LABORATORY INSTRUCTION MANUAL

CIRCUIT THEORY & NETWORK LAB

EE 391

ELECTRICAL ENGINEERING DEPARTMENT
JIS COLLEGE OF ENGINEERING
(AN AUTONOMOUS INSTITUTE)
KALYANI, NADIA
Stream: EE

Subject Name: CIRCUIT THEORY AND NETWORK LAB

Subject Code: EE391

LIST OF EXPERIMENTS
1. Transient response of R-L and R-C network: simulation with PSPICE/MATLAB /Hardware
2. Transient response of R-L-C series and parallel circuit: Simulation with PSPICE/MATLAB / Hardware
3. Study the effect of inductance on step response of series RL circuit in MATLAB/HARDWARE.
4. Determination of Impedance (Z) and Admittance (Y) parameter of two port network: Simulation / Hardware.
5. Frequency response of LP and HP filters: Simulation / Hardware.
7. Generation of Periodic, Exponential, Sinusoidal, Damped Sinusoidal, Step, Impulse, Ramp signal using MATLAB in both discrete and analog form.
8. Determination of Laplace transform and Inverse Laplace transform using MATLAB.
EXPERIMENT NO : CKT /1

TITLE : TRANSIENT RESPONSE OF R-L AND R-C NETWORK: SIMULATION WITH PSPICE/MATLAB /HARDWARE

OBJECTIVE : Study and obtain the transient response of a series R-C and series R-L circuit using MATLAB.

THEORY:

Let us consider the R-C circuit as shown below:

![R-C Circuit Diagram]

Applying KVL, we obtain

\[ v(t) = Ri(t) + \frac{1}{C} \int i(t)dt \]

Taking Laplace transform on both sides of the above equation,

\[ V(s) = RI(s) + \frac{1}{C} \left[ \frac{I(s)}{s} + \frac{q(0_+)}{s} \right] \]

or,

\[ V(s) = RI(s) + \frac{I(s)}{sC} + \frac{v_c(0_+)}{s} \]

Now as all initial conditions set equal to zero, i.e. \( v_c(0_+) = 0 \), so the equation becomes

\[ V(s) = RI(s) + \frac{I(s)}{sC} \]

or,

\[ V(s) = I(s) \left[ R + \frac{1}{sC} \right] \]
Let us consider the R-L circuit as shown below:

![R-L Circuit Diagram]

Applying KVL, we obtain

\[ v(t) = Ri(t) + L \frac{di(t)}{dt} \]

Taking Laplace transform on both sides of the above equation,

\[ V(s) = RI(s) + L[sI(s) - i(0⁺)] \]

Now as all initial conditions set equal to zero, i.e. \( i(0⁺) = 0 \), so the equation becomes

\[ V(s) = I(s)[R + sL] \]

\[ I(s) = \frac{V(s)}{R + sL} = \frac{1}{L} \cdot \frac{V(s)}{s + \frac{R}{L}} \]

Software Used: MATLAB/ SIMULINK
**Example 1:** To simulate and study the transient response of a series R-C circuit using MATLAB where $R=200\Omega$, $C=10\mu F$ for the following conditions:

1) source voltage is $40V$ DC with all initial conditions set equal to zero.
2) source voltage is a pulse signal with a period of $0s$, width of $5ms$, rise and fall times of $1\mu s$, amplitude of $20V$ and an initial value of $0V$ and all initial conditions set equal to zero.

**For Case - 1:-**

$$v(t) = 40u(t) \quad \therefore V(s) = \frac{40}{s}$$

Therefore,

$$I(s) = \frac{sC}{RC(s + \frac{1}{RC})} \cdot \frac{40}{s} = \frac{40}{R} \cdot \frac{1}{s + \frac{1}{RC}}$$

Taking Inverse Laplace transform on both sides of the above equation,

$$i(t) = \frac{40}{R} e^{-\frac{1}{RC}t}$$

Putting $R = 200\Omega$ and $C = 10\mu F$, we get

$$i(t) = \frac{40}{200} e^{-500t}$$

At $t = 0$, $i(t) = \frac{40}{200} = 200mA$

At $t = \infty$, $i(t) = 0$

At $t = \tau = RC = 2ms$, $i(t) = 200 \times (37\%) = 74mA$

Voltage drop across the resistor $R$ is,

$$V_R(t) = Ri(t) = 200 \times \frac{40}{200} e^{-500t} = 40e^{-500t}$$

At $t = 0$, $V_R(t) = 40V$

At $t = \infty$, $V_R(t) = 0$
The plot of $i(t)$ vs. $t$ and $V_R(t)$ vs. $t$ are as follows:

