

Design and Simulation of MPPT Controller for a PV Generator Using Simscape-Matlab

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Abstract

In modern time the demand of electric energy widely increases day by day due to the reduction of the fossil fuels like (gases, liquids, coals, oil etc.) and the other environmental issues the all of world is looking for the alternative. The solar energy is the most renewable and sustainable energy sources. This paper present Simscape based modeling and performance of the photovoltaic generator and this paper presents the two different methods is used to maximize the PV generator output power. Thus , a comparison between the 'Perturb and Observe' method and the 'Fuzzy Logic' controller based maximum power point tracking (MPPT) algorithm is discussed an analyze.

Keywords

DC-DC converter, Fuzzy logic algorithm, PV array, P and O algorithm, Maximum power point tracking (MPPT) controller, Photovoltaic (PV).

Introduction

Now a day, the renewable energy sources are widely used due to the energy crisis due to pollution and global warming effect. The demand of the electricity increases day by day due to the shortage of the fossil fuels and increase the prices of the oils, so the world is looking for the alternatives. To overcome this problem the renewable energy sources are mostly used like solar, wind turbine, biomass energy, biogas system, to meet the demand of the electricity. This most important renewable energy sources are the solar energy because it is non- polluted energy and free of cost energy. The solar energy depends on the principle of the 'Photovoltaic effect' which convert the sun light into the electrical energy with the help of semiconductor device. The output power of the solar panel and efficiency depending upon the irradiation level and temperature and load impedance. In this system there is a many solar cells are connected in series to make a PV generator. The Simscape based modeling of the PV generator and its characteristics are given in the next section.

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Modeling of PV generator model in Simscape Matlab environmental

In the modeling of a PV generator first of all the sub-module, module and array of the solar cell are prepared. The structure of the solar cell is given in figure1.



Figure 1. Symbol of a solar cell

Sub-module

This solar cell block is drawn from the Smscape library. In the solar cell there is three terminals one is the positive terminal, second is the negative terminal and third is the insolation or irradiance terminal [2]. The PS constant block is used for the irradiation terminal which provides the variable or constant irradiance to the cell. The open circuit voltage V_{OC} of this cell is 0.6 volt and the short circuit current I_{SC} is 7 amps. The output voltage of the single cell is very small which does not meet the load demand.

Module

In the module there is a combination of the solar cells which are connected in the series or parallel to increase the output voltage. In the module of a PV generator 20 numbers of solar cells are connected in series, each having voltage of 0.6 volt [1-2]. The short circuit current of each solar cell is considered as 7amp. The Open circuit voltage V_{OC} of each module = (Open circuit voltage of each cell)*(total no of solar cells connected in series = $(0.6*20) = 12$ volts and $I_{SC} = 7$ amp [1-2].

PV Array

In the PV array 20 numbers of solar modules have been connected in series to build up the solar array to meet the desired demand or output. The voltage and current specification of solar array is given below. The open circuit voltage V_{OC} of solar array = (Open circuit voltage of each solar module) * (Total no of solar module connected in series) = $(12*20)$ volts = 240 volts and short circuit current I_{SC} of solar module = 7 amp. The block diagram of the complete PV generator is given in figure 2.the diagram having a PV generator, a DC/DC Converter, P and O MPPT controller, fuzzy logic based MPPT controller, a battery system or the DC load connected. The Current versus Voltage(I-V) and Power versus Voltage(P-V) characteristics and the scope results or shown figure 2(a-g) [1-2].The efficiency of the PV generator is increase with the help of maximum power point tracking controller. The two different methods are used namely Perturbation and Observation method or Fuzzy logic controller based method. The complete explanation of the Perturbation and Observation controller and the Fuzzy logic based controller based maximum power point (MPPT) is given in the next section.

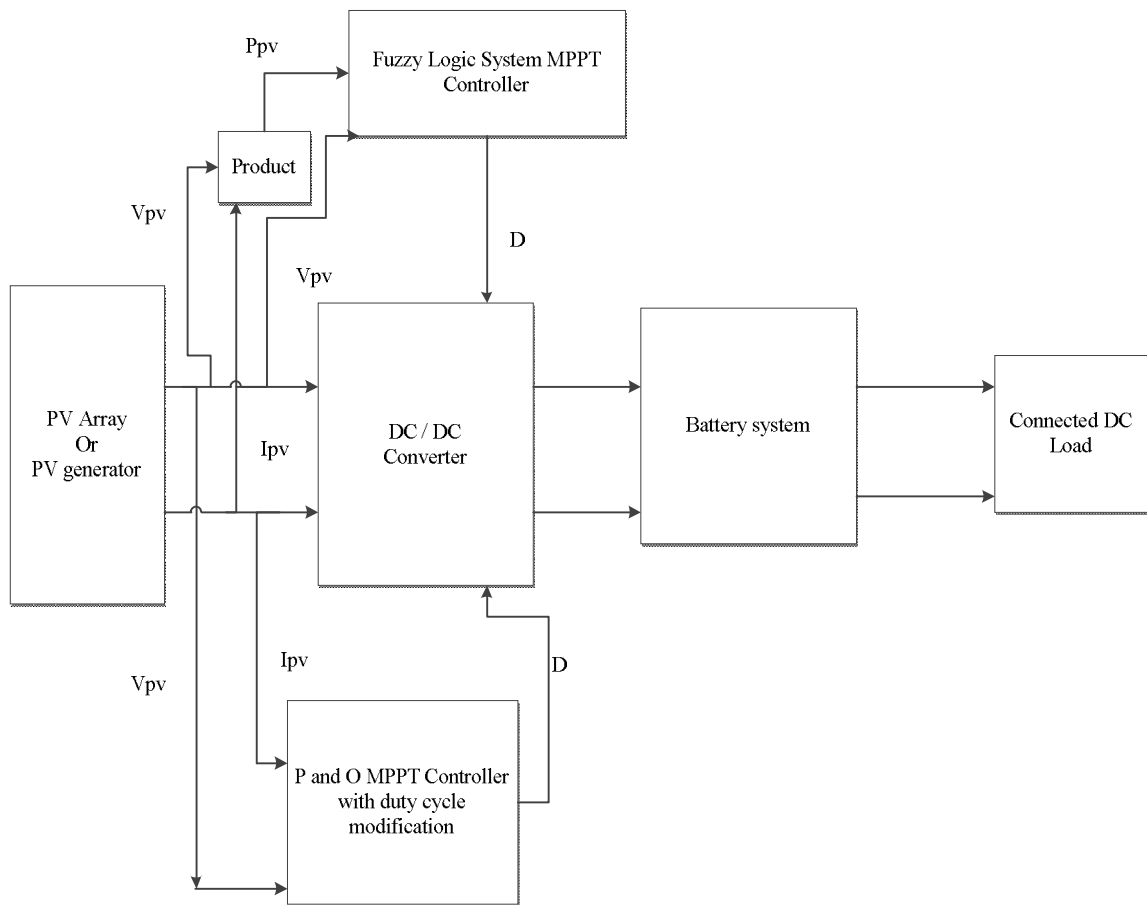


Figure 2. Block diagram of PV generator connected with DC/DC converter and MPPT controller

The different characteristic of the PV generator

Current versus Voltage (I-V) characteristics

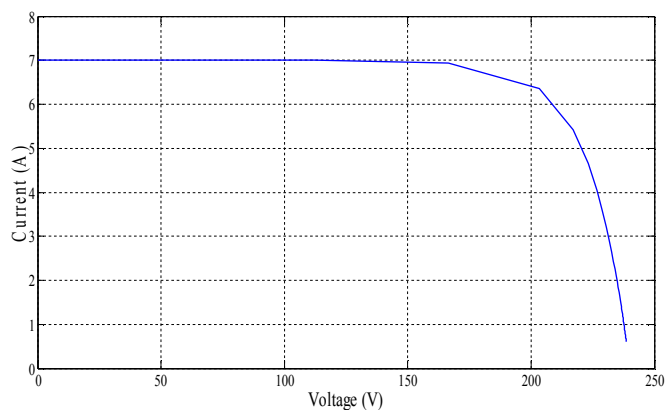


Figure 2a. I-V characteristic of PV generator

Power versus Voltage (P-V) characteristic

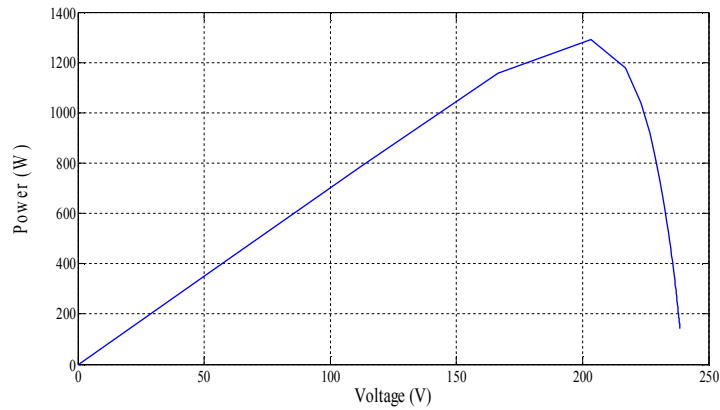


Figure 2b. P-V characteristic of PV generator

The scope result of PV generator

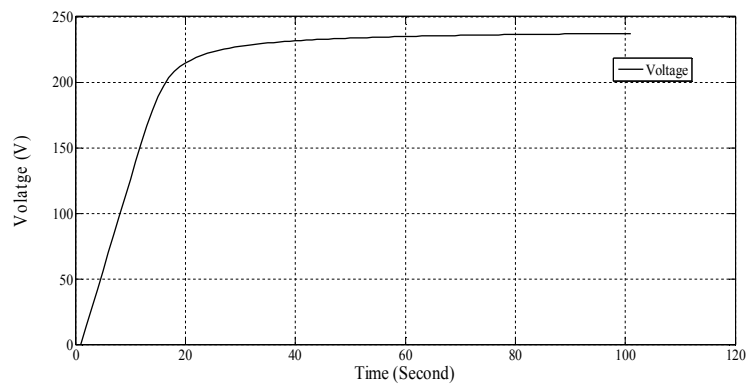


Figure 2c. Voltage versus Time graph of PV generator

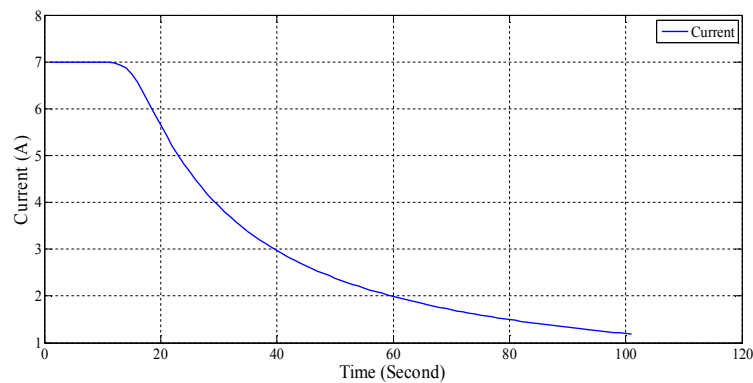


Figure 2d. Current versus Time graph of PV generator

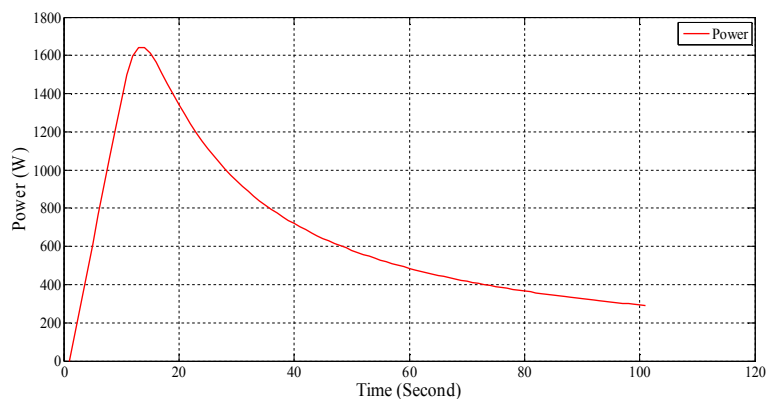


Figure 2e. Power versus Time graph of PV generator

The I-V and P-V characteristic of PV generator with different insolation level

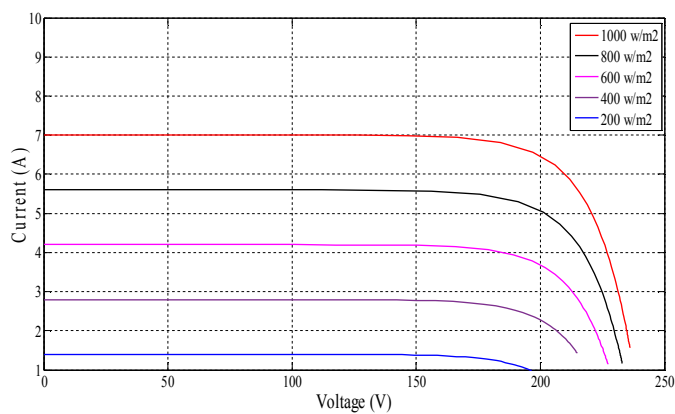


Figure 2f. I-V characteristic of PV generator with different insolation level

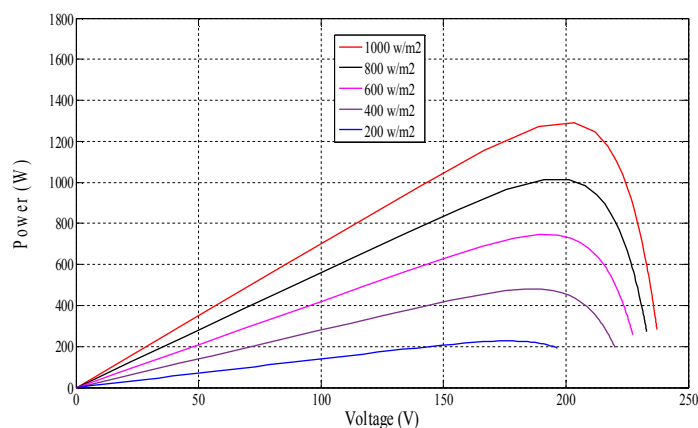


Figure 2g. P-V characteristic of PV generator with different insolation level

Maximum Power Point Tracking

There are different method to find the maximum power point of the PV generator namely as:

- [1] Perturbation and Observation method or (P and O method)
- [2] Incremental conductance methods
- [3] Constant voltage methods
- [4] Fuzzy logic methods

These are the methods which are used to track the maximum power from the PV generator and increase the efficiency of the PV generator of the PV array. The most commonly used method is the Perturbation and Observation method or the artificial intelligence based fuzzy logic method. The algorithms of these methods are given below [3].

Perturbation and observation method (P and O method)

In the modern time due to the simplicity and generic nature the Perturbation and Observation method are mostly used. This method is based on the fact that the derivative of the power in role of the voltage is zero at MPP [3-4]. The algorithm of the P and O method in given below in figure 3.

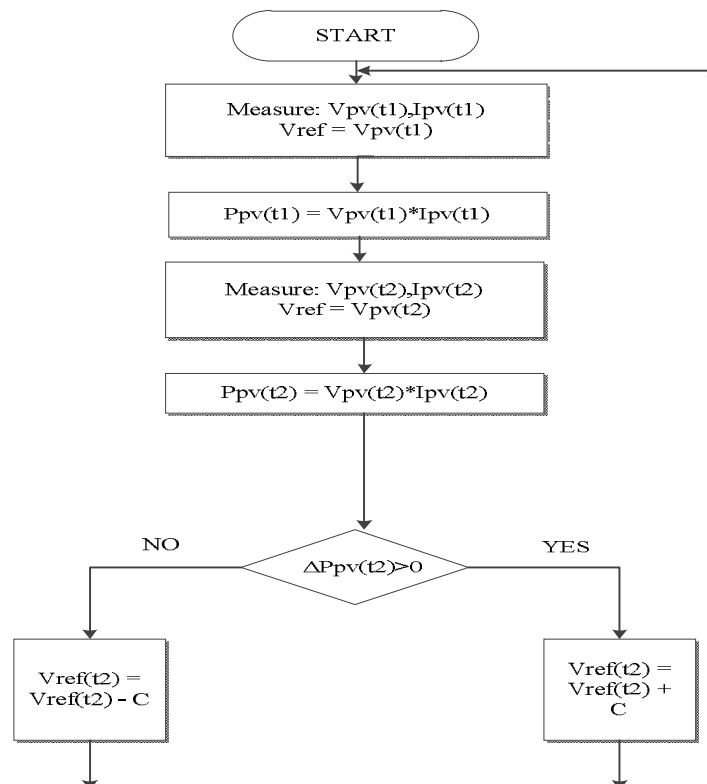


Figure 3. Flow chart or algorithm of P and O method

At the operating point on the P-V curve if the derivative of power $dP > 0$ then the perturbation (increase or decrease) move the array operating point toward the MPP and if

the derivative of power $dP < 0$ then the perturbation move the array operating point away from the MPP. If the $dP = 0$ then the operation point is MPP in the P-V curve. The output taken from the Perturbation and Observation is in the form of Duty cycle. The duty cycle is given to the switch of the DC/DC converter and checks the output power of the converter with the help of scope [3-4]. The range of the duty cycle in between 0 and 1. Due to change the duty cycle the output of converter changes and the result will be shown below.

Fuzzy Logic method

The artificial intelligence based fuzzy logic method is a best technique to find the maximum power point tracking (MPPT) of the PV generator. The block diagram of the fuzzy logic system is given in figure 4[5].

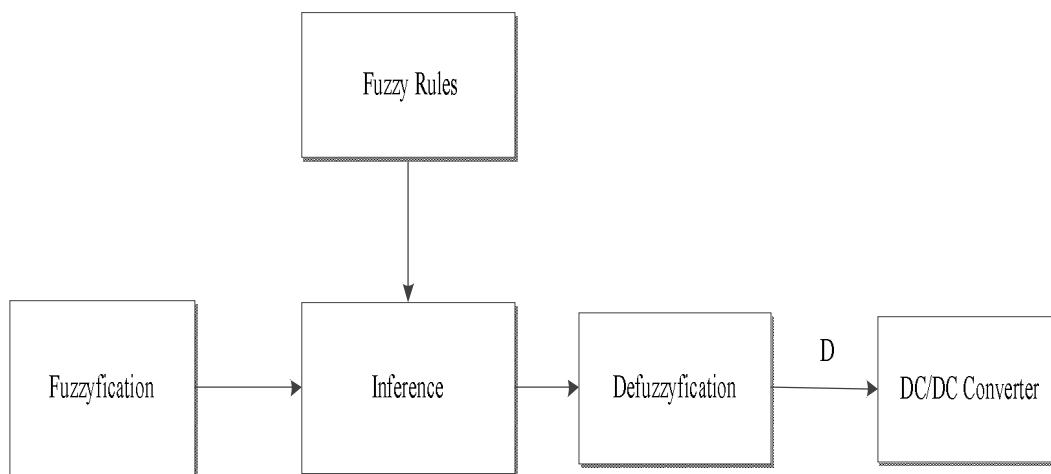


Figure 4. Block diagram of fuzzy logic system

The fuzzy system will be create by writing the FUZZY in the command window of the Matlab software then the fuzzy window will be open on the screen . In the fuzzy system create the two input membership function (MF's) and one output membership function (MF's) .In the input membership function there is an error (E) or change in error (CE). The error is represented by the power (P) and the change in error is represented by derivative of the voltage ΔV . The output membership function is duty cycle which is represented by (D). The values of the input member are select according to the model requirement. In this model the output voltage is 240 volt and the current is 7 amps then the total output power will be 1.6 kW. In the fuzzy logic system the range of the derivative of voltage ΔV (-10 0 10) and the range of the power is (0 to 1800) and the range of the duty cycle is (0 to 1). In the inference a mamdani block is show where the rules will be created according to the two inputs and one output membership function. There are total 25 rules in the mamdani block [5]. The output of the fuzzy system in the form of duty cycle, this duty cycle is given to switch of the DC/DC conversion device. The scope which is connected with the converter shows the output voltage [5].

Simulation results of MPPT controller of PV generator

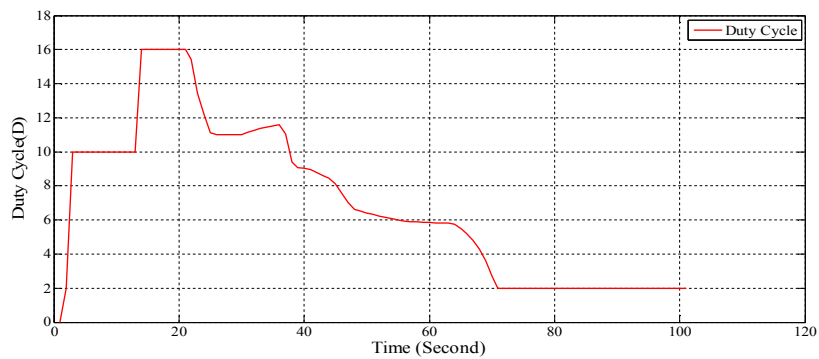


Figure 5. Duty cycle versus Time graph

Output voltage with or without MPPT controller

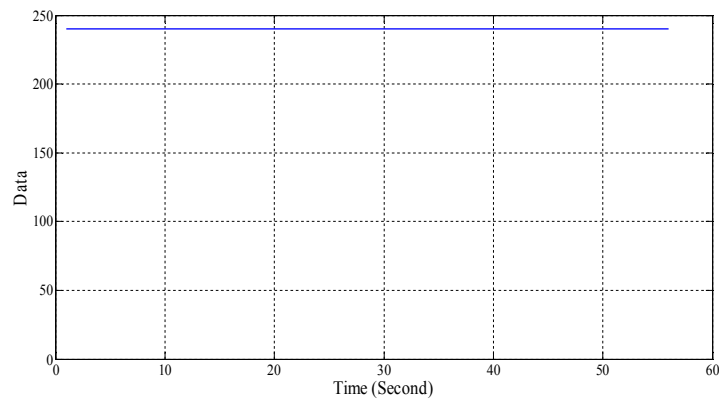


Figure 6. Output voltages without MPPT controller [3]

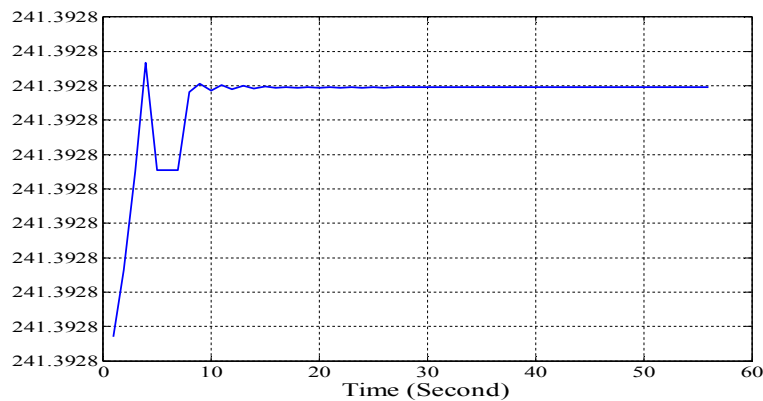


Figure 7. Output voltages with MPPT controller [3]

Conclusion

This paper is mainly about the Simscape based modeling of the PV generator by using the MATLAB- SimPowerSystem. In this different characteristic and the scope results of the PV generator is drawn. The P and O method and the fuzzy logic method are used to find the MPPT and output voltage will be shown without MPPT or with MPPT controller.

References

- [1]. Varshney, Gunjan, D. S. Chauhan, and M. P. Dave. Simscape Based Modelling & Simulation of MPPT Controller for PV Systems. *PP* 41-46, (Nov – Dec. 2014).
- [2]. Raju, Dr P. Sangameswar, and Mr G. Venkateswarlu. Simscape Model of Photovoltaic cell." *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering* 2.5 (2013).
- [3]. Srivastava, Manish, Sunil Agarwal, and Ekta Sharma. Design and Simulation of Perturb and Observe MPPT Algorithm for 72 Cell Solar PV System.
- [4]. Kondawar, Sangita S., and U. B. Vaidya. A comparison of two MPPT techniques for pv system in Matlab simulink. *International Journal of Engineering Research and Development* 2.7 (2012): 73-79.
- [5]. Cheng, Po-Chen, et al. "Optimization of a Fuzzy-Logic-Control-Based MPPT Algorithm Using the Particle Swarm Optimization Technique." *Energies* 8.6 (2015): 5338-5360.

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