Foundations of Radio for Scientists and Technologists

The go-to text for non-specialists requiring a serious introduction to radio. Designed for those without a specialist theoretical background in electronic and electromagnetic engineering, it uses a holistic, physics-based approach to describe the theory underpinning radio science and engineering. It covers a wide range of topics, from fundamentals such as radio wave theory, the electronics of radio, antennas and radio wave propagation, to software radio, spread spectrum and MIMO. With a wealth of practical exercises and examples accompanying the book online, this is the ideal text for graduate students, professionals and researchers who work on radio systems and need to understand both the science and practice of radio.

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Preface

Radio is one of the most pervasive technologies of the twentieth century and is a major element in all of our lives. Besides being the major technology that makes the broadcast and telecommunication industries possible, it is an important supporting technology for the transport industry, the military and the emergency services. In the sphere of scientific research, it is an important element in data gathering and, through radar, provides a primary research tool for geology, meteorology and environmental science. Furthermore, through radio telescopes, it is a major tool for astronomers. It is clear that many scientists will need to understand, and even design, radio systems of considerable sophistication. Whilst such scientists might not need to design the electronics, they will certainly need to understand its capability and performance limitations. However, such knowledge is usually the preserve of the professional RF engineer; knowledge he will have gleaned from a series of courses in diverse areas that include electronics, signal processing, communications, electromagnetism, antennas and propagation. Material from these topics constitutes the subject of radio. Many scientists, and technologists, do not have the luxury of being able to study such a range of material in detail. Consequently, it is the aim of the presented text to provide such readers with a basic understanding of radio, both its theory and practice.

This is not a book about the design of radio frequency circuits, but rather a book about the phenomenon of radio and how it works. Consequently, there is an even balance between the physics of radio and the technology that has made it possible. The primary aim in writing this book has been to make some quite advanced topics in radio accessible to a more general audience. However, due to the mathematical nature of most radio theory, there is a danger that such a book can end up as just a list of facts and formulas. To avoid this, the book uses a more physics-based approach to the complex theory of radio. This not only aids the reader's understanding but also avoids the requirement of a large prerequisite knowledge in advanced mathematics. Indeed, the reader only needs some basic knowledge of vectors, calculus and complex numbers. In particular, the book does not require knowledge of vector calculus. As a consequence, the book should be accessible to a large range of scientists, engineers and technicians.

The book develops the theory of electromagnetism in a historical fashion, from early ideas concerning electrostatics to the prediction and discovery of radio waves. It then looks at the fundamental technological developments that have made modern radio possible. The book intertwines the history of radio with the theory, hence giving the reader an idea of how, and why, certain technologies were developed. Importantly, the book

discusses issues that can affect the performance of radio systems. The book develops, in some detail, the important topics of transmission lines, antennas and propagation. Additionally, it looks at some important modern radio technologies such as spread spectrum, cellular radio, MIMO and radar. Whilst the book does not aim to train the reader in radio electronics, the book will provide a sufficient background for the reader to progress onto relatively advanced texts in this area. Much of the material in this book grew out of courses given to non-specialists with a need to understand radio in more detail than is offered by most introductory texts. The students on these courses were mainly users of radio (ionospheric physicists and radar scientists for example) with a need to understand radio in greater depth. Such students are the intended readership of this book. However, the book might also be of interest to those with an electrical and electronic engineering (EEE) background. The coverage of radio in a typical EEE degree tends to be disjointed and it is possible that this book might prove useful to those who wish to fill gaps in their knowledge of radio, or simply to revise their knowledge. For those readers interested in the practical application of the material in this book, the online resources include numerous examples and exercises.

I would like to thank my wife, Marilyn, for her invaluable support and help in preparing this book.