Q.5 i. Explain the need of compensation network in the control system. **3**

ii. Design a lag compensator for a unity feedback system with process transfer function **7**

$$G_p(s) = \frac{K(s+4)}{(s+2)(s+8)(s+12)}$$

Given the following specifications:

Static error constant=100

Phase margin=40^0

OR iii. A second order system in shown in Figure-4. If a proportional controller of gain K_c is added in the forward path, find its effect on the value of damping ratio, natural frequency and the steady-state error. Comment on the result. **7**

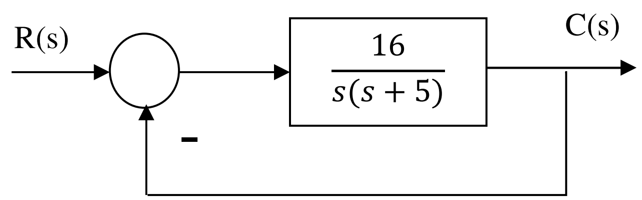

Figure-4

Q.6 i. State the advantage of state space approach. **2**

ii. Define state transition matrix and write its properties. **3**

iii. The transfer function of a control system is given by, **5**

$$\frac{Y(s)}{U(s)} = \frac{s+2}{s^3+9s^2+26s+24}$$

Check for controllability.

OR iv. A linear time invariant system is represented by a state model, **5**

$$\dot{X} = \begin{bmatrix} -1 & 1 \\ 0 & -2 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} r$$

Find out the solution of state model of the system. Given r = u(t).

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Total No. of Questions: 6 *Total No. of Printed Pages:4*

Enrollment No.....................................

Faculty of Engineering

End Sem (Odd) Examination Dec-2019

EC3CO09 / EI3CO09 Control Systems

Programme: B.Tech. Branch/Specialisation: EC/EI

Duration: 3 Hrs. **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated.Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d.

Q.1 i. Block diagrams can be used to represent: **1**

(a) Only linear system

(b) Only nonlinear systems

(c) Both linear and nonlinear systems

(d) Time –invariant as well as time –varying systems

ii. In the signal flow graph of Figure 1, the gain C/R will be **1**

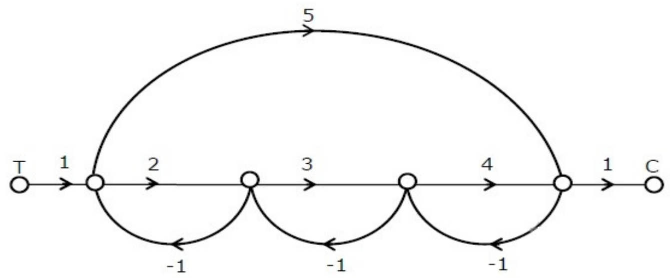

Figure-1

(a) 11/9 (b) 22/15 (c) 44/23 (d) 24/23

iii. A transfer function has two zeros at infinity. Then the relation between the numerator degree (N) and the denominator degree (M) of the transfer function is **1**

(a) N = M + 2 (b) N = M – 2

(c) N = M + 1 (d) N = M – 1

iv. The transfer function of a first order system is $T(s) = \frac{10}{s+5}$. The time constant of the system is. **1**

(a) 0.2 s (b) 2 s (c) 5 s (d) 1.15 s

v. Which one of the following methods can determine the closed loop system resonance frequency operation? **1**

(a) Root locus method (b) Nyquist method

(c) Bode plot (d) M and N circle

vi. If the gain of the open loop system is doubled, the gain of the system is: **1**

(a) Not affected (b) Doubled

(c) Halved (d) One fourth of the original value

vii. To achieve the optimum transient response, the indicating instruments are so designed as to **1**

(a) Be undamped.

(b) Be critically damped.

(c) Provide damping which is slightly less than the critical value.

(d) Provide damping which is slightly more than the critical value.

viii. A controller transfer function is given by $\frac{0.1(1+2s)}{1+0.2s}$. What is its nature and parameter? **1**

(a) lag compensator, $\beta = 10$ (b) lag compensator, $\beta = 2$

(c) lead compensator, $\alpha = 0.2$ (d) lead compensator, $\alpha = 0.1$

ix. The number of state variables of a system is equal to: **1**

(a) The number of integrators present in the system

(b) The number of differentiators present in the system

(c) The sum of the number of integrators and differentiators present in the system.

(d) None of these

x. The eigenvalues of the state model are the same as the: **1**

(a) Open-loop poles (b) Closed-loop poles

(c) Both (a) and (b) (d) None of these

Q.2 i. Write the Mason's gain formula for signal flow graph. Indicate what each term represents. **4**

ii. A mass spring dashpot system as shown in Figure-2 is mounted on a cart. The mass of the cart in M_1. The cart is moved at a constant speed. Obtain the transfer function $Y_2(s)/Y_1(s)$ (where Y_1 is I/P and Y_2 is output) **6**

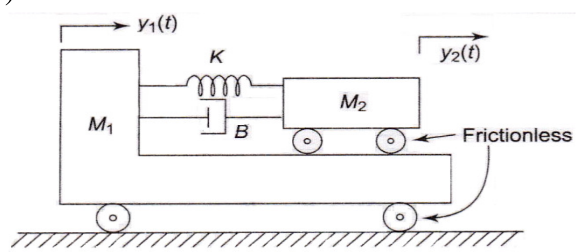

Figure-2

OR iii. Reduce the block diagram shown in Figure-3 to determine the transfer function C(s)/R(s) **6**

