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MPPT USING TYPE-2 FUZZY LOGIC CONTROLLER

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ABSTRACT
This paper describes a new technique in maximum power point tracking (MPPT) of PV system which is based on fuzzy type-2 controller. The proposed fuzzy type-2 controller performance is compared with MPPT of fuzzy logic controller type-1 (FLC1). The PV system consist of a PV panel, DC-DC boost converter, PLC unit simulated in matlab/Simulink. The experiment results indicates that the fuzzy type-2 controller has better improvement in providing MPPT.

Keywords: PV panel, maximum power point, boost converter, Fuzzy logic.

I. INTRODUCTION
In this paper we describe fuzzy logic control for high power point tracking in PV system. Maximum power available or MPPT is a concern of challenge if it is extracted in efficient manner. It can raises the energy demand at big levels. If the constraints of a system can be achieved precisely, then its control would be a straight forward problem and model-depend closes to PID and pole placement could be used. Meanwhile, in real industrial based system, it is the case that there exist difficulties in achieving a good model. However when the model is sufficiently perfect, there are lot of other uncertainties example like the precision of the sensors, noise generated by the sensors, environmental based conditions of the sensors, and actuators nonlinear characteristics. In these cases, model-free closes are generally used both for modelling and control purposes. The extreme useful model-free closes to use of fuzzy logic system (FLSs).This work will enhances the effect of intelligent and digital control techniques for PV system efficiency optimization. These methods resembles both physical as well as Type-2 fuzzy depend MPPT tracking methods.This work useexperimental data to consider the potential of solar energy in India and the effect of the environment on efficiency of PV systems.

II. DIFFERENT TECHNIQUES OF MPPT
MPPT algorithms are essential in PV applications since the MPP of a solar panel varies with temperature. Hence the use of MPPT algorithms is essential in order to achieve the maximum power from a solar array.Past to current time many techniques to obtain the MPP have been developed and published. These methods differ in many parameterssuch as requirement of sensors, complexity, range of effectiveness, cost, convergence speed, accurate tracking whenirradiation or change of temperature , hardware required for the implementation or famous among others.From these methods, the P&O and the incond algorithms are the most used.These methods have benefits of an easy implementation but they also have demerits, these limitations are eliminated using fuzzy logic controller.

Both P&O and INC algorithms are depend on the principle of “hill-climbing” which are made of operation point moving of the PV array in the direction of power increases.Hill-climbing include a perturbation on the duty cycle ofthe power converter and P&O a perturbation in the operating voltage of the DC link between the PV array and the power converter. In case of Hill-climbing, perturbing the duty cycle of the power converter indicates the modifying voltage of the DC link between the PV array and the power converter. Hence both names referred to the same methods.In this techniques, the last sign perturbation and the last increment in the power are used to calculate the next perturbationthe limitation of these methods are of two types. The first and important one is that they can lose track easily of the MPP if there is a rapid change of irradiation. In case if step changes they track the MPP very well since there is an instantaneous change and the curve does

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not keep on changing. As a result it is not possible for the algorithms to predict whether thepower change is due to increase in its own voltage or due to the irradiation changes.To reduce we use fuzzy logic controller. Fuzzy logic controller handleswith imprecise inputs, does not require better mathematical model and can dealnonlinearity. Microcontrollers also helps in the popularity of fuzzy logic control. The fuzzy logic contains three stages: fuzzification, inference system and defuzzification. Fuzzification the process of transforming numerical crop inputs into linguistic variables depend on the degree of membership to certain amount

III. CONVERTER AND CONTROLLER DESIGN

The power generated from a photovoltaic module based strongly on the operating voltage of the load to which it is connected, as well as to the solar radiation level and temperature of cell. If a variable load resistanceoperating point is determined by the intersection of module I-V curve and the load I-V characteristic. Figure 1 illustrates the operating characteristic of a PV module. It consists of two regions: Zone I is the current source region, and Zone II is the voltage source region. In Zone I, the internal impedance of the module is high, while in Zone II the internal impedance is low. The maximum power point P_{mp}, is located at the knee of the power curve.

