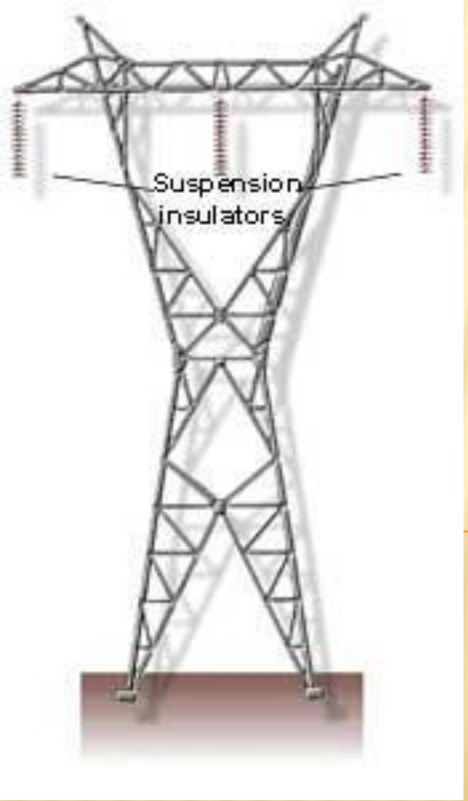
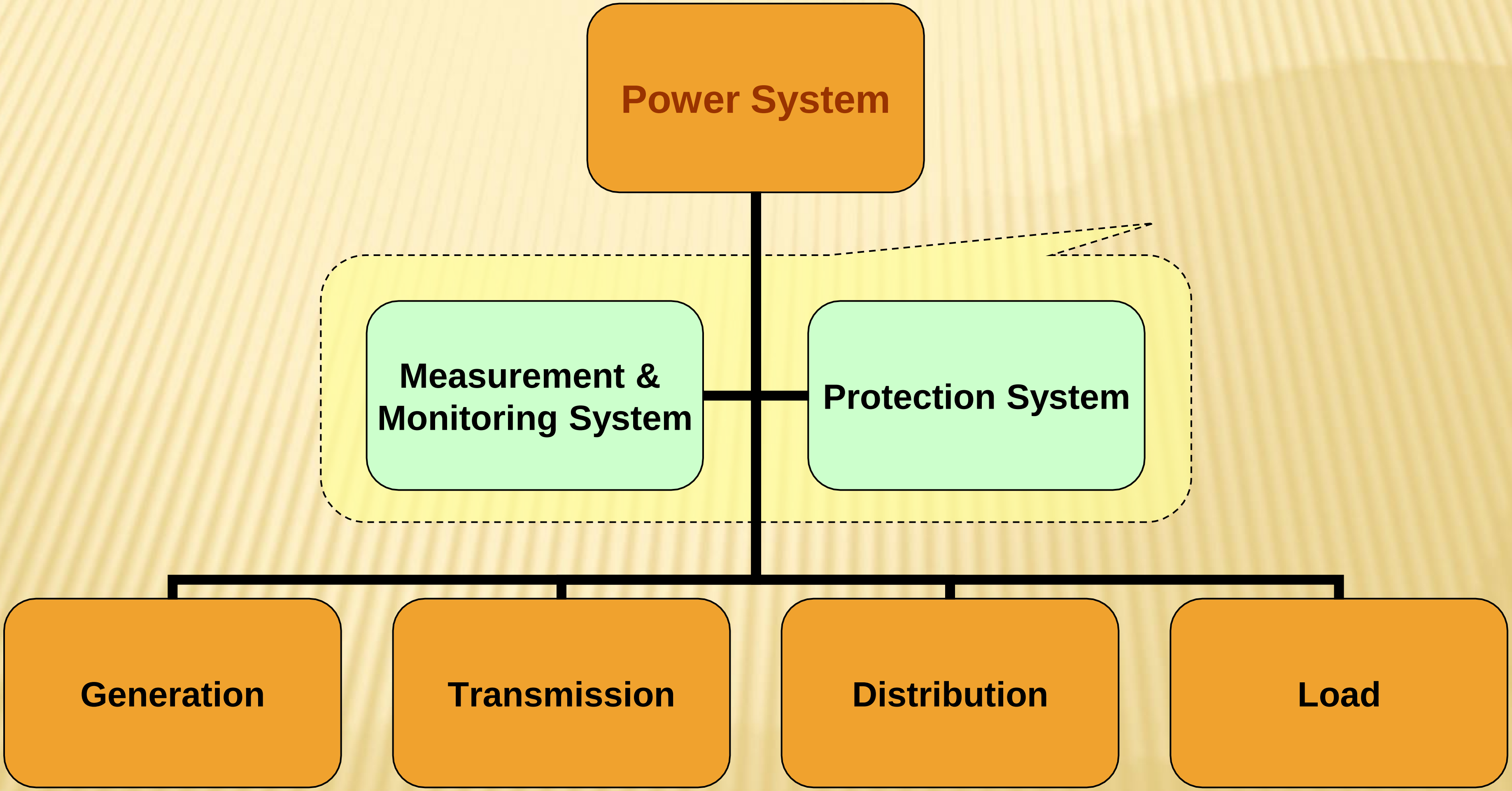
K.S.JHA CI/ELECTRICAL

ELECTRICAL INFRASTRUCTURE




Power System
Measurement & Monitoring System
Protection System
Generation
Transmission
Distribution
Load

POWER SYSTEM

- It should be

1. Reliable
2. Strong
3. Flexible

SUB-STATION

- A substation is a part of an electrical generation, transmission and distribution system. The assembly of apparatus used to change some characteristics (e.g. voltage, frequency, p.f., A.C. to D.C. etc.) of an electrical supply is called a substation.

Some of the main operations of substations are:

☐ To receive energy transmitted at high voltage from the generating stations.

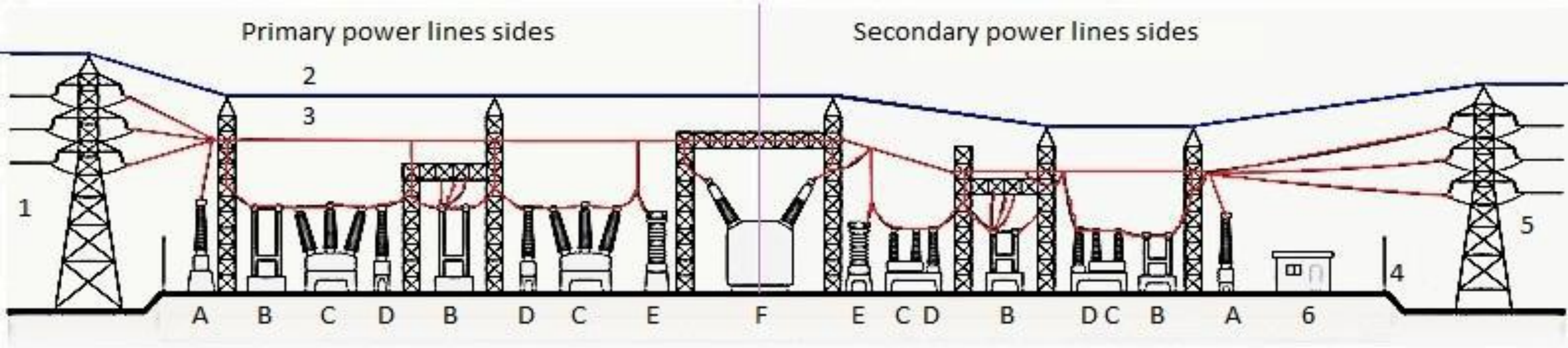
☐ To decrease the voltage to a value appropriate for local distribution.

☐ To provide switching facilities.

Electric power may flow through several substations between generating plant and consumer, and its voltage may change in several steps.

- Generation, Transmission & Distribution
- Switchgears
- Safety
- Metering & Monitoring

ELEMENTS OF SUBSTATION



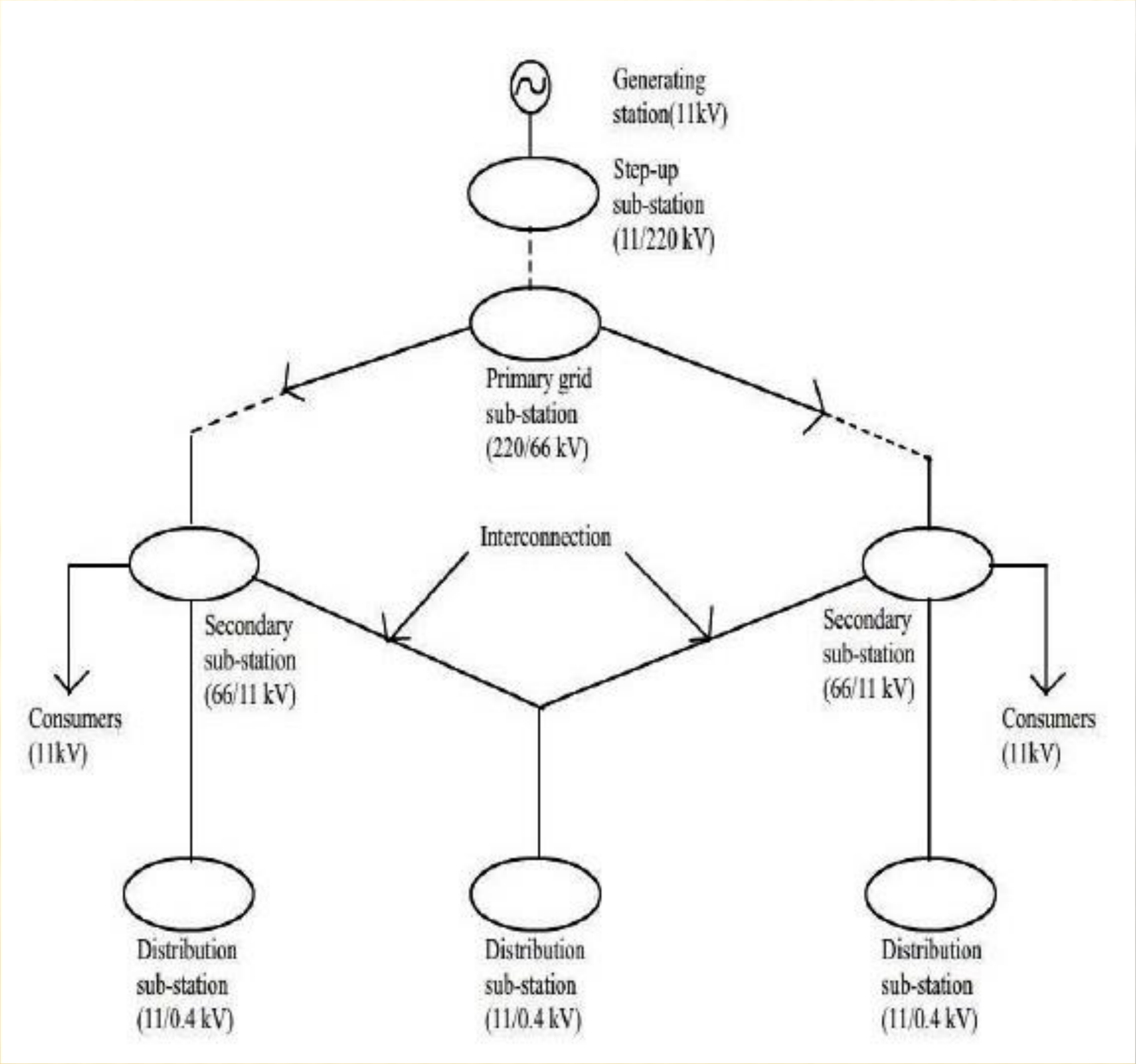
Side view of Electrical Substation

Description:

1 - Primary power lines
2 - Ground wire
3 - Overhead lines
4 - Security fence
5 - Secondary power lines
6 - Control building

A - Transformer for measurement of electric voltage
B - Disconnect switch
C - Circuit breaker
D - Current transformer
E - Lightning arrester
F - Main transformer

Note: Purple line indicates an imaginary seperation between primary power line sides and secondary power line sides.

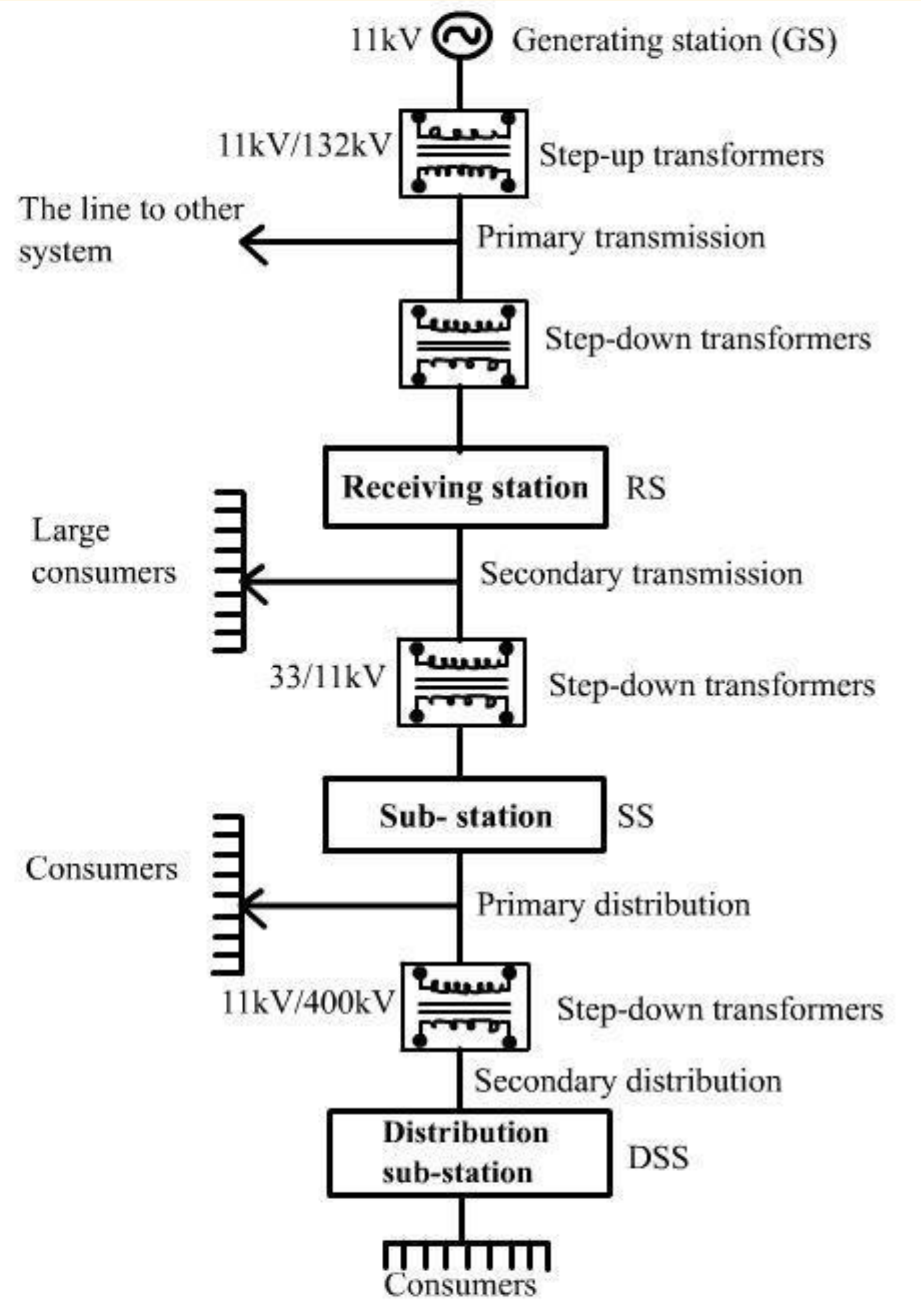

Generating station(11kV)
Step-up sub-station (11/220 kV)
Primary grid sub-station (220/66 kV)
Interconnection
Secondary sub-station (66/11 kV)
Secondary sub-station (66/11 kV)
Consumers (11kV)
Consumers (11kV)
Distribution sub-station (11/0.4 kV)
Distribution sub-station (11/0.4 kV)
Distribution sub-station (11/0.4 kV)

TRANSMISSION AND DISTRIBUTION OF ELECT. POWER

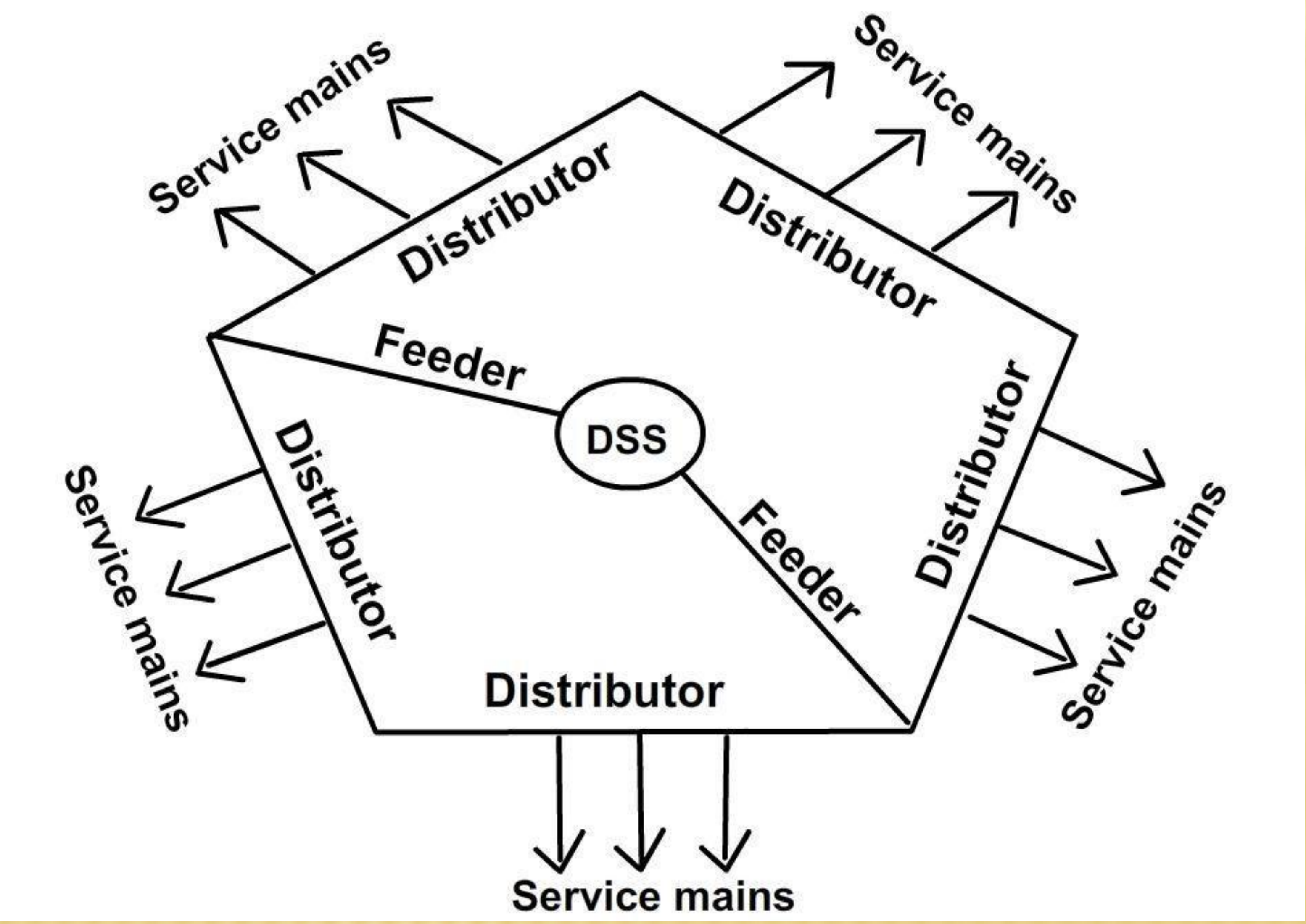
- By transmission and distribution of electrical power is meant its conveyance from the central station where it is generated to the places where it is demanded by the consumers (like pumping stations, residential and commercial buildings, mills, factories etc.)

The maximum generated voltage in India is 11kV.

