COURSE DESCRIPTION CARD - SYLLABUS

Course name

Power electronics systems in renewable energy systems and electric vehicles [S1Eltech2>PO11-OZE]

Course

Field of study
Electrical Engineering

Year/Semester
4/7

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
15

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

dr inż. Łukasz Ciepliński
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Lecturers

Prerequisites

Knowledge - Basic knowledge of electrical engineering, electronics and power electronics, and electrical machines Skills - Ability to effectively self-educate in the field related to the chosen field of study; ability to make the right decisions when solving simple tasks and formulating problems in the field of broadly understood electrical engineering Competencies - The student is aware of expanding his/her competences, demonstrates readiness to work in a team, and is able to comply with the rules applicable during lectures, project work, and laboratory classes.

Course objective

Discussion of the latest achievements and application solutions of electrical energy conversion systems in Renewable Energy Sources (RES) systems and in broadly understood electromobility, including systems used in electric vehicles

Course-related learning outcomes

Knowledge:
1. The student has basic knowledge of renewable energy sources and electromobility.
2. The student has structured knowledge of the construction, operating principles, and operation of

static and kinetic electromagnetic energy converters, as well as technical systems used in renewable energy systems and mobile power systems (electromobility).
3. The student has knowledge of the construction and operating principles of electronic and power electronics systems used in renewable energy systems and electromobility.
4. The student has structured knowledge of applied energy storage systems.
5. The student has basic knowledge of systems monitoring the charge status of chemical energy storage systems.
6. The student has structured knowledge of systems controlling the charging and discharging process of chemical energy storage systems.
7. The student has basic knowledge of automation (closed-loop control systems).

Skills:
1. The student is able to design, build, commission, and test selected electrical energy conversion systems used in renewable energy sources and mobile electrical systems.
2. The student is able to utilize professional programming and simulation environments in the design of selected energy conversion systems.

Social competences:
1. The student understands the importance of knowledge in solving problems and improving professional, personal, and social competencies.
2. The student is aware that in technology, knowledge and skills quickly become obsolete.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture:
- assessment of knowledge and skills demonstrated in a problem-based written test,
- continuous assessment - during each class - rewarding activity and substantive content of the presentation. Laboratory:
- testing and rewarding knowledge necessary to complete individual laboratory exercises,
- continuous assessment - during each class - of student activity and the level of their knowledge and skills, as well as social competences related to teamwork, - assessment of knowledge and skills related to the completion of laboratory tasks, evaluation of the report on the completed exercise.

Programme content

1. Electromagnetic and electromechanical energy conversion,
2. Basic laws,
3. Electricity generation systems,
4. Methods of storing electrical energy,
5. Drive systems used in renewable energy sources,
6. Power electronic converters.

Course topics

Lecture:
Systems for converting various forms of energy into electrical energy. Primary energy sources and conversion systems. Sommerfeld's concept: energy and co-energy. Electromagnetic and mechanical systems - analogies. Principle of virtual operation. Dynamics of electromechanical systems - Hamilton's principle and Lagrange's equations. Wind, hydro, photovoltaic, and fuel cell power plants. Types and characteristics of hydro, wind, and photovoltaic power plants. Electromechanical energy sources; generators with rotary and linear motion - structure, principle of operation, basic operational characteristics. Photovoltaic and chemical sources of electrical energy: photovoltaic panels and fuel cells. Electric energy storage systems. Mobile drive systems used in broadly defined traction. Converter systems coupling sources and receivers requiring electrical energy with various parameters - selected structures and their principle of operation. Selected control algorithms for power electronic converters, including: MPPT (Maximum Power Point Tracking). The problem of signal synchronization in power electronic converters dedicated to energy conversion in renewable energy systems. Control methods for power electronic converters enabling increased efficiency of electrical energy conversion. Laboratory:
- Selection of components for a grid-coupled photovoltaic electricity source, analysis of the voltage and

current curve shape at the inverter output, the problem of current and voltage harmonics, and effective methods for eliminating disturbances.
- Generator operation of an asynchronous machine: autonomous operation - capacitor selection, machine self-excitation conditions; operation on a separated grid (island operation) - the problem of insufficient inductive reactive power.
- Generator operation of a synchronous machine: autonomous operation, operation on the grid.
- Peltier cell - source of cooling and electricity; tests of permissible temperature differences.
- Micro-fuel cell - production of "fuel" through water distillation (photovoltaic energy source); load tests; Measurements of emitted "pollutants."
- A variable-speed drive unit with a synchronous motor operating under dynamically changing load conditions; determination of basic operational characteristics.
- A DC/DC pulse converter cooperating with a photovoltaic panel implementing the MPPT algorithm.
- A standalone voltage inverter as a controlled voltage source in renewable energy systems.
- A grid-tied inverter as a controlled current source enabling the return of energy to the AC grid.
- A system for monitoring the charge status of selected battery types.
- Battery charging systems operating in CV and CC modes.
- A converter system dedicated to cooperation with a synchronous generator, enabling increased energy conversion efficiency.
- Implementation of developed algorithms for monitoring the charge status of battery batteries.
- Development of the structure and control algorithms for passive and active balancers dedicated to selected battery types.
- Cascade control in complex converter systems dedicated to renewable energy sources (including the selection of the control system structure and parameters).
- Selection of control structures and methods to limit leakage current in PV-based systems.
- Selection of a converter system cooperating with a synchronous generator enabling energy return to the AC grid.

Teaching methods

Lectures - presentation of topics using multimedia, illustrated with examples provided on the board, and discussion of the issues;
Laboratory - simulation and laboratory testing of selected electrical energy conversion systems in renewable energy systems and electromobility.

Bibliography

Basic:
1.Mikielewicz J., Cieśliński J.T.: Niekonwencjonalne urządzenia isystemy konwersji energii. Maszyny Przepływowe pod red. E.S. Burki.Tom 24. IMP PAN, Ossolineum Wrocław 1999.
2.Cieśliński J.T.:Niekonwencjonalne urządzenia i układy energetyczne. Przykłady obliczeń. Wyd. PG 1997.
3. Romański L. 2013. Odnawialne źródła energii. Oficyna wydawnicza ATUT
4. Nowak W., Stachel A.A., Borsukiewicz-Gozdur A.: Zastosowania odnawialnych źródeł energii,Wydawnictwo Politechniki Szczecińskiej, Szczecin 2008.
5. Lewandowski W.M.: Proekologiczne źródłaenergii odnawialnej. WNT W-wa, 2001.
6. Griffiths D.J. : Podstawy elektrodynamiki. PWN W-wa 2001
7. Turowski J.: Elektrodynamika techniczna. WNT W-wa 1993
8. Dmowski A., Energoelektroniczne układy zasilania prądem stałym, Wydawnictwo NaukowoTechniczne, Warszawa, (1998)
9. T. Kaczorek, Control and systems theory (in polish), Wyd. Naukowe PWN, W-wa , 1999.
10. R. Strzelecki and H. Supronowicz, “The power factor of AC circuits and correction method” (in polish), OWPW, Warszawa, 120-135 (2000)

Additional:
1.Piotrowski J., Starzomska M., Sobierajski J. „ Odnawialne źródła energii”WydawnictwoPolitechniki Świętokrzyskiej, 2009
2. Twidell J.W., A.D Weir: Renewable energy sources. London: Chapman and Hall 1990.
3. Bogdanienko J.: Odnawialne źródła energii, PWN, Warszawa 1991.
4. Jastrzębska G., Energia ze źródeł odnawialnych i jej wykorzystanie, Wydawnictwa Komunikacji i Łączności WKŁ, 2017
5. Sibiński M., Znajdek K., Przyrządy i instalacje fotowoltaiczne, Wydawnictwo Naukowe PWN, 2016.

Breakdown of average student's workload

	Hours	ECTS
Total workload	55	2,00
Classes requiring direct contact with the teacher	30	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	25	1,00