



VISHAY SEMICONDUCTORS

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Diodes and Rectifiers

White Paper

Advancing Semiconductor Packaging: Innovations for a Compact and Reliable Future

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Semiconductor technology has been central to the technological revolution, with materials like silicon, gallium arsenide (GaAs), and silicon carbide (SiC) enabling the creation of diodes, transistors and integrated circuits. These delicate components require protective packaging to maintain their functionality and lifespan, with materials such as siloxane polyimide, epoxy resin, aluminum and ceramic composites commonly being used.

As electronic devices evolve, so too has PCB design and manufacturing. The push for higher component density has led to innovative packaging methods, maximizing functionality within compact designs. New soldering techniques and advanced automated manufacturing processes have made PCB assembly highly intricate, necessitating automated inspection systems to ensure component reliability.

Historically, packaged semiconductors were mounted on PCBs using through-hole assembly, where leads were run through board apertures and soldered. Though largely replaced by more modern methods, through-hole technology is still used in designs requiring stronger mounting, better heat dissipation, and resistance to mechanical stress.

Surface-mount technology (SMT) allows for more compact and efficient designs by enabling more components to fit on a single PCB. Surface-mount devices (SMDs) are lighter, smaller, and thinner than their through-hole counterparts. SMT also streamlines the manufacturing process, allowing for greater automation, fewer mechanical errors, and higher efficiency production.

Innovations in SMT packaging often involve advancements in packaging materials, bonding methods, and die-supporting substrates, complemented by improvements in manufacturing techniques such as automated optical inspection (AOI), enhanced thermal transfer methods, and automated placement and soldering processes. Notable SMT packaging innovations include the transition from gullwing pins to under-chip surface-mount tabs, which allows for significant space reductions on the board. Vishay's DFN series with a side wall tin plating design featuring wettable flanks and AOI capability, along with packaging that utilizes surface-mount tabs, eliminates the need for costly X-ray verification of solder efficacy, thereby reducing manufacturing costs and enhancing reliability. Additionally, expanding tabs beneath SMD components has improved heat transfer from the die to the PCB, enhancing power efficiency and overall device reliability. These innovations have led to the development of components that offer significant improvements over previous generations.

Vishay Intertechnology has been a leader in electronic component innovation for over 60 years, with a diverse product lineup that includes everything from high power capacitors to miniaturized LEDs. As technology advances and applications become more demanding, semiconductor packaging must adapt to meet the needs of modern industrial and automotive sectors. This includes enhancing thermal resistance, power efficiency, and mechanical durability, while also achieving slimmer form factors for increasing component density in compact devices. Vishay has responded to these challenges with a range of specialized semiconductor packaging solutions designed to support critical growth areas such as factory automation, electric and hybrid vehicles, wireless networking, and the industrial Internet of Things. In the following sections, we will explore several of these innovative packaging types and their specific applications.

WHITE PAPER



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eSMP®

Vishay's eSMP series packages are more compact and efficient solutions than previous SMT iterations due to their reduced form factor and reliability. The expanded cathode pad design enables maximized power ratings while still saving valuable board space. Devices in the eSMP series include TMBS®; Schottky rectifiers; Silicon Carbide (SiC); FRED Pt® rectifiers; ultrafast recovery, avalanche, standard- and fast-recovery rectifiers; PAR® and TransZorb® TVS; ESD protection diodes; and Zener diodes. eSMP devices are optimal solutions for lighting, telecommunications, industrial, and automotive applications requiring high dependability under harsh conditions.

The low profile of the eSMP series is a significant upgrade for SMT. The MicroSMP, for example, is just 2.5 mm by 1.3 mm by 0.68 mm, allowing for closer stacking of boards and more overall space in multi-board designs (Figure 1). The MicroSMP also takes up 76 % less board space than its predecessor, the SMA.

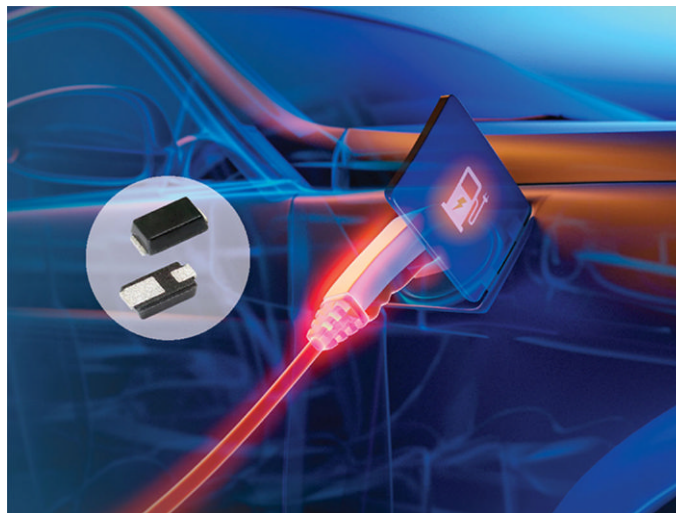


Fig. 1 - The MicroSMP package

Power DFN

Vishay's DFN packaging solutions also offer a further reduced footprint while providing much lower thermal resistance and overall package inductance. These properties make DFN packages optimal for high power density and mid-range switching frequency applications.

Even though there are no terminal lead on the product, DFN packages implement wettable flanks on the sides of the package to make the soldering connections. Specific DFN packages also boast an AOI feature, a capability typically associated with standard packages with exposed leads. AOI allows for continual monitoring of the solder between the chip and PCB for strength and reliability, a key factor in meeting the strict safety requirements that some automotive and industrial applications demand.

The Power DFN series includes the DFN3820A (Figure 2), which is designed primarily for standard, FRED Pt® and TMBS® rectifiers and TVS. Measuring 3.85 mm by 2.08 mm by 0.88 mm, it's same as the SMP package case, while delivering up to double the performance under equivalent thermal conditions. Rectifiers in the DFN3820A package have a maximum 7 A rating, TVS in DFN3820A package have 1.5 times reverse surge power. DFN-packaged components are AEC-Q101 certified for automotive applications, and can also be used in industrial, computer, consumer electronics, and telecommunications applications.

The latest package in Vishay's Power DFN family, the DFN33A, features a compact 3.3 mm by 3.3 mm footprint and an extremely low typical height of 0.88 mm, allowing Vishay standard and TMBS rectifiers to make more efficient use of PCB space. Compared to the conventional SMB (DO-214AA) and eSMP series SMPA (DO-220AA), the package's footprint on the PCB is 44 % and 20 % smaller, respectively. In addition, the device's low profile is 2.6x thinner than the SMB (DO-214AA) and SMC, and 7 % thinner than the SMPA (DO-220AA). At the same time, the rectifiers' optimized copper mass design and advanced die placement technology allow for superior thermal performance that enables operation at higher current ratings.

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Fig. 2 - Offering peak pulse power of 600 W at 10/1000 μ s in the compact DFN3820A package with wettable flanks and a low typical height of 0.88 mm - the same peak pulse power as products in the SMB, which is 2.6 x its size - our industrial-grade TRANSZORB® and Automotive Grade PAR® TVS provide space-saving solutions for automotive, computer, consumer, and industrial applications

Signal DFN

Like the Power DFN series, Vishay's Signal DFN packages provide reliable performance in a smaller form factor than the competition. The DFN Ultra Compact model for small signal Zener, Schottky, switching, and ESD protection diodes takes up only 10 % of the board space compared to conventional SOD/T packages, and boasts soldering joints that can be examined visually instead of through X-ray or AOI inspection. Their leadless, compact packaging (1 mm by 0.6 mm by 0.45 mm) delivers extreme reliability and better power dissipation than their predecessors, while reducing noise and current leakage. The DFN 1006 package is only 1 mm by 0.6 mm, providing more available board space with a reduced size profile, significantly lower thermal resistance, and reduced inductance due to its shortened leads. Several specifications are available in the DFN1110-3A package as well.

FlatPAK 5 x 6

Vishay's FlatPAK 5 x 6 package saves board space by providing a hybrid solution in a single package that typically requires two SMC-size packages in more conventