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.
6. Frequency response of BP and BR 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.

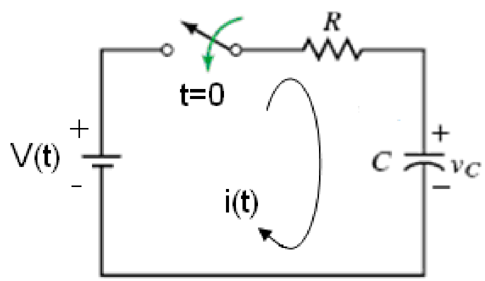
EXPERIMENT NO : CKT /1

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:



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,

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

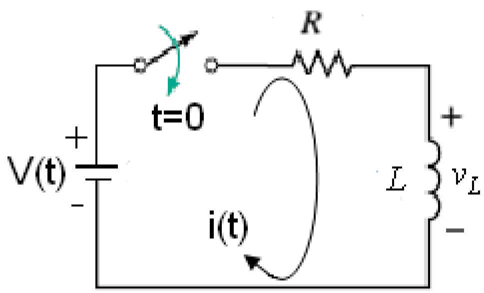
or, $$V(s) = RI(s) + \frac{I(s)}{sC} + \frac{v_C(0\_)}{s}$$

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:



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

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

or, $$I(s) = \frac{V(s)}{R + sL} = \frac{1}{L}.\frac{V(s)}{s + \frac{R}{L}}$$

Software Used: MATLAB/ SIMULINK

Example 1: To simulate and study the transient response of a series R-C circuit using MATLAB where R=200Ω, C=10µF 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 **1µs**, amplitude of **20V** and an initial value of 0V and all initial conditions set equal to zero.

For Case - 1:-

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

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

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

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

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

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

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

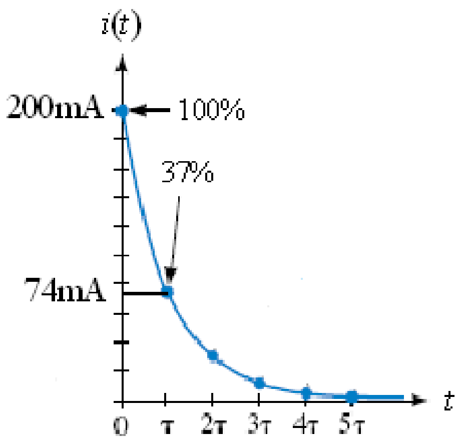
Voltage drop across the resistor R is,

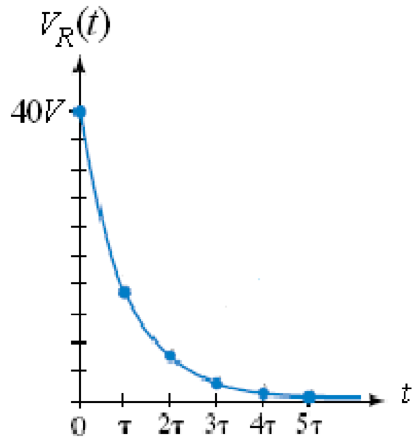
$$V_R(t) = Ri(t) = 200 \times \frac{40}{200}.e^{-500.t} = 40e^{-500.t}$$

At $t = 0$, $V_R(t) = 40\text{V}$

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

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





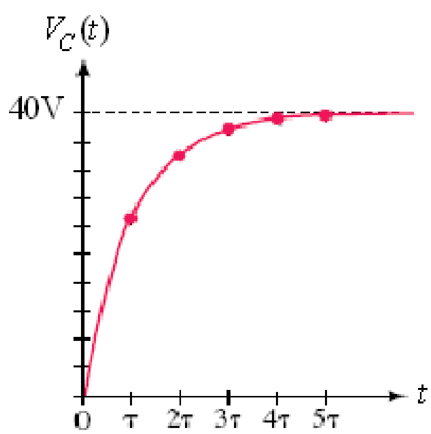
Voltage drop across the capacitor C is,

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

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

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

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



For Case - 2:-

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

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

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

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

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

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

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

Voltage drop across the resistor R is,

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

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

At $t=0$, $V_R(t)=20\text{V}$

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

Voltage drop across the capacitor C is,

$$V_C(t)=v(t)-V_R(t)=20(1-e^{-500.t})u(t)-20(1-e^{-500.(t-1)})u(t-1)$$

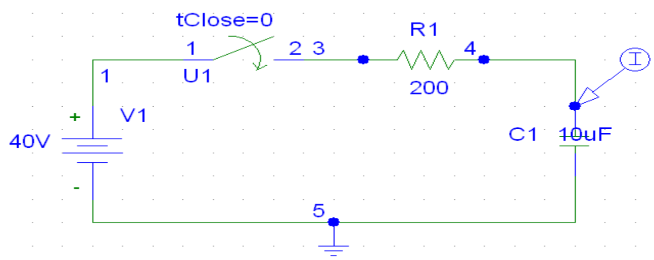
At $t=0$, $V_C(t)=0$

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

At $t=T=5\text{ms}$, $V_C(t)=18.36\text{V}$

<u>SIMULATION DIAGRAM</u>:

For Case - 1:-



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

<u>Transient</u>:-
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 .

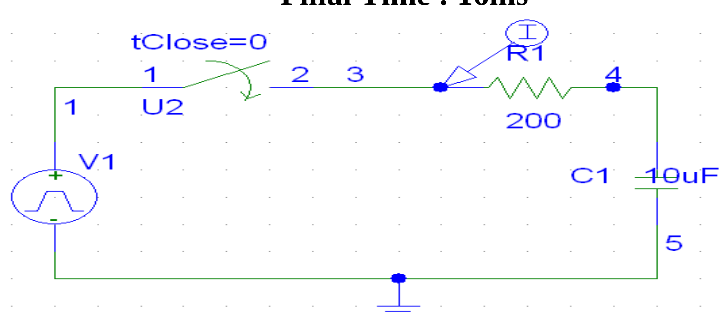
For Case - 2:-

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:**

<u>Transient</u>:-
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=100Ω, L=10mH 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 $i_L(0\_) = 20\text{mA}$.

