Using Improved MPPT Charge Controller Improvement Functioning Efficiency of Power Grid Connected Solar Photovoltaic System

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Abstract. In recent decades, the world’s energy demand is closely linked to the rise of manufacturing, transport and the media. Today, large amount of the power is provided by non-renewable energy including coal, natural gas, oil and uranium. Pace of regeneration of energy is very sluggish, which adds to the possibility of short-term depletion. This paper focuses on power grid-connected photovoltaic systems. The primary objective is to regulating power pumped into the grid from solar panels and improving the configuration and regulation of inverters as used to supply electricity to the grid with optimum efficiency and according to networking requests as an interface between the grid and photovoltaic systems. The infused power management not only contains the aggressive force control but also the reactive power control. An algorithm is proposed for the design of a simple and robust grid-connected inverter power. It is based on the strategy for digital power. The proposed work analyses and improves the constraints of the VSCs’ Voltage Source Converters as converters for supplying active and reactive power into the grid, ensuring the best possible connection from the solar panels, ensuring effective operation of the inverter, increasing the current injection into the grid power and harmonic levels.

1. Introduction
Demand is growing, exceeding supply, which results in a high fluctuation in world oil prices. On the other hand, this type of consumption of energy influences the environmental impact. For example, for oil and coal, significant greenhouse gas emissions are generated daily playing a role in climate change and increased pollution [1]. These analysis lead to the search for more innovative solutions to address the energy deficit and limit the negative impact about the environment. Thus, the development of clean and non-polluting sources based on renewable energies are increasingly requested by energy producers and government. However, the solution to reduce the consumption of fossil fuels is the generation of electrical energy from renewable energy, renewable energy has to be regenerated naturally and indefinitely in time. The sun's energy meets these criteria in its abundance on earth and its practically...
infinite regeneration. It can be used directly as thermal [2] or converted into electrical energy by photovoltaic effect, this last, although known for many years, as a source that can produce energy from mill-watts to mega-watts, has been situated for many years, in an anecdotal stage and is not still develops in large proportions, mainly due to the too high costs of solar panels.

Worldwide, the photovoltaic systems market has known, for now and for more than 10 years a very high growth, around 30 to 40% per year and according to the Association of the European Photovoltaic Industry (EPIA), photovoltaic energy will be able to provide 12% of the European electricity demand for 2020, because the evolution of this technology will be faster. For example, in 2009 photovoltaic in Spain covered more than 1.5% of the national electricity demand, with which it can be affirmed that it is no longer a source totally marginal and they assure, the electricity from solar panels will cost less than that of the electricity bill from 2012 [3]. This remarkable growth is clearly represented by technical advancement and a price decrease on photovoltaic panels, but also in significant research and development activities on the power electronics market, primarily due to photovoltaic installations linked to the power distribution network [4][5].

In reality, the technological efficiency and reliability of electrical electricity inverters used by photovoltaic systems can differ considerably from year to year and thus the financial readability of an electricity system. Investors generally suffer from low returns on real plants, due to many technical issues, demonstrating non-optimization of conversion and transfer of the energy of the panels that has the random behaviour. This makes the systems they are too expensive with shortcomings in terms of reliability. Also, your life time three to five years is not enough to satisfy the need for a power source reliable and long-lasting compared to the lifetime of PV panels from commercial guarantee for a period of more than 25 years. On the other hand, the large increase in photovoltaic installations connected to the grid and in inverters that are connected to the electricity grid as an interface to renewable energy systems has forced the development of new and stricter recommendations and related regulations with the quality of the energy injected into the grid. One of the inverter specifications connection to the grid is that they are inverters that only inject active power into the grid with a high-power factor according to the standards in force.

Today, the large increase in photovoltaic installations connected to the grid and the restoration of new standards have motivated the development of investors capable of delivering reactive power to the grid. To overcome the reluctance of many potential consumers and meet the needs of the new European standards on the expected performance of the corresponding systems conversion into real plants, it is important to conduct research to solve technical problems related to power electronics, improving the quality of the power and performance of the inverters from the point of view of topology and control. Other problems always caused in the use of a photovoltaic conversion plant are focus on the coupling problem between the photovoltaic generator and the type load continuous and alternative or connection to the network. The technological problems that exist in this coupling type are, the system is poorly designed, and the production and transfer of the power of the photovoltaic generator (GFV) deteriorates and makes the whole work away from your maximum resources. Power generation is certainly guaranteed, but it is done with significant losses production and, therefore, it is more expensive than expected. The objective is to make the GFV work, at the point of maximum power. Literature is very prolific in this emerging field and proposes algorithms for trackers that perform a search for the maximum power point (MPPT), when the GFV is coupled to a load through a static converter. Know the Exact performance of full power point trackers is normally difficult, many research papers are devoted to this topic and propose a series of criteria for comparative evaluation.

2. Photovoltaic Solar Energy
Renewable resources are inexhaustible, renewable, self-managed and have a further benefit of complementing and promoting integration. The Photovoltaic solar energy offers a very promising alternative, it is one of the new forms of "clean" energy. It is having a broad development, favoured by the awareness of governments and other organizations to preserve the environment in which we live,
which is why more and more aid and subsidies are given to promote this type of facilities. In the past, photovoltaic solar energy has been used as a power source only for some loads, such as satellites or areas far from the sources of the conventional energy. Currently, from the environmental concern of society, arose interest in renewable or clean energy such as solar and wind, presenting itself as the energy solution for current and future society as shown in figure 1.

![Figure 1. PV Generation Systems Block Diagram](image)

Although the use of renewable energy as a primary source is limited by its cost, there is a growing recognition that solar energy can play in reducing of pollution, particularly in stabilizing the levels of carbon dioxide carbon and preserve the environment in which we live. This energy can be a solution for the electricity production for many applications in developing countries, where a large part of the population lives without access to electricity. Photo voltaic solar energy is the one with the greatest potential for use in a dispersed and diversified. Due to its modular nature, it can be used in the countryside and in the city, in populated and unpopulated places, in small and large locations. Basically, it distinguishes two types of applications of photovoltaic solar energy: isolated systems and systems connected to the network. In the first case the application possibilities are huge: from isolated and independent homes or facilities, to central rural electricity, telecommunications, water pumping, cathode protection, signalling, stereos, lighting systems, computers or portable phones, cameras, calculators, etc. However, and appreciating the possibilities offered very positively isolated systems, especially because of their contribution to solidarity, We consider that in wired network networks (where electrification levels are near to saturation level), photovoltaic solar energy may give a major difference in Europe. The growing use of solar photovoltaic energy is the power grid link. In the current situation there are economic stimuli for renewable energy in different countries of Europe, Japan and the USA, among others that aim to control climate change. In this respect, the photovoltaic grid connection and the compensation for kWh sold to the power supply provider are funded with special credits.

3. Motivation

These findings have motivated various research works to develop sources sustainable photovoltaic, improving cell performance and reducing costs. Currently, the amount of silicon required to produce a Wp is reduced at a rate of order of 5% per year, thereby achieving significant savings: This constant improvement, and the great variety of cell types or materials capable of producing the effect photo voltaic, is the result of the quantity and quality of innovation in the Sector.
4. Literature Review

The overall performance of a network-connected PV system depends primarily on the inverter's efficiency from two angles: topology and power. The inverter specifications are optimum power point, high performance, regulation of the grid.

The power, a high capacity factor and a low harmonic distortion inserted into the network.

The first part of this section presents the different inverter topologies connected to the network. In the second part, the most used control techniques in inverters connected to the grid:

a) Linear control of current
b) The current hysteresis controls
c) Predictive current control

In the third part, a review is made of the control structures used in the present in the inverters connected to the network and the solutions provided in different references for three-phase inverters and single-phase inverters.

Author [6] proposed the trackers of the maximum power point, MPPT (Maximum Power Point Tracers) they are electronic devices capable of operating photovoltaic modules around the working point where the maximum power capable of being obtained is generated for the irradiance and temperature conditions of that moment. Monitoring systems of the MPPT type are based on a control of the variables panel (voltage and current), although it is also possible to control the Inverter output electrical variables (voltage and current), due to the fact that they are related to those of the panel by means of a variable also known as the duty cycle (D). With the knowledge of these data, the work point is defined of the generator, in order to approximate it, at each instant, with the maximum point power (MPP), and thus increase the efficiency of the entire system.

Author [7] work related to photovoltaic systems connected to the grid, the Inverter design topology is always limited to injecting only active power to the network without injecting reactive power. The inverter is designed to inject current in phase with the mains voltage and a unit power factor. No capacity analysis is done of the inverter to deliver reactive power to the electrical grid and the hardware implementation of the control is always complex. Thus, in this work, an inverter design is proposed that allows deliver active and reactive power based on the needs of the electrical network with a robust and simple digital control.

In inverters connected to the electrical network the output voltage signal will be the signal of grid in the case of grid-switched inverters or must be synchronized with the grid signal for auto-switched inverters [8]. The signal of the injected current should be as sinusoidal as possible in this sort of device. For switching, static inverters use semiconductor power devices that operate only in two cut (OFF) and in driving mode (ON). The alternating signal at the output is also square. The power filters can make a square signal sinusoidal. The harmonic method of filtering closer to the simple needs bulky condensers and coils to minimize device efficiency. Therefore the goal is to obtain output signals with smaller value of the harmonics when designing an investor.

Author [9] provide the study of the evolution of the inverters currently used in the systems photovoltaic connected to the grid, most low-power inverters use the control with high switching frequency. Therefore, the output waves obtained are sinusoidal, high power factor and low harmonic distortion and the inverter is always limited to inject active power into the grid without injection of reactive power. The control of the real power and active power of photovoltaic systems is necessary for a correct operation m of power distribution system.

In PWM pulse width modulation, the voltage is controlled by the variation of the width of several pulses. In a single-phase inverter the signals of control by comparing a sinusoidal signal that acts as a reference signal (Vref), with amplitude Vref and frequency fref, and a triangular signal (Vtri) with amplitude Vtri and frequency ftri, which always maintains its amplitude. The result of this comparison will activate the inverter drive circuit. The frequency of the output voltage is always constant and determines the frequency of the output voltage and the frequency of the triangle signal determines the number of pulses in each half cycle [10].
The variation of the output voltage from 0 volts to the maximum output voltage is performed by varying the amplitude of the reference sinusoidal signal, which determines the variation of the pulse width from a minimum value to a maximum value that depends on the relationship between the frequency of the triangular signal and the reference signal. In the applications of inverters (VSI) connected to the network, it is necessary to adjust the value of the voltage obtained at the inverter output. The voltage regulation will depend on the reference signal that controls the operation of the inverter and determines the trigger pulses of the controlled switches that constitute it. The reference signal is determined from the feedback loops available in the system, which will be responsible for compensating variations that may occur in the load or in the supply voltage [11].

The configuration of the power circuit together with the current source of the photovoltaic module connected to its input and to the AC connection to the electrical network can be made by multiple types of configurations following the so-called bridge configuration either single-phase for small powers or three-phase for medium and large powers. The single-phase bridge configuration consists of two branches of semiconductors connected to the two poles of the photovoltaic field, between the midpoints of the switch branches are connects directly to the electrical line in the facilities connected to the network [12].

5. Methodology

In the case of an isolated photovoltaic system without connection to the electricity grid, the control that must be used is that of tension. However, both voltage control and current control can be used with inverters that are connected to the grid.

![Figure 2. Block Diagram of Grid Connected PV System](image-url)

The most used of the two for photovoltaic applications is the self-switched current-controlled inverter because it is you can get a high-power factor with a simple control circuit and it is also possible to suppress the current transient when there is some kind of distortion or noise, such as for example, voltage changes in the power system. However, investors auto-switched can be connected to the network since they can synchronize their alternating voltage from output with the voltage of the electrical network, so that they inject any level of current to the net [13]. Voltage regulation is done by PWM pulse width modulation, increased the width of the pulses that trip the circuit breakers in the event that the voltage at the output decreases and vice versa. They are inverters that switch at high frequency and can generate the current signal in phase with the mains voltage signal by correcting the power factor [14]. A VSI voltage source inverter can operate in current control mode if equipped a
current regulation loop and vice versa. An investor in source of CSI current can operate in voltage control mode if a voltage regulation loop is added as shown in figure 2.

Tension within the VSI inverter modulation techniques, two types of control can be distinguished:

➢ Scalar control of VSI inverters: in this type of control you act by modifying the value of an electrical quantity to a reference signal, which determines the trigger signals of the switches.
➢ Vector control of VSI inverters: in this type of control you act by modifying the amplitude and phase of a reference, which is called the reference vector, from the which will determine the trip signals of the controlled switches that allow get the desired signal at the output.

5.1 Proposed Methodology

First of all, a generator is needed to generate photovoltaic solar electricity photovoltaic, that is, a set of solar panels connected to each other. Second instead, to transform the direct current produced by a solar generator photovoltaic in alternating current "AC" with the same characteristics as the grid conventional (alternating current at 230V and frequency of 50Hz) an inverter is needed [15]. Photovoltaic inverters for connection to the electrical grid are different from those inverters used in conventional electronics, are characterized by operating connected directly to the photovoltaic generator, the inverter is installed between the photovoltaic generator and the point of connection to the network [16][17]. Once the solar energy has been transformed by the inverter into electrical energy, all that energy is injected into the network, with the economic advantages and environmental issues that this entails [18].

To optimize the degree of utilization of the PV generator, inverters must follow the maximum power point. They must also work with maximum performance, generating energy with a certain quality (low harmonic distortion, high power factor, low electromagnetic interference) and also meet certain safety standards (for people, equipment and the electrical network). In fact, the photovoltaic generator (set of photovoltaic modules) has a curve non-linear characteristic as shown in figure 3.

![Curve of Photovoltaic Modules](image)

6. Result and Analysis

To analyse the behaviour of the control strategy developed in proposed work for the single-phase inverter connected to the grid through a filter or an LCL filter, we have used the expressions of power
factor and harmonic distortion [19]. In Figure 4, the relationship between the switching frequency $f_c$ and the value of the inductance for an output filter $L$, achieving a power factor $MP = 0.996$. In figure 4 it is shown how the inductance of the filter $L$ varies as a function the switching frequency (or frequency modulation index).

![Figure 4. Filter Inductance L as a Function of the Switching Frequency fc](image)

With this method it is possible to achieve inductance values of the order of 0.327mH for a switching frequency of 20kHz and 8mH for a frequency of 2.2kHz. In Table 1, some values of the switching frequency $f_c$ are given as a function of the inductance value $L$ [20].

| $f_c$ [kHz] | $L$ [mH] |
|------------|----------|
| 1.5        | 20       |
| 2.2        | 8        |
| 3          | 3        |
| 5          | 1.43     |
| 9          | 0.74     |
| 10         | 0.67     |
| 15         | 0.56     |
| 20         | 0.45     |

### Table 1. The Switching Frequency V/s Filter Inductance L for FP = 0.996

7. **Conclusion**

Digital monitoring of a single-phase inverter connected to the grid that increases the performance of the photovoltaic device connected to the grid has been achieved as the main goal of this research project. In this work, we plan to use the phase shift of the output voltage from the inverter with the
power regulation that is attached to the grid with the grid. The dependency between the phase shift of the inverter output and the grid voltage and the shortcomings of the inverter for active and reactive grid supply were studied. A new technique was introduced to monitor the amplitude of the output current of the inverter, the power factor and therefore the voltage delivered both active and reactive, based on modulation patterns and on the phase change of the inverter power output voltage.

8. References

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