Programme syllabus

Master's Programme, Embedded Systems, 120 credits
Masterprogram, inbyggda system
120.0 credits

Valid for students admitted to the education from autumn 15 (HT - Autumn term; VT - Spring term).

This is a translation of the Swedish, legally binding, programme syllabus.

Programme objectives

Embedded Systems is the most common form of computer systems, i.e., those that are built into machines, devices and power and manufacturing plants, and therefore is not perceived as a computer system. Today, around 98% of all manufactured processors are used in embedded systems application, from sewing machines, to respirators, TV, power consumption measurement equipment and satellites. The common denominator for these embedded systems is high demands on functionality and reliability. The embedded systems are often real-time systems in the sense that they closely interact with the surrounding world that they control.

The enormous price/performance development for electronics coupled with the flexibility and programmability that the technology brings, means that new products and new functionalities in existing products are strongly increasing. This conveys large opportunities for innovation, company development and new enterprises.

The industry is at the same time experiencing severe problems with sustaining competence within the area and is also facing large challenges in managing the integration of software and hardware, to define suitable system architectures and to verify the products.

The purpose of the Master program is to give a broad education within Embedded Systems with a possibility to enter deeply and specialize within the areas (Embedded Electronics, Embedded Platforms, Embedded Software, and Embedded Control) covering theoretical as well as practical aspects for development of products based on Embedded Systems. Special weight is put on engineering skills, integration of software and hardware, system design, integration and verification, and the management of the design process.

Knowledge and understanding

Upon successful completion of the program the students shall

- Be able to design and evaluate the properties of an Embedded System.
- Have good knowledge of current research and development and industrial trends.
- Have good knowledge of processes, methods, and tools for development of Embedded Systems.
- Have a good foundation in Natural and Technical Science with a deepened understanding on an advanced level in one of the profiles of the program.

Skills and abilities

Upon successful completion of the program the students will be able to

- Show an ability that with a holistic approach be able to integrate knowledge, in an independent way and with a critical eye, identify and constrain, formulate and handle complex problems within the area.
- Show an ability to create technical solutions that fulfill human and societal needs.
• Show an ability to independently or within a group, plan and with adequate methods and tools, create relevant products and systems within given time frames, and evaluate this work.
• Through his/her evaluation capability and style of being, be a good ambassador for KTH in industry and the world.

Ability to make judgements and adopt a standpoint
Upon successful completion the students will be able

• to critically read technical reports and design documents;
• to assess its strong and weak points;
• to formulate their assessment in concrete and constructive terms.

Extent and content of the programme
The program is a two year, 120 higher education credit education.

The program offers four informal tracks:

**Embedded Electronics track** has the main focus on the design of electronics in an embedded system, i.e., how sensors, AD/DA-converters and other components work, and how to design Printed Circuit Boards, ASICs and programming FPGAs. The student can study to become a specialist in the development of Sensor-based and Mixed-Signal Systems, (Multi-Processor) System-on-Chip (SoC) design, or building electronic gadgets for Internet-of-Things (IoT).

**Embedded Platforms track** has the main focus on Embedded Platform - i.e., embedded hardware and its interaction with embedded software - design. The student can study to become a specialist in the development of Embedded (Multi-care) DSP platforms, Embedded (Multi-core) Computer platforms, and Embedded (Multi-care) Control platforms.

**Embedded Software track** has the main focus in software engineering of (Distributed) Embedded Systems, i.e., development, management and test of (Distributed) Embedded Software for Embedded (Multi-care) Platforms. The student can study to become a specialist in Embedded Real-Time (Control) SW and general Embedded (Multi-care) Computer SW.

**Embedded Control track** has the main focus on design, management and development of (Distributed) Embedded Control Systems for applications in Automation, Mechatronics, and Robotics;

The instruction language is English in all courses.

Eligibility and selection

General requirements

1. Previous studies
A completed Bachelor's degree, equivalent to a Swedish Bachelor's degree (180 higher education credits), from a university recognized by government or accredited by other recognized organization. A Bachelor's degree in Science or Engineering is required for most programmes (please see the relevant programme description).

