SNS COLLEGE OF ENGINEERING

Kurumbapalayam (Po), Coimbatore – 641 107

AN AUTONOMOUS INSTITUTION

Approved by AICTE, New Delhi and Affiliated to Anna University, Chennai

INTERNAL ASSESSMENT EXAMINATION – III- ANSWER KEY

V Semester

B.E-ELECTRICAL AND ELECTRONICS ENGINEERING

19EE501 – TRANSMISSION AND DISTRIBUTION

Regulations 2019

Duration : 1 Hour 30 Minutes

Date : 07.10.2024 Session: FN Maximum: 50 Marks

Answer ALL questions

	PART A - (5 X 2 = 10 marks)			
Q.No	**Question**	**M**	**CO**	**BL**
1	What is stringing chart. A stringing chart is a graphical representation used to determine the correct tension and sag for a transmission line conductor during installation. It helps in maintaining proper clearance and ensures that the conductor remains within the desired limits under various conditions.	2	CO-4	L -2
2	What is the necessity of grading of an under cable. Grading of an underground cable is necessary to ensure uniform voltage distribution across the insulation layers. It minimizes the electric stress in the insulation, reducing the risk of insulation breakdown and prolonging the cable's life.	2	CO-4	L -2
3	List the properties of the insulators • High dielectric strength • High resistance to electrical conduction • Ability to withstand mechanical stresses • Resistance to environmental factors like moisture and temperature variations	2	CO-4	L -2
4	What are the various methods of earthing in substation? System Earthing & Equipment Earthing	2	CO-5	L -2

5	Define safety factor. Safety factor is the ratio of the ultimate strength (or maximum stress a material can withstand) to the actual working stress in a system. It provides a margin of safety to prevent failure under unexpected loads or conditions.	2	CO-5	L -2

PART B - (2 X 13 = 26 marks)

6.	(a)	A single core cable for use on 11 kV, 50 Hz system has conductor area of 0·645 cm^2 and internal diameter of sheath is 2·18 cm. The permittivity of the dielectric used in the cable is 3·5. Find (i) the maximum electrostatic stress in the cable (ii) minimum electrostatic stress in the cable (iii) capacitance of the cable per km length (iv) charging current. **Solution.** Area of cross-section of conductor, $a = 0.645\ cm^2$ Diameter of the conductor, $d = \sqrt{\frac{4a}{\pi}} = \sqrt{\frac{4 \times 0\cdot645}{\pi}} = 0\cdot906$ cm Internal diameter of sheath, $D = 2\cdot18$ cm (*i*) Maximum electrostatic stress in the cable is $g_{max} = \frac{2V}{d \log_e \frac{D}{d}} = \frac{2 \times 11}{0\cdot906 \log_e \frac{2\cdot18}{0\cdot906}}$ kV/cm = **27·65 kV/cm *r.m.s.*** (*ii*) Minimum electrostatic stress in the cable is $g_{min} = \frac{2V}{D \log_e \frac{D}{d}} = \frac{2 \times 11}{2\cdot18 \log_e \frac{2\cdot18}{0\cdot906}}$ kV/cm = **11·5 kV/cm *r.m.s.*** (*iii*) Capacitance of cable, $C = \frac{\varepsilon_r\, l}{41\cdot4 \log_{10} \frac{D}{d}} \times 10^{-9}$ F Here $\varepsilon_r = 3.5$; $l = 1$ km = 1000 m ∴ $C = \frac{3.5 \times 1000}{41\cdot4 \log_{10} \frac{2\cdot18}{0\cdot906}} \times 10^{-9}$ = **$0\cdot22 \times 10^{-6}$ F** (*iv*) Charging current, $I_C = \frac{V}{X_C} = 2\pi f C V = 2\pi \times 50 \times 0\cdot22 \times 10^{-6} \times 11000$ = **0·76 A**	13	CO-4	L-3

OR

	(b)	Discuss the different type of Insulators used in the transmission line. The insulators provide necessary insulation between line conductors and supports and thus prevent any leakage current from conductors to earth. Pin type insulators.	13	CO-4	L-2

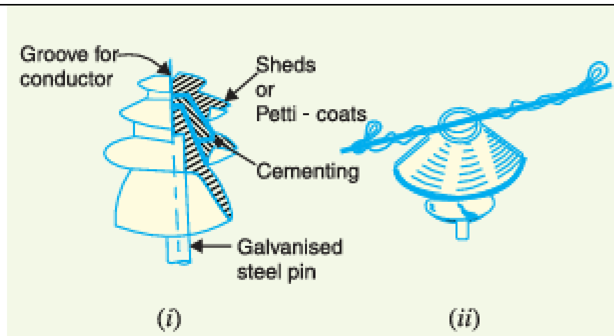


Fig. 8.5. Pin-type insulator

Suspension type insulators.

