Electromagnetic Foundations of Electrical Engineering

J. A. Brandão Faria

Instituto Superior Técnico – Technical University of Lisbon, Portugal

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To the memory of my wife,
Fernanda Faria

'Let there be light', and there was light
Genesis 1:3

$$\begin{cases} \operatorname{curl} \mathbf{E} = -\dfrac{\partial \mathbf{B}}{\partial t} \\ \operatorname{div} \mathbf{B} = 0 \\ \operatorname{curl} \mathbf{H} = \mathbf{J} + \dfrac{\partial \mathbf{D}}{\partial t} \\ \operatorname{div} \mathbf{D} = \rho \end{cases}$$

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About the Author

J. A. Brandão Faria received his PhD degree and aggregate title in electrical engineering from the Instituto Superior Técnico of the Technical University of Lisbon, where, since 1994, he has been a Full Professor of Electrical Engineering teaching undergraduate and graduate courses in electromagnetics. His teaching activities also include lecturing courses at the Portuguese Air Force Academy.

Professor Brandão Faria was a senior scientist with the former Centro de Electrotecnia Teórica e Medidas Eléctricas where he served as President from 1994 until 2000. Since 2008, he has been at the recently created CIEEE (Center for Innovation in Electrical and Energy Engineering).

Professor Brandão Faria was the recipient of two Honorable Mentions awarded in 1994 and 2007 by the Portuguese State Department of Science and Technology, and by the Technical University of Lisbon, respectively. His areas of interest include electromagnetic field

problems, power lines, and wave propagation phenomena in multiconductor transmission lines. He is the author of two books on electrical engineering subjects, namely *Optica* and *Multiconductor Transmission-Line Structures*, and has published over 100 technical papers.

Professor Brandão Faria is a member of the Editorial Board of the *European Transactions on Electrical Power* (John Wiley & Sons, Ltd) and a senior member of the IEEE.

For more details follow the author's website link at:
https://fenix.ist.utl.pt:443/homepage/ist11545.

Preface

This book has been written bearing in mind not only my own students but also electrical engineering students in general, including European students now facing the challenges of the Bologna Reform.

The primary goal of this textbook, *Electromagnetic Foundations of Electrical Engineering*, is to provide undergraduate students taking courses in electrical engineering with a scientifically founded and unified basis of fundamental knowledge on electromagnetic field phenomena, which will enable them to grasp advanced topics and specialized applications that will be dealt with later in their courses, or that they will come across in their professional lives as engineers.

Several distinguishing features make this new textbook unique in its area. It is primarily a balanced foundations book with a broad scope. The emphasis is on basic principles, concepts and governing laws that can be used precisely by electrical engineering students pursuing studies in areas as diverse as power and energy systems, telecommunications, electronic circuits, control systems, bioengineering, etc. In order to reach and serve as large a readership as possible, bias towards specific areas has been deliberately avoided. Electrical engineering professionals (practitioners) with a need for a refresher course in electromagnetic foundations will also find the book a valuable asset.

A project-solving oriented posture is adopted to capture more easily the reader's interest. However, it is not my intention to provide ready-made recipes or rote procedures for students; my approach emphasizes problem solving as a thought process based on concepts and on concept linking. Right at the beginning of the book, a project portfolio is proposed and offered to students in order to capture their attention and trigger their curiosity (project solutions will be available separately). These projects tie together a diversity of knowledge components whose roots lie in different chapters in the text; this salient feature, it is hoped, will help readers understand the big picture, avoiding segmented perspectives. The key idea is to enable students' knowledge integration skills so that, after completing the book, they can solve the various problems and questions included in the proposed project portfolio. When they do, both the students and the book will have accomplished their goals.

In addition, in all chapters, several fully worked-out application examples are presented to illustrate the theory and concepts that have just been introduced and developed. End-of-chapter homework problems, intended to help guide students in their learning process,