

(3 pages)

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**  
**SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2016****Electrical & Electronics Engineering**(Control Systems, Guidance and Navigational Control, Electrical Machines, Power System  
and Control)**01EE6116: SLIDING MODE CONTROL****Time: 3 Hours****Max Marks: 60***Answer any two FULL questions from each part***Part A (Modules I & II)**

1) a. Consider a system described by  $\dot{x} = f(x, t, u)$  with scalar control  $u$  subject to discontinuities on some sliding surface given by  $s(x)=0$ . Assume that the switch performing the control has a hysteresis. Prove that the velocity vector that will be obtained in the above case is one and the same as that obtained using Filippov's continuation method. (6)

b. For an  $n^{\text{th}}$  order continuous time system derive a sliding mode control using a reaching law approach based on proportional rate reaching law if the sliding surface is chosen as  $\sigma = c^T x$ . (3)

2) a. Design a sliding surface using eigen value placement for the system described by

$$\dot{x} = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 3 \\ 1 & 0 & 1 \end{bmatrix} x + \begin{bmatrix} 0 & 1 \\ 1 & -1 \\ -1 & 0 \end{bmatrix} u$$

(6)

b. Differentiate between sliding mode control and variable structure control with the help of an example. (3)

- b. Derive an expression for a non switching based sliding mode control of a discrete time SISO system subjected to parametric variations in system matrix and is also subjected to external disturbances. (4)

**Part C (Modules V& VI)**

- 7) a. Briefly explain the design of an Utkin observer for an LTI system. (6)  
b. Explain the term relative degree and order w.r.t to sliding mode control system. (4)  
c. For a system described by

$$\dot{x}_1 = x_2, \dot{x}_2 = x_3, \dot{x}_3 = x_4, \dot{x}_4 = u$$

and assume a sliding surface  $\sigma = c_1x_1 + c_2x_2 + x_3$  is designed. Find the relative degree w.r.t  $\sigma$  for the above system. Is it possible to design a classical SMC for the above system with the above sliding surface if not why?. (2)

- 8) a. Prove that in an Utkin's sliding mode observer sliding mode will takes place in finite time. (6)  
b. Explain in detail design of a second order sliding mode controller that will provide a continuous control. (6)
- 9) a. Explain the need of an observer. Also, compare the features of a sliding mode observer and Leunberger observer. Also mention their respective observer dynamics and error dynamics. (6)  
b. Explain in detail design of a super-twisting based differentiator. (6)
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