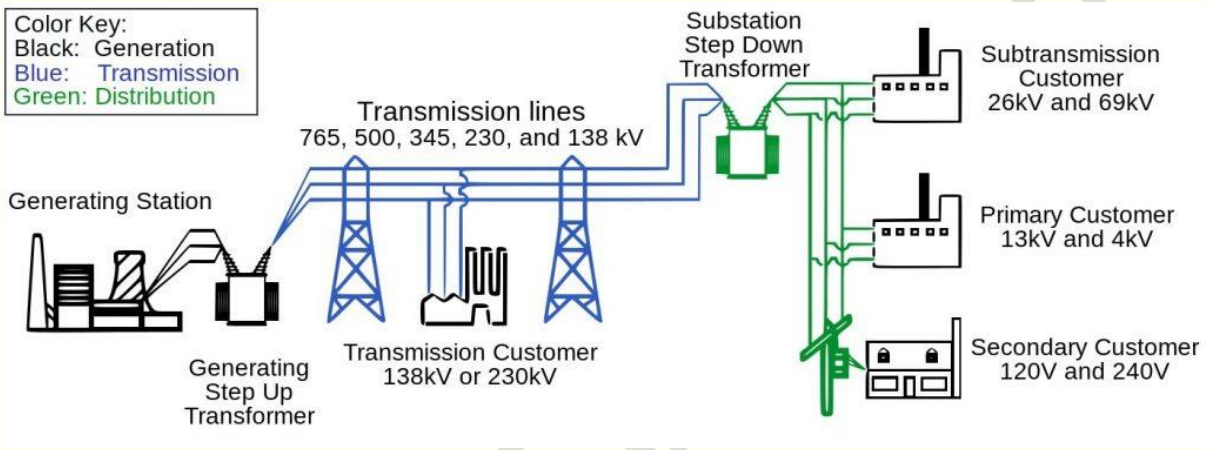
POWER SYSTEM BASICS AND STRUCTURE

Basic overview:

A power system is a complex network that delivers electrical energy from generating sources to consumers. It consists of several interconnected components, including power plants, transmission systems, and distribution systems.



Breakdown of the key components and their roles:

1. Power Plants (Generation):

- **Role:**

Generate electrical energy from various sources like fossil fuels, nuclear energy, hydro power, or renewable sources (solar, wind, etc.).

- **Example:**

A thermal power plant using coal or natural gas to generate steam, which then drives a turbine connected to a generator.

2. Transmission System:

- **Role:** Transports the generated electricity from power plants to substations and load centers.
- **Components:** High-voltage transmission lines (overhead or underground).
- **Purpose:** High voltage transmission is used to minimize energy loss during transmission over long distances.

3. Sub-transmission and Distribution Systems:

- **Role:** Reduce the voltage from high-voltage transmission levels to lower levels for distribution to customers.
- **Sub-transmission:** Connects the transmission system to local substations.

- **Distribution:** Delivers power to individual homes, businesses, and other consumers.
- **Components:** Substations, transformers, distribution lines (overhead or underground).

4. Key Components and Devices:

- **Transformers:** Step-up or step-down voltage levels.
- **Circuit Breakers:** Protect the system from overloads and faults.
- **Conductors:** Transmit electrical current (wires in transmission and distribution lines).
- **Protective Devices:** Detect and isolate faults to prevent damage and outages.

5. System Functioning:

- Power is generated at power plants, stepped up by transformers for efficient transmission.
- Transmission lines carry the power to substations, where it's stepped down to suitable voltages for distribution.
- Distribution systems deliver power to consumers, and the system ensures a balance between power generation and demand.

Let us dive deep into the topic to develop an in-depth understanding:

SECTION 1: INTRODUCTION TO POWER SYSTEM

Q1. What is a power system?
Ans: A power system is a network of electrical components used to generate, transmit, and distribute electric power. It includes power plants (generators), transmission lines, substations, distribution lines, and loads (consumers).

Q2. What are the main components of a power system?
Ans:

1. **Generating Stations** (e.g., thermal, hydro, nuclear, solar)
2. **Transmission System** (high-voltage power transfer)
3. **Substations** (voltage step-up/step-down)
4. **Distribution System** (delivers electricity to consumers)
5. **Loads** (industrial, commercial, residential consumers)

