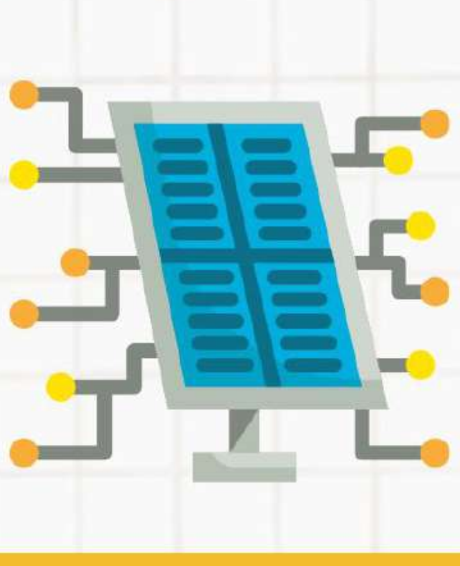
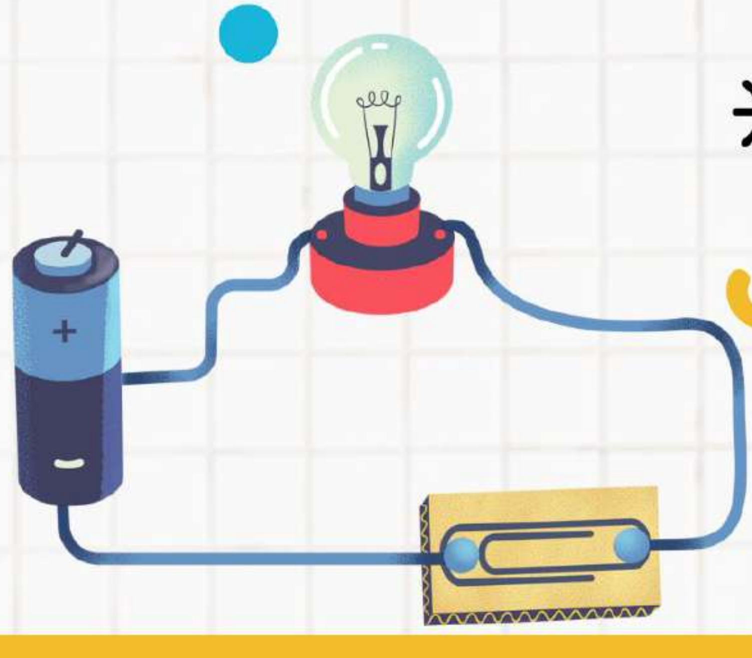
Pusat Asasi Sains dan Perubatan UniSZA
UniSZA Science and Medicine Foundation Centre

LABORATORY MANUAL PHYSICS II

SEM II 2023/2024

1. Multimeter
2. Color code & Ohm's Law
3. Current and Resistance in a Parallel Connection
4. Kirchhoff's Law
5. Capacitors in Direct Current Circuits & Capacitors in Alternating Current Circuits





PRACTICAL 1

Multimeter

OBJECTIVES

1. To identify and interpret meter scales, functions and ranges used for multimeter.
2. To identify the ohmmeter function and ranges.
3. To measure voltage, current and resistance using the multimeter.

LEARNING OUTCOMES

Upon completion of this experiment, students should be able to :

1. Practice how to read the scale and set the range of multimeter.
2. Give knowledge about the usage of multimeter and ohmmeter and their functions.
3. Do all the measurements by using multimeter.

APPARATUS

- DC Power Supply
- Multimeter
- Breadboard
- R1 = 100 kΩ
- R2 = 470 kΩ

PROCEDURES

TASK A:

1 It is usually not very difficult to read and interpret meter scales, but sometimes the use of multiple scales, functions, and ranges make it seem difficult. However, this difficulty is soon overcome with practice and experience. A linear meter scale for dc volts is shown below. What is the highest voltage that can be read from this scale?

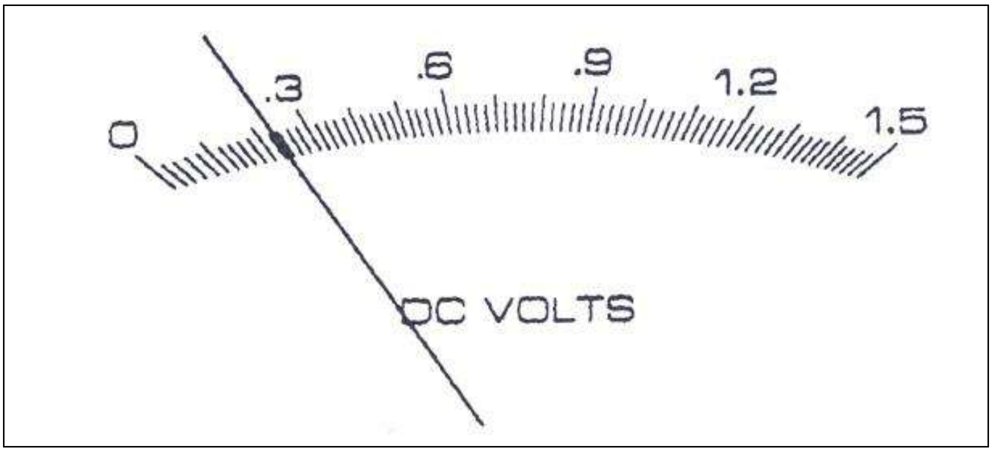


Figure 1

Answer : ______________________________

2 What voltage is being measured if the pointer is over the first short mark (picket) to the right of .9?

Answer : ______________________________

3 What values do the two long pickets between .6 and .9 represent?

Answer : ______________________________

4 Assuming the meter scale shown in above Figure 1 could indicate 15 volts at full scale, what voltage would be indicated at the .7 mark?

Answer : ______________________________

5 Based on the scale in Figure 2, give the reading of the following parameter?

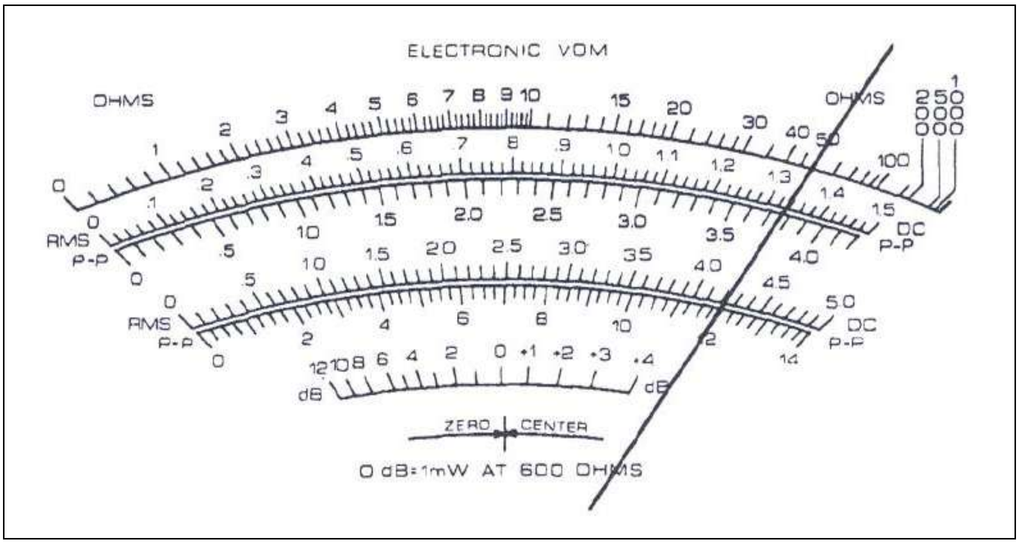


Figure 2

Table 1: Multimeter reading

Quantity Measured	Meter's Setting	Meter's Reading
Voltage	AC V : 140 V	
Voltage	DC V : 15 V	
Current	AC A : 1.4 A	
Current	DC A : 5 mA	

6 Before using any meter, you must make sure the indicator (pointer) rests over the zeros at the left of the scales. Explain its techniques?

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TASK B

1 The multimeter also can be used as an ohmmeter to measure resistance. The one is marked Ω and is for measuring the values of resistors, checking for opens and shorts and for checking continuity.

