UNIVERSITEIT TWENTE.

PROGRAMME-SPECIFIC PART OF THE EDUCATION AND EXAMINATION FOR THE BACHELOR’S DEGREE PROGRAMME IN

ELECTRICAL ENGINEERING

July 9, 2017

CONTENTS

Chapter A General provisions

Article A1 Applicability

The following regulations form the programme-specific part of the university-wide Education and Examination Regulations as referred to in Article 7.13 of the Higher Education and Research Act (WHW), and apply to the Bachelor's degree programme in Electrical Engineering, from now on referred to as "the programme".

Article A2 Attainment targets of the programme

The general attainment targets for graduates of the Bachelor's degree programme in Electrical Engineering are listed below.

Knowledge:

1. Have knowledge and understanding in the field of Electrical Engineering, in particular analogue and digital electronics, Maxwell theory, control engineering, communication science and analogue and digital signal processing.
2. Have knowledge and understanding of programming, digital logic and computer systems.
3. Have knowledge and understanding of calculus, linear algebra, differential and difference equations, linear systems, and probability.
4. For those who choose the module Device Physics: Have knowledge and understanding of the physics of basic quantum mechanics, electronic components, transducers and optical devices.
5. For those who choose the module Network Systems: Have knowledge and understanding of basic principles and key protocols in communication systems, networks, and networked applications.
6. Have knowledge on academic level of key theories, methods and practices in the fields mentioned above.
7. Can understand and reflect on theories, methods and practices in the field of electrical engineering.
8. Have knowledge of methods for planning and management of individual and team-based projects.

Skills:

9. Can use modern methods and tools in research and design to describe, analyse, model, implement, test and document systems in the domain of electrical engineering on a scientific basis.
10. Can assess theoretical and practical issues and substantiate and select appropriate solutions based on literature studies, models, analyses, simulations and / or test.

Competences:

11 Can work systematically and methodically.
12 Have ability to handle complex development-oriented and research-oriented situations.
13 Have ability of carrying out studies and draw valid conclusions on a scientific basis.
14 Can independently function in a disciplinary as well as in an interdisciplinary collaboration with a professional attitude.
15 Is able to communicate academic problems and solutions to peers and non-specialists or partners and users.
16 Can translate academic knowledge and skills into practical problem solving.
17 Is able to study another academic field and is able to identify research and/or design in that field.
18 Can identify own learning needs and structure their own learning in different learning environments.
19 Have insight into another academic field and can use different approaches for research or design.
20 Takes account of the temporal and social context of science and technology and is able to integrate this into his or her scientific work.

Article A3 Structure of the programme

All students must follow the programme full-time.

Article A4 Scope of the programme

The programme has a study load of 180 credits.

Article A5 Language of the programme

A 5.1

The Electrical Engineering programme will be taught in English.

A 5.2

1. The examinations of the programme will be held in English. Examinations may be held in a language other than English, with the permission of the Examination Board.
2. Having regard to the University's Code of Conduct for Working Languages, the provisions of Paragraphs 1 and 2 may be dispensed with, with the permission of the Examination Board.
3. Students do not need to know Dutch.

A 5.3

Students from abroad must be able to demonstrate that they have an adequate command of English, both oral and written.

a. Students from countries that are signatories to the Treaty of Lisbon and who had English in their school-leaving examination meet this requirement.
b. Students with a different previous education are required to pass a recognized test in order to obtain admission to the programme –at least 6.0 in the IELTS test for both the active level of English (writing, speaking) as well as the passive level (reading, listening) or at least 80 in the Internet-based TOEFL test. Students with a diploma from a country where English is the only official language of education are exempted from this language requirement.

Article A6 Laptop

Students should have a notebook (laptop) when they start their studies. The Notebook Service Centre (NSC) of the University of Twente will inform the future students about the minimum requirements for the laptop.

Article A7 Enrolment for exams and tests

1. Every student must sign up in SIS for participation in a module. It is also mandatory to register beforehand for every intermediate test.
2. By way of exception to the provisions of paragraph 1, any student who has correctly signed up for participation in the instruction/classes for a particular course and has been admitted will also be signed up for the subsequent interim examination, unless the degree programme stipulates a different approach.

Article A8 Registration of results

1. The value 'VR' will be assigned to exemptions. In modules an exemption does not get a numerical value. In courses of the old curriculum an exemption counts as a 6.
2. The highest grade always counts, also for the intermediate tests in the modules.

Article A9 Rules regarding BSA

1. The programme makes uses of the BSA (Binding Study Advise) module in OSIRIS
2. The BSA is based on the obtained results in the first four modules. In article B.5 an overview is given of the parts of each module of which the results will be kept, even if the module is not completed.
3. A positive BSA is given only if the student has successfully completed at least 45 EC in the first year.
4. An additional condition for a positive BSA is that two of the four mathematics grades should be at least 5.5.

5. After the first module a positive, neutral or negative interim advice will be given.
6. The official advices are the interim and final advices.
7. The official advice is provided by the programme director.
8. The BSA is sent by e-mail and is signed digitally.

Article A10 Evaluation and safeguarding of education

1. Within 2 weeks after the closure of a module, each student participating in a module will receive an invitation to participate in the UT – Student Experience Questionnaire (UT-SEQ). The UT-SEQ is a centrally organised online evaluation addressing various aspects of the respective module.
2. The programme has installed an independent evaluation committee. On request of the programme committee, the programme director, or via the student organization Scintilla, this evaluation committee will organize an evaluation, consisting of at least two panel discussions. A panel discussion consists of three to six students participating in the module that is being evaluated, the module coordinator and / or lecturers involved in the module that is being evaluated and a chair from the evaluation committee.

Chapter B Various types of assessment and the degree programme

Article B1 The content of the programme

1. The first year consists of the following units of study, with the indicated study load in credits:

   a. IEEE (Introduction to Electrical and Electronic Engineering) 15 credits
   b. Electric Circuits 15 credits
   c. Electronics 15 credits
   d. Fields and Waves 15 credits

2. The second year consist of the following units of study, with the indicated study load in credits:

   a. The compulsory modules:
      Computer Systems 15 credits
      Systems and Control 15 credits
      Signal Processing and Communications 15 credits
   b. The elective modules (one of them to be chosen):
      Device Physics 15 credits
      Network Systems 15 credits

3. The third year consist of the following units of study, with the indicated study load in credits:

   a. Two elective minor modules of 15 credits each 30 credits
   b. Electronic Systems Design 15 credits
   c. The Bachelor thesis project 15 credits

A detailed description of each module is given in Appendix B.

Article B2 Special features of the modules

1. Projects form an integral part of all modules.
2. Lab work forms an integral part of all modules.
3. Projects and lab work are carried out individually and by groups of students according to the regulations of the individual modules.

