

PRESENTATION ON SUB-STATION EQUIPMENTS

- B.V.Girish

Chief Engineer Electy., KPTCL,
RT & R&D, Kaveri Bhavan, Bangalore.

E mail: bvgirishholla@gmail.com

SUBSTATION

A Substation is an assembly of equipments which conveys/transform the characteristics of electrical energy from one form to another, duly providing all the necessary protection to each Line/Equipment.

A Substation is a vital link between the generation of power and the ultimate consumer.

COMPONENTS OF SUB STATION

POWER TRANSFORMERS

CURRENT TRANSFORMERS

VOLTAGE TRANSFORMERS/CVT

CIRCUIT BREAKERS

CONTROL AND RELAY PANELS

ISOLATORS-WITH EARTH SWITCH/WITHOUT EARTH SWITCH

COMPONENTS OF SUB STATION

BUS BARS

POWER CABLES

SURGE ARRESTERS

SHUNT CAPACITORS

SERIES CAPACITORS

SHUNT REACTORS

11KV SWITCHGEAR

COMPONENTS OF SUB STATION

CONTROL CABLES

DC SYSTEM-BATTERY/CHARGER/DC PANEL

LT AC SYSTEM-SWITCHGEAR/AUX TR/DG SET

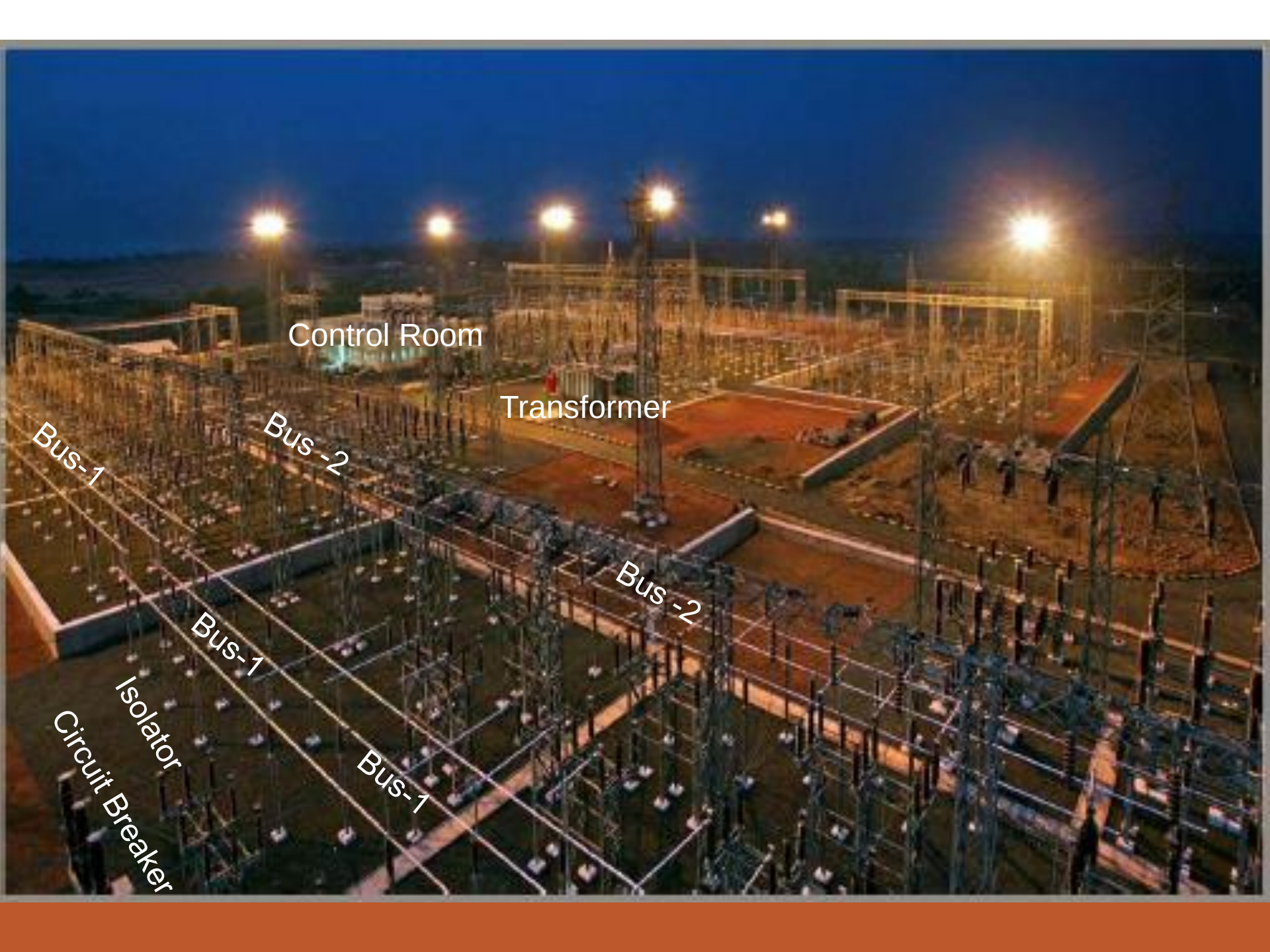
COMMUNICATION / CARRIER EQUIPMENT

STATION EARTHING

YARD LIGHTING

FIRE FIGHTING SYSTEM

A solid orange horizontal bar at the bottom of the slide.



Control Room

Transformer

Bus-1

Bus -2

Bus -2

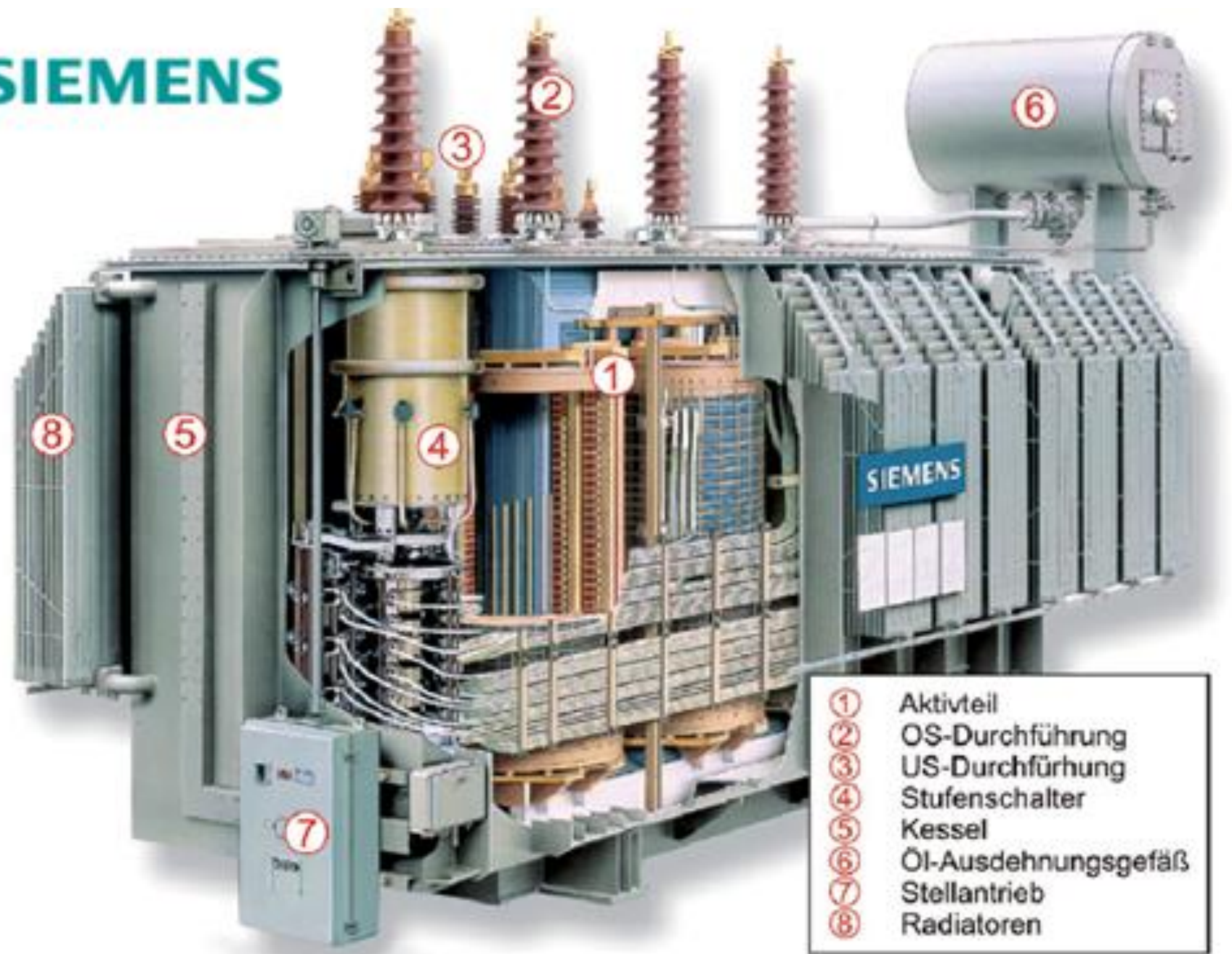
Bus-1

Bus-1

Isolator

Circuit Breaker

SIEMENS







WINDINGS
U phase

WINDINGS
V phase

WINDINGS
W phase

Tap Changer

CURRENT TRANSFORMERS

Normally the secondary cores of any 5 core CT will be distributed as

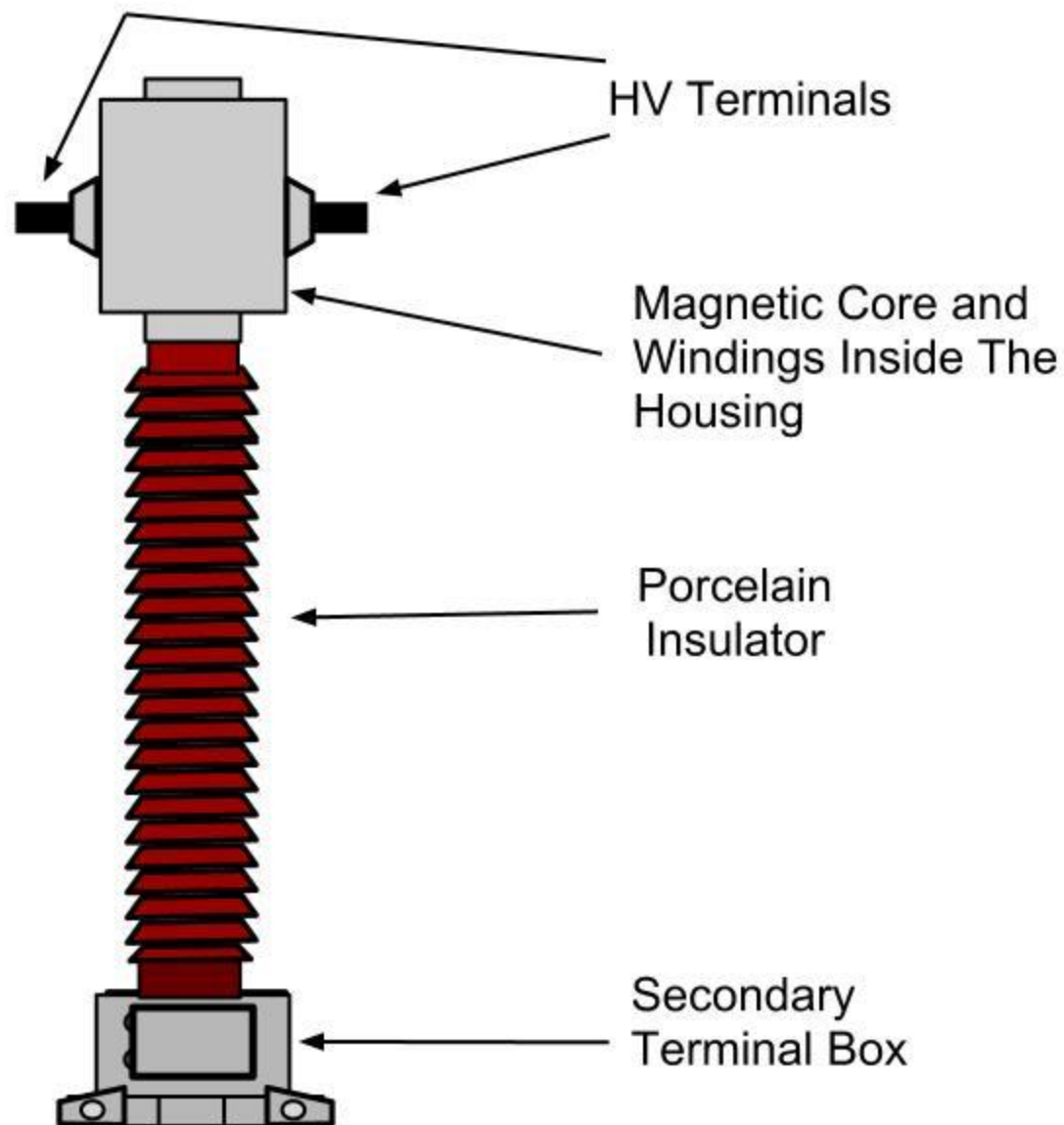
Core 1 – Primary Protection

Core 2 – Metering.

Core 3 – Back Up Protection.

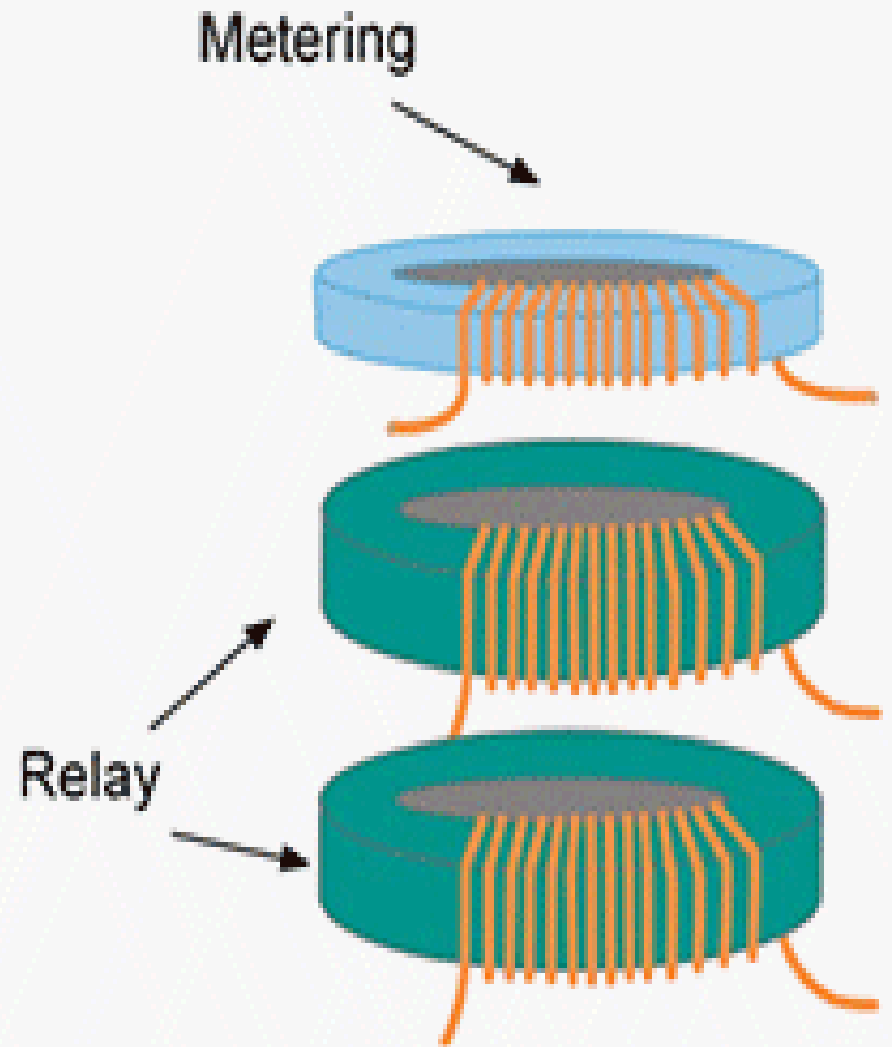
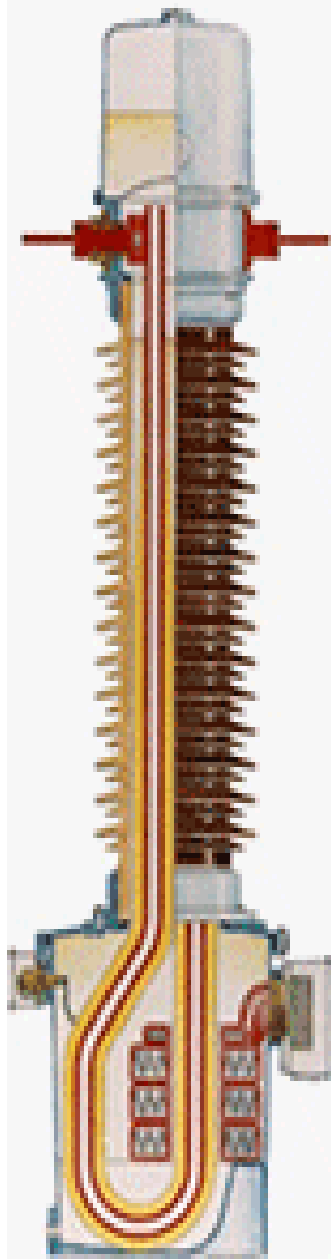
Core 4 – Bus Bar Protection (Main Zone)

