# Creative Technology module 5a: Smart Technology

## 1. Education

Creative Technology

## 2. Module number and name

Module 5a: Smart Technology

## 3. Module team

- Edwin Dertien - Sensors
- Peter Breedveld - Control Systems
- Geert Folkertsma - Control Systems
- Gjerrit Meinsma - Control Systems
- Cora Salm – Circuits and Electronics
- Erik Faber – Circuits and Electronics
- Mark Bentum - Telecommunications
- Petri de Willigen - Information Specialist
- Paolo Frasca - Systems and Signals
- Erik Faber - Module coordinator

## 4. Description of the content of the module

This module and its counterpart (Module 5b: New Media) are so called “Tool” modules. In order for the CreaTe student to exert his profession some fundamental knowledge of frequently used tools is necessary. The Smart Technology module focuses on providing such tools on an academic basis. The focus in this module is on physical (mostly electrical or mechanical) systems like electronics, telecommunication systems, sensors, controlled systems and the interfacing of such systems to the digital world. In addition signal descriptions in time and frequency domain play an important role, as well as modification, modulation and conversion of signals in time and frequency domain. The treatment of some of the underlying (physical) principles governing such systems will go hand in hand with the treatment on the system level. Practical (lab) skills will play an important role to provide the link between theory and application. In addition, this module contains an individual project which provides the student the opportunity to follow his fascination in technology and deepen his knowledge on a Human-Interface-Device related topic. This focuses on the Smart Technology context in close relation with users. The topics of this module are:

| | | **Instructional format** | | | | |
|---|---|---|---|---|---|---|
| **Topic** | **EC** | Lecture | Tutorial | Lab session | Individual feedback | Self study |
| Project | 2 | x | | | x | x |
| Circuits and Electronics | 2.5 | x | x | x | | x |
| Sensors | 3 | x | x | x | | x |
| Telecommunications | 2 | x | x | x | | x |
| Control Systems | 3 | x | x | x | | x |
| Math: systems and signals | 2 | x | x | | | x |
| Tutoring | 0.5 | | | | x | x |
| Total | 15 | | | | | |

## Relations between the topics and integration

Roughly speaking, the module contains 3 different parts:

1) Project and Portfolio. The project enables the student to follow his fascination in Smart Technology and deepen his knowledge. This project will be a literature based project and not a "make and prototype" project. This project will train the student in the academic skills of doing research. This skill will also come into practice in the final graduation project in year 3 and the consecutive master studies (if any). Via the portfolio topic the student can reflect both on the things learned during the project and during the courses and become conscious of the role and usefulness of Smart Technology related tools in the context of his Creative Technology study and his potential later profession. In principle the following two days have been reserved for the individual and group meetings, respectively. Wednesday afternoon in week 3 (17$^{th}$ of September) has been reserved for individual meetings and Wednesday afternoon in week 6 (8$^{th}$ of October) has been reserved for the group meeting. Of course the tutor has the right to plan additional meetings at other Wednesday afternoons in this quartile.

2) The four Smart Technology related courses. These show strong ties and interconnections towards each other. They serve both the purpose of necessary theory and/or ideas for the project and providing the student with the relevant understanding and mastering of some of the most important concepts, operating principles and theory of present day electronic Smart Technology and Smart Environments. The foundation of Smart Technology is Circuits and Electronics in which the foundation of (passive and active electronic) components and the analysis and operation of basic electric circuits (transients, filtering, amplification, etc.) will be laid down. Sensors is about connecting the physical world to the digital world. Sensors will be treated according to the physical domain in which they operate and will be characterized in practical lab session. The interfacing from analog to digital world also plays a crucial role. Telecommunications provides a basic introduction into the communication aspects of sending and receiving information over short (e.g. in its simplest case via a wire to advanced communication systems like Bluetooth) and long distances (e.g. global communication via satellites). Finally, in the Control Systems course focus will be on modeling (mathematical models, simulation models) of both controlled and uncontrolled systems. Furthermore, the basic principles of simple (e.g. PID) and advanced controllers in both the analog and digital domain will be treated there.

3) The Smart Technology related courses are supported by the mathematics course Systems and Signals. It provides the mathematical foundation for all four ST courses. Topics treated include amongst others: goniometric functions, Fourier series and Fourier Transformation, Laplace Transformation and Complex number theory. The math is integrated as much as possible with the ST courses in order to keep a close relationship between mathematical foundation and the application within the ST context.

