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Adaptive Neuro Fuzzy Modelled Maximum Power Point Tracking (MPPT) For Grid-Tied Solar Array Applications Using A QZSI

R.Punitha*, C.S.Satheesh *, C.Ramkumar*, Dr.S.Saravanan*

*(Electrical and Electronics Engineering, Muthayammal Engineering College, Rasipuram
Email:punithapuni005@gmail.com)

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Abstract:

The system is fully based on the energy harvesting and maximum power point (MPPT).The maximum power point is tracking only for a solar array (PV).The solar array is based on a single-stage grid-tied qZ-source inverter. It is used for regulating the charge of the batteries and the PV modules can produce the greatest amount of energy and also the variations in climatic conditions. The output power of a Solar Array System (SAS) is fully based on the solar irradiance and the operating temperature so it is easy to implement maximum power point tracking controllers (MPPT) and obtain the maximum power of a PV for variations in climatic conditions. The solution for MPPT controllers is used meta-heuristic algorithm, is mainly used to improving the results. The linear coefficients of ANFIS shares most of the computational cost of training algorithm. ANFIS and meta-heuristic algorithms can be used to train all the parameters. These parameters not only reduce computational cost of ANFIS and also provide the efficiency using meta-heuristic algorithm. This system can provide the design and modelling of a fuzzy logic controller to track the maximum power of a Solar Array System. Matlab/Simulink is used for the modelling the components of the proposed model.

Keywords — **Fuzzy controller, Solar Array System, MPPT, quasi Z-Source inverter (qZSI) and meta-heuristic algorithm.**

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I. INTRODUCTION

Among the renewable energy generation systems solar power generation has received the most power. However, the characteristic of a solar cell are nonlinear and it depends on the solar irradiance level and temperature finally it gives a unique current–voltage (I–V) curve. Consequently, the operating point (OP) of a PGS must be adjusted which is extent to the maximum efficiency of the solar cells. Once the solar cell can be achieved then the technique is called as maximum power point tracking (MPPT). The perturb and observe (P&O) method is the most common method for MPPT .This method is used to determine the difference of the power output between the current system state and previous system. To determine the perturbation step that is applied to a system. When a substantial perturbation step is utilized when, the time required for the system is to track the maximum power point (MPP) and achieve a steady state is short, but the amount of power loss caused by the perturbation is high. By contrast, a small perturbation step can deviate the power loss caused by the perturbation but decrease the tracking speed of the system. This phenomenon is generally known as the trade-off between tracking speed and tracking accuracy. Generally, MPPT methods are applied to the fixed-step size method that is affected by the trade-off. Alternatively, fuzzy logic controller (FLC)-is one of the techniques that are applied to nonlinear systems. Moreover, such techniques do not require accurate parameters or mathematics models to achieve some superior control performance. Now a day the, FLC-based MPPT methods have become a one of the research topic.

II. FUZZY LOGIC OVERVIEW

Regarding the input variable selection, most FLC-based MPPT techniques take the error (e(t)), usually defined as Ppv(t) − Ppv(t−Δt), dPpv(t)/dVpv(t) or dPpv(t)/dIpv(t), where Ppv(t) represents the panel output power and the change in error (de(t)/dt) as inputs. However, the requirement of differentiation not only increases the complexity of calculation, but also may induce large amounts of errors from merely small amounts of measurement noise. The solar insolation and panel temperature are applied as FLC inputs; however, most of the small PV systems are not equipped with these sensors, and hence these methods are not suitable for low cost PGS. In terms of the design of the input/output membership functions (MFs). Finally, FLC can also be used to assist conventional MPPT techniques such as P&O and incremental conductance methods. This study investigated an MF design methodology that can improve the effectiveness of FLC-based MPPT methods. Due to the asymmetrical characteristic of the solar cell P–V curve, asymmetrical MF is proposed to have a better performance.

