PRACTICAL WORK BOOK

For Academic Session 2013

CIRCUIT THEORY II
(EE-312)

For

T.E (EE) & T.E (EL)

Name:

Roll Number:

Class:

Batch: **Semester:**

Department :

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CONTENTS

LAB SESSION 01

INTRODUCTION TO MATLAB

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy solution to matrix analysis.

In laboratory we will use MATLAB as a tool for graphical visualization and numerical solution of basic electrical circuits we are studying in our course.

HOW TO START:

Step 1: Make a new M file. (From Menu bar select New and then select M-File)
Step 2: When Editor open, write your program.
Step 3: After writing the program, select Debug from menu bar and then select run and save.

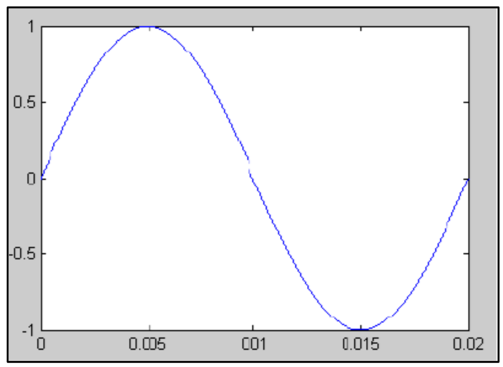
Further information can be obtain from the website www.mathworks.com
Some basic commands are;
clear all: Clear removes all variables from the workspace. This frees up system memory.
close all: Close deletes the current figure.
clc : Clear Command Window.
% : To write comments

Graphical commands:
plot : Linear 2-D plot.
grid : Grid lines for two- and three-dimensional plots.
xlabel : Label the x axis, similarly ylabel for y axis labeling.
legend : Display a legend on graphs.
title : Add title to current graph.

IN-LAB EXERCISE 1

1.1. TO GENERATE SINE WAVE AT 50 Hz

```
clear all;
close all;
clc;
f=50;
 %Defining a variable ‘frequency’
t=0:0.000005:0.02;
 %Continuous time from 0 to 0.02 with steps
0. 000005
x=sin(2*pi*f*t);
% pi is built in function of MATLAB
plot(t,x)
```



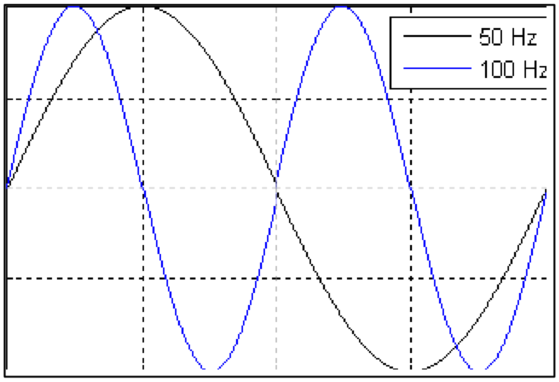
1.2. TO GENERATE TWO SINE WAVE AT 50Hz AND 25 Hz

```
clear all; close all; clc;
% t is the time varying from 0 to 0.02
t=0:0.000005:0.02;
f1=50;
f2=100;
% Plotting sinusoidal voltage of frequency
100Hz & 50Hz
v1=sin(2*pi*f1*t);
v2=sin(2*pi*f2*t);
plot(t,v1,t,v2)
```

RUN THE PROGRAM.
ADD SOME COMMANDS IN THE SAME PROGRAM AND THEN AGAIN RUN IT.

```
xlabel('Voltage');
ylabel('Time in sec');
```

```
legend('50 Hz','100 Hz');
title('Voltage Waveforms');grid;
```



1.3. PLOT THE FOLLOWING THREE FUNCTIONS:

v1(t)=5cos(2t+45 deg.)

v2(t)=2exp(-t/2)

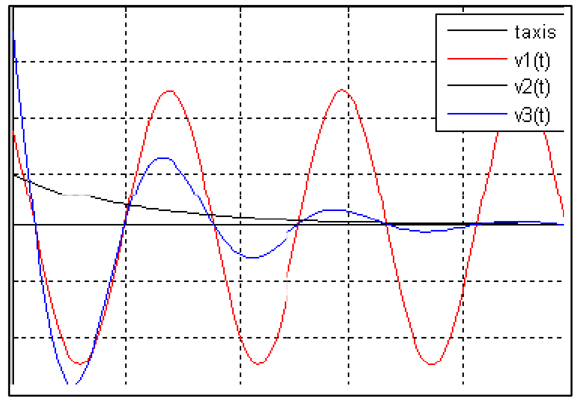
v3(t)=10exp(-t/2) cos(2t+45 deg.)

MATLAB SCRIPT:

```
clear all; close all; clc;
t=0:0.1:10;
% t is the time varying from 0 to 10 in steps of 0.1s
v1=5*cos(2*t+0.7854);
%degrees are concerted in radians
taxis=0.000000001*t;
plot(t,taxis,'k',t,v1,'r')
grid ; hold;
v2=2*exp(-t/2);
plot (t,v2,'g')
v3=10*exp(-t/2).*cos(2*t+0.7854);
plot (t,v3,'b')
title('Plot of v1(t), v2(t) and v3(t)')
xlabel ('Time in seconds')
ylabel ('Voltage in volts')
legend('taxis','v1(t)','v2(t)','v3(t)');
```

NOTE:

The combination of symbols .* is used to multiply two functions. The symbol * is used to multiply two numbers or a number and a function. The command "hold on" keeps the existing graph and adds the next one to it. The command "hold off" undoes the effect of "hold on". The command "plot" can plot more than one function simultaneously. In fact, in this example we could get away with only one plot command. Comments can be included after the % symbol. In the plot command, one can specify the color of the line as well as the symbol: 'b' stands for blue, 'g' for green, 'r' for red, 'y' for yellow, 'k' for black; 'o' for circle, 'x' for x-mark, '+' for



plus, etc. For more information type `help plot` in matlab.

POST LAB EXCERCISE

Task 1.1

W rite a program to plot inverted sine waveform.

Task 1.2

Write a program to plot 2 cycles of sine wave.

Task 1.3

W rite a program to plot three phases waveform showing each phase 120 degree apart.

LAB SESSION 02

IN-LAB EXERCISE 2

OBJECTIVE OF LAB-2:

1. Plot instantaneous voltage, current & power for R, L ,C and mixed. loads
2. Compute Real Power and Power Factor for single phase loads.
3. Phasor Analysis.

2.1 Instantaneous Voltage, Current and Power for Resistive Load

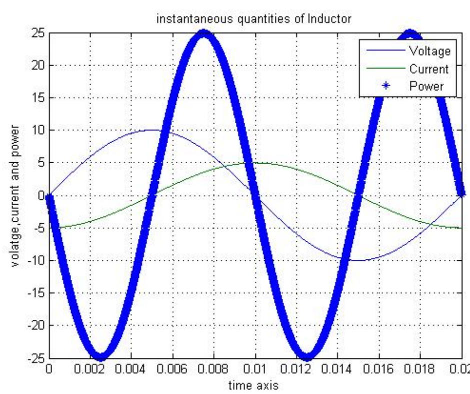
MATLAB SCRIPT:

```
clear all; close all; clc;
f = 50; %frequency of the source
t= 0 : .00001 : (1/f); %initiating the time
array
Vm = 10; %peak voltage in Volts
theta_V = 0;
v = Vm*sin (2 * pi * f * t + theta_V);
%voltage array
R = 2; % value of resistance in ohms
Im = Vm / R; %Peak value of current in
Ampere
theta_i = angle(R); %impedance angle
i = Im * sin (2 *pi * f * t - theta_i );
%current array
plot(t, v, t, i); %plotting voltage and
current array
p = v.*i; %instantaneous power
hold on
plot (t, p,'*')
xlabel('time axis')
ylabel('volatge,current and power')
legend('voltage', 'current', 'power')
title('instantaneous quantities of
Resistor')
grid on
```

2.2 Instantaneous Voltage, Current and Power for Inductive Load

MATLAB SCRIPT:

```
clear all; close all; clc;
f = 50; %frequency
t= 0 : .00001 : (1/f); %time array
Vm = 10; %peak voltage in Volts
theta_V = 0;
v = Vm*sin (2 * pi * f * t + theta_V); %
voltage aarray
L = 6.4e-3; %Inductane in Henry
Xl = 2*pi*f*L;
Z = 0 + j*Xl; % Impdance of load
angle_Z = angle(Z); %impedance angle
Im = Vm / abs (Z); %magnitude of load
current in Ampere
i = Im*sin(2*pi*f*t-angle_Z); %current
array
plot(t, v, t, i);
hold on
p_L = v.*i; %instantaneous power
plot(t, p_L,'*')
xlabel('time axis')
ylabel('volatge,current and power')
legend('Voltage','Current','Power')
title('instantaneous quantities of
Inductor')
grid on
```



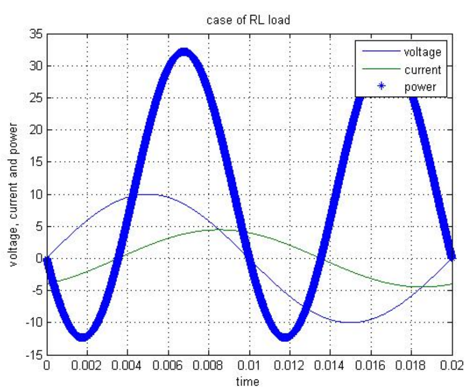
2.3 Instantaneous Voltage, Current and Power for Capacitive Load

Modify the code in Section 2.2 for Capacitive load, choose the value of Capacitance so that it offers an impedance of 2 ohms

2.4 Instantaneous Voltage, Current and Power for RL Load

MATLAB SCRIPT:

```
clear all; close all; clc;
f = 50;
t= 0 : .00001 : (1/f);
Vm = 10;
theta_V = 0;
v = Vm*sin (2 * pi * f * t + theta_V);
R=1;
L = 6.4e-3;
Xl = 2*pi*f*L;
Z = R + j*Xl;
angle_Z = angle(Z);
Im = Vm / abs (Z);
i_theta = angle(Z);
i = Im * sin (2*pi*f*t-i_theta);
plot(t,v,t,i)
hold on
p = v.*i;
plot(t, p,'*')
grid on
legend('voltage','current','power')
xlabel('time')
ylabel('voltage, current and power')
title('case of RL load')
```



2.5. CALCULATE the absolute value of complex value of voltage V=10+j10.

MATLAB SCRIPT:

```
clear all; close all; clc;
v=10+10*j;
x=abs(v);
fprintf('Vabsolute: %f \n',x);
```
or

```
display (x)
```

In this program two new commands are introduced; 'abs' (for absolute value of a complex quantity) and 'fprintf' (for printing a value where %f is defining that fixed value & \n new line). **Answer:** absolute=10

2.6. DETERMINE,

Average power, power factor and rms value of voltage when v(t)=10cos(120πt+30) and i(t)=6cos(120πt+60)

MATLAB SCRIPT:

```
clear all; close all; clc;
t=1/60;
Vm=10;%Maximum value of voltage
Im=6;
Vtheta=30*pi/180; %angle in radians
Itheta=60*pi/180;
p.f=cos(Vtheta-Itheta); %power factor & avg. power
P_avg=(Vm*Im/2)*cos(Vtheta-Itheta);
V_rms=Vm/sqrt(2);
fprintf('Average Power: %f \n',P_avg); %\n is for new line
fprintf('Power Factor: %f \n',p.f);
fprintf('rms voltage: %f \n',V_rms);
```

ANSWER: Average Power: 25.980762, Power Factor: 0.866025, rms voltage: 7.071068

In the above program add the following commands and comment on the resulting plot.

```
t=0:0.00005:0.04; plot(t,P_avg);
```

PHASORS IN MATLAB

Euler's formula indicates that sine waves can be represented mathematically as the sum of two complex-valued functions:

$$A \cdot \cos(\omega t + \theta) = A/2 \cdot e^{i(\omega t+\theta)} + A/2 \cdot e^{-i(\omega t+\theta)},$$

as the real part of one of the functions:

$$\begin{aligned} A \cdot \cos(\omega t + \theta) &= \mathrm{Re}\left\{A \cdot e^{i(\omega t+\theta)}\right\} \\ &= \mathrm{Re}\left\{A e^{i\theta} \cdot e^{i\omega t}\right\}. \end{aligned}$$

As indicated above, phasor can refer to either $Ae^{i\theta}e^{i\omega t}$ or just the complex constant, $Ae^{i\theta}$. In the latter case, it is understood to be a shorthand notation, encoding the amplitude and phase of an underlying sinusoid. And even more compact shorthand is angle notation: $A\angle\theta$.