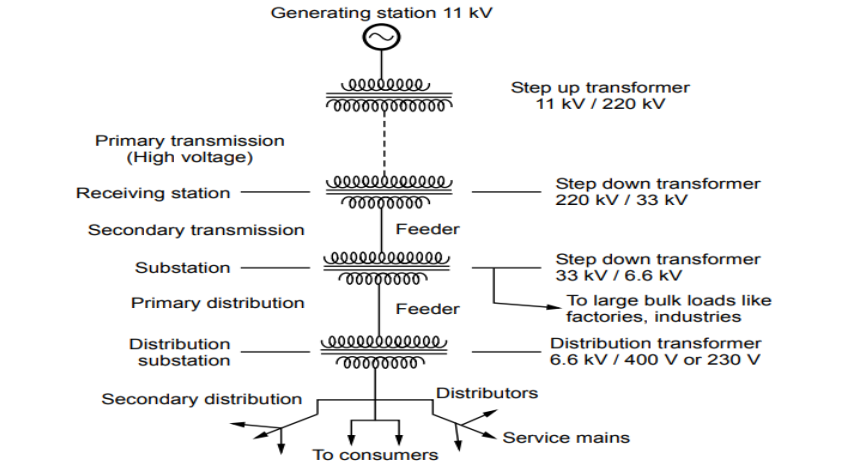


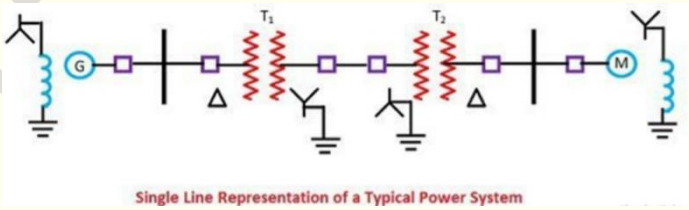
Fig. 1.2.2 Line diagram of a typical transmission distribution scheme

Q3. What is the importance of a power system?
Ans: It ensures the reliable and efficient delivery of electrical energy from the point of generation to end-users for domestic, commercial, and industrial applications.

SECTION 2: STRUCTURE OF POWER SYSTEM

Q4. Describe the basic structure of an electrical power system.
Ans:

1. **Generation** at power stations
2. **Step-up Transformer** boosts voltage for transmission
3. **Transmission Lines** carry electricity over long distances
4. **Step-down Transformer** reduces voltage for distribution
5. **Distribution Lines** deliver power to users



Single Line Representation of a Typical Power System

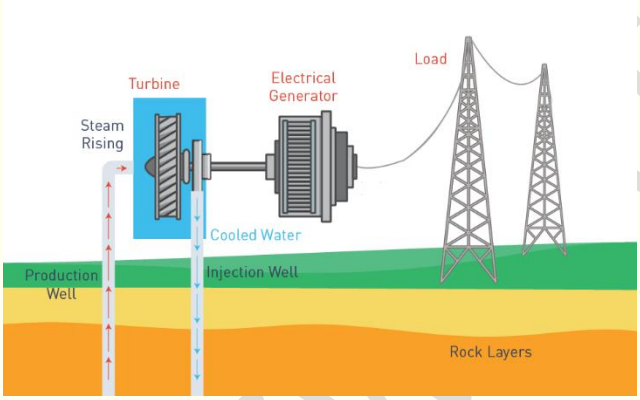
Q5. What is the typical voltage level used in each stage?
Ans:

- **Generation:** 11–25 kV
- **Transmission:** 132, 220, 400, 765 kV
- **Sub-transmission:** 33 or 66 kV
- **Distribution:** 11 kV (primary), 415V/230V (secondary)

SECTION 3: Generation

Q6. What are the different types of power plants?
Ans:

1. **Thermal Power Plant** – uses coal/gas
2. **Hydroelectric Plant** – uses water
3. **Nuclear Power Plant** – uses nuclear fission
4. **Renewable Plants** – solar, wind, biomass



Q7. What is base load and peak load?
Ans:

- **Base load** is the minimum demand on the grid over 24 hours.
- **Peak load** is the maximum demand during a certain period.

