When e-mobility know-how meets SiC power inverter technology

Author: Mike Sandyck, Marketing Director, CISSOID

The e-mobility industry harbours many ambitions, primary among which is of course sustainability. However, the delivery of sustainable transportation relies on astute product designs grounded in efficient operation. Developing a high-efficiency drive system, for example, is high on the list of priorities at e-mobility manufacturers, with an increasing number turning to CISSOID's silicon carbide (SiC) based power modules and inverters for the solution.

SiC technology is critical to unlocking higher efficiency, compactness and thermal resilience in e-mobility drivetrain applications. However, few e-mobility manufacturers will accept these benefits if it means compromising power. Engineers also want to develop high-efficiency drives that reduce cooling requirements and maximise reliability.

Figure 1: E-mobility solutions offer multiple-path redundancy to mission critical performance

Choosing a high-efficiency SiC-based inverter means users do not have to sacrifice prerequisites like high power and high reliability. This is largely thanks to the lower switching losses and higher temperature capabilities of SiC, leading to more available headroom in the temperature range of the power module. Greater headroom means more capacity for sustained power. In addition, as the ageing process in semiconductors is mainly due to constant working at the permissible limits of junction temperature, the operating life of the power semiconductors sees a significant increase.

Design engineers can also tap into further advantages of high-efficiency SiC-based inverters. For instance, choosing a more efficient switching solution means a decrease in cooling requirements, enabling a reduction in the size and weight of the cooling system. This factor is critical because weight is among the principal enemies of an electric vehicle due to its propensity to prompt faster battery drain and reduced range. Higher efficiency also supports choice: either a reduction in battery size to retain the same range capabilities, or maintaining the same battery size to enjoy an increase in range.

CISSOID has a long heritage in high-temperature semiconductor manufacturing, together with expertise in the production of modules and semiconductors that can withstand the extreme vibration environments common of today’s road surfaces. Experience of this nature is pivotal in an era when the fast-paced evolution of power electronics demands a delicate balance between performance, flexibility and time-to-market. Engineers often face a difficult choice: rigid, off-the-shelf inverters that limit optimisation, or fully custom hardware and software that require extensive development time and validation.

Figure 2: Fully functional and customizable SiC inverter platform

The company’s bench-top and on-board inverter reference designs can significantly reduce the development time for an electric drivetrain. Engineers can take an existing, proven solution to get their electric motor running and calibrated within days. It can also be mounted into a proof-of-concept or prototype within a short time, drastically accelerating time-to-market.

These complete SiC inverter reference designs are based on CISSOID’s 3-phase 1200V/340A-550A SiC Inverter Control Modules (ICMs), covering a power range from 50 to 460kW (60s peak) on a 50~850V bus voltage. The reference designs contain a bespoke low-inductance DC link capacitor, current sensors and a DC bus EMC/EMI filter, together with the necessary power and comms+control connectors. All in a less than 7-litre volume housing, achieving over 67kW per litre of power density.

Notably, those ICMs offer a pre-qualified, functionally safe solution that combines the efficiency of off-the-shelf systems with the customisation capabilities of discrete hardware components. This ‘best of both worlds’ approach enables manufacturers to tailor their inverter designs to specific voltage, power and motor control requirements, accelerating development while ensuring safety and performance.

By integrating field-proven inverter control technology with customisable hardware interfaces, the ICMs allow developers to fine-tune their inverters to maximise efficiency and reliability and comply with strict safety standards. Their scalability and ease of integration help customers future-proof designs and reduce development risks, making them a game-changing solution for next-generation e-mobility solutions.

Figure 3: Compact and efficient 3-Phase Inverter Control Module

As a point of note, the capability of SiC power modules to switch faster and operate at higher frequencies makes it essential to access motor controller technology that can run real-time algorithms faster. The processor at the heart of CISSOID's ICM inverter platform is Silicon Mobility's Adaptive Control Unit T222 (ACU T222). This highly flexible processor – developed specifically to drive electric motors in a safe and efficient manner – houses programmable hardware that accelerates response times to critical events.

Using a dual ARM® Cortex-R5F core running in lock-step operation mode, the ACU T222 takes real-time and critical safety processing to the next level. Indeed, the on-board programmable logic in the Flexible Logic Unit drives significant acceleration in the real-time processing and control of sensors and actuators.

The flexible programable logic off-loads precious core processing cycles to the Advanced Motor Event Control (AMEC®) block, enabling the rapid detection of faults and executing corrective actions. All this results in dazzlingly fast response times, reducing system-level fault detection, correction and containment to within tens of nanoseconds. Further attributes include CAN communication ports and a Lauterbach TRACE interface for calibration and debug activities.

All these features enable reliable and fast execution of safety-critical applications in real time. Both the T222 processor and inverter software are ISO26262 ASIL-D certified for functional safety, whereas CISSOID's ICM technology is ISO-26262 ASIL-C Ready certified.

The control hardware and software effectively manage signals from motor position, current and temperature sensors. Of particular note, mechanical and electrical integration between the control board and intelligent power modules removes another hurdle from the developer's path.

