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Shunt advantages and challenges for EV current measurement

Sponsored by: Isabellenhütte

In the last decade, electric vehicles (EVs) have grown from something of a novelty into a technology that could realistically supplant internal combustion-powered automobiles as the world's primary transportation method. Proper energy management is paramount to an EV's operation, facilitated by efficient and precise current measurement from the battery during operation, and to the battery during charging.

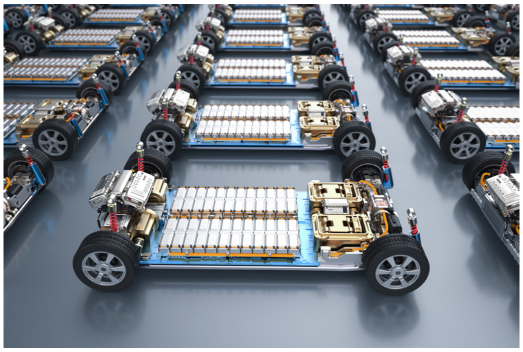

Figure 1. Having the resources to solve the most demanding EV current sensing challenges is how sustainable alternatives will continue to become the norm. Source: AdobeStock/phonlamaiphoto

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The use of current shunts — which are installed at the pack side of the battery and measure using a simple implementation of Ohm's Law — is a robust way to take measurements in the rigorous automotive environment. Since voltage across a resistor in a circuit equals current times resistance (V = IR), current therefore equals voltage divided by resistance (I = V/R). If the voltage drop is measured across a known resistor in series, current flowing across it can easily be inferred using this equation as V/R. This principle is well-established, having been known and used since at least the early 19th century, and it is both reliable and cost-effective. However, producing ultra-precise measurements in modern EVs and other electrically powered devices presents several challenges.

The challenge of precision shunt measurement

Any resistance across a busbar creates inefficiency due to heat losses. Therefore, especially in high-current applications like EVs, the R value in a shunt must be kept to a minimum. Busbar shunts from Isabellenhütte can be spec'd to a resistance of hundreds, or even tens of µOhms — tens of millionths of an ohm. For example, Isabellenhütte's BAN shunt, appropriate for monitoring very high currents, has a resistance of just 25 µOhm. In this case, a current of 1,000 amps would produce a voltage drop of .025 V (1,000 A x .000025 Ohm), minimizing current loss due to resistance heating.

The tradeoff to using minimal R values, which produce a low voltage drop across the shunt, is that the resulting current measurement resolution and precision are correspondingly small. More resistance means greater measurement precision and more heat, while lower resistance means less measurement precision and less heat. There will therefore always be a compromise between maximum resolution and minimum power loss in shunt-based current measurement.

Other effects, such as induced voltage, voltage drop across the leads and thermoelectric voltage must be minimized and accounted for, and shunt resistor/conductor materials must be well understood and stable across the expected temperature range. Since the designed voltage drops are kept as low as possible, precise knowledge of these factors is essential to get the most out of voltage readings, which are amplified and processed for measurement use.

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Improved voltage shunt knowledge, improved EV performance

Shunt resistance varies depending on the current temperature, and this property can also change over time due to microstructural effects caused by long-term heating. Even if each shunt is made within a specification, variations between individual devices will make readings slightly different. These differences must be accounted for in the end product — the EV — making overall specs and performance lower than they otherwise could be.

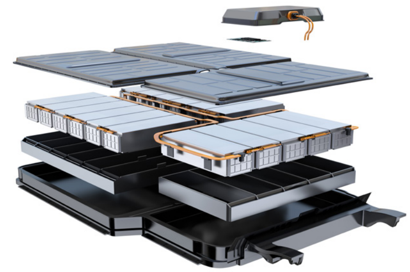

Figure 2. Detailed view of an EV's battery pack. Source: Adobe Stock/chesky

To enable good measurement properties, voltage shunts are typically individually tested to determine their resistance values at a set temperature. Since busbar shunt resistance is temperature-dependent, a temperature coefficient (TCR) is also needed for a full picture of its properties. Typical manufacturers measure this coefficient based on batches of shunts. Isabellenhütte, however, measures a TCR for each individual shunt — which can be marked on the device as a data matrix code (DMC). This allows for ultra-precise voltage and current measurement across temperature ranges. Additionally, Isabellenhütte shunts are engineered for long-term stability, meaning that busbar material properties changes are minimal over their lifetime.

Analog voltage shunt options for high-volume production

With voltage shunt properties precisely known, input processing must also be considered. Isabellenhütte offers a range of shunt products to meet customer needs. For low and medium volumes, a digital measurement solution may be appropriate, with processing and electronics built into the shunt assembly itself. These devices process inputs and send out digital signals —typically in CAN format — for use in automobile ECUs. This saves upfront engineering costs, but also incurs a higher price per unit, especially considering that an EV's ECU may already be capable of interpreting analog voltage signals.

The other alternative is to use an analog voltage shunt, which sends unprocessed analog voltage signals directly to an automobile's ECU for processing. This type of shunt is available from Isabellenhütte in a variety of sizes and configurations, and can include connection ports to facilitate assembly. Here, off-the-shelf parts are only a starting point, as the majority of analog shunts sold by Isabellenhütte are customized to meet user needs.

Since each individual analog shunt is less expensive than its digital counterpart, engineering costs can be amortized across each automobile produced. This makes analog shunts especially attractive for high-volume production. Based on individual customer input, Isabellenhütte can provide guidance as to what class of shunt, as well as the individual standard or customized solution that will work best for a given project.

Isabellenhütte capabilities ensure measurement excellence

Isabellenhütte consists of three divisions: Precision Alloys, Precision and Power Resistors, and Precision Measurement. The Precision Measurement division is ultimately responsible for the current sensing shunts outlined here, which require precision power resistors, made out of precision alloys. These three critical areas of expertise are integrated under one umbrella in the Isabellenhütte family, making them uniquely qualified to produce extreme precision busbar shunt solutions with minimal ohmic losses.

Isabellenhütte, founded before 1482, has a 500-plus year history. Today they employ over 1,100 people, with worldwide distribution, giving them the resources to solve the most demanding EV current sensing challenges. Isabellenhütte can provide all levels of busbar shunt integration, from bare analog sensors, to complete integrated current and voltage sensing with insulation monitoring. Get in touch at isabellenhuetteusa.com to learn how they can help facilitate excellence in EV current measurement.

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ABOUT ISABELLENHÜTTE

Isabellenhütte USA is headquartered in Swansea MA, and has developed an industry-wide reputation for providing high quality products and unparalleled customer support. We are known world-wide in industries ranging from aerospace and medical to energy and automotive. 500 years ago, a simple copper smelter perfected techniques to serve a royal customer base. Today, Isabellenhütte is one of the world's leading manufacturers of precision measurement systems, resistance and thermo alloys as well as high power resistors.