Article B3 The procedure for examinations

1. Modules will be assessed by means of intermediate tests, which may be oral or written.
2. For an oral test, there must be proof that the student was treated properly and that the assessment is reliable. This can be shown by, e.g., the presence of a

second expert or a video recording of the sitting of the oral test. The assessment is documented through a form that shows that the intended learning outcomes are met.

3. A single grade will be given for each module. The grade shall be based on the results of tests, papers and lab work. Compensation of insufficient grades of intermediate tests is arranged within the module (if applicable). The rules will be made clear to all students before the start of the module. An assessment of all parts of the module by the team of teachers at the end of the module leads to the final grade. One person of the Examination Board will be involved and monitor this assessment.
4. Within modules students get opportunities for repeating the intermediate tests.
5. The Examiner may deviate from the provisions of Paragraphs 1 to 4 in individual cases in agreement with the examination board.
6. In the case of a minor, the Education and Examination Regulations of the department teaching that minor shall apply.
7. The assessment of lab work and projects being part of the modules, referred to in Article B2, may require a logbook to be kept during the lab work and/or a written and/or an oral report on the lab work and project. Lab work and a project are assessed on the basis of the performance shown during the exercise, and on the basis of the logbook, the report and/or the presentation on the exercise if they are demanded.
8. A report or paper must be written and a presentation must be given on the activities involved in the Bachelor thesis project. The Examiners for these units of study may also require interim presentations to be given.

Article B4 Prior knowledge requirements

1. Students are entitled to start with the two elective modules in the third year without limitation on the number of completed modules. Elective modules may have prior knowledge requirements, which can be found in the Osiris description of these modules.
2. Students are entitled to start with the Electronic Systems Design module (module 11) only after having successfully completed 8 out of the 10 previous modules in the Electrical Engineering curriculum, as well as having successfully completed module 3.
3. Students are entitled to start with the Bachelor thesis project (module 12) only after successfully completing all modules of the first and second year.

Article B5 Period of validity for intermediate tests

1. In the EE curriculum the validity of intermediate tests of failed modules is valid until the start of the given module the next academic year.
2. The period of validity for a sufficient module grade is infinite
3. Each module consists of a core activity (or a couple of related core activities). In some modules, some satellite activities are identified as well. If the core

activity or the satellite activity is finished with a positive result (higher or equal 5.5), this result can be reused. The validity of the core or satellite results is the same as the validity of module grades.

4. For each of the 10 modules in the curriculum the core activities and satellite activities are defined as:
   a. Module 1 : Satellite = mathematics line (4EC); Core = the rest of the module (11EC)
   b. Module 2 : Satellite = mathematics line (3EC); Core = the rest of the module (12EC)
   c. Module 3 : Satellite = mathematics line (3EC); Core = the rest of the module (12EC)
   d. Module 4 : Satellite = mathematics line (3EC); Core = the rest of the module (12EC)
   e. Module 5 : Satellite = mathematics part (5EC); Core = the rest of the module (10EC)
   f. Module 6 : Complete module is core activity (15EC)
   g. Module 7A : Complete module is core activity (15EC)
   h. Module 7B : Complete module is core activity (15EC)
   i. Module 8 : Complete module is core activity (15EC)
   j. Module 11 : Complete module is core activity (15EC)
   k. Module 12 : Complete module is core activity (15EC)

5. Individual request other than mentioned in this article can be sent to the exam board if well motivated with a study planning and after advice of the study advisor.

Article B6 The Minor

1. A student who is enrolled for the Bachelor's degree programme in Electrical Engineering and who meets the admission requirements referred to in Article B4 Paragraph 1, may take any minor offered by the University, with the exception of those minors listed in the 'Minor admission review', for which the Examination Board has stated that these may not be chosen by the student. The Examination Board shall update the 'Minor admission overview' annually.
2. In addition to the provisions of Paragraph 1, a student may, with the permission of the Examination Board, put together a minor by combining his own selection of the units of study offered by any university ("free minor"). The Examination Board shall draw up guidelines for the approval of such requests.

Article B7 The Bachelor thesis project

1. When the prior knowledge requirements referred to in Article B4 Paragraph 3 are met, the student may select a chair at any university as the site where the student will carry out the Bachelor thesis project. If the assignment is performed outside the department of Electrical Engineering of the University of Twente, the permission of the Programme Director is required. In any case one of the chairs of the department of Electrical Engineering at the University of

Twente is responsible for the assignment. The following research groups (chairs) take part in the Electrical Engineering programme:

Name of the chair	***Abbreviation***	***Specialisation***
Biomedical and Environmental Sensorsystems	BIOS	lab-on-a-chip systems for biomedical and environmental applications
Biomedical Signals and Systems	BSS	neurotechnology and biomechatronics
Computer Architecture for Embedded Systems	CAES	dependable integrated systems
Robotics & Mechatronics	RAM	robotics and mechatronics
Design and Analysis of Communication Systems	DACS	communication networks
Integrated Circuit Design	ICD	integrated circuit design
Optical Science	OS	integrated optical microsystems
NanoElectronics	NE	nanoelectronics
Services, Cybersecurity and Safety	SCS	computer vision and biometrics
Semiconductor Components	SC	devices for integrated circuits
Telecommunication Engineering	TE	telecommunication engineering
Micro Sensors and Systems	MSS	micro sensors and systems

2. The chair shall appoint a supervisory committee consisting of at least three persons. The committee consists of the daily supervisor, an assistant professor or associate professor or full professor of the chosen research chair and a member not being a member of the research chair involved (sometimes called an external member).
3. The supervisory committee shall include at least two examiners.
4. The Bachelor thesis project has a study load of 15 credits. The project should be finished within the module.
5. The student's performance shall be assessed on the closing date, irrespective of the stage his work has reached.
6. If the grade for the assignment is below a pass grade, the chair may give the student the opportunity to continue working on the assignment so as to meet the requirements for a pass grade. The extra time allowed shall however be limited to a study load equivalent to 3 credits. The grade for the assignment may not exceed a 6 in this case.
7. The Programme director (OLD) decides about additional time in cases that a delay is not caused by the student.

8. If the student's performance is still unsatisfactory after extra time has been allowed, the student will have to do a new assignment with another theme and a different supervisory committee or under the authority of a different chair.

Article B8 Extra Curricular Activities

For those students who are looking for more than the usual academic challenges, extracurricular activities are organised in the Honours programme. The Honours programme is designed for talented, interested and highly motivated students. The student is offered a 30 EC programme. The programme starts in the first year and sometimes in the second year.

If the honours programme is completed successfully, this will be stated on the degree supplement as an extracurricular programme.

Article B9 Cum Laude

The Bachelor Electrical Engineering examination can be taken with the designation 'cum laude'. This will be mentioned on the diploma. The guidelines for awarding this designation are that each of the following conditions must be fulfilled:

a. The Bachelor is finished within 3.5 years (time limits requirement);
b. The average module grade is 8.0 or higher;
c. All modules are assessed with a 6 or higher;
d. No exemptions were granted.
e. The assessment of the final project (Module 12 for the TOM curriculum) is 9 or higher.

