# A Fuzzy Algorithm Based MPPT Control for SEPIC Converter with Sliding Mode Control

D Vel murugan[1] | Arun P Babu[2] | Sandeep Prasanth S[3] | Thiyagaraja perumal[4] | A Dineshkumar[5]

[1] (*Research Scholar, Department of Electrical and Electronics Engineering, INFO institute of engineering, Coimbatore)*
[2,3,4,5] *(UG student, Department of Electrical and Electronics Engineering, INFO institute of engineering, Coimbatore, velmurugan004@gmail.com)*

***Abstract*** - This work proposes a fuzzy algorithm based on both the Voltage-current characteristic of a photovoltaic (PV) panel and the sliding-mode control of the input inductor current of an associated converter is investigated in a static application. A single ended primary inductance converter (SEPIC) converter charging a battery from a PV generator illustrates the procedure whose effectiveness is proved with experimental results. To Design and develop a simulation and hardware implementation of intelligent control based maximum power point tracking using SEPIC converter. Voltage from PV is insufficient for the grid system, so the DC-DC boost converter is required for the design to step-up and regulates the PV voltage controlled using fuzzy logic controller. The fuzzy logic controller works towards minimizing the error between Vref and the measured voltage by varying the duty cycle through the switch. A maximum power point tracker (MPPT) is used for extracting the maximum power from the solar PV module and transferring that power to the load. The proposed system is simulated under MATLAB environment using Simulink.

***Keywords —*** DC-DC Converter, SEPIC Converter, MPPT, Photo Voltaic Systems, Fuzzy Logic, Boost Converter, Buck Converter

## I. INTRODUCTION

Developed countries are trying to reduce their green house gas emissions so photovoltaic(PV) power generation has an important role to play due to the fact that it is a green source. The only emissions associated with PV power generation are those from the production of its components. After their installation they generate electricity from the solar irradiation without emitting greenhouse gases. Also they can be installed in places with no other use, such as roofs and deserts, or they can produce electricity for remote locations, where there is no electricity network [1]. The efficiency of a PV Array is affected mainly by three factors the efficiency of the PV panel, the efficiency of the inverter and the efficiency of the maximum power point tracking(MPPT) algorithm [4]. The maximum power point tracking (MPPT) is one of the most important features of a system that process the energy produced by a photovoltaic generator must hold.

It is necessary, in fact, to design a controller that is able to set the value of voltage or current of the generator and always ensure the working within its maximum power point. This point can considerably change its position during the day, essentially due to exogenous variations, then sunshine and temperature. The fuzzy logic algorithms are suggested to succeed in the MPP tracking under conditions of changing irradiance.

The DC/DC converter is responsible for transferring maximum power from the solar PV module to the load. The simplest way of implementing an MPPT is to operate a PV array under constant voltage and power reference to modify the duty cycle of the DC-DC converter [2]. In all these cases ,the local converters are conventional structures, the transformer-less SEPIC being the most simple non inverting voltage step-up/step-down converter which employs a simple control signal [3]. However, both Cuk and buck-boost converter operation cause large amounts of electrical stress on the components, this can result in device failure or overheating. SEPIC converters solve both of these problems [2]. Each SEPIC can operate like the cuk converter as a voltage step-up or step-down structure but unlike this one it does not result in a sign inversion at the output voltage.

## II.PROPOSED CONVERTER OPERATION

Fig 1.1 Shows the Block Diagram for Proposed Converter. The proposed system consists of SEPIC converter, BI-Directional Converter, Voltage Source Inverter. Modes of operation of Converter Can be explained as follows.

Mode 1:

Supply from PV panel is directly connected to the load. in this mode about 12V from panel is supplied to the load through SEPIC converter ,VSI and step up transformer. Here SEPIC converter increases the 12V supply to 24V,which is then fed to VSI to covert dc to ac. the output from VSI is stepped up and fed to load.

Mode 2:

External battery is connected to the load. During mode 1 s1 of bidirectional converter is on and charging of battery takes place from surplus power from PV panel switch s2 of bidirectional converter is on during mode 2 hence connecting battery to load.

