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Tele-Monitoring the Battery of an Electric Vehicle

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Abstract

Nowadays, transportation is one of the main air pollution sources and has a significant impact on human health and environmental quality. The electric vehicle is a zero emission vehicle powered by an electric motor with power from an electricity source, usually a battery or super-capacitor. However, monitoring and managing the recharging of electric vehicles represents a challenge. The purpose of this paper is to present a new concept of telemonitoring the battery charging process. The paper presents a general overview of existing techniques and solutions for powering electric vehicles and evaluates different sensors for tele-monitoring the battery. Furthermore, we evaluate the feasibility of the novel concept to monitor redox flow batteries.

Keywords: Electric Vehicle, Battery, Sensors, Tele-Monitoring..

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1. Introduction

Since 2008, the number of research projects conducted in the field of electric vehicle manufacturing has constantly increased [1]. These efforts are justified by the following facts: efficiency (electric vehicles are around three times more efficient than internal combustion engine vehicles), reduction of the greenhouse gas emissions and the high consumption of natural resources (one of the main reason for the growth of oil price). One key aspect of finding alternatives in this field is represented by the development of a powerful, efficient and reliable energy supply, in order to meet the requirements of recently-developed technologies. One of the goals of our research is to assess the way to monitor redox flow batteries as a potential power source for hybrid electric vehicles.

This hybrid concept between Vanadium Redox Flow Battery and Hydrogen Fuel Cell, has been already used for energy management in an electric vehicle, with zero emission [2]. Furthermore, the battery is environment-friendly, 98% recyclable and the main idea behind this concept is to recharge the battery simply by changing the electrolyte. This offers a solution which allows dual charging, by replacing the electrolyte (3 - 5 minutes) or by grid connection (8 - 12 hours). In addition to this, the proposed model has no limitation in charge/discharge number of cycles, supporting up to 15000 – 20000 cycles [2]. Another challenge is related to finding and testing the adequate sensors for monitoring all aspects of interest when evaluating the parameters which define a vehicle's internal state: temperature, humidity, pH, current, voltage, acceleration and so on [3].

Our goal is to pick the sensors which have a low level of electric consumption and a high resolution, in order to meet the industrial requirements. In the current paper, we will briefly go through the ones which we picked as viable solutions for our current project, and focus on their key characteristics. The rest of the paper is organised as follows: Section II presents related work in the field of searching alternatives for power supplies, Section III presents the design of the tele-monitoring and communication system, Section IV describes the integration and experimentation of the solution. Section V concludes the paper.

2. Related Work

This section presents related work in the field of battery alternatives, the weak points of currently available batteries and a brief introduction to solutions for these issues. Energy storage remains a critical issue in contemporary world. By developing an alternative battery system in a short period of time, a significant breakthrough can be made, consistent with the market development [4].

There are types of batteries available, such as high-temperature batteries, lithiumbased batteries and nickel-metal hybrid batteries [5]. Because of their extremely high energy density, they offer unprecedented vehicle ranges, up to 250 km [6]. Furthermore, the batteries of electrical vehicles nowadays present a set of characteristics that makes their use impractical and even stressful in some situations [7].

For example, when travelling long distances, one must make sure that his vehicle’s battery is fully charged, because there may not be a charging point on his way. The charging time is also an important drawback: it lasts between 8 and 12 hours for a full charge, thus making it incompatible with the needs of many customers [8]. Therefore, the duration of such batteries can be a problem, especially when using the car in a remote area or somewhere far enough from a big city. Recently, Fuji Heavy Industries, parent company of Subaru, set out to develop its first hybrid vehicle using National Instruments (NI) solutions, more specifically the PXI platform [9]. Moreover, the sealed nickel metal-hydride battery, invented by H. Mori, K. Sakamoto, T. Bandou and K. Okabe, is expected to show a high output density and an excellent performance especially in a cold atmosphere [10]. The second type of battery discussed, the lithium-ion battery, is the most frequently used one now, being indispensable for all mobile equipment, as well as for electric vehicles [11]. Future lithium-ion are designed to last over 100000 miles, while the actual ones need to be replaced about every 25000 miles, comparing to the original lead-acid based GM EV1 battery, which has a range of about 60 miles [12]. For example, Tesla’s lithium-ion based Roadster prototype has a range of about 245 miles combined city/highway usage [13].

