INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

ELECTRICAL CIRCUITS LABORATORY							

I Semester: EEE / ECE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
AEED04	**Foundation**	-	-	2	1	40	60	100

Contact Classes: Nil	Tutorial Classes: Nil	Practical Classes: 45	Total Classes: 45

Prerequisite: There are no prerequisites to take this course

I. COURSE OVERVIEW:

The course is designed to provide students with hands-on experience and practical skills in the field of electrical engineering. The course serves as a complement to theoretical concepts learned in the concurrent electrical circuits course. Through a series of structured experiments, students gain an in-depth understanding of fundamental electrical circuits, components, measurement techniques, and troubleshooting procedures.

II. COURSES OBJECTIVES:
The students will try to learn

1. The gap between theoretical knowledge and practical applications by exposing students to a wide range of electrical components and circuit configurations.
2. The essential skills in circuit design, measurement, testing, and analysis using laboratory equipment such as multimeters, and power supplies.
3. The basic laws, network reduction techniques and theorems for different circuits.

III. COURSE OUTCOMES:
At the end of the course students should be able to:

CO 1: Solve the source resistance, currents, voltage and power using various laws associated with electrical circuits

CO 2: Analyze the alternating quantities for different periodic waveforms.

CO 3: Perform the superposition principle, reciprocity and maximum power transfer condition for the electrical network with DC excitation.

CO 4: Demonstrate Thevenin's and Norton's theorems to reduce complex networks into simple equivalent networks with DC excitation.

CO 5: Apply Faraday's laws of electromagnetic induction for calculating the various performance parameters in magnetic circuits.

CO 6: Make use of two port network parameters for enumerating the symmetry, reciprocity, internal voltages and currents in the various electrical circuits

DO's
1. Once the operation is completed pull the plug itself rather chord attached to it.
2. To repair the equipment switch-off the supply and go on.
3. To operate the equipment on supply, see that hands are dry, if that is not possibly hide the hand in the pockets.
4. If a person comes in contact with current unexpectedly don't touch the person with hands but immediately use any insulator material and shut down the power (like leather belts, wood and plastic bars etc).
5. If water is nozzles on the equipment, immediately shunt down the power using circuit breaker or pull out the plug.
6. Use the connecting wires of good continuity, short circuit of connecting wire leads damage of circuit parameters.

DON'Ts
1. Do not wear loose clothing and do not hold any conducting materials in contact with skin when the power is on.
2. Do not pull out the connections until unless all the currents are dead.
3. Do not wait for switches to de-magnetize when there is a delay but pull out the plug.
4. Do not overload the circuit by plugging in too many appliances.
5. If you are mentally and physically stressed don't operate the power equipment.
6. Never operate the equipment under wet conditions.
7. Do not interconnect two or more wires, take appropriate length of wire.

SAFETY NORMS
1. The lab must be equipped with fire extinguisher.
2. See that the connections are made tight.
3. Use single plug for each equipment.
4. Cover the body completely to avoid arc effect.
5. To change the connections during the experiment, switch off the supply and carry on.
6. Used equipment may get heated, so take care handling the equipment after it is used.
7. Do the wiring, all set ups and check the circuit connections before the supply is on

EXERCISES FOR ELECTRICAL CIRCUITS LABORATORY

**Note:** Students are encouraged to bring their own laptops for laboratory practice session

1. Getting Started Exercises

### 1.1 Introduction to electrical circuits

1. Understand the basic electrical equipments used in the laboratory.
2. Become familiar with the operation and usage of basic DC electrical laboratory devices, namely DC power supplies and digital multimeters.
3. Learn the measurement of resistance values using colour code and digital multimeter.
4. Learn the basics of circuit design using Simulink.

