Preface

Broadcast television reception uses the radio spectrum. In the days before digital TV, spots, hash, snowstorms, colour and vision distortion and occasionally complete loss of picture were all symptoms of the same cause – electromagnetic interference. Interference still occurs, but its manifestation on digital pictures is different – pixellation, “blocking” in parts, and complete freezing of the picture are the modern curse, and might perhaps be regarded as more annoying than the analogue effects.

It is irritating for the viewer when the picture flickers or is wiped out during a crucial programme, just as it is irritating for a music lover who has carefully taped an important radio broadcast only to find that the quiet passages are ruined by the intrusion of the neighbour’s electric drill. It is far more critical when the emergency services are unable to communicate within a city centre because their radio signals are obscured by the electromagnetic “smog” emitted by thousands of computer terminals in the buildings around them.

The coexistence of all kinds of radio services, which use the electromagnetic spectrum to convey information, with technical processes and products from which electromagnetic energy is an undesirable by-product, creates the problem of what is known as “electromagnetic compatibility” (EMC). The solution is a compromise: radio services must allow for a certain degree of interference, but interfering emissions may not exceed a certain level, which normally involves measures to limit or suppress the interference energy. There is an economic trade-off inherent in this compromise. A lower level of interference would mean that less powerful transmitters were necessary, but the suppression costs would be higher. Alternatively, accept high power transmitters – with the attendant inefficient spectrum usage – in return for lower suppression costs. This economic balance has been tested over the past decades with the establishment of various standards for allowable levels of interference.

The problems of EMC are not limited to interference with radio services. Electronic equipment of all kinds is susceptible to malfunctions caused by external interference. This phenomenon is becoming more noticeable for two reasons: the greater pervasiveness and interaction of electronic products in all aspects of daily life, and the relatively worse immunity of modern equipment using plastic cases and microprocessors. Susceptibility to interference is now an issue for many kinds of electronic device, especially those whose continued correct operation is vital for safety or economic reasons. Automotive and aviation control systems are examples of the former category, banking and telecommunication networks are examples of the latter.

Recognizing the need for EMC protection measures and at the same time to eliminate the protectionist barriers to trade throughout the European Union, the European Commission adopted in 1989 a Directive “on the approximation of the laws of the Member States relating to electromagnetic compatibility”, otherwise known as the EMC Directive. It has been revised twice, and the third edition has come into effect in 2016. It is discussed in detail in Chapter 2 of this book.

Every company that manufactures or imports electrical or electronic products should have in place measures that will enable its products to comply with the Directive. This means that an awareness of EMC must penetrate every part of the enterprise. EMC is undoubtedly affected by the design of the product, and the design and development group is where the awareness normally starts. But it also depends on the way an individual product is put together, so it affects the production department; by the way it is installed, so it affects the installation and service technicians, and the user documentation; it needs to be assured for each unit, so it affects the test department; it impacts the product's marketing strategy and sales literature, so it affects the sales and marketing departments; and it ultimately affects the viability and liabilities of the company, so it must be understood by the senior management.

There are various means of implanting and cultivating this awareness. An EMC training course would be a good starting point. You could bring in consultants to handle every aspect of the EMC compliance process, but for many products this would be expensive and cumbersome and would not necessarily result in improved awareness and expertise within the company where it was really needed. It would also be possible to send every appropriate member of staff on a training course. This would certainly raise awareness but it may not prove so effective in the long run, since EMC techniques also need to be practised to be properly understood.

A typical compromise is to nominate one person, or a group if the resources are available, to act as the centre of EMC expertise for the company. His, her or its responsibility should be to implement the requirements of the EMC Directive and any other EMC specifications to which the company may need to work. In the long term, it should also be to make the EMC centre redundant: to imbue a knowledge of EMC principles into each operating division so that they are a natural part of the functioning of that division. This, though, takes years of continuous oversight and education. Meanwhile, the tasks include:

- reviewing each new product design throughout the development and prototyping stages for adherence to EMC principles, and advising on design changes where necessary;
- devising and implementing an EMC test and control plan for each product;
- supervising pre-compliance and compliance tests both in house and in liaison with external test houses;
- maintaining an intimate knowledge of the EMC standards and legislation that apply to the company's products;
- liaising with marketing, sales, production, test, installation and servicing departments to ensure that their strategies are consistent with EMC requirements.

This gives an indication of the breadth of scope of the EMC engineer's job. It is comparable to that of the quality department, and indeed can sometimes be incorporated within that department.

Preface to the fifth edition

This fifth edition comes out 24 years after the first. In that time the EMC Directive has become fully functional and the vast majority of manufacturing companies have become familiar with it. But the EMC world has not stood still: the Directive has been substantially revamped (twice), more new product standards have been published, new test methods have become established and much has been learned to improve old tests. Although Maxwell's laws haven't changed, there is more understanding of how best to apply them to maximize the compatibility of individual products. The onward and upward march of clock speeds and the shrinking of product, package and interconnect dimensions has continued. And so, even if you were familiar with earlier editions, you will find quite a lot of new material in this one.

This book is intended to help the work of the company's EMC centre. It seems to be serving its purpose: I have been pleasantly surprised by how widely earlier editions have been recommended. It can be used as a reference for the EMC engineer, as background reading for designers and technicians new to the subject, or as part of the armoury of the development group tackling a new project. It is structured into three parts. The first part (Chapters 1–6) discusses the legislative and standards framework now erected to encompass EMC. These chapters are mainly non-technical in nature. Chapter 1 introduces the subject of interference, and Chapter 2 goes on to discuss the provisions of the EMC Directive and its new partner, the Radio Equipment Directive, and the means of achieving compliance with them. Chapter 3 looks at the major EMC compliance regimes outside Europe. Chapter 4 details the standards-making structure and describes the various standards that are now in existence and which are relevant for compliance with the Directive. Chapter 5 covers requirements for those sectors that are only peripherally affected by the RED and EMCD: automotive, military, aerospace and rail transport. A new Chapter 6 reviews the increasingly important subject of the electromagnetic compatibility aspects of functional safety.

Both design engineers and project managers need to have a feel for the tests to which their products will be submitted. As well as witnessing tests carried out by third party test houses, it is likely that many will be doing pre-compliance and full compliance tests themselves. The second part of the book looks at these areas. Chapter 7 covers the test methods for RF emissions that are laid down in the standards and which have to be followed both in-house and by external test houses. Chapter 8 does the same for the immunity tests: RF immunity, ESD and transient immunity. Chapter 9 considers the low frequency techniques, both mains input harmonics and flicker emissions, and immunity to magnetic field and voltage dips and interruptions. Finally, the tests do not happen by themselves: they must be planned, and Chapter 10 looks at this sadly neglected aspect of EMC compliance.

The third part of the book discusses techniques for achieving an acceptable EMC performance at minimum extra cost, at the design stage. It is usually possible to add screening and suppression components to an existing design to enable it to meet EMC standards. This brute force method is expensive, time-consuming and inefficient. Far better is to design to the appropriate principles from the start, so that the product has a good chance of achieving compliance first time, or if it doesn't then modifications are made easy to implement.

Chapter 11 covers the basic principles involved in coupling electromagnetic interference from a source to a victim. Chapter 12 looks at the techniques which can be applied before resorting to the more traditional methods of screening and suppression: attention to equipment and PCB layout and grounding, and Chapter 13 discusses choice of circuit configuration, components and software features. Chapter 14 carries on to detail the accepted "special" EMC techniques, which include cable configuration and termination, and filtering methods and components. Shielding theory and practice – the two are not always related – are covered in Chapter 15. Many products are used within systems, and so product designers need an appreciation of system-related EMC, which is encapsulated in Chapter 16, including a look at installation practices for the increasing scourge of power switching converters. Chapter 17 discusses EMC management and control principles and, finally, a series of appendices gather together some reference information, along with a few case studies and a comment on CAD.

Much of the book grew out of course notes that were prepared for seminars on Design and Test for EMC, and I am grateful to those designers who have attended these seminars and stimulated me to continually improve and hone the presentation. Many people have helped with its progress. I would particularly like to acknowledge the work of Prof. Andy Marvin and Dr John Dawson and their colleagues at York University, as well as that of Dr Jasper Goedbloed and Prof. Piet van der Laan. I have had a long and fruitful relationship with Schaffner EMC (now Teseq) and TÜV SÜD, and am continually grateful especially to Ken Webb, David Riley, John Dearing, Ray Hughes and Nick Smith. Pete Dorey and his international colleagues at TÜV SÜD have helped substantially with Chapter 3, and Sandie Houghton at the same company has been magnificent in organising and administering the courses I have presented there for many years. I must also thank Prof. Alistair Duffy of De Montfort University, as well as my consultant colleagues, Dave Imeson, Keith Armstrong, Dave Foster, Roy Ediss and Phil Carter. Keith has been particularly supportive, especially in providing information for, and critiquing, Chapter 6. As always the responsibility for this book remains the author's alone. I hope you find it useful.

Tim Williams
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