INTERNATIONAL JOURNAL OF HYDROGEN ENERGY XXX (2016) 1–13

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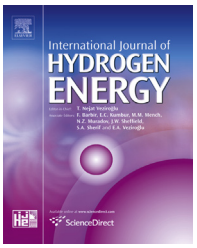

Short Communication

Supervisor control and optimization of multi-sources pumping system with battery storage

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ARTICLE INFO

Article history:
Received 30 March 2016
Received in revised form
12 May 2016
Accepted 12 May 2016
Available online xxx

Keywords:
Photovoltaic system
Wind power system
Battery
MPPT
Fuzzy logic control
Pumping

ABSTRACT

In this paper, we propose an energy management for the photovoltaic (PV) system (main source) and wind power system (secondary source) associated with battery storage, to adapt the production of renewable sources as required load. With the increased use of this application, more attention has been paid to their optimum utilization. Many methods have been developed to determinate the maximum power point (MPP). To control the DC bus voltage, we apply field oriented control (FOC) strategy to induction motor (IM) supplied by a PV system. And to maximize the efficiency of the proposed PV pumping system, we apply three maximum power point tracking methods: the adaptive fuzzy logic controller (AFLC), the fuzzy logic controller (FLC) and the classical Perturb and Observ (P&O). Different tests have been carried to prove the effectiveness of the proposed control system. A supervisor control for the hybrid power system based on a photovoltaic array, wind system, a battery bank, and a moto-pump is developed in this paper. The main objective is to meet the power load requirements through effective utilization of the batteries. Simulation results obtained under Matlab/Simulink and other results obtained by practice are presented.

Introduction

During these last years, hybrid power systems using renewable energy sources as received, considerable attention worldwide [1,3,5,6,13,15,17–21]. These systems may contain various elements as a DC distribution system or alternating current, the system storage, converters, filters and the control system to manage the load, which can be connected to different architectures [5,19,10]. The photovoltaic array has a unique operating point (MPP) that can supply maximum power to the load. The locus of this point has a non-linear variation with solar irradiation and temperature. Therefore, to maximize the efficiency of the photovoltaic energy system, it is necessary to track the maximum power point of the PV array. Many methods and controllers have been widely

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http://dx.doi.org/10.1016/j.ijhydene.2016.05.096

Nomenclature

C_b	internal capacity of the battery, F
C_{bat}	capacity battery, Ah
Cp	power coefficient
E	solar irradiance, W/m^2
E_b	electromotive force depending on the battery charge state, V
g	gravity, m/s^2
H	manometric head, m
I_{bat}	battery current, A
I_m	maximum current at PPM, A
I_{pv}	photovoltaic current, A
i_{sa}, i_{sb}, i_{sc}	real stator currents, A
I_{sc}	short circuit current, A
L_m	magnetizing inductance of the IM, H
L_r	rotor inductance of the IM, H
L_s	stator inductance of the IM, H
L_{ss}	stator inductance of the PMSM, H
n_b	serial number of the battery cells
p	number of pole pairs
P_{bat}	battery power, W
P_{hyb}	hybrid power, W
P_{pv}	photovoltaic power, W
P_{pvm}	maximum power point, W
P_t	turbine power, W
Q_n	flow rate, m^3/h
q_v	volume flow, m^3/s
R_b	internal resistance which varies with the state of charge, Ω
r_c	internal resistance of the battery during charging, Ω
r_d	internal resistance of the battery during discharge, Ω
R_{ss}	stator resistance of the PMSM, Ω
t_m	mechanical time constant of the machine PMSM, s
T	temperature, °C
t	time, s
T_r	resistive torque, N.m
V	volume of water, m^3
V_{bat}	battery voltage, V
V_c	charging voltage, V
V_d	discharge voltage, V
V_m	maximum voltage at PPM, V
V_{oc}	open circuit voltage, V
V_{pv}	photovoltaic voltage, V
V_v	wind speed, m/s
W_t	mechanical turbine speed, m/s
Z_{bat}	complex impedance, Ω

Greek letters

α_{sc}	temperature coefficient of short-current, A/K
β_{oc}	voltage temperature coefficient, V/K
λ	specific speed, m/s
η_{IM}	IM performance, %
η_{inv}	inverter performance, %
η_{pump}	pump performance, %
ρ	Density, kg/m^3

Abbreviations

AC	Alternate current
AFLC	Adaptive Fuzzy Logic Controller
BN	Big Negative
BP	Big Positive
DC	Direct Current
DOD	Depth Of Discharge
FLC	Fuzzy Logic Controller
FOC	Field Oriented Control
IM	Induction Motor
MN	Means Negative
MP	Means Positive
MPPT	Maximum Power Point Tracking
PI	Proportional Integrator
PMSM	Permanent Magnet Synchronous Machine
PV	Photovoltaic
P&O	Perturbation and Observation
SN	Small Negative
SOC	State Of Charge
SP	Small Positive
Z	Zero

developed and implemented to track the maximum power point (MPP) [2,14], and the first system with MPPT was introduced in 1968 for a space system [11]. Most control schemes use the Perturb and Observ (P&O) method, which is based on iterative algorithms to track continuously the MPP, because it is easy to implement [2,16] but the oscillation problem, is unavoidable. In many references the effectiveness of a fuzzy logic and adaptive fuzzy logic controller is shown [2,12] compared to the (P&O) method. It improves control robustness and this control gives robust performance under parameters and load variation.

Several authors have presented much attention to the study of the dynamic performance of the photovoltaic pumping systems. A. Terki and al [7] have presented an analysis of the dynamic performance of a permanent magnet brushless DC motorcontrolled through a hysteresis current loop. Also, the performance optimization of an induction motor associated at a PV generator have been studied by Ref. [8] and Field Oriented Control (FOC) of induction motor pumping system supplied by photovoltaic generator has been studied by Makhlouf and al [9]. In H. Hadi [10], hybrid pumping system with battery is proposed to reduce the overheating of the motor temperature and increase the efficiency. The battery is installed as the storage of the surplus energy and backup energy.

In this article, we present a water pumping system (solar/wind) with battery storage and the induction motor coupled to a centrifugal pump. The AFLC and FLC controller is applied to ensure a maximum operating of the photovoltaic array. And to improve the FLC and AFLC controller, we make a comparison with the classical MPPT, the Perturb and Observ (P&O). A supervisor control for the hybrid power system is presented; the main objective is to meet the power load requirements through effective utilization of the batteries. Obtained results

Please cite this article in press as: Serir C, et al., Supervisor control and optimization of multi-sources pumping system with battery storage, International Journal of Hydrogen Energy (2016), http://dx.doi.org/10.1016/j.ijhydene.2016.05.096