



# Modulation and Coding for Wireless Communications

By Alister Burr

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A new advanced communications book on Modulation & Coding for Radio Communications. Ideal for advanced undergrad courses, taught masters and professionals.

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### Editorial Review

#### From the Back Cover

*Modulation and Coding for Wireless Communications* is an authoritative, modern text on two interrelated and increasingly important topics within communications engineering. This text will provide a useful reference to modulation and coding as well as a review of current practice. Accessibly written, this will be a suitable textbook for students on advanced communications as well as for those involved in the wireless communications industry.

The text uses visual, graphical approaches wherever possible in order to help the reader understand abstract concepts in a familiar setting. Equally helpful to the student is the inclusion of examples from real radio systems, which help to apply and demonstrate theoretical principles. This modern text includes all the latest techniques, such as OFDM and turbo-codes, as well as looking forward to future developments.

#### FEATURES:

- Provides an integrated approach to modulation and coding
- Employs a visual 'geometric' approach
- Places an emphasis on wireless communications
- Fully up to date, referencing current standards and techniques
- Includes worked examples based around real systems

#### About the Author

Alister Burr is a Reader in Electronics at the University of York, UK. He has developed new communications courses and workshops at all levels and is an active researcher. In addition, he has performed extensive consultancy work for various organizations, including British Telecom, British Aerospace, the British National Space Centre, and Nortel. He has also served as Chair of the IEE Radiocommunications Professionals Group Committee.

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### Preface

It is superfluous to expatiate here on the importance of wireless communications in the modern world. However, the central role of modulation and coding in wireless communications is the main subject of this book. Modulation and coding provide the fundamental link between the user (the customer) and the wireless channel, and determine the performance of the system and its use of the resources of bandwidth and signal power. I write this preface shortly after the auction of the third generation mobile radio spectrum in the UK for in excess of £20 billion, after which no one can doubt the monetary value of these resources!

This book, then, is concerned with the principles of modulation and coding as they apply to wireless systems (although other systems are also mentioned), and with the actual modulation and coding schemes that are found in modern wireless systems. It is therefore pitched at a somewhat higher level than most introductory

undergraduate textbooks on communications, in order to provide the necessary theoretical underpinning for these schemes.

In fact, the book has developed from the notes of a successful MSc module (also taken as a week-long stand-alone short course for industry), which I have taught for some years at the University of York and elsewhere. This in turn developed from a final year MEng course on 'Advanced Modulation and Coding' at York, as well as from 15 years of research in wireless communications. The book is thus aimed primarily at final year undergraduate or Master's level postgraduate students, with the implications that some prior exposure to basic communication principles would be helpful. In an academic context, then, I hope it will support courses towards the end of a Bachelor's program (or an equivalent first degree in Europe), or Master's level courses or in support of Doctoral programmes. While it is designed as an integrated whole, many of the chapters will stand alone, so it could also be used in courses on modulation or coding only.

However, it is also my hope that it will be suitable for practising communications engineers, both to provide an introduction to the more advanced topics in this area, and also to give practical guidance in developing and applying the schemes described. To this end a number of practical examples are included, as well as tables and graphs and a full chapter on implementation issues.

The implicit premise behind the book is that modulation and coding are best regarded as a single process, rather than as two separate processes. This implies not only that they should be implemented jointly, but also that they should be taught jointly. We then find, serendipitously, that there are a plethora of common principles between the two aspects, which greatly aid understanding. It also provides a natural basis for such techniques as coded modulation and coded orthogonal frequency division multiplexing (OFDM), in which coding and modulation are inextricably combined.

Modulation and (especially) coding are notorious for being heavily mathematical subjects. I suspect this reputation is not entirely accurate—or it would be beyond my understanding! I have, therefore, tried to keep the mathematical content of the book to an absolute minimum (but now below!), and to make use of graphical and verbal explanations of the sort I have myself found helpful. Mathematics has been included either where it actually aids understanding, or where it is essential to allow numerical calculations. Detailed derivations of results have generally been omitted, with reference to the original literature for the interested reader. In a couple of cases mathematical detail has been relegated to appendices.

An important motivation for the book has been to provide the basis for understanding the modulation and coding schemes actually used in modern wireless systems, and as mentioned above, this has largely dictated the level of the book. With such a rapidly developing field, however, it is impossible to keep up, and there have been some significant developments even during the gestation of the book which I have had to leave out. However, I have been able to include such advanced techniques as OFDM and turbo-codes, which are now appearing in 'live' systems and which are not well covered in other texts. Other content, such as the effect of multipath and of non-linear amplifiers, is peculiar to wireless systems and again is not often included in books of this sort. I should emphasize here, however, that 'coding' in this book refers to error control coding, and in particular to forward error correcting coding. Other very important types of code, such as speech/video coding and cryptography, are outside its scope.

The book is accompanied by a Companion Web Site, hosted by Pearson Education at [www.booksites.net/burr](http://www.booksites.net/burr). This will include a variety of material, which I hope will helpfully supplement the book. In particular it will include worked solutions to the problems, which are included in all but the two final chapters. These problems, by the way, are intended not only as exercises for students when the book is used as a course text, but also to extend the material presented in the book in ways which may be of use to practicing engineers. The web site will also contain some of the *Mathematica* scripts that were used

in obtaining results presented in the text, in the hope that they may be of use in obtaining new results.

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