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**DESIGN AND IMPLEMENTATION OF FUZZY
MACHINE LEARNING BASED CONTROLLER FOR
MAXIMUM POWER POINT TRACKING OF A PV
FARM SYSTEM**

By

Mohamed Mohsen Mahmoud Helmy

A Thesis Submitted to the
Faculty of Engineering, Cairo University
in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

in

Electrical Power and Machines Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY

GIZA, EGYPT

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Summary:

Solar energy systems are considered one of the most important systems that researchers have been developing due to their importance in generating electrical energy, but these systems suffer from a fundamental problem, which is the dependence of the power extracted from solar panels on radiation strength and temperature, and they are by nature variable. Therefore, in this research a simulation was made to design artificial intelligence controllers such as fuzzy logic or artificial neural networks to follow the maximum power point extracted from these systems during sudden changes in temperature and solar radiation by calculating the voltage corresponding to the maximum power and then controlling the DC – DC Converter to obtain this voltage. These controllers are divided into two types, the first type is based on machine learning technology and aims to obtain the voltage value corresponding to the maximum power, while the second type aims to control the DC-DC converter to ensure the required voltage is reached. The proposed controllers were tested by modeling them with a solar cell system and DC-DC converters using the MATLAB program under different temperatures and radiation levels. The tests included actual temperatures and radiation levels registered in Cairo. The results have demonstrated the effectiveness and ability of the proposed first type controller in determining the required voltage value for the maximum power compared to traditional methods, as well as the effectiveness and ability of the second type controller built using fuzzy logic or neural networks in reaching the voltage extracted from the first type controller with high accuracy and speed compared to the second type controllers proposed.

DISCLAIMER

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

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Abstract

In recent years, some research has been done in the area of optimizing PV performance when combined with a wide range of loads utilizing Power Electronics converters. Such converters can be DC-DC and DC-AC single and three stage converters. Control technique for these converters is based on a number of algorithms that have been developed and optimized for Maximum Power Point (MPP) detection, such as Incremental Conductivity, Perturbation and Observation (P&O). Even though its complexity, the most common MPPT algorithm is Incremental Conductance due to several advantages compared to others.

Current research in the field of Maximum Power Point Tracking focuses on new and more flexible ways to change the size of the duty ratio step. This thesis aims to design duty ratio step size controllers to track the maximum power of a farm system to provide 400KW.

This is done using two stages of work. The first stage is to extract the voltages that give the maximum power for different temperature and irradiance using the PV cells under consideration. These data are, then, used to train a fuzzy controller using fuzzy machine learning to determine the reference voltage that gives the maximum power for certain temperature and irradiance. The second stage is to adjust the real value of the output voltage of the PV system as the previously mentioned reference voltage using conventional PI Controller tuned by both particle swarm optimization (PSO) and Ziegler-Nichols method.

Adaptive Neuro Fuzzy Inference System (ANFIS) like PI Controller and Fuzzy controller tuned using Fuzzy machine learning are, also, developed. The developed controllers are tested using temperature real data gathered during one day in Cairo. In addition, different simulation scenarios are implemented to validate the efficiency of the proposed controllers. The simulation results show that the proposed controllers monitor the PV system's MPP in short time with minimal error and low oscillation under large changes in environmental conditions. Furthermore, the results showed that ANFIS is the most powerful among the proposed controllers as a PI operator.

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