EEE DEPARTMENT

POWER SYSTEMS II

UNIT I : Transmission Line Parameters

Types of conductors – calculation of resistance for solid conductors – Calculation of inductance for single phase and three phase, single and double circuit lines, concept of GMR & GMD, symmetrical and asymmetrical conductor configuration with and without transposition, Numerical Problems. Calculation of capacitance for 2 wire and 3 wire systems, effect of ground on capacitance, capacitance calculations for symmetrical and asymmetrical single and three phase, single and double circuit lines, Numerical Problems

UNIT-II

Performance of Short and Medium Length Transmission Lines

Classification of Transmission Lines – Short, medium and long line and their model representations – Nominal- T, Nominal-Pie and A, B, C, D Constants for symmetrical & Asymmetrical Networks, Numerical Problems. Mathematical Solutions to estimate regulation and efficiency of all types of lines – Numerical Problems.

UNIT-III

Performance of Long Transmission Lines

Long Transmission Line-Rigorous Solution, evaluation of A,B,C,D Constants, Interpretation of the Long Line Equations, Incident, Reflected and Refracted Waves -Surge Impedance and SIL of Long Lines, Wave Length and Velocity of Propagation of Waves – Representation of Long Lines – Equivalent-T and Equivalent Pie network models (numerical problems)

UNIT – IV

Power System Transients

Types of System Transients – Travelling or Propagation of Surges – Attenuation, Distortion, Reflection and Refraction Coefficients – Termination of lines with different types of conditions – Open Circuited Line, Short Circuited Line, T-Junction, Lumped Reactive Junctions (Numerical Problems). Bewley's Lattice Diagrams (for all the cases mentioned with numerical examples)

UNIT-V

Various Factors Governing the Performance of Transmission line

Skin and Proximity effects – Description and effect on Resistance of Solid Conductors – Ferranti effect – Charging Current – Effect on Regulation of the Transmission Line, Shunt Compensation. Corona – Description of the phenomenon, factors affecting corona, critical voltages and power loss, Radio Interference and power factor improving methods.

UNIT-VI

Sag and Tension Calculations and over head line insulators

Sag and Tension Calculations with equal and unequal heights of towers, Effect of Wind and Ice on weight of Conductor, Numerical Problems – Stringing chart and sag template and its applications Types of Insulators, String efficiency and Methods for improvement, Numerical Problems – voltage distribution, calculation of string efficiency, Capacitance grading and Static Shielding

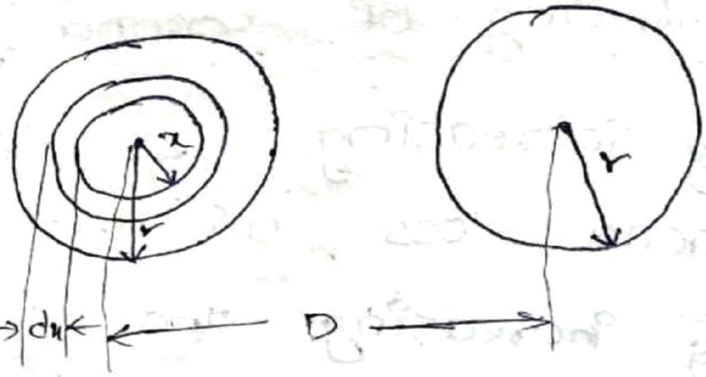
UNIT- I

Transmission Line parameters

Inductance

* Inductance : $L = \frac{N\phi}{I}$

Inductance means flux linkages for Amp. Let us. Consider the two Conductor of radius ~~are~~ "r". distence b/w is "D". and Consider the a ring of radius "x". in the Conductor and change in the thickness of the ring is dx.



Here

r = radius of the Conductor.

x = ~~rad~~ inner radius of the conductor.

D = Distence b/w the Conductor.

Assuming Current density in the ring equal to the Current density in the Conductor.

$$\therefore \frac{I}{\pi r^2} = \frac{I_x}{\pi x^2}$$

$$I_x = \frac{I \cancel{\pi} x^2}{\cancel{\pi} r^2}$$

$$I_x = \frac{I x^2}{r^2} \quad \text{——— (1)}$$

Magnetic feild strength in the ring

$$H_x = \frac{I_x}{2\pi x}$$

the substitute equ ① in above equation.

$$H_x = \frac{\frac{Ix^2}{r^2}}{2\pi x}$$

$$= \frac{Ix^{\cancel{2}}}{r^2} \times \frac{1}{2\pi \cancel{x}}$$

$$H_x = \frac{Ix}{2\pi r^2}$$

Magnetic flux density $B_x = \mu H_x$.

$$B_x = \mu_0 \mu_r H_x \quad [\because \mu = \mu_0 \mu_r]$$

$$B_x = \mu_0 \mu_r \cdot \frac{I x}{2\pi r^2} \quad \left[H_x = \frac{Ix}{2\pi r^2}\right]$$

Flux $\phi_x = B_x \times A_x$ [Let us consider 1 m length of conductor and thickness dx]

$$\phi_x = B_x \times 1 \times dx.$$

$$\phi_x = \mu_0 \mu_r \cdot \frac{Ix}{2\pi r^2} \times dx \quad \text{——— ②}$$

flux linkages $= N_x \times \phi_x$.

where N_x is the ratio of inner and outer dia of conductors.

$$\text{flux linkages} = \frac{x^2}{r^2} \times \mu_0 \mu_r \cdot \frac{Ix}{2\pi r^2} \times dx$$

$$= x^3 \times \mu_0 \cdot \mu_r \cdot \frac{I}{2\pi r^4} \times dx.$$

$$= \frac{x^3}{} \times \mu_0 \times \mu_r \times I \times dx,$$

$$L = \int_r \frac{\mu_0}{2\pi x} \cdot dx.$$

$$= \frac{\mu_0}{2\pi} \int_r^D \frac{1}{x}\, dx$$

$$= \frac{\mu_0}{2\pi} \left[\log x\right]_r^D \qquad \left[\because \int \frac{1}{x} \cdot dx = \log x\right]$$

$$= \frac{\mu_0}{2\pi} \left[\log D - \log r\right]$$

$$= \frac{\mu_0}{2\pi} \left[\log\left(\frac{D}{r}\right)\right]$$

$$\boxed{\therefore\ L = \frac{\mu_0}{2\pi}\left[\log\left(\frac{D}{r}\right)\right]} \longrightarrow B$$

Now: Total indutance = inductance in inside Conductor + inductance in outside Conductor

Now. By adding equation A & B

$$L = \frac{\mu_0 \mu_r}{8\pi} + \frac{\mu_0}{2\pi}\left[\log\left(\frac{D}{r}\right)\right]$$

$$\boxed{L = \frac{\mu_0}{2\pi}\left[\frac{\mu_r}{4} + \log\frac{D}{r}\right] \text{ Henry}}$$

$$\therefore L = \frac{\cancel{4\pi} \times 10^{-7}}{\cancel{2\pi}}\left[\frac{\mu_r}{4} + \log\frac{D}{r}\right]$$

For Consider Non-Magnetic Material.

$$L = 2\times 10^{-7}\left[\frac{1}{4} + \log\frac{D}{r}\right]$$

$$\text{inductance}/m = \left[0.5 + 2\log\frac{D}{r}\right] \times 10^{-7} \text{ Henrys/meter}$$

$$\text{Inductance}/km = \left[0.5 + 2\log\frac{D}{r}\right] \times 10^{-7} \times 10^{3} \text{ Henry}/km.$$

$$\boxed{\text{inductance}/km = \left[0.5 + 2\log\frac{D}{r}\right] \times 10^{-4} \text{ Henry}/km.}$$

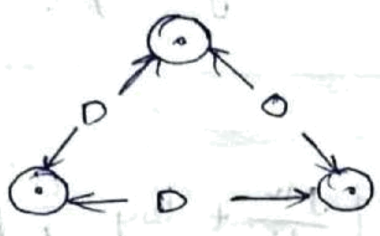
* For 3-ϕ Transmission System:

When the Spacing between the Conductors are equal then, inductance for meter & km are

$$\text{inductance}/m = \left[0.5 + 2.\log\frac{D}{r}\right] \times 10^{-7} \times \cancel{10^{3}} \text{ Henry}/\cancel{k}m.$$

$$\text{inductance}/km = \left[0.5 + 2\log\frac{D}{r}\right] \times 10^{-4} \text{ Henry}/km.$$

* when conductors are equally spaced :



* When conductors are unequally spaced :

$$D = \sqrt[3]{D_1 , D_2 D_3}.$$

$$\text{induce}/m = \left[0.5 + 2\log \frac{\sqrt[3]{D_1 D_2 D_3}}{r}\right] \times 10^{-7} \text{ Henry}/m.$$

* steps to Find inductance :

* Current dencity.

I_x

$$H_x = \frac{I_x}{2\pi x}$$

$$B_x = \mu . H_x .$$

$$\phi_x = B_x \times A_x$$

$$\text{Flux linkages} = \frac{\cancel{\phi_x}}{\phi} \quad N_x \times \phi_x$$

$$\text{inductance} = \int \frac{\text{linkages}}{I} . dx .$$

Problems on Inductance :

~~In~~ When a 3-ϕ Transmission line having 3-Conductors are equally spaced at a distence of 0.8 meters. are Conductor radius is 0.7cm. Find out the inductive reactance. when frequency is 50 Hz.

→ **Given data :**

In 3-ϕ Transmission line

Distence $D = 0.8$ meters.

radius of Conductor $r = 0.7$ cm.

frequency $f = 50$ Hz.

Inductive reactence = ?

$$\text{inductance}/M = \left[0.5 + 2\log\left(\frac{D}{r}\right)\right] \times 10^{-7}$$

$$= \left[0.5 + 2\log\left(\frac{0.8}{0.7}\right)\right] \times 10^{-7}$$

$$= [0.5 + 2.05] \times 10^{-7}$$

induc /m $= \cancel{20.81 \times 10^{-7}}$. ~~Hen~~/m 0.615 $\times 10^{-7}$ Hen/m

Now $X_L = 2\pi f l$

$$= 2 \times \pi \times 50 \times 2.57 \times 10^{-7}$$

$\boxed{X_L = \cancel{8.07 \times 10^{-5}}\ \Omega/m}$ $\boxed{X_L = 1.9 \times 10^{-5}\ \Omega/m}$

2. Spacing blue Conductors 0.8, 0.7, 0.9 m.

→ Given data :

Distence $D_1 = 0.8$ meters.

$D_2 = 0.7$ meters.

$D_3 = 0.9$ meters.

radius of Conductor $r = 0.7$ cm.

Frequency $f = 50$ Hz.

Inductive Reactance. = ?

$$\text{inductance}/M = 0.5 + 2.\log\left[\frac{\sqrt[3]{D_1 D_2 D_3}}{r}\right] \times 10^{-7}$$

$$= 0.5 + 2\log\left[\frac{\sqrt[3]{0.9 \times 0.8 \times 0.7}}{0.7 \times 10^{-2}}\right] \times 10^{-7}$$

$$\boxed{L = 4.61 \times 10^{-7} \text{ Henry}/M}$$

Now $X_L = 2\pi f L$

$= 2 \times \pi \times 50 \times 4.61 \times 10^{-7}$

Let us consider two conductors a and B having radius are and distence between the centre of conductors is "D". Conductor A is positive charge and conductor B is negitive charge. Let a point "p" is taken at a distence "x" from the centre of the conductor A. The distence from point P to centre of conductor B is D-x.

