FACULTY OF ELECTRICAL ENGINEERING

SUBJECT CARD

Name in Polish:	**Automatyka napędu elektrycznego-zagadnienia wybrane**
Name in English:	**Controlled electrical drives - selected problems**
Main field of study (if applicable):	**Electrical Engineering**
Specialization (if applicable):	**Industrial Electrical Engineering**
Level and form of studies:	**2nd level, part-time**
Kind of subject:	**obligatory**
Subject code:	**ELR053268**
Group of courses:	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU):	22		22		
Number of hours of total student workload (CNPS):	120		60		
Form of crediting:	examination		crediting with grade		
For group of courses mark (X) final course:					
Number of ECTS points:	4		2		
including number of ECTS points for practical (P) classes :			2		
including number of ECTS points for direct teacher-student contact (BK) classes:	2.80		1.40		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

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

SUBJECT OBJECTIVES

C1. Consolidate knowledge and/or filling the knowledge gap in the field of torque control of the DC and AC (induction 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 sensorless, adaptive, predictive and sliding-mode control methods.

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 LEARNING OUTCOMES

relating to knowledge:

PEU_W01 Has matured knowledge on the basic torque and speed control methods of the DC motor drives and vector control methods of AC motor drives and active rectifiers (AC/DC converters).

PEU_W02 Has matured and in-depth knowledge on modern control methods of complex DC and AC motor drives, including basis of sensorless, adaptive, sliding and predictive control.

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. Cascade control structure – advantages and disadvantages. PI/PID controllers – performance, design criteria. Saturation phenomenon and anti-wind-up solutions.	2
Lec 2	Vector control in converter fed drives - consolidate knowledge and/or filling the knowledge gap on the field-oriented control (DFOC, IFOC) and direct torque control (DTC-ST, DTC-SVM) of the induction motors.	2
Lec 3	Vector control in converter fed drives - consolidate knowledge and/or filling the knowledge gap on the field-oriented control (FOC) and direct torque control (DTC-ST, DTC-SVM) of the synchronous permanent magnet motors.	2
Lec 4	Vector control methods in converters (AC/DC active rectifiers) and in converter-fed AC drives – similarities to vector control methods of AC motors, specific features.	2
Lec 5	Sensorless drives - estimation methods for feedback signals of AC motor drives. State variables estimators – classification, theoretical backgrounds of the Luenberger observers and Kalman filter design for chosen dynamical systems.	2
Lec 6	Estymatory typu MRAS oraz neuronowe dla silników prądu przemiennego. Przykłady zastosowań.	2
Lec 7	Adaptive control – classification, design, application examples.	2
Lec 8	Sliding-mode control – theoretical backgrounds. Sliding-mode control of the induction motor – direct and cascade control concepts. Part 1.	2
Lec 9	Sliding-mode control – theoretical backgrounds. Sliding-mode control of the induction motor – direct and cascade control concepts. Part 2.	2
Lec 10	Predictive control – theoretical background, predictive controller structure, performances, examples of application in power electronics and drives	2
Lec 11	Control structures for drive systems with elastic couplings: structures with additional feedbacks and with the state controller – design, performance.	2
	Total hours:	**22**

Form of classes - laboratory		**Number of hours:**
Lab 1	Introduction. 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 2	Testing of the PWM techinques, including space vector modulator SVM for a voltage inverter-fed induction motor.	2
Lab 3	Testing of the vector control methods for the induction motor - comparison of the FOC and DTC metods. Part 1.	2
Lab 4	Testing of the vector control methods for the induction motor - comparison of the FOC and DTC metods. Part 2.	2
Lab 5	Testing of the vector control method for AC/DC converter and the induction motor drive system with active rectifier.	2
Lab 6	Testing of the sensorless induction motor drives with chosen flux and speed estimators.	2
Lab 7	Testing of the adaptive control structure for the DC and/or AC motor drive.	2
Lab 8	Testing of the sliding-mode control structure for the induction motor drive.	2
Lab 9	Testing of the predictive control structures for electrical drive.	2
Lab 10	Testing of the chosen control structures of the driver system with elastic coupling – PI/PID controllers and-or state controller.	2
Lab 11	Additional term. Crediting with grade	2
	Total hours:	**22**

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] P.Vas, Sensorless Vector and Direct Torque Control, Oxford University Press, 1998
[2J M.D.Murphy, F.G.Turnbull, Power Electronic Control of AC Drives, Pergamon Press, Oxford, 1988
[3] W. Leonhard, Control of Electrical Drives, Springer Verlag, 1990
[4] K. Ogata, Modern Control Engineering

SECONDARY 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] Orlowska-Kowalska T., Automatyka napędu elektrycznego - podstawy. Oficyna Wydawnicza P.Wr., Wrocław, w druku
[4] Szabat K., Struktury sterowania elektrycznych układów napędowych z połączeniami sprężystymi, Oficyna Wyd. P.Wr., Wrocław, 2008
[5] Zawirski K., Deskur J., Kaczmarek T., Automatyka napędu elektrycznego, Wyd. Polit. Poznańskiej, 2012
[6] T. Kaczorek, A. Dzieliński, W Dobrowolski, R. Łopatka. Podstawy teorii sterowania, WNT, 2005
[7] P. Tatjewski, Sterowanie zaawansowane obiektów przemysłowych. Struktury i algorytmy, Exit 2000

SUBJECT SUPERVISOR

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