ELECTRIC POWER DISTRIBUTION EQUIPMENT AND SYSTEMS

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Dedication

To the future. To Jared. To Logan.

Preface

In industrialized countries, distribution systems deliver electricity literally everywhere, taking power generated at many locations and delivering it to end users. Generation, transmission, and distribution—of the big three components of the electricity infrastructure, the distribution system gets the least attention. Yet, it is often the most critical component in terms of its effect on reliability and quality of service, cost of electricity, and aesthetic (mainly visual) impacts on society.

Like much of the electric utility industry, several political, economic, and technical changes are pressuring the way distribution systems are built and operated. Deregulation has increased pressures on electric power utilities to cut costs and has focused emphasis on reliability and quality of electric service. The great fear of deregulation is that service will suffer because of cost cutting. Regulators and utility consumers are paying considerable attention to reliability and quality. Customers are pressing for lower costs and better reliability and power quality. The performance of the distribution system determines greater than 90% of the reliability of service to customers (the high-voltage transmission and generation system determines the rest). If performance is increased, it will have to be done on the distribution system. Utilities are looking for the most cost-effective and efficient management of their distribution assets.

This book is a spinoff from the *Electric Power Distribution Handbook* (2004) that includes the portions of that handbook that target equipment and applications of equipment. It includes overhead designs, underground issues and applications, and voltage regulation and capacitor applications. Managing these assets is key to controlling costs, regulating voltage, controlling maintenance, and managing failures. Proper specification, application, and maintenance will improve equipment reliability, which will help reduce costs, improve safety, and improve customer reliability.

I hope you find useful information in this book. If it's not in here, hopefully, one of the many bibliographic references will lead you to what you're looking for. Please feel free to e-mail me feedback on this book including errors, comments, opinions, or new sources of information—I'd like to hear from you. Also, if you need my help with any interesting consulting or research opportunities, I'd love to hear from you.

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First and foremost, I'd like to thank my wife Kristin—thank you for your strength, thank you for your help, thank you for your patience, and thank you for your love. My play buddies, Logan and Jared, energized me and made me laugh. My family was a source of inspiration. I'd like to thank my parents, Bob and Sandy, for their influence and education over the years.

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Many other people reviewed portions of the draft and provided input and suggestions including Dave Smith (Power Technologies, Inc.), Dan Ward (Dominion Virginia Power), Jim Stewart (Consultant, Scotia, NY), Conrad St. Pierre (Electric Power Consultants), Karl Fender (Cooper Power Systems), John Leach (Hi-Tech Fuses, Inc.), and Rusty Bascom (Power Delivery Consultants, LLC).

Thanks to Power Technologies, Inc. for opportunities and mentoring during my early career with the help of several talented, helpful engineers, including Jim Burke, Phil Barker, Dave Smith, Jim Stewart, and John Anderson. Over the years, several clients have also educated me in many ways; two that stand out include Ron Ammon (Keyspan, retired) and Clay Burns (National Grid).

EPRI has been supportive of this project, including a review by Luther Dow. EPRI has also sponsored a number of interesting distribution research projects that I've been fortunate enough to be involved with, and EPRI has allowed me to share some of those efforts here.

As a side-note, I'd like to recognize the efforts of linemen in the electric power industry. These folks do the real work of building the lines and keeping the power on. As a tribute to them, a trailer at the end of each chapter reveals a bit of the lineman's character and point of view.

About the Author

Mr. Short has spent most of his career working on projects helping utilities improve their reliability and power quality. He performed lightning protection, reliability, and power quality studies for many utility distribution systems while at Power Technologies, Inc. from 1990 through 2000. He has done extensive digital simulations of T&D systems using various software tools including EMTP to model lightning surges on overhead lines and underground cables, distributed generators, ferroresonance, faults and voltage sags, and capacitor switching. Since joining EPRI PEAC in 2000 (now EPRI Solutions, Inc.), Mr. Short has led a variety of distribution research projects for EPRI, including a capacitor reliability initiative, a power quality handbook for distribution companies, a distributed generation workbook, and a series of projects directed at improving distribution reliability and power quality.

As chair of the IEEE Working Group on the Lightning Performance of Distribution Lines, he led the development of IEEE Std. 1410-1997, *Improving the Lightning Performance of Electric Power Overhead Distribution Lines*. He was awarded the 2002 Technical Committee Distinguished Service Award by the IEEE Power Engineering Society for this effort.

Mr. Short has also performed a variety of other studies including railroad impacts on a utility (flicker, unbalance and harmonics), load flow analysis, capacitor application, loss evaluation, and conductor burndown. Mr. Short has taught courses on reliability, power quality, lightning protection, overcurrent protection, harmonics, voltage regulation, capacitor application, and distribution planning.

Mr. Short developed the Rpad engineering analysis interface (www.Rpad.org) that EPRI Solutions, Inc. is using to offer engineering, information, mapping, and database solutions to electric utilities. Rpad is an interactive, web-based analysis program. Rpad pages are interactive workbook-type sheets based on R, an open-source implementation of the S language (used to make many of the graphs in this book). Rpad is an analysis package, a web-page designer, and a gui designer all wrapped in one. Rpad makes it easy to develop powerful data-analysis applications that can be easily shared on a company intranet.

Mr. Short graduated with a master's degree in electrical engineering from Montana State University in 1990 after receiving a bachelor's degree in 1988.

Contents

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