Fuzzy Logic Controller for Designing of MPPT

Debasish Pattanaik, Sarat Chandra Swain, Ritesh Dash

Abstract*: This research paper presents Maximum PowerPoint Tracking method used in solar photovoltaic grid connected PV system under different solar radiation and temperature. As because the output of the PV panel is non- linear hence current and voltage of the solar PV panel behaves as a non-linear characteristic which ultimately depends upon environmental parameter and thereby causing change is maximum output power of the PV panel. At different environmental condition the solar photovoltaic set its MPP. In order to operate the PV system at different MPP so as to extract the maximum available power it is required to control the buck-boost converter proportional to the output level of the PV panel. In this paper fuzzy logic based MPPT has implemented whose output is fed to the boost converter for increasing the efficiency of the system. PI controller is used as a current control technique for obtaining satisfactory performance. The goal of this paper is to achieve higher efficiency from solar photovoltaic system by operating the system at its MPP. MATLAB Simulink is used to model the solar photovoltaic system. The result obtained fro the simulation can be implemented in Homer for optimizing the fuel cost

***Keywords* : MPP, current control techniques(CCT), boost converter.**

I. INTRODUCTION

Demand for clean and efficient energy is increasing day by day throughout the globe. Insufficient availability of conventional sources of energy such as coal, gas, oil leads us to think for harvesting energy from unconventional sources such as solar, wind, water etc. The idea behind this is to create a sustainable environment where the present generation can make their energy demand and thereby creating a situation where future generation can meet their demand. One of the biggest drawbacks present in the unconventional sources is that, they are intermitant in nature and thereby producing a variable output. From the electrical energy point of view it is required to produce a constant output so that it can be interconnected to the utility grid. The output of the PV panel is usually low as it depends upon the solar insolation, temperature and other environmental parameters. In order to increase the output to a sufficiently consumable level it is required to introduce some kind of power electronic device which can drive the output level upto the MPP from where maximum power can be extracted.

Revised Manuscript Received on January 30, 2020.
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In literature their are four groups of MPPT such as: Conventional MPPT, Hybrid MPPT, Power electronic modelling or DC-to-DC converter and Numerical MPPT. Most of the MPPT are designed either in speed and accuracy model or in a cost effective manner. But from the operation point of view it is required to develop a MPPT which can have all the three features as stated above. SEPIC converter can be used to achieve higher accuracy but the cost is comparatively high as compared to other types of converter available in the market. Fuzzy logic controller can be used in conjunction with the MPPT to change the firing angle of the boost converter in an efficient manner as compared to the conventional PWM converter. To provide a constant output for current and voltage PI controller is implemented. The aim behind the use of PI controller is that it is easy to implement and from economic point of view it is also feasible. The schematic diagram implementing fuzzy logic controller along with its current control topology is shown below:-

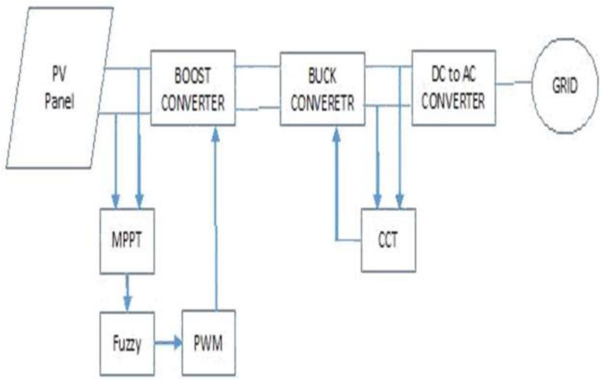

Fig 1: FLC and grid connected SPV (Solar PV)

In the above configuration two types of DC-DC converter was used such as BOOST converter for increasing the PV output to approximately 1.75 times from its present value followed by another DC-DC converter for making the DC level to grid compatible. The Boost converter is being powered by the DC voltage coming from the PV side and is controlled by fuzzy enabled MPPT. The output of the MPPT is fed to PWM generator through a FLC. Similarly the Buck converter is controlled by a PI enabled CCT. The advantages of this model over the SEPIC converter is that it does not require the detailed circuit parameters as required by a SEPIC converter. Although SEPIC converter has advantages of performing both BUCK and BOOST in a single circuit but it is very complex to design. In the present model single phase grid connected system is developed to observe the power quality of a grid connected solar PV system by using FLC.

