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Line conductors

Date No.

1. $f = 60\,Hz$, $d = 1.2cm$, $r = 0.6cm$, copper conductor

$\mu_r = 0.999994 \approx 1$

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

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

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

$$= 0.5 \times 10^{-7}\ H/m$$

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

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

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

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

$$= 9.346 \times 10^{-7}\ H/m$$

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

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

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

$R_n = 0.137\text{m} = 15.7\text{cm}$ //

3. 60Hz, 3Φ, 3 wire, $d = 1\text{cm}$

$r = 0.5\text{cm}$ $r' = 0.5 \times 10^{-2} \times 0.78 = 3.9 \times 10^{-3}\text{m}$

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

3 wire system $\Rightarrow$ no neutral wire $\rightarrow$ no neutral current $\rightarrow$ Balanced system

$\Rightarrow i_A + i_B + i_C = 0$

$i_B + i_C = -i_A$

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

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

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

$$L_A = \frac{\lambda_A}{i_A} = \frac{\mu_0}{2\pi}\ln\left|\frac{1.2}{3.9\times10^{-3}}\right| = 1.146\times10^{-6}\ \text{H/m}$$ //

$X_L = 2\pi f \cdot L_A = 120\pi \times 1.146\times10^{-6} = 0.432\times10^{-3}\ \Omega/\text{m}$

$= 0.432\ \Omega/\text{cm}$ //

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4. 500kV, 3Ø, 1 ft ≈ 12 inches

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

$D_{ac} = 70$ ft

$d = 1.34r$ inches

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

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

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

$L_A = \frac{\mu_0}{2\pi} \ln\left|\frac{GMD}{GMR}\right| = 2\times10^{-7} \ln\left|\frac{44.097}{0.0444}\right| = 1.38 \times 10^{-6}$ H/m

$= 1.38$ mH/km