UNIT-3

AIS & GIS

Air Insulated Substations (AIS) – Indoor & Outdoor substations, Substations layouts of 33/11 kV showing the location of all the substation equipment.

Bus bar arrangements in the Sub-Stations: Simple arrangements like single bus bar, sectionalized single bus bar, double bus bar with one and two circuit breakers, main and transfer bus bar system with relevant diagrams.

Gas Insulated Substations (GIS) – Advantages of Gas insulated substations, different types of gas insulated substations, single line diagram of gas insulated substations, constructional aspects of GIS, Installation and maintenance of GIS, Comparison of Air insulated substations and Gas insulated substations.

What is substation?

The assembly of apparatus used to change some characteristic(e.g. Voltage, a.c to d.c, frequency, power factor etc) of electric supply is called a sub-station.

Example: 33/11 kv Sub-Station.

The following factors are considered while making site selection for a substation:

1. Type of **Substation**
2. Availability of Suitable and Sufficient Land
3. Communication Facility
4. Atmospheric Pollution
5. Availability of Essential Amenities to the Staff
6. Drainage Facility.

CLASSIFICATION OF SUB STATIONS

The Substation is a part of electrical Power System. That is the part of an electrical generation, transmission and distribution system. It is regarded as the source of energy supply for the local areas of distribution in which these are located. The main function is to receive energy transmitted at high voltage form the generating station, reduce the voltage to appropriate for local distribution and provide facilities for switching.

Some substations are simply switching stations where different connections between various transmission lines are made, others are converting substations which either convert ac into dc or vice versa or convert frequency from higher to lower or vice versa.

Substations have some additional functions. They provide points where safety devices may be installed to disconnect equipment or circuit in the event of fault. Voltage on the outgoing distribution feeders can be regulated at a substation.

A substations is convenient place for installing synchronous condensers at the end of the transmission line for the purposes of improving power factor and make measurements to check the operation of the various parts of the power system.

Street lighting equipment as well as switching controls for street lights can be installed in a substations.

SUBSTATION CAN BE CLASSIFIED ON THE BASIS OF FOLLOWING:

1. Basis of Nature of Duties

1. Step-Up or Primary Substations.

Such substations are usually associated with generating stations. The generated voltage, which is usually low (3.3, 6.6, 11 or 33 KV), is stepped up to primary transmission voltage so that huge blocks of power can be transmitted over long distance to the load centers economically.

2. Primary Grid Substations.

Such substations are located at suitable load centers along the primary transmission voltage is stepped down to different suitable secondary voltages. The secondary transmission lines are carried over to the secondary substations situated at the load centers where the voltage is further stepped down to sub-transmission or primary distribution voltages.

3. Step-Down or Distribution Substations

Such substations are located at the load centers, where the sub-transmission/primary distribution voltage is stepped down to secondary distribution voltage (415/240V). These are the substations which feed the consumers through distribution network and service lines.

2. Basis of Service Rendered

1. Transformer Substations:

Transformers are installed on such substations to transform the power from one voltage level to another level as per needs.

2. Switching Substations:

Such substations are meant for switching operation of power lines without transforming the voltage. At such substations different connections are made between various transmission lines.

3. Converting Substations:

Such substations are meant for either converting ac to dc or vice versa or converting frequency from higher to lower or vice versa.

3. Basis of Operating Voltage

1. High Voltage Substations (HV Substations) involving voltage between 11 KV and 66 KV.
2. Extra High Voltage Substations (EHV Substations) involving voltages between 132 KV and 400 KV.
3. Ultra High Voltage Substations (USV Substations) operating on voltage above 400 KV.

4. Basis of Importance

1. Grid Substations.

These are the substations from where bulk power is transmitted from one pint to another point in the grid. These are important because any disturbance in these substations may cause the failure of the grid.

2. **Town Substations:**

These substations step-down the voltages at 33/11 KV for further distribution in the towns and any failure in such substations results in the failure of supply for whole of the town.

5. Basis of Design

1. **Indoor Type Substation**

In such substations the apparatus is installed within the substation building. Such substations are usually for a voltage up to 11 KV but can be erected for the 33 KV and 66 KV when the surrounding atmosphere is contaminated with impurities such as metal corroding gases and fumes, conductive dust etc.

2. Outdoor Substation

(a) Pole Mounted Substations:

Such substations are erected for distribution of power in localities. Single stout pole or H-pole and 4-pole structures with suitable platforms are employed for transformers of capacity up to 25 KVA, 125 KVA and above 125 KVA (but up to 250 KVA) respectively.

(b) Foundation Mounted Substations:

For transformers of capacity above 250 KVA the transformers are too heavy for pole mounting. Such substations are usually for voltage of 33,000 volts and above.

OUTDOOR SUBSTATIONS OVER INDOOR SUBSTATIONS

Advantages:

The outdoor substations have the following main advantages over indoor substations.

i. All the equipment is within view and therefore fault location is easier.

ii. The extension of the installations is easier, if required.

iii. The time required in erection of such substations is lesser.

iv. The smaller amount of building materials (steel-concrete) is required.

v. The construction work required is comparatively smaller and cost of the switch-gear installations is low.

vi. There is practically no danger of a fault which appears at one point being carried over to another point in the installation because the apparatus of the adjoining connections can be spaced liberally, without any appreciable increase in costs.

vii. Repairing work is easy.

Disadvantages:

i. The various switching operations with the isolators, as well as supervision and maintenance of the apparatus is to be performed in the open air during all kinds of weather.

ii. More space is required for the substation.

iii. Protection devices are required to be installed for protection against lighting surges.

iv. The length of control cables required is more.

v. The influence of rapid fluctuation in ambient temperature and dust and dirt deposits upon the outdoor substation equipment makes it necessary to install apparatus specially designed for outdoor service and, therefore, more costly.

INDOOR TYPE SUBSTATIONS DESCRIPTION AND CLASSIFICATION:

Indoor Type Substations is the substations in which the apparatus is installed within the substation building. Indoor Type Substations are usually for a voltage up to 11,000 V but can be erected for 33,000 V and 66,000 volts when the surrounding atmosphere is contaminated with impurities such as metal corroding gases and fumes, conductive dust etc.

The switch-gear on supply or primary side will consist of oil circuit breakers only. The high voltage supply is given to the primary of the transformer through circuit breaker. From the bus-bar various feeders emerge out. The panel for each feeder consists of an isolator switch and circuit breaker.

In addition to isolator and circuit breaker, the panel is provided with the measuring instruments. As regards protection of feeders usually reverse power relay is employed. For the protection of oil filled transformers with conservator tanks Buchholz's relay is most common.

The auxiliaries of the indoor type substations are

1. Storage Batteries
2. Firefighting equipment such as water buckets, fire extinguishers, etc.

The batteries are used for the

(i) Operation of the protective gear and switch operating solenoids and

(ii) Emergency lighting in substations in case of failure of supply.

TYPES OF INDOOR SUBSTATIONS:

According to construction indoor distribution transformer substations and high voltage switchboards are further subdivided into the following categories.

1. Substations of the integrally Built Type
2. Substations of the composite Built-Up Type
3. Unit Type Factory Fabricated substations and Metal Clad Switch boards

1. **Substations of the Integrally Built Type**

In this indoor substations types, the apparatus is installed on site. In such substations the cell structures are constructed of concrete or bricks.

2. Substations of the Composite Built-Up Type

In this indoor substations types, the assemblies and parts are factory or workshop prefabricated, but are assembled on site with in a substation switch-gear room. The compartments of such substations take form of metal cabinets or enclosures, each of which

contains the equipment of one main connection cell. Within such cabinets or enclosures an oil minimum circuit breaker, a load-interrupter switch and one or more voltage transformers may be mounted.

3. **Unit Type Factory Fabricated Substations and Metal Clad Switchboards**

In this indoor substations types, electrical workshops and are shipped to the site of installations fully preassembled. After installations of substations and switchboards only connection to the incoming and outgoing power circuits are required to be made. Cubicles for unit type switchboards or substations take the form of fully enclosed metal-clad cabinets.

Metal-clad cubicles designed with withdrawal trucks and divided into several compartments are usually employed. The several compartments in which the cubicle is divided are control compartment, indicating and metering instrument and protective device compartment, circuit breaker and operating mechanism compartment, main bus-bar compartment and current transformers and cable sealing box compartment.

To prevent any possible opening or closing of the disconnecting devices when the circuit breaker is closed, these cubicles are designed with interlocks which prevent the truck from being rolled in or withdrawn when the circuit breaker is closed.

OUTDOOR SUBSATIONS/ AIR INSULATED SUBSTATION (AIS)

The AIS uses air as the primary dielectric from phase to phase, and phase to ground insulation. They have been in use for years before the introduction of GIS.

Actually, most substations across all regions are AIS. They are in extensive use in areas where space, weather conditions, seismic occurrences, and environmental concerns are not an issue such as rural areas, and favorable offsite terrain.

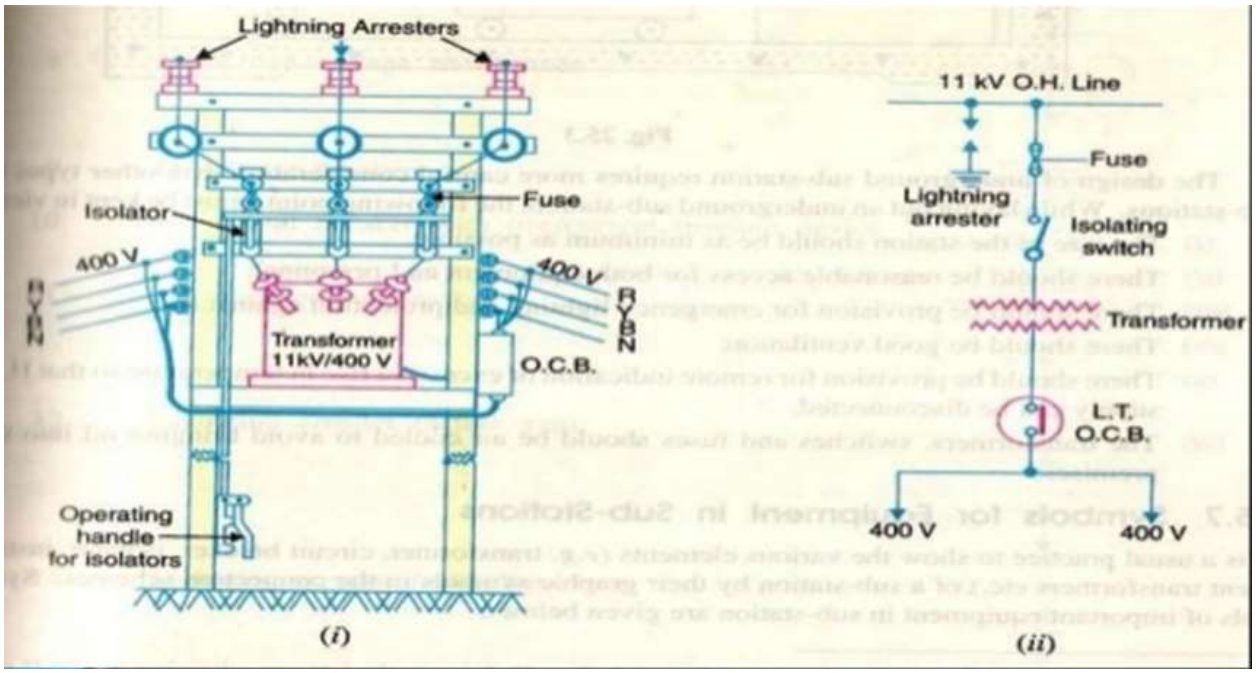
The indoor AIS version is only used in highly polluted areas, and salty conditions, as the air quality is compromised.

1. POLE MOUNTED SUBSTATION

Pole mounted substation are erected for mounting distribution transformers of capacity up to 250 KVA. Such substations are cheapest, simple and smallest of substations. All the equipment is of outdoor type and mounted on the supporting structure of high tension distribution line. Triple Pole Mechanically Operated (TPMO) switch is used for switching “on” and “off” of high tension transmission line. HT fuse unit is installed for protection of high tension side. To control low tension side iron clad low tension switch of suitable capacity with fuses is installed. Lightning arresters are installed over the high tension line to protect the transformer from the surges. Substation is earthed at two or more places

Generally transformers of capacity up to 125 KVA are mounted on double pole structure and for transformers of capacity above 125 KVA but not exceeding 250 KVA 4-pole structure with suitable platform is used. This type of pole-mounted substation is erected in very thickly populated location.

The maintenance cost of such substations is low and by using a large number of such substations in a town it is possible to lay the distributors, at a lower cost. But owning to increase in number of transformers, total KVA is increased, no load losses increase and the cost per KVA is thus more. Economy is the main consideration when a choice is made for such substation. Typical 200 KVA pole mounted substation.



2. FOUNDATION MOUNTED SUBSTATION

Foundation Mounted Substation are built entirely in the open and in such substations all the entirely in the open and in such substations all the equipment is assembled into one unit usually enc-loaded by a fence from the point of view of safety. Substations for primary and secondary transmission and for secondary distribution, (above 250 KVA) are foundation mounted outdoor type. Since equipment required for such substations is heavy, therefore, site selected for theses substation must have a good access for heavy transport. Again, owing to exposed bus-bars and other associated equipment the clearances and spacing are not only to be governed by the operating voltage but also from the considerations of the encroachment form outside. Low level type substations are designed except when the space available is limited as these provide facility of easy inspection, cleaning and maintenance.

The switch-gear consists of circuit breakers of suitable type on both the sides but with the increased reliability of the modern transformers, the practice is to dispense with the circuit breaker on the incoming side form the economic considerations. The isolating switches thus serve the purpose.

OUTDOOR SUBSTATION ADVANTAGE DISADVANTAGES:

Advantages of Air insulated Substation (AIS):

1. This type of substation arrangement is best suited for low voltage rating substations (step down substations) and for those substations where there is sufficient amount of space available for commissioning the equipment of the substation.
2. The construction work required is comparatively less to indoor switch yard and the cost of switchgear installation is also low.
3. In future the extension of the substation installation is easier.
4. The time required for the erection of air insulated substation is less compared to indoor substation.
5. All the equipment in AIS switch yard is within view and therefore the fault location is easier and related repairing work is also easy.
6. The primary choice for areas with extensive space

7. With quality design, the system is viable due to the low construction costs and cost of switchgear

8. Less construction time, thereby more suited for advanced installations

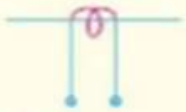
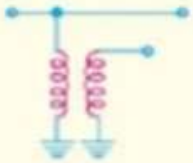
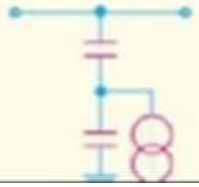
9. Easy maintenance as all the equipment is within view.

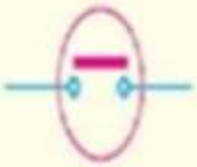
10. It is easy to notice and attend to faults.

Disadvantages of Air insulated Substation (AIS):

1. More space is required for outdoor substation when compared to indoor gas insulated substation (GIS)
2. Outdoor switch yards are more open to faults as it is located in outside atmosphere which has some influence from pollution, salty environment and other environmental factors. Deposition of saline particles on insulators can cause insulator failures. They are also open to to direct lightning strikes and other external events such as heavy winds, rains and cyclones. Therefore reliability wise air insulated substation or outdoor substations are relatively low compared to indoor substation
3. Regular maintenance is required compared to indoor substations (Maintenance for Gas Insulated Substation is very minimal and reliability is very high) as they are exposed to outside environment
4. More maintenance requirements, thus leading to high maintenance costs
5. The poor dielectric properties of air, as well as secondary factors such as humidity, pollutants, moisture means that more space is required for efficacy.

SYMBOLS FOR EQUIPMENT IN SUBSTATIONS:

S.No.	Circuit element	Symbol
1	Bus-bar	
2	Single-break isolating switch	
3	Double-break isolating switch	
4	On load isolating switch	
5	Isolating switch with earth Blade	
6	Current transformer	
7	Potential transformer	
8	Capacitive voltage transformer	

9	Oil circuit breaker	
10	Air circuit breaker with overcurrent tripping device	
11	Air blast circuit breaker	
12	Lightning arrester (active gap)	
13	Lightning arrester (valve type)	

ELECTRICAL BUS SYSTEM AND ELECTRICAL SUBSTATION LAYOUT

There are many different electrical bus system schemes available but selection of a particular scheme depends upon the system voltage, position of substation in electrical power system, flexibility needed in system and cost to be expensed.

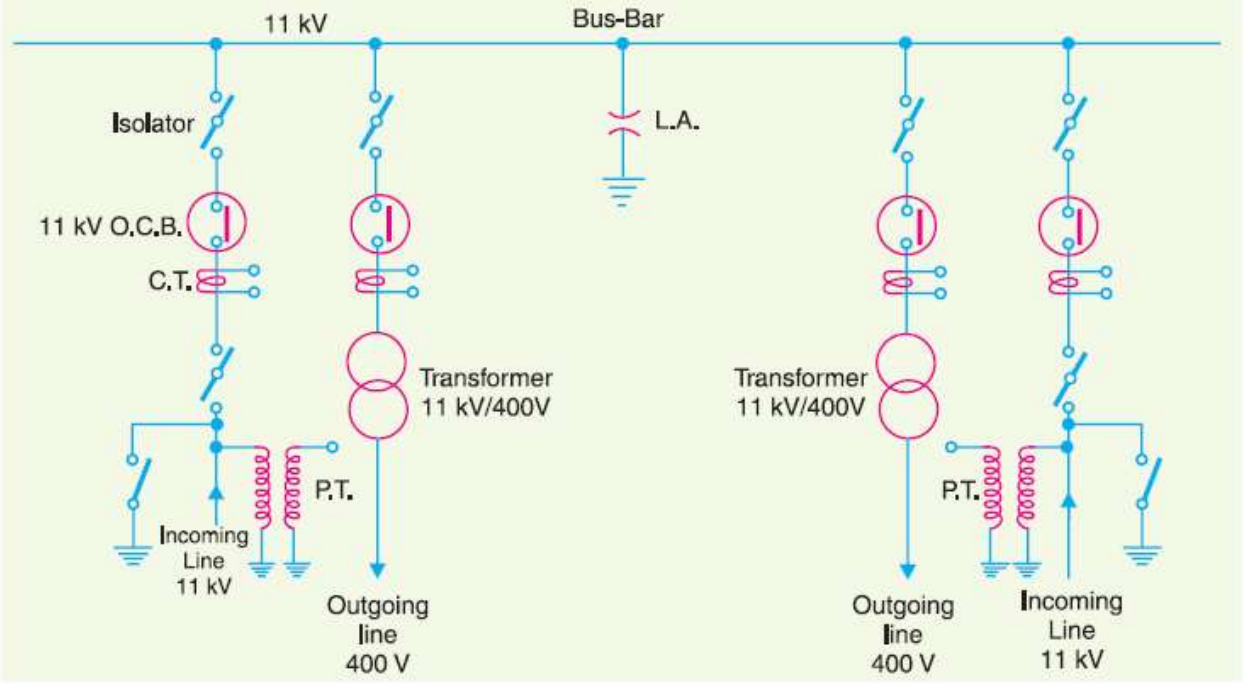
Considerable points to select a bus bar:

1. Simplicity of system.
2. Easy maintenance of different equipments.
3. Minimizing the outage during maintenance.
4. Future provision of extension with growth of demand.
5. Optimizing the selection of bus bar arrangement scheme so that it gives maximum return from the system.

Some very commonly used bus bar arrangement are discussed below-

SINGLE BUS SYSTEM:

Single Bus System is simplest and cheapest one. In this scheme all the feeders and transformer bay are connected to only one single bus as show.



Advantages of Single Bus System

1. This is very simple in design.
2. This is very cost effective scheme.
3. This is very convenient to operate.

Disadvantages of Single Bus System

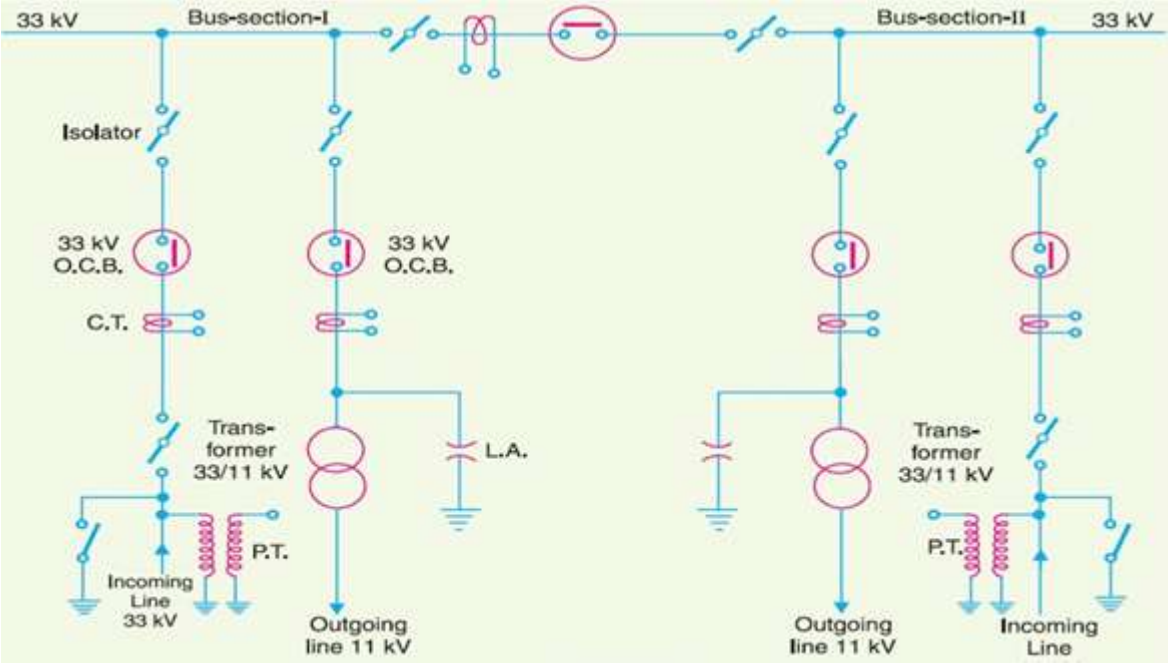
1. One but major difficulty of these type of arrangement is that, maintenance of equipment of any bay cannot be possible without interrupting the feeder or transformer connected to that bay.
2. The indoor 11 KV switchboards have quite often single bus bar arrangement.

SINGLE BUS SYSTEM WITH BUS SECTIONALIZER:

Some advantages are realized if a single bus bar is sectionalized with circuit breaker. If there are more than one incoming and the incoming sources and outgoing feeders are evenly distributed on the sections as shown in the figure, interruption of system can be reduced to a good extent.

Advantages of Single Bus System with Bus Sectionalizer

If any of the sources is out of system, still all loads can be fed by switching on the sectional circuit breaker or bus coupler breaker. If one section of the bus bar system is under maintenance, part load of the substation can be fed by energizing the other section of bus bar.

