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Role of MPPT for Fast Charging of Battery From Solar System - A Review

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Abstract

Electricity is needed for daily life and production. The power system consists of four sections: power generation, power transmission, power conversion, and power consumption. In remote farms, forest farms, and islands, it is not easy to set up transmission and transmission systems for small power demands. Renewable energy is power derived from natural possessions, such as solar, wind, waves, or geothermal energy. These resources are renewable and can be recycled naturally. Therefore, compared to the depletion of traditional fossil fuels [1], these sources of information are considered inexhaustible. The global power crunch provides a new impetus for the development or maturity of clean or renewable energy [2]. Generally, the generation of electrical power through PV system depends on availability of solar irradiance. The solar irradiance is randomly varying and even not available during night time as well as cloudy days. Therefore an energy device such as battery is required to maintain load when it is required. At the same time the output voltage of PV system is not constant due to it's depending on solar irradiance. Therefore an effective converter is required to maintain constant voltage to charge the battery. Generally a boost converter is using for this purpose. Moreover, the PV system needs to be operated at particular voltage to enhance maximum power for best utilization. In this article various MPPT techniques are elaborated for getting maximum power output and fast charging of battery. This also gives the comparative analysis of various MPPT techniques.

Keywords: Renewable Energy, Solar Photovoltaic System, Maximum Power Point Tracking, Boost Converter, Battery

Introduction

Global warming is of great concern, and shifting energy production based on renewable energy production is an excellent way to reduce fossil fuel emissions. Therefore, for these reasons, it is necessary to build a renewable energy system outside the grid. One of the benefits of mixing different power sources is to provide sustainable power in areas that conventional power grids cannot supply. They are instrumental in many applications, but due to their non-linearity, hybrid energy systems have been proposed to overcome this problem and make essential improvements. In general, hybridization involves combining multiple energy and storage units in the same approach to optimize production and energy management. Solar systems use a combination of renewable energy sources, such as wind and solar, to generate electricity. Solar panels are used to generate electricity in this setup.

A. Global Energy Scenario

The current trend in the developing economy has led to the expansion of renewable power. Over the past three years, figure 1 shows that renewable energy and biomass energy account for a significant part of current renewable energy consumption.

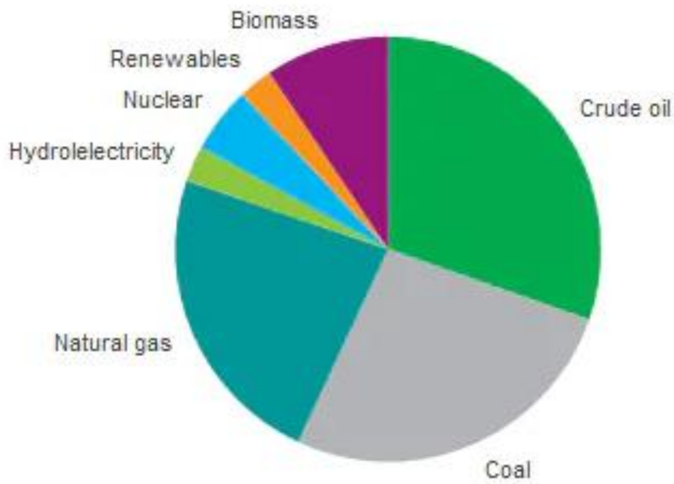

Figure 1: Global Energy Consumption in the Year 2020 [1]

B. Types of Renewable Energy Sources

Wind Power

Wind turbines can be utilized to outfit the force created by the wind current [3]. The power of turbines used per day is approx 600 kW to 5 MW [4]. Because power output is a function of wind speed, it amplifies hastily as wind speed increases. Recent advances have become wind turbines, which are more resourceful than better aerodynamic construction.

Solar Power

The evolution of solar energy came from the British astronomer John Herschel [5], who used solar collectors for cooking food during his travels to Africa. Solar power can be used in two main ways. First, the extracted heat can be used as energy from the sun and heat the atmosphere. Another option is to convert solar radiation into electrical energy, which is the most needed form of power. This can be accomplished with solar photovoltaic cells [6] or solar-powered power stations.

Small Hydropower

Power plants running with up to 10 MW are considered high-power generators and are regarded as renewable energy sources [7]. It uses hydraulic turbines to convert potential energy for water stored in dams into usable electricity. The purpose of flood power is to use the kinetic energy in the water without the need to build dams or dams.

Biomass

Plants catch energy from the sun through photosynthesis. These plants discharge energy when they copy. In this way, biomass can be used as a natural battery to store solar energy to produce it if needed.

Geothermal

Geothermal energy is the thermal energy generated by storage in different layers of the earth [9]. The gradient prepared in this way results in a continuous heat transfer from the base to the ground's surface. This media can be used to heat water to produce very hot steam and use it to run a gas turbine to produce electricity. Significant losses in geothermal energy are often associated with areas near the tectonic plate boundary, although recent developments in technology have become popular [10].

Solar Photovoltaic

Correspondingly, the solar power generation system is proposed in figure 2. A solar cell or panel comprises a model derived from solar cells connected in series or parallel to provide the required currents and energy. Solar intertie photovoltaic (PV) systems are not particularly complex. First there are panels, which collect the sunlight and turn it into electricity.

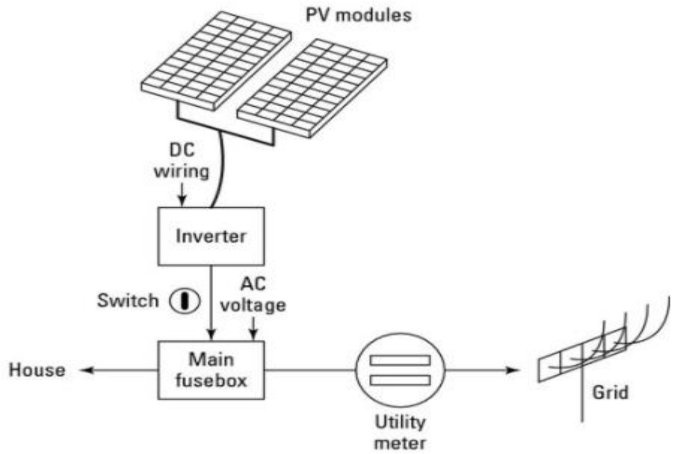

Figure 2: Working diagram of PV System

In order to supply the required current and voltage, the solar cell array or panel is made up of a suitable number of solar cell modules connected in series or parallel to form a single unit. Storage batteries provide backup power during inclement weather by storing excess power or a portion of the power generated by solar panels. It is used for private energy use, meteorological stations, radio or television relay stations, entertainment venues such as cinemas, hotels, restaurants, settlements and islands. It is also used to generate electricity for the grid. Traditional p-n junction solar cells are the most well-established solar energy harvesting methods now available. The fundamental physics of energy absorption and carrier generation and the characteristics of the materials and their related electrical properties are discussed (i.e. band gap). In order to excite an electron from the valence band into the conduction band, a photon must have energy larger than 2eV, which is the energy of the band gap. At 6000 K, the solar frequency spectrum, on the other hand, is quite close to the black body spectrum. Solar radiation that reaches the Earth contains photons with energy larger than the band gap of silicon, which accounts for a significant portion of the total solar radiation. The solar cell will absorb photons with increased energy because of this.

Nonetheless, the difference in energy between these photons and the silicon band gap is transformed into heat (through lattice vibrations known as phonons), rather than electrical energy, by the silicon crystal structure. This sets an upper efficiency of ~20% for a single-junction cell. The current research path of implementing complex, multi-junction PV designs to overcome efficiency limitations does not appear to be a cost-effective solution. The optimized PV materials are only operational during daylight hours and require direct (perpendicular to the surface) sunlight for optimum efficiency.

Equivalent Circuit of Solar Cell

Solar panels are how solar energy is converted into electrical energy. Solar panels can either transform the energy into a usable form or use the induced energy to heat water. As with computer technology, PV (Photovoltaic) cells contain semiconductor architectures similar to that of solar cells. Because of the absorption of sunlight by this material, electrons from the atoms to which it is linked can be seen emitting from them. A current is activated as a result of this release. Photovoltaics is defined as the process between the absorption of a light beam and the generation of energy. Solar power is converted into electric power with a common principle and individual components. Solar batteries can be represented with an equivalent circuit of a current source, a resistor, and Solar batteries can be represented with an equivalent circuit of a current source, a resistor and a diode in parallel, and an external load-resistor, as seen in figurer 3.

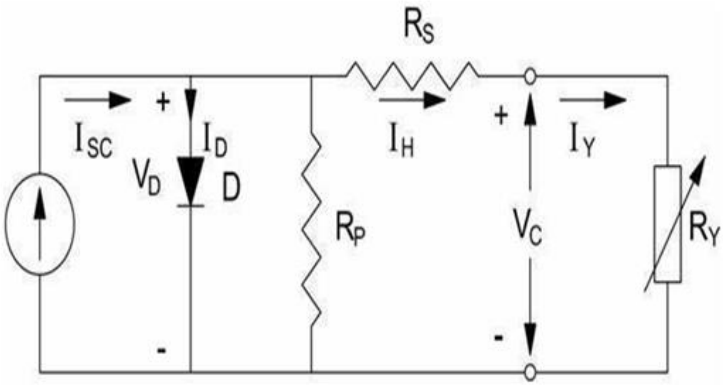

Figure 3: Equivalent Circuit of Solar Battery

Related previous research

Zhou et al. (2011) proposed the Perturb and Observed method to use the maximum power in a photovoltaic solar system. It can be easily applied with analog circuits. The algorithm disrupts the operating point of a PV system by increasing or decreasing the control parameters in a tiny step. The advantages of the P&O method are fewer control parameters, easy implementation, and a simple algorithm. The disadvantage of this method is that it rotated when the MPP arrived, and it cannot be adequately followed when conditions change [1].

Wang and Peng (2012) The photovoltaic solar system is connected to the load through two bridge converters currently operating with multiple inverters. In this embodiment, the small capacitors in the film replace the high-voltage capacitors that are common in the system. Even under rapidly changing conditions, this program can provide high efficiency. The 5kW PV converter was developed to test the efficiency of the algorithm. The control of both active bridges and multilevel inverters is the disadvantage of this approach [2].

Lee et al. (2013) proposed MPPT monitoring technology for solar photovoltaic systems. This technique considers the thermal stress exerted by the semiconductor switch on the converter. As a result, losses are reduced, and overall efficiency is improved. The algorithm works better with climate change changing the environment [3].

Kollimalla et al. (2014) batteries and super capacitors have the advantage of high energy content and high power density. Combining them in a hybrid energy storage system (HESS) can meet a variety of micro grids requirements. A balanced system power supply and DC bus power supply can be achieved by implementing a power management strategy. The HESS control strategy is designed to satisfy the required / discharge requirements and minimize battery damage caused by frequent discharge waves. Based on the HESS DC micro grid system model of the MATLAB / Simulink platform, the simulation results validate the feasibility of the control strategy. Solar and wind energy are the primary sources of renewable energy. Researchers work hard on both sides to get as much energy as possible. Many algorithms have been developed to work with energy conversion systems from solar or wind to maximum power (MPP) [4].

Hamzeh et al. (2015) DC Micro-grid with photovoltaic. Controlled energy storage systems include batteries, super-capacitors, DC loads, electric motors, and energy management systems (EMS). In MATLAB / Simulink, the system is configured with different input conditions and loads, and the results are obtained. It is found from the obtained results that the DC Micro grid using the energy control system meets the requirements of all the conditions [5].

Wei et al. (2016) MPPT algorithm developed for energy conversion systems. Combine the artificial neural network and the Q learning algorithm to obtain the maximum energy point. Follow the maximum power of the corresponding rotor speed. The results and experiments are provided to validate the ANN-based MPPT control algorithm designed for a 5MW wind-to-wind energy conversion system (WECS). The small chemical WECS Artificial neural networks require more training time [6].

Manan Dhar et al. (2018) with renewable energy development such as hydrogen energy, renewable energy supply has become an integral part of the DC Microgrid. Related monitoring and power management have become the focus of current research. The Microgrid DC photovoltaic / fuel / DC energy storage in this article includes photovoltaic (PV), fuel cells, lithium-ion batteries, and super capacitors, as well as DC / DC and DC / AC converters. To ensure the stability of the photovoltaic / fuel cell / hybrid DC microgrid energy storage. This paper presents a control and energy management system. The proposed power control and management system effectively controls the cost of the bus and balances the power by automatically controlling the power of each model. Under the power control and management system, when the load changes suddenly, the bus load stays stable, and the power supply remains balanced. The effectiveness of the proposed method was verified by simulation [7].

Motahhir et al. (2019) Adherence to the MPP of a photovoltaic (PV) model is critical to improving utilization. In the partial shade condition, the P-V curve shows multiple peaks. Therefore, the function of state-of-the-art technology (MPPT) is to monitor the location of the global power supply and prevent running over the top of the city. Especially in partial shadow [8].

Saravia et al. (2019) This article presents the design and control of the MPPT of the small-scale Autonomous Photovoltaic Solar System, which aims at distributing electrical energy from renewable sources to small towns without power grid service. The DTC power of 6 KW was thus considered as a simulation tool using MATLAB. A 90W two-axis autonomous photovoltaic solar module and a Buck loading controller with MPPT control have been designed for validation purposes. A DAQ-USB 6008 was used from the national instruments and Lab VIEW for the purpose of acquisition of solar energy data and Arduino Nano v3.0 was used for control purposes [9].

Yuwanda et al. (2020) Indonesia is a tropical country that has the advantage of acquiring daylight over time to foster the sunlight based energy use as a sun oriented power plant. One of the issues in the sunlight based plant framework is the energy unsteadiness created by sun oriented boards as they depend intensely on illumination and somewhat little proficiency in energy change. To manage this issue, the MPP Methods for P&O require maximum control. This P&O MPPT control empowers sun based PV to work at the MPP point, accordingly maximizing sunlight based PV energy. However, the MPPT P&O control which works at the MPP points additionally augments the yield voltage to the heap and causes overvoltage. This paper talks about accordingly the alteration of the consistent power age (CPG) MPPT Perturb and Observe Algorithm, which consolidates MPPT P&O with power control settings at the maximum furthest reaches of sunlight based PV. This technique can build up 2 sunlight based PV working conditions, in particular MPPT and CPG mode. The MPPT mode capacities when the sun oriented PV yield is not exactly the reference power to boost sunlight based PV yield. In any case, if the power yield is more prominent than or equivalent to the reference power, the CPG mode restricts the power yield of the sun based board. In view of the recreated results from this MPPT-CPG control, the heap voltage reaction can be kept up with consistent 48 V with less than 5% blunder and confirmed utilizing a scope of light and reference power [10]

Chitra et al. (2021) presents the demonstrating and recreation of sunlight based controlled DC engine speed controls utilizing MPPT and DSMC. Thusly, an effective nonlinear regulator is required when there are vulnerabilities on the heap side and voltage changes on the source side; DSMC can beat these issues. Fueled by a sunlight based board, the Boost converter is set to the P&O MPPT calculation for greatest force. The expanded voltage is provided to the DC engine through the exchanging circuit and the speed of the DC engine is constrained by DSMC strategy utilizing an upgraded voltage control technique. The chopper door beat is constrained by the discrete regulator against the real speed. The issue of non-linearity of the framework is settled with DSMC and its power is exhibited by presenting varieties in light. The proposed controlled framework utilizes sun based energy in a vigorous, proficient, straightforward and practical way [11].

Trusova et al. (2021) Additional lumped conversion elements such as an MPPT controller, inverter, and sine filter must also be placed. The control system presented allows all these devices to be combined into one distributed system, moving into a modular multi-level conversion topology. The proposed article also considers that the use of a proportional-resonant regulator will abandon the use of phase-locked loop frequency and, in turn, simplify the control system to ensure the flexibility and ability for operation in any network configuration. The present article considers a 10 kW power plant model for a standard 220V power supply voltage [12].

Summary

Various maximum power point tracking techniques are discussed for solar PV energy conversion systems in this review article. Many types of a control algorithm for solar system is discussed. The advantages and disadvantages of the MPPT techniques are explained. The objective of the proposed research work is to find a suitable method for MPPT tracking.

MPPT Techniques

There are various MPPT techniques as explained below;

A. Hill-Climbing Techniques

Many types of MPPT algorithm are available. Some of the popular MPPT schemes are hill climbing method, incremental conductance method, constant voltage control method, modified hill climbing method, system oscillation method and ripple correction method etc. In hill claiming method the duty cycle is continuously perturbed at regular intervals and the resulting voltage, current and then power are obtained. Once the power is obtained, the slope of the PV curve is checked. Based on the positive slope and negative slop of the PV curve the following correction is carried out.

Algorithmic steps

Step 1: Measure the value of voltage and current of solar PV.

Step 2: Set the modulation index m.

Step 3: Calculate the initial power Pm.

Step 4: Increase the value of m.

Step 5: Sense the voltage and current of solar PV.

Step 6: Calculate the modified power Pf.

Step 7: If the change in power is positive, increase m, if it is negative decrease the value of m. If no change the value m is maintained.

Step 8: Repeat step 5.

B. Perturb and Observe

Perturb and Observe method is a most commonly used method for solar energy conversion system. In case of solar PV system the PV output voltage and current are measured two consecutive intervals. The power is calculated for two successive intervals. The change of power to change voltage is calculated dP/dV. Based on the positive and negative values of the slope dP/dV the duty cycle is incremented or decremented. Accordingly the voltage and power are adjusted to the maximum power point. If the slope dP/dV=0, then the maximum power point is reached for the present environmental conditions. This is a continuous process.

Algorithmic steps:

Step 1: Measure the two consecutive values of voltages and currents of solace PV.

Step 2: Calculate the powers P(n) and P(n-1).

Step 3: If the powers are increasing, then decrease the duty cycle.

Step 4: If the powers are decreasing, then increase the duty cycle.

Step 5: Go to step 1.

C. Incremental Conductance

The incremental conductance method is to determine the terminal voltage of the PV module by measuring and comparing the incremental conductance with the instantaneous conductance. The maximum power is reached when the incremental conductance is equal to the instantaneous conductance. The terminal voltage of the PV module is continuously perturbed at regular intervals until the incremental conductance is equal to the instantaneous conductance. This is represented in the following equation (Ting-Chung & Yu-Cheng 2012).

Algorithmic steps

Step 1: Sense the two consecutive voltages and current of solar PV

Step 2: Calculate the dI/dV.

Step 3: If dI/dV>0, the operating point is in the left of MPP. Increment the voltage.

Step 4: If dI/dV<0, the operating point is in the right of MPP. Decrement the voltage.

Step 5: Go to step 1.

D. Fuzzy Logic Control

Over the past decade, fuzzy logic controls have become more popular because they can handle inaccurate inputs, do not require accurate mathematical models, and tolerate inequalities. A single microcomputer contributes to the information of fuzzy logic controls. Fuzzy logic consists of 3 stages: development, system thinking, and destruction. Fuzzification involves the procedure of transforming a digital entry into a language change depending on the level of membership in a particular group. The member function (as in Figure 4) is used to associate a priority with each word. The number of member jobs depends on the precision of the monitor but often varies between 5 and 7 .In fig. 3.4, seven odd levels are used: NB (significant negative), NM (negative medium), NS (small negative), ZE (zero), PS (small positive), PM (moderately positive), and PB (great bad). The values a, b, and c are based on the mean of numerical values. In some cases, the function of members is not very symmetric and has even been validated for application to obtain accurate accuracy.

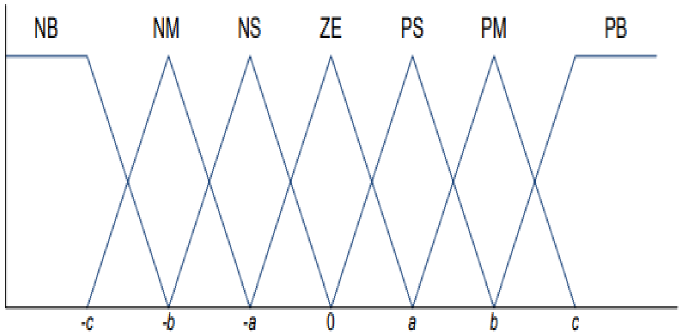

Figure 4: Membership Functions

E. Neural Networks

Another MPPT strategy truly appropriate for microcontrollers is the earphone network [8]. They have fluffy rationale and have a place with what is designated "delicate registering." The most straightforward illustration of a neural organization has three layers: an info layer, a secret layer, and a yield layer, as displayed in Figure 5. More intricate NN develops add more secret layers. The quantity of layers and hubs in each layer and the activities utilized by each layer will be unique and rely upon the information on the client. The application factors can be various principles, climatic information, or a mix thereof. The yield is generally at least one signs, for example, heading cycles or DC transport input voltage.

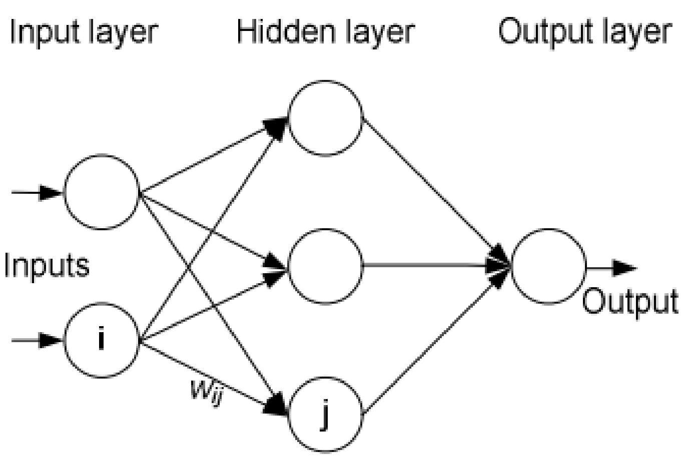

Figure 5: Neural Network

Results and discussion

After discussing about the various MPPT techniques, we have concluded that, MPP tracker plays a very important role for getting maximum output from the photovoltaic system. Perturb and observe MPPT technique having various advantages as compare to other MPPT techniques on the behalf of parameters as more voltage, current and getting MPP in the lesser period. As in case of SPV system, MPPT techniques can be employed in wind power system or solar wind hybrid power system. By using the MPPT techniques in case of wind system, maximum output can be drawn.

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