College of Engineering, Pune

(An Autonomous Institute of Govt. of Maharashtra)

End-Semester Examination 2011-12

First Year M. Tech (Electrical- Control Systems)

Subject: - Robust Control (EE·5213)

Day & Date: Monday, 14th May 2012 Max. Marks: - 50

Time: 09.00 AM -12.00 NOON

Instructions:

1) ALL questions are compulsory.
2) Figures to the **RIGHT** indicate **FULL** marks.
3) Make suitable assumptions, if necessary and state the same.
4) Use of non-programmable pocket calculator is allowed.
5) Answer of ALL questions has to be written in the same sequence as they appear in the question paper.

Que. 1

a) What is *Gilbert's Realization?* Also explain the concept of invariant zeros of the system. -------- (05)

b) What is controller parameterization? Explain **Youla parameterization** ------ (05)

Que. 2 a) In case of triangular inequality, prove that

$$\|x+y\| \leq \|x\| + \|y\|$$ -------------------------------- (05)

b) What is *Smith-McMillan Form? Find McMillan Form for the transfer matrix G(s)*

$$G(s) = \begin{bmatrix} \frac{1}{(s+1)(s+2)} & \frac{2s+1}{(s+1)(s+2)} & \frac{s}{(s+1)(s+2)} \\ \frac{1}{(s+1)^2} & \frac{s^2+5s+3}{(s+1)^2} & \frac{s}{(s+1)^2} \\ \frac{1}{(s+1)^2(s+2)} & \frac{2s+1}{(s+1)^2(s+2)} & \frac{s}{(s+1)^2(s+2)} \end{bmatrix}.$$

Also find poles and transmission zeros of the same. ---------------------------------- (05)

Q.3 a) Explain different properties of LFT. Consider a feedback system with disturbance *d*, sensor noise *n*. Represent this system in LFT form. -------------------- (05)

b) What is ***Redheffer Star Product***? Write MATLAB program for getting **Redheffer Star Product of a system.** -------------------- (05)

Q.4 a) With necessary proof, explain what is Small Gain theorem? ----------------- (05)

b) With suitable example explain the concept of internal stability. --------------- (05)

Q.5 a) What is *Co prime Factorization over* $RH\infty$. Find *Co prime Factorization* for following system ----------------- (05)

$$P(s) = \frac{s-2}{s(s+3)} \text{ and } \alpha = (s+1)(s+3).$$

b) What is inner product? List the properties for the same. --------------- (05)

Department of Electrical Engineering

College of Engineering Pune

End Semester Exam 2012

F.Y. M. Tech (Control System)

Sliding Mode Control (CS 514)

Time Duration 03Hrs. Max. Marks (50)

Instructions: Solve all questions. All questions carry equal marks. Assume suitable data if needed.

Given a system

$$\begin{aligned} \dot{X} &= \begin{pmatrix} 0 & 1 \\ -2 & 3 \end{pmatrix} X + \begin{pmatrix} 0 \\ 1 \end{pmatrix} u + \begin{pmatrix} 0 \\ 1 \end{pmatrix} 0.6 \sin 2t \\ y &= [1 \quad 0] X \end{aligned}$$

(Q.1): Design a sliding mode controller to get closed-loop pole at -8. Use Gao's constant rate reaching law. Illustrate how Gao's constant rate reaching law ensures reachability condition.

(Q.2): Design a discrete sliding mode controller with Su's disturbance estimator. Use Utkin's law to construct a control.

(Q.3a): Develop the static output feedback control for the above given system.

(Q.3b): Develope the MROF scheme to estimate states for the given system with the assumption that the disturbance is zero. Consider $\tau = 0.1$sec.

(Q.4): Design a sliding mode observer to estimate the states and disturbance both for the given system using extended system.

(Q.5a): What is the relative degree of y to u for the given system. Illustrate the convergence of twisting algorithm used to establish higher order sliding mode control.

(Q.5b): Prove the finite time convergence of super twisting algorithm used for establishing HOSM via Lyapunov approach.

Department of Electrical Engineering

College of Engineering Pune

End Semester Exam 2012

F.Y. M. Tech (Control System)

System Identification and Control (CS 502)

Time Duration 03 Hrs. Max. Marks (50)

Instructions: Solve all questions. All questions carry equal marks. Assume suitable data if needed.

(Q.1a): From the following observations of the (MA) process Determine the order.

$$y = \{1.2 \;\; 1.0 \;\; 0.4 \;\; 0.2 \;\; 0.12 \;\; 0.09\}$$

(Q.1b): Demonstrate the procedure of order determination for the following process.

$$y(n) = y(n-1) - 0.5y(n-2) + e(n)$$

(Q.2): Develop ARMAX and OE structures of prediction error model. Obtain prediction error equations for these models with one step ahead prediction.

(Q.3): Develop least square estimation formulation for parametric estimation. Obtain recursive least square estimation therefrom.

(Q.4): What is PRBS ? Why it is called PRBS? Design feedback gains for three stage PRBS generator to have period 5 with initial condition {1 0 1}.

(Q.5a): Consider a system

$$\dot{y} = -ay + bu \quad (1)$$

$$\dot{y}_m = -a_m y_m + b_m u \quad (2)$$

$$u = \theta_1 u_c - \theta_2 y, \quad (3)$$

where (1) is plant dynamics, (2) is model dynamics of the desired model and u_c in (3) is command input. Design adaptation mechanism that will yield MRAS, using MIT rule.

(Q.5b): Illustrate STR for developing adaptive control. How Ayryabhatta identity can be used to develop MRAS in STR.

College of Engineering Pune
Multivariable Control Systems

Programme: M.Tech. (Electrical)
Specialization: Control System
Duration: 3 Hours

Date: 11-05-2012
Max. Marks: 60

Instructions:

1. Figures to right indicate full marks.

Qu. 1	a	What are various types of representations of multivariable control systems?	5
	b	Identify whether the following polynomial matrices are proper, row proper or column proper: $\begin{bmatrix} (s^2+s+1) & (2s+1) \\ (s) & (s^2+2) \end{bmatrix}$ and $\begin{bmatrix} (s+1) & (s^2+2s+2) \\ (2) & (s^2) \end{bmatrix}$	5
	b	What is the order of the system in the D. O. form of representation? Prove the answer.	5
	c	Obtain the state-space controllable realization of the following T(s). Is it minimal? $T(s)=\begin{bmatrix} 2(s-1) & S+1 \\ 4 & -s \end{bmatrix}\begin{bmatrix} (s+4) & 2(s+1) \\ 0 & (s^2-s+4) \end{bmatrix}^{-1}$	10
	a	Explain the LSVF through observer using a block diagram.	10 (8)
		Write short notes on: 1. Controllability criterion and its proof. 2. Minimal system and related algorithms in time and frequency domain	15
		Obtain the observable state space realization for following system. Is this minimal? $$\text{T(s)} = \begin{bmatrix} \dfrac{(s^2-s-2)}{s(s-1)^2} & \dfrac{1}{(s-1)^2} \\ \dfrac{-1}{s} & 0 \\ \dfrac{2}{s(s-1)} & \dfrac{1}{(s-1)} \end{bmatrix}$$	10