3. Design of the Tele-monitoring Solution

In this section we describe the methodology for analyzing and tele-monitoring the behavior of the battery in the electric vehicle. For measurements, a Gemalto Concept Board [14] and myDAQ [15] module from NI were used. The initial technical requirements are specified in Table 1.

Table 1. Initial technical specification

Input/Output Data	Type of measurement	Format
Digital Input 1	Date and time	Date + time
Analog Input 1	Ambient temperature	Double (^{o}C)
Analog Input 2	Relative humidity	Double (%)
Analog Input 3	Voltage and standard deviation of the measured value	Double (Volt)
Analog Input 4	Intensity of current	Double (Ampere)
Analog Input 5	pH level of battery electrolyte	Double (pH)
Digital Output 1	XY Chart - current function of date and time	Graph
Digital Output 2	XY Chart - pH function of date and time	Graph
Digital Output 3	XYZ Chart - Digital Output 1 and Digital Output 2	Graph

For tele-monitoring the battery system of the electric vehicles, we proposed a solution as presented in Fig. 1

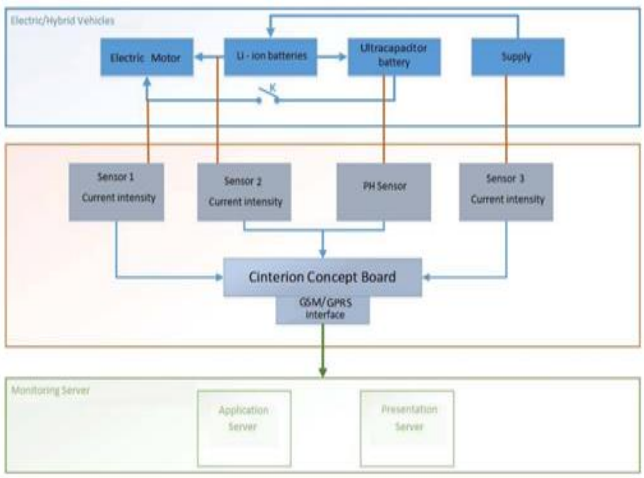


Figure 1. Conceptual design of the tele-monitoring system.

K switch with ultra-capacitor battery is designed to protect (i.e. increases the lifetime of lithium-ion batteries) Li-ion battery. Due to acceleration / deceleration the engine introduces wide variations of current in circuit. The data is transmitted to an application server for processing and to a presentation server for visualization.

4. Integration and Measurement Results

In this section we describe the integration of the sensors and measurements done for an electric vehicle. The integration of the monitoring system of the vehicle that is equipped with a redox flow (RF) 6kWh accumulator and the components for dynamic monitoring and real-time communication of the technical parameters are presented in Fig. 2.

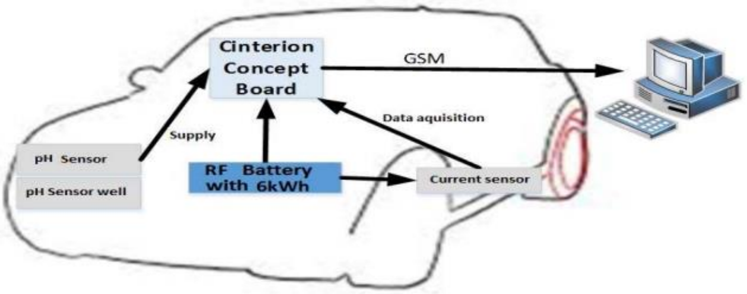


Figure 2. Integration of the tele-monitoring system for a vehicle equipped with a RF 6kWh battery

The main components, as mentioned in the initial specification in Fig. 1, are connected to a myDAQ board:

- Cinterion Concept Board acquisition board: has voltage at power interface applied at 5V between -0.3 and 5V and interface source of the power application's signals between -50 and 50mA, operating at a temperature between 0 and 350 C.
- Current sensor: ACS7091 (Fig. 3) has an operating voltage between 3-5.5 V and an output sensitivity of 18.5 mV/A when VCC is at 3.3 V (or 28mV/A when VCC is 5 V).
- pH sensor and probe well: has heating voltage 5 +/- 0.2V(AC/DC) at a current of 5-10mA, the detection range of the concentration pH 0-14, the temperature range detected between 0-100 degree Celsius and response time <= 5 s.

Data is transmitted via a compact GSM modem used in the transfer of data, voice, SMS and fax over a GSM network, having multiple standard interfaces, an integrated SIM card reader, with elements that enable the use this terminal as quad band GSM M2M (Machine 2 Machine) terminal. Frequency bands in which the M2M GSM module can operate are 850/900/1800/1900MHz for GSM/GPRS/EDGE and 800/850/900/1900/2100MHz for UMTS/HSPA.
It is possible the data transfer via GPRS, Class 12 multislot which supports more coding schemes and a stack PPP (Point-to-point Protocol).
The data were also sent by CSD (Circuit Switched Data) that represents the original form of data transmission, developed for mobile systems based on TDMA (Time Division Multiple Access) with protocol USSD (Unstructured Supplementary Service Data). Transmission rate is 9.6Kbps.
The concept board is programmable using a Java platform that includes an API (Application Programming Interface) for AT interpreter type, USB interface, Flash file system type or TCP / IP and enables multi-threaded programming and multi-application execution and data transmission over HTTP / SSL.

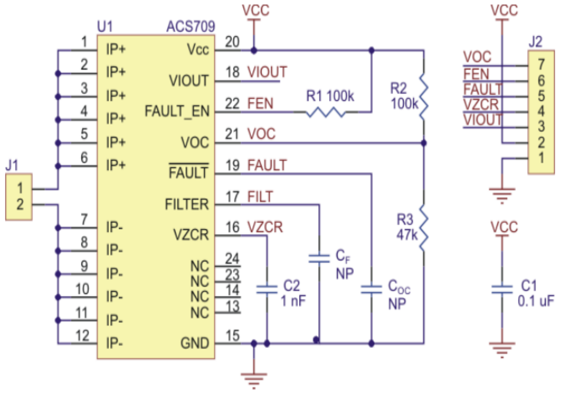
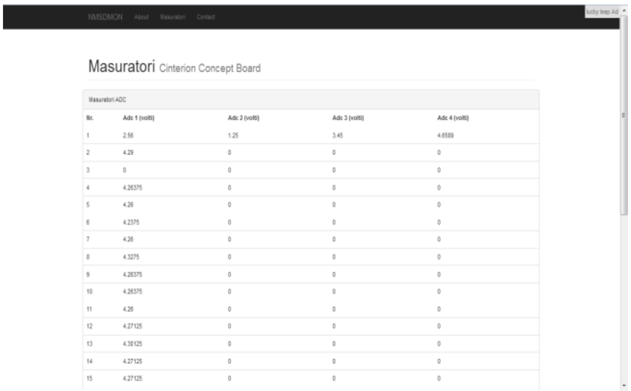


Figure 3. Electric current sensor schematic diagram

The sample measurements are presented in Fig .4, using a MySQL database for storing the digital outputs processed via PHP scripts after they are received via GSM.


NMSDMON About Masuratori Contact

Masuratori Cinterion Concept Board

Masuratori ADC

Nr.	Adc 1 (volti)	Adc 2 (volti)	Adc 3 (volti)	Adc 4 (volti)
1	2.56	1.25	3.45	4.6589
2	4.29	0	0	0
3	0	0	0	0
4	4.26375	0	0	0
5	4.26	0	0	0
6	4.2375	0	0	0
7	4.26	0	0	0
8	4.3275	0	0	0
9	4.26375	0	0	0
10	4.26375	0	0	0
11	4.26	0	0	0
12	4.27125	0	0	0
13	4.30125	0	0	0
14	4.27125	0	0	0
15	4.27125	0	0	0

Figure 4. Web based graphical interface for visualizing data on the presentation server

After creating the application server, a graphical user interface has been created for visualizing the data stored in the database, being responsive to the screen size of the user which runs the presentation application.

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5. Conclusions

Providing the energy that will sustain future electric vehicle poses challenges for current tele-monitoring systems. We presented related work in the field of batteries for electric vehicles and proposed a design for tele-monintoring based on sensors and general purpose data acquisition boards. Based on the measurement results, we can conclude that the main purpose of the research presented in this paper was reached, namely to tele-monitor a resilient energy source that meets the demands of all electric vehicles manufacturers and which will help reducing the pollution level. In order to achieve this goal, we have to make the right compromise between the efficiency and capacity of the power supply and the parameters of the main consumers of energy – sensors. As future work we envision to test our proposed solution with more battery and sensor types.

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