

ELECTRICAL POWER TRANSMISSION
AND
DISTRIBUTION

BRANCH: EE/EEE

SEM: 5TH

MODULE: 5

Short Question Answers

- ① Generally 3-Phase, 4 wire AC System is used for Electrical power Distribution. why? (2018)

Ans:- The Distribution are 3 phase 4 wire circuit because a neutral wire is necessary to supply 1 ϕ loads of domestic and commercial consumers.

- ② How 3 wire Transmission system is converted to 4 wire distribution system.

Ans:- By using a Delta/star Transformer it is possible to convert 3 wire system to 4 wire system. 4th conductor is the neutral conductor.

- ③ What is the difference between a Feeder and distributor. (2016-2017)

Ans:- Feeder is the 3 ϕ -3 wire conductor that connects to the Substation. Generally no Tapping is provided on feeder. While designing Feeder current is taken into account.

In Distributor Tapping are provided and while designing Distributor voltage drop is considered.

④ Compare O.H line with underground cable as medium of power transmission. (2016-17)

Ans:-

O.H line

cable

- | | |
|---|--|
| 1) High initial cost | 2) Low as compared to OH line. |
| 2) more liable to fault | 2) Less chance of fault. |
| as exposed to atmosphere. | |
| 3) Fault location and maintenance is easy | 3) Fault location and repair is difficult. |
| 4) Less public safety | 4) more public safety. |

⑤ what are service mains? How are they connected (2017-2018)

Ans:- Service main is the small cable which connects the distributor to the consumer terminal. Service main generally connected between a Phase and neutral.

⑥ What is ring distributor? State any two advantage of ring main system.

Ans:- A ring distributor is a distributor which is arranged to form a closed circuit and which is fed at one or more than one point.

Advantage:- By using a ring distributor feed properly, great economy in copper can be affected.

⑦ How cable classified based on operating voltage. (2014)

Ans:- Based on operating voltage cable are classified as under:

- LV - upto 1 KV.
- HV - upto 11 KV
- ST - upto 33 KV
- EHV - 33 KV - 66 KV
- EST - Beyond 66 KV.

⑧ List the different types of distribution system based on connection.

Ans:- Based on Connection The distribution system, it is three types.

- (i) Radial system.
- (ii) Ring main system.
- (iii) Inter Connected system.

⑨ what should be the desirable characteristics of Insulating material used in cable.

Ans:- The desirable characteristic of insulating material are.

- (a) High electrical Resistance.
- (b) Non-hygroscopic
- (c) Non-inflammable.
- (d) Non toxic.

(10)

What are the commonly used insulating materials in cable.

Ans:- The most commonly used insulating material in cable are
① PVC.
② V.I.R.
③ Impregnated Paper.
④ Varnish cambric.

(11)

What is the purpose of metallic sheath in cable.

Ans:- In order to protect cable from moisture, gases and other damaging liquid in the soil and atmosphere metallic sheath is provided.

(12)

Why a Inter connector is provided in ring main Distributore

Ans:- In order to reduce voltage drop in various section, distant point of the distribution are joined through a conductor called interconnector.

(13)

What are the advantage of XLPE cable.

Ans:- ① XLPE Cable can withstand higher Temperature.

- ② High over-load capacity.
- ③ Lower installation cost.
- ④ High short circuit rating.

(14) what is a booster and what for it is used?

The booster is a direct Series Generator and its function is to inject or add certain voltage into a circuit so as to compensate the IR drops in the feeder etc.

(15) what is a radial system? where it is employed?

Ans. in this system separate feeders originate from a single Substation (S/S) and feed distributor at one end only. This system is employed only when the power is generated at L.V and S/S located at the centre of the load.

(16) How feeder differs from Distributor?

Ans: A feeder is a conductor which connect the Sub-station to the area where power is to be distributed. Generally no tappings are taken from feeder.

Distributor is a conductor from which tappings are taken for supply.

The main consideration in design of feeder is current carrying capacity while for designing distributor is voltage drop.

(17) Why Kelvin's law does not give the exact economical size of conductor.

Ans As Annual charge depend partly on the area of cross-section a partly it is constant, total amount capital cost ($C_1 + C_2$) is not strictly true. Corona loss is not consider which may be very high for small diameter of conductor, bad weather condition and H.V operation make calculation of energy waste is very difficult thus Kelvin's law does not gives the exact economical size of conductor.

(18) State Kelvin's law?

Ans Kelvin law states that the most economical Kelvin law states that for which the area of conductor is that for which the variable part of annual charge is equal to the cost of energy loss per year.

(19) Write advantages of interconnection of power system.

Ans The advantage of interconnection of power station area:

- (i) Exchange of power is can be possible at peak load.
- (ii) Economical operation can be ensured.
- (iii) Diversity factor will increase.

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what are the limitation of Kelvin's law?

- Ans
- (i) it is not easy to estimate the energy loss in the line without load curve.
 - (ii) this law does not take into account several physical factors like safe current density, mechanical strength, corona loss etc.
 - (iii) interest and depreciation on the Capital outlay can't be determined accurately.

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what is lamp flicker what is its cause.

ans:- The sudden change in voltage due to change of load cause sudden change in the intensity of illumination of lamp is called lamp flicker.

cause

- (i) motor starting
- (ii) Electric furnace.
- (iii) Electric welding equipment

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what are the application of capacitors to distribution system.

Sol

- (i) reduction in circuit current
- (ii) increase in voltage level at load
- (iii) improve in voltage regulation.
- (iv) Reduction in kVA loading of Generators, Transformer and Lines.

(23) What are the good requirement of a distribution system

- ans
- (i) Economy
 - (ii) reliability
 - (iii) Growth of load.
 - (iv) capacity addition.

(24) what are the design consideration in distribution system.

- (i) Economy
- (ii) reliability
- (iii) voltage level and regulation
- (iv) feasibility of expansion.
- (v) site and right of way.

Long Question Answer

① Derive the expression of Capacitance of single core cable.

Ans:- A single core cable can be considered to be equivalent to two long co-axial cylinders. Conductors of cable is inner cylinder and lead sheath is outer cylinder which is at earth potential.

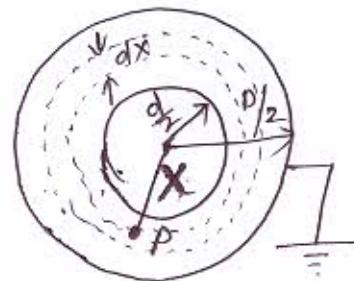
Let Q = Charge per meter axial length

ϵ = Permittivity of insulation material.

d = Conductor diameter

D = Sheath diameter

fig:



Consider a cylinder of radius x meter and axial length 1 meter. The surface area of this cylinder = $2\pi x \cdot 1 = 2\pi x \text{ m}^2$

Electric Flux Density at Point P

$$D_x = \frac{Q}{2\pi x} \text{ c/m}^2$$

$$\begin{aligned} \text{Electric Intensity at point } p, E_x &= \frac{Q}{\epsilon} \\ &= \frac{Q}{2\pi n e} \\ &= \frac{Q}{2\pi n \epsilon_0 \epsilon_r} \end{aligned}$$

The work done in moving a unit +ve charge from point p through a distance dx in the direction of electric field is $E_x dx$. Hence work done in moving a unit +ve charge from conductor to sheath, which is the potential difference

$$\begin{aligned} \text{Hence } V &= \int_{d/2}^{D/2} E_x \cdot dx = \int_{d/2}^{D/2} \frac{Q}{2\pi n \epsilon_0 \epsilon_r} dx \\ &= \frac{Q}{2\pi \epsilon_0 \epsilon_r} \log_e \left(\frac{D}{d} \right) \end{aligned}$$

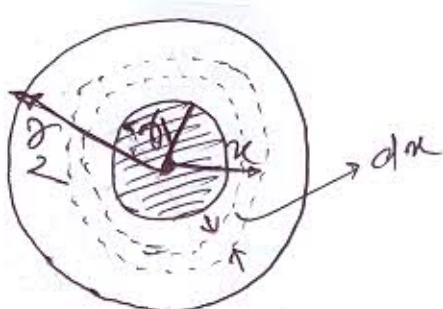
Hence capacitance of cable is

$$\begin{aligned} C &= \frac{Q}{V} = \frac{Q}{\frac{Q}{2\pi \epsilon_0 \epsilon_r} \log_e \left(\frac{D}{d} \right)} \\ &= \frac{2\pi \epsilon_0 \epsilon_r}{\log_e \left(\frac{D}{d} \right)} \end{aligned}$$

(2) Derive the expression of insulation resistance of cable.

Ans:- The opposition offered by insulation to leakage current is known as insulation resistance of cable. For satisfactory operation insulation resistance must be high.

fig



Consider a single-core cable of conductor radius r_1 and internal sheath radius r_2 . Let l be the length of cable and ρ is the ~~resistivity~~ Resistivity of insulation

Consider a very small layer of insulation thickness dx at a radius x . The length through which leakage current flows is dx and area of cross-section is $2\pi xl$.

$$\text{Insulation Resistance} = \rho \frac{dx}{2\pi \mu}$$

Insulation Resistance of Whole Cable is

$$R = \int_{r_1}^{r_2} \rho \frac{dx}{2\pi \mu}$$

$$= \frac{\rho}{2\pi \mu} \int_{r_1}^{r_2} \frac{dx}{\kappa}$$

$$= \frac{\rho}{2\pi \mu} (\log r_2 - \log r_1)$$

$$= \frac{\rho}{2\pi \mu} \log \frac{r_2}{r_1}$$

Q) Explain Kelvin's law for economic size of conductor and state its limitation?

Ans This law states that "The most economical area of conductor is that for which the total annual cost of transmission line is minimum".

The total annual cost of transmission line divided into two parts

- (i) annual charge on Capital outlay
- (ii) annual cost of energy wasted in the conductor

annual charge on capital outlay

This is due to the interest and depreciation on the capital cost of installation. This cost

is due to conductor, support and insulator

and cost of their erection. In overhead line insulator cost is constant conductor

cost is proportional to the cross sectional area

and cost of support and their erection

is inversely proportional to the x-sectional area

Therefore annual charge is given by

$$\text{annual Charge} = P_1 + P_2 \alpha$$

P_1, P_2 = constant, α = area of cross sectional.

Annual cost of energy waste

This is due to energy lost due to loss

Assuming a constant current resistance is

inversely proportional to the area of cross section

$$\text{Annual cost of energy waste} = \frac{P_3}{\alpha}$$

Total annual cost, C

$$C = P_1 + P_2 a + \frac{P_3}{a}$$

Therefore total annual cost of transmission will be minimum

$$\frac{d(C)}{da} = 0$$

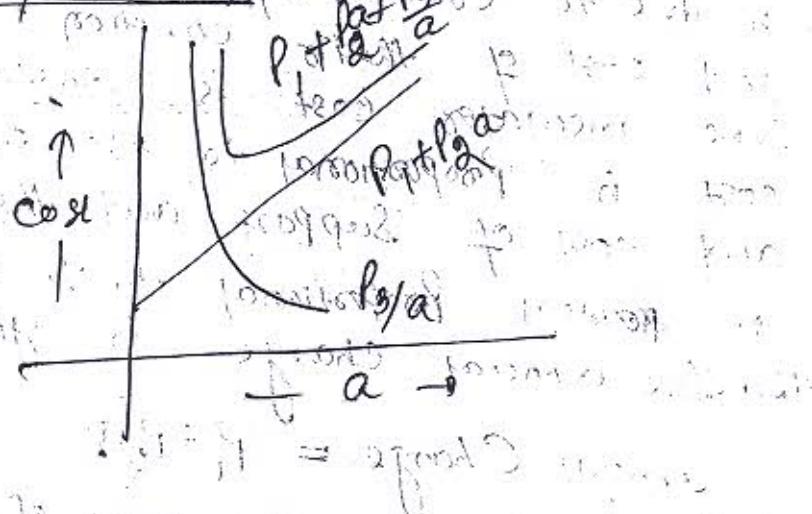
$$P_2 - \frac{P_3}{a^2} = 0$$

$$P_2 a^2 = P_3 \quad \text{or} \quad a^2 = \frac{P_3}{P_2} \quad \text{or} \quad a = \sqrt{\frac{P_3}{P_2}}$$

variable part of annual charge

= annual cost of energy work

Graphical representation



④

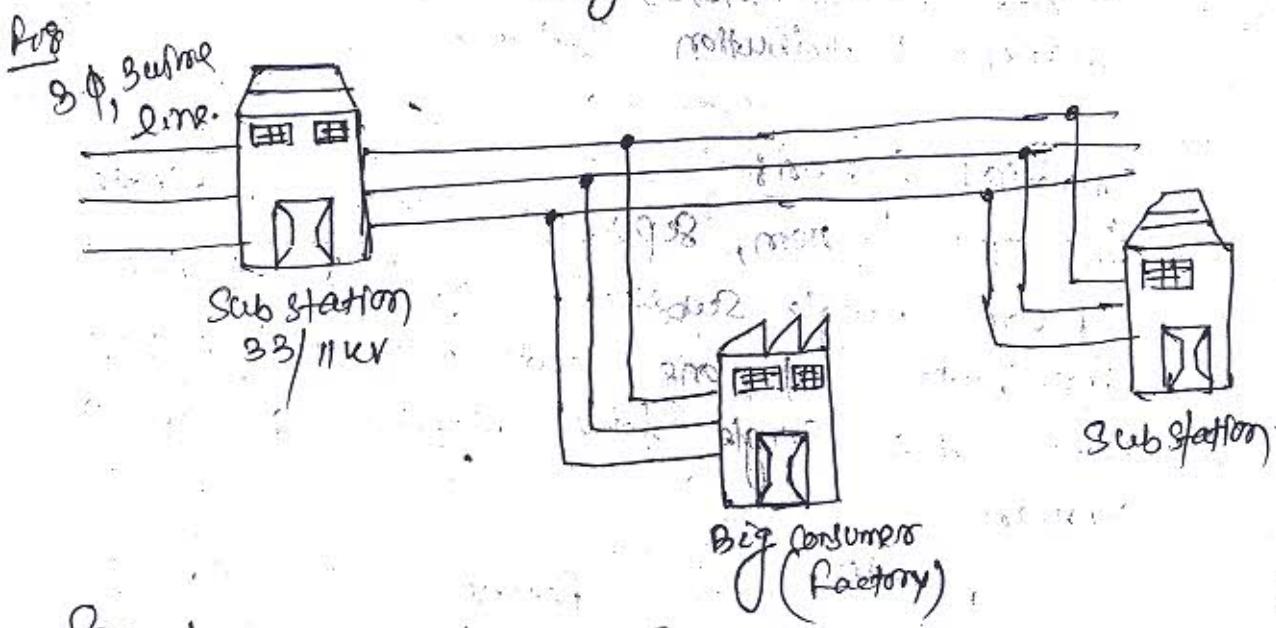
With neat sketch, explain A.c system for distribution of electrical energy.

In the A.c distribution system, the energy is distributed in the following manner.

- (i) Primary distribution system.
- (ii) Secondary distribution system.

Primary Distribution System:-

it is the part of a.c distribution system which operate at voltage somewhat higher than general utilization and handle large block of electrical energy than the average low-voltage consumer use. The voltage used for Primary distribution depends upon the amount of power to be conveyed and the distance of the Substation required to be fed. The most commonly used Primary distribution voltage are 11 KV, 6.6 KV and 3.3 KV. Due to economic consideration, primary distribution is carried out by 3φ, 3 wire system.



Secondary Distribution System:-

It is the part of a.c distribution system which include the range of voltage at which the ultimate consumer utilise the electrical energy delivered to him. The Secondary distribution employs 400/230 V, 3φ, 3 wire system.

Q8

Explain how to do the RSC.



Q5

wrote short notes for radial and ring main distribution system.

Ans.

radial system:-

In this system, separate feeders originate from single substation and feed the distributor at one end only. The fig shows the single line diagram of a radial system.

(1)

System

feeders

feeders

A line

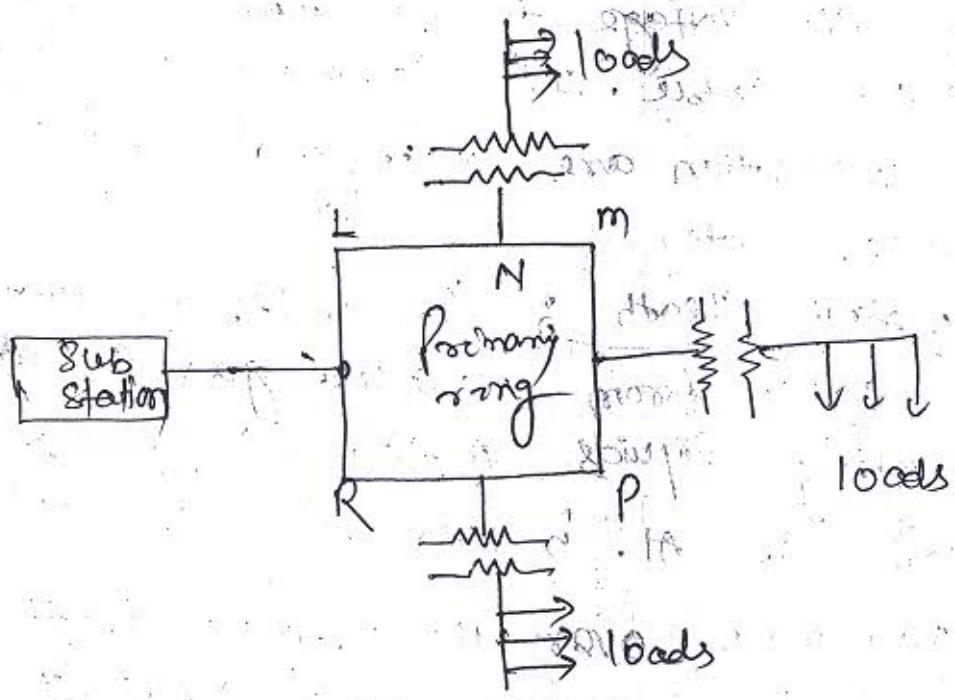
Substation

Feeders

distributors

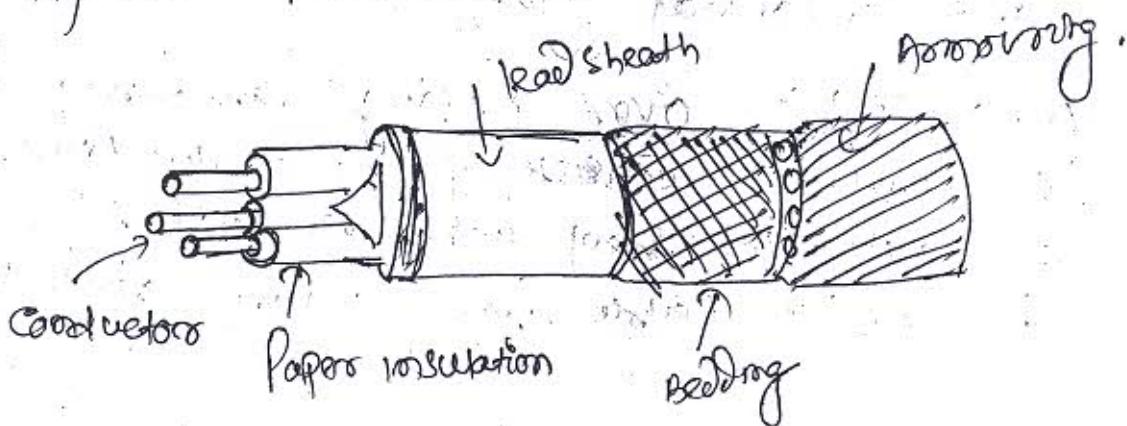
ring main system

In this system, the primaries of distribution transformers form a loop. The loop circuit starts from the Substation bus bar makes a loop through the area to be served and return to the Substation. The distributor are tapped from feeders.



Q6 Explain the general construction of a cable with neat figure. What is the speciality of a pressure cable.

Sol



(i) Core or Conductor

A cable may have one or more than one core (Conductor) depending upon the type of service for which it is intended. If there are three conductors then it is used for 3φ 3-wire system.

(ii) Insulation:- Each core or conductor provided with a suitable thickness of insulation, the thickness of layer depending upon the voltage to be withstand by the cable. The commonly used material for insulation are impregnated paper, rubber etc.

(iii) Metallic Sheath :- In order to protect the cable from moisture gas or other damaging liquids metallic sheath of lead or Al. is provided over insulation.

(iv) Bedding:- Over the metallic sheath a layer of bedding which consists of fibrous material like jute, hessian, etc. It protects the cable from corrosion and mechanical injury due to armouring.

Armouring:- Over bedding armouring is provided consists of one or two layers of galvanised steel wire or steel tape. It protect cable from injury while laying.

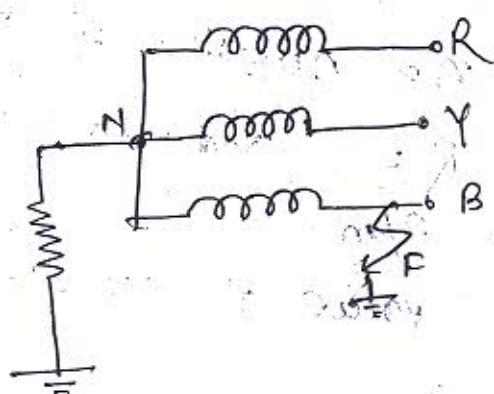
Screening: In order to protect armoring from atmosphere condition a layer of fibrous material similar to bedding provided over armoring this known as Screening.

Specially of Pressure Cable :-

for Voltage beyond 66kv, Solid type of cable are undesirable because there is a danger of breakdown of insulation due to presence of voids when the operating voltage are greater than 66kv Pressure cable is needed.

7) write short notes on resistance Grounding?

Ans It is one type of method of neutral grounding when the neutral point of 3φ system i.e. 3φ Generators, 3φ Transformer etc. is connected to earth through a resistor it is called resistance grounding.



For the voltage level between 3.8 KV and 22 KV, the ground current is not large to use resistance grounding. The value of R is neither be very low nor very high. If the value of earthing resistance R is very low, the earth fault current will be large and the system becomes similar to solid ground system. On the other hand, if the earthing resistance R is very high, the system condition become similar to ungrounded neutral system. The value of R is chosen that the earth fault current is limited to safe value. In practice the value of R is selected that limits the earth fault current to 2 times the normal full load current of the earthed generator or transformer.

(18) How can heat current rating of cable is determined? What are the factors affecting this?

Sol Let n = number of phases.

R = conductor resistance

at 85°C in Ω/m .

$I = \text{Rms value of current in each core}$

Hence the total core loss is given by

$$n D^2 R$$

The heat generated in the core of the cable passes through the dielectric medium to the sheath.

Let θ_m = maximum permissible temperature of the core.

θ_s = sheath temperature.

$$n D^2 R = \frac{\theta_m - \theta_s}{S_1}$$

where S_1 = thermal resistance of the dielectric.

$$\text{let } \lambda = \frac{\text{sheath loss}}{\text{core loss}}$$

$$\text{sheath loss} = 1 \text{ core loss}$$

$$\therefore \text{total loss} = \text{core loss} + \text{sheath loss}.$$

$$= (1+\lambda) \text{ core loss} = (1+\lambda) n D^2 R$$

This is the heat flowing through bedding, serving and ground. While the total thermal resistance of bedding, serving and ground

$S_y + S_g + G$. Hence we can write

$$(1+\lambda) n D^2 R = \frac{\theta_s - \theta_a}{S_y + S_g + G}$$

A θ_s is generally not known

$$\theta_m - \theta_s = n D^2 R S_1$$

$$\text{and } \theta_s - \theta_a = (1+\lambda) n R s_1 (S_y + S_5 + G)$$

$$\therefore \theta_m - \theta_a = n R [s_1 + (1+\lambda)(S_y + S_5 + G)]$$

$$\therefore I_d = \sqrt{\frac{\theta_m - \theta_a}{n R [s_1 + (1+\lambda)(S_y + S_5 + G)]}}, \text{ Amp}$$

This is the required current carrying capacity of a cable.

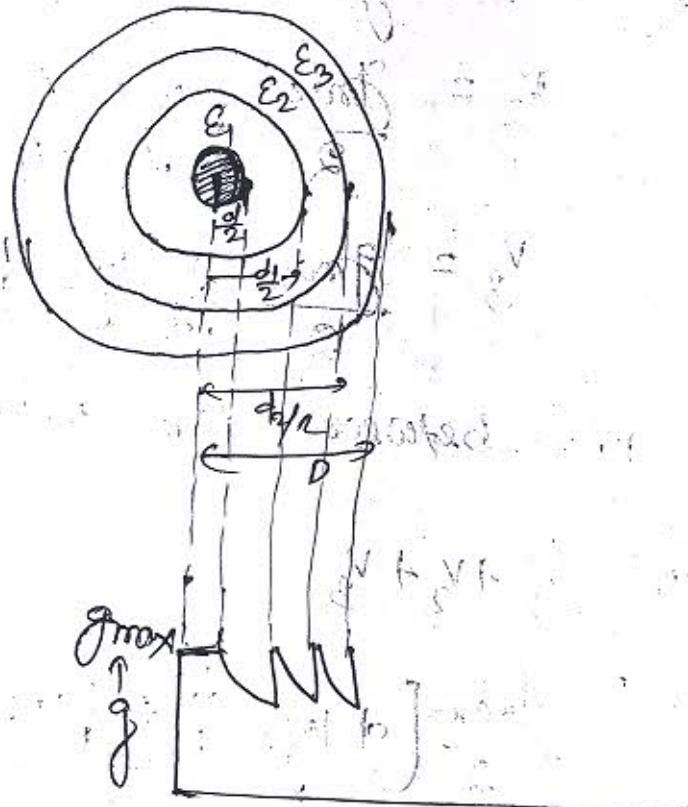
It depends on the factors like load factor, load cycle, ambient temp., temperature of insulation = R .

Q) Why grading of cable is necessary?

Explain the capacitance grading of cable with necessary diagram.

Sol Grading of cable are necessary to have uniform distribution of stress all among the insulation and to avoid breakdown of the insulation. The capacitance grading of cable with necessary diagram is discussed below.

Ans.



There are three dielectrics of outer diameter d_1, d_2, D and of relative permittivity $\epsilon_1, \epsilon_2, \epsilon_3$ respectively. If the permittivity are such that $\epsilon_1 > \epsilon_2 > \epsilon_3$ and the three dielectric are worked at the same maximum stress.

$$\frac{1}{\epsilon_1 d_1} = \frac{1}{\epsilon_2 d_1} = \frac{1}{\epsilon_3 d_2}$$

$$\frac{\epsilon_1 d_1}{d_1/2} = \frac{\epsilon_2 d_1}{d_1/2} = \frac{\epsilon_3 d_2}{d_2/2}$$

$$V_1 = \int_{d_1/2}^{d_2/2} j dx = \int_{d_1/2}^{d_2/2} \frac{Q}{2\pi \epsilon_0 \epsilon_1 x} dx$$

$$= \frac{Q}{2\pi \epsilon_0 \epsilon_1} \log \frac{d_2}{d_1} = \frac{j_{max}}{2} d_1 \log \frac{d_2}{d_1}$$

Similarly, Potential across second layer (M_2) and third layer (M_3) is given by

$$V_2 = \frac{q_{\max}}{2} d_1 \log_e \frac{d_2}{d_1}$$

$$V_3 = \frac{q_{\max}}{2} d_2 \log_e \frac{d_3}{d_2}$$

Total P.d between core and earthed sheath

$$V = V_1 + V_2 + V_3$$

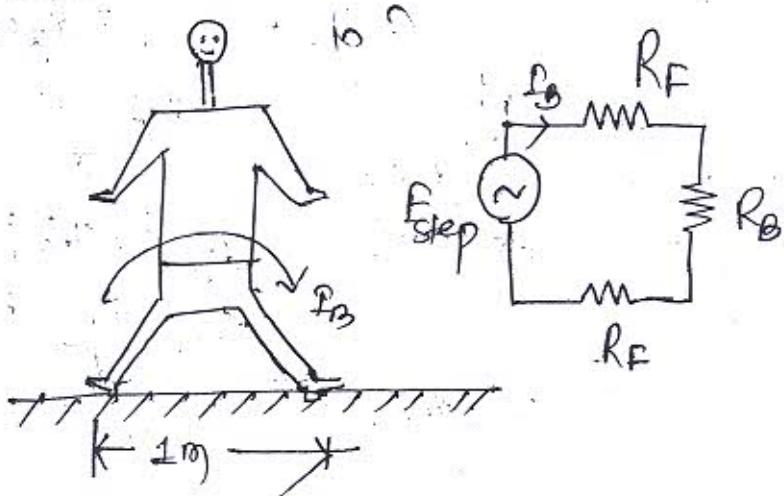
$$= \frac{q_{\max}}{2} \left[d_1 \log_e \frac{d_1}{d_1} + d_1 \log_e \frac{d_2}{d_1} + d_2 \log_e \frac{d_3}{d_2} \right]$$

If the cable had homogeneous dielectric

$$V' = \frac{q_{\max}}{2} d \log_e \frac{D}{d}$$

- (10) write short notes on (i) step voltage
- (ii) touch voltage

Step voltage



Defn:- Step voltage is the voltage between feet of a person standing near an energized ground object.

The potential difference between the body is limited to the maximum value between two accessible points on ground, separated by one pace (equal to 1m). R_f is the earthing resistance of one foot, R_B is the resistance of body.

$$\therefore E_{\text{step}} = (R_B + 2R_f) I_B \text{ V.}$$

we know $I_B = 0.116/R_t$

$$R_f = 3f_s; f_s = \text{Soil resistivity}$$

$$\text{and } R_B = 1000 \Omega$$

Putting all these in above eqⁿ

$$E_{\text{step}} = (1000 + 6f_s) 0.116/R_t \text{ V.}$$

Touch voltage

Defn:- Touch voltage is the voltage between the energized object and the feet of a person in contact with the object.

