

TEACHING OF EMC PROBLEMS - THE POINT OF HIGH IMPORTANCE

ING. ALEŠ HÁLA, CSC.¹

Abstract: In the paper, it is discussed why, where and what to teach in the EMC sphere. The approach to the problem depends on existing or not existing of the subject EMC in a study plan. It is noted that EMC problems should be mentioned in all electrical related subjects. The best solution for solid students' knowledge in the EMC sphere is the existence of the special subject "Problems of EMC". The content of this subject is shortly denoted.

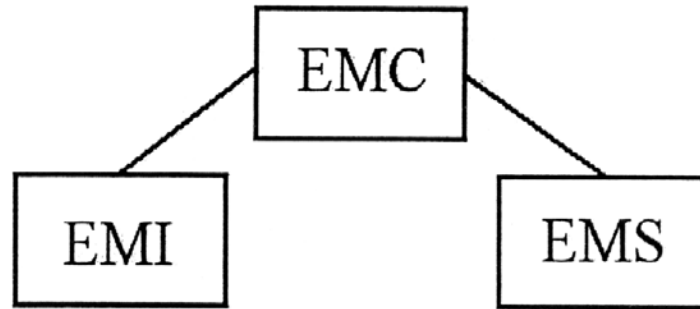
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1. Introduction

Currently, problems of Electromagnetic compatibility (EMC) are highly discussed. Teaching of electrical engineering is very closely connected with EMC problems, but the attitude depends on teacher. The teacher of each electrical engineering subject from fundamental to upper special level should connect discussed problems with EMC problems. The teacher of subject Electromagnetic Field Theory (EFT), unless there is a special subject EMC, should be a guarantor of students' good knowledge in the field of EMC. Therefore, the best solution is existence of the special subject "Problems of EMC". The same subject – but at a higher level – is planned for postgraduate studies.

The production of the electromagnetic smog (unwanted radiation of electrical and electronic systems) and the theme of electromagnetic susceptibility of apparatus and systems have to be explained to technical university students during their technical university studies, not after graduation and starting of their real business professions. The main parts of EMC are in Fig. 1.

¹ Vojenská akademie v Brně, katedra elektrotechniky a elektroniky, Kounicova 65, 612 00
Brno, e-mail ales.hala@vabo.cz



EMC - electromagnetic compatibility

EMI - electromagnetic interference

EMS - electromagnetic susceptibility

Fig. 1 The parts of electromagnetic compatibility

Basically, subjects of Electrical Engineering Grounding and Electromagnetic Field Theory should provide students with basic knowledge of physical units and basic electrical terms. Afterwards, they employ this knowledge at the end of the Electromagnetic Field Theory course, which is a part dealing with electromagnetic compatibility. Anyway, we can rather use this kind of knowledge in an independent subject possible titled "Problems of EMC". However, this subject has not been in the study plan at our technical university till now.

Laboratory exercises are very important part of every subject of electrical base, where main ideas of EMC can be given to students. In laboratory exercises, there is useful to draw attention to EMC problems by opportunities which will originate, or which may be created on purpose.

2. Some problems of EMC teaching (in EFT)

First, there is a discussed concept of EMC and main parts (see Fig. 1). The students already have gained some knowledge about the subject during laboratory exercises.

Anyway, we suppose to discuss problems of noise sources and couplings, but we do not have enough space to solve the problem of internal compatibility of instrument or system. As well, EMC standards are mentioned only briefly.

Problems concerning EMI measurements, EMS measurements and wider acquainting with EMC standards should be mainly mentioned in the subject Problems of EMC.

Basic EFT laboratory exercises join us with EMC mainly through the problem of shielding and problem of generation of homogeneous fields for electromagnetic immunity tests.

It is appropriate to talk about antennas used in EMC sphere by EMI and EMS measurements in lessons dedicated to radiation and laboratory exercises joined with antennas.

In special subject Problems of EMC, laboratory exercises should be focused on problems of emissions and their limitation and mainly on problems of EMC immunity, too.

Based on time reasons, it is possible to discuss a little bit more only EMC of technical systems. Besides the incidence one's techniques on another one, there are an interrogation of the electromagnetic fields incidence on living organisms. Some students are mostly interested not only in threshold values heat effects on human organism, but also in incidence of weak electromagnetic fields. They are interested in this problem, namely in connection with used techniques, which particularly means connection with mobile phones as well as in opportunities to measure these levels.

3. The scheme of subject Problems of EMC

3.1 Remarks to Problems of EMC for graduate studies

The short outline of summary EMC lessons for graduate (master) study and, on higher level, for postgraduate students:

- Basic terms and EMC definition, couplings, noise sources, electromagnetic environment
- Electromagnetic emissions and EMI measurements
- Electromagnetic susceptibility (immunity), tests of electromagnetic interference immunity, test of susceptibility to transient from switching, test of susceptibility to transients from lightning, test of magnetic susceptibility, ...
- Reduction of emissions (filtering, shielding), noise suppression
- Protection of instruments and systems (lightning, electrostatic) and protection against designed emissions and destruction
- Standards in EMC sphere

Very important and motivating should be introduction some case studies, see [3], e.g.

3.2 Remarks to Problems of EMC for postgraduate studies

Postgraduate students should keep a watch on EMC, too. I would like to class the subject Problems of EMC in the study schedule for postgraduate studies. At this level, a student is electrically well-educated and has some scope. Subject contents can be fitted to specialisation of the student.

Laboratory exercises must be a part of lessons (about one third). However, laboratory equipment is usually very expensive (spectral analysers, measuring receivers, generators, probes, testers etc.). Very useful seems to be a visit to an anechoic room. EMC cell is quite useful for EMC laboratory, because it is smaller and cheaper and can be realised at university workrooms.

Very important part is EMC control, EMC prediction techniques and computational electromagnetic modelling. EMC control ensures that the EMC design is correctly implemented at every level of development and manufacture of equipment or a system. Computer programs are other very useful things in EMC prediction. They are useful in EMI investigations, too. They reduce the probability of arithmetic error and speed up the computation.

It is appropriate to discuss shortly the problem of computational methods used in numerical electromagnetic analyses. Mainly, it is the method of moments (MoM) and final element method (FEM). The moment method is a technique for solving complex integral equations by reducing them to a system of simpler linear equations. The moment method can be used for analysing a wide variety of electromagnetic radiation problems. The students are familiar with finite elements method in the field of solving of electrostatic problems in EFT (MEP, e.g.). The finite elements method is widely used method based on solving of partial differential equations with given border conditions. It is useful to introduce Finite Difference Time-Domain method (FDTD), which is excellent for transient analysis.

4. Conclusion

EMC is very extensive area and it implies knowledge from many fields of electrical engineering, but the most dominant is knowledge from the field of electromagnetism. The importance of EMC knowledge increases with progress in electrical engineering and technology at large. In this paper, there are outlined only several problems.

In summary we can say that electromagnetic compatibility is certainly a diversification of otherwise considerably theoretic subject of Electromagnetic Field Theory. During discussions of EMC problems, I meet considerably more positive acceptance than during analysis of sometimes more theoretic passages of electromagnetism.

References

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