LABORATORY MANUAL

ON

ELECTRICAL CIRCUITS & SIMULATION LABORATORY

2018 – 2019

II B. Tech I Semester (CREC-R17)

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CHADALAWADA RAMANAMMA ENGINEERING COLLEGE

(AUTONOMOUS)
Chadalawada Nagar, Renigunta Road, Tirupati – 517 506

Department of Electrical and Electronics Engineering
ELECTRICAL CIRCUITS AND SIMULATION LABORATORY

III Semester: EEE

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Category</th>
<th>Hours / Week</th>
<th>Credits</th>
<th>Maximum Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>17CA02305</td>
<td>Core</td>
<td>L T P C</td>
<td>CIA SEE Total</td>
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<td></td>
<td></td>
<td>- - 4 2</td>
<td>30 70 100</td>
<td></td>
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</table>

Contact Classes: Nil
Tutorial Classes: Nil
Practical Classes: 68
TotalClasses: 68

OBJECTIVES:
The course should enable the students to:
I. Apply different techniques used in electric circuit analysis to calculate circuit parameters and two port network parameters.
II. Demonstrate the applications of Fourier transforms in electric circuits.
III. Design filters and analyze through digital simulation in electrical circuits.

LIST OF EXPERIMENTS

<table>
<thead>
<tr>
<th>Expt. 1</th>
<th>MEASUREMENT OF THREE PHASE ACTIVE POWER AND REACTIVE POWER</th>
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<td></td>
<td>Measurement of three phase active and reactive power for balanced and unbalanced loads.</td>
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<thead>
<tr>
<th>Expt. 2</th>
<th>IMPEDANCE(Z) AND ADMITTANCE(Y) PARAMETERS</th>
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<tbody>
<tr>
<td></td>
<td>To calculate and verify 'Z' parameters and ‘Y’ parameters of two-port network.</td>
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<tr>
<th>Expt. 3</th>
<th>TRANSMISSION (ABCD) AND HYBRID(h) PARAMETERS</th>
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<tr>
<td></td>
<td>To calculate and verify 'ABCD' parameters and ‘h’ parameters of two-port network.</td>
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<th>Expt. 4</th>
<th>FOURIER ANALYSIS</th>
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<td>Fourier analysis of square wave, half wave rectified and full wave rectified sine wave using MATLAB.</td>
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<th>Expt. 5</th>
<th>TRANSIENT RESPONSE OF ELECTRICAL CIRCUITS BY SIMULATION</th>
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<tr>
<td></td>
<td>To study and plot the transient response of series and parallel RL and RC circuits using</td>
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<tr>
<td>Expt. 6</td>
<td>TRANSIENT RESPONSE OF ELECTRICAL CIRCUITS BY SIMULATION</td>
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<tr>
<td>---------</td>
<td>--------------------------------------------------------</td>
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<tr>
<td>To study and plot the transient response of series and parallel RLC circuit using MATLAB and PSPICE.</td>
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<tr>
<th>Expt. 7</th>
<th>DESIGN OF LOW PASS AND HIGH PASS FILTERS USING SIMULATION</th>
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<tr>
<td>Simulation of low pass and high pass filters using digital simulation.</td>
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<tr>
<th>Expt. 8</th>
<th>VIRTUAL INSTRUMENTS (VI) USING LabVIEW</th>
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<tr>
<td>Editing and building a VI, creating a sub VI.</td>
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<table>
<thead>
<tr>
<th>Expt. 9</th>
<th>STRUCTURES USING LabVIEW</th>
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<tr>
<td>Using FOR loop, WHILE loop, charts and arrays, graph and analysis VIs.</td>
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<thead>
<tr>
<th>Expt. 10</th>
<th>GENERATION OF COMMON WAVE FORMS USING LabVIEW</th>
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<tr>
<td>Signal generation, display of wave form, minimum and maximum values of wave form, modulation.</td>
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</tbody>
</table>

<table>
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<tr>
<th>Expt. 11</th>
<th>SINE WAVE GENERATION USING LabVIEW</th>
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<tbody>
<tr>
<td>Three phase sine wave generation and display.</td>
<td></td>
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</table>

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<thead>
<tr>
<th>Expt. 12</th>
<th>FREQUENCY MEASUREMENT USING LabVIEW</th>
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<tbody>
<tr>
<td>Frequency measurement using Lissajous figures in LabVIEW.</td>
<td></td>
</tr>
</tbody>
</table>

**Reference Books:**


**Web References:**
**Course Home Page:**

**SOFTWARE AND HARDWARE REQUIREMENTS FOR A BATCH OF 36 STUDENTS:**

**SOFTWARE:** MATLAB R2015a, Wplsoft software and LabVIEW

**HARDWARE:** Desktop Computers (04 nos)

**Course Outcome:**

At the end of the course, a student will be able to:

1. Learn and analyze the basic law and theories of electrical engineering.
2. Understand different techniques used in electric circuit analysis to calculate circuit parameters and two port network parameters.
3. Demonstrate the applications of Fourier transforms in electric circuits.
4. Design filters and analyse through digital simulation in electrical circuits.
EXPERIMENT NO: 1

AIM: To calculate and verify 'Z' parameters of two-port network.

APPARATUS REQUIRED: Power Supply, Bread Board, Five resistances, Connecting Leads. Voltmeter, Ammeter

BRIEF THEORY: In Z parameters of a two-port, the input & output voltages \( V_1 \) & \( V_2 \) can be expressed in terms of input & output currents \( I_1 \) & \( I_2 \). Out of four variables (i.e \( V_1, V_2, I_1, I_2 \) \( V_1 & V_2 \) are dependent variables whereas \( I_1 & I_2 \) are independent variables. Thus,

\[
V_1 = Z_{11}I_1 + Z_{12}I_2 \quad (1)
\]

\[
V_2 = Z_{21}I_1 + Z_{22}I_2 \quad (2)
\]

Here \( Z_{11} & Z_{22} \) are the input & output driving point impedances while \( Z_{12} & Z_{21} \) are the reverse & forward transfer impedances.

CIRCUIT DIAGRAM:

![Circuit Diagram](image)

PROCEDURE:

a) Connect the circuit as shown in fig. & switch ‘ON’ the experimental board.
b) First open the O/P terminal & supply 5V to I/P terminal. Measure O/P Voltage & I/P Current.
c) Secondly, open I/P terminal & supply 5V to O/P terminal. Measure I/P Voltage & O/P current using multi-meter.
d) Calculate the values of Z parameter using Equation (1) & (2).
e) Switch ‘OFF’ the supply after taking the readings.

OBSERVATION TABLE:

<table>
<thead>
<tr>
<th>S.No</th>
<th>When I/P is open ckt</th>
<th>When O/P is open ckt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V₂</td>
<td>V₁</td>
</tr>
</tbody>
</table>

SAMPLE CALCULATION:

(1) When O/P is open circuited
   i.e. I₂ = 0
   Z₁₁ = \( \frac{V₁}{I₁} \)
   Z₂₁ = \( \frac{V₂}{I₁} \)

(2) When I/P is open circuited
   i.e. I₁ = 0
   Z₁₂ = \( \frac{V₁}{I₂} \)
   Z₂₂ = \( \frac{V₂}{I₂} \)

RESULT/CONCLUSION: The Z-parameters of the two port network has been calculated and verified.

DISCUSSION: The Z-parameters are open circuit parameters.

PRECAUTIONS:
   a) Make the connections according to the circuit diagram.
      Power supply should be switched off.
   b) Connections should be tight.
   c) Note the readings carefully.
EXPERIMENT NO: 2

AIM: To calculate and verify 'Y' parameters of two-port network.

APPARATUS REQUIRED: Power supply, Bread Board, Five resistances, Connecting Leads, Voltmeter, and Ammeter.

BRIEF THEORY: In Y parameters of a two-port, the input & output currents $I_1$ & $I_2$ can be expressed in terms of input & output voltages $V_1$ & $V_2$. Out of four variables (i.e $I_1$, $I_2$, $V_1$, $V_2$) $I_1$ & $I_2$ are dependent variables whereas $V_1$ & $V_2$ are independent variables.

\[ I_1 = Y_{11} V_1 + Y_{12} V_2 \] -------- (1)

\[ I_2 = Y_{21} V_1 + Y_{22} V_2 \] -------- (2)

Here $Y_{11}$ & $Y_{22}$ are the input & output driving point admittances while $Y_{12}$ & $Y_{21}$ are the reverse & forward transfer admittances.

