YTU ELECTRICAL & ELECTRONICS FACULTY
DEPARTMENT OF CONTROL & AUTOMATION ENGINEERING
KOM3712 CONTROL SYSTEM DESIGN, Assignment-1&2

Name and Surname:

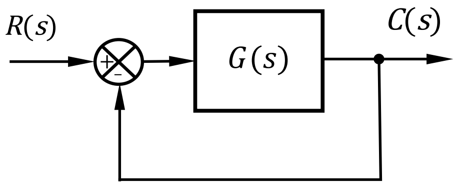
Student number:

Signature:

Date: April 07, 2019
Due Date: April 17, 2019
Warning: Do it yourself!

Probs. & Grades			Probs. & Grades		
1.	30		**6.**	10	
2.	10		**7.**	20	
3.	20		**8.**	20	
4.	20		**9.**	30	
5.	20		**10.**	20	

Problem-1: Considering the unity feedback system given,



- **(a)** Obtain an analytical expression for the magnitude and phase responses for each transfer function $G_x(s)$.
- **(b)** Sketch the Bode magnitude and phase plots of each $G_x(s)$ with asymptotes on the logarithmic planes provided on the last pages. Write the slopes and critical level values of each asymptotes on the plots, then draw the actual response. Show the correction on the magnitude plot for the system having underdamped components.
- **(c)** Plot the actual Bode plots in Matlab for comparison purpose.
- **(d)** Sketch the Nyquist diagram for each $G_x(s)$.
- **(e)** Plot the actual Nyquist diagrams in Matlab for comparison purpose.

$$G_1(s) = \frac{2}{s+5} \qquad G_2(s) = \frac{2}{s-5} \qquad G_3(s) = \frac{24}{(s+2)(s+6)}$$

$$G_4(s) = \frac{10(s+4)}{s(s+2)(s+20)} \qquad G_5(s) = \frac{20(s+2)}{s(s^2+2s+36)}$$

Solution-1: *You may first use the rest of this page. Add papers if needed. Use logarithmic planes presented at the end of this file.*

Problem-2: Considering the subsystem whose Bode plots are shown below under **Problem-3**,

(a) Determine the system type, ______________________

(b) Find the appropriate static error constant, ______________________

(c) and the steady state-error. ______________________

(d) What is the slope of the Bode magnitude plot in high frequencies (in dB/octave and dB/decade)? ______________________

Solution-2: *Answers will be given on the Problem.*

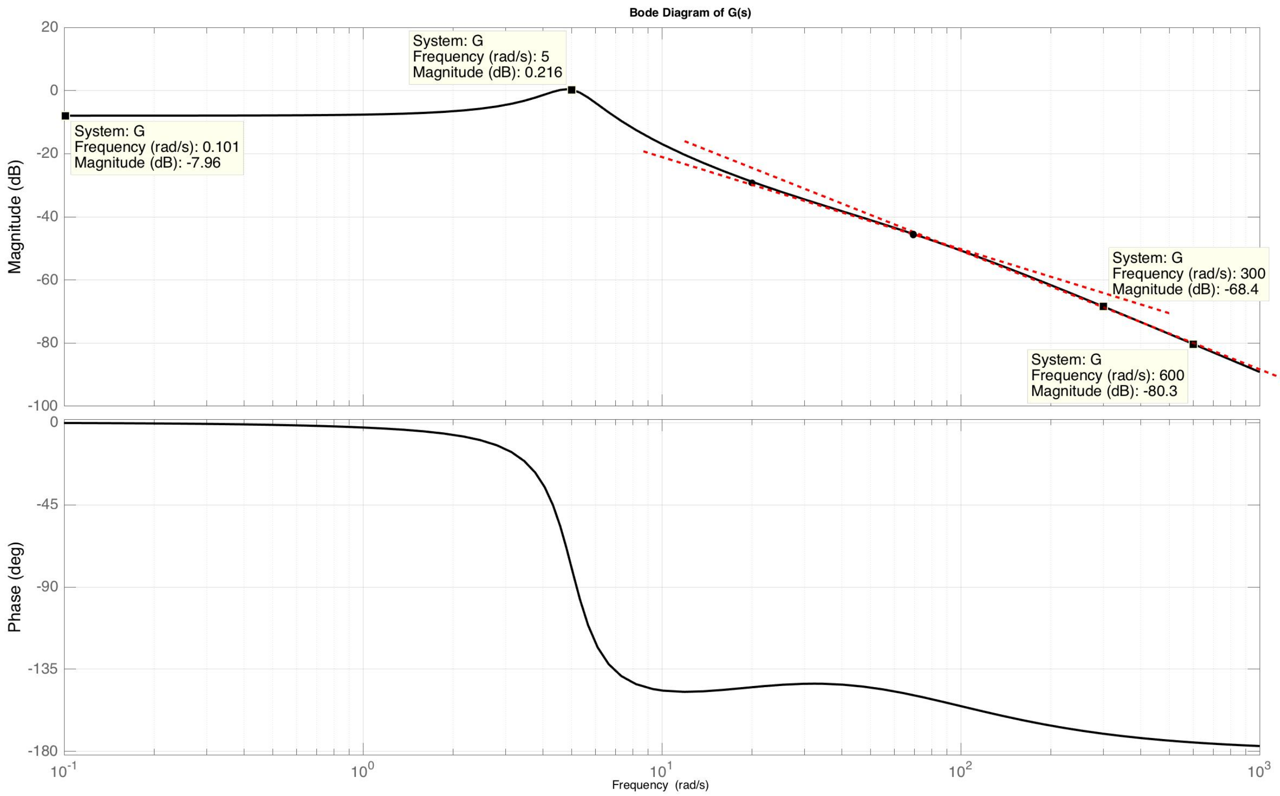
Problem-3: Propose an approximate transfer function $G(s)$ for the subsystem whose Bode plots are shown below. As a guideline answer the following questions.

i. What is the relative order of the subsystem? ______________________

ii. Determine the number of zeros and poles. ______________________

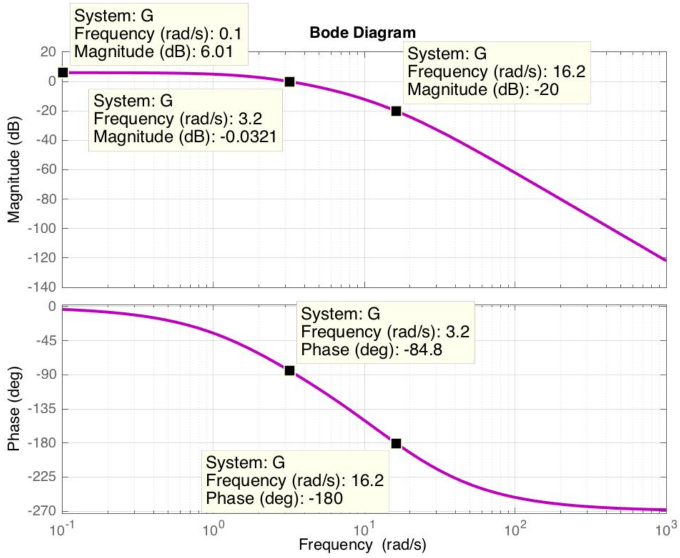
iii. Find the location of zeros and poles approximately. ______________________

iv. Calculate the gain. ______________________



Solution-3: *Answers will be given on the Problem. Computations should be presented below.*

Problem-4. For the Bode plots on the right, which were obtained experimentally from a subsystem $G(s)$ for K=800,



- **(a)** Determine the Gain Margin in dB,
- **(b)** and Phase Margin in degrees.
- **(c)** What is the value of gain, K_{cr}, that makes the system marginally stable?
- **(d)** What would be the period of oscillation, T_{cr}, in sec at this gain?
- **(e)** Write the range of gain K to keep the system stable.
- **(f)** Determine the system type then find the appropriate static error constant and the corresponding steady state error.
- **(g)** Suppose that these Bode plots were obtained for K=1200; what would be the new static error constant and the corresponding steady state error?
- **(h)** What would be the new Gain Margin in dB? Is this new GM larger or smaller than the initial GM?

Solution-4:

Problem-5: Considering the unity feedback system given in **P-1**, where $G(s)$ is now as follows,

$$G(s) = \frac{80}{(s+5)(s^2+4s+64)}$$

(a) Sketch the Nyquist plot of $G(s)$ and determine the real- and imaginary-axis crossing points.

(b) Using the Nyquist criterion find the range of K for stability.

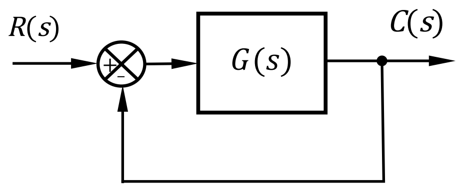
(c) Find the Gain Margin in dB.

(d) What would be the value of gain when working with a gain margin of 8 dB?

(e) What would be the real-axis crossing value at that gain?

Solution-5:

Problem-6. Considering the unity feedback system on the RHS, where the open-loop transfer function is,



$$G(s) = \frac{K}{s(s+40)(s+100)}$$

find the value of gain K to yield a closed-loop step response with 20% overshoot (ζ=0.456) using frequency response techniques.
Then simulate the system to evaluate how much the output meets the requirements.

You may follow the steps below.

1. *Draw Bode diagram for a gain K so that the magnitude of* $G(s)$ *is* 0 dB *for* $\omega = 1$rad/s.
2. *The Phase Margin to meet the maximum percent overshoot of* 20% *would be*

$$PM = \tan^{-1}\frac{2\zeta}{\sqrt{-2\zeta^2+\sqrt{1+4\zeta^4}}}$$

3. *Find the value of K to yield this phase margin.*

Problem-7. Design a Lag Compensator for the system given in **Problem-6** for K = 120,000 that will reduce the steady-state error 10 times while still operating with 20% overshoot.
Then simulate the system to evaluate how much the output meets the requirements.

You may follow the steps below.

1. *Set the gain, K, to the value that satisfies the steady-state error specification and plot the Bode magnitude and phase diagrams for this value of gain.*
2. *Find the frequency where the phase margin is* 10° *greater than the phase margin that yields the desired transient response. At this freq., the magnitude plot must go through zero* dB.
3. *Now design the compensator by starting from drawing the high-frequency asymptote. Arbitrarily select the higher break frequency to be about one decade below the phase-margin frequency. Starting at the intersection of this frequency with the lag compensator's high-frequency asymptote, draw a* – 20 dB/decade *line until* 0 dB *is reached. Then find the lower break frequency. Select a gain value to yield a dc gain of unity.*

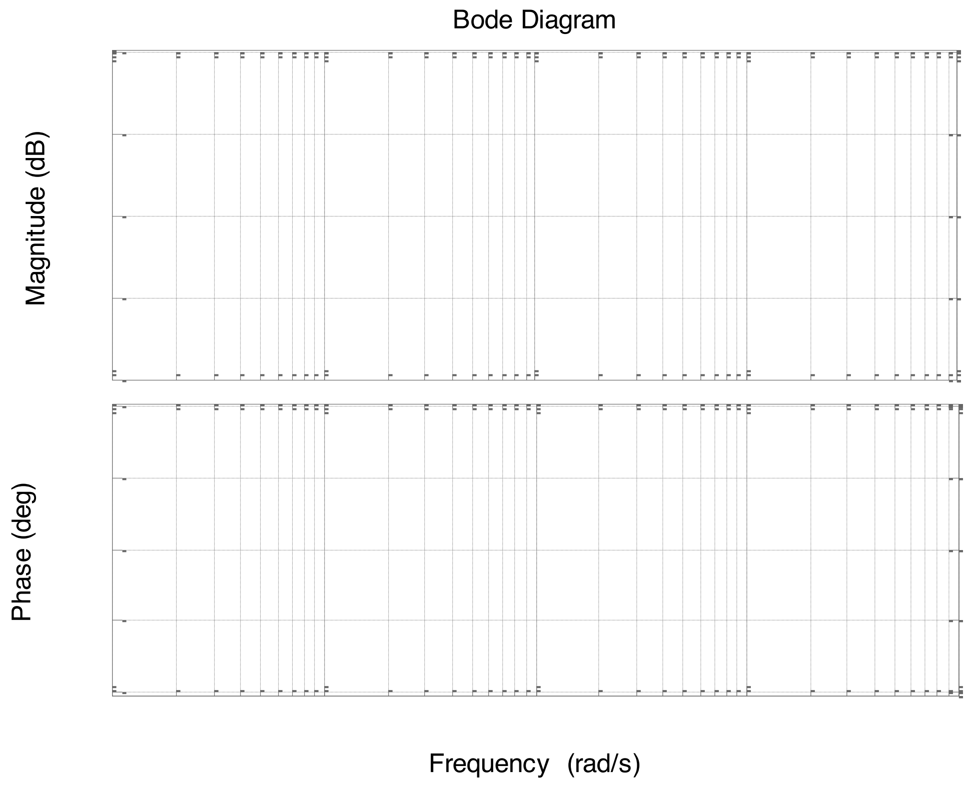
Problem 8. (a) Design a lead-lag compensator whose general expression is given below for the parameters of $\gamma = 5,\ T_1 = 0.05,\ T_2 = 0.2$, where K is to be determined to yield 0 dB at low frequencies. **(b)** Sketch its Bode plots by hand.

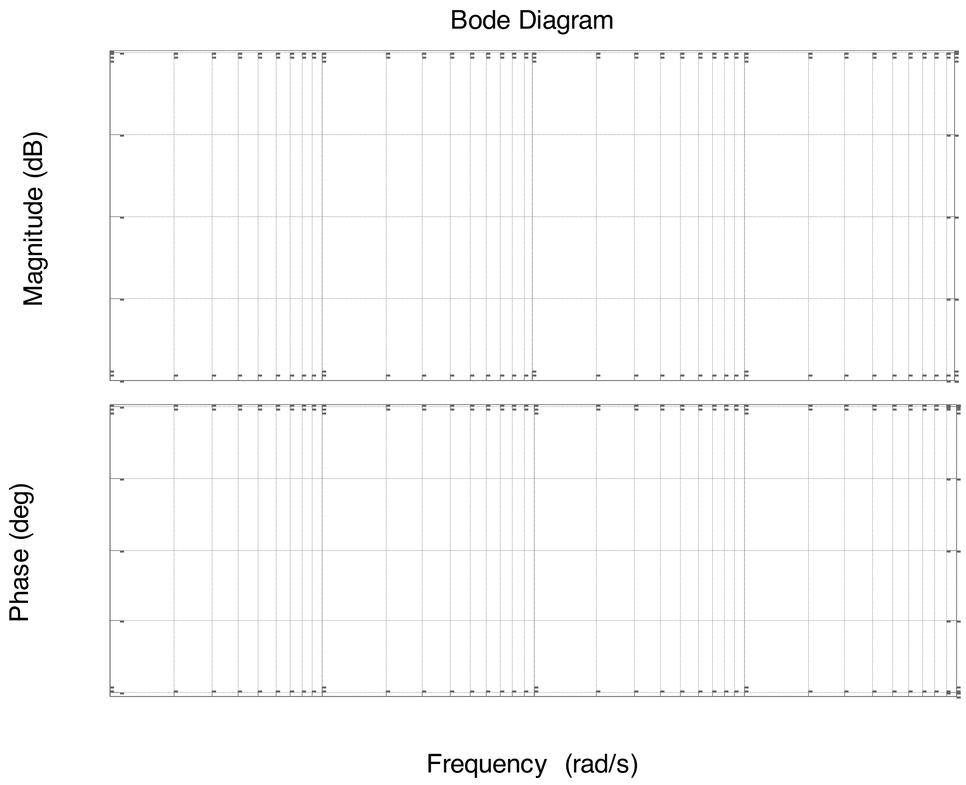
$$G(s) = K\left(\frac{s+\frac{1}{T_1}}{s+\frac{\gamma}{T_1}}\right)\left(\frac{s+\frac{1}{T_2}}{s+\frac{1}{\gamma T_2}}\right)$$

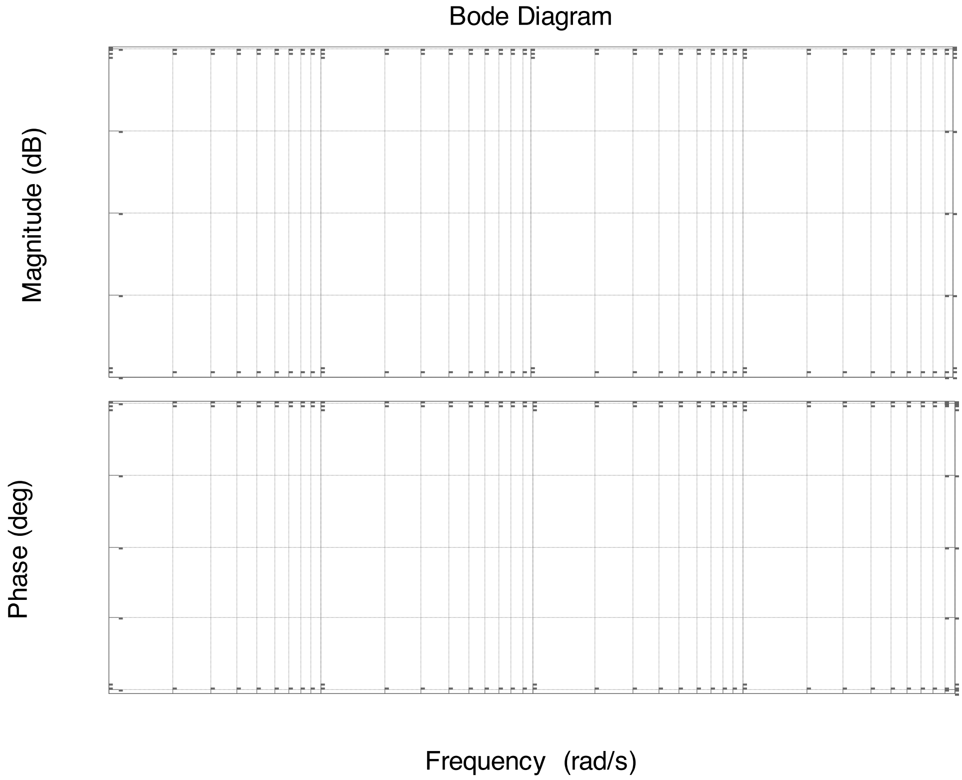
Problem-9. Design a lag-lead compensator for a unity feedback system with the forward-path transfer function, $G(s) = \frac{K}{s(s+8)(s+30)}$ to meet the following specifications:
$\%OS = 10\%, T_p = 0.6$ sec and $K_v = 10$. Use frequency response techniques.

