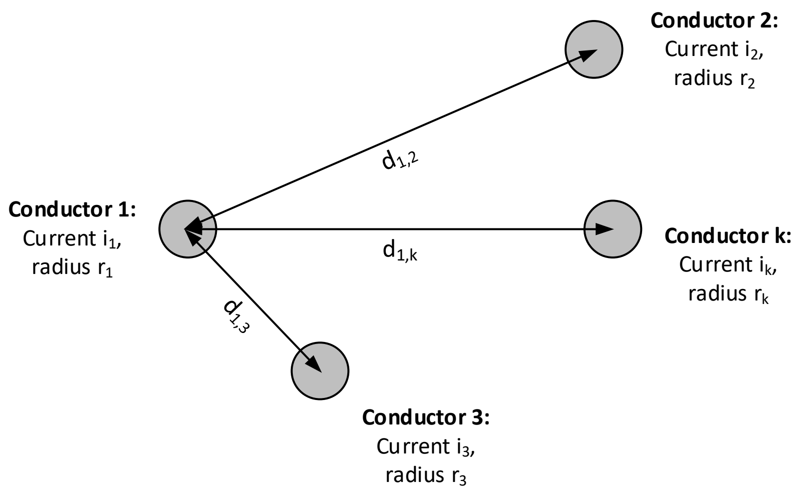
(Distributed) Inductance of solid conductors

Reminder: Transmission (and distribution) lines are not made of a *single* solid conductor. They are made from stranded conductors: a number of solid conductors (strands) wrapped together.

To determine the inductance of stranded conductors, let's start with the inductance of solid conductors. We can then expand this to stranded conductors.

For n solid conductors with current i_k:



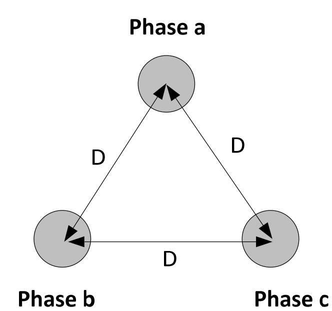
If $\sum_{k=1}^{n} i_k = 0$, flux linkage of conductor 1 is: $\lambda_1 = \frac{\mu_0}{2\pi}\left(i_1.\ln\frac{1}{r_1{}'} + i_2.\ln\frac{1}{d_{1,2}} + \cdots + i_n.\ln\frac{1}{d_{1,n}}\right)$

where: μ_0 is permeability of free space = $4\pi \times 10^{-7}$ H/m

$r' = e^{-1/4}.r = 0.7788\ r$

Since $\lambda = L.i$, we can write this as: $\lambda_1 = L_{1,1}.i_1 + L_{1,2}.i_2 + \cdots + L_{1,n}.i_n$

For a balanced 3ϕ line made from solid conductors and with <u>symmetric alignment</u>:



$$\lambda_a = \frac{\mu_0}{2\pi}\left(I_a.\ln\frac{1}{r'} + I_b.\ln\frac{1}{D} + I_c.\ln\frac{1}{D}\right)$$

$$= 2 \times 10^{-7}\left(I_a.\ln\frac{1}{r'} + (I_b + I_c).\ln\frac{1}{D}\right)$$

$$= 2 \times 10^{-7}\left(I_a.\ln\frac{1}{r'} - I_a.\ln\frac{1}{D}\right) = 2 \times 10^{-7}\left(I_a.\ln\frac{D}{r'}\right) \rightarrow \quad L_a = \frac{\lambda_a}{I_a} = 2 \times 10^{-7}\ \ln\frac{D}{r'}$$

This is the distributed inductance for a solid conductor in a balanced three phase system with symmetric alignment. Values for L_b and L_c are identical.