AE-777A (Optimal Space Flight Control)

Practice Quiz

Quiz Procedure

1. Clearly write out your solution to the quiz problems within the specified time on blank sheets of paper. (Marks will be given only for complete calculation/derivation steps.)

2. Take *low-resolution* pictures of your solution, convert them into a single PDF file (about 1MB), and send it to me by email (ashtew@iitk.ac.in) from your *registered* email account.

3. The time limit will be *strictly enforced*, and late submissions will *not* be accepted.

Practice Quiz (Time 60 min)

(Marks for each part are indicated in parentheses.)

For a system governed by the following differential equations:

$$\dot{\xi}_1 = \xi_1^3 + \xi_2$$

$$\dot{\xi}_2 = \eta - \xi_1 + \xi_2^2$$

where $\xi_1(t) \in \mathbb{R}$ and $\xi_2(t) \in \mathbb{R}$ are state variables, and $\eta(t) \in \mathbb{R}$ is the control input:

(a) Linearize the system about the reference solution, $\xi_1 = c = \text{const.}$, $\xi_2 = 0$, and determine the state-space coefficient matrices, A and B of the linearized system. (8)

(b) Determine the state response, $x_1(t) = \xi_1(t) - c$, $x_2(t) = \xi_2(t)$, of the linearized system when a unit impulse function, $\eta(t) = \delta(t)$, is applied at $t = 0$, with zero initial condition, $x_1(0) = x_2(0) = 0$. (15)

(c) Investigate the stability of the linearized system. (7)

(d) Investigate the controllability of the linearized system. (7)

(e) Is the linearized system observable with $y = \xi_2$ being the only output? (8)

(f) If possible, design a state-feedback regulator for the linearized system such that the closed-loop characteristic polynomial is the following:

$$s^2 + 2s + 2 = 0$$

(15)

Please send your solution to me (ashtew@iitk.ac.in) before 1:00 p.m. today.