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Block Diagram

$$\frac{Y(s)}{R(s)} = \frac{G(s)}{1+G(s)}$$

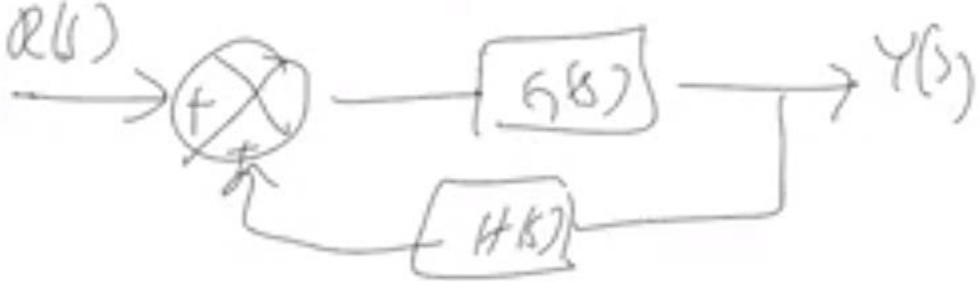
$$E(s) = R(s) - Y(s)$$

$$G(s)\left(R(s) - Y(s)\right) = Y(s)$$

$$G(s)\,R(s) = \left(1 + G(s)\right) Y(s)$$

$$\frac{Y(s)}{R(s)} = \frac{G(s)}{1+G(s)}$$

$$\frac{Y(s)}{R(s)} = \frac{G(s)}{1+G(s)H(s)}$$



$$\frac{Y(s)}{R(s)} = \frac{G(s)}{1-G(s)H(s)}$$

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Navigate to the next page (if any, create a new page).

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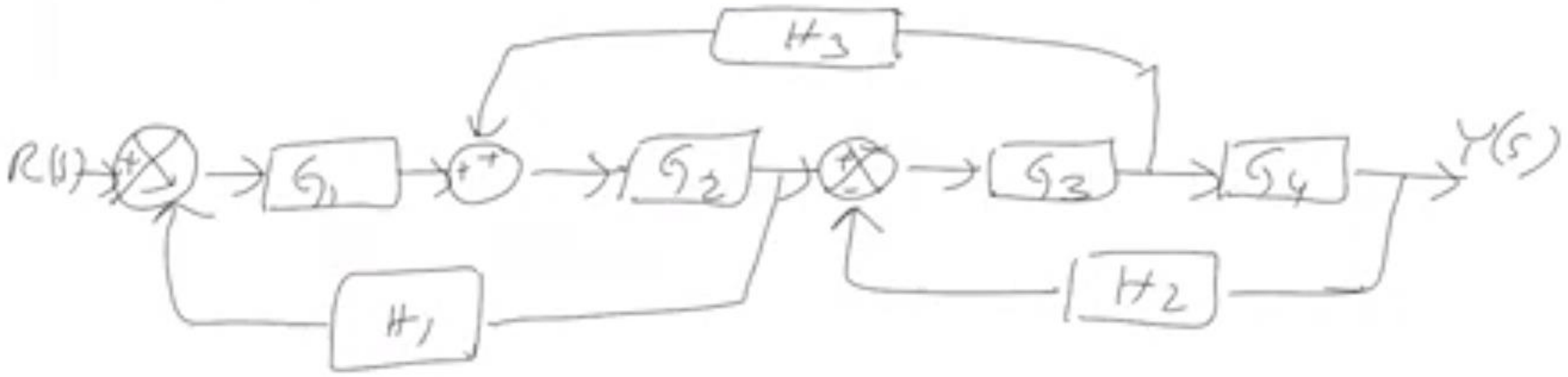

