FL. 2018 ESE 447.02 Robotics Lab

Lab Journal 15

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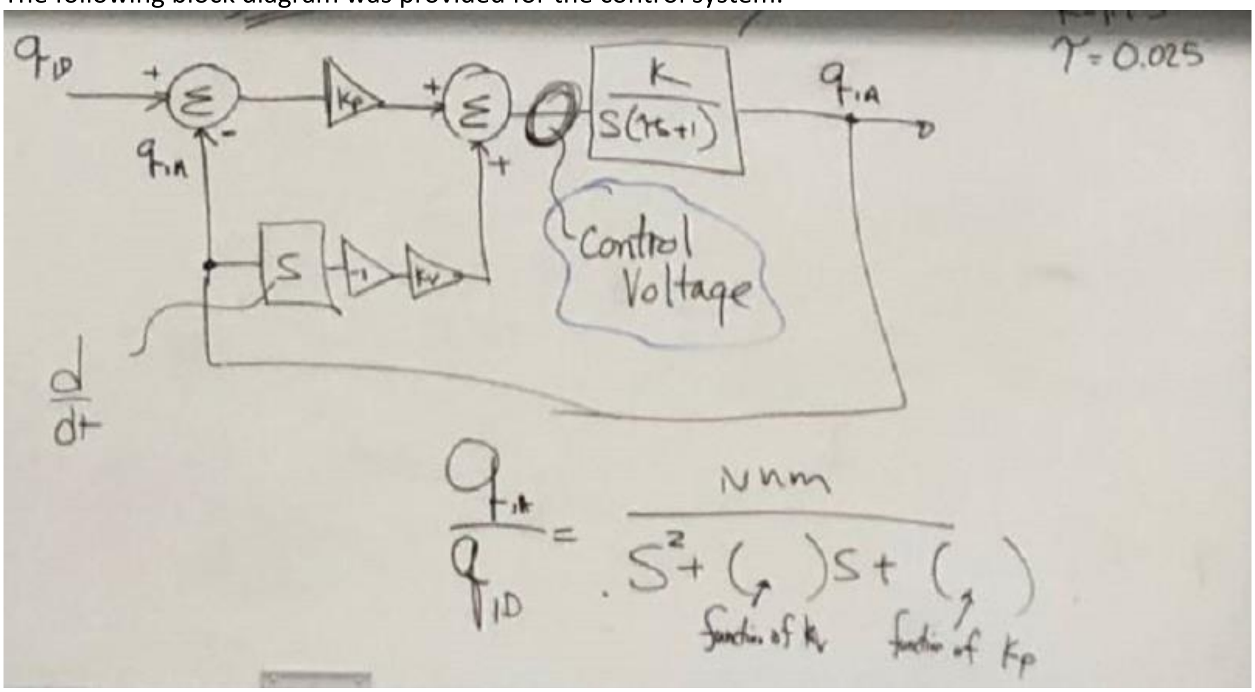
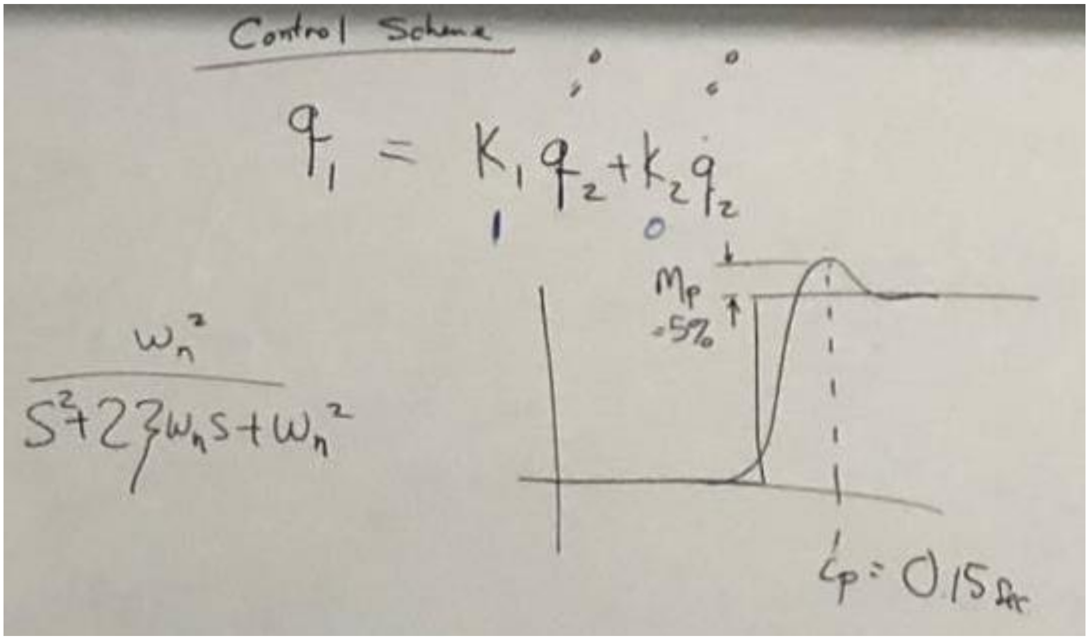
1. The swing-up controller.
   The swing-up controller includes the Simulink model needed to control the motor attached to link 1. The purpose of the swing-up controller was to make link 2 swing up from the static position to the position where the balance of link 2 can happen. This was achieved by oscillating q1 in particular frequencies and amplitudes. Varies frequencies and amplitudes can be used for the oscillation, so we just need to try with different values to get a relatively efficient setting. The swing-up controller should be a control system that can be modeled as a second-order control system. The performance of the control system would be defined by two parameters, the natural frequency and the damping ratio.
   The following block diagram was provided for the control system.

