Register No. | | | | | | | | | | | | |

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 – I- ANSWER KEY

V Semester

B.E-ELECTRICAL AND ELECTRONICS ENGINEERING

19EE501 – TRANSMISSION AND DISTRIBUTION

Regulations 2019

Duration : 1 Hour 30 Minutes

Date : 28.08.2024 Session: FN Maximum: 50 Marks

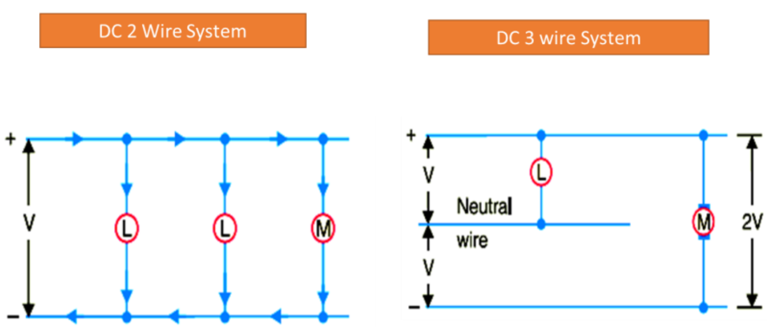
Answer ALL questions

	PART A - (5 X 2 = 10 marks)			
Q.No	**Question**	**M**	**CO**	**BL**
1	What are the various components of power system? **Answer:** The main components of a power system include: 1. **Generation units** - where electricity is generated (e.g., power plants). 2. **Transmission lines** - to carry electricity over long distances. 3. **Substations** - where voltage levels are adjusted (stepped up/down). 4. **Distribution systems** - to distribute electricity to consumers. 5. **Loads** - where electricity is consumed	2	CO-1	L -2
2	List the types of distribution system. Nature of Supply AC & DC distribution Nature of Connection • Radial distribution system • Ring main distribution system • Interconnected distribution system	2	CO-1	L -2
3	State the advantages of interconnected system. • Improved **reliability** - in case of a failure in one part of the system, power can be supplied from another part.	2	CO-1	L -2

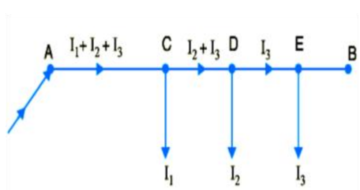
	• Better **load management** - helps in managing peak loads efficiently. • Economic **operation** - allows power to be generated in more efficient plants.			
4	What is meant by skin effect? **Answer:** The skin effect is the phenomenon where alternating current (AC) tends to flow mainly on the surface of a conductor, leading to a reduced effective cross-sectional area and an increased resistance as the frequency increases.	2	CO-2	L -2
5	Define proximity effect. **Answer:** The proximity effect occurs in conductors carrying alternating current (AC) placed close to each other, where the current distribution is influenced by the presence of nearby conductors, causing an increase in the effective resistance.	2	CO-2	L -2

PART B - (2 X 13 = 26 marks)

6.	(a)	An industrial park is planning to implement a new direct current (DC) distribution system to improve energy efficiency and reliability. Discuss the various types of DC distributors, including radial, ring, and mesh configurations. Evaluate the benefits and drawbacks of each type in terms of system reliability, fault tolerance, and maintenance requirements. Analyze which DC distribution type would be most suitable for the industrial park, considering factors such as load distribution and operational efficiency.	13	CO-1	L-4



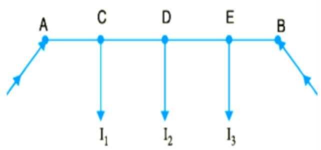
Distributor fed at one end



- Current goes on Decreasing
- The voltage across the loads away from the feeding point goes on decreasing.
- continuity of supply is interrupted, if fault occurs

Distributor fed at one end

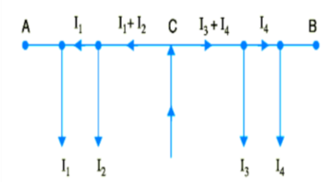
Distributor fed at both end



- continuity of supply is maintained from the other feeding point
- The area of X-section required for a doubly fed distributor is much less

Distributor fed at both end

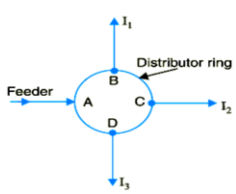
Distributor fed at centre



It is equivalent to two singly fed distributors, each distributor having a common feeding point and length equal to half of the total length.

