Battery management systems and the role of the sensor in EV driving range and safety

The latest sensors used in electric vehicles (EVs) not only help to prevent on-board fires but also contribute to tackling the driving range challenges, says **Jérémie Piro, Global Product Manager BMS at LEM**

Whenever EVs are discussed, the number one topic raised is range - the distance that they are capable of travelling on a single charge. Even though distance travelled on a full tank is usually a long way down the list of criteria for most people buying a petrol or diesel vehicle, for EVs it is at the very top.

Despite the average car journey being around 10 miles, drivers insisted in a recent survey that what they expected from an EV was the ability to drive around 375 miles on a single charge. Of course, the reality (at the time of writing) is that most drivers will not be able to travel anywhere near that distance on a fully charged EV lithium-ion (Li-Ion) battery.

This highlights a clear dilemma for the automotive sector. The technology used in EVs is completely different to what customers are familiar with and comparisons with the internal combustion engine (ICE) are erroneous.

There is another criterion that is increasingly governing people's choice of electric vehicles – safety, in particular from the risk of fire. This topic is expected to take on even greater importance in the coming years.

Why has safety become such a major issue? Simply because as modern EVs need to be designed to charge faster in order to satisfy the demands described earlier, on-board systems are going to have to deal with higher current and higher voltage and this will require greater isolation. There is a genuine concern in the automotive sector – whether among OEMs, manufacturers of EV chargers or charge point operators – that while it is vital to deliver all the benefits drivers are looking for, there has to be an absolute priority given to avoiding any possibility of leakage or fire within vehicles.

State of charge, state of health

The battery management system (BMS) installed in every EV is the main component of a vehicle's battery pack. It fulfils two essential requirements for the driver. Firstly, it evaluates the state of charge (SoC), which is the level of charge of an EV battery relative to its capacity. This dictates the driving range that the vehicle can achieve. Secondly, the BMS manages the battery pack's state of health (SoH) with an on-board safety function designed to prevent leakage or fire. The more accurate these evaluations are, the happier motorists will be in terms of addressing driving range anxiety as well as concerns over safety.

For a BMS to deliver these vital functions, it has to incorporate reliable sensing elements. Not surprisingly current sensors are key components of any BMS and these devices have gone through significant changes as demands increase from the EV sector.

LEM has recently developed the third generation CAB series of transducers for delivering SoC figures with optimum accuracy. The premium CAB range was first developed for battery management systems 12 years ago and has evolved as customer requirements have altered. The first model represented a breakthrough technology that made it possible to achieve more accurate current measurements by eliminating magnetic offset and delivered contactless current

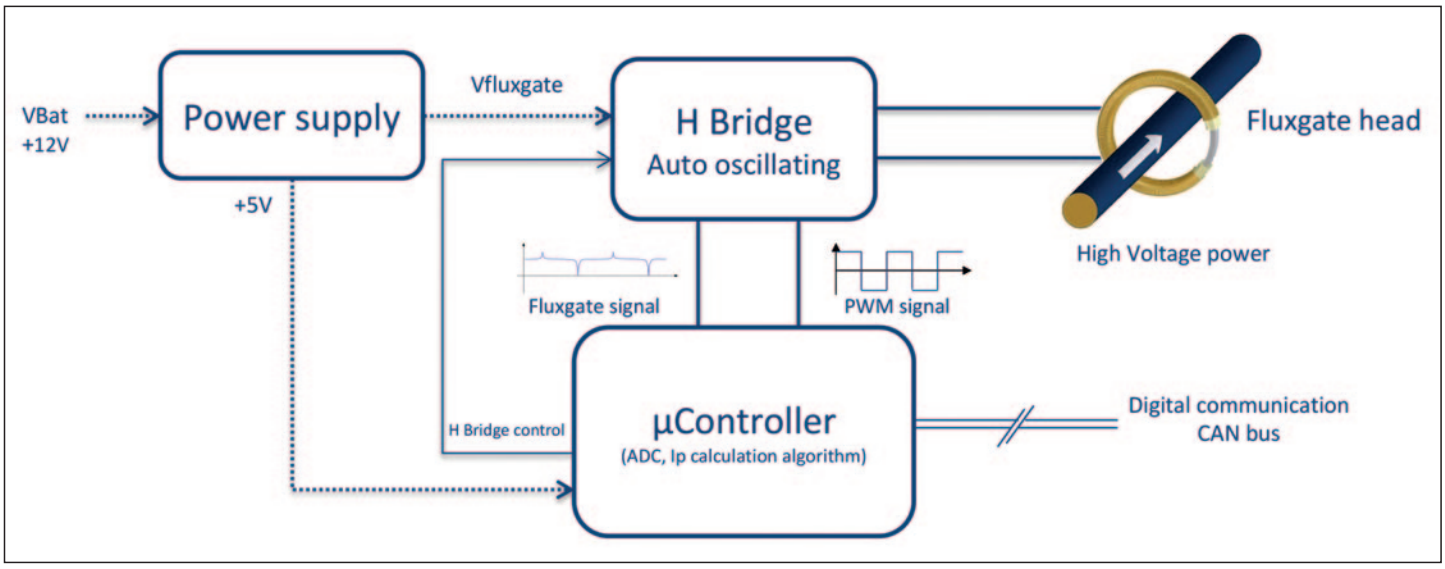

Figure 1: In the CAB 1500, the fluxgate sensing head's induction coil ensures rapid transition between linear and saturated state.

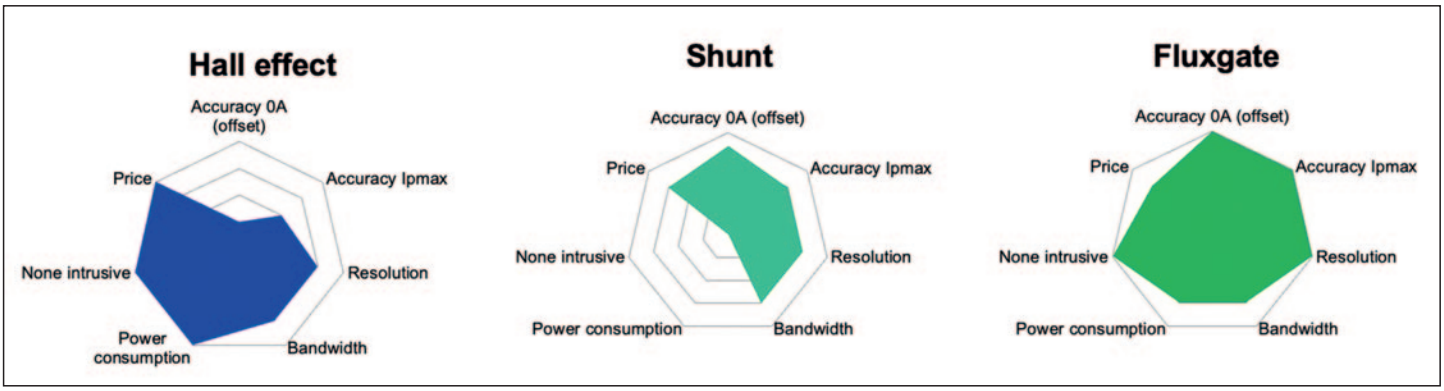

Figure 2: Fluxgate technology offers resolution up to 0.1%, Ip max accuracy and offset, non-intrusive measurement and isolation up to 2.5kV combined with lower power consumption than shunt technology.

measurement. The next model had a higher current range (from 300A to 500A) and improved safety levels.

The latest iteration of the transducer is the CAB 1500 with an extended current range of up to ±1500A. In terms of functional safety, this ASIL (automotive safety integrity level) C device complies with ISO26262. Additionally, it makes redundant current measurement possible using just a single current sensor in the BMS instead of a pair, due to two internal independent channels. Integral electrical features for safety management include over-current detection, with an internal error flag set to one when current is above 1600A, a safety goal violation flag set to one (depending on plausibility check results between the analogue and digital channels), a sequence counter and a CRC (cyclic redundancy check) for end-to-end communication protection.

The CAB 1500 has the ability to treble the current range within the same footprint as earlier models. It is also claimed to deliver best-in-class accuracy of 0.5% over a temperature range of −40°C to +85°C. As well as its extremely low offset, which enables accurate coulomb counting for SoC estimations, the sensor uses the non-intrusive measuring principle while offering full galvanic isolation and compatibility with 800V applications.

Other key features include the option to be busbar or panel mounted and a unipolar +12V battery power supply. The fluxgate sensing head is made of an induction coil which combines very high permeability with low remanence (Hc), ensuring rapid transition between linear and saturated state. Fluxgate technology is particularly suitable for battery management systems because it offers resolution up to 0.1%, best in class accuracy Ip max and offset, non-intrusive measurement and isolation up to 2.5kV, and low power consumption when compared to shunt technology.

Sensors take to the road

Incorporating the most advanced current sensors into new battery management system designs, engineers can differentiate products in a competitive market. With sensors becoming smarter, developers are able to incorporate more advanced software which makes it easier to collect and process greater amounts of data in a single device. At the same time, designers will be enabling automotive manufacturer customers to put the EVs they offer at the forefront of the marketplace in terms of performance, cost and safety.

Anticipating the need for higher safety levels, LEM is working actively on two new concepts. The first is to increase features as the sensor become multi-functional and take on the role of sensing a wider range of different factors within the battery disconnect unit. For instance, while a current sensor would traditionally sense the battery pack current only, it is now also expected to monitor the pack voltage at different locations as well as detect any hot spots. Additional features such as triggering the pyrofuse in case of any over-current or monitoring the high voltage pack insulation to ensure there is true isolation between the battery pack and the mass of the car's chassis is also becoming popular. These reflect a trend to turn the current sensor into a sensing hub to service the BMS.

The second concept is based on two different technologies to sense the current. Putting 'shunt + Hall' in a single package may not be revolutionary but it represents a very competitive solution. The company claims that by combining its 50 years' of sensing experience based on the open loop technology with a new ASIC, makes it possible to reach very high accuracy levels for the redundant path. This concept can be used as a standalone module or in addition to a multi-point sensing module and offers an optimised and robust sensing head which is easily compatible with the highest rank of safety level, ASIL D.

Mapping the route ahead

In summary, demands within the automotive sector are pushing the technological advances required to satisfy them. It may be sobering news for those 'playing catch up' that the demands are only going to get stronger and more challenging. The only way to 'get ahead of the game' is to embrace the kind of technology that will enable them to achieve a quantum leap in the market. At the very core of these advances in the EV sector will be current sensors operating as part of sophisticated BMS that will take EVs to new levels for range and safety.

Looking to the future, the current sensor is set to become a crucial part of the intelligence of a BMS where data will need to be transferred to the BMS simultaneously. Cost and mechanical integration will also be key factors as the market moves forward, because the BMS and battery pack will have to become smaller and lighter.

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