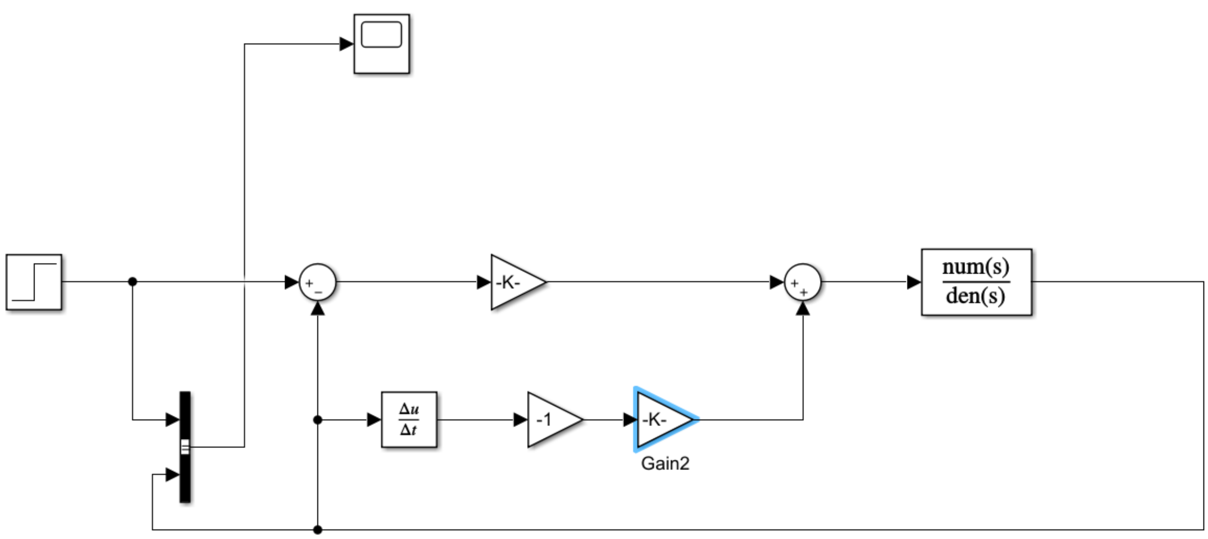


   In the diagram, the desired q1 is given as the input and the actual q1_dot is fed back, the gains for desired q1 and actual q1_dot show different importance between these two signals for the control system. The transfer function was given for the system we were using. It defines the ratio between the output and the input in Laplace domain.
   A typical step response of a second order system is shown as the curve below.



The curve shows how the system responses when given a specific step input. Our desired overshoot for the system was 5%. The step input is namely the desired q1. We attempted to specify the desired q1 and give it to the second-order system to accomplish the swing-up, so we gave an estimated relationship between desired q1 and q2, q2_dot so that the desired q1 can be constantly fed back to the controller.

2. Solving the block diagram for Kp and Kv.
   In order to get the desired performance of the control system, we derived the characteristic equation for the system by solving the block diagram. The gains Kv and Kp were then calculated such that we could get a percent overshoot of 5%.
   The gains we calculated were Kp = 12.1 and Kv = $-9.87\text{x}10^{-4}$.
   Kv is very small compared to Kp, which means the actual q1_dot signal has much less weight regarding controlling the output.
   The primary Simulink model we built based on the block diagram is shown in the picture below.



The gains blocks are where we give the Kp and Kv.