BLOCK DIAGRAM:

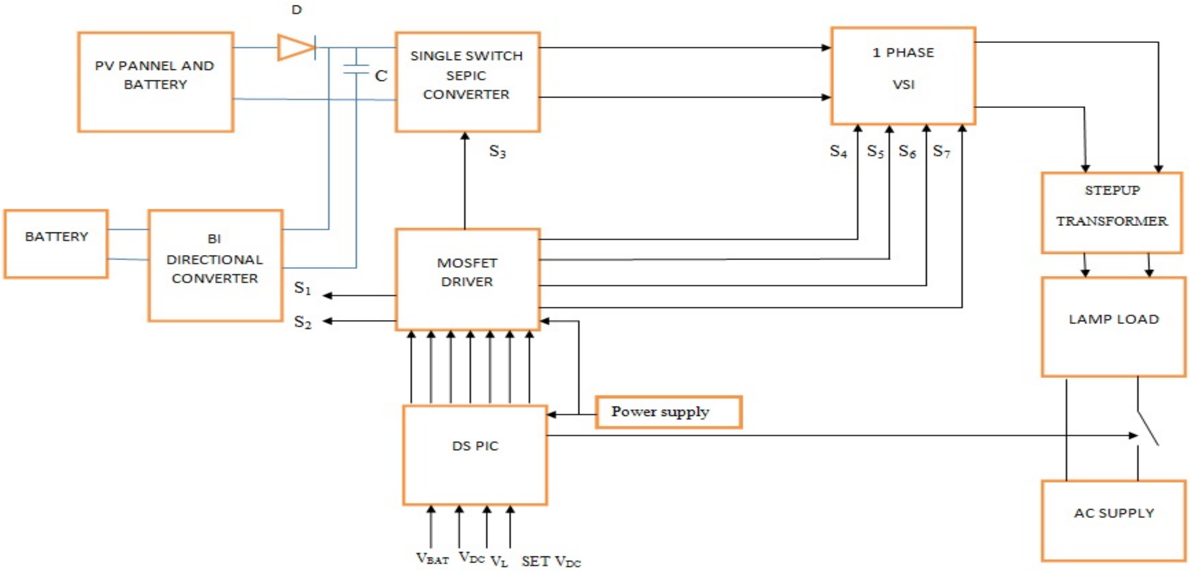


Fig1.1 Block Diagram for Proposed Converter

Mode 3:

Operation takes place when charge of battery falls below 10% and supply is not available from pv panel ,in this mode ac supply is directly connected to the load.

III. MATHATICAL MODELLING

PHOTOVOLTAIC ARRAY

The power that one module can produce is seldom enough to meet requirements of a grid, so the modules are linked together to form an array. Most PV arrays use an inverter to convert the DC power produced by the modules into alternating current that can be used for grid application. The modules in a PV array are usually first connected in series to obtain the desired voltage; the individual strings are then connected in parallel to allow the system to produce more current. Solar arrays are typically measured under STC (standard test conditions) or PTC (PVUSA test conditions), in watts, kilowatts, or even megawatts.

Costs of production have been reduced in recent years for more widespread use through production and technological advances. One source claims the cost in February 2006 ranged $3–10/watt while a similar size is said to have cost $8–10/watt in February 1996, depending on type. For example, crystal silicon solar cells have largely been replaced by less expensive multi crystalline silicon solar cells, and thin film silicon solar cells have also been developed recently at lower costs of production.

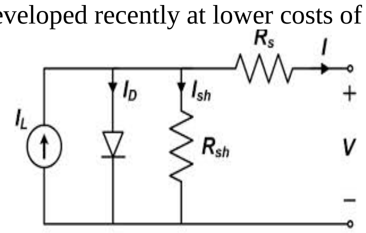


Figure 1.2 Simplified-equivalent circuit of photovoltaic cell.

Although they are reduced in energy conversion efficiency from single crystalline "siwafers", they are also much easier to produce at comparably lower costs.PV arrays are built up with combined series/parallel combinations of PV solar cells, which are usually represented by a simplified equivalent circuit model such as shown in Figure. 1.2

The PV cell output voltage is a function of the photocurrent that mainly determined by load current depending on the solar irradiation level during the operation.

$$V_C = \frac{AKT_C}{e}\ln\left(\frac{I_{ph}+I_O-I_C}{I_O}\right) \qquad (1)$$

Where the symbols are defined as follows:

A:Diode ideality factor

e: electron charge (1.602 × 10-19 C).

k: Boltzmann constant (1.38 × 10-23 J/oK).

Ic: cell output current, A.

Iph: photocurrent, function of irradiation level and junction temperature (5 A).

Io: reverse saturation current of diode (0.0002 A).

Rs: series resistance of cell (0.001 Ω).

Tc: reference cell operating temperature (20 °C).

Vc: cell output voltage, V

IV. CONVERTER TOPOLOGY

SEPIC CONVERTER:

Single-ended primary-inductor converter (SEPIC) is a type of DC-DC converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input; the output of the SEPIC is controlled by the duty cycle of the control transistor. It consist of two air core inductor supported by a driver circuit IRF840. It has filtering components that reduces harmonics. The SEPIC used is a single switch SEPIC converter. The SEPIC converter is have advantages Compared to overcome the existing system.

MODEL OF THE CONVERTER

The model of the converter is derived to be:

$$\boldsymbol{L_1 \frac{di_1}{dt} = -(1-u)(v_1 - v_2) + E} \text{.......... (2)}$$

$$\boldsymbol{C_1 \frac{dv_1}{dt} = (1-u)i_1 - ui_2} \text{..................... (3)}$$

$$\boldsymbol{L_2 \frac{di_2}{dt} = uv_1 - (1-u)v_2} \text{.................... (4)}$$

$$\boldsymbol{C_2 \frac{dv_2}{dt} = (1-u)(i_1 + i_2) - \frac{v_2}{R}} \text{........... (5)}$$

where υ1 and i1 are, respectively, the voltage across capacitor C1 and the current through the inductor L1, υ2 and i2 are, respectively, the voltage across the capacitor C2 and the load R, and the inductor current L2. The source voltage E is constant. The control input u is the switch position function taking values in {0, 1}.

## V. INVERTER SWITCH MODEL

The voltage and current rating of the switching devices is completely based on the power rating across the MSC and LSC. In order to choose the correct rating of the switching devices, the following modeling is performed.

Active power flow of the machine side ($P_{sw}$) and load side system ($P_{sh}$) is considered as 40 $kW$ and 70 kW respectively. The reactive power flow ($Q_{sw}$) in MSC and LSC depends on magnetization inductance ($L_m$=0.0397), frequency ($f = 50\ Hz$) and maximum line voltage of MSC/LSC, ($V_{msc} = 415\ V$) which is formulated using the following equation.

$$Q_{sw} = V_{msc}^2 / 2\pi f L_m \text{kVar} \text{..........................(6)}$$

Thus, the VA rating is obtained from square root of the active and reactive power flow.

$$VA_{msc} = \sqrt{P_{sw}^2 + Q_{sw}^2} \text{.......................(7)}$$

Thus, based on the VA rating and MSC line voltage, the current flow of the MSC can be obtained based on the following formulations.

$$I_{sw} = VA_{msc} / (\sqrt{3} * V_{msc}) \text{..................................(8)}$$

Now, the rating of the switching devices (MOSFET/IGBT) can be chosen with the 25% margin of the attained voltage and current rating. The same procedure can be followed for the selection of rating of Load Side converter (LSC).

