

# Study of photovoltaic systems with differences connecting configuration topologies for applications in renewable energy systems

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**Abstract** –This paper focuses in the optimization of the efficiency of photovoltaic power conversion systems; we present a new alternative for improving both the optimization of the efficiency of photovoltaic power conversion chain. In this way, we present to the valuation problem of photovoltaic by new coupling systems between photovoltaic generators and their loads and performance of photovoltaic (PV) systems and the efficiency of the energy conversion by using different configuration of power converters. Different type's improvements have been proposed of different architecture in order to choose the correct PV architecture for each PV installation on the efficiency improvement in all power conversion level stages between PV cells and loads. In this context, this work presents the study and adaptive simulation of photovoltaic systems with micro inverters configurations for applications of renewable energy. We performed comparative between a central and distribution connection of converter via an adaptation floor with Maximum Power Point Tracker (MPPT) control. For this reason, it is important to know different types of architecture and different configuration of power converters in order to choose the correct PV architecture for each PV installation. Simulation results are used to demonstrate the proposed topologies to provide improvement in efficiency over existing traditional PV systems.

**Keywords:** Photovoltaic systems, Maximum Power Point Tracker MPPT, Topologies, micro inverters, performance, power, DC-DC Converters

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## I. Introduction

The world's major energy sources are non-renewable and are faced with ever increasing demand, thus are not expected to last long. Besides being non-renewable, these sources include mainly fossil fuels, contribute tremendously to the perennial problem of global warming, renewable sources of energy acquire growing importance due to its enormous consumption and exhaustion of fossil fuel. Solar energy could be one of the significant sources as an alternative energy for the future. Such ambient energy can come from various green energy sources such as solar, thermal, wind, and kinetic energy. In regard to endless importance of solar energy, it is worth saying that photovoltaic energy is a best prospective solution for energy crisis [1].

In the literature, different topologies for distributed power conversion for PV system have been studied.

The architecture of the power converter is important in a PV system. This structure determines the main characteristics of the photovoltaic installation, the competitive topologies must be ready to fulfill these requirements with minimal changes on the 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 [2].

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 [3].

The competitive topologies must be ready to fulfill these requirements with minimal changes on the installation. The main architectures of the nowadays PV system will be analyzed, following their evolution and looking for the future tendency.

In the central inverter topology means that PV-panels are connected in one common array both series and parallel that is connected to one large inverter (implemented by MPPT system). Moreover, 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, the result of PV array is connected to a single DC/DC converter. This topology has the economic benefits as the number of the inverters is small, but the partial shadowing of the one panel will effect on the whole array power output. The reduction of the generated power is caused by the characteristics of the PV-panels. The main advantages of the centralized inverter are the simplicity of the layout [4].

In the String Inverter configuration, each string has its own inverter and all inverters operate in parallel to supply the load.. This system increases the system efficiency, but with additional cost due to the increase in the number of inverters [5].

The goal of the research presented in this paper is structured around three main parts.

Firstly, we present different topologies in details and discussing different proposed PV topologies such as Adaptive PV central-inverter configuration, and the Adaptive PV string-inverter configuration including some illustrations of different operational conditions and the controller logic.

Secondly, we describe and analyze this characteristic curve by using DC-DC converters. The switching power converter DC-DC are widely used in photovoltaic systems to transform DC power, and are also used in maximum power point tracker (MPPT) an adaptive photovoltaic (PV) system is proposed adaptive configuration is analyzed form different possible topologies.

Finlay is organized as follows. 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. Furthermore, a prototype has been designed and developed we present and discuss the obtained results via simulation using a co-simulation MATLAB and PSIM software. Furthermore, results of both systems are analyzed and compared.

In the conclusion, the key show your results presented a potential research idea for future work in this field is proposed.

## II. CONNECTION TOPOLOGIES OF PV SYSTEMS

Many type of association can be envisaged, the series and parallel connection of converter involve a major power transfer capability, 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; central converter topology, string converter topology.

### II.1. Centralized converter topology

The simplest configuration is the central inverter system, shown in Fig. (1), where PV modules are connected to form strings. In the central inverter topology, strings consisting of series connected PV panels are connected in parallel to obtain the desired power. The resulting PV array is connected to a single DC/DC converter. The main advantage of the central inverter topology is the low cost as compared to other topologies as well as the ease of maintenance of the inverter. The thus structured PV high power of the generator is connected DC side to a single converter. This central inverter has a high efficiency at reduced costs. However, this topology has low reliability as the failure of the inverter will stop the PV system from operating [6]. This is because each string has its own MPP according to the operational conditions and shadowing effect.