2.7. SOLVING LINEAR EQUATIONS & MATRICES

Assume you have the following two linear complex equations with unknown I1 and I2:

(600+1250j)I1 + 100j.I2 = 25
100j.I1 + (60-150j).I2 = 0

Matrix form of above two equations is,

$$\begin{bmatrix} 600+1250j & 100j \\ 100j & 60-150j \end{bmatrix} \begin{bmatrix} I1 \\ I2 \end{bmatrix} = \begin{bmatrix} 25 \\ 0 \end{bmatrix}$$

This can be written in matrix form: A.I = B. To solve this in MATLAB we will use command: **I = inv(A)*B.**

MATLAB SCRIPT:

```
clear all; close all; clc;
A=[600+1250j 100j;100j 60-150j];
B = [25;0];
I = inv(A)*B
MAGN=abs(I);
%Converting angle from degrees into radians
ANG=angle(I)*180/pi;
fprintf('MAGNITUDE: %f \n',MAGN);
fprintf('ANGLE: %f \n',ANG);
```

We used the abs() operator to find the magnitude of the complex number and the angle() operator to find the angle (in radians). To get the result in degree we have multiplied the angle by 180/pi as shown above.

ANSWER: I = 0.0074 - 0.0156i
0.0007 - 0.0107i

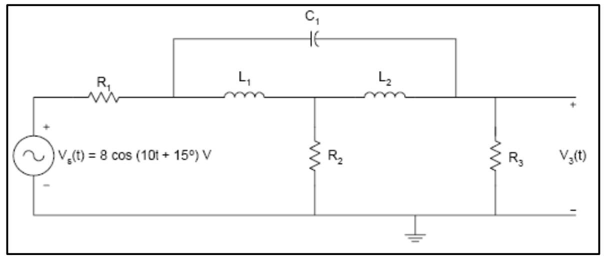
MAGNITUDE: 0.017262, MAGNITUDE: 0.010685
ANGLE: -64.522970, ANGLE: -86.324380

In standard phasors format currents are,

I1=0.01726∠-64.5229, I2= 0.01068∠-86.3243

In the program add following commands & observe;

```
i1= 0.017262*exp(pi*-64.54*j/180);
i1_abs=abs(i1);
i_ang=angle(i1)*180/pi;
```




```
fprintf('Magnitude of i1\n',i1_abs);
fprintf('Angle of i1: %f \n',i_ang);
```

2.8. CALCULATE

V_3 (t) In Figure, if $R_1 = 20\Omega$, $R_2 = 100\Omega$, $R_3 = 50\Omega$, and $L_1 = 4$ H, $L_2 = 8$ H and $C_1 = 250\mu F$, when w = 10 rad/s.

Solution: Using nodal analysis, we obtain the following equations. At node 1, node 2 and node 3 the equations are;

$$\frac{V1-Vs}{R1} + \frac{V1-V2}{j10L1} + \frac{V1-V3}{\frac{1}{j10C1}} = 0 \quad (1)$$

$$\frac{V2}{R2} + \frac{V2-V1}{j10L1} + \frac{V2-V3}{j10L2} = 0 \quad (2)$$

$$\frac{V3}{R3} + \frac{V3-V2}{j10L2} + \frac{V2-V3}{\frac{1}{j10C1}} = 0 \quad (3)$$

Substituting the element values in the above three equations and simplifying, we get the matrix equation,

$$\begin{bmatrix} 0.05-j0.0225 & j0.025 & -j0.0025 \\ j0.025 & 0.01-j0.0375 & j0.0125 \\ -j0.0025 & j0.0125 & 0.02-j0.01 \end{bmatrix} * \begin{bmatrix} V1 \\ V2 \\ V3 \end{bmatrix} = \begin{bmatrix} 0.4\angle 15 \\ 0 \\ 0 \end{bmatrix}$$

The above matrix can be written as,

[I]=[Y][V]

We can compute the vector [v] using the MATLAB command;

V=inv(Y)*I

Where inv(Y) is the inverse of the matrix [Y]

MATLAB SCRIPT

```
clear all; close all; clc;
Y = [0.05-0.0225*j 0.025*j -0.0025*j;
0.025*j 0.01-0.0375*j 0.0125*j;
-0.0025*j 0.0125*j 0.02-0.01*j];
c1 = 0.4*exp(pi*15*j/180);
I = [c1;0;0]; % current vector entered as
column vector
V = inv(Y)*I; % solve for nodal
voltages
v3_abs = abs(V(3));
v3_ang = angle(V(3))*180/pi;
fprintf('Voltage V3, magnitude: %f \n',
v3_abs);
fprintf(' Voltage V3, angle in degree:
%f', v3_ang);
```

ANSWER: (output on command window)
Voltage V3, magnitude: 1.850409
Voltage V3, angle in degree: -72.453299

From the MATLAB results, the time domain voltage $v_3(t)$ is;

$V_3(t) = 1.85\cos(10t - 72.45^o)$ V

POST LAB EXCERCISE

TASK 2.1 Plot instantaneous voltage, current and power for a pure inductor of 6.4mH when the voltage $10\sin(100\pi t + 45°)$ is applied across it.

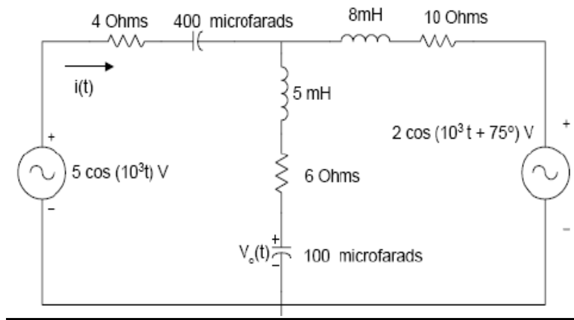
TASK 2.2 Write detailed comments for the four cases discussed in this lab session

TASK 2.3 Solve example 2.7 numerically on paper and compare the answers with the result given by MATLAB.

TASK 2.4 For the circuit shown in

Figure, find the current $i_1(t)$ and the voltage $V_C(t)$ by MATLAB. (Hint: I= inv(Z)*V)

TASK 2.5 Solve Practice Problem 11.9 of your text book using Matlab



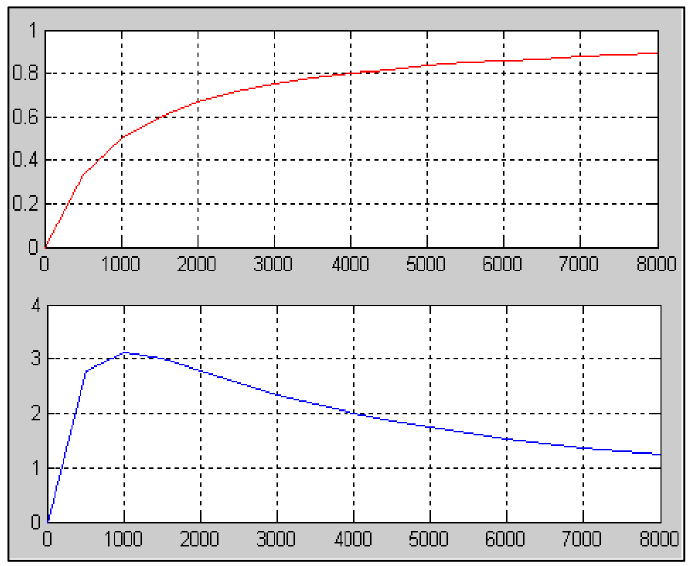
LAB SESSION 03

Object:

MAXIMUM POWER TRANSFER THEOREM USING MATLAB

MATLAB SCRIPT

```
clear all; close all; clc;
% Load Resistance is 'r'
r=input('please input the load resistances: ')
Rth=input('please input the thevenin resistance:')
% Total resistance is 'Rt'
Rt=Rth+r
% Source voltage is 'Vs'
Vs=input('please input the source voltage: ')
V=(Vs)/(sqrt(2))
% Current is the ratio of voltage and resistance
Il=V./Rt;
Vrl=(V*r)./(Rt)
format long
Il=single(Il)
%Input power 'Pin' and Output power 'Po'
Pin=V*Il*1000
Po=Vrl.*Il*1000
%power in mW
n=(Po./Pin)
subplot(2,1,1)
plot(r,n,'r'); grid on;
subplot(2,1,2)
plot(r,Po,'b');grid on;
```




```
% Check command window
```

Maximum Power Transfer Theorem

Object:

Analysis of Maximum Power Transfer Theorem for AC circuit

Apparatus:

Digital Multimeter, Power Supply (10V, 50Hz sinusoidal), Resistors of various values , connecting wires and Breadboard.

Theory:

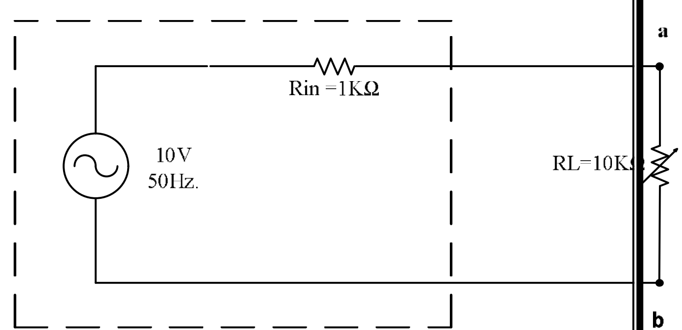
- The maximum power transfer theorem states that when the load resistance is equal to the source's internal resistance, maximum power will be developed in the load or An independent voltage source in series with an impedance Z_{th} or an independent current source in parallel with an impedance Z_{th} delivers a maximum average power to that load impendence Z_L which is the conjugate of Z_{th} or $Z_L = Z_{th}$. Since most low voltage DC power supplies have a very low internal resistance (10 ohms or less) great difficulty would result in trying to affect this condition under actual laboratory experimentation. If one were to connect a low value resistor across the terminals of a 10 volt supply, high power ratings would be required, and the resulting current would probably cause the supply's current rating to be exceeded. In this experiment, therefore, the student will simulate a higher internal resistance by purposely connecting a high value of resistance in series with the AC voltage supply's terminal. Refer to Figure 13.1 below. The terminals (a & b) will be considered as the power supply's output voltage terminals. Use a potentiometer as a variable size of load resistance. For various settings of the potentiometer representing R_L, the load current and load voltage will be measured. The power dissipated by the load resistor can then be calculated. For the condition of

$R_L = R_i$, the student will verify by measurement that maximum power is developed in the load resistor.

Procedure

1. Refer to Figure 1, set R_{in} equal to 1 KΩ representing the internal resistance of the ac power supply used and select a 10 KΩ potentiometer as load resistance R_L. V_{in}=10V,50Hz.

a. Using the DMM set the potentiometer to 500 ohms.



b. Connect the circuit of Figure 1. Measure the current through and the voltage across R_L. Record this data in Table 1.

c. Reset the potentiometer to 1KΩ and again measure the current through and the voltage across R_L. Record.

d. Continue increasing the potentiometer resistance in 500 ohm steps until the value 10 KΩ is reached, each time measuring the current and voltage and record same in Table 1. Be sure the applied voltage remains at the fixed value

R_L (Ω)	I_L (mA)	V_{RL} (V)	P_{in} (mW)	P_{out} (mW)	% eff.
500					
1000					
1500					
2000					
2500					
3000					
3500					
4000					
4500					
5,000					
6,000					
7,000					
8,000					

of 10 volts after each adjustment in potentiometer resistance.

1. For each value of R_L in Table 1, calculate the power input to the circuit using the formula:
$P_{input} = V_{input} \times I_L$

2. For each value of R_L in Table 1, calculate the power output (the power developed in R_L) using the formula:
$P_{out} = V_{RL} \times I_L$.

3. For each value of R_L in Table.1, calculate the circuit efficiency using the formula:
% efficiency = $P_{out}/P_{in} \times 100$.

4. On linear graph paper, plot the curve of power output vs. R_L. Plot R_L on the horizontal axis (independent variable). Plot power developed in R_L on the vertical axis (dependent variable). Label the point on the curve representing the maximum power.

Observation:
Conclusion and comments:

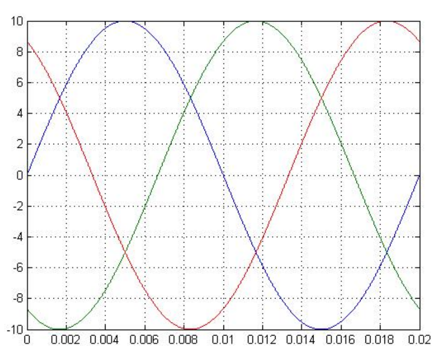
LAB SESSION 04

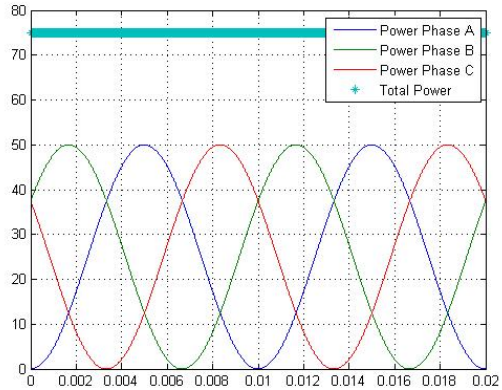
Object: Verification, Proofs and Analysis of various aspects of Polyphase systems using MATLAB

4.1 : Proof of constant instantaneous power for three phase balanced load

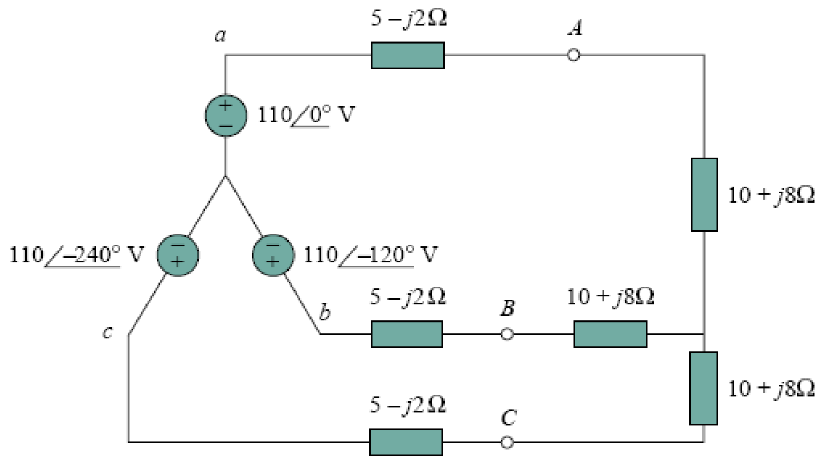
MATLAB SCRIPT:

```
clear; close all; clc;
t=0:.00001:.02; %time array
f=50; %frequency
Vm=10; %peak voltage
va=Vm*sin(2*pi*f*t); %phase A voltage
vb=Vm*sin(2*pi*f*t - deg2rad(120)); %phase B voltage
vc=Vm*sin(2*pi*f*t - deg2rad(240)); %phase C voltage
plot(t,va,t,vb,t,vc);
grid on;
R=2; %Resistance
% Computing Current
Im=Vm/R; %Peak current
ia=Im*sin(2*pi*f*t);
ib=Im*sin(2*pi*f*t-deg2rad(120));
ic=Im*sin(2*pi*f*t-deg2rad(240));
% Computing Power
pa=va.*ia;
pb=vb.*ib;
pc=vc.*ic;
pt=pa+pb+pc;
figure;
plot(t,pa,t,pb,t,pc,t,pt,'*');
grid on;
legend('Power Phase A','Power Phase B','Power Phase C','Total Power');
```





4.2 **:** Finding Line currents for balanced Y-Y system using Matlab



MATLAB SCRIPT:

```
Van=110;
Zy=15+6*j;
Ian=Van/Zy;
MAGNa=abs(Ian);
ANGa=angle(Ian)*180/pi;
fprintf('Ia \n MAGNITUDE: %f \n ANGLE:%f \n',MAGNa,ANGa);
Ibn=abs(Ian)*exp((ANGa-120)*pi*j/180);
MAGNb=abs(Ibn);
ANGb=angle(Ibn)*180/pi;
fprintf('Ib \n MAGNITUDE: %f \n ANGLE:%f \n',MAGNb,ANGb);
Icn=abs(Ian)*exp((ANGa+120)*pi*j/180);
MAGNc=abs(Icn);
ANGc=angle(Icn)*180/pi;
fprintf('Ic \n MAGNITUDE: %f \n ANGLE:%f \n',MAGNc,ANGc);
```

Check Command Window for results

4.3 : Prove that the summation of voltage and current in balanced three phase circuit is zero.
In code for Section 4.1 add following lines

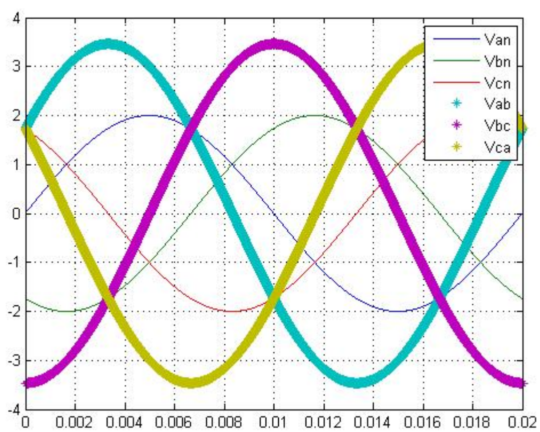
MATLAB SCRIPT:

```
Vn = va + vb + vc;
In = ia + ib +ic;
figure;
plot(t,Vn,t,In);
ylim([-10 10]);
```

4.4 : Plot Line Voltages and Phase Voltages for a Y connected source when
Van = 2 sin (wt)

MATLAB SCRIPT:

```
clear; close all;clc;
 t=0:0.000001:0.02;
f=50; % frequency
Van=2*sin(2*pi*f*t);
Vbn=2*sin(2*pi*f*t-deg2rad(120));
Vcn=2*sin(2*pi*f*t-deg2rad(240));
Vab=Van-Vbn;  %line voltage Vab
Vbc=Vbn-Vcn; %line voltage Vbc
Vca=Vcn-Van; %line voltage Vca
plot(t,Van,t,Vbn,t,Vcn,t,Vab,'*',t,Vbc,'*',t,Vca,'*')
legend('Van','Vbn','Vcn','Vab','Vbc','Vca'); grid;
```

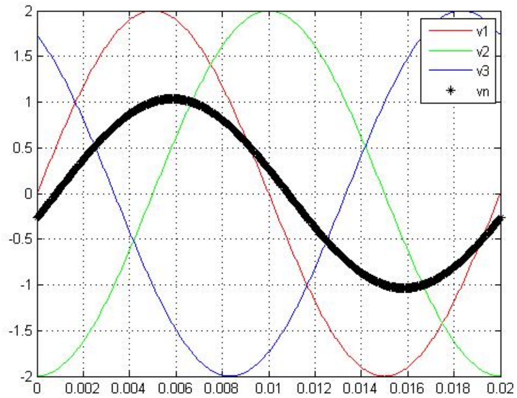


4.5 : Plot neutral voltage for Unbalanced Y Connected Source with Van = 1<0, Vbn = 1<-90, Vcn = 1<-240

MATLAB SCRIPT:

```
clear all; close all; clc;
t=0:0.00005:0.02;
f=50;
v1=2*sin(2*pi*f*t);
v2=2*sin(2*pi*f*t-90*pi/180);
```

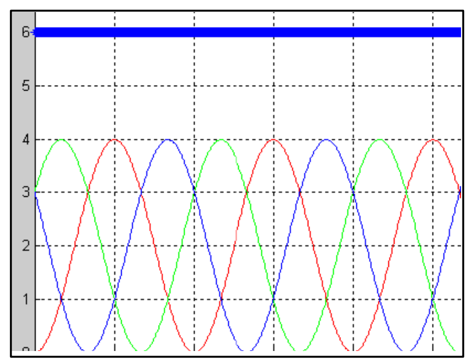
```
v3=2*sin(2*pi*f*t-240*pi/180);
Vn=v1+v2+v3;
plot(t,v1,'r',t,v2,'g',t,v3,'b',t,Vn,'k*');grid;
legend('v1','v2','v3','vn')
```

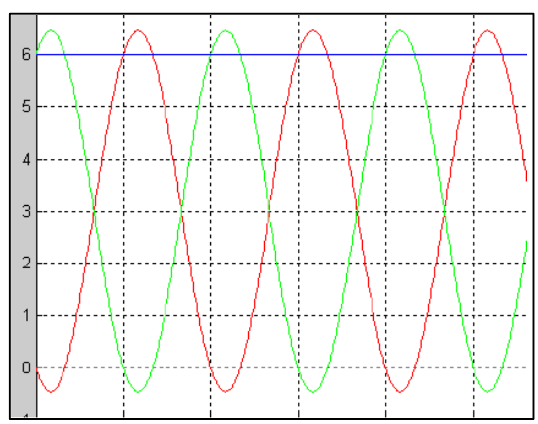


4.6 : Prove that the power measured by two wattmeter at each and every instant is same as the power compute p(t) = vaia+vbib+vcic.