SIMULATION ENVIRONMENT

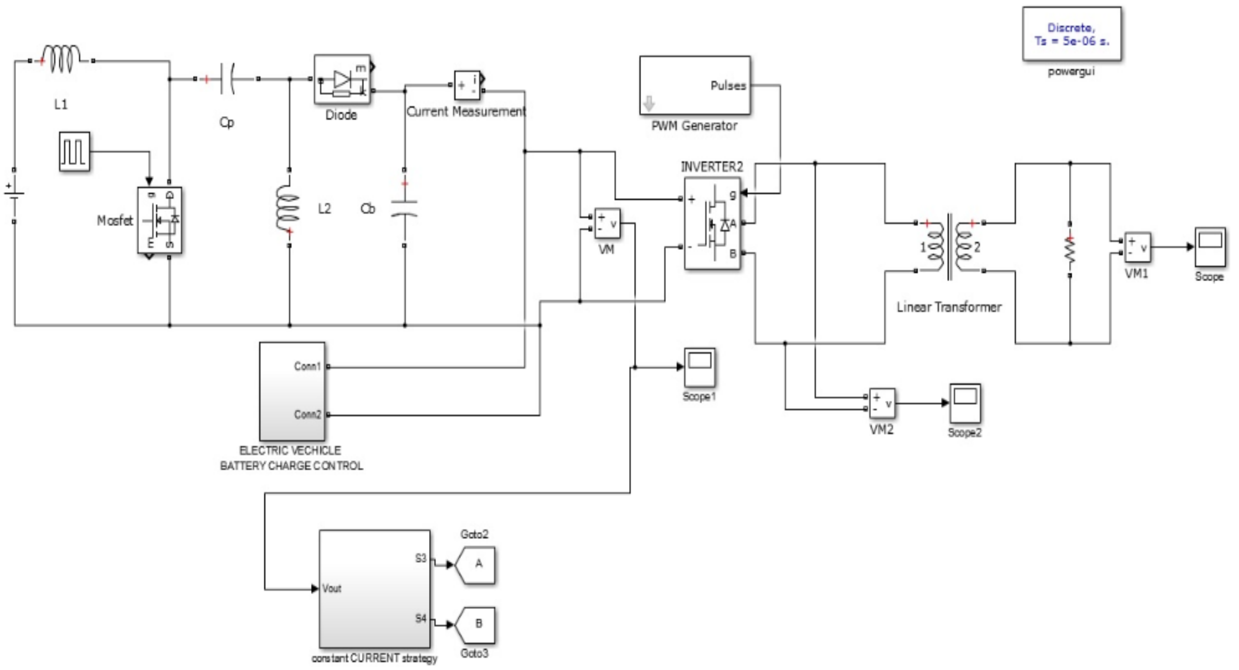


Fig.1.4 Circuit Diagram for Proposed Converter with Simulation

## VI.SIMULATON RESULTS

Fig.1.4 shows the Circuit Diagram for Proposed Converter with Simulation. In this existing Method Boost Converter based MPPT Control technique used to convert the maximum voltage. MPPT Technique is used to observe the more energy for the renewable energy. In this existing system only they are considered $v_{ref,}$, $I_{ref}$ for the maximum voltages to be obtained from Perturb and observe method can be used. The existing system efficiency is less. So we have to improve the efficiency of the converter design the A Fuzzy algorithm based MPPT control for SEPIC converter with sliding mode control. The proposed converter consists of Fuzzy logic, SEPIC Converter and MPPT technique is used. SEPIC converter is containing both BOOST & BUCK converter. It Perform both operation. In this proposed converter input voltage is given to SEPIC converter. SEPIC converter converts the 24 Voltage into lower value. Fig 1.5 shows the diagram for output of the SEPIC converter. The input applied 12V of the converter and the SEPIC converter converts the voltage into 24V.

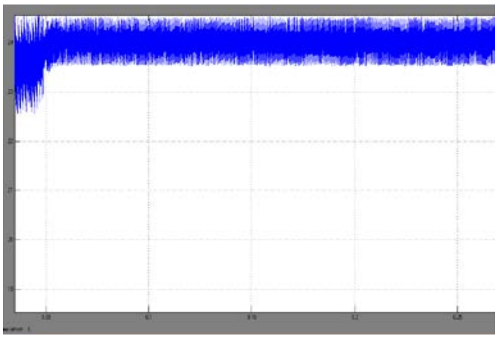

Fig.1.5.Output of SEPIC converter

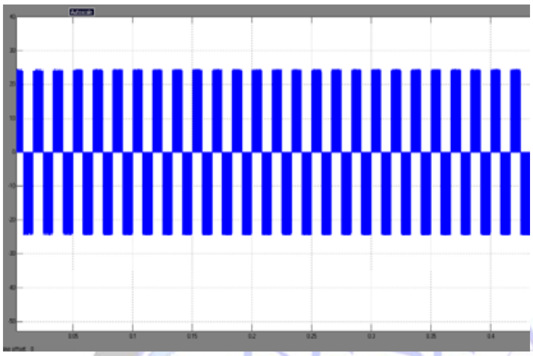

Fig.1.6 Output of voltage source inverter

Fig.1.6. shows the Output of voltage source inverter. The proposed converter 24V is given to Voltage Source Inverter. Voltage Source Inverter Converts the DC voltage into ACVoltage.

