

## DOCTORAL DEGREE STUDY OF MEASUREMENT AND INSTRUMENTATION IN THE CZECH REPUBLIC

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**Abstract** – The basic information concerning opportunities of doctoral degree study in measurement and instrumentation in the Czech Republic is mentioned in the first part of the paper. The study is running usually as a specialisation of the branch control engineering. The separate study programme “Measurement and Instrumentation” is running at the Czech Technical University in Prague – Faculty of Electrical Engineering, which is described in the second part of paper in detail.

**Keywords** Education, Doctoral Degree, Measurement and instrumentation

### 1. INTRODUCTION

The doctoral degree programmes take in the Czech Republic in all universities 3 or 4 years in nominal. The study is divided into two parts in the area of engineering – an educational phase and a phase, which is primarily focused on research work.

Attendance in several courses is usually compulsory during the first 3 or 4 semesters. The courses are oriented either to the special parts of mathematics and/or physics and theoretical parts concerning the studied branch, or there are auxiliary courses from other branches, which correspond to the topic of dissertation. Besides attendance in these courses, the students are involved in study and analysis of materials and achievements in the field of knowledge in which falls the topic of their dissertation. Fulfilment of the coursework component of the individual plan is completed by passing the prescribed examinations and by presenting and defending a study reflecting the current state of the subject of dissertation in the world. It is then possible to take the final degree examination, in which students should demonstrate their specialised theoretical knowledge, methods of scientific work, and the ability to acquire new scientific knowledge and to apply it creatively. Successful completion of this examination is a pre-requisite for the presentation and defence of the doctoral thesis.

During the following years of study students concentrate themselves on research in the subject area of their dissertation, on preparation of publications and on writing the dissertation theses. They can be submitted in the form of a work that has been published (or is being prepared for publication), or as a collection of publications, and must contain original new findings. The presentation and defence

of the work is conducted by the *Board for the Defence of a Doctoral Thesis*, and it is open to the public.

### 2. PhD STUDY OF MEASUREMENT & INSTRUMENTATION IN THE CZECH REPUBLIC

Measurement and instrumentation in doctoral level can be studied at 5 technical universities in the Czech Republic<sup>1</sup>. The whole number of graduates on doctoral level in the Czech Republic in Measurement and Instrumentation is 15 – 20 per year. This specialisation belongs usually in the frame of the branch *Control engineering*. The separate branch *Measurement and Instrumentation* is offered at the Czech Technical University in Prague – Faculty of Electrical Engineering (CTU – FEE) only, but the difference is not very important. It usually lies in the scope of obligatory courses (if they exist) concerning the study branch. While in the branch control engineering, where measurement and instrumentation is only one of several specialisations, 1 or 2 courses concerning selected parts from automatic control (e.g. Distributed Control Systems, Fuzzy Modelling and Control, Modelling and Identification of Dynamical Systems etc.) are often obligatory, the PhD students in the branch *Measurement and Instrumentation* at CTU in Prague attend such courses only as far as they bear on their dissertation topic.

The Institute of Chemical Technology offered till previous year also the separate branch *Measuring Techniques* in the study programme *Chemical and Process Engineering*. The field of interest embraced problems of chemical sensors and research concerning automatic analysers for measurement of concentration quantities. Research activity concentrated on the study of new materials for chemical sensors, methods of sensor signal processing and investigation of general regularities of the sensitivity and selectivity of individual types of chemical sensors. Several examples of thesis topics are presented below:

- Nanocomposite materials for active layer of gas sensors
- HF methods for sensing by gas sensors
- Electrochemical sensors based on electrically conducting polymers

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<sup>1</sup> Czech Technical University in Prague, Brno University of Technology, University of Technology of Ostrava, University of Technology of Liberec, Institute of Chemical Technology in Prague

- Electrochemical receptors and measuring systems for electronic tongues

However, separate branch *Measuring Techniques* was conjoined with the branch *Technical Cybernetics* as one of several specialisations this year because of low number of students.

The further special branch *Metrology and Quality Assurance Testing* can be studied at Brno University of Technology – Faculty of Mechanical Engineering. The area of quality and safety in production and services, quality management systems, environmental management systems belong also to the contents of study. Courses concerning physical principles of metrology, applied statistics, system reliability etc. create the theoretical basis for the branch. The following examples of typical topics of dissertation in this branch give good overview concerning its contents:

- Analysis of measurement in systems of quality management of technological processes
- Application of new methods and tools in evaluating the quality of die-cast Al alloys
- Definition fidelity measuring and methodology quantification
- New types of intuitive methods quality control and their application
- Optimisation of accuracy of manufacturing process and his verification
- The analysis of material surface structure for high precision technologies

The topics pertain to measurement and instrumentation can be found also in the branch *Air Traffic Control* that can be studied at CTU in Prague. It concerned e.g.:

- Aerometrical systems calibration with a usage of towed probe
- GPS based attitude evaluation
- Methods of sensors' data validation in aircraft instrumentation
- Methods of sensors' error reducing in aeronautics and astronautics

### 3. DOCTORAL STUDY PROGRAM AT CTU – FEE, BRANCH MEASUREMENT & INSTRUMENTATION

Doctoral Degree Study (PhD) in the branch *Measurement and Instrumentation* at the CTU – FEE is provided by the Department of Measurement. At present, 23 PhD students are studying at the Department of Measurement in the doctoral study programme “Measurement and instrumentation”, further 12 students finished nominal study period and they are writing up their dissertation thesis. The education is focused to following areas:

- Measurement science
- New sensors, measuring instruments and systems
- New methods for precise measurement, calibration or diagnostics including digital signal processing.

The students have to pass exams from 4 – 6 courses according their individual study plans during the first phase

of their study. There are two groups of courses. The first ones are oriented both to special parts of mathematics and/or physics, the second ones are focused to theoretical passages concerning measurement and instrumentation as follows:

- Advanced Methods of Analogue Signal Digitalisation and Reconstruction
- Selected Chapters of Signal Processing
- Advanced Methods for Precision Measurement of Electrical Quantities
- Advanced Methods of Measurement of Non-Electric Quantities
- Selected Methods of Diagnostics

The auxiliary courses from other branches are chosen when they are considered to be suitable regarding the topic of dissertation.

The final degree examination, in which students should demonstrate their specialised theoretical knowledge, can be passed after fulfilment of the coursework component of the individual plan. It contains following topics:

- Theory of measurement
- Measuring circuits and Instrumentation
- Sensors and transducers
- Measuring and DAQ systems
- Digital signal processing

However, the dominant part of Ph.D. study programme is dedicated to the solving the topic of dissertation. More than 20 topics are offered now for students, which are interested in PhD study. Some examples are presented in Appendix.

The integral part of study is also publications of student's own results, of course. At least one paper in the international scientific journal should be published (or to be in print) before defence of the doctoral work. Several publications in international conference proceedings are also supposed. Each of students should study one or two semesters abroad.

### 4. STUDY FINANCING, COOPERATION ON RESEARCH PROJECTS OR PROGRAMMES

Students in doctoral study programme at CTU-FEE are usually supported using two financial sources – basic scholarship, and grant for an external research project or programme. The basic scholarship is paid from budget of Ministry of Education. Its amount reached about 1/3 of average salary in the Czech Republic in 2008 and it is equal to the minimum salary. However, the offered topics of dissertation work result from research projects or programmes solved at competent departments and students participating in them are also partially supported from these grants.

The most of PhD students at the Department of measurement are supported from the grant gained for the programme “Research of Methods and Systems for Measurement of Physical Quantities and Measured Data Processing”, others from the grant obtained from the Czech Science Foundation “Orthogonal fluxgate based on

magnetic microwire” or furthers collaborate with Josef Bozek Research Centre of Engine and Automotive Engineering in the area of automotive electronic and communication systems. Using this way, the total income of our students reaches usually more than 2/3 of average salary in the Czech Republic.

The new version of the Act on the Support of Research and Development aims the part of financial support as a target support for doctoral study. This support has to be divided at each university to the student’s research teams using internal competition of grants. It is possible to presuppose that the additional means will be gained by this way from the next year. It helps to increase also the total income of our students.

## 5. CONCLUSION

81 students finished the doctoral study programme *Measurement and instrumentation* at CTU – FEE during the last 10 years, from that 34 successfully and 47 unsuccessfully (most of them either exited during the first year of study, or did not write up their dissertation thesis after finishing nominal study period). The students whose finished their study prematurely, leave the study often for economical reason – their income during doctoral study is sufficient for coverage of living costs of student, but not to support their family after weddings. These students move to industry or business, where salaries are much bigger.

One of our students gained the previous year the rector’s award, three the best doctoral theses are prepared for publishing (in extended version) in Shaker Verlag GmbH in a book series “Reports on Sensors and Instrumentation”. One of our previous best students – David Slepicka – gained this year from IEEE - I&M Society the Outstanding Young Engineer Award “*In recognition of contributions to the dynamic metrological characterization of ADCs.*”

## APPENDIX

Examples of PhD thesis topics for the admission procedure in the branch of study Measurement and Instrumentation:

- Calibration of impedance standards at frequencies up to 1 MHz
- Testing of ADC modules in the frequency range up to tens MHz
- Methods of high resolution signal digitalisation
- Image processing using FPGA and DSP for contactless measurement
- Precise time and process synchronization in distributed and heterogeneous DAQ, control and monitoring systems
- Signal separation and classification methods in technical diagnostics
- Distributed systems in vehicles, their implementation and diagnostics
- Measurement of audio and video quality parameters of telecommunication network interfaces
- Sampling methods in magnetic measurements
- Implanted sensors and systems: communication, contactless power transmission, biocompatibility
- Automotive sensors: increasing of their accuracy and resistance

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