Exploration of Solar PV Modules: A Review

Prashant Singh[1], Dr.Shailesh Kumar Singh[2]
[1]M.Sc. Physics, [2]Head of Department
[12]Monad University, Hapur

Abstract- Solar PV modules, power electronics, including charging and discharging Controllers, inverters, test instruments and computer monitoring, and storage Battery or other energy storage and auxiliary power plant to form photovoltaic The system shown in this paper. PV system design should be followed to meet load supply Requirements, making the system cost low, seriously considering the design of software and hardware, And general software design before the hardware design of this article. Adopt design Taking photovoltaic system as an example, the paper gives an analysis of system software design. System hardware, economic benefits, basic ideas and steps for installation connect the system. It elaborates on information acquisition, software and System hardware design, system evaluation and optimization. Finally, it shows Analysis and Prospect of Solar Photovoltaic Technology in Outer Space Applications Lighting, highways and communications.

Keyword- Solar Modules, Power Electronics, PV System Design, Grid Connected PV Solar System

I. INTRODUCTION

The SPV power plant consists of SPV units in groups (total wattage of 1 kW or more), rechargeable battery bank, power conditioning unit (inverter and charging control), etc. When the sun hits the SPV unit, a direct stream is produced that is stored in the battery bank. The inverter converts the direct current of the battery into an alternating current that is used in turn to operate multiple loads, such as lamps, fans or other electrical appliances in the building, subject to a total load (Watt) limited to the unit capacity (Wp).

1.1 Solar Power Works

Solar power can be obtained from solar energy systems or concentrated solar energy.

1.2Photovoltaic (PV)

Photovoltaic energy converts solar energy directly into electricity. It works on the principle of photoelectric effect. When certain substances are exposed to light, they absorb photons and release free electrons. This phenomenon is called photovoltaic effect. Photoelectric effect is a means of producing direct current electricity based on the principle of photoelectric effect.Based on the principle of photoelectric effect, solar cells or photovoltaic cells are manufactured. They turn sunlight into direct current (DC). However, single photovoltaic cells do not produce enough electricity. Therefore, many photovoltaic cells are installed under the support and are electrically connected to each other to form a photovoltaic unit or solar panel. Solar panels typically range from several hundred watts (for example, 100 watts) to a few kilowatts (ever heard of solar panels 5 kW?) Available in different sizes and price ranges. Solar panels or units are designed to supply electrical power with a certain voltage (e.g. 12 volts), but the current they produce depends directly on the incident light. From now on, it is clear that photovoltaic units produce electricity from DC. But most of the time we need AC power, therefore, the solar system also consists of reflector.

1.3 Photovoltaic Solar Power System

According to the power requirements, the PV modules are electrically connected to each other to form a photovoltaic matrix and achieve more energy. There are different types of photovoltaic systems according to their implementation.

- PV Direct system: These systems provide load only when the sun is bright. There is no stored energy generated, therefore, the batteries are absent. The inverter may or may not be used depending on the type of load.
- Off-grid systems: This type of system is commonly used in places where network power is not available or unreliable. The solar system outside the grid is not connected to any electrical network. It consists of solar panels, accumulators and inverter circuits.
- Grid connected systems: These solar systems are connected to networks so that the necessary energy can be accessed from the network. May or may not be supported by batteries.

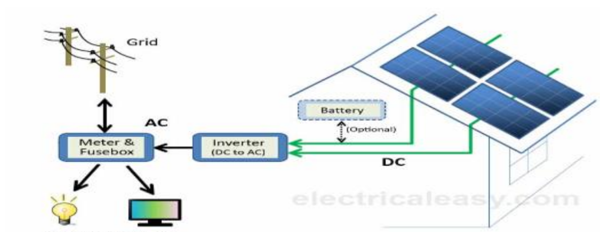

Fig.1: Typical grid connected PV solar system

1.4 Advantages

- The emergency power source can be used at any time for 4 hours or more per day, increasing the unit's capacity.
- Does not contain moving parts and is easy to operate and maintain
- For areas facing power outages, the SPV power plant is a boon because it provides an uninterrupted emergency operation such as fans, lights, computers, etc.
- No fuel is required and frequent power consumption charges are reduced / canceled.