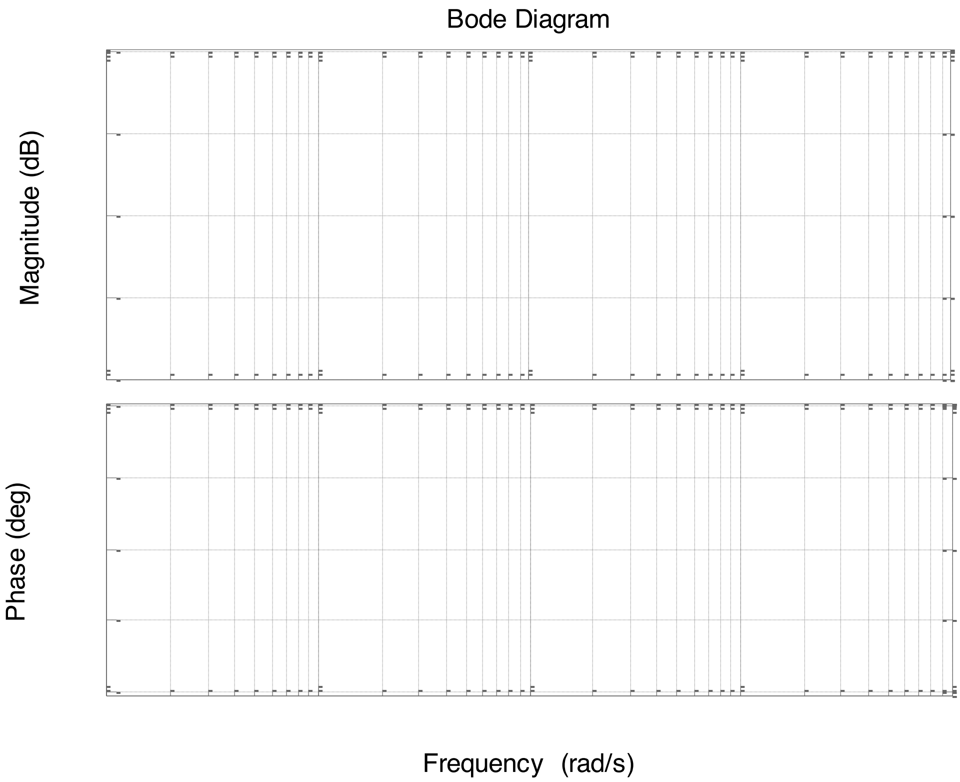
Problem-10. Repeat Problem 9 using root-locus techniques.

