Substation :- A substation is a part of an electrical generation, transmission and distribution system. It transfer voltage from high to low or low to high for efficient transmission and distribution of power.

Necessity of substation :-

1. Voltage transformation :-

Changes voltage levels for efficient transmission and distribution.

2. System protection :-

Protects electrical networks by isolating faults with circuit breakers and relay.

3. Used for load balancing
4. Used for metering to find losses.

5. Power quality Improvement :-

Substations can incorporate devices like capacitors and reactors to improve power quality by ~~red~~ regulating voltage and compensating for reactive power.

Classification of substation :-

Substations can be classified based on various criteria.

Based on Voltage level :-

(1) High - voltage Substations :- Operates at extra high voltage (EHV) and ultra - high voltage (UHV) for long distance transmission.
above 33 KV

HV - 33 - 66
EHV - 132 - 400
UHV - above 400 kv

(2) Medium - voltage Substations (MV) :- Operate at medium voltage for regional and local distribution.
between 11 kv - 33 kv.

(3) Low voltage substation :- Operate at low voltage for direct connection to consumers.
below 11 kv.

Based on construction :-

(1) Outdoor substation :- Equipment is installed in open air.

(2) Indoor substation :- Equipment is installed in a closed space or buildings.

(3) Underground (4) Pole mounted

Based on function :-

① ~~To substation :-~~
Step up substation :- Increase voltage for efficient long-distance transmission

② Step-down substation :- Decrease voltage for distribution to consumers.

③ Switching substations :- Primarily used for switching and controlling power flow.

④ Converting substation :-

Aspect	outdoor substation	Indoor substation
Location	Equipment is installed in open air.	Installed inside a building.
Space Requirements	Requires more space	Requires less space.
Cost	Lower installation cost	Higher installation cost.
Maintenance	Easier to maintain	Maintenance is complex
Weather impact	affected	not affected
Application	Suitable for rural or open areas.	Suitable for urban or congested areas.

List the materials required for 66 KV substation with their specifications.

1. Power Transformers :-

* Specifications :-

Rating : 66/11 KV, appropriate MVA rating based on load demand.

Cooling type : ONAN (oil-natural, air-natural) or ONAF (oil-natural, air-forced).

Impedance : To limit short-circuit currents.

Tap changer : On-load tap changer for voltage regulation.

Insulation class : suitable for the expected environmental conditions.

2. Circuit Breakers :-

* Specification :-

Voltage rating : 66 KV and 11 KV

Interrupting capacity : sufficient to interrupt fault currents.

Type :- SF6, ACB, Vaccum, etc.

3. Disconnectors :-

* Specifications :-

Voltage rating :- 66 kV and 11 kV
current rating :- To handle the load current.

4. Current Xmer :-

* Specification :-

Accuracy class : To ensure accurate metering and protection.
Burden : To match the connected protective relays

5. Potential Xmer :-

* Specification :-

- Accuracy class : For metering and protection.
- Voltage ratio : To step down high voltage for measurement and control.

6. Busbars :-

* Specification :-

Material : Copper or aluminum
Current Rating : To handle the maximum load current.
Insulation :- Adequate insulation to prevent short circuits.

7. Control and relay panels :-

* Specifications :-

Relay : Overcurrent, differential, distance and other protective relays.
Controls : for switching, metering and automation.

8. Battery Bank and charger :-

* Specification :-

- Capacity : To provide backup power for control and protection systems.
- Charger : To maintain the battery charge.

9. Earthing system :-

* Specifications :-

- Ground Grid : To provide a low-resistance path for fault currents.
- Earth Electrodes : Ground rods or plates.

10. Civil works :-

* Specifications :-

- Foundation : To support heavy equipment.
- Control Room : For housing control and protection equipment.
- Fencing and security :- To protect the substation.

Capacitor Bank :-

Capacitor banks are electrical devices used to improve power factor by supplying reactive power to the electrical system. This helps reduce energy losses, improve voltage regulation, and increase the capacity of existing power systems.

* Specifications :-

Voltage rating : The maximum voltage that the capacitor bank can withstand.

Capacitance : The amount of charge that the capacitor bank can supply.

KVAR rating :- The amount of reactive power that the capacitor bank can store.

Frequency rating :- The frequency at which the capacitor bank is designed to operate.

Connection type :- The type of connection used to connect the capacitor bank to the power system.

Protection :- The type of protection used to protect the capacitor bank from overvoltage, overcurrent and other faults.

Selection of capacitor bank :-

① Load characteristics :- The type of load, its power factor and its power demand.

② System voltage and frequency :-

The voltage and frequency of the power system.

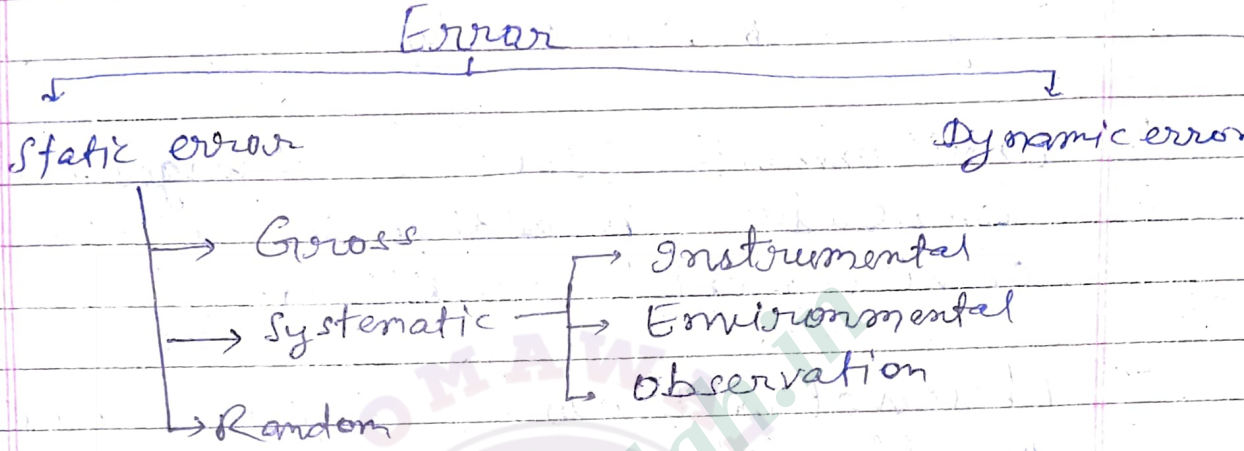
③ Desired power factor : The desired power factor after the installation of the capacitor.

Space constraints :- The available space for the purchase and installation of the capacitor bank.

Budget :- The available budget for the purchase and installation of the capacitor bank.

Unit 8. Substation Energy meter

* **Error :-** The difference between actual value and measured value is known as error.



* **Gross Error :-** These are significant errors caused by human mistakes, such as incorrect readings, faulty wiring or improper instrument setup.

- using instrument
- Reading
- calculation

* **Random error :-** The error are unpredicted and does not occur always.

eg :- If a person repeats the observation, he may get different reading everytime.

* Systematic error :- The type of error arrises due to defect in measuring instrument is called systematic error.
They can be caused by :-

1. Environmental Errors :- Changes in temperature, humidity or other environmental conditions.

2. Observation Errors :- Errors caused by the observer's technique or limitations.

3. Instrumental Errors :- Errors due to imperfection in the instrument itself, such as calibration error or component aging.

Sensitivity :- It is the ratio of the change in output of the instrument to the change of input or measured quantity.

The sensitivity of an instrument should be high.

$$\text{Sensitivity} = \frac{\text{Change in output}}{\text{Change in input}}$$

Accuracy :- Accuracy shows that how closed a measured value is to the actual value.

Precision :- Precision shows that how closed the measured value are to each other.

Example :-

Accuracy	Precision
If a meter reads 100.1 KWh and the actual energy consumed is 100 KWh, the accuracy is high.	A meter consistently reads 100.1, 100.2 and 100.5 KWh. It's precise, but may not be accurate

Resolution :- It is the smallest portion of the signal that can be observed by the instrument.

Tolerance :- This is the permissible variation or deviation from a specified value. It defines the acceptable range of error for a meter.