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Dedicated to

Saroj, Sheetal and Chetan

FOREWORD

There has been a long-felt need of a book giving comprehensive and systematic information of "Switchgear and Protection and Power System Studies". The author is to be congratulated for fulfilling this need by publishing a book. I am proud that Shri Sunil S.Rao, the author of the book, is an old student of mine and I am very happy to write this foreword.

The author has a brilliant academic career and holds a first class B.E. degree in Electrical Engineering of Karnataka University and a first class M.E. degree in 'Power Systems' of Poona University. He has good practical experience in many of the reputed Electrical Firms and Organisations like Hindustan Brown Boveri Ltd., Baroda, Kirlosker Electrical Co Ltd, Bangalore, State Electricity Boards of Karnataka and Maharashtra etc. He is working at Maulana Azad Regional College of Technology, Bhopal, as a lecturer in Electrical Engineering, and has been teaching "Switchgear Protection and Power Systems".

The author has presented the subject matter in five sections, spread over 59 chapters. **Section I** deals with principles of current interruption, constructional and operational aspects of various circuit breakers including SF_6 circuit breakers, vacuum circuit breakers, and discusses about the choice, erection, maintenance and testing of high voltage/low voltage switchgear and EHV apparatus.EHV A.C. Transmission and HVDC transmission.

Section II deals with fault current calculations, role of network analysers and digital computers in the calculation of fault current of complicated system networks.

Section III deals with constructional and operational aspects of electromagnetic protective relays and protective systems for generators, transformers, motors and transmission lines.

Section IV deals with fundamentals of static relays and static protection schemes.

Section V deals with advanced topics in power system controls, applications of digital computer and microprocessors for load- frequency control and back-up protection, Power-System Stability, Load Frequency Control, Voltage control and compensation of Reactive Power, Voltage Stability, Power System Network Automation have been explained.

The matter is presented in a very lucid style and simple English. The book is profusely illustrated by neat, clear sketches and diagrams and graphs. The author is to be congratulated for having consulted the leading technical journals in the field and presenting the information regarding "Switchgear Protection and Power Systems" up-to-date, in his book. The author has exhibited a mature art of teaching in the presentation of the subject matter inspite of his short teaching experience. Some typical solved problems are given throughout the book.

With addition of some unsolved problems, summary and provocative questions at the end of each chapter, the book may serve as a text book in universities for a course in "Switchgear Protection and Power Systems" in the under-graduate and postgraduate curriculum. The book should also serve as a useful guide and reference to Power Engineers, considering the volume of practical information it provides.

I am very proud of the young author and express my sincere thanks to him for giving me the privilege of writing the Foreward to this book of his.

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PREFACE TO THE THIRTEENTH EDITION

The widespread acceptance of the earlier Editions promoted this revised and enlarged edition. The book presents in-depth knowledge about the principles and practices of modern power system engineering. It gives an integrated approach to the complex phenomena related with Switchgear, Protection, Fault-Calculations, Power System Analysis-Operation-Control-Automation, Digital relays, Micro-processor based Relays and Microprocessor based Integrated Control and Protection Systems, Energy Systems.

The book will serve as a regular text book for electrical engineering courses to prepare the students for the careers in power sector. The book will also serve as a reference book to electrical engineers working in power sector, electrical manufacturing industry, academic and testing institutions, etc.

Since the publication of the first edition of the book Switchgear and Protection in 1973, many advances have occured in field of the Switchgear, Protection and Power System Automation. While the conventional protection and switching devices will continue to serve, entirely new type of devices and techniques are now available. The development of SF_6 and Vacuum circuit-breakers have made the other types nearly obsolete. The static relays have replaced the electro-mechanical relays. EHV-AC and HVDC transmission are now commercially successful. Large interconnected networks are being automatically controlled from load control centres by means of on-line SCADA, AGC and EMS Systems. The developments in power electronics have resulted in the successful use of static VAR Sources (SVS), HVDC Convertors etc. Digital computers and microprocessors are being increasingly used for protection and automation. Fibre-optic cables have been successfully used for data transmission.

Due to the energy crisis and increasing capital costs of power projects, there is a world-wide trend towards interconnecting adjacent AC Networks by means of EHV-AC or HVDC links.

The techniques of testing and maintenance have advanced with an aim of increased reliability and availability of electrical power supply. Knowledge of specifications, testing, maintenance, commissioning has gained significance. The power system analysis techniques have also advanced significantly.

India and other developing countries have ambitions development plans in power sector. Some landmarks in the power sector of India include indigenous capability of design, manufacture and commissioning of EHV-AC Sub-stations and apparatus, establishment of 400 kV. AC network, introduction of HVDC Systems, interconnections between Regional Grids, introduction of static relays and static protection systems, increasing use of digital computers and microprocessors, expansion of testing facilities, etc.

The technology of protection and automation have been revolutionised by the introduction of microprocessor based combined protection, control, monitoring systems. Such systems have been introduced for substation protection, generator protection, HVDC protection. This book covers the principles and applications of this latest technology and the important topics in Interconnected Power Systems. The new chapters include EHV-AC Transmission, HVDC Transmission Systems, Interconnections, Power System Automation with SCADA Systems, Power System Planning, Latest Power map of India, Microprocessor based Protection. Energy Technology-Renewable and Nonconventional and Conventional. The Corelation between Energy Sector and Power sector has been illustrated.

Chapters on Power system Calculations and Load Flow Studies, The principles and procedures of network calculations and load flow studies have been simplified and explained by a few solved examples. `Recent Advances' in Intelligent Circuit Brea kers, Fiber-optic Cable Applicaions, Compact Intelligent Substations, ISO-9000 and TQMI are covered in Appendix-A, while Appendix-B highlights overall system description of Distribution Management System.

The patronage of Academic Institutions and Power System Engineers to this book is hereby gratefully acknowledged.

— Author

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SECTION II - FAULT CALCULATIONS