Dr. B. B Sharma 21/11/2023

Roll No.:.................. 60

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Name of the Examination: B.Tech. Electrical Engineering (End Semester Examination, Nov./Dec. 2023)			
Branch	: Electrical Engineering	Semester	: 7th
Course Name	: Modern Control Systems	Course Code	: EE– 411
Time	3 Hours	Max. Marks	: 50

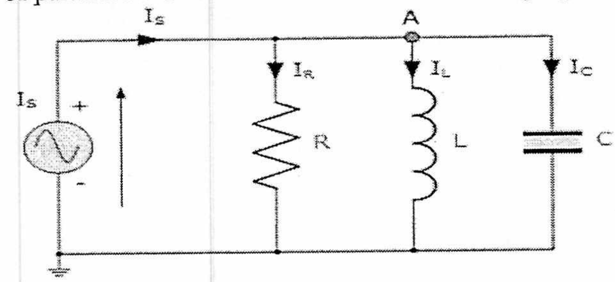
Note: (i) Attempt all the questions. All parts of a given question should be attempted in continuation.
(ii) Assume any missing data while making suitable explanation for the choice made.

Q. No.1: (a) The transfer function of a 3rd order control system is given as follows:

$$T(s) = \frac{y(s)}{u(s)} = \frac{6}{(s+2)(s+1)^2}$$

Obtain the state space model systematically in Diagonal/Jordan Canonical Form (DCF/JCF) while following the underlying procedure. Also draw the block diagram for the obtained model.

(b) Obtain the state space model of parallel RLC Network as shown in following figure:



Assume the input current as $I_s(t) = I_m \sin(\omega t)$ and the output as voltage $v(t)$ across the capacitor.

5+5=(10)

Q. No.2: Using **Kalman** as well as **Gilbert method,** check whether the following system is completely controllable and observable or not. Also find out the transfer function of the system.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u; \quad y = \begin{bmatrix} 2 & 3 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

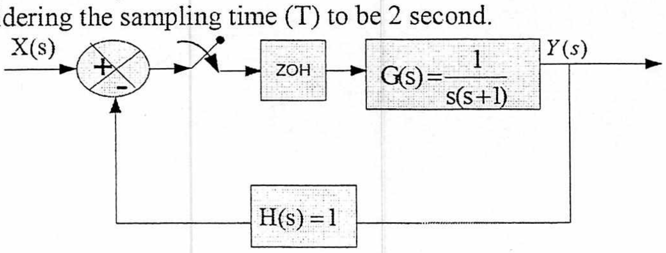
(10)

Q. No.3: (a) Explain the necessary requirements for pole placement based control design technique? Consider a 3rd order system described by following state space model in phase variable canonical form:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -5 & -10 & -7 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

Using pole placement technique, find coefficients of the controller such that the closed-loop system has the performance measures corresponding to damping ratio ξ=0.6 and undamped natural frequency as $\omega_n = 5$ rad/sec.

(b) For the sampled data system shown below, find out the pulse transfer function and response to unit impulse input while considering the sampling time (T) to be 2 second.



5+5=(10)

Q. No.4: **(a)** State the necessary and sufficient conditions for stability analysis using Jury's test. The pulse transfer function for a discrete control system is given as

$$T(z) = \frac{Y(z)}{U(z)} = \frac{z+1}{z^4 - z^3 + z^2 - z + 1}$$

Check the stability of the above system using Jury's Test.

(b) A second order control system described by differential description $\ddot{y}(t) = u(t)$ is preceded by an ideal relay with two points setting as $\pm$A unit. Draw the phase trajectories of the system in phase plane, when a constant input is given to system with unity feedback closed loop operation.

5+5=(10)

Q. No. 5: Attempt ***any four*** out of the following:

(a) Comment on Nyquist like stability criteria used to ascertain stability of nonlinear systems using Describing Function Approach.

(b) "Harmonic linearization naturally happens in majority of non-linear systems, thus, enabling to represent the nonlinearities by Describing Function." Justify the above statement.

(c) "Amplitude decay in nonlinear systems is accompanied by change in frequency of oscillation, whereas such phenomenon is not recorded in linear systems." Explain in detail.

(d) For the following linear system, investigate the stability of origin as equilibrium point using Lyapunov Equation based method:

$$\dot{x}_1 = x_2;$$
$$\dot{x}_2 = -x_1 - x_2.$$

(e) The eigenvalues of a second order control system are given as $\lambda_{1,2} = -\alpha \pm j\beta$. Draw the approximate trajectories of the system for given initial conditions and comment on the nature of corresponding singular point in phase plane.

4x2.5=(10)
