University-based EMC Precompliance Center and its Impact on the EMC Education

Bogdan Adamczyk – Grand Valley State University, adamczyb@gvsu.edu
Jim Teune – Gentex Corp., jim.teune@genetx.com
Scott Mee – Johnson Controls Inc., Scott.Mee@jci.com

Abstract

This paper describes the newly-developed Electromagnetic Compatibility (EMC) Center at Grand Valley State University (GVSU). The EMC Center provides two types of services: EMC education and EMC precompliance testing. EMC education at GVSU serves two different populations: the university-enrolled students and the local EMC professionals. For the GVSU students, four semester-long junior-, senior-, and graduate-level courses are available. For the local EMC practitioners, four short courses spanning the EMC theory and application are offered. In addition to the EMC courses, the EMC Center supports senior and graduate projects, and in the near future will provide internship for GVSU students. For the local industry, the EMC Center offers EMC precompliance testing and design support. Additionally, the EMC Center hosts regular meeting of the newly-established IEEE EMC Chapter of West Michigan. Many tests performed at the EMC Center find their way into the EMC course content, laboratory exercises and demonstrations for the GVSU students. Several course design projects are tested at the EMC Center providing the students with the exposure to the current EMC regulations, testing equipment and procedures.

Section 1. Introduction

Five years ago GVSU and a local electronics supplier began collaborating in the area of Electromagnetic Compatibility. The collaboration evolved from the desire to make the university EMC education relevant to today's industry needs and to provide the EMC professionals in the local company with an educational resource that enhances their in-house EMC knowledge.

The collaboration started with one of the authors, GVSU professor, spending one day a week at a local EMC lab, shadowing the EMC engineers, learning about the EMC equipment, testing procedures and standards. The author's original motivation behind this involvement was to understand the needs of the contemporary engineering company and develop a relevant EMC curriculum at a local university. The motivation behind the industrial partner's involvement was a development of an in-house educational material for EMC technicians and engineers.

Soon, such collaboration resulted in several in-house "lunch-and learn" presentations [1-5]; publications [6-7]; hardware presentations at the IEEE EMC Symposia [8-13], and an invaluable educational material for the university EMC courses. The content of the EMC courses was completely revised, and several EMC projects developed at a local EMC lab found their way into the laboratory experiments and demonstrations. Perhaps the most pronounced result of the GVSU-industry cooperation was a creation of the EMC Center at GVSU. The EMC Center serves both the local EMC professionals and GVSU engineering students.

This paper is organized as follows. GVSU EMC Center is described in Section 2. Section 3 presents the senior and graduate projects supported by the EMC Center. Section 4 is devoted to the EMC education at GVSU, while Section 5 describes the EMC Chapter of West Michigan and its activities. Summary and Conclusions are in Section 6.

Section 2. GVSU EMC Center

EMC Center [14] is located just a few blocks of the GVSU's engineering building. This 400-square-foot facility includes a seminar room (where the IEEE EMC Society Chapter meetings and presentations take place) and the EMC pre-compliance lab. The EMC Center is housed in the renovated warehouse, shown in Fig. 2.1.

Figure 2.1 GVSU EMC Center

EMC Center at GVSU offers the following services to local industry:

- EMC Pre-compliance Testing
- EMC Design Support
- EMC Education

The EMC Pre-compliance Lab contains:

- Two screen rooms, one for conducted emissions, and another for conducted immunity testing,
- Gigahertz Transverse Electromagnetic (GTEM) cell for radiated immunity and radiated emissions testing, (shown in Fig. 3.2),
- Near-field scanner for PCB emissions characterization,
- Transient measurement equipment, - Several EMC antennas,
- Numerous measurement and diagnostic tools.

Two more chambers are being assembled: a semianechoic chamber for radiated emissions, and reverberation chamber for radiated immunity.

In addition to the pre-compliance testing the EMC Center also offers:

- Design reviews for schematic and PCB layout,
- Diagnostic support,
- EMC test plan development.

While the EMC Center is primarily designed to be a "teaching resource" it can fill a key need to complement commercial EMC labs (which, in general, are not pre-compliance focused). Interestingly, a local compliance lab has recognized the value of maintaining a linkage to GVSU, as it provides an opportunity for its customers to have a "baseline" of EMC when formal compliance testing is being planned. The EMC Center also assists many small and medium sized companies that cannot afford pre-compliance facilities in-house, yet need to meet EMC requirements. They can utilize GVSU's resources up-front prior to testing in a formal certified EMC lab.

We have also been fortunate to receive a number of items as donations, and recently we have had the opportunity to receive full chambers as donated items – which substantially increases our educational content and assistance to industry. Another aspect that has worked well is the fact that some of our equipment is designed and built by our own students – thus enhancing their education and our resources on a very cost effective basis.

Section 3. Senior and Graduate Projects at EMC Center

In addition to supporting the local industry needs, the EMC Center supports senior and graduate student projects. This Section describes two student projects developed at the EMC Center: 1) Near-Field Scanner (senior project) and 2) GTEM Correlation Study (graduate project).

3A. Near-Field Scanner

Four GVSU students worked over a period of nine months as part of their senior design capstone project to develop an emissions diagnostic tool called a Near-Field Scanner. This tool is used to understand the root-causes behind radiated emissions based failures that result from either traditional compliance testing or pre-compliance testing. The scanner is capable of locating RF 'hot spots' and illustrating the noise paths contributing to failures. Under the direction of the authors of this paper, the students developed an automated mechanism with an integrated camera system which aids the user in the setup, detection and reporting of results for scans performed over various printed circuit boards. The system is capable of mounting several different types of RF near-field probes for either magnetic field or electric field detection. A drawing of the scanner station is shown in Fig 3.1 while a sample scan can be seen in Figure 3.2.

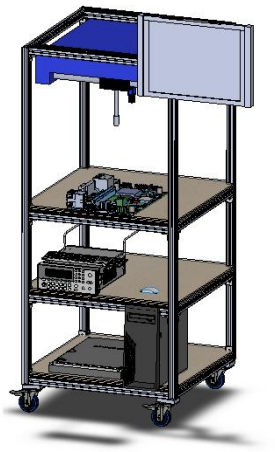

Figure 3.1 Near-field scanner for PCB emissions characterization

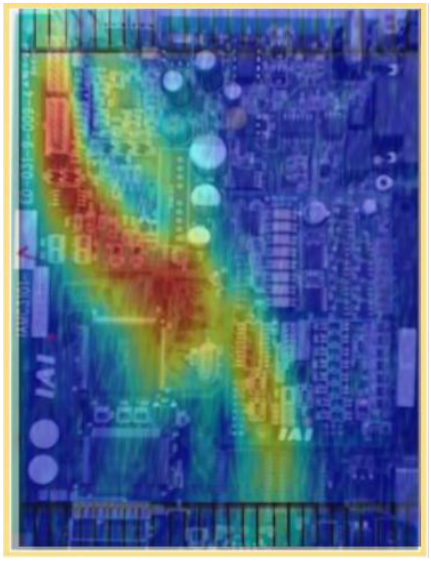

Figure 3.2 Sample scan

3B. GTEM Cell Correlation Study

One of the graduate projects (in progress) at GVSU EMC Center is a GTEM cell correlation study. The GTEM 5317 test cell, shown in Figure 3.2, has recently been donated to GVSU by a local EMC compliance lab.

Figure 3.2 GTEM Cell for radiated immunity and radiated emissions

While the cell is useful for both emissions and immunity EMC testing, the primary purpose of the cell in this application is to perform pre-compliance unintentional emissions measurements and characterize RF transmitter products.

In order to complete the project, measurements should first be taken at OATS site (Open Area Test Site) by referencing the EN55022 standard for setup of radiated emissions 3 meter measurements. Next, measurements should be taken at a local certified CISPR25 emissions chamber by referencing the CISPR25 standard for setup of radiated emissions 1 meter

measurements. Finally, by using experimentation, a setup for DUT (Device Under Test) & wire harness should be identified by comparing dynamic measurement results from the GTEM to results already obtained in OATS and CISPR25 environments.

Once an optimal setup has been identified a fixture will be constructed that supports both the DUT and wire harness in the GTEM cell. The last step is to define two correction factors for future use at the GVSU EMC Center. The two correction factors will be applied to data collected in the GTEM to correlate to a 1 meter CISPR25 result and also to a 3 meter OATS results. A reference source along with a 2 meter wire harness with 50ohm load will be provided for use in all measurements.

Once these key steps are completed, the test cell may be used to perform emissions measurements for local industry and will be used for GVSU EE courses and labs.

Section 4. EMC Education at GVSU

EMC Center directly supports EMC education at GVSU. EMC education serves two different populations: university –enrolled students and the local EMC professionals.

For the GVSU students, the following four semester-long courses are available:
1) junior-level *Applied Electromagnetics*,
2) senior-level *Electromagnetic Compatibility*,
3) graduate-level *PCB Design*,
4) *EMC* and *EMC Special Topics*.

For the local EMC practitioners GVSU offers the following four courses:
1) *Math and Circuits Foundations of EMC*,
2) *Electromagnetics Foundations of EMC*
3) *EM Waves, Transmission Lines and Antennas Foundations of EMC*,
4) *EMC Special Topics*.

Section 5. IEEE EMC Society Chapter of West Michigan

EMC Center hosts regular meeting of the newly-established IEEE EMC Society Chapter of West Michigan[15]. The EMC Chapter was established in November 2011 by the authors of this paper. The authors also assumed the roles of the chapter officers. The inaugural chapter meeting took place in March 2012 and was attended by over 30 local EMC practitioners. Since then several presentations took place, many of them delivered by IEEE Distinguished Speakers.

The topics presented since the inaugural meeting:
1) Reducing Emissions in DC-DC Switched-Mode Power Supplies
2) EM Simulations Methods
3) Radiated Emissions Testing
4) Common Impedance Coupling

5) Simulating with Mentor Graphics Tools
6) Rationale for Reverberation Chamber Testing
7) Crosstalk between PCB Traces
8) Measurement Uncertainty
9) Differential Signaling.

Figure 5.1 shows one of the EMC Chapter presentations at the EMC Center.

Figure 5.1 Presentation by Prof. Adamczyk on Crosstalk between PCB Traces

The attendance at the meetings varies between 30-60 persons; some of the attendees are GVSU engineering students. The meetings not only enhance their EMC education but also provide them with an opportunity to network with EMC professionals.

Section 6 Summary and Conclusions

This paper described the newly-developed EMC Center at GVSU. The EMC Center supports EMC education EMC precompliance testing. Additionally, the EMC Center hosts regular meeting of the newly-established IEEE EMC Chapter of West Michigan. Many tests performed at the EMC Center are incorporated into the EMC course content, laboratory exercises and demonstrations for the GVSU students. Several course design projects are tested at the EMC Center providing the students with the exposure to the current EMC regulations, testing equipment and procedures.

References

1. J. Teune, B. Adamczyk, *PCB-Based EMC Issues: Crosstalk vs. Circuit Topology* – presentation at Gentex Corp., Zeeland, MI, September 2008

2. J. Teune, B. Adamczyk, *PCB-Based EMC Issues: Non-Ideal Behavior of Components* – presentation at Gentex Corp., Zeeland, MI, September 2008

3. B. Adamczyk, J. Teune, *Decoupling Capacitors* – presentation at Gentex Corp., Zeeland, MI, July, 2009

4. B. Adamczyk, J. Teune, *Signal and Trace Discontinuities* – presentation at Gentex Corp., Zeeland, MI, Nov, 2009

5. B. Adamczyk, J. Teune, *Return Path Effects on Audio and Video Circuitry* –presentation at Gentex Corp., Zeeland, MI, July, 2010

6. B. Adamczyk, J. Teune, *EMC Crosstalk vs. Circuit Topology*, 2009 Spring Conference of the ASEE North Central Section, Grand Rapids, MI

7. B. Adamczyk, J. Teune, B. Spence, *EMC Decoupling Capacitors Impact on PCB Radiated Emissions*, 2010 Spring Conference of the ASEE North Central Section, Pittsburgh, PA

8. J. Teune, B. Adamczyk, *EMC Hardware Demonstration – Non-Ideal Behavior of Components*"– 2008 IEEE International Electromagnetic Compatibility Symposium in Detroit, MI

9. J. Teune, B. Adamczyk, *EMC Hardware Demonstration – Crosstalk vs. Circuit Topology* – 2008 IEEE International Electromagnetic Compatibility Symposium in Detroit, MI

10. B. Adamczyk, J. Teune, *EMC Hardware Demonstration – Radiated Emissions and Susceptibility* – 2009 IEEE International Electromagnetic Compatibility Symposium, Austin, TX

11. B. Adamczyk, J. Teune. *EMC Hardware Demonstration – Grounding Strategy Effect on Video and Audio Circuitry* – 2010 IEEE International Electromagnetic Compatibility Symposium, Ft. Lauderdale, FL

12. B. Adamczyk, J. Teune. *EMC Hardware Demonstration – Effectiveness of Shielding Materials and Impact of Slots and Bonding of Shields on PCB Radiation and Immunity* – 2011 IEEE International Electromagnetic Compatibility Symposium, Long Beach, CA

13. B. Adamczyk, J. Teune, S. Piper, *EMC Hardware Demonstration – Embedded Capacitance Effectiveness vs. Board Topology* – 2012 IEEE International Electromagnetic Compatibility Symposium, Pittsburgh, PA

14 http://www.gvsu.edu/engineering/EMCCenter

15 http://www.westmichigan-emc.org/