In exceptional cases, in response to a student's request, the examination committee can award the designation "cum laude" if the student had pardonable grounds for non-compliance with the time limits requirement. This could be the case, for instance, when delay has been acknowledged in accordance with the provisions stipulated by the institution.

Chapter C Master's programmes following Bachelors in Electrical Engineering

Article C1 Master's programmes following Bachelors in Electrical Engineering

Students with a Bachelor's degree in Electrical Engineering from the University of Twente are entitled to take the following Master's degree programmes:

- The Master's degree programmes in Electrical Engineering at the University of Twente, Delft University of Technology and Eindhoven University of Technology
- The Master's degree programme in Systems & Control offered jointly by the University of Twente, Delft University of Technology and Eindhoven University of Technology.
- The Master's degree programme in Embedded Systems offered jointly by the University of Twente, Delft University of Technology and Eindhoven University of Technology.
- The Master's degree programme in Nanotechnology at the University of Twente

Chapter D Free-choice Bachelor's degree programme

Article D1 Relevant concepts

1. The free-choice Bachelor's degree programme is a programme as referred to in Article 7.3c of the Higher Education and Research Act (WHW). A student can put such a programme together by selecting from the units of study offered by an institution. Since a diploma is also awarded for successful completion of a free-choice programme, the programme requires permission from the most relevant Examination Board.
2. When giving such permission, the Examination Board shall determine which degree programme the free-choice programme compiled by the students in question shall be deemed to belong to.

Article D2 Permission of the Examination Board

The Examination Board shall draw up guidelines for granting the permission referred to in Article D1, with the provision that the free-choice degree programme must be coherent, must have a level comparable with that of the Bachelor's programme referred to in Chapter B, and must meet the requirements stated in Article D3.

Article D3 Examinations and structure of the free-choice Bachelor's degree programme

1. The free-choice Bachelor's degree programme has a final assessment for the Bachelor's degree.
2. The free-choice Bachelor's degree programme must be followed full-time, and has a study load of 180 credits.

Article D4 The composition of the free-choice Bachelor's degree programme

The free-choice Bachelor's degree programme shall contain at least one component that is comparable with the Bachelor thesis project referred to in Article B7. This component shall have a study load of 15 credits.

Article D5 Validity of arrangements

1. The Education and Examination Regulations applying to the degree programme to which the unit of study in question normally belongs is leading. This concerns the periods during which examinations can be taken, the frequency of the examinations, the prior knowledge requirements for the various units of study, the way in which examinations are held and the form in which the examination results are announced.

2. If the regulations conflict or lead to insuperable problems for students, the Electrical Engineering Examination Board may permit departures from the regulations.
3. Units of study that have to be successfully completed in accordance with the provisions of Paragraph 1 before a student can proceed to units of study that form part of the free-choice degree programme need not necessarily belong to the free-choice degree programme themselves.
4. In exceptional circumstances, the examiner for a unit of study that must be successfully completed before another unit of study is started may decide that this condition may be waived.

Article D6 Sequence of the various parts of the free-choice Bachelor's degree programme

1. A student who has submitted a request for approval of a free-choice Bachelor's degree programme the student has put together, shall include the sequence in which the various parts of the programme shall be taken.

2. The Examination Board charged with giving the approval may decide that certain parts of the programme shall be taken in another sequence than that specified by the applicant.

3. a. In particular, the Examination Board charged with giving the approval may decide that certain named parts of the programme may not be taken until other named parts of the programme have been successfully completed.
   b. The assignment referred to in Article D4, may not be started until at least 120 EC have been successfully completed.
   c. The chair under whose authority the unit of study referred to in Article D4 is performed may determine, in addition to the provisions of a. and b. above, that if the content of the assignment demands this, at most two named units of study with a study load of at most 15 credits shall be successfully completed before the assignment may be started.

Chapter E Study Plan

1. The study advisor is responsible for overseeing the drawing up of the study plan. The study advisor shall send students a digital study plan form, at a time that allows them at least 10 working days to fill it. The completed form must be submitted by students no later than the last working day before the examination period of the second or the fourth quarter.

2. All first-year students are asked to amend the study plan before the start of each successive quarter of the first year. If students can demonstrate that they are making the expected progress in their studies, this requirement is a request rather than an obligation.

3. First-year students are asked to amend the study plan each quarter to take into account changes in the curriculum recorded in the supplement to the programme-specific appendix relating to Article 2.

4. The study plan is a standard item of discussion for first-year students in the talks they have with the study advisor. If the study advisor considers this to be necessary, the study advisor will send students a written comment on their study plan in the form of an e-mail message.
   In the case of second and third-year students, the study advisor shall determine when, and to which students, the study advisor sends a comment on the study plan.
   If a student asks the study advisor for advice on his completed study plan, the student will always receive a comment from the study advisor.

5. Most of the comments made by the study advisor on a student's study plan will be made orally, during the regular supervisory meetings with the student. In addition, written comments may be made on completed study plans. If a student asks for advice, a comment is always sent.

6. *Binding recommendation on continuation of studies*: advice about the study plans submitted may not be used as evidence in procedures relating to binding recommendation on continuation of studies.

Chapter F Final and introductory provisions

Article F1 Hardship clause

If these regulations give rise to evidently unfair or otherwise unintended consequences, the Programme Director or the Examination Board (depending on which is competent to deal with the issue in question) may authorize a departure from these regulations.

Article F2 Introduction and amendment of these regulations

1. Amendments to these regulations are approved by the Dean in a separate decree, and recorded in Article F3 Paragraph 2.
2. Amendments to arrangements and guidelines relating to these regulations but formulated elsewhere are approved by the Dean in a separate decree, and recorded in Article F3 Paragraph 2.
3. No amendment to these regulations will become active during the current academic year, unless they can be reasonably assumed not to have any adverse effect on the interests of students (including external students). Amendments shall if possible be announced six months before they take effect.
4. The replacement of the old regulations and the amendments introduced in these new regulations shall further not adversely influence the interests of students (including external students) as regards:
   - the period of validity of the regulations as determined by the Examination Board,
   - the approval by the Examination Board of a free-choice degree programme or a free-choice minor put together by students (including external students),
   - any other decision concerning students (including external students) taken by the Examination Board pursuant to these regulations or the preceding regulations.
5. When these regulations or arrangements and guidelines relating to these regulations but formulated elsewhere are amended, transitional arrangements shall be approved to determine in any case under what circumstances and/or during which period use can still be made of the original regulations.

Article F3 Date of commencement

These regulations will be active on 1 September 2017

Appendix A. Transitional arrangement for new Education and Examination Regulations for 2017/18

Article 1 deals with the general concepts of the transitional arrangements.

Article 1.1 General concepts

1. After a course is terminated in the old curriculum, there will be test-opportunities for two additional years.
2. The test opportunities can be written exams in the same quartile as in the old curriculum, but also oral exams might be scheduled if only a few students need to take the resit.
3. Two years after termination of the course, no extra tests will be offered. Students who did not complete all the courses in the old curriculum will be transferred to the TOM-module curriculum (which can result in re-doing parts which were finished before).

Article 1.2. Special arrangements

1. In case the courses “Theory of Electromagnetic fields + practical work” and “Electrodynamics” should be done, students can do the module “Fields and Waves” (without the math part). The grade for the module will be taken as grade for both the “Theory of Electromagnetic fields + practical work” and “Electrodynamics” courses.
2. For the courses “Control Engineering”, “Dynamical Systems”, “Linear Systems” and the “Mechatronics project” the module “Systems and Control” can be done. The grade for the subtests in the module will count as grade for the individual courses. The complete module must be done.
3. For the courses ‘Probability theory’, ‘Introduction to communication systems’ and ‘Random signals and noise’ module 2.4, ‘Signal processing and communications’ can be taken as alternative. This module integrates the three courses. Grade of the module will count as grade for the three courses.
4. The course ‘Dynamical Systems’ is identical to the MSc-course ‘Engineering Systems Dynamics’ (191210431). This MSc-course is a bridging course for non-EE students. Students who need to do the ‘Dynamical Systems’ course can follow the MSc-course (in first quartile). Several written tests will be offered during the academic year

Article 2 deals with arrangements for courses from the old Electrical Engineering curriculum.

Article 2.1 Arrangements for first year courses:

No possibilities for old first year courses are given anymore. Students who did not complete the first year courses in the old curriculum will be transferred to the TOM-module curriculum (which can result in re-doing parts which were finished before).

Article 2.2 Arrangements for second year courses:

No possibilities for old second year courses are given anymore. Students who did not complete the second year courses in the old curriculum will be transferred to the TOM-module curriculum (which can result in re-doing parts which were finished before).

Article 2.3 Arrangements for third year courses:

No possibilities for old third year courses are given anymore. Students who did not complete the third year courses in the old curriculum will be transferred to the TOM-module curriculum (which can result in re-doing parts which were finished before).

Two exceptions are in place:

- For the minor, students can choose existing minor modules.
- For the Bachelor thesis project arrangements see Article B7.

Appendix B. Detailed description of the EE modules

In this appendix, a detailed description of the 11 Electrical Engineering modules is given. The learning aims of the module are given. For all modules the language of instruction and testing is in English. As presented in Article B5 of this document, the mathematics parts of modules 1-5 is allowed for separated assessment. All other parts, as well as the remaining six modules are considered as core activity.

In summary:

Module	Name:	Parts	ECs	Content
1	IEEE	IEEE	11	Introduction to Electrical Engineering and Electronics (20%), Lab-work IEEE (13%), Programming in C (20%), project (20%)
		Mathematics-line	4	Calculus-1
2	Electric Circuits	Electric Circuits	12	Circuit Analysis (44%), Lab-work (13%), Project (23%)
		Mathematics-line	3	Calculus-2
3	Electronics	Electronics	12	Electronics (47%), Project (33%)
		Mathematics-line	3	Vector Calculus
4	Fields & Waves	Fields & Waves	12	Electro and magnetostatics (53%), Project (27%)
		Mathematics-line	3	Linear Algebra
5	Computer Systems	Computer Systems	10	Computer Architecture and Organization (20%), Digital Hardware (20%), Project (27%)
		Linear Difference and differential equations	5	
6	Systems & Control		15	Linear Systems (20%), Engineering System Dynamics (20%), Control Engineering (20%), Project (40%)
7A	Device Physics		15	Quantum mechanics (10%), Semiconductor Physics (20%), Semiconductor Devices (20%0, Transducers (20%), Photonics (10%), Project (20%)
7B	Network Systems		15	Programming (20%), Network systems (80%): Challenges (15%), Theory (50%), Integration project (15%)
8	Signal Processing & Communications		15	Digital audio storage (21%), Signal analysis and processsing (31%), Communications (17%), Noise in circuits and systems (21%), Project (10%)
11	Electronic System Design		15	Embedding Signal Processing (35%), Systems to Design for Society (25%), System Engineering (20%), Project (20%)
12	Bachelor thesis project		15	Assignment: Scientific Quality (50%), Organisation (20%), Communication (30%). Reflection (20%)

B.1. Module 1 – Introduction to Electrical Engineering and Electronics

The course Introduction to Electrical Engineering and Electronics gives an overview of the field of an EE engineer. It teaches the basic knowledge in electronics, electronic networks, signal theory, electronic instrumentation, system thinking (object oriented) programming to electronic hardware and the related mathematical foundation. The course covers the whole range of physical phenomena, supporting mathematical tools, electronic and electrical theory, system thinking programming and laboratory practice.

Learning aims:

Give students an introduction in the wide field of knowledge and skills of an electrical engineer.

1. Project skills
   a) students can work in (intercultural) groups, make a project plan following detailed instructions from the HELP manual
   b) give a short presentation about the project with emphasis on demonstration of the results
   c) write a report about the project following the guidelines.
   d) Give peer feedback on the functioning of their team mates.
   e) Reflect on their functioning in the the group.

2. Mathematics and signal analysis
   Given an ordinary LTI differential equation with order 1 or 2, and given the boundary condition at t=0:

   2.1. The student is able to find the free solution.

   2.2. With the input equal to a constant:
   - The student is able to give a plausible trial solution for the particular solution.
   - The student is able to solve the unknown parameters of trial solution.

   2.3. Given a periodic signal:
   - The student is able to calculate the mean, the signal energy (MS), and the RMS of a) a sine wave; b) a square wave; c) a triangular wave, and d) a sawtooth wave.
   - The student can demonstrate his understanding of MS and RMS by being able to relate this parameters to the power of an electrical signal that is dissipated in a resistor.

   2.4. The student is able to find the Fourier coefficients of a few periodic signals, i.e. the square wave, the sine wave, and the sawtooth wave. For that, the student may confer a table with standard integrals.

   2.5. The student is able to give a qualitative interpretation of some characteristic spectra, i.e. broadband versus narrow band, spectra of continuous versus discontinuous signals.

2.6. From the differential equations describing 1st and 2nd order of R, C and L networks (or analogous systems in other domains), the student is able to deduce the parameters: RC time constant, natural frequency, and relative damping.

2.7. Given a RC network: the student is able to construct the corresponding Bode diagram. Reproducible knowledge is: cut-off frequency, slope, amplitude and phase transfer at the cut-off frequency, and the phase at extreme frequencies (zero and infinity).

2.8. Given the amplitude transfer function of a 2nd order LTI differential equation:

- The student is able to find the asymptotic behaviour of the transfer (slopes).
- The student is able to find the resonance frequency (giving maximum transfer).
- The student is able to construct the amplitude transfer diagram (Bode diagram without phase).
- For a bandpass filter: the student can calculate the Q-factor and the bandwidth from the relative damping and the natural frequencies.

