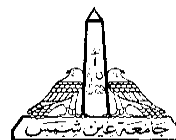


بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Ain Shams University
Faculty of Engineering
Electrical power and Machines Dept.



**LOW VOLTAGE RIDE THROUGH
CAPABILITY IMPROVEMENT OF GRID-
CONNECTED PHOTOVOLTAIC POWER
PLANTS**

Master Thesis
By

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Submitted in partial fulfillment of the Requirements for
the Master Degree in Electrical Engineering

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Statement

This thesis is submitted to Ain Shams University in partial fulfillment of the requirements for Master 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.

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To

**My husband, my children, my
brothers, my sister and their
families.**

Acknowledgements

The author would like to express her sincerest gratitude to **Prof. Dr. Hany Mohamed Hasanien and Dr. Amr Magdy Abdin** 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

Among the world of renewable energy sources, solar energy is growing powerfully and robustly. There are many advantages for the photovoltaic (PV) systems including small installation time, easy circuitry, long life of operation, and low maintenance requirements. The solar power plants are connected to the electric grid on large scale. PV systems prices were continuously decreasing during the last decade.

It is essential to model the PV module to use it in the PV system simulation process, this model plays an important role through the dynamic analysis of these systems and helps to predict their behavior under different operating conditions. The mathematical model of the PV module is a nonlinear I-V characteristic including several unknown parameters as the PV manufacturers' data are not sufficient. The equivalent circuit models used to describe the non-linear I-V relationship are: single, double and three diode models. The three models are introduced to achieve higher level of accuracy. The parameter extraction problem of the three different models is formulated as a search optimization problem. The fitness function is evaluated by minimizing the Root-Mean-Square error between calculated current and measured current experimental data through adjusting parameters of the PV models. This optimization is executed through a new nature-inspired meta-heuristic optimization technique known as the Whale Optimization Algorithm (WOA).

The WOA-based PV models are validated by the simulation results, which are carried out under various environmental conditions using MATLAB program. The effectiveness of the WOA-based PV models is checked by comparing their results

with that obtained using other optimization methods. To obtain a realistic study, these simulation outcomes are compared with the experimental outcomes of a Kyocera KC200GT PV module. Moreover, the WOA-based PV model is efficiently evaluated by comparing the absolute current error of this model with that obtained using other PV models. Using this meta-heuristic algorithm application, an accurate PV model can be obtained.

The designed PV system consists of a PV array connected to the electric grid through a DC boost converter, a DC-link capacitor, a grid-side inverter, a step up transformer, and transmission lines. Control Systems are connected to the PV systems in order to improve the performance of PV system and enhance the low voltage ride through (LVRT) capability during abnormal operation conditions. An open fractional voltage control strategy that satisfies maximum power point tracking operation is applied to the DC-DC converter. A cascaded voltage control technique that controls both the voltage at the point of common coupling and the DC link voltage at the grid-side inverter is applied. Both of the control systems are based on Proportional Integral (PI) controllers. Response surface methodology (RSM) is used to create the fitness function for this system through Minitab program. To get PI controller parameters that guarantee the optimum design of the controllers, the fitness function is optimized using a new swarm intelligence technique called Salp Swarm Algorithm.

The proposed control system is tested under various fault scenarios to examine the validity of the control system. The results show that the proposed control system works with high performance under different fault conditions.

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