Bringing the Cool to EV Charging

Steve Drumm, Strategic Marketing Manager – Solutions in Energy, OMRON Electronic Components Europe B.V., explains how consumer, commercial and industrial AC EV chargers can get cooler, smaller, and longer lasting.

EV-Charger Design Challenges

The ongoing shift toward electrification holds the promise of cleaner and more energy-efficient living. On the other hand, end-user expectations continue to drive demand for more compact equipment that fits neatly and stylishly into lives and living spaces while also delivering higher performance. These demands for smaller, slimmer, and faster apply to everything, from accessories and small appliances to power adapters and chargers including electric vehicle service equipment (EVSE).

High-power EVSE wallboxes are an increasingly common sight in today's homes and businesses. These support Mode 3 charging, which stipulates built-in control and protection functions for safety, and can charge an EV at up to 22kW from a three-phase AC supply. By providing convenient access to safe and secure charging, ideal for use overnight or during the working day, these wallboxes can certainly help dispel the speed of charge and range anxiety often cited as the main reasons for motorists' reluctance to adopt EVs as daily transport.

On the other hand, size and aesthetics are highly important and become a key differentiator between manufacturers. However, cramming the circuitry into the smallest and thinnest possible enclosure brings thermal management challenges that must be addressed to ensure the long-term

reliability of the EVSE as well as user safety.

Wallboxes like these could be in continuous use or may be connected to several vehicles in rapid succession, especially when installed in a workplace scenario, giving little or no opportunity to cool down between charges. In direct sunlight, the internal temperature can easily reach 70-80˚C, and cycle through 50-60˚C variances within the space of a couple of hours.

While units equipped with temperature sensors can throttle the charging current in overtemperature conditions, which is good for safety, this means slower charging rates and less convenience for the end user. On a particularly hot day, or if a fault is causing the wallbox to overheat, the charger may not be able to function at all. Addressing these thermal challenges can enhance reliability, safety, and the user experience.

Self-Heating Effects

Within the wallbox circuitry, resistive components, power transistors, inductors, transformer windings, cables, and connectors exhibit self-heating due to power dissipation that increases with the square of the current flowing (I2R).

A surprising amount of I2R-related heat in the wallbox is associated with the contact resistance of the main switching device, which is usually an electromagnetic relay or contactor. Unlike power transistors, which can be connected in parallel to distribute load current, paralleling electromagnetic switches is impractical. As the full load current must pass through the relay, the contact resistance when closed has a considerable heating effect. Even a one milliohm increase in the relay contact resistance can equate to as much as *18˚C in increased load terminal temperature rise.

Excessive heat dissipation within the enclosure is undesirable, of course, and also mitigates against achieving slimmer and more compact wallbox designs. For a given heat load, a small-sized enclosure has less surface area from which to dissipate heat and so will experience a higher temperature rise. In addition, packing components more tightly in the

