

CHANGES IN EDUCATION OF MEASUREMENT AND INSTRUMENTATION AT CTU IN PRAGUE CAUSED BY IMPLEMENTATION OF BOLOGNA DECLARATION

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Abstract - Changes in study programmes at the Czech Technical University in Prague based on the Bologna declaration concern also the education of Measurement and Instrumentation. The bachelor stage and the master stage are strictly separated in the new study plans. The amount of theoretical courses going before technological courses rapidly decrease in the bachelor stage. It requires both to change the teaching method and to skip some theoretically exacting parts. The change of the whole structure leads also to the reduction of an extent of all courses. The new conception leads also to the changes in the master stage - the additional courses of theoretical disciplines are planned here to compensate the low amount of theoretical courses in the bachelor stage. The paper aims to show how we are trying to solve it in the branch Measurement and Instrumentation.

Keywords: teaching of measurement, Bologna declaration, structure of study

1. INTRODUCTION

The existing study programme at the Faculty of Electrical Engineering of the Czech Technical University (CTU) in Prague is primarily drawn up as a long master programme. However, there is a possibility to modify an individual student's study plan in the 5th to 7th semesters, and to finish the study after 3.5 years (in nominal) with the bachelor degree. However, the novelization of the Czech High Education Law (proceeding from the Bologna declaration) supposed, that the most of university study programmes will be structured into three strictly separated stages (bachelor, master, and Ph.D.). It leads to basic changes in study plans.

The change of the whole structure of the bachelor stage (further economical and social courses were inserted) and the short cut to 3 years in nominal leads to the reduction of an extent of all courses. Especially the amount of theoretical courses going before technological courses rapidly decreases. It requires in these courses both to change the teaching method and to skip some theoretically exacting parts.

The new conception leads also to the changes in the master stage - the additional courses of theoretical disciplines are planned here to compensate the low amount of theoretical courses in the bachelor stage. Besides, some

special parts of mathematics physics or signal processing are integrate to the other courses.

There are prepared two study plans of the master programme. The first one, which presupposed the bachelor graduation in the same or similar branch of study (e.g. electronic, communication, measurement, automation, power engineering etc.) runs 2 years in nominal. The second one, which presupposed the bachelor graduation in the other technical branch of study, offers the compensatory courses for an acquirement of a basic knowledge of electrotechnics in the first year. It runs 3 years in nominal.

The structure of doctoral study programme stays without changes.

The main idea by preparing new study plans was to improve the quality of bachelors with the regards to their assertion in practice, and to preserve the existing good level of the master degree. Concerning the measurement and instrumentation, we are convinced that every bachelor of electrical engineering should be able to choose a suitable method and suitable instrument(s) if confronted with the task of measuring an electrical quantity or a parameter of passive elements with the prescribed accuracy in given conditions (frequency range, disturbance etc.). It provides a basic course in electrical measurement and instrumentation, obligatory for all students of electrical engineering (except of computer engineering, where the special course is prepared).

2. MEASUREMENT COURSES IN THE BACHELOR PROGRAMME

The common obligatory courses for all students of the bachelor study programme of Electrical and Computer Engineering are offered only in the first year of study. The four branches (*Electronics and Telecommunication, Power Engineering, Cybernetics and Measurement, and Computer Engineering*) are separated already from the third semester.

The basic obligatory course of *Electrical Measurement and Instrumentation* (at present in the amount 3 hours of lectures + 3 hours of labs per week) is planned for the 3rd semester, and it will be reduced to 2 + 2 hours per week for all branches (except of *Computer Engineering*) in a new curricula. To be possible to realise it, it will be modified according the branch - the topics, which will be tough in following special courses are deleted (e.g. the part

concerning a basic measurement of non-electrical quantities in the branch *Cybernetics and Measurement*, because the special obligatory course *Sensors and transducers* will be tough here in the next semester). It should provide students with basic skills and knowledge necessary for performing specific measurement tasks also by a smaller hours extension.

A measurement uncertainty evaluation, principles of electromechanical (very briefly) and electronic instruments, and methods of measurement of all basic electrical and magnetic quantities are explained. Principles of digital measuring instruments, basics of measuring systems including their programming, and measuring transducers using operational amplifiers are also dealt with. This course is user-oriented and the teaching process is based on the way “the knowledge of principle” → “properties of instruments or methods” → “the area of their application”.

Concerning labs (2 teaching hours per week), the students will solve 2 tasks each week. The principle of applied instruments and methods including their both positive and negative properties will be shown here. The measurement uncertainty estimation is an integral part of the most of the tasks.

Results of the latest technological achievements should be at least partially reflected in the basic course, because students will be confronted with them after graduation. Since the amount of time for lectures and labs is limited, some at present less used methods and instruments are left aside.

A special course *Measurement in Digital Circuits* (1 hour of lectures + 2 hours of labs per week) is prepared for the branch *Computer Engineering*. The basic methods of measurement of electrical quantities (voltage, current, power, frequency, resistance, capacitance and inductance), measuring transducers, D/A and D/A converters, electrical and electronic measuring instruments, and digital instruments are very briefly introduced in the 1st part of the course. The 2nd part is pointed to testing and measuring methods in a digital technology, standard instruments for a digital device testing and their application.

3. THE BACHELOR PROGRAMME OF THE BRANCH “CYBERNETICS & MEASUREMENT”

In addition to the basic course of *Electrical Measurement and Instrumentation*, three other obligatory courses concerning measurement and instrumentation are integrated in the curricula of the branch *Cybernetics & Measurement* in the bachelor study programme (see Table 1). There is also an offer of three optional courses for students specialised in measurement and instrumentation.

The additional two courses concerning measurement and instrumentation are offered for students, who study another branch in the bachelor study programme.

The bachelor study culminates in the 6th semester, when students solve the *Bachelor project*. It is closed by the bachelor state examination and by the defence of the project. Some examples of their topics are shown in Appendix I.

TABLE 1. Bachelor study programme - courses concerning measurement and instrumentation offered in the branch *Cybernetics and Measurement*

Type of course	Sem.	Name of Course	
Obligatory for the branch <i>Cybernetics and Measurement</i>	3	Electrical Measurement and Instrumentation	2+2
	4	Sensors and Transducers	2+2
	5	Data Transmission	2+2
	6	Processing of Signals and Images	2+2
	6	Bachelor Project	0+5
Optional for the branch <i>Cybernetics and Measurement</i>	4	Circuits for Digital Instruments	2+2
	5	Measuring Systems and their Programming	2+2
	6	Microprocessors in Instrumentation	2+2
Optional courses offered for other branches	4, 6	Diagnostics of Digital Devices	1+2
	5	Sensors and DAQ Systems	2+2

3. MASTER STUDY PROGRAMME OF CYBERNETICS & MEASUREMENT – SPECIALIZATION MEASUREMENT & INSTRUMENTATION

The new master study programme of Electrical and Computer Engineering is prepared at the Faculty of Electrical Engineering of CTU in Prague in seven branches: *Electronics, Telecommunication & Radiotechnology, Power Engineering, Cybernetics & Measurement, Computer Engineering, Management of Electrotechnology and Energetic and Biomedical Engineering*. The specialisation *Measurement & Instrumentation* ranks to the branch *Cybernetics & Measurement*. There are only six common obligatory courses for the whole branch (*Mathematics 6, Theory of Dynamic Systems, Decision Support Systems, Diagnostic Systems and Safety and Quality Management*). The course *Diagnostic Systems* is provided by Dept. of Measurement.

Four additional courses are obligatory for students in specialisation *Measurement & Instrumentation* (see Table 2). The students can choose further courses according their interests and topic of their project - the 8 optional courses concerning measurement are offered. The line of projects in the 2nd semester and in the 3rd one culminate with the Diploma thesis in the last semester. The master study is closed by the state examination and by the defence of the Diploma thesis. Some examples of their topics are shown in Appendix II.

Dept. of Measurement provides also the special courses concerning DAQ systems in the branches *Electronics and Biomedical Engineering*.

Department of Measurement (DMs) is also responsible for teaching in specialisation *Airplanes information and control systems*. The courses for this specialisation are provided in co-operation with Dept. of Radioelectronic (DR), Dept. of Automatic Control (DAC), Dept. of Mechanics (DMc) and Faculty of Mechanical Engineering (FME). The structure of courses determined for this specialisation is published in Table 3.