(feild intencity)

Capacitence "C" = $\frac{Q}{V}$

Capacitence is the ratio of charge in coloumb to the potential difference in volts.

feild intencity $E_A = \frac{Q}{2\pi\epsilon_0\epsilon_r x}$

Feild intencity at point B is

$$E_B = \frac{-Q}{2\pi\epsilon_0\epsilon_r(D-x)}$$

potential at A $V_A = E_A \cdot dx$.

$$V_A = \frac{Q}{2\pi\epsilon_0\epsilon_r x} \cdot dx \quad \left[\because E_A = \frac{Q}{2\pi\epsilon_0\epsilon_r x}\right]$$

potential at B $V_B = E_B \cdot dx$

$$= \frac{-Q}{2\pi\epsilon_0\epsilon_r(D-x)} \cdot dx.$$

$$\left[\because \frac{-Q}{2\pi\epsilon_0\epsilon_r(D-x)}\right]$$

potential difference at point 'p' is

$$V_p = V_A - V_B$$

$$= \frac{Q}{2\pi\epsilon_0\epsilon_r x} dx - \left[\frac{-Q}{2\pi\epsilon_0\epsilon_r(D-x)}\right] dx.$$

$$V_p = \frac{Q}{2\pi\epsilon_0\epsilon_r x} dx + \frac{Q}{2\pi\epsilon_0\epsilon_r(D-x)} \cdot dx$$

$$V_p = \frac{Q}{2\pi\epsilon_0\epsilon_r}\left[\frac{1}{x} + \frac{1}{(D-x)}\right] \cdot dx.$$

$$V_p = \frac{Q}{2\pi\epsilon_0}\left[\frac{1}{x} + \frac{1}{(D-x)}\right] \cdot dx. \quad [\because \epsilon_r = 1]$$

(v) total potential difference $= \int_r^{D-r} \frac{Q}{2\pi\epsilon_0}\left[\frac{1}{x} + \frac{1}{(D-x)}\right] \cdot dx.$

$$V = \frac{Q}{2\pi\epsilon_0}\int^{(D-r)}\left[\frac{1}{x} + \frac{1}{(D-x)}\right] \cdot dx.$$

$$\frac{Q}{2\pi\varepsilon_0}\left[\log x - \log(D-x)\right]^{(D-r)}_{r}$$

$$V = \frac{Q}{2\pi\varepsilon_0}\left[\log(D-r) - \log r - (\log(D-(D-r)) - \log(D-r))\right]$$

$\log(D-D+r)$

$$V = \frac{Q}{2\pi\varepsilon_0}\left[\log(D-r) - \log r - \log r + \log(D-r)\right]$$

$$V = \frac{Q}{2\pi\varepsilon_0}\left[2.\log(D-r) - 2\log r\right]$$

$$V = \frac{Q}{2\pi\varepsilon_0}\times 2\left[\log(D-r) - \log r\right]$$

$$V = \frac{\cancel{2}Q}{\cancel{2}\pi\varepsilon_0}\left[\log\left(\frac{D-r}{r}\right)\right]$$

$$V = \frac{Q}{\pi\varepsilon_0}\left[\log\left(\frac{D}{r}\right)\right].$$

Capacitence $C = \frac{Q}{V} = \dfrac{\cancel{Q}}{\dfrac{\cancel{Q}}{\pi\varepsilon_0}\left[\log\left(\frac{D}{r}\right)\right]}$

$$\cancel{C} = \cancel{\pi\varepsilon_0}\left[\log(D/r)\right] \qquad C = \frac{\pi\varepsilon_0}{\log(D/r)}$$

$$\boxed{\therefore\ \cancel{C} = \cancel{\pi\varepsilon_0}\left[\log\left(\frac{D}{r}\right)\right]}$$

$$\boxed{C = \frac{\pi\varepsilon_0}{\log(D/r)}}$$

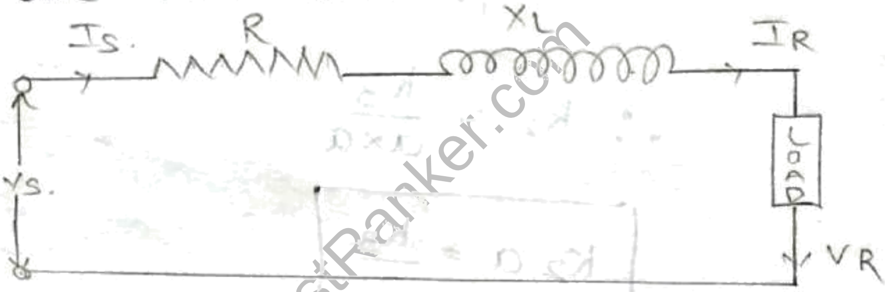
classification of Transmission lines :-

The transmission lines are mainly divided in to 3 - types.

(i) short Transmission lines.
(ii) medium Transmission lines.
(iii) Long Transmission lines.

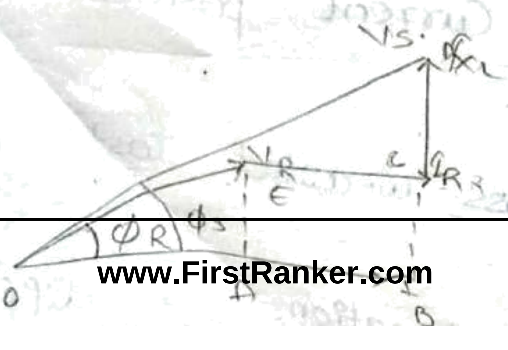
* short Transmission lines.

These are used to up to 50 km. and the rating of voltage is up to 20 kV. ~~the~~ It has low voltage and capacitence effects so these are not Considerd.



where Vs = Sending voltage.
Is = Sending Current.
X_L = Reactence R = Resistence.
I_R = Reseiving Current
V_R = Resiving voltage.

* voltage Regulation :



... difference between the sending end voltage and Resiving end voltage to the Reciving End voltage

$$\therefore \text{voltage Regulation} = \frac{V_S - V_R}{V_R}$$

$$\eta \text{ of voltage Regulation} = \frac{V_S - V_R}{V_R} \times 100 \ \%.$$

Consider ΔOBD.

According to pythagarous theorem.

$$OD^2 = OB^2 + BD^2$$

$$OD^2 = (OA + AB^2) + (BC + CD)^2 \quad (\because \text{Vector diagram})$$

$$\therefore V_S^2 = (\cos\phi_R V_R + IR)^2 + (V_R \sin\phi_R + IX_L)^2$$

$$\left[\because \begin{array}{l} \Delta OEA \Rightarrow \cos\phi_R = \frac{OA}{V_R} \quad \therefore OA = \cos\phi_R V_R \\ \sin\phi_R = \frac{BC}{V_R} \Rightarrow BC = \sin\phi_R \cdot V_R \end{array}\right]$$

$$\therefore V_S = \sqrt{(\cos\phi_R \cdot V_R + IR)^2 + (V_R \sin\phi_R + IX_L)^2}$$

$$I_R = I_S(\cos\phi_R + j\sin\phi_R).$$

* efficiency of Transmission lines :

$$\eta = \frac{O/P}{I/P} = \frac{V_R I_R \cos\phi_R}{V_S I_S \cos\phi_S} = \frac{V_R I_R \cos\phi_R}{V_R I_R \cos\phi_R + I^2 R}$$

The ratio of output power to the input power is known as efficiency.

Transmission line having a Resiving End voltage of 11 KV. and delivers a power 200 KVA. and Resistence for phase equal to 5Ω and Reactence for phase is 3Ω Find out the voltage Regulation. and efficiency of Transmission line at 0.85 power factor lagg.

→ Given data:

$V_R = 11\ KV$
$= 11 \times 1000\ V$
$= 11000\ V$

$P_R = 200 \times 1000\ VA$
$= 200000\ VA.$

$R = 5\ \Omega$

$X_L = 3\ \Omega.$

$\cos\phi_R = 0.85$

$\phi_R = \cos^{-1}(0.85)$
$= 31.78$

$\sin\phi_R = (31.78)\sin$
$= 0.52$

$\therefore\ I = \frac{P_R}{V_R} = \frac{200 \times 1000}{11000} = 18.18\ Amp.$

$\therefore\ I = 18.18\ Amp.$

$\therefore\ V_S = \sqrt{(V_R\cos\phi_R + IR)^2 + (V_R\sin\phi_R + IX_L)^2}$

$= \sqrt{[(11000 \times 0.85) + 18.18]^2 + [(11000 \times 0.52) + (18.18 \times 3)]}$

$= 11004.4724$

$= \sqrt{(9350 + \ldots 8.18)^2 + (5720 + \ldots 54.54)^2}$

$= \left[\sqrt{81762796.5 + 35145185.5}\right]$

$= \cancel{10977.7} \quad 11004.91294.$

$V_s = \cancel{10978}.$ ~~volts~~. $11004.91294.$

Now Voltage Regulation $= \dfrac{V_s - V_R}{V_R}$

$= \dfrac{\overset{11004.91}{\cancel{10978}} - 11000}{11000}$

Voltage Regulation $= 4.46 \times 10^{-4}$.

$\%_{VR} = \cancel{4.46 \times 10^{-4} \times 100} = \dfrac{11004.91 - 11000}{11000} \times 100$

$= \cancel{0.044}$

$= 0.46 \times 100 = 4$

* classification of over head Transmission lines

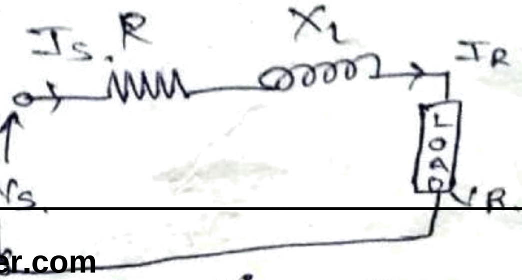
These are devided in to 3 types.

(i) short Transmission line (50 km) 20 kv.

(ii) Medium. Transmission line. (50 – 150 Km) 100 Kv.

(iii) Long Transmission, lines. (above 150 km) Above 100 kv

i) Short Transmission lines :



where V_s = sending voltage.

I_s = sending Current.

X_L = Reactence.

voltage

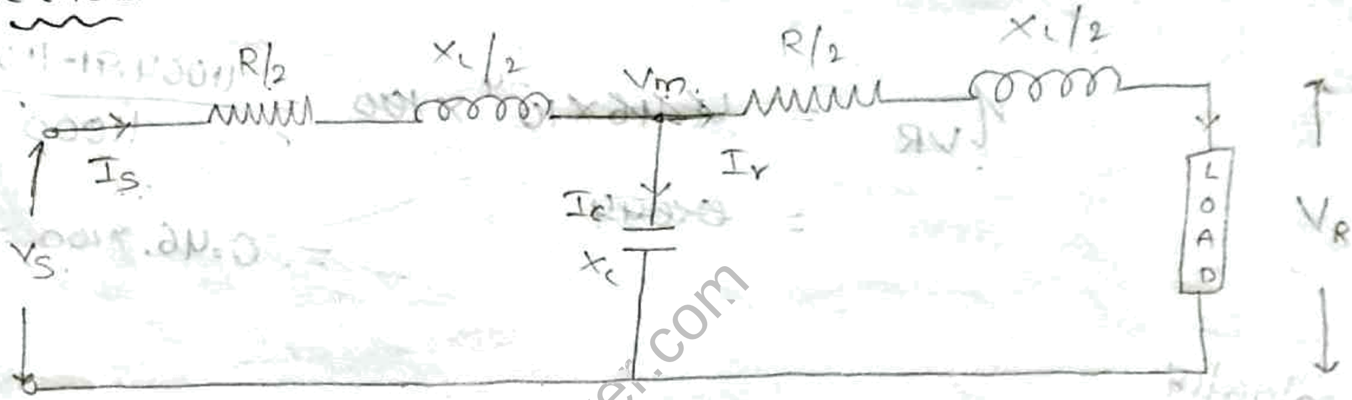
medium transmission lines :

The length is lies between 60 - 150 km. and voltage is 20 - 100 kV. is called medium. Transmission lines.

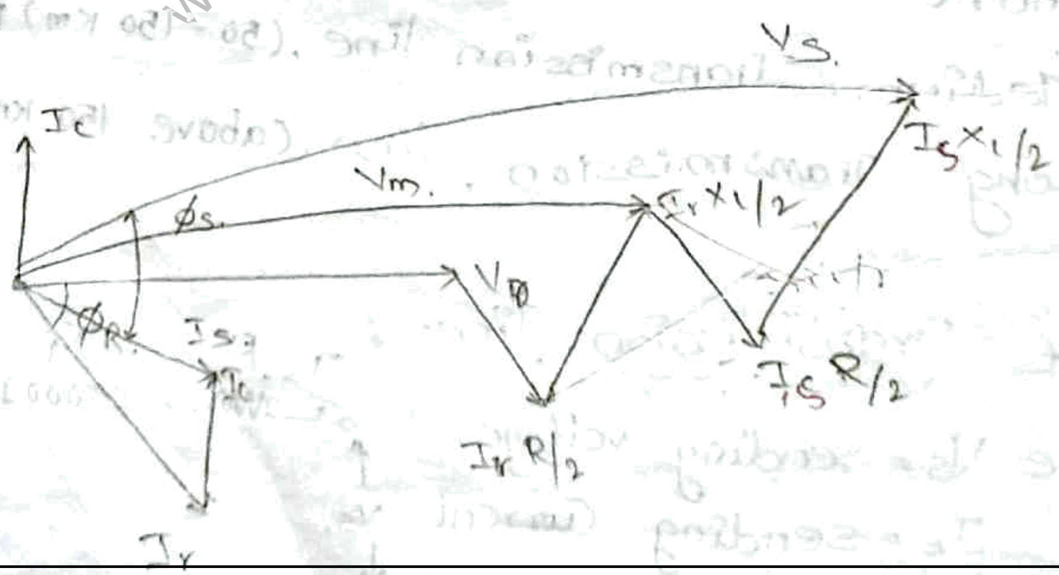
These are divided in to 3 types.

(i) End Condenser
(ii) T - method.
(iii) π - method.

* T - method :



* phasor diagram :



From the diagram.

$$\vec{I_s} = \vec{I_c} + \vec{I_r}$$

$$I_c = \frac{V}{X_c} \qquad X_c = \frac{1}{2\pi F c}.$$

$$V_m = V_R + I_r(R/2 + j X_L/2).$$

$$V_s = V_m + I_s(R/2 + j X_L/2).$$

* problemes :

1. A medium Transmission line having a riciving End voltage 66 KV. and delivers a power of 150 KVA and Total Resistence is 6Ω and inductive Reactence of 4Ω and the capacitor value is 200 NF. Find the voltage Regulation and efficiency of Transmission line. if the frequency 50 Hz. Assume $\cos\phi_R = 0.8$ lag and any missing data.

→ Given data :

$V_R = 66$ KV $= 66\times1000$. volts.

$P = 150$ KVA $= 150\times1000$ VA

Total Resistence $= 6\,\Omega$

$$\therefore R/2 = 6/2 = 3\,\Omega$$

Inductence $= 4\,\Omega$

$$\therefore \frac{X_L}{2} = \frac{4}{2} = 2\,\Omega$$

Capacitor value $C = 200$ nF.

$$= 200\times10^{-9}\ F.$$

$\cos\phi_R = 0.8$ lag.

$\phi_R = 36.86 \quad \sin\phi_R = 0.6$

Frequency = 50 Hz.

Voltage Regulation = ?

Now. We know that.

$$V_m = V_R + I_R\left[R/2 + j\,X_L/2\right]$$

$$\bar{I}_r = I_r(\cos\phi_r - j\sin\phi_r)$$

$$I = \frac{P}{V} = \frac{150\times1000}{66\times1000} = 2.272$$

$$\boxed{\therefore\ I_r = 2.272}$$

$$\therefore\ \bar{I}_r = I_r(\cos\phi_r - j\sin\phi_r)$$

$$= 2.272(0.8 - j\,0.6)$$

$$= 1.817 - j\,1.363$$

Now $V_m = V_R + \bar{I}_r(R/2 + j\,X_L/2)$.

$$= (66\times10^3) + (1.817 + j\,1.363)(3 + j\,2)$$

$$= (66\times10^3) + [2.724 + j\,7.718]$$

$$V_m = 66002.724 + j\,7.718.$$

$$\boxed{\therefore\ V_m = 66002.724 + j\,7.718}$$

we know that.

$V_s = V_m + I_s (R/2 + j X_L/2).$

$I_s = I_r + I_c.$

$$I_c = \frac{V_m}{X_c} = \frac{V_m}{1/2\pi F C} = V_m \times 2\pi F C.$$

$$= [66002.724 + j7.718] \times 2 \times \pi \times 50 \times 200 \times 10^{-9}.$$

$$= [66002.724 + j7.718]\, 6.283 \times 10^{-5}.$$

$$I_c = 4.092 + j\, 0.0004.$$

Now $I_s = I_r + I_c$

$$I_s = [1.817 + j1.363] + [4.092 + j0.0004].$$

$$I_s = [\cancel{7.434} + \cancel{j5.57}]\ [5.909 + j1.364]$$

Now Convert to polar $= \cancel{9.28} \angle \cancel{36.84}$

$= 6.06 \angle 12.9$

Now. $V_s = V_m + I_s (R/2 + j X_L/2).$

$\times [V_s = [66002.724 + j7.718] + [7.434 + j5.57][3 + j2]$

$= [66002.724 + j7.718] + [\cancel{33.492}\ 11.162 + j31.5$

$V_s = [66002.724 + j7.718] + [5.909 + j1.364][3 + j2]$

$= [66002.724 + j7.718] + [14.99 + j15.91].$

$= 66017.7 + j\, 23.628$

Now Voltage Regulation $= \frac{V_S - V_R}{V_R}$

$$= \frac{66041.3 - 66000}{66000} \times 100 =$$

$$= 0.0625$$

Now efficiency $= \frac{V_R I_R \cos\phi_R}{V_S I_S \cos\phi_S}$

$$= \frac{66 \times 10^3 \times 2.272 \times 0.8}{66041.3 \times 6.06 \times 0.97}$$

$$= 0.33 \times 100$$

$$\eta = 33\ \%$$

2. A 1-ϕ Transmission line having a riciving End power of 18 KVA. and riciving End Current of 4.55 Amp. and the transmission line Resistence 12 Ω & inductance value of 20 milli Henrys and frequency 50 Hz a Capacitor value of 250 NF Find out the voltage Regulation, & Transmission efficiency at 0.85 power factor, lag.

→ Given data:

power $P = 18$ KVA.

$= 18 \times 1000$ VA,

$I_r = 4.55$ Ampers.

$R = 12\ \Omega \Rightarrow R/2 = 12/2 = 6\ \Omega$

$X_L = 20 \times 10^{-3}$ Henrys $\frac{X_L}{2} = 0.01$

$\cos\phi_R = 0.85 \Rightarrow \phi_r = \cos^{-1}(0.85) = \phi_r = 31.788$

$\sin\phi_r = 0.526$.

Now. voltage Regulation = ? , efficiency = ?

$V = P/I = \frac{18\times1000}{4.55} = 3956.043$. $V_r = 3.956\times10^3$.

$I_r = I_r[\cos\phi_r + j\sin\phi_r] = 4.55(0.85 + j0.5)$

$I_r = (3.8675 + j2.275)$

Now $V_m = V_r + I_r(R/2 + jX_L/2) = 3.9\times10^3 + (3.8675 + j2.275)(6 + j0.01)$.

$= 3.9\times10^3 + (23.18225 + j13.688)$

$V_m = (3923.18225 + j13.688)$

$V_s = V_m + I_s(R/2 + jX_L/2) \Rightarrow$

$I_s = I_r + I_c \Rightarrow I_c = \frac{V_m}{1/2\pi FC} = V_m\times2\pi FC$

$= (3923.18225 + j13.688)\times2\times\pi\times50\times250\times10^{-9}$.

$I_c = (0.308 + 1.075\times10^{-3}$ $3923.18225 + j13.688$.

Now. $I_s = I_r + I_c \Rightarrow$ ~~4.55~~ $[$

$I_s = (3.8675 + j2.275] + [3923.18225 + j13.688]$

$I_s = 3927.049 + j15.963 = 3927.08\angle0.0232 - \phi_1$

$V_s = V_m + I_s(R/2 + jX_L/2) \Rightarrow [3923.18 + j13.6] + [3927.049 + j15.9][6 + j0.01]$

$V_s \Rightarrow [3923.18 + j13.6] + [23562.13 + j134.67)$

$= 27485.3 + j148.27 \Rightarrow 27485.3\angle0.309 - \phi_2$

$V_s = 27485.3\angle0.309$ $\phi_s = \phi_1 + \phi_2 = \angle0.02 + 0.30 = \angle0.32$

 $C = 250 \times 10^{-9}$.

$pf = 0.85$ lag.

$\cos\phi_R = 0.85 \Rightarrow \phi_r = \cos^{-1}(0.85) = \phi_r = 31.788$.

$\sin\phi_r = 0.526$.

Now. voltage Regulation = ? , efficiency = ?

$V = P/I = \frac{18 \times 1000}{4.55} = 3956.043$. $V_r = 3.956 \times 10^3$.

$I_r = I_r[\cos\phi_r + j\sin\phi_r] = 4.55(0.85 + j0.5)$

$I_r = (3.8675 + j2.275)$

Now $V_m = V_r + I_r(R/2 + jX_L/2) = 3.9 \times 10^3 + (3.8675 + j2.275)(6 + j0.01)$.

$= 3.9 \times 10^3 + (23.18225 + j13.688)$.

$V_m = (3923.18225 + j13.688)$

$V_s = V_m + I_s(R/2 + jX_L/2) \Rightarrow$

$I_s = I_r + I_c \Rightarrow I_c = \frac{V_m}{1/2\pi FC} = V_m \times 2\pi FC$

$= (3923.18225 + j13.688) \times 2 \times \pi \times 50 \times 250 \times 10^{-9}$.

$I_c = (0.308 + 1.075 \times 10^{-3})$ $3923.18225 + j13.688$.

Now. $I_s = I_r + I_c \Rightarrow$

$I_s = (3.8675 + j2.275) + [3923.18225 + j13.688]$

$I_s = 3927.049 + j15.963 = 3927.08 \angle 0.0232 - \phi_1$

$V_s = V_m + I_s(R/2 + jX_L/2) \Rightarrow [3923.18 + j13.6] + [3927.04 + j15.9][6 + j0.0$

$V_s \Rightarrow [3923.18 + j13.6] + [23562.13 + j134.67)$

$= 27485.3 + j148.27 \Rightarrow 27485.3 \angle 0.309 - \phi_2$

$V_s = 27485.3 \angle 0.309$ $\phi_s = \phi_1 + \phi_2 = \angle 0.02 + 0.30 = \angle 0.3$

$\cos\phi_s = 0.99$

[illegible] Line having a receiving end voltage of 33 KV and delivers a power of 120 KVA the resistence for phase is 16 Ω and inductive Reactence for phase is 8 Ω and a capacitor is connected at mid point the admitence value is 30 m and delivers power factor of 0.9 lag. Find out the voltage Regulation, Efficiency, Sending End power factor, and Sending End voltage.

