THESIS SUPERVISOR'S REPORT

I. IDENTIFICATION DATA

Thesis title:	Open Hardware Motion Controller for Model-Based Rapid Prototyping with NuttX RTOS
Author's name:	Štěpán Pressl
Type of thesis :	bachelor
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Control Engineering
Thesis reviewer:	Ing. Pavel Píša, Ph.D.
Reviewer's department:	Department of Control Engineering

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment **challenging**

How demanding was the assigned project?

The design of the complete motion control system hardware is complex task and plan was not to only design single purpose minimal platform but system for broad range of applications from PMSM, DC, stepper motors to special purpose actuators like piezoelectric elements with all kinds of communication interfaces (CAN FD, Ethernet, RS-485). Even that KyR study program is missing proper hardware design related courses as well as proper processor systems knowledge basic introduction, Štěpán Pressl has learned all these skills and with some consultation from Ing. Petr Porazil (Elektroline.cz and PiKRON.com HW expert) has designed system on profession level with open-source KiCAD electronic design/PCB system. The student proved his quality in the frame of the preceding Bachelor Individual Project and that is why initial idea to focus mainly on hardware has been extended to include even integration into pysimCoder rapid control application design system.

Fulfilment of assignment **fulfilled**

How well does the thesis fulfil the assigned task? Have the primary goals been achieved? Which assigned tasks have been incompletely covered, and which parts of the thesis are overextended? Justify your answer.

All planned goals have been implemented and six enhancements of SAMv71 peripheral support (incremental encoder index, extension to 32-bits, PWM mutual synchronization and ADC sampling synchronized by PWM) have reached NuttX RTOS mainline source tree as part of its porting to SaMoCon hardware. Nine corresponding design blocks enhancements have reached pysimCoder mainline tree. The student invested even time into adaptation of the system to control the piezoelectric-actuator to allow its use in a research project at Institute of Information Theory and Automation of the Czech Academy of Sciences.

Activity and independence when creating final thesis **A - excellent.**

Assess whether the student had a positive approach, whether the time limits were met, whether the conception was regularly consulted and whether the student was well prepared for the consultations. Assess the student's ability to work independently.

The invested time, self-motivation and self-study of the student has been extraordinary. Student even provided time to prepare leaflets and HW for CTU participation at Embedded World Exhibition and Conference in Nuremberg.

Technical level **A - excellent.**

Is the thesis technically sound? How well did the student employ expertise in his/her field of study? Does the student explain clearly what he/she has done?

The result is professional level hardware prototype design which has reached an serial production HW form factor. There are some small problems caused by gradual understanding the SAMv71 peripherals and limitations which would require the second iteration. But most of these problems have been overcome by manual corrections on PCB for testing on the initial prototype.

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Formal level and language level, scope of thesis	**A - excellent.**
Are formalisms and notations used properly? Is the thesis organized in a logical way? Is the thesis sufficiently extensive? Is the thesis well-presented? Is the language clear and understandable? Is the English satisfactory?	
I consider thesis text as well structured and is provides broad range of important knowledge for continuation on the project and for its users who can use project for lower level (C-language) implemented control systems as well for high level rapid control application design in pysimCoder which allows to utilize graphical model level design approach.	

Selection of sources, citation correctness	**A - excellent.**
Does the thesis make adequate reference to earlier work on the topic? Was the selection of sources adequate? Is the student's original work clearly distinguished from earlier work in the field? Do the bibliographic citations meet the standards?	
32 references to sources as well as 72 pages of the bachelor thesis text body are above average.	

Additional commentary and evaluation (optional)
Comment on the overall quality of the thesis, its novelty and its impact on the field, its strengths and weaknesses, the utility of the solution that is presented, the theoretical/formal level, the student's skillfulness, etc.
The project provides valuable results and Štěpán Pressl plans to continue on the project to investigate NuttX RTOS latencies and cooperate on pysimCoder and NuttX enhancements. The revision of the hardware design is planned in frame of continuing project with Institute of Information Theory and Automation.

III. OVERALL EVALUATION, QUESTIONS FOR THE PRESENTATION AND DEFENSE OF THE THESIS, SUGGESTED GRADE

Summarize your opinion on the thesis and explain your final grading.

The grade that I award for the thesis is **A - excellent.**

Date: 3.6.2024 Signature:

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REVIEWER'S OPINION OF FINAL THESIS

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Thesis name:	**Click herOpen Hardware Motion Controller for Rapid Prototyping with NuttX RTOSe to enter text.**
Author's name:	Štěpán Pressl
Type of thesis :	bachelor
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Control Engineering
Thesis reviewer:	Roberto Bucher
Reviewer's department:	extern

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment — **challenging**

Evaluation of thesis difficulty of assignment.

The project contains a lot of elements related to control theory. Knowledge in Rapid Prototyping and Linux are required.

Satisfaction of assignment — **fulfilled**

Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.

The requirements of the project are covered. The theoretical part is complete included the description of the tool used (pysimCoder) described in a simple and complete form. The descriptions of the motors and sensors is well made and complete.
Descriptions of the NuttX OS, pysimCoder, motors and actuators are complete and demonstrate that the student has deep analyzed all these environments.

Method of conception — **correct**

Assess that student has chosen correct approach or solution methods.

The solution is well presented. Some parts can be more clearly described by using a better name of some variables. For example, H(s) is used both for plant and controller (as in formula 3.6). It is better to use for example G(s) (or H(s) for the plant and C(s) for the PID controller.
The derivative part of the controller is not realizable in continuous time as simple derivative, but should realized as Lead controller (not proper transfer function).
In the schematic of Figures 8.3 and 8.5 it is better to use a discrete integrator instead of the continuous one: this will reduce the computational time at each sampling period, with better timing (but I'm not sure that this solves the problem with shorter sampling times).
Better sampling can be reached using for example "timer hook" provided by NuttX and described here:
https://cwiki.apache.org/confluence/display/NUTTX/Short+Time+Delays
This can be implemented with few modifications in NuttX and pysimCoder, in order to obtain a better behavior.

Technical level — **B - very good**

Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.

The HW part is well realized and discussed. This part in my opinion can be also as "A" judged. The difficulty of the application, however, is less than other theses I have analyzed in the past.

Formal and language level, scope of thesis — **A - excellent**

Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.

The documentation is complete and well readable. The student demonstrates an excellent command of the English language.

All the technical terms are correct and used appropriately.

Selection of sources, citation correctness **A - excellent.**

Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.

All the sources are presented and well documented.

Additional commentary and evaluation

Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.

Despite some very little points, the student provides a good and complete thesis. Compared to other theses that I have already reviewed in the past, I've proposed in this case a "B" evaluation.

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.

The author proves his skills in particular in the HW part. I evaluate handed thesis with classification grade

B - very good.

only because, compared to other theses in the past, I see not the same level in finding new and original solutions for the proposed problem.

By the defense of the these project, the student can demonstrate to be eventually graded as A.

Date: 31.5.2024 Signature: