ELEC 341 – Graded Assignments

Assignment A-5

10 Marks

Learning Objectives

- State-Space Representations
- Transfer Functions from S-S Matrices

- Matlab
  - ss()
- Simulink
  - n/a

A State-Space representation of the "Mechanical Circuit" in Assignment #3 allows you to compute angles, positions and spring and damper forces, without having to derive an electrical equivalent first.

*Since torque is constant, the motor is being powered by a **CURRENT SOURCE**.*

*Configure your matrices so that applying a **UNIT** step to your State-Space object applies the **SPECIFIED TORQUE** to the system.*

Calc 1 2 mark(s) A Matrix

Assume all initial conditions are 0.

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

a) $\bar{x} = [\theta 1\ \ \theta 2\ \ \theta 3\ \ \theta M\ \ \omega 1\ \ \omega 2\ \ \omega 3\ \ \omega M]^T$
b) All angles in (rad), all speeds in (rad/s)

Compute the **MECHANICAL** A matrix for the system.

- C1_A = A matrix (mixed units)

Calc 2 1 mark(s) B Matrix

Compute the B matrix.

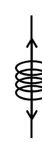
- C2_B = B matrix (mixed units)

Calc 3 1 mark(s) C Matrix

Use the following output vector.

For all torques, τXx is the **COMPRESSIVE** torque in element Xx.

a) $\bar{y} = [\tau K1\ \ \tau K2M\ \ \tau K23\ \ \tau K3\ \ \tau B1\ \ \tau B2\ \ \tau BM]^T$
b) All angles in (rad). All speeds in (rad/s). All torques in (Nm).



Compute the C matrix.

- C3_C = C matrix (mixed units)

Calc 4 1 mark(s) D Matrix

Compute the D matrix.

- C4_D = D matrix (mixed units)

Would you get the same A,B,C,D matrices from the equivalent electric circuit ???

***Prove it, for extra practice**.*

*Want to check your work ??? Just use **ss()** and **step()** to see the step response of all outputs. Some of these were solved in A3. If they agree, that's a good sign.*

All final values should be easy to compute BY INSPECTION. Are they ok ???

The sign (pos or neg) of all signals should be easy to check too. Do they all make sense ???

When the motor is powered by a VOLTAGE SOURCE, current and torque vary so you must include the electrical impedance of the motor in your State-Space model. Ignore the torque specification and include the Electrical Motor Parameters shown below.

Calc 5 5 mark(s) State-Space Matrices

Assume all initial conditions are 0.

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

a) $\bar{x} = [i\ \ \theta 1\ \ \theta 2\ \ \theta 3\ \ \theta M\ \ \omega 1\ \ \omega 2\ \ \omega 3\ \ \omega M]^T$
b) $\bar{y} = [Vw\ \ \tau M]^T$
c) All angles in (rad). All speeds in (rad/s). All torques in (Nm). All currents in (A).
d) All output torques are compressive.

Compute the **ELECTRO-MECHANICAL** State-Space matrices for the system.

- C5_A = A matrix (mixed units)
- C5_B = B matrix (mixed units)
- C5_C = B matrix (mixed units)
- C5_D = B matrix (mixed units)
- C5_STM = State Transition matrix (mixed units)

Are current & motor torque constant when you use a VOLTAGE SOURCE ??? Check !!!

Do you get the expected FV for each output ??? Check !!!

Electrical Motor Parameters

- Lw = (#F / 10) H
- Rw = (#C / #H) x 2 Ω
- K_M = (#C / #H) Vs
- V_{in} = 6 V