Analysis of PV Array and MPPT Algorithm

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Abstract : The performance of photovoltaic (PV) arrays is affected by temperature, solar isolation, and shadows. And array configuration. Normally, the PV array will be obscured by the passing clouds, completely or partially obscured. Adjacent buildings and towers, trees, electricity and utility poles. Under partial shadow conditions, The PV characteristics of multiple peaks become more complex. However, understanding and forecasting are very important they are meant to extract the greatest possible power. Residue in a typical series wiring scheme The energy generated by the partially shielded battery can neither be collected (if the diode is bypassed) or worse, hindered Collect electricity from the remaining fully illuminated battery (if there is no bypass). Rapid fluctuation of shadow Mode makes it difficult to track the maximum power point (MPP); in general, there will be multiple local MPPs. Their values change as quickly as lighting.

Keyword- Photovoltaic, PV Array, Diode, Maximum Power Point, Maximum Power Point (MPP)

1. Introduction

The first photovoltaic cell was developed in 1954 by researchers at Bell Phone. Since the late 1950s, photovoltaic cells have been used to operate US space satellites. In the late 1970s, photovoltaic panels provided electricity at remote locations or outside the grid without power lines. Since 2004, most of the photovoltaic panels in the United States have been in networked systems in homes, buildings and power plants at the Central Station. Technological advances, low PV costs, various fiscal incentives and government policies have helped to expand the use of PV power dramatically since the mid-1990s. Hundreds of thousands of networked PV systems are now installed in the United States.

The United States Energy Information Administration (UIA) estimates that electricity generation in public-utility photovoltaic plants has increased from 76 million kilowatt-hours in 2008 to 63 billion kilowatt hours per year. The public has a generating capacity of at least 1,000 kW (or one megawatt). Environmental impact assessment estimates that in 2018, 30 billion kilowatt-hours were generated in photovoltaic systems connected to the small grid, compared with 11 billion kilowatts in 2014.

1.2 Applications of photovoltaic systems

Small PV systems use calculators and wristwatches. Larger systems can provide electricity to pump water, supply power equipment, supply electricity to one home or business, or create large groups that provide electricity to thousands of consumers.

1.3 How photovoltaic systems operate

Photovoltaic cell is the main component of the photoelectric system. Individual cells can vary in size from about 0.5 inches to about 4 inches in width. However, the cell produces only 1 or 2 watts, which is enough electricity for small uses only, such as calculators or wrist watches.

The photoelectric cells are electrically connected to the unit or the panel is electrically charged and packed. PV units vary in size and amount of electricity that can be produced. The power generation power of the photovoltaic unit increases with the number of cells in the unit or on the unit surface. The photovoltaic modules can be connected in groups to form a light matrix. The PV module can consist of two or hundreds of photovoltaic modules. The amount of photovoltaic units connected to the photovoltaic matrix determines the total amount of electricity that can be produced by the matrix.

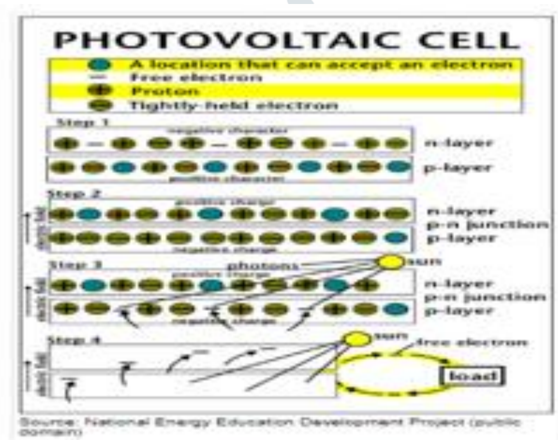

Fig 1. Photovoltaic cell

Photovoltaic cells generate direct current (DC). DC power can be used to charge batteries, which in turn use power devices that use direct electricity. Almost all electricity is supplied by AC (AC) in electrical transmission and distribution systems. Devices called transformers are used in optical units or arrays to convert DC power to AC power.