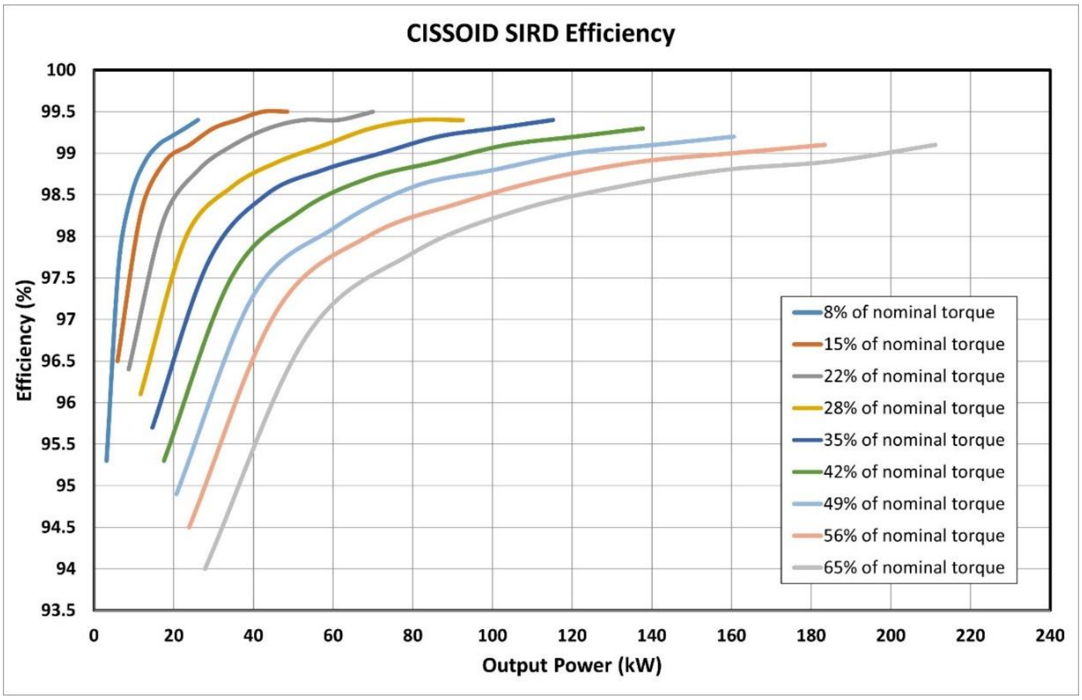

Figure 4: SiC Inverter Reference Design Efficiency

Thanks to its advanced power stage design and SiC technology, the inverter platform consistently delivers peak efficiencies above 99%. In real-world e-mobility applications, it maintains excellent performance across a wide operating range - typically achieving 94~96% efficiency across the full speed and torque envelope of the electric drivetrain.

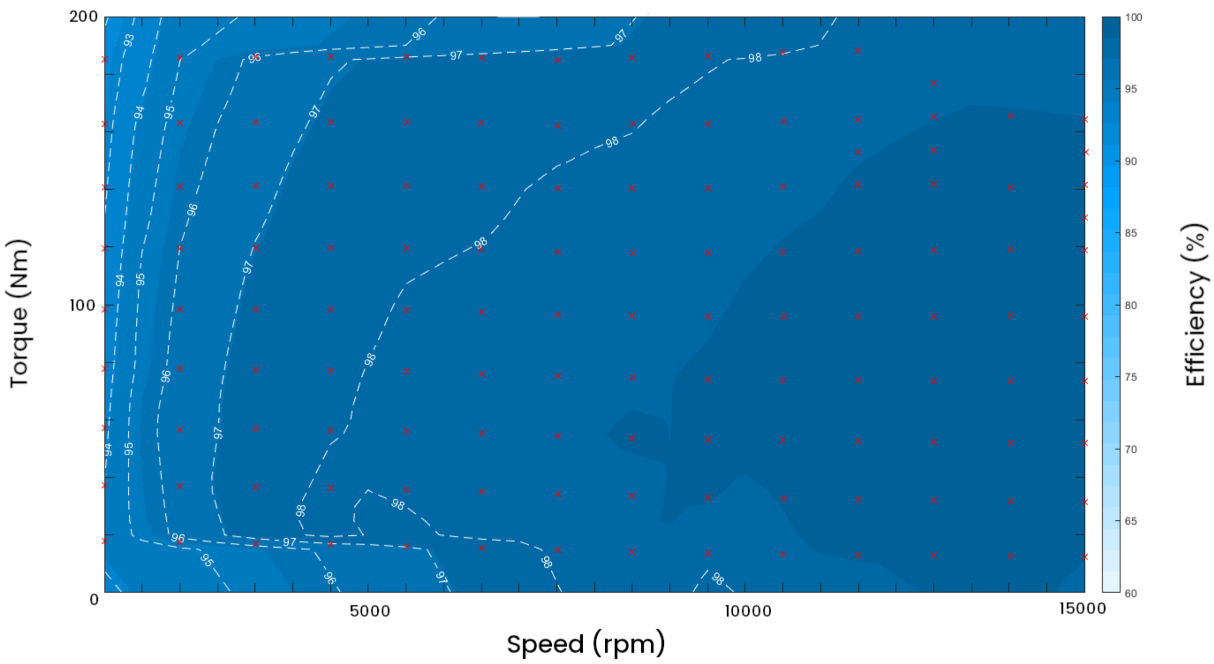

Figure 5: High SiC inverter efficiency across the entire operating range

Ultimately, the unique position of CISSOID's solution is that engineers can start from a ready-made, off-the-shelf solution to get up and running very quickly. The solution then offers the capability to start customising both the software and hardware to the degree necessitated by the application. E-mobility suppliers therefore benefit from rapid integration into diverse product configurations without extensive custom engineering. This approach significantly shortens development cycles and accelerates time-to-market - essential for competitive, innovation-driven markets like e-mobility.

CISSOID recognises that overcoming the technological bottleneck of SiC adoption is crucial for accelerating e-mobility. By providing a ready-to-use, functionally safe SiC-based inverter platform - from gate drivers to embedded software - designers can focus on their core innovations and competitive advantages rather than the complexities of power electronics integration.