Battery Management Systems for Use in an Electric Vehicle

Introduction

The key source of energy for any electric vehicle is its battery pack. The failure of the batteries means the failure of the vehicle; therefore, the batteries must be kept in a healthy condition. If they become too hot or overcharged, they may rupture and cause a fire. In order to autonomously track the health of the batteries while in use and turn them off when necessary, a monitoring and managing system is utilized. This paper is a technical review of several commercially available battery management systems (BMS) that could be used in an electric vehicle application, the underlying technology used in these systems, and implementing such a system in a solar powered car.

Commercially Available Battery Management Systems

All commercial battery management systems contain at least three key features. First, they must monitor the state of the battery, including current, voltages, and temperatures. Secondly, a BMS should balance the charge among separate battery packs. Thirdly, the BMS needs a way to protect the batteries from over-charging or over-temperature to prevent combustion [1].

At its simplest, a BMS can use analog circuitry to set charge limits. The S48 BMS 16 Cell can protect batteries from over charging, over discharging, reaching a charge state that is too low, balance charge, and protect from a ground shorting. In all those cases besides charge balancing, the circuit simply cuts off the batteries from the load drawing current. However, the cost of such a system is relatively cheap, only being 85.95 USD [2].

Some BMS make use of a small onboard computer that communicates with the temperature, voltage, and current sensors. The computer then calculates the batteries’ state of charge and alerts the driver to any issues with temperature or charge levels. The computer can also control when to turn off certain blocks of cells if they are becoming over charged, can control a fan to cool the battery packs, and can balance the different packs if they have unequal charges [3]. These kinds of systems, when compared to their analog counterpart, can be very expensive. The GBS 24V Package from Electric Motor Sport can cost anywhere from 400.00 USD to 1600.00 USD [4].

Some commercial BMS utilize a feature known as “limp mode,” similar to a laptop’s power-saving mode. A BMS will normally not allow the batteries to drain below a 30% to 40% reserve in order to preserve their lifetime. However, if the batteries are drained down to the reserve level the BMS will switch the vehicle over to limp mode, allowing it to use the reserve charge but only allowing a max speed of around 40mph for electric/hybrid cars, or half the normal max speed [5,6].
Underlying Technology of Battery Management Systems

The analog BMS system is made up of simply a circuit board with wires going to each individual battery cell in a multi-cell system. The circuit is designed such that it cuts off the connection between the load and the batteries when voltages, current draw, or temperatures reach a certain specified level. The S48V BMS 16 Cell is set to break a connection when a battery reaches more than 4V, current draw is greater than 60A, or temperature exceeds 65°C. Since each individual battery cell has its own circuit, the circuit does not require operation amplifiers or passive circuit elements that can operate at high voltage levels (60V to 96V). They may instead operate at reasonable 3.2V [2].

The more complicated computer BMS system has the additional features of operating cooling equipment, cut-off circuits, and calculating the charge state of the overall system [3]. Generally the BMS computer must track the health of each individual cell, and thus must be wired to each cell, creating a mess of wires when a battery pack can contain up to 36 cells [1]. Advancements have been made in a computer BMS system by Yamar Electronics, who has developed the DC-BUS SIG60 system. The SIG60 has individual chips that connect between battery cells, and a single wire that connects the computer to the positive and negative terminals of the battery pack. The chips relay all relevant battery health information to the computer, significantly reducing the amount of wiring, but still maintaining the functionality of monitoring each individual cell [7].

Implementing a BMS in a Solar Powered Car

A battery management system is vital to a solar powered car as there is no way to stop power from being converted by the solar cells (outside of blocking the cells from the sun). In addition to the normal function of cutting off power to the load (in this case, an electric motor), the BMS must be able to stop the cells from transferring power to the batteries. This requires the BMS to be able to calculate the charge state of the batteries, and therefore requires an onboard computer to process the sensor readings.

While commercial options can be expensive (over 1600 USD) [4], small single board computers, such as the Beagle Board or PIC microcontroller, can be custom programmed for BMS functions, and only cost 150 USD and 45 USD, respectively [8,9]. A Beagle Board adds the functionality of USB, allowing wireless connections for broadcasting information to the driver. It is vital for the driver of the solar vehicle to know the health of the batteries at all times in the case of a system failure between the solar cells and the batteries and the batteries overheat and combust. The main goal however, is for the BMS to autonomously preserve the batteries health without the driver needing to worry.


