INTRODUCTION TO MATLAB/SIMULINK APPLICATION IN LINEAR CONTROL SYSTEMS

Fall 2024

SESSION 2

AGENDA

Solve Differential Equations

Laplace Transform

Transfer Function

Plot in MATLAB

State Space

SOLVE DIFFERENTIAL EQUATIONS

syms

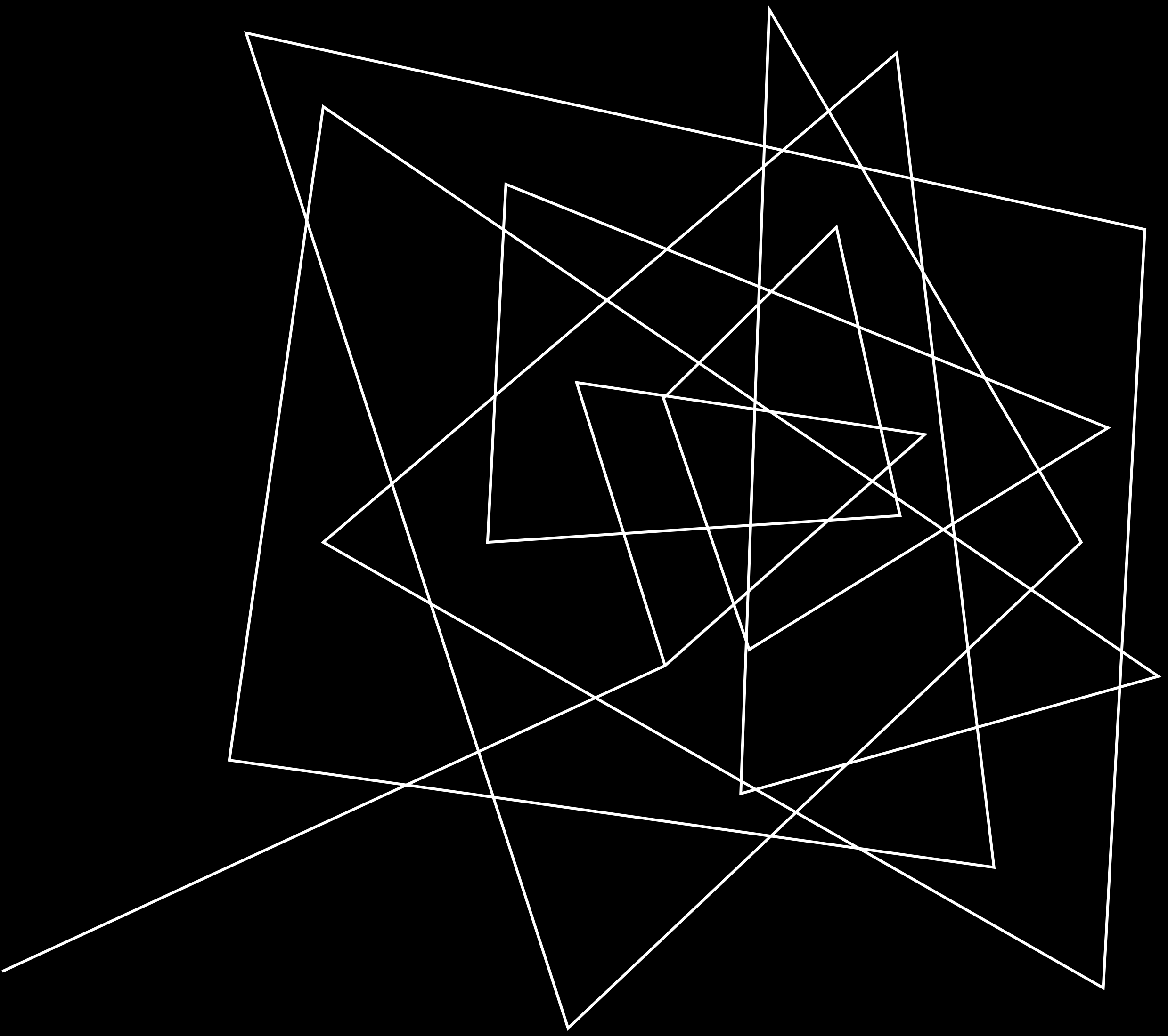
dsolve()

Solve the first-order differential equation $\frac{dy}{dt} = ay$.

Specify the first-order derivative by using `diff` and the equation by using `==`. Then, solve the equation by using `dsolve`.

```
syms y(t) a
eqn = diff(y,t) == a*y;
S = dsolve(eqn)
```

S = $C_1 e^{a t}$



LAPLACE TRANSFORM

laplace()

```
syms a t y
f = exp(-a*t);
F = laplace(f)
```

F =

$$\frac{1}{a+s}$$

ilaplace()

```
syms a s
F = 1/(s-a)^2;
f = ilaplace(F)
```

f = $t\,e^{a\,t}$

TRANSFER FUNCTION

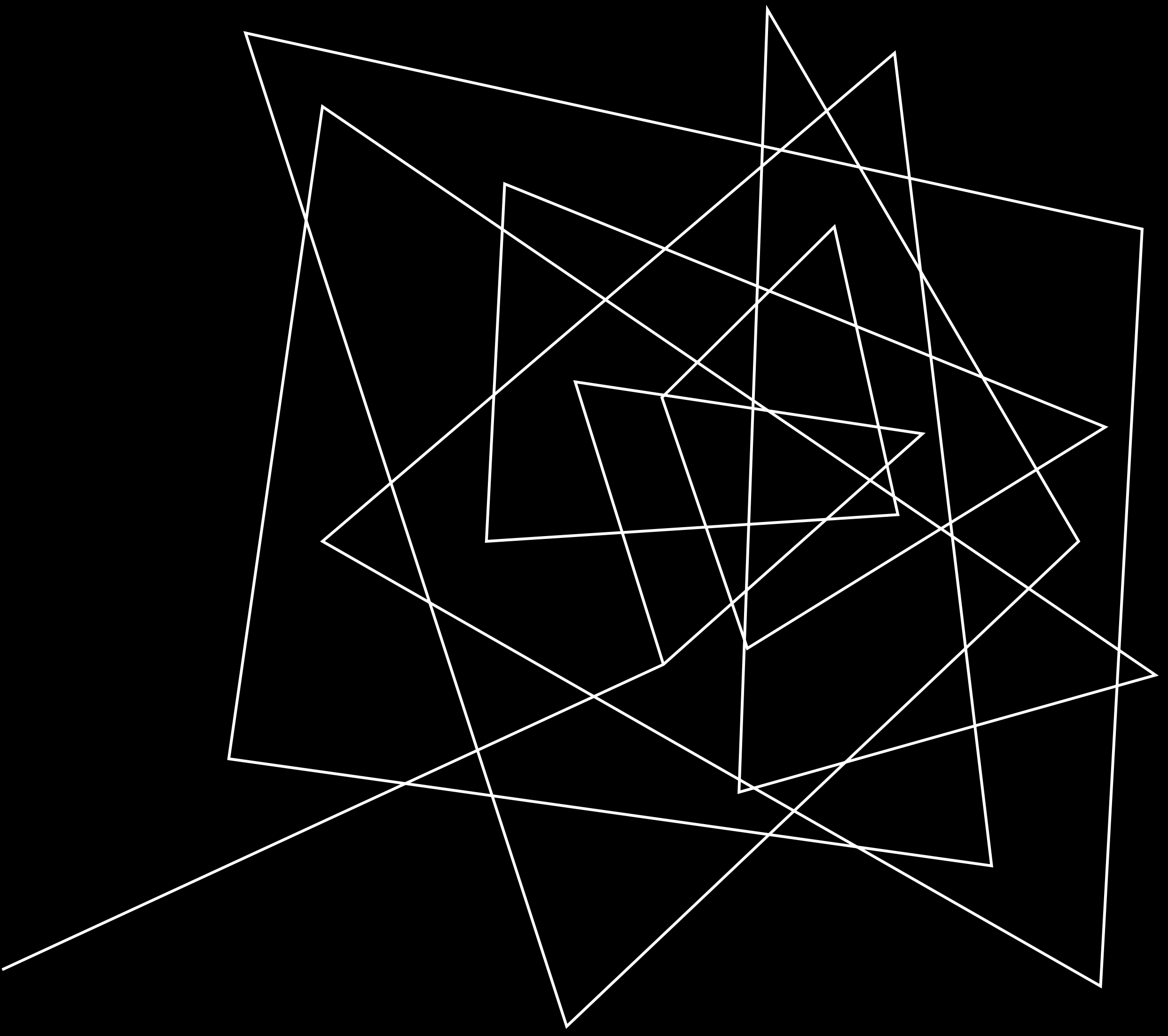
tf()

$$sys(s) = \frac{1}{2s^2 + 3s + 4}.$$

Specify the numerator and denominator coefficients ordered in descending powers of s, and create the transfer function model.

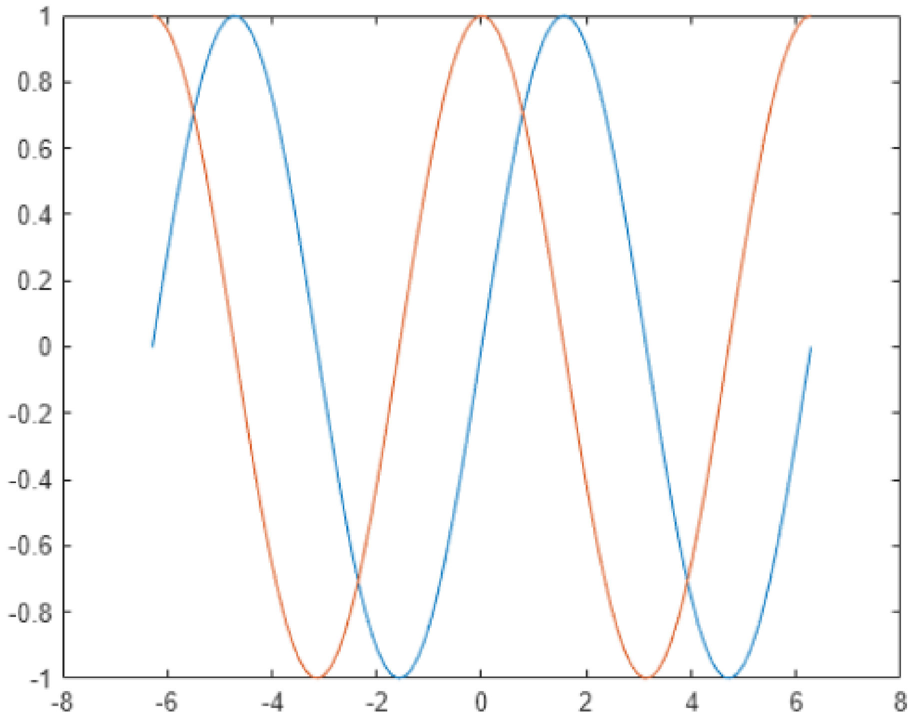
```
numerator = 1;
denominator = [2,3,4];
sys = tf(numerator,denominator)
```

```
sys =

         1
  ---------------
  2 s^2 + 3 s + 4

Continuous-time transfer function.
```



PLOT IN MATLAB

```
x = linspace(-2*pi,2*pi);
y1 = sin(x);
y2 = cos(x);

figure
plot(x,y1,x,y2)
```



STATE SPACE

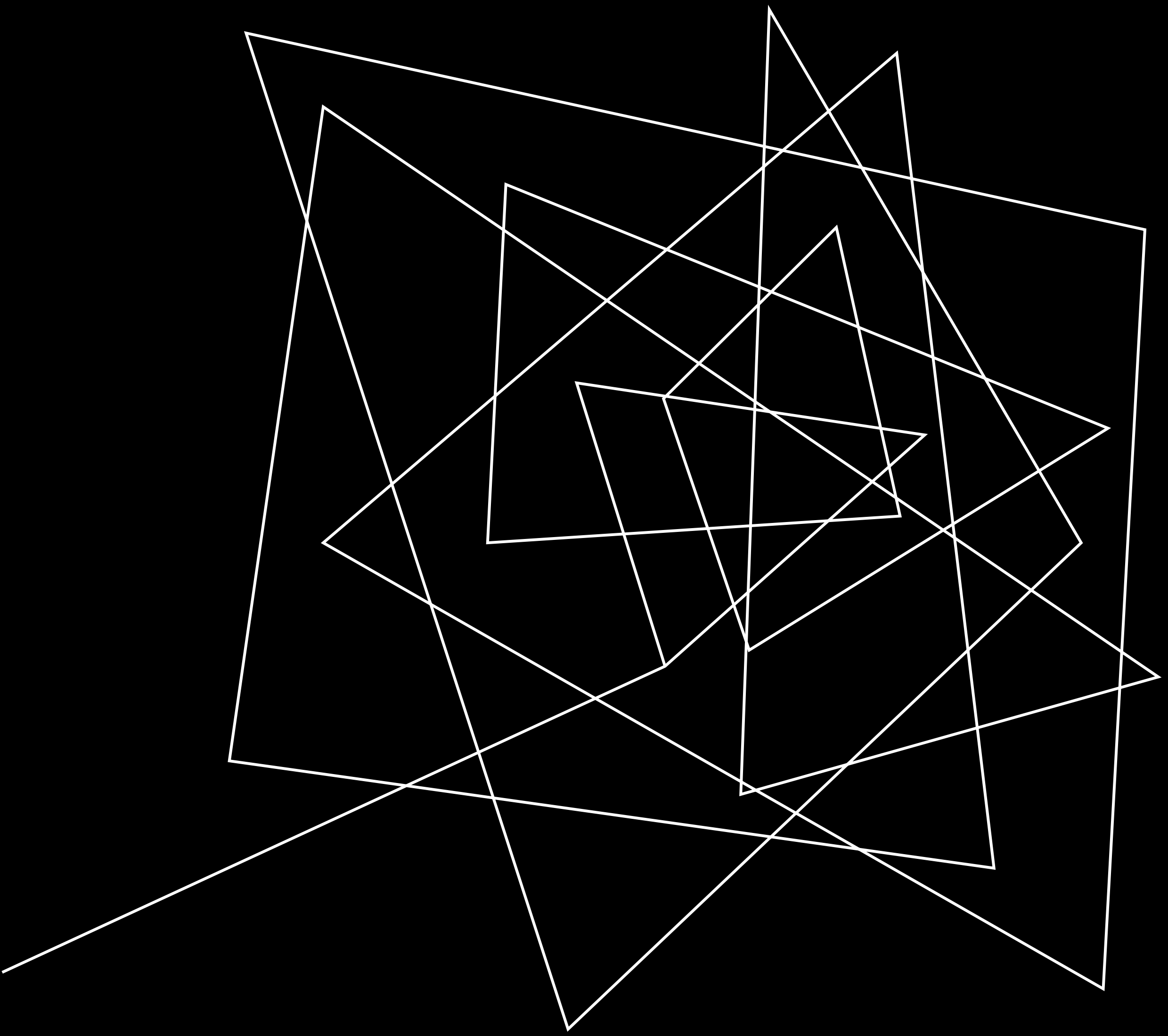
Create the SISO state-space model defined by the following state-space matrices:

$$A = \begin{bmatrix} -1.5 & -2 \\ 1 & 0 \end{bmatrix} \quad B = \begin{bmatrix} 0.5 \\ 0 \end{bmatrix} \quad C = [0 \quad 1] \quad D = 0$$

Specify the A, B, C and D matrices, and create the state-space model.

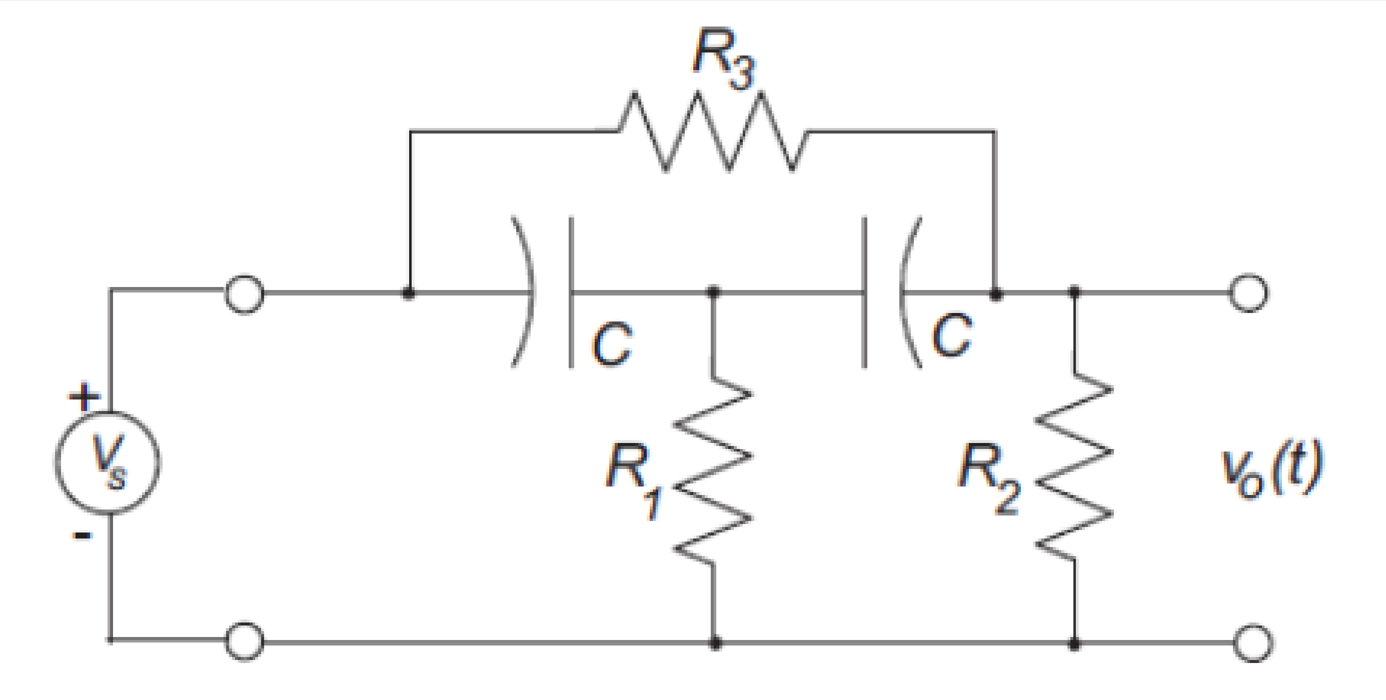
```
A = [-1.5,-2;1,0];
B = [0.5;0];
C = [0,1];
D = 0;
sys = ss(A,B,C,D)
```

```
sys =

  A =
          x1    x2
   x1   -1.5    -2
   x2      1     0

  B =
         u1
   x1   0.5
   x2     0

  C =
        x1  x2
   y1    0   1
```

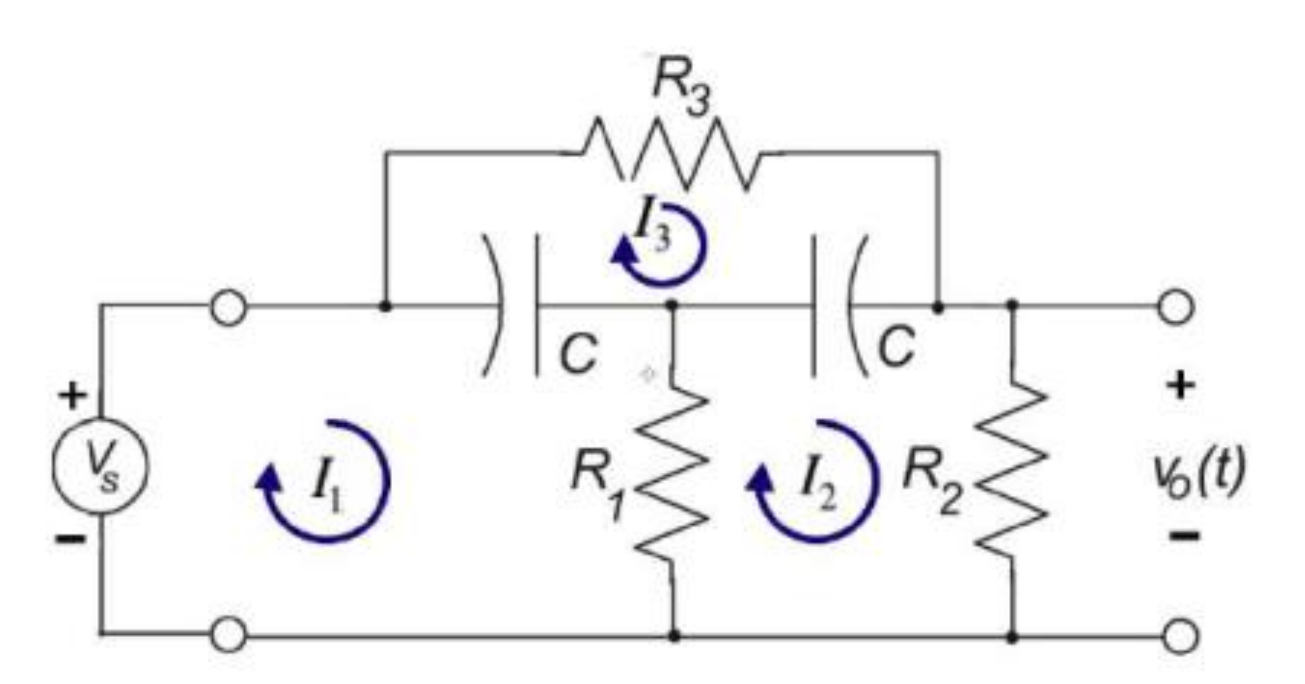


EXAMPLE

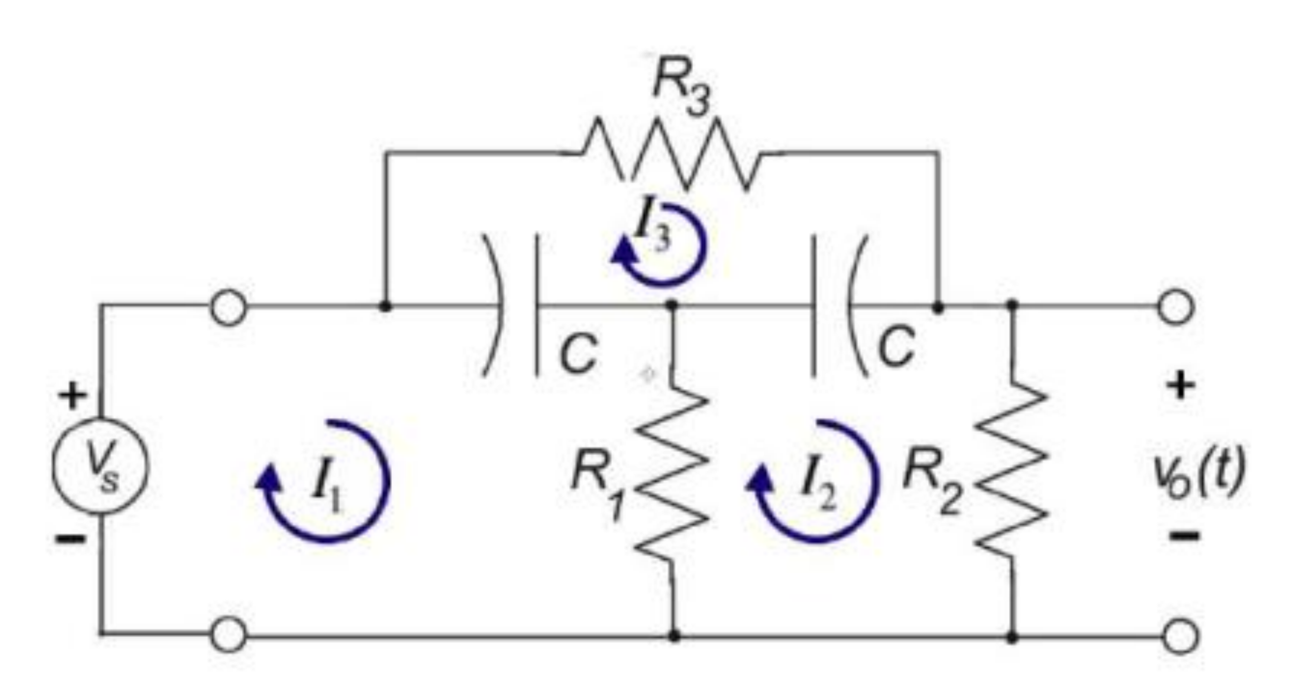
Bridged-T Filter



Bridged-T Filter

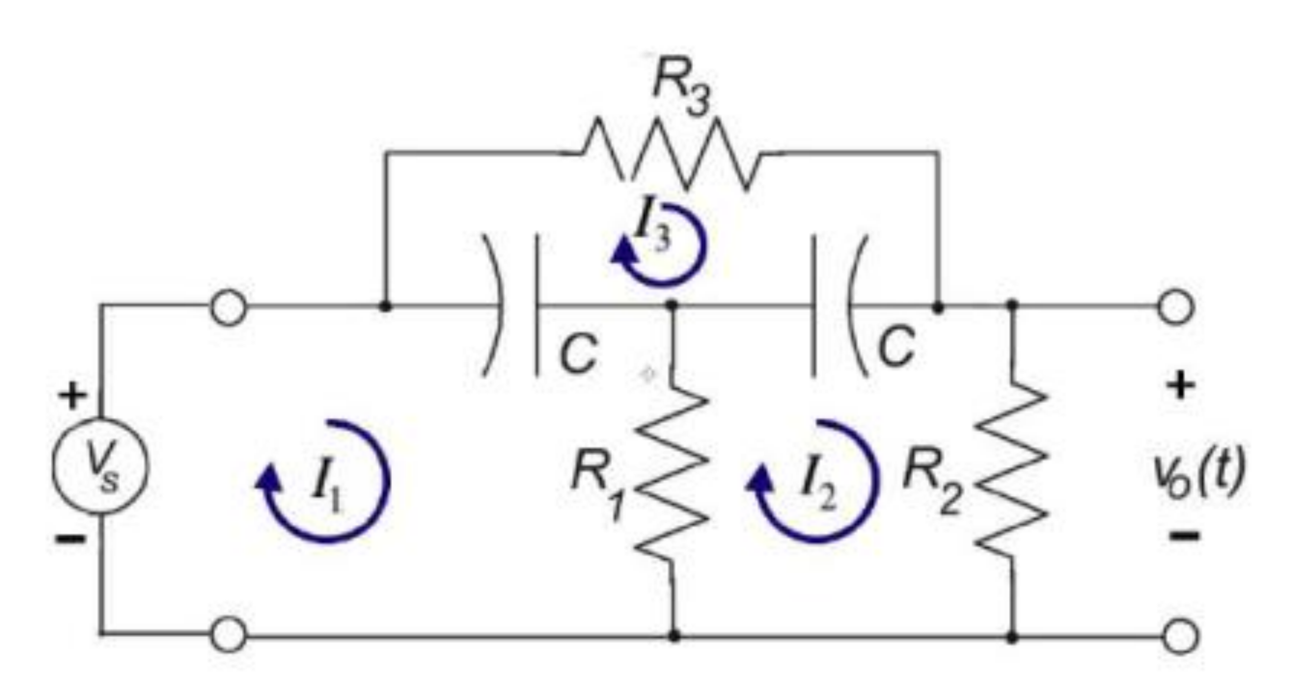


Bridged-T Filter



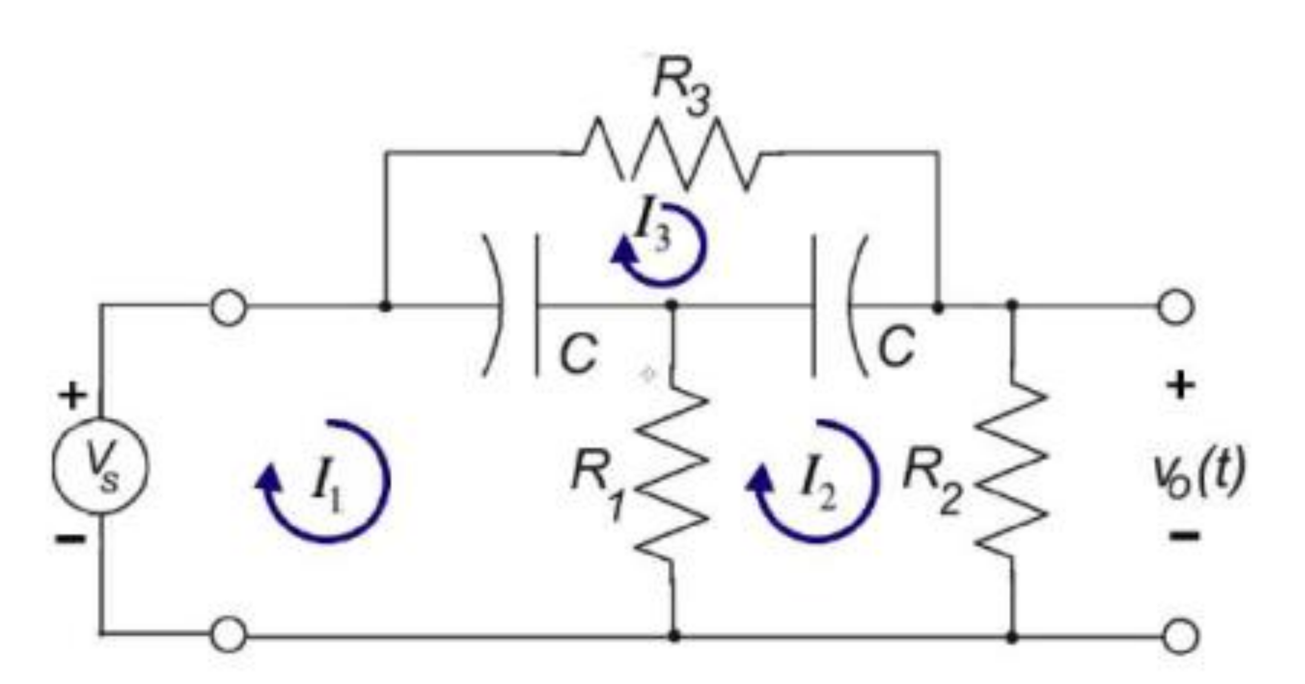
Loop 1: $-V_s + \frac{1}{Cs}(I_1 - I_3) + R_1(I_1 - I_2) = 0$

Bridged-T Filter



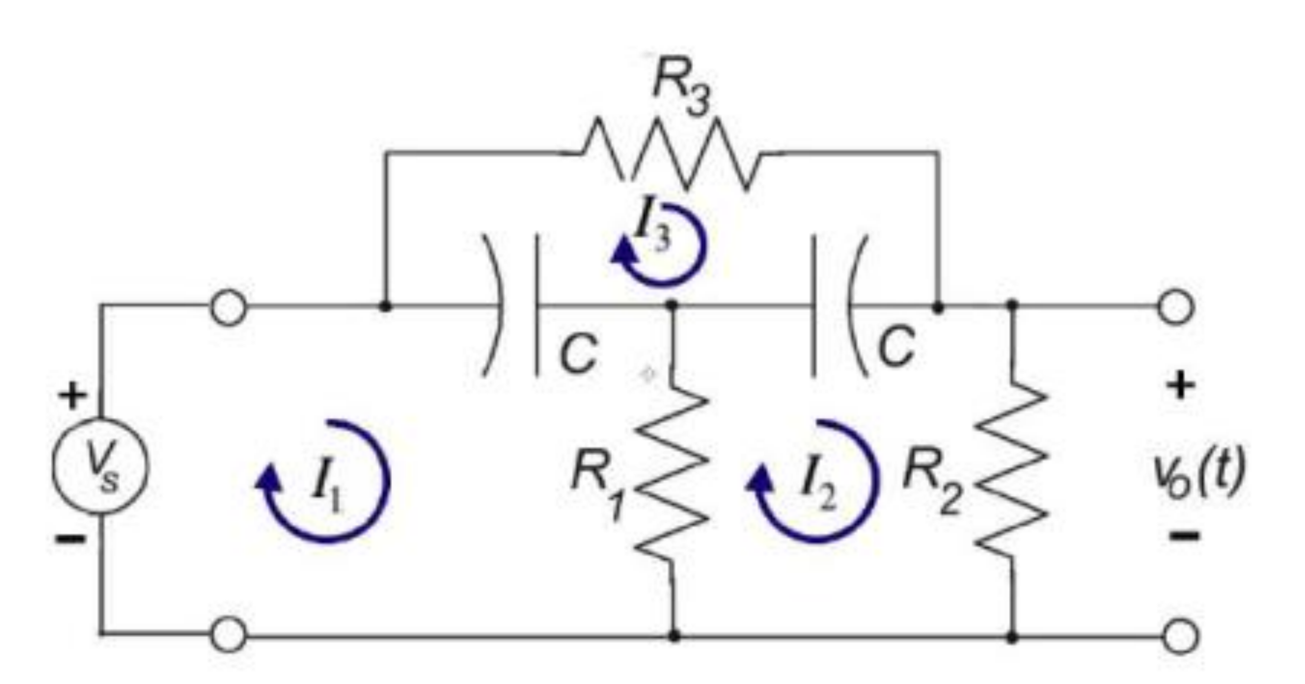
$$\text{Loop 1:} \quad -V_s + \frac{1}{Cs}(I_1 - I_3) + R_1(I_1 - I_2) = 0$$
$$\text{Loop 2:} \quad R_1(I_2 - I_1) + \frac{1}{Cs}(I_2 - I_3) + R_2 I_2 = 0$$

Bridged-T Filter



$$\text{Loop 1:} \quad -V_s + \frac{1}{Cs}(I_1 - I_3) + R_1(I_1 - I_2) = 0$$
$$\text{Loop 2:} \quad R_1(I_2 - I_1) + \frac{1}{Cs}(I_2 - I_3) + R_2 I_2 = 0$$
$$\text{Loop 3:} \quad \frac{1}{Cs}(I_3 - I_1) + R_3 I_3 + \frac{1}{Cs}(I_3 - I_2) = 0$$

Bridged-T Filter



$$H(s) = \frac{V_o(s)}{V_s(s)} = \frac{(R_1 R_3 C^2 s^2 + 2R_1 C s + 1)R_2}{R_1 R_3 R_2 C^2 s^2 + (2R_1 R_2 + 2R_1 R_3 + R_3 R_2)Cs + R_2 + R_3}$$

THANK YOU

GitHub: https://github.com/LinearControlSystems/MATLAB-Simulink-Applications