RESEARCH ARTICLE OPEN ACCESS

Design and Control of a Hybrid electric SystemUsing Energy management unit

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ABSTRACT: New-Zero-Emission-Hybrid-Electric-Vehicles have been selected to be an attractive research issues due to its capability to reduced emissions. In contrast, New Zero Emission system has some main limits derived from charging procedure. To solve hybrid electric drawbacks, a new dynamic design is developed and detailed. In the proposed configuration, the main supply fuel celis chosen as the principal source and an ultracapcitor is added as recovery unit to regulate energy demand. To regulate the energy demand, ansuperviosiry algorithm is proposed. The proposed algorithm aims to control the energy according two modes. The results show that the proposed design prove the efficient of the proposed approch using the Matlab/Simulink environment.

Keywords: Fuel Cell, Ultracapacitor, Energy Management Unit, performance. Simulations.

Date Of Submission: 21-08-2019 Date Of Acceptance: 05-09-2019

I. INTRODUCTION

Air pollution-induced primarily by vehicle traffic and the use of chemical batteries were the primary issues of the large nations. In reality, the use of batteries is still restricted due to its small autonomy[1]-[2]. New zero-emission cars have been selected as an appealing alternative to battery issues.New zero-emission cars have been implemented in transport apps due to their small oil consumption. To this stage, several fresh zero-emission hybrid electric cars (such as Hybrid Series, Hybrid Parallel and Hybrid-Dual modes) have been created and distinguished[3].To this end, fuel cells have demonstrated to be a successful source of energy for the provision of viable and eco-safe energy[4]-[5]. In particular, proton exchange membrane fuel cells have been chosen because of their advantages and performance (low operating temperature, easy and safe operating modes, etc). Fuel cell tanks are still linked to its weak dynamics, its inability to respond to transient electrical loads. For this reason, ultra-capacitors have been included in parallel with the Fuell cell to regulate transient events and satisfy the energy demand during the peak periods [6]-[7].UCap is more efficient than battery because of its limited life cycle, fast storage and power consumption. Indeed, it has been selected in several industrial applications because it provides a high-cycle paraport reserved for batteries. Batteries have low power density and limited life [8]-[9]. Energy demand for automotive applications become increasingly important, the standard battery design has become obsolete. The hybrid electric system is proposed as a potential solution to avoid chemical cells because of its high power applications[10]-[11].

Many settings of hybrid electric vehicles have been described in the literature. Many methods to the development of a hybrid electrical scheme have been included. In the quote, for instance. The writers have implemented a hybrid electrical scheme that connects a fuel cell with a supercapacitor.

The suggested scheme is intended to prevent the energy demand of the hybrid system and the loading situation according to the velocity circumstances, and an effective power management unit is suggested and reviewed using the FLC. The findings acquired have shown the effectiveness of the suggested settings. A hybrid electrical system using Ucp as a backup source is included and tested. A supercapacitor hybrid electrical scheme was used as an energy storage system as proposed[14]-[15]. The layout supplied is intended to regulate the volatility of fuel cells. A precise comparison assessment of the two settings was provided in [16]. The findings are tests to show the finest method using Matlab[17]. The findings acquired have shown the efficiency of hybrid energy using a fuel cell as the primary cause of energy.Convinced that the proposed energy methods are not intended to properly regulate and cooperate between the fuel cell and the supercapacitor, this article extends the ideas of previous research by proposing an energy management system. This method is used to ensure the efficient distribution of energy flows.

In brief, the input of this paper to the growth of a true hybrid system is pooled in the existence of an effective energy management unit.

The rest of this article is designed as follows: New zero-emission hybrid vehicle centers installed on the design of electric hybrid stem cells and the results of the power management unit section and the results dedicated to simulation results and concluding comments are discussed in the section conclusions.

II. HYBRID ELECTRIC SYSTEM

The layout suggested is shown in Fig. 1. The scheme comprises of two energy inputs, PEMFC and UCap, which are divided by a power management unit that controls the scheme. In this case, PEMFC is the main source of power that converts the demand for the load by converting hydrogen into electricity. Introduced as an energy recovery scheme, UCap aims to handle energy demand during critical periods when the fuel cell refuses to provide the necessary energy..