TABLE 2. Master study programme - courses offered in the specialisation *Measurement and Instrumentation*

Type of course	Sem.	Name of course
Obligatory courses for specialisation <i>Measurement and Instrumentation</i>	1	Analogue signal processing and their digitalisation
	2	Theory of Measurement
	2	Industrial DAQ systems
	3	Videometry and contactless measurement
Optional courses for specialisation <i>Measurement and Instrumentation</i>	1	Laboratory and industry systems programming
	1	Design of control part of instruments
	2	Special measuring instruments
	2	Basics of HF technology
	3	Metrology of electrical quantities
	3	Magnetic Elements and Magnetic Measurements
	3	EMC of Instruments and Systems
Optional courses offered for all branches	2, 4	Laboratory exercises on microprocessor techniques
	3	FPGA Applications

TABLE 3. Master study programme - courses offered in the specialisation *Airplanes informatic and control systems*

Type of course	Sem.	Name of course	Dept.
Obligatory courses for specialisation <i>Airplanes information and control systems</i>	1	Aerodynamics and Mechanics of Flight	DMc
	2	Flight Navigation	DR
	2	Airplane Instrumentation	DMs
	3	Flight Control Systems	DAC
Optional courses for specialisation <i>Airplanes information and control systems</i>	1	Radiocommunication Systems	DR
	1	Construction and Engines of Airplanes	FME
	2	Programming of Avionic Systems	DMs
	2	Control of Air Traffic	DR
	3	Diagnostics of Airplane Systems	DMs
	3	Airboards Control and Information Systems	DAC
	3	Airplane Buses	DMs
4	Airplanes Ergonomy	DAC	

4. Ph.D. STUDY PROGRAMME IN MEASUREMENT & INSTRUMENTATION

The Ph.D. study programme runs in Czech republic in all universities 3 years in nominal. Students attend the special courses (usually 4 – 6) related to the topics of their dissertation in the 1st and partially also in the 2nd year of study. They are pointed either to the special parts of mathematics and/or physics and theoretical passage concerning studied branch, or it is going of auxiliary courses from other branches. The courses of the first group, which

are offered by Dept of Measurement for Ph.D. students of the branch Measurement and Instrumentation 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

For the students of other branches are intended the following auxiliary courses:

Electromagnetic Compatibility of DAQ systems
Magnetism in Engineering Practice
Measurement and DAQ Systems

However, the dominant part of Ph.D. study programme is dedicated to the solving the topic of dissertation. Some examples of them are shown in Appendix III. The integral part of study is also the publication of own results, of course.

5. CONCLUSION

All of the courses mentioned above will be offered also in English, of course, same as the most of courses in existing curricula. The textbook for the basic course of *Electrical Measurement and Instrumentation* was written in English [3] and published in Publishing House of CTU. For other courses we recommend students to consult textbooks from abroad.

The system of study at CTU in Prague has undergone vast modifications since the political changes in the Czech Republic in November 1989. Students now have more freedom in selecting their specialisation and in selection of courses. The subsequent change comes now. It is not easy to build the new curricula so that it covers all demands put on new structure of study mentioned in Introduction (to improve the quality of bachelors with the regards to their assertion in practice, and to preserve the existing good level of master degree). The new curricula will start in the academic year 2003/04.

APPENDIX I.

Some examples of topics of Bachelor project:

- Semiconductor light source controlled by microprocessor
- Input circuits of AD transfer standard
- Data transmission using supply wires
- Universal interface for sensors
- Measurement of disturbing AC magnetic field in 3 axes

APPENDIX II.

Some examples of topics of Diploma thesis

- Application of MATLAB for parameters of non-stationary signals measurement
- Analysis of Algorithms for voice transmission quality in GSM nets
- ispPAC circuits application in 3-axes magnetometer

- Simple optoelectronic position sensor with CCD camera
- Analysis of measurement uncertainty of virtual vectorvoltmeter

APPENDIX III.

Some examples of topics of Dissertation

- Calibration of mutual-inductance standards based on application of Hall Quant Effect
- Modelling of AD modules errors and their influence to measurement uncertainty of virtual instruments
- Time and spectrum analysis of acoustic emission in diagnostics
- Application of magnetoresistors for navigation and ferromagnetic object detection

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