Implementation of Simulink and Hardware System of MPPT by using Fuzzy Logic Control in Solar

Radhika Wasekar[1], Nilesh Chamat[2]

[1]PG Scholar, Dept. of Electrical Engineering, Ballarpur Institute of Technology, Balharshah, Maharashtra, India
[2]Assistant Professor, Dept. of Electrical Engineering, Ballarpur Institute of Technology, Balharshah, Maharashtra, India

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Abstract - The output intensity of a photovoltaic (PV) module relies upon the solar irradiance and the operating temperature; in this manner, it is important to execute maximum power point tracking controllers (MPPT) to get the maximum intensity of a PV framework paying little mind to varieties in climatic conditions. The traditional solution for MPPT controllers is the perturbation and observation (P&O) algorithm, which presents oscillation problems around the operating point; the motivation behind why improving the outcomes acquired with this calculation has become a significant objective to go after researchers. This paper introduces the structure and displaying of a fuzzy controller for tracking the maximum power point of a PV System. Matlab/Simulink (MathWorks, Natick, MA, USA) was utilized for the demonstrating of the segments of a 12V 10 W PV framework: PV module, buck converter and fuzzy controller; highlighting as main novelty the use of a mathematical model for the PV module, which, dissimilar to diode based models, just needs to figure the curve fitting parameter. A P&O controller to compare the outcomes got and the fuzzy control was planned. The simulation results demonstrated the superiority of the fuzzy controller in terms of settling time, power loss and oscillations at the operating point.

***Key Words*:** Fuzzy Logic Controller; Maximum Power Point Tracking (MPPT); Dc-Dc Converter; Photovoltaic System.

1. INTRODUCTION

In recent years, the use of photovoltaic (PV) energy has experienced significant progress as an alternative to solve energy problems in places with high solar density, which is due to pollution caused by fossil fuels and the constant decrease of prices of the PV modules. Unfortunately, the energy conversion efficiency of the PV modules is low, which reduces the cost-benefit ratio of PV systems.

The maximum power that a PV module can supply is determined by the product of the current and the voltage at the maximum power point, which depends on the operating temperature and the solar irradiance. The short-circuit current of a PV module is directly proportional to the solar irradiance, decreasing considerably as the irradiation decreases, while the open circuit voltage varies moderately due to changes in irradiation. In contrast, the voltage decreases considerably when the temperature increases, while the short circuit current increases moderately.

In summary, increases in solar irradiation produce increases in the short-circuit current, while increases in temperature decrease the open circuit voltage, which affects the output power of the PV module. This variability of the output power means that in the absence of a coupling device between the PV module and the load, the system does not operate at the maximum power point (MPP).

In contrast to MPPT controllers, traditional controllers make a direct connection of the PV modules to the batteries, which requires that the modules operate in a voltage range that is below to the voltage in maximum power point. For example, in the case of a 12 V system, the battery voltage can vary between 11 V and 15 V, but the voltage at the maximum power point is a typical value between 16 V and 17 V. Due to this situation, with the traditional controllers the energy that the PV modules can deliver is not maximized.

Taking into account the above, different researches have been carried out using traditional algorithms for the modeling and implementation of MPPT controllers [2], of which the following are highlighted: perturb and observe (P&O) [3,4], modified P&O [5,6], fractional short circuit current [7], fractional open circuit voltage [8], sliding mode control [9,10] and incremental conductance [11]. The P&O algorithm has been used traditionally, but it has been shown that this method has problems for tracking the MPP when there are sudden changes in solar irradiance [12].

Also, algorithms based on artificial intelligence techniques such as fuzzy logic [13] and neural networks have been used, as well as the implementation of optimization algorithms such as glowworm swarm, ant colony and bee colony. These algorithms are part of soft computing techniques and have the advantage of being easily implemented using embedded systems. Additionally, MPPT controllers are widely used in hybrid power systems, in which different control techniques based on neural networks, fuzzy logic and particle swarm optimization have been evaluated. In the effectiveness of these control techniques was demonstrated in order to achieve a fast and stable response for real power control and power system applications. The implementation of new control and optimization techniques that are detailed in for electrical power and energy systems can be studied in the modeling and implementation of MPPT controllers.

This paper presents the design and modeling of a fuzzy controller to track the maximum power point of a PV module, using the characteristics of fuzzy logic to represent a problem through linguistic expressions . This paper presents as a novelty the use of the mathematical model proposed in for modeling the PV module, which, unlike diode based models, only needs to calculate the curve fitting parameter.

