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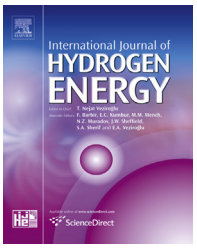

Short Communication

PEM fuel cell/ battery storage system supplying electric vehicle

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ABSTRACT

In this paper, a study of Hybrid power system to supply energy to an electric vehicle is presented. The hybrid system is used to produce energy without interruption and it consists of a proton exchange membrane fuel cell (PEMFC) and a battery bank. PEMFC systems work in parallel via DC/DC converter and the battery bank is used to store the excess of energy. The mathematical model topology, the identification of each subsystem and the control supervision of the global system are the contribution of this paper. Obtained results under Matlab/Simulink and some experimental ones are presented and discussed.

Introduction

In hybrid power systems, different sources can be used, conventional ones as coal, natural gazes, fossil fuels, or renewable ones as solar, wind, hydraulic,… [1–13]. However, due to the intermittent character of these sources, a storage system, in general a battery bank must be inserted. These past few years, manufacturers have taken an interest in hydrogen or fuel cell vehicles which can have autonomy of 400–800 km depending on car models, and which reject less carbon dioxide. The fuel cells were invented more than 165 years ago. It was discovered in 1839 that the electrolysis process could be reversed. In a fuel cell, hydrogen and oxygen react to form water and electricity is produced. A fuel cell consists essentially of the electrodes separated by an electrolyte. There are different types of fuel cells depending on the type of electrolyte. In order to obtain appreciable output voltages, several fuel cells have to be combined to obtain a fuel cell stack. Most mobile applications and particularly automobiles are dominated by proton exchange membrane fuel cells (PEMFC). This is due to their low operating temperature, so PEMFCs can produce immediately power after start-up. The delivered power can be of a few kW to several hundred kW.

The present work is dedicated to Supervisor and Control a Stand-Alone Hybrid Power System which supplies energy to an electric vehicle (EV). The advantages of each source used, allow us to obtain a cheaper and a less polluting electric

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Nomenclature

A_f	frontal surface area of the vehicle, m^2
C_d	aerodynamic drag coefficient
E	voltage source, V
E_{Nernst}	voltage Nernst, V
F_r	total force, N.m
f_{ro}	rolling resistance force constant
F_{tire}	rolling resistance force Z, N.m
m	vehicle total mass, kg
n_b	number of cells
r	tire radius, m
T_{PEMFC}	absolute operating temperature of the stack, °K
U_{act}	activation overvoltage, V
U_{conc}	concentration or diffusion over-voltage, V
U_{ohm}	resistive or ohmic over-voltage, V
V	vehicle speed, m/s
V_{PEMFC}	fuel cell voltage, V

Greek letters

ΔT	heating of the accumulator, °K
ρ_{air}	air density, kg/m^3

Abbreviations

AC	alternate current
DC	direct current
DTC	direct Torque Control
EV	electric vehicle
FC	fuel cell
HPS	hybrid power system
IM	induction motor
PEMFC	proton exchange membrane fuel cell
PM	power management
RFOC	rotor flux oriented control
SFOC	stator flux oriented control

vehicle. We use in our case an induction motor (IM) of 3 kW for propulsion of the EV. To keep the DC bus voltage at a constant value when the speed of the rotor varies, different control techniques can be used as stator oriented control (SFOC), rotor flux oriented control (RFOC), Direct Torque Control (DTC) [14–17]. In our work, the IM is controlled using DTC Strategy, which is a powerful control method for motor drives. The global system is presented, modeled and simulated under Matlab/Simulink. Each subsystem is identified and then simulated separately, and hence the control supervision of the proposed system is given. Obtained simulation results and some experimental ones are presented and discussed.

Studied system

The global system consists of a proton exchange membrane fuel cell (PEMFC), two DC converters, a battery bank and a inverter supplying an electric vehicle, The power management based on the opening and closing of the three switches K1, K2 and K3, according to deferent modes exist (Fig. 1).

Modelling of the studied system

Fuel cell PEMFC model

A PEMFC is an electrochemical energy converter. The chemical energy is directly converted into electrical energy and heat. Hydrogen and oxygen react separately to form water. A cell system is composed of the heart cell associated with all necessary ancillaries to the operation of a fuel cell in an embedded application. There are different types of fuel cells

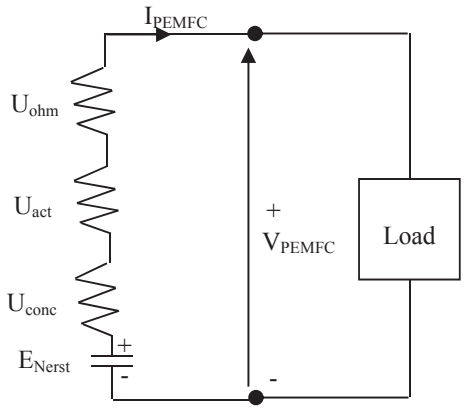

Fig. 2 – Electrical representation of a PEMFC.

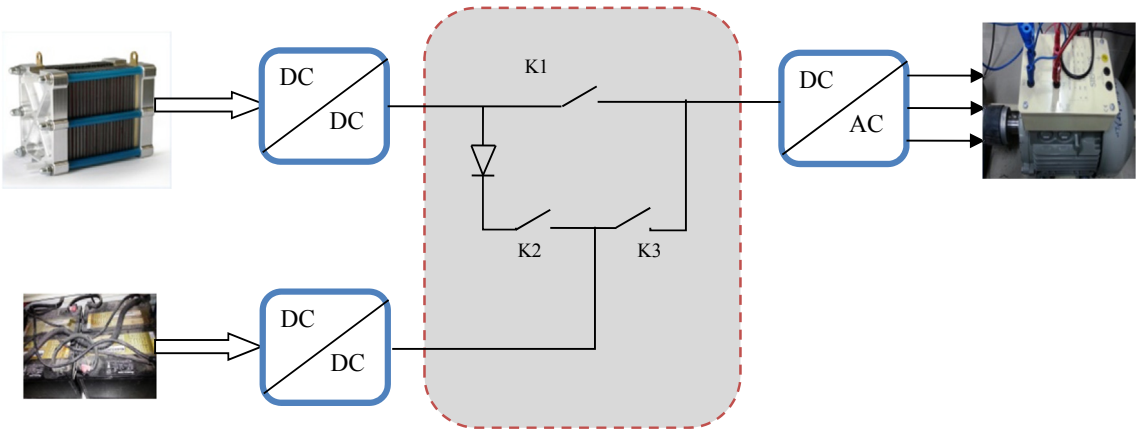

Fig. 1 – System description.

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