

ELEC 341 – Graded Assignments

Project P5

10 Marks

Learning Objectives

- State-Space Representation
 - Motor & Finger Angles
 - Spring Torques
- Simulink State-Space Models
 - State-Space Block
 - Demux
 - Mux
 - Terminator

Develop a State-Space representation of the “Mechanical Circuit of Gripper” in P3 that can be used to find angles, forces, or anything else.

State Matrices

Assume all initial conditions are 0.

Use the following state vector, in the following order. Delete any dependent states.

- $\bar{x} = [\theta_M \ \theta_G \ \theta_F \ \theta_L \ \omega_M \ \omega_G \ \omega_F \ \omega_L]^T$
- All angles in (rad), all speeds in (rad/s)

Compute the **MECHANICAL** A & B matrices.

- P5_A = A matrix (mixed units)
- P5_B = B matrix (mixed units)

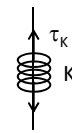
Output Matrices

Use the following output vector.

For all angles, **UP** corresponds to a **POSITIVE** angle, as drawn.

For all torques, τ_K is the **COMPRESSIVE** torque in spring K.

- $\bar{y} = [\theta_M \ \theta_L \ \omega_M \ \tau_{KG} \ \tau_{KF} \ \tau_{KL}]^T$
- All angles in (rad). All speeds in (rad/s). All torques in (Nm).



Compute the C & D matrices.

- P5_C = C matrix (mixed units)
- P5_D = D matrix (mixed units)

Spring Torques

Apply a step that is $\frac{1}{2}$ the stall torque of the motor, just like you did in P3.

Plot all spring torques on the same figure. Use solid, dashed and dotted lines, and different colours to show overlapping traces.

- Torque (Nm)
- Time (msec)
- LineWidth = 3
- Add Grid & Legend

Notice anything strange about **ALL** the final values ??? Is this just a coincidence ???

State Space Block

Use the Simulink State-Space block to update the “**Loaded Motor Model**” you created in P4. Your new **State-Space** block should be used to replace BOTH **LTI System** blocks.

Develop a Simulink model that outputs both **angles**. Don’t include any currents or torques.

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

Your SS model returns a vector of outputs. Use a Demux to separate it.

Use a Mux to re-combine your angles so you only need one gain block for unit conversion.

There is a Sink block called a “Terminator” that is useful for signals you aren’t using.

Do you still need the integrator block ???

State Space Angle Plot
Re-generate the “**Angle Plot**” you created in P4 using your new **State-Space** model.

- Motor Angle (deg)
- Load Angle (deg)

Configure your plot so it is easy to read. Nobody should ever have to tell you to do this.

Set the time vector so the system settles and you can see as much detail as possible.

Set the trace widths so they are comfortable to read.

Add a legend if needed.

Change the axis labels so they are meaningful & correct.

Deliverables

Values

1. P5_A (3 marks)
2. P5_B (1 marks)
3. P5_C (1 marks)
4. P5_D (1 marks)

Figures

1. Spring Torques (2 marks)
2. SS Block (1 marks)
3. SS Angle Plot (1 marks)