ELECTRICAL LABORATORY SAFETY

Objectives At the end of the session the student will be able to :
Understand the safety rules and regulations in the laboratory.
Practice the safety rules and regulations.

Apparatus None

Introduction

The important aspects of safety are:-

1. Safety is a concern to all in order to prevent accident and to save lives.
2. To build-up self awareness about safety among student.
3. To practice safety precaution and self discipline towards the highest level all the time.

Personnel safety is very important during practical experiment in laboratory/workshop. It is also important to ensure safety for work places and equipments must be observed at all times.

PERSONNEL SAFETY

In order to secure your safety, the following rules and regulations should be followed:-

1. Make sure your hands are not dirty or oily.
2. Should wear protective equipment such as safety shoes, goggles, apron according to the requirement of our working environment and situation.
3. Please wear proper clothing, based on the environment and situation.
4. Don't wear any jewelry during laboratory experiment that involves with electrical equipment because it is a good conductor of electric current.
5. Don't eat, drink or horse-play in the laboratory/workshop during the experiment; especially when you are involved with electrical machine.
6. Rules, regulations and instruction given by the instructor must be followed.

SAFETY AT WORK PLACE

During laboratory experiment, the following rules and regulations should be followed:-

1. The location of First Aid kit and Emergency Switches in the laboratory or workshop must be identified.
2. Laboratory and workshop must be kept clean and tidy.
3. Make sure the laboratory floor is cleaned from water and oil.
4. Make sure the laboratory windows are opened and cleaned. Its purpose is for a good ventilation.
5. Make sure the tables only consist of equipments that are needed for the experiment.
6. Make sure that all the equipment are arranged and put back to their original place.

SAFETY OF THE EQUIPMENT

In order to maintain the good condition of every equipment, make sure the following rules and regulation are followed:

1. Read the instruction/manual carefully before using any of the equipment.
2. Make sure that all the equipment are in good condition before using them.
3. Proper equipment must be used for every experiment.

4. Please inform your lecturer, if the equipment used is not working properly or damage. It should be labeled as faulty equipment.

There are three types of accidents can happen in the laboratory:

1. Electrical Shock
2. Mechanical injury
3. Fire

Mechanical injuries such as cuts and bruises, are caused by carelessness and not following the proper procedure when using the equipment. Fire may be caused by short circuit where excessive current flow in the circuit. Fire extinguisher should be available in every laboratory/ workshop.

Electrical Shock

Electrical Shock is caused by the flow of electrical current through our body. The level of electrical shock is base on value of the voltage and current flow. The effect of electrical shock is depended on few factors, such as:

1. Current Level

Current level is base on the value of current that flows in our bloodstream. If the value is higher, than effect of electrical shock is greater.

Level of current	Result
0.001A	Cause a little bit of electrical shock
0.01A	Causes greater shock and pain can cause lose control in our body stream system.
0.1A	Shock that can kill an individual within seconds.
1A and above	Dead and burnt.

2. Directions Of The Current Flow

Direction of the current flow is another factor which determines the severe of electrical shock. It is base on from where and to where the current that flow through our body. The table below shows the effects and direction of current flow which can cause electric shock:

Directions of current flow	Result
Foot-to-foot	Less danger cause current flow only from feet to earth.
Hand-to-foot or Hand-to-hand	More danger causes as the current will flow through your heart and can cause a person hard to breathe.
Head-to-foot	Very dangerous as current flow through the blood stream to the brain and spine code.

3. Duration of Current Flowing Through Body System

The duration is another factor that can determine how fatal the electrical shock Small amount of current needs longer time compare to the large amount of current that can cause danger to body.

4. Voltage Level

The effect of electric shock to a person is depending on the amount of voltage, for examples:

275KV : less than 1 foot from the victim can cause burns.

11KV	: less than ½ foot from the victim can cause burns.
415V / 240V	: making contact with any part of our body is very fatal.

The amount of current that can flow through our body is based on the value of voltage and resistance in our body. Resistance's of our body depends on the affected and exposed area. Small amount of resistance can cause a higher flow of current.