→ Given data:

$V_R = 33$ KV $= 33 \times 1000$ V. $\quad V_r/ph = \frac{V_r}{\sqrt{3}} = \frac{33 \times 1000}{\sqrt{3}} = 19052.5$

$P = 120$ KVA $= 120 \times 1000$ VA. $\quad P_r = \sqrt{3}\, V_r I_r$

$R/ph = 16\ \Omega$ $\quad I_r = P_r / \sqrt{3}. V_r$

$X_L/ph = 8\ \Omega$

admitence value $y = (3.10$ $\quad = 120/\sqrt{3} \times 33$

$\cos\phi = 0.9.$ $\quad = 120/57.15 = 2.0$

voltage Regulation = ?

Efficiency = ? $\quad I_r = 2.0$ A

$\cos\phi_s = ?$ $\quad \cos\phi_R = 0.9 \quad \phi_r = \cos^{-1}(0.9).$

$V_s = ?$ $\quad = 25.84$

$\sin\phi_r = 0.43$

Now $\vec{I_r} = I_r[\cos\phi_r + j\sin\phi_r]$

$= 2[0.9 + j\,0.43]$

$= 1.8 + j\,0.86.$

$\therefore \vec{I_r} = 1.8 + j\,0.86.$

$\vec{V_m} = \vec{V_R} + \vec{I_R}\left(R/2 + jX_L/2\right)$.

$= 19052.5 + [1.8 + j0.86][8 + j4]$.

$= 19052.5 + [10.96 + j14.08]$

$\vec{V_m} = 19063.46 + j14.08$.

Now We know that $\vec{V_s} = V_m + I_s\left(R/2 + jX_L/2\right)$.

$\vec{I_s} = \vec{I_r} + \vec{I_c}$

$I_c = \dfrac{\vec{V_m}}{X_c}$ $\quad X_c = \dfrac{1}{Y_c} = \dfrac{1}{20\times10^{-3}} = 50$

$I_c = \dfrac{19063.46 + j14.08}{j50}$

$I_c = 381.2692 + j0.2816$.

Now $\vec{I_s} = \vec{I_r} + \vec{I_c}$

$= [1.8 + j0.86] + [381.2692 + j0.2816]$

$\vec{I_s} = 383.06 + j1.1416$.

The above is converted in to polar.

$\vec{I_s} = 383.06 \angle 0.170 \quad - \phi_1$

Now $\vec{V_s} = \vec{V_m} + \vec{I_s}\left[R/2 + jX_L/2\right]$

$= [19063.46 + j14.08] + [383.06 + j1.1416]$
$[8 + j4]$.

$= [19063.46 + j14.08] + [3059.9 + j1541.3]$

$= [19063.46 + j14.08] + [3059.9 + j1514.3]$

$\vec{V_s} = 22123.3 + j1528.38 = 38318.67 + j2647.2$

Converted in to polar $= 38410.0 \angle 3.95 \rightarrow \phi_1$

$V_s = 22176.03 \angle 3.9519. \quad \phi_2 \times \sqrt{3}$

Now. $\phi_s = \phi_1 + \phi_2$

$= \angle 0.170 + \angle 3.9519$

$\phi_s = 4.1219.$

Now. $\cos\phi_s = 0.99.$

Now. Voltage Regulation $= \frac{V_S - V_R}{V_R}$

$= \frac{[22123.3 + j1528.38] - 33000}{33000}$

V_s is Convert to line.

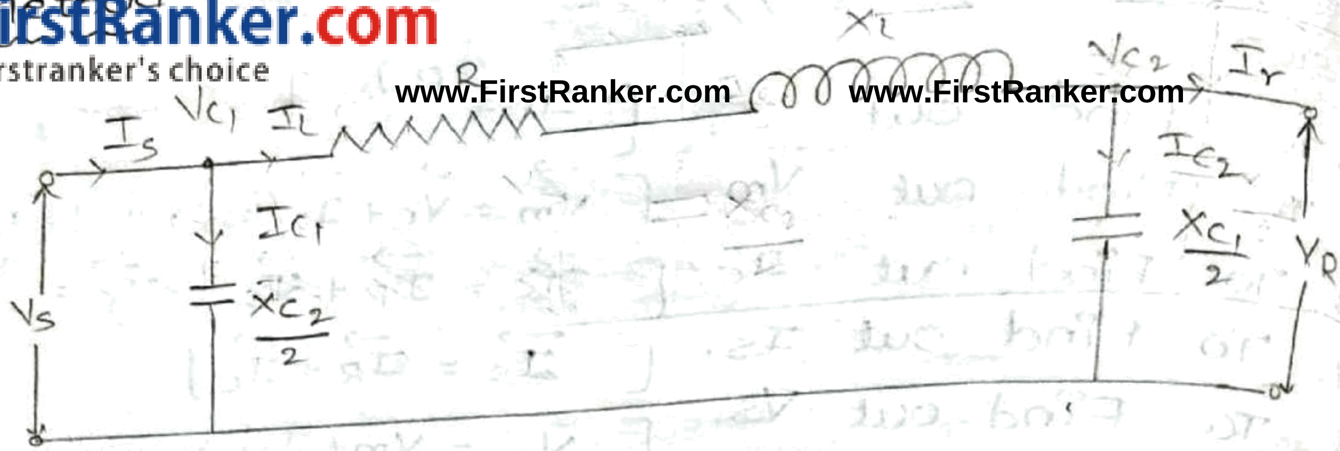
$= \frac{38410.0 - 33000}{33000}$

Voltage Regulation. $= 0.16 \times 100 = 1.60$

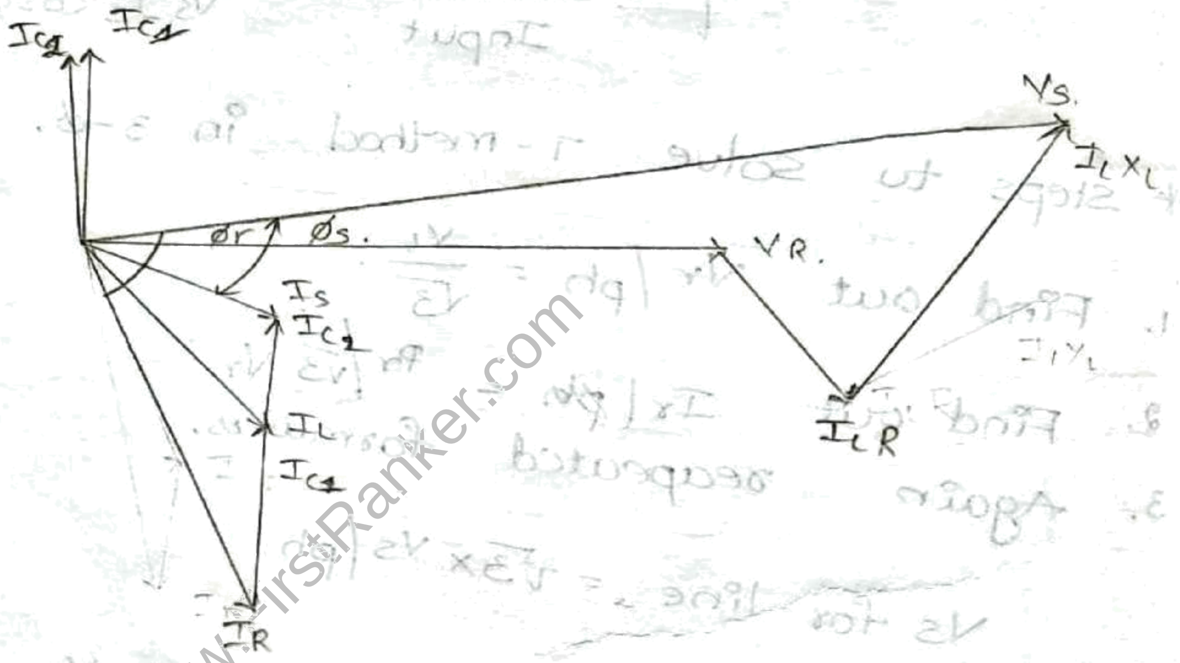
Now. Efficiency $= \frac{V_R I_R \cos\phi_R}{V_s I_s \cos\phi_s} =$

$= \frac{(33 \times 10^3) \times 2 \times 0.9}{38410 \times 383.06 \times 0.99} \times 100$

$\eta = 0.40\,\%$



* Vector diagram :



* Formulas :

$$\vec{I_r} = I_r[\cos\phi_r + j\sin\phi_r]$$

$$\vec{I_L} = \vec{I_{C1}} + \vec{I_r}$$

$$I_{C1} = V_r/(X_{C1}/2) = \frac{2V_r}{X_{C1}}$$

$$V_s = V_R + I_L(R + jX_L).$$

UNIT: III

PERFORMANCE OF LONG TRANSMISSION LINE:

$$\frac{\sqrt{y}\,A_1 e^{x\sqrt{yz}}}{\sqrt{z}} - \frac{\sqrt{y}\,A_2 e^{-x\sqrt{yz}}}{\sqrt{z}}$$

$$I = \frac{A_1 e^{x\sqrt{yz}}}{\sqrt{z/y}} - \frac{A_2 e^{-x\sqrt{yz}}}{\sqrt{z/y}}$$

$$\sqrt{yz} = \delta$$

$$\sqrt{z/y} = z_c$$

$$I = \frac{A_1 e^{\delta x}}{z_c} - \frac{A_2 e^{-\delta x}}{z_c}$$

$$\boxed{V = A_1 e^{\delta x} + A_2 e^{-\delta x}}$$

$$A_1 = \frac{V_R + I_R z_c}{2}$$

$$A_2 = \frac{V_R - I_R z_c}{2}$$

$$I = I_R,\ V = V_R,\ x = l$$

$$I_s = \left(\frac{V_R + I_R z_c}{2}\right)\frac{e^{\delta l}}{z_c} - \left(\frac{V_R - I_R z_c}{2}\right)\frac{e^{-\delta l}}{z_c}$$

$$= \frac{V_R \cdot e^{\delta l}}{2 z_c} + \frac{I_R z_c \times e^{\delta l}}{2 z_c} - \frac{V_R}{2} * \frac{e^{-\delta l}}{z_c} + \frac{I_R z_c}{2} \cdot \frac{e^{-\delta l}}{z_c}$$

$$I_s = \frac{V_R}{z_c}\left(\frac{e^{\delta l} - e^{-\delta l}}{2}\right) + I_R\left(\frac{e^{\delta l} + e^{-\delta l}}{2}\right)$$

(Long transmission) line performance:

consider a long transmission line having a over[all]

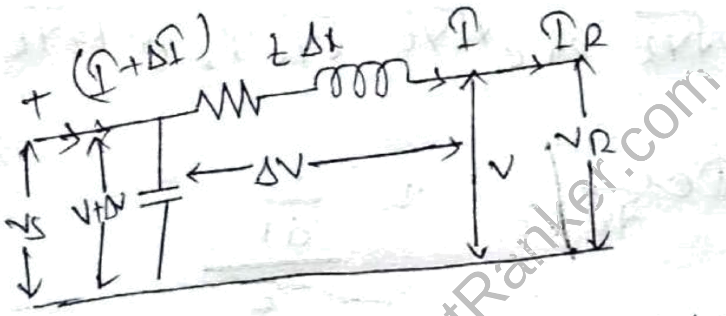
[im]pedance $= z\Delta x$

capacitance admittance $= y\Delta x$

V_s, I_s are the sending voltage & sending curre[nt]

I is the current flowing through the line of distance of (Δx)

the current flowing through the capacitance is consider as ΔI



The voltage drop across $z\Delta x = \Delta V = Iz\Delta x$

$$\frac{\Delta v}{\Delta x} = Iz$$

$$\frac{dv}{dx} = Iz \longrightarrow (1)$$

$$\Delta I = (v + \Delta v)y\Delta x$$

$$\Delta I = vy\Delta x + \Delta vy\Delta x$$

$$\Delta I = vy\Delta x$$

$$\frac{\Delta I}{\Delta x} = vy$$

$$\boxed{dI/dx = vy}$$

$$\frac{dv}{dx} = Iz$$

$$\frac{d^2v}{dx^2} = z \cdot \frac{dI}{dx}$$

$$\frac{d^2v}{dx^2} = z \cdot vy$$

$$\frac{d^2v}{dx^2} - zy \cdot v = 0$$

$$v = A_1 e^{x\sqrt{zy}} + A_2 e^{-x\sqrt{zy}}$$

$$\frac{dv}{dx} = \sqrt{yz}\, A_1 e^{x\sqrt{yz}} - \sqrt{yz}\, A_2 \cdot e^{-x\sqrt{yz}}$$

$$I = \frac{dv}{dx} \Big/ z \qquad I = \frac{\frac{dv}{dx}}{z}$$

$$= \frac{\sqrt{yz}\, A_1 e^{x\sqrt{yz}} - \sqrt{yz}\, A_2 \cdot e^{-x\sqrt{yz}}}{z}$$

$$= \frac{\sqrt{yz}\, A_1 e^{x\sqrt{yz}}}{z} - \frac{\sqrt{yz}\, A_2 e^{-x\sqrt{yz}}}{z}$$

$$= \frac{\sqrt{y}\cancel{\sqrt{z}}\, A_1 e^{x\sqrt{yz}}}{\sqrt{z}\cdot\cancel{\sqrt{z}}} - \frac{\sqrt{y}\cancel{\sqrt{z}}\, A_2 e^{-x\sqrt{yz}}}{\sqrt{z}\cancel{\sqrt{z}}}$$

$$\boxed{I_s = \frac{V_R}{Z_c}\sinh \delta L + I_R(\cosh \delta L)}$$

$\sinh x = \frac{e^x - e^{-x}}{2}$

$\cosh x = \frac{e^x + e^{-x}}{2}$

$$V_s = \left(\frac{V_R + Z_c I_R}{2}\right) e^{\delta L} + \left(\frac{V_R - Z_c I_R}{2}\right) e^{-\delta L}$$

$$= \frac{V_R \cdot e^{\delta L}}{2} + \frac{I_R Z_c e^{\delta L}}{2} + \frac{V_R e^{-\delta L}}{2} + \frac{I_R Z_c e^{-\delta L}}{2}$$

$$V_s = V_R\left[\frac{e^{\delta L} + e^{-\delta L}}{2}\right] + I_R Z_c\left(\frac{e^{\delta L} + e^{-\delta L}}{2}\right)$$

$$\boxed{V_s = V_R \cosh \delta L + I_R Z_c \sinh \delta L}$$

Q

A 3-φ long transmission line delivers a power of 150 kV and receiving an voltage is 66 kV at a p.f of 0.88 lag and the transmission line distance is 120 km & the line resistance is 0.2 Ω/ph/km & Inductance is 3 mH & the capacitance is 0.01μ find out the voltage regulation & efficiency & ABC constants for the transmission line.

$V_s = ?$

$V_s = V_R \cosh \delta l + I_R Z_c \sinh \delta L$

$I_s = \frac{V_R}{Z_C} \sinh \delta L + I_R \cdot \cosh \delta L$

$\delta l = ?$

$Y_C = \sqrt{Z/4}$

$R = 0.2$

$L = 3\ mH$

$Z = \sqrt{R^2 + X_L^2}$

$X_L = 2\pi f L$

$= 2\pi \times 50 \times 3 \times 10^{-3}$

$X_L = 0.94\Omega$

$Z = \sqrt{(0.2)^2 + (0.94)^2}$

$Z = 0.96$

$Y_C = ?$

$C = 0.01\mu F$

$X_C = \frac{1}{2}\pi f C$

$Y_C = \frac{1}{X_C} = 2\pi f C$

$= 2\pi \times 50 \times 0.01 \times 10^{-6}$

$Y_C = 3.14 \times 10^{-6}$

$\beta = \sqrt{Z Y_C}$

$= \sqrt{0.96 \times 3.14 \times 10^{-6}}$

$\beta = 1.73 \times 10^{-3}$

$\beta l = (1.73 \times 10^{-3}) \times 120$

$$= \sqrt{\frac{0.96}{3.14 \times 10^{-6}}}$$

$$Z_C = 552.93$$

$$P_R = \sqrt{3} V_R I_R \cos\phi_R$$

$$I_R = \frac{P_R}{\sqrt{3} V_R \cos\phi_R}$$

$$I_R = \frac{150 \times 10^3}{\sqrt{3} \times 66 \times 10^3 \times 0.88}$$

$$I_R = 1.49 A$$

$$V_S = V_R \cosh \gamma l + I_R \cdot Z_C \sinh \gamma l$$

$$= 66 \times 10^3 \{\cosh(0.207)\} + 1.49 \{552.93 \times \sinh(0.207)\}$$

$$V_S = 67.70 \, kV$$

$$I_S = \frac{V_R}{Z_C} \cdot \sinh \gamma l + I_R \cdot \cosh \gamma l$$

$$= \left(\frac{66 \times 10^3}{551.9} \times \sinh(0.207)\right) + 1.49 \cosh(0.207)$$

$$I_S = 26.4 A$$

$$\% V_R = \frac{V_S - V_R}{V_R} \times 100$$

$$= \left(\frac{67700 - 66000}{66000}\right) * 100$$

$$= 2.57\%$$

$$\eta = \frac{O/P}{I/P} = \frac{150 * 10^3}{(150 * 10^3) + I_3^2 R'} = \frac{150 \times 10^3}{(150 \times 10^3) + (26}$$

$$A = \cosh \delta l \Rightarrow \cosh(0.207) = 1.02$$

$$B = Z_C \cdot \sinh \delta l \Rightarrow 552.93 \sinh(0.207) = 1$$

$$C = \frac{\sinh \delta l}{Z_C} = \frac{\sinh(0.207)}{552.93} = 3.77 * 10^{-4}$$

$$D = \cosh \delta l$$

$$= 1.02.$$

voltage = 33kv

Resistance = 10 Ω

reactance $X_L = 15\,\Omega$

power = 1100 kw

$\cos\phi_R = 0.8$, $\sin\phi_R = 0.6$

$$I_R = \frac{1100}{33 \times 0.8}$$

$$I_R = 41.66A$$

$$V_s = \sqrt{(V_R\cos\phi_R + I_R R)^2 + (V_R\sin\phi_R + I X_L)^2}$$

$$= \sqrt{(33\times10^3\times0.8 + 41.66\times10)^2 + (33\times10^3\times0.6 + 41.66\times15)^2}$$

$$= \sqrt{(26400+416.6)^2 + (19800+624.9)^2}$$

$$= \sqrt{719130035.6 + 417176190}$$

$$= 33709.14$$

$$V_s = 33.7\,kV.$$

Regulation $= \frac{33.7-33}{33} \times 100$

$\frac{V_S - V_R}{V_R} \times 100$

$= 2.14\%$

$$\cos\phi_S = \frac{V_R \cos\phi_R + I.R}{V_S}$$

$$= \frac{33\times10^3 \times 0.8 + 41.66\times10}{33.709\times10^3}$$

$$= \frac{26400 + 416.6}{33.709\times10^3}$$

$$= \frac{26816.6}{33709} = 0.8$$

$$\eta = \frac{33\times10^3 \times 41.66 \times 0.8}{33.709\times10^3 \times 41.66 \times 0.8} \times 100$$

$= 97.8\%$

A 3-ϕ short transmission line delivers a power 500 kVA at a voltage of 22 kV at the pf 0.85 lag resistance of the line is 5 Ω & inductance 6 Ω find out the voltage regulation & efficiency of transmission line.

P.f = 0.85 lag

resistance = 5Ω

Inductance = 6Ω

voltage = 22 kV

power = 5000 kVA

$\cos\phi_r = 0.85$ $\sin\phi_r = 0.52$ $P_r = 5000\times10^5$

$= 0.8$ $= 0.6$

$P_r = \sqrt{3}V_r I_r$ $\phi_r = \cos^{-1}(0.85)$

$\phi_r = 31.78$

$I_r = \frac{P_r}{\sqrt{3}V_r} = \frac{5000\times10^5}{\sqrt{3}\times22\times10^3} = 131.21$

$V_s = \sqrt{(V_r\cos\phi_r + IR)^2 + (V_r\sin\phi_r + IX_L)^2}$

$I\bar{v} = 131.21[(\cos(0.8 - j(\sin(0.6))]$

$= 111.528 - j78.72$

$= 136.5\ \angle -35.2$

$V_s = \sqrt{(V_r\cos\phi_r + IR)^2 + (V_r\sin\phi_r + IX_L)^2}$

$= \sqrt{(22\times10^3\times0.8 + 136.5\angle-35.2)^2 + (22\times10^3\times0.6 + 136.5\angle-35.2\times6)^2}$

UNIT - 4

Transient Analysis

GMR (Geometric Mean Radius)

Consider the Inductance out side the conduct is Equal to overall Inductance of the conductor when Inductance outside the conductor having a radius of GMR (in place of r)

Inductance outside the conductor = overall Inductance

$$\frac{\mu_0}{2\pi}\left(\log\frac{D}{GMR}\right) = \frac{\mu_0}{2\pi}\left(\frac{1}{4}+\log\frac{D}{r}\right)$$

$$\log\frac{D}{GMR} = \frac{1}{4}+\log\frac{D}{r}$$

$$\log\frac{D}{GMR} = \log_e e^{1/4}+\log D/r$$

$$\boxed{\frac{\mu_0}{2\pi}\log\frac{GMD}{GMR}}$$

$$\frac{D}{GMR} = e^{1/4}\frac{D}{r}$$

$$e^{1/4}\,GMR = r$$

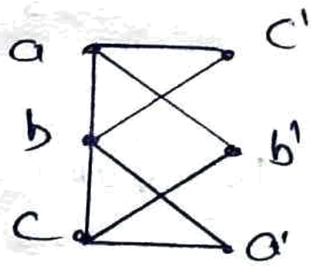
$$GMR = r.e^{-1/4}$$

$$GMR = 0.7788\,r$$

$= {}^{12}\sqrt{D_{ab} D_{ab'} D_{ac} D_{ac'} D_{bc} D_{bc'} D_{ba} D_{ba'} D_{ca} D_{ca'} D_{cb} D_{cb'}}$

GMD for double ckt line:

consider a 6 conductors abc & a'b'c'.



