

FIGURE 6-16

In a toroid, shown here, the magnetic flux is almost entirely confined to the interior of the winding.

The inductance of the toroid is then

$$L = \frac{\Lambda}{I} = \frac{\mu N^2 r^2}{2R} \quad (4)$$

where L = inductance of toroid, H

μ = permeability (uniform and constant) of medium inside coil, H m^{-1}

N = number of turns of toroid, dimensionless

r = radius of coil (see Fig. 6-16), m

R = radius of toroid, m

Consider next a *coaxial transmission line* constructed of conducting cylinders of radius a and b , as in Fig. 6-17. The current on the inner conductor is I . The return current on the outer conductor is of the same magnitude. The flux density B at any radius r is the same as at this radius from a long straight conductor with the same current, or

$$B(\text{at } r) = \frac{\mu I}{2\pi r} \quad (5)$$

The total flux linkage for a length d of line is then d times the integral of (5) from

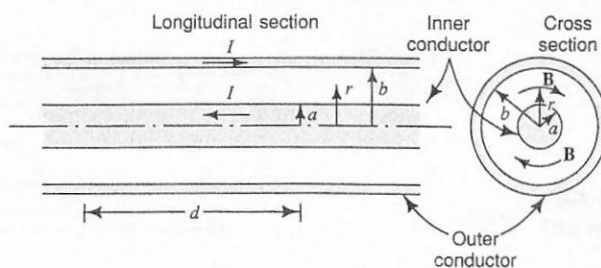


FIGURE 6-17

Coaxial transmission line.

the inner to the outer conductor or

$$\Lambda = d \int_a^b B \, dr = \frac{d\mu I}{2\pi} \int_a^b \frac{dr}{r} = \frac{d\mu I}{2\pi} \ln \frac{b}{a} \quad (6)$$

Hence, the inductance of a length d of the coaxial line is

$$L = \frac{\Lambda}{I} = \frac{\mu d}{2\pi} \ln \frac{b}{a} \quad (\text{H}) \quad (7)$$

or the inductance per unit length (L/d) for the coaxial line is given by

$$\frac{L}{d} = \frac{\mu}{2\pi} \ln \frac{b}{a} \quad (\text{H m}^{-1}) \quad (8)$$

where μ = permeability (uniform and constant) of medium inside coaxial line, H m^{-1}

b = inside radius of outer conductor

a = outside radius of inner conductor (in same units as b)

It is assumed that the currents are confined to the radii a and b . This is effectively the case when the walls of the conductors are thin.

Evaluating (8), the inductance per unit length d of the coaxial line is

$$\frac{L}{d} = 0.2\mu_r \ln \frac{b}{a} = 0.46\mu_r \log \frac{b}{a} \quad (\mu\text{H m}^{-1}) \quad (9)$$

where μ_r = relative permeability, dimensionless.

Let us consider finally a *two-wire transmission line* as illustrated in Fig. 6-18. The wire radius is a , and the spacing between centers is D . At any radius r from one of the wires the flux density B due to that wire is given by (5). The total flux linkage due to both wires for a length d of line is then d times twice the integral of (5) from a to D , or

$$\Lambda = 2d \int_a^D B \, dr = \frac{\mu Id}{\pi} \int_a^D \frac{dr}{r} = \frac{\mu Id}{\pi} \ln \frac{D}{a} \quad (10)$$

Hence, the inductance of a length d is

$$L = \frac{\Lambda}{I} = \frac{\mu d}{\pi} \ln \frac{D}{a} \quad (11)$$

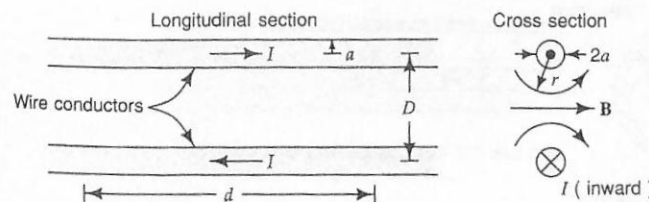


FIGURE 6-17
Coaxial transmission line.

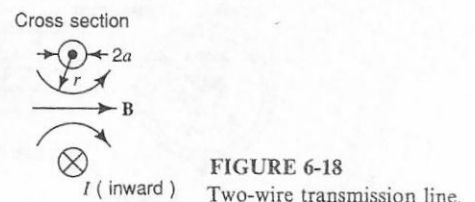


FIGURE 6-18
Two-wire transmission line.