Homework #5

EEET–427–01:Controls Systems

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11/17/2021

1 Section 1

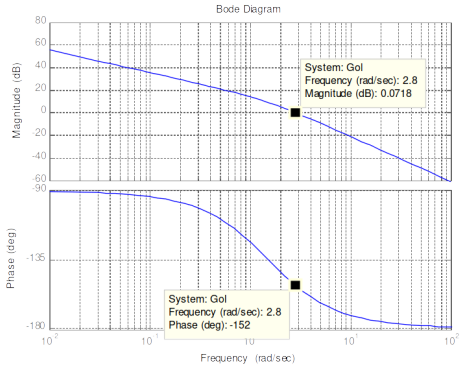
1. Create a bode plot showing the magnitude in dB and phase of the below lead compensator. Clearly mark on the plot the peak phase in degrees created by the compensator and at what frequency the peak phase is created (in rad/sec).
$$G_c(s) = 10\frac{s+50}{s+500} \tag{1}$$
2. Using the design formula for $_{max}$ in terms of α, what is the theoretial max value of phase that the compensator adds? You will need to figure out what α is and plug it into the formula.
3. At what frequency is the phase max?
4. Using the formula of the lead compensator, calculate (using a calculator) what the magnitude of the compensator gain is at $\omega = 5rad/sec$.
5. ... at $\omega = 5000rad/sec$.

2 Section 2

6. Design a phase lead compensator to produce a max of 30° of phase shift at a frequency of $\omega = 10rad/sec$. Include 5° of margin in your design. What is the value of α?
7. What is the value of T for this lead compensator?
8. What is the transfer function of the compensator? Specifically, where are the poles and zeroes? Create a bode plot (both gain and phase) for the compensator.
9. What is the gain of the compensator (in dB) at $\omega = 0.1rad/sec$?
10. ... $\omega = 10rad/sec$?
11. ... $\omega = 1000rad/sec$?

3 Section 3

12. A control system has an open loop gain transfer function of:
$$G_{ol}(s) = \frac{9}{s(s+1.5)} \tag{2}$$
The open loop gain bode plot is shown below:
Design a phase lead compensator to achieve a closed loop step response with a 10% overshoot. Note that the percent overshoot is related to the damping ratio through the formula given in the design overview section above. What does the damping ratio have to be?



13. What does the phase margin have to be to achieve this damping ratio?
14. How much phase in degrees must the lead compensator contribute to achieve this damping ratio? Be sure to include an additional 5° of margin in your answer?
15. What is the value of α?
16. What is the value of T?
17. What are the poles and zeros of the final lead compensator transfer function?
18. What is the gain of the compensator (in dB) at $\omega = 0.1 rad/sec$?
19. $\ldots \omega = 3 rad/sec$?
20. $\ldots \omega = 1000 rad/sec$?