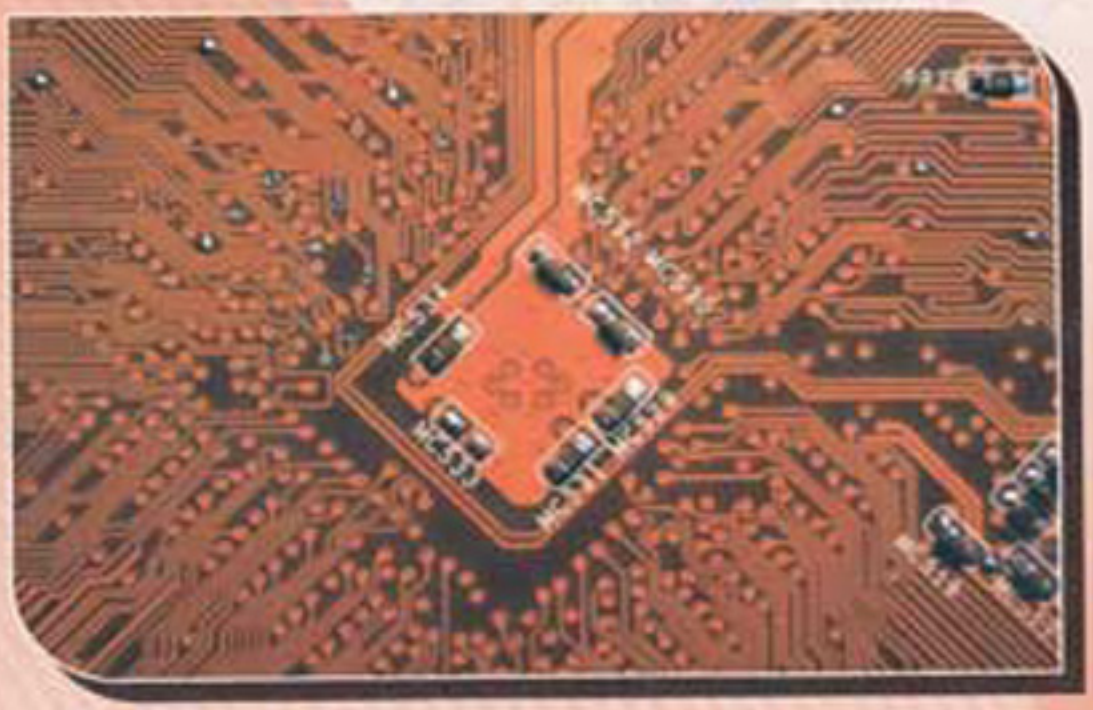
'G' Scheme Semester VI MSBTE

THIRD YEAR DIPLOMA COURSE IN ELECTRICAL ENGINEERING GROUP

POWER ELECTRONICS

2017 EDITION

K. P. AKOLE
K. R. PATIL



NIRALI PRAKASHAN
ADVANCEMENT OF KNOWLEDGE

Text Book Of

POWER ELECTRONICS

SEMESTER VI

FOR

THIRD YEAR DIPLOMA IN ELECTRICAL ENGINEERING GROUP

As Per MSBTE's 'G' Scheme Syllabus

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Dedicated to

My Father and Mother

Akole K. P.

Preface ...

With tremendous advancement in Power Electronics since last few decades a number of semiconductor devices have come up in power electronic field. This rapid development made significant change in the field of electrical engineering. The field of electrical engineering is generally segmented into three major areas Electronics, Power and Control. The function of power electronics is to process and control the electrical energy by supplying voltage and current in a form that is optimally suited to the load. **Power Electronics** plays a vital role in many domestic and industrial appliances. Electrical machines are controlled by power electronics. Various conventional controls and relays are replaced by electronic system consisting of power electronic circuits.

Power electronics is popular for technical as well as economical reasons. Electrical power generation, transformation, transmission and distribution are in A.C. but almost all terminal equipments used in industries, laboratories, agriculture and domestic require D.C. power. In order to satisfy these requirements, easy conversion of power is essential. Power electronics provides solution for all such requirements.

By considering these facts, power electronics subject is included in the curriculum of degree and diploma engineering in Electrical and Electronics Engineering group. This book is intended for imparting fundamental knowledge to diploma students of electrical and electronics engineering group for studying power electronics related subjects such as power electronics and drives, industrial electronics, power electronics etc. This book is mainly designed as per the semester pattern curriculum for sixth semester diploma in electrical engineering group. This book is an outcome of the author's realization of the fact that the important subject power electronics must be learnt by the students with clarity and ease. It is written in a simple straightforward style, emphasizing the core concepts underlying various power electronic circuits without deriving complex mathematical

equations. This book is expected to serve as a student friendly text to students of electrical and electronics engineering diploma programme.

The book is divided into five chapters. The book begins with introductory chapter related to power electronic devices with main focus on SCR. The next three chapters explain basic concepts of converter, inverter and chopper circuits. The last chapter is devoted to the discussion on the concept of D.C. and A.C. drives. Power electronic applications are also discussed in last chapter. At the end of each chapter, few review questions are given for self feedback. Sample test papers and end semester examination sample papers are included for practice purpose.

Every care has been taken to check mistakes and misprints. Yet it is very difficult to claim perfection. Any constructive criticism and suggestions from professionals, teachers and students are most welcome that help us in improving this book.

Authors

Acknowledgement

Authors are very much thankful to Dineshbhai Furia of Nirali Prakashan and Shri P. M. More whose inspiration and constant motivation are responsible for producing this book within a short period of time. Authors are also very much thankful to Shri Jigneshbhai Furia who has contributed quite a lot for this publication. In fact the entire staff of Nirali Prakashan especially Mr. Santosh Bare, Mr. Kiran Velankar and Mrs. Prachi Sawant has put in a lot of efforts for producing this book. We cannot express their efforts in words.

We hope that this book will prove to be useful to all readers. Any errors, omissions and suggestions for the improvement of this book, brought to our notice will be thankfully acknowledged and incorporated in the next edition.

Authors

Prof. K. P. Akole

Prof. K. R. Patil

Syllabus

1. INTRODUCTION TO POWER ELECTRONICS (10 Hrs., 20 Marks)

- Necessity of power conversion using solid state devices
- Applications of power electronics
- Thyristor family
  - ✤ Characteristics and symbolic representation of SCR, DIAC, TRIAC, GTO, SUS, LASCR, IGBT
- SCR : Construction, operation, two transistor analogy
- Triggering methods of SCR
  - ✤ Voltage triggering
  - ✤ dv/dt triggering
  - ✤ Light triggering
  - ✤ Gate triggering
    - – DC gate triggering
    - – AC gate triggering
    - – Pulse gate triggering
- SCR turn-off process with waveforms of voltage and current
- SCR specifications/ratings : Voltage, current, power, temperature
- SCR selection factors
- SCR testing

2. CONVERTERS (12 Hrs., 20 Marks)

- Necessity of converters
- Concept of firing angle and conduction angle
- Single-phase full-controlled half wave converter
  - – With resistive load
  - – RL load without freewheeling diode
  - – RL load with freewheeling diode
- Single-phase full wave controlled converter
  - – With resistive load
  - – With RL load
- Single-phase fully controlled bridge converter
  - – With resistive load
  - – With RL load
- Three-phase fully controlled bridge converter
  - – With resistive load
  - – With RL load
- Three-phase fully controlled bridge converter
  - – With R load
- Comparison of 3ϕ and 1ϕ converters on the basis of efficiency, ripple factor, RMS values and average values
- Effect of source impedance on converter operation
- Cycloconverters : 1ϕ - Principle of operation, input and output waveforms.

3. INVERTERS (14 Hrs., 20 Marks)

- Need of inverter
- Classification :
  - 1ϕ and 3ϕ inverters
  - Line (natural) commutated inverters
  - Forced commutated inverters : Series, parallel and bridge inverters (circuit, description and waveforms)
- Series inverters : Operation of basic series inverter, modified series inverter, three-phase series inverter
- Parallel inverters : Operation of basic parallel inverter circuit
- Single-phase bridge inverter
  - Half bridge inverter
  - Full bridge inverter
- Voltage and frequency control of 1ϕ inverter
  - Necessity of control of output voltage
  - Methods for output voltage control : External control of DC voltage, external control of AC voltage and internal control
  - Pulse width modulation (PWM) method : Single pulse width modulation, multiple pulse width modulation, sinusoidal pulse width modulation
- Waveform control (Harmonic reduction) : Single pulse width modulation, transformer connections, using filter (LC, resonant).
- Concept of MOSFET inverter and comparison with thristor based inverter

