Program overview

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<th>Code</th>
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**Program for TI students with variant CS**

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<td>TI2716-A</td>
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<td>Electronic Circuits</td>
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</table>

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**ET-Mi-109-17**

**Minor Coordinator**
Dr.ing. I.E. Lager

**ECTS Program**
30

**Administration by the Faculty of**
EWI

**Administration by the Education of**
EE

**Minor Title**
Minor Electrical Engineering for Autonomous Exploration Robots

**Contact for Students (Minor)**
Dr.ing. I.E. Lager

**Intended for**
Bachelor students at Aerospace Engineering, Mechanical Engineering, Marine Technology (i.e. constructing sciences), Applied Sciences and Computer Science

**Gives access to**
The minor offers the students a platform for self-assessing their potential to do an Electrical Engineering (EE) MSc. For being admitted to the EE MSc, the students will have to do a number of homologation courses, with "Electromagnetics" (EE3P11, 5 ECTS) being mandatory.

**Expected prior Knowledge**
Calculus, Linear Algebra and Physics; Signals and Systems is advisable

**Prerequisites Minor**
Calculus, Linear Algebra, elementary BSc physics

**Minor Exit Qualifications**
- Students will gain knowledge and skills in the elementary disciplines of Electrical Engineering, and knowledge and skills to analyse and solve electrotechnical problems.
- Students will become capable to identify electrotechnical aspects in the field of their major and evaluate potential use of various electrotechnical solutions.
- Students will be prepared for a possible admission to the Master Electrical Engineering.

**Minor Coherence / Goal**
This minor offers the students a wide range of courses and one integrating project, enabling them to build up insight and adequate instruments (skills) in Electrical Engineering (EE) and apply this knowledge in the students own (major) discipline. The latter goal is further supported by carrying out a (partially open-end) project. It is important to keep in mind that, in view of the ubiquitous presence of EE elements in present day technology, understanding and manipulating basic concepts in this field equips the future specialist with exceptional career prospects. This minor also offers interested students a basis for assessing their potential to do an EE MSc programme.

**Minor Content 1**
The minor offers a number of courses and one project as follows:
- ET3033TU, Circuit Analysis (3 ECTS)
- ET3604LR, Electronic Circuits (3 ECTS)
- ET3310TU, Telecommunication Techniques (3 ECTS)
- TI2725-B, Digital Systems (5 ECTS)
- EE3330TU, Guiding & Radiating (4 ECTS)
- ET3051TU, Electronic Power Conversion (4 ECTS)
- ET3052TU, Structured Electronic Design (4 ECTS)
- ET3039TU, Mars Rover project (4 ECTS)

The ET3039TU Mars Rover Project is a typical Electrical Engineering project, in which groups of about 4-5 students ultimately realise a robot vehicle (rover) with some form of autonomous behaviour. The project is based on a digitally controlled stepper-motor driven platform. The digital control is created using an on-board Field Programmable Gate Array (FPGA) module (a reconfigurable custom hardware, filling the space between custom chips and programmable computers). The design of an FPGA based system is very similar to the design of chips. The system is to be augmented with a number of sensors, enabling a wide range of functions to be performed, allowing the platform to function as a Mars Rover. The courses in this minor provide the background knowledge in order to carry out this project successfully, and must all be taken for a total of 30 ECTS.

**Education Methods**
Lectures, project

**Minor Assessment**
Written and oral exams, reports/presentations

**Maximum number of participants**
200

**Minor Remarks / Schedule**
All courses and the project in this minor are assessed separately, and must be graded with a 6 or higher.

The language for all courses, instructions and practical assignments is English. All assessments and reading materials are in English.
### Regular program

<table>
<thead>
<tr>
<th><strong>Minor Coordinator</strong></th>
<th>Dr.ing. I.E. Lager</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECTS Program</strong></td>
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<tr>
<td><strong>Administration by the Faculty of</strong></td>
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<td><strong>Administration by the Education of</strong></td>
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<td>Dr.ing. I.E. Lager</td>
</tr>
<tr>
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<td>The minor offers the students a platform for self-assessing their potential to do an Electrical Engineering (EE) MSc. For being admitted to the EE MSc, the students will have to do a number of homologation courses, with &quot;Electromagnetics&quot; (EE3P11, 5 EC.) being mandatory.</td>
</tr>
<tr>
<td><strong>Expected prior Knowledge</strong></td>
<td>Calculus, Linear Algebra and Physics; Signals and Systems is advisable</td>
</tr>
<tr>
<td><strong>Prerequisites Minor</strong></td>
<td>Calculus, Linear Algebra, elementary BSc physics</td>
</tr>
</tbody>
</table>
| **Minor Exit Qualifications** | - Students will gain knowledge and skills in the elementary disciplines of Electrical Engineering, and knowledge and skills to analyse and solve electrotechnical problems.  
- Students will become capable to identify electrotechnical aspects in the field of their major and evaluate potential use of various electrotechnical solutions.  
- Students will be prepared for a possible admission to the Master Electrical Engineering. |
| **Minor Coherence / Goal** | This minor offers the students a wide range of courses and one integrating project, enabling them to build up insight and adequate instruments (skills) in Electrical Engineering (EE) and apply this knowledge in the students own (major) discipline. The latter goal is further supported by carrying out a (partially open-end) project. It is important to keep in mind that, in view of the ubiquitous presence of EE elements in present day technology, understanding and manipulating basic concepts in this field equips the future specialist with exceptional career prospects. This minor also offers interested students a basis for assessing their potential to do an EE MSc programme. |

### Minor Content 1

The minor offers a number of courses and one project as follows:
- ET3033TU, Circuit Analysis (3 ECTS)
- ET3604LR, Electronic Circuits (3 ECTS)
- ET3310TU, Telecommunication Techniques (3 ECTS)
- TI2725-B, Digital Systems (5 ECTS)
- EE3330TU, Guiding & Radiating (4 ECTS)
- ET3051TU, Electronic Power Conversion (4 ECTS)
- ET3052TU, Structured Electronic Design (4 ECTS)
- ET3039TU, Mars Rover project (4 ECTS)

The ET3039TU Mars Rover Project is a typical Electrical Engineering project, in which groups of about 4-5 students ultimately realise a robot vehicle (rover) with some form of autonomous behaviour. The project is based on a digitally controlled stepper-motor driven platform. The digital control is created using an on-board Field Programmable Gate Array (FPGA) module (a reconfigurable custom hardware, filling the space between custom chips and programmable computers). The design of an FPGA based system is very similar to the design of chips. The system is to be augmented with a number of sensors, enabling a wide range of functions to be performed, allowing the platform to function as a Mars Rover. The courses in this minor provide the background knowledge in order to carry out this project successfully, and must all be taken for a total of 30 ECTS.

NOTE: Depending on the chosen variant, some students in the BSc Computer Science programme may have had the course TI2725-B Digital Systems in their second year education. These students must then replace this course with TI2716-A Signal Processing. With this adjustment, the minor is still construed as Et-Mi-109, EE for autonomous exploration robots (thus NOT a "free minor").