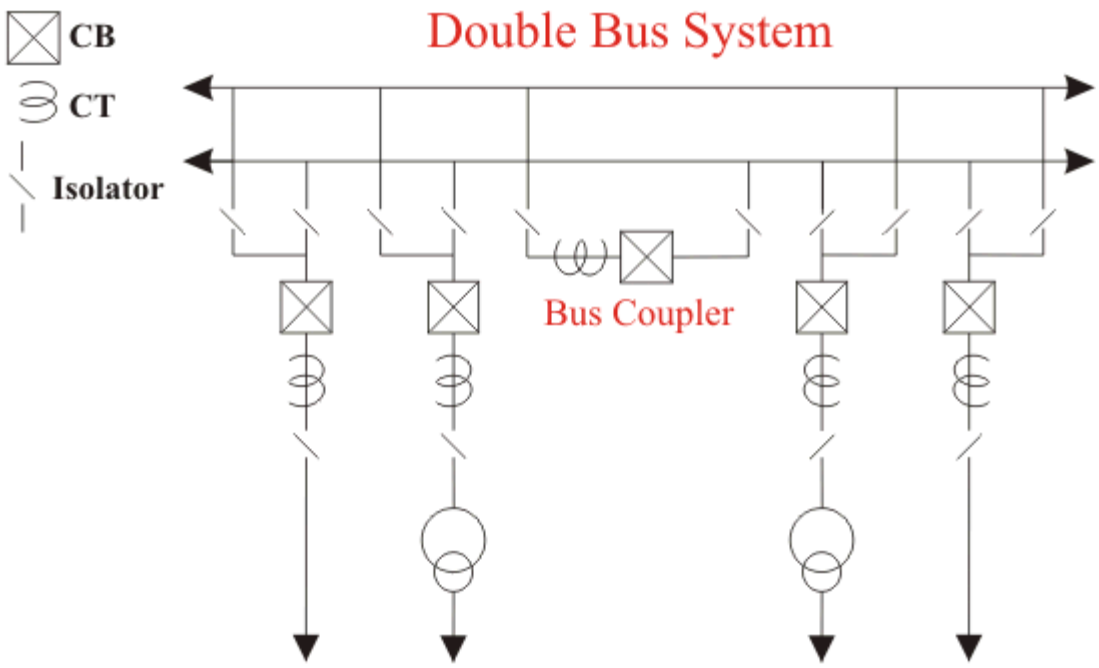


Disadvantages of Single Bus System with Bus Sectionalizer

1. As in the case of single bus system, maintenance of equipment of any bay cannot be possible without interrupting the feeder or transformer connected to that bay.
2. The use of isolator for bus sectionalizing does not fulfill the purpose. The isolators have to be operated 'off circuit' and which is not possible without total interruption of bus – bar. So investment for bus-coupler breaker is required.

DOUBLE BUS SYSTEM:

1. In double bus bar system two identical bus bars are used in such a way that any outgoing or incoming feeder can be taken from any of the bus.
2. Actually every feeder is connected to both of the buses in parallel through individual isolator as shown in the figure.



By closing any of the isolators one can put the feeder to associated bus. Both of the buses are energized and total feeders are divided into two groups, one group is fed from one bus and other from other bus. But any feeder at any time can be transferred from one bus to other. There is one bus coupler breaker which should be kept close during bus transfer operation. For transfer operation, one should first close the bus coupler circuit breaker then close the isolator associated with the bus to where the feeder would be transferred and then open the isolator associated with the bus from where feeder is transferred. Lastly after this transfer operation he or she should open the bus coupler breaker.

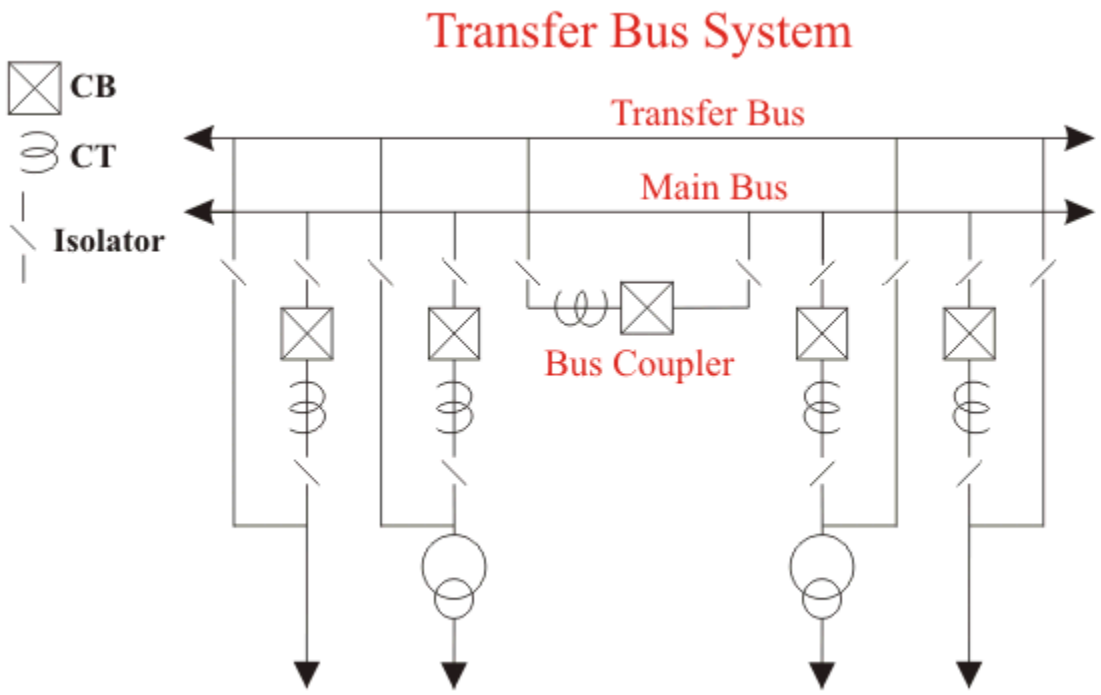
Advantages of Double Bus System

Double Bus Bar Arrangement increases the flexibility of system.

Disadvantages of Double Bus System

The arrangement does not permit breaker maintenance without interruption.

MAIN AND TRANSFER BUS SYSTEM:



This is an alternative of double bus system. The main conception of Main and Transfer Bus System is, here every feeder line is directly connected through an isolator to a second bus called transfer bus. The said isolator in between transfer bus and feeder line is generally called bypass isolator. The main bus is as usual connected to each feeder through circuit breaker and associated isolators at both side of the breaker. There is one bus coupler by which couples transfer bus and main bus through a circuit breaker and associated isolators at both sides of the breaker. If necessary the transfer bus can be energized by main bus power by closing the transfer bus coupler isolators and then breaker. Then the power in transfer bus can directly be fed to the feeder line by closing the bypass isolator. If the main circuit breaker associated with feeder is switched off or isolated from system, the feeder can still be fed in this way by transferring it to transfer bus.

Switching Operation for Transferring a Feeder to Transfer Bus from Main Bus without Interruption of Power

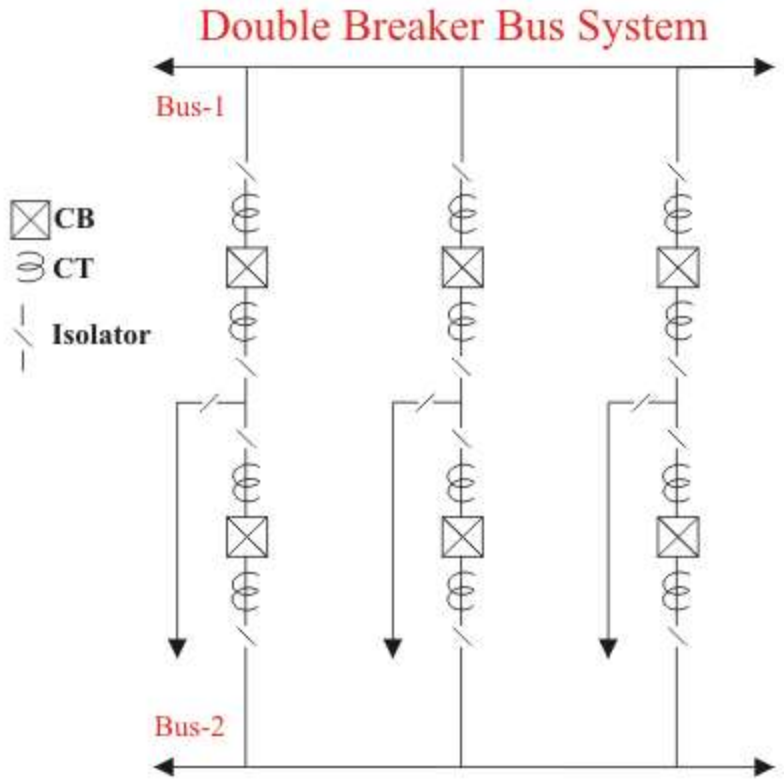
1. First close the isolators at both side of the bus coupler breaker.
2. Then close the bypass isolator of the feeder which is to be transferred to transfer bus.

3. Now energized the transfer bus by closing the bus coupler circuit breaker from remote.
4. After bus coupler breaker is closed, now the power from main bus flows to the feeder line through its main
5. Breaker as well as bus coupler breaker via transfer bus.
6. Now if main breaker of the feeder is switched off, total power flow will instantaneously shift to the bus coupler breaker and hence this breaker will serve the purpose of protection for the feeder.
7. At last the operating personnel open the isolators at both sides of the main circuit breaker to make it isolated from rest of the live system.

So, it can be concluded that in Main & Transfer Bus System the maintenance of circuit breaker is possible without any interruption of power. Because of this advantage the scheme is very popular for 33 KV and 11KV system.

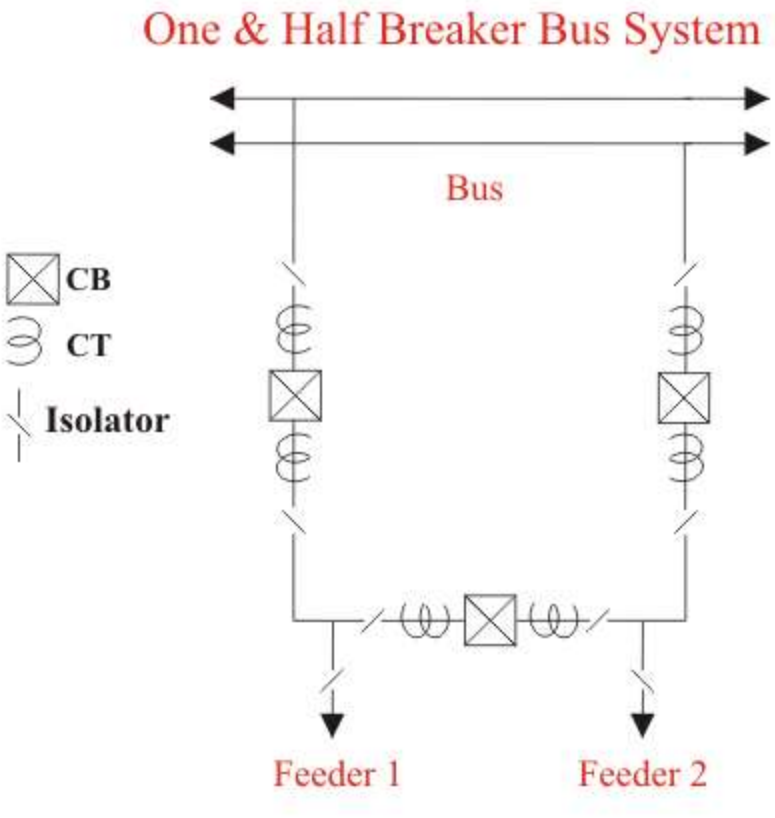
DOUBLE BREAKER BUS SYSTEM:

In double breaker bus bar system two identical bus bars are used in such a way that any outgoing or incoming feeder can be taken from any of the bus similar to double bus bar system. Only difference is that here every feeder is connected to both of the buses in parallel through individual breaker instead only isolator as shown in the figure. By closing any of the breakers and its associated isolator one can put the feeder to respective bus. Both of the buses are energized and total feeders are divided into two groups, one group is fed from one bus and other from other bus similar to previous case. But any feeder at any time can be transferred from one bus to other. There is no need of bus coupler as because the operation is done by breakers instead of isolator. For transfer operation, one should first close the isolators and then the breaker associated with the bus to where the feeder would be transferred and then he or she opens the breaker and then isolators associated with the bus from where feeder is transferred.



ONE AND A HALF BREAKER BUS SYSTEM:

This is an improvement on the double breaker scheme to effect saving in the number of circuit breakers. For every two circuits only one spare breaker is provided. The protection is however



complicated since it must associate the central breaker with the feeder whose own breaker is taken out for maintenance. For the reasons given under double breaker scheme and because of the prohibitory costs of equipment even this scheme is not much popular. As shown in the figure that it is a simple design, two feeders are fed from two different buses through their associated breakers and these two feeders are coupled by a third breaker which is called tie breaker. Normally all the three breakers are closed and power is fed to both the circuits from two buses which are operated in parallel. The tie breaker acts as coupler for the two feeder circuits. During failure of any feeder breaker, the power is fed through the breaker of the second feeder and tie breaker, therefore each feeder breaker has to be rated to feed both the feeders, coupled by tie breaker.

Advantages of One and A Half Breaker Bus System

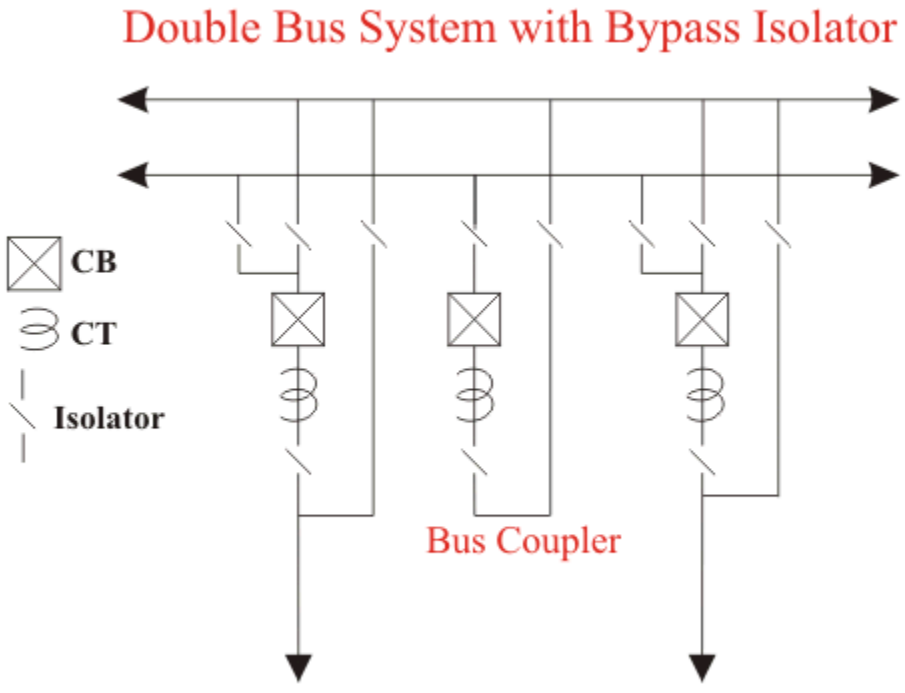
During any fault on any one of the buses, that faulty bus will be cleared instantly without interrupting any feeders in the system since all feeders will continue to feed from other healthy bus.

Disadvantages of One and A Half Breaker Bus System

This scheme is much expensive due to investment for third breaker.

DOUBLE BUS SYSTEM WITH BYPASS ISOLATORS:

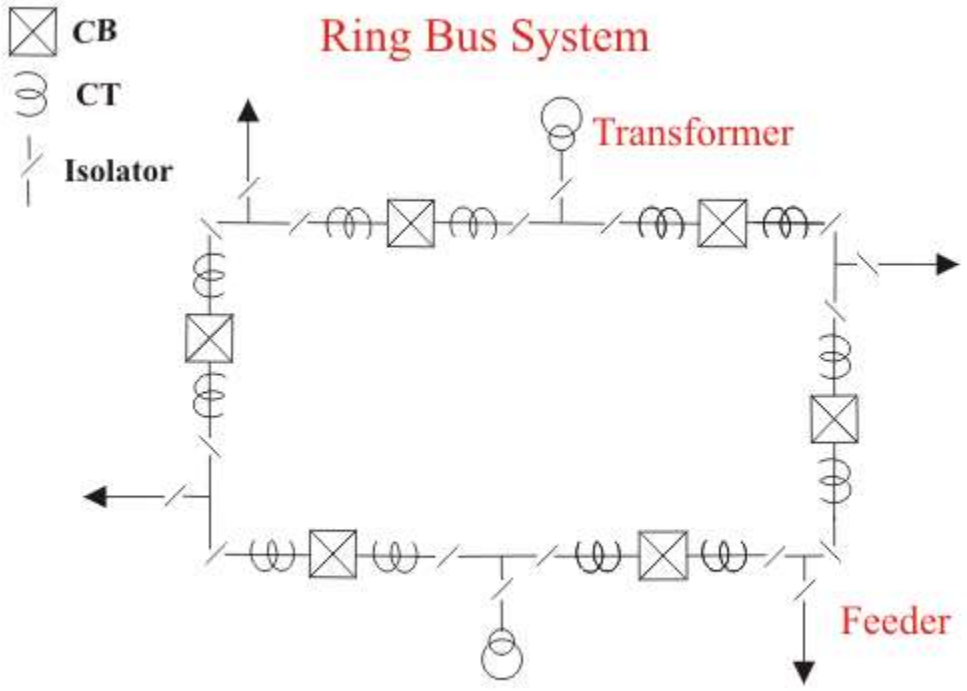
This is combination of the double bus system and main and transfer bus system. In Double Bus



System with Bypass Isolators either bus can act as main bus and second bus as transfer bus. It permits breaker maintenance without interruption of power which is not possible in double bus system but it provides all the advantages of double bus system. It however requires one additional isolator (bypass isolator) for each feeder circuit and introduces slight complication in system layout. Still this scheme is best for optimum economy of system and it is best optimum choice for 220 KV system.

RING BUS SYSTEM:

The schematic diagram of the system is given in the figure. It provides a double feed to each feeder circuit, opening one breaker under maintenance or otherwise does not affect supply to any feeder. But this system has two major disadvantages. One as it is closed circuit system it is next to impossible to extend in future and hence it is unsuitable for developing system. Secondly, during maintenance or any other reason if any one of the circuit breaker in ring loop is switch of reliability of system becomes very poor as because closed loop becomes opened. Since, at that moment for any tripping of any breaker in the open loop causes interruption in all the feeders between tripped breaker and open end of the loop.



Key Diagram of 66/11 kV Sub-Station:

Fig. 25.10 shows the key diagram of a typical 66/11 kV sub-station. The key diagram of this substation can be explained as under:

(***i***) There are two 66 kV incoming lines marked 'incoming 1' and 'incoming 2' connected to the bus-bars. Such an arrangement of two incoming lines is called a double circuit. Each incoming line is capable of supplying the rated sub-station load. Both these lines can be loaded simultaneously to share the sub-station load or any one line can be called upon to meet the entire load. The double circuit arrangement increases the reliability of the system. In case there is a breakdown of one incoming line, the continuity of supply can be maintained by the other line.

(***ii***) The sub-station has duplicate bus-bar system; one 'main bus-bar' and the other spare busbar. The incoming lines
can be connected to either bus-bar with the help of a bus-coupler which consists of a circuit breaker and isolators. The advantage of double bus-bar system is that if repair is to be carried on one bus-bar, the supply need not be interrupted as the entire load can be transferred to the other bus.

(***iii***) There is an arrangement in the sub-station by which the same 66 kV double circuit supply is going out *i.e.* 66 kV double circuit supply is passing through the sub-station. The outgoing 66 kV double circuit line can be made to act as incoming line.

(***iv***) There is also an arrangement to step down the incoming 66 kV supply to 11 kV by two units of 3-phase transformers; each transformer supplying to a separate bus-bar. Generally, one transformer supplies the entire sub-station load while the other transformer acts as a standby unit. If need arises, both the transformers can be called upon to share the sub-station load. The 11 kV outgoing lines feed to the distribution sub-stations located near consumers localities.

(***v***) Both incoming and outgoing lines are connected through circuit breakers having isolators on their either end. Whenever repair is to be carried over the line towers, the line is first switched off and then earthed.

(***vi***) The potential transformers (P.T.) and current transformers (C.T.) and suitably located for supply to metering and indicating instruments and relay circuits (not shown in the figure). The P.T. is connected right on the point where the line is terminated. The CTs are connected at the terminals of each circuit breaker.

(***vii***) The lightning arresters are connected near the transformer terminals (on H.T. side) to protect

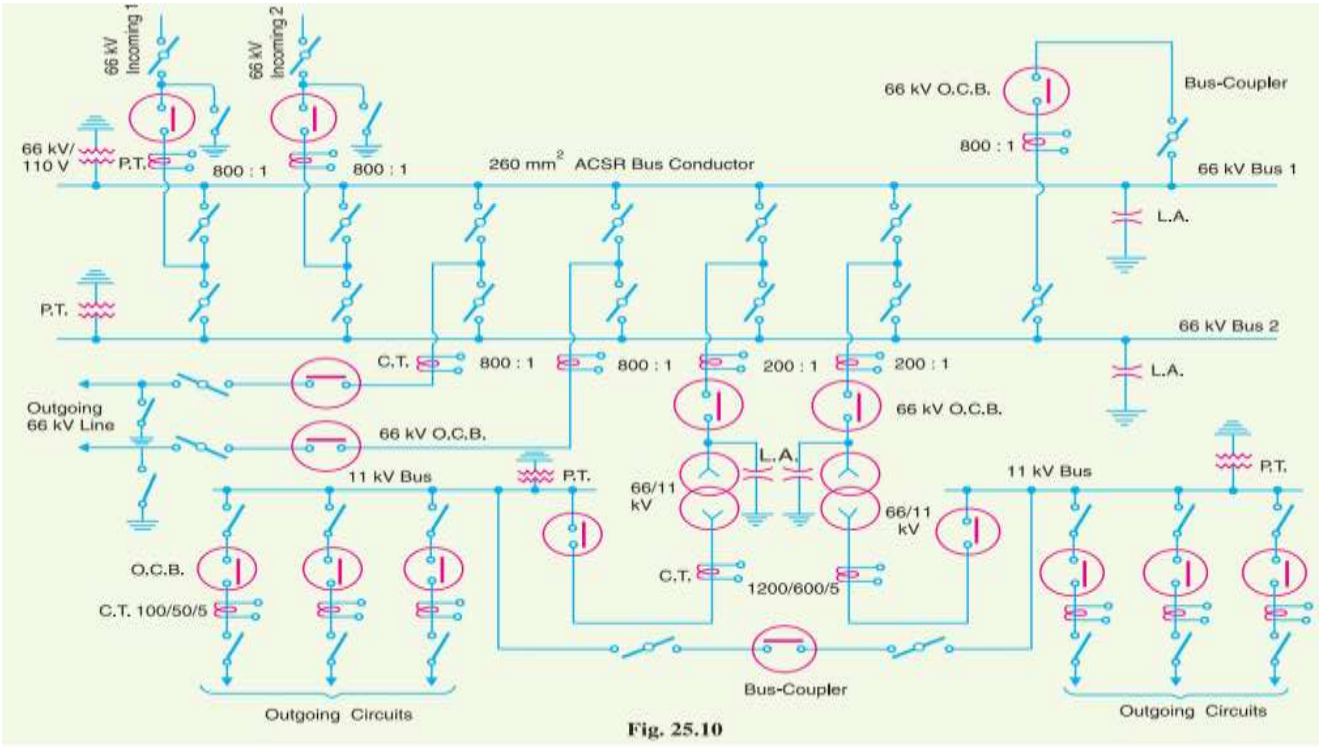


Fig. 25.10

them from lightning strokes.

(***viii***) There are other auxiliary components in the sub-station such as capacitor bank for power factor improvement, earth connections, local supply connections, d.c. supply connections etc. However, these have been omitted in the key diagram for the sake of simplicity.

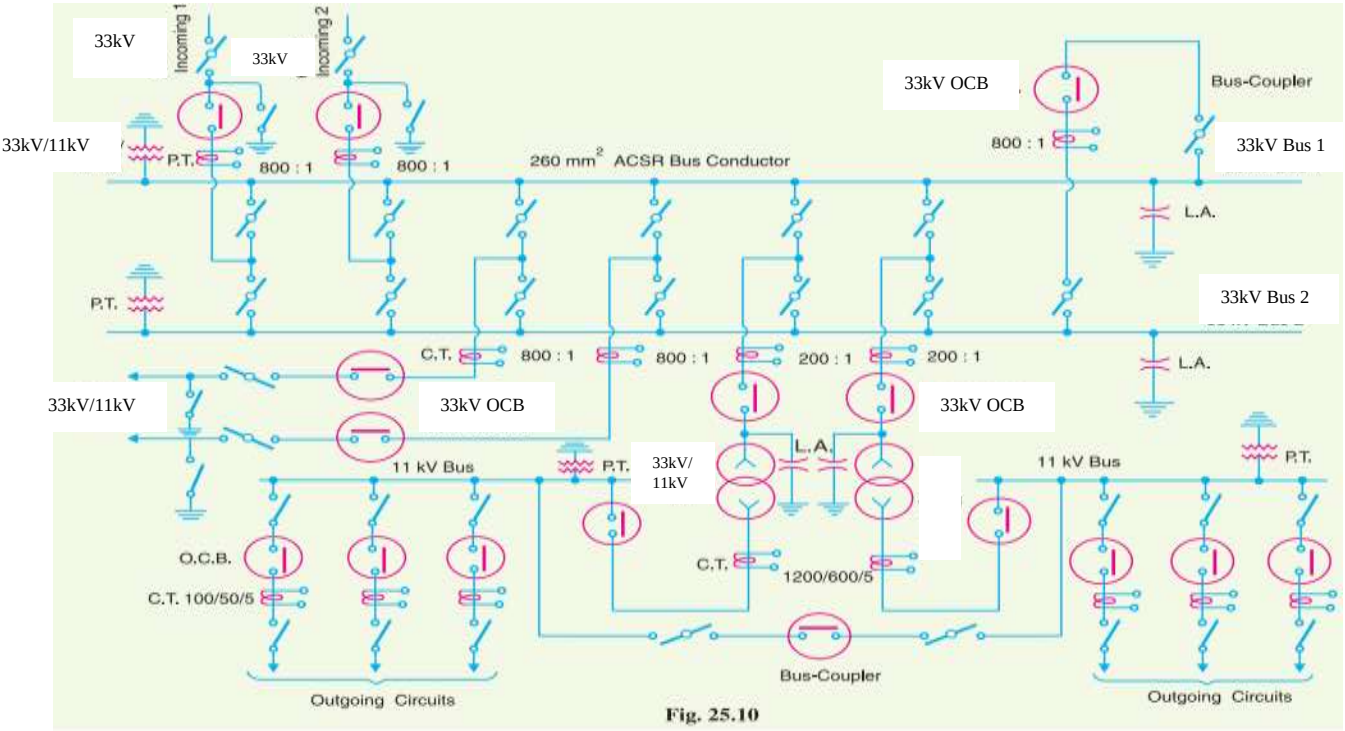


Fig. 25.10

GAS INSULATED SUBSTATION:

Introduction

Gas Insulated Substation uses sulfur hexafluoride (SF6) gas which has a superior dielectric properties used at moderate pressure for phase to phase and phase to ground insulation. In Gas Insulated Substation the high-voltage conductors, circuit breaker interrupters, switches, current transformers, voltage transformers and lightning arresters are encapsulated in SF6 gas inside grounded metal enclosures.

Why Gas Insulated Substations are used?

Gas Insulated Substations are used where there is space for providing the substation is expensive in large cities and towns. In normal substation the clearances between the phase to phase and phase to ground is very large. Due to this, large space is required for the normal or Air Insulated Substation (AIS). But the dielectric strength of SF6 gas is higher compared to the air, the clearances required for phase to phase and phase to ground for all equipment's are quite lower. Hence, the overall size of each equipment and the complete substation is reduced to about 10% of the conventional air insulated substation.

Locations where Gas Insulated Substation is preferred:

- Large cities and towns
- Underground stations
- Highly polluted and saline environment Indoor GIS occupies very little space
- Substations and power stations located Off shore
- Mountains and valley regions

Explanation:

The SF6 Gas Insulated Substation (GIS) contains the same compartments as in the conventional outdoor substations. All the live parts are enclosed in metal housings filled with SF6 gas. The live parts are supported on cast resin insulators. Some of the insulators are designed as barriers between neighboring modules such that the gas does not pass through them.

The entire installation is sub divided into compartments which are gas tight with respect to each other. Thereby the gas monitoring system of each compartment can be independent and simpler.

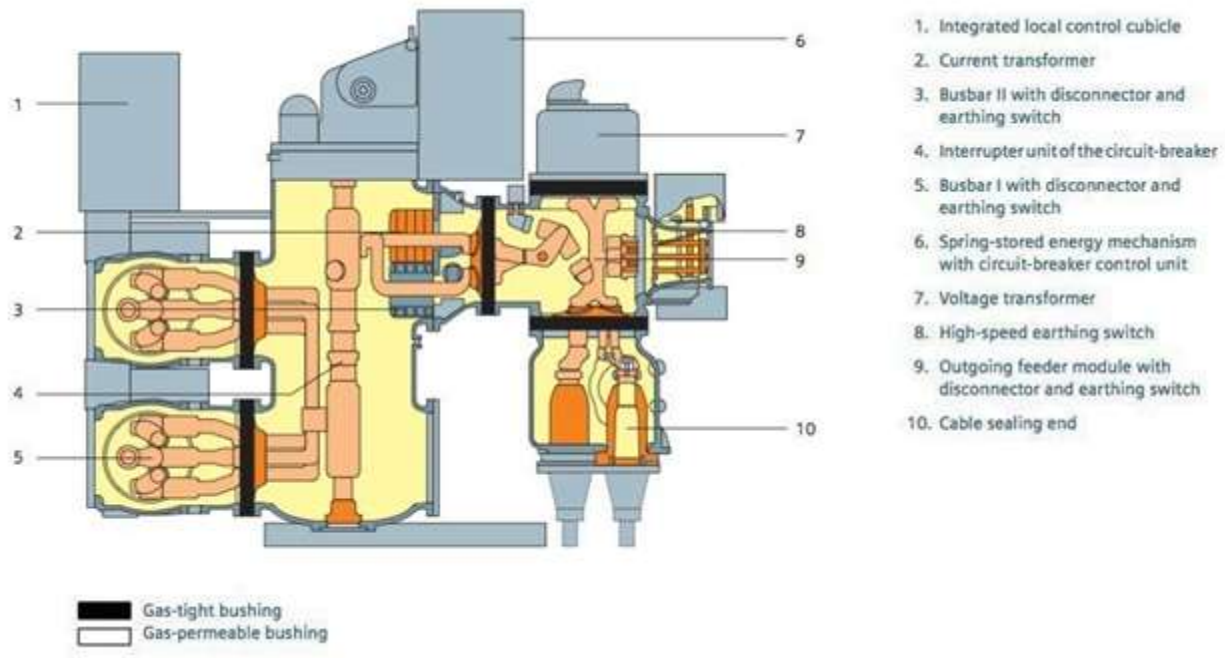
The enclosures are of non-magnetic materials such as aluminum or stainless steel and are earthed. The gas tightness is provided with static 'O' seals placed between the machined flanges. The 'O'- rings are placed in the grooves. 'O'-seals are important to ensure gas tight performance of Gas Insulated Substation.