Applicants admitted to longer technical study programmes and who have completed courses equivalent to an amount of 180 higher education credits, will be considered on a case-by-case basis.

2. Language requirements
A good knowledge of written and spoken English. Applicants must provide proof of their proficiency in English. KTH accepts

• TOEFL paper based test, total of 575, with at least 4.5 in the writing section
• TOEFL internet based test, total of 90, with at least 20 in the writing section
IELTS score of at least 6.5, no band lower than 5.5 (only academic training accepted)

English proficiency tests are waived for applicants with English as language of instruction (minimum 3 years of full-time higher education studies).

Swedish applicants should have a good knowledge of English, equivalent to English B.

Specific requirements

Bachelor's degree in Electrical Engineering or Computer Engineering, or an equivalent degree, including a combination of courses equivalent to at least an extent of 60 higher education credits in: Microelectronics, Electronics, Computer engineering, Computer science, Automation and Control, or Communication engineering.

Pre-requisites all line of studies: Computer Hardware Organization basics, Electric Circuits Theory (equivalent to EI1202 or IE1206), a basic course in programming (preferably C/C++).

Special pre-requisites for Embedded Electronics track: Digital Design basics (equivalent to IE1204 or IE1205), a basic course in Analog Electronics (equivalent to IE1202), and Signal Theory (see adaption courses below), i.e., sufficient knowledge in math including Laplace and Fourier Transforms, and Mathematical Statistics is required.

Special pre-requisites for Embedded Platform track: Digital Design basics. For the DSP related courses, a course in Signal Theory is required (see adaption courses below), i.e., sufficient knowledge in math including Laplace and Fourier Transforms, and Mathematical Statistics is required.

Special pre-requisites for Embedded Software track: None, except good programming skills.

Special pre-requisite for Embedded Control-track: A course in basic Mechanics (equivalent SG1102). For the control related courses, a course in Control Theory is highly recommended (see adaption courses below), i.e., sufficient knowledge in math including Laplace and Fourier Transforms, and Mathematical Statistics is required.

Adaption courses:

Students who want to study some courses within Embedded Electronics, Embedded Platforms, Embedded Control and/or DSP area need to have a basic course on Analog Electronic basics (Operational Amplifiers), Control Theory and/or Signal Theory in their portfolio. Students that lack at most ONE of these courses may study it upon arrival.

The specific requirements may be assessed as not fulfilled if:

- the average grade is in the lower third on the grading scale used (above pass level)
- the degree awarding institution is not considered to meet acceptable quality standards by the authorities of the country in which the institution is located
- the degree does not qualify for admission to equivalent Master level in the country where the degree is awarded.

Selection

The selection process is based on the following selection criteria: University, previous studies (for instance GPA, grades in specific subjects and English), motivation for the studies (for instance letter of motivation, references, thesis proposal and relevant work experience). The evaluation scale is 1-75.

Implementation of the education

Structure of the education

In year one many of the courses are compulsory. All tracks study Embedded Systems, while taking the compulsory courses of each specific track. The basic concepts of embedded systems are introduced. Year two is dominated by specialized courses and design projects. It concludes with a master thesis project.
Courses
The programme is course-based. Lists of courses are included in appendix 1.

The program is course-based. Lists of courses are included in appendix 1. 90 higher education credits are compulsory and for the remaining 30 higher education credits, up to a total of 120 higher education credits, courses can be selected freely from the program tracks.

Grading system
Courses in the first and the second cycle are graded on a scale from A to F. A-E are passing grades, A is the highest grade. The grades pass (P) and fail (F) are used for courses under certain circumstances.

Conditions for participation in the programme
Study enrolment is made before each term. Student chose a track and potential adaption courses at application time, before arrival to the program. Track Courses are chosen by the student prior to the second quarter and prior to the second term of the first year, and prior to each of the two terms of the second year. The choice is limited to the courses stated in the course list. Students announce their participation in an individual course to the teacher responsible for the course in the beginning of the course. Students announce possible interruptions in their studies to the teacher responsible for the course.

A student is allowed to start the second year of studies after promotion to the second year. The condition for promotion to the second year is completion of 45 higher education credits in the first year.

