

Editor Rod Waterhouse

Printed Antennas for Wireless Communications



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Printed Antennas for Wireless Communications

Editor

Rod Waterhouse

Pharad, Maryland, USA



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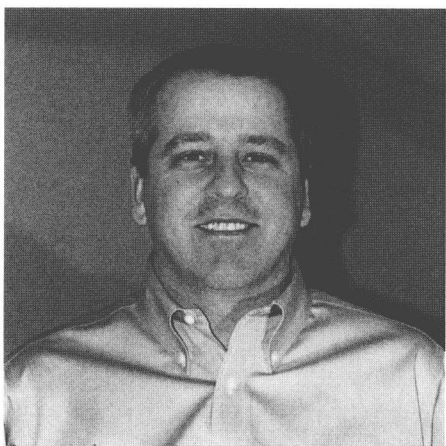
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Printed Antennas for Wireless Communications

*In memory of Professor J. James and his pioneering
work in printed antennas*

About the Editor



Rod Waterhouse received his BEng, MS, and PhD in Electrical Engineering from the University of Queensland, Australia, in 1987, 1989, and 1994, respectively. In 1994 he joined RMIT University as a lecturer and became a Senior Lecturer in 1997 and an Associate Professor in 2002. In 2001 he took a leave of absence from RMIT and joined the venture-backed Dorsal Networks, which was later acquired by Corvis. In 2003 he left Corvis and resigned from his position at RMIT and worked for Photonic Systems Inc. as a principal engineer. In 2004 he cofounded Pharad, a broadband wireless communications company, where he is now a Vice President. His 2003 book on printed antenna

design follows more than 200 publications and ten patent applications in the field of antennas, electromagnetics, microwave, and photonics engineering. Dr Waterhouse is an associate Editor for *IEEE Transactions on Antennas and Propagation*. He chaired the IEEE Victorian MTTS/APS Chapter from 1998 to 2001. Dr Waterhouse is an adjunct Senior Fellow within the Department of Electrical and Electronic Engineering at the University of Melbourne. In 2000 he received an IEEE Third Millennium Medal for Outstanding Achievements and Contributions.

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Preface

In 2004 I was approached by Professor James to write a book on printed antennas for wireless systems. After much debate (internally and with Professor James!), we decided on a book that could provide the reader with a valuable reference for printed antennas for many wireless applications and also a glimpse into the future of wireless systems and the role to be played by printed radiators. To achieve this goal, we needed to rely on a wealth of information, probably too much for a single person to accumulate, so we set about assembling a team of experts to give valuable insight and design methodologies for many forms of printed antennas as well as how this technology could be incorporated into advanced wireless concepts. I believe, because we have assembled some very good engineers (from academic and industry backgrounds) who are contributing in areas in which they have published significant papers on the particular topics, there is no book of a similar nature to the one presented here that covers the material. Having said that, the book is similar to some well-known and highly praised books that typically fall into the category of handbooks. Importantly the reader will be given opinions from various experts and so it will not be a collage of one person's efforts and their subsequent, and perhaps somewhat biased, opinion. I believe too that the addition of the final section of this book gives the reader a glimpse at the state of the art in wireless technologies and the direction of future communication systems.

The objective of this book is to provide the reader with an understanding of how to design printed antennas and associated technologies relevant for state-of-the-art wireless systems. Experts from around the world have contributed to this book to give the reader valuable insight into important technological breakthroughs in these areas. One common observation throughout this book is the utilization of rigorous analysis tools to help understand the phenomena associated with the radiating structures and their surrounding environments.

After the introduction chapter, which presents the latest systems and new platforms being investigated for wireless technology, the book is divided into three parts: (I) fundamental wideband printed antennas for wireless systems; (II) small printed antennas for wireless applications; and (III) advanced concepts and applications in wireless systems. The first part really focuses on printed antenna solutions that are directly applicable to present-day and future wideband systems (such as ultra wideband (UWB) applications) as well as antenna platforms where multiple wireless communication interfaces are required. The five chapters in this part provide a thorough summary of the five fundamental wideband printed radiators and how these antennas can be designed for a variety of applications. In each chapter practical examples are given.

In Part II we focus on a wireless area where printed antennas have helped accelerate the advances in wireless systems: small antennas for portable terminals. In these chapters

we present all the relevant approaches to making small printed antennas, multilayered and uniplanar, and how these radiators can be integrated in WLAN equipment and other platforms. In these chapters the impact of the environment in which the antenna is mounted is also presented. In Part III we present advanced concepts and new applications that require printed antenna technology. In these chapters the usefulness of the previously described printed antenna solutions is highlighted. A thorough examination of printed antennas in reflectarrays is given. We also present ways that artificial magnetic conductors can be used with printed antennas and how printed antennas can be integrated with active devices for concepts such as wireless systems on a chip as well as configured in advanced wireless systems such as software defined radio and multiple-input multiple-output (MIMO). In all the chapters experimental data will be provided when appropriate and theoretical models will be applied to present design performance trends as well as to give the reader an in-depth coverage of the relevant area.

It should be noted that each chapter presents new previously unpublished material. Although some of the concepts presented in the book are available in the public environment, several of the presented designs for a variety of wireless systems are not. To my knowledge some of the presented design procedures are also unavailable in the public literature. There are also several chapters in this book related to topics that have not been addressed before in printed antennas, especially for wireless applications. These include using metamaterials (high-impedance ground-planes) and the integration with software-defined radios and MIMO systems. Also the chapters on the various wideband technologies have not been presented in one collective document before, which will be extremely useful for the reader.

I sincerely acknowledge the contributions from all the authors of the chapters in this book; they should be proud of their efforts. As I said before, I believe such a collection of concepts and insightful views could not be accumulated by one person; at least not in one lifetime. As a technologist I have already used some of the design philosophies and approaches highlighted in this book to yield practical antenna solutions. I hope the reader will get as much out of this book as I already have!

Rod Waterhouse

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1

Wireless Systems and Printed Antennas

Rod Waterhouse and Dalma Novak

Pharad, Maryland, USA

1.1 INTRODUCTION

Wireless systems are playing an ever increasingly important role in society. Whether they are used to assist in the distribution/collection of large amounts of information or to make home entertainment systems more convenient, wireless systems are becoming more and more integrated into daily activities. The utilization of wireless technology is not currently confined to either the commercial or the military sectors. In fact, it seems that both sectors are striving for wireless solutions to enhance their resources, or simply to make their product more readily accessible and useful to the consumer.

One of the important enabling technologies for wireless communications is the transducer, which converts guided energy to radiated energy (and vice versa): the antenna. Although advances in antenna engineering cannot be credited for the globalization of wireless technologies, it still plays an important role, whether it provides an aesthetically pleasing solution or helps improve the overall radio frequency (RF) link budget, or allows multiple users to utilize the single interface and thereby increase the capacity. It is undeniable that good radiator engineering allows for better wireless systems.

Figure 1.1 shows a 'snapshot' of present and future commercial wireless systems, highlighting cellular and satellite communications, as well as the extremely popular wireless local area network (WLAN) and short-range connectivity systems such as Bluetooth. Also shown is the quandary facing next-generation systems and how they were interface with a variety of technologies including computers and small handsets.

Figure 1.2 shows the frequency spectrum indicating current and next-generation wireless systems between 300 MHz and 100 GHz. As can be seen, there are a plethora of wireless systems utilizing various advantages of the different spectra. For example, systems at the