Needless to say, the sun is the world's largest source of renewable energy. The fact is that although the earth receives only a fraction of the energy generated by the sun (i.e., solar energy), this part of the solar energy is also huge. The Earth receives solar energy in the form of light and heat. But in today's world, "power" and "energy" tend to be about "electricity." This article explains how electricity is extracted from solar energy and how it is used.

II. BACKGROUND

1. Bagher et al. (2015) study of Solar cells are an electronic device that converts sunlight directly into electricity. The light that illuminates the solar cell produces a current and voltage to generate electricity. This process requires, first of all, a material in which the absorption of light raises the electron to a higher energy state, and secondly, the movement of this higher-energy electron from the solar cell to an external circuit. The electron then expels its energy in the external circuit and returns to the solar cell. A variety of materials and processes can meet the requirements of photovoltaic power conversion, but in practice virtually, each photovoltaic power conversion uses semiconductor materials in the form of p-n junction. In terms of sustainable energy development, such as solar energy, we will study the types and applications of solar cells.

2. Bravo (2018).propos the effects of energy quality (PQ) for solar PV converters are not yet documented. This document presents PQ performance for 17 photovoltaic solar power plants (SPVPP) in 12 different substations, 11 distributions and 1 sub-transmission. The SPVPP generation panel oscillates between 1.5 MW and 12 MW. First, this document will provide the typical installation and configuration of the PQ scale. In addition, the performance of both SPVPPs will be provided in the power quality maps. These plots will include distortion of the current demand (ITDD), distortion of total voltage harmonics (VTHD) and power of the photovoltaic (P) power station as a function of time. Additionally, it will provide an SPVPP performance analysis. Finally, conclusions and recommendations from this investigation will be provided including what needs to be done to reduce these devices from harmonics in the network. The information provided in this document can be used to develop, test and validate computer models for the distribution or study of bundled systems.

3. A. Sharma &M. Sharma (2017) study of solar energy provides a resource for clean, environmental and eternal energy for humanity. Solar electricity can be generated using two different technologies, photovoltaic (PV) and concentrated solar (CSP) systems. Using thermal energy storage techniques, solar energy storage systems can store energy to generate electricity on cloudy days or at night compared to photovoltaic systems, resulting in flexibility in the power grid. The most important problem in the energy market is the competitive cost of energy. Factory photovoltaic power price is lower compared to concentrated solar power plants. Concentrated solar systems with the ability to store heat energy effectively can be used to overcome the interference problems of photovoltaic systems to balance demand while providing electrical power within secure levels of reliability by improving energy production. This document attempts to discover possible ways to improve energy and energy produced by solar technologies to reduce carbon emissions. In addition, photovoltaic solar systems and concentrated solar systems are compared in two locations in the tropical state of India and simulated in the (SAM) System Advisor Model and graphically presented.

4. Liu et al. (2018) propose with the acceleration of global warming and the increasing consumption of traditional fossil fuels, many countries have begun to pay attention to solar energy. However, the characteristics of solar energy, such as twists and turns, make it difficult to integrate into the power grid. Various prediction models have been provided to generate solar energy to facilitate solar penetration, but most have no application evidence. In this work, many models of the current solar PV status have been investigated. In particular, the accuracy of these models is examined by comparing the production forecast based on the solar photovoltaic model with the measurement of photovoltaic production in the real world. Based on the exact comparison, scenarios for applying many models are discussed in a more comprehensive manner.