Recognition of previous academic studies
Receiving credit for previous studies is done according to the policy of the Royal Institute of Technology.

Studies abroad
The courses of the first year of the program should be followed at KTH. The master's thesis project in the second year may be performed at universities or at companies abroad.

Degree project
In the master thesis project the student shall demonstrate that he/she is able to solve a given design or research problem largely on his/her own with limited guidance from the supervising teacher. In particular, the student shall plan how to ad dress the task, assess the difficulties of the individual steps, be able to make a realistic schedule for the project, identify obstacles and problems and suggest changes of the original task or plan if deemed necessary. The student shall demonstrate that he/she is able to find relevant, related work in the literature and to put his/her own work in perspective of other work. If the project includes the design of hardware or software, the student has to be able to demonstrate the correctness of the design. Relevant experiments have to be designed and conducted that allow the drawing of unambiguous and useful conclusions. Finally, the project has to be described in a well-structured way in a report and a presentation.

The project is graded on a scale from A to F. A-E are passing grades, A is the highest grade. The criteria for grading are, with equal weight, the technical content, the documentation and presentation of the work, and the process of conducting the project. The prerequisite to start the degree project is the successful completion of 60 credits of courses that are compulsory or elective in the chosen track.

Degree
The Master's degree is obtained after completion of the courses and the thesis with a total of 120 higher education credits. The degree is "Teknologis masterexamen", translated into English as "Degree of Master of Science (two years)". The degree is awarded after application from the student. Application for degree is made through the Personal menu at www.kth.se.

Appendix 1 - Course list
Appendix 2 - Programme syllabus descriptions
Appendix 1: Course list

Master's Programme, Embedded Systems, 120 credits (TEBSM), Programme syllabus for studies starting in autumn 2015

General courses

Year 1

Mandatory courses (7.5 credits)

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>IL2206</td>
<td>Embedded Systems</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td></td>
<td>All Tracks</td>
<td></td>
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</table>

Recommended courses

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE1202</td>
<td>Analog Electronics</td>
<td>7.5</td>
<td>First cycle</td>
</tr>
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</table>

Prerequisite for some courses in Embedded Platforms requiring Analog Electronics

Year 2

Mandatory courses (22.5 credits)

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>EH2760</td>
<td>Management of Projects</td>
<td>6.0</td>
<td>Second cycle</td>
</tr>
<tr>
<td>II2202</td>
<td>Research Methodology and Scientific Writing</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>MF2063</td>
<td>Embedded Systems Design Project</td>
<td>9.0</td>
<td>Second cycle</td>
</tr>
</tbody>
</table>

Supplementary information

Degree project 30 credits advanced level is mandatory during the spring term.
### Year 3

**Track, Embedded Electronics (INEL)**

### Year 1

**Mandatory courses (22.5 credits)**

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
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</thead>
<tbody>
<tr>
<td>II2302</td>
<td>Sensor Based Systems</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IL2217</td>
<td>Digital Design with HDL</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IL2238</td>
<td>Fundamentals of Integrated Electronics</td>
<td>7.5</td>
<td>Second cycle</td>
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</table>

**Conditionally elective courses**

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
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<tbody>
<tr>
<td>DD2459</td>
<td>Software Reliability</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>EK2350</td>
<td>Microsystem Technology</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>ID2218</td>
<td>Design of Fault-tolerant Systems</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IL2212</td>
<td>Embedded Software</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IL2219</td>
<td>Radio Electronics</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IL2220</td>
<td>Low Power Analogue and Mixed Signal ICs</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IL2225</td>
<td>Embedded Hardware Design in ASIC and FPGA</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IL2236</td>
<td>Embedded Many-Core Architectures</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IL2237</td>
<td>Electronic Systems Design</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IL2450</td>
<td>System Level Validation</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IS2202</td>
<td>Computer Systems Architecture</td>
<td>7.5</td>
<td>Second cycle</td>
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</table>

**Recommended courses**

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
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</thead>
<tbody>
<tr>
<td>EQ1220</td>
<td>Signal Theory</td>
<td>7.5</td>
<td>First cycle</td>
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Prerequisites for courses in Signal Processing

