



Advantages of Semiconductor-Based Power Modules Over Discrete Components

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In the ever-evolving landscape of power electronics, the choice between semiconductor-based power modules and discrete components has a significant impact on the efficiency, reliability, and overall performance of electronic systems. In recent years, semiconductor-based power modules have gained prominence due to their numerous advantages over traditional discrete components. In this article, we explore the key advantages of semiconductor-based power modules before diving into the specific offerings that Vincotech brings to the table.

Advantages of Semiconductor-Based Power Modules

Semiconductor-based power modules integrate multiple components into a single package, resulting in a more compact design compared to discrete components. Modules can easily integrate anything from capacitors to improve switching behavior and stray inductance to shunts for current measurement. Their space efficiency is crucial in size-constrained and space-limited electronic systems such as book-size frequency inverters, renewable energy systems, and uninterruptible power supplies. Semiconductors are placed to ensure small commutation loops that utilizes the efficiency to its maximum and enables some features that are hardly to realize with discrete components.

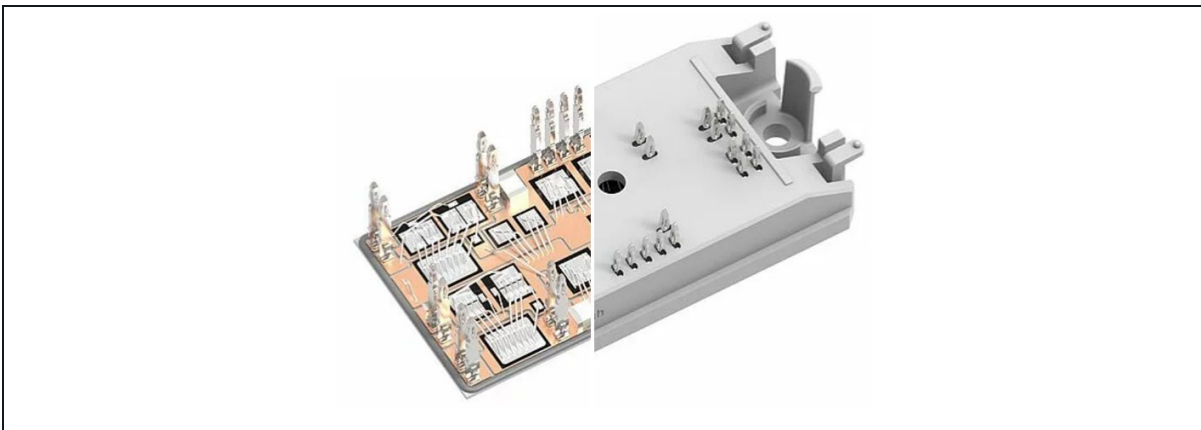


Figure 1: *flow 1* IGBT module with integrated capacitors

Another aspect is enhanced reliability. In many applications, reliability is weighted higher than price. Traditional discrete components are prone to reliability issues such as solder joint failures and thermal stress. Semiconductor-based power modules, on the other hand, are designed with advanced packaging technologies that improve thermal performance and reduce the risk of component failures. Their enhanced reliability is essential in mission-critical applications where system downtime is not an option.

Reliability includes thermal performance. Power modules often feature advanced thermal management solutions, such as direct bonding technology, to dissipate heat more efficiently. This lowers their operating temperature, extending the lifespan of the components and ensuring stable performance over time. Different DCB materials come with different thermal properties. While Al_2O_3 is a widely used material, AlN, for example, offers very high thermal conductivity. Because it is more fragile, Si_3N_4 is a good compromise of both materials.

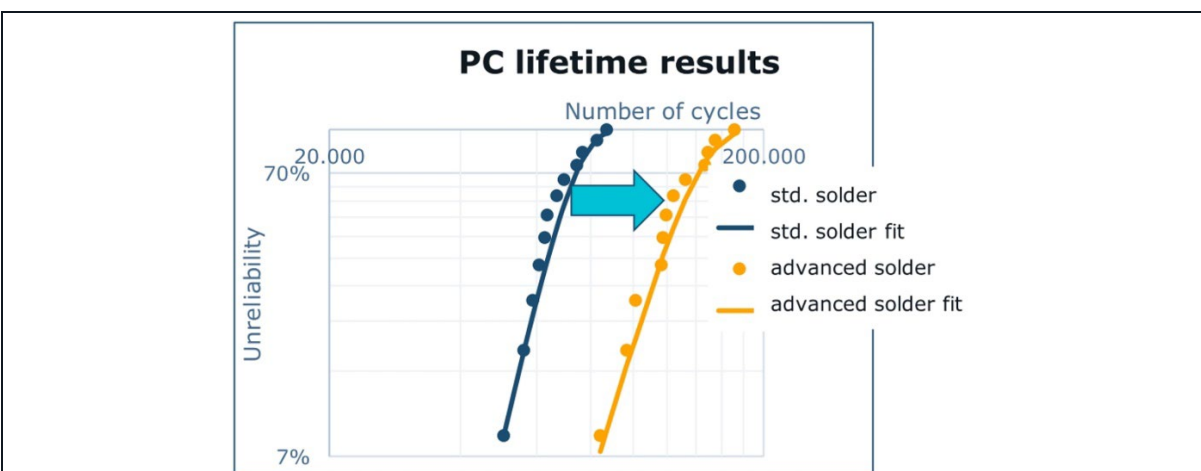


Figure 2: Comparing the power cycling capability of standard versus advanced solder material



A very important topic is the simplified integration and reduction of assembly costs. Integrating discrete components requires careful consideration of component placement, routing, and thermal management. Semiconductor-based power modules simplify the integration process by consolidating multiple components into a single package. This reduces assembly costs and streamlines manufacturing, resulting in faster time-to-market for electronic systems. Several steps can be spared as modules come with an electrical insulation to the heatsink, can come with a layer of pre-applied thermal interface material, and only need a limited number of screws to be mounted.

Finally, power modules achieve much higher power density compared to discrete components. By tightly packing components in a compact form factor, semiconductor-based modules can deliver more power in a smaller space. This is particularly advantageous in applications with critical power efficiency and size constraints, such as solar inverters and portable electronics like welding machines, and even more critical in embedded drive applications.

Vastly simplified handling and assembly

A deeper comparison between the mechanics of discrete components and power modules reveals vast differences in their handling and assembly. Modules are essentially pre-tested sub-systems. Their manufacturers guarantee that all parts shipped have passed rigorous mechanical and electrical testing. Discrete components, on the other hand, require many additional, largely manual, processes that influence their reliability: Pins need to be bent, thermal interface materials applied, and, in some cases, additional electrical isolation added to the heatsink. Components to be handled include through-hole components such as the TO-220, TO-264, etc. that need to be assembled, fixed, and soldered to the PCB before being mounted to a heatsink. They are connected to form an inverter stage, a PFC circuit, or a brake chopper. Drive applications commonly use bridge rectifiers. The challenge is always to make assembly as stress-free as possible, which can be tough, as discrete components come in different heights.

A comparison of their electrical behavior reveals further drawbacks of discrete components. For one, discrete components cannot be positioned to perform optimally in the case of commutation paths. And, secondly, due to their physical size, discrete components require more space on the PCB and cannot be placed as close to each other as the IGBTs and diodes used in a power module. Consequently, discrete components have a lower power density than power modules.

The figure below highlights differences between using discrete components and a power module in a small power application.

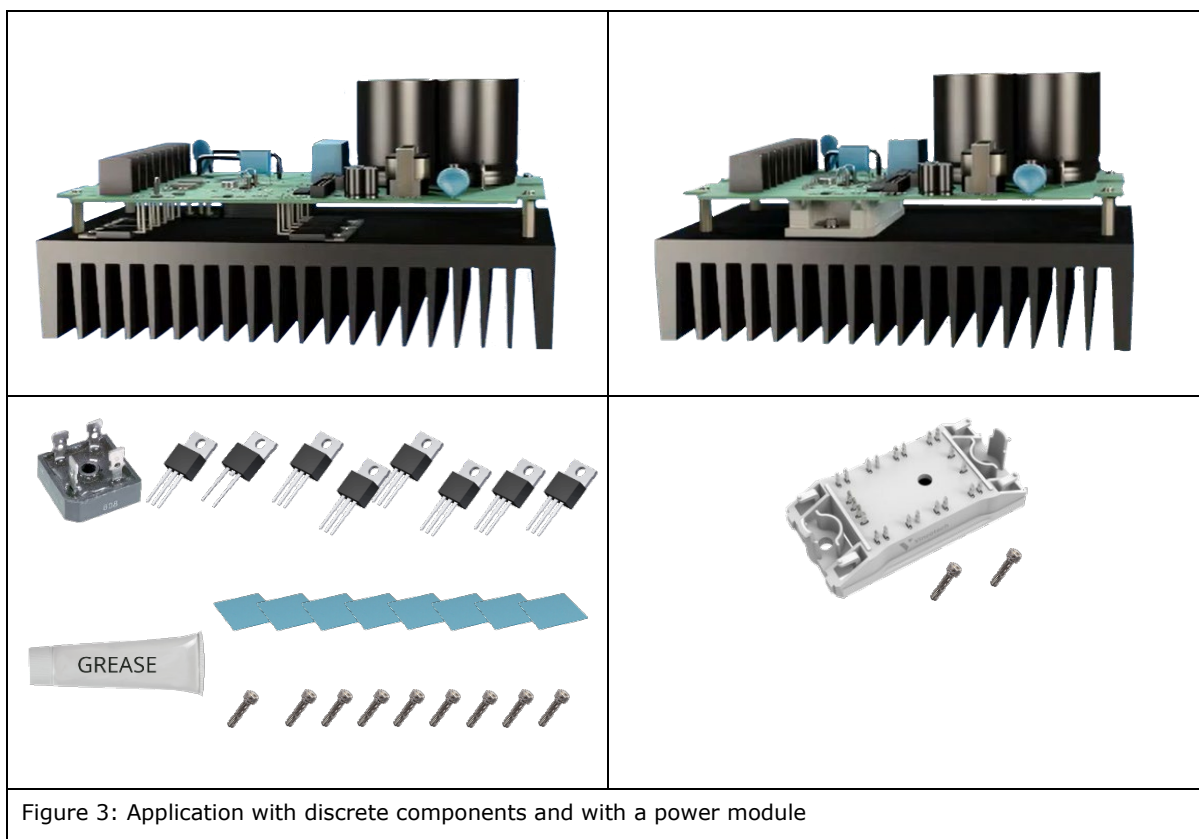


Figure 3: Application with discrete components and with a power module

Moreover, parallelizing discrete components requires considering even more components, while power modules can simply be replaced with the next larger housing size. To further facilitate handling, modules can be delivered with solder pins, press-fit pins, and, on request, with pre-applied phase-change material.

Semiconductor-based power modules offer a host of advantages over traditional discrete components, from their compact design and enhanced reliability to improved thermal performance and simplified integration. As a leading player in the industry, Vincotech has contributed significantly to the evolution of power module technology. With its commitment to innovation, customization, and sustainability, Vincotech's offerings empower electronic system designers to meet the demands of today's dynamic and competitive market.

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