Lab Session 04
Ohm's Law, Kirchhoff's Voltage and Current Laws

Objective:

- This exercise examines Ohm's law, one of the fundamental laws governing electrical circuits. It states that voltage is equal to the product of current times resistance.

- To verify Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL) in a Passive Resistive Network

Equipments Required:

- Variable DC power supply(maximum 30V)
- DMM (Digital multi meter)
- resistors (values as mention in procedure)

Theory:

"Ohm's law is commonly written as V = I * R. That is, for a given current, an increase in resistance will result in a greater voltage. Alternately, for a given voltage, an increase in resistance will produce a decrease in current."

As this is a first order linear equation, plotting current versus voltage for a fixed resistance will yield a straight line. The slope of this line is the conductance, and conductance is the reciprocal of resistance. Therefore, for a high resistance, the plot line will appear closer to the horizontal while a lower resistance will produce a more vertical plot line.

Kirchhoff's Voltage Law:

"The algebraic sum of all voltages in a loop must equal zero"

A series circuit is defined by a single loop in which all components are arranged in daisy-chain fashion. The current is the same at all points in the loop and may be found by dividing the total voltage source by the total resistance. The voltage drops across any resistor may then be found by multiplying that current by the resistor value. Consequently, the voltage drops in a series circuit are directly proportional to the resistance. An alternate technique to find the voltage is the voltage divider rule. This states that the voltage across any resistor (or combination of resistors) is equal to the total voltage source times the ratio of the resistance of interest to the total resistance.

Kirchhoff's Current Law:

"The algebraic sum of all currents entering and leaving a node must equal to zero"

A parallel circuit is defined by the fact that all components share two common nodes. The voltage is the same across all components and will equal the applied source voltage. The total supplied current may be found by dividing the voltage source by the equivalent parallel resistance. It may also be found by summing the currents in all of the branches. The current through any resistor branch may be found by dividing the source voltage by the resistor value. Consequently, the currents in a parallel circuit are inversely proportional to the associated resistances. An alternate technique to find a particular current is the current divider rule. For a two resistor circuit this states that the current through one resistor is equal to the total current times the ratio of the other resistor to the total resistance.

When measuring voltage levels, make sure the voltmeter is connected in parallel (across) the element being measured, as shown in Fig. 4.1. In addition, recognize that if the leads are connected as shown in the figure, the reading will be up-scale and positive. If the meter were hooked up in the reverse manner, a negative (down-scale, below-zero) reading would result. The voltmeter is therefore an excellent instrument not only for measuring the voltage level but also for determining the polarity. Since the meter is always placed in parallel with the element, there is no need to disturb the network when the measurement is made.

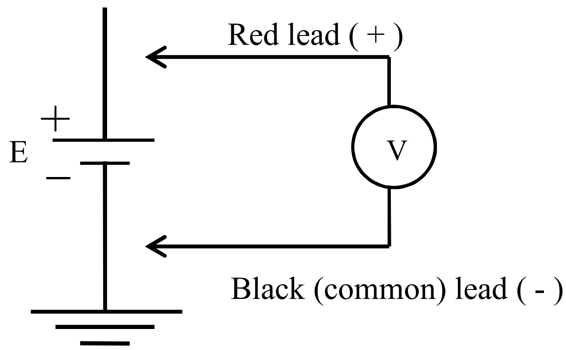


Fig. 4.1 Voltmeter connection

Ammeters arc always connected in series with the branch in which the current is being measured, as shown in Fig. 4.2, normally requiring that the branch be opened and the meter inserted. Ammeters also have polarity markings to indicate the manner in which they should be connected to obtain an upscale reading. Since the current I of Fig. 4.2, would establish a voltage drop across the ammeter as illustrated, the reading of the ammeter will be up-scale and positive. If the meter were hooked up in the reverse manner, the reading would he negative or down-scale. In other words, simply reversing the leads will change a below-zero indication to an up-scale reading.

