LAB MANUAL

Programme (UG/PG) : UG

Semester : III

Abstract:

Signal and Network Lab is one of the important laboratories which is useful for both 'Electrical Engineering' & 'Electronics & Communication Engineering' of under graduate students. The laboratory experiments in Electrical Network Analysis course are dedicated for practical understanding of signal and network theory concepts. Linking the theory with practice, it is very important to motivate the students for learning theory and to encourage them to use this theoretical knowledge in practical activity. In this lab both hardware and simulation based experiments are conducted. Curriculum of the 'Signal and Network Laboratory' course in the Electrical Engineering department is designed to give a fundamental understanding in practical cases on two port networks, attenuator circuit, transient circuit analysis, signal generation and Laplace transform. This course is a one-semester course since 2009. Every week students have classes in the laboratory with three lecture periods. The credit point of this Lab is two. Students usually work in groups, but separate reports have to be prepared and presented to the instructor for individual assessment. Mostly digital types instruments are provided to meet the objectives of the laboratory. For simulation design, computers are provided. We use MATLAB based circuit simulation software. In the hardware lab, students can design different types of electrical circuits using different passive components like resistors, inductors and capacitors with DC power supply. They learn here how to use a multimeter, function generator, cathode ray oscilloscope or digital storage oscilloscopes. Apart from hardware design, by writing different programmes using MATLAB programming code, they can generate different signals, simulate Laplace transform methods, and analyze transient analysis. Also, they are encouraged to design their own hardware circuitry to apply their learning in practical model designing.

ELECTRICAL Signal and Network LABORATORY OBJECTIVES: The objective of Signal and Network laboratory is to impart hands on experience in circuit design, verification of result in different type of network analysis, study of circuit characteristics and simulation of different signals, Laplace and its inverse transform, transient response of R-C, R-L circuit. It also aims to introduce a circuit simulation software tool MATLAB. It enables the students to gain sufficient knowledge on the programming and simulation of Electrical circuits.

OUTCOMES: Upon the completion of Electrical Circuit and simulation practical course, the student will be able to attain the following:

- Familiarity with two port network and circuit analysis techniques.
- Analyze complicated circuits using different T and π type network and attenuator circuits.
- Acquire skills of using MATLAB software for electrical circuit studies.
- Determine the Laplace and inverse Laplace transform, different signal generation.
- To analyze transient response for R-L and R-C or combination of both type circuit for step input
- To enhance the research motivation, encouraged to design their own hardware model.

GUIDE LINES FOR THE EXPERIMENTS AND REPORT PREPARATION

1. **Preparation for the experiment:** Before conducting the experiment, the student is required to have read the experiment background and procedure from the experiment manual and studied the related theory. The lab instructor may, during the experiment, ask students questions pertaining to the procedure and theory.

2. **Laboratory teams:** The class will be divided in teams of five or six students. Each lab experiment requires a report. The lab reports are due on the next lab meeting. The lab report for the final experiment is due a week after the final lab meeting. Each student has to submit one report per experiment. The grade of the report is given to 20 Marks. Late reports are penalized by taking 2 points off per each week past the due date of the report.

3. **Preparation of the report:** The report must contain the following sections: a) Cover page: Include number and title of the experiment, date the experiment was performed and the names of the team members. b) Objective: Give a short description of the purpose of the experiment. c) Theoretical background: Give a brief description of the relevant theory. d) The experimental procedure: Summarize what was done for each experiment procedure. Do not copy or repeat the procedure description from the lab manual. Report the measurement and other experimental data. Tabulate measurements if necessary. Include title over tables. Conclusions: Summarize the experiment and the results. Discuss the factual knowledge gained.

List of Experiments

Hardware Based Experiments:

Experiment No	Title	Week/hours
1.	Evaluation of 'Z' parameter	3hrs
2.	Evaluation of 'Y' parameter	3hrs
3.	Evaluation of 'ABCD' parameter	3hrs
4.	Attenuator Network	3hrs

Simulation Based Experiment:

Experiment No	Title	Week/hours
5.	Generation of signals using MATLAB in analogue and discrete form	4 hrs
6.	Determination of Laplace transform and Inverse Laplace Transform using MATLAB	2hrs 30 mints
7.	Electrical Network Problems solving approach using MATLAB programming	2hr.
8.	Transient response of R-L and R-C network: simulation with MATLAB /Hardware Or Low Budget Project work: Choice based hardware design for each group	2hr-

Experiment No: 1

Title: Evaluation of 'Z' parameter

Objectives:

i. To evaluate 'Z' parameter of a T network
ii. To evaluate 'Z' parameter of a π network
iii. To evaluate 'Z' parameter of a network which have a 'T' network and 'π' network in series.

Theory:

Z-parameters are defined by these following two equations:

$$V_1 = Z_{11}I_1 + Z_{12}I_2$$
$$V_2 = Z_{21}I_1 + Z_{22}I_2$$

$Z_{11} = \frac{V_1}{I_1}$ Where $I_2 = 0$;(Driving input impedance)

$Z_{12} = \frac{V_1}{I_2}$ Where $I_1 = 0$;(Reverse transfer impedance)

$Z_{21} = \frac{V_2}{I_1}$ Where $I_2 = 0$;(Forward transfer impedance)

$Z_{22} = \frac{V_2}{I_2}$ Where $I_1 = 0$;(Driving Output impedance)

Circuit Diagrams:

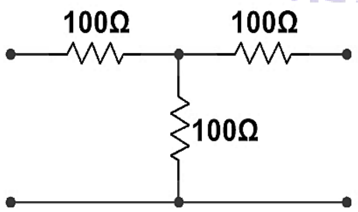

Fig-A

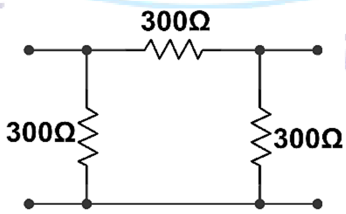

Fig-B

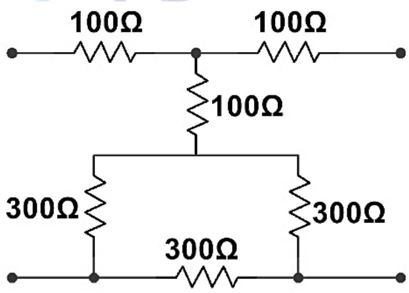

Fig-C

Procedure:

i. Make the circuit as shown in figure A, figure B, figure C.

ii. Apply 10volt from input side with output open circuited. Hence record I_1, V_2 by multimeter.

iii. Apply 8volt from output side with input open circuited. Hence record I_2, V_1 by multimeter.

Apparatus Table:

Sl. No.	Components Name	Range	Quantity	Type	Makers Name

Theoretical Calculation:

Data Table:-

Circuit No	V_1	V_2	I_1	I_2	$Z_{11} = \frac{V_1}{I_1}$	$Z_{21} = \frac{V_2}{I_1}$	$Z_{12} = \frac{V_1}{I_2}$	$Z_{22} = \frac{V_2}{I_2}$	'Z' Parameter
Figure A Theoretical	10V								
		8V							
Figure A Practical									
Figure B Theoretical									
Figure B Practical									
Figure C Theoretical									
Figure C Practical									

Conclusion:

Report:

What is the relationship between 'Z' parameters obtained in these three networks?

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Signature of Teacher with date

Signature of student with date

Department:

Roll No. :

Experiment No: 2

Title: Evaluation of 'Y' parameter

Objective:

- i. To evaluate 'Y' parameter of a T network
- ii. To evaluate 'Y' parameter of a π network
- iii. To evaluate 'Y' parameter of a network which have a 'T' network and 'π' network in parallel.

Theory: Y-parameters are defined by these following two equations:

$$I_1 = y_{11}V_1 + y_{12}V_2$$
$$I_2 = y_{21}V_1 + y_{22}V_2$$

$y_{11} = \frac{I_1}{V_1}$ Where V_2=0; (Driving input admittance)

$y_{12} = \frac{I_1}{V_2}$ Where V_1=0; (Forward transfer admittance)

$y_{21} = \frac{I_2}{V_1}$ Where V_2=0; (Reverse transfer admittance)

$y_{22} = \frac{I_2}{V_2}$ Where V_1=0; (Driving output admittance)

Circuit Diagram:

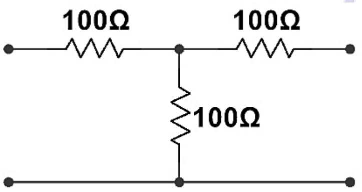

Fig-A

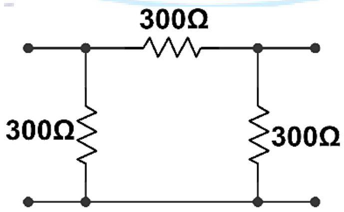

Fig-B

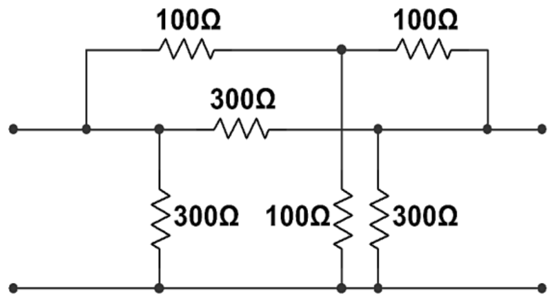

Fig-C

Procedure:

i. Make the circuit as shown in figure A, figure B, figure C.

ii. Apply 10volt from input side with output side short circuited. Hence record I_1, I_2 by multimeter.

iii. Apply 8volt from output side with input side short circuited. Hence record I_1, I_2 by multimeter.

Apparatus Table:

Sl. No.	Components Name	Range	Quantity	Type	Makers Name

Theoretical Calculation:

Data Table:-

Circuit No	V_1	V_2	I_1	I_2	$Y_{11} = \frac{I_1}{V_1}$	$Y_{21} = \frac{I_2}{V_1}$	$Y_{12} = \frac{I_1}{V_2}$	$I_{22} = \frac{I_2}{V_2}$	'Y' Parameter
Figure A Theoretical	10V								
		8V							
Figure A Practical									
Figure B Theoretical									
Figure B Practical									
Figure C Theoretical									
Figure C Practical									

Conclusion:

Report:

What is the relationship between 'Y' parameters obtained in these three networks?

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Signature of Teacher with date

Signature of student with date

Department:

Roll No. :

Experiment No: 3

Title: Evaluation of ABCD parameter

Objective:

i. To evaluate ABCD parameter of a 'T' network
ii. To evaluate ABCD parameter of a 'π' network
iii. To evaluate ABCD parameter of a network which have a 'T' network and 'π' network connected in cascade.

Theory: ABCD-parameters are defined by these following two equations:

$$V_1 = AV_2 - BI_2$$
$$I_1 = CV_2 - DI_2$$

$A = \frac{V_1}{V_2}$ Where I_2=0; (The reverse voltage ratio with receiving end open)

$B = -\frac{V_1}{I_2}$ Where V_2=0; (The transfer impedance with receiving end short circuited)

$C = \frac{I_1}{V_2}$ Where I_2=0; (The transfer admittance with receiving end open)

$D = -\frac{I_1}{I_2}$ Where V_2=0; (The reverse current ratio with the receiving end short circuited)

Circuit Diagram:

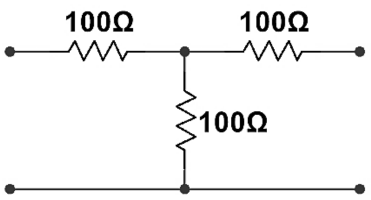

Fig-A

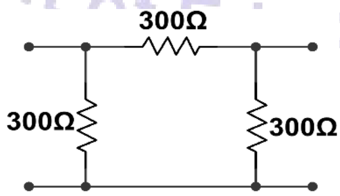

Fig-B

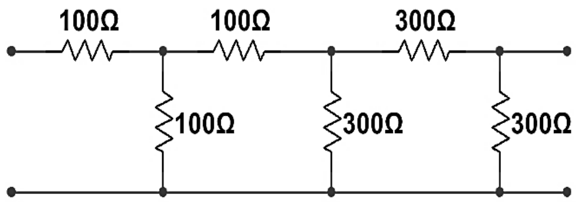

Fig-C

Procedure:-

i. Make the circuit as shown in figure A, figure B, figure C.

ii. Apply 10volt from input side with output side open circuited. Hence record I_1, V_2 by multimeter.

iii. Apply 10 volt from intput side with output side short circuited. Hence record I_1, I_2 by multimeter.

Apparatus Table:

Sl. No.	Components Name	Range	Quantity	Type	Makers Name

Theoretical Calculation:

Data Table:-

Circuit No	V_1	V_2	I_1	I_2	$A = \frac{V_1}{V_2}$	$C = \frac{I_1}{V_2}$	$B = \frac{V_1}{I_2}$	$D = \frac{I_1}{I_2}$	'ABCD' Parameter
Figure A Theoretical	10V								
	10V								
Figure A Practical									
Figure B Theoretical									
Figure B Practical									
Figure C Theoretical									
Figure C Practical									

Conclusion:

Report:-

What is the relationship between ABCD parameters obtained in these three networks?

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Department:
Roll No. :

Experiment No: 4

Title: Attenuator Network

Objective: To attenuate voltage using resistive network.

Theory: An attenuator is to reduce, by known amounts, the voltage, current of power between its property terminated input and output ports. An attenuator is a two-port resistive network and its propagation function is real. The attenuation is independent of frequency. Attenuation may be symmetrical or asymmetrical. An attenuator of constant attenuation is called 'pad'.

If the input and output image impedance or the ratio of voltage to current at input port and output port are equal; then the magnitude ratios of the input to output currents or input to output voltages may be written as-

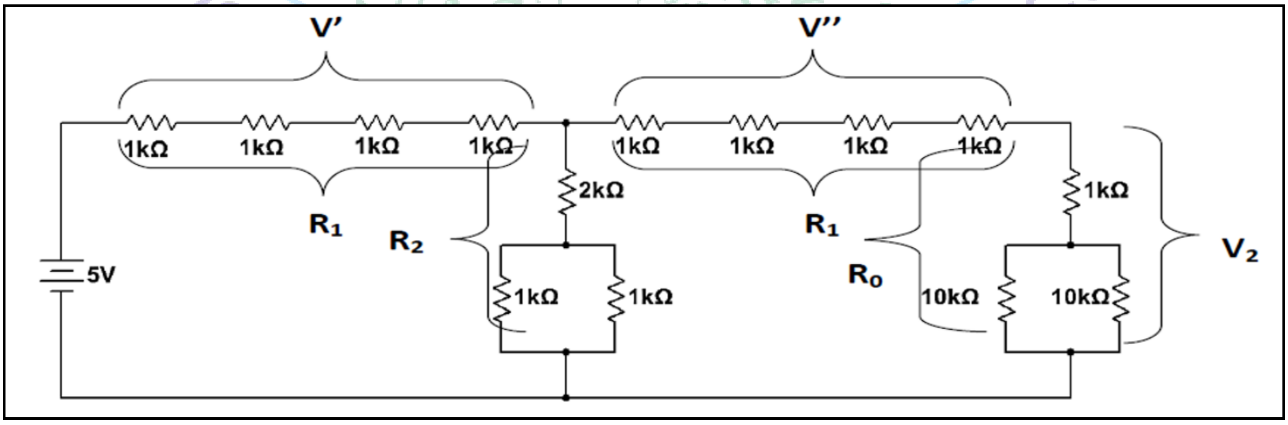
$$\frac{I_1}{I_2} = \frac{V_1}{V_2} = e^{\gamma} = N$$

Where N is the attenuation and γ is called propagation constant and $\gamma = \alpha + i\beta$ where $\alpha =$ attenuation constant and β is known as phase constant. Now, attenuation can be represented by two ways-

Attenuation in dB, $(\alpha_{dB}) = 20log_{10}\left(\frac{V_1}{V_2}\right) = 20log_{10}(\frac{I_1}{-I_2})$

Attenuation in Neper, $(\alpha_{nep} = ln\left(\frac{V_1}{V_2}\right) = ln(\frac{I_1}{-I_2})$

Circuit Diagram:



Procedure:-

i. Make the circuit as shown in figure.

ii. Apply 5volt in the input side and record I_1, I_2, and V_2 by multimeter.

Apparatus Table:

Sl. No.	Components Name	Range	Quantity	Type	Makers Name

Theoretical Calculation:

Data Table:-

V_1 (Volt)	V_2(Volt)	I_1(mA)	I_2(mA)	R_1(kΩ)	R_2(kΩ)	R_0(kΩ)	$\alpha_{nep}=\ln(V_1/V_2)$	$\alpha_{dB}=20\log(V_1/V_2)$

Conclusion:

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Signature of Teacher with date

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Signature of student with date
Department:
Roll No. :

Experiment – 5

Experiment Title: Generation of signals using MATLAB in analog and discrete form.

Introduction to MATLAB:

MATLAB (short for Matrix Laboratory) is a software package which was designed initially for use as a tool for signal processing research. It was developed by John Little and Cleve Moler of MathWorks, Inc. MATLAB was originally written to provide easy access to the matrix computation software packages LINPACK and EISPACK. There is no compilation and linking as is done in high-level languages, such as C or FORTRAN. Computer solutions in MATLAB seem to be much quicker than those of a high-level language such as C or FORTRAN. It is numeric computation software for engineering and scientific calculations. It is also now one of the most popular tools for signal analysis in industry as well as research and education. It allows the user to manipulate signals using high level commands such as matrix multiply and convolution. The user is thus spared the tedious chore of writing low level C programs for these fundamental operations which everyone uses. MATLAB also has a series of extremely easy to use Graphical User Interface commands which allow images to be displayed, graphs to be plotted etc. Programs written in MATLAB are stored in files called MATLAB scripts and they contain MATLAB commands. MATLAB script files are recognized by having the extension .m after the filename. All computations are performed in complex-valued double precision arithmetic to guarantee high accuracy. MATLAB has a rich set of plotting capabilities. The graphics are integrated in MATLAB. Since MATLAB is also a programming environment, a user can extend the functional capabilities of MATLAB by writing new modules. It has a large collection of toolboxes in a variety of domains. Some examples of MATLAB toolboxes are control system, signal processing, neural network, image processing, and system identification. The toolboxes consist of functions that can be used to perform computations in a specific domain.

Procedure:

- Open the MATLAB command window by clicking on the MATLAB icon.
- Write down the programme on the edit window and save it.
- Run the file and see the output.

When MATLAB is invoked, the command window will display the prompt

>>. MATLAB

is then ready for entering data or executing commands.

To quit MATLAB, type the command exit or quit MATLAB has on-line help. To see the list of MATLAB's help facility, **type help**.

The help command followed by a function name is used to obtain information on a specific MATLAB function.

Some Basic MATLAB Commands

Command	Description
%	Comments. Everything appearing after % command is not executed.
demo	Access on-line demo programs
clear	Clears the variables or functions from workspace
clc	Clears the command window during a work session
clg	Clears graphic window
diary	Saves a session in a disk, possibly for printing at a later date
Linspace	Linearly evenly spaced vectors
logspace	Logarithmically evenly spaced vectors
.* , .\ , ./, .^	Element-by-element multiplication, left division, right division, and raising to the power respectively. [Array operations refer to element-by-element arithmetic operations. Preceding the linear algebraic matrix operations, * / \ ' , by a period (.) indicates an array or element-by-element operation.]
plot(x,y)	Plots vector 'y' verses vector 'x'
stem(n,y)	Plot the discrete signal.

Example:

- linspace(i_value, f_value, np)
- logspace(i_value, f_value, np)

where,i_value is the initial value ,f_value is the final value , np is the total number of elements in the vector.

- **Plot the straight-line using plot command y=mx+c, where m=0.5,c=-2 and the x coordinates are x=0,1.5,3,4.5.**

```
m=0.5;
c=-2;
x= [0 1.5 3 4.5];
y=m*x+c;
plot (x,y)
```

- **Generate a damped sinusoidal signal in analog and discrete form.**

```
x=0:0.1:5;
y=sin (x.^2).*exp(-x);
plot (x,y)
stem(x,y)
```

- **Generate unit step function in analog and discrete form.**

```
t=0:0.01:2;
y=stepfun (t,0);
plot (t,y)
axis ([0 2 0 2]);
t=0:0.1:2;
y=stepfun (t,0);
stem (t,y)
```

- **Generate unit impulse, step, ramp, parabolic,sinusoidal and triangular ramp signal.**

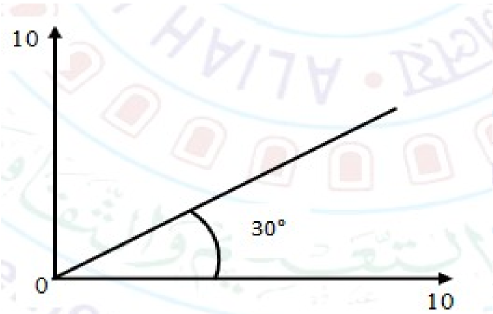
```
tmin=-5; dt=0.1; tmax=5;
t=tmin:dt:tmax
%.......Unit Impulse Signal…….
x1=1;
x2=0;
x=x1.*(t==0)+x2.*(t~=0)
subplot(3,3,1);
plot(t,x)
xlabel('time')
ylabel('x(t)')
title('Unit Impulse Signal')

%.......Unit Step Signal…….
x1=1;
x2=0;
x=x1.*(t>=0)+x2.*(t<0)
subplot(3,3,2);
plot(t,x)
xlabel('time')
ylabel('x(t)')
title('Unit Step Signal')

%.......Unit Ramp Signal…….
x1=t;
x2=0;
x=x1.*(t>=0)+x2.*(t<0)
subplot(3,3,3);
plot(t,x)
xlabel('time')
ylabel('x(t)')
title('Unit Ramp Signal')
```

```
%.......Unit Parabolic Signal…….
A=0.4;
x1=(A*(t.^2))/2;
x2=0;
x=x1.*(t>=0)+x2.*(t<0)
subplot(3,3,4);
plot(t,x)
xlabel('time')
ylabel('x(t)')
title('Unit Parabolic Signal')

%.......Sinusoidal Signal…….
T=2;
F=1/T;
x=sin(2*pi*F*t)
subplot(3,3,5);
plot(t,x)
xlabel('time')
ylabel('x(t)')
title('Sinusoidal Signal')

%.......Triangular Ramp Signal…….
a=2;
x1=1-abs(t)/a;
x2=0;
x=x1.*(abs(t)<=a)+x2.*(abs(t)>a)
subplot(3,3,6);
plot(t,x)
xlabel('time')
ylabel('x(t)')
title('Triangular Ramp Signal')
```

Assignments:

1. Create a vector t with 10 elements 0 to 1 and plot the signals
   a) y=sin(t.^2)./(t.^2)

2. Generate a ramp signal of $\theta=30^0$;



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Department:

Roll No:

Experiment – 6

Experiment Title: Determination of Laplace transform and Inverse Laplace Transform using MATLAB.

Laplace Transform:

Laplace (F) is the Laplace transform of the scalar function F with default independent variable t.The default return is a function of S.

To determine the Laplace transform of a given function F(t), we first multiply f(t) by e^{-st} , 's' being a complex number $s = \sigma + j\omega$, then integrate this product w.r.t time with limits as zero to infinity.

Laplace transform of $f(t) = F(S) = \int_0^\infty f(t)e^{-st}dt$

Example:

syms a ω t;

laplace (a*cos(ω*t))

result:

a*s/(s^2+ω^2)

Inverse Laplace Transform

F=ilaplace(L) is the inverse Laplace transform of the scalar sym L with default independent variable 's'. The default return is a function of 't'.

Example:

syms s ;

ilaplace (1/(s-1))

Result: exp (t)

Procedure:

- Open the MATLAB Command Window by clicking on the MATLAB icon.
- Write down the program on edit window and save it.
- Run the file and see the output.

Assignments:

Find out the Laplace transform of the following functions;
Compare with the theoretical values.

1. e^{-at}
2. $e^{-at}\sin(\omega t)$
3. $\sin(\omega t)$
4. te^{-at}
5. $te^{-2t}+2t\sin(\omega t)$

Find out the Inverse Laplace transform of the following functions;
Compare with theoretical values.

1. $\frac{1}{s^2}$
2. $\frac{a}{s+b}$
3. $\frac{1}{s^2+4s+8}$
4. $\frac{s}{s^2+4^2}$
5. $\frac{s+3}{s^2+6s+18}$

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Signature of Teacher with date | Signature of student with date

Department:

Roll No:

Experiment – 7

Experiment Title:

Electrical Network Problems solving approach using MATLAB programming

Problem:

1. If R = 10 Ohms and the current is increased from 0 to 10 A with increments of 2A, write a MATLAB program to generate a table of current, voltage and power dissipation.

Objective: To evaluate the current, voltage and power dissipation using MATLAB programming

MATLAB Script

```
diary ex1.dat
% diary causes output to be written into file ex1_1.dat
% Voltage and power calculation
R=10; % Resistance value
i=(0:2:10); % Generate current values
v=i.*R; % array multiplication to obtain voltage
p=(i.^2)*R; % power calculation
sol=[i v p] % current, voltage and power values are printed
diary
% the last diary command turns off the diary state
```

2. Simplify the complex number z and express it both in rectangular and polar form.

$$Z=\frac{(3+j4)(5+j2)(2\angle 60^\circ)}{(3+j6)(1+j2)}$$

Objective: To evaluate the complex number, z, and express the result in polar notation and rectangular form.

MATLAB Script

```
diary ex2.dat
```

```
% Evaluation of Z
% the complex numbers are entered
Z1 = 3+4*j;
Z2 = 5+2*j;
theta = (60/180)*pi; % angle in radians
Z3 = 2*exp(j*theta);
Z4 = 3+6*j;
Z5 = 1+2*j;
% Z_rect is complex number Z in rectangular form
disp('Z in rectangular form is'); % displays text inside brackets
Z_rect = Z1*Z2*Z3/(Z4+Z5);
Z_rect
Z_mag = abs (Z_rect); % magnitude of Z
Z_angle = angle(Z_rect)*(180/pi); % Angle in degrees
disp('complex number Z in polar form, mag, phase'); % displays text
%inside brackets
Z_polar = [Z_mag, Z_angle]
diary
```

3. For the circuit shown below, find the nodal voltages V_1, V_2, and V_3.

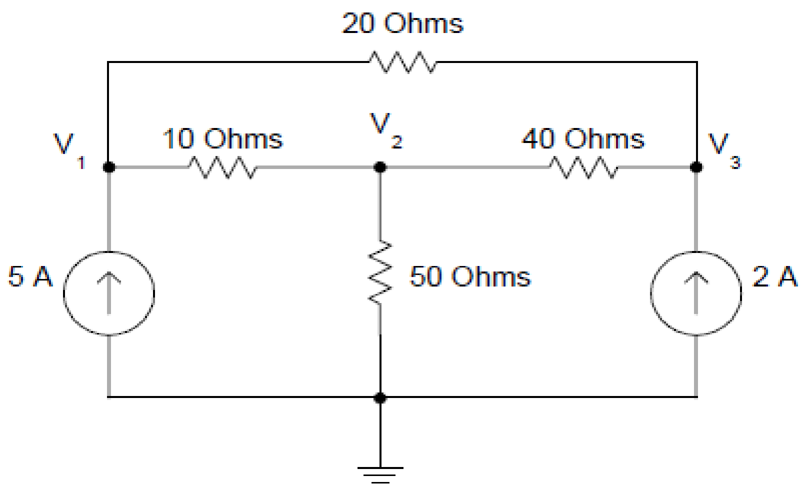

Fig. 1 Circuit with Nodal Voltages

Solution:

Solving the circuit, we are getting the matrix form

$$\begin{bmatrix} 0.15 & -0.1 & -0.05 \\ -0.1 & 0.145 & -0.025 \\ -0.05 & -0.025 & 0.075 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 5 \\ 0 \\ 2 \end{bmatrix}$$

Objective: To evaluate the nodal voltages V_1, V_2, and V_3.

MATLAB Script

```
diary ex3.dat
% program computes the nodal voltages
% given the admittance matrix Y and current vector I
% Y is the admittance matrix and I is the current vector
% initialize matrix y and vector I using YV=I form
Y = [ 0.15 -0.1 -0.05;
-0.1 0.145 -0.025;
-0.05 -0.025 0.075];
I = [5; 0; 2];
% solve for the voltage
fprintf ('Nodal voltages V1, V2 and V3 are \n')
v = inv(Y)*I
diary
```

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Signature of Teacher with date

Signature of student with date

Department:

Roll No: