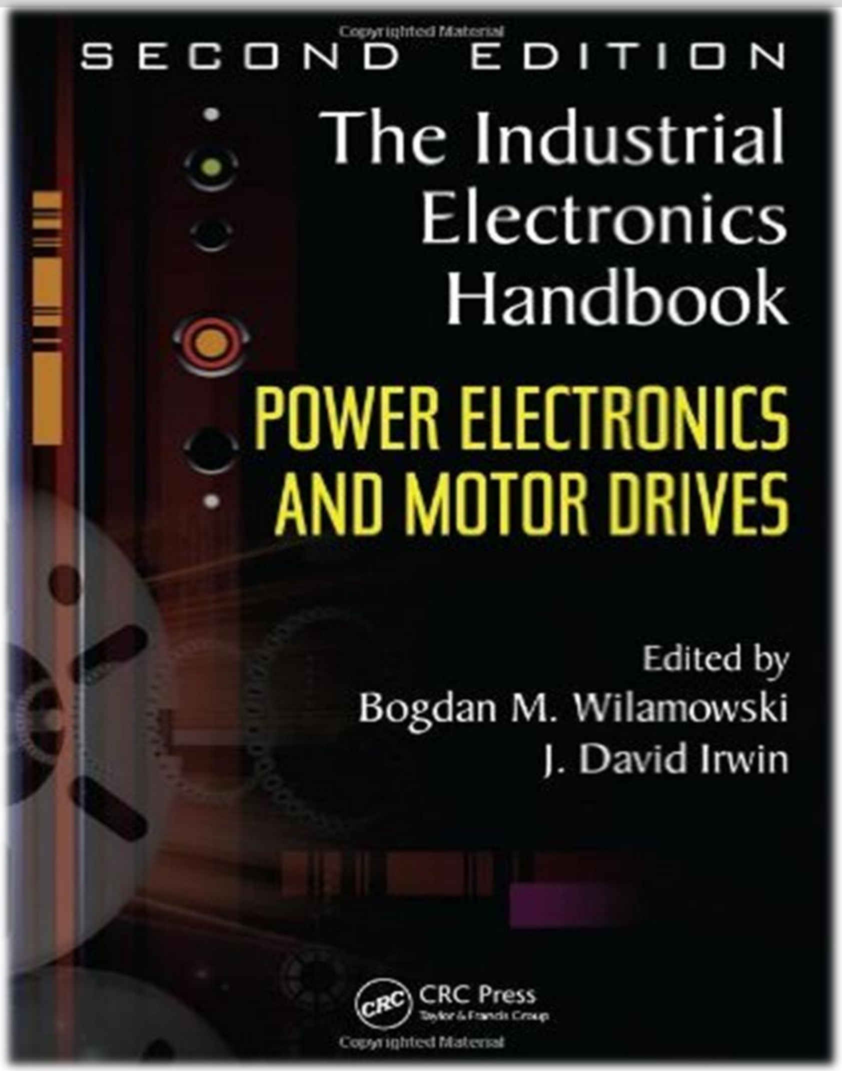
Monografie Naukowe i Podręczniki



23

Standalone Double-Fed Induction Generator

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23.1 Introduction

Standalone, AC voltage, power generation systems with conversion of mechanical energy mainly use wound rotor synchronous generators (WRSGs) operated with fixed speed, related to the reference frequency, e.g., 50 or 60 Hz. Power systems, like wind turbines or water plants, in which fixed speed is difficult to obtain, can be adopted to standalone variable-speed operation and provide standard fixed frequency AC voltage. Normalized voltage can be obtained by the use of full-range power electronics converter, as a coupler interface between variable-speed generator and an isolated load (Figure 23.1). WRSG or permanent magnet synchronous generator (PMSG) based systems can be equipped with an AC/DC diode rectifier with an optional DC/DC converter and a DC/AC converter (Figure 23.1a). In case of cage induction generator (CIG) (Figure 23.1b), back-to-back converter is necessary (controlled AC/DC and DC/AC). Power inverter, responsible for generation of standard AC voltage, in standalone mode requires an output L_f–C_f filter, to obtain high-quality generated voltage [1–3].

Other variable-speed power generation system, which is recently often applied in grid-connected wind turbines, consists of doubly fed induction generator (DFIG) and rotor-connected power electronics converter (Figure 23.2) [4–6]. The typical speed range of DFIG generation system equals ±33% around synchronous speed. For that speed range, the power electronics converter is limited to 33% of DFIG rated power.

In comparison to the total system power, the DFIG corresponds to 75% and converter corresponds to 25% of maximum produced power, due to the fact, that during over-synchronous speed operation, power is delivered via stator side as well as rotor and power electronics converter. The variable-speed systems with DFIG, driven by wind turbines, are dedicated only to grid-connected systems, if not supported by energy storage or other power source.

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VSWT BASED ON DFIM MANUFACTURERS 65

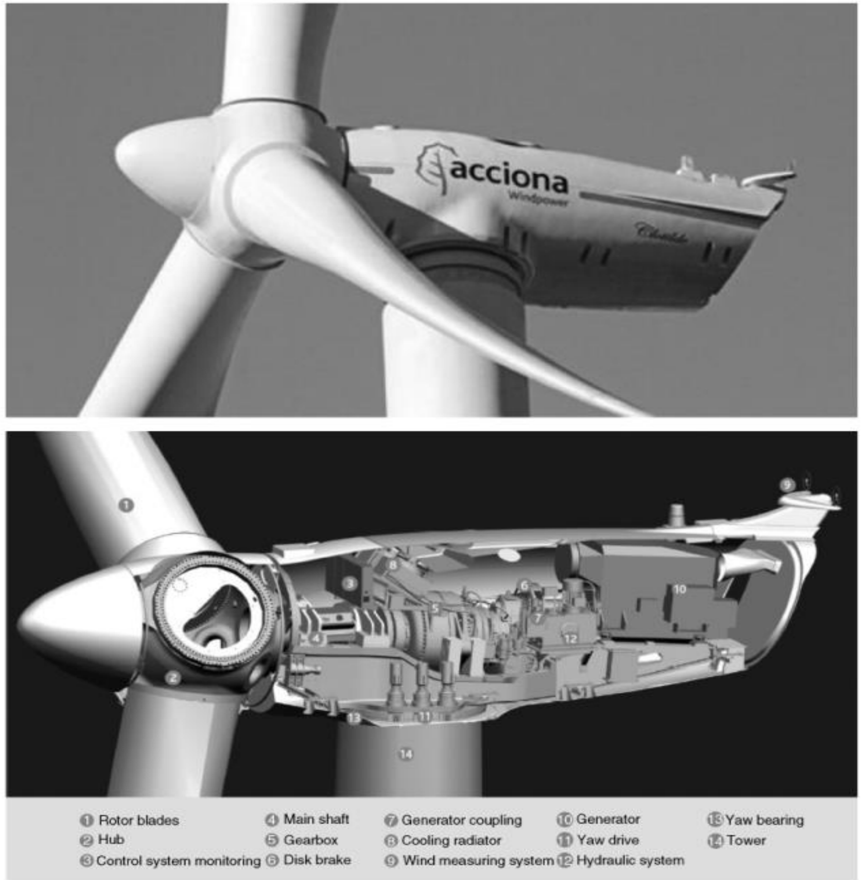

Figure 1.49 Main components of an AW 3000 nacelle. (*Source*: Acciona.)

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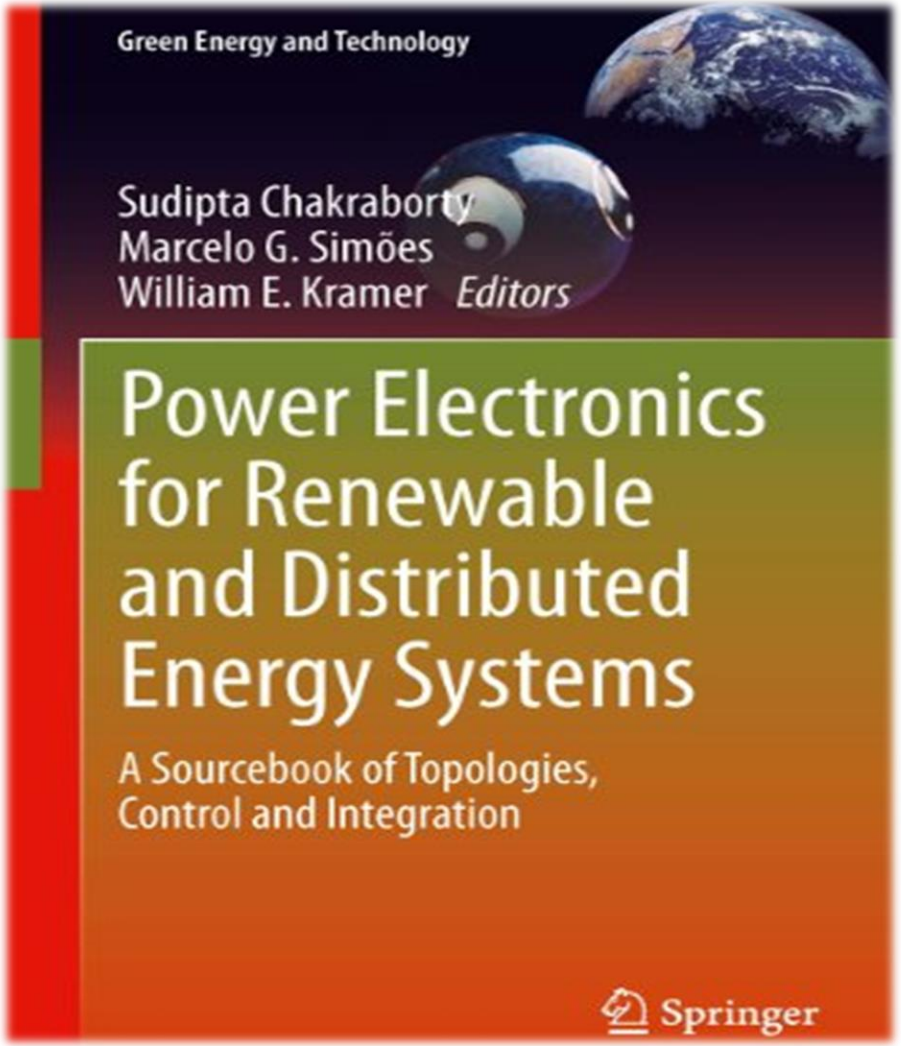
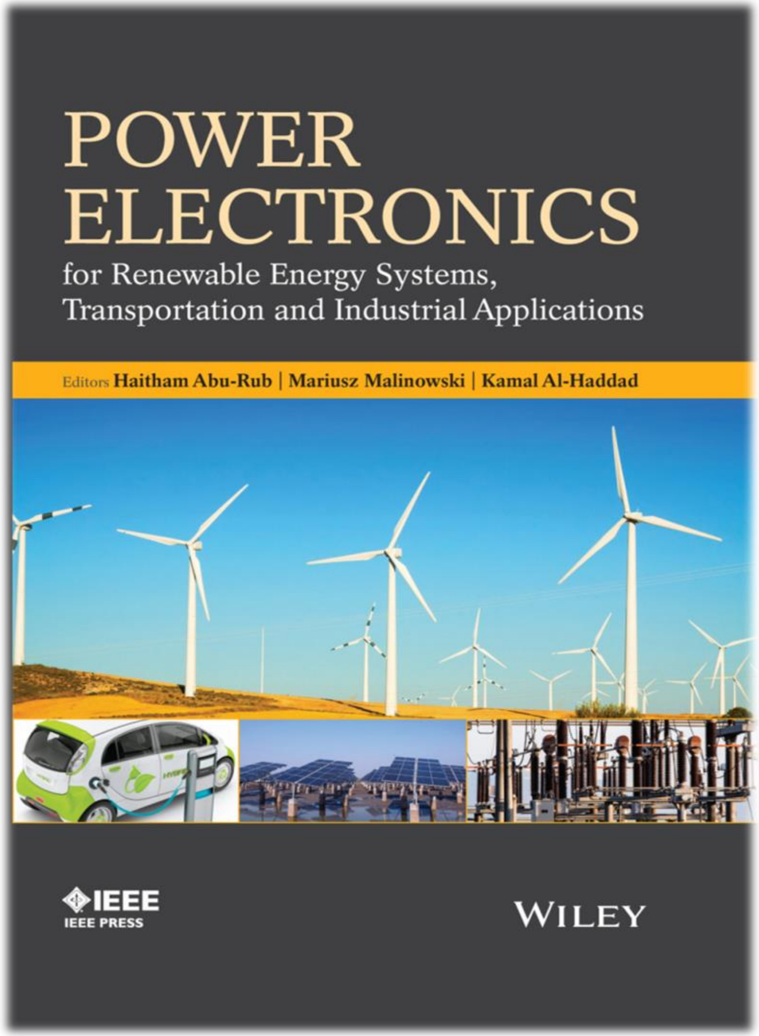


