Standard Products

New Li-Ion Battery Management Chipset ATA6870, ATA6871 for Electrical and Hybrid Vehicles

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Electric or hybrid vehicles offer a viable means of increasing the efficiency of today's cars and thus tackling the dual problems of fuel consumption and CO_2 emissions. At the heart of electric or hybrid engines is a powerful battery; however, the amount of storable energy in these vehicles is limited by the weight and mass of the battery. New generations of Lithium Ion (Li-Ion) batteries are up to 30% smaller and 50% lighter than conventional Nickel Metal Hybrid (NiMH) batteries. These Li-Ion batteries offer concrete advantages in terms of size, weight, recharge speed, life span, and resistance to memory effects.

For this reason, the majority of electric and hybrid vehicle manufacturers have now started to develop high-performance batteries on a Li-Ion basis. This is no easy task because these high-performance batteries are energy bundles that provide voltages of between 150V and 500V, and even up to 1000V or more for busses. These high voltages are needed for an extremely simple reason. With a voltage of 1V, 1000A of current would be needed to generate 10 kW of output with an electric drive. In this case just a few mΩ of line resistance would prevent any energy whatsoever from reaching the motor because of the voltage drop caused by the current. However, with a voltage of 500V, only 20A would be needed into provide the same output.

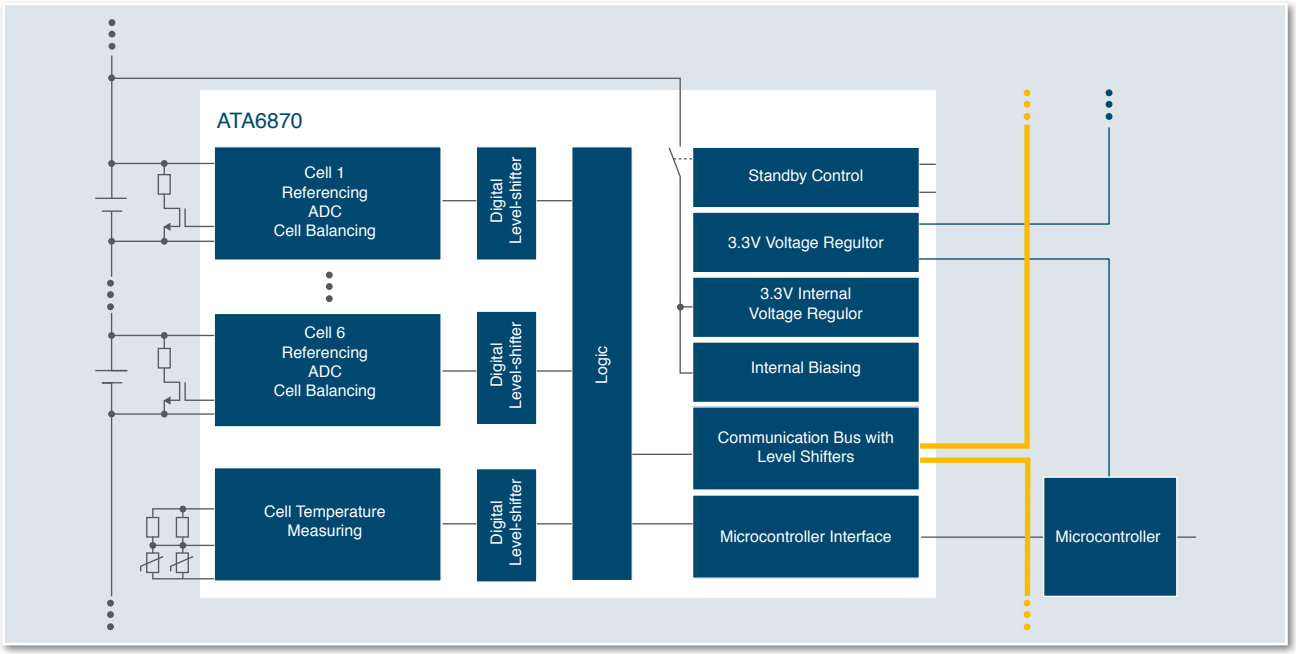

Figure 1. Block Diagram Battery Management Circuit

In order to provide these high voltages, approximately 50-200 cells with a typical cell voltage of approx. 3.6V are connected in series in several strings. Each individual cell is electronically monitored so that functions such as state-of-charge determination, cell balancing, overvoltage/undervoltage monitoring and temperature monitoring can be provided. In order to make this monitoring as simple as possible, Atmel has developed the ATA6870, a measuring, power supply and cell balancing circuit for Li-Ion batteries.

ATA6870, Measuring, Power Supply and Charge Balancing IC

In addition to 6 high-precision AD converters for cell voltage measurement, the ATA6870 also features charge balancing between the individual cells. The capacity of battery cells varies due to the manufacturing process, self-discharging and ageing. Charge balancing is carried out between the individual cells so that the performance of the entire battery is not determined by the weakest cell. This is done by using a bypass switch to make the energy bypass a cell via a resistor and go to the next one. In order to prevent the balancing from taking a long time because of the large number of cells in a modern high-performance battery, the charge balancing can be carried out simultaneously at any number of cells in the ATA6870.