Try

1. Calculate the resistance value of Resistor – 1, Resistor – 2 and Resistor – 3 using colour code and verify using a digital multimeter

| Resistor – 1 | Resistor – 2 | Resistor – 3 |
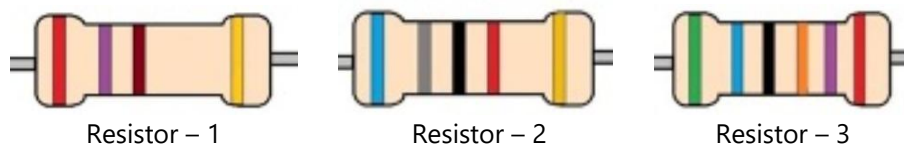
2. Design Circuit – 1 using Simulink and find the voltages V_1, V_2, V_3 and Current I. Where V_s = 6 V, R_1 = 100 Ω, R_2 = 220 Ω, R_3 = 1k Ω
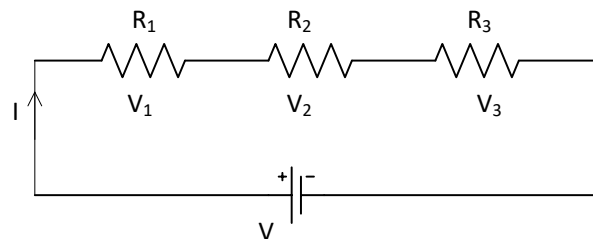
Circuit – 1

3. Design Circuit – 2 using Simulink and find the currents I_1, I_2 and I_3. Where V_s = 6 V, R_1 = 100 Ω, R_2 = 220 Ω, R_3 = 1k Ω
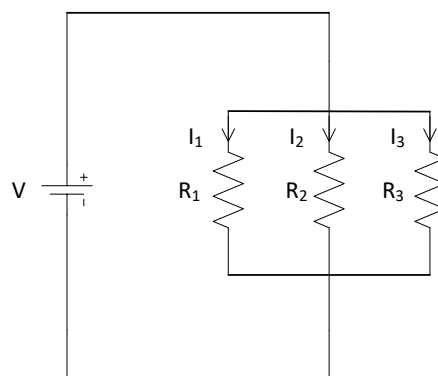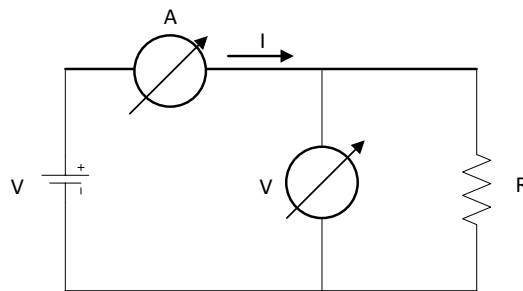

Circuit – 2

2. Exercises on Basic Electrical Circuit Law's

2.1 Ohm's law

Examine Ohm's law of Circuit – 3 and draw the V-I characteristic of linear resistors R = 1k Ω.

Circuit - 3

Try

1. Verify Ohm's law of Circuit – 3 using Simulink and draw the V-I characteristics of a linear resistor R = 470 k Ω.
2. An electric heater takes 1.48 kW from a voltage source of 220 V. Find the resistance of the heater.

2.2 Kirchhoff's voltage law

Examine Kirchhoff's voltage law using basic series DC Circuit - 4 with resistors. Where V_s = 6 V, R_1 =100 Ω, R_2 = 220 Ω, R_3 = 1k Ω.
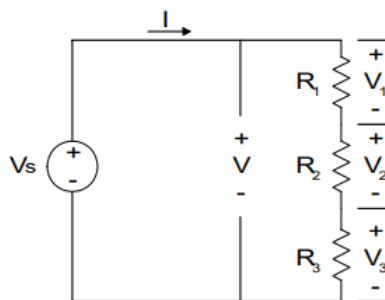
Circuit – 4

Try

1. Design and Verify Kirchhoff's voltage law for Circuit – 4 using Simulink.
2. Determine the voltage V_2 by replacing the resistor R_2 = 150 Ω in Circuit – 4.
3. Find the total current I flowing through the Circuit – 4.

2.3 Kirchhoff's current law

Examine Kirchhoff's current law using basic parallel DC Circuits - 5 with resistors. Where V_s = 6 V, R_1 = 100 Ω, R_2 = 220 Ω, R_3 = 1k Ω
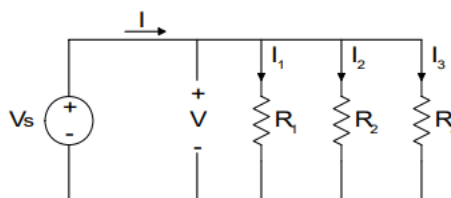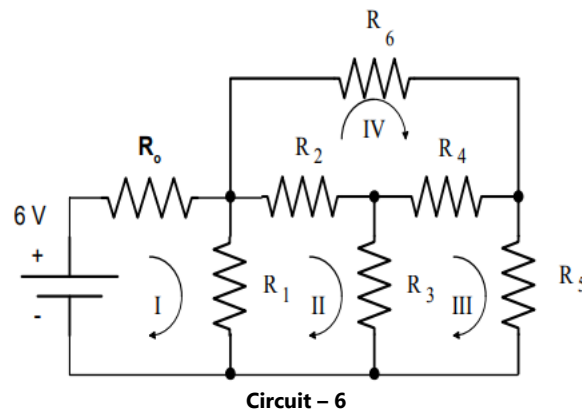

