G.PULLAIAH COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPT OF EEE

Electrical Distribution Systems

UNIT-3

BASIC TERMS AND DEFINITIONS:

Substation	A substation is a part of an electrical generation, transmission, and distribution system. Substations transform voltage from high to low, or the reverse, or perform any of several other important functions
Distribution Substation	Distribution substation typically operates at 2.4 – 34.5 kV voltage levels, and deliver electric energy directly to industrial and residential consumers. Distribution feeders transport power from the distribution substations to the end consumers' premises. These feeders serve a large number of premises and usually contain many branches.
Feeder	In electric power distribution, Feeder is "voltage power line transferring power from a distribution substation to the distribution transformers" In an electrical wiring circuit in a building which feeder is a "wire/line that carries power from a transformer or switch gear to a distribution panel."
Indoor substation	In such type of substations, the apparatus is installed within the substation building. Such type of substations is usually for the voltage up to 11 KV but can be raised for the 33 KV or 66 KV when the surrounding air is polluted by dust, fumes or gasses, etc.
Outdoor substation	Such Substations are erected for distributions of power in the localities. Single stout pole or H-pole and 4-pole structures with relevant platforms are operating for transformers of capacity up to 25 KVA, 125 KVA, and above 125KVA.
Bus-Bar	Bus-Bar are thick copper rods which is operate at constant voltage and carrying an electric current to which many connections may be made.
Sectionlaizer	The sectionalizer is a self-contained, circuit-opening device used in conjunction with source-side protective devices, such as reclosers or circuit breakers, to automatically isolate faulted sections of electrical distribution systems.
Fault	In an electric power system, a fault or fault current is any abnormal electric current. For example, a short circuit is a fault in which current bypasses the normal load. An open-circuit fault occurs if a circuit is interrupted by some failure. In three-phase systems, a fault may involve one or more phases and ground, or may occur only between phases. In a "ground fault" or "earth fault", current flows into the earth.
Potential Transformer	Potential transformer or voltage transformer gets used in electrical power system for stepping down the system voltage to a safe value which can be fed to low ratings meters and relays.

Current Transformer	A current transformer (CT) is a type of transformer that is used to measure alternating current (AC). It produces a current in its secondary which is proportional to the current in its primary.
Isolator	Isolator is a mechanical switch which isolates a part of circuit from system as when required. Electrical isolators separate a part of the system from rest for safe maintenance works.
Circuit Breaker	Circuit breaker always trip the circuit but open contacts of breaker cannot be visible physically from outside of the breaker and that is why it is recommended not to touch any electrical circuit just by switching off the circuit breaker.
Power Transformer	Power transformer is used for the transmission purpose at heavy load, high voltage greater than 33 KV & 100% efficiency. It also having a big in size as compare to distribution transformer, it used in generating station and Transmission substation .high insulation level.

Concepts:

Factors to be considered for optimal location of substation:

Distribution substation design must be a combination of reliability and quality of the power supply, safety, economics, maintainability, simplicity of operation, and functionality.

Important Factors And Standardization In The Design of The Distribution Substation:

Safety of life and preservation of property are the two most important factors in the design of the substation. Codes must be followed and recommended practices or standards should be followed in the selection and application of material and equipment. Following are the operating and design limits that should be considered in order to provide safe working conditions:

1. Interrupting devices must be able to function safely and properly under the most severe duty to which they may be exposed.
2. Accidental contact with energized conductors should be eliminated by means of enclosing the conductors, installing protective barriers, and interlocking.
3. The substation should be designed so that maintenance work on circuits and equipment can be accomplished with these circuits and equipment de-energized and grounded.
4. Warning signs should be installed on electric equipment accessible to both qualified and unqualified personnel, on fences surrounding electric equipment, on access doors to electrical rooms, and on conduits or cables above 600 V in areas that include other equipment.
5. Emergency lights should be provided where necessary to protect against sudden lighting failure.
6. Operating and maintenance personnel should be provided with complete operating and maintenance instructions, including wiring diagrams, equipment ratings, and protective device

settings.

Factors affecting substation expansion:

1. Feeder limitations
2. Transmission Voltage
3. Tie Capacity
4. Load Forecast
5. Present capacity & Configurations
6. Projection limitations
7. Physical size and land availability
8. Economic factors
9. Power Losses

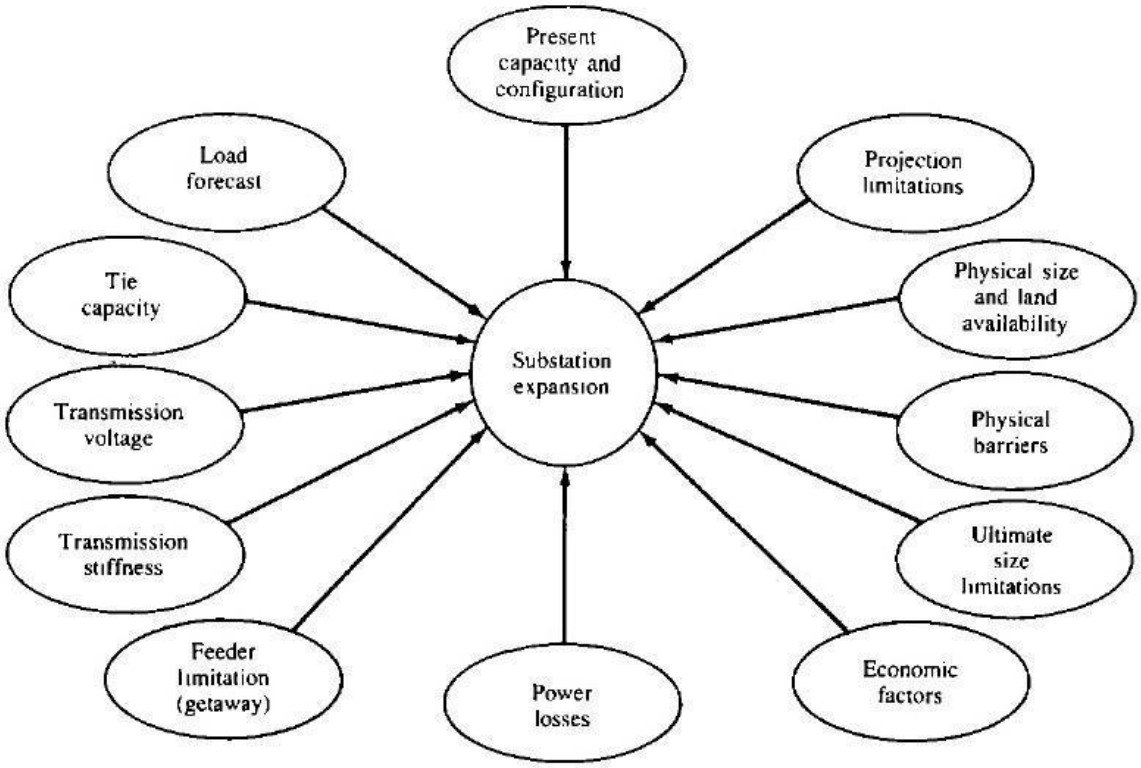


Figure: Factors affecting Site Selection

Total Cost: The substation planning must be within the cost limits and distribution of power in the large amount with low losses.

Factors affecting total Cost:

1. Capital Costs

2. Installation Costs
3. Construction Cost
4. Building Costs
5. Cost of materials
6. Maintenance Cost
7. Operating Cost
8. Cost of taxes
9. Power losses
10. Interest lost during Construction

Classification of Substations:

The substation is the medium of transferring the power from generating unit to the consumer end. It consists different types of equipment like transformer, generator, power cable which helps in the power transmission. The generation, transmission and distribution are the main work of the substation.

The substation which generates the power is known as the generating substation. Similarly, the transmission substation transmits the power, and the distributing substations distribute the power to the load. The subcategories of the electrical substations are explained below.

Classifications of Substations:

The substations may be classified in numerous ways, such as by nature of duties, service rendered operating voltage, importance, and design.

Classification of Substations by Nature of Duties:

The classification of the substation by nature of functions is explained below in details.

Step-up or Primary Substations – Such types of substations generate low voltage like 3.3, 6.6, 11, or 33kV. This voltage is stepped up by the help of a step-up transformer for transmitting the power over large distances. It is located near the generating substation

Primary Grid Substations – This substation lowered the value of primary stepped up voltages. The output of the primary grid substation acts as the input of the secondary substations. The secondary substation is used for stepping down the input voltage to more lowered for further transmission.

Step-down or Distribution Substations – This substation is placed near the load centre where the primary distribution is stepped down for sub-transmission. The secondary distribution transformer feeds the consumer through the service line

Classification of Substations by Service Rendered:

Transformer substations – In such type of substation transformers are installed for transforming the power from one voltage level to another level as per need.

Switching Substations – The substations use for switching the power line without disturbing the voltage is known as the switching substations. This type of substations is placed between the transmission line.

Converting Substations – In such types of substations, AC power converting into DC power or

vice versa or it can convert high frequency to lower frequency or vice versa.

Classification of Substations by Operating Voltage

The substations, according to operating voltage, may be categorised as

High Voltage Substations (HV Substations) – Involving voltages between 11 KV and 66 KV.

Extra High Voltage Substations – Involving voltages between 132 kV and 400 KV.

Ultra High Voltage – Operating voltage above 400 KV.

Classifications of Substation by Importance:

Grid Substations – This substation is used for transferring the bulk power from one point to another. If any fault occurs on the substation, then the continuity of whole of the supply is affected by it.

Town Substations – These substations step down the voltage at 33/11 kV for more distribution in the towns. If there is any fault occurs in this substation, then the supply of the whole town is blocked.

Classification of Substations by Design:

Indoor Type Substations – In such type of substations, the apparatus is installed within the substation building. Such type of substations is usually for the voltage up to 11 KV but can be raised for the 33 KV or 66 KV when the surrounding air is polluted by dust, fumes or gasses, etc.

Outdoor Substations – These substations are further subdivided into two categories

Pole Mounted Substations – Such Substations are erected for distributions of power in the localities. Single stout pole or H-pole and 4-pole structures with relevant platforms are operating for transformers of capacity up to 25 KVA, 125 KVA, and above 125KVA.

Foundation Mounted Substations – Such types of substations are used for mounting the transformers having capacity 33,000 volts or above.

Bus-Bar Arrangements:

When a number generators or feeders have same voltage then there is necessity to connect all unit electrically, bus-bars are used as the common electrical component. In this article, we will discuss about different bus-bar arrangements.

Bus-Bar:

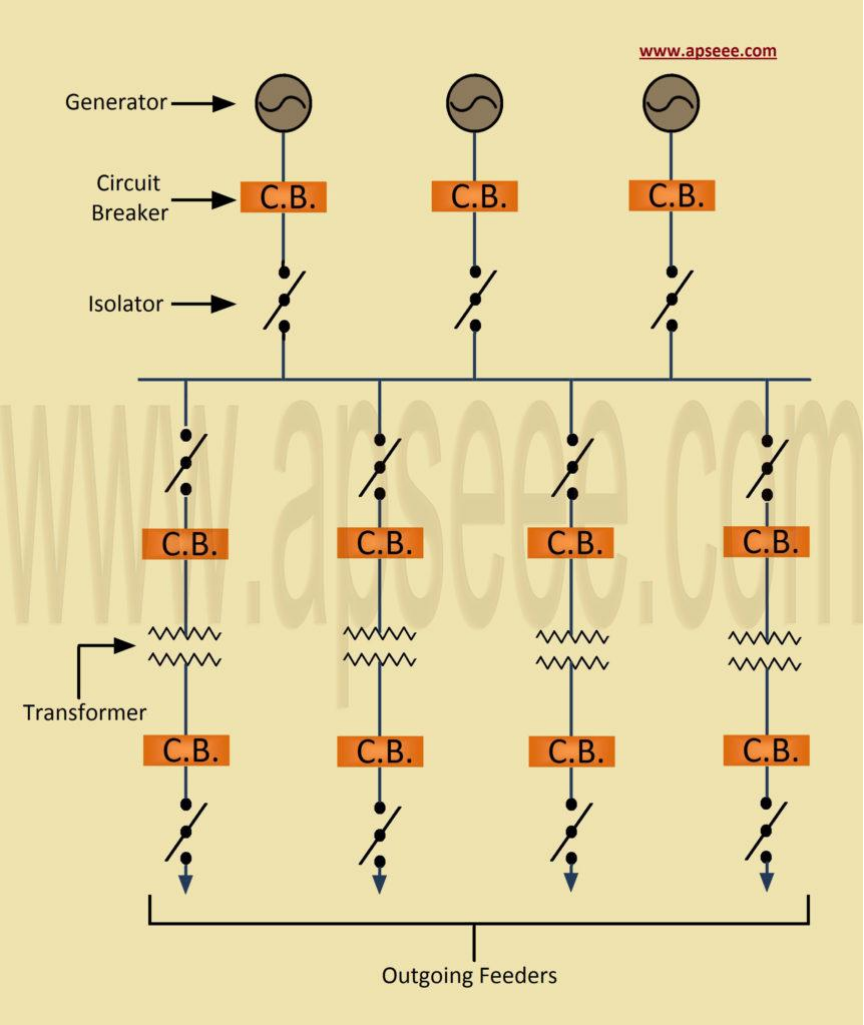
Bus-Bar are thick copper rods which is operate at constant voltage and carrying an electric current to which many connections may be made.

The Bus-bar is arranged in different manner. The different bus-bar arrangements are given below.

1. Single Bus-Bar Arrangement:

It is a simplest form of arrangement of bus-bar. It is used in power stations and small outdoor substations having small number of incoming and outgoing feeders. Each generator and feeder is

controlled by a circuit breaker.



Advantages:

It has low initial cost.

It required less maintenance.

Simple operation.

Disadvantages

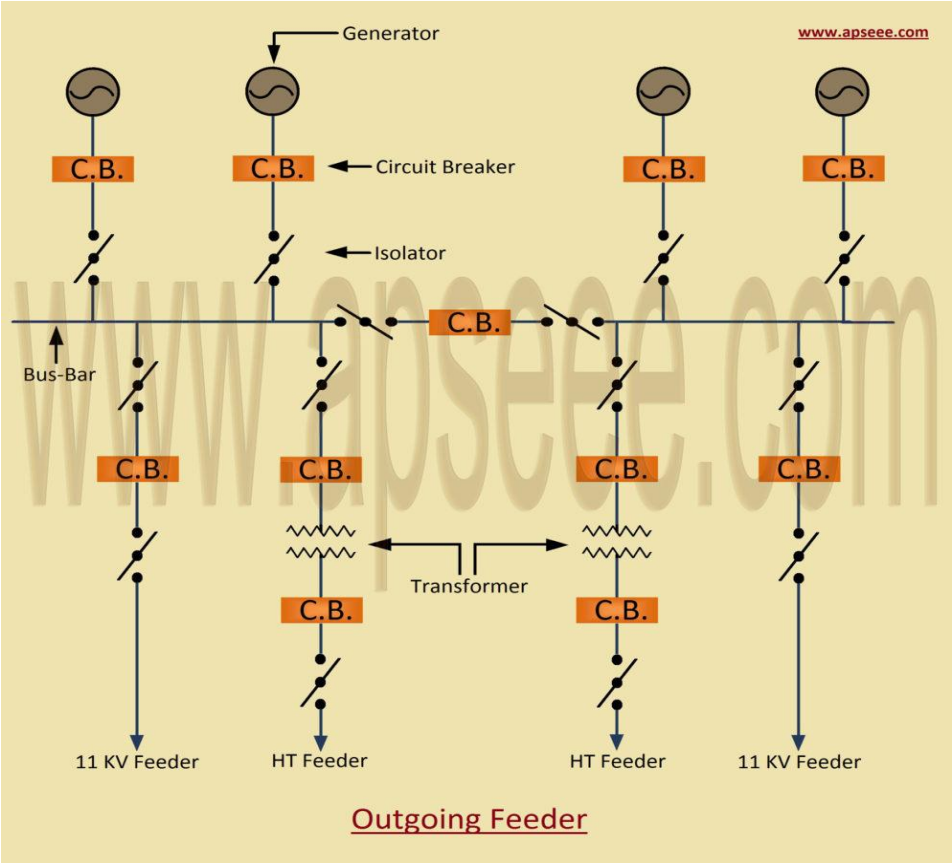
If fault occurs on bus-bar, whole supply is affected.

For repair and maintenance of the bus-bar, whole of the system has need to be de-energized.

2. Single Bus-Bar Arrangement with Sectionalization:

In large power generating stations, where several numbers of generators and feeders are required to be connected to the bus-bar. In that cases, Single bus-bar arrangement with

sectionalization is employed. Normally the number of sections of a bus-bar is 2 to 3 in generating station and substation.



Advantages:

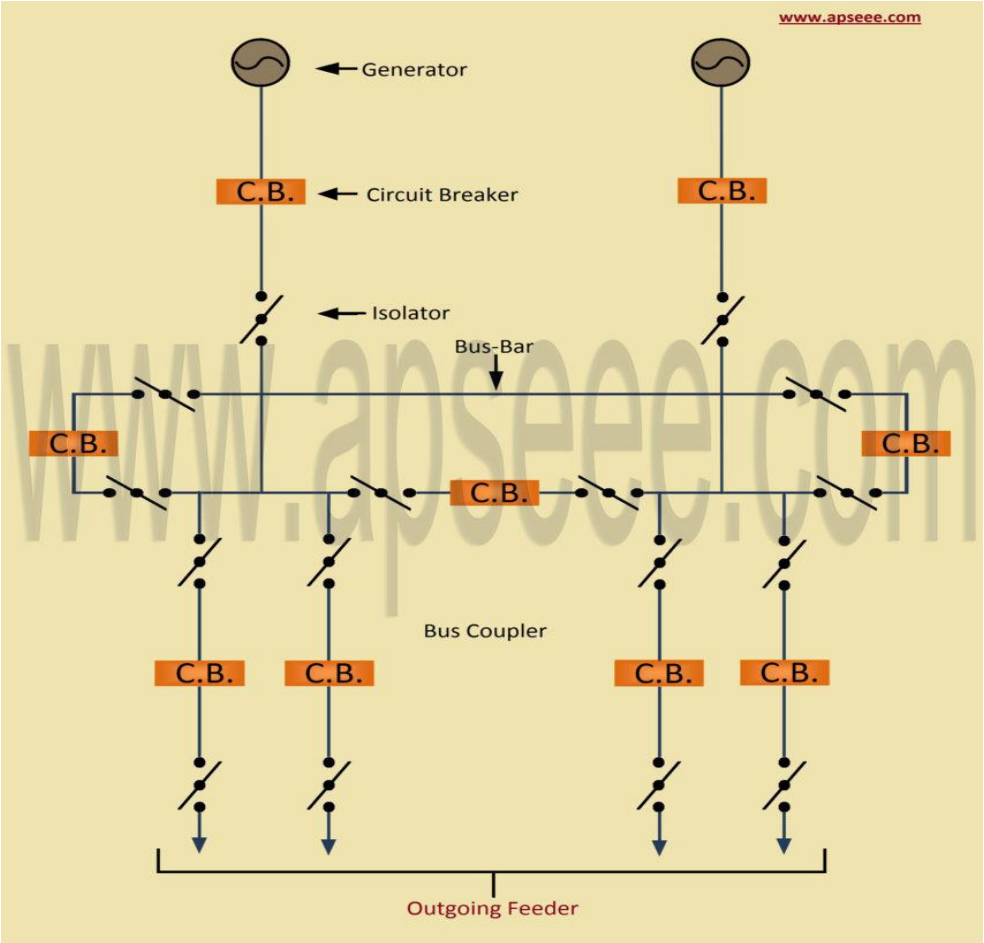
1. In case, when fault occurs on any section faulty section can be disconnected without affecting other section.
2. This arrangement is more reliable that single bus-bar arrangement.
3. The repair and maintenance of any section of the bus-bar can be carried out be disconnecting that section only.
4. Future extension is possible in this arrangement.

Disadvantages:

In this arrangement additional circuit breakers and isolators are required for sectionalisation. Hence, cost is increased.

Ring Bus-Bar Arrangement:

In this arrangement, each feeder is supplied from two paths. This is an extension of the sectionalized arrangement.



Advantages:

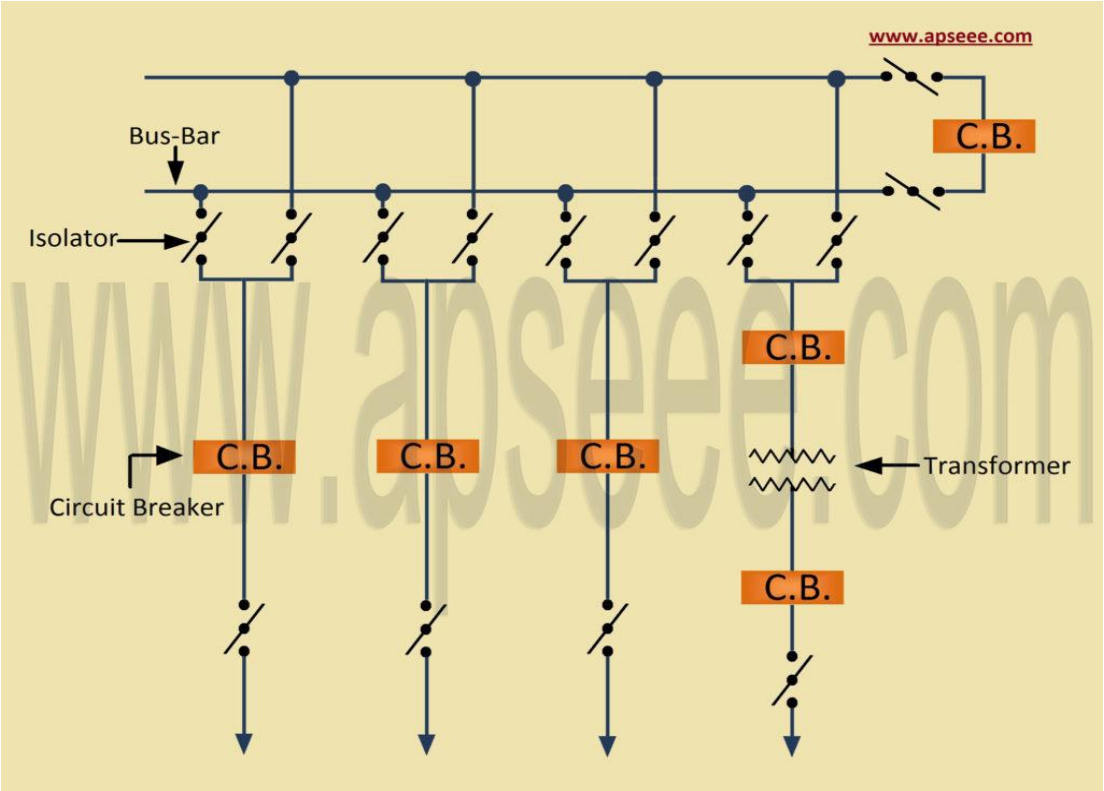
- This arrangement provides greater flexibility. In case, fault occurs , it does not affects the other section.
- The number of circuit breaker required in this arrangement almost same as in a single phase bus-bar system. It reduces the initial cost.

Disadvantages:

Extension is not possible in this arrangement. Separately protection system is required for each circuit.

Main and Transfer Bus-Bar Arrangements:

Such a arrangement consists of two bus-bars a “main bus-bar” and “an auxiliary bus-bar. This arrangement is adopted where continuity of supply. Each generator and feeder may be connected to either bus-bar with the help of bus coupler which consists of a circuit breaker and isolating switches.



Advantages:

If fault occurs on the bus-bar, supply can be maintained by transferring it to the healthy.

The other feeders can be connected to the bus-bars without disturbing the existing system.

Important Questions:

1. Explain the criteria for location of a substation and what are the benefits obtained through optimal location of Substation?
2. How the rating of distribution substation can be calculated. Explain taking a general case with `n' no. of feeders?
3. Explain the single bus bar system with sectionalization and what are its merits and demerits?
4. Discuss about the classification of different types of substations. State the advantages and disadvantages of each substation.
5. Compare the four and six feeder's patterns in substation location.