The heart of the ATA6870, however, are the high-precision 12-bit AD converters. Each cell is monitored by its own AD converter. This allows all cells to be measured at the same time, which is important for the state-of-charge detection of a complete battery. Moreover, the cell voltage does not need to be analog-level-shifted to the IC's ground potential, which would decrease the converter accuracy. The ATA6870 shifts the digital result of the ADC without any accuracy losses. This is crucial as the AD converter accuracy is one of the most important features of a Li-Ion battery management IC. However, it is no use having high precision if the DC signal that is being measured is superimposed with noise or spikes, which are unavoidable with the high currents and load changes of a battery. For this reason the ATA6870 has an incremental AD converter. During the sampling time of 8.2 ms, this automatically forms the average of the signal that is present at the input. Noise and voltage spikes are therefore reliably suppressed. This also impressively demonstrates the filtering characteristics of the AD converter (see figure 2), a low pass with an extremely low cut-off frequency of 30 Hz.

However, the biggest impression is made by the "no-drift" reference voltage that is used in the AD converter, which is not influenced at all by temperature (see figure 3). As well as the basic functions of a battery management IC such as

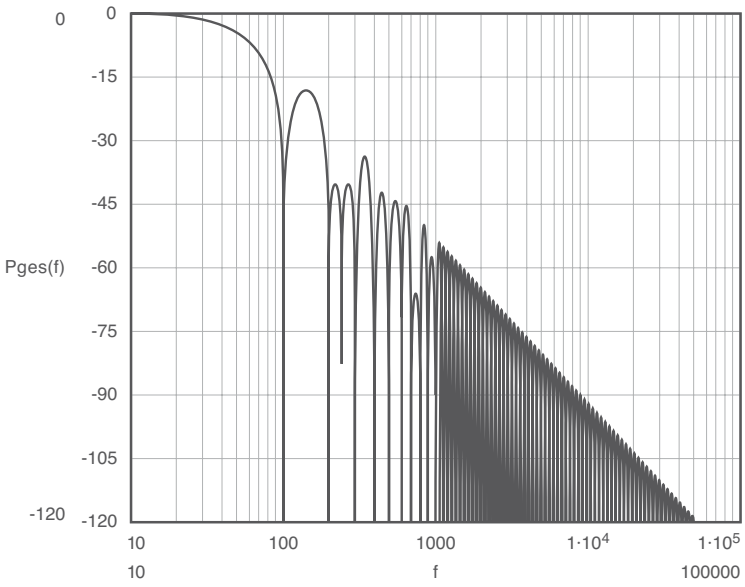

Figure 2. Input Filter for Cell-voltage Measurement

cell voltage measurement, cell temperature measurement and charge balancing, the ATA6870 also has a multitude of other characteristics. One of these is known as “hot plug-in capability”, a feature that is extremely important in the battery manufacturing process. When the modules containing the monitoring electronics are connected to the battery cells during the manufacturing process, they are already at their full voltage. Because of the large number of cells that are connected in series, it is not impossible for individual IC inputs to be subjected to overvoltage for short periods or even have reverse polarity because of timing during assembly or by the contact bouncing that occurs when they are being plugged together. It goes without saying that the battery management IC must not be destroyed in this case. Another reliability feature is the extremely robust data communication between the stacked ICs, which is based on current sources. This data transmission can be made even more reliable if the user activates the checksum feature. This is an 8-bit security code which is generated from the transferred data and then appended to it.

A battery management system also needs a microcontroller, which, in turn, requires a voltage supply. To avoid that the microcontroller’s power consumption causes any cell imbalance, the controller that generates the supply voltage must obtain its power from the highest cell in the string, and lead it back via the lowest cell. This means, of course, that several 100V of voltage will be lost via this controller in extreme cases. The ATA6870 solves this issue by providing the option to stack the integrated power supply for the microcontroller to the IC itself. Thus, the current that is needed to supply the microcontroller can be taken from the top cell, and be fed back into the battery string’s bottom cell. This helps designers to save expensive high-voltage devices.

