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High Accurate Sensorless Dual Axis Solar Tracking System Controlled by MPPT for Microgrid Application

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Abstract - *Maximum power point trackers (MPPTs) play a significant role in extracting power from photovoltaic (PV) generators as they draw the maximum power output (MPP) available irrespective of continuous changes of temperature and irradiation conditions. Therefore, in the efficiency of the global PV system, MPPTs take the foremost place. A DC-DC boost converter boosts the DC voltage generated by the photovoltaic system. Various MPPT algorithms pilot these trackers out of which Perturb and Observe (P&O) technique is emphasized upon as it is highly simple to implement within electronic programmable circuits. This paper incorporates into the model various environmental factors to study the behavior of the PV panel output of which is controlled by MPPT trackers. The components of the proposed system with their function are followed by a simulation of a sample system in MATLAB/Simulink software to verify the advantages of proposed integrated system.*

Key Words: **Photovoltaic, Boost converter, harmonics, controller, MPPT, Perturb and Observe.**

1. INTRODUCTION

Renewable resources, are offering many challenging scopes for the researchers since past few decades by showing their never ending power generation capability. Non-conventional sources based power generation ranges from a few watts to millions of watts. When compared to other renewable sources, solar offers the best with its wide range of availability, maximum utilization capability, eco friendliness and less operational and maintenance cost. Considering all, “Photovoltaic Generation” is playing an important role due to its sustainable development. The biggest challenge faced by the researchers in PV generation is its low efficiency due to the nonlinearity in output characteristics with varying insolation levels. Even though the theoretical efficiency is about 28% practically it will meet only about 15% [1-2]. So for effective utilization of PV based generation, it is necessary to improve the efficiency of the photovoltaic system by some cost effective techniques like “Maximum Power Point Tracking (MPPT)” algorithm [8]. Recently many MPPT algorithms and control schemes of PV generation system have been proposed. The disadvantages of existing P&O and Incremental Conductance MPPT algorithms are oscillations at maximum power point, complexity, and also having an accuracy that contradicts with tracking steps. In this paper the Incremental Conductance and P&O algorithms are proposed with CVT (Constant Voltage Tracking) algorithm which improves the performance by reducing the above discussed with no limitations [3].

1.1 Photovoltaic system

A photovoltaic (PV) system is a system composed of one or more solar panels combined with an inverter and other electrical and mechanical hardware that use energy from the Sun to generate electricity. PV systems can vary greatly in size from small rooftop or portable systems to massive utility-scale generation plants. Although PV systems can operate by themselves as off-grid PV systems, this article focuses on systems connected to the utility grid, or grid-tied PV systems.

System Components

In addition to the solar panels, there are other important components of a photovoltaic system which are commonly referred to as the "balance of system" These components (which typically account for over half of the system cost and most the of maintenance) can include inverters, racking, wiring, combiners, disconnects, circuit breakers and electric meters.

1.2 Maximum Power Point Tracking

A Maximum power point tracking (MPPT) controller is an essential part of almost all photovoltaic (PV) systems. It adjusts the operating point of a PV module used in a PV system to the maximum power point (MPP) of the PV module. Thus, a MPPT controller significantly increases the energy conversion efficiency of a PV system by extracting as much instant power as possible from its PV module. Different MPPT methods are used. Some methods are offline, and other MPPT techniques are online. Open-circuit voltage (OCV) technique uses the OCV of the PV module to estimate the MPP voltage. Temperature technique is an online version of the OCV method estimating the OCV of the PV module using its temperature under operating condition. Short-circuit current (SCC) method measures the SCC to estimate the MPP current. The Maximum Power Point Tracking (MPPT) is one such method, which has a huge importance in the era of Photovoltaic Technology. Now-a-days this technique is vastly used to develop maximum possible power from a varying source under a variable temperature and irradiance conditions. We know, the Maximum Power Transfer Theorem tells that the output power of a circuit is maximum, when the Thevenin impedance of a circuit i.e. the source impedance matches with the load impedance and complex conjugate to it. So, MPPT problem is one kind of impedance matching problem. Solar cells have a very complex relationship between solar irradiation, temperature and the total resistance that develops a non-linear output efficiency which can be analyzed based on the I-V curve. So the main function of MPPT is to sample the output of the cells and apply the proper load to obtain the maximum power for any given location, time, season and environmental conditions. The MPPT not only enables an increase in the power delivered from the PV module to the load, but also enhances the operating lifetime of the PV system.

Various types of MPPT methods can be differentiated based on various features including the types of sensors required, convergence speed, cost, range of effectiveness, implementation of hardware requirements, popularity etc. The operating characteristics of a solar cell consist of two regions i.e. the current source region and the voltage source region. In the current source region, the internal impedance of the solar cell is high and this region is located on the left side of the current-voltage curve. The voltage source region, where the internal impedance is low, is located on the right side of the current -voltage curve.

2. BLOCK DIAGRAM OF PV SYSTEM WITH MPPT

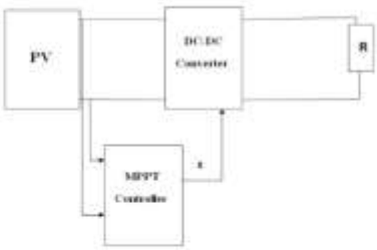

Fig -1: Block diagram of PV system with MPPT controller

For determining MPP appropriate tracker is introduced between PV system and load. It is to be designed that gives good performance, fast response, and less fluctuations. Since the efficiency of the PV is affected by the panel's irradiance and temperature which are stochastic and unpredictable. For this reason, it is not possible to connect the load directly to the PV to obtain the maximum power, so it is necessary to include a balance of system. Typically this BOS is a DC-DC converter to adjust the properties of the load. This converter has the advantage of managing the power delivered to the load.

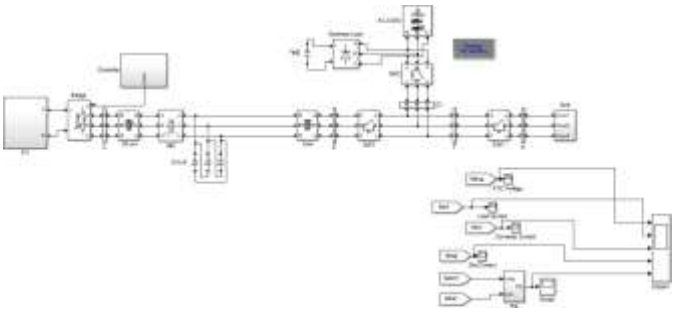

Fig -2: Block diagram of Matlab Simulink

The output of photovoltaic (PV) is depends on many factors such as solar radiations, temperature etc. with variation of these two parameters the output also get changed. That cause introduces fluctuations and harmonics on the utility side which is totally unpleasant. In this model solar irradiance of 1000 is given to the PV, and along with that irradiance a constant block is added which will give a constant temperature to PV of 55°. A step is given to the irradiance; the step time is taken as 3, so that it will change in 3 steps with initial value and final value as 0 and 200 respectively. Sampling time is 0. Similarly for temperature, step is given to change the temperature with step time 2 and having initial value 0 and final value 5 i.e. it will change from 50 to 55. The change from solar irradiance and the temperature is given to the PV array. The effect due to change in the irradiance and temperature is input to the PV array, which will vary due to change in effect. The current controlled source (CCS) parameters will change accordingly. Then the changes are filtered and output is obtained of PV array.

The output from PV is then boosted after applying the inductance. But while boosting the output from PV needs to check continuously due to increase and decrease in value of irradiance and temperature. Here boost converter is used as it is a step up converter; it is DC-DC converter that steps up voltage while stepping down current from its supply to load. For continuous checking a output PV and boosting we need to do tracking of system. For tracking the system here we used boost converter using MPPT. MPPT has given input from the PV current i.e. current obtained from PV panel, and P&O (Perturb and Observer) model is applied. In P&O model, the current and previous current are taken and subtracted and the output named as δp and checked. Simultaneously voltage and previous voltage are taken and subtracted and δv is obtained. Then product of both δp and δv is calculated which further applied to signum function and multiplied by δt. And the final voltage is then added with base voltage. The continuous output voltage from P&O is taken as reference voltage (Uref). Then the boost voltage is obtained. In this system the output from PV is converted from DC to AC. While converting DC to AC some harmonics are created and fluctuations are generated due to additions of load. Controller is used to eliminate the fluctuations. In controller V_{abc} and V_{ref} are inputs. The V_{abc} is converted to d_{qo} by applying V_{abc} and PLL i.e. sine cosine wave. And the error of V_d V_q is obtained by subtracting with V_{dref} and V_{qref} . and the error is eliminated using PI controller. The output is divided by nominal DC, and real imaginary is obtained to get the angle and magnitude. From the obtained angle, the sine cosine waveform is generated, which will multiply with our obtained magnitude and the output is U_{ref} . U_{ref} is the reference signal which is generated. The controller output U_{ref} is given to integral delay and given input to PWM. PWM generally generate sinusoidal reference signal, but here whatever variation occurs due to which changes are caused and that changes are given as feedback from the obtained errors. The feedback pulses of PWM are eliminating the harmonics generated due to disturbances.

After PV output which applied to controller and PWM the signal are given as supply. The AC signal are then filtered using the inductor, so that the step wave will converted to sinusoidal waveform. The filtered signal are given to transformer and one capacitor bank is used after transformer. Inductance is applied after capacitor bank and one breaker (SW3) is used after last inductor in system and having parameters . Here mainly LTCL topology is used. Active AC load is given as load to supply and breaker (SW2) are applied to check ON-OFF condition of breaker. Supply is supplied grid and breaker (SW1) is used with parameters. All the disturbances are checked in the system after running the MATLAB simulation and the result are observed and conclusion are obtained.

3. Results and discussion

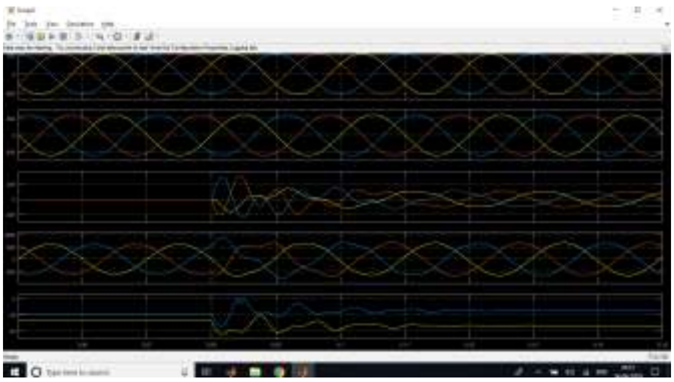

Fig -3: Output waveform of system

Fig -4: Output waveform of converter current

As seen from the output waveform of the Matlab simulation its clearly seen that, at 0.8 load is changed and due to which harmonics are generated and fluctuation occurred in the system. Before 0.8 the circuit is open that means not connected. Between time period of 0.08 to 0.1 the disturbances are cleared and harmonics are eliminated which is seen on the scope of converter current. Here the efficiency is improved and more accuracy is achieved and within small time period the disturbances are cleared using the Perturb and observe technique of MPPT using boost converter. Perturb and observe is the most commonly used MPPT method due to its ease of implementation. Perturb and observe method may result in top level efficiency.

4. CONCLUSIONS

From the above observations, it is found that proposed P&O is improved in the number of oscillations and proposed Incremental Conductance method can withstand its accuracy even if tracking steps increased and starting complexity is decreased. The performance of proposed P&O and boost converter are analyzed and simulated in MATLAB. The PV Array has been mathematically modeled. The programs implemented in the MPPT techniques achieve the maximum power point. It has been shown that for the particular irradiance levels the maximum power delivered by the PV array is delivered to the load. The same is carried out if there is a variation in temperature. It is a simple MPPT setup resulting in highly efficient systems. In, conclusion, non-conventional sources of energy in the near future and here one uses the greatest renewable energy of all.

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