CIRCUIT DIAGRAM:

![Circuit Diagram]

PROCEDURE:

a) Connect the circuit as shown in fig. & switch ‘ON’ the experimental board.

b) First short the O/P terminal & supply 5V to I/P terminal. Measure O/P & I/P current.

c) Secondly, short I/P terminal & supply 5V to O/P terminal. Measure I/P & O/P current using multi-meter.

d) Calculate the values of Y parameter using Eq. (1) & (2).
e) Switch ‘off’ the supply after taking the readings.

OBSERVATION TABLE:

<table>
<thead>
<tr>
<th>S.No</th>
<th>When I/P is short ckt</th>
<th>When O/P is short ckt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(V_2)</td>
<td>(I_1)</td>
</tr>
</tbody>
</table>

SAMPLE CALCULATION:

(1) When O/P is short circuited
i.e. \(V_2 = 0\)
\[Y_{11} = \frac{I_1}{V_1}\]
\[Y_{21} = \frac{I_2}{V_1}\]

(2) When I/P is short circuited
i.e. \(V_1 = 0\)
\[Y_{12} = \frac{I_1}{V_2}\]
\[Y_{22} = \frac{I_2}{V_2}\]

RESULT/CONCLUSION: The Y-parameters of the two port network has been calculated and verified.

DISCUSSION: The Y-parameters are short circuit parameters

PRECAUTIONS:

a) Make the connections according to the circuit diagram. Power supply should be switched off.
b) Connections should be tight.
c) Note the readings carefully.
EXPERIMENT NO: 3

AIM: To calculate and verify 'ABCD' parameters of two-port network

APPARATUS REQUIRED: Power Supply, Bread Board, Five resistances, Connecting Leads, Voltmeter, and Ammeter.

BRIEF THEORY: ABCD parameters are widely used in analysis of power transmission engineering where they are termed as “Circuit Parameters”. ABCD parameters are also known as “Transmission Parameters”. In these parameters, the voltage & current at the sending end terminals can be expressed in terms of voltage & current at the receiving end. Thus, Here “A” is called reverse voltage ratio, “B” is called transfer impedance “C” is called transfer admittance & “D” is called reverse current ratio.

CIRCUIT DIAGRAM:

PROCEDURE:

a) Connect the circuit as shown in fig. & switch ‘ON’ the experimental board.
b) First open the O/P terminal & supply 5V to I/P terminal. Measure O/P voltage & I/P current.
c) Secondly, short the O/P terminal & supply 5V to I/P terminal. Measure I/P & O/P current using multi-meter.
d) Calculate the A, B, C, & D parameters using the Eq. (1) & (2).
e) Switch ‘off’ the supply after taking the readings.

OBSERVATION TABLE:
<table>
<thead>
<tr>
<th>S.No</th>
<th>When O/P is open ckt</th>
<th>When O/P is short ckt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V₁</td>
<td>V₂</td>
</tr>
</tbody>
</table>

**SAMPLE CALCULATION:**

(1) When O/P is open ckt.
   open circuited
   i.e. \( I₂ = 0 \ A \)
   \( V₁/V₂ \)
   \( C = I₁/V₂ \)

(2) When O/P is short ckt.
   i.e. \( V₂ = 0 \)
   \( B = -V₁/I₂ \)
   \( D = -I₁/I₂ \)

**RESULT/CONCLUSION:** The ABCD-parameters of the two-port network has been calculated and verified.

**DISCUSSION:** ABCD parameters are transmission parameters.

**PRECAUTIONS:**

a) Make the connections according to the circuit diagram. Power supply should be switched off.

b) Connections should be tight.

c) Note the readings carefully.
EXPERIMENT NO: 4

AIM: To calculate and verify 'H' parameters of two-port network

APPARATUS REQUIRED: Power supply, Bread Board, Five resistances, Connecting Leads, Multimeter.

