Preface

Electromagnetic field computations in either man-made or natural complex structures pose challenging problems with respect to electromagnetic wave propagation modeling, microwave circuit and antenna design, electromagnetic compatibility issues, high bit rate and ultra-wide band communications, biological hazards and numerous other problems. Since different problems exhibit specific combinations of geometrical features and scales, material properties and frequency ranges no single method is best suited for handling all possible cases: instead, a combination of methods is needed to attain the greatest flexibility and efficiency.

Naturally, with progress of computing facilities, the main focus has shifted from analytical computations to numerical ones. However, in many instances, the computations are performed in order to design a certain component, such as an antenna or a filter. Dealing with design and optimization problems requires not only the modeling of a given structure but also the evaluation of the sensitivities to parameter changes. In these cases it is worthwhile to attain the highest numerical efficiency in order to be competitive.

The present scenario witnesses the use of several different methods that, apart for a few noticeable exceptions, are not merged together. Clearly, from the efficiency point of view it would be desirable to solve the problem at hand in the most efficient way, thus subdividing the computational space in various subregions and by employing in each subregion the most satisfactory approach. Moreover, while the above procedure has been followed in several specific contributions, it is also important that the sought approach can be *systematically* employed for all cases. Of particular relevance are the rigorous treatment of the field at boundaries and the appropriate field representations inside bounded or unbounded regions.

The common ground which allows to achieve solutions that are rigorous, preserve energy conservation, and that can unify different methods, is the use of network theory, i.e. a rigorous translation of our field problem into an equivalent network problem. In particular the field at boundaries can be rigorously represented by using the Tellegen theorem for fields, which provides the generalized transformer network representation. In fact, a boundary can be seen as a region of zero volume in which no energy is stored neither dissipated, exactly as in a transformer. A region of finite volume, instead, when lossless can be seen as a resonator and its behavior may be described in terms of its resonances. Also, field propagation in an infinite region can be described in terms of spherical transmission lines, which provide an infinite, discrete, set of modes traveling along the radial direction. Such scenario, to our knowledge, has not been presented systematically in a book

and, in our humble opinion, deserve instead some considerations. The aim of this book is therefore to illustrate with some detail how it is possible to describe whatever realistic electromagnetic field problem in terms of network elements, i.e. generalized transformers, RLC elements and transmission lines. The plan and content of the book is described in some detail in Chapter 1 and thus is not detailed here.

The reader may be interested in the genesis of this manuscript. Ties with Leopold Felsen were initiated through his invited attendance of the "International Workshop on Discrete Time Domain Modeling of Electromagnetic Fields and Networks", which convened in Munich in October 1991. Over a 14 years period we have had a fruitful scientific cooperation. It was 1996 and two of us, Leopold Felsen and Mauro Mongiardo were staying as Visiting Scientists with the third one, Peter Russer at the Technische Universität München. A topic that was often debated was that of complexity and how to find a systematic approach to compute electromagnetic field in complex structures. For those who have a more deep knowledge of the personality of Leopold Felsen it would not be difficult to believe that not every discussion was a smooth one. Nonetheless, after some time, we have found a considerable agreement on the procedure synthetically illustrated above. From this starting point we have worked on a sequence of papers illustrating the procedure, and in particular on triplet that was later published in a special issue of the International Journal for Numerical Computation. Also, a few other contributions increased our belief in this approach. A few years later, we agreed to start to work on a monograph on this subject and several other vivid discussions followed. Also a plan of the chapters started to evolve and after a certain time we initiated the actual work on the book. Our aim was to introduce the reader gradually with respect to the novelties; to this end we have started the book with standard electromagnetic theory.

As a large part of the book was already assembled and reviewed, the health conditions of Leopold Felsen deteriorated significantly leading to his untimely departure. This event left us with a deep sorrow for we greatly missed Leopold Felsen and his invaluable suggestions. The monograph project we tried to make what would have pleased him most. Since at that time Leopold Felsen has already contributed to the writing and corrections of the first four chapters of this book we decided to leave them in the form he was comfortable with. Accordingly, our task for this chapters has been only to implement his handmade corrections and improve figure qualities and other minor details. Also Chapter 5, although not yet complete, was already discussed with Leopold Felsen and agreed by him. The completion of this chapter and some other refinements have put the book in a condition that seems appropriate for disseminating the main ideas contained in it.

We are grateful to Leopold Felsen, for the instructive and pleasant time spent together. In Leopold Felsen we admired not only the exceptional scientist but also

a strong human character who has confronted his life's challenges with strength, courage and honesty and in the spirit of reconciliation.

We would like to express our appreciation to Patrizia Basili, Christos Christopoulos, Nikolaus Fichtner, Roberto Sorrentino and Cristiano Tomassoni for many helpful discussions. We thank Nikolaus Fichtner and Uwe Siart for support in solving typesetting problems. A particular thank goes to Christiane Wangerek who with her constant assistance has made possible for us to concentrate on the scientific part and rely on her superb organizational skills. We also would thank Leopold Felsen's son Michael Felsen who always has been very close to his father and has also taken the task of keeping us informed about his health and finally has encouraged us to finish this project. We would also like to express a sincere thank to our family members that have tolerated our secluded time and have provided constant and strong support to our effort.

Munich and Perugia, *Mauro Mongiardo*
November 2008 *Peter Russer*

http://www.springer.com/978-3-540-93945-0

Electromagnetic Field Computation by Network Methods

Felsen, L.B.; Mongiardo, M.; Russer, P.

2009, XIV, 214 p. 58 illus., Hardcover
ISBN: 978-3-540-93945-0