4. CHOPPERS (10 Hrs., 16 Marks)

- Chopper principle
- Control techniques : Constant frequency system, variable frequency system
- Classification of choppers : Class A, class B, class C, class D, class E
- Communication methods of choppers : Auxiliary commutation, load commutation
- Jones chopper
- Step-up chopper

5. APPLICATIONS OF POWER ELECTRONICS (18 Hrs., 16 Marks)

5.1 DC Drives

- Speed control of DC series motor with 1ϕ half and full control converter, step u and step down chopper

5.2 AC Drives

- Speed control of 3ϕ induction motor
  - Variable frequency control : Voltage source inverter, current source inverter, cycloconverter
- Other applications : Circuit diagram, operation
  - Static circuit breaker (DC and AC)
  - Induction heating control
  - Dielectric heating control
  - Electric welding control
  - Battery charger control
  - Automatic street lighting circuit using SCR
  - Static VAR compensation system
  - Closed loop speed control method for DC and AC servo motors

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Contents ...

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Chapter 1

INTRODUCTION TO POWER ELECTRONICS

Weightage of Marks = 20, Teaching Hours = 10

Objectives

After learning this chapter, we will be able to

1. State purpose of power conversion.
2. List application areas of power electronics.
3. Select specific thyristor device for required applications.
4. State meaning and importance of power electronics in electrical field.
5. Sketch symbol and constructional diagram of SCR, identify the terminals.
6. Compare planar and mesa SCR.
7. Sketch and illustrate transistor analogy of SCR.
8. Plot and explain V-I characteristics of SCR.
9. Define break over voltage, latching current, holding current.
10. Understand the process of thyristor triggering methods such as voltage triggering, gate triggering, dv/dt triggering and light triggering.
11. Classify commutation methods and state working principles of various commutation methods.
12. State specifications of SCR and SCR selection factors.
13. Sketch symbol and V-I characteristics of thyristor family devices such as DIAC, TRIAC, SUS, SCS, SBS, LASCR, PUT, GTO, IGBT.

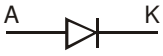
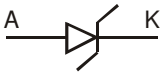
1.1 REVIEW OF ELECTRONIC COMPONENTS

- To understand power electronic devices and circuit, it is essential to have knowledge about basic electronic components.
- Two main categories of electronic components are (a) Passive components, (b) Active components.
- Passive component's working does not depend on external biasing supply.
- Examples of passive components are resistor, capacitor and inductor.

- For the operation of active component, external biasing supply is essential. Examples of active components are diode, BJT, FET, UJT etc.
- Electronic devices can be classified as tube devices and semiconductor devices.
- In early days of electronics (1900 to 1940) tube devices were most commonly used. Tube devices are further classified as vacuum tube devices and gas filled tube devices.
- Vacuum tube diode, triode, CRT (Cathode Ray Tube) are few examples of vacuum tube devices. Vacuum tube devices are operated using 'thermionic emission' i.e. emission of electrons due to heating of cathode.
- Thyratron, ignitron, mercury arc rectifier, nixie tube, neon lamp are from gas filled tube device category.
- 'Gas ionization' is the basic working principle of gas filled tube devices i.e. gas ionization occurs due to applied potential.

  Semiconductor components are also known as solid state components. Semiconductor materials are having specific electrical conductivity between that of good conductor and that of good insulator.
- Their ability of carrying electrical current can be enhanced by the addition of certain chemical impurities.
- Semiconductor materials in pure form are called as intrinsic semiconductors.
- The most commonly used semiconductor is Si and the less frequently used is Ge.
- The process of addition of impurity material to pure semiconductor is called as doping.
- Due to addition of impurity, impure semiconductor is formed. This impure semiconductor is called as extrinsic semiconductor.
- Two types of extrinsic semiconductors are P-type semiconductor and N-type semiconductor.
- By using these extrinsic semiconductors, various electronic devices are manufactured. Table 1.1 shows symbol, terminal names and applications of basic semiconductor devices.

Table 1.1

Device	Symbol	Applications
P-N Junction Diode		1. Rectifier 2. Clipping circuit 3. Clamping circuit 4. Digital circuit
Zener Diode		1. Voltage regulation 2. Meter protection 3. Over voltage detection 4. Battery charger

… Contd.

Power Electronics

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