## Project

The individual project is about your (re)search towards your own fascination within the context of Smart Technology. Inspiration can arise from projects in year 1, hobbies, things you think that aren't possible but perhaps they are when you have the right knowledge. The Smart Technology context should be framed into a Human Interface Device, i.e. the user should also play a central role in the topic of your fascination. You write a research question based on your fascination. This contains the question you want to research and to answer. The project is about going in depth in this research question using literature study. In a literature study you investigate what other scientists have found and achieved regarding your topic. A literature study is useful to know what has been done and investigated so far regarding your question so you don't have to invent the wheel from the beginning. This is an academic skill which will be trained in this module and which will be very useful for your final BSc assignment and future (academic) career. Finally, the student can report his findings both in a written report and via a poster presentation.

Four phases can be distinguished in this project:

Phase 1: Find own fascination and formulate a research question based on this. The research question will be checked and approved by an academic staff member. This phase will take place in weeks 1 – 4.

Phase 2: find a relevant set of key-words in order to perform the literature survey; perform a literature survey and select 3 relevant scientific papers/articles and discuss and summarise this in a report (part 1 of the report). This will be done in close collaboration with the faculty's information specialist.

Phase 3: relate the findings to the research question and based on this come up with new ideas concerning the product, service, idea, concept, etc. in the research question (part 2 of the report).

Phase 4: All findings will be presented both via a written report and via a poster presentation. The poster presentations will be a joint session with the New Media students.

Guidance throughout the project phase will be offered by one academic staff member who is allocated to the student based on his research question. In addition guidance will be offered by the information specialist in phase 2 of the project.

### Project learning goals

At the end of this project the student can:

1. Formulate a research question for a product, idea, service based on his/her fascination in the context of a Human Interface Device, i.e. Smart Technology context in close relation with human beings (users or clients).
2. Perform a scientific literature research based on his knowledge of all necessary steps in the execution of such research.
3. Deliver a small-scale, defined literature research
    a. On the basis of key-words related to the research question, search systematically in the scientific literature
    b. Can select 3 relevant papers or articles from this search
    c. Can summarise those selected papers in a scientific report
    d. Can perform a relevant discussion based on the findings of the literature survey and the research question and draw relevant conclusions (internal consistency)
4. Come to new ideas for products, services, inventions, etc. based on his/her insights from the literature research. These new ideas are related to the own fascination and research question.
5. Present his findings both via a written report and via a poster presentation for his/her fellow students and lecturers.

## 5. Learning goals of the module and study load of each of the learning goals

The table below shows the topics in the Smart Technology module and their relation with the previous years when Smart Technology was a 15EC track.

| Topic | Part of ST track in 2012 – 2013? | EC old | EC in ST module |
|---|---|---|---|
| Intro to Electronics | Yes | 4 | 2.5 |
| Sensors | Yes | 4 | 3 |
| Intro Telecom | Yes | 2 | 2 |
| Networks and Protocols | Yes (will move to module 8) | 2 | 0 |
| Control Systems | Yes | 3 | 3 |
| Systems and Signals | No (was separate course in Y2) | 3 | 2 |
| Creative Exploration of Art Science and Technology | No (was individual project in Y2) | 2 | 2 |
| Tutoring | No (was part of individual course in Y2) | 0.5 | 0.5 |
| Total | | 20.5 | 15 |

Some of the courses have decreased in EC study load. This has been mostly done by reducing the amount of topics treated in these courses. Some of the removed parts will be offered as selectable specialisation topics of Smart Technology in module 8.

The learning goals of this module are:

| Nr. | Learning Goal | Total EC load in module |
|---|---|---|
| 1 | Based on his/her fascination in the Smart Technology context, can do a scientific literature review in order to obtain deeper scientific insight in his/her topic of investigation so that he/she is able to produce new ideas, services or products | 2 |
| 2 | Characterise AC and DC electric networks (using complex numbers) | 1.1 |
| 3 | Characterise resistive, capacitive, magnetic, acoustic and optical sensors | 1.3 |
| 4 | understand mathematical description of (electrical) signals and noise and understand Transport and conversion principles and systems in various fields of applications | 3.2 |
| 5 | Model 1st and 2nd order electrical systems in the time and frequency domain | 1.2 |
| 6 | Model dynamical systems using various methods and representations | 2.5 |
| 7 | Design and build analog controllers using blocks and functions from analog electronics | 0.7 |
| 8 | Understand advantages and disadvantages of digital and advanced control principles | 0.5 |
| 9 | Perform all necessary steps in laboratory work: building, measuring, analysing electronic circuits; discuss the results and draw conclusions; provide a written representation either in a measurement report or in a log book | 2 |
| 10 | Reflect about the importance of smart technology in his/her future profession as a creative technologist | 0.5 |
| | Total | 15.0 |

## 6. Educational formats within the module

The primary formats in which education is provided in this module are lectures, tutorials, lab sessions, project hours and tutoring. The division of educational formats over the week is given below:

| Week | Lectures | Tutorials | Labs | Self study | Tutoring |
|---|---|---|---|---|---|
| 1 | 16 | 2 | 8 | 0 | 2 |
| 2 | 12 | 4 | 4 | 4 | 2 |
| 3 | 12 | 4 | 8 | 2 | 2 |
| 4 | 12 | 6 | 4 | 4 | 2 |
| 5 | 10 | 4 | 8 | 6 | 2 |
| 6 | 12 | 10 | 4 | 8 | 2 |
| 7 | 8 | 6 | 0 | 6 | 2 |
| 8 | 6 | 2 | 12 | 16 | 2 |
| 9 | 4 | 4 | 0 | 16 | 2 |
| Total | 92 | 42 | 48 | 62 | 18 |

[DISCLAIMER: Lecturers and coordinators have done their utmost best to compile a well integrated, consistent and coherent module. Since this is the first time that this module will be implemented and carried out, the lecturers and coordinators reserve the right to change the schedule during the module if this proves to be in the best interest of both students and lecturers]

Below is the table that shows the amount of hours per course given the EC load of the course (1EC is 28 hours) and the hours that have been scheduled.

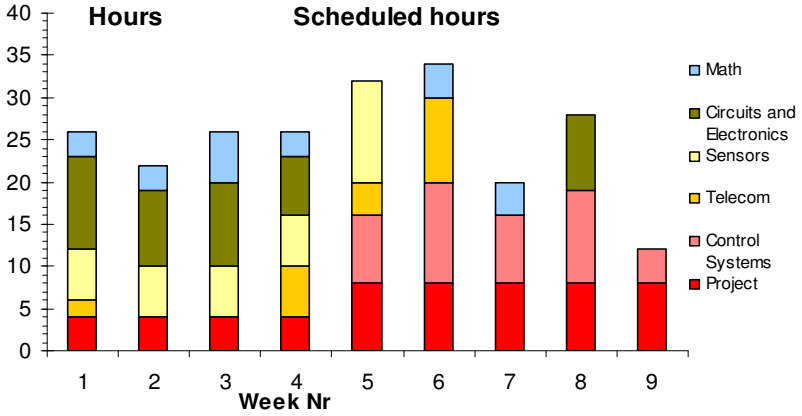
| Topic | EC | EC in hours | Hours in schedule |
|---|---|---|---|
| Project | 2 | 56 | 74 |
| Circuits and Electronics | 2.5 | 70 | 46 |
| Sensors | 3 | 84 | 36 |
| Telecommunications | 2 | 56 | 22 |
| Control Systems | 3 | 84 | 43 |
| Math: systems and signals | 2 | 56 | 23 |
| Tutoring | 0.5 | 14 | 18 |
| Total | 15 | 420 | 262 |

The total module has a study load of 15EC which amounts 15 EC · 28 hours/EC = 420 hours of work. 262 hours have been scheduled. The remaining hours (158 hours) are meant for self-study and (preparation of) tests.

### Week to week schedule

The schedule will differ significantly per week since the basis for the schedule is the learning goals and related topics. Topics per week have been clustered as much as possible in order to offer well integrated and coherent parts of theory and laboratory practices.

The scheduled hours per week per course are given in the table below.




Systems and Signals (Math) and Circuits and Electronics are foundation courses within Smart Tech. and are mainly scheduled in the beginning weeks 1-4. Sensors seamlessly incorporates the knowledge of these courses and connects it to the theory and practice of various sensors in weeks 1-5. Telecommunications will be mainly scheduled in weeks 4 - 6. Control systems will be mainly scheduled in the second part (weeks 5 – 9) of the module. The project has been scheduled for 4 hours of self-study per week in weeks 1-4 and 8 hours per week in weeks 5-8. Weeks 9 and 10 are scheduled for testing and final presentation of the project.

The total schedule of this module is given below (note: always check the online schedule since the schedule is subject to change).