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<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
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<tbody>
<tr>
<td>EQ2310</td>
<td>Digital Communications</td>
<td>9.0</td>
<td>Second cycle</td>
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### Year 2

#### Conditionally elective courses

<table>
<thead>
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<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
</tr>
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<tbody>
<tr>
<td>DD2425</td>
<td>Robotics and Autonomous Systems</td>
<td>9.0</td>
<td>Second cycle</td>
</tr>
<tr>
<td>EK2360</td>
<td>Hands-On Microelectromechanical Systems Engineering</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>EP2510</td>
<td>Advanced Networked Systems Security</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>II2300</td>
<td>Product Realization Processes I</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IL2221</td>
<td>Advanced Topics in Mixed Mode Design</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IL2452</td>
<td>System Design Languages</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IS2500</td>
<td>RFID Systems</td>
<td>7.5</td>
<td>Second cycle</td>
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### Year 3

#### Track, Embedded Software (INMV)

#### Year 1

**Mandatory courses (30.0 credits)**

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<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
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<tbody>
<tr>
<td>DD2459</td>
<td>Software Reliability</td>
<td>7.5</td>
<td>Second cycle</td>
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<tr>
<td>ID2202</td>
<td>Compilers and Execution Environments</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>ID2207</td>
<td>Modern Methods in Software Engineering</td>
<td>7.5</td>
<td>Second cycle</td>
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<tr>
<td>IL2212</td>
<td>Embedded Software</td>
<td>7.5</td>
<td>Second cycle</td>
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**Conditionally elective courses**

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
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<tr>
<td>DD2427</td>
<td>Image Based Recognition and Classification</td>
<td>6.0</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2431</td>
<td>Machine Learning</td>
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<td>Second cycle</td>
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<tr>
<td>DT2140</td>
<td>Multimodal Interaction and Interfaces</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>EL2450</td>
<td>Hybrid and Embedded Control Systems</td>
<td>7.5</td>
<td>Second cycle</td>
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<tr>
<td>EP2500</td>
<td>Networked Systems Security</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>ID1217</td>
<td>Concurrent Programming</td>
<td>7.5</td>
<td>First cycle</td>
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<tr>
<td>ID2010</td>
<td>Programming of Interactive Systems</td>
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### Course code

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<tr>
<th>Course code</th>
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<tbody>
<tr>
<td>ID2201</td>
<td>Distributed Systems, Basic Course</td>
<td>7.5</td>
<td>Second cycle</td>
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</table>
| ID2203      | Distributed Systems, Advanced Course
  *Requires ID2201* | 7.5     | Second cycle |
| ID2204      | Constraint Programming                                    | 7.5     | Second cycle |
| ID2216      | Developing Mobile Applications                            | 7.5     | Second cycle |
| ID2218      | Design of Fault-tolerant Systems                          | 7.5     | Second cycle |
| IK2000      | Security Architecture for Open Distributed Systems        | 7.5     | Second cycle |
| IK2002      | Security in Mobile and Wireless Networks                  | 7.5     | Second cycle |
| IS2200      | Parallel Computer Systems                                 | 7.5     | Second cycle |
| IS2202      | Computer Systems Architecture                             | 7.5     | Second cycle |
| MF2044      | Embedded Systems for Mechatronics, II                     | 6.0     | Second cycle |

### Year 2

**Conditionally elective courses**

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<th>Edu. level</th>
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<tbody>
<tr>
<td>DD2425</td>
<td>Robotics and Autonomous Systems</td>
<td>9.0</td>
<td>Second cycle</td>
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<tr>
<td>DT2140</td>
<td>Multimodal Interaction and Interfaces</td>
<td>7.5</td>
<td>Second cycle</td>
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<td>EP2510</td>
<td>Advanced Networked Systems Security</td>
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<td>Second cycle</td>
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<tr>
<td>ID1217</td>
<td>Concurrent Programming</td>
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<td>First cycle</td>
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<tr>
<td>ID2201</td>
<td>Distributed Systems, Basic Course</td>
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<td>Second cycle</td>
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<tr>
<td>ID2213</td>
<td>Logic Programming</td>
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<td>Product Realization Processes I</td>
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<td>Second cycle</td>
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<td>IL2217</td>
<td>Digital Design with HDL</td>
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<td>Second cycle</td>
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<td>IL2225</td>
<td>Embedded Hardware Design in ASIC and FPGA</td>
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<td>Second cycle</td>
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### Year 3

