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BASIC ELECTRICAL ENGINEERING

Common to all branches

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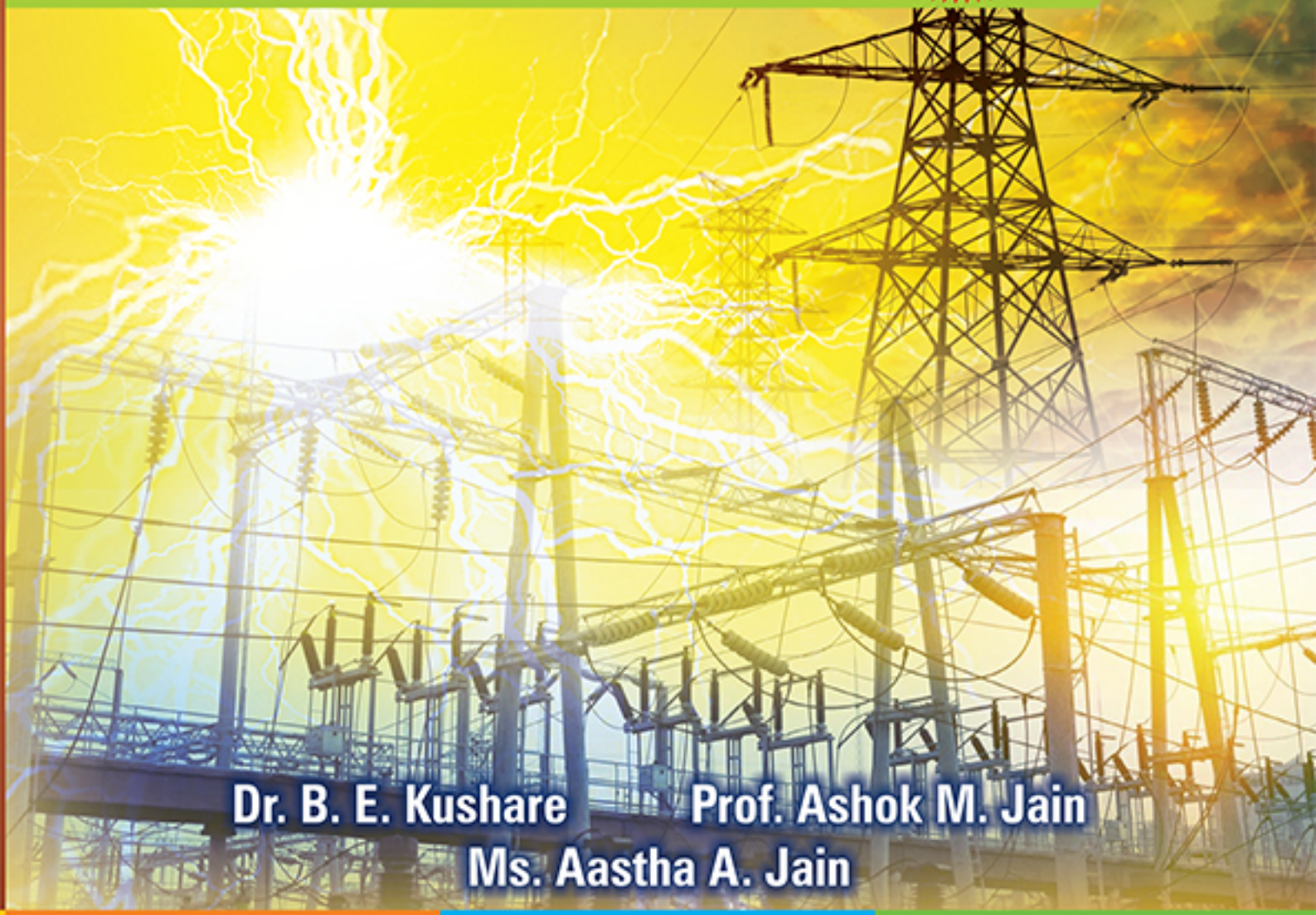

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Ms. Aastha A. Jain

Gigatech Publishing House
Igniting Minds

Basic Electrical Engineering

Semester I & II
First Year Engineering Common to All Branches
As per the new revised syllabus of SSPU. w.e.f. academic year 2012-2013

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First Edition : 2017

Published By –

Gigatech Publishing House

631/32, Budhawar Peth,

Office No. 105, First Floor, Shan Bramha Complex, Pune – 411 002 .

Phone No. 952 952 0952

ISBN NO. : 978-81-934140-64

Price : ₹ 310**/-**

Available at All Leading Book Stalls

Distributor :

PRADEEP BOOK DISTRIBUTORS

102/3, 1ST Floor, Shan Bramha Complex,
Pune. Telephone No. 020 – 24458333,
942 208 7031 / 844 699 5959

E-mail : pbd0909@gmail.com

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Preface

We are delighted to present this book to the students of First Year (all branches) from all the engineering colleges affiliated to the Savitribai Phule Pune University.

Electrical is a mandatory subject for first year engineering students, where almost all the important engineering elements of the subject are covered. This book is written according to the **revised (2012) curriculum** of 'Basic Electrical Engineering '. The aim of writing this book has been to present the material in a concise and simple way so that even weak students can grasp the fundamentals. Each Unit of the book starts with simple introduction and then related topics are covered with required description along with the help of figures. A large number MCQ's and solved problems, properly graded have been added in all units to enable the students to attempt different types of questions in the university examination without any difficulty.

This book has been written after understanding the exact requirement of F.E. (all branches) students thoroughly. We are sure that it will satisfy all the needs of F.E. students from the Savitribai Phule Pune University.

We express our sincere thank to Hon. Prof. M. N. Navale, Founder-President STES, Hon. Dr. (Mrs.) Sunanda M. Navale, Founder- Secretary STES, Hon. Mr Rohit Navale, Vice president (HR), STES and Hon. Mrs. Rachana Navale – Ashtekar, Vice President (Admin), STES as they are constant source of inspiration to us right from the first day of our teaching carrier. We would also like to thanks Principal SCOE, SKNCOE, NBNSOE, SAE, SITS, RMDSOE, SIT, SKNSITS, K.K.W.I.E.E.& R Nasik & Chairman Mr. Balasaheb D. Wagh , K.K. Wagh Education Society, Nashik for their co-operation and support. We would also thank our department colleagues for their suggestions and timely help.

Any suggestions for the improvement of this book will be sincerely acknowledged and incorporated in the next edition.

We are thankful to Mr. Harshal J Potadar and Rohit K Dongare from **Gigatech Publishing House (GPH)** for their continuous support and patience in preparing this book.

SYLLABUS

Unit - I : Elementary Concepts (06 Hrs.)

Prerequisite : Concepts of emf, potential difference, current and resistance. Ohm's law, effect of temperature on resistance, resistance temperature coefficient, insulation resistance. S.I. units of work, power and energy. Conversion of energy from one form to another in electrical, mechanical and thermal systems.

Unit - II : Electromagnetism (06 Hrs.)

Magnetic effect of an electric current, cross and dot conventions, right hand thumb rule and cork screw rule, nature of magnetic field of long straight conductor, solenoid and toroid. Concept of m.m.f., flux, flux density, reluctance, permeability and field strength, their units and relationship. Simple series and parallel magnetic circuits, comparison of electrical and magnetic circuit, force on current carrying conductors placed in magnetic field, Fleming's left hand rule.

Faraday's laws of electromagnetic induction, Fleming's right hand rule, statically and dynamically induced e.m.f., self and mutual inductance, coefficient of coupling, energy stored in magnetic field.

Unit – lll : Single phase Transformers and Electrostatics (06 Hrs.)

A) Single phase transformers : Construction, principle of working e.m.f. equation, voltage and current ratios, losses, definition of regulation and efficiency, determination of these by direct loading method. Descriptive treatment of autotransformers.

B) Electrostatics : Electrostatic field, electric flux density, electric field strength, absolute permittivity, relative permittivity and capacitance. Capacitor, composite dielectric capacitors, capacitors in series and parallel, energy stored in capacitors, charging and discharging of capacitors (no derivation) and time constant.

Unit – IV : AC fundamentals (06 Hrs.)

Sinusoidal voltages and currents, their mathematical and graphical representation, concept of cycle, period, frequency, instantaneous, peak (maximum), average and r.m.s. values, peak factor and form factor. Phase difference, lagging, leading and in phase quantities and phasor representation. Rectangular and polar representation of phasors.

Study of A.C. circuits consisting of pure resistance, pure inductance, pure capacitance and corresponding voltage-current phasor diagrams, voltage-current and power waveforms.

Unit - V : Single Phase A.C. Circuits and Polyphase A.C. Circuits (06 Hrs.)

A) Single phase A.C. Circuits : Study of series and parallel R-L, R-C, R-L-C circuits, concept of impedance, admittance in case of above combinations, wave form and

relevant voltage current phasor diagrams, concept of active, reactive, apparent, complex power and power factor, resonance in series RLC circuit.

B) Polyphase A.C. Circuits : Concept of three-phase supply and phase sequence, balanced and unbalanced load, voltage, currents and power relations in three phase balanced star-connected loads and delta-connected loads along with phasor diagrams.

Unit - VI : D.C. Circuits (06 Hrs.)

Classification of electrical networks. Kirchhoff's laws and their applications for network solutions using loop analysis. Simplifications of networks using series and parallel combinations and star-delta conversions. Energy sources - iedal and practical voltage and current sources. Superposition theorem, Thevenin's theorem.

Recommended by SPPU Text Books and Reference Books

Text Books :

1. Principles of Electrical Engineering by Del. Toro, PHI Learning Pvt. Ltd.
2. Theory and Problems of Basic Electrical Engineering – I. J. Nagrath and Kothari, PHI Learning Pvt. Ltd.
3. Basic Electrical Engineering, V.K.Mchta, S. Chand and Company Ltd., New Delhi.

Reference Books :

1. Electrical Technology – H. Cotton, C.B.S. Publications.
2. A Textbook of Electrical Technology : Volume – I – B. L. Theraja, S. Chand and Comp[any Ltd, New Delhi.
3. Basic Electrical & Electronics Engg. By S. K. Bhattacharya, Pearson.
4. Basic Electrical Engineering. By D. C. Kulshreshtha, Tata Mc Graw Hill.
5. Electrical Technology – Edward Hughes, Pearson.

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CONTENTS

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Unit
1

Elementary Concepts

Syllabus

Prerequisite : Concepts of emf, potential difference, current and resistance. Ohm's law, effect of temperature on resistance, resistance temperature coefficient, insulation resistance. S.I. units of work, power and energy. Conversion of energy from one form to another in electrical, mechanical and thermal systems.

1.1. The Atomic Structure :

All matters are composed of atoms. Matter composed of single type of element is called an element. When different kinds of atoms are combined chemically they form compounds. The atom consists of mainly two parts 1) Nucleus: The centre of the atom called as nucleus, contains protons having positive charges and neutrons which are electrically neutral. Proton has 1837 times as much mass as electrons. 2) The electrons which rotates in orbit around nucleus of the atom in the same manner as the earth rotates around the sun. Electrons have negative charges and no. of electrons are equal to the number of protons in an atom. Therefore, total negative charges. Hence atom is electrically neutral. The electron spins around the nucleus in an elliptical path. As there is a force of attraction between oppositely charged protons & electrons, electron in motion remains associated with nucleus and thus the electrons in motion have kinetic energy.

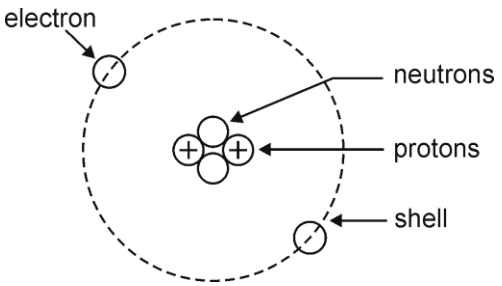


Fig. : 1.1

1.1.1 Electron Energy Levels and Shells :

Electrons associated with nucleus possess two kinds of energy.

1) Each electron is constantly in motion about the nucleus; hence it has energy of motion or kinetic energy.

2) Because of force of attraction between negatively charged electrons and positively charged protons in nucleus, hence electrons posses potential energy. If an electron is nearer to nucleus the greater kinetic energy it possesses. If it is far away from the nucleus the greater potential energy it possesses. Kinetic energy develops force that pulls the electrons away from nucleus and potential energy arises from charge attraction that pulls towards the nucleus. At certain energy level equilibrium is established and the electron goes into the orbit. The atoms of different elements have different number of electrons and protons. As the number of electrons and protons increases their arrangement around the nucleus follow a known pattern with each energy level able to hold only definite maximum electrons. These energy level groups are called as shells, labelled as K, L, M, N, O, P, Q reading from nucleus outwards, each shell (orbit) has a fixed capacity to accommodate electrons. If the number of electrons exceeds the capacity of a particular shell the next shell is occupied. The following relation is valid for determining the number of electrons in first four shells of an atom, but is not generally applicable for atoms containing additional shells $N = 2n^2$ where n is the shell number. Table 1.1 gives maximum number of electrons in a shell.

Shell	**Max. Electrons (N)**
K	$2(1)^2 = 2$
L	$2(2)^2 = 8$
M	$2(3)^2 = 18$
N	$2(4)^2 = 32$
O	18
P	18
Q	2

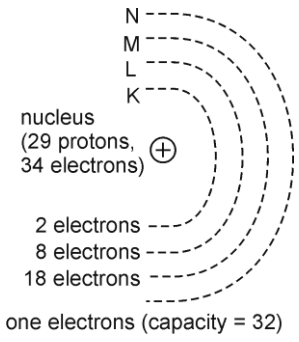


Fig. : 1.2 Diagram of Copper Atom

The outermost shell of an atom is known as valance shell, in case of copper atom, the electrons in valance shell is one, though it has a capacity to accommodate 32 electrons.

1.1.2 Valance Electrons :

The electrons in the outermost shell of an atom are called as valance electrons which are involved in chemical reaction and electric current. The force of attraction between nucleus and electrons decreases as the electrons situated away from nucleus. Thus valance

electrons are held to the nucleus with less force of attraction than the inner shell electrons. Hence valance electrons can be easily removed from the parent atom than the electrons in the inner shells. In general the farther the electrons from the nucleus, the more energy it possesses. Hence valance electrons posses more energy than the inner shell electrons.

1.1.3 Free Electrons :

As we known that valance electrons are associated with parent atom with less force of attraction, and it is at maximum energy level than inner shell electrons. Once valance electrons gain additional external energy sufficient to overcome the force of attraction towards nucleus, it gets temporarily separated from parent atom. **The valance electrons separated from parent atoms are free to wander in a space around the atom, hence are called as free electrons.** Only the valance electrons are capable of becoming free electrons. One way to provide additional energy to free an electron is to heat the atom. The other way is the atom is subjected to an electronic field. In an copper atom the external energy is in the form of heat at room temperature which is sufficient to detach the valance electrons from copper atom. Hence in case of copper material at room temperature large number of free electrons is available which are drifting in random way.

1.1.4 Electricity in Motion :

As from the previous section it is clear that the valance electrons are held with less force of attraction. Whenever the valance electrons will gain additional energy sufficient to overcome the force of attraction towards nucleus, the valance electrons will get separated from parent atom and become free electrons. In case of copper atom, the external energy required to detach the valance electrons from parent atom is available at room temperature. Hence in case of copper at room temperature large number of free electrons are available, moving in a copper material in a random way. Hence in case of isolated copper conductor though large number of free electrons is available at room temperature, but because of their random motion there is no resultant motion of electrons in a specified direction as shown in fig. 1.3. Hence there is no net transfer of charge. Hence to direct the free electrons moving in a random direction some external force is needed. Let us consider a simple arrangement as shown in fig. 1.4. As long as the switch is open there is no resultant motion of electrons in a specified direction. As soon as the switch is closed, the positive terminal (which has deficiency of electrons) of a cell attracts free electrons of copper wire, because of dissimilar charges attract each other. The –ve terminal of the cell has excess of electrons. Hence free electrons in copper wire connected to –ve terminal will experience force of repulsion tending to move the free electrons from –ve terminal of battery through copper wire towards the positive terminal of batter. At the same time equal number of electrons travel within the cell from +ve to –ve terminal of the cell. Thus from the above simple experiment, it is clear that when we connect the cell and complete the circuit the electrons are set in motion. As we know that the electrons

have negative charges, hence motion of electrons within copper conductor are nothing but a transfer of charge (i.e. negative charge) from one point to another point in a circuit. This continuous stream of electrons in a specified direction constitutes electric current. **The direction of flow of electrons is from –ve to +ve terminal, but the conventional direction of current is always considered as being from +ve to –ve terminal.** (Outside the battery as shown in fig. 1.4)

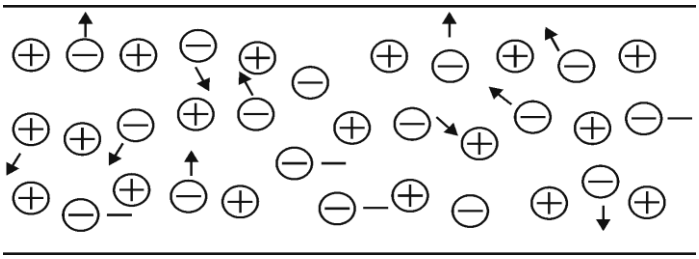


Fig. 1.3 : at room temp. before switching on
free electrons moves in a random fashion.

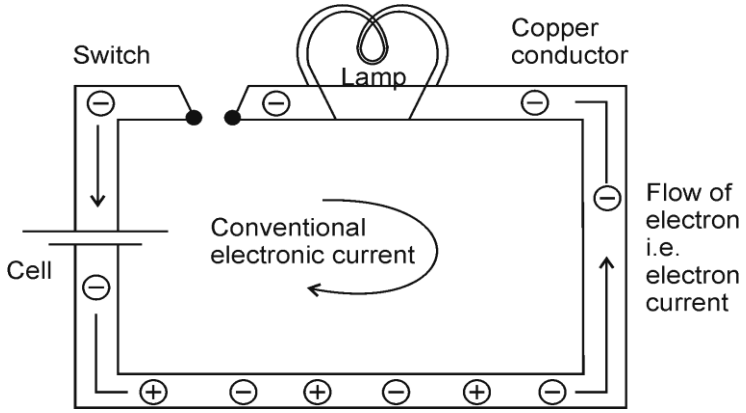


Fig. : 1.4

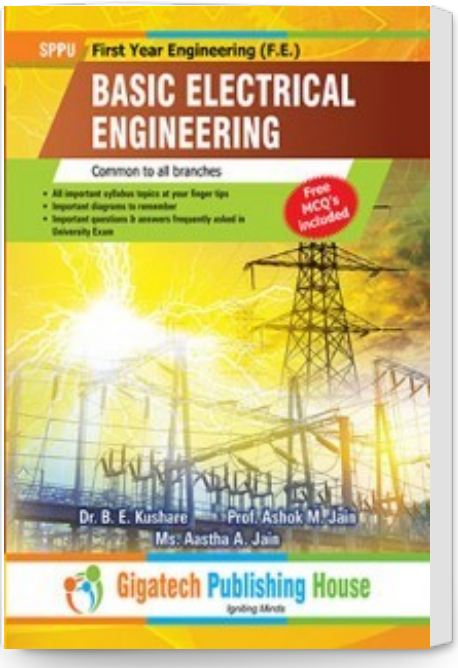
1.1.5 Current :

It is defined as the rate of flow of charged particles in a specified direction. The charged particles may be an electron, a positive ion or a negative ion. In a solid the charged particle is electron.

Electric current exists in a material when there is a net transfer of charge through the material from one region to another region and is measured in terms of the rate at which the charge is transferred past a point per unit time.

$$i = \frac{dq}{dt}$$

Basic Electrical Engineering Semester I And II (Common for all branches)



Publisher : Gigatech Publishing House

ISBN : 9788193414064

Author : B E Kushare, Ashok M Jain And Aastha A Jain