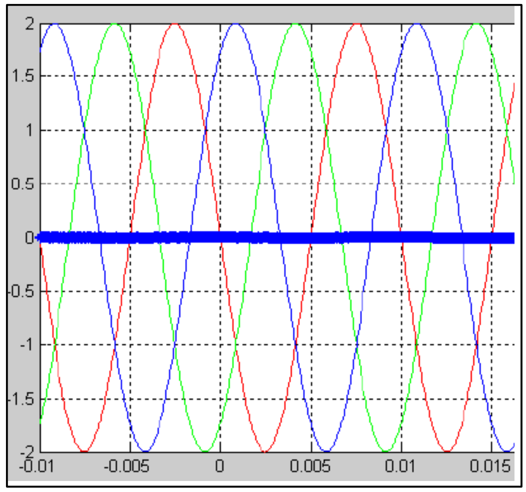
MATLAB SCRIPT:

```
clear all; close all; clc;
t=-.01:0.00005:0.02;
f=50;
v1=2*sin(2*pi*f*t);
v2=2*sin(2*pi*f*t-120*pi/180);
v3=2*sin(2*pi*f*t-2*120*pi/180);
%At unity power factor and
% For Task R=1 ohm
i1=2*sin(2*pi*f*t);
i2=2*sin(2*pi*f*t-120*pi/180);
i3=2*sin(2*pi*f*t-2*120*pi/180);
V1=(v1-v2);
V2=(v2-v3);
V3=(v3-v1);
p1=v1.*i1;p2=v2.*i2;p3=v3.*i3;
pt=p1+p2+p3;
plot(t,p1,'r',t,p2,'g',t,p3,'b',t,pt,'*')
grid; figure;
%Two Wattmeter method
w1=(v1-v3).*i1;
w2=(v2-v3).*i2;
w=w1+w2;
plot(t,w1,'r',t,w2,'g',t,w,'b')
grid; figure; plot(t,pt,'y*',t,w,'b');
```



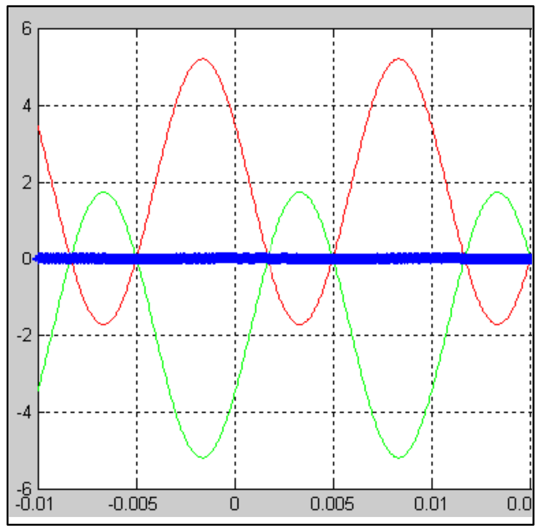


4.7 : Prove that the power measured by two wattmeter at each and every instant is same as the power compute p(t)=vaia+vbib+vcic when the load is purely inductive.



MATLAB SCRIPT:

```
clear all; close all; clc;
t=-.01:0.00005:0.02;
f=50;
v1=2*sin(2*pi*f*t);
v2=2*sin(2*pi*f*t-120*pi/180);
v3=2*sin(2*pi*f*t-2*120*pi/180);
%At unity power factor and R=1 ohm
i1=2*sin(2*pi*f*t-90*pi/180);
i2=2*sin(2*pi*f*t-120*pi/180-90*pi/180);
i3=2*sin(2*pi*f*t-2*120*pi/180-90*pi/180);
V1=(v1-v2);V2=(v2-v3);V3=(v3-v1);
p1=v1.*i1;p2=v2.*i2;p3=v3.*i3;
pt=p1+p2+p3;
plot(t,p1,'r',t,p2,'g',t,p3,'b',t,pt,'*')
grid; figure;
%Two Wattmeter metod
w1=(v1-v3).*i1;
w2=(v2-v3).*i2;
w=w1+w2;
plot(t,w1,'r',t,w2,'g',t,w,'b')
grid; figure;
plot(t,pt,'y*',t,w,'b');
ylim([-6 6]);
```



Post Lab Exercise

1. Describe your observations for each task.
2. Using Matlab prove that the power measured by two wattmeter at each and every instant is same as the power compute p(t)= vaia+vbib+vcic when the p.f is 0.5 lagging.
3. Solve Example 12.1 of your text book using Matlab
4. A balanced Y connected source is supplying power to an unbalanced delta connected load, if Zab = 10 ohms, Zbc is j5 ohms and Zca is –j10 ohms. Compute all line currents using Matlab. Take Van = 120 <0 V

LAB SESSION 05

TIME DOMAIN SIGNAL ANALYSIS

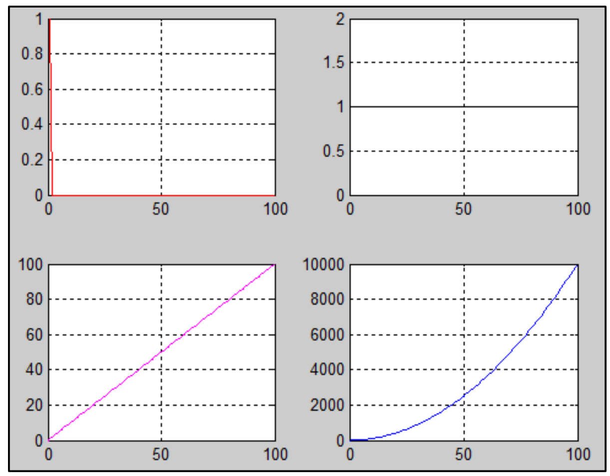
Object:
Time Domain signal plotting and their understanding using MATLAB

IN-LAB EXERCISE

1. **Plot unit step, unit ramp, unit impulse, and t^2 using MATLAB commands ones and zeros.**

MATLAB SCRIPT:

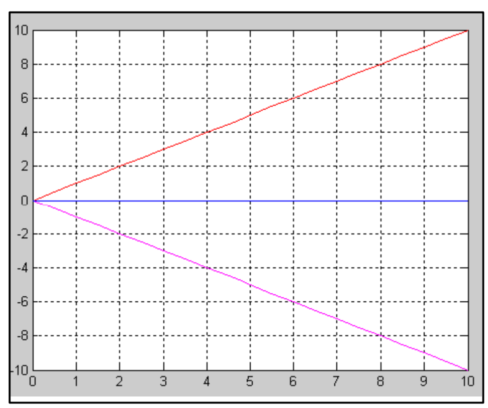
```
close all; clear all; clc;
t =0:0.001:1;
f=0:1:100;
y1 = [1, zeros(1,99)];
% impulse, zeros(1,99)returns
%an m-by-n matrix of zeros
y2 = ones(1,100);       % step
y3 = f;                 % ramp
y4 = f.^2;
% Now start plottings
subplot(2,2,1)
plot(y1,'r');grid;
subplot(2,2,2)
plot(y2,'b');grid;
subplot(2,2,3)
plot(f,y3,'m');grid;
subplot(2,2,4)
plot(f,y4,'b');grid;
```



2. **Plot f(t)=t+(-t)**

MATLAB SCRIPT:

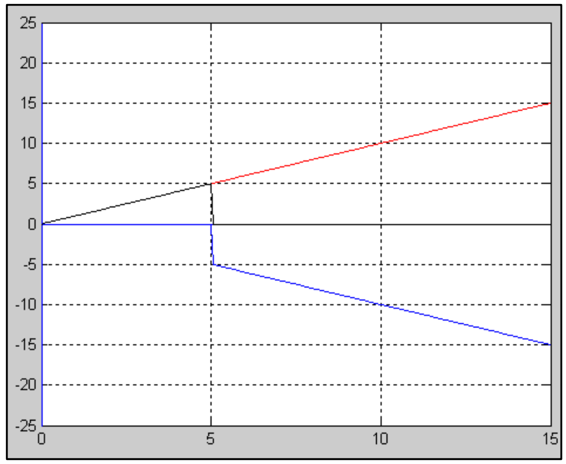
```
close all;clear all; clc;
tx=0:0.5:10;
y1=tx;
y2=-tx;
y=y1+y2;
plot(tx,y1,'r',tx,y2,'g',tx,y,'b');grid;
```



3. **Plot f(t)=tu(t)-tu(t-5)**

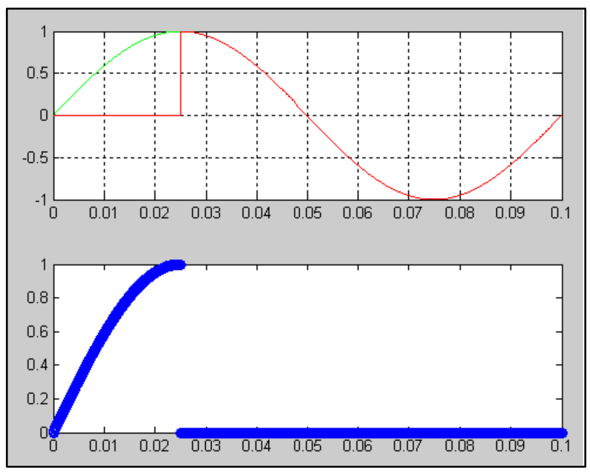
MATLAB SCRIPT:

close all;clear all;clc;
~~t1=0:0.05:10;~~
~~t1_axis=0*t1;~~
~~%plot(Y) plots, for a vector Y, each %element against its index. If Y is a %matrix, it plots each column of the %matrix as though it were a vector.~~
~~plot([0 0], [-25 25]);~~
~~hold;~~
~~plot(t1,t1_axis);grid;~~
t=[0:0.05:15];
y=t;
%/we need to find when y=5 and before 5 all columns must be zero.
a=find(y==5)
y1=-t
y1(1:a)=0
y2=y+y1
plot(t,y,'r',t,y1,'b',t,y2, 'k');



4. **Plot f(t)=sinwt u(t)-sinwt u(t-4)**

MATLAB SCRIPT:
close all;clear all;clc;
t=0:0.00005:0.1;
y=sin(t*2*pi*10)
subplot(2,1,1);
plot(t,y,'g');grid;hold;
z=sin(t*2*pi*10);
a=find(z==1)
z(1:a)=0;
plot(t,z,'r');
u=y-z;
subplot(2,1,2);
plot(t,u,'yo');



5. **Plot $f(t)=e^{-st}$ in 3-D and show its different views.**

MATLAB SCRIPT:
t=[0:1:150];
f = 1/20;
r=0.98;
signal=(r.^t).*exp(j*2*pi*f*t);
figure;
plot3(t,real(signal),imag(signal));

```
grid on;
xlabel('Time');
ylabel('real part of exponential');
zlabel('imaginary part of exponential');
title('Exponential Signal in 3D');
%Select one command of view at a time

% view([0 0 0])
% view([1 0 0]) %(positive x-direction is up) for 2-D views
% view([0 0 1]) %(positive z-direction is up) for 2-D views
% view([0 1 0]) %(positive y-direction is up) for 2-D views
```

a. Plot $f(t)=e^{-st}$ in 3-D and show its different views through animation.

MATLAB SCRIPT:

```
clear all; close all; clc;
t=[0:1:150];
f = 1/20;
r=0.98;
signal=(r.^t).*exp(j*2*pi*f*t);
m=[0 0 1;0 1 0;1 0 0;0 0 0];
for k = 1:4
   plot3(t,real(signal),imag(signal));grid on;
   view(m(k,:))
   pause(1)
end
```

POST LAB EXCERCISE

Task 1.1

Plot example 3 with new technique using the time function;
f(t)= tu(t)-(t-5)u(t-5)-5u(t-5)

Task 1.2

TASK: Plot the curves a = 0.9, b = 1.04, c = -0.9, and d = -1.0.
Plot a^t, b^t , c^t and d^t when t=0:1:60. Comment on the plot.

Task1.3 (+2 Bonus Marks)

Plot $f(t)=e^{-st}$ in 3-D and show its different views through animation using movie command and convert file into .avi format.

LAB SESSION 06

IN-LAB EXERCISE

Objective:

1. Apply Laplace transform using MATLAB
2. Solving complex Partial fraction problems easily.
3. Understanding Pole zero constellation.
4. Understanding s-plane.

