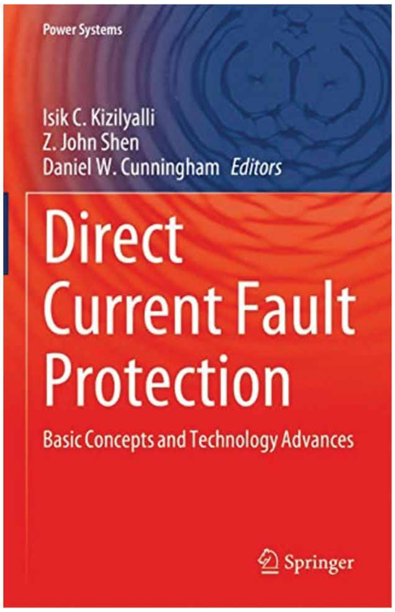
by Fei (Fred) Wang

Direct Current Fault Protection: Basic Concepts and Technology Advances

Global scientific publisher Springer recently published a book "Direct Current Fault Protection: Basic Concepts and Technology Advances" edited by Isik C. Kizilyalli, Z. John Shen, and Daniel W. Cunningham with about 60 contributing authors from industry, academia, research organizations, and government agencies. To the reviewer's knowledge, this is the first book exclusively dedicated to direct current (dc) fault protection. It is a very timely book given the rapid growth and tremendous interests in dc systems for various applications, including datacenters, electrified transportations (vehicles, airplanes, ships, and trains), energy storage systems, renewable energy systems, and electric grid, across all voltage levels from hundreds of volts to hundreds of kilovolts.

This book consists of five parts. Part I starts with the introduction and overview of the dc circuit breaker technologies, proposing a new unified classification of dc fault interruption methods. Part II focuses on solid-state circuit breakers (SSCB) with seven chapters, covering from relatively mature silicon (Si) insulated-gate commutated thyristor/insulated-gate bipolar transistor (IGCT/IGBT) based SSCB product and prototype to more advanced concepts including wide bandgap (WBG) semiconductor-based trimode intelligent SSCB, T-type dc circuit breaker, Z-source SSCB, and light-triggered SSCB. Part III emphasis is on hybrid circuit breakers (HCB) that contain both mechanical and power electronic switches. The five chapters on HCB present circuit breakers based on various commutation schemes (i.e., natural, resonant, and current injection) and for various applications, including the 535 kV/25 kV HCB installed in the world's first meshed multiterminal high voltage dc (HVDC) project. Part IV includes one chapter each on HV gas discharge tube dc circuit breakers, converter-based breakerless dc fault protection, and dc fault current limiters. It also has a chapter on eliminating SF_6 from switchgear. Finally, Part V provides the future outlook with one chapter on fundamental challenges and future outlook and the other on commercialization of medium voltage dc (MVDC) systems.



Clearly, this book is very well structured and comprehensive, even though there are contributions from so many authors. It shows the excellent job by the editing authors in organizing the materials, and it is also a reflection of the well-organized Advanced Research Projects Agency–Energy (ARPA-E) programs, as most of the materials are based on the projects in ARPA-E's Creating Innovative and Reliable Circuits Using Inventive Topologies and Semiconductors (CIRCUITS) and Building Reliable Electronics to Achieve Kilovolt Effective Ratings Safely (BREAKERS) programs. As is suggested by its title, and can be seen from its contents aforementioned, the book covers both basic concepts and technology advances, making it suitable for professionals, both engineers and researchers, interested in learning about dc fault protection, as well as those working in this rapidly advancing field. In addition, this book also provides a good balance between relatively mature industry products and more advanced laboratory protypes based on new components, innovative

Digital Object Identifier 10.1109/MPEL.2023.3326007
Date of publication: 26 December 2023

topologies, and advanced controls. In presenting different circuit breaker technologies, most chapters have also discussed their designs, such as circuit, control, insulation, thermal management, and mechanical integration.

While the book focuses on dc circuit breakers, it also provides valuable discussions and insight on benefits of dc systems for various applications. Some of the approaches used in implementing the dc fault current interruption and limiting can be used in other applications as well, such as press-pack devices with high pulse current capability and pulsating heat pipes independent of orientation. The series-type HCB presented in the future outlook chapter is an excellent concept that should drive further interest in this field.

However, there are some minor shortcomings that could be improved in future. With its focus on protection devices, this book has left some issues unaddressed on dc fault protection, especially the fault protection coordination for dc grid. Some chapters on SSCB do not explain clearly how the high efficiency has been achieved. While it is important to explain the benefits of the dc systems to justify the importance of the dc fault protection, some of the listed advantages of the dc systems may need further research. For example, this reviewer is not convinced that a dc system will necessarily offer better stability than its ac counterpart as indicated in the book.

In conclusion, "Direct Current Fault Protection: Basic Concepts and Technology Advances" is a highly recommended book for anyone interested in dc systems and their protection technologies. Its comprehensive coverage of the topic makes it a good starting point for newcomers to learn, and also ensures that readers can apply what they've learned.

About the Author

Fei (Fred) Wang (Fellow, IEEE) (f.wang@ieee.org) received the Ph.D. degree in electrical engineering from the University of Southern California in 1990. He has been a Professor and the Condra Chair of Excellence in Power Electronics with the University of Tennessee, Knoxville (UTK), USA, since 2009. He is a Co-Founder and the Technical Director of the NSF/DOE established Engineering Research Center CURENT. He also holds a joint appointment with Oak Ridge National Lab. Prior to UTK, he also worked at GE and Virginia Tech. His current research interests are mainly on WBG power electronics and power electronics for grid and transportation applications. He is a Fellow of the U.S. National Academy of Inventors.

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