- The amount of power that has to be transmitted through transmission lines is very large and of this power is transmitted at 11kV (or 33kV) *the line current and power loss would be very large. Therefore this voltage is stepped up to a higher value by using step up transformers located in sub-stations.*
- The transmission voltages in India are 400 kV, 220 kV and 132 kV.
- The transmission lines and feeders are 3-phase 3-wire circuits.
- The distributors are 3-phase 4-wire circuits because a neutral wire is necessary to supply the single-phase loads of domestic and commercial consumers.
- *The transmission network is commonly known as Grid.*


11kV
Generating station (GS)
11kV/132kV
Step-up transformers
The line to other system
Primary transmission
Step-down transformers
Receiving station
RS
Large consumers
Secondary transmission
33/11kV
Step-down transformers
Sub- station
SS
Consumers
Primary distribution
11kV/400kV
Step-down transformers
Secondary distribution
Distribution sub-station
DSS
Consumers

LOW VOLTAGE DISTRIBUTION SYSTEM



SECONDARY DISTRIBUTION

- *Feeders: These are line conductors which connect the stations to the areas, to be fed by those stations. Normally no tapping are taken from feeders. They are designed mainly from point of their current carrying capacities.*
- *Distributors: These are conductors from which several tappings for the supply to the consumers are taken. They are designed from the point of view of the voltage drop in them.*
- *Service mains: These are the terminals which connect the consumer's terminals to the distributors.*

CLASSIFICATION OF TRANSMISSION LINES

- Short transmission lines
  - ☐ Length less than 50km
  - ☐ Operating voltage less than 20kV.

- Medium transmission lines
  - ☐ Length between 50km and 160km.
  - ☐ Operating voltage is between 21kV and 100kV.

- Long transmission lines
  - ☐ Length more than 160km.
  - ☐ Operating voltage is above 100kV.

BUS BAR

- In electrical power distribution, a bus bar is a strip of *copper or aluminium that conducts electricity within a switchboard, distribution board, substation or other electrical apparatus.*
- The size of the bus bar determines the maximum amount of current that can be safely carried. Bus bars can have a cross-sectional area of as little as 10 mm2 but electrical substations may use metal tubes of 50 mm in diameter (1,963 mm2) or more as bus bars.
- Bus bars are typically either flat strips or hollow tubes as these shapes allow heat to dissipate more efficiently due to their high surface area to cross-sectional area ratio.

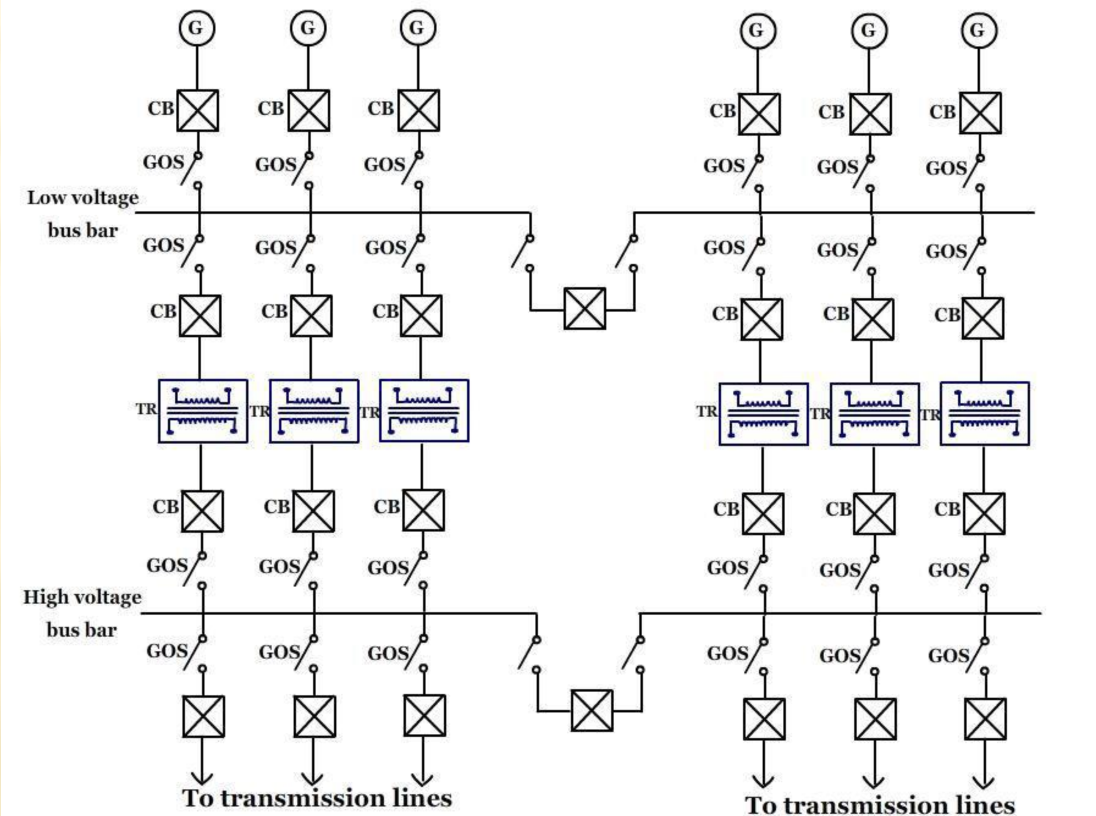
BUSBAR

BUS-BAR ARRANGEMENTS:

- Single bus-bar system.
- Double bus-bar system.

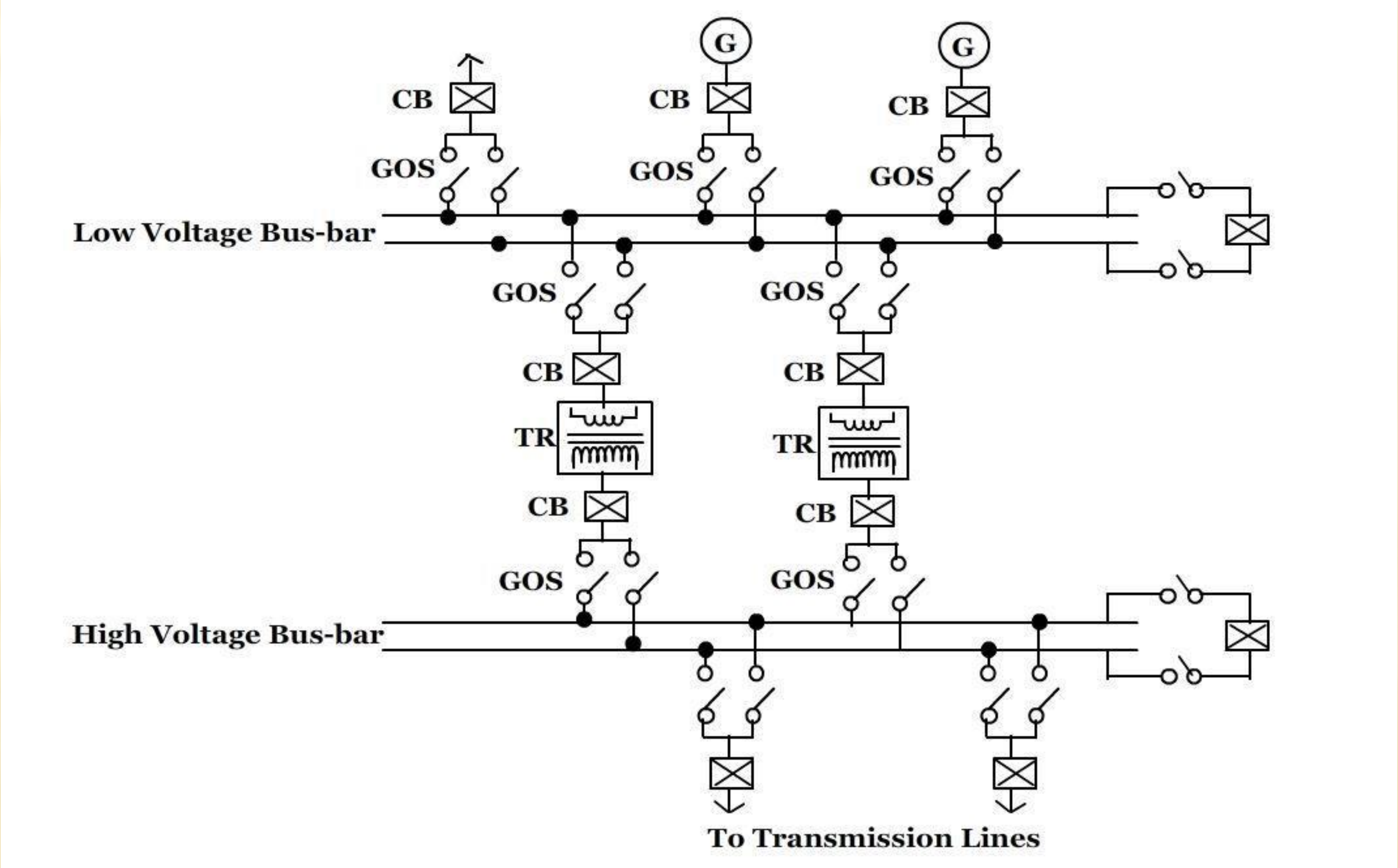
SINGLE BUS-BAR SYSTEM:

- A power plant which has number of generators and single bus-bar arrangement, the bus-bar is sectionalised by circuit breakers. The advantage of this type of system is that fault on one part of the bus-bar or system does not completely shut down the whole station.



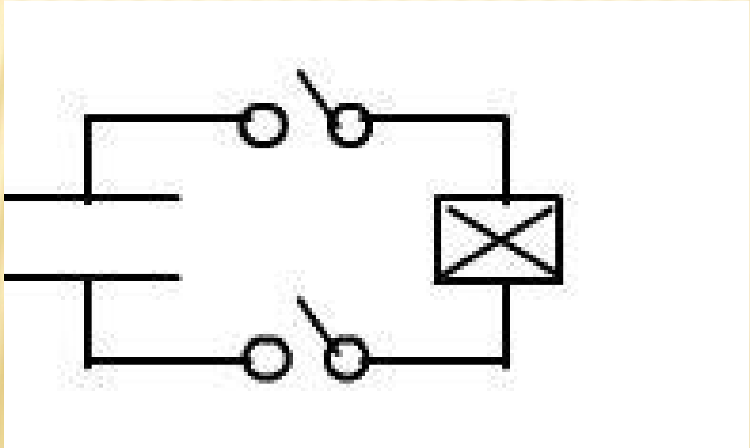
DOUBLE BUS-BAR SYSTEM WITH SECTIONALISATION

- In this system both low voltage and voltage bus-bars are duplicated, any of the bus-bar sections can be used as desired. There is a provision of a *bus-bar coupling switch for transferring operation from one bus-bar to another.*



