SYLLABUS

Name: ***Circuit theory (AESAu-E>SI2CT24)***
Name in Polish:
Name in English: ***Circuit theory***

Information on course:

Course offered by department: Faculty of Automatic Control, Electronics and Computer Science
Course for department: Silesian University of Technology

Default type of course examination report:
EGZ
Language:
English
Course homepage:
https://platforma.polsl.pl/rau3/course/view.php?id=80215
Short description:
The main objective of the course is to provide both basic and advanced knowledge of electrical circuits, including linear and nonlinear direct current (DC) circuits, alternating current (AC) circuits, and transmission line analysis. The course covers fundamental laws, principles, and theorems, as well as the description and analysis of circuits in the time and frequency domains. Students will learn to analyze circuits in the time domain, using methods such as s-domain (Laplace transform) analysis for first- and higher-order circuits, and in the frequency domain for AC and transmission line circuits. Additionally, students will develop practical skills in using simulation software to solve circuit problems and gain a deeper understanding of circuit behavior across different operating conditions.
Description:
Lectures:
1. Circuit variables — Basic terms and definitions, classification of electric circuit problems, circuit elements (resistors, sources). Passive/active sign conventions, circuit diagrams.
2. Passive two-terminal elements — Resistor (Ohm's law), equivalent resistance, voltmeter, ammeter, practical voltage and current sources, Kirchhoff's laws, voltage/current dividers.
3. Superposition principle — Energy and power conservation, two-terminal subcircuits, Thevenin's/Norton's theorem, passive two-terminal subcircuits, series connection of resistors, active two-terminal subcircuits, maximum power transfer theorem, source substitution theorem.
4. Multi-terminal elements — Element description with conductance/resistance matrix, passive/active multi-terminal elements, three-terminal elements (one-port), analysis of circuits with multi-terminal elements.
5. Analysis of complex circuits — Node voltage (nodal) analysis.
6. Analysis of nonlinear circuits — Graphical methods, conversion to a single-loop circuit, analysis using Piecewise Linear (PWL) approximation.
7. Transient analysis — Kirchhoff's laws, relationships for resistors, capacitors, inductors; RC and RL circuits; time domain and s-domain models.
8. Transient analysis in first-order circuits — Zero and non-zero initial conditions; boundary value methods; characteristic and response analysis; practical steps and pulses.
9. First-order circuit analysis — s-domain method using Laplace transforms; capacitor and inductor models; s-domain and time-domain relationship.
10. Transient analysis with arbitrary excitation — Transfer functions, properties, examples such as integrator and differentiator.
11. Second-order circuits — s-domain method, Heaviside formula, natural and complete response, handling higher-order circuits.
12. Introduction to simulation software — PSpice tutorial; DC and time-domain examples.
13. Dependent (controlled) elements — Description of arbitrary dependent elements, controlled sources; their modeling uses.
14. Transistors, operational amplifiers, and controlled sources — Circuit analysis involving controlled sources and multi-terminal elements.
15. Time domain circuits. Transfer function-based transient analysis – examples.
16. AC steady-state analysis. Alternating current – RMS value, phasor notation. Complex numbers.
17. Phasor analysis. Kirchhoff's laws. Current-voltage relationship: resistor, inductor, capacitor. General two-terminal phasor circuit, phasor impedance.
18. AC steady-state analysis. Application of nodal analysis.
19. AC steady-state power. Measures of power. Instantaneous power. Average or real power. Apparent power. Reactive power. Complex power. Maximum power transfer theorem.
20. Frequency characteristics of the two-terminal subcircuit. Ideal elements – summary (Resistor. Inductor. Capacitor). Practical coil and practical capacitor characteristics, their impedances, and behaviors.
21. Simple electric filters RC, RL. Transfer function in the frequency domain. Amplitude and phase characteristics. Bode Plot (log-log characteristic).
22. Resonant circuits. Series-resonant circuit RLC. Parallel-resonant circuit RLC. Complex-resonant circuit. Resonant filters. Transfer function approach - frequency response. Bode (logarithmic) plot. Filters. Low-pass filter – LPF. High-pass filter – HPF. Band-pass filter – BPF. Band-stop filter – BSF.
23. Introduction to electronic circuits simulation software – AC domain examples.
24. Mutual inductance and transformers. Mutual inductance – basic transformer. Ideal transformer. Practical iron-core transformer. Step-up, step-down, and isolations transformers. Impedance converter.
25. Circuits with distributed parameters. Transient analysis in the transmission line.
26. AC analysis – standing waves. Matched load line. Arbitrary termination. Open-circuited line. Short-circuited line. A transmission line as a circuit element, input impedance.
27. Three-phase circuits. Wye-wye systems. Delta-delta and wye-delta systems. Combinational systems. Power in three-phase systems.
28. Introduction to electronic circuits simulation software – transmission line examples.
29. Electrical circuit summary lecture. Exam exemplary problems.

