EEEN 460

Optimal Control

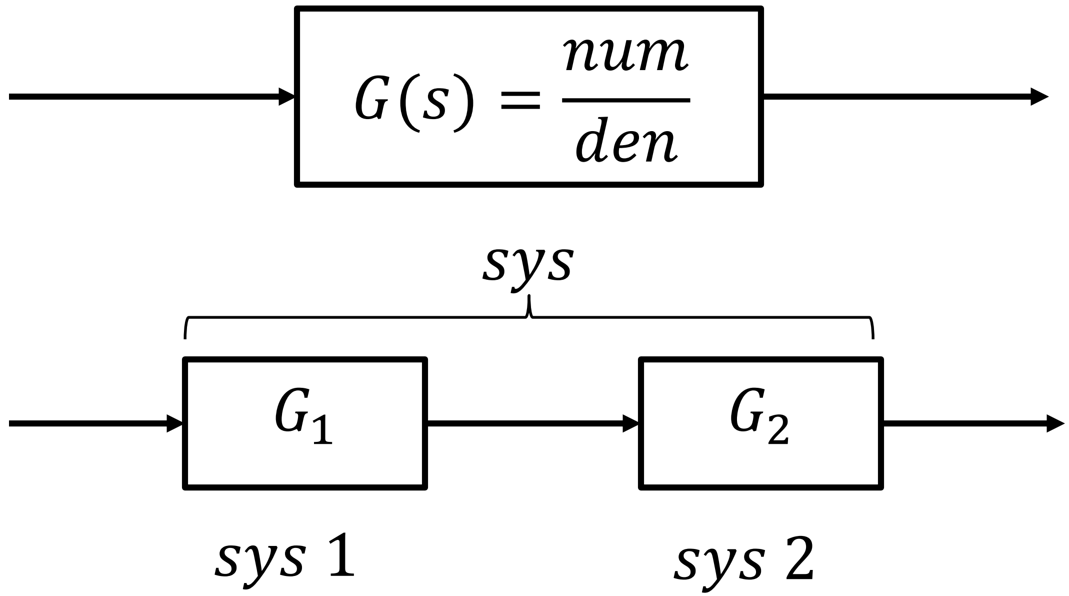
2020 Spring

Lecture V

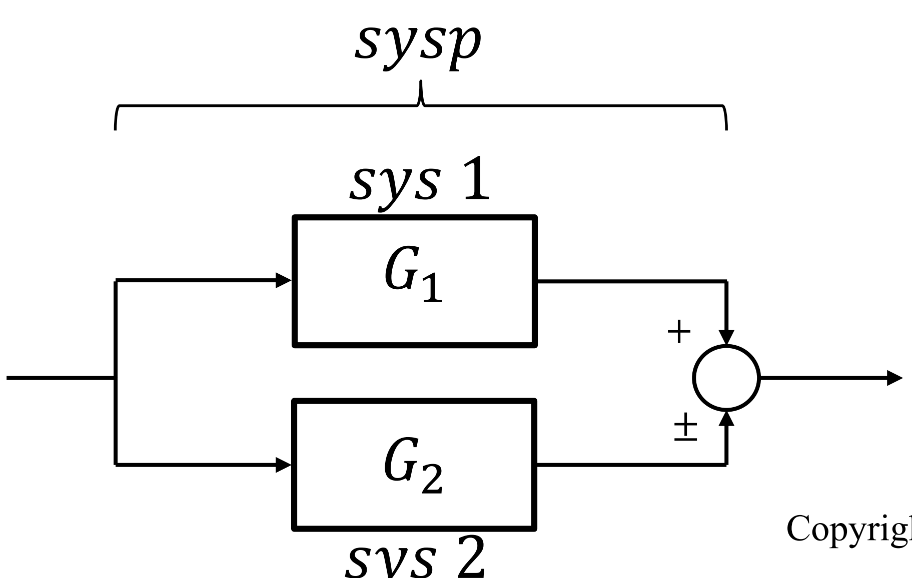
System Representation and Reduction with Matlab

