/gadepall/school/trunk/
    control/codes
```

1 Signal Flow Graph

1.1 Mason's Gain Formula

1.2 Matrix Formula

1.3 Example

2 Bode Plot

2.1 Introduction

2.2 Example

Question: Consider the following asymptotic Bode magnitude plot (ω is in rad/s).

Which of the following transfer function is best represented by the above Bode magnitude plot?

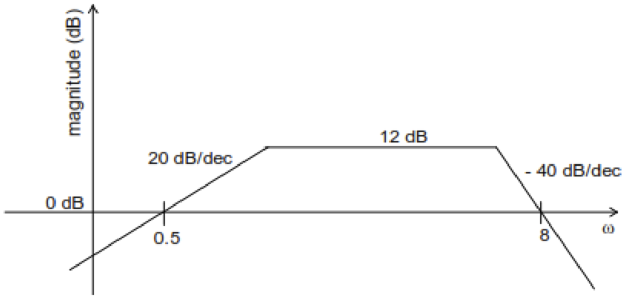

Fig. 2.0: Plot of G(s)

$$(A)\frac{2s}{(1+0.5s)(1+0.25s)^2} \quad (B)\frac{4(1+0.5s)}{s(1+0.25s)}$$

$$(C)\frac{2s}{(1+2s)(1+4s)} \quad (D)\frac{4s}{(1+2s)(1+4s)^2}$$

By looking to the plot, we can say that since the initial slope is +20, there must be a zero at the origin. Let the corner frequencies of the plot be ω_{01} and ω_{02}. They can be calculated as follows:

$$slope = \frac{M_2 - M_1}{log\omega_2 - log\omega_1}$$

Therefore for ω_{02},

$-40 = \frac{0-12}{log8 - log\omega_{02}}$

$log8 - log\omega_{02} = \frac{12}{40}$

$log\omega_{02} = \log 8 - \frac{12}{40}$

$\omega_{02} = 4$

And for ω_{01},

$20 = \frac{0-12}{log0.5 - log\omega_{01}}$

$\log 0.5 - \log\omega_{01} = \frac{-12}{20}$

$log\omega_{01} = \log 0.5 + \frac{12}{20}$

$\omega_{01} = 2$

So, the corner frequencies are ω_{01}=2 and ω_{02} = 4. At ω_{01}, the change in slope is -20dB, so their exists one pole at this frequency and at ω_{02}, the change in slope is -40dB, so their exists two pole at this frequency.

The denominators have the form $(1 + \frac{s}{\omega})$

So, the denominator of the transfer function is $(1+\frac{s}{2})(1+\frac{s}{4})^2$

Therefore, the transfer function is,

$$\frac{cs}{(1+\frac{s}{2})(1+\frac{s}{4})^2}$$

here c is some constant

The answer is therefore option (A)

$$\frac{2s}{(1+0.5s)(1+0.25s)^2}$$

We will now plot the bode plot of the given transfer function to verify it. The bode plot is:

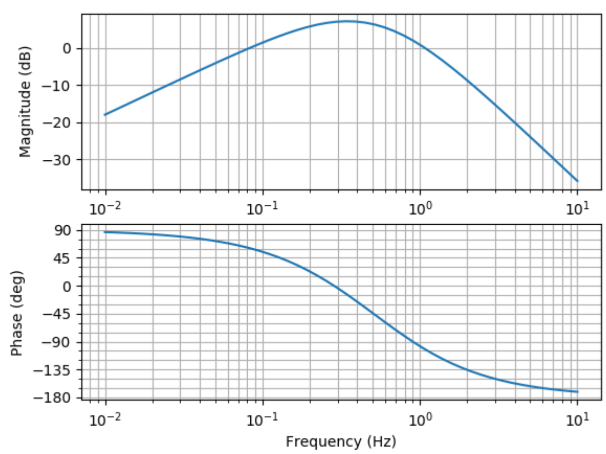

Fig. 2.0: Plot of G(s)

The plot was plotted using the following code:

```
import numpy as np
import control.matlab as ml
import matplotlib.pyplot as plt

num = np.array([2, 0])
den = np.polymul(np.array([0.5, 1]), np.array
    ([0.25, 1]))
den = np.polymul(den, np.array([0.25, 1]))

g = ml.tf(num, den)
print(g)
print(ml.pole(g))
print(ml.zero(g))
```

```
mag, phase, w = ml.bode(g)
plt.show()
```

2.3 Phase

3 Second order System

3.1 Damping

3.2 Example

3.3 Settling Time

4 Routh Hurwitz Criterion

4.1 Routh Array

4.2 Marginal Stability

4.3 Stability

4.4 Example

4.5 Example

5 State-Space Model

5.1 Controllability and Observability

5.2 Second Order System

5.3 Example

5.4 Example

5.5 Example

5.6 Example

5.7 Example

6 Nyquist Plot

6.1 Introduction

6.2 Example

7 Compensators

7.1 Phase Lead

7.2 Lag Lead

7.3 Example

8 Gain Margin

8.1 Introduction

8.2 Example

8.3 Example

9 Phase Margin

9.1 Intoduction

9.2 Example

10 Oscillator

10.1 Introduction

10.2 Example

11 Root Locus

11.1 Introduction