| 14-15 | Module 5a: Smart Tech | | | semester 1 | Quartile 1 | 26 Jun 2014 0:00 | | | | 1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
| | 1 Sep 2014 | 8 Sep 2014 | 15 Sep 2014 | 22 Sep 2014 | 29 Sep 2014 | 6 Oct 2014 | 13 Oct 2014 | 20 Oct 2014 | 27 Oct 2014 | 3 Nov 2014 |
| | 1 | | TESTS | TESTS | TESTS | TESTS | TESTS | TESTS | TESTS | 8:45 |
| | 2 | | TESTS | TESTS | TESTS | TESTS | TESTS | TESTS | TESTS | 10:30 |
| | 3 Kick off College | Project Inf.Spec L | Sys&Sign3 (2ndO) | Sys&sign5 (Sign f,t) | Project L | Control1 L | Project L | C&E11 (id opamp) | Control7 L | 10:45 |
| | 4 NM en ST | Project Inf.Spec L | Sys&Sign3 (2ndO) | Sys&sign5 (Sign f,t) | Project L | Control1 L | Project L | C&E11 (id opamp) | Control7 L | 12:30 |
| Mo | 6 Project HC | C&E4 (C&L) | C&E7 (2nd step) | C&E9 (2nd Fil) | Project (self st) | Control1 T | Project (self st) | Control6 L | Control7 T | 13:45 Mo |
| | 7 Project HC | C&E4 (C&L) | C&E7 (2nd step) | C&E9 (2nd Fil) | Project (self st) | Control1 T | Project (self st) | Control6 L | Control7 T | 15:30 |
| | 8 C&E1 (Ohm) | C&E5 (1st step) | | | Project (self st) | Telecom5 | Project (self st) | | | 15:45 |
| | 9 C&E1 (Ohm) | C&E5 (1st step) | | | Project (self st) | Telecom5 | Project (self st) | | | 17:30 |
| | 2 Sep 2014 | 8 Sep 2014 | 16 Sep 2014 | 23 Sep 2014 | 30 Sep 2014 | 7 Oct 2014 | 14 Oct 2014 | 21 Oct 2014 | 28 Oct 2014 | 4 Nov 2014 |
| | 1 Sensors1 L (Res) | Sens2 L (Cap) | Sys&Sign3 T / C&E | Sys&Sign5 T / C&E | Sens5 L (ADDA) | | | | Lab Resit | 8:45 |
| | 2 Sensors1 L (Res) | Sens2 L (Cap) | Sys&Sign3 T / C&E | Sys&Sign5 T / C&E | Sens5 L (ADDA) | | | | Lab Resit | 10:30 |
| | 3 C&E2 (superpos) | C&E T | Sens3 L (Magn) | Telecom2 | Telecom4 | Sys&Sing6 (Lapl) | Sys&Sing7 (Lapl) | C&E/Control T | Lab Resit | 10:45 |
| | 4 C&E Tut | C&E T | Sens3 L (Magn) | Telecom2 | Telecom4 | Sys&Sing6 (Lapl) | Sys&Sing7 (Lapl) | C&E/Control T | Lab Resit | 12:30 |
| Tue | 6 Sens1 lab (6-9) | Sens2 Lab | Sens3 Lab | C&E / Telecom T | Sens5 Lab | Telecom Lab? | Control 4 L | C&E Lab (Opamp) | Control 8 L | 13:45 Tue |
| | 7 Sens 1 lab (6-9) | Sens2 Lab | Sens3 Lab | C&E / Telecom T | Sens5 Lab | Telecom Lab? | Control4 L | C&E Lab (Opamp) | Control 8 L | 15:30 |
| | 8 Vrijhof lab (6-9) | Sens2 Lab | Sens3 Lab | | Sens5 Lab | Telecom Lab? | Control 4 T | C&E Lab (Opamp) | Control 8 T | 15:45 |
| | 9 Vrijhof lab (6-9) | Sens2 Lab | Sens3 Lab | | Sens5 Lab | Telecom Lab? | Control4 T | C&E Lab (Opamp) | Control 8 T | 17:30 |
| | 3 Sep 2014 | 10 Sep 2014 | 17 Sep 2014 | 24 Sep 2014 | 1 Oct 2014 | 8 Oct 2014 | 15 Oct 2014 | 22 Oct 2014 | 29 Oct 2014 | 5 Nov 2014 |
| | 1 Sens1 lab (1-4) | Project guest L | | | | Control2 L | | | Project (self st) | Project presentation 8:45 |
| | 2 Sens1 lab (1-4) | Project guest L | | | | Control2 L | | | Project (self st) | Project presentation 10:30 |
| | 3 Vrijhof lab (1-4) | Sys&sign2 (CN) | Sys&sign4 (LTI) | C&E10 (diode,FET) | Telecom T | Control2 T | | C&E12 (Non Id Opam | Project (self st) | Project presentation 10:45 |
| | 4 Vrijhof lab (1-4) | Sys&sign2 (CN) | Sys&sign4 (LTI) | C&E10 (diode,FET) | Telecom T | Control2 T | | C&E12 (Non Id Opam | Project (self st) | Project presentation 12:30 |
| Wed | 6 Tutoring (6-9) | Tutoring (6-9) | Project FormResQ | Project chk ResQ | Tutoring (6-9) | Tutoring (6-9) | Tutoring (6-9) | Tutoring (6-9) | Tutoring (6-9) | Project presentation 13:45 Wed |
| | 7 Tutoring (6-9) | Tutoring (6-9) | Project FormResQ | Project chk ResQ | Tutoring (6-9) | Tutoring (6-9) | Tutoring (6-9) | Tutoring (6-9) | Tutoring (6-9) | Project presentation 15:30 |
| | 8 Vrijhof lab (6-9) | Project Self (6-9) | Project FormResQ | Project chk ResQ | Project Self (6-9) | Project Self (6-9) | Project Self (6-9) | Project self (6-9) | Project self (6-9) | Project presentation 15:45 |
| | 9 Vrijhof lab (6-9) | Project Self (6-9) | Project FormResQ | Project chk ResQ | Project Self (6-9) | Project Self (6-9) | Project Self (6-9) | Project self (6-9) | Project self (6-9) | Project presentation 17:30 |
| | 4 Sep 2014 | 11 Sep 2014 | 18 Sep 2014 | 25 Sep 2014 | 2 Oct 2014 | 9 Oct 2014 | 16 Oct 2014 | 23 Oct 2014 | 30 Oct 2014 | 6 Nov 2014 |
| | 1 | C&E6 (com imp) | C&E Lab (2nd O) | Sens4 L (Acou) | Sens6 L (opt) | Telecom 6 | Project (self st) | Control lab (PID) | Project (self st) | 8:45 |
| | 2 | C&E6 (com imp) | C&E Lab (2nd O) | Sens4 L (Acou) | Sens6 L (opt) | Telecom 6 | Project (self st) | Control lab (PID) | Project (self st) | 10:30 |
| | 3 Sys&Sign1 | Sys&Sign2 T / C&E | C&E Lab (2nd O) | Telecom3 | Multiport&Matrix L | Telecom T | Project (self st) | Control lab (PID) | Project (self st) | 10:45 |
| | 4 Sys&Sign1 | Sys&Sign2 T / C&E | C&E Lab (2nd O) | Telecom3 | Multiport&Matrix L | Telecom T | Project (self st) | Control lab (PID) | Project (self st) | 12:30 |
| Thu | 6 C&E3 (signals) | Self St. / GOGBOT | C&E8 (1st Fil) | Sens4 Lab | Sens6 Lab | Control3 L | Control5 L | Control lab (PID) | Project (self st) | 13:45 Thu |
| | 7 C&E3 (signals) | Self St. / GOGBOT | C&E8 (1st Fil) | Sens4 Lab | Sens6 Lab | Control3 L | Control5 L | Control lab (PID) | Project (self st) | 15:30 |
| | 8 Telecom1 | Self St. / GOGBOT | | Sens4 Lab | Sens6 Lab | Control3 T | Control5 T | Control lab (PID) | Project (self st) | 15:45 |
| | 9 Telecom1 | Self St. / GOGBOT | | Sens4 Lab | Sens6 Lab | Control3 T | Control5 T | Control lab (PID) | Project (self st) | 17:30 |
| | 5 Sep 2014 | 12 Sep 2014 | 19 Sep 2014 | 26 Sep 2014 | 3 Oct 2014 | 10 Oct 2014 | 17 Oct 2014 | 24 Oct 2014 | 31 Oct 2014 | 7 Nov 2014 |
| | 1 | Self St. / GOGBOT | Test Peer review | Test Peer review | Test Peer review | Test Peer review | Test Peer review | Test Peer review | Test Peer review | Final Resit 8:45 |
| | 2 | Self St. / GOGBOT | Test Peer review | Test Peer review | Test Peer review | Test Peer review | Test Peer review | Test Peer review | Test Peer review | Final Resit 10:30 |
| | 3 Sys&Sign1 T /C&E | Self St. / GOGBOT | Sys&Sign4 T / C&E | C&E / Telecom T | Multiport& Matrix T | Sys&Sign6 T / Cont | Sys&Sign7 T / Cont | | | Final Resit 10:45 |
| | 4 Sys&Sign1 T /C&E | Self St. / GOGBOT | Sys&Sign4 T / C&E | C&E / Telecom T | Multiport& Matrix T | Sys&Sign6 T / Cont | Sys&Sign7 T / Cont | | | Final Resit 12:30 |
| Fri | 6 Project guest L | Self St. / GOGBOT | Project guest L | Test Resit | Test Resit | Test Resit | Test Resit | Test Resit | Test Resit | 13:45 Fri |
| | 7 Project guest L | Self St. / GOGBOT | Project guest L | Test Resit | Test Resit | Test Resit | Test Resit | Test Resit | Test Resit | 15:30 |
| | 8 | Self St. / GOGBOT | | | | | | | | 15:45 |
| | 9 | Self St. / GOGBOT | | | | | | | | 17:30 |