For Case - 1:-

$$v(t) = 10u(t) \qquad \therefore V(s) = \frac{10}{s}$$

Therefore, $$I(s) = \frac{1}{L}.\frac{\frac{10}{s}}{s+\frac{R}{L}} = \frac{1}{L}\left[\frac{10}{s(s+\frac{R}{L})}\right] = \frac{10}{R}\left[\frac{1}{s} - \frac{1}{s+\frac{R}{L}}\right]$$

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

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

Putting $R = 100\Omega$ and $L = 10mH$, we get

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

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

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

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

Voltage drop across the resistor R is,

$$V_R(t) = Ri(t) = 100 \times \frac{10}{100}(1 - e^{-10^4.t}) = 10(1 - e^{-10^4.t})$$

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

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

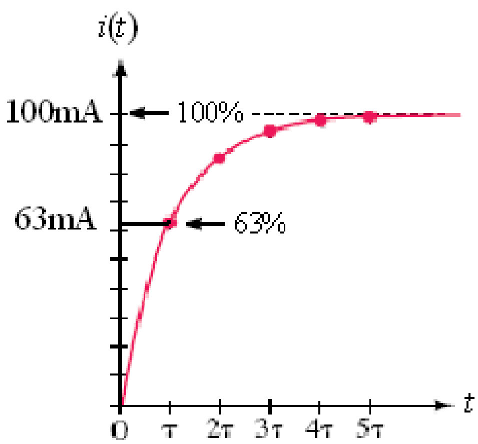
Voltage drop across the inductor L is,

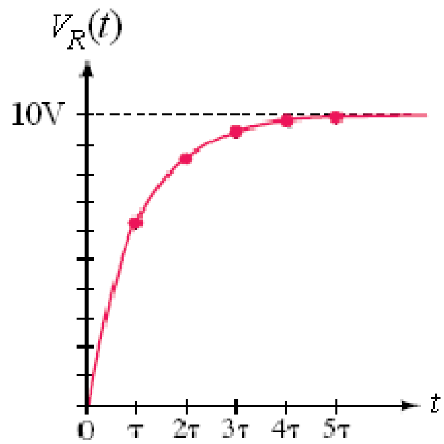
$$V_L(t) = v(t) - V_R(t) = 10e^{-10^4 . t}$$

At $t = 0$, $V_L(t) = 10\text{V}$

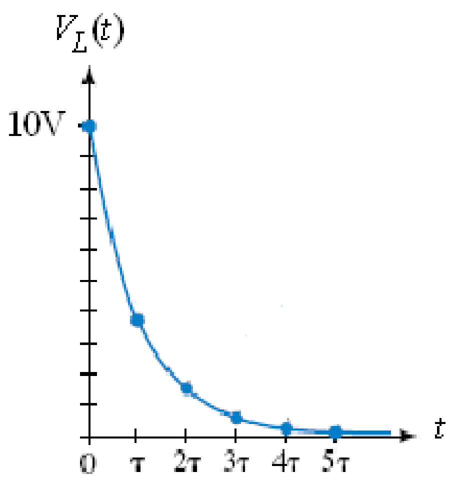
At $t = \infty$, $V_L(t) = 0$

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





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



For Case - 2:-

$$v(t) = 10u(t) \quad \text{and} \quad i_L(0\_) = 20\text{mA}$$

$$\therefore V(s) = \frac{10}{s}$$

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

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,

$$i(t) = 0.1 - 0.08e^{-10^4.t}$$

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

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

Voltage drop across the resistor R is,

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

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,

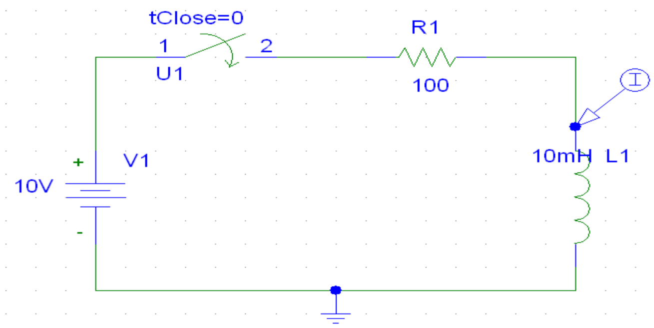
$$V_L(t) = v(t) - V_R(t) = 8e^{-10^4.t}$$

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

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

SIMULATION DIAGRAM:

For Case - 1:-



For **Inductor L1**: **IC=0A**

For **Analysis Setup:**

Transient:-

Print Step : 0µs

Final Time : 100µs

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**:

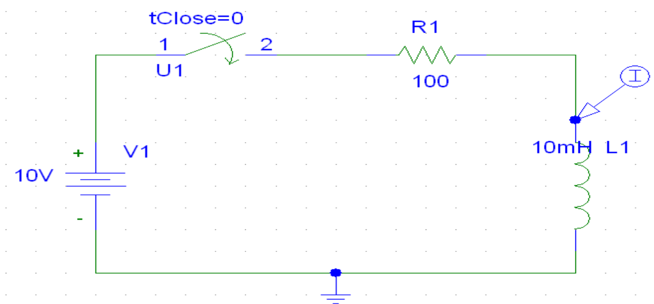
IC=20mA

For **Analysis Setup:**

Transient:-

Print Step : 0s

Final Time : 500µs



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

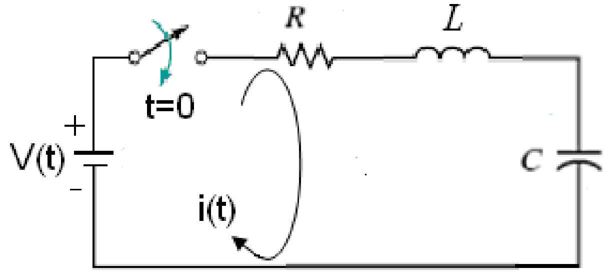
EXPERIMENT NO : CKT/2

TILLE : 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,

$$V(s) = RI(s) + L[sI(s) - i(0\_)] + \frac{I(s)}{sC} + \frac{v_C(0\_)}{s}$$

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

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

Here, $v(t) = u(t)$ $\therefore V(s) = \frac{1}{s}$

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

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

The roots of the denominator polynomial of the above equation are,

$$s^2 L + \frac{R}{L}s + \frac{1}{LC} = 0$$

or, $s_1 = -\frac{R}{2L} + \sqrt{\frac{R^2}{4L^2} - \frac{1}{LC}}$ and

$$s_2 = -\frac{R}{2L} - \sqrt{\frac{R^2}{4L^2} - \frac{1}{LC}}$$

Let $\omega_0 = \frac{1}{\sqrt{LC}}$ and $\xi\omega_0 = \frac{R}{2L}$

$$\therefore \xi = \frac{R}{2}\sqrt{\frac{C}{L}}$$

Now,

$$I(s) = \frac{1/L}{(s-s_1)(s-s_2)} = \frac{\frac{1}{L(s_1-s_2)}}{(s-s_1)} + \frac{\frac{1}{L(s_2-s_1)}}{(s-s_2)}$$

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:-

$$\mathrm{R} < 2\sqrt{\frac{L}{C}}$$

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:-

$$\mathrm{R} = 2\sqrt{\frac{L}{C}}$$

i.e. $\xi = 1$

$$i(t) = \frac{1}{L} t.e^{-\omega_0 t}$$

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

Case - 3:-

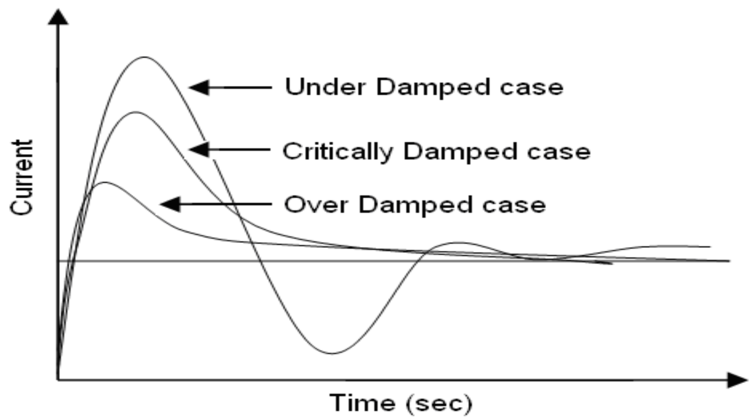
$$\mathrm{R} > 2\sqrt{\frac{L}{C}}$$

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:

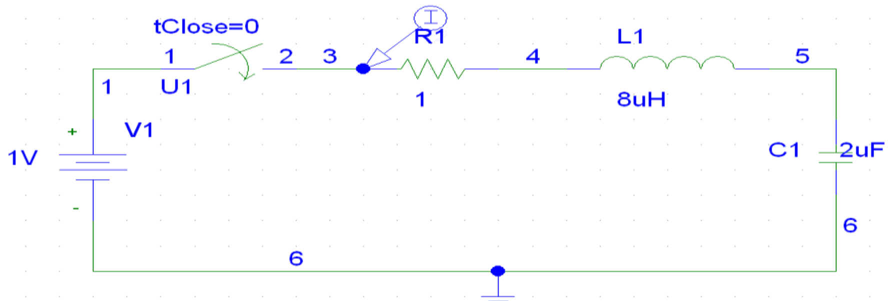


Example 1: Obtain the transient response of a series RLC circuit, excited by a unit step input, using MATLAB where $\mathrm{L} = 8mH$ and $\mathrm{C} = 2\mu\mathrm{F}$ for the following conditions:

1) $\mathrm{R} < 2\sqrt{\dfrac{L}{C}}$, under damped case where $\mathrm{R} = 1\Omega$
2) $\mathrm{R} = 2\sqrt{\dfrac{L}{C}}$, critically damped case where $\mathrm{R} = 4\Omega$
3) $\mathrm{R} > 2\sqrt{\dfrac{L}{C}}$, over damped case where $\mathrm{R} = 6\Omega$

SIMULATION DIAGRAM:

For Case - 1:-



For

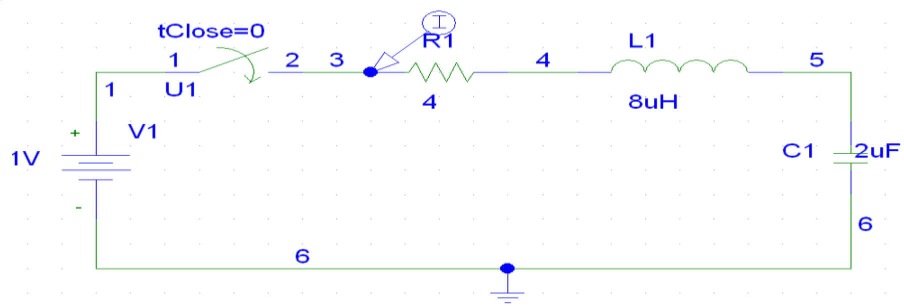
Inductor L1: **IC=0A**
Capacitor C1: **IC=0V**

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:-



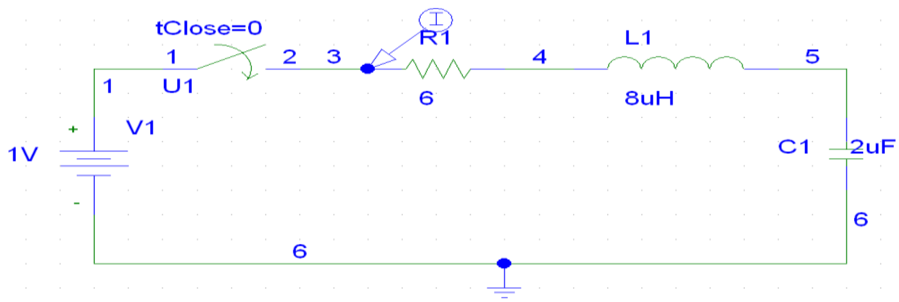
For

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

For **Analysis Setup:**

<u>Transient</u>:-
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:**

<u>Transient</u>:-
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

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

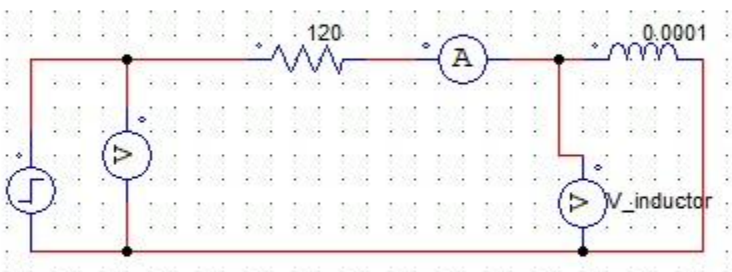
OBJECTIVE : To determine

I. The effect of inductance on step response of series RL circuit**.**

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: Discus the graph Voltage across inductor vs time and Current vs time in the light of Rise time, Peak time, Settling time.

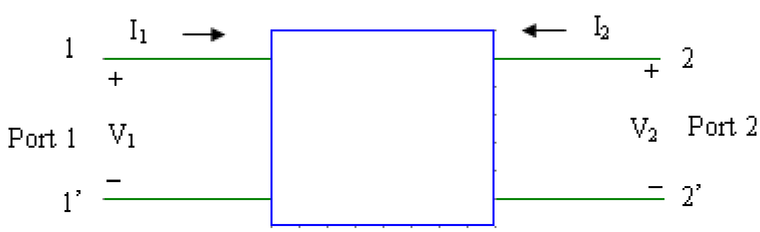
EXPERIMENT NO : CKT/4

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.

$$\therefore \quad Z_{11} = \frac{V_1}{I_1}\Big|_{I_2=0}$$

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

$$\therefore \quad Z_{21} = \frac{V_2}{I_1}\Big|_{I_2=0}$$

is called the forward transfer impedance with output open circuited.

$$\therefore \quad Z_{12} = \frac{V_1}{I_2}\Big|_{I_1=0}$$

is called the reverse transfer impedance with output open circuited.

$$\therefore \quad Z_{22} = \frac{V_2}{I_2}\Big|_{I_1=0}$$

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.

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

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

$$\therefore \qquad Y_{11} = \frac{I_1}{V_1}\bigg|_{V_2=0}$$

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

$$\therefore \qquad Y_{21} = \frac{I_2}{V_1}\bigg|_{V_2=0}$$

is called the forward transfer admittance with output short circuited.

$$\therefore \qquad Y_{12} = \frac{I_1}{V_2}\bigg|_{V_1=0}$$

is called the reverse transfer admittance with input short circuited.

$$\therefore \qquad Y_{22} = \frac{I_2}{V_2}\bigg|_{V_1=0}$$

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.