### Minor Assessment

**Education Methods**
- Lectures, project

**Minor Assessment**
- Written and oral exams, reports/presentations

**Maximum number of participants**
- 200

**Minor Remarks / Schedule**
- All courses and the project in this minor are assessed separately, and must be graded with a 6 or higher. The language for all courses, instructions and practical assignments is English. All assessments and reading materials are in English.
### EE3039TU

**Marsrover project**

<table>
<thead>
<tr>
<th>Course</th>
<th>Responsible Instructor</th>
<th>Instructor</th>
<th>Instructor</th>
<th>Contact Hours / Week</th>
<th>Education Period</th>
<th>Start Education</th>
<th>Exam Period</th>
<th>Course Language</th>
<th>Course Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE3039TU</td>
<td>Dr. J. Hoekstra</td>
<td>Dr.ir. J.S.S.M. Wong</td>
<td>Dr.ir. G.J.M. Janssen</td>
<td>0/x/0/0</td>
<td>2</td>
<td>2</td>
<td>none</td>
<td>English</td>
<td>In this project a group of 4 or 5 students have the task to develop a Mars Rover. The Mars Rover is based on a simple vehicle that is driven by several electric stepper motors which are controlled by an onboard FPGA. The students have the task to feed the robot with solar energy and to enhance the robot with sensing and localization abilities such that the robot is capable to perform certain predefined tasks. In order to have control over the movement and the sensors the FPGA has to be programmed in VHDL. All the basic knowledge and skills needed for this project are provided by the courses in the minor. Study Goals: Applying the knowledge and skills obtained during the courses in the minor. Education Method: Project in groups of 4/5 students. Assessment: Delivery of a functional Mars Rover.</td>
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### EE3310TU

**Telecommunications Techniques**

<table>
<thead>
<tr>
<th>Course</th>
<th>Responsible Instructor</th>
<th>Contact Hours / Week</th>
<th>Education Period</th>
<th>Start Education</th>
<th>Exam Period</th>
<th>Course Language</th>
<th>Expected prior knowledge</th>
<th>Summary</th>
<th>Course Contents</th>
<th>Study Goals</th>
<th>Education Method</th>
<th>Literature and Study Materials</th>
<th>Assessment</th>
<th>Permitted Materials during Tests</th>
<th>Special Information</th>
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<tbody>
<tr>
<td>EE3310TU</td>
<td>Dr.ir. G.J.M. Janssen</td>
<td>2/0/0/0 lecture; 2/0/0 instruction (3 weeks)</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>English</td>
<td>Mathematics in general. Some basic knowledge on linear systems and signals, the Fourier transform and stochastic processes, will be an advantage.</td>
<td>Transmission and distribution of information by means of telecommunication techniques form the backbone of our modern society. The course Telecommunications Techniques provides mathematical methods to describe and analyse communication systems for the transmission of digital signals.</td>
<td>In this course, mathematical methods are given to describe and evaluate communication systems for the transmission of digital signals: - decibelnotation, - mathematical description of signals and definition of bandwidth, - propagation loss in guided and unguided (wireless) media, - noise and system noise calculations (link budget), - signal sampling, - analogue pulse modulation (PAM, PCM, Delta-modulation), - digital waveforms in baseband, power density spectrum and spectral efficiency, - line codes, - bandpass signals and systems: complex baseband description, modulation, demodulation, generic transmitter and receiver concepts, - digital modulation techniques (OOK, FSK, BPSK, QPSK, MSK), - matched filtering, - bit error probability after detection of digital signals.</td>
<td>The student has gained insight in the basic concepts of signal processing for telecommunications, as described under Course Contents, especially those related to the transmission of digital signals, and is able to apply this knowledge by solving related problems by means of calculations.</td>
<td>Lectures, instruction lectures, homework exercises</td>
<td>Couch, L.W., Digital and Analog Communication Systems, 8th edition, ISBN 978-0-13-291538-0, Prentice Hall, 2013.</td>
<td>Written exam (closed book).</td>
<td>During the exam, the student is allowed to use a non-programmable electronic calculator, the overview Tables and Figures to be used at the exam Telecommunications Techniques (EE3310TU/EE8020) available on the Blackboard page of this course and a hand-written page of equations: 1 page A4, two-sided self-written (no copy and it should not contain worked out exercises or examples).</td>
<td>This course is part of the minor Electrical Engineering for Autonomous Exploration Robots (EE3039TU).</td>
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### EE3330TU  
**Guiding & Radiating**

<table>
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<tr>
<th>Responsible Instructor</th>
<th>Dr. D. Cavallo</th>
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<td>Start Education</td>
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<td>Exam Period</td>
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<tr>
<td>Expected prior knowledge</td>
<td>Complex numbers, vector algebra, integration and differentiation.</td>
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</table>
| Course Contents        | - Basic electromagnetic concepts (5 lectures)  
                          - Traveling waves  
                          - Electrostatics  
                          - Magnetostatics  
                          - Time-varying electromagnetic fields  
                          - Plane waves and Polarization  
                          - Transmission lines (4 lectures)  
                          - Theory of transmission lines  
                          - Characteristic parameters of transmission lines  
                          - Generator and load mismatch  
                          - Examples  
                          - Antennas (4 lectures)  
                          - Antenna characteristic parameters  
                          - Short and half-wave dipoles  
                          - Antenna links  
                          - Examples  |
| Study Goals            | The students will be able to  
                          - explain the basic concepts of electromagnetism and describe the properties of electromagnetic waves  
                          - list and define the antenna and transmission lines characteristic parameters  
                          - solve transmission lines and plane waves problems  
                          - solve antenna links and power budget problems  |
| Education Method       | - Lectures through PowerPoint slide projection  
                          - Practicing sessions with exercises  
                          - Solution of practical examples with blackboard and slides  |
| Assessment             | - Two intermediate written tests (25% + 25%)  
                          - Final written exam (50%)  
                          - Oral exam (optional)  |
| Permitted Materials during Tests | - An equation sheet will be provided during the tests  
                          - Calculator is needed  |

### EE3331TU  
**Structured Electronic Design - Basics**

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<tr>
<th>Responsible Instructor</th>
<th>Dr.ir. C.J.M. Verhoeven</th>
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<td>Course Language</td>
<td>English</td>
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<tr>
<td>Course Contents</td>
<td>This course focuses on a systematic approach to the design of analog electronic circuits for non-electrical engineers. The methodology presented in the course is based on the concepts of hierarchy, orthogonality and efficient modelling. It is applied to the design of negative-feedback amplifiers. It is shown that aspects such as ideal transfer; noise performance, distortion and bandwidth can be optimized independently. A systematic approach to biasing completes the discussion. Lectures are interactive and combined with weekly sessions where students can work on exercises under supervision of the professors. After this course the students should be able to effectively communicate with a professional expert analog designers and understand and discuss the design considerations.</td>
</tr>
</tbody>
</table>
| Study Goals            | After the course a student:  
                          - Has become familiar with a scientific way to design circuits.  
                          - Knows the contrast between the standard heuristic methods (familiar but incomprehensible for most of the students) that are mainly based on encyclopaedial experience and a well-structured way that is based on insight  
                          - Knows the basic principles of a systematic, hierarchical design methodology for analog circuits, using negative feedback amplifiers as an example.  
                          - Is able to design high performance basic circuits based on insight instead of experience that only builds up after many years of practical work.  
                          - Can do a bandwidth estimation using the loopgain-poles product  
                          - Can effectively use nullors to find optimal designs  
                          - Can do a noise optimization of a negative feedback amplifier  
                          - Knows how to use a simulator like Spice to verify a circuit design  
                          - Can use symbolic circuit simulator SilCap for root locus analysis  
                          - Masters a systematic way to bias analog circuits  
                          - I able to select the optimal amplifier topology with respect to source and load  
                          - Knows the best design order  
                          - Can estimate and explain the effect of loopgain in a negative feedback amplifier  
                          - Is able to rank feedback networks based on their performance  
                          - Is able to estimate the errors when a second-best option has to be chosen for a design because of practical limits |
| Education Method       | Lectures and instructions |
| Assessment             | Written exam with open questions |
Circuit Analysis

Responsible Instructor: Dr.ing. I.E. Lager

Contact Hours / Week: 3/0/0/0

Education Period: 1

Start Education: 1

Exam Period: 1

Course Language: English

Expected prior knowledge: The course requires familiarity with handling the complex numbers algebra.

