



SÄHKÖ- JA TIETOTEKNIIKAN OSASTO
SÄHKÖTEKNIIKAN KOULUTUSOHJELMA

MASTER'S THESIS WRITING INSTRUCTIONS

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Grade _____

Teekkari, T¹. (2005) Manual for thesis writing². The University of Oulu, Department of Electrical and Information Engineering, Thesis Writing Instructions, 35 p.

ABSTRACT IN FINNISH ³

Näissä ohjeissa opastetaan valmistumisvaiheessa olevaa opiskelijaa diplomityön tekemisessä. Ohjeissa selvitetään työn asema diplomi-insinööritutkinnossa, kerrotaan toimenpiteet, joihin työn tekijän on ryhdyttävä työn eri vaiheissa sekä määritellään yksityiskohtaisesti diplomityön kirjallinen rakenne. Myös sähkö- ja tietotekniikan osaston kirjoittamisen tapa esitellään. Ohjeiden ja diplomityön rakenteet on pyritty tekemään mahdollisimman samankaltaisiksi käytön helpottamiseksi.

Avainsanat: diplomi-insinöörin tutkinto, opinnäytetyön kirjoitusohjeet, diplomityön rakenne.

¹ Initials should be written down

² 4th revised edition

³ This abstract should not be considered as a good model for a thesis abstract. See Chapter 3.3.

Doe J¹ (2005) How to Prepare a Master's Thesis. University of Oulu, Department of Electrical and Information Engineering. Writing Instructions, 35 p.

ABSTRACT

This guide instructs a graduating student in writing a Master's Thesis. The position of the Master's Thesis in the M.Sc. Degree is defined and the necessary measures the student has to take in the different stages of the work are presented. Moreover, the guide presents the literary tradition of the Department of Electrical and Information Engineering. The literary structure of the thesis is defined in detail. The structures of the guide and the Master's Thesis are as similar as possible to facilitate its use.

Key words: M. Sc. degree, writing instructions, master's thesis structure.

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¹ The initials of first names are to be indicated.

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FOREWORD

These instructions have been compiled at the Department of Electrical and Information Engineering of the University of Oulu. The aim has been to devise detailed instructions for the purpose of constructing and writing a thesis. These instructions are based on and adapted from earlier department thesis writing instructions, the writing instructions of the publication series Acta Universitatis Fennica, and The Instructions for Technical Writing. Several persons from the Department of Electrical and Information Engineering have participated in setting up these instructions. The first edition of the manual was compiled under the leadership of Pentti Lappalainen. It was then edited and added to by the Study Commission of the Department of Electrical and Information Engineering in 2005.

Oulu, 2 September 2005.

Study Commission of the Department of Electrical and Information Engineering

LIST OF ABBREVIATIONS AND SYMBOLS¹

| | |
|-------------------------|---|
| AGC | Automatic Gain Control |
| AWGN | Additive White Gaussian Noise |
| BER | Bit Error Ratio |
| SNR | Signal-to-Noise Ratio |
| $\lfloor \cdot \rfloor$ | Integer part |
| $(\cdot)^*$ | Imaginary part |
| $\arg(\cdot)$ | argument |
| B | signal bandwidth |
| B_d | Doppler broadening |
| \mathbf{b}_k | auxiliary variable matrix at instant k |
| c_0 | 1 st pin coefficient of filter |
| f_d | Doppler frequency |
| β | form factor |
| ε_k | error signal value at instant k |
| $\Phi_n(t)$ | stage of n th multipath transmitted signal at instant t |
| $\Phi(t)$ | stage of received signal at instant t |
| σ^2 | variance |

¹ These abbreviations and variables are examples and therefore do not appear in the text.

1. GENERAL INSTRUCTIONS

A thesis forms a major part of an engineering student's studies. Its purpose is to prepare the student for independent work as an engineer. Hence direct supervision plays a smaller role in thesis writing than the studies that precede it. A thesis is typically a solution to a relatively large problem or dilemma in a technical field. Although a thesis often necessitates additional studies in a given field, the ultimate purpose is to make students apply the knowledge and skills they have acquired in their studies in solving their research problem.

1.2. Starting to Work on Your Thesis

As a general rule, students should start working on their thesis at the end of their studies; generally, a recommended timeframe is to start in the autumn term of the 5th study year. You could also start earlier depending on how far you have advanced in your studies. The ground rule should be to start your thesis once you only have about 15 to 30 study points left to do on your degree. One should also bear in mind that certain fields of study require the completion of certain courses before work is commenced on the master's thesis. You should always check these things in advance from your supervisor.

N.B. Check your degree requirements from the secretary of your department, and check your credit point record in WebOodi.

1.3. The Thesis Topic

A professor or docent employed by the Department of Electrical and Information Engineering can give you a topic, in which case your topic will most likely be linked with ongoing research at the department. You can also do your thesis at a company operating in a relevant industry by contacting the company or facility directly or through a professor at your department, and agreeing on the terms of thesis supervision with a professor in a relevant field (one covered in your thesis). It is important that you contact a supervisor right at the start. Thus the topic of your thesis and the field it covers can be properly outlined, and you can agree on the parameters of supervision and monitoring of your thesis with your supervisor right away. Usually a thesis is done on a topic within the range of the research fields of the department. However, topics proposed by industries are often multi-disciplinary or cross-scientific, i.e. the topic does not fit into the realm of any one particular department. In these cases the parameters of supervision should be agreed upon with a professor who best represents the overall aim or focal point of the thesis.

1.4. Getting Approval for a Thesis Topic

Once you have sufficiently delimited the realm of your thesis, you should contact a professor (from hereon referred to as "supervisor") who would be willing to supervise and guide your thesis work. You should remember, however, that an

academically acclaimed professor is not therefore automatically a good supervisor. You should also agree with your supervisor on the final topic of your thesis. If you will be doing your thesis work within the commercial and/or industrial sectors, you should first make a short written description of the field covered in your thesis, as well as agree on the terms of supervision between your supervisor and the company/facility. You then propose your thesis topic to be **approved** by the Department Council by filling out a form, which is available at the office of the department (or online at <http://www.ee.oulu.fi/opiskelu/lomakkeet/Yhteiset/>). You should apply for approval as soon as possible once you have started working on your thesis. The Department Council will then formally approve your topic, and appoint a supervisor and an additional second examiner. Once approved, the topic is binding. However, the thesis title/focus can still be changed in agreement with the supervisor, if things change during the process.

In addition to the official supervisor and the second examiner, in the case that a thesis is done at a company, industrial facility etc., there must be a technical instructor/supervisor present to assist the student in practical and routine matters, and who at the end fills out a report, in which s/he expresses his/her view on the quality of the thesis (see appendix 3, master's thesis evaluation form for the buyer). The form does not, however, require that the name of the technical supervisor be filled in.

1.5. The Supervision and Guidance Involved in a Thesis Study

The student should **agree** with the **supervisor** well in advance about the topic(s) covered in a thesis, the timeframe, and the terms of supervision. It is important to contact the supervisor well in advance in order to make sure that the topic is suitable as a Master's thesis topic. The supervisor will identify the additional examiner, i.e. the student does not have to worry about finding one. If the thesis is done within the commercial and/or industrial sector, the student should also have a technical supervisor, who will assist the student concerning the practical aspects involved at the company or facility.

Figure 1 portrays instructions concerning the timeframe of a thesis.

