

# Preface

## Overview

The demand for the generation and transmission of large amounts of electric power today, necessitates transmission at extra-high voltages. In developed countries like the USA, power transmission voltages have reached 765 kV to 1100 kV, and 1500 kV systems are also being built. In our country, 750 kV ac power systems have already come into operation, and in another 10 years' time, every state is expected to be linked by a National Power Grid operating at 750 kV to 1100 kV.

## Target Audience

In the current industrial scenario, a practicing electrical engineer or a student of electrical engineering is expected to possess knowledge of high-voltage techniques and should have sufficient background in high-voltage engineering. Unfortunately, at present, very few textbooks in high-voltage engineering are available, compared to those in other areas of electrical engineering. Even among these, no single book has covered the entire range of topics in high-voltage engineering in depth and presented the material in a lucid manner. Therefore, an attempt has been made in this book, to bring together different topics in high-voltage engineering to serve as a single-semester course for final-year undergraduate students or postgraduate students studying Electrical Engineering, Electronics Engineering, and Applied Physics.

This book is also intended to serve power engineers in the industry who are involved in the design and development of electrical equipment as well as engineers in the electricity supply and utility establishments. It provides all the latest information on insulating materials, breakdown phenomena, overvoltage, and testing techniques. It is useful for self-study by engineers in the field of electricity utilities and design, development testing of electrical apparatus, transmission line hardware, particle acceleration, etc.

## About the Book

The material in this book has been organized into five sections, namely

- (i) insulating materials and their applications in electrical and electronic engineering,
- (ii) breakdown phenomena in insulating materials—solids, liquids, and gases,
- (iii) generation and measurement of high dc, ac, and impulse voltages and currents,
- (iv) overvoltage phenomena in electrical power transmission systems and insulation coordination, and
- (v) high-voltage testing techniques, testing of apparatus and equipment, and planning of high-voltage laboratories.

Much of the information on these topics has been drawn from standard textbooks and reference books and have been simplified and reorganized to suit the needs of the students and graduate engineers. Many research publications have also been referred to, and relevant standard specifications have been quoted to help the reader gain easy access to the original references.

## Salient Features

- Includes latest industry inputs on HV Construction Kits
- HVDC Systems and Testing expanded to cover the updates in technology, such as
  - Surge Arresters for EHV systems
  - HVDC Divider for HVDC Transmission Systems
  - Testing of HVDC valves and systems
- Dedicated chapter on *Design, Planning and Layout of High-Voltage Laboratories*
- Pedagogy enhanced and revised to suit examination requirements:
  - 47 Worked Examples
  - 14 Short-Answer Questions
  - 140 Review Questions
  - 34 Problems
  - 199 Multiple-Choice Questions

## Chapter Organization

The text is organized in 11 concise chapters.

**Chapter 1** introduces the basic concepts of high-voltage engineering and includes numerical methods for electric field computations (viz., FEM, CSM, BEM techniques)

**Chapter 2** is on conduction and breakdown in gases and has been revised to include the basics of collisions processes; breakdown phenomenon in SF<sub>6</sub> and SF<sub>6</sub>—air mixtures. This chapter also has a completely revised section on Paschen's Law with supporting problems.

**Chapter 3** is on conduction and breakdown in liquid dielectrics and contains information on the recent developments in liquid insulents.

**Chapters 4 and 5** are on breakdown in solid dielectrics and applications of insulating materials respectively, and incorporate the latest solid insulating materials and their applications in electric power apparatus.

**Chapter 6** discusses the generation of high voltages and currents, while **Chapter 7** deals with measurement of high voltages and currents. This chapter also explains electric field ( $E$ ) measurements, field intensity meters, impulse test and measuring systems.

**Chapter 8** is on overvoltage phenomenon and insulation coordination in electric power systems. Over voltages and testing of Gas Insulated Substation (GIS) has been added in this edition (chapters 5 and 8).

**Chapter 9** discusses non-destructive testing of materials and electric apparatus, and **Chapter 10** is on high-voltage testing of electric apparatus.

Finally, **Chapter 11** is on design, planning and layout of high-voltage laboratories. It also includes the recent developments in HV testing laboratories and includes a brief description of the UHV laboratory, CPRI, Hyderabad. Details of high-voltage laboratories across the world have also been made up-to-date. (Table 11.6).

**Further testing of HVDC Valves and equipment is added in the present edition.**

This edition offers almost 100 fresh problems in different sets such as multiple-choice questions, review questions, solved and unsolved problems to help students in self-study and understanding. Updates in the text have been made wherever necessary.

## Online Learning Centre

The text is accompanied by an exhaustive Online Learning Centre which can be accessed at <http://www.mhhe.com/hve5>

It contains the following material:

### *For Students*

- Interactive Quiz
- Useful Web links for further reading

### *For Instructors*

- Solution Manual (for selected problems)
- PowerPoint Slides with figures from text

## Acknowledgements

First, the authors wish to express their gratitude to all the reviewers who took out time to review the book.

The authors acknowledge, with thanks, for the permission given by

- Central Power Research Institute, UHV Laboratory, Hyderabad, to refer to the details of their institute
- Ms Emile Haefely and Co. Ltd., Switzerland, to include the photographs of their equipment
- MWB HV TEST SYSTEMS, Bangalore

The authors express their sincere gratitude to the Director, Indian Institute of Science, Bangalore, and Vice Chancellor, Jawaharlal Nehru Technological University, Hyderabad, for their constant encouragement.

It is hoped that students, readers, academicians and engineers will continue to favor and patronize the book.

## Feedback

Suggestions for further improvement of the book are welcome and every effort will be made to incorporate them in the next edition.

**(Late) M S Naidu and V Kamaraju**

## **Publisher's Note**

Do you have any further request or a suggestion? We are always open to new ideas (the best ones come from you!). You may send your comments to

[tmh.elefeedback@gmail.com](mailto:tmh.elefeedback@gmail.com)

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