DI03000101: Electrical Power Transmission & Distribution

GTU Course Presentation

July 25, 2026

Course Contents I

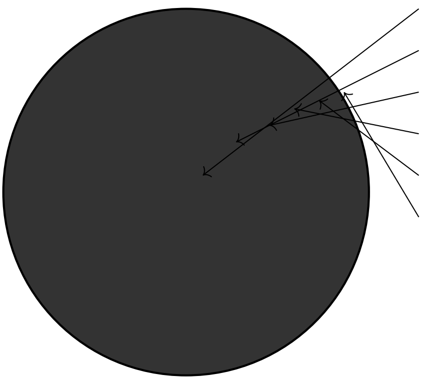
Overhead vs. Underground Transmission I

Comparative analysis of transmission systems and the necessity of underground cables.

Key Points

- Underground cables are necessary in densely populated urban areas, near airports, and in congested metropolitan districts where overhead lines pose safety hazards and aesthetic issues.
- They offer high safety and low vulnerability to environmental factors such as wind storms, lightning, and traffic accidents.
- However, they require significantly higher initial capital cost (approx. 10 to 15 times that of overhead lines) and have complex fault localization.
- System charging current is higher due to larger capacitance $C = \frac{2\pi\varepsilon_0\varepsilon_r}{\ln(D/d)}$ compared to overhead systems.

General Construction of a Single-Core Cable I



General Construction of a Single-Core Cable II

Key Points

- The core/conductor transmits the electrical power and is made of stranded copper or aluminium.
- Insulation (impregnated paper, varnished cambric, or XLPE) prevents leakage currents between conductor and sheath.
- Metallic sheath protects the cable from moisture, acids, or alkalies in the soil.
- Bedding protects the metallic sheath from corrosion and mechanical injury from the armouring.
- Armouring consists of galvanized steel wire or tape to protect the cable from mechanical damage during laying.
- Serving is a layer of fibrous material (like jute) to protect the armouring from atmospheric conditions.

Conductor & Insulation Specifications I

Engineering details on core conductor materials and dielectric properties.

Conductor & Insulation Specifications II

Key Points

- Conductors: Standard conductor materials are stranded Copper (Cu) or Aluminium (Al) to provide flexibility. Electrical conductivity of Cu is higher, meaning smaller diameter cables can be used compared to Al for the same current rating.
- Operating temperature limit: Paper insulation (approx. 65°C to 80°C), XLPE (Cross-linked Polyethylene) up to 90°C under normal load, and 250°C under short-circuit conditions.
- Dielectric Strength: Impregnated paper has a breakdown strength of 20 to 30 kV/mm, whereas XLPE is typically 20 to 40 kV/mm.
- Insulation Thickness (t) calculation: Determined by the maximum electric stress (g_{max}) at the conductor surface, given by: $g_{max} = \frac{2V}{d \ln(D/d)}$ where V is

Protective Layers: Sheath, Bedding, Armour & Serving I

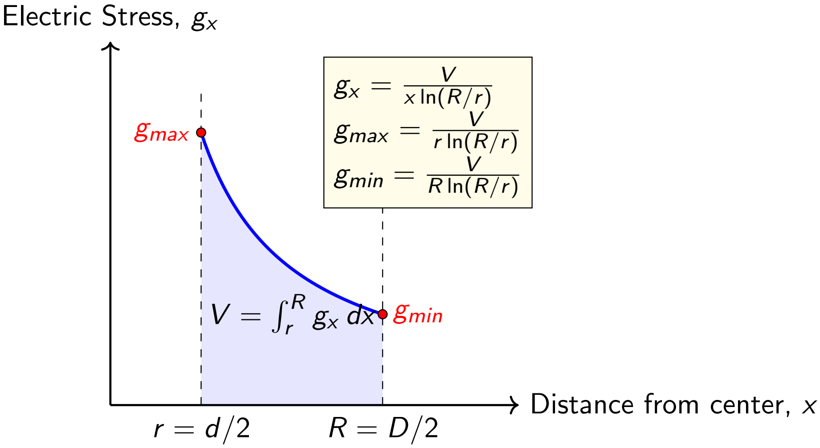
The physical barriers ensuring cable longevity under harsh subterranean conditions.

Protective Layers: Sheath, Bedding, Armour & Serving II

Key Points

- Metallic Sheath: Extruded Lead (Pb), Lead alloy, or Aluminium (Al) is used to create a completely moisture-proof barrier. Since lead is soft and heavy, Aluminium sheaths are sometimes preferred for lighter weight and higher mechanical strength, though they are more prone to corrosion.
- Bedding: Consists of a fibrous material like jute or hessian tape treated with a preservative compound (bitumen). Thickness is typically around 1.5 mm to 2 mm. It prevents galvanic action between the steel armouring and lead sheath.
- Armouring: Steel wire armour (SWA) or double steel tape armour (DSTA) provides high tensile strength to withstand tension during installation and protect

Electrostatic Stress Distribution in Cable Insulation I



Electrostatic Stress Distribution in Cable Insulation II

Key Points

- The potential gradient or electric stress (g_x) at any point x in the dielectric is inversely proportional to the distance from the center.
- Stress is maximum (g_{max}) at the conductor surface ($x = r$) and minimum (g_{min}) at the inner sheath surface ($x = R$).
- Ratio of stresses: $\frac{g_{max}}{g_{min}} = \frac{R}{r} = \frac{D}{d}$. A low ratio ensures uniform stress distribution.
- To design a cable with minimum size for a given voltage V and maximum stress g_{max}, the optimum ratio is $R/r = e \approx 2.718$.

Requirements of Insulating Materials I

Key physical and electrical properties required for underground cable insulation.

Requirements of Insulating Materials II

Key Points

- High Insulation Resistance: To avoid leakage currents, resistivity (ρ) must be extremely high (10^{12} to 10^{16} Ω·cm at operating temperature).
- High Dielectric Strength: Must withstand high electric stress without breakdown. Typically needs to be > 20 kV/mm.
- Low Dielectric Loss: Power loss in the insulation ($P_{loss} = \omega C V^2 \tan\delta$) must be minimized to avoid thermal runaway.
- Mechanical Properties: Must be flexible and possess high mechanical strength to withstand bending during transport and installation.
- Chemical Inertness: Non-hygroscopic (does not absorb moisture from soil/air) and non-inflammable, resistant to soil acids and alkalis.

Industrial Applications & Design Limits I

Summary of underground cable applications, advantages, disadvantages, and future trends.

Industrial Applications & Design Limits II

Key Points

- Applications: Crucial for distribution in crowded city streets, railway networks, substation exits, submarine crossings, and offshore wind connections.
- Advantages: Low maintenance cost, neat appearance, less chance of faults from weather, zero risk of direct contact shock.
- Disadvantages: High charging currents due to high capacitance, difficulty in finding and repairing faults, strict limits on operating voltage due to heat dissipation issues.
- Future Trends: Transitioning from traditional oil-filled cables to XLPE (Cross-linked Polyethylene) and superconducting cables for high power density transmission.