Benha University
Faculty of Engineering (Shoubra)
Electrical Engineering Department

3rd year (Comps) -1st Semester
Mid-Term Exam - 1 Hour
Automatic Control (14/11/2016)

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1. Find the transfer function C(s)/R(s) for the following control system shown in Fig. (1):

(i) Using block reduction method.

(ii) Using signal flow graph.

2. Determine the transfer function $E_o(s)/E_i(s)$ of the circuit shown in Fig. (2) and then draw the block diagram.

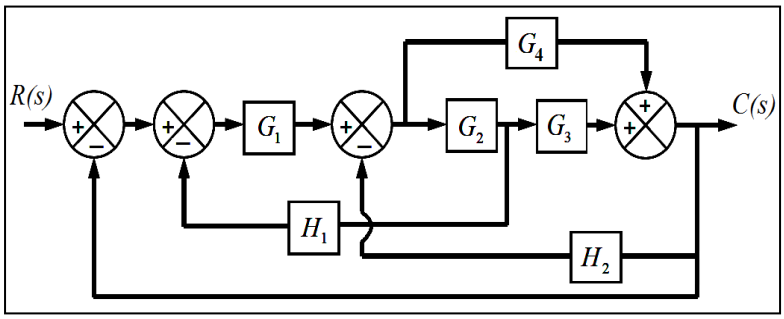

Fig. (1)

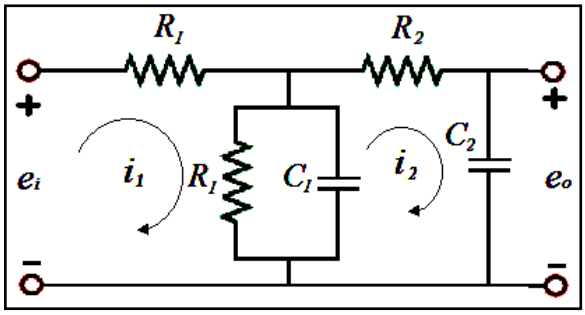

Fig. (2)

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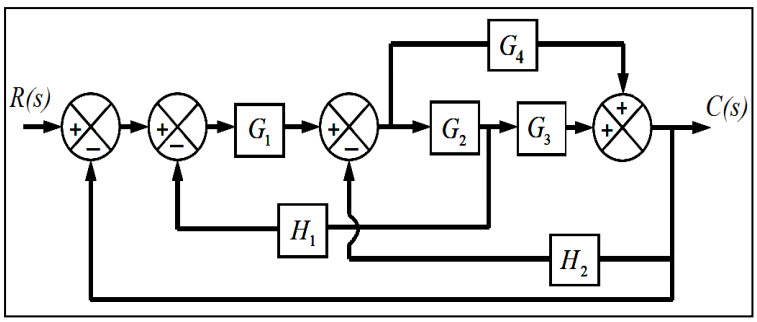

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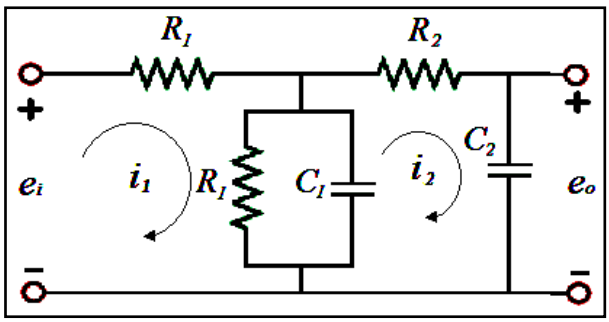

Fig. (2)

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Automatic Control 3rd Comp 2016-2017
1st Term

(1)

" Model Answer "

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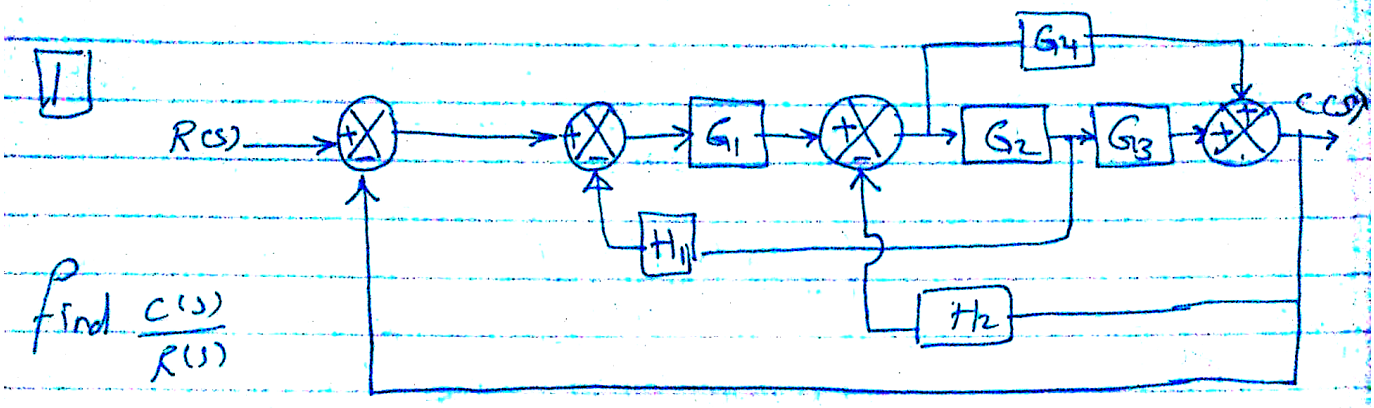
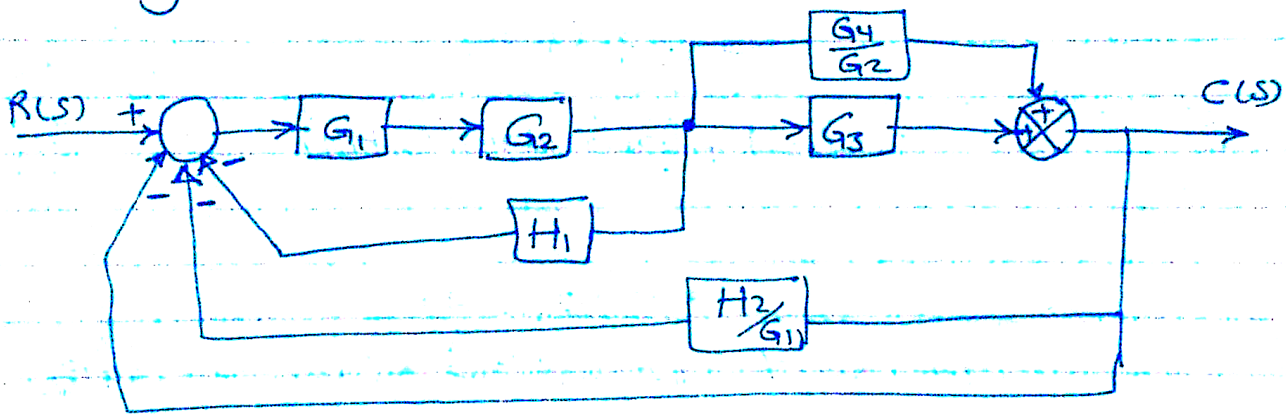
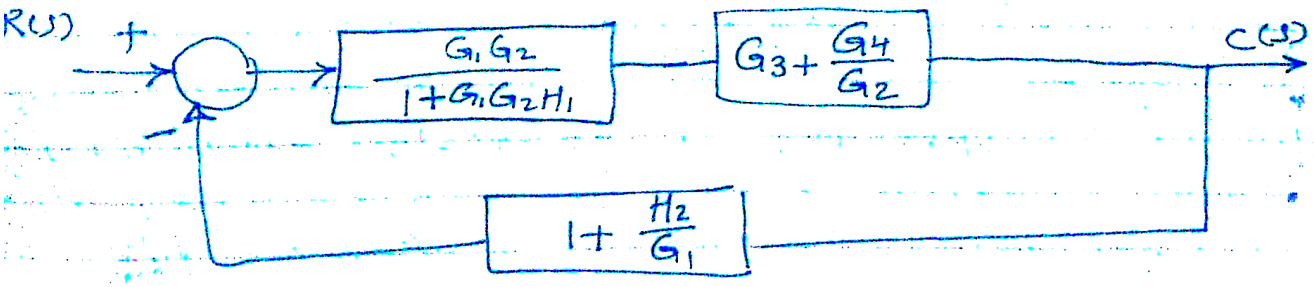


Find $\frac{C(s)}{R(s)}$

(i) Using block reduction Method:

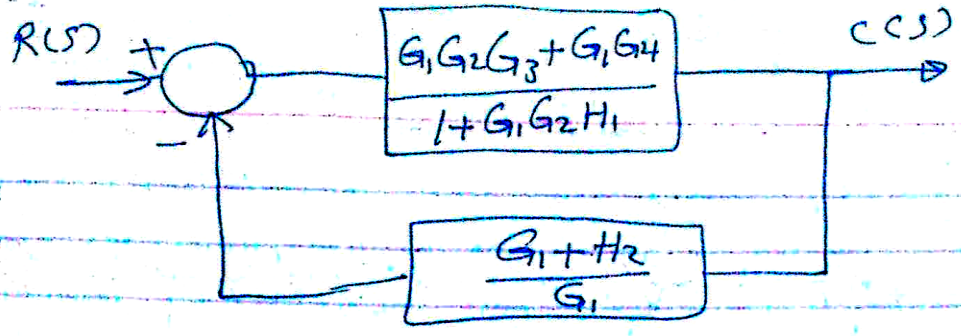




$$\therefore \quad \frac{G_1 G_2}{1+G_1 G_2 H_1} * \frac{G_2 G_3 + G_4}{G_2} = \frac{G_1 G_2 G_3 + G_1 G_4}{1+G_1 G_2 H_1}$$

$$\therefore \quad 1 + \frac{H_2}{G_1} = \frac{G_1 + H_2}{G_1}$$

(2)



$$\text{So } \frac{C(s)}{R(s)} = \frac{\left(\frac{G_1G_2G_3+G_1G_4}{1+G_1G_2H_1}\right)}{1+\left(\frac{G_1G_2G_3+G_1G_4}{1+G_1G_2H_1}\right)*\left(\frac{G_1+H_2}{G_1}\right)}$$

$$= \frac{G_1G_2G_3+G_1G_4}{1+G_1G_2H_1+(G_2G_3+G_4)(G_1+H_2)}$$

$$= \frac{G_1G_2G_3+G_1G_4}{1+G_1G_2H_1+G_1G_2G_3+G_1G_4+G_2G_3H_2+G_4H_2}$$

$$\text{So } \frac{C(s)}{R(s)} = \frac{(G_1G_2G_3+G_1G_4)}{1+(G_1G_2G_3+G_1G_4)+G_1G_2H_1+(G_2G_3+G_4)H_2}$$

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(3)

(ii) Using signal flow Graph.

$L_1 = -G_1G_2H_1$

$L_2 = -G_1G_4$

$L_3 = -G_1G_2G_3$

$L_4 = -G_4H_2$

$L_5 = -G_2G_3H_2$

$\Delta = 1 + G_1G_2H_1 + G_1G_4 + G_1G_2G_3 + G_4H_2 + G_2G_3H_2$

$= 1 + G_1G_2G_3 + G_1G_4 + G_1G_2H_1 + (G_2G_3 + G_4)H_2$

$P_1 = G_1G_2G_3 \quad (\Delta_1 = 1)$

$P_2 = G_1G_4 \quad (\Delta_2 = 1)$

$$\therefore \frac{C(s)}{R(s)} = \frac{G_1G_2G_3 + G_1G_4}{1 + G_1G_2G_3 + G_1G_4 + G_1G_2H_1 + (G_2G_3 + G_4)H_2}$$

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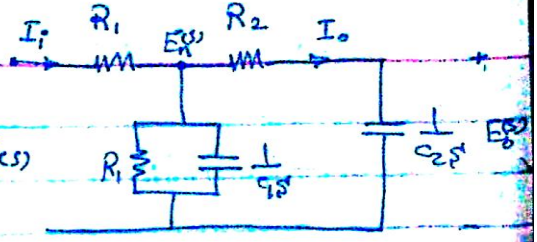
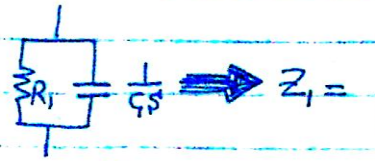
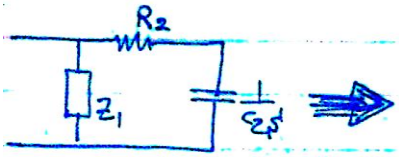
(4)

Find $\frac{E_o(s)}{E_i(s)} = ?$





$$\Rightarrow Z_1 = \frac{R_1 \cdot \frac{1}{C_1 s}}{R_1 + \frac{1}{C_1 s}} = \frac{R_1}{1 + R_1 C_1 s}$$



$$\Rightarrow Z_2 = \frac{Z_1 (R_2 + \frac{1}{C_2 s})}{Z_1 + (R_2 + \frac{1}{C_2 s})} = \dots\dots = \frac{R_1 + R_1 R_2 C_2 s}{1 + R_1 C_1 s + R_2 C_2 s + R_1 R_2 s + R_1 R_1 C_1 C_2 s^2}$$

Voltage divider Rule:

$$* \frac{E_n(s)}{E_i(s)} = \frac{Z_2}{R_1 + Z_2} \quad \& \quad * \frac{E_o(s)}{E_n(s)} = \frac{(\frac{1}{C_2 s})}{R_2 + \frac{1}{C_2 s}} = \frac{1}{1 + R_2 C_2 s}$$

① ②

Multiply ① by ② To get $\frac{E_o(s)}{E_i(s)}$

$$\frac{E_o(s)}{E_i(s)} = \dots\dots\dots\dots\dots\dots$$

$$= \dots\dots\dots\dots\dots\dots$$

$$= \dots\dots\dots\dots\dots\dots$$

$$= \frac{R_1 + R_1 R_2 C_2 s}{2R_1 + R_1^2 C_1 s + R_1^2 C_2 s + R_1^2 R_2^2 C_1 C_2^2 s^3 + R_1^2 R_2 C_2^2 s^2 + 2 R_1 R_2^2 C_2^2 s^2 + 2 R_1^2 R_2 C_1 C_2 s^2 + 4 R_1 R_2 C_2 s}$$

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Note that: $E_i(s) = I_i(s) * (R_1 + Z_2)$, $E_n(s) = I_i(s) * Z_2$, $E_n(s) = I_o(s) * (R_2 + \frac{1}{C_2 s})$, $E_o(s) = I_o(s) * \frac{1}{C_2 s}$