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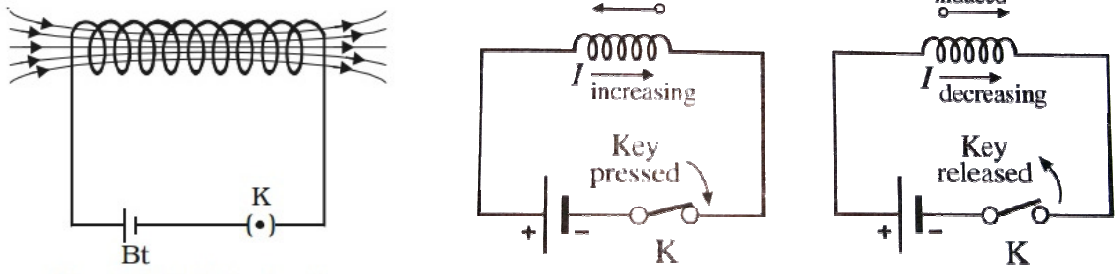
SELF INDUCTANCE (స్వయం ప్రేరణ)

Self induction:

This phenomenon was discovered by J.Henry. According this, when a current 'i' flows through a coil, a magnetic field is developed in it. If the current through the coil changes with time, an induced e.m.f. is set up in the coil. According to Lenz's law, the induced e.m.f. opposes the change in the current. Therefore, when the current increases, the induced e.m.f. acts against the current and when the current decreases, the induced e.m.f acts in the direction of current. Thus, the induced e.m.f. opposes any change of the original current. This phenomenon is called as 'self induction'.

Further, the property of a circuit by virtue of which any change in magnetic flux linked with it, induces an e.m.f. and is termed as inductance. It is also called as 'back e.m.f.' when the switch is on the self induction opposes the growth of current. When the switch is OFF, the self induction oppose the decay of current.



Coefficient of self induction:

The total magnetic flux Φ_B linked with a coil is directly proportional to the current 'i' flowing in it, i.e.,

$\Phi_B \propto i \Longrightarrow \Phi_B = Li$ ------(1)

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Where, L is called as coefficient of self induction or self induction of the coil. When i=1amp, Φ_B=L. therefore, the coefficient of self induction is numerically equal to the magnetic flux linked with the coil when a unit current flows in it.

Using equation (1) and from the basic definition of induced e.m.f., Induced e.m.f. in the coil is given by

$e = -\left(\frac{d\Phi_B}{dt}\right) = -\frac{d(Li)}{dt} = -L\frac{d(i)}{dt}$ (here, the negative sign indicates that the e.m.f's direction is to oppose any change.

Further, when $\frac{d(i)}{dt} = 1, e = -L$

Therefore, the coefficient of self inductance is numerically equal to induced e.m.f. in the coil when the rate of change of current is unity.

Furthermore, when the current in a coil is switched ON, self inductance opposes the growth of current, i.e., the current flows against back e.m.f.. here, some work is done against back e.m.f.

$\therefore dW = -eidt \Longrightarrow dW = -\left(-L\frac{d(i)}{dt}\right)idt = +L\frac{d(i)}{dt}idt$ $(\because e = -L\frac{d(i)}{dt})$ -------(2)

The total work done in bringing current from zero to maximum i_0 is given by

$\int dW = W = L\int_0^{i_0} i\frac{di}{dt}.dt = L\int_0^{i_0} idi \Longrightarrow W = \frac{1}{2}Li_0^{\,2}$ -------(3)

This is called as energy stored in magnetic field. When i_0=1, L=2W

Thus, the coefficient of self induction is twice the workdone against the induced e.m.f. in establishing a unit current.

Units for inductance 'L' is henry.

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Self inductance of a long solenoid: (పొడవైన సోలనాయిడ్ వల్ల స్వయం ప్రేరణ)

Consider a long air core solenoid of length 'l'metre which has a uniform cross section area 'A' metre^2. Let 'n' be the number of turns per metre in which a current 'i' flows in it. The magnetic field inside the solenoid is given by

$B = \mu_0 ni \ \frac{weber}{metre^2}, \quad where, \ is \ permeability$

Magnetic flux through each turn is given by

$\Phi_B = BA = \mu_0 ni \ A \ weber$ ----------(4)

If there are 'N' turns in the coil, the flux linked with all the turns is given by

$\Phi_B = \mu_0 ni \ A \ N = \mu_0 ni \ A \ nl = \mu_0 n^2 i \ A \ l \qquad (\because N = nl)$ ----------(5)

From the relation between magnetic flux and of self inductance, $\Phi_B = Li$, one can write

$Li = \mu_0 n^2 i \ A \ l \implies L = \mu_0 n^2 \ A \ l$ ----------(6)

As n=N/l, the above expression is expressed in terms of 'N' by

$L = \mu_0 \left(\frac{N}{l}\right)^2 A \ l = \frac{\mu_0 N^2 A}{l} \ henry$ ----------(7)

Model questions(మాదిరి ప్రశ్నలు)

1. Define the coefficient of self induction
2. Derive an expression for the self inductance of a solenoid
3. What is self induction? Define coefficient of self induction and obtain an expression for the self induction due to a solenoid.
4.

References:

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