

FACULTY OF ELECTRICAL
ENGINEERING**SUBJECT CARD**

Name in Polish: **Automatyka napędu elektrycznego - podstawy**
 Name in English: **Controlled Electrical Drives - fundamentals**
 Main field of study (if applicable): **Control Engineering and Robotics**
 Specialization (if applicable):
 Level and form of studies: **1st level, full-time**
 Kind of subject: **optional**
 Subject code: **ARR043212**
 Group of courses: **NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU):	30		15		
Number of hours of total student workload (CNPS):	90		30		
Form of crediting:	examination		crediting with grade		
For group of courses mark (X) final course:					
Number of ECTS points:	3		1		
including number of ECTS points for practical (P) classes :			1		
including number of ECTS points for direct teacher-student contact (BK) classes:	2.10		0.70		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a matured knowledge in the field of commonly used electrical machines and basics of the drive systems.
2. Has a knowledge on the methods of mathematical description, stability analysis methods and dynamical properties of linear and nonlinear control systems.
3. Can solve the problems related to the analysis of linear controlled systems; knows how to use the proper mathematical methods for time-domain analysis of controlled plants.
4. Can use the Malab/Simulink environment in engineering applications.
5. Understands the necessity of taking part in student laboratories and exercises to obtain new knowledge and skills.

SUBJECT OBJECTIVES

- C1. Familiarizing students with the basic methods and structures of controlled converter-fed DC motor drives and their practical realization.
- C2. Familiarizing students with the basic methods and structures of scalar and vector controlled converter-fed AC motor drives and their practical realization.
- C3. The acquisition of practical knowledge and skills for testing and analysis of chosen DC and AC motor drives.
- C4. Perfecting skills for measuring, data acquisition and elaboration of test results, their interpretation and analysis.
- 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 control methods and basic structures of DC motor.
 PEK_W02 Has matured knowledge on control methods and basic structures of induction motor drive and brushless DC and AC motors with permanent magnets.
 PEK_W03 Can define and describe basic control methods and structures for DC motors, induction motors, brushless DC and AC motors, and characterize their performance.

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.

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, the main goal of the lecture, credit requirements. Classification of the control structures for electrical drives. Static and dynamical optimization of the drive systems.	2
Lec 2	Basic torque control structures of electrical motors.	2
Lec 3	Methods of adjustment of linear controllers for electrical drives: integral criteria, modulus and symmetry criteria.	2
Lec 4	Influence of the control mode to the dynamical performance of the DC motor. Operation with constant and variable excitation flux.	2
Lec 5	Cascade and parallel speed control structure of the DC motor drive. Controllers' adjustment, dynamical performances obtained in both control structures. Comparison. Part 1.	2
Lec 6	Cascade and parallel speed control structure of the DC motor drive. Controllers' adjustment, dynamical performances obtained in both control structures. Comparison. Part 2.	2
Lec 7	Induction motor – mathematical model using vector representation, state equations, equivalent circuit in vector form.	2
Lec 8	Influence of the control method to the static characteristic of the induction motor.	2
Lec 9	Frequency controlled induction motor drives - torque control methods of the induction motor.	2
Lec 10	Methods and structures of the field-oriented control (FOC) of an induction motor; control idea, flux and torque control structure, basic problems of practical realization.	2
Lec 11	Methods and structures of the direct torque control (DTC) of an induction motor; control idea, flux and torque control structure, basic problems of practical realization.	2
Lec 12	Scalar control methods with constant flux and constant slip frequency.	2
Lec 13	Frequency control methods for permanent magnet motors - control of BLDC motor; control idea, speed control structure, performance and applications.	2
Lec 14	Frequency control methods for permanent magnet synchronous motors - control of PMSM drive; vector control idea, speed and torque control structure, performance and applications.	2
Lec 15	Trends and developments in controlled electrical driver – sensorless control, intelligent control.	2
Total hours:		30

Form of classes - laboratory		Number of hours:
Lab 1	Introduction, presentation of laboratory rules and safety requirements. Introduction to laboratory stands. Repetition of basic methods of dynamical system modeling using Matlab/Simulink.	1
Lab 2	Synthesis of control structure for 2nd order dynamical system using modulus and symmetry criteria.	2
Lab 3	Testing of the cascade control structure for the DC motor drive; part 1 – simulation tests.	2
Lab 4	Testing of the cascade control structure for the DC motor drive; part 2– experimental tests.	2
Lab 5	Scalar control of the induction motor drive - experimental tests.	2
Lab 6	Testing of the field-oriented control structure for the induction motor drive; part 1 – simulation tests..	2
Lab 7	Testing of the field-oriented control structure for the induction motor drive; part 2 – experimental tests.	2
Lab 8	Testing of the drive system with permanent magnet synchronous motor (PMSM). Crediting with grade.	2
Total hours:		15

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.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT		
Evaluation <i>F – forming (during semester) 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	Final exam.
P(W)	$P=0,1 \cdot F1 + 0,9 \cdot F2$	
F1(L)	PEK_U01 PEK_U02 PEK_K01	Activity during laboratory exercises (including grades obtaining during short tests).
F2(L)	PEK_U01 PEK_U02 PEK_K01	Preparation of the report.
P(L)	$P=0,3 \cdot F1 + 0,7 \cdot F2$	

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [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] Zawirski K., Deskur J., Kaczmarek T., Automatyka napędu elektrycznego, Wyd. Polit. Poznańskiej, 2012 [4] Orłowska-Kowalska T., Automatyka napędu elektrycznego. Oficyna Wydawnicza P.Wr., Wrocław, w druku SECONDARY LITERATURE: [1] Napęd elektryczny, praca zbiorowa pod red. Z. Grunwalda, WNT, 1987 [2] P.Vas, Sensorless Vector and Direct Torque Control, Oxford University Press, 1998 [3] J.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

SUBJECT SUPERVISOR
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**MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT
ARR043212 - Controlled Electrical Drives - fundamentals
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY Control Engineering and Robotics**

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	K1AIR_AMPU_W05	C.1	Lec1 Lec2 Lec3 Lec4 Lec5 Lec6	N.1 N.2
PEK_W02	K1AIR_AMPU_W05	C.2	Lec7 Lec8 Lec9 Lec10 Lec11 Lec12 Lec13 Lec14 Lec15	N.1 N.2
PEK_W03	K1AIR_AMPU_W05	C.1 C.2	Lec1 Lec2 Lec3 Lec4 Lec5 Lec6 Lec7 Lec8 Lec9 Lec10 Lec11 Lec12 Lec13 Lec14 Lec15	N.1 N.2
PEK_U01	K1AIR_AMPU_U05	C.3 C.4 C.5	Lab1 Lab2 Lab3 Lab4 Lab5 Lab6 Lab7 Lab8	N.3 N.4
PEK_U02	K1AIR_AMPU_U05	C.3 C.4 C.5	Lab1 Lab2 Lab3 Lab4 Lab5 Lab6 Lab7 Lab8	N.3 N.4
PEK_K01	K1AiR_K03 K1AiR_K09	C.5	Lab1 Lab2 Lab3 Lab4 Lab5 Lab6 Lab7 Lab8	N.3 N.4