**Track, Embedded Platforms (INPF)**

### Year 1

**Mandatory courses (30.0 credits)**

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
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<tbody>
<tr>
<td>DD2459</td>
<td>Software Reliability</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IL2217</td>
<td>Digital Design with HDL</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IL2225</td>
<td>Embedded Hardware Design in ASIC and FPGA</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>IS2202</td>
<td>Computer Systems Architecture</td>
<td>7.5</td>
<td>Second cycle</td>
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**Conditionally elective courses**

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<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
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<tbody>
<tr>
<td>EK2350</td>
<td>Microsystem Technology</td>
<td>7.5</td>
<td>Second cycle</td>
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<tr>
<td>EL2450</td>
<td>Hybrid and Embedded Control Systems</td>
<td>7.5</td>
<td>Second cycle</td>
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<td>EN2401</td>
<td>Image and Video Processing</td>
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<td>EP2500</td>
<td>Networked Systems Security</td>
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<td>Second cycle</td>
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<tr>
<td>EQ2300</td>
<td>Digital Signal Processing</td>
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<td>Second cycle</td>
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<tr>
<td>EQ2310</td>
<td>Digital Communications</td>
<td>9.0</td>
<td>Second cycle</td>
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<td>ID2202</td>
<td>Compilers and Execution Environments</td>
<td>7.5</td>
<td>Second cycle</td>
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<tr>
<td>ID2218</td>
<td>Design of Fault-tolerant Systems</td>
<td>7.5</td>
<td>Second cycle</td>
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<tr>
<td>II2302</td>
<td>Sensor Based Systems</td>
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<td>Second cycle</td>
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<td>IK2000</td>
<td>Security Architecture for Open Distributed Systems</td>
<td>7.5</td>
<td>Second cycle</td>
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<td>IK2002</td>
<td>Security in Mobile and Wireless Networks</td>
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<td>IL2212</td>
<td>Embedded Software</td>
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<td>Second cycle</td>
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<td>Radio Electronics</td>
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<tr>
<td>IL2236</td>
<td>Embedded Many-Core Architectures</td>
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<td>Second cycle</td>
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<tr>
<td>IL2237</td>
<td>Electronic Systems Design</td>
<td>7.5</td>
<td>Second cycle</td>
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<tr>
<td>IL2238</td>
<td>Fundamentals of Integrated Electronics</td>
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### Recommended courses

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### Year 2

#### Conditionally elective courses

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<td>EP2510</td>
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<td>ID2202</td>
<td>Compilers and Execution Environments</td>
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### Year 3

#### Track, Embedded Control (INSR)

### Year 1

#### Mandatory courses (28.5 credits)

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<td>Applied Estimation</td>
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<td>Hybrid and Embedded Control Systems</td>
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### Conditionally elective courses

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<td>DD2431</td>
<td>Machine Learning</td>
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### Recommended courses

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<td><em>Prerequisite for advanced courses in Automatic Control</em></td>
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### Year 2

#### Conditionally elective courses

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<tr>
<td>DD2423</td>
<td>Image Analysis and Computer Vision</td>
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<td>Second cycle</td>
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<tr>
<td>DD2425</td>
<td>Robotics and Autonomous Systems</td>
<td>9.0</td>
<td>Second cycle</td>
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<td>DD2432</td>
<td>Artificial Neural Networks and Other Learning Systems</td>
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<td>EK2360</td>
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<td>Embedded Hardware Design in ASIC and FPGA</td>
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**Year 3**
Appendix 2: Specialisations

Master's Programme, Embedded Systems, 120 credits (TEBSM), Programme syllabus for studies starting in autumn 2015

Track, Embedded Electronics (INEL)

Track, Embedded Software (INMV)

Track, Embedded Platforms (INPF)

Track, Embedded Control (INSR)