Faculty of Engineering
Electrical Power and Machines Dept.

Dynamic Performance Improvement of Automatic Voltage Regulator System Using Computation Evolutionary Algorithms

M.Sc. Thesis
By

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Submitted in partial fulfillment of the requirements for the
M.Sc Degree in Electrical Engineering

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Approval Sheet

For The thesis:

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Date: / / 2020

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Statement

This thesis is submitted to Ain Shams University in partial fulfillment of the requirements for M.Sc degree in Electrical Engineering.

The included work in this thesis has been carried out by the author at the Electrical Power and Machines Department, Faculty of Engineering, Ain Shams University. No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

Name **:** Romany Girges George
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To

My, Mother, fiancée, my brother, and my sister.

Acknowledgements

The author would like to express his sincerest gratitude to **Prof. Dr. Mohamed Abd-Lattif Badr, and Prof. Dr. Hany Mohamed Hasanien** for the great support, excellent supervision and encouragement shown during the period of this study.

Special thanks to the Electrical Power and Machines Department, Faculty of Engineering; Ain shams University, for the great support and encouragement.

Abstract

Synchronous generators have been widely used to provide electricity for most customers. One of the most significant criteria that should be stabilized over the normal and abnormal operation of the synchronous generator is the terminal voltage of the synchronous generator. Automatic voltage regulators (AVRs) are control circuits dedicated to stabilizing the terminal voltage of the synchronous generator. However, such these control circuits only manifest some deficiencies during steady-state and transient responses.

Various control systems have been proposed to enhance the output response of AVR. The Proportional-Integral-Derivative (PID) controller is a control system that has been used to improve the terminal voltage of the synchronous generator. However, the most challenging technique with this controller is how to tune these parameters properly. Some strategies have been devoted to fine-tuning of PID.

The main contribution of this thesis is to enhance the output response of the AVR control system employed with a PID controller using various optimization techniques. In addition to the deterministic techniques that have been suggested to obtain fine-tuning of PID controller, meta-heuristic algorithms are proposed in this thesis to investigate the optimal design of PID controller which includes Whale Optimization Algorithm (WOA), Water Cycle Algorithm (WCA), and Moth-Flame Optimization (MFO) so as to enhance the output response of AVR control system. To ensure the effectiveness of these proposed algorithms with the AVR control system, a comparison is performed between these algorithms and Genetic Algorithm (GA) executing the same

fitness function (F.F). The fitness function in this thesis is the integral square error between the terminal voltage and the reference voltage. The WCA shows better performance than the GA, WOA, and MFO do. Also, the convergence towards the optimal solution obtained by WCA is faster than GA, WOA, and MFO. The AVR control system combined with the PID controller is executed in MATLAB/Simulink. The proposed algorithms employed to optimize the PID controller parameters are also coded in MATLAB script file which afterward are called for further optimization.

In addition to the meta-heuristic algorithms, Model Predictive Control (MPC) is also proposed in this thesis to enhance the output response of AVR control system. The model predictive control, in this thesis, studies the state-space of the automatic voltage regulator and depending on the difference between the reference voltage and the output response control signals are determined to match the input-output characteristic. Also, for ensuring the performance of AVR engaged with MPC, a comparison is implemented between the MPC and the most efficient meta-heuristic algorithm employed in this thesis, which is WCA. MPC and AVR control system are executed in MATLAB toolbox and MATLAB/Simulink.

Another contribution performed in this thesis is studying the saturation characteristic of the DC exciter model. The saturation characteristic of the exciter model is combined with the AVR model to make the model more accurate and realistic. By this overall model, the output response of the AVR control system is analyzed.

Keywords: *Automatic Voltage Regulator - PID Controller -Meta-heuristic Algorithms- Model Predictive Control.*

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