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III. QUASI-Z-SOURCE INVERTER

The boost converter is used to interface between low voltage dc to high voltage dc supply. The additional boost converter is mainly used to increases the cost and size of the system and also reduces the performance of the system. To avoid boost converter more option is available. Impedance-source (IS) inverters are one of the emerging technologies of single-stage buck-boost electric energy. It is used for Conversion of renewable energy sources applications. The term quasi-impedance source inverter (qZSI) was derived from basic impedance ZSI by the rearrangement of the input side components to achieve lower voltage stress and continuous input current. This inverter can provide buck operation by controlling the boost operation in the Shoot-through mode.

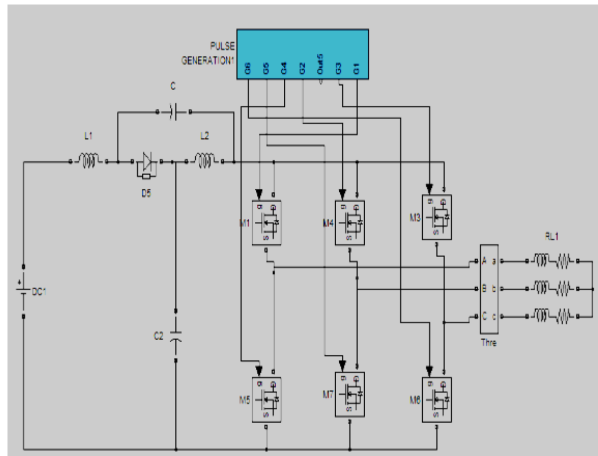

Fig: 1 quasi impedance source inverter circuit diagram

The switched-boost inverter (SBI) is presented as a simpler alternative device to the impedance of Z source inverter. The impedance of Z source inverter that contains fewer components that is compared to the normal Z source inverter. This inverter has discontinuous of input current and dc voltage gain has lower when compare to the Z source inverter. The energy requirement with wide voltage variation like solar photovoltaic, wind, non-isolated inverters have high dc voltage gain that is required only for stable operation of the grid. The boost inverters can allow utilization of low voltage and also increase the energy level for abnormal climatic conditions. DC voltage gain is can be used to improve using the IS network that can be cascaded to enhance dc voltage and coupled inductors. Coupled inductors can be used to derive a new IS network with higher dc voltage. The switched-inductor and switched-capacitor cells implemented in IS network. From the all method have been used to some problems that may be required for additional passive components duty cycle loss caused by leakage inductance of a coupled Inductor etc. In this method Quasi Z source inverter and BSL- Quasi Z source inverter circuit is proposed used. Other font types may be used if needed for special purposes.

Recommended font sizes are shown in Table 1.

A. SYSTEM FUNCTIONAL MODEL

The linear coefficients of Artificial Neuro fuzzy inference system is one of the most computational cost of training algorithm. Further-more, instead of gradient based learning mechanism is one of the typical Artificial Neuro fuzzy inference systems and also the meta-heuristic algorithms are mainly used to train all the parameters. This will not only reduce computational cost and also increase the efficiency. The output power of a Solar Array System (SAS) can be fully depends on the solar irradiance and the operating temperature can be used to implement maximum power point tracking controllers (MPPT) to attain the maximum power of a PV system

Additionally, the system can be focused towards energy harvesting of maximum power point (MPPT) tracking solar array (PV) system can be fully based on a single-stage grid-tied Quasi Z-source inverter. The traditional solution for MPPT controllers is the meta-heuristic algorithm.

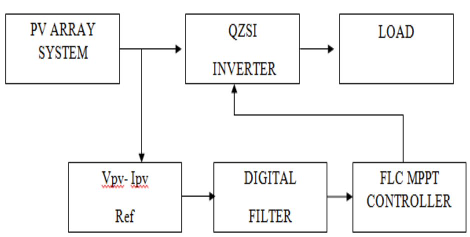

Fig: 2 functional block diagram of the system

The block diagram of the proposed system is shown in Figure 2. From Figure 2, the whole system can be divided into three major parts: PV array system, energy conversion unit and main control unit.

Detailed descriptions about each unit will be given in the following subsections:

(a) PV array can be adopted for input power source. This feature is long-term recording function and its time interval as 0.05 s.

