Indian Institute of Technology Delhi

Department of Electrical Engineering

Sample Paper

PhD Written test in Control Engineering

Instructions

1. Please return the question paper with answer-sheet.
2. Read all questions carefully.
3. Mobile phones are not allowed inside the exam hall.

Part-I

1. Find the eigenvalues of the matrix: $A = \begin{bmatrix} 2 & 1 \\ 0 & 2 \end{bmatrix}$. How many independent eigenvectors does the matrix A have? Compute all the independent eigenvectors of A.
2. What are the equilibrium points of the dynamical system: $\dot{x} = -x^3 + x$?
3. A system with the transfer function $G(s) = \frac{1}{(s+1)^2}$ is: i) Stable, ii) Unstable and iii) Marginally Stable?
4. An LTI system has a DC gain of 10dB, gain crossover frequency of 20 rad/sec, phase crossover frequency of 10 rad/sec. Is this system Stable or Unstable?
5. What is/are the equilibrium point(s) of $\dot{x} = x$, and $\dot{x} = \begin{bmatrix} 1 & 0 \\ 0 & -2 \end{bmatrix} x$.

Part-II

6. Write your understanding/interpretation about the following paragraph in five to six statements point-wise.

   “ *This article considers the following two problems for a parametric uncertain linear time-invariant (LTI) system. The first problem is as follows: Let a feedback gain matrix be designed such that the closed loop system response satisfies the specified transient performance bounds. Then, compute a ball in the uncertain parameter space such that for all parameter perturbations within it, the closed loop response continue to satisfy the same transient performance bounds. As a solution to this problem, an explicit expression for the radius of ball is provided. The second problem is on the synthesis of a robust static state feedback control, which: i) minimizes the Frobenius norm of gain matrix, ii) maximizes the radius of ball in the uncertain parameter space and iii) ensures achieving specified transient behaviour in the closed loop. For this, a sub-optimal linear matrix inequality (LMI) optimization is formulated by linearizing the associated non-linear matrix inequalities. The desired transient behaviour is achieved by* *assigning the closed loop poles within some pre-defined LMI regions in the complex plane. The efficacy of the developed results are demonstrated with a practical example, where it is observed that the gain matrix, designed via LMI optimization, provides robust transient performance in the closed loop against a wide range of parameter perturbations. The proposed methodology can also be applied to design a static state feedback control for robust pole clustering of a polytopic uncertain system.”*