Grid Integrated PV battery system for Residential and Electrical Vehicle Application: A Review

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ABSTRACT-

The use of photovoltaic system is increasingly growing in importance since they involve a utilization of solar radiation constituting an energy source which is renewable available in most places, pollution free and abundant. Nowadays, available fuels to run vehicles are less and after some years they will be finished at one point because of day by day the use of fossil fuels such as coal, oil, nuclear, gas, etc. So, it is to use renewable energy sources as tidal, wind, solar, hydro. There is another energy source which plays an important role in this running world that is Electricity to run the vehicles. The power electronics plays very important role in use of renewable energy sources because it gives clean energy generation, bulk storage of electricity efficient energy utilization and higher efficiency than conventional resources. The MPPT techniques which are developed to extract maximum power from available PV panel capacity are discussed. And also, solar photovoltaic system for different applications is reviewed.

Keywords: - *MPPT, Incremental Conductance, DC link, photovoltaic system, PI controller.*

1. INTRODUCTION-

In today's world conventional energy sources are insufficient to fulfill the increasing electric energy demand with increase in energy utilization and population growth of world. Due to this there is imbalance between demand and supply which is major global issue today. There are many renewable sources are available such as solar, wind, tidal, biomass, ocean, thermal etc. So, from all this solar energy is considered as most promising source of energy due to its abundance almost anywhere with advantages as quite work environment and low maintenance cost the output of solar photovoltaic system is DC converted into AC by using the inverters. The grid interfaced inverters have many challenges as cost, efficiency, circuit topology and control algorithm to improve energy conservation efficiency and reliability with longer life. Also proposed various MPPT techniques to extract maximum power and energy from solar photovoltaic panel in order to achieve maximum efficiency in operation are studied.

The initial cost of SPV systems is high because of the high cost of SPV panels. But after installation the main focus is on extracting maximum energy output from the plant. The design and implementation for partial shaded conditions and load variation due to solar irradiation and meteorological conditions such as passing clouds, rotation of earth [1]. Modified incremental conductance algorithm is mostly used for partially shaped conditions and load variations of PV system because it is simple to track GMPP with introduced to modulate the duty cycle of the DC-DC converter in order to insure fast MPPT process [2][3]. Nowadays, power electronic playing important role in energy saving also it gives higher efficiency than traditional methods. Also, it gives clean energy generation, bulk storage of electricity and efficient energy utilization.

The incremental conductance (Inc. Cond) algorithm, fuzzy logic control, perturbation and observation (P & O) and Hill climbing, temperature method, neural network are various MPPT technologies studied to extract maximum power from the PV panel [4].

1.1 Solar Photovoltaic Design and Implementation-

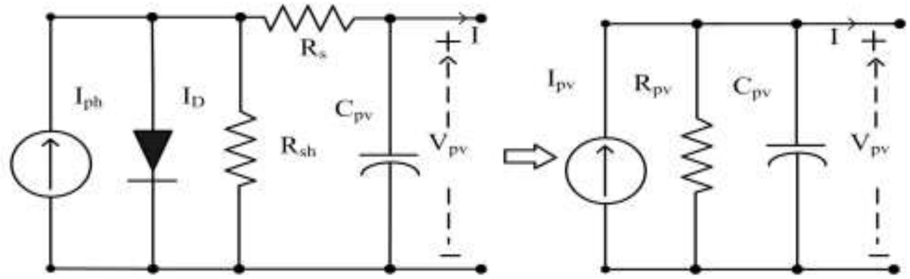

Fig. **1**: Equivalent circuit of PV panel

A simple equivalent circuit model of PV cell consists of a real diode in parallel with as a current source. There are two conditions for actual PV and for its equivalent circuit are as

1. The current that flows when the terminals are shorted together i.e. (I_{sc}).
2. The voltage across terminals when the leads are left open (V_{oc}).

When the leads of the equivalent circuit for PV cell short circuited together, no current flows in diode is V_d=0, so the whole current from the whole ideal source flows though the shorted leads. Since the short-circuited current must equal to Isc, the magnitude of ideal current source itself must be equal to Isc. When the leads from the PV cell are left from the load current I, is null and the voltage on the load is equal.

