ELEC 341 – Graded Assignments

Project P-4

10 Marks

Learning Objectives

- Develop Accurate Motor Model
  - Electrical
  - Mechanical
  - Feedback Loop
- Update Actuated Gripper Model with Accurate Motor Parameters
  - Dynamic Bearing Friction
  - Mechanical (Motor + Load) Model
  - Motor & Finger Angle

Mech Damping

Compute the mechanical damping of your Maxon motor

- P4_Bm = Dynamic Bearing Friction (Nms)

*If you apply **Nominal Voltage** to the motor, as motor speed increases, back-emf also increases, so current drops and torque drops. This relationship is called the **Speed/Torque Gradient**. It is a by-product of the **Motor Constant** and has nothing to do with **Dynamic Bearing Friction**, even though they have the same physical units.*

*This is pure coincidence and causes many to confuse **Speed/Torque Gradient** with **Dynamic Bearing Friction,** which is not explicitly provided by the data-sheet.*

*To find **Bm**, consider the following.*

*If you apply **Nominal Voltage** to a motor, it turns at **No Load Speed**, and draws **No Load Current**, which means it must be delivering **No Load Torque,** which you can calculate using the **Motor Constant**.*

*But the motor is connected to **NOTHING** and it is not accelerating. So what is balancing the torque that the motor is delivering ??? The answer is **Dynamic Bearing Friction Bm.***

*Maxon did this exact experiment and recorded their results in the data-sheet so you have all the info you need to calculate **Bm**.*

Time Constant

Calculate the speed your motor should reach at the **Mechanical Time Constant**.

- P4_TCspd = Motor Speed @ Time Const (RPM)

No Load Current & Speed

Develop a Simulink model of the un-loaded motor.

Use the **LTI System Block** to integrate **Ym** right into your Simulink Model without deconstructing it into coefficients, poles, or zeros.

Use a regular Transfer Function block for Electrical Admittance **Ye** since it is convenient to specify in terms of coefficients.

Add a scope to plot **No Load Current** and

Add another scope to plot **No Load Speed** and **TCspd** together**.**

Be consistent with the physical units and time axis from the data-sheet.

- Simulink Model
- No-Load Current Plot
- No-Load Speed Plot

Does the plotted values agree with the data-sheet ??? How about the time constant ???

What's the difference between No-load and Nominal speed ??? Did you read page 72 ???

*By how much does it differ ??? Does this mean you did something wrong ??? How do you know ??? Did you read page 72 **CAREFULLY** ???*

Updated Motor Model

Re-calculate Ym from P-3 using the non-zero motor Bm you just calculated.

- P4_Ym = $\omega M/\tau M$ = Motor **Speed** / Motor Torque (rad/Nms)

Load Model

Re-calculate θL from P-3.

- P4_Gf = $\theta L/\tau M$ = Finger **Angle** / Motor Torque (deg/Nm)

Loaded Motor Model

Develop a Simulink model that outputs both **angles**:

- Loaded Motor = output motor angle (deg)
- Loaded Motor = output load angle (deg)

Motor models should include all relevant motor parameters

- Winding Resistance Rw
- Winding Inductance Lw
- Motor Constant Km
- Dynamic Bearing Friction Bm
- Rotor Inertia Jm

Angle Plot

Apply a step that is ½ the nominal voltage of the motor.
Plot both the motor and load angles.

- Simulation time = 10 x **Mechanical Time Constant**
- In Scope window: **View/Configuration Properties/Time/Time units = Metric**
- In Scope window: **View/Configuration Properties/Time/Show time-axis label**

How does this step response compare to the one from the previous assignment ???
In the previous assignment you ignored motor friction. Was anything else different ???
Should you expect the same FV ??? How can you check ???
Should you expect the same envelope (Tr, Tp, Ts, OS) ???
Did motor friction affect your results in the way you would expect it to ???
How do the results compare if you use the exact same time scale ???
These are the questions you should ask to figure out if your results are reasonable.
DO NOT IGNORE THEM.

Deliverables

Values

1. P4_Bm (1 marks)
2. P4_TCspd (1 marks)
3. P4_Ym (1 marks)
4. P4_Gf (1 marks)

Figures

1. No-Load Curr & Spd (2 marks)
2. Loaded Motor Model (2 marks)
3. Angle Plot (2 marks)