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Maximum Power Point Tracking Control Method of Photovoltaic Cell under Shadow Influence

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Abstract

In view of the poor effect of battery power tracking control in the current solar power generation system, the maximum power point tracking (MPPT) control method of photovoltaic cell under the influence of shadow is proposed. The MPPT control method of photovoltaic cell is optimized by using the influence of shadow, the structural characteristics of photovoltaic cell are optimized, and the voltage rise and fall DC / DC conversion circuit is adopted, The maximum power identification algorithm of photovoltaic cells is set, and the voltage disturbance method is used to realize the MPPT, so that the solar photovoltaic cells always maintain the maximum power output, so as to ensure the control effect. Finally, the experiment shows that the MPPT control method of photovoltaic cells has high practicability and fully meets the research requirements.

Keywords: shadow effect; Photovoltaic cells; Maximum power; Tracking control

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1. Introduction

The increasingly severe energy crisis and environmental problems make people constantly explore new energy. Solar energy is one of the most environmentally friendly, abundant and easy to use directly, and is widely used in various ways.

One efficient method of utilizing solar energy is through photovoltaic power generating, which has become a research hotspot[1]. Solar energy is the most direct clean energy available to mankind. It is pollution-free, noise-free, inexhaustible and inexhaustible, ambient temperature, sunlight level and other elements[2]. The output voltage and current of solar photovoltaic cells change greatly, which makes the output power unstable and reduces the efficiency of photovoltaic system. Therefore, how to further improve the conversion efficiency of solar cells and make full use of the energy converted by photovoltaic arrays has always been an important topic in the research into solar photovoltaic power generation system[3]. The output characteristics of solar cells are analyzed, the control principle and control algorithm of MPPT are studied, and the maximum power tracking controller of solar power generation is designed and manufactured. The controller uses microcontroller to realize the tracking control of maximum power point, which effectively improves the output efficiency of solar cells.

2. MPPT control of photovoltaic cells

2.1. Stryctural characteristics of photovoltaic cells

The solar generation system is known as the prototype system of solar power generation, refers to the photovoltaic power generation system for users,as shown in figure 1. This system is mostly used for offshore lighthouses, buoys and wireless relay stations on the top of the mountain away from the urban area[4]. The transition of solar generation into large-scale commercial electricity and its integration with the electrical industry is a critical direction.[5]

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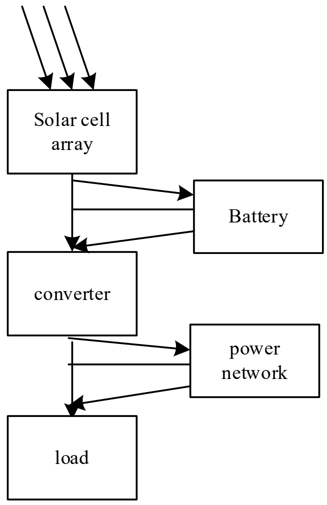

Figure 1. Basic structure of photovoltaic power generation system

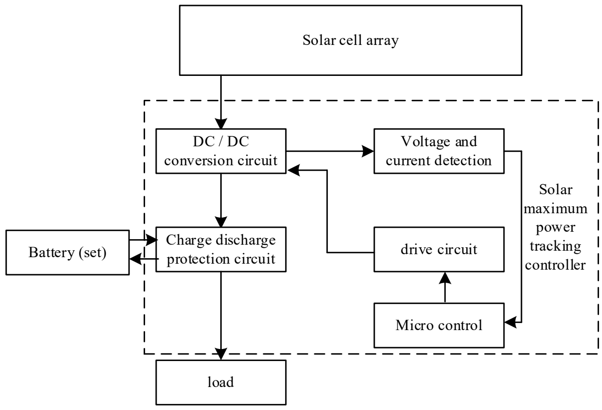

Figure 2. Solar power generation system with high power tracking control function

There is an interconnected relationship between battery (Group) and solar cell array, so the following three situations are very likely to occur. Firstly, when the solar cell array has not operated at the maximum power point, its output voltage and current are very unstable, and the system output power cannot achieve the maximum value, which consumes local energy and reduces the overall output benefit of the device[6]. Currently, the local energy is lost, and the overall output benefit of the corresponding solar cell is reduced. Third, when external factors or light intensity are changed, the overall output current and output voltage of the solar photovoltaic cell array will be unstable. In this way, the charging current corresponding to the battery will fluctuate, which will have a serious impact on the application time of the battery[7]. To address the issues mentioned above, we add the MPPT control equipment between the battery (Group) and the solar cell array. The actual value of the overall output voltage for the solar cell array collected can be realized. Compared with the corresponding voltage changes before and after, the operation position can be changed until the system realizes the maximum power point, which can successfully enhance the overall output benefit of the solar cell[8]. Meanwhile, it can also supply the automatic management performance of many systems such as overcharge, over discharge and anti reverse charge for the battery, and the application time of using the battery is greatly enhanced. The solar photovoltaic power generation system with maximum power tracking control performance is shown in the figure 2 below.

