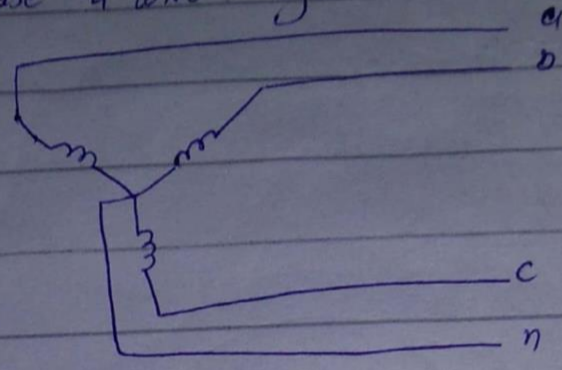
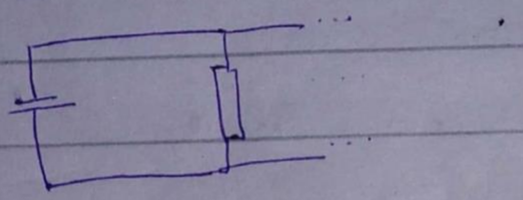
Q No 2 (a)

ASAD ULLAH KHAN
15435

Three phase 4 wire system



Two wire DC



Volume of copper comparison

In 2-wire DC

$I = P/V_m$

$R = \rho \frac{L}{A}$

Total copper losses

$W = 2I^2R = 2\left(\frac{P}{V_m}\right)^2 \rho \frac{L}{A}$

$A = 2\left(\frac{P}{V_m}\right)^2 \rho \frac{L}{W}$

Total volume

$V = 2AL$

$= 2 \times 2\left(\frac{P}{V_m}\right)^2 \rho \frac{L}{W} \times L =$

$V = \frac{4P^2 \rho L}{V_m^2 W}$

Consider the above volume $= K$

For 3-phase 4-wire AC

ASAD ULLAH KHAN
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Assuming the load is balanced no current flows through neutral and A of neutral is always half of each conductor i.e. $A_n = 0.5 A_c$

Now,

$$V_m = \sqrt{2}\, V_{ph} \qquad P = 3 P_{ph}$$

$$A = \frac{2}{3} \frac{P^2}{V_m^2 \cos^2\phi} \times \frac{\rho L}{W}$$

The above area is derived from three ϕ 3 wire system.

As,

$$I_{ph} = \frac{P/3}{\left(\frac{V_m}{\sqrt{2}}\right)\cos\phi}$$

$$R_{ph} = \frac{\rho L}{A}$$

$$W = 3 I_{ph}^2 R_{ph} = 3 \frac{2}{9} \frac{P^2}{V_m^2 \cos^2\phi} \frac{\rho L}{A}$$

$V = 3 \times A \times L$ (obtain A from above eq)

$$V = \frac{2}{\cos^2\phi} \frac{P^2 \rho L^2}{W V_m^2} = \frac{0.5\, K}{\cos^2\phi} \qquad \left(\because K = 4\frac{P^2 \rho L}{V_m^2 W}\right)$$

Now, for 3ϕ 4 wire system

$$V = 3AL + 0.5AL = 3.5AL = 3.5 \times \frac{2}{3} \times \frac{P^2}{V_m^2 \cos^2\phi} \frac{\rho L}{W} \times L$$

$V = \frac{7K}{12\cos^2\phi}$ Here K is the volume of copper required by 2 wire DC system.

Hence proved

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We have calculated the amount of copper required for 3 ϕ 4 wire system.

$$V = \frac{7}{12\cos^2\phi}\left(\frac{4P^2 \rho L}{V_m^2 W}\right)$$

Now for a DC system with two live wires and a third wire neutral with half area compared to the live wires.

Considering balanced load $I_N = 0$

$$I = \frac{P}{2V_m}$$

Total copper loss

$$W = 2I^2R = \frac{2P^2}{4V_m^2}\rho\frac{L}{A} = \frac{P^2}{2V_m^2}\rho\frac{L}{A}$$

Now finding volume of copper

$$V = 2AL + 0.5AL = 2.5AL$$

$$= 2.5 \times \frac{P^2}{2V_m^2}\rho\frac{L}{W} \times L = \frac{2.5}{8}\left(\frac{4P^2\rho L^2}{V_m^2 W}\right)$$

Now comparing volume of copper for both systems

Three ϕ 4 wire $V = \frac{7}{12\cos^2\phi}\left(\frac{4P^2\rho L}{V_m^2 W}\right)$

3 wire DC with one neutral $V = \frac{2.5}{8}\left(\frac{4P^2\rho L}{V_m^2 W}\right)$

Q No 3 (a)

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Data.

line span = l = 200 m　　$A = 1.29\,cm^2$

Weight of C = w = 1170 Kg/Km = 1.17 Kg/m

Wind pressure = 122 Kg/m²　　$w_w = 122 \times 1.29 \times 10^{-2} \times 1 = 1.56$ Kg

Tension = $T = 4218 \times 1.29 \times 5 = 1088$ Kg

Sol.

Weight of conductor/m $\Rightarrow w_t = \sqrt{w^2 + w_w^2} = \sqrt{(1.17)^2 + (1.56)^2}$

$= 1.95$ Kg

Slant sag $= \dfrac{w_t \times l}{8T} = \dfrac{1.95 \times 200^2}{8 \times 1088} = 8.96$ m

$\theta = \tan^{-1}\left(\dfrac{w_w}{w}\right) = \tan^{-1}\left(\dfrac{1.56}{1.17}\right) = 53.13°$

Vertical sag $= S\cos\theta = 8.96 \times \cos(53.13) = 5.37$ m

$\boxed{S_v = 5.37\,m}$

Q No 3 (c)

Data

Weight = w = 680 Kg/Km = 0.68 Kg/m

Strength = 3100 Kg　　Saffty factor = 2

L = 260 m　　Ground clearance = 10 m

Sol.

