

Kandó Kálmán Faculty of Electrical Engineering**Institute of Automation****Address: Bécsi út 94-96, H-1034 Budapest, Hungary****Tel.: +36-1-666-5801****Fax: +36-1-666-5809****E-mail: iroda@aut.bmf.hu****Website: <http://www.aut.bmf.hu>****Head of Institute: György Fehér****1 Introduction**

The specialization of Automation which is one of the main departments of the Kandó Kálmán Faculty of Electrical Engineering, currently offers seven modules for students specializing in electrical engineering.

The optional group of specific modules is connected to one particular field of engineering of wider scope:

- They review the current technological instruments of a given field (elements of automation, electric machines, building units, measuring instruments and systems). Students are trained in laboratories to learn how to apply these.
- In addition, they review the typical systems built from the known instruments, the organizational principles of these systems, the selection of elements. Students learn how to put these systematically into operation. In the laboratories they can practise how to identify a well-operating system and also errors in the system.

In the Institute 22 full-time and 1 part-time teachers carry out the educational activities. Depending on the number of students and the curriculum for the term, highly experienced extra teachers are available mainly for conducting laboratory exercises. The special knowledge of one specific subject is conveyed to our students by invited lecturers.

An actual and successfully completed learning process can be demonstrated in the best way by the number of students having acquired a degree. At the same time it shows the proportion of full-time, part-time and distance-learning courses. The number of graduate engineering assistants can also be seen from the table. The table below shows the distribution of the number of theses and final papers

submitted between 2000 and 2005. This means that basically the same number of students successfully completed their final exams and became junior electrical engineers.

Year	Full-time			Engineering Assistant		Total
	Full-time	Correspondent	Distance-learning	Full-time	Correspondent	
2000	55	0	-	-	-	55
2001	55	19	-	11	-	85
2002	60	19	-	-	-	79
2003	68	12	-	-	17	97
2004	52	20	34	7	-	113
2005	60	9	26	13	11	119
2006	48	14	24	13	12	111
Total:	398	93	84	44	40	659

2 Educational Profile

The aim of the training of the specialization of Automation supervised by the Institute of Automation is to successfully train electrical engineers and engineering assistants, who are able to deal with the application, conformation, quality control and quality assurance of the typical sensors, regulators and actuators with special regards to regulated electrical drives, process control, robots and CNC machines. Students will be able to successfully complete tasks in connection with vehicular engineering, and also the planning, establishing, operating and controlling tasks of building supervisory systems. Graduate students will be able to solve tasks of planning, calculation, modelling and simulation supported by a computer.

To simplify, the Institute cultivates the field of automation of fractional technological processes assisted by intelligent servo systems. In this field, the new and modern establishments are operated in a typically integrated computerised operational system. In these systems, quality assurance and quality control will result in the building of automated intelligent measuring systems during and at the end of production, through which computer networks will assist the collection of measurement data, its processing and archiving. The supervisory systems should provide real-time surveillance of the processes and their parameters with the help of the same networks. If needed it should also provide interference in a defined system of hierarchy, as well as the modification of parameters.

The applied microcomputer control and regulation in the systems of shared intelligence will become more and more complex due to the increase in adaptivity and the better handling of non-linearities. Their planning and operation will

require engineers to extend their knowledge into the application of recent CAD systems.

Through the training of electrical engineers in the specialization of Automation by the Institute, graduate students – regardless of a particular field of study – will be able to use the computer confidently in solving planning and calculating tasks, as well as accomplishing computer aided planning and operational tasks in the field of electrical engineering. Therefore in the specialization, a high level of training is ensured in electronics, automation and applied IT as these constitute the basics of this specialization.

In addition to the training of students in the specialization of Automation, the Institute takes part in the training of students in electrical engineering in the specialization of Electrical Energetics, as well as in the training of Technological IT, teacher training for engineers, technological managers, and integrated training for engineers in English. On the Óbuda site of the Kandó Kálmán Faculty of Electrical Engineering of Budapest Tech, training is given in the following major subjects:

- Electronics,
- Digital technique,
- Technology,
- Measurement technique,
- Automation.

The Institute will teach the following subjects to all students choosing to study in the specialization of Automation:

- Electric machines,
- Power electronics,
- Computer-controlled systems,
- Quality assurance,
- Computer-aided design (CAD).

The subject ‘Computer-controlled systems’ is one of the founding courses of the specialization of automation, therefore signing up for this subject is mandatory for all students including full-time, correspondent and distance learning studies.

In this multiple term subject, students will get familiar with very important PLC controls, IT communication (serial, GPIB, CAN, PROFIBUS, etc.) as well as with the issues of data collection, projection and virtual instrumentation.

Our students will have the opportunity to obtain a deeper knowledge of one particular field of study within automation. The training of a chosen module is conducted in small groups, 10-15 students being in each group. Within the

specialization of Automation the following seven modules are being offered at present:

Module ‘Computer-controlled Production’

Students get familiar with the location, role and means of electronic control. Both in theory and practice they learn the development and application of eight-bit micro-processors and programmable logical control (PLC). They will obtain knowledge about signal generators and actuators, the measuring methods and means of non-electric quantities, as well as the analogue-digital converters, the display devices and their interfacing. Students learn about the methods of micro-controllers and their programming, the hardware and software solutions for digital control, the processing means and methods of the signals of transducers and sensors, as well as the programmable control systems. The full absorption of the curriculum, and the skills in interlocking, installation and error-search are made complete by the high number of laboratory exercises.

Module ‘Vehicle Electricity’

The students will familiarize with the tasks, structure and typical modes of the electric systems of cars, as well as their operation, error-search and correction. They will find out about the electronic control of car engines, brake-systems and other units, their operation, and the characteristics of measuring techniques. Students will learn about the role, the means and ways of traditional and microcomputer aided car-diagnostics. The theoretical knowledge and skills to identify errors will be made complete by several practical training.

Module ‘Building and Public Utilities Automation’

Students will learn about tasks to be solved in building and public utilities automation, the bus-structures of building supervisory systems, their means and programming. They will obtain knowledge in the technology of lighting, heating/cooling, air-conditioning and security (fire, entry-protection, access systems). Students will obtain detailed information about the topology, technology, communication, planning, installation, issues of visualization of two, wide-spread, structurally different supervisory systems (European Installation Bus and Johnson Controls METASYS) and will learn how to put these into operation.

They will examine the problems of energy-supply and energy management of buildings, as well as the opportunities for using alternative energy. Students will get familiar with the technology, process-control, technological projection of the facilities for the systems of water and gas supply, drainage, sewage and district-heating, as well as with the communication of distant units. Training is made complete by several laboratory practices.

Module ‘Robots and CNC Machines’

Students will obtain knowledge in the structure, movement-equations and sensors of robots, as well as track planning and different programme languages for robots.

They will learn about the methods of installment, application and operation, as well as the auxiliary devices connected to robots. They will deal with the development, control and regulation for driving robots. All subjects include a significant number of laboratory practices where first students will solve exercises, and later on they will carry out measuring and developing work related to their theses.

Module ‘Electric Machines’

Students will get to know the electric machines applied in the field of automation, operating electronics in organic unity with the machines, as well as the info-electronic environment. In the subject ‘Computer-aided Test (CAT)’ students will encounter particular measurement techniques, micro-computers and further knowledge related to electric machines which can help solve quality-control and quality-assurance by computers during and at the end of production. In the subject ‘CAD’ they will learn about the methods and means of computerized planning, construction and drawing. The absorption of this subject will be made complete by the students solving individual tasks during laboratory exercises.

Module ‘Drive Control’

Students will familiarize with the structure and operation of transistor-, thyristor-, direct- and alternative current regulated drives, the theory of analogue and digital control, the hardware and software solutions for controlling IT electronics, as well as the fundamental structure and test programme of shared intelligence systems. Through laboratory exercises they will become familiar with the installation and measuring of up-to-date drives and functional units, as well as the development of computerised communication systems. Students will acquire the conditions and solutions for arranging shared intelligence systems into the computerized supervising systems.

Module ‘Power Electronics’

The topics of subjects cover the structure of power electronic systems, their connection, the observance of control specifications resulting from the quality of the used semi-conductors. Students will learn about the light-and heavy-duty equipment for converting the different types of currents, as well as rectifiers, inverters, frequency-converters and choppers. They will deal in details with the tasks in the current converters as actuators of power control, as well as measuring and installation procedures, the simulational examination of units and the methods for tracking down operational errors. Theoretical knowledge is reinforced by high number of laboratory practices.

The Institute of Automation has 14 laboratories and measuring is conducted in one of them. It is more and more typical that one of the laboratories belonging to one of the specializations of the Institute is the venue of in-service trainings for the request of different professional associations and companies. As a consequence of this scheduling problem arise occasionally regarding auditoriums and laboratories.

Theses

Two to four theses written by our students achieve first and second placement annually in different competitions. Efficiency is further proved by the fact that in our training several implemented theses are published as educational supplementary material or as accomplished practical devices. Year to year there are theses of 'confidential' results which constitute significant innovation of a particular company (eg. one thesis written in German and one in Hungarian were ordered by AUDI in Győr and Ingolstadt). We can presume that the level of knowledge of our graduate students is appreciated at an international level as well. As far as we know, as a consequence of this, our graduate students find jobs relatively easily. It goes without saying that lack of language skills is an obstacle for students to obtain higher positions immediately. The Institute considers it its task to teach the special technical language and have it practised (interim foreign language exercises, translations), however, the Institute cannot undertake the job of teaching the basics of the language.

During the ten-year operation of the predecessor in title 'Faculty of Heavy current' about 1500 students obtained a degree in electrical engineering, a further 2500 students graduated in the specialization of Automation in the past 25 years, thus altogether about 4000 students qualified as electrical engineers in the past 35 years.

Cooperative Training

The above mentioned external invitations for writing theses can only be realized if there is a close relationship and permanent cooperation between the industry and the Institute. This can be proved and strengthened by having voluntary professional practice, that is cooperative training in the fourth year.

The third academic year is followed by a ten-month long professional practice, the cooperative training for which interest has been steadily growing from year to year both by the students and companies with engineering profile. Today, practically 80-90% of students having completed their third year (undergraduates) take part in this form of training. The number of companies accommodating and employing students in a professional way reach 70-80. These companies at approximately 50% provide topics for our students to write their theses, they serve as external consultants with regular feedback, on one hand they acknowledge the activities of the Institute, on the other hand they inform the Institute immediately about deficiencies. This criticism is an assurance for the Institute to train practice-centered, useful engineers. During the professional practice the Institute continuously monitors the changes of the companies' expectations obtaining valuable information about the demands of development and enlargement of the taught subjects. This form of education thus is the scene for introducing and testing new topics and subjects.

Distance Learning

Distance learning was introduced some years ago making it possible for talented and motivated people who mostly have full time jobs and live far from the College, to study. The Institute of Automation was among the first to join the programme of distance learning. In order to make distance learning as high standard as that of full-time studies, students are provided with special course books and supplements (video-cassettes), furthermore they are in constant contact with the college through centres for consultation.

Training for Electrical Engineer Assistants

Our Institute is one of those sites where there is a possibility to take part in the training for electrical engineer assistants, which can be accomplished in a shorter period of studies than the full-time course, however, at the same time it provides high-standard and well-grounded training in higher-education.

3 Research and Scientific Activity

The research, development and publication activities of our educators teaching in the Institute is basically grouped around four topics (see below some of the fields of study, typical of the Institute).

PhD Activities

1 Investigation of High-Temperature Superconducting Fault Current Limiter

The inductive type, high-temperature, superconducting fault current limiter (HTS FCL) is an effective means of controlling fault currents appearing in the power grids. The experiments in the behaviour of fault limiters and its simulations, as well as the analysis of the procedures in the high-temperature superconductors, and its modelling determine the possibilities for applying fault current limiters (FCL). This is the base for producing current limiters suitable for industrial application, which can be used for the protection of any system. According to general opinion, the industrial application and launching of fault current limiters can be reasonably predicted for the near future. The preparation of the domestic launching of this modern technology is an important and timely task. The number of publications related to to this topic is 13.

2 Sensorless Control Unit for Synchronous Motor Drive

In the framework of the research the influence of digital control (eg. sampling, quantifying, finite number representation) is examined on the performance of the drive (eg. accuracy, sensitivity and decoupling). On the other hand it makes research in the field of feasibility of the so-called 'sensorless electric drives'.

