

Trends in Integrated Packaging: More Efficient Automotive Inverter Power Assemblies

Integrating IGBTs, control boards, busbars and other components improves power efficiency, shrinks size and lowers costs.

Overview

The continued electrification of automobiles, trucks and commercial transportation systems is driving a series of important changes in the way inverters and power modules are designed, manufactured and integrated with other systems in the vehicles.

Typically, modern inverters are built around high-power insulated-gate bipolar transistors (IGBTs) that handle all of the electronic switching functions at the heart of the process. A number of subassemblies and components, such as control boards, busbars, current sensors, capacitor banks, cooling circuits, etc., surround the IGBT. When integrated together, all of these elements comprise the functional inverter stack.



According to the automotive industry report *EV/HEV Power Electronics in Electric and Hybrid Vehicles* (Published by Yole Développement Nov. 2014):

“Inverters, and more importantly power modules, are fast becoming one of a car’s key ingredients, and car makers want to control it. In this context, the supply chain is evolving and power module manufacturing is becoming a difficult concurrence zone. Pre-established business models must be reshaped. Tier 1 companies in particular must integrate power modules to stay competitive, taking into account that more and more car makers are moving to vertical integration as well.”

As the hybrid and electric vehicle markets ramp up to high volumes and inverters become both more powerful and more critical, Tier 1 suppliers and auto manufacturers are looking for ways to improve power system efficiency and manufacturability.

In order to achieve these objectives, OEMs need new interconnect and packaging approaches that deliver high power efficiency, more compact form factors and support for integration of multiple inverter stacks. Each requires tighter integration from the chip-level through the module level, with shorter electrical paths, fewer connections and simpler packaging.



Fundamentals of Inverter Integration

In early hybrid drive designs, the inverters often had all of the subassemblies packaged separately and then tied together using a variety of connectors, ribbon cables, bolts, etc. The power module in the center was surrounded by individual units connected via harnesses and fasteners.

As inverter designs evolved, engineers packaged the subassemblies in smarter, more efficient ways, such as stacking the control board right on top of the power module. On-going advances are now focused on bringing all of the subassemblies closer together and improving power efficiency.

Earlier design integration steps were effective but not very efficient, especially with regard to inductance, the voltage created by changing current flows. Inductance can be a killer of efficiency for modern inverters, with current running through parallel buses and switching frequencies increasing.

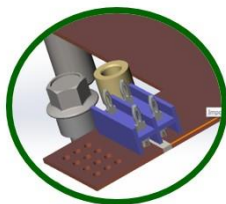
Moving to more tightly integrated designs with short current paths and pluggable solderless interfaces both improves performance and reduces costs of assembly. By shortening the current paths – from where DC power comes in to where AC power goes out to drive the motor – these integrated designs can provide a much higher level of efficiency with much lower inductance.



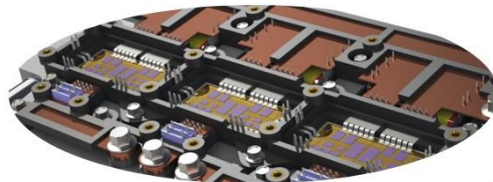
Stacked Power Module



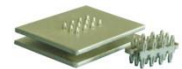
Power Lead Frame
with Press-fit Integration



AC Bus with Press-fit Integrated
Current sensor



DC Link Bus with Dual Press-fit
Interconnection



Using pluggable solderless connections between the subassemblies also overcomes one of the key challenges that power module designers have always faced – dealing with dissipated heat and thermal cycling issues. New high-force press-fit interfaces provide excellent current carrying capacities and robust electrical interfaces, along with spring-based retention force that handles thermal expansion (CTE) without the risks of failure that are inherent to solder joints.

Summary

Traditional interconnect methods, such as bolting and welding harness connections cannot keep up with today's requirements because they are inefficient, cumbersome, and assembly-process intensive. They result in larger assemblies with longer current paths and higher overall inductance.

In contrast, the full integration of inverters and power modules by using pluggable, high-force, press-fit technology can significantly improve power efficiency, reduce the bill-of-material costs, decrease assembly complexity and shrink the overall physical size of the power assembly.

The modular integration approach with standardized, pluggable, solderless interconnects also gives designers much greater flexibility for configuring multi-phase, high-power applications. This enables Tier 1 suppliers and automotive OEMS to differentiate their designs, without having to build custom interconnect strategies for every application.

As the worldwide auto industry continues its trend towards electrification, more automakers are vertically integrating their power electronics development. Car builders have been hiring specialized engineers to build up their electric motor and inverter know-how in an attempt to drive down costs and increase efficiencies.

While some OEMs are moving towards designing their own power modules from the ground up, as an integrated complete powertrain, the ability to leverage highly efficient pluggable interface technologies will be of benefit to OEMs as well as their suppliers of packaged parts and subassemblies for use in the final power applications.

More information regarding new and emerging power management technologies and products can be found on the web by visiting www.interplex.com or by calling (718) 961-6212.