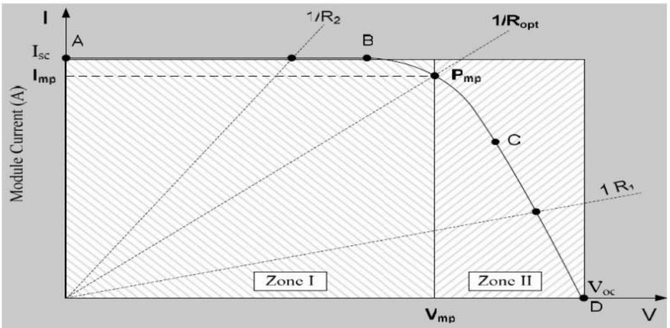

Figure 1.Behavioral curve of MPP for different converter operation

According to the maximum power transfer theory, the power delivered to the load is Maximum when the source internal impedance matches the load impedance. The load characteristic is a straight line with a slope of I /V = 1/ R. If R is small, the module operates in the region AB only and behaves like a constant current source at a value close to I_{sc}. If R is large, the module operates in the regionCD behaving like a constant voltage source, at a value almost equal to V_{oc}.Type-2 fuzzy sets were introduced in limelightby Zadeh in 1975 as an enhancement of type-1 fuzzy stets. Mendel and Karnik have discovered the concept of type-2 fuzzy sets. The conceptualbackground of interval type-2 fuzzy system and its implementing principles are explained. T2FLSs seems to be a more promising technique when compared to type-1 counterparts for controllinguncertainties like noisy data and change of environments. The causes of the measurement and identifiers are simulated to obtain a comparative analysis. It is included that the utilization of T2FLCs in real world applications which producesmeasurement noise and modeling uncertainties can be a good when compared to type-1 FLCs (T1FLCs). The type-2 FLSs are given in Figure 2. It is clear from Figure 2.An extra block (type reduction) is required in type-2 FLS design. Moreover the structure in Figure 2 provides some benefits advantages over uncertainties it also enhances the computational burden.

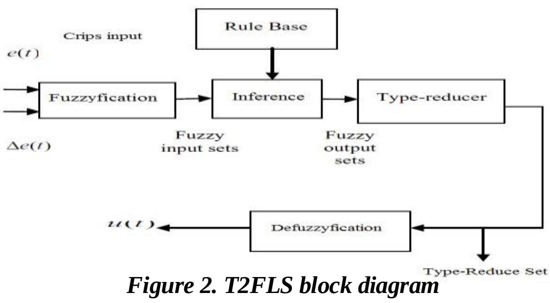

Figure 2. T2FLS block diagram

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The followings are the main blocks of a T2FLS:Fuzzifier: The fuzzifier maps crisp inputs into type-2 fuzzy sets which gives action to the inference engine. Rule base: The rules in T2FLS held the same as in T1FLS but antecedents and consequents are denoted by interval type-2 fuzzy sets. Inference: Inference block provides fuzzy inputs to fuzzy outputs by using the rules given in the rule base and the operators like union and intersection.

In type-2 fuzzy sets, *join* (⊔) and meet operators (⊓) known as new concepts in fuzzy logic conceptual theory are used despite of unionand intersectionoperators. These two new operators are extensively used in secondary membership functions.Type-reduction: The type-2 fuzzy outputs of the inference engine are deformed into type-1 fuzzy sets that are known type reducedSets. There are two common techniques for the type-reduction operation in the interval T2FLSs: One is referred as the Karnik- Mendel iteration noise in type-1 and type-2 FLCs (T2FLCs algorithm) and the other is known as Wu-Mendel uncertainty bounds method. These two techniques depend on the calculation of the centroid.Defuzzification: The type reduction block output are given to block of defuzzification.The type-reduced sets are obtained by their point of left end point and right end point, the defuzzified value is then calculated the average of all these points.

IV. SIMULATION AND EXPERIMENTAL RESULTS

By using matlab program and manually feeding the data in the program we get the simulation result for the duty cycle signal.

Figure 3- Fuzzy Membership function voltage(outer)

Figure 4. Fuzzy Membership function of current

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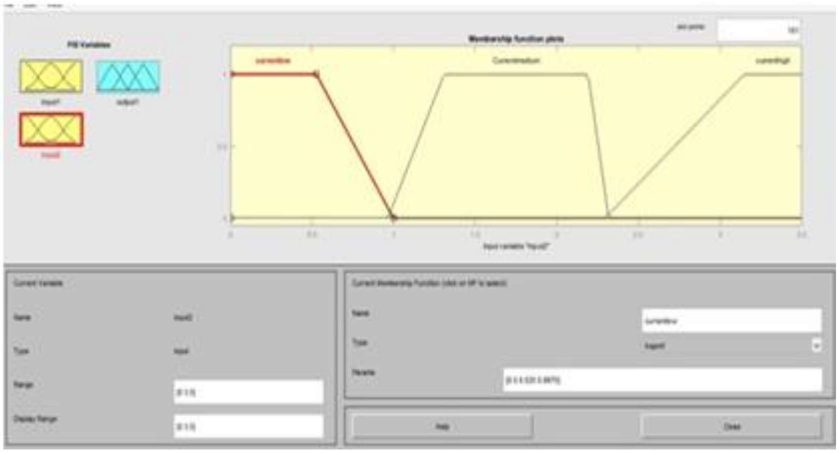