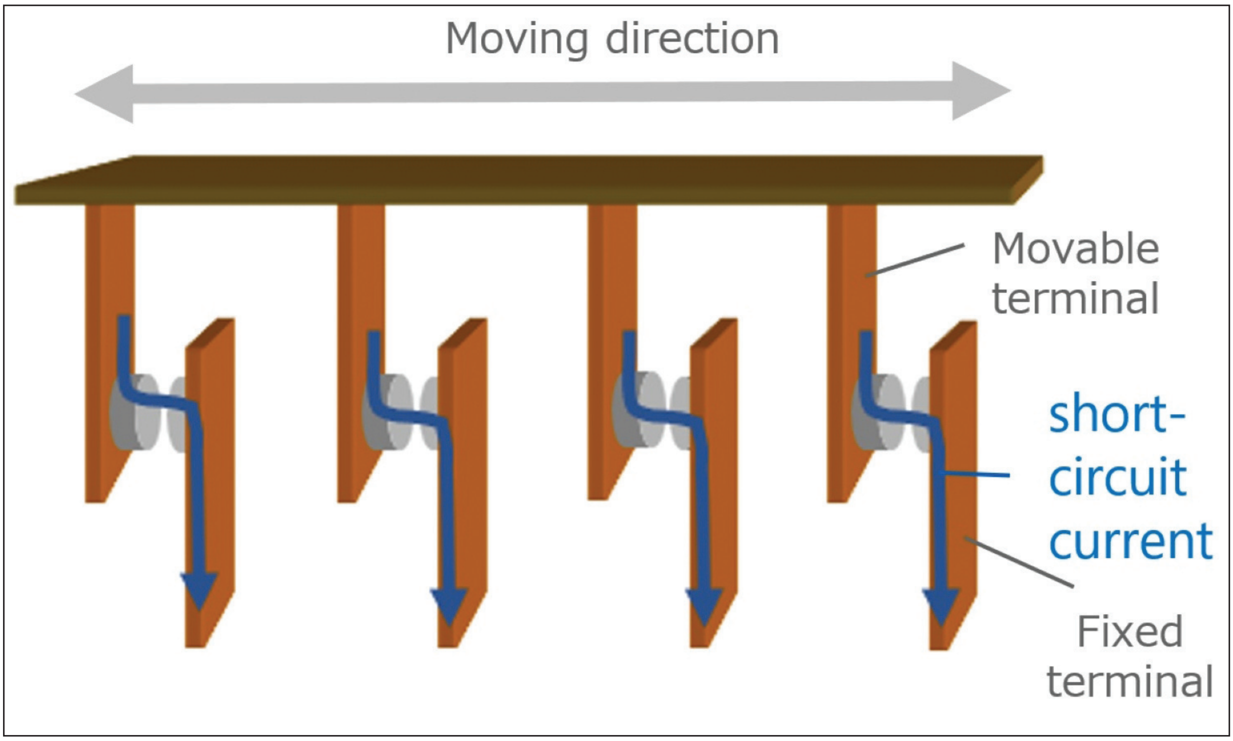

Fig 1_Image of mechanically coupled 4-pole structure.jpg

compact space can restrict airflow and lead to localised hotspots. Extra thermal management, possibly including heatsinks, increased ventilation, or active cooling such as a fan, may be required. However, this will increase the wallbox cost and complexity. Moreover, a fan can be noisy and compromises the overall reliability.

Relay Evolution

Lowering the heat load resulting from the electrical components, including the relay contacts, can break this impasse and allow designers more freedom to reduce the wallbox dimensions. Advancements from the cutting edge of relay design now enable compact new relays in PCB-mount form factors that combine high current capability with low contact resistance, resulting in lower dissipation and reduced temperature rise.

Historically, PCB relays have been best suited to applications up to about 25 A. For higher currents, designers have tended to specify contactors, which are typically off-board, DIN rail-mount components fitted with screw terminals. The latest PCB relays introduce new features to handle current significantly above 25 A and can replace traditional contactors in equipment such as high-power industrial systems and utility-grade power conditioners.

Among new high-power relays emerging as a result of this trend, the Omron G9KC series has a guaranteed initial contact resistance of less than 6 milliohms - roughly half that of any equivalent solution on the market - and contains features optimised for AC wallbox applications. As well as improving charging efficiency and performance, the ultra-low resistance at full load (32A per live phase) significantly reduces hotspots caused by flowing current and reduces the likelihood of current throttling. The reliability and longevity of the relays themselves, as well as surrounding components are also improved. Crucially, the relay retains a low contact resistance throughout its lifetime. This is particularly important given that wallboxes are typically expected to remain in service for several years or more.

At the heart of the G9KC is a purpose developed mechanically coupled double-break contact design providing class leading endurance due to its enhanced contact card (cradle) structure that significantly improves energy efficiency while reducing heat dissipation. As a result, with good overall charger design, operating temperatures in a typical 22 kW 32 A wallbox can be reduced by as much as 10°C. This not only facilitates faster, more efficient charging, but also unlocks new possibilities for wallbox designers to develop more compact and robust designs.

With a 4mm main contact gap and 10 kA short circuit capability, tested according to IEC62955 (TUV approved), the G9KC exceeds the requirements of the upcoming Electric vehicle conductive charging system Standard IEC 61851 ED4. Moreover, with its compact 4-pole structure, the G9KC can replace larger multi-pole contactors or up to four individual single-pole relays. This useful combination widens the scope of applications to include Behind the Meter (BTM), inside EV Charger and In Front of Meter (FTM).

Conclusion

While Mode-3 chargers offer convenience and safety to address EV range anxiety, charging infrastructure must continue improving to accommodate the rapidly growing EV market. Using more thermally efficient components could let designers add more functionality, such as extra sensors to monitor charging speeds, while further new developments could include wireless charging.

On the other hand, thermal management will continue to be one of the most critical design challenges governing wallbox size, shape, efficiency, reliability, and safety. The latest developments in relay technology contribute towards enabling new designs to be unobtrusive and easily installed, as well as ensuring more efficient charging.

**Reference Thermal Simulation conditions: 32A carry current on three load terminals. T.Amb.85?. PCB evaluation board (2 layers of 10 mm wide, 0.3 mm depth copper foils)*

For more information on the G9KC, please visit:
https://components.omron.com/eu-en/products/relays/G9KC
http://components.omron.com/eu-en
https://www.linkedin.com/company/omron-electronic-components-europe-b-v-/