



# Hybrid Energy Storage Control Strategy for Stabilizing Wind-Photovoltaic Hybrid Power Generation

C.Kumaresan, Dr.V.Dhinesh.M.E.,PH.D.,

Department of Power Electronics and Drives, AVS Engineering College, Military Road, Ammapet, Salem, Tamil Nadu, India

Department of Electrical and Electronics Engineering, AVS Engineering College, Military Road, Ammapet, Salem, Tamil Nadu, India

**ABSTRACT:** Solar photovoltaic system performance depends on environmental conditions. Solar photovoltaic panel is a power source having nonlinear internal resistance. To extract maximum power from the panel, the load resistance should be equal to the internal resistance of the panel. For three-level boost converter, both capacitor voltages need to be sensed and an additional voltage balancing control loop is required to balance the capacitor voltages. In the proposed work, the optimization technique used for MPPT control is based on fuzzy logic and the voltage balancing control with sensing only inductor current is proposed. Interleaved Boost converter (IBC) has better performance characteristics when compared to a conventional boost converter due to its increased efficiency, reduction in size and greater reliability. The interleaved boost converter is used instead of three level boost converter. Simulation studies have been carried out using MATLAB.

## I. INTRODUCTION

PV cells are made of semiconductor materials, such as silicon. For solar cells, a thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current that is, electricity. This electricity can then be used to power a load. The basic structure of a PV cell is shown in Fig.1.1

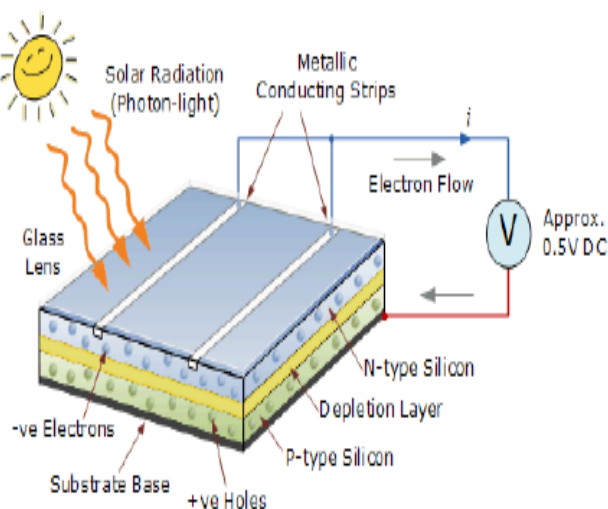


Fig 1.1 Basic structure of PV cell

Photovoltaic (PV) systems, making use of the renewable source of solar energy, draw increasing attention due to improvements in PV technology, environmental concerns, and their lack of fuel costs. PV cells have a nonlinear relationship between the current and the voltage, and the maximum power point (MPP) of PV cells changes with environmental conditions such as solar irradiance and ambient temperature.

Therefore, MPPs must be estimated using direct or indirect methods, which are used to match the PV source and the load impedance for all environmental conditions to ensure maximum power generation from PV modules. The performance of any PV system depends also on the electric load operating conditions. When designing the PV system, the combined effect of the electric load, ambient temperature and solar irradiation variations should all be considered. Because the output voltage furnished by a PV module is quite low (20-40V), usually a series connection of different modules, denoted as string, have to be employed in order to obtain a sufficient output dc voltage. The conversion efficiency of commercial PV modules is still rather low; therefore it is particularly important to achieve, in every operating situation, the maximum possible energy. In high power applications, the voltage and current stress can easily go beyond the range that one power device can handle. Multiple power devices connected in parallel and/or series could be one solution. However, voltage sharing and/or current sharing are still the concerns. Instead of paralleling power devices, paralleling power converters is another solution which could be more beneficial. Furthermore, with the power converter paralleling architecture, interleaving technique comes naturally.

## II. PROPOSED SYSTEM

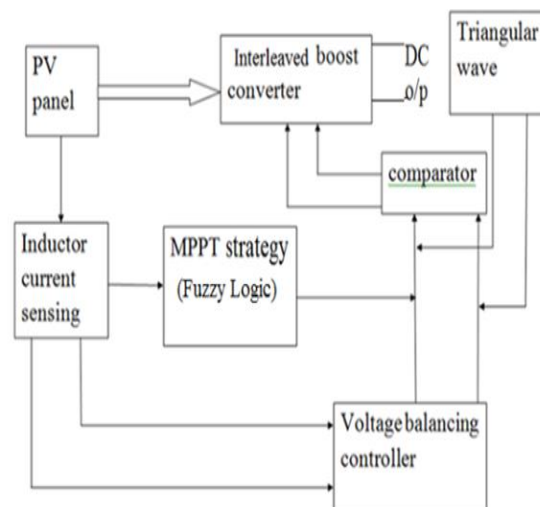


Fig 2.1 proposed block diagram

In the proposed work, the inductor current is sensed and given as input for MPPT and voltage balancing controller.

