Current Electricity

Self Inductance of a Long Solenoid :-

Let a long air-cored solenoid having a length 1 metre, Total number of closely-wound turns N, and area of cross-section A metre^2. The Number of turns per unit meter length = N/l. Let a current i ampere flow through it. Then the magnetic field inside the solenoid.

$$\boxed{B = \mu_0 \left(\frac{N}{l}\right) i \ \omega/m^2}$$

where μ_0 is the permebility constant. The magnetic flux through each turn is

$$\Phi_B = BA = \mu_0 \left(\frac{N}{l}\right) i A$$

weber.

∴ Total magnetic flux through the solenoid

$$N\Phi_B = N\mu_0\left(\frac{N}{l}\right) iA = \frac{\mu_0 N^2 i A}{l} \text{ weber-turns.}$$

The self inductance of the Solenoid is Therefore,

$$L = \frac{N\Phi_B}{i} = \frac{\mu_0 N^2 A}{l} \text{ henry}$$

Self Inductance of a Toroid

Let a toroid of mean radius r, total number of turns N and carrying a current i,

The Magnetic field inductance at a Point within its core is

$$B = \frac{\mu_0}{2\pi}\left(\frac{Ni}{r}\right)$$

where μ_0 is the Permeability constant. The magnetic flux through each turn is given by

$$\boxed{\Phi_B = BA = \frac{\mu_0}{2\pi}\left(\frac{Ni}{r}\right)A}$$

where A is the cross-sectional area of each turn. The no. of flux linkages through the toroid is given by

$$N\Phi_B = \frac{\mu_0}{2\pi}\frac{N^2 i A}{r}$$

By definition, the self-inductance of the toroid is given by.

$$L = \frac{N\Phi_B}{i} = \frac{\mu_0}{2\pi}\frac{N^2 A}{r} \text{ henry.}$$