



APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SECOND SEMESTER M.TECH DEGREE EXAMINATION, APRIL-MAY 2017
Electrical and Electronics Engineering
Control Systems, Guidance and Navigational Control

01EE6116: SLIDING MODE CONTROL

Time: 3 hrs

Max. Marks: 60

Answer any two full questions from each part

PART A (Module I and II)

1. (a) Explain the terms reaching condition, finite time reaching and η reachability condition. (4)
- (b) What are the conditions to be satisfied for a system to be finite time stable. Derive the time of reaching t_r for a finite time stable system. (5)
2. (a) Explain the significance of equivalent control. (3)
- (b) Obtain the equivalent control for a simple pendulum with friction, when a torque is applied. (6)
3. (a) Explain the linear quadratic minimization technique for the design of sliding surface. (5)
- (b) Consider the system (4)

$$\dot{x} = \begin{pmatrix} 0 & 1 \\ 4 & 5 \end{pmatrix} x + \begin{pmatrix} 0 \\ 1 \end{pmatrix} (u + 0.5 \cos t)$$

Design a stable sliding surface for the given system.

PART B (Module III and IV)

4. (a) Explain the condition for convergence based on Sarpturk reaching law in discrete time systems. (3)
- (b) Explain the technique of an integral sliding mode control. Obtain the structure of the control law in ISMC and show that the disturbance is completely rejected in steady state. (6)
5. (a) Derive an expression for quasi sliding mode band in discrete time systems. (3)
- (b) Obtain the multirate output feedback based quasi sliding mode control for an uncertain discrete time system. (6)
6. (a) Explain the significance of multirate output feedback control. (2)

- (b) Consider a second order linear time invariant system sampled at an interval $\tau = 0.1$ sec given as (7)

$$x(k+1) = \begin{pmatrix} 0 & 1 \\ -1 & 1 \end{pmatrix} x(k) + \begin{pmatrix} 0 \\ 1 \end{pmatrix} u(k)$$

$$y(k) = (1 \ 0) x(k)$$

Design a stable sliding surface and obtain the discrete time sliding mode controller. Obtain the QSMB choosing appropriate parameter values.

PART C (Module V and VI)

7. (a) Explain the design of a second order sliding mode controller that will provide a continuous control. (6)
- (b) Prove that in an Utkin sliding mode observer, sliding mode will take place in finite time. (6)
8. (a) Explain the design technique of a sliding mode observer. (6)
- (b) Explain the design of a twisting controller. (6)
9. (a) Explain the design of a super twisting based differentiator. (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)