

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, full-time**
 Kind of subject: **obligatory**
 Subject code: **ELR053212**
 Group of courses: **NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU):	30		30		
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 drives.

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:

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. Part 1.	2
Lec 5	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. Part 2.	2
Lec 6	Sensorless drives - estimation methods for feedback signals of AC motor drives. State variables estimators – classification and theoretical backgrounds.	2
Lec 7	Sensorless drives - state variables estimators – classification. Design of the Luenberger observers and Kalman filter for chosen dynamical systems.	2
Lec 8	Estymatory typu MRAS oraz neuronowe dla silników prądu przemiennego. Przykłady zastosowań.	2
Lec 9	Adaptive control – classification, design, application examples.	2
Lec 10	Sliding-mode control – theoretical backgrounds. Sliding-mode control of the induction motor – direct and cascade control concepts. Part 1.	2
Lec 11	Sliding-mode control – theoretical backgrounds. Sliding-mode control of the induction motor – direct and cascade control concepts. Part 2.	2
Lec 12	Predictive control – theoretical background, predictive controller structure, performances, examples of application in power electronics and drives. Part 1.	2
Lec 13	Predictive control – theoretical background, predictive controller structure, performances, examples of application in power electronics and drives. Part 2.	2
Lec 14	Control structures for drive systems with elastic couplings: structures with additional feedbacks and with the state controller – design, performance. Control of the systems with nonlinear friction and backlash. Part 1.	2
Lec 15	Control structures for drive systems with elastic couplings: structures with additional feedbacks and with the state controller – design, performance. Control of the systems with nonlinear friction and backlash. Part 2.	2
Total hours:		30

Form of classes - laboratory		Number of hours:
Lab 1	Introduction. Modeling of basic drive system elements using Matlab/Simulink - repetition.	2
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 PWM techniques, including space vector modulator SVM for a voltage inverter-fed induction motor.	2
Lab 4	Testing of the vector control methods for the induction motor - comparison of the FOC and DTC methods. Part 1.	2
Lab 5	Testing of the vector control methods for the induction motor - comparison of the FOC and DTC methods. Part 2.	2
Lab 6	Testing of the vector control method for AC/DC converter and the induction motor drive system with active rectifier.	2
Lab 7	Testing of the sensorless induction motor drives with chosen flux and speed estimators. Part 1.	2
Lab 8	Testing of the sensorless induction motor drives with chosen flux and speed estimators. Part 2.	2
Lab 9	Testing of the adaptive control structure for the DC motor drive.	2
Lab 10	Testing of the adaptive control structure for the AC motor drive.	2
Lab 11	Testing of the sliding-mode control structure for the induction motor drive.	2
Lab 12	Testing of the predictive control structures for electrical drive.	2
Lab 13	Testing of the chosen control structures of the driver system with elastic coupling – PI/PID controllers.	2
Lab 14	Testing of the chosen control structures of the driver system with elastic coupling – state controller.	2
Lab 15	Additional term. Crediting with grade.	2
Total hours:		30

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 <i>F – forming (during semester)</i> <i>P – concluding (at semester end)</i>	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)	$P=0,1 \cdot F1 + 0,9 \cdot F2$	
F1(L)	PEU_U01 PEU_U02 PEU_K01	Activity during laboratory exercises (including short written tests)
F2(L)	PEU_U01 PEU_U02 PEU_K01	Preparation of the reports.
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] Orłowska-Kowalska T., Automatyka napędu elektrycznego - podstawy. Oficyna Wydawnicza P.Wr., Wrocław, w druku
 [4] Szabat K., Struktury sterowania elektrycznych układów napędowych z połączeniami sprzężystymi, 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

SECONDARY LITERATURE:

- [1] P.Vas, Sensorless Vector and Direct Torque Control, Oxford University Press, 1998
 [2] 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

SUBJECT SUPERVISOR

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