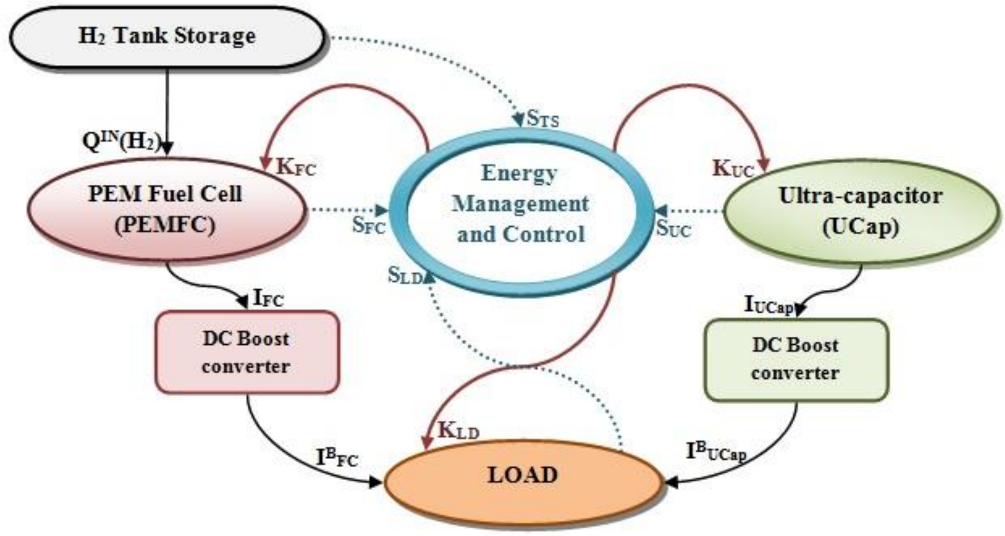


Figure 1.Hybrid electric design

Energy management

The proposed energy management aims to ensure clean operation between PEMFC and UCap and to regulate energy demand. The method described focuses on a number of selection variables (ε1, ε2, and ε3). The current PEMFC (IFC), current Iload and current UCap are adapted and organized.The suggested method is focused on two methods of procedure (with and without PEMFC). The two methods are described as follows.

The first mode

$\varepsilon1=I_{Load}-I_{FCn}$

for $\varepsilon1\geq0 \rightarrow \varepsilon2= \varepsilon1- I_{UCap\_max}$

for $\varepsilon2 \geq0 \rightarrow I_{Load}=I_{FC} \rightarrow K_{FC}=K_{LD}=1$ and $K_{UC}=0$

for $\varepsilon2<0 \rightarrow I_{Load}=I_{FC}- I_{UCap} \rightarrow K_{FC}=K_{LD}=K_{UC}=1$

The second mode

$\varepsilon1=I_{Load}-I_{FC\_n}$

for $\varepsilon1<0 \rightarrow \varepsilon3= \varepsilon1- I_{UCap\_min}$

for $\varepsilon3 \geq0 \rightarrow I_{Load}=I_{FC} \rightarrow K_{FC}=K_{LD}=1$ and $K_{UC}=0$

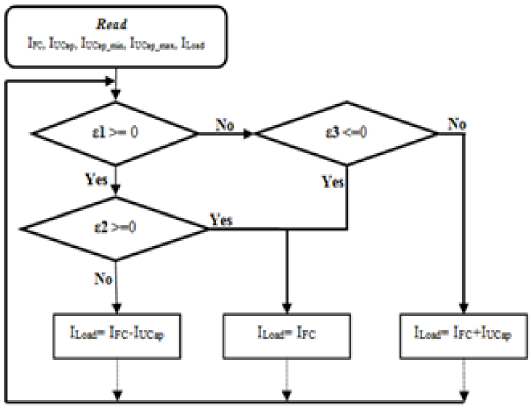
for $\varepsilon3<0 \rightarrow I_{Load}=I_{FC}+I_{UCap} \rightarrow K_{FC}=K_{LD}=K_{UC}=1$