Core 5 – Bus Bar Protection (Check Zone)



Sketch of Top Core Type Current Transformer





VOLTAGE TRANSFORMERS/CVT

Voltage Transformers transform Voltage from High Value to Low Value at a
given ratio, Volt -Ampere rating smaller compared to that of Power Transformer and the Secondary of which are used for Metering and Protection purposes.

The Rated Secondary Voltage of VTs are normally 63.5 V (Ph-N) or 110V (Ph-Ph).

VTs have 1 no. to 3no.s of secondary windings depending on the requirement.

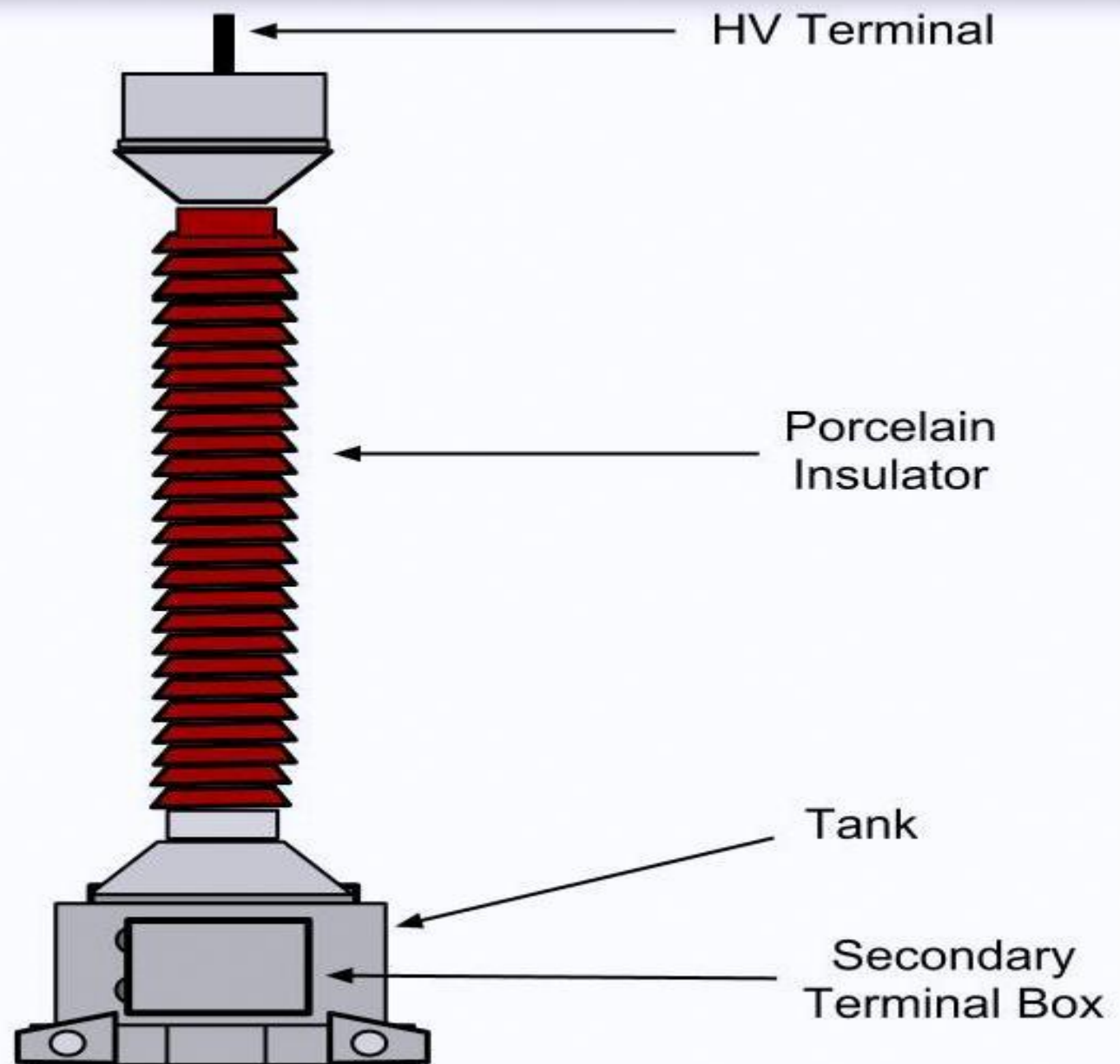
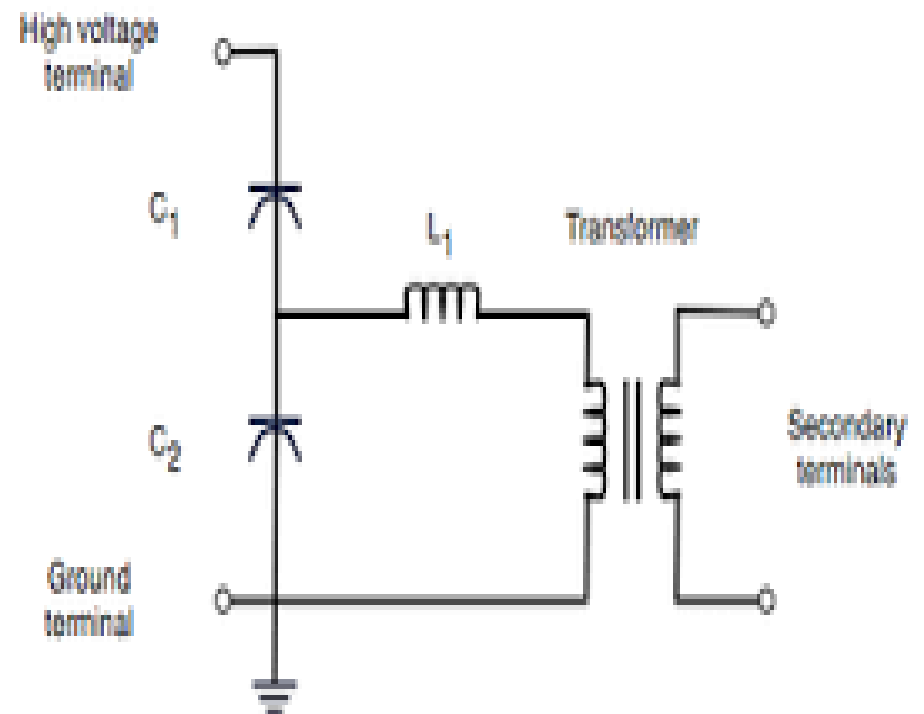
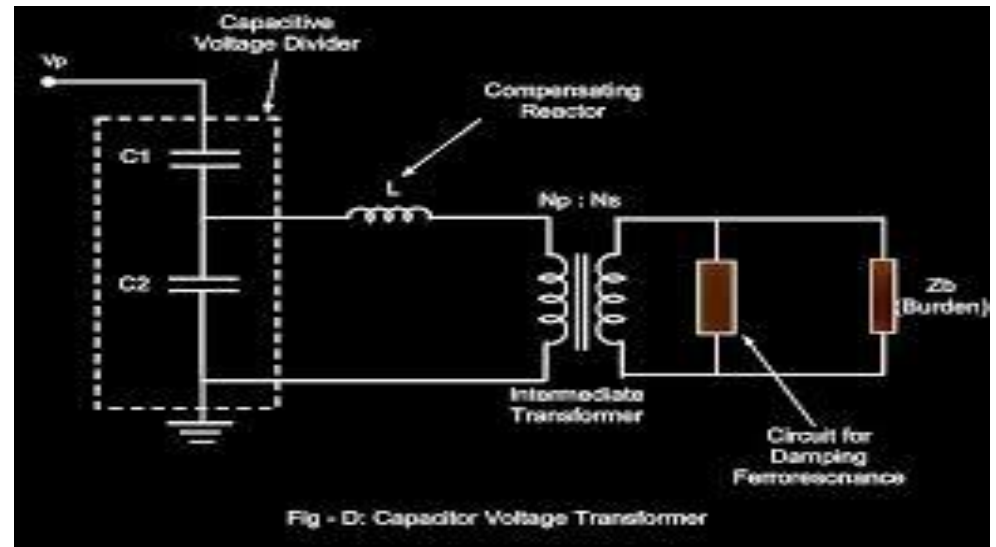


Fig-C: Sketch of Voltage Transformer



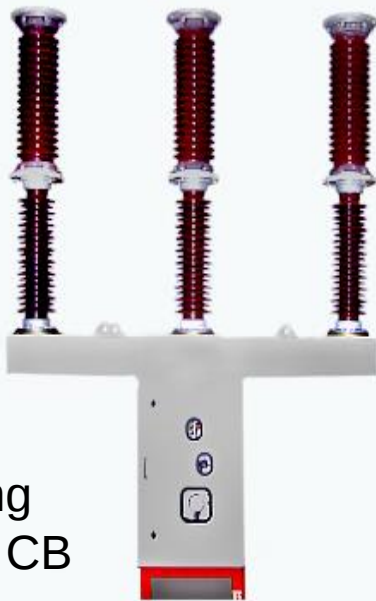
CIRCUIT BREAKERS

Circuit Breaker is device which is capable of making, Breaking an electric circuit under normal and abnormal conditions.

The different arc quenching media used in Circuit Breakers are Insulating Oil, Compressed Air, Vacuum, Sulphur hexa- Fluoride Gas etc.

CIRCUIT BREAKERS

The energy required for operation of a Circuit Breaker is generally derived from Tension or compression type Springs or Compressed Air or compressed Hydraulic Fluid and in some cases combination of the above.



66kV gang
operated CB



110kV gang
operated CB



400kV CB
with
grading
Capacitor
& PIR



220kV CB



3 Pole Gang Operated CB



3Pole Individual Operated CB



CONTROL AND RELAY PANELS

Type of C & R Panels

- Simplex type wherein, the control panel and relay panel are placed separately.
- Panels with Substation Automation System (SAS) compatibility houses relays, BCU & control switches all in simplex panels.
- Duplex type wherein, the control panel and the relay panel are placed one behind the other and are separated by space for corridor.

Conventional CONTROL PANEL

Control switches for Breaker control switch, Isolators Control, PT selection, Protection Transfer etc. are provided in the control panel.

Meters for display of value of current, voltage, MW, MVAR etc. and Energy meter are fixed in the control panel.

Indication lamps for display of status of Breaker, Isolators etc. and annunciation scheme are fixed in the control panel.

CONTROL PANEL compatible to SAS

C&R panels with SAS compatibility will be fixed with Bay Control Unit (BCU)

for all the controls, Indications, Annunciations, display of value of I,V,MW,MVAR etc. In addition, BCU does the functions of DR, Event Logger, Data Logging etc.

Control switch for emergency operation of Breaker will be provided.

ISOLATORS-WITH / WITHOUT EARTH SWITCH

Isolator is a device which can be opened or closed only under no current conditions and provides isolation of a circuit for maintenance purposes.

Earth switch is a device which connects a conductor to the Earth so as to discharge the charges on the conductor to the earth and generally mounted on the frames of an Isolator.

EARTH SWITCH

Earth Switches which can earth an incoming line directly OR through a

CB can be operated if and only if the line is dead.

Can be operated only if the isolators on both the sides are OPEN.

BUS BARS

The Bus Bar arrangement in any Sub Station is based on the following.

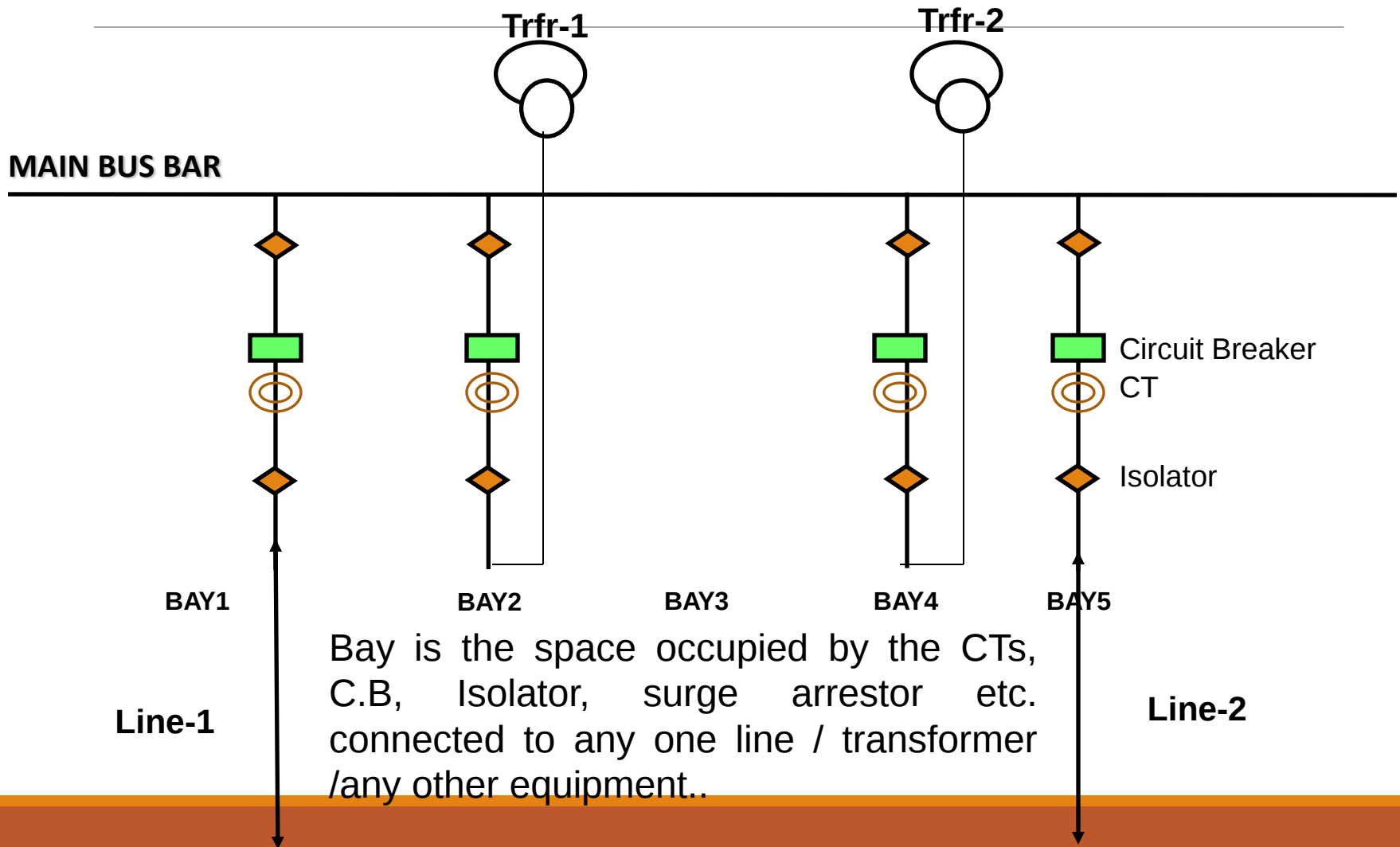
-
- Degree of flexibility desired.
 - Importance of the Loads fed from the Sub Station, availability of land, freedom of availing total shut down and it's period.
 - Economic consideration, availability and cost, Technical considerations, Ease of Maintenance, Safety of Persons, simplicity, Busbar protection zones etc.

BUS BAR ARRANGEMENTS

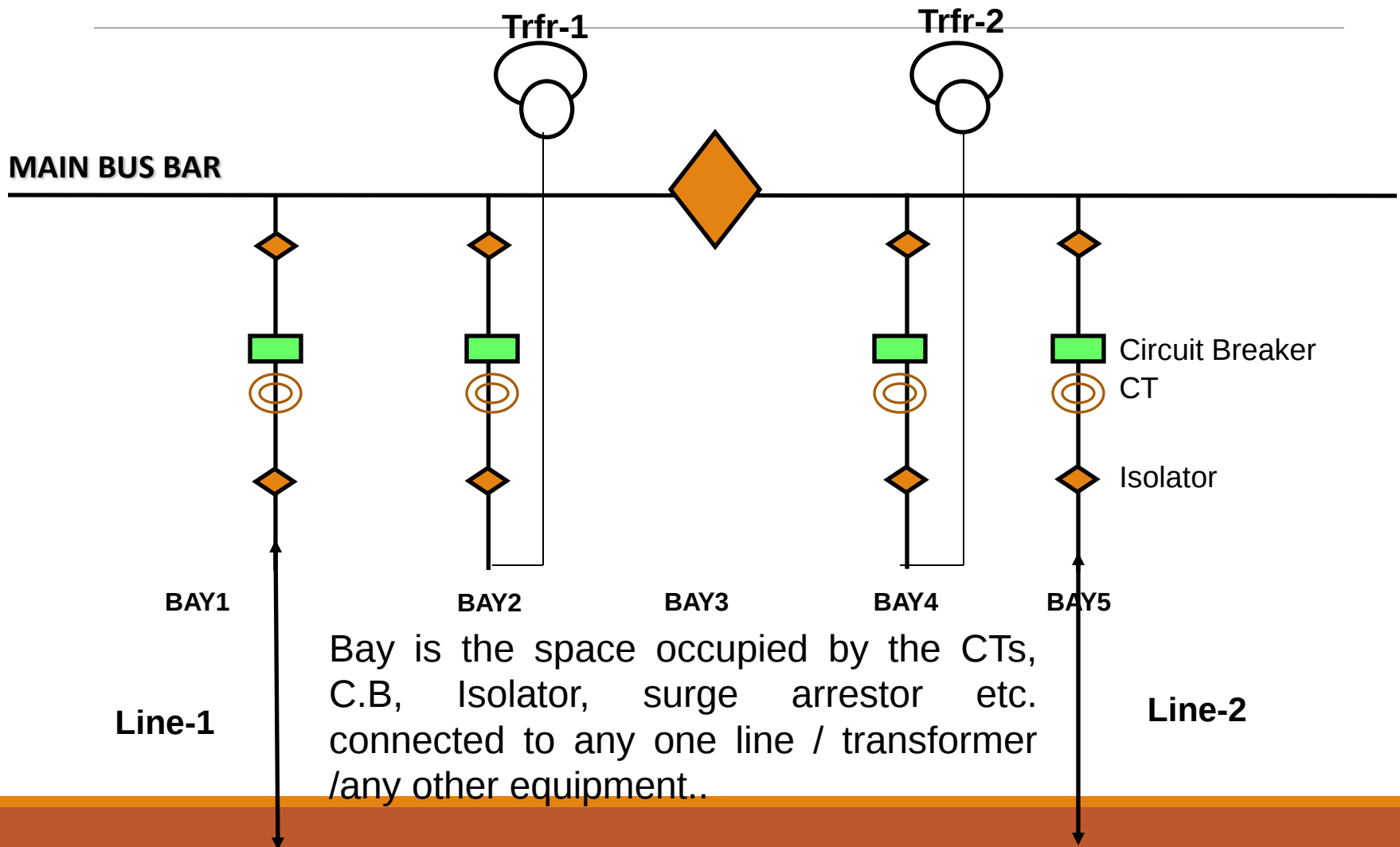
Single Bus Bar Arrangement.

This arrangement consists of a single Bus Bar to which various feeders are connected. In case of a fault or maintenance of Bus Bar, total shut down occurs and hence provides least flexibility.

SINGLE BUS SYSTEM



SINGLE BUS SYSTEM WITH SECTIONALISING ISOLATOR



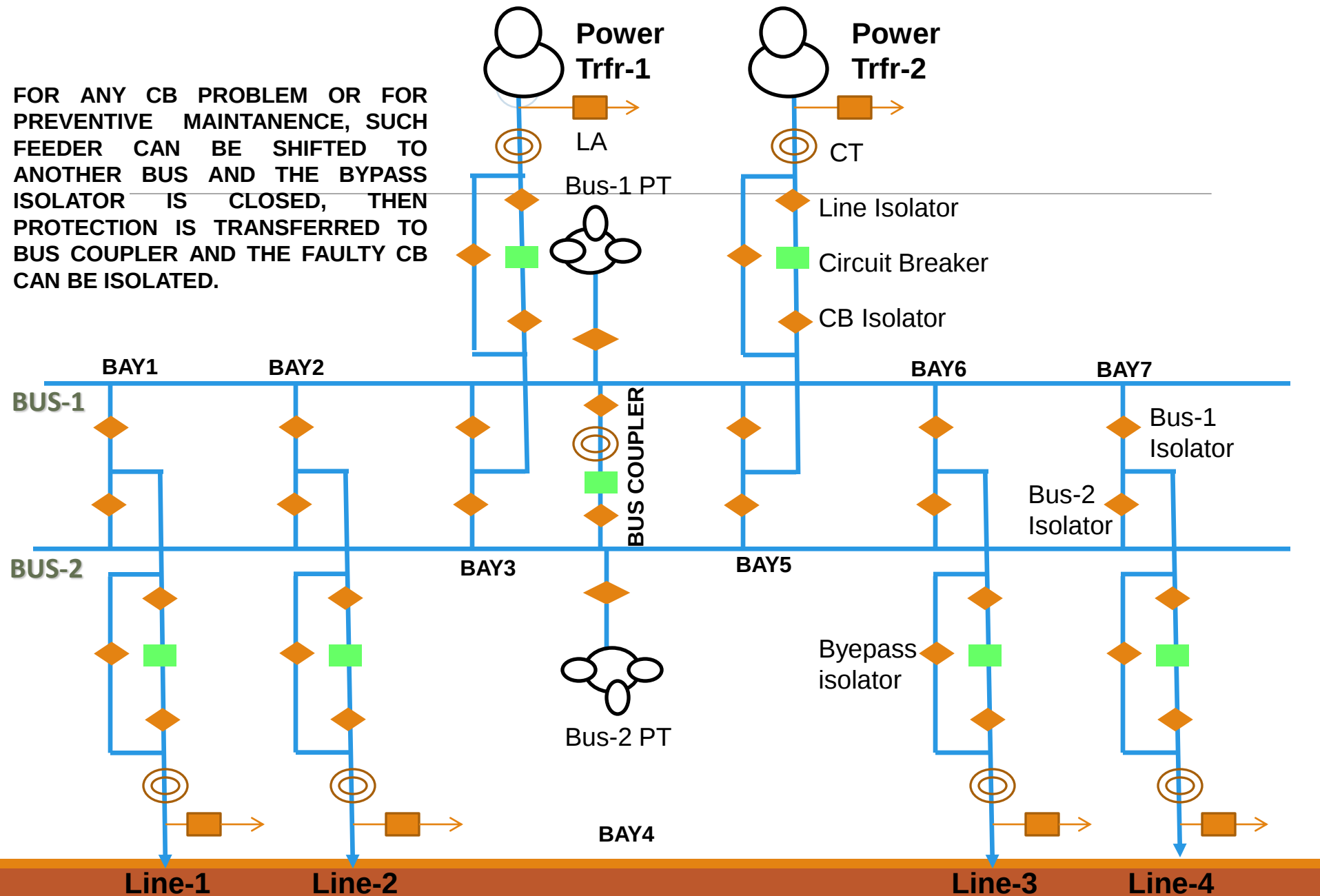
BUS BAR ARRANGEMENTS

Two Bus Bar system.

This arrangement provides additional flexibility, continuity of Power Supply, permits periodic maintenance without total shut down as there is redundant Bus Bar and Circuit Breaker (Bus Coupler).

TWO BUS SYSTEM

FOR ANY CB PROBLEM OR FOR PREVENTIVE MAINTENANCE, SUCH FEEDER CAN BE SHIFTED TO ANOTHER BUS AND THE BYPASS ISOLATOR IS CLOSED, THEN PROTECTION IS TRANSFERRED TO BUS COUPLER AND THE FAULTY CB CAN BE ISOLATED.

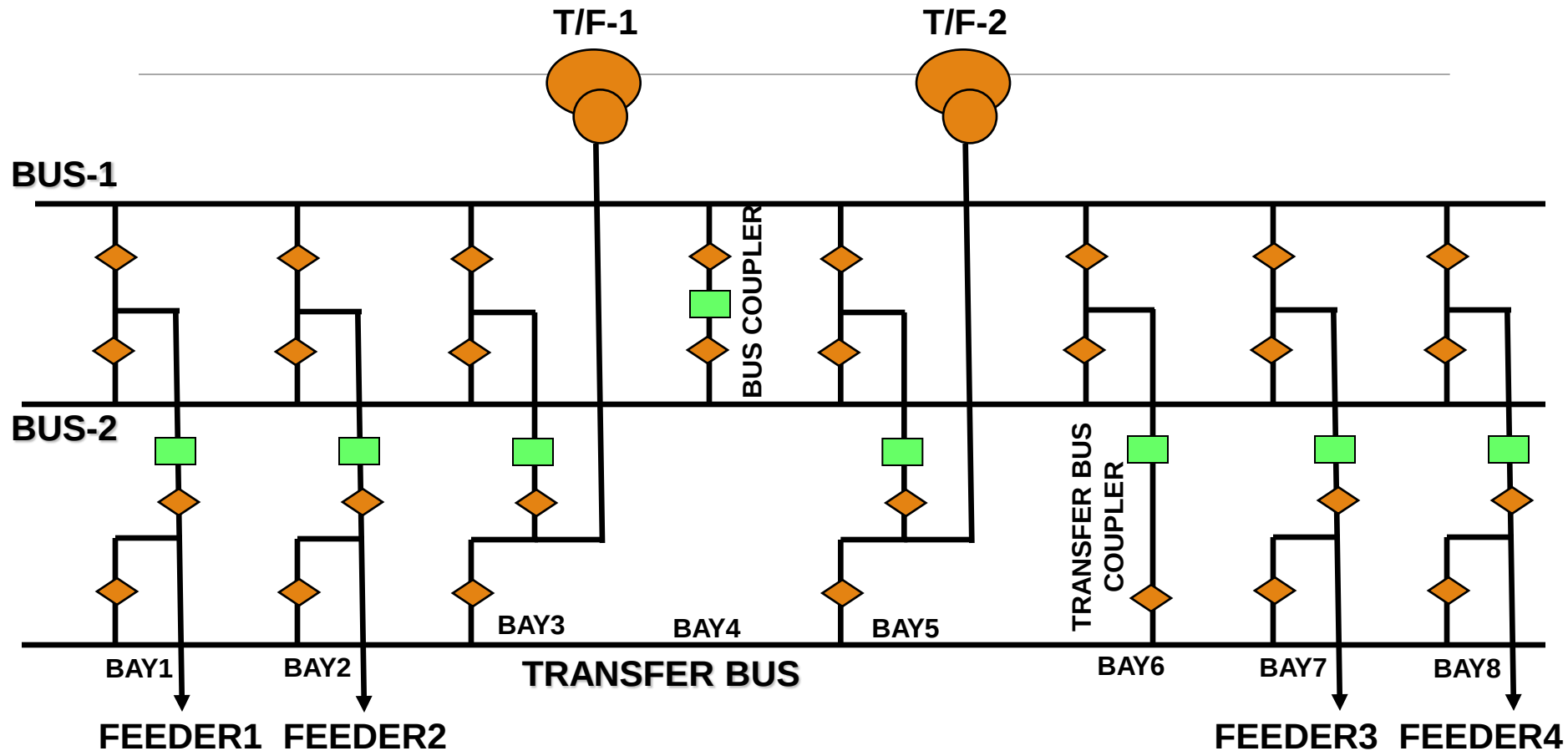


BUS BAR ARRANGEMENTS

Double Bus Bar Arrangement with Transfer Bus.

This arrangement provides more additional flexibility, continuity of Power Supply, permits periodic maintenance without total shut down as the two main buses can be operated independently with the same redundancy.

DOUBLE MAIN BUS & TRANSFER BUS SYSTEM

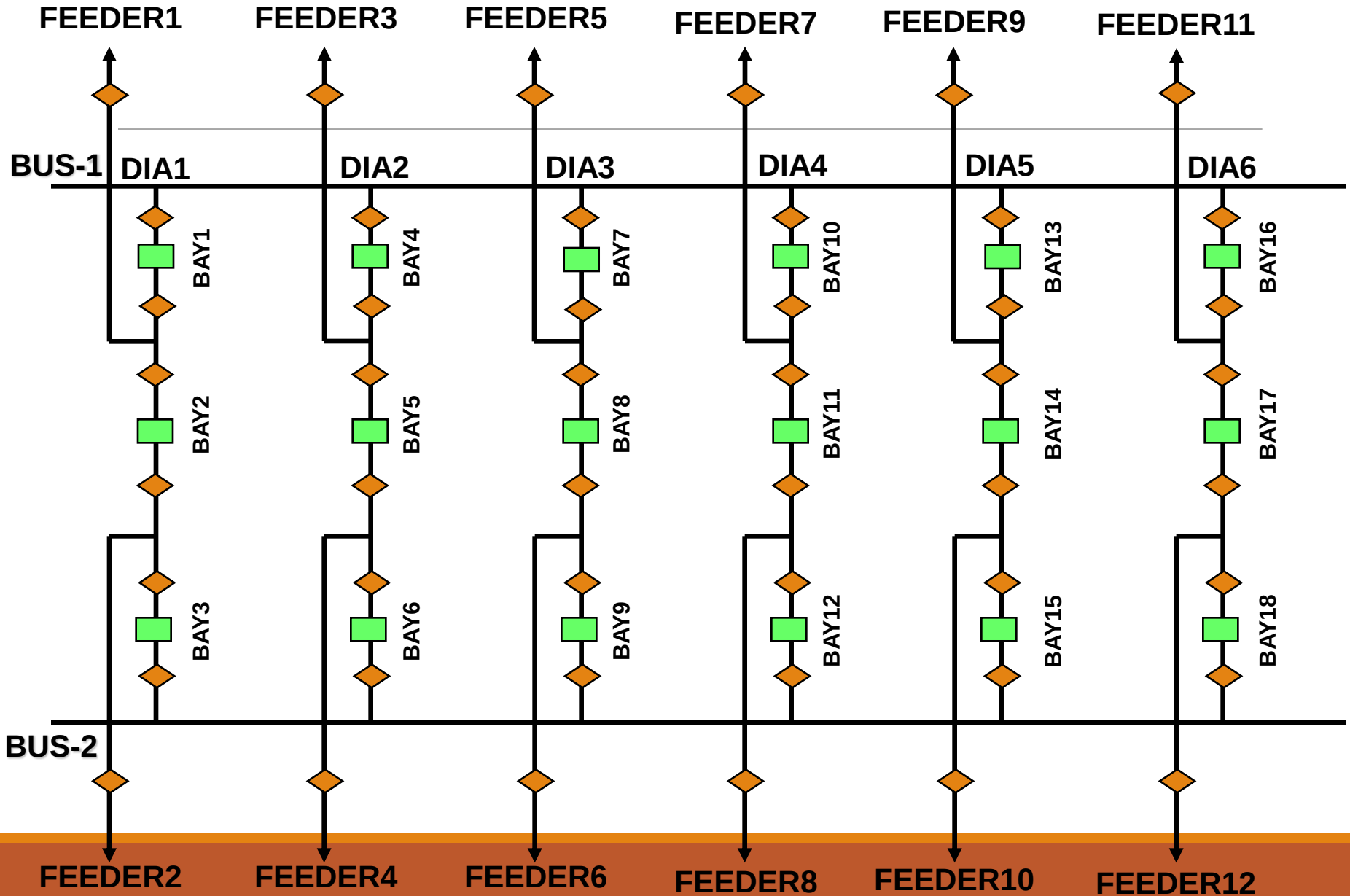


BUS BAR ARRANGEMENTS

One and a Half Breaker Arrangement.

This arrangement provides three circuit breakers for every two circuits. It gives high security against loss of supply but higher cost is involved. Hence this is provided for important 400KV Sub Stations.

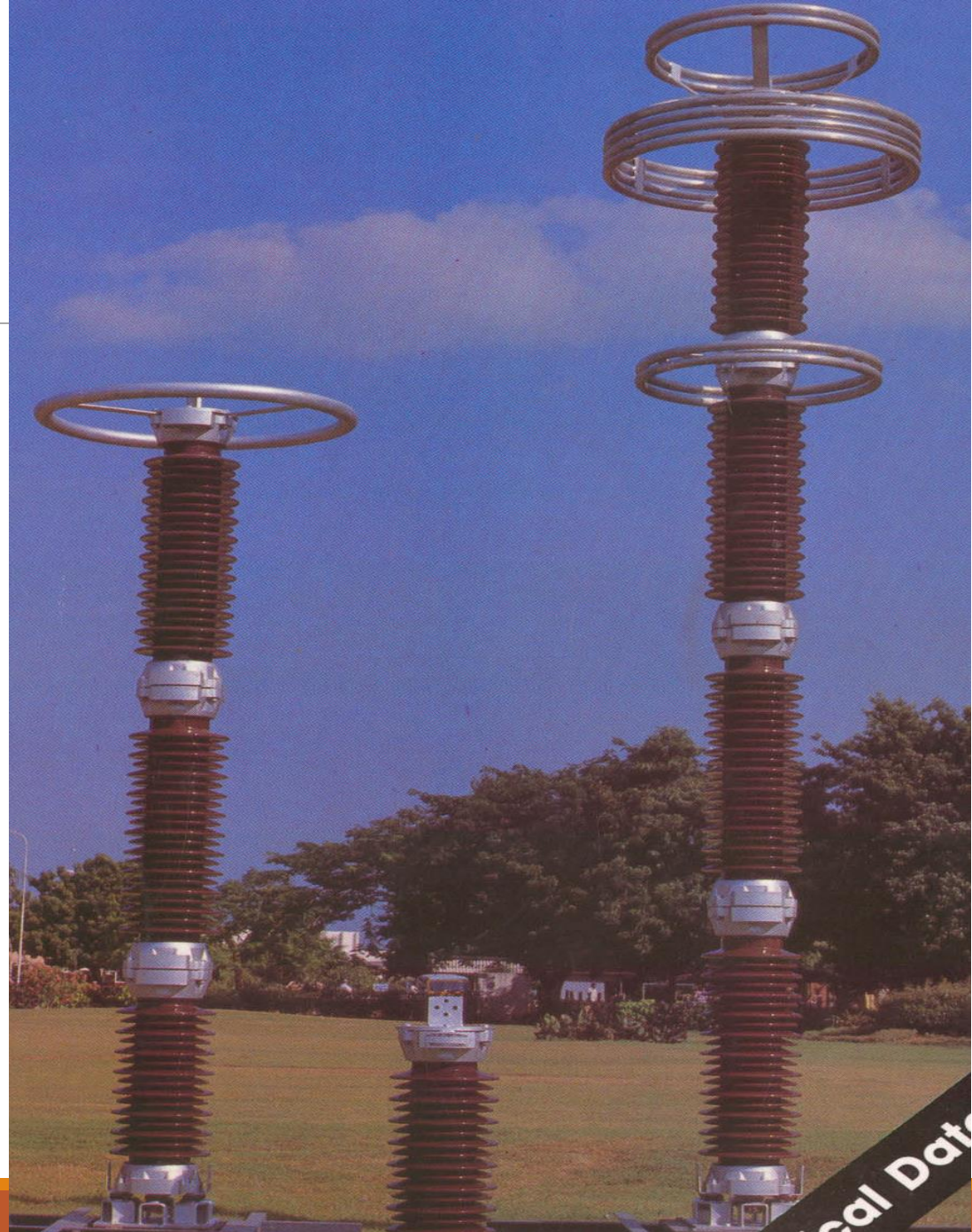
I-CONFIGUARATION



SURGE ARRESTERS

Surge Arrestors are provided to discharge the Switching Over Voltage and Lightning Over Voltages to Earth and protect Line/equipments.

Surge Arrestor



SHUNT CAPACITORS

Shunt capacitors will provide reactive power compensation to the low Lagging Power Factor loads and hence improve the overall Power Factor of the system.

SHUNT REACTORS

Shunt Reactors are provided in case of long EHV Lines to compensate for the shunt capacitive reactance of the line so that shoot up of Voltage at the receiving end during switching and low load conditions are minimised.

11KV SWITCHGEAR

11KV Switchgear is the vital component of any Sub Station feeding the auxiliary supply and power supply to local areas and Industries.

Two types of switchgear are

- ❖ Metal Clad Switchgear (MCVCB)
- ❖ Porcelain Clad Switchgear (PCVCB)

DC SYSTEM-BATTERY/CHARGER/DC PANEL

DC Battery is the source of stored energy for the operation of the entire
protective relaying and other functions in any sub station.

The DC system voltage is 220V in case of 220KV and above sub stations, 110V in case of 110KV and below sub stations.

The rating of the Battery is in Ampere Hours (AH) on 10 hour basis and is chosen based on the DC load of the Sub Station.

DC SYSTEM-BATTERY/CHARGER/DC PANEL

The DC system voltage is achieved by connecting number of 2V cells in series.

The specific gravity (SG) of the electrolyte in each cell is to be 1.200 at 27°C room temperature when the cell is fully charged.

Normally, when auxiliary supply is available, Float Charger will feed the DC loads of the Sub Station and also keeps the Battery set in floating condition by charging it.

STATION EARTHING

The non current carrying metallic parts in every electrical sub station are connected to the under ground earthing mesh called **Earth Mat** at earth potential for the safety of the personnel and for discharging fault currents. This system is called 'Equipment Earthing'.

The station earthing should have low earth resistance; low touch potential and low step potential.

STATION EARTHING

Step Potential is the voltage between the feet of a person standing on the floor of the sub Station with 0.5m spacing between the two feet (one step) during the flow of Earth Fault current through the earthing system.

Touch Potential is the voltage between the fingers of raised hand touching a faulted structure and the feet of a person standing on the floor of the sub Station.

STATION EARTHING

All the equipment structures in the substation are connected to the earth mat for the safety of the equipment and also the staff working in the substation who may come in contact with structures.

There will be Earth Potential rise during any fault when the fault current is flowing even though for a very short time. Hence secure connection to the earth mat is absolutely necessary.

COMMUNICATION / CARRIER EQUIPMENT

Power Lines used to transmit electrical power can be used for communication purpose also by coupling communication equipments to EHV Line through suitable devices. This is termed as Power Line Carrier Communication (PLCC) which was in use from many years.

It consists of

- Coupling Capacitor & LMU
- Wave Trap
- PLCC equipment
- Protection Coupler

Owing limitations of the band width and speed, Optic Fiber Ground Wire (OPGW) is provided now a days for Lines and Communication is through Optic Fiber.

YARD LIGHTING

Normally, the luminance at the work plane height around the equipments area has to be 50 Lux and the average luminance in the whole Sub Station area need to be 20 Lux.

The fittings used for yard lighting will have to be arranged in such a way as to get the above illumination.

FIRE FIGHTING SYSTEM

Transformers are provided with system to sense the occurrence of fire by means of sensors, generate an alarm, to disconnect the power supply to that region by means of Relays and extinguish the fire by means of High Velocity Water Spray or Nitrogen injection depending on the type of system provided.

FIRE FIGHTING SYSTEM

Portable Fire Extinguishers of Foam type, CO2 type, Dry Chemical Powder (DCP) type of different capacity are also provided for different types of fires in the Sub Station area.