The main objective of this work is the design, modeling and simulation of a fuzzy logic controller and a dc-dc converter for an off-grid PV system. In a second stage, the fuzzy logic controller will be implemented using the low-cost Arduino platform, taking as a reference the input variables, output, fuzzification, inference system and defuzzification evaluated during the modeling stage. The dc-dc converter will also be implemented according to the design conditions evaluated in the simulations.

2. Methodology

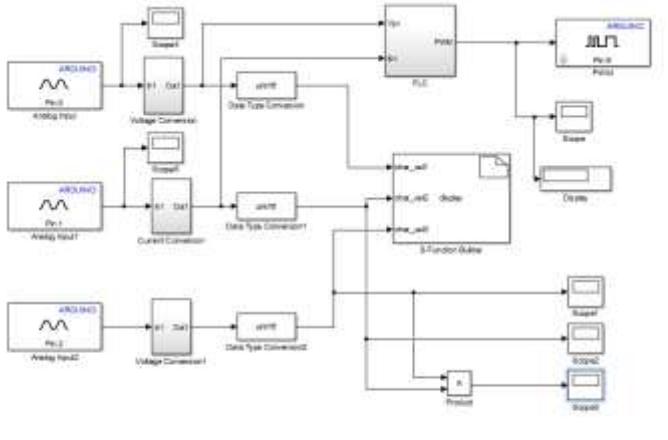

Fig-2.1: Simulink support packages of Arduino hardware with MPPT of Fuzzy Logic controller

In this process the MATLAB fuzzy file (FIS), which was created in simulation section, was converted to Arduino code in order to apply fuzzy controller on practical setup Figure. To apply the proposed fuzzy algorithm on the real MPPT, the 15A charge regulator, which is shown in Figure, was modified by removing the PWM pin of Arduino mega 2560 controller from the board of charge controller and replaced with Arduino PWM pin. In other words, the PWM pin of Arduino was connected to the pin on the board that feeds PWM signal into MPPT and log data from PV as well. Figure displays the modification process of the MPPT where there is two external wires the green for Arduino PWM pin and the black for Arduino ground pin.

2.1 Design and Modeling of PV System

Figure 2.1 shows the general diagram of the PV system, which is composed of the 65WPV module, the buck converter, the battery and the MPPT algorithm (fuzzy or P&O).

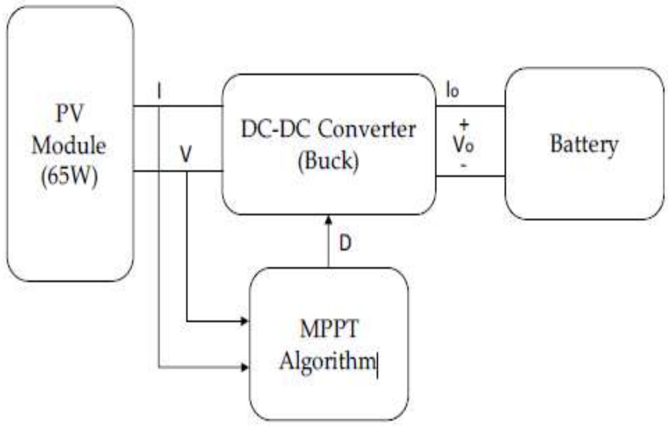

Fig-2.1.1: Block diagram of the photovoltaic (PV) system.

2.2. MPPT

This area covers the operation of "Maximum Power Point Tracking" as utilized as a part of solar electric charge controllers.

A MPPT or maximum power point tracker is an electronic DC to DC converter that improves the match between the solar based group (PV panels), and the battery bank or utility grid. Fundamentally, they change over a higher voltage DC output from solar panels down to the lower voltage anticipated that would charge batteries. There are numerous calculation for MPPT. I utilized the power under quick differing climatic conditions however it still exceptionally mainstream and basic than some other strategy.

With the goal that the state of the output is Square PWM wave. In this paper utilized this on the grounds that on the off chance that we pass this sort of flag in a low pass channel than we get sine wave which matches to the network.

Table2.1: Specification of PV Pannels

Specifications	Ratings
Open Circuit Voltage(Voc)	21.6V
Short Circuit Current (Isc)	0.63A

Maximum Power Voltage (Vmp)	17.4V
Maximum Power Current (Imp)	0.59A
Dimension	250x250x17mm

2.3. DC-DC Converter Model

A buck converter as control device was used. Figure 3 shows the circuit that was designed to ensure that the converter operates in the continuous conduction mode (CCM); in order to avoid that, the current in the inductor reaches zero during a time interval.

