Subject (course) name: **Surges in power systems**		
Programme: **Electrical engineering** Specialty:		Subject code: **12O** Title graduate: **Engineer**
Type of course: **obligatory**	Course level: **First-cycle studies**	Year: **III** Semester: **V** Semester: **winter**
Form of classes: **Lectures, Labs**	Number of hours per week: **2L, 0, 2Lab, 0, 0**	Credit points: **4 ECTS**

GUIDE TO SUBJECT

SUBJECT OBJECTIVES

C1. General knowledge on surges in power engineering systems.

C2. Particular knowledge of methods of analysis of circuits with lumped and distributed parameters, which are prone to surges.

C3. General ability to analyze circuits with surges.

SUBJECT REQUIREMENTS

1. ability to solve ordinary differential equations
2. knowledge of circuit theory
3. knowledge of high voltage fundamentals

LEARNING OUTCOMES

EK 1 – Student is able to distinguish different kinds of surges in power engineering systems, their features and methods of analysis. Student is able to clarify and characterize different methods of surge analysis

EK 3 – Student avails of theoretical knowledge and is able to apply it to solve practical problems in the laboratory. Student is able to identify a problem, carry out the analysis of a circuit and interpret the results of experimental research.

EK3 – Student is able to cooperate with other team members, is engaged in fulfilment of tasks in the lab, strides at a proper fulfilment of his/her tasks.

SUBJECT CONTENT

Form of classes - lectures

Topic	Hours
W1 – Introduction – classification of surges	**2**
W2 – Classification of circuits. Surge coefficient. Over-dimensioning of network devices	**2**
W3 – Phenomena in circuits with lumped parameters. Self-oscillations and resonant oscillations of a linear RLC circuit	**2**
W4,5 – Self-oscillations of an RLC circuit with nonlinear inductance. Ferro-resonance. Harmonic balance method	**2**
W6,7 – Wave equations. The equivalent circuit of a fragment of lossy and loss-less transmission line. Telegraphers' equation. Notion of wave impedance. Line	**2**

parameters in the context of real-life power engineering systems	
W8,9 – Solution of wave equation with Bernoulli's and d'Alembert's methods. Interpretation of the phenomenon of moving waves. Wave energy. Petersen's circuits for a node	**2**
W10 – Equivalent circuits of components of power engineering system for the analysis of switching processes.	**2**
W11 – Time dependencies for switching off AC short-circuits. Transient return voltage.	**2**
W12 – Switching of inductive and capacitate currents.	**2**
W13 – Return voltage in chosen real-life circuits	**2**
W14 – Atmospheric surges - fundamentals	**2**
W15 – Recap	**2**
Total	**30**

Form of classes – laboratory

Topic	Hours
L1 – Making up laboratory teams, getting acquainted with the study program and the lab regulations	**2**
L2 – Wave hitting a surge arrester	**2**
L3 – Compensation of earth surges with the Petersen's coil in MV networks	**2**
L4 – Determination of surges in the auto-reclosing cycle	**2**
L5 – The influence of transmission line length on the value of surge	**2**
L6 – Extra notice meeting time	**2**
L7 – A colloquium	**2**
L8 – Wave phenomena in the transmission line	**2**
L9 – Voltage distribution in a single turn coil	**2**
L10 – Determination of the protected zone of a vertical lighting rod	**2**
L11 – The influence of a switcher on the value of surge	**2**
L12 – V-I dependence for the variable-resistance pile	**2**
L13 – Wave hitting a lumped capacitance	**2**
L14 – A colloquium	**2**
L15 – Extra notice meeting time, credits, recap	**2**
Total	**30**

STUDY METHODS

1. Lectures using multimedia presentations
2. Discussion during the course and during individual consultations
3. Laboratory – teamwork

EDUCATIONAL TOOLS

1. Audiovisual equipment, black(white)board, lectures in electronic version
2. Textbooks
3. Laboratory classes

METHODS OF ASSESMENT (F – Forming, P – Summary)

F1. assessment of self preparation for laboratory classes – oral answer
F2. assessment of correctness and timeliness of lab reports
P1. assessment of the ability to follow the study highlights – a colloquium (50% of the final credit mark)
P2. laboratory – assessment of the ability to solve problems, draw conclusions and prepare reports – team reports from lab classes (50% of the final credit mark)

STUDENT WORKLOAD

Form of activity		Averaged workload (hours)		
		[h]	∑ [h]	ECTS
Participation in class activities	lecture laboratory	30 30	60	3
Preparation for lectures and lab reports		15	25	1
Preparation for lab classes		10		
Total			**85**	**4**

A. BASIC READING

1. E. Kuffel et al. High voltage engineering. Fundamentals. Second Edition, Butterworth-Heinemann 2000
2. Z. Ciok, Procesy łączeniowe w układach elektroenergetycznych, WNT 1992 (in Polish)
3. J. L. Jakubowski, Podstawy teorii przepięć w układach energoelektrycznych, PWN, Warszawa 1968 (in Polish)

B. FURTHER READING

1. Z. Flisowski, Technika wysokich napięć, WNT 1992 (in Polish)
2. W. Skomudek, Analiza i ocena skutków przepięć w elektroenergetycznych sieciach średniego i wysokiego napięcia, Wyd. Politechniki Opolskiej 2008 (in Polish)
3. M. Babikow et al., Technika wysokich napięć, WNT 1967 (in Polish)

Learning objectives	In relation to the learning outcomes specified for the field of study	Subject objectives	Study methods	Methods of assessment
EK1	KE1A_W10	C1 C2	lecture	P1
EK2	KE1A_U09 KE1A_U27	C2, C3	lab	P1
EK3	KE1A_K03 KE1A_K04	C2, C3	lab	P1

II. EVALUATION

Grade	Outcome
EK1	**Student enumerates the kinds of surges in power engineering systems, distinguishes their features and methods of their analysis. Student is able to explain and characterize methods of analysis of surges**
2	Student does not distinguish the surges in power engineering systems, cannot classify them.
3	Student is able to enumerate the kinds of surges in power engineering systems, can name their fundamental features and methods of their analysis.
3.5	Student is able to enumerate the kinds of surges in power engineering systems, may enumerate and characterize their fundamental features and methods of their analysis.
4	Student can carry out a correct classification of surges, may carry out a detailed analysis for a simple circuit.
4.5	Student can carry out a correct classification of surges, may carry out a detailed analysis for an average circuit.
5	Student can carry out a correct classification of surges, may carry out a detailed analysis for an high complexity circuit..
EK2	**Student avails of theoretical knowledge and is able to use it for solving practical problems in the lab. Is able to identify a problem, carry out the analysis of the system and interpret the experimental results.**

2	Student cannot avail of theoretical knowledge obtained during the lecture. Student is not able to formulate a scientific problem properly..
3	Student is able to formulate a scientific problem properly.
3.5	Student is able to formulate a scientific problem properly and indicate a method how to solve it.
4	Student is able to formulate a scientific problem properly and attempts to solve it.
4.5	Student is able to formulate a scientific problem properly and solves it in a correct way with a little help from tutor. Student is able to interpret the research in a correct way.
5	Student is able to formulate a scientific problem properly and solves it in a correct way without any guidance. Student is able to interpret the research in a correct way.
EK3	**Student is able to cooperate with other team members is engaged in fulfilment of tasks in the lab, strides at a proper fulfilment of his/her tasks.**
2	Student cannot cooperate within a team.
3	Student can cooperate within a team as an ordinary team member.
3.5	Student can cooperate within a team as an ordinary team member. He/she is engaged during fulfilment of his/her tasks.
4	Student can cooperate within a team taking different roles, including being a team leader. He/she is engaged during fulfilment of his/her tasks and exhibits initiative..
4.5	Student can cooperate within a team taking different roles, including being a team leader. He/she is engaged during fulfilment of his/her tasks and exhibits high level initiative. He/she is extremely accurate, pedantic and scrupulous.
5	Student can cooperate within a team taking different roles, including being a team leader. He/she is engaged during fulfilment of his/her tasks and exhibits high level initiative. He/she is extremely accurate, pedantic and scrupulous. He is extremely creative when solving the problems.

III. OTHER USEFUL INFORMATION

1. All information for students on the schedule are available on the notice board and on the website: www.el.pcz.pl
2. Information on the consultation shall be provided to students during the first lecture and will be placed on the website www.el.pcz.pl
3. Terms and conditions of credit courses will be provided to students during the first lecture