If $Q^N(H_2)>Q^S(H_2)$
Then $Q^R(H_2) = Q^S(H_2)$
If $Q^N(H_2)<Q^S(H_2)$
Then $Q^R(H_2) = Q^N(H_2)$

Where IUCap max and IUCap min are the maximum and minimum load and release rates. The nominal potential of the PEMFC is provided by IFCn. Generally, the PEMFC present relies on the quantity of hydrogen collected. This amount can be described as a feature of hydrogen quantity (Q(H2)). In fact, it can be calculated according to the previous flowchart. In order to treat the non-existence of the Fuel Cell, a control flowchart algorithm based on the duty cycle is included. Suggested algorithms relied on the 5-007UCap variable to fulfill the previous requirements.

- When $I_{UCap} \geq I_{Load}$: The deactivation of the UCap boost
- When $I_{UCap}<I_{Load}$: The activation of the UCap boost

SalsabilGherairiJournal of Engineering Research and Application   www.ijera.com   ISSN : 2248-9622 Vol. 9,Issue 9 (Series -I) September 2019, pp 09-15



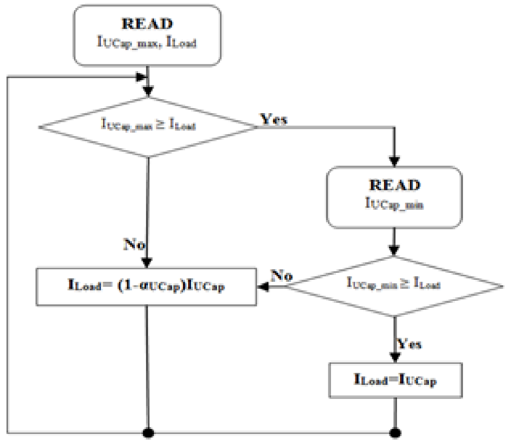


Figure 2. The main Control AlgorithmFigure 3. Algorithm nonexistence of PEMFC

III. SIMULATION AND RESULTS

The simulation section, we evaluate of our hybrid generation system PEMFC/UCapeffectiveness and the performance according to the simulation results. Based on the Fuel Cell constraints and energy demand, the energy management unit is developed and traited. The developed approach was verified according to the following assumptions:

- Provetheoptimal Load behavior.
- Assure the energy demand during any fluctuations.
- Respect of the slow dynamics of the PEMFC

The energy balance in the scheme, which is directly influenced by the energy management strategy adopted, is used to determine hourly energy flows such as the amount of hydrogen storage, the UCap charge status, and overall system efficiency. For this purpose, we need to evaluate the efficiency of each method of action.

The following figure presents the different characteristics of the PEMFC such as the current, the voltage and the power. As mentioned previously, we should be reminded that, the PEMFC boost converter is only intervening when the I_{FC}<I_{Load}before the activation of the UCap. In fact, the variation of the boost duty cycle is given by the figure 6.The figures 7 is composed by two curves. The first presents the variation of the different energy flows according to the adopted energy management approach. Whereas, the second presents the evolution of the H_2 gas quantity in the tank storage.In the first curve, we can educe three principal states. The state A shows the behavior of the UCap during the transient events. While, in the state B, we can note that the $I^{B}_{FC}$is greater than I_{Load}. Consequently, the excess of power can be issued to the UCap in order to be stored. That explains the increasing value of SOC (see figure 8). At the same time, the H_2 stored quantity deceases until it reaches its minimum value. Thus, the PEMFC global efficiency variation is presented by the figure 8. In fact, the value of this latter can be ranged between 40% and 75%.The figure 9 presents the UCap and the overall system efficiencies in the concerning operating. In fact, the first curve is given to present the UCap efficiency, which reaches at maximum 70%. While, the second presents the overall operating mode efficiency. This latter, is none other than the product of the PEMFC and the UCap efficiencies. The maximum value of η_{Sys_a} is 50%.We should be noted that, the UCap boost is activated when I_{UCap}current is lower than I_{Load}(I_{UCap}<I_{Load}). That explains, the variation of the boost duty cycle between 0.5 and 0.Concerning the UCap state of charge, in this stage the load consumes the electricity stored in the UCap. Consequently, the SOC is deceasing during the time. The global efficiency of UCap reaches at maximum 60%.

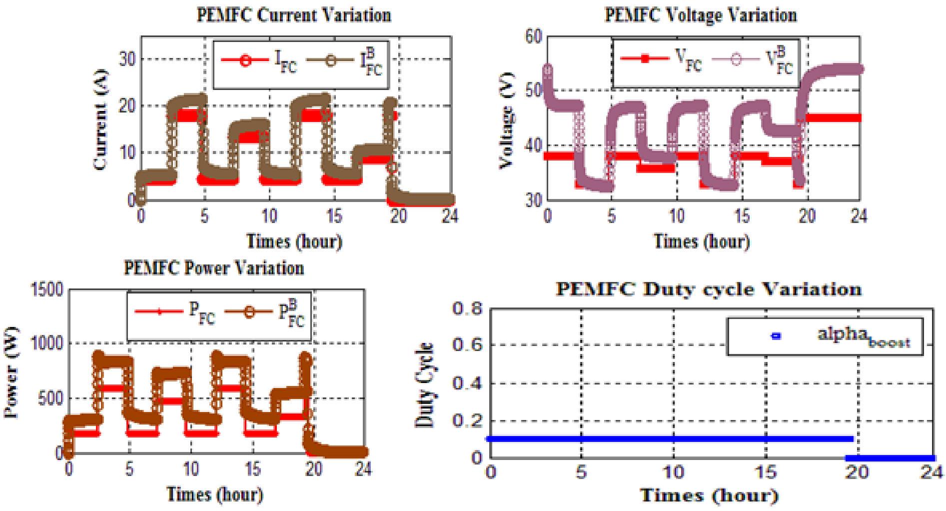


Figure 4.PEMFCCharacteristics

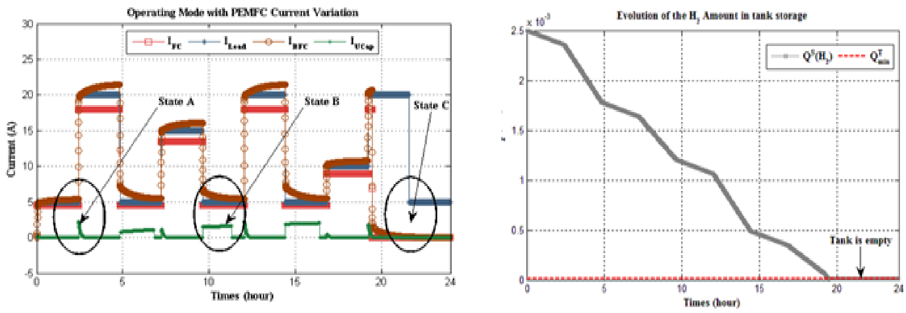


Figure 5. Operating mode with the PEMFC

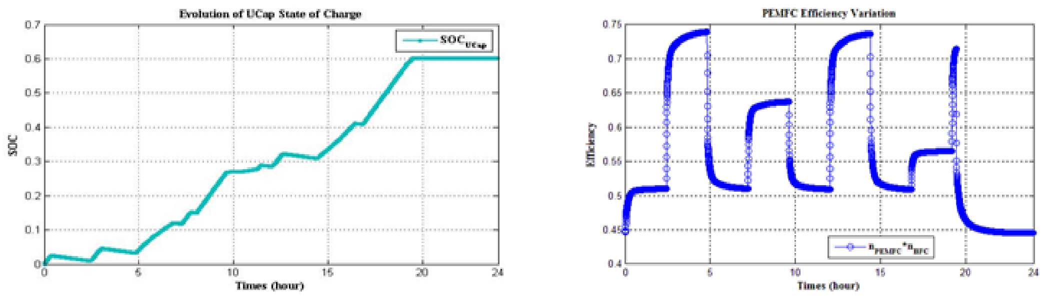


Figure 6.UCap SOC and PEMFC global efiiciency variation

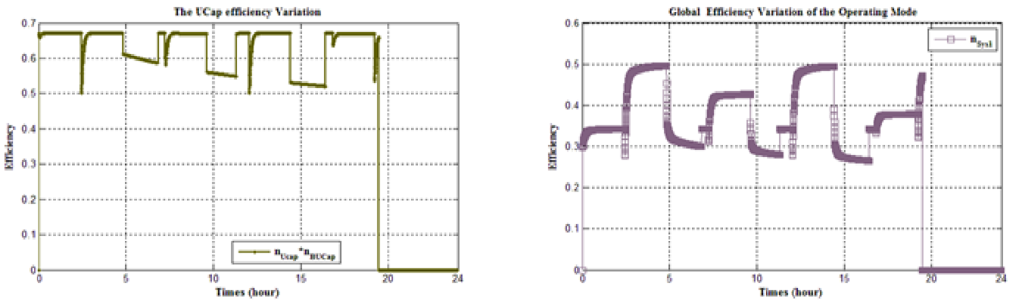


Figure 7. Operating Mode with PEMFC Global Efficiency

In this subsection, we treats the operating modewhich is characterized by the absence of the PEMFC. Hence, the UCapis working only. Thus, the figures 10and 11 present the main characteristics of the concerned operating mode such as the UCap current, the boost duty cycle variation, the UCap state of charge and UCap global efficiency.

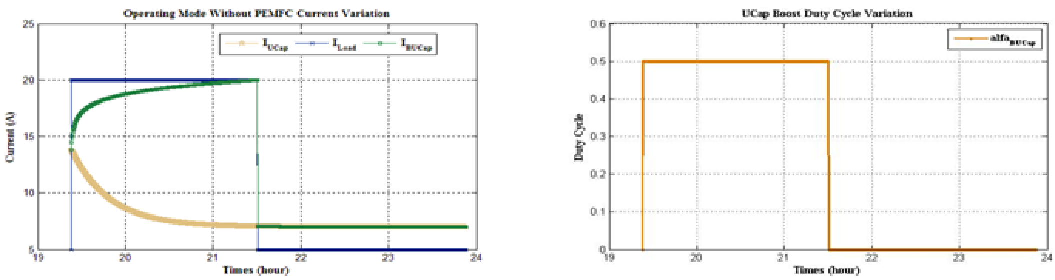


