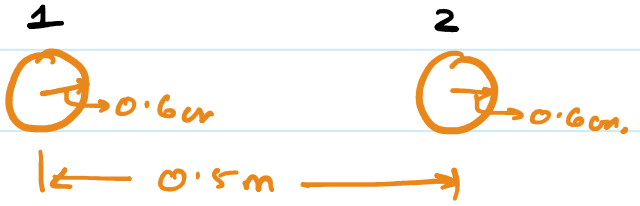
9.2 Line Conductors

Friday, 18 March 2022 3:01 pm

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

$\mu_r = 0.999994 \approx 1$



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

$L_{int} = \frac{\lambda_{int}}{I} = \frac{\mu}{8\pi} = \frac{\mu_0 \mu_r}{8\pi}$ relative permeability of copper,

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

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

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

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

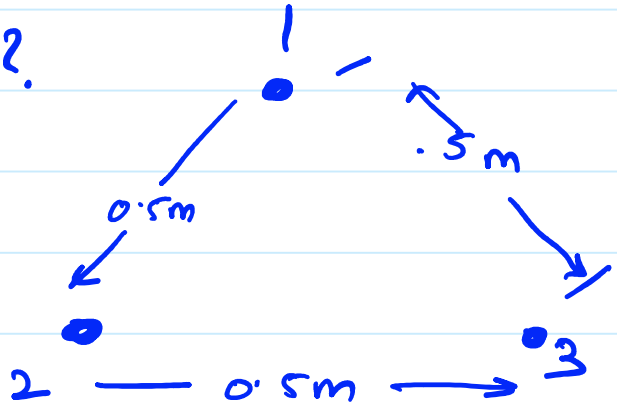
$= 4.68 \times 10^{-3}\ \text{m}$

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

$= 0.24 \times 10^{-7}\ \text{H/m}$

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

2) GMR?



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

GMR = Geometrical Mean Radius

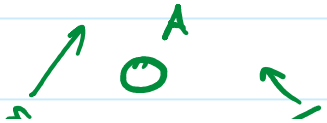
$= (r' \times d_{12} \times d_{13})^{1/3}$

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

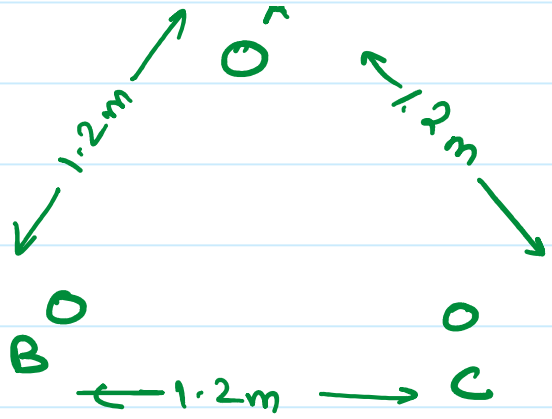
$R_m = 0.157\text{ m} = 15.7\text{ cm}$

3) 60Hz, 3φ, 3-wire, d = 1cm

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



L → H/m ?



L → H/m ?

X_L → Ω/1 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 ⇒ No neutral wire

↓

Balanced system ← No neutral current

$$i_A + i_B + i_C = 0$$

$$i_B + i_C = -i_A$$

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

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

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

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

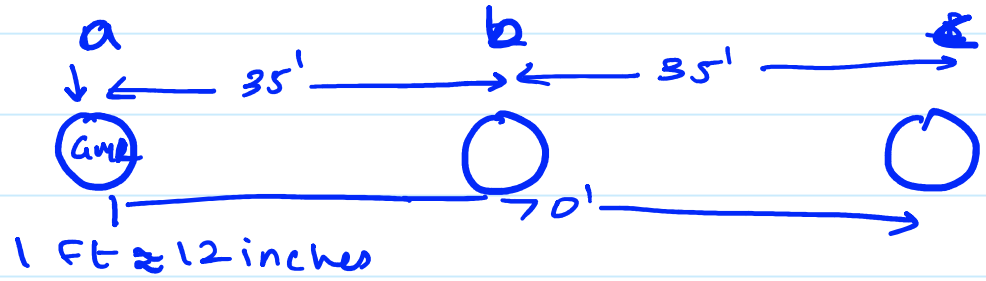
$= 1.146 \times 10^{-6}$ H/m.

$X_L = 2\pi f \cdot L_A = 120\pi \times 1.146 \times 10^{-6}$ H/m

$= 0.432 \times 10^{-3}$ Ω/m

$X_L = 0.432$ Ω/km

4 500 kV, 3φ,



1 Ft ≈ 12 inches

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

$D_{ac} = 70$ Ft

$d = 1.345$ inch =

GMR = 0.5328 inch.

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

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

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

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

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

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

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

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

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