Course Contents:

- The course provides an overview of the main concepts, such as current and charge, voltage and current sources, electrical circuits, circuit symbols, direct current, alternating current, resistors, capacitors, and inductors, Ohm's law, Kirchhoff's laws, power dissipation in resistors, series, and parallel connections.

- Measurement of voltages and currents: common wave forms, measuring techniques and equipment.

- Resistance and DC Circuits: Thévenin and Norton theorems, superposition, nodal analysis, mesh analysis, (solving) circuit equations.

- Capacitance and electric fields: capacitors and capacitance, electric field strength and flux density, series and parallel connected capacitors, capacitor I/V relationship, sinusoidal voltage and current, energy stored in a capacitor.

- Inductance and Magnetic Fields: electromagnetism, reluctance, inductance, self-inductance, series and parallel connections, inductor I/V relationship, sinusoidal voltage and current, energy stored in an inductor, mutual inductance, transformers.

- Alternating voltages and currents: resistance vs. reactance, impedance, phasor diagrams, complex notation.

- Power in AC circuits: power dissipation in resistive circuits, power in capacitors and inductors, power in circuits with resistance and reactance, active and reactive power, power factor correction, three phase systems, power measurement.

- Frequency characteristics of AC circuits: two-port networks, the decibel, frequency response, filter networks, Bode diagrams, RL/RC circuits and resonance, stray capacitance and inductance.

- Transient behaviour: Charging of capacitors and energising of inductors, discharging and de-energising, first order systems, generalised response, second order systems, higher order systems.

Study Goals: The course aims at building up insight and analysis instruments in the area of linear electrical circuits and components. It will also establish a solid foundation for understanding, analysing and synthesising electronic circuits using non-linear active components in both the analogue and digital domains.

Education Method: The education is based on a pitch -> self-study -> solving exercises -> discussion of the solutions cycle; there is a high emphasis on pre-preparation of lectures and self-study.


Assessment: Homeworiks + written exam

Permitted Materials during Tests: The book not in electronic format! In exceptional cases, the printout of the slides will be permitted. A standard electronic calculator is allowed, graphic calculators being only allowed in exceptional cases.

Judgement: The final grade is calculated as a weighted average as:

Final grade = 0.9 Ex + ( ( 30  2 Ex ) Hw ) / 100

with Ex being the exam grade (0-10) and Hw the average homework assignments grade (0-10); the final grade is rounded off to 0.5 points. A Hw=0 is accounted for in case no homework assignments are handed in. In case of a resit, the Hw grade obtained during the term remains valid.

maximum aantal deelnemers: 100
<table>
<thead>
<tr>
<th>ET3051TU</th>
<th>Electronic Power Conversion</th>
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<tbody>
<tr>
<td>Responsible Instructor</td>
<td>Prof.dr. J.A. Ferreira</td>
</tr>
<tr>
<td>Instructor</td>
<td>Ir. F. Pansier</td>
</tr>
<tr>
<td>Contact Hours / Week</td>
<td>0/2/0/0 hc</td>
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<td>Education Period</td>
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<td>Start Education</td>
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<td>Course Language</td>
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<tr>
<td>Course Contents</td>
<td>This course is part of the minor and is an introduction to power electronics. First the principles of power conversion with switching circuits are treated as well as main applications of power electronics. Next the basic circuits of power electronics are explained, including ac-dc converters (diode rectifiers), dc-dc converters (non-isolated and isolated) and dc-ac converters (inverters). Related issues such as pulse width modulation, methods of analysis, voltage distortion and power quality are treated in conjunction with the basic circuits. The main principles of operation of most commonly used power semiconductor switches are explained. Finally, the role of power electronics in sustainable energy future, including renewable energy systems and energy efficiency is discussed.</td>
</tr>
<tr>
<td>Study Goals</td>
<td>To get acquainted with applications of power electronics, to obtain insight in the principles of power electronics, to get an overview of power electronic circuits and be able to select appropriate circuits for specific applications and finally to be able to analyse the circuits. The focus in the course is mainly on analysis.</td>
</tr>
<tr>
<td>Education Method</td>
<td>Lectures</td>
</tr>
<tr>
<td>Assessment</td>
<td>Written exam (closed book)</td>
</tr>
<tr>
<td>Permitted Materials during Tests</td>
<td>It is allowed to use one single sided A4 sheet with formulas and figures from the text book ONLY(solutions from previous exams and other material not allowed)</td>
</tr>
<tr>
<td><strong>ET3604LR</strong></td>
<td><strong>Electronic Circuits</strong></td>
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<tr>
<td><strong>Responsible Instructor</strong></td>
<td>Dr.ir. C.J.M. Verhoeven</td>
</tr>
<tr>
<td><strong>Contact Hours / Week</strong></td>
<td>4/0/0/0</td>
</tr>
<tr>
<td><strong>Education Period</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Start Education</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Exam Period</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>Course Language</strong></td>
<td>English</td>
</tr>
</tbody>
</table>
| **Parts** | Lectures  
Lab exercise  
In-class assignments |
| **Major topics:** | Electronics in information processing (sensor readout)  
Design principles and trajectory  
Signal processing functions  
Electronic design analysis  
Negative feedback amplifiers  
Operational amplifiers  
Components and networks  
Semiconductor diodes  
Power supplies and voltage regulators  
Semiconductor transistors and IC technology (basic)  
Oscillators  
Assembly and measurement techniques (laboratory exercise) |
| **Special topic:** | The design and operation of the DelfiC3 satellite. Working hardware will be demonstrated and the behavior of DelfiC3 in orbit will be discussed.  
During the lectures DelfiC3 may be used frequently as example. |
| **Course Contents** | The purpose of this course is:  
to become conversant with the world of electronics and a number of often used comprehensions and technical terms;  
to get used to information-carrying signals as a time phenomenon and as a spectral phenomenon  
to learn the relation among voltages, currents and powers;  
to learn about impedances and networks in relation to their signal behaviour;  
to learn about semiconductor components, such as diodes and transistors and their applications;  
to get acquainted with signal-processing functions, such as amplification, filtering, switching, multiplication, conversion;  
to get acquainted with analog electronic circuits and the systems for energy supply of these circuits;  
to get acquainted with the process of system analysis and synthesis;  
and finally to get acquainted with construction and measuring techniques, along with the problems that may arise by wrong construction and the interaction with physical and mechanical phenomena.  
After this course students should also be able to understand the electronic behavior of the DelfiC3 system and be able to read and understand the circuit diagrams. |
| **Study Goals** | To gain insight (in a structured manner) in the function of electronics as information-processing technique in our society; its usefulness in products; modelling and characteristics of components, circuits and systems; to get on speaking terms with electronics designers. |
| **Education Method** | Lecture/Lab exercise |
| **Literature and Study Materials** | Electronics: A Systems Approach Fourth of Fifth Edition (or later)  
Neil Storey  
Published by Prentice Hall  
For sale at:  
Leonardo da Vinci  
ETV  
Hand Outs |
| **Assessment** | Written/Lab exercise test |
### ET3604LRP

<table>
<thead>
<tr>
<th>Responsible Instructor</th>
<th>Dr. ir. A.M.J. Slats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical Coordinator</td>
<td>Dr. ir. C.J.M. Verhoeven</td>
</tr>
<tr>
<td>Contact Hours / Week</td>
<td>x/0/0/0</td>
</tr>
<tr>
<td>Education Period</td>
<td>1</td>
</tr>
<tr>
<td>Start Education</td>
<td>1</td>
</tr>
<tr>
<td>Exam Period</td>
<td>1</td>
</tr>
<tr>
<td>Course Language</td>
<td>English</td>
</tr>
<tr>
<td>Expected prior knowledge</td>
<td>Contents of the first weeks of the lectures (amplification)</td>
</tr>
<tr>
<td>Course Contents</td>
<td>The course ET3604LR is accompanied by this laboratory exercise. The result of the written examination will become valid after successful completion of this exercise.</td>
</tr>
<tr>
<td>Study Goals</td>
<td>Learn to use electronic measurement equipment.</td>
</tr>
<tr>
<td>Education Method</td>
<td>Have a practical design experience with a circuit containing an operational amplifier.</td>
</tr>
<tr>
<td>Books</td>
<td>The lab guide.</td>
</tr>
<tr>
<td>Assessment</td>
<td>Assessment is done by the assistants present during the lab. The grade can either be pass of fail.</td>
</tr>
</tbody>
</table>

### T12726-A

<table>
<thead>
<tr>
<th>Responsible Instructor</th>
<th>Dr. ir. J. S. S. M. Wong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical Coordinator</td>
<td>Ing. A. M. J. Slats</td>
</tr>
<tr>
<td>Contact Hours / Week</td>
<td>4/0/0/0; 4/0/0/0 lab</td>
</tr>
<tr>
<td>Education Period</td>
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</tr>
<tr>
<td>Start Education</td>
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</tr>
<tr>
<td>Exam Period</td>
<td>1</td>
</tr>
<tr>
<td>Course Language</td>
<td>English</td>
</tr>
<tr>
<td>Expected prior knowledge</td>
<td>No prior knowledge is expected from student.</td>
</tr>
<tr>
<td>Course Contents</td>
<td>This course introduces the following aspects in digital design: combinational digital systems, sequential systems, complex combinational and sequential building blocks, reconfigurable hardware and complex digital systems. All the important aspects of digital design will be discussed: number systems, Boolean algebra, combinational logic, 2-level and multilevel networks and reduction techniques/design tools, timing hazards, Moore/Mealy machines, Finite State Machines (FSM) and more. The lab starts with the realization of simple circuits and will end with complex systems realized on an FPGA.</td>
</tr>
<tr>
<td>Study Goals</td>
<td>The student (at the end of the course) will have learned the two fundamental notions of digital systems, namely combinational and sequential networks, and will have learned the basics of VHDL. First, the student will be able to translate non-digital functions to a digital representation. Second, the student is subsequently able to establish the needed combinational and sequential networks that have to obey specific design requirements (e.g., area, timing, and functionality). Furthermore, the student is able to model simple circuits in VHDL and understand them. The student will have gained enough knowledge to follow more advanced course, such as, computer architecture, computer systems, and embedded systems.</td>
</tr>
</tbody>
</table>
| Assessment             | * Multiple-choice exam and successful completion of lab.  
* Weekly online tests (5x) that can lead to "striking out an incorrect answer" at the first upcoming exam when 80% of the online tests questions are correctly answered. This rule does not apply for resits. |
| Permitted Materials during Tests | Book and lecture slides, excluding old exams and tests. |
| Judgement              | There are two requirements for students to pass the course. First, an obligatory lab must be successfully completed. Only successful completions are registered. Second, a written exam (comprising 20 multiple-choice questions) must be taken resulting in a passing grade, i.e., 6 or higher. Each year there are two possibilities (regular exam in the same quarter and a resit in the subsequent quarter) to take the exam according to the exam regulations that also defines the validity duration of the exam results. In order to motivate students to study the course during the quarter it is given, an online test system (via Blackboard) is set up with up to 15 multiple-choice questions. The questions are put online in sets of 3 during a period of 5 weeks and relate to any of the material given in preceding weeks. Upon correctly answering 80% or more of these questions, 1 incorrectly answered multiple-choice of the first ensuing exam will be stricken. Once again, this online test result will only count for the first upcoming exam that is given in the same quarter and does not count for the resit nor for exams in subsequent years. Furthermore, interested and motivated students are given the opportunity to interact more with the lecturer via study groups in 5 meetings spread over 5 weeks. Registration is required in order to participate in these groups as the number of seats is limited. One task of students participating in these study group is to come up with multiple choice questions that can be used in the earlier mentioned online test. After discussion and vetting by the lecturer, each group will select 3 questions for the weekly sets. As a bonus for their participation, each student in each group will receive a pass for the three questions selected in the meeting. |
| Co-Instructor          | Ing. A. M. J. Slats |
Program for TI students with variant CS

<table>
<thead>
<tr>
<th>Minor Coordinator</th>
<th>Dr.ing. I.E. Lager</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS Program</td>
<td>30</td>
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<tr>
<td>Administration by the</td>
<td></td>
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<tr>
<td>Faculty of</td>
<td></td>
</tr>
<tr>
<td>Administration by the</td>
<td></td>
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<tr>
<td>Education of</td>
<td></td>
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<tr>
<td>Minor Title</td>
<td>Minor Electrical Engineering for Autonomous Exploration Robots</td>
</tr>
<tr>
<td>Contact for Students</td>
<td>Dr.ing. I.E. Lager</td>
</tr>
<tr>
<td>(Minor)</td>
<td></td>
</tr>
<tr>
<td>Intended for</td>
<td>Bachelorstudents Aerospace Engineering, Mechanical Engineering, Marine Technology (i.e. constructing sciences), Applied Sciences and Computer Science</td>
</tr>
<tr>
<td>Gives access to</td>
<td>The minor offers the students a platform for self-assessing their potential to do an Electrical Engineering (EE) MSc. For being admitted to the EE MSc, the students will have to do a number of homologation courses, with &quot;Electromagnetics&quot; (EE3P11, 5 ECTS) being mandatory.</td>
</tr>
<tr>
<td>Expected prior Knowledge</td>
<td>Calculus, Linear Algebra and Physics; Signals and Systems is advisable</td>
</tr>
<tr>
<td>Prerequisites Minor</td>
<td>Calculus, Linear Algebra, elementary BSc physics</td>
</tr>
</tbody>
</table>
| Minor Exit Qualifications| - Students will gain knowledge and skills in the elementary disciplines of Electrical Engineering, and knowledge and skills to analyse and solve electrotechnical problems.  
- Students will become capable to identify electrotechnical aspects in the field of their major and evaluate potential use of various electrotechnical solutions.  
- Students will be prepared for a possible admission to the Master Electrical Engineering. |
| Minor Coherence / Goal  | This minor offers the students a wide range of courses and one integrating project, enabling them to build up insight and adequate instruments (skills) in Electrical Engineering (EE) and apply this knowledge in the students own (major) discipline. The latter goal is further supported by carrying out a (partially open-end) project. It is important to keep in mind that, in view of the ubiquitous presence of EE elements in present day technology, understanding and manipulating basic concepts in this field equips the future specialist with exceptional career prospects. This minor also offers interested students a basis for assessing their potential to do an EE MSc programme. |
| Minor Content 1         | The minor offers a number of courses and one project as follows:  
- ET3033TU, Circuit Analysis (3 ECTS)  
- ET3604LR, Electronic Circuits (3 ECTS)  
- ET3310TU, Telecommunication Techniques (3 ECTS)  
- TI2725-B, Digital Systems (5 ECTS)  
- EE3330TU, Guiding & Radiating (4 ECTS)  
- ET3051TU, Electronic Power Conversion (4 ECTS)  
- ET3052TU, Structured Electronic Design (4 ECTS)  
- ET3039TU, Mars Rover project (4 ECTS)  

The ET3039TU Mars Rover Project is a typical Electrical Engineering project, in which groups of about 4-5 students ultimately realise a robot vehicle (rover) with some form of autonomous behaviour. The project is based on a digitally controlled stepper-motor driven platform. The digital control is created using an on-board Field Programmable Gate Array (FPGA) module (a reconfigurable custom hardware, filling the space between custom chips and programmable computers). The design of an FPGA based system is very similar to the design of chips. The system is to be augmented with a number of sensors, enabling a wide range of functions to be performed, allowing the platform to function as a Mars Rover. The courses in this minor provide the background knowledge in order to carry out this project successfully, and must all be taken for a total of 30 ECTS. |
| NOTE: Depending on the chosen variant, some students in the BSc Computer Science programme may have had the course TI2725-B Digital Systems in their second year education. These students must then replace this course with TI2716-A Signal Processing. With this adjustment, the minor is still construed as Et-Mi-109, EE for autonomous exploration robots (thus NOT a "free minor"). |
| Education Methods       | Lectures, project                      |
| Minor Assessment        | Written and oral exams, reports/presentations |
| Maximum number of       | 200                                     |
| participants            |                                        |
| Minor Remarks / Schedule| All courses and the project in this minor are assessed separately, and must be graded with a 6 or higher.  
The language for all courses, instructions and practical assignments is English. All assessments and reading materials are in English. |
EE3039TU  Marsrover project  4

<table>
<thead>
<tr>
<th>Responsible Instructor</th>
<th>Dr. J. Hoekstra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor</td>
<td>Dr.ir. J.S.S.M. Wong</td>
</tr>
<tr>
<td>Instructor</td>
<td>Dr.ir. G.J.M. Janssen</td>
</tr>
<tr>
<td>Contact Hours / Week</td>
<td>0/x/0/0</td>
</tr>
<tr>
<td>Education Period</td>
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</tr>
<tr>
<td>Start Education</td>
<td>2</td>
</tr>
<tr>
<td>Exam Period</td>
<td>none</td>
</tr>
<tr>
<td>Course Language</td>
<td>English</td>
</tr>
<tr>
<td>Course Contents</td>
<td>In this project a group of 4 or 5 students have the task to develop a Mars Rover. The Mars Rover is based on a simple vehicle that is driven by several electric stepper motors which are controlled by an onboard FPGA. The students have the task to feed the robot with solar energy and to enhance the robot with sensing and localization abilities such that the robot is capable to perform certain predefined tasks. In order to have control over the movement and the sensors the FPGA has to be programmed in VHDL. All the basic knowledge and skills needed for this project are provided by the courses in the minor.</td>
</tr>
<tr>
<td>Study Goals</td>
<td>Applying the knowledge and skills obtained during the courses in the minor</td>
</tr>
<tr>
<td>Education Method</td>
<td>Project in groups of 4/5 students</td>
</tr>
<tr>
<td>Assessment</td>
<td>Delivery of a functional Mars Rover</td>
</tr>
</tbody>
</table>

EE3310TU  Telecommunications Techniques  3

<table>
<thead>
<tr>
<th>Responsible Instructor</th>
<th>Dr.ir. G.J.M. Janssen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact Hours / Week</td>
<td>2/0/0/0 lecture; 2/0/0/0 instruction (3 weeks)</td>
</tr>
<tr>
<td>Education Period</td>
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<tr>
<td>Start Education</td>
<td>1</td>
</tr>
<tr>
<td>Exam Period</td>
<td>2</td>
</tr>
<tr>
<td>Course Language</td>
<td>English</td>
</tr>
<tr>
<td>Expected prior knowledge</td>
<td>Mathematics in general. Some basic knowledge on linear systems and signals, the Fourier transform and stochastic processes, will be an advantage.</td>
</tr>
<tr>
<td>Summary</td>
<td>Transmission and distribution of information by means of telecommunication techniques form the backbone of our modern society. The course Telecommunications Techniques provides mathematical methods to describe and analyse communication systems for the transmission of digital signals.</td>
</tr>
<tr>
<td>Course Contents</td>
<td>In this course, mathematical methods are given to describe and evaluate communication systems for the transmission of digital signals: - decibel notation, - mathematical description of signals and definition of bandwith, - propagation loss in guided and unguided (wireless) media, - noise and system noise calculations (linkbudget), - signal sampling, - analogue pulse modulation (PAM, PCM, Delta-modulation), - digital waveforms in baseband, power density spectrum and spectral efficiency, - lijncodes, - bandpass signals and -systems: complex baseband description, modulation, demodulation, generic transmitter and receiver concepts, - digital modulation techniques (OOK, FSK, BPSK, QPSK, MSK), - matched filtering, - bit error probability after detection of digital signals.</td>
</tr>
<tr>
<td>Study Goals</td>
<td>The student has gained insight in the basic concepts of signal processing for telecommunications, as described under Course Contents, especially those related to the transmission of digital signals, and is able to apply this knowledge by solving related problems by means of calculations.</td>
</tr>
<tr>
<td>Education Method</td>
<td>Lectures, instruction lectures, homework excercises</td>
</tr>
<tr>
<td>Assessment</td>
<td>Written exam (closed book).</td>
</tr>
<tr>
<td>Permitted Materials during Tests</td>
<td>During the exam, the student is allowed to use a non-programmable electronic calculator, the overview Tables and Figures to be used at the exam Telecommunications Techniques (EE3310TU/EE8020) available on the Blackboard page of this course and a hand-written page of equations: 1 page A4, two-sided self-written (no copy and it should not contain worked out exercises or examples).</td>
</tr>
<tr>
<td>Special Information</td>
<td>This course is part of the minor Electrical Engineering for Autonomous Exploration Robots (EE3039TU).</td>
</tr>
<tr>
<td>EE3330TU</td>
<td>Guiding &amp; Radiating</td>
</tr>
<tr>
<td>----------</td>
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</tr>
<tr>
<td><strong>Responsible Instructor</strong></td>
<td>Dr. D. Cavallo</td>
</tr>
<tr>
<td><strong>Contact Hours / Week</strong></td>
<td>0/4/0/0</td>
</tr>
<tr>
<td><strong>Education Period</strong></td>
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<td><strong>Start Education</strong></td>
<td>2</td>
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<tr>
<td><strong>Exam Period</strong></td>
<td>3</td>
</tr>
<tr>
<td><strong>Course Language</strong></td>
<td>English</td>
</tr>
<tr>
<td><strong>Expected prior knowledge</strong></td>
<td>Complex numbers, vector algebra, integration and differentiation.</td>
</tr>
</tbody>
</table>
| **Course Contents** | - Basic electromagnetic concepts (5 lectures)  
- Traveling waves  
- Electrostatics  
- Magnetostatics  
- Time-varying electromagnetic fields  
- Plane waves and Polarization  
- Transmission lines (4 lectures)  
- Theory of transmission lines  
- Characteristic parameters of transmission lines  
- Generator and load mismatch  
- Examples  
- Antennas (4 lectures)  
- Antenna characteristic parameters  
- Short and half-wave dipoles  
- Antenna links  
- Examples |
| **Study Goals** | The students will be able to  
- explain the basic concepts of electromagnetism and describe the properties of electromagnetic waves  
- list and define the antenna and transmission lines characteristic parameters  
- solve transmission lines and plane waves problems  
- solve antenna links and power budget problems |
| **Education Method** | - Lectures through PowerPoint slide projection  
- Practicing sessions with exercises  
- Solution of practical examples with blackboard and slides |
| **Assessment** | - Two intermediate written tests (25% + 25%)  
- Final written exam (50%)  
- Oral exam (optional) |
| **Permitted Materials during Tests** | - An equation sheet will be provided during the tests  
- Calculator is needed |

