

FACULTY OF ELECTRICAL  
ENGINEERING**SUBJECT CARD**

Name in Polish: **Dynamika i sterowanie napędami prądu stałego i przemiennego**  
 Name in English: **Dynamics and Control of AC and DC Drives**  
 Main field of study (if applicable): **Electrical Engineering**  
 Specialization (if applicable): **Renewable Energy Systems**  
 Level and form of studies: **2nd level, full-time**  
 Kind of subject: **obligatory**  
 Subject code: **ELR033225**  
 Group of courses: **NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU):	30		15	15	
Number of hours of total student workload (CNPS):	120		30	30	
Form of crediting:	examination		crediting with grade	crediting with grade	
For group of courses mark (X) final course:					
Number of ECTS points:	4		1	1	
including number of ECTS points for practical (P) classes :			1	1	
including number of ECTS points for direct teacher-student contact (BK) classes:	2.80		0.70	0.70	

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Has knowledge in the control theory (basics), informatics and fundamentals of electrical drives.

**SUBJECT OBJECTIVES**

- C1. Consolidate knowledge and/or filling the knowledge gap in the field of torque and speed control of the DC and AC (induction motors and PMSM) motor drives.
- C2. Familiarizing students with the extended knowledge on the application of advanced control theory methods in controlled converter-fed motor drives, including adaptive and sensorless control.
- C3. The acquisition of practical knowledge and skills for design, testing and analysis of advanced control structures for DC and AC motor drives, including sensorless drives.
- C4. Perfecting skills for the understanding, analysis and interpretation of steady-state and transient processes in chosen controlled DC and AC drive systems.
- C5. Acquisition and fixing the social competences related to work in teams, solving engineering problems together; responsibility, honesty and fairness, observance of manners which are obligatory for academia and society.

**SUBJECT EDUCATIONAL EFFECTS***relating to knowledge:*

- PEK\_W01 Has matured knowledge on the torque and speed control methods of the converter-fed DC motor drives, including adaptive systems.
- PEK\_W02 Has matured and in-depth knowledge on modern control methods of converter-fed induction motor drives (including scalar and vector methods, sensorless control).
- PEK\_W03 Has matured and in-depth knowledge on modern control methods of converter-fed brushless DC and AC motors drives (including vector methods and sensorless control)

*relating to skills:*

- PEK\_U01 Can realize the simulation tests of chosen controlled electrical drive in Matlab/Simulink environment using delivered software and can make analysis of the obtained results.
- PEK\_U02 Can realize the experimental tests of chosen controlled electrical drive in laboratory set-up and can make analysis of the obtained results.
- PEK\_U03 Can design and test in simulation a chosen structure of speed or position control of electrical drive.

*relating to social competences:*

- PEK\_K01 Student can act independently and cooperate within a group working on a complex engineering project.

## PROGRAMME CONTENT

Form of classes - lecture		Number of hours:
Lec 1	Introduction. Basics of control system synthesis problems for electrical drives; control quality indexes for electrical drives.	2
Lec 2	Static and dynamical optimization for electric motor drives. Torque control structures of electrical drives: classification, characteristic features, performance.	2
Lec 3	Adjustment criteria for linear controllers, integral criteria, modulus and symmetry criteria, pole-placement method.	2
Lec 4	Static optimization conditions for DC motor; constant and variable flux control, dynamical properties for constant and variable excitation flux.	2
Lec 5	Speed control methods of converter-fed DC motor drives: series and parallel speed control structure; dynamical performance comparison.	2
Lec 6	Influence of static rectifier to the DC motor drive dynamical performance; adaptive control structures.	2
Lec 7	Induction motor – mathematical model using vector representation, state equations.	2
Lec 8	Frequency controlled induction motor drives – conditions of static optimization. Torque control methods of the induction motor.	2
Lec 9	Influence of the control method to the static mechanical characteristic of the induction motor drive. Influence of the control orientation to dynamical performance of the induction motor drive.	2
Lec 10	Scalar control methods for induction motor drives; constant flux and constant slip frequency methods.	2
Lec 11	Field-oriented control methods and structures for the induction motor drive - part 1.	2
Lec 12	Field-oriented control methods and structures for the induction motor drive - part 2.	2
Lec 13	Direct torque control methods and structures for the induction motor drive.	2
Lec 14	Control methods of brushless DC and AC permanent magnet motors. Field-oriented and direct torque control methods.	2
Lec 15	Sensorless drives, state variables estimation methods and structures for AC motor drives.	2
Total hours:		<b>30</b>

Form of classes - laboratory		Number of hours:
Lab 1	Introduction. Modeling of basic drive system elements using Matlab/Simulink - repetition.	1
Lab 2	Simulation tests of the cascade control structure for chosen dynamical object. Application of different design methods for the PI/PID controllers. Anti-windup systems.	2
Lab 3	Testing of the cascade control structure of DC motor drive; simulation and experimental tests.	2
Lab 4	Testing of the scalar control method for the induction motor.	2
Lab 5	Testing of the vector control methods for the induction motor - the FOC method. Part 1 - simulation tests.	2
Lab 6	Testing of the vector control methods for the induction motor - the FOC method. Part 2 - experimental tests.	2
Lab 7	Testing of the direct torque control method for the induction motor drive.	2
Lab 8	Testing of the chosen sensorless control structure of the induction motor drive. Crediting with grade.	2
Total hours:		<b>15</b>

