BSc in Electrical and Electronics Engineering
Course Title: Electrical Circuit –I Sessional
Course Code: EEE 0713-1102

OBE
Curriculum

Department of Electrical & Electronics Engineering
University of Global Village (UGV), Barishal

Part C – Description of all Courses

Course Code: EEE-0713-1102	**Credit: 1**
	CIE Marks: 30
Semester End Exam (SEE) Hours: 3 hrs.	**SEE Marks:** 20

Course learning outcomes (CLO): After successful completion of the course students will be able to -

CLO-1	Conduct experiments on simple dc circuits.
CLO-2	Use different measuring instruments like ammeter, voltmeter and wattmeter.
CLO-3	Analyze different circuit concepts and theorems.
CLO-4	Practical application and evaluation of electrical parameters in different circuit configurations.

Sl.	Content of Course	Hrs	CLOs
1	Identification, connection, and measurement techniques using various electrical instruments (e.g., VM, AM, Multimeter, Galvanometer, WM, Energy meter, etc.).	20	CLO2
2	Verification of fundamental electrical laws and circuit behaviors: Ohm's Law, KVL, KCL, and characteristics of series, parallel, and mixed circuits.	20	CLO1, CLO3
3	Analysis and validation of circuit theorems: Thevenin's, Norton's, Superposition, and Maximum Power Transfer Theorems.	25	CLO2, CLO3, CLO4
4	Practical application and evaluation of electrical parameters in different circuit configurations.	20	CLO1, CLO5

ASSESSMENT PATTERN

CIE- Continuous Internal Evaluation (30 Marks)

Bloom's Category Marks (out of 30)	Tests (20)	Quiz (10)	External Participation in Curricular/Co-Curricular Activities (20)
Imitation	06	06	Bloom's Affective Domain: (Attitude or will) Attendance: 10 Viva-Voca: 5 Report Submission: 5
Manipulation	04	04	
Precision	06		
Articulation	02		
Naturalization	02		

SEE- Semester End Examination (20 Marks)

Bloom's Category	Tests
Imitation	12
Manipulation	8
Precision	6
Articulation	2
Naturalization	2

Electrical Circuit I Sessional (EEE 0713-1102)

1 Credit Course

Class:	**17 weeks (1 classes per week)** **Total Class Duration: 2 hrs.** **Total Practice Duration: 3 hrs.** **Total=85 Hours**
Preparation Leave (PL):	02 weeks
Exam:	04 weeks
Results:	02 weeks
Total:	**25 Weeks**

Attendance:

Students with more than or equal to 70% attendance in this course will be eligible to sit for the Semester End Examination (SEE). SEE is mandatory for all students.

SYNOPSIS / RATIONALE

This course is offered to the students to develop practical concepts of Electrical Parameters, variables, theorems related to DC and AC analysis and different measuring instruments.

Course Objective

- Understand basic electrical circuit concepts and laws.
- Analyze simple resistive circuits using Ohm's Law and Kirchhoff's Laws.
- Apply nodal and mesh analysis techniques to analyze complex circuits.
- Learn the use of circuit simulation software for analysis and design.
- Develop skills in troubleshooting and debugging electrical circuits.

Outline of Course

1	Identification of electrical measuring instruments, use, connection procedure & measuring with VM, AM, ΩM, Multi meter, Galvanometer, WM, Energy meter, Pf meter, Frequency meter, Temperature meter.
2	Verification of Ohm's Law.
3	Verify the characteristics of series circuit.
4	Verify the characteristics of parallel circuit.
5	Verification of Characteristics of Series-Parallel or Mixed Circuit
6	Verify Kirchhoff's voltage law (KVL).
7	Verify Kirchhoff's current law (KCL).
8	Verify Thevenin's Theorem.
9	Verify Norton's Theorem.
10	Verify Superposition Theorem.
11	Verify Maximum Power Transfer Theorem.

Course Schedule

Week	Topic	Teaching Learning Strategy	Assignment Strategy	Corresponding CLOs
1-2	Identification of electrical measuring instruments, use, connection procedure & measuring with VM, AM, ΩM, Multi meter, Galvanometer, WM, Energy meter, Pf meter, Frequency meter, Temperature meter.	Lecture, Demonstration	Report writing, Quiz	CL01, CLO2, CLO3
3-4	Verification of Ohm's Law.	Lecture, Group discussion	Report writing, Quiz	.CLO 1
5	Verify the characteristics of series circuit.	Lecture, Demonstration, Group discussion	Report writing, Quiz	CLO1
6	Verify the characteristics of parallel circuit.	Lecture, Demonstration, Discussion	Report writing, Quiz	CLO1
7	Verification of Characteristics of Series-Parallel or Mixed Circuit	Lecture, Demonstration, Group discussion	Report writing, Quiz	CLO1, CLO2

Course Schedule

Week	Topic	Teaching Learning Strategy	Assignment Strategy	Corresponding CLOs
8	Verify Kirchhoff's voltage law (KVL).	Lecture, Demonstration, Group discussion	Viva , Quiz	CLO1, CLO2
9	Verify Kirchhoff's current law (KCL).	Lecture, Demonstration	Report writing, Quiz	CLO1, CLO2
10-11	Verify Thevenin's Theorem.	Lecture, Demonstration, Video presentation	Report writing, Quiz	CLO1, CLO2, CLO3
12-13	Verify Norton's Theorem.	Lecture, Demonstration, Oral presentation	Report writing, Quiz	CL01, CLO2
14	Verify Superposition Theorem.	Lecture, Demonstration, Discussion	Report writing, Quiz	CLO1, CLO3

Course Schedule

Week	Topic	Teaching Learning Strategy	Assignment Strategy	Corresponding CLOs
15	Verify Maximum Power Transfer Theorem.	Lecture, Demonstration, Group discussion	Viva , Quiz	CLO2, CLO3
16	Review Class	Demonstration, Group Discussion	Quiz	CL01, CLO2, CLO3, CLO4
17	Lab Quiz	Lecture, Demonstration, Discussion	Report writing, Quiz	CLO1, CLO3

Experiment 1: Identification of electrical measuring instruments, use, connection procedure & measuring with VM, AM, ΩM, Multi meter, Galvanometer, WM, Energy meter, Pf meter, Frequency meter, Temperature meter.

Objective:

To identify different electrical measuring instruments, understand their usage, connection procedures, and measure electrical quantities using:

1. Voltmeter (VM)
2. Ammeter (AM)
3. Ohmmeter (ΩM)
4. Multimeter
5. Galvanometer
6. Wattmeter (WM)
7. Energy Meter
8. Power Factor (Pf) Meter
9. Frequency Meter
10. Temperature Meter

Apparatus Required:

- Voltmeter
- Ammeter
- Ohmmeter
- Multimeter
- Galvanometer
- Wattmeter
- Energy Meter
- Power Factor Meter
- Frequency Meter
- Temperature Meter
- Resistor (various values)
- Power supply
- Connecting wires

Theory:

Each measuring instrument has a specific purpose in an electrical circuit:

- **Voltmeter**: Measures voltage across a component.
- **Ammeter**: Measures current through a circuit.
- **Ohmmeter**: Measures resistance of a component.
- **Multimeter**: Combines functionalities of Voltmeter, Ammeter, and Ohmmeter.
- **Galvanometer**: Measures small currents, typically used in null-balance circuits.
- **Wattmeter**: Measures power consumption of a circuit.
- **Energy Meter**: Measures energy consumed over time.
- **Pf Meter**: Measures the power factor of an AC circuit.
- **Frequency Meter**: Measures the frequency of an AC signal.
- **Temperature Meter**: Measures the temperature, often using thermocouples.

