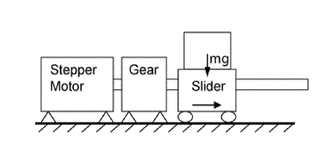
6.3 Dynamics optimizing - 15 points

Opened: Tuesday, 19 November 2024, 10:00 AM
Due: Tuesday, 3 December 2024, 10:00 AM

A motor is connected to a gear which controls the linear movement of a slider via a ball screw. The combined mass of the slider and the load is 100 kg. The ball screw and the slider are assumed to be frictionless and the efficiency of the gear is 1.



The specifications of the system are:

- Maximum torque produced by the motor T_{max} = 5 Nm
- Maximum motor shaft velocity n_{max} = 6000 rpm
- Mass of the slider and the load m = 100 kg
- Inertia of the motor rotor J_r = 32 x10-4 kgm2
- Inertia of the gearbox is neglegted
- Pitch of the ball screw p = 4 mm
- Inertia of the screw J_s = 90 x10-4 kgm2

Build a Simulink model of the system described. The motor can be assumed to be an ideal torque source i.e. it can produce the maximum torque until the maximum rotating speed is reached. Using your model, find the optimal gear ratio for moving the load a distance of two meters as quickly as possible from stand still. The end speed of the load does not matter, only the time it takes for the displacement of the mass to be 2 m.

When buildin a Simulink-model, consider the following things:

- How to limit the motor speed? (Function blocks 'Min' or 'Saturation' or 'Integrator' parameters)
- How to end the simulation, when the mass has moved 2 m? (Function blocks 'Compare to constant', 'Stop')

To solve the optimal gear ratio, build a Matlab function that takes the gear ratio variable as an input parameter, simulates the system with that ratio and returns the time it takes to move the mass (end time of the simulation i.e. time of the last data point).
Minimize that function with a built-in optimizing function 'fminbnd'. Do not make a manual iteration loop or guestimate, use fminbnd. Example script given as an attachment below.

1. Show an image of your model.
2. Plot the velocity and displacement of the slider with the optimal gear ratio.
3. Explain why a gear ratio as big as possible is not the best option.
4. What is the optimal gear ratio and how long does it take to reach the displacement of 2 meters.

Return your answer as a .pdf file. Return also your Simulink model and the optimization scripts.

Tips and resources:

- The equation for reducing the mass of the slider to equivalent moment of inertia **on the axis of the ball screw** is $J_{red} = mp^2/(4\pi^2)$
- Matlab function
  - The function must be a separate script file in the same folder as the model file and the main script file.
  - Simulink uses by default the variables defined in the main workspace of Matlab. The function you will create has an independent workspace i.e. the variables defined in the normal Matlab workspace are not usable inside the function. When you run your Simulink model from inside your function with the function "sim()", use the following commands to make the Simulink model uses the variables defined inside your function. These options also limit the maximum time step of the simulation.
    - options=simset('SrcWorkspace','current','MaxStep','0.0001');
    - sim('yourmodelname',[ ],options)
- To access the last value of a vector, you can use the following syntax "vector(end)"
- Optimizing function fminbnd.
  - The first required parameter for the function is the name of the function with @ before the name. The name defined in the function must match the filename of the function .m file.
  - The two latter parameters define the bounds for the search space of the optimal gear ratio i.e. the minimum and maximum gear ratios the function will try. You need to estimate some sensible bounds. The function to be optimized must be continuous between the bounds. Make sure the simulation time in your model is long enough so the slider reaches the end also with the gear ratio at the ens of your search space.
  - There must be only on minimum point for the optimization to work properly (should not be a problem in this exercise).
- Be careful if you are going to use variable name 'i'. By default it refers to the unit complex number. This means that if you forget to define your gear ratio, which should be defined in variable 'i', Matlab will not give an error but makes the calculations with the unit complex number and then of course the results are not what you expected.

Optimization example.zip 7 October 2024, 10:12 AM

Submission status

Submission status	No submissions have been made yet
Grading status	Not graded
Time remaining	Assignment is overdue by: 83 days 23 hours

Previous activity
◄ 6.2 Potentiometer - microcontroller - DC motor - 10 points

Next activity
Solutions for exercise round 6 ►