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.

Factors Affecting the Selection of Wiring

Durability
Safety
Appearance
Cost
Accessibility
Maintenance Cost

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". The electrical conduit provides an enclosure to avoid any damages in wiring due to external factors. Nowadays PVC conduits are widely used. Conduit wiring may run over the surface of the walls and ceiling or may be concealed under masonry work. There are two types of conduit wiring according to pipe installation.

Surface conduit wiring

If conduits installed on roof or wall, It is known as surface conduit wiring. in this wiring method, they make holes on the surface of wall on equal distances (not more than 1.2m) and conduit is installed then with the help of rawal plugs.

Surface Conduit Wiring

The conduit should be laid completely before cables are drawn in and the entire conduit should be permanently connected to earth. Surface conduit wiring is used for factory or workshop lighting and motor wiring.

Concealed conduit wiring

If the conduits are hidden inside the wall slots with the help of plastering, it is called concealed conduit wiring. In other words, the electrical wiring system inside the wall, roof or floor with the help of plastic or metallic piping is called concealed conduit wiring. Here conduits are embedded along walls or ceiling at the time of construction. The conduits are fixed by means of saddles or staples not more than 60 cm apart. The VIR of PVC cables are drawn into the concealed conduits by means of spring of GI wire.

Concealed Conduit wiring

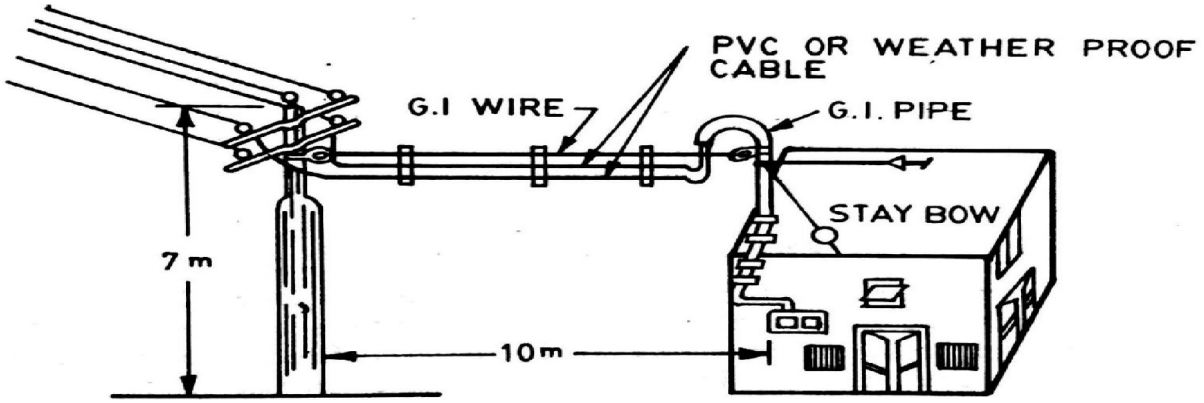
Conduit wiring is a professional way of wiring a building. Mostly PVC conduits are used in domestic wiring. But lead conduits are used in factories or when the building is prone to fire accidents.

Important wiring materials

Switch
Holders
Ceiling rose
Socket outlet/plug
Main switch
PVC casing-capping wiring
cables (VIR (Vulcanized Indian Rubber) or PVC (Poly Vinyl Chloride) insulated)
Elbow
Junction boxes
Coupling
Saddles
Clamp
Conduit pipe
Fuse
Meter box

Service connection

The line bringing electric power from supplier's low voltage distribution up to the energy meter installed at the consumer's premises is called the service connection. Service connection may be by mean of underground cables or by mean of overhead conductors or cables.



Basic Requirements for electric connection/installation

Cut Out Fuse

Energy Meter
Main Switch
Miniature Circuit Breaker
Earth Leakage Circuit Breaker
Neutral Link

Cut out fuse

Each Service connection shall be provided with an aerial cut-out fuse in the tapping point of the pole / box, such that in case of any overload / faults /surge etc inside the consumer premises, the supply to the premises will be safely cut off. It is a combination of a fuse and a switch. The supplier/owner of the installation shall provide at the point of commencement of supply a suitable isolating device with cut out. It is not more than 2.75 metres above the ground so as to completely isolate the supply to the building in case of emergency.

Energy meter

The energy meter is an electrical measuring device, which is used to record Electrical Energy Consumed over a specified period of time in terms of units. The commercial unit of electrical energy is kilo-watt-hours (KWh).

Energy = (Power x Time) Watt seconds or Joules.

If t is in hours, P is in kilo-watts, then the energy is expressed in kilo-watt-hours (KWh)

Now a days digital energy meters are used.

Main Switch

It is a linked switch operating simultaneously on phase and neutral wire. It is to be provided immediately after meter inorder to isolate the consumer installation from supply. The advantage of main switch is for safety. In the event of fire or flash flood you can shut the power off safely by means of a singel switch.

These are of following types

ICDP (Iron Clad Double Pole)- use for single phase supply control (15 A, 30A, 60A, 100A, 250 V)

ICTP(Iron Clad Triple Pole)- use for three phase-three wire and three phase four wire supply control (15A, 30A, 60A, 100A, 150A, 200A, and 500V)

Miniature Circuit Breaker(MCB)

MCB is a device that provides definite protection to the wiring installations and sophisticated equipment against over currents and short circuit faults. MCB's are connected in phase lines of each branch circuit from the distribution box.

Earth Leakage Circuit Breaker(ELCB)

An Earth-leakage circuit breaker (ELCB) is a safety device used in electrical installations with high Earth impedance to prevent shock. It detects small stray voltages on the metal enclosures of electrical equipment, and interrupts the circuit if a dangerous voltage is detected.Also, the ELCB is used to protect the circuit from the electrical leakage.When someone gets an electric shock, then this circuit breaker cuts off the power at the time of 0.1 sec. for protecting the personal safety and avoiding the gear from the circuit against short circuit and overload.

In electrical installations earthing is done in order to i)Equipment protection ii)Protects operators from electrical shock

Neutral link

Neutral links are utilised as the terminating point for neutral wires in a typical electrical circuit and can vary in construction depending on the number of neutral terminations.A neutral link that is used to terminate more than one wire is generally referred to as a neutral bar. Neutral links are metallic bars that are usually constructed of copper, aluminium or brass and can act as an electrical terminal in an electrical circuit.

Power

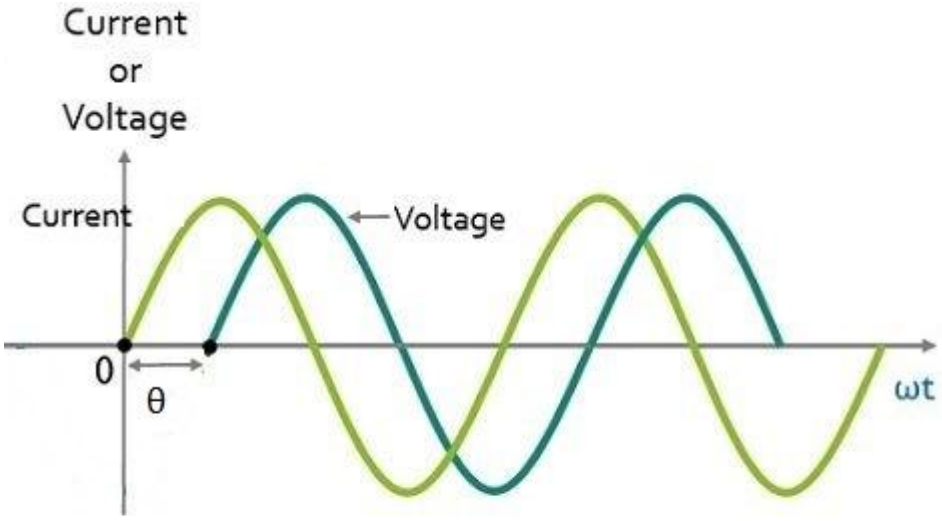
The rate of doing work or the amount of energy transferred by a circuit per unit time is known as power in electrical circuits

