



Book Review

EMC Made Simple-Printed Circuit Board and System Design®

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This fifth book authored by Mark Montrose, self-published, is sure to be a best seller. *EMC Made Simple-Printed Circuit Board and System Design*® uses a totally unique style of presentation along with visual concepts to simplify both theory and application of electromagnetic compatibility, especially for those who do not work in the field of EMC on a full time basis.

I saw an endorsement by Keith Armstrong about the book. He said “People who communicate about EMC are experts in some way or another, and they mostly write for other EMC experts. When they try to communicate EMC to electronic designers, most of them fail to ‘connect’. But not Mark Montrose—whose new book “*EMC Made Simple*” lives up to its title and should be on every designer’s desk!” I fully agree with what Keith stated.

Although electromagnetic theory is well known in the engineering community, many authors attempt to describe field propagation and engineering design solely using Maxwell’s equations at an academic level with a focus on mathematical analysis. These authors usually ignore the general engineering population who has minimal exposure to the field or are at a junior level. What Mark recognized as a consultant and trainer was that missing from the bookshelf was a publication that focused on the need to simplify the field of electromagnetics, especially for non-EMC engineers or those who never took a class in electromagnetics in college. His approach was to not preach to the [EMC] choir, but to educate everyone on what the field of EMC is all about. There are very few books worldwide that focus on applied engineering in a simplified, easy to read style with every item discussed and fully justified with sound theory and physics which this book does.

The most fascinating thing I read was something stated in the Prefix. Mark clearly identifies the target audience, or those that would benefit greatly from the content, and then clearly states that this book is “unsuited” for a certain group of engineers who already believe they know everything there is about electromagnetic compatibility, which I agree with!

The basic concept regarding EMC Made Simple is understanding transmission line theory in the time domain. Mark clearly states that when he has an EMI problem, he solves it using an oscilloscope and not a spectrum analyzer. A spectrum analyzer only tells us the presence of an electromagnetic field, not what *caused* the field to be created, which is loss in a transmission line, easily measured with an oscilloscope or through computational analysis. He illustrates that fact that it is easier to solve problems in the time domain instead of the frequency domain, for most engineers, especially early in the design process.

We propagate an electromagnetic field (signal) from a transmitter to receiver through some media (a.k.a. transmission line) which is either free space or a metallic interconnect such as a printed circuit board trace or cable. If there is any loss in the transmission line, the magnitude of this loss is the magnitude of common-mode current that gets developed. This is essentially Kirchhoff’s law in action yet we rarely mention Kirchhoff on a daily basis but focus on Ampere’s law. Yes, current flows in a loop but if there is loss in the transmission line, the lost energy must propagate somewhere to satisfy Kirchhoff which is generally free space or radiated EMI. The concept described in the book is so simple, yet EMC engineers generally focus only on Ampere’s Law which is one of Maxwell’s equations. Kirchhoff is not mentioned by Maxwell, yet this law is what causes job security for those working in the field of EMC.

The book is divided into six chapters, each with a focus on a particular aspect of printed circuit board and system level design, all with the words “*Made Simple*” in the chapter title.

Chapter 1 is the most exciting section titled “*EMC or Maxwell Made Simple*”. In this chapter, Mark explains electromagnetics in a manner that has never been presented in any other book that I am aware of, with a unique twist. He walks the reader through field theory using a visual approach by converting the

calculus of Maxwell into simplified algebra. Too much emphasis is placed, in academic environments, on solving Maxwell's equations with no relationship to applied engineering applications. What engineers need to understand is "What does Maxwell tell us"? He figured out a way to explain what each equation represents using a single sentence that anyone can comprehend. Once one understands how to translate the equations into simple transmission line theory, the field of electromagnetics becomes easy to work with. Mark also explains, for the first time again in any book, how common-mode current is actually created in a transmission line, not the fact that common-mode current flows in the return path in the same direction as the signal path. This visualization is so elegant that I am surprised that nobody has figured out how to explain it in a simplified manner.

Chapter 2 is titled "*Transmission Line Theory Made Simple*". The field of electrical engineering involves sending an electromagnetic field from a source to receiver using a transmission line as the propagation path. Mark explains in detail the difference between lossy and lossless transmission line structures. If there is any loss of propagated electromagnetic energy in the transmission line, the magnitude of this loss is undesired common-mode current. An extensive discussion also exists on how to minimize losses and enhance signal integrity in the time domain within a printed circuit board layout.

Chapter 3, the smallest chapter of the book, "*Inductance Made Simple*" is an elegant discussion on what inductance is without heavy math. It highlights the fact that every transmission line contains inductance and inductance is a significant contributor to the creation of common-mode current. To be a successful designer, one must minimize inductance during layout. Computational analysis or simulation can then occur after initial layout to determine if there is too much inductance and the magnitude of any problem it may create. Again, most designers want to understand inductance in a simplified manner and how to design transmission lines quickly and at low cost, since many engineers will never simulate anything for a variety of personal reasons but rely on rules of thumb, which we all know is poor engineering practice but does occur in real life.

I found Chapter 4, "*Power Distribution Networks Made Simple*" exciting to read and one of the larger sections in the book. He explains what a capacitive structure is in simplified terms along with various design concerns and parameters that most engineers take for granted or are forgotten by designers. Almost everything associated with creating a stable power distribution network, including power and return planes is discussed (note-he does not use the words ground plane in this chapter). I found the section on rules-of-thumb fascinating. He clearly investigates many rules to determine if they are valid or not, with the correct answer of "*It depends*" for each rule.

Moving onto Chapter 5, "*Referencing Made Simple (a.k.a Grounding)*" was my favorite, having authored the book *Grounds for Grounding*. Mark clearly describes that fact that ground is an invalid word in electrical engineering without a prefix to describe exactly what is being referenced. We must reference RF field propagation to a return or reference path, not ground or a ground plane. Various grounding methodologies are presented as well as breaking up ground loops which cause common-mode current generation in a simplified manner for system designers.

Chapter 6, "*Shielding, Gasketing and Filtering Made Simple*" is the largest chapter. Here Mark simplifies many related topics. What I did not realize until reading the book is that a shield is actually a transmission line with high impedance to the propagating field, uniquely described for the first time in any book. This chapter deals mainly with aspects of system design and is a must read since printed circuit boards are installed in some form of enclosure where shielding, gasketing and filtering may be required.

The book concludes with several Appendixes. This includes understanding Fourier Analysis, Using the Decibel, Conversion Tables, an extensive Glossary with unique descriptions that really clarifies word(s) instead of a typical dictionary description, plus References.

This book simplifies the theory and application of applied EMC engineering, avoiding complicated math unlike other books on EMC. It is an easy to follow, pleasant to read and a must have on the desk. It is based on many years of practical experience of the author with "real world" design cases. I found it to be an excellent reference and useful for any design engineer who has to get the job done quickly and at low cost.