SAFETY PRECAUTION TO PREVENT ELECTRICAL SHOCK

As you know, that electrical shock is very dangerous, so each precaution must be taken to ensure our safety is secure. The following steps of safety need to be taken into account:

1. **Please don't rely** on the protection fuse equipment only; sometimes it may be harmful to us.
2. Be careful of such equipment that can cause danger, be at least 1 meter from the victim or else it can cause burns.
3. **Do not carry** out any experiment without lecturer's supervision because you might be exposed to electrical shock.
4. **Do not disconnect** the earth terminal from any electrical appliances.
5. **Do not change** the value of the fuse that has been fixed into the equipment.
6. **Do not put any unnecessary things** on the experimental tables such as connecting cables, other components and etc.
7. **Do not attempt** to carry out any changes or maintenance while the circuit current is still ON.
8. **Wear proper clothing**, headgear and use non-conductive materials.
9. Safety rules and regulations must be followed at all time.
10. Always remember **"SAFETY comes FIRST".**

Question 1 . State three reasons why safety is important.

____

____

____

____

2.The following statements relate to personal safety rules while working in the workshop. Mark (√) for statements which are true and (X) for statements which are false in the spaces provided below:

a) Students should not wear jewelries in the workplace ( )
b) Slippers are allowed in the workplace ( )
c) Do not work if you are sick ( )
d) Always adhere to the instructions from the lecturers or supervisors ( )
e) Keep the workplace clean and tidy at all time ( )
f) Use the right tools for the task you are undertaking ( )

3. How does a fuse or a circuit breaker function as a current limiter?

____

4. The most dangerous place to use electrical equipment is?
A. indoors.
B. outdoors.
C. near water.
D. near other electrical equipment

5. The earth, water, concrete and the human body are all conductors of electricity
A. True
B. False

6.The effects of an electrical shock on the body depend upon all of the following *EXCEPT:*
A. current.
B. path.
C. duration.
D. body weight.

7. It is the responsibility of all students to understand and use electrical safety everyday.
A. True
B. False

EXPERIMENT 1: MULTIPLE DEFLECTION METER (MULTIMETER)

Objectives At the end of the session the student will be able to :
Know multimeter and each part of it.
Use the correct ranges and scales of multimeter.
Able to calibrate multimeter correctly.
Able to measure current, voltage and resistor using multimeter

Apparatus Variable power supply bench
Multimeter
Resistor.

Introduction

Multimeter is an apparatus that really useful during electrical workshop. It can be used to measure electric quantity such as resistor, voltage and current. It also can be used as a test meter for electrical circuit.

