FACULTY OF ELECTRICAL ENGINEERING

SUBJECT CARD

Name in Polish:	**Inteligentne systemy pomiarowe**
Name in English:	**Smart Metering**
Main field of study (if applicable):	**Industrial Control Engineering**
Specialization (if applicable):	
Level and form of studies:	**1st level, full-time**
Kind of subject:	**optional**
Subject code:	**APR012504**
Group of courses:	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU):	30		15		
Number of hours of total student workload (CNPS):	30		30		
Form of crediting:	crediting with grade		crediting with grade		
For group of courses mark (X) final course:					
Number of ECTS points:	1		1		
including number of ECTS points for practical (P) classes :			1		
including number of ECTS points for direct teacher-student contact (BK) classes:	0.70		0.70		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has knowledge of the basics of electrical engineering (voltage, current, active power, reactive power, energy, power compensation, power factor, complex numbers, analog filter, transformer, magnetic circuit, Hall's effect, THD, instantaneous value, the RMS value, Fourier transformation, Ohm's law, Kirchoff’s law).
2. Can conduct quantitative and qualitative analyzes and conclude on the basis of the obtained results.
3. Is capable of use the Matlab-Simulink environment.
4. Has knowledge of the basics of electrical measurement (measurement of voltage, current, power, temperature, analog to digital converter).

SUBJECT OBJECTIVES

C1. To familiarize the student with various needs in the field of measurement solutions in the intelligent power system.

C2. Familiarizing the student with measurement methods.

C3. Acquisition by the student of knowledge allowing to make informed decisions when selecting measurement solutions in systems.

SUBJECT LEARNING OUTCOMES

relating to knowledge:

PEU_W01	The student understands the requirements for measurement solutions in systems related to the generation and processing of electric energy.
PEU_W02	He has knowledge about measurement methods used in systems related to the generation and processing of electric energy.

relating to skills:

PEU_U01	Is able to develop guidelines for a measurement solution that meets the minimum system requirements.
PEU_U02	Is able to verify the obtained measurement results in terms of the correctness of the applied measurement solution.

relating to social competences:

PEU_K01	Is aware of the necessity of constant learning in order to improve their professional and social competences.

PROGRAMME CONTENT		
Form of classes - lecture		**Number of hours:**
Lec 1	Introduction to the subject, minimum requirements, literature and how to pass. The variety of solutions for generation, transport, distribution, storage and processing of electric energy as a source of requirements for various measurement solutions and methods.	2
Lec 2	Electric power system: basic concepts, dynamic phenomenas, energy quality, grid codes, selected system services, the concept of a virtual power plant. The "big data" concept.	2
Lec 3	Selected control concepts in outline for AC and DC systems.	2
Lec 4	The concept of a smart network and microgrids.	2
Lec 5	Measurement requirements for the needs of islanded microgrid operation and its synchronization with the power system.	2
Lec 6	Measurements of non-electrical quantities (temperature, position, speed, vibration, acoustics) related to the operation of the power system.	2
Lec 7	Synchronization to system frequency using the phase locked loop (PLL) method - concepts, advantages and challenges. Impact of the measurement quality on synchronization.	2
Lec 8	The DC component of the AC current in low and medium frequency systems. Selected methods of its measurement and compensation.	2
Lec 9	Phasor measurements part 1. The concept.	2
Lec 10	Phasor measurements part 2. Applications/practical solutions.	2
Lec 11	Local measurements and distributed measurements (Wide Area Monitoring System, WAMS) - concepts, advantages and challenges.	2
Lec 12	Measurements for the needs of identification and diagnostics of devices - in reference to the algorithms used. The Shannon's theorem in practice.	2
Lec 13	Ensuring the safety integrity level (SIL) of devices and systems (in outline) versus measurement solutions.	2
Lec 14	Summary of the lecture.	2
Lec 15	The final test.	2
	Total hours:	**30**

Form of classes - laboratory		Number of hours:
Lab 1	Introduction	1
Lab 2	Study of the influence of measurement resolution and sampling frequency on the size of occupied computer memory and the time of data processing.	2
Lab 3	Study of the influence of resolution, frequency and delay of measurement on the control quality of static and dynamic states. On the example of regulation of the output voltage of a switching mode power supply.	2
Lab 4	Study of position and speed measurement with use of a resolver. The influence of uncompensated errors in amplitude, phase and offset on the accuracy of the measurement.	2
Lab 5	Examination of selected Phase Locked Loop (PLL) solutions for the purpose of synchronization with a given sinusoidal signal.	2
Lab 6	Testing of a measurement method of a small constant current (<1 A) in large sinusoidal currents (> 1kA).	2
Lab 7	Examination of a selected method of the voltage phasor measurement in the network.	2
Lab 8	Summary.	2
	Total hours:	**15**

TEACHING TOOLS USED

N1. Informative lecture

N2. Multimedia presentations with references to the literature.

N3. Laboratory classes based on the implementation of exercises in groups. Exercises carried out by means of computer simulations in the Matlab-Simulink environment.

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	Written and/or oral test.
P(W)	P=F1	
F1(L)	PEU_U01 PEU_U02 PEU_K01	Activity and discussion in lab sessions.
F2(L)	PEU_U01 PEU_U02 PEU_K01	Evaluation of laboratory exercises reports.
P(L)	P = 0,5F1 + 0,5F2	

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] P. F. Ribeiro, C. A. Duque, P. M. Ribeiro, A. S. Cerqueira, “Power Systems Signal Processing for Smart Grids”, Wiley, 2013.
[2] Peter W. Sauer, M. A. Pai, Joe H. Chow, „Power systems dynamics and stability with synchrophasor measurement and power system toolbox”, IEEE Press-Willey, 2018.
[3] Krzysztof Billewicz, „Smart metering, inteligentny system pomiarowy”, PWN, 2012.
[4] A. B. M. Shawkat Ali editor, “Smart grids, opportunities, developments and trends”, Springer, 2013.

SECONDARY LITERATURE:

[1] P. Purkait, B. Biswas, S. Das, Ch. Koley, “Electrical and electronics measurements and instrumentation”, McGraw Hill Education Offices, 2013.
[2] G. F. Franklin, J. D. Pwell, M. Workman, „Digital control of dynamic systems”, Wllis-Kagle Press, 2006.
[3] K. Ogata, „Modern control engineering”, Prentice Hall, 2010.

SUBJECT SUPERVISOR

Radosław Nalepa, radoslaw.nalepa@pwr.edu.pl