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(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^{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 reative degree w.r.t σ 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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