DESCRIPTION OF THE COURSES

- Course code: ARR2106
- Course title: FUNDAMENTALS OF DIGITAL POWER SYSTEM PROTECTION AND CONTROL
- Language of the lecturer: Polish

Course form	***Lecture***	***Classes***	***Laboratory***	***Project***	***Seminar***
*Number of hours/week**	*1*		*2*		
*Number of hours/semester**	*15*		*30*		
Form of the course completion	*exam*		*pass*		
ECTS credits	*2*		*2*		
Total Student's Workload	*60*		*60*		

- Level of the course (basic/advanced): advanced
- Prerequisites:
  completed courses: Fundamentals of Control Engineering 1, 2, Power System Protection Fundamentals
- Name, first name and degree of the lecturer/supervisor:
  Janusz Szafran, Prof., Ph. D., D. Sc.
- Names, first names and degrees of the team's members:
  Andrzej Wiszniewski, Prof., Ph. D., D. Sc.
  Waldemar Rebizant, Ph. D., D. Sc.
  Mirosław Łukowicz, Ph. D.
- Year: 3 Semester: 6
- Type of the course (obligatory/optional): obligatory
- Aims of the course (effects of the course):
  As an effect of the course completion the students are expected to present the knowledge on the theory of digital power system control and protection systems. The students should show the ability of solving practical problems related to the theory presented during lectures.
- Form of the teaching (traditional/e-learning): traditional
- Course description:
  The course contains the basic problems and practical aspects of digital power system control and protection. After an introduction and general theoretical and numerical basis, the following practical problems are presented: analogue filtration, A/D conversion, digital filtration (FIR & IIR filters design and parameters), estimation of signal parameters (criterion values), decision making methods and algorithms, chosen algorithms of power system control, integrated measurement and control systems. A computer-based laboratory supplements the course.
- Lecture:

Particular lectures contents	*Number of hours*
1. Introduction. Structure of digital power systems protection and	*1*

control terminals.	
2. *Analogue filters: standard low-pass approximations, frequency and time response of the filter, analogue filter design, frequency band transformation.*	*2*
3. *Analogue to digital converters, multiplexer and analogue memory, quantization time and errors, Shannon sampling theorem, practical sampling rates.*	*1*
4. *Mathematical basis for control and protection algorithms: complex Fourier series, Fourier transforms, discrete Fourier transform, Z-transform theorems, analogue and discrete integration.*	*2*
5. *Classification of digital filters, design of recursive filters using impulse invariant techniques, design of recursive filters using bilinear transformation.*	*2*
6. *Design of non-recursive digital filters using a window function, commonly used FIR filter window functions and associated frequency responses.*	*2*
7. *Signal orthogonalization algorithms.*	*1*
8. *Measurement of power system quantities: algorithms of estimation of signal magnitude, active and reactive power, impedance components, signal phase, digital estimation of power system frequency and frequency deviation.*	*2*
9. *Decision making process, decision regions and borders, deterministic and probabilistic decision making methods.*	*1*
10. *Adaptive control and protection systems, multicriterial systems, integrated measurement, control and protection systems.*	*1*

- Classes – the contents:
- Seminars – the contents:
- Laboratory – the contents:
  1. Getting acquainted with SIGNAL PROCESSING Toolbox of MATLAB programme
  2. Elements of analogue signal pre-processing path including D/C conversion
  3. Analysis and synthesis of digital recursive filters
  4. Analysis and synthesis of finite impulse response filters
  5. Discrete Fourier Transform (DFT) – features and application for signal analysis.
  6. Digital measurement algorithms based on averaging approach
  7. Least squares techniques and correlation methods
  8. Digital algorithms of signal magnitude and power estimation using orthogonal components
  9. Digital measurement of impedance and its components
  10. Algorithms of frequency and phase measurement
  11. Digital filters of symmetrical components
  12. Dynamics of measurement and decision-making processes
- Project – the contents:
- Basic literature:

[1] H. Ungrad, W. Winkler, A. Wiszniewski: “Protection techniques in electrical energy systems”, Marcel Dekker Inc. New York, Basel, Hong Kong, 1995.

[2] Szafran J., Wiszniewski A., „Algorytmy pomiarowe i decyzyjne cyfrowej automatyki elektroenergetycznej”, WNT, Warszawa, 2001.

[3] W. Winkler, A. Wiszniewski: “Automatyka zabezpieczeniowa w systemach elektroenergetycznych”, WNT, Warszawa, 2004.

- Additional literature:
- Conditions of the course acceptance/credition:

Lecture – passing the exam
Laboratory – reports from all scheduled exercises

***** - depending on a system of studies