EE324 Control Systems Lab

Problem sheet 1

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Question 1

Obtaining the transfer functions of Various systems using Scilab

G1(s) = 10/(s^2+2s+10)   G2(s) = 5/(s+5)

(a) Cascade system:

In above we have the G1(s) transfer function which has the input R(s) and let the output be Y(s). The second transfer function G2(s) has the input Y(s) and the output C(s).
Both the transfer functions are defined as:

G1(s) = Y(s)/R(s)   (1)

G2(s) = C(s)/Y(s)   (2)

We know the transfer function of whole system:

G(s) = C(s)/R(s)   (3)

From the equation (1) and (2) we can write equation (3) as:

G(s) = G1(s)*G2(s)

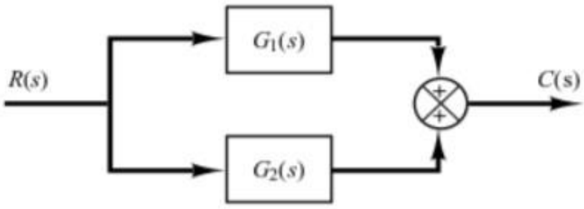
Scilab Code for the same:

```
s=poly(0,'s')
g1 = 10/(s^2+2*s+10)
g2 = 5/(s+5)
g = g1*g2
sys = syslin('c', g)
```

```
--> sys = syslin('c',g)
 sys  =


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

(b) Parallel system:



In above we have the G1(s) transfer function which has the input R(s) and the output be Y1(s). The second transfer function G2(s) has the input R(s) and the output Y2(s).

Both the transfer functions are defined as:

$$G1(s) = Y1(s)/R(s) \qquad (1)$$

$$G2(s) = Y2(s)/R(s) \qquad (2)$$

The equivalent output y(s) is equal with the sum between y1(s) and y2(s):

$$Y(s) = Y1(s)+Y2(s) \qquad (3)$$

We know the transfer function of whole system:

$$G(s) = Y(s)/R(s) \qquad (4)$$

From the equation (1) , (2) and (3) we can write equation (4) as:

$$G(s) = G1(s)+G2(s)$$

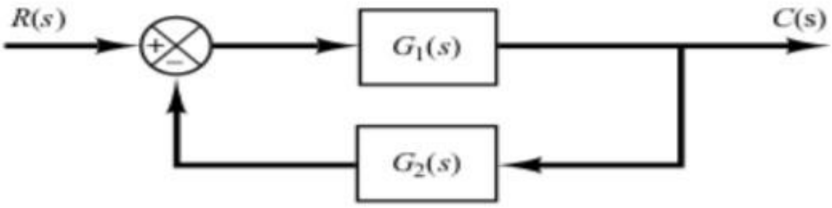
Scilab Code for the same:

```
s=poly(0,'s')
g1 = 10/(s^2+2*s+10)
g2 = 5/(s+5)
g = g1+g2
sys = syslin('c', g)
```

```
--> sys = syslin('c',g)
 sys  =

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

(c) Feedback(closed loop) system:



In above we have the G1(s) transfer function which has the input R(s)-U2(s) , let the output be Y1(s). The second transfer function G2(s) has the input Y1(s) and the output Y2(s).

Both the transfer functions are defined as:

G1(s) = Y1(s)/U1(s) (1)

G2(s) = Y2(s)/U2(s) (2)

The equivalent output y(s) is equal with the sum between y1(s) and y2(s):

U1(s) = U(s)+Y2(s) (3)

We know the transfer function of whole system:

G(s) = G1(s)/1+G2(s) (4)

Scilab Code for the same:

```
s=poly(0,'s')
g1 = 10/(s^2+2*s+10)
g2 = 5/(s+5)
g = g1/(1+g1*g2)
sys = syslin('c',g)
```

```
--> g = g1/(1+g1*g2)
 g  =


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

(d) Unit step Response to the Transfer function G1(s):

G1(s) = 10/(s^2+2s+10)

Scilab Code for the Plot:

```
s=poly(0,'s')
g1 = 10/(s^2+2*s+10)
t=0:0.01:3;
plot2d(t, csim('step',t,g1));
xlabel("Time [s]");
ylabel("C(s)");
title("Unit Step Response");
xgrid(1, 1, 10);
```

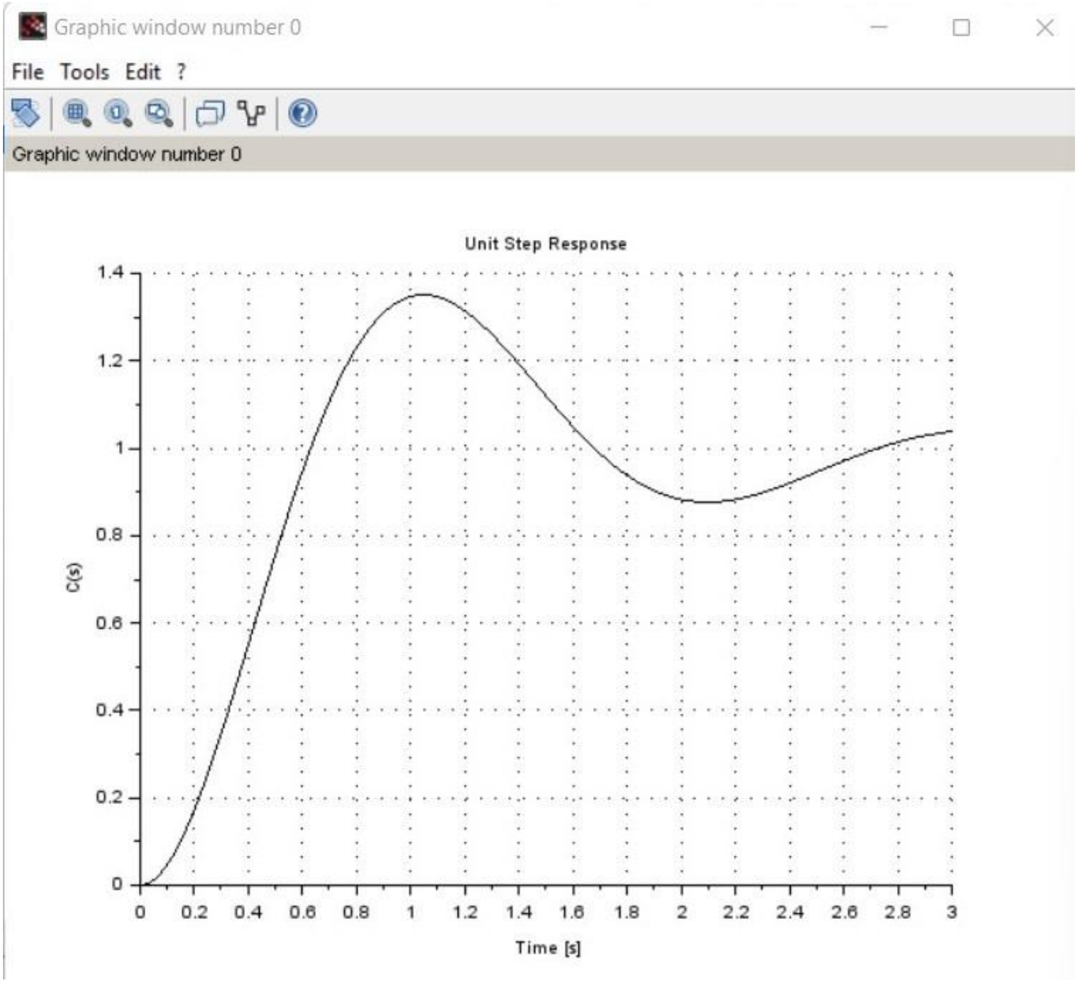


Figure1: Unit Step Response Plot

Question 2

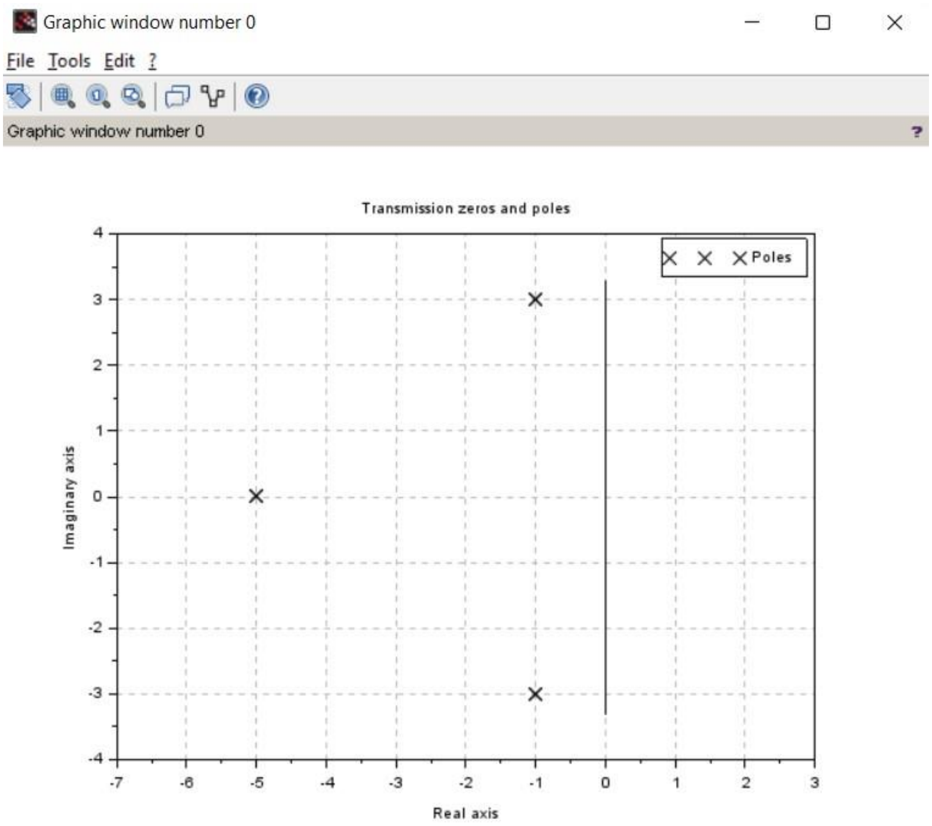
Obtaining the Zeros and Poles of Various systems using Scilab:

G1(s) = 10/(s^2+2s+10)   G2(s) = 5/(s+5)

(a) Cascade system:
Transfer function of the Overall system:
G(s) = G1(s)*G2(s)
$G(s) = 50/(50+20s+7s^2+s^3)$
Zeros of the transfer function are the roots of the **Numerator** polynomial
i.e., **50** => Roots = None
Poles of the transfer function are the roots of the **Denominator** polynomial,
i.e., **$50+20s+7s^2+s^3$** => Roots = ***-5, -1+3i and -1-3i***

Scilab Code for finding Poles and zeros of the transfer function:

```
s=poly(0,'s')
g1 = 10/(s^2+2*s+10)
g2 = 5/(s+5)
g = g1*g2
sys=syslin('c',g)
d = sys.den
poles=roots(d)
plzr ( sys )
```



(a) Roots and Zeros of the transfer function
(b)

(b) Parallel system:

Transfer function of the Overall system:

G(s) = G1(s)+G2(s)

G(s) = $100+20s+5s^2/(50+20s+7s^2+s^3)$

Zeros of the transfer function are the roots of the **Numerator** polynomial

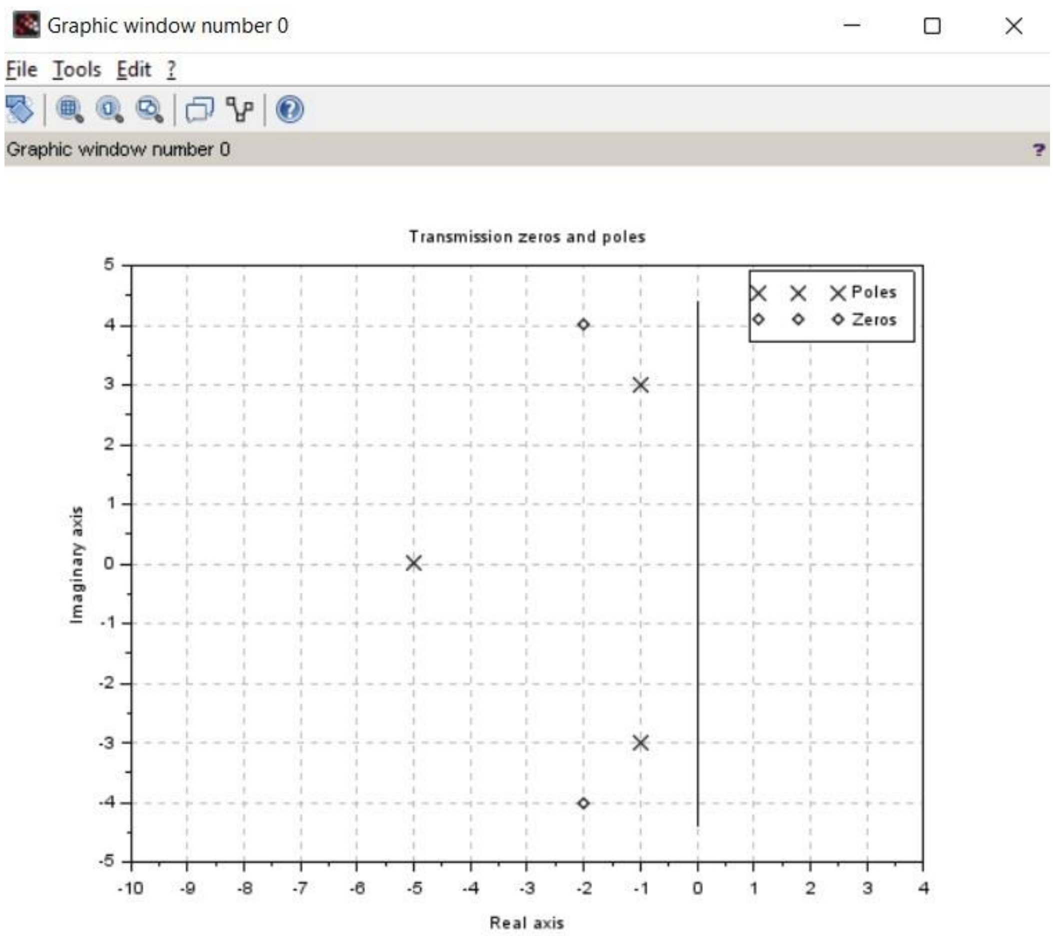
i.e., **$100+20s+5s^2$** => Roots = ***-2+4i, -2-4i***

Poles of the transfer function are the roots of the **Denominator** polynomial,

i.e., **$50+20s+7s^2+s^3$** => Roots = ***-5, -1+3i and -1-3i***

Scilab Code for finding Poles and zeros of the transfer function:

```
s=poly(0,'s')
g1 = 10/(s^2+2*s+10)
g2 = 5/(s+5)
g = g1+g2
sys=syslin('c',g)
n = sys.num
zeron = roots(n)
d = sys.den
poles=roots(d)
plzr ( sys )
```



(a) Roots and Zeros of the transfer function

c) Feedback(closed loop) system:

Transfer function of the Overall system:
G(s) = G1(s)/1+G1(s)*G2(s)
G(s) = 50+10S/(100+20s+7s^2+s^3)
Zeros of the transfer function are the roots of the **Numerator** polynomial
i.e., **50+10S** => Roots = ***-5***
Poles of the transfer function are the roots of the **Denominator** polynomial,
i.e., 100+20s+7s^2+s^3 => Roots = ***-6.33, -0.332+3.95i, -0.332-3.95i***

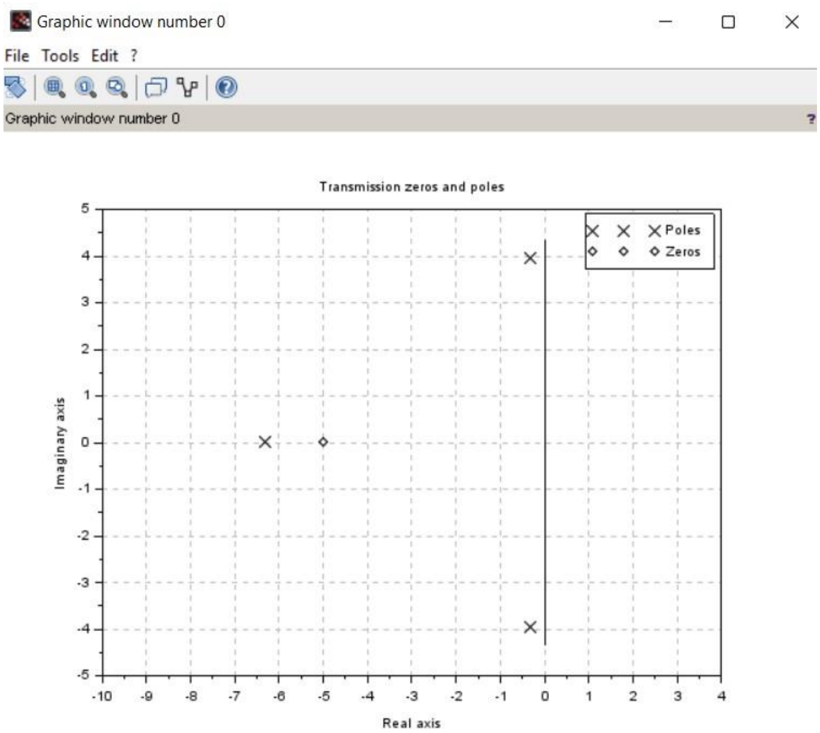
Scilab Code for finding Poles and zeros of the transfer function:

```
s=poly(0,'s')
g1 = 10/(s^2+2*s+10)
g2 = 5/(s+5)
g = g1/(1+g1*g2)

sys=syslin('c',g)
n = sys.num
zeron = roots(n)

d = sys.den
poles=roots(d)

plzr ( sys )
```



(b) Roots and Zeros of the transfer function

Question 3

Mesh analysis, in matix vector form Z(s)I(s)=V(s)

Mesh 1 equations

(2(1+s)+1/s+1)i1 - (1/s+1)i2 – (s+1)i3 = 0

Mesh 2 equation:

(1/s+1)i1- (1/(s+1)+1+s+2)i2+2i3 = 0

Mesh 3 equation:

(1+s)i1 +2i2 – (1+1+s+2+1/(1+s)+2) = -v1

$$B = \begin{matrix} \frac{4*s+2*s^2+3}{s+1} & -\frac{1}{s+1} & (s+1) \\ \frac{1}{s+1} & -\frac{s^2+4*s+4}{s+1} & 2 \\ 1+s & 2 & -\frac{s^2+7*s+6}{1+s} \end{matrix}$$

Scilab Code for finding transfer function:

```
s=poly(0,'s')
A = [0; 0; -1]
B = [(4*s+2*s^2+3)/(s+1) -1/(s+1) -(s+1); 1/(s+1) -(s^2+4*s+4)/(s+1) 2; 1+s 2 -
(s^2+7*s+6)/(1+s)]
C = inv(B)
A*C
```

- Find the matix vector from the Mesh analysis equations and then take inverse of the matix
- Multiply the inverse matrix with the matrix A

The transfer functions s I_1(s)/V_1(s), I_2(s)/V_1(s), I_3(s)/V_1(s) are as follows:

```
--> C*A
 ans  =

                  2   3
      6 + 8s + 5s + s
   -------------------------
                 2     3   4
   46 + 81s + 56s + 16s + s
                    2
         7 + 9s + 4s
   -------------------------
                 2     3   4
   46 + 81s + 56s + 16s + s
                   2     3
     11 + 17s + 10s + 2s
   -------------------------
                 2     3   4
   46 + 81s + 56s + 16s + s
```