COURSE DESCRIPTION

1. **Course title**: EMBEDDED SYSTEMS PROGRAMMING

2. **Course code**: ESP

3. **Validity of course description**: 2019/2020

4. **Level of studies**: 2nd cycle of higher education

5. **Mode of studies**: intramural studies

6. **Field of study**: informatics

7. **Profile of studies**: general academic

8. **Specialty**: Industrial Informatics Systems

9. **Semester**: 2

10. **Faculty teaching the course**: Institute of Informatics

11. **Course instructor**: Dariusz Caban, PhD, Michał Maćkowski, PhD

12. **Course classification**: specialization courses

13. **Course status**: obligatory

14. **Language of instruction**: English

15. **Pre-requisite qualifications**: Computer Programming, Microprocessor and Embedded Systems, Computer Construction

16. **Course objectives**: The aim of the course is to introduce students into topics of designing of embedded systems software, both bare-metal and executed under the supervision of the real-time system kernel. The issues related to the optimization of programs: memory and energy are also presented.

17. **Description of learning outcomes**:

<table>
<thead>
<tr>
<th>No.</th>
<th>Learning outcomes description</th>
<th>Method of assessment</th>
<th>Teaching methods</th>
<th>Learning outcomes reference code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The student has knowledge of the C language extensions for embedded systems programming.</td>
<td>Discussion</td>
<td>Lecture</td>
<td>K2A_W11</td>
</tr>
<tr>
<td>2.</td>
<td>The student learns the methods of memory and energy optimization of C programs for embedded systems.</td>
<td>Discussion</td>
<td>Lecture</td>
<td>K2A_W11</td>
</tr>
<tr>
<td>3.</td>
<td>The student knows the services provided by the real-time kernel.</td>
<td>Discussion</td>
<td>Lecture</td>
<td>K2A_W11</td>
</tr>
<tr>
<td>4.</td>
<td>The student knows how to write software, which is resilient to errors induced by electromagnetic fields.</td>
<td>Discussion</td>
<td>Lecture</td>
<td>K2A_W11</td>
</tr>
</tbody>
</table>
The student is able to write software for embedded systems, both bare-metal and executed under the supervision of the real-time kernel.

The student is able to optimize the program in terms of memory usage and energy consumption.

18. Teaching modes and hours
Lecture: 15 h. Laboratory: 30 h

19. Syllabus description:

Lecture
The embedded system definition. The features of embedded system software. The C language extensions for embedded systems programming. The memory optimization of C programs. The cross linker. The formats of files with executable code. The embedded system software architectures. Using of interrupts, the data sharing problem. The impact of interrupt blocking on the system response time. Alternatives to interrupt blocking.

The introduction to real-time kernel. The tasks and their states. The services of the kernel: semaphores, message queues, mailboxes, time functions, dynamic memory allocation. The interrupt service routines in programs executed under supervision of the kernel. Basics of designing programs executed under supervision of the kernel. The time and memory overheads being introduced by the kernel. Energy optimization of embedded system software.

As part of the lecture, the legal regulations applicable in the European Union will be presented related to the introduction of embedded systems into the market. Lecture issues: electromagnetic disturbances, sources of disturbances, types of couplings, effects of disturbances, grounding and mass, immunity to radiated and conducted disturbances, improving software performance against susceptibility to EMI, software techniques for comprehensive EMC testing of embedded systems, EMC-aware programming.

Laboratory
Memory optimization of C programs for AVR microcontrollers
The FreeRTOS kernel for PIC18 microcontrollers
The software for embedded system with ZigBee interface
Energy optimization of embedded system software
Immunity of communication standards to electromagnetic disturbances.
Radiated emission of IT devices.
Influence of IT equipment on voltage fluctuations in the power grid.
Testing of devices immunity to SURGE and ESD.
Emission and immunity - aware programming

20. Examination: no

21. Primary sources:

22. Secondary sources:

23. Total workload required to achieve learning outcomes

<table>
<thead>
<tr>
<th>No.</th>
<th>Teaching mode:</th>
<th>Contact hours / Student workload hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Lectures</td>
<td>15 /15</td>
</tr>
<tr>
<td>2.</td>
<td>Classes</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Laboratory</td>
<td>30 /15</td>
</tr>
<tr>
<td>4.</td>
<td>Project</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>BA/MA Seminar</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Other (exam)</td>
<td></td>
</tr>
<tr>
<td>Total number of hours:</td>
<td>45 / 30</td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------</td>
<td></td>
</tr>
</tbody>
</table>

24. **Total hours:** 75

25. **Number of ECTS credits:** 3

26. **Number of ECTS credit allocated for contact hours:** 2

27. **Number of ECTS credit allocated for in-practice hours (laboratory, classes, project):** 1

28. **Comments:**

---

Approved:

…

(date, instructor’s signature)

(date, the Director of the Faculty Unit signature)