نقل وتوزيع الطاقة

1st term — « Model Answer » — 3rd year

« Transmission & Distribution of Electrical Energy »

Q_1 [25]

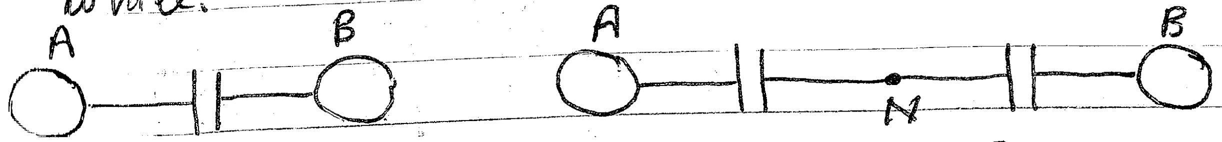
Q_1 a) The electric power is generated at Low Voltage and it needs step-up transformer, Also distribution but the η of Transmitted D-C power is $> \eta_{AC}$

(4) Marks

Q_1 b) the sag in Electrical O.H.T.L is necessity to occupy the geographical field & variation of temperature.

(4) Marks

Q_1 c) The C of T.L depends on the ground effect while:



CAB — CAN = 2CAB — CBN = 2CAB

where $C = \frac{Q}{V}$, $V_{AB} = 2V_A$, $V_A = V_{AN} = V_{BN}$

$C_{AN} = \frac{Q}{V_{AN}} = \frac{Q}{V_{AN}}$ but $V_{AB} = \frac{Q}{C_{AB}}$

$\therefore C_{AB} = \frac{Q}{2V_{AN}} = \frac{1}{2}\frac{Q}{V_{AN}} = \frac{1}{2}C_{AN}$

$\therefore C_{AN} = 2C_{AB}$ #

(3 Marks)

d) p.f $\Longrightarrow$ $Reg\,\% = \frac{I \cdot R \cos\phi_R \mp I \cdot X_L \sin\phi_R}{V_R} \times 100$

(3 Marks)

$\eta\,\% = \frac{V_R I_R \cos\phi_R}{V_R I_R \cos\phi_R + I^2 \cdot R} \times 100$

1,e) at no load of long line $U_R > U_S$ (Ferranty effect) due to charging current (C dominant in long T.L.
(5 Marks)

1,f) The max. stress in Cable is at Conductor surface
(3 Marks)

1,g) As: Rubber, Vulcanised Rubber, Impregnated paper, Varnished Cambric polyvinyl choride (PVC) (3 Marks)

Q2 [20]

2,a)) the insulators should have the following desirable properties:—
(5 Marks)

- High mechanical strength
- " electrical resistance of insulator materials to avoid leakage current to earth.
- High relative permittivity of insulator materials.
- High ratio of puncture strength to flashover.

2,b)) methods of improving string of insulators:—
(5 Marks)

1- by using longer cross-arms.
2- by grading the insulators.
3- by using a guard ring.

} with details

3,c)) $W = 1.925$ Kg, $t_{stress} = 8000$ kg/cm^2; Area $= 2.2$ cm^2
$h = 15$ m, $X_1 + X_2 = 600$ m,
(10 Marks)

$$\text{Working stress} = \frac{\text{ultimate strength}}{\text{safety factor}}$$

Working Tension = Working stress * Conductor area

3

$T = \frac{\text{ultimate} \times \text{area}}{\text{safety}}$ Sol, $= \frac{8000 \times 2.2}{5}$

$= 3520\ kg$

total weight of 1m length of conductor is:

$W_t = w + w_{ice} = 1.925 + 1 = 2.925\ kg$

$x_1 + x_2$ = the distance between two supports

$x_1 + x_2 = 600\ m \longrightarrow (1)$

$h = S_2 - S_1 = \frac{W_t \times X_2^2}{2T} - \frac{W_t X_1^2}{2T}$

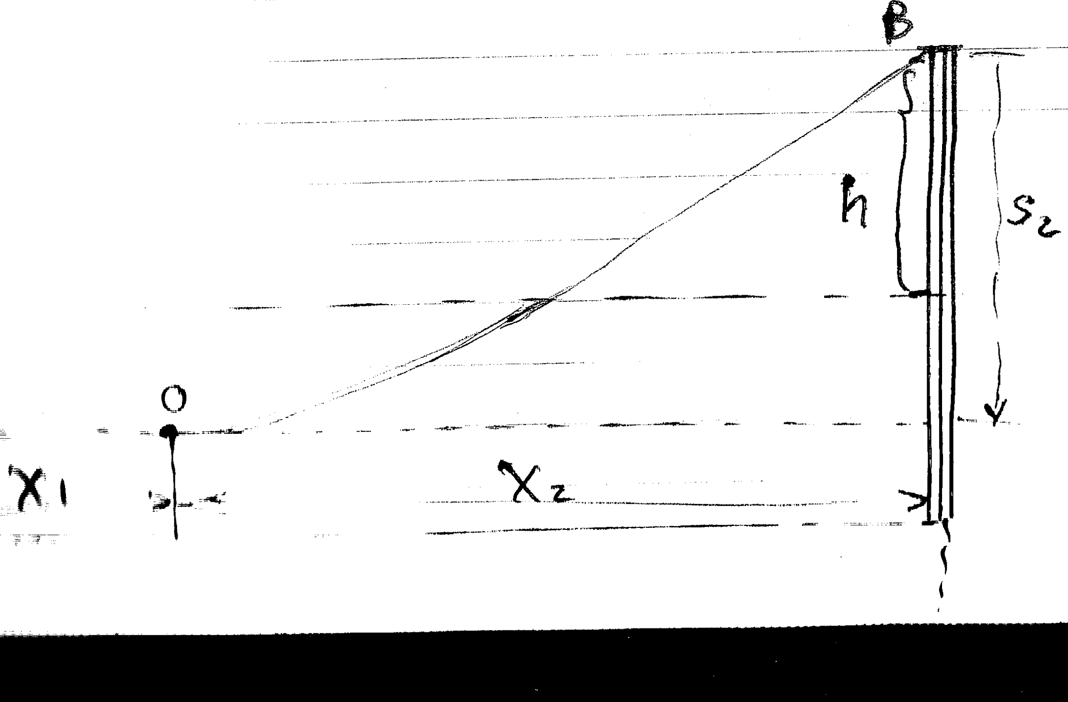
$15 = \frac{W_t}{2T}(x_1 - x_2)\underbrace{(x_1 + x_2)}_{600}$

$15 = \frac{2.925}{2 \times 3520}(x_1 - x_2) \times 600$

$x_1 - x_2 = 60\ m \longrightarrow (2)$ by solving (1) & (2)

$x_1 = 270\ m$ & $x_2 = 330\ m$

$S_2 = \frac{W_t \cdot X_2^2}{2T} = \frac{2.925 \times (330)^2}{2 \times 3520} = 45.24\ m$



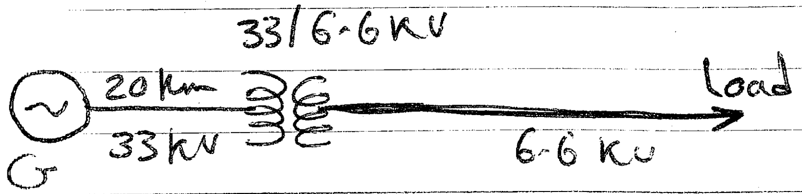
Q3 [20]

Q3 a)) $\vec{A}, \vec{B}, \vec{C}, \vec{D}$ are generllised circuit constants of T.L. The values of these constants depends upon the particular method adopted for solving T.L. (5 Marks)

Once the values of these constants are known, performance calculations of the T.L can be easily worked out.

Q3 b)) in T.L The transmitted power is transmitted through 3-phase while in distribution the consumers need the fourth wire to neutral or earth. (5 Marks)

Q3 c))



R of each conductor = 20 * 0.4 = 8 Ω
[illegible] ~ = 20 * 0.5 = 10 Ω } for 20 Km

[illegible] for transf;

= primary (R, X) + R, X (secondary)

$R_{transf,\,total} = 7.5 + 0.35 * \left(\frac{33}{6.6}\right)^2 = 7.5 + 8.75 = 16.25\ \Omega$

$X_{transf,\,total} = 13.2 + 0.65 \left(\frac{33}{6.6}\right)^2 = 13.2 + 16.25 = 29.45\ \Omega$

Total R (for line + transf) = 8 + 16.25 = 24.25 Ω
Total X (~ ~ ~) = 10 + 29.45 = 39.45 Ω

$V_{ph} = 33000/\sqrt{3} = 19052\ V$

Line current = $I = \frac{2000\,kVA * 10^3}{\sqrt{3} * 33000} = 35\ A$

→

$V_s = V_R + I R \cos\phi_R + I X_L \sin\phi_R$ (approximate)

$= 19052 + 35 * 24.25 * 0.8 + 35 * 39.45 * 0.6$

$V_{s\,phase} = 20.559\ kV$

$V_{line} = \sqrt{3} * 20.559 = 35.6\ kV$

$\cos\phi_s = \dfrac{V_R \cos\phi_R + I R}{V_s} = \dfrac{19052 * 0.8 + 35 * 24.25}{20559}$

$\cos\phi_s = 0.7826$

line losses $= 3 I^2 R = 3 * (35)^2 * 24.25$

$= 89.12\ kW$

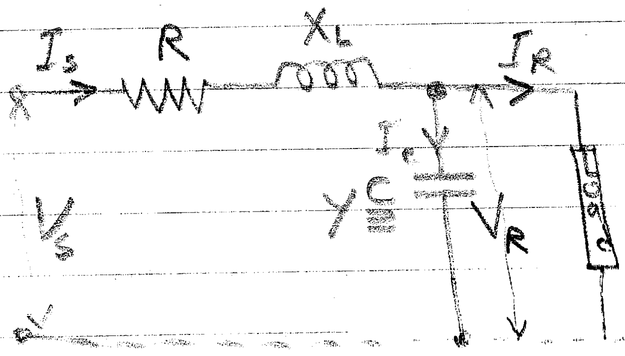
$P_{out} = 2000\ kVA * 0.8 = 1600\ kW$

$\eta = \dfrac{P_{out}}{P_{out} + losses} = \dfrac{1600}{1600 + 89.12}$ (10 Marks)

$= 94.72\ \%$

(35)

Q4 a) The C of the line lumped at end R.



I_R ...

$V_R \cdot Y \rightarrow I_s = I_R + Y V_R$ (6 Marks)

$I_s (R + jX) + V_R \longrightarrow$

6

$V_s = (I_R + V_R Y)(R + JX_L) + V_R$

$= Z I_R + V_R ZY + V_R$

$V_s = (1 + ZY) V_R + Z I_R \longrightarrow (1)$

$\vec{V_s} = A\vec{V_R} + B\vec{I_R}$ & $I_s = Y V_R + I_R \longrightarrow (2)$

$\vec{I_s} = C\vec{V_R} + D\vec{I_R}$

$BC = 1 \longrightarrow$ Constraint

$ZY = 1$

first Constrain is not found

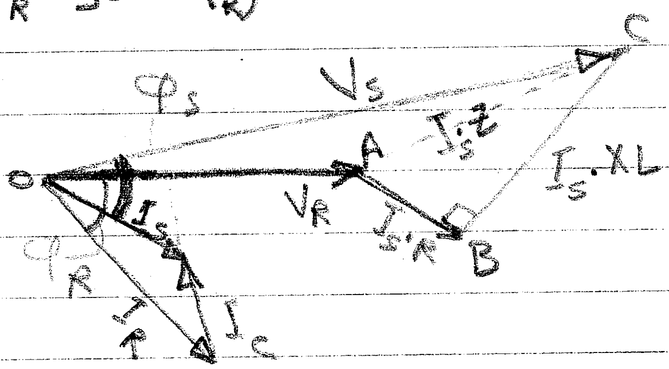
$A \neq D$

$V_s = V_R$, $\vec{I_R} = I_R(\cos\varphi_R - J\sin\varphi_R)$

$= J V_R$ $= J 2\pi f C \vec{V_R}$

$\vec{I_R}$

$\vec{V_R}$



Q4 b) The insulation resistance of a Cable $\propto \frac{1}{\text{length}} \longrightarrow$ (4 Marks)

$R_{ins} \propto \frac{1}{\text{length}}$

1 - φ Q4 c)

V_{drop} 15% * 11kV = 1650 V

V_{drop} = I_1 * 0.15 = 1650 V (15 Marks)

I_1 = $\frac{1650}{0.15}$ = 11000 A → ①

P = $I_1 V \cos\varphi$

= 11000 A * 11000 V * 0.8

= 9.68 * 10^4 kW → ②

D.C system

$I_2 . V_2$ = 9.68 * 10^4 (kW)

I_2 = $\frac{9.68 * 10^7}{V_2}$ (A)

V_{drop} = $I_2 . R_2$ = $\left(\frac{9.68 * 10^7}{V_{2 d.c}}\right)$ * 0.05

25% = $\frac{25}{100}$ * V_2

$\left(\frac{9.68 * 10^7}{V_2}\right)$ * 0.05 = 0.25 V_2

$V_{d.c}$ = 9.68 * 100 * 5 * 1000 / 0.25

V^2 = 1936 * 10000

V^2_{dc} = 1936 * 10^4

$V_{d.c}$ = $\sqrt{1936 * 10^4}$ [2] → = 4400 volt D.C

$$I_2 = \frac{9.68 \times 10^7 \, W}{4400} = 22000 \, A$$

From above result:-

(1) $I_{2dc} > I_{1AC_{1-\varphi}} \Longrightarrow I_{2dc} = 2 I_{1AC_{1-\varphi}}$

$V_{2dc} < V_{1AC_{1-\varphi}}$

4400 V ← V_{2dc}, 11000 V ← $V_{1AC_{1-\varphi}}$

The Consumer Can feed more loads → but he needs more Cost for feeder.

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