PPT ON
POWER SYSTEMS PROTECTION
VII SEM (IARE-R16)

UNIT 1
CIRCUIT BREAKERS

WHAT IS A CIRCUIT BREAKER?

- **Circuit breaker is an equipment that breaks a circuit either manually or automatically under all conditions at no load, full load or short circuit.**

WHAT IS A CIRCUIT BREAKER?

Operating Principle

- Two contacts called electrode remains closed under normal operating conditions. When fault occurs on any part of the system, the trip coil of the circuit breaker get energized and contacts are separated.

Arc Phenomenon

- An arc is struck when contacts are separated. The current is thus able to continue. Thus the main duty of a circuit breaker is to distinguish the arc within the shortest possible time.
- The arc provides the low resistance path to the current and the current in the circuit remains uninterrupted.

- ***The arc resistance depends upon the following factors.***

  - **Degree of ionization**
  - **Length of the arc**
  - **Cross Section of the arc**

Methods of Arc Extinction

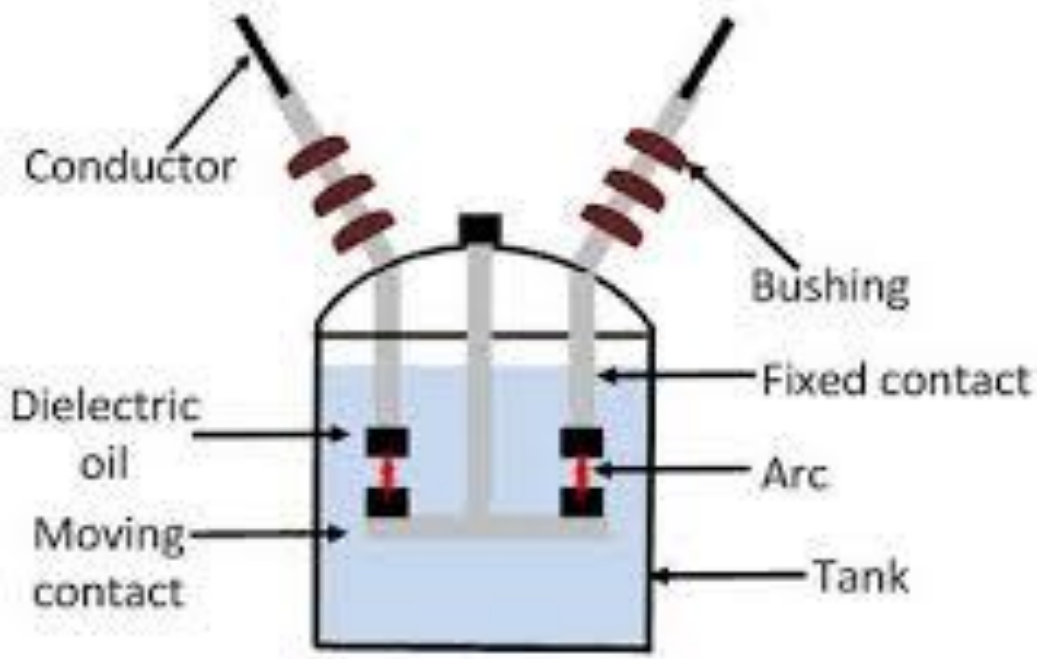
1.High Resistance Method

2. Low Resistance Method

TYPES OF CIRCUIT BREAKERS

1. Oil Circuit breaker
2. Air Blast Circuit breaker
3. SF6 Circuit breaker
4. Vaccume Circuit breaker

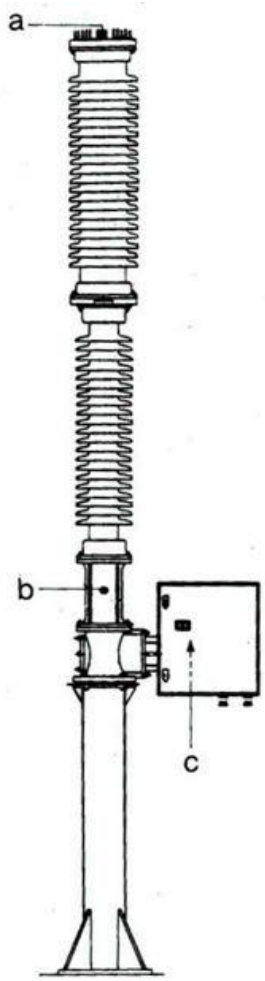
BULK OIL CIRCUIT BREAKER



Bulk Oil Circuit Breaker

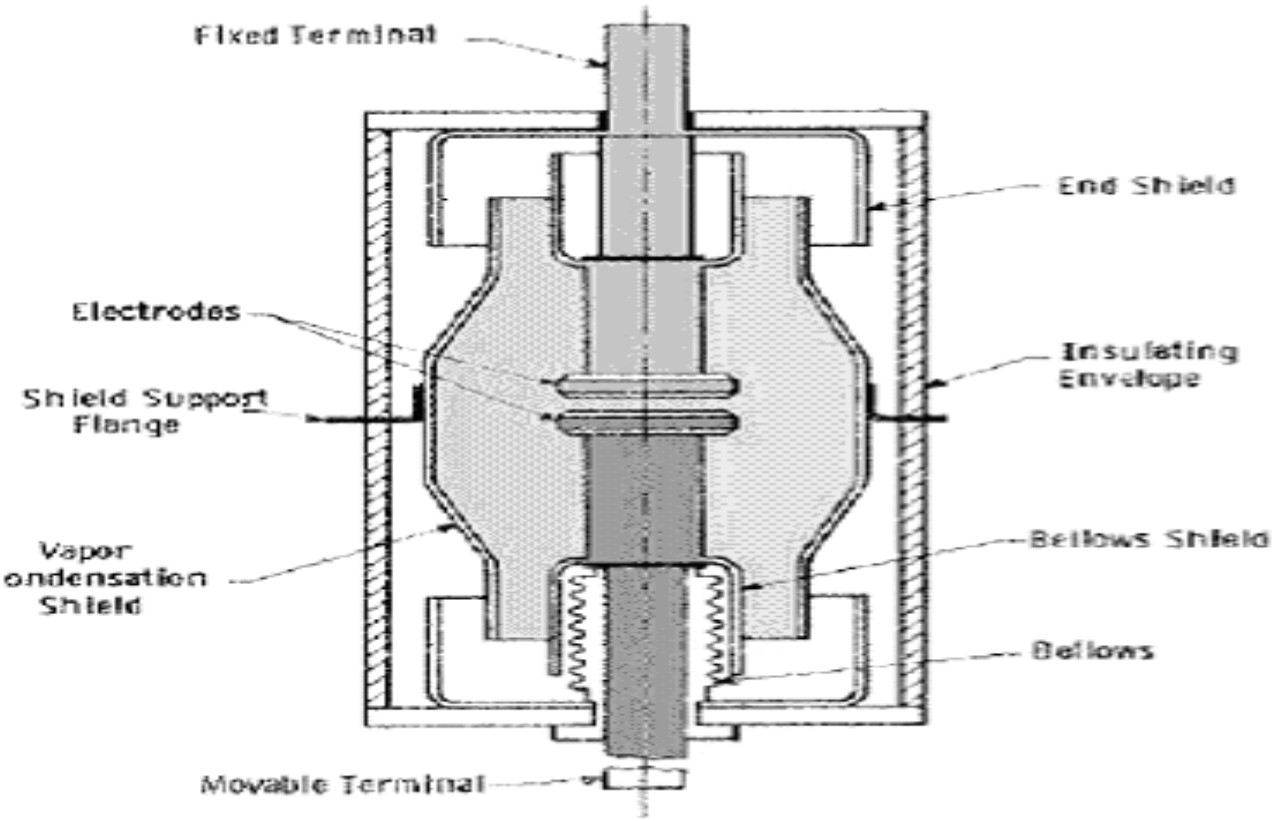
Circuit Globe

Low Oil Circuit Breaker

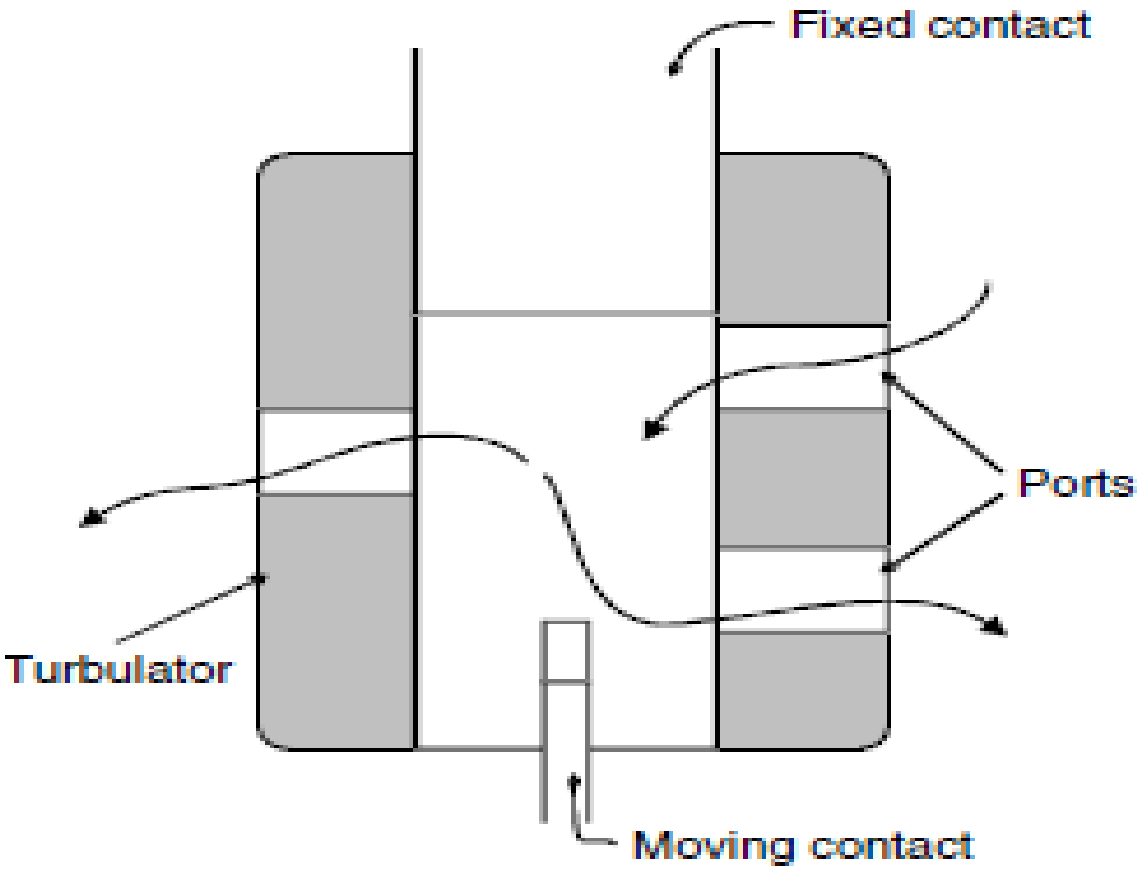


Supporting Chamber.
Circuit-Breaking chamber consist of fixed and moving contact

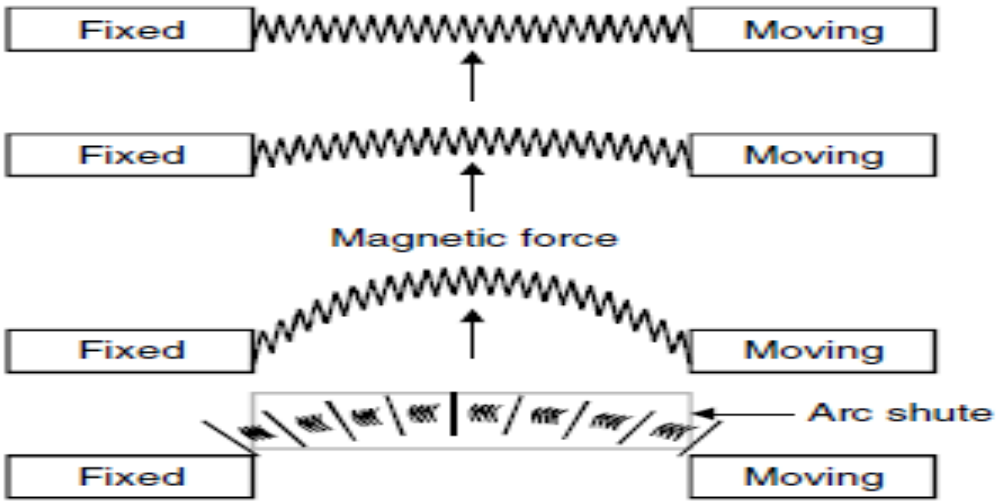
Vacuum Circuit Breaker



SF6 Circuit Breaker



Air break circuit breaker



Comparison of insulating methods for CBs

Property	Air	Oil	SF6	Vacuum
Number of operations	Medium	Low	Medium	High
'Soft' break ability	Good	Good	Good	Fair
Monitoring of medium	N/A	Manual test	Automatic	Not possible
Fire hazard risk	None	High	None	None
Health hazard risk	None	Low	Low	None
Economical voltage range	Up to 1 kV	3.3–22 kV	3.3–800 kV	3.3–36 kV

UNIT 2
ELECTROMAGNETIC, STATIC AND NUMERICAL RELAYS

Electromechanical relay

- Moving parts—inertia-causes inherent time delay
- Disc rotates on bearing –friction causes time delay
- Dust, magnetic particles attracts to brake magnet and influences the operation
- Plugs or rotating knobs for adopting settings
- One function =one relay
- Requires maintenance and monotiring

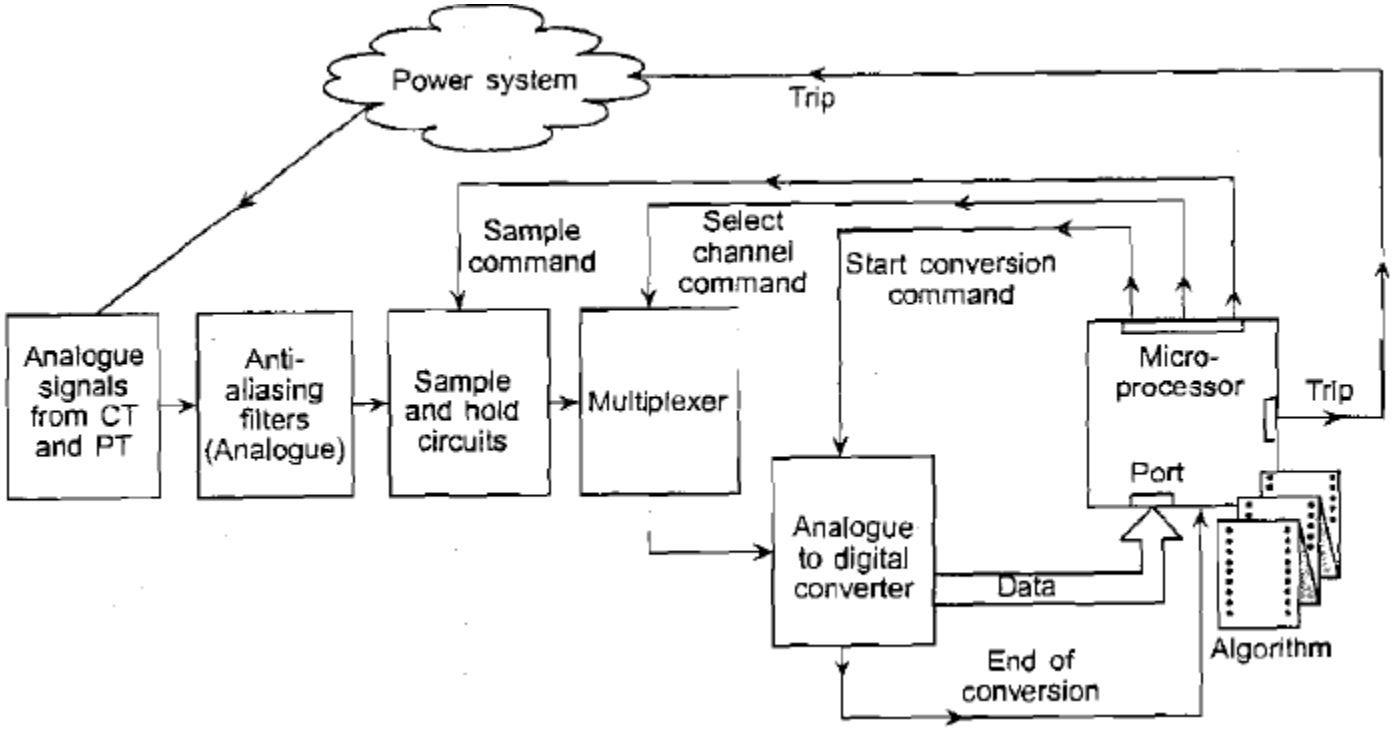
Static relay

- Size became less
- No moving parts
- improved performance
- Still same for settings adoption
- Self diagnostic feature

Numerical Relays

- Microprocessor-based relay, works on numbers representing instantaneous values of the signals. Hence, they are named numerical relay. Other popular nomenclatures for such relays are digital relay, computer-based relay or microprocessor-based relay.

Block Diagram of Numerical Relay



Intelligent Electronic Device' (IED)

The functions of a typical IED can be classified into 5 main areas, namely

- protection,
- control,
- monitoring,
- metering and
- communications.

UNIT 3
SUBSTATIONS AND PROTECTION OF FEEDER / BUS BAR

Functions of Electrical Power Substations are:

- Supply electric power to the consumers continuously
- Supply of electric power within specified voltage limits and frequency limits
- Shortest possible fault duration.
- Optimum efficiency of plants and the network
- Supply of electrical energy to the consumers at lowest cost

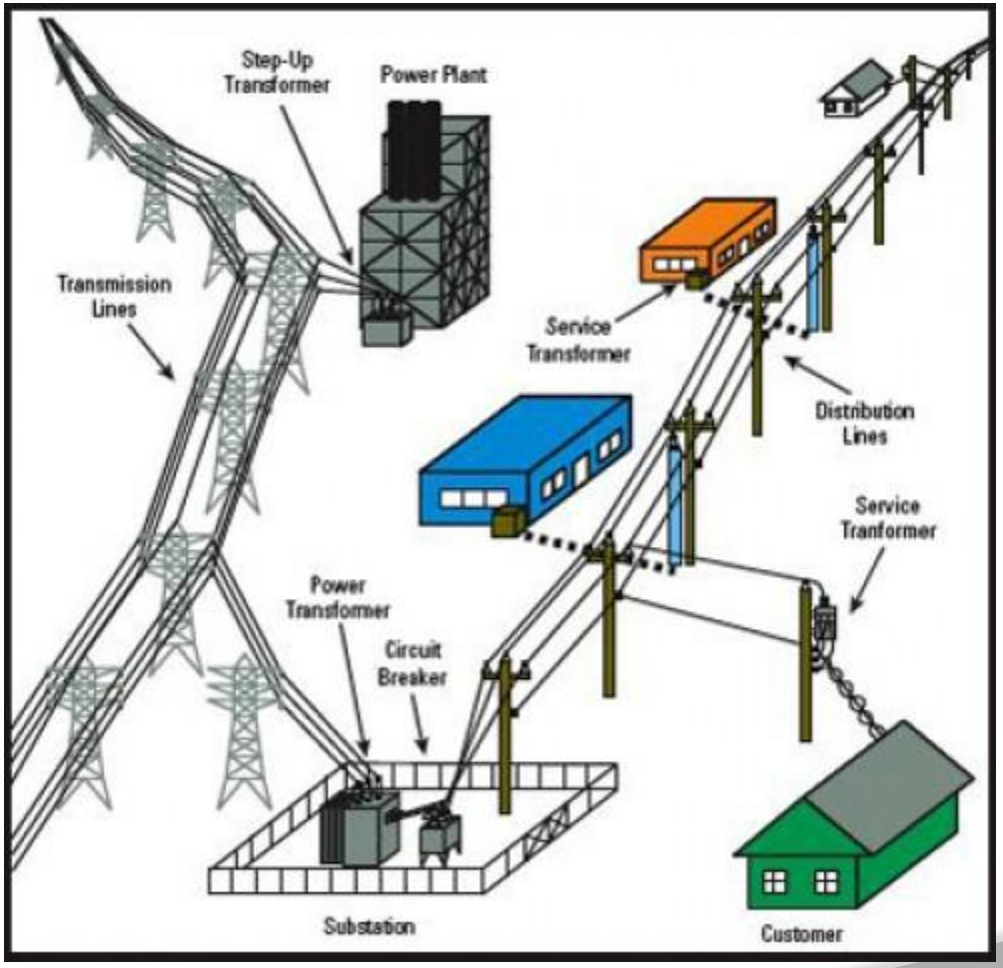
Types Of Electrical Power Substations: Based ON Nature Of Duties

1. Step up or primary Electrical P
2. Primary Grid Electrical Power Substation:
3. Step Down or Distribution Electrical Power Substations:
4. Transformer Substation
5. Switching Substation
6. Converting Substation
7. over substation

Based on Operation Voltage:

1. Based on Operation Voltage:
2. Extra High Voltage Electrical Power Substation
3. Ultra High Voltage Electrical Power

SUBSTATION LAY OUT



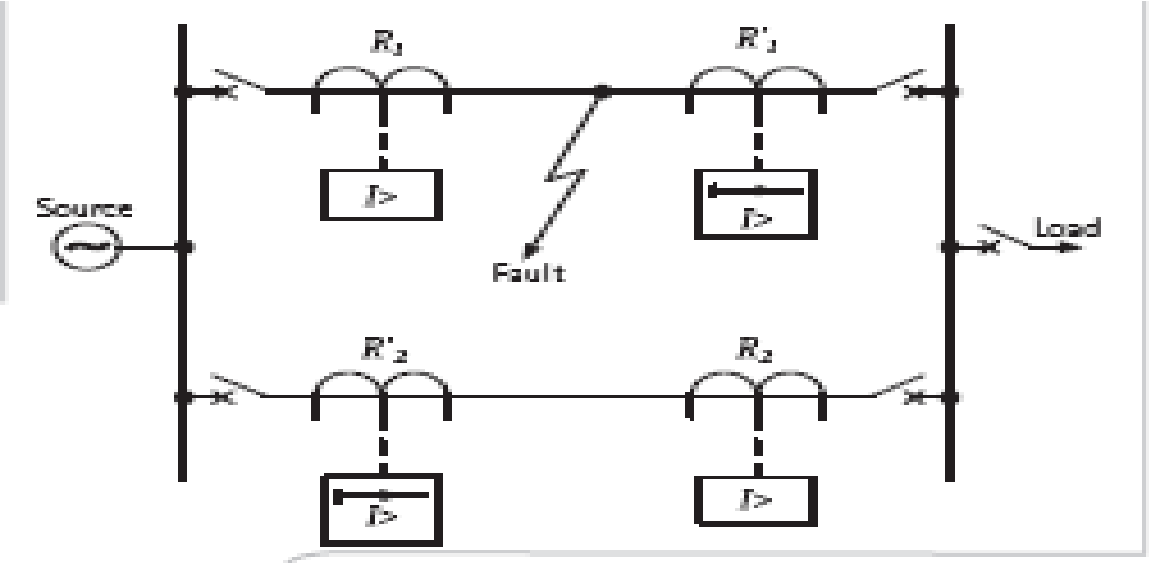
Based On Substation Design

1. Outdoor Electrical Power Substations:
2. Indoor Electrical Power Substation:
3. Air Insulated Electrical Power Substation:
4. Gas Insulated Electrical Power Substation

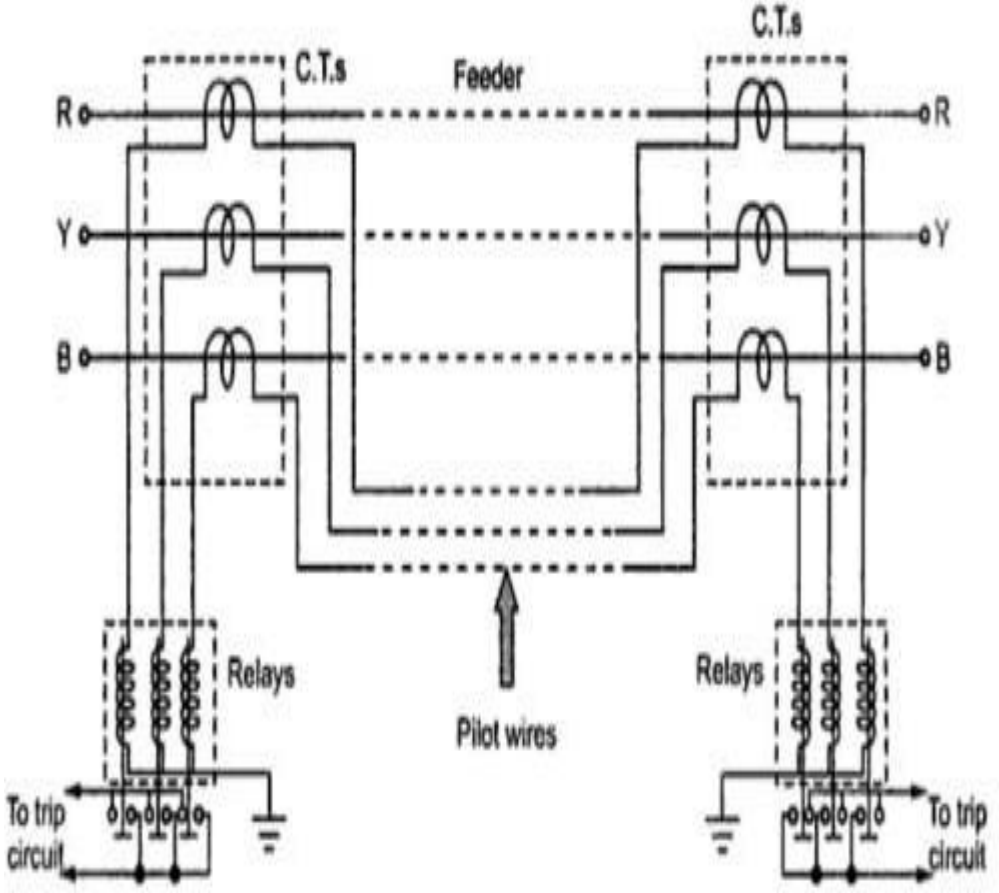
Gas Insulated Electrical Power Substation

PROTECTION OF FEEDERS

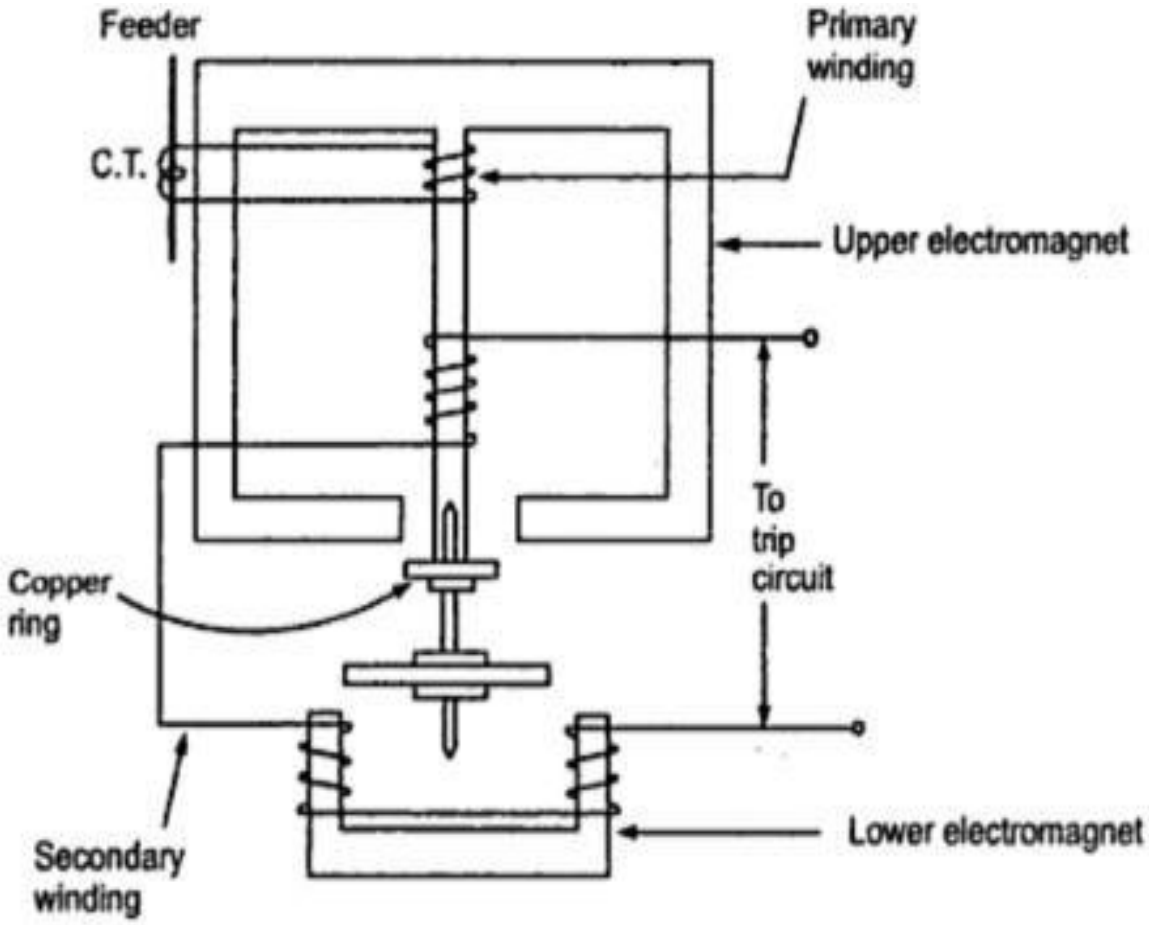
- **Over current and earth fault protection**