It can be seen from the above figure that most of the battery (Group), load and solar maximum power tracking control equipment[9]. Among them, the performance of battery (Group), solar cell array and load has been described in detail above. Energy conversion equipment refers to solar cell array, while energy storage equipment refers to battery (Group). The instrument for tracking solar maximum power is one of the essential components of this system, which is composed of a large number of scattered circuit units such as voltage and current detection circuit, DC / DC conversion circuit, microcontroller, driving circuit and charge discharge maintenance circuit[10]. Compared with the information collected in the previous time, the microcontroller will have pulse width adjustment signal output, Through this adjustment signal, the driving circuit continues to be controlled[11]. Among them, the charge discharge maintenance circuit can timely detect the terminal voltage of the battery (Group). When the battery is overcharged, this circuit can quickly close the system input circuit; During the over discharge event of the battery, this circuit can close the system output circuit in time, and has the performance of preventing reverse charging, which can effectively enhance the application time of the battery (Group). The output characteristics of solar cells are nonlinear and impacted by numerous outside variables, the main factors are light intensity and ambient temperature. The volt ampere characteristic curve of solar cell is shown in the figure 3, 4.

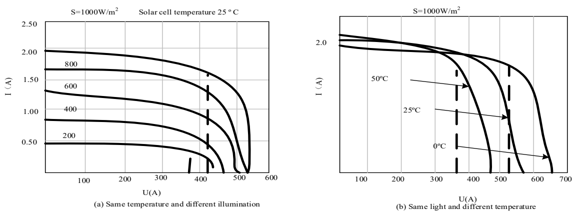

Figure 3. U-I characteristic curve of solar cell under the influence of shadow

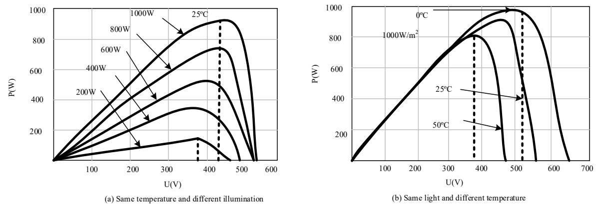

Figure 4. P-U characteristic curve of solar cell under the influence of shadow

The solar cell cannot provide a steady current or voltage. It is a nonlinear DC power supply. Within the majority of the working voltage range, its output current is rather stable.[12]. After passing the current corresponding to the maximum power point, the current decreases rapidly with the increase of voltage. If the solar cell is directly matched with the load, the following problems may occur [13]. Figure 5 displays the block diagram of the solar generation system with the MPPT function.

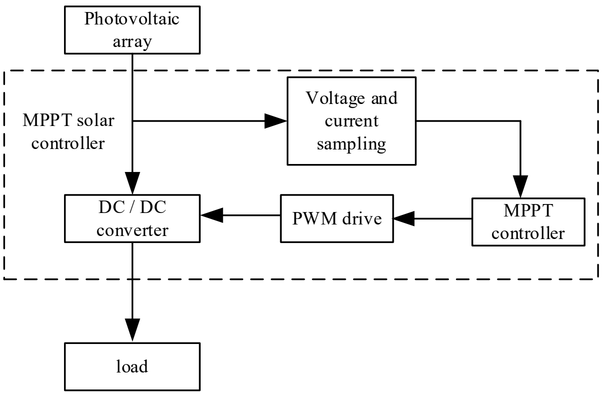

Figure 5. Solar power generation system with MPPT function

To increase the efficiency of solar power generation, it is necessary to track the maximum power point of solar cells[14]. The solar photovoltaic power generation system is mainly composed of photovoltaic panel, solar controller, battery and load[15]. The solar controller is the core part of the whole system, which mainly completes the functions of MPPT, battery charging, load power supply and battery protection[16]. Its performance directly determines the performance of the whole photovoltaic system. The system block diagram is shown in the figure 6 below.

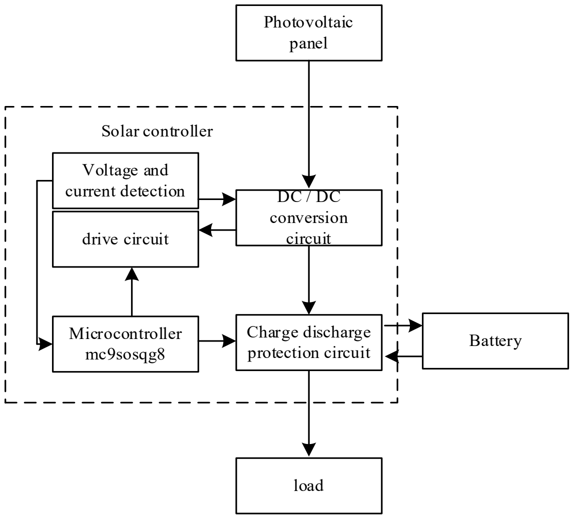

Figure 6. Block diagram of solar power generation control system

The solar controller includes voltage and current detector, DC/DC converter circuit, microcontroller, charge and discharge protection circuit, driving circuit and other circuit units[17]. The controller adopts a low-power and high-performance 8-bit microcontroller MC9S08QG8. The analog signal collected by the voltage and current detection circuit is sent to the microcontroller through the A / D port for analysis and calculation[18]. The microcontroller outputs PWM pulse control signal through the driving circuit to regulate the on-off of the internal switch of the DC / DC conversion circuit to control the output voltage and current of the conversion circuit[19]. In order to prevent overcharging or discharge of the battery, the controller may also detect the battery's terminal voltage in real time.

2.2. MPPT and recognition algorithm of photovoltaic cells under shadow influence

According to the fact that the working voltage at the maximum output power point of solar cells changes very little when the light intensity is high, the earliest maximum power tracking control method, that is, the fixed voltage tracking method, came into being[20]. This control method can be realized as long as the output voltage of the solar cell is clamped at the set voltage. It has the advantages of simple control and easy implementation, and this simple method makes its operation stable and reliable. However, the light intensity of the external environment C_1 is not always stable under a certain light intensity, but changes from time to time, and the output characteristics of solar cells are also affected by temperature, so this control method can not track the maximum power point of solar cells in real time. The mathematical model of photovoltaic array can be expressed as:

$$I = I_{sc}\left(1 - C_1\left(\left[\frac{V-\Delta V}{e}\right]^{\frac{C_2 V_{OC}}{2}} - 1\right)\right) + \Delta I \qquad (1)$$

Where:

$$\Delta I = \alpha \frac{R}{R_{ref}} \Delta T + \left(\frac{R}{R_{ref}} - 1\right) I_{sc} \qquad (2)$$

$$\Delta V = -\beta \Delta T - R_S \Delta I \qquad (3)$$

The reference conditions are defined as shadow influence intensity R_{ref} = 1kW / m2, battery temperature ΔT = 25 °C, ISC is the short-circuit current under the reference conditions, and $C_2 V_{OC}$ is the open circuit voltage under the reference conditions; α is temperature coefficient of current variation under reference sunlight (A / °C); β is the temperature coefficient of voltage change under reference sunlight (V / °C); RS is the series resistance of photovoltaic module. C1, C2 and TC can be expressed as:

$$C_1 = \left(1 - \frac{I_m}{I_{sc}}\right) e^{-\frac{V_m}{C_2 V_{OC}}} \qquad (4)$$

$$C_2 = \left(\frac{V_m}{V_{OC}} - 1\right) \ln^{-1}\left(1 - \frac{I_m}{I_{sc}}\right) \qquad (5)$$

$$T_c = T_a + t_c R \qquad (6)$$

Where I_m and V_m are the corresponding current and voltage at the maximum power point; I_{sc} is the shadow influence intensity (w / m2); V_m is the ambient temperature (°C); U is the temperature coefficient of photovoltaic cell module. Generally speaking, the output characteristics of a single panel constituting a photovoltaic array can be obtained by superposition. According to the formula, it can be assumed that the scale of photovoltaic array is V_{OC}, where N is the number of series, that is, the number of photovoltaic cells in each series branch; M is the number of parallel, that is, the number of series branches connected in parallel in the photovoltaic array. Then the relevant parameters of the photovoltaic array can be obtained, as shown in the formula:

$$\begin{cases} I_A = M \times I \\ I_{scA} = M \times I_{sc} \end{cases} \qquad (7)$$

$$\begin{cases} U_A = N \times U \\ U_{ocA} = N \times U_{oc} \end{cases} \qquad (8)$$

$$R_{sA} = N / M \times R_s \qquad (9)$$

Where: I_A stands for photovoltaic array "array"; R_{sA} and U_A are the output current and output voltage of the photovoltaic array respectively; q and k are the short-circuit current and open circuit voltage of the photovoltaic array respectively; TN is the series equivalent resistance of the photovoltaic array. Generally, the output characteristic expression of photovoltaic array is:

$$I_A = I_{scA} - \frac{I_{scA}}{\exp\left(\frac{qU_{oc}}{kTN}\right)\left\{\exp\left[\frac{q(U_A + R_{sA} I_A)}{nkTN}\right] - 1\right\}} \qquad (10)$$

Under the condition of local shadow, the output characteristics of photovoltaic array are:

$$I_A = \sum_{x=1}^{M} I_{Ax} = \sum_{x=1}^{M} I_{scAx} \cdot \left\{1 - \exp\left[\frac{q(U_A + R_{sAr} I_{Ax} - U_{ocAx})}{nkTN(M - N_{Dx})}\right]\right\} \qquad (11)$$

Where: I_{scAx} is the number of photovoltaic cells in series; N_{Dx} is the number of shaded batteries. Photovoltaic cells are devices that convert solar energy into electrical energy. U_{ocAx} is the equivalent circuit diagram of photovoltaic cell is shown in the figure 7.