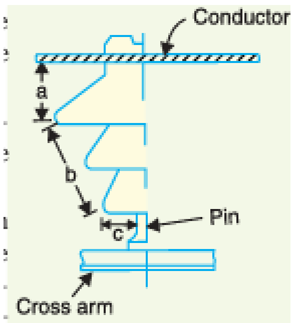
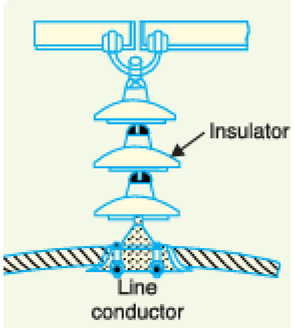
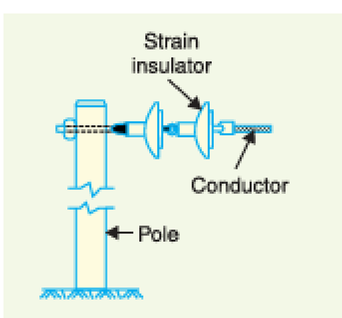


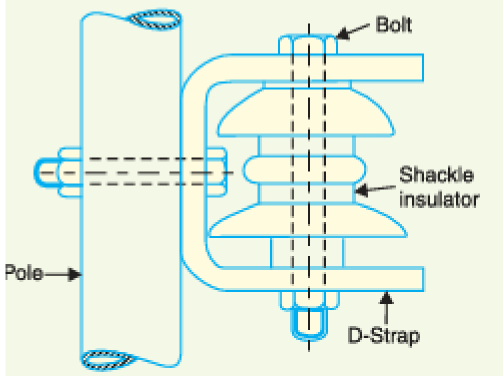
Fig. 8.6



Strain insulators.



Shackle insulators

		 Fig. 8.9			
7.	(a)	A 230 kV, 3-phase, 50 Hz, 200 km transmission line has a capacitance to earth of 0.02 μF/km per phase. Calculate the inductance and kVA rating of the Peterson coil used for earthing the above system. Supply frequency, f = 50 Hz Capacitance of each line to earth, C = 200 × 0.02 = 4 × 10–6 F Required inductance of Peterson coil is $L = \frac{1}{3\omega^2 C}$ $= \frac{1}{3\times(2\pi\times 50)^2 \times 4\times 10^{-6}} = \mathbf{0{\cdot}85\ H}$ Current through Peterson coil is $I_F = \frac{V_{ph}}{X_L} = \frac{230\times 10^3/\sqrt{3}}{2\pi\times 50\times 0{\cdot}85} = 500\ A$ Voltage across Peterson coil is $V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{230\times 1000}{\sqrt{3}}\ V$ $\therefore$ Rating of Peterson coil $= V_{ph} \times I_F = \frac{230\times 1000}{\sqrt{3}} \times 500 \times \frac{1}{1000}$ **kVA = 66397 kVA**	13	CO-5	L-3
		OR			
	(b)	Explain the various types of grounding. The process of connecting the metallic frame (i.e. non-current carrying part) of electrical equipment or some electrical part of the system (e.g. neutral point in a star-connected system, one conductor of the secondary of a transformer etc.) to earth (i.e. soil) is called grounding or earthing	13	CO-5	L-2

Equipment Grounding

The process of connecting non-current-carrying metal parts (i.e. metallic enclosure) of the electri cal equipment to earth (i.e. soil) in such a way that in case of insulation failure, the enclosure effectively remains at earth potential is called equipment grounding.

