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SUMMARY INFORMATION OF DOCTORAL DISSERTATION

Title of doctoral thesis: Smart control of permanent magnet synchronous generator for grid-connected variable speed wind energy systems application.
Major: Control and automation engineering; Code: 9520216
Name of PhD student: Nguyen Ngoc Anh Tuan
Science instructor: 1. PhD. Pham Cong Duy
2. PhD. Luu Hoang Minh
Training facilities: Ho Chi Minh City University of Transport.

1. Scientific arguments need to be solved in the dissertation

The content of this dissertation aims to answer the following basic scientific questions:

- Is it possible to control the stator flux constant for the machine side controller of PMSG wind turbine?
- Is it possible to design a single-layer neural controller to find the maximum power point based on the DE algorithm and combine the d-axis stator current control technique for the machine-side controller of the PMSG wind turbine?

2. Objective of the dissertation

2.1. Overall objective

Propose intelligent controller to achieve maximum power and low-cost goals.

2.2. Detail objectives

- Propose CSFL control method for MSC of PMSG because of good response and low cost and experiment on OPAL-RT OP5707XG.
- Propose DE or EO algorithm as optimal algorithm with high efficiency to find MPPT for PMSG;
- Design RBFNN controller to find MPPT based on DE algorithm and combine d-axis stator current control techniques (ZDC, UPF and CSFL) to control MSC of PMSG wind turbine.

3. Limitations of the dissertation

The thesis focuses on studying d-axis stator current control methods and optimization algorithms, thereby designing a single-layer neural network to control the maximum power point tracking in wind turbine systems using PMSG, in order to achieve maximum power and reduce costs.

4. Subject and scope of research

- *Research subjects*: PMSG wind turbine with capacity of 2 MW connected to the local grid.
- *Research scope:* limited to two aspects including technical; specific mathematical tools as follows:
  - Technical aspect: intelligent control for wind turbine systems using PMSG to achieve maximum power and low cost.
  - Mathematical aspect and mathematical tools: mathematical models; intelligent algorithms; analysis, calculation and simulation tools (Matlab).

5. Research methods and approaches

The thesis was carried out with the following research methods:

- Data collection, synthesis analysis, evaluation analysis, modeling and simulation.

- The method of data collection is to study and research the problem, grasp the content that predecessors have done, without wasting time repeating the work that predecessors have done;

- The method of analysis and evaluation is to divide the general into different parts, then examine each part specifically to understand each detail, from there make assessments and comments to clarify the research problem, then be ready to redesign, improve or make necessary changes to bring about efficiency;

- The method of modeling and simulation is to demonstrate the systematic relationship between factors.

6. Scientific and practical significance of the dissertation

6.1. Scientific significance

The thesis has researched and successfully built a mathematical model describing a wind turbine system using PMSG with a controller combining a maximum power point tracking controller using a neural network based on intelligent control algorithms and d-axis stator current control techniques for the generator side. The thesis has proposed optimal control algorithms to improve the quality of the maximum power point tracking controller for the machine side of the wind energy system using PMSG.

6.2. Practical significance

The research results of the thesis have been published in international journals. These research results will be useful documents for the research community in both academia and industry to benefit the government in planning future energy policies.

7. New contributions of the thesis

7.1. Theoretically

- Build a mathematical model describing the wind turbine system using PMSG and a mathematical model of the PMSG generator.

- Build a d-axis stator current control algorithm for the machine side of the wind turbine system using PMSG.

- Build an intelligent control algorithm for the machine side of the wind energy system using PMSG.

- Build a control algorithm combining a maximum power point tracking controller using a neural network based on intelligent control algorithms and d-axis stator current control techniques for the generator side of the wind energy system using PMSG.

7.2. About practice

- Simulate the mathematical model describing the wind turbine system using PMSG and the mathematical model of the PMSG generator.

- Simulate the d-axis stator current controller for the machine side of the wind turbine system using PMSG.

- Simulate the intelligent controller for the machine side of the wind energy system using PMSG.

- Improve the maximum power using neural networks based on intelligent control algorithms and d-axis stator current control techniques for the generator side of the wind energy system using PMSG.

- Experimental application on OPAL-RT (OP5707-XG) to verify the reliability of d-axis stator current control methods of the wind turbine system in real time.

8. Structure of the thesis

The thesis is organized including the introduction as presented, the thesis is organized into 4 chapters corresponding to the objectives, tasks and research results as follows:

Chapter 1 Overview of wind power system structure. This chapter introduces the general overview of wind power system, structure of wind turbine energy conversion system and types of generators in wind power system. In addition, this chapter presents the mathematical model of wind turbine and PMSG.

Chapter 2 Methods of controlling d-axis stator current in wind power system. In this chapter, the author introduces three methods of controlling d-axis stator current including ZDC, UPF and CSFL. From there, analyze and compare these three control methods.

Chapter 3 Intelligent algorithms for maximum power point tracking controller in wind power system using PMSG. In this chapter, the author presents optimization algorithms for MPPT controller such as GA, PSO, EO, DE. Thereby, compare and evaluate these methods to select the most optimal method.

Chapter 4 Design of maximum power point tracking controller using RBFN for PMSG in wind power system. In this chapter, the author presents common MPPT algorithms, from which the design of a neural controller for a wind power system with a capacity of about 2MW to simulate the wind power system.

Conclusion and development direction.

Ho Chi Minh City, October 03, 2024

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