Distributor fed at centre

Distributor fed at ring



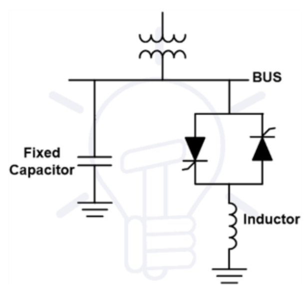
- Form of a closed ring
- It is equivalent to a straight distributor fed at both ends with equal voltages

Distributor fed at ring

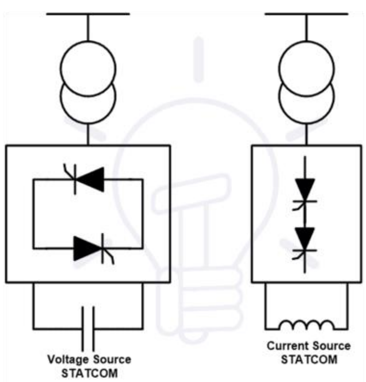
OR

<table>
<tr><td></td><td>(b)</td><td>A transmission system operator is looking to enhance the stability and control of their AC transmission network through the integration of Flexible AC Transmission Systems (FACTS) devices. Explain the different types of FACTS devices, such as SVC (Static Var Compensator), STATCOM (Static Synchronous Compensator), and UPFC (Unified Power Flow Controller). Discuss the key functions and benefits of each device in improving system performance, stability, and power quality. Provide examples of how these devices are applied in real-world scenarios to address power system challenges.

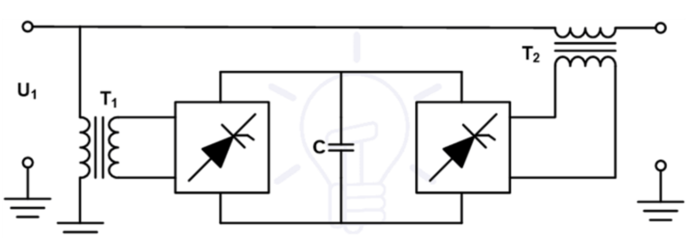
Static VAR Compensation (SVC)



Static Synchronous Compensator (STATCOM)



Unified Power Flow Controller (UPFC)


</td><td>13</td><td>CO-1</td><td>L-4</td></tr>
</table>

7.	(a)	An electrical engineering team is tasked with designing a new three-phase transmission line and needs to determine its capacitance to ensure optimal performance. Derive the formula for the capacitance per unit length of a three-phase transmission line, considering parameters like conductor spacing and line height. Analyze how changes in these parameters influence the capacitance and the overall performance of the transmission line.	13	CO-2	L-4

In a 3-phase transmission line, the capacitance of each conductor is considered instead of capacitance from conductor to conductor. Here, again two cases arise *viz.,* symmetrical spacing and unsymmetrical spacing.

(i) Symmetrical Spacing. Fig. 9.24 shows the three conductors A, B and C of the 3-phase overhead transmission line having charges Q_A, Q_B and Q_C per metre length respectively. Let the conductors be equidistant (d metres) from each other. We shall find the capacitance from line conductor to neutral in this symmetrically spaced line. Referring to Fig. 9.24, overall potential difference between conductor A and infinite neutral plane is given by (Refer to Art. 9.9);

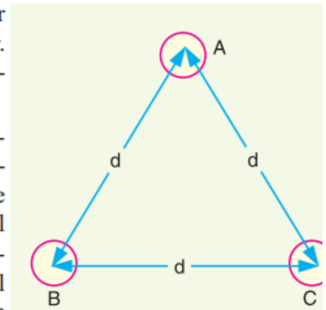


Fig. 9.24

$$V_A = \int_r^\infty \frac{Q_A}{2\,\pi x \varepsilon_0}\,dx + \int_d^\infty \frac{Q_B}{2\,\pi x \varepsilon_0}\,dx + \int_d^\infty \frac{Q_C}{2\,\pi x \varepsilon_0}\,dx$$

$$= \frac{1}{2\pi\,\varepsilon_0}\left[Q_A \log_e \frac{1}{r} + Q_B \log_e \frac{1}{d} + Q_C \log_e \frac{1}{d}\right]$$

$$= \frac{1}{2\pi\,\varepsilon_0}\left[Q_A \log_e \frac{1}{r} + (Q_B + Q_C) \log_e \frac{1}{d}\right]$$

Assuming balanced supply, we have, $Q_A + Q_B + Q_C = 0$

$\therefore \quad Q_B + Q_C = -Q_A$

$$\therefore \quad V_A = \frac{1}{2\pi\,\varepsilon_0}\left[Q_A \log_e \frac{1}{r} - Q_A \log_e \frac{1}{d}\right] = \frac{Q_A}{2\pi\varepsilon_0} \log_e \frac{d}{r} \text{ volts}$$

$\therefore$ Capacitance of conductor A w.r.t neutral,

$$C_A = \frac{Q_A}{V_A} = \frac{Q_A}{\frac{Q_A}{2\pi\,\varepsilon_0}\log_e \frac{d}{r}}\text{ F / m} = \frac{2\pi\,\varepsilon_0}{\log_e \frac{d}{r}}\text{ F / m}$$

$$\therefore \quad C_A = \frac{2\pi\,\varepsilon_0}{\log_e \frac{d}{r}}\text{ F / m}$$

Note that this equation is identical to capacitance to neutral for two-wire line. Derived in a similar manner, the expressions for capacitance are the same for conductors B and C.

