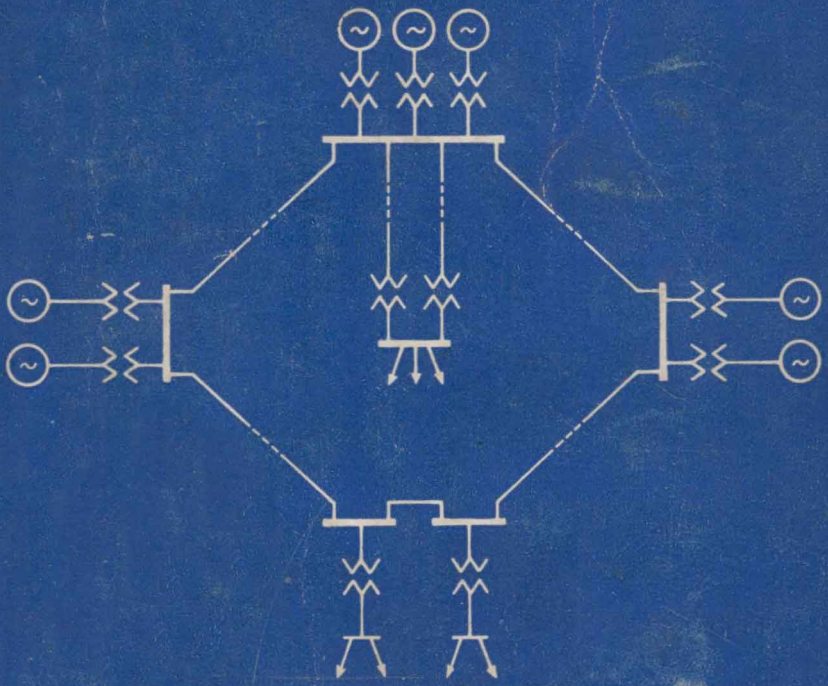
Electrical Power System



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ASHFAQ HUSAIN

PREFACE

This book has been designed as a textbook for the engineering degree, diploma, AMIE or equivalent examinations in Electric Power System in India and abroad. It will also be useful to students preparing for various competitive examinations. It is equally helpful to practising engineers to understand the theoretical aspects of their profession.

The book includes the recent rapid developments that are taking place in the field of Electric Power Systems which are not at present readily available in a single text-book because of the diversity of the topics. The present book brings many widely varied topics together to cater for the needs of revised syllabi of engineering and competitive examinations. Besides, this book bridges the gap between old and new concepts in Electric Power Systems Engineering. The text lays emphasis on the basic concepts and at the same time introduces modern methods of solution of power system problems.

The book is divided into twenty-three chapters. Each chapter is self-contained and is dealt with comprehensively. The subject matter in each chapter has been developed systematically from basic principles using the S.I. system of units. Generalized approach has been given in treatments. Matrix analysis is used wherever necessary. The technical information available on the topics is uptodate.

The chapters on 'Conductors', 'Insulators' and 'Power Cables' are written specially with a view to put before the reader recent developments in this important field which has not attracted much attention by previous authors. Clear diagrams and photographs are given for better understanding. The concepts of GMD and GMR which are necessary for handling calculations for lines having any conductor configuration are clearly discussed. Performance of short, medium and long lines is adequately explained. The chapter on 'General Network Constants' gives the performance calculations of transmission lines by general methods. It emphasizes a unified approach to the problems instead of various partial solutions. The subject matter on Power Circle diagrams covers analytical as well as graphical methods to demonstrate clearly the actual performance of lines.

In view of the importance of High Voltage Direct Current (HVDC) transmission in the present juncture of technological development

in the subject, a chapter on Power Transmission by Direct Current is included in the text.

The mechanical performance of overhead lines under various operating conditions is fully discussed. The chapters on Load Flow Studies and Economic Operation of Power Systems are meant to introduce the basic aspects of the problems involved in this area.

Throughout the text, the importance of extra high voltage transmission of energy is discussed in detail. Recent developments regarding the choice of next higher voltages, standardization of transmission voltages are presented. One full chapter is devoted to the comprehensive treatment of Corona. Emphasis has been laid on generalized treatment of fault analysis instead of partial solutions.