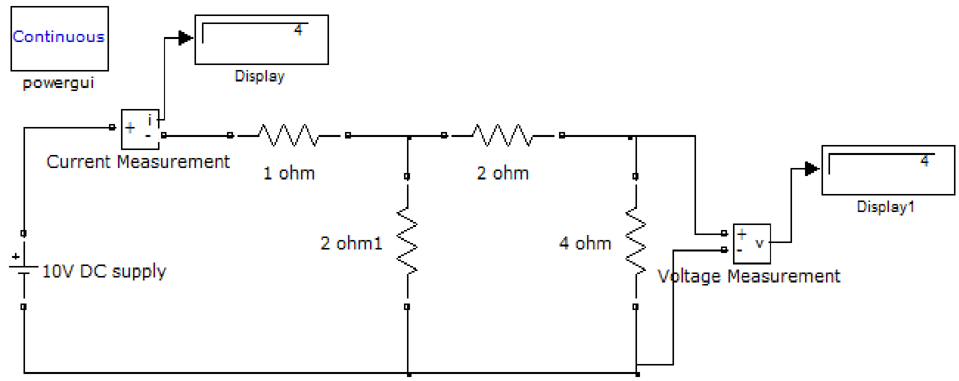


Fig:1

Output port open circuited,

Z_{11}=2.5 Ohm

Z_{21}=1 Ohm

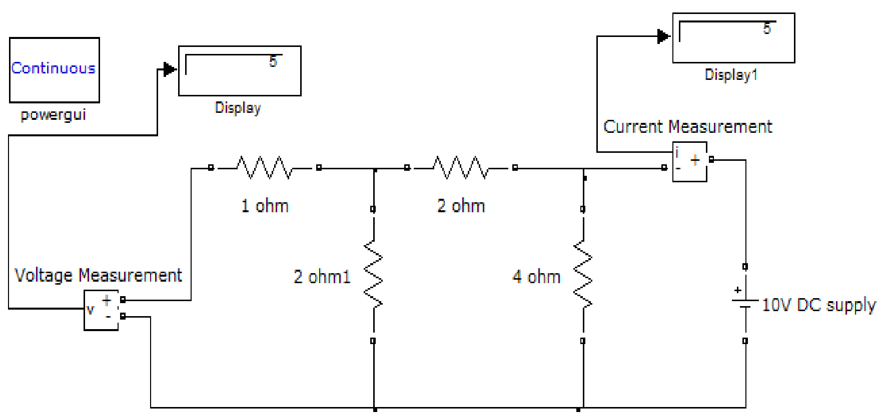


Fig:2

Input port open circuited,

Z_{12}=1 Ohm

Z_{22}=2 Ohm

Example 2: Determine the short circuit admittance parameters from the network as shown in the figure below using MATLAB simulation.

Applied voltage *at out*put port is 10 V.

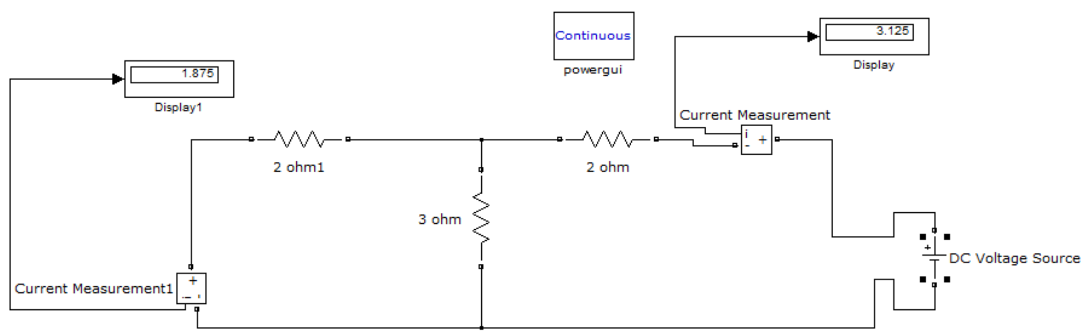


Fig:1

For the input port short circuited, we have

Y_{22}=0.3125 mho

Y_{12}=0.1875 mho

Applied voltage *at inp*ut port is 10 V.

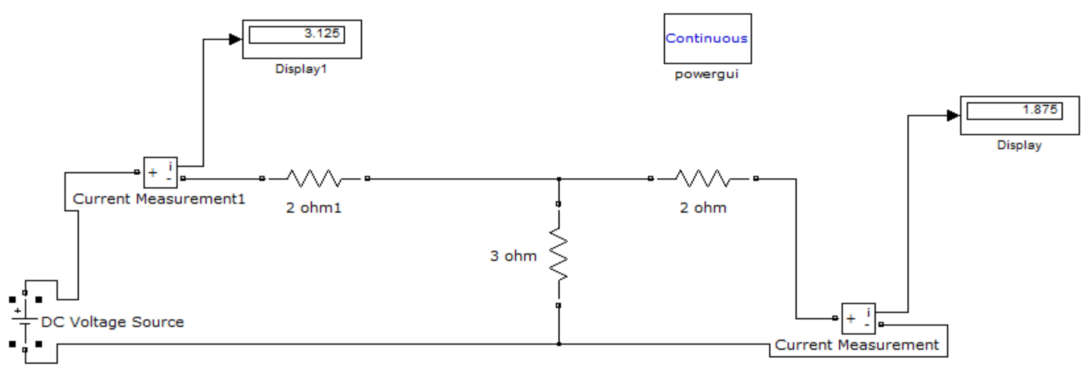


Fig:2

For the output port short circuited,

Y_{11}=0.3125 mho

Y_{21}=0.1875 mho

Example 3: Determine the short circuit admittance parameters from the network as shown in the figure below using MATLAB simulation.

Applied voltage *at inp*ut port is 10 V.

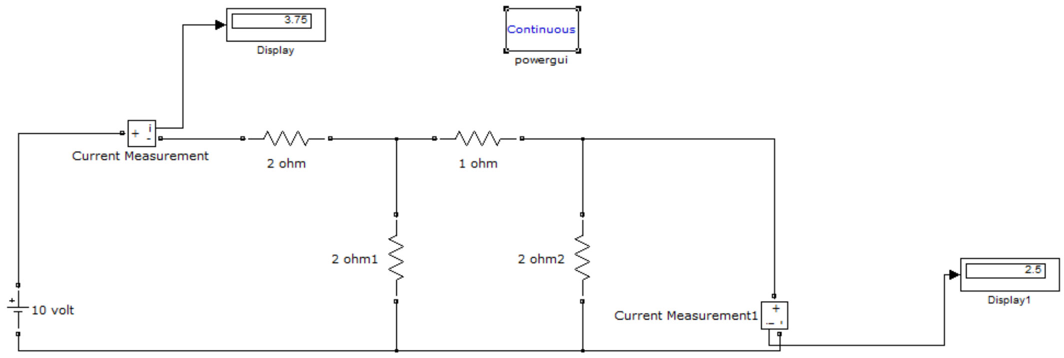


Fig:1

For the output port short circuited,

Y_{11}=0.375 mho

$Y_{21=}$ 0.25 mho

Applied voltage *at out*put *port* is 10 V.