Gas Insulated Substation has gas monitoring system. Gas inside each compartment should have a pressure of about 3kg/cm^2.The gas density in each compartment is monitored. If the pressure drops slightly, the gas is automatically trapped up. With further gas leakage, the low pressure alarm is sounded or automatic tripping or lock-out occurs.

Properties of Gas Insulated Substation (GIS)

1. SF_6 is non-toxic.
2. Maintains atomic and molecular properties even at high voltages.
3. High cooling properties.
4. Superior arc quenching properties.

SF_6 has superior dielectric properties compared to other gases thereby provide favorable insulation for the phase to phase and phase to ground moderation.



Advantages of GIS

1. It occupies very less space (1/10th) compared to ordinary substations. Hence these Gas Insulated Substations (GIS) are most preferred where area for substation is small (eg: Cities)
2. Most reliable compared to Air Insulated Substations, number of outages due to the fault is less
3. Low maintenance requirements due to expedient design and protection against external elements.
4. It Can be assembled at the shop and modules can be commissioned in the plant easily
5. Under scheduled maintenance, SF6 neither ages nor depletes. There is no need to top up the gas levels throughout the equipment lifetime (approx 40 years).
6. The maintenance of GIS is free.
7. GIS has no risk for fire and explosion due to leakage of oil.
8. They generate no noise and have no radio interference.

Disadvantages of GIS

1. Cost is higher compared to Air Insulated Substation or conventional substation.
2. Procurement of SF6 gas and supply of gas to the site is problematic
3. Normally this type of substations are indoor type and requires separate building
4. Maintaining Cleanliness is very important. Dust or moisture inside the compartment causes the flash overs
5. When fault occurs internally, the outage period will be very long. The damage effect will also be severe.

DIFFERENT TYPES OF GAS INSULATED SUBSTATIONS:

According to metal enclosed switchgears GIS are classified as

Isolated phase GIS

In this configuration, each phase of the bay is assembled separately. That is, for each phase, one pole of circuit breaker, a single pole of electrical isolator, one phase assembly of current transformer are assembled together. This type of GIS requires larger bay width as compared to other gas insulated switchgear system.

Integrated 3 Phase GIS

In this configuration all three phase of circuit breaker, 3 phases of disconnections and three phase current transformer are encapsulated in an individual metal enclosure. The arrangement forms a three phase module for the element. The size of this type of module is one third of the isolated phase GIS.

Hybrid GIS System

It is a suitable combination of isolated phase and three phase common elements. Here three phase common bus bar system simplifies the connection from the bus bar. The isolated phase equipment prevents phase to phase faults. This is an optimum design considering, both facts in mind, i.e. space requirement and maintenance facility.

Compact GIS

In this GIS or gas insulated switchgear system than one functional element are encapsulate in a single metal enclosure. For example, in some design, a three phase circuit breaker, current transformer, earth switches, even other feeder elements are covered together in a single metal capsule.

Highly Integrated System

This design was introduced in the year of 2000, where, total substation equipment's are encapsulated together in single enclosure housing. This single unit gas insulated substation has gained user appreciation as it is a complete solution for an outdoor substation, in a single unit. As such, only equipment (HIS) is substitute of a total outdoor switch yard.

CONSTRUCTIONAL ASPECTS OF GIS

The GIS equipment is usually of modular construction. The enclosures for GIS equipment are fabricated using carbon steel and alloy steel, or cast using aluminum. Various components such as bus bars, circuit breakers, voltage transformer, current transformer, isolator, etc. are contained in earthed enclosures filled with SF6 gas and segregated by gas -tight insulating cones. The costly aluminum enclosures are preferred as they are light -weight and entail low production costs. The entire installation is subdivided into compartments which are gas -tight which connect each other. Thereby the gas -monitoring system of each compartment can be independent and simple. The gas tightness is presided by static '0' seals placed between machined flanges. The '0' rings are placed in the grooves such that after assembly the '0' rings get squeezed by about 20%. As per guideline followed by specter energies, the gas compartments of the three phases are fully segregated. Each gas compartment, within a phase, provided with a gas service connection to which a vacuum pump, gas refilling tank, or a gas recuperating plant can be connected. Protective items, such as absorber and bursting disks, are provided for proper functioning of the SF6gas system. In addition to above, to monitor the pressure and temperature of gas, densimeters are provided in compartments of each phase. This meter also gives alarm for loss of gas. SF6gas leakage rate is normally less than or equal to one percent per annum.

INSTALLATION

Installing a GIS high voltage substation can be faster than installing its metal-clad AIS counterpart. This is largely due to the fact that GIS systems are significantly smaller and weigh less (despite the gas weighing more than air). Provided the technician doesn't need to handle the gas itself, GIS substations are quicker to install. AIS systems need bus-bar connections and boots on the switchgear. The average installation time is reduced by approximately 30% with a GIS installation (when no gas-handling is required). GIS systems also take up less space than AIS. The physical footprint of a GIS is about 35% less than AIS.

OPERATION

GIS systems are significantly easier to care for on a regular basis as they offer front instead of rear access. They also contain their own integrated testing instruments.

Arc flashes are rare in GIS because all the interior elements are insulated, with only the cable compartment being accessible. As the parts are fully insulated, no cables or linkage can come in contact with the live parts.

MAINTENANCE

As discussed in point one, GIS switchyards require significantly less maintenance. On average, GIS systems need only be visually inspected every four years or more, depending on the specific manufacturer recommendation for your device. GIS drives only need to be re-greased after about 20 years (again, this varies between manufacturers).

AIS systems should be visually inspected every year to two years (again, based on the specific manufacturer recommendation). When inspected, all compartments must be checked, unlike GIS where the individual compartments and elements are fully insulated and can be monitored. On average, an AIS breaker will need about four hours of maintenance for each two-year period.

In terms of maintenance, AIS systems require significantly more effort, especially due to the thoroughness of the inspections. Inspections include having a technician torque, draw-out, clean, lubricate and vacuum the unit. They also need to be checked for visual signs of copper corrosion,

something that doesn't occur in GIS due to the units being sealed. That sealing also protects the components from environmental damage.

Comparison of AIS and GIS

S.No	Particulars	AIS	GIS
1	Area requirement	More	Less
2	Maintenance cost	More	Less
3	Installation cost	More	Less
4	Concrete work to do	More	Less
5	Flashovers and Breakdown occurs	Frequently	Rarely
6	Voltage rating	Low	High
7	Visualization spark	Visible	Not visible
8	Repair and Replacement cost of equipment	Low	High