The chapters on 'Travelling Voltage Surges', and 'Power Systems Stability' have been discussed exhaustively.

The numerous illustrative examples enhance the utility of the text and make it easy for the beginner to thoroughly grasp the presentation of the theory. The worked-out examples are very carefully selected in the text to illustrate the practical applications. Most simplified methods of solving the problems are given. In most cases, the worked-out examples illustrate the technique of solving problems. At the end of each chapter a large number of representative numerical examples of wide variety have been included for practice. Many of them have been selected from the past examination papers of standard institutions. The problems are of practical nature.

A Bibliography has been given at the end of the book for those interested in further reading.

While utmost care has been exercised to eliminate misprints and errors, the author would feel obliged to have mistakes brought to his notice. He would welcome any comments and suggestions for the improvement of book.

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INTRODUCTION

1.1. IMPORTANCE OF ENERGY

From the very outset energy has played a vital role in the development of civilization. There has been a universal basic drive towards better living through expanded utilization of energy. The history of civilization shows a close relationship between the utilization of energy and the process of mankind. The degree of utility of energy is the symbol of the progress of a country.

Energy consciousness in the people has created interest in them to tap new sources of energy from time to time. Of the various forms so far discovered the electrical energy has contributed a lot to the world's energy requirements.

1.2. ADVANTAGES OF ELECTRICAL ENERGY

Electrical energy is the most refined form of energy. The advantages derived from electrical energy are many in number. Some of its important advantages over other forms of energy are :

1. It can be generated in large quantities at comparable cost with other types of energy.
2. It can be conveniently transmitted over long distances.
3. It can be utilized efficiently in a number of processes requiring energy.
4. It has got maximum flexibility and has most sensitive susceptibility to control.

1.3. SOURCES OF ELECTRICAL ENERGY

The energy requirements have also increased due to rapid growth of the world's population. Therefore, it has become essential to harness more power resources with utmost economy so as to keep pace with the requirements of the world's population.

The main resources of generating power on large scale are steam,

water, diesel, oil and nuclear energy. Other possible sources of electrical power are solar radiation, tidal and wind power. Magnetohydrodynamic (MHD) generation of power by direct conversion of heat energy to electrical energy is drawing a great attention of experts in recent times. The choice of a particular method of generating power largely depends upon the technical and economical considerations. The generation of power by steam is common at places where there is abundance of supply of coal, oil or natural gas. Diesel power stations are preferred in countries rich in oil. Hydroelectric generation of power is adopted in hilly areas where water resources are in abundance and the rainfall is heavy. In countries where other resources are limited nuclear power generation has to be adopted.

The site of the power station depends upon the type of power station. The present trend is to install bigger sizes of alternators to generate large amount of power to cater the required increasing demand. Thermal power stations are being constructed at pit heads (near the coal mines). The site of hydropower stations is governed by the place of available water. The capital cost of thermal station is comparatively less than that of hydro station. It becomes necessary to use nuclear energy for generation of power at places where coal supply is not sufficient and at the same time hydro potential is not adequate to cope up with the demands. This is the problem in India also. It is necessary under the present circumstances to develop nuclear energy in India. With the development of nuclear energy India's industrial progress will be rapid.

1.4. INTERCONNECTION

Two or more generating stations are interconnected by tie lines. Interconnection of generating stations enables the mutual transfer of power as desired. It permits the generation of energy at the most efficient and cheapest stations at every time. If there is a major breakdown of a generating unit in an interconnected system there is no interruption of service. Similarly, when a machine is taken out of service for its scheduled maintenance and inspection, the continuty of supply is maintained. In other words, the planning of plant outages for maintenance and repair work is facilitated. The standby reserve generating capacity is reduced for the interconnected system. The size of the biggest unit is not related to peak load of an individual system but it relates to the peak load of the interconnected system. Thus, fewer but larger machines of greater efficiency are to be installed. This reduces the fixed charges, operating cost and cost of energy generated. Thus, interconnection provides the best use of power resources and ensures greater security of supply. An interconnected power system covering a major portion of a country's territory is called a *grid*.