Sliding Mode Observer of a Grid Connected Photovoltaic Generation System with Active Filtering Function

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Abstract

The first problem in our third millennium is energy. For this raison, we try to find a new solution to develop different ways of distribution and energy use. This article presents the design of a sliding mode controller using sliding mode observation technique which aims to simplify the control procedure. For ameliorating the quality of the energy transferred from the power supply to the load, and minimizing the harmful effects of the harmonics generated by nonlinear load. The virtual grid flux vector estimated in the sliding-mode observer yields robustness against the line voltage distortions. We propose a new multi-function converter as an efficient solution to improve the power quality. The good dynamic and static performance under the proposed control strategy is verified by simulation.

Index terms— harmonics, three phase apf, PWM rectifier, DPC, virtual line flux linkage observer, mvbpf, PV, sliding mode(SM), SMO.

1 INTRODUCTION

he widespread use of power electronics in domestic and industrial applications had induced power line losses and electrical interference problems, which resulted in low power factor, efficiency and bad quality of the power electrical distribution system.

Classical solutions use passive filters, made up of capacitors and inductors, to reduce line current harmonics and to compensate reactive power. But these filters have several drawbacks: risk of parallel and series resonance with the AC source, bulky passive components, and low flexibility due to fixed compensation characteristics.

Active filters can be connected in series or in parallel to the nonlinear loads. Shunt active filters are the most important and widely used industrial processes for active filtering The main purpose of shunt filters is to cancel the load current harmonics fed to the supply, so that the power supply needs only to feed the fundamental active current component.

In this frame, photovoltaic generation systems have the opportunity to be as much as suitable for their important advantage being able to produce electrical energy very close to the electric loads. In this way the transmission losses are avoided and it is also possible to satisfy the daily load diagrams' peaks since they supply the maximum power quite in correspondence to the maximum request.

The sliding mode control (SMC) is one of the popular strategies to deal with uncertain control systems [9]. The main feature of SMC is the robustness against parameter variations and external disturbances. Various applications of SMC have been conducted, such as robotic manipulators, aircrafts, DC motors, chaotic systems, and so on [10] The motivation for this work was to design a digitally controlled, combination active filter and photovoltaic (PV) generation system.

2 Sliding Mode Control of a Grid Connected Photovoltaic Generation System with Active Filtering Function

The motivation for this work was to design a digitally controlled, combination active filter and photovoltaic (PV) generation system. This work focuses on a proposed control scheme for the dual function system and on the effects of delay on the control of an active filter. The scheme of the proposed multi-function converter is shown in Fig. 1 T With I and V are respectively the PV current and voltage, I 0 : leakage or reverse saturation current, q: electron charge, n: Ideality factor, K is the Boltzman's constant (1.38.10 -23 J/K), R sr :series cell resistance, R sh :shunt cell resistance .

3 b) Boost converter

The Boost converter shown in Figure 2, it has step-up conversion ratio. Therefore the output voltage is always higher than the input voltage. The converter will operate throughout the entire line cycle, so the input current does not have distortions and continuous. It has a smooth input current because an inductor is connected in series in with the power source. In addition the switch is source-grounded; therefore it is easy to drive. **??**d-q) frame through the Park transformation as follows [1], see appendix:1 1 fd f sd fd fq fd f f f fq f sq fq fd fq f f f q c d fq fd di R v i wi v dt L L L di R v i wi v dt L L L d dU d i i dt C C ? = + + ? ? = + + ? = +

Where d d ,d q d-Axis and q-axis switching state functions,

(2)

Sliding Mode Observer of a Grid Connected Photovoltaic Generation System with Active Filtering Function XIII Issue VIII Ve sd v ? and sq v ? -d-Axis and q-axis supply voltages.

The bi-directional characteristic of the converter is very important in this proposed photovoltaic system, because it allows the processing of active and reactive power from the generator to the load and vice versa, depending on the application. Thus, with an appropriate control of the power switches it is possible to control the active and reactive power flow. i i v P i i q i i v ? ? ? ? ?? ? = ? ? ? ?? ? + ? ? ? ? ? ? ? ? ? ? Where d v ? and q v ? are the estimated main line d)

The state equations are shown in (4) and summarized as (**??**)1 1 f sd fd f f f fd fd fq fq sq fq f f f f R v di w L L L i v dt i v v di R w L L dt L ? = + ? I AI Bu G = + ? ?

The sliding surfaces (S) are equal to the error of state variables, which can be express as:SMP f SMI f S K E K E dt = + ? Where * * * * 0 0 ; ; ; ; 0 0 d SMPd SMid fd f SMP SMI q SMPq SMiq fq S k k i S E I I I K K S k k i ? ? ? ? ? ? ? ? ? = = ? = = = ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? Where SMPd k , SMPq k , SMid k and SMiq k 3 are positive constants And consequently, their temporal derivatives are given by:SMP f SMI f S K E K E = + ? ?

The equivalent control can be calculated from the formula 0 S = ? , and the stabilizing control is given to guarantee the convergence condition (5).

4 * (

) 0SMP SMI f SMP S K I K E K AI Bu G = + ? + ? = ? ?

The equivalent control eq u is deduced by imposing the sliding regime condition S ? obtaining:1 * ( ) ( ) eqd eq SMP SMI f SMP eqq u u K B K E K AI Bu G I u ? ? ? ? ? = = ? + ? + ? ? ? ? ? ? ? ?

Finally, the control law is given by: ( )( ) sd sq eqd eqd disd eq dis eqq disq eqq u k sign S u u u u u u u k sign S + ? ? + ? ? = + = =? ? ? ? + + ? ? ? ? ? ?

For the sliding mode DC-link voltage controller based on integrator can be determined by substituting the reference line current, is chosen to determine switching surface functions:* * ( ) ( ) dc SMPC c c SMIC c c S K U U K U U d t = ? + ?

? And consequently, their temporal derivative is given by:* * ( ) ( ) 0 dc SMPC c c SMIC c c S K U U K U U = ? + ? = ? ? ?

Finally, the control law is given by:* * * (( )) ( ) SMIC ceq c c c SC c c SMPC K i C U U U K sig n U U K = ? + + ? ?

The sliding mode observer uses the system model with model with the sign feedback function. The continuous time version of the SMO is described by Equation (15).

5 (. ( )

f f f est f f f f f f est f f f i i i i v d sign R i i i i v dt L ? = ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?

The estimated values of the grid voltage are obtained from the law-pass filter: f f est s estSMO f f est s estSMO i i v LPF sign i i v ? ? ? ? ? ? ? ? ? ? ? ? ? = ? ? ? ? ? ? ? ? ? ?**(16)**

While the (???) components of the virtual grid flux are calculated as follows:0 0 (. ( ) f f est est est f f est est est i i sign dt i i ? = + ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?

Hence the structure of the virtual grid flux sliding-mode observer presented in Fig. 3.

The sliding surface representing the error between the measured and references courrents are given by this relation.f f est f f est i i i i ? ? ? ? ? ? ? ? ? ? ? ? ? ? = ? ? ? ? ? ? ? ? ? ?

The sliding mode will exist only if th following condition

6 Simulation Result

In simulation part, power system is modeled as 3wired 3-phase system by an RL load with uncontrolled diode rectifier. In the circuit, the ac source with frequency of 50Hz. The grid side line voltage is 220V. The line resistor is 0.25?. The line inductance of each phase is 1mH. The dc capacitor is 5000?F; the dc voltage is set to be 700V. The switching frequency for three-phase is 15 kHz.

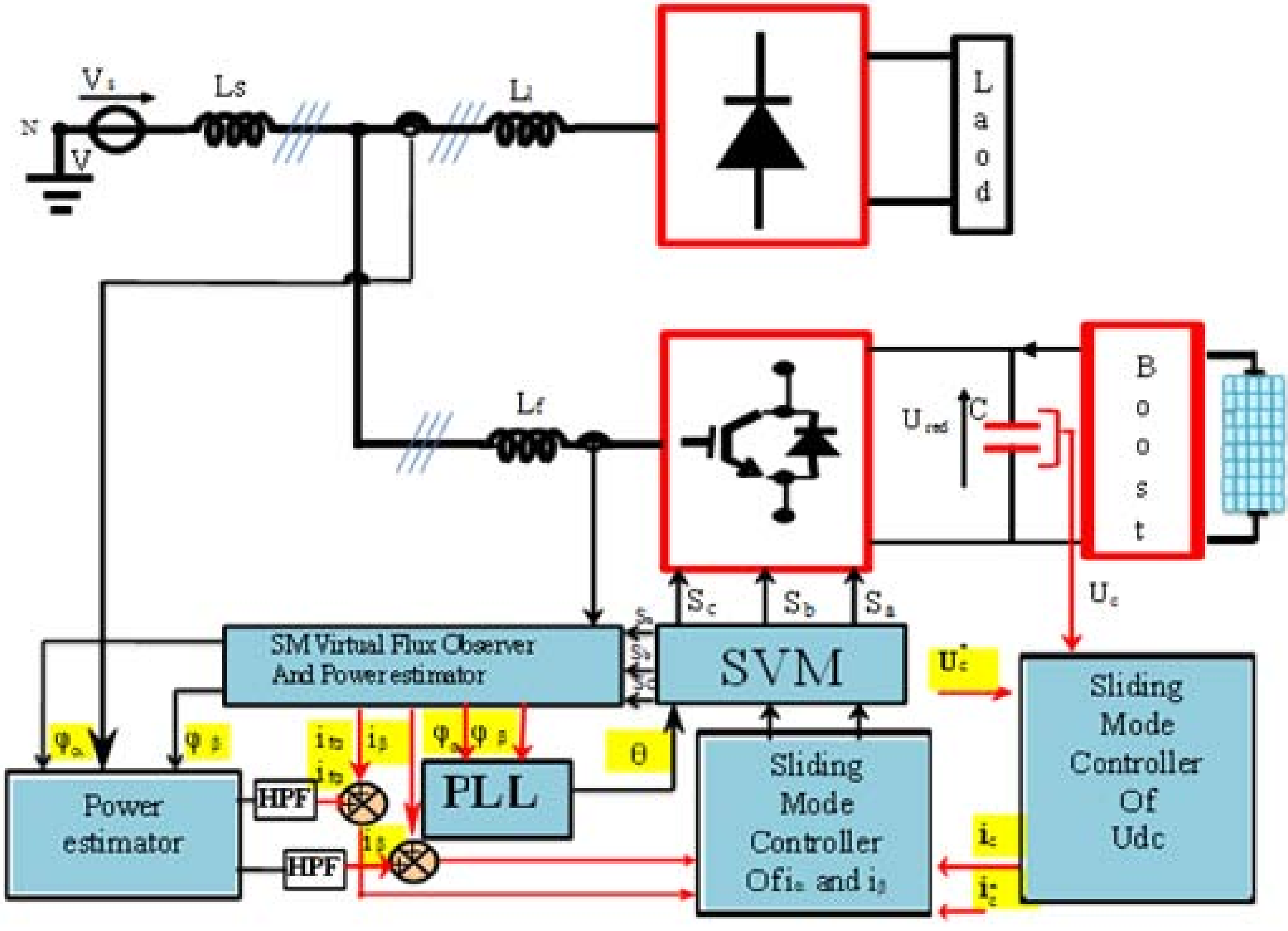
The Pv model applied in simulation is as Fig .

7 Conclusion

This paper outlined the modeling and development of the control system for the active filter/PV generation system with sliding mode controller based on a Sliding Mode Observer. The results verify the validity of the proposed control scheme. Unity power factor is achieved, active and reactive current are decoupled controlled in the synchronous reference frame and the objective of maintaining balanced voltages in DC-link capacitors is carried out effectively with the proposed SVM, and it offers sinusoidal line currents (low THD) for ideal and distorted line voltage . [1]

1

Figure 1: Figure 1 :



2

Figure 2: Figure 2 :

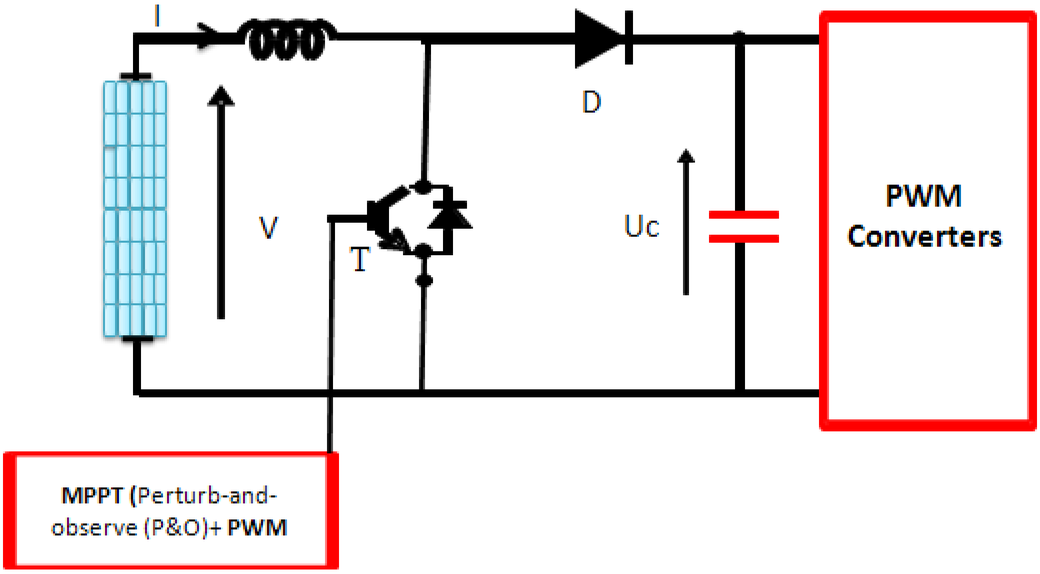


Figure 3: F

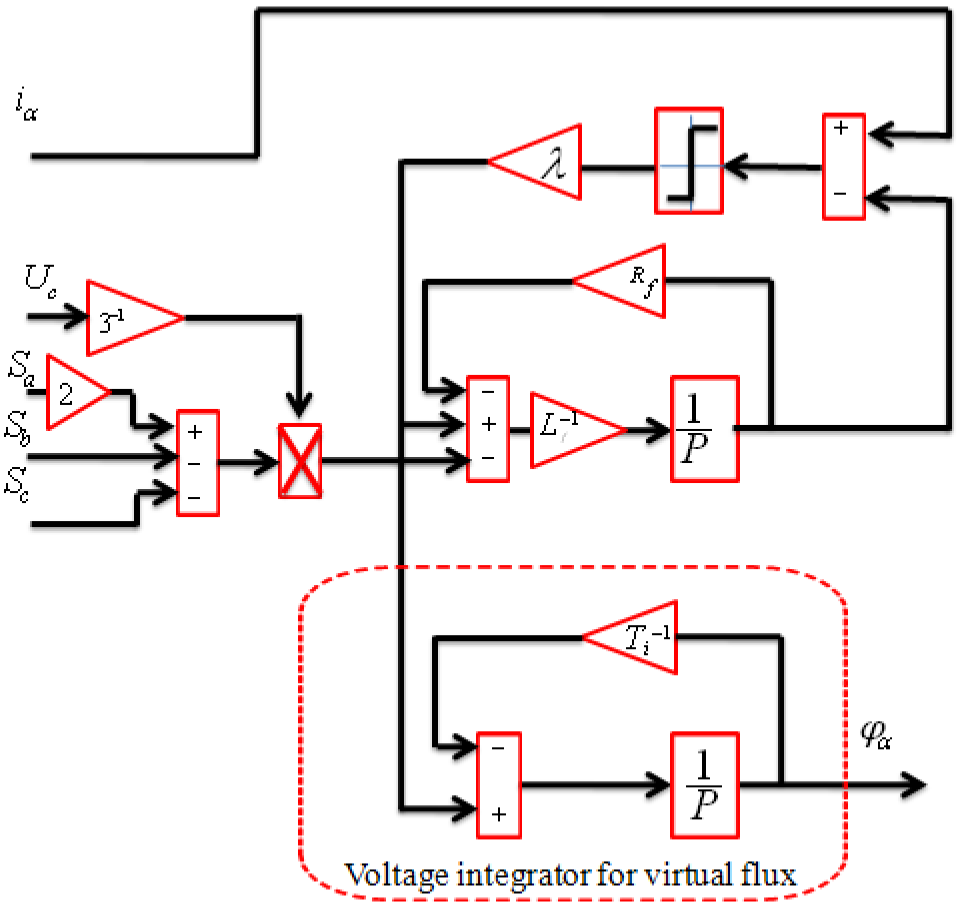


Figure 4: F

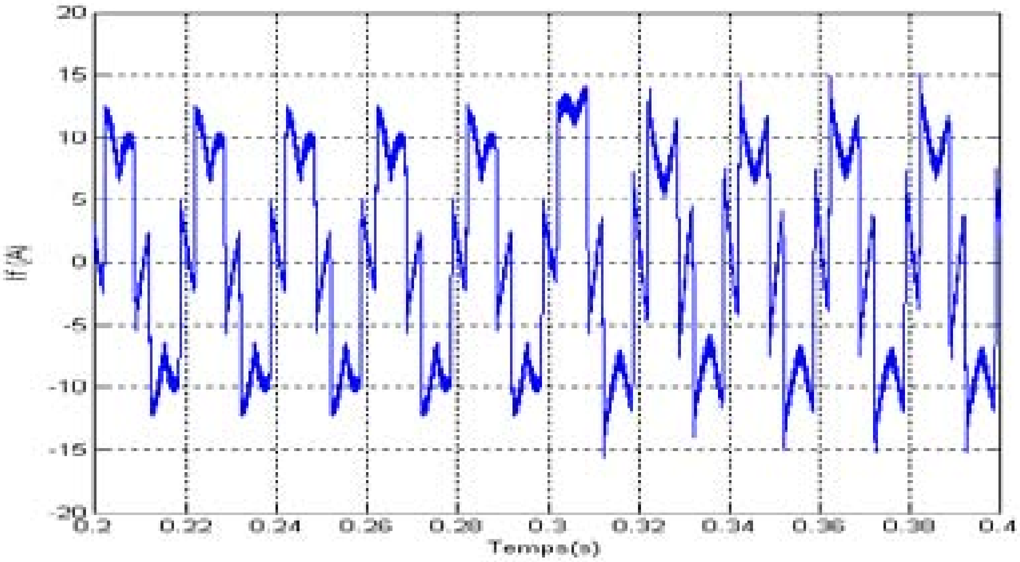


Figure 5:

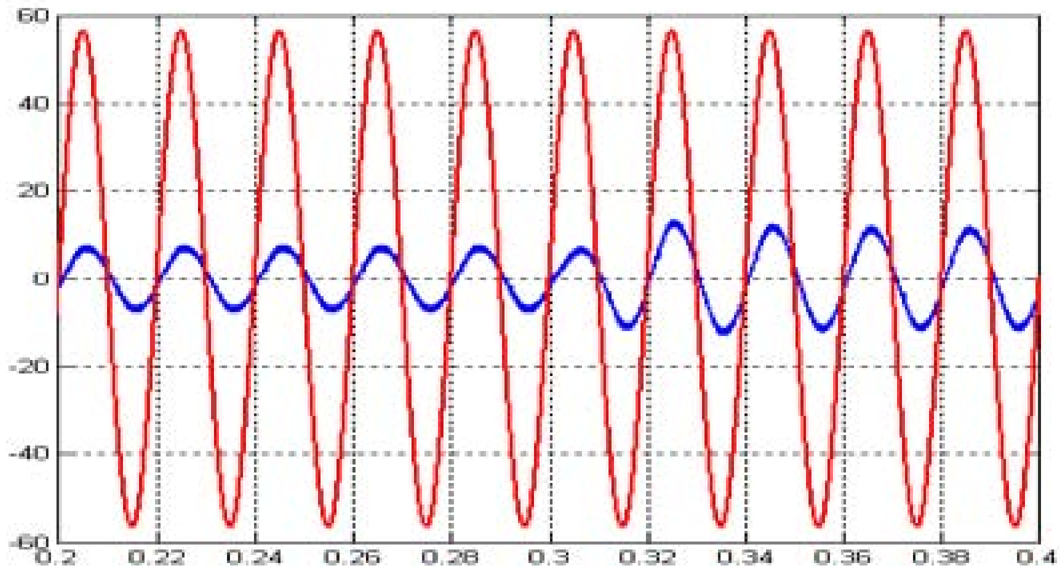


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Figure 6: Figure 3 :

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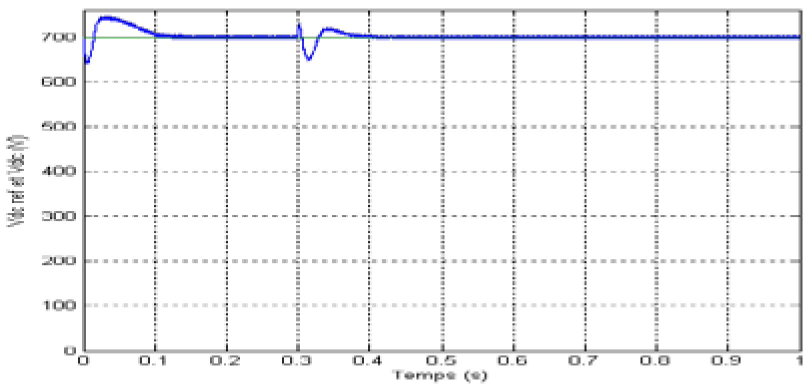

Figure 7: 4 .Fig. 7 .

7

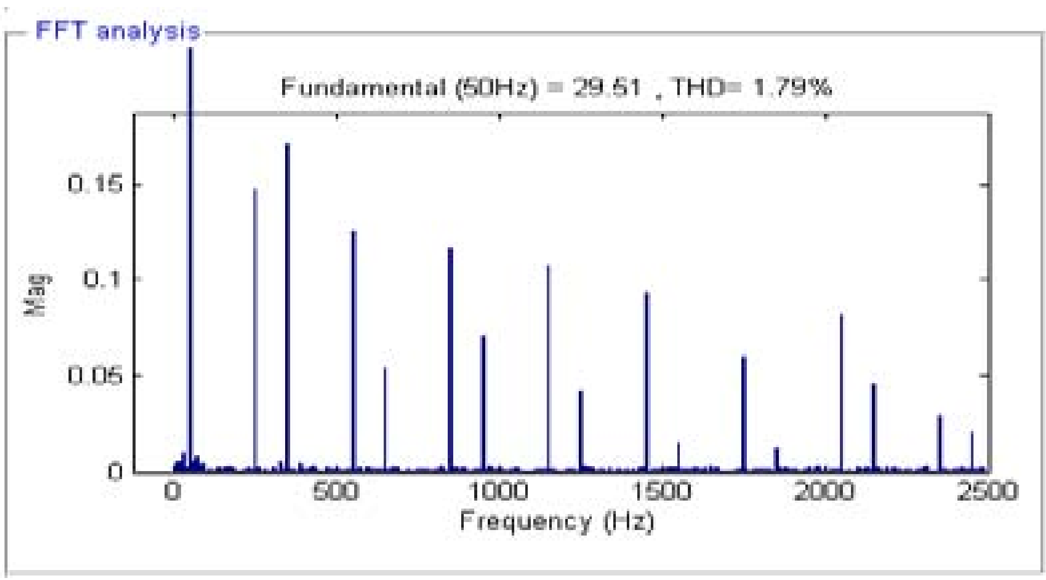

Figure 8: Fig . 7 .

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