Design of Fuzzy Logic and Neural Network Controller for Solar PV System Feeding 1ϕ Induction Motor

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Abstract-- *The main objective of this paper is to perform a comparative analysis between Fuzzy Logic Controller (FLC) and Neural Network Controller (NNC) in a solar PV system which is extracting maximum power from the solar panel to supply an AC load of 1HP. Maximum power point tracking (MPPT) algorithm are required in all photovoltaic (PV) system. The incremental conductance algorithm is used to track maximum power from the solar panel. To step up the voltage available from the solar panel, the SEPIC dc – dc converter is used. The main advantage of the converter is having non-inverted output. The converter act as the interface between PV module and load. The entire system is modelled and simulated using MATLAB/Simulink 2015a software.*

Keywords-MPPT, Photovoltaic, SEPIC, Incremental conductance, Fuzzy Logic and Neural Network Controller, Induction motor.

I. INTRODUCTION

Among all renewable energy sources, solar power system attracts more attention because they provide excellent opportunity to generate electricity. Solar energy is a clean renewable resource with zero emission. Power demand is increasing day by day, so we have to switch to renewable energy sources which are eco-friendly and exist abundant in nature. The maximum power point tracking (MPPT) controller is used to improve the efficiency of the PV system. In which Perturb & Observe (P&O) and Incremental Conductance (INC) are frequently used [3]. The incremental conductance algorithm determines the gradient of the P-V curve. This method has overcome the disadvantage of the P&O method to track the peak power under fast varying atmospheric condition. The incremental conductance can determine that the MPPT has reached the maximum power point (MPP) and stop perturbing the operating point or else the relationship between dI/dV & -I/V can be used to determine the direction in which the MPPT operating point must be perturbed [2].

A dc to dc converter is needed and commonly available converters are the boost, buck, buck-boost, Cuk, SEPIC. In which the single-ended primary-inductance converter (SEPIC) is a DC/DC-converter that provides a positively regulated output and non-inverted output. Buck-boost converters are cheaper because they require only a single inductor and a capacitor. But the drawback is the high amount of input current ripple which create harmonics, in many applications, these harmonics require using a large capacitor or an LC filter. This often makes the buck-boost inefficient or expensive, and that can complicate the usage of buck-boost converters is the fact that they invert the output voltage. Cuk converters solve both of these problems by using an extra inductor and capacitor. However, both buck-boost and Cuk converter operation cause large amounts of electrical stress on the components, this can result in device overheating or failure. SEPIC converters solve both of these problems [7].

In this paper, SEPIC converter regulates the dc voltage obtained from the solar panel and feeds the single phase inverter. This single phase inverter runs the single phase Induction motor of 1HP capacity. The speed of the induction motor is used as a feedback signal from which voltage is derived and error and change in error are obtained and given to Fuzzy Logic / Neural Network controller. The generated pulses from the controller are combined with the pulses obtained from the Incremental Conductance Algorithm of a Solar panel and given to SEPIC converter and desired output voltage is produced.

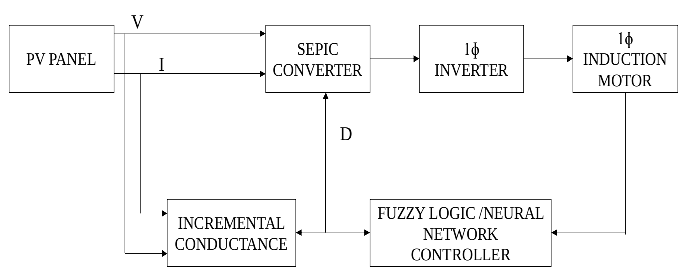


Figure 1. Block diagram of the system

II.SEPIC CONVERTER

A SEPIC (single-ended primary inductor converter) is one type of DC-DC converter. It consists of boost converter followed by a buck-boost converter. The main advantage of this converter is capable of providing a non-inverted output (i.e. the output has the same polarity as the input). Its output voltage must be greater than or less than or equal to the input voltage and it widely used in battery operated applications.

The output voltage is controlled by adjusting the duty cycle of the control switch. The control switch is typically a MOSFET, which offers much higher input impedance, low voltage drop and lower switching losses. A SEPIC converter is a fourth order converter, it means these converters have four energy storage elements they are two inductors and two capacitors, and it is used to transfer the energy from input side to output side. The input inductor L1 is together with the MOSFET control switch to be like a boost topology. Where the inductor L2 location is similar to a buck-boost topology.

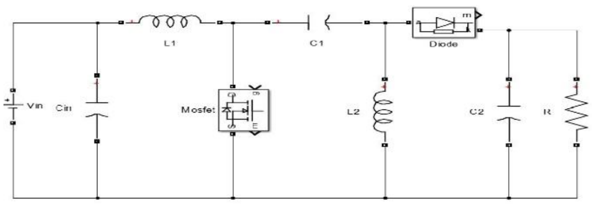


Figure 2. SEPIC operational diagram

III. INCREMENTAL CONDUCTANCE

A wide range of MPPT Algorithms is available. Of all the available algorithms, Incremental Conductance Algorithm lends itself well. The incremental Conductance method is often considered, due to its high performances such as easy implementation, high tracking speed, better efficiency and it gets easily adjustable for the changing environmental conditions thus increasing the efficiency of PV system. It is found to be the best technique and easily adaptable to the changing environmental conditions. On comparing the efficiency results obtained from Perturb & Observe (P & O) 95% and the Incremental Conductance Algorithm 98% [5].

This algorithm senses the output current and voltage of the PV array using sensors. The demerits of the P&O method to track the peak power under the fast varying atmospheric condition is overcome by INC method. The incremental conduction can determine the MPPT and if the MPP is reached it stops perturbing the operating point.

$$(dP/dV)_{MPP}=0$$
$$d(VI)/dV = 0$$
$$I(dv/dv) + v(dI/dv) = 0$$
$$I+V(dI/dV)_{MPP} = 0$$
$$(dI/dV)_{MPP} = - I/V$$

The term –I/V represents the instantaneous conductance of the PV panel and the term (dI/dV) represents incremental conductance of the PV module. This method is based on the fact that the slope of the power curve is zero at the MPP, if the slope is decreasing MPP lies on the right side and if the slope is increasing MPP lies on the left side. This can be given by,

$$(dI/dV)_{MPP} = - I/V, \text{ at the MPP}$$
$$(dI/dV)_{MPP} > - I/V, \text{ on the left}$$
$$(dI/dV)_{MPP} < - I/V, \text{ on the right}$$

The perturbation is repeated until the MPP to zero. Until a change in current is measured, the MPPT continues to operate at the same point.

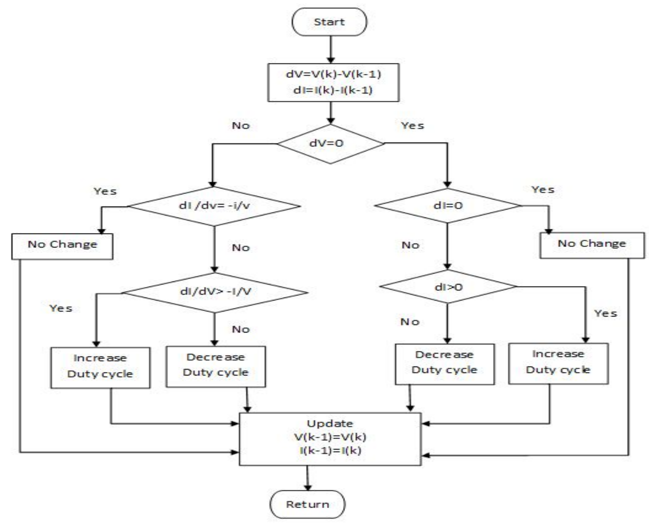


Figure 3. Flow chart for INC algorithm

IV. FUZZY LOGIC CONTROLLER

Fuzzy logic depends on the concept of fuzzy set. A fuzzy set is a set with unclear boundary. In fuzzy logic, a curve is defined in which the input space is mapped to a membership value ranging from 0 to 1 is called as a membership function [9, 10]. The input space is also referred as a universe of discourse. To keep the fuzzy values at the extrema, a standard logical operation is used. The logical operations used are AND, OR and NOT. If then statement rules are used to formulate the conditional statements [11]. The process involved in the fuzzy logic controller are

1. Fuzzification: During fuzzification, all fuzzy statements are resolved into a degree of membership between 0 to 1.

2. Rule base: To shape the fuzzy output, the degree of support is used. Basically, one rue alone will not be so effective [12]. Each and every rule delivers fuzzy set as output. In this paper, Mamdani base fuzzy inference system is used.