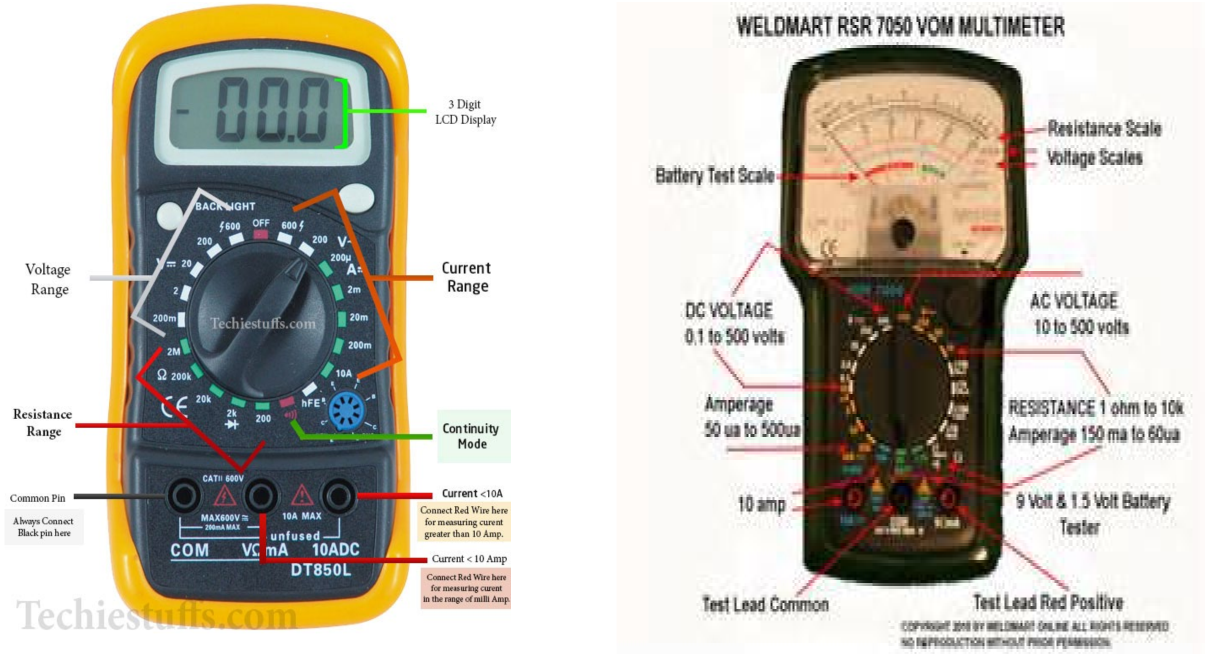


Figure 1.1 : Multimeter

Function and Scale

Multimeter have a variety of functions, it is used to measure value of voltage (AC or DC), current (AC or DC) and resistance. However, there are some types of multimeters that can be used to measured other quantities, such as the value of inductance and capacitance. Figure 2.1 shows common types of multimeter. For analog meter it has three scale as shown in Figure 2.2 ; the uppermost scale is used for resistance measurement while the remaining two scales can be used for voltage or current measurement for AC or DC supply.

Figure 1.2 : Scale Meter for Analog Multimeter

Current and Voltage Range

A multimeter main control consist of the Function switch and the Range Switch. The Function switch is used to choose the quantity being measured such as voltage (AC or DC) or current (AC or DC) and resistance.

Resistance Range

Resistance measurement is done using the Rx10k to Rx1 range. With the Function switch set to R and the Range switch set to Rx1, the resistance scale is read directly in the units of Ohm. In the Rx1k range however, all resistance values displayed by the indicator has to be multiplied by 1k. For example, if the indicator shows a reading of 30, the resistance value is thus 30 x 1k = 30kΩ.

Analogue multimeters

An analogue meter moves a needle along a scale. Switched range analogue multimeters are cheap but are difficult for beginners to read accurately, especially on resistance scales. The meter movement is delicate and dropping the meter is likely to damage it. For current measurement, the circuit must be broken to allow the ammeter to be connected in series. Ammeters must have a *low* resistance , meanwhile to measure potential difference (voltage), the circuit is not changed. The voltmeter is connected in parallel and it must have *high* resistance. For measuring resistance, the component must be removed from the circuit altogether. Ohmmeters work by passing a current through the component being tested.

Procedure

A. Multimeter is used as an AC Voltmeter

i. Turn the selector switch on multimeter from Ohm (Ω) to ACV. (make sure you use the highest range first, now it ready to use as voltmeter)
ii. Turn on variable power supply. (make sure your lecturer assist you to ON this equipment and the adjustable knob were set to minimum '0')
iii. Set the selector switch of variable power supply to AC.
iv. Connect your probe with refer to the right color and read the meter properly.
v. Fill in the reading with reference to the value setting in Table 1.1 below.

B. Multimeter is used as an DC Voltmeter

i. Turn the selector switch on multimeter from Ohm (Ω) to DCV. (make sure you use the highest range first, now it ready to use as voltmeter)
ii. Turn on variable power supply. (make sure your lecturer assist you to ON this equipment and the adjustable knob were set to minimum '0')
iii. Set the selector switch of variable power supply to DC.
iv. Connect your probe with refer to the right color and read the meter properly.
v. Fill in the reading with reference to the value setting in Table 1.2 below.

