Implementation of a MPPT Neural Controller for Photovoltaic Systems on FPGA Circuit

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Abstract: - The maximum power point tracking (MPPT) system controls the voltage and the current output of the photovoltaic (PV) system to deliver maximum power to the load. Parameters values were extracted using Newton Raphson method from characteristics of Shell SP75 module. This paper presents a comparative analysis of incremental conductance (IC), and neural network based MPPT techniques. The Artificial Neural Network (ANN) method is used to deliver the appropriate duty cycle signal used to drive boost converter to track the MPP even with variations of the input values using Matlab/Simulink for the simulation and Hardware Description Language (VHDL) for the implementation on kit Field Programming Gate Array (FPGA) Spartan-3E of Xilinx.

Key-Words: - Artificial neural network, Photovoltaic systems, Incremental conductance, MPPT, VHDL, FPGA

1 Introduction

Demand for electrical energy has remarkably increased during the recent years with growing population and industrial progress. Since long time ago, fossil fuels have served as the major source of generating electrical energy. However the transfer of energy resulting from photovoltaic conversion remains relatively weak. Therefore, many tracking control strategies have been proposed in existing literatures, such as perturb and observe, incremental conductance, Variable voltage, and fuzzy logic methods [1,2,14]. But for this work a novel BP neural networks MPPT algorithm has been used. These new control techniques feature advantages of simplicity, high flexibility and less fluctuation around the maximum power point which increase efficiency of the PV system [3]. In [4], Newton Raphson method is used due to the nonlinearity of Current/Voltage (I-V) characteristics of PV module. Selection of appropriate converter is also very important for an efficient PV system [13]. There are a few topologies can be used with PV system for load connectivity, among them boost converter has been selected here due to its available use in standalone and grid connected PV system and simultaneous step up capability [5,6]. This paper results show that the proposed BP MPPT method can track maximum power point (MPP) in different temperature and irradiation, which has excellent output characteristic of high accuracy and good robustness as compare with method IC. Experimental results from implementation of a FPGA allow the validity of the proposed neural control and deliver the appropriate duty cycle signal under different values of solar radiation and temperature as comparing with Matlab/Simulink simulation.

The sequential work flow of this paper is as follows: In section 2, complete working procedure of the system has been described. Section 3 covers mathematical modelling of PV using a Newton Raphson method, and followed by discussion on boost dc-dc converter and MPPT algorithms in Sections 4 and 5 respectively. Simulation and experimental works and results are discussed in Section 6 and 7. Lastly, in section 8, a precise conclusion has been added to finalize the work.

2 Complete System Overview

A photovoltaic cell is basically a PN semiconductor junction diode and this cell converts solar light energy into electricity [7].