Department of Electrical Drives

Annual Report 1991

Department of Electrical Drives
Faculty of Electrical Engineering
TECHNICAL UNIVERSITY
Svermova 9
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Czech and Slovak Federal Republic

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Contents

1. Foreword

The Department of Electrical Drives is one of the largest departments of the Faculty of Electrical Engineering. It was created in 1969 from the original Department of General Electrotechnics which was a part of the Faculty of Mechanical Engineering from 1953. The Department is responsible for education in the field of Heavy-Current Electrical Engineering. The main aim is to prepare students for careers in industry and for research. The Department offers Master of Science and Doctor of Philosophy degrees.
The Department has 34 full academic staff, 6 researchers and 10 support staff.
The research carried out of the Department of Electrical Drives, covers a broad field of interest. It is concentrated on controllable electrical drives, power electronics converters with improved dynamic properties, applicability studies of control theories to the control of complicated drives (multi-motor drives of manufacturing lines, drives of robots and manipulators) an on microcomputer implementation of control algorithms and their hardware realization.

2. Faculty

Head	Assoc.Prof. Jozef Fedor Ph..D.
Associate Head for research	Assoc.Prof. Jaroslav Dudrík Ph.D.
Associate Head for education	Assoc.Prof. Ján Fetyko Ph.D.

Division of Electrical Drives

Chief: Prof. Ladislav Zboray Ph.D.
Members: Prof. Jaroslav Timko Ph.D.
Assoc.Prof. Ján Fetyko Ph.D.
Assoc.Prof. Jaroslav Tomko Ph.D.
Assist.Prof.František Ďurovský
Assist.Prof.Stanislav Pčola
Assist.Prof.Marcela Halušková
Ľudovít Višnyi - researcher
Miroslav Nagy - researcher
Karol Daubner - Ph.D. Student
Anna Elšigová - Ph.D. Student

Division of Power Electronics

Chief:	Assoc.Prof.	Jozef Ondera Ph.D.	
Members:	Assoc.Prof.	Imrich Pokorný Ph.D.	
	Assoc.Prof.	Juraj Oetter Ph.D.	
	Assoc.Prof.	Jaroslav Dudrík Ph.D.	
	Assist.Prof.	Irena Kováčová Ph.D.	
		František Magyar Ph.D.	- researcher
		Peter Višnyi Ph.D.	- researcher
		Rastislav Uhrín	- Ph.D student

Division of Electrical Machines and Apparatus

Chief:	Assist.Prof.	Pavol Struckel	
Members:	Assoc.Prof.	Jozef Fedor Ph.D.	
	Assoc.Prof.	Michal Kostelný Ph.D.	
	Assist.Prof.	Želmíra Ferková	
	Assist.Prof.	Bartolomej Fedor Ph.D.	
	Assist.Prof.	Pavol Záskalický Ph.D.	
	Assist.Prof.	Ján Kaňuch	
		Marián Kerestúri	- Ph.D.Student
		Miroslav Tvrdoň	- Ph.D.Student

Division of Motion and Process Control Technology

Chief:	Assoc.Prof.	Michal Girman Ph.D.	
Members:	Assoc.Prof.	Viliam Fedák Ph.D.	
	Assoc.Prof.	Pavol Fedor Ph.D.	
	Assist.Prof.	Juraj Haluška Ph.D.	
	Assist.Prof.	Ladislav Kiovský	
	Assist.Prof.	Stanislav Fedor	
	Assist.Prof.	Daniela Perduková	
		Rastislav Harčarufka	- researcher
		Peter Bober	- Ph.D.Student
		Peter Košč	- Ph.D.Student
		Jaroslav Maxim	- Ph.D.Student

Division of General Electrotechnics

Chief:	Assist.Prof.Stanislav Kovalčin Ph.D.	
Members:	Assist.Prof.Juraj Németh	
	Assist.Prof.Eva Dobošová	
	Assist.Prof.Dionýz Milly	
	Assist.Prof.Vladislav Maxim	
	Assist.Prof.Vladimír Rožek	
	Assist.Prof.Jarmila Žilková	
	Assist.Prof.Silvia Hrehorová	

Other members:	Mária Ritóková	- technician
	Katarína Gočová	- technician
	Veronika Majerníková	- secretary
	Viera Grejtáková	- technician
	Branislav Tresa	- technician
	Peter Hajduk	- technician
	Anton Nagy	- technician
	Vasil Graban	- technician
	Pavel Chovanec	- technician
	Soňa Juhásová	- technician

3. Overview of the Areas of Research

Following current research projects are carried out at the Department of Electrical Drives for the period 1991-93.