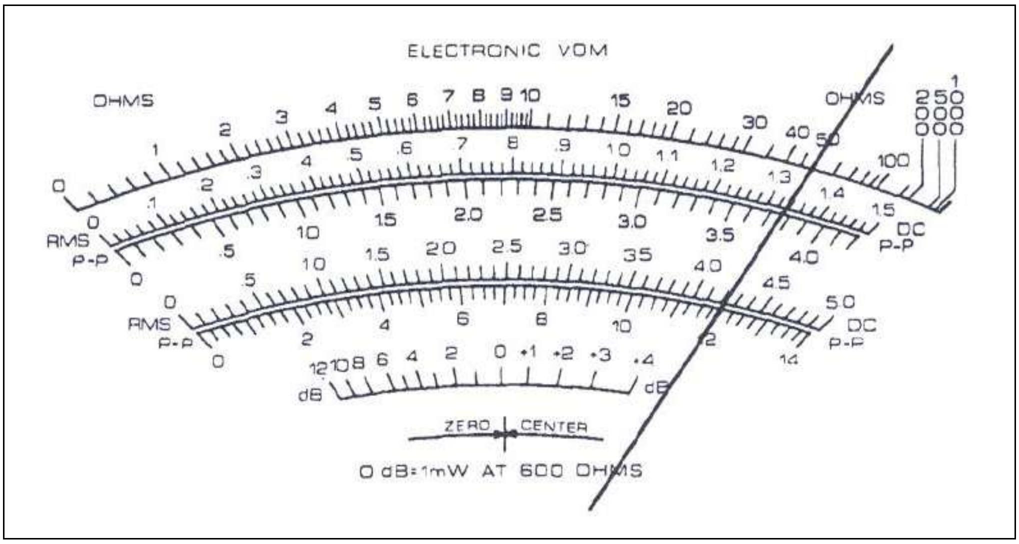

Figure 3

2 If the range switch is in the R x 100 position, what value of resistance is being measured on the ohms scale as shown in Figure 3?

Answer : ________________________________

3 Before using the ohmmeter function it is necessary to calibrate it. Explain the calibration techniques.

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____

4 Select a number of resistors, R_1 and R_2. Use the ohmmeter to verify their resistances.

Resistor	Meter's Setting	Measured Value
R_1		
R_2		

TASK C

1 The ammeter can measure alternating current (ac) and direct current (dc). A separate current range switch marked AC/DC CURRENT selects full scale ranges of 15µA, 150 µA ,1.5 mA, 150 mA, 1.5 A.
The multimeter can also measure DC or AV voltage. A separate voltage range switch marked AC/DC V selects full scale ranges of 600, 300, 120, 30 and 6 V.

2 Suppose you are using the ammeter to measure current in a circuit that has about 60 mA dc flowing in it. Which function switch would select? Which current range would you select?

Answer : ________________________________

3 If the ACA function switch is depressed and the current range switch is set to 150µA what value and type of current is shown by the meter in Figure 3?

Answer : ________________________________

4 Connect Resistor R_1 and R_2 to the dc power sources as shown in Figure 4. Apply the dc voltage 10V. Measure the following electrical parameters and complete the Table 2.

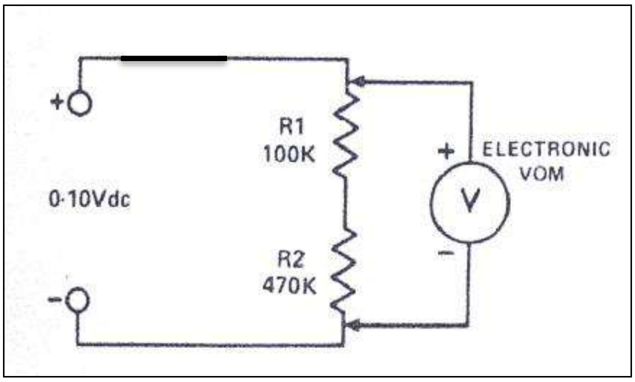


Figure 4

Table 2: Multimeter readings

Electrical quantity	Meter's Setting	Meter's position in circuit	Measured quantity
emf			
Current			
Voltage across R_1			
Voltage across R_2			

CONCLUSION

Write the conclusion in the laboratory report.

PRACTICAL 2

Color Code and Ohm's Law

OBJECTIVES

1. To learn how to read color-coded and tolerance of resistors.
2. To determine the resistance of resistor.
3. To calculate the unknown resistance using Ohm's law.

LEARNING OUTCOMES

Upon completion of this experiment, students should be able to :

1. Identify the value of resistor and its tolerance by color coding and ohmmeter.
2. Understand the concept of electric resistance.
3. To verify Ohm's Law experimentally and determine the relationship between voltage, current and resistance in a circuit.

INTRODUCTION

Electrical current is the amount of charge passing by a given point in a conducting path (circuit) per unit time: $I= dQ/dt$

The unit of current is the Ampere, which is equal to a (Coulomb/second) and, although it is defined by other relations, a current of one ampere exists in a wire if approximately 6.21 x 10^{18} electrons (charge of one Coulomb) flow through a given cross-section of wire in one second. It is agreed for convenience that the direction of the current is the same as the direction of movement of positive charges in electric field. In a metallic conductor, such as a wire, the only mobile particles are negatively charged electrons, which move in a direction opposite to that chosen for the conventional current.

The relationship between the voltage, current, and resistance in a metallic conductor is given by Ohm's law. It states as follows: If the temperature and other physical conditions of a metallic conductor are unchanged, the ratio of the potential difference across the conductor (V) to the current (I) is a constant. This constant ratio (R) is the resistance of the conductor.

$$R = V/I \qquad (1)$$

If potential difference is measured in Volts and current is in Amperes, resistance will be in Ohms (unit of resistance, equal to one Volt per Ampere).