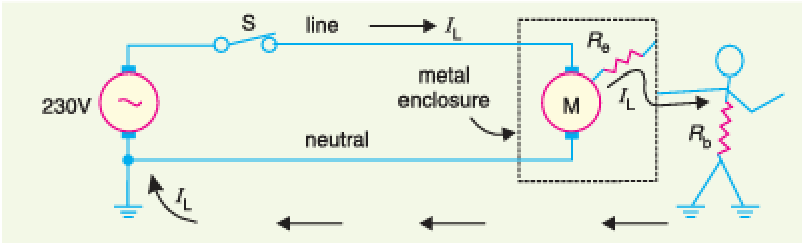


Fig. 26.1

(iii) Ground wire connected to enclosure. To get rid of this problem, we install a third wire, called *ground wire*, between the enclosure and the system ground as shown in Fig. 26.4. The ground wire may be bare or insulated. If it is insulated, it is coloured green.

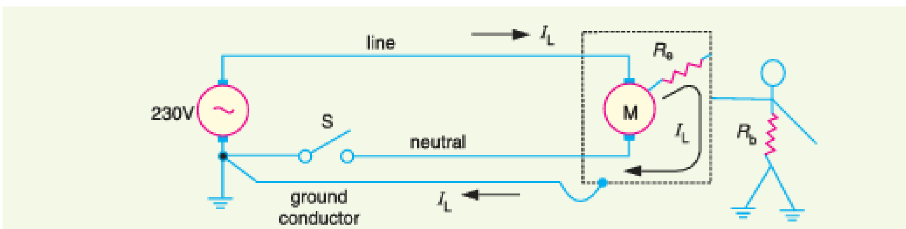


Fig. 26.4

System Grounding

The process of connecting some electrical part of the power system (e.g. neutral point of a star connected system, one conductor of the secondary of a transformer etc.) to earth (i.e. soil) is called system grounding.

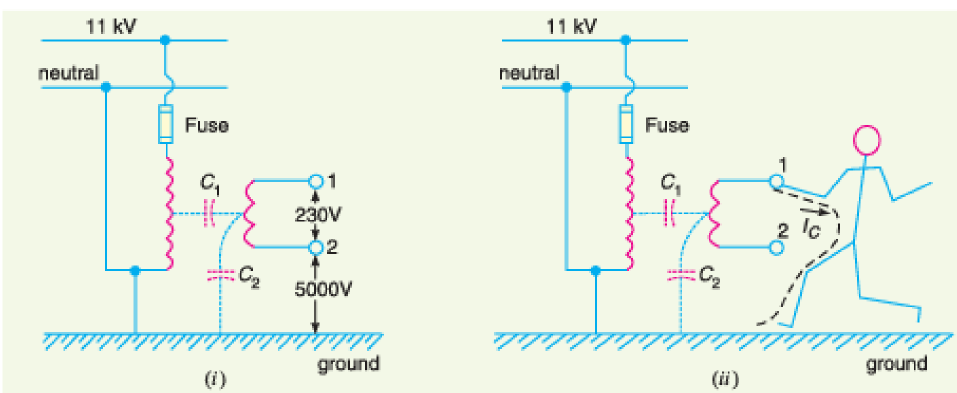


Fig. 26.5

PART C –(1 x 14 = 14 Marks)					
8.	(a)	In a 33 kV overhead line, there are three units in the string of insulators. If the capacitance between each insulator pin and earth is 11% of self-capacitance of each insulator, find (i) the distribution of voltage over 3 insulators and (ii) string efficiency.	14	CO-4	L-3

Solution. Fig. 8.14. shows the equivalent circuit of string insulators. Let V_1, V_2 and V_3 be the voltage across top, middle and bottom unit respectively. If C is the self-capacitance of each unit, then KC will be the shunt capacitance.

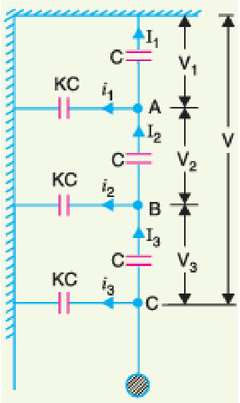


Fig. 8.14

$$K = \frac{\text{Shunt Capacitance}}{\text{Self - capacitance}} = 0.11$$

$$\text{Voltage across string, } V = 33/\sqrt{3} = 19{\cdot}05 \text{ kV}$$

At Junction A

$$I_2 = I_1 + i_1$$

or $$V_2 \omega C = V_1 \omega C + V_1 K \omega C$$

or $$V_2 = V_1 (1 + K) = V_1 (1 + 0{\cdot}11)$$

or $$V_2 = 1{\cdot}11\ V_1 \qquad \ldots(i)$$

At Junction B

$$I_3 = I_2 + i_2$$

or $$V_3 \omega C = V_2 \omega C + (V_1 + V_2) K \omega C$$

or $$V_3 = V_2 + (V_1 + V_2) K$$

$$= 1{\cdot}11 V_1 + (V_1 + 1{\cdot}11\ V_1)\ 0{\cdot}11$$

$\therefore$ $$V_3 = 1{\cdot}342\ V_1$$

(i) Voltage across the whole string is

$$V = V_1 + V_2 + V_3 = V_1 + 1{\cdot}11\ V_1 + 1{\cdot}342\ V_1 = 3{\cdot}452\ V_1$$

or $$19{\cdot}05 = 3{\cdot}452\ V_1$$

$\therefore$ Voltage across top unit, $V_1 = 19{\cdot}05/3{\cdot}452 =$ **5·52 kV**

Voltage across middle unit, $V_2 = 1{\cdot}11\ V_1 = 1{\cdot}11 \times 5{\cdot}52 =$ **6·13 kV**

Voltage across bottom unit, $V_3 = 1{\cdot}342\ V_1 = 1{\cdot}342 \times 5{\cdot}52 =$ **7·4 kV**

(ii) String efficiency $= \dfrac{\text{Voltage across string}}{\text{No. of insulators} \times V_3} \times 100 = \dfrac{19{\cdot}05}{3 \times 7{\cdot}4} \times 100 =$ **85·8%**

OR					
	(b)	The towers of height 30 m and 90 m respectively support a transmission line conductor at water crossing. The horizontal distance between the towers is 500 m. If the tension in the conductor is 1600 kg, find the minimum clearance of the conductor and water and clearance mid-way between the supports. Weight of conductor is 1·5 kg/m. Bases of the towers can be considered to be at water level.	14	CO-5	L-3

Here, l = 500 m ; w = 1·5 kg ; T = 1600 kg.

Difference in levels between supports, h = 90 − 30 = 60 m. Let the lowest point O of the conductor be at a distance x_1 from the support at lower level (*i.e.*, support A) and at a distance x_2 from the support at higher level (*i.e.*, support B).

Obviously, $$x_1 + x_2 = 500 \text{ m} \quad ...(i)$$

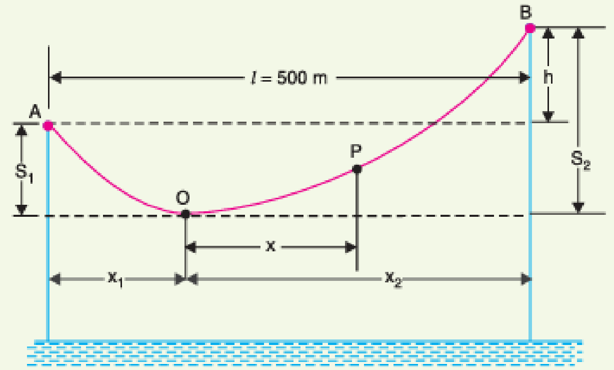


Fig. 8.28

Now Sag $S_1 = \frac{w\,x_1^2}{2T}$ and Sag $S_2 = \frac{w\,x_2^2}{2T}$

$$\therefore \quad h = S_2 - S_1 = \frac{w\,x_2^2}{2T} - \frac{w\,x_1^2}{2T}$$

or $$60 = \frac{w}{2T}(x_2 + x_1)(x_2 - x_1)$$

$$\therefore \quad x_2 - x_1 = \frac{60 \times 2 \times 1600}{1\cdot 5 \times 500} = 256 \text{ m} \quad ...(ii)$$

Solving exps. (i) and (ii), we get, x_1 = 122 m; x_2 = 378 m

Now, $$S_1 = \frac{w\,x_1^2}{2T} = \frac{1\cdot 5 \times (122)^2}{2 \times 1600} = 7 \text{ m}$$

Clearance of the lowest point O from water level

= 30 − 7 = **23 m**

Let the mid-point P be at a distance x from the lowest point O.

Clearly, $$x = 250 - x_1 = 250 - 122 = 128 \text{ m}$$

Sag at mid-point P, $$S_{mid} = \frac{w\,x^2}{2T} = \frac{1\cdot 5 \times (128)^2}{2 \times 1600} = 7\cdot 68 \text{ m}$$

Clearance of mid-point P from water level = 23 + 7·68 = 30·68 m