Direct line/email

+44 (0) 115 951 5549

Mark.Sumner@nottingham.ac.uk

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Faculty of Engineering

University Park
Nottingham
NG7 2RD
UK
www.engineering.nottingham.ac.uk

Professor Wojciech Paszke,
Chair of PhD Panel

Dear Professor Wojciech Paszke,

PhD Thesis: The Effect of Spread -Spectrum Modulated EMI on the Power Line Communication Systems

PhD Candidate: Waseem Elsayed

This PhD thesis describes an investigation into the conducted electromagnetic emissions (EMI) from a DC-to-DC convertor, and specifically their effect on "Power Line Communication" (PLC) systems, as used by Smart Meters. This is a timely research topic as DC-to-DC convertors are proliferating with the increasing use of renewables and energy storage on grids and Smart Meters will underpin the move to more sustainable energy systems. The work specifically aims to determine whether modifications to the modulation strategy for the DC-to-DC convertor can reduce the errors seen in a nearby PLC communication system.

The thesis provides the required theoretical background to the investigation. This includes the generation of modulation signals for power convertors (including spread spectrum techniques), the operation of PLC equipment, and the appropriate standards and regulations associated with this technology. The candidate also provides a review of previous research in this field and justifies the study of spread spectrum technologies for improving the error rate of power line communications as the main focus of this work.

Chapter 4 presents a simulation of the proposed system under investigation i.e. a G£-PLC system coupled to a simple DC-DC buck convertor, and investigates the effect of various spread spectrum parameters on the behaviour of the PLC. These include switching frequency, shape of the (periodic/non-periodic), spreading factor.

The simulation results were validated in Chapter 5 using an experimental system and the final chapter presents the individual chapter summaries and then some directions for future work.

The thesis is presented to the standard expected of PhDs – the structure, use of language and presentation of graphs etc are all very good. There are an appropriate number of references. The research has presented some novel findings with regard to informing the

use of spread spectrum modulation techniques as a mechanism for reducing EMI from DC-DC convertors – particularly associated with PLC used by Smart Meters. and this is evidenced by eight conference and six journal papers published from this work. However, I have several recommendations which I believe would improve the quality of the thesis presented as a technical document.

Page 4 – there needs to be a clear statement defining the "contribution to knowledge" of the work presented in this thesis.

Page 6 – is eqn 2.2 correct? If yes, then it needs to be introduced with more detail/discussion e.g. it refers to a "spread function". What is that (spread spectrum modulation is introduced in the next section)?

Fig 2.3 – replace "Narrowband" with "conventional" in the figure itself to be consistent.

Eqn 2.13. Please define Δf'

Page 27, first paragraph of 4.1.1 – sentence repeated at the end.

Within Chapter 2 there needs to be a stronger justification for using spread spectrum modulation and in particular a better justification that it does not require any changes to other parts of the system. There is an argument that the inductors/capacitors designed for a specific (deterministic) switching frequency will be suboptimal when operating with a wider range of switching frequencies. The assumptions made in this work regarding the complete DC-DC convertor system when comparing deterministic and spread spectrum techniques need to be clearly justified.

Page 41 – The summary to Chapter 4 is brief and vague. Please add some specific detailed conclusions from the simulations undertaken in this chapter.

Page 44 – the way that the control is implemented and executed is very important to understanding the behaviour of this system. If a microcontroller is hand coded in C the programmer defines exactly what happens and when it happens and can be confident that the algorithm is being executed correctly. However, the author has provided very little detail here about what is happening, simply stating the "Matlab Simulink software tool" which I presume is an automatic code generation tool. The reader needs more details of what exactly is happening here eg how are the block diagrams converted to real-time instructions, and how can the author be confident that the algorithm has been coded exactly as it should be?

Page 48 – Please explain and justify why BER is not used in the experimental work. It is usual for experiment to match as close as possible simulation work, especially for the measurement parameters used so that it is easy for the reader to compare and contrast experimental and simulation results.

On page 49, not all readers (including me) will be familiar with "box and whisker" plots. I would recommend that the author add a short description in the text of what these are

in general and what they are intended to show in terms of displaying results for presumably multiple measurements.

Figure 5.15 – which convertor is which in the picture – pleased label.

Page 60 – paragraph 2. This explanation is very vague and confusing. Please clarify.

Page 71 – The summary to Chapter 5 is brief and vague. Please add some specific detailed conclusions from the experiments undertaken in this chapter.

The thesis presents a number of simulation and experimental results to understand the influence of spread spectrum modulation techniques on the typical power line communication techniques used with smart meters. The various results indicate that, (eg bottom of page 66)

"In conclusion, these results are contradictory to the conventional assumption: "when applying spread spectrum techniques EMI is being mitigated"".

However, there is no discussion as to why this may be the case. Usually, a PhD offers insights into why unexpected results are observed. For example, what does the candidate think are the physical processes that would create the "conventional assumption" and what does he think is now actually happening based on the results he has observed? Chapters 5 and 6 should provide a discussion which considers the mechanisms for why the PLC is affected by PWM, and why it seems to get worse if spread spectrum modulation is employed. This potentially should include a detailed consideration of the measurement processes used to justify why the effect observed is not due to the measurement technique employed.

The candidate should also link together his conclusions in Chapter 6 to define a "contribution to knowledge" resulting from this research project.

Notwithstanding these comments I would commend the thesis as a document which meets the standards and expectations for a doctoral degree.

Yours sincerely

Mark Sumner

Professor of Electrical Energy System

Department of Electrical and Electronic EngineeringUniversity of Nottingham