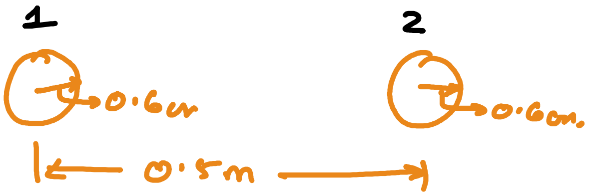
9.2 Line Conductors

Friday, 18 March 2022 3:01 pm

1) $F = 60\text{Hz}$, $d = 1.2\text{cm}$, $r = 0.6\text{cm}$, copper conductors

$\mu_r = 0.999994$
≈ 1



a) $\lambda_{int} = \frac{\mu}{8\pi} \cdot I$ [only internal flux linkage] - λ_{inner},

$$L_{int} = \frac{\lambda_{int}}{I} = \frac{\mu}{8\pi} = \frac{\mu_0 \mu_r}{8\pi}$$

μ_r → Relative permeability of copper.

$$= \frac{4\pi \times 10^{-7}}{8\pi}$$

$$= \frac{1}{2} \times 10^{-7} \text{ H/m}$$

b) $L_{total} = 2 \times 10^{-7} \ln \frac{R}{r'} = \frac{\mu_0}{2\pi} \ln \frac{R}{r'}$

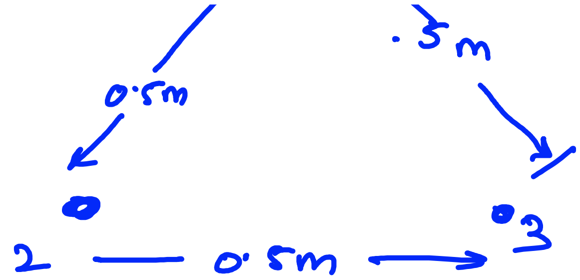
$$r' = r \cdot e^{-\frac{\mu_r}{4}} = r e^{-1/4} = 0.6 \times 10^{-2} \times 0.78$$

$$= 4.68 \times 10^{-3} \text{ m}$$

$$L_1 = L_2 = 2 \times 10^{-7} \ln \left(\frac{0.5}{4.68 \times 10^{-3}} \right)$$

$$= 9.34 \times 10^{-7} \text{ H/m}$$

2) GMR?



$r = 2\,cm, \; r' = 2e^{-1/4} = 1.56\,cm,$

GMR = Geometrical Mean Radius

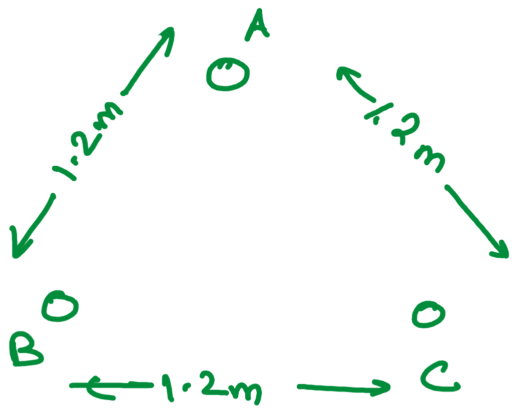
$= (r' \times d_{12} \times d_{13})^{1/3}$

$= (1.56 \times 10^{-2} \times 0.5 \times 0.5)^{1/3}$

$R_n = 0.157\,m = 15.7\,cm$

3) 60Hz, 3 ϕ, 3-wire, $d = 1cm$

$r = 0.5cm \quad r' = 0.5 \times 10^{-2} \times \underbrace{0.78}_{e^{-1/4}} = 3.9 \times 10^{-3}\,m$



$L \rightarrow H/m$?

$X_L \rightarrow \Omega/Km$

$$\lambda_A = \frac{\mu_0}{2\pi}\left[i_A \ln\frac{1}{r'_A} + i_B \ln\frac{1}{D_{AB}} + i_C \ln\frac{1}{D_{AC}} \right]$$

3-wire system $\Rightarrow$ No neutral wire

$\downarrow$

Balanced system $\leftarrow$ No neutral current

$i_A + i_B + i_C = 0$

$i_B + i_C = -i_A$

$D_{AB} = D_{BC} = 1.2 = D$

$$\lambda_A = \frac{\mu_0}{2\pi}\left[\ln \frac{1}{r_1'} + \ln \frac{1}{1.2}\left[-i_A\right]\right]$$

$$= \frac{\mu_0}{2\pi} i_A \ln \left| \frac{1.2}{3.9\times10^{-3}} \right|$$

$$L_A = \frac{\lambda_A}{i_A} = \frac{\mu_0}{2\pi} \ln \left| \frac{1.2}{3.9\times10^{-3}} \right|$$

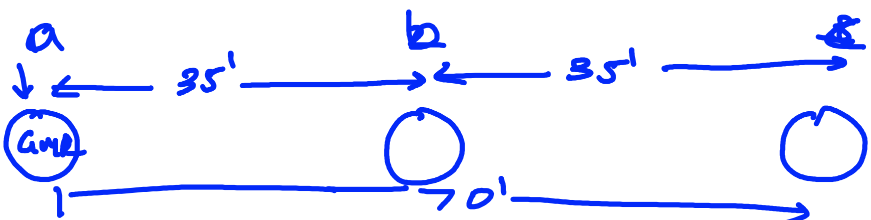
$$= 1.146\times10^{-6} \text{ H/m.}$$

$$X_L = 2\pi f \cdot L_A = 120\pi \times 1.146\times10^{-6} \text{ H/m}$$

$$= 0.432\times10^{-3} \ \Omega/\underline{m}$$

$$X_L = 0.432 \ \Omega/\text{km}$$

4 500 kV, 3ϕ,



1 Ft $\approx$ 12 inches

$D_{ab} = D_{bc} = 35$ Ft

D 70 Ft

$D_{ac} = 70$ ft

$d = 1.345$ inch

GMR $= 0.5328$ inch.

$= \frac{0.5328}{12}$ ft $= 0.0444$ ft

$$GMD = (D_{ab} \cdot D_{bc} \cdot D_{ca})^{1/3}$$

$$= (35 \times 35 \times 70)^{1/3} = 44.097 \text{ ft}$$

$$L_A = \frac{\mu_0}{2\pi} \ln \left| \frac{GMD}{GMR} \right|$$

$$= 2 \times 10^{-7} \ln \left| \frac{44.097}{0.0444} \right|$$

$$= 1.38 \times 10^{-6} \text{ H/m}$$

$$L_A = 1.38 \times 10^{-6} \times 1000 \text{ H/km}$$

$$= 1.38 \text{ mH/km}$$

$$L_A = \frac{\mu_0}{2\pi} \ln \frac{GMD}{GMR}$$