Control Systems

G V V Sharma*

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*The author is with the Department of Electrical Engineering, Indian Institute of Technology, Hyderabad 502285 India e-mail: gadepall@iith.ac.in.

***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
```

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2 Bode Plot

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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?

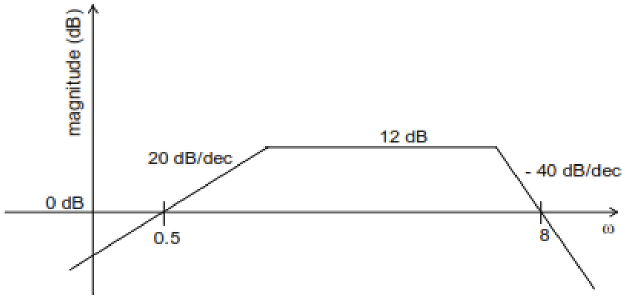

Fig. 2.0: Plot of G(s)

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

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

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

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

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

ω_{02} = 4

And for ω_{01},

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

log0.5 - logω_{01} = $\frac{-12}{20}$

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

ω_{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:

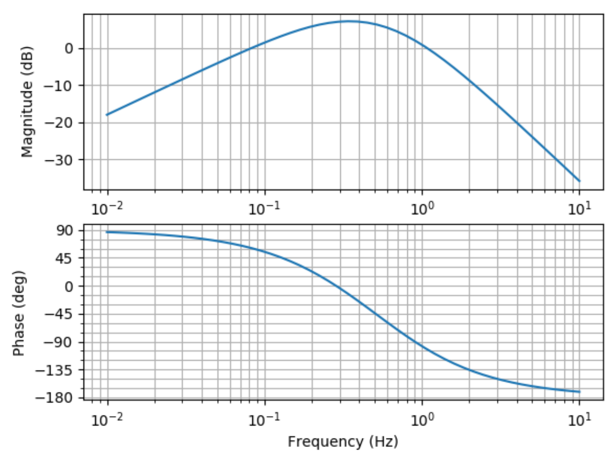

Fig. 2.0: Plot of G(s)

The plot was plotted using the following code:

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

# If using termux
import subprocess
import shlex
#end if

# num is the numerator of the trasfer
    function which is (2s)
# dem is the denominator of the transfer
    function which is (0.25s + 1)(0.25s + 1)
```

```
    (0.5s + 1)
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]))

# Generating the transfer function
g = ml.tf(num, den)
print("The transfer function is: ", g)
print("The poles of the above function are ",
    ml.pole(g))
print("The zeros of the above function are ",
    ml.zero(g))

# Generating the bode plot as well as plotting
     it
mag, phase, w = ml.bode(g)

# If using termux
plt.savefig("./figs/ep18btech11016_plot.pdf")
plt.savefig("./figs/ep18btech11016_plot.eps")
subprocess.run(shlex.split("termux-open ./figs
    /ep18btech11016_plot.pdf"))
# else
plt.show()
```

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