Results

Table 1.1 AC voltage measurement

Label	**Reading of multimeter**
Minimum (10%)	
Medium (50%)	
Maximum (75%)	

Table 1.2 DC voltage measurement

Label	**Reading of multimeter**
Minimum (10%)	
Medium (50%)	
Maximum (75%)	

EXPERIMENT 2: RESISTOR COLOUR CODE

Objectives At the end of the session the student will be able to :

1. Use the correct ranges and scales of a multimeter.

2. Measure resistance, current and voltage values using a multimeter.

3. Determine the color of resistor.

Apparatus
1. Multimeter,
2. Resistors.

Introduction

RESISTOR

The value of resistors is shown by a pattern of colored rings. The value of a resistor is determined by reading from the closest band from one end to another. The colors are internationally defined as listed below. However, the precise color code of the resistors may differ from one manufacturer to the other. For example 'red' or 'blue' color of a manufacturer looks as if it is brown to another manufacturer. In any case, when in doubt it is highly recommended to use meters to measure the values.

How to Read

The **4-band code** is used for marking low precision resistors with 5%, 10% and 20% tolerances. Identifying the value will become easy with a little practice, as there are only a few simple rules to remember:

- The **first two bands** represent the most **significant digits** of the resistance value. Colors are assigned to all the numbers between 0 and 9, and the color bands basically translate the numbers into a visible code. Black is 0, brown is 1, red is 2 and so on (see the table on the next page). So, for example, if a resistor has brown and red as the first two bands, the most significant digits will be 1 and 2 (12).
- The **third band** indicates the **multiplier** telling you the power of ten to which the two significant digits must be multiplied (or how many zeros to add), using the same assigned value for each color as in the previous step. For example, if this band is red (2), you will multiply it by 10^2 = 100 (or add 2 zeros). So, for the resistor we used in the previous example, the value would be: 12 x 100=1200Ω(1.2kΩ).

  ****Note**: If the multiplier band is gold or silver, the decimal point is moved to the left by one or two places (divided by 10 or 100).

- The **tolerance** band (the deviation from the specified value) is next, usually spaced away from the others, or it's a little bit wider. A color is assigned to each tolerance: gold is 5%, silver is 10%. 20% resistors have only 3 color bands - the tolerance band is missing.

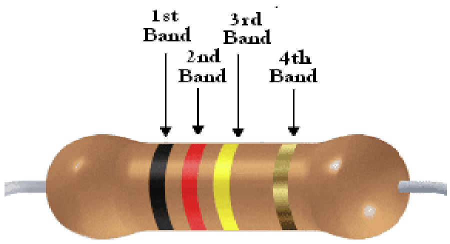


Figure 2.1 : 4 Band code

Table 2.1: The standard resistor color code

Color	Band 1 1st Figure	Band 2 2nd Figure	Band 3 3rd Figure	Band 4 Tolerance
Black	0	0		
Brown	1	1	0	
Red	2	2	00	
Orange	3	3	000	
Yellow	4	4	0000	
Green	5	5	00000	
Blue	6	6	000000	
Violet	7	7	0000000	
Gray	8	8	00000000	

White	9	9	000000000	
Gold			0.1	5%
Silver			0.01	10%
None			0.001	20%

Example:

1st Band	2nd Band	3rd Band	4th Band	Value (Ohm)
Yellow	Violet	Red	Gold	4700 ± 5% Ω
Orange	Orange	Brown	Gold	330 ± 5% Ω
Red	Red	Red	Silver	2200 ± 10% Ω
Green	Blue	Yellow	No Colour	560K ± 20% Ω

MULTIMETER

In this experiment, you must know how to use multimeter. It is very important for you to know how to measure the value of current (ampere), voltage (volt) and resistance (Ω). Besides that, you should have a good skill of knowledge to be able to select and used the correct value of the scale. Multimeter can be used for any kinds of measurement, such as Ampere for measuring current, Volt for measuring voltage and resistance for measuring ohm. On the other hand, some others multimeter can only measured one special particular measurement.