Maintenance of substation equipments

maintenance

Maintenance is the works carried out on any equipment to ensure it's proper, reliable, efficient, smooth working condition and keeping the same in fit condition for continuous operation.

Maintenance

Any maintenance work will basically cover the following:-

Inspection

Preventive Maintenance

Condition based monitoring

Reliability Centered maintenance

Breakdown Maintenance

Overhauls

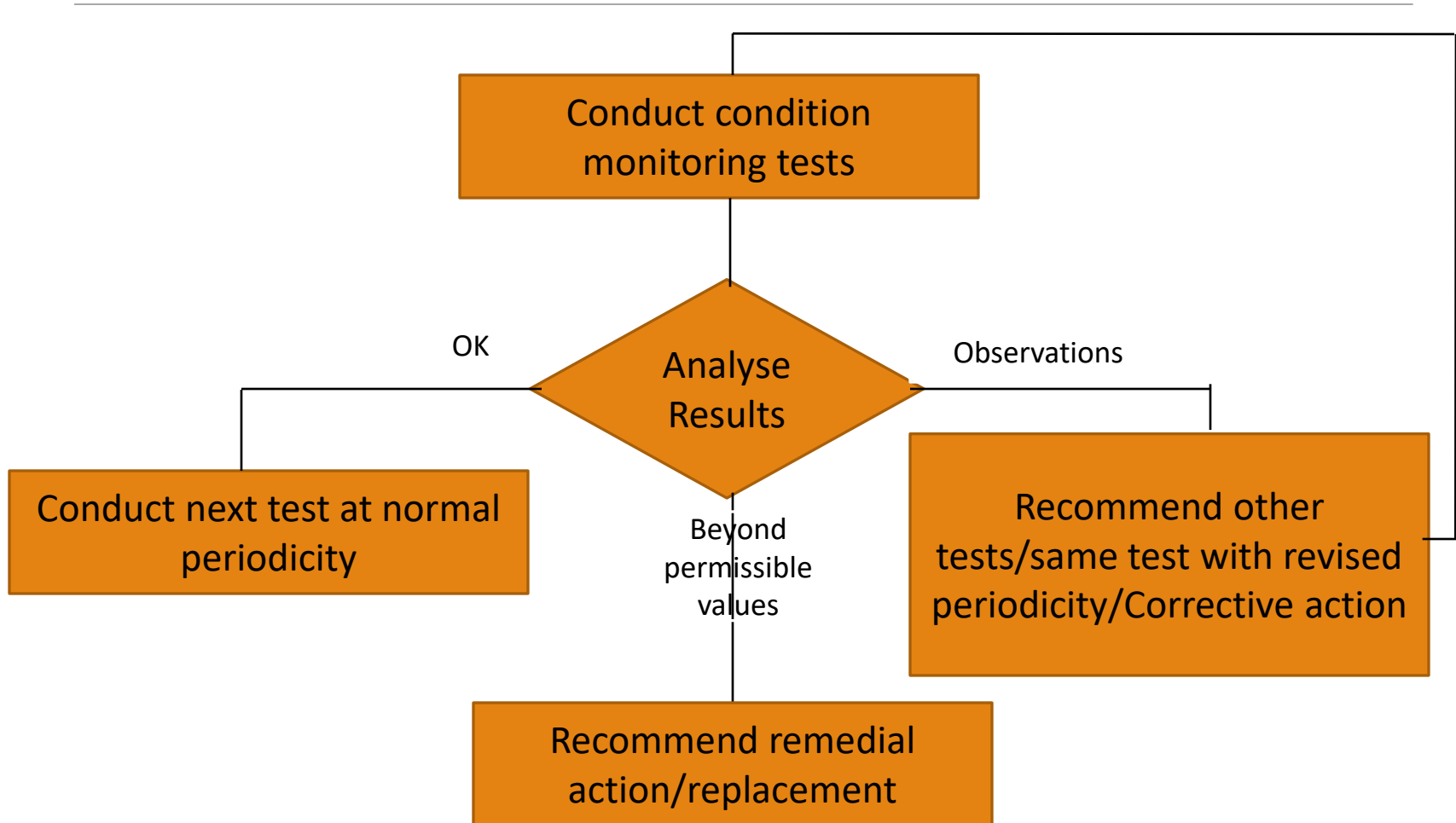
Condition monitoring

Condition monitoring is the process of evaluation the health of different Substation equipments through out their service life by conducting non-destructive tests at regular intervals.

SYMPTOMS OF DETERIORATION

- ❖ Reduction in insulation resistance.
- ❖ Increase in dielectric losses (Tan Delta)
- ❖ Excessive temperature raise.
- ❖ Increase in resistance.
- ❖ Gas evolution.
- ❖ Visual, audible & ultra-violet discharges.

Condition monitoring tests



Condition monitoring of substation equipments

Sino	Equipment	Condition Monitoring tests recommended	Normal periodicity	Testing equipment required
1	Power Transformer & condenser bushings	Tan δ & capacitance test	Once in a year	Automatic Tan δ kit
		Insulation Diagnostic test	Once in a year	IDAX kit
		Tests on the insulating oil	Once in a year	To be done in standard oil Lab
		IR and PI test	Quarterly	IR tester
		Sweep Frequency Response Analysis	Once in a year	SFRA kit
		Winding resistance measurement test	Once in two years.	Winding Resistance kit

Condition monitoring of substation equipments

Slno	Equipment	Condition Monitoring tests recommended	Normal periodicity	Testing equipment required
2	Circuit Breaker	Operational timing test with DCRM for 220KV and above. Operational timing test for 110KV & below.	Once in two years	CB Operation analyser or CB timer kit.
		Contact Resistance measurement test	Once in two years	Contact Resistance kit OR Micro Ohmmeter
		IR test	Once in 6 months	IR tester

Condition monitoring of substation equipments

Slno	Equipment	Condition Monitoring tests recommended	Normal periodicity	Testing equipment required
2	Circuit Breaker	Dew point of SF6	Once in one year OR Gas handling done	Dew point Meter
3	Surge arrestor	Measurement of third harmonics resistive leakage current	Quarterly	Leakage Current Monitoring kit
4	Capacitance Voltage Transformer (CVT)	Tan δ & capacitance test	Once in a year	Automatic Tan δ kit

Condition monitoring of substation equipments

Sino	Equipment	Condition Monitoring tests recommended	Normal periodicity	Testing equipment required
5	Current Transformer & Potential Transformer (CT/PT)	Tan δ & capacitance test	Once in a year	Automatic Tan δ kit
		IR test	Quarterly	IR tester
		Checking of core characteristics	Once in a year	CT/PT Analyser
6	Isolators	Contact Resistance test	Once in two years	Contact Resistance kit
7	Earth Mat	Earth Mat resistance & Integration test	Once in two years	Earth Resistance test kit
8	Calibration of protection relays	Testing of accuracy & timing of operation of protection relays	Once in a Year	Numerical relay test & Back up protection relay test kit

Condition monitoring of substation equipments

Slno	Equipment	Condition Monitoring tests recommended	Normal periodicity	Testing equipment required
9	DC Battery set	Internal Impedance test	One in a year	Battery impedance kit
		Discharge test	Once in three years	Battery test & discharge kit
10	Monitoring of temperature of various joints of the substation.	Thermo-vision scanning	Once in three months	Thermo-vision camera

Condition monitoring of gas insulated switchgear (GIS) substation

Sno	Equipment	Condition Monitoring tests recommended	Normal periodicity	Testing equipment required
1	Each GIS Bay module	Contact Measurement of each chamber and total Bay	Once in a year	Contact Resistance kit
2	Each GIS Bay module	Gas dew point Measurement of each chamber.	Once in a year	Dew point Meter
3	Each GIS Bay module	Gas purity Measurement of each chamber	Once in a year	Gas Purity Meter

Condition monitoring of gas insulated switchgear (GIS) substation

Slno	Equipment	Condition Monitoring tests recommended	Normal periodicity	Testing equipment required
4	All the GIS bays	PD measurement	Real time wherever system is provided	PD sensors
		PD measurement	Once in one year	PD sensor system

THANK YOU.

A solid orange horizontal bar at the bottom of the slide.