<table>
<thead>
<tr>
<th>EE3331TU</th>
<th>Structured Electronic Design - Basics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Responsible Instructor</strong></td>
<td>Dr.ir. C.J.M. Verhoeven</td>
</tr>
<tr>
<td><strong>Contact Hours / Week</strong></td>
<td>0/4/0/0</td>
</tr>
<tr>
<td><strong>Education Period</strong></td>
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</tr>
<tr>
<td><strong>Start Education</strong></td>
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</tr>
<tr>
<td><strong>Exam Period</strong></td>
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</tr>
<tr>
<td><strong>Course Language</strong></td>
<td>English</td>
</tr>
<tr>
<td><strong>Course Contents</strong></td>
<td>This course focuses on a systematic approach to the design of analog electronic circuits for non-electrical engineers. The methodology presented in the course is based on the concepts of hierarchy, orthogonality and efficient modelling. It is applied to the design of negative-feedback amplifiers. It is shown that aspects such as ideal transfer; noise performance, distortion and bandwidth can be optimized independently. A systematic approach to biasing completes the discussion. Lectures are interactive and combined with weekly sessions where students can work on exercises under supervision of the professors. After this course the students should be able to effectively communicate with a professional expert analog designers and understand and discuss the design considerations.</td>
</tr>
</tbody>
</table>
| **Study Goals** | After the course a student:  
- Has become familiar with a scientific way to design circuits.  
- Knows the contrast between the standard heuristic methods (familiar but incomprehensible for most of the students) that are mainly based on encyclopaedial experience and a well-structured way that is based on insight  
- Knows the basic principles of a systematic, hierarchical design methodology for analog circuits, using negative feedback amplifiers as an example.  
- Is able to design high performance basic circuits based on insight instead of experience that only builds up after many years of practical work.  
- Can do a bandwidth estimation using the loopgain-poles product  
- Can effectively use nullors to find optimal designs  
- Can do a noise optimization of a negative feedback amplifier  
- Knows how to use a simulator like Spice to verify a circuit design  
- Can use symbolic circuit simulator SluCap for root locus analysis  
- Masters a systematic way to bias analog circuits  
- Is able to select the optimal amplifier topology with respect to source and load  
- Knows the best design order  
- Can estimate and explain the effect of loopgain in a negative feedback amplifier  
- Is able to rank feedback networks based on their performance  
- Is able to estimate the errors when a second-best option has to be chosen for a design because of practical limits |
<p>| <strong>Education Method</strong> | Lectures and instructions |
| <strong>Assessment</strong> | Written exam with open questions |</p>
<table>
<thead>
<tr>
<th>ET3033TU</th>
<th>Circuit Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Responsible Instructor</strong></td>
<td>Dr.ing. I.E. Lager</td>
</tr>
<tr>
<td><strong>Contact Hours / Week</strong></td>
<td>3/0/0</td>
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<td><strong>Education Period</strong></td>
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<td><strong>Start Education</strong></td>
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<tr>
<td><strong>Exam Period</strong></td>
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</tr>
<tr>
<td><strong>Course Language</strong></td>
<td>English</td>
</tr>
<tr>
<td><strong>Expected prior knowledge</strong></td>
<td>The course requires familiarity with handling the complex numbers algebra.</td>
</tr>
</tbody>
</table>
| **Course Contents** | Electrical circuits fundamentals / basic concepts and components: current and charge, voltage and current sources, electrical circuits, circuit symbols, direct current, alternating current, resistors capacitors and inductors, Ohm's law, Kirchhoff's laws, power dissipation in resistors, series and parallel connections. Measurement of voltages and currents: common wave forms, measuring techniques and equipment.
Resistance and DC Circuits: Thévenin and Norton theorems, superposition, nodal analysis, mesh analysis, (solving) circuit equations.
Capacitance and electric fields: capacitors and capacitance, electric field strength and flux density, series and parallel connected capacitors, capacitor I/V relationship, sinusoidal voltage and current, energy stored in a capacitor.
Inductance and Magnetic Fields: electromagnetism, reluctance, inductance, self-inductance, series and parallel connections, inductor I/V relationship, sinusoidal voltage and current, energy stored in an inductor, mutual inductance, transformers.
Alternating voltages and currents: resistance vs. reactance, impedance, phasor diagrams, complex notation.
Power in AC circuits: power dissipation in resistive circuits, power in capacitors and inductors, power in circuits with resistance and reactance, active and reactive power, power factor correction, three phase systems, power measurement.
Frequency characteristics of AC circuits: two-port networks, the decibel, frequency response, filter networks, Bode diagrams, RLC circuits and resonance, stray capacitance and inductance.
Transient behaviour: Charging of capacitors and energising of inductors, discharging and de-energising, first order systems, generalised response, second order systems, higher order systems. |
| **Study Goals** | The course aims at building up insight and analysis instruments in the area of linear electrical circuits and components. It will also establish a solid foundation for understanding, analysing and synthesising electronic circuits using non-linear active components in both the analogue and digital domains. |
| **Education Method** | The education is based on a pitch -> self-study -> solving exercises -> discussion of the solutions cycle; there is a high emphasis on pre-preparation of lectures and self-study. |
| **Assessment** | Homeworks + written exam |
| **Permitted Materials during Tests** | The book not in electronic format! In exceptional cases, the printout of the slides will be permitted. A standard electronic calculator is allowed, graphic calculators being only allowed in exceptional cases. |
| **Judgement** | The final grade is calculated as a weighted average as: Final grade = 0.9 Ex + [( 30  2 Ex ) Hw ] / 100 with Ex being the exam grade (0-10) and Hw the average homework assignments grade (0-10); the final grade is rounded off to 0.5 points. A Hw=0 is accounted for in case no homework assignments are handed in. In case of a resit, the Hw grade obtained during the term remains valid. |
| **maximum aantal deelnemers** | 100 |
**ET3051TU**  |  **Electronic Power Conversion**  |  4

| **Responsible Instructor** | Prof. dr. J.A. Ferreira |
| **Instructor** | Ir. F. Pansier |
| **Contact Hours / Week** | 0/2/0/0 hc |
| **Education Period** | 2 |
| **Start Education** | 2 |
| **Exam Period** | 2 |
| **Course Language** | English |

**Course Contents**

This course is part of the minor and is an introduction to power electronics. First the principles of power conversion with switching circuits are treated as well as main applications of power electronics. Next the basic circuits of power electronics are explained, including ac-dc converters (diode rectifiers), dc-dc converters (non-isolated and isolated) and dc-ac converters (inverters). Related issues such as pulse width modulation, methods of analysis, voltage distortion and power quality are treated in conjunction with the basic circuits. The main principles of operation of most commonly used power semiconductor switches are explained. Finally, the role of power electronics in sustainable energy future, including renewable energy systems and energy efficiency is discussed.

