Solution of Question Paper (for B.Tech. VIth Sem EC)

Subject: Control System-I Subject Code - RIC-603

First Sessional Examination, Even Sem. 2019-2020

SECTION-A

Q.1

a) $T.F. = \dfrac{\sum_{i=1}^{N} \Delta_i P_i}{\Delta}$ N = Number of forward paths.

b) Forward Path: is the path in the direction of arrows starting from start node to terminating at the end node.

Path Gain: is the product of gains of all ~~for~~ branches in the path.

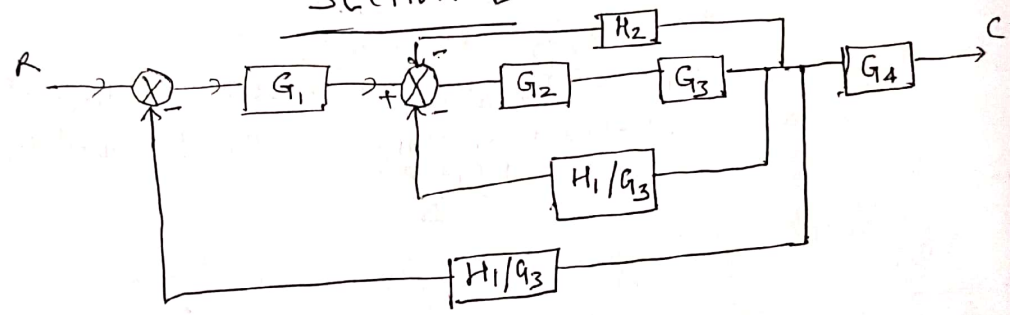
c) Types of feedback control system: i) open loop and closed loop systems.
ii) continuous and discrete time systems
iii) time dependent and time independent system etc.

d) ~~open loop~~ washing machine and A.C.

e) $M \leftrightarrow L$, $D \leftrightarrow R$, $K \leftrightarrow C$ for f-v analogy
and $M \leftrightarrow C$, $D \leftrightarrow R$, $K \leftrightarrow L$ for f-i analogy.

SECTION-B

2(a)



$$\frac{C}{R} = \frac{G_1G_2G_3G_4}{1+G_2(H_1+G_3H_2)+G_1G_2H_1}$$

2(b) $P_1 = G_1G_2G_3G_4G_5G_6G_7G_8$ $P_2 = G_7G_8G_9$

$L_{11} = -G_1H_1$, $L_{21} = -G_2G_3G_4G_5G_6H_4$, $L_{31} = -G_4H_2$, $L_{41} = -G_5H_3$

$L_{51} = -G_7H_5$, $L_{61} = G_9H_1H_4$

$L_{12} = 1\times3 = G_1G_4H_1H_2$, $L_{22} = 1\times4 = G_1G_5H_1H_3$, $L_{32} = 1\times5 = G_1G_7H_1H_5$

$L_{42} = 3\times5 = G_4G_7H_2H_5$, $L_{52} = 4\times5 = G_5G_7H_3H_5$, $L_{62} = 3\times6 = -G_4G_9H_2H_1H_4$

$L_{72} = 4\times6 = -G_5G_9H_1H_3H_4$.

$L_{13} = 1\times3\times5 = -G_1G_4G_7H_1H_2H_5$

$L_{23} = 1\times4\times5 = -G_1G_5G_7H_1H_3H_5$

$\Delta_1 = 1$

$\Delta_2 = 1 + G_4H_2 + G_5H_3$

$\Delta = 1 - (L_{11}+L_{21}+L_{31}+L_{41}+L_{51}+L_{61}) + (L_{12}+L_{22}+L_{32}+L_{42}+L_{52}+L_{62}+L_{72}) - (L_{13}+L_{23})$

$T.F. = \dfrac{P_1\Delta_1 + P_2\Delta_2}{\Delta}$

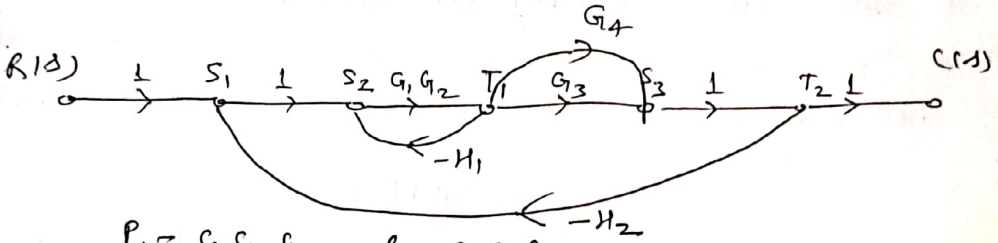
2(c): Different terminologies used in SFG are Input node, output node, Dummy node, path, path gain, forward path, forward path gain, loop, loop gain, self loop, nontouching loops.

2(d): i) Basic components of control system are as following: Potentiometers, Synchros, Transducers Tachometer, Modulator and Demodulator, motors etc.

ii) Reduction in gain, improvement in sensitivity Rejection of disturbance signal, increase or decrese in stability depending on type of feedback.

