EEE 342 Feedback Control Systems
Spring 2024-2025

Lab 3 - Margin Analysis of a System

The purpose of this lab is to understand how gain, phase and delay margins can be estimated by using mathematical model, and how these calculations can be verified.

Part-1: Margin Estimation

A controller is designed for your plant, which contains a first order LPF and PI controller, s.t.

$$G_c(s) = \left(\frac{1}{s + \tau_{LPF}}\right)\left(\frac{K_c(s+80)}{s}\right)$$

where $K_c,\ \tau_{LPF}$ is found by

$$K_c = \frac{2}{K_g}, \quad \tau_{LPF} = \frac{3}{\tau_p}$$

where K_g is the DC gain of the plant, and τ_p is the reciprocal of distance of pole of the plant to the imaginary axis (τ found in lab-1).

1. For this controller ($G_c(s)$) and the first order approximation of DC motor ($G_p(s)$) with time delay (you need to use the first order Pade approximation introduced in lab-2), draw the Bode plot.

2. Calculate gain margin and phase margin by using this plot. Also, calculate the delay margin (DM) by using phase margin and crossover frequency. You can check your results using ‶allmargin″command.

Check-1 Show your calculations (DM) and Bode plot to one of TAs.

Report Plot the Bode diagram and show your calculations and estimated margins.

Part-2: Margin Verification

1. Download `lab3_step_GM.slx` and `lab3_read.slx` from moodle. Configure these files as you did in first lab (you can use manual of first lab). **Note that the initial buffer size must be set as 128 in order to avoid any error related with memory size**. Do not forget to adjust target hardware, baud rate, sampling period etc. Click on "Build, Deploy & Start" button to deploy your code on Arduino Board.

2. Set $r(t) = 40u(t)\ rpm$ and your controller ($G_c(s)$), and increase gain (K) until the system is unstable (you need to find the gain margin experimentally, therefore you can start with the GM you estimated in part-1, and decrease if it is already unstable or increase if it is not. At the end, you need to find the exact value of K_f that makes the system unstable, so that the system is stable for $K < K_f$).

Check-2 Show your calculated GM, observed GM and response of the system for two cases: K_1 is slightly less than K_f, so that the system is stable, and K_2 is slightly larger than K_f such that the system is unstable.

3. Download `lab3_step_DM.slx` from moodle. Configure this file as you did in first lab (you can use manual of first lab). Do not forget to adjust target hardware, baud rate, sampling period etc. Click on "Build, Deploy & Start" button to deploy your code on Arduino Board.

4. Set $r(t) = 40u(t)\ rpm$ and your controller ($G_c(s)$). The block with the title 'Delay' causes time delay in system. Increase the time delay until the system is unstable to find the delay margin (h_f). You can use the same procedure as explained in step-2.

Check-3 Show your calculated DM, observed DM and response of the system for two cases: h_1 is slightly less than h_f, so that the system is stable, and h_2 is slightly larger than h_f such that the system is unstable.

Report Compare estimated and calculated margins. Draw the plots you used to get checks. If they are different, explain the reasons.

In your report, you are expected to explain the work done in order. It needs to include all plots you drew, all mathematical equations you did (handwritten results will not be accepted), and all the results you obtained in the lab. You also need to comment on each result you obtained between lab checks. All Matlab code should be included in your reports. Do not forget to use report template and write introduction and conclusion parts.