GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Wind Power Plants, PG_00042159					
Field of study	Power Engineering, Power Engineering, Power Engineering, Power Engineering, Power Engineering					
Date of commencement of studies	October 2020		Academic year of realisation of subject		2022/2023	
Education level	first-cycle studies		Subject group		Optional subject group Subject group related to scientific research in the field of study	
Mode of study	Full-time studies		Mode of delivery		at the university	
Year of study	3		Language of instruction		Polish Polish or english	
Semester of study	6		ECTS credits		3.0	
Learning profile	general academic profile		Assessment form		exam	
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					
Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	0.0	15.0	0.0	0.0	45
	E-learning hours included: 0.0						

	Additional information: Lecture: 1. Wind turbine power: principles of wind energy conversion, kinetic power of the air stream, Betz Cp coefficient, average annual power obtained from a wind turbine, turbine dimensioning, 2. Aerodynamic issues: forces acting on the rotor blade, rotor aerodynamics, mechanical characteristics of the wind turbine. 3. Construction of a wind power plant: elements, tasks, safety, solutions of wind turbines: power plants with a horizontal axis 4. Generators, power supply and control systems in wind farms. 5. Auxiliary systems and lightning protection system. 6. Compressed air generators, alternative and innovative methods of wind energy conversion - the use of kites, oscillatory converters. Lab: 1. Mathematical model of a wind turbine. Determination and testing of wind turbine characteristics. 2. Simulation models of power control systems in wind farms. 3. Wind models - Rayleigh and Weillbull distributions and shaping characteristics with auxiliary systems, shaping the power curve of a wind power plant. 4. Physical model of a wind power plant - fan inverter configuration, measurement system for determining the characteristics of the power plant, measurements and testing of turbine characteristics, analog and digital bucket anemometers, hot anemometers - testing methods for measuring wind speed, 5. Power control of a wind power plant with optimal power tracking. (MPPT - Maximum Power Point Tracking) 6 Control of a wind power plant with a double-fed machine. Outdoor activities at the end of the semester (June) - visit to MMB Drives or to the wind farm.

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	25.0	75

Subject objectives

Acquisition of competences in the field of wind turbines, construction and applications, power control systems and auxiliary systems. Learning the principles of wind energy conversion, basic aerodynamic issues, wind properties, construction of a wind farm. Wind turbine power control, stall effect, turbine power control by pitch adjustment. Generator constructions and power converters. Fixed and variable speed wind turbines. Hierarchical structure of the wind farm control system, control principles. Optimum control of the power plant. Maximum power point tracking algorithms.

Learning outcomes

Course outcome	Subject outcome	Method of verification
K6_W08	know basics of control systems, physics of wind turbine operation, digital signals theory and processing methods.	[SW3] Assessment of knowledge contained in written work and projects
K6_W05	know basics of generation, conversion and distribution of wind energy.	[SW1] Assessment of factual knowledge
K6_U04	student can design and start control system of the wind turbine.	[SU3] Assessment of ability to use knowledge gained from the subject

Subject contents

Lecture:

Theory of wind energy conversion. Selected issues of the wind energy conversion: principles of wind energy conversion, basic of aerodynamics, wind characteristics, wind energy resources calculation, estimation and prediction, wind turbine construction, electrical electrical generator construction and features, power converters topologies, control system synthesis for fixed, variable and sensorless speed control systems, maximum power point tracking control systems including auxiliary pitch and yaw control devices. Measurement of wind turbine characteristics. Hierarchical structure of the wind farm control system and control rules and limitations. Introduction into reactive power compensation, energy quality requirements stated by the electrical grid operators and building law requirements. Offshore wind farms design and features. Fault diagnosis and case study examples.

Laboratory:

1. Wind turbine characteristics modeling including Cp=f(), $P_w()$ for different blade pitch angle and including generator with control system $P_g(v_{wind})$. Control system quality analysis.
2. Wind energy resoures indetification, measurement and statistical analysis.
3. Wind turbine characteristics Cp=f(), $P_w()$, $P_g(v_{wind})$ measurement. Optimal power curve aproximation.
4. Maximum power point tracking control algorithm implementation in microcontroller and experimental testing.
5. Measurement analysis of wind turbine operating in off-grid microgrid
6. Double fed induction machine operating as wind turbine.
7. Wind turbine tests using squirrel cage induction generator

Prerequisites and co-requisites

Basic knowledge in circuit theory and power electronics.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Lecture test	50.0%	50.0%
Laboratory exercises	100.0%	50.0%

Recommended reading

Basic literature	1. H Abu-Rub, A Iqbal, J Guzinski, "High performance control of AC Drives with MATLAB/Simulink models", A John Wiley & Sons, New York 2. Bogalecka, Elżbieta, Krzemiński, Zbigniew. (2007). Control of the wind turbine generator. *Power Electronics And Electrical Drives : Selected Problems*, 453-462 3. Haitham Abu-Rub, Mariusz Malinowski, Kamal Al-HaddHaddHaddad, Power Electronics for Renewable Energy Systems, Wiley 2014.3 4. Zbigniew Lubośny:Farmy wiatrowe w systemie elektroenergetycznym, PWN, Gdańsk 2016 5. Qiuwei Wu, Yuanzhang Sun, Modeling and Modern Control of Wind Power, Wiley 2018
Supplementary literature	IEEE articles and papers shared from lecturer.
eResources addresses	Adresy na platformie eNauczanie:

Example issues/ example questions/ tasks being completed

1. Characteristics of the wind turbine and optimum power curve aproximation
2. Wind turbine power curve with MPPT and power limitation region of the control system.
3. Maximum power point tracking algorithms for wind turbine control system.
4. Control system of the double fed induction generator.
5. Adaptation of the induction motor drive as generator in wind turbine.

Work placement

Field exercises