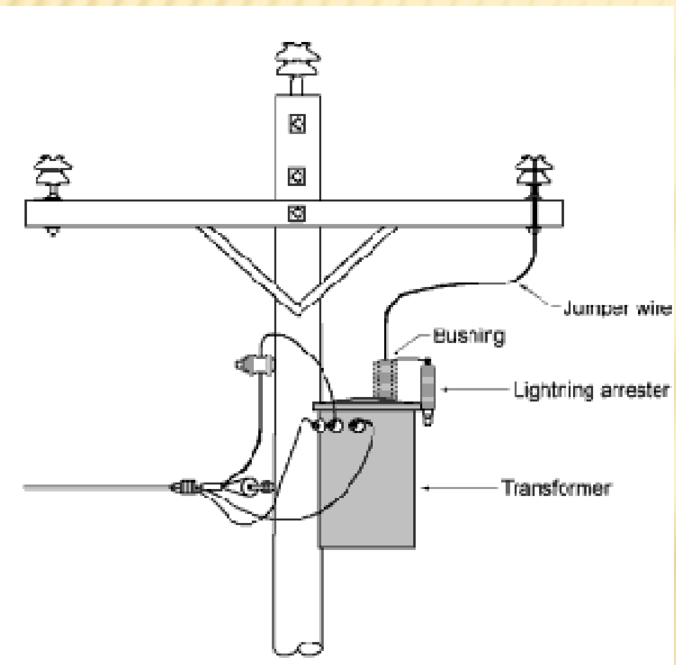
BUS COUPLER

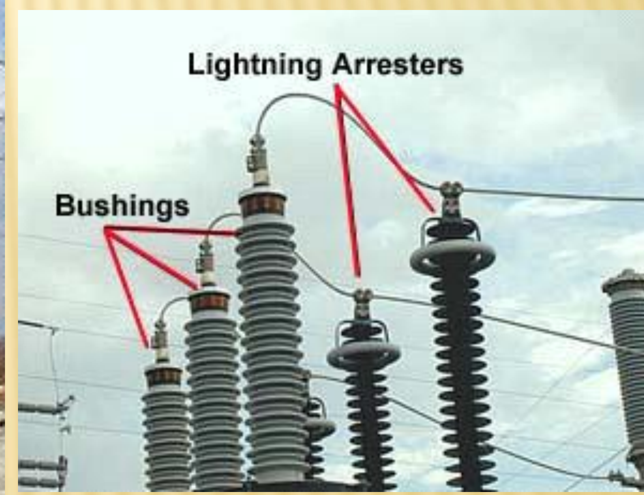
- Bus coupler is a device which is used switch from one bus to the other without any interruption in power supply and without creating hazardous arcs. It is achieved with the help of circuit breaker and isolators.



LIGHTNING ARRESTER

- Lightning arresters are protective devices for limiting surge voltages due to lightning strikes or equipment faults or other events, to prevent damage to equipment and disruption of service. Also called surge arresters.

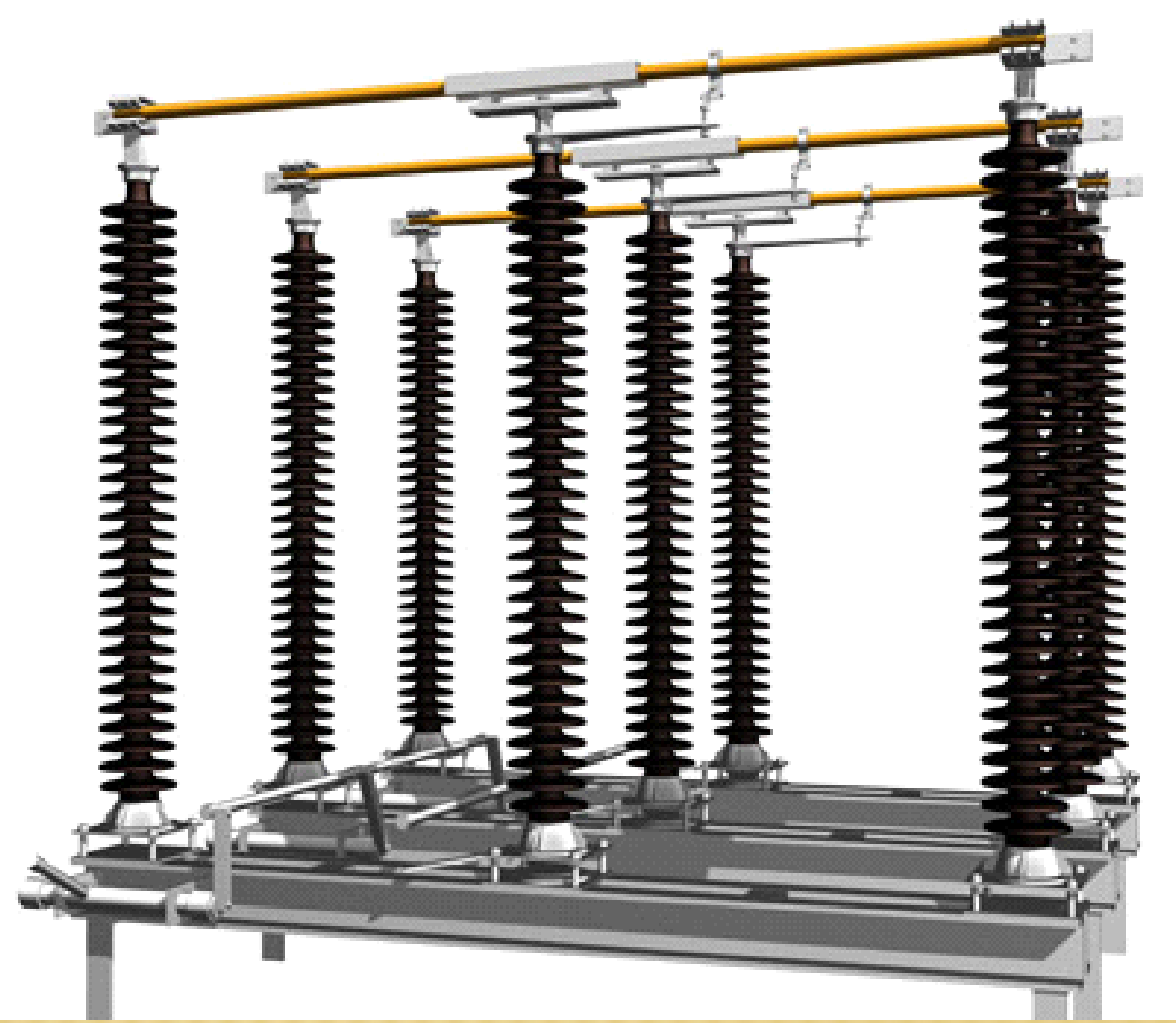




ISOLATOR SWITCH (GROUP/GANG OPERATED SWITCHES)

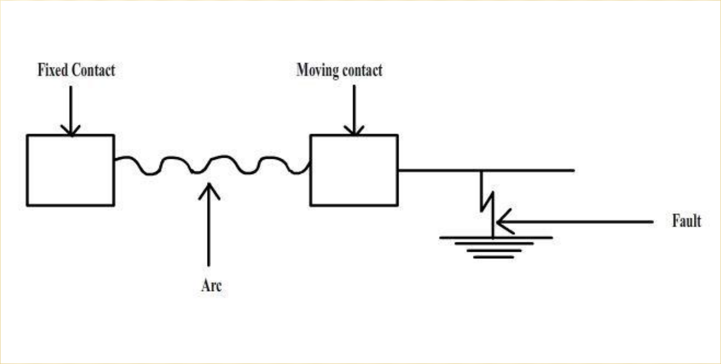
- Isolators are known as disconnector or isolator switch. Isolator is used to make sure that an electrical circuit can be completely de-energized for service or maintenance.
- In some designs the isolator switch has the additional ability to earth the isolated circuit thereby providing additional safety. Such an arrangement would apply to circuits which inter-connect power distribution systems where both end of the circuit need to be isolated.
- When the isolator is opened, it can be visually seen and hence service men are assured that is safe to work on the isolated equipment.