Procedure:

1. **Identification**:
   - Observe each instrument and note its distinguishing features (scale, markings, terminals, etc.).
2. **Connection Procedure**:
   - Connect each instrument according to its intended use:
     - **Voltmeter**: Parallel to the circuit element.
     - **Ammeter**: Series with the circuit.
     - **Ohmmeter**: Across the component when disconnected from the circuit.
     - **Wattmeter**: Follow the wattmeter's manual for current coil and potential coil connections.
     - **Energy Meter**: Insert into the power line to measure cumulative energy.
     - **Pf Meter**: Connect as per the manual to measure the phase angle between voltage and current.
     - **Frequency Meter**: Connect to the output terminals of an AC signal source.
     - **Temperature Meter**: Place the sensor in the medium to be measured.
3. **Measurement**:
   - Record the measurements for voltage, current, resistance, power, energy, power factor, frequency, and temperature using appropriate instruments.
   - Note the accuracy and range of each instrument.

Observation Table:

Instrument	Measured Quantity	Range	Reading	Connection Type
Voltmeter	Voltage (V)	0–300 V		Parallel
Ammeter	Current (A)	0–10 A		Series
Ohmmeter	Resistance (Ω)	0–100 kΩ		Across Component
Multimeter	Multiple	0–		Various
Galvanometer	Current (mA)	0–5 mA		Series/Null-Balance
Wattmeter	Power (W)	0–1 kW		Series/Parallel
Energy Meter	Energy (kWh)	0–10 kWh		Series
Pf Meter	Power Factor	0–1		Series/Parallel
Frequency Meter	Frequency (Hz)	50–60 Hz		Parallel
Temperature Meter	Temperature (°C)	0–100 °C		As per Manual

Calculations:

- Use the formulas associated with the measured quantities (Ohm’s Law, Power = Voltage × Current, etc.).

Results:

- Summarize the observations, highlighting any discrepancies or insights into instrument accuracy.

Viva Questions:

1. What is the purpose of a galvanometer, and how does it differ from an ammeter?
2. Why is a voltmeter connected in parallel while an ammeter is connected in series?
3. What is the significance of the power factor in an AC circuit?
4. How does a temperature meter function using thermocouples?

Experiment No: 02 **Date: ....** **Time: 120 Minuit**

Experiment Name: Verification of Ohm's Law.

Introduction: In 1828, German scientist Georg Simon Ohm discovered this formula. The formula is named Ohm's Law after him. The formula is considered as the basic formula in electrical circuits. This formula can be used to determine the relationship and value between current, voltage and resistance. If the characteristic lines of voltage, current and resistance are drawn, it can be seen that the value of resistance follows a straight line which is characteristic of constant value. However, this will not apply to all nonmetallic conductors such as silicon carbide, nonlinear devices such as zener diodes, etc. Because in all these cases the current flow characteristics change.

Objectives:

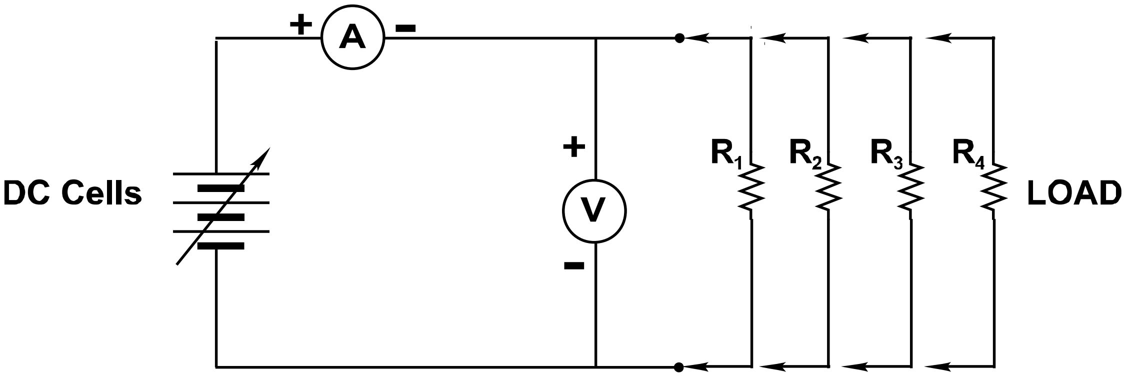
(1) To verify the truth of Ohm's law.
(2) Know how to construct the circuit by connecting source, ammeter, voltmeter, load.
(3) To know the method of proving Ohm's law from the data obtained.

Theory: A constant number is the ratio of the value of the potential difference between two points of a conductor to the value of the current flowing through the points at constant temperature.
I.e $\frac{V}{I}=$ Constant or $\frac{V}{I}=R$ Constant where R is the value of resistance between the two points of the conductor.

Required instrument and materials:

1. DC Circuit/ Network Trainer Board...............................1nos.
2. Digital Multi-meter……………………………………2nos.
3. Dry cell, D-D size, 1.5 Volt.. 3nos.
4. Battery Case (for three cells)………………………….1nos.
5. Jumper with crocodile clip……………………………10nos.

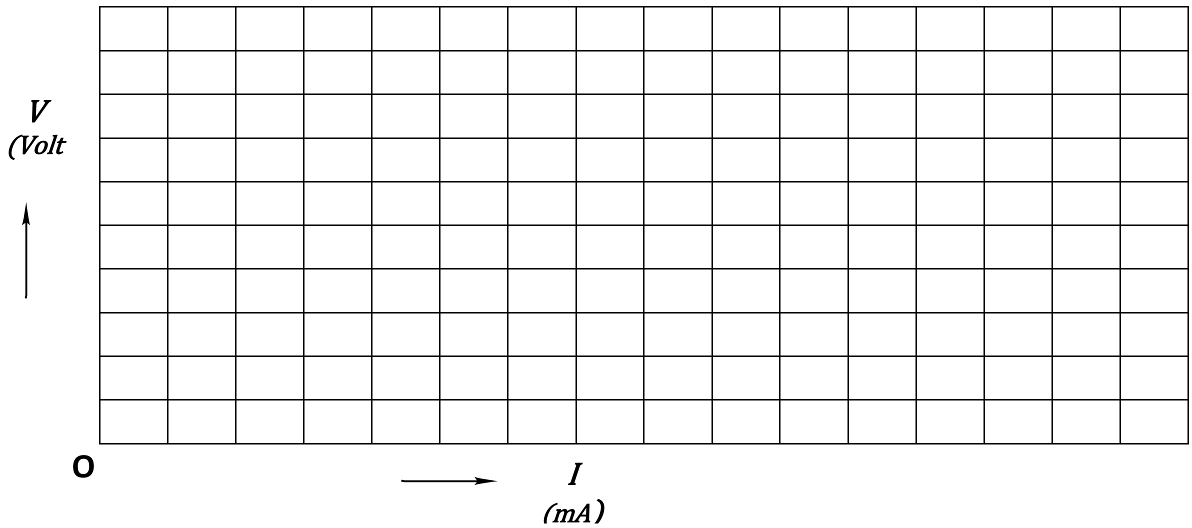
Circuit Diagram:



Data Sheet:

Obs. No.	For R_1 (Ω)		For R_2 (Ω)		For R_3 (Ω)		For R_4 (Ω)		Remark
	Voltage	Current	Voltage	Current	Voltage	Current	Voltage	Current	
1									
2									
3									

Feature lines:



Plot the relationship between voltage, current and resistance from the data obtained.

Work steps:

1. Collect the necessary equipment and materials and connect the meters and loads according to the circuit diagram and polarity.
2. The ammeter should be connected in series and the voltmeter in parallel with the load in the circuit.

3. When using multimeter as ammeter and voltmeter, proper scale with adjustment should be selected.
4. Again, instead of R1 resistance, R2 resistance should be connected and the ammeter reading should be placed in the data sheet by applying the same voltage as in step 4 above.
5. Again, instead of R2 resistance, R3 resistance should be connected and the ammeter reading should be placed in the data sheet by applying the same voltage as in the previous step 4.
6. Again, instead of R3 resistance, R4 resistance should be connected and the reading of the ammeter should be placed in the data sheet by applying the same voltage as in the previous step 4.

Caution:

(1) It should be noted that the +ve and -ve port leads of the meter are properly connected.

(2) Care should be taken to avoid short circuit at all times.

(3) In order to avoid unnecessary battery depletion, the battery should be connected only during reading and disconnected immediately after reading.

(4) At least 5 Watt or 10 Watt ceramic resistance should be used so that it does not get hot even if the current flows in the resistance.

(5) Correct quality meter should be selected.

(6) If a multimeter is used, a specific scale should be selected.

(7) Care should be taken to connect according to polarity.

(8) Meter reading should be taken vertically to avoid optical illusion.

(9) Each connection should be given firmly in order to obtain correct results.

(10) After completing the connection process, the circuit should be checked before supplying.

Conclusion: (Write yourself)

Experiment No: 03 **Date: ....** **Time: 120 Minuit**

Experiment Name: Verification of Characteristics of Series Circuit.

Introduction: Even though the current is equal in all parts of a series circuit, the supplied voltage is divided among different loads. Series circuits are used wherever voltage is to be regulated or divided. For example- lighting decoration, use of regulator in ceiling fan control, use of choke coil in tube light etc. It is easy to control the voltage of a load if the series circuit characteristics are known.

Objectives:

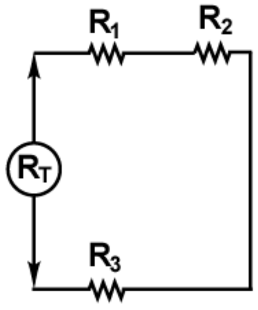
(1) To know how to construct a series circuit and how to connect the source.
(2) To determine the properties of series circuit ie relationship of total voltage and voltage per load, relationship of total current and current per load, relationship of total resistance and resistance per load etc.

Theory: If multiple loads are connected in a circuit in such a way that there is only one path of current flow and the same amount of current flows through all the resistors. But it is called series circuit. The characteristics of current, voltage and resistance of the series circuit are given mathematically- $I_T=I_1=I_2=.........= I_N$, $V_T=V_1+V_2+...+V_N$, $R_T=R_1+R_2+R_3....+R_N$

Required instrument and materials:

1. Trainer Board--- 1nos.
2. Digital Multi-meter--- 1nos.
3. Dry cell, D-D size, 1.5 Volt----------------------------------- 3nos.
4. Battery case (for three cells) ---------------------------------- 1nos.
5. Jumper with crocodile clip ------------------------------------ 10nos.

Circuit diagram:



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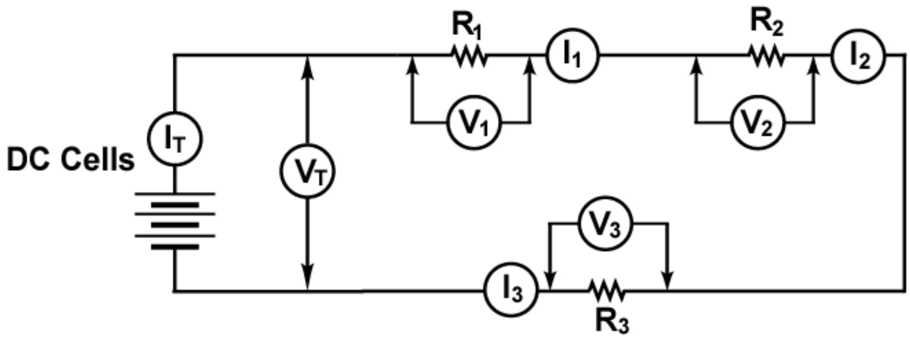


fig - b

Data Sheet:

OBS NO	V_T	V_1	V_2	V_3	$V_{CAL}= V_1+V_2+V_3$	% Error= $(\frac{V_T - V_{CAL}}{V_T})\times 100$	Remarks
1							
2							

OBS NO	R_T	R_1	R_2	R_3	$R_{CAL}= R_1+R_2+R_3$	% Error= $(\frac{R_T - R_{CAL}}{R_T})\times 100$	Remarks
1							
2.							

OBS NO	I_T	I_1	I_2	I_3	Remarks
1					
2					

Work steps:

(1) After collecting the necessary equipment and materials, the value of each resistance should be measured separately with the help of Ohm meter in order to observe the characteristics of the resistance.
(2) Now connect the resistances in series according to fig-a, and measure the total resistance and put it on the data sheet to verify the truth of the formula of resistance.
(3) Now connect the meters and loads according to the polarity of the circuit diagram fig-b.
(4) Ammeter should be in series and voltmeter in parallel with the load in the circuit.
(5) If multi-meter is used instead of ammeter and voltmeter, proper scale should be selected and pointer should be zero adjusted if necessary.
(6) Check whether the circuit is correct before supplying the circuit.

(7) The meter readings should be taken correctly and placed on the data sheet.
(8) Complete the data sheet by making necessary calculations.

Precautions:

(1) If multi-meter is used, specific scale should be used.
(2) Ammeters in series, voltmeters must be connected in parallel.
(3) Care must be taken to connect according to polarity.
(4) Meter reading should be taken vertically to avoid optical illusion.
(5) Each connection should be given firmly in order to obtain correct results.

Conclusion: (Write yourself)

Experiment No: 04 **Date: ....** **Time: 120 Minuit**

Experiment Name: Verification of Characteristics of Parallel Circuit.

Introduction: As each load in a parallel circuit receives a voltage equal to the supply voltage, the loads can operate at their full capacity. Moreover, as each load can be controlled separately, this circuit is used in almost all places including homes, offices-courts, and factories etc.

Objectives:

(1) To know how to construct a parallel circuit and how to connect the source.

(2) To determine the characteristics of parallel circuits ie relationship of total voltage and voltage per load, relationship of total current and current per load, relationship of total resistance and resistance per load etc.