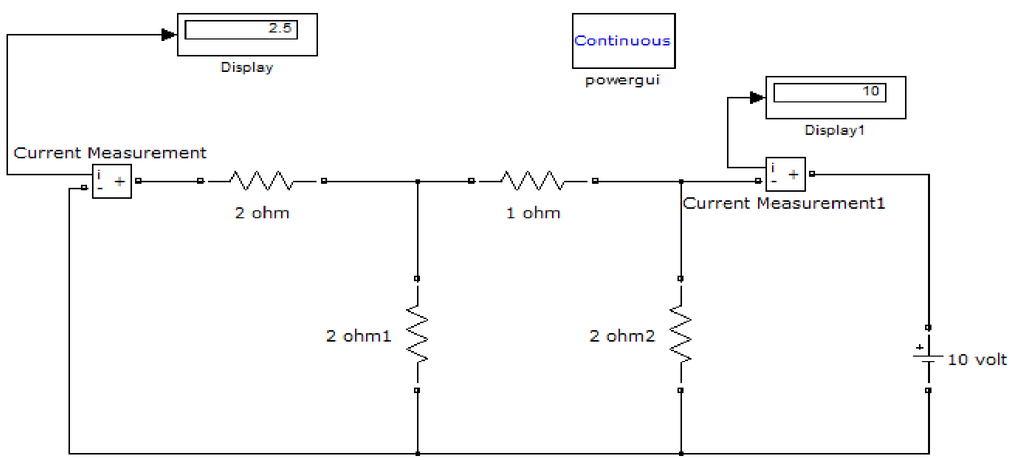


Fig:2

For the input port short circuited,

Y_{22}=1 mho

$Y_{12=}$ 0.25 mho

EXPERIMENT NO : CKT/5

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

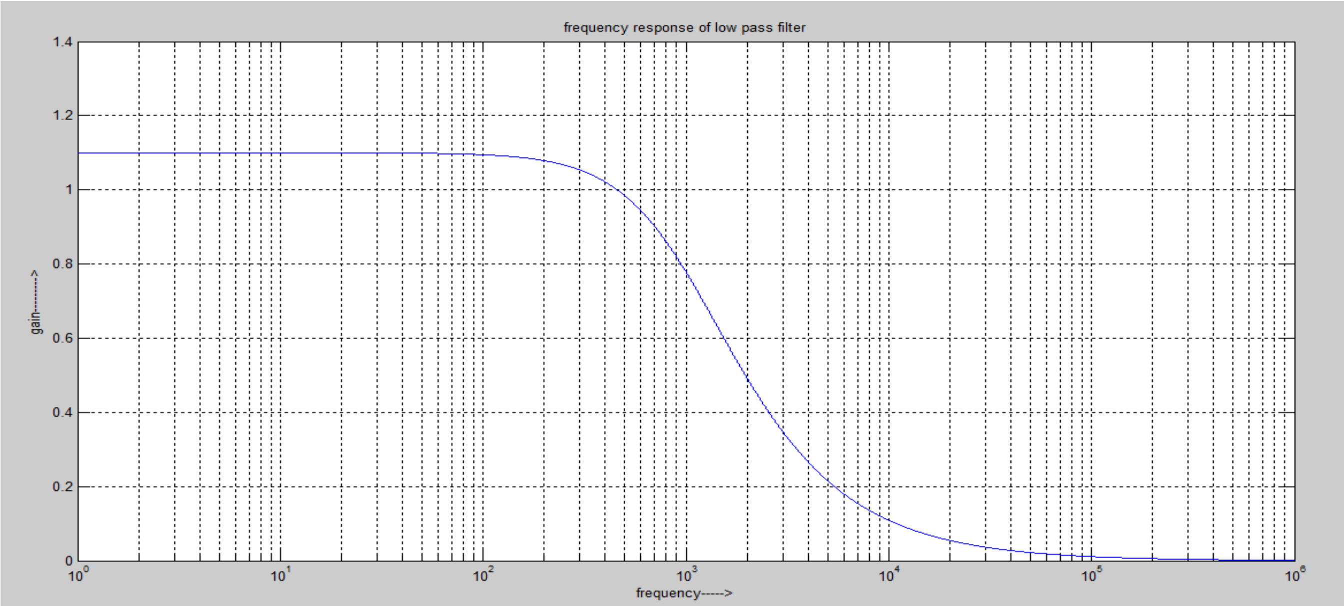
OBJECTIVE : To study the frequency response of Low Pass and High Pass filter using MATLAB.

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

Matlab Code :

```
f=0:1:10^6
r1=10000
rf=1000
r=15900
c=0.01*10^-6
af=(1+rf/r1)
fc=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 :

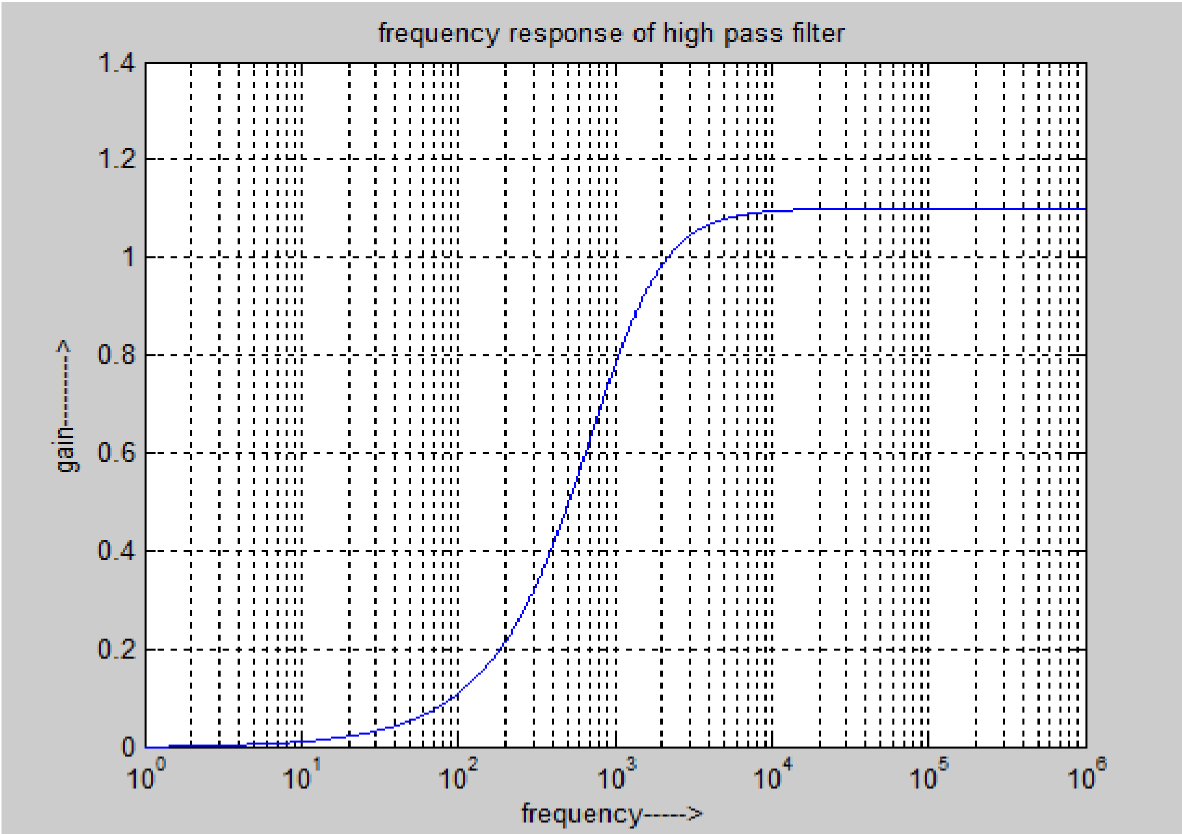


Example 1: Show the frequency response of a high pass filter.

Matlab Code :