GROUP/GANG OPERATED SWITCHES



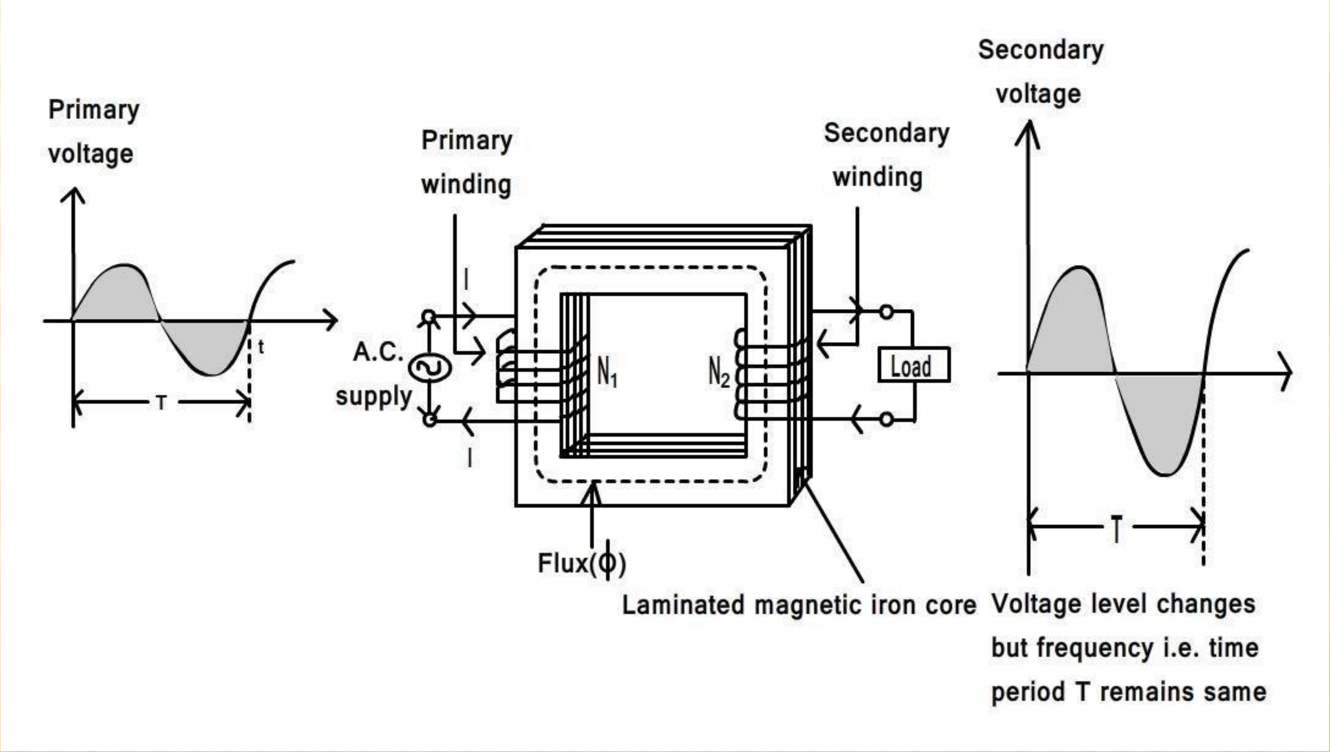
CIRCUIT BREAKERS

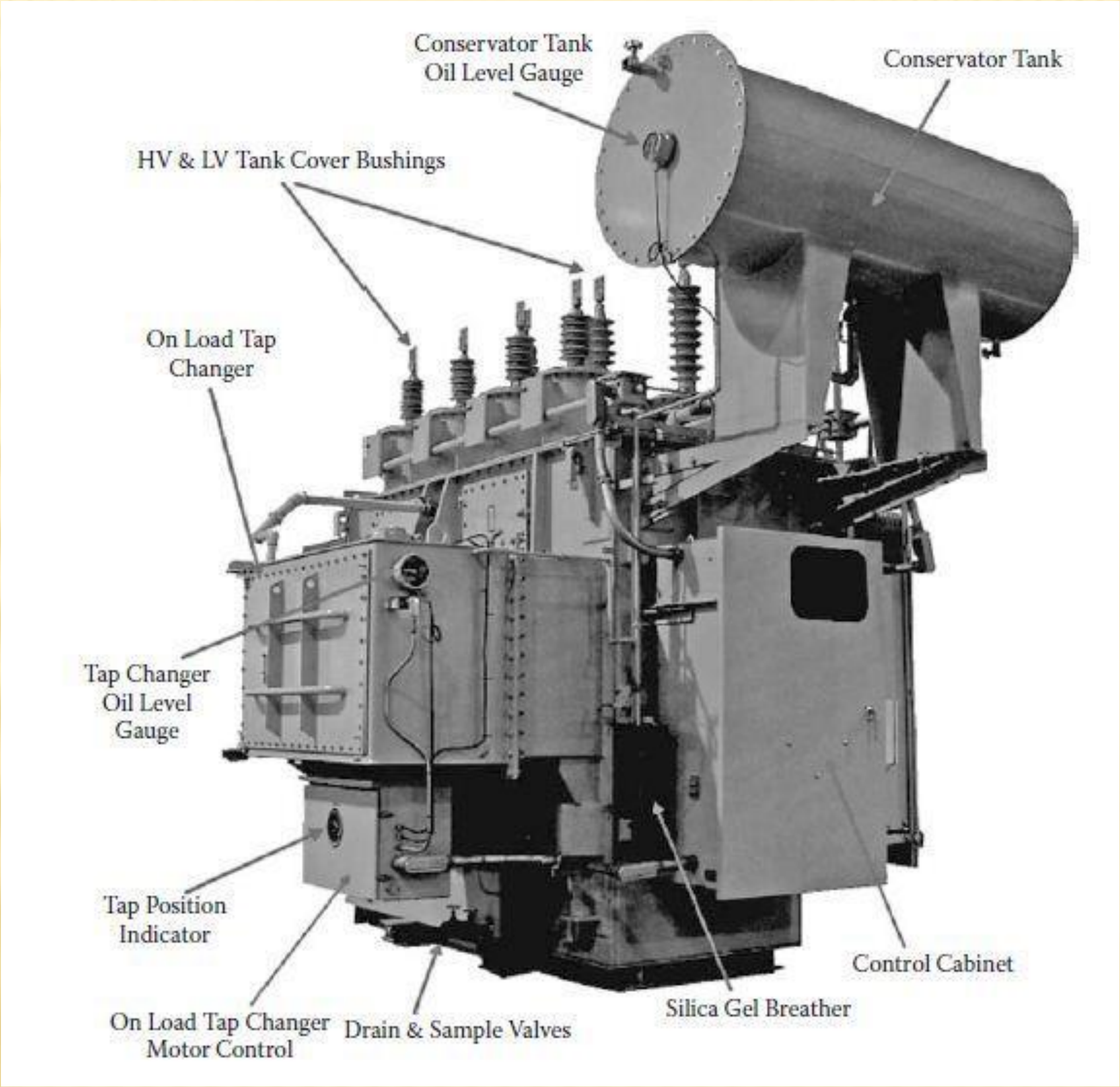
- A circuit breaker is an automatically operated electrical switch designed for to protect an electrical circuit from damage caused by overload or short circuit.
- the function of a circuit breaker is to isolate the faulty part of the power system in case of abnormal conditions.
- A protective relay detects abnormal conditions and sends a tripping signal to the circuit breaker. After receiving the trip command signal from the relay the circuit breaker isolates the faulty part of the power system.
- A circuit breaker has two contacts- a fixed contact and a moving contact. Under normal conditions these two contacts remain in closed position. When the circuit breaker is required to isolate the faulty part, the moving contact moves to interrupt the circuit.



TRANSFORMERS

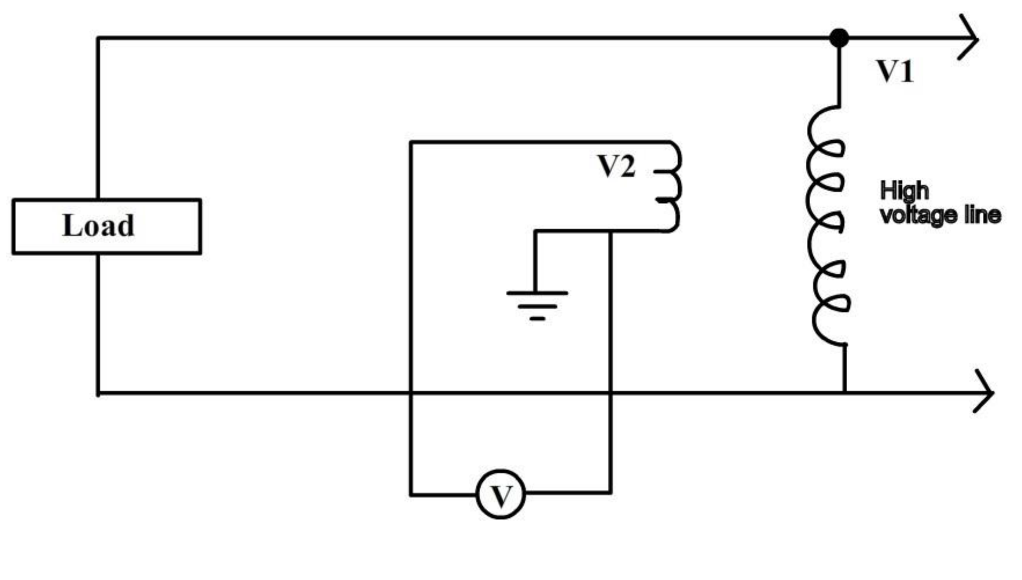
- The transformer is a static piece of apparatus by means of which an electrical power is transferred from one alternating current circuit to another with the desired change in voltage and current without any change in frequency.




Conservator Tank
Oil Level Gauge
Conservator Tank
HV & LV Tank Cover Bushings
On Load Tap
Changer
Tap Changer
Oil Level
Gauge
Tap Position
Indicator
Control Cabinet
Silica Gel Breather
On Load Tap Changer
Motor Control
Drain & Sample Valves

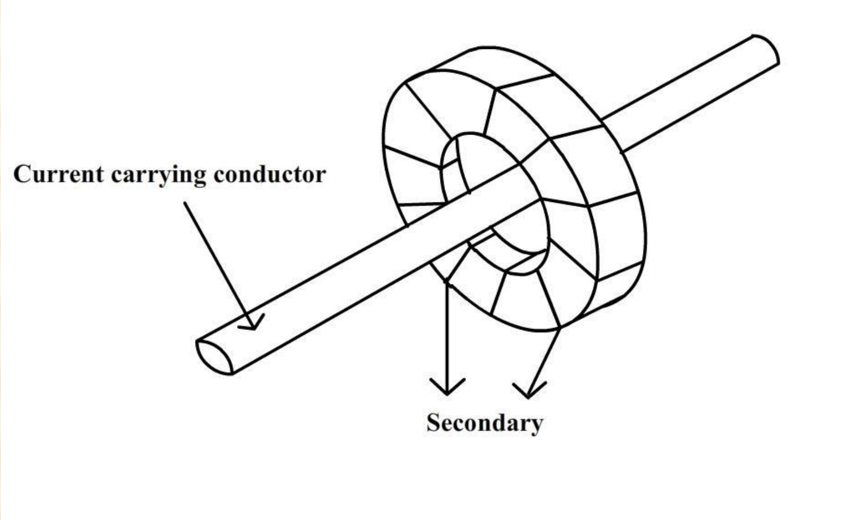
INSTRUMENT TRANSFORMERS

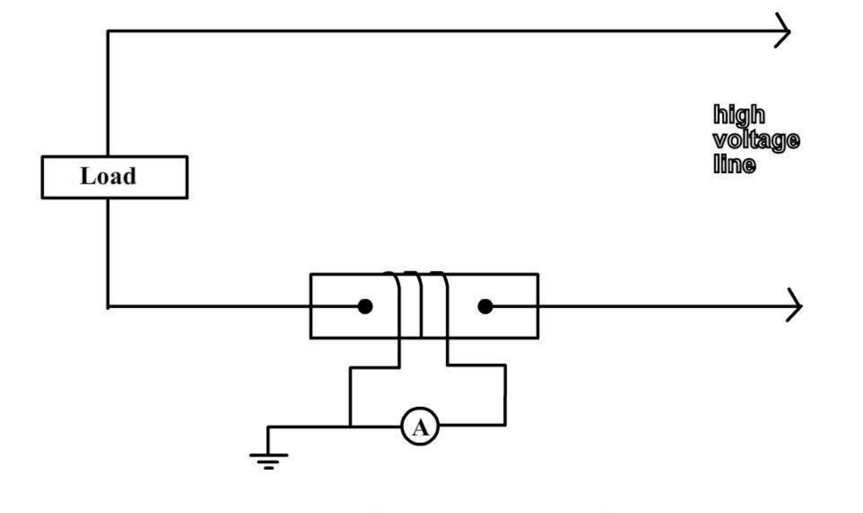
- Potential transformers(P.T.): is a step down transformer used along with a low range voltmeter for measuring a high voltage. The primary is connected across the high voltage supply and the secondary to the voltmeter or potential coil of the wattmeter.



