

Survey on Solar Power Control Strategies for Optimum Power Extraction

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Abstract: This paper elaborates a comprehensive overview of a photovoltaic (PV) system model, and maximum power point tracking (MPPT) algorithms in normal and partial shading conditions. Performance evaluation techniques are discussed on the basis of the dynamic parameters of the PV system. The voltage of the photovoltaic generator is nonlinear and exhibits multiple peaks, including many local peaks and a global peak in non-uniform irradiance. The technic of MPPT is the important component of photovoltaic systems although many review articles discussed conventional techniques such as P & O, incremental conductance, the correlation ripple control and very few attempts have been made with intelligent MPPT techniques.

KEYWORD - maximum power point tracking; photovoltaic systems; partial shading conditions; performance evaluation

I. INTRODUCTION

The much concerned with the fossil fuel exhaustion and the environmental problems are caused by the conventional power generation. Nowadays, renewable energy sources, such as photovoltaic (PV) panels and wind-generators, are now widely used. PV systems are the most direct way to convert solar radiation into electricity and are based on the PV effect, which was first observed by Henri Becquerel in 1839. It is quite generally defined as the emergence of an electric voltage between two electrodes attached to a solid or liquid system upon shining light onto this system. Practically, all PV devices incorporate a PN junction in a semiconductor across which the photo voltage is developed. These devices are also known as solar cells. Light absorption occurs in a semiconductor material. The semiconductor material has

to be able to absorb a large part of the solar spectrum [1]. The PV generation is gaining increased importance as a renewable source. It is used today in many applications e.g. battery charging; water pumping, home power supply, swimming-pool heating systems, satellite power systems. The PV systems have the advantage of being maintenance and pollution-free but their installation cost is high and, in most applications; they require a power conditioner (DC/DC or DC/AC converter) for load interface. Since PV modules still have relatively low conversion efficiency. The overall system cost can be reduced using high efficiency power conditioners which, in addition, are designed to extract the maximum possible power from the PV module.

A. Solar Photovoltaic System

The solar photovoltaic system is one of the important renewable energy sources. It offers many advantages such as the energy produced is not polluting, requiring little maintenance, most promising and inexhaustible. However, the PV system still has relatively low conversion efficiency. Indeed, the power produced by the photovoltaic generator relates to the irradiance, temperature, and electrical loads, and it has a MPP at a certain working point. At the MPP (Maximum Power Point), the PV operates at its highest efficiency. Therefore, to extract the maximum power under the different conditions stated earlier, a maximum power point tracking (MPPT) technique is used via a DC-DC converter to help get stable and reliable power from PV system for both loads, and thus improve both steady and dynamic behaviors of the whole generation system. The Fig.1 shows the simplified block structure of the

investigated system. It contains a photovoltaic generator, power electronic components, filter and local loads.

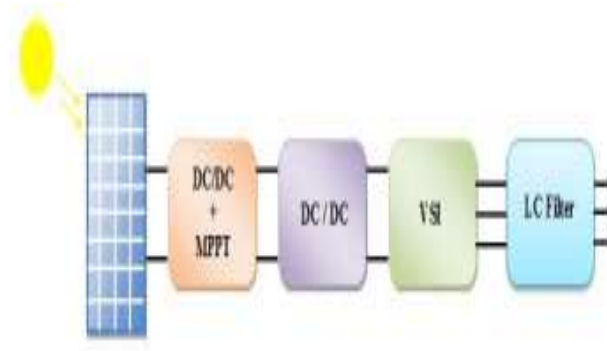


Figure 1 Block diagram of the system

II. LITERATURE REVIEW

F.E. Tahiri [1] this paper presents a modeling and simulation, in Matlab/Simulink environment, of a stand-alone solar PV system in order to analyse its performance under irradiation and load variations. Indeed, to supply an alternative load with a sinusoidal line without harmonic distortion under weather conditions, a MPPT (Maximum Power Point Tracking) algorithm has used to control a DC-DC boost converter to generate the MPP (Maximum Power Point) of the photovoltaic generator to alternative load via a PWM (Pulse Width Modulation) three phase inverter.

Diran Liua [2] the characteristics of intermittent and stochastic of solar energy has brought great challenges to power grid system in terms of operation and regulation. Power forecasting is an important factor for optimal schedule of power grid system and assessing the working performance of PV systems. In order to forecast the power output of a PV system located in Ashland at 24-hour-ahead for higher efficiency, a back propagation (BP) neural network model is proposed. Before designing the model, correlation analysis is done to investigate the relationship between power output and solar irradiance and ambient temperature, which are key parameters affecting the power output of PV systems. Based on a correlation analysis, the model admitted the following input parameters: hourly solar radiation intensity, the highest, and the lowest daily and the average daily temperature, and hourly power output of the PV system.

S. B. Efe [3] In this paper, an actual system that consist of a switched reluctance motor (SRM) and photovoltaic (PV) generation was analyzed to determine

operational behaviors in terms of both generating and motor units. System was designed without an energy storage unit. This type of design allows obtaining more convergence and actual results during operation in different t conditions. According to this aim, a system that includes such structures was constructed physically. System was operated and observed for different weather and l loading conditions. As the proposed system was aimed to use for agricultural electrical vehicle applications, results were discuss end by using graphs that obtained from various points, especially in terms of these approaches.

III. PV-HYBRID SYSTEMS

Hybrid systems generally refers to the combination of any two input sources, here solar PV can be integrated with Diesel Generator, Wind Turbines, Bio-mass or any other renewable on non-renewable energy sources. Solar PV systems will generally use battery bank to store energy output from the panels to accommodate a pre-defined period of insufficient sunshine, there may still be exceptional periods of poor weather when an alternative source is required to guarantee power production. PV-hybrid systems combine a PV module with another power sources - typically a diesel generator, but occasionally another renewable supply such as a wing turbine. The PV generator would usually be sized to meet the base load demand, with the alternate supply being called into action only when essential. This arrangement offers all the benefits of PV in respect of low operation and maintenance costs, but additionally ensures a secure supply. Hybrid systems can also be sensible approach in situations where occasional demand peaks are significantly higher than the base load demand. It makes little sense to size a system to be able to meet demand entirely with PV if, for example, the normal load is only 10 % of the peak demand. By the same token, a diesel generator-set sized to meet the peak demand would be operating at inefficient part-load for most of the time. In such a situation a PV-diesel hybrid would be a good compromise.

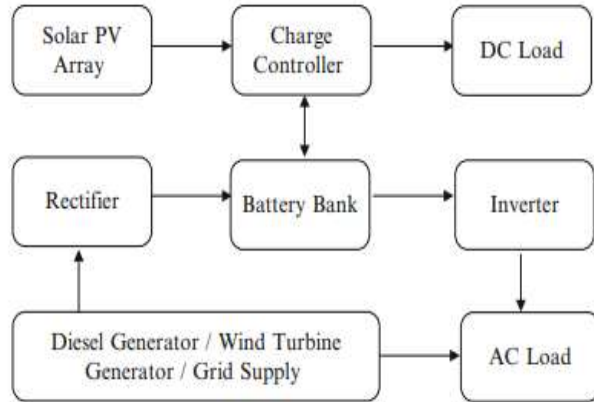


Figure 2 Block diagram of photovoltaic hybrid system

IV. PHOTOVOLTAIC SOLAR MODULES

Solar photovoltaic modules, as the core of any SPV system, generate electrical energy from incident sun rays based on photovoltaic effect. Multiple solar cells, typically 60 or 72, connected mainly in series in a module comprise 2 adjoining semiconductor layers with separate metal contacts, and thus create a negative “n” layer with surplus of electrons and positive “p” layer with deficiency of electrons. Due to the difference in the concentration, electrons flow from “n” to “p” area creating an electric field or so-called space charge zone. Forced by this built-in electric field free excited electrons travels outside of the space charge zone, into the external electrical load where the excess energy will be dissipated. When an electrical load is connected, the power circuit is closed meaning that the electrons flow across the load to the solar cell’s rear contact and then back to the space charge zone. As a result, solar cells produce direct current (DC), flowing in a single direction only, which later gets converted into alternate current (AC) by an inverter.

V. I-V CURVE

PV cells are the basic elements of a PV system; through series or parallel connection they form PV modules to produce desired voltage; PV modules are further connected together to constitute PV arrays for practical use. To describe the characteristics of a PV module, I-V curve is a fundamental way to show the performance of the PV module, and through it some important parameters of modules can be obtained.

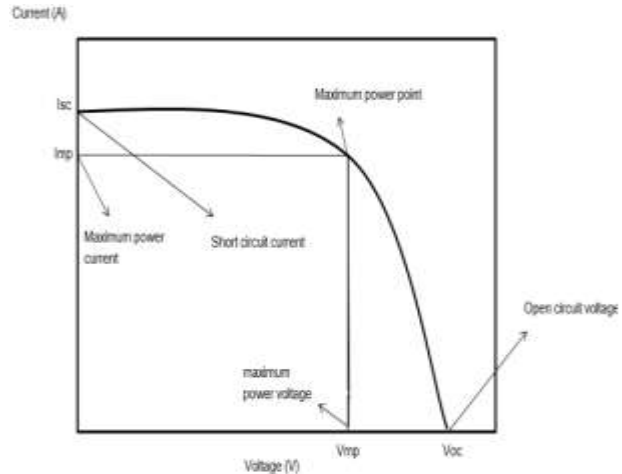


Figure 3 I-V curve of PV modules

In the I-V curve figure, the maximum power point is the module operating point at which the power output of modules reaches maximum value; the corresponding current and voltage are called maximum power current and maximum power voltage respectively. This value of maximum power point can be used to evaluate performance of PV modules under standard test condition or other circumstances.

VI. MAXIMUM POWER POINT TRACKERS (MPPT)

Maximum power point trackers are a form of DC-DC converter. It uses electronic components to adjust PV outputs and make it operate at its maximum power point under changing irradiance and temperature. Interactive inverters often contain MPPT circuits. For large PV system with multiple PV arrays, individual MPPTs are designed to connect each array, in this way it is more efficient for MPPTs to operate at maximum output with each array that has different characteristics. So the total performance of PV system improves. In some system, battery charge controllers have the function of MPPT, so there is no need to contain MPPT circuits in inverters.

VII. MAXIMUM POWER POINT TRACKING (MPPT) CHARGE CONTROLLERS

This kind of charge controllers can make system operating as close as possible to the maximum power point on I-V curve through monitoring the circuit and changing the resistance or input voltages dynamically.

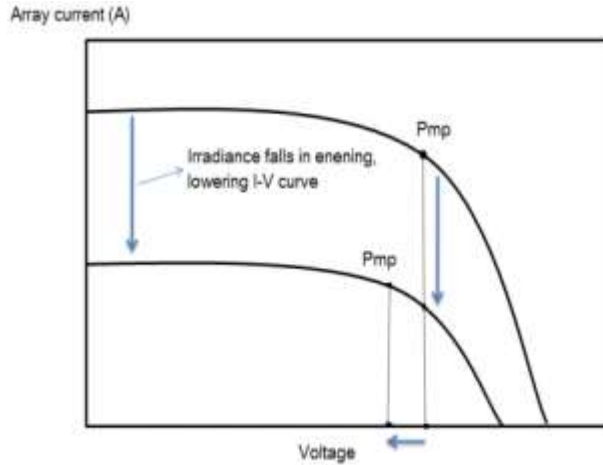


Figure 4 Maximum power point tracking

When external condition changes as irradiance reduction as shown in the figure, the I-V curve has a new pattern as well as the position of maximum power point. MPPT controller can adjust voltage according to current conditions to continue get maximum power. MPPT charge controllers improve battery charging performance effectively. Without MPPT control the array will operate at low battery voltage with a power loss of about 20%.

VIII. TYPES OF PV SYSTEMS

Based on the electric energy production, PV modules can be arranged into arrays to increase electric output. Solar PV systems are generally classified based on their functional and operational requirements, their component configurations. It can be classified into grid-connected and stand-alone systems.

A) GRID-CONNECTED SOLAR PV SYSTEM

The primary component of grid-connected PV systems is power conditioning unit (PCU). The PCU converts the DC power produced by the PV array into AC power as per the voltage and power quality requirements of the utility grid. A bi-directional interface is made between the PV system AC output circuits and the electric utility network, typically at an on-site distribution panel or service entrance. This allows the AC power produced by the PV system to either supply on-site electrical loads or to back-feed the grid when the PV system output is greater than the on-site load demand.

B) STAND-ALONE SOLAR PV SYSTEM

Stand-alone PV systems or direct coupled PV systems are designed and sized to supply DC and/or AC electrical

loads. It is called direct coupled systems because, the DC output of a PV module or array is directly connected to a DC load. There is no electrical energy storage (batteries) in direct-coupled systems as because of that, the load only operates during sunlight hours. The maximum power point tracker (MPPT) is used between the array and load to help better utilize the available array maximum power output and also for matching the impedance of the electrical load to the maximum power output of the PV array.

C) STAND-ALONE HYBRID AC SOLAR POWER SYSTEM WITH GENERATOR AND BATTERY BACKUP

A stand-alone hybrid solar PV configuration is essentially identical to the DC solar power system. In this alternating current inverters are used to convert DC into AC. The output of inverter is square waves, which are filtered and shaped into sinusoidal AC waveforms. Any waveform, when analyzed, essentially consists of the superimposition of many sinusoidal waveforms known as harmonics.

IX. CONCLUSION

This survey investigates a dynamic modeling, simulation and control of Photovoltaic (PV)-wind hybrid system connected to electrical grid, considering changes of environmental conditions. In addition, the daily variations of critical load power are considered. The studied hybrid system consists of two Photovoltaic (PV) stations placed at different locations and one wind farm are integrated into main AC bus to enhance the system effectiveness. The PV/wind hybrid system feeds large plant with critical variable loads and electrical utility grid. The technique of extracting maximum power point can be applied for both photovoltaic stations to capture maximum power under varying climatic conditions. Modeling and simulation of the studied hybrid system can be performed using matlab-Simulink software.

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