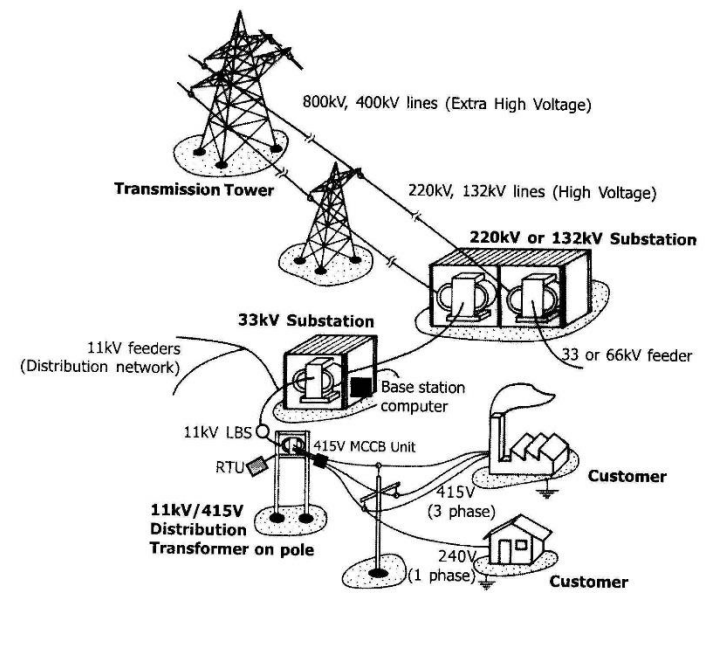
SECTION 4: TRANSMISSION SYSTEM

Q8. Why is high voltage used in transmission?
Ans: High voltage reduces current for the same power, which minimizes **I^2R losses** and allows efficient long-distance transmission.

Q9. What are the common transmission line configurations?
Ans:

- **Single circuit**
- **Double circuit**
- **Underground cables** (in urban or sensitive areas)

Q10. Define transmission and distribution losses.
Ans: These are energy losses due to resistance and inefficiencies in the system. They occur as heat and are usually between 8–15%.



SECTION 5: SUBSTATIONS

Q11. What is a substation and its function?
Ans: A substation is a part of the power system where voltage is transformed, and switching and protection equipment are installed to manage the power flow.

Q12. What are the types of substations?
Ans:

- **Step-up/Step-down**
- **Indoor/Outdoor**
- **Distribution substation**
- **Gas Insulated Substation (GIS)**

SECTION 6: Distribution System

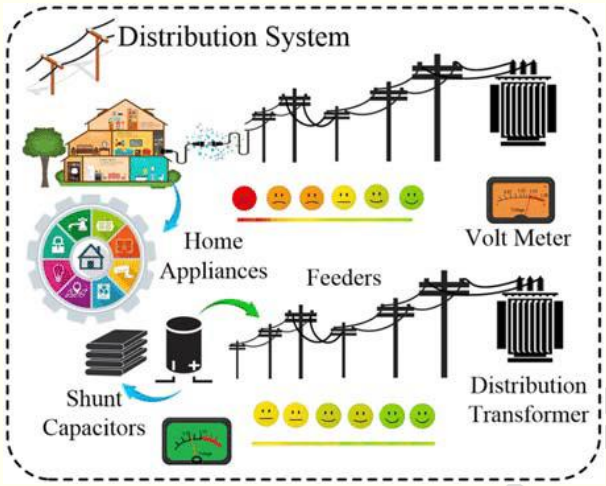
Q13. What is the difference between primary and secondary distribution?
Ans:

- **Primary distribution:** 11 kV, supplies large loads or secondary substations
- **Secondary distribution:** 415V or 230V, supplies households and small businesses

Q14. What is a feeder, distributor, and service main?
Ans:

- **Feeder:** Transmits power from substation to distribution point (no tapping)
- **Distributor:** Has multiple tapping points for loads

- **Service main:** Final connection from distributor to consumer



SECTION 7: Power System Classification

Q15. What are the types of power systems?
Ans:

1. **AC vs DC systems**
2. **Single-phase vs Three-phase**
3. **Radial, Ring, and Mesh distribution systems**

Q16. What is a balanced and unbalanced power system?
Ans:

- **Balanced system:** Equal magnitude and 120° phase difference
- **Unbalanced system:** Unequal phase voltages or currents

SECTION 8: POWER SYSTEM PERFORMANCE PARAMETERS

Q17. What are key performance metrics for a power system?
Ans:

- Voltage regulation
- System stability
- Transmission losses
- Power factor
- Reliability and continuity of supply

Q18. What is power factor and why is it important?
Ans: Power factor is the cosine of the angle between voltage and current. A high power factor reduces losses and improves system efficiency.

SECTION 9: PROTECTION AND RELIABILITY

Q19. What makes a power system reliable?
Ans:

- Adequate redundancy
- Fast fault detection and isolation
- Well-designed protection and control systems
- Preventive maintenance

Q20. What is grid stability?
Ans: The ability of the power system to remain in equilibrium under normal and disturbed conditions.

SECTION 10: MODERN TRENDS

Q21. What is a smart grid?
Ans: A smart grid uses digital communication and automation to monitor and control the generation, transmission, and distribution of electricity for improved efficiency, reliability, and sustainability.

Q22. How do renewable energy sources affect power system structure?
Ans: They introduce variability and require grid integration tools like inverters, storage, and smart management systems for stability and synchronization.