1.1. Laplace Transform

Please find out the Laplace transform of

1.sinwt

2. f(t)= -1.25+3.5te$^{(-2t)}$+1.25e$^{(-2t)}$

MATLAB SCRIPT:

```
clear all;close all;clc;
syms s t % It helps to work with symbols
g=sin(3*t);
G=laplace(g)
a=simplify(G)
pretty(a)
```

Check the result on command window.

```
clear all;close all; clc;
syms t s
f=-1.25+3.5*t*exp(-2*t)+1.25*exp(-2*t);
F=laplace(f)
a=simplify(F)
pretty(a)
```

1.2. Inverse Laplace Transform

Please find out the Inverse Laplace transform of

1 F(s) = (s-5)/(s(s+2)^2);

1. F(s) = 10(s+2)/(s(s^2+4s+5));

MATLAB SCRIPT:

```
clear all;close all;clc;
syms t s ;
F=(s-5)/(s*(s+2)^2);
a=ilaplace(F)
pretty(a)
% Second  example
F1=10*(s+2)/(s*(s^2+4*s+5))
a1=ilaplace(F1)
pretty(a1)
```

1.3. Polynomials in MATLAB

The rational functions we will study in the frequency domain will always be a ratio of

polynomials, so it is important to be able understand how MATLAB deals with polynomials. Some of these functions will be reviewed in this Lab, but it will be up to you to learn how to use them. Using the MATLAB 'help' facility study the functions **'roots', 'polyval', and 'conv'**. Then try these experiments:

Roots of Polynomials

Finding the roots of a polynomial:

F(s)= s^4+10s^3+35s^2+50s+ 24

Write in command window

a= [1 10 35 50 24];

r= roots (a)

In command window the roots are;

r= -4.0000,-3.0000, -2 .0000, -1.0000

Multiplying Polynomials

The **'conv'** function in MATLAB is designed to convolve time sequences, the basic operation of a discrete time filter. But it can also be used to multiply polynomials, since the coefficients of *C(s) = A(s)B(s)* are the convolution of the coefficients of *A* and the coefficients of *B*. For example:

a= [1 2 1];b=[1 4 3];

c= conv(a,b)

c= 1 6 12 10 3

In other words,

$(s^2+2s+1)(s^2+4s+3)=s^4+6s^3+12s^2+10s+3$

Evaluating Polynomials

When you need to compute the value of a polynomial at some point, you can use the built-in MATLAB function **'polyval'**. The evaluation can be done for single numbers or for whole arrays. For example, to evaluate $A(s)=s^2+2s+1$ at $s=1,2,$ and 3, type

```
a=[1 2 1];
polyval(a,[1:3])

ans =
        4 9 16
```

To produce the vector of values $A(1) = 4$, $A(2) = 9$, and $A(3) = 16$.

1.4. Partial Fraction Easy to solve….

First Example:

$$H(s)=\frac{s^2+1}{(s+1)(s+2)(s+3)}=\frac{s^2+1}{s^3+6s^2+11s+6}$$

Use the command residue for finding partial fraction.
See Help for residue command.

MATLAB SCRIPT:

```
clear all; close all;clc
num=[1 0 1];
den=[1 6 11 6];

[r p k]=residue(num,den)
```

Result on command window will be:

```
r =
    5.0000
   -5.0000
    1.0000
p =
   -3.0000
   -2.0000
   -1.0000
k = [ ]
```

This means that $H(s)$ has the partial fraction expansion

$$H(s)=\frac{5}{(s+3)}+\frac{-5}{(s+2)}+\frac{1}{(s+1)}$$

(For Task 2(3). find its Inverse Laplace transform)

Second Example:

```
clear all; close all;clc
num=[1 2 3 4];
den=[1 6 11 6];
[r p k]=residue(num,den)
```

After watching the command window, add command:
`[n,d]=residue(r,p,k)`
It's interesting to see what you get in command window now.

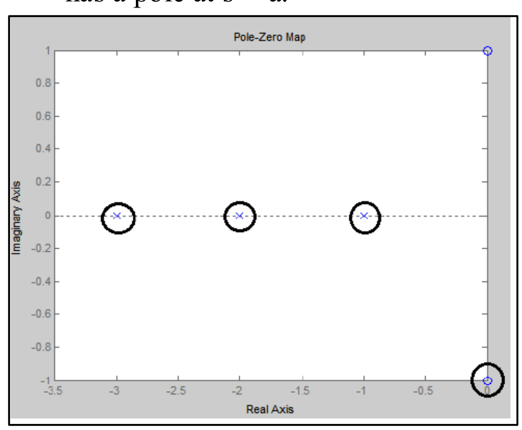
1.5. Poles, Zeros and transfer funtion

The transfer function H(s) is the ratio of the output response Y(s) to the input excitation X(s), assuming all initial conditions are zero.
In MATLAB it will be written as

H=tf([num],[den])

Let we have H(s) = 1/(s+a), the system have two conditions,

1. H(s) = 0 at s=infinity, that is the system has a zero at iinfinity.
2. H(s) = infinity at s= -a, system has a pole at s= -a.



First Example:

Taking the first example of 1.4 we have,

H=tf([101],[1611 6]) pzmap(H)

Second Example:

Plot poles and zeros for H(s) = s+2 / (s^2+2s+26)

```
H=tf([1 2],[1 2 26])
num=[1 2]
den=[1 2 26]
[r p k]=residue(num,den)
```

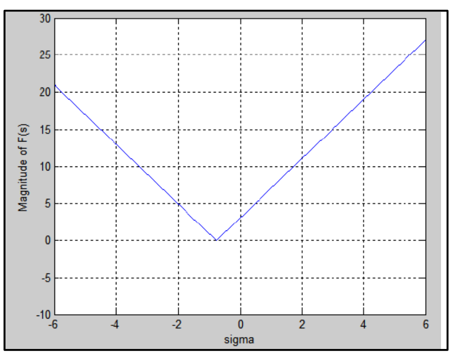
1.6. Complex Frequency Response when w =0

First Example:

Let **F(s) = 3+4s**, and s=σ+jω, suppose that only real component is present and w=0.
Now we will plot magnitude of F(s) with respect to s.

MATLAB SCRIPT:

```
clear all; close all; clc;
sigma=-6:0.0005:6;
omg=0;
s=sigma+j*omg;
z1=3+4*s;
z=abs(z1);
plot(s,z);
grid;
ylim([-10 30])
xlabel('Sigma')
ylabel('Magnitude of F(s)')
```



Find x intercept and y intercept, that is the value of sigma at which function is equal to zero and value of function when sigma equal to zero.

Second Example:

F(s) = 1 / (s2+5s+6)

Draw its pole zero constellation and plot |F(σ)| verses sigma.

MATLAB SCRIPT:

```
clear all; close all; clc;
sigma=-6:0.0005:6;
omg=0;
s=sigma+j*omg;
z1=1./(s.^2+5*s+6);
z=abs(z1);
plot(s,z);
grid;
ylim([-10 30])
xlabel('Sigma')
ylabel('Magnitude of F(s)')
figure;
h=tf([1],[1 5 6])
pzmap(h)
```

Complex Frequency Response when σ = 0

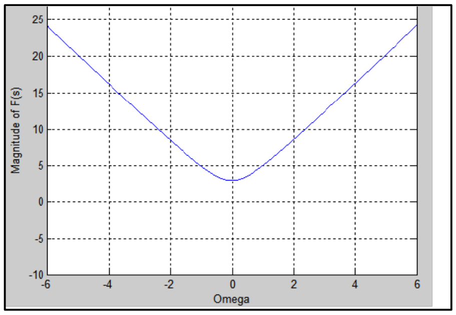
First Example:

Same F(s) as in 1.6, that is, **F(s) = 3+4s**

MATLAB SCRIPT:

```
clear all;close all; clc;
%Magnitude Plot
omg=-6:0.0005:6;
sigma=0;
s=sigma+j*omg;
z1=3+j*4*omg;
z=abs(z1);
plot(omg,z);
grid;
ylim([-10 30])
xlabel('Omega');
ylabel('Magnitude of F(s)');figure;

%Phase plot
z_phase=atan(4*omg./3)
z_phase1=rad2deg(z_phase)
plot(omg,z_phase1);grid;
xlabel('Omega');
ylabel('Phase Plot of F(s)');
```

Find x intercept and y intercept, that is the value of omega at which function is equal to zero and value of function when omega equal to zero. In phase plot find values of w when angle is equal to 45 and 90.

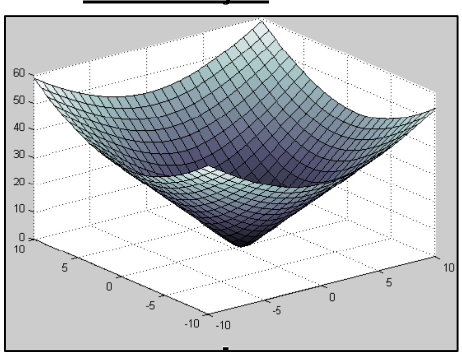


Second Example: F(s)= 1/(s2+5s+6), find its complex frequency response when sigma=0.

MATLAB SCRIPT:

```
clear all;close all; clc;
%Magnitude Plot
omg=-6:0.0005:6;
sigma=0;
s=sigma+1i*omg;
z1=1./(s.^2+5*s+6);;
z=abs(z1);
plot(omg,z);
grid;
xlabel('Omega');
ylabel('Magnitude of F(s)');figure;
%Phase plot
z_phase=atan((5*omg)./(6-omg.^2))
z_phase1=rad2deg(z_phase)
plot(omg,z_phase1);grid;
xlabel('Omega');
ylabel('Phase Plot of F(s)');
```

1.7. Complex Frequency Response when s=σ+j*ω



F(s) = s

POST LAB EXCERCISE

Task 1.1:

Find Laplace of;

1. Cos(wt)
2. g(t)=[4-4e$^{(-2t)}$)cost+2e$^{(-2t)}$sint]u(t)

Task 1.2:

Find Inverse Laplace of:

1. G(s)=10(s+2)/s(s2+4s+5)
2. F(s)=0.1/(0.1s+1)
3. $H(s)=\frac{\mathbf{5}}{(s+\mathbf{3})}+\frac{-\mathbf{5}}{(s+\mathbf{2})}+\frac{\mathbf{1}}{(s+\mathbf{1})}$

Task 1.3

1. $V(s) = 180s^4/(s^2+9)(90s^2+18s^2+40s+\;)$

Apply partial fraction.

Ans: r =1.0470 + 0.0716i; 1.0470 - 0.0716i
-0.0471 - 0.0191i; -0.0471 + 0.0191i
0.0001

p = -0.0000 + 3.0000i; -0.0000 - 3.0000i
-0.0488 + 0.6573i; -0.0488 - 0.6573i; -0.1023

2. $F(s) = \frac{2}{s(s+6)^2}$

Task 1.4

1. Draw the pole zero constellation for **H(s)=25/s^2+s+25**
2. Draw |F(σ)| vs σ and |F(jω)| vs ω.

a. F(s)=2+5s
b. F(s)=s / (s+3)(s+2)(s+1)
c. F(s)=(s+1) / (s^3+6s^2+11s+6)

Write analysis for a, b and c in your own words.

Task 1.5

Write a program in MATLAB to plot surface plot for 1.7

LAB SESSION 7

IN-LAB EXERCISE

Objective:

3. Analyzing / Visualizing systems transfer function in s-domain.
4. Analysis of system response using LTI viewer.

1. **Understanding F(s) = s**

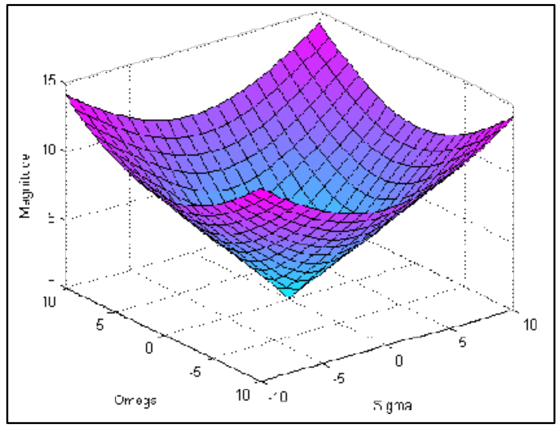
Plot and understand the function F(s)=s

MATLAB SCRIPT:

```
% Transfer Function is F(s)=s
close all; clear all; clc;
num=[1 0]
den=[1]
H=tf([num],[den])
% Pole Zero constellation
pzmap(H)
figure;

% Defining sigma and omega
sigma=-10:1:10;
omega=-10:1:10;

%***Creating a Matrix***
[X,Y]=meshgrid(sigma,omega);
Z=abs(X+j*Y);
surf(X,Y,Z);

xlabel('Sigma')
ylabel('Omega')
zlabel('Magnitude')
```

ANALYSIS :

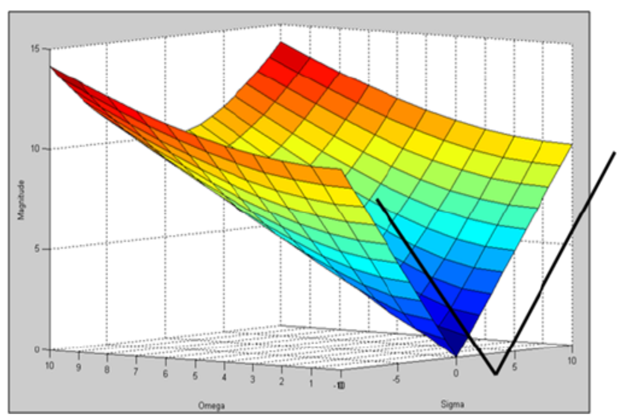
ADD COMMANDS:
View([0 0 1])
Put data cursor on the most midpoint and see if function is zero when s=0 (or X and Y are zero) or not.



CHANGES IN THE ORIGIINAL PROGRAM (3D)

Slicing the curve from mid.

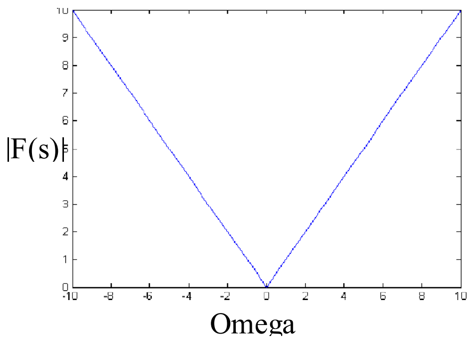
```
sigma=-10:1:10;
omega=0:1:10;
```

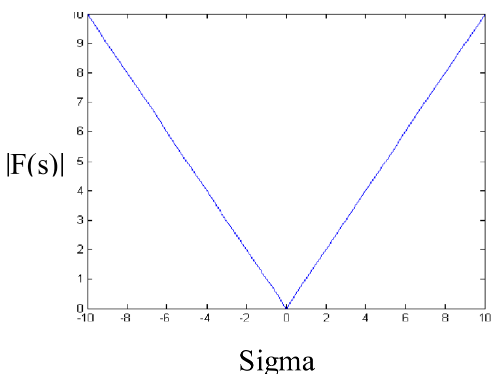


If you see from right side you will see a V curve between sigma and omega.

CHANGES IN THE ORIGIINAL PROGRAM (2D)

ADD COMMANDS:
```
% Plot when sigma is zero
plot(omega,Z(omega==0,:));
xlabel('Omega');
ylabel('Magnitude');
figure;
% Plot when Omega is zero
plot(sigma,Z(:,omega==0))
xlabel('Sigma');ylabel('Magnitude')
```





2. **Understanding F(s) = (s+2)**

Plot and understand the function
F(s)=s+2

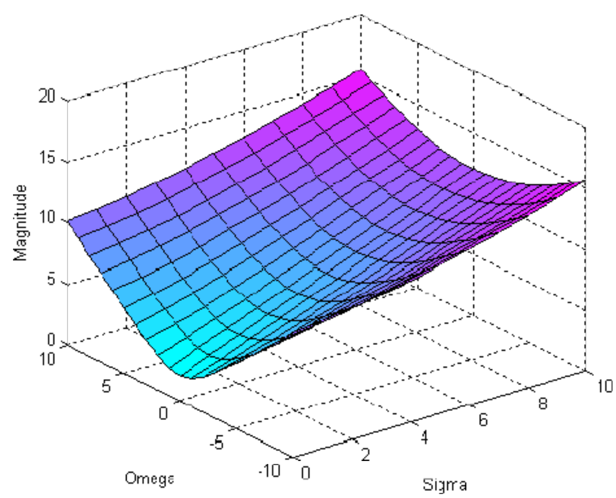
MATLAB SCRIPT:
```
close all; clear all; clc
num=[1 2]
den=[1]
H=tf([num],[den])
pzmap(H)
figure;
% Defining sigma and omega
sigma=-10:1:10;
omega=-10:1:10;
%Creating a Matrix
[X,Y]=meshgrid(sigma,omega)
;

Z=abs((X+j*Y)+2);

surf(X,Y,Z);
xlabel('Sigma');
ylabel('Omega');
zlabel('Magnitude');
%Untill here check the output
```

ANALYSIS:

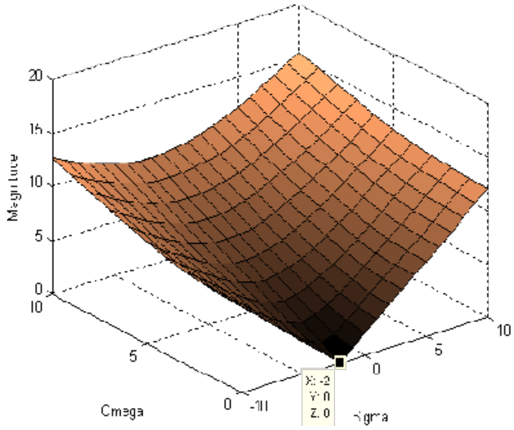
ADD command
View([0 0 1])
Put data cursor on the most midpoint and see if function is zero when s=-2 (or X and Y are zero) or not.

CHANGES IN THE ORIGINAL PROGRAM (3D)

```
%Slicing the curve from mid.
sigma=-10:1:10;
omega=0:1:10;
```

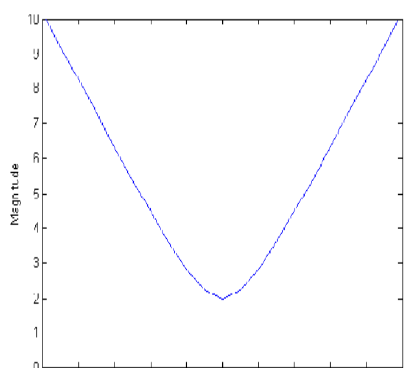


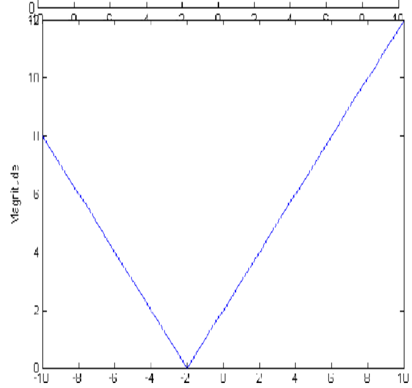
and when we change as;
```
sigma=-10:1:10;
omega=0:1:10;
```



CHANGES IN THE ORIGIINAL PROGRAM (2D)
ADD Commands:

```
figure;
% Plot when sigma is zero
plot(sigma,Z(omega==0,:));
xlabel('Sigma');
ylabel('Magnitude');
figure;
% Plot when w is only
positive
plot(omega,Z(:,sigma==0))
xlabel('Omega')
ylabel('Magnitude')
```





ylim([0 10])

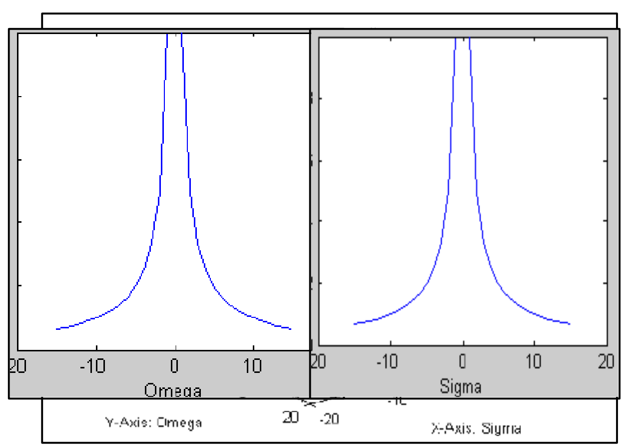
3. **Understanding F(s) = (1/s)**

Plot and understand the function

1. **F(s)=1/s**

MATLAB SCRIPT:

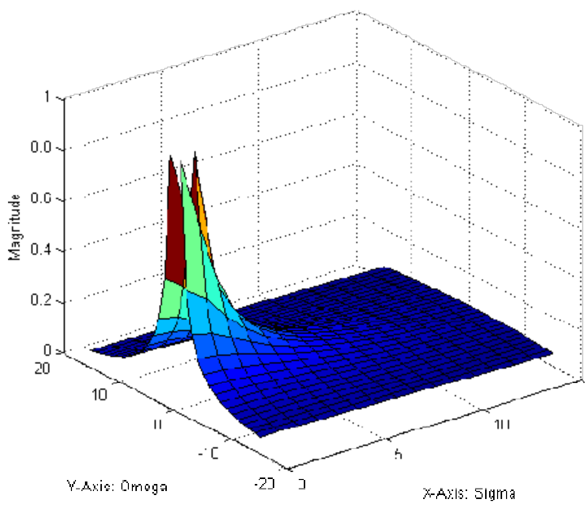
```
clear all;close all;clc;

sigma=-15:1:15;
omega=-15:1:15;

[X,Y]=meshgrid(sigma,omega)
;
Z=abs(1./((X+j*Y)))
a=surf(X,Y,Z); hold;

xlabel('X-Axis: Sigma')
ylabel('Y-Axis: Omega')
zlabel('Magnitude')

figure;
% Plot when sigma is zero

plot(sigma,Z(omega==0,:));
xlabel('Sigma');
ylabel('Magnitude');
figure;

% Plot when w is only
positive
plot(omega,Z(:,sigma==0))
xlabel('Omega')
ylabel('Magnitude')
```



Slice the plot:

MATLAB Script:

```
clear all;close all;clc;
sigma=-0:1:15;
omega=-15:1:15;
[X,Y]=meshgrid(sigma,omega)
;
Z=abs(1./((X+j*Y)))
a=surf(X,Y,Z);
colormap(Pink); hold;
xlabel('X-Axis: Sigma')
ylabel('Y-Axis: Omega')
zlabel('Magnitude')
```



POST LAB EXCERCISE

Task 1:

Understanding the plot and perform the analysis of

1. $F(s) = 1/(s+3)$
2. $F(s) = 25/(s^2+s+25)$

a. Write Transfer function and draw PZ plot.
b. Draw s-plane representation.
c. Slice it w.r.t σ and ω plane.
d. Draw 2-D plot and w.r.t σ and ω plane and compare it with the plots of part 'c'.