The output of MPPT is send to voltage balancing controller then to comparator. In comparator the output from voltage balancing controller is compared to triangular signal with 120 degree phase shift for giving gate signal for interleaved boost converter. In the proposed work Interleaved boost converter for Dc-Dc conversion and Fuzzy Logic to handle uncertainties and parameter variations in a controlled environment are considered. The use of interleaved boost converter instead of three level boost converter in order to obtain expected output with

1. Reduce total harmonic distortion
2. Increase efficiency
3. Reduced ripple content

### III. INTERLEAVED BOOST CONVERTER

In the field of power electronics, application of interleaving technique can be traced back to very early days, especially in high power applications. Benefits like harmonic cancellation, better efficiency, better thermal performance, and high power density can be obtained

A basic boost converter converts a DC voltage to a higher DC voltage. Interleaving boost converter has benefits such as reduced ripple currents in both the input and output circuits. Higher efficiency is realized by splitting the output current into two paths, substantially reducing  $I^2R$  losses and inductor AC losses. Fig 3.3 shows the basic interleaved boost topology. When SW1 turns on, current ramps up in L1 with a slope depending on the input voltage, storing energy in L1. D1 is off during this time since the output voltage is greater than the input voltage. Once SW1 turns off, D1 conducts delivering part of its stored energy to the load and the output capacitor. Current in L1 ramps down with a slope dependent on the difference between the input and output voltage. One half of a switching period later, SW2 also turns on completing the same cycle of events. Since both power channels are combined at the output capacitor, the effective ripple frequency is twice that of a conventional single channel boost regulator.

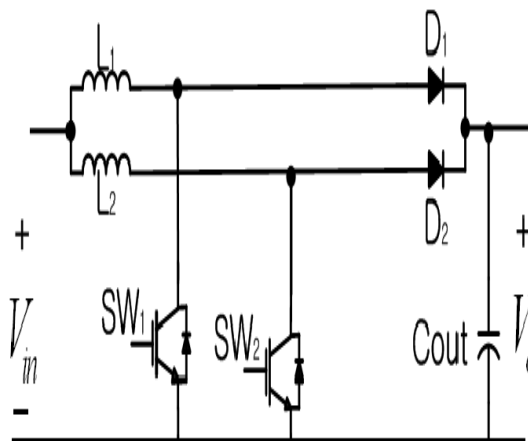


Fig 3.3: Basic interleaved boost converter

#### FUZZY LOGIC BASED MPPT

Fuzzy logic is one of the most powerful control methods. It is known by multi-rules-based resolution and multivariable consideration. Fuzzy MPPT is popular for over a decade. Fuzzy logic controllers have the advantages of working with imprecise inputs, no need to have accurate mathematical model, and it can handle the nonlinearity. Fuzzy logic is a logic having many values. Unlike the binary logic system, here the reasoning is not crisp, rather it is approximate and having a vague boundary. The variables in fuzzy logic system may have any value in between 0 and 1 and hence this type of logic system is able to address the values of the variables those lies between completely truth and completely false. The variables are called linguistics variables and each linguistic variable is described by a membership function which has a certain degree of membership at a particular instance.

System based on fuzzy logic carries out the process of decision making by incorporation of human knowledge into the system. Fuzzy inference system is the major unit of a fuzzy logic system. The decision making is an important part of the entire system.

The fuzzy inference system formulates suitable rules and based on these rules the decisions are made. This whole process of decision making is mainly the combination of concepts of fuzzy set theory, fuzzy IF-THEN rules and fuzzy reasoning. The fuzzy inference system makes use of the IF-THEN statements and with the help of connectors present (such as OR and AND), necessary decision rules are constructed. The basic Fuzzy inference system may take fuzzy inputs or crisp inputs depending upon the process and its outputs, in most of the cases, are fuzzy sets.

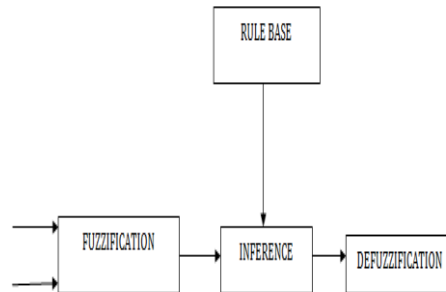


Fig 1.2 Fuzzy Logic Controller

Fuzzy logic uses fuzzy set theory, in which a variable is a member of one or more sets, with a specified degree of membership.