## 7. Course descriptions of the components

*General introduction on the Smart Technology module*

Since the start of the information technology about 50 years ago the world we live in shows a higher complexity and functionality. At first all artificial intelligence was isolated to our personal computers or other complex (and often expensive) devices. Nowadays also simple and cheap devices in our daily environments evolve rapidly in the sense that they become more versatile and more intelligent or "smarter". A product or functional space is not anymore invented for a sole purpose but shows multifaceted interaction with users and other (sub)systems. These "smarter" environments and products all have in common that in order to operate properly at such high complexity they:

1. Contain electronic circuitry for signal processing such as: filtering, signal or power conversions, amplification, etc.,
2. sense or measure physical quantities in their environment and have an effect on the environment or user,
3. communicate within subsystems of the device or between devices over short or long distances,
4. contain intelligent software or hardware (in so called embedded systems) in which the sensory information is used for steering towards optimal and desired behavior.

The Smart Technology course aims at supplying the right balance between theory and practice on the technological side of smart products and smart environments. It trains students in the engineering skills and attitude necessary for developing, understanding, testing and prototyping Smart Products. This course consists of four topics or building blocks of a smart product:

*The project*

The project description is provided in chapter 4.

*Circuits and Electronics*

electronic components and the functions engineered with them are fundamental in every smart product. This block trains basic understanding of electronic components (resistor, capacitor, inductor, transistor, IC etc) and their applications in electronic networks, filters, amplifiers, converters, etc. Moreover, basics in signal analysis in the time and frequency domain and in the analog and digital domain are treated here.

*Sensors*

To make products smart or 'aware', they need to get input from users or their environment, typically using sensors. Various sensing domains (locative, environmental, bio) are explained and various sensing principles (resistive, capacitive, magnetic, optical, ultrasonic) are treated. All necessary steps in a given sensing system (sensing, conditioning, conversion, interpreting) are explained and necessary tools (periodic/aperiodic signals, ADC design, (instrumentation) amplifiers, conditioning circuits) are deployed, aimed at embedded system design.

*Introduction to Telecommunication*

Every product needs to communicate. The focus here is on the interaction between technical subsystems (e.g. ,a phone that connects to a satellite for sending and receiving the speech information or text). In most cases, signals cannot be transmitted straight forward but need a modulation in order to be transmitted over certain media. This requires knowledge on signal analysis and on signal modulation and demodulation techniques. Moreover,

understanding of influence of media properties (e.g., coax, glass fibre, air etc.) on signal transport and how to influence them are fundamental in every smart product and are treated here.

*Control Systems*

Most smart products need to do something in our world. Think of products like a 3D printer, balancing scooter (segway) or a quadcopter (drone). They need to deploy actuators and be able to control them, either autonomously or with intervention of the user. Control Systems deals with both aspects of control. Describing and modelling dynamic behaviour and designing and realizing control methods. Classical feedback control (PID, root locus design) is treated in depth. Finally an insight is given in more complex control strategies (Fuzzy, Neural networks, MiMO).

*Systems and Signals (Math)*

The main goal of the course is to introduce the student to some concepts from the mathematical theory of signals and systems, which are relevant in the understanding of modern smart technologies and are needed in other courses such as control systems and telecommunications.

*Tutoring*

Creative Technology emphasizes that students should take their own responsibility for setting and reaching the ambitions for their future. Creative Technology students are self-directing learners. They collect their progress in a portfolio. They start in the first year and continue in the second and third year. The portfolio is a proof of long term development as a "Creative Technologist." Tutors assist students in their self-directed learning. Students and tutors use the Creative Technology Tutoring Syllabus ("The road to the final qualifications of a Creative Technology graduate") as a guideline for setting goals and monitoring progress towards reaching those goals. Together with the tutor and their peers students select competencies that fit the ambitions of their future career. Together they look for ways to achieve these ambitions.

### Study Studiemateriaal

*Books*

- Neil Storey, "Electronics, a systems approach", 5th edition, Pearson Education, Inc, **2013**. ISBN-13: 9780273773276, ISBN-10: 0273773275. Book for Circuits and Electronics and reference book for the complete Smart Technology module.
- S. Haykin and M. Moher, "Introduction to Analog and Digital Communications". Book for Intro to Telecommunications.
- Job van Amerongen, "Dynamical Systems for Creative Technology", 2nd edition, Enschede, **2011**. Book for Control Systems and reference book for the complete Smart Technology module.
- Rob van Tulder, "Skill Sheets", 2nd edition, Pearson Benelux B.V., **2012**. ISBN-13: 9789043023139, ISBN-10: 9043023132. Book on academic skills needed for year 2 and 3.

*Readers etc.*

- Reader: "Circuits and Electronics " (available via pdf)
- Reader: "Sensors" (available via pdf)
- Reader(s): "Control Systems" (available via pdf)
- Toolkit: "Arduino starter kit". Available as 'Create ProtoBox' at the STORES
- Sheets and handouts with assignments

## 8. Assesment and assesment criteria

The components of this module are:

1. The project
2. The four ST theory supplying courses: circuits and Electronics, Sensors, Intro to Telecommunicatons and Control Systems; and the supporting math course: systems and signals.
3. Tutoring

The project and tutoring are individually graded. The theory supplying courses, however, are assessed via integral tests. The module learning goals form the basis for this. The module learning goals, their respective weight in ECs and the contributions of the courses to the respective learning goals are given below in the table.

| Nr. | Learning Goal | Learning goal level (tax. Bloom) | Learning goald finished in week | Total EC load in module | Project | Circuits and Electronics | Sensors | Telecom | Control Systems | Systems and Signals | Portfolio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | based on his/her fascination in the Smart Technology context, can do a scientific literature review in order to obtain deeper scientific insight in his/her topic of investigation so that he/she is able to produce new ideas, services or products | 5 | 10 | 2 | 100% 2EC | | | | | | |
| 2 | characterise AC and DC electric networks (using complex numbers) | 4 | 2 | 1.1 | | 72% 0.8EC | | | | 28% 0.3EC | |
| 3 | Charcterise resistive, capacitive, magnetic, acoustic and optical sensors | 4 | 5 | 1.3 | | | 100% 1.3EC | | | | |
| 4 | understand mathematical description of (electrical) signals and noise and understand transport and conversion principles and systems in various fields of applications | 4 | 6 | 3.3 | | 6% 0.2EC | 15% 0.5EC | 61% 2EC | | 18% 0.6EC | |
| 5 | model 1st and 2nd order electrical systems in the time and frequency domain | 4/5 | 4 | 1.2 | | 50% 0.6EC | | | | 50% 0.6EC | |
| 6 | model dynamical systems using various methods and representations | 4 | 7 | 2.5 | | | | | 76% 1.9EC | 24% 0.6EC | |
| 7 | design and build analog controllers using blocks and functions from analog electronics | 5/6 | 8 | 0.7 | | 70% 0.5EC | | | 30% 0.2EC | | |
| 8 | understand advantages and disadvantages of digital and advanced control principles | 2 | 9 | 0.5 | | | | | 100% 0.5EC | | |
| 9 | Perform all necessary steps in laboratory work: building, measuring, analysing electronic circuits; discuss the results and draw conclusions; provide a written representation either in a measruement report or in a log book | 6 | 8 | 2 | | 20% 0.4EC | 60% 1.2EC | | 20% 0.4EC | | |
| 10 | reflect about the importance of smart technology in his/her future profession as a creative technologist | 6 | 10 | 0.5 | | | | | | | 100% 0.5EC |
| | | | | | | | | | | | |
| | | | | 15.1 | | 2.50 | 3.00 | 2.00 | 3.00 | 2.10 | |

In the column right to the learning goals the learning goal level is indicated according to the taxonomy of Bloom with 1 being the lowest level and 6 the highest level. The next column shows in which week the specific learning goals is finished.

Learning goals 1 and 10 belong totally to the project and tutoring, respectively. They are finished in week 10.

Learning goal 9 belongs to the lab and practical skills in the module and is finished in week 8.

Learning goals 2-8 belong to the theoretical components of this module and are assessed via written tests per learning goal. This is called “integral testing”. Traditionally, each course had its own tests. Instead, test will now be about the learning goals and as can be seen in the table above multiple courses can contribute to a learning goal. The module coordinator will coordinate the compilation of all tests. The test scheme will look as the table below.

| Week | Test on learning goal | EC load | Cum. EC load | Resit on learning goal |
|---|---|---|---|---|
| 1 | - | - | 0 | - |
| 2 | - | - | 0 | - |
| 3 | 2 | 1.1 | 1.1 | - |
| 4 | - | - | 1.1 | 2 |
| 5 | 5 | 1.2 | 2.3 | - |
| 6 | 3 | 1.3 | 3.6 | 5 |
| 7 | 4 | 3.2 | 6.8 | 3 |
| 8 | 6 | 2.5 | 9.3 | 4 |
| 9 | 7,8 | 1.2 | 10.5 | 6 |
| 10 | 9 (lab) + 1,10 | 2 + 2.5 | 15.0 | 7,8 |

To summarise: Learning goal 1 is the project and is assessed via a written report and poster presentation. Learning goal 10 is the portfolio and is assessed by the tutor both on update of the student's portfolio and on a self reflection essay of the student. Learning goal 9 is the lab session and is assessed via lab journals and/or lab reports. Learning goals 2-8 are tested via written tests; a total of 6 written tests are proposed.

