Book Review

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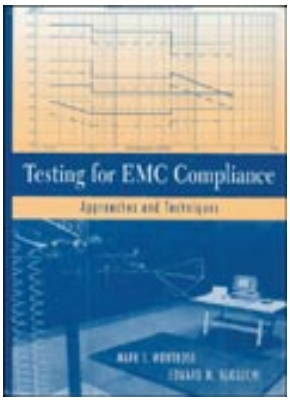
Title: Testing for EMC Compliance -Approaches and Techniques
Authors: Mark I. Montrose and Edward M. Nakauchi
Publisher: Wiley/IEEE Press
Year Published: 2004
ISBN: 0-471-43308-X
Number of Pages: 460



Testing for EMC Compliance–Approaches and Techniques, is the third in a series of books on EMC by Mark I. Montrose and the first with co-author Edward M. Nakauchi. The first two books dealt with EMC design and layout for printed circuit boards. This book's focus is on EMC testing as the title suggests. Testing, as described in this book, is heavily weighed towards commercial requirements, (i.e., CISPR, FCC, etc.), while also having applicability to MIL-STD testing.

It is the opinion of this reviewer that this book should be mandatory reading for every engineer that needs to witness or perform EMC testing of electrical and electronic devices for compliance with international standards. Additionally, product development managers should read this book to understand the ramifications of not fully testing early during the design cycle to gain knowledge of their product's performance in a world immersed in interfering sources. Testing details and descriptions of the "whys" provided in this book are most helpful in understanding the principles of EMC compliance verification and the interpretation of test results.

This book is divided into nine chapters preceded by a Preface and Acknowledgements, followed by two Appendices, a Glossary, Bibliography and Index.

Chapter 1 "Introduction" (16 pages) contains a narrative for the need to comply with requirements followed with definitions and then an excellent description of the nature of interference. This is followed by a short overview of product testing including the test environment, self-compatibility, and validation of measured data. There is also an introduction to problems that may be encountered during emissions testing that are expanded upon in subsequent chapters. This first chapter also contains an explanation on the differences between time domain and frequency domain analysis and when to use each properly. Finally, EMC testing methodologies, i. e. the differences between development and diagnostic testing, and furthermore the differences between compliance and pre-compliance testing, is described in detail. This too is augmented in later chapters so that the reader is well informed of the unique distinctions of each.

Chapter 2 "Electric, Magnetic, and Static Fields" begins with the relationship between each field. This discussion is essential for the reader to understand the ensuing text of this chapter. After this presentation, the authors describe in great detail the different methods of noise (EMI) coupling for both conducted and radiated emissions. This further develops the reader's understanding leading to even more detailed analysis on common-mode vs. differential-mode currents, and conversion from differential to common-mode noise including equations. Finally, the authors describe static fields including electrostatic and tribo-electric fields and the resultant failure modes for each.

Chapter 3 deals with the "Instrumentation" necessary to measure time domain and frequency domain electromagnetic energy. Several pages are devoted to oscilloscopes, spectrum analyzers, frequency selective voltmeters (receivers), and correlation analyzers. The differences between pre-compliance and compliance instrumentation is fully described. The use of peak detection versus quasi-peak and average is examined completely as well as when to use each. Coherence factors for signal correlation are also described in this chapter.

In Chapter 4 the authors discuss the use of "Test Facilities" including Open-Area-Test-Sites (OATS), chambers (shielded enclosures) and Transverse Electro-Magnetic (TEM) cells. This chapter clearly can be used to understand test facility differences for commercial vs. MIL-STD testing. Detailed information about test setup configurations for the system, and power and signal interface cables are presented along with operating conditions and measurement precautions. The distinction between anechoic, semi-anechoic, reverberation and shielded enclosures, and the use of each is fully described. The TEM and G (GHz) TEM cells are shown to be adequate facilities to use for physically small device testing.

"Probes, Antennas, and Support Equipment" are presented in Chapter 5. Although this chapter could have followed Chapter 3 on Instrumentation and before Chapter 4 on Test Facilities, it nevertheless is absolutely complete on the chapter title subject. In this chapter, not only are transducers described well including their usage, they are shown with schematics and drawings in addition to how to fabricate many of these sensors. Appendix A of this book goes into greater detail on the fabrication of these devices. The definition

of transfer impedance as it pertains to current probes is given. Line Impedance Stabilization Networks (LISN's) are also completely described. Voltage probes, absorption and insertion clamps for capture and injection of interfering signals (noise) are detailed. Homemade probes known as small "sniffers" are also discussed. Reading this chapter requires patience because it is packed with very useful information.

Chapters 6 and 7 of this book contain the "meat" of the title subject matter and are the most important reasons for readers to purchase the book. These two chapters talk about "Conducted" and "Radiated" testing, the two fundamental parameters of EMC compliance. Chapter 6 begins with an overview of conducted currents including the difference between common and differential-mode currents and their coupling paths. This is a bit of a refresher considering that both common-mode and differential-mode currents were previously discussed in Chapter 2. What are new in the beginning of this chapter are conducted test requirements. Next, this chapter describes general statements about the performance of conducted current tests, followed with emissions and immunity (susceptibility) testing. Conducted emissions testing is limited to the most commonly applied tests because of this book's close ties to commercial products, especially related to AC power mains and potential problems that may be encountered when making such measurements. This is followed with in situ emissions testing of systems and installations.

Chapter 6 discusses conducted immunity (susceptibility) testing in both the frequency and time domains. Like testing for conducted emissions, this part of the chapter is limited to conducted immunity testing of AC power mains, probably for the same reason. Fast transient, burst and surge testing is discussed. For the next three subjects, "Conducted RF Current Immunity", "AC Mains Supply, Dips, Dropouts, and Interruptions", and "Power Line Harmonics", the authors establish a format for this book to flow from how the noise got there, to how to measure it, to diagnosing and fixing the problem. This chapter ends with measurement of "Voltage Fluctuation and Flicker".

Chapter 7 begins with a general discussion about investigative emissions testing in a laboratory or office environment, and then moves on to pre-compliance testing and analysis of the results. Next, the authors discuss formal EMC qualification radiated emissions testing followed with a dissertation on in situ testing of systems and installations. The remainder of this chapter is devoted to radiated immunity (susceptibility) testing. This part of Chapter 7 is divided into three subchapters. First there is radiated immunity testing in the traditional sense, i.e. the generation of electric fields and immersing the test item(s) in that field. The next part deals with electrostatic discharge (ESD) testing. This part of Chapter 7 is well thought out and complete. The last part of Chapter 7 deals with power frequency magnetic fields and the testing involved to evaluate a disturbance from this particular type of field.

The last two Chapters of this book deal with "Troubleshooting" which is fault or failure isolation and appropriate corrective action. This is by all means the hardest part of being an EMC engineer, and requires many years experience to be proficient.

Chapter 8 describes "General Approaches to Troubleshooting." This chapter describes general system troubleshooting techniques including unique emissions and immunity testing and potential problems encountered during evaluation of those test results. This chapter also gives a systematic approach to troubleshooting techniques to isolate problems. The ever-present question about repeatability of one's test results is discussed in some detail and continues to unexpected problems that may be encountered after production has begun. This chapter ends with several examples and case studies.

Chapter 9 deals specifically with "On-Site Troubleshooting Techniques." This chapter is filled with tricks of the trade to isolate problem areas quickly when evaluating and troubleshooting installed and working systems.

As previously stated, Appendix A contains a great detail of information about fabrication methods for building special probes useful for isolating noise sources emanating from equipment or circuits. Appendix B contains 58 pages of a test procedure useful to the reader who wishes to create their own test laboratory, or to repeat a particular test that failed at a commercial test facility.

The authors have developed a logical approach to understanding testing for EMC. The examples and equations are most helpful in understanding the mechanisms involved for coupling of interfering signals (noise) to victim equipment and circuits. The conversion from common-mode conducted current to a radiated electric field is particularly useful in understanding the radiated emissions coupling mechanism. **EMC**

About the Book Review Guest Associate Editor

Larry G. Campbell has worked in the EMI/EMC field for nearly 44 years. At present he is a Senior Contractor for MEI Technologies headquartered in Houston, Texas with local offices in Littleton, Colorado where Mr. Campbell is currently contracting with Lockheed Martin supporting a variety of space programs. Mr. Campbell holds a California professional engineers license in Quality Engineering and is a NARTE certified EMI/EMC Engineer. Mr. Campbell's employment history spans the history of the aerospace industry. He started in the industry in 1962 working for Autonetics in Downey, California, then a division of North American Aviation (the maker of the P40 Mustang and the F86 Super Saber Jet). Mr. Campbell worked on the Minuteman I, II and III, radar systems and submarine systems, as well as the Apollo moon landing mission while at Autonetics. After five years in the RFI test laboratory at Autonetics, Mr. Campbell went to Collins Radio Company in Newport Beach, California. At Collins Radio Company, Mr. Campbell was instrumental in the development of TEMPEST and

EMI testing techniques applied to secure communications systems still used throughout the industry. Seven years after joining Collins Radio Company, Mr. Campbell left to manage a now defunct R.F. shielded enclosure manufacturing business. Mr. Campbell then spent the next three years at Hughes Aircraft Company in Fullerton, California managing the EMI test laboratory performing EMI and TEMPEST tests. Mr. Campbell was recruited by Martin Marietta in Colorado to work on the Peacekeeper program in 1979. He then spent the next 22 years working on the Peacekeeper and a variety of programs that followed. Mr. Campbell retired from Lockheed Martin in 2001 and four months later went to work as a contracting engineer for MEI Technologies.

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