How To Measure Resistance

The unit for resistance is ohm (Ω). Equipment that is used to measure resistance is an ohm meter. Do not attempt to measure a resistor when the circuit is still connected to the power supply. Multimeter has its own battery to supply electrical current through the resistance for measuring the value of the resistance. First, you must calibrate the ohm meter before doing any measurements. Connect both end probes together and adjusted the knob until the meter reading is zero ohm. This calibration should be carried out every time you change the value at the indicating scale. When the indicating scale is R x 1, the reading indicate real the value of the resistance being measured. On the other hand, if the scale is R x 10, the reading is measured at 30, then the value of the resistance is 30 x 10 = 300 Ω. Ohm meter sometimes can be part of the multimeter.

Procedure

A. Determine the resistance value by using colour code

1. Set the resistor given to label A, B,C D and E.
2. Determine the colour for each band and record all in Table 2.1 below.
3. Calculate the minimum and maximum value of each resistor by using 4^{th} band as reference.
4. Fill in the calculation result form procedure 3 in Table 2.1 below.

B. Determine the resistance value by using multimeter

1. Turn the range switch to R x 1kΩ.
2. Insert the Red Probe at the P source and the Black Probe at the N source.
3. Connect (Short) both ends of the probes together and calibrate it to 0 Ω.
4. Connect the end of the probes to both of the resistor's leg as shown below.
5. Read the multimeter indicator's scale. Then multiply the reading with the range value used:-

   Example: Scale Measurement : 10

   Range Used : 100

   Resistor's value : 10 x 100Ω = 1kΩ.

6. Measure all the resistor's value provided by repeating procedure 3 to 5 and record all measurements in Table 2.2 below.

Results

Table 2.1: Resistor's value using color code

LABEL	COLOR CODE				RESISTOR'S VALUE		
	1^{st} Band	2^{nd} Band	3^{rd} Band	4^{th} Band	Minimum	Value	Maximum
A							
B							
C							
D							
E							

Table 2.2: Resistor's value measured with ohmmeter

LABEL	SCALE READING	RANGE USED	RESISTOR'S VALUE
A			
B			
C			
D			
E			

EXPERIMENT 3 : SERIES CIRCUIT

Objectives At the end of the session the student will be able to :

1. Connect a series circuit.
2. Measure current and voltage.
3. Understand Ohm's Law and calculate current and voltage.

Apparatus

1. Multi-meter
2. DC Power Supply
3. Resistors – 3.3kΩ, 470Ω, 560Ω.
4. Alligator clip wires.
5. Jumper wires.
6. Project Board.

Introduction

A series circuit is any circuit having only one path for current flow. In other words, two or more electrical components or elements are connected so the same current passes through all the connected components. This situation exists when components are connected end-to-end in the circuit external to the source, Figure 3.1. This is termed a two-component series circuit. Also, notice there is only *one possible path* for current flow from the source's negative side, through the external circuit, and back to the source's positive side. In a series circuit, the total voltage drops across the resistor is equal to the voltage supplied while the current that flows at any point in the circuit is the same. The equivalent resistance for the circuit can be determined using Ohm's Law, which can found by divide the voltage supplied with the current produced in the circuit.

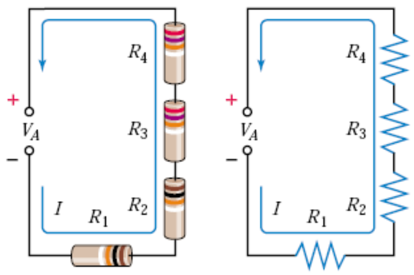


Figure 3.1 : Four-resister series circuit.

Series Circuit Total Resistance Formula

If the circuit current must sequentially flow through all the resistors since there is only one path for current, then the total resistance to current flow will equal the *sum* of all the resistances in series. Once again, in series circuits, the total resistance (*RT* or *R* total) equals the sum of all resistances in series. Two important facts about series circuits: first, *current* is the same throughout all parts of a series circuit. Second, the total circuit *resistance* equals the sum of all the resistances in series, which indicates total resistance must be greater than any one of the resistances.