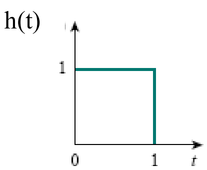
LAB SESSION 8

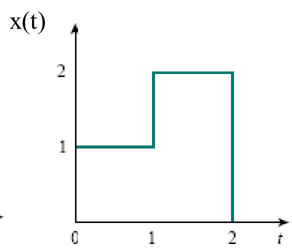
Convolution

Object:

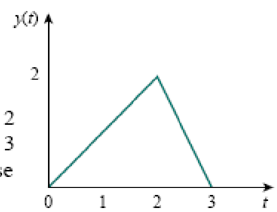
Perform convolution in time domain when impulse response is $x_2(t)$.

MATLAB Script:





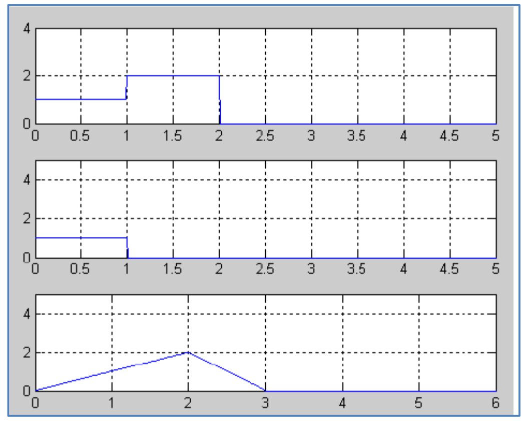
$$y(t) = \begin{cases} t, & 0 \le t \le 2 \\ 6 - 2t, & 2 \le t \le 3 \\ 0, & \text{otherwise} \end{cases}$$




```
clear all;close all;clc
tint=-10;
tfinal=10;
tstep=.01;
t=tint:tstep:tfinal;
x=1*((t>=0)&(t<1))+2*((t>=1
)&(t<=2));
subplot(3,1,1),
plot(t,x);grid
axis([0 5 0 4])
h=1*((t>=0 & (t<=1)));
subplot(3,1,2),plot(t,h);gr
id
axis([0 5 0 5])
t2=2*tint:tstep:2*tfinal;
y=conv(x,h)*tstep;
subplot(3,1,3),plot(t2,y);g
rid
axis([0 6 0 5])
```

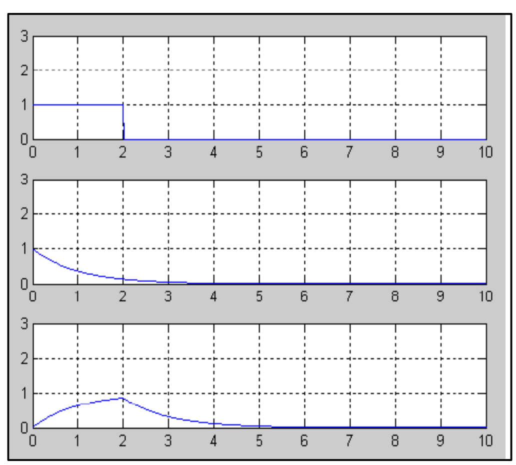
Example 2:

Perform convolution between h(t)=e(-t); and x(t)=1u(t)-u(t-2)

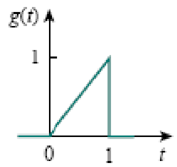


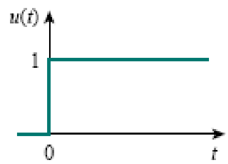
MATLAB Script:

```
tint=0;
tfinal=10;
tstep=.01;
t=tint:tstep:tfinal;
x=1*((t>=0)&(t<=2));
subplot(3,1,1),
plot(t,x);grid
axis([0 10 0 3])
h=1*exp(-1*t)
subplot(3,1,2),plot(t,h);gr
id
axis([0 10 0 3])
t2=2*tint:tstep:2*tfinal;
y=conv(x,h)*tstep;
subplot(3,1,3),plot(t2,y);g
rid
axis([0 10 0 3])
```



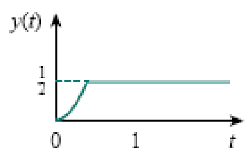
TASK:
Perform the time domain convolution on MATLAB as well as on paper.





ANS:

$$y(t) = \begin{cases} \frac{1}{2}t^2, & 0 \le t \le 1 \\ \frac{1}{2}, & t \ge 1 \end{cases}$$



LAB SESSION 9

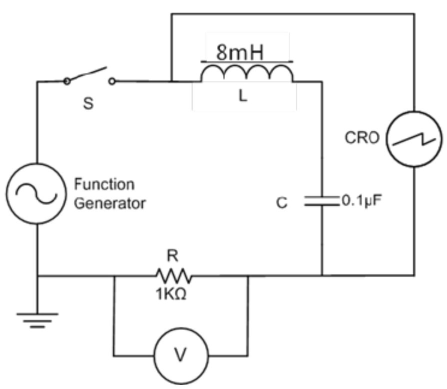
IN-LAB EXERCISE

Objective:

Calculations and Graphical analysis of series and parallel resonance circuits

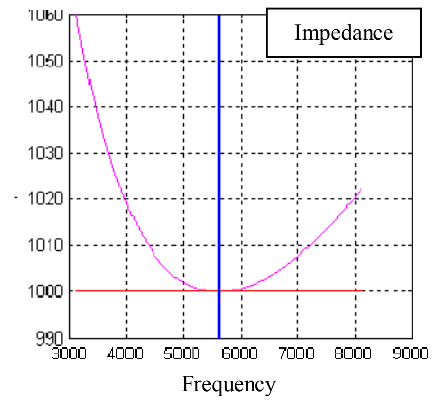
1. **Series Resonance**

For the given circuit, determine resonance frequency, Quality factor and bandwidth.



MATLAB SCRIPT:

```
%Calculation of resonance frequency
%for series RLC resonant circuit

clear all;
close all;
clc;
R=input('Please inuput the
Resistance(Ohm): ');

L=input('Please inuput the
Inductance(H): ');

C=input('Please inuput the
Capacitance(F): ');

wo=1./(L.*C).^(0.5)
fr=wo./(2.*pi)
Q=wo.*L./R
B=wo./Q

%Check the result on
command window
```



2. **Series Resonance**

Plot the response curves for Impedance, reactance and current.

MATLAB SCRIPT:

```
clear all;close all;clc;

V=10
R=1000;
L=8e-3;
C=0.1e-6;


wo=1./(L.*C).^(0.5)
fr=wo./(2.*pi)
f=(fr-2500):0.5:(fr+2500);
Xl=2.*pi.*f.*L;
Xc=1./(2.*pi.*f.*C)

%Impedance
Z=(R.^2+(Xl-Xc).^2).^(0.5);

%Plot reactances
plot(f,Xl,'r',f,Xc,'g');grid;
xlabel('Frequency')
ylabel('Reactances')

%Plot Impedance
figure;
```

```
plot(f,Z,'m',f,R,'r');grid;hold
ylim([990 1060]);
plot([5627 5627], [990 1070])
xlabel('Frequency')
ylabel('Impedance')
```

POST LAB EXCERCISE

Task 1.1:

Plot the current response verses frequency using MATLAB. Write brief statement for these plots.

Task1.2:

Perform 1.1 and 1.2 for parallel resonance circuits.

LAB SESSION 10

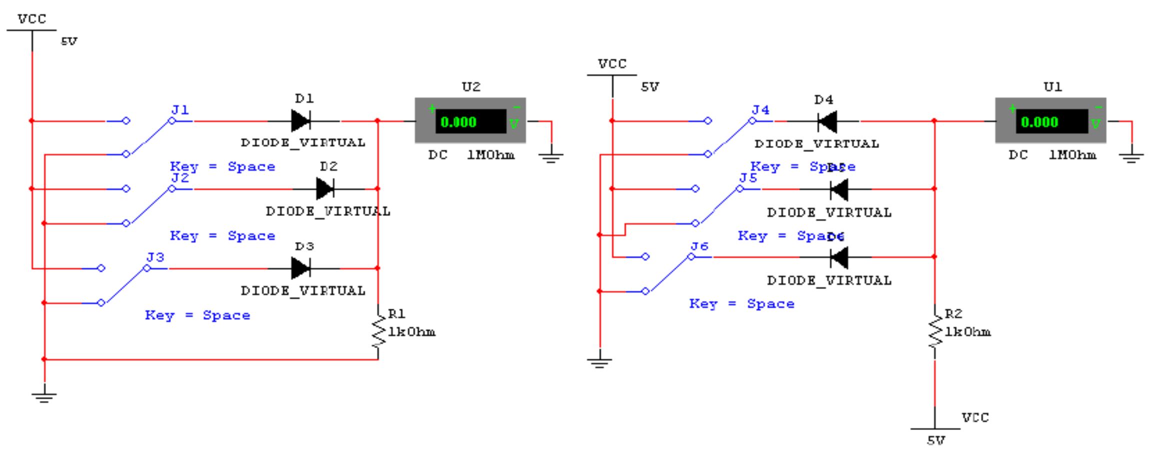
Diode Logic

Object:
Analysis of Diode and DTL Logic circuits.

Apparatus:
Power supply, Resistors, Diodes, Transistor, DMM and SPDT Switch on each input.

Theory:
Analog signals have a continuous range of values within some specified limits and can be associated with continuous physical phenomena.
Digital signals typically assume only two discrete values (states) and are appropriate for any phenomena involving counting or integer numbers. The active elements in digital circuits are either bipolar transistors or FETs. These transistors are permitted to operate in only two states, which normally correspond to two output voltages. Hence the transistors act as switches. There are different logic through which we can achieve our desired results such as Diode Logic, Transistor-Transistor logic, Diode Transistor logic, NMOS Logic, PMOS logic and a number of others. In this experiment and OR logics are achieved through Diode logic and NAND Logic is achieved by using NAND Logic

Circuit diagram:



Procedure :

1. Connect the circuit according to the circuit diagram..
2. Place the Oscilloscope channel A at the input and output at channel B.
3. Also, place the voltmeter at output
4. Now, observe the waveform, measure and record the readings in the observation table for three different type of input

Observation:

(When diodes are forward biased.)

Sr. No.	Input A(V)	Input B(V)	Input C(V)	Output y(V)
1				
2				
3				
4				
5				
6				
7				
8				

When diodes are reverse biased.

Sr.no.	Input A(V)	Input B(V)	Input C(V)	Output y(V)
1				
2				
3				
4				
5				
6				
7				
8				

Analysis:

LAB SESSION 11

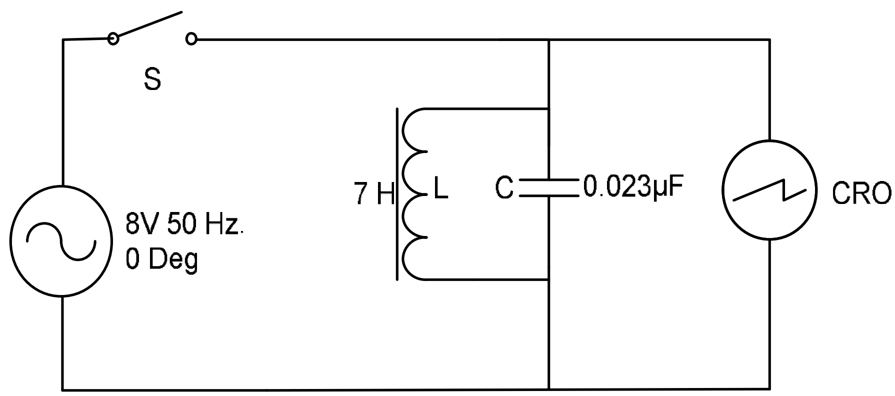
LC Circuit

Object:
Analysis of LC Circuit

Apparatus:
Power Supply, Capacitor, Inductor, SPDT switch, breadboard, connecting wires and Oscilloscope

Theory:
The value of the resistance in a parallel RLC circuit becomes infinite or that in a series RLC circuit becomes zero, we have a simple LC loop in which an oscillatory response can be maintained forever at least theoretically. Besides we may get a constant output voltage loop for a fairly long period of time. Thus it becomes a design of a lossless circuit. Total Response = Forced Response + Natural Response
Forced Response = Forcing Function (Sinusoidal in this Case)
Natural Response = Content voltage waveform.