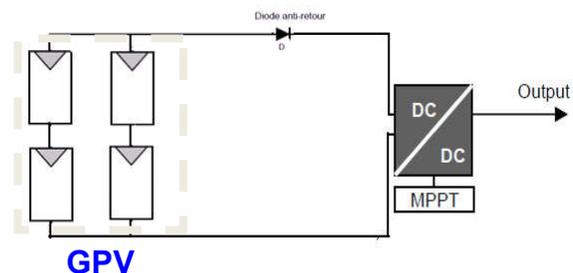


Fig. 1. Central converter configuration

### II.2. String converter topology

In the String converter configuration, shown in Figure (2), each string has its own converter and all inverters operate in parallel or series to supply the load. In string topology, each string is connected to a DC-DC converter. The outputs of the DC-DC converters are connected to the centralized grid-tied inverter, which may not be the desired voltage required to obtain MPPT for all panels. Consequently with this configuration not all the panels are utilized effectively.

The problems of the partial shadowing of array each of the PV-modules gets equipped by parallel diode, that by passes the module in case if module is shadowed or damaged. Some of the modules get produced with built in diodes for several cells of PV-panel. This system increases the system efficiency, but with additional cost due to the increase in the number of converter [5].

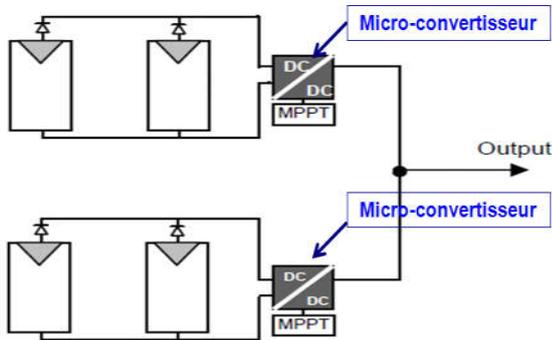


Fig. 2.String converter configuration

### III. 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 [7]. 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 [8].

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.

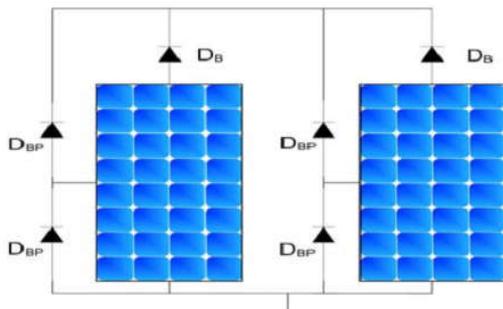


Fig. 3.The typical electric protections in a PV module.

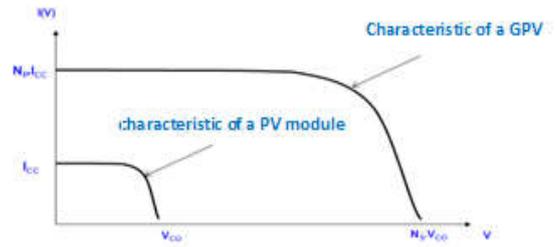


Fig. 4.The association of PV module

### IV. SHADING OF PV SYSTEM

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 [9]. PV modules are very sensitive to shading. When one full cell is hard shaded by structure that stops light from reaching the cell(s), the voltage of that module will drop to half of its non shaded value in order to protect itself as shown in Fig. (5).

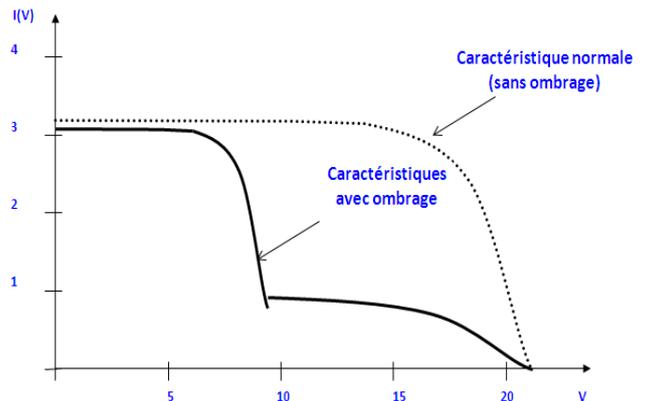


Fig.5. Shading affects me a tiny drain of energy on the entire system

**V. MAXIMUM POWER POINT TRACKING (MPPT)** The main goal of a MPPT control is to automatically find at each time the VOPT and IOPT of a PV array. 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 [10].