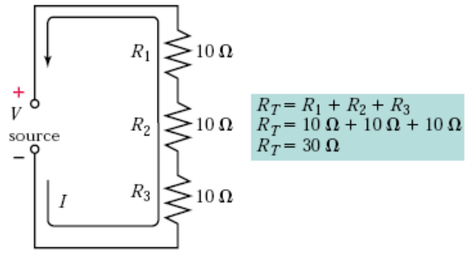


Figure 3.2 : Application of series-circuit total resistance formula

Voltage in Series Circuits

Because there is only one path for current, the current *(I)* through each resistor (R_1, R_2, and R_3) must have the same value since it is the same current, Figure 3.3. From Ohm's law, the value of voltage dropped by R_1 must equal its I times its R, or

$$V_1 = I_{R1} \times R_1$$

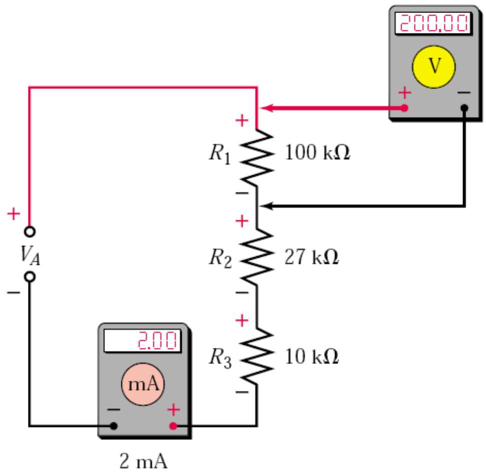
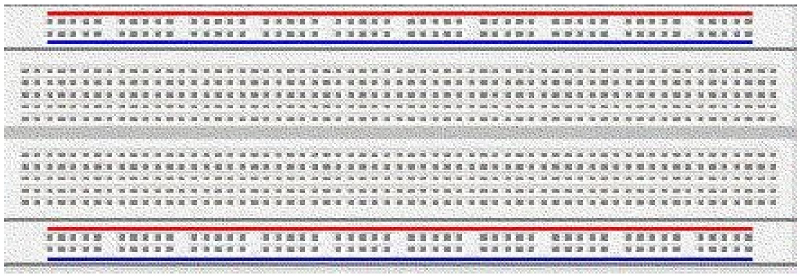


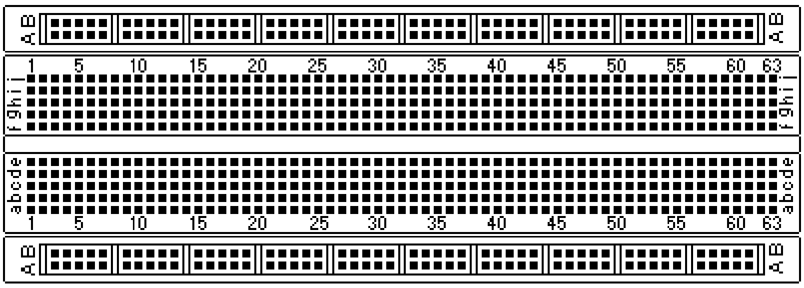
Figure 3.3 : Voltage distribution in series circuits

Breadboard

The breadboard is a set of already connected holes. Companies make these boards, which range in complexity from simple loose strips to complete design systems with power supplies, function generators, switches, potentiometers, etc. already built in. The key for a successful use of this breadboard knows how the holes are connected. The breadboard has many holes into which circuit components like ICs and resistors can be inserted. A typical breadboard is shown below:



(a)



(b)

Figure 3.4 : Holes distribution of a breadboard

It is composed of two different styles of connection strips:

- Component connection strips: This section has holes that are grouped in units of five, where each hole in a group of five is connected to all other holes in that group.
- Power connection strips: This section is also grouped in fives, but all groups that are in the same row are connected together forming a bus.