Matlab representation of systems in block diagram form

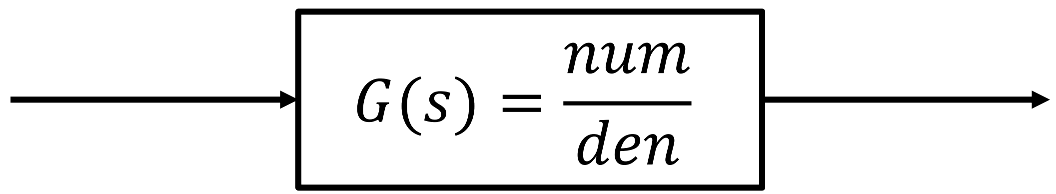
Series-connected blocks



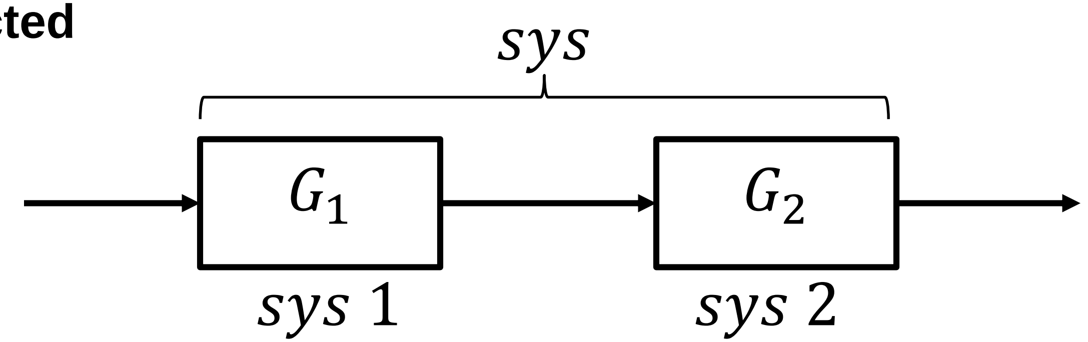
Parallel-connected blocks



Matlab representation of systems in block diagram form



Series-connected blocks



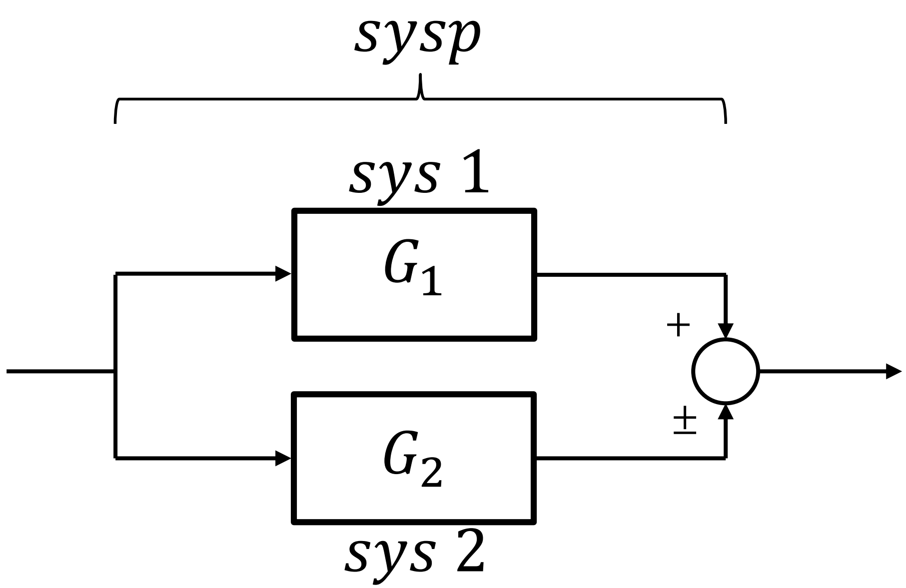
$$sys1 = tf(num1, den1)$$

$$sys2 = tf(num2, den2)$$

$$syss = series(sys1, sys2)$$

Parallel-connected blocks

Parallel-connected blocks



$$sys1 = tf(num1, den1)$$

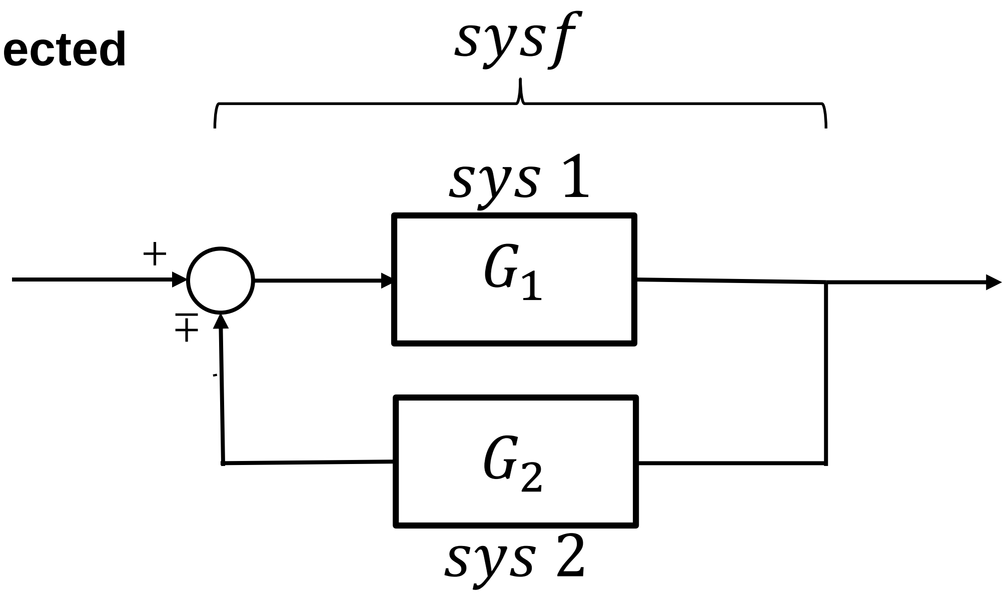
$$sys2 = tf(num2, den2)$$

$$sysp = parallel(sys1, sys2)$$

or $$sysp = parallel(sys1, -sys2)$$

Feedback-connected blocks

Feedback-connected blocks



$$sys1 = tf(num1, den1)$$

$$sys2 = tf(num2, den2)$$

Note that by default feedback is negative

$$sysf\ = feedback(sys1, sys2)$$

If the feedback is positive

$$sysf\ = feedback(sys1, -sys2)$$

Example

Example:
A system’s building blocks are given as:

$$G_1(s) = \frac{10}{s^2 + 2s + 10}, \qquad G_2\,(s) = \frac{5}{s+5}$$

Obtain the transfer functions of
a)Series(cascaded) system
b)Parallel system
c)Feedback system

Matlab Script and Program Output

```
%Defining the blocks
num1=[10];
den1=[1 2 10];
num2=[5];
den2=[1 5];
sys1=tf(num1,den1);
sys2=tf(num2,den2);
%----------------------
%series system
disp('series system');
syss=series(sys1,sys2)
%----------------------
%parallel system
disp('parallel system');
sysp=parallel(sys1,sys2)
%----------------------
%feedback system
disp('feedback system');
sysf=feedback(sys1,sys2)
```

