General Engineering

Unit 4 ELECTRICITY AND ELECTRICAL DISTRIBUTION SYSTEM

Electricity

- Electricity is defined as the rate of flow of charges in a conductor.
- It is a secondary energy source which means that we get it from the conversion of other sources of energy, like coal, natural gas, oil, nuclear power and other natural sources, which are called primary sources.
- The energy sources we use to make electricity can be renewable or non-renewable, but electricity itself is neither renewable or non-renewable.

Voltage

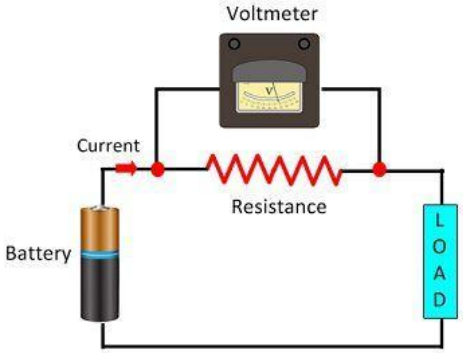
- Volt is the unit of potential difference between two points. If 1 joule work is done to move 1 coulomb positive charge from one point to another, then the potential difference between the points is 1 volt.

  IV = 1JC-1

- One volt is also defined as the potential difference across a resistance of 1 Ohm when 1 ampere of current flows through it.

Voltmeter

- The instrument which measures the voltage or potential difference in volts is known as the voltmeter.
- It works on the principle that the torque is generated by the current which induces because of measurand voltage and this torque deflects the pointer of the instrument.
- The deflection of the pointer is directly proportional to the potential difference between the points.
- The voltmeter is always connected in parallel with the circuit.



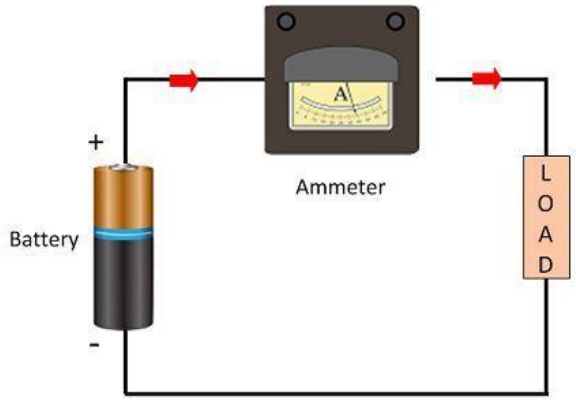
Ampere

- One ampere of current represents one coulomb of electrical charge, i.e. 6.24×1018 charge carriers, moving in one second.

Ampere = 1 Coulomb / Second

Ammeter

- The meter uses for measuring the current is known as the ammeter.
- The current is the flow of electrons whose unit is ampere.
- Hence the instrument which measures the flows of current in ampere is known as ampere meter or ammeter.
- The ideal ammeter has zero internal resistance. But practically the ammeter has small internal resistance.
- The measuring range of the ammeter depends on the value of resistance.



Watts

- A unit of electrical power. One watt is equivalent to one joule per second, corresponding to the power in an electric circuit in which the potential difference is one volt and the current one ampere.

Wattmeter

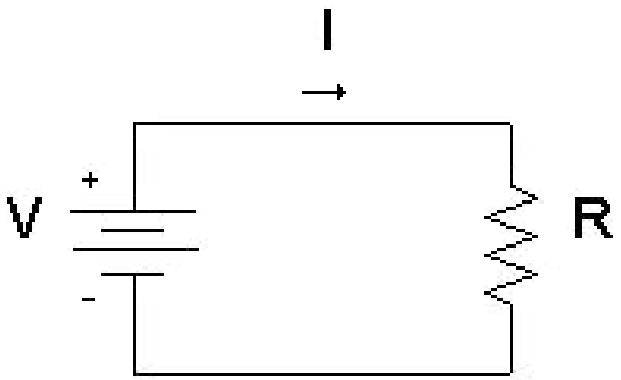
- The wattmeter is an instrument for measuring the electric power (or the supply rate of electrical energy) in watts of any given circuit.

Ohms

- A unit of measure of resistance. One ohm is equivilant to the resistance in a circuit transmitting a current of one ampere when subjected to a potential difference of one volt.
- The SI unit of resistance is Ohm which is denoted by the symbol Omega (Ω)

Ohms Law

- Ohm's Law states that the current flowing through a conductor is directly proportional to the potential difference applied across its ends, provided the temperature and other physical conditions remain unchanged.



V=IR

- Where,

  V= potential difference in volt

  I= current in ampere

  R=resistance of the conductor

Sample problems in Ohms Law

Example #1

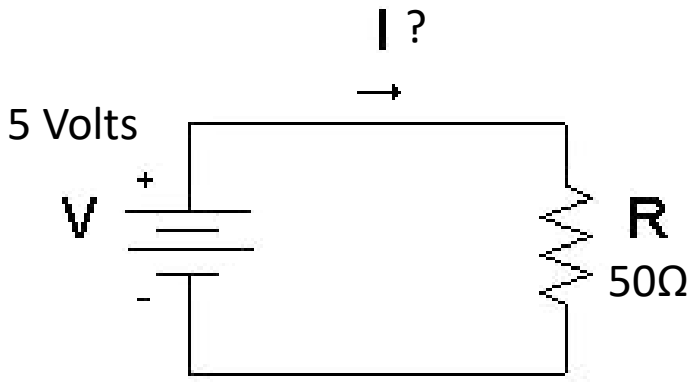
Find the current of an electrical circuit that has resistance of 50 Ohms and voltage supply of 5 Volts.

Solution:

V = 5V

R = 50Ω

I = V / R = 5V / 50Ω = 0.1A = 100mA



Sample problems in Ohms Law

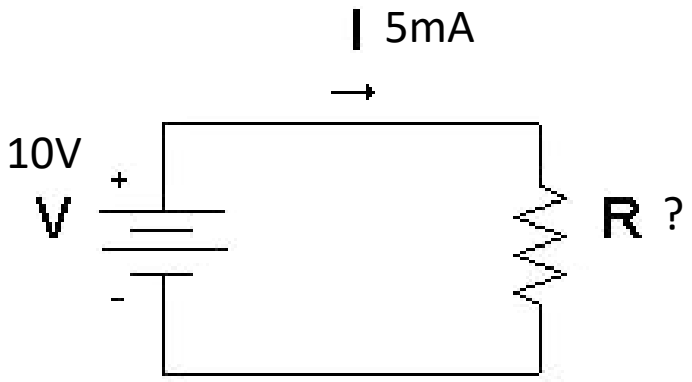
Find the resistance of an electrical circuit that has voltage supply of 10 Volts and current of 5mA.

Solution:

V = 10V

I = 5mA = 0.005A

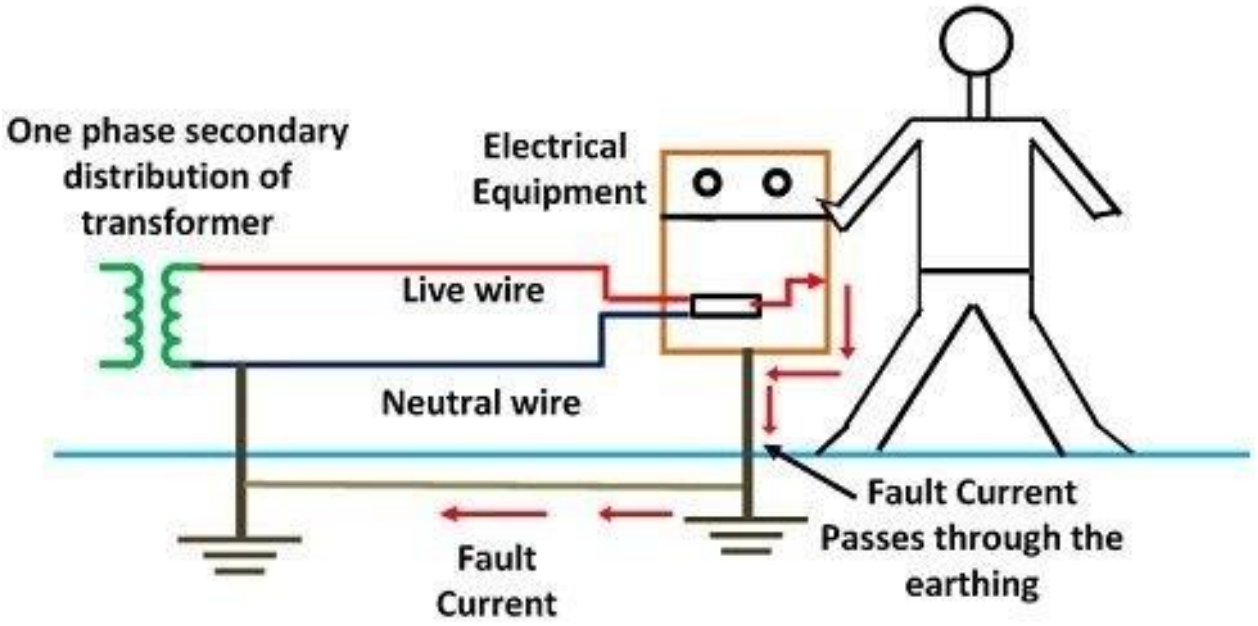
R = V / I = 10V / 0.005A = 2000Ω = 2kΩ



Grounding

- Electrical grounding is a backup pathway that provides an alternating route for the current to flow back to the ground if there is a fault in the wiring system.
- It facilitates a physical connection between the ground and the electrical equipment and appliances in your home.
- The electricity in a residential wiring system consists of electrons flowing through metal circuit wires and this electricity is always looking for the shortest possible route back to the ground. So, if there is a problem with the neutral wire, grounding your electrical system will provide a direct pathway to the ground and prevent power surges that can invite electrical hazards.

Grounding


One phase secondary distribution of transformer
Electrical Equipment
Live wire
Neutral wire
Fault Current Passes through the earthing
Fault Current

Purpose of grounding

- Equipment grounding is a very important aspect of the electrical system. Grounding of electrical equipment has two purposes:
- To ensure that persons in the area are not exposed to dangerous, electric-shock voltage.
- To provide current-carrying capability that can accept ground-fault current without creating a fire or explosive hazard.
- To protect personnel from electric shock, all enclosures that house electrical devices that might become energized because of unintentional contact with energized electrical conductors should be effectively grounded. If the enclosure is grounded adequately, stray voltage will be reduced to safe levels. If the enclosures are not grounded properly, unsafe voltages could exist, which could be fatal to the operating personnel.
- The lightning arresters installed in electrical systems cannot operate satisfactorily unless they are grounded well. Under elevated static voltage or lightning strikes, lightning arresters will short-circuit the above-normal voltages to ground. If the lightning arresters are not grounded properly, elevated voltage will enter the windings of transformers, control, and/or motors, causing component failures.

Purpose of grounding

Protects Against Electrical Overloads

You may experience power surges at times or you may be exposed to lightning during extreme weather conditions. These events may produce dangerously high electricity which can completely damage your electrical appliances. By grounding the electrical system, all the excess electricity will go into the earth instead of frying the appliances connected to the system. The appliances will be safe and protected from large electrical surges.

Stabilizes the Voltage Levels

When you ground the electrical system, it makes it easier for you to distribute the right amount of power at the right places. This ensures that the circuits are not overloaded at any point and get blown as a result of it. The earth can be considered as a common reference point for the voltage sources in any electrical system. This helps in providing stabilized voltage levels throughout the electric system.

Purpose of grounding

Earth Conducts with Least Resistance

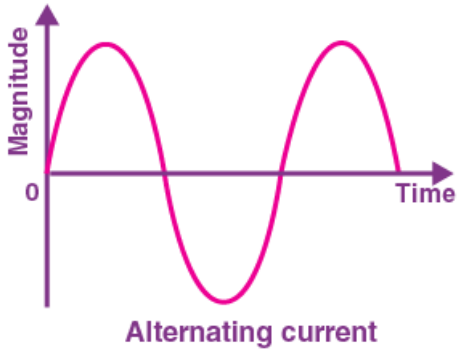
One of the main reasons why you should ground your electrical appliances is that the earth is a great conductor and it can conduct all the excess electricity with least resistance. When you ground the electrical system and connect it to the earth, it means that you are giving the excess electricity to go somewhere without resistance rather than going through you or your appliances.

Prevents Serious Damage and Death

When you do not ground the electrical system, you will put your appliances and even your life at high risk. When high electricity passes through any device, it will be fried and get damaged beyond repair. An excessive amount of electricity may even start a fire, putting your property and the life of your loved ones at risk.

AC Current

Alternating current can be defined as a current that changes its magnitude and polarity at regular interval of time. It can also be defined as an electrical current which repeatedly changes or reverses its direction opposite to that of Direct Current or DC which always flows in a single direction as shown below.



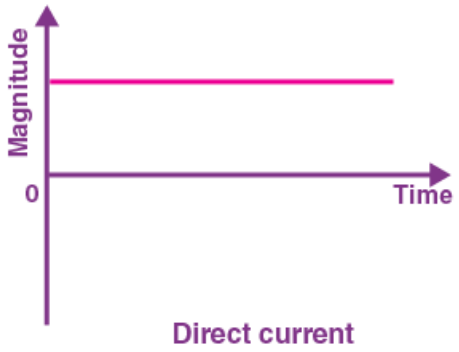
AC Current

From the graph, we can see that the charged particles in AC tend to start moving from zero. It increases to a maximum and then decreases back to zero completing one positive cycle. The particles then reverse their direction and reach the maximum in the opposite direction after which AC again returns to the original value completing a negative cycle. The same cycle is repeated again and again.

Alternating currents are also accompanied usually by alternating voltages. Besides, alternating current is also easily transformed from a higher voltage level to lower voltage level

DC current

- DC stands for Direct Current, although it is often referred to as “DC Current”.
- DC current is defined as a unidirectional flow of electric charge.
- In DC current, the electrons move from an area of negative charge to an area of positive charge without changing direction.

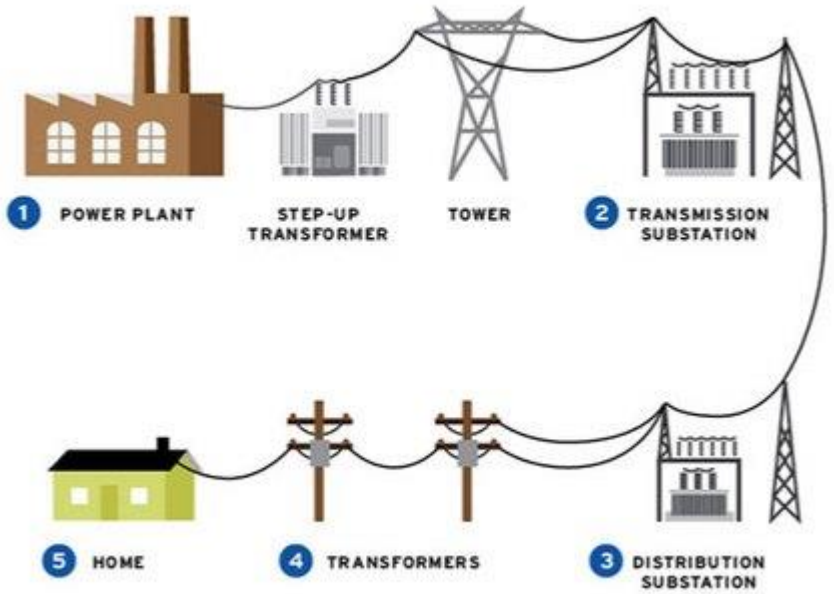


Comparison of AC & DC current

Alternating Current	Direct Current
AC is safe to transfer longer distance even between two cities, and maintain the electric power.	DC cannot travel for a very long distance. It loses electric power.
The rotating magnets cause the change in direction of electric flow.	The steady magnetism makes DC flow in a single direction.
The frequency of AC is depended upon the country. But, generally, the frequency is 50 Hz or 60 Hz.	DC has no frequency of zero frequency.
In AC the flow of current changes its direction backwards periodically.	It flows in a single direction steadily.
Electrons in AC keep changing its directions – backward and forward	Electrons only move in one direction – that is forward.

Electrical Distribution systems

The electrical distribution system consists of three major components: generation, a high-voltage transmission grid, and a distribution system.

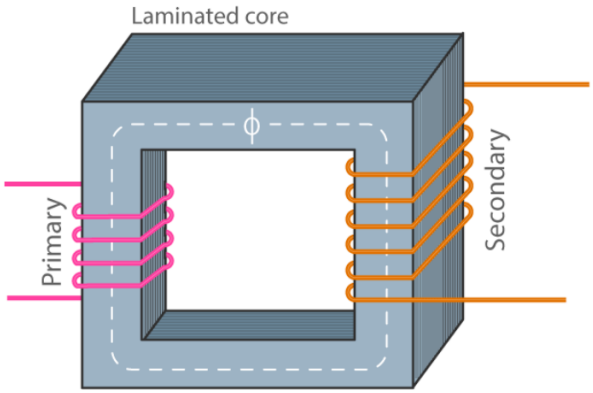


Transformers

Transformers

- A transformer is a device used to increase (step-up) or decrease (step-down) the voltage of an alternating current.
- It is used in power transmission to reduce power losses and to increase the efficiency of power supply.
- A transformer changes voltage, but not the frequency of the alternating current.
- A step-up transformer is used to increase a low voltage to a high voltage.
- A step-down transformer is used to decrease a high alternating voltage to a low alternating voltage.

Transformers

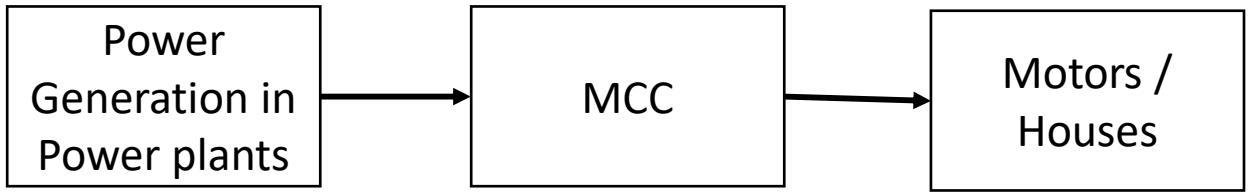


- Transformer has two coils wound over a laminated core.
- Primary coil has Np turns. Secondary coil has Ns turns.
- The primary coil is the input coil and the secondary coil is the output coil of the transformer.
- When an alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux which links the secondary and induces an voltage in it.
- The value of this voltage depends on the number of turns in the secondary.

Motor Control Centers (MCC)

Motor Control Centers (MCC)

- A motor control center (MCC) is an assembly to control some or all electric motors in a central location.
- It is used to switch on or off of a electrical power to some area.
- It consists of multiple enclosed sections having a common power bus and with each section containing a combination starter, which in turn consists of motor starter, fuses or circuit breaker, and power disconnect.
- A motor control center can also include push buttons, indicator lights, variable-frequency drives, programmable logic controllers, and metering equipment.



Switch

- The switch is a simple device used to either break the electric circuit or complete it.
- The most common form of the electric power switch is a basic manual electromechanical unit.
- A switch is said to be in ON position when it makes or completes the circuit and allows the current to pass through.
- Similarly, a switch is in an OFF position when it breaks the circuit and does not allow the current to pass through.

Fuses

- The primary use of an electric fuse is to protect electrical equipment from excessive current and to prevent short circuits or mismatched loads.
- The fuse wire in an electrical fuse is made up of alloy of lead and tin.
- Under normal conditions, the fuse wire is a part of the circuitry, contributing to a complete loop for charges to flow through it.
- When an excessive amount of current flows through the fuse wire, the heating effect of current causes the fuse wire to melt.
- This is because the fuse wire is chosen such that it has a low melting point.
- This causes the loop to break thereby stopping the flow of charges in the circuit.

Circuit breakers

- A switching device which interrupts the faulty current and performs the function of a switch thus protecting the electrical system from damage.
- When the circuit is closed which is a normal condition, the contacts touch each other and carry the current under this condition.
- When there is a faulty current in the flowing through any part of the system, the trip coil of the breaker gets energized thereby moving away from each other, thus opening the circuit.

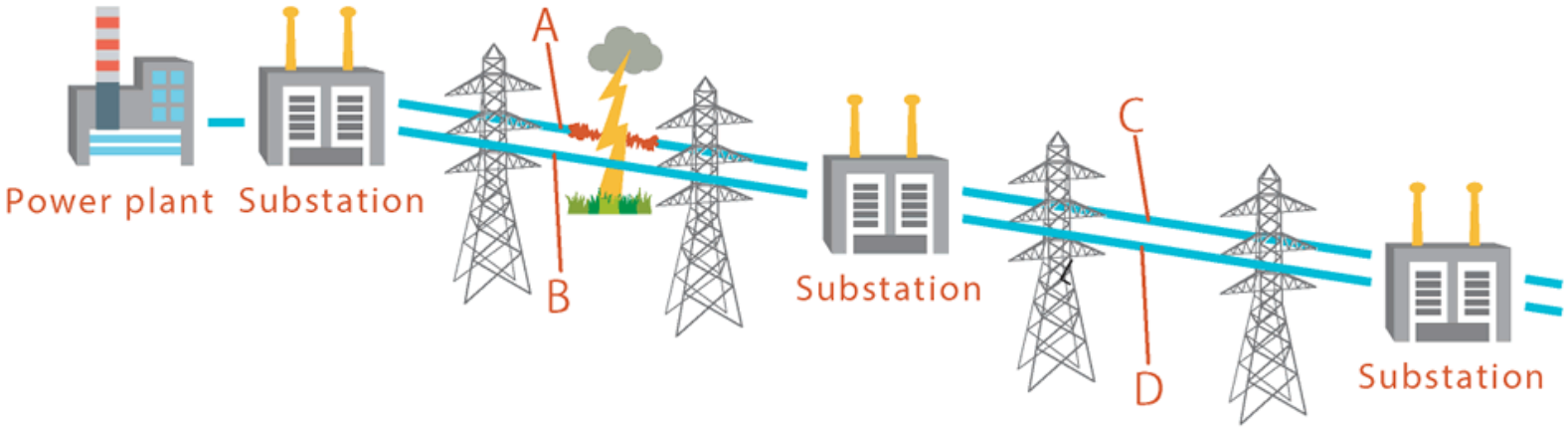
Fuse vs Circuit Breakers

Fuse	Circuit Breaker
Works on the thermal and electrical properties of the conducting materials	Works on the switching principle and electromagnetism
It doesn't give any indication of overloads	It gives an indication of overloads
Fuse can only be used once	A circuit breaker can be used many numbers of times
Provides protection against power overloads	Provides protection against power overloads and short circuits
It detects and interrupts faulty circuit conditions	It performs the interruption process only. Faults are detected by a relay system.
Low breaking capacity compared to the circuit breaker	High breaking capacity
Automatic operation	Can either be automatic or manually operated
Operating time of fuse is 0.002 seconds	Operating time of the circuit breaker is 0.02 – 0.05 seconds
Low Cost	High Cost

Electrical power failure

- A power failure (also known as a power cut, power outage/power outrage, power loss, or blackout) is a short- or long-term loss of the electric power to an area.
- The causes of power failures are faults at power stations, damage to power lines, substations or other parts of the distribution system, a short circuit, or the overloading of electricity mains.
- Power failures are particularly critical at sites where the environment and public safety are at risk.
- Institutions such as hospitals, sewage treatment plants, mines, etc., will usually have backup power sources, such as standby generators, which will automatically start up when electrical power is lost.
- Other critical systems, such as telecommunications, are also required to have emergency power.

Electrical power failure



Electrical power failure

- Power outages are categorized into three different phenomena, relating to the duration and effect of the outage:
- A transient fault is a momentary (a few seconds) loss of power typically caused by a temporary fault on a power line. Power is automatically restored once the fault is cleared.
- A brownout or sag is a drop in voltage in an electrical power supply. The term brownout comes from the dimming experienced by lighting when the voltage sags.
- A blackout refers to the total loss of power to an area and is the most severe form of power outage that can occur. Blackouts which result from or result in power stations tripping are particularly difficult to recover from quickly. Outages may last from a few minutes to a few weeks depending on the nature of the blackout and the configuration of the electrical network.

Effect at power failure in process units

- When power is lost for any reason, pumps stop pumping, compressors stop running, stirrers quit mixing, lights go out, and instruments and controls may malfunction.
- These equipment outages may lead to tank overflows, runaway chemical reactions, temperature or pressure increases or decreases, all of which could lead to a spill, explosion, or fire.
- Even if there is no immediate release, there may be a delayed reaction caused by thermal shock or other factors that can compromise equipment mechanical integrity during subsequent operation.
- When power is restored even after a brief interruption, some equipment may automatically restart before process operations are ready while others may need to be reset and manually restarted.

Effect at power failure in process units

- Damage to pipe lines like crack or flange leaks or gasket failure.
- Fire accidents can occur on sudden power failure.
- Explosion of vessels and boilers may happen.
- Spillage of chemical due to pump failure.
- Environment get polluted due to spillage, pressure relief, flaring (burning of excess chemicals)
- Accidents to humans due to the above reasons.
- Uncontrolled reaction in atomic reactors.

Effect at power failure in process units

Electrical Emergency system

- An emergency power system is an independent source of electrical power that supports important electrical systems on loss of normal power supply.
- A standby power system may include a standby generator, batteries and other apparatus.
- Emergency power systems are installed to protect life and property from the consequences of loss of primary electric power supply.
- It is a type of continual power system.

Uninterrupted power source (UPS)

- An uninterruptible power supply is an electrical apparatus that provides emergency power to a load when the input power source or mains power fails.
- UPS is a type of power supply system with an integrated battery and in the absence of primary mode or when power is shut down, the battery is used for the power source.
- The on-battery run-time of most uninterruptible power sources is relatively short but sufficient to start a standby power source or properly shut down the protected equipment.
- An UPS can provide power to 1 to 5 hours, which gives people enough time to do activities due to the power failure.
- The UPS operates as an intermediary or as a link between the general source and the machine.
- A UPS is typically used to protect hardware such as computers, data centers, telecommunication equipment or other electrical equipment where an unexpected power disruption could cause injuries, fatalities, serious business disruption or data loss.

Uninterrupted power source (UPS)