Chapter - 1
Introduction to Electricity

Though you cannot see electricity, you are aware of it every day. You see it used in countless ways. You cannot taste or smell electricity, but you can feel it. Basically, there are two kinds of electricity - static (stationary) and dynamic (moving). This module is about dynamic electricity because that is the kind commonly put to use. Electricity (dynamic) is characterized by the *flow of electrons through a conductor*.

A material that contains many free electrons and is capable of carrying an electric current is called a conductor. Metals and (generally) water are conductors. Gold, silver, aluminum and copper are all good conductors. Materials that contain relatively few free electrons are called insulators. Non-metallic materials such as wood, rubber, glass and mica are insulators. Fair conductors include the **human body**, earth, and concrete.

The below Table 1 shows the Fundamental Electrical Terms used to control every electric circuit.

Fundamental Electrical terms				
Function	Term	Symbol	Unit of measure	Abbreviation
Force	Voltage	E	Voltage	V
Result of Force	Current	I	Ampere	A
Resists current flow due to physical properties	Resistance	R	Ohm	Ω
Resists current flow due to magnetic effect	Reactance	X	Ohm	Ω
Total opposition to current flow in AC systems	Impedance	Z	Ohm	Ω

Table – 1

Electrical Safety: Electrical hazards can cause shocks, burns and electrocution (death).

1.1 Shock

Electric shock occurs when the human body becomes part of a path through which electrons can flow. The resulting effect on the body can be either direct or indirect.

a. Direct

Injury or death can occur whenever electric current flows through the human body. Currents of less than 30 mA can result in death. A thorough coverage of the effects of electricity on the human body is contained in the section of this module entitled *Effects of Electricity on the Human Body.*

b. In direct

Although the electric current through the human body may be well below the values required to cause noticeable injury, human reaction can result in falls from ladders or scaffolds, or movement into operating machinery. Such reaction can result in serious injury or death.

1.2 Burns

Burns can result when a person touches electrical wiring or equipment that is improperly used or maintained. Typically, such burn injuries occur on the hands.

1.2 Explosions

Explosions occur when electricity provides a source of ignition for an explosive mixture in the atmosphere. Ignition can be due to overheated conductors or equipment, or normal arcing (sparking) at switch contacts.

1.3 Fires:

Electricity is one of the most common causes of fire both in the home and workplace. Defective or misused electrical equipment is a major cause, with high resistance connections being one of the primary sources of ignition. High resistance connections occur where wires are improperly spliced or connected to other components such as receptacle outlets and switches. This was the primary cause of fires associated with the use of aluminum wire in buildings during the 1960s and 1970s.

1.4 Effects of Electricity on the Human Body:

The effects of electric shock on the human body depend on several factors. The major factors are:

a. Current and Voltage

b. Resistance

c. Path through body

d. Duration of shock

The muscular structure of the body is also a factor in that people having less musculature and more fat typically show similar effects at lesser current values.

We can sum up the lethal effects of electric current as follows:

1. Current flow greater than the "let-go" threshold of an individual may cause a person to collapse, become unconscious and can result in death. The current flow would most often have to continue for longer than five seconds. Although it may not be possible to determine the exact cause of death with certainty, asphyxiation or heart failure are the prime suspects.

2. Current flow through the chest, neck, head or major nerve centers controlling respiration may result in a failure of the respiratory system. This is usually caused by a disruption of the nerve impulses between the respiratory control center and the respiratory muscles. Such a condition is dangerous since it is possible for the respiratory failure to continue even after the current flow has stopped.

3. The most dangerous condition can occur when fairly small amounts of current flow through the heart area. Such current flow can cause ventricular fibrillation. This asynchronous movement of the heart causes the hearts' usual rhythmic pumping action to cease. Death results within minutes.

4. When relatively large currents flow through the heart area, heart action may be stopped entirely. If the shock duration is short and no physical damage to the heart has occurred, the heart may begin rhythmic pumping automatically when the current ceases.

Chapter – 2

Electrical Components Symbols and Functions

The below Table 2 shows the various components, their symbols and functions used in electrical circuits.

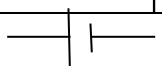
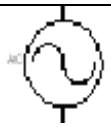
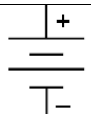
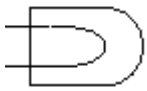
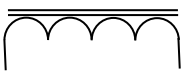
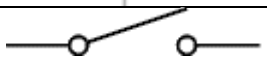
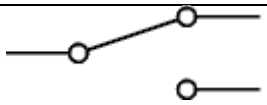
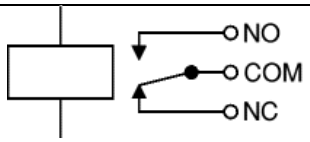
Name	Symbol	Function
Conductor		Conductor is a metal that conducts electric current.
Connection		It connects the devices to make a closed circuit.
Battery		It is a DC Storage device.
Alternating Current (AC)		The type of electric current which reverses at regularly recurring intervals of time and which has alternately positive and negative values.
Direct Current (DC)		The type of electric current in which the electrons move continuously in one direction through the conductor.
Fuse		Over current protection device
Lamp		Used for industrial and domestic lighting applications.
Iron cored Inductor (Choke)		Basic electrical component employed in most circuits. Stores energy in the form of electro-magnetic field.
Florescent lamp starter		Fluorescent lamp starter is a bi-metallic switch for the purpose of starting the fluorescent lamp.
One way switch		Used to allow or prevent the circuit current.
Two way switch		Used two connect two different circuits alternatively from a common point.
Magnetic relay with 1NO + 1NC		Relay is an electro mechanical switch used to make& break the circuit. **no- normally open** **NC - normally closed.** When Relay coil is energized NO contact closes and NC contact opens. When it is de-energized contacts come back to normal position.

Table 2

Exercise 1: Single lamp controlled by one-way switch

Aim: To control a lamp by one-way switch

Circuit Description: A one-way switch is used to control the working of a single incandescent lamp. This circuit is used for controlling the operation of lamps and fans. It must be ensured that the phase be connected through fuse that is used for excess current and short circuit protections. Here the Phase is the live part and the Neutral is the return path for the circuit current.

When the switch s is operated, circuit closes and the lamp is getting energized. Fig - 1 shows the circuit of a lamp controlled by one-way switch.

