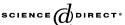


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Sliding mode controller for the single-phase grid-connected photovoltaic system

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Abstract

A sliding mode controller for the single-phase grid-connected photovoltaic system has been proposed in this paper. Contrary to the conventional controller, the proposed system consists of maximum power point tracker (MPPT) controller and sliding mode current controller only. The proposed MPPT controller generates current reference directly from the solar array power information and the current controller uses the sliding mode technique for the tight regulation of current. The new MPPT controller does not require the measurement of the voltage derivative which can be a cause of divide-by-zero singularity problems. The sliding mode controller has been constructed based on a time-varying sliding surface to control the sinusoidal inductor current and solar array power simultaneously. The proposed system can avoid the current overshoot and make optimal design for the system components. The structures of a proposed system are simple, but they show the robust tracking property against modeling uncertainties and parameter variations. The mathematical modeling is developed and the experimental results verify the validity of the proposed controller. © 2005 Elsevier Ltd. All rights reserved.

Keywords: Photovoltaic power systems; Sliding mode controller; Maximum power point tracker

1. Introduction

In recent years the need for renewable energy has become more pressing. Among them, the photovoltaic system (PV) such as solar cell is the most promising energy. The PV

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Nomenclature A deviation factor from the ideal p-n junction diode, dimensionless nominal input de link capacitor in uF $C_{\rm n}$ grid voltage in V $e_{s}(t)$ inverter switching frequency in Hz $f_{\rm s}$ solar cell output current in A inductor current in A $i_{\rm I}$ light generated current in A peak value of the current in A $I_{\rm pk}$ current reference in A I_{ref} $i_{\rm sa}$ solar array current in A average solar array current in V $i_{\text{sa_avg}}$ cell reverse saturation current in A I_{sat} nominal output filter inductor in mH $L_{\rm n}$ number of parallel modules, dimensionless $N_{\rm p}$ number of series modules, dimensionless $N_{\rm s}$ P_E power transferred to the grid in W average power of the grid in W $P_{E \text{ avg}}$ power reference in W $P_{\rm ref}$ solar array power in W $P_{\rm sa}$ average solar array power in W $P_{\text{sa_avg}}$ electronic charge: 1.6022×10^{-19} C q output filter inductor resistance in Ω $R_{\rm L}$ $R_{\rm s}$ series resistance in Ω shunt resistance in Ω . $R_{\rm sh}$ full-bridge inverter switch $S_1 - S_4$ Tcell temperature in K control input, dimensionless u(t)equivalent input, dimensionless $u_{\rm eq}$ nonlinear control input, dimensionless $u_{\rm n}$ solar cell output voltage in V peak grid voltage in V $V_{\rm EP}$ $V_{\rm mp}$ maximum power voltage in V solar array voltage in V $V_{\rm sa}$ average solar array voltage in V sliding mode controller gain, dimensionless boundary values of the uncertainties, dimensionless η_1,η_2 Boltzmann's constant: 1.3807×10^{-23} J/K θ grid voltage phase angle in ° sliding surface, dimensionless $\Delta f_1, \Delta f_2$ modeling uncertainties, dimensionless

energy is free, abundant and distributed through the earth. Among the PV energy applications, they can be divided into two categories: one is stand-alone system and the other is grid-connected system. Stand-alone system requires the battery bank to store the PV

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