Theory: If multiple loads are connected in a circuit in such a way that one end of each load is connected to a specific point and the other end is connected to another specific point and current can flow through each load separately, then this type of circuit is called a parallel circuit. In case of parallel circuit-

$I_T=I_1+I_2+.......+ I_N$, $V_T=V_1=V_2= ....=V_N$, $\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}+......+\frac{1}{R_N}$, **or** $R_T= ((R_1^{-1}+ R_2^{-1}+.....+ R_n^{-1}))^{-1}$

Necessary equipment and goods:

1. Trainer Board--- 1nos.
2. Digital Multi-meter-- 1nos.
3. Dry cell, D-D size, 1.5 Volt---------------------------------- 3nos.
4. Battery case (for three cells) --------------------------------- 1nos.
5. Jumper with crocodile clip ----------------------------------- 10nos.

Circuit diagram:

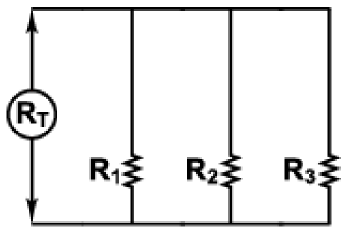


fig-a

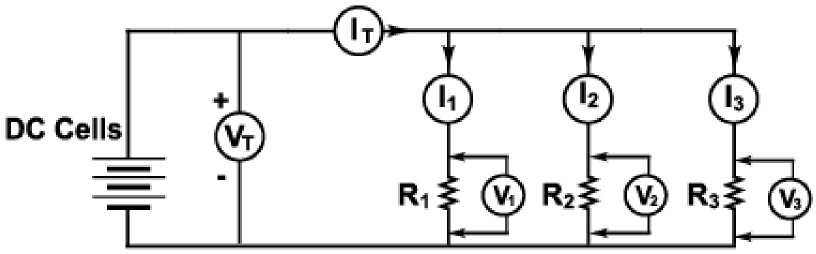


fig-b

Data Sheet:

OBS NO.	I_T	I_1	I_2	I_3	$I_{CAL}=I_1+I_2+I_3$	% Error = $(\frac{I_T - I_{CAL}}{I_T})\times 100$	Remarks
1							
2							

OBS NO.	R_T	R_1	R_2	R_3	$R_{CAL}=\frac{1}{\frac{1}{R1}+\frac{1}{R2}+\frac{1}{R3}}$	% Error= $(\frac{R_T - R_{CAL}}{R_T})\times 100$	Remarks
1							
2							

OBS NO.	V_T	V_1	V_2	V_3	Remarks
1					
2					

Work steps:

(1) After collecting the necessary equipment and materials, the value of each resistance should be measured separately with the help of Ohm meter in order to observe the characteristics of the resistance.
(2) Now connect the resistances in parallel as per Fig-a and measure the total resistance and put it on the data sheet to verify the truth of the formula of resistance.
(3) Now connect the meters and loads according to the polarity of the circuit diagram fig-b.
(4) Ammeter should be in series and voltmeter in parallel with the load in the circuit.
(5) If multimeter is used instead of ammeter and voltmeter, proper scale should be selected and pointer should be zero adjusted if necessary.
(6) Check whether the circuit is correct before supplying the circuit.

(7) The meter readings should be taken correctly and placed on the data sheet.
(8) Complete the data sheet by making necessary calculations.

Precautions:

(1) If multi-meter is used, specific scale should be used.
(2) Ammeters in series, voltmeters must be connected in parallel.
(3) Care must be taken to connect according to polarity.
(4) Meter reading should be taken vertically to avoid optical illusion.
(5) Each connection should be given firmly in order to obtain correct results.

Conclusion: (Write yourself)

Experiment No: 05 **Date: ....** **Time: 120 Minuit**

Experiment Name: Verification of Characteristics of Series-Parallel or Mixed Circuit

Introduction: The use of series-parallel or mixed circuits is often seen inside an apparatus. Even if the voltage supplied to a complete device is the same, different values of voltage may operate at different locations inside. A combination of multiple simple circuits leads to a complex state. In this experiment, an attempt will be made to prove the characteristics of series-parallel or mixed circuits by a simple circuit. Where there will be only a few resistances and only one source.

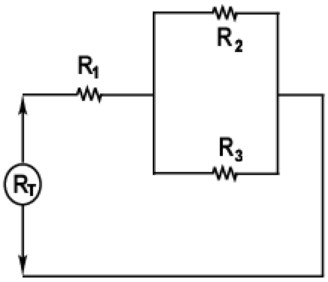
Objectives:
(1) To identify series-parallel or mixed circuits.
(2) Know the method of measuring the voltage drop and current of each resistor.

Theory: A circuit in which some resistances are connected in series and some resistances are connected in parallel is called a series-parallel or mixed circuit - in this case the total resistance of the circuit will be the equivalent value of all the resistances and the total current will be $I_T = \frac{V_T}{R_T}$.

The value of the voltage drop and current flowing across each resistor will be according to the value and position of the resistance described in the circuit.

Necessary equipment and goods:
1. Trainer Board-- 1nos.
2. Digital Multi-meter--- 1nos.
3. Dry cell, D-D size, 1.5 Volt----------------------------------- 3nos.
4. Battery case (for three cells) ---------------------------------- 1nos.
5. Jumper with crocodile clip ------------------------------------ 10nos.

Circuit diagram:



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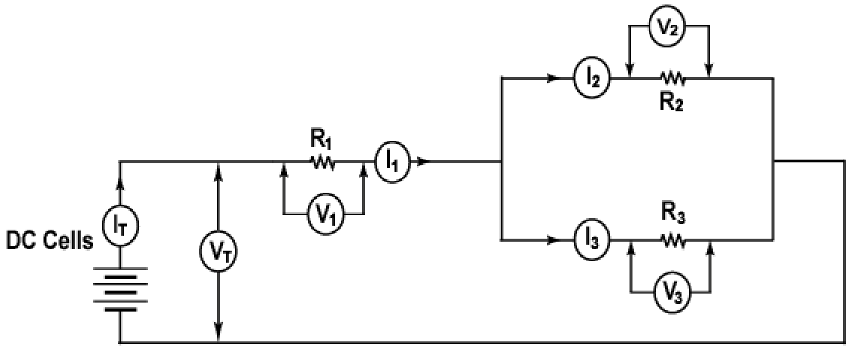


fig - b

Data Sheet:

	Measured Value				**Calculated Value**	**% Error=**	**Remarks**
OBS NO	**$I_{T(meas)}$**	**I_1**	**I_2**	**I_3**	**$I_{T(cal)}$**	$\left(\frac{I_{T(meas)} - I_{T(Cal)}}{I_{T(Cal)}}\right)\times 100$	
1							
2							

OBS NO	**Measured Value**				**Calculated Value**		
	$R_{T(meas)}$	**R_1**	**R_2**	**R_3**	**$R_{T(cal)}$**	**% Error=** $\left(\frac{R_{T(meas)} - R_{T(Cal)}}{R_{T(Cal)}}\right)\times 100$	**Remarks**
1							
2							

OBS NO.	**Measured Value**				**Calculated Value**	**% Error=**	**Remarks**
	$V_{T(meas)}$	**V_1**	**V_2**	**V_3**	**$V_{T(cal)}$**	$\left(\frac{V_{T(meas)} - V_{T(Cal)}}{V_{T(Cal)}}\right)\times 100$	
1							
2							

Work steps:

(1) After collecting the necessary equipment and materials, the value of each resistance should be measured separately with the help of Ohm meter in order to observe the characteristics of the resistance.