II. DESIGNING OF SOLAR PV SYSTEM

The solar PV cell can be treated as a semi conducting device which can generate current when comes in contact in solar insolation. Though it depends upon the solar insolation level where it is partially controlled by the environment in which it is operating. The equivalent circuit of a solar cell is shown in fig 2:

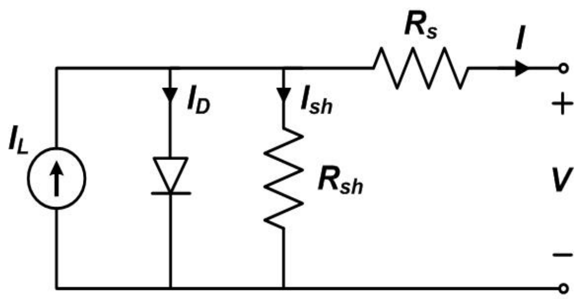

Fig 2: Equivalent circuit of solar cell

As shown in fig 2 the solar cell is presented by its equivalent current source which generates current 'I', the diode represents the internal barrier present between p and n layer of solar cell. R_{se} represents the internal series resistance at the point of inter connection of solar cell with the electrical circuits. Generally this series resistance is very small as compared to parallel resistance present in the system. This is because to deliver the maximum current from the solar cell to the output circuit and thereby developing maximum voltage at the input of output circuit

$$I_{se} = I_0 - I_d \qquad (1)$$

Where I0 represents the photo generated current and Id represents the diode current. The diode current can be written with reference to the Shockley equation as

$$I_d = I_0 [\exp\{q((V+IR_{se})/ nkT) \} - 1] \qquad (2)$$

Where, n represents diode ideality factor

, k represents the Boltzmann constant i.e, $1.38*10^{-23}$ J/K

, T represents temperature

, q represents charge of electron

The output of a solar cell is usually very less and approximately it is nearly about 1.5 W.

As the output of the solar cell is very less therefore it is required to determine the power voltage and current voltage characteristics curve from the available data sheet before design of power electronic model. In this present model TP-300WP solar module was used to obtain the desired result. Different electrical parameters of TP-300WP is shown in table -1.

Sl. No.	Paramete	Rating
1	STC Power	300 W
2	PTC Power	273.5 W
3	Peak	15.46 %
4	No. of	72
5	I	8.2 A
6	V	36.6 V
7	I	8.84 A
8	V	45.3 V
9	N	45 degree C
1	T	Poly Crystalline

Table 1 : Electrical characteristics of solar cell

PV and IV characteristics of the solar cell is shown in Fig. 3 and 4 respectively. From PV curve it can be seen that at MPP, power becomes 253 W and V_{oc} becomes 28 V. This clearly indicates that the maximum operating voltage of the solar cell becomes 28 V and power becomes 253 W.

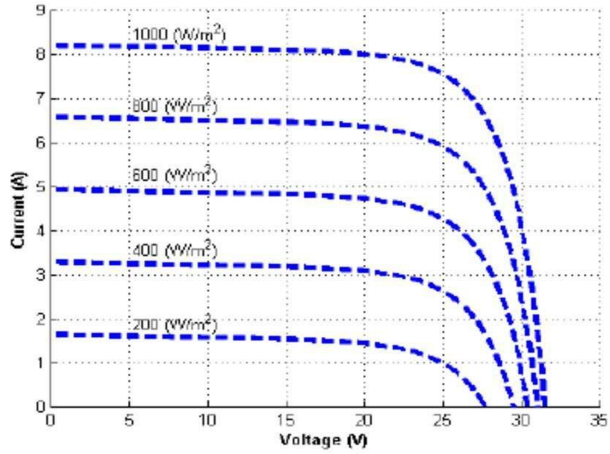

Fig:3. PV Characteristic of SPV Module

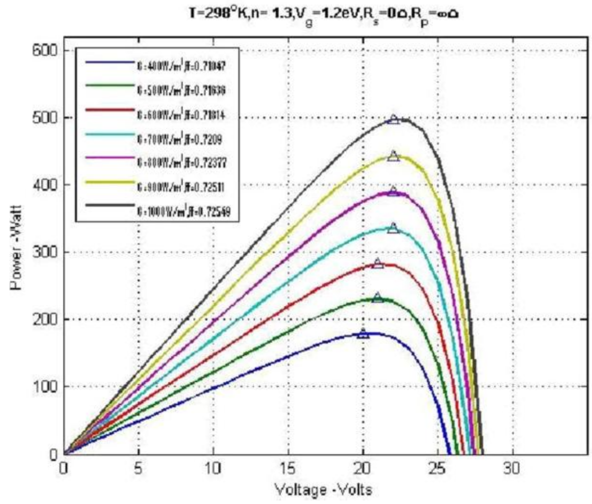

Fig:- 4. IV Characteristic of SPV Module

III. FUZZY LOGIC CONTROLLER

Fuzzy logic controller (FLC) is used in this paper to help the maximum power point tracking (MPPT) controller to find its optimal point of operation. Although fuzzy is quite difficult to implement because of its trial and error method but it can enhance the efficiency to a higher level if implemented in a proper manner. Fuzzy logic controller has three main operation: a) Fuzzification b) Analysis c) Defuzzification. Fuzzification is the process where all the input parameter are converted into membership function. A set of rules generally written in "if-then" statements is used to take a decision and finally defuzzification to convert back the crisp output into its previous form.

Input to the fuzzy logic controller (FLC) for designing a controller for MPPT does not require the knowledge about the present model of MPPT. It requires only two parameters i.e. the error (E) and the change in error(E). In order to simplify the present model then PV characteristic was considered for developing the FLC.

When P(n) - P(n-1) > 0 it represents the MPP is at higher side as compared to its previous state P(n-1). Therefore voltage need to be regulate to higher side for achieving MPP.

Retrieval Number: B7720129219/2020©BEIESP
DOI: 10.35940/ijitee.B7720.019320
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
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Similarly when P(n) - P(n-1) < 0 it represents power is maximum at the previous state and hence voltage needs to be decreased to the previous state for achieving the goal. Based on the above analysis the membership function table is shown on table 2.

	NL	NM	NS	ZE	PS	PM	PL
NL	NL	NLM	NM	NSM	NS	NS	ZE
NM	NLM	NM	NSM	NS	NS	ZE	PS
NS	NM	NSM	NS	NS	ZE	ZE	PS
ZE	NSM	NS	NSM	ZE	PS	PSM	PM
PS	NS	NSM	ZE	PSM	PS	PS	PM
PM	NS	NSM	NS	PS	PSM	PM	PM
PL	ZE	PSM	PS	PSM	PSM	PML	PL

Table 2 : Fuzzy membership function

IV. RESULT ANALYSIS

The proposed Fuzzy logic controller and its Membership function is shown in figure 5 as block diagram representation.

