CHAPTER 2

ELECTRO MAGNETISM

2.1. Overview of the Chapter

The purpose of this chapter is to make the student understand the concept of magnetism and electromagnetic induction phenomenon. These topics are very important in understanding the concept of inductance. Inductance plays a very important role in the engineering field. The noteworthy contributors to this field are Ampere, Oersted, Faraday and Joseph Henry.

A substance that attracts iron filings and points in the direction of North-South, when suspended freely, is called a magnet. This property exhibited by the magnet is called magnetism. Natural magnet is found in the form of an Iron ore, which is an oxide of Iron, known as Magnetite (Fe_3O_4). Natural magnets are very weak magnets and their magnetic intensities cannot be varied.

2.1.1. Important Formulas to remember

1. $I_{aV} = \dfrac{\text{Area of half cycle}}{\text{Base width of half cycle}}$

2. $I = \sqrt{\dfrac{i_1^2 + i_2^2}{+} i_3^2 + \cdots + i_n^2 n}$ Amps

2.1.2. Important Theorems to remember

1. Auxiliary Potentials
2. Harmonic Time Variation
3. Particular Solutions for an Unbounded Homogenous Region with Sources
4. Poynting Vector
5. Reciprocity Theorem
6. Boundary Conditions
7. Uniqueness Theorems
8. TM and TE Field Analysis

2.1.3. Important Notations to remember

1. Explicit standard notation for tensors
2. Multiple-subscript notation for tensors
3. Pre-subscript, pre-superscript notation for tensors
4. Arrow notation for tensors
5. Post-subscript, post-superscript notation for tensors

2.2. SHORT QUESTIONS AND ANSWERS

SQ 2.1. A current of 8A flowing through a coil of 600 turns produces a flux of 0.04 Webber. If the current is uniformly reduced to 2A in 0.05 seconds, find the average e.m.f induced in the coil.

Ans. [$L = 3\,\mathsf{H}; e = 360\,\mathsf{v}$] ♦

SQ 2.2. 10A of current flows through a coil of 600 turns and of inductance 6mH. Calculate the flux surrounding the coil. If the current is reversed in 10 millisecond, find the e.m.f induced in the coil.

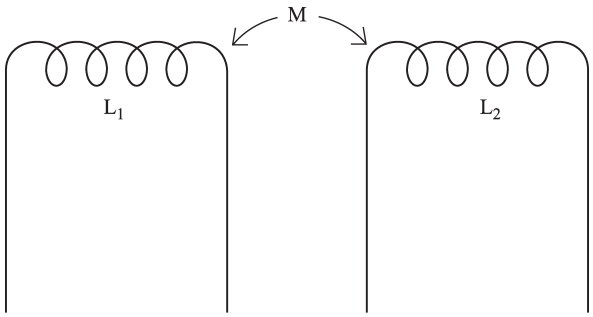
Ans. [$\Phi = 1 \times 10^{-3}\mathsf{wb}; e = 12\,\mathsf{volts}$] ♦

2.3. LONG QUESTION AND ANSWER

LQ 2.1. Two coils having 30 and 600 turns respectively are wound side by side in a closed iron circuit of area of cross section 100 sq.cm and mean length 200 cms. Estimate the

mutual inductance between the coils if the relative permeability of the iron is 2000. If a current of zero ampere grows to 20A in a time of 0.02 second in the first coil, find the e.m.f induced in the second coil.

Answer:



Given

$$N_1 = 30$$
$$N_2 = 600$$
$$a = 100 \text{ cm}^2$$
$$l = 200 \text{ cm}$$
$$\mu_1 = 2000$$
$$dI_1 = (20 - 0)\text{A}$$
$$dt = 0.02 \text{ sec}$$

We have

$$S = \frac{1}{\mu_o \mu_r a} = \frac{2}{4\pi \times 10^{-7} \times 2000 \times 100 \times 10^{-4}}$$
$$M = \frac{N_1 N_2}{S} = \frac{30 \times 600}{2} \times 4\pi \times 10^{-7} \times 2000 \times 100 \times 10^{-4}$$
$$= 0.226\,\text{H}$$
$$e_M = M\frac{dI_1}{dt} = 0.226 \times \frac{20}{0.02}$$
$$= 226\,\text{volts}$$

LQ 2.2. Two identical coils A and B lie in parallel planes. A current changing at the rate of 1500 Amperes/Second in A induces an e.m.f of 11.25 volts in B. Calculate the mutual inductance of the arrangement.

Answer: Given

$$\frac{dI_1}{dt} = 1500\,A/\text{sec}$$

$$e_M 11.25 \text{ volts}$$

We have

$$e_M = M\frac{dI_1}{dt}$$

$$11.25 = M \times 1500 \text{Therefore } M \qquad = \frac{11.25}{1500} = 7.5 \times 10^{-3}\,H$$

2.4. Numerical Questions

NQ.2.1. State and explain Faraday's Laws of Electromagnetic Induction.

NQ.2.2. State and explain Fleming's right hand rule.

NQ.2.3. Explain the terms "Absolute permeability'' and "relative permeability''.

NQ.2.4. State and explain Lenz's Law.

NQ.2.5. Define self inductance of a coil.

NQ.2.6. Derive an expression for self inductance of a coil.

NQ.2.7. Write a brief note on "self and mutual inductances''.

NQ.2.8. Derive an expression for dynamically induced e.m.f in a conductor.

NQ.2.9. Explain the term "coefficient of coupling''.