DESIGN AND SIMULATION OF FUZZY LOGIC CONTROLLER BASED MPPT OF PV MODULE USING MATLAB SIMULINK

[1]Y SAI JYOTIRMAYI, [2]Dr. K VENKATA SUBBAIAH, [3]BHUMIREDDY RAVINDRAREDDY, [4]BATHULA SANJAY KUMAR, [5]DESHAMONI NISHANTH, [6]DURSHEETTY SAI DINESH, [7]GONDLA SAI GOUTHAM

[1]Assistant Professor, Dept. Of EEE, DRK INSTITUTE OF SCIENCE & TECHNOLOGY, Hyderabad,

[2]Professor & Principal, Dept. Of CSE, DRK INSTITUTE OF SCIENCE & TECHNOLOGY, Hyderabad,

[3]Assistant Professor & HOD, Dept. Of MECH, DRK INSTITUTE OF SCIENCE & TECHNOLOGY, Hyderabad,

[4,5,6,7]BTech Student, Dept. Of EEE, DRK INSTITUTE OF SCIENCE & TECHNOLOGY, Hyderabad

Abstract: Maximum power point tracking System (MPPT) is so important in PV systems to increase the efficiency of solar cells. So many methods are proposed to generate the maximum voltage from PV modules under different weather conditions. This paper proposed an intelligent method for maximum power point tracking using the P & O algorithm. The model contains a PV module connected to DC-to-DC boost converter. The PV System is tested under disturbance in the solar irradiation and temperature level. The simulation results show the maximum power tracker could track the maximum power accurately and successfully in all conditions tested. Comparison of various working parameters such as: tracking efficiency and response time of the system shows that the proposed method gives higher efficiency and better performance than the conventional perturbation and observation method. The voltage, current, and power of the Module can be measured through the P&O Method. The Fuzzy logic based Mppt controller is proposed in this method to increase the voltage Pv module. The proposed method used the fuzzy logic-based controlled (FLC) to initiate the control command to the output buck-boost converter as there is a change in the voltage and current across the PV panel. The modelling of the FLC-based MPPT controller is done for the PV module with the help of MATLAB/SIMULINK.

Keywords: Boost converter, MPPT, Fuzzy Logic controller.

I.   INTRODUCTION

Energy not only plays an important role in our life but also in the overall economy of the country. The requirement for energy is

increasing in our daily life due to the industrial revolution. In the most developing country like India, the large share of energy generation mainly depends upon non-renewable energy sources. The gradual depletion of these sources such as fossil fuels, oils, etc. leading the developing countries towards the un-sustainability of civilization. Along with that, the generation of energy through conventional sources is also a reason for greenhouse gases. It has become a global challenge to reduce the emission of greenhouse gasses like CO_2 and CO_3 to ensured secure, clean, and affordable energy. Whereas clean and sustainable energy is perfectly generated through renewable energy sources [1]. There are many renewable sources of energy such as solar energy, wind energy, Hydro energy, etc. The Photovoltaic (PV) system is the most efficient renewable source of energy which has taken the great attention of the researchers. Solar energy is a source of energy that is clean, Pollution free, maintenance-free, and no noise produced due to the absence of moving parts [2]. However, two important factors limit the implementation the solar energy. The cost of installation and low efficiency of energy conversion. To have control over these factors which means solar system installation cost and to increase the efficiency of the photovoltaic power

system, the maximum power point tracking system (MPPT) of photovoltaic modules is one of the most effective methods. MPPT is used to extract the maximum power of the PV module and provide it to the load to increase its efficiency [3]. There are different techniques to maximize the output power of PV modules. One of the methods is the constant voltage tracking method. This method compares the measured voltage of the PV module with a reference voltage to continuously alter the duty cycle of the DC-DC converter and hence operate the PV module at the predetermined point close to the MPPT. A very simple method is the CVT (Constant Voltage Tracking) Method. It can track the maximum power point under uncertain conditions. There is an alternate method to obtain the Maximum Power Point of the PV Module i.e. P&O (Perturbation and Observation) Method. The voltage, current, and power of the Module can be measured through the P&O Method. Then it perturbs the voltage to change the direction towards the maximum voltage. This method has a slow speed of tracking and also high oscillations around the MPPT. This paper presents a new method based MPPT controller to obtain maximum power point tracking.

II. The MPPT based Fuzzy logic controller

Renewable energy resources have a wide range of applications for the Fuzzy Logic controllers (FLC). From the last decade, the requirement of FLC has been increased due to simplicity. FLC also deals with the imprecise input, which does not need any accurate mathematical model for the controller. FLC can easily handle nonlinearity conditions for obtaining the maximum power from PV Modules. It is capable of performing in any weather condition or any change in the temperature or irradiance level.
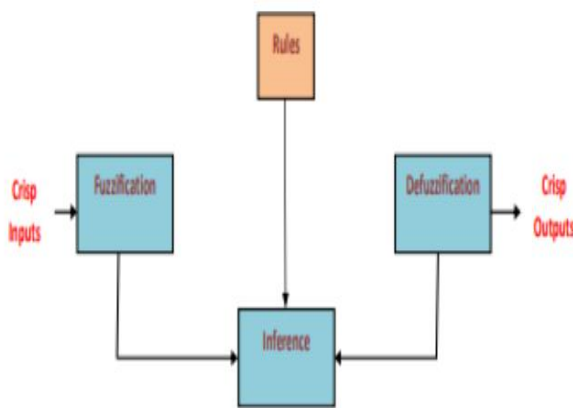

Fig.1 The Stages of Fuzzy Logic controller

Fuzzy logic controller process can be assorted into three categories:-

1. Fuzzification

2. Rule Evaluation

3. Defuzzification.

The First Category i.e. Fuzzification it takes the crisp input, for example, the change in input voltage levels. After taking the Crisp Input, it converts into fuzzy input

with the stored membership function. When the fuzzy values are designed then, the first stage of FLC i.e fuzzification takes place.

Fuzzy logic

Fuzzy logic, unlike binary logic, is considered 'gray' logic in that it describes values that are somewhere in the middle between two distinct features. In other words, fuzzy logic creates a data range by assigning two distinct values – namely, 1 (indicating a maximum degree) and 0 (indicating a minimum degree). Figure 1-2a shows varying degrees of cool air, with 70 degrees Fahrenheit being designated as the ideal of "cool air" and thus given a value of 1. Any temperature above 80 degrees Fahrenheit is therefore designated as "hot", while temperatures less than 60 degrees Fahrenheit are designated as "cold". In this way, temperatures lower than 60 and higher than 80 are considered outside the ideally "cool" range. A different way to consider this range of "cool" temperatures is shown in Figure 1-2b. In the figure, we can see that the dotted line indicates temperatures that are not cool (i.e., they are instead either cold or hot). So, a temperature of 65 degrees Fahrenheit is framed in a fuzzy logic algorithm as being "half cool and half cold" or 50% cool / 50% cold. This demarcation points to a certain range or

degree of coolness. However, temperatures less than 60 degrees Fahrenheit are designated by fuzzy logic algorithm as "cold".
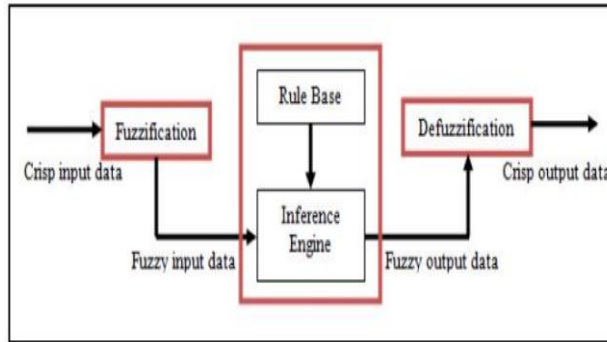

Fig. 2 An Architecture of Fuzzy Logic System

Fuzzification

Fuzzification is a process whereby clearly delineated values are made fuzzy. To accomplish fuzzification, the linguistic variables and terms to be utilized must first be defined. Numerical values are not used in this process; rather, words and/or phrases from a natural language comprise both the input and output variables. To start the process, a specific linguistic variable is broken down (i.e., decomposed) into its composite linguistic terms. Take, for instance, an air-conditioning system. In this system, temperature (T) is the linguistic variable that designates the room's temperature, which can be described (qualified) in general linguistic terms as "hot" or "cold". Working from this point, Temperature (T) = {too cold, cold, warm, hot, too hot} can then serve as the decomposition set for the linguistic variable temperature. The individual features of this decomposition are labelled as linguistic terms and represent a part of the temperature's total values. Then, in order to translate the "crisp" (i.e., non-fuzzy) input data to fuzzy linguistic terms, we can apply membership functions.

Rule Evaluation

The rule provided to the MPPT block in FLC design has divided the input variable and output variable into different levels: - NB (negative big), NS (negative small), ZE (Zero), PB (Positive big), PS (positive small). The Variables are provided to the Sampling Sequence are provide w.r.t. sampling time. While the Fuzzification process is performing it convert numerical input to the lingual variable which is based on membership function. The design of rules of MPPT is on the fact which involve the change in voltage that causes the Power to increase while designing the rules. The moving of the change is always kept in the same direction as there is an increase otherwise if decrease the next change is in the other direction. After the theoretical designing of the membership function and rules were adjusted with the errors to obtain the maximum performance.

III.   DESIGN AND SIMULATION

The fuzzy Logics controller is designed to track the maximum power point of the PV cells under changing weather conditions. Fast-changing solar radiation is taken into account while designing a fuzzy rules base. In this work, only the simulation part was presented by simulation through the Matlab program
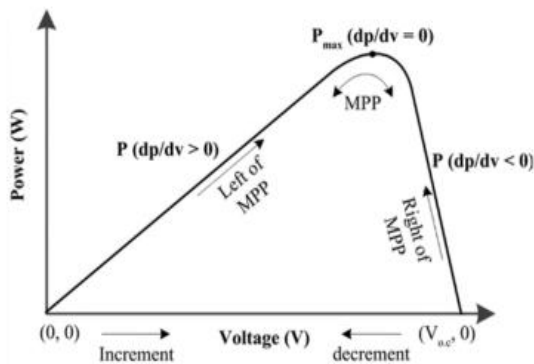

Fig.3 The concept principle of MPPT fuzzy logic controller

Five fuzzy logic levels are used for all input and output variables: NB is Negative big, NS is Negative small, ZE is Zero, PS is Positive big and, PB is Positive small. A rule base used in the fuzzy logic controller is shown in Table 1. Figure 4 shows a functional diagram of a fuzzy logic controller algorithm to track the maximum power of an MPPT solar cell.
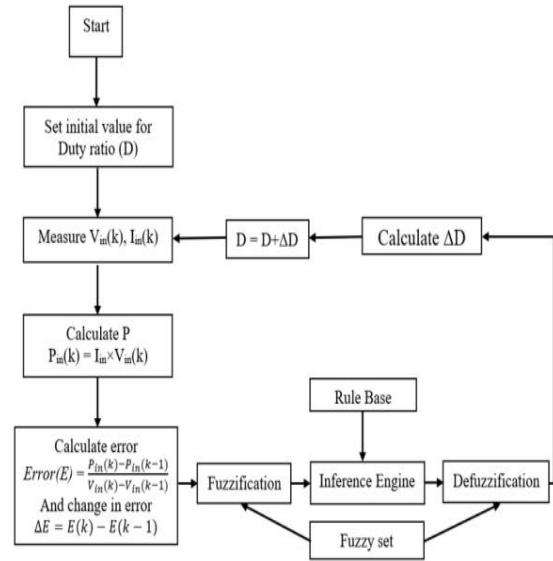

Fig.4 Flow chart of fuzzy logic controller algorithm MPPT

The inputs of the Fuzzy logic controller system are the output voltage of the PV cells (ΔV) and output power of the PV cells ΔP that change each time, which be related to the modulation signal used to the Pulse Width Modulation modulator to produce the pulses switching in DC-DC boost converter. The Proposed fuzzy logic control-based MPPT in MATLAB/Simulink is shown in Figure 5 shows the surface viewer of the Fuzzy rule.
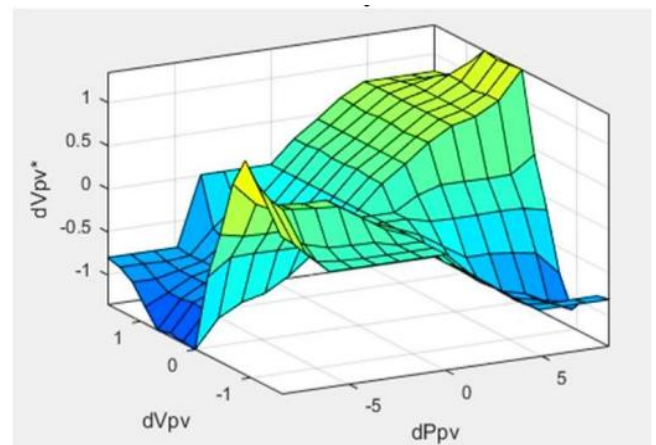
Fig.5 The surface viewer of the MPPT Fuzzy rule

IV.   CONCLUSION

The design and operation of Fuzzy Logic Bases MPPT Controller under uncertain conditions have been considered in this paper. The model is designed using Matlab/SIMULINK. Many researchers used the P&O algorithm based MPPT system to control the output of the DC-DC boost converter. In this paper, the FLC based MPPT system has been presented and then the results of the proposed model have been compared with other conventional MPPT Metho. In this article, the Maximum Power Point Tracking (MPPT) controller is a fuzzy logic control to identify MPPs. The fuzzy logic controls are presented and used in a Matlab-Simulink environment. Then the boost converter circuit increases the voltage of the PV system for the PV to produce maximum power.

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