# COURSE DESCRIPTION CARD - SYLLABUS

Course name
Fault-tolerant control systems [N2AiR1-ISA>SSTU]

## Course

Field of study
Automatic Control and Robotics

Year/Semester
2/3

Area of study (specialization)
Intelligent Control Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
part-time

Requirements
compulsory

## Number of hours

Lecture
10

Laboratory classes
20

Other
0

Tutorials
0

Projects/seminars
0

## Number of credit points

3,00

## Coordinators

dr hab. inż. Stefan Brock prof. PP
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## Lecturers

## Prerequisites

Knowledge: The student starting this course should have knowledge of automation and robotics corresponding to the 6th level of the Polish Qualifications Framework, in particular knowledge of the analysis of automation models and signal processing. Skills: The student should have the ability to analyze and implement control and measurement systems in the field of automation and robotics and the ability to obtain information from the indicated sources. They should also understand the need to expand their competences and be ready to cooperate in a team. Social competences: In addition, in terms of social competences, the student must show such qualities as honesty, responsibility, persistence, cognitive curiosity, creativity, personal culture, respect for other people.

## Course objective

1. To provide students with knowledge on methods used in control systems tolerating selected classes of faults. 2. To develop in students the ability to develop systems for automatic diagnosis and reconfiguration of the control system using the available techniques for signal analysis and processing. 3.To educate students on the importance of knowing technologies and recommendations related to the design of fault-tolerant control systems.

## Course-related learning outcomes

Knowledge
1. knows and understands selected branches of mathematics to a deeper degree; has extended and deepened knowledge necessary to formulate and solve complex tasks in the field of control theory, optimization, modeling, identification and signal processing; [K2_W1].
2. has a structured and deepened knowledge of adaptive systems; [K2_W9].
3. has a structured and in-depth knowledge related to control systems and control and measurement systems; [K2_W11].

Skills
1. is able to simulate and analyze the operation of complex automation and robotics systems, and to plan and perform experimental verification; [K2_U9].
2. is able to design control systems for complex and non-typical multidimensional systems; is able to consciously use standard functional blocks of automation systems and to shape dynamic properties of measuring circuits; [K2_U27].
Social competences
1. is familiar with the importance of the non-technical aspects and effects of engineering activities, including their impact on the environment and the related responsibility for making decisions; is willing to develop professional achievements; [K2_K2].
2. The student is aware of the need for a professional approach to technical issues, meticulous familiarization with the documentation and environmental conditions in which devices and their components can function; [K2_K4]

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
The knowledge acquired in the lecture is verified by a written exam and individual discussion of the exam questions. The exam consists of 8-10 questions (test and open), variously scored. The pass mark is 50%. Examination problems on the basis of which the questions are based are made available to students during the semester.
The skills acquired in the laboratory classes are verified on the basis of reports.
Summative assessment:
a) in the field of lectures, verification of the assumed learning outcomes is carried out by:
i. assessment of the knowledge and skills shown on the written test in the form of a test
ii. discussion of the credit results.
b) in the scope of the laboratory, verification of the assumed learning outcomes is carried out by:
i. assessment of the student's preparation for individual classes,
ii. continuous assessment during each class (oral answers) - rewarding the increase in the ability to use the learned rules and methods,
iii. evaluation of tasks partially prepared during the classes, and also after their completion.
Obtaining additional points for activity during classes, in particular for:
i. independent construction of a distributed system of testing and diagnostics consisting of several electronic modules with microprocessors communicating in real time and development of documentation,
ii. the effectiveness of applying the acquired knowledge while solving a given problem
iii. remarks related to the improvement of teaching materials.

## Programme content

The programme content covers the following groups of topics:
1. Basic concepts: fault, failure, malfunction, defect, disturbance and modelling uncertainty, relationship between fault-tolerant system and safety system for machinery and equipment.
2. Passive and active fault tolerant control (FTC), features of passive FTC, structure of an FTC control system, structure of active control system with FTC.
3. Description of a component in a control system, analysis of the system as a system of interconnected components, internal and external component faults, open-loop and closed-loop fault detection.
4. Overview of fault detection methods: fault detection based on threshold overruns, fault detection based on signal models, fault detection by equivalent equation method, concept of residues for fault detection, fault signatures based on residues.
5. The concept of a virtual sensor and the use of a virtual sensor to provide redundancy.
6. Anomaly detection in control systems by machine learning methods.

7. The concept of predictive maintenance of machines and equipment, determination of remaining correct operation time.

The syllabus of the laboratory classes includes an illustration of the topics discussed in the lectures. During laboratory classes, students analyse and design selected parts of a fault-tolerant control system, design systems for detecting anomalies in the operation of equipment, analyse systems for predictive maintenance.

## Course topics

1. The concepts of fault, failure, malfunction, defect, disturbance and modelling uncertainty.
2. The relationship between fault tolerant and safety systems for machinery and equipment.
3. Concepts: passive and active fault tolerant control (FTC), features of a passive FTC control system, structure of an active control system with FTC.
4. Description of a component in a control system, analysis of the system as a system of interconnected components, internal and external faults of components.
6. Overview of fault detection methods: fault detection based on exceedances, thresholds, fault detection based on signal models.
7. Fault detection by equivalent equation method, concept of residues for fault detection, fault signatures based on residues.
8 Concept, implementation and use of virtual sensor.
9. Anomaly detection methods using machine learning methods.
10. Periodic and preventive maintenance of plant and machinery, determination of remaining correct operation time.

The syllabus of the laboratory classes includes an illustration of the topics discussed in the lectures. During laboratory classes, students analyse and design selected parts of a fault-tolerant control system, design systems for detecting anomalies in the operation of equipment, analyse systems for predictive maintenance.

## Teaching methods

1. Lecture: multimedia presentation, illustrated by examples given on the blackboard.
2. Laboratory exercises: the implementation of laboratory exercises, the study of prepared problems , discussion, teamwork, workshop - independent development of the project to solve the given control problems.

## Bibliography

Basic
1. Materials made available by the lecturer during the class
2. Iserman R. Fault-Diagnosis Systems, Springer
2. Kowalczuk Z. Systemy wykrywające, analizujące i tolerujące usterki. PWNT Warszawa
3. Kościelny J. M. Diagnostyka zautomatyzowanych procesów przemysłowych, AOW Exit Warszawa
Additional
1. Blanke M. i in. Diagnosis and Fault-Tolerant Control, Springer
2. Jiang J. i. in. Active Fault Tolerant Control Systems, Springer

## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 75 | 3,00 |
| Classes requiring direct contact with the teacher | 30 | 1,50 |
| Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation) | 45 | 1,50 |