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Renewable Energy Using Simulation Technique

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ABSTRACT: The pvg is a nonlinear AC source; its voltage output can be affected by climatic factors. So, in general the use of a potential converter in gcps is accompanied by a maximum power point tracking control mppt in order to make the pvg working at its maximum power point. In our case, we choose to satisfy the grid requirement by tracking a reference AC voltage fixed by the grid and not by the mppt.

To insure this function, the buck-boost potential converter is controlled by the sliding mode control which aims the generation of the control signal d of the converter's switches detailed in section b.

This converter is controlled by the sliding mode control smc and a fuzzy sliding mode controller. The controllers are used to track the AC reference voltage which is used to satisfy the main grid. The second stage is composed of a AC bus and a three-phase voltage inverter, which serves as an interface to the pvg and the grid utility. The inverter output is regulated by means of suitable filters to inject the high quality pv power into the grid. The gcps has been implemented in the matlab software and further studies have been presented to evaluate its effectiveness. The performances of the fuzzy sliding controller are compared to the results obtained by a sliding mode controller. The satisfactory potential results thus show the efficiency of the proposed control law, which reduces the phenomenon of chattering. The result indicates the robustness of the control law against variation of the load and the source voltage of the converter.

KEYWORDS: buck-boost potential converter, chattering phenomenon, fuzzy sliding mode control,matlab simulink, sliding mode control, robustness.

I. INTRODUCTION

The photovoltaic energy is one of the renewable energy technologies which draw more and more attention due to the rapid growth of the power electronics technique. The photovoltaic generation connected to the grid utility is becoming a fast growing sector. The static converters structure and control influence the performance and efficiency of energy conversion. The basic structure of gcps includes a buck-boost potential converter, a AC-bus, inverter and grid. Potential converter must provide a regulated AC output voltage even when varying load or the input voltage varies. The two most common closed-loop control methods for pwm potential converters are the voltage-mode control and the current-mode control. Among the control methods of potential converters, the hysteretic control is very simple for hardware implementation. However, this control induces a variable frequency operation of the power switches. In general, the linear conventional control solutions applied to buck boost converters, fail to accomplish robustness under nonlinearity, load disturbance and variation of parameters and input voltage. The potential converters usually have high nonlinear characteristics. Thus the pid controller will not allow disturbances rejection and fast transient response time. Sliding mode controllers are known for their stability and robustness. But this controller operates at infinite switching frequency, which is known as the chattering phenomenon. The high speed switching in power converter introduces high switching losses and electromagnetic interference noise. This project proposes a control strategy for buck-boost potential converter considering all the details of a real power circuit and working in fixed frequency pmw based fuzzy sliding mode control (fsmc). The results obtained are compared with the results of sliding mode control (smc), in terms of starting behaviour and robustness to disturbances.

Mathematical model of gcps

the proposed three-phase gcps includes a pvg, a buck-boost potential converter, a AC-bus, a three-phase voltage inverter and an ac grid filter is shown in figure 1.

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$$I_{PV} = N_P I_{Ph} - N_P I_{ss}\left[\exp\left(\frac{V_{PV} + R_s I_{PV}}{N_s V_T}\right) 1\right] \quad (1)$$

I_{PV} and V_{PV} are the respective pv current and voltage, I_{Ph} is the light-generated current, I_{ss} is the reverse saturation current, V_T = n.kb.t/q is the thermodynamic potential, n is the ideality factor of pn junction, kb is the boltzmann's constant ($1.38.10^{-23}$j/k), t is the temperature of photovoltaic array (°k) and q is the electron charge of ($1.6.10^{-19}$c), N_P and N_S are the respective number of pv modules in parallel and series and r_s is the series internal resistance of pv module [1-3].

Modeling of the buck-boost potential converter

A buck-boost converter provides an output voltage which can be higher or lower than the input voltage [4-6]. The output voltage polarity is opposite to that of the input voltage. Fig 2 shows a simplified structure of the buck-boost converter. It consists of a AC input voltage source (v_{in}), a controlled switch (s_w), a diode (*d*), a filter inductor (*l*), a filter capacitor (*c*) and a load resistance (*r*).

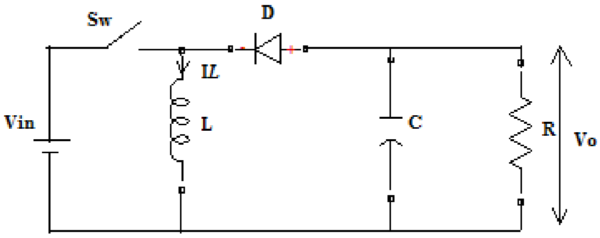

Fig. 2 the buck-boost potential converter

The mathematic model is also contributed. By considering (i_l, V_{DC}, I_{inv}) as state variables and v_{pv} as control input, we develop a new state model which is given by model 2.

