Control Systems EE2227

Gate Problems (EE2017 SET 1 paper)

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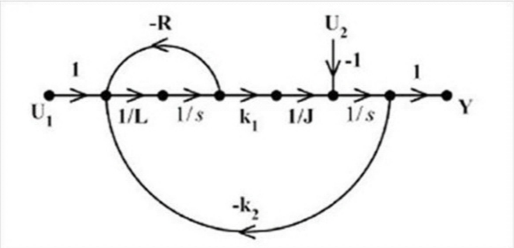
Question

In a system whose signal flow graph is shown in the figure, $U_1(s)$ and $U_2(s)$ are inputs. The transfer function $\dfrac{Y(s)}{U_1(s)}$ is



(a) $\dfrac{k1}{JLs^2 + JRs + k_1k_2}$

(b) $\dfrac{k1}{JLs^2 - JRs - k_1k_2}$

(c) $\dfrac{k1 - U_2(R + sL)}{JLs^2 + (JR - U_2L)s + k_1k_2 - U_2R}$

(d) $\dfrac{k1 - U_2(sL - R)}{JLs^2 - (JR + U_2L)s - k_1k_2 + U_2R}$

Solution

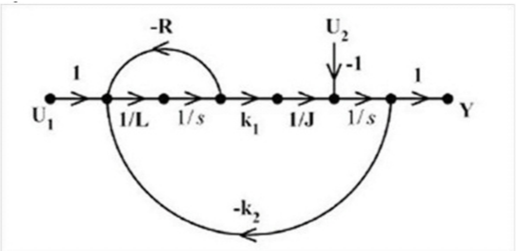
Masons Gain Formula:

$$T = \frac{C(s)}{R(s)} = \frac{\sum_{i=1}^{N} P_i \Delta_i}{\Delta}$$

where,

- T is the transfer function or the gain between R(s) and C(s)
- C(s) is the output node
- R(s) is the input node
- P_i is the ith forward path gain
- $\Delta = 1 -$(sum of all individual loop gains)+(sum of gain products of all possible two non touching loops)-(sum of gain products of all possible three non touching loops)+....
- Δ_i is obtained from Δ by removing the loops which are touching the ith forward path

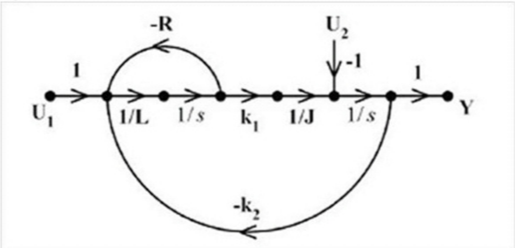
Solution



$$\left.\frac{Y(s)}{U_1(s)}\right|_{U_2(s)=0}$$

$$P_1 = 1 \cdot \frac{1}{L} \cdot \frac{1}{s} \cdot k_1 \cdot \frac{1}{J} \cdot \frac{1}{s} \cdot 1 = \frac{k_1}{LJs^2}$$

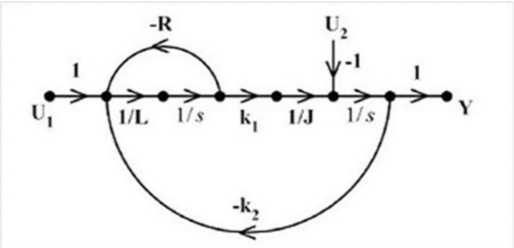
Solution



$$\Delta_1 = 1$$

After removing the loops that are touching the forward path, the system will have no loops .Therefore, Δ_1 will be 1.

Solution



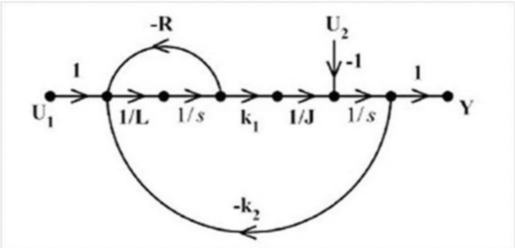
$\Delta = 1 -$(sum of all individual loop gains) as in this system there are no non touching loops. Let L_1 and L_2 be the individual loops.

$$\Delta = 1 - (L_1 + L_2)$$

$$\mathrm{L}_1 = \frac{1}{L} \cdot \frac{1}{s} \cdot (-R) = \frac{-R}{Ls}$$

$$L_2 = \frac{1}{L} \cdot \frac{1}{s} \cdot k_1 \cdot \frac{1}{J} \cdot \frac{1}{s} \cdot -(k_2) = \frac{-k_2 k_1}{LJs^2}$$

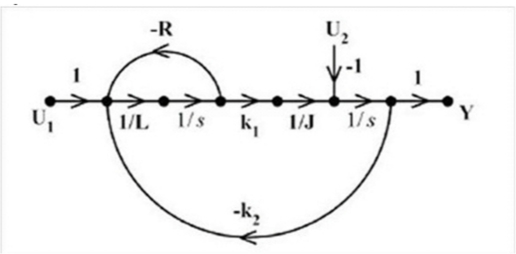
Solution



$$P_1 = \frac{k_1}{LJs^2} \qquad \Delta_1 = 1 \qquad L_1 = \frac{-R}{Ls} \qquad L_2 = \frac{-k_2 k_1}{LJs^2}$$

$$\frac{Y(s)}{U_1(s)} = \frac{P_1 \Delta_1}{1 - (L_1 + L_2)} = \frac{\dfrac{k_1}{s^2 LJ}}{1 + \dfrac{R}{Ls} + \dfrac{k_2 k_1}{LJs^2}}$$

Solution



$$\frac{Y(s)}{U_1(s)} = \frac{k_1}{s^2LJ + sRJ + K_1k_2}$$