Battery and Energy Management in Cars and Trucks

As a result of ever-increasing customer demands with regard to comfort and safety in the car and the pressure of competition among car manufacturers, the number of electrical components and systems in vehicles continues to increase. The continuous electrical power requirement of a mid-size vehicle these days is approximately 1 kW and, according to forecasts, is likely to reach 2 to 3 kW or more within the next 10 years. The situation becomes far more complex when the highly dynamic developments in hybrid vehicles are taken into account. In addition to all these innovations, the vehicle of the future is also supposed to become better, safer, more comfortable and, with even better performance, use less energy at the same time. This report is by Isabellenhütte Heusler GmbH & Co. KG.

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1 Introduction

In view of these developments, there is a need for an electrical powertrain that provides the electrical energy required for each of the components and systems without failure whenever it is needed. This in turn is only possible with a vehicle-wide energy management system in which all energy sources (battery, generator, engine, supercaps, etc.) and components (lighting, steering, infotainment system, electrical heating system, etc.) are monitored, controlled and used most efficiently. Therefore, this calls for a hierarchical sub-division of the components with a time-dependent or situation-dependent deactivation of each component by the electronics.

2 Battery Management

Although the battery has been treated and used as little more than a passive energy storage mechanism in the vehicle for almost 100 years, the need for battery management – which has already been a standard feature in laptops and cameras for years – has become increasingly apparent as the number of battery-related breakdowns on the road has surged over the past 10 years.

Calculating battery data such as the state of charge (SOC) and state of health (SOH) requires that the current, voltage and temperature of the battery be measured to a relatively high level of accuracy. The first attempts to measure battery current with magnetic sensors ultimately failed due to the extreme requirements involved. Not only must the sensor be capable of measuring the starter current of 1000 A or more in a highly dynamic manner, it also has to reliably measure the idling current of the vehicle with a resolution of just a few mA at the same time. The first technical solution came with the physically optimised, extremely low-resistance Manganin® resistors developed by Isabellenhütte, which are used in combination with ultra-precise evaluation electronics.

Today, shunts with values of between 50 and 200 μΩ are used. Despite the high requirements, they can be manufactured at a relatively low cost by punching an electron beam welded composite material (copper/Manganin®/copper). The Manganin® precision-resistance alloy provides the required low temperature coefficient, good long-term stability and a low thermal emf against copper. The latter is an absolute precondition for the required resolution for measuring currents of only a few mA in the idle (quiescent) state of the vehicle .

The ASIC that has also been developed by Isabellenhütte in conjunction with a well-known semiconductor manufacturer provides a highly accurate, offset-free four-channel data acquisition system for measuring ultra-low voltages down to the μV range. With this combination, it was possible to bridge the two extremes in terms of technical requirements on the one hand and the high requirements of the automotive industry on the other, concerning size, reliability and costs. As a result, this technology is now widely accepted throughout the world.

ments in terms of direct switching or relay outputs, mean that the system is not directly transferable. Special versions with a resistance of 30 to 50 μOhm and the possibility of measuring both battery voltages are currently being developed.

Nevertheless, future versions of the battery sensor will benefit from the further integration of data acquisition, μC and bus drivers into a single package, thus further reducing the inhibition threshold for other vehicle manufacturers in applying them in series production.

3 Energy Management in the Vehicle

However, for complete and correct energy management – which is certainly a medium-term requirement – the measurement of the battery current alone is not sufficient, because it does not provide information about the current used in the vehicle or generated by the alternator. One solution here could be to measure the battery and vehicle current simultaneously at a suitable central connection on the high side at which all current flows come together, **Figure 3**. In this solution, the starter current would, as before, be measured as a battery current, and the alternator current would be calculated as the sum of the vehicle current and the battery current, **Figure 4**.

The hardware shown in **Figure 5** for such a double sensor would only be slightly more complex and hardly more expensive than today's solution. It comprises a double resistor (e.g. 100 μOhm plus 200 μOhm) with practically the same evaluation electronics as for the ground-based battery sensor. The idle current flows through both resistors and can therefore be determined much more accurately in the total circuit. Although operation on the high side requires a separate power supply for the ASIC and a level converter for the digital communication with the microcontroller, the advantages in terms of safety, reliability, functionality and integration possibilities for other functions required (such as safety shutdown of the battery connection, electronic fuses, shutting down and monitoring of individual main circuits and further diagnosis requirements) will be of greater importance.