The resistance of a metallic conductor depends only on its length, the area of cross-section, the material of the conductor and its temperature. It does not depend on either V or I. At a given temperature

$$R = \rho L/A \, ,$$

where ρ,L and A are, respectively, resistivity, the length, and cross sectional area of the resistor. A resistor is called a "linear device", as opposed to a "non-linear device" such as diode, that does not obey the linear Ohm's law even without significant change in temperature. In this experiment we will study a regular resistor with constant resistance only.

APPARATUS

- DC power supply (V1)
- Ammeter (XMM1)
- Voltmeter /Multi-meter (XMM2)
- Potentiometer (1 K), or Rheostat
- Resistors 10 ,100 ,270 ,470 , 1 K,1.5 K, 4.7 K, 10 K, 47 K
- Screwdriver

PROCEDURES

TASK A

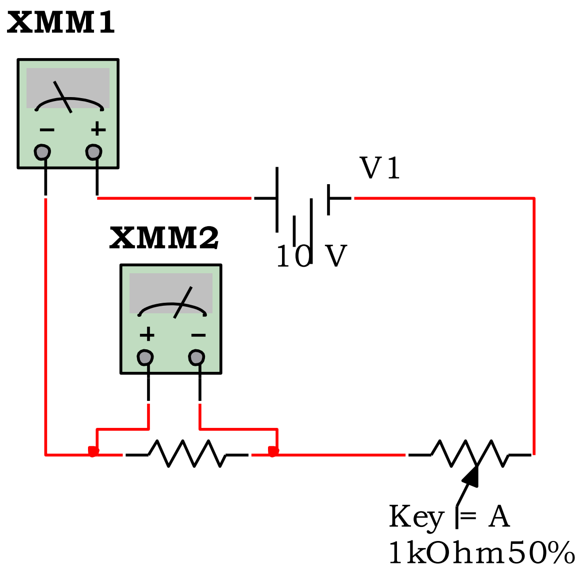
1. Several resistors will be given. **Write** the color code resistors value and tolerance rating of each resistor on the table.
2. Use the tolerance rating of each resistor to compute the low and high limits of its resistance range, and add this information to the table.
3. **Measure** the actual resistance of each resistor and add this information to the table. Do the calibration of the ohmmeter, each time you change the range.

Table 1: Resistor Color Code

R	Color Code	Tolerance	Low Limit	High Limit	Measured Resistance (Ω)
10 Ω					
100 Ω					
270 Ω					
470 Ω					
1 KΩ					
1.5 KΩ					
3.3 KΩ					
4.7 KΩ					
10 KΩ					
47 KΩ					

TASK B

1. In this experiment you are to take pairs of reading of the current through, and voltage across the fixed resistor. After each pair of reading, use the variable resistor (potentiometer) to alter the value of the current in the circuit below and read the miliammeter again.



2. Take 10 sets of reading and complete this table.

Reading	1	2	3	4	5	6	7	8	9	10
Voltage (V)										
Current (mA)										

3. Plot graph voltage (V) versus current (mA). Determine the resistance of fixed resistor.

4. Measure the fixed resistor using ohmmeter compare your value with the calculated value found in (3)

ATTENTION
When testing the resistance of a resistor that is wired into a circuit one load of the resistor should be removed from the terminal, to which it is connected.

CONCLUSION

Write the conclusion in the laboratory report.

PRACTICAL 3

Current and Resistance in a Parallel Connection

OBJECTIVES

1. To study the parallel connection in circuit.
2. To learn how the loads in a parallel circuit are connected.
3. To calculate the voltage, drop, equivalent resistance and total current in the parallel circuit.

LEARNING OUTCOMES

Upon completion of this experiment, students should be able to :

1 . Identify a circuit as being either parallel or series circuit.
2 . Connect the loads in parallel circuits.
3 . Determine the equivalent resistance, total current and voltage drop across each resistor in parallel circuit.

INTRODUCTION

Most common household electrical circuits are made of many devices connected in parallel. Each device is hooked to the power source in parallel with all the other devices, each connected to the same voltage source and availing itself of the same voltage. Each device has its own characteristic resistance, and therefore each draws from the source a different amount of current, depending on its resistive value.

While the voltage being accessed is nearly the same for all devices, the amount of current drawn from the source increases as each device draws its respective current based on its resistance.

As a result as more and more devices are connected in parallel, the total amount of current drawn from the source increases. It thus has the effect of causing the resistance to decrease with each additional resistance added.

Additional devices added to a circuit, require additional current from the source until something is overloaded. More current is required beyond that which can be supplied by the source or carried by the conductors without burning up.