Circuit – 5

Try

1. Design and Verify Kirchhoff's current law for Circuit – 5 using Simulink.
2. Determine the current I_2 by replacing the resistor R_2 = 150 Ω in Circuit – 5.

3. Exercises on Mesh Analysis

Determine mesh currents in the complex electrical Circuit - 6 by using principles of basic electrical circuits. Where $R_0 = 47\Omega$, $R_1 = 100\ \Omega$, $R_2 = 220\ \Omega$, $R_3 = 1k\ \Omega$, $R_4 = 150\ \Omega$, $R_5 = 82\ \Omega$, $R_6 = 100\ \Omega$.
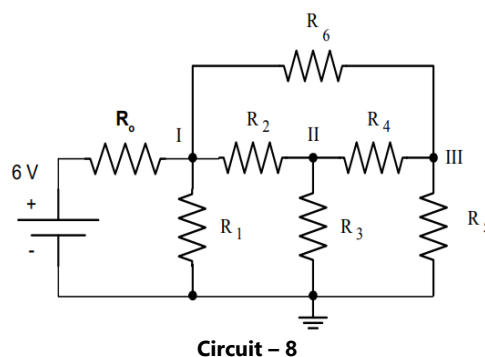

Circuit – 6

Try

1. Use Simulink to simulate the Circuit – 6 for determining the current flowing through each resistor and compare these values to those you obtained from your experiments.
2. Find the current flowing through the resistor R_2 and R_3 by replacing the values of the resistors $R_2 = 100\ \Omega$, $R_3 = 470\ \Omega$ in Circuit – 6.
3. Find the current flowing through the resistor R_3 for Circuit – 7 using mesh analysis when $V_1 = 10$ V, $V_2 = 6$ V, $R_1 = 100\ \Omega$, $R_2 = 220\ \Omega$ and $R_3 = 1k\ \Omega$.
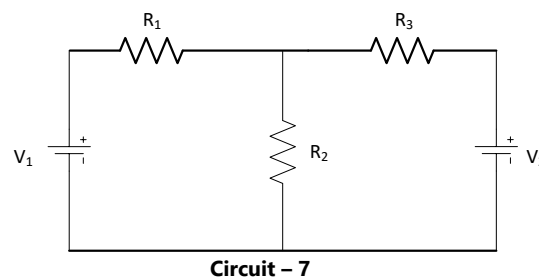
Circuit – 7

4. Exercises on Nodal Analysis

Determine nodal voltages in complex electrical Circuit – 8 by using principles of basic electrical circuits.
Where $R_0 = 47\Omega$, $R_1 = 100\ \Omega$, $R_2 = 220\ \Omega$, $R_3 = 1k\ \Omega$, $R_4 = 150\ \Omega$, $R_5 = 82\ \Omega$, $R_6 = 100\ \Omega$.
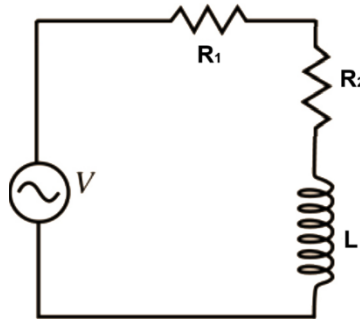

Circuit – 8

Try

1. Use Simulink to simulate the Circuit – 8 for determining the voltage across each resistor and compare these values to those you obtained from your experiments.
2. Determine the voltage at node - II by replacing the resistor $R_2 = 150\ \Omega$ in Circuit – 8.
3. Find the node voltage for Circuit – 7 using nodal analysis when $V_1 = 10$ V, $V_2 = 6$ V, $R_1 = 100\ \Omega$,

R$_2$ = 220 Ω and R$_3$ = 1 k Ω.