The sensorless drive is such a speed regulated drive, where the system doesn't contain mechanical speed sensor, thus eliminating very expensive maintenance elements. The elimination of the mechanical sensor – in addition to drastically reducing the price of the system- increases reliability if the digital control is developed in appropriate quality. Certainly, the mechanical sensor can only be eliminated, if the signal proportional to the speed control is generated with the help of any model. This can be a state model, or models based on fuzzy, neural and genetic artificial intelligence. The number of publications related to the topic is 9. The results of the papers can directly be integrated into the training (modules of 'Electric machines of Automation', 'Drive control' and 'Robot-CNC').

3 Application of Symbolic Simulation in Logic Networks and Software Systems

In the case of the method of symbolic simulation in logic networks, at testing not random bit-combinations (true and false status) are placed on the input of the real and model instruments, but logic input variables. The advantage of symbolic simulation is, that the number of input combinations increases in a linear way, as in the case of the n variable the number of input combinations is not 2^n but only n . The complexity of the method starts when the logic network is determined by a programme written in hardware description language.

4 The Examination of Permanent Magnet-excited Small and Medium Power Synchronous Servomotors

One of the aims of the research is the geometric developing of rotor and stator which can be implemented in the case of such serial production, where the smallest possible torque ripple appears. Within the framework of the machine optimization such construction must be implemented which results in the small torque ripple, highly efficient and high performance density motors. Due to the high price of the technological instruments and tools needed for the production of electric machines it is a realistic requirement that in the planning phase, the electric machine can accurately be modelled. The further aim of the research is the modelling of the experimental engine, as well as the development of the measuring system of the machine for the model testing.

Development of Course Materials Linked to Applications

1 Vehicle Measuring (Tempus IB_JEP-14191)

The aim of the TEMPUS programme called 'Euroconform Complex Retraining of Specialists in Road Transport' was that our transport specialists should acquire knowledge in public vehicles and public transport systems used in the EU.

The aims of the projects are:

- Facilitating technological changes regarding public vehicles in the field of vehicle automation, vehicle IT and vehicle diagnostic. The adoption of

EU standards in the above topics is a primary aspect, as well as the adaptation and recognition of requirements with regards to environmental and noise protection, security of techno-economics and law.

- In the field of public transport, the application of artificial intelligence and GPS in traffic control, furthermore the adaptation of intelligent systems introduced in the EU in 2002.

2 Electric Measuring Instruments and their Application (Public Endowment 'Apertus')

The project solved the development of educational programme in measurement technique in interactive form and by e-learning. The discussed topics are: concepts of measurement technique, the measuring of electro-mechanic instruments, digital instruments, oscilloscopes and electric quantities. A special feature of the project is that it has been developed for intermediate and proficient levels of training.

3 Development of Material for E-learning for the work group in mechanical engineering in the field of measuring electric machines (Publishing House 'Műszaki' and Public Endowment 'Apertus')

All three applications have aimed at developing educational materials through which their consequences and results were directly built into the training.

Contracted Jobs Carried out for the Expense of the Innovation Fund and for Industrial Requests

The number of industrial request has substantially decreased compared to the years before the political change-over. By now, more and more companies have started recognizing the potentials in the engineers and researchers employed by the Institute. See below some of the industrial requests representing the fields of study provided by the Institute.

1 The Development and Implementation of One Quadrant Switching Power Supply (Client: Remy Hungary Co. Ltd.)

Within the framework of the research development contract we have developed a 0-28 VDC, 2000 A power supply, which is suitable for the testing of high powered starting motors. The equipment suitable for industrial purposes is a step-down type switching power supply, the voltage control method is Pulse Width Modulation (PWM). Due to economic reasons the necessary high-output power has been solved with parallelly connected Field Effect Transistors (MOSFET-s). During the development of the equipment we have prepared the computerized checking of the voltage-, current and heating requirements and the computerized modelling of the specific operational conditions. After building it, we have compared the results of the simulation with those of the measurements. One publication, the results of the

development and of simulation have been integrated into the subject 'Power electronics'.

2 The Examination of Prototype Wind Generators (Client: Rész DOMÉN Kft.)

The examination of small power prototype wind generators to be patented. Due to the small power prototype wind generators to special breaking generators had to be made. The results of the tests have been integrated into the subject 'The electric machines of automation'.

3 The Testing of the Regulated Drives of the 30 Ton Bridge Crane in the Reactor Hall of Paks Nuclear Power Station (Client: Paks Nuclear Power Station Ltd.)

The subject of the contract is examining and carrying out necessary repair works of the regulated drives of the 30-ton-bridge crane in the reactor hall earlier made by the participants. The speciality of the work is that great care must be taken in keeping the energy-law and its connected regulations, as well as meeting the requirements for reliability and quality assurance deriving from its specific operation. The results of the paper have been integrated into the subject 'Drive Control'.

4 Suitable System for Projecting Advertisements in the Underground Tunnel (ESMA innovation contract)

The concept is that using the features of the underground, a few second long advertisements should be projected for the public travelling in the underground carriages, that is some flashing images should be shown on the walls of the underground tunnel at the height of the windows. Showing these flashing images requires serious calculating efficiency as from the speed and the acceleration of the train, the right moment – when the image is exactly opposite the window – should be determined. The person travelling in the carriage can see a moving image when looking out of the window. The individual images are placed between the glass panes on the front side of the metal boxes containing them. The metal box with the images contains the light fittings (flash modules) necessary for the high intensity and short time exposure, as well as the calculating- and control electronics.

The Research and Development Activities of the Lecturers of the Institute of Automation within a Workshop

1 Battery-driven Vehicles

Due to their efficiency and environment-friendly operation, battery-driven, brushless, permanent magnet rotor type motors can be used well in low power electric vehicles. In the past few years several electric vehicles driven by electrically commutated motors (electric scooter, wheel-chairs, golf cars, bicycles and tricycles) have been developed in the Institute of Automation of the Kandó Kálmán Faculty of Electrical Engineering of Budapest Tech.

The structure of the motors is very varied: built-in or glued magnet on rotor surface; radial or axial flux; armature winding with or without iron cores. The supply voltage is 12-71 V, their output current is 30-600 A.

Change-over between the motor and break operation is automatic, the breaking energy is recuperated into the battery. The quick DSPs which are becoming cheaper and cheaper mean new possibilities for the control of drives. Considering the possibilities of economic viability we are looking for new solutions in drive control. Results: 5 publications (4 of it in foreign language journals or conference publications), the serial production of 'ELGO' made for the disabled (Factory for Medical Aids). The topic has been integrated into the course material 'Electric machines of Automation'. In the BSc course we want to introduce a new subject built on our experiences in this area.

2 Microcomputer (DSP)-aided Measuring of Electric Machines

In the Institute of Automation of the Kandó Kálmán Faculty of Electrical Engineering of the Budapest Tech we have been working on the computer-aided measuring of electric machines for over two decades. The latest phase of this development is a DSP controlled measuring instrument which can be connected to a host computer, which is appropriate for the simultaneous measuring of voltages, currents and components of electric powers. The instruments communicating with the PC and each other can be structured into a three-phase measuring system as well. Based on the sampling results or measuring points forwarded to the host computer, it is possible to have the waveforms or different (for example no-load, loaded and short circuited) characteristics drawn. The measuring instrument is relatively cheap, owing to isolation, its operation is reliable, and compared to the electro-mechanic instruments it can be serviced better. Therefore it can be used well in the case of laboratory measuring and standard qualifications, as well as in training.

Results: 5 publications (2 of which were published in foreign language papers), the prototype (UPSM used for laboratory measuring in the subject 'Electrocity' in the Institute of Electric Energetics) and its industrial application (HOTBOX, client: A.O: Smith Ltd.) of the measuring instrument. The results of the research and development have been integrated into the subject 'Computer aided measurements'.

3 Testing Devices Controlled by Micro-Computers or PLC-s for Industrial Request (eg. 'Test bench for examination of magnetic switches of starting motors'. Client: Delco Remy Hungary Ltd.)

The test bench for the magnetic switches of starting motors in utility vehicles has been developed for industrial request. During the load test the test bench cyclically checks the correct operation and the case temperature of the contactor, while the closed contact is loaded with prescribed (400/60/0 A) current waveform. The method of diagnosing the error is the comparison of the

measured current through the switch with the prescribed current in the given phase. Before the start of the lifelong test, the user is able to define the time durations of switching processes, the temperature limit of the contactor and the prescribed cycles of test.