Circuit Diagram LC Circuit.



Procedure:
1. Connect the circuit according to the circuit diagram..
2. ON Power switch and set the oscilloscope according to requirement.
3. Place the channel A of Oscilloscope at the input and channel B at output.
4. Initially switch is open observe waveform.
5. Observe waveforms when switch is closed.
6. Again open the switch and observer output waveform.
7. Draw observed waveforms in the observation table.

Observation:

Position of switch	Output Waveform
Switch at pos B	
Switch at pos A	
Switch at pos B	

Result:

The output waveform suggests that the natural response of a LC circuit is a constant voltage waveform showing the property of a lossless circuit.

LAB SESSION 12

OBJECTIVE

To measure the Three Phase Power of Star connected load using Three Wattmeter methods.

APPARATUS

- ✓ Three Watt-meters
- ✓ Ammeter
- ✓ Voltmeter
- ✓ Star Connected Load

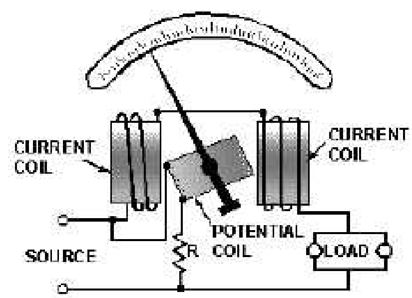
THEORY

Power can be measured with the help of

1. Ammeter and voltmeter (In DC circuits)
2. Wattmeter
3. Energy meter

By Ammeter and Voltmeter:
Power in DC circuits or pure resistive circuit can be measured by measuring the voltage & current, then applying the formula P=VI.

By Energy Meter:
Power can be measured wuth the help of energy meter by measuring the speed of the merter disc with a watch, with the help of following formula:



$$P = \frac{N \times 60}{K} \quad kW$$

Where
N= actual r.p.m of meter disc
K= meter constant which is equal to disc revolutions per kW hr

By Wattmeter: A wattmeter indicates the power in a circuit directly. Most commercial wattmeters are of the dynamometer type with the two coils, the current and the voltage coil called C.C & P.C.

Power in three phase circuit can be measured with the help of poly phase watt-meters which consist of one two or three single phase meters mounted on a common shaft.

Single Phase Power Measurement:
One wattmeter is used for single phase load or balanced three phase load, three and four wire system. In three-phase, four wire system, p.c. coil is connected between phase to ground, while in three wire system, artificial ground is created.

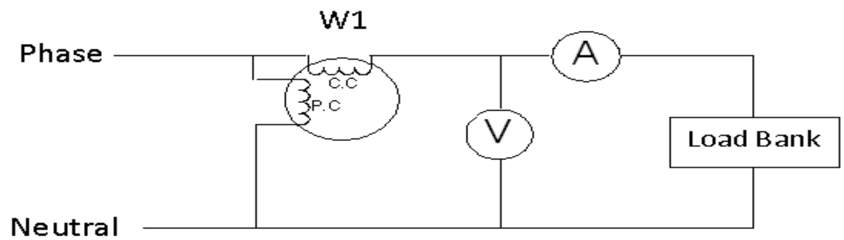


Figure: Single Wattmeter Method

PROCEDURE

Arrange the watt-meters as shown above.

OBSERVATION

Phase Voltage: _______

S. No.	Size of Load Bank (By Observation)	Measured Load (Using Wattmeter)	Current (A)	Voltage (V)
1	05x100W			
2	10x100W			

Three Phase Power Measurement Using Three Wattmeter Method:

Two watt-meters & three watt-meters are commonly used for three phase power measurement. In three watt-meter method, the potential coils are connected between phase and neutral.

For three wire system, three watt-meter method can be used, for this artificial neutral is created.

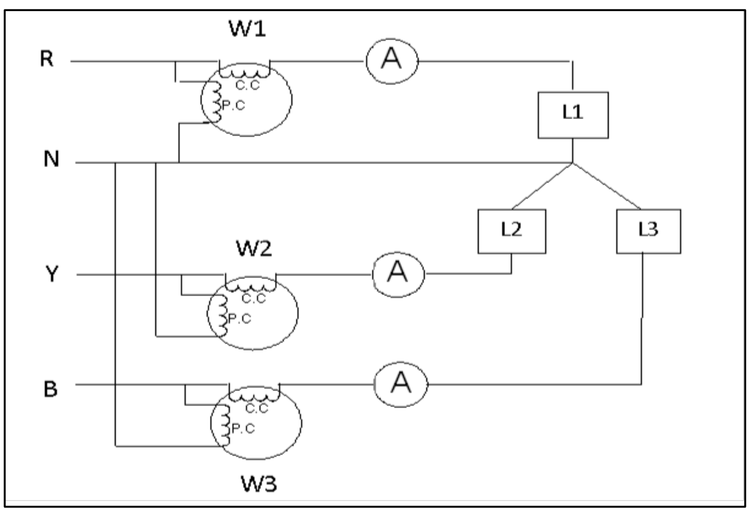


Figure: Three wattmeter method

PROCEDURE

Arrange the watt-meters as shown above.

OBSERVATION

Power of Star Connected Load: ________________________W
Line to Line Voltage: _____________ V
Line to Phase Voltage: _____________ V

Using Three Wattmeter Method

S. No	Wattmeter Reading (W1)	Wattmeter Reading (W2)	Wattmeter Reading (W3)	W1+W2+W3	Current (A)
1					

EXERCISE:

Here we are connecting phase with neutral without any load, doing this using a small wire in house could be very dangerous, then how it is possible here?

____
____
____
____
____

What do you understand by balance and unbalance load? In our case, is load balance or unbalance?

____
____
____
____
____

Suppose L1 is 70 W, ceiling fan, L2 is 100 W bulb, L3 is 350 W PC (Personal Computer), what amount of current will flow in the neutral?

____
____
____
____
____

LAB SESSION 13

OBJECTIVE

To measure the Three Phase Power of Delta connected load using Two Wattmeter methods.

APPARATUS

- ✓ Three Watt-meters
- ✓ Ammeter
- ✓ Voltmeter
- ✓ Star Connected Load

THEORY

Two Wattmeter Method:

In two watt-meter method, two wattmeters are used & their potential coils are connected between phase to phase and current coil in seies with the line. Two wattmeters can be used to measure power of star and delta connected load, but here we are performing experiment on delta connected load only, same method can be applied for star connected load. Following formulas are used for calculating P, Q and p.f.

TWO WATTMETER CALCULATIONS

1) Real power

$$P = W_1 + W_2$$

2) Reactive power

$$Q = \sqrt{3}\ (W_2 - W_1)$$

3) Power Factor

$$\cos\theta = \frac{P}{\sqrt{P^2+Q^2}}$$

$$\cos\theta = \sqrt{\frac{P^2}{P^2+Q^2}}$$

$$\cos\theta = \sqrt{\frac{(W_1+W_2)^2}{(W_1+W_2)^2+3\,(W_2-W_1)^2}}$$

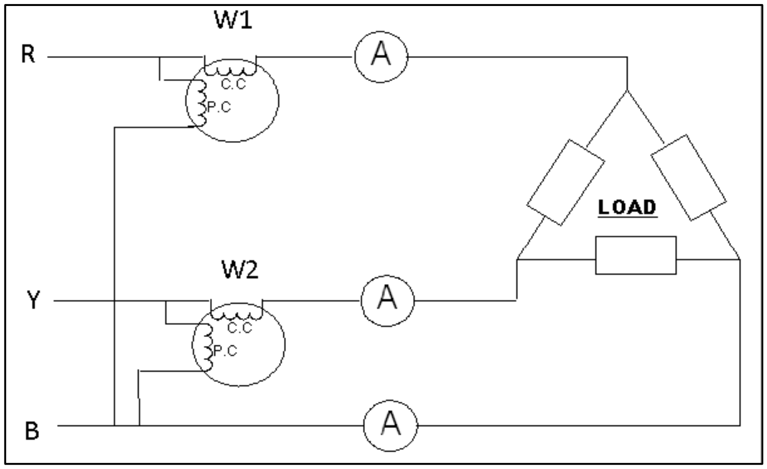


Figure: Two Wattmeter Method

PROCEDURE

Arrange the watt-meters according to the load (single phase or three-phase) and whether neutral available or not (as shown in the above figures).

OBSERVATION

Power of Delta Connected Load: 2 bulbs in series of ___________ W
Line to line Voltage: _____________ V

Using Two Wattmeter Method

S. No	Type of Load	Wattmeter Reading (W1)	Wattmeter Reading (W2)	W1+W2	p.f.	Current (I_L)
1	Three Phase Delta Connected Load					

RESULT:

The two wattmeter method of three phase power measurements have fully understood & performed.

EXERCISE:

Here for each delta connected load we are connecting two bulbs in series, why?

____
____
____
____
____

LAB SESSION 14

Bode Plot

Object:
Design a circuit showing the Bode Plot i.e.: Magnitude and Phase-plot.

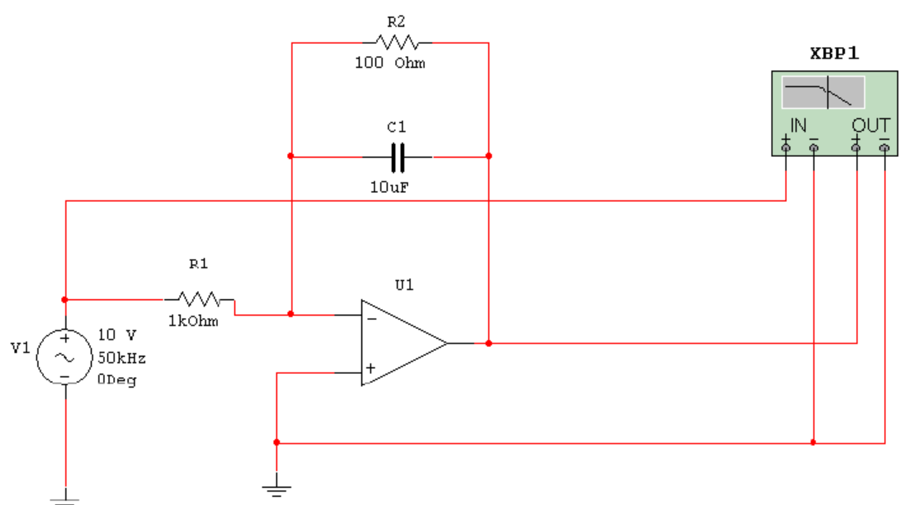
Apparatus:
AC power supply, Resistors, Operational Amplifier and Bode Plotter.

Theory:
Bode Diagram is a quick method of obtaining an approximate picture of the amplitude and phase variation of a given transfer function as function of 'ω'. The approximate response curve is also called an 'Asymptotic plot'. Both the magnitude and phase curves are plotted using a logarithmic frequency scale. The magnitude is also plotted in logarithmic units called decibels (db).

$$H_{dB} = 20 \log |H(j\omega)|$$

where the common logarithm(base 10) is used

Circuit Diagram:



Exercise: (Find H_{dB} and H_{phase} for given network**)**

Asymptotic Bode plot:

Observed bode plot:

Conclusion: