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Review Article

Sliding mode based power control of grid-connected photovoltaic-hydrogen hybrid system

Issam Abadlia [a,*], Mohamed Adjabi [a], Hamza Bouzeria [b]

[a] Department of Electrical Engineering, Badji Mokhtar University, P. Box 12, Annaba 23000, Algeria
[b] Department of Transport Engineering, University of Brothers Mentouri – Constantine-1, 25000, Algeria

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ABSTRACT

In this work, the siding mode based power control scheduling for a grid-connected photovoltaic-hydrogen hybrid system is proposed to sufficiently explore fuel energy and to benefit customers at demand side. In the proposed power generation system photovoltaic (PV) is a main source and hydrogen fuel is the supplementary. Electrical power generates from PV arrays meets the user loads where the surplus is used for water electrolysis to produce hydrogen (H_2) where the aim is to search the maximize of the PV user and to optimize H_2 user to keep it as a storage system. In order to make the system more flexible, expandable and efficient, simple control strategies are applied. Perturb and observe (P&O) maximum power point tracking (MPPT) method is used to maximize the injected PV power; A simple cascade control loop of DC-DC converter operating fuel cell (FC) generator to ensure maximum power; The principal goal of the work is to develop a simple control strategy with a high performance for the grid connected the hybrid system. It is the sliding mode control (SMC) technique. According to the law of this strategy of the control the stability is always vitrified. SMC is developed and applied inside grid to ensure an independent control of the active (P) and the reactive (Q) powers. Simulation model of the proposed power system is performed using MATLAB software during a time equal to 2.4 s considered equivalent to 24 h of one summery day proving that the proposed grid interconnection renewable-storage scheme often more conversion of electrical energy capabilities with good control performances as well as allow loads to generate a continuous demands overhaul. In addition, P and Q can be controlled independently with high performance using the SMC theory.

Contents

* Corresponding author.
E-mail address: i_abadlia@yahoo.fr (I. Abadlia).

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Nomenclature

P_{PV}	photovoltaic power, W
P_{FC}	fuel cell power, W
P	active power, W
Q	reactive power, VAR
S	apparent power, VA
V_{Bus}	output DC voltage, V
Vg	grid voltage, V
ig	grid current, A
L	grid inductance, H
L_f	filter inductance, H
f	frequency, Hz
ω	natural pulsation, rad/s
ζ	phase angle, rad

Abbreviations

PV	photovoltaic
FC	fuel cell
VSS	variable structure system
SMC	sliding mode control
SS	sliding surface
VC	vector control
P&O	Perturb and observe
MPPT	maximum power point tracking
PF	power factor

Introduction

The development in energy demand variability established by the periodic sources such as renewable which presents the new challenges to augment the flexibility of the electrical energy. PV system is increasing as a renewable source due to its advantages of little maintenance, absence of moving mechanical parts, no noise and no pollutant emission [1–3]. However, PV output power is irregular and dependent on climatic conditions. One method to overcome this problem is to integrate the PV systems with other conventional power sources such as diesel and wind [4,5]. Diesel generator has some significant disadvantages such as noise and gases pollution. Wind power system consists of a variable speed wind turbine, alternative machine, three-phase DC-AC inverter, and a DC–DC converter which controlled to extract MPPT [6]. Consequently, an elevated cost to ensure the installation of the wind equipments. In the last years, new technologies of hybrid PV applications collaborate with the static energy sources are added to produce enough energy to ensure the load demands such as batteries for energy storage and hydrogen fuel cells [7–12]. The stored energy can then be used when the electricity price from the grid is high, during peak power demand, or when the renewable power is unavailable. Because of the instable and variable nature of their conditions of operation as temperature and solar radiation, PV systems are often used in combination with storage systems. The fuel cells produce heat when generating electricity, thus they are combined the cooling heat and power applications. FCs offers a high efficiency energy conversion and presents many advantages over other generation systems as low pollution, high efficiency, diversity of fuels, and reusability of exhaust heat as onsite installation [13].

Literature review

Many hybrid power systems comprising of PV and Hydrogen fuel generation have been discussed in literature. In Ref. [14], D. Rekioua et al. investigate different hybrid renewable hydrogen systems for standalone applications where hybrid PV-H_2 system has been simulated. The mathematical model and the simulation of a stand-alone renewable hydrogen power system was described by J.J. Hwang et al. in Ref. [15], have also received considerable attention. A study of hydrogen production by means of PV panels for home's energy application is presented by A. Yunez-Cano et al. [16], referred to as “Solar-hydrogen hybrid system integrated to a sustainable house in Mexico”, this work is perform an analysis of the PV/H_2 system, including the solar array capacity and H_2 dispositive size. Important researches have reported on the benefit of applying PV energy with the storage systems as standalone or connected to the grid. However very few works have been conducted on the use of grid interconnection PV combined with the hydrogen fuel systems. For grid-connected hybrid renewable-storage systems, the varying electricity price imposed by the grid, the instant of power transaction, and the difference between renewable power generation and load demand are main challenges encountered. The interconnection of grid with PV system has the effective advantage of the utilization of generated power. However, the technical

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