MPPT using Fuzzy Logic Control gains several advantages of better performance, robust and simple design. In addition, this technique does not require the knowledge of the exact model of system.

The main parts of FLC, fuzzification ,rule-base, inference and defuzzification. In the proposed design, the universe of discourse for the first input variable voltage is assigned in terms of several linguistic variables by using three fuzzy subsets namely min(minimum), med(medium),max(maximum).The membership function of variable are shown in fig 3.15.The second input variable current, which is classified into 2 fuzzy sets, namely max(maximum) and nor(normal) which is shown in fig 3.16. The output variable duty cycle membership function is given by fig 3,17.

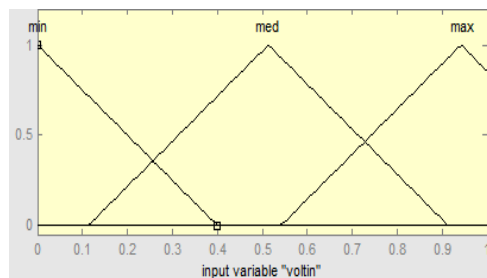


Fig 3.15 Membership function of input voltage

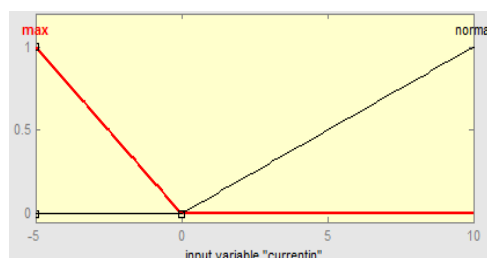


Fig 3.16 Membership function of input current

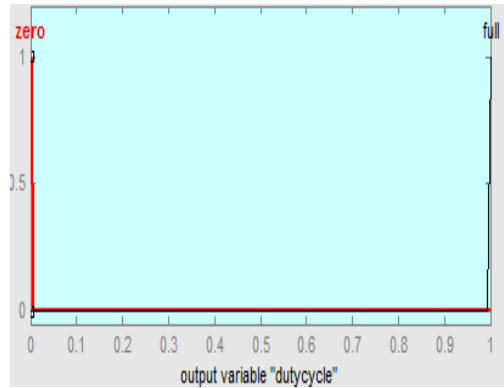


Fig 3.17 Membership function of output duty cycle

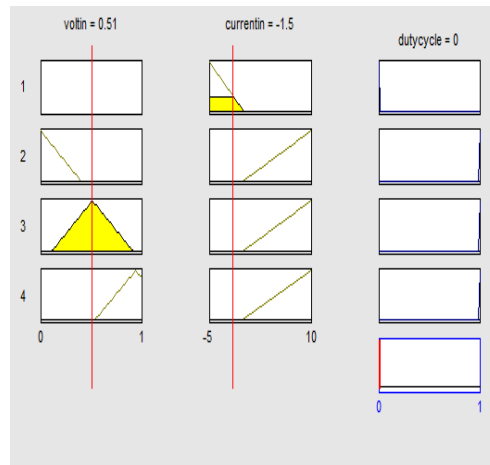


Fig 3.18 Rule based FLC

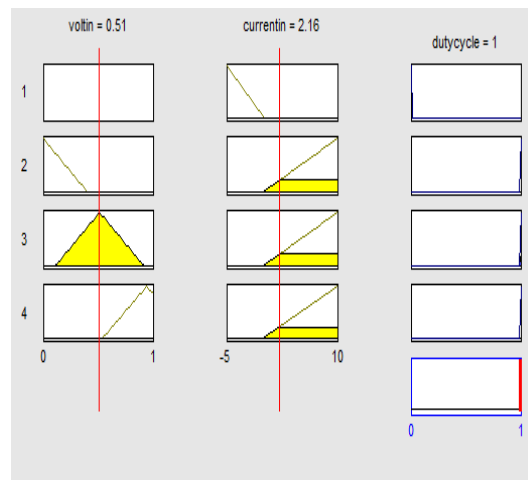


Fig 3.19 Rule for proposed FLC

**Advantages of Using Fuzzy Logic Controller**

- Computing with words also allow us to develop mathematical models of events articulated in language only.
- By fuzzifying crisp data obtained from measurements, fuzzy logic enhances the robustness of a system without fuzzification systems designed to act at certain input data points would not know what to do when data is somewhat corrupted.
- Representing a solution with fuzzy sets reduces computational burden. In some cases fuzzy technology makes a solution possible that would be otherwise unthinkable due to cost of computing every single crisp data point.