5. Exercises on Characteristics of Periodic Waveforms

5.1 Sinusoidal waveform

Calculate the average value, RMS value, form factor and peak factor of the sinusoidal waveform for Circuit – 9. Where V = 5V, R$_1$ = 1k Ω, R$_2$ = 100 Ω and L = 10mH.

Circuit – 9

Try

1. Use Simulink to simulate the Circuit – 9 for determining the average value, RMS value, form factor and peak factor of the sinusoidal waveform.
2. Find the Average Value, RMS Value, form Factor and Peak Factor for the wave shown in the Figure 1.
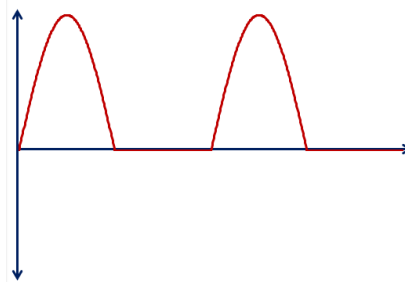
Figure 1. Periodic wave

5.2 Square waveform

Calculate the average value, RMS value, form factor and peak factor of the square waveform shown in Figure 2.
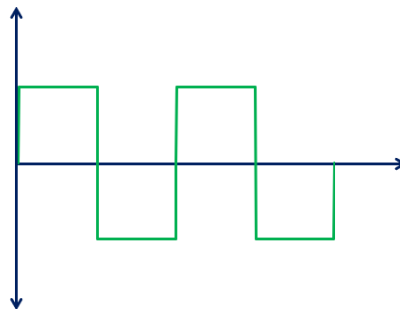
Figure 2. Square wave

Try

1. Find the Average Value, RMS Value, form Factor and Peak Factor for the wave shown in Figure 3.
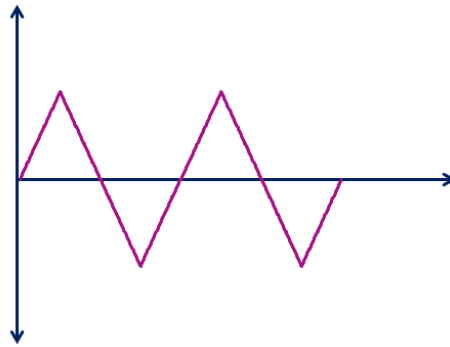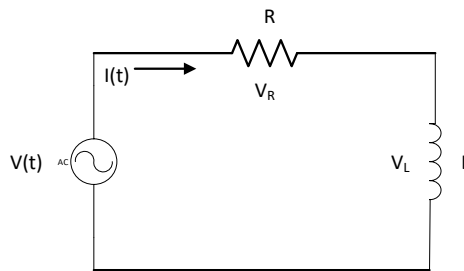
Figure 3. Tranguler wave

2. Sketch both sinusoidal and square waveforms on the same set of axes over two complete cycles and label the key points.

6. Exercises on Determination of Circuit Impedance

6.1 Impedance of series RL circuit

Determine the impedance of the series RL circuit shown in Circuit – 10 by considering V(t) = 5 V, R = 150 Ω and L = 10 mH.
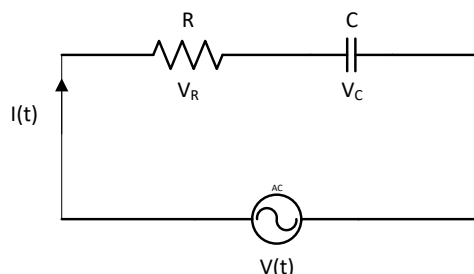

Circuit – 10

Try
1. Use Simulink to simulate the RL circuit response for Circuit – 10 and compare these values to those you obtained from your experiments.
2. Calculating the angular frequency (ω) of the AC source.
3. Sketch the phasor diagram for the RL circuit.

6.2 Impedance of series RC circuit

Determine the impedance of the series RC circuit shown in Circuit – 11 by considering V(t) = 5 V, R =150 Ω and C = 0.1 μF.
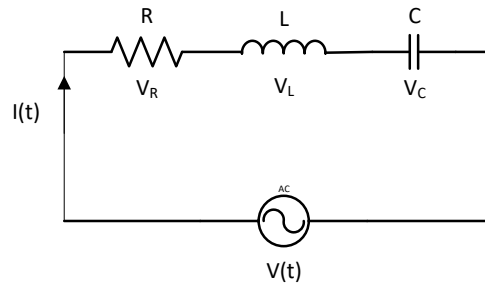

Circuit – 11

Try
1. Use Simulink to simulate the RC circuit response for Circuit – 11. Compare these values to those you obtained from your experiments.
2. Calculating the angular frequency (ω) of the AC source.
3. Sketch the phasor diagram for the RC circuit.