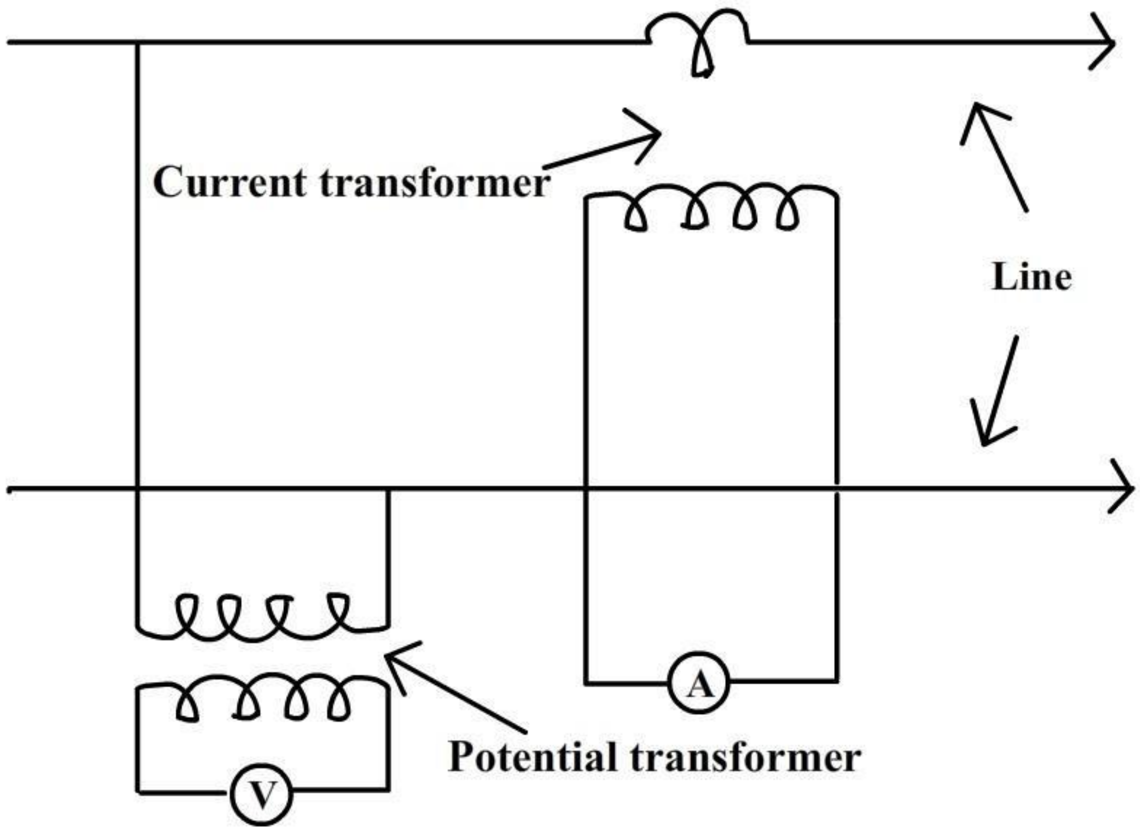
Connection of potential transformer

- Current transformers: The range of the D.C. ammeter is extended using a shunt, similarly a current transformer performs the same function in A.C. circuits. Thus a high magnitude A.C. can be measured by a combination of current transformer and a low range ammeter.





Current transformer connection



Wiring diagrams for potential and current instrument transformer

DISTRIBUTION SUB-STATION

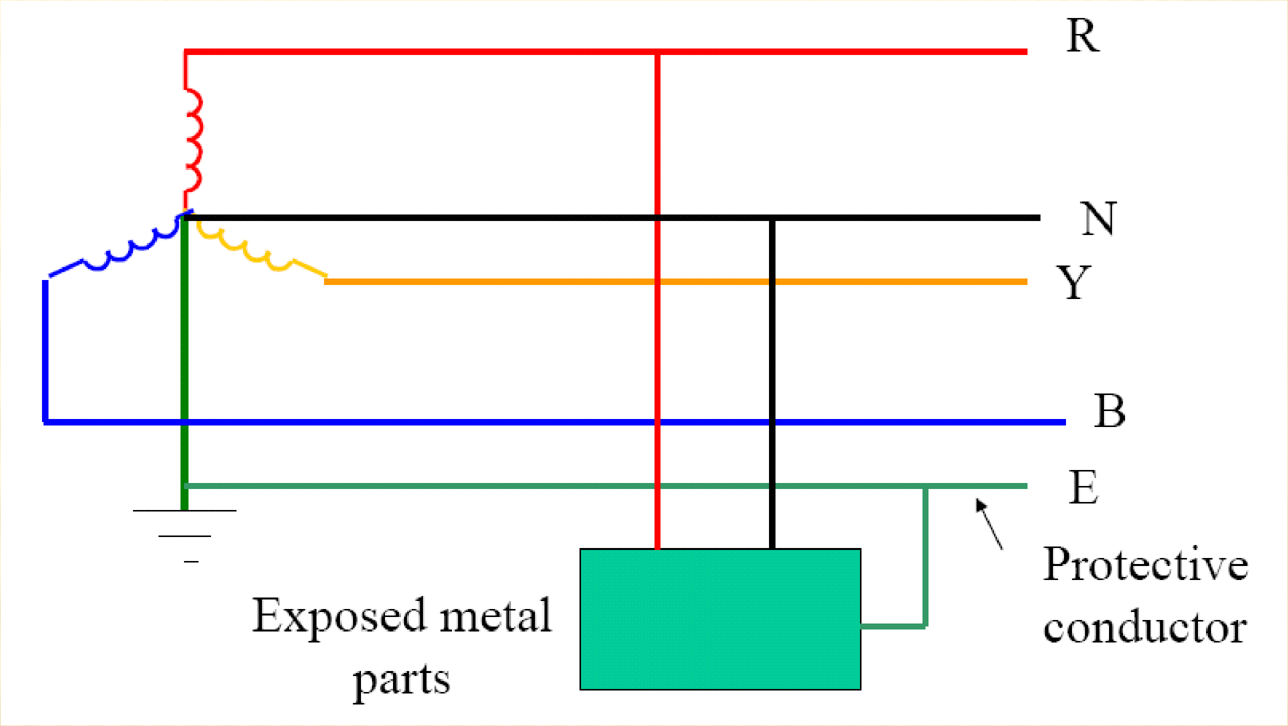
- Distribution Substations (33kV, 11kV)
  - Indoor substation
  - Outdoor substation
  - Pole mounted substation
  - Compact substation
  - Underground substation
- Transformer capacity
  - 100kVA, 300kVA, 500kVA, 750kVA and 1000kVA

LOCAL DISTRIBUTION

- Could be 3-phase and 1-phase:

3-phase for industrial;

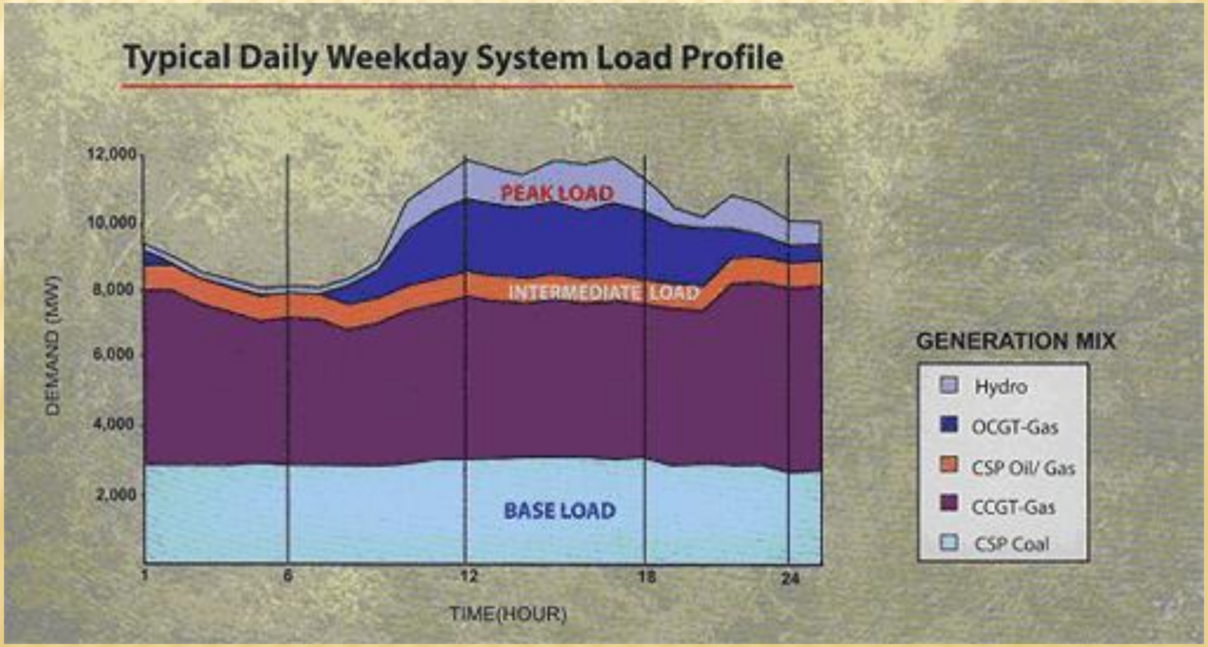
1-phase for domestic & small sector



LOAD DURATION CURVE

3 types of load

- Base load -- has to be fed 100% of the time.
- Intermediate loads - have to be fed <100% of the time.
- Peak load - May occur 0.1% of the time.

