Summary

Electromagnetic compatibility has been consolidated as a necessary and inherent process in designing electrical and electronic devices that, due to smart cities, become part of an interconnected systems-of-systems infrastructure. DC micro-grids, DC nano-grids, solar photovoltaic, and thermal energy systems are examples of grids infrastructure that led to a significant increase in the number of power electronic converters connected to the electricity grid. Hence, leading to an increase in the electromagnetic interference in smart grids.

Remarkably, over the last few decades, the electromagnetic interference within 9 to 150 kHz was especially accentuated since the switching frequency of power electronic converters is still limited to several kHz. Thus, bringing up the debate on regulation. From the point of view of the electromagnetic interference noise shape, two cases represent the extremes of possibilities among the various possible converter control algorithms: the deterministic and pseudo-random modulation. Over the last decades, pseudo-random modulation has been considered a complementary methodology to achieve electromagnetic compatibility, jointly with the electromagnetic interference filters and improvements on the printed circuit board layouts.

However, the research carried out and presented in this thesis aims to understand if it is possible to develop new, dedicated converter control algorithms that allow shaping the spectrum of disturbances to meet standardization or technical requirements. Although it seems trivial, the electromagnetic interference measured level depends on the setting of the EMC-test bench system, and the impact of pseudo-random modulation on measured conducted electromagnetic interference is still unclear for the low frequency range.

For instance, evaluating any electromagnetic interference noise spreading approach is not apparent once it depends on several pseudo-random modulation parameters, dwell time and resolution bandwidth. The conventional super-heterodyne frequency band stepping EMI test receiver defines the dwell time and the resolution bandwidth. For this reason, historically, pseudo-random modulations have been questioned and accused of being a fraudulent way of passing regulations. Nonetheless, research has been presented over the last decades to support the electromagnetic interference noise spreading approach in practical situations, e.g., with power

line communication systems.

The research carried out and presented in this thesis, as well as providing an innovative insight into the behaviour of rectangular pulse trains and the conducted electromagnetic interference measurements standards, show that it is possible to develop new, dedicated converter control algorithms that allow shaping the spectrum of disturbances to meet standardization or technical requirements. Furthermore, once it has been found that the conventional EMC test based on frequency scanning might not be sufficient to evaluate randomly modulated DC/DC converter appropriately. A methodology is proposed to control the switching rate of change of DC/DC converters using pseudo-random modulation, which can achieve a suitable EMI measurement, regardless if long dwell times are considered.

The developed modulation algorithms using the National Instruments PXI platform as a fast prototyping platform were defined as an EMC-friendly pulse-width modulation technique. The control of the pulse-width modulation generation scheme shapes the electromagnetic interference noise from the critical fault areas of the information and communications technology devices. Thus, increasing the effectiveness of an electromagnetic interference filter already implemented, thereby strengthening EMC compliance for DC systems in smart grids.

Therefore, the objectives of this thesis are related to the identification and realization of whether it is possible to develop new, dedicated converter control algorithms that allow shaping the spectrum of disturbances to meet standardization or technical requirements, based on:

- Usage of National Instruments PXI with Field-Programmable Gate Array based control hardware with a fixed point processor as a cyber-physical fast prototyping platform enabling electromagnetic compatibility investigations of pseudo-random modulated converters;
- EMC-friendly PWM technique: the control of the pulse width modulation generation scheme, shaping the electromagnetic interference noise from the critical fault areas of the information and communications technology equipment (increasing the effectiveness of an already implemented EMI filter);
- Description of a concept of the control algorithm for power electronic converters, enabling electromagnetic interference shaping, providing 30% reduction of Frame Error Rate in Power Line Communication;
- Case study showing possibility of development of new, dedicated converter control algorithms that allow shaping of the spectrum of disturbances to meet standardization or technical requirements as well as presentation of the system for flexible implementation and validation of developed concepts.