T = strength / S_F = 3100/2 = 1550 Kg

Sag $= \dfrac{w l^2}{8T} = \dfrac{0.68 \times (260)^2}{8 \times 1550} = 3.7$ m

Including ground clearance height of support should be $H = 10 + 3.7 = 13.7$ m

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Q No. 3 (b)

Ferranti's Effect.

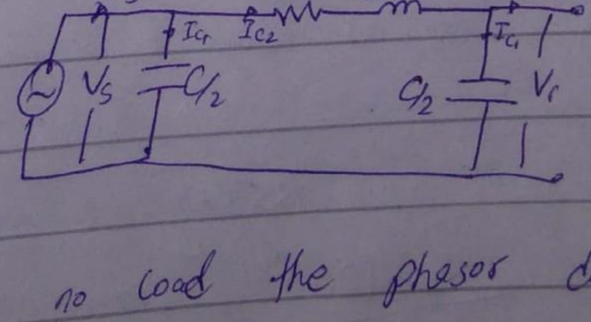
This is an effect observed in transmission lines when the voltage at receiving end is greater than that on the sending end.

Causes.

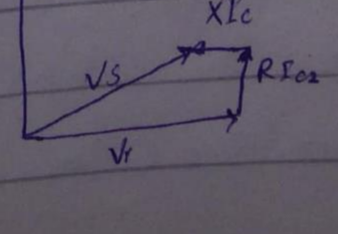
This effect occurs due to charging current of a line. On lines above 240 m the capacitance of line is not concentrated at some fixed points but is uniformly distributed along the whole line. When a voltage is applied at the sending end the current drawn due to capacitance is more than the load demands. Thus, at no load or small load the voltage at receiving end is larger.

Example.

Consider the following model



At no load the phasor diagram will be



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For the above model

$$V_s = \left(1 + \frac{ZY}{2}\right) V_r + Z I_r$$

At $I_r = 0$

$$V_s = \left(1 + \frac{ZY}{2}\right) V_r$$

$$V_s - V_r = \left(1 + \frac{ZY}{2}\right) V_r - V_r$$

$$V_s - V_r = \frac{YZ}{2} V_r \qquad \left(\because Z = (r + j\omega L)s, \; Y = (j\omega C)s\right)$$

$$V_s - V_r = \frac{1}{2}(j\omega L)(j\omega C) s^2 V_r$$

$$V_s - V_r = -\frac{1}{2} \omega^2 s^2 LC V_r$$

As seen from above eq. the negative sign shows that $V_r > V_s$

Q No 1 (a)

We can see from the map that distance from Tarbela to Peshawar is 127 Km and from Peshawar to Swat is 150 Km. Both these lines are considered to be medium transmission lines. So, their voltage should be < 100 KV and their parameters can be considered to be uniformly distributed

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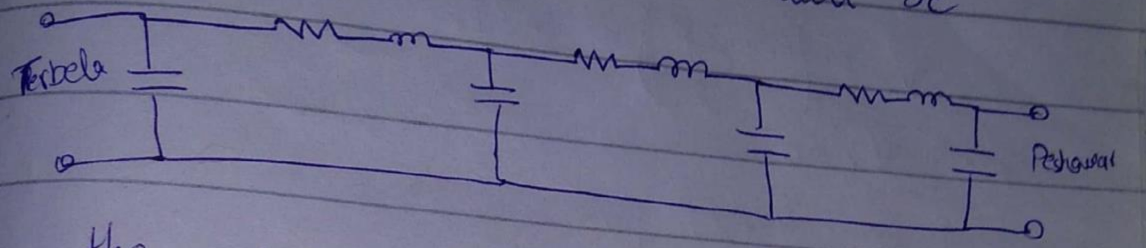
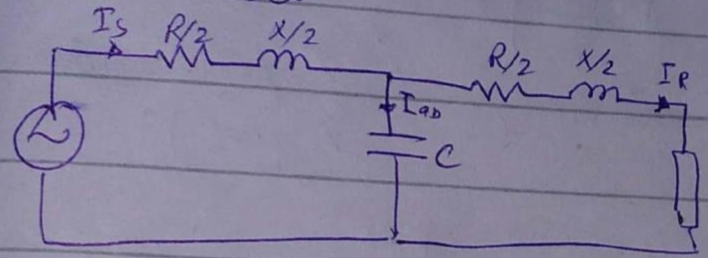
The ~~sy~~ schematic for both lines will be



For the design I will consider a nominal T model



Here $Z = R + jX$ $\quad Y = j\omega C$

The relation between V_R and V_s for such
I_R and I_s

model will be

$$\begin{bmatrix} V_s \\ I_s \end{bmatrix} = \begin{bmatrix} 1+\frac{ZY}{2} & Z+\frac{Z^2Y}{4} \\ Y & 1+\frac{ZY}{2} \end{bmatrix} \begin{bmatrix} V_r \\ I_r \end{bmatrix}$$

For such a system as the TL falls into medium category the effects of capacitance will be taken into account and a lumped load model will be considered as it can give a resonably accurate result for such system.

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Q No 1 (b)

When the primary side voltage of the previous system is increased upto 700 KV the voltage falls into the category of long transmission line. But the distance between nodes for the system don't change thus the system will not be stable and a lot of problems will occurs

Advantages

1) Smaller volume of copper will be used for such a system.
2) Copper costs will decrease while building such system.

Disadvantages

1) Copper losses will increase.
2) Corona effect will also be included for such system.
3) The conductors should be placed further apart increasing capital cost
4) Overall power losses will increase per phase.