3. Defuzzification: After defuzzification, crisp numerical output values are obtained. For this centre of gravity, method is employed.

Table 1. Fuzzy Logic Rule Table

ce / e	**NB**	**NM**	**NS**	**ZE**	**PS**	**PM**	**PB**
NS	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NB	NB	NB	NM	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

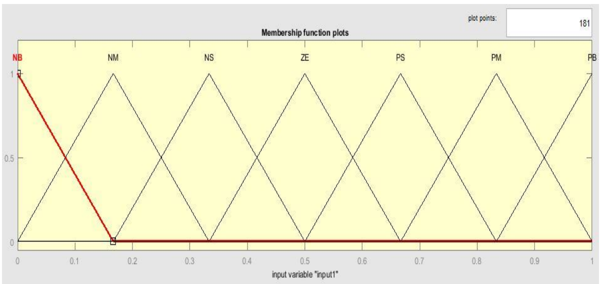


Figure 4. Fuzzy Logic Input 1

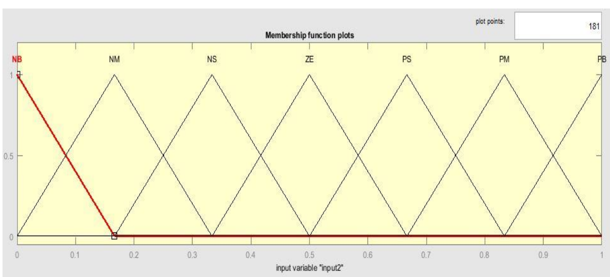


Figure 5. Fuzzy Logic Input 2

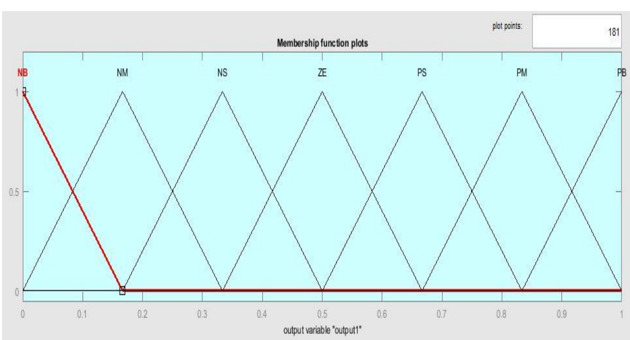


Figure 6. Fuzzy Logic Output

V. NEURAL NETWORK CONTROLLER

A neural network is a mathematical model inspired by biological neural networks [13, 14]. A neural network consists of an interconnected group of artificial neurones, and it processes information using a connectionist approach to computation. Basically, the neural network has three layers namely input layer, the output layer and hidden layer. The hidden layer may or may not be present depending on the application used. This neural network for speed control of induction motor has two layers namely input layer and output layer [15]. The change in voltage or error voltage is fed as input to the neural network and the input is processed and the suitable value for the pulse generation of SEPIC converter is produced.

