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Maximum Power Point Tracking

PV Systems Operating Under Changing Atmospheric Conditions

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TABLE OF CONTENTS

1. Photovoltaic Theory

1.1 Introduction

Photovoltaic cells convert energy from sun directly into electricity. Photovoltaic cells provide a clean and reliable energy. As it is not based on fossil fuel so it is free from harmful products. Most of the energy needed to support life is provided by the sun which is the main source of other alternative sources of energy. The renewable energy resources such as geothermal, wind, biomass, from solar energy. The amount of solar power received by earth on an average is 1.2 10^{17}W[Hoffert .M.I (2000)].Thus maximum solar energy potential depends on the efficiency of the system and cost of the system. The efficiency of the Maximum Power Point Tracking (MPPT) circuits affects the efficiency of the solar photovoltaic powered system.

This chapter aims at presenting the motivation behind the work done in this research. The characteristics and configurations of the elemental solar PV module and basic DC-DC converter-based MPPT circuits are discussed. The literature survey of previous research has been done and the recent knowledge of DC-DC converter-based MPP tracking circuits is discussed.

DC-DC converter is the most basic element used in solar PV powered conditioning system as shown in Figure1.1.

2. PModelling of Solar Cell

2.1 Modeling of PV Cell

The PV generators are neither constant current sources nor voltage sources but they are considered as current generators having dependent voltage sources. The equivalent circuit representing a solar cell can be shown by a current source in parallel with a diode [Ari, G.K. (2012)]. The output available from the PV panel (i.e. photocurrent, 'I_{ph}') is directly related to the solar insolation, that is , on the amount of light falling on it and absorbed light by it. So, during night time or when no light is available solar cell does-not produce electricity. The PV panels either have voltage or current at its output terminals. But if its connected with an external large voltage source then it could generate a current known as dark current 'I_D' or diode current. This helps in determination of the I-V characteristics of the cell.

The PV model is made more accurate and more complex by introducing the following.[Gonzalez-Longatt, F.M. (2005)]

1) Shunt resistance 'R_{sh}' which should be added in parallel to the diode and corresponding to the ground leakage current(generally neglected)

2) Series resistance 'R_s' is added to represent the losses occurring internally because of the current flow. It gives a more correct shape to the PV curve.

3) Photo current 'I_L' or 'I_{Ph}' which depends on temperature

4) Diode saturation current Io which depends upon temperature.

3. Maximum Power Point Tracking

3.1 Introduction

The major drawback of a solar cell is that its conversion efficiency is very low. Various techniques has been proposed to increase the efficiency of the PV system by matching the source and load properly known as maximum power point tracking (MPPT) [Salas, V et. Al.(2005)] Maximum possible power can be extracted by varying the source. The I-V characteristic of a photovoltaic system is generally non-linear hence making it difficult to power a certain load. Different types of converter such as boost converter, buck converter, buck boost converter are used whose duty cycle can be varied by using an MPPT algorithm.

3.2 Methods for MPPT

There are several common algorithms available in literature

1) Short Circuit Current Pulse Method
2) Open Circuit Voltage Method
3) Perturb and Observe Methods
4) Incremental Conductance Method
5) Fuzzy Logic Control MPPT
6) Neural Network based MPPT
7) Ripple Correlation Control
8) Load Current or Load Voltage Maximization
9) dP/dV or dP/dI Feedback Control
10) Constant Voltage MPPT Method

3.2.1 Short Circuit Current Pulse Method [Liu, F et. Al. (2008), Mutoh,N et. Al. (2006)]

In Short circuit current pulse method technique, the non-linear characteristic of PV system is

4. A Low Cost More Efficient Fractional Voltages Based MPPT Method

4.1 Proposed MPPT:

The implementation of the constant voltage scheme is simplest among all the available schemes. But its disadvantage is that, normally the panel is disconnected from the load momentarily to measure the open circuit voltage. The measured Voc is stored and used for calculation of the reference voltage. The main drawback of this method is that the power delivered to the load falls to zero during sampling period. Moreover, the ambient conditions may change between the different sampling intervals and the PV panel may operate at a voltage other than the MPP voltage.Both these factors contribute to a reduced energy output from the PV panel. To overcome the above mentioned disadvantages, an analog MPPT was proposed in the literature, wherein a small pilot PV panel is used to measure the open circuit voltage. The use of pilot PV panel increases the cost of the full system and moreover there are manufacturing defects between two sets of PV panel which leads to erroneous reading/generation of signals.

For standalone applications, deployment of two PV panels was not suggested as the cost of PV panel for standalone application is very high. Taking the case of standalone system on roof top of home, for which the load rating is 1000 W. The range for a 1 KW system quoted at the expo by various solutions providers is between INR 1.20 lakhs to INR 1.80 lakhs.Small solar systems of INR 45,000 which can run up to three lights, a couple of fans and a TV. Newer products in the sub INR 25,000 range and an intermediate system at INR 75,000 are soon to be announced. Hence placing an extra PV panel as pilot PV panel for calculating the value of V_{oc} is not suggested. Moreover using the readings from two PV panel will have calibration error, system error etc.

5. Summary

For a proper operation of a large electric power systems where large size PV systems network are to be incorporated. It is extremely important that efficiency of each part of SPV system should be high. So, the maximum power point tracking of a PV array should be incorporated for grid tied PV system as well as standalone system.

In this thesis modeling and simulation of a photovoltaic cell, array and MPPT has been done. A Matlab/Simulink model of the cell and array has been developed considering the effects of insolation and temperature respectively.

Moreover a new low cost, fractional voltage based MPPT algorithm has been proposed with increase in the efficiency of the PV system and thereby reduction of cost of system. Further if microcontroller based controller is implemented then it would result in increase in the efficiency of the system. The proposed model has been designed and simulated for PMDC load.

We have reviewed various types of MPPT algorithms and their characteristics have been summarized. This analysis may help the designers, researchers and engineers working in the area of photovoltaic systems in the selection of MPPT algorithm for a specific application.

Then the simulation of the MPPT model was done and we come to the solution that the efficiency of the solar array increases with the load, that is, PMDC motor with the proposed MPPT algorithm.