The cells and photovoltaic units will produce as much electricity as they face the sun directly. Photovoltaic modules and arrays can use tracking systems that move units to meet the sun continuously, but these systems are expensive. Most photovoltaic systems contain units in fixed mode with units directed directly to the south (in the northern hemisphere, just north of the southern hemisphere) and in a corner that improves the physical and economic functioning of the system.

1.4 The flow of electricity

The movement of electrons, each with a negative charge, towards the front surface of the cell leads to an electrical charge defect between the front and rear surfaces of the cell. This imbalance, in turn, creates effort voltage such as positive and negative terminals of the battery. The electrical conductors of the cell absorb electrons. When the connectors are connected to an electric circuit with an external load, such as the battery, the electricity flows into the circuit.

1.4.1 Photovoltaic cells convert sunlight into electricity
Photovoltaic cells (PV), commonly called solar cells, are a non-mechanical device that converts sunlight directly into electricity. Some photovoltaic cells can convert artificial light into electricity.

1.4.2 Photons carry solar energy
Sunlight consists of photons, or solar particles. These photons contain varying amounts of energy that correspond to the different wavelengths of the solar spectrum. The photovoltaic cell consists of a semiconductor material. When photons collide with photovoltaic cells, they can be reflected in the cell, passing through the cell or absorbed by a semiconductor material. Only absorbed photons are the ones that provide energy to generate electricity. When a semiconductor absorbs enough sunlight, the electrons are released from the atoms of the material. Special processing of the material surface during manufacturing makes the front surface of the cell more receptive to the electrons that have been evacuated or free, so that the electrons migrate naturally to the surface of the cell.

1.5 Some advantages of PV systems are
Photovoltaic systems can provide electricity in places where electricity distribution systems (power lines) are not available and can also provide electricity to the electricity grid.

- PV arrays can be quickly installed and can be of any size.
- Optical matrices can be installed quickly and can be of any size
- The environmental effects of photovoltaic systems located in buildings are minimal.

2. Background

1. Mafimidiwo & Saha (2019) study recent research to improve solar power generation and efficiency has led to the study and use of new 3D techniques to achieve these tasks. This article presents the modeling and simulation of a two-dimensional and three-dimensional thermal photovoltaic system to investigate the impact of three-dimensional technology on concentrated PV photovoltaic with similar capacity and materials. The results showed that the performance of the three-dimensional design system is better than modeling in two dimensions in terms of resulting energy output and efficiency. In addition, a piece of points and other simulated plots were obtained on a concentrated thermal photoelectric system of two concentrates and a thermal photovoltaic system of three concentrates. The results obtained showed that the destructive effect of temperature was much lower in the concentrated three-dimensional thermal photoelectric system than the effect of the concentrated two-dimensional thermal photoelectric system.

2. Snegirev et al. (2019) propose the rapid increase in the installed capacity of the solar power plant has great difficulties in operating and controlling the electrical system, due to the highly random nature of solar collection. The document addresses the problem of forecasting the production of the daily solar power plant, based on meteorological data. Optimizing the prediction of solar plant production simplifies the planning of the power system operation mode by integrating market procedures and active allocation of power generation reserves. As a case study, the authors use meteorological data for a truly functioning solar power plant. As a result of regression modeling, the statistical importance of meteorological parameters was analyzed. The optimal mathematical formula for the regression model was presented. In addition, the document provides an idea of the experimental modeling approach, which provides a significant improvement in the accuracy of the prediction.

The results of verification in real data make it possible to decide on the applicability of the methods proposed in the industrial process.

3. Abdulmouti *et al*. (2019) the global demand for electricity is outpacing the energy source. Solar cell energy is an alternative way of generating energy. In this report, the application of new concentrated photovoltaic technology, called the solar field, has been tested. This technique works by collecting solar energy and concentrating in a small area (focal point). Concentrated solar power is capable of generating a large amount of energy that can be used to produce electricity far more than alternative photovoltaic designs. Experiments are conducted for different types of different shapes, sizes and liquids. First, 3 forms are tested: a whole ball, only the upper half of the ball, only the bottom half of the ball. Next, they are compared with regular photovoltaic (PV) cells that have the same area areas. The entire ball with the same material produces approximately three times the output power and four times the output power of the other PV in the same area. Also used are three different spherical sizes: diameter 10 cm in diameter 12 cm in diameter 30 cm. The ball produces a diameter of 12 cm 0.8 times the output power in the diameter of 10 cm, while the ball produced a diameter of 30 cm about 4 times the power output of the field 12 cm. Diameter. The results indicate that increasing the size of the ball results in an increase in the output power. Finally, different materials (solids, liquids, gases) are tested. Solids are glass, crystal and acrylic, while liquids are oil, water, alcohol, and gases used are air. Experiments show that all solids produce the highest output capacity. However, these solids produce high heat at the same time, so they are undesirable to generate electricity. The oil-filled ball produces 1.5 times as much energy as the alcohol-filled ball, while the alcohol-filled ball produces twice as much energy as the water-filled field. The air-filled area had the lowest output power compared to other materials.

4. Hu et al. (2019) This document presents a new strategy for maximum power output (MOPPT) for a double active switch (DAB3) to double the bridge to incorporate large-scale photovoltaic power generation into medium voltage DC networks. The DAB3 adapter is used as a single-stage solution to increase DC voltage levels and track the maximum power point of the PV farm at the same time. To achieve a high weighted average efficiency in a wide range of operation, the spectral induction design and rotation ratio of the transformers are presented to form the DAB3 thin switch area to suit the transformer area. The maximum strengths of photovoltaic panels under certain environmental conditions. To maximize the energy efficiency of the entire PV system, a new MOPPT method was proposed to track the maximum power point of the DAB3 adapter. MOPPT is performed by controlling the closed-loop cascade voltage with PV power compensator to improve dynamic performance. The effectiveness of the proposed control strategy is validated by simulation and experimental verification of a low-volume laboratory prototype.

5. Nour et al. (2019) studied there has been a steady and rapid increase in electric vehicle sales (VE) recently. EVs are shipped from the power system, generally in distribution networks, which is a challenge for distribution networks. This paper presents a study to mitigate the effects of uncontrolled EV load on a low voltage distribution network (LV) that provides commercial consumers. For this, photovoltaic power generation is used decentralized. This study takes into account the current status of the distribution networks as there is no communication infrastructure or advanced measurement infrastructure (AMI) devices in the network, and there is no control center. Therefore, there is no coordination between EV load and optical generation. The adapter load, cable load and voltage profile are checked at the farthest point of the transformer and daily power loss for three operating scenarios. The first scenario is the original case (the basic case) of a low voltage distribution network serving only commercial consumers, and no EV or photovoltaic power is connected. In the second scenario, EVs are connected to the network for charging. In the third scenario, EVs are connected to the network for charging and photovoltaic power is available. The study was conducted using DIgSILENT Power Factory. The 24-hour time simulation series is run with load flow every 15 minutes. The results show that decentralized photovoltaic power generation can mitigate the effects of uncontrolled EV load in a commercial low voltage distribution network.

6. Cui et al. (2019) study of the traditional method of photovoltaic (PV) is based on sufficient historical data (historical power generation data for the photovoltaic power station and meteorological weather forecasting weather data), which is not suitable for the newly created PV power plant. For the calculation of photovoltaic irradiation and photovoltaic power prediction, an actual prediction approach based on solar radiation is proposed on tilted surfaces. This method selects three decomposition models and four transformation models that are integrated into 12 integrated prediction models. In addition, the solar spectral response, the falling angle and the dirt factor are taken into account in the modified model. The results show that the methods that combine the Leo-Jordan switch model have better predictive accuracy in different weather types. Among them, the forecasts of the Erbs + Liu-Jordan model are the most accurate.

7. Faizura Norhasmi et al. (2018) the renewable energy system has become one of the key solutions to overcoming global warming. Because of its availability, reliability and safety, the PV system is of interest to people from all over the world. In addition to reducing electricity bills, this system is also free maintenance. In this document, simulations were performed using the Dig-SILENT program to compare the voltage profile with and without the photovoltaic solar system. The system's voltage profile can be improved by installing a predefined capacity of the solar PV system. However, the distribution system will see increased voltage when the solar PV capacity is larger than the local load. In this document, photovoltaic power factor control is shown to improve the voltage profile through the feeder in the distribution system.

8. Dhlamini & Chowdhury (2018) study of the availability of solar energy in large amounts of the sun has generated the potential for rapid growth of the large generation of solar energy with the potential to be integrated with existing distribution and transport networks. The continued growth of solar power generation has created potential problems for the integration and operation of the existing network of energy service system engineers. This research study attempts to highlight the effects of the integration of the stable state of photovoltaic (PV) generation on current transmission and distribution networks. The study analyzes the effects of stable state integration in the current network on the voltage level of the system, line loss, voltage format, low voltage and network voltage stability. The study was carried out on modeling the current transmission and distribution network in North Cape, South Africa, known as the Solar Passage using MATLAB. The Solar Corridor was chosen due to its high solar resource at an average of 2000 W / mz and the significant investment in commercial solar PV generation. Compare the study approach between the impact of the stable state on the existing public services network without the integration of photovoltaic solar power and with different levels of penetration of solar photovoltaic generation. The results of the study showed that the integration of solar photovoltaic power generation in the current network has a significant impact on the voltage profile, line loss and low voltage, and improvements in stability of the stable state of the network. . The study concluded that the amount of photovoltaic power integrated into the network is limited if the individual wants to maintain the stable state of the current network.

9. Jayakumaran *et al.* (2018) studied in the current scenario of energy in the world, it has become clear that we must rely on alternative sources of energy. Most of these abundant renewable sources are solar energy. The main problem is the high dependence on solar energy for the low efficiency of current solar cells and the climate surrounding solar installations. This brings us to the subject of this document, monitoring the maximum power point or MPPT. The maximum power point in the fourth characteristics of the solar cell fluctuates relentlessly due to many factors including solar radiation variation, photovoltaic cell temperature, and current / voltage characteristics at variable temperature and photovoltaic energy-related load cell. To maximize the output of the cell, the maximum power point must be tracked continuously. That's why most solar-powered transformers have controllers that use some form of MPPT. In recent years, many MPPT techniques have been published. However, the techniques that are found to be more suitable for many PV applications are disturbance and observation (P & O), and additional conductivity (IC).

10. Khin et al. (2018) study to maximize the resulting energy of the solar photovoltaic system, it is necessary to have the surface of the solar panels vertically on the direction of solar radiation. Therefore, solar tracking is widely used to increase the energy generated by solar photovoltaic. However, tracking solar energy is costly and inappropriate for some sites. Another solution is to increase the resulting energy of the photovoltaic solar installation, which is to create optimal tilt angles. The advantage of this solution is that there is no additional cost for the device, but the power obtained is less than the solution used by the solar tracker. This work is a systematic methodology to detect the optimal slope angles of the University of Khon Kaen \ pmb (latitude = 16.472 degrees north and latitude = \ pmb102.826 ° east). The calculation and experiment methods are used to find optimal monthly, seasonal and seasonal inclination angles. For the calculation method, optimal mathematical tilt angles were determined by finding the maximum daily solar radiation received by changing the tilt angles from 0 ° to 60 ° 5 ° for each change step. For the experimental method, optimal tilt angles were determined by the creation of 5 mono-crystalline solar modules for five different tilt angles of 0 °, 16 °, 30 °, \ pmb45 ° and / pmb60 °. The experiment was carried out from March to May. Of the results, the ideal monthly inclination angles of the experiment and calculation methods are approximately identical.

3. Mathematical Model

Mathematical equivalent circuit for photovoltaic array

Figure below shows the equivalent circuit of the photovoltaic cell. Current Iph represents the photovoltaic current of the cell. Rsh and Rs are the resistance in the intrinsic and sequential derivation of the cell, respectively. In general, the Rsh value is very large and the Rs value is too small, so it can be neglected to simplify analysis (Pandiarajan and Muthu, 2011). In practice, photovoltaic cells are assembled into larger units called photovoltaic modules and these units are connected in a series or parallel to the creation of photovoltaic arrays that are used to generate electricity in photovoltaic systems. Figure 2 shows the equivalent circuit of the PV assembly.

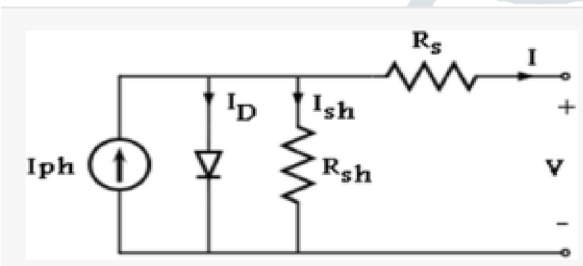

Fig.2. PV cell equivalent circuit (Salmi et al. 2012)

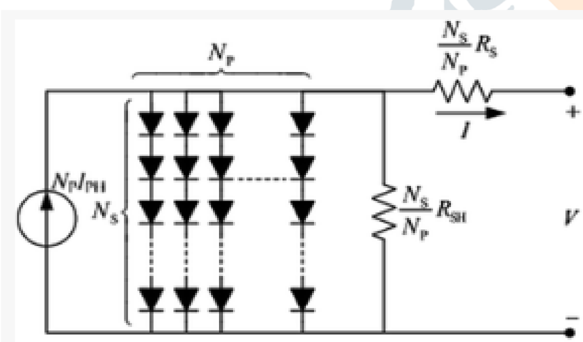

Fig. 3 Equivalent circuit of solar array (Tu and Su 2008)

The characteristic equation of the solar cell voltage is provided (Tu and Su 2008; Salmi et al., 2012): Iph module:

$$I_{ph} = [I_{sc} + K_i(T - 298)] \times Ir/1000 \qquad (1)$$

Here is the current picture (A); Isc: short circuit current (A); Ki: short circuit current of the cell at 25 ° C and 1000 W / m 2; W / M2).

Module reverse saturation current Irs:

$$I_s = I_s/\left[exp\left(q^{Voc}/N_{N^{knT}}\right) - 1\right] \qquad (2)$$

Here, q: the charge of the electron, = 1.6 × 10-19C; Voc: open circuit voltage (V); Ns: the number of connected cells in a chain; n: the ideal factor of the diode; k: the Boltzmann constant, = 1.3805 × 10-23 J / K.

The saturation current of unit I0 varies with the cell temperature, which is given by:

$$I_0 = I_{rs}\left[\frac{T}{T_r}\right]^3 exp\left[\frac{q \times E_{g0}}{nk}\left(\frac{1}{T} - \frac{1}{T_r}\right)\right] \qquad (3)$$

With

$$V_t = \frac{k \times T}{q} \qquad (4)$$

And

$$I_{sh} = \frac{V \times N_P/N_S + I \times R_S}{R_{sh}} \qquad (5)$$

Here: Np: number of PV modules connected in parallel; Rs: series resistance (Ω); Rsh: shunt resistance (Ω); Vt: diode thermal voltage (V).

Conclusion

Introduced the main solar photovoltaic technologies, including photovoltaic power generation, hybrid photovoltaic power generation, various light absorbing materials, photovoltaic system performance and reliability, size, distribution and control. It also introduces different applications of solar photovoltaic systems, such as building integration systems, desalination plants, space, solar home systems and pumps. This article will be useful to solar PV system manufacturers, academics, researchers, generation members and decision makers. In recent years, renewable energy has experienced significant growth due to its technological improvements and the goal of reducing carbon dioxide production, one of the gases that cause greenhouse gases. For the next generation, people have chosen to prevent the planet from pollution and the willingness to generate electricity without restrictions, renewable energy, especially solar photovoltaic systems.

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