Basic Electrical Engineering (TEE 101)

Lecture 56: Components of LT Switchgear

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Content

This lecture covers:

- **Introduction to LT Switchgear**
- **Working of various switchgear devices such as SFU, MCB, ELCB, RCD MCCB**

Introduction to LT Switchgear

Switchgear: The apparatus used for switching, controlling and protecting the electrical circuits and equipment is known as switchgear.

The term 'switchgear' is a generic term encompassing a wide range of products like circuit breakers, switches, switch fuse units, off-load isolators, HRC fuses, contactors, earth leakage circuit breaker, etc.

Classification of Switchgear:

Switchgear can be classified on the basis of voltage level into the following:

- **Low voltage (LV) Switchgear: upto 1KV**
- **Medium voltage (MV) Switchgear: 3 KV to 33 KV**
- **High voltage (HV) Switchgear: Above 33 KV**

Essential Features of Switchgear

The essential features of switchgear are :

- Complete Reliability
- Absolutely certain discrimination
- Quick operation
- Provision for manual control
- Low initial and maintenance cost

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1. Low Voltage Switchgear

The commonly used low voltage devices include:

- **Oil Circuit Breakers (OCBs),**
- **Air Circuit Breakers (ACBs),**
- **switch fuse units (SFUs),**
- **Off-load Isolators,**
- **HRC fuses,**
- **Earth Leakage Circuit Breakers (ELCBs),**
- **Residual Current Protective Devices (RCCB & RCBO),**
- **Miniature Circuit Breakers (MCB), and**
- **Moulded Case Circuit Breakers (MCCB)**

2. Medium Voltage Switchgear

- Medium voltage switchgear is mainly used for the distribution of electrical energy connected to various electrical networks.
- They include most of the substation equipment such as:
  - **Minimum Oil Circuit Breakers,**
  - **Bulk Oil Circuit Breakers,**
  - **Air Magnetic,**
  - **SF6 Gas-insulated,**
  - **Vacuum, And**
  - **Gas-insulated Switchgear.**

3. High Voltage Switchgear

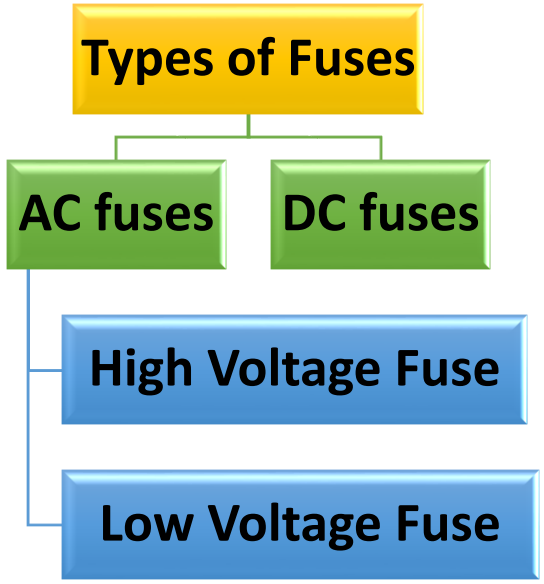
- **High voltage circuit breakers include: SF6 Circuit breaker or Vacuum Circuit breaker**.
- They are the main component of HV switchgear.
- Hence high voltage circuit breaker should have special features for safe and reliable operation.
- As the voltage level is high the arcing produced during switching operation is also very high.
- So, special care to be taken during designing of high voltage switchgear.

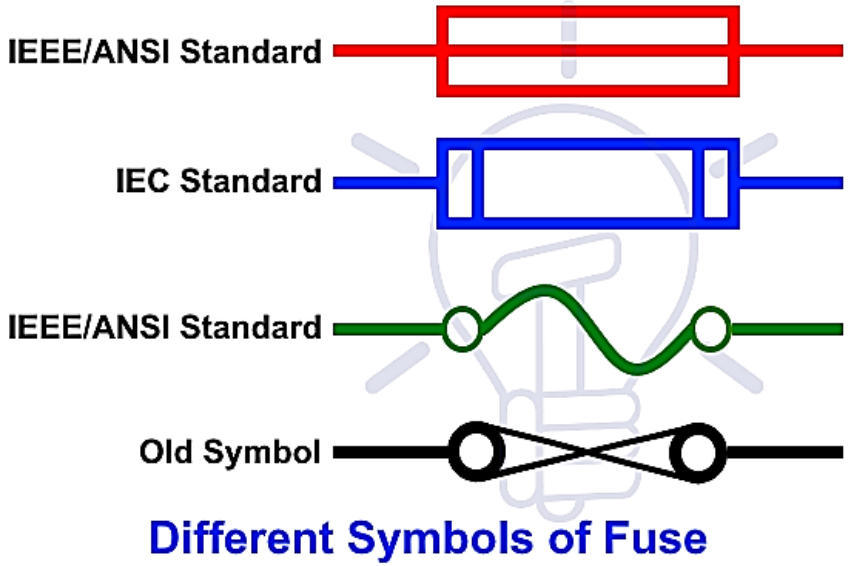
A section of a large switchgear panel

Components of LT Switchgear

1. Fuses

- A **fuse** is an **electric / electronic or mechanical device**, which is used to protect circuits from over current, overload and make sure the protection of the circuit.
- Electric fuse was invented by Thomas Alva Edison in 1890.
- There are many types of fuses, but the function of all these fuses is the same.





Different Symbols of Fuse

Advantages:

1. Cost Effective
2. Low or no maintenance
3. Less complexity and automatic operation
4. It interrupts huge short circuit currents without noise, flame, gas or smoke.

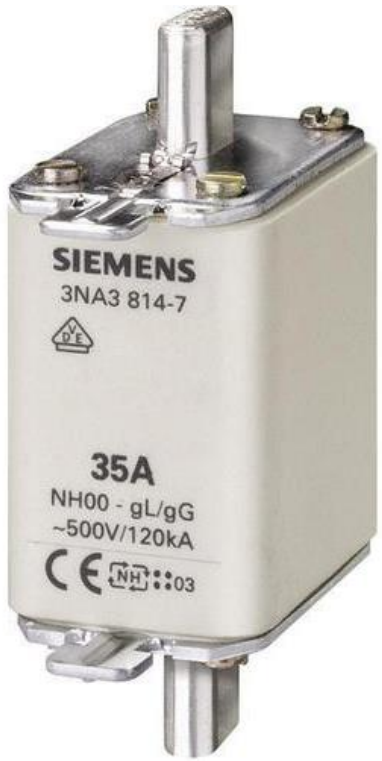
Disadvantages:

1. Significant time is required in rewiring or replacing a fuse after operation.
2. When fuses are connected in series it is difficult to discriminate the fuse unless the fuse has significant size difference

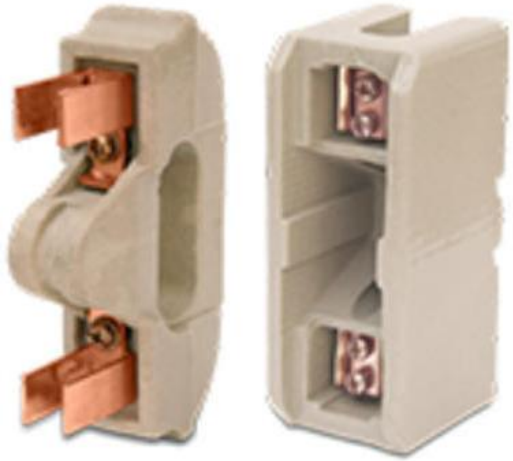
Fuses can also be categorized based on one time or multiple Operations. Such as:

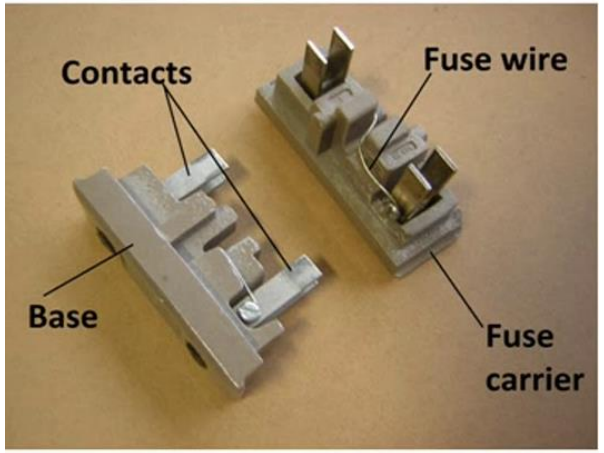
- **Rewirable Fuse**
- **Cartridge Fuses**
  - **D – Type Cartridge Fuse**
  - **HRC (High Rupturing Capacity) Fuse or Link Type Cartridge Fuse**

Cartridge Fuse



HRC Fuse





Rewirable Fuse

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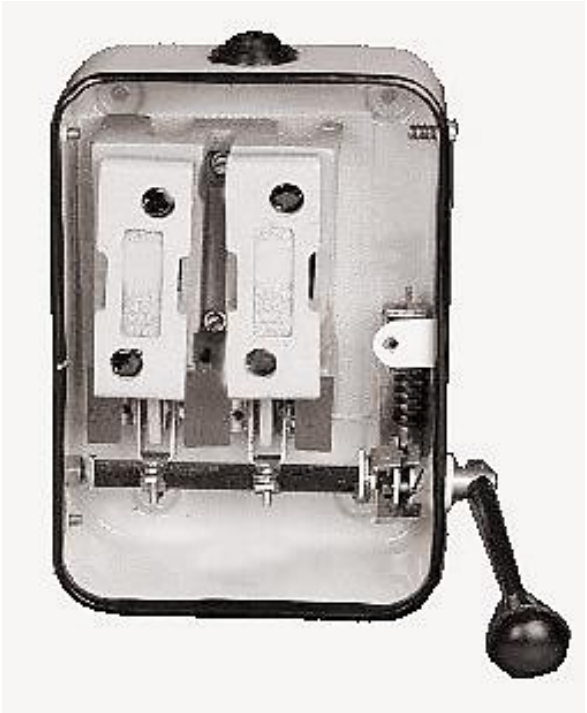
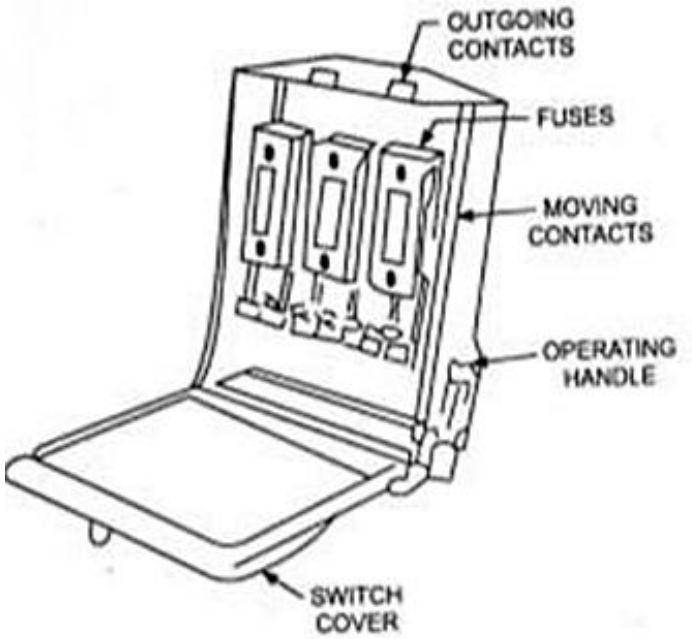
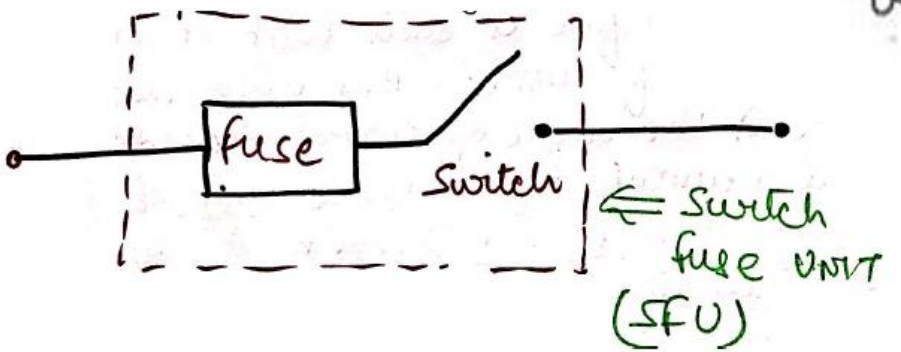
Switch Fuse Unit (SFU)

- Switch fuse unit is compact combination, generally metal enclosed of a switch and a fuse.
- Switch fuse is a combined unit and is known as an iron clad switch, being made of iron.
- It is very widely used for low and medium voltages.
- It may be **double pole** for controlling **single phase two-wire circuits** or **triple pole** for controlling **three-phase, 3-wire circuits** or **triple pole** with **neutral link for controlling** 3-phase, 4-wire circuits.
- They are known as:
  - Double Pole Iron Clad (DPIC): 240V, 16A, DPIC switch fuse
  - Triple Pole Iron Clad (TPIC), 500 V, 32A (63/100/150 amperes)
  - Triple Pole with Neutral Link Iron Clad (TPNIC) switches. 415V, 32A







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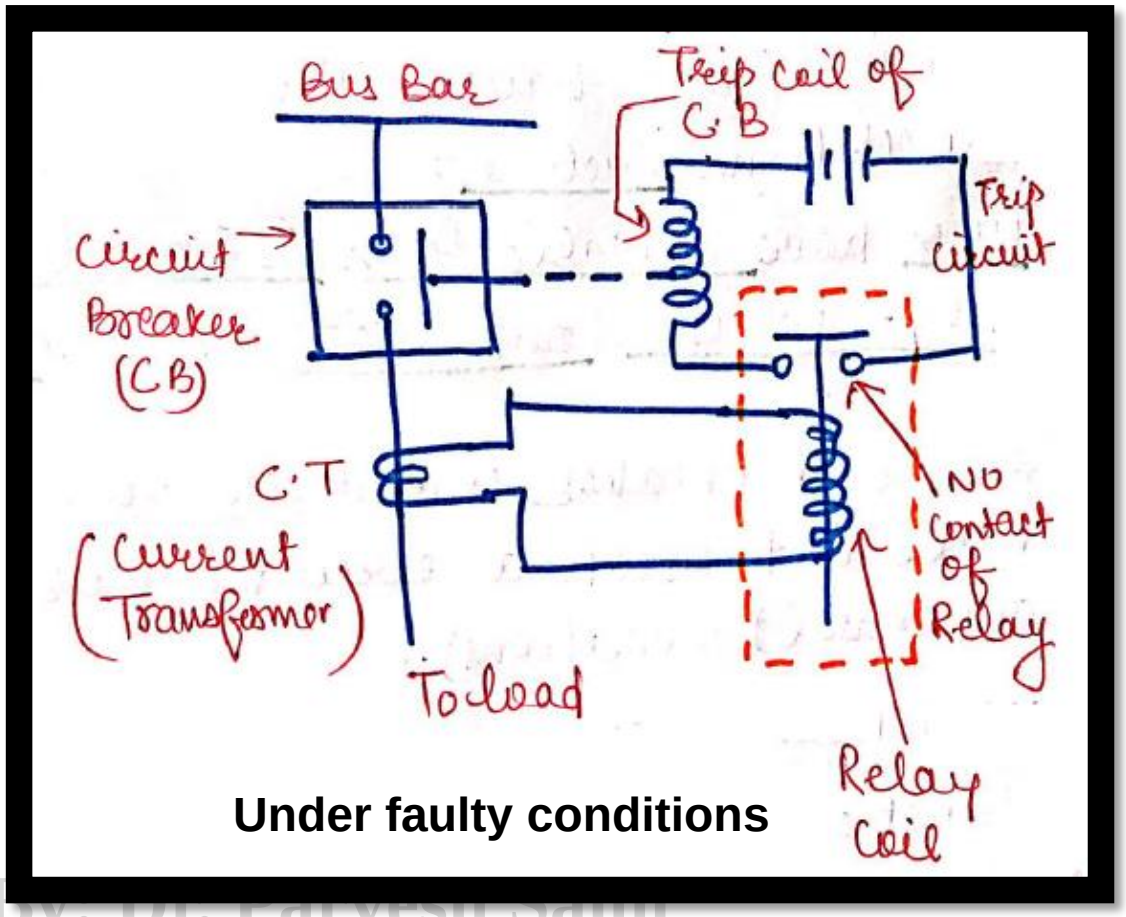
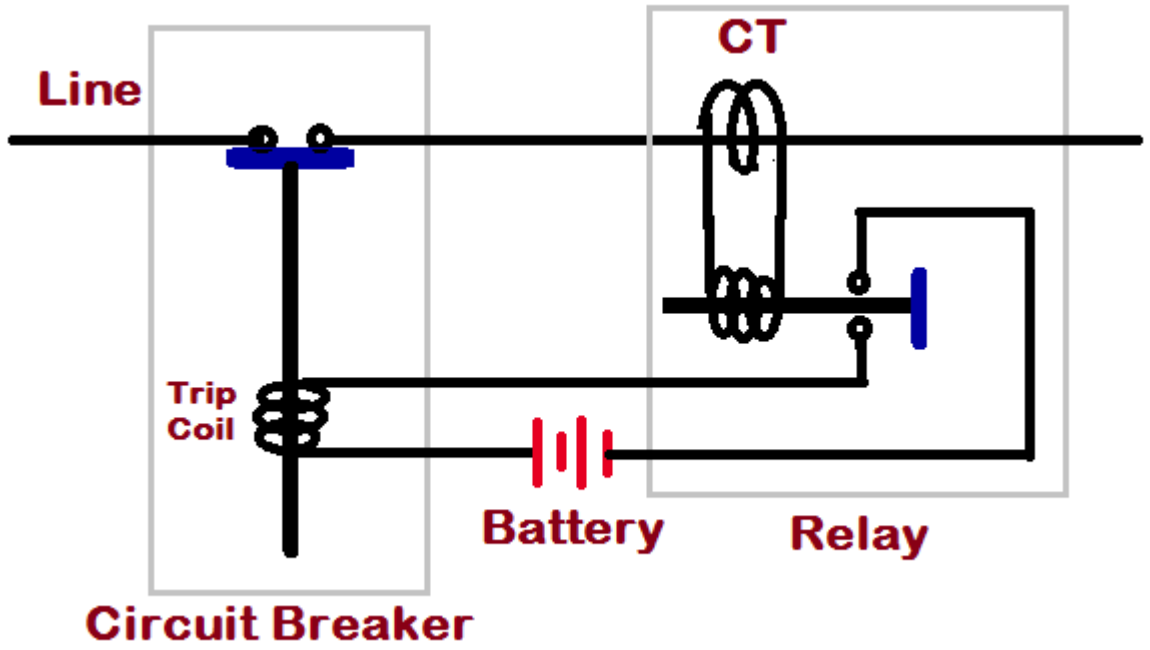
Circuit Breakers

An electrical circuit breaker is a switching device which can be operated manually and automatically for controlling and protecting an electrical power system.

Working Principle of Circuit Breaker



Under faulty conditions



Under normal conditions

Types of Circuit Breakers

For the low voltage applications, the following types of circuit breakers are available:

- **Miniature Circuit Breaker (MCB)**
- **Moulded – Miniature Circuit Breaker (MCCB)**
- **Earth Leakage Circuit Breaker (ELCB)**
- **Residual Current Circuit Breaker (RCCB)**

MCCB

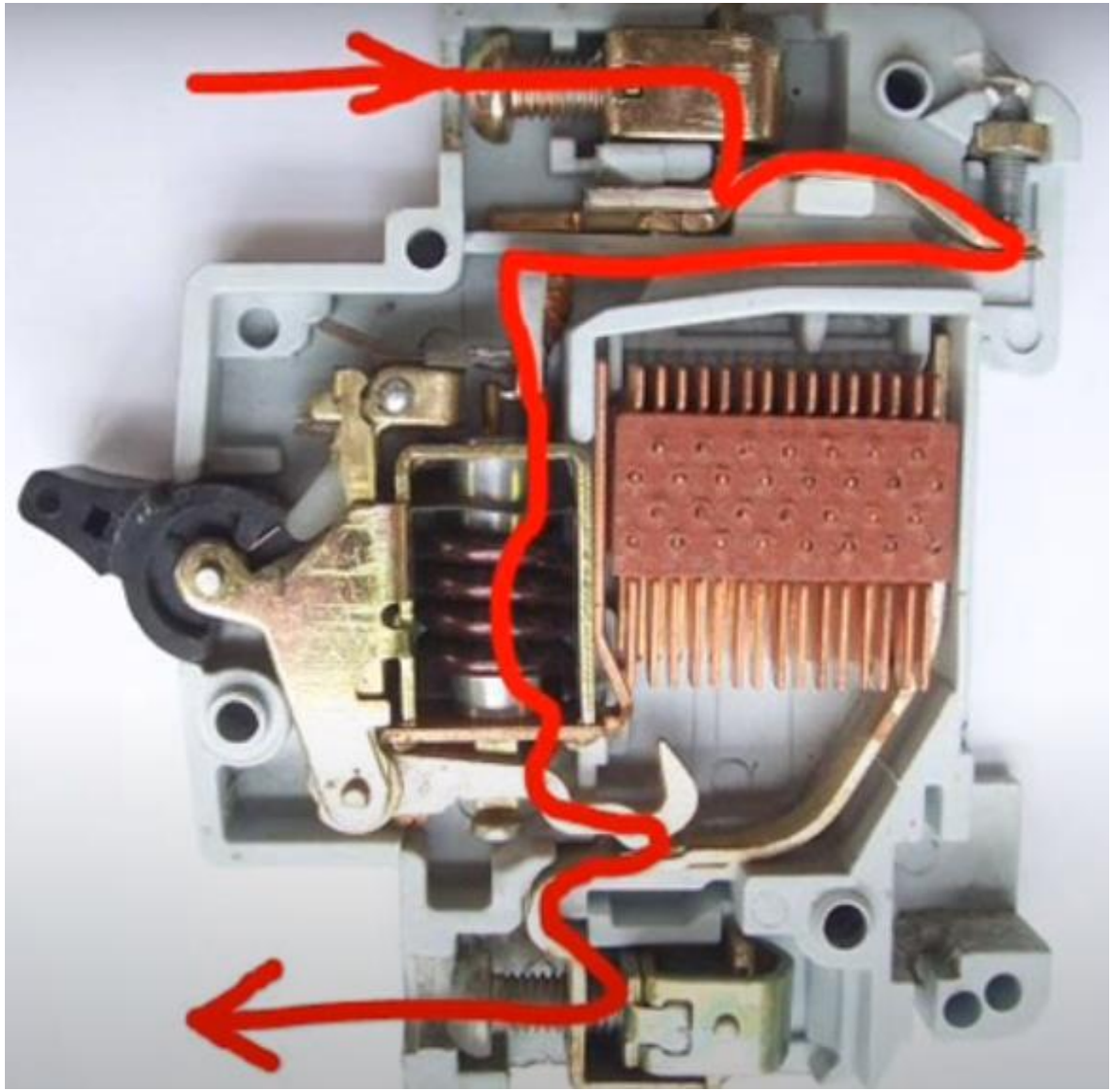
Miniature Circuit Breaker (MCB)

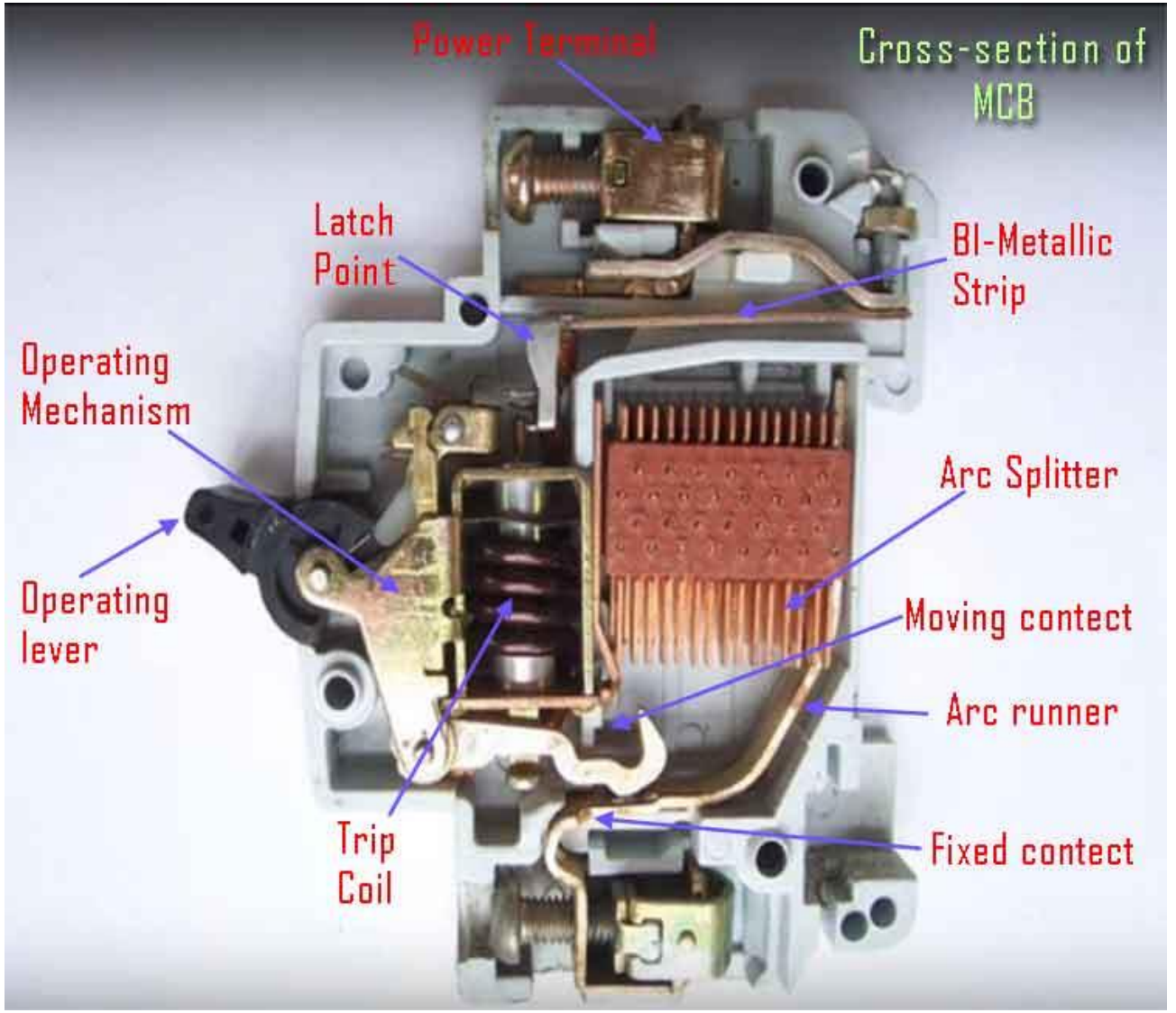
Advantages of Circuit Breaker

Circuit-breakers offer the following advantages compared to fuses.

- Circuit-breakers respond quicker than fuses.
- Circuit-breakers are more reliable.
- Circuit-breakers are more sensitive.
- Unlike fuses which only operate once and need to be replaced a circuit-breaker can be reset.

Miniature Circuit Breaker (MCB)
And
Moulded – Miniature Circuit Breaker (MCCB)





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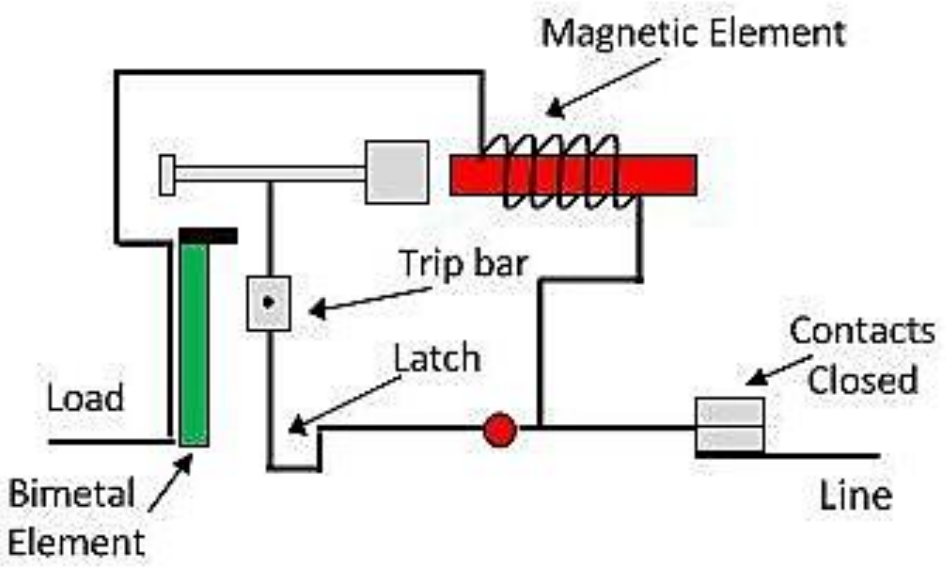
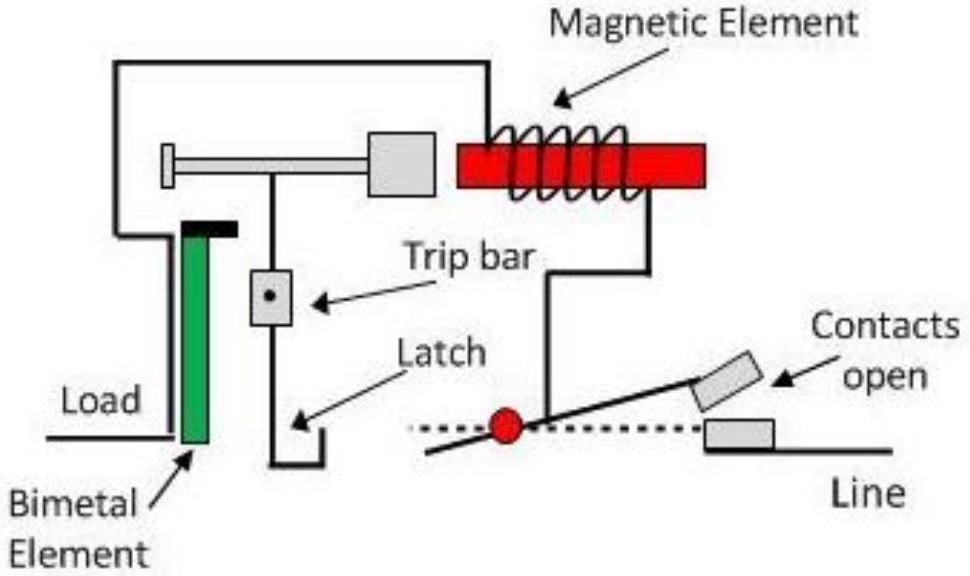


Under normal conditions



Under faulty conditions

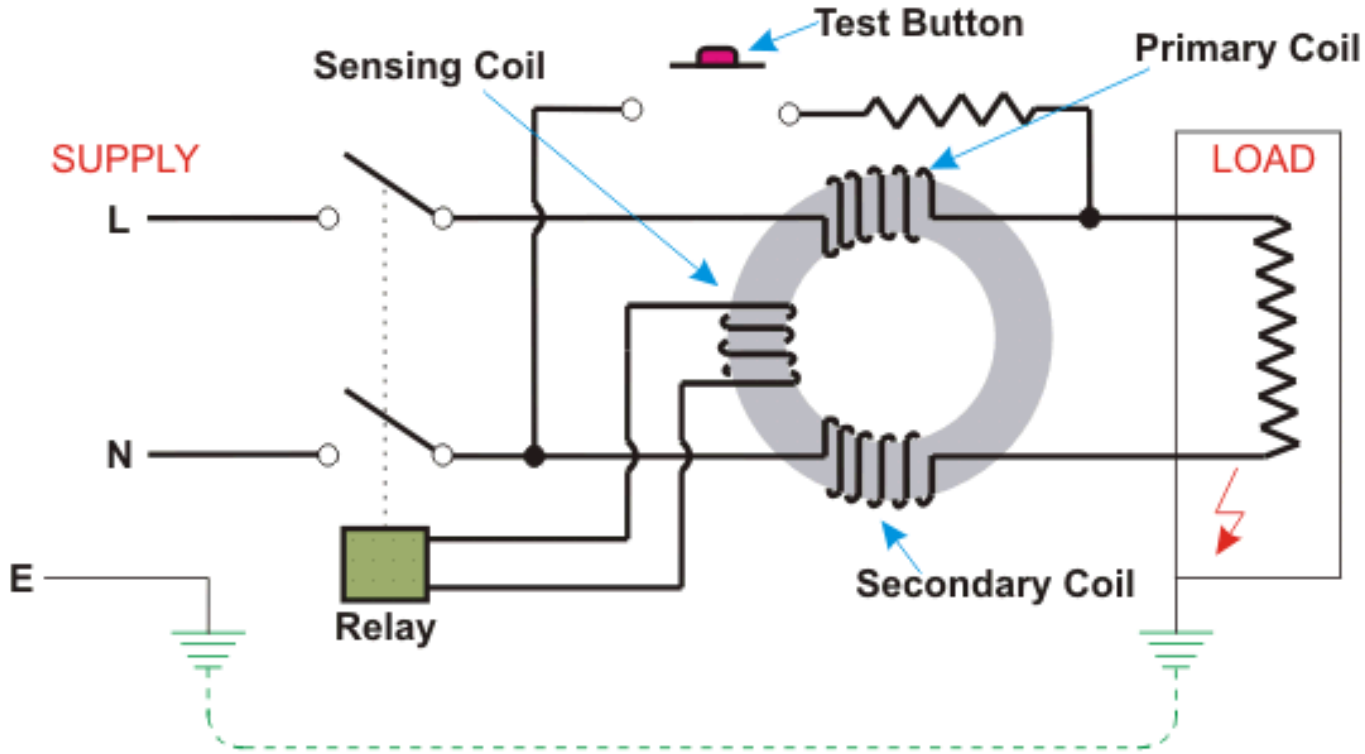
- The working principle of the miniature circuit is very simple.
- Their main function is to protect the equipment from overcurrent.
- It has two contacts one is movable, and the other one is fixed.
- When the current increases from the predefined limit, their movable contacts are disconnected from the fixed contacts which make the circuit open and disconnects them from the main supply.

Differences Between MCB and MCCB

Basis for Comparison	MCB	MCCB
Definition	Type of switch which protects the system from overloaded current.	Protects the equipment from over temperature and fault current.
Abbreviation	Miniature Circuit Breaker	Moulded case circuit breaker.
Tripping circuit	Fixed	Movable
Pole	Available in single, two and three versions.	Available in single, two, three and four versions.
Interrupting Rating	1800 A	10k -200k
Remote on / off	Not Possible	Possible
Rating Current	100 amps	10 - 200 amps
Applications	In lightning circuit and for low loads.	In heavy current circuit
Uses	For domestic purpose.	For commercial and industrial use.

Residual Current Circuit Breaker (RCCB)

- A Residual Current **Circuit** Breaker (**RCCB**) is an important safety measure when it comes to protection of electrical circuits.
- It is a current sensing device, which can automatically measure and disconnect the **circuit** whenever a fault occurs in the connected **circuit** or the current exceeds the rated sensitivity.
- It has very simple working based on Kirchhoff's Current Law ie the incoming current in a circuit must be equal to the outgoing current from that circuit.
- Also known as Current Operated ELCB or Residual Current Device (RCD)



Working Principle of Residual Current Circuit Breaker

- This circuit breaker is made such that whenever a fault occurs the current balance of line and neutral did not matches (imbalance occurs, as the fault current finds another earthing path of current).
- Its circuit is made such that an every instance it compares the value of incoming and outgoing circuit current. Whenever it is not equal, the residual current which is basically the difference between the two currents actuates the circuit to trip/switch off.

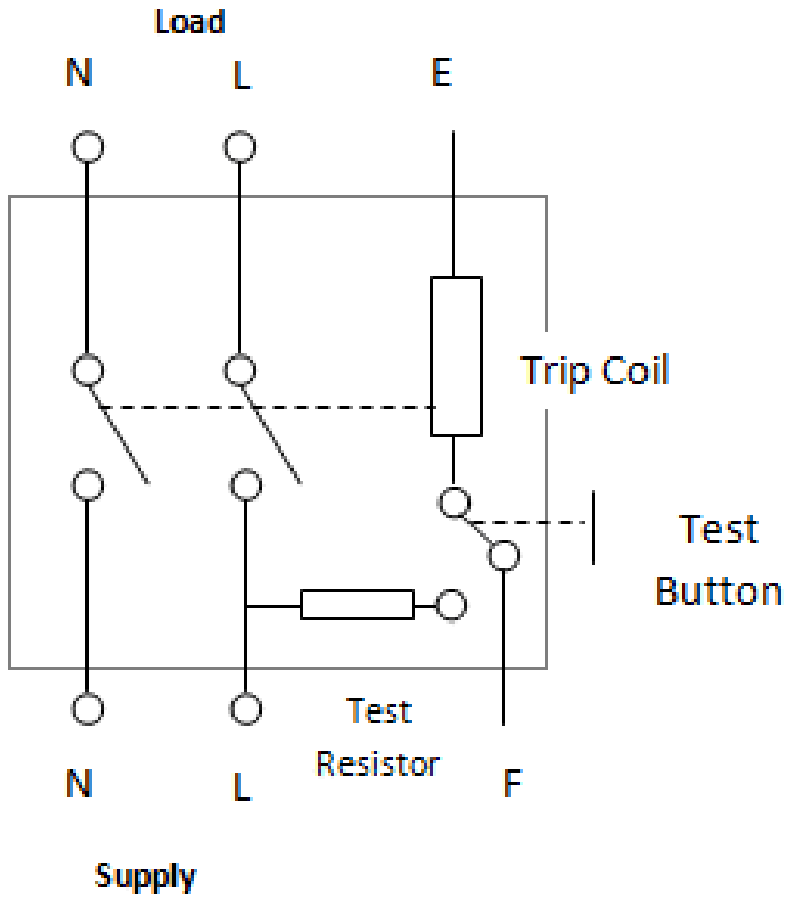
- The basic operating principle lies in the Toroidal Transformer shown in the diagram containing three coils.
- There are two coils say Primary (containing line current) and Secondary (containing neutral current) which produces equal and opposite fluxes if both currents are equal.
- Whenever in the case there is a fault and both the currents changes, it creates out of balance flux, which in-turn produces the differential current which flows through the third coil (sensing coil shown in the figure) which is connected to relay.
- The Toroidal transformer, sensing coil and relay together is known as RCD – Residual Current Device.

- **Test Circuit:**
- The test circuit is always included with the RCD which basically connects between the line conductor on the load side and the supply neutral.
- It helps to test the circuit when it is on or off the live supply.
- Whenever the test button is pushed current starts flowing through the test circuit depending upon the resistance provided in this circuit.
- This current passes through the RCD line side coil along with load current.
- But as this circuit bypasses neutral side coil of RCD, there will be an unbalance between the line side and neutral side coil of the device and consequently, the RCCB trips to disconnect the supply even in normal condition.
- This is how the test circuit tests the reliability of **RCCB**.

Earth Leakage Circuit Breaker (ELCB)

- An Earth Leakage Circuit Breaker is a safety device used in Electrical circuits with high Earth impedance to prevent the risk of Electrical shock.
- Unlike previously studied RCCB, an ELCB is a voltage operated device.
- ELCB detects small stray voltages across metal enclosures of electrical installations and interrupts the circuit if the voltage level exceeds danger threshold.

- As depicted in the picture, the device consists of double pole switch connecting the supply and load sides.
- This double pole switch is internally connected to a solenoid trip coil.
- The trip coil is connected between Earth and the exposed metallic frame of the electrical installation.
- As seen in the picture, Terminal E of the trip coil is connected to Earth electrode and Terminal F is connected to metallic enclosure.
- During **normal operation**, the double pole switch is closed and the current flows from supply to load side through the two lines (Phase, Neutral).
- During this period, there is no current flowing to earth between terminal F and E.
- Therefore the voltage between terminal E and F is negligible (almost Zero).



Schematic of ELCB

- In case of a **fault condition**, the voltage on terminal F connected to exposed metal work rises up and the voltage at terminal E is at zero potential.
- Thus, there rises a potential difference between terminals E and F.
- This causes the connected trip coil to operate.
- The movement of trip coil then opens up the double switch and thus breaks the circuit.
- There is a test button seen.
- It is used to test the operation of ELCB.
- When it is pressed, it temporarily connects the terminal F to line via test resistor.
- It disconnects the supply back to metal enclosure so as to avoid dangerous electrical current back to the metallic enclosure.

Advantages of ELCB over RCCB

- One major advantage of ELCB over RCCB is that it is less sensitive to fault conditions over RCCB, hence it has less occurrences of nuisance tripping.

Disadvantages of ELCB

- Nuisance tripping may cause during thunderstorms due to lightening strikes ELCBs do not detect fault current that doesn't pass through connected earth rod. E.g. a person coming in direct contact with live conductor. Hence in such cases, ELCB does not offer any protection.
- Leaky appliances such as Water heaters, immersion heaters may cause leakage current to pass through F terminal connected to ground and may cause nuisance tripping.

Thank You