OULUN YLIOPISTO
UNIVERSITY of OULU

DEGREE PROGRAMME IN ELECTRICAL ENGINEERING
or
DEGREE PROGRAMME IN WIRELESS COMMUNICATIONS ENGINEERING

MASTER'S THESIS GUIDE

Thesis author _____
John Doe

Thesis supervisor _____
Jane Dove

Approved _____

Grade _____

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ABSTRACT

This document provides general guidance for a degree student of Electrical Engineering or Wireless Communications Engineering in preparing his/her master's thesis. This guide defines the role of a thesis in the M.Sc. Degree, presents the actions to be taken in different phases of the thesis procedure and introduces the way that master's thesis is written at the degree programmes organized by the Department of Electrical Engineering and the Department of Communications Engineering. The format of this guide demonstrates the structure appropriate to a Master's Thesis of Electrical Engineering or Wireless Communications Engineering at the University of Oulu.

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

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TIIVISTELMÄ

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 Sähkötekniikan ja Tietoliikennetekniikan osastojen tuottamien koulutusohjelmien kirjoittamisen tapa esitellään. Ohjeiden ja diplomityön rakenteet on pyritty tekemään mahdollisimman samankaltaisiksi.

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

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FOREWORD

The aim of this manual is to give detailed guidelines for composing and writing a master's thesis. Guidelines are based on thesis instructions of the former Department of Electrical and Information Engineering, the instructions of the publication series Acta Universitatis Fennica, and the book "Teknisen kirjoituksen laatiminen" [1, 2, 3].

Several persons from the former Department of Electrical and Information Engineering have participated in setting up these instructions. The preparation of the first version was led by Prof. Pentti Lappalainen.

The guidelines were edited by the Study Committee of the Department of Electrical and Information Engineering in 2005 and 2010-2011, and revised by the Degree Programme Committee of Electrical Engineering in 2011 and 2012. This document is applicable for thesis started in and after 2012.

Oulu, August 28, 2012

Degree Programme Committee of Electrical Engineering

LIST OF ABBREVIATIONS AND SYMBOLS[1]

AGC	automatic gain control
AWGN	additive white Gaussian noise
BER	bit error ratio
SNR	signal-to-noise ratio
B	signal bandwidth
B_d	Doppler spread
$\boldsymbol{b}_k$	auxiliary variable matrix at instant k
c_0	1st tap coefficient of filter
f_d	Doppler frequency
β	shape factor
ε_k	error signal value at instant k
$\Phi_n(t)$	phase of n^{th} multipath transmitted signal at instant t
$\Phi(t)$	phase of received signal at instant t
σ^2	variance
$\lfloor\ \rfloor$	integer part
$(\ )^*$	imaginary part
arg( )	argument

[1] Even though a symbol or an abbreviation is explained on this page, it should be written out full when appearing in the text for the first time.

1. GENERAL INSTRUCTIONS

Writing a thesis takes on a major part of completing the master's degree studies in Electrical Engineering and Communications Engineering. The thesis assignment prepares for the independent engineering work. Hence, supervision plays a smaller role in thesis procedure than during previous studies. A typical master's thesis represents a solution to a relatively extensive technical problem. Additional studies in the given field are often necessary; however, the aim of the thesis work is to make use of the knowledge and skills acquired during preceding studies. Furthermore, technical and scientific documentation skills will be strengthened.

The thesis work can be a conducted as a part of a larger project, but the master's thesis itself should be written individually.

1.1. Getting Started

The thesis work is usually undertaken in the final phase of the studies. In the Degree Programme of Electrical Engineering, the autumn term of the 5th study year is recommended. For the Master's Degree Program in Wireless Engineering, the master's thesis is scheduled in the second year. It is possible to start earlier depending on advancement in studies. Basically, it is time to get started, when there are 15 to 30 credit points left of the total coursework. Some fields of study require certain courses to be completed before the master's thesis. Requirements should always be checked in advance with the supervisor.

Note: Information on the degree specific requirements is provided by the secretary of the degree program and the registered credit points can be viewed in WebOodi.

1.1.1. Thesis Topic

A topic for a master's thesis can be provided by a professor, a docent or a doctor of technology employed at the Department of Electrical Engineering or at the Department of Communications Engineering. In that case, the topic will most likely be linked with ongoing research at the corresponding department. The thesis can also be conducted in relevant industry. In order to do so, the company or facility should be contacted directly or through a department professor, and the terms of thesis supervision should be discussed with a professor in a relevant field (the one covered in your thesis). It is important that you contact a supervisor right at the beginning. This way the topic of your thesis and the field it covers can be properly outlined. You can also agree on the routines of supervision and monitoring of your thesis with your supervisor right away. Usually, a thesis is done on a topic within the area of your orientation (major). However, topics proposed by the industry are often multi-disciplinary or cross-scientific and the topic does not fit into the realm of any one particular orientation (or department). In these cases the supervision should be agreed with a department professor or doctor who best represents the overall field of the thesis work.

1.1.2. Approval of Thesis Topic

As soon as the subject of the thesis is mature enough, a faculty professor or a doctor to serve as a supervisor can be approached to discuss the final topic. If conducted in industry, the student should begin with submitting a short written description of the field covered, followed by an agreement on the terms of suitability and supervision between the supervisor and the company. Then the formal approval of the thesis topic should be applied by filling out a form available at the secretary of the study program. You should apply for approval as soon as possible, but at the latest before the preceding meeting of the degree program committee. The form is presented in Appendix 1. The chair of the degree program committee will formally approve the topic and appoint a supervisor and an additional second examiner. Once approved, the topic is binding. However, the thesis title can still be fine-tuned in agreement with the supervisor, if changes occur during the process.

If the thesis is conducted in a company, a technical instructor should be available too to assist the student in practical matters there, and to evaluate the final work according to the evaluation criteria presented below. When the thesis is conducted in a research group at the university, a technical instructor is usually named as well. The technical instructor need not be named in the topic proposal form.

The approval for writing the thesis in English is applied at the same time as the thesis topic by using the form in Appendix 2. If the work is written in English, a proof reading by a professional translator can be required. In 2010, the cost for language revision was about 15 € per page. Language is one of the thesis evaluation criteria.

1.2. Supervision and Guidance

Topic, timeframe and terms of supervision should be agreed with the supervisor well in advance. It is important to contact the supervisor early enough to ensure the suitability of the thesis topic. The supervisor will find a second examiner for the thesis. If the thesis is done in the industry, the student should also have a local technical supervisor, who will assist the student in the practical aspects involved at the company or facility.

Figure 1 below presents instructions for the timeframe of a thesis. A master's thesis is a maturity test, in which the independent work of the student plays the main role. It is the final learning possibility at the university. Hence, the supervisor will usually give guidance and even detailed advice to the student in order to ensure the optimal quality of the thesis. The student should often enough discuss relevant issues with his supervisor. Regular appointments are recommended. If the thesis work is conducted in the industry, it is convenient to get technical supervision from the technical supervisor there. Also in this case a very close contact with the supervisor at the university should be kept, especially in the write-up phase. At the beginning of the write-up phase, guidance from the supervisor is crucial concerning the structure, presentation order and style of the thesis. During the write-up, frequent meetings with the supervisor should be held 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 should mainly concern the structuring of the thesis.

