Subject name and code	Control systems in renewable energy sources		
Field of study	Electrical Engineering		
Level of studies	undergraduate studies	Type of subject	elective
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	2018/2019	Language of instruction	English
Semester of study	V	ECTS credits	4.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Department of Controlled Electric Drives -> Faculty of Electrical and Control Engineering		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Piotr Kołodziejek	
	Teachers	dr hab. inż. Elżbieta Bogalecka dr hab. inż. Jarosław Guziński, prof. nadzw. PG dr inż. Piotr Kołodziejek	

Lesson type and method of instruction	Lesson type	Lectur	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	15	0.0	0.0	30
	E-learning hours included: 0.0						

Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
	Number of study hours	45	5.0	50.0	100

Subject objectives	Get basic knowedge and skill on renewable energy conversion and control systems

Learning outcomes

Course outcome	Subject outcome	Method of verification
K_W05	ma uporządkowaną wiedzę z zakresu pomiarów elektrycznych, dokumentowania ich wyników i obliczania niepewności pomiaru	- student presents measurement procedures of wind turbine characteristics - students draws characteristics of PV module and wind turbine
K6_W08	zna podstawy automatyki oraz układy regulacji automatycznej, ma podstawową wiedzę w zakresie teorii sygnałów i metod ich przetwarzania	students explains maximum power point tracking algorithms for photovoltaics and wind turbine control
K6_W09	zna podstawy wytwarzania, przesyłania i rozdziału energii elektrycznej	students explains power conversion devices and techniques
K_U03	potrafi przygotować i przedstawić krótką prezentację dotyczącą zadania inżynierskiego i jego wyników	students presents implementation of sensorless MPPT for wind turbine
K_U07	potrafi zaprojektować i uruchomić układy sterowania i napędowe	students presents implementation of hybrid MPPT for shaded PV
K6_K05	potrafi zareagować w sytuacjach awaryjnych, zagrożenia zdrowia i życia przy użytkowaniu urządzeń elektrycznych	student explains wind turbine operation safety issues
K6_K82	posiada przygotowanie do uczestniczenia w wykładach, seminariach, laboratoriach prowadzonych w języku obcym	students presents issues of wind and solar energy generation in English

Subject contents

Lectures.

Opis treści programowych wykład

Lecture:

Theory of renewable energy conversion with particular emphasis on photovoltaics and wind energy conversion.

I. Solar energy conversion. Characteristics of Sunlight and light sources. PN junction basics, materials, conduction, band gap, doping, intristic and equilibrium carrier concentration. Light absorption and electron-hole pair generation and recombination, total current calculation. Solar cells parametrs IV and PV curves, Voc, Isc, efficiency. Resistive, temperature and radiation effects. Photovoltaic module design issues: AR coatings, textutring, reflectors, lifetime. PV modules modeling, operation issues: shading effect, DC/DC, DC/AC dedicated converters and lcontrol system synthesis. Efficiency, characteristics and equivalent circuit model parameter measurement and estimation.

Maximum Power Point Tracking algorithms, extremal control strategies, local and global extremum identification, fault tolerant control.

II. Selected issues of the wind energy conversion: principles of wind energy conversion, basic aerodynamic problems, wind characteristics and energy resources estimation, wind turbines construction, electrical generators, power converters topologies, control system synthesis for fixed, variable and sensorless speed control system, maximum power point tracking extremal control systems including auxiliary pitch and yaw control. Measurement of wind turbine characteristics. Fault tolerant control systems. Hierarchical structure of the wind farm control system and control rules. Introduction into reactive power compensation, power grid operator and building law requirements. Offshore wind farms.

Laboratory:

1. Modeling and simulation of photovoltaic modules, I-V and P-V characteristics examination including radiation and temerature effects, equivalent circuit parameters calculation, energy generation analysis.
2. Wind turbine characteristics modeling including $Cp=f(\lambda)$, $P_w(\omega)$ for different blade pitch angle and including generator with control system $P_g(v_{wind})$. Control system quality analysis. Fault tolerant control.
3. Hybrid maximum power point tracking algorithms for the PV shading effect and fault tolerant control.
4. Solartracker control algorithms. Sensorless maximum power point tracking. Fault tolerant control.
5. Wind and solar energy resources measurement and analysis.
6. Wind turbine characteristics measurement. Optimal power curve aproximation.
7. Maximum power control algorithms for wind turbine control system. Fault tolerant control.
8. Photovoltaic module characteristics measurement and efficeincy analysis and equivalent circuit parameters calculation.

Prerequisites and co-requisites

Basic knowledge on electrical circuit theory, power electronics and controlled electric drives.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Final test	60.0%	50.0%
Laboratory reports	60.0%	50.0%

Recommended reading

Basic literature	1. Haitham Abu-Rub, Mariusz Malinowski, Kamal Al-Haddad, "Power Electronics for Renewable Energy Systems", Wiley 2014. 2. Zbigniew Lubośny:"Farmy wiatrowe w systemie elektroenergetycznym", PWN, Gdańsk 2016 3. Qiuwei Wu, Yuanzhang Sun, "Modeling and Modern Control of Wind Power", Wiley 2018 4. Elżbieta Bogalecka, Piotr Kołodziejek, Marcin Licznerski "Sterowanie elektrownią wiatrową w warunkach częściowego przesłonięcia, Przegląd Elektrotechniczny 2012.
Supplementary literature	
eResources addresses	

Example issues/ example questions/ tasks being completed

1. Characteristics of the photovoltaic module including temperature, radiation, resistive and shading effects.
2. Characteristics of the wind turbine and optimum power curve aproximation
3. Wind turbine power curve with MPPT and power limitation region of the control system.
4. Maximum power point tracking algorithms for solar power plant control system.
5. Maximum power point tracking algorithms for wind turbine control system.
6. Hybrid extremal control systems application in the renewable energy sources.
7. Sensorless solartracker control system.
8. Fault tolerant control of the solar power plant.
9. Fault tolerant control of the wind turbine.

Work placement

Laboratory of Control Systems in Renewable Energy Sources (EM303)