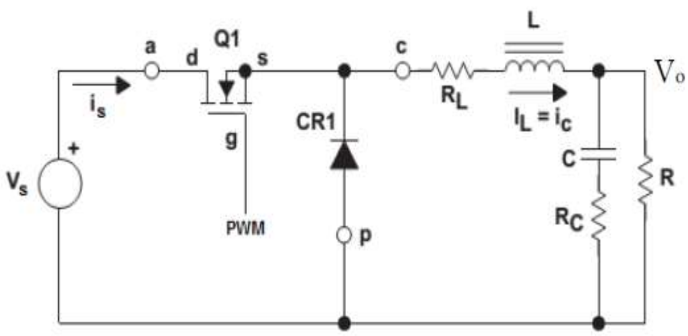

Fig-2.3.1: Buck converter circuit.

2.4 Fuzzy Controller Design

Fuzzy control is a method that allows the construction of nonlinear controllers from heuristic information that comes from the knowledge of an expert. Figure 8 shows the block diagram of a fuzzy controller. The fuzzification block is responsible for processing the input signals and assign them a fuzzy value. The set of rules allows a linguistic description of the variables to be controlled and

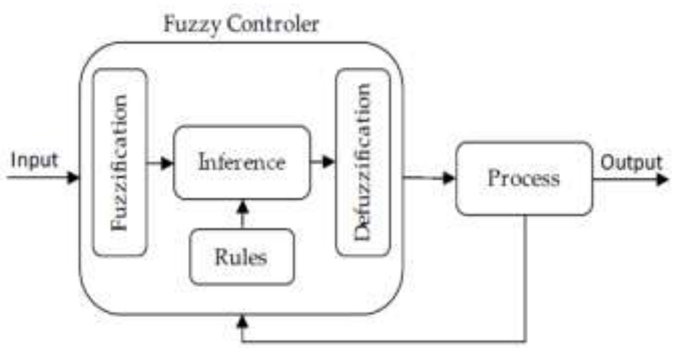

Fig-2.4.1: Block diagram for a fuzzy controller

is based on the knowledge of the process. The inference mechanism is responsible for making an interpretation of the data taking into account the rules and their membership functions. With the defuzzification block, the fuzzy information coming from the inference mechanism is converted into non-fuzzy information that is useful for the process to be controlled.

2.4.1 Fuzzification

The membership function values are assigned to the linguistic variables using seven fuzzy subset called negative big (nb), negative medium (nm), negative small (ns), zero(zr), positive small (ps),positive medium (pm),positive big (pb).Fuzzy associative memory for the proposed system. Variable e and Δe are selected as the input variables, where e is the error between the reference voltage (Vr) and actual voltage (Vo) of the system, Δe is the change in error in the sampling interval. The output variable is the reference signalfor PWM generator U. Triangular membership functions are selected for all these process. The range of each membership function is decided by the previous knowledge of the proposed scheme parameters.

2.4.2 Inference engine

Inference engine mainly consist of Fuzzy rule base and fuzzy implication sub blocks. The inputs are now fuzzified are fed to the inference engine and the rule base is then applied. The output fuzzy set are then identified using fuzzy implication method. Here we are using MIN-MAX fuzzy implication method.

2.4.3 Defuzzification

Once fuzzification is over, output fuzzy range is located. Since at this stage a non-fuzzy value of control is available a defuzzification stage is needed.Centroid defuzzification method is used for defuzzification in the proposed scheme.

3. RESULT

The performance of MPPT using the FLC techniques is verified by operating them under the variation of irradiance. The transient responses of the tracking power curves obtained from both control algorithms. As seen in the figure, the proposed response is much faster than that of the conventional MPPT while the overshoots of the system are almost the same. The energy obtained from the both controllers; clearly, the proposed controller gains more energy than the conventional P&O technique.

Fig-3.1: Interfacing of simulation and hardware system

The following figures shows the all the required characteristics of the given system:

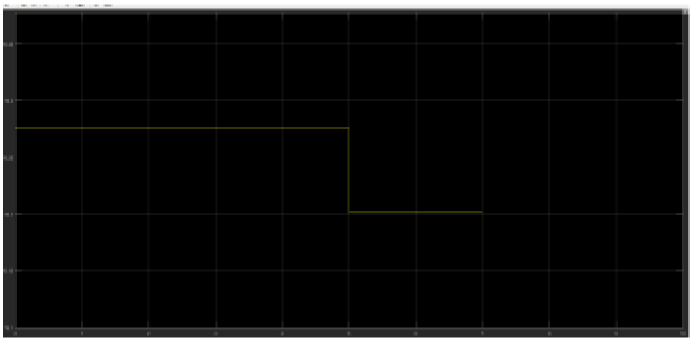

Fig-3.2: Input Current

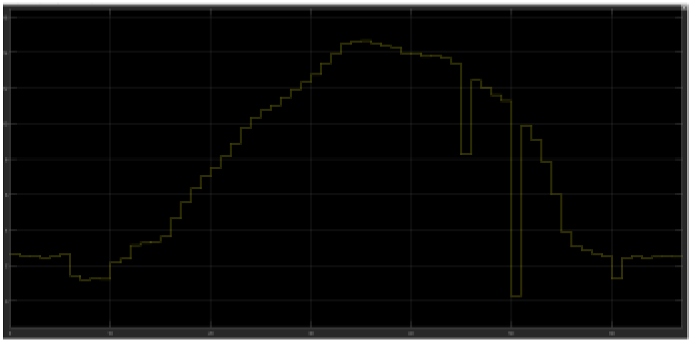

Fig-3.3: Output Current

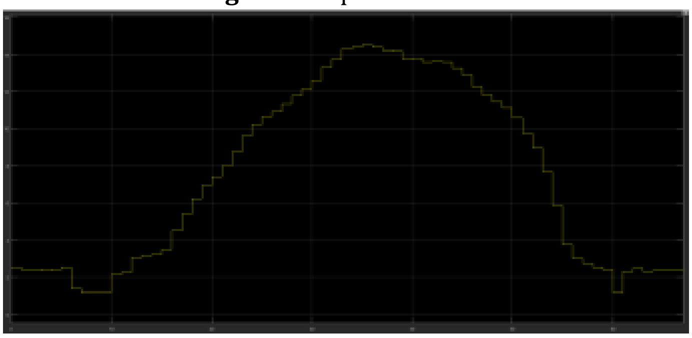

Fig.3.4: Output Power

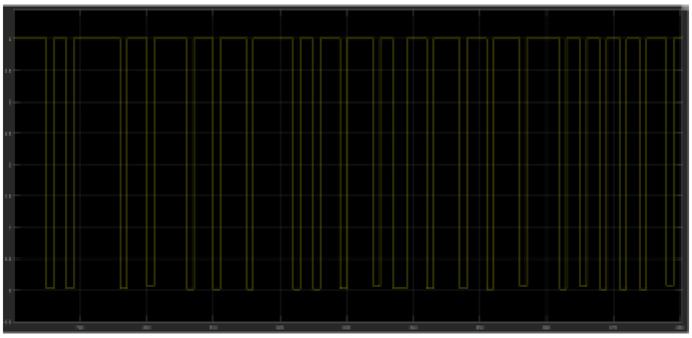

Fig-3.5: Pwm Output

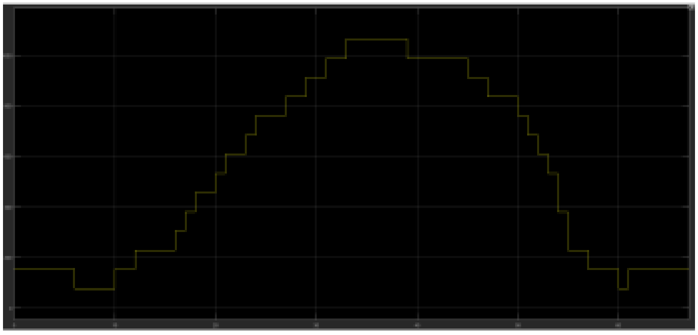

Fig3.6: Voltage And Current

4. CONCLUSION

A complete fuzzy logic based maximum power point tracker for a PV system was successfully designed and implemented. The design of the fuzzy logic controller structure and formulation of the algorithm has been presented. The power circuit is based on a buck-boost converter, while the controller used a microcomputer with a fuzzy logic control algorithm that searches for the optimum duty cycle and transfers the peak power from the solar panel to a resistive load. The system is ready to be implemented in a dedicated microcontroller and fitted to a larger installation.

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