```
f=[0:1:10^6];
r1=10000;
rf=1000;
r=15900;
c=0.01*10^(-6);
af=(1+rf/r1);
fc=1/(2*pi*r*c);
a=f/fc;
acl_lp=af.*a./sqrt(1+a.*a);
semilogx(acl_lp)
xlabel('frequency----->')
ylabel('gain--------->')
title('frequency response of high pass filter')
grid
```

Output :



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

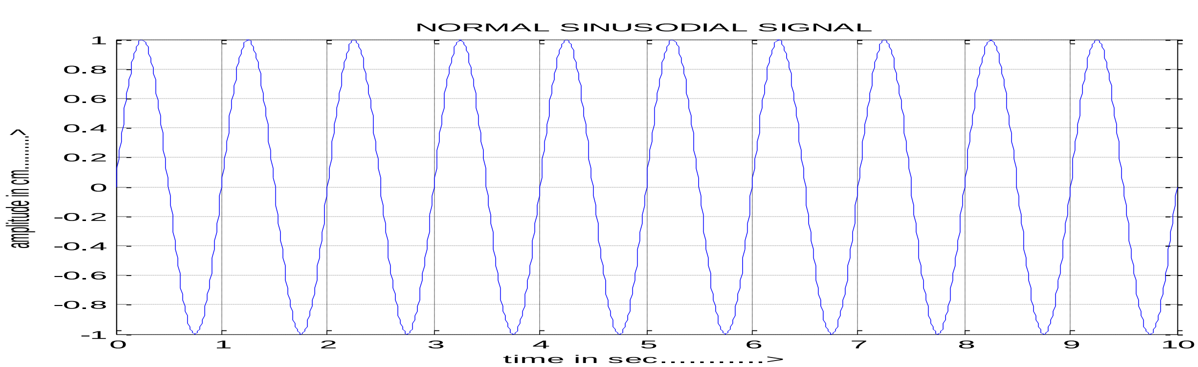
Example 1: Generate normal sinusoidal signal

Matlab Code:

```
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
```



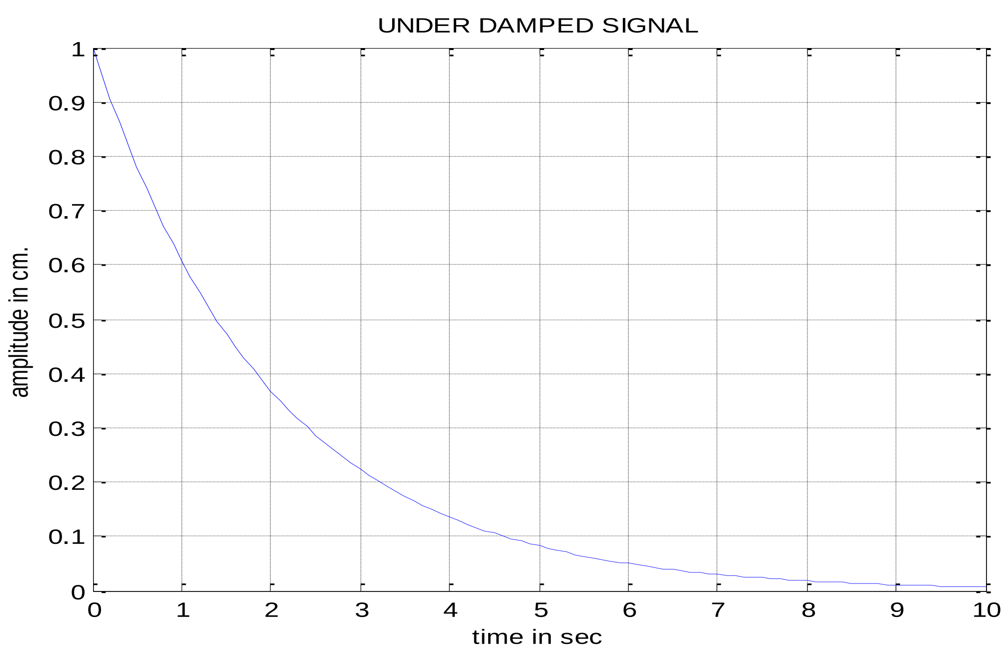
Example 2: Generate Under damped signal

Matlab Code:

```
a=input('enter the damping costant:');
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
```



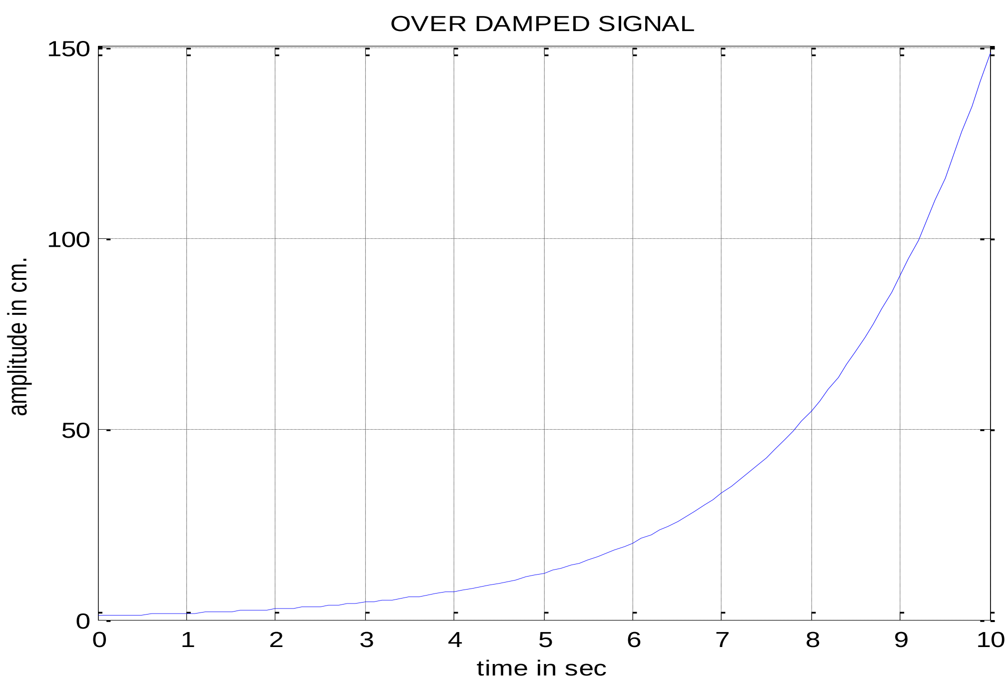
Example 3: Generate Over damped signal

Matlab Code:

```
a=input('enter the damping costant:');
l=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



