FACULTY OF ELECTRICAL ENGINEERING

SUBJECT CARD

Name in Polish:	**Zaawansowane techniki pomiarowe w inżynierii elektrycznej**
Name in English:	**Advanced Measurement in Electrical Power Engineering**
Main field of study (if applicable):	**Electrical Engineering**
Specialization (if applicable):	**Control in Electrical Power Engineering**
Level and form of studies:	**2nd level, full-time**
Kind of subject:	**obligatory**
Subject code:	**ELR033312**
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):	60		60		
Form of crediting:	crediting with grade		crediting with grade		
For group of courses mark (X) final course:					
Number of ECTS points:	2		2		
including number of ECTS points for practical (P) classes :			2		
including number of ECTS points for direct teacher-student contact (BK) classes:	1.40		1.40		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a knowledge of electrical circuits basis. Has ordered knowledge of electrical circuits elements and issues with electrical circuit topology.
2. Has a basic knowledge of electrical metrology and how electronic components works.
3. Is able to apply theoretical basis to analyze linear steady-state electrical circuits for sinusoidal input signals. Knows the time and frequency methods to solve electrical circuits.
4. Is able to do measurements of electrical quantities using analogue and digital instruments or oscilloscope. Is able to designate nonlinear elements characteristics, present given results in numerical, tabular and graphical form. Can calculate results using uncertainty theory, correctly interpret the result and draw the right conclusions.
5. Is able to correctly and effectively use electrical metrology knowledge to quality and quantity problems analysis connected with study subject.

SUBJECT OBJECTIVES

C1. Familiarize student with knowledge of the metrology terms, measurement errors and uncertainties, the metrological characteristics of analog devices, the properties of inductive current transducers, RMS converters.

C2. Familiarize student with the basics of digital technology. Student awareness of the principle of operation and properties of the generators, digital oscilloscopes and data acquisition cards.

C3. Knowledge acquisition in the theory of high-voltage systems measurement.

C4. Acquisition of practical skills to transducers tests, measuring circuit components, analysis the research results and to draw the correct conclusions.

C5. Skills sophistication of using autonomous instruments and data acquisition cards with the LabVIEW graphical programming environment.

SUBJECT EDUCATIONAL EFFECTS	
relating to knowledge:	
PEK_W01	Knows error and uncertainty theory. Knows structure and principle of operation RMS value converters and inductive methods of power line current processing.
PEK_W02	Has expertise knowledge of voltage and current measurements in high-voltage lines, PD, quantities characterizing high voltage insulation. Has mastered knowledge for diagnostic of high-voltage electric, acoustic and physicochemical methods.
PEK_W03	Has a knowledge of digital signal processing in metrology. Knows structure and principle of operation of oscilloscope, generator and data acquisition cards. Has a knowledge about local serial buses used in measurement equipment measurements.
relating to skills:	
PEK_U01	Is able to do tests of power line inductive transducers. Has abilities to determination and geometrical interpretation of power. Can write basic programs in LabView, can do visualization of virtual instrument.
PEK_U02	Is prepared to self-make high-voltage measurements. Has basic skills to work in industry as an engineer of high-voltage equipment insulation quality tests and to work in electrical power industry as a specialist of high-voltage equipment.
PEK_U03	Is able to write program on single-chip processor for simple measurement tasks.
relating to social competences:	
PEK_K01	Understands the need to work in a team, is aware of the responsibility for the work.

PROGRAMME CONTENT		
Form of classes - lecture		**Number of hours:**
Lec 1	Basic terms of metrology. Error theory and uncertainty theory. Accurate and precision. Error propagation law.	2
Lec 2	Metrological properties of analogue and digital meters. Moving-coil meters, moving-iron meters. Indirect measurements – method error. Power current processing methods.	2
Lec 3	Metrological properties of minimum, maximum, mean and RMS value converters. RMS converter described by implicit and explicit function.	2
Lec 4	Introduction to digital methods of measurement information processing. Sample-hold circuits. Signals sampling, quantization and coding.	2
Lec 5	Functional structures of signal processing line. Structure of universal data acquisition card (multiplexer, amplifier, filters).	2
Lec 6	Data buffering measurement data in acquisition systems. Cyclic buffering algorithm.	2
Lec 7	Generators: arbitrary wave, signal, DDS, logical.	2
Lec 8	Digital oscilloscope, spectrum analyzer, logical state analyzer.	2
Lec 9	High-voltage measurements characteristics. Targets and insulation diagnostic tests of high-voltage devices.	2
Lec 10	High-voltage test systems.	2
Lec 11	Direct method of high-voltage measurements.	2
Lec 12	Different types of dividers to measure high-voltage: DC, AC 50 Hz. Cooperation capacitive voltage dividers with voltage transformer.	2
Lec 13	Diagnostic methods of high-voltage systems insulation.	2
Lec 14	Physical and metrological basis of discharge measurements in high-voltage equipment insulation.	2
Lec 15	Test.	2
	Total hours:	**30**

Form of classes - laboratory		**Number of hours:**
Lab 1	Presentation the Procedure Health and Safety Rules and Laboratory Rules. Establish rules for passing. Presentation of measuring stands.	2
Lab 2	Geometrical interpretation of power.	2
Lab 3	Properties of current inductive transducers with homogoneous magnetic circuit.	2
Lab 4	Introduction to LabView. Program realization which can calculate the result on basis input data and known relation with visualization. Basis programming structures.	2
Lab 5	Type A virtual instrument. Instrument control with GPIB or USB interface program realization with uses Niven driver. Programming structures.	2
Lab 6	DDS generators practical application. Frequency and phase modulation.	2
Lab 7	Haterodyn spectrum analyzer. Example curves analysis.	2
Lab 8	SCPI instructions used in programming instruments.	2
Lab 9	Local serial interfaces: Launching didactic layouts and writing sample program. Processor programming. Realization of serial port RS232 buffor transmition. Interrupt transmission operation.	2
Lab 10	SPI main line, I2C main line.	2
Lab 11	Scale factor Fm determination of high-voltage 50 Hz AC measurement system.	2
Lab 12	High impulse voltage generation and measurement.	2
Lab 13	Direct methods of high-voltage 50 Hz measurements.	2
Lab 14	Indirect methods of high-voltage 50 Hz measurements.	2
Lab 15	Assessment and complement laboratory arreas.	2
	Total hours:	**30**

TEACHING TOOLS USED

N1. Traditional lecture, multimedia presentations.

N2. Laboratory – check knowledge in oral answer form, report preparation, presentation wrote program and discussion, office hours.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation *F – forming (during semester)* *P – concluding (at semester end)*	**Educational effect number**	**Way of evaluating educational effect achievement**
F1(W)	PEK_W01 PEK_W02 PEK_W03	Test
P(W)	P=F1	
F1(L)	PEK_U01 PEK_U02 PEK_U03	Check preparation to laboratory.
F2(L)	PEK_U01 PEK_U02 PEK_U03	Activity on laboratory
F3(L)	PEK_U01 PEK_U02 PEK_U03	Report preparation
P(L)	P=0,3F1+0,1F2+0,6F3	

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Morris A.S., Measurement and Instrumentation Principles, Butterworth-Heinemann, 2001.
[2] Nawrocki Z., Dusza D., Kosobudzki G, Metrological analysis of integrated analog RMS converters described by explicit and implicit functions, Measurement (London). 2009, vol. 42, nr 2, s. 308-313
[3] Van de Plassche R., CMOS integrated analog to digital and digital to analog converters, Kluwer Academic Publishers, 2003
[4] Lyons R.G., Understanding Digital Signal Processing, Pearson Education; 1996.
[5] J.Mc.Ghee, I.A. Henderson, M.J. Korczyński, W.Kulesza: Scientific metrology, Technical University of Lodz, Lodz, 1998.
[6] Mc.Ghee, I.A. Henderson, M.J. Korczyński, W.Kulesza: Measurement data handling, vol. 1 and vol.2 , Technical University of Lodz, Lodz, 2001
[7] N.Kularanta: Digital and analogue instrumentation. IEE, London, 2003.
[8] D.Kind: An introduction to high voltage experimental technique, Vieweg 1980.
[9] E.Kuffel, W.S. Zaengel, J. Kuffel: High Voltage Engeneering Fundaments, Elsevier, 2000

SECONDARY LITERATURE:

[1] Tumański S., Technika pomiarowa, WNT, Warszawa, 2007
[2] Nawrocki W., Rozproszone systemy pomiarowe, WKŁ, Warszawa, 2006
[3] Świsulski D., Komputerowa Technika Pomiarowa, Oprogramwanie wirtualnych przyrządów pomiarowych w LabView, PAK, 2005
[4] Praca zbiorowa pod red. J. Fleszyńskiego: Laboratorium wysokonapięciowe w dydaktyce i elektroenergetyce, Oficyna Wydawnicza PWr. Wrocław 1999

SUBJECT SUPERVISOR

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MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT
ELR033312 - Advanced Measurement in Electrical Power Engineering
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **Electrical Engineering**
AND SPECIALIZATION **Control in Electrical Power Engineering**

Subject educational effect	Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)	Subject objectives	Programme content	Teaching tool number
PEK_W01	K2ETK_W05 S2CPE_W12	C.1	Lec1 Lec2 Lec3 Lec4	N.1
PEK_W02	K2ETK_W05 S2CPE_W12	C.3	Lec9 Lec10 Lec11 Lec12 Lec13 Lec14	N.1
PEK_W03	K2ETK_W05 S2CPE_W12	C.2	Lec5 Lec6 Lec7 Lec8	N.1
PEK_U01	K2ETK_U04	C.4 C.5	Lab1 Lab2 Lab3 Lab4 Lab5	N.2
PEK_U02	K2ETK_U04	C.3	Lab11 Lab12 Lab13 Lab14	N.2
PEK_U03	K2ETK_U04	C.4	Lab6 Lab7 Lab8 Lab9 Lab10	N.2
PEK_K01	S2CPE_K02	C.1 C.2 C.3 C.4 C.5	Lab1 Lab2 Lab3 Lab4 Lab5 Lab6 Lab7 Lab8 Lab9 Lab10 Lab11 Lab12 Lab13 Lab14 Lab15	N.1 N.2