**IV. SIMULATION RESULT AND DISCUSSION**

**MATLAB CIRCUIT**

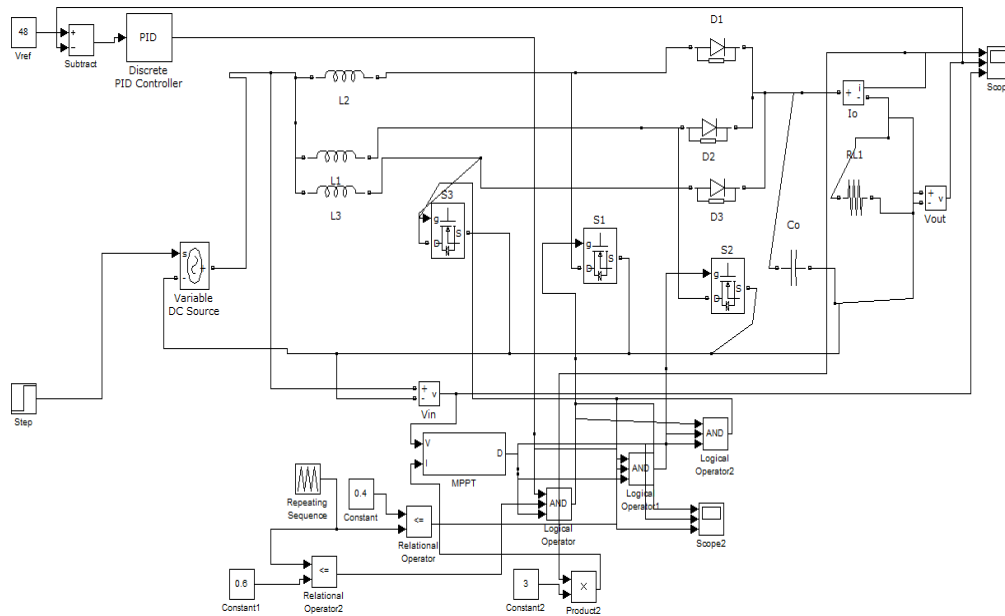


Fig 4.1: MATLAB simulation diagram

Table 4.1: MATLAB parameters

PARAMETERS	MEASUREMENTS
Input voltage(from pv)	(16-23) v
Input current	5 A
Inductance	13e-7 H
MOSFET	Ron=0.1 Rd=0.01
Load resistance	20 ohm
Output voltage	49 v
Output current	3.5 A

The expected output of interleaved boost converter by use of fuzzy logic for MPPT with above details is obtained as in fig 4.4.

#### 4.3 Output of interleaved boost converter

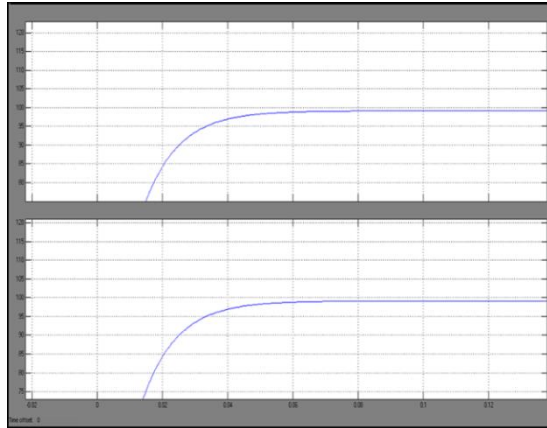


Fig 4.3:Output of interleaved boost converter

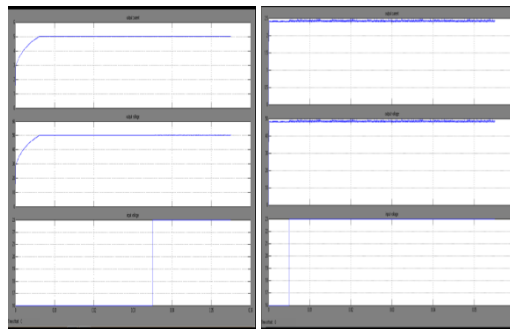


Fig 4.4: Output waveform before and after Fuzzy Logic in proposed system

From the above waveforms, the settling time is reached quicker as in case of applying fuzzy logic. Due to which the output efficiency is increased.

#### V. CONCLUSION

In the proposed method Fuzzy Logic to handle uncertainties and parameter variations in a controlled environment is considered. The proposed methods reduce the sensor count and save the cost. This paper presents an intelligent control strategy of MPPT for the PV system using the FLC. Simulation results show that the proposed MPPT can track the MPP faster when compared to the conventional P&O method. In conclusion, the proposed MPPT using fuzzy logic can improve the performance of the system. As a result of MATLAB simulation the IBC having higher efficiency and reduced ripple content can be well understood. For the future work, we intend to implement the proposed technique in the real PV system.

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