To overcome the drawbacks such as marginal reliability, loss of efficiency in partially shaded conditions and complex operations in the existing solar PV systems, use of PV module integrated inverters is one of the best solution, which is referred as a micro-inverter. In PV panel integrated system, the operation is mainly designed to work only in grid connected mode and it shuts down in the event of grid supply failure. So, important task is to reduce the cost, improve the efficiency and features which will allow it to work and deliver the load power even in the event of grid failure. It enhances the system utilization ratio and improves power quality. All operations are monitored and controlled intelligently through the DSC TMS320F28027 with switching frequency 60 KHz. The SEPIC converter is operated in CCM mode to ensure optimum power transfer. As the duty ratio increases, the converter output increases. Integrated converter-inverter system is the most promising method for grid synchronization. The standalone (isolated) inverter operation is achieved using voltage mode control without MPPT in order to provide the load a steady operating voltage with VAR compensator operation is implemented through the reactive power control while only inverter participates in the control keeping SEPIC converter off [1].

1.2 MPPT Technologies and algorithms-

There are various MPPT technologies have been introduced to extract maximum power from PV panel, also to achieve optimal performance under uniform insulation. The efficiency of energy conservation is currently low and initial cost for implementation is still high. Since it become necessary to use modified techniques in order to achieve maximum efficiency in operation. However, under partial shaded conditions the conventional algorithms are unsuccessful in identifying the GMPP among the local MPP’s therefore reducing overall efficiency of the PV system. Also, conventionally the duty cycle of converter is modulated step by step to reach the desired voltage, and it is time consuming or slow for large PV array. Therefore, a faster algorithm to obtain the desired voltage is introduced. So, there is need of modifications in conventional algorithms. Inc. Cond algorithm is altered to realize a simple linear equation to track the GMPP which is based on a multifaceted duty cycle control method that effectively utilizes the periodic P–V characteristics of partially shaded condition successfully demonstrated in tracking the GMPP under varying loads and weather conditions. It is implemented instead of P&O algorithm due to its consistent performance under fast-varying weather conditions, introduced to provide fast tracking of the MPPs. It is used to modulate the duty cycle of the converter, and thus, the tracking speed is improved, also able to respond rapidly and accurately to the variation in the load and the solar irradiation during partial shading conditions [2].

The operation of P&O algorithm is based on periodic measures of the voltage and current of the PV system. The main advantage of this technique is its simplicity with having disadvantages such as oscillations around of the MPP and failures due to abrupt changes in weather conditions. Fuzzy logic controller consists of three stages fuzzification, fuzzy inference mechanisms and defuzzification. Advantages of this method are its independence of the mathematical model of the system and its ability to handle system nonlinearities with disadvantage that its effectiveness depends on the error calculation. The beta method was presented as a good solution regarding high-quality TF, reduced and smaller ripple voltage in steady state, good transient performance, and medium complexity of implementation; however, it is dependent on the PV characteristics [3].

2. Operation of grid interfaced SPV system-

For control of this multifunctional VSC, interweaved DFSOGI (Double Frequency Second Order Generalized Integrator) which is combination of SRF (Synchronous Reference Frame) is used which possesses the feature of good steady state performance along with fast dynamic response even under sudden load changes at CPI. Also, this algorithm provides a solution to tradeoff between steady state and dynamic performance. An adjustable DC link voltage structure is used to accommodate CPI voltage variation which helps in reduction of losses in the power circuit and to regulate DC voltage PI controller is used. The adjustable DC link voltage not only helps in reduction of switching losses in all the power devices but also in reduction of high frequency ohmic losses in the interfacing converter which is achieved at under voltage and at nominal CPI voltage. The increased ripple in the inductor current causes increased ripple in the grid current which is depends on instantaneous voltage difference between the line voltage and the DC link voltage. Therefore, high frequency ripple current is higher in conventional system, which responsible high frequency ohmic losses. A two-stage grid tied multifunctional solar energy conversion system helps in power quality improvement at CPI and feeds the available solar energy into the grid. Also not only helps in improving the voltage power quality but also helps in reduction of distribution losses[5].

There is still no model-based MPPT for partially shaded PV systems, mainly because the available models are complex and time consuming. There are three developed rules governing in the formation of power peaks in partially shaded PV system to quickly determine the peaks of a PV system without simulating the entire power curve and thus saves sufficient time. The effectiveness is to find the power peaks quickly and accurately was verified using MATLAB simulation [6].

The single-phase low voltage SPV inverters are installed in the distribution system which helps in the reduction of losses in the distribution line and the transformer. The SECS (solar energy conversion system) not only feed solar energy into the grid but also performs all features of the shunt active power filter. The system acts as a distributed generation system which helps in the reduction of losses in distribution system with purpose of reactive power compensation helps in and improved utilization. Fast dynamic response and MPPT control is obtained by using load and PV feed-forward terms and adjustable DC-link voltage respectively. The system has been used for feeding solar PV energy into the distribution network and power quality improvement which helps in reducing the distribution line losses and transformer also compensation for the reactive power and harmonics [7].

The battery energy storage system (BESS) forms the weakest link in the system which acts as load and stores the energy while in excess, and acts as a source to meet the demand of extra power by the load thus increasing the reliability of the system. The literature review has revealed various benefits of inculcating a BESS in the system which are enlisted. The vast research has been carried out in maintaining a continuous power supply to the load especially critical loads such as medical equipment, telecommunication network etc. s. Second order generalized integrator (SOGI) based phase locked loop is implemented to achieve the synchronization with the grid parameters. The resynchronization is achieved using a PLL-PI (Phase Locked Loop - Proportional Integral) based controller to achieve a smooth transition of VSC from standalone to grid connected mode. To counteract the nonlinearity of converters, the phase margins and the bandwidth of the controllers are kept high enough to maintain the stability of the system. The system used for a PV array and battery energy storage system (BESS) to a single-phase grid with multifunctional properties also best suited for residential applications especially for critical loads and charging/discharging of electric vehicles due to the reliability of uninterruptable power to the grid and the load. The system has ability to resynchronize with the grid which helps in achieving the fast time response of the system, thus making it a suitable choice for residential applications [8].

In electrical vehicles power system consist SVP, battery and ultra-capacitors. The main source is battery which is supported by UC under transient phase such as starting and breaking and by SPV under steady state operation, which effect is enhanced travel range, reduced battery size, enhanced battery life and excellent dynamic response which results in smooth ride, optimal energy utilization and optimal sizing of energy sources. The control strategies to ensure stability and fuel efficiency of the EV, includes the inner current and outer voltage correcting loops for the storage interfaces to render fast dynamic response. Interfacing of battery and Ultra capacitor through a multi-input port dc-dc converter has the limitation that the Ultra capacitor voltage is always less than the battery voltage resulting in simplified operation. Also, PV has limitations of VOC, ISC and dependency on factors like change in weather conditions and geographical location. So, interfacing of PV, battery and UC with the dc link through a boost converter and two individual buck-boost bi-directional converters is used. Control loops have been designed to maintain battery voltage and UC voltage at their nominal values to ensure effective utilization of storage and avoid violation of any ratings, to modulate and design it state space analysis is used. Presence of UC helps in reducing the battery size also extends the range of distance covered by vehicle. It improves system performance by contributing burst of power during vehicle acceleration and absorbing the regenerated energy while deaccelerating. Development and implementation of separate and efficient current and voltage loops have resulted in more effective control leading to improved dynamic response of the system. More results will be presented in a future paper [9].

3. CONCLUSIONS

In this paper, various MPPT techniques to extract maximum power from PV panel, from this Incremental Conductance is mostly used because it gives improved tracking speed due to which system able to respond rapidly and accurately to the load variation and solar irradiation. DC link voltage structure for CPI helps in reduction losses in power circuit. The comparison of interleaved DFSOGI based algorithm and conventional SRF theory discussed about its effectiveness. The algorithms for SPV system have advantages as improved reliability, energy conservation efficiency, clean energy generation, bulk storage of electricity, improved tracking speed and power quality improvement. In proposed scheme DC link is implemented which results in smooth ride and optimal energy utilization for electrical vehicle. Ultra-capacitor is used to burst of energy during starting and acceleration also provides regenerative breaking operation which absorbs extra power generated by the load to avoid overcharging of the battery.

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