(ii) Unsymmetrical spacing. Fig. 9.25 shows a 3-phase transposed line having unsymmetrical spacing. Let us assume balanced conditions *i.e.* $Q_A + Q_B + Q_C = 0$.

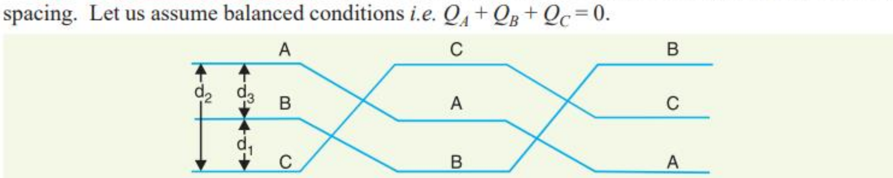


Fig. 9.25

Considering all the three sections of the transposed line for phase A, Potential of 1st position, $V_1 = \frac{1}{2\pi\varepsilon_0}\left(Q_A \log_e \frac{1}{r} + Q_B \log_e \frac{1}{d_3} + Q_C \log_e \frac{1}{d_2}\right)$

Potential of 2nd position, $V_2 = \frac{1}{2\pi\varepsilon_0}\left(Q_A \log_e \frac{1}{r} + Q_B \log_e \frac{1}{d_1} + Q_C \log_e \frac{1}{d_3}\right)$

Potential of 3rd position, $V_3 = \frac{1}{2\pi\varepsilon_0}\left(Q_A \log_e \frac{1}{r} + Q_B \log_e \frac{1}{d_2} + Q_C \log_e \frac{1}{d_1}\right)$

Average voltage on condutor A is

$$V_A = \frac{1}{3}(V_1 + V_2 + V_3)$$

$$= \frac{1}{3 \times 2\pi\varepsilon_0} * \left[Q_A \log_e \frac{1}{r^3} + (Q_B + Q_C)\log_e \frac{1}{d_1 d_2 d_3}\right]$$

As $Q_A + Q_B + Q_C = 0$, therefore, $Q_B + Q_C = -Q_A$

$$\therefore \quad V_A = \frac{1}{6\pi\varepsilon_0}\left[Q_A \log_e \frac{1}{r^3} - Q_A \log_e \frac{1}{d_1 d_2 d_3}\right]$$

$$= \frac{Q_A}{6\pi\varepsilon_0} \log_e \frac{d_1 d_2 d_3}{r^3}$$

$$= \frac{1}{3} \times \frac{Q_A}{2\pi\varepsilon_0} \log_e \frac{d_1 d_2 d_3}{r^3}$$

$$= \frac{Q_A}{2\pi\varepsilon_0} \log_e \left(\frac{d_1 d_2 d_3}{r^3}\right)^{1/3}$$

$$= \frac{Q_A}{2\pi\varepsilon_0} \log_e \frac{(d_1 d_2 d_3)^{1/3}}{r}$$

Capacitance Measurement using bridge

$\therefore$ Capacitance from conductor to neutral is

$$C_A = \frac{Q_A}{V_A} = \frac{2\pi\varepsilon_0}{\log_e \frac{\sqrt[3]{d_1 d_2 d_3}}{r}} F/m$$

OR

	(b)	A single phase transmission line has two parallel conductors 4 m apart, the radius of each conductor being 2 cm. Calculate the loop inductance per km length of the line if the material of the conductor is (i) copper (ii) steel with relative permeability of 100	13	CO-2	L-3

$d = 400\,cm$

$r = 2\,cm$

Loop Inductance $= 10^{-7}(\mu_r + 4\log_e(d/r))$

(i) Copper conductor

loop Inductance $= 10^{-7}(1 + 4\log_e(\frac{400}{2}))H$

$= 2.219 \times 1000$

$= 2.219\,mH$

(ii) Steel

Loop Inductance $= 10^{-7}(100 + 4\log_e(400/2))H$

$= 1.211 \times 10^3 \times 10^{-5}\,H$

$= 12.11\,mH.$

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<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">PART C –(1 x 14 = 14 Marks)</td></tr>
<tr><td>8.</td><td>(a)</td><td>A 2-wire d.c. distributor cable AB is 2 km long and supplies loads of 100A, 150A, 200A and 50A situated 500 m, 1000 m, 1600 m and 2000 m from the feeding point A. Each conductor has a resistance of 0·01 Ω per 1000 m. Calculate the potential difference at each load point if a potential difference of 300 V is maintained at point A