BRIEF THEORY: In ‘h’ parameters of a two port network, voltage of the input port and the current of the output port are expressed in terms of the current of the input port and the voltage of the output port. Due to this reason, these parameters are called as ‘hybrid’ parameters, i.e. out of four variables (i.e. V₁, V₂, I₁, I₂) V₁, I₂ are dependent variables.

Thus,

\[ V₁ = h₁₁I₁ + h₁₂V₂ \]  (1)

\[ I₂ = h₂₁I₁ + h₂₂V₂ \]  (2)

H₁₁ and H₂₂ are input impedance and output admittance.
H₂₁ and H₁₂ are forward current gain and reverse voltage gain.

CIRCUIT DIAGRAM:

![Circuit Diagram](image)

PROCEDURE : 

a) Connect the circuit as shown in fig. & switch ‘ON’ the experimental board.
b) Short the output port and excite input port with a known voltage source Vs. So that V₁ = Vs and V₂ = 0. We determine I₁ and I₂ to obtain h₁₁ and h₂₁.
c) Input port is open circuited and output port is excited with
the same voltage source \( V_s \). So that \( V_2 = V_s \) and \( I_1 = 0 \), we determine \( I_2 \) and \( V_1 \) to obtain \( h_{12} \) and \( h_{22} \).

d) Switch ‘off’ the supply after taking the readings.

**OBSERVATION TABLE:**

<table>
<thead>
<tr>
<th>S.No</th>
<th>When O/P is short ckt</th>
<th>When I/P is short ckt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( V_1 )</td>
<td>( I_1 )</td>
</tr>
</tbody>
</table>

**SAMPLE CALCULATION:**

(1) When O/P is short circuited
\[ h_{11} = \frac{V_1}{I_1} \quad h_{21} = \frac{I_2}{I_1} \]

(2) When I/P is open circuited
\[ h_{12} = \frac{V_1}{V_2} \quad h_{22} = \frac{I_2}{V_2} \]

**RESULT/CONCLUSION:** The \( h \)-parameters of the two port network has been calculated and verified.

**DISCUSSION:** The \( h \)-parameters are short circuit parameters

**PRECAUTIONS:**

a) Make the connections according to the circuit diagram.
   Power supply should be switched off.

b) Connections should be tight.

c) Note the readings carefully.
EXPERIMENT NO: 5

ANALYSIS OF HIGH PASS FILTER USING MATLAB

AIM: To analyze high pass filter using Matlab

APPARATUS REQUIRED: Matlab software with PC

Transfer function

\[ G(s) = \frac{sl}{r+sl} \]

\[ G(s) = \frac{s}{s+r} \]

Program

```matlab
r=1;l=1;
>> G=tf([1 0],[1 r/l])
G =
    s
-----
    s + 1
bode(G), grid
>> r=5;G1=tf([1 0],[1 r/l]);
```
>> r=20;G2=tf([1 0],[1 r/l]);
>> bode(G,'b',G1,'r',G2,'g'),grid
>> legend('r=1','r=5','r=20')
EXPERIMENT NO: 6

ANALYSIS OF LOW PASS FILTER USING MATLAB

**AIM:** To analyze of low pass filter using Matlab

**APPARATUS REQUIRED:** Matlab software with PC

Transfer function

\[ G(s) = \frac{\frac{1}{sc}}{r + \frac{1}{sc}} \]

\[ G(s) = \frac{\frac{1}{rc}}{s + \frac{1}{rc}} \]

**PROGRAM**

```matlab
>> r=1;c=1;
G=tf([0 1/(r*c)],[1 1/(r*c)])
G =
    1
-----
```

\[ s + 1 \]
Continuous-time transfer function.

>> bode(G),grid

>> r=5;G1=tf([0 1/(r*c)],[1 1/(r*c)]);

>> r=20;G2=tf([0 1/(r*c)],[1 1/(r*c)]);

>> bode(G,'b',G1,'r',G2,'g'),grid

>> legend('r=1','r=5','r=20')

>>
EXPERIMENT NO: 7

RC TRANSIENT ANALYSIS

AIM

To plot RC transient analysis

C = 10 µF, use MATLAB to plot the voltage across the capacitor if R is equal to (a) 1.0 kΩ, (b) 10 kΩ and (c) 0.1 kΩ.

APPARATUS

1) Matlab Software

Circuit diagram

![Circuit Diagram](image)

Explanation

Using KCL, we get

\[ C \frac{dv_a(t)}{dt} + \frac{v_a(t) - V_s}{R} = 0 \]

If the capacitor is initially uncharged, that is \( v_0(t) = 0 \) at \( t = 0 \), the solution to Equation (5.3) is given as

\[ v_0(t) = V_s \left( 1 - e^{-\frac{t}{CR}} \right) \]
Matlab code

% Charging of an RC circuit %

c = 10e-6; r1 = 1e3;
tau1 = c*r1;
t = 0:0.002:0.05;
v1 = 10*(1-exp(-t/tau1));

r2 = 10e3;
tau2 = c*r2;
v2 = 10*(1-exp(-t/tau2));

r3 = .1e3;
tau3 = c*r3;
v3 = 10*(1-exp(-t/tau3));

plot(t,v1,'+',t,v2,'o', t,v3,'*')
axis([0 0.06 0 12])
title('Charging of a capacitor with three time constants')

xlabel('Time, s') ylabel('Voltage across capacitor')
text(0.03, 5.0, '+ for R = 1 Kilohms')
text(0.03, 6.0, 'o for R = 10 Kilohms')
text(0.03, 7.0, '* for R = 0.1 Kilohms')
EXPERIMENT NO: 8

RL TRANSIENT ANALYSIS

Aim

To analyze transient analysis of RL series circuit

Problem

The current flowing through the inductor is zero. At $t = 0$, the switch moved from position a to b, where it remained for 1 s. After the 1 s delay, the switch moved from position b to position c, where it remained indefinitely. Sketch the current flowing through the inductor versus time.

![RL Circuit Diagram]

Explanation

For $0 < t < 1$ s, we can use Equation (5.9) to find the current

$$i(t) = 0.4 \left(1 - e^{-\frac{t}{\tau_1}}\right)$$

where

$$\tau_1 = \frac{L}{R} = \frac{200}{100} = 2 \text{ s}$$

At $t = 1$ s

$$i(t) = 0.4 \left(1 - e^{-0.5}\right) = I_{\text{max}}$$

For $t > 1$ s, we can use Equation (5.6) to obtain the current

$$i(t) = I_{\text{max}} e^{-\frac{t-0.5}{\tau_2}}$$
MATLAB CODE

% tau1 is time constant when switch is at b
% tau2 is the time constant when the switch is in position c

tau1 = 200/100;
for k=1:20
    t(k) = k/20;
    i(k) = 0.4*(1-exp(-t(k)/tau1));
end
imax = i(20);

tau2 = 200/200;
for k = 21:120 t(k) = k/20;
    i(k) = imax*exp(-t(k-20)/tau2);
end

% plot the current
plot(t,i,'o')
axis([0 6 0 0.18])
title('Current of an RL circuit')
xlabel('Time, s')
ylabel('Current, A')

\[ \tau_2 = \frac{L}{R_{eq2}} = \frac{200}{200} = 1 \text{ s} \]
Current of an RL circuit
Aim: To perform mesh analysis.

Theory:
- Explain how the circuit can be solved using mesh analysis?

Circuit to be solved.

Matlab Simulation
Conclusion:

Hence we have studied and analyzed the circuit for mesh analysis and also verification is done in matlab.

Exercise No 2: (2 Hours) – 1 Practical
To perform nodal analysis.

Aim: To perform nodal analysis.

Theory:
- Explain how the circuit can be solved using nodal analysis.

Circuit to be solved:

Matlab Simulation

Conclusion:
Hence we have studied and analyzed the circuit for nodal analysis and also verification is done in matlab.

Exercise No 3: (2 Hours) – 1 Practical

**To verify superposition theorem.**

**Aim:** To verify superposition theorem.

**Theory:** State superposition theorem and explain how the circuit can be simplified by using superposition theorem.

**Circuit to be solved:**

![Circuit Diagram]

**Matlab Simulation**
**Conclusion:** Hence superposition theorem is used to solve linear network containing more than one independent source and dependent source and also the same is verified in matlab.

**Exercise No 4 : ( 2 Hours) – 1 Practical**

**To verify Thevnis theorem**

**Aim:** To verify Thevnis theorem

**Theory:** State thevenins theorem and explain how the circuit can be simplified by using thevenins theorem.

**Circuit to be solved:**
Matlab Simulation
Conclusion: Hence we have studied and analyzed the Vin's theorem to find its equivalent circuit. We can conclude that the Vin's theorem convert complex network into simple equivalent network having one voltage source and verified in Matlab.

Exercise No 5: (2 Hours) – 1 Practical

To verify Nortans theorem

Aim: To verify Nortans theorem

Theory: State Nortans theorem and explain how the circuit can be simplified by using Nortans theorem

Circuit to be solved:
Matlab Simulation

Conclusion: Hence we have studied and analyzed nortans theorem to find norton equivalent circuit for complex network and verified in matlab.

Exercise No 6: (2 Hours) – 1 Practical

**To Study maximum Power transfer theorem**

**Aim:** To Study maximum Power transfer theorem.

**Theory:** State maximum Power transfer theorem and explain how the circuit can be simplified by using maximum Power transfer theorem

Plot the graph of power against RL for maximum power transfer theorem.
Circuit to be solved:

Matlab Simulation

Vary RL from 200ohm to 1200 ohm in the steps of 100ohm

RLmax=600ohm
Conclusion:

Maximum power transfer theorem when load resistance RL is equal to source resistance is verified in matlab.
Exercise No 7: (2 Hours) – 1 Practical

To verify reciprocity theorem

**Aim:** To verify reciprocity theorem

**Theory:** State reciprocity theorem and explain how the circuit can be simplified by using reciprocity theorem.

**Circuit to be solved**

![Circuit Diagram]

**Matlab Simulation**
Conclusion: -

Thus we have studied reciprocity theorem and verified that ratio of output and input is constant even though voltage source position is interchanged and the same is verified in matlab.
Exercise No 8: (2 Hours) – 1 Practical

Verification of Millmans equivalent circuit.

**Aim:** To verify Millmans equivalent circuit.

**Theory:** State Millmans theorem and explain how the circuit can be simplified by using Millmans theorem.

**Circuit to be solved**

![Circuit Diagram]

**Matlab Simulation**
Conclusion: Hence we have studied millmans theorem and verified in matlab.

Exercise No 9: (2 Hours) – 1 Practical
To Study analysis of RL circuit

Aim: To Study and analyse RL circuit

Theory:
Explain series RL circuit.
Derive the expression for voltage and current in a series RL circuit.
Matlab simulation
Conclusion:
Hence we have studied and analyzed the response of RL circuit using matlab.

Exercise No 10: (2 Hours) – 1 Practical

To Study analysis of RC circuit

Aim: To Study and analyse RC circuit

Theory:
Explain series RC circuit.

Derive the expression for voltage and current in a series RC circuit.
Matlab simulation.
**Conclusion:**

Hence we have studied and analyzed the response of RC circuit using matlab.
3. **Conduction of Viva-Voce Examinations:**

Teacher should take oral exams of the students with full preparation. Normally, the objective questions with guess are to be avoided. To make it meaningful, the questions should be such that depth of the students in the subject is tested. Oral examinations are to be conducted in co-cordial environment amongst the teachers taking the examination. Teachers taking such examinations should not have ill thoughts about each other and courtesies should be offered to each other in case of difference of opinion, which should be critically suppressed in front of the students.

4. **Evaluation and marking system:**

Basic honesty in the evaluation and marking system is absolutely essential and in the process impartial nature of the evaluator is required in the examination system to become popular amongst the students. It is a wrong approach or concept to award the students by way of easy marking to get cheap popularity among the students to which they do not deserve. It is a primary responsibility of the teacher that right students who are really putting up lot of hard work with right kind of intelligence are correctly awarded.