EE 301P: Control Systems Laboratory
Lab Exercise 3

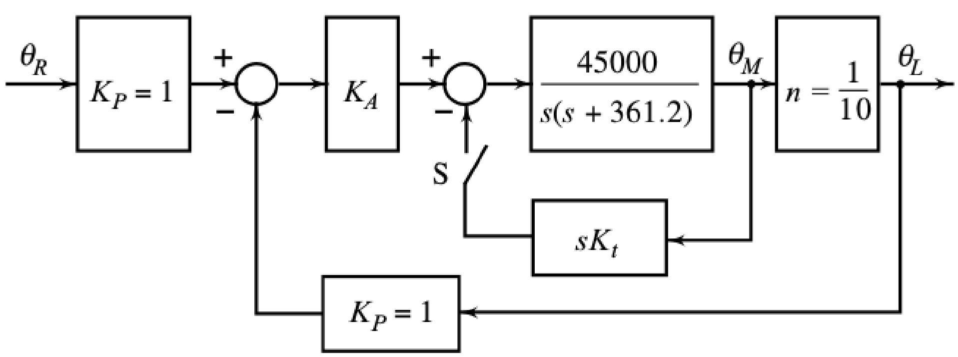
Lab session: September 1, 2023. *Report due*: September 08, 2023

1 Objective

To study the time response of a position control system, and tune the system parameters to achieve desired output.

2 Pre-lab exercise

The figure below shows the block diagram of a control system whose objective is to control the position of a mechanical load. The two potentiometers having sensitivity K_P convert the input and output positions into proportional electrical signals which can then be compared to find the error signal. The error signal is amplified by a factor K_A and then applied to the armature circuit of a dc motor whose field winding is excited with a constant voltage. The motor is coupled to the load through a gear train of ratio n. The block diagram also shows a minor feedback loop which corresponds to a tachogenerator (with transfer function sK_t) connected in the system to improve the damping. When the switch S is open, the tachogenerator is disconnected (as shown in the figure), K_A remains the only system parameter. One must then tune K_A to achieve the desired system output.



1. Simplify the block diagram and find the equivalent transfer function $\theta_L(s)/\theta_R(s)$ of the system.

2. Find the undamped natural frequency and the damping ratio in terms of K_A.

3 Lab exercises

1. Tune the parameter K_A to achieve
   (a) an over damped system
   (b) a critically damped system
   (c) an under damped system.
2. For the above cases, wherever applicable, find the undamped natural frequency, frequency of damped oscillations, peak overshoot, rise time and settling time.
3. Plot the step response of the system for each setting of K_A using MATLAB/Simulink; and verify the qualitative behaviour of the system output as well as the performance characteristics computed above. Plot the location of the poles in the complex plane for each setting of K_A. Draw inferences regarding the relationship between the location of the roots and the behaviour of system output observed above.
4. When the switch S is closed, the minor feedback loop with the tachogenerator comes into play. For this scenario, find the transfer function $\theta_L(s)/\theta_R(s)$. Assume that $K_t = 1$. Would the parameter tuning done in part (1) above still hold for the three cases (a), (b) and (c)?

4 Deliverables

1. Lab report must contain the following:
   (a) Derivations of the transfer function $\theta_L(s)/\theta_R(s)$ and the expression for the damping ratio ζ in terms of K_A.
   (b) Values of K_A for each case in part (1) with proper justification.
   (c) Computations showing all the terms derived in part (2).
   (d) Plots showing step response for each case in part (1) with the values of K_A chosen in part (1). The values of various transient response specifications must be marked on the plot and this must be validated by the computations shown.
   (e) Plots showing pole locations for each case in part (1).
   (f) Answers to questions in parts (3) and (4).
2. MATLAB code/ Simulink model.