



# Book/Software Reviews

## ***The Next Big Leap in MIMO***

■ **Alfy Riddle**

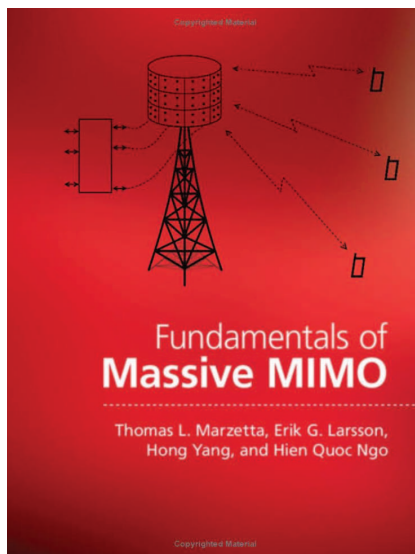
**M**ultiple-input/multiple-output (MIMO) has been a huge success. Integrated circuits with receivers, transmitters, and transceivers on one chip have enabled the inexpensive use of multiple antennas, which has, in turn, made signal quality for Wi-Fi much more reliable in highly reflective environments and those with mobile users. *Fundamentals of Massive MIMO* describes the next big leap in MIMO, and this leap has some huge possibilities. The book is put together by an excellent team of authors: the originator of massive MIMO, Thomas Marzetta; a second member of his Nokia Bell Labs team, Hong Yang; a professor from Linköping University, Erik Larsson; and a researcher also from Linköping University, Hien Quoc Ngo.

Massive MIMO systems remind me of the Liliputians tying down Gulliver in *Gulliver's Travels*. Many small things working together may have an advantage over a big thing. *Fundamentals of Massive MIMO* offers a systems perspective and is intended to be a self-contained resource

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***Fundamentals of Massive MIMO***  
by T.L. Marzetta, E.G. Larsson, H. Yang,  
and H.Q. Ngo  
Cambridge University Press, 2016  
ISBN 978-1-107-17557-0  
220 pages: US\$79.99.

on massive MIMO. One warning is that the authors use a good number of acronyms (which Appendix H helps to sort out). Also, to me, this book reads like a research lab monograph, as it is a nice reference but is not designed as a textbook or a tutorial with lots of examples, just a clear and detailed presentation of the subject.

The book consists of eight chapters and eight appendices. The appendices provide background on Gaussian vectors and random matrices as well as further details on capacity, single cells, signal-to-interference-plus-noise ratio, links, hexagons, and, as mentioned, the many acronyms.

The most extensive chapter (Chapter 3) focuses on single cells, and this forms a foundation for the presentation of multiple cells and case studies. The two earlier chapters provide an introduction and a study of models. The introduction covers the evolution of communication from point-to-point to multiuser systems requiring signal processing of  $M$  sources and  $K$  receivers. Channel hardening, channel learning, and minimizing antenna power and processing are all described. The second chapter focuses on channel models and discusses coherence, fading, and orthogonal frequency-division multiplexing signals.

As noted, the real foundation is in the third chapter on single cells. This chapter discusses coherence, mean-squared-error channel estimation, matrix signal processing, zero forcing, and power control. The fourth chapter describes the next logical step after a single cell, i.e., multiple cells. Signal contamination and interference are the main topics of this

chapter. MIMO has proven to be very effective at minimizing signal nulls and fading, which, in the past, were dealt with by increasing transmitter power or moving variedirectional antennas. Where massive MIMO has even greater potential is in efficiency: the fifth chapter of the book discusses power control and massive MIMO efficiency.

The last three chapters are primarily about using massive MIMO. Chapter 6 goes beyond a typical monograph and contains three cases studies of massive MIMO. Chapter 7 provides a review of propagation channels and how they introduce fading and scattering and limit capacity. And, as one would expect, the final chapter is about the future of massive MIMO.

Massive MIMO will be enabled by lower-cost and smaller electronics as well as by cooperative communication devices. *Fundamentals of Massive MIMO* provides an excellent overview of the subject as understood by a few of the top experts in the field. If you are interested in this topic, this is a must-have on your bookshelf.

## Electromagnetic Compatibility—An Expert Overview

■ James Chu

Author Tim Williams worked for a variety of companies as an electronic design engineer before starting his own consultancy specializing in electromagnetic compatibility (EMC) design and test advice and training. He has 25 years of experience in EMC technologies and directives, along with their associated standards.

His text *EMC for Product Designers* is divided into three parts: Part 1, "Legislation and Standards," includes Chapters 1–6; Part 2, "Testing," spans Chapters 7–10; and Part 3, "Design," comprises Chapters 11–17. The book is based on a European Union environment.

### Part 1: Legislation and Standards

Chapter 1, "Introduction," offers an introduction defining EMC, its scope, and related issues. Chapter 2, "The EMC and Radio Directives," discusses the history and requirements of legislation, while Chapter 3, "International EMC Compliance Requirements," includes the standards, rules, and approval routes and test requirements for the United States,

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Canada, China, Australia, New Zealand, Japan, Taiwan, and Russia.

Chapter 4, "Commercial Standards," discusses the main standards-making bodies and general standards, and Chapter 5, "Other Standards and Legislation," covers requirements for sectors marginally

affected by radio or EMC directives, such as automotive EMC directives and military directive MIL-STD 461. Chapter 6, "EMC and Functional Safety," includes hardware and software design for functional safety.

### Part 2: Testing

Chapter 7, "RF Emissions Measurements," discusses the requirements for emissions-measuring instruments and covers the receiver, spectrum analyzer, probes, antenna, site and facilities requirements, and equipment arrangement and test setup. Chapter 8, "Immunity Tests," explains immunity test requirements for equipment such as signal sources, power amplifiers, screened-room facilities, and test setup.

Chapter 9, "Low-Frequency Tests," considers harmonics and flicker emissions, as well as magnetic-field and power-quality immunity. The equipment requirements include ac supply sources, current transducers, and wave analyzers. Chapter 10, "Test Planning," lists the requirements for accreditation and standards, the contents of the test plan, and the details of test setup.

### Part 3: Design

Chapter 11, "Interference Coupling Mechanisms," covers the basic principles involved in coupling an electromagnetic interface from a source to a victim. It