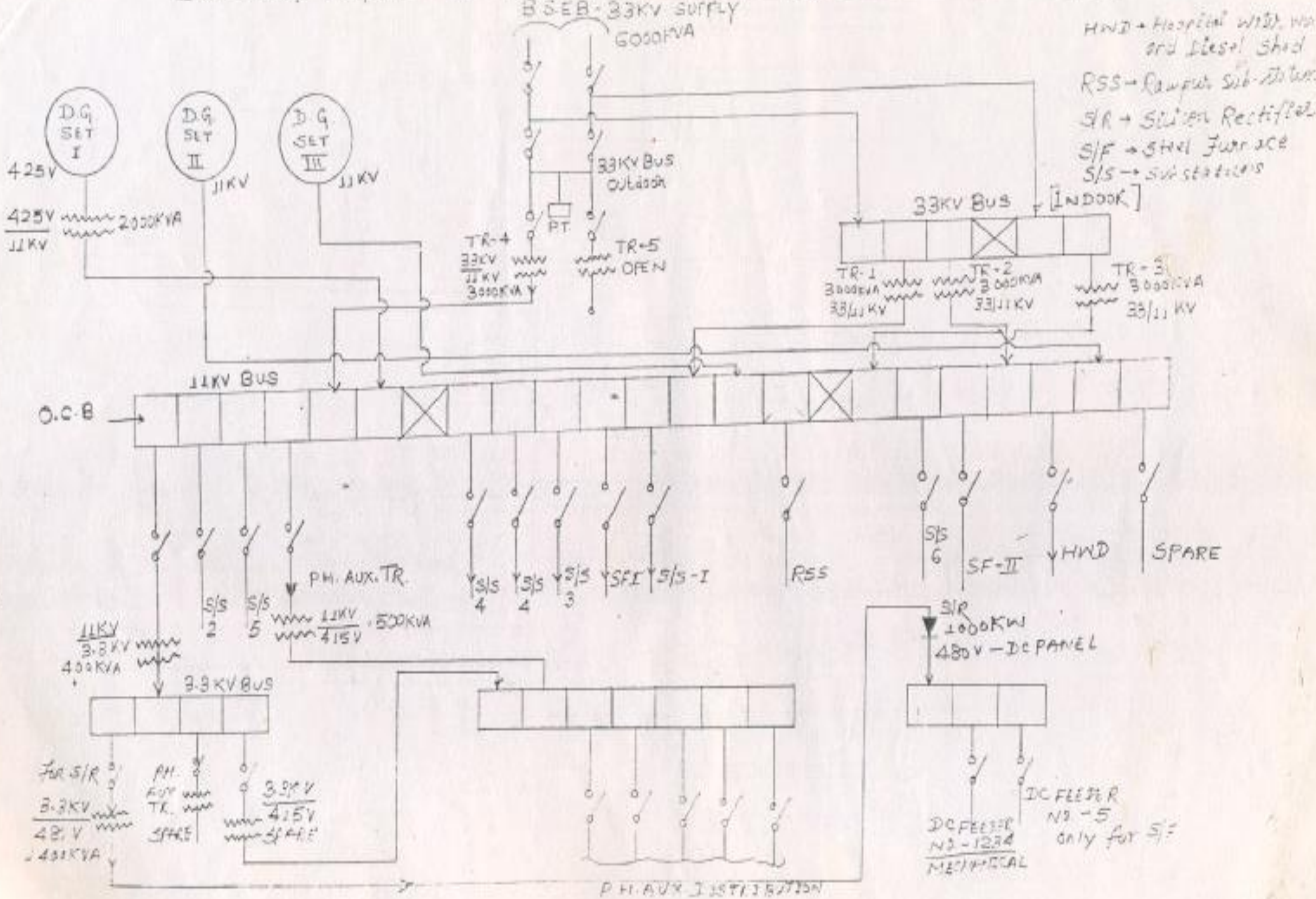


JAMALPUR WORKSHOP

POWER SUPPLY ARRANGEMENT

- The contract demand from BSEB is 6MVA at 33KV.
- The receiving point located inside JMP workshop is also known as "Power House"
- 33KV supply is stepped down to 11KV by 3MVA transformer. 04 such transformer are employed for this purpose.
- This Power House is having 3 DG Sets having 2MVA capacity each.
- 2 DG Set generates 11 KV and 1 DG Set generates 415V.
- 415 V is then stepped up to 11 KV by Transformer.
- The 11 KV supply from DG sets & 415V/11KV transformer are connected to 11 KV Bus bars

EXISTING LAYOUT OF JAMALPUR POWER HOUSE



STD. METERING AT SUBSTATION

- Ammeter & Voltmeter with selector switch for transformer.
- MW, MVA & MVAR meters on HV side of transformer
- KV meter on HV & LV panels.
- KWH meter on control panel
- Ammeter & Voltmeter on feeder panel
- KWH meter on feeder panel

SWITCHGEARS

Basic Function:

- Electrical Protection –

1. Against Overload currents
2. Against Short Circuit currents
3. Against Insulation failures
4. Against Under – Voltage (Specific devices)

- Safe Isolation from live parts
- Locally/Manually or Remote switching

ELECTRICAL PROTECTION

- Protection of circuit elements against the thermal and mechanical stresses of short – circuit currents
- Protection of appliances and apparatus being supplied (motor etc.)
- Protection of operating personnel & person and animals in the event of insulation failure.

ISOLATION

- A state of isolation clearly indicated by an approved “fail proof” indicator, or the visible separation of contacts.
- An isolating devices must fulfill the following requirements:

1. All poles of a circuit including neutral must be open
2. It must be provided with a means of locking open with key
3. I must confirm IEC 947-3 concerning clearance between contacts, over voltage withstand capability etc.

A PROTECTIVE DEVICE MUST POSSES THE FOLLOWING CHARACTERISTICS:

- 1.**Reliability** – must operate under abnormal conditions.
- 2.**Discrimination** – should not have any adverse effect on the other devices protecting healthy circuits.
- **3.Non – destructive** – must retain its original characteristics throughout its life.
- **4.Adequate breaking/rupturing capacity** – able to clear the fault without any damage to itself.

FUSE

- It is over current protection device.
- It has critical component a metal wire or strip that will melt when heated by a prescribed electric current.
- Properly-selected fuses are part of a power distribution system to prevent fire or damage due to overload or short-circuits.
- It has a Inverse time-current characteristic which shows the time required to melt the fuse and the time required to clear the circuit for any given level of overload current

FUSE CHARACTERISTICS

- It has the "Inverse Current-Time Characteristics:

- Current
- Time
- Fusing Factor =Minimum fusing current/Rated current
- It will always greater than 1 (1.9 to 2);For 5 Amp.fuse
- Re wirewable fuse operates at 5x1.9 =9.5 Amp.

CIRCUIT BREAKER

- It is an automatically-operated electrical switch which is designed to protect an electrical circuit from damage caused by overload or short circuit, Over & Under voltage, Unbalanced load, Earth faults, reverse current or any other abnormal operating conditions.
- It can be reset (either manually or automatically) to resume normal operation.

METHODS OF OPERATION

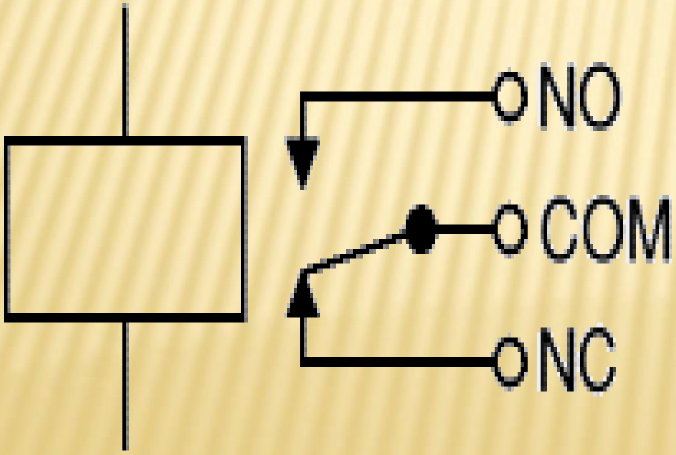
- Dependent Manual Operation – Using manual energy directly.
- Dependent Power Operation – Energy of a solenoid, electric motor or compressed air.
- Stored Energy Operation – mechanical energy stored in the mechanism prior to the completion of the operation.
- Independent Manual Operation – A stored energy operation where the energy originates from manual power stored and released in one continuous operation.

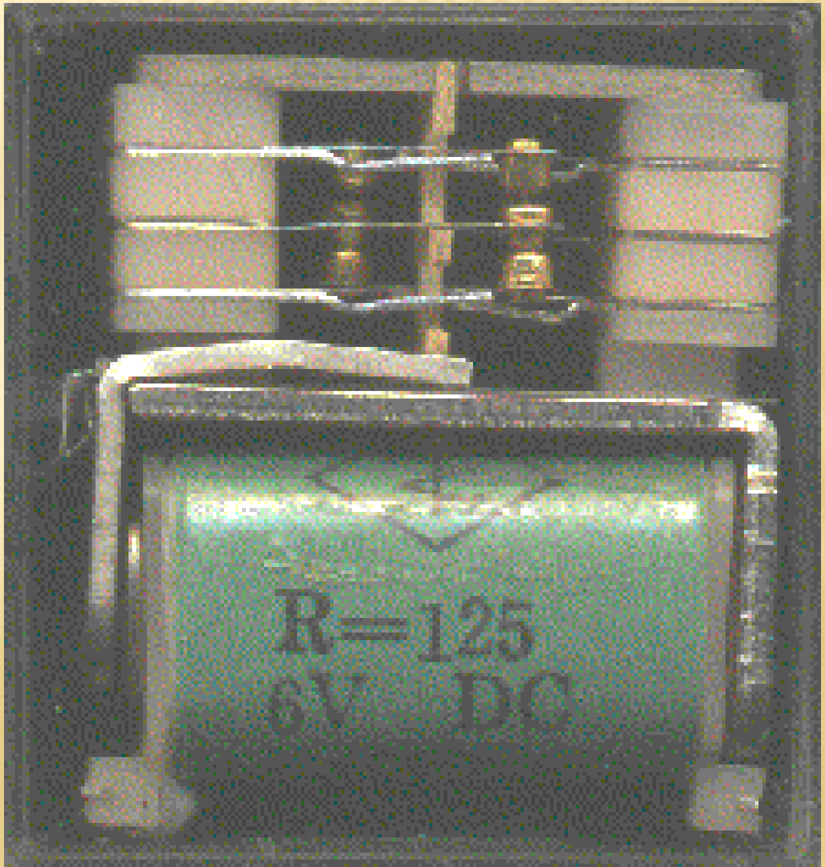
AUTO – RECLOSURE CIRCUIT BREAKER

- The arrangement to open the circuit instantaneously when a fault occurs and reclose it automatically after about a second and repeat the operation once more if the fault persists.
- It is designed to clear non – persistent faults:
  1.Lighting flashovers of line insulators.
  2.Momentary contact of two conductors due to high wind.
  3.Stray piece of wire dropped by a bird.
  4.Momentarily contact with tree branches.
  5.Other transient nature conditions.

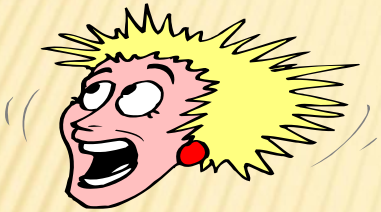
ELECTRICAL RELAY

- A *solenoid* is a device that produces mechanical motion from the energization of an electromagnet coil. The movable portion of a solenoid is called an *armature*.
- A *relay* is a solenoid set up to actuate switch contacts when its coil is energized.