Find $\frac{Y(s)}{R(s)}$

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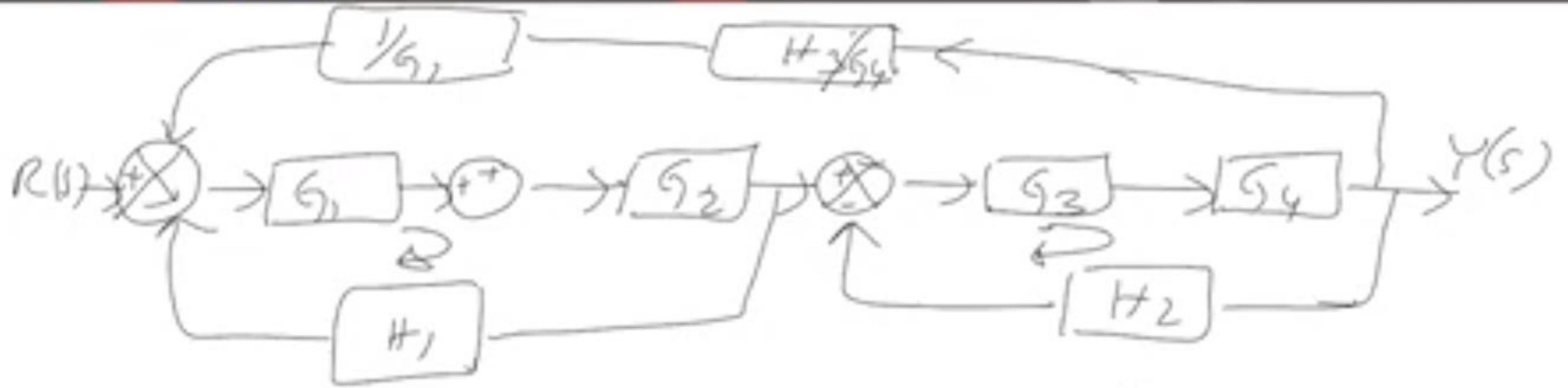


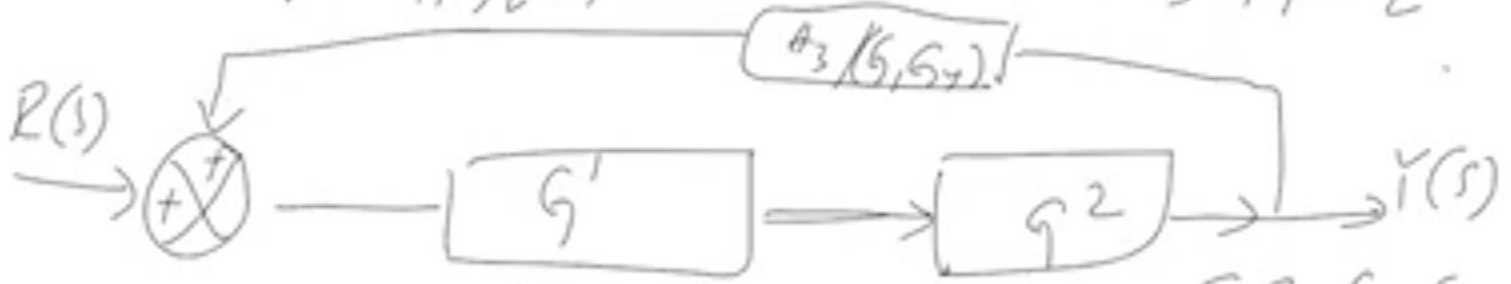
Find $\frac{Y(s)}{R(s)}$

$\Downarrow$

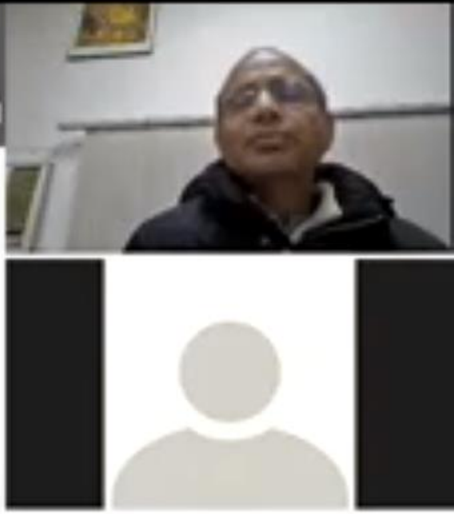
$$\frac{G_1 G_2}{1 + G_1 G_2 H_1} = G^1$$

