Simulation of Type 1 Fuzzy Logic MPPT Controller for PV System

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Abstract: Solar supported power system is widely used to meet the reliable power supply to the load. Efficient power can be extracted from solar photovoltaic array using different Maximum power point tracking techniques. This paper presents the implementation of Type 1 Fuzzy Logic MPPT controller. DC-DC converter is placed between PV panel and load to get the required voltage at a load side. Linguistic rule based Fuzzy algorithm is applied to control boost converter for maximum power point tracking. To modulate the DC-DC converter linguistic variables are implemented in the fuzzy logic controller. Type 1 controller is capable of tracking maximum power under varying weather conditions, great execution and good accuracy compared to conventional method. The proposed method is validated by simulation using MATLAB/SIMULINK.

Keywords: Photovoltaic, Fuzzy Logic controller, DC-DC converter, linguistic variable.

I. INTRODUCTION

Power sector is the main concern in regularly increasing power demand. It can be accomplished by the use of conventional or non-conventional energy. Photovoltaic is one of the widely available energy but due to environmental issue the power decreases. Maximum power point tracking is utilized to maintain the power. Many approaches have been developed such as Perturbation and observation (P&O), Constant voltage tracking (CV) and Incremental conductance (INC).

However the (P&O) algorithm has limitations that reduce its MPPT efficiency. One such limitation is that as the amount of sunlight decreases the Power voltage curve flattens out. This method becomes unstable with rapid change in atmospheric condition.

To overcome from this problem Type 1 Fuzzy Logic MPPT controller is used. It improves the tracking accuracy with minimum oscillations [2]-[5].

The proposed controller is simulated using Matlab/Simulink. The comparison of Fuzzy logic controller with (P&O) method is presented.

II. PROPOSED SYSTEM

The Block diagram of the system is shown in the Fig.1.Here DC-DC converter is interfaced between solar panel and load.

The Type 1 Fuzzy controller generates the PWM signal to switch of the DC-DC converter.
The mathematical expression for equivalent circuit is shown below

\[ I = I_{ph} - I_d - I_p \]  \hspace{1cm} (1)

\[ I = I_{ph} - I_0 \left[ \exp \left( \frac{V + IR}{AN} \right) - 1 \right] - \frac{V + IR}{R_p} \]  \hspace{1cm} (2)

Where \( V_T = \frac{KT}{q} \)

\( I_{ph} \) is the photo current, \( I_0 \) is diode reverse saturation current (A), \( q \) is the electron charge \((1.602 \times 10^{-19} \text{ C})\), \( K \) is the Boltzmann’s constant \((1.381 \times 10^{-23} \text{ J/K})\), \( T \) is the junction temperature in Kelvin (K), \( N \) is the ideality factor, \( R_s \) is the series resistance, \( R_p \) is the parallel resistance.

B. DC-DC Converter

Boost converter is used for stepping up the voltage. The load is connected to PV through Boost converter. Boost converter circuit is shown in Fig. 3. Output voltage is expressed as:

\[ V_0 = \frac{V_s}{1 - D} \]  \hspace{1cm} (3)

D. Type 1 Fuzzy Logic MPPT Controller

Fuzzy logic controller is widely used method which gives good accuracy compared to other Algorithm. Type 1 FLC check the PV power at each sample and calculates the change in power with respect to voltage \((dp/dv)\). If the \((dp/dv)\) is greater than zero, the FLC changes the duty cycle of the PWM to increase the voltage until the maximum power is achieved. If the \((dp/dv)\) is less than zero, the FLC changes the duty cycle of the PWM to decrease the voltage until the power reached its maximum. The block diagram of fuzzy controller is shown in Fig. 5. It consists of three modules, they are fuzzification inference, defuzzification.

C. Perturb and Observe method

P&O is an iterative method, it senses operating voltage continuously and compares the present output power with that of the previous power and resulting change in power is observed. The Fig. 4 shows the flowchart for P&O technique. As this method becomes unstable with rapid change in atmospheric conditions such as irradiance and temperature it oscillates around the maximum power point. Also, it reduces the maximum power point tracking efficiency.
where $P(k)$ is power of PV generator, error and change in error are two input variables with triangular membership function.

**E. Fuzzification**
In fuzzification, the real value is converted into fuzzy value using some membership function.

**F. Inference**
The fuzzy inference is based on the Mamdani’s method which is associated with the max-min method. There are five membership function named as NB (negative big), NS (negative small), ZE (zero), PS (positive small), PB (positive big). The rule table is designed and shown in Table 1.

**G. Defuzzification**
In defuzzification, the fuzzy value is converted back to real value. In the proposed scheme centroid method is applied to return a proper value for the variation of duty cycle ($\Delta D$). The output of fuzzy controller is given to switch of boost converter.

**TABLE I FUZZY RULE TABLE**

<table>
<thead>
<tr>
<th>E</th>
<th>NB</th>
<th>NS</th>
<th>ZE</th>
<th>PS</th>
<th>PB</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE</td>
<td>NB</td>
<td>ZE</td>
<td>PS</td>
<td>NS</td>
<td>NB</td>
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<td>ZE</td>
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</tr>
<tr>
<td>PB</td>
<td>PB</td>
<td>PS</td>
<td>NS</td>
<td>ZE</td>
<td>ZE</td>
</tr>
</tbody>
</table>

**IV. SIMULATION RESULTS**
The Electrical characteristics of 20W solar panel are shown in Table 2.

**TABLE II CHARACTERISTICS OF PANEL**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum power</td>
<td>20W</td>
</tr>
<tr>
<td>Maximum voltage</td>
<td>17.64 V</td>
</tr>
<tr>
<td>Maximum current</td>
<td>1.18 A</td>
</tr>
<tr>
<td>Open circuit voltage</td>
<td>21.64 V</td>
</tr>
<tr>
<td>Short circuit current</td>
<td>1.23 A</td>
</tr>
</tbody>
</table>

The Simulink block of Type 1 FLC system is shown in Fig. 9. The power versus voltage and current versus voltage graph is shown in Fig. 10 and Fig. 11. The comparison of Type 1 Fuzzy logic controller and perturb and observe method is simulated using MATLAB and output voltage and current is measured, and it is shown in Fig. 12 and Fig. 13.
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REFERENCES


V. CONCLUSION

The Tracking of Maximum Power Point of photo voltaic systems using fuzzy logic controller is presented here. The performance of this technique has been evaluated with Matlab/Simulink. The simulation results show that the FLC technique presents good performance and it is an excellent solution regarding the best efficiency.