Solution. Fig. 13.6 shows the single line diagram of the distributor with its tapped currents.
Resistance per 1000 m of distributor = 2 × 0·01 = 0·02Ω
Resistance of section AC, R_{AC} = 0·02 × 500/1000 = 0·01 Ω
Resistance of section CD, R_{CD} = 0·02 × 500/1000 = 0·01 Ω
Resistance of section DE, R_{DE} = 0·02 × 600/1000 = 0·012 Ω
Resistance of section EB, R_{EB} = 0·02 × 400/1000 = 0·008 Ω
Referring to Fig. 13.6, the currents in the various sections of the distributor are :
I_{EB} = 50 A ; I_{DE} = 50 + 200 = 250 A
I_{CD} = 250 + 150 = 400 A ; I_{AC} = 400 + 100 = 500 A

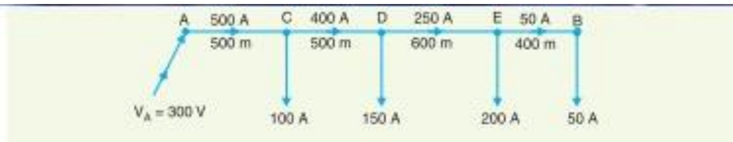
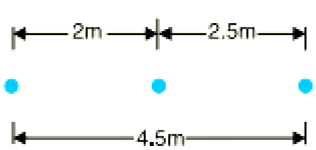


Fig. 13.6
P.D. at load point C, V_C = Voltage at A – Voltage drop in AC
= $V_A - I_{AC} R_{AC}$
= 300 – 500 × 0·01 = 295 V
P.D. at load point D, V_D = $V_C - I_{CD} R_{CD}$
= 295 – 400 × 0·01 = 291 V
P.D. at load point E, V_E = $V_D - I_{DE} R_{DE}$
= 291 – 250 × 0·012 = 288 V
P.D. at load point B, V_B = $V_E - I_{EB} R_{EB}$
= 288 – 50 × 0·008 = 287·6 V</td><td>14</td><td>CO-1</td><td>L-3</td></tr>
<tr><td colspan="6">OR</td></tr>
<tr><td></td><td>(b)</td><td>A 3-phase, 50 Hz, 66 kV overhead line conductors are placed in a horizontal plane as shown in Figure. The conductor diameter is 1·25 cm. If the line length is 100 km, calculate (i) capacitance per phase, (ii) charging current per phase, assuming complete transposition of the line

</td><td>14</td><td>CO-2</td><td>L-3</td></tr>
</table>

assuming complete transposition of the line.

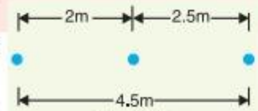


Fig. 9.26

Solution. Fig 9.26 shows the arrangement of conductors of the 3-phase line. The equivalent equilateral spacing is

$$d = \sqrt[3]{d_1 d_2 d_3} = \sqrt[3]{2 \times 2 \cdot 5 \times 4 \cdot 5} = 2 \cdot 82 \text{ m}$$

Conductor radius, $r = 1 \cdot 25/2 = 0 \cdot 625$ cm

Conductor spacing , $d = 2 \cdot 82$ m $= 282$ cm

(*i*) Line to neutral capacitance= $\dfrac{2\pi\varepsilon_0}{\log_e d/r}$ F/m $= \dfrac{2\pi \times 8 \cdot 854 \times 10^{-12}}{\log_e 282/0 \cdot 625}$ F/m

$$= 0 \cdot 0091 \times 10^{-9} \text{ F/m} = 0 \cdot 0091 \times 10^{-6} \text{ F/km} = 0 \cdot 0091 \ \mu\text{F/km}$$

∴ Line to neutral capacitance for 100 km line is

$$C = 0 \cdot 0091 \times 100 = \mathbf{0 \cdot 91\ \mu F}$$

(*ii*) Charging current per phase is

$$I_C = \frac{V_{ph}}{X_C} = \frac{66{,}000}{\sqrt{3}} \times 2\pi f C$$

$$= \frac{66{,}000}{\sqrt{3}} \times 2\pi \times 50 \times 0 \cdot 91 \times 10^{-6} = \mathbf{10 \cdot 9\ A}$$