Classes:
1. Simple electric circuits — Application of Ohm's law and Kirchhoff's laws, equivalent resistance, voltage/current dividers, relationships in passive and active elements, ideal and real meters.
2. Passive two-terminal elements — Current-voltage characteristics, resistor (equivalent resistance), voltmeter, ammeter, sources (ideal and real), power and energy Dissipation.

3. Superposition principle — Circuits with multiple sources, incremental analysis, power dissipation.
4. Equivalent active elements — Thevenin’s and Norton’s theorems, methods of calculation (circuit, measurement, characteristic), maximum power transfer.
5. Nodal analysis — General approach, exceptions (power balance).
6. Transient analysis (First-order circuits, part 1) — Time domain analysis, initial conditions.
7. Transient analysis (First-order circuits, part 2) — Continuation of transient analysis.
8. Assessment preparation — Practice problems and example exercises.
9. Transients in the first-order circuits with zero and non-zero - material reminder.
10. AC domain circuits. Phasors. Phasor diagrams.
11. Power in AC domain circuits.
12. Frequency response of AC circuit. Resonant circuits and filters. Linear and logarithmic characteristics.
13. Transmission line. Time-domain analysis.
14. AC steady-state analysis of transmission line (standing wave).

Laboratory:
1. Introduction to oscilloscope & non-linear DC circuits.
2. Transient in first-order circuits with zero and non-zero initial conditions switched on a DC source.
3. AC circuits in time and frequency domains.
4. Passive filters and resonances.
5. Transmission lines.

The number of hours of classes with direct participation of academic teachers or other persons teaching courses and students. Contact hours:
Lecture: 60h
Classes: 45h
Laboratory: 15h

Student's own work:
Preparation for classes, weekly tests: 20h
Preparation for laboratory exercises, tests: 25h
Laboratory reports: 20h

Preparation for assessment: 30h
Computer tests on DLP: 30h
Preparation for the exam: 30h

Total workload: 275
Number of ECTS credits: 11

Bibliography:

- Rutkowski J., Circuit Theory, Wydawnictwo Politechniki Śląskiej, Gliwice 2006.
- Richard C. Dorf, James A. Svoboda, Introduction to electric circuits, john Wiley & Sons, Inc. (8th edition, 2009).
- Allan H. Robbins and Wilhelm C Miller, Circuit Analysis: Theory and Practice, Delmar Cengage Learning; 4 edition (July 19, 2006).
- http://platforma.polsl.pl/rau3

Learning outcomes:

Knowledge
The student knows and understands:
- elements of physics, electrical and electronics engineering (K1A_W7),
- basics of electrical engineering, including electric circuit theory (K1A_W7),
- issues in electronics, analog electronic systems, power systems, sensors (K1A_W7).

Skills
The student is able to:
- use known principles and methods of electricity (K1A_U1) by applying analytical, simulation, and experimental methods;

Assessment methods and assessment criteria:

According to SUT regulations, lecture attendance is optional (although highly recommended), whereas laboratory experiments and classes are obligatory.
The condition for passing the course is obtaining positive results in the laboratory experiments, lecture tests, and final exam, where:
- Passing the laboratory requires completing and passing all exercises, which include:
- Passing the entrance tests (condition for admission to the exercises),
- Acceptance of all reports.
Caution! There are 5 obligatory laboratory exercises carried out in sections. Students must complete all exercises and prepare reports (one per section) containing processed information (plots, diagrams) and conclusions. If, for any reason, the labs are conducted remotely, all students must do the remote labs, but only one report per section is needed (both students must upload the same reports to the distance learning platform). Each report should be completed within a two-week period. Reports can be prepared in electronic form; in this case, a declaration of the student's original work is required. Teachers may verify the obtained results. The final laboratory grade is an average of all reports and all entrance tests (all must be passed).

There are 3 separate chapters (tests), namely: DC test, Time_Domain test and AC test. Both tests must be passed.
Exam (tests) outcome: The exam, in the form of a test on the distance learning platform, can only be taken if the last lecture test was passed. The maximum score for exam (test) no. 3 is reduced accordingly.
The exam outcome is an average of three passed tests: DC test, Time domain test and AC test.

The final grade is calculated based on a weighted average of individual activities: 0.4 * Laboratory average + 0.6 * Exam outcome, rounded according to the university grading scale.

The syllabus is valid from the 2024/25 academic year, and its content cannot be changed during the semester.

Course credits in various terms:

<without a specific program>			
Type of credits	Number	First term	Last term
European Credit Transfer System (ECTS)	11	2024/2025-Z	