5. Mandi (2017) study of Coal-fired power plants form the backbone of the energy sector in India, which accounts for about 59 percent of total installed power. Coal-fired power generation produces carbon dioxide emissions of about 0.2 million tons per hour. In addition, coal is a limited source of energy that can be depleted and non-renewable. On the other hand, in the Indian energy scenario, due to the large gap between supply and demand for energy, power cuts often face, requiring the use of diesel generator whose cost is very high, as well as exchange of currencies concerned due to oil import. For sustainable energy growth in the country, the use of renewable energy systems such as photovoltaic power plant provides constant energy during daylight hours. If an SPV power station is implemented through an interactive network system, power is imported during non-solar hours from the grid and excess power is pumped through the solar clocks in the grid. The installation of a 500 kW power plant at the University of REVA will generate 852.4 MWh with an initial investment of $ 0.30 million. The recovery period will take 3 years and 11 months and the life span will be $ 2.35 million. Specific power generation is 1.70 MWh / kW / y. This will help reduce carbon emissions (CO2) by 895 tonnes per year, adding to the green energy revolution.

6. Senthilkumar et al. (2018). This document introduces a dynamic energy flow management system for photovoltaic (PV) system using a one-phase DC / DC adapter based on a single direct-load independent DC feeder powered by a rechargeable battery. A voltage control system has been proposed to share time to manage the flow of power between photovoltaic solar energy and battery and DC load. It also maintains constant DC load voltage and achieves traceability to the maximum point of energy in photovoltaic solar energy. The implementation of the control plan is described in detail. The constant state performance of the mono-phase transformer was explained by the relevant analytical expressions derived with the properties. The state average area model was developed to simulate transient behavior and validate the operation of the system for gradual changes in the next PV solar and DC loads. A hardware prototype was manufactured for the proposed system and the proposed console was implemented using the dSPACE DS1103 real-time interface. The proposed scheme for different levels of solar insolation of inputs and demand for direct load energy has been satisfactorily demonstrated, and the corresponding results have been presented.

7. Maleki&Varma (2016) This article introduces new control of the photovoltaic solar plant as STATCOM (PV-STATCOM) in coordination with (PSS) Power System Stabilizers to reduce electromechanical oscillations in the power system. The power system is simulated in two regions with a 150 MW photovoltaic solar power station connected in the middle of the link line in the PSCAD / EMTDC program. During emergencies, the residual PV power is used after real power generation for the dynamic exchange of the interactive energy to achieve damping in the energy fluctuation. The master and slave feature is used in the PSCAD / EMTDC program to perform driver improvement and coordination. Coordinated control in PV-STATCOM and PSS can effectively improve the damping of energy oscillations, leading to higher power transmission in the lines. This new control of photovoltaic farms will lead to the optimal use of high-cost photovoltaic systems to stabilize the grid and improve power transmission capacity.

8. Ahmad &Anand (2016) propose to connect solar PV (PV) to a single-phase network, AC / AC adapters are used as a front. To track the maximum power of each series of solar photovoltaic panels, DC / DC converters are connected between photovoltaic arrays and reflectors. This ensures that each sequence operates at maximum output power, regardless of the variation of solar radiation between different chains. Traditionally, the DC-DC adapter used for this application will handle the full power of the series. Full power processing structure (FPP) leads to high conversion losses. This document proposes a conversion-based partial power converter, which offers high conversion efficiency, compared to conventional DC converters. In addition, the proposed scheme also eliminates low frequency frequencies (double the power frequency) in the voltage chain in the case of single-phase transformers, which increases the efficiency of energy extraction. The main advantages of the proposed scheme are power separation, low conversion losses, high extraction efficiency, and DMPPT. Detailed simulation studies are conducted to validate the performance of the proposed scheme. The proposed schema comparison is also included with the traditional total energy processing scheme.

9. Pradeepa et al. (2017) study of solar energy is a kind of unconventional energy. Only a fraction of the available solar energy is used in practice. Solar power generation depends on the photovoltaic system and thermal motors. To harvest solar energy, the most common method is to use photovoltaic panels that will receive photon energy from the sun and convert it into electrical energy. The efficiency of the PV module is very low and the output power depends on the level of solar insulation and ambient temperature, so maximizing the output power more efficiently is of particular importance. In this document, the Soft Transfer Relay Adapter (ISSBC) is proposed for the photovoltaic power generation system. The chassis used increases the efficiency of the AC / DC adapter for PVPCS and reduces conversion losses by adopting a soft resonance conversion method. This project proposes a new two-unit switching transformer consisting of two units to convert the initial booster and auxiliary booster. The proposed control system uses PWM techniques to regulate the output power of the booster adapter at maximum value and simultaneously controls the battery charge process. This converter is capable of converting both active power switches to zero voltage to reduce conversion losses, and of course increase conversion efficiency. Since the initial two parallel booster units are identical, the analysis of the process and the design of the transformer unit have become very simple. The resulting system has very fast tracking speed, high efficiency and low cost. The circuit will be simulated using MATLAB Simulink.

10. Babasaki& Higuchi (2018). Study of Solar plants have ways to diagnose the failure of their solar panels. In this document, they suggest a remote diagnostics method that uses data from photovoltaic cell chains. Some tendon meters are used for continuous remote monitoring of solar panels. Solar panels generate low energy due to broken panels, skeletal shadows, weeds, etc. If these faults can be classified by fault rating using remote string measurement data, it is possible to reduce unnecessary repair procedures and more efficient settings. They use automatic learning to categorize the reasons for the decline in solar generation automatically, such as broken boards, shadows or weeds. They apply this diagnostic method to some large solar plants. The results of our experience showed that the learning accuracy of this proposed method is 100%. When they tested this method of classification in another solar station, the accuracy of the classification was 99%. This finding indicates that this diagnostic method is useful and can reduce maintenance.

III. MATHEMATICAL MODELLING

Basic Circuit Configuration of Photovoltaic System

Below is a basic configuration of the PV system in Fig. 2.5. This model represents the equivalent circuit diagram of the photoelectric system and is called a "four-parameter model" consisting of an existing source, diode, sequential resistance and parallel resistance. The current source represents the light current from the solar cell. The diode represents the nonlinear impedance of the p-n junction. Serial resistance represents the internal electrical losses and the derivation resistance corresponds to the leakage current with the earth. The diode is connected in a counter-way parallel to the current light source, representing the theoretical model of the ideal solar cell. When solar radiation falls on the cell, the direct current generated in linearly changes with solar radiation.

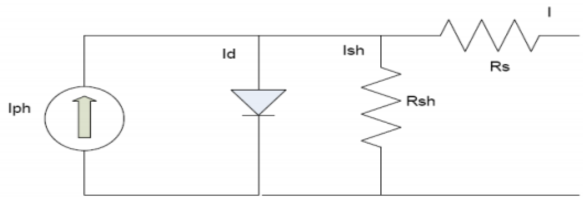

Fig.2: Basic circuit diagram of Photovoltaic module

The characteristic equation of the circuit diagram for the optical panel described in Fig. 2.5 was developed.

Apply KCL, the current output of the cell is.

$$\mathrm{I} = \mathrm{I_{ph}} - \mathrm{I_d} - \mathrm{I_{sh}} \qquad (2.1)$$

The current of the light or the current of the image varies by radiation and temperature is given by these mathematical equations (2.1 to 2.7)

$$\mathrm{I} = \mathrm{Iph} - \mathrm{Is}\left[\exp\frac{(\mathrm{V+IRs})\mathrm{q}}{\mathrm{akTNs}} - 1\right] - \frac{\mathrm{V+IRs}}{\mathrm{Rsh}} \qquad (2.2)$$

$$I_{p\square} = I_r \frac{1_{sc}}{1_{r0}} \qquad (2.3)$$

$$I_s = I_{sc} / \left[exp\left(\frac{V_{oc}}{aV_t}\right) - 1\right] \qquad (2.4)$$

$$I_d = I_{sc}\left[exp\left(\frac{V+IR_s}{aV_t}\right) - 1\right] \qquad (2.5)$$

$$I_{s\square} = (V + IR_s)/R_{s\square} \qquad (2.6)$$

$$V_t = \frac{kTN_s}{q} \qquad (2.7)$$

These expressions represent the relationship between voltage and current of the photovoltaic unit. Mathematical Equation (2.2) is a nonlinear equation with coefficients

N_s represent series connected cells
I_{ph} is the light generated current
$I_S$is the reverse saturation current
R_S and R_{sh} represent the series and parallel inherent resistances of the cell.
q is the electron charge 1.60217646×10^{-19} C
k Boltzmann's constant 1.3806503×10^{-23} J/K and
a the ideality factor Modified.

IV. CONCLUSION

The photovoltaic charge controller is a voltage regulator. Their main function is to prevent overcharging by sensing the battery voltage. When the battery is fully charged, the controller will stop or reduce the amount of current flowing into the battery from the PV array. They come in different sizes.

Some charging controllers have other features:

- Light. When the battery voltage is low, they indicate when the battery is fully charged.
- Meter. One of them is a voltmeter that emphasizes the battery voltage, high, normal or low, and the other is an ammeter that indicates if the array is working properly.
- Temperature compensation. When the battery temperature is below 15℃ or above 35℃, the charging voltage should be adjusted. Some controllers have temperature sensors to automatically change the charging voltage.

V. REFERENCES

[1]. Bagher,M.,A. AbadiVahid,M.M.,&Mohsen,MM.(2015). Types of Solar Cells and Application. *American Journal of Optics and Photonics,3(5),*94-113.

[2]. R. J. Bravo, "Solar PV Power Plants Harmonics Impacts," *2018 IEEE/PES Transmission and Distribution Conference and Exposition (T&D)*, Denver, CO, 2018, pp. 1-9. doi: 10.1109/TDC.2018.8440264

[3]. A. Sharma and M. Sharma, "Power & energy optimization in solar photovoltaic and concentrated solar power systems," *2017 IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC)*, Bangalore, 2017, pp. 1-6. doi: 10.1109/APPEEC.2017.8308973

[4]. Y. Liu, Z. Lu and F. Yang, "The investigation of solar PV models," *2018 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT)*, Washington, DC, 2018, pp. 1-5. doi: 10.1109/ISGT.2018.8403350

[5]. R. P. Mandi, "Grid interactive rooftop solar PV power plant for educational institute," *2017 International Conference On Smart Technologies For Smart Nation (SmartTechCon)*, Bangalore, 2017, pp. 1473-1478. doi: 10.1109/SmartTechCon.2017.835860

[6]. A. I, S. Senthilkumar, D. Biswas and M. Kaliamoorthy, "Dynamic Power Management System Employing a Single-Stage Power Converter for Standalone Solar PV Applications," in *IEEE Transactions on Power Electronics*, vol. 33, no. 12, pp. 10352-10362, Dec. 2018. doi: 10.1109/TPEL.2018.2804658

[7]. H. Maleki and R. K. Varma, "Coordinated control of PV solar system as STATCOM (PV-STATCOM) and Power System Stabilizers for power oscillation damping," *2016 IEEE Power and Energy Society General Meeting (PESGM)*, Boston, MA, 2016, pp. 1-5. doi: 10.1109/PESGM.2016.7741813

[8]. M. W. Ahmad and S. Anand, "Power decoupling in solar PV system using partial power processing converter," *2016 10th International Conference on Compatibility, Power Electronics and Power Engineering (CPE-POWERENG)*, Bydgoszcz, 2016, pp. 196-201. doi: 10.1109/CPE.2016.7544184

[9]. K. Pradeepa, S. Krishnan, M. D. Dharshinii and S. R. Akshaya, "Implementation of interleaved soft switching boost converter and

H-bridge inverter for solar pv power generation system to attain maximum output voltage and reduced harmonics," *2017 International Conference on Information Communication and Embedded Systems (ICICES)*, Chennai, 2017, pp. 1-6. doi: 10.1109/ICICES.2017.8070778

[10]. T. Babasaki and Y. Higuchi, "Using PV string data to diagnose failure of solar panels in a solar power plant," *2018 IEEE International Telecommunications Energy Conference (INTELEC)*, Turin, 2018, pp. 1-4. doi: 10.1109/INTLEC.2018.8612400.