ISSN (Print): 0974-6846 ISSN (Online): 0974-5645

Simulation for Maximum Power Point Tracking Using Fuzzy Logic Control Technique

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Abstract

Objectives: We present the simulation of fuzzy control method for haul out the highest power source from the photovoltaic (PV) scheme with change in value of temperature and under variable value of solar irradiations. Methods/Analysis: The schemerigging the fuzzy logic controller (FLC) as a MPPT controller is to take out the highest voltage and power source profile from PV scheme under variable temperature and solar irradiations. The dc-dc converter is used to boost the tracked voltage from the PV system and it fed to the 2 level voltage source inverter. Matlab/simulink worn as a software instrument to verify the simulation results of the projected scheme. Findings: The fuzzy logic controller (FLC) output power and voltage levels are compared with other MPPT algorithms and the output voltage attainment from the 2-level VSI circuit superior. The membership function of FLC for PV voltage and current sampled with variations of solar irradiations and temperature change. DC-DC conventional boost converter used for recuperating the output voltage source of the PV scheme method. Novelty/Improvement: Fuzzy logic controller stand MPPT can pull out the highest power from PV system compare to other conventional MPPT algorithms. Therefore overall proposed system output voltage can be enhanced.

Keywords: Fuzzy Logic Control (FLC) Technique, Maximum Power Point Tracking (MPPT) System, Photovoltaic (PV) Array, Voltage Source Inverter (VSI)

1. Introduction

Due to powerrequire and ecologicalaccountability, growing energy values, global warming and air pollution, the photovoltaic (PV) systems are becoming more effective and alternative sources of energy¹. Currently the solar scheme has turn into one of the majority gifted renewable source due to its infinite with other environmental rewards². In daily activities the energy plays a significant function, as there is much increase in population and industrial applications. It is one of renewable energy source, which has more potential of counteracting a significant amount of the world's energy requirement^{3,4}. The main fuels like coal, diesel,

petrol, nuclear and other natural gases are depleting day by day. PV array has concerned additional concentration in the very last few years as it meets the requirements of creature environmentally well-suited with reserve preserving⁵. The occurrence of increasing the rate of energy expenditure and supply is decreasing that the result into energy deficiency⁶. The PV system is set to play a continually increasing part in generating the form, the affecting the exterior and creation of construction. When linking the pv array to the load, the photovoltaic voltage and current value PV cells varies according to the solar irradiations^{7,8}. The source produced from the PV scheme is not sufficient to run the motor load system, for that the DC-DC boost up

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converter employed to get superior the engendered PV power⁹. Generally used MPPT algorithms like perturb and observe (P&O), incremental conductance method, neural network technique, short circuit process and fuzzy logic control to get better output from the PV cells¹⁰. In this proposed system, the simulation of highest power point path with fuzzy logic controller technique fed voltage source inverter was realized. The PV system investigated with change in temperature and solar radiations and for extracting the maximum power fuzzy logic control MPPT prepared. The generated pulse from MPPT controller applied to boost up converter to enhance the source range and it is fed to the VSI circuit with R load. The proposed system block diagram is shown in Figure1.

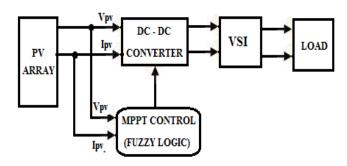


Figure 1. Block diagram of proposed system

2. PV Array Modelling and VSI Circuit

2.1 PV array modelling

The power circuit of PV arrayconsists of current source, 2 diodes and resistors and load, which is shown in Figure 2.

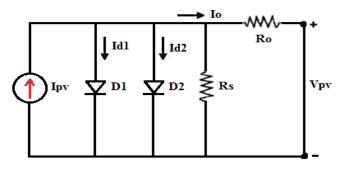


Figure 2. Power circuit for PV array modelling

The photovoltaic or photo-electric unit is a power semiconductor apparatus to exchanges light to electrical source with PV consequence. When power of photon of radiance is more than the band gap of electron is released with surge of electron which generates the current flow in the circuit^{11,12}. Regularly, the solar cell model can be sculpted by a current source with an inverter system diode associated in equivalent to it. And it has both parallel and series type of resistance. The power circuit has the following current equations are,

$$\mathbf{I} = \mathbf{I}_{sc} - \mathbf{I}_{d} \tag{1}$$

$$I \square_{\downarrow} d = I_{\downarrow} q \left(e^{\dagger} (p v_{\downarrow} n / r T) \square_{1} \right)$$
 (2)

$$I = I_q \left(e^{\frac{V + IR_s}{n_s + V_t}} - 1 \right) - \frac{V + IR_s}{R_{sh}}$$
 (3)

Where I_q – reverse use saturation current value of the device, p- electron charge in the device, V_n – the voltage across the device, r- Boltz fixed value and T is the branch temperature for the PV model. PV system assembled to generate the DC voltage from the light energy and a PV panel is one or more PV cell assembled, designed to provide a field connected unit, while a PV array is the smallest installed assembly of PV panels or modules, carry structures, practicalities and other components used for installation I^3 .