THEORY:

Parallel resistors experience the same voltage, but (possibly) different currents. This is in contrast to series resistors. A typical pure parallel circuit is shown below. The voltage (V_{ab}) has to be the same for the three resistors, because they are all between the same two points of the circuit (**a** and **b**). The current in each resistor is determined by the equation I=V/R. Since the voltage V is the same for each resistor ($V_1=V_2=V_3=V_{ab}$), the larger the resistance R of a particular resistor, the smaller the current through that resistor. Charge or flow conservation requires that

$$I = I_1 + I_2 + I_3.$$

Point **a** is a dividing point. Current I divides at point **a** into I_1, I_2, and I_3. At point **b**, I_1, I_2, and I_3 merge to form I again.

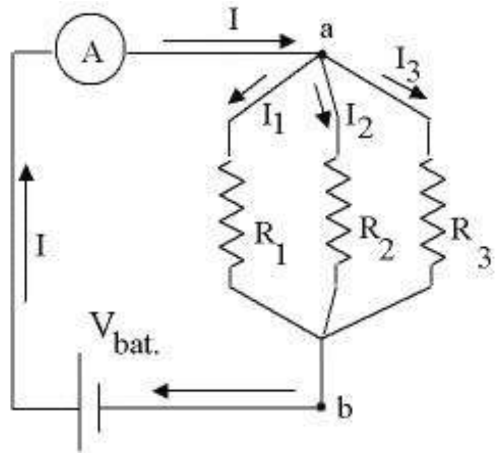


Fig. 2

Note that the voltage across each of the resistors is V_{ab}**.** If we neglect the small voltage-drop across the ammeter, the voltage V_{ab} is equal to the battery voltage V_{bat}**.** This is because there is no circuit element (other than the ammeter) between point **a** and the battery, or between point **b** and the battery**.** The ammeter (**A**) does not contribute to any significant voltage drop**;** the voltage drop across an ammeter can usually be neglected.

For a different case, where there is a fourth resistor between point a and the battery, or between point b and the battery, V_{ab} is **not** equal to V_{bat}. This is going to be case (iii) in this experiment. Here, for parallel resistors:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

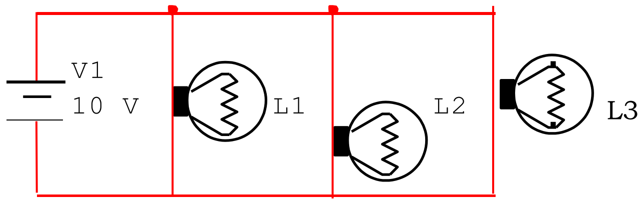
APPARATUS

- Circuit board/project board.
- DC power supply.
- 3 units miniature lamps
- DC Milliammeter.
- Multimeter.
- Resistors R_1 = 100, R_2 = 470, R_3 = 1k

PROCEDURE

TASK A

1. Wire the parallel circuit shown below



2. Remove one of the lamp from its socket.
3. Observe do the other lamps in the circuit continue to operate?

   ____

4. Place all the lamps into their sockets.
5. Measure the voltage across power supply.
   This is the voltage applied (rise) to the circuit.
   = ______V
6. Measure the voltage across each lamp in the circuit.

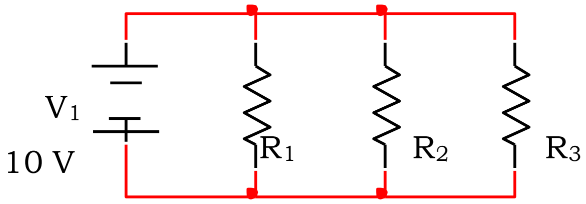
   V_{L1} =___V
   V_{L2} =___V
   V_{L3} =___V

7. Is the voltage across each lamp equal to the applied voltage?

   ____

TASK B

1. Wire the circuit shown below.



2. Measure the total current, I_T in the circuit.

   I_T =___A

3. Measure the current through the R_1, R_2 and R_3.

   I_{R1} = ____A
   I_{R2} = ____A
   I_{R3} = ____A

4. What is the sum of there currents?

   I_{R1} + I_{R2} + I_{R3} = ____A

5. Does the sum of the branch currents equal the total current?

6. Disconnect the supply from circuit. Measure the total resistance of the circuit using ohmmeter.

7. Calculate total resistance of the circuit.

8. Compare your calculated value and measured value. Are they the same?

CONCLUSION

Write the conclusion in the laboratory report.

PRACTICAL 4

Kirchhoff's Law

OBJECTIVES

1. To apply Kirchhoff's rules for the circuit with two loop.
2. To verify Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL) using mesh and nodal analysis of the circuit.
3. To determine the currents and voltage drops in each loop of the circuit.

LEARNING OUTCOMES

Upon completion of this experiment, students should be able to :

1. Investigate the Kirchhoff's Law to the circuit.
2. Apply the KVL and KCL to predict voltages and currents in the circuits.
3. Measure the voltages drop and currents through circuit resistors and compare to the theory.