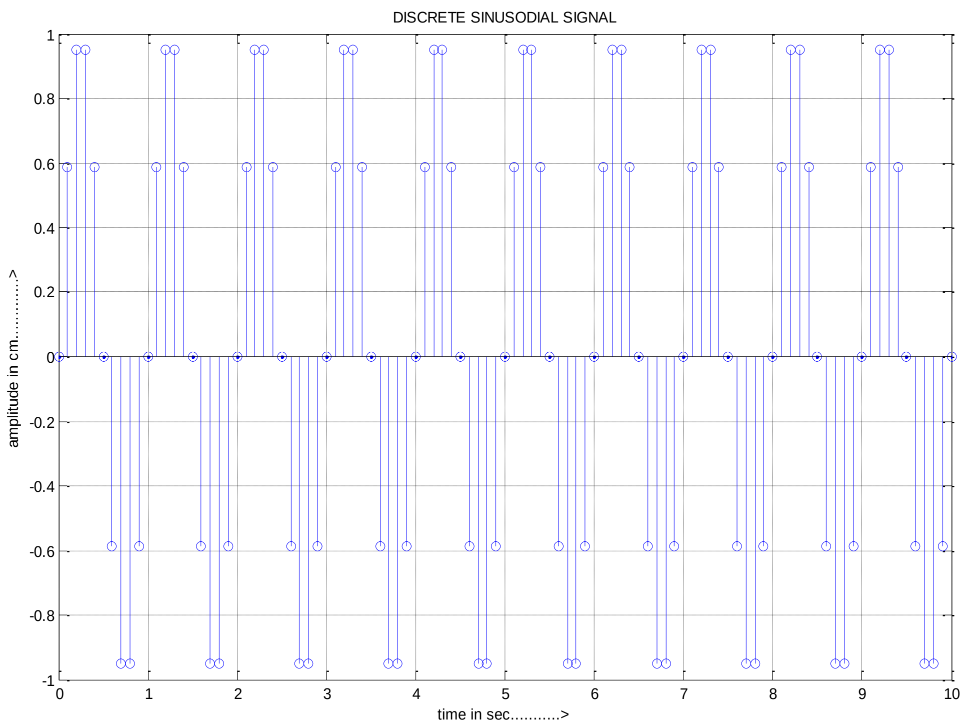
Example 4: Discrete Sinusoidal signal

Matlab Code:

```
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
```



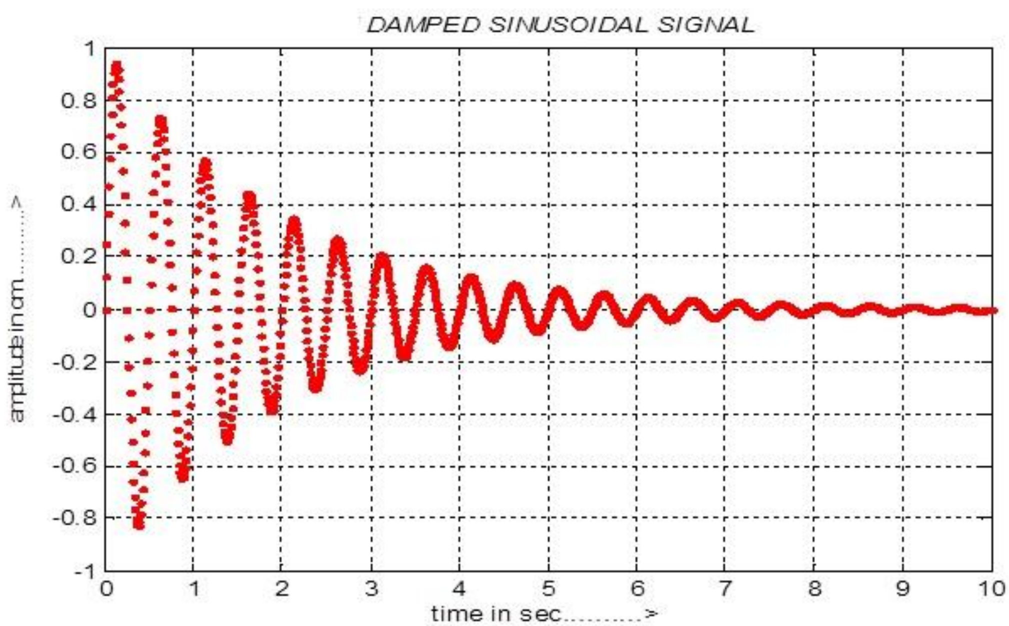
Example 5: Damped Sinusoidal signal

Matlab Code:

```
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
```

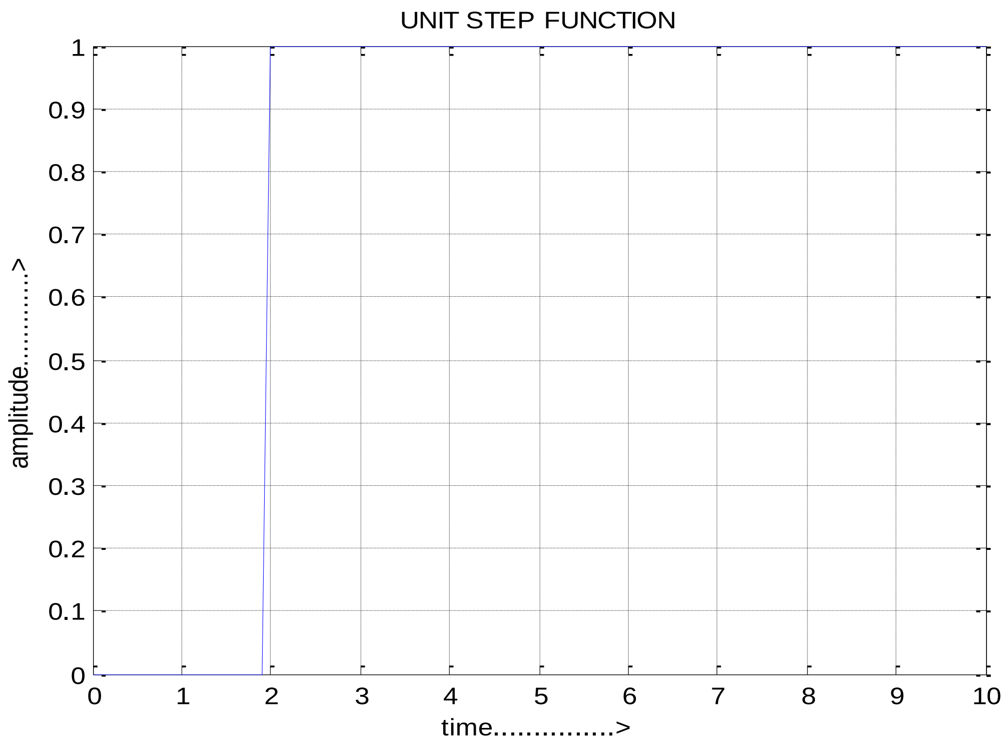


Example 6: Generate Unit step function

Matlab Code:

```
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 :

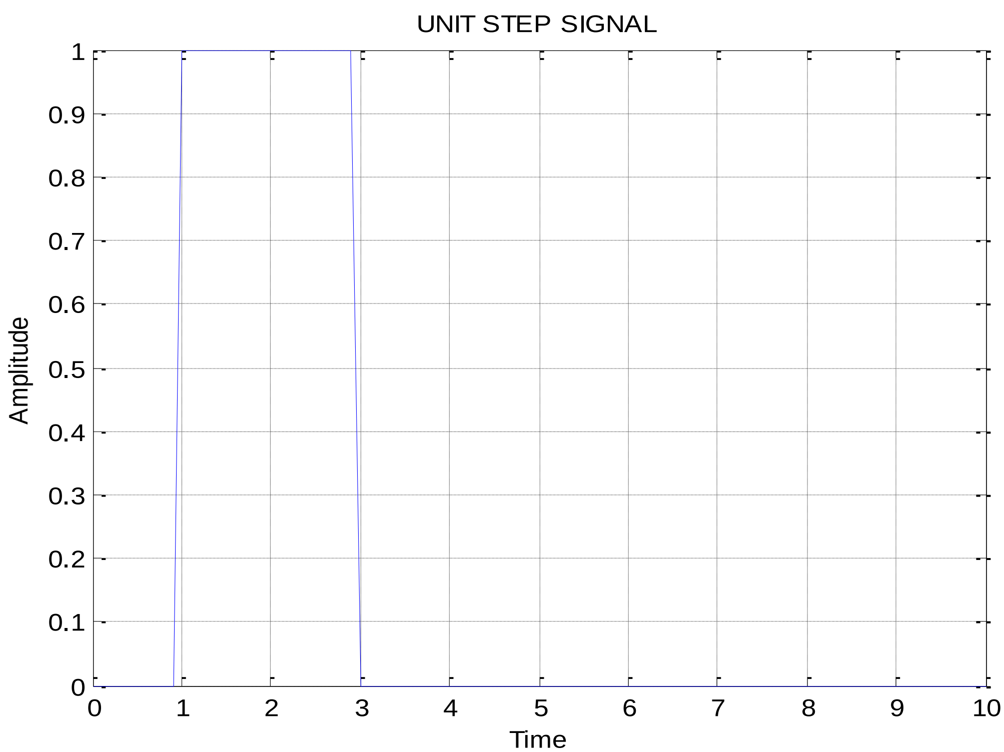


Example 7: Generate Unit step function 2

Matlab Code:

```
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 :



EXPERIMENT NO : CKT/8

TILLE : 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, $L[e^{at} f(t)] = F(s-a)$

- $L[t] = \int_0^\infty t.e^{-st} dt = \frac{1}{s^2}$
- $L[e^{at}] = \int_0^\infty e^{at}.e^{-st} dt = \int_0^\infty e^{(a-s)t} dt = \frac{1}{s-a}$
- $L[e^{at} f(t)] = F(s-a)$, $f(t) = t$ & a= -3

$$\therefore\ F(s)=\frac{1}{s^2}$$

$$\therefore\ L[e^{-3t}.t]=\frac{1}{(s+3)^2}$$

- $$L[(1-e^{-at}-ate^{-at})/a^2]=\frac{1}{a^2}\{L[1]-L[e^{-at}]-aL[te^{-at}]\}$$
$$=\frac{1}{a^2}[\frac{1}{s}-\frac{1}{s+a}-\frac{a}{(s+a)^2}]$$

- $L[e^{at}f(t)]=F(s-a)$, $f(t)=\sin\omega t$, $a=-3$ & $\omega=10$
$$\therefore\ F(s)=\frac{\omega}{s^2+\omega^2}$$
$$\therefore\ L[e^{-3t}.\sin 10t]=\frac{10}{(s+3)^2+100}$$

Derivation of inverse Laplace transform:-

$$L^{-1}[F(s)]=f(t)$$

- $$L^{-1}[\frac{1}{s-a}]=e^{at}$$
$$F(s)=\frac{s+2}{s^2(s+1)}=\frac{A}{s^2}+\frac{B}{s}+\frac{C}{s+1}=\frac{2}{s^2}-\frac{1}{s}+\frac{1}{s+1}$$

$$\therefore\ L^{-1}[F(s)]=2t-1+e^{-t}=2t-2e^{-t/2}(\frac{e^{t/2}-e^{-t/2}}{2})$$
$$=2t-2e^{-t/2}\sinh(t/2)$$

- $$F(s)=\frac{5}{s}+16+\frac{1}{s+3}$$
$$\therefore\ L^{-1}[F(s)]=L^{-1}[\frac{5}{s}]+L^{-1}[16]+L^{-1}[\frac{1}{s+3}]=5+16\delta(t)+e^{-3t}$$

Laplace Transform:

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

Program:

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

Output:

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

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

Program:

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

Output:

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

Example 3: f(t)=sin2t

Program:

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

output:

$fs=2/(s^2+4)$

Example 4: f(t)=cos5t

Program:

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

Output:

$fs=s/(s^2+25)$

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

Program:

Syms t s

$ft=t^6$

fs=laplace(ft)

output:

$fs=720/s^7$

Example 6: $f(t)=t^2 \sin 6t$

Program:

```
Syms t s
ft=t^2*sin(6*t)
fs=laplace(ft)
```

output:

```
fs=36*(s^2-12)/(s^2+36)^3
```

Example 7: $f(t)=e^{3t} \sin 2t$

Program:

```
Syms t s
ft=exp(3*t)*sin(2*t)
fs=laplace(ft)
```

output:

```
fs=2/(s^2-6*s+13)
```

Example 8: $f(t)=e^{-3t} \cos 7t$

Program:

```
Syms t s
ft=exp(-3*t)*cos(7*t)
fs=laplace(ft)
```

output:

```
fs=(s+3)/(s^2+6*s+58)
```

Example 9: $f(t)=e^{-2t} \sin 4t$

Program:

```
Syms t s
ft=exp(-2*t)*sin(4*t)
fs=laplace(ft)
```

output:

```
fs=4/(s^2+4*s+20)
```

Example 10: $f(t)=e^{7t} \cos 2t$

Program:

```
Syms t s
ft=exp(7*t)*cos(2*t)
fs=laplace(ft)
```

output:

```
fs=(s-7)/(s^2-14*s+53)
```

Inverse Laplace Transform:

Example 1: f(s)=s+1/s(s+2)(s+3)

Program:

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

output:

```
ft=-2/3*exp(-3*t)+1/2*exp(-2*t)+1/6
```

Example 2: f(s)=(s^3+3s^2+4s+4)/(s+1)(s+4)

Program:

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

output:

```
ft=dirac(1,T)-2*dirac(t)+2/3*exp(-t)+28/3*exp(-4*t)
```

Example 3: f(s)=3/s^2+8s+25

Program:

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

output:

```
ft=exp(-4*t)*sin(3*t)
```

Example 4: f(s)=s/s^2+a^2

Program:

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

output:

```
ft=cos(a*t)
```

Example 5: f(s)=1/s+a

Program:

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

output:

```
ft=exp(-a*t)
```