Double ckt:

GMR for Double ckt line:

$D_{aa'}, D_{bb'}, D_{cc'}$

$GMR_A = \sqrt{D_{aa'} \cdot r'}$

$GMR_B = \sqrt{D_{bb'} \cdot r'}$

$GMR_C = \sqrt{D_{cc'} \cdot r'}$

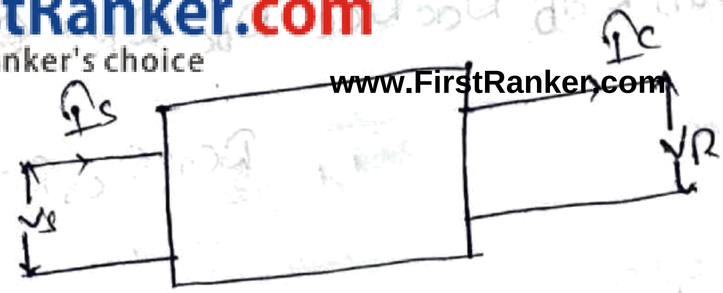
$r' = 0.7788 r$

$GMR = \sqrt[3]{GMR_A \cdot GMR_B \cdot GMR_C}$

To find out the ABCD constants for transmission line:

consider a 2 port network it may be 'T' 'π' shape

(a) medium transmission line

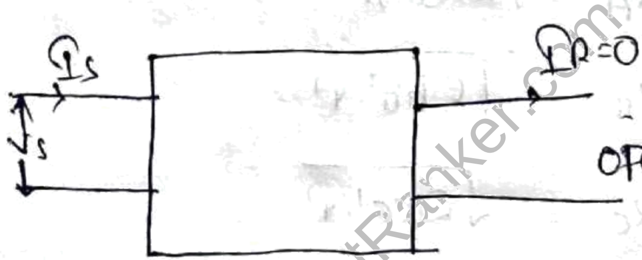


$$V_S = AV_R + BI_R$$

$$I_S = CV_R + DI_R$$

To findout the line constants A & C the receiving side of the transmission line should open

Hence $I_R = 0$



$V_S = AV_R \big|_{I_R=0}$ | $I_S = CV_R \big|_{I_R=0}$

$A = \frac{V_S}{V_R}$ | $C = I_S/V_R$

To find out the line constants B & D the secondary of 2 port network is short circuited

 www.FirstRanker.com

$V_s = B I_R \big|_{V_R=0}$ | $I_s = D I_R \big|_{V_R=0}$

$B = \frac{V_s}{I_R}$ | $D = \frac{I_s}{I_R}$

A 11kv transmission line. having a receiving on voltage of 10kv & sending end volt current of 140Ap. & receiving end power of 150kw & receiving end p.f 0.85 lagging Findout the A,B,C,D constants for the given transmission line (3-Φ)?

G.T $V_s = 11kV$

$V_R = 10kV$

$I_R = 140\,Amp$

$P = 150$

$p.f_r\ (\cos\phi_r) = 0.85$

$$I_R = \frac{P}{\sqrt{3}\, V_r \cos\phi_r} = \frac{150\times10^3}{\sqrt{3}\times10\times10^3\times0.85}$$

$I_R = 10.18A$

$$A = \frac{V_S}{V_R}$$

$$= \frac{11\times10^3}{10\times10^3} = 1.1$$

$$B = \frac{V_S}{I_R} = \frac{11\times10^3}{10.18} = 1080.55$$

$$C = \frac{I_S}{V_R} = 0.014$$

$$D = \frac{I_S}{I_R} = 13.75$$

1Q Types of conduct:

1. solid
2. strandard
3. Bundle

AAC:- All alluminium conductor

AAAC :- All Alluminium Alloy conductor

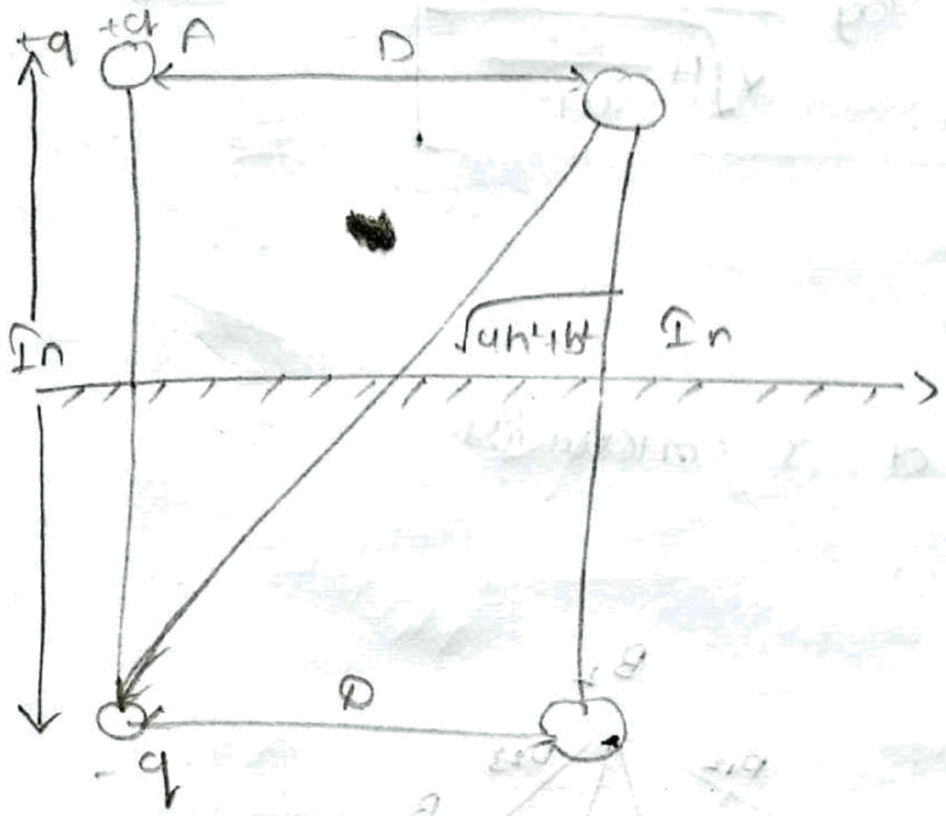
ACSR :- Alluminium conductor steel reinforce

No of strandards $N = 3n(n-1)+1$

overall diameter of ACSR conductor $D = (2n+1)d$

$\therefore d$ = diameter of each strandard

Effect of ground on capacitance:



potential Diff between two conducts without consider the ground effect $V_{ab} = \dfrac{q}{\pi \epsilon_0 \log \frac{D}{r}}$

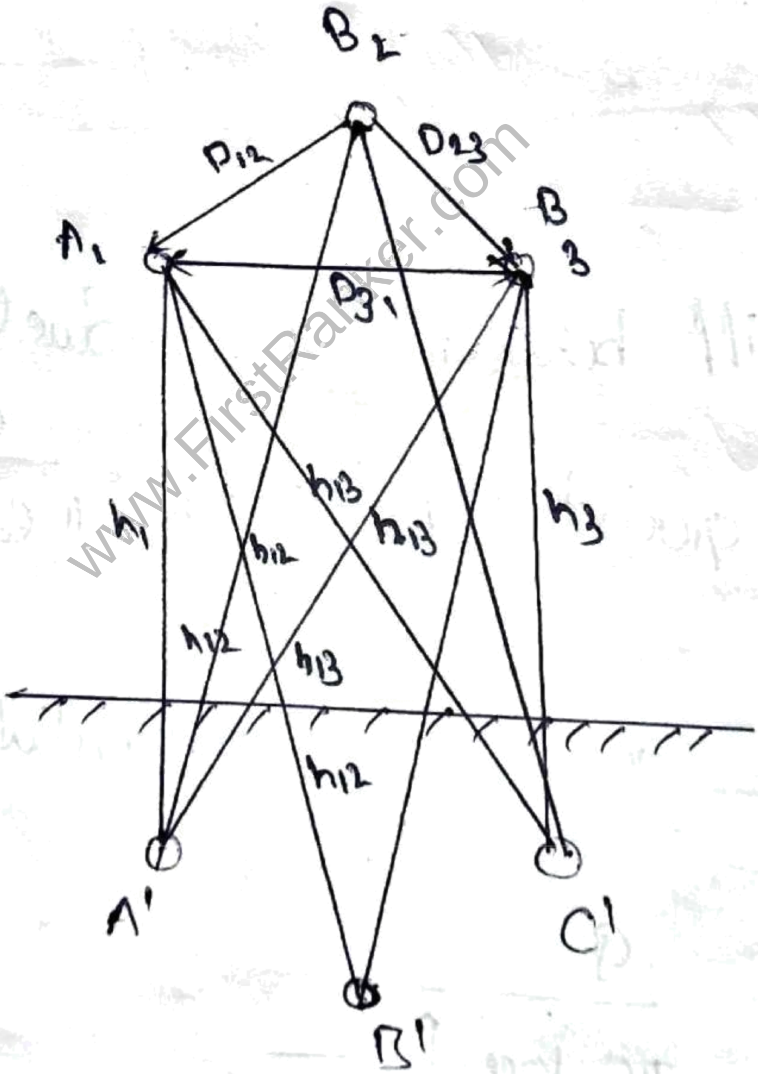
" " " " the potential diff is changes

$$V_{ab} = \frac{q}{\pi \epsilon_0 \log \dfrac{D}{r\sqrt{\dfrac{D^2+4h^2}{4h^2}}}}$$

$$V_{ab} = \frac{q}{\pi \epsilon_0 \log \dfrac{D}{r\sqrt{1+\dfrac{D^2}{4h^2}}}}$$

$$\boxed{C = \frac{\pi \epsilon_0}{\log \frac{D}{r\sqrt{1+\frac{D^2}{4h^2}}}}}$$

consider a 3 conductors



UNIT - 5

Transmission Line effects

Synchronization means to match the voltage

and frequency.

The isolators are used for only OFF ~~mode~~ Load conditions.

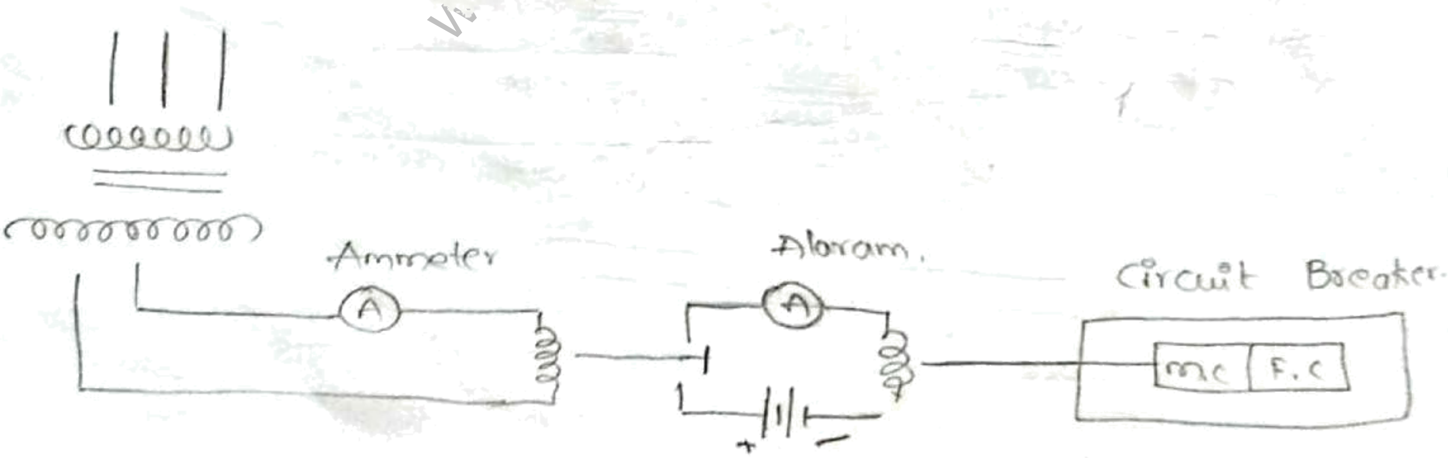
The circuit breakers are used for on load condition.