1. State control of electrical drives

2. Control of AC drives fed by frequency converters

3. Software and hardware development for distributed control systems for multimotor drives and drive complexes

4. Modern types of AC drives

1. State control of electrical drives

Research activity of this group is concentrated on:
- State control design for nonlinear systems
- Nonlinear observer design for DC and AC drives
- Variable structure state control of drives
- Control of the drive system with elastic two-mass connection
- State control for robot servosystem

Associated Faculty: Ladislav Zboray, Jaroslav Tomko, Ján Fetyko, Marcela Halušková, Stanislav Pčola, František Ďurovský, Juraj Németh, Miroslav Nagy, Ľudovít Višnyi, Karol Daubner

Concrete results
- realization of a DC drive position state control with observer
- realization of a DC drive with variable structure position control
- there is in realization state control of a DC series motor
- has been simulated state control of AC drives according to feedback linearization method
- was built the model of a mill with consideration of its elasticity
- has been completed the literature survey containing recent control design methods for non-linear systems
- were prepaired technical equipments and algorithms for drive control (using transputer and signal processor)

Journal Papers: [1],[4],[5]
Conference Papers: [1],[4],[5]

2. Control of AC drives fed by frequency converters

Research activity of this group is focused on:
- Research and development of frequency converters with switched-off power semiconductor devices (bipolar transistors, MOSFETs, IGBTs and GTO thyristors)
- New control structures of AC drives
- Development and construction of laboratory prototypes of power frequency converters
- Realization of laboratory prototypes of control circuits of AC drives

Associated Faculty: Jaroslav Timko, Pavol Fedor, Jozef Ondera, Imrich Pokorný, Peter Bober, Eva Dobošová, Jaroslav Dudrík, Peter Košč, Irena Kováčová, Stanislav Kovalčin, Peter Višnyi, Rastislav Uhrín

In task solution
- there were ended works on one version of frequency converter with bipolar transistors
- was made software of control circuits of AC drives with AC machine for field-oriented control
- were started works on AC regulated drive linear machine
- is before ending the construction of laboratory prototype of frequency converter with MOSFET transistor
- was constructed system for resonancy frequency converter
- was worked up the theory of control by Fuzy sets and its application in the regulated drives

Journal Papers: [2], [3], [6]
Conference Papers: [2], [3]
Patents and Application of Patents: [1], [2], [3], [4], [5], [6]

3. Software and hardware development for distributed control systems for multimotor drives and drive complexes

Research activity of this group is concentrated on:
- Mathematical description of multimotor drives and appropriate production technology from the view of control algorithms design
- Control algorithms derivation on the basic of extension and application of existing multivariable control theories
- Development of corresponding software for automated design control algorithmus using CAD
- Realisation of laboratory prototype of multimotor drive and designed control system

Associated Faculty: Michal Girman, Viliam Fedák, Pavol Fedor, Juraj Haluška, Ladislav Kiovský, Stanislav Fedor, Daniela Perduková, Rastislav Harčarufka, Jozef Bořik, Branislav Tresa, Peter Bober, Sylvia Hrehorová, Jaroslav Maxim

Concrete results
- there was carried out and is being carried out research about the state of problematics of program equipment of control systems drive

of drive complexes. For standard was taken the program equipment of control system fy Siemens
- for object programming it is necesstary to purchase the programming language TOP SPEED MODULA 2 fy JPI. There are no financial means for this at present time
- for building the control system there was designed the configuration and purchased the technical means MMS, KIRS, transputer modules, the work is going on according to scheduled time
- a mathematical desscription of multi-motor drive complex and analysis of needs and dimensioning the communication among the single knots is planned for the year 1992/93

Journal Papers: 0
Conference Papers: [2]

4. Modern types of AC drives

Research activity of this group is concentrated on:
- Controlled electrical drive with switched reluctance motor
- Analysis of properties of AC drives with new types of converter
  a) Asynchronous motor fed by an indirect frequency converter with a parallel high-frequency resonant circuit
  b) Noise dampening in asynchronous motor fed by new types of converters

Associated Faculty: Jozef Fedor, František Magyar, Juraj Oetter, Michal Kostelný, Bartolomej Fedor, Pavol Struckel, Dionýz Milly, Želmíra Ferková, Vladislav Maxim, Ján Kaňuch, Marián Kerestúri

The research is worked out, all the points of the task are being currently solved
- there is realized the reluctance motor $2p_1/2p_2 = 6/4$, P = 3 kW
- the constructed functional model of transistor converter is at revival phase
- there is finished the electromagnetic design of reluctance motor with the axial air gap. The design and manufacturing of stamping tools was finished
- there was carried out the research on the basis of which the model of frequency converter with parallel resonance semicircuit is designed. The converter is in the state of simulation
- there was worked out the theory and carried out the count of

exciting components of noice in magnetic field into an air gap of induction motor with non-harmonic voltage

Journal Papers: 0
Conference Papers: [4], [5]

4. Faculty Essays

Teachers

Jaroslav Timko
Professor
Ph.D., The Technical University of Košice, 1976
His branch specialization is progresive control of AC drives fed by power electronic frequency converters using AC asynchronous machines and linear asynchronous machine

Ladislav Zboray
Professor
Ph.D., The Technical University of Transport and Communications of Žilina, 1964
His research interest includes application of nonlinear state control methods for DC and AC electrical drives

Jaroslav Dudrík
Associate Professor
Ph.D., The Technical University of Košice, 1986
He is interested in area of power electronics. His research work includes analysis and design of static power converters and their control

Viliam Fedák
Associate Professor
Ph.D., The Technical University of Košice, 1981
His research in last years has concentrated on the application on

the methods of modern multivariable control theory for the control of multi-motor drives. Various methods of the design of centralized and decentralized controllers, robust feedback control including observers have been investigated. A second area of interest concerns the system identification and modelling of drive systems

Jozef Fedor
Associate Professor
Ph.D., The Technical University of Košice, 1981
He works in area of switching electrical circuit and switching apparatus. He is also busy at applications of power semiconductor devices and circuits for a switch technique

Pavol Fedor
Associate Professor
Ph.D., The Technical University of Košice, 1985
Field of his interest is a software for automatization and control system (mainly real-time-software) and new control methods of electrical drives. Now he works in region of parallel and distributed programming and application software for transporter system

Ján Fetyko
Associate Professor
Ph.D., The Technical University of Košice, 1981
His research interest includes the dynamic approach to motion generation of manipulation robots and the non-adaptive and adaptive control of electrical servosystems for driving industrial robots

Michal Girman
Associate Professor
Ph.D., The Technical University of Košice, 1981
Field of his interest is a software for automation and control systems. Now he works in region of parallel and distributed

programming-multitasking on PC&LAH and software for transputer systems

Michal Kostelný
Associate Professor
Ph.D., The Technical University of Košice, 1983
He works in area of electrical machines.

Juraj Oetter
Associate Professor
Ph.D., The Technical University of Košice, 1979
He aims at the new types of power semiconductor converters scientifically. He specializes in the controlling of these mainly. Last years he works in a research of microcomputer controlled tranzistor converters for switched reluctance motors

Jozef Ondera
Associate Professor
Ph.D., The Technical University of Košice, 1985
Field of his interest is design and control of power semiconductor converter. His research in last years has focused on the solution of direct-current converter.

Imrich Pokorný
Associate Professor
Ph.D., The Technical University of Košice, 1980
His current interest includes inverters with and without DC line. His present research deals with the design of resonance inverters. He studies back influence on feeding line and the content of higher harmonics in the output voltage and current

Jaroslav Tomko
Associate Professor
Ph.D., The Technical University of Košice, 1981
He is specialized in modern methods of electrical drives control,

particularly state space control, adaptive systems with time delay and electrical drives for technological lines

Eva Dobošová
Assistant Professor
Her research interests include analysis and control electric power systems. Her primary area of research is control of asynchronous machine

František Ďurovský
Assistant Professor
He is interested in control of electric drives especially state space control, design of observers and creating of control programs for electrical drives

Bartolomej Fedor
Assistant Professor
Ph.D., Moscow Power Engineering Institut, 1985
He works in area of switching electrical circuit and switching apparatus. He is also busy at application of power semiconductor devices and circuits for a switch technique

Stanislav Fedor
Assistant Professor
He is interested in computer control, SMT and Hybrid technology. He was obtain some results in design of measuring instruments for testing and diagnostic of energetic devices

Želmíra Ferková
Assistant Professor
She is specialized in the field of electric machines with orientation on the research of switched reluctance motor

Juraj Haluška
Assistant Professor
Ph.D., The Technical University of Košice, 1988
His interest is in the areas of digital control system, first of all multiple processor systems and reliability of control systems

Marcela Haluškova
Assistant Professor
Her research interests include variable structure systems, sliding mode operations, control of linear and nonlinear systems which have applications in electrical drives problems

Ján Kaňuch
Assistant Professor
He is interested in design of disk step motor and disk reluctance motor, also application of CAD methods in design of electrical machines and devices

Ladislav Kiovský
Assistant Professor
He is interested in industrial control electronics, especially in microcomputer peripheral electronic devices and interfaces for motion and process control, applications of new types of microcomputers and VLSI circuits like transputer and field programmable gate arrays in automatic control systems, also in microcomputer control of switched reluctance motor drive

Stanislav Kovalčin
Assistant Professor
Ph.D., The Technical University of Košice, 1988
His field of work is power electronics, control of power semiconductor converters by use of microcomputer technics and its application in the industry

Irena Kováčová
Assistant Professor
Ph.D., The Technical University of Košice, 1988
The main direction of her work is power electronics. Her interest is especialy concentrated on the application of power MOSFETs in the circuits of power electronics

Vladislav Maxim
Assistant Professor
His area of interest is power electronics. He works in field of frequency changers PWM with sinusoidal input current

Dionýz Milly
Assistant Professor
He is specialized in the field of frequency changers with sinusoidal input and ouput currents and control circuits for static power conwerters

Juraj Németh
Assistant Professor
He deals with problems of the models of frequency controlled AC machines, especialy with field vector oriented control and with control of the efficiency and power factor

Stanislav Pčola
Assistant Professor
He works in design and realisation of non-linear controllers of DC series motor and PM synchronous motor

Daniela Perduková
Assistant Professor
She is busy about a design method and new control structure for the centralized controller of the multi-motor drive of a production line in which the motors are mechanically coupled by a continuous moving web. Model reference adaptive control systems

in synthesized by means of the Ljapunov Second Method. Its priority consists in quick tuning of the simple controller, which secures excellent dynamic properties of the system

Vladimír Rožek
Assistant Professor
He is specialized in modern methods of electric drives control

Pavol Struckel
Assistant Professor
His interest are rotating AC electrical machines, respecially magnetic field effects and noise of induction machines. Besides he deals with CAD (Computer Aided Design) at sphere of elecrical machines

Pavol Záskalický
Assistant Professor
Ph.D., The Technical University of Košice, 1984
His field of interest are electrical apparatus and machines

Jaroslava Žilková
Assistant Professor
Her main interests are in the area of theory and practical application of process control

Researchers

Rastislav Harčarufka
The field of his interest is a software for automation and control systems (mainly real-time software). Now he works in region of parallel and distributed programming-multitasking on PC & LAN and software for transputer systems

František Magyar
Ph.D., The Technical University of Transport and Communications of Žilina, 1969
His professional interest belongs to power electronics particularty to power converters for controlled AC motor drivings.

Miroslav Nagy
His research interests include control of electrical drives state feedback control, control with an observer, application of microcomputers to control

Ľudovít Višnyi
He is interested in the field of electronics, computer technic design applications of special microprocessors and other integrated circuits at control of electrical drives

Peter Višnyi
Ph.D., The Technical University of Košice, 1983
He is a specialist on digital speed and position control of electric machines. He is interested especially in extremly high dynamic performance and precise electrical drives of small power

5. Research Publications

Journal Papers

1. Halušková,M.: Application of sliding modes to DC motor control. Elektrotechnický časopis (in press)

2. Kováčová,I.: Nové zapojenie usmerňovača. Elektrotechnický časopis (v tlači). (New connection of rectifier - in press)

3. Kováčová,I., Kováč,D.: A new connection of three phase rectifier. Archiv fur Elektrotechnik (in press)

4. Zboray,L.: Entwurf einer Zustandsregelung mit Systemordnungs-reduktions. Automatisierungstechnik 1991 (v tlači)
(State control design with system order reduction - in press)