The bread board has strips of metal which run underneath the board and connect the holes on the top of the board. The metal strips are laid out as shown below. Note that the top and bottom rows of holes are connected horizontally while the remaining holes are connected vertically.

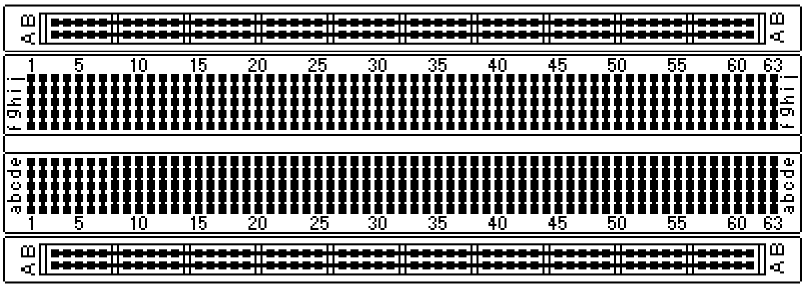


Figure 3.5: Holes connections in the breadboard.

To use the bread board, the legs of components are placed in the holes. Each set of holes connected by a metal strip underneath forms a *node*. A node is a point in a circuit where two components are connected. Connections between different components are formed by putting their legs in a common node.

The long top and bottom row of holes are usually used for power supply connections. The rest of the circuit is built by placing components and connecting them together with jumper wires. ICs are placed in the middle of the board so that half of the legs are on one side of the middle line and half on the other.

Breadboard tips:

It is important to breadboard a circuit neatly and systematically, so that one can debug it and get it running easily and quickly. It also helps when someone else needs to understand and inspect the circuit. Here are some tips:

1. Always use the side-lines for power supply connections. Power the chips from the side-lines and not directly from the power supply.
2. Use black wires for ground connections (0V), and red for other power connections.
3. Keep the jumper wires on the board flat, so that the board does not look cluttered.
4. Route jumper wires around the chips and not over the chips. This makes changing the chips when needed easier.
5. You could trim the legs of components like resistors, transistors and LEDs, so that they fit in snugly and do not get pulled out by accident.

Procedure

1. Connect the circuit as in Figure 3.6 using project board given.

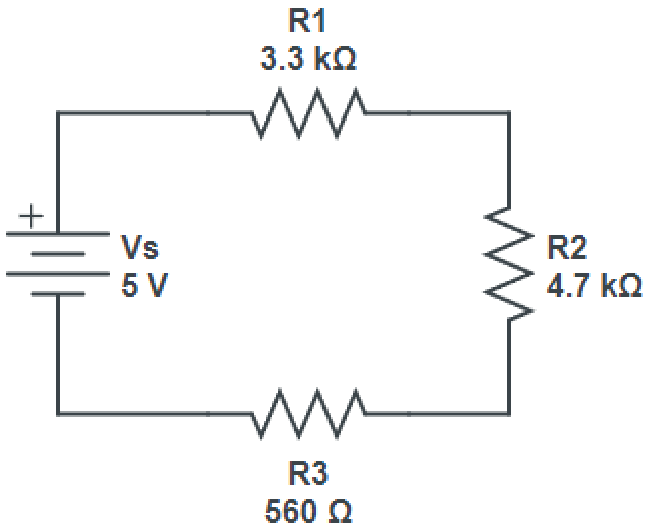


Figure 3.6: Series with 5V power supply.

2. Use your multimeter to measure the current and voltage as in table below. Record all your readings in the Table 3.1.

Results

Table 3.1: Result for three-resistor series circuit

Voltage Supply	**Measurement**				**Theoretical Result (Calculation)**			
	V1	V2	V3	I	V1	V2	V3	I
5 V								
10 V								
15 V								

Discussion

1. Plot a V-I graph (Voltage Supply Vs Current) by referring to your measurements.
2. Derive the formula that can be made from your graph.

3. Show the calculation steps for V1, V2, V3 and I.

Conclusion