Voltage drop across the capacitor $C$ is,

$$V_C(t) = v(t) - V_R(t) = 40(1 - e^{-500t})$$

At $t = 0$, $V_C(t) = 0$

At $t = \infty$, $V_C(t) = 40V$

The plot of $V_C(t)$ vs. $t$ is as follows:

For Case - 2:-

$$v(t) = 20[u(t) - u(t - 1)]$$

Therefore,

$$V(s) = \frac{20}{s} \left(1 - e^{-s}\right)$$
and,

\[ I(s) = \frac{20sC(1-e^{-s})}{sRC(s + \frac{1}{RC})} \cdot \frac{1}{s} = \frac{20}{R} \cdot \left[ \frac{1}{(s + \frac{1}{RC})} - \frac{e^{-s}}{(s + \frac{1}{RC})} \right] \]

Taking Inverse Laplace transform on both sides of the above equation,

\[ i(t) = \frac{20}{R} \left[ e^{\frac{1}{RC}t} u(t) - e^{\frac{1}{RC}(t-1)} u(t-1) \right] \]

Putting \( R = 200\Omega \) and \( C = 10\mu F \), we get

\[ i(t) = \frac{20}{200} \left[ e^{-500t} u(t) - e^{-500(t-1)} u(t-1) \right] \]

At \( t = 0 \), \( i(t) = \frac{20}{200} \) A = 100mA

At \( t = \infty \), \( i(t) = 0 \)

Voltage drop across the resistor \( R \) is,

\[ V_R(t) = Ri(t) = 200 \times \frac{20}{200} \left[ e^{-500t} u(t) - e^{-500(t-1)} u(t-1) \right] \]

or,

\[ V_R(t) = 20 \left[ e^{-500t} u(t) - e^{-500(t-1)} u(t-1) \right] \]

At \( t = 0 \), \( V_R(t) = 20V \)

At \( t = \infty \), \( V_R(t) = 0 \)

Voltage drop across the capacitor \( C \) is,

\[ V_C(t) = v(t) - V_R(t) = 20(1-e^{-500t}) u(t) - 20(1-e^{-500(t-1)}) u(t-1) \]

At \( t = 0 \), \( V_C(t) = 0 \)

At \( t = \infty \), \( V_C(t) = 0 \)

At \( t = T = 5\text{ms} \), \( V_C(t) = 18.36V \)
**SIMULATION DIAGRAM:**

For Case - 1:-

![Simulation Diagram](image)

For **Capacitor C1**: IC=0V  
For **Analysis Setup**:

- **Transient**:
  - Print Step : 0s  
  - Final Time : 20ms

Simulate the individual circuits and draw the plot of \( i(t) \) vs. \( t \), \( V_R(t) \) vs. \( t \) and \( V_C(t) \) vs. \( t \).

For Case - 2:-

For **Capacitor C1**: IC=0V  
For source voltage **VPULSE**:

- V1: 0V; V2: 20V  
- TD: 0s  
- TR: 1µs; TF: 1µs  
- PW: 5ms; PER: 0s

For **Analysis Setup**:

- **Transient**:
  - Print Step : 0s  
  - Final Time : 16ms

Simulate the individual circuits and draw the plot of \( i(t) \) vs. \( t \), \( V_R(t) \) vs. \( t \) and \( V_C(t) \) vs. \( t \).
Example 2: To simulate and study the transient response of a series R-L circuit using PSPICE where \( R=100\Omega, \ L=10\, mH \) for the following conditions:

1) source voltage is \( 10V \) DC with all initial conditions set equal to zero.
2) source voltage is \( 10V \) DC with initial condition \( i(t)(0-) = 20mA \).

For Case - 1:-

\[
v(t) = 10u(t)
\]

\[
I(s) = \frac{1}{L} \cdot \frac{10}{s} = \frac{1}{L} \left[ \frac{10}{s(s + \frac{R}{L})} \right] = \frac{10}{s} \left[ \frac{1}{s + \frac{R}{L}} - \frac{1}{s} \right]
\]

Therefore,

\[
i(t) = \frac{10}{R} \left[ 1 - e^{-\frac{R}{L}t} \right]
\]

Taking inverse Laplace transform on both sides of the above equation,

\[
i(t) = \frac{10}{100} \left[ 1 - e^{-10^4t} \right]
\]

At \( t = 0 \), \( i(t) = 0 \)

At \( t = \infty \), \( i(t) = \frac{10}{100} \, A = 100mA \)

At \( t = \tau = \frac{L}{R} = 100\mu s \), \( i(t) = 100 \times (63\%) = 63mA \)

Voltage drop across the resistor \( R \) is,

\[
V_R(t) = Ri(t) = 100 \times \frac{10}{100} \left( 1 - e^{-10^4t} \right) = 10(1 - e^{-10^4t})
\]

At \( t = 0 \), \( V_R(t) = 0 \)

At \( t = \infty \), \( V_R(t) = 10V \)
Voltage drop across the inductor $L$ is,

$$V_L(t) = v(t) - V_R(t) = 10e^{-10^4t}$$

At $t = 0$, $V_L(t) = 10V$

At $t = \infty$, $V_L(t) = 0$

The plot of $i(t)$ vs. $t$ and $V_R(t)$ vs. $t$ are as follows:

![Plot of i(t) vs. t](attachment:image1)

![Plot of V_R(t) vs. t](attachment:image2)

The plot of $V_L(t)$ vs. $t$ is as follows:

![Plot of V_L(t) vs. t](attachment:image3)
For Case - 2:

\[ v(t) = 10u(t) \quad \text{and} \quad i_L(0-) = 20 \text{mA} \]

\[ \therefore \quad V(s) = \frac{10}{s} \]

\[ V(s) = RI(s) + L[sI(s) - 20 \times 10^{-3}] \]

or,

\[ \frac{10}{s} + 20 \times 10^{-4} = LI(s)\left[s + \frac{R}{L}\right] \]

or,

\[ I(s) = \frac{0.02}{s + 10^4} + \frac{10^3}{s(s + 10^4)} \]

Taking inverse Laplace transform on both sides of the above equation,

\[ i(t) = 0.1 - 0.08e^{-10^4t} \]

At \( t = 0 \), \( i(t) = 20 \text{mA} \)

At \( t = \infty \), \( i(t) = 100 \text{mA} \)

Voltage drop across the resistor \( R \) is,

\[ V_R(t) = Ri(t) = 100 \times i(t) = 100(0.1 - 0.08e^{-10^4t}) = 10 - 8e^{-10^4t} \]

At \( t = 0 \), \( V_R(t) = 2 \text{V} \)

At \( t = \infty \), \( V_R(t) = 10 \text{V} \)

Voltage drop across the inductor \( L \) is,

\[ V_L(t) = v(t) - V_R(t) = 8e^{-10^4t} \]

At \( t = 0 \), \( V_L(t) = 8 \text{V} \)

At \( t = \infty \), \( V_L(t) = 0 \)
SIMULATION DIAGRAM:

For Case - 1:

For Inductor L1: \( \text{IC}=0 \text{A} \)

For Analysis Setup:

- **Transient:**
- Print Step: 0\(\mu\)s
- Final Time: 100\(\mu\)s

Simulate the individual circuits and draw the plot of \(i(t)\) vs. \(t\), \(V_R(t)\) vs. \(t\) and \(V_L(t)\) vs. \(t\).

For Case - 2:

For Inductor L1: \( \text{IC}=20 \text{mA} \)

For Analysis Setup:

- **Transient:**
- Print Step: 0s
- Final Time: 500\(\mu\)s

Simulate the individual circuits and draw the plot of \(i(t)\) vs. \(t\), \(V_R(t)\) vs. \(t\) and \(V_L(t)\) vs. \(t\).
EXPERIMENT NO : CKT/2

TITLE : TRANSIENT RESPONSE OF R-L-C SERIES AND PARALLEL CIRCUIT SIMULATION WITH PSPICE/MATLAB / HARDWARE

OBJECTIVE : To determine

I. Transient response of a series R-L-C circuit, excited by a unit step input using MATLAB.
II. Transient response of a R-L-C parallel circuit, excited by a unit step input using MATLAB.