INTRODUCTION

1. ***Kirchhoff's Voltage Law*** states that the algebraic sum of all the voltages around any closed path (loop or mesh) is zero. Applying Kirchhoff's voltage law to the first and the second loops in the circuit shown in Figure 1 yields:

   Loop 1: $-V_s + V_1 + V_2 + V_5 = 0$ (1a)

   Loop 2: $-V_2 + V_3 + V_4 = 0$ (1b)

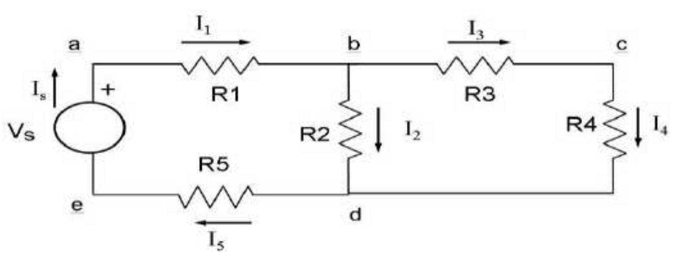


Figure 1

2. ***Kirchhoff's Current Law*** states that the algebraic sum of all the currents at any node is zero. Applying Kirchhoff's current law to the first four nodes in the circuit shown in

Figure1 yields the following equations;

Node a: -Is + I1 = 0 (2a)

Node b: -I1 + I2 + I3 = 0 (2b)

Node c: -I3 + I4 = 0 (2c)

Node d: -I2 - I4 + I5 = 0 (2d)

APPARATUS

- Circuit board/project board.
- DC power supply.
- Multimeter.
- Resistors

PROCEDURE

1. Construct the circuit shown in Figure 1 using the values below:

   R_1 = 1 KΩ

   R_2 = 2.4 KΩ

   R_3 = 1.2 KΩ

   R_4 = 1 KΩ

   R_5 = 1.2 KΩ

2. Set the Variable Power Supply (Vs) to 5 Volts.
3. Accurately measure all voltages and currents in the circuit using the Digital Multi-Meter (DMM).
4. Record the measurements in a tabular form containing the measured voltage and current values as shown below.

Branch current/v	R [KΩ]	I [mA]	V [volts]
V_1, I_1			
V_2, I_2			
V_3, I_3			
V_4, I_4			
V_5, I_5			
V_s, I_s	-		

5. Verify KVL for the loops in the circuit using equations 1a and 1b.
   Answer : _______________

6. Verify KCL for the nodes in the circuit using equations 2a, 2b, 2c and 2d.
   Answer : _______________

CONCLUSION

Write the conclusion in the laboratory report.

PRACTICAL 5

(PART A) Capacitors in Direct Current Circuits

OBJECTIVES

1. To investigate the effect of capacitor into a direct current (DC) circuit.
2. To describe the charging and discharging (decay) of the voltage on a capacitor.
3. To examine equivalent capacitance in DC circuit containing a capacitor.

LEARNING OUTCOMES

Upon completion of this experiment, students should be able to :

1. Identify the function of capacitors and how capacitors perform in DC circuit.
2. Explain what happens to the capacitances when switching on and switching off.
3. Calculate the equivalent capacitance in DC circuit using the equation C = Q/V.

INTRODUCTION

A capacitor consists of two conductors separated by an insulator. The choice of plate area, plate separation, and insulating material determines the "capacitance" of the capacitor. The typical method for transferring equal and opposite charges to the plates of a capacitor is to use a voltage source such as a battery or power supply to create a potential difference between the two conductors. Electrons will then flow off of one conductor (leaving positive charges) and on to the other until the potential difference between the two conductors is the same as that of the voltage source. The capacitance of a given capacitor is defined mathematically as the ratio of the magnitude of the charge, q, on either one of the conductors to the voltage, V, applied across the two conductors so that:

$$C = Q / V$$

Thus, capacitance is defined as a measure of the amount of net or excess charge on either one of the conductors per unit voltage. You can draw on some of your experiences with electrostatics to think about what might happen to a parallel plate capacitor when it is hooked to a power supply as shown in Figure 1 below. This thinking can give you an intuitive feeling for the meaning of capacitance. For a fixed voltage from a power supply, the net charge found on either plate is proportional to the capacitance of the pair of conductors.

