Geometric Mean Radius (GMR)

⇒ it is the effective distance upto which self flux linkage occur

$$L_{ext} = \frac{\mu_0}{2\pi} \ln \frac{D}{r}, \quad L_{Total} = \frac{\mu_0}{2\pi} \ln \frac{D}{r'}$$

r' replaces r

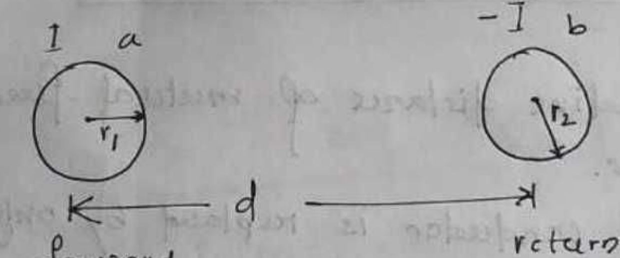
upto 'D' Distance mutual ϕ and 'r'' self flux.

⇒ if we replace the conductor by another hypothetical conductor with no internal flux then radius for hypothetical conductor should be equal to GMR.

$$L = \frac{\mu_0}{2\pi} \ln \frac{D}{r'}, \quad L = L' \Rightarrow R = R'$$

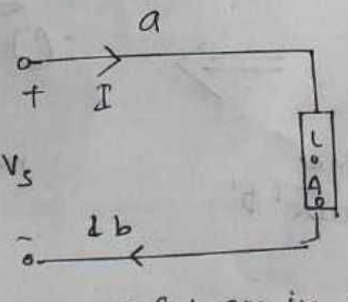
⇒ Single phase Two wire line

- Two conductor are present in this line out of which one acts as forward path while the other acts as Return path.



- Mutual flux will be consider upto distance 'd'

$$L_a = \frac{\mu_0}{2\pi} \ln \frac{d}{r_1'} \quad L_b = \frac{\mu_0}{2\pi} \ln \frac{d}{r_2'}$$



a & b are in Series

$$L = L_a + L_b$$

$$L = \frac{\mu_0}{2\pi}\left[\ln\frac{d}{r_1'} + \ln\frac{d}{r_2'}\right]$$

$$= \frac{\mu_0}{2\pi}\ln\frac{d^2}{r_1' r_2'}$$

$$= \frac{\mu_0}{2\pi}\ln\frac{d}{\sqrt{r_1' r_2'}}$$

where $\sqrt{r_1' r_2'}$ geometric mean of r_1' and r_2'

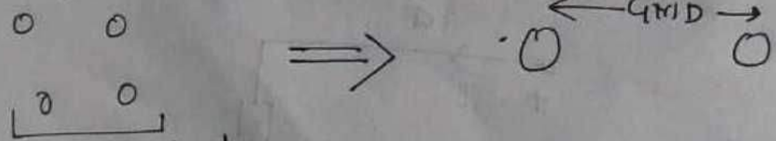
$$L = \frac{4\pi\times10^{-7}}{\pi}\ln\frac{d}{\sqrt{r_1' r_2'}}$$

$$\boxed{L = 0.4\ln\frac{d}{\sqrt{r_1' r_2'}}\ mH/km}$$

⇒ Geometric Mean Distance (GMD)

- It is the effective distance of mutual-flux linkages between two conductors.
- if a group of conductor is replaced by only two conductors then the two conductors should be placed at distance equal to GMD to have same value of mutual-flux linkage.

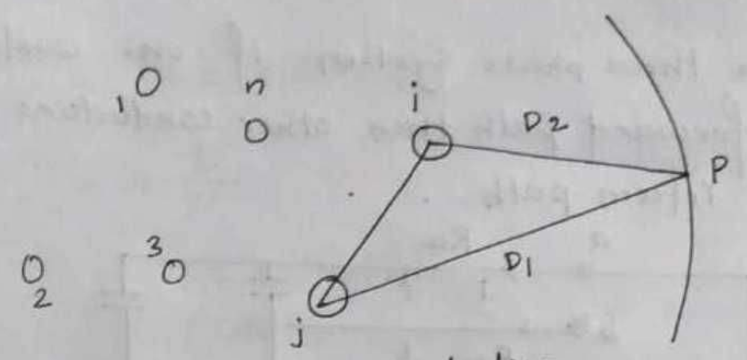
ex: $GMD = [d\times d]^{1/2} = d$



n conductors
mutual flux 'φ'

mutual flux 'φ'

Flux linkage of conductor in a groups



n – conductors

if we want to derive flux linkage of conductor 'i' due to itself as well as due to other conductors.

$$\boxed{\lambda_i = \frac{\mu_0}{2\pi} \sum_{j=1}^{n} I_j \ln \frac{1}{D_{ij}}}$$

if $j = i$

$$\lambda_{ii} = \frac{\mu_0}{2\pi} I_i \ln 1/D_{ii} = \qquad D_{ii} = r_i'$$

λ_{ii} = flux linkage of 'i' due to itself (self flux linkage)

$$\lambda_{ii} = \frac{\mu_0}{2\pi} I_i \ln 1/D_{ii}$$

$$\boxed{L_{self} = \frac{\lambda_{ii}}{I_i} = \frac{\mu_0}{2\pi} \ln 1/D_{ii}}$$

$$\lambda_{ik} = \frac{\mu_0}{2\pi} I_k \ln \frac{1}{D_{ik}}$$

where D_{ik} = Distance betn 'i' and 'k'

→ flux linkage of 'i' due to 'k'

λ_{ik} = mutual flux

$$\boxed{L_m = \frac{\lambda_{ik}}{I_k} = \frac{\mu_0}{2\pi} \ln \frac{I}{D_{ik}}}$$

mutual inductance

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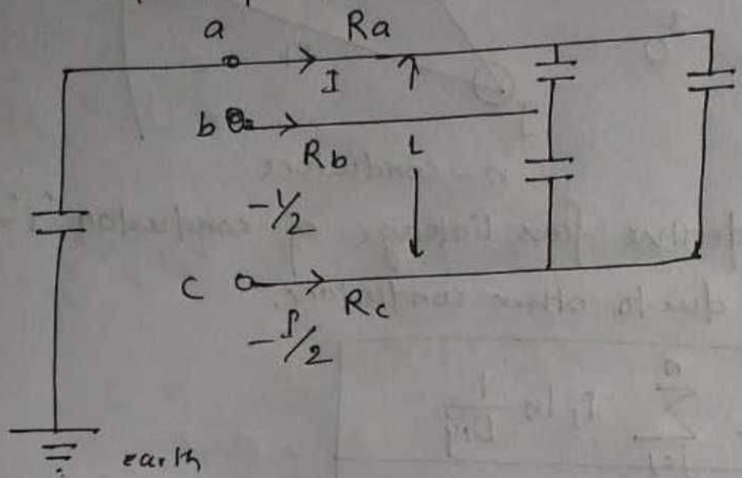
application :

⇒ In a three phase system if one conductor acts as forward path then other conductors will act as return path .



$$\lambda_a = \frac{\mu_0}{2\pi}\left[I \ln \frac{1}{D_{aa}} - \frac{I}{2} \ln \frac{1}{D_{ab}} - \frac{I}{2} \ln \frac{1}{D_{ac}} \right]$$

$$= \frac{\mu_0}{2\pi}\left[I \ln 1/r_a' - \frac{I}{2} \ln \frac{1}{D_{ab} D_{ac}} \right]$$

$$= \frac{\mu_0}{2\pi}\left[I \ln 1/r_a' - I \ln \frac{1}{\sqrt{D_{ab} D_{ac}}} \right]$$

⇒ 1^{st} term self flux

⇒ 2^{nd} term mutual flux

$$GMD = \sqrt{D_{ab} D_{ac}}.$$

Summary

$$L_{int} = \frac{\mu_0}{8\pi} = 0.05 \text{ mH/km}$$

$$L_{ext} = \frac{\mu_0}{2\pi} \ln \frac{D}{r} = 0.2 \ln \frac{D}{r} \text{ mH/km}$$

$$L_{Total} = \frac{\mu_0}{2\pi} \ln \frac{D}{r'}$$

$$r' = 0.7788 r$$

(GMR)

$$L(1-\phi) = \frac{\mu_0}{\pi} \ln \frac{d}{\sqrt{r_1' r_2'}} = 0.4 \ln \frac{d}{\sqrt{r_1' r_2'}}$$

$$\lambda_i = \sum_{j=1}^{n} \frac{\mu_0 I_j}{2\pi} \ln \frac{1}{D_{ij}}$$

——— x ———