2.9. The student can perform basic operations with respect to decibels:

- The student can reproduce the definition of decibels.
- The student can reproduce the attenuation factor that is associated with a few standard decibels. That is 0 dB, 3 dB, 6 dB and 20 dB.
- The student is able to interpret decibels that are easily deduced from the standard decibels. That is 40 dB, -20 dB, 26 dB, -14 dB, and so on.

3. Basics electric networks:

3.1 The student is able to apply the laws of Kirchhoff and Ohm to analyse a simple network with at most two unknown variables (currents or potential differences), or a network that is easily simplified to such a simple network.

3.2 The student is able to calculate the parameters of a Thévenin model by the open circuit voltage and the closed circuit current.

3.3 The student knows the element equations of C and L; can interpret them in their physical context, and can apply them in both the integral and differential form.

3.4 The student is able to find the 1st and 2nd order differential equation of a RC-network, a parallel LRC network and a serial LRC network.

4. Basics measurements and electronic instrumentation

4.1 The student is able to design an inverting amplifier with given amplification using an ideal opamp.

4.2 The student is able to design a first order passive and active filter given the cut-off frequency, and, if active, the amplification.

4.3 The student is able to design simple active filters (up to 4th order) by conferring a book of reference (or web). Design parameters are, for instance, cut-off frequency, order, etc.

4.4 Basic sensor technology: the student is able to design a simple measurement system equipped with basic electronic sensors for the following physical quantities: pressure, strain, skin potential differences, temperature, hydraulic level,… The student is able to interpret the basic specifications of the sensor: sensitivity, range, linearity, noise.

5. Physics

7.1. With given lumped element relations (i.e. Hook's law, Newton's law, etc) the student can set-up ordinary differential equations (up to 2nd order) in the thermal, mechanical and hydraulic domain for simple configurations.

7.2. With the techniques borrowed from electrical networks, the student is able to solve simple differential equations.

7.3. The student can explain the difference between energy and power (flow of energy, or change of buffered energy).

7.4. The student can calculate the power that is dissipated in a resistor of buffered into an inductive or capacitive element. The student can verify the balance of power (=conservation of energy).

7.5. The student can also apply these concepts to elements in the mechanical, thermal and hydraulic domain.

6. Experimentation

6.1. The student can handle basic measurement instrumentation systems, i.e. the oscilloscope, the function generator, the universal meter.

6.2. The student can build a simple network either using an experimentation PCB, or breadboard.

6.3. Under the guidance of a written instruction booklet (lab manual), the student is:

- able to raise an expectation on the behaviour of a given simple network, i.e. to analyse.
- able to build an experimental set-up to verify his expectation.
- able to produce data, to process data, to present data; either graphical (Matlab) or using tables).
- able to discuss the results and to draw conclusions.
- able to log his activities and results in a log book.

6.4. Processing data as alluded to above include:

- calculation of mean and standard deviation (functions mean and std in Matlab)
- basic plotting (plot in Matlab)
- calculation of power spectrum density (function periodogram in Matlab)

6.5. The student is aware of measurement errors that occur during an experiment. The student can mention three of the following types of error sources: thermal noise, component tolerance, calibration errors, resolution errors, modelling errors.

7. Basic programming skills in C

7.1. The students understand the basic concept of programming including the syntax of the language, data types, statements, arrays, structures, loops and branching mechanism.

7.2. The student can work with functions and recursion

7.3. The student can work with pointers

7.4. The student can read and write files

7.5. The student can design and implement simple algorithms

8. First steps in system analysis

8.1. The student can apply basic concepts from system modelling to describe the principle of operation of a complex system (complex means: consisting of interacting elements).

8.2. Systematic design: the student is able to distinguish between hierarchical levels of a design, i.e. the functional level, the implementation level, and the realization level.

8.3. Systematic design: the student is aware of design optimization. That is: defining a quantitative measure of performance, and next tuning the design parameters to maximize this performance.

The study load of module-parts:
The study load of this module is divided in:
- Mathematics (27%)
- Programming in C (20%)
- Introduction to Electrical Engineering and Electronics (20%)
- Lab-work IEEE (13%)
- Project (20%)

B.2. Module 2 – Electric Circuits

In this module, various methods for systematic circuit analysis are introduced. These methods rely on basic mathematical knowledge: solving sets of equations, solving 1st and 2nd order differential equations, calculations with complex numbers, integration, partial derivatives and integration by parts, limits and using series (e.g. Fourier and Taylor) to represent signals. Part of these mathematics were introduced in module I, while the rest is part of this module. A very important general concept is introduced: modeling a system (in this case an electric circuit) using ideal elements described by ideal element equations and the analysis of the static and dynamic behaviour of the system, i.e. the response in the form of voltages, currents and power dissipated, to various input signals (excitations). This important concept and the methods for analysis presented in this course are fundamental and applicable to many areas also outside the field of Electrical Engineering.

Learning aims:

The student has to demonstrate the proficiency in the following mathematical subjects:

1. Limits and Continuity
2. Differentation
3. Applications of Derivatives
4. Integration and Techniques of Integration
5. Infinite Sequences and Series / Taylor polynomials
6. Functions of two variables

The student has to demonstrate the proficiency in the following main subjects:

1. Node voltage method for circuits with sources and resistors
2. Superposition, source transformations, maximum power transfer
3. First order circuits with 1 capacitor or inductor
4. Second order circuits with 1 capacitor and 1 inductor
5. Sinusoidal signals and phasor domain
6. Power of sinusoidal signals
7. Bode diagrams
8. Fourier series
9. Convolution
10. Two-port anlaysis

The study load of module-parts:
The study load of this module is divided in:

- Mathematics (20%)
- Circuit Analysis (44%)
- Lab-work (13%)
- Project (23%)

B.3. Module 3 – Electronics

The content of this module is twofold. The larger part of this module is dedicated to electronics, and builds upon the knowledge obtained in the previous 2 modules. This electronics part starts with an introduction into modelling of non-linear components and an introduction into semiconductor physics of diodes, bipolar transistors and MOS transistors. This is subsequently used for analysis and synthesis of basic analogue circuits. These analogue circuits are then extended into systems with feedback to create well-behaved stable circuits and well-behaved oscillators. The last part of the module presents an introduction into (radio frequency) transmitter systems, more complex analogue circuits and digital electronics. The material is presented in the form of lectures/exercise classes and labs/projects. The final project of this module is the design, realisation and characterization of an RF-transmit-receiver system to transmit audio wirelessly. The mathematics part of this module deals with solving sets of linear equations. This mathematics part introduces matrices, vectors and transformations. Some relevant properties of vectors and matrices that will be discussed in detail include (in)dependent vectors, the base, the dimension and the determinant. Linear Algebra is useful for implementing nodal and mesh circuit analysis methods and digital signal processing algorithms: this mathematics part of module 3 extends Electric Circuits in module 2.

Learning aims:

For the electronics part, after this module the student should be able to:

- Know how to model a diode and analyse circuits using the large signal behaviour of diodes, rectifiers, clamping circuits and voltage multipliers.
- Know how to bias a BJT and a MOSFET and understand the limitations of the different bias circuits with respect to variations in temperature and component properties.
- Know the small signal equivalent circuit of a diode, BJT and MOSFET.
- Be able to transform a transistor circuit to its small signal equivalent form, analyse its behaviour and make a bode plot of small signal properties like gain and in- and output impedances.
- Know the basic one transistor stages and their gain and input- and output impedances, and use this knowledge to choose and combine appropriate stages.
- Know and be able to analyse the effect of feedback on circuit properties like gain, bandwidth, distortion, input impedance and output impedance.
- Be able to analyse the stability of feedback circuits by Nyquist plots and bode plots of the loop gain.
- Understand the workings of an oscillator and determine its oscillation criteria.
- Know and be able to analyse the various building blocks inside an opamp like differential pair, current mirror and amplifier stages.
- Know the basic workings of an antenna and be able to match it to a circuit.
- Be able to design, simulate, build and measure circuits with transistors and opamps according to a given set of specifications.
- Work in a scientific way by comparing calculations, simulations and measurements

For the mathematics part, after this module the student should be able to:

1. work with systems of linear equations, vectors, matrices, subspaces of Rn and explain the connections between these concepts
   - determine an echelon form and the reduced echelon form of a matrix
   - write a linear system in the form Ax = b
   - determine if a linear system is (in)consistent
   - determine the solution set of a linear system
   - perform operations with vectors and matrices (addition, scalar multiplication, multiplication, transpose, linear combinations
   - apply properties of operations with vectors and matrices
   - define the concept of inverse of a matrix
   - apply properties of an invertible matrix
   - calculate the inverse of a regular matrix
   - characterize an invertible matrix in terms of its echelon form, its columns (rows), linear systems
   - interrelate the solution sets of Ax = b and Ax = 0
   - examine the linear (in)dependency of a set of vectors
   - explain the concepts of subspace and basis
   - determine (a basis for) a subspace (e.g. column space, null space of a matrix)
   - compute coordinate vectors w.r.t. a basis
   - determine the dimension of a subspace

2. work with determinants, eigenvalues, eigenvectors, linear transformations and connect them with the previous concepts
   - explain the concept of determinant of a matrix
   - compute the determinant of a matrix using cofactor expansion
   - apply properties of determinants (w.r.t. row- and column operations and multiplication)
   - characterize an invertible matrix in terms of its determinant
   - calculate the area of a parallelogram or volume of a parallelepiped using determinants
   - explain the concepts of eigenvalue and eigenvector of a matrix
   - compute the eigenvalues and eigenvectors of a matrix, using the characteristic equation
   - determine if a matrix is diagonalizable
   - explain the concept of linear transformation (domain, codomain, images)
   - calculate the standard matrix of a linear transformation
   - examine properties of linear transformations (one-to-one, onto)

The study load of module-parts:
The study load of this module is divided in:

- Mathematics (20%)
- Electronics (47%)
- Project (33%)

B.4. Module 4 – Fields and Waves

In this module electric and magnetics fields, as well electromagnetic fields will be introduced. This includes:

- *Fields*: vector- and scalar fields, gradient, divergence, rotation, flux and circulation of vector fields, Theorems of Gauss and Stokes;

- *Waves*: the wave equation and its solutions;

- *Electrostatics*: electric field, Coulomb's Law, superposition of fields from charges and charge distributions, Gauss's Law, electrostatic potential, dipole, equations of Laplace and Poisson, dielectrics, electrostatic analogues;

- *Magnetostatics*: magnetic field, Ampere's Law, Law of Biot and Savart, vector potential, current and current density, magnetic dipole, energy density,.

- *Electrodynamics*: induction, plane waves in free space, radiation, interference, polarization, resonance in cavities, waveguides, transmission lines, phase and group velocity, pointing vector, reflection and diffraction.

Also a mathematics part is part of the module, containing partial derivatives and multi integrals

Learning aims:

- The student will be able to use Maxwell's classical theory of electromagnetism to describe and evaluate electromagnetic fields and waves produced by electric charges, which are either stationary (producing static electric fields), moving at constant velocity (producing static magnetic fields) or accelerating (leading to emission of electromagnetic waves).
- Using force- and potential fields, the student will be able to calculate forces acting on charges that are stationary or moving at constant velocity.
- The student will also be able to understand and model how accelerating charges in antennas may be used to emit (send) and absorb (receive) electromagnetic waves (information).
- The student will be able to use Maxwell's field theory to describe other physical phenomena, such as gravitational forces or heat flow.
- With respect to field calculations, The student will be able to:
    - calculate electric- and magnetic fields for highly symmetric charge- or current density distributions using integral rules (Gauss's- and Stokes's laws);
    - calculate these fields by means of summation (integration) over sources, which can be used if the location of the charges and/or currents is known;
- The student will have designed, constructed and tested a sending antenna for a wireless communication device. The student will have used the method of moments (NEC2) to calculate electromagnetic radiation (antenna patterns and impedance);
- The student will have limited knowledge on electric fields inside linear, isotropic materials.

Mathematics part:

- Work with partial derivatives and applications
- apply the parameterization of a curve and the tangent vector
- apply the chain rule (in several forms)
- calculate a directional derivative, and apply its properties
- calculate the gradient (vector)
- apply the relations between gradient and level sets
- calculate the tangent plane and normal line
- apply a linearization (standard linear approximation)
- estimate a change using differentials
- calculate Taylor polynomials (first and second order, two variables)
- apply the first and second derivative tests
- calculate the absolute extreme values on closed bounded regions
- apply the method of Lagrange multipliers
- Define and evaluate double and triple integrals over bounded regionssketch the region and find the limits of integration
- calculate an iterated integral (by changing the order of integration)
- define area, volume, mass or the average value as an integral
- apply polar, cylindrical or spherical coordinate substitutions or a given transformation

The study load of module-parts:
The study load of this module is divided in:
- Mathematics (20%)
- Electro and magnetostatics (53%)
- Project (27%)

B.5. Module 5 – Computer Systems

The module Computer Systems is part of the second year of both the EE- and CS-Bachelor programme. It addresses the basics of computer systems (organization and architecture) and offers a specialization into digital hardware design for EE bachelors and operating systems for CS Bachelors. In the project, which is mainly dealt with in the last two weeks of the module, EE- and CS-students cooperate to design and realize a system integrating all subjects of the first 8 weeks. Besides the topics related to computer systems, the module provides mathematics; 5 EC for EE covering Difference and Differential Equations.

Learning aims:

The Module Computer Systems (Module CS) is a module for the Bachelor Electrical Engineering and Computer Science. The Module contains a Common part (mandatory for both CS and EE students), an Electrical Engineering specific part and a mathematics part:

- Common part - Computer Architecture and Organisation

  Afterwards the student is able to:
  - Design circuits using basic logic gates
  - Calculate with different number representations
  - Understand mechanisms within a processor
  - Program a processor
  - Indicate the elements of a computer system and explain their functionality
  - Design specific parts of a computer system
  - Integrate the knowledge and skills that are taught in the module.
  - Have students from EE and CS cooperate within a project.

- Electrical Engineering specific - Digital hardware:

  Afterwards the student is able to:
  - Design correctly timed digital hardware
  - Implement tests for digital hardware
  - Realize digital hardware

- Mathematics part - Difference and Differential Equations:

  Afterwards the student is able to:
  - determine basis and dimension of vector spaces and rank, eigenvectors and eigenvalues of matrices and linear transformations
  - set up and solve least squares problems, determine orthogonal projections and verify inner products and check whether a matrix is orthogonal or not
  - solve linear differential equations with constant coefficients and determine phase portraits of 2nd order ODEs
  - solve linear difference equations with constant coefficients
  - determine the stability properties of difference and differential equations

- recognise improper integrals and determine Laplace transform and apply it on differential equations
- analyse convergence properties of infinite sequences and series, in particular power

The study load of module-parts:
The study load of this module is divided in:

- Computer Architecture and Organization (20%)
- Digital Hardware (20%)
- Diferential and difference equations (33%)
- Project (27%)

B.6. Module 6 – Systems & Control

The Module Systems & Control focuses on the analysis, modeling, simulation, and control of dynamic systems. The topics covered by this module are:

- Representations and methods of analyzing systems and signals in both continuous and discrete time domains: difference and differential equations, state-space representations, step response, transfer function, convolution sum and integral, stability, state-transition matrix, Fourier series, Fourier transform, Laplace transform, z-transform.
- Port-based modeling and bond graph representation of dynamic systems in various physical domains
- Model transformation, from a domain-specific, ideal physical model, via a bond-graph to different equations, block diagram or signal flow graph, vice versa
- Numerical simulations methods and numerical solution verification of the models.
- Energy-based analysis of multiports
- 20sim simulation package (Controllab Products B.V. The Netherlands)
- Representation and analysis of dynamic systems in the s-domain: root locus
- Analysis of dynamic systems in frequency domain: Bode plots, Nyquist plots
- Synthesis of feed-forward and state-feedback: PID controller, lead and lag networks
- Feed-back control to reduce the sensitivity of a dynamic system for disturbances and parameter variations
- Stability and sensitivity analysis

Learning aims:

The learning aims of the module are to develop:

- Understanding of the dynamic behavior of physical systems
- Knowledge on how to model, analyze, and simulate the dynamic behavior of physical systems that belong to various physical domains
- Methodology for the representations and the analysis of linear systems and their signals, in both continuous and discrete time domains
- Experience to design a feed-back control of linear/linearized dynamic systems

The study load of module-parts:
The study load of this module is divided in:
- Linear Systems (20%)
- Engineering System Dynamics (20%)
- Control Engineering (20%)
- Project (40%)

B.7. Module 7A – Device Physics

As is commonly known applications in the field of electrical engineering are manifold. Examples are automotive, portable electronics, health care and information & communication technology (ICT). Many of those applications consist of several key basic building blocks, also called devices. This course identifies the devices that are regularly used and will treat the physical working principle for each of them. It is tried to give an overview of one of the most dynamic fields of technical science, and provide the understanding to future trends. The devices will be modelled and, if possible, translated into their electrical characteristics. To this aim the course will dive into quantum physics, semiconductor physics, (electro-)mechanics and photonics. The physical working principles are, in most of the cases, illustrated using diagrams of energy, electric field, electrical potential and concentration.

Learning aims:

The course comprises five related parts: quantum physics, semiconductor physics, semiconductor devices, (electro-)mechanics/transducers and photonics.

Quantum physics:

After this course the student:

- has a general notion of the Schrödinger equation
- knows the particle-wave duality
- has a general notion of the tunneling concept
- has a general notion of the concept quantum confinement
- is able to calculate energy quanta of an electron in a rectangular box/potential well
- recognizes the Krönig-Penney model
- understands there is a relation between the band gap, effective mass and atomic spacing (lattice constant)
- understands the concept of charging energy
- understands Coulomb blockade and single-electron tunneling
- understands the transport characteristics of an SET in the classical and quantum regime

Semiconductor physics:

Students must know what is a semiconductor and understand the physics behind it. After this course the student:

- has a general notion of charge carrier transport through metals and semiconductors
- understands the concept of energy band diagram and its importance for devices
- understands the drift-diffusion equations
- knows the concept “thermal equilibrium”
- recognizes the Fermi-Dirac statistics
- has a general notion of the Boltzmann relations and the mass-action law
- recognizes the Einstein relation
- has the general notion of the concept of recombination/generation

- understands the energy-exchange and momentum-exchange when systems are out of equilibrium

Semiconductor devices:

Students should know why semiconductor components are being successfully applied in the field of electronics. They should understand how and why the electrical behaviour of various components are modelled.

After this course the student:

- understands the concept “depletion approximation” and charge conservation
- understands Gauss’s law for determining the electric field/potential
- understands the formation of the pn-junction diode and MOS capacitor at thermal equilibrium
- understands the rectifying behavior of the pn-junction diode
- is able to model the electrical characteristics of the pn-junction diode and MOSFET in steady state condition and during switching (transients, small/large signal)
- understands the concept of threshold voltage and built-in voltage
- knows the concept heterojunctions
- understand the notion of contact resistance
- recognizes the different aspects of “transistor performance”
- understands the relation between physical dimensions and transistor action
- recognizes physical limitations in the transistor architecture
- has a basic notion of the IC technology and development

Transduction and Mechanical Devices:

After this course the student:

- Understand the difference between “energy storing vs. dissipative” and “generator vs. modulator” types of transducers. Be able to label a certain transducer according to these categories.
- Understand the concepts of strain and stress, and be able to calculate those in both axially and transversely loaded beams.
- Understand the basic physics of metal and semiconductor strain gauges (piezo-resistive transduction), and be able to design a simple elastically deforming structure with optimal placement of sensing elements.
- Understand the role of potential energy function in equilibrium and stability analysis of energy storing generator type of transducers. Be able to derive the potential energy function for such transducers and based on this perform equilibrium and stability analysis.
- Understand the definition of the coupling factor and its role in stability analysis of two-port energy storing transducers.
- Understand the relation between coupling factor and energy transfer in basic cyclic transduction processes.
- Apply the concepts above to design electrostatic and magnetic transducers.
- Understand the difference and be able to model and design the capacitive “comb-drive” and “gap-closing” configurations.
- Understand the relation between the potential energy function of a generator type transducer and its small signal parameters

Photonics:

After this course the student:

- understands the propagation of electromagnetic fields: propagation constant, wavelength, refractive index, electromagnetic field as a superposition of monochromatic waves of different frequencies (temporal FT), electromagnetic field as superposition of waves with different spatial frequencies (spatial FT).
- knows the Maxwell equations and their relation with Schrödinger equations: solution to the Maxwell equations, boundary conditions, wave equation.
- has a general notion of the dispersion relation (ω-k), its meaning, and relation to the E-k diagrams of electrons in solids (neff vs meff). Application to optical waveguides.
- has a general notion of the principles of photo detection, light emission and lasing in semiconductors
- understands the working principle of a laser
- understands the rate equations for photons and carriers in a semiconductor laser, threshold current, slope efficiency, photon lifetime.
- knows the concepts direct modulation of a semiconductor laser, frequency chirp, maximum modulation speed.
- knows the modulation schemes, including on-chip optical modulators

The study load of module-parts:

The study load of this module is divided in:

- Quantum mechanics (10%)
- Semiconductor Physics (20%)
- Semiconductor Devices (20%)
- Transducers (20%)
- Photonics (10%)
- Project (20%)

B.8. Module 7B – Network Systems

The module Network Systems focuses on computer networking for open infrastructures, such as the Internet and GSM/UMTS, as well as embedded networks, such as sensor, in-car and home automation networks. Such networks are typically designed using a layered architecture of protocols. This course covers all layers of this architecture: physical layer (e.g., Shannon limit, error correction, propagation), link layer (e.g., medium access control, retransmission schemes, switching), network layer (e.g., routing, addressing, router architecture), transport (e.g., congestion control, flow control), and application layer (email, web, peer-2-peer). It covers both basic principles of communication systems, networks, and networked applications, as well as the operation of key protocols underlying the operation of the Internet (e.g., Ethernet, IP, TCP, DNS). Furthermore, the course treats security aspects, some basic performance models, and network monitoring tools.

Learning aims:

After following this course students should be able to:
- understand basic principles communication systems, networks, and networked applications
- describe and understand key protocols underlying the operation of the Internet
- make simple quantitative models of network systems, and use them to evaluate these systems
- analyze the behavior of common networking systems using network monitoring tools
- design and implement basic networking protocols and applications
- write programs making good and correct use of object-oriented programming concepts and multithreading, and with basic insights in datastructures and algorithm efficiency.

The study load of module-parts:
The study load of this module is divided in:
- Programming (20%)
- Network systems (80%)
    - Challenges (15%)
    - Theory (50%)
    - Integration project (15%)

B.9. Module 8 – Signal Processing and Communications

Learning aims:

In this module students learn how to represent information (such as sound, images, or sensor data) as a signal, in such a way that it can be processed, transmitted, received, and/or stored. After the module the student is able to understand how the properties of a signal can be described, and how the choice for a suitable signal is influenced by:

- the type of information;
- the operation to be performed (processing, transmission, or storage) and required performance;
- available resources such as time, bandwidth, power/energy, and hardware considerations such as size, weight, complexity and costs.

The study load of module-parts:
The study load of this module is divided in:

- Digital audio storage (21%)
- Signal analysis and processsing (31%)
- Communications (17%)
- Noise in circuits and systems (21%)
- Project (10%)

B.10. Module 11 – Electronic System Design

This module is a T-shaped module with both a deepening of the electrical engineering knowledge through 'embedded signal processing' as well as a broadening of the knowledge in the fields of 'system design' and ' philosophy of design'. The project aims to bring the different parts of the module together. In the project, students work in teams on the architecture and design of a complex electronic system (with practical implementation signal processing sub-systems) and reflect on the philosophical aspects.

Learning aims:

After passing this course, students should be able to:

- Make use of philosophical writings, especially from philosophy of technology and related fields.
- Analyse and evaluate a technology (product/service) by using philosophical concepts and frameworks, and use this actively in the design of a new technology.
- Incorporate philosophy of technology in the project reports, in which (a) the student makes use of writings from philosophy of technology (and related fields) and (b) presents arguments that support her/his analysis, evaluation and design of a technology (product/service).

- Obtain and maintain an overview in a multidisciplinary design project
- Plan and manage a multidisciplinary design project
- Recognize and use practical and theoretically substantiated design principles and techniques.
- Reflect on the design process in the context of these principles and techniques.

- Understand and explain the basic functionality of radios, analog filters, PLLs, analog-to-digital converters, digital FIR filters and sample-rate converters.
- Discuss these circuits in terms of fundamental properties like power, speed, noise, sample frequency, quantization error, SNR and frequency transfer.
- Use this understanding to explore the design space in a signal processing system, make trade-offs between analog and digital and partition the system accordingly.
- Use the insights of this process in the design of the signal processing blocks in a larger system.

- Design and build a complex electronic system, with detailed analysis and design of the signal-processing parts of the system.
- Work in a team to produce a working prototype at a technical level that is in correspondence with the Bachelor courses in the EE curriculum.
- Explicitly use the knowledge and skills of the other topics in this module to benefit the design.
- Communicate about the design and the project in the form of a project plan, a report and a demonstration with accompanying presentation.

The study load of module-parts:

The study load of this module is divided in:

- Embedding Signal Processing (35%)
- Systems to Design for Society (25%)
- System Engineering (20%)
- Project (20%)

B.11. Module 12 – Bachelor thesis project

The Bachelor thesis project is the culmination of the Bachelor's EE- programme. The main objective of the Bachelor thesis project is for the student to learn to apply a suitable methodology under supervision.

The assignment is performed at one of the research chairs related to the EE programme, and under supervision of a Bachelor's Assignment Committee (BAC).

Learning aims:

After passing this course, students should be able to:

- use modern methods and tools in research and design to describe, analyze, model, implement, test and document systems in the domain of electrical engineering on a scientific basis;
- assess theoretical and practical issues and substantiate and select appropriate solutions based on literature studies, modules, analyses, simulations and or tests;
- use its knowledge on academic level of key theories, methods and practices in the Electrical Engineering fields;
- to understand and reflect on theories, methods and practices in the field of electrical engineering;
- use its knowledge of methods for Planning, project management, individual & team-based projects;
- work systematically and methodologically;
- handle complex development- and research oriented situations in study and work context;
- carry out studies and draw valid conclusions on a scientific basis;
- independently function in a disciplinary and interdisciplinary collaboration;
- communicate academic problems and solutions to peers and non-specialist;
- translate academic knowledge and skills into practical problem solving
- reflect on the scientific and societal dimensions and implications of their work.

The study load of module-parts:
The study load of this module is divided in:

- Individual research (80%)
    - Scientific Quality (50%)
    - Organisation (20%)
    - Communication (30%)
- Reflection (20%)