**Study Goals**

To get acquainted with applications of power electronics, to obtain insight in the principles of power electronics, to get an overview of power electronic circuits and be able to select appropriate circuits for specific applications and finally to be able to analyse the circuits. The focus in the course is mainly on analysis.

**Education Method**

- Lectures
- Problem solving sessions

**Literature and Study Materials**


Optional material:

**Assessment**

Written exam (closed book)

**Permitted Materials during Tests**

It is allowed to use one single sided A4 sheet with formulas and figures from the text book ONLY (solutions from previous exams and other material not allowed)
**Electronic Circuits**

<table>
<thead>
<tr>
<th><strong>ET3604LR</strong></th>
<th><strong>Electronic Circuits</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Responsible Instructor</strong></td>
<td>Dr. ir. C. J. M. Verhoeven</td>
</tr>
<tr>
<td><strong>Contact Hours / Week</strong></td>
<td>4/0/0/0</td>
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<tr>
<td><strong>Education Period</strong></td>
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<tr>
<td><strong>Start Education</strong></td>
<td>1</td>
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<tr>
<td><strong>Exam Period</strong></td>
<td>1/2</td>
</tr>
<tr>
<td><strong>Course Language</strong></td>
<td>English</td>
</tr>
<tr>
<td><strong>Parts</strong></td>
<td>Lectures, Lab exercise, In-class assignments</td>
</tr>
<tr>
<td><strong>Major topics:</strong></td>
<td>Electronics in information processing (sensor readout), Design principles and trajectory, Signal processing functions, Electronic design analysis, Negative feedback amplifiers, Operational amplifiers, Components and networks, Semiconductor diodes, Power supplies and voltage regulators, Semiconductor transistors and IC technology (basic), Oscillators, Assembly and measurement techniques (laboratory exercise)</td>
</tr>
<tr>
<td><strong>Special topic:</strong></td>
<td>The design and operation of the DelfiC3 satellite. Working hardware will be demonstrated and the behavior of DelfiC3 in orbit will be discussed. During the lectures DelfiC3 may be used frequently as example.</td>
</tr>
<tr>
<td><strong>Course Contents</strong></td>
<td>The purpose of this course is: to become conversant with the world of electronics and a number of often used comprehensions and technical terms; to get used to information-carrying signals as a time phenomenon and as a spectral phenomenon; to learn about impedances and networks in relation to their signal behaviour; to learn about semiconductor components, such as diodes and transistors and their applications; to get acquainted with signal-processing functions, such as amplification, filtering, switching, multiplication, conversion; to get acquainted with analog electronic circuits and the systems for energy supply of these circuits; to get acquainted with the process of system analysis and synthesis; and finally to get acquainted with construction and measuring techniques, along with the problems that may arise by wrong construction and the interaction with physical and mechanical phenomena. After this course students should also be able to understand the electronic behavior of the DelfiC3 system and be able to read and understand the circuit diagrams.</td>
</tr>
<tr>
<td><strong>Study Goals</strong></td>
<td>To gain insight (in a structured manner) in the function of electronics as information-processing technique in our society; its usefulness in products; modelling and characteristics of components, circuits and systems; to get on speaking terms with electronics designers.</td>
</tr>
<tr>
<td><strong>Education Method</strong></td>
<td>Lecture/Lab exercise</td>
</tr>
<tr>
<td><strong>Literature and Study Materials</strong></td>
<td>Electronics: A Systems Approach Fourth of Fifth Edition (or later)</td>
</tr>
<tr>
<td></td>
<td>Neil Storey</td>
</tr>
<tr>
<td></td>
<td>Published by Prentice Hall</td>
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<tr>
<td></td>
<td>For sale at: Leonardo da Vinci, ETV</td>
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<tr>
<td><strong>Assessment</strong></td>
<td>Written/Lab exercise test</td>
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<tr>
<td><strong>ET3604LRP</strong></td>
<td><strong>Electronic Circuits</strong></td>
</tr>
<tr>
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<tr>
<td><strong>Responsible Instructor</strong></td>
<td>Dr.ir. C.J.M. Verhoeven</td>
</tr>
<tr>
<td><strong>Practical Coordinator</strong></td>
<td>Dr.ir. C.J.M. Verhoeven</td>
</tr>
<tr>
<td><strong>Practical Coordinator</strong></td>
<td>M. Schumacher</td>
</tr>
<tr>
<td><strong>Contact Hours / Week</strong></td>
<td>x/0/0/0</td>
</tr>
<tr>
<td><strong>Education Period</strong></td>
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</tr>
<tr>
<td><strong>Start Education</strong></td>
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<tr>
<td><strong>Exam Period</strong></td>
<td>1, 2</td>
</tr>
<tr>
<td><strong>Course Language</strong></td>
<td>English</td>
</tr>
<tr>
<td><strong>Required for</strong></td>
<td>ET3604LR, this course is accompanied by this laboratory exercise. The result of the written examination will become valid after successful completion of this exercise.</td>
</tr>
<tr>
<td><strong>Expected prior knowledge</strong></td>
<td>Contents of the first weeks of the lectures (amplification)</td>
</tr>
<tr>
<td><strong>Course Contents</strong></td>
<td>The course ET3604LR is accompanied by this laboratory exercise. The result of the written examination will become valid after successful completion of this exercise. You need to prepare yourself by buying and checking out the manual. For any questions related to the practical, contact Martin Schumacher, 015-2781850 or <a href="mailto:m.schumacher@tudelft.nl">m.schumacher@tudelft.nl</a>.</td>
</tr>
<tr>
<td><strong>Study Goals</strong></td>
<td>Learn to use electronic measurement equipment. Have a practical design experience with a circuit containing an operational amplifier.</td>
</tr>
<tr>
<td><strong>Education Method</strong></td>
<td>Two sessions of half a day involving practical work.</td>
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<tr>
<td><strong>Assessment</strong></td>
<td>Assessment is done by the assistants present during the lab. The grade can either be pass or fail.</td>
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<tr>
<td>T12716-A</td>
<td>Signal Processing</td>
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<tr>
<td><strong>Responsible Instructor</strong></td>
<td>Prof.dr.ir. R.L. Lagendijk</td>
</tr>
<tr>
<td><strong>Expected prior knowledge</strong></td>
<td>Calculus: series, integration, complex numbers, complex exponents, Euler's formula. Linear algebra: vector and matrix manipulations. Special attention is asked for complex numbers. Self-check exercises and study material is provided via Blackboard.</td>
</tr>
<tr>
<td><strong>Course Contents</strong></td>
<td>Digital signal processing is used in many modern computer sciences systems and applications. Examples are content recommenders in information systems; speech, music and image content based retrieval and searching; music and video compression; sensor data processing in embedded systems; bioinformatics and medical data analysis. This course deals with the foundations and principles of digital signal processing. The first part concentrates on acquiring digital signals (sampling) and the basic linear filtering operations and convolution. The second part of the course introduces the concept of frequency or Fourier description of signals and systems. This concept is the foundation of many of today's computer science-based systems and applications, and has found wide applications in the processing of a variety of sound, music, sensor, image, video and other multimedia information.</td>
</tr>
<tr>
<td><strong>Study Goals</strong></td>
<td>1. Properties of digital signals and systems. The student is able to explain, compute and apply the properties of time-discrete linear time-invariant systems and the input-output relation; explain and use the principle of superposition; write arbitrary signals in terms of the sum of impulse signals.</td>
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<td>2. Linear time-invariant (LTI) filters and convolution. The student is able to explain, determine and apply the impulse response of a time-discrete LTI system such as FIR or IIR filter; explain the relation between impulse response, input-output relation and convolution; manually (for short signals) or numerically (using Matlab, for long signals) convolve the input signal and the impulse response to compute the output signal; explain and apply the properties of convolution, including the difference between linear and circular convolution; recursively compute the output of an IIR filter; implement and visualize convolution via Matlab; implement and apply FIR filters in practical exercises and assignment, and visualize and interpret the results.</td>
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<td></td>
<td>3. Sampling. The student is able to explain and apply the process of data acquisition (sampling) and Shannon's sampling theorem; explain the concepts of oversampling, undersampling and aliasing; explain how to avoid aliasing; use of zero-order and linear interpolation for the reconstruction of time-continuous signals; make audible (using Matlab) original and processed audio signals and interpret the results.</td>
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<td></td>
<td>4. Discrete Fourier Transform (DFT). The student is able to write a periodic signal as the sum of complex exponentials; explain the concepts and differences of Fourier series, DFT/FT and DFT; explain and interpret the complex spectrum, magnitude spectrum and phase spectrum; compute and visualize manually (for short signals) or numerically (for longer signals) the magnitude and phase of DFT and DFT coefficients, and interpret the results; explain the difference between the numerical results computed using the DFT for finite-length signals and the theoretical results computed using the DTFT/FFT for infinite-length signals; explain the principles of the fast Fourier transform (FFT); apply the DFT and FFT to practical exercises and assignments.</td>
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<td>5. Frequency response of LTI filters. The student is able to compute manually (for short impulse responses) or numerically (for longer impulse responses) the frequency response of an LTI system using DFT/FFT and DFT; visualize and explain the magnitude and phase response of an LTI system; evaluate convolution via product of frequency response of the filter and Fourier transform of the input signal; compute the frequency response of cascaded filters; numerically determine the impulse response of an FIR filter with desired frequency response using the inverse-DFT method.</td>
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<td></td>
<td>6. Applications of filters and DFT. The student is able to apply theory and practice to (simplified) versions of relevant computer science-based signal processing problems and assignments, such as music compression and recognition.</td>
</tr>
<tr>
<td><strong>Education Method</strong></td>
<td>The course consists of - 7 plenary lectures in which the main concepts are explained and discussed; - 7 working group in which theory and practical (Matlab-based) exercises are solved and discussed; - 6 hands-on sessions in which practical (Matlab-based) assignments need to be solved and approved by the instructor.</td>
</tr>
<tr>
<td><strong>Computer Use</strong></td>
<td>The course includes a compulsory set of computer (Matlab-based) assignments that need to be solved and approved by the instructor during the hands-on sessions. Matlab software is pre-installed on the computers available during the hands-on sessions. Students can also install Matlab software on their own computer.</td>
</tr>
<tr>
<td><strong>Literature and Study Materials</strong></td>
<td>The course loosely follows the book ‘Signal Processing First’ James H. McClellan, Ronald W. Schafer and Mark A. Yoder ISBN 0-13-120265-0 Prentice Hall. Alternatively, also on-line material may be used, such as 'The Scientist and Engineering’s Guide to Digital Signal Processing’, S.W. Smith (<a href="http://www">http://www</a> dspguide.com/pdfbook.htm). Slides used during the lectures are made available via Blackboard. Theory and practical exercises, as well as the Matlab assignments are available for download via Blackboard. During the course several pointers to on-line MOOCs and video lectures will be given.</td>
</tr>
<tr>
<td><strong>Permitted Materials during Tests</strong></td>
<td>The lecturers have prepared one page with key equations (formuleblad). This page is permitted during the examination. It is also allowed to make notes on this one printed page.</td>
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<tr>
<td><strong>Enrolment / Application</strong></td>
<td>Enrolment is necessary for both partial examinations. Due to the cut-off dates, students are advised to immediately sign-up for...</td>
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</tbody>
</table>
the first partial examination in week 4. It is not necessary to enroll for the Matlab hand-on assignments.

**Tags**
- Image processing
- Information & Communication
- Mathematics
- Modelling
- Project
- Signals and Systems

**Judgement**
The final grade at the end of the quarter in which the course is lectured is determined as follows.
1. The grade (rounded to one decimal) of the first partial examination counts for 30%.
2. The grade (rounded to one decimal) of the second partial examination counts for 70%.
3. The Matlab hands-on assignments have to be completed and approved by the instructor. The approval of each assignment must be done within the week set for that assignment. In case of unforeseen circumstances (like illness) the instructor can allow for a delay of maximally one week, and only if such approval is obtained at the latest in the week the assignment should have been completed.

Validity of partial examination results and completed Matlab hands-on assignments.
* The results of the partial examinations expire at the end of the quarter in which the course was lectured if the Matlab hands-on assignments have not been completed and approved by the instructor before the second partial examination.
* The completed Matlab hands-on assignments are valid for an entire academic (study) year, but expire at the end of the academic (study) year.

The grade of the resit examination is determined as follows.
1. The grade of the resit examination.
2. The Matlab hands-on assignments completed before the resit examination. Students who had not yet completed the hands-on assignments during the regular sessions are invited to contact the instructor to make a single appointment to verify and approve all (remaining) assignments. These appointments take place in the weeks before the resit examination.

**Self test**
Fourier transforms, DTFT and DFT rely heavily on the description of signals as a sum of complex exponentials. It is important that the student brings operational knowledge of complex numbers (see first years Calculus). A set of self-tests is available as well as self-study materials. Complex exponents are assumed background knowledge and not discussed during the lectures.
<table>
<thead>
<tr>
<th>Name</th>
<th>Unit</th>
<th>Department</th>
<th>Telephone</th>
<th>Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. D. Cavallo</td>
<td>Elektrotechn., Wisk. &amp; Inform.</td>
<td>Tera-Hertz Sensing</td>
<td>+31 15 27 89538</td>
<td>36.LB 01.450</td>
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<tr>
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<td>ESE Programmes</td>
<td>+31 15 27 86220</td>
<td>36.LB 03.500</td>
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<td>+31 15 27 83836</td>
<td>36.LB 01.250</td>
</tr>
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<td>Dr.ir. G.J.M. Janssen</td>
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<td>Circuits and Systems</td>
<td>+31 15 27 86736</td>
<td>36.HB 17.060</td>
</tr>
<tr>
<td>Dr.ing. I.E. Lager</td>
<td>Elektrotechn., Wisk. &amp; Inform.</td>
<td>Electrical Engineering Education</td>
<td>+31 15 27 85591</td>
<td>36.LB 01.410</td>
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<tr>
<td>Ir. F. Pansier</td>
<td>Elektrotechn., Wisk. &amp; Inform.</td>
<td>DC systems, Energy con &amp; Stor</td>
<td>+31 15 27 84231</td>
<td>36.LB 03.820</td>
</tr>
<tr>
<td>M. Schumacher</td>
<td>Elektrotechn., Wisk. &amp; Inform.</td>
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<td>+31 15 27 81850</td>
<td>36.LB 01.271</td>
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<tr>
<td>Dr.ir. C.J.M. Verhoeven</td>
<td>Elektrotechn., Wisk. &amp; Inform.</td>
<td>Elektronica</td>
<td>+31 15 27 86482</td>
<td>36.HB 18.130</td>
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