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):	**Industrial Control Engineering**
Specialization (if applicable):	
Level and form of studies:	**1st level, full-time**
Kind of subject:	**optional**
Subject code:	**APR013212**
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		60		
Form of crediting:	examination		crediting with grade		
For group of courses mark (X) final course:					
Number of ECTS points:	3		2		
including number of ECTS points for practical (P) classes :			2		
including number of ECTS points for direct teacher-student contact (BK) classes:	2.10		1.40		

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 knew 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 LEARNING OUTCOMES

relating to knowledge:

PEU_W01	Has matured knowledge on control methods and basic structures of DC motor.
PEU_W02	Has matured knowledge on control methods and basic structures of induction motor drive and brushless DC and AC motors with permanent magnets.
PEU_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:

PEU_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.
PEU_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:

PEU_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 LEARNING OUTCOMES ACHIEVEMENT		
Evaluation *F – forming (during semester)* *P – concluding (at semester end)*	**Educational effect number**	**Way of evaluating educational effect achievement**
F1(W)	PEU_W01 PEU_W02 PEU_W03	Participation in lectures.
F2(W)	PEU_W01 PEU_W02 PEU_W03	Final exam.
P(W)	P=0,1*F1+0,9*F2	
F1(L)	PEU_U01 PEU_U02 PEU_K01	Activity during laboratory exercises (includings grades obtaining during short tests).
F2(L)	PEU_U01 PEU_U02 PEU_K01	Preparation of the report.
P(L)	P=0,3*F1+0,7*F2	

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Kaźmierkowski M.P., Tunia H., Automatyka napędu przekształtnikowego. PWN, 1987
[2] Orlowska-Kowalska T., Bezczujnikowe 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] Orlowska-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

Teresa Orłowska-Kowalska, teresa.orlowska-kowalska@pwr.edu.pl