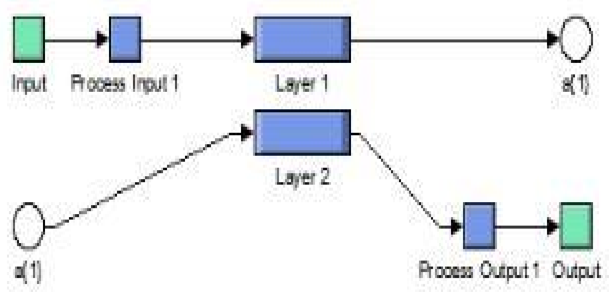
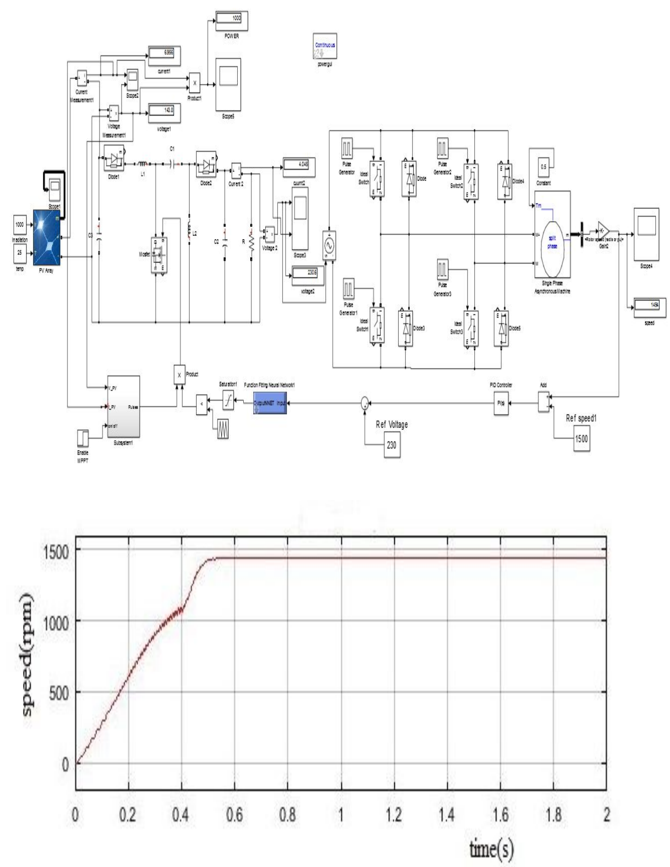


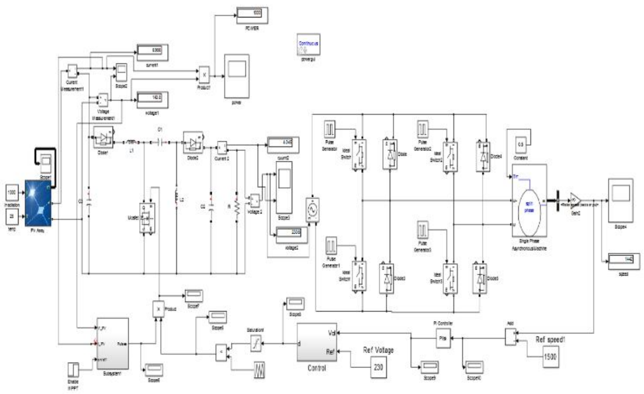
Figure 7. Neural Network Model

VI. SIMULATION CIRCUIT & RESULT

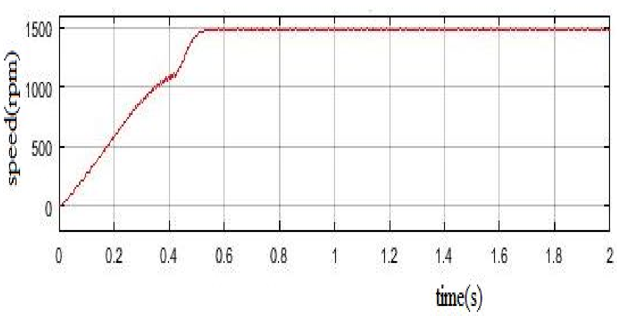


(b)

Figure 8. (a) Modelling of circuit with neural network controller (b) Speed of the motor for neural network controller



(a).



(b)

Figure 9. (a) Modelling of circuit for fuzzy logic controller (b) Speed of the motor for fuzzy logic controller

Comparison of Output Parameter for Fuzzy Logic and Neural Network Controller

Parameter	**Without controller**	**Fuzzy Logic Controller**	**Neural Network controller**
Speed(rpm)	1330	1442	1494

VII. CONCLUSION

This paper highlights the design of fuzzy logic controller and the neural network controller for the speed control of single induction motor of the rated capacity of 1HP which is driven by solar energy system. The voltage and current obtained from the solar panel is regulated by SEPIC converter which feeds the single phase inverter and that drives the induction motor. The simulation for the fuzzy logic controller and neural network controller separately has been carried out. From simulation results obtained, it is observed that Neural Network controller performs better than the Fuzzy Logic controller for the speed control of induction motor.

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