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UNIT

1 Chapter 1 - Elementary Concepts

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Previous Year Question
(2024 Pattern)

1.7 Elementary Power System → (Generation, Transmission, Distribution)

- Draw and explain single line diagram for elementary power system and list any four components of electrical power system.

[Nov24]

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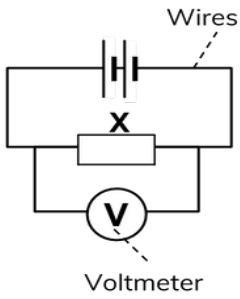
◂ Potential difference ▸

- Potential difference, also called voltage, is the difference in electric potential energy between two points in a circuit.

- Think of it like the difference in height between two points on a hill. Just as water flows from a higher point to a lower point, electric charges flow from a point of higher potential to a point of lower potential.

1. Symbol: Potential difference is represented by the letter V.
2. Unit: The unit of potential difference is the Volt (V).
   1 Volt = 1 Joule of energy per 1 Coulomb of charge.
3. Purpose: It provides the "push" or energy needed to move electric charges (electrons) through a circuit.

Potential difference is calculated using:



$$V = \frac{W}{Q}$$

- V = Potential difference (Volts, V).
- W = Work done or energy transferred (Joules, J).
- Q = Charge (Coulombs, C).

Potential Difference Work:

1. Electric charges (like electrons) have potential energy when they are in an electric field.

2. A battery or power supply creates a potential difference between its two terminals:
   - The positive terminal has higher potential energy.
   - The negative terminal has lower potential energy.

3. Electrons flow from the negative terminal (lower potential) to the positive terminal (higher potential) through the circuit.

◂ Ohm's law ▸

The ohm's law states that the ratio of potential difference (V) between any two points and the current flowing between them is constant if temperature is constant. the ratio is termed as resistance R.

Ohm's Law Formula :-

$$V = I \times R$$

Where:-

- V = Voltage (Volts, V).
- I = Current (Amperes, A).
- R = Resistance (Ohms, Ω).

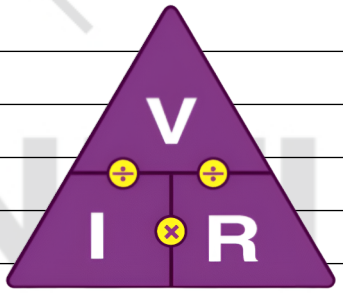
Ohm's Law Triangle

- To make it easier to remember, you can use the Ohm's Law Triangle:

To find Voltage: $V = I \times R$

To find Current: $I = \frac{V}{R}$

To find Resistance: $R = \frac{V}{I}$



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Practical Examples of Ohm's Law

Example 1: Finding Voltage

- If I = 2A and R = 5Ω,

  then: $V = I \times R = 2 \times 5 = 10V$

Example 2: Finding Current

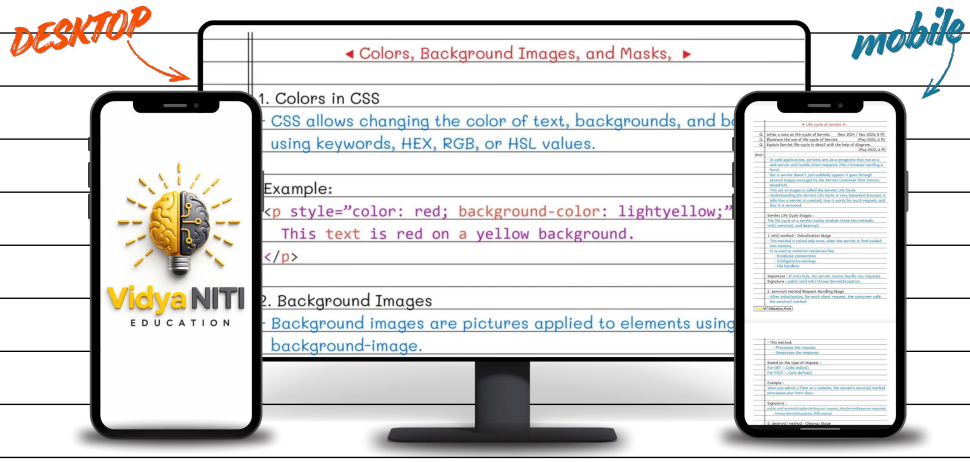
- If V = 12V and R = 4Ω,

  then: $I = \frac{V}{R} = \frac{12}{4} = 3A$

Example 3: Finding Resistance:

- If V = 9V and I = 3A,

then: $R = \frac{V}{I} = \frac{9}{3} = 3\Omega$



CLICK HERE

◂ Energy Sources ▸

- Energy sources are the resources we use to produce energy for electricity, heat, transportation, and other needs. They can be divided into two main categories:

- Conventional Energy Sources: Traditional sources like coal, oil, and natural gas.

- Non-Conventional Energy Sources: Renewable and alternative sources like solar, wind, and hydro power.

Energy Sources in Electrical Engineering:

- In electrical engineering, energy sources are used to generate electrical power for various applications. The two main types of energy sources in circuits are:

1. Voltage Source

- A voltage source is a device that provides a constant voltage to a circuit, regardless of the current flowing through it.

Ideal Voltage Source

An ideal voltage source maintains a fixed voltage across its terminals, no matter how much current is drawn from it.

Characteristics:

- Voltage remains constant (V=constant).
- Internal resistance is zero.

Example: A perfect battery that never runs out of energy.

Practical Voltage Source

A real-world voltage source has some internal resistance, which causes the voltage to drop as current increases.

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Characteristics:

- Voltage decreases slightly as current increases.
- Internal resistance (Rinternal) is not zero.

Example: A real battery or a power supply.

2. Current Source

- A current source is a device that provides a constant current to a circuit, regardless of the voltage across it.

Ideal Current Source

An ideal current source supplies a fixed current to the circuit, no matter what the voltage across it is.

Characteristics:

- Current remains constant (I=constant).
- Internal resistance is infinite.

Example: A theoretical device that always supplies the same current.

Practical Current Source

A real-world current source has some internal resistance, which causes the current to vary slightly with voltage.

Characteristics:

- Current decreases slightly as voltage increases.
- Internal resistance is not infinite.

Example: A transistor-based current source or a solar cell.

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◂ Elementary power system ▸

1. Generation

Purpose: Produce electrical energy from various energy sources.

Components:

Power Plants: Facilities that generate electricity.

- Thermal Power Plants: Use coal, natural gas, or oil to produce steam, which drives turbines connected to generators.
- Hydroelectric Power Plants: Use flowing water to spin turbines and generate electricity.
- Nuclear Power Plants: Use nuclear reactions to produce heat, which generates steam to drive turbines.

Renewable Energy Sources: Solar panels, wind turbines, and geothermal plants generate electricity using renewable resources.

Generators: Convert mechanical energy (from turbines) into electrical energy.

2. Transmission

Purpose: Transport high-voltage electricity over long distances from power plants to substations near populated areas.

Components:

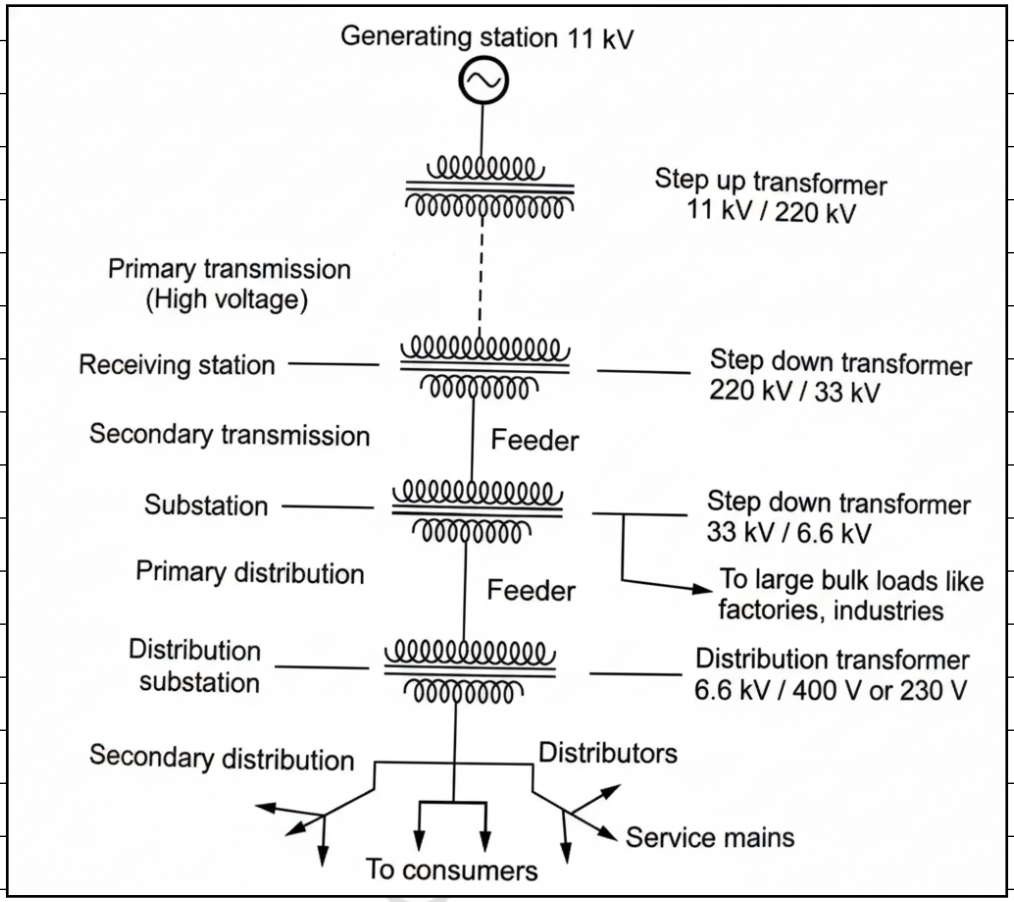
Step-up Transformers: Increase the voltage of electricity generated at power plants (e.g., from 11 kV to 132 kV or higher) to reduce energy losses during transmission.

Transmission Lines: High-voltage power lines (supported by towers or poles) that carry electricity over long distances.

- Overhead Lines: Common in rural and open areas.
- Underground Cables: Used in urban areas where space is limited.

Substations: Facilities that house transformers and other equipment to regulate voltage levels.

Block diagram of elementry power system



i. Primary Transmission

- Primary transmission is the first stage of electric power transfer from generating stations to main or grid substations.
- It carries bulk power over long distances at very high voltages, generally between 132 kV and 400 kV (sometimes up to 765 kV).
- The high voltage reduces current and transmission losses, making it efficient for long-distance power transfer.

ii. Secondary Transmission

- Secondary transmission transmits power from the main grid substations to regional or city substations.
- The voltage level is reduced to 33 kV to 132 kV, depending on the system.
- This stage covers moderate distances and delivers power closer

to the load centers, preparing it for distribution within towns or industrial areas.

iii. Primary Distribution

- Primary distribution starts at the distribution substation, where the voltage from the secondary transmission is stepped down to 11 kV or 6.6 kV.
- Power is then distributed through primary feeders to various areas or distribution transformers located near consumer zones.
- This stage supplies electricity within cities or industrial estates for further voltage reduction.

iv. Secondary Distribution

- Secondary distribution is the final stage where electricity from distribution transformers is supplied directly to consumers.
- The voltage is stepped down to 400 V (three-phase) or 230 V (single-phase) for domestic, commercial, and small industrial use.
- It ensures safe and usable power reaches homes, offices, and shops.

3. Distribution

i. Substation :

Transmission lines bring the power upto the substations at a voltage level of 22 kV or 33 kV. At the substation the level is reduced to 3.3 kV or 6.6 kV. Then using feeders, the power is given to local distribution centres.

ii. Local distribution station :

It consists of distribution transformer which steps down the voltage level from 3.3 kV, 6.6 kV to 400 V or 230 V. Then it is distributed further using distributors. This is also called distribution substation.

iii. Feeders :

These are the conductors which are of large current carrying

capacity. The feeders connect the substation to the area where power is to be finally distributed to the consumers. No tappings are taken from the feeders. The feeder current always remains constant. The voltage drop along the feeder is compensated by compounding the generators.

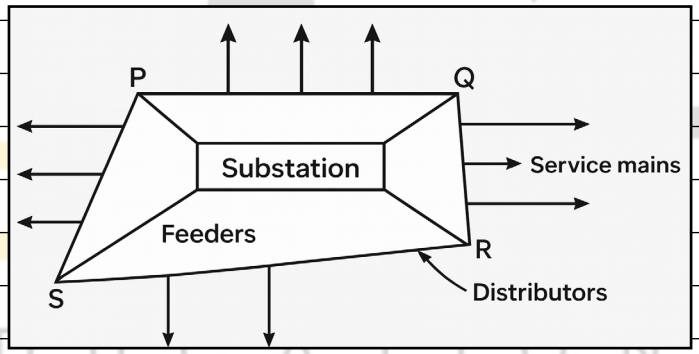
iv. Distributors :

These are the conductors used to transfer power from distribution centre to the consumers. From the distributors, the tappings are taken for the supply to the consumers. The voltage drop along the distributors is the main criterion to design the distributors.

v. Service mains

These are the small cables between the distributors and the actual consumer premises.

The interconnection of feeders, distributors and service mains is shown in the Fig.



There is no tapping on feeders. PQ, QR, RS and PS are the distributors which are supplied by the feeders. No consumer is directly connected to the feeder. The service mains are used to supply the consumers from the distributors. Tappings are taken from the distributors.

Expected Questions

1. Draw and explain the block diagram of elementary power system showing the stages of generation, transmission and distribution of electrical energy.

2. Draw the single line diagram of electrical power network from the generating station to consumers.

3. Explain the meaning of feeder, distributor and service mains.

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