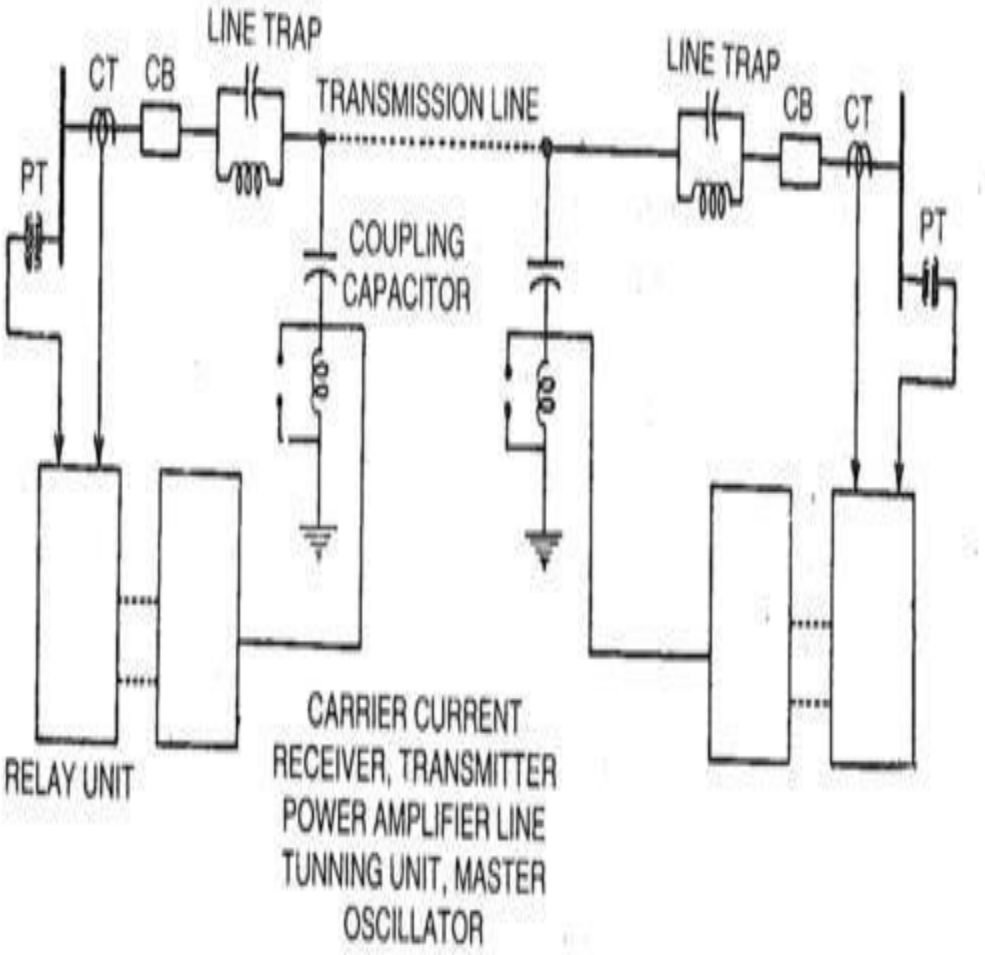
Merz-Price Voltage Balance System



Translay Scheme

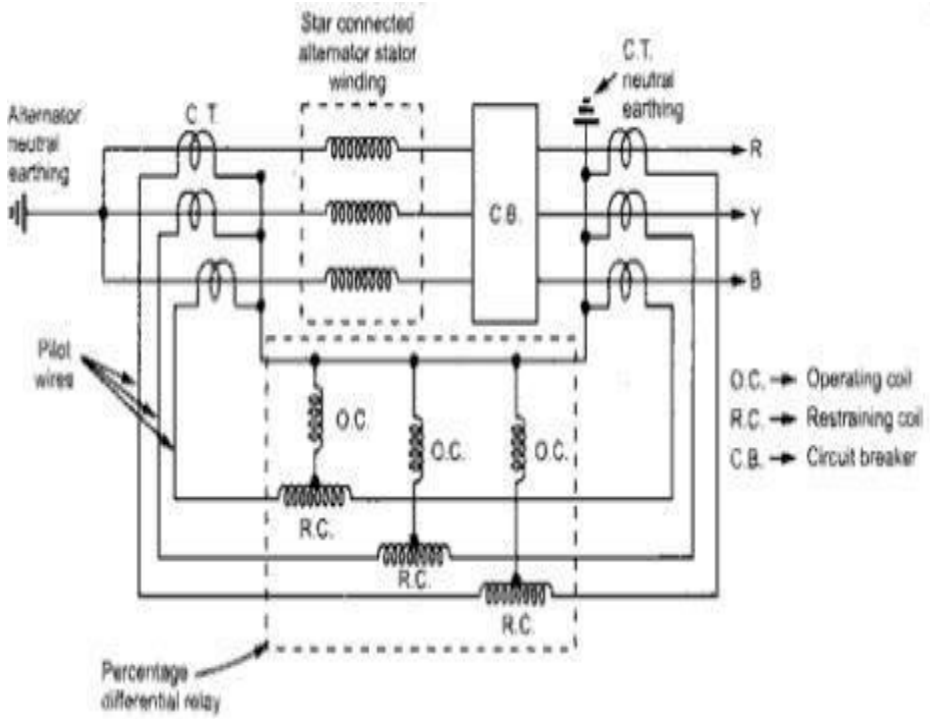


Carrier Current unit protection system

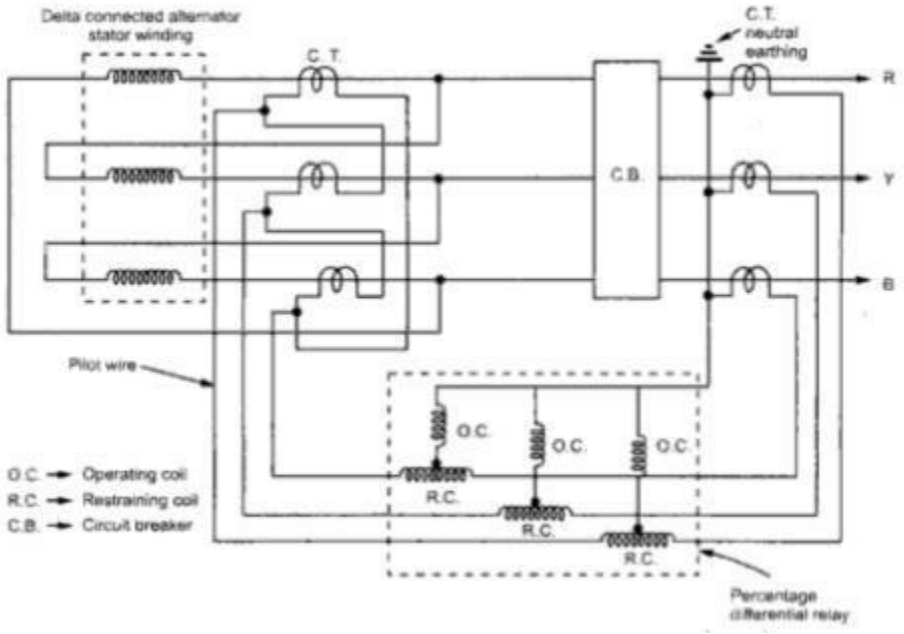


UNIT 4
GENERATOR AND TRANSFORMER PROTECTION

Biased Differential scheme (Merz-Price Scheme) protection of Generators



Delta connected alternator stator winding



Kinds of Faults Generators are Subjected to:

- **Due to problems within generator**
- **Stator ground faults**
- **Stator phase faults**
- **Stator inter-turn faults**
- **Rotor ground faults**
- **Duplicate ground faults**

Due to external conditions

- Asymmetric faults
- Stator overload
- Rotor overload
- Over-voltage
- Under-frequency
- Motoring

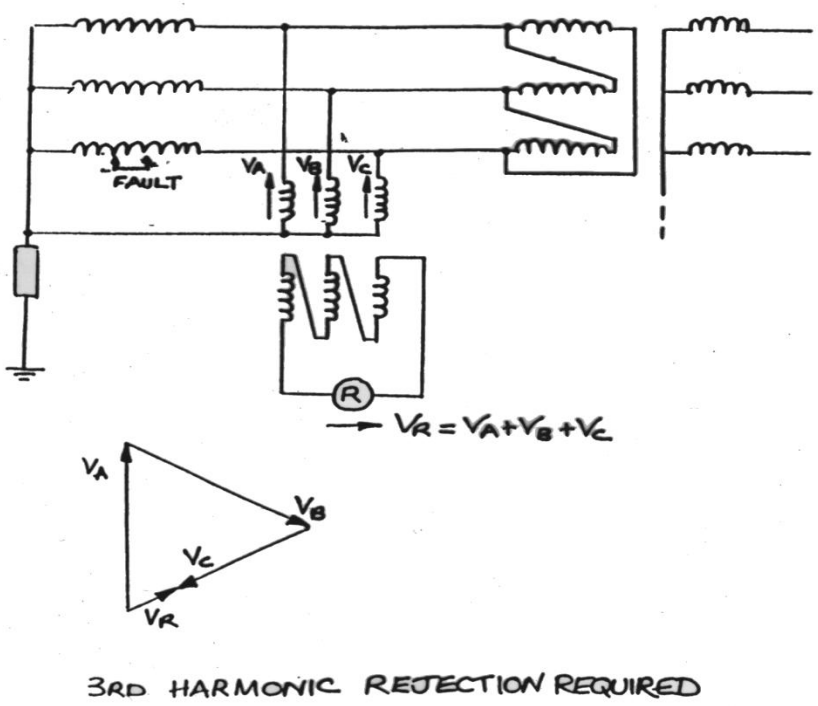
Stator Ground Fault Protection

- One of the most frequent internal generator faults
- Fault current will depend on the method of grounding
- High fault currents will cause damage to the core

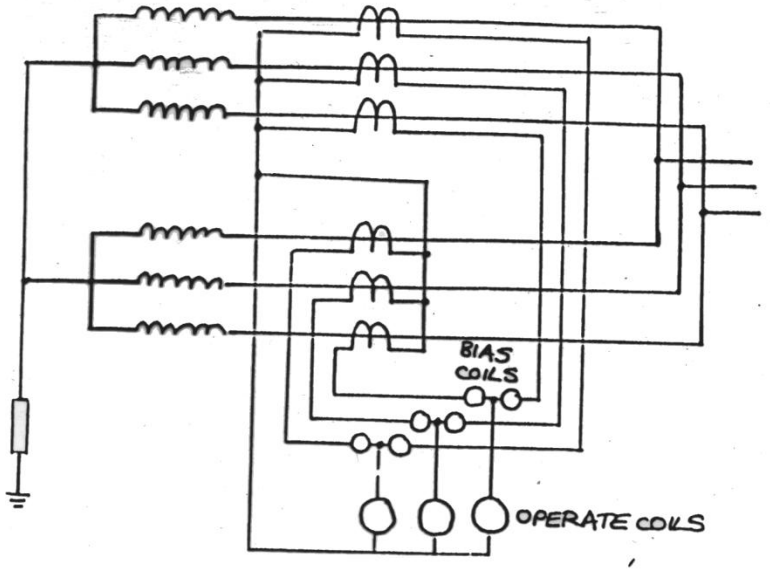
Methods of Limiting Erath Fault Currents

- Resistance earthing
- Distribution Transformer earthing

Stator Interturn Protection



3RD HARMONIC REJECTION REQUIRED



Stator Phase Fault Protection

- Differential protection
  - High impedance method
  - Biased differential protection

- Overall differential protection

  Biased differential protection

UNIT 5
PROTECTION AGAINST OVER VOLTAGES

Causes for Voltage Surge

- **Internal Causes : Switching Surges**
  - **Sudden interruption of a loaded line under short circuit conditions**
  - **Switching in of an Unloaded transmission line**
  - **Arcing Grounds**
  - **Interruption of capacitive**

Causes for Voltage Surge

- External Causes: Lightning
  - Due to Direct Stroke
  - Due to Induced

Co-ordination of Insulation in a Sub-station

- Transmission Line Insulation Level
- Approach Towers Insulation Level
- Transformer, Switchgear Insulation Level
- Lightning Arresters Insulation Level
- Transformer bushing road gap

Basic Impulse Levels

- 11 KV, 75KV peak impulse strength
- 33 KV, 170KV peak impulse strength
- 132 KV, 650KV peak impulse strength
- 220 KV, 1050KV peak impulse strength
- 400 KV, 1550KV peak impulse

Lightning Protection

Facts about Lightning

- A strike can average 100 million volts of electricity
- Current of up to 100,000 amperes
- Can generate 54,000 ^{o}F
- Lightning strikes somewhere on the Earth every second
- Kills 100 US residents per year

Lightning Doesn’t Go Straight Down

Four Main Features of Lightning Protection

- 1) Air terminal
- 2) Conductors
- 3) Ground termination
- 4) Surge protection

Surge Protection Is A Must