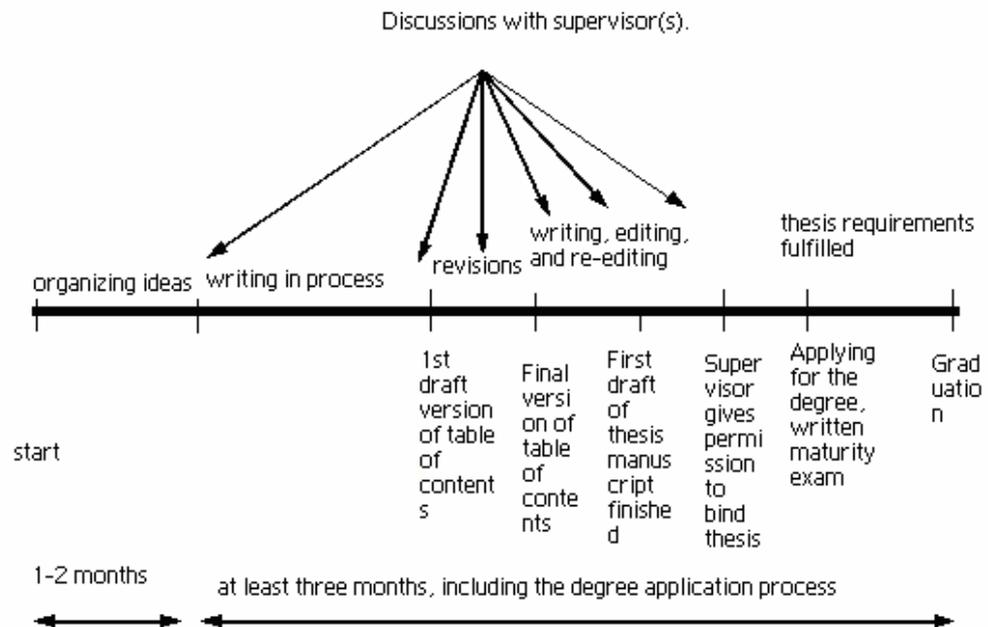


Figure 1. Typical thesis process.

A master's thesis is ultimately a test of maturity, in which the role of the independent work of a student is accentuated. However, the supervisor will usually give guidance and even detailed advice to the student, to ensure that the quality of the thesis is as good as possible. For this reason, the M.Sc. candidate should meet with the supervisor often and discuss all relevant issues with him/her. Therefore, the student should fix regular meetings with the supervisor. If the thesis is done within the commercial and/or industrial sector, it would be logical if the technical supervisor were an employee of the company or facility where most of the actual thesis work is done. In this case however, you should remember to keep very close contact with your supervisor at the university, especially in the write-up phase. At the beginning of the write-up phase, it is crucial to get information from your supervisor concerning the structure and presentation order of the thesis. During the write-up you should also see the supervisor frequently, in order to discuss a) whether the information order and emphases are right, b) whether the issues being covered or planned to be covered are relevant to the thesis, and c) whether some areas have been overlooked. The emphasis in the meetings with the supervisor will mainly fall on the structuring of your thesis.

1.6. The Evaluation of Masters Theses

The student hands in the thesis to the supervisor for final **examination and grading** after the supervisor has established that the thesis is ready to be bound. The evaluation of the thesis will be based on this final version, which does not yet have to be actually bound at the time of evaluation. However, it already has to include all sections of the thesis, such as appendices, the bibliography, figures, tables, etc. Since the evaluation will be done by two independent examiners (the supervisor and the

second examiner), one should allow ample time for evaluation. Hence, the thesis should be handed in for evaluation no later than **10 days** prior to a Department Council meeting. The supervisor and the second examiner will present their written statements on the thesis, which then stand to be approved by the Council (Appendices 1 and 2). When a thesis is done within the commercial or industrial sectors, a representative of the respective company or facility has to present their evaluation to the thesis supervisor no later than **one week** before a Department Council meeting. An evaluation form designed for this purpose can be found e.g. at the end of these instructions (Appendix 3). A Master's thesis that has passed approval will be evaluated according to university regulations with the following **grades**: *satisfactory*, *very satisfactory*, *good*, *very good*, and *excellent*. In addition to the thesis grades, the degree certificate can be granted distinction and marked *outstanding* if the thesis was graded *excellent*, and the weighted average of all grades is not lower than 4.00. For students who are graduating according to the new degree regulations (students who enrolled in 2005 or later), grading requirements are different; detailed information concerning this can be acquired from the Study Affairs Office. The title of the thesis, the name of the supervisor, as well as the grade will be printed on the Degree Certificate.

The student has the right to gain knowledge of the grade proposed by the supervisor, as well as a statement of reasons for the grade **three** days prior to the Department Council meeting. The student then has the opportunity to issue a written or oral **appeal** to the Faculty of Technology concerning the evaluation of his/her thesis no later than **fourteen days** after having received the information.

1.7. Formal Application Procedure for a M.Sc. Degree in Engineering

Printed (and bound) thesis

1. Get a copy of the title page of your thesis from the secretary of the department in which you are majoring.
2. Bring one bound and one unbound version of your thesis to the department secretary at the latest on the Monday of the week in which the Department Council meeting will be held.
3. Bring a copy of your thesis to your supervisor before the deadline he or she has given you.

M.Sc. degree in Engineering

1. Get the following **documents** from your department secretary:
 - A form called Application for Degree Certificate (tutkintotodistushakemus)
 - A form called Amendments and Additions (korjaukset/lisäykset –lomake)
 - A form called Thesis Abstract (tiivistelmä opinnäytetyöstä)
 - A follow-up questionnaire on the future employment of recent graduates.
 - A questionnaire by the Technical Society of Finland.

You must also get a copy of your study record from the office of the Faculty of Technology.

2. You then need to pass the so-called **maturity exam**. The maturity exam is proof that the student portrays an adequate knowledge of either Finnish, Swedish or English (you can choose one of these languages to perform the maturity exam in). The maturity exam will be taken as proof by Finnish officials of your language competence. In the test you are normally asked questions from your own thesis or an aspect of your thesis. You must agree on the time and place of your maturity test with your supervisor when you are at the stage of getting your thesis approved.
3. Return all university **library books**, as well as **keys, equipment, machinery, and tools** belonging to the university that you have had in your possession.
4. Bring in the form called “application for degree certificate,” which you have filled in, to your department secretary **two weeks** prior to a Department Council meeting.

1.8. The Archiving of Master’s Theses

According to a law that applies to the archiving of theses that came into effect in 1992, all Master’s theses are microfilmed. You must bring one unbound copy of your thesis to the department secretary for this purpose.

1.9. The Principle of Free Access Concerning Master’s Theses

A master’s thesis is a **public** document. A thesis must therefore not reveal any **business secrets**. Should any major conflicting interests arise between the author of the thesis and the “buyer” of the thesis concerning the publication of information, the author of the thesis should turn to the thesis supervisor for consultation.

The Ministry of Education has issued a set of written statements to universities and colleges concerning the public nature of theses. The statements assert that theses must not contain classified information, and that theses are made public immediately once they are approved. (The ownership as well as the publication and/or patent rights should be agreed upon together with the supervisor, author, and the buyer (usually the company or facility under the auspices of which the thesis was made.)).

1.10 Thesis Awards

The Technological Society of Finland issues the Best Thesis of the Year Award, chosen from a list of candidates compiled by Finnish universities and colleges, which is compiled from amongst all theses published annually in Finland.

2. THESIS WRITING INSTRUCTIONS

2.1. Introduction

A Master's thesis in engineering is usually formed of an **implementation part** (literature survey, device modeling, software, measurements, etc.), and the **written part** (the actual text body). How the implementation part is carried out depends on the individual topic, hence no general guidelines can be issued thereupon. However, each type of publication has its distinct layout. All publications should therefore be presented in a layout particular to the type of publication. This set of instructions will explain in detail the writing and layout style that has become the convention at the Department of Electrical and Information Engineering. Typography greatly affects the readability of a text. Hence the instructions should be adhered to diligently. By following the instructions, the thesis authors can properly learn a good way of expressing themselves formally in writing. Furthermore, having learned one way of formal writing makes it easier to later learn the ways of an established writing culture of a company or facility, and this is useful knowledge when considering future employment.

Before commencing work on your thesis, it is a good idea to **mind-map** or **chart out** the various issues that will be included in a thesis, and then divide them into themes as well as actual chapters with actual titles, as well as estimated numbers of pages to be included in each chapter. The list of chapters, i.e., the index, should be discussed in detail with the supervisor. Even more importantly, you should discuss the weighting and dynamics with your supervisor, i.e., which issues you will accentuate and focus on. You should reserve ample time for your thesis, so that its content and structure will be as good as possible. It should be remembered that the bound thesis book is probably the only document through which your whole thesis work can later be assessed.

2.2. The Linguistic Style of a Thesis

Students who have completed their matriculation exam in Finland write their Master's thesis in **Finnish** or **Swedish**. Foreign students, or students who do their theses abroad, or persons who are not fluent in Finnish can write their thesis in **English**. In other instances, one should apply for permission in writing to the Department Council. Irrespective of the language used, the thesis should have an abstract and title in both English and Finnish. When the language of the thesis is English, the abstract in English comes before the abstract (tiivistelmä) in Finnish. It is recommended that Finnish-speaking students write in Finnish. It is challenging enough to do a thesis in your mother tongue, let alone a foreign language. One should remember that apart from anything else, the literary style of your thesis and your style of writing will also affect evaluation. How clearly you get your message across forms an important part of the evaluation.

You should always remember your audience. In the case of a student's Master's thesis the main audience are people who have received a formal and/or academic training in engineering. Thesis authors should therefore avoid issues and topics not fully within their grasp. You should apply **professional terminology** when available.

This rule also applies to all figures and tables.

You should aim for a clear and well-structured thesis, without unnecessary verbosity. The language (**English/Finnish/Swedish**) should be fluent and readable, and it should adhere to the conventions and recommendations applied in a particular language. For example, in Finnish decimals are indicated with commas (e.g., € 4,99), but in English decimals are indicated with points (e.g., € 4.99). Advice on such issues can be obtained from various language guides. Concerning the Finnish language you can find advice in *Kielikello*, the journal of The Finnish Language Bureau [4]. There are also several excellent sources in the internet, e.g. [6,7].

2.3. Thesis Text-editing

A thesis written in English has to be officially text-edited by an official text-editing business, a person qualified to edit technological vocabulary in English, a native English speaker, or a person holding the degree of M.A. in English Philology. It is up to the author of the thesis to obtain a certificate as proof of the text-editing. The author must bring the certificate to the thesis supervisor.

2.4. Typography

- Font: Times New Roman
- Paragraph settings:
 - Left indentation: 4.5 cm
 - Right indentation: 2.0 cm
 - Upper margin: 2.5 cm
 - Lower margin: 3.0 cm
- Spacing
 - Before a heading: 2 empty rows
 - After a heading: 1 empty row
 - Between two headings: 1 empty row
- Line spacing: the default value for each font size, which is usually the font size + 2 pts.
- 1 empty row should be left between chapters. The 1st paragraph after a heading should not be indented. Subsequent paragraphs should be indented by 0.4 cm.
- 1 empty row should be left between text and caption text.
- Table structure and the different fonts used in different instances are explained in table 1.
- In tables, the table heading has to be placed above the table. The table heading should **not** end in a full stop.
- The caption text is situated underneath the table and the caption text **does end**

in a full stop. There should be no references in a caption text.

- If a figure is a combination of several figures, its structure should be formed according to Figure 2.
- Do not start a chapter with a figure, embed it in the text content. A figure should always appear in the text after its reference.

Table 1. The font types used in a Master's thesis.

| Font size (p.) | Layout | | | |
|-------------------|---|--|---|--|
| | Regular | Bold | <i>Italic</i> | <i>Bold italic</i> |
| 10 | Footnotes and endnotes | | | |
| 12 | Standard text, figures, tables, table headings, captions, references. | 1st degree subheadings, abstract, abstract in Finnish (tiivistelmä) | <i>3rd degree subhead- ings</i> | <i>2nd degree subheadings</i> |
| 14 | AUTHOR NAME | CHAPTER TITLE 1 | | |
| 18 | | THESIS TITLE | | |

1. Each full chapter should be started from a new page.

You should not decimalize chapters beyond the 3rd grade (e.g., 1.2.1.1.). Should the need arise for further decimalization the following method should be applied:

The small-signal model of a field-effect transistor

The frequency settings of the amplifier are best illustrated with the help of the following small-signal models. This shows how...etc.

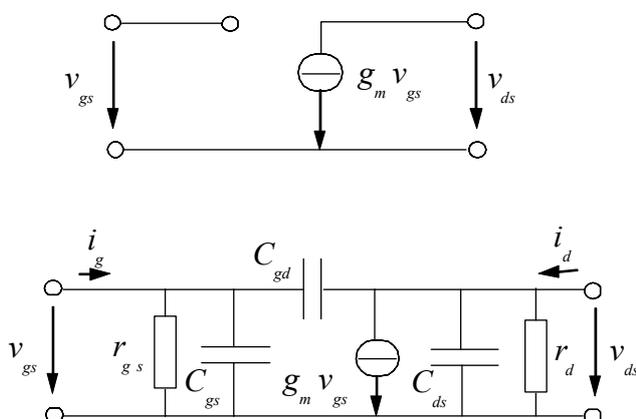


Figure 2: Small-signal models of a field-effect transistor: a) simplified small-signal model, b) large-signal model.

Figures, tables and appendices are parts of a written presentation. They must each be **referred to** in the text body in the order in which they appear. Figures and tables can be numbered from the beginning to the end of the thesis regardless of the chapter, or to coincide with the numbering in each chapter in the case that there are a significant number of figures and tables.

2.5. Practical Advice for Writing a Master's Thesis

On average, it takes between two to three months of full-time work to write a Master's thesis. You might be able to write a thesis in a much shorter time, but you should realize that it takes much longer than you think to edit and re-edit a thesis, considering both information structure and presentation style as well. In the following we have listed some practical advice, which serves the purpose of making it easier to start the writing phase.

1. Do not leave the writing until the end

Developing and constructing the ideas and experiments included in a thesis, and simultaneously writing a thesis force the author to **clarify and reformulate** ideas, which might often lead to new ideas. By developing ideas and building constructions etc., and writing a thesis simultaneously it is possible to save time on editing, re-editing and restructuring later. At the least you should start gathering and getting acquainted with your literature and charting out your written part into clearly defined units and chapters at an early stage. Once you have done this and you know where you are going, you will have a much more secure feeling of the scope of your thesis.

2. Discuss things in detail with your supervisor before you start writing, and design a skeleton for your thesis

It is in the best interest of the supervisor that the student graduates as fast as possible and is left without wider difficulties. S/he therefore has an excellent motive to discover sources of concern in time. A typical problem at the beginning stage that can be fixed easily is a content structure, in which theory and practice have been divided into two separate parts. If left unfixed, this will often lead to repetition and it can also be very difficult to work with divided content of that nature.

Hence, start your writing by planning a content structure, i.e., table of contents, which will function as your skeleton all throughout your work. Usually it is a good idea to construct your chapters so that you first give each heading and subheading a working name even if you do not have a final idea of the exact title at this stage. Each structural unit (heading) should have a few code words that act as the key to each heading. You can also look at it this way: code words convey a message to the reader, a message you as the author want to tell them. Later when you have started doing the actual writing, you should build on these code words and crystallize the message in each chapter to correspond to these code words. Thinking ahead like this will reduce the pain of creation, give you confidence and help you trust that your thesis is solid.

3. Write things in the right order

Most people find it convenient to write their thesis in the order of their table of contents. It is usually a good idea to start by writing the introduction, because the introduction spells out and defines the wider scope as well as the focal point of the thesis. The other chapters in the opening part of the thesis usually lay out the parameters and working environment, and potentially, the theoretical basis of the thesis; they can also be written fairly early on in the process. The opening part of the thesis also includes the literature review. It is highly recommended that you keep track of your references and document them while you are writing, because you might forget or lose track of your sources later.

4. Write clearly

The first sentence of a chapter should define its contents. The following sentences clarify the issue. This results in a clear and easily understandable way of presenting, since each chapter should contain information only on one or two separate issues. Chapters structured like that will be easy to cut and paste elsewhere, if structural rearrangements are later required. To avoid fragmentation, it is important not to present the same things again in different chapters. It will be easier for the reader to develop an idea of your message when your thesis structure is logical and its linguistic style is systematic throughout the thesis. Hence, do not go “over the top” and try to impress the reader with too extravagant ways of presenting your ideas. Instead, present your case as you would like others to present their thesis.

5. Ask your supervisor to go through what you have written

Sometimes the "official" supervisor (the one appointed by the Department Council) and a direct supervisor are two separate persons, especially in the case where the thesis work is done in the industrial/commercial sector. In this case you should first have your work read by your direct supervisor. After that edit your work according to his/her advice before you bring it for revision to your department-appointed official supervisor. A direct supervisor has a better feel of your work as s/he interacts with you on a regular basis, and can therefore go through your work much faster. Your official supervisor, however, can form a better view of your work when you bring him/her a more finished product. You should make good use of the expertise provided to you by your direct supervisor at all stages of your research and write-up phases. However, do not feel intimidated to show your work to your official supervisor at the beginning of your writing phase (see chapter 2 above). It is your official supervisor who has the final say of the criteria attached to a Master's thesis and it is s/he along with the second examiner who will grade your work.

6. Do not get stuck

Figure 3 shows how difficult writing can be sometimes. If you feel you are not advancing with your writing although you feel like you know your topic, there might be something wrong in the way you work. In this case, do not waste time in wondering and fretting; instead seek advice in the instructions above. If this does not help, then usually your supervisor(s) can help you in solving your problem. At the most difficult time it is good to remember that every engineer you see out there has

once been in the same situation as you are now, and yet they were still able to graduate.



Figure 3: Writing angst and the pain of creation. “Writing your thesis can sometimes make you run outside and howl at the moon. - *It’s already the fourth week and I haven’t been able to write anything else besides my name down.*”

3. THE LITERARY STRUCTURE OF A MASTER'S THESIS

The structure of a text is based on a pre-designed content structure (table of contents, skeleton) that can vary a great deal from thesis to thesis depending on the topic as well as the scope of the thesis. The presentation order of the opening pages is fixed, and should be presented as it is described in sections 3.1 to 3.7 in these instructions. When applying **page numbering**, the first page to be numbered is the title page.

3.1. The Front Cover

The words MASTER'S THESIS (DIPLOMITYÖ in Finnish) should be printed in the middle of the front cover (Theses written in English should be printed with the words MASTER'S THESIS, and theses in Finnish with the word DIPLOMITYÖ). The NAME OF THE AUTHOR of the thesis should be printed in the lower right hand corner of the front cover. The NAME OF THE AUTHOR and year of publication should be printed in the spine of the thesis. You have to have your thesis bound at a printing house specialized in printing theses. The printing house will also produce and attach the cover to the printout that you have brought with you. The color of the cover has to be black. The text has to be **printed** on the cover, i.e., **stickers should not be applied**.

3.2. Title Page

You obtain the title page form (appendix 4) (nimiölehti in Finnish) from your department secretary (from the department of the subject in which you are majoring). Those writing in English have it in English and those writing in Finnish have it in Finnish.

Students majoring in Electrical Engineering or Electronics should contact Ms Rauni Ticklén, directly at her office at TS 111, or by email at rauni@ee.oulu.fi.

Students majoring in Information Engineering or Information Networks should contact Ms Varpu Pitkänen directly at her office at TS 112, or by email at vp@ee.oulu.fi.

Students majoring in Telecommunications should contact Ms Vaili Jämsä directly at her office at TS 444, or by email at vjamsa@ee.oulu.fi.

3.3. Abstract

The abstract of your thesis will be fed into various **information systems and catalogues (Appendix 5)**. It should crystallize the essence of your thesis. The abstract should be an independent piece of work, i.e., the reader should be able to get a clear picture of your thesis from the abstract alone. There must not be any references to your thesis or other sources, but it should also not include any information not found in your thesis. The abstract should include the main elements, as well as the results obtained and main conclusions of your thesis. The recommended length of an abstract is 200 words. Rare terminology and

abbreviations should be avoided. The bibliographic information (see section 5) of the thesis should be printed at the top of the abstract page. The keywords of your thesis should be printed below the abstract. The recommended number of keywords is 2-6 keywords or word sets. It is recommended that the keywords are not any words included in the title of the thesis. Keywords serve an important purpose for anyone performing literature searches in a library and other information catalogues. The abstract also has to be written in the form titled thesis abstract (appendix 6), which can be obtained from your department secretary.

3.4. Abstract in Finnish

You also have to write your thesis abstract in Finnish (see appendix 7), or have your abstract translated into Finnish. It should be written in flawless Finnish.

3.5. The Table of Contents

The table of contents lists the chapters with their headings and subheadings and their respective page numbers. The titles of the first pages of your thesis (abstract, abstract in Finnish, forewords, list of abbreviations, table of contents) are not to be numbered; numbering starts from the forewords, and the title page of your thesis is the first page of your thesis. The first page number is printed on the page after the forewords. Numbering is by Arabic numerals, page numbers are placed at the top right hand corner of the page.

3.6. Forewords

The forewords-page should describe the aim of the thesis, and its various research stages, and present the partners and circumstances involved in the thesis project. The forewords should also include words of gratitude, addressed to people who have been incremental in your thesis-writing process.

3.7. The List of Abbreviations and Symbols Page.

All abbreviations and symbols used in the thesis have to be listed on this page. You should check the validity of all abbreviations and symbols from **reliable sources**. Concerning measurement units, you should apply the internationally approved SI-system of symbols [5]. You also have to explain all abbreviations and symbols when they first appear in the text.

You should first explain all mathematical (and other similar) symbols, then abbreviations, so that Latin, Greek, etc. letters are all grouped separately.

3.8. Introduction

In the introduction, you should describe the background of your thesis, introduce the reader to your research questions and methodology, describe in detail the aims of your thesis, and on what basis have you outlined your research area. When needed, you can make references to earlier work done in the field. You should not discuss the results of your thesis in the introduction.

Nowadays Master's theses in engineering are often a part of wider research

projects at universities or industries, and it might therefore be difficult for the reader to discern when the author is describing his/her personal work, and when is s/he describing the work of a research group. In cases like these, the author should describe as best as possible what exactly was his/her role in the research/project. At the end of the introduction, you might want to give an overview about the structure of your thesis.

3.9. How to Manage the Core Text Part of Your Thesis

How you handle the core topic of your thesis depends essentially on the nature of your research/project. Most theses first describe (usually one to two separate chapters) the scientific environment of the thesis, its goal(s), and its boundary conditions so that it is later clear why one approach or method was chosen over another. In the beginning, you can also describe and analyze optional approaches or methods, e.g., by applying system-level modeling. You can also present solutions proposed in literature sources, although you should avoid going too deeply in that direction. Some thesis research could include a theoretical analysis of a given topic, in which you present the grounds on which you analyze the topic, based either on literature sources or your own reasoning. However, you should avoid unnecessary writing-up, i.e., the theory you present should be closely linked to the focus of your thesis. You should also notice that many theses do not have a separate theory section at all. **Hence you should not try to forcefully include a theory in your thesis, unless the theory fits directly into your overall research goal(s).** (Mathematical) equations and denotations often play an important role in describing a theory. However, one must bear in mind that mathematics is a useful tool in writing, and not an end purpose in itself. It is not always necessary to present and back up every single detail with a mathematical equation. It suffices to present the basic equations, the relevant variables, and the end results. You can also include these as appendices if you need to. Science and technology use two types of equations

- Equations between quantities where letter symbols represent quantifiable variables, and
- Equations between numerical values, where letter symbols represent the numeric values of equations.

An equation is the sum of a numerical value and the measurement unit that is used with it. The measurement unit should always be separated with a space from the numerical value preceding it (e.g., 5 °C; N.B., however, 5°). It is recommended that equations between quantities are used, because unlike equations between numerical values, equations between quantities are not dependent on which measurement unit is used. Equations are calculated according to the rules of algebra, and the symbols used in equations are usually one-letter symbols. The mathematic variables and symbols used in equations should be italicized. Vectors should be italicized in bold. Numbers, symbols of units, and sub-indices or subscripts should not be italicized (sub-indices or subscripts that include symbols of equations should all be italicized). Greek letters should not be italicized. Every equation should be a part of full sentence. An empty row should be left at the top and at the bottom of an equation, and equations should be numbered by applying consecutive numbering, from the

beginning to the end of the thesis. However, if you have a large number of equations, you should number them per chapter. The numbering should take place at the right side of the equation in parentheses. You should refer to the equation in the text by referring to the number of the equation, e.g.: "As seen in equation (1), the..."

In steady movement, speed is

$$v = \frac{s}{t} , \quad (1)$$

in which t is the amount of time required by the movement, and s is the distance achieved by the movement.

After the opening sections of your thesis, you should present the actual personal contribution your thesis is making, although some of this can already be included in the previous chapters. Typically, a thesis progresses so that you first describe a device construction, the electronic circuit, the software, the measurement decisions, the production method(s), etc., and the reasoning and justifications behind the decisions. This is usually followed by measurement, simulation, etc., results and other potential observations by which you want to prove that your methodology, etc., is valid and functions well in the context. So that your observations will benefit your readers, you should record and publish them in your thesis in as thorough and detailed a way as possible in their original format (such as tables, etc.). You must be careful not to mix actually obtained results and your estimates of the results.

In construction, or software-based theses, you should approach your research questions by means of system planning. You should only describe the necessary details of your basic theory and construction, which are directly relevant to the construction or software. You can include a broader description of the constructions and/or software in an appendix if you deem it important. You should describe the details of your construction/software in sections, starting from a general level, and then going into more detail, level by level. You should avoid a too detailed description concerning the operational principles of electronic circuits and software structures. However, concerning details that are essential to the thesis - especially details that cover new ground or are not clear even to experts in the field - it is a good idea to include such details. Measurements are essential to theses involving constructions, and they should be well planned. The same goes for theses where software is included.

3.10. Discussion

A good thesis or other scientific work always has a discussion or results section. In order to write this, you should be able to look at your work as if from a distance, to "step out of the box", as they say. You should be self-critical, compare your work to similar work in the field, and think analytically. You should be able to crystallize the results of your work, and put them into words. This can often be difficult even for an experienced writer, but it helps if you are well acquainted with published literature in the field.

In this section you can also present your estimate of the extent to which the aims of your thesis have been met, and the reasoning behind this. You can also discuss the overall significance of your thesis on a more general level, and compare your work to similar work done in the field. You can also discuss the potential of further development based on your thesis, especially if you have put forth clearly new or ground-breaking ideas. However, you should avoid unnecessary speculation here, as well as elsewhere.

3.11. Conclusion

In the conclusion you should present clearly in a nutshell the aims of your thesis, its main content, your results, and the significance of your results. You should lay special emphasis on your results if you feel you have accomplished something. You should not make references, or present any results not found elsewhere in your thesis.

An abstract and a conclusion overlap to a certain extent; they both share the feature of describing the main contents and results of a thesis. However, the nature of the conclusion is broader. In it, you should describe your aims, and you could describe any optional solutions or approaches, backed by explaining why you chose the solutions and approaches that you did. The abstract on the other hand could just describe in detail the solutions and approaches chosen for the thesis, leaving the optional approaches out. You might also want to include here the future prospects generated by your thesis.

3.12. References

You should apply consecutive numbering for referencing and present your reference sources in your bibliography **in the order in which they appear in the text**. The last name of the author should be written first, followed by the initials of the author's first names. Reference in the text should be indicated with a reference number, e.g., [1] or [1, 2, 5]. When a reference or quote applies to the whole sentence, the reference is situated at the end of the sentence before the full stop. When a reference is made to a certain page of a source, you should write, e.g., [1 p. 14] or [1 p. 14 – 15]. You should present your references so that it will not remain unclear to the reader which claim is obtained from a reference source, and which claim belongs to the author. Furthermore, unpublished sources, all sentence quotes, as well as the source of all equations and figures must be made reference to. You cannot make reference to a source that you have never seen yourself. You should adopt a skeptical stance towards internet sources. However, if you make reference to an internet source, you must save a copy of the publication and include it either directly in your thesis as an appendix, or keep a copy of it in your files.

Acronyms should be written in capital letters, irrespective of how it is written in full. Abbreviations should be indicated with a full stop at the end. It is not recommended to use abbreviations in other languages. Names of publications in the bibliography should be written out in the language of the publication. The way in which you present your references in the bibliography can best be exemplified by the following examples:

Series:

- [1] Kostamovaara J. (1986) Techniques and Devices for Positron Lifetime Measurement and Time-of-Flight Laser Ranging. Acta Universitatis Ouluensis, Series C, Technica 37. The University of Oulu, Oulu, Finland.

Journal:

- [2] Arai Y. & Oshugi T. (1989) TMC-A CMOS Time to Digital Converter VLSI. IEEE Transactions on Nuclear Science 36, p. 528 – 531.

A section of compiled work:

- [3] Gajski D. (1991) Essential Issues and Possible Solutions in High-Level Synthesis. In: Camposano R. & Wolf W. (eds.) High-Level VLSI Synthesis. Kluwer Academic Publishers, Boston, Mass., p.1–26.

Book:

- [4] Hakalahti H., Lappalainen P. & Tervonen M. (1978) Minitietokoneet: Rakenne, ohjelmointi, prosessiliitännät. Guild of Electrical Engineering, Oulu, Finland, 431 p.

Conference proceedings:

- [5] Mitra S.K. (1991) Some Unconventional Signal Processing Applications of Multirate Techniques. In: IEEE International Symposium on Circuits and Systems, June 11 – 14, Raffles City, Singapore, Vol. 1, p. 13 – 16, New York.

Author unknown:

- [6] Living Standards: The Real Estate Yearbook (1991). The Finnish Real Estate Union, Helsinki, 72 p.

Thesis:

- [7] Kurikka P. (1992) Tietokoneavusteisen elektroniikkasuunnittelun kehitysjärjestelmien vertailu ja arvionti. Master's thesis. The University of Oulu, Department of Electrical and Information Engineering, Oulu, Finland.

Internet publication:

- [8] Krishnan V. & Torrealis J. (accessed on 22 October 1999) A Chip-Multiprocessor Architecture with Speculative Multithreading. URL: <http://computer.org/tc/tc1999/t0866abs.htm>.

3.13. Appendices

Things you can include as an appendix are, e.g., derivations of equations or formulas, details of important computer programs, various tables, or performance characteristics and descriptions of special equipment or components applied in the thesis work. You can also include construction drawings and parts catalogues in the appendix. Appendices are titled as shown on page 24.

4. CONCLUSION

These instructions describe the various stages of writing and going about creating a thesis. We have described the role of a master's thesis in an engineering degree, and we have talked about the importance of keeping close contact with your thesis supervisor. We have also described the standard procedure, according to which a Master's thesis at the Department of Electrical and Information Engineering is to be written.

5. BIBLIOGRAPHY

- [1] Lappalainen P., Suutari-Jääskö L. & Silvén O. (1994) Diplomityön teko-ohjeet. The University of Oulu, the Department of Electrical and Information Engineering, Oulu, Finland, 31p.
- [2] Ohjeita kirjoittajille (1997). The publications commission of the series Acta Universitatis Ouluensis, Leena Rautio (ed.). The University of Oulu, Oulu, Finland, 20 p.
- [3] Tirronen K. (1987) Teknisen kirjoituksen laatiminen. The Technological Society of Finland (STS), the Academy of Technical Science, Jyväskylä, 89 p.
- [4] Maamies S. (ed.) (1998) Kielikello. Journal of Text-editing # 3. The Research Centre for Domestic Languages.
- [5] SI-opas: suureet ja yksiköt, SI-mittayksikköjärjestelmä (Système international d'unités) (1974). Finnish Standards Association SFS, Office of Weights and Measures, Helsinki, Finland, 23 p.
- [6] Korpela (accessed on 9 November 2006) Nykyajan kieliopas. URL: <http://www.cs.tut.fi/~jkorpela/kielenopas/>
- [7] Research Institute for the Languages of Finland (accessed on 9 November 2006). URL: <http://www.kotus.fi/kielitoimisto/>

6. APPENDICES

- | | |
|------------|---|
| Appendix 1 | Master's Thesis Evaluation Form in Finnish (Diplomityön arviointilomake osastoa varten) |
| Appendix 2 | Master's Thesis Evaluation Form in English |
| Appendix 3 | Master's Thesis Evaluation Form for the Buyer |
| Appendix 4 | The title page of a Master's thesis |
| Appendix 5 | Abstract in Finnish (Tiivistelmä) |
| Appendix 6 | Master's Thesis Abstract Form (Form for editing) |
| Appendix 7 | Abstract in English |
| Appendix 8 | Instructions for the Evaluation of a Master's Thesis in Finnish (Diplomityön arviointilomakkeen soveltaminen) |
| Appendix 9 | Instructions for the Evaluation of a Master's Thesis |

N.B! Page numbering is done by consecutive numbering. Additional appendices, that are attached to the thesis (such as copies, drawings, etc.) are left without page numbers and placed at the end of the thesis.

| | |
|---------------------------|---------------|
| Työn tekijä: | Työn valvoja: |
| D-työn nimi: | |
| Työnluonne ¹ : | Työnantaja: |

| OMINAISUUS | | ARVIOINTI | | | | | |
|---|-------------|-----------|---|---|---|---|--------------------|
| Työn laajuus | suppea | 1 | 2 | 3 | | | laaja ² |
| Työn vaikeusaste (teoreettisuus, käsitteellisyys) | helppo | 1 | 2 | 3 | | | vaikea |
| Aiheen jäsentäminen (työn looginen rakenne) | heikko | 1 | 2 | 3 | 4 | 5 | hyvä |
| Ongelmakentän ja aiemman tutkimuksen esittely | heikko | 1 | 2 | 3 | 4 | 5 | hyvä |
| Tavoitteen saavuttaminen | heikko | 1 | 2 | 3 | 4 | 5 | hyvä |
| Työntekijän suorittama tulosten arviointi | heikko | 1 | 2 | 3 | 4 | 5 | hyvä |
| Tulosten merkitys | vähäinen | 1 | 2 | 3 | 4 | 6 | suuri |
| Oma-aloitteisuus | passiivinen | | 1 | 2 | 3 | | aktiivinen |
| Kieliasu (tekstin rakenne, oikeinkirjoitus) | heikko | 1 | 2 | 3 | 4 | 5 | hyvä |
| Ulkoasu (kirjoitusohjeiden noudattaminen) | heikko | | 1 | 2 | 3 | | hyvä |
| Yhteispistemäärä ³ | | | | | | | |

Yleisarviointi:

Arvosanaehdotus:

Tarkastajat:

Nimien selvennykset:

Valvoja Toinen tarkastaja

¹ Arviointiasteikko: tutkimus, tuotekehitys, muu.

² Asteikkoa 1 – 3 sovelletaan vaikeasti arvioitaviin ominaisuuksiin.

³ Liitä arviointilomakkeeseen tiivistelmä. Ohjeellinen arvosteluskaala: 10 - 15 p. tyydyttävä; 16 - 21 p. erittäin tyydyttävä; 22 - 28 p. hyvä; 29 - 35 p. erittäin hyvä; 36 - 42 p. kiitettävä.



DEPARTMENT OF ELECTRICAL AND INFORMATION ENGINEERING

| | |
|-------------------------------|-------------|
| Name of Author: | Supervisor: |
| Title of thesis: | |
| Type of thesis ¹ : | Employer: |

| FEATURE | | EVALUATION | | | | | | |
|---|---------|---|--------------------|---|-------|--------------------|---|-------|
| Scope | limited | <table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 15%;">1</td> <td style="width: 15%;">2</td> <td style="width: 15%;">3</td> <td style="width: 15%;">broad²</td> </tr> </table> | 1 | 2 | 3 | broad ² | | |
| 1 | 2 | 3 | broad ² | | | | | |
| Degree of difficulty (theoretical depth, conceptuality) | easy | <table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 15%;">1</td> <td style="width: 15%;">2</td> <td style="width: 15%;">3</td> <td style="width: 15%;">difficult</td> </tr> </table> | 1 | 2 | 3 | difficult | | |
| 1 | 2 | 3 | difficult | | | | | |
| Organisation of topic (logical structure) | poor | <table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 15%;">1</td> <td style="width: 15%;">2</td> <td style="width: 15%;">3</td> <td style="width: 15%;">4</td> <td style="width: 15%;">5</td> <td style="width: 15%;">good</td> </tr> </table> | 1 | 2 | 3 | 4 | 5 | good |
| 1 | 2 | 3 | 4 | 5 | good | | | |
| Introduction to the problem and state of the art | poor | <table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 15%;">1</td> <td style="width: 15%;">2</td> <td style="width: 15%;">3</td> <td style="width: 15%;">4</td> <td style="width: 15%;">5</td> <td style="width: 15%;">good</td> </tr> </table> | 1 | 2 | 3 | 4 | 5 | good |
| 1 | 2 | 3 | 4 | 5 | good | | | |
| Achievement of aims | poor | <table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 15%;">1</td> <td style="width: 15%;">2</td> <td style="width: 15%;">3</td> <td style="width: 15%;">4</td> <td style="width: 15%;">5</td> <td style="width: 15%;">good</td> </tr> </table> | 1 | 2 | 3 | 4 | 5 | good |
| 1 | 2 | 3 | 4 | 5 | good | | | |
| Evaluation of results | poor | <table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 15%;">1</td> <td style="width: 15%;">2</td> <td style="width: 15%;">3</td> <td style="width: 15%;">4</td> <td style="width: 15%;">5</td> <td style="width: 15%;">good</td> </tr> </table> | 1 | 2 | 3 | 4 | 5 | good |
| 1 | 2 | 3 | 4 | 5 | good | | | |
| Significance of results | minor | <table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 15%;">1</td> <td style="width: 15%;">2</td> <td style="width: 15%;">3</td> <td style="width: 15%;">4</td> <td style="width: 15%;">5</td> <td style="width: 15%;">major</td> </tr> </table> | 1 | 2 | 3 | 4 | 5 | major |
| 1 | 2 | 3 | 4 | 5 | major | | | |
| Initiative | passive | <table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 15%;">1</td> <td style="width: 15%;">2</td> <td style="width: 15%;">3</td> <td style="width: 15%;">active</td> </tr> </table> | 1 | 2 | 3 | active | | |
| 1 | 2 | 3 | active | | | | | |
| Language (structure, spelling) | poor | <table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 15%;">1</td> <td style="width: 15%;">2</td> <td style="width: 15%;">3</td> <td style="width: 15%;">4</td> <td style="width: 15%;">5</td> <td style="width: 15%;">good</td> </tr> </table> | 1 | 2 | 3 | 4 | 5 | good |
| 1 | 2 | 3 | 4 | 5 | good | | | |
| Outward appearance (conformity with writing instructions) | poor | <table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 15%;">1</td> <td style="width: 15%;">2</td> <td style="width: 15%;">3</td> <td style="width: 15%;">good</td> </tr> </table> | 1 | 2 | 3 | good | | |
| 1 | 2 | 3 | good | | | | | |
| Total Score ³ | | <table border="1" style="display: inline-table; border-collapse: collapse; width: 100%;"> <tr> <td style="width: 15%; height: 20px;"></td> <td style="width: 15%;"></td> </tr> </table> | | | | | | |
| | | | | | | | | |

General evaluation:

Grade proposed:

Examined by:

Names in block letters:

Supervisor

Second examiner

¹ Scale: research, product development, other.
² Features difficult to assess are evaluated on a scale 1 - 3.
³ Attach the abstract of the Master's Thesis to be evaluated. Recommended evaluation scale: 10 - 15 p. satisfactory; 16 - 21 p. highly satisfactory; 22 - 28 p. good; 29 - 35 p. very good; 36 - 42 p. excellent.



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INFORMATION TECHNOLOGY

Name of the author: _____

Thesis title: _____

Supervisor: _____

Buyer/Client: _____

| FEATURE | | GRADING | | | | | |
|---|---------|---------|---|---|---|--------------------|--------|
| Scope | limited | 1 | 2 | 3 | | broad ¹ | |
| Degree of difficulty (theoretical depth, conceptuality) | easy | 1 | 2 | 3 | | difficult | |
| Organisation of topic (logical structure) | poor | 1 | 2 | 3 | 4 | 5 | good |
| Achievement of aims | poor | 1 | 2 | 3 | 4 | 5 | good |
| Evaluation of results | poor | 1 | 2 | 3 | 4 | 5 | good |
| Significance of results | minor | 1 | 2 | 3 | 4 | 5 | major |
| Initiative | passive | 1 | 2 | 3 | | | active |

Features difficult to assess are evaluated on a scale of 1 - 3.

General evaluation: _____

Supervisor, tel.: _____
Email _____

N.B! The technical supervisor should fill in this form at logical intervals when the thesis is nearing completion, so that the Department of Electrical and Information Engineering can take into consideration the view of the buyer/client when evaluating the thesis. Please return this form at the address: **The University of Oulu, Department of Electrical and Information Engineering, Linnanmaa P.O. Box 4500, 90014 THE UNIVERSITY OF OULU**, fax 08-553 2600, or to the official supervisor in person.



SÄHKÖ- JA TIETOTEKNIIKAN OSASTO
SÄHKÖTEKNIIKAN KOULUTUSOHJELMA

MODELING AND OPTIMIZATION OF FLIP CHIP- CONNECTIONS IN MILLIMETRE WAVEBANDS

Author _____
John Doe

Supervisor _____
Jouko Vähäkangas

Approved _____

Grade _____

Valkeakari J. (1989) Mikroprosessorin käyttö hakkuritehomuuttajien takaisinkytketyn säädön toteutuksessa. Oulun yliopisto, sähkö- ja tietotekniikan osasto. Diplomityö, 79 s.

TIIVISTELMÄ

Tässä työssä tutkitaan hakkuritehomuuttajien takaisinkytketyn säädön toteuttamista mikroprosessorin avulla. Erityisesti kiinnitetään huomiota mikroprosessorin käyttömahdollisuuksiin UPS-laitteisiin (katkottoman vaihtojännitesyötön varmistava laite) soveltuvien tehomuuttajien säätämisessä. Hakkuritehomuuttajien perustopologioille johdetaan aikadiskreetit tilamallit ja niiden pohjalta suunnitellaan aikadiskreettejä säätöalgoritmeja. Myös mikroprosessorin laskenta-viive on otettu huomioon tilamalleissa. Säätöalgoritmeista esitetään erilaisia versioita erimittaisille näytteenottoväleille. Lisäksi pohditaan mikroprosessorin ja muiden digitaalisen säätimen komponenttien suorituskykyvaatimuksia.

Algoritmien toimintaa tutkitaan yksinkertaisissa jännitteenalentimen ja jännitteenkorottimen koekytkennöissä, joissa säätimenä käytetään 16-bittistä mikrokontrolleria. Lisäksi samalla säätimellä ohjataan hakkuritekniikkaan perustuva vaihtosuuntaajaa ja suuren tehokertoimen omaavaa tasasuuntaajaa, joka ottaa sinimuotoisesta verkkojännitteestä sinimuotoista virtaa. Näiden koekytkentöjen mittaustulokset on esitetty.

Avainsanat: katkoton syöttö, hakkurimuuttajan tilamalli, aikadiskreetti säätö.

**Master's thesis abstract
form**

TEKNILLINEN TIEDEKUNTA

(Form for editing)

| | | | |
|------------------------|-------|-------------|-----------------|
| Department | | Laboratory | |
| Author | | Supervisor | |
| Thesis title | | | |
| Field of study | Level | Time period | Number of pages |
| Abstract | | | |
| Place of storage | | | |
| Additional information | | | |

Valkeakari J.T¹. (1989) Microprocessor-Based Feedback Control of Switched-Mode Power Converters. Department of Electrical and Information Engineering, University of Oulu, Oulu, Finland. Master's Thesis, 79 p.

ABSTRACT

This work is a study of microprocessor-based feedback controls of switched-mode power converters. Attention is paid especially to the microprocessor-controlled power converters that can be used in a UPS (uninterruptible power supply) system. Discrete-time state models are derived for basic topologies of switched-mode power converters and several discrete-time control algorithms are designed. The computation delay of the microprocessor is included in the state models as well. Different versions of algorithms for different sampling intervals are presented. Moreover, the required performance of the microprocessor and other components of digital controller are discussed.

The control algorithms have been studied in practice with simple voltage step-down and step-up test circuits controlled by a 16-bit microcontroller. Also a switched-mode inverter and a high-power factor rectifier which takes sinusoidal current from sinusoidal line voltage were controlled by the same microprocessor-based controller. The experimental results of these test circuits are presented.

Key words: uninterruptible power supply, UPS state model, discrete-time control.

¹ Initials of first names are written out.

DIPLOMITYÖN ARVOINTILOMAKKEEN SOVELTAMINEN

Diplomityö arvostellaan lopullisen sisältönsä mukaan. Jos valvoja on avustanut merkittävästi joidenkin kohtien parantamisessa, voidaan pistemäärästä vähentää yksi piste. Tätä sääntöä sovelletaan kohtiin 3, 4, 6, 9 ja 10. Arviointiperusteet ovat ohjeellisia ja tapauskohtaista harkintaa suositellaan.

| Piirre | Ohjeet |
|--|---|
| 1. Aiheen laajuus 1 – 3 p. | <ol style="list-style-type: none"> 1. Aihe on suppeahko asiakokonaisuus. 2. Aihe edellyttää perehtymistä muutamaan asiakokonaisuuteen. 3. Aihe käsittää monia asiakokonaisuuksia ja edellyttää tekijältä kykyä (perehtyneisyyttä) tehdä vertailuja ja valintoja näiden välillä. |
| 2. Työn vaikeusaste 1 – 3 p. | <ol style="list-style-type: none"> 1. Työn teoreettiseksi pohjaksi riittää perusopinnoissa saavutettava tietotaso. 2. Edellisen lisäksi työssä on kyettävä soveltamaan aihepiiriin (uusinta) tietoa ja menetelmiä. 3. Työ on teoreettisesti tai toteutukseltaan erittäin vaativa. Työssä on esim. omaksuttava aihepiiriin perusteoria ja sitä käyttäen mallitettava tai kvantitatiivisesti arvioitava ilmiöitä tai ratkaistava ongelmia. |
| 3. Aiheen jäsentäminen 1 – 5 p. | <ol style="list-style-type: none"> 1. Työn tekijällä on suuria vaikeuksia ongelmakentän hahmottamisessa. Työ ei ole rakenteeltaan looginen eikä esitetyille asioille ja ratkaisuille esitetä perusteita työssä. 2. Työn loogisessa rakenteessa on puutteita, mistä syystä työssä käytettyjä menetelmiä ja esitetyjä ratkaisuja saattaa olla vaikea ymmärtää. 3. Työn looginen rakenne on johdonmukainen. 4. Työn looginen rakenne on selkeä ja johdonmukainen. Lisäksi keskeisiä asioita on painotettu oikein niin, että käytettyjen menetelmien ja saavutettujen tulosten arviointi on helppoa. 5. Työn looginen rakenne on selkeä, johdonmukainen ja painotuksiltaan oikea. Lisäksi se osoittaa tekijän perehtyneisyyden ongelmakentän keskeisiin kysymyksiin. |
| 4. Ongelmakentän ja aiemman tutkimuksen esittely 1 – 5 p. | <ol style="list-style-type: none"> 1. Ongelmakentän tai aiemman tutkimuksen esittelyssä on vakavia puutteita tai virheitä. 2. Ongelmakentän esittely on pintapuolista, kaavamaisista tai epätarkkaa. 3. Ongelmakenttä on esitelty siten, että työn keskeiset ongelmat ja niiden ratkaisuihin tarvittavat ja käytetyt menetelmät ovat ymmärrettävissä. 4. Ongelmakenttä on esitelty siten, että lukijan on mahdollista verrata työssä käytettyjä menetelmiä ja työn tuloksia kyseisen tekniikan- tai tieteenalan nykytilaan. 5. Ongelmakenttä on esitelty kattavasti ja syvällisesti. Lisäksi aiempia tutkimustuloksia tai teknisiä toteutuksia on arvioitu niin, että työssä käytetyt menetelmät ovat perusteltuja suhteessa kyseisen tekniikan- tai tieteenalan nykytilaan. |
| 5. Tavoitteen saavuttaminen 1 – 5 p. | <ol style="list-style-type: none"> 1. Työn tavoitetta ei ole saavutettu. Ongelman ratkaisussa on selviä puutteita. 2. Työn tavoitetta ei ole täysin saavutettu. Ongelman ratkaisussa on lieviä puutteita tai tavoitteen saavuttamista ei ole todistettu tai dokumentoitu riittävästi. 3. Työn keskeiset tavoitteet on saavutettu. 4. Työn keskeiset tavoitteet on saavutettu ennakoitua paremmin; nopea suoritus, ongelmakenttään uusia näkökulmia. 5. Työn keskeiset tavoitteet on saavutettu ennakoitua paremmin. Työ on merkittävästi edistänyt tutkimus- ja kehitystyötä tai työssä on saavutettu tieteellisesti merkittäviä tuloksia, jotka on julkaistu merkittävässä julkaisussa. |
| Piirre | Ohjeet |

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| <p>6. Työntekijän suorittama tulosten arviointi 1 – 5 p.</p> | <p>Kaikkia esitettyjä tuloksia, kuten numeeriset tulokset, stimuloinnit tai mittaukset, täytyy arvioida ja analysoida. On kuvattava miten tulos saavutettiin, mitä vaikutuksia oletuksilla tai mittauskytkennällä on tulosten laatuun jne. Tuloksia täytyy vertailla myös teorian sekä mahdollisesti muissa lähteissä esitettyihin tuloksiin.</p> <ol style="list-style-type: none"> 1. Tuloksia ei ole arvioitu suhteessa tavoitteeseen. 2. Tulosten arviointi on pintapuolista tai riittämättömästi perusteltua. 3. Tuloksia on arvioitu suhteessa tavoitteisiin ja arviot ovat oikein perusteltuja. 4. Tuloksia on arvioitu suhteessa tavoitteisiin, verrattu muissa lähteissä esitettyihin tuloksiin ja arviot ovat oikein perusteltuja. Myös jatkokehitysmahdollisuuksia on tarkasteltu. 5. Tuloksia on verrattu asetettuihin tavoitteisiin ja ne on selkeästi ja oikein perusteltu. Tulosten yleisempää merkitystä nykyiselle tekniikalle tai tieteelle on tarkasteltu sekä niiden merkitys yritykselle, yhteisölle tai projektille on pohdittu. |
| <p>7. Tulosten merkitys 1 – 5 p.</p> | <p>Tulosten merkitystä työn tilaajalle ja tekniikan- tai tieteenalalle on tarkasteltava.</p> <ol style="list-style-type: none"> 1. Työn merkitys vähäinen. 2. Työn merkitys odotettua pienempi. 3. Työn merkitys odotettu. 4. Työn merkitys odotettua suurempi. 5. Työssä esitetty merkittävä parannus tai uusi tulos. Työ saattaa johtaa sen julkaisemiseen merkittävässä julkaisussa tai patenttiin. |
| <p>8. Oma-aloitteisuus 1 – 3 p.</p> | <p>Tässä kohdassa arvioidaan opiskelijan kykyä itsenäiseen työskentelyyn sekä ohjauksen tarvetta. Ohjaajan ja valvojan tehtävänä on antaa opiskelijalle neuvoja ja opastusta, mutta heidän ei tarvitse ratkaista ongelmia opiskelijan puolesta.</p> <ol style="list-style-type: none"> 1. Passiivinen. 2. Normaali suoritus. 3. Aktiivinen, hallitsee diplomityön tekemisen, hoitaa aikataulut ja tapaamiset. |
| <p>9. Kieliasu 1 – 5 p.</p> | <p>Kieliasuun kuuluu myös tekstin selkeys ja luettavuus.</p> <ol style="list-style-type: none"> 1. Kieliasu selkeästi puutteellinen (kieli- ja oikeinkirjoitusvirheitä, terminologiavirheitä). 2. Kieliasu lievästi puutteellinen (heikko luettavuus, tarpeeton lyhenteiden käyttö, kömpelöt lauserakenteet). 3. Kieliasu moitteeton. 4. Kieliasu moitteeton ja selkeä. 5. Kieliasu moitteeton, selkeä ja viimeistelty. |
| <p>10. Ulkoasu 1 – 3 p.</p> | <ol style="list-style-type: none"> 1. Ulkoasussa puutteita, jotka heikentävät työstä syntyvää vaikutelmaa tai vaikeuttavat sen lukemista (esim. liian pienet tekstit tai epäselvät kuvat, grafiikan "väärinkäyttö"). 2. Ulkoasussa lieviä puutteita, jotka paikoin heikentävät työstä syntyvää vaikutelmaa. 3. Ulkoasu moitteeton (esim. kuvat selkeitä ja kuvatekstit yhdenmukaisia diplomityön kielen kanssa). |

INSTRUCTIONS FOR THE EVALUATION OF A MASTER'S THESIS¹

Evaluation is based on the final content of the thesis. If the supervisor has significantly assisted the author regarding some parts of the thesis, one point can be subtracted from the total. This applies to items 3, 4, 6, 9 and 10. The evaluation criteria below are guidelines, and should be applied with individual consideration.

| Aspect | Criteria for evaluation |
|---|--|
| 1. Scope of thesis 1-3 points | <ol style="list-style-type: none"> 1. Relatively limited scope. 2. Requires knowledge of a number of themes. 3. Comprises several themes and shows the ability of the author to compare and prioritize them. |
| 2. Challenge 1-3 points | <ol style="list-style-type: none"> 1. Basic studies provide sufficient theoretical background for the thesis. 2. Apart from the above, requires ability to apply the latest knowledge and methods of the theme. 3. Very demanding theoretically or in implementation (e.g., basic theory of the theme must be studied and applied in modelling or quantitative evaluation of phenomena). |
| 3. Outlining of the theme 1-5 points | <ol style="list-style-type: none"> 1. The author has great difficulty in defining the problem. The thesis is not logical, and the presented facts or solutions are not well argued. 2. Shortcomings in the logical structure which make it difficult for the reader to understand the applied methods and presented solutions. 3. Consistent structure. 4. Clear, consistent structure. The main issues are appropriately emphasised making it easy to evaluate the applied methods and achieved results. 5. Clear, consistent structure with appropriate emphasis. It also shows the author's thorough knowledge of the main issues in the problem. |
| 4. Introduction to the problem and state of the art 1-5 points | <ol style="list-style-type: none"> 1. Critical shortcomings or mistakes in introduction to the problem and previous research. 2. Superficial, stereotyped or inaccurate introduction to the problem. 3. Main issues and methods applied in the solution of the problem are comprehensible. 4. Introduction of the problem makes it possible for the reader to compare the applied methods and results to the state of the art in the field. 5. Comprehensive, in-depth introduction. Prior research or technical solutions have also been considered so that the methods used in the thesis are justified in relation to the state of the art in the field of engineering or science in question. |
| 5. Achievement of aims 1-5 points | <ol style="list-style-type: none"> 1. The aims have not been achieved. Obvious shortcomings in solution of the problem. 2. The aims have not been fully achieved. Minor shortcomings in the solution of the problem or insufficient proof or documentation regarding achievement of aims. 3. The essential aims have been achieved. 4. The essential aims have been achieved better than expected; swift performance, fresh viewpoints into the problem. 5. The essential aims have been achieved better than expected. The thesis has remarkably contributed to research and development or achieved scientifically significant results that have been published in a prominent publication. |

¹ First translated into English by Ms Maritta Juvani, edited by Mr Ilari Sohlo.

| Aspect | Criteria for evaluation |
|---|---|
| 6. Author's evaluation of results 1-5 points | <p>All presented results, such as numeric results, simulations or measurements, must be evaluated and analysed. The author must describe how the result was obtained, what impact the hypotheses or measuring setup have on the results, etc. The results must be compared with the theory, possibly with results presented in other sources, as well.</p> <ol style="list-style-type: none"> 1. Results have not been assessed in relation to set aims. 2. Assessment of results is superficial or inadequately argued. 3. Results have been assessed in relation to set goals and the evaluations are properly argued. 4. Results have been assessed in relation to set goals, compared with results presented in other sources and the evaluations are properly argued. Possibilities for further development have been considered as well. 5. Results have been compared with set goals and they are clearly and properly argued, their general significance to modern engineering or science has been considered and their significance to the company, organisation or project has been discussed. |
| 7. Significance of results 1-5 points | <p>Significance of the results to the employer and to the field of engineering or science must be discussed.</p> <ol style="list-style-type: none"> 1. Minor significance. 2. Significance smaller than expected. 3. Expected significance. 4. Significance greater than expected. 5. The thesis introduces a remarkable improvement or new result. The thesis may be published in a prominent publication or patented. |
| 8. Initiative 1-3 points | <p>Here the ability of the student to work independently and the nature of his/her need for guidance are assessed. The duty of the supervisor is to counsel and guide the students but not to solve problems for them.</p> <ol style="list-style-type: none"> 1. Passive. 2. Normal performance. 3. Active, familiar with thesis work, manages scheduling and meetings appropriately. |
| 9. Language 1-5 points | <p>The clarity and legibility of text are also taken into consideration.</p> <ol style="list-style-type: none"> 1. Obvious shortcomings in language such as linguistic and spelling errors, as well as incorrect terminology. 2. Minor shortcomings such as poor legibility, undue use of acronyms and clumsy sentences. 3. Impeccable language. 4. Impeccable and clear language. 5. Impeccable, clear and polished language. |
| 10. Layout (conformity with instructions) 1-3 points | <ol style="list-style-type: none"> 1. Shortcomings in the layout that undermine the general impression of the thesis or impede reading, such as too small font, unclear images or inappropriate graphs. 2. Minor shortcomings in the layout that sometimes impede the total presentation. 3. Impeccable layout (clear pictures, captions consistent with the language of the thesis). |