6.3 Impedance of series RLC circuit

Determine the impedance of the series RLC circuit shown in Circuit – 12 by considering V(t) = 5V, R = 150Ω, L = 10mH and C = 0.1µF.
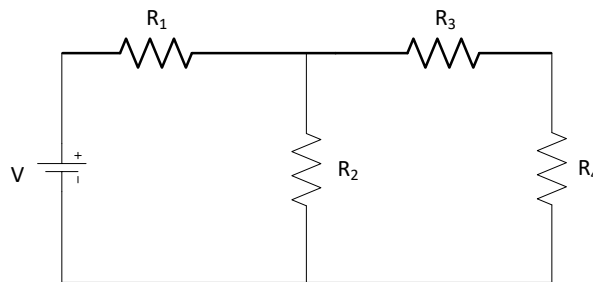

Circuit – 12

Try

1. Use Simulink to simulate the RLC circuit response for Circuit – 12 and compare these values to those you obtained from your experiments.
2. Calculating the angular frequency (ω) of the AC source.
3. For the RLC circuit, calculate the phase angle (ɸ) between the current and voltage.
4. Sketch the phasor diagram for the RLC circuit, representing the impedance, current, and voltage phasors.

7. Exercises on Thevenin's Theorem

1. Determine Thevenin's equivalent voltage (V_{th}) and resistance (R_{th}) at R_4 by applying Thevenin's theorem for Circuit – 13.
2. Determine load or unknown current through a R_4 resistor using Thevenin's equivalent circuit. Where
   V = 10V, R_1 = 100 Ω, R_2 = 220 Ω, R_3 = 1k Ω and R_4 = 150 Ω.

Circuit – 13

Try

1. Use Simulink to simulate the Circuit – 13 for determining the current thought R_4 resistor using Thevenin's theorem and compare this value to those you obtained from your experiment.
2. Find the current thought R_4 resistor using any circuit reduction technique and verify this value to those you obtained from Thevenin's theorem.
3. Find the current flowing through R_2 resistor in Circuit – 14 using Thevenin's theorem for the below circuit. Where V_1 = 10 V, V_2 = 5 V, R_1 = 100 Ω, R_2 = 220 Ω, R_3 = 1k Ω.
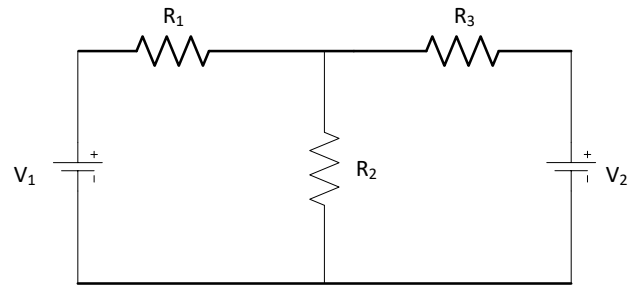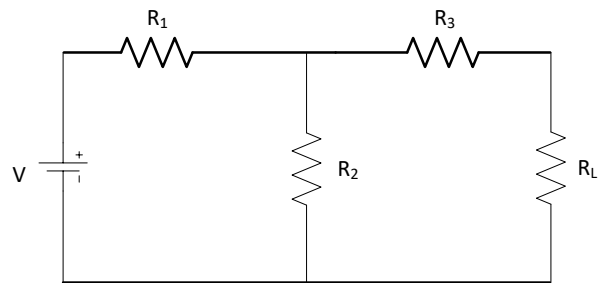
Circuit – 14

8. Exercises on Norton's Theorem

1. Find Norton equivalent current (I_N) and resistance (R_N) by considering R_L = 150 Ω resistor for the Circuit – 15 by applying Norton's theorem.
2. Find load or unknown current through R_L resistor using Norton's equivalent circuit. Where V = 10 V, R_1 = 100 Ω, R_2 = 220 Ω and R_3 = 1k Ω.
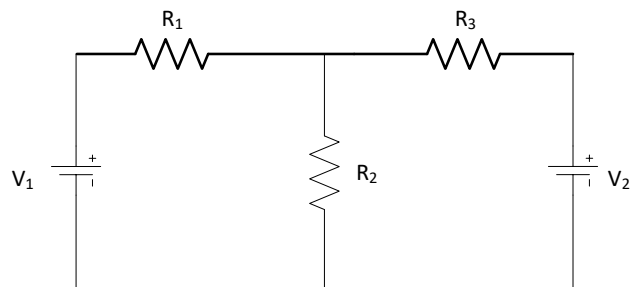

Circuit – 15

Try

1. Use Simulink to simulate the Circuit – 15 for determining the current through R_L resistor and compare this value to those you obtained from your experiment.
2. Find the current thought R_L using any circuit reduction technique and verify this value to those you obtained from Norton's theorem.

9. Exercises on Superposition Theorem

Investigate the current thought R_2 resistor using superposition theorem to multiple DC source Circuit – 16.
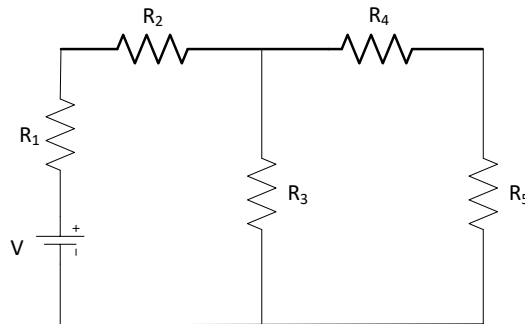

Circuit – 16

Try

1. Use Simulink to simulate the Circuit – 16 for determining the current through a resistor R_2 and compare this value to those you obtained from your experiment.
2. Find the current thought R_2 in Circuit – 16 using any circuit reduction technique and verify this value to those you obtained from the superposition theorem.
3. Find the current through the R_4 resistor using the superposition theorem for the Circuit – 17.
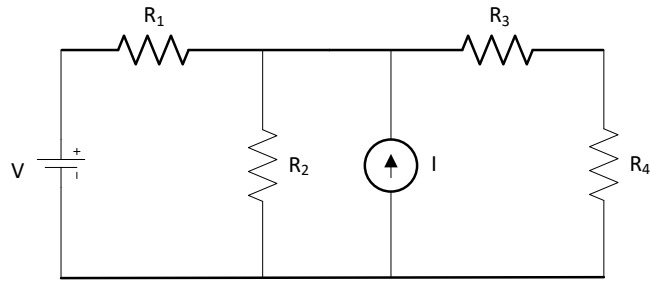
Circuit – 17

10. Exercises on Reciprocity Theorem

Understand the reciprocity theorem by analyzing Circuit – 18 with interconnected components using fundamental circuit laws where V = 10 V, R_1 = 100 Ω, R_2 = 220 Ω, R_3 = 1k Ω, R_4 = 150 Ω and R_5 = 82 Ω.
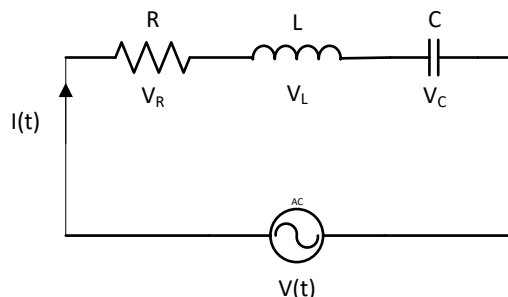

Circuit – 18

Try

1. Use Simulink to simulate Circuit–18 for determining the current through R_5 and R_1 by interchanging the voltage source in series with the R_5 resistor and compare this value to those you obtained from your experiment.
2. Find the current thought R_3 using Thevenin's theorem.

11. Exercise on Series and Parallel Resonance

11.1 Series resonance

Study the frequency response characteristics of series resonance circuit of Circuit – 19 and hence to determine the inductance, bandwidth and quality factor of the circuit. Where R = 1 kΩ, L = 10 mH, C = 0.1 μF.
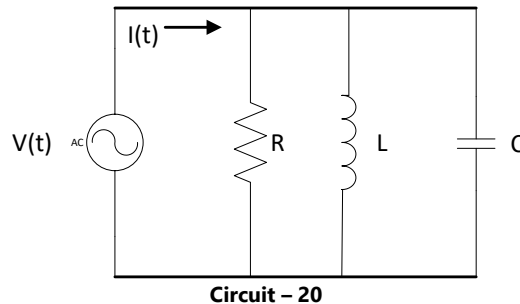

Circuit – 19

Try

1. Use Simulink to simulate Circuit–19 and plot the waveforms V_R, V_L and V_C verses frequency.
2. For series resonant circuit find I, V_R, V_L and V_C at resonance when V = 10 V, R = 2 Ω, X_L = 10 Ω and X_C = 10 Ω.
3. If the resonant frequency is 5000 Hz, find bandwidth.

11.2 Parallel resonance

Study the frequency response characteristics of parallel resonance circuit of Circuit – 20 and hence to determine the inductance, bandwidth and quality factor of the circuit. Where R = 1k Ω, L = 10 mH, C = 0.1 μF.


Circuit – 20

Try

1. Use Simulink to simulate parallel resonance circuit of Circuit – 20 and plot magnitude of response vs frequency. Considered the frequency range from 600 Hz to 2,500 Hz in increments of 100 Hz and compare with the experimental plot.

12. Exercise on Maximum Power Transfer Theorem

1. Find the value of R_L at which maximum power is transferred to the load in Circuit – 21.
2. Determine the maximum power transferred to the load. Where V = 10 V, R_1 = 100 Ω, R_2 = 220 Ω, R_3 = 1k Ω, R_4 = 150 Ω.
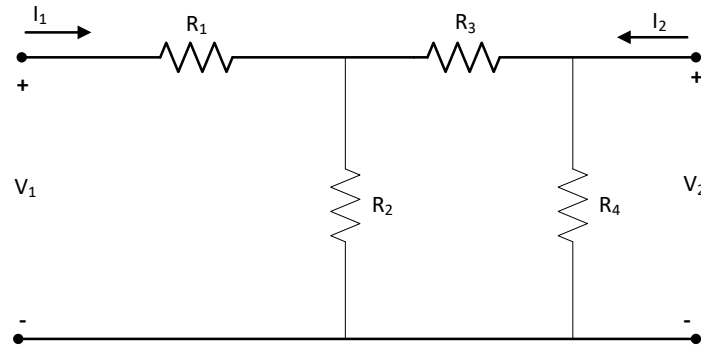

Circuit – 21
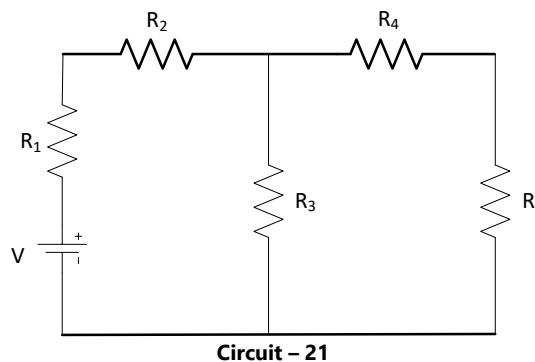
Try

1. If the internal resistance of a voltage source is adjustable, and the load resistor is fixed. Determine the range of source resistance values that will result in effective power transfer. Calculate the corresponding load power for each extreme of the source resistance range.
2. Use Simulink to simulate Circuit – 21 for determining the current thought R_L and compare this value to those you obtained from your experiment.

## 13. Exercise on Z and Y Parameters

Calculate Z-parameters and Y-parameters for Circuit – 22, and analyze the network's response to different conditions (open and short circuits). Where R_1 = 100 Ω, R_2 = 220 Ω, R_3 = 1k Ω and R_4 = 150 Ω.
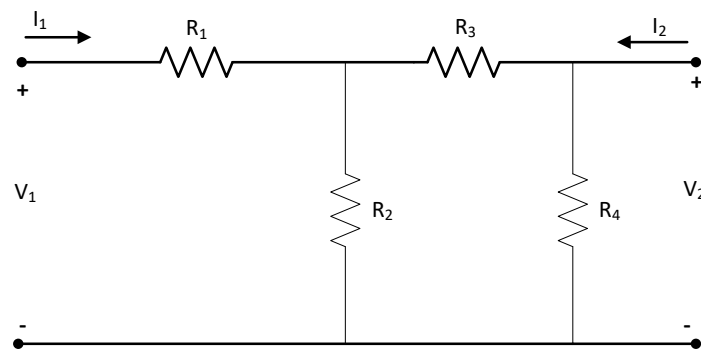
Circuit – 22

Try

1. Use Simulink to simulate Circuit–22 for determining the Z and Y parameters and compare the values to those you obtained from your experiment.

