Silicon Carbide (SiC) technology has shown performance improvements over traditional silicon (Si) components across the board, including lower power losses, faster switching, higher operating temperatures, greater power density, and overall higher efficiency.

Wolfspeed’s upgraded portfolio of power modules can provide these advantages in industry-standard footprints with configurations that serve a variety of applications while also helping to bridge the power continuum between lower-power, discrete-based applications through industry standard footprints and optimized footprints in high power modules.

This article will demonstrate how designers can increase system efficiency while lowering cost but most importantly, greatly increase the overall reliability system-wide.

**A brief overview of the Wolfspeed product line**

The Wolfspeed portfolio covers many industries and applications that require small- to high-power solutions, including electric vehicles (EVs), industrial power, grid infrastructure, solar and renewable energy, test equipment, uninterruptible power supplies (UPS), and other high-ampacity systems. It provides 1200 V and 1700 V SiC-based, multi-socketed modules with a variety of MOSFET topologies, with both Schottky and MOSFET body diode anti-parallel options that can be simulated upfront for quicker time to market. *Figure 1* shows this product line and some of the power ranges and applications.
You'll note that while the Wolfspeed WolfPACK™ family of power modules serve medium-power applications in a spring-loaded, baseplate-less design containing press-fit pins, the BM-, XM-, and HM-base-plated devices operate at even higher current ranges. Regardless of the application, all modules have been designed to achieve the same goal of maximizing power density, simplifying layout/assembly, enabling scalable systems and platforms, minimizing costs of labor and system components, while providing the highest level of reliability.

**Wolfspeed WolfPACK™ Silicon Carbide power modules**

The all-new new Wolfspeed WolfPACK™ family of products (FM3/GM3) delivers power in a baseplate-less, press-fit-interconnect housing. Two of the most common MOSFET arrangements — six-pack and half-bridge currently — are offered with this product family to allow numerous power stages the ability to benefit from the advantages of SiC. These modules also provide lower-weight system components containing a higher power density. Altogether, the Wolfspeed WolfPACK™ module helps lower overall size and complexity while simultaneously decreasing system and maintenance costs as well. The Wolfspeed WolfPACK™ modules provide designers with a solid medium-power range solution that can be scaled appropriately, thereby enabling seamless system upgrades when necessary.

The Wolfspeed WolfPACK™ housing features metal mounting tabs for a spring-force interface, complete with a heatsink designed to optimize thermal management and provide uniform pressure throughout the thermal junction. Taking a closer look, its ceramic direct-bonded copper substrate provides increased electrical isolation to the heatsink with low thermal impedance. This allows for better thermal performance with higher ampacity. The Wolfspeed WolfPACK™ also comes equipped with press-fit pins, which provide high reliability and excellent electrical and mechanical properties due to the tight compression when inserted into a plated PCB. With pin arrays corresponding to the internal MOSFET arrangements, designers enjoy simple, one-way installation in an industry-standard footprint. If an application requires multiple modules, the internal PCB mounting methods provide options for wiring several together to meet high-power demands.

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<table>
<thead>
<tr>
<th>Module Type</th>
<th>Wolfspeed WolfPACK™</th>
<th>Leadframe with Baseplate</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOSFET Gen</td>
<td>Gen 3</td>
<td>Gen 2/Gen 3</td>
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<tr>
<td>Voltage</td>
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<td>1.27/1.7kV</td>
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<tr>
<td>Recommended Applications</td>
<td>PV, Energy Storage, Low Cost Industrial Apps, Off Board Charger</td>
<td>Rail Aux Pwr, Broad Industrial</td>
</tr>
</tbody>
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Figure 1: Wolfspeed module portfolio
demands. **Figure 2** shows the FM3 and GM3 WolfPACK™ modules.

![Wolfspeed WolfPACK™ FM3 (top) and GM3 (bottom) housings](image)

**Wolfspeed’s BM industry-standard 62-mm footprint**

Wolfspeed’s industrial-standard 62 mm SiC modules offer the industry’s broadest portfolio of high-power solutions, specially made to meet several requirements with unprecedented system power and efficiency. Designers can now replace 62 mm IGBT devices with Wolfspeed 62 mm BM modules containing SiC technology to help reduce cooling requirements, system cost, power losses, and system inductance, all while optimizing voltage utilization.

The family of BM 62 mm modules comes in 1.2 kV and 1.7 kV half-bridge topologies that deliver up to 530 A. Material for these modules have been selected to target different operating conditions, e.g., Wolfspeed offers THB-80 qualified housing material option to provide additional robustness for applications against harsher environment.

The BM family of modules (see **Figure 3**) features screw terminals for a secure connection in high-power systems utilizing laminated bus bars or PCBs and a copper baseplate for maximized thermal conductivity and mechanical robustness. Additionally, the screw terminals include creepage and clearance for 5 kV isolation to support 1.7 kV active devices. All of this comes in an industry-standard, 62 mm footprint to allow for easy, 200 kW+ system upgrades and drop-in replacements.
Some of the applications that are supported by these modules include both off-board charging and EV fast-charging systems, rail and traction applications, industrial test equipment, and industrial motor drives. Wolfspeed’s BM family of products allows for simple adoption and SiC upgrade with many instantaneous benefits, including improved power efficiency, better power density, higher switching frequencies, and an overall increase in robustness and reliability.

**Wolfspeed’s XM3 and HM3 platforms**

While the Wolfspeed WolfPACK and BM families of products provide industry-standard packaging, the XM3 and HM3 devices are included in the greater Wolfspeed portfolio as a means of providing designers with the advantages associated with custom housing options.

The XM3 half-bridge module (top view, shown in Figure 4) features a package that is 50% smaller and lighter than the 62 mm industry-standard footprint. Other features include optimized conduction and switching losses, low-inductance bus bar interconnections, an integrated temperature sensor, built-in voltage sensing, and a high-reliability power substrate with enhanced power-cycling capabilities. The housing is designed to be modular, scalable, and re-configurable, with inductance as low as 6.5 nH.
When compared with similar power modules, such as the SemiTrans 3 or EconoDual, both of which feature similar voltage and current ratings (up to 450 A at 1200 V), the XM3 modules provide designers with an option that is not only 50% smaller but also produces 50% less inductance while lowering overall switching losses. Additionally, XM3-based inverters such as the 300 kW (CRD300DA12E-XM3) and 600 kW (CRD600DA12E-XM3) devices provide significant improvements with regards to both weight (up to 50% less) and volumetric power density (up to 20×) when compared with traditional silicon inverters.

The HM3 family of devices offers Wolfspeed’s highest-power–density power modules available. With a lightweight Aluminum Silicon Carbide (AlSiC) baseplate, compact footprint that supports high currents (<800 A), and low inductance at high frequencies, the HM3 delivers a SiC-optimized footprint with unprecedented power density. Two voltage nodes are available, including a 1200 V half-bridges at 481 A (with Schottky diodes) and 765 A, as well as 1700 V at 380 A (with Schottky diodes) and 650 A.

The housing for the HM3 device (shown in Figure 5) contains 62 mm bolt compatibility with an AlSiC baseplate and silicon nitride substrate for strong thermo-mechanical performance and a 4.9 nH inductance terminal design for high-power laminated bus bar connections. The interface pins have creepage and clearance to accommodate 1.7 kV devices. Inside, the device features a network of gate and Kelvin resistors and allows for 12 devices in parallel per switch position. Additionally, the module comes with a gate driver reference design, the CGD1700HB3P-HM3, for quick start up providing basic protections and sensing. Liquid Cold Plate Heat Sinks such as the CP3009-XP from Wieland Microcool can be implemented in order to further reduce operating temperature of the module.

Additional benefits and resources provide designers with confidence and a quicker time to market

Wolfspeed’s power modules are designed to meet each customer’s system unique requirements with a package that offers best-in-class SiC performance. Furthermore, there are two distinct product categories offered to serve different customer value propositions: Industry-Standard Footprints and Optimized Footprints.

Industry-standard footprints are well-established footprints / packages that have been internally optimized for SiC, and provide a relatively straight-forward, drop-in replacement at the package level for customers using these platforms with either Si or SiC devices. Optimized footprints, on the other hand, are developed by Wolfspeed to offer enhanced functionality for modules designed with SiC.

Wolfspeed has released evaluation gate drivers for each package platform to help designers improve their efficiency in the
lab. Additional evaluation kits and reference designs (such as inverters, power converters, chargers, and many more) are also offered to speed up time to market.

Reference designs come complete with application notes, user guides, design files, and allow designers to create rugged and reliable systems with best-in-class power density, performance, and efficiency. Worth noting in this regard: Wolfspeed has partnered and collaborated with brands that have been exclusively tested and integrated into evaluation and reference designs, providing the designer with a complete picture and documented data to reference during all stages of development.

Finally, the Wolfspeed SpeedFit 2.0 Design Simulator further improves the SiC design process by helping select the right Wolfspeed product. It can be used to run simulations to easily predict and minimize conduction and switching losses, quickly compare different device and thermal configurations, and generate circuit diagrams as well as a summary report to help bring the whole project together.

**A portfolio that covers every need**

Wolfspeed’s modules portfolio has seen some significant upgrades in recent years. Today, it covers the entire power spectrum, ranging from low to high power ranges. And because all of these modules feature Wolfspeed’s industry leading SiC technology, designers can either upgrade pre-existing modules to enjoy the benefits of SiC solutions or begin a new design that incorporates smaller, lighter, and more capable subsystem components.

Indeed, today’s system designers are at a major advantage with this portfolio available to them, as they not only have options that span the entire power continuum, but also access to Wolfspeed’s reference designs, companion hardware, and simulation and CAD programs. What’s more, Wolfspeed provides dedicated SiC system and circuit design experts as well as access to exclusive ecosystem partnerships as a means of providing designers with the support and flexibility needed to eliminate risk and help improve time to market.