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 varied directional 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.


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, 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
includes transmission-line coupling, radiated emissions, and conducted emissions. This chapter also covers EMC issues regarding power supplies with nonlinear loads.

Chapter 12, “Layout and Grounding,” covers the printed circuit board (PCB) low-noise layout concept, its requirements, and ground techniques such as single-point and multipoint grounding. The author points out the right and wrong way of designing a grounding layout for double-sided and multilayered PCBs, along with how these techniques can be applied to low-cost PCBs. The chapter also includes a discussion about how to ground the heatsink. A large central processing unit heatsink without solid grounding can introduce high digital noise to the equipment. The chapter also describes an internal cable grounding technique. In the concluding section, the author lists PCB layout rules to follow before routing begins and during routing itself.

Chapter 13, “Digital and Analog Circuit Design,” discusses the choice of circuit configuration, components, and software features. The interference of radiation coupling from the differential mode and common modes is also examined, the emissions from different logic families (including digital clocks) are explained, and methods for reducing emissions are presented. Component placement is a major issue in good EMC design, and the author points out the PCB layout methods that can be used to reduce ground-noise current loops. He also offers a detailed discussion of low-noise power supply design for a multilayered board. The chapter also covers immunity and electrostatic discharge protection.

Chapter 14, “Interfaces and Filtering,” deals with cable interference between modules or subsystems. Different types of cables and grounding of cable shields are discussed, including shielded and unshielded twisted-pair cables and connector conductive clamps. Grounding techniques for pigtail cables, ribbon cables, ferrite components, filters, and chokes are presented. For power supply design, this chapter is indispensable.

Chapter 15, “Shielding,” discusses basic shielding theory and design, including shielding box design and practice. Five groups of shielding materials and nine types of conductive gaskets are listed and explained. Shielding surface treatment and coating techniques also are included. In addition, the author suggests a low-cost image plane under a PCB, which serves as a ground reference and can allow a significant drop in emissions.

Chapter 16, “Systems EMC,” introduces issues facing systems designers from the point of view of a product designer whose project must be capable of being installed and interfacing at the system level and so requires caution in providing intra- and intersystem EMC (i.e., with the whole system). The discussion covers earthing and bonding within cabinets, cubicles, and chambers. The chapter also explains how to design ventilation panels, shielded windows, screened windows or doors, and cabling and how a switching-converter power supply installation can be used to achieve minimum emissions.

Chapter 17, “EMC Management,” discusses the EMC design process, design rules, design reviews, and EMC test management. This includes in-house confidence checking and control-plan requirements and generation.

The appendix provides a case study of a real cockpit display. It both documents how to solve difficult EMC issues and offers specific solutions that EMC designers can use as a reference design.

This book is a sufficient tool for anyone associated with EMC—a legislator, EMC tester, or, especially, an EMC designer: the detailed discussion, data collection, and examples will be extremely valuable to any EMC designer.

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From the Editor’s Desk (continued from page 6)

We appreciate that you share your limited reading time with us! I would like to thank Alfy Riddle, Ali Darwish, and Mike Golio for being part of the survey team. And, of course, I thank you for taking the time to make your voices heard.

The issue you have in your hands right now (or on your electronic reader, or both) is also a diverse one. You will find technical features focused on measurements, as well as Student Design Competition articles that did not make the January/February 2018 issue. As you may have read in some of Alfy’s previous “From the Editor’s Desk” columns, we have a backlog of articles waiting to be published. The good news is that we are slowly working through this article queue. Even better news is that we are still receiving new contributions that authors wish us to consider publishing. The backlog of articles indicates the popularity of the magazine as a showcase for the overview and tutorial articles you spend part of your hour (or more) reading. It also means that authors have experienced a bit of a delay in getting their material into print. Please note that we are working through the backlog as best we can. Still, if you have an idea for an overview or tutorial article, please consider writing it up for the magazine.

The technical features in this issue have been solicited and organized by Nuno Borges Carvalho and Jon Martens and focus on the theme “Measurements for Future Wireless Communications.” I will let you read the details in their “From the Guest Editors’ Desk” column, but the technical features cover the challenges in measurements and the new frontiers in fifth-generation, terahertz-range, and multiple-input/multiple-output applications. Many of our columns are getting back into their regular rotation in the magazine, such as “Book/Software Reviews” and various MTT-S news items. We also have a “Speaker’s Corner” column, written by John Bandler, that is a reprint of an article about the engineer’s “mysterious feel for a problem” and the concept of “space mapping.” I would like to thank Bruce Van-Lane, EIC of IEEE Canadian Review, for providing the materials for the reprint. Alfy and I both thought it a thought-provoking article, and I hope you will too.