Session 3547

# Assessing the need to introduce Electromagnetic Compliance and Interference (EMC/EMI) in Engineering Technology programs.

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## ABSTRACT

A common goal of Engineering Technology programs is to produce highly qualified graduates serving industry and the society. They need to provide students with not only practical hands-on experience, but also with the critical thinking and technical skills to solve the problems and challenges that graduates will face in their professional careers. Engineering Technology programs need then to anticipate the future needs of industry in order to be abreast of the ever-changing market in technological fields.

Our experience in the Biomedical Engineering and Telecommunication Engineering Technology programs show that Electromagnetic Compliance and Interference (EMC/EMI) will be a key issue for the US industry in the very near future, if not today. We can expect in the future regulatory agencies will issue new Standards in a manner similar to the European experience, which will result in a demand of graduates with background in EMC/EMI.

In this paper, we analyze the industry needs to address EMC/EMI issues, presenting a tentative EMC course suitable for an Electrical Engineering Technology program. Our goal is to contribute to prepare students to become successful professionals in the next millennium.

## INTRODUCTION

Engineering Technology programs are designed to produce highly qualified professionals to solve the problems that industry faces today. These programs are aimed at training future professionals in the maintenance, repair, acquisition and management of technical equipment. However, it is widely recognized that industry and technology are undergoing major changes and consequently the training of these future professionals needs to be reviewed and updated. In particular, Electrical Engineering Technology programs should respond to the needs of today's industry, as well as to anticipate what will be required from professionals in the upcoming years.

There are several factors that characterize today's technology. First, technology in general, and more specifically electronic devices, have increased their integration density in several orders of magnitude with respect to their density 10 or even 5 years ago. The design of integrated circuits contemplates now the second- and higher-order effects that arise as different parts of the chip interact with each other. What is of more concern to us, however, is the fact that as the integration density increases, the electronic devices may become more susceptible to signals originated outside the chip enclosure and even by external sources. We can also find that a large number of our routine activities in our daily life employ instruments with one or more microprocessors or microcontrollers. Alarm clocks, microwave ovens, TV sets and remote control and the car that we drive to work, all have their basic functions controlled by a microprocessor. These devices, as do all digital circuits, generate broadband radio-frequency signals that can leak from their enclosures. In recent years, we have witnessed the explosion of personal communication devices. We have digital systems with several microprocessors with a very high integration density that deliberately emit considerable amounts of energy in the radio-frequency band. As the demand for these services increase, the electromagnetic spectrum becomes even more congested causing the different services to be closer together in frequency to decrease the parts of the spectrum reserved for guard bands. Finally, in order to decrease the congestion in the radioelectric spectrum, new services tend to operate at higher frequencies, thus making the physical dimensions of their systems comparable to their wavelength. All these facts increase the possibility of harmful interference between different channels or services and consequently special attention needs to be taken when designing the different parts of communication systems.

The aim of this paper is to explore the current and future needs in Electrical Engineering Technology regarding the area of Electromagnetic Compliance and Interference (EMC/EMI), as well as to present a course outline that would comply with these goals.

## THE EFFECTS OF EMI IN TODAY'S TECHNOLOGY

Literature shows a wide collection of cases where Electromagnetic Interference has been the reason for the malfunctioning of equipment that resulted in the possibility of accidents or even accidents themselves. The Center for Devices and Radiological Health (CDRH) at the FDA has been examining the effects of interference on medical devices, finding that a large number of medical instrumentation are very susceptible to interference. The Center has also examined reported accidents, and as a consequence has sponsored Standards in EMI/EMC. In particular, the Center's Web Site (http://www.fda.gov/cdrh/emc/) has, among others, documents that describe and analyze the effects of radio-frequency interference in motorized wheelchairs and the effects of cellular telephones on patients wearing pacemakers, that are topics of major social concern. In general, electromagnetic interference in a hospital is a critical issue today as the welfare of patients depends strongly on electronic equipment. It is then necessary to ensure the correct working condition of all the equipment in a hospital (Turcotte and Witters, 1998).

The effect of cellular telephones on the medical equipment in a hospital is certainly a major topic in the healthcare and communications industries today. The solution that has been adopted by most of the hospitals is to prohibit the use of cellular phones inside the hospital or close to critical equipment. Although this solution solves today's problem, new and better technological solutions will have to be adopted for a variety of reasons. First, it is predicted that clinical staff will use cellular phones inside the hospital to communicate with internal external services, and secondly and more important, it is difficult to shield the critical areas from the use of cell phones in the allowed places or even the exterior of the hospital (Hanada et al., 1998). There are also reports of television stations testing their new digital high-definition TV systems (HDTV) interfering with the telemetry systems of hospitals in the same city.

In addition to the problems caused by communication systems, electromagnetic interference is also caused by natural causes such as lighting (Uman and Krider, 1982), by surges in the power distribution lines (Hasse and Birk, 1998), by the non-linearities in the devices used in electronic systems known since the widespread use of semiconductors, and by electrostatic discharges (Wilson and Ma, 1991). An electrostatic discharge (ESD) is one of the causes that is suspected to have contributed to the accident of the TWA flight 800 (Abrams, 1997).

## THE INVOLVEMENT OF TECHNOLOGISTS IN EMC/EMI

The previous situations demonstrate the increasing need to attack EMI from all levels. It is necessary to identify sources of interference before they produce a harmful effect on other equipment. It has been proven that the best option to avoid interference is to design equipment with very low levels of radiation (Ritenour, 1998). On the other hand, as this is sometimes impossible, it is necessary to shield sensitive equipment from the external sources of radiation. In this situation, the knowledge of shielding techniques and materials also becomes critical (Buttler, 1997). As the European Union has imposed EMC regulations on all equipment that is sold or imported inside its boundaries, worldwide manufacturers need to be in compliance with these Standards, which will affect the design process. Furthermore, we can expect mandatory regulations for EMI, ESD and power disturbance in the US (Gerke and Kimmel, 1994). In any case, because American industry needs to be competitive in international markets, EMC is going to be a determining factor in both, today's and tomorrow's industry.

In this area, the involvement of technologists will be in two fronts. They will have to identify and fight EMI problems, troubleshooting equipment affected by interference and providing solutions to this problem. At the same time, technologists should be able to understand and follow the measurement conditions and protocols that are described in the applicable Standards. EMI testing is very specific, and can be carried out by qualified technicians that will be involved in the process of measurement and data collection.

## EMI/EMC EDUCATION

Education in EMI/EMC, although still small, is increasing especially in Electrical Engineering programs despite the hesitancy of the faculty that should develop it, mainly due to the "mystery" surrounding this area of study (Nelson, 1997). EMC courses have also been incorporated in some Electrical Engineering Technology programs although they are not common. It appears that most of the EMC programs are heavily theoretical, studying the propagation mechanisms and effects of electromagnetic waves in other equipment, with this course being the continuation of a traditional Electromagnetic Fields course. We believe that, especially for Electrical Engineering Technology, a more hands-on experience EMC/EMI course will better suit the needs of graduates. An outline of such course is shown in the next paragraph. We believe that the topics described in the outline would make up a rigorous course in which the weight has been shifted from a theoretical to a laboratory content. We believe that this course should be taken by EET students in their senior year when the have the basis to comprehend and interrelate the concepts from different areas in the profession.

## A model of a course in EMI/EMC

**1. Introduction to Electromagnetic Compatibility**
- 1.1 The Electromagnetic environment
- 1.2 Historical notes
- 1.3 Practical EMI problems and concerns
- 1.4 EMI vs. RFI

**2. Sources of EMI**
- 2.1 Natural Noise
- 2.2 Electrostatic Discharges
- 2.3 Electromagnetic Pulses

**3. EMI from systems and circuits**
- 3.1 Electromagnetic Emission
- 3.2 Noise from relays and switches
- 3.3 Nonlinearities in circuits
- 3.4 Transients in power supply lines

**4. EMI Measurement Demands**
- 4.1 Open-Area Test measurements
- 4.2 Precautions
- 4.3 Spectrum Analyzers
- 4.4 Antennas
- 4.5 Other equipment

**5. Measurement of Radiated Interference**
- 5.1 Equipment
- 5.2 TEM Cells
- 5.3 Reverberating Chambers
- 5.4 Immunity to Radiated interference

**6. Measurement of Conducted Interference**
- 6.1 Conducted noise on power supply lines
- 6.2 Conducted EMI from equipment
- 6.3 Immunity to conducted interference
- 6.4 Line Impedance Stabilization Networks

**7. Grounding, Shielding and Bonding**
- 7.1 Grounding
- 7.2 Shielding
- 7.3 Electrical Bonding

**8. EMI Filters**
- 8.1 Characteristics of filters
- 8.2 Power line filter design
- 8.3 Filters installation
- 8.4 Filter evaluation

**9. Cables, connectors and components**
- 9.1 EMI suppression cables
- 9.2 EMC connectors
- 9.3 EMC Gaskets
- 9.4 Isolation Transformers
- 9.5 Opto-isolators
- 9.6 Transient and surge suppression devices

**10. Frequency assignment and spectrum conservation**
- 10.1 Frequency allocation and assignment
- 10.2 Modulation techniques
- 10.3 Spectrum conservation

**11. EMC Standards**
- 11.1 Standards for EMI/EMC
- 11.2 Military Standards (MIL-STD-461/462)

11.3 IEEE/ANSI Standards
11.4 European Standards
11.5 FCC Regulations

## CONCLUSION

This paper describes the need in today's industry to address EMC/EMI problems at all levels. These include the design of equipment to limit the amount of unwanted radiation, the shielding of critical parts, making equipment less immune to external interference and the capacity to carry out the tests specified in the applicable Standards. We believe that industry will demand that the future graduates in Electrical Engineering Technology have a knowledge of electromagnetic interference issues, in order to locate and troubleshoot radiating equipment as well as to have the ability to understand and follow the measurement procedures developed in the Standards. In order to maintain the competitiveness of the American industry, technologists need to be aware and follow the Standards issues in the countries where their products will be sold. In any case, it is expected that the regulatory agencies in the US will follow the European experience issuing Standards for radiation, electrostatic discharge and susceptibility in electronic equipment.

This course has not been offered yet at the authors' institution, although we strongly believe that the program in EMC/EMI described in this paper will provide the students with the theoretical and practical knowledge needed to satisfy the demands of tomorrow's industry.

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