Intelligent Control of Photovoltaic System Using Fuzzy Logic for MPPT

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ABSTRACT

This paper suggests a method for the maximum power point tracking (MPPT) of a solar system under variable insulation conditions. A fuzzy Logic control (FLC) based MPPT technique is proposed to improve the efficiency of a standalone solar energy system. Fuzzy logic controller is applicable to a DC-DC converter device. The various design steps of fuzzy logic controller are presented along with its simulation. A fuzzy system for tracking the maximum power point of a PV system. A simulation model consists of PV panel, Buck converter, and fuzzy based MPPT developed. Maximum power can be tracking by using fuzzy logic controller has been simulated in MATLAB/Simulink.

Keywords: Fuzzy logic, photovoltaic (PV) Module, Maximum Power Point Tracking.

I. INTRODUCTION

The energy demand in the world has been increased due to growth in the industrial revolution. Fossil fuels available are gradually reducing due to the increasing population; therefore energy can be saved by usage of renewable energy sources. Renewable energy is a form of sustainable energy. Renewable energy sources available are wind energy, solar energy, etc.

By using photovoltaic system solar energy can be generated which is a most important renewable energy sources. There are several advantages in PV system such as fuel cost, clean, pollution free, little maintenance and no noise. The efficiency of the solar energy can be increased by using MPPT Technique.

In this technique the maximum power of the PV module can be extracted and it is delivered to the load. While extracting the maximum power of the PV module the temperature and insulation factors are also taken into account. The objective of this is to work is to maintain the voltage of the PV system closer to the voltage at which maximum power is produced. Because of environmental pollution, global warming PV system is mostly preferred nowadays. But the efficiency of the PV should be increase. This can be done with the help of MPPT control. Voltage and current feedback back methods and P&O technique, incremental conductance method. The proposed work deals with the intelligent fuzzy based MPPT controller to improve the efficiency by tracking the maximum power from the PV system.

II. MODELING AND CHARACTERISTICS OF PV MODULE

Equivalent circuit model of photovoltaic is a major part to analysis the operation of device and the dynamic interactions. In this paper, PV module is described using various mathematical equations and Matlab/Simulink is used to simulate the PV module.

A. Equivalent circuit of PV module

The solar panel consists of many solar cells, by connecting those solar cells in series and parallel that can form a PV module. The single diode model consists of current source, diode and two resistors. Whereas two diode model also available but not consider here. The equivalent circuit of the PV cell is shown in figure 2.1
B. Equations of PV module

From the theory of photovoltaic system, the following are the characteristic equations for a photovoltaic is given by

\[ I_D = I_0(\frac{V_D}{I_0} - 1) \]  \hspace{2cm} (1)

\[ I_{SC} - I_D = \frac{V_D}{R_p} - I_{PV} = 0 \]  \hspace{2cm} (2)

\[ V_{PVcell} = V_D - R_S I_{PV} \]  \hspace{2cm} (3)

C. Matlab/Simulink modelling of PV module

The simulation model used for the implementation of the required PV module is as shown in figure 2.1. In this paper, I described current-input PV module, it has two inputs and two outputs. The inputs are PV current \( I_{PV} \) [A] and insulation [W/m^2] and outputs are PV voltage [V] and PV output power \( P_{PV} \) [W]. This design is used for this method when the modules are connected in series, it shares the same current. Here temperature effect is not designed. The data-sheet parameters are shown as below:

1. Short-circuit current \( I_{SC} \)
2. Open-circuit voltage \( V_{OC} \)
3. Rated current \( I_{P} \) at maximum power point (MPP)
4. Rated voltage \( V_{R} \) at MPP

III. NEED FOR MAXIMUM POWER POINT TRACKING

Due to changes in extrinsic and intrinsic factors in power voltage (P-V) and nonlinear current voltage (I-V) characteristics, we can achieve maximum efficiency at anytime in PV and also reduce the cost of energy. The PV system gives maximum power, when the maximum power point is unique point. There are many factor that can be considered, where the most important one is power point tracking in PV generation. The MPPT is nonlinear control problem. This is due to the nonlinearity present in the PV or parameter variations in PV.

To overcome this problem control methods like P&O, incremental conductance, neural and fuzzy are used. These control techniques requires high cost and these are complex. MPPT are simplicity and low cost, ease of implementation quick tracking under changing conditions, and small output power fluctuation.

IV. INTELLIGENCE MPPT TECHNIQUES

The photovoltaic system operation based on the load characteristics. When the direct connection between the source and load, the operating point is not optimal and output of PV module is seldom maximum. We use adaption device to overcome those problem that are MPPT controller with a DC-DC converter between source and load.
Whenever the insulation variation arises the MPPT controller track new modified maximum power point. The proposed Matlab/Simulink model of FUZZY based maximum power point tracking controller is depicted in Fig. 2.3

Many MPPT control technique are distinguish as:
1. Voltage feedback based method by comparing the reference voltage and PV operating voltage to generate PWM.
2. Current feedback based methods is done by computing short circuit of PV as a feedback to compute optimal current(maximum Power )
3. Power based method is used to track the maximum power point with the help of voltage and current of PV system.

A.FL-Based MPPT Technique:

Intelligent based MPPT shows better performance and lesser steady state error without any overshoot for fast changing temperature and irradiance. This proposed controller has two inputs and one output. One input is error (E) and another one is change in error (CE).

The following are the error (E) and change in error (CE) equations are shown as below:
\[ e(k) = \frac{dP}{dV}(k) - \frac{dP}{dV}(k-1) \]  
(4)

\[ C_e(k) = e(k) - e(k-1) \]  
(5)

Thus e (K) implies error at Kth instant. Fuzzy inference system used is Mamdani’s and defuzzification is done by centre of gravity method, of this fuzzylogic-based MPPT as shown in Fig. 2.3. The rules are shown in below table.1

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Table.1.Rules

V. RESULTS AND DISCUSSION

Simulation of PV module is done using fuzzy logic based MPPT controller is shown in section II .In this work DC-DC buck converter is connected between the load and PV for maximum power point tracking. Here fuzzy performance the control of duty cycle for buck converter in order to transfer maximum power to load and also comparison is done between PV with fuzzy and PV without controller.

The resulting outputs of voltage and current at insolation level of 900W/m2 are given in Figs. 5.1, 5.2 respectively. The proposed method results shows various from FUZZY based MPPT method shows several advantages when compare to other conventional methods of MPPT. FUZZY based MPPT method does not consume power in perturbation for maximum power point unlike the conventional P&O method. The major benefits of the presented MPPT method is that it can easily pick the rapidly changing environmental conditions without producing intrinsic steady state oscillations near the maximum power point.

VI. CONCLUSION

From the above results it is inferred that MPP is tracked faster by using proposed MPPT method. Further it is observed that performance of the system is improved better by the implementation of FLC based MPPT
method. For non-linear system, this controller finds to be more effective than other controllers.

VII. Future work

Hardware implementation of the proposed FUZZY based MPPT controller by connecting Matlab with PV module and buck converter. An efficient MPPT controller of low cost and small size can be realized using a microcontroller and FUZZY based control scheme.

VIII. References


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