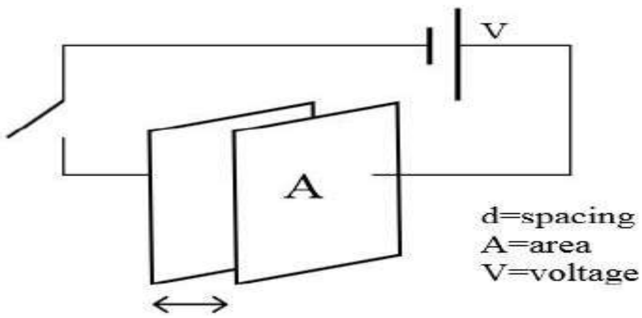


Figure 1: A parallel plate capacitor with a voltage V

APPARATUS

- Connector,straight,moduleS
- Connector,angled,moduleSB
- Connector,Tshaped,moduleSB
- Connector,interrupted,moduеSB Switchon/off,SB
- Switch change-over ,SB
- Socket for incandescent lampE10,
- Capacitor (ELKO) 47µF,SB
- Capacitor (ELKO) 470µF, SB
- Connecting cord,32 A,500 mm,red
- Connecting cord,32 A,500 mm,blue
- Connecting cord,32 A,250 mm, red
- Connecting cord,32 A, 250 mm, blue
- Filament lamp, 4 V /0.04A,E10,
- Multi-range meter,analogue
- Power Supply,0...12 V DC/ 6V,12 V AC

PROCEDURE

TASK A

1. Connect up the circuit as shown in Fig. 2, using the 470 µF capacitor initially. Turn the on/off switch to the off position and the changeover switch to position 1.
2. Switch on the power supply and set 12 V direct volt-age.
3. Close the on/off switch and observe the lamp.
4. Turn the on/off switch off and on, observing the lamp;note your observations under (1).
5. With the on/off switch closed, turn the changeover switch to position 2 and observe the lamp.
6. Repeatedly operate the changeover switch and note what you observe under (2).
7. Return the changeover switch to position 1, then open the on/off switch to break the circuit.

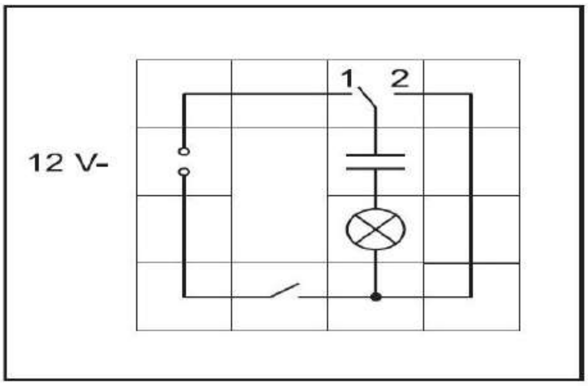


Figure 2

TASK B

1. After 1 or 2 seconds, turn the changeover switch to position 2, observe the lamp and note what you observe under (3).
2. Replace the 470 μF capacitor which is in the circuit with the 47 μF capacitor. Close the circuit with the on/off switch and repeatedly operate the changeover switch; observe the lamp and note what you observe under (4).
3. Set the multi range meter to measurement range 30 mA and install it in the circuit as an ammeter in place of the filament lamp.
4. Repeatedly operate the changeover switch; observe the ammeter and note what you observe under (5).
5. Switch off the power supply.

OBSERVATION

(1) ____
____
____

(2) ____
____
____

(3) ____
____
____

(4) ____
____
____

5) ____
____
____

QUESTIONS

1. Compare and explain the observations noted under (1) and (2).

2. Explain the observations noted under (3).

3. What follows from observations (4) and (5)?
   (Note: The capacity (C) of a capacitor for an electric charge is measured in Farad units (F). One microfarad (1 µF) is a millionth of a Farad;
   $C = Q / U$; $1 F = 1 A \bullet s/V$).

4. Look closely at the capacitors used in this experiment and describe them.

CONCLUSION

Write the conclusion in the laboratory report.

PRACTICAL 5

(PART B) Capacitors in Alternating Current Circuits

OBJECTIVES

1. To investigate the effect of the capacitor into an alternating current (AC) circuit.
2. To describe the charging and discharging (decay) of the voltage on a capacitor.
3. To examine equivalent capacitance in an AC circuit containing a capacitor.

LEARNING OUTCOMES

Upon completion of this experiment, students should be able to :

1. Identify the function of capacitors and how capacitors perform in AC circuit.
2. Explain what happens to the capacitances when switching on and switching off.
3. Calculate the equivalent capacitance in AC circuit using the equation C = Q/V.

INTRODUCTION

DC (Direct Current) differs from AC (alternating Current) where it implies that the current has a constant value and it flows in only one direction through a circuit, whereas, in AC, it implies that the current has a value that is constantly changing, like a sine wave. The current flows both forwards and backwards through a circuit. Associated with any wave is a frequency. The frequency, ***f***, is the number of cycles that occur per second and one complete cycle of current is shown below.