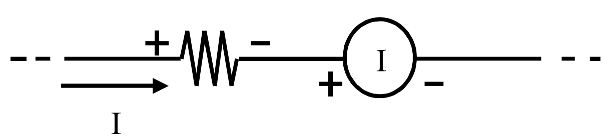


Fig. 4.2 Ammeter connection

For both the voltmeter and the ammeter, always start with the higher ranges and work down to the operating level to avoid damaging the instrument.

Procedure:

Current versus Voltage:

1) Construct the circuit of fig. 4.3
2) Do not switch on the power supply. Disconnect the resistor R from the circuit and set it to 2.2 kΩ by using ohmmeter. Now reconnect it.
3) Turn on the power supply and adjust it to 5V. Measure the current *I* in amperes and record it in the table.
4) Measure and record in turn, the current *I* (in amperes) at each of the voltage settings shown in the table, for $R = 2.2K\Omega$.
5) Calculate the value of current I by using $I = V/RT$. Use measured value of resistance.
6) Plot a graph of I versus V. (use measured values)

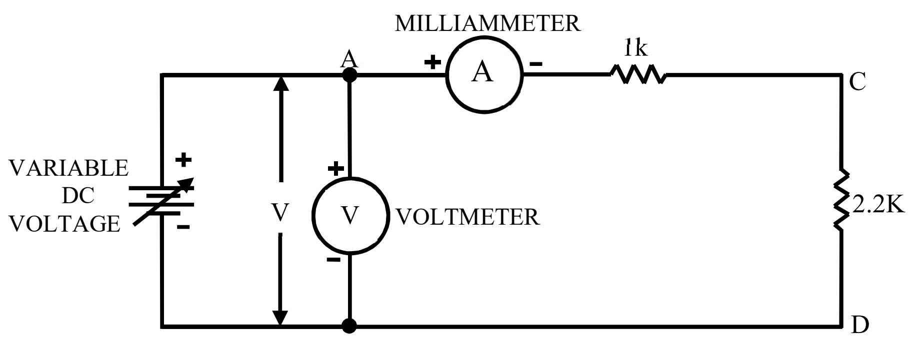


Fig.4.3

Current Versus Resistance:

1) Construct the circuit of fig. 4.4.

2) Do not switch on the power supply. Disconnect the resistor R from the circuit and set it to 1000Ω by using ohmmeter. Now reconnect it.

3) Turn on the power supply and adjust it to 20V. Measure the current *I* in amperes and record it in the table.

4) Measure and record in turn, the current *I* (in amperes) at each of the resistance settings shown in the table, for *V*= 20V.Be sure to set the resistor values in the same way as described in step 2.

5) Calculate the value of resistance RT by using $R = V/I$. Use measured value of Voltage and current.

6) Plot a graph of I versus R. (use measured values)

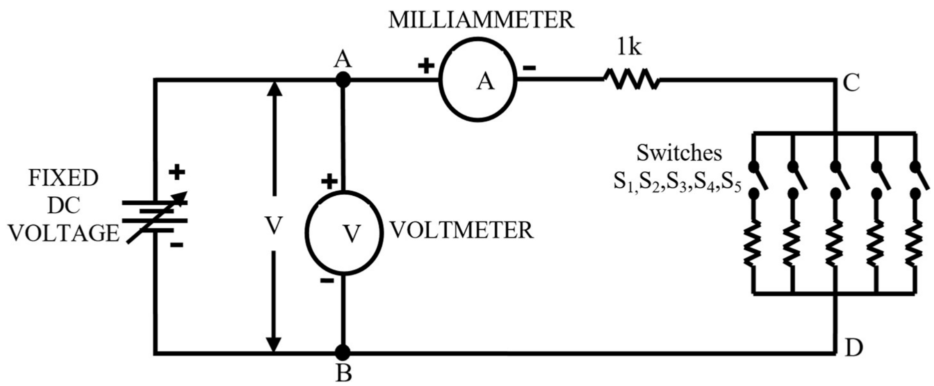


Fig. 4.4

Observations:

Current vs. Voltage:

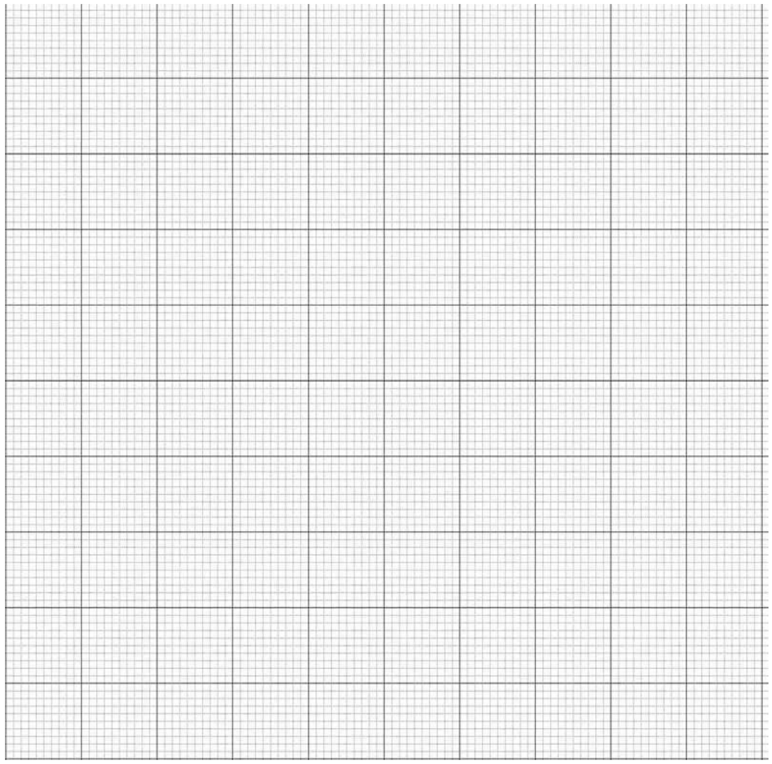
S. No.	Voltage (V)	R_t (kΩ) Calculated	R_t (kΩ) Measured	I (Amp) Calculated	I (Amp) Measured
1	5				
2	10				
3	15				
4	20				
5	25				
6	30				

Table 4.1

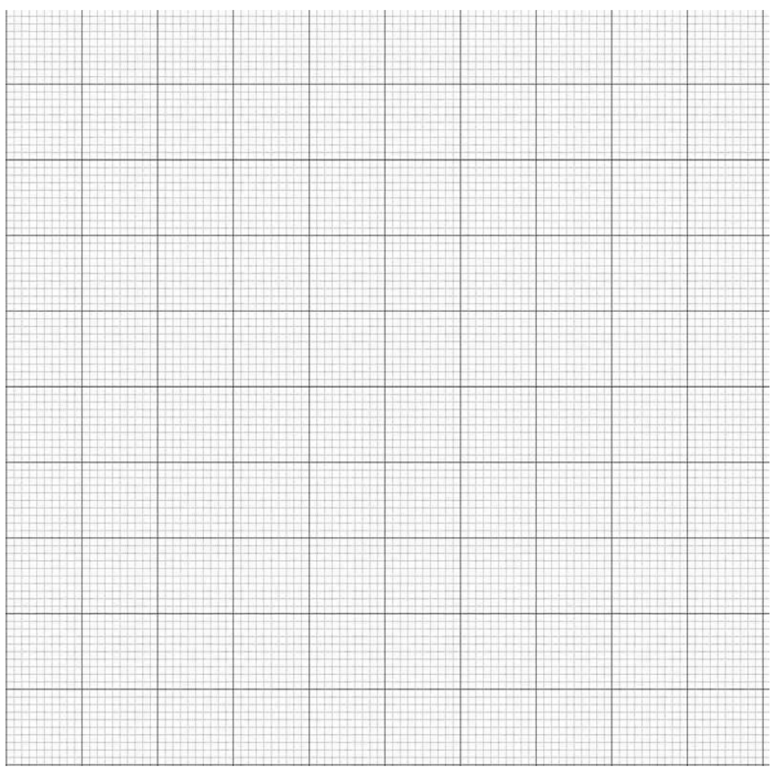
Current vs. Resistance:

S. No.	Voltage (V)	R_t (kΩ) Calculated	R_t (kΩ) Measured	I (Amp) Calculated	I (Amp) Measured
1	20				
2	20				
3	20				
4	20				
5	20				
6	20				

Table 4.2



Current versus voltage



R(kΩ)

Current versus resistance

KVL

1. Construct circuit of fig. 4.5 using the values R1 , R2, R3 as shown in the figure 4.5
2. Adjust the output of the power supply so that Vs = 20V. Measure and record this voltage in table.

3.3 also measure and record the voltages V1, V2, V3 and enter the sum in the same table.

KCL

1- Connect the circuit of Fig. 4.6 with Vs =20 V.

2- Measure and record in Table 4 currents I_{R1},I_{R2},I_{R3} and I_{total}.

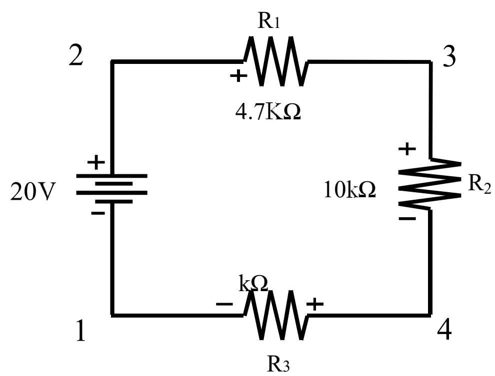


Fig. 4.5

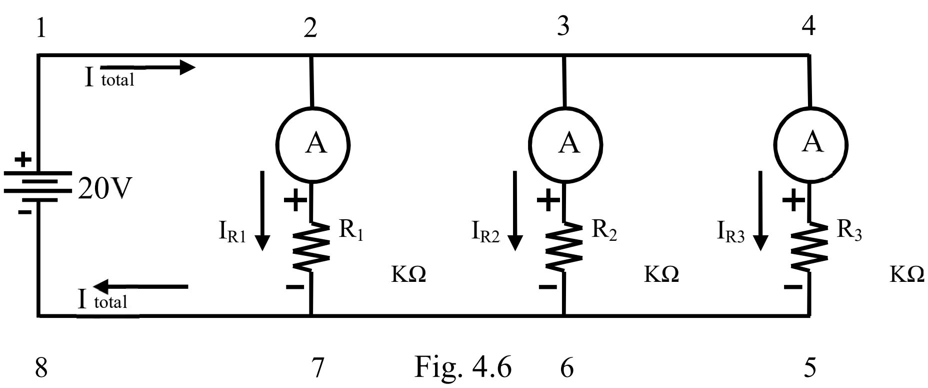


Fig. 4.6

Observations:

V_T	V_1	V_2	V_3	Sum (V_1+V_2+V_3)

Table 4.3

I_{Total}	I_{R1}	I_{R2}	I_{R3}	Sum (I_{R1}+ I_{R2}+ I_{R3})

Table 4.4

Conclusion & Comments:

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Question

Q-1) What is the relationship between voltage and current, provided that the resistance is fixed?

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Q-2) Two parallel resistors (1kΩ and 3300Ω) are supplied by 15V battery. It has been found that 3300Ω resistor draws more current? Is the statement correct? Why?

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KVL

Q-1) In fig. 4.5 V_1=10V, V_2=12V, V_3=20V. The applied voltage V_S must then equal ____________ V.

Q-2) In Fig. 4.5, V_1=15V, V_2=20V and V_S = 100V. The Voltage V_3 = ____________V.

Q-3) Is KVL verified practically as well as mathematically in the above performed lab? If no, explain reason.

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For KCL:

Q-1) In fig 4.6, if I_{R1}=5A, I_{R2}=2A and I_{R3}=1A, then I_{total} should be equal to

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Q-2) Is KCL verified practically as well as mathematically in the above performed lab? If no, explain reason.

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