Current Transformer means to increase the voltage and to decrease the current for measure the current. It is a step up Transformer.

potential transformer means to decrease the voltage and to increase the current for measure the voltage. It is step down T/F.

operation of Circuit breaker :

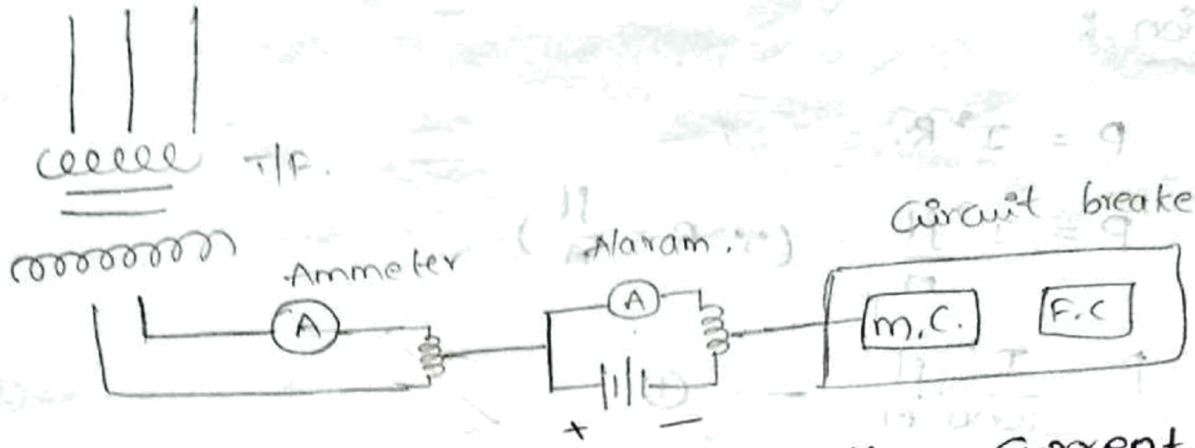
Out of fault :



circuit breaker is used for find out fault easily. The found out by

...ve process: Before in fault the Current is measured in Ammeter. if any flatuationes that Current will be absorb by coil. This is the process before fault.

* In fault :



When the coil absorb the current then the coil will be magnetised then the iron peace is attracted then the circuit will be closed then closed when the circuit will be second. coil will be alaram. start ring then the moving coil magnetised. then the coil attracts this is then the circuit will be opened. This is the process.

* Effect of voltage on Current, efficiency, power loss :

(i) When increase the voltage then the Current will be decreases $(\because V \propto \frac{1}{I})$.

(ii) When increase the voltage then the power loss will be decreases.

When the voltage increases then the η efficiency will also increased

iv) Volume :

When the voltage increases then the volume will be decreases.

* derivation :

$$P = I^2 R.$$

$$P = I^2 \frac{\rho l}{A} \quad (\because R = \frac{\rho l}{A})$$

$$P = \frac{I^2}{1000} \times \frac{\rho l}{A} \quad \text{——} \ (1)$$

$$P = \frac{V I \cos\phi}{1000} \Rightarrow P = \frac{V\cos\phi}{1000} \times I.$$

we want to required

$$I = \frac{1000 \times P}{V\cos\phi} \quad \text{——} \ (2)$$

Now (2) is sub in (1)

$$P = \frac{\left[\frac{(1000)^2 \times P^2}{V^2 \cdot \cos^2\phi}\right]}{1000} \times \frac{\rho l}{A}.$$

$$l = \frac{1000 \times P}{V^2 \cos^2\phi} \times \frac{\rho l}{A} \Rightarrow a = \frac{1000 \times P}{V^2 \cos^2\phi} \times \rho l \times l$$

$$V = \frac{1000 \times P}{V^2 \cos^2\phi} \times \rho l^2 \Rightarrow V \propto \frac{1}{V^2}$$

Kelvin for voltage : (above 50 km)

1 Km = 655 V
actually difference 400 to 800.

$$V = \left(5.5\sqrt{\frac{l}{1.61} + \frac{3P}{150}}\right) \text{K.V.}$$

where l = length
p = power
v = volume.

Table :

Distence	0-15 km.	15-30	31-80	81-120	120-240	240-400
voltage.	11 KV	11/22	33/66	66/110	110/132	132/220

above 400 the voltage is 220 used.

* properties of Conducting materials :

(i) The Resistence will be low.
(ii) the mechanical strength is high
(iii) High Conductivity.
(iv) It should be easily available in market
(v) Low Cost.

* Differences between Ac and DC.

* AC system :
i) Transmit high power.
ii) Can be step up (or) step down.
(iii) Skin effect high.

i) ... losses
) proximaty effect is high

DC Supply system:

i) The Transmit cost will be low.
ii) It doesnot have skin effects.
iii) The losses will be low.
iv) should have Converting equpment Cost will be very high.

* Effects of voltage and frequency on Transmission line: (Transformer)

Transformer voltage equation $v = 4.44 f \phi_m N$.

(i) voltage of the Transformer depends upon the supply frequency.

(ii) if we change the frequency (decrease) then voltage will be changed. that means decrease

(iii) maintain the voltage level is Constant

: We must increase the no. of turns of the T/F and Cost of the T/F will increases.

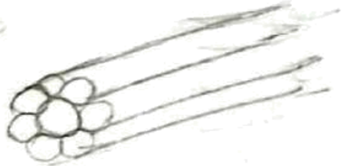
) If we change the frequency then the alternator speed will be changed it effects the system

* ...f Conductors (4) :-

i) Salid Conductors
ii) Standard type. Stranded
iii) Hallow type.
iv) Bundeld type.

i) Solid Conductors :

It has only single lead and it is used in limited Applicationes. It is very ~~low~~ high weight so the more chances to break easily form wind force. Because of ~~low~~ high weight.



ii) Standard :

It has large Cross sectional area compare to the salid Conductors. In middle lead is surrounded by the no. of leads. It has more Carona loss and skin effect.

No of layers $N = (3n+1)+1$

where N = No. of layers of Conductors.

n = no. of leads of Conductors.

and the Conductor dia depends on the formula is.

$D = (2n+1)d$.

where D = total dia of Conductor, d = dia of lead

* Current distrotion effect :-

The following effects are placed in Conductor

(i) Skin effect

(ii) proximity effect

(iii) spirality effect.

(iv) kelvin's law

* skin effect :

Due to this effect Current will flows through the surface of the Conductor only. at the middle of the Conductor No Current will flows. This effect is known as skin effect.

effect depending on the following factors.

(i) voltage

If we increase the voltage the skin effect is also increased.

(ii) Frequency :

If we increase the frequency then skin effect is also increased virvisa decreased.

(iii) Diameter :

The skin effect mainely depending on the diameter of the conductor.

(iv) perimiability :

which allow the magnetic flux is known as perimiability.

* proximity effect :

The effect of flux of another conductor is the effect on the first conductor. due to this. Consider on the flux of one conductor crowded one effect the flux of one conductor. That means the flux in the one side of conductor is more then another side of same side conductor. If we increase the distence between conductor then the proximity effect will be less.

* Spirality effect :

A wire is sarounded by the same number of ~~wires then the Conductor internal~~ Resistence.

Internal Reactence and inductance will be increase. This effect is known as spirality effect. for non-magnetic materials this effect will be less.

* kelvin's law :

kelvin's law is used to find the size of the Transmission line conductor Economically is known as kelvin law. (1881) The cost of T/ion line depends upon the size of the conductor so. The Annual cost of tramission line is divided in to two types.

(i) Annual charge on capital cost

(ii) Annual cost due to Energy losses.

Annual cost of capital cost $= k_1 + k_2 a$.

If we use increase the area of the conductor then annual charge on capital cost increases k_1 is the fixed cost (i.e, supports, insulators).

Annual cost of Energy losses depends upon the I^2R losses. for Esuming current as constant the Resistence value changes by changing the area of the conductor. This cost is inversely proportional to the area of the conductor.

Annual charge of Energy losses $= \frac{k_3}{A}$.

Total cost = Annual charge on Capital Cost + Annual charge on Energy loss

$$= k_1 + k_2 a + \frac{k_3}{a}.$$

For Economical Cost of the Conductor.

$$\frac{d}{da}\left[k_1 + k_2 a + \frac{k_3}{a}\right] = 0$$

$$\frac{d}{da}[k_1] + \frac{d}{da}[k_2 a] + \frac{d}{da}\left[\frac{k_3}{a}\right] = 0$$

$$0 + k_2 \cdot 1 + k_3\left(\frac{1}{a^2}\right) = 0$$

$$k_2 + \frac{k_3}{a^2} = 0.$$

$$\therefore k_2 = \frac{k_3}{a \times a}$$

$$\boxed{k_2 a = \frac{k_3}{a}}$$

For Economical Cost of the Conductor at which the variable part of Capital Cost is equal to the Annual charge on Energy losses.

* Limitations:

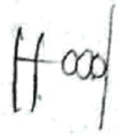
1. In Only Constant Current position this law was applicable.
2. The Energy loss weasted cost estimation is ~~difficult~~.
3. Capital Cost estimation is difficult.

UNIT-6

Sag Caclulations & Tension

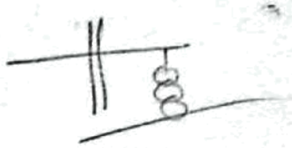
i) pin type
ii) strain
iii) Suspention
iv) Shakel.

* pin type : only in Distribution System (11 kv, 440 v)

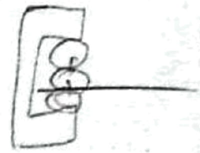


* Strain type : distribution (11 kv, 440 v).

* Suspention : High voltage (66, 132 33, kv)



* Shakel : Dead end poles, Distribution.



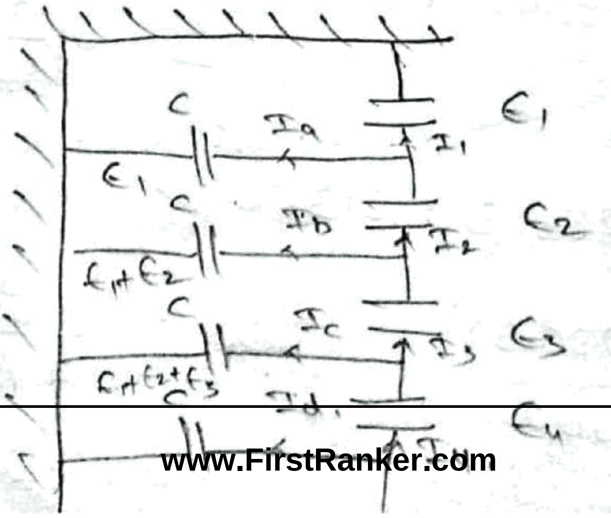
due to Dust particals the Current passing from conductor to insulator is known dry flashover.

Breaking insulator is called puncheor insulator.

due to water particals in the raing seasons the current passing from Conductor to insulator is known as wet flashover.

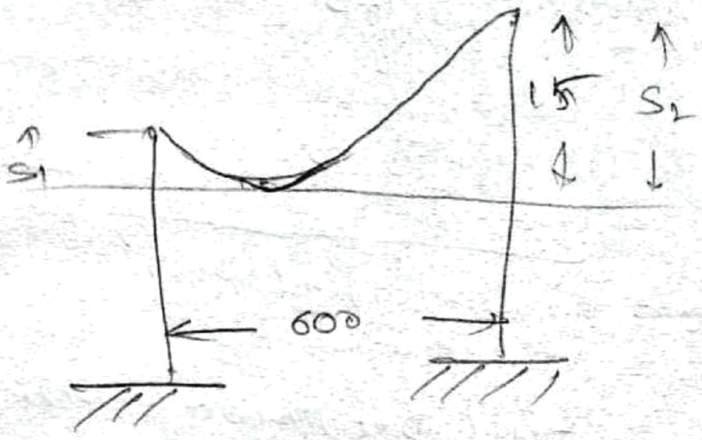
*string : the Combination of insulators.

* Voltage Distribution Across Suspention insulators:



A overhead transmission line having a conductor weight of 1.925 kg/m, and Area of Cross-section of conductor is 2.2 cm² and ultimate strength is 8000 kg/cm² the supportors are 600 m apart having 15 m difference calculate Sag from two supportors. Saftey factor shall be 5 wind pressure is 16 kg/m² & ice density is 1 kg/m thickness of i

→ Given data : cond 0.8 cm.



$W_c = 1.925$ kg/m.

$A = 2.2$ cm².

$S = 8000$ kg/cm²

$l = 600$ m.

$h = 15$ m.

Saf $= 5$

$W_p = 60$ kg/m²

$W_i = 1$ kg/m.

$t = 0.8$ cm.

$$S_1 = \frac{W x_1^2}{2T} \qquad S_2 = \frac{W x_2^2}{2T}$$

$$T = \frac{\text{Strength}}{\text{Saf } f}$$

$$= \frac{8000}{5} \times 2 \times 10^4$$

$T = 16000$

$$x_1 = \frac{l}{2} - \frac{hT}{Wl}$$

$$= \epsilon_1 \omega c \left[3 + \frac{1}{m^2} + \frac{4}{m}\right] + \epsilon_1 \omega c \left(3 + \frac{1}{m} + m\right)$$

$$= \epsilon_1 \omega c \left(3 + \frac{1}{m^2} + \frac{4}{m} + 3 + \frac{1}{m} + m\right)$$

$$= \epsilon_1 \omega c \left(6 + \frac{1}{m^2} + \frac{5}{m} + m\right]$$

$$\therefore I_4 = \epsilon_1 \omega c \left(6 + \frac{1}{m^2} + \frac{5}{m} + m\right]$$

Now. $\epsilon_4 = I_4 \times \dfrac{1}{\omega m c}$

$$= \frac{\epsilon_1 \cancel{\omega} \cancel{c} \left(6 + \frac{1}{m^2} + \frac{5}{m} + m\right]}{\cancel{\omega} m \cancel{c}}$$

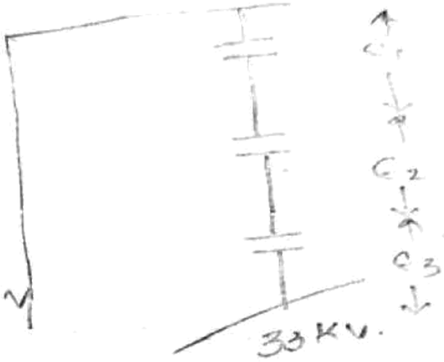
$$= \epsilon_1 \left(\frac{6 + \frac{1}{m^2} + \frac{5}{m} + m}{m}\right)$$

$$= \epsilon_1 \left(\frac{6}{m} + \frac{1}{m^3} + \frac{5}{m^2} + 1\right].$$

$$\boxed{\epsilon_4 = \epsilon_1 \left(1 + \frac{6}{m} + \frac{5}{m^2} + \frac{1}{m^3}\right].}$$

A string consisting of 3 insulators and voltage of Transmission line is 33 kV the mutual capacitance 9 times of the ground capacitance. Find the voltage distribution across each insulator?

Given data:



Insulators = 3

Voltage = 33 kV. = $V_{ph} = \frac{33\times10^3}{\sqrt{3}}$

$= 19052.54\,V$

Condition $mC = 9C$

$\boxed{m = 9}$

Now. $\epsilon_T = \epsilon_1 + \epsilon_2 + \epsilon_3.$

$$\epsilon_T = \epsilon_1 + \epsilon_1\left(1+\frac{1}{m}\right) + \epsilon_1\left(1+\frac{1}{m^2}+\frac{3}{m}\right)$$

$$\epsilon_T = \epsilon_1\left(1+1+\frac{1}{m}+1+\frac{1}{m^2}+\frac{3}{m}\right) = \epsilon_1\left(3+\frac{4}{m}+\frac{1}{m^2}\right)$$

$$\epsilon_T = \epsilon_1\left(3+\frac{4}{m}+\frac{1}{m^2}\right)$$

$$19052.54 = \epsilon_1\left(3+\frac{4}{9}+\frac{1}{9^2}\right)$$

$$19052.54 = \epsilon_1(3+0.4+0.012)$$

$$19052.54 = \epsilon_1(3.41)$$

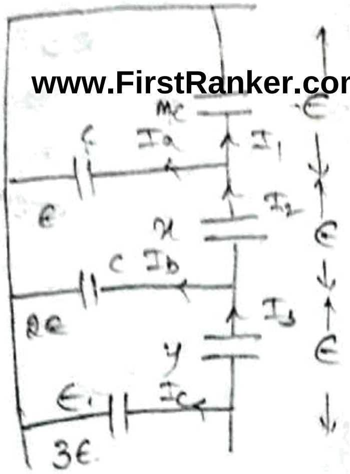
$$\epsilon_1 = \frac{19052.54}{3.41}$$

$$\epsilon_1 = 5587$$

Now. $\epsilon_2 = \epsilon_1\left(1+\frac{1}{m}\right)$

$= 5587.2\left(1+\frac{1}{9}\right) = 6208\,V.$

Grading of Insulators :



$\rightarrow \quad I_1 = \frac{e}{1/\omega mc} = e\omega mc.$

$$I_a = \frac{e}{1/\omega c} = e\omega c.$$

$$I_2 = \frac{e}{1/\omega x} = e\omega x.$$

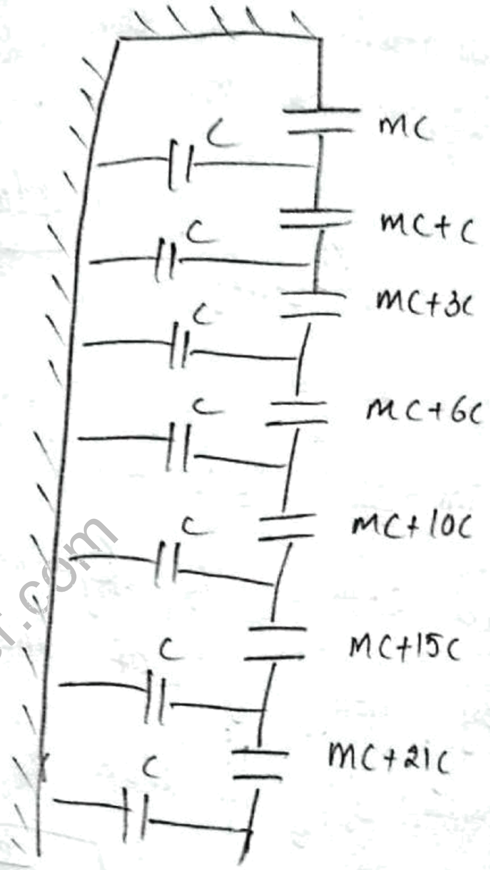
$$I_2 = I_1 + I_a$$

$$e\omega x = e\omega mc + e\omega c$$

$$e\omega x = e\omega(mc + c)$$

$$e\omega x = e\omega(mc + c).$$

$$\boxed{x = (mc + c)}$$



$$I_b = 2e \cdot \omega c.$$

$$I_3 = I_b + I_x$$

$$I_3 = 2e \cdot \omega c + e\omega x$$

$$I_3 = \frac{e}{1/\omega y} = e\omega y$$

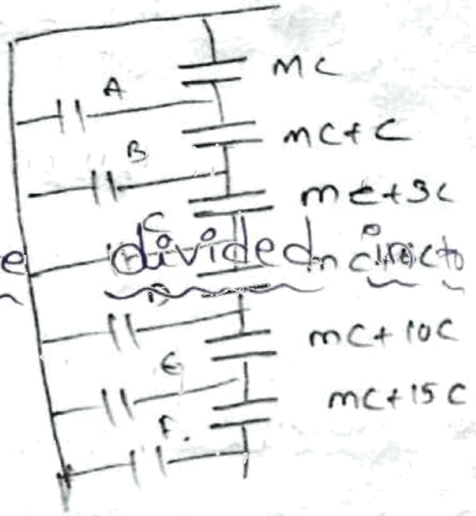
$$e\omega y = 2e \cdot \omega c + e\omega x.$$

$$\cancel{e\omega}\, y = \cancel{e\omega}\,(2c + x)$$

$$\boxed{y = (2c + x).}$$

* operations problems
(v) It is used for Controlling & Switching operations regulators and voltages

* A string Consisting of ... is Same and mutual
Converts
distributed at each insulator potential T/F ground Capacitance
* Eg: Transformers is 8 times the
Capacitence is the
Isolaters
find the Capacitence of each Bus bar insulator.
Circuit Breakers
→ Condition $mC = 8C$
Current T/F
$\boxed{m = 8}$



* Based on Location the Substations are divided into
Capacitance of B insulator = $mC + C$

$= 8C + C = 9C.$

(i) Indoor
"C" $= mC + 3C$
(ii) Outdoor.
$= 8C + 3C = 11C$

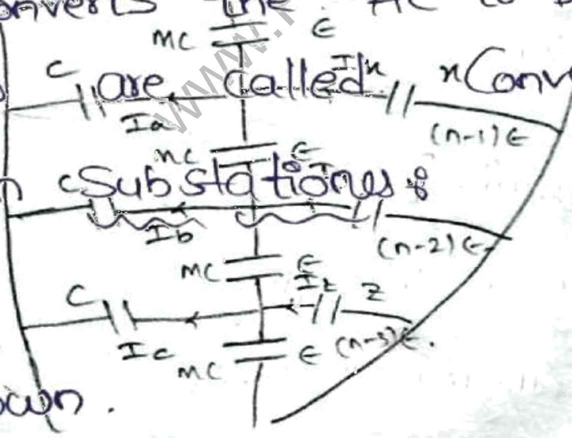
"D" $= mC + 6C$

Indoor: These are protected from atmosphere by $= 8C + 6C$
using wall Constructions
"E" $= 8C + 10C = 18C$

"F" $= mC + 15C = 8C + 15C = 23C.$

Outdoor: These are not protected from atmosphere

* Converting Sub-Stations:
(ii) Guarding
which Converts the AC to DC & DC to AC that
Substations are called Converting Substations.



* Distribution Substations:
(i) step up
(ii) step-down.

* primary Substations: (or) Switch yards:
These are nearer to power plants & Substations
$\frac{\epsilon}{1/\omega mC} = \frac{(n-1)\epsilon}{1/\omega x}$
power Transformers used in this Substations
$\epsilon(\omega C) = (n-1)$