OPTIMIZED ELECTRICAL ARCHITECTURES AND THE CONTROL OF ENERGY IN PV APPLICATION.

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Abstract:  
In this paper, we present a study simulation and evaluation of shading effect on GPV connection with different DC-DC converter topologies for photovoltaic application. The objective of this paper is investigates different photovoltaic configurations and their effect on the PV array efficiency, while this paper focuses in the optimization of the efficiency of photovoltaic power conversion chain. It provides different improvements on the electrical architecture and evaluation of shading effect in fact, for this latter we use two configurations, the series and the parallel connection of a converter that involves a major power transfer capability. Obviously, these two topologies have some advantages. Each power converter can control the power conversion of each module individually, which results in increased overall energy conversion of the entire system. The MPPT control system in this case can react effectively to atmospheric variations and to study the influence of the effect of partial shading different values of solar radiation concerning performance of PV cells. Taking the effect of irradiance into consideration, the output current and voltage characteristic of the photovoltaic system. We simulated and compared the different conversion configurations in order to find the best one in terms of efficiency and produced energy. The obtained results are very interesting; it allows the selection of the best PV
topology and the best configurations of différents DC-DC converter topologies. The obtained results are very interesting; it allows the selection of the best PV topology for a given application.

Key words: Photovoltaic Generator, Maximum Power Point Tracker MPPT, shading, performance, power, DC-DC Converters.

1. Introduction:

Renewable energy resources are more and more consider by decision makers to have a fundamental role in the world wild energetic mix. Because of their independence from limited fossil and nuclear resources and their low impact on the environment they will become the only crisis-proof and reliable energy supply within the next decades. The world's major energy sources are not renewable and are faced with ever increasing demand, thus are not expected to last long. Besides being non-renewable, these sources includes mainly of fossil fuels, contribute tremendously to the perennial problem of global warming [1]. Energy harvesting is the act of scavenging small amounts of power from the ambient energy resources. Such ambient energy can come from different sources such as solar, thermal, wind and kinetic energy [2]. These energies, which are additional to those available on the distribution grid, can be used to increase this available power, to supply isolated or autonomous sites and/or to reduce the frequency of charge/discharge cycles of batteries up to possible reducing of their need, thus allowing an increase in overall life of the energy production system [3].

Solar energy could be one of the significant sources as an alternative energy for the future. In regard to endless importance of solar energy, it is worth saying that photovoltaic energy is a best prospective solution for energy crisis [4]. The architecture of the power converter is important in a PV system. This structure determines the main characteristics of the photovoltaic installation, as the amount the PV modules need for the PV system and its type of connection. The effect of the partial shadowing or mismatch between PV modules in the energy production will also depend on the type of the architecture. Nevertheless, the price and cost of the PV also depends on the choice of the architecture, the choice will involve a bigger or smaller energy production and efficiency as well as an importance difference in the cost. For this reason, it is important to know different types of architecture in order to choose the correct PV architecture for each PV installation [5]. Upgradeable PV systems should be able to except additional modules, to increase the plant’s power rating, and future module technologies without disrupting normal operation [6]. The upgradeability of topologies can be evaluated by detecting evolvable patterns, which they do not interfere with the overall operation. Furthermore, if modules need to be replaced during the plant’s lifespan, an upgradeable installation must easily integrate new components without degrading its initial performance [7]. Another important phenomenon in PV field is the mismatching effect of unequal voltage between strings that occur because of dissimilarity between the voltages of the modules in different strings. In order to solve this problem, blocking (string) diodes are used in each string to prevent the back feed current between strings. This method is beneficial but also has additional losses that will be added to the PV system losses.

The losses due to partial shading are reduced because each string operates at its maximum power point. Additional strings can be easily added to the system to increase its power rating, thus, increasing the flexibility in the design of the PV system. This system increases the system efficiency, but with additional cost due to the increase in the number of inverters [8].

In this work, we perform study comparative between a series and parallels connection different arrangements of PV modules with their associated power converters have been developed to increase power production and reliability of the solar generators and the simulated partial shaded array with difference with the numerical methods Analyses and simulation of the performance of the different configurations are presented tools are
used to demonstrate that the proposed topologies provide improvement in efficiency over existing traditional PV systems. In the conclusion, the key show your results presented a potential research idea for future work in this field is proposed.

2. Photovoltaic Arrays:

In order to implement the cell into real application, a combination of cells forms different sizes where a module consists of connected PV cells in one frame, and an array is a complete PV unit consisting of connected modules with structural support [9]. Each PV array is comprised of parallel connected strings. Each string consists of multiple series connection of PV modules that provide the required voltage of the array. These structures can be used to supply power to scalable applications known as photovoltaic plants, which may be stand-alone systems or grid-connected systems [10]. Modules can be connected in different ways to form PV array. This is done for the sake of voltage/current requirement of the power conditioning units of the PV system. In order to do that, a series and parallel connections of PV modules are needed.

![Fig. 1. Connection of PV module.](image)

Shading and mismatch losses of PV system are considered very critical problems in the PV systems. Significant reduction in generated power from solar PV arrays occurs when the shading falls across some PV modules, leading to extra losses [11].

3. Connection Topologies of Converter:

The utility interactive system, the simplest system in terms of its number of components, can be configured with added components to serve its intended purpose and improve efficiency. These configurations can be classified into; series and/or parallel converter topology. The interconnecting different structures, new tasks that only with one converter cannot be achieved are reached. For instance, Many type of association can be envisaged, the series and parallel connection of converter involve a major power transfer capability. The series connections increase the voltage. The parallel connections are used to increase the current.

A. Series-Connected DC-DC Converter Control Strategy

In this paper the series-connected DC-DC converter system topology is composed of Boost converters that are assembled in strings. Each panel is then connected to a single DC-DC converter, as presented below Fig 2. In series connected ports, the voltages are added. Thus, higher voltage can be achieved in the output port, and therefore, this output port can be directly connected to a grid-tied inverter, assuring an adequate voltage level for its inversion and grid connection. Nevertheless, as all the output must have the same current level, the system often presents a big instability and its control a high complexity to resolve it, representing the biggest drawback of this kind of connection. [12].
The number of series-connected converters is directly linked to the required Boost voltage ratio in order to maintain a decent DC bus voltage. In normal operation, they participate equally to the string voltage. Hence, the output voltage of each Boost converter is VDC/N. Consequently, the more converters are placed per string; the lower is the voltage ratio for each converter. Considering normal operation of the PV system, the Boost converters can fulfill both MPPT and maintain a sufficient DC bus voltage. However, in degraded mode operation (i.e., Partially shaded strings) the output voltage of the Boost converters may require an additional control strategy in order to limit over-voltage. [13].

This solution keeps the advantage of discretization power management and to achieve the required voltage level for proper operation sets panels DC-DC converter is then connected in series as a string of same manner as in a conventional structure. If illumination falling on a panel, the voltage produced by this panel will inevitably fall and the output DC-DC converter. Although the study of series connected PV converters is increasing, the parallel connection is still used today and many authors’ present innovative advances to find the best structure to this kind of structures.

B. Parallel-Connected dc-dc Converter Control Strategy

The parallel connection of converters allows the connection of almost all the converters structures. Either DC-DC converters or inverters can be connected in parallel. Nevertheless, a successful selection of the paralleling scheme requires a firm understanding of merits and limitations of different paralleling schemes.

The paralleling scheme must be selected by taking the complexity, cost, modularity, and reliability into consideration. Various interactions among converters modules must be incorporated into the control design and system integration to ensure stability, reliability and good dynamic performance. [12].

Fig. 2. String converter connected in series.

Fig. 3. String converter connected in parallels.
The major advantage of these structures is the reduction of the thermal and electric stress in the components. As the charge is divided, a bigger power charge can be transferred without an increase in the power component stress. In this way, the system gains in robustness and in reliability.

4. DC-DC Converter Control:

The DC-DC converter control strategy consists in extracting the maximum power of the PV array by determining the optimal input voltage reference. The voltage reference is set by using a MPPT algorithm which tracks the evolution of the PV array power in order to find the optimal voltage reference. [14]. The use of DC optimizers to extract the maximum photovoltaic energy is more widely used. These structures are placed next to the PV module, and they extract the maximum energy from the PV module in a distributed way. According to photovoltaic use forecast studies. [15]. The last proposed architecture to optimize power transfer, is to use a matching stage DC / DC controller with MPPT. This management architecture corresponds to a discrete architecture. In fact, each given field will have its own floor of adaptation to exploit the power available at the terminals of PV. Thus, approaching as close to the source of production, it is hoped to produce maximum power. The diagram in Fig.4 thus shows the principle of power control.

![Fig. 4. Simplest electrical scheme block of a typical power conversion chain.](image)

The main goal of a MPPT control is to automatically find at each time the VOPT and IOPT of a PV array and then to allow it to operate at its PMPP under given temperature and irradiance. Best MPPT control algorithms have to be fast, stable, robust, and efficient. MPPT methods, commonly used in widespread applications, are currently reported in the literature [16].

5. Analysis of DC / DC Converter:

In this paper we describe and analyze a new way to measure characteristic curve by using DC-DC converters. The switching power converter DC-DC are widely used in photovoltaic systems to transform DC power between a voltage and another, and are also used in maximum power point tracker (MPPT).

The goal of the DC optimizer is to extract the maximum power possible from the PVG, placing the MPPT in a distributed way [17], [19]. The DC-DC converters concerned in this study are step-up voltage converters known as boost converters. The electrical scheme of the boost converter is reminded in the fig. (5). The boost converter is one of the simplest DC-DC converters. In a DC transformer the relationship of transformation can be controlled electronically by changing the duty cycle of the converter in the range [0, 1].

In this study concerned of Si-IGBT (Insulated Gate Bipolar Transistor) switched mode converter able to produce a dc output voltage that is greater in magnitude than the dc input voltage [18]. Analysis of the DC / DC elevator is based on the equivalent circuit of the DC / DC converter in the light loss is shown in Fig. 6.
6. Simulation Resultants and Discussion:

The simulations were done using MATLAB's Simulink toolbox, for simulation of PV generator and PSIM software for electrical circuits BOOST converter simulation while modeling BOOST converter is provided by PSIM.

A. The converters are connected in series

In the series topology of converter we have used two PV panels and two converters connected in series and controlled with an MPPT controller. The model of each converter is the same as each string converter for this case of simulation.

The simulation resultants of Vs (output voltage), IS (output current), and η (efficiency) are shown in the following figures.
That means that the efficiency \( \eta \) increases rapidly with the power to reach a maximum yield of 77% - 78%.

**Damage on a single converter**

![Simulation results of the string converter connected in parallels.](image)

That is the efficiency \( \eta \) increases rapidly with the power to reach a maximum yield of 61% - 62%.

**B. The converters are connected in parallels**

The model of each converter is the same as each string converter, the two converters connected in parallel. The simulation resultants of \( V_s \) (output voltage), \( I_S \) (output current), and \( \eta \) (efficiency) are shown in the following figures:

![Simulation results of the string converter connected in parallels.](image)

That means that the efficiency \( \eta \) increases rapidly with the power to reach a maximum yield of 85% - 86%.

**Damage on a single converter**

![The yield effect in case of single converter damage.](image)
In the case of damage on a single converter, it is noticed that the efficiency $\eta$ increases rapidly with the power to reach a maximum yield of 80% - 81%.

7. Conclusion:

In this work, we have studied in detail use two configurations, the series and the parallel connection of a converter that involves a major power transfer capability can be connected in series and/or parallel. The approach adopted in this paper was based on a comparison study between series and parallel architectures and evaluation of shading effect in the different configurations. Different simulation tests were conducted on these two topologies. The obtained results confirmed our expectations. In the distributed topology, the series connections are used to increase the voltage. However, these structures are unstable and require complex control systems. Indeed, these structures allow the improvement of efficiency and are normally and taking the effect of irradiance into consideration, the output current and voltage characteristic of the photovoltaic system are simulated using the proposed by the different configurations. Avoiding the problems due to the mismatching of them. In this way, the system can extract the maximum power of the PV. This was the motivation behind this work. As future work it is important to compare these simulation results to experimental ones for the different PV arrays architectures.

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