Figure 5. Fuzzy MF for duty cycle

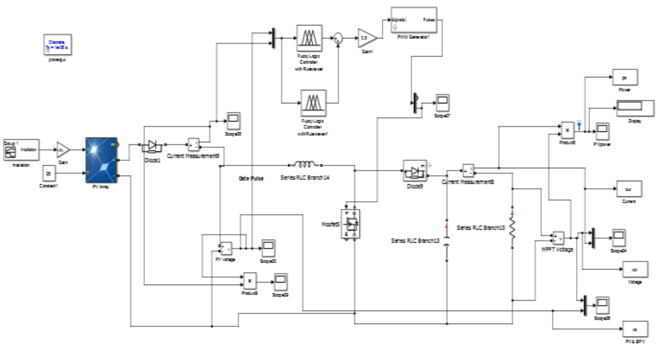

Figure 6. Simulation diagram of PV array with type 2 FLC

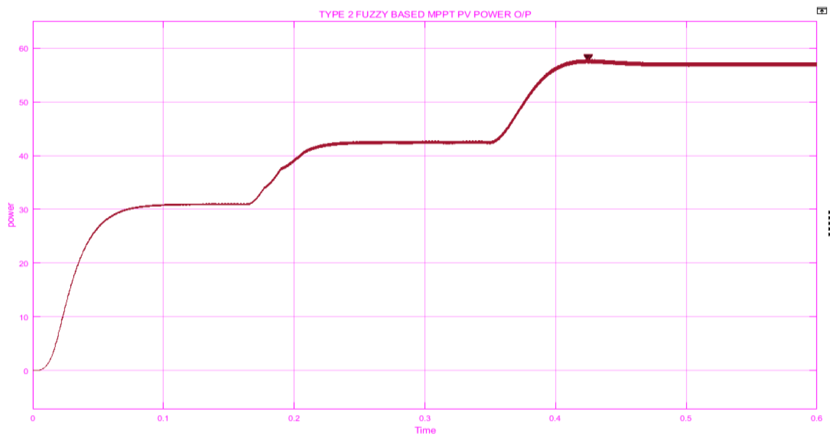

Figure 7. Type 2 Fuzzy based MPPT PV output power

From figure 8.10 maximum output power approaches to 250 w/m2 is 6.90 watt, at 500 w/m2 it is obtained as 22.95 watt, at 750 w/ m2 it is obtained as 44.25 watt and at 1000w/m2 it is obtained as 59.29 watt. From these results we determinethat type 2 fuzzy FLC depend MPPT is faster and more efficient when compared to all the methods discussed above. It gives a smooth response, less oscillation close to maximum power point improves transition handling capability.

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TABLE 8. Comparison of various techniques at various irradiance levels

Irradiance(w/m2)	P&O	INC	FUZZY (MAMDANI)	TYPE 2 FLC
1000	50.07 W	55.34 W	58.07 W	59.29 W
750	40.13 W	41.70 W	42.86 W	44.59 W
500	17.64 W	27.38 W	22.14 W	22.95 W
250	4.65 W	13.13 W	6.65 W	6.90 W

TABLE 9. Convergence time of various techniques to reach MPP under (STC)

MPPT technique	Time to reach MPP (seconds)
P&O	0.289
INC	0.268
Fuzzy (Mamdani)	0.120
TYPE 2 FLC	0.106

V. CONCLUSION

The objective of this thesis was to introduce a technique to optimize the energy extraction in a photovoltaic power system. The idea of PV module maximum power point tracking has been introduced and various methodology of addressing existing challenges are discussed. A fuzzy logic depend algorithm for tracking the maximum power is recommended in this work. In order to calculate and implement the algorithm, a system model is required. The various components and subsystems are determined, modeled, validated, and combined together to generate a complete maximum power point tracker model .Efforts have been made to get the maximum power point in less possible time. Simulation results indicates that the recommended TYPE 2 fuzzy logic algorithm has an average efficiency approaches to 99% under rapidly varying situations and in the presence of measurement noise. The results when compared to other MPPT methods it gives better performance in parameters like Oscillations about the maximum power point, speed and sensitivity to variation of parameter. This is possible due to fuzzy logic controller rules can be designed separately for the various regions of operation which indicates an effective small-signal and large-signal operation.

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