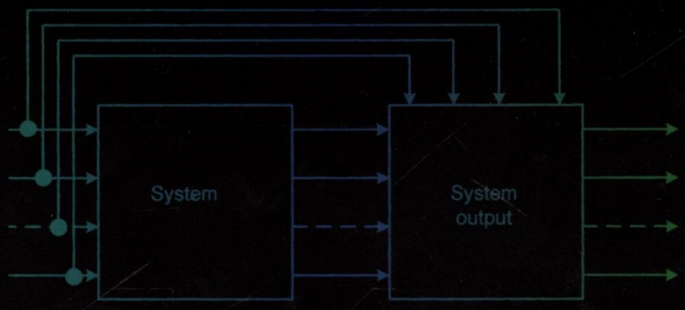

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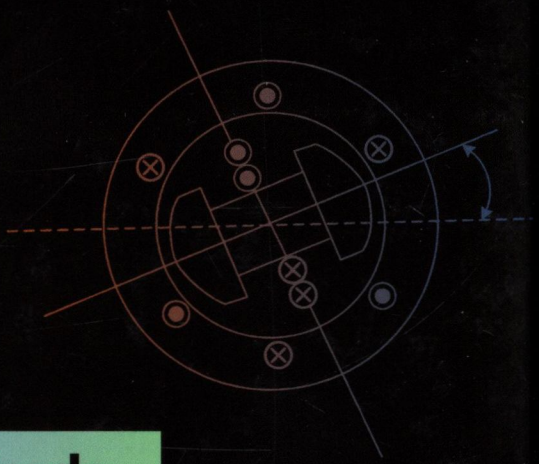

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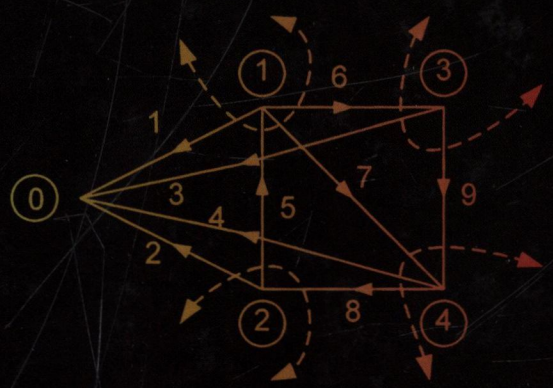

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Power Systems Handbook - Volume 1

Short-Circuits in AC and DC Systems

ANSI, IEEE, and IEC Standards

This book provides an understanding of the nature of short-circuit currents, current interruption theories, circuit breaker types, calculations according to ANSI/IEEE and IEC standards, theoretical and practical basis of short-circuit current sources, and the rating structure of switching devices. Short-circuit studies are the initial studies that are conducted for a power system. The book explains the nature of short-circuit currents, the symmetrical components for unsymmetrical faults, and matrix methods of solutions, which are invariably used on digital computers. It includes innovations, worked examples, case studies, and solved problems.

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Volume 1

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Power Systems Handbook

Short-Circuits in AC and DC Systems

ANSI/IEEE and IEC Standards

Volume 1

Power Systems Handbook

Series Author
J.C. Das
Power System Studies, Inc., Snellville, Georgia, USA

Volume 1: Short-Circuits in AC and DC Systems:
ANSI, IEEE, and IEC Standards

Volume 2: Load Flow Optimization and Optimal Power Flow

Volume 3: Harmonic Generation Effects Propagation and Control

Volume 4: Power System Protective Relaying

Series Preface

This handbook on power systems consists of four volumes. These are carefully planned and designed to provide state-of-the-art material on the major aspects of electrical power systems, short-circuit currents, load flow, harmonics, and protective relaying.

An effort has been made to provide a comprehensive coverage, with practical applications, case studies, examples, problems, extensive references, and bibliography.

The material is organized with sound theoretical base and its practical applications. The objective of creating this series is to provide the reader with a comprehensive treatise that could serve as a reference and day-to-day application guide for solving the real-world problem. It is written for plasticizing engineers and academia at the level of upper-undergraduate and graduate degrees.

Though there are published texts on similar subjects, this series provides a unique approach to the practical problems that an application engineer or consultant may face in conducting system studies and applying it to varied system problems.

Some parts of the work are fairly advanced on a postgraduate level and get into higher mathematics. Yet the continuity of the thought process and basic conceptual base are maintained. A beginner and advanced reader will equally benefit from the material covered. An underground level of education is assumed, with a fundamental knowledge of electrical circuit theory, rotating machines, and matrices.

Currently, power systems, large or small, are analyzed on digital computers with appropriate software. However, it is necessary to understand the theory and basis of these calculations to debug and decipher the results.

A reader may be interested only in one aspect of power systems and may choose to purchase only one of the volumes. Many aspects of power systems are transparent between different types of studies and analyses—for example, knowledge of short-circuit currents and symmetrical component is required for protective relaying and fundamental frequency load flow is required for harmonic analysis. Though appropriate references are provided, the material is not repeated from one volume to another.

The series is a culmination of the vast experience of the author in solving real-world problems in the industrial and utility power systems for more than 40 years.

Another key point is that the solutions to the problems are provided in Appendix D. Readers should be able to independently solve these problems after perusing the contents of a chapter and then look back to the solutions provided as a secondary help. The problems are organized so these can be solved with manual manipulations, without the help of any digital computer power system software.

It is hoped the series will be a welcome addition to the current technical literature.

The author thanks CRC Press editor Nora Konopka for her help and cooperation throughout the publication effort.

—J.C. Das

Preface to Volume 1: Short-Circuits in AC and DC Systems

The first three chapters of this volume—design and analyses concepts of power systems, modern electrical power systems, and wind and solar power generation—are of a general nature applicable to this series.

Short-circuit studies are the very first studies that are conducted for a power system. It is important to understand the nature of short-circuit currents, the symmetrical components for unsymmetrical faults, and matrix methods of solutions that are invariably used on digital computers. This material is covered in Chapters 4, 5, and 6. A long-hand calculation of unsymmetrical fault current even in a simple system in Chapter 5 shows the complexity of such calculations and paves the way for discussions of matrix methods in Chapter 6.

A description of the AC current interruption process is provided in Chapter 7. An understanding is important to appreciate the interruption of various types of short-circuit currents, overvoltages, TRV, restrikes, and multiple reignitions in circuit breakers. This is followed by Chapter 8, which details the rating structures of circuit breakers and fuses according to ANSI/IEEE standards. The major short-circuit contributing sources are synchronous generators and rotating motors. Their models are developed using Park's transformation and circuits of a unit machine followed by their behavior on short circuit and the resulting decaying transients.

Chapters 10 and 11 detail the methodology of short-circuit calculations using ANSI/IEEE and IEC standards. There are conceptual and analytical differences in the calculations illustrated with real-world examples. Chapter 12 is devoted to the short-circuit currents in DC systems.

This book, therefore, provides an understanding of the nature of short-circuit currents, current interruption theories, circuit breaker types, calculations according to ANSI/IEEE and IEC standards, theoretical and practical basis of short-circuit current sources, the rating structure of switching devices, and the short-circuit currents in DC systems. This volume covers a wide base of short-circuit current in the power systems and can be considered a treatize on this subject of practical and academic value.

—J.C. Das

Author

J.C. Das is an independent consultant, Power System Studies, Inc. Snellville, Georgia. Earlier, he headed the electrical power systems department at AMEC Foster Wheeler for 30 years. He has varied experience in the utility industry, industrial establishments, hydroelectric generation, and atomic energy. He is responsible for power system studies, including short circuit, load flow, harmonics, stability, arc flash hazard, grounding, switching transients, and protective relaying. He conducts courses for continuing education in power systems and is the author or coauthor of about 70 technical publications nationally and internationally. He is the author of the following books:

- *Arc Flash Hazard Analysis and Mitigation*, IEEE Press, 2012.
- *Power System Harmonics and Passive Filter Designs*, IEEE Press, 2015.
- *Transients in Electrical Systems: Analysis Recognition and Mitigation*, McGraw-Hill, 2010.
- *Power System Analysis: Short-Circuit Load Flow and Harmonics*, Second Edition, CRC Press 2011.
- *Understanding Symmetrical Components for Power System Modeling*, IEEE Press, 2017.

These books provide extensive converge, running into more than 3000 pages, and are well received in the technical circles. His interests include power system transients, EMTP simulations, harmonics, passive filter designs, power quality, protection, and relaying. He has published more than 200 electrical power system study reports for his clients.

He has published more than 200 study reports of power systems analysis addressing one problem or the other.

Das is a Life Fellow of the Institute of Electrical and Electronics Engineers, IEEE, (USA), Member of the IEEE Industry Applications and IEEE Power Engineering societies, a Fellow of the Institution of Engineering Technology (UK), a Life Fellow of the Institution of Engineers (India), a Member of the Federation of European Engineers (France), a Member of CIGRE (France), etc. He is registered Professional Engineer in the states of Georgia and Oklahoma, a Chartered Engineer (CEng) in the UK, and a European Engineer (EurIng) in Europe. He received a meritorious award in engineering, IEEE Pulp and Paper Industry in 2005.

He earned a PhD in electrical engineering at Atlantic International University, Honolulu, an MSEE at Tulsa University, Tulsa, Oklahoma, and a BA in advanced mathematics and a BEE at Panjab University, India.

Contents