EMC Education: A Status Report

The education/ training of future EMC engineers is inefficient, and often deficient, and must be supplemented at some point in their career.

DR. CLAYTON R. PAUL, DEPARTMENT OF ELECTRICAL ENGINEERING, UNIVERSITY OF KENTUCKY, LEXINGTON, KY

INTRODUCTION

This article is a review of the status of various educational methods available to an individual who desires to become an EMC engineer or to improve his/her expertise in the field. The various methods can be grouped into the following categories:

1. University/college courses and organized programs
2. Short courses offered by consultants and by companies on an in-house basis
3. Individual study materials

Each of these categories will be reconsidered in terms of their availability and efficiency. It is important to keep in mind that there are two distinct classes of individuals who may need or desire EMC education: those wishing to make EMC a career and those who, although not interested in EMC as a career, need to become familiar with rudimentary principles of EMC design. Examples of the latter category are digital circuit designers, printed circuit board layout personnel, product managers, etc.

The field of EMC has often been characterized as one in which the participants became involved more or less by default; that is, more because of circumstances than their own conscious career planning. This somewhat random career decision process is not necessarily bad but does indicate that the availability and attractiveness of the field of EMC was not adequately, if at all, presented to that individual in his/her earlier educational institution. It also indicates a degree of inefficiency in that individual's career preparation. It evidently makes more sense to provide the individual with enough information about the field of EMC early on so that he/she can make a conscious career choice and can efficiently begin preparing for that career. The current pool of EMC engineers lies primarily within the Electrical Engineering discipline. Students graduating with a BSEE degree have already been exposed to other EE career choices, such as digital circuit design, power systems, microwave circuits and devices, signal processing, etc., and have begun to prepare themselves for a specific career choice through elective courses in their senior years. The future EMC engineer does not currently have a similar career planning advantage. These considerations illustrate that the education/training of future EMC engineers is inefficient and often deficient and must be supplemented at some point in their career.

To those readers actively involved in EMC, it is not necessary to point out the problems resulting from the design of electronic systems without sufficient thought being given to EMC throughout that design process. For those not actively involved in EMC, it is probably sufficient to point out that most electronic products today cannot be legally sold virtually anywhere

in the world if they do not comply with the governmental regulatory limits on radiated and conducted emissions. Furthermore, the marketability of those products that comply with the regulatory requirements, but are susceptible to external interference such as radar and radio transmitters or electrostatic discharge (ESD), will be significantly affected by customer dissatisfaction such that compliance with the regulatory requirements becomes a moot point. Therefore, EMC considerations are an integral part of quality product design. In the intensely cost competitive markets today, companies that produce these products cannot afford to allow the random incorporation of EMC considerations into their product development cycles. Companies that design and manufacture these products realize that virtually all of their design personnel must be aware of some basic EMC design principles and must be sensitive to the impact of failing to incorporate these design principles into their designs.

EMC EDUCATION OPTIONS

These considerations suggest that companies should strive to educate all of their designers in at least the rudimentary ideas involved with EMC if they are currently deficient in this knowledge base. The question becomes one of the most efficient and effective way of doing this. Individual study is the simplest to implement, but can be inefficient. Numerous textbooks are geared to the industrial professional. A host of "trade publications," such as this publication, give excellent tutorial articles along with the latest EMC design materials, such as gasket materials, suppression components, and test equipment. The IEEE EMC Symposium Record frequently contains excellent tutorial articles. In order to provide a compact and self-contained source of publications concerning EMC, the Education Committee of the IEEE EMC Society has prepared an EMC Bibliography that lists these important publications. That bibliography can be obtained by sending a diskette formatted on the system you wish to use to Mr. Kimball Williams, EATON EMC

Laboratory, Box 766, 26201 Northwestern Highway, Southfield, MI 48037. Kimball can copy this to either 3 1/2-inch or 5 1/4-inch diskettes in either WordPerfect 5.0 or ASCII format. A return address and the appropriate version should be indicated.

Efficient organization and presentation of the material leads to the maximum retention of the material and the minimum time period of study. This is the primary advantage of organized programs in colleges/universities as well as the various short courses offered by consultants or in-house personnel. Numerous consulting organizations offer short courses whose length varies from one day to two weeks. The length is usually commensurate with the depth of coverage of the material. For example, one-day courses are generally overviews of the EMC discipline for those who have little or no prior knowledge of the field. Many companies offer their own in-house EMC courses similar to those offered by external consultants. The key to a company being able to offer an in-house training course lies in that company having its own personnel who (1) are adequately trained in the principles and practice of EMC and (2) have the background in teaching and course organization that will produce an effective instructional program. Since the course is short by design, the instructor must have experience in effective teaching methodology if such an in-house short course is to be as successful as those offered by external consultants who have extensive experience in this area.

The last area of EMC education - college/university courses and programs - represents potentially the most effective and efficient method of education. The availability to the undergraduate of organized courses in EMC has many advantages. Perhaps one of the more important advantages is that the college/university represents the last time that all of these potential engineers will be located in one place. Therefore, a wide class of engineers with varied career objectives can be efficiently exposed to

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the discipline of EMC. Once these engineers move into the workplace, it becomes increasingly difficult to insure that all those who may someday impact EMC will have been exposed to the basic EMC principles. An additional advantage is that many of those undergraduates who would have otherwise not been aware of EMC may choose it as their career and begin to efficiently and effectively prepare for that career. Of course, the reader may agree with these advantages but ask why this is apparently not being done.

The Education Committee of the IEEE EMC Society conducted a survey of educational institutions with regard to their offering an EMC course or the incorporation of EMC principles into other existing courses. In the Fall of 1985, a survey form was mailed to all 350 IEEE Student Chapters in the U.S. and Canada. Eighty-four responses were received. Only 2 (2.4%) offered a course specifically dealing with EMC. Some 18 (21.4%) presented material on EMC in the context of another course. An amazing 63 (75%) were of the opinion that the subject should be covered in the undergraduate EE curriculum. No more recent survey has been conducted. However, the author's personal informal survey via contacts with other academics through EMC symposia suggests that there are some six institutions offering dedicated EMC courses in the U.S. and Canada, including the one offered by the author in alternating semesters at the University of Kentucky. Those known to the author are at Auburn University, University of Missouri at Rolla, Florida Atlantic University, University of California at Berkeley, University of Ottawa, and University of Kentucky. Universities outside the U.S. and Canada seem to have been more active than those in the U.S. and Canada in offering EMC courses. One of the earliest such programs has been offered at the University of York in the United Kingdom under the direction of Dr. Andy Marvin. A recent collaboration has begun between the University of York and the University of Hull. Various universities throughout Europe cur-

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rently offer EMC courses and have done so for some time.

So the availability of specific EMC courses in universities is increasing but at a slow rate. The industrial demand for experienced EMC engineers seems to greatly exceed the availability of graduates having a direct career goal in EMC. What is the reason for this inability of the educational institutions to keep pace with the industrial need? There are several important and practical reasons. For a more detailed discussion see "Establishment of a University Course in Electromagnetic Compatibility," IEEE Transactions on Education, February 1990 by the author. This author receives perhaps one call each month from educators at other institutions who wish to establish a course in EMC. So the recognition of the need for an EMC course in the undergraduate curriculum is present. The two primary reasons that prevent the establishment of a dedicated EMC course are (1) lack of sufficient room in an already crowded undergraduate EE curriculum, and (2) lack of a textbook designed for the specific needs of a university course.

The undergraduate EE curriculum, like all other disciplines, is, has been, and will probably continue to be a four-year program. An enormous amount of technical information and advances has been incorporated in the program and very little has been removed. Therefore every academic program must consider the organization and efficiency of presentation of the requisite material as a critical objective. Faculty routinely reorganize and compact the undergraduate material for this reason. There is virtually no room in any undergraduate curriculum for inefficient teaching or new courses. These practical considerations clearly make the introduction of a new course devoted to EMC a very difficult problem for educators. None of the basic, required material can or should be removed. Successful EMC engineering depends strongly upon a firm understanding of all the basic areas of EE: circuits, signals, digital design, electromagnetic field theory, etc. This author has incorporated an EMC course into the undergraduate EE program in spite of these constraints. This course was included among the list of senior technical electives from which the undergraduate is required to select five. Therefore it did not (and should not) displace the required fundamental courses. It also occurs at a point where the student's maturity has developed sufficiently so that he/she can appreciate the topic and its importance. It is recommended that other institutions desiring to incorporate an EMC course into the undergraduate curriculum do so in this fashion. Several schools have chosen to implement an EMC course at the graduate level rather than the undergraduate level perhaps because it is simpler to do so. The graduate curriculum tends to be less crowded than the undergraduate curriculum. However, this placement in the graduate curriculum has an important drawback since the majority of graduating engineers who may not choose EMC as a career objective but will nevertheless need some exposure to EMC may never be exposed to the subject in this organized fashion.

A number of textbooks cover the primary aspects of EMC design. However, these are generally designed for the industrial professional and are based on a short-course format. University textbooks have unique needs: depth of presentation, abundance of problems for the student to work, completeness in the presentation of results with regard to restrictions and applicability of derived results, etc. Some of the existing books have been used in university courses with mixed success. An important reason for the need for a detailed text that contains sufficient problems for the student to work is that very few instructors in the academic community have the necessary industrial experience in EMC to successfully prepare such a course. This is not to say that industrial experience is necessary or even sufficient. However it helps perhaps more so in an EMC course than in any other course. The availability of a detailed textbook on EMC that specifically is designed to satisfy the unique needs of a university/college course will have a significant impact on the addition of EMC courses to the undergraduate EE programs, and consequently the number of engineers choosing the field as a career.

CONCLUSION

The increased availability of undergraduate courses will impact on the EMC design expertise of those engineers who do not choose EMC as a career but nevertheless need to be aware of the basics. EMC has become the concern of all designers of electronic systems. The efficient education of those designers will become critically important to the industry in the future, and it is incumbent on academic institutions to address this need today.

Clayton R. Paul is a Professor of Electrical Engineering at the University of Kentucky, Lexington. He is a Fellow of the IEEE and Chairman of the IEEE EMC Society Education Committee. (606) 257-1644.