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HABILITATION THESIS

- SUMMARY -

Development of new research topics in electromagnetic compatibility

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Summary

The motivation of the application for the habilitation certificate in electrical engineering stays mostly under sign of the binomial mentor – disciple. But, for being a good mentor, one must continue learning, acting like a disciple his whole active life. In the same time, one must have a team spirit as well and must to be able to lead a team, even a small one, like the one formed by a PhD student and his thesis director.

That is why I consider that it is never too late to continue to work with the students at a higher level, that of PhD thesis director. Moreover I consider that I am recommended by my previous activity of consultant for several PhD students and co-author of their scientific papers, as one can see from the list of my publications.

The present habilitation thesis is pleading for electromagnetic compatibility, a concept and a study discipline that was not formalized at the time I graduated the Electrical Engineering Faculty of the former Polytechnic Institute of Cluj-Napoca. However, considering the recent evolutions of technology, one must admit that electromagnetic compatibility, by all her aspects is interfering more and more seriously in the general concept of quality of life.

The thesis is structured on three parts, which continue somehow my PhD studies; my thesis was entitled "Contributions regarding electromagnetic interference on low voltage grids".

1. Electromagnetic biocompatibility, a novel term and concept, situated at the border between electromagnetic compatibility and the environmental science
2. Analysis of the dichotomy between electrical power quality versus electromagnetic compatibility
3. Anti-perturbation methods in electromagnetic compatibility.

As far as I know, the first two directions were introduced for the first time in my scientific papers and I consider that they deserve to be developed in future research and in PhD thesis. At the same time, to develop anti-perturbation methods in order to reduce the effects of the electromagnetic interference is compulsory and this will be also an important research topic.

The first section deals with the concept of "electromagnetic biocompatibility", introduced for the first time by the author of this thesis in the paper Towards a New Concept: Electromagnetic Biocompatibility, Springer**,** 2009, in MEDITECH 2009, IFMBE Proceedings 26 and ISBN 978-3-642-04292-8. The paper attempts to structure this new concept and performs a comparative analysis of this one versus electromagnetic compatibility.

The importance of the further development of this concept is supported by a series of epidemiological studies, highlighting the association between cancer among children and adults and extremely low frequency magnetic fields.

For a better understanding of the necessity for a proactive attitude towards this matter, in this section are presented also a series of case studies in several environments, generally considered

electromagnetic "benign": the first in a residential environment, the second in a industrial environment and the last in a hospital facility.

The conclusion was that those environments ware not '"benign", so always is better to prevent than cure and therefore the prudential avoidance of risks should be the better conduct in this matter.

The direction developed in the second section analyses the dichotomy power quality versus electromagnetic compatibility. It is well known that in the study of these two concepts different frequencies are involved and consequently different standards, techniques and measuring instruments are considered. However, a deeper understanding reveals a close interaction between physical phenomena involved in the two fields of research. Basically it is a matter of looking closely for possible reactions of one phenomenon into another range of the frequency spectrum.

After a short review of the two concepts, the section develops a case study regarding an air handling unit, AHU, containing two centrifugal fans driven by brushless DC motors.

The air handling unit was submitted to three categories of tests:

- Limits for harmonic current emissions
- Limits for conducted electromagnetic emissions
- Immunity for conducted electromagnetic perturbations

The result of these tests was that standard limits were exceeded both for the harmonic current and for the conducted electromagnetic emissions. As for the electromagnetic immunity, a temporary degradation of the operation along with the loss of some performances or even the shutdown of the equipment were observed during the electrical fast transient/burst immunity test and voltage dips, short interruptions and voltage variations immunity tests.

The association between power quality and electromagnetic compatibility is demonstrated in the last section which deals with the anti-perturbation methods.

As a mitigation method of the AHU's issues, retrofitting an EMI filter at the mains ports is needed.

In the first part of this final section the circuit's components of a usual EMI filter are depicted. The mathematical models that yield considerable insight into the non-ideal behavior of components were developed.

It is obvious that in order to design an EMI filter one should primarily "think EMC", in other words think to the "hidden schematics" of the components, taking into account the behavior of the components in a large range of frequency, namely in the range of 150 kHz – 30 MHz, when conducted electromagnetic emissions are considered.

The filter characteristics were obtained using a tracking generator and a spectrum analyzer. The spectrum characteristics revealed an insertion loss of 30 - 35 dB.

After retrofitting the filter at the mains port of the air handling unit, the tests for harmonic current and conducted electromagnetic emissions were performed again, this time with positive results.

The main conclusion was that the measure used for the mitigation of conducted emissions was beneficial for the harmonic currents as well. In other words, EMI filtering represents in this case a combined solution, useful both for power quality and for electromagnetic emissions issues.

From the habilitation thesis and from the author's papers several research topics can be highlighted. I'll recall a few here:

- measuring and monitoring of the power quality parameters for renewable energy production plants,
- measuring and monitoring of the power quality electromagnetic compatibility parameters for electrical installations in multi – areas buildings, and in special purpose buildings
- measuring and monitoring the electromagnetic pollution of the environment,
- the development of the concept of electromagnetic biocompatibility,
- assessing the electromagnetic compatibility and power quality of medical electronic instrumentation,
- study of anti-perturbation methods in reducing the negative effects of power quality and electromagnetic interference, and increasing energy efficiency
- design methods of active and passive filtering,
- integration of renewable energies in conventional power systems,
- monitoring and control of domotic systems,
- assessing power quality and electromagnetic compatibility of the electronic power converters and of the adjustable (variable) speed drives
- assessing the performances and optimization of the multi-level electronic power converters
- assessing the performances and optimization of brushless DC motors

Taking into account that the author of this thesis is part of the teaching staff of the Faculty of Building Services, a series of other interdisciplinary topics could be developed, regarding near zero energy buildings and the increase of energy efficiency in residential, industrial, commercial and tertiary buildings.