VASAVI COLLEGE OF ENGINEERING

(AUTONOMOUS)
(Affiliated to Osmania University)
Hyderabad - 500 031.

DEPARTMENT OF : ECE

NAME OF THE LABORATORY : Control Systems

Name G. Sri Ganga Pranav Roll No. 1602-21-735-117 Page No.

Block diagram reduction

Aim:- To reduce the given complex representation of control system into simpler one. and model and verify it in MATLAB.

Apparatus:- PC loaded with MATLAB

Theory:-

Block diagram reduction in fundamental technique in control systems engineering used to simplify complex systems for analysis and design purposes. It involves manipulating block diagrams by combining or eliminating blocks and signals to create a more manageable representation of the system.

Significance of block diagram reduction:-

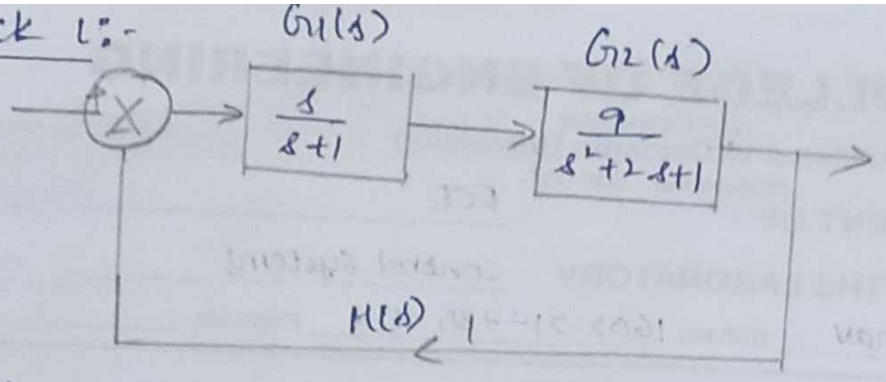
1) Simplifying complex systems:- Large and intricate control systems can be challenging to understand and analyse. Block diagram reduction simplifies these into more manageable forms.

2) Facilitating analysis:- By reducing the complexity of a system, performing stability analysis and transient analysis becomes easy.

3) Aiding Design:- Simplified block-diagrams make it easier to design controllers and compensators to achieve desired system performance.

4) Enhancing modularity:- Simplified block diagrams provide modularity in system design, allowing engineers to focus on individual components without being overwhelmed by complexity

Block 1:-



Final reduced diagram

$\frac{9}{s^3+3s^2+12s+1}$

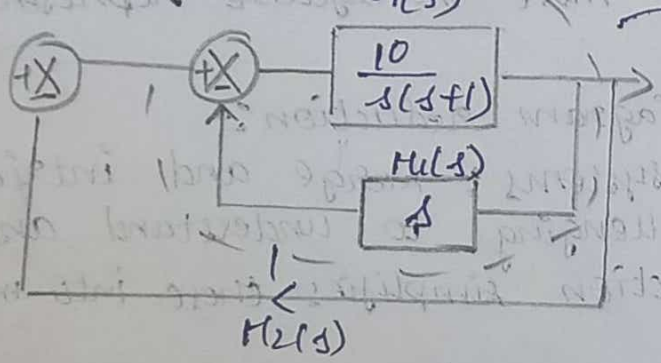
$G_1(s) = \frac{s}{s+1}$ $\quad G_2(s) = \frac{9}{s^2+2s+1}$

$G(s) = G_1(s)\,G_2(s)$

$= \frac{9s}{(s+1)^3}$ $\quad H(s) = 1$

Overall $= \frac{G(s)}{1+G(s)H(s)} = \frac{\frac{9s}{(s+1)^3}}{1-\frac{9s}{(s+1)^3}} = \frac{9}{s^3+3s^2+12s+1}$

Block 2:-



$G_1(s) = \frac{G(s)}{1+G(s)H(s)}$

$= \frac{\frac{10}{s(s+1)}}{1+\frac{10s}{s(s+1)}}$

$= \frac{10}{s^2+11s}$

Overall $G_2(s) = \frac{G_1(s)}{1+G_1(s)H_2(s)}$

$= \frac{\frac{10}{s^2+11s}}{\frac{10}{s^2+11s}+1} = \frac{10}{s^2+11s+10}$

Reduced diagram:- $\boxed{\frac{10}{s^2+11s+10}}$

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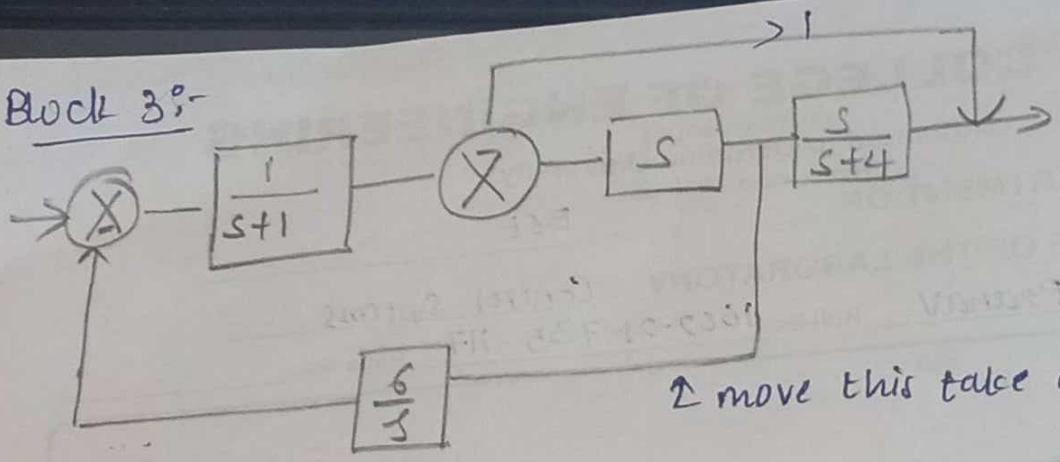
Code:-

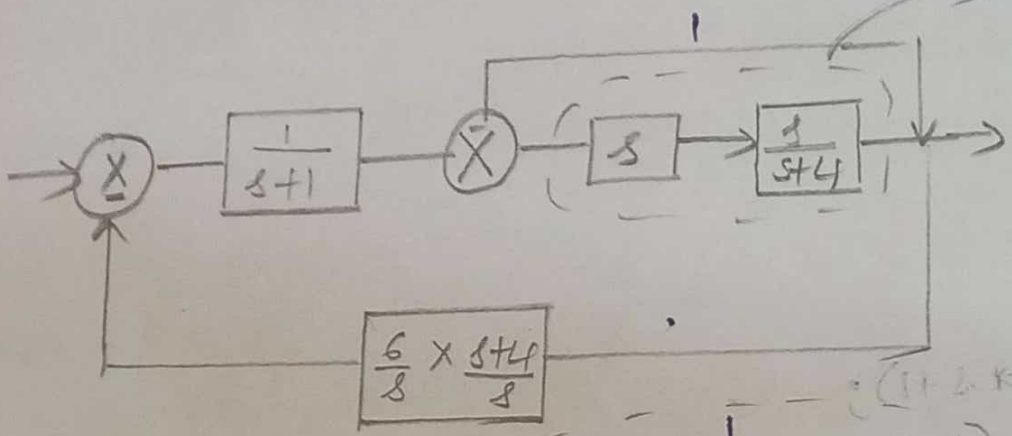
```
% Block 1
clc;
clear;
close all;
s = tf('s')
g1 = s/(s+1);
g2 = g1/(s^2 + 2*s +1);
g = series(g1,g2)
h = 1
final = feedback(g, h, -1)

% Block 2
clc;
clear;
close all;
s = tf('s')
g1 = 10/(s*(s+1));
h1 = s;
g2 = feedback(g1, h1, -1);
h2 = 1;
final = feedback(g2, h2, -1)
```

Block 3:-

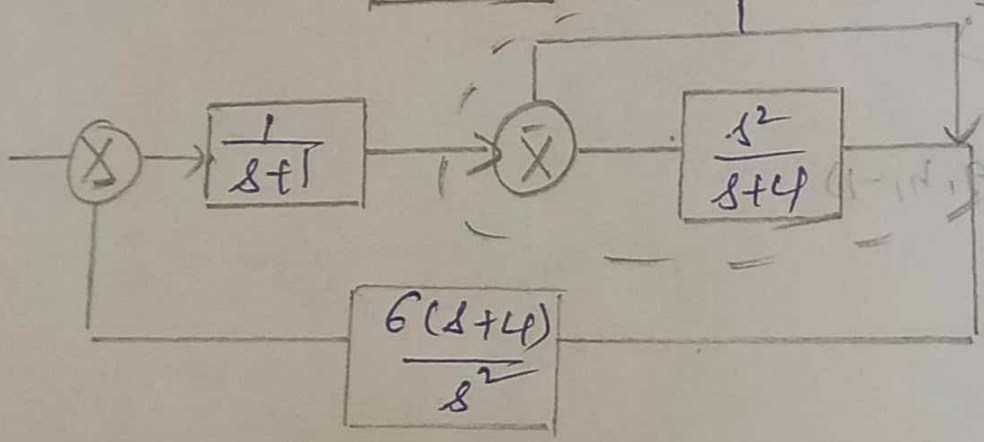


Σ move this take off point

serially cascaded

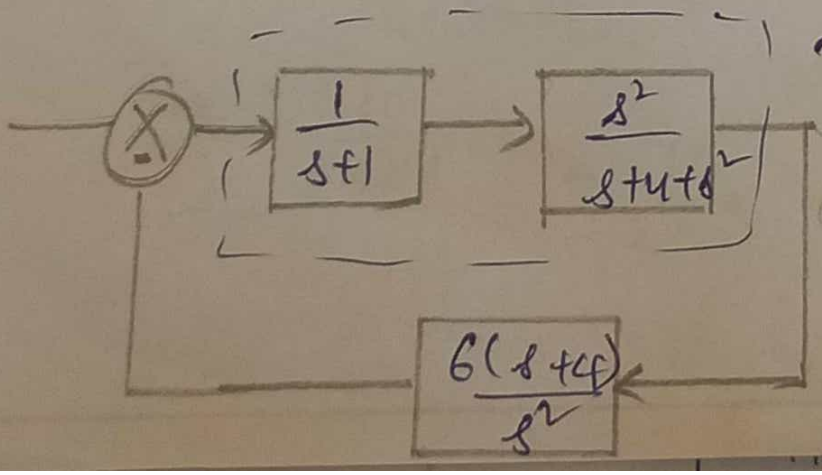


a



$$a(s) = \frac{s^2}{\frac{s+4}{1+\frac{s^2}{s+4}}} = \frac{s^2}{4+s+s^2}$$

serially cascaded.



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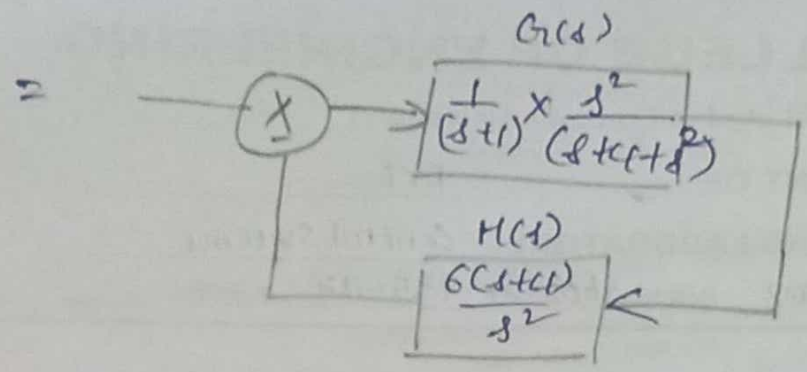
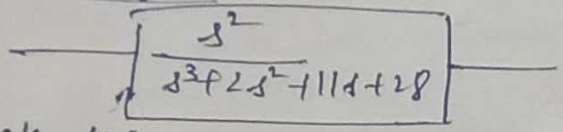
```
% Block 3
clc;
clear;
close all;
s = tf('s')
g1 = 1/(s+1)
g2 = s
g3 = s/(1+4)
h1 = 6/s
g4 = series(g2, g3)
h1 = h1/g3
h2 = 1
g5 = feedback(g4, h2, -1)
g6 = series(g1, g5)
final = feedback(g6, h1, -1)

% Block 4
clc
close all;
clear
s = tf('s');
g1 = s;
g2 = zpk([], [], 6);
g3 = zpk([], [], 4);
g4 = 1/s;
```



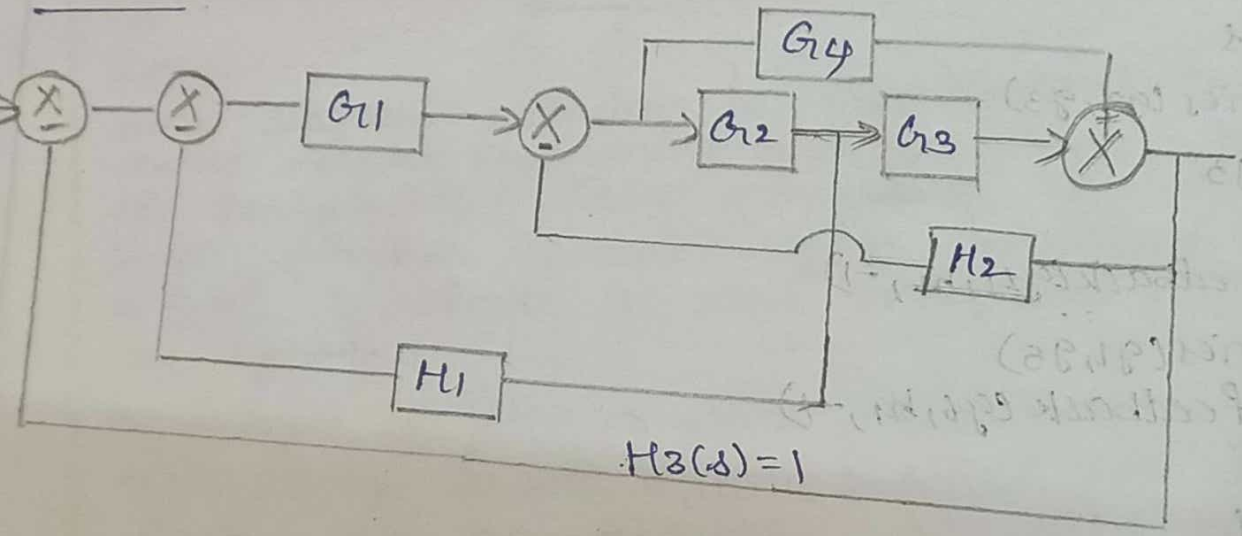
Overall $G_H(s) = \frac{G(s)}{1 + G(s)H(s)} = \frac{\frac{1}{(s+1)} \frac{s^2}{(s+4+s^2)}}{1 + \frac{1}{(s+1)} \frac{s^2}{(s+4+s^2)} \frac{6(s+4)}{s^2}}$

Final diagram:-



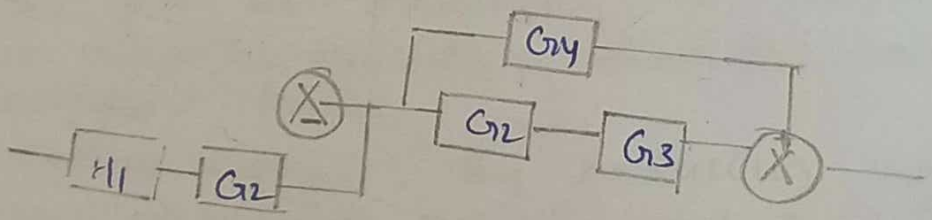
$= \frac{s^2}{s^3+2s^2+11s+28}$

BLOCK 4:-



$G_1 = 1$
$G_2 = 6$
$G_3 = 4$
$G_4 = \frac{1}{s}$
$H_1 = 2$
Let $H_2 = 1$

≡



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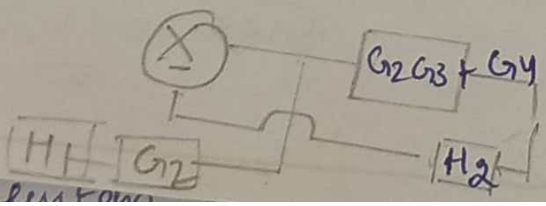

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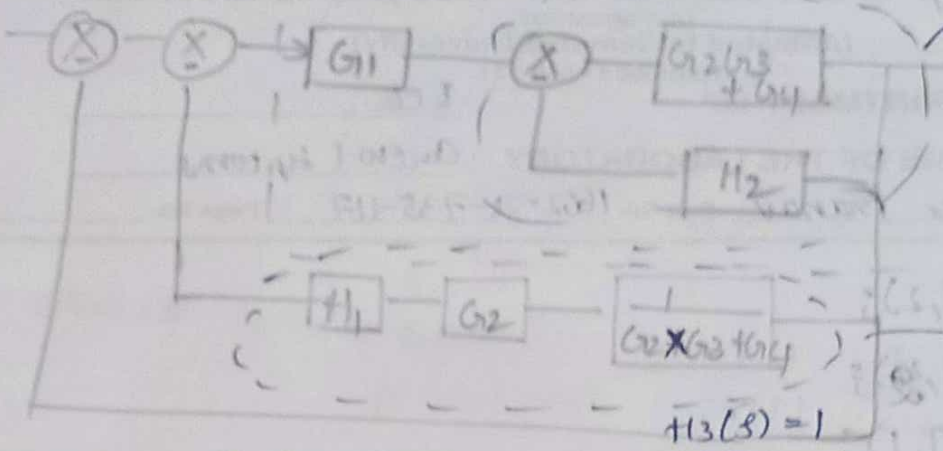
```
h1 = zpk([],[],2);
h10 = zpk([],[],2);
h2 = zpk([],[],1);
h3 = zpk([],[],1);
h1 = series(h1,g2);
Gr4 = series(g2,g3);
Gr4 = Gr4+g4;
g5 = feedback(Gr4,h2,-1);
g6 = series(g5,g1)
temp = series(h10,g2)
h4 = series(temp,1/Gr4)
g7 = feedback(g6,h4,-1);
g8 = feedback(g7,h3,-1)
```



$$g5 = \frac{G_2G_3 + G_4}{1 + G_2G_3H_2 + G_4H_2} \quad ; \quad g6 = \frac{G_4G_2G_3 + G_1G_4}{1 + G_2G_3H_2 + G_4H_2}$$

$$\text{Feedback } (g7) = \frac{\frac{G_1G_2G_3 + G_1G_4}{1 + G_2G_3H_2 + G_4H_2}}{1 + \left(\frac{G_4G_2G_3 + G_1G_4}{1 + G_2G_3H_2 + G_4H_2}\right)\left(\frac{H_1G_2}{G_2G_3 + G_4}\right)}$$

$$= \frac{G_1G_2G_3 + G_1G_4\,(G_2G_3 + G_4)}{(1 + G_2G_3H_2 + G_4H_2)(G_2G_3 + G_4) + (G_1G_2G_3 + G_1G_4)(H_1G_2)}$$

$$\text{Overall } (g8) = \frac{g7}{1 + g7H3(s)} = \frac{g7}{1 + g7}$$

$$g8 = \frac{G_1G_2G_3 + G_1G_4}{1 + (G_2G_3 + G_4)H_2 + H_1G_1G_2 + G_1G_2G_3 + G_4G_4}$$

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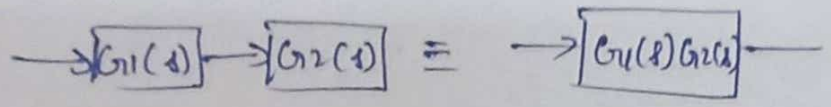
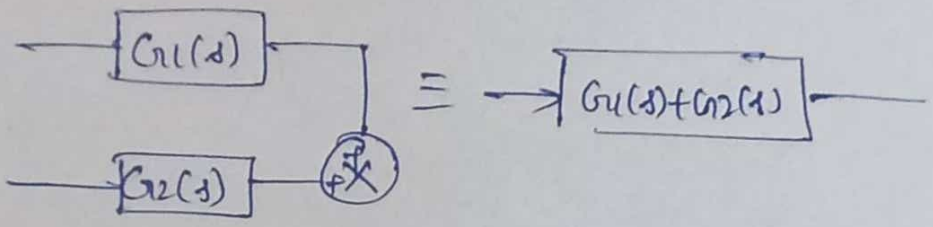
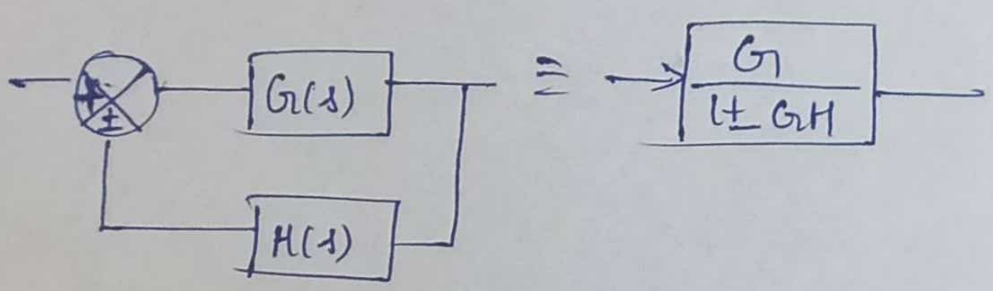
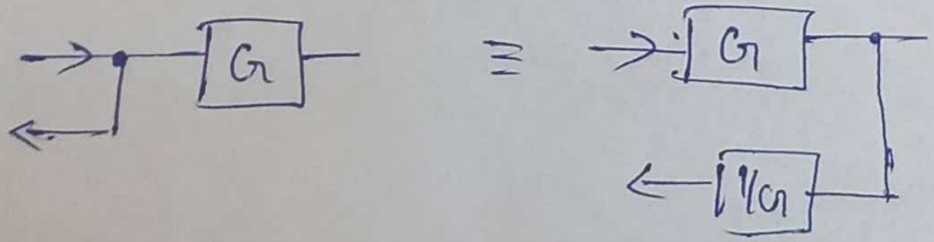
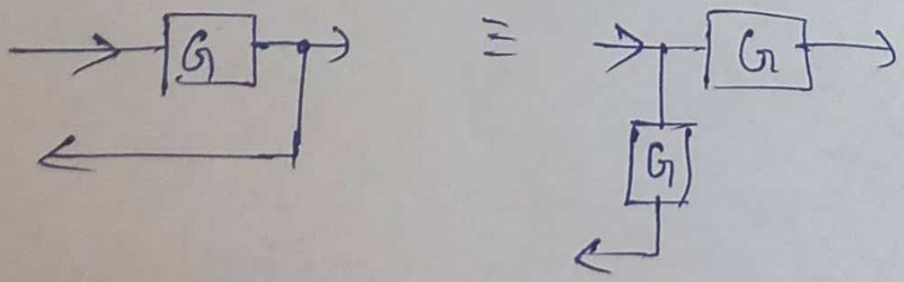
Rules followed:-

1) 

2) 

3) 

4) 

5) 

Result:- Reduced the given complex block diagrams by simulating in MATLAB