THEORY: Let us consider the R-L-C circuit as shown below:

Applying KVL, we obtain

\[ v(t) = Ri(t) + L \frac{di(t)}{dt} + \frac{1}{C} \int i(t)dt \]

Taking Laplace transform on both sides of the above equation,

\[ V(s) = RI(s) + L[sI(s) - i(0^\text{--})] + \frac{I(s)}{sC} + \frac{v_c(0^\text{--})}{s} \]

Now as all initial conditions set equal to zero, i.e. \( i(0^\text{--}) = 0 \) and \( v_c(0^\text{--}) = 0 \), so the equation becomes,

\[ V(s) = I(s) \left[ R + sL + \frac{1}{sC} \right] \]
Here, $v(t) = u(t)$  \[ v(t) = u(t) \]

\[ : \quad V(s) = \frac{1}{s} \]

Therefore, \[ \frac{1}{s} = I(s) \left[ R + sL + \frac{1}{sC} \right] \]

or, \[ I(s) = \frac{1/L}{s^2L + \frac{R}{L}s + \frac{1}{LC}} \]

The roots of the denominator polynomial of the above equation are, \[ s^2L + \frac{R}{L}s + \frac{1}{LC} = 0 \]

or, \[ s_1 = -\frac{R}{2L} + \frac{\sqrt{R^2 - \frac{4}{LC}}}{2L} \quad \text{and} \quad s_2 = -\frac{R}{2L} - \frac{\sqrt{R^2 - \frac{4}{LC}}}{2L} \]

Let \[ \omega_0 = \frac{1}{\sqrt{LC}} \quad \text{and} \quad \xi \omega_0 = \frac{R}{2L} \]

\[ \therefore \quad \xi = \frac{R}{2\sqrt{L}} \]

Now, \[ I(s) = \frac{1/L}{(s - s_1)(s - s_2)} = \frac{1}{L(s_1 - s_2)} \left( \frac{1}{s - s_1} + \frac{1}{s - s_2} \right) \]

or, \[ I(s) = \frac{1}{2\omega_0 L\sqrt{\xi^2 - 1}} \left[ \frac{1}{(s - s_1)} - \frac{1}{(s - s_2)} \right] \]
Taking inverse Laplace Transform on both sides,

\[ i(t) = \frac{1}{2\omega_0 L \sqrt{\xi^2 - 1}} e^{-\xi \omega_0 t} \left[ e^{\omega_0 t \sqrt{\xi^2 - 1}} - e^{-\omega_0 t \sqrt{\xi^2 - 1}} \right] \]

**Case - 1:-**

\[ R < 2\sqrt{\frac{L}{C}} \]

i.e. \( \xi < 1 \)

\[ i(t) = \frac{1}{\omega_0 L \sqrt{1 - \xi^2}} e^{-\xi \omega_0 t} \sin\left( \omega_0 t \sqrt{1 - \xi^2} \right) \]

The network is then said to be **Under Damped** or **Oscillatory**.

**Case - 2:-**

\[ R = 2\sqrt{\frac{L}{C}} \]

i.e. \( \xi = 1 \)

\[ i(t) = \frac{1}{L} t e^{-\alpha_0 t} \]

The network is then said to be **Critically Damped**.

**Case - 3:-**

\[ R > 2\sqrt{\frac{L}{C}} \]

i.e. \( \xi > 1 \)

\[ i(t) = \frac{1}{\omega_0 L \sqrt{\xi^2 - 1}} e^{-\xi \omega_0 t} \sinh\left( \omega_0 t \sqrt{\xi^2 - 1} \right) \]

The network is then said to be **Over Damped**.
The current response for the above three cases is shown in the figure below:
Example 1: Obtain the transient response of a series RLC circuit, excited by a unit step input, using MATLAB where $L = 8\text{mH}$ and $C = 2\mu\text{F}$ for the following conditions:

1) $R < \frac{\sqrt{L}}{\sqrt{C}}$, under damped case where $R = 1\Omega$

2) $R = 2\frac{\sqrt{L}}{\sqrt{C}}$, critically damped case where $R = 4\Omega$

3) $R > 2\frac{\sqrt{L}}{\sqrt{C}}$, over damped case where $R = 6\Omega$

SIMULATION DIAGRAM:

For Case - 1:-

For Inductor L1: IC=0A
For Capacitor C1: IC=0V

For Analysis Setup:

- Transient:
- Print Step : 0µs
- Final Time : 100µs

Simulate the circuit and draw the plot of $i(t)$ vs. $t$.
Note the value of the first peak of the current response.

For Case - 2:-

For Inductor L1: IC=0A
For Capacitor C1: IC=0V
For Analysis Setup:

Transient:  
Print Step : 0µs  
Final Time : 50µs

Simulate the circuit and draw the plot of \( i(t) \) vs. \( t \).
Note the value of the first peak of the current response.

For Case - 3:-

For Inductor L1: IC=0  
Capacitor C1: IC=0V  
For Analysis Setup:  
Transient:  
Print Step : 0µs  
Final Time : 70µs

Simulate the circuit and draw the plot of \( i(t) \) vs. \( t \).
Note the value of the first peak of the current response.
EXPERIMENT NO : CKT/3

TITLE: STUDY THE EFFECT OF INDUCTANCE ON STEP RESPONSE OF SERIES RL CIRCUIT IN MATLAB/HARDWARE.

OBJECTIVE: To determine


Example 1: Study the effect of inductance for step input in the circuit given below when,

1. R = 200 ohm, L = 0.0001H
2. R = 200 ohm, L = 0.0005H
3. R = 200 ohm, L = 0.001H
4. R = 200 ohm, L = 0.005H
5. R = 200 ohm, L = 0.01H

SIMULATION DIAGRAM:

RESULT: Discuss the graph Voltage across inductor vs time and Current vs time in the light of Rise time, Peak time, Settling time.
EXPERIMENT NO  : CKT/4

TILLE :  DETERMINATION OF IMPEDANCE (Z) AND ADMITTANCE (Y) PARAMETER OF TWO PORT NETWORK: SIMULATION / HARDWARE.

OBJECTIVE : To determine

I. The open circuit impedance parameters of the ‘T’ network.
II. The short circuit admittance parameters of the ‘π’ network

THEORY: Let us consider a linear passive two port network as shown in figure below:

We know,  \( V_1 = Z_{11} I_1 + Z_{12} I_2 \) ..............(1)
\( V_2 = Z_{21} I_1 + Z_{22} I_2 \) ..............(2)

Z-parameters are obtained by making either terminals 11’ open circuited or terminals 22’ open circuited.

\[ Z_{11} = \left. \frac{V_1}{I_1} \right|_{I_2=0} \]

is called the input impedance or driving point impedance with output open circuited.

\[ Z_{21} = \left. \frac{V_2}{I_1} \right|_{I_2=0} \]

is called the forward transfer impedance with output open circuited.

\[ Z_{12} = \left. \frac{V_1}{I_2} \right|_{I_1=0} \]

is called the reverse transfer impedance with output open circuited.

\[ Z_{22} = \left. \frac{V_2}{I_2} \right|_{I_1=0} \]
is called the output impedance with input open circuited.

The Y-parameters of this network can be obtained by expressing $I_1$ and $I_2$ in terms of $V_1$ and $V_2$.

$$I_1 = Y_{11} \, V_1 + Y_{12} \, V_2 \quad \text{..............(1)}$$
$$I_2 = Y_{21} \, V_1 + Y_{22} \, V_2 \quad \text{..............(2)}$$

Y-parameters are obtained by making either terminals 11’ short circuited or terminals 22’ short circuited.

$$\therefore \quad Y_{11} = \left. \frac{I_1}{V_1} \right|_{V_2=0}$$

is called the input admittance or driving point admittance with output short circuited.

$$\therefore \quad Y_{21} = \left. \frac{I_2}{V_1} \right|_{V_2=0}$$

is called the forward transfer admittance with output short circuited.

$$\therefore \quad Y_{12} = \left. \frac{I_1}{V_2} \right|_{V_1=0}$$

is called the reverse transfer admittance with input short circuited.

$$\therefore \quad Y_{22} = \left. \frac{I_2}{V_2} \right|_{V_1=0}$$

is called the output admittance with input short circuited.
Example 1: Determine the open circuit impedance parameters from the network as shown in the figure below using MATLAB simulation.

Output port open circuited,
\[ Z_{11} = 2.5 \text{ Ohm} \]
\[ Z_{21} = 1 \text{ Ohm} \]

Input port open circuited,
\[ Z_{12} = 1 \text{ Ohm} \]
\[ Z_{22} = 2 \text{ Ohm} \]
**Example 2:** Determine the short circuit admittance parameters from the network as shown in the figure below using MATLAB simulation.

