DC powerline communications for management of high voltage battery packs

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Abstract

High voltage battery packs consist of a large number of individual rechargeable cells. As such, they are extremely expensive and their tight manament is of crucial importance. Herein described is a way to employ the DC powerline as the medium for communicating data and commands reliably between the multiple individual cells and the main electronic control unit.

1. Introduction

Modern Battery packs, such as Lithium-Ion, consist of a set of individual re-chargeable battery cells. Each of the cells requires strict operation within specified temperature and voltage range. An individual cell that operates outside its specified conditions may be permanently damaged and potentially hazardous. Therefore, a Battery Management System (BMS) [1] that monitors and controls each of its constructing cells is essential.

This paper briefly describes a DC-BUS-based communication scheme that provides the physical layer for the management of multiple-cell re-chargeable battery packs. Such a system may be refered to as a NanoGrid, see e.g. [2]. The solution employs the exsisting DC powerline between the battery packs for communicating data and information with no additional wiring. It is based on a semiconductor component designed to provide reliable (multi-point) connectivity over the noisy DC powerline, by using an innovative multiphase modulation with a simple UART interface.

2. The Battery Management System

An example system is depicted in Figure 1. It consists of multiple battery packs (3 in this example and typically 8 packs in practice) connected in series to provide the required high voltage (typically 300-380v). A master ECU is present to monitor and control all the baterry packs. The ECU serves as the master of the system, while the individual packs are the slaves, in the sense that, typically, the ECU initiates all the activities and communications in the system.

Each battery pack consists of multiple low-voltage cells. The battery pack should provide information about its specification, individual cell voltages, temperatures and usage history. This information determines the optimum charging/discharging profile for the pack. To achieve this, associated with each battery pack is a so-called *cells monitoring module* (CMM). The CMM also handeles the communications for the pack using a DC-BUS transciver (transmitter/receiver) [3]. The CMM is connected in parallel to the battery pack and so it communicates over the DC power line. Thus, all the DC-BUS transcivers are connected in series.

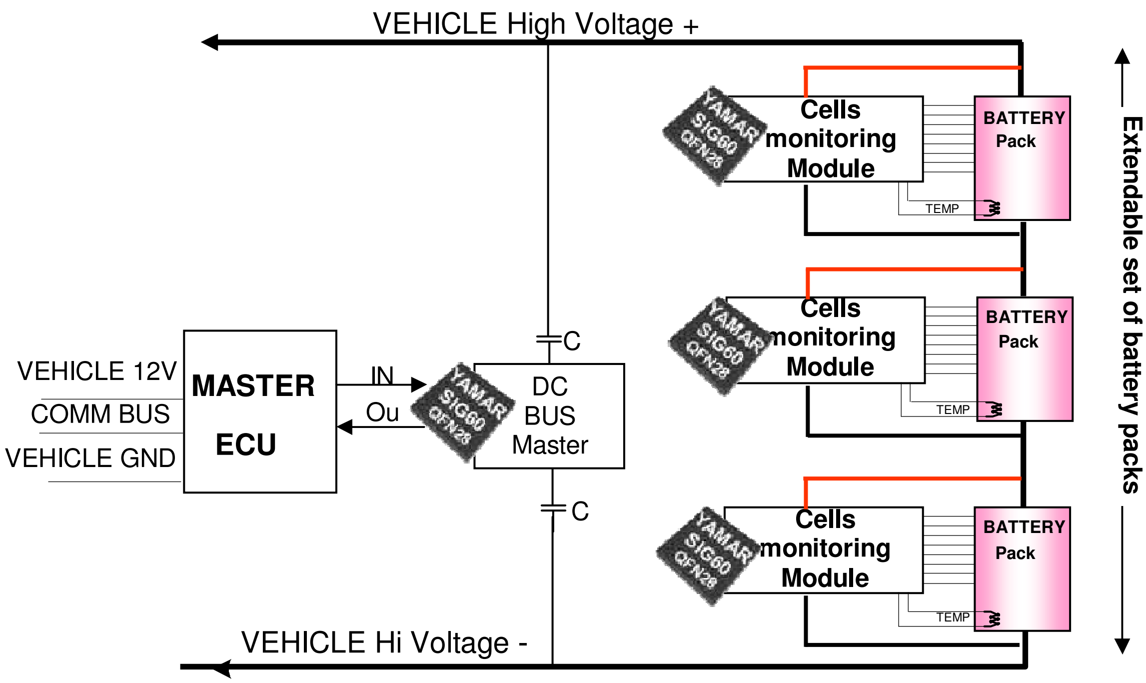

Figure 1. Battery Management System (BMS) enabled by DC-BUS powerline communications.

The so-called *DC-BUS Master* acts as the ECU transciver. The ECU has to be able to access each and every CMM in this series configuration. Hence, to close the communication loop, the ECU connected to the high voltage powerline (high frequency-wise) as shown in Figure 1. Clearly, galvanic separation must be provided between the high voltage DC powerline and the *DC-BUS Master*.

3. Communication Challenges

Data is communicated between the CMM's and the ECU via the DC powerline using a high frequency modulated carrier. Achieving reliable data communications in such an enviroment is a chalanging task due to the very small impedance – high signal attenuation – of the batteries, as well as the very noisy nature of the DC powerline (e.g. high-frequency switching noises of the power invertors, engine generated noises and other in-vehicle inductive loads – see Figure 2).

Furthermore, we established by simulations and measurements that there are operational frequency related issues that must be considered:

1. the operational frequency band (center frequency as well as bandwidth) must be chosen carefully so as to achieve good balance between channel attenuation and (exsisting) system-related noises and interferences;
2. EMC related: both conducted and radiated high frequency components must be restrained to adhare to the relevant in-vehicle standard requirements.

4. The solution

The solution for the abovementioned challenges is a DC-BUS transciver desined to operate over the noisy powerline as encountered in EV (electric-vehicle) high-voltage battery. The DC-bus transciver is implemented into a semiconductor component that provides reliable network over the noisy powerline. The data coming from the UART is used to modulate a high frequency carrier using an innovative multiphase approach that is more resilient to powerline noise.

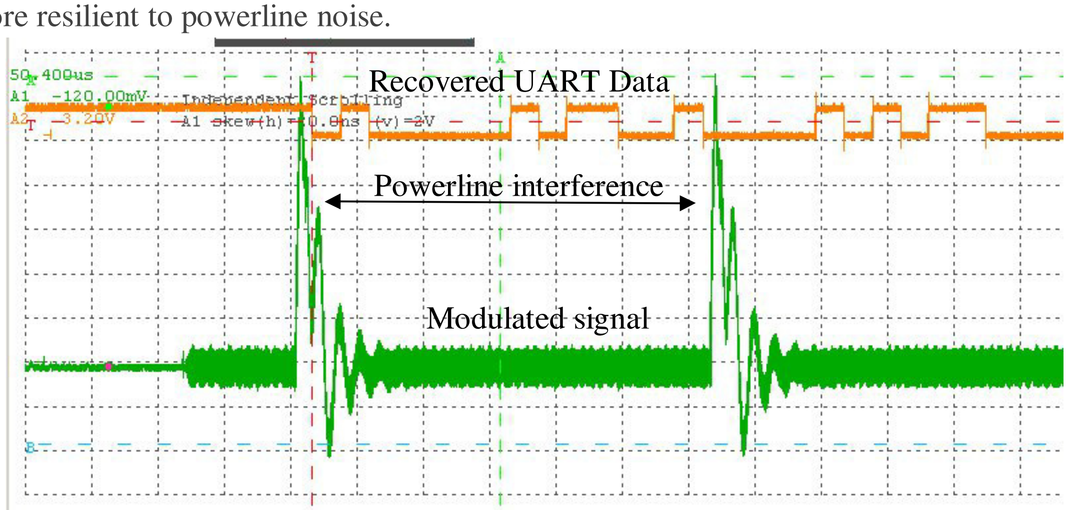

Figure 2. Measured signals: received signal perturbed by inverter switching interference (Green), recovered modulating signal (orange).

Figure 2 is a snapshot of an actual measurement showing two signals: the green trace represents the received signal perturbed by noise and high level interference (periodic pulse with ringing) caused by the switching inverter; the orange trace represents the recovered signal as conveyed to the UART.

Tests over an actual BMS noisy battery powerline were conducted. The obtained results indicate that the proposed communication scheme provides reliable communication for the NanoGrid. Figure 3 is a screenshot of a PC monitoring program that measured the communication performance between the Master ECU and the CMMs (Bit error rate better than 10^{-5} is achieved).

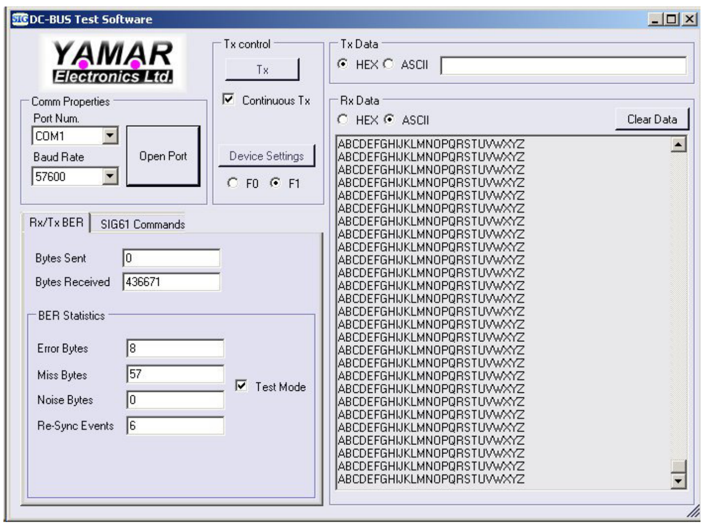

Figure 3. BMS performance monitoring program.

References

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[2] R. H. Lasseter. "Microgrids." IEEE Power Engineering Society Winter Meeting. vol. I, pp. 305-308. 2002.

[3] SIG60 Transciever datasheet, http://www.yamar.com/datasheet/DS-SIG60.pdf.