UNIVERSIDAD CARLOS III DE MADRID

TESIS DOCTORAL

IMPLEMENTACIÓN DE UN CONTROL DIGITAL DE POTENCIA ACTIVA Y REACTIVA PARA INVERSORES. APLICACIÓN A SISTEMAS FOTOVOLTAICOS CONECTADOS A RED

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Madrid, 24 de Noviembre de 2010

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Thèse de Doctorat

IMPLEMENTATION D'UN CONTROLE DIGITAL DE PUISSANCE ACTIVE ET REACTIVE POUR DES ONDULEURS. APPLICATION AUX SYSTÈMES PHOTOVOLTAÏQUES CONNECTES AU RÉSEAU

This thesis is focused on photovoltaic systems connected to the grid. The aim is to control the power injected into the grid from solar panels, by optimizing the design and control of inverter when are used as an interface between electrical power and photovoltaic systems, in order to deliver energy to the grid with the best quality and according to the grid demands. Injected power does not only include the control of the active power, but also the reactive power.

An algorithm for design a simple and robust control of the inverter connected to the grid is proposed in this work. It is based on the digital control strategy DSPWM *"Digital Sinusoidal Pulse Width Modulation"*, associated to the control of the phase shifting of the inverter output voltage with respect to the grid voltage.

This work develops and analyzes the limitations of the converters VSCs "Voltage Source Converters" as inverters to deliver active and reactive power to the grid ensuring optimal connection from the solar panels, caring inverter operation and improving the power factor and harmonic content of the current injected into the grid.

A new control strategy has been developed. The proposed control is able to control, not only the current injected into the grid, but also the power factor, with a minimum number of DSPWM patterns. Varying the power factor, within a certain range, the injected reactive power (inductive or capacitive) can be dynamically changed and controlled. The basic idea of the proposed control is to obtain a low cost and simple inverter implementation using a phase shifting strategy with a minimum number of DSPWM patterns previously calculated and tabulated (look-up table), applied to a constant DC bus voltage. Acting on the phase shift of the inverter output voltage as control parameter, the output current amplitude and the power factor can be controlled, and therefore the amplitude of the power injected into the grid, both active and reactive power. The proposed control strategy is simple and required a relatively low hardware and computational resources. The behavior of this method for different configuration within the overall control system, using the inverter output filter L and a LCL filter by calculate the total harmonic distortion of current for each configuration is analyzed.

A method for maximum power point tracking and a structure of the control loop and digital implementation of the control are presented.

The current controller, the voltage controller of DC-bus and the phase modulator are obtained by developing a model of linear equations for the controller design and stability analysis of the inverter connected to the grid.

In this line of research and in order to carry out digital control of inverter, the bipolar and unipolar DSPWM modulation has been implemented using FPGA *"Field Programmable Gate Array"* platform and validated by means of simulation and experimental results.

The proposed control has been validated by simulations of averaging and switched inverter model with phase control. Finally, this control has been implemented in a FPGA and validated with simulations and experimental results.