2.1.1 MPPT method

A typical solar radiation converted into electrical energy by 35 to 45 percent from the solar panel. To progress effectiveness of the solar scheme highest power source point tracking is prepared. The extracting of maximum power decided when the solar irradiations and temperature will be constant. When the variations occur in solar irradiation and temperature, the improved MPPT method has to implement. The dc-dc boost up converter supplementary in the PV array side in direct to augment the tracked source as of the PV scheme¹⁴. Moreover with altering duty value of dc boost converter the requisite demand voltage could achieve, to facilitate gives the source voltage matched with the load voltage. Based on this situation PV voltage source with current value deliberated. The PV array scheme, a P-V characteristic of is exposed with Figure 3.

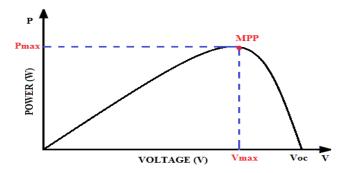


Figure 3. P-V characteristics of PV array system

The P & O technique chooses the maximum extracts of power based on the position movement. When the percentage of alteration in voltage source to modify in current is positive, then there is a small increment. If the proportion of modify in voltage to adjust in current is less than zero, then the large increment will occur at the same position of tracking also change. By observance the solar irradiation and temperature as constant to take out the maximum power from the projected system. The value of PV voltage, current & power can be determined. The PV array systems I-V characteristics of are shown in Figure 4.

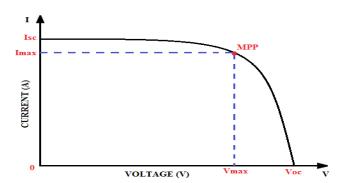


Figure 4. I-V characteristics of PV array system

2.1.2 Variation in Temperature and solar radiation

The conventional MPPT process can track in incorrect direction due to the changes occur in temperature and solar irradiations. And solar irradiations can change moderately faster corresponding to a variation of the rated power from 0% to 100% ranges within very small period of time in very small PV systems. But the chance of such fast solar radiation changes is tremendously very low¹⁵. The PV system with variation of solar radiation of I-V characteristics are shown in Figure 5.

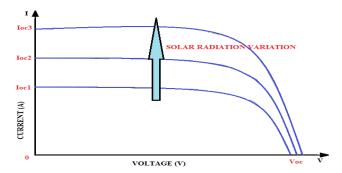


Figure 5. I-V characteristics of PV system with variation of solar radiation

If the changes in the temperature and solar radiations cause a greater revolutionize in power source than the one reason by the growth in the voltage value, the MPPT could acquire perplexed, as it will understand the revolutionize in the power source as an outcome of its own exploit. The conventional MPPT algorithm cannot read the direction of tracking the maximum power and voltage at the time variation occur in the temperature and solar radiations. The PV system with variation of temperature of I-V characteristics are shown in Figure 6.

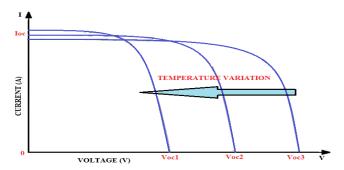


Figure 6. I-V characteristics of PV system with variation of Temperature

a. Voltage Source Inverter (VSI)

Generally single phase VSIs wrap all small range power relevance and the major reason of these methods to afford a single phase voltage source, where the peak voltage, phase and frequency range of the voltages must be forever convenient and changeable. Even though the majority of the applications involve sinusoidal voltage waveforms (such as Adjustable Speed Drives, Uninterrupted Power Supplies, Flexible ACTransmission Systems, VAR compensators) randomvalue of voltages required for the applications like active filters, band pass filters, voltage and current compensators. The two level VSI for PV scheme with boost up converter topology is exposed in Figure 7.

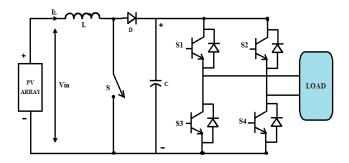


Figure 7. Two level VSI for PV system with boost converter

The inverter power source switches in any of the leg (S1, S2, S3, S4) can't be turned on concurrently since this will affect the short circuit across dc link voltage source. Likewise, in instruct to evade approximate switching states in the VSI inverter, with hence indeterminate ac output lie to line voltages, the inverter power switches in every of the leg are turned off concurrently as this cause in voltages that will depend upon the particular line to line current divergence. Thus the ensuing ac output line to line voltages consists of distinct values of voltage values are $+V_{\rm in}$, 0, $-V_{\rm in}$.

3. Fuzzy logic controller (MPPT algorithm)

In recent years fuzzy logic controllers implemented in PV system to extracts the maximum power. It is simple to design and has more advantages compare to other conventional MPPT algorithms. The universal block diagram for fuzzy logic control scheme is exposed in Figure 8.

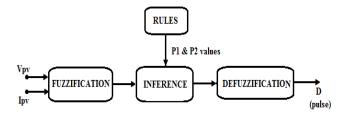


Figure 8. General block diagram for fuzzy logic controller

FLC has implemented in order to synthesize the MPPT algorithm with constant temperature and solar irradiations. The inputs are the slope of the P/I and V/I features which shows the change in power, which express the moving reaction on solar irradiation. The membership function for the fuzzy logic controller calculated by the amount of voltage and power tracked from the

PV system. Based on these voltage and power values the membership functions D(t) and CD(t) calculated.

$$D(t) = \frac{P_{pv}(t) - P_{pv}(t-1)}{V_{pv}(t) - V_{pv}(t-1)} \eqno(4)$$

$$CD(t) = D(t) - D(t - 1)$$
(5)

Where, P_{pv} -Instant power generation in PV array, D(t) - error value in the system and CD(t) - change in error value in the proposed system. Membership function mapping for PV voltage & current for variations of temperature and solar irradiations shown in Figure 9.

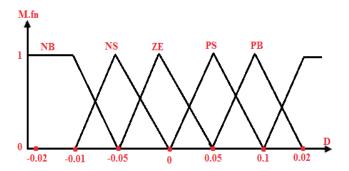


Figure 9. Membership function mapping for PV voltage & current

Based on the variation k value the direction of MPPT movement, if the value in negative it moves to left side and if positive value it moves to right side tracking. The maximum power and voltage can tracked based on the error and variable k value of the PV system at particular instant of time period. Based on the duty pulse obtained from the fuzzy logic MPPT controller, the boost converter turned off/on will take place, the boosted voltage fed to 2-level voltage source inverter with R load circuit.

4. Simulation Results and discussion

The simulation model of maximum power point track using fuzzy logic controller technique fed voltage source inverter was verified using MATLAB/simulink 11.b. In this proposed system the PV array generates the power under the solar radiation of 200W/m² to 1000W/m² and similarly the temperature variation of 20 to 38 degree ranges. Simulation diagram of two level VSI with fuzzy based PV system is shown in Figure 10.

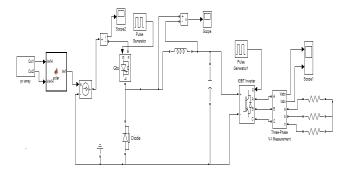


Figure 10. Simulation diagram of two level VSI with fuzzy based PV system

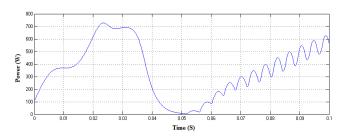


Figure 11. Output power waveform of the boost converter

In Figure 11 shows the output power from the boost up converter, which is highest of 700 W, the output current obtained from the PV array with 0.7 A is shown in Figure 12.

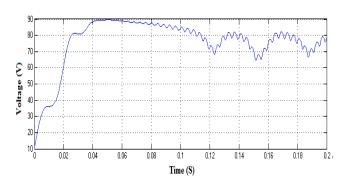


Figure 13. Output voltage waveform of the PV array

In Figure 13 illustrate the direct output voltage source from the PV array without boosting is maximum of 90V. And Figure14 shows the pulses generated from fuzzy logic MPPT controller with PV array input voltage and current.PV array generates the power under the solar radiation of 200W/m² to 1000W/m² and similarly the temperature variation of 20 to 38 degree ranges are shown in Figure 15.

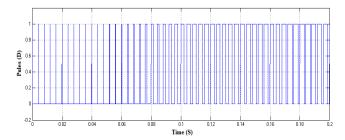


Figure 14. Pulses generated from fuzzy logic MPPT controller

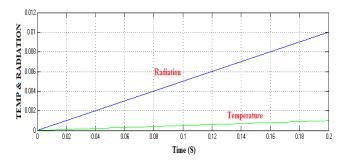


Figure 15. Variation of temperature and solar radiation in PV system

5. Conclusion

The fuzzy logic controller was implemented as a MPPT controller in this proposed system. Obviously the FLC is better than the other conventional MPPT methods even during the variations of temperature and solar radiations. The tracked maximum voltage as a pulse was applied to DC-DC converter to improve input voltage range and boosted voltage applied to the voltage source inverter with R load circuit. The simulations results of the projected scheme were verified usingMatlab/Simulink model.

6. References

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