



# Robust Modulation Methods and Smart Antennas in Wireless Communications

By Bruno Pattan

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**KEY BENEFIT:** This is a systematic, practical tutorial covering every key technology for maximizing the capacity and performance of wireless systems. **KEY TOPICS:** The book's reader-friendly coverage introduces spectral and power efficiencies within Shannon bounds, as well as key techniques for bandwidth-efficient modulation. These techniques include higher-order modulation waveforms, signal state-space diagrams, performance representations, and much more. Understand today's robust digital signal modulation methods; advanced approaches for mitigating interference in spread spectrum systems; signal formats and performance specifications in terrestrial cellular; and the rapid evolution of smart antennas and smart arrays. Coverage also includes: the dynamics of linear and continuous phase modulations in digital communications; fundamentals of error correction coding; the advantages of trellis coded modulation; Butler matrix beam forming networks; side lobe cancellers; and switched multi-beam smart antennas and adaptive arrays. The book contains extensive figures, illustrations, and glossaries of terms throughout. **MARKET:** For all wireless systems designers.

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## **Editorial Review**

From the Inside Flap

Preface

The aim of this book is to regale the reader with an overview of some of the technologies peculiar to wireless communications. I have addressed what I believe are important aspects of the subject. The material is tailored for technical personnel working in the field of wireless, who are seeking additional information on the technologies in this area. The practicing engineer will find the text to contain useful information concerning the design of wireless systems. The material presented is also suitable for senior undergraduate or graduate students majoring in communications. The prerequisite knowledge is a first course in communication theory, some exposure to probability and random noise theory, and a nodding acquaintance with matrices.

Wireless communications have consistently exceeded the capacity of available technology. The exponential increase in voice service (mobile in particular), together with the ever-growing demand for data services, have pushed current systems beyond their capacities. There is therefore a continuous pursuit to satisfy these burgeoning demands and for advancing the technological frontiers.

The coverage in this book is broad, encompassing subjects from signal formats to smart antennas, with the latter developing in the continuous pursuit of more capacity. The material is not rigorous, but is reader-friendly with a tutorial slant. The text is complemented with numerous figures to make the presentation more lucid.

The various technologies described in this book are as follows: The first two chapters deal with spectral efficiencies and power efficiencies within Shannon bounds. Providing wireless service in a spectrum where there is paucity of spectrum is an ever-present challenge. Chapter 3 discusses various higher order modulation methods in the presence of limited bandwidth, which can achieve increased spectral efficiency (b/s-Hz), but with a concomitant increase in power requirements. Chapter 4 deals with modulation methods which provide high spectral efficiency and robustness in a stressed environment. The latter includes fading induced amplitude fluctuations in the received signals and nonlinearities in the communications channel, and hence permits the utilization of efficient-C amplifiers. This is followed by Chapter 5, which deals with error-correcting codes with coding gain - a necessary adjunct in wireless to cope with the fading signal environment and other deleterious interference. Both random and bursty errors are generated, which are combatted by various coding schemes. Chapter 6, Trellis Coded Modulation, is a compliment to the coding chapter. This modulation type provides coding gain without sacrificing additional bandwidth and is truly a breakthrough in coding theory.

Chapter 7, Spread Spectrum Communications, describes a cellular standard now used in the U.S. This standard mitigates interference from systems using co-channel operation by tagging each channel with its unique identifying orthogonal code. Each signal channel sees the other channels as adding noise-like interference to its channel (which puts a bound on capacity). It potentially can significantly increase capacity to cellular systems, even though this has yet to be established.

Chapter 8, Terrestrial Cellular Communications, presents some of the concepts used in terrestrial cellular, including the various signal formats and performance specifications used by various standards, which have

been developed and used globally.

The next few chapters deal with the evolution of smart antennas. These antenna systems use phased arrays to produce beams in space which can increase the capacity of a system. Chapter 9 starts with a discussion of the Butler matrix, which is an integral component of some smart antennas. The Sidelobe Canceller, discussed in Chapter 10 had its origin in radar and was used to reduce interference coming into radar antenna sidelobes. It has few applications in cellular, but is presented for historical value and lays the groundwork for smart arrays. Chapters 11-13 deal in more detail with the two basic types of smart arrays - that is, switched-multiple beam and adaptive array configurations. The attributes and shortcomings of both are given. The last chapter, Chapter 14, is a summary of smart antennas and where they are going in cellular communications.

All chapters are complemented by a list of references through which the reader may seek additional information.

From the Back Cover

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Covers both terrestrial and satellite systems Maximizing wireless system capacity and performance: a practical tutorial

Robust Modulation Methods & Smart Antennas in Wireless Communications is a systematic, practical tutorial covering each key technology for maximizing the capacity and performance of wireless systems.

The book's reader-friendly coverage introduces spectral and power efficiencies within Shannon bounds, and key techniques for bandwidth-efficient modulation, including higher-order modulation waveforms, signal state-space diagrams, performance representations, and much more. Author Bruno Pattan reviews today's robust digital signal modulation methods; approaches for mitigating interference in spread spectrum systems; signal formats and performance specifications in terrestrial cellular; and the rapid evolution of smart antennas and smart arrays. Coverage includes:

- The dynamics of linear and continuous phase modulations in digital communications
- Fundamentals of error correction coding
- Trellis-coded modulation, its advantages, and factors that can degrade its performance
- Butler matrix beamforming networks, including planar array beams, multiple volumetric beams, and Butler matrix applications
- Side lobe cancellers in smart antenna applications, including single and multiple interferers
- Switched multi-beam smart antennas and adaptive arrays

The book contains extensive figures and illustrations throughout, making it easier to understand each technology and how it may be implemented. In particular, Pattan's thorough, up-to-the-minute coverage of smart antennas and smart arrays will enable wireless designers and other professionals to substantially increase the capacity of their systems.

About the Author

Bruno Pattan has 35 years of experience in engineering, research, and analysis of radar, satellite, and wireless technology. A senior member of the technical staff at the Federal Communications Commission's Office of Engineering and Technology, he has been principal technical investigator on studies of direct

broadcast, and non-GSO satellite systems; spread spectrum systems, and spectral-efficient higher-order modulation signals.

## **Users Review**

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