(2) Now connect the resistances according to fig:a and measure the total resistance and put it on the data sheet to verify the truth of the formula of resistance.

(3) Now connect the meters and loads according to the polarity of the circuit diagram fig:b. (4) Ammeter should be in series and voltmeter in parallel with the load in the circuit.

(5) If multi-meter is used instead of ammeter and voltmeter, proper scale should be selected and pointer should be zero adjusted if necessary.
(6) Check whether the circuit is correct before supplying the circuit.
(7) The meter readings should be taken correctly and placed on the data sheet.
(8) Complete the data sheet by making necessary calculations.

Precautions:
(1) If multi-meter is used then precision scale should be used.
(2) Ammeters in series, voltmeters must be connected in parallel.
(3) Aim to connect according to polarity.
(4) Meter reading should be taken vertically to avoid optical illusion.
(5) Each connection should be given firmly to obtain correct results.

Conclusion: (Write yourself)

Experiment No: 06 **Date: ....** **Time: 120 Minuit**

Experiment Name: Verification of Kirchhoff's Voltage Law (KVL).

Introduction: Any combination of sources of electrical energy, resistances and other circuit elements is called an electrical network. Generally, the value of current in a circuit with one source is determined using Ohm's law, but it is not possible to apply Ohm's law where there is more than one source. One of the methods used in such places is Kershoff's formula. One of the two laws of German physicist Gustav Kershoff is called Kirshoff's current law (for short KCL), and the other is Kershoff's voltage law (for short KVL). This formula is widely used to determine the current of any branch of the electrical network, So we will discuss the Kershoff's voltage law (for short KVL) here.

Objectives: Monitoring the voltage source of electrical networks with multiple sources.

Theory:
Kershoff's 2nd Law or Kershoff's Voltage Law- Algebraic sum of all emf and voltage drop in a closed loop of a network is zero i.e. ΣσE= ΣσIR where Σ is the sign of the combined value, E=EMF, IR=Voltage drop, σ =Closed path. The formula can be summarized as the sum of potential rise and drop in a closed loop is zero.

Required instruments & materials:
1. Trainer set............................. 1 no.
2. Digital multimeter...................1 no.
3. Dry cell, size D-D, 1.5V..........4 nos.
4. Battery case for 3 cells...........1 no.
5. Battery case for 1 cell.............1 no.
6. Jumper with crocodile clip.....According to necessary

Circuit diagram:

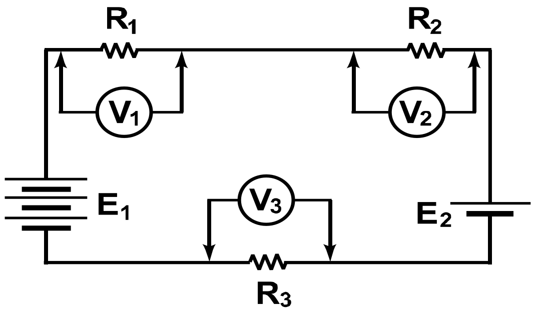


Fig-a

Data Sheet:

OBS NO.	**E_1 (volt)**	**E_2 (volt)**	**$\sum E$**	**IR_1 (volt)**	**IR_2 (volt)**	**IR_3 (volt)**	**$\sum IR$ (Volt)**	**% Error** $\frac{\sum E - \sum IR}{\sum E} \times 100$	**Remark**
1									**KVL**
2									

Work steps:

1. To prove KVL, the circuit should be made by looking at the polarity of the source, fig-a.
2. Measure the emf of each source and the voltage drop of each load while the circuit is in operation and enter the data.
3. Prove Kershoff's voltage formula by calculating the total emf (ΣE) and the total voltage drop (ΣIR). Reverse the direction of the source E_2 and solve No. 7 and 8 once again and place in the OBS NO-2.

Precautions:

1. Complete circuit should be arranged with EMF source off.
2. Meters should be installed at appropriate places.
3. Try to take as short but accurate reading as possible so as not to drain the battery unnecessarily.
4. The same meter can be used in different parts to get the correct value.
5. Care should be taken that the cells are never directly connected (short circuit).

Conclusion: (Write yourself)

Experiment No: 07 **Date: ....** **Time: 120 Minuit**

Experiment Name: Verification of Kirchhoff's Current Law (KCL).

Introduction: Any combination of sources of electrical energy, resistances and other circuit elements is called an electrical network. Generally, the value of current in a circuit with one source is determined using Ohm's law, but it is not possible to apply Ohm's law where there is more than one source. One of the methods used in such places is Kershoff's formula. One of the two laws of German physicist Gustav Kershoff is called Kirshoff's current law (for short KCL), and the other is Kershoff's voltage law (for short KVL). This formula is widely used to determine the current of any branch of the electrical network, So we will discuss the Kershoff's current law (for short KCL) here.

Objectives:
(1) To observe Kershoff's current law.

Theory:
Kershoff's 1st Law or Kershoff's Current Law - The sum of the total incoming currents at any junction point in an electrical network will be equal to the sum of the total outgoing currents. In other words, the algebraic sum of the currents at any junction point in a network is zero. That is $\Sigma I_{incoming} = \Sigma I_{outgoing}$

Required instruments & materials:
1. Trainer set.............................. 1 no.
2. Digital multimeter...................1 no.
3. Dry cell, size D-D, 1.5V..........4 nos.
4. Battery case for 3 cells...........1 no.
5. Battery case for 1 cell.............1 no.
6. Jumper with crocodile clip.....According to necessary

Circuit diagram:

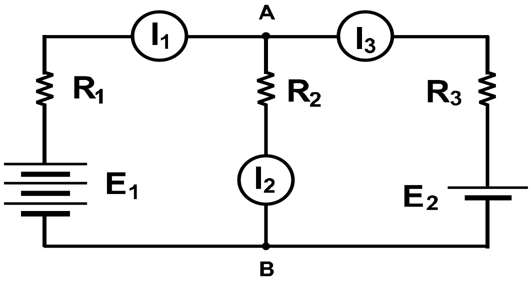


fig - a KIRCHHOFF'S CURRENT LAW

Data Sheet:

OBS NO	I_1 (mA)	I_2 (mA)	I_3 (mA)	$\sum I_{in}$ (mA)	$\sum I_{out}$ (mA)	% Error $\frac{\sum I_{in} - \sum I_{out}}{\sum I_{in}} \times 100$	Remark
1							**KCL**
2							

Work steps:

1. After collecting the necessary equipment and materials for KCL tests, the circuit should be made according to the circuit diagram by observing the polarity of the source and the meter as shown in the diagram. fig: a.
2. A junction point should be fixed for testing convenience (point A).
3. The value of incoming current and outgoing current at the junction point should be placed separately in the data.
4. The sum of incoming currents and outgoing currents must be verified to verify the validity of Kershoff's current formula.
5. Reversing the direction of the upper direction of the E2 source and again solving No. 3 and 4, the should be placed in the OBS NO-2.