The complete unit can be installed compactly and at low cost in a hybrid power package with bus bar terminals. A high-performance μC provides the data measurement and evaluation functions as well as the switching functions. Communication with the on-board electronics is via CAN or FlexRay, which means that it is fast enough for a complete diagnosis of all components

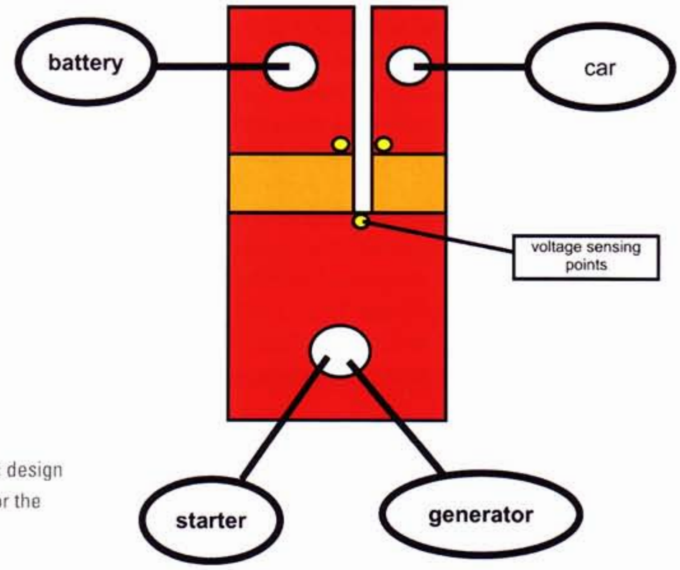

Figure 4: Schematic design and sense points for the double resistor

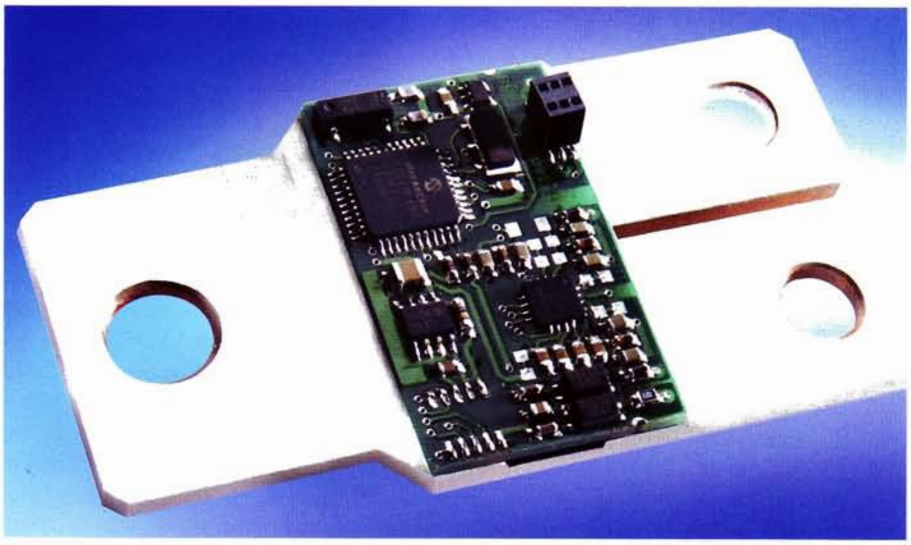

Figure 5: Example of the design of a high-side double resistor for measuring battery/vehicle current, on-board network voltage and battery temperature

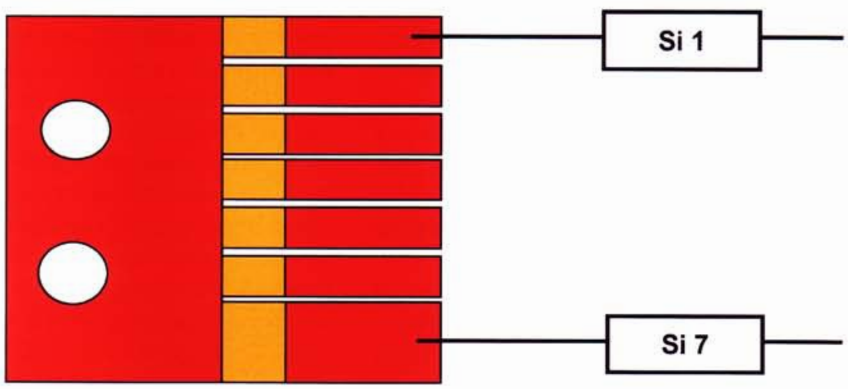

Figure 6: Multiple resistor with common high-side terminal for measuring the main circuits in the vehicle

using a PC in automotive workshops without the need for major investment in expensive and complex measuring systems.

For the diagnosis of individual main circuits, it may be possible to use a multiple resistor positioned upstream of the fuses, with a common high-side connection, **Figure 6**. In the event of a failure, the measuring terminals can be connected to the evaluation electronics on a multiplexed basis. This would enable faults to be found very quickly and even permit the realization of emergency running properties and self-setting electronic fuses.

4 Summary

Thanks to the availability of high-quality shunts and evaluation circuits, shunt-based current measurement in intelligent battery sensors has become well established and will therefore have increased applications in the cars of the future, while also contributing to further cost reductions. However, for a complete energy management system that will meet all future requirements in terms of safety and reliability, the vehicle current must also be measured. A low-cost and space-saving solution could be achieved by using a double resistor in an energy distribution box on the high side to measure the battery and vehicle current. This could also contain functions such as safety shutdown devices and electronic fuses as well as other measurement functions for individual main circuits. ■

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