(b) Energy conversion unit: the energy conversion unit is mainly used to supply the power to load. The energy conversion unit utilized for simple boost DC-DC converter with Quasi Z-source inverter.

For controlling the PWM signal, the maximum available PV energy can be transferred to load. This system design and implementation of this circuit is conventional. The voltage conversion ratio of a boost converter can be expressed as:

$$\frac{V_0}{V_m} = \frac{1}{1-D} \qquad (1)$$

Where V_{in} is the input voltage; Vo is the output voltage; and D represents the duty cycle. Assuming the conversion efficiency of the boost converter is 100%, relationship between the output current and the input current can be written as:

$$\frac{I_0}{I_m} = 1 - D \qquad (2)$$

From Equations (1) and (2), when duty cycle varies, relationship between the input impedance and the output load of the boost converter can be described using Equation (3):

$$R_m = \frac{V_m}{I_m} = (1-D)^2 R_L \qquad (3)$$

(c) Main control unit: The main control unit can send the PWM signal .The boost converter is used to track the peak power then the peak power is available from PV panel. A digital signal controller (DSC) can gathers and analyses the voltage and current data of PV panel.

B. DERIVATION OF THE SYMMETRICAL FLC-BASED MPPT CONTROLLER

The detailed block diagram of the symmetrical FLC-based MPPT controller is shown in Figure 3. From Figure 3, the proposed FLC-based MPPT controller consists of input/output MFs, a fuzzy inference engine, fuzzy rules and a defuzzifier. Observing Figure 3c, the absolute value of dPpv/dVpv of a PV panel varies smoothly; therefore it can be used as a suitable parameter for determining the step size of the proposed MPPT algorithm.

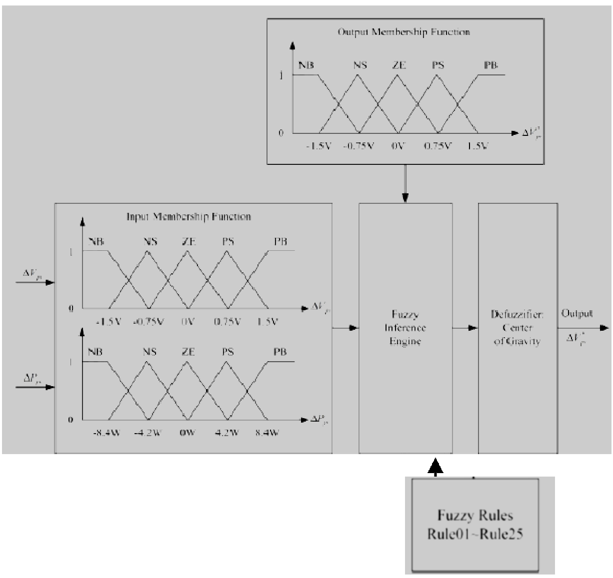

Fig: 3. Block diagram of the implemented FLC-based MPPT controller

C. HEURISTIC SEARCH ALGORITHM STEPS:

1. Initialization: set the algorithm parameters
2. Generation of new nest (exploration)
3. Exploitation

Intensification search: For each ant if the number of hunting sites in its memory is less than a predefined number then create a new site in its neighbourhood and exploit the new site
else if the previous site exploitation was successful then
    Exploit the same site again
  Else
    Exploit a probabilistically selected site
  End
End

Erase sites: from the memory of ants erase all sites that have been explored unsuccessfully more than a predefined consecutive number of times
Information sharing: Choose two ants randomly and exchange information between them. The information exchanged is the best site in their memory at the current iteration
Next movement:
If the condition for nest movements is satisfied,
    Go to step (4)
Else, Go to step (3.1)
End

Termination test:
if the test is successful,
    STOP
Else
    Empty the memory of all ants and go to step (2)
End.