Applied voltage at output port is 10 V.

![Fig:1](image1.png)

For the input port short circuited, we have
\[ Y_{22} = 0.3125 \text{ mho} \]
\[ Y_{12} = 0.1875 \text{ mho} \]

Applied voltage at input port is 10 V.

![Fig:2](image2.png)

For the output port short circuited,
\[ Y_{11} = 0.3125 \text{ mho} \]
\[ Y_{21} = 0.1875 \text{ mho} \]
Example 3: Determine the short circuit admittance parameters from the network as shown in the figure below using MATLAB simulation.

Applied voltage at input port is 10 V.

For the output port short circuited,
\[ Y_{11} = 0.375 \text{ mho} \]
\[ Y_{21} = 0.25 \text{ mho} \]

Applied voltage at output port is 10 V.

For the input port short circuited,
\[ Y_{22} = 1 \text{ mho} \]
\[ Y_{12} = 0.25 \text{ mho} \]
EXPERIMENT NO : CKT/5

TITLE : FREQUENCY RESPONSE OF LP AND HP FILTERS: SIMULATION / HARDWARE.

OBJECTIVE : To study the frequency response of Low Pass and High Pass filter using MATLAB.

Example 1: Show the frequency response of a low pass filter.

Matlab Code :

```matlab
f=0:1:10^6
rl=10000
rf=1000
r=15900
c=0.01*10^-6
af=(1+rf/rl)
f=1/(2*pi*r*c)
a=f/fc
acl_lp=af./sqrt(1+a.*a)
semilogx(acl_lp)
xlabel('frequency-----')
ylabel('gain---------')
title('frequency response of low pass filter')
grid
```

Output :
**Example 1:** Show the frequency response of a high pass filter.

Matlab Code:

```matlab
f=[0:1:10^6];
rl=10000;
rf=1000;
r=15900;
c=0.01*10^(-6);
ar=1+rf/rl;
fc=1/(2*pi*r*c);
a=f/fc;
aclp=af.*a./sqrt(1+a.*a);
semilogx(aclp)
xlabel('frequency----->')
ylabel('gain--------->')
title('frequency response of high pass filter')
grid
```

Output:

![Frequency response of high pass filter](image_url)
**EXPERIMENT NO.: CKT/7**

**TILLE:** GENERATION OF PERIODIC, EXPONENTIAL, SINUSOIDAL, DAMPED SINUSOIDAL, STEP, IMPULSE, RAMP SIGNAL USING MATLAB IN BOTH DISCRETE AND ANALOG FORM.

**OBJECTIVE:** To generate

I. Normal sinusoidal signal  
II. Under damped signal  
III. Over damped signal  
IV. Discrete sinusoidal signal  
V. Discrete damped sinusoidal signal  
VI. Unit step function-1  
VII. Unit step function-2  
VIII. Ramp wave  
IX. Impulse wave

**Example 1:** Generate normal sinusoidal signal

**Matlab Code:**

```matlab
f=input('enter the freq:');
n=input('enter the length:')
w=2*pi*f;
t=0:0.01:10
y=sin(w*t)
plot(t,y);
xlabel('time in sec...........>');
ylabel('amplitude in cm..........>');
title('NORMAL SINUSODIAL SIGNAL');
grid on;
```

**Output:**

Enter the frequency: 1  
Enter the length: 10

![Graph of Normal Sinusoidal Signal](image-url)
Example 2: Generate Under damped signal

Matlab Code:
```matlab
% input damping constant and length
a=input('enter the damping constant:');
l=input('enter the length:');
t=0:0.1:10
y=exp(-a*t);
plot(t,y);
xlabel('time in sec');
ylabel('amplitude in cm.');
title('UNDER DAMPED SIGNAL');
grid on;
```

Output:
Enter the damping constant: 0.5
Enter the length: 10
Example 3: Generate Over damped signal

Matlab Code:
```matlab
a=input('enter the damping constant:');
I=input('enter the length:');
y=exp(a*t);
t=0:0.1:10
plot(t,y);
xlabel('time in sec');
ylabel('amplitude in cm.');
title('OVER DAMPED SIGNAL');
grid on;
```