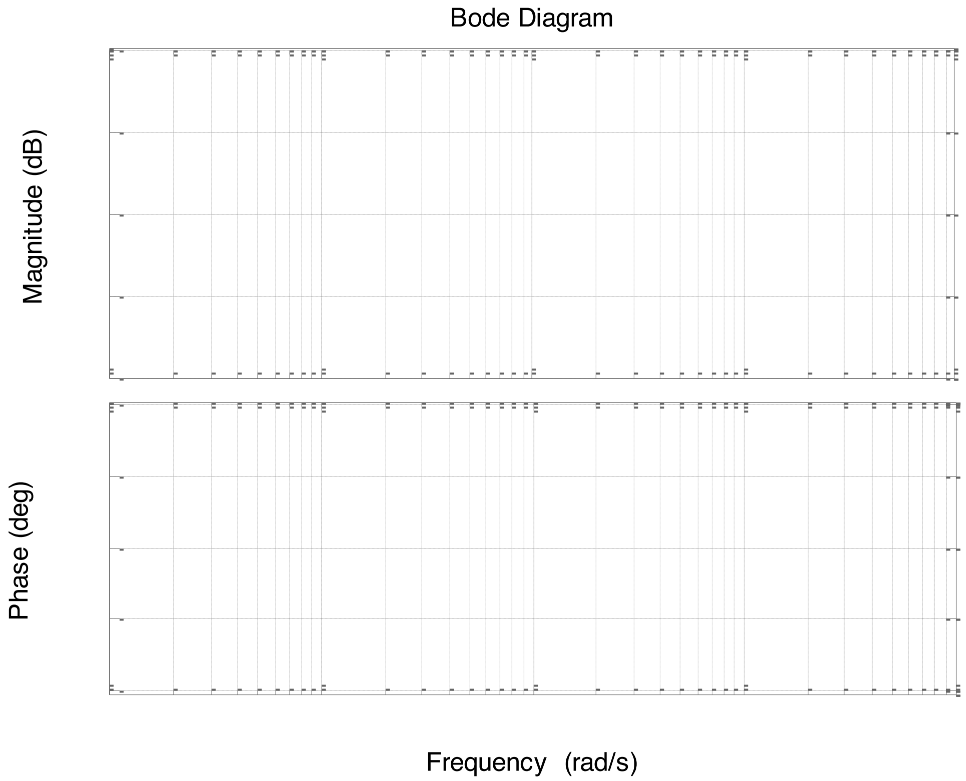
Solutions 6 to 10 will be presented separately on additional pages.

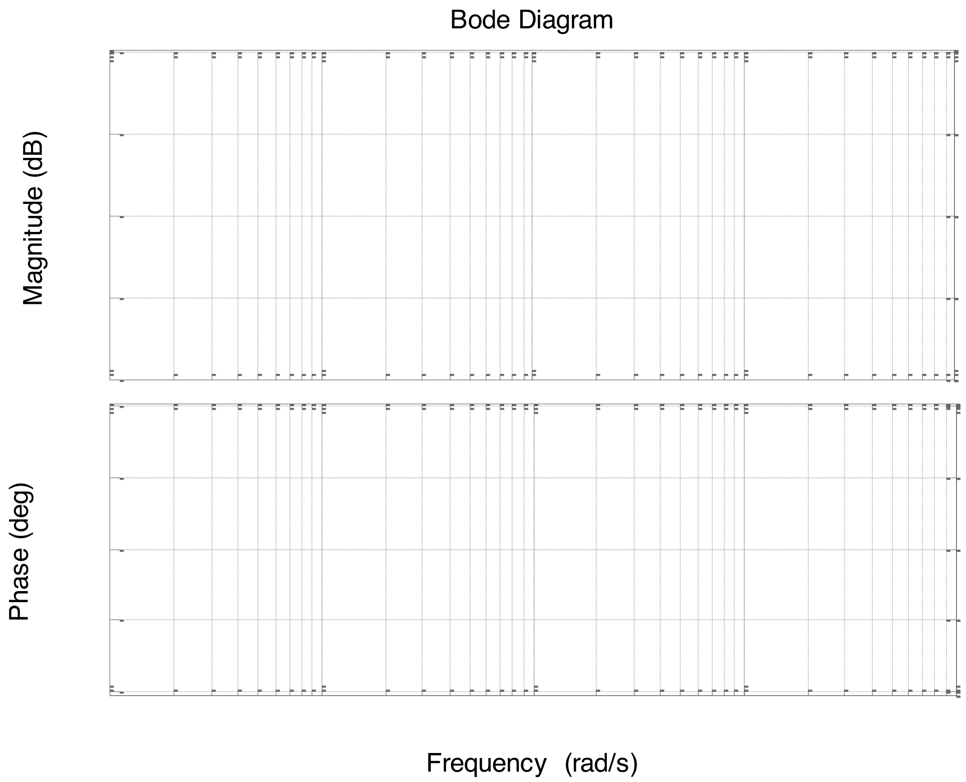

Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/s)


Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/s)


Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/s)


Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/s)


Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/s)


Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/s)