For each written test a resit is scheduled two weeks after the first attempt. The Friday in the same week as the test is a peer review session of the test. This peer review session is mandatory in order to participate in the resit. In case one or more tests have not been sufficient yet a final resit on the last day of the module is scheduled. This will cover the complete material of the module.

| Test | Week | Resit end of week | Learning Goals | Learning Goal specification |
|---|---|---|---|---|
| 1 | 3 | 4 | 2 | Characterise AC and DC electric networks (using complex numbers) |
| 2 | 5 | 6 | 5 | model 1st and 2nd order electrical systems in the time and frequency domain |
| 3 | 6 | 7 | 3 | Charcterise resistive, capacitive, magnetic, acoustic and optical sensors |
| 4 | 7 | 8 | 4 | understand mathematical description of (electrical) signals and noise and understand transport and conversion principles and systems in various fields of applications |
| 5 | 8 | 9 | 6 | model dynamical systems using various methods and representations |
| 6 | 9 | 10 (Monday) | 7,8 | design and build analog controllers using blocks and functions from analog electronics + understand advantages and disadvantages of digital and advanced control principles |
| Lab | 10 | | 9 | Perform all necessary steps in laboratory work: building, measuring, analysing electronic circuits; discuss the results and draw conclusions; provide a written representation either in a measruement report or in a log book |
| Project | 10 | | 1 | based on his/her fascination in the Smart Technology context, can do a scientific literature review in order to obtain deeper scientific insight in his/her topic of investigation so that he/she is able to produce new ideas, services or products |
| Portfolio | 10 | | 10 | reflect about the importance of smart technology in his/her future profession as a creative technologist |

## Grading

**Lab sessions**

For the lab session the following grading criteria applies. There are 10 lab session (2 Circuits and Electronics + 1 Vrijhof Audio lab, 5 Sensors, 1 Telecom and 1 Control Systems). A lab session can be documented either in a lab

journal or in a measurement report. Each lab session will be grades with a numerical mark 1-10. Exception is the Vrijhof Audiolab which will be graded with a Pass or Fail. The average of the 9 lab sessions (excluding the Vrijhof lab) should be a 5.5. The minimum grade per lab should be at least a 4.0. The criteria for grading will be based for 50% on the structure of the lab journal or report and for 50% on the content (completeness, correctness, consistency). One resit will be offered for a lab session in week 9.

**Theory**

There will be 6 written tests. The minimum grade for each test should be at least 5.0. For each written test a resit is scheduled two weeks after the first attempt. The Friday in the same week as the test is a peer review session of the test. This peer review session is mandatory in order to participate in the resit. In case one or more tests have not been sufficient yet, a final resit on the last day of the module is scheduled (a third attempt). This will cover the complete material of the module.

**Project + Portfolio/tutoring**

The project will be graded on the written report and the poster presentation. It will be combined with the grading of the portfolio course as these two fit well together in this module (see project manual module 5).

The portfolio will be graded on the following criteria: active participation in both the individual and group tutor meetings; a representative update of the portfolio at the end of the quartile; contribution in the group meeting on the poster presentation session. In principle the following two days have been reserved for the individual and group meetings, respectively. Wednesday afternoon in week 3 (17$^{th}$ of September) has been reserved for individual meetings and Wednesday afternoon in week 6 (8$^{th}$ of October) has been reserved for the group meeting. Of course the tutor has the right to plan additional meetings at other Wednesday afternoons in this quartile.

Since project and portfolio make up 2.5EC (2EC and 0.5EC, respectively) of the total module the following division has been made: Project written report = 60%, project poster presentation = 20% and portfolio = 20%. Both project and portfolio are graded via “rubrics” and numerical grades rounded to one decimal will be given for each component.

**Module grade**

The overall grade of the module will be based on the weighted average of the 6 tests, the final lab grade and the grade for the combined project+portfolio. The weighing factors of each component are their respective study (EC) load as indicated in the table on page 9. The minimum grade for passing the Smart Technology module and obtain 15EC is a 5.5 under the condition that all the minimum grade requirements have been met (see the table below).

The minimum grades for the individual components are:

| Topic | Learning Goals | Minimum grade | Weight in module (%) |
|---|---|---|---|
| Theory test 1 (written) | 2 | 5.0 | 7 |
| Theory test 2 (written) | 5 | 5.0 | 8 |
| Theory test 3 (written) | 3 | 5.0 | 8 |
| Theory test 4 (written) | 4 | 5.0 | 22 |
| Theory test 5 (written) | 6 | 5.0 | 17 |
| Theory test 6 (written) | 7 + 8 | 5.0 | 8 |
| Lab grade | 9 | 5.5 | 13 |
| Project + portfolio | 1 + 10 | 5.5 | 17 |

All topics will have grades rounded to 1 decimal. The module average will be determined using these unrounded grades and their respective weight.

## 9. Evaluation plan

Formal evaluation of this module will be done by:

- The CreaTe Evaluation Committee (CREEC). They will organize three times a panel discussion with a group of participating students in this module. Two evaluations will be done during the module and the final one is after the module has finished.

- There will be a formal UT questionnaire at the end of the module.

Informal evaluation will be done by the teachers in this module. Half-way the module a written questionnaire will be planned accompanied with individual talks with the students.