# COURSE DESCRIPTION CARD - SYLLABUS

Course name
Electric Drive for Air Robots [S2AiR2-SIiB>NERP]

## Course

Field of study
Automatic Control and Robotics

Year/Semester
1/1

Area of study (specialization)
Intelligent and Unmanned Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

## Number of hours

Lecture
30

Laboratory classes
30

Other
0

Tutorials
0

Projects/seminars
0

## Number of credit points

4,00

## Coordinators

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## Lecturers

## Prerequisites

The student entering this subject should have a structured, theoretically underpinned general knowledge of electrical circuit theory and DC and AC (including three-phase) electrical engineering; Should have a structured knowledge of the structures and principles of operation of analogue and discrete control systems (open circuit and feedback) and linear and simple Should have an advanced knowledge and understanding of basic controller synthesis criteria and tuning methods, tools and techniques for automatic selection of controller settings and object identification The student should be able to read with understanding design technical documentation and simple process diagrams of automation and robotics systems; The student should be able to use information and communication technology; Students should be aware of the importance of and understand the non-technical aspects and consequences of engineering activities, including their impact on the environment and the related responsibility for their decisions; they should be ready to take care of the heritage and traditions of the profession;

## Course objective

To learn about the construction, principle of operation and methods and structures of advanced sensor and sensorless control systems, fault classification, control under fault conditions occurring in electrical propulsion systems used in aircraft.

## Course-related learning outcomes

Knowledge:
K2_W1 has an advanced and in-depth knowledge and understanding of selected branches of mathematics; has an advanced and in-depth knowledge necessary to formulate and solve complex tasks in control theory, optimisation, modelling, identification and signal processing;
K2_W7 has an advanced and in-depth knowledge of methods of analysis and design of control systems;
K2_W12 has knowledge of development trends and the most significant new achievements in the field of automation and robotics and related scientific disciplines

Skills:
K2_U10 is able to determine models of simple systems and processes and use them for the analysis and design of automation and robotics systems;
K2_U13 is able to select and integrate elements of a specialised measurement and control system including: control unit, executive system, measurement system and peripheral and communication modules;

Social competences:
K2_K2 is aware of the importance of and understands the non-technical aspects and effects of engineering activity, including its impact on the environment and the related responsibility for making decisions; is willing to develop his/her professional output;
K2_K3 is aware of the responsibility for his/her own work and is ready to follow the rules of teamwork and take responsibility for jointly implemented tasks; he/she is able to lead a team, set objectives and determine priorities leading to the completion of a task;

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture: credit: consists of a test in the form of a written answer to a given question and a discussion (optional) on selected issue(s) with explanation of written answers from the scope of the programme content.
Laboratory exercises: attendance at classes and performance of laboratory exercises in groups and submission of written reports.

## Programme content

To learn about the construction, principle of operation and methods and structures of advanced sensor and sensorless control systems, fault classification, control under fault conditions occurring in electrical propulsion systems used in aircraft.

## Course topics

Lecture.
General structure of an automated drive system based on a DC motor drive. Cascaded speed control structure with subordinate current (electromagnetic torque) control. State controller. Neural adaptive controller. BLDC and PMSM motor control methods (vector:sensor and sensorless control (Kalman filter, Luenberger observer )). Inertia drive. High-speed drives with SRM switchable reluctance slinker. Control in zone II with weakened magnetic flux;Types of faults in electric drives, especially aerial robots, methods for their monitoring, diagnosis and classification, especially intelligent methods. Control methods under fault conditions, especially fault-tolerant drive systems.
Laboratory exercises. The programme of laboratory exercises includes familiarisation with the design, software, commissioning and testing of static and dynamic properties of selected physical drive systems discussed in lectures.

## Teaching methods

Lecture
Lecture with multimedia presentation (including: drawings, photos, animations, sound, films) supplemented by examples given on the blackboard. Initiating discussion during the lecture.
Laboratory.
Working in teams and team programming, performing tasks given by the instructor - practical exercises.

## Bibliography

Basic:
1. Zawirski K., Deskur J., Kaczmarek T., Automatyka napędu elektrycznego, Wydawnictwo Politechniki Poznańskiej, Poznań, 2012.
2. Kaczmarek T. , Napęd elektryczny robotów, Wydawnictwo Politechniki Poznańskiej, Poznań, 1998
3. Kaźmierkowski M.P, Tunia H., Automatic Control of Converter-Fed Drives, ELSEVIER, Amstertdam, London, New York, Tokyo, Warszawa , 1994
4. Zawirski K., Deskur J., Kaczmarek T., Automatyka napędu elektrycznego, Wydawnictwo Politechniki Poznańskiej, Poznań, 2012.
5. Lech Grzesiak L., Kaszewski A., Ufnalski B.: Sterowanie napędów elektrycznych. Analiza, modelowanie, projektowanie. Wydawnictwo Naukowe PWN, Warszawa 2016.
6. Sieklucki G., Bisztyga B., Zdrojewski A., Orzechowski T., Sykulski R.: Modele i zasady sterowania napedami elektrycznymi, Wydawnictwo AGH, Kraków 2014.

Additional:
1. Leonhard W., Control of Electrical Drives, Springer, Berlin, New York, 2001
2. Leonhard W., Control of Electrical Drives, Springer, Berlin, New York, 2001
3. Stefan Brock, Dominik Łuczak, Krzysztof Nowopolski, Tomasz Pajchrowski, Krzysztof Zawirski, Two Approaches to Speed Control for Multi-Mass System with Variable Mechanical Parameters , IEEE Transactions on Industrial Electronics, ( Volume: 64, Issue: 4, April 2017) p. 3338-3347, DOI: 10.1109/TIE.2016.2598299
Deskur J., Pajchrowski T., Zawirski K.: ?Speed Controller for a Drive With Complex Mechanical Structure And Variable Parameters?, Proceedings of 16th International Power Electronics and Motion Control Conference and Exposition, PEMC?2014, 21-24 September 2014, Antalya/Turkey, CD.
6. Brock S., Łuczak D., Nowopolski K., Pajchrowski T., Zawirski K.: Two Approaches to Speed Control for Multi-Mass System With Variable Mechanical Parameters, IEEE Transactions on Industrial Electronics, VOL. 64, NO. 4, APRIL 20
7. Zawirski K., Janiszewski D., Muszyński R.: Unscented and Extended Kalman filters study for Sensorless Control of PM Synchronous Motors with Load Torque Estimation, Bulletin of Polish Academy of Sciences ? Technical Sciences, vol. 61, No. 4, 2013
8. Fabiański B., Zawirski K.: Simplified model of Switched Reluctance Motor for real-time calculations, Przegląd Elektrotechniczny, ISSN 0033-2097, R. 92 NR 7/2016
9. Nowopolski K., Wicher B., Zawirski K.: Experimental Analysis of Selected Control Algorithms of Electromechanical Object with Backlash and Elastic Joint, IEEE 17th International Conference on Power Electronics and Motion Control, Varna, Bulgaria, 25 ? 30 of September 2016
10. Szczesniak P., Urbanski K., Fedyczak Z., Zawirski K.: Comparative study of drive systems using vector-controlled PMSM fed by a matrix converter and a conventional frequency converter, TURKISH JOURNAL OF ELECTRICAL ENGINEERING & COMPUTER SCIENCES, vol. 24, pp. 1516?1531, 2016

## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 100 | 4,00 |
| Classes requiring direct contact with the teacher | 60 | 2,50 |
| Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation) | 40 | 1,50 |