Output:
Enter the damping constant: 0.5
Enter the length: 10

![Graph of Over Damped Signal]
Example 4: Discrete Sinusoidal signal

Matlab Code:

```matlab
f=input('enter the freq:');
n=input('enter the length:');
w=2*pi*f;
t=0:0.1:10
y=sin(w*t)
stem(t,y);
xlabel('time in sec...........>');
ylabel('amplitude in cm.............>');
title('DISCRETE SINUSODIAL SIGNAL');
grid on;
```

Output:

Enter the frequency: 1
Enter the length: 10
Example 5: Damped Sinusoidal signal

Matlab Code:
```matlab
f=input('enter the freq:');
l=input('enter the length:');
a=input('enter the damping constant:');
w=2*pi*f;
for(t=0:0.01:10)
    y=sin(w*t)*exp(-a*t)
    plot(t,y,'r');
    xlabel('time in sec............>');
    ylabel('amplitude in cm............>');
    title('DAMPED SINUSOIDAL SIGNAL');
    grid on;
    hold on;
end;
```

Output:
Enter the frequency: 2
Enter the damping constant: 0.5
Enter the length: 10
Example 6: Generate Unit step function

Matlab Code:
```matlab
t=0:0.1:10;
t0=2;
y=0*(t<t0)+1*(t>=t0)
plot(t,y);
xlabel('time..............>');
ylabel('amplitude.............>');
title('UNIT STEP FUNCTION');
grid on;
```

Output:
Example 7: Generate Unit step function 2

Matlab Code:
```matlab
t=0:0.1:10;
y=1*(t>=1)-1*(t>=3);
plot(t,y);
xlabel('Time');
ylabel('Amplitude');
title('UNIT STEP SIGNAL');
grid on;
```

Output:

![Graph of UNIT STEP SIGNAL](attachment:image.png)
EXPERIMENT NO : CKT/8

TILL: DETERMINATION OF LAPLACE TRANSFORM AND INVERSE LAPLACE TRANSFORM USING MATLAB.

OBJECTIVE: To find the Laplace & Inverse Laplace transform by using Matlab commands.

THEORY:

The mathematical expression for Laplace transform is

\[ Lf(t) = F(s) = \int_{0}^{\infty} f(t) e^{-st} dt \]

The term “Laplace transform of f(t)” is used for the letter Lf(t). The time function f(t) is
obtained back from the Laplace transform by a process called inverse Laplace transformation
and denoted by \( L^{-1} \) thus

\[ L^{-1}[Lf(t)] = L^{-1}[F(s)] = f(t). \]

The time function f(t) and its Laplace transform F(s) are a transform pair.

Derivation of Laplace transform:

Laplace transform of \( e^{at} \) is

\[ L[e^{at}] = \int_{0}^{\infty} e^{at} e^{-st} dt = \int_{0}^{\infty} e^{(a-s)t} dt = \frac{1}{s-a} \]

Now put \( a=jw \)

\[ L[e^{j\omega t}] = L[\cos \omega t + j \sin \omega t] = \frac{1}{s-j\omega} = \frac{s + j\omega}{(s^2 + \omega^2)} \]

\[ L[\cos \omega t] = \frac{s}{s^2 + \omega^2} \quad \& \quad L[\sin \omega t] = \frac{\omega}{s^2 + \omega^2} \]

Now, \( L[e^{at} f(t)] = F(s-a) \)

- \( L[t] = \int_{0}^{\infty} t e^{-st} dt = \frac{1}{s^2} \)
- \( L[e^{at}] = \int_{0}^{\infty} e^{at} e^{-st} dt = \int_{0}^{\infty} e^{(a-s)t} dt = \frac{1}{s-a} \)
- \( L[e^{at} f(t)] = F(s-a), \quad f(t) = t \quad \& \quad a = -3 \)
\[
F(s) = \frac{1}{s^2}
\]
\[
L[e^{-3t}t] = \frac{1}{(s+3)^2}
\]
\[
L[(1-e^{-at} - ate^{-at})/a^2] = \frac{1}{a^2} \{L[1] - L[e^{-at}] - aL[te^{-at}]\}
\]
\[
= \frac{1}{a^2} \left[ \frac{1}{s} - \frac{1}{s+a} - \frac{a}{(s+a)^2} \right]
\]
\[
L[e^{at}f(t)] = F(s-a), \quad f(t) = \sin \omega t, \quad a = -3 \quad \text{and} \quad \omega = 10
\]
\[
F(s) = \frac{\omega}{s^2 + \omega^2}
\]
\[
L[e^{-3t}\sin 10t] = \frac{10}{(s+3)^2 + 100}
\]

**Derivation of inverse Laplace transform:**

\[
L^{-1}[F(s)] = f(t)
\]
\[
L^{-1}\left[ \frac{1}{s-a} \right] = e^{at}
\]
Laplace Transform:

Example 1: \( f(t) = e^{-5t} \)

Program:
```matlab
Syms t s
ft=exp(-5*t)
fs=laplace(ft)
```

Output:
```
fs=1/(s+5)
```

Example 2: \( f(t) = e^{3t} \)

Program:
```matlab
Syms t s
ft=exp(3*t)
fs=laplace(ft)
```

Output:
```
fs=1/(s-3)
```

Example 3: \( f(t) = \sin 2t \)

Program:
```matlab
Syms t s
ft=sin(2*t)
fs=laplace(ft)
```

Output:
```
fs=2/(s^2+4)
```

Example 4: \( f(t) = \cos 5t \)

Program:
```matlab
Syms t s
ft=cos(5*t)
fs=laplace(ft)
```

Output:
```
fs=s/(s^2+25)
```

Example 5: \( f(t) = t^6 \)

Program:
```matlab
Syms t s
ft=t^6
fs=laplace(ft)
```

Output:
```
fs=720/s^7
```
**Example 6:** \( f(t) = t^2 \sin 6t \)
Program:
```matlab
Syms t s
ft=t^2*sin(6*t)
fs=laplace(ft)
```
Output:
```latex
fs = \frac{36(s^2-12)}{(s^2+36)^3}
```

**Example 7:** \( f(t) = e^{3t} \sin 2t \)
Program:
```matlab
Syms t s
ft=exp(3*t)*sin(2*t)
fs=laplace(ft)
```
Output:
```latex
fs = \frac{2}{s^2-6s+13}
```

**Example 8:** \( f(t) = e^{-3t} \cos 7t \)
Program:
```matlab
Syms t s
ft=exp(-3*t)*cos(7*t)
fs=laplace(ft)
```
Output:
```latex
fs = \frac{s+3}{s^2+6s+58}
```

**Example 9:** \( f(t) = e^{-2t} \sin 4t \)
Program:
```matlab
Syms t s
ft=exp(-2*t)*sin(4*t)
fs=laplace(ft)
```
Output:
```latex
fs = \frac{4}{s^2+4s+20}
```

**Example 10:** \( f(t) = e^{7t} \cos 2t \)
Program:
```matlab
Syms t s
ft=exp(7*t)*cos(2*t)
fs=laplace(ft)
```
Output:
```latex
fs = \frac{s-7}{s^2-14s+53}
```
Inverse Laplace Transform:

**Example 1:** \( f(s) = \frac{s+1}{s(s+2)(s+3)} \)
Program:

```matlab
Syms t s
fs=(s+1)/(s^3+5*s^2+6*s)
ft=ilaplace(fs)
```
output:

\( ft = -\frac{2}{3}e^{-3t} + \frac{1}{2}e^{-2t} + \frac{1}{6} \)

**Example 2:** \( f(s) = \frac{s^3+3s^2+4s+4}{(s+1)(s+4)} \)
Program:

```matlab
Syms t s
fs=(s^3+3*s^2+4*s+4)/(s^2+5*s+4)
ft=ilaplace(fs)
```
output:

\( ft = \text{dirac}(1,t) - 2*\text{dirac}(t) + \frac{2}{3}e^{-t} + \frac{28}{3}e^{-4t} \)

**Example 3:** \( f(s) = \frac{3}{s^2+8s+25} \)
Program:

```matlab
Syms t s
fs=3/( s^2+8*s+25)
ft=ilaplace(fs)
```
output:

\( ft = e^{-4t}\sin(3t) \)

**Example 4:** \( f(s) = \frac{s}{s^2+a^2} \)
Program:

```matlab
Syms a t s
fs=s/(s^2+a^2)
ft=ilaplace(fs)
```
output:

\( ft = \cos(at) \)

**Example 5:** \( f(s) = \frac{1}{s+a} \)
Program:

```matlab
Syms a t s
fs=1/(s+a)
ft=ilaplace(fs)
```
output:

\( ft = e^{-at} \)