Chapter 7
Variable-Speed Power Generation

Wlodzimierz Koczara and Grzegorz Iwanski

Abstract Theory of the variable (adjustable) speed generation systems is described. The main part is related to island (autonomous) operation. Variable speed means an additional degree of freedom of the generation system. Moreover, it provides higher speed than conventional system based on wound rotor synchronous generator. The higher speed results in higher power of driving engine. Adjustable speed provides reduction of fuel consumption. To reduce the engine fuel use, its speed is adjusted to areas of low specific fuel consumption. Two basic topologies are presented. First topology is based on application of the permanent magnet generator, whereas second on the slip-ring induction machine. Power flow drawn from the engine via generator is controlled by power electronic converters. In case of use of permanent magnet generator, the applied power electronic converter is built on the basis of the intermediate DC link voltage. The generator voltage of variable frequency and amplitude is rectified and then converted to the AC voltage. This concept is realized by application of several different rectifier and inverter topologies. The power electronics converter controls the rectified current and in this way adjusts the load torque produced by the generator. Speed control systems of the driving engine are presented. The variable speed power generation with slip-ring induction machine system uses a control method based on space vector theory. According the reference stator voltage vector, the rotor current amplitude, frequency, and phase are adjusted to provide sinusoidal three-phase stator voltage.

Monografie Naukowe i Podręczniki



Properties and Control of a Doubly Fed Induction Machine

Gonzalo Abad[1] and Grzegorz Iwanski[2]

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10.1 Introduction. Basic principles of DFIM

10.1.1 Structure of the Machine and Electric Configuration

The doubly fed induction machine (DFIM) or wound rotor induction machine (WRIM) are terms commonly used to describe an electrical machine, which has been used over many decades in various applications, often in the range of megawatts of power and also less commonly in the range of a few kilowatts. This concept of the machine is as an alternative to more common asynchronous and synchronous machines. It can be advantageous in applications that have a limited speed range, allowing a reduction in the size of the supplying power electronic converter as, for instance, in variable-speed generation, water pumping and so on.

The typical supply configuration of the DFIM is shown in Figure 10.1. The stator is supplied by three-phase voltages directly from the grid at constant amplitude and frequency, creating the stator magnetic field [1, 2]. The rotor is also supplied by three-phase voltages that take a different amplitude and frequency at steady state in order to reach different operating conditions of the machine (speed, torque, etc.). This is achieved by using a back-to-back three-phase converter, as represented in the simple schematic in the figure. This converter, together with the appropriate control strategy, is in charge of imposing the required rotor AC voltages to control the overall DFIM operating point and to perform the power exchange through the rotor to the grid. Although a voltage source converter is shown, different configurations or converter topologies could be utilized. Further details regarding the operation of the machine are described in subsequent sections.

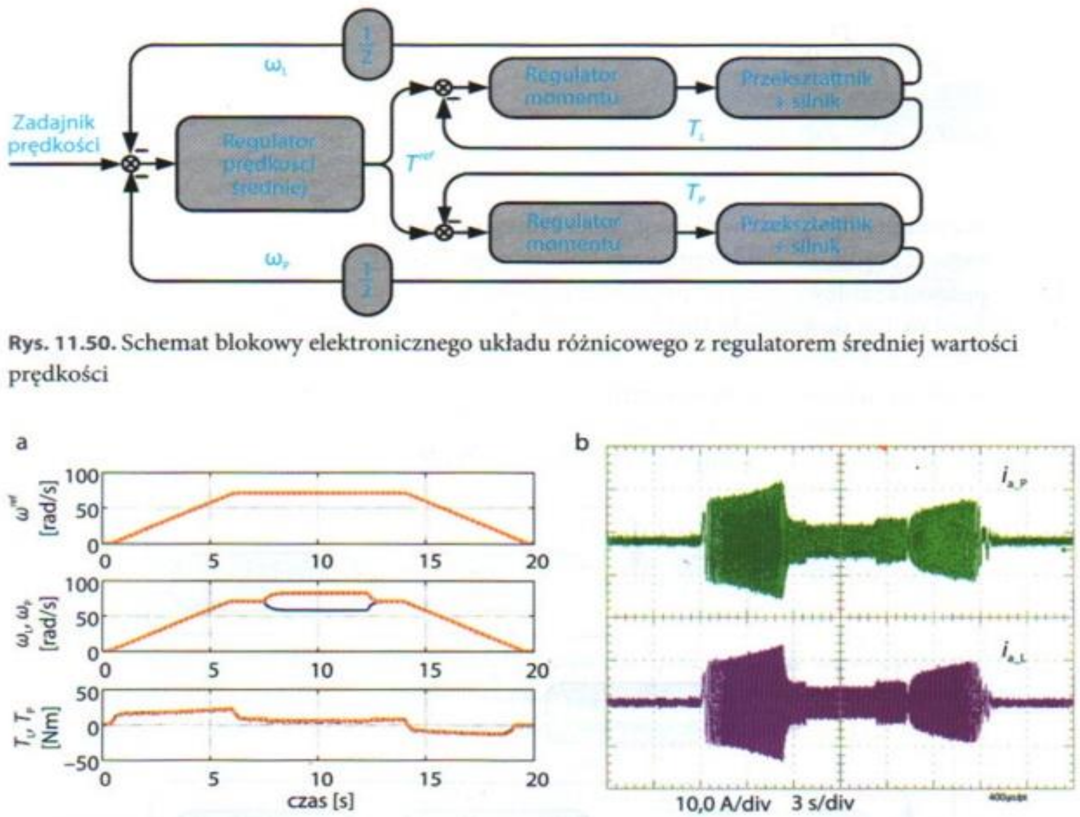
MONOGRAFIE NAUKOWE I PODRĘCZNIKI

Chapter 9
Advanced Control and Optimization Techniques in AC Drives and DC/AC Sine Wave Voltage Inverters: Selected Problems

Barłomiej Ufnalski, Lech M. Grzesiak and Arkadiusz Kaszewski

Abstract This chapter presents the application of a particle swarm optimization (PSO) to a controller tuning in selected power electronic and drive systems. The chapter starts with a relatively simple tuning of a cascaded PI speed and position control system for a BLDC servo drive. This example serves as the background for a discussion on selecting the objective function for the PSO. Then the PSO is used in two challenging controller tuning tasks. This includes optimizing selected learning parameters in the adaptive artificial neural network (ANN) based online trained speed controller for an urban vehicle (3D problem) and selecting penalty factors in the LQR with augmented state (i.e. with oscillatory terms) for a three-phase four-leg sine wave inverter (15D problem). It is demonstrated with the help of these case studies why and where the PSO, or any other similar population based stochastic search algorithm, can be beneficial. Engineers encounter many non-straightforward controller tuning problems in power electronic systems and this chapter illustrates that in some cases it is relatively easy to reduce these tasks into the objective function selection problem. The relevant controller parameters are then determined automatically by the PSO.

Monografie Naukowe i Podręczniki



Rys. 11.50. Schemat blokowy elektronicznego układu różnicowego z regulatorem średniej wartości prędkości

Rys. 11.51. Przebiegi prędkości zadanej, prędkości kątowych i momentów elektromagnetycznych (*a*) oraz prądów jednej fazy (*b*) silników napędowych kół lewego i prawego w układzie z regulatorem średniej wartości prędkości podczas pokonywania zakrętu

mgr inż. Piotr Biernat 11.10
mgr inż. Andrzej Gałecki 11.10
prof. dr. hab. inż. Lech Grzesiak 12.1 - 12.6
dr. inż. Bartłomiej Kamiński 6.8 - 6.11
dr. Inż. Arkadiusz Kaszewski 11.10
mgr inż. Marek Michalczuk 3, 12.1 - 12.6
mgr inż. Marcin Nikoniuk 6.8 - 6.11
mgr inż. Piotr Rumniak 11.10
dr. inż. Bartłomiej Ufnalski 12.1 - 12.6