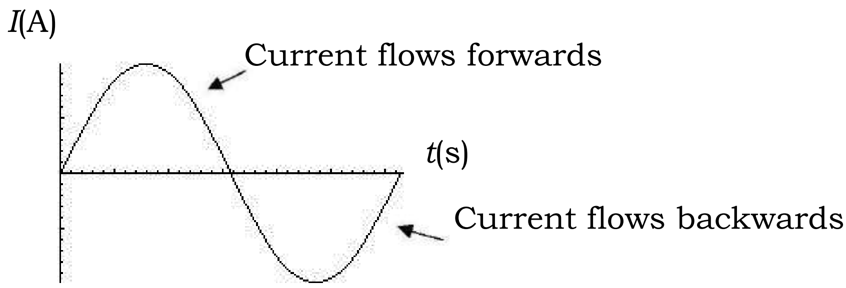


Figure 1: Current Vs. Time Graph

Compared to DC circuits, inductors and capacitors act differently in AC circuits. When capacitors are in an AC circuit they act like they have a resistance. For a capacitor this "resistance" is called a *capacitive reactance*. The capacitive reactance is defined by the following equation ...

$$x_C = \frac{1}{2\pi f C}$$

X_C is the capacitive reactance (in ohms, Ω)
f is the frequency (in hertz, Hz)
C is the capacitance (in farads, F)

Since X_C acts as a resistance, you can use a form of Ohm's Law to find the voltage across the capacitor ...

$$V_C = IX$$

V_C is the voltage across the capacitor (in volts, V)
I is the apparent current through the capacitor (in amps, A)
X_C is the capacitive reactance (in ohms, Ω)

APPARATUS

- Connector, straight, module SB
- Connector, angled, module SB
- Connector, T-shaped, module SB
- Connector, interrupted, module SB
- Junction, module SB
- Switch on/off, module SB
- Switch, change-over, module SB
- Socket f. incand. lamp E10, mod.SB
- Capacitor 47 µF, module SB
- Capacitor 470 µF, module SB
- Connecting cable, 25 cm, red
- Connecting cable, 25 cm, blue
- Connecting cable, 50 cm, red
- Connecting cable, 50 cm, blue
- Filament lamp, 6 V/0.5 A,
- Filament lamp, 4 V/0.04 A
- Multi range meter, analogue
- Power supply, 0...12 V-,6 V~, 12 V~

PROCEDURE

TASK A

1. Connect up the circuit as shown in Fig. 2, with the on/off switch open; make connection to the 6 V~ alternating voltage source and set it to measurement range 300 mA~.
2. Close the alternating current circuit, measure the current and observe the brightness of the lamp; enter what you observe and the measured value under (1), Table 1.
3. Change the measurement range to 3 A~.
4. Replace the 47 µF capacitor by the 470 µF capacitor, measure the current and note the value.
5. Replace the capacitor by a connector module, mea-sure the current and note the value.
6. Switch off the power supply.

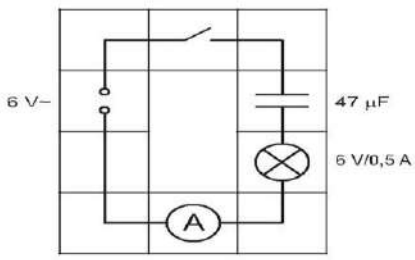


Figure 2

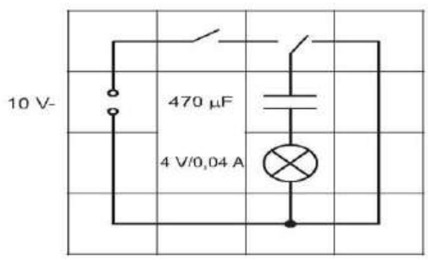


Figure 3

TASK B

1. Connect up the circuit as shown in Fig. 3, with the on/off switch first open; turn the changeover switch to position 1 and set the power supply to 10 V alternative current; prior to inserting the capacitor in the circuit, dis-charge it by short circuiting it.
2. Switch on the power supply, close the circuit and observe the lamp; note what you observe under (B).
3. Replace the 470 µF capacitor by the 47 µF capacitor; operate the changeover switch, first slowly, then in ever quicker succession (with increasing switching frequency), and observe the lamp; note what you observe under (C).
4. Switch off the power supply.

Observations and Measurement Results

Components in the alternating current circuit	Lamp lights up	Current I /mA
47 µF capacitor		
470 µF capacitor		
No capacitor		

Table 1.

Observation B

____
____
____

Observation C

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QUESTIONS

1. Capacitors in direct current circuits represent an infinitely large resistance, as they interrupt the circuit. What follows from the results of the first experiment entered in Table 1?

2. Which can you state, from the observations noted under (3), on the relationship between the resistance of a capacitor in an alternating circuit and the frequency?

CONCLUSION

Write the conclusion in the laboratory report.