C. SIMULATION AND RESULTS

Simulink, an add-on product to MATLAB, provides an interactive, graphical environment for modelling, simulating, and analysing of dynamic systems. It enables rapid construction of virtual prototypes to explore design concepts at any level of detail with minimal effort. For modelling, Simulink provides a graphical user interface (GUI) for building models as block diagrams. It includes a comprehensive library of pre-defined blocks to be used to construct graphical models of systems using drag-and-drop mouse operations. The user is able to produce an “up-and-running” model that would otherwise require hours to build in the laboratory environment. It supports linear and nonlinear systems, modelled in continuous-time, sampled time, or hybrid of the two. Since students learn efficiently with frequent feedback, the interactive nature of Simulink encourages you to try things out, you can change parameters “on the fly” and immediately see what happens, for “what if” exploration. Lastly, and not the least, Simulink is integrated with MATLAB and data can be easily shared between the programs. The Simulink model and the results of the Simulink are given below:

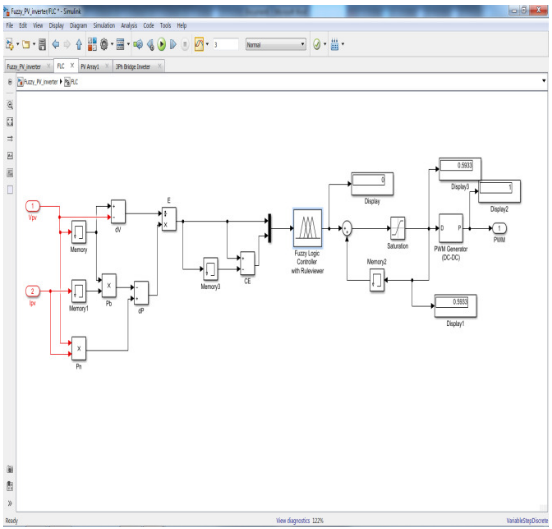

Fig:4 Fuzzy Logic Controller Sub Block

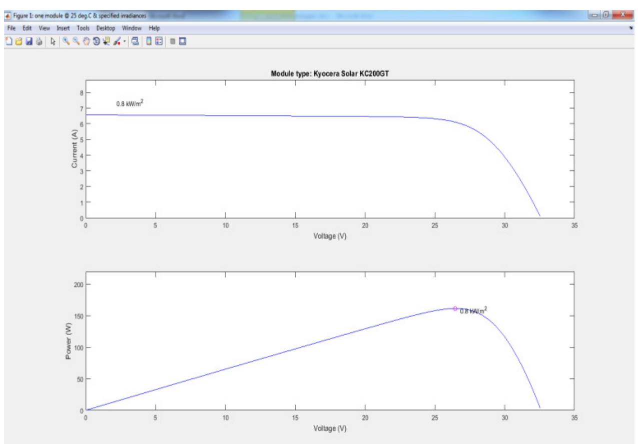

Fig: 5 PV characteristics

IV. CONCLUSIONS

In this paper, an FLC-based MPPT method is proposed. The design and implementation of the proposed method is discussed in detail. To further improve the performance of the proposed MPPT method, two design methodologies are presented to determine the input MF setting values. The first method determines the input MF setting values according to the P–V curve of solar cells under STC. Comparing with the symmetrical FLC-based MPPT method, the transient time and the MPPT tracking accuracy are improved by 25.2% and 0.05% under STC, respectively. Moreover, since the symmetrical FLC-based MPPT method fails to track the real MPP when irradiance level is low and asymmetrical FLC-based MPPT method can successfully deal with this problem; therefore, the improvement of tracking accuracy will be more significant under low irradiance levels.

The advantage of the first design method is that it is simple and easy to adopt. The second method applies the Meta-heuristic technique to obtain the optimized input MF setting values. Compared with the first design method, the transient time and the MPP tracking accuracy can further be improved by 0.88% and 0.93%, respectively.

This proves that Meta-heuristic can be successfully applied to obtain the optimized MF setting values. In addition, since the Meta-heuristic approach must target a cost function and optimize, a cost function design methodology that meets the performance requirements of practical PGSs is also proposed. According to the simulated and experimental results, the fitness values of the proposed two asymmetrical FLC-based MPPT method are both higher than those of P&O and conventional symmetrical FLC-based MPPT methods.

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