Precautions:

1. Complete circuit should be arranged with EMF source off.
2. Meters should be installed at appropriate places.
3. Try to take as short but accurate reading as possible so as not to drain the battery unnecessarily.
4. The same meter can be used in different parts to get the correct value.
5. Care should be taken that the cells are never directly connected (short circuit).

Conclusion: (Write yourself)

Experiment No: 08 **Date: ....** **Time: 120 Minuit**

Experiment Name: Verification of Thevenin's Theorem.

Introduction: Determining or calculating the current in any branch of a multi-source linear (i.e. parameter value that does not change as a result of changes in voltage and current), bilateral (i.e. current can flow equally in both directions) networks is quite complicated. In 1883 with the help of the theorem given by the French engineer M.L Thevenin, it is possible to solve it in a very simple process, even if the network is of a very complex structure. He proved that it is possible to visualize a complex network as a simple circuit with two terminals of a single emf and a single series resistance, so that the load current can be determined in a very short time. This theorem applies to both AC and DC, but for DC, R_{th} will be and for AC, Z_th will be provided here to prove the theorem.

Objectives:

(1) To prove that it is possible to transform a complex network into a simple circuit with a single source.
(2) Prove that it is possible to reduce a complex network to a single resistance circuit.
(3) To determine the direction of current of any branch (load) of a complex network with the help of Thevenin's theorem.

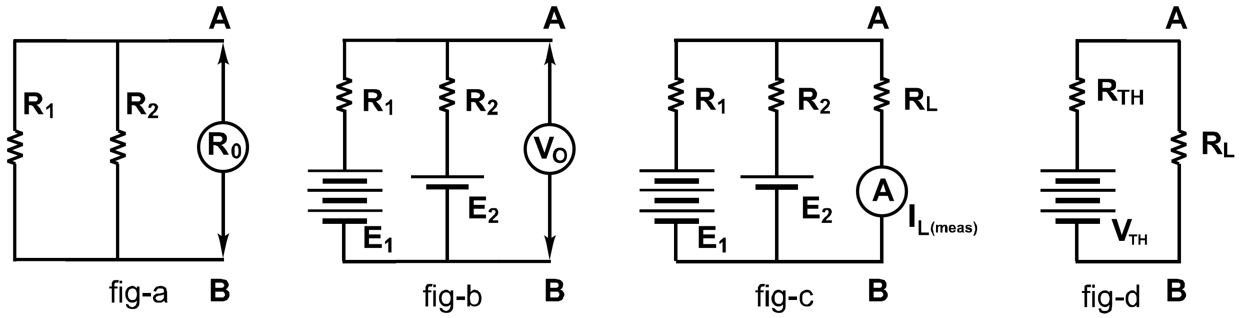
Theory: An A and B two-terminal linear, bilateral, DC network is replaceable by a single emf source (E_{th}) and a series resistance (R_{th}).

<u>Thevenizing:</u> In this condition, when the load resistance of A and B ends is open, the voltage of those ends will be V_o which should be equal to V_{th} and the resistance found between A and B ends will be R_o which should be taken as R_{th}. When measuring the resistance R_o=R_{th} any emf source should be opened and shorted but the internal resistance of the source will be substituted in place of the source. And if there is a current source, it should be caught open circuit but the resistance that is parallel to the current source will remain in place.

Required instruments & materials:

1. Trainer set............................ 1 no.
2. Digital multi-meter..................1 no.
3. Dry cell, size D-D, 1.5V.........4 nos.
4. Battery case for 3 cells...........1 no.
5. Battery case for 1 cell.............1 no.
6. Jumper with crocodile clip.....According to necessary

Circuit Diagram:



Data Sheet:

OBS NO	Measure without source				Measure with source			
	R_1 (Ω)	**R_2 (Ω)**	**R_L (Ω)**	**R_O (Ω)**	**E_1 (volt)**	**E_2 (volt)**	**V_O (volt)**	**$I_{L(meas)}$ (mA)**
1								
2								

Theoretical Calculation						Remark
R_{Th} (Ω)	V_{Th} (Ω)	$I_{L(cal)} = \frac{V_{TH}}{R_{Th}+R_L}$ (mA)	% Error= $\frac{R_0 - R_{Th}}{R_0}\times 100$	% Error = $\frac{V_0 - V_{Th}}{V_0}\times 100$	% Error = $\frac{I_{L(cal)} - I_{L(meas)}}{I_{L(cal)}}\times 100$	

Working steps:

(1) First measure R_1, R_2, R_L separately.

(2) Then R_{OPEN} (R_O) should be measured at A and B ends as per fig-a.

(3) After that E_1, E_2, V_O should be determined in circuit on state by arranging as per fig-b.

(4) Then load current $I_{L(Measured)}$ abbreviated as $I_{L(Meas)}$ should be measured by applying load as per fig-c.

(5) Now V_{th}, R_{th}, $I_{L(Calculated)}$ in short $I_{L(Cal)}$ should be determined theoretically with the help of Thevinin's theorem from the data obtained in step 1, 2, 3, 4 (fig-d)

(6) $I_{L(Meas)}$ and $I_{L(Cal)}$ values should be compared and comments should be written.

(7) Write a comment comparing V_O and V_{th}, R_O and R_{th}, $I_{L(Meas)}$ and $I_{L(Cal)}$ from the data obtained from the above step and theoretical values.

(8) Reverse the direction of the source and place it in OBS NO-2 and do the above operations again.

Precautions:

(1) Work steps should be done in sequence.
(2) No source shall be fitted during determination of R_O.
(3) No resistor shall become hot during full test.
(4) Readings should be taken properly and caution should be observed while calculating.

Conclusion: (Write yourself)

Experiment No: 09 **Date: ....** **Time: 120 Minuit**

Experiment Name: Verification of Norton's Theorem.

Introduction: Norton's theorem is named after the engineer E.L Norton who first developed this theorem. This theorem makes it easy to find the value of current in networks where there are multiple sources or where complex networks exist because the complex network is represented by a single current source and a single parallel resistance. The theorem is applicable to both DC and AC cases but the elements must be linear bilateral. The test here will be restricted to DC only.

Objectives :
(1) To prove that a complex network can be reduced to a simple circuit of a single current source.
(2) To prove that a complex network can be reduced to a simple circuit of a single resistance.
(3) To determine the value and direction of current in any load resistance of a complex network with the help of Norton's theorem.

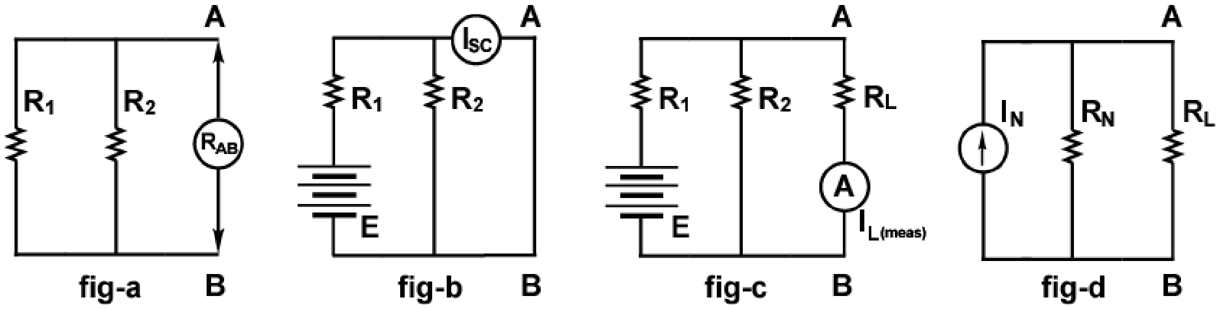
Theory: An A and B two-terminal linear, bilateral DC network—replaceable by a single current source I_N and a single parallel resistance R_N.

