PREFACE

This book is the result of many years of wondering about and researching the conceptual foundations of electromagnetics. My goal was to write a book that provided the reader with a conceptual understanding of electromagnetics and the insight to efficiently apply this understanding to real problems that confront scientists, engineers, and technicians. The fundamental equations that govern electromagnetic phenomena are those given to us by James Clerk Maxwell, and are commonly known as Maxwell's equations. Excepting quantum phenomena, all electromagnetic problems can be solved from Maxwell's equations. (The complete theory of electromagnetics, which includes quantum effects, is quantum electrodynamics, often abbreviated as QED.) However, many people lack the time and/or mathematical background to pursue the laborious calculations involved with the equations of electromagnetism. Furthermore, mathematics is just a tool, albeit a very powerful tool. For many problems, exacting calculations are not required. To truly understand, develop, and apply any branch of science requires a solid conceptual understanding of the material. As Albert Einstein stated, "Physics is essentially an intuitive and concrete science. Mathematics is only a means for expressing the laws that govern phenomena."* To this end, this book does not present Maxwell's equations and does not require any knowledge of these equations; nor is it required for the reader to know calculus or advanced mathematics.

The lack of advanced math in this book, I'm sure, will be a tremendous relief to most readers. However, to some readers, lack of mathematical rigor will be a negative attribute and perhaps a point for criticism. I contend that as long as the facts are correct and presented clearly, mathematics is not necessary for fundamental understanding, but rather for detailed treatment of problems. Moreover, everyday scientific practice shows that knowing the mathematical theory does not

*Quoted in A. P. French, ed., *Einstein: A Centenary Volume*, Cambridge, Mass.: Harvard University Press, 1979, p. 9.

ensure understanding of the real physical "picture." Certainly, mathematics is required for any new theories or conclusions. The material that I cover has been addressed formally in the literature, and readers are encouraged to pursue the numerous references given throughout. Conceptual methods for teaching the physical sciences have long been in use, but I think that the field of electromagnetics has been neglected and needs a book such as this. If relativity, quantum theory, and particle physics can be taught without mathematics, why not electromagnetics?

As inspiration and guide for my writing I looked to the style of writing in works such as *The Art of Electronics* by Paul Horowitz and Winifred Hill, several books by Richard Feynman, and the articles of the magazine *Scientific American*.

SUGGESTED AUDIENCE AND GUIDE FOR USE

This text is mainly intended as an introductory guide and reference for engineers and students who need to apply the concepts of electromagnetics to real-world problems in electrical engineering. Germane disciplines include radio frequency (RF) design, high-speed digital design, and electromagnetic compatibility (EMC). Electromagnetism is the theory that underlies all of electronics and circuit theory. With circuit theory being only an approximation, many problems, such as those of radiation and transmission line effects, require a working knowledge of electromagnetic concepts. I have included practical tips and examples of real applications of electromagnetic concepts to help the reader bridge the gap between theory and practice.

Taking a more general view, this book can be utilized by anyone learning electromagnetics or RF theory, be they scientist, engineer, or technician. In addition to self-study, it could serve well as a companion text for a traditional class on electromagnetics or as a companion text for classes on RF or high-speed electronics.

Those readers interested in RF or electromagnetics in general will find the entire book useful. While Chapter 1 serves as a good introduction for everyone, Chapters 2, 3, and 4 cover the basics and may be unnecessary for those who have some background in electromagnetics. I direct those readers whose discipline is digital design to focus on Chapters 1, 7, 8, and 12. These four chapters cover the important topics that relate to digital circuits and electromagnetic compatibility. EMC engineers should also focus on these four chapters, and in addition will probably be interested in the chapters that cover radiation (Chapter 5), shielding (Chapter 9), and antennas (Chapter 11). Chapter 6, which covers rela-

tivity and quantum theory, is probably not necessary for a book like this, but I have included it because these topics are fascinating to learn about and provide a different perspective of the electromagnetic field.

PARTING NOTES

I gladly welcome comments, corrections, and questions, as well as suggestions for topics of interest for possible future editions of this book. As with any writing endeavor, the publishing deadline forces the author to only briefly address some topics and omit some topics all together. I am also considering teaching one- or two-day professional courses covering selected material. Please contact me if such a course may be of interest to your organization. Lastly, I hope this book is as much a pleasure to read as it was to write.

Ron Schmitt, emag_schmitt@yahoo.com
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