Where c is the capacitance of the AC-bus and l is the value of the inductance. 'd' represents the control signal of the switches that takes:

- 1 if k is on and d is off
- 0 if k is off and d is on

Modeling of the AC-bus

A AC-bus is used to insure an energy balance between the power generated by the pvg and the power injected into the grid by charging or discharging the capacitor [7-9]. The AC-bus current i_c is given by model 3 (marouani and mami, 2010).

$$i_c = c\,(dvp/dt) \quad (3)$$

Modeling of the three-phase voltage inverter

A three-phase voltage inverter is used to interface the pvg with the grid by converting the AC power generated by the pvg into ac power to be injected to the grid (lee et al, 2008; weslati et al, 2008; yu et all, 2006). The simple modulated voltages which are the output voltages of the inverter (V_{s1}, V_{s2}, V_{s3}) are expressed by model 4, where (K_1, K_2, K_3) are the switches control signals of the inverter (marouani and mami, 2010).

Modeling of the ac grid filter

An inductor filter (R_f, L_f) is placed between the inverter and the main utility in order to produce an alternating current to be injected to the grid [10-12].

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By considering the grid filter currents (I_d, i_q) as state variables and the grid voltages (E_d, E_q) as control inputs, the state model of the ac grid filter in the *d-q* referential axis is given by model 5, (marouani and mami, 2010; weslati et al, 2008).

$$\begin{cases} \frac{dI_d}{dt} = \frac{-R_f}{L_f} I_d + \omega I_d + \frac{K_d}{L_f} V_{pv} - \frac{1}{L_f} E_d \\ \frac{dI_q}{dt} = -\omega I_d - \frac{R_f}{L_f} I_q + \frac{K_q}{L_f} V_{pv} - \frac{1}{L_f} E_q \end{cases}$$

Application of sliding mode control to the buck-boost converter

The pvg is a nonlinear AC source; its voltage output can be affected by climatic factors. So, in general the use of a potential converter in gcps is accompanied by a maximum power point tracking control mppt in order to make the pvg working at its maximum power point. In our case,

To insure this function, the buck-boost potential converter is controlled by the sliding mode control which aims the generation of the control signal d of the converter's switches detailed in section b.

Thus, we can define the sliding surface s as follows (sahbani et al, 2009):

$$S = g_1 (I_L - I_L{*}) + g_2 (V_{DC} - V_{DC}{*}) \qquad (6)$$

determination of v_{AC}*

In order to insure the injection of the maximum real power into the grid, the AC voltage required by the grid.

The state model of the buck-boost potential converter can be rewritten as in model 9.

$$I_l^* = \frac{V_{dc}^* - V_{pv}}{V_{pv}} * I_{inv} \qquad (9)$$

The sliding mode is obtained at the following condition:

$$s = \dot{S} = 0 \qquad (10)$$

So, we can deduce the expression of the control signal d as follows.

$$d = d_{eq} + d_n \qquad (11)$$

Where:

$$d_{eq} = \frac{C_{g1} V_{DC} - L_{g2} (I_L + I_{inv})}{C_{g1} (V_{DC} - V_{pv}) - L_{g2} I_L} \qquad (12)$$

$$d_n = g3 \operatorname{sign}(s) \qquad (13)$$

Where: g_3 is a negative constant.

Fuzzy sliding mode control design

Fuzzy controllers belong to the class of knowledge based systems. Their main goal is to implement human knowledge in the form of a computer program. The combination of the sliding mode control with the fuzzy logic control aims to improve the robustness and the performance of the controlled nonlinear systems [13]. Let us consider the sliding surface defined by the equation (6). The proposed fuzzy sliding mode controller forces the derivative of the lyapunov function to be negative definite.

$$v = \frac{1}{2} S^2 \qquad (14)$$

$$\dot{V} = s\dot{S} < 0 \qquad (15)$$

so, the rule base table is established to satisfy the inequality (15).

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Suppose that *s* >0 and $\dot{s}$ >0, the duty cycle must increase. Also if *s* <0 and $\dot{s}$ <0, the duty cycle must decrease. Thus, the surface *s* and its variation $\dot{s}$ are the inputs of the proposed controller. The output signal is the control increment $\delta u(k)$ which is used to update the control law. The control signal is defined as follows:

The proposed fuzzy sliding mode controller is a zero order sugeno fuzzy controller which is a special case of mamdani fuzzy inference system. Only the antecedent part of the sugeno controller has the fuzzyness, the consequent part is a crisp function. In the sugeno fuzzy controller, the output is obtained through weighted average of consequents [14].

Triangular membership functions, denoted by n (negative), z (zero) and p (positive), were used for both the surface and the surface change. They are presented in fig.5 in the normalized domain. For the output signals, fives normalized singletons denoted by nb (negative big), nm (negative middle), z (zero), pm (positive middle), pb (positive big) are used for the output signal.

$\dot{s}$ \ s	N	Z	P
P	Z	PM	PB
Z	NM	Z	PM
N	NB	NM	Z

Table i. Rule base of the proposed fsmc

potential results

In order to validate the theoretical analysis presented in this paper, the potential of the proposed gcps is carried out By means of matlab/simulink software with the following parameters:

Table. Ii studied buck-boost converter parameters

Parameters	Values
B	152.13^{-6} f
S	10.10^{-3} h
R	28 Ω

The proposed fuzzy sliding mode controller is tested by potential. The electrical parameters of the simulated buck boost converter are given in table ii. These parameters allow a continuous conduction mode [15]. The sliding mode control solution, described above, is compared to the proposed fuzzy sliding mode control law.

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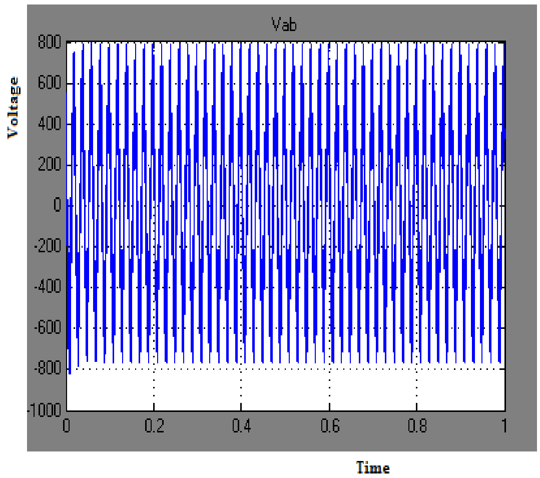
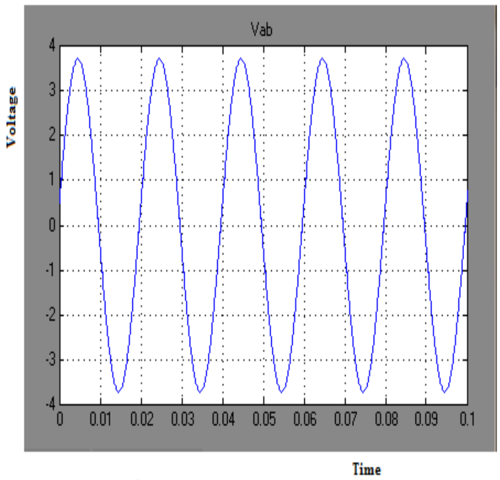
Fig. 5 simulink diagram





the output obtained from the inverter contains harmonics. Harmonics in a system will reduce its performance. Lc filters are used for reducing the harmonics. Reduced harmonic current is therefore injected into the grid [16].

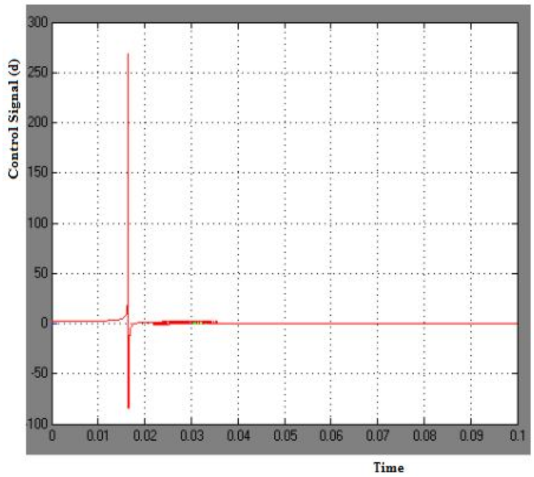


Fig. 10 control signal given to buck boost converter

Summary and concluding remarks

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This study presents a grid connected photovoltaic system with two static converters. The first is a buck-boost potential converter employed to track the reference AC voltage required by the grid. The potential results prove the robustness of the sliding mode control applied to this converter to satisfy this condition. But it contains distortions in the output voltage due to the chattering phenomenon. To overcome this fuzzy sliding mode control has been used for improving the robustness and the dynamical performances of a buck boost converter. The fuzzy controller design has inputs as the sliding surface and its variation. It defines the control signal to satisfy the stability and the attraction condition of the sliding surface. The potential results show that the proposed controller overcomes the chattering problem. Moreover, it is proven that the proposed controller is robust for the case of the desired output currents variation and input voltage variations.

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