Nortnizing:
(i) In case $I_{SC} = I_N$ will be equal to the current that will flow if two ends A and B are short circuited.
(ii) $R_{AB} = R_N$ will be equal to the resistance found in the circuit from A and B ends. However, the condition is that if there is an emf source it should be opened and shorted but the internal resistance of the source is substituted in place of the source. And if there is a current source, it must be made open circuit but the resistance that is parallel to the current source will remain in place.

Required instruments & materials:
1. Trainer set.............................. 1 no.

2. Digital multimeter..................1 no.
3. Dry cell, size D-D, 1.5V..........3 nos.
4. Battery case for 3 cells...........1 no.
5. Jumper with crocodile clip.....According to necessary

Circuit Diagram:



Data Sheet:

OBS NO	Without Source				With Source			
	R_1 (Ω)	R_2 (Ω)	R_L (Ω)	R_{AB} (Ω)	I_{SC} (mA)	$I_{L(meas)}$ (mA)	$V_{1(meas)}$	$V_{2(meas)}$
1								
2								

Theoretical Calculation							Remark
OBS NO	R_N (Ω)	I_N (mA)	$1_{L(cal)}$= (mA)	% Error= $\frac{R_{AB}-R_N}{R_{AB}}\times 100$	% Error= $\frac{I_{SC}-I_N}{I_{SC}}\times 100$	% Error= $\frac{I_{cal}-I_{meas}}{I_{cal}}\times 100$	
1							
2							

Equation's:

$$R_N = \frac{1}{\frac{1}{R1}+\frac{1}{R2}}$$

$$I_{SC} = I_N = I_{R1} + I_{R2} = \frac{V_1}{R_1} + \frac{V_2}{R_2}$$

$$I_L = I_N\left(\frac{R_N}{R_N + R_L}\right)$$

Work steps:

(1) First measure R_1, R_2 and R_L separately.
(2) Then measure the total resistance R_{AB}= R_N across A and B as per fig-a.
(3) Then measure current I_{SC} in short circuit condition as per fig-b.

(4) After that according to Fig-c remove the short circuit and load between points A and B and measure the load current $I_{L(measured)}$.
(5) Now from the obtained values of E, R_1, R_2, R_L etc. with the help of Norton's theorem theoretically the value of load current $I_{L(measured)}$ should be determined (fig-d).
(6) $I_{L(measured)}$ and $I_{L(calculated)}$ should be compared and comments should be written.
(7) Comment should be written by comparing R_N, $I_{L(measured)}$ and $I_{L(calculated)}$ from the data obtained from the above step and the theoretical value.
(8) Write comments comparing I_{SC} and I_N, R_{AB} and R_N, $I_{L(meas)}$ and $I_{N(cal)}$.

Caution:
(1) Steps of work should be done in sequence.
(2) No source shall be connected during RAB determination.
(3) No resistor shall become hot during full test.
(4) Readings should be taken properly and caution should be observed while calculating.

Conclusion: (Write yourself)

Experiment No: 10 **Date: ....** **Time: 120 Minuit**

Experiment Name: Verification of Superposition Theorem.

Introduction: In a linear bilateral network, when multiple sources act together, the total effect on any one element is equal to the superimpose of the separately effective effects of the sources. It is from this superimpose that the superposition theorem is named. The value and direction of the current has to be determined by arranging the circuit separately for each source. Then add the currents flowing in the same direction. In such a case, the value and direction of the total load current (toward the larger one) can be obtained by subtracting the smaller value from the larger one and the point through which the final current enters the load will be the point of higher potential. In this type of solution there is only one source at a time, so the overall solution is long but simple.

Objectives:
(1) To verify the truth of superposition theorem.
(2) Determination of value, direction, value of voltage drop, high potential point of voltage in a load with the help of superposition theorem.

Theory: The superposition theorem states that in any linear, bilateral network, if multiple sources are active together, then the current flowing through any branch or element is the same as that of each source individually. The superposition theorem states that in any linear, bilateral network, if multiple If the sources are active together, the current flowing through any branch or element is equal to the algebraic sum of the currents flowing from each source individually, and correspondingly the total voltage drop is equal to the algebraic sum of the voltage drops caused by each source individually. In such a case any source should be opened and shorted if there is any other EMF source during use but the internal resistance of the source will be substituted in place of the source. And if there is a current source, it must be made open circuit but the resistance that is parallel to the current source will remain in place. The current will flow equal to their algebraic sum and correspondingly the total voltage drop will be equal to the algebraic sum of the voltage drops caused individually for each source. In such a case any source should be opened and shorted if there is any other EMF source during use but the internal resistance of the source will be substituted in place of the source. And if there is a current source, it must be made open circuit but the resistance that is parallel to the current source will remain in place.

Required instruments & materials:

1. Trainer set............................. 1 no.
2. Digital multi-meter...................1 no.
3. Dry cell, size D-D, 1.5V..........4 nos.
4. Battery case for 3 cells...........1 no.
5. Battery case for 1 cell.............1 no.
6. Jumper with crocodile clip.....According to necessary

Circuit Diagram:

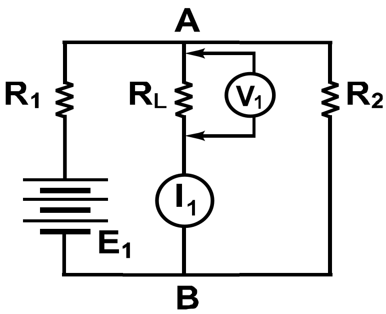


Fig-a

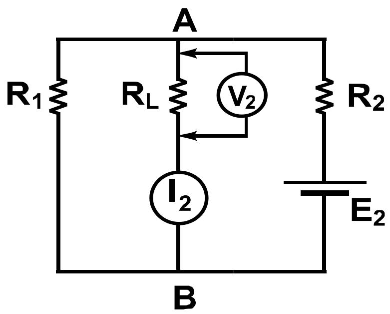


Fig-b

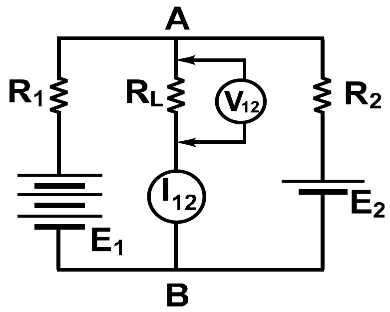


Fig-c

Data Sheet:

OBS NO.	Only for E_1 source, measured load current I_1(mA)	Only for E_2 source, measured load current I_2 (mA)	At a time both for E_1 & E_2 source, measured load current $I_{1,2}$ (mA)	Individually for E_1 & E_2 source, calculated load current $I_{cal}=\sum(I_1 \& I_2)$ (mA)	% Error $\frac{I_{1.2}-I_{cal}}{I_{12}}\times 100$
1					
2					

OBS NO	Only for E_1 source, measured Voltage drop at load= V_1 (Volt)	Only for E_2 source, measured Voltage drop at load= V_2 (Volt)	At a time both for E_1 & E_2 source, measured Voltage drop at load= $V_{1,2}$ (Volt)	Individually for E_1 & E_2 source, calculated Voltage drop at load $V_{cal}=(\sum V_1 \& V_2)$ (Volt)	% Error $\frac{V_{1,2}-V_{cal}}{V_{1,2}}\times 100$
1					

2					

Work steps:

(1) After collecting the required equipment, make the circuit for E1 source only and determine the load current and direction of current and the value of voltage drop and put it in the data fig-a. Also marks should be placed on the circuit for direction of current and higher potential.

(2) Then for E2 source only load current and direction of current and value of voltage drop should be determined and placed in data fig-b.

(3) Now using both the sources the value and direction of load current and voltage drop data should be placed in fig-c

(4) Algebraic sum of the direction and value of current in steps 1 and 2 should be compared with the value and direction of current obtained in step 3.

(5) In the same way the value of voltage drop obtained in step 1 and 2 should be compared with the value of voltage drop obtained in step 3 and the high potential point should be identified.

Precautions:

(1) Make a separate circuit for each source and put the measured amount in the data. Arrows should be placed for direction of current and +/- for voltage drop.

(2) Add or subtract the value of current keeping in mind the polarity of the reading taken.

(3) When the load current is measured with two sources connected together, the direction of the current should be observed which will help in determining the point of higher potential.

(4) Reading should be taken upright to avoid illusions.

(5) Special care should be taken to ensure that the direction of polarity is not random.

Conclusion: (Write yourself)

Experiment No: 11 **Date: ....** **Time: 120 Minuit**

Experiment Name: Verification of Maximum Power Transfer Theorem.

Introduction: The Maximum Power Transfer Theorem is the idea of determining how to transfer maximum power from a source to a load. Although the theorem is used in all branches of electrical engineering, it is particularly useful in the analysis of communication networks where only a few milliwatts or microwatts are involved. In electrical engineering, efficiency is almost always given priority in transmission and distribution, but here efficiency is secondary as the matter of sending or receiving maximum power is paramount. In this condition the maximum efficiency is only 50%.

Objectives:

(1) To know how all components of a source and parts of the source can be converted into a single EMF source.

(2) Knowing how to convert all resistances of a source into a single resistance.

(3) Verification of the maximum power transfer theorem.

Theory: A resistive load will draw maximum power from a linear, bilateral, DC network only when the value of the load resistance is equal to the value of the combined resistance of the network. As per fig-a the combined resistance of generator resistance R_G and other conductors or line antennas etc. is visualized as internal resistance of the network and denoted as R_{in} or R_{th} and load resistance is taken as R_L. Hence the condition for maximum power transfer is $R_L = R_{in}$. In this case the value of load current will be $I = \frac{E_{th}}{R_{in}+R_L}$ and the value of power absorbed by the load will be $P_L = I^2 R_L = \frac{E^2{}_{TH} R_L}{(R_{in}+R_L)^2} = \frac{E^2}{4R_L}$ Note here that the voltage across the load (AB) will be half of the open state as R_{in} and R_L are equal, the source voltage will be divided by half.

Required instruments & materials:

1. Trainer set.............................. 1 no.
2. Digital multimeter...................1 no.
3. Dry cell, size D-D, 1.5V..........3 nos.
4. Battery case for 3 cells...........1 no.
5. Jumper with crocodile clip.....According to necessary

Circuit Diagram:

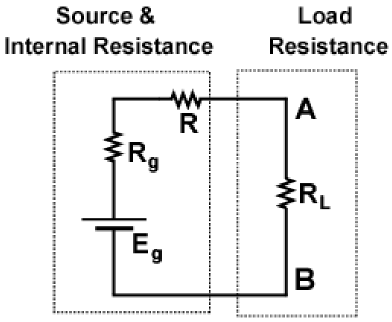


fig-a

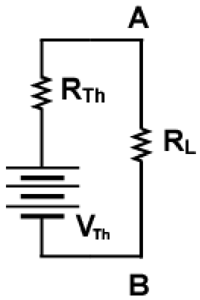


fig-b

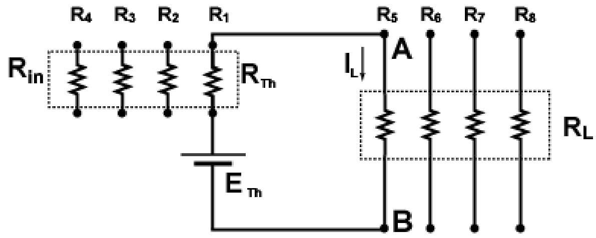


fig-c

Data Sheet:

OBS NO	V_o or E_{Th} (V)	R_{in} or R_{Th} (Ω)	R_L (Ω)	I_L (mA)	$P_L=I^2R_L$ (mW)	Mark, which one absorbed maximum power
1			R_5=			
2		R_1=	R_6=			
3			R_7=			
4			R_8=			
5			R_5=			
6		R_2=	R_6=			
7			R_7=			
8			R_8=			
9			R_5=			
10		R_3=	R_6=			
11			R_7=			
12			R_8=			
13			R_5=			
14		R_4=	R_6=			
15			R_7=			
16			R_8=			

Work steps:

(1) First, R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8 should be measured separately in the data sheet and it should be noted here that to get the correct result, the equivalent resistance of R_1, R_2, R_3, R_4 is R_5 respectively. , R_6, R_7, R_8 are better taken.

(2) After that the network should be made as per fig-a with a source and a resistance as R_{in}.

(3) By placing R_1 in place of R_{in}, R_5, R_6, R_7, R_8 in place of R_L respectively, the value of I_L should be determined in each condition and the result should be compared by filling the cells of P_L.

(4) Similarly, according to step 3, replace R_{in} with R_2, R_3, R_4 respectively and calculate the power in each case as per step 3.

(5) Compare which R_{in} is connected to which R_L is the highest power available at the load.

(6) Comments should be made according to the quality of the data.

Caution:

(1) The circuit should be arranged as per fig-a where $R_1=R_5$, $R_2=R_6$,$R_3=R_7$, $R_4=R_8$ equal to or close to the value, the result will be more obvious.

(2) The resistances specified as R_{in} and the resistances used as R_L should be kept separate to avoid confusion. (Here R_1, R_2, R_3, R_4 are denoted as R_{in} and R_5, R_6, R_7, R_8 as R_L)

(3) In both R_{in} and R_L the resistances must be added according to the increasing value.

(4) Even if the value of current is in milliampere, it should be calculated to 5 decimal places.

(5) Power values should be calculated up to 7 decimal places.

(6) Power must be calculated correctly according to the formula $P_L=I^2R_L$.

(7) Carefully review the quality of received power.