UNSW

AUSTRALIA

**SCHOOL OF ELECTRICAL ENGINEERING
AND TELECOMMUNICATIONS**

A Single Stage Grid-connected PV Converter

by

Zhenning JIANG

Student ID: z5082223

Thesis submitted as a requirement for the degree

Master of Engineering (Electrical Engineering)

Submitted: May 16, 2017
Supervisor: Georgios Konstantinou

Abstract

The review of current design of single phase grid-connected photovoltaic system, initial model of the system and the concept of hardware-in-the-loop simulation are presented in this paper. A model of the system including solar cell model, MPPT controller, converter controller are developed both in Matlab and RT-LAB. Some initial results demonstrate the overall system performance.

Acknowledgements

I wish to thank all the people who have made contributions to the contents of this document; in particular Toan Phung and Julien Epps.

Abbreviations

BE Bachelor of Engineering

EE&T School of Electrical Engineering and Telecommunications

SSGPVC Single Stage Grid-connected PV Converter

DSP digital signal processor

AC Alternating Current

DC Direct Current

PV Photovoltaic

MPPT maximum power point tracking

HIL hardware-in-the-loop

SIL software-in-the-loop

ADC analog to digital converter

DAC digital to analog converter

SOGI second order generalized integrator

GPIO general purpose input output

CPU central processing unit

FPGA field-programmable gate array

IC incremental conductance

PO perturb and observe

PLL phase-locked loop

PI proportional integral

Contents

Chapter 1

Introduction

Having a set of clear requirements to their thesis is important to student finalising their BE, or other, degree. Such requirements are both in relation to the physical appearance of the thesis, as well as the writing style and organisation. The present document tries to concisely state the theses requirements while appearing in layout and structure as a thesis itself.

Chapter 2 explains the background for this document. Chapter 3 states the style and submission related requirements to theses submitted at the school. Chapter 4 explains content related requirements to theses and how to avoid some commonly seen problems. Chapter 5 evaluates the thesis requirements template. Finally, Chapter 6 draws up conclusions and suggests ways to further improve the thesis requirements template.

Chapter 2

Background

Every semester, students ask their supervisor how to write their thesis, what the requirements are, and what to write in it. This document tries to answer all such questions.

2.1 Previous work

Previously, Nooshabadi [5] has described style-related thesis requirements, Shepherd [7] has provided LaTeX templates while other academics have discussed contents with their students. This work draws all the relevant information regarding thesis writing into one document. The previous versions of the present template/document was heavily influenced by Nooshabadi and Shepherd, while the current version reflects recent changes in the submission procedures, and improves the LaTeX template.

Chapter 3

Style and Submission Requirements

Requirements for other parts of the thesis work can be found on the thesis Moodle page [6]. The requirements below are for the written thesis only.

3.1   Format

The following format specifications must be adhered to for the thesis report (the LaTeX template available from the school ensures this):

1. The thesis must be typeset on *A4 size page format* using a legible *12 pt font*.

2. The thesis must be prepared using a *word-processor* of the student's choice.

3. The thesis must be submitted electronically in *Portable Document Format* (pdf) with all *fonts embedded*.

4. *Margins* on all sides must be no less than 25 mm.

5. *1.5 line spacing* (about 8 mm per line) must be used.

6. All pages must be *numbered*. The main body of the thesis must be numbered consecutively from beginning to end. Other sections must either be included or have their own logical numbering system.

7. The *title page* must contain the following information:

    (a) University and School names.

    (b) Title of Thesis/Project.

    (c) Name of Author and student ID.

    (d) The degree the thesis is submitted for.

    (e) Submission date (month and year).

    (f) Supervisor's name.

3.2 Other physical appearance

Other requirements to the physical appearance of the thesis report are:

1. If a hardcopy is requested by supervisor or assessor, the report must be *printed* and *spiral bound* (at the student's own cost).

2. Formulas must be *typed* (not cut-and-pasted in). Complicated or difficult-to-type objects may be *neatly hand-drawn* and *scanned in high resolution*.

3. *Graphs, diagrams and photographs* should be inserted as close as possible to their *first reference* in the text. Rotated graphs etc are to be arranged so as to be conveniently read, with the bottom edge to the right-hand side of the page. *Graphs and diagrams must be legible!*

4. Relevant *computer programs* and *engineering drawings* should be included in the thesis, usually in an appendix.

3.3 Submission

Finally, here are some requirements to the submission procedure.

1. All students are required to write and submit *individual thesis reports*. The *author* of the thesis is *responsible* for the preparation of the thesis, proofreading the manuscript and having corrections made as necessary, and uploading the thesis before the deadline.

2. A *thesis summary sheet* must be included in the thesis report. This summary sheet is designed to assist in determining the overall input by students into the thesis work. The guidelines for completing the summary sheet and the summary sheet form can be downloaded from the thesis Moodle site.

3. In some cases, the thesis work may involve *several students* working on a *larger project.* Thus, some aspects of the work may have been carried out independently whilst other aspects may have been done as a group. The thesis reports must be *clearly distinguishable*, and appropriately cross referenced to each other. The common work overlapping between the thesis reports must be clearly identified.

4. There is a *page limit* of 100 pages for the main body of the thesis.

5. If applicable, relevant data and program files should be put on a *CD-rom* and submitted directly to the thesis supervisor for archiving.

Chapter 4

Content Requirements

Students should consult the literature (e.g. [8, 9, 2, 1, 10]) and other resources for material on how to write a good thesis. The present document is only a very brief introduction as to what is expected.

4.1 Structure

Most theses are structured similarly to the present document. The main part of the thesis can be structured in many different ways, however, but must contain: a *problem definition*, *scope* and work *motivation*; a contemporary *literature review* on the thesis problem and relevant related works; relevant *theory* and *considerations* on how to solve the problem; a description of the *solution method* (dimensioning, construction, etc.); presentation of *results* (measurements, simulations, etc.); a *discussion* of the results (validity, deviations, comparison with previous solutions, etc.); and finally the *conclusions*.

4.2 Style of writing

1. Audience: The thesis must be addressed to engineers at the same level as the student but without the special knowledge gained during the thesis work. Such a third-person must be able to reconstruct the results on the basis of the thesis alone.

2. Every used concept/symbol/abbreviation which is not widely know must be *defined*. The wording should be *short* and *concise*; a suitable length is 40–70 pages (plus appendices). Readable(!) *figures* and *graphs* enhance comprehensibility.

3. Units. *SI units* must be used. Units must be used correctly throughout the thesis.

4.3 Documentation

1. The work must be well documented; i.e. enclosed must be the *complete schematics* of designed electronic circuits/test set-ups and/or a *program listing*, and/or etc. Documentation of *simulation results* and/or *measurement results* likewise.

2. References: For every declaration/equation/method/etc., which is not widely known, a *reference to the literature* must be given (or a 'proof' if it is the authors own work). In case material is copied verbatim, quotes and references must be used. This is also the case when referring to partners work in larger projects. Figures not of the student's own making must have the source referenced in the figure caption.

3. Plagiarism: Failure to give proper references to the literature is *plagiarism*. Plagiarism is considered serious offence and severe penalties may apply.

4.4 Avoiding common problems

The thesis project, including the thesis report, is expected to be a professionally executed body work. Solutions to some commonly seen report problems are given below.

4.4.1 Figure quality

If at all possible, students should create their own figures using suitable software packages, as shown in the example in Figure 4.1. It is possible to use bitmap figures (as opposed to vector graphics) that are not photographs, but it must be ensured that the resolution is high and that lines and text are clear and have good contrast. Legibility is key: the pdf files generated from the used word processor should be verified for legibility early.

When graphs are including in the thesis, again it must be ensured that the plotting software generates clear, legible outputs and that axes have clear labels as shown in Figure 4.2.
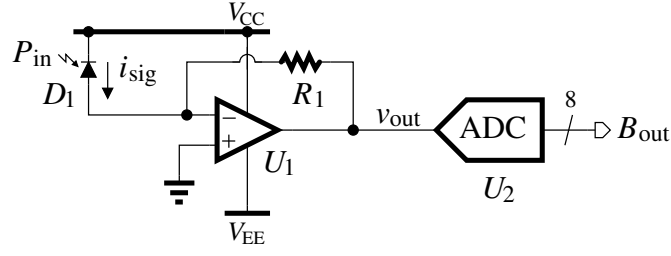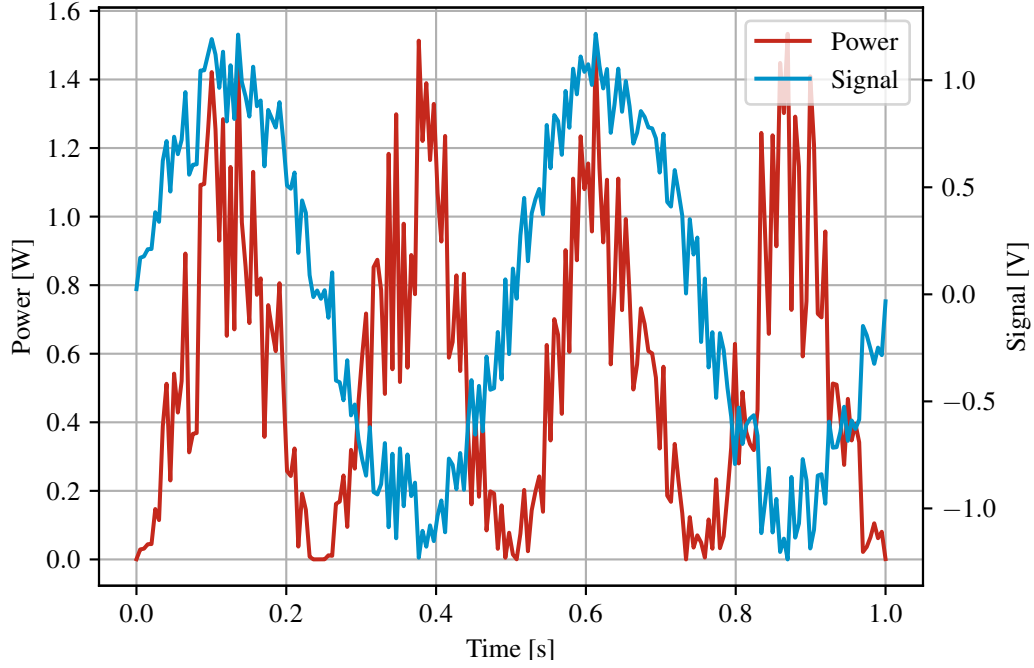
Figure 4.1: Schematic of electronic circuit.

Figure 4.2: Plot of some random data.

4.4.2 Attention to detail

It is key to a good document that the author pays attention to detail. This includes concise definitions and descriptions, making sure that concepts are explained in a logical order that the reader can follow, and that consistent symbol use is diligently practiced. For instance: "the output voltage, v_{out} in Figure 4.1 is given by Equation 4.1, where it is assumed that $R_1 = 1\,\text{k}\Omega$".

$$v_{\text{out}} = -R_1 \cdot i_{\text{sig}} \tag{4.1}$$

4.4.3 Story telling

It is important that the reader knows where the writing in thesis is heading at all times. An early introduction of high-level conceptual design of the proposed solution can be a good help, as

can a well defined thesis scope. Developing well-constructed, logical arguments for the work also greatly help in convincing the reader of the thesis merits.

Chapter 5

Evaluation

This chapter is mainly provided for the purpose of showing a typical thesis structure. There are no more thesis requirements described.

5.1 Results

The result of this work is the present document, being both a LaTeX template and a thesis requirement specification.

5.2 Discussion

The dual function of this document somewhat de-emphasises the primary purpose of the document, namely the thesis requirements. It would be better, perhaps, if these could be stated on a few concise pages.

Chapter 6

Conclusion

A thesis requirements/template document has been created. This serves the dual purposes of giving students specific requirements to their theses — both style and content related — while providing a typical thesis structure in a LaTeX template.

6.1 Future Work

Extract the requirements from the template in order to have very concise requirements.

Bibliography

[1] Write reports in science and engineering. http://learningcentre.usyd.edu.au/wrise/, accessed 8/11/2016, 2016. The Learning Centre, USyd.

[2] Bruce M. Cooper. *Writing Technical Reports*. Penguin Books, Middlesex, 1964.

[3] Tawfique Hasan, Torsten Lehmann, and Chee Yee Kwok. A 5V charge pump in a standard 1.8V 0.8μm CMOS process. In *IEEE International Symposium on Circuits and Systems*, pages 1899–1902, Kobe, Japan, 2005.

[4] Jannik Hammel Nielsen and Torsten Lehmann. An implantable CMOS amplifier for nerve signals. *Analog Integrated Circuits and Signal Processing*, 36(1–2):153–164, July-August 2003.

[5] Saeid Nooshabadi. Bachelor of engineering thesis and project: timetable and notes for students. http://scoff.ee.unsw.edu.au/document/thesis/thnotes2.pdf, accessed 14/11/2005, 2005. School of El. Eng. and Telecom., UNSW.

[6] Toan Phung. ELEC4121 BE thesis part B Moodle site. http://moodle.telt.unsw.edu.au/, accessed 1/11/2016, 2016. School of El. Eng. and Telecom., UNSW.

[7] John Shepherd. Doing a cse thesis. http://www.cse.unsw.edu.au/~jas/talks/thesis/, accessed 14/11/2005, 2005. School of Comp. Sci. and Eng., UNSW.

[8] Charles H. Sides. *How to Write & Present Technical Information*. Cambridge University Press, Cambridge, 3rd edition, 1999.

[9] William Strunk Jr. and E. B. White. *The Elements of Style*. Macmillan Publishing Co., New York, 3rd edition, 1979.

[10] Joe Wolfe. Writing an honours thesis. http://newt.phys.unsw.edu.au/~jw/hons.html, accessed 8/11/2016, 2016. School of Physics, UNSW.

Appendix 1

In the source code for this document, some commonly used LaTeX operations can be found. The typesetting opportunities with LaTeX are vast, and there exist an enormous collection of packages that give added functionality. Modern LaTeX distributions come with many of the most common packages (some used in this document) and many more can be found on the web.