Power in a dc circuit

If V is the voltage across load and I is the current flowing through load in a dc circuit, then power is given by the equation P=VI

Power in ac circuits

Consider single phase ac circuit , Let V be the rms value of voltage across the load and I be the rms value of current through the load and **θ** be the phase angle between voltage and current,then



Apparent power

The product of root mean square (RMS) value of voltage and current is known as Apparent Power. This power is measured in (VA)Volt Ampere, kVA (Kilo Volt Ampere) or MVA(Mega Volta Ampere).

Apparent power S = V x I = VI

Active power

The power which is actually consumed or utilised in an AC Circuit is called True power or Active power or Real power, It is measured inWatts(W), kilowatt (kW) or MW.

Active power,P = V x I x Cosθ (in Single phase AC Circuits)

Reactive power

The power that continuously bounces back and forth between source and load is known as reactive Power (Q). Also known as (Use-less Power, Watt less Power)

$Q = V I \sin\theta$

This power is measured inVAR(Volt Ampere Reactive)or kVAR(Kilo Volt ampere Reactive) or MVAR(Mega Volt Ampere Reactive).

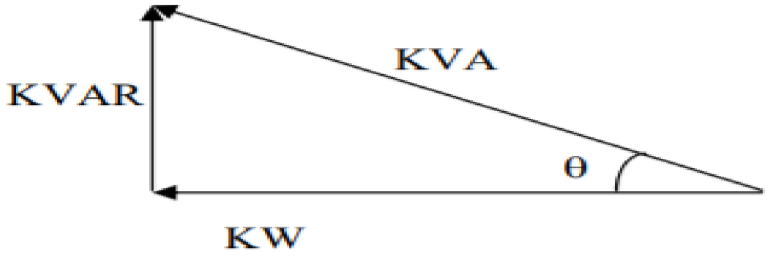
Power factor

Power Factor (P.F.) is the ratio of active power to Apparent Power.

Power Factor =KW/KVA

Power triangle

The "Power Triangle" illustrates this relationship between KW, KVA, KVAR, and Power Factor.

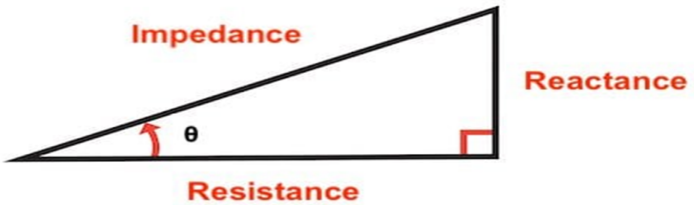


From power triangle $\cos\theta$=kW/kVA=power factor

Hence power factor can also be defined as the cosine of the phase angle between voltage and current.

The Impedance Triangle

The impedance triangle conveys the impedance characteristics of a circuit; the horizontal and vertical sides correspond to the resistance and reactance, respectively, and the hypotenuse is the complex impedance. The angle between resistance and impedance is the same as the angle between active power and complex power in the power triangle



If R is the resistance, X is the reactance and Z is the impedance, then from impedance triangle, power factor $\cos\theta$=R/Z

Power factor can also be defined as the cosine of the phase angle between resistance and impedance.

Power in three phase system

If V_L and I_L are the line voltage and current and θ be the angle between voltage and current , then

Three phase active power =$\sqrt{3}V_L I_L Cos\theta$

Three phase reactive power=$\sqrt{3}V_L I_L Sin\theta$

Three phase apparent power=$\sqrt{3}V_L I_L$

If V_{Ph} and I_{ph} are the phase voltage and current and θ be the angle between voltage and current , then

Three phase active power =$3V_{ph} I_{ph} Cos\theta$

Three phase reactive power=$3V_{ph} I_{ph} Sin\theta$

Three phase apparent power=$3V_{ph} I_{ph}$

Problems

Qn: A single phase load at 220 V draws a current of 3A at a power factor of 0.8 lag.Calculate (i)Active power (ii)Reactive power (iii)Apparent power

Hint: Given V,I and power factor ,Cosθ=0.8

Find θ using formula $Cos^{-1}(0.8)$

Then Active power =VICosθ

Reactive power= VISinθ

Apparent power= VI

Q: A circuit consisting of resistance 50Ω and inductive reactance 30Ω in series is supplied with an ac voltage of 250 V . Determine i) Impedance of the circuit ii) Power factor of the circuit iii)Active power

Hint: Given R= 50Ω , X_L=30Ω, V=250V

Impedance, $Z = \sqrt{R^2 + {X_L}^2}$

Power factor =R/Z(can be calculated), which is equal to Cosθ

Active power =VICosθ

Calculate I using formula I=V/Z

And then active power can be calculated

Electrical Energy

Total amount of work done in an electrical circuit is called electrical energy

Electrical Energy = Power x Time

units of Electrical Energy is:

Watt Second(Ws) or Joule

Commercial unit of electrical energy is Kilo Watt hour (kWh)

Calculation of Monthly Electricity Bill

Qn: Consider a residential building using following appliances and their hour of operation per day as shown below. Calculate the monthly electricity bill for the month April at a rate of Rs 3 per unit.

SI No.	Appliance	Power Rating	No. of Appliances	Hours Of operation
1	Fan	80 W	3	8
2	Tubelight	40 W	3	8
3	LED Bulb	10 W	4	8
4	Television	100 W	1	6
5	Refrigerator	140 W	1	12
6	Iron box	750 W	1	2
7	Water Pumb	750 W	1	1

Hint : kWh=$\frac{Number\ of\ appliances\ X\ Power\ in\ watts\ x\ time\ in\ hours}{1000}$

Calculate kWh per day for each appliances
Then calculate total units consumed per day
Then calculate total units consumed in the given month=
total units consumed in a day x Number of days in given month
Then calculate electricity bill= total units consumed in the given month x rate of one unit

Importance of Electrical Safety in a Work Place

Electricity is dangerous (if not handled properly !!!)
Dangers from electricity are due to :

- Electric shocks resulting in burns, injury, deaths.
- Electric flashovers resulting in deaths, fires, damages.
- Electric faults resulting in arcing, explosions and fires.
- Explosions in electrical equipment resulting in damage to installations and deaths.
- Fire hazards resulting in destruction, loss of life and release of smoke, dust, gases which spread over large areas quickly.

Effect of Electricity in human body
When current passes through the human body, electric shock is received.
The severity of electric shock depends on:-path of current through the body,amount of current flowing through the body, length of time the body is in the circuit.
Range of current lasting 1 second will have the following reactions on human body:-

- 1 Milliampere
  Just a faint
- 5 Milliampere
  Slight Shock felt. Most people can let go.
- 6-30mA
  Painful Shock. Muscular Control is lost. It may not be possible to let go.
- 50- 100mA

extremely painful shock. Breathing stops and severe muscular contraction and death is possible.

- 1 - 4.3 A
  Stops Heart pumping action, nerves get damaged and death happens.

Basic electrical safety precautions

- Use protective devices like Fuse and MCB (Miniature Circuit Breaker) for overload and short circuit protection from ac mains.
- Use ELCB (Earth Leakage Circuit Breaker) or RCCB (Residual Current Circuit breaker) for protection.
- Never touch any electrical equipment with wet hands.
- Always use the proper rating of Fuse.
- Turn off and secure electrical circuits before working on the line or item.
- All metallic parts should be earthed properly.
- Do not use damaged Power tools and damaged extension cord.
- use personal protective Equipments (PPE) like Shoes, Helmet and gloves while operating with electricity.
- Sand buckets and fire extinguishers should be placed near electrical panels or equipment.
- Never overload plug Socket.
- Don’t put fingers into the Socket.