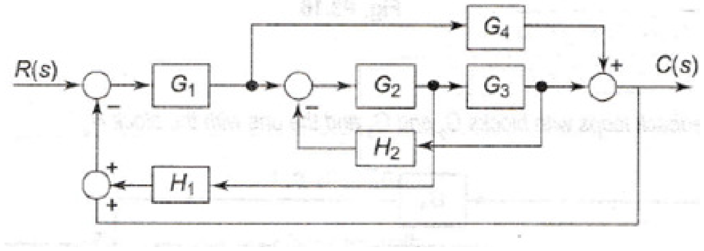

Figure-3

Q.3 i. The characteristic equation of a system is, **3**

$$s^5 + 5s^4 + 3s^3 + 15s^2 + 16s + 20 = 0$$

Comment on the system stability.

ii. For the second order system described by the transfer function, determine the frequencies of un-damped and damped oscillations, maximum overshoot, peak time, rise time. Settling time and the final value due to a unit step input. **7**

$$\frac{C(s)}{R(s)} = \frac{144}{s^2 + 9.6s + 144}$$

OR iii. Sketch the root locus of a system with open-loop transfer function **7**

$$G(s)H(s) = \frac{K}{(s+3)^3}$$

Q.4 Attempt any two:

i. Plot the Polar plot for the following transfer function **5**

$$G(s) = \frac{15}{(s+1)(s+3)(s+6)}$$

ii. A feedback system has the open loop transfer function **5**

$$G(s)H(s) = \frac{K(s+2)}{(s+1)(s-1)}; \qquad K > 0;$$

Using Nyquist criterion, investigate the stability of the system.

iii. Draw the log magnitude asymptotic plot for the transfer function, **5**

$$G(s)H(s) = \frac{1000s}{(s+10)(s+100)}$$

Find the gain crossover frequencies, and the frequencies at3-dB attenuation.

Marking Scheme
EC3CO09 / EI3CO09 Control Systems

Q.1	i.	Block diagrams can be used to represent: (c) Both linear and nonlinear systems		**1**
	ii.	In the signal flow graph of Figure 1, the gain C/R will be (c) 44/23		**1**
	iii.	A transfer function has two zeros at infinity. Then the relation between the numerator degree (N) and the denominator degree (M) of the transfer function is (b) N = M – 2		**1**
	iv.	The transfer function of a first order system is $T(s) = \frac{10}{s+5}$. The time constant of the system is. (a) 0.2 s		**1**
	v.	Which one of the following methods can determine the closed loop system resonance frequency operation? (d) M and N circle		**1**
	vi.	If the gain of the open loop system is doubled, the gain of the system is:		**1**
	vii.	To achieve the optimum transient response, the indicating instruments are so designed as to (c) Provide damping which is slightly less than the critical value.		**1**
	viii.	A controller transfer function is given by $\frac{0.1(1+2s)}{1+0.2s}$. What is its nature and parameter? (d) lead compensator, α = 0.1		**1**
	ix.	The number of state variables of a system is equal to: (a) The number of integrators present in the system		**1**
	x.	The eigenvalues of the state model are the same as the: (b) Closed-loop poles		**1**
Q.2	i.	Mason's gain formula	2 marks	**4**
		Indicate what each term represents.	2 marks	
	ii.	Equations	3 marks	**6**
		Final transfer function $Y_2(s)/Y_1(s)$	3 marks	
OR	iii.	Determine the transfer function C(s)/R(s)		**6**
		Stepwise marking		
Q.3	i.	RH Array	2 marks	**3**
		Comment on the system stability	1 mark	
	ii.	Frequencies of un-damped and damped oscillations	2 marks	**7**
		Maximum overshoot	1 mark	
		Peak time	1 mark	
		Rise time	1 mark	
		Settling time	1 mark	
		Final value due to a unit step input.	1 mark	
OR	iii.	Sketch the root locus of a system with open-loop transfer function		**7**
		P, z plot	1 mark	
		σA	1 mark	
		Centroide	1 mark	
		$\emptyset$	1 mark	
		RH	2 marks	
		Plot	1 mark	
Q.4		Attempt any two:		
	i.	$G(jw)$	1 mark	**5**
		$\|M\|L$	2 marks	
		Plot	2 marks	
	ii.	Nyquist criterion	2 marks	**5**
		Investigation	2 marks	
		Stability of the system	1 mark	
	iii.	Calculation	3 marks	**5**
		Plot for the transfer function	2 marks	
Q.5	i.	Need of compensation network in the control system.		**3**
	ii.	Bode Plot	3 marks	**7**
		Phase margin	1 mark	
		Compensator design	2 marks	
		Final Answer	1 mark	
OR	iii.	Effect of controller gain K_c on the value of		**7**
		Damping ratio	2 marks	
		Natural frequency	2 marks	
		Steady-state error	2 marks	
		Comment on the result	1 mark	
Q.6	i.	Advantage of state space approach.		**2**
	ii.	Definition of state transition matrix	1 mark	**3**
		Properties	2 marks	
	iii.	State Space	3 marks	**5**
		Controllability	2 marks	
OR	iv.	STM	3 marks	**5**
		Final equation	2 marks	

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