Sensata Technologies

HOW ADVANCED ELECTRICAL PROTECTION ENABLES DC FAST CHARGING

WHITE PAPER

EV charging systems are rapidly maturing, leveraging DC fast charging with the latest in electrical protection solutions.

Now that the latest Electric Vehicles (EVs) are exhibiting operational ranges that are more acceptable to the general public, the attention has shifted to battery charging times. These EVs are using the latest in wide-bandgap semiconductor solutions and power topologies, with system voltages often well over several hundred volts. EV charging systems are migrating rapidly in the direction of DC-based 50kW to 350kW or even up to Megawatt charging power solutions, which can reduce charging times to under a half-hour.

The need to address the EV-using public's charging-time desires must also be balanced with the need to maintain safety, performance, and reliability. The significant increase in power, voltage, and current levels being used in the latest EVs and their charging systems present new design challenges. When it comes to DC fast charging, the challenges related to higher voltages and power levels present some electrical protection issues.

In addition to industry issues like compliance with fast charging standards, challenges for charging infrastructure include addressing thermal efficiency and heat management as well as protecting electrical systems from faults. Companies like Sensata Technologies are focusing on electrical protection for DC fast charging systems as many high-power chargers are migrating to power levels of 1,000V and 350kW or higher to shorten the charging time.

This puts a great deal of pressure on the electrical protection components of the charging system, as the higher voltage levels and currents force the components in the system, such as contactors and fuses, to keep up. One of the most obvious concerns in a high-voltage power circuit of any kind is that attempting to open a circuit under higher DC voltages often forms a self-sustaining arc that is difficult to extinguish. In such situations, contactors and fuses need to employ techniques to increase the separation distance to quickly quench any arcs.

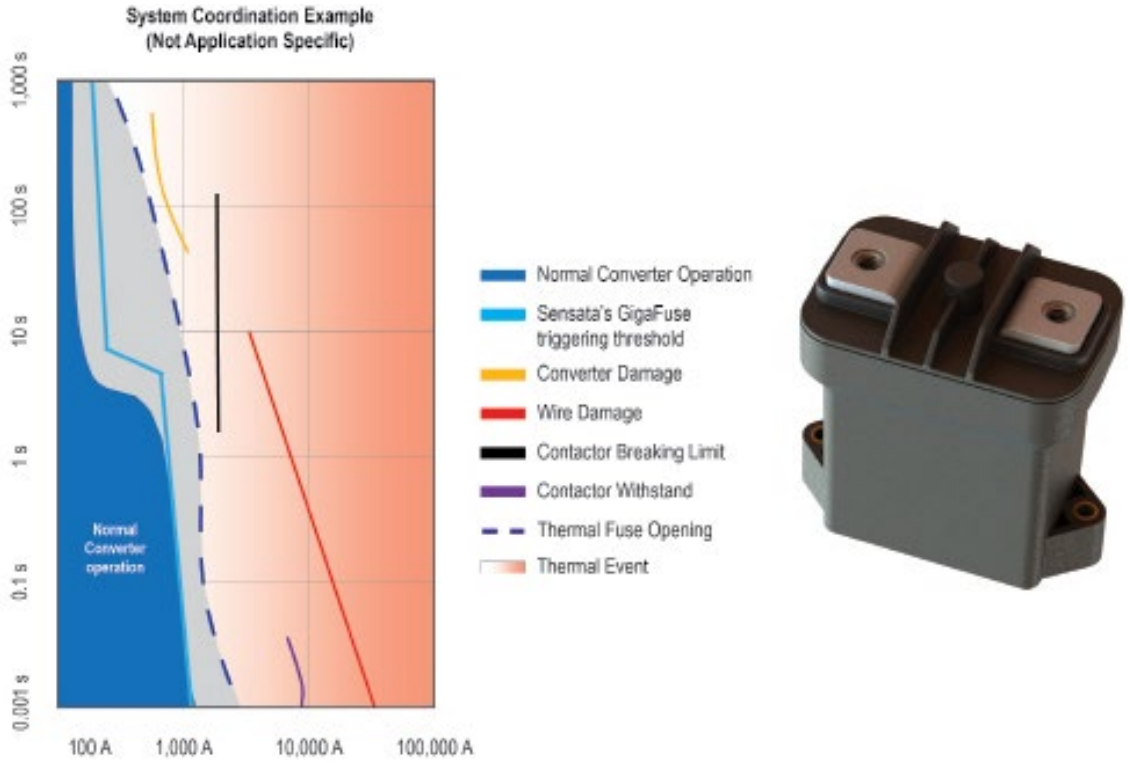
An uninterrupted arc can cause a contactor or fuse to undergo extremely rapid catastrophic thermal failure, creating a fire hazard and potential explosion risk. Another potential failure state can occur when the contactor and fuse are not paired appropriately during the overcurrent condition. This is where the contactor begins to break a circuit and starts to dissipate some of the overcurrent within itself, preventing that current from being used to properly break the fuse connection. Again, the potential impact could be a catastrophic failure of the system. A solution such as Sensata's fast disconnect, where the contactor and fuse are paired to work together, helps prevent such risks.

ADDRESSING HIGHER VOLTAGES IN DC FAST CHARGING APPLICATIONS

Using higher voltage and current levels in a power system can reduce charging times, but it also increases the safety risks as well as other system design challenges. High-voltage contactors used to provide safe circuit continuity during normal operations need to be deployed in tandem with fuses to protect the system in the face of a threatening short-circuit event. Conventional DC thermal fuse technology addresses short-circuit situations by using a melted connection to break the circuit. The challenge with DC thermal fuses is that in overcurrent situations the current may not be high enough to melt the link, creating a dangerous delay in the protection response.

Such an overcurrent situation where there is insufficient energy to break the thermal fuse creates a dangerous gray zone where current levels may overwhelm the contactor's ability to interrupt the load but never reach the thermal point for the thermal fuse to trigger. The risk of a time delay before a thermal fuse can be disconnected while exceeding the breaking capability of a contactor is eliminated with solutions like Sensata's GigaFuse, which helps bridge the gap between the upper limit of the safe operating current range for contactors in normal operation and the current at which the fuse trips, providing both overcurrent and short-circuit protection.

Figure 1



Solutions like Sensata's GigaFuse help bridge the circuit protection gap between contactors and fuses, providing a fast and precise circuit protection solution for advanced power systems during short circuit and overcurrent situations.

Contactors and fuses are mission-critical components for DC fast charging systems. Contactors provide safe circuit continuity during normal charging, while fuses protect the charging system during hazardous short-circuit and overcurrent conditions. It is critical to have contactors and fuses that can work in tandem to ensure seamless protection for the chargers during normal operating and overcurrent conditions.

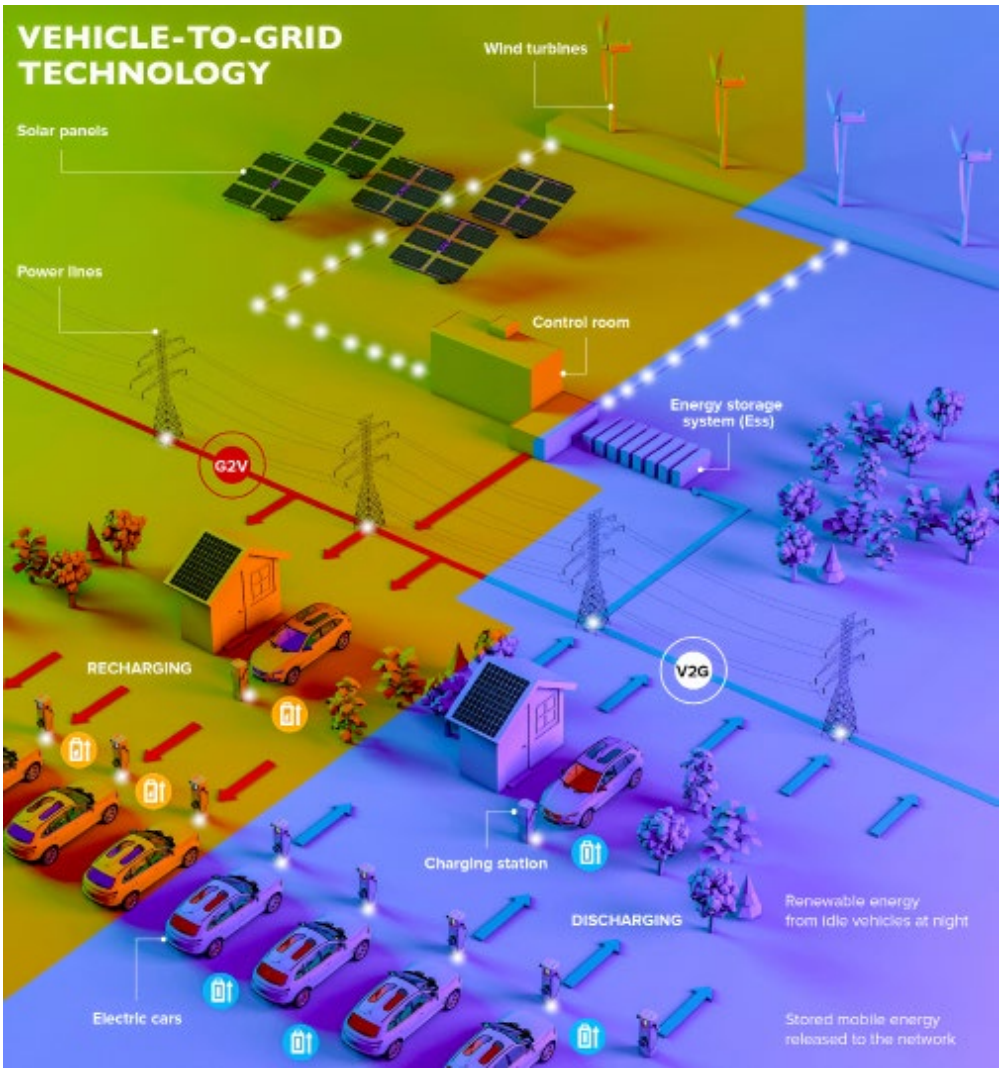
NEXT GENERATION CONTACTORS AND FUSES

The higher voltage and power charging levels in charging systems mean that contactors also need to have a higher breaking capability and is leading to an increased demand for contactors rated up to 1500V and 1000A. Another demand for required functionality is for contactor bi-directionality, which enables EV battery charging from the grid and/or a V2G (vehicle-to-grid) system, allowing for the utilization of grid intelligence in an energy exchange market.

Dynamic power allocation is another technology approach that can tailor the charging process to the actual demand, by combining or sharing power from multiple charging ports. The bidirectional functionality of contactors enables chargers to allocate the power dynamically by allowing the current flow either forward or backward.

Sensata Technologies' robust contactor solutions are hermetically sealed and filled with gas, providing the necessary capacity to switch in a relatively small size compared to open-air contactors. Sensata's high voltage electromechanical fuse, the GigaFuse, is designed for high power applications like DC charging and includes both passive and passive/active combinations.

Figure 2



An emerging requirement for contactor functionality is bi-directionality, which enables EV battery charging from the grid and/or a V2G (vehicle-to-grid) system, allowing for the utilization of grid intelligence in an energy exchange market.

To address drivers' concerns, the industry is moving towards more efficient EVs that have longer ranges and charge in less time. The latest high power charging solutions can address these battery-charging demands, but only if the circuits involved operate at their highest potential. This is where advanced electrical protection solutions can not only improve safety and reliability, but also performance and functionality. Using the latest solutions, like Sensata's GigaFuse, can increase system efficiency, eliminate thermal aging, and provide design flexibility in charging systems, especially those operating at high power levels.