

AE-777A (Optimal Space Flight Control)

Quiz No. 1

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.

Quiz No. 1 (Time 60 min)

(Marks for each part are indicated in parentheses.)

For a system governed by the following differential equations:

$$\dot{\xi}_1 = \xi_2$$

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

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.