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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH DEGREE EXAMINATION, OCT/NOV 2021

Branch: Electrical and Electronics Engineering

Stream(s): Control Systems, Guidance and Navigational Control, Electrical Machines, Power System and Control

01EE6116: SLIDING MODE CONTROL

Duration: 3 hrs Max. Marks: 60

Answer any two full questions from each PART

Limit answers to the required points.

PART A

1. (a) Prove that the matrix pair (A_{11}, A_{12}) in regular form is controllable if and only if the pair (A, B) is controllable. (5)

   (b) Design a sliding mode control for a double integrator system. (4)

2. (a) Given the system (4)

$$\dot{x} = Ax + Bu$$

and

$$\sigma = Gx$$

with σ as the sliding output, find the equivalent control u_{eq} and the sliding dynamics. Given

$$A = \begin{pmatrix} 1 & 1 & 1 \\ 0 & 1 & 3 \\ 1 & 0 & 1 \end{pmatrix}, \quad B = \begin{pmatrix} 3 & 9 \\ 1 & -2 \\ -1 & 0 \end{pmatrix}, \quad G = \begin{pmatrix} 1 & 29 & 0 \\ 1 & 12 & 0 \end{pmatrix}$$

   (b) Explain in detail the method to solve dynamical systems with discontinuous right hand sides. (5)

3. (a) Consider the dynamic equation of a hot air balloon where the control input is the fuel flow into the burner which is represented by (7)

$$\dot{x} = Ax + Bu$$

where

$$A = \begin{pmatrix} 0 & 1 & 0 \\ 0 & -2 & 1 \\ 0 & 0 & -1 \end{pmatrix}, \quad B = \begin{pmatrix} 0 \\ 0 \\ 10 \end{pmatrix}$$

Design a sliding surface for the system so as to obtain the sliding mode poles at $-1 \pm j$ and obtain the sliding mode control.

   (b) Explain the significance of η reachability condition. (2)

PART B

4. Derive an expression for sliding mode control of a discrete time SISO system subjected to parametric variations in system matrix and also subjected to external disturbances. (9)

5. Obtain an integral sliding mode controller to stabilize a simple pendulum with a frictional force acting on it. (9)

6. (a) Show that the fast output sampling technique exactly realizes an estimator. (4)

   (b) Derive the multirate output feedback based quasi sliding mode control for uncertain systems. (5)

PART C

7. (a) Explain second order sliding mode controllers. (4)

   (b) Prove the finite time convergence of trajectories in higher order sliding mode controllers. (8)

8. (a) Explain super twisting based observers. (6)

   (b) Obtain the sliding mode observer for a triple integrator. (6)

9. (a) Explain the variable gain super twisting algorithm. (6)

   (b) Show that the sliding mode based observation in an uncertain LTI system yields a reduced order motion during sliding mode independent of uncertainty. (6)