

## Embedded Systems

Code: MK5BEAGR04RX17-EN

ECTS Credit Points: 4

Evaluation: mid-semester grade

Year, Semester: 2<sup>nd</sup> spring semester

Its prerequisite(s): -

Further courses are built on it: Yes/No

Number of teaching hours/week (lecture + practice): 0+4

### Topics:

Fundamentals of embedded systems. Real (deterministic) and non-real (non-deterministic) time operation, control and data acquisition. Architecture, data and control processes, state machine implementation. Hardware architecture: peripheral circuits, CPU, FPGA, and field networks. Software architecture: deterministic and non-deterministic processes: user interface, network communication, deterministic control. RTOS (Real-Time Operating System) and FPGA implementation. FPGA and CPU communication: DMA and FIFO. Sharing variables: current value, queue, real-time FIFO, real-time shared variable.

Embedded software architecture, real-time program design patterns. Periodic and event-driven loops. State machines: user event and inter process communication. Producer-consumer design pattern.

Diagnostic of embedded systems: real-time monitoring of resources. Monitoring and storage of monitoring and operating data. Dynamic and static allocation of memory (resource).

Embedded system robustness: operation and implementation of watchdog.

### Literature:

#### Compulsory:

- Alan Burns, Andy Wellings "Real-Time System and Programming Languages", Addison-Wesley, 3rd ed. 2001, ISBN 0 201 72988 1
- National Instruments, „NI LabVIEW for CompactRIO Developer’s Guide”, 2017 ed.
- National Instruments “LabVIEW TM Real-Time Module User Manual” 2003 April ed.

### Schedule

1 <sup>st</sup> week Registration week	
2 <sup>nd</sup> week: Practice: Embedded systems introduction. Embedded system development environment practice.	3 <sup>rd</sup> week: Practice: System architecture, data and control streams, stream control state machines. Embedded system state machine programming practice.
4 <sup>th</sup> week: Practice: Hardware architecture. I/O circuits, CPU, FPGA, field communication interface. Embedded system and networking practice.	5 <sup>th</sup> week: Practice: Software architecture: deterministic and non-deterministic processes: user interface, network communication. User interface programming practice.
6 <sup>th</sup> week: Practice: Deterministic software control loop architecture: RTOS (Real-time	7 <sup>th</sup> week: Practice: CPU and FPGA Communication: DMA and FIFO.

Operating System) and FPGA implementation.	DMA and FIFO programming practices.
Deterministic control loop programming practice.	
<b>8<sup>th</sup> week: 1<sup>st</sup> drawing week</b>	
<b>9<sup>th</sup> week:</b> Practice: Non-real-time variable sharing among embedded systems and processes: tabs, and queues.	<b>10<sup>th</sup> week:</b> Practice: Real-time variable sharing among embedded systems and processes: real-time FIFOs, real-time shared variables.
<b>11<sup>th</sup> week:</b> Practice: Embedded system architectures, real-time programming patterns.	<b>12<sup>th</sup> week:</b> Practice: Periodic and even-driven loops. State machines: user and machine controlled state machines.
<b>13<sup>th</sup> week:</b> Practice: Producer-Consumer programming patterns.	<b>14<sup>th</sup> week:</b> Practice: Embedded system diagnostics: real time monitoring of resources.
<b>15<sup>th</sup> week: 2<sup>nd</sup> drawing week</b>	

## Requirements

### A, for a signature:

Attendance at **lectures** is recommended, but not compulsory.

Participation at **practice** is compulsory. Students must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Students can't make up a practice class with another group. Attendance at practice classes will be recorded by the practice leader. Being late is counted as an absence. In case of further absences, a medical certificate needs to be presented. Missed practices should be made up for at a later date, being discussed with the tutor. Students are required to bring the drawing tasks and drawing instruments to the course with them to each practice class. Active participation is evaluated by the teacher in every class. If a student's behaviour or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.

During the semester there are two tests: the 1<sup>st</sup> test in the 7<sup>th</sup> week and the 2<sup>nd</sup> test in the 15<sup>th</sup> week. Students have to sit for the tests.

### B, for grade:

The course ends in a **mid-semester grade** based on the test results.

The minimum requirement for both mid-term and end-term tests is 50%. Based on the score of the tests separately, the grade for the tests is given according to the following table:

Score	Grade
0-39	fail (1)
40-52	pass (2)
52-63	satisfactory (3)
64-71	good (4)
72-80	excellent (5)

If the score of the sum of the two tests is below 40, the student once can take a retake test of the whole semester material.