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SCHOOL OF SCIENCE AND HUMANITIES

DEPARTMENT OF PHYSICS

UNIT – I - Fundamentals of Electrical Circuits

Branch: **B.Sc. Physics**

Subject: **Electrical Wiring**

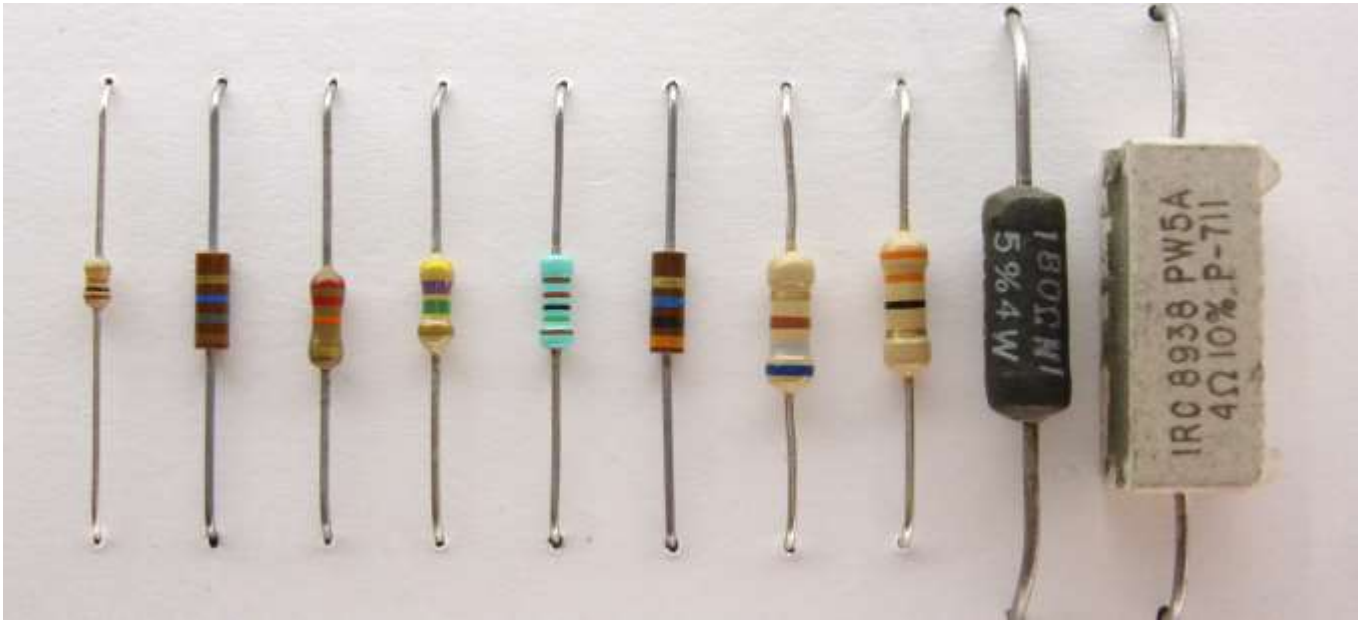
Batch: **2018-21**

Subject Code: **SPH1317**

Components & Symbols

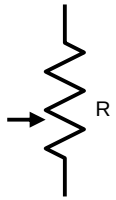
Resistors

- **A resistor is a component that is used to restrict the flow of current in an electrical circuit**
  - **somewhat analogous to a valve in a water line**

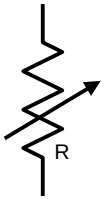


SCHEMATIC SYMBOLS

fixed resistor



potentiometer

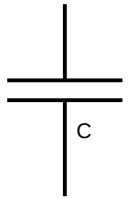


variable resistor

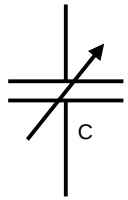
Components & Symbols

Capacitors

SCHEMATIC SYMBOLS

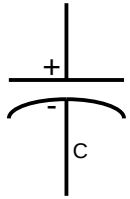


un-polarized capacitor



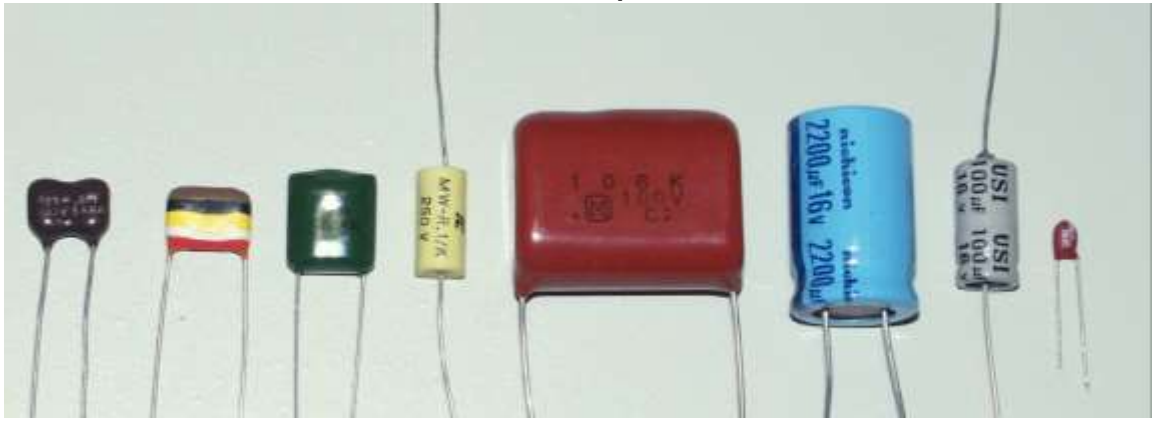
variable capacitor

- **Capacitors are components that store energy in an electrostatic field**
- **They may be called condensers in older manuals**
- **Capacitors oppose a change in voltage**



polarized capacitor

Ceramic Capacitors



Polarized Capacitors

DC & AC Fundamentals

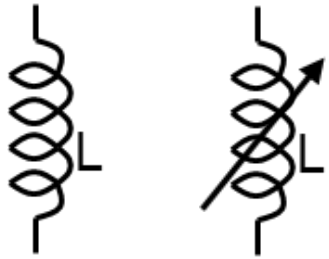
Components & Symbols

Inductors

- **Inductors are components that store energy in a magnetic field**
- **They may be referred to as coils or chokes**

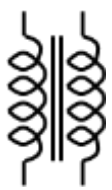
- **Inductors oppose a change in current flow**

SCHEMATIC SYMBOLS



variable coil

Components & Symbols



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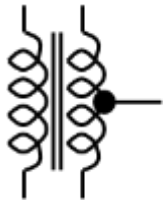


tapped transformer

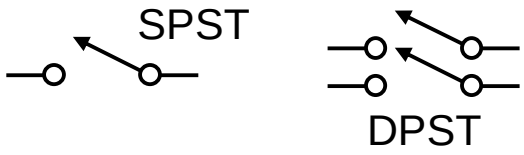
Transformers

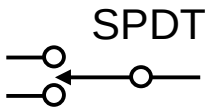
- **Transformers are components that contain one or more inductors in a single structure**
- **Transformers are used to:**
  - **change one voltage to another**
  - **transfer electrical energy from one circuit to another**

Transformer

Power Transformer

SCHEMATIC SYMBOLS





Switches

- **Switches are components used to make or break an electrical circuit**

Electrical Meters

DC Voltage & Current

DC (such as from a battery) does not change in value from one point in time to another point in time

AC Voltage & Current

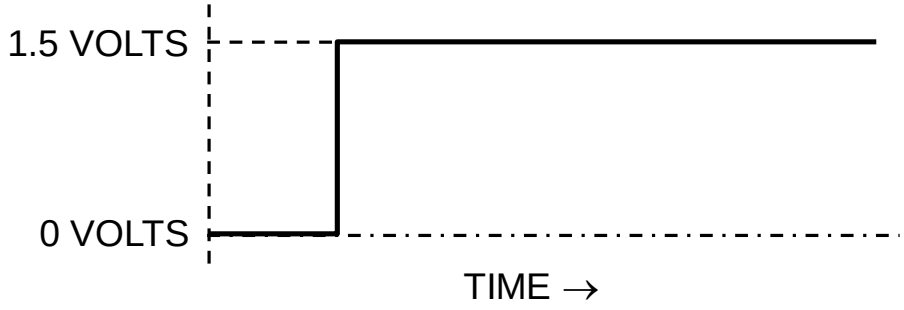
AC continually changes in value

Household voltage = 120 volts rms

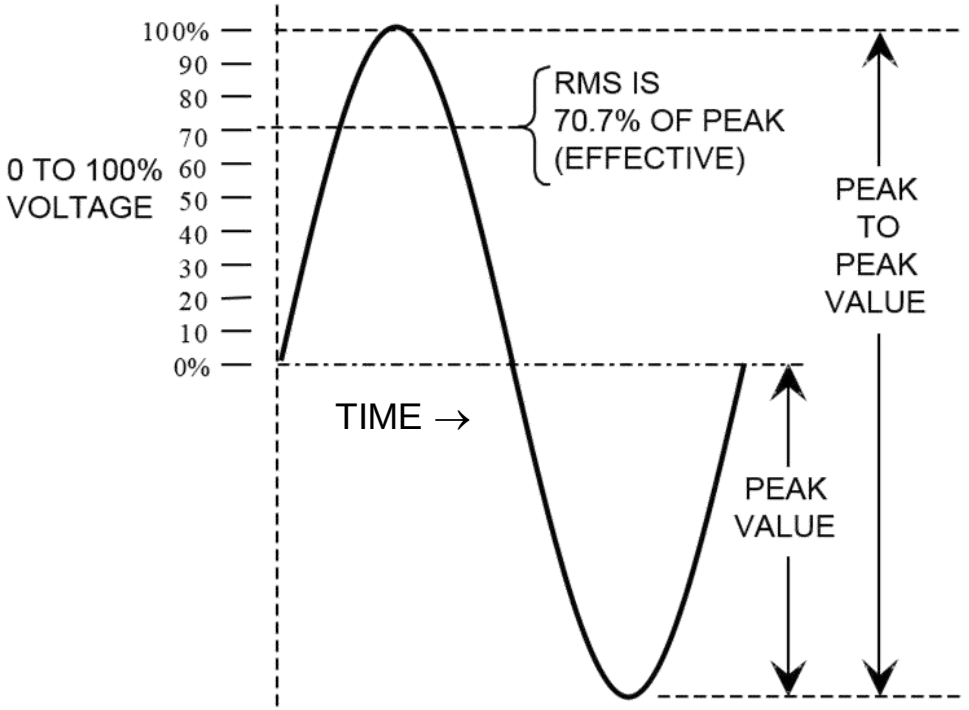
Household peak voltage = 155.16 volts peak

Household peak to peak voltage = 310.32 volts peak to peak

Amplitude of DC



Amplitude of AC (AC SINE WAVE)



Electric Current

- An electric potential difference causes electric charges to move
- The flow of electric charge is called electric current
  - Positive charge accelerates toward lower electric potential
  - Negative charge accelerates toward higher electric potential
- The rate of flow of electric charge (I) through a conducting material is the amount of charge (Q) that flows divided by the time (t) it takes to flow, or

$$I = Q/t$$

  - SI units are coulombs per second (C/s), called amperes (A), where *1 coulomb/sec = 1 Ampere*
- By convention, electric current is defined as the flow of positive charge flowing from high potential (+) to low potential (-)

Resistance

- The physical property of a material to "impede" the flow of electric charge is called electrical resistance
- An object's resistance (R) depends on:
  - Its inherent ability to conduct electricity, its resistivity (ρ)
  - The surface area (A): the wider the area the more room for current to flow
  - The length (L) of the object: the longer the object the more material the current must be pushed through

$$R \sim L/A$$

- Conductors (like metals) have low resistance
- Insulators (plastics & non-metals) have high resistance

Ohm's Law

- For a given potential difference (V), the magnitude of electric current (I) depends on the physical properties of the conductor (dimensions and material)
- The electric current that will flow through a circuit is
  - proportional to the potential difference (V)
  - Inversely proportional to the resistance of the circuit

$$I = V/R$$ {this is Ohm's Law}

- For many substances, R is constant:

$$R = V/I = \text{a constant value}$$

Georg Simon Ohm (1789-1854)

- German physicist
- Originally a secondary school (gymnasium) teacher
  - Pursued research to obtain a university post
- Studied electricity and the physics of hearing
- Most famous work (on "Ohm's Law") was published in a book in 1827

- Electrical studies were strongly influenced by Fourier's work on heat conduction

Electric Power

- It takes effort and energy (work) to drive electric charge through a circuit (against its resistance)
- The rate of energy (power or P) required to drive electric current through a circuit (or part of a circuit) is proportional
  - To the potential difference (V) across
  - To the electric current (I) that flows through a circuit

$$P=VI$$

- The SI units of power are _____
  - Volts (V) times amperes (A)
  - Joules per second (J/s)
  - Watts (W)

Direct Current (DC) & Alternating Current (AC)

- When the power source running an electric circuit moves charge only one direction it is a direct current (DC) circuit
  - Current flows from the high potential terminal (+) to the low potential terminal (-)
  - In DC circuits, the power source supplies the electrons
  - Batteries and photoelectric cells produce DC current
- When the power source driving an electric circuit moves charge back-and-forth it is a an alternating current (AC) circuit
  - In AC circuits, you supply the electrons
  - Our wall sockets typically fluctuate between +170 V and –170 V at a rate of 60 Hz
  - The fluctuating voltage has a sinusoidal waveform:

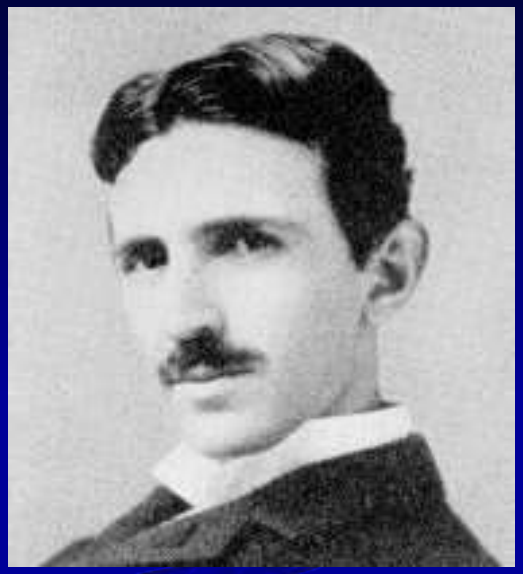
Alessandro Volta (1745-1827)

- Italian physicist & inventor
- First person to isolate methane
- Fascinated with electricity at an early age
- Pioneered the field of electrochemistry

- Constructed the first battery to produce electricity (called a voltaic pile)

Nikola Tesla (1856-1943)

- Serbian-American inventor & engineer
- A major rival of Thomas Edison
- Pioneered the use of AC current for commercial power
- Sold many of his patents to Westinghouse Corporation
- Notable inventions:
  - Radio
  - Fluorescent lights
  - Wireless communication
  - Alternating current transmission
  - Tesla coil transformer
  - An electric automobile (the Pierce Arrow)
  - Over 700 patents



"Science is but a perversion of itself unless it has as its ultimate goal the betterment of humanity"

Electric Circuits

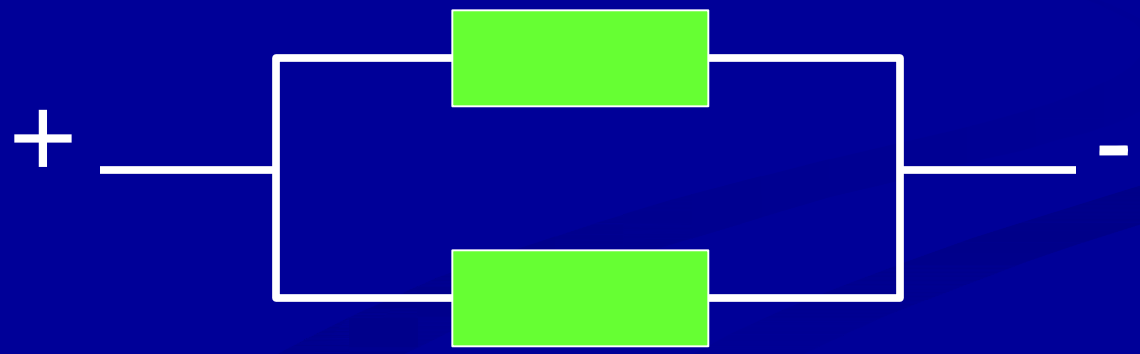
- **Power supply:** provides the electric potential difference between its terminals
  - A device that transforms energy from one form of energy (such as chemical) into electrical energy
  - Characterized by its electromotive force (V)
    - The potential difference or voltage between the terminals
- **Connecting wires:** provide a path for electric current to flow (their resistance is usually very small ~ 0 Ω)
- **Consumer (or load):** any electrical device connected to the circuit (characterized by its resistance, R)

Electric Circuits

Types of electrical connections:

- Series:
  - components are connected head-to-tail

- Parallel:
  - Components are connected head-to-head & tail-to-tail



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SCHOOL OF SCIENCE AND HUMANITIES

DEPARTMENT OF PHYSICS

UNIT – II – Wiring materials and Accesseries

Branch: **B.Sc. Physics**

Subject: **Electrical Wiring**

Batch: **2018-21**

Subject Code: **SPH1317**

TYPES OF WIRES AND CABLES

CABLES

- A cable is most often two or more wires running side by side and bonded, twisted, or braided together to form a single assembly, but can also refer to a heavy strong rope. In mechanics, cables, otherwise known as wire ropes, are used for lifting, hauling, and towing or conveying force through tension. In electrical engineering cables are used to carry electric currents.
- An optical cable contains one or more optical fibers in a protective jacket that supports the fibers.
- Electric cables discussed here are mainly meant for installation in buildings and industrial sites. For power transmission at distances greater than a few kilometers see high-voltage cable, power cables, and HVDC.

ELECTRICAL CABLES

- Electrical cables may be made more flexible by stranding the wires. In this process, smaller individual wires are twisted or braided together to produce larger wires that are more flexible than solid wires of similar size. Bunching small wires before concentric stranding adds the most flexibility. Copper wires in a cable may be bare, or they may be plated with a thin layer of another metal, most often tin but sometimes gold, silver or some other material. Tin, gold, and silver are much less prone to oxidation than copper, which may lengthen wire life, and makes soldering easier. Tinning is also used to provide lubrication between strands.
- . Tinning was used to help removal of rubber insulation. Tight lays during stranding makes the cable extensible (CBA – as in telephone handset cords).[further explanation needed]
- Cables can be securely fastened and organized, such as by using trunking, cable trays, cable ties or cable lacing. Continuous-flex or flexible cables used in moving applications within cable carriers can be secured using strain relief devices or cable ties.
- At high frequencies, current tends to run along the surface of the conductor. This is known as the skin effect.

CLASSIFICATION OF ELECTRICAL CABLES

Electrical cables can be classified as follows:-

- Based on shape
  - Ribbon Cable
- Based on construction and cable properties
  - Coaxial cable
  - Twinax cable
  - Flexible cable
  - Non-metallic sheathed cable
  - Metallic sheathed cable
  - Multicore cable
  - Shielded cable
  - Single cable
  - Twisted Pair cable
  - Twisting Cable

- Special cables
  - Arresting Cable
  - Bowden Cable
  - Heliax Cable
  - Direct-Buried Cable
  - Heavy lift Cable
  - Elevator Cable

RIBBON CABLE

- A Ribbon cable (also known as multi-wire planar cable) is a cable with many conducting wires running parallel to each other on the same flat plane. As a result the cable is wide and flat. Its name comes from the resemblance of the cable to a piece of ribbon.

- Ribbon cables are usually seen for internal peripherals in computers, such as hard drives, CD drives and floppy drives. On some older computer systems (such as the BBC Micro and Apple II series) they were used for external connections as well. Unfortunately the ribbon-like shape interferes with computer cooling by disrupting airflow within the case and also makes the cables awkward to handle, especially when there are a lot of them; round cables have almost entirely replaced ribbon cables for external connections and are increasingly being used internally as well.

- The ribbon cable was invented in 1956 by Cicoil Corporation, a company based in Chatsworth, California. The company's engineers figured out how to use a new material, silicone rubber, to 'mold' a flat cable containing multiple conductors of the same size. Since the cable looked like a flat ribbon or tape, it was named a ribbon cable. The ribbon cable allowed companies like IBM and Sperry/Univac to replace bulky, stiff round cables with sleek, flexible ribbon cables.[citation needed]

The early ribbon cables were used in the mainframe computer industry, on card readers, card punching machines, and tape machines. Subsequently ribbon cables were manufactured by a number of different companies, including 3M. Methods and materials were developed to simplify and reduce the cost of ribbon cables, by standardizing the design and spacing of the wires, and the thickness of the insulation, so that they could be easily terminated through the use of Insulation Displacement Connectors, or IDC connectors. Due to the simplicity of ribbon cables, their low profile, and low cost due to standardization, ribbon cables are used today in most computers, printers, and many electronic devices.

COAXIAL CABLE

- Coaxial cable, or coax, is a type of cable that has an inner conductor surrounded by a tubular insulating layer, surrounded by a tubular conducting shield. Many coaxial cables also have an insulating outer sheath or jacket. The term coaxial comes from the inner conductor and the outer shield sharing a geometric axis. Coaxial cable was invented by English engineer and mathematician Oliver Heaviside, who patented the design in 1880.[1] Coaxial cable differs from other shielded cable used for carrying lower-frequency signals, such as audio signals, in that the dimensions of the cable are controlled to give a precise, constant conductor spacing, which is needed for it to function efficiently as a radio frequency transmission line.

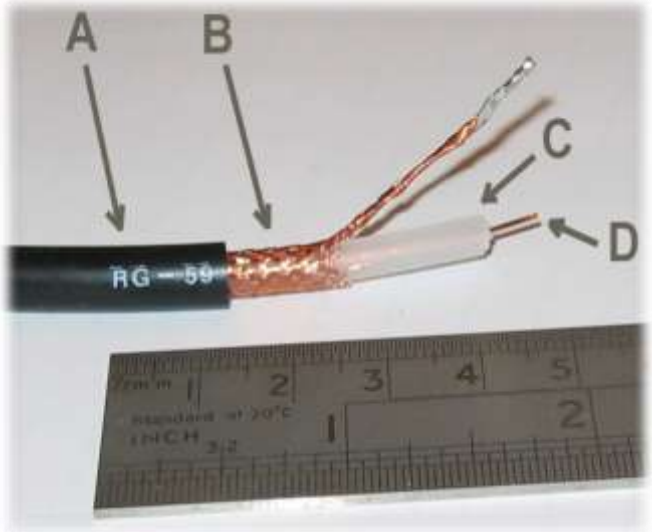
RG-59 coaxial cable

A: Plastic outer insulation

B: Copper-clad aluminium braid shield conductor

C: Dielectric

D: Central conductor (copper-clad steel)



TWINAX CABLE

- Twinaxial cabling, or "Twinax", is a type of cable similar to coaxial cable, but with two inner conductors instead of one. Due to cost efficiency it is becoming common in modern (2013) very-short-range high-speed differential signaling applications.
- Historically, Twinax was the cable specified for the IBM 5250 terminals and printers, used with IBM's midrange hosts, iSeries, (currently Power systems hardware running IBM's 'i' operating system i5/OS), and also with its predecessors, such as the S/32, S/34, S/36, S/38 and AS/400 (Application System 400) minicomputers. The data transmission is half-duplex, balanced transmission, at 1 Mbit/s, on a single shielded, 110 Ω twisted pair.

MULTICORE CABLE

- A multicore cable is a generic term for an electrical cable that has multiple cores made of copper wire. The term is normally only used in relation to a cable that has more cores than commonly encountered. For example, a four core mains cable is never referred to as multicore, but a cable comprising four coaxial cables in a single sheath would be considered multicore.
- The term snake cable is frequently used in the professional audio recording industry to refer to an audio multicore cable.
- Multicore cables are used with professional video cameras. In television studios, 26-pin cables are used to connect "cameras" to camera control units (CCU). Triaxial cables are used primarily in outside broadcasting however both are capable of delivering an HD-SDI feed and 30 - 40 Watts of power for the Cameras.
- Many different kinds of multicore cable can be found in the list of video connectors.
- Typical signals multicore cable can provide both digital signal and analog signals:

Video out (Serial digital interface (SDI))
Video out (composite video)
Video out (component video)
Audio out (microphone on board)

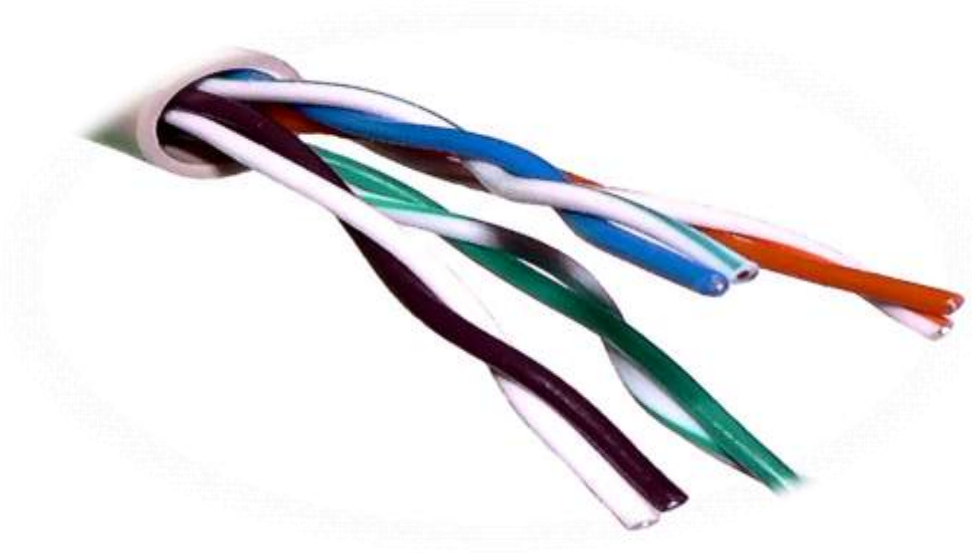
Video in (genlock in the form of color burst)
Return video in (composite)
Return video in
Interruptible feedback Intercom
Tally light trigger

SHEILDED CABLE

- A shielded cable is an electrical cable of one or more insulated conductors enclosed by a common conductive layer. The shield may be composed of braided strands of copper (or other metal, such as aluminium), a non-braided spiral winding of copper tape, or a layer of conducting polymer. Usually, this shield is covered with a jacket. The shield acts as a Faraday cage to reduce electrical noise from affecting the signals, and to reduce electromagnetic radiation that may interfere with other devices (see electromagnetic interference). The shield minimizes capacitively coupled noise from other electrical sources. The shield must be applied across cable splices.
- In shielded signal cables the shield may act as the return path for the signal, or may act as screening only.
- High voltage power cables with solid insulation are shielded to protect the cable insulation and also people and equipment.

TWISTED PAIR CABLE

- Twisted pair cabling is a type of wiring in which two conductors of a single circuit are twisted together for the purposes of canceling out electromagnetic interference (EMI) from external sources; for instance, electromagnetic radiation from unshielded twisted pair (UTP) cables, and crosstalk between neighboring pairs. It was invented by Alexander Graham Bell.
- Twisted pair cables were invented by Alexander Graham Bell in 1881. By 1900, the entire American telephone line network was either twisted pair or open wire with transposition to guard against interference. Today, most of the millions of kilometers of twisted pairs in the world are outdoor landlines, owned by telephone companies, used for voice service, and only handled or even seen by telephone workers.

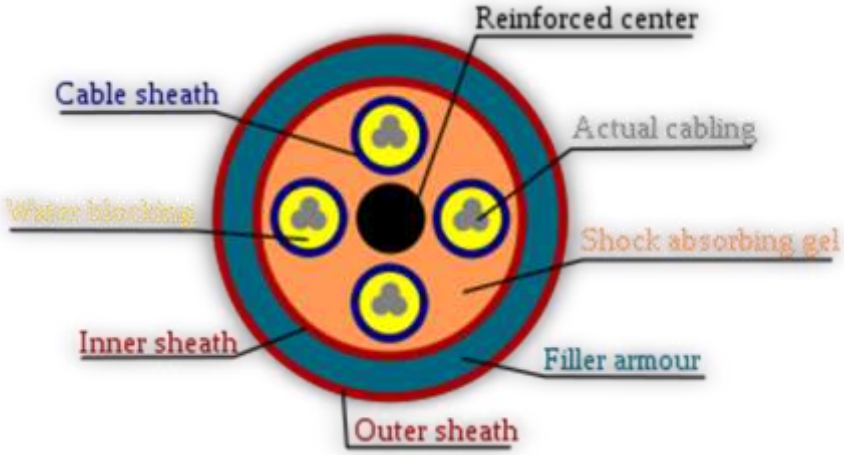


BOWDEN CABLE

- A Bowden cable is a type of flexible cable used to transmit mechanical force or energy by the movement of an inner cable (most commonly of steel or stainless steel) relative to a hollow outer cable housing. The housing is generally of composite construction, consisting of a helical steel wire, often lined with nylon, and with a plastic outer sheath.
- The linear movement of the inner cable is most often used to transmit a pulling force, although push/pull cables have gained popularity in recent years e.g. as gear shift cables. Many light aircraft use a push/pull Bowden cable for the throttle control, and here it is normal for the inner element to be solid wire, rather than a multi-strand cable. Usually provision is made for adjusting the cable tension using an inline hollow bolt (often called a "barrel adjuster"), which lengthens or shortens the cable housing relative to a fixed anchor point.

DIRECTLY BURIED CABLE

- Direct-buried cable (DBC) is a kind of communications or transmissions cable which is especially designed to be buried under the ground without any kind of extra covering, sheathing, or piping to protect it.
- Most direct-buried cable is built to specific tolerances to heat, moisture, conductivity, and soil acidity. Unlike standard telecommunications and power cables, which have only a thin layer of insulation and a waterproof outer cover, DBC consists of multiple layers of heavy metallic-banded sheathing, reinforced by heavy rubber covers, shock absorbing gel, wrapped thread-fortified waterproof tape, and stiffened by a heavy metal core.

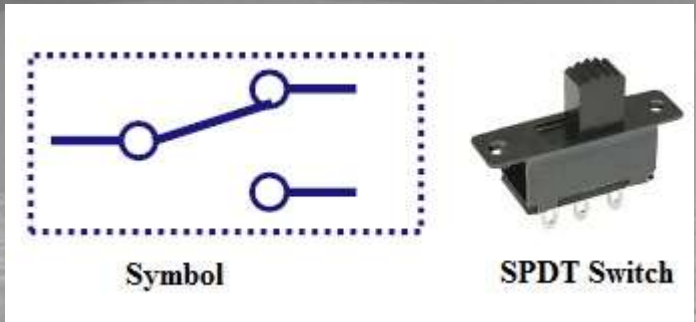


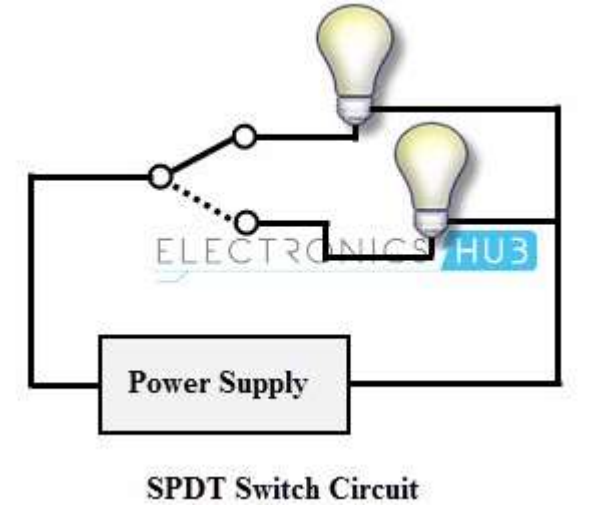
Electrical Switches

Based on the number of poles and throws, switches are classified into following types. The **pole** represents the number of individual power circuits that can be switched. Most of the switches are designed have one, two or three poles and are designated as single pole, double pole and triple pole.

The number of **throws** represents the number of states to which current can pass through the switch. Most of the switches are designed to have either one or two throws which are designated as single throw and double throw switches.

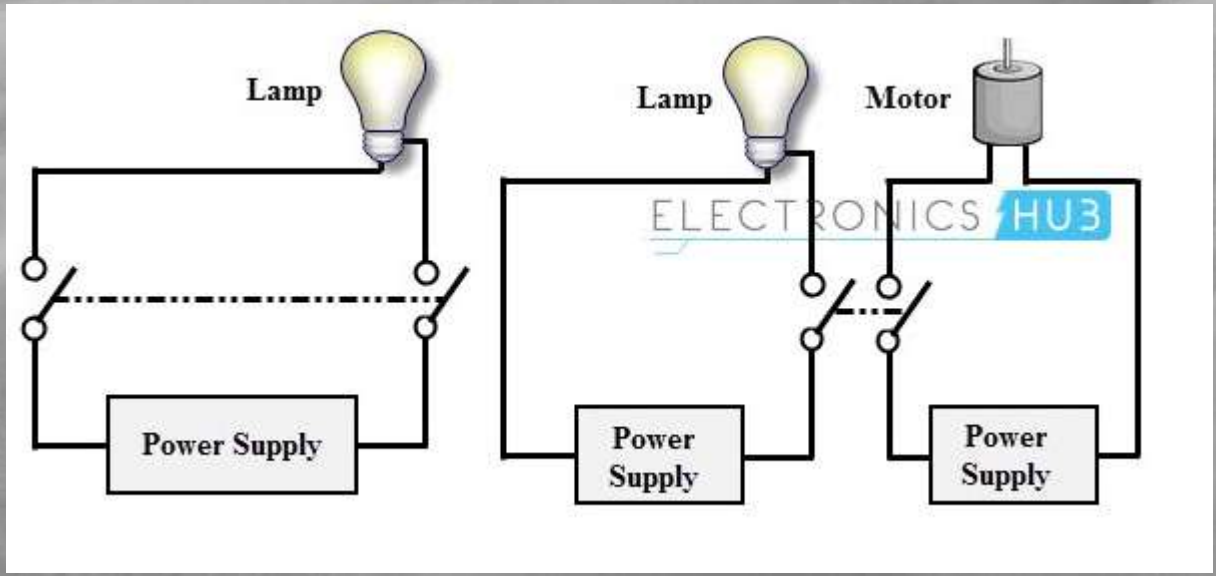
Single Pole Double Throw Switch (SPDT)





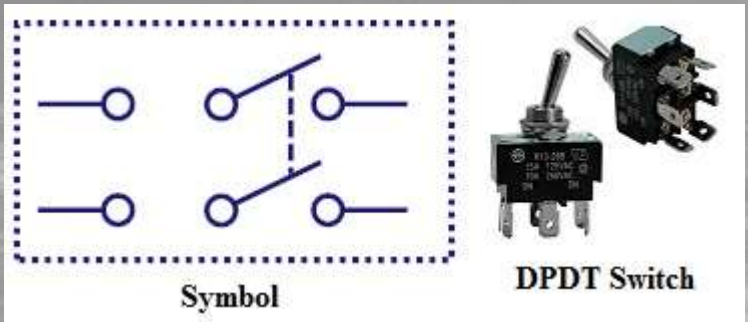
- This is the basic ON and OFF switch consisting of one input contact and one output contact.
- It switches a single circuit and it can either make (ON) or break (OFF) the load.
- The contacts of SPST can be either normally open or normally closed configurations .

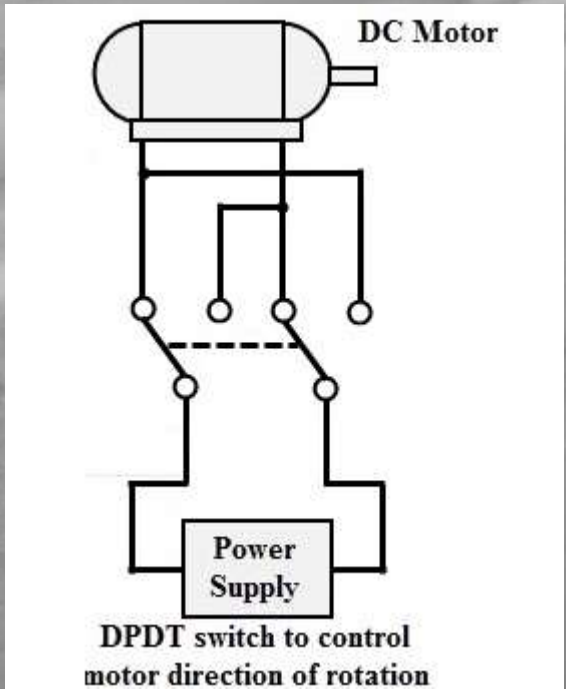
Double Pole Single Throw Switch (DPST)



- This switch consists of four terminals, two input contacts and two output contacts.
- It behaves like a two separate SPST configurations, operating at the same time.
- It has only one ON position, but it can actuate the two contacts simultaneously, such that each input contact will be connected to its corresponding output contact.
- In OFF position both switches are at open state.
- This type of switches is used for controlling two different circuits at a time.
- Also, the contacts of this switch may be either normally open or normally closed configurations.

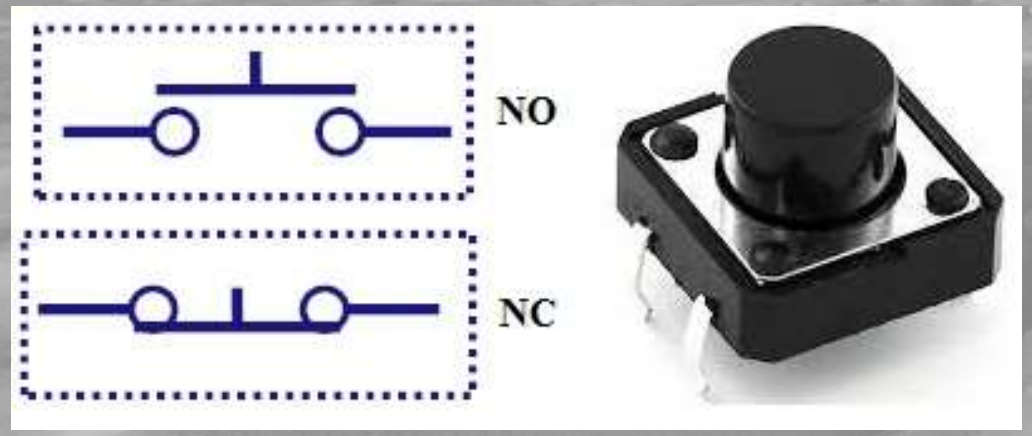
Double Pole Double Throw Switch (DPDT)





- This is a dual ON/OFF switch consisting of two ON positions.
- It has six terminals,two are input contacts and remaining four are the output contacts.
- It behaves like a two separate SPDT configuration, operating at the same time.
- Two input contacts are connected to the one set of output contacts in one position and in another position, input contacts are connected to the other set of output contacts.

Push Button Switch



- It is a momentary contact switch that makes or breaks connection as long as pressure is applied (or when the button is pushed).
- Generally, this pressure is supplied by a button pressed by someone's finger.
- This button returns its normal position, once the pressure is removed.
- The internal spring mechanism operates these two states (pressed and released) of a push button.
- It consists of stationary and movable contacts, of which stationary contacts are connected in series with the circuit to be switched while movable contacts are attached with a push button.
- Push buttons are majorly classified into normally open, normally closed and double acting push buttons as shown in the above figure.
- Double acting push buttons are generally used for controlling two electrical circuits.

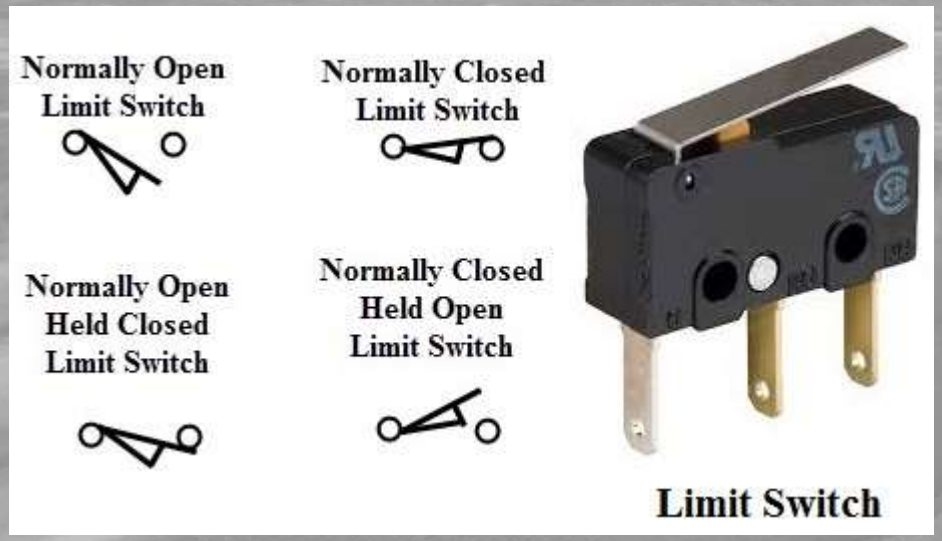
Toggle Switch

•A toggle switch is manually actuated (or pushed up or down) by a mechanical handle, lever or rocking mechanism. These are commonly used as light control switches.

•Most of these switches come with two or more lever positions which are in the versions of SPDT, SPST, DPST and DPDT switch. These are used for switching high currents (as high as 10 A) and can also be used for switching small currents.

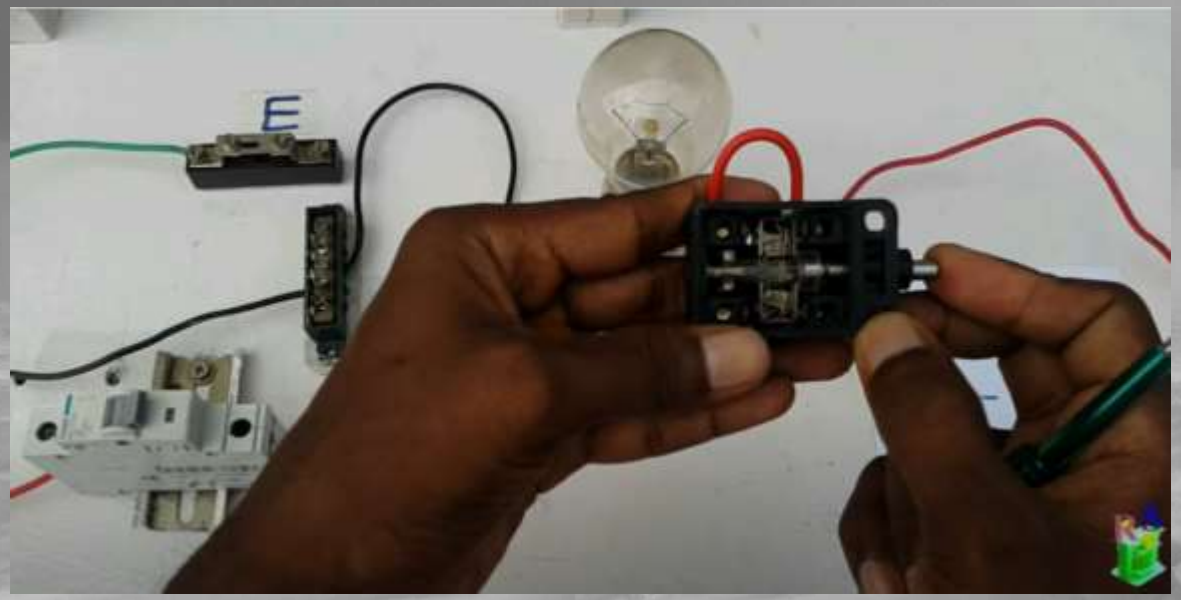
•These are available in different ratings, sizes and styles and are used for different type of applications. The ON condition can be any of their level positions, however, by convention the downward is the closed or ON position.

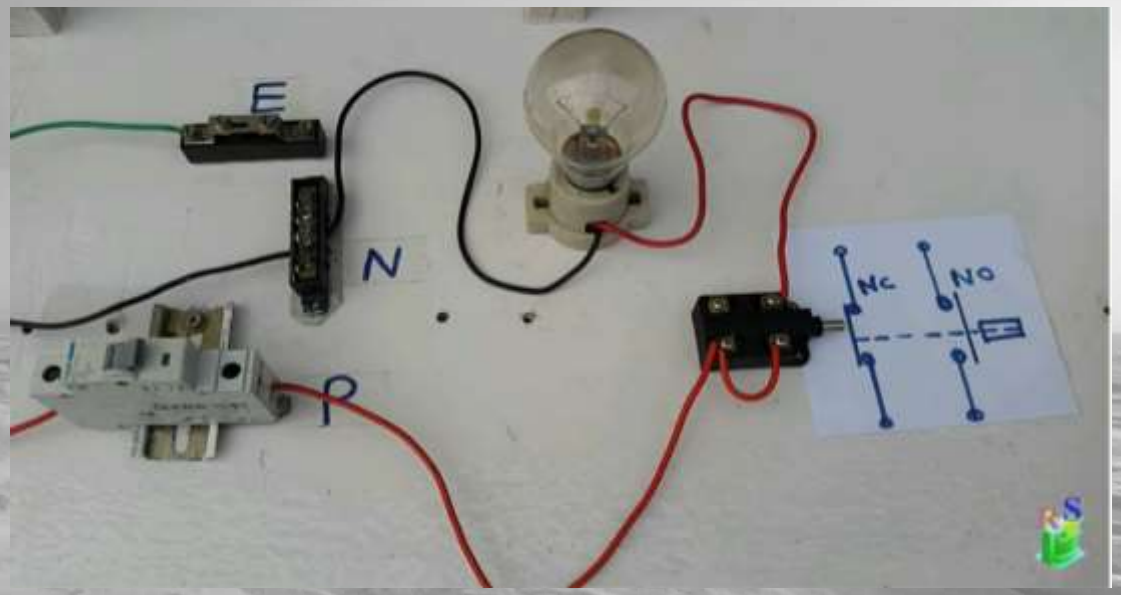
Limit Switch



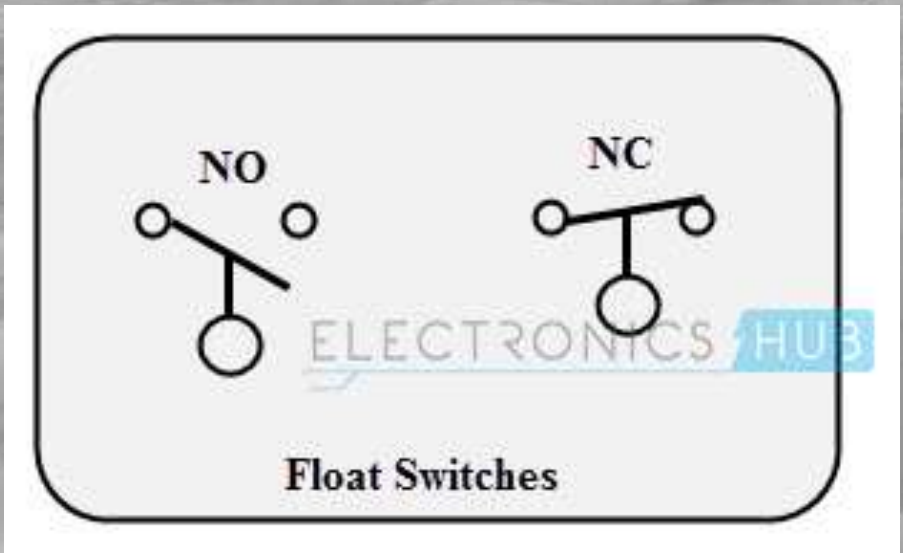
- The control schemes of a limit switch are shown in above figure , in which four varieties of limit switches are presented.
- Some switches are operated by the presence of an object or by the absence of objects or by the motion of machine instead of human hand operation. These switches are called as limit switches.
- These switches consist of a bumper type of arm actuated by an object. When this bumper arm is actuated, it causes the switch contacts to change position.

Limit Switch





Float Switches



•Float switches are mainly used for controlling DC and AC motor pumps according to the liquid or water in a tank or sump.

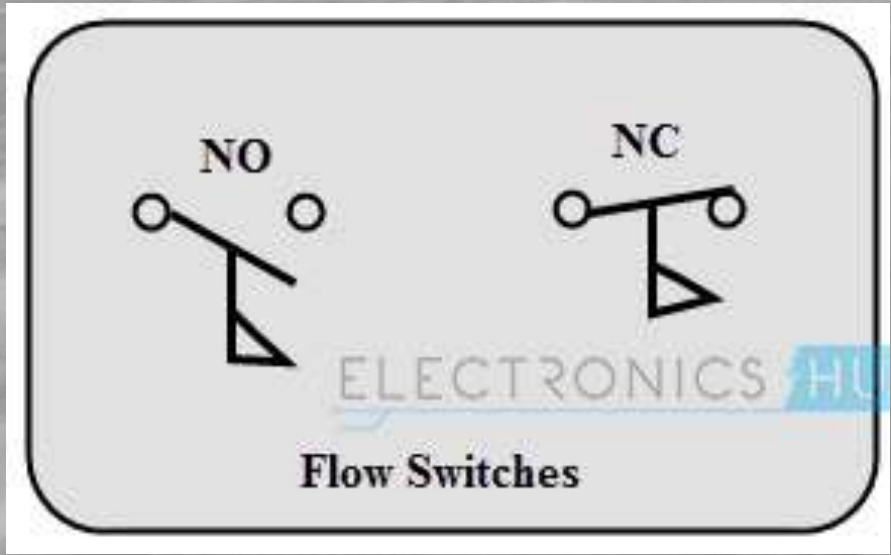
•This switch is operated when the float (or floating object) moves downward or upward based on water level in a tank.

•This float movement of rod or chain assembly and counterweight causes to open or close electrical contacts. Another form of float switch is the mercury bulb type switch that does not consist of any float rod or chain arrangement.

•This bulb consist of mercury contacts such that when the liquid level rises or falls, the state of contacts also changes.

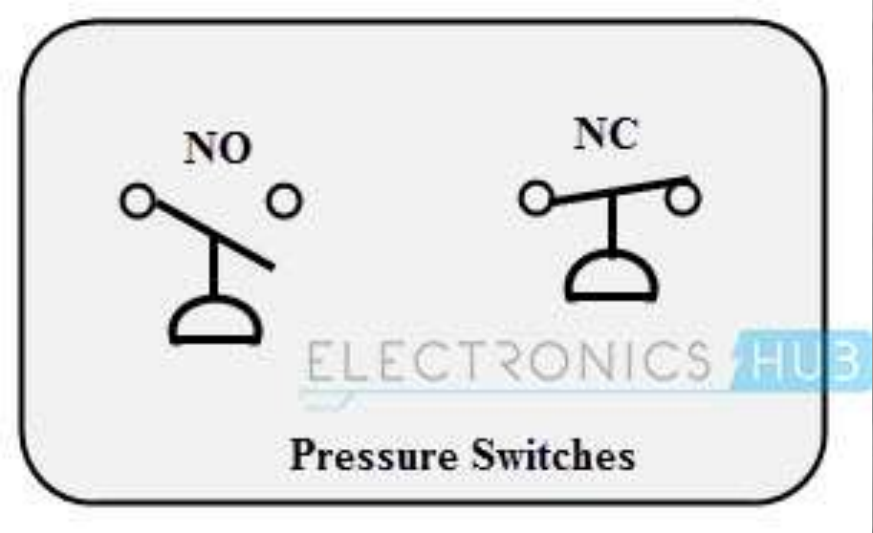
•The ball float switch symbol is shown in the above figure. These float switches can be normally open or normally closed type.

Flow Switches



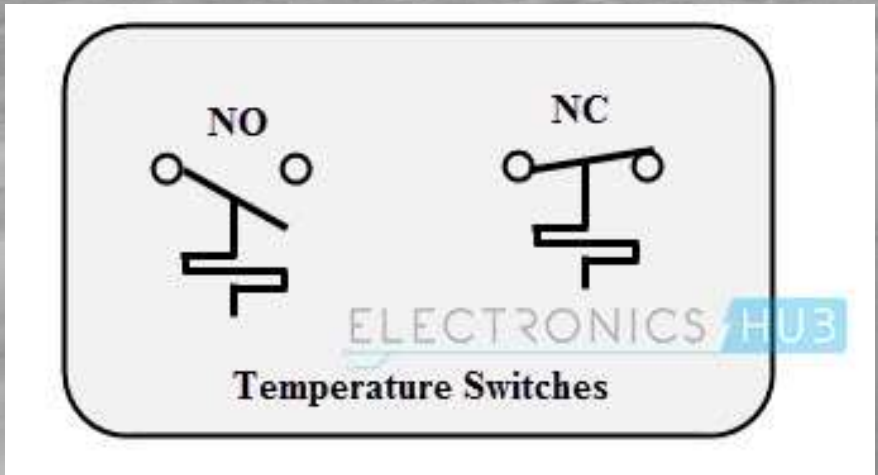
- These are mainly used to detect the movement of liquid or air flow through a pipe or duct. The air flow switch (or a micro switch) is constructed by a snap-action.
- This micro switch is attached to a metal arm .To this metal arm, a thin plastic or metal piece is connected.
- When a large amount of air passes through the metal or plastic piece, it causes the movement of metal arm and thus operates the contacts of the switch.
- Liquid flow switches are designed with a paddle that inserted across the flow of liquid in a pipe. When liquid flows through the pipe, force exerted against the paddle changes the position of the contacts.
- The above figure shows the switch symbol used for both air flow and liquid flow. The flag symbol on the switch indicates the paddle which senses the flow or movement of liquid.
- These switches again normally open or normally closed type configurations.

Pressure Switches



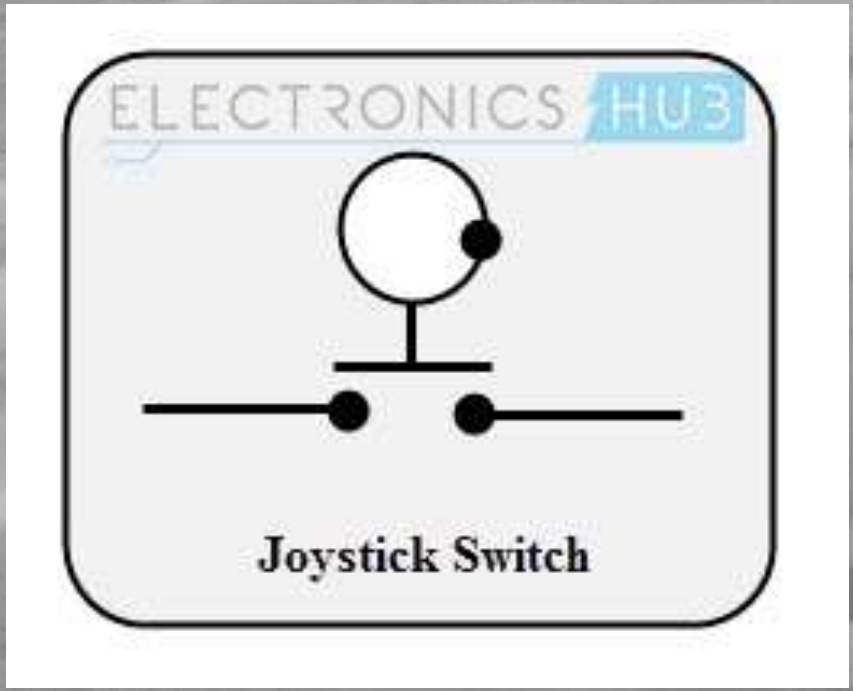
- These switches are commonly used in industrial applications in order to sense the pressure of hydraulic systems and pneumatic devices.
- Depends on the range of pressure to be measured, these pressure switches are classified into diaphragm operated pressure switch, metal bellow type pressure switch and piston type pressure switch.
- In all these types, pressure detection element operates a set of contacts (which can be either double pole or single pole contacts).
- This switch symbol consist a half-circle connected to a line in which flat part indicates a diaphragm. These switches may be either normally open or normally closed type configurations.

Temperature Switches



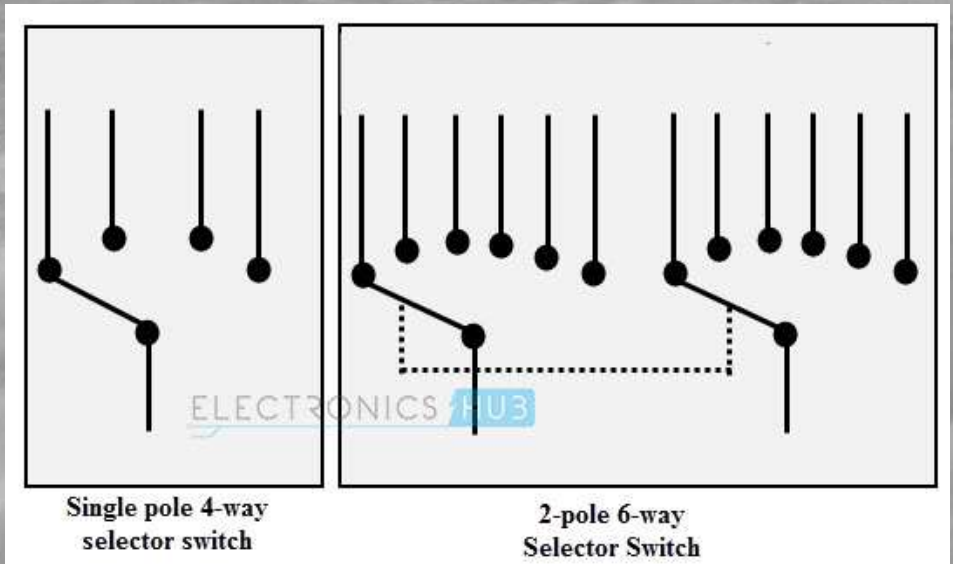
- The most common heat sensing element is the bimetallic strip that operates on the principle of thermal expansion.
- The bimetallic strips are made with two dissimilar metals (that are having different thermal expansion rates) and are bonded with each other.
- The switch contacts are operated when the temperature causes he strip to bend or wrap. Another method of operating the temperature switch is to use mercury glass tube.
- When the bulb is heated, mercury in the tube will expand and then generates pressure to operate the contacts.

Joystick Switch



- Joystick switches are manually actuated control devices used mainly in portable control equipments.
- It consists of a lever which moves freely in more than one axis of motion.
- Depending on the movement of the lever pushed, one or more switch contacts are actuated.
- These are ideally suited for lowering, raising and triggering movements to the left and right.
- These are used for building machinery, cable controls and cranes. The symbol for the joystick is shown below.

Rotary Switch



- These are used for connecting one line to one of many lines.
- Examples of these switches are range selectors in electrical metering equipment, channel selectors in communication devices and band selectors in multi-band radios.
- It consists of one or more moving contacts (knob) and more than one stationary contact.
- These switches are come with different arrangement of contacts such as single pole 12-way, 3-pole 4-way, 2-pole 6-way and 4-pole 3-way.

PENDENT HOLDER

- A pendant light, sometimes called a drop or suspender is a lone light fixture that hangs from the ceiling usually suspended by a cord, chain or metal rod.
- Pendant lights are often used in multiplex, hung in a straight line over kitchen countertops and dinette sets also near the stairs of building.
- Pendants come in a huge variety of sizes and vary in materials from metal to glass or concrete and plastic.
- Many modern pendants are energy-saving low voltage models and some use halogen or fluorescent bulbs.

FLUORESCENT TUBE LIGHT HOLDER

- The fluorescent tube light lamp holder are of two type i.e. 1) Two Pin & 2) Bayonet Cap Type
- Pin type Tube holders are generally used for 20 Watt To 40 Watt Tube
- Bayonet Cap Type holders are generally used for 20 Watt To 40 Watt Tube

ANGLE HOLDER

- A light emitted by Bulb arranged in a position of angle of inclination with a fixture called as Angle holder
- It fitted on wall or place from where illumination occur more likewise used in multiplex wall, wall of kitchen and near stair side of building, etc.
- Angle Holder comes in a huge variety of sizes according to ratings also having switches with spark shield **Concealed** terminals with silver cadmium contacts
- Ratings of given angle holder: current rating- 6A, Voltage Rating- 220V To 240V, Frequency- 50-60Hz
- Many modern angle holders are energy-saving low voltage models and some use for halogen or fluorescent bulbs

SCREW LAMPED HOLDER

- Edison screw (ES) is a standard socket for light bulbs in the United States.
- It was developed by Thomas Edison and was licensed in 1909 under the Mazda trademark.
- Normally, the bulbs have right-hand threaded metal bases (caps) which screw into matching threaded sockets (lamp holders).
- For bulbs powered by AC current, the thread is connected to neutral and the contact on the bottom tip of the base is connected to live terminal
- Screw Lamped holders comes in a huge variety of sizes according to ratings also having threaded switches with spark shield **concentric** terminals

JUMBO BATTEN LAMPED HOLDER

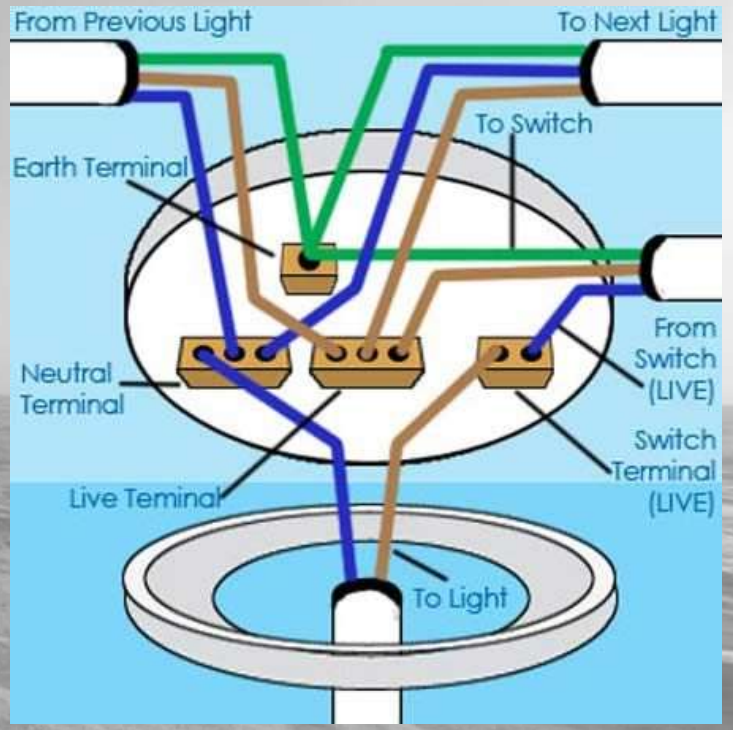
- **Ideal for replacing broken lamp holders fixed to the ceiling, this jumbo batten holder comes with inner metal rings.**
- **It fitted on wall or place from where illumination occur more likewise used in multiplex wall, wall of kitchen and near stair side of building, etc.**
- **Jumbo Batten Lamp Holder also comes in a huge variety of sizes according to ratings also having switches with spark shield Concealed terminals with silver cadmium contacts with smooth operation**
- **Ratings of given Batten holder: current rating- 0.25A, Voltage Rating- 220V to 240V, Frequency- 50-60Hz.**
- **Many modern jumbo Batten holders are energy-saving low voltage models and some use for halogen or fluorescent bulbs**

FACNCY BATTEN LAMPED HOLDER

- **It is type of batten holder look fancy in design having higher current capacity, low resistance contact with metal ring inside.**
- **It is made up of polycarbonate material with heat dissipation capacity means of duct provided on the outer surface for heat dissipation also having Brass terminals & pins for better conductivity.**
- **Fancy Batten Lamp Holder also comes in a huge variety of sizes according to ratings also having switches with spark shield Concealed terminals with smooth operation**
- **Ratings of given fancy Batten holder: current rating- 0.25A, Voltage Rating- 220V to 240V, Frequency- 50-60Hz.**
- **Many modern fancy Batten holders are energy-saving low voltage models and some use for halogen, tungsten and fluorescent bulbs**

PARALLEL PIN HOLDER

- **Parallel Pin like holders are commonly used for two way switch mode for different application likewise used to glow bulb as a holder and to plug in the switch for another application.**
- **Parallel pin holder is often used in multiplex, hung in a straight line over kitchen countertops and dinette sets also near the stairs of building across switch.**
- **Parallel Pin Lamp Holder also comes in a huge variety of sizes according to ratings also having switches with spark shield Concealed terminals with Hi-grade Polycarbonate material and Heavy Brass Parts for better electrical conductivity.**
- **Ratings of given parallel pin holder: current rating- 0.25A, Voltage Rating- 220V to 240V, Frequency- 50-60Hz.**



A device for securing a lamp to its support; specifically, a socket or holder fitted with electric terminals, into which the top of the glass globe of an incandescent lamp is fitted, or from which it hangs.

What is Distribution Board?

Distribution board is a safe system designed for house or building that included **protective devices**, **isolator switches**, **circuit breaker** and **fuses** to connect safely the cables and wires to the sub circuits and final sub circuits including their associated Live (Phase) Neutral and Earth conductors. **Distribution board is also known as "Fuse Board"**, **"Panel Board" or "Consumer Unit"**. following are the types of Distribution boards.

•Related Wiring Tutorial: Wiring of the Distribution Board (Single Phase Supply From Utility Pole & Energy Meter to the Consumer Unit)

Types of Distribution Boards

- **Main Distribution Board (MDB)**
- **Sub Distribution Board (SDB)**
- **Final Distribution Board (FDB)**

MDB = Main Distribution Board

A distribution board unit installed in the buildings which firstly receive the incoming single phase electric supply (AC low voltage (LV) (**230V AC or 120V AC in US**) from transformer secondary through electric pole and energy meter or the distribution company's electric service provider outlets is known as **Main Distribution Board**.
Main Distribution Board (MDB) is also known as Fuse board or consumer unit where the main protective and isolation devices are installed to provide electricity in a safe range to the connected electrical appliances.

SDB = Sub Distribution Board

The Distribution Board which is used to distribute electrical wiring and circuits within a selected area in a building or house, i.e. floor in a multi storey building. The Sub distribution board is connected and supplied from the Main Distribution Board through different wires and cables rated according to the load requirement.

FDB = Final Distribution Board

The Distribution Board which provide electric supply to the Final and Sub Final Circuits is known as Final Distribution Board. FDB (Final Distribution Board) directly connected through SDB (Sub Distribution Board) and the final switches are used to control the connected electrical devices and appliances such as light, air-conditioner, fan etc.

Wiring Accessories for Single Phase Distribution Board

Main Distribution Board or Fuse Boards (Consumer Unit) usually contains on the following three main units to control and distribute electric supply to the different connected appliances and devices through electrical wiring cables and wires.

- ***DP = Double Pole MCB (The main isolator or main switch).***
- ***RCD (Also DP) Residual Current Devices for safety.***
- ***SP = Single Pole MCB (Circuit Breakers and Fuses).***
- ***MCB & CB = Miniature Circuit Breaker and Circuit Breaker.***

Circuit Breaker

A circuit breaker is a switching device that interrupts the abnormal or fault current. It is a mechanical device that disturbs the flow of high magnitude (fault) current and in additions performs the function of a switch. The circuit breaker is mainly designed for closing or opening of an electrical circuit, thus protects the electrical system from damage.

Working Principle of Circuit Breaker-link

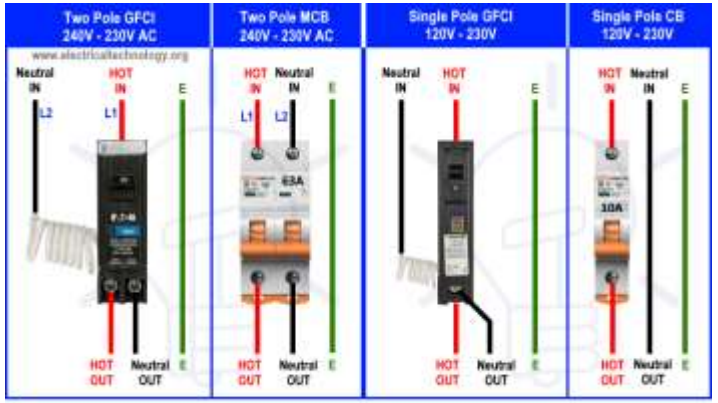
Circuit breaker essentially consists of fixed and moving contacts. These contacts are touching each other and carrying the current under normal conditions when the circuit is closed. When the circuit breaker is closed, the current carrying contacts, called the electrodes, engaged each other under the pressure of a spring.

During the normal operating condition, the arms of the circuit breaker can be opened or closed for a switching and maintenance of the system. To open the circuit breaker, only a pressure is required to be applied to a trigger.

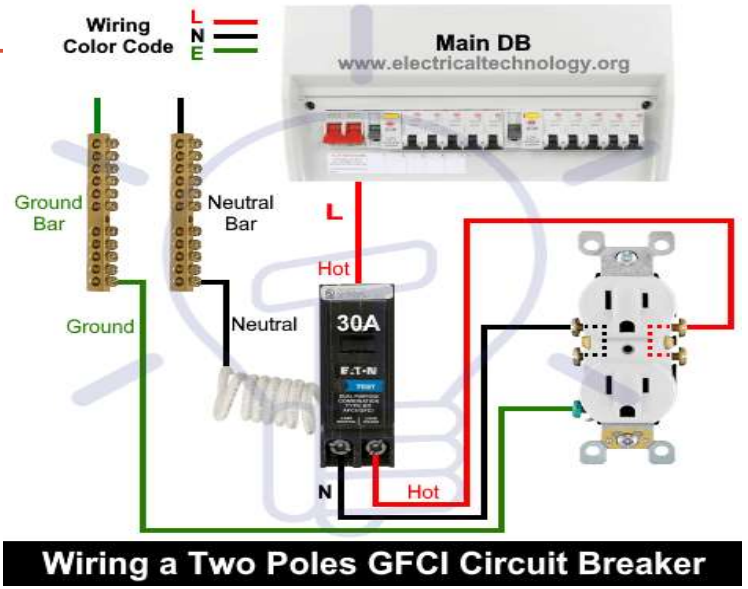
Whenever a fault occurs on any part of the system, the trip coil of the breaker gets energized and the moving contacts are getting apart from each other by some mechanism, thus opening the circuit.

Types of Circuit Breaker

Circuit breakers are mainly classified on the basis of rated voltages. Circuit breakers below rated voltage of 1000V are known as the low voltage circuit breakers and above 1000V are called the high voltage circuit breakers.



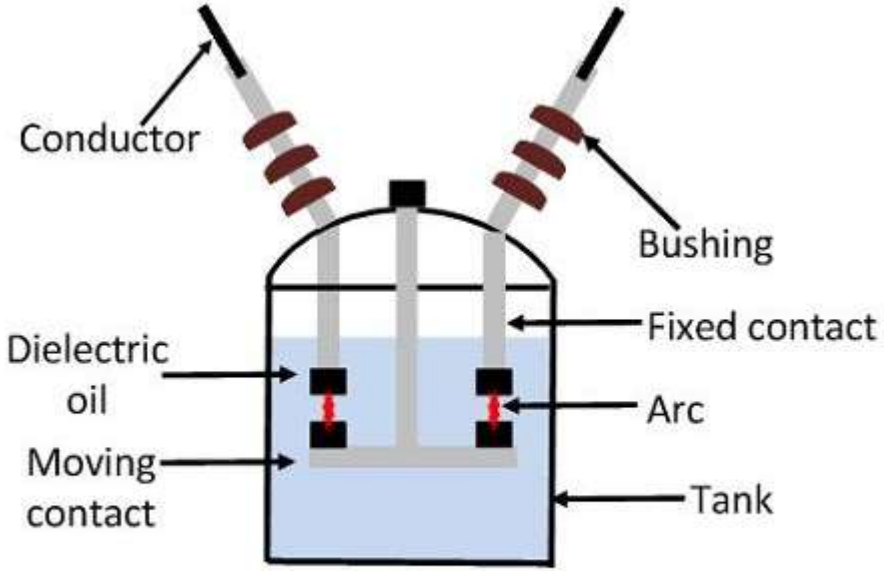
Difference between 1 & 2 Poles MCB and GFCI Breaker Terminals & Wiring



Wiring a Two Poles GFCI Circuit Breaker

The most general way of the classification of the circuit breaker is on the basis of the medium of arc extinction. Such types of circuit breakers are as follows :-

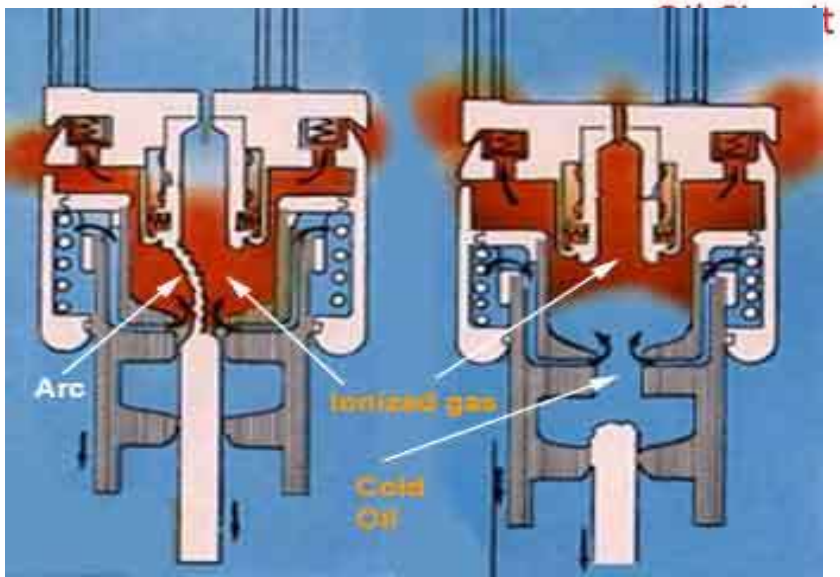
1.Oil Circuit Breaker



Oil circuit breaker is such type of circuit breaker which used oil as a dielectric or insulating medium for arc extinction. In oil circuit breaker the contacts of the breaker are made to separate within an insulating oil.

- Bulk Oil Circuit Breaker
- Minimum Oil Circuit Breaker

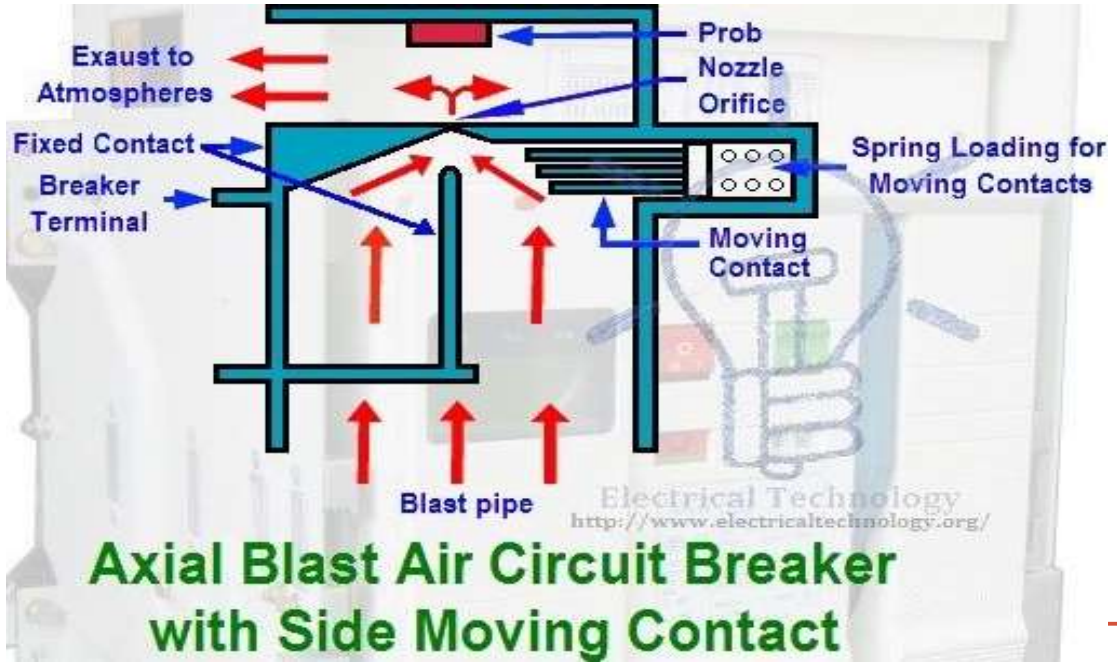
2. Minimum Circuit Breaker



t Breaker

Circuit Globe

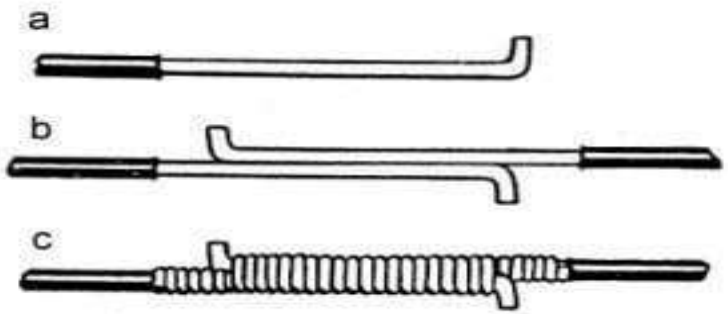
3. Air Blast Circuit Breaker



DIFFERENT TYPES OF JOINTS

- Britannia Joint
- Straight Joint
- Tee Joint
- Western Union Joint

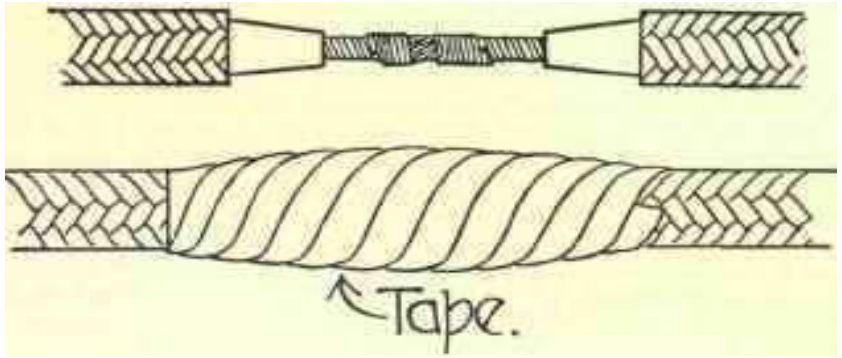
1. **Britannia Joint** : The Britannia joint is a form of electrical joint used for bare overhead wires where great tensile strength is required. The two wires are each tinned, and then each have a short shoulder bent in them, and are then bound together with tinned wire before the whole is soldered.



Britannia T Joint

2. Straight Joint

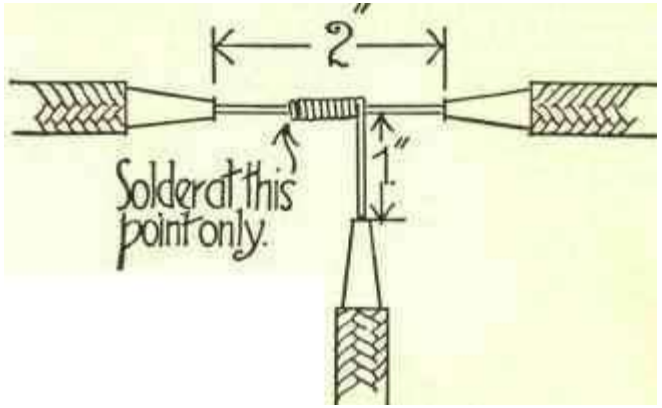
- The braiding is cut back to a distance of about 6 inches, and a shoulder is neatly formed with a sharp knife. The rubber insulation is also cut back and neatly tapered to a conical form about 1 1/2 inch in length. The copper wires are separated for a length of about 2 inches from the end, and carefully cleaned with emery cloth. The remainder of the exposed copper wires are twisted tightly together, and the central strand is cut out as close as possible to the point where the strands commence to



3. T Joint

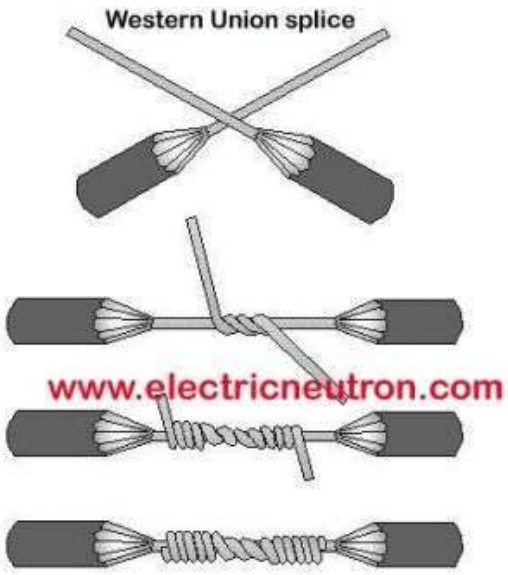
- When a tee joint is to be made in single wires, about 2 inches of the main cable and 2 inches of the branch cable are bared, the insulating material being treated as before described. The wires are cleaned, and about

1 inch of the branch is wound round the main cable, and soldered to it at the extreme end.



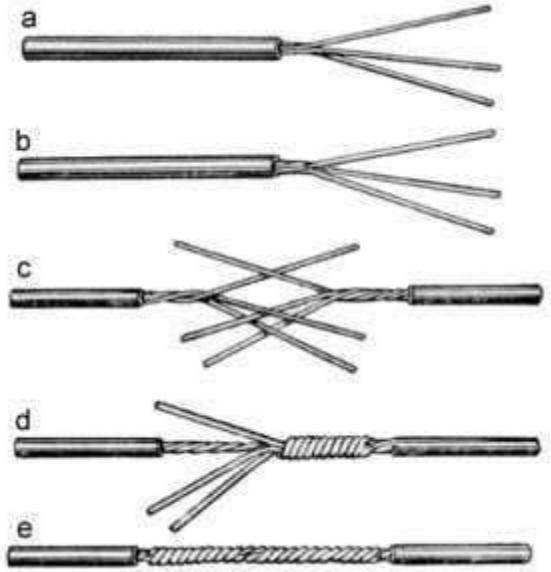
4. Western Union Joints

The wires are crossed positioned to make a long twist or bend in each wire. One end of the wire is wrapped and then the other end four or five times around the straight portion of each wire The ends of the wires are pressed down as close as possible to the straight portion of the wire.



5. Married Joint

- The married joint is an electrical joint used for joining multi-strand cables. The wires are unstranded, then interlaced with the wires of the other cable, and then married (twisted) together before finally being soldered.



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SCHOOL OF SCIENCE AND HUMANITIES

DEPARTMENT OF PHYSICS

UNIT – III – Types of Wiring System

Branch: **B.Sc. Physics**

Subject: **Electrical Wiring**

Batch: **2018-21**

Subject Code: **SPH1317**

Residential and Commercial Electrical Systems

Electrical Wiring

- A process of connecting various accessories for distribution of electrical energy from supplier's meter board to home appliances such as lamps, fans and other domestic appliances is known as Electrical Wiring.
- The wiring system selected will depend to a large extent on the types of service required.

Factors Affecting the Selection of Wiring

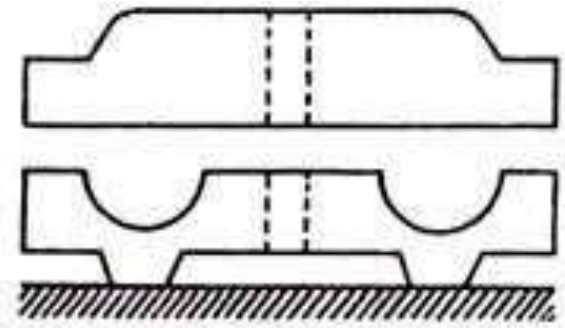
1. **Durability**
2. **Safety**
3. **Appearance**
4. **Cost**
5. **Accessibility**
6. **Maintenance Cost**

Types of Internal Wiring

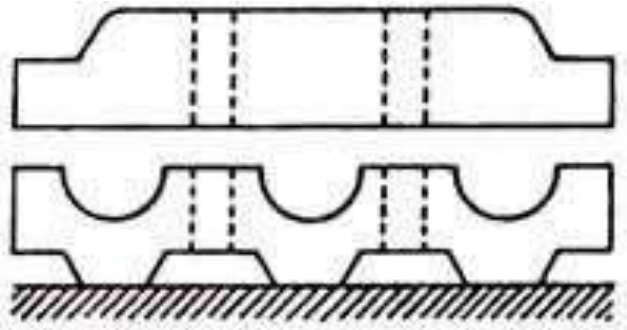
- Cleat wiring
- Casing and capping wiring
- Batten wiring
    a) CTS or TRS or PVC sheath wiring
    b) Lead sheathed or metal sheathed wiring
- Conduit wiring
    a) Surface or open Conduit type
    b) Concealed or underground type Conduit

Cleat Wiring

- In this system of wiring, cables are supported and gripped between porcelain cleats and 6mm. above the wall or roof.
- The main part is base, which is grooved to accommodate the cables, the other part is the cap which is put over the base



(i) Cleat with two grooves



(ii) Cleat with three grooves


CLEAT WIRING

- Cleats are placed above the wall or roof at an interval of 30 to 60 cm.
- The cables recommended for this type of wiring are VIR or PVC cables and any other approved insulated cables.

Advantages

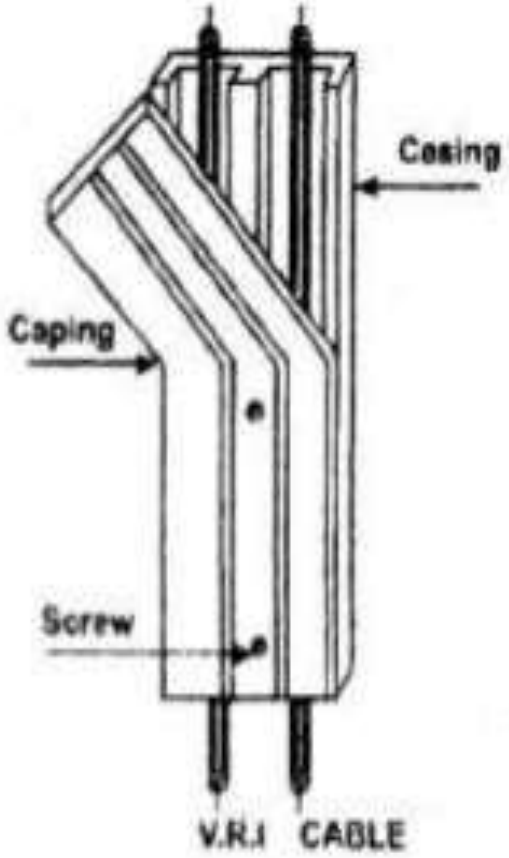
1. It is the cheapest system.
2. Installation and dismantling is easy.
3. Less skilled persons are required.
4. Inspection is easy.
5. Alterations and additions are easy.

Disadvantages

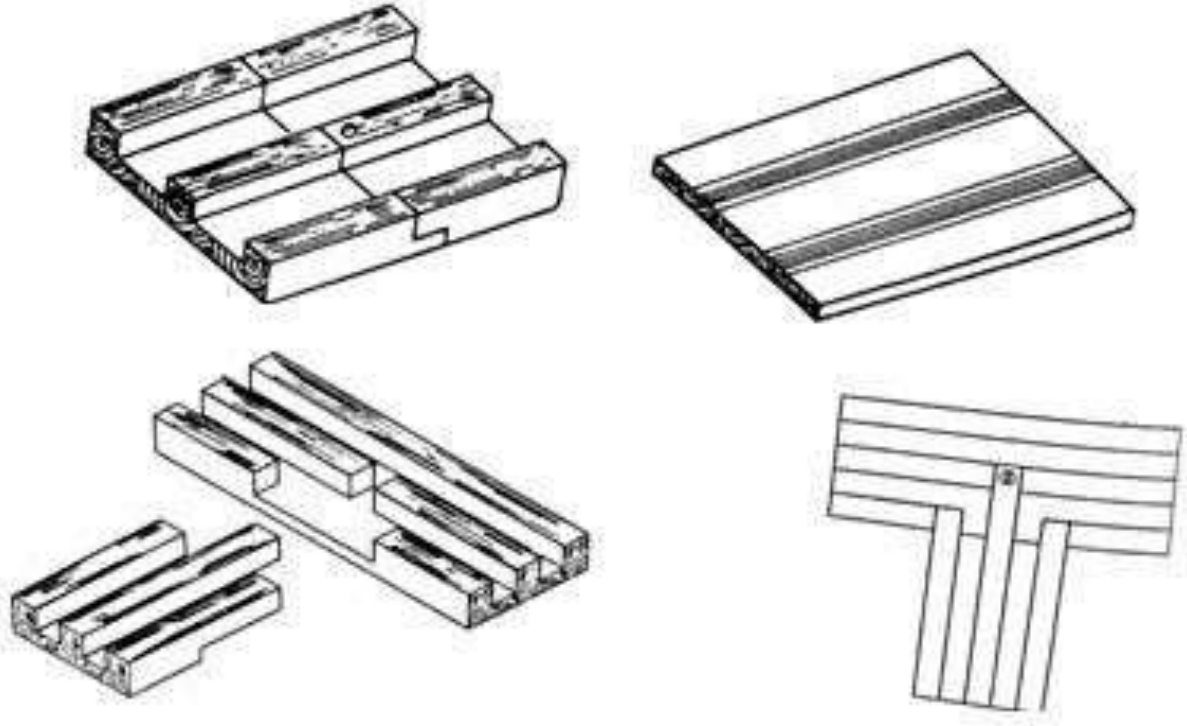
1. It is purely temporary wiring system.
2. Appearance is not good.
3. Cables are exposed to atmosphere and there is a possibility of mechanical injury.
4. This system should not be used in damp places other wise insulation gets damaged.

Casing and Capping Wiring

- It consists of rectangular blocks made from seasoned and knots free wood (preferably teak-wood).
- The casing has usually two (or three) ‘U’ shaped grooves, into which the VIR or PVC cables are laid in such a way that the opposite polarity cables are laid in different grooves.
- The casing is covered by means of a rectangular strip of the same width as that of casing known as capping and is screwed to it.
- This system of wiring is suitable for low voltage installations.



Wooden Casing & Capping Wiring System



Advantages

1. It provides good insulation as conductors are apart.
2. It provides good mechanical strength.
3. Easy to inspect by opening the capping.

Disadvantages

1. It is costly system now – a – days because it needs seasoned, knot free wood.
2. There is every risk of fire.
3. The labor cost is more because it requires skilled carpenters.
4. This system can not be used in damp places.

CTS or TRS or PVC Sheath Wiring

- CTS cables are available in single-core, twin-core or three-core with a circular or oval in shape.
- CTS cables are sufficiently chemical proof, water proof, steam proof.
- The cables are run or carried on well seasoned, perfectly straight and well varnished (on all four sides) teak wood batten of thickness 10 mm. at least.
- The width of the batten depends upon the number and size of cables to be carried by it. Battens are fixed to the walls or ceilings by means of gutties or wooden plugs.
- The cables are held on the wooden batten by means of tinned brass link clips spaced at an interval of 10 cm.
- .This system is suitable for low voltage installations..


CTS OR TRS
WIRING

Advantages

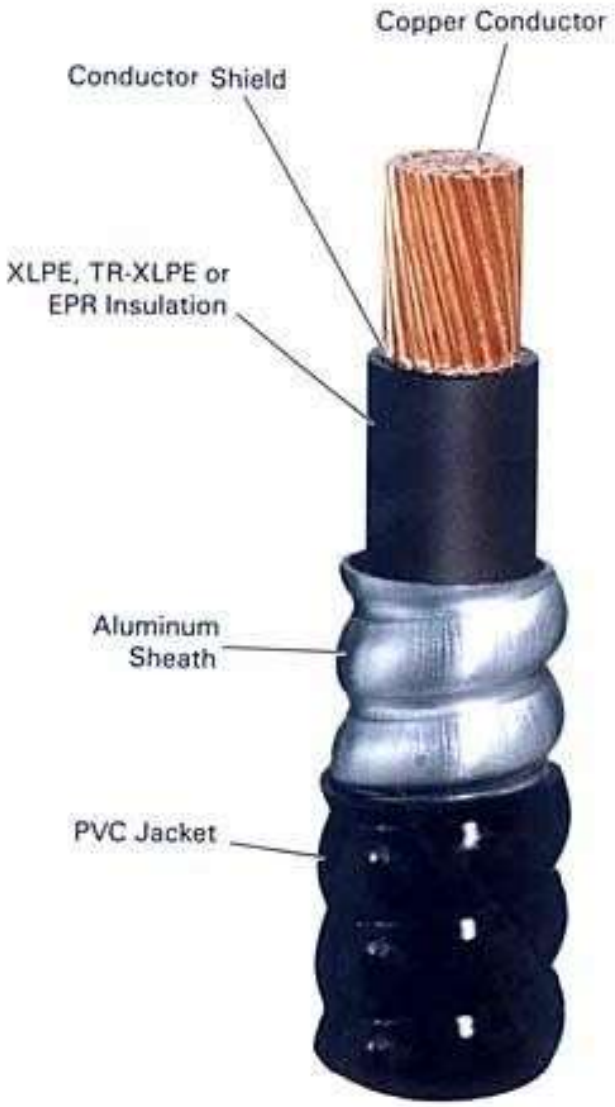
1. It's appearance is good, if carried properly.
2. It's life is sufficiently long.
3. It can withstand the action of most chemicals such as acids and alkalies.
4. It's installation is easy and quick compared to casing-capping.
5. It is cheap compared to casing – capping, metal conduit and lead sheathed wiring.

Disadvantages

1. This system of wiring is not recommended in situations exposed to sun and rain, unless preventive steps are taken.
2. It can not be used in damp places.
3. Good work man ship is required to make a sound job.
4. Only suitable below then 250V.

Metal Sheathed Wiring

- In lead sheathed or metal sheathed wiring the cables used are insulated wires, TRS or PVC, with metal outer covering of about 1 mm. thick. The metal covering is known as sheathing and is made of lead – aluminium alloy containing about 95% of lead. The metal sheathed cables are run on wooden batten and are fixed to it by link – clips.


Copper Conductor
Conductor Shield
XLPE, TR-XLPE or
EPR Insulation
Aluminum
Sheath
PVC Jacket

Advantages

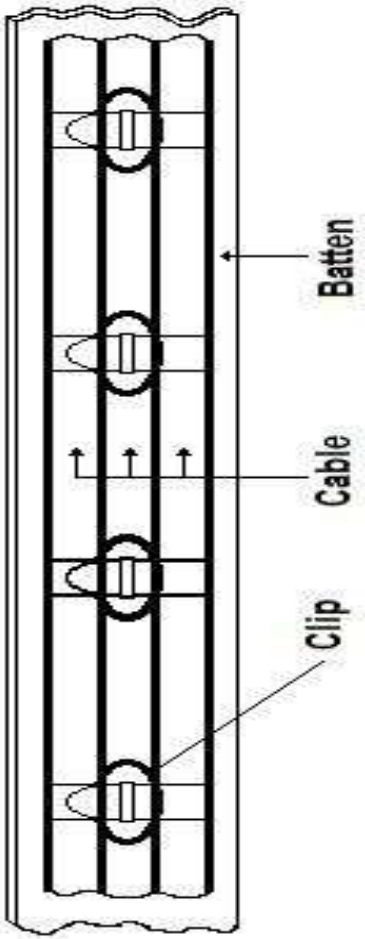
1. It provides protection against mechanical injury.
2. It can be used in damp situations.
3. It can be used in situations exposed to-sun, and rain provided no joint is exposed.
4. It has longer life.

Disadvantages

5. It is costly system of wiring.
6. It is not suitable where chemical (acids and alkalies) corrosion may occur.
7. In case of insulation damage, the metal sheath become alive and gives shock.

Batten Wiring

Old Wiring System



Conduit Wiring System

Conduit wiring system consists of either VIR or PVC cables taken through tubes or pipes and terminated at the outlets or switches / sockets. The tube or pipe is known as “conduit”. Conduit wiring may run over the surface of the walls and ceiling or may be concealed under masonary work.

Types of Conduits

1. Rigid steel / metal conduit.
2. Rigid PVC / non-metallic conduit.
3. Flexible steel conduit.
4. Flexible PVC / non-metallic conduit.

MS Conduit Pipes

Surface Conduit Wiring

All steel conduits should be coated or finished with galvanized or enameled surface. Conduit accessories must be of threaded type. No steel conduit less than 12.7 mm. in diameter should be used.

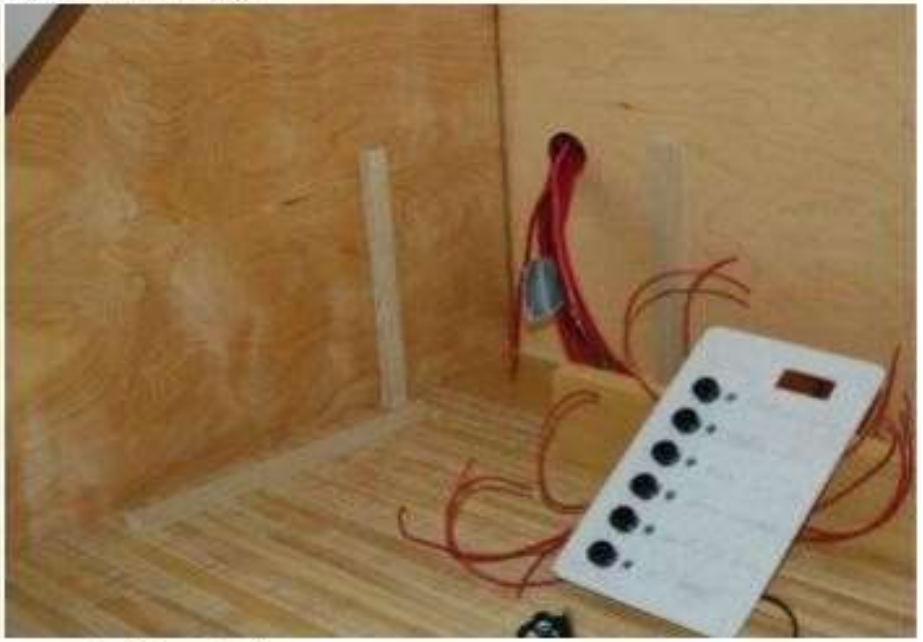
The conduit should be laid over the wooden gutties, and should be fixed to the wall by means of saddles at an interval of not more than 1.2 m.

Concealed Conduit Wiring

The conduits (metal or PVC) are embedded along walls or ceiling in plaster at the time of building construction. The conduits are fixed by means of saddles not more than 60 cm. apart. The VIR or PVC cables are drawn into the concealed by means of GI wire of size 18 SWG.

PVC conduits are increasingly being used in place of steel conduits. PVC conduits are less expensive and the labour time saved may be as much as 25% to 50% compared to the time taken when installing steel conduits. PVC conduits are resistant to acids alkalies, oil and moisture.

Surface Conduit Wiring



Concealed Conduit wiring

Advantages

1. It provides protection against mechanical damage.
2. Metal conduits provides protection against fire due to short circuit etc.
3. The whole system is water proof.
4. It's life is long.
5. Replacement of defective wiring is easy.
6. It is shock proof if earthing is done properly.
7. PVC conduit wiring (particularly concealed) is cheap.
8. PVC conduit wiring requires less time.
9. Concealed conduit wiring appearance is very good.

Disadvantages

1. PVC conduit does not provide protection against fire.
2. Metal conduit wiring is very costly.
3. Metal conduit wiring requires more time.
4. Metal conduit wiring needs skilled labour.
5. Very hard to find the defects in the wiring.
6. Very complicated to manage additional connection in the future.

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SCHOOL OF SCIENCE AND HUMANITIES

DEPARTMENT OF PHYSICS

UNIT – IV – Wiring Circuits

Branch: **B.Sc. Physics**

Subject: **Electrical Wiring**

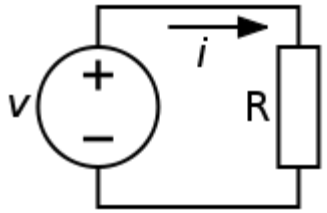
Batch: **2018-21**

Subject Code: **SPH1317**

Basic Circuits

An electric circuit is an unbroken path along which an electric current exists and/or is able to flow. A simple electrical circuit consists of a power source, two conducting wires (one end of each being attached to each terminal of the cell), and a small lamp to which the free ends of the wires leading from the cell are attached.

When the connections are made properly, the circuit will “close” and current will flow through the circuit and light the lamp.



A simple electrical circuit

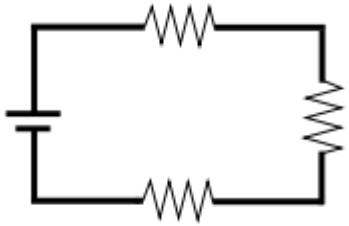
Once one of the wires is removed from the power source or a “break” is made in the flow, the circuit is now “open” and the lamp will no longer light.

In practical application, circuits are “opened” by such devices as switches, fuses, and circuit breakers. Two general circuit classifications are series and parallel.

The elements of a series circuit are connected end to end; the same current flows through its parts one after another.

Series Circuits

In a series circuit , the current through each of the components is the same, and the voltage across the components is the sum of the voltages across each component.



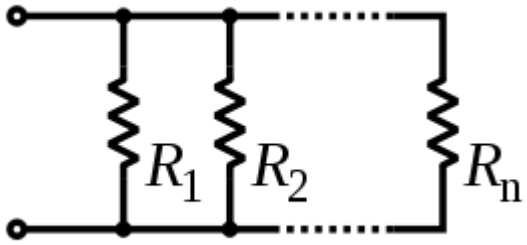
An example of a Series Circuit

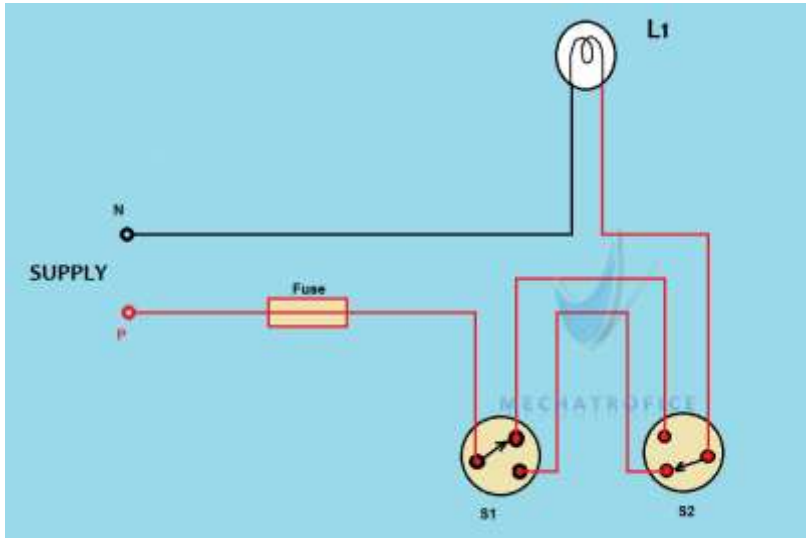
Parallel Circuits

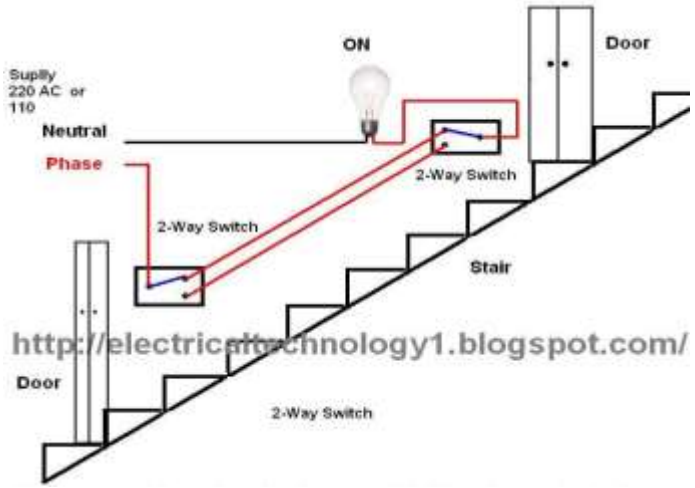
In a parallel circuit, the voltage across each of the components is the same, and the total current is the sum of the currents through each component.

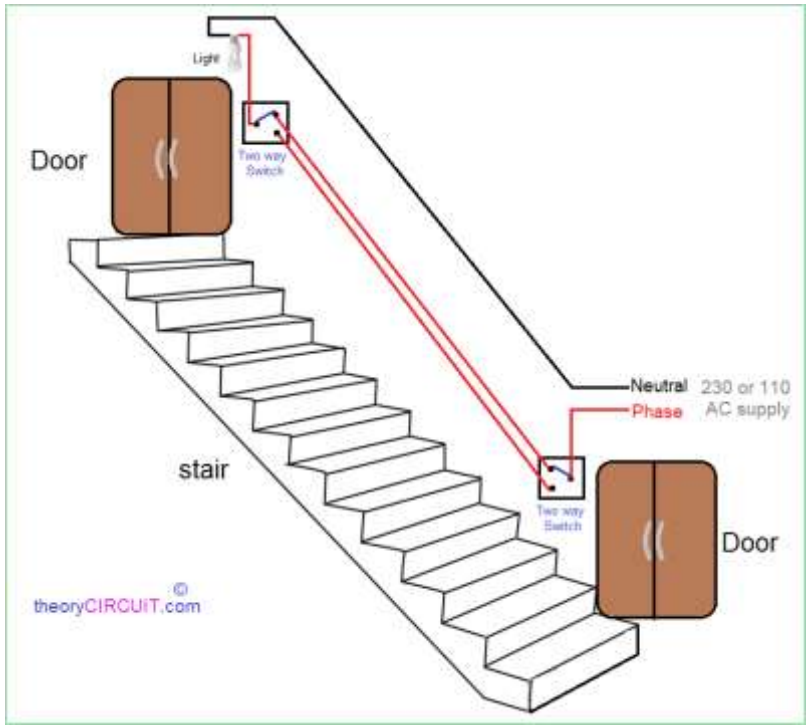
If two or more components are connected in parallel they have the same potential difference (voltage) across their ends. The potential differences across the components are the same in magnitude, and they also have identical polarities. The same voltage is applicable to all circuit components connected in parallel.

If each bulb is wired to the battery in a separate loop, the bulbs are said to be in parallel.

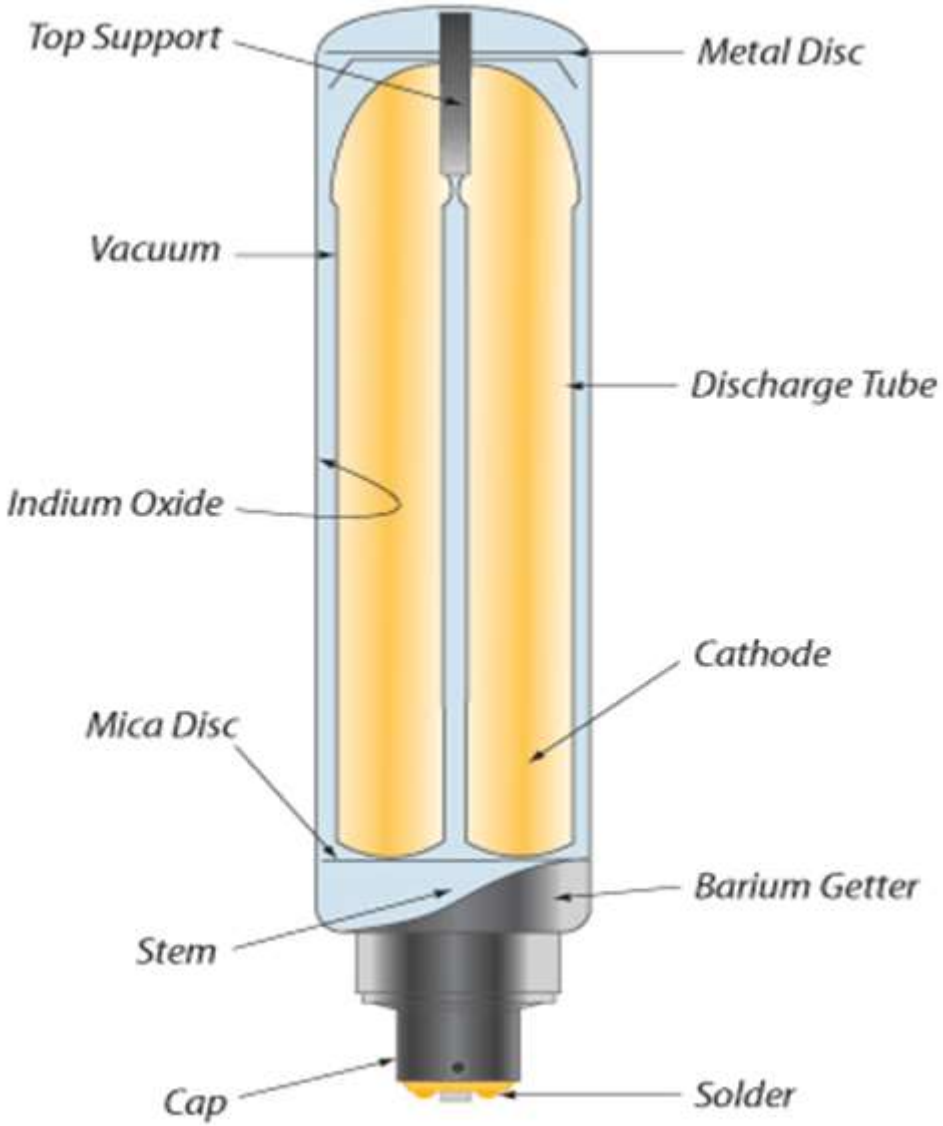



L1
N
SUPPLY
Fuse
P
S1
S2


ON
Door
Supply
220 AC or
110
Neutral
Phase
2-Way Switch
2-Way Switch
Stair
http://electricaltechnology1.blogspot.com/
Door
2-Way Switch

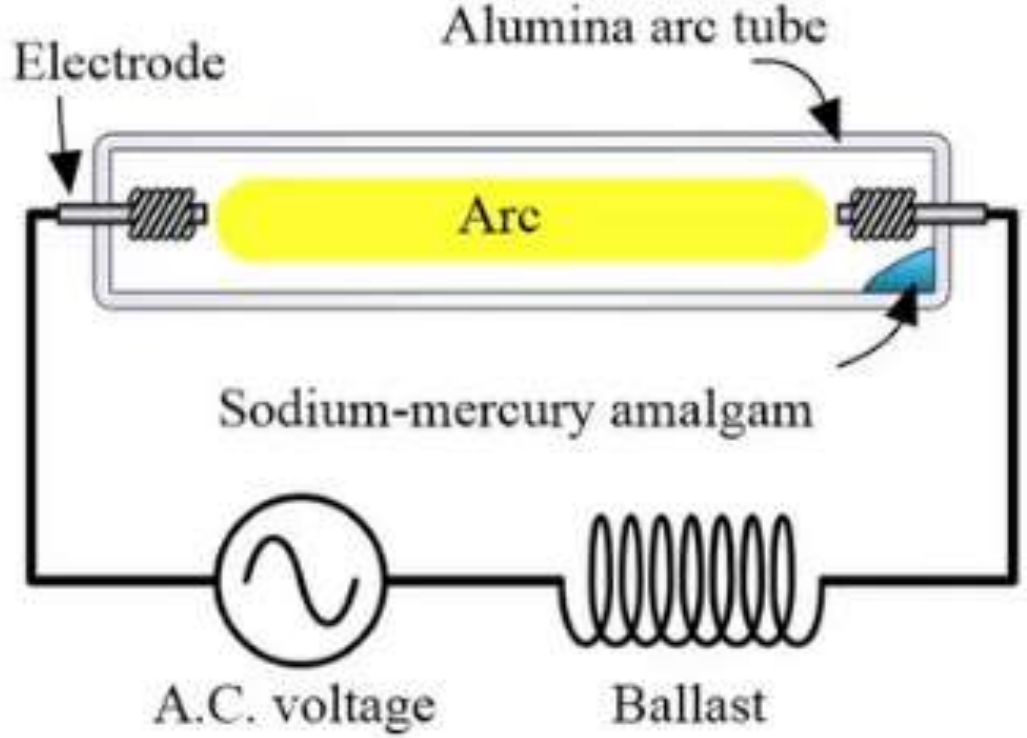

Light
Door
Two way Switch
Neutral
Phase
230 or 110
AC supply
stair
Two way Switch
Door
©
theoryCIRCUIT.com

Sodium Vapour Lamp



A Low-Pressure Sodium Vapor lamp (or LPSV lamp) is termed as a "miscellaneous discharge lamp" as it possesses some characteristics of High-Intensity Discharge (HID) lamps as well as it resembles fluorescent lamps in other areas.

Basically, an LPSV lamp is a gas discharge lamp that uses sodium in an excited state to produce light. A typical LPSV lamp is shown in the figure below.



The constructional features of the LPSV lamp are given below:
1.The outer envelope is made from borosilicate glass. The inner surface of the outer glass case is coated with indium oxide. This heat-reflective coating of indium oxide allows visible light to pass but reflects infra-red radiation back inside the tube as a result of which both light output and temperature inside the tube increases.
2.The arc tube of the LPSV lamp is made of glass and bent in the form of a U-shape in order to increase the length of the arc. The arc tube is supported at both ends. The arc tube contains a mixture of metallic sodium and inert gases argon and neon.

Now we will discuss how an LPSV lamp actually operates. The basic operation of the LPSV lamp is similar to other gas discharge lamps in a sense that an arc is passed through a tube containing a metallic vapor. A starting gas is also required which is generally a mixture of inert gases argon and neon. The operation is explained step by step in details below:

1.Electric power is given to the lamp and it is energized.

2.The electrodes produce an arc and this arc strikes through the conductive gas and the lamp produces a reddish-pink light, characteristic of neon.

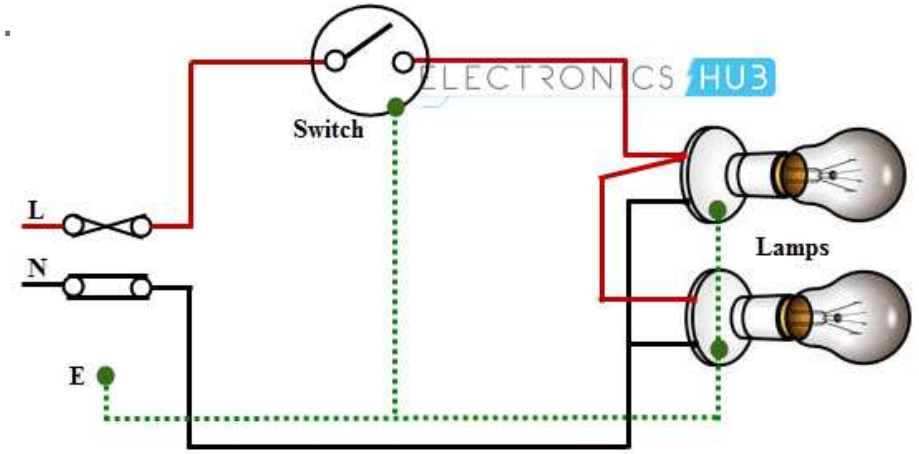
3.Current flowing through the inert gas mixture of argon and neon generates heat.

4.This heat vapourises the metallic sodium.

5.With the passage of time, the quantity of sodium in the arc stream increases and this produces the characteristic monochromatic orange color at a wavelength of 489.6 nm.

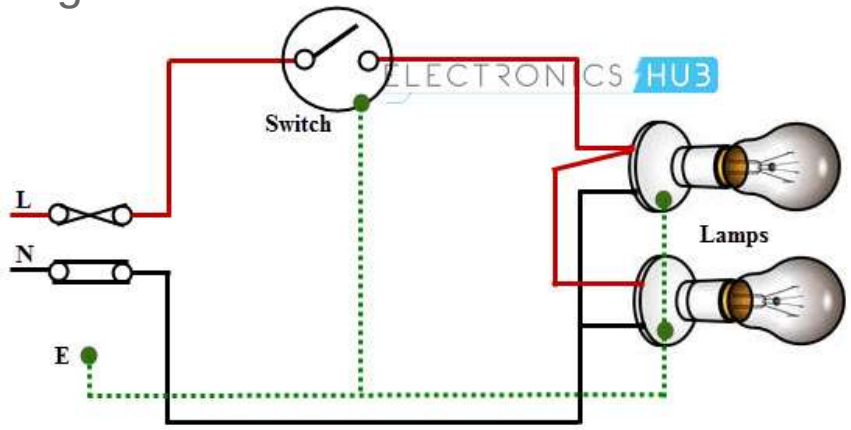
Single bulb controlled by a one way switch

In this, hot wire is connected to the one terminal of the switch and other terminal of the switch is connected to the bulb positive terminal, then bulb negative terminal is connected to the neutral wire as shown in figure.



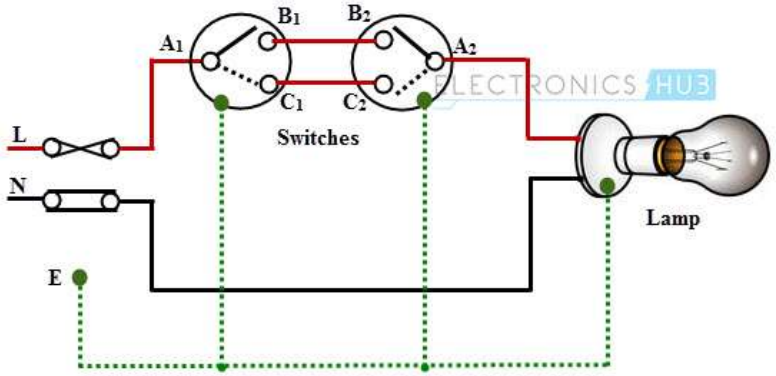
Two blubs are controlled by a one way switch

In this, two bulbs are connected in parallel with the supply wires (phase and neutrals) which are routed by single one-way switch as shown in figure.



Single blub (or any other load) controlled by two way switches

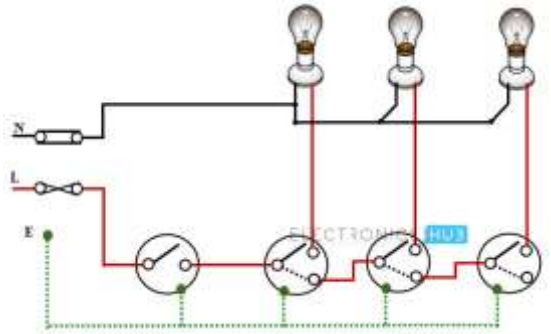
This wiring is also called as staircase wiring in which a light lamp is controlled from two sources by using two two-way switches. This type of wiring is used in bed rooms to switch ON/OFF the lamp from two sources (at the bed side and at switchboard). The connection of switches with the lamp is shown below.



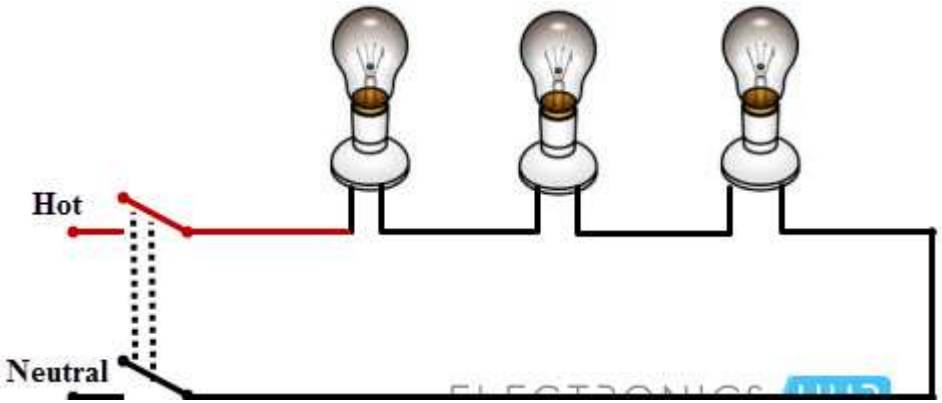
Godown Wiring

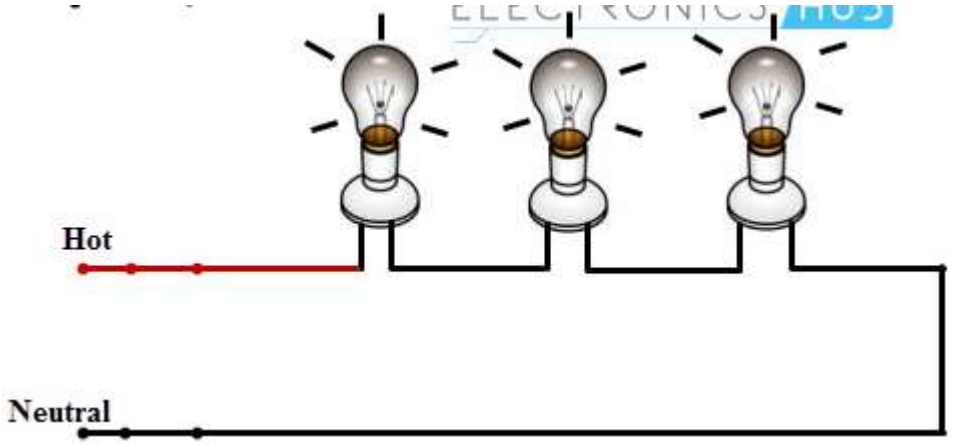
This type wiring is used in big godowns, long passages, warehouses and tunnel like structures having many rooms or portions. It follows the linear sequence for switching the lights from one end to the other.

When a person leaves from one room and enters next, by turning the light switch makes earlier lamp switched OFF while present room is switched ON. It turns OFF the lamp while switching another. The schematic wiring diagram for godown wiring is shown in below.



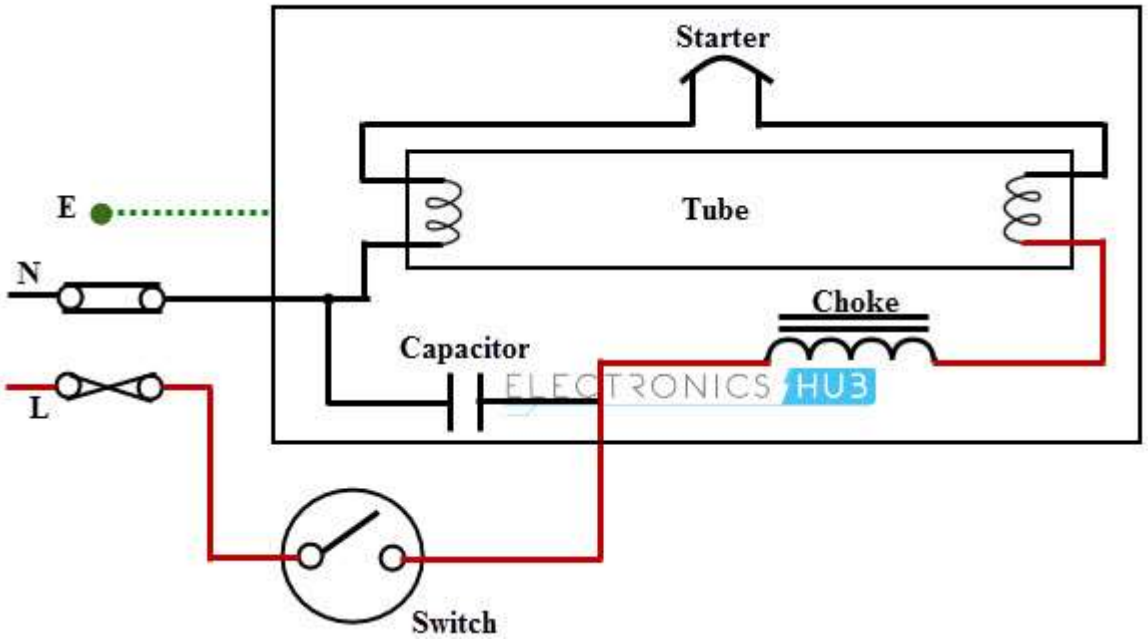
The **series wiring** is the rarely used wiring in which hot wire is routed through the several devices and then last device terminal is connected to the neutral wire. It is like an old Christmas lights or serial lights wiring in which one light burnout leads to the shutdown of the entire network.

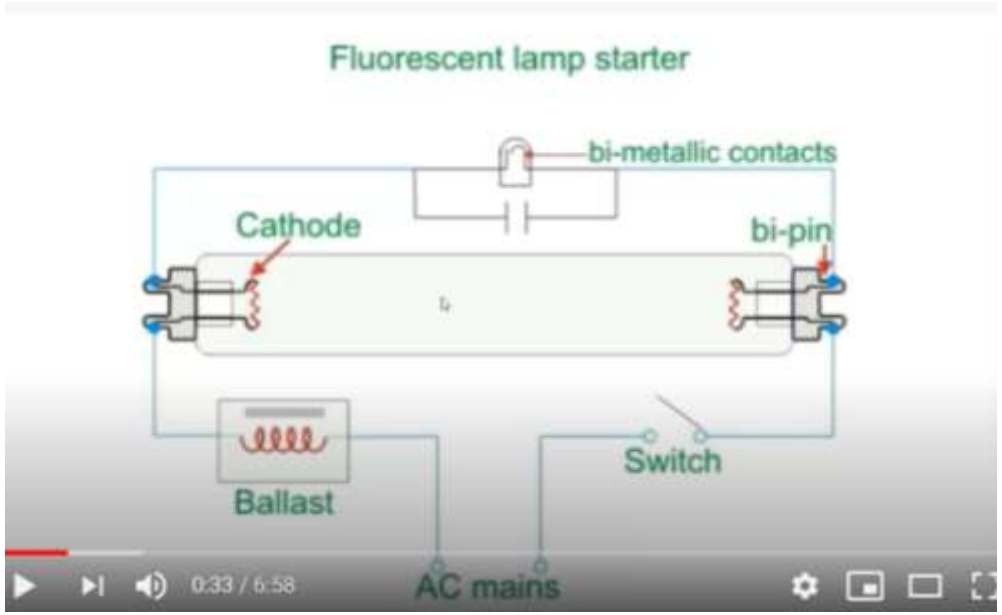




Fluorescent lamp controlled by a one-way switch

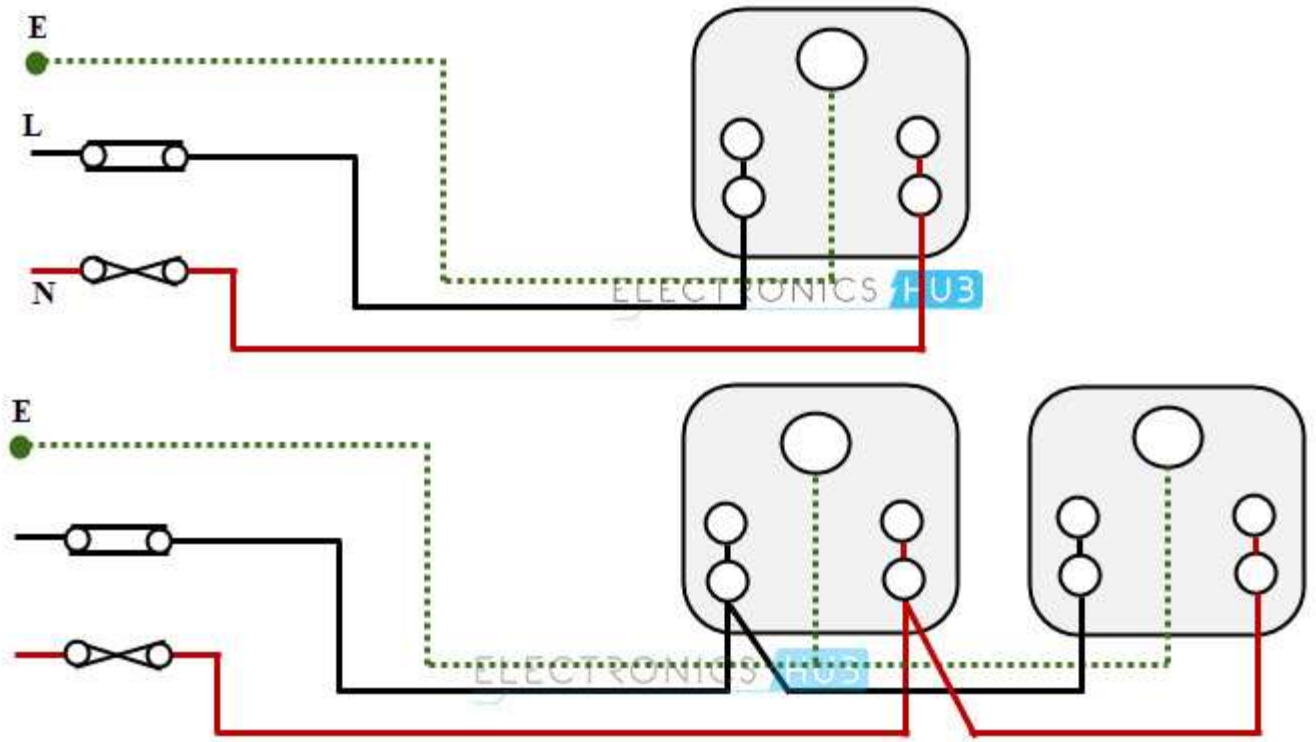
The switching of fluorescent lamp with single one-way switch through ballast and capacitor is shown in below figure. In this, phase wire is connected to the one end of the switch and another end of the switch is connected to the choke (or ballast). One electrode of the lamp is connected to the choke and other to neutral terminal as shown in figure.





Socket outlet wiring

The outlet holds a plug and passes the current through it when the power is routed to the socket through a switch. The single socket connection and radial socket connection are shown in below figure.



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SCHOOL OF SCIENCE AND HUMANITIES

DEPARTMENT OF PHYSICS

UNIT – V – Earthing and Electricity Rules

Branch: **B.Sc. Physics**

Subject: **Electrical Wiring**

Batch: **2018-21**

Subject Code: **SPH1317**

General Rules for Wiring

The following general rules should be kept in mind while executing the electrical wiring work:

1. The current rating of the cable / conductor should be slightly greater (at least 1.5 times) than the load current.
2. Every live wire / line should be protected by a fuse of suitable rating as per load requirements.
3. Every sub-circuit should be connected with the fuse distribution board.
4. All metal coverings used for the protection of earth must be connected to earth.
5. No switch or fuse is used in earth or neutral conductor.
6. Every apparatus should be provided with a separate switch.

7. No additional load should be connected to the existing installation until it has been satisfied that the installation can safely carry the additional load.
8. All the switches and starters should be accessible to the operator.
9. A caution notice (danger plate) should be fixed on very equipment.
10. In any building light wiring and power wiring should be kept separately.
11. When the installation has been completed it should be tested before giving the supply and the leakage in the wiring should not exceed 1/5000 of the maximum current of the load.
12. In 3-phase, 4 – wire installation the load should be distributed almost equally on all the phases.
13. In case of 3-phse, 4-wire system, at the main board, indication should be done in Red, Yellow and Blue. Neutral should be indicated in black.

General Requirements of Electrical Installation

a) Layout wiring
b) Conductors
c) Rating of lamp, fan and socket outlet point
d) Joint box and looping in system
e) Reception and distribution of main supply
f) Arrangement of apparatus on switchboards
g) Single phase supply
h) Three phase, four wire supply
i) Sub distribution board
j) Sub circuits
k) Diversity
l) Diversity factor for sub circuit

Basic First Aid for Medical Emergencies

Session Objectives

- •Recognize the benefits of obtaining first-aid and CPR certification
- •Identify proper procedures for a variety of medical emergencies
- •Assist in administering first aid when a co-worker is injured
- •Do no further harm

Prequiz:
True or False?

F •After an accident, immediately move the victim to a comfortable position.

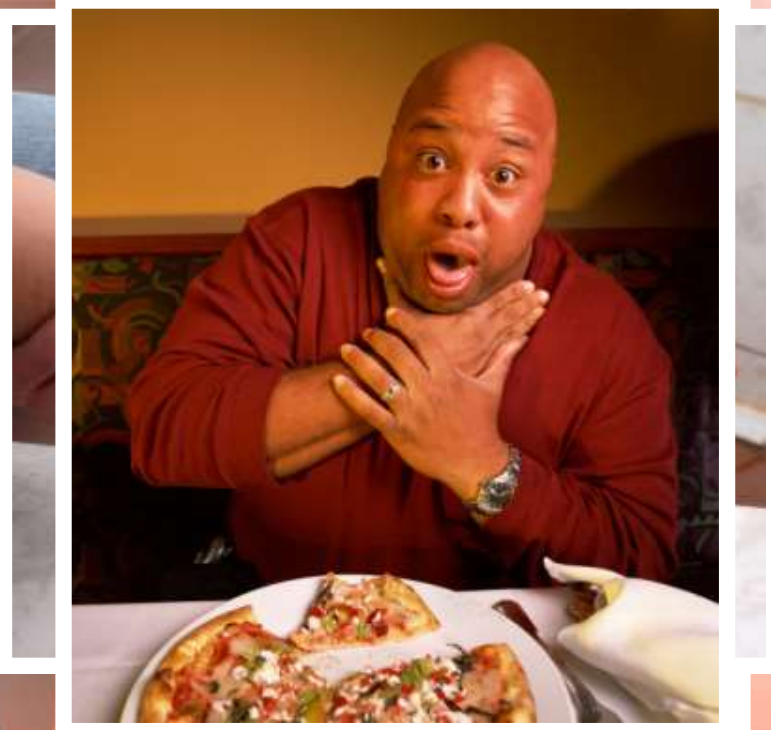
F •If a person is bleeding, use a tourniquet.

T •Signs of a heart attack include shortness of breath, anxiety, and perspiration.

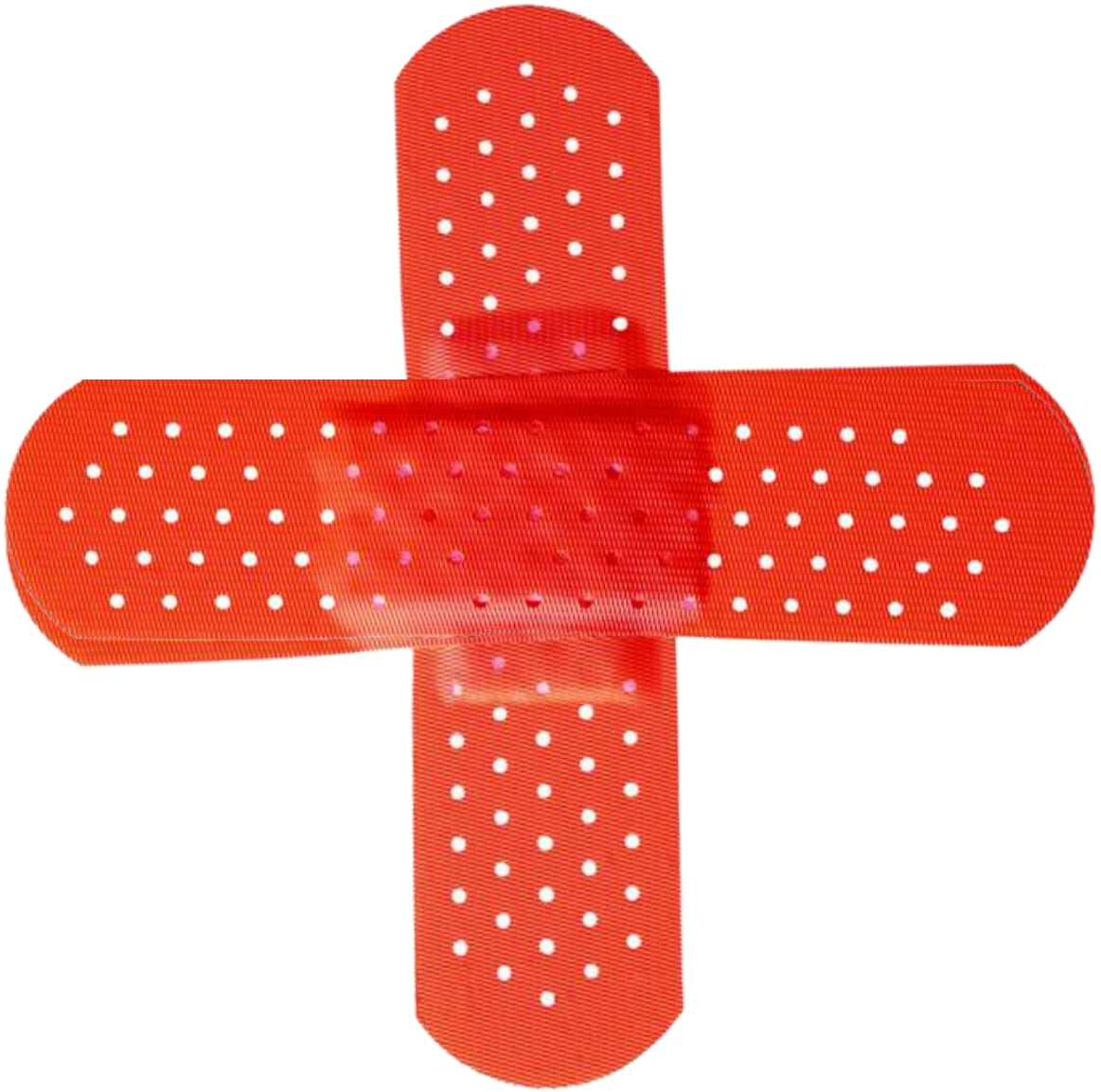
F •All burns can be treated with first aid alone; no emergency medical attention is necessary.

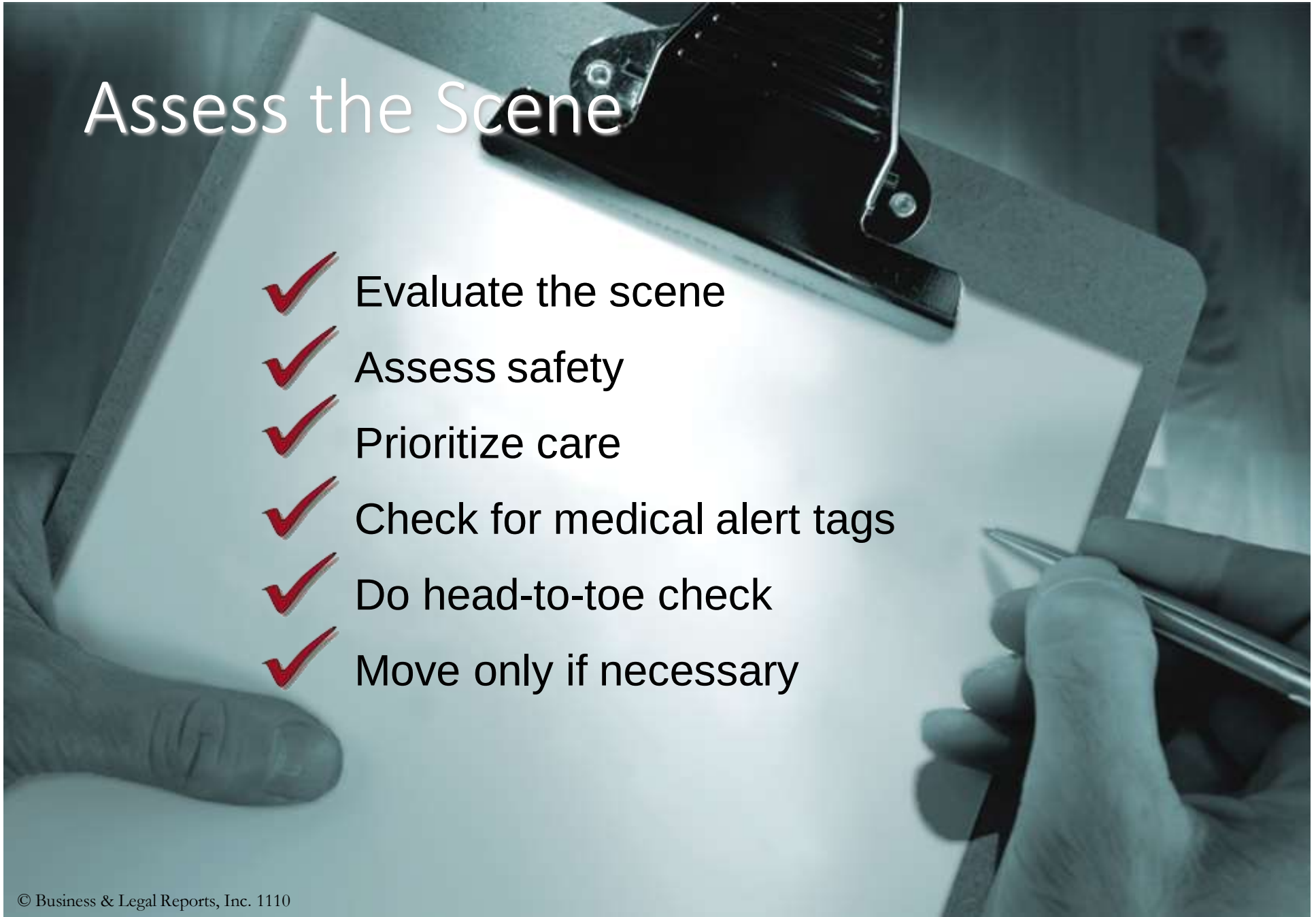
Help! Emergency!

- **Minutes could make a difference**



Four Basic Rules





No Breathing

- Administer CPR:
  - Lay the person on his or her back
  - Give chest compressions
  - Tilt head slightly
  - Breathe into the person's mouth
  - Continue until EMS personnel arrive

Bleeding

- Stop the flow of blood
- Wear gloves
- Cover the wound
- Apply pressure
- If a body part has been amputated, put it on ice

Shock

- Lay the victim down
- Cover
- Raise feet

Heart Attack

- Call 108
- Make victim comfortable
- Loosen tight clothing
- Check for medication
- Keep victim still
- Don’t give stimulants

Choking

- Ask a person to speak or cough
- Deliver 5 back blows
- Perform abdominal thrusts
- Repeat sequence of back blows and abdominal thrusts

If Abdominal Thrusts Don’t Work

- Call 108
- Finger sweep
- Abdominal thrusts
- Check ABCs
- Perform CPR if not breathing

Electrical Shock

1. Don’t touch!
2. Turn power off
3. Call 108
4. Remove person from live wire
5. Check for breathing

Exercise

Match the problem with the correct first-aid procedure.

Bleeding	CPR
Choking	Elevate feet
No breathing	Keep victim still
Heart attack	Direct pressure
Shock	Abdominal thrusts

Review

- Do you understand first-aid procedures for:
  - No breathing?
  - Bleeding?
  - Shock?
  - Heart attack?
  - Choking?
  - Electrical shock?

Eye Injuries

- **Splashes**
- **Particles in eye**
- **Blow to eye**
- **Cuts near eye**
- **Penetrating objects**

Burns

- First-degree burns—Reddened, painful skin
- Second-degree burns—Blistering
- Third-degree burns—Charring, deep tissue damage

Exposure to Hazardous Materials

- Eyes
- Skin
- Inhalation
- Ingestion

- Eyes
- Skin
- Inhalation
- Ingestion

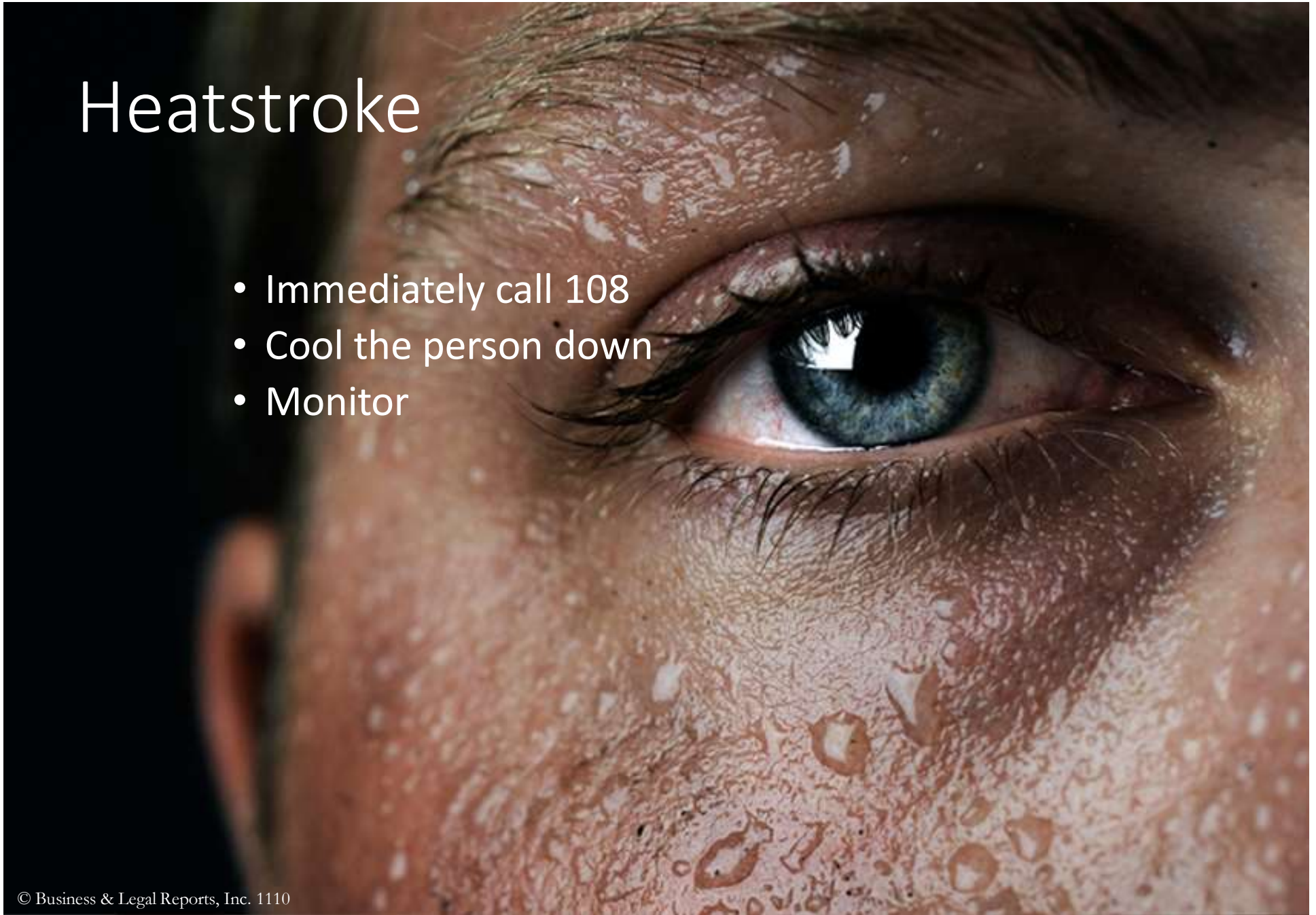
Broken Bones

- Look
- Ask
- Treat for shock

Heat Exhaustion

- Move to cool place
- Lay victim down
- Elevate feet
- Loosen clothing
- Give fluids
- Apply cool compresses

Heatstroke



- Immediately call 108
- Cool the person down
- Monitor

Fainting

- Check for breathing
- Administer CPR if necessary
- Call 108 if more than a few minutes
- If conscious, lay the victim down with feet elevated

Epileptic Seizures

- Remove victim from hazards
- Check for breathing
- Nothing in the mouth
- Keep comfortable
- Call 108 if medical assistance is needed

Exercise

Multiple choice

Which is the worst kind of burn?	a. First degree b. Third degree
For a particle in the eye:	a. Flush with water b. Rub eye
For inhalation of vapors or gases:	a. Induce vomiting b. Move to fresh air
For heatstroke:	a. Call 108 b. Don’t call 108

Review

- Do you understand first-aid procedures for:
  - Eye injuries?
  - Burns?
  - Exposure to hazardous materials?
  - Broken bones?
  - Heat exhaustion and heatstroke?
  - Fainting?
  - Epileptic seizures?

KEY POINTS To Remember!

- •Medical emergencies can happen anytime.
- •Act quickly, calmly, and correctly.
- •Consider being certified in first aid and CPR.

EARTH TESTING

PRACTICAL

EARTH TESTING TECHNIQUES AND

MEASUREMENT INSTRUMENTS

EARTH / GROUND BASICS

What is ground?

A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of earth*

Ground is a connection to Earth made either intentionally or accidentally

*NFPA 70-2000 (National Fire Protection Association)

EARTH / GROUND BASICS

Why ground?

To protect people and equipment

By dissipating stray energy from:

Electrical faults (fuses, breakers etc.)
Lightning strikes
Radio Frequency
Static discharges

REAL EXAMPLES

Why test? – Catch the problem before it happens!

Estimate: at least 15% of power quality problems are related to grounding

Lightning strikes on equipment with poorly maintained protection systems destroy millions of dollars of equipment and lost production every year

Using ground testing in a PDM protocol will help prevent possible dangerous situations and loss of downtime (= money)

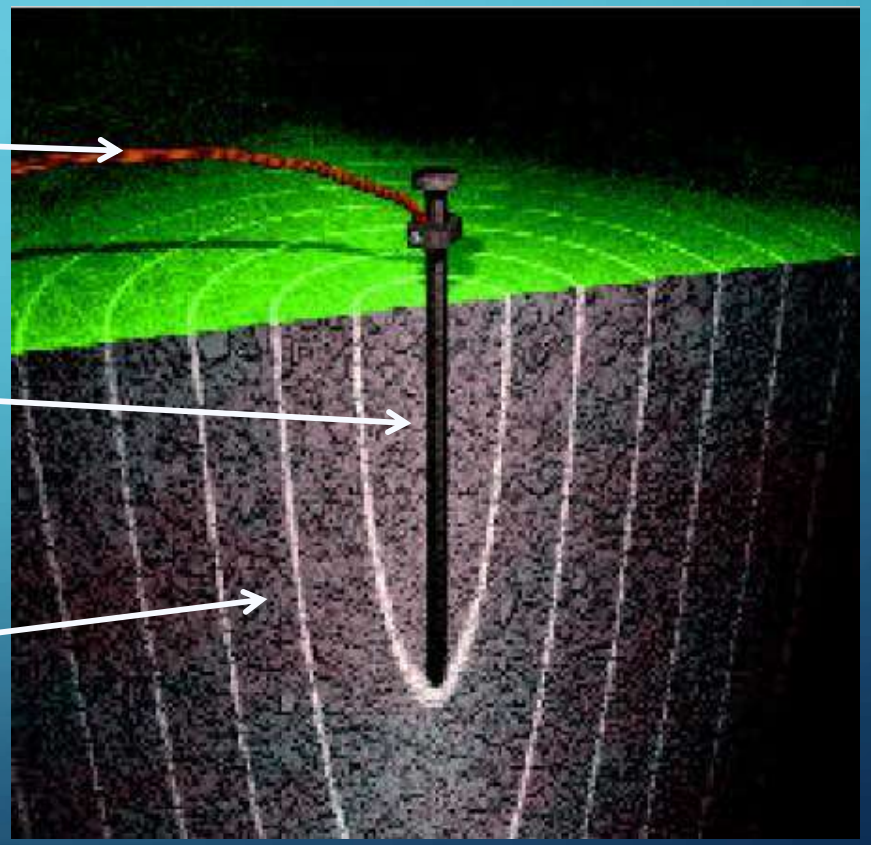
EARTH / GROUND BASICS

How do you connect to earth?

Cable or tape

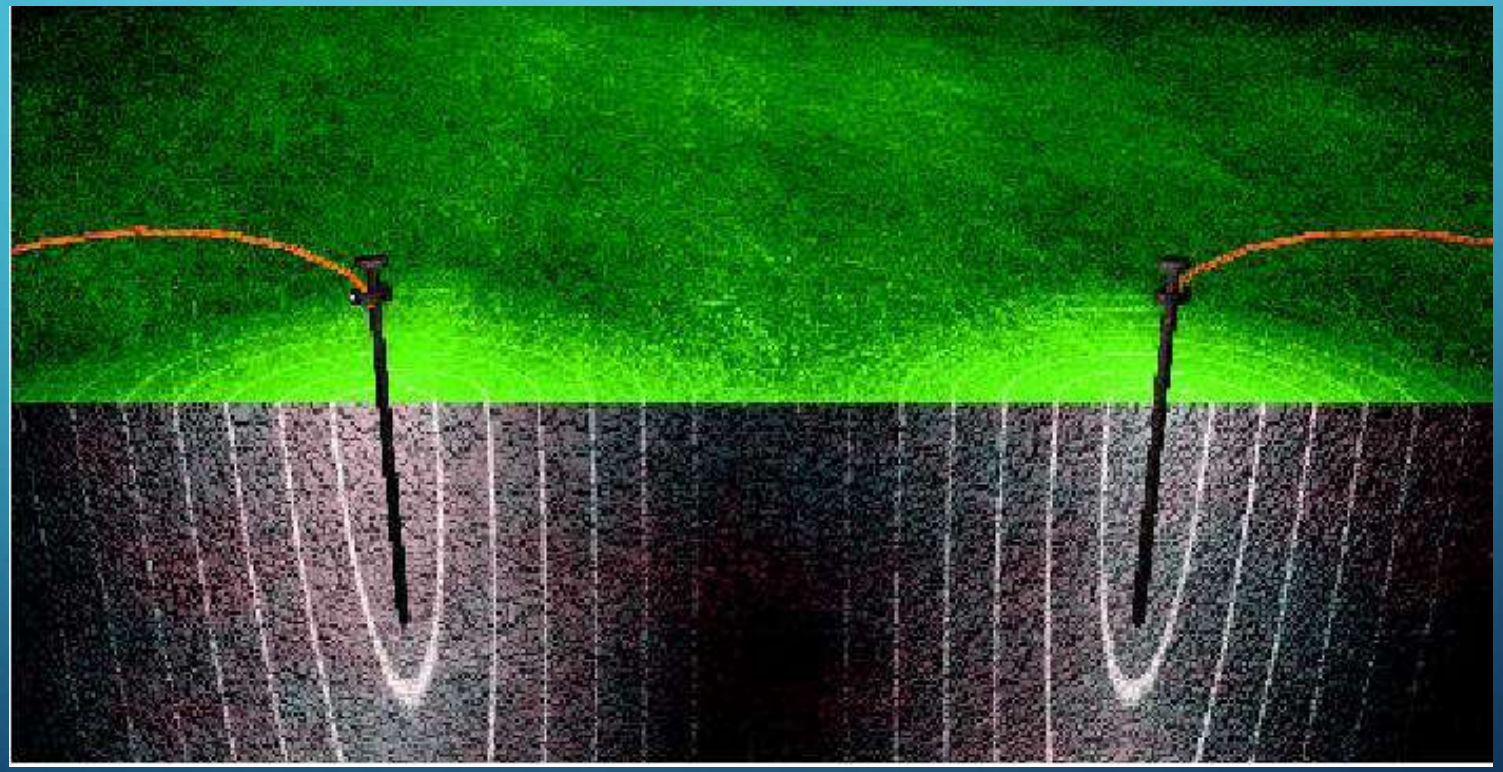
Stake or rod

Earth material

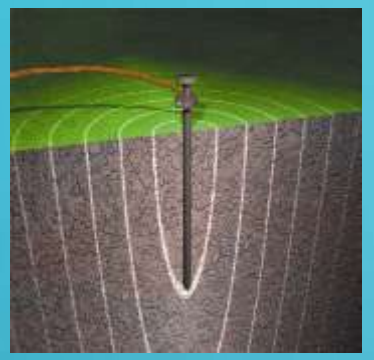


EARTH / GROUND BASICS

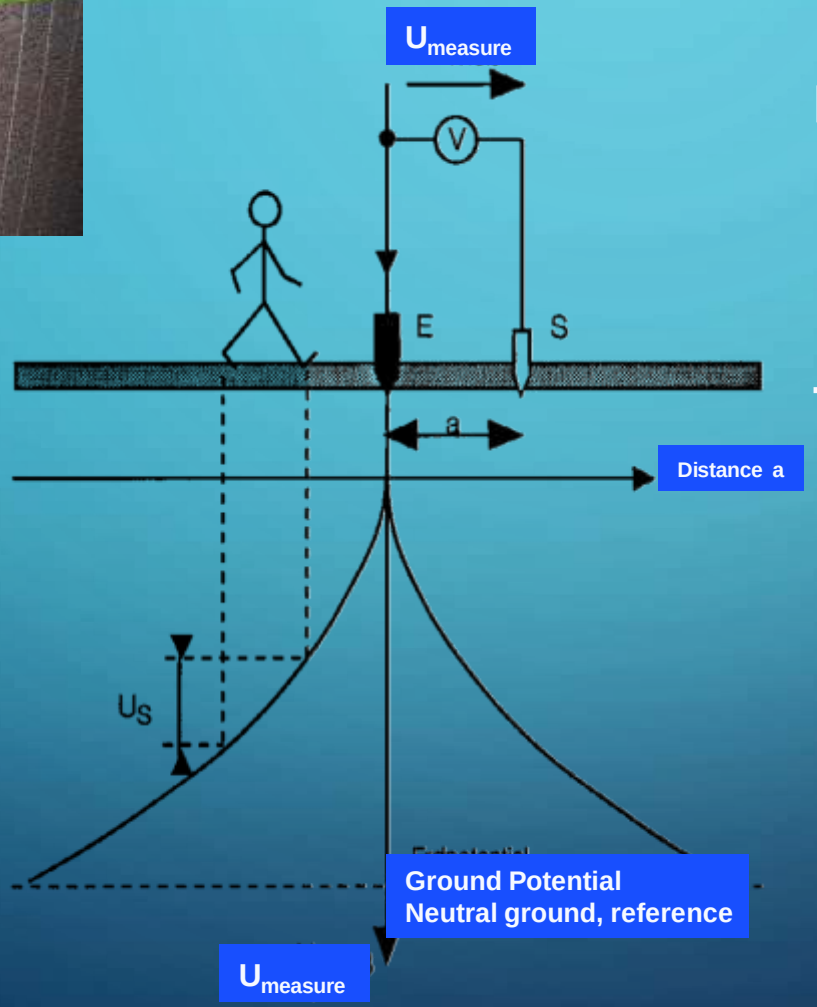
Spheres of influence



Earth / Ground Basics



ATTENTION! POTENTIAL GRADIENTS!



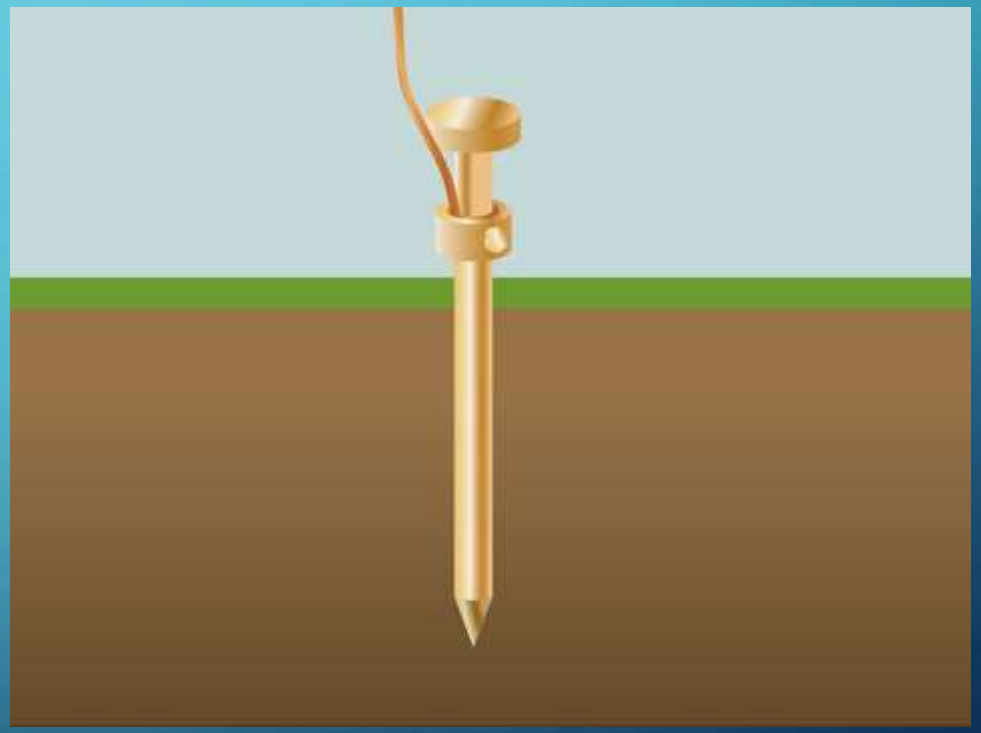
Potential gradients around the earth electrode can reduce the accuracy of measurements!

The probe must always be placed outside this area! Typical distance: >20m

EARTH / GROUND BASICS

Types of Grounding Systems

- Many different types available
- Choice depends on local conditions and required function
- Simplest form is a single stake
- Mostly used for:
  - Lightning protection
  - Stand alone structures
  - Back-up for utility ground



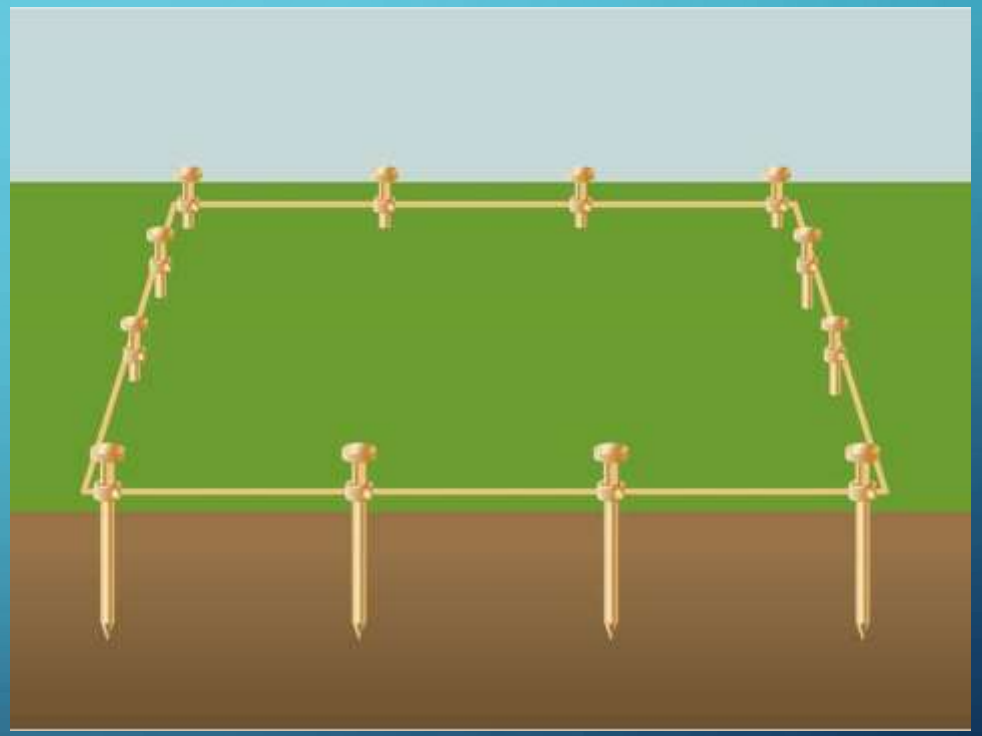
Ground rod

EARTH / GROUND BASICS

Types of Grounding Systems

- ground rod group

- typically for lightning protection on larger structures or protection around potential hotspots such as substations.

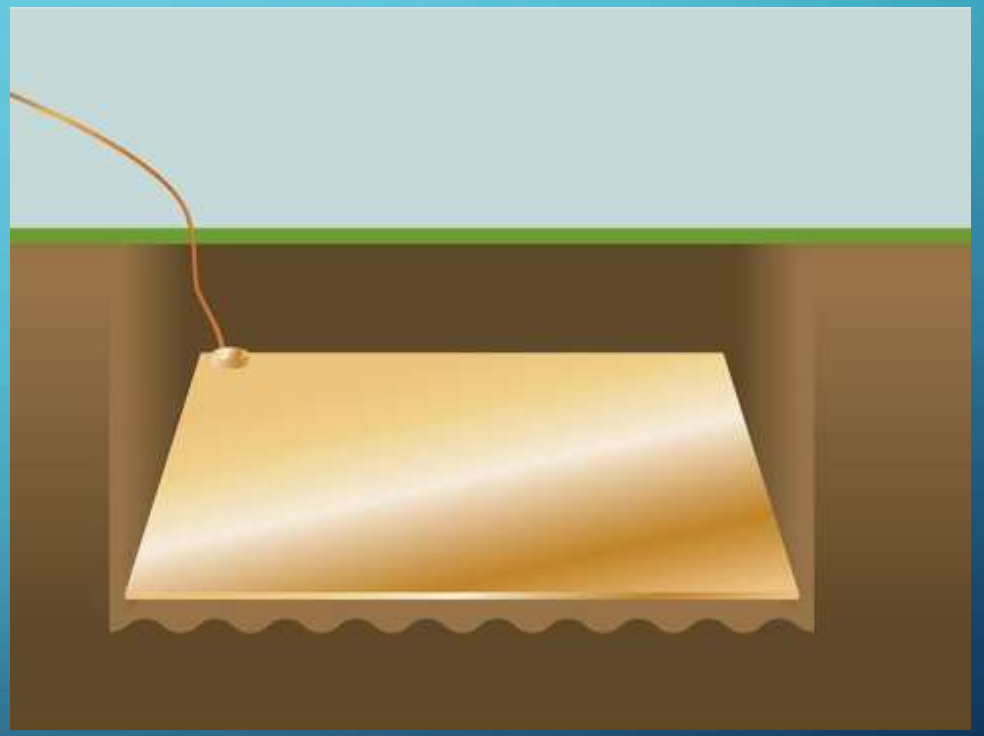


Ground rod group

EARTH / GROUND BASICS

Types of Grounding Systems

- For areas where there is rock (or other poor conducting material) fairly close to the surface ground plates are preferred as they are more effective

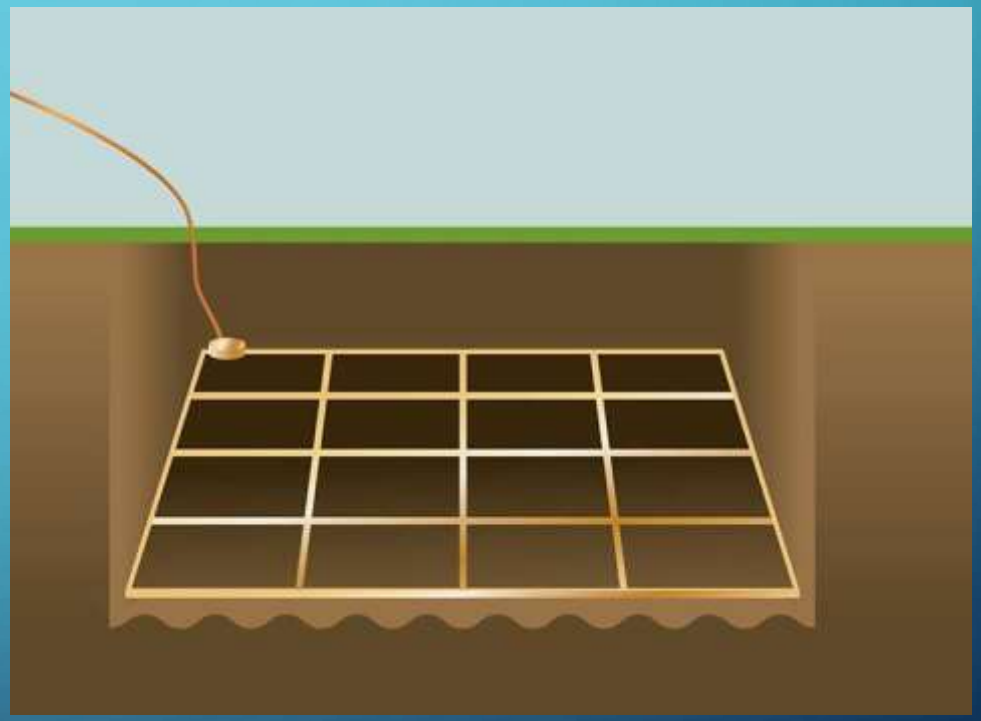


Ground plate

EARTH / GROUND BASICS

Types of Grounding Systems

- A ground mesh consists of network of bars connected together, this system is often used at larger sites such as electrical substations.

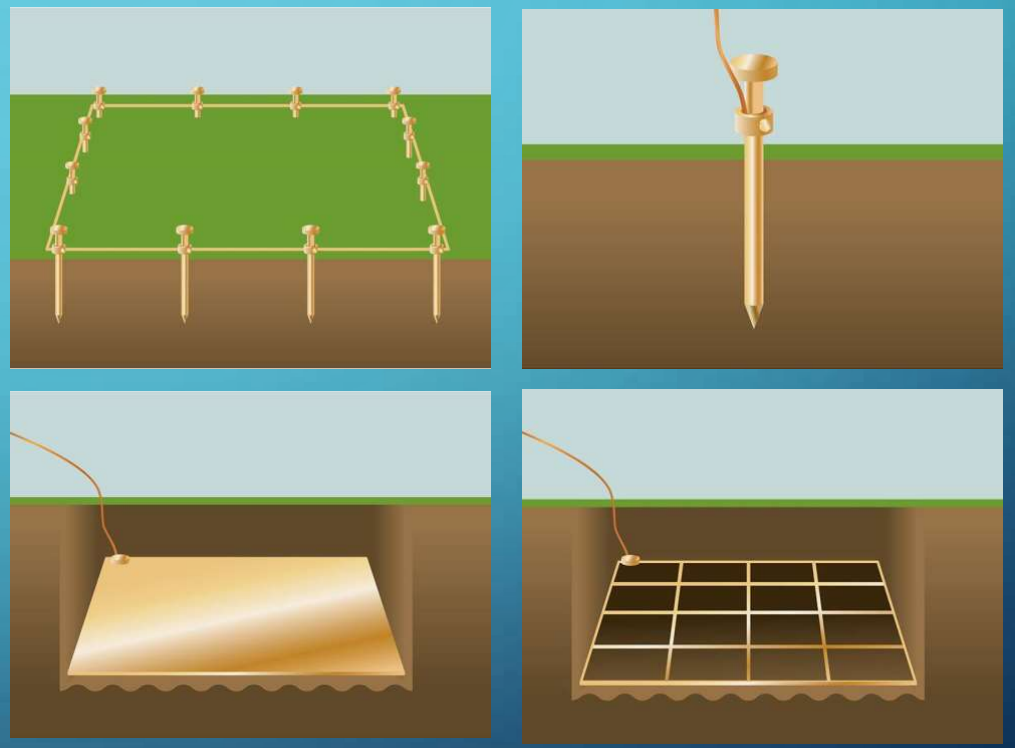


Ground mesh

EARTH / GROUND BASICS

Types of Grounding Systems

For the purposes of this presentation the grounding system will referred to as ‘ground electrode’.



GROUND TESTING METHODS

What are the available techniques?

- Resistivity

- Fall of Potential – Three and Four Pole Testing
- Selective Testing
- Stakeless Testing
- Two pole method

GROUND TESTING METHODS (1)

Resistivity Measurement

The purpose of resistivity measurements is to quantify the effectiveness of the earth where a grounding system will be installed.

Differing earth materials will affect the effectiveness of the grounding system.

The capability of different earth materials to conduct current can be quantified by the value ρ_E **(resistivity in Ω.m).**

Resistivity measurements should be made prior to installing a grounding system, the values measured will have an effect on the design of the grounding system.

GROUND TESTING METHODS (1)

Resistivity values for different earth materials

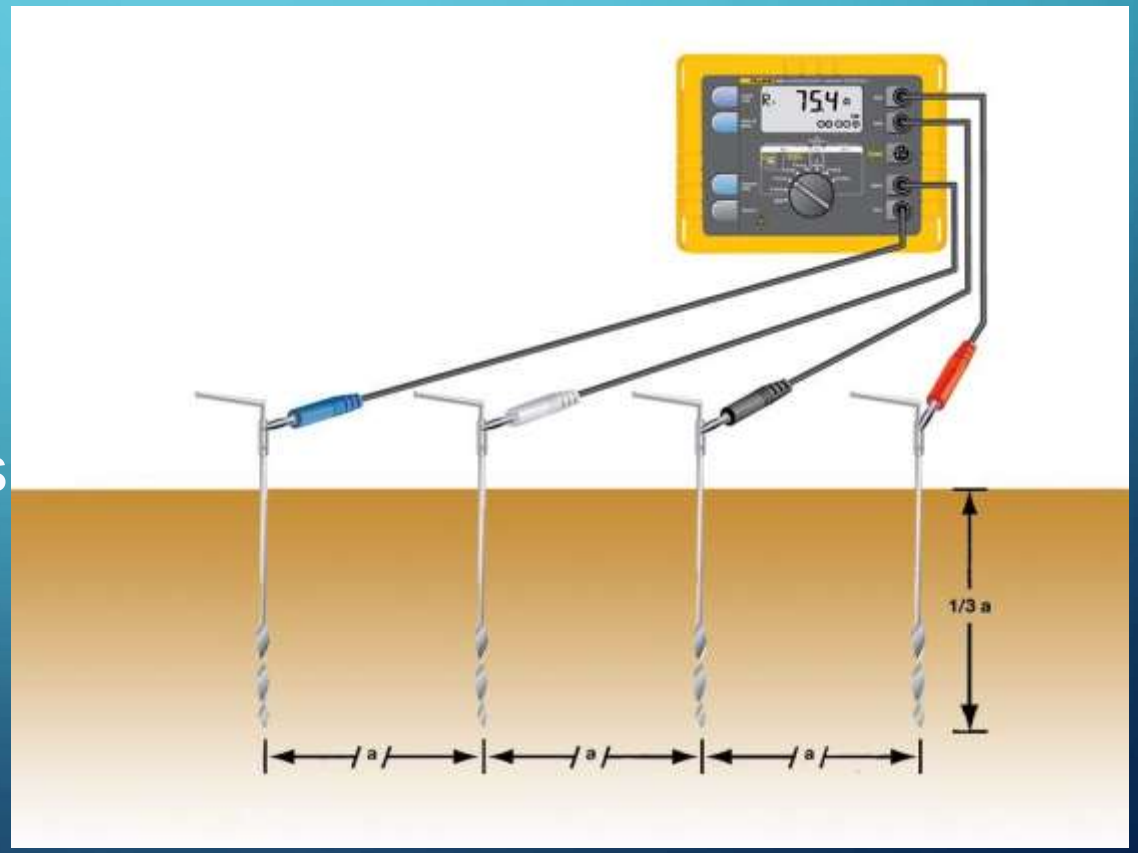
Type of Soil	Soil resistivity R_E	Earthing resistance (Ω)					
		Earthing rod m depth			Earthing strip m		
	Ω m	3	6	10	5	10	20
Moist humus soil, moor soil, swamp	30	10	5	3	12	6	3
Farming soil loamy and clay soils	100	33	17	10	40	20	10
Sandy clay soil	150	50	25	15	60	30	15
Moisty sandy soi	300	66	33	20	80	40	20
Dry sand soil	1000	330	165	100	400	200	100
Concrete 1: 5	400	-	-	-	160	80	40
Moist gravel	500	160	80	48	200	100	50
Dry gravel	1000	330	165	100	400	200	100
Stoney soil	30,000	1000	500	300	1200	600	300
Rock	10^7	-	-	-	-	-	-

GROUND TESTING METHODS (1)

Resistivity Measurement (Wenner method)

Resistivity measurements are performed by using a four wire method.

Used to determine which KIND of earthing should be used, so BEFORE placing earth stakes



GROUND TESTING METHODS (1)

Resistivity Measurement

From the indicated resistance value R_E, the soil resistivity is calculated according to the equation :

$$\rho_E = 2 \pi . a . R_E$$

ρ_E ..... mean value of soil resistivity (Ω.m)
R_E ..... measured resistance (Ω)
a ..... probe distance (m)

GROUND TESTING METHODS (1)

Resistivity Measurement

Curve 1: As ρE decreases only deeper down, a deep earth electrode is advisable

Curve 2: As ρE decreases only down to point A, an increase in the depth deeper than A does not improve the values.

Curve 3: With increasing depth ρE is not decreasing: a strip conductor electrode is advisable.