Motor Modeling and Position Control Lab
Week 3: Closed Loop Control

1. Review

In the first week of motor modeling lab, a mathematical model of a DC motor from first principles was derived to obtain a first order system. The open and closed loop (proportional-derivative) control was implemented specifically for this motor model. In the second week, a physical DC motor (Quanser SRV-02) was used for open-loop control implementation and the first order transient characteristics were observed. Based on the model response, DC motor parameters (time constant) were estimated both by hand-calculations as well as using MATLAB. You should have also observed in the open loop control of actual DC motor that the motor positions start to drift over time indicating continuous accumulation of error within the system. Another observation that should have been made is that there is no way to enforce the output of the motor to track the input voltage in the absence of any feedback loop.

In the final week of this lab, you will try to address some of these issues by realizing the benefits of closed-loop control of DC motor. In particular, you will:

1. study transient characteristics of a typical second order system and evaluate model or system responses using these specifications.
2. extend the closed loop control implemented in the first week of this lab to the actual DC motor
3. analyze the effects of proportional-, derivative- and integral- control individually and in combination on the closed loop response of motor
4. solve a position control problem by calculating PD controller gains analytically and validate the control by monitoring the motor response for different desired trajectories
5. design a PID controller for the actual DC motor using Ziegler-Nichols' method and compare the performance with that of the PD controller

2. DC Motor Model

We derived the mathematical model of DC motor earlier and obtained the following first order transfer function that relates the motor velocity (rad/s) to input voltage (V) as:

$$\frac{\Omega_l(s)}{V_m(s)} = \frac{K}{\tau s + 1}. \tag{1}$$

where τ is the mechanical time constant of the system, and K is the steady state gain(also known as DC gain).

Since, angular position can be obtained by integration of angular velocity, the open loop transfer function between angular position (rad) and input voltage (V) can be obtained from (1) as in (2):

$$\frac{\Theta_l(s)}{V_m(s)} = \frac{K}{s(\tau s + 1)} = \frac{K}{\tau s^2 + s} = \frac{a}{s^2 + bs} \quad \because \Theta_l(s) = \frac{1}{s}\Omega_l(s) \tag{2}$$

Motor Modeling And Position Control Lab Week 3 Closed

Padhraic Smyth

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