Publication Activity

Based on the publication list of employees of the Institute, 20 to 23 publications appear yearly in the Institute, which means that annually, on average each full-time lecturer publishes one publication (22 full-time and 1 part-time teachers).

The Scientific of Work of Student Groups

Our students regularly take part in the activity of the scientific work of student groups (TDK). This activity can only be realized and be effective through very close cooperation between teachers and students, carried out in workshops. In the last few years 17 papers were written. Out of these, several publications have been rewarded both in-house and national competitions.

International Relations

The Institute has international relations (Socrates-Erasmus contracts) with Bethune IUT (France), ECAM (Brussels, Belgium), Savonia Polytechnic (Kuopio, Finland) and the college of Breme (Germany). On the basis of these contracts in the past three years 10 of our teachers had 3-7 day visits to the above mentioned institutes, and 13 teachers paid a visit to our Institute. On the occasion of such visits, we regularly organise open days where our Institute is introduced. We also hold lectures, reconciliation on the curriculum and prepare applications. Last year the participating colleges all concluded the 'Carolus Magnus' agreement in the framework of which they all wish to submit joint applications for European Union programmes. In the same period 26 of our students attended school abroad and from the above named institutes 24 students were received by our college.

PR Activity

Seventeen lecturers of the Institute are the members of the Hungarian Electrotechnical Association. Two of the lecturers are members of the Hungarian Industry Application Chapter of the IEEE. Mr. András Farkas is one of the columnists of the journal 'Elektrotechnika'. In 2003, Mr. Zoltán Pálfi was awarded the prize 'Elektrotechnika' by the Hungarian Electrotechnical Association.

Institutional Infrastructure

The development of infrastructure is determined by the available financial and human resources. In the past 4-5 years there have been considerable changes regarding the available resources. Of the financial resources the rate of income from state financing and contracted company jobs has substantially decreased, at the same time the role of co-operative training, financial support received through

applications and the role of vocational contribution has increased and become dominant. For example, the amount of vocational contribution coordinated by the Institute of Automation aiming at the improvement of the tangible conditions of practical training was HUF 7.37 million in 2002, HUF 6.33 million in 2003, HUF 10.66 million in 2004, while from state funding, the Institute of Automation was allocated HUF 2.465 million in 2004.

The integration of the available financial resources into the educational process is affected by the timetable and other commitments of the lecturers and educational assistants (eg. laboratory assistants). From this point of view, in the given period the condition have considerably deteriorated: human resource capacity available for elaborating new measurement techniques is limited by the different newly introduced educational forms, the large increase in the number of students, the over-burden and ageing of educational assistants directly involved in training.

The Institute of Automation currently has 14 laboratories, and one of the most important strengths of the practical training carried out by the Institute is that in our laboratories 277 different measurements can be carried out. Based on this figure, the number of current measurements under development is 14 (5%), and in the recent past the number of elaborated and considerably modified measurements has been 110 (39.7%). From the survey it can be seen that despite the increase on the burden of our teachers, the Institute regards this field very important from the educational point of view. The infrastructure of the Institute has been examined from the aspects of financial support for education and research.

To support research opportunities, five research sites have been established in the Institute. On the research sites our aim is to acquire equipment for emulation and tracing. During this period we have started the application of DSPs for the aims of measurement techniques and drive control.

Opportunities for Development in the Specialization of Automation

The development of a specific field in education, research and the development of infrastructure represented by the specialization of Automation requires the following from the Institute:

- The training for industrial IT must be further developed (eg. the subject ‘Computer controlled systems’ should be developed and harmonized with the subject ‘IT II’);
- The extension of training in the intelligent equipment for measuring the parameters for products and producing equipment (size, speed, acceleration, force, torque, current, voltage, components of electric power...) even through establishing optional subjects;
- The selection of hardware elements of automation must be realized both in the existing and the new subjects;

Institute of Automation

- In the laboratories, new inner communication networks must be established and the supervisory systems connected to them must be developed;
- Hardware and software instruments of simulation must be purchased to substitute the devices which are unavailable but cannot be neglected in education etc;
- The Institute must be prepared to provide training in foreign languages in the major subjects.

The mentioned and not at all complete specifications can only be envisaged with human resource development, which cannot be achieved just by receiving support from successful applications and vocational funds.