Book REVIEWS

If you are interested in reviewing a book for *IEEE Circuits & Devices Magazine*, please visit our Web site at http://www.ieee.org/cdmag for a complete list of available titles.

LIGHTNING, PHYSICS AND EFFECTS

By V.A. Rakov and M.A. Uman, Cambridge University Press, 2003.

It is exciting to study the physics of lightning and, indeed, the physics of many aspects of nature, such as hurricanes, tornados, floods, earthquakes, etc., so that someday we will be able to control these natural events and eventually turn the vast energy of nature from destructive to useful resources. The authors of this book deserve to be complimented for their study of natural events and their efforts in writing this book.

This large monograph covers all aspects of lightning, including about 6,000 references published up to the spring of 2002. There are 20 chapters in this book.

The first chapter gives a brief historical overview of lightning and classifies lightning into four different types: downward-negative lightning, upward-negative lightning, downward-positive lightning, and upward-positive lightning, according to the electric discharges between the cloud and ground. Downward-negative lightning occurs most (more than 90%) of the time. Details of the reviews of many observations of various lightning discharges are described in Chapters 4–11. The process of lightning is, understandably, very complicated and, so far, there is no unified interpretation of the complete picture involved in lightning and thunder. In Chapter 12, the authors review existing views and classify them into four different groups: 1) the gas dynamic model, based more on the physics involved with factors such as temperature, pressure, gas density, and electrical conductivity, etc.; 2) the electromagnetic model, based more on the spectrum of the discharge mechanisms; 3) the distributed circuit model based on the concept of treating the radiation from the column of lightning as an antenna; and 4) the engineering or empirical model, by suggesting formulas involving various empirical parameters for practical engineering applications over limited environmental ranges.

Chapter 13 reviews observations of lightning in the atmosphere over very long distances, such as whistlers. Chapter 14 reviews the effects of lightning in the middle and upper atmosphere. Chapter 15 explains the effect of lightning on the chemistry in the atmosphere. Chapter 16 describes some observations that could be indications of lightning on other planets. Chapter 17 gives a brief description of lightning-locating systems. Chapter 18 briefly describes various protective techniques. Chapter 19 briefly covers the hazards of lightning to humans and animals. Chapter 20 reviews observations of some unusual lightning not reported in scientific literatures.

This book is a very good review of all aspects of lightning, but most of the interpretations are primarily limited to linear analysis. In nature, most effects are very large in scale and in the magnitude of signals, thus, nonlinear models both in time and also in space are often required to describe the actual processes. It may be a good idea to break up the large-scale model into many small-scale models that can be treated separately by well-known techniques. The concept of nonlinear interactions mostly will be very important to reveal the complete understanding of the basic principles.

Unfortunately, most college courses focus on the study of small-signal linear systems. It is believed that studies of nonlinear systems will become more and more important and popular in time. In this respect, it is also important to investigate the stability of various processes in order to develop techniques to control nonlinear interactions.

This book is obviously not a textbook, but it is a very useful reference book not only for people interested in lightning and thunder, due to the extensive list of references, but also for researchers and scientists working on high-voltage engineering and nonlinear systems, because the extensive review of various observations also provides guidance for further future investigations. For example, it's good to consider lightning discharge as an electrical transmission line, but the line is mostly not uniform and very nonlinear in practice. Furthermore, it may be worthwhile to investigate whether there may be some correlation between the various observed optical and electrical spectrum of the lightning. In fact, even the acoustic spectrum of thunder may be correlated to lightning through spatial nonlinear interactions.

8755-3996/05/$20.00 ©2005 IEEE