Software and Hardware Advancements for Electrification

Leveraging modularization to address integration and manufacturing challenges related to electrified powertrain systems

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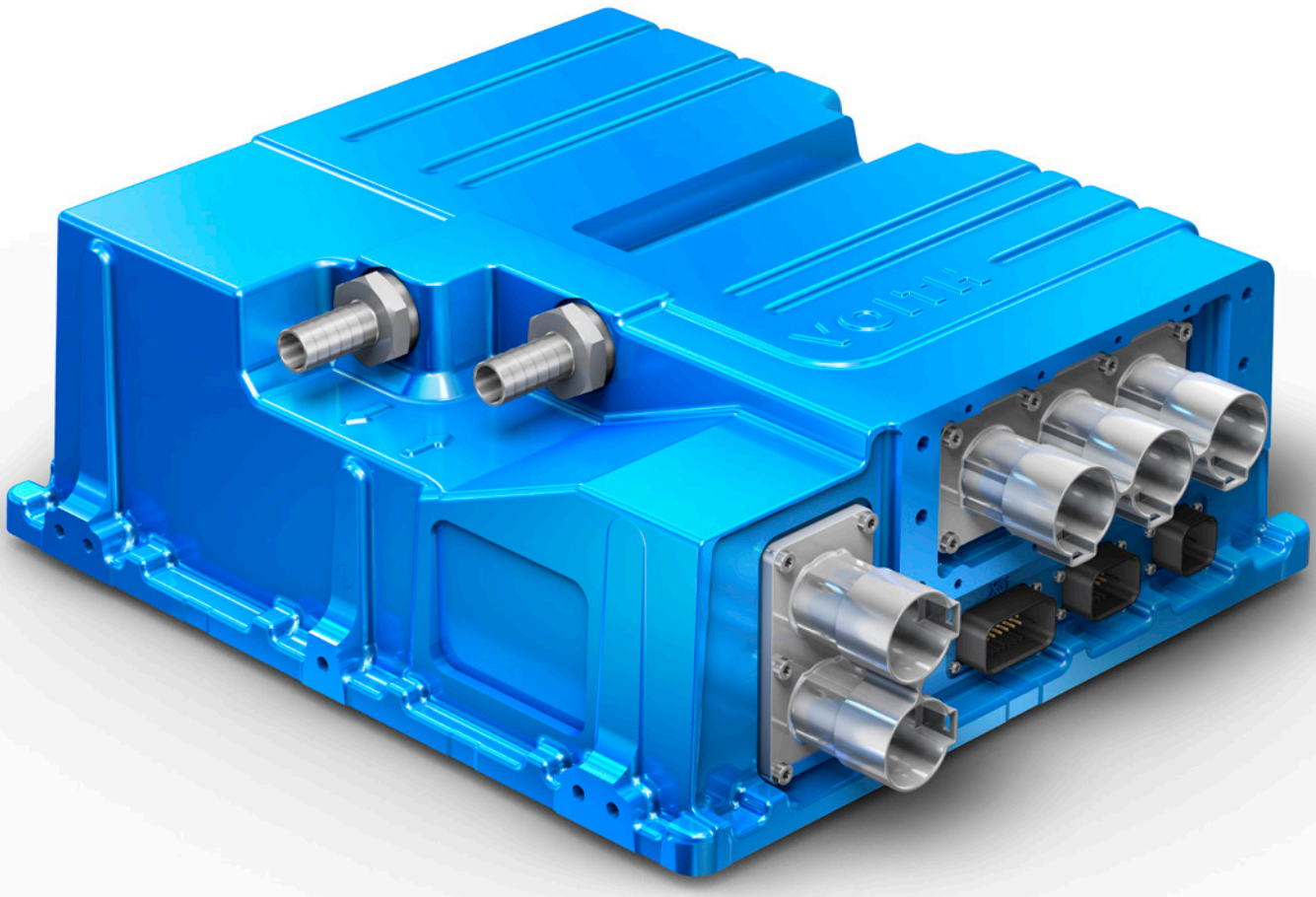
The advancement in the technologies for electrified commercial vehicles combined with government incentives for a more sustainable transportation industry, are driving a boost in the demand and deployment of zero emission technologies.

In the rapidly evolving landscape of electrified powertrain systems for the transportation sector, manufacturers face a myriad of challenges. From meeting stringent regulatory requirements to satisfying customers' demands for performance and efficiency, the industry is under constant pressure to innovate.



The Next Gen Voith Inverter is modularized with four different power levels, from 150 kW to 390 kW, uses AutoSAR software standards, and complies to ISO 21434—Cyber Security and ISO 26262 (ASIL C)—Functional Safety standards.

Additionally, more than any other technology advancement in the commercial vehicle industry in the past, electrification brings the complete symbiose of hardware and software, both equally important elements to the success of the vehicle performance and efficiency. Terms like functional safety, cyber security and others are important parts of the discussions of the development teams at original equipment manufacturers (OEM) and suppliers; researchers; fleets associations; regulatory agencies and government.

One approach that holds significant promise in overcoming these obstacles is modularization of hardware and software. By breaking down complex systems into smaller, interchangeable modules, manufacturers can ensure smooth integration, streamline production processes, enhance flexibility, and improve overall product quality.

Understanding the Software Integration and Hardware Manufacturing Challenges

Before delving into the benefits of modularization, it is crucial to grasp the manufacturing challenges faced by the electrified powertrain sector.

Complexity: Electrified powertrain systems are comprised of numerous components, each with its own specifications and requirements. Coordinating the assembly of these components in a traditional manufacturing setup can be time-consuming and prone to errors. Additionally, electrification also requires software integration, which is extremely important and complex.

Customization: Consumer preferences for electric vehicles vary widely, necessitating flexibility in manufacturing and in software and hardware architecture to accommodate different configurations and features.

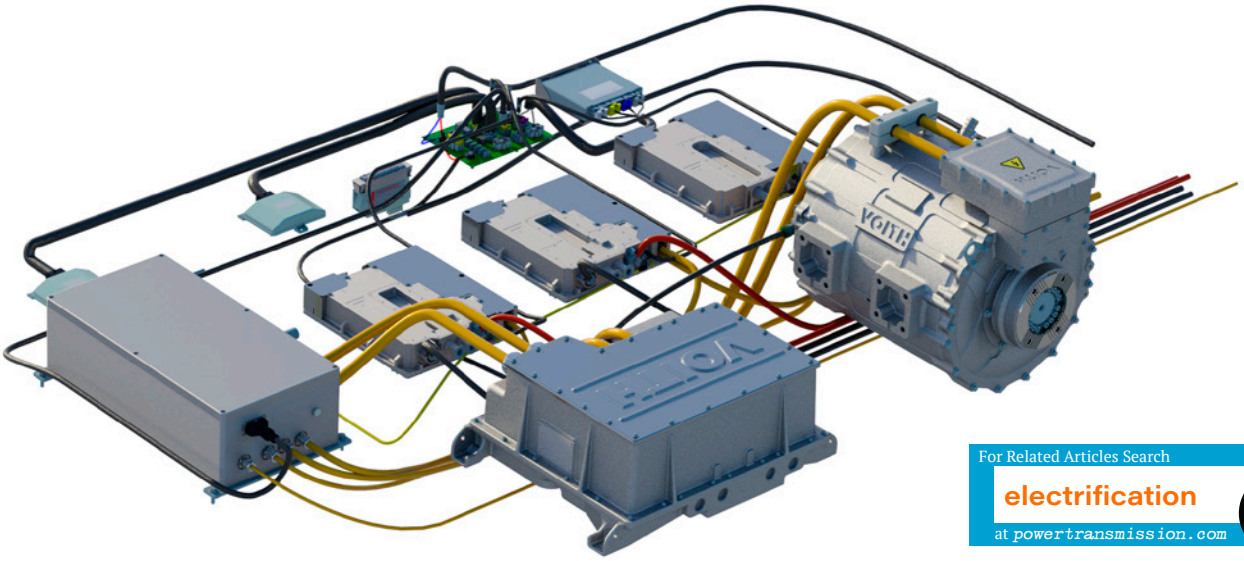
Cost: Developing, manufacturing, and integrating electrified powertrain systems involves significant upfront investments in technology, software and hardware development; and infrastructure. Minimizing costs while maintaining quality is a constant concern for manufacturers.

