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Ultra Wideband Signals and Systems in Communication Engineering, by Mohammad Ghavami, Lachlan B. Michael, Ryuji Kohno, published by Wiley, second edition, 2007, ISBN: 978-0-470-02763-9, 334 pages, hardbound. *Reviewed by Weifeng Su (weifeng@eng.buffalo.edu), State University of New York (SUNY) at Buffalo, New York*.

Ultra wideband (UWB) technologies were originally developed for military applications such as accurate UWB radars and anti-jamming wireless communications. In recent years, UWB technologies have attracted considerable attention by the wireless communication industry, in large part due to their superior properties in terms of low power usage, high data rates, precise positioning capabilities, and extremely low interference. Since the Federal Communications Commission (FCC) approved the use of UWB radio in 2002 for the spectrum range of 3.1–10.6 GHz, a variety of UWB commercial applications have been exploited and several UWB standards have been developed. The resulting maturation of the field makes it timely to offer a book in this area that can summarize both technical advances and related applications and regulations.

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Currently, there are many books on UWB, which generally focus either on theoretical results or industrial implementations. *Ultra Wideband Signals and Systems in Communication Engineering* covers both UWB principles and applications. It provides a useful resource for students and engineers to understand the basic concepts of UWB technologies, current UWB applications, and standards. The book is suitable as a textbook for a senior undergraduate course or as a basic graduate textbook. The book may also serve as a reference for academic researchers wishing to learn about existing and potential UWB applications as well as the current state of standardization efforts.

The book consists of an introduction and 11 chapters. In the introduction, the authors present a general overview of UWB including key technical benefits, historical notes, regulations and standardizations, opportunities, and challenges. The introduction provides a very good motivation as to why UWB is considered to be a strong wireless communication technology. The 11 chapters can be categorized in two parts: discussion devoted to the principles of UWB technologies and discussion regarding UWB applications.

The first part (Chapters 1–7) introduces the principles of UWB technologies and systems. Specifically, in Chapter 1, the authors review the basic properties of UWB signals and systems, including power spectral density, basic pulse shapes, FCC spectrum masks, multipath channel fading, capacity, and power consumption.

Chapter 2 provides a detailed discussion regarding the generation of UWB waveforms. It introduces Gaussian pulses, monocycles, and doublets based on the Gaussian function and differentiation. In particular, this chapter focuses on generating these UWB waveforms while adhering to FCC spectral masks.

Chapter 3 reviews basic signal processing techniques for analyzing UWB signals and systems, including both time and frequency domain techniques. Concepts of linear time-invariant systems and impulse responses, the Laplace transform, the Fourier transform, and the z-transform are reviewed.

Chapter 4 focuses on aspects of UWB channel modeling that are unique to UWB systems. First a general multipath channel model with multipath delay spread and amplitude fading distribution is considered. Second, a path loss model of the channel that uses a simple two-ray UWB propagation mechanism is considered. Third, a statistical frequency-domain autoregressive model is detailed, followed by the Saleh Valenzuela model recommended by IEEE Standard 802.15.3a.

Chapter 5 presents several major components of UWB communication systems, including transceiver design, detection, and multiple access. Additionally, this chapter covers various modulation schemes, such as pulse position modulation, biphase modulation, pulse amplitude modulation and on-off keying. It also compares UWB communication systems with other popular wideband communication systems, such as direct sequence spread spectrum systems and orthogonal frequency division multiplexing systems.

Chapter 6 is an extension of Chapter 2 and discusses more advanced UWB waveforms for UWB communication systems. Orthogonal UWB pulses are

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designed based on Hermite polynomials, spheroidal wave functions, and wavelet packets.

Chapter 7 introduces basics regarding UWB antennas and antenna-arrays. Antenna fundamentals are briefly reviewed and challenges of antenna designs for UWB signals are discussed. This chapter also addresses UWB antenna arrays, beamforming, and factors that affect antenna performance.

The second part of the book (Chapters 8–11) addresses existing and potential applications of UWB technologies as well as recent standardization efforts. Specifically, Chapter 8 discusses UWB applications in positioning and location tracking. The chapter reviews conventional wireless positioning technologies and existing positioning systems and then discusses the advantages of UWB technologies in promising positioning applications such as personal location, inventory control, smart highways, smart homes and office, and node location in ad-hoc networking.

Chapter 9 surveys existing major UWB applications, including UWB systems and chip sets developed by leading companies. At the end of the chapter, potential applications of UWB in the medical industry are addressed, in which fundamentals and challenges of medial UWB radar and UWB respiratory monitoring system are specifically discussed.

Chapter 10 presents the status of current UWB standardizations efforts. This chapter focuses on the review of two UWB communication standards, IEEE 802.15.3a and 802.15.4a, for wireless personal area networks (WPAN).

Finally, in Chapter 11, advanced topics related to UWB technologies are discussed, including UWB ad-hoc networks, UWB sensor networks, space-time coding for multiple-input, multiple-output UWB systems, and the coexistence of UWB systems with WiMAX and other communication systems.

The first edition of the book was published in 2004. In this second edition, two chapters (Chapters 10 and 11) have been added to help readers to understand current status of UWB applications, standardizations efforts, and to be aware of some hot topics in current UWB research and development. The second edition also enhances the scope of the content and greatly improves the balance between UWB technical principles and applications.

The book has three features that this reviewer found to be particularly valuable. First, a variety of methods are introduced that generate UWB signals and emphasizes the ways to generate UWB waveforms adhering to FCC spectral masks (Chapters 2 and 6). Second, the book addresses every aspect of a UWB communication system from transmitter side, such as modulation and power consumption, to receiver side, such as tracking and detection (Chapters 4 and 5). Third, the book provides a comprehensive survey on existing UWB applications and standardization efforts as well as promising UWB potentials in the medical industry (Chapters 8–11). This is the strongest feature of the book. The only issue that is somewhat disappointing is that some topics are covered in too broad of a manner, without significant depth, and this often is distracting to the flow of the book. For example, the discussion regarding antenna fundamentals, which is covered in Chapter 7, is fairly basic and not unique to UWB. As a result, this discussion (which is not needed), seems a bit distracting and leaves the reader wondering what aspects of antennas are specific to UWB systems. Further, the reviews of basic signal processing concepts (for example, classification of signals and systems) in Chapter 3 are straightforward and could be excluded from the book.

Further, the book is well written and easy to read. It includes plenty of figures and charts, which are very helpful for understanding related concepts, protocols, and systems. The book contains few mathematical derivations and omits complicated proofs of the underlying theories. Instead, theoretical results are intuitively and clearly explained. This makes it suitable as an introductory book for beginners in this area, allowing students with a basic communications background to quickly grasp the main ideas of UWB. This feature, however, may also be a disadvantage for researchers in this area who would like to know more technical details. Consequently, this book may be better used as a textbook for an undergraduate course or as a basic graduate textbook. In order to support use of the book in the classroom, the authors have included problems at the end of each chapter and the publisher has set up a companion Web site: http://www.wiley.com/go/ghavami, which contains a solution manual, MATLAB programs for the examples and problems in the book, and electronic versions of most of the figures in the book.

It is useful to compare this book with another recently published book, *UWB Communications Systems: A Comprehensive Overview* edited by M. Benedetto, T. Kaiser, A.F. Molisch, I. Oppermann, C. Politano, and D. Porcino (Hindawi, 2006). This book also provides a broad coverage of UWB topics including UWB basics, propagation channels, transceiver designs, networking, ranging, regulation and standardization, and some advanced UWB topics. However, this book, which consists of contributions from over 30 leading UWB researchers, is targeted at more advanced academic researchers, wireless designers, and senior graduate students who desire to greatly enhance their knowledge of all aspects of UWB systems. Therefore, the UWB research topics that are the focus of Benedetto's book may not immediately accessible to beginners in the area. By contrast, the book by M. Ghavami, L.B. Michael, and R. Kohno is more suitable for beginners who do not have UWB research experience or an advanced signal processing background. Moreover, Ghavami's book provides a great review of current and potential UWB applications, which is a valuable resource for both beginners and academic researchers.

In summary, *Ultra Wideband Signals and Systems in Communication Engineering* is a well-developed, introductory book on UWB technologies and applications, which is a strong resource for both beginners who seek an introduction to UWB principles and their applications, and for researchers who wish to better understand the application of UWB technologies to practical systems. SP