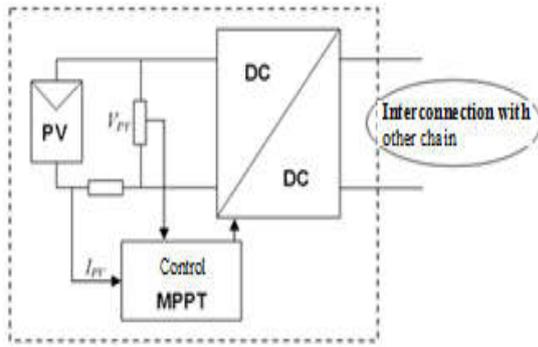


Fig.6. Simplest electrical scheme block of a typical power conversion chain

The current and voltage measurements are important parts in the MPPT controls, since they affect in the accuracy and the efficiency of the controls.

## VI. 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 electrical schema of the boost converter is reminded in the fig. (7), 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].

The relationships used for the design are the conventional relationship between the output voltage, the input signal and the duty ratio [11]:

$$V_{OUT} = \frac{1}{1 - \alpha} V_{in}$$

Nowadays, there are two widespread and cost-effective technologies suitable for the implementation of the proposed converter switches: MOSFET and IGBTs because both technologies are available for the intended operation voltage, current and frequency [12].

### Losses of IGBT

Conduction losses mainly depend on the duty cycle, load current and junction temperature, whereas, switching losses depends on the load current, dc link voltage, junction temperature and switching frequency [12]. If the switching frequency is higher, then the losses

will be higher. The total average power of the IGBT is the sum of the conduction loss, turn on and turn off losses as shown in Eqn. (1).

$$P_{avg\ IGBT} = P_{cond} + P_{on} + P_{off} \quad (2)$$

When the IGBT turns on, collector current increases rapidly and the voltage across the collector to emitter decreases.

$$P_{avg\ cond} = \frac{1}{T} \int_0^T [V_{ce}(\theta) \times I_{ce}(\theta)] dt \quad (3)$$

Time period 'T' is inversely proportional to frequency 'f'

$$T = \frac{1}{f} \quad P_{avg\ cond} = f \int_0^T [P(\theta)] dt$$

The total average power loss incurred in the IGBT can be obtained by integrating all the values of power losses over a period of time. The total average power loss for the IGBT can be split into three phases;

- 1) Turning on the device,
- 2) Conducting period,
- 3) Turning off the device.

$$P_{avg\ IGBT} = P_{cond} + P_{on} + P_{off}$$

The conduction losses are independent of the switching frequency but dependant on the duty cycle, the values for the energy loss  $E_{on}$  and  $E_{off}$  are given in the Dynex datasheet; therefore there is no need to calculate these values [12]. The switching energies are then simply multiplied by the switching frequency to give the power loss for on and off time as shown in Eqn. (5).

$$P_{sw\ IGBT} = (E_{on} + E_{off}) \times f_{sw}$$

Total Losses:

$$P_{avg\ IGBT} = P_{cond,IGBT} + P_{sw,IGBT}$$

The average total power loss in diode is given by Eqn. (7).

$$P_{avg\ diode} = P_{cond,diode} + P_{rec,diode}$$

Reverse Recovery Time:

When the device turns off it generates losses called recovery loss and the time required to recover is called the reverse recovery time. Change of forward voltage and forward current can give the RD resistance value.

$$V_f = V_{D0} + R_D \times I_c$$

The average power losses in diode are when operated under PWM sine wave switching is given by Eqn.(9).

$$P_{rec,diode} = E_{rec} \times f_{sw}$$

## VII. SIMULATION RESULTANTS AND DISCUSSION

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

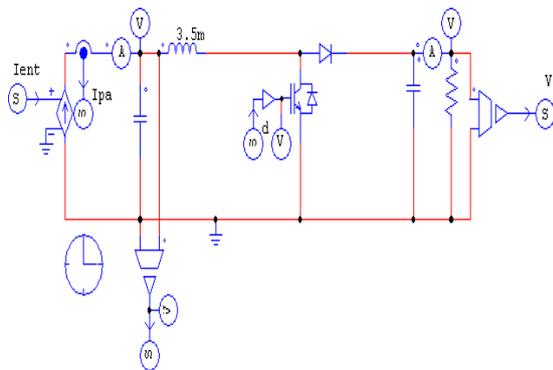


Fig.7. Electric structure of the boost power converter

The parameters have been used throughout the simulations, these are listed below:

$L = 3.5 \text{ mH}$ .  $C1 = C2 = 5.6 \text{ mF}$ .  
The switching frequency:  $f_{sw} = 5 \text{ kHz}$

### A. Simulation of a central converter

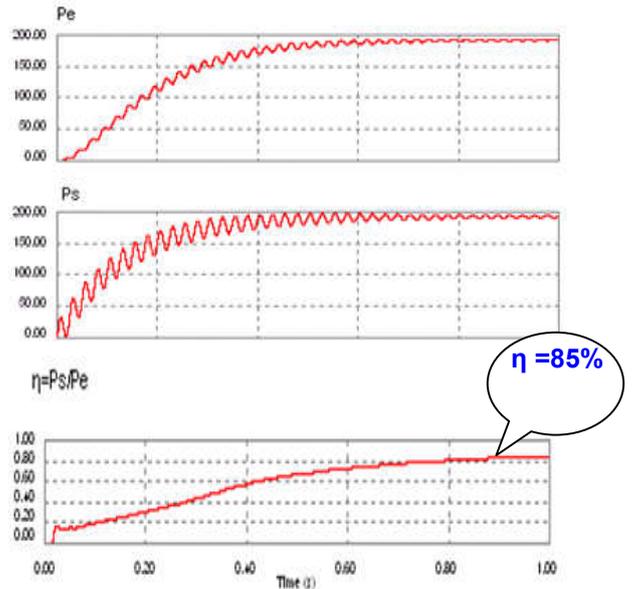
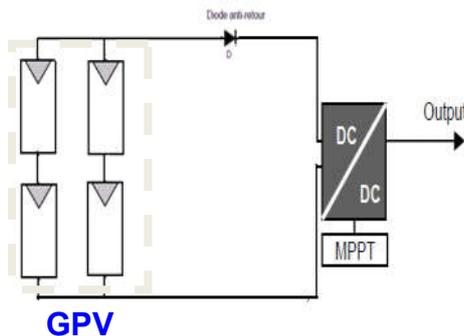


Fig.8. The central converter.

The figures show a simulation of the variables:  
The figures (9) show a variation of efficiency simulation of a power converter in relation with input power.

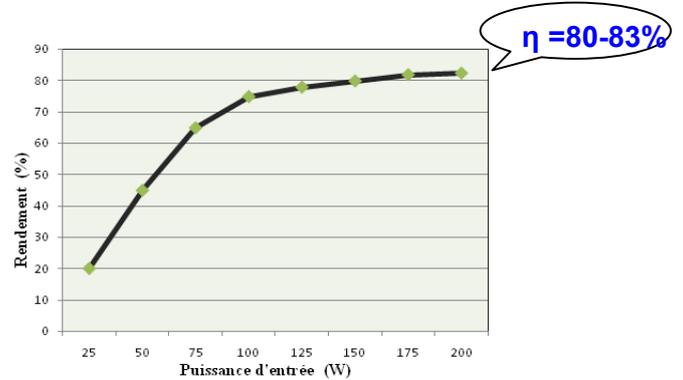
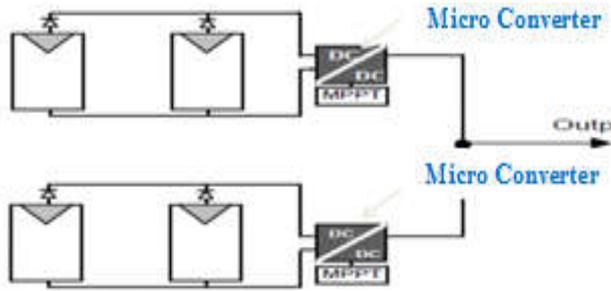


Fig.9. Efficiency simulation of a power converter in relation with input power

That the efficiency  $\eta$  increases rapidly with the power to reach a maximum yield of 80% -83 %.

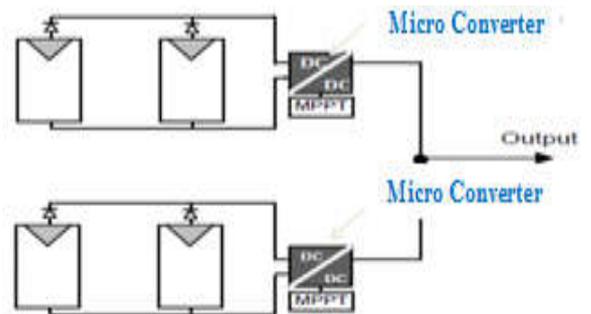
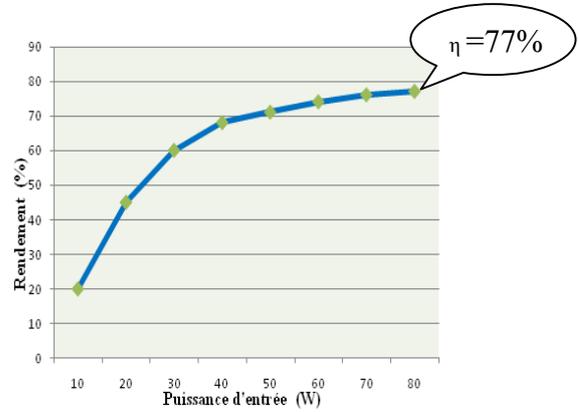
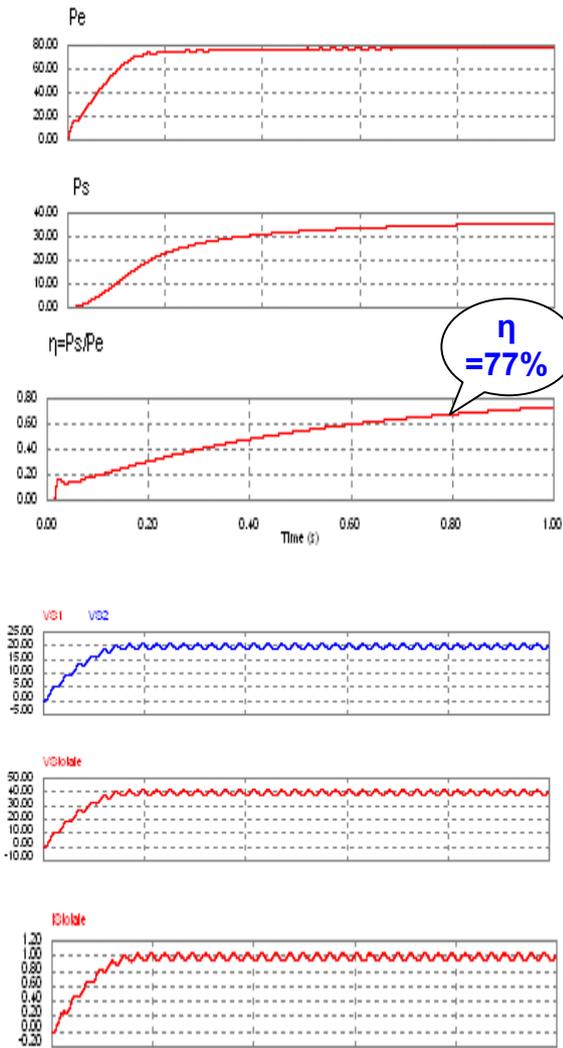
### B. Simulation of a string converter

The converters are connected in series:



The figures show a simulation of the variables:  $P_e$  (input power),  $P_s$  (output power),  $\eta$  (efficiency),  $V_e$  (input voltage),  $V_s$  (output voltage),  $I_s$  (output current). The fig. (11) show a variation of efficiency simulation of a power converter in relation with input power

The model of each converter is the same as the central converter, the two converters connected in series



The model of each converter is the same as the central converter, the two converters connected in parallel.

Fig.10. Simulation results of the string converter connected in series

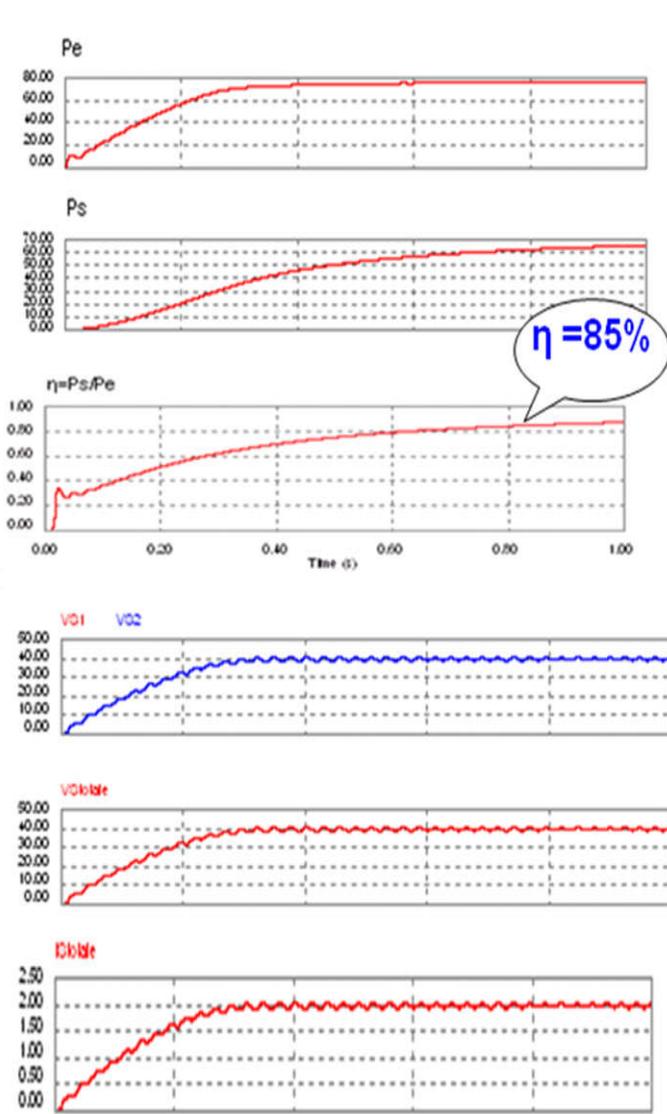
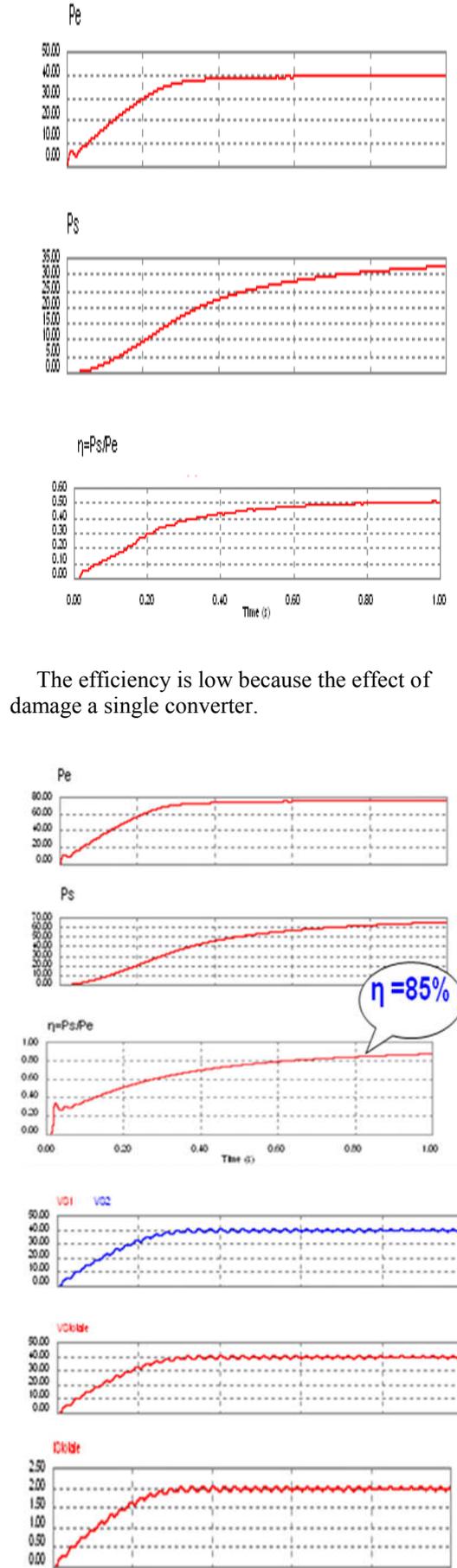


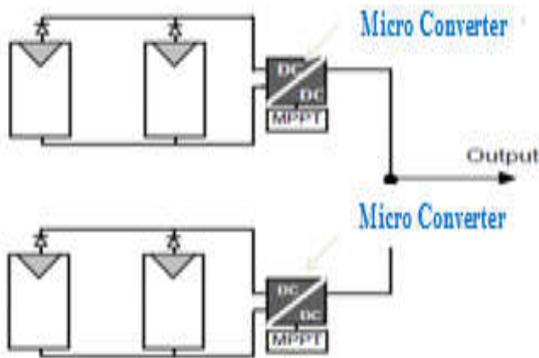
Fig.11. Simulation results of the string converter connected in parallels

**Damage on a single converter**



The efficiency is low because the effect of damage a single converter.

**Parallels**



The model of each converter is the same as the central converter, the two converters connected in parallel.

Fig.12. Results the string converter connected in parallels

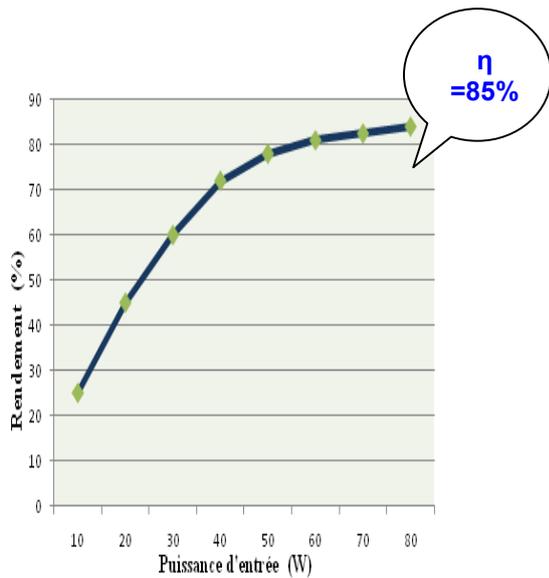
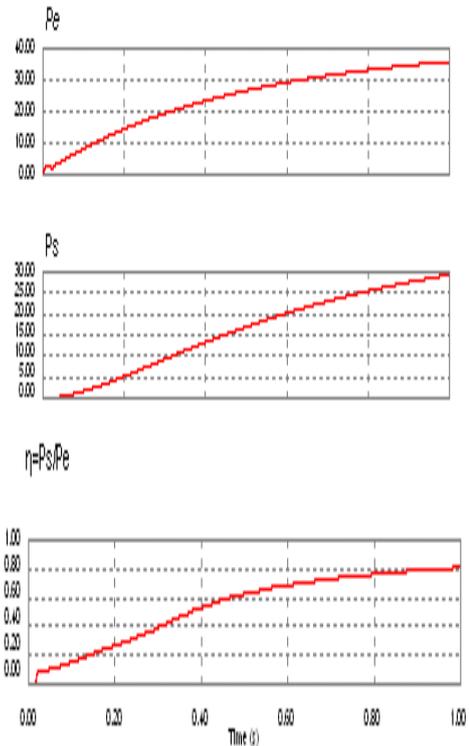


Fig.13. Converter image with input power

**Damage on a single converter**

If you destroy a converter the yield is low.

**V. Conclusion**

In conclusion to paper, we are proposing different topologies system between central and distribution. The approach proposed in this paper a comparison study by simulation of these two approaches. The obtained results showed the efficacy of the proposed; in the centralized topology which divides the PV arrays into strings, a bigger division is taking place; and the PV group is directly divided in individual PV modules connected to a unique power a DC-DC converter. In string topology, each string is connected to a DC-DC converter. In the topologies, string benefits of the MPPT control and the maximum power point tracking is carried out in more distributed way than the centralized architecture. Thus, a failure in one of the string does not affect to the energy production of other strings and the PV power production is improved. Nevertheless, the price and cost of the PV also depends on the choice of the architecture. For this reason, it is important to know different types of architecture in order to choose the correct PV architecture for each PV installation.

The conclusion of the paper is presented a potential research idea for future work. This work was motivated by these issues and hopes to have contributed to their progression. The future work will be simulate the different architecture with series connection or parallel DC / DC and compare this result with experimental typical configurations.

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