Figure 8. Operating Mode Without PEMFC

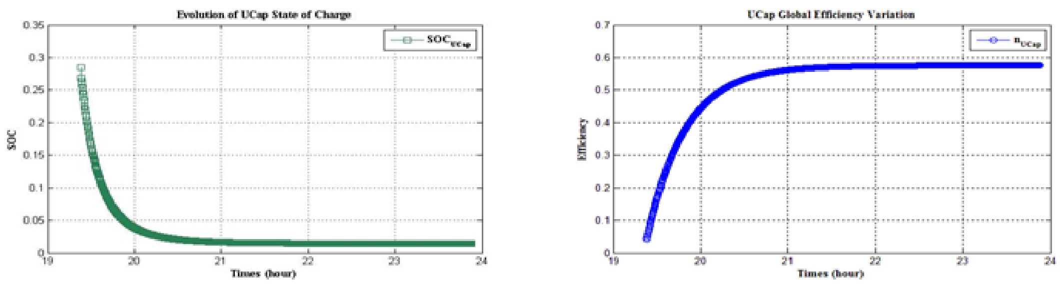


Figure 9.UCap SOC and efficiency variation

Characteristics are shown in the figure. 12 constitute complete energy management, UCap worldwide loading position, and general system efficiency. In fact, the PEMFC feeds the load up to 7 p.m. During this moment, PEMFC will highlight the working method.During this moment, the PEMFC working method is illustrated. At the same moment, the UCap SOC was evolving. When the PEMFC is unable to meet the load requirements, the UCap intervenes to cover the deficit power. In this situation, we're talking about a PEMFC-free working system. As has already been shown, this phase is defined by the decline of the

