EEE 342 Spring 2019

Lab-1 Preliminary Work Manual

A company asks you to identify a system by using the input signal (a step input with an amplitude of 90 degrees) and the response data of a closed loop system they designed. They also let you know that the system consists of a DC motor which can be represented by a first order strictly proper transfer function, a low pass filter (LPF) that filters the error in rpm units to provide voltage to DC motor, and a proportional (P) controller in the closed position loop which amplifies the error signal in degree units and provides reference input to closed velocity loop in rpm units. You are given the following block diagram from the company.

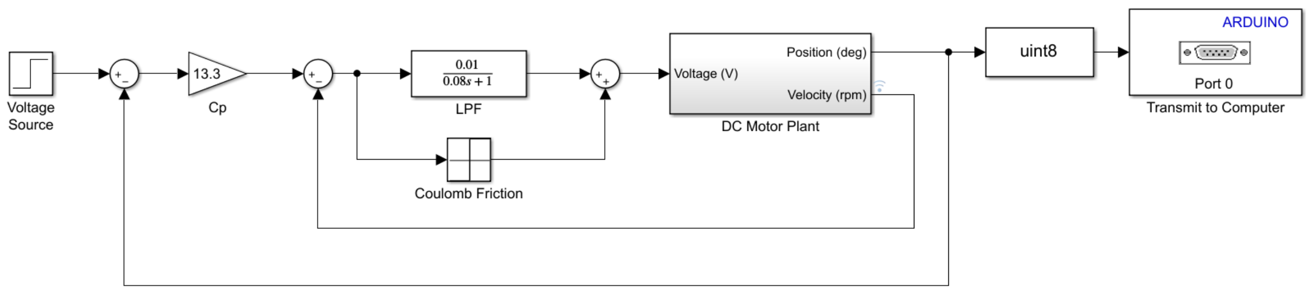


Figure 1: Test setup provided by company

Note that the Coulomb Friction block is designed to compensate the nonlinear effect (naturally, an imperfect compensation). Thus, you may assume the closed loop system is linear (you can ignore that block and the summation before the Voltage input of DC Motor Plant block).

Additionally, the system design engineers inform you that the time delay can be neglected during identification since it is low and does not affect the frequency range you will be working on. By assuming that there are no zeros in the given system, you design the following block diagram whose parameters are to be estimated by using the input signal, output data and the given closed loop system in previous figure.

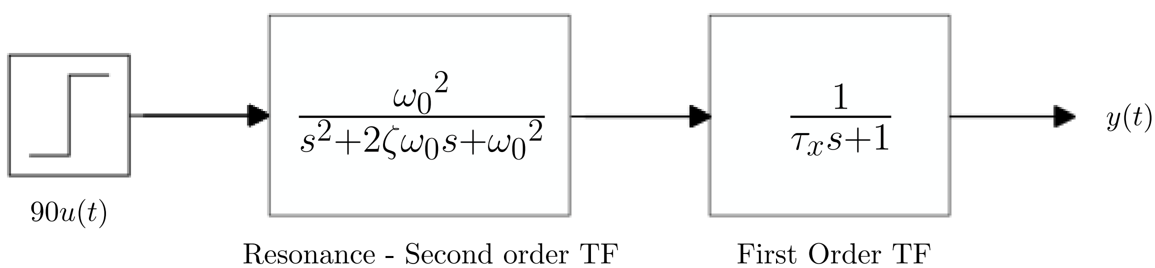


Figure 2: Simplified form of closed loop transfer function

You will achieve your goal when you estimate the parameters of DC motor in the form $K/(\tau s + 1)$. To do this, you will need to apply following steps:

1. Find $T_p(s)$, the closed loop transfer function of the position loop, in terms of K and τ.
2. Separate $T_p(s)$ into 2 parts as shown in Fig. 2.
3. Estimate $\boldsymbol{\omega_0}$ and $\boldsymbol{\zeta}$ by assuming that the second order dynamics are dominant. You can use approximations of maximum overshoot and settling time formulas.

4. You will end up with 3 unknowns $\tau_x,\ K,\ \tau$. Analytically calculate these parameters. Note that due to scaling, numerators do not have to be equal (Hint: $w_0^2 \neq N_{T_p}(s)$, where N_X is the numerator of function X).

5. Implement the block diagram in Simulink by using the first order approximation you found for DC motor. You will need to use the following blocks in Simulink Library:

   Simulink $\rightarrow$ **Sources** $\rightarrow$ **Step:** Set step time to 0, initial value to 0, and final value to proper amplitude.

   Simulink $\rightarrow$ **Continuous** $\rightarrow$ **Transfer Fcn:** Enter the values you found in previous parts accordingly in numerator and denominator. Note that entering [1 2 4] results with $s^2 + 2s + 4$. To enter the undefined parameter τ, read the last step.

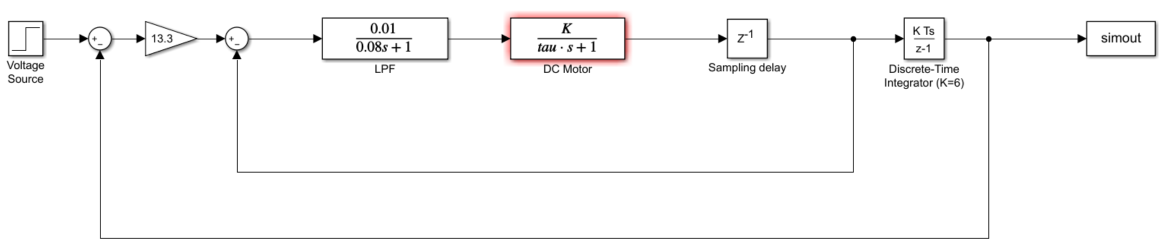
   Simulink $\rightarrow$ **Discrete** $\rightarrow$ **Delay:** The arduino transmits encoder count per 10 milliseconds. Since the sampling time you will be using in Simulink is also 0.01 seconds, enter 1 for delay length.

   Simulink $\rightarrow$ **Discrete** $\rightarrow$ **Discrete-Time Integrator:** The angle data is obtained by integrating velocity data calculated by using encoder output. Since position data is in degree units, the gain of integrator is 6 ($p(t) = \int 6v(t)dt$).

   Simulink $\rightarrow$ **Sinks** $\rightarrow$ **To Workspace:** This block will provide you to interpret the output data in the workspace. The "Variable name" property defines the string of the double-array that will be present at your Workspace.

   Lastly, you will need to configure the simulation time and sampling time. Press Ctrl+E to open configuration window (or simply click the generic tools button). In "Solver" section, choose the type of "Solver selection" as **Fixed-step**, and open Solver details. Set fixed-step size (fundamental sampling time) to 0.01, which means the Simulink will return samples with a sampling time of 10 milliseconds. Set simulation time to 10 seconds.

   Your final Simulink block diagram will look like the following figure.



6. Run the Simulink tool. Plot the output of your result on top of plot of given data and provide a single plot.

Matlab and Simulink will be used in all lab assignments. Therefore, check Simulink tool before attending the first lab to finish assignments in time.

In your report, provide the figure of response data that is given to you and specify the points that you use through your calculations (use data tips to specify points, i.e. max. overshoot, settling time, steady state value on a single plot). Also, Simulink block diagram needs to be shown in your report. Lastly, plot output of your block diagram and the data on a single figure. Comment on your results and explain the reasons behind differences between responses (Hint: think about the steps we followed).

Show the mathematical equations you used clearly. Note that 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.