Form of classes - project		Number of hours:
Proj 1	Introduction, basic requirements for course assessment. Methodology for project realization. Description of the project topics and distribution the project between student groups.	1
Proj 2	Description of the modeling methodology of chosen elements of the drive systems in Matlab/Simulink. Implementation of basic mathematical and simulation models (DC motor, induction motor. AC/DC and DC/AC converter, modulator for DC/AC converter).	2
Proj 3	Realization of the projects in students groups. Presentation and continuous consultations on project results.	10
Proj 4	Project presentation. Crediting with grade.	2
Total hours:		<b>15</b>

## TEACHING TOOLS USED

N1.	Lecture with multimedia tools combined with classical lecture (problem oriented).
N2.	Consultations.
N3.	Laboratory exercises in student groups; testing of student knowledge with short test before laboratory exercises.
N4.	Assessment of the laboratory exercises by reports.
N5.	Project presentation and its evaluation.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT		
Evaluation <i>F – forming (during semester)</i> <i>P – concluding (at semester end)</i>	Educational effect number	Way of evaluating educational effect achievement
F1(W)	PEK_W01 PEK_W02 PEK_W03	Participation in lectures.
F2(W)	PEK_W01 PEK_W02 PEK_W03	Exam.
P(W)	$P=0,1F1+0,9F2$	
F1(L)	PEK_U01 PEK_U02 PEK_K01	Activity during laboratory exercises (including short written tests).
F2(L)	PEK_U01 PEK_U02 PEK_K01	Preparation of the reports.
P(L)	$P=0,3F1+0,7F2$	
F1(P)	PEK_U03 PEK_K01	Evaluation of the activity during classes.
F2(P)	PEK_U03 PEK_K01	Evaluation of the project and the form of its presentation.
P(P)	$P=0,3F1+0,7F2$	

PRIMARY AND SECONDARY LITERATURE
<b>PRIMARY LITERATURE:</b> [1] M.P. Kazmierkowski, F. Blaabjerg, R. Krishnan, Control in Power Electronics - Selected Problems, Academic Press, USA, 2002 [2] P. Vas, Sensorless Vector and Direct Torque Control, Oxford University Press, 1998 [3] M.D. Murphy, F.G.Turnbull, Power Electronic Control of AC Drives, Pergamon Press, Oxford, 1988 [4] W. Leonhard, Control of Electrical Drives, Springer Verlag, 1990 [5] K. Ogata, Modern Control Engineering <b>SECONDARY LITERATURE:</b> [1] Kaźmierkowski M.P., Tunia H., Automatyka napędu przekształtnikowego. PWN, 1987 [2] Orłowska-Kowalska T., Bezczytnikowe układy napędowe z silnikami indukcyjnymi. Oficyna Wydawnicza P.Wr., Wrocław, 2003 [3] Orłowska-Kowalska T., Automatyka napędu elektrycznego - podstawy. Oficyna Wydawnicza P.Wr., Wrocław, w druku [4] Zawirski K., Deskur J., Kaczmarek T., Automatyka napędu elektrycznego, Wyd. Polit. Poznańskiej, 2012 [5] T. Kaczorek, A. Dzieliński, W Dobrowolski, R. Łopatka. Podstawy teorii sterowania, WNT, 2005

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MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT  
**ELR033225 - Dynamics and Control of AC and DC Drives**  
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **Electrical Engineering**  
AND SPECIALIZATION **Renewable Energy Systems**

Subject educational effect	Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)	Subject objectives	Programme content	Teaching tool number
PEK_W01	K2ETK_W04	C.1 C.2	Lec1 Lec2 Lec3 Lec4 Lec5 Lec6	N.1 N.2
PEK_W02	K2ETK_W04	C.1 C.2	Lec7 Lec8 Lec9 Lec10 Lec11 Lec12 Lec13 Lec15	N.1 N.2
PEK_W03	K2ETK_W04	C.1 C.2	Lec7 Lec14 Lec15	N.1 N.2
PEK_U01	K2ETK_U03	C.3 C.4	Lab1 Lab2 Lab3 Lab4 Lab5 Lab6 Lab7 Lab8	N.3 N.4
PEK_U02	K2ETK_U03	C.3 C.4	Lab1 Lab2 Lab3 Lab4 Lab5 Lab6 Lab7 Lab8	N.3 N.4
PEK_U03	K2ETK_U03	C.4 C.5	Proj1 Proj2 Proj3 Proj4	N.3 N.4
PEK_K01	K2ETK_K02 S2RES_K01	C.5	Lab1 Lab2 Lab3 Lab4 Lab5 Lab6 Lab7 Lab8 Proj1 Proj2 Proj3 Proj4	N.5