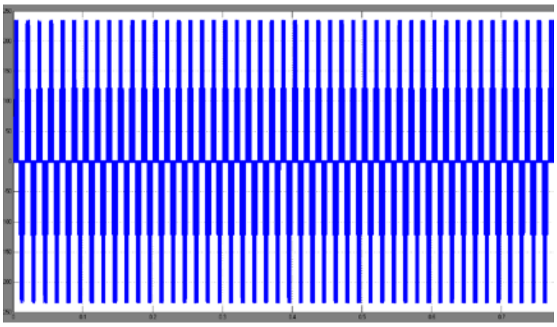

Fig.1.7.Output of step up transformer

Fig 1.7 shows the Output of step up transformer the AC voltage is given to Step up Transformer. The voltage is converted into low to high. The results of the voltage are given to load. The SEPIC Converter output voltage is controlled by Fuzzy logic with sliding mode control.

VII.CONCLUSIONS

The following fuzzy controller with satisfaction at the sharp variations of temperature and illumination and a fast response time and less than that of conventional algorithms (P & O and INC). This eliminates the fluctuations in the power, voltage and duty ratio in steady state. The controllers by fuzzy logic can provide an order more effective than the traditional controllers for the nonlinear systems, because there is more flexibility. A fast and steady fuzzy logic MPPT controller was obtained. It makes it possible indeed to find the point of maximum power in a shorter time runs.

REFERENCES


**[1].** Safari A., Mekhilef S, (2011) “simulation and hardware implementation of incremental conductance MPPT with direct control method using cuk converter,” IEEE Trans. Ind. Electron., vol. 55, no. 7.

[2]. Liu.l, S. Duan, F. Liu, B. Liu, and Y. Kang,(2008) “A variable step size INC MPPT method for PV systems,” IEEE Trans. Ind. Electron., vol. 55.

[3]. González-Longatt F. M.(2008), “Model of photovoltaic module in Matlab,” in 2do congresoiberoamericano de estudiantes de ingenierıacute; aeléctrica,electrónica y computación, ii cibelec.

[4]. Esram.T and Chapman P. L.(2007), “Comparison of photovoltaic array maximum power point tracking techniques,” IEEE Trans. Energy Convers., vol. 22, no. 2, pp. 439–449..

[5]. Salas.V, Olias.E, Barrado.A, and Lazaro.A.(2006), “Review of the maximum power point tracking algorithms for stand-alone photovoltaic systems,”Sol. Energy Mater. Sol. Cells, vol. 90, no. 11, pp. 1555–1578.

[6]. Petrone. G, Spagnuolo.G, and Vitelli M,(2008). “Reliability issues in photovoltaic power processing systems,” IEEETrans. Ind. Electron., vol. 55, no. 7, pp. 2569–2580.

[7]. Salem.F, Adel Moteleb M. S, and Dorrah H. T,(2005). “An enhanced fuzzy-PI controller applied to the MPPT problem,” J. Sci. Eng., vol. 8, no. 2, pp. 147–153.

[8]. Fortunato. M., Spagnuolo.A, and Vitelli.V,(2008) .“Maximum power point tracking in a one-cycle-controlled single-stage photovoltaic inverter,” IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2684–2693.

[9]. Kim.I.S, Kim.M.B, and Youn.M.J,(2006). “New maximum power point tracker using sliding-mode observer for estimation of solar array current in the grid-connected photovoltaic system,” IEEE Trans. Ind. Electron., vol. 53, no. 4.

[10]. Xiao.W, Lind.M.G.J, Dunford.W.G, and Capel.A,(2006) .“Real-time identification of optimal operating points in photovoltaic power systems,” IEEETrans. Ind. Electron., vol. 53, no. 4, pp. 1017–1026.