The Role of Modularization

Modularization offers a strategic approach to address these challenges by reimagining how electrified powertrain systems are designed, integrated, produced, and assembled.

Simplified Assembly Processes: By dividing complex systems into smaller modules, manufacturers can simplify the hardware assembly processes. Each module can be developed and tested independently, reducing the risk of errors, and speeding up production times. Additionally, modularization facilitates parallel production, allowing multiple modules to be manufactured simultaneously, further optimizing efficiency. By considering software architecture modularization, the whole vehicle and its different main control units can be more easily integrated, reducing development costs and timing.

Enhanced Flexibility: Modular hardware and software designs enable greater flexibility to meet diverse customer requirements. Manufacturers can offer a range



Voith Modular Concept (with current inverter design (DIS): Four different e-motors and inverter with four different power levels can be configured with up to three different auxiliary inverters and cables to simplify the hardware and software integration to the different vehicle platforms of the same OEM customer. In total, more than 30 different configurations can be achieved.

of modules with varying features and specifications, allowing customers to customize their vehicles according to their preferences. This flexibility extends to future upgrades and maintenance, as modules can be easily replaced or upgraded without requiring extensive rework.

Scalability and Standardization: Modularization promotes scalability and standardization across production lines. Common interfaces and standardized modules facilitate interoperability between different components, reducing the complexity of integration. Moreover, scalable modular designs can accommodate fluctuations in demand more effectively, enabling manufacturers to adjust production levels as needed without overcommitting resources.

Cost Optimization: While the initial development of modularized hardware and software systems may require additional investment, the long-term benefits in terms of cost savings are significant. Modularization reduces the need for custom-made manufacturing processes for a particular customer and instead allows for economies of scale in production. Moreover, the standardized nature of modules simplifies sourcing and inventory management, further driving down costs.

Case Study: Implementing Modularization in Electrified Powertrains

Voith has embraced modularization for the next generation of inverters.

In this single product, the Voith Inverter can accommodate each of the different electric motors Voith uses varying from 150 kW to 410 kW and from 950 Nm to 3,100 Nm. It can also handle all the different variants of the additional components Voith manufactures for electrified powertrains including high-voltage power distribution boxes (PDB), central electric interfaces (CEI), high voltage cables, control cables, and others, all integrated through *AutoSAR* software standards.

When applied to the vehicle, modularization of the electrified powertrain systems can be achieved by using similar concepts to integrate software and components for different vehicle types (e.g., delivery truck, school bus or yard tractor) and zero emission energy sources, like batteries or fuel cells. Voith simplifies OEMs integration efforts by using more than 80 percent of the same components for both energy sources when comparing similar vehicle applications.

The Road Ahead: Embracing Modularization for Future Success

As the electrified powertrain sector continues to evolve, the adoption of hardware and software modularization will play a crucial role in shaping the industry's future. By leveraging modular hardware designs, manufacturers can overcome production challenges, enhance flexibility, and drive innovation. By leveraging software modular designs, manufacturers can overcome integration challenges, enhance standardization, and reduce cost and time-to-market. However, realizing the full potential of modularization requires collaboration across the entire value chain, from component suppliers (Tier 2 or Tier 3) to vehicle manufacturers (OEMs). By working together to standardize interfaces and develop interoperable modules, stakeholders can unlock new opportunities for efficiency and growth in the electrified transportation sector.

Modularization offers a compelling solution to the vehicle integration and manufacturing challenges facing the electrified powertrain sector. By simplifying integration and assembly processes, enhancing flexibility, promoting scalability, and optimizing costs, modular hardware and software designs enable manufacturers to meet the demands of a rapidly evolving market while driving innovation and sustainability in transportation. As industry players embrace modularization and collaborate to develop standardized solutions, the electrified powertrain sector is poised for continued growth and success in the years to come.

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