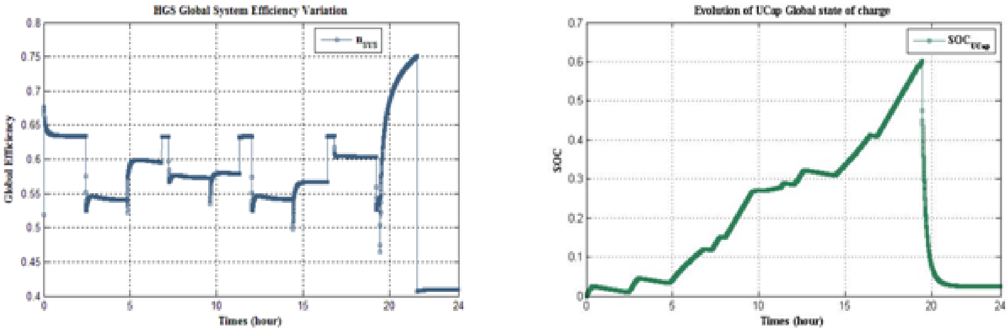


Figure 10. System efficiencies

UCap SOC. Concerning the overall system efficiency, we note that the value of this latter is ranged between 40% and 75%.

IV. CONCLUSION

In this article, we suggested and priced an electric hybrid scheme that incorporates PEMFC and UCap. The use of the latter is essential to react well to the soft dynamics of the PEMFC. We notice that our strategy to ensuring a healthy transition and governance of energy.

Finally, we assessed our input through scenarios and demonstrated the strength of the suggested strategy. Our potential job involves the introduction of fresh power technologies, optimization techniques and energy conditioning units using distinct topologies to demonstrate the energy economy.

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Nomenclature

K_{FC}, K_{UC}, K_{LD}	: Key decision	S_{TS}, S_{FC}, S_{UC}, S_{LD}	: State system components
I_{UCap}	: The UCap current	I_{FC}	:The PEMFC current
I_{UCap_max}	: Maximum current value of UCap	I_{UCap_min}	: Minimum current value of UCap
I_{Load}	: Current of the load	P_{Lmax}	: Maximum Load power (w)
V_{FC}	: PEMFC voltage (V)	V_{UCap}	: UCap voltage (V)
E_{rev}	: Reversible voltage (V)	V_a	: Activation overvoltage (V)
V_{con}	: Concentration overvoltage (V)	V_{ohm}	: Ohmic voltage (V)
R_{UCap}	: UCap resistance (ohm)	C_{UCap}	: UCap capacitance (nF)
E_{UCap}	: UCap energy (J)	E_{max}	: Maximum UCap energy (J)
E_{min}	: Minimum UCap energy (J)	SOC_{max}	: UCap maximum state of charge
SOC_{min}	: UCap minimum state of charge	V_{UCap_max}	: Maximum UCap voltage (V)
I^B_{FC}	: Output Boost FC current (A)	M_{FC}	: Margin coefficient of PEMFC
I^B_{UCap}	: Output Boost UCap current (A)	M_{UCap}	: Margin coefficient of UCap
P_{FC}	: PEMFC nominal power (W)	N_{FC}	: cell numbers of PEMFC
η_{UCap}	: Overall UCap efficiency (%)	α_{UCap}	: UCap boost Duty cycle
η_{PEMFC}	: Overall PEMFC efficiency (%)	η_{MAT}	: Material PEMFC efficiency (%)
η_{vol}	: Voltaique PEMFC efficiency (%)	η_{th}	: Thermal PEMFC efficiency (%)
η_{FC}	: PEMFC faraday efficiency (%)	η_{Sys}	: Overall system efficiency (%)
D_{max}	: Maximum of decharge rate	T_D	: UCapdecharge time (s)
$Q^N(H_2)$	: Necessary H_2 amount (mol)	$Q^R(H_2)$	: Reacted H_2 amount (mol)
$Q^S(H_2)$	: Stored H_2 amount (mol)	ε_1, ε_2, ε_3	: The decision operating coefficients
η_{Sys_a}	: Route a system efficiency (%)	η_{Sys_b}	: Route b system efficiency (%)
η_{BFC}	: Boost PEMFC efficiency (%)	η_{BUCap}	: Boost UCap efficiency (%)

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