$\Downarrow$

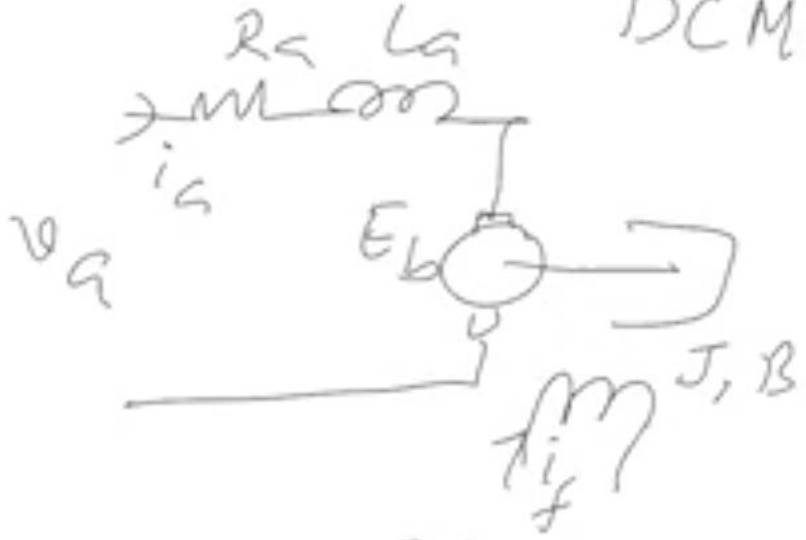
$$\frac{G_3 G_4}{1 + G_3 G_4 H_2} = G^2$$



$$\frac{Y(s)}{R(s)} = \frac{G^1 G^2}{1 - G^1 G^2 H_3 / (G_1 G_4)} = \frac{G_1 G_2 G_3 G_4}{1 + G_1 G_2 H_1 + G_3 G_4 H_2 - G_2 G_3 H_3 + G_1 G_2 G_3 G_4 H_1 H_2}$$



DC Motor



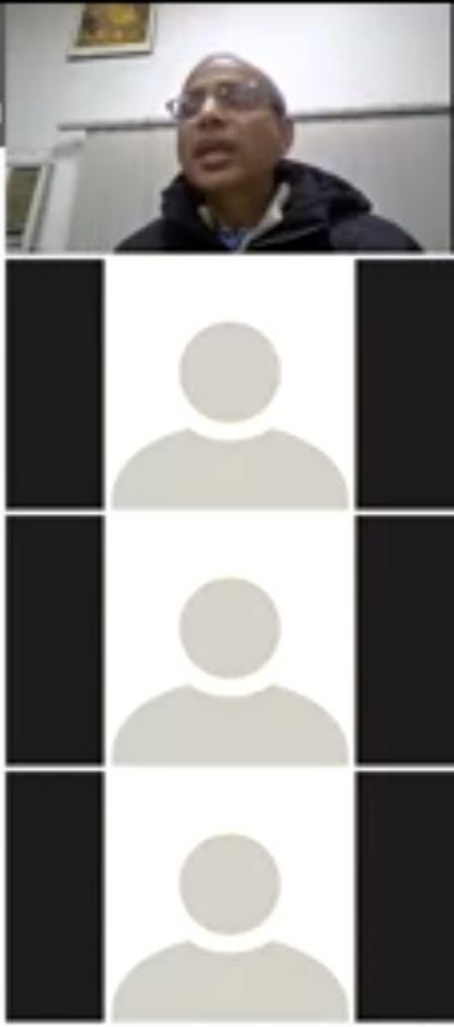
$$v_a = R_a i_a + L_a \frac{di_a}{dt} + E_b$$

$$E_b = K_b \omega$$

$$T_M = K_T i_a$$
$$= J \frac{d^2\theta}{dt^2} + B \frac{d\theta}{dt}$$

Find out $\frac{\theta(s)}{V_a(s)}$ using Block diagram

$$V_a(s) - E_b(s) = R_a I_a(s) + L_a s I_a(s)$$



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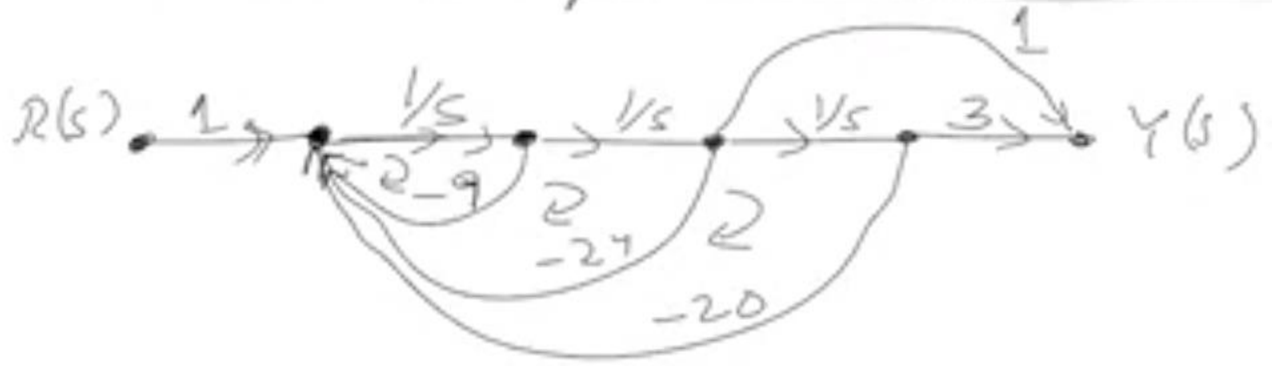
$$\frac{W(s)}{V_a(s)} = \frac{\left(\frac{K_T}{R_a + L_a s}\right)\left(\frac{1}{Js + B}\right)}{1 + \frac{K_b K_T}{(R_a + L_a s)(Js + B)}}$$

$$= \frac{K_T}{(R_a + L_a s)(Js + B) + K_b K_T}$$

$$\frac{\Theta(s)}{V_a(s)} = \frac{\Theta(s)}{W(s)} \cdot \frac{W(s)}{V_a(s)} = \frac{K_T}{s\left[(R_a + L_a s)(Js + B) + K_b K_T\right]}$$

$s \rightarrow$ diff
$\frac{1}{s} \rightarrow$ integrator

Signal Flow Graph

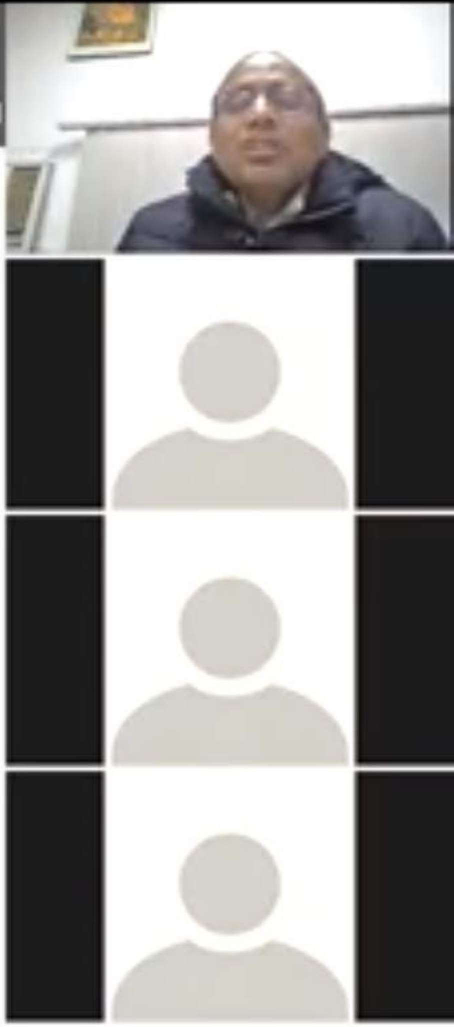


1. forward path gain $\frac{3}{s^3}$
2. forward path gain $\frac{1}{s^2}$

1 - loop gain $-\frac{9}{s}$

2 - loop gain $-\frac{24}{s^2}$

3 - loop gain $-\frac{20}{s^3}$



Mason's gain formula

$$\frac{Y(s)}{R(s)} = \sum_{K=1}^{N} \frac{M_K \Delta_K}{\Delta}$$

M_K = gain of the K^{th} forward path

Δ = 1 − (sum of all individual loop gains)

+ sum of product of all possible comb of two nontouching loops

− sum of product of all possible comb of 3 non touching loops + ..

Δ_K = The Δ for that part of SFG that is non touching Kth forward path

$$\frac{Y(s)}{R(s)} = \frac{\frac{3}{s^3}\times 1 + \frac{1}{s^2}\times 1}{1-\left(-\frac{9}{s}-\frac{24}{s^2}-\frac{20}{s^3}\right)}$$

$$= \frac{\left(\frac{3+s}{s^3}\right)}{\left(1+\frac{9}{s}+\frac{24}{s^2}+\frac{20}{s^3}\right)}$$

$$= \frac{s+3}{s^3+9s^2+24s+20}$$