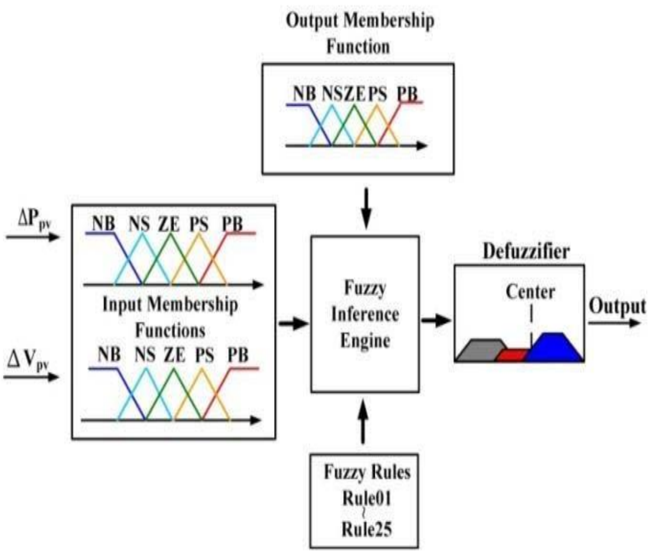

Fig:-5. Block diagram representation of Fuzzy Controller

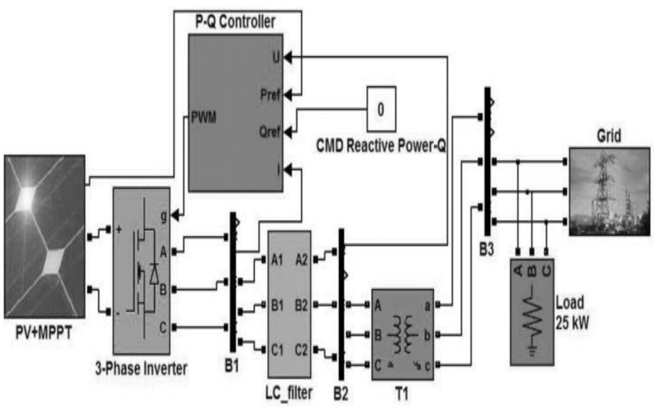

Fig:6. MATLAB simulink model of Fuzzy Logic Controller

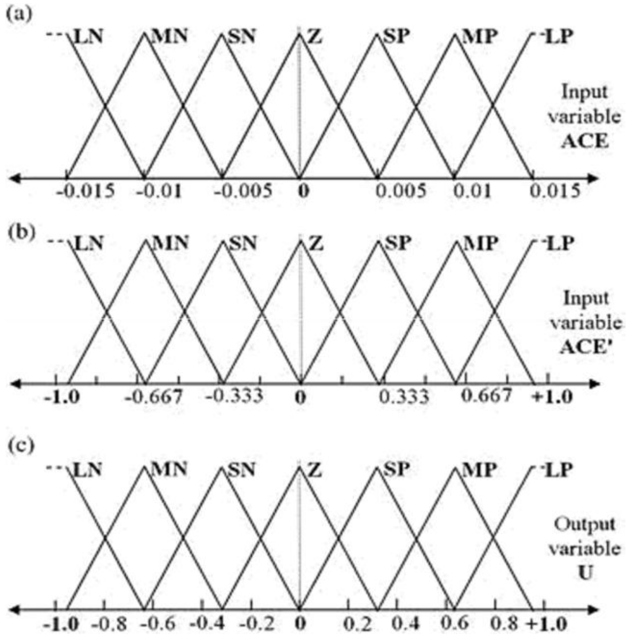

Fig:- 7. Triangular Membership Function for Fuzzy Logic

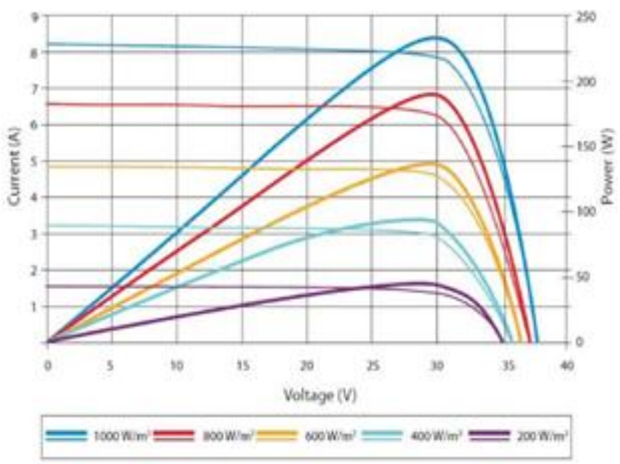

Fig-8. PV & IV Characteristic of MPPT Controller

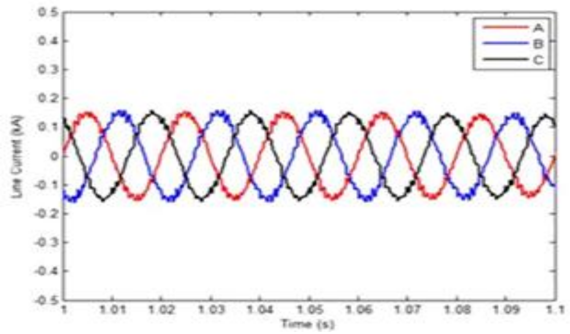

Fig:-9. Pu Three Phase Voltage & Current

Fig.8 & 9 shows the PV and system output voltage. From fig.9. it is clear that during grid synchronisation there is presence of some disturbance can be seen on the wave from. Similarly in from fig.10 A capacitive voltage of 800V is maintained at the input of the DC-DC converter for grid synchronisation

