EV/Alt. Power Thermal Management Systems: Control and Communication Considerations

Author: Benjamin Trainum

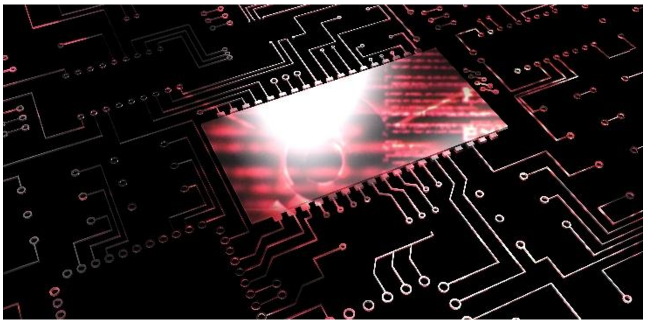
With continued electrification of on- and off- highway vehicles—including hybrids, battery electrics, and fuel cells—the capabilities of thermal management solutions for said vehicles must advance; compared to diesel engines, batteries are sensitive to temperature variations, with nominal operating ranges often between 15 °C and 30 °C. This range is low enough that passive cooling with liquid-to-air heat exchangers does not work in many cases. Thus, AKG offers EV Battery Thermal Management Systems (BTMS), which utilize a refrigeration loop to achieve sub-ambient cooling and provide precise, adaptive, and efficient thermal management for large battery packs in heavy duty applications.

Compared to a thermostat and radiator fans, maintaining strict temperature control over a wide range of ambient conditions and load levels with an active cooling BTMS requires consideration in many more areas including: communication & compatibility with the host system (vehicle master controller), response time and error % in temperature control, tuning for performance and efficiency, and control stability.

In vehicle applications, a CAN bus is a strong choice for a communication interface. Implementation by the host system (master controller) is typically easy, as there are often multiple CAN buses being integrated already. And it brings all the benefits of a CAN bus, including easy customizability of amount and frequency of feedback data, and the sharing of detailed DBC files to communicate system information. Going further, recent expansions to the SAE J1939 standard are supporting EV thermal management with standardized frames and signals for batteries, electronics, and refrigerant-based BTMSs. Where the standard does not fully cover the needs of a system, Proprietary B messages can be implemented for control and feedback. AKG's BTMS has flexible CAN communication and—built on modular software—can be customized to specific integration needs, including J1939 support.

On a vehicle CAN bus, it is relatively easy to get each device or subsystem the information it needs from other devices and subsystems. However, if less information is required, these further decreases implementation time and increases flexibility on which bus a subsystem can be placed, without needing message hops between buses. The AKG BTMS is designed and optimized to run utilizing only sensor data from within the BTMS, while still achieving high performance—maintaining less than one °C variation under load and high ambient conditions. This allows a wider range of compatible systems for which the BTMS can be integrated plug-and-play, saving time and money for the host system designer. Should external control inputs be necessary, the flexible software still allows for modification, giving the best of both worlds.

To keep BTMS performance at its best, there are necessary considerations in the design of the system itself. Long coolant loops and/or low coolant flow applications add more thermal



elasticity to the system. They make it more difficult to control and should be avoided where strict temperature regulation is required. Additionally, a BTMS operating under a heat rejection significantly below the unit's capacity also increases the risk of oscillations—specifically coolant temperature oscillations around the on/off setpoints. Extra considerations, such as a larger hysteresis window or a colder allowed overcooling point may be implemented to reduce fast on/off cycles of the compressor. AKG rigorously tests/validates software to continuously improve capability.

Finally, the BTMS must have robust measures to counteract instability in abuse cases. The BTMS is a critical system for the operation of a heavy-duty EV; if the host system is demanding (and therefore expecting) cooling, a BTMS must avoid failure modes which remove its ability to cool. Therefore, reductions in output to avoid hard faults are encouraged, so long as the host system is notified of the reduction and can respond accordingly. This is in contrast to providing max cooling capacity until a fault demands a hard stop, such as a dangerous over-pressure event in the refrigerant loop. Such conditions can be avoided with proper reduction before the hard fault condition is reached.

Please reach out to Benjamin Trainum/Vykram Vijayasekaran if you have any questions on this topic or inquiries related to EV/Alt.Power for your applications at sales@akg-america.com or 919-563-4286.

AKG Green Thermal Solutions.

MADE IN USA • MADE IN USA •