SECTION-C

3(a)



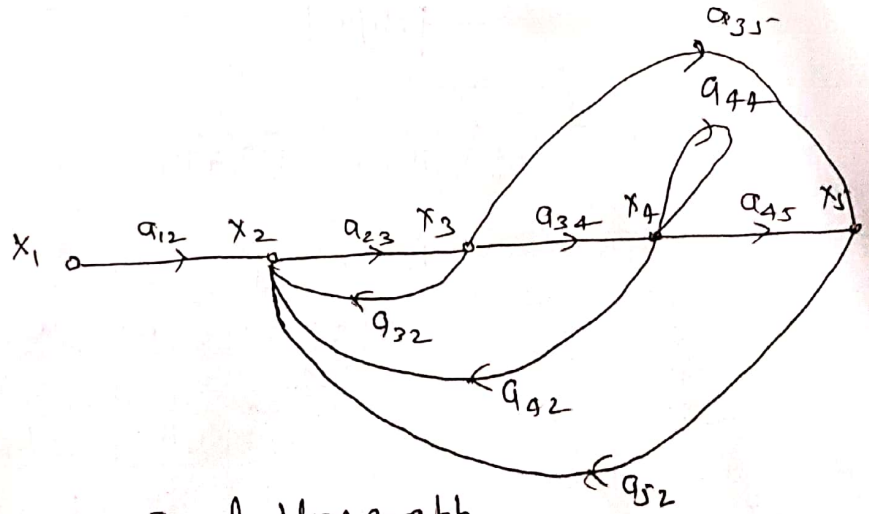
$P_1 = G_1G_2G_3$, $P_2 = G_1G_2G_4$

$L_{11} = -G_1G_2G_3H_2$, $L_{21} = -G_1G_2H_1$, $L_{31} = -G_1G_2G_4H_2$

$\Delta = 1-(L_{11}+L_{21}+L_{31})$ $\Delta_1 = 1$ and $\Delta_2 = 1$.

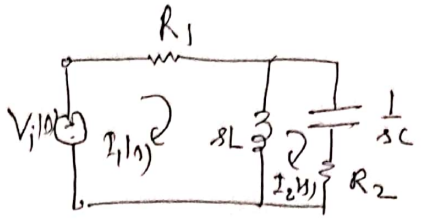
$$T.F. = \frac{P_1\Delta_1 + P_2\Delta_2}{\Delta}.$$

3(b)



Signal flow graph for given set of equations.

4(a)



$$V_i(s) = (R_1 + sL) I_1(s) - sL I_2(s) \quad \text{(i)}$$

and $$0 = \left(sL + \frac{1}{sC} + R_2\right) I_2(s) - sL I_1(s) = 0 \quad \text{(ii)}$$

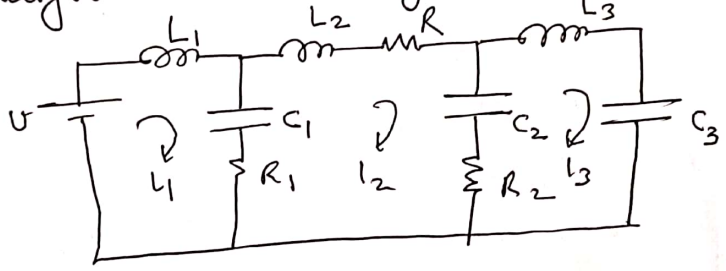
from (i) & (ii) $$\frac{V_o(s)}{V_i(s)} = \frac{sL(1 + sR_2C)}{s^2 LC(R_1 + R_2) + s(L + R_1R_2C) + R_1}$$

4(b) $$f = M_1 \frac{d^2x_1}{dt^2} + D_1 \frac{d(x_1 - x_2)}{dt} + K_1(x_1 - x_2) \quad \text{(i)}$$

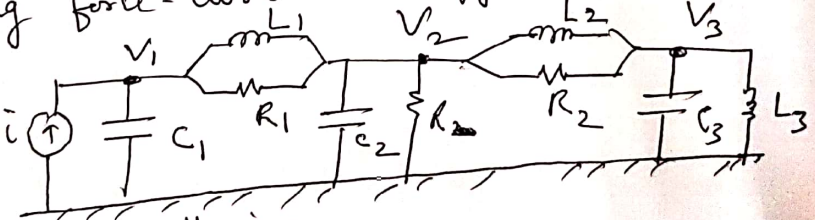
$$0 = M_2 \frac{d^2x_2}{dt^2} + D \frac{dx_2}{dt} + D_2 \frac{d}{dt}(x_2 - x_3) + K_2(x_2 - x_3) + K_1(x_2 - x_1) + D_1 \frac{d}{dt}(x_2 - x_1)$$

$$0 = M_3 \frac{d^2x_3}{dt^2} + K_3 x_3 + D_2 \frac{d(x_3 - x_2)}{dt} + K_2(x_3 - x_2) \quad \text{(ii)}$$

5(a) Analogous network using force-voltage analogy



5(b) Equivalent electrical network for the systems using force-current analogy



Equations are as following

$$i = C_1 \frac{dv_1}{dt} + \frac{1}{L_1} \int (v_1 - v_2)\, dt + \frac{1}{R_1}(v_1 - v_2) \quad \text{(i)}$$

$$0 = C_2 \frac{dv_2}{dt} + \frac{1}{R} v_2 + \frac{1}{R_2}(v_2 - v_1) + \frac{1}{L_2} \int (v_2 - v_3)\, dt + \frac{1}{L_1} \int (v_2 - v_1)\, dt + \frac{1}{R_1}(v_2 - v_1) \quad \text{(ii)}$$

$$0 = C_3 \frac{dv_3}{dt} + \frac{1}{L_3} \int v_3\, dt + \frac{1}{R_2}(v_3 - v_2) + \frac{1}{L_2} \int (v_3 - v_2)\, dt \quad \text{(iii)}$$