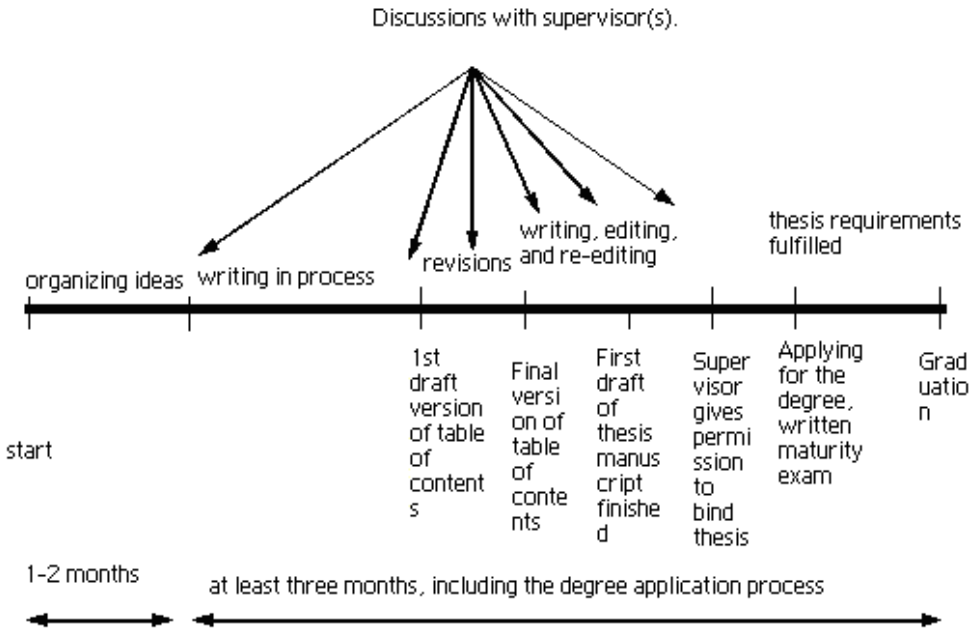

Figure 1. Typical thesis process.

1.3. Evaluation

After the supervisor has given permission to bind the thesis, it will be given to the supervisor for the final **examination and grading**. The evaluation of the thesis will be based on this final manuscript, which does not yet have to be actually bound at the time of evaluation. However, it already has to be complete, including the appendices. Since the evaluation will be done by two independent examiners, the supervisor and the second examiner, enough time for the evaluation should be allowed. The thesis should be given for evaluation no later than **10 days** prior to a Study Programme Committee Meeting. Committee meetings are held mainly once per month.
The supervisor and the second examiner will present their written statements to the Study Programme Committee concerning the thesis using Appendix 3 and its criteria. In the Appendix 4 the application of criteria is presented. If the thesis is completed in the industry, a representative of the respective company or facility has to submit their evaluation to the thesis supervisor no later than **one week** before the meeting. An evaluation form for this purpose can be found in Appendix 5. Using Appendix 6, the knowledge level of the thesis author can be evaluated. The Study Programme Committee approves the thesis based on the evaluations by supervisor and the second examiner.

A master's thesis that has been approved will be evaluated according to the university regulations with the following grades: satisfactory (1), very satisfactory (2), good (3), very good (4), and excellent (5). In addition to the thesis grades, the degree can be granted the mark "outstanding" if the grade of the thesis was at least

"very good" and the weighted average of all M.Sc. level grades is 4.00 or higher. The title of the thesis, the name of the supervisor, as well as the grade will be printed on the Master's Degree Certificate.

The student has the right to see the grade proposed by the supervisor, as well as the grading statement, **three** days prior to the Committee meeting. In case the student feels mistreated, she/he has the opportunity to issue a written **appeal** to the board of examiners of the Faculty of Technology concerning the evaluation of his/her thesis no later than **fourteen days** after having received the information. This process evidently delays the graduation.

1.4. Formal Approval

The degree procedure is described below:

Printed and bound thesis

1. Request a copy of the title page of your thesis from the secretary of the degree programme.

2. Hand a copy of your thesis to your supervisor in good time before the deadline. Remember that also the second examiner needs enough time to evaluate the thesis, so you must agree on a reasonable schedule with your supervisor.

3. Take one bound and one unbound version of your thesis to the programme secretary one week before the evaluation meeting at the latest. Also make a bound version available for the supervisor.

M.Sc. degree in Engineering

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

2. Attend the **maturity test.** Passing the maturity test is required for all degree students and it is taken after the completion of the thesis. The students with Finnish/Swedish as the language of their elementary education will write the test in Finnish/Swedish. If the elementary education has been taken in some other language, the maturity test is taken in English. The maturity test is a written examination based on the thesis, where the candidate is asked to write an essay about the topic(s). The registration for the maturity test should be discussed with the supervisor as you are getting your thesis approved.

3. Return all university library books, as well as keys, equipment, machinery, and tools belonging to the university.

4. Return the form “Application for Degree Certificate,” filled in, to your department secretary two weeks prior to a department meeting. The secretaries will prepare your papers, calculate your GPA, etc.

1.4.1. Archiving

According to the current archiving rules, all Master’s theses are filed in paper form. An unbound copy of the thesis should be taken to the department secretary for this purpose.

1.4.2. Publicity

A master’s thesis is a public document. A thesis must therefore not reveal any business secrets or confidential information. The thesis can only be evaluated based on its written contents. Should any major conflicting interests arise between the author and the buyer concerning the publication of information, the author should turn to the thesis supervisor for consultation.

The Ministry of Education has issued a set of written statements concerning the public nature of master’s theses to universities and colleges. According to the statements the thesis must not contain classified information, and once approved, the thesis should be public. The ownership as well as the publication and/or patent rights should be agreed upon together with the supervisor, author, and the possible buyer.

1.5. Thesis Awards

The Technological Society of Finland and the IEEE Finland section issue the Best Thesis of the Year Award, chosen from a list of candidates that is compiled by Finnish universities and colleges and is including almost all theses published annually in Finland.

2. THESIS WRITING INSTRUCTIONS

2.1. Introduction

A Master's thesis in engineering usually consists of an implementation part (literature survey, device modeling, software, measurements, etc.), and a written part (the text body). How the implementation part is carried out depends on the topic, so no general guidelines can be issued. However, each type of publication has its distinct layout and structure to be followed. The following set of instructions will explain in detail the writing and layout style that are in use at the corresponding departments. Typography affects the readability of the text greatly, so the instructions should be followed strictly. By following these instructions, the thesis authors can properly learn a fine way of expressing themselves formally in writing. After having learned one way of formal writing, it is easier to get used to the formalism used at your future workplace.

Before starting to write your thesis, it is a good idea to mind-map or chart out the various issues that will be included in a thesis. After that, you should divide them into themes, actual chapters with actual titles, and estimated numbers of pages to be included in each chapter. The contents should be discussed in detail with the supervisor. Even more importantly, you should discuss the weighting and focus with your supervisor. You should reserve enough time for writing 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

Students who have completed their matriculation exam in Finland write their Master's thesis in Finnish or Swedish. Foreign students, students who do their theses abroad or persons who are not fluent in Finnish can write their thesis in English. Regardless of the language used, the thesis should have an abstract and a title in both English and Finnish. If the language of the thesis is English, the abstract in English comes before the abstract (tiivistelmä) in Finnish. One should remember that also the style and the clarity of the presentation affect the grading of the thesis.

A Master's thesis is written to people who are educated in engineering. Thesis authors should therefore avoid issues and topics not fully within their grasp. You should also apply professional terminology when available. This rule also applies to all figures and tables.

The aim is a clear and well-structured thesis, without unnecessary excessive use of words – a thesis usually has 40-100 pages. The language (**English/Finnish/ Swedish)** should be fluent and readable, and it should adhere to the conventions and recommendations applied in a particular language. Advice on such issues can be obtained from various language guides (in Finnish, e.g., [4]). There are also several excellent sources on the internet, e.g., [5, 6].

2.3. Text-editing

The style of a thesis written in English has to be flawless. If the student is weak in English, or the supervisor feels that he is not capable of checking the language well enough, the supervisor can demand the thesis 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.

2.4. Typography

In the text typography, you need to use the following guidelines and rules.

- Font: Times New Roman
- Paragraph settings:
  - Left indentation: 4,5 cm
  - Right indentation: 2,0 cm
  - Right indentation: 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 figure caption text is situated underneath the table and the caption text ends 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, but embed it in the text content. A figure is supposed to 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**	*Italic*	***Bold italic***
10	Footnotes and endnotes			
12	Standard text, equations, references, tables, captions, table headings	**1st level subheadings, abstract, abstract in Finnish (tiivistelmä)**	*3rd level subheadings*	***2nd level sub-headings***
14	AUTHOR NAME	**CHAPTER TITLE[1]**		
18		**THESIS TITLE**		

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

You should not use single subsections – for example, Section 2.1 needs to be accompanied by Section 2.2. Also, please do not number sections beyond the 3rd grade (e.g., 1.2.1.1). Should the need arise for further decimalization the following method (a bolded, unnumbered title) should be applied:

Formatting the figure captions

Figures, tables and appendices are a part of the written presentation. All these need to be referenced to in the text body, preferably before the figure is placed in the text – i.e., first the referring text, then the figure or table. Figures and tables have a running number through the document – or chapter wise, if there are plenty of figures.

Fig. 2 serves as an example of a figure and a text referring to it. Figure captions are below the figure, and the caption text ends with a full stop. A short caption is centered, while a long caption extending to a several lines is justified on both sides. According to the copyright enactments, you must always have the permission of the publisher to display a figure from its origin. The writer should grow towards to mainly using figures of his own in the thesis.

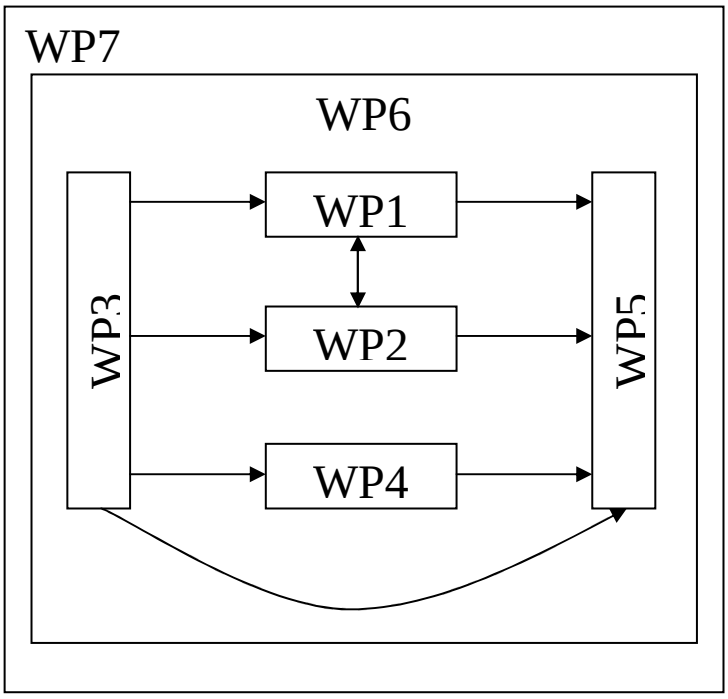

Figure 2.Connections between work packages (WP).

2.5. Practical Advice

On average, it takes between two to three months of full-time work to write a Master's thesis – around one finalized page per day. You might be able to write a thesis in a shorter time, but you should understand that it takes much longer than you think to edit and re-edit a thesis, considering both structure and presentation style. 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 to the last

Working on the implementation and written thesis in parallel will force the author to clarify and reformulate ideas, which might often lead to new ideas and 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 in detail with your supervisor before you start writing and design a body 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. She/he therefore has an excellent motive to give

help 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 clearly divided into two separate parts. If left unfixed, this may often lead to repetition and problems in combining the parts.

Hence, start your writing by planning a content structure, (table of contents), which will function as your backbone 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 look at these code words and crystallize the message in each section to correspond to these code words. Thinking ahead like this will reduce the pain of creation, give you confidence and help you feel 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 aims and scope of the thesis. The other chapters in the opening part of the thesis usually lay out the parameters and working environment, the needed theoretical basis of the thesis etc.; 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 simply

The first sentence of a paragraph should define its contents. The following sentences clarify the issue. This method results in a clear and easily understandable way of presenting, since each paragraph should contain information only on one or two separate issues. Paragraphs structured like that will be easy to cut and paste elsewhere, if structural rearrangements are later required. To avoid fragmentation, it is important to not present the same things again in different chapters. It will be easier for the reader to follow the idea 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 technical supervisor to go through what you have written

Sometimes the official supervisor (the one appointed by the Chair of the Degree Programme) and a technical supervisor are two separate persons, especially in the case where the thesis work is done in the industry. In this case you should first have your work read by your technical supervisor. After that edit your work according to

his/her advice before you bring it for revision to your department-appointed official supervisor. A local supervisor has a better feel of your work as he/she 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 technical 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 selection of the criteria attached to a Master's thesis and it is she/he along with the second examiner who will grade your work.

It is very usual to get blind to typos in one's own text, and one also easily assumes some topics to be so self-evident that a reader is not familiar with all the details of the problems following the text. This is most easily found by a colleague who is not so familiar with the topic. Alternatively, you can take a break of a few days to look your text with fresh eyes – or just concentrate very carefully on what you are really saying and what you just know without writing it.

6. Do not get stuck

Figure 3 shows how difficult the 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.

(Veikko Savolainen; Unto Uneksija)

Kuva 3. Kirjoittamisen vaikeus ja ahdistus.

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."

7. Hints for editing

A well-prepared document template with pre-defined paragraph formats speeds up writing. Also the use of automatic numbering helps to minimize manual corrections, when the order of figures, for example, is changed.

Most word processors have a spelling checker feature that is recommended to be used. This way your supervisor does not need to spend time on spotting and correcting typos, but can concentrate on the actual contents of the thesis.

8. An electrical version

University of Oulu is preparing an electrical archiving of M.Sc. theses, and it has also currently using a program called Urkund for checking the correctness of referencing of the theses. By Finnish law a written thesis is the property of the author, but it is strongly advised that the student gives permission for both the electrical reference checking via Urkund, and for the electrical archiving of the thesis. A pdf file following the format described in this guide is sufficient for this.

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 and the body) 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. First Pages

3.1.1. Front Cover

The words MASTER'S THESIS should be printed in the middle of the front cover. 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 must 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!

3.1.2. Title Page

You obtain the title page form from the secretary of your degree programme, and it is presented in Appendix 7. The contact information of the secretaries can be found from the www-pages of degree programme.

3.1.3. Abstract

The abstract of your thesis will be fed into various databases and catalogues (see model in 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 methods used and 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 model is presented in Appendix 8. Also you have to write a separate form titled thesis Abstract which is presented in Appendix 9. It is obtained from your degree secretary.

3.1.4. Abstract in Finnish

You also have to write your thesis abstract in Finnish as presented in Appendix 8, or have your abstract translated into Finnish. It should be written in flawless Finnish. Abstract in English is placed first, abstract in Finnish (Tiivistelmä) after it.

3.1.5. 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, Table of contents, Foreword, List of Abbreviations and Symbols) 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 to be printed on the page is after the title Introduction. Numbering is by Arabic numerals, page numbers are placed at the top right hand corner of the page.

3.1.6. Foreword

The foreword page should describe the aim of the thesis, and its various research stages, and present the partners, funding 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. List of Abbreviations and Symbols

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 [7]. 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.

3.2. Introduction

In the introduction, you should describe the background and motivation of your thesis, introduce the reader to your research questions and methodology, describe in detail the aims of your thesis, and on what basis the scope of your research area has been chosen. 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 and contribution in the research/project. At the end of the introduction, you might want to give an overview about the structure of your thesis.

3.3. 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 and state-of-the-art 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 do not have to include a theory in your thesis, unless the theory fits directly into your overall research goal(s) or is needed in the work.**

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 formally prove 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 lengthy derivations as appendices if you need to. Science and technology use two types of equations

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

A quantity consists of a numerical value and the basic unit of the quantity. The 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 units are used. Equations are written 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, 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 complete sentence. An empty row should be left at the top and at the bottom of an equation, and equations should be numbered by applying running numbering, from the beginning to the end of the thesis. However, if you have a large number of equations, you can 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..."

An example: In steady movement, speed v is

$$v = \frac{s}{t}, \tag{1}$$

where t is the amount of time required by the movement, and s is the distance.

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 the implementation part: 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 verification by measurement, simulation, etc., results and other potential. 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. A Master’s thesis is not a measurement report, though, and all results are not necessary to report. Instead, every figure and every table you present should have a clear statement that you want to show.

3.4. Discussion

A good thesis or other scientific work always has a discussion. 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 honest 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. Outlining potential further development based on your thesis, is valuable, especially if you have put forth clearly new or ground-breaking ideas. However, you should avoid unnecessary speculation here, as well as elsewhere: all statements should be well reasoned and brief.

3.5. Summary

In the Summary 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. In Conclusions you should not make references, or present any results not found elsewhere in your thesis.

An Abstract and a Summary overlap to a certain extent; they both describe 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, and motive the choices you have made the abstract on the other hand could just describe in detail the solutions and approaches chosen for the thesis, leaving the optional approaches out.

3.6. References

The use of references serves many purposes. Scientific method relies on familiarizing with the topic and state of the art. However, efficient referencing can also compress you text, as you can leave the details in the references and repeat only the most important results.

The literature survey should be close to exhaustive, and this means that most of the information you present is taken from references. If a piece of information is not derived or devised by you, it is borrowed, and the origin of the information must be stated. Presenting somebody else’s finding as your own is a scientific theft (plagiarism) that has serious consequences.

You should refer to original sources of the data – for example, to a book and not the handouts made based on the book. Be careful when referencing: the things you state really need to be found from the reference.

The references a mostly cited in your own words, and direct quoting is used only if you want to emphasis the source. In this case you place the quote in hyphens, for

example saying that the exact phrasing of Moore's law is of form "The complexity for minimum component costs has increased at a rate of roughly a factor of two per year." [x].

You should apply a running 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 single sentence, the reference is placed at the end of the sentence before the full stop. If the reference supports the entire paragraph, the cite is placed at the end of the paragraph, after the last full stop.

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. 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 Rangefinding. Acta Universitatis Ouluensis, Series C, Technica 37. Oulun yliopisto, Oulu.

Journal:

[2] Arai Y. & Oshugi T. (1989) TMC-A CMOS Time to Digital Converter VLSI. IEEE Transactions on Nuclear Science 36, s. 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. (toim.) High-Level VLSI Synthesis. Kluwer Academic Publishers, Boston, Mass., s.1–26.[1]

Book:

[4] Hakalahti H., Lappalainen P. & Tervonen M. (1978) Minitietokoneet: Rakenne, ohjelmointi, prosessiliitännät. Sähköinsinöörikilta ry, Oulu, 431 s.

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, s. 13 – 16, New York.

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[1] If page numbering if Chapter based, use as: p. 3-1 ... 3-2.

Author unknown:

[6] Asumistaso: asuntoasian vuosikirja (1991). Suomen Asuntoliitto, Helsinki, 72 s.

Thesis:

[7] Kurikka P. (1992) Tietokoneavusteisen elektroniikkasuunnittelun kehitysjärjestelmien vertailu ja arvionti. Diplomityö. Oulun yliopisto, sähkö- ja tietotekniikan osasto, Oulu.

Internet publication:

[8] Krishnan V. & Torrealis J. (luettu 22.10.1999) A Chip-Multiprosessor Architecture with Speculative Multithreading. URL: http://computer.org/tc/tc1999/ t0866abs.htm.

3.7. 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 before. As with figures and tables, all appendices you include should have a clear meaning – there number of appendices itself is not a merit.

If your text seems to contain a lot of references to an appendix, it may be easier for the reader that you copy the information (e.g., a schematic) into the text. This way the reader does not need to browse between pages.

Large block diagrams or schematics can be copied on A3 size paper. This needs to have two bends (Z-like) so that the right side of the appendix lies top and with a width of ca 2/3 of A4 page.

4. SUMMARY

These instructions describe the various stages of writing a Master’s 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 Departments of Electrical Engineering and Communications Engineering, is to be written.

5. REFERENCES

[1] Lappalainen P., Suutari-Jääskö L. & Silvén O. (1994) Diplomityön teko-ohjeet. Oulun yliopisto, Sähkö- ja tietotekniikan osasto, Oulu, 31 s.

[2] Ohjeita kirjoittajille (1997). Acta Universitatis Ouluensis -sarjan julkaisutoimikunta, toim. Leena Rautio. Oulun yliopisto, Oulu, 20 s.

[3] Tirronen K. (1987) Teknisen kirjoituksen laatiminen. Suomen Teknillinen Seura STS r.y., Teknillisten Tieteiden Akatemia, Jyväskylä, 89 s.

[4] Maamies S. (toim.) (1998) Kielikello. Kielenhuollon tiedotuslehti 3. Kotimaisten kielten tutkimuskeskus.

[5] Korpela (luettu 9.11.2006) Nykyajan kielenopas. URL: http://www.cs.tut.fi/~jkorpela/kielenopas/

[6] Kielitoimisto (luettu 9.11.2006). URL: http://www.kotus.fi/kielitoimisto/

[7] SI-opas: suureet ja yksiköt, SI-mittayksikköjärjestelmä (Système international d´unitès) (1974). Suomen standardisoimisliitto, Vakaustoimisto, Helsinki, 23 s.

6. APPENDICES

Appendix 1 Application for Diploma/Master's Thesis Topic

Appendix 2 Application to Write the Master's Thesis in English

Appendix 3 Master's Thesis Evaluation Form

Appendix 4 Instructions for the Evaluation of a Master's Thesis

Appendix 5 Master's Thesis Evaluation Form for the Subscriber

Appendix 6 Knowledge Evaluation Form for the Subscriber

Appendix 7 The title page of a Master's thesis

Appendix 8 Example Abstract

Appendix 9 Opinnäytetyön tiivistelmäpohja

Note 1: 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.

Note 2: The latest version of the forms can be obtained from the www-pages of degree programmes.