5. Zboray,L.: Nonlinear control for a synchronous motor. Trans. TU Košice Riecansky Sc.Publ., Cambridge (in press)

6. Varga,L., Gardoš,M., Kovalčin,S., Klein,M.: Meranie krokových dotykových napätí a uzemnení v elektrických zariadeniach. Zborník Aktívu revíznych technikov el. zariadení, Košice 1991
(Measuring of step contact voltage and grounding in electrical equipment)

Conference Papers

1. Fetyko,J.: Štruktúry stavového riadenia servosystémov s dvojfázovým motorom. Zborník XXII. celostátní konference o elektrických pohonech, Plzeň 1991 p.61-68
(Structures of state control of servosystems with two-phase motor)

2. Fedor,P., Fedák,V., Bober,P., Timko,J.: Field oriented induction motor drive with indirect rotor flux sensing. 4. europ. konf. EPE 91 Florencia, Sept. 1991 p. II.-214-217

3. Kovalčin,S.: Súprava na meranie zemných odporov. Zborník prác z konf. SEKEL, Praha 1991
(Set for measuring ground resistances)

4. Maxim,V., Tomko,J.: Bezkontaktný samonapájateľný spínač v nule. Zborník konf. SEKEL Praha 1991 p. 82-84
(A contactless self-fed switch in zero)

5. Tomko,J., Maxim,V.: Úprava meniča frekvencie typu RLL pre skalárne riadenie striedavého pohonu. Zborník konf. SEKEL Praha 1991 p.114 - 118
(Arrangement of frequency converter type RLL for the scalar control of AC drive)

František Magyar
Ph.D., The Technical University of Transport and Communications of Žilina, 1969
His professional interest belongs to power electronics particularty to power converters for controlled AC motor drivings.

Miroslav Nagy
His research interests include control of electrical drives state feedback control, control with an observer, application of microcomputers to control

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Journal Papers

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3. Kováčová,I., Kováč,D.: A new connection of three phase rectifier. Archiv fur Elektrotechnik (in press)

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(Measuring of step contact voltage and grounding in electrical equipment)

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(A contactless self-fed switch in zero)

5. Tomko,J., Maxim,V.: Úprava meniča frekvencie typu RLL pre skalárne riadenie striedavého pohonu. Zborník konf. SEKEL Praha 1991 p.114 - 118
(Arrangement of frequency converter type RLL for the scalar control of AC drive)

Patents

1. Kováčová,I., Kováč,D.: Zapojenie generátora impulzov pre riadenie trojfázového tranzistorového usmerňovača. AO č.274 382
(Connection of pulse generator for control of three-phase transistor rectifier)

2. Šimková,I., Kováč,D.: Zapojenie číslicového generátora impulzov. AO č. 272 492 (Connection of digital-pulse generator)

3. Šimková,I., Kováč,D.: Zapojenie štvorkvadrantového impulzového meniča s výkonovými poľom riadenými tranzistormi typu MOS s M kanálom. AO č. 274 359
(Connection of fourquadrant DC converter with power MOSFET with N channel)

Application of patents

4. Kováčová,I., Kováč,D.: Zapojenie galvanického oddelovacieho člena s optrónmi.
(Connection of galvanic separating unit with optrons)

5. Kováčová,I., Kováč,D.: Zapojenie prepäťovo-nadprúdovej ochrany výkonových poľom riadených tranzistorov.
(Connection of overvoltage-overcurrent protection of power FET transistors)

6. Pokorný,I.: Zapojenie na vyprázdnenie rezonančných obvodov rezonančných meničov frekvencie.
(Connection for reseting of resonance circuits of resonance frequency converters)

6. Current Postgraduates and Projects

Ph.D. Students in 1991

1. Bober Peter: MSc. 1989 TU Košice
Ph.D., dissertation title:
Digital control of drive with AC motor
Thesis Advisor: Fedor Pavol

2. Čverčko Ján: MSc. 1989 TU Košice
Ph.D.,dissertation title:
Adaptive control of strip's elongation in the finishing cold-strip mills
Thesis Advisor: Ján Fetyko

3. Daubner Karol: MSc. 1990 TU Košice
Ph.D., dissertation title:
Drive control with flexible connection
Thesis Advisor: Jaroslav Tomko

4. Dobošová Eva: MSc. 1987 TU Košice
Ph.D., dissertation title:
Phase control of small-power AC machines
Thesis Advisor: Jaroslav Vladář

