MODULE III

Washing Machine

- The main principles behind the working of a washing machine are the centrifugal and centripetal forces.
- The washing machine operates in two primary cycles.

1.wash cycle

2. rinse cycle

- The wash cycle involves the principle of centrifugal force.
- This force’s direction is from inside to outside, which makes sure that every part of the cloth is rinsed adequately in the soap water mixed in the machine.

- The rinse cycle involves the principle of centripetal force.
- This force acts from outside to inside and creates a vacuum-like space in the middle of the washing machine. It helps to remove any leftover detergent or dirt from your clothes.
- These two cycles work one after another several time, and as a result, the entire cleaning process occurs.

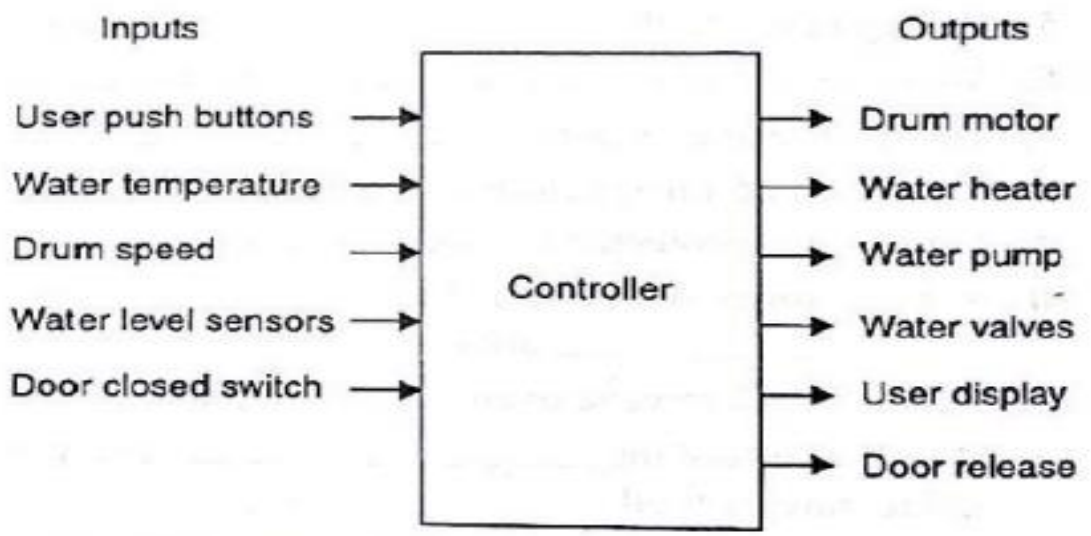
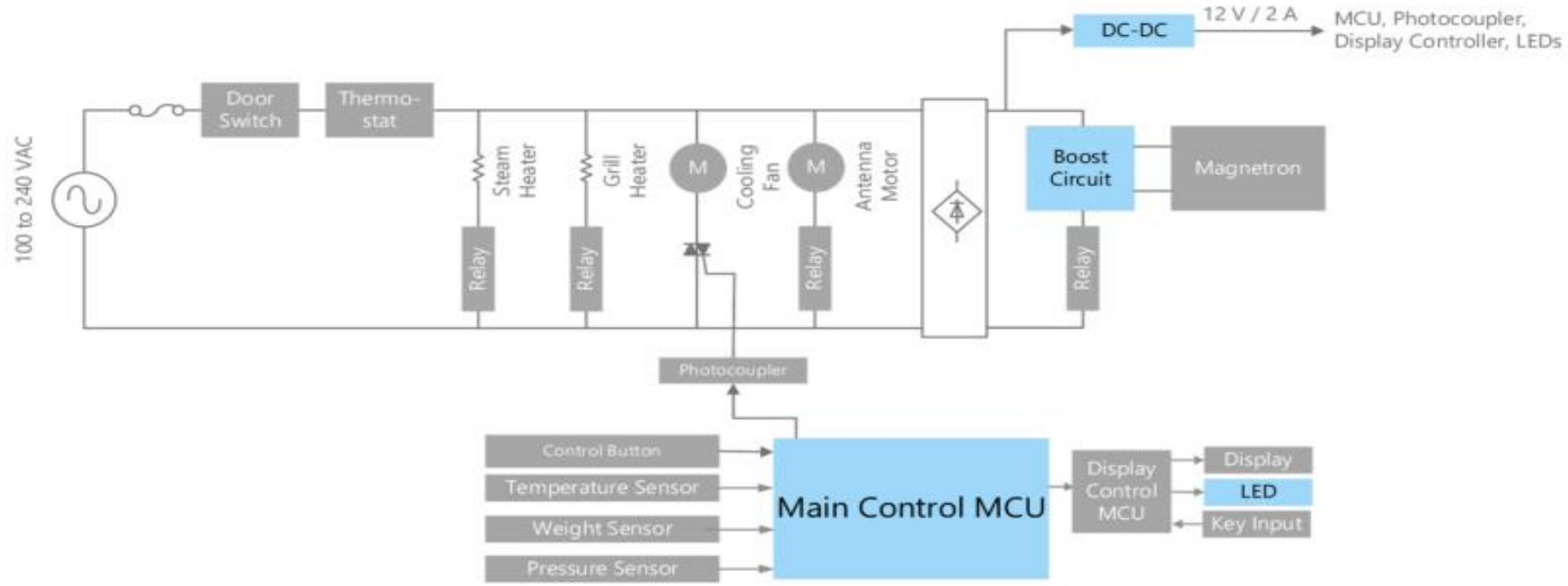


Fig. 51.1 *Inputs and outputs in an electronic washing machine*

- Push button keyboard enables the desired program to be selected. The microcontroller checks firstly that the safety cut out is in the ON position.
- The water is then admitted (valve opened) and the water level is constantly monitored. When the required quantity of water has been provided the valve closes.
- The water temperature is measured and the heater is switched until the water reaches the required temperature.

- The washing powder is admitted from a container and the hardness of water is noted, at the same time the drum motor is switched on, so that the dirty washing is evenly moved through the water.
- According to the selected programs, the motor is switched to high speed spinning and the suction pump is switched on to move the washing water and the rinsing water to waste.
- At the end of the washing cycle the machine switches off and provides a signal to indicate this

- **Microwave Oven**



- Microwave ovens work on the principle of conversion of electromagnetic energy into thermal energy
- Traditional cooking methods suggest heat input to the food surface. Further heat is distributed inside due to heat conduction.
- The heating food process in a microwave oven differs fundamentally. In this case, heat is generated inside the food using water molecules.
- Therefore, the rate of volumetric heating by microwaves is significantly higher.
- The microwave radiation does not cause chemical changes in food and preserves from 75 to 98 % of the vitamins in food.

- Main Components of Microwave Oven

High Voltage Transformer

- Unlike many other household appliances, the microwave oven requires more power than the normal voltage that the home's electrical wiring carries.
- To accomplish this, a step-up transformer with a high-voltage output is placed inside the oven.
- The 240V supply is jumped to a few thousand volts, which is then fed to the cavity magnetron

Cavity Magnetron:

- A cavity magnetron is a high-powered vacuum tube that transforms the electrical energy into long-range microwave radiations, and hence it is the most important component of a microwave oven.

Micro-controller:

- A microcontroller is something that enables communication between a user and a machine. It is a controlling unit that contains one or more processing cores along with memory and programmable input/output peripherals. It processes the instructions that a user gives to the microwave oven and also displays them on a seven-segment display or a LED screen, depending on the model of the oven

Wave Guide:

- As the name suggests, a waveguide is a hollow metallic tube that guides the waves generated at the magnetron’s output toward the cavity (the place where we place the food).

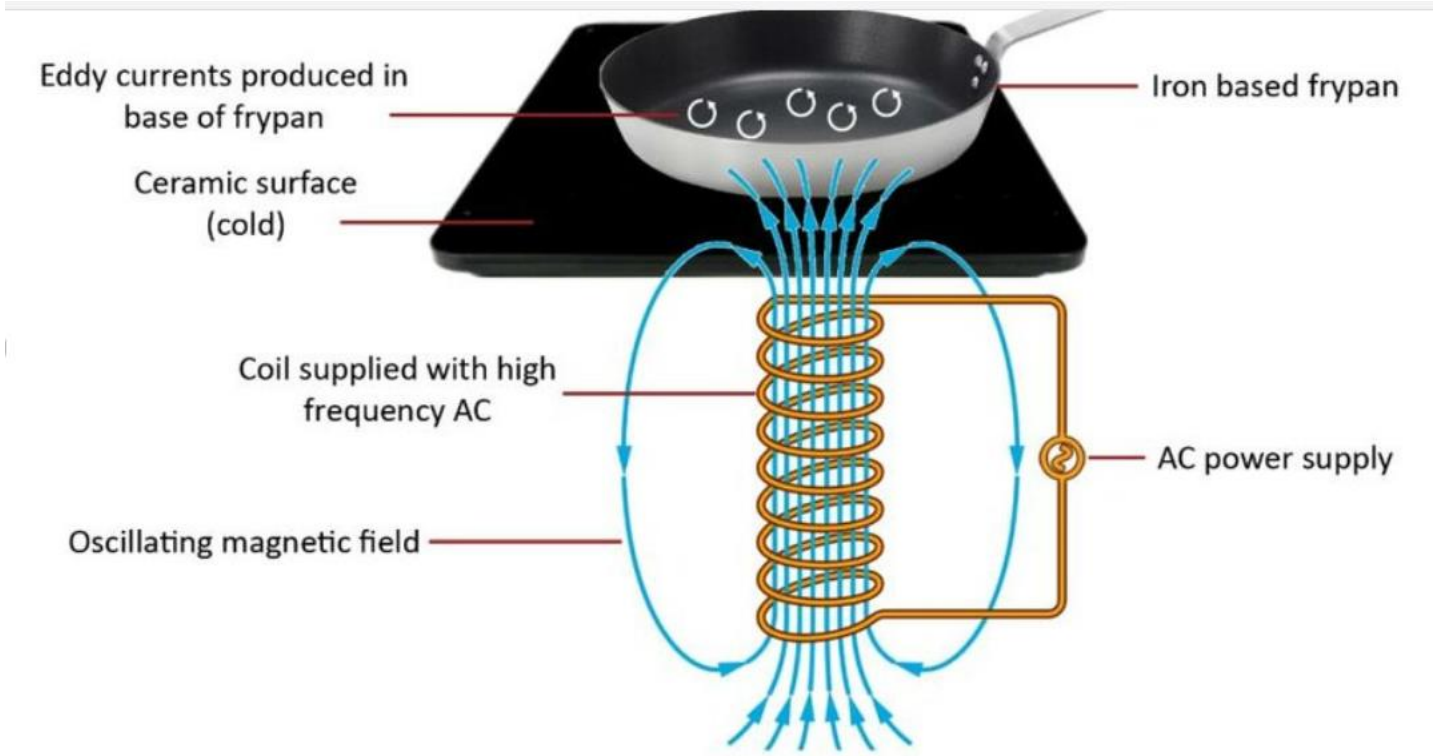
Cooling Fan:

- Cooling fans reduce the magnetron’s operating temperature and ensure its efficacy and longevity.

Working Mechanism

- The microwaves penetrate through the surface of the food and reach the water molecules present inside it.
- As the orientation of the electric field changes over time, the polar molecules of water attempt to follow the field by changing their orientation inside the material to line up along the field lines in an energetically favorable configuration (namely, with the positive side pointing in the same direction as the field lines).
- As these molecules change direction rapidly (millions of times per second at least), they gain energy, which increases the temperature of the material. This process is **called dielectric heating**.

Induction stove



Schematic of the principle of induction stove

- An induction stove operates based on the principle of **electromagnetic induction**.

1. **Induction Coil**: Beneath the ceramic surface of the induction stove, there are one or more copper coils. When an electric current passes through these coils, they generate a magnetic field.
2. **Magnetic Field**: The magnetic field created by the coil is confined to the space directly above it.
3. **Ferromagnetic Cookware**: To use an induction stove, you need cookware made of ferromagnetic material, such as cast iron or steel. These materials contain magnetic properties and can be magnetized.

- **Creation of Eddy Currents**: When you place a pot or pan made of ferromagnetic material on the surface of the induction stove, the magnetic field induces an electric current, known as an eddy current, within the cookware.

- **Resistance and Heat Generation**:

The resistance of the cookware to the flow of these eddy currents generates heat directly in the cookware itself.

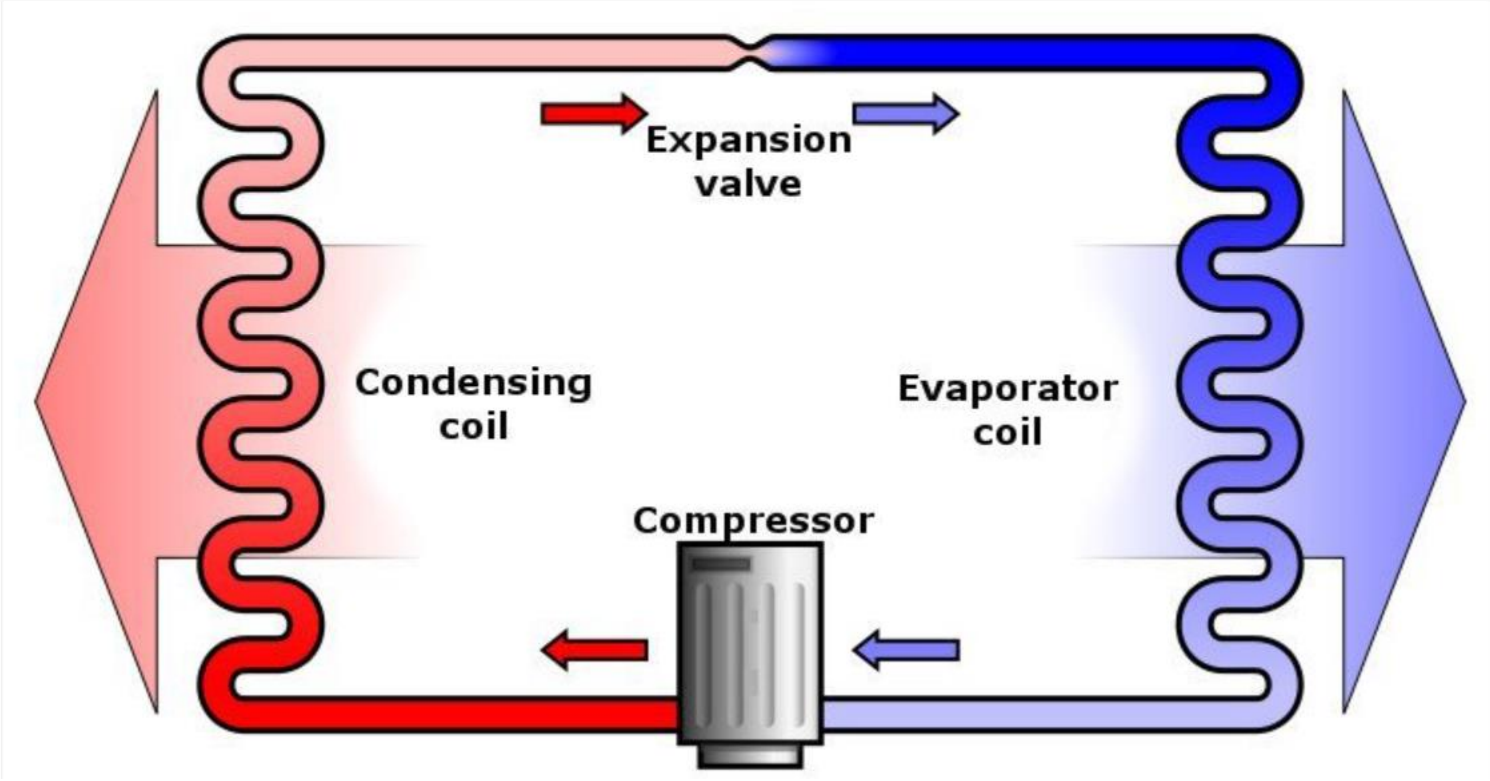
This is different from traditional gas or electric stoves, where the heat is generated externally and then transferred to the cookware.

- **Temperature Control**:

The intensity of the heat produced by the induction stove can be controlled by adjusting the strength of the electric current flowing through the coil.

Induction stoves typically offer precise temperature control, making them efficient and convenient for cooking.

Air conditioner



Key Components Of An Air Conditioner

1.Refrigerant

- The refrigerant is the most important component of an air conditioner.
- It is the gas that moves through the heat exchanger coils of the unit, absorbing heat within a room and expelling it outside.
- The refrigerant circulates within the air conditioner in a cycle of evaporation and condensation, contributing to the reduction of the air temperature inside a room.
- The most commonly used refrigerants include HCFCs (hydrochlorofluorocarbons

2.Evaporator

- An evaporator is essentially a heat exchanger coil responsible for gathering heat from the interior of a room through the use of refrigerating gas.
- This component is named an evaporator because it’s where the liquid refrigerant absorbs heat (from the room) and transforms into a gas.
- Typically constructed from copper or aluminum, these metals are chosen for their excellent heat conduction properties.

3.Compressor

- This component compresses the refrigerant gas into a high-pressure and high-temperature state.
- The compressor functions as a pump, taking refrigerant gas from the evaporator (or the unit inside the room), compressing it to elevate both pressure and temperature, and subsequently transferring the high-pressure/high-temperature gas to the condenser located outside the room.

4.Condenser

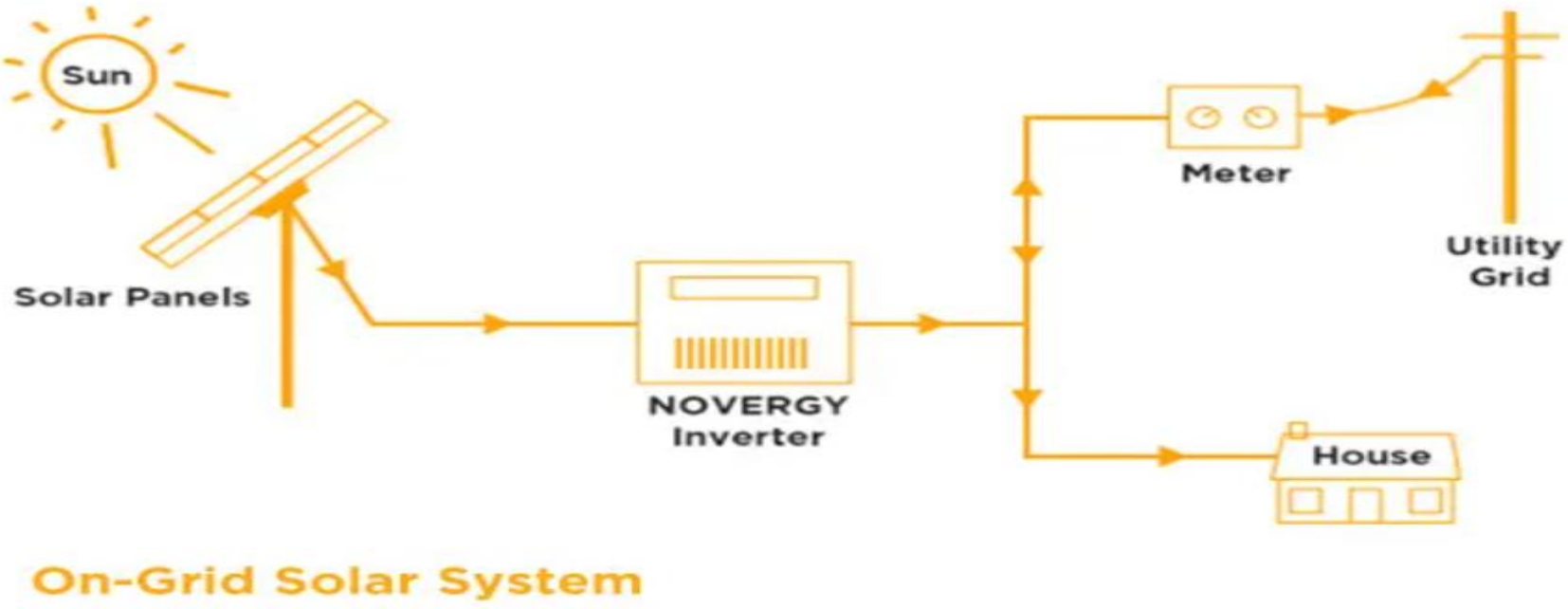
- A condenser is another heat exchanger, situated outside the room. It earns its name by being the site where hot gas undergoes condensation into a liquid.
- When the high-pressure/high-temperature gas reaches the condenser, a fan blows ambient air over the heat exchanger, cooling the refrigerant gas and transforming it into a liquid.
- This procedure enables the refrigerant to release the heat it absorbed from the room.
- They are housed in a unit outside the room.

5. Expansion Valve

- An essential component of air conditioning units, an expansion valve is positioned between a condenser and evaporator.
- It regulates the quantity of refrigerant flowing toward the evaporator.
- The expansion valve converts high-pressure liquid refrigerant from the condenser into low-pressure/low-temperature liquid.
- Subsequently, this low-pressure/low-temperature liquid is directed to the evaporator, where the cycle continues.

Solar energy system-on grid and off grid

On grid system

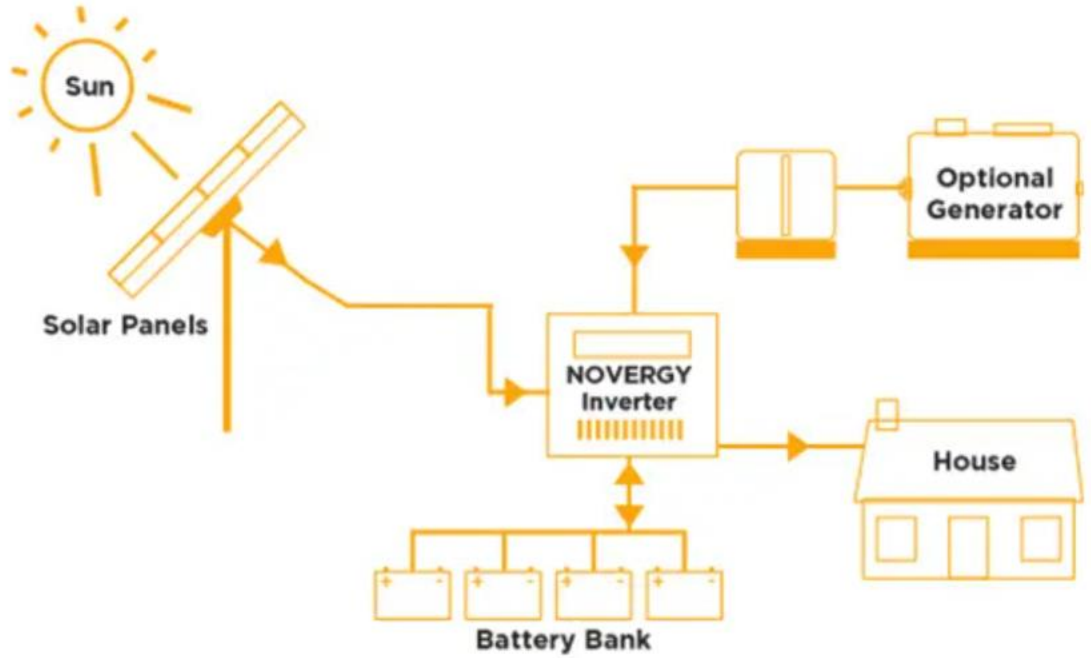


1. **Connection to the Grid**: On-grid, also known as grid-tied or grid-connected, solar systems are connected to the electrical grid. This means they are linked to the local utility power supply.
2. **Power Generation and Consumption**: The solar panels generate electricity when the sun is shining. This electricity can be used to power the appliances and equipment within the home or business connected to the on-grid system.
3. **Net Metering**: Excess electricity generated by the solar panels can be fed back into the grid. In many places, a mechanism called net metering is used. During times when the solar system produces more electricity than is being consumed on-site, the surplus is sent to the grid, and the owner gets credit for it.

4.Reliance on Grid Power: During periods of low solar energy production (such as at night), power is drawn from the grid. On-grid systems do not typically include energy storage systems, relying on the grid for power when the solar panels are not producing electricity.

5.Advantages: On-grid systems are usually more cost-effective because they do not require the installation of energy storage systems like batteries. They allow users to take advantage of incentives, such as net metering, and can potentially result in lower electricity bills.

Off grid system



Off-Grid Solar System

1.Independence from the Grid:

- Off-grid solar systems, as the name suggests, operate independently of the electrical grid.
- They are designed to provide power to locations that are not connected to the grid or where grid power is unreliable or expensive to install.

2.Energy Storage (Battery Bank):

- One of the key components of an off-grid solar system is a battery bank.
- Excess electricity generated by the solar panels during sunny periods is stored in batteries for use during times when the sun is not shining.

3.Inverter and Charge Controller:

- Off-grid systems typically include an inverter to convert the direct current (DC) generated by the solar panels into alternating current (AC) for use in most household appliances.
- Charge controllers are also used to regulate the charging of batteries and prevent overcharging.

4.Autonomy:

Off-grid systems provide autonomy and self-sufficiency.

They are commonly used in remote areas where extending the grid is impractical, in cabins, RVs, boats, and for emergency backup power.

5.Challenges:

The main challenge with off-grid systems is ensuring that the system is properly sized to meet the energy demands, especially during periods of low sunlight.

Adequate battery capacity is crucial to store enough energy for periods without sunlight.

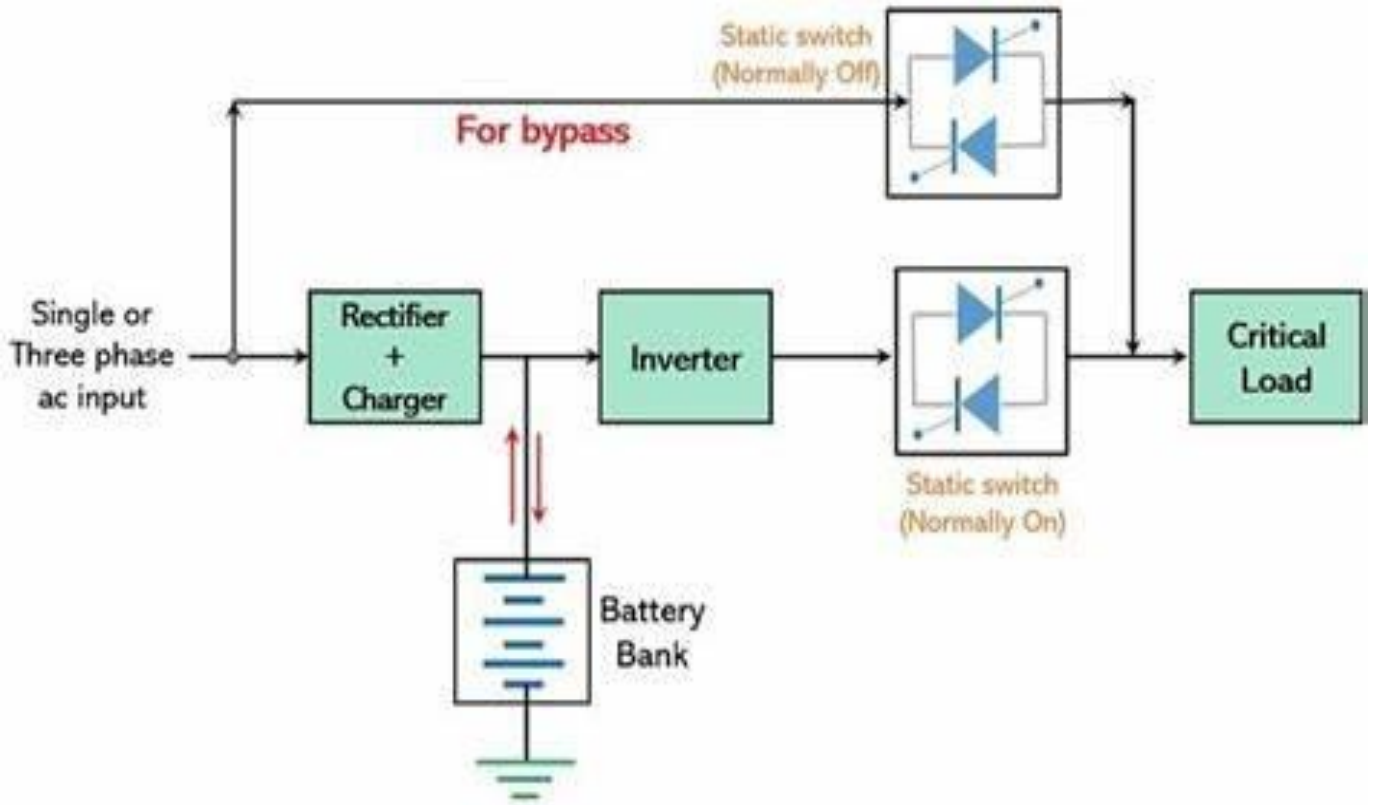
UPS

- A UPS, or Uninterruptible Power Supply, is a device that provides emergency power to a load when the input power source, typically mains power, fails.
- UPS systems are crucial for ensuring continuous operation of critical equipment, such as computers, servers, networking hardware, telecommunications equipment, and medical devices, during power outages or fluctuations.

TYPES

- On line UPS
- Offline UPS

Online UPS



Block Diagram of On-line UPS System

1.Continuous Power Supply:

- In an online UPS, the connected equipment is powered continuously from the UPS's inverter, which is itself continuously powered by the UPS's battery system.

2.**Double Conversion**:

- The input AC power is first converted to DC and then back to AC by the inverter before being supplied to the connected devices.
- This double conversion process ensures a clean and stable power supply, free from voltage fluctuations or disturbances.

3.No Transfer Time:

- Since the connected equipment is always powered by the UPS's inverter, there is no transfer time during a power outage or voltage fluctuation.
- This seamless transition ensures uninterrupted operation of sensitive equipment.

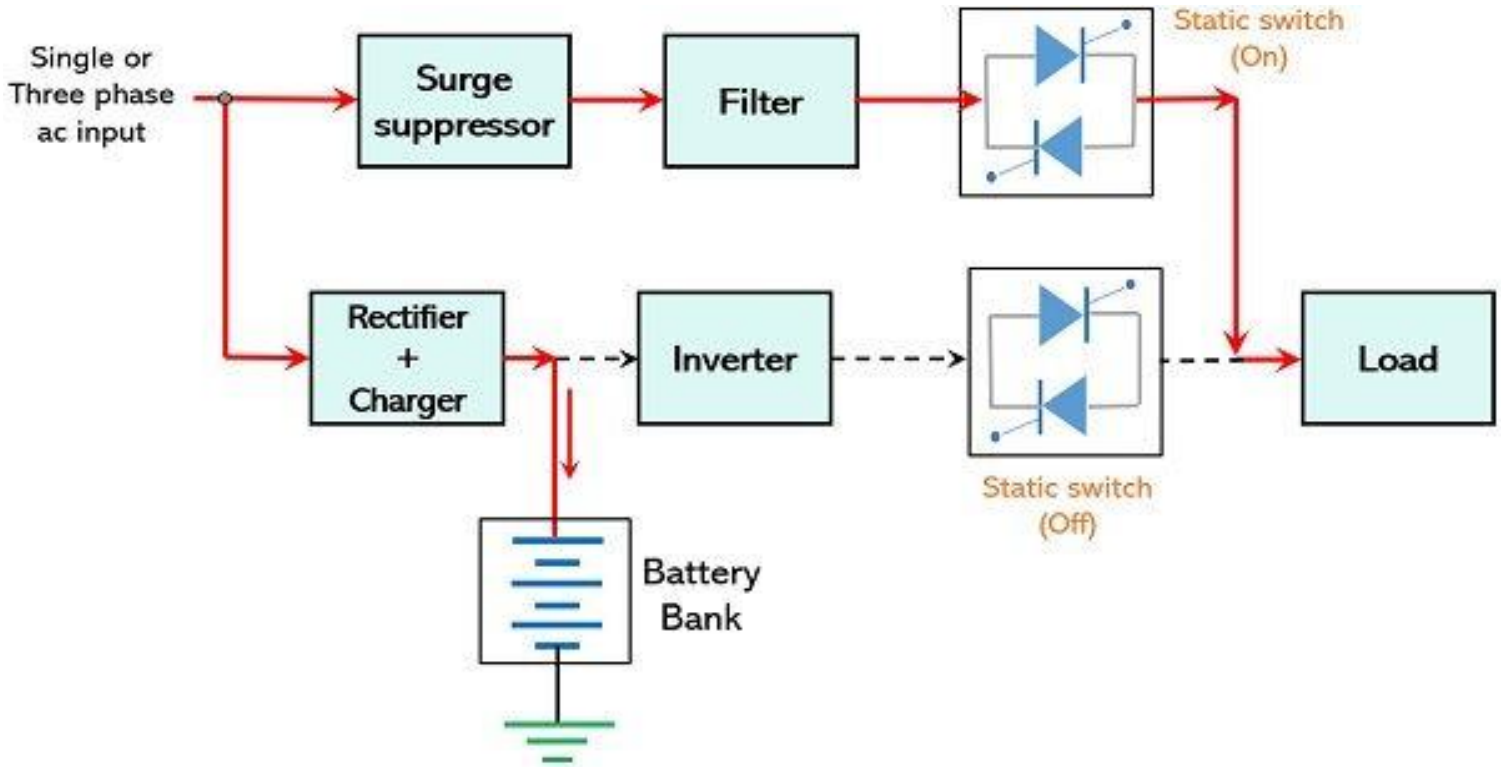
4.Higher Cost:

- Online UPS systems are typically more expensive than offline UPS systems due to their higher level of functionality and continuous operation.

5. Applications:

Online UPS systems are ideal for protecting critical equipment such as servers, data centers, medical devices, telecommunications equipment, and industrial machinery where even the slightest interruption in power could lead to data loss, equipment damage, or system downtime.

Off line UPS



Block Diagram of Off-line UPS System (mains supply on)

1. **Basic Functionality**: In an offline UPS, also known as a standby UPS, the connected equipment is typically powered directly from the mains supply.
2. **Battery Backup**: When a power outage or voltage fluctuation occurs, the UPS switches to battery power to provide temporary backup power to the connected devices.
3. **Switching Time**: There is a small delay, usually in milliseconds, during the transition from mains power to battery power. This brief interruption may cause sensitive equipment to reset or experience a momentary loss of power.
4. **Applications**: Offline UPS systems are suitable for protecting desktop computers, networking equipment, and other non-critical loads where short power interruptions are tolerable.