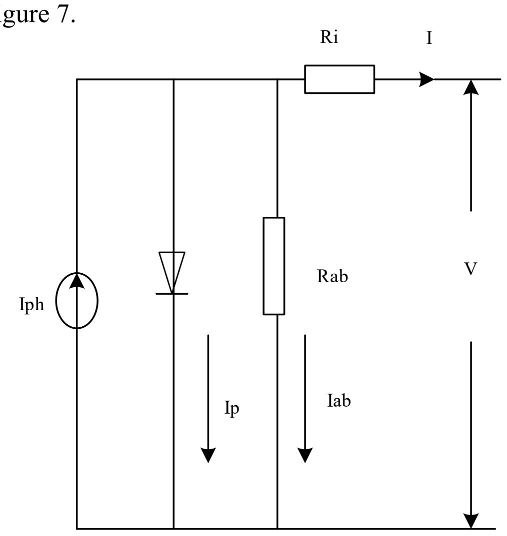

Figure 7. Equivalent circuit diagram of photovoltaic cell

According to the theory of electronics, the equivalent mathematical model of photovoltaic cell is:

$$I = I_{ph} - I_0\left(\exp\frac{q\left(V + I^* R_s\right)}{AKT} - 1\right) - \frac{V + I^* R_s}{R_{si}} \qquad (12)$$

Through some approximation and resolution steps, the single exponential mathematical model of photovoltaic cell is:

$$I_0 = I_{SC}\{1 - C_1[\exp(V / C_2 V_\alpha - 1)]\} \qquad (13)$$

In general, there is only one maximum power point in the output characteristic curve of photovoltaic cells, if $\frac{dP}{dU}$. The judgment of the maximum power point is as follows. When UI = 0, at the maximum power point, $\frac{dI}{dU}$ > 0, at the left of the maximum power point, $\frac{d(UI)}{dU} < 0$, at the right of the maximum power point. The formula is obtained by transforming DP / Du:

$$\frac{dP}{dU} = \frac{d(UI)}{dU} = I + U\frac{dI}{dU} \tag{14}$$

$$\frac{I}{U} + \frac{U}{U}\cdot\frac{dI}{dU} = G + dG \tag{15}$$

From the formula, we can judge whether the point on the characteristic curve of photovoltaic cells is the maximum power point by judging the symbol of the sum of conductance and its variation. This method is also called conductance increment method. The relationship between output current and voltage of photovoltaic array is:

$$I = N_{\mathrm{p}} I_{\mathrm{ph}} - N_{\mathrm{p}} I_{\mathrm{s}} \left(e^{\frac{q}{AkT}\left(\frac{V}{N_s}\frac{TR_1}{N_{\mathrm{p}}}\right)} - 1 \right) - \frac{N_{\mathrm{p}}}{R_{\mathrm{sh}}}\left(\frac{V}{N_{\mathrm{s}}} + \frac{IR_{\mathrm{s}}}{N_{\mathrm{p}}}\right) \tag{16}$$

Where, the number of photovoltaic cells in series is N_p and the number of photovoltaic cells in parallel is IR_S Since the V value and e value are relatively large, I_{ph} is the ripple current flowing through the inductor is very small, and the voltage above the load will also change very little. Ideal treatment is done here, that is, when the circuit works, the current flowing through the inductor remains unchanged, and the voltage at the load end remains unchanged, then the stored energy and released energy of the inductor are equal 3536 in one cycle of switching on and off of the switching device, If the on time of the switching device is U_0, the off time is I_L, and the cycle U is the sum of T_1 and T_2, then:

$$UI_L T_1 = (U_0 - U) I_L T_2 \tag{17}$$

Simplification can result in:

$$U_0 = \frac{T_1 + T_2}{T_2} U \tag{18}$$

The calculation formula of duty cycle D is as follows:

$$D = \frac{T_1}{T_1 + T_2} \tag{19}$$

The sum of T1 and T2 is greater than T2, so the load terminal voltage is higher than the power supply voltage, which is also the reason why the circuit is called boost circuit. In practical application, because the values of inductance and capacitance cannot be infinite, the ripple on the inductance cannot be infinitely small, and the load terminal voltage cannot remain unchanged. However, as long as the values of inductance and capacitance are large enough and generally greater than the critical value calculated by the actual circuit, then the current on the inductor and the voltage at the load end will change very little. In the actual photovoltaic power generation system, a single photovoltaic cell needs to be connected in series and parallel to form a photovoltaic array for power generation, so as to meet the requirements of output voltage and output power of the power generation system.

2.3. Realization of MPPT control for photovoltaic cells

The fundamentals of solar photovoltaic cell power generation is based on the photoelectricity principle of semiconductor materials. This principle of photoelectricity is mainly based on the internal diffusion of semiconductor materials, that is, the diffusion of electrons and holes between N region with high electron density and P region with high hole density, which will form PN junction. When the surface of this material is radiated by the sun, part of the valence electrons of its internal atoms will be affected by the radiation energy, resulting in some electron hole pairs in a non-equilibrium state. At this time, from the external point of view, an electric field opposite to the original PN junction electric field direction is formed. If the load is connected, electric energy can be supplied to the load. In order to study the electrical characteristics of bypass diode in the circuit, when local shadows are generated. The series structure of the two photovoltaic cells is shown in the figure 8, set the two parameters to be consistent.

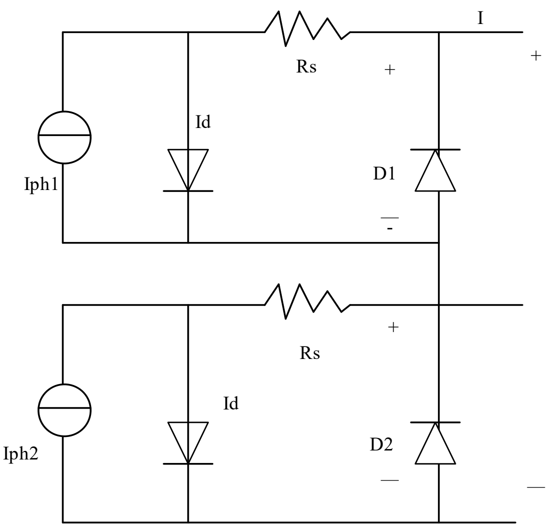

Figure 8. Series equivalent circuit diagram of photovoltaic cells

As shown in the figure, the bypass diodes of two photovoltaic cells. The photovoltaic cell module works under the following two conditions: when the light is uniform, that is, when the two photovoltaic cells are exposed to the same light, the photogenerated current U_b = m2, and the bypass diodes D1 and D2 are not connected. At this time, the output IU characteristic curve is single knee, and the ph characteristic curve has only one peak point. When the photovoltaic cell module 2 is shaded and the light intensity is lower than that of the cell module 1, according to its output characteristics, the photogenerated current $\frac{nkT}{q}$ at this time will turn on the bypass diode D2 of the cell module 2. At this stage, module 2 exits the power supply. At this time, the output characteristics of photovoltaic cell module, that is, the output characteristics of module 1.

$$U_1 = \frac{nkT}{q}\ln\left(\frac{I_{ph1}-I}{I_0}+1\right) - U_b - IR_s I_{ph2} < I < I_{ph1} \tag{20}$$

Where U_1 is the bypass diode voltage, generally taken as 0.7V. With the increasing load, the output current gradually decreases until the output current of the circuit is less than the photogenerated current of photovoltaic module 2. The bypass diode U_2 of battery module 2 is turned off. At this stage, battery module 2 and battery module 1 jointly output power. The system output characteristics are as follows:

$$U = U_1 + U_2 \tag{21}$$

$$U = \frac{nkT}{q}\ln\left(\frac{I_{ph1}-I}{I_0}+1\right) + \frac{nkT}{q}\ln\left(\frac{I_{ph2}-I}{I_0}+1\right) - 2IR_s < I < I_{ph2} \tag{22}$$

To sum up, the IU characteristics of the two photovoltaic cells are changed due to the addition of bypass diode in the system. When the bypass diode is on and off, the multimodal mathematical model expression of the system is obtained according to P = U:

$$P = \begin{cases} \frac{nkTI}{q}\ln\left(\frac{I_{ph1}-I}{I_0}+1\right) - IU_b - I^2R_s I_{ph2} < I < I_{ph1} \\ \frac{nkTI}{q}\ln\left(\frac{I_{ph1}-I}{I_0}+1\right) + \frac{nkTI}{q}\ln\left(\frac{I_{ph2}-I}{I_0}+1\right) - 2I^2R_s < I < I_{ph2} \end{cases} \tag{23}$$

The table 1 shows the different light intensities received by five series photovoltaic cells. Shadow case 1 to shadow case 4 respectively indicate that 1 to 4 photovoltaic cells are shaded to varying degrees.

Table 1. The different light intensities received by five series photovoltaic cells

Illumination	First battery	Second battery	Third battery	Fourth battery	Fifth battery
No shadow	1000W/m^2	1000W/m^2	1000W/m^2	1000W/m^2	1000W/m^2
Case 1	1000W/m^2	1000W/m^2	1000W/m^2	1000W/m^2	800W/m^2
Case 2	1000W/m^2	1000W/m^2	1000W/m^2	800 W/m^2	600W/m^2
Case 3	1000W/m^2	1000W/m^2	800W/m^2	600 W/m^2	400W/m^2
Case 4	1000W/m^2	800W/m^2	600W/m^2	400 W/m^2	200W/m^2

In the photovoltaic system, the inverter converts the DC output electric energy of solar cells into AC. For photovoltaic power generation systems that need to supply power to AC loads or feed electric energy to AC power grid, inverter has become an indispensable and important part of the system. At present, it is mainly used in power supply systems such as families and villages with AC power supply, and there are two categories of inverters used in communication base stations, troops, railway communication, signal and field places where the power grid cannot be extended, namely, independent operation of inverter and grid connected inverter. At present, almost all photovoltaic power generation systems in China are independent operation systems, using independent inverter. The grid connected inverter feeds back the power generated by the solar cells to the power grid to the greatest extent through the internal power regulator. The main performance characteristics of the grid connected photovoltaic inverter include: pulse width modulation, vector control, photovoltaic module MPPT technology (MPPT), night zero power consumption technology, perfect protection function, etc. Table 2 gives the technical indexes of various types of inverters.

Table 2. Technical indexes of inverter

Technical characteristics	Square wave inverter	Sine wave inverter	Grid connected inverter
Power range	100-900VA	1-200KVA	1KW-400KW
Phase number	Single-phase	Single phase or three phase	1-6kw single phase, 10-400kw three phase
Wave form	Square wave	Sine wave	The current waveform is sine wave
Resistive load efficiency	70%-80%	75%-90%	More than 90%
Protection function	Undervoltage and overvoltage protection, overcurrent and short circuit protection	Undervoltage and overvoltage protection, overcurrent and short circuit protection	Undervoltage, overvoltage, underfrequency, overfrequency and overheating protection
Application occasion	Low power user factor	High power system and power station	Photovoltaic buildings and large grid connected power stations

Grid photovoltaic power generation system includes building photovoltaic system (BIPV), ground photovoltaic system (including saline alkali land, desert, large desert photovoltaic power station, etc.) and grid connected photovoltaic system. The photovoltaic grid connected power generation system discussed in this paper is to convert the DC generated by solar cells into 220V AC through inverter and connect it to commercial power grid. Based on this, the management steps of photovoltaic cell power tracking control are optimized, as shown in the following figure 9:

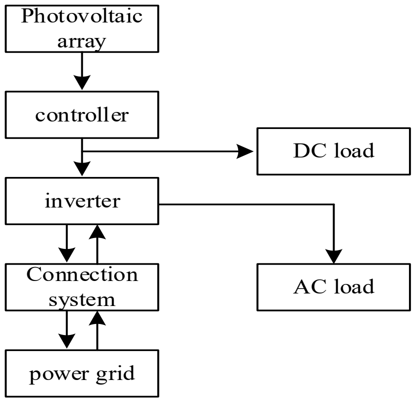

Figure 9. Photovoltaic cell power tracking control management steps

As an indispensable key component in photovoltaic system, the characteristic performance of solar cell has a very important impact on the whole system. Analyzing the characteristics of solar cells and understanding their electrical characteristics is a necessary step in the development of a photovoltaic system. It is a solid-state device that directly converts light energy into electric energy by using the electronic properties of semiconductor materials. It occupies an extremely important position in photovoltaic power generation. Its research is one of the most potential research topics in the utilization of solar energy. The volt ampere characteristics of solar cells are affected by ambient temperature and sunlight irradiance.

3. Analysis of experimental results

The voltage Hall sensor needs to be connected with current limiting resistor in series on the primary side in order to make the input current signal on the primary side within its rated working current range. The output current signal will become a voltage signal after passing through the sampling resistance, and then pass through a voltage follower after filtering. This design can isolate and enhance the driving ability, so that the sampling circuit has a certain anti-interference ability. The voltage Hall sensor used in the experimental device is tbv10 / 25A, and its parameters are shown in the table 3:

Table 3. Hall sensor parameters

Parameter name	Parameter value	Company
Rated input RMS current	12	mA
Measuring current range	15	mA
Measuring resistance	100(min) 350(max)	Ω
Rated output RMS current	25±0.6%	mA
Supply voltage	±1.6	V
Turn ratio	2500:1000	-
Zero current offset	±0.2	mA
Current offset temperature drift	-40ºC~+85ºC±0.5	mA
Response time	50	µs
Linearity	≤0.3	%FS
Insulation voltage	50HZ,1min 2.5	kV
Primary coil resistance	220	Ω
Secondary coil resistance	120	Ω
Working temperature	-50~+90	ºC
Storage temperature	-50~+130	ºC

A photovoltaic cell is connected to a continuously adjustable pure resistive load, and its output u-p characteristic curve is shown in the figure 10 under the conditions of ambient temperature of about 30 ℃ and different light intensity. The output curve characteristics are consistent with the previous analysis.

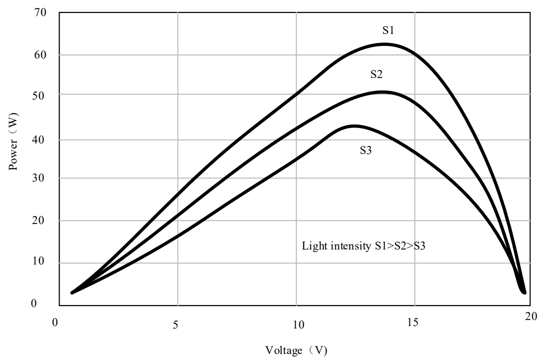

Figure 10. Measured Pu curve of photovoltaic cell

The experiment uses a photovoltaic cell, cover the fixed area on the surface of the photovoltaic cell with gauze, measure and record the maximum power output point of the photovoltaic cell. Then, the conventional adaptive algorithm and the improved algorithm proposed in this paper are used to start the MPPT to simulate the sudden change of light intensity by removing the masking gauze. In the removal process, the conventional adaptive algorithm and the improved algorithm proposed in this paper are used for maximum power tracking. The maximum power tracking circuit commonly used in photovoltaic power generation system achieves the optimal working point of the system by adjusting the output voltage of the system. Its main circuit and control structure are shown in the figure 11.

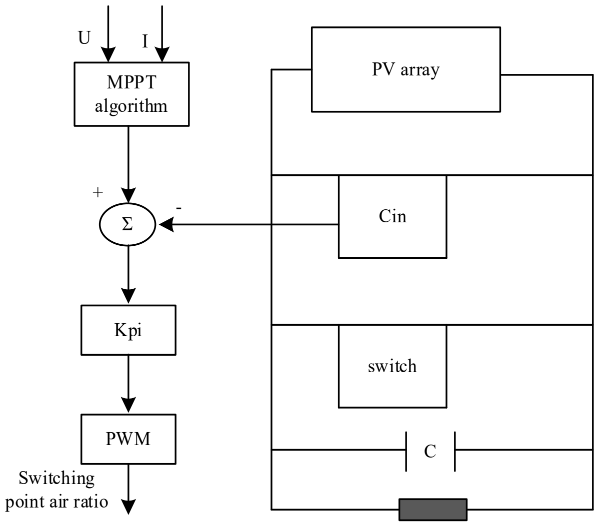

Figure 11. Main circuit diagram of maximum power tracking control

The improved disturbance observation method is used to track and control the maximum power point of solar cells. The output voltage of solar panels is measured under different light intensities. The voltage values are shown in the table 4 below.

Table 4. Control output voltage values of solar cells under different light intensities

Light intensity/(W/ m^2)	50	100	150	200	250
Output voltage/V	8.96~ 10.03	9.40~ 10.58	9.76~ 10.93	10.17 ~11.39	10.28 ~11.47

It can be seen from the table that the output voltage of the solar panel changes within a certain range, which is precisely because the MPPT controller is constantly searching for the maximum power point by using the improved disturbance observation algorithm. In order to verify the effect of maximum power tracking control on improving the output efficiency of solar cells, comparative experiments are carried out: solar cells are directly connected to the battery to charge the battery; The solar cell charges the battery through the maximum power tracking controller. When the ambient temperature remains unchanged and the light intensity changes, measure the charging current of the solar cell to the battery under two different charging modes, as shown in the table 5 below.

Table 5. Main parameters of battery test

	Voc	Isc	Rs	Rsh	FF	Eff	Irev2
A	0.615	7.99	0.0029	70.0	77.23	15.52	0.59
B	0.615	7.97	0.0029	75.7	77.49	15.55	0.56
C	0.615	7.89	0.0027	79.6	77.53	45.52	0.43
D	0.615	8.01	0.0030	60.7	76.85	15.49	0.53
E	0.618	8.06	0.0033	44.8	76.52	15.55	0.73

A PWM converter is used to connect the photovoltaic array and the load, and the step size of the duty cycle is adjusted through a reasonable MPPT optimization algorithm to enable the system to operate at its maximum power point. In order to verify the rapidity of this algorithm, the research group has built an experimental platform for the MPPT control of photovoltaic array. The control signal is generated by RT-LAB real-time simulation device. The whole system can be simulated in real time and tested with external circuit. The initial state of the simulation is that the solar radiation intensity r = 430W / m2 and the battery temperature Tc = 36 ℃, and the initial duty cycle of the switching device is 0.5. When the simulation time is 1s, the solar radiation intensity suddenly decreases by 5%, and then remains unchanged for 1s. When the simulation time is 2S, the solar radiation intensity slowly rises to the initial intensity and remains stable, and the rise time is 0.5s. The variation curve of environmental parameters and the power output curve of maximum power tracking control simulation realized in this paper are shown in the figure 12.

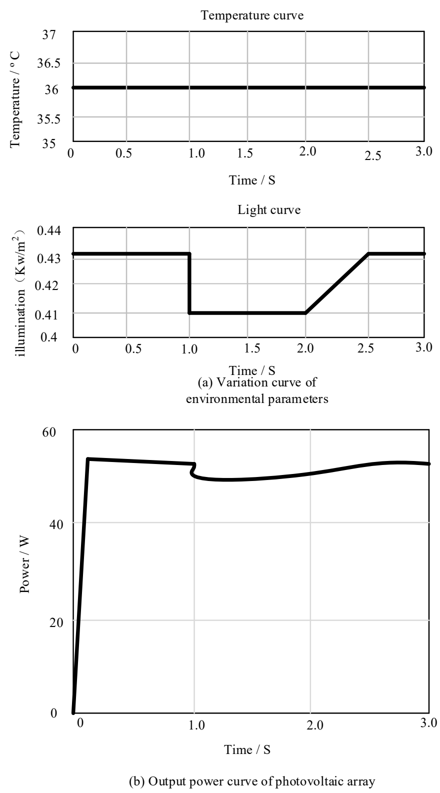

Figure 12. Simulation results of fuzzy control of photovoltaic cells

Figure a shows the change curve of environmental parameters, and figure B adopts the power output curve in this paper. The results of comparative simulation using disturbance observation method, basic fuzzy control method and this method are shown in the figure 13.

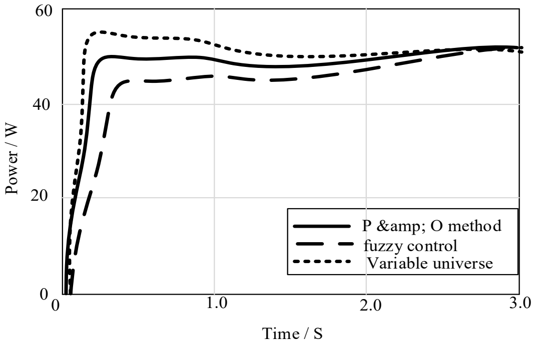

Figure 13. Comparison of photovoltaic cell power curves of three methods

The PV array output characteristics of the algorithm when the environmental conditions change are shown in the figure 14.

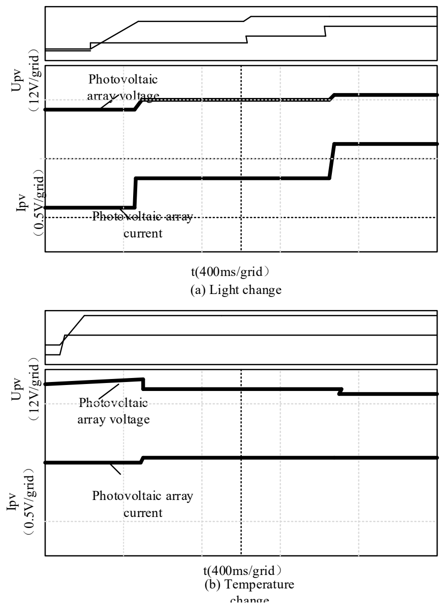

Figure 14. Experimental results of photovoltaic cell control method under environmental changes

Furthermore, the maximum power tracking results of the proposed method and the traditional mountain climbing method under local shadow are shown in figure 15.

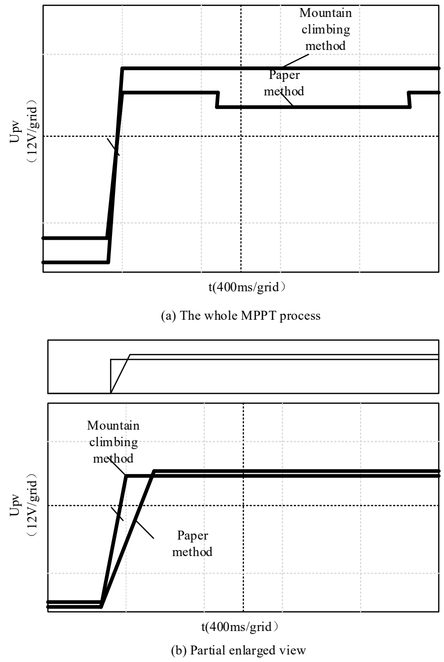

Figure 15. Comparison of control performance experimental results between traditional method and this method under local shadow

The experimental findings demonstrate that the embedded PV optimizer can regulate the energy output under mismatched illumination, and make all photovoltaic cells work at their maximum power points. Compared with the dispersed MPPT control structure, the unified MPPT control method proposed in this paper simplifies the system structure, reduces the cost and makes the control more simple and feasible on the premise of ensuring the output power.

4. Conclusion

The MPPT control method of photovoltaic cell under shadow impact was applied to ehance the power tracking control performance in solar power generation system. The control effect of consistently maintaining the maximum power output for the photovoltaic cell was successfully ensured by the optimization of photovoltaic cell structural, the adoption of voltage rise and fall DC/DC conversion circuit, the setting of maximum power identification algorithm and the utilization of voltage disturbance method. The MPPT and recognition algorithm of photovoltaic cells under shadow influence was investigated systematically, and the experimental results indicated that our method could effectively guarantee output power while simplifying the system structure, cutting costs, and improving controllability. As a result, our research demonstrated that the MPPT control method for photovoltaic cells was highly feasible and satisfied the research specifications.

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