5. Elšigová Anna: MSc. 1991 TU Košice
Ph.D., dissertation title: still not estimated
Thesis Advisor: Ján Fetyko

6. Ferková Želmíra: MSc. 1987 TU Košice
Ph.D., dissertation title:
Contribution to the theory of reluctance motor
Thesis Advisor: Fedor Šimkovic

7. Halušková Marcela: MSc. 1986 TU Košice
Ph.D., dissertation title:
Application of the variable structure state control concept for dc motor position control
Thesis Advisor: Ladislav Zboray

8. Kaňuch Ján: MSc. 1987, TU Košice
   Ph.D., dissertation title:
   Contribution to the solution of pulse-wise fed motors with the axial air gap
   Thesis Advisor: Michal Kostelný

9. Kerestúri Marián: MSc. 1990 TU Košice
   Ph.D., dissertation title:
   Power semiconductor switch without backward influence
   Thesis Advisor: Jozef Fedor

10. Košč Peter: MSc.1988 TU Košice
    Ph.D., dissertation title:
    Application of fuzzy control in the electrical drives
    Thesis Advisor: Viliam Fedák

11. Maxim Jaroslav: MSc. 1991 TU Košice
    Ph.D., dissertation title: still not estimated
    Thesis Advisor: Viliam Fedák

12. Maxim Vladislav: MSc. 1988 TU Košice
    Ph.D., dissertation title:
    Fourquadrant frequency converter with the limited influence on the mains
    Thesis Advisor: Juraj Oetter

13. Németh Juraj: MSc. 1990 TU Košice
    Ph.D., dissertation title:
    State control of asynchronous motor
    Thesis Advisor: Ladislav Zboray

14. Perduková Daniela: MSc. 1989 TU Košice
    Ph.D., dissertation title:
    Control of multimotor drive with mechanical linkage
    Thesis Advisor: Pavol Fedor

15. Struckel Pavol: MSc. 1990 TU Košice
    Ph.D., dissertation title:
    Exciting components of magnetic field into an air-gap of induction motor with non-harmonic voltage

    Thesis Advisor: Ladislav Hruškovič

16. Tvrdoň Miroslav: MSc. 1991 TU Košice
    Ph.D., dissertation title: still not estimated
    Thesis Advisor: Michal Kostelný

17. Uhrín Rastislav: MSc. 1990 TU Košice
    Ph.D., dissertation title:
    Frequency converter with the switch units with the use of progressive semiconductor devices
    Thesis Advisor: Imrich Pokorný

7. Seminars, Colloquia and Visitors

Seminars

The Department of Electrical Drives conducts a series of scientific seminars to encourage the informal mingling of faculty and graduate students.

Conference

Department of Electrical Drives is an organizer of International Conference on Electrical Drives and Power Electronics which is held every second year in Košice.
The next conference will be held on Sept. 14-16, 1992

International Cooperation

The Department of Electrical Drives is involved in the TEMPUS project. JEP coordinator is the Napier Polytechnic from UK and the participating institutions are Technical University of Miskolc, Technical University of Košice, Politecnica de Valencia and

Politecnico di Torino. The Project is aim at the folloving areas: development of the overall course structure, development of curricula and syllabuses, development of experimental and hands-on work programmes, organisation and planning of student training placemets, lecturing on the course microcomputer controlled drive systems in Industrial automation.

Visitors

January 1, 1991 - December 31, 1991

Prof. Sinclair Gair
Napier Polytechnic
United Kingdom

Prof. Manuel Pineda Sanchez
Universidad Politechnica de Valencia
Spain

Prof. Attila Gati
The Technical University of Miskolc
Hungary

Prof. Tivadar Szarka
Technical University of Miskolc
Hungary

Prof. Francesco Profumo
Politecnico di Torino
Italy

Dr.Ing. Marek Rozycki
Politechnika Lubelska
Lublin, Poland

Dr.Ing. Jan Kolano
Politechnika Lubelska
Lublin, Poland

Mr. Miguel Angel Ordoñez Alfonsin - student
Madrid, Spain

8. Joint Projects with Industrial Sector

1. Struckel,P., Kaňuch,J.: Measures of charakteristics in asynchronous motors fed from transistor converter MINIREG-M

2. Tomko,J. et al: Development of control algorithms of winders TSP 1700