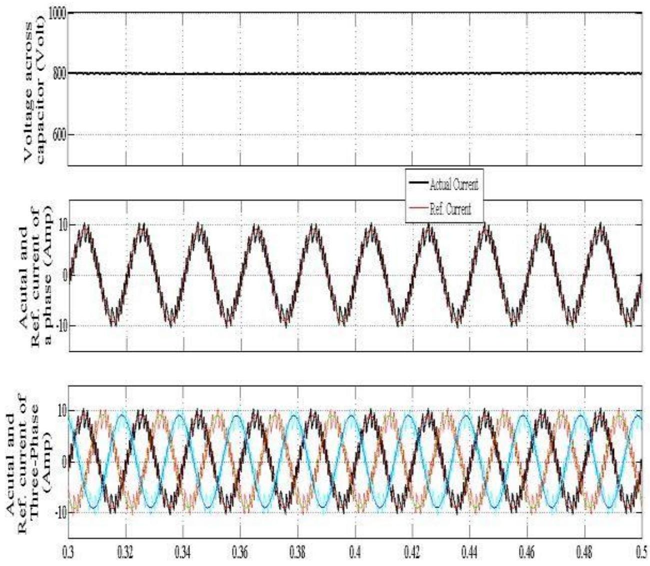

Fig:-10 Capacitor Voltage, Real Power & Reactive exchanged between system and Grid.

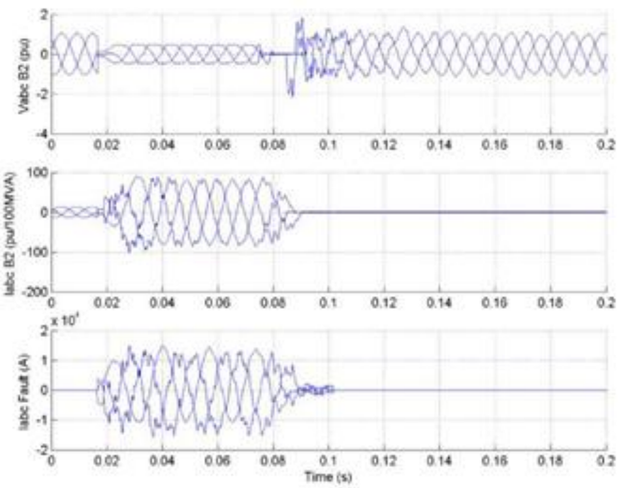

Fig:-10 Voltage performance during unbalanced condition

Sl. No.	Parameter	PI-Controller (Under Balanced Operation Condition)	Fuzzy-PI-Controller (Under Balanced Operation Condition)
1	Settling Time	0.04 Sec	0.027 Sec
2	Rise Time	0.015Sec	0.005 Sec
3	Over Shoot	21%	11%

Table3 - Performance comparison between the two controllers

Fuzzy logic controller is used to maintain a constant voltage across the capacitor or at the input side of the inverter. Performance of the fuzzy logic controller is compared with the performance of PI-controller. From the comparison it can be found that, fuzzy logic based controller maintains a constant DC voltage across the input of inverter whereas PI controller based DC source is slightly variable in nature. Table 1 shows the performance comparison between the two controllers.

V. CONCLUSION

The proposed system has been tested under different irradiance and temperature condition with fuzzy logic controller. The present investigation shows that the performance of controller has been increased from 92 % to 94.3 % with less variation. During the simulation the output voltage and current was maintained at a constant level and different power quality issues such as voltage sag, swell were not observed during grid synchronization. Total harmonic distortion was limited to 18.54 %.

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