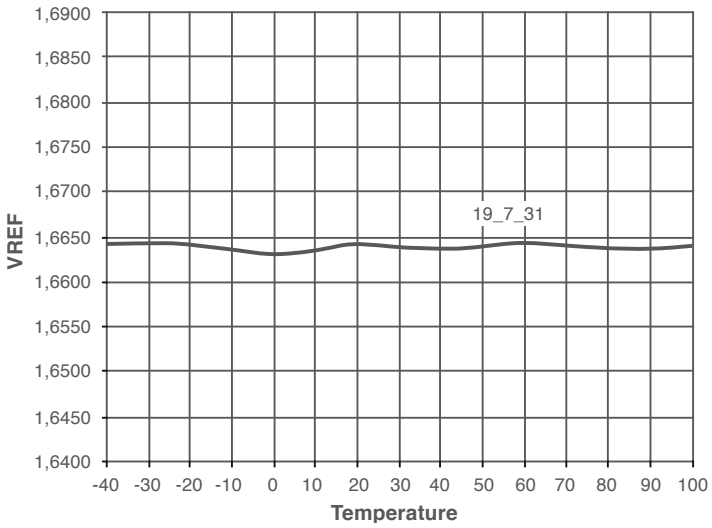

Figure 3. ADC Reference-voltage Temperature Characteristic

ATA6871 Secondary Li-Ion Battery Protection Device

Unfortunately, Li-Ion batteries also feature some undesirable characteristics. In case of overcharging or deep discharging they tend to heat or – in some exceptional cases – to burn. To prevent this, a special safety concept is necessary. Atmel uses a 2-chip strategy that ensures a continuously operating security mechanism, even in the event of device destruction due to, for example, overvoltage.

As previously explained, the ATA6870 operates as a precise cell voltage and overtemperature monitoring circuit. The ATA6871 (which can be stacked the same way as the ATA6870) serves as second-

ary protection device and provides additional security if the ATA6870 fails due to software errors or destruction. The ATA6871 monitors 6 Li-Ion cells via comparators with regard to over- and undervoltage. An additional comparator for temperature monitoring is optionally available. The device incorporates a hardware-implemented self test that checks the circuit's functions: over- and undervoltage, cell temperature, and data communication between the ICs. In addition, the cables to the battery cells are monitored to prevent disconnection or short-circuit. This is done without using a microcontroller, thus avoiding any potential software errors. By doing so, the ATA6871 sets completely new benchmarks for safe Li-Ion battery monitoring.

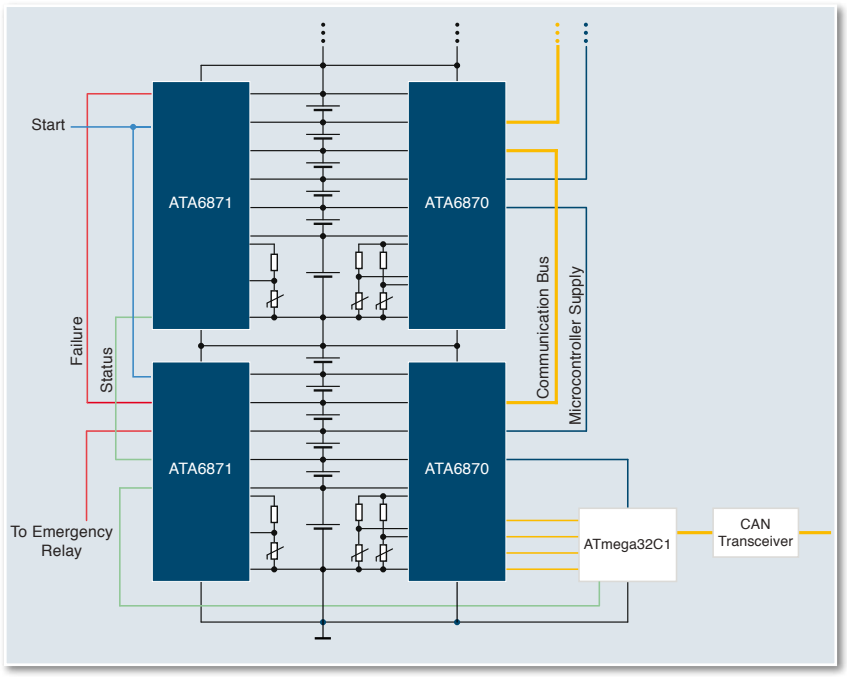

Figure 4. Primary / Secondary Protection System Overview

Evaluation Kit

Atmel supplies evaluation boards for the two ATA6870 and ATA6871 battery monitoring circuits that enable customers to test the components easily and quickly. On each of these boards there are three ATA6870s or ATA6871s in a stack for monitoring the 18 Li-Ion battery cells. Of course, the boards are stackable, meaning that a complete monitoring system for a Li-Ion high-performance battery can be quickly and easily set up in the laboratory and evaluated.

For the ATA6870 Atmel also provides actuation software with a graphical user interface that allows the boards to be easily controlled from a PC or laptop. As well as measuring and providing a graphical display of the cell voltages, this software also makes it possible to easily monitor individual cells for undervoltage and overvoltage and control the cell balancing function. Advanced users also have the option of writing entire program sequences with which they can verify a complete run of the monitoring and control of a Li-Ion battery. These sequences can also be executed in step mode to make simple debugging of such sequences possible.

With circuits such as the ATA6870 and the ATA6871, it will be possible to develop high-performance batteries in future that are cheaper, more efficient and more reliable than is currently possible. This is another step in support of the triumphant success of electrical and hybrid electrical vehicles.