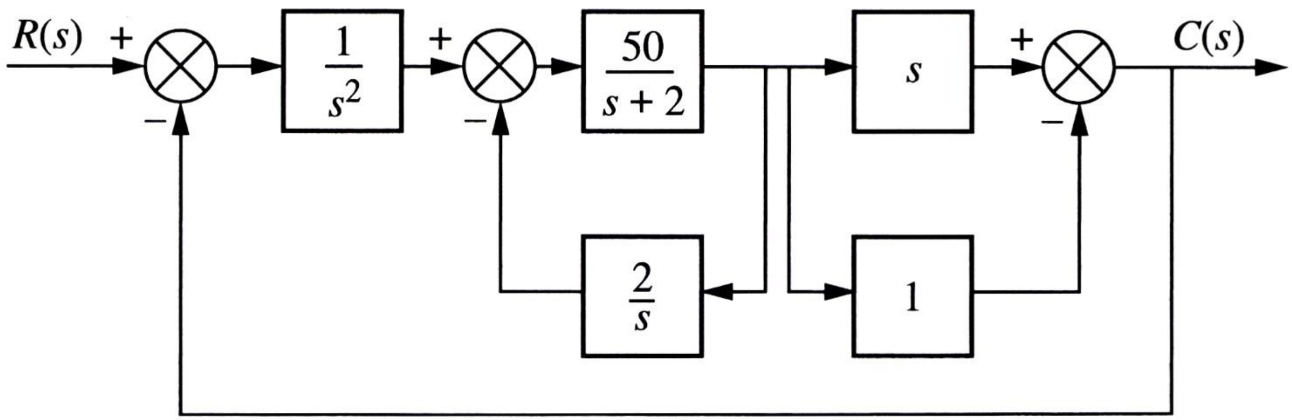
Save under the name TransferFunc.m

and Run

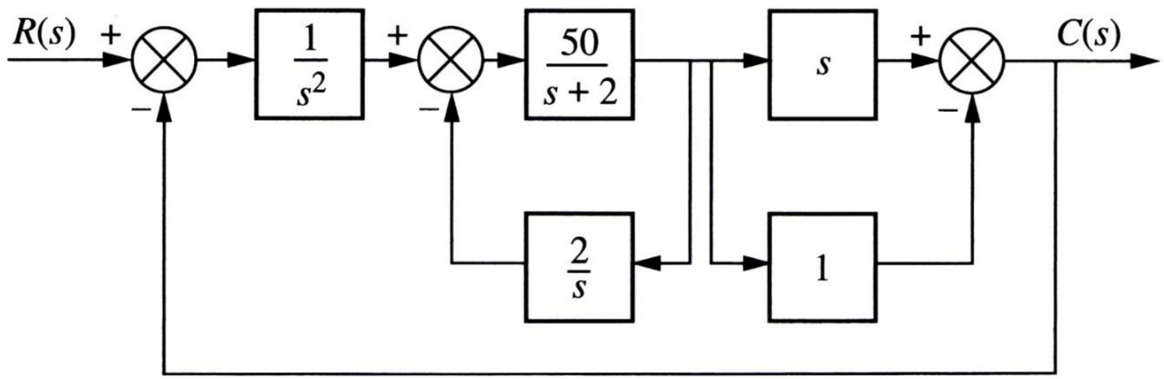
```
>> TransferFunc
series system

syss =

         50
  ----------------------
  s^3 + 7 s^2 + 20 s + 50

Continuous-time transfer function.

parallel system

sysp =

   5 s^2 + 20 s + 100
  ----------------------
  s^3 + 7 s^2 + 20 s + 50

Continuous-time transfer function.

feedback system

sysf =

       10 s + 50
  -----------------------
  s^3 + 7 s^2 + 20 s + 100

Continuous-time transfer function.
```

Problem 5.1

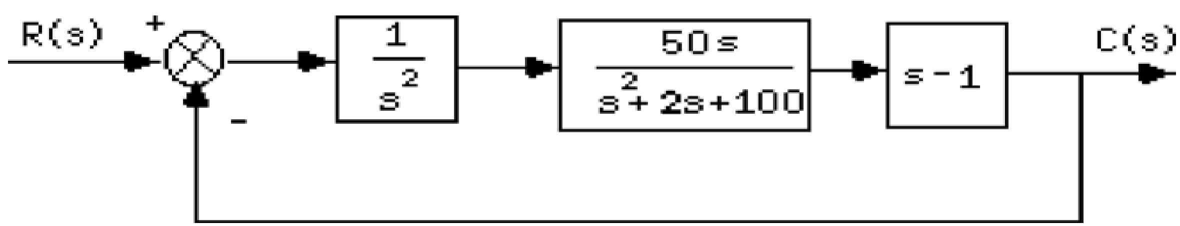
Find the transfer function of the following system



