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B. R. SHARMA

-SATYA PRAKASHAN, NEW DELHI

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By

B. R. SHARMA

Author of : Elements of Electrical Engineering and
Electronics ; Elements of Electronics, and
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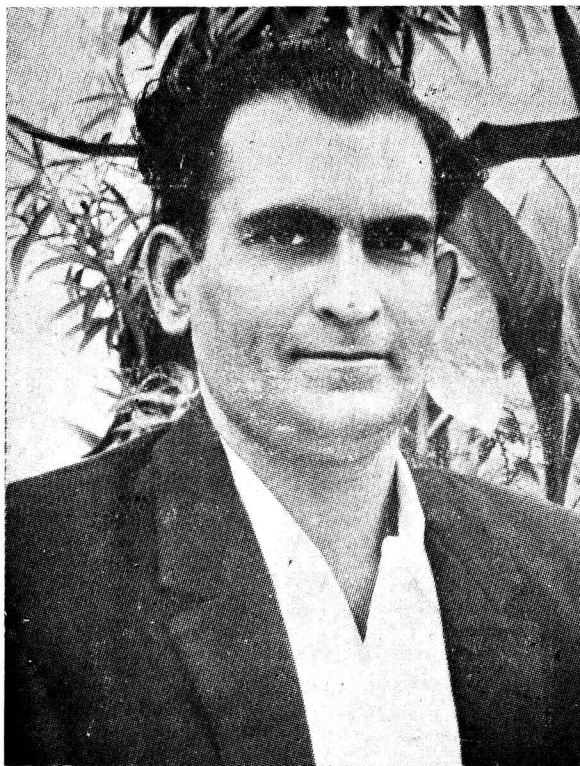
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PREFACE TO THE REPRINT EDITION

It really makes me elevated to know from my Publishers that the book has been sold out. Considering the popularity of the book. I am sincerely grateful to my readers for this kind appreciation of my work and feel amply rewarded for the labour that I have put into the subject of Electrical Machines.

This book fully covers the syllabuses of Indian Universities, U.P.S.E., A.M.I.E. Sec. B and other Engineering Examinations.

I would be glad to receive suggestions with thanks in the treatment of the subject matter for the improvement of its revised Edition.

Sundernager

Dated : 11th July, 1981

—AUTHOR

PREFACE TO THE FIRST EDITION

I take this opportunity of placing before the students specially preparing for A.M.I.E. (India) Section B New Scheme effective from May 1974 in Electrical and Electronics branches, Indian Engineering Services, Degree and Diploma examinations, taking paper on the subject Electrical Machines, the first edition of this book.

This book on Electrical Machines, is a standard treatise on the subject written completely in rationalised M.K.S. system of units incorporating International System (S.I.) of units, in a very simple and convincing manner. The book fully caters to the needs of the students appearing for the A.M.I.E. (India) Section B new scheme examination in Electrical and Electronics branches, Indian Engineering Services examination of U.P.S.C., Degree and Diploma examinations of the various Universities and state boards.

It is impossible to acquire a thorough understanding of Electrical Machines without working out a large number of numerical problems and due to this fact number of numerical problems have been included and solved from the Institution of Engineers (India) and other universities examinations. This volume covers both d.c. and a.c. machines.

Although every care has been taken to check the mistakes and misprints but in a volume like this, it is too much to expect perfection. All such errors and imperfections, brought to my notice, will be gratefully acknowledged and duly incorporated in the coming editions of the book.

I wish to express my sincere thanks to Shri R.P. Handa, proprietor M/S Satya Prakashan, New Delhi, the publisher of this book for his unlimited help to write this book and untiring efforts to bring this volume in this shape.

I am also thankful to M/S Friends Printers for composing the book and M/S. S. Narayan & Sons for printing the same in such a nice manner.

Now I am placing this book in the hands of my student-readers, fellow teachers and other engineers for their valuable suggestions regarding further improvement and development of the subject.

Sundernager

Dated : 18th April 1981.

—B.R. SHARMA

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Electro-magnetic Induction

★ 1-1. **Electro-magnetic Induction**

E.M.F. may be produced or generated in various ways, three of them are given below :

- (i) By chemical action ;
- (ii) By heating the junction of two dissimilar metals ; and
- (iii) By electro-magnetic induction.

The chemical action method of producing e.m.f. has a **limited** application, and is useful only where small amounts of electrical energy are required. This principle is employed in batteries only. Very weak e.m.f. is produced by heating the junction of two dissimilar metals, and has extremely limited application on the measurement of temperatures by thermocouples.

The method of generating e.m.f. by electro-magnetic induction is the most important, and it is the only method used for commercial generation of power.

In 1831, Faraday discovered that an e.m.f. is generated in a circuit whenever the number of magnetic lines of force linked with a moving conductor. This was a discovery of great importance. He showed that the voltage could be generated in a conductor by moving either the conductor or the flux or both. This phenomenon is known as **electro-magnetic induction**. He also showed that the e.m.f. induced is proportional to the rate of change of magnetic flux and to the number of turns linked with this flux.

This principle of electro-magnetic induction is used in d.c. motors and generators, also in a.c. generators. The e.m.f. generated by the motion of either the armature conductors or the field poles : as in d.c. and a.c. generators is called *generated e.m.f.*

★ 1-2. **Static and Dynamic Induction**

When there is no actual movement of either the magnetic field or of the electric circuit, the induction is said to be **static induction**. An important practical example of this is the *transformer*.

Sometimes the change in flux-linking can be done by either

(a) moving the electric circuit relative to the stationary magnetic field ; or

(b) moving the magnetic field relative to a stationary electric circuit so as to bring the same effect.

This is called the dynamic induction.

Method (a) is adopted in d.c. generators.

Method (b) is adopted in a.c. generators.

★1-3. Faraday's Laws of Electro-Magnetic Induction

[A.M.I.E. (New Scheme) May 1974]

First Law :

Whenever the magnetic flux linked with an electric circuit is altered, an e.m.f. is induced in the circuit.

Second Law :

The magnitude of this induced e.m.f. is directly proportional to the rate of change of flux linkages.

Mathematical Explanation :

Let us have a coil of N -turns. Let us suppose that it is linked with an initial flux ϕ_1 webers and then in time t seconds it is linked with a final flux ϕ_2 webers. Thus the flux changes in the coil from ϕ_1 to ϕ_2 in time t seconds.

$$\text{Change of flux/conductor} = (\phi_2 - \phi_1) \text{ Wb}$$

\therefore rate of change of flux per conductor.

$$= \frac{d\phi}{dt} = \frac{\phi_2 - \phi_1}{t} \text{ Wb/sec}$$

Induced e.m.f. per conductor

$$= -d\phi/dt \text{ V}$$

Hence the induced e.m.f. in N conductors,

$$\begin{aligned} e &= -N \cdot \frac{d\phi}{dt} \text{ V} \\ &= -N \frac{\phi_2 - \phi_1}{t} \text{ V} \end{aligned}$$

$$\text{or } e = -N \phi/t \text{ V.}$$

The negative sign in the expression signifies the fact that the induced e.m.f. sets up a current such that the magnetic effect due to the current opposes the very cause producing it [Lenz's law].