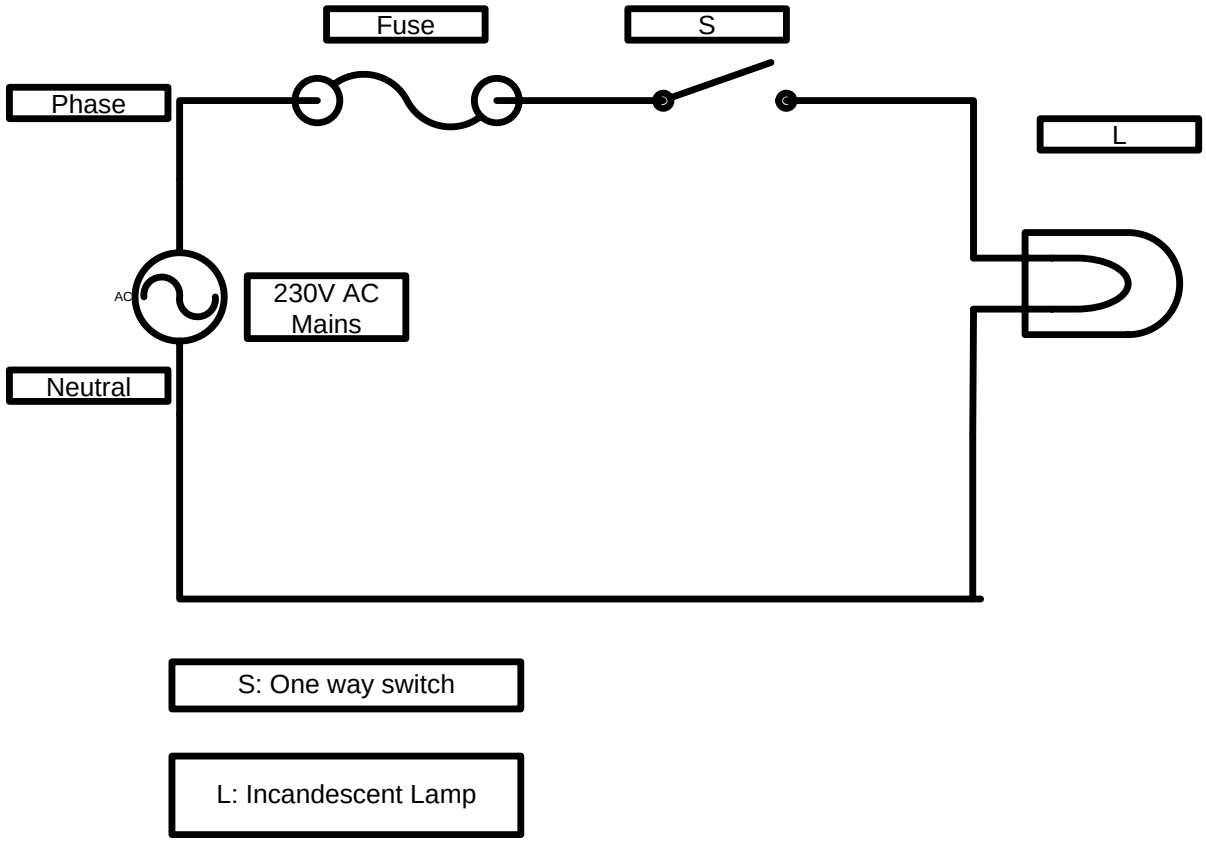


Fig - 1

Exercise 2: Single lamp controlled by 2 two way Switches

Aim: To control a lamp by 2 two way switches

Circuit Description: The lamp is controlled by two way switches as shown in figure - 2. It glows when both S1 and S2 are in either position 1 or 2. When S1 is in position 1 and S2 in position 2 or vice versa, the lamp is off. This enables the lamp to be controlled from two different locations that are situated away from each other.

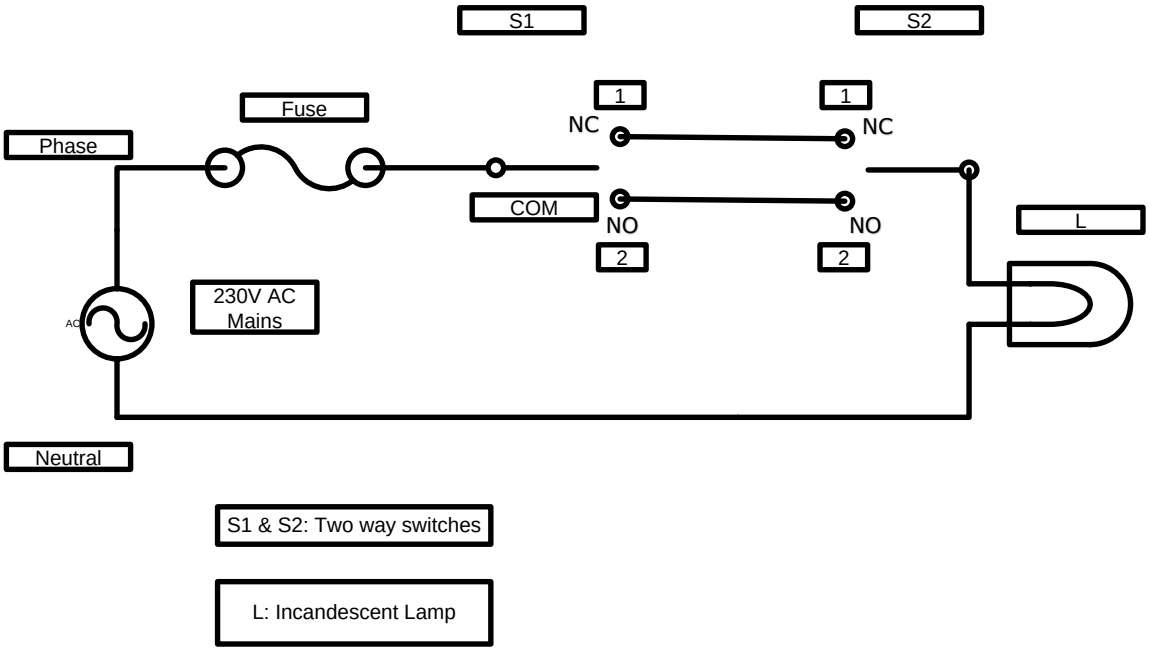


Fig - 2

Exercise 3: Series and parallel connection of lamps

Aim: To connect series and parallel of lamps

Circuit Description: The operation of switches S1 and S2 determines the series – parallel behavior of the circuit. When S1 is closed and S2 is open, lamps L1 and L2 are connected in series across the AC power supply. Thus they share the applied voltage and glow DIM. When we close S2 also, the two terminals of lamp L1 are connected together resulting in the entire supply voltage available across lamp L2 alone. Thus lamp L2 glows BRIGHT.

In practice, this arrangement is used to test motor and transformer windings for any short circuit. The winding under test is connected to supply with a lamp in series. With faulty / shorted winding, the lamp glows BRIGHT, as the winding Impedance is zero. Fig - 3 shows the circuit of two lamps connected in series and parallel.

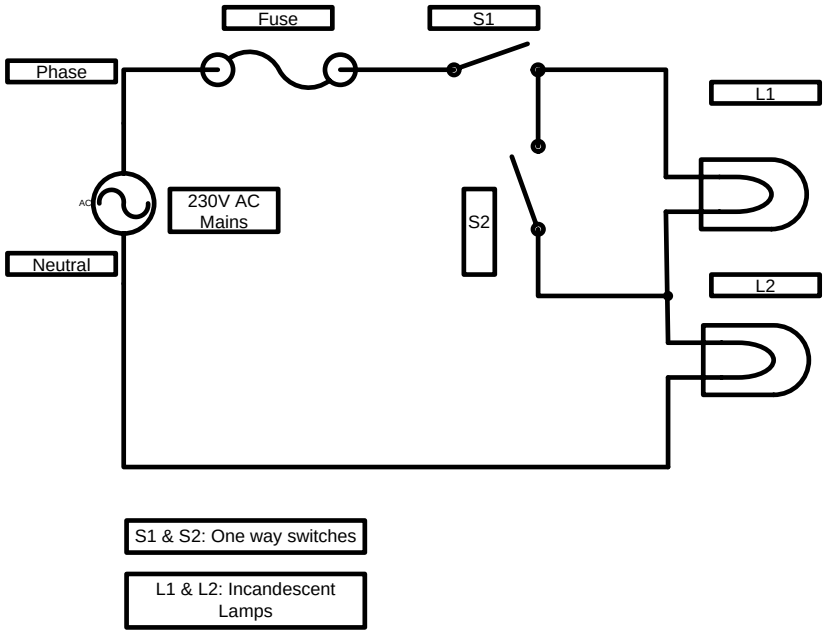


Fig - 3

Exercise 4: Florescent lamp control

Aim: To control a Florescent lamp

Circuit Description: An iron cored inductor (Choke) and a florescent lamp starter is included in the circuit with the florescent lamp as shown in fig- 5.

Fluorescent lamp starter which is shown in fig - 4 is a switch for the purpose of starting the fluorescent lamp that opens the preheating circuit of the lamp and applies the necessary striking high pulse voltage for starting to the both ends of the lamp after the cathode of the lamp has been preheated.

The fluorescent lamp starter consists of bi-metallic contacts sealed with a small discharge bulb with an argon gas. When the AC mains voltage which exceeds the fluorescent lamp starter operating voltage is supplied, a glow discharge within the small discharge bulb occurs and a bi-metallic contact is heated, causing the contact to bend and make contact with the other contact and close.

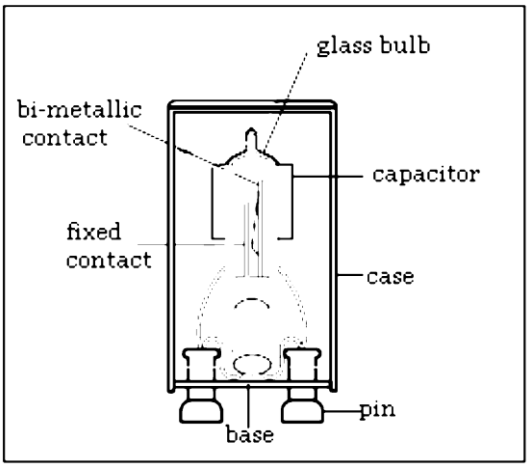


Fig – 4

When the switch S is closed, the AC mains voltage is applied to the circuit. At first, the lamp does not operate, since there is no electrical connection from one end to the other. A non-operating fluorescent tube will appear as an open circuit and the current does not flow.

In order to start the lamp, striking high pulse voltage must be applied across the lamp to ionize the gas and "strike the arc" within. The full AC mains voltage appears across the contacts of the fluorescent lamp starter via the Choke L and lamp cathodes, since the fluorescent lamp starter is switched electrically in parallel with the lamp. When the AC mains voltage which exceeds the fluorescent lamp starter operating voltage is supplied, a glow discharge within the small discharge bulb occurs and a bi-metallic contact is heated, causing the contact to bend and make contact with the other contact and close.

The contacts touch completes the circuit, and the choke and the lamp cathodes are now series connected across the AC mains, and allowing preheat current to flow between the lamp cathode through the starter and the choke.

Since the glow discharge within the small discharge bulb has now ceased by the close of the bi-metallic contact, the bi-metallic contacts cool down and re-open, breaking the short circuit.

Because the inductance of the choke tries to maintain current flow, the sudden interruption of the preheat circuit causes a voltage spike (striking high pulse voltage) at the instant of the opening of the contacts to trigger which starts the lamp. At this point, the lamp will work and the starter consumes no power while the lamp is operating. If it does not, the fluorescent lamp starter's contacts close again and the cycle repeats.

Once the lamp has started, the choke controls its current and voltage to the correct levels, so that the lamp running current is enough to keep the cathodes hot and emitting electrons.

Since the lamp's running voltage is much lower than the AC mains voltage (less than half AC mains), there is not enough voltage to cause a glow discharge in the fluorescent lamp starter, so it remains open circuit. This is the reason why the lamp continues to glow even with the absence of the starter.

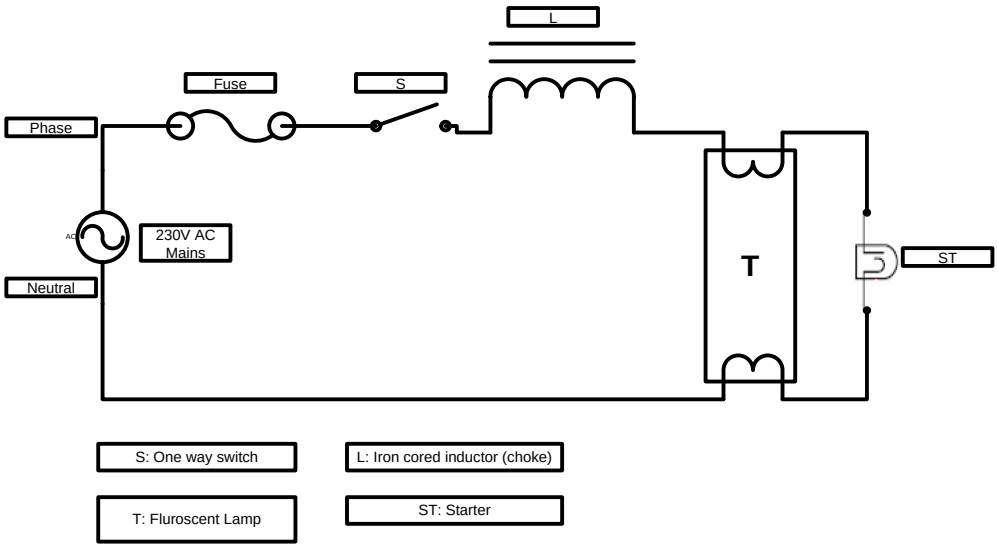


Fig - 5

Appendix
Additional exercises

1. Design a circuit to start and stop the given lamp by using push buttons switches.

2. Design a circuit to control three lamps (LI, L2 and L3) positioned inside a Godown. The required behavior is:
   a. Upon operating first switch, L1 should glow.
   b. L1 and L2 should glow upon operating second switch.
   c. L1, L2 and L3 all should glow once we operate third switch.
   d. The sequence should reverse while one wants to make them OFF.

3. Design a circuit to control three lamps (LI, L2 and L3) positioned inside a Godown, in Energy saving method. The required behavior is:
   a. Upon operating first switch, L1 should glow.
   b. Upon operating second switch L1 should off and L2 should glow.
   c. Upon operating third switch L2 should off and L3 should glow.
   d. The sequence should reverse while one wants to make them OFF.

4. Design a circuit to control a lamp with Electronic fan regulator as Dimmer.

5. Design a circuit to connect two lamps in series and parallel using two switches.

6. Design a circuit to control two lamps alternately using a 2 c/o Relay contacts.

Chapter - 1

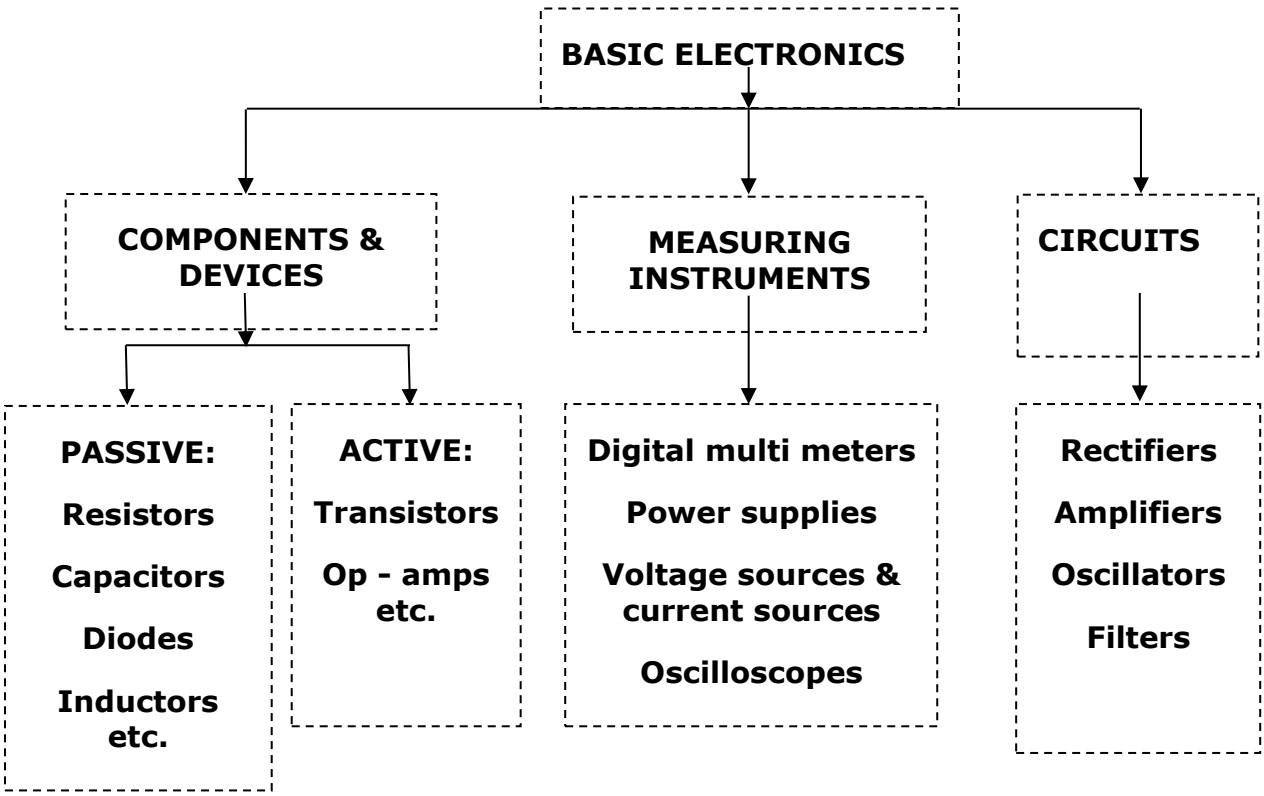
Introduction to Electronics

If one wants to gain a good understanding of electronics, he or she should build circuits and test them independently. For this one should acquire a practical knowledge of the characteristics of different devices and in constructing various circuits. This lab is very useful& informative.

Before start the hands on practice of electronics you should know about the basic electronics components, safety measures and required information.

There are two types of components that we come across namely **Active** and **Passive** components. Resistors, Inductors, Capacitors, etc., are known as passive components because they can only attenuate the electrical voltage and signals and cannot amplify. Whereas devices like transistors, operational amplifier (Op Amp) can amplify or increase the amplitude and energy associated with the signals. Hence the transistors and Op Amp come under active devices. These components can be combined in different configurations by interconnecting them with conducting wires to build different useful Electronic circuits. Apart from the components and circuits we must also have familiarity on the principle of operations and usefulness of some of the essential electronic measuring instruments such as digital multi meters, regulated power supplies, Function generators, oscilloscopes, etc., These help us in trouble shooting the circuits and identify the faulty components whenever the circuits that we build do not work as expected.

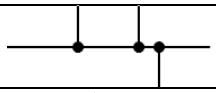
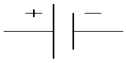
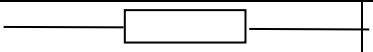
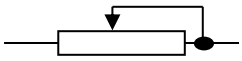
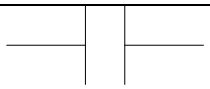
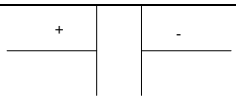
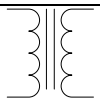
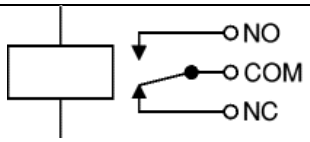
1.2 Classification of basic electronics:



Chapter - 2

Electronic Components Symbols and Functions

The below Table 1 shows the various components, their symbols and functions used in electronic circuits.

Name	Symbol	Function
Conductor		Conductor is a metal that conducts electric current.
Connection		It connects the devices to make a closed circuit.
Battery		It is a DC Storage device.
Fixed Resistor		It resists the flow of current. The resistance value is fixed.
Variable Resistor		Its resistance value can be varied. Example: Radio and TV volume controls.
Non polar Capacitor		It stores electro-static energy and it is used for filtering purposes Example: Ceramic Capacitor.
Electrolytic Capacitor		It is a polarized capacitor
Inductor Air cored		A coil of enameled wire without any core material present inside.
Inductor iron cored		A coil of enameled wire with iron core present inside Example: Tube light Choke
Transformer		Transformer is a device which is used to step up or step down voltages.
Magnetic relay with 1NO + 1NC		Relay is an electro mechanical switch used to make& break the circuit. NO- NORMALLY OPEN NC - NORMALLY CLOSED. When Relay coil is energized NO contact closes and NC contact opens. When it is de-energized contacts come back to normal position.

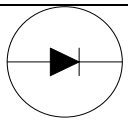
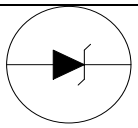
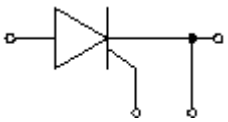
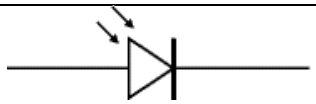
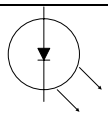
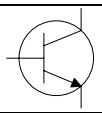
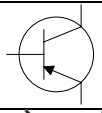
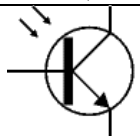
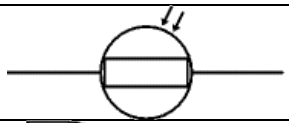
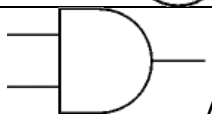
Diode		- It is a PN junction diode that allows current in a single direction. It converts Alternating current (AC) in to Direct Current (DC).
Zener diode		It is a semiconductor device used for voltage regulation. It is always reverse biased.
Silicon Controlled Rectifier (SCR)		It is a semiconductor device used for controlled rectification. It converts alternating current to direct current and also helps in controlling this conversion. Ex: It can be used both inverter and rectifier.
DIAC		It is a three layer, two terminals, bi directional device. It is used to trigger TRAIC
Seven segment display		There are two types of seven segment display. 1. Common anode display and 2. Common cathode display
Photo diode		It's a reverse biased PN junction diode. It has two terminals. It is used to detect the light radiation. It is used in photo voltaic applications.
Light Emitting diode (LED)		It is a forward biased PN junction diode. When current flows it emits the light.
NPN transistor		used as electronic switch and amplifier.
PNP transistor		used as electronic switch and amplifier.
Photo transistor		In this transistor that conducts upon receiving light radiation. It is used in electrical isolation circuits.
Light dependent resistor(LDR)		It is a semi-conductor device whose resistance varies with applied intensity
Logic Gate	 AND Gate	A logic gate is an elementary building block of a digital circuit

Table 1

2.1 Color coding of Resistors:

Example

Say, 1: Brown
2: Black
3: Orange
4: Gold

The Value is 10,000 ohms (or) 10 K ohms and the tolerance is ±5%

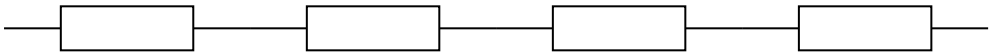
The below Table 2 shows the color coding of resistors.

Color	1st band	2nd band	3rd band (multiplier)	4th band (tolerance)
Black	0	0	$\times 10^0$	
Brown	1	1	$\times 10^1$	±1%
Red	2	2	$\times 10^2$	±2%
Orange	3	3	$\times 10^3$	
Yellow	4	4	$\times 10^4$	
Green	5	5	$\times 10^5$	±0.5%
Blue	6	6	$\times 10^6$	±0.25%
Violet	7	7	$\times 10^7$	±0.1%
Gray	8	8	$\times 10^8$	±0.05%
White	9	9	$\times 10^9$	
Gold			$\times 10^{-1}$	±5%
Silver			$\times 10^{-2}$	±10%

Circuit Description:

5.1 Resistors in series: Resistors can be connected in series; that is, the current flows through them one after another. The circuit in figure shows four resistors connected in series. Note that since there is only one path for the current to travel, the current through each of the resistors is the same. Also, the voltage drops across the resistors must add up to the total voltage supplied by the battery. Therefore, the equivalent resistance of resistors connected in series is the sum of their resistances.

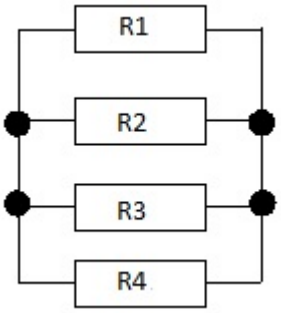
Thus total resistance is = R1 + R2 + R3 + R4



R1 R2 R3 R4

5.2 Resistors in parallel: Resistors can be connected such that they branch out from a single point (known as a node), and join up again in the circuit. This is known as a parallel connection. The potential difference will be the same across each resistor. Also, the current splits as it travels. So, the total current is sum of the currents through four branches.

Thus, total resistance is $(1/R_{total}) = (1/R1) + (1/R2) + (1/R3) + (1/R4)$



Sl No		Series	Parallel
1	Calculated Equivalent Resistance (Rc)		
2	Allowed Tolerance@±5% of Rc		
3	Measured Equivalent Resistance (Rm)		
4	Actual Tolerance (Rm-Rc)		

Exercise 6: Light Activated Switch

Aim: To test the circuit of Light Activated Switch

Circuit Description: The circuit is incorporating LDR. LDR stands for Light dependent resistor. Its resistance varies according to the light intensity. When it is kept under dark, the resistor value will be very high. Under applied light resistor value is low. We use this LDR for biasing the transistor used to switch ON the LED. When sufficient Light falls on the LDR, the transistor gets biasing voltage to switch ON the LED as shown in fig 4.

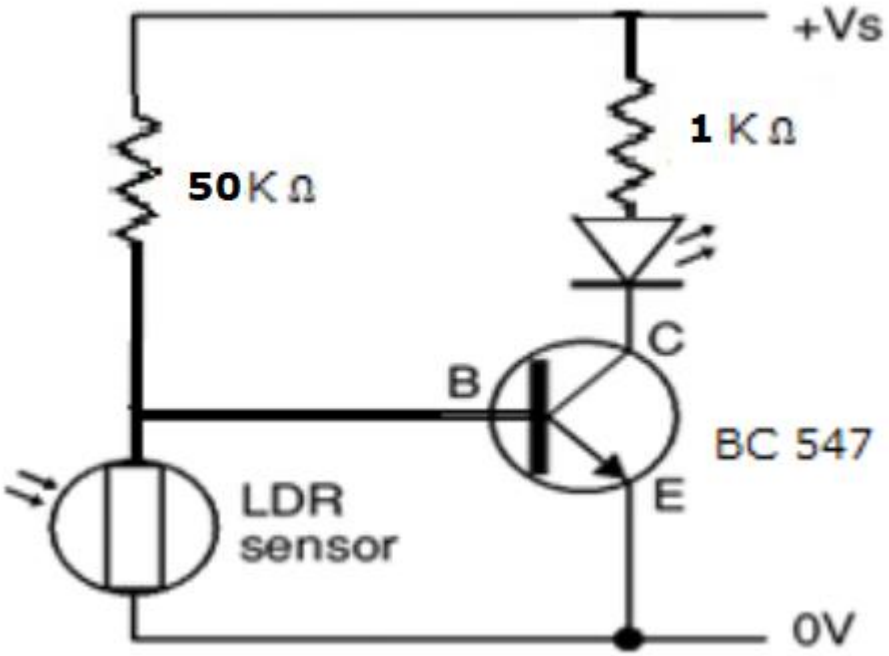


Fig 4

Exercise 7: Automatic LED flasher

Aim: To test the circuit of Automatic LED flasher

Circuit Description: This circuit is an as table Multi vibrator as shown in fig 5. Here we are using two set of components with the same value and Specifications. In this circuit our aim is switch ON the two LED's alternatively and automatically. When the circuit is first powered up, neither transistor will be switched on However, this means that at this stage they will both have high base voltages and therefore a tendency to switch on, and inevitable slight asymmetries will mean that one of the transistors is first to switch on. This will quickly put the circuit into one of the above states, and oscillation will ensue. In practice, oscillation always occurs for practical values of R and C. In this

circuit, we can change the flashing rate of the LED by changing the values of capacitor or biasing resistor.

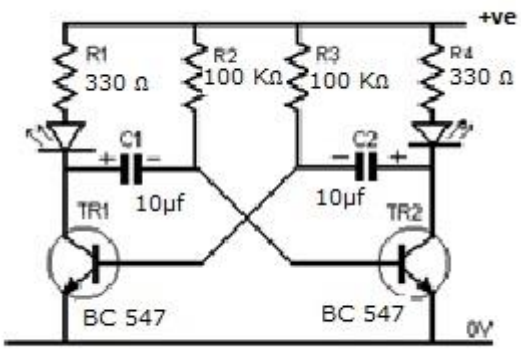


Fig 5

Appendix

Additional exercises:

1. Design a Buzzer circuit using Transistors.
2. Design a circuit of transistor that acts as an Inverter.
3. Design a circuit of Automatic Night Lamp Indicator.
4. Design a circuit of Zener Diode Tester.
5. Design a circuit of Touch Activated Light or LED using Transistors.
6. Design a circuit of Burglar Alarm.