EEE 342 **Spring 2019**

Lab-2 Preliminary Work Manual

In this work, you will need to use root locus to design a PI controller such that the step response of the closed velocity loop has least settling time. Note that for an LTI system, the settling time is minimum when the maximum value of real parts of poles of the closed loop transfer function is minimized (i.e. the pole/s that are closest to imaginary axis needs to be as far as possible from the imaginary axis).

To achieve your goal, you will need to apply following steps:

1. Find $G_p(s) = K/(\tau s + 1) \times e^{-hs}$, by taking the average of K and τ values you found for 3 cases in lab-1.

2. In lab-1, we observed that there is a time delay in our systems. Therefore, by assuming that the time delay is exactly 10 milliseconds (h = 0.01), you need to use first pade approximation as follows

$$e^{-hs} \approxeq \frac{-hs/2+1}{hs/2+1} \rightarrow G_p(s) \approxeq \frac{K}{\tau s+1} \times \frac{-hs/2+1}{hs/2+1}$$

   Define this plant in Matlab by using `tf()` command.

3. Since the controller is PI (i.e. $G_c(s) = K_c(-s/z+1)/s$), you will need to check root loci for z values in the following range: `z=-100:0.1:-1`.

   (i) By using `rlocus()` command in Matlab for each z value, save minimum of maximum real parts of closed loop poles and corresponding K values in an array.

   (ii) Plot the minimum of maximum real parts of closed loop poles with respect to z values. Choose the z_1 value at global minimum of this graph.

   (iii) Plot the root locus for chosen z_1 value. Show the point where the closest poles to imaginary axis have minimum real parts (it should also show the corresponding gain (K_c)).

   (iv) Choose $z_2 = z_1/2$ and $z_3 = z_1/3$.

4. Design the closed velocity loop in Simulink. Use $G_c = K_c(-s/z_i + 1)/s$ as your controllers ($i = \{1, 2, 3\}$) and G_p as your plant. Show the block diagram in your report.

5. Use Step block as you have done in first preliminary work to provide the following input: $r(t) = 10u(t)$. Plot the step responses of 3 various systems on same figure. Note that you will need to use Simulink for your results. The results obtained from `step` command of Matlab will not be accepted. Use legends and labels to show your results clearly. Comment on your plot.

This is a technical report, therefore you need to type equations by using mathematical tools of the text editor you are using, and use the appropriate template with introduction and conclusion sections. Also, your report should include all the Matlab codes you used for this work. Note that you need to do your preliminary works individually.