Recommended Assessment

Lead Compensator

Lead Compensator Design

1. Find the magnitude of the frequency response of the plant-integrator transfer function, ($|P_i(s)|$), in terms of the frequency ω.

2. The system has a gain of 1 (or 0 dB) at the crossover frequency ω_g. Find the expression for the crossover frequency in terms of the model parameters K and τ for $P_i(s)$ and calculate the value of the crossover frequency.

3. Generate the bode plot of $P_i(s)$ and provide a screenshot of the plot. Validate that the crossover frequency calculated in the previous question is accurate.

4. Using the Bode plot for $P_i(s)$, find the proportional gain K_c necessary such that $K_c P_i(s)$ has a crossover frequency of 20 rad/s and generate the Bode plot of $K_c P_i(s)$ and take a screenshot of the plot. Convert the gain from decibels (dB) to absolute units.

5. Calculate how much phase lead ϕ_m, needs to be added to the system $K_c P_i(s)$ by the lead compensator.

6. Calculate the constant α , use the equation from the concept review,

7. Determine the new crossover frequency, ω_m.

8. Validate whether the crossover frequency obtained meets the desired requirements.

9. Derive the transfer function of the Lead compensator.

10. Calculate the pole and zero locations of the lead compensator. And generate the Bode Plot. Validate that the desired phase margin occurs at the target frequency. Attach a screenshot of the plot.

11. Generate a Bode plot of fully compensated loop $K_c C_L(s) P_i(s)$. Take a screenshot of the Bode plot. Are the system requirements met?

12. How does modifying the variables `cross_freq_des` and `PM_des` within the MATLAB script lead_design.m, affect the system requirements?

13. If the system requirements were not met and changes were made to the system bandwidth and phase margin, describe the process for changing them and show the final values for PM and ω_m.

14. Simulate the step response of the completed system loop using Section 6 of the MATLAB script, lead_design.m. Take a screenshot of the plot and the performance metrics. Are the system requirements met?
    Note: It is okay if the system requirements are not met at this stage, they will be adjusted in the implementation stage.

15. Generate a Bode diagram showing both the uncompensated and compensated system plots overlayed. Show a screenshot of the response.

Lead Compensator Implementation

16. Show the plot of the response (`Speed (rad/s)` and `Vm (V)` scopes) obtained from the hardware implementation of the Lead compensator. Use the measurement tool as shown to measure the percentage overshoot and peak time of the response. Does the response match the predicted step response from the previous section? Does the response meet the requirements for the system? If it does not, adjust K_c until the requirements are met.