2. Calculate Z parameters and convert in terms of Y parameters for Circuit – 23. Where R_1 = 100 Ω, R_2 = 220 Ω, R_3 = 1k Ω, R_4 = 150 Ω and R_5 = 82 Ω.
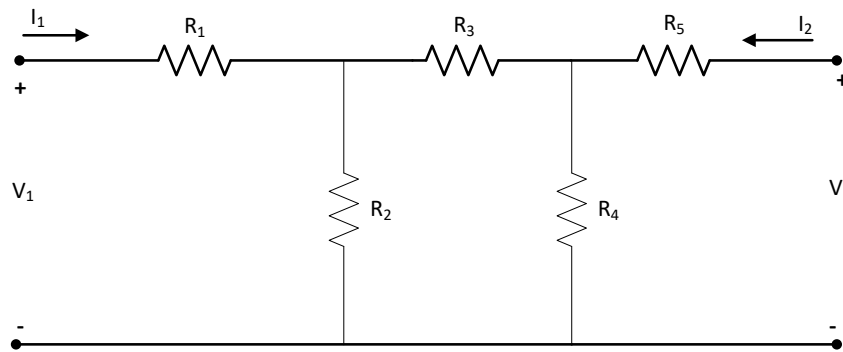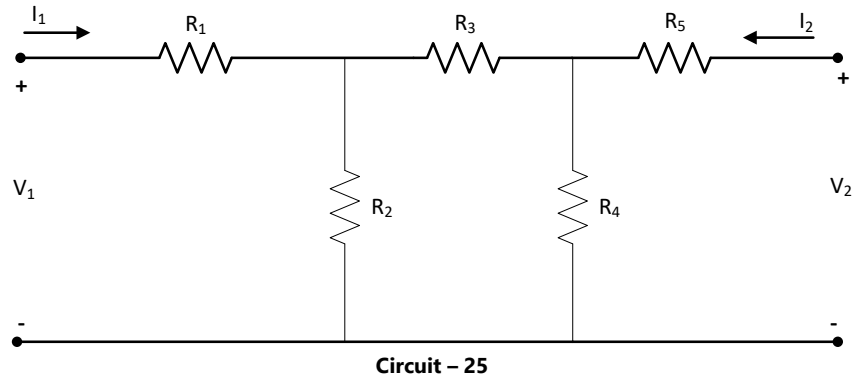

Circuit – 23

14. Exercise on H and ABCD Parameters

Calculate H and ABCD parameters for Circuit – 24, and analyze voltage gain and impedance transformation. Where R_1 = 100 Ω, R_2 = 220 Ω, R_3 = 1k Ω and R_4 = 150 Ω.

Circuit – 24

Try

1. Use Simulink to simulate Circuit – 24 for determining the H and ABCD parameters and compare the values to those you obtained from your experiment.

2. Calculate H parameters and convert in terms of Y parameters for Circuit – 25. Where R_1 = 100 Ω, R_2 = 220 Ω, R_3 = 1k Ω, R_4 = 150 Ω and R_5 = 82 Ω.

Circuit – 25

V. TEXT BOOKS:

1. A Chakrabarti, "*Circuit Theory*", Dhanpat Rai Publications, 8th Edition, 2021.
2. William Hayt, Jack E Kemmerly S.M. Durbin, "*Engineering Circuit Analysis*", Tata McGraw Hill, 9th Edition, 2020.

VI. REFERENCE BOOKS:

1. CL Wadhwa, *Electrical Circuit Analysis including Passive Network Synthesis*, International, 2nd Edition, 2009.
2. David A Bell, *Electric circuits*, Oxford University Press, 7th Edition, 2009.

VII. ELECTRONICS RESOURCES:

1. https://www.allaboutcircuits.com/textbook/
2. https://onlinecourses.nptel.ac.in/noc22_ee93/preview
3. https://www.iare.ac.in

VIII. MATERIALS ONLINE

1. Course template
2. Lab manual