BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: M.TECH **SEMESTER :I**
BRANCH: EEE **SESSION : MO/19**

SUBJECT: EE515 CONTROL SYSTEM DESIGN

TIME: 3 HOURS **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) Produce the set of performance specifications characterizing desired frequency response frequently used for designing the control system. Frequency response of a feedback control system should be similar to that of an ideal low pass filter. Justify this statement. [5]

Q.1(b) A feedback control system is controlling the position of a single-link robot manipulator on a manufacturing floor. It comprises of a sensor, a proportional controller and an actuator. Suggest suitable devices and describe their characteristics. Interconnect the devices to build a feedback control system and describe the processing of signals in the loop. Give units of signals involved in it. [5]

Q.2(a) Examine the effect on steady state error due to a unit ramp input to a second order system when a PD controller is added to the system. Prove your answer mathematically. [5]

Q.2(b) A PI controller has the constants K_p and K_I. Explain the effects of the PI controller on the steady state error, rise time, settling time and bandwidth of the system. Does the PI controller change the systems type? [5]

Q.3(a) Give and illustrate with the help of suitable example the design procedure of a cascade lag compensator through Bode plot method. [5]

Q.3(b) Investigate the fact that a cascade-lead compensator may not be able to improve the transient response of a given system with dominant complex open-loop poles. Illustrate with the help of an example. [5]

Q.4(a) What is an observer? Under what conditions would you use an observer in your state feedback design of a control system? Briefly describe the configuration of an observer. [5]

Q.4(b) A regulator system has the plant [5]

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} X + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} X$$

(i) Design a state-feedback controller which will place the closed loop poles at $-2 \pm j3.464, -5$. Give a block diagram of the control configuration.

(ii) Design a full-order state observer, the observer-error poles are required to be located at $-2 \pm j3.464, -5$. Give all the relevant observer equations and a block diagram description of the observer structure.

Q.5(a) Apply and demonstrate a suitable mapping method for conversion of analog compensator D(s) to an equivalent digital compensator D(z). [5]

Q.5(b) Establish the conditions for the following transfer function to be physically realizable. [5]

$$G_c(z) = \frac{b_m z^m + b_{m-1} z^{m-1} + \ldots + b_1 z + b_0}{a_n z^n + a_{n-1} z^{n-1} + \ldots + a_1 z + a_0}.$$

Analyze the three methods of decomposition of digital controller for digital programming.

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