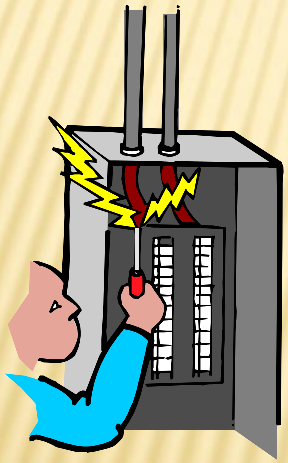




HAZARDS OF ELECTRICITY



SHOCK



ARC

BLAST

DANGERS OF ELECTRICAL SHOCK

- Currents above 10 mA can paralyze or "freeze" muscles.
- Currents more than 75 mA can cause a rapid, ineffective heartbeat -- death will occur in a few minutes unless a defibrillator is used

Electrical Burns

- Most common shock-related, nonfatal injury
- Occurs when you touch electrical wiring or equipment that is improperly used or maintained
- Typically occurs on the hands
- Very serious injury that needs immediate attention

ELECTRICAL BLAST

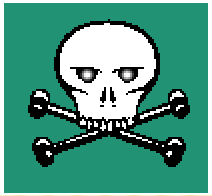
- Fire/Blast where electricity could be the source of ignition in a potentially flammable or explosive atmosphere. The temperature can reach 35,000°F - this is *four times hotter than the surface of the sun.*
- *Fatal burns can occur at distances over 10 ft.*

CONTROLLING ELECTRICAL HAZARDS

- **Most electrical mishaps are caused by a combination of three factors:**
  - Unsafe work practices
  - Unsafe equipment and/or installation,
  - Workplaces made unsafe by the environment

UNSAFE WORK PRACTICES

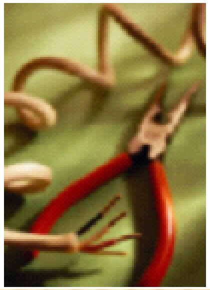
- Failure to de-energize, lockout and tagout hazards during maintenance, repair or inspections
- Use of defective and unsafe tools
- Removing the third prong (ground pin) to make a 3-prong plug fit a 2-prong outlet
- Overloading outlets with too many appliances



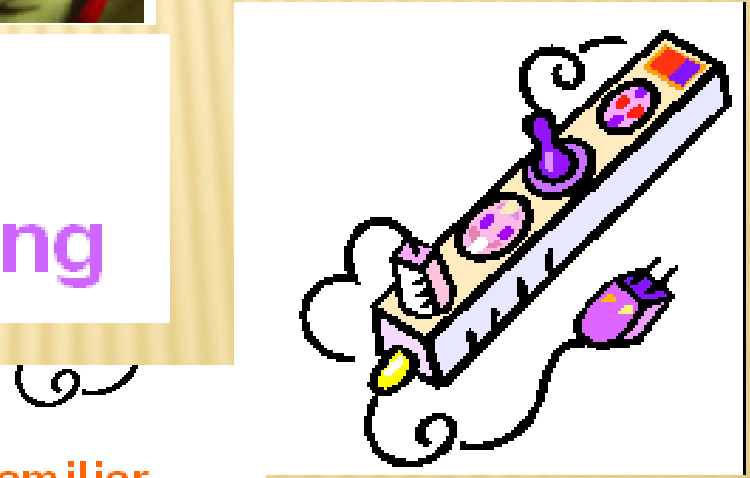
- Failure to read and follow all safety signs, symbols and barriers
- Failure to use good housekeeping with respect to tools and work areas

UNSAFE EQUIPMENT

- Un-inspected electrical tools
- Un-inspected portable extension cords
- Improper grounding (removal of third prong)
- Defective parts



- Overloaded outlets
- Faulty electric cording



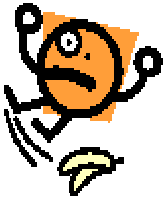
Caution:

- ✓ Be extremely careful around unfamiliar equipment and areas.
- ✓ Inspect all equipment, cords, switches, and components prior to each use.

UNSAFE ENVIRONMENTS

- Flammable fumes, combustible dust , or excess oxygen can be ignited by a spark. (*Use ventilation to minimize hazard.*)
- Poor housekeeping: blocked electrical boxes, flammable materials stored in equipment rooms, lack of proper hazard signs, excess clutter

- **Wet working conditions:** Never work with electricity if you or the work area have been exposed to wet weather.
- **Check your surroundings:**
  - Make sure energized electrical parts cannot come in contact with you or anything that may come in contact with you.
  - Make sure there are no trip hazards.



Hazards

- Inadequate wiring
- Exposed electrical parts
- Wires with bad insulation
- Ungrounded electrical systems and tools
- Overloaded circuits
- Damaged power tools and equipment
- Using the wrong PPE and tools
- Overhead power lines
- All hazards are made worse in wet conditions

Protective Measures

- Proper grounding
- Use fuses and circuit breakers
- Guard live parts
- Lockout/Tagout
- Proper use of flexible cords
- Close electric panels
- Training

ATTENTION

- Electrical equipment must be:
  - Listed and labeled
  - Free from hazards
  - Used in the proper manner
- If you use electrical tools you must be:
  - Protected from electrical shock
  - Provided necessary safety equipment

SIX WAYS OF PREVENTING ELECTRICAL SHOCK

- Be Safety Conscious
- Shut the Power Off
- Test the Circuit
- Use Insulated Ladders
- Wet Locations Precaution
- Observe Warning Labels

REMEMBER!

- The results of a mistake with electrical energy occur at the speed of light. There is not time to react after the error is made. You must think ahead.
- Pre-job briefs, planned work instructions, and facility requirements are not optional.
- Pay attention and obey all the rules, not just the ones that are convenient. They provide the edge you need to be safe with electrical energy.
- Post-job reviews help keep us from repeating errors – participate in them.
- You are responsible for your safety.

FINAL ADVICE

Treat electricity with the respect it demands, and it will serve you efficiently and effectively

WHY INSTALL A POWER MONITORING SYSTEM?

- There are many benefits to installing a power monitoring system — some of which strongly interrelate with each other. A properly designed and installed monitoring system offers a deeper understanding of the operational parameters of the facility's electrical system.

- *Environmental* — A better knowledge of how energy is used within a facility allows you to identify an array of prospects to improve efficiency, minimize waste, and reduce energy consumption, thereby allowing the facility to be a better steward of its allotted natural resources.
- *Reliability* — Assessment of data from the monitoring system can reveal existing or imminent issues that can adversely affect the operation and product within a facility. Historical data from power monitoring systems can help locate and correct both acute and chronic problems, resulting in increased productivity.
- *Maintenance* — Data trends can forecast and notify the appropriate people when discrete equipment parameters may be exceeded, allowing you to plan ahead instead of facing an unscheduled shutdown.
- *Safety* — Monitoring systems can limit the exposure of personnel to potentially hazardous electrical environments by providing remote status and operational parameters of equipment within hazardous areas. Some monitoring devices also offer a variety of additional parameters (temperature, pressure, flow rate, vibration, status indicators, etc.) through the use of transducers.
- *Financial* — Each benefit discussed above either directly or indirectly influences a business's bottom line. In most cases, the monetary impact from even one or two benefits can quickly justify the purchase and installation of a power monitoring system.

WHAT EQUIPMENT SHOULD BE INSTALLED?

- The three primary components of a power monitoring system include:
- 1) discrete metering devices to record data,
- 2) software to accumulate, manage, and display the data,
- 3) a communications interface between the software and metering devices.
- The monitoring system components should be compatible to ensure that the greatest benefits are realized from the system.

POWER SYSTEM AUTOMATION

- Data acquisition refers to acquiring, or collecting, data. This data is collected in the form of measured analog current or voltage values or the open or closed status of contact points. Acquired data can be used locally within the device collecting it, sent to another device in a substation, or sent from the substation to one or several databases for use by operators, engineers, planners, and administration.
- Supervision Computer processes and personnel supervise, or monitor, the conditions and status of the power system using this acquired data. Operators and engineers monitor the information remotely on computer displays and graphical wall displays or locally, at the device, on front-panel displays and laptop computers.
- Control refers to sending command messages to a device to operate the I&C and power system devices. Traditional supervisory control and data acquisition (SCADA - Supervisory Control and Data Acquisition) systems rely on operators to supervise the system and initiate commands from an operator console on the master computer. Field personnel can also control devices using front-panel push buttons or a laptop computer.

DATA ACQUISITION

- The instrument transformers with protective relays are used to sense the power system voltage and current. They are physically connected to power system apparatus and convert the actual power system signals. The transducers convert the analog output of an instrument transformer from one magnitude to another or from one value type to another, such as from an ac current to dc voltage. Also the input data is taken from the auxiliary contacts of switch gears and power system control equipment.
- Main processing instrumentation and control (I&C) device The I&C devices built using microprocessors are commonly referred to as intelligent electronic devices (IEDs). Microprocessors are single chip computers that allow the devices into which they are built to process data, accept commands, and communicate information like a computer. Automatic processes can be run in the IEDs. Some IEDs used in power system automation are:

Remote Terminal Unit (RTU)A remote terminal unit is an IED that can be installed in a remote location, and acts as a termination point for field contacts. A dedicated pair of copper conductors is used to sense every contact and transducer value. These conductors originate at the power system device, are installed in trenches or overhead cable trays, and are then terminated on panels within the RTU. The RTU can transfer collected data to other devices and receive data and control commands from other devices. User programmable RTUs are referred to as "smart RTUs."

MeterA meter is an IED that is used to create accurate measurements of power system current, voltage, and power values. Metering values such as demand and peak are saved within the meter to create historical information about the activity of the power system.Digital fault recorderA digital fault recorder (DFR) is an IED that records information about power system disturbances. It is capable of storing data in a digital format when triggered by conditions detected on the power system. Harmonics, frequency, and voltage are examples of data captured by DFRs.Programmable logic controller (PLC)A

Programmable Logic Controller can be programmed to perform logical control. As with the RTU, a dedicated pair of copper conductors for each contact and transducer value is terminated on panels within the PLC.It is like a work-horse which work upon the command given by their master.

Protective relayA protective relay is an IED designed to sense power system disturbances and automatically perform control actions on the I&C system and the power system to protect personnel and equipment. The relay has local termination so that the copper conductors for eac