Solution

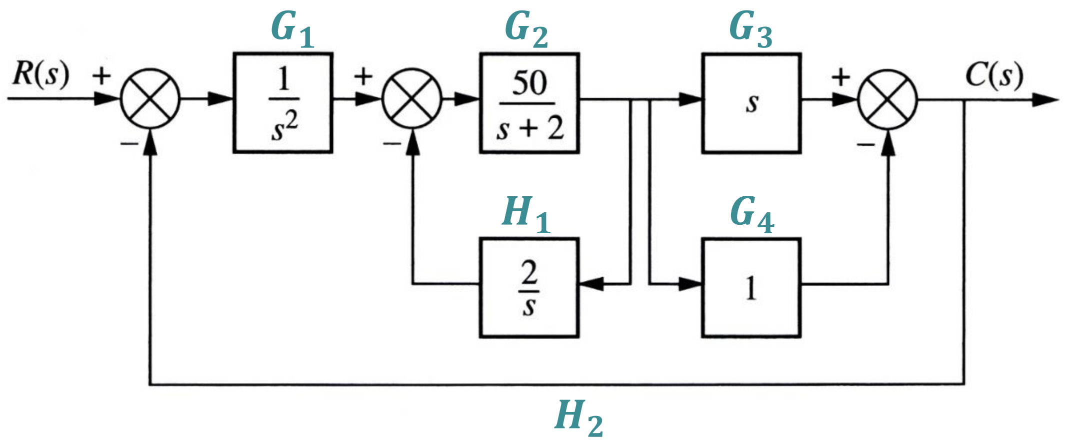


a. Combine the inner feedback and the parallel pair.



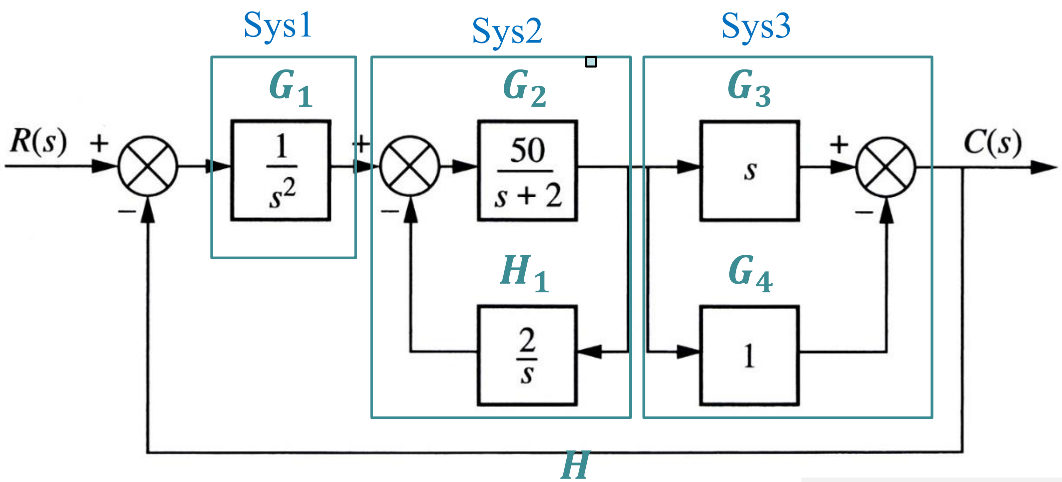
$$T(s)=\frac{50(s-2)}{s^3+2s^2+150s-50}$$

Matlab Solution




```
% Defining the system
'G1(s)'
G1=tf(1,[1 0 0])
%--------------------------
'G2(s)'
G2=tf(50,[1 2])
%--------------------------
'H1(s)'
H1=tf(2,[1 0])
%--------------------------
'G3(s)'
G3=tf([1 0],1)
%--------------------------
'G4(s)'
G4=1
%--------------------------
'H2(s)'
H2=1
%----------------------
```

Matlab Solution




```
% Defining the system
'G1(s)'
G1=tf(1,[1 0 0])
%--------------------------
'G2(s)'
G2=tf(50,[1 2])
%--------------------------
'H1(s)'
H1=tf(2,[1 0])
%--------------------------
'G3(s)'
G3=tf([1 0],1)
%--------------------------
'G4(s)'
G4=1
%--------------------------
'H (s)'
H=1
%----------------------
```

```
%--------------------------
'Sys1'
Sys1=G1
%--------------------------
'Sys2'
Sys2=feedback(G2,H1)
%--------------------------
'Sys3'
Sys3=parallel(G3,-G4)
% Finding the forward path, G(s)
'G(s)'
GA=series(Sys1,Sys2);
G=series(GA,Sys3)
% Finding the transfer function, T(s)
'T(s)'
T=feedback(G,H)
```

Matlab Solution

```
ans =

T(s)


T =

        50 s^2 - 50 s
  ----------------------------
  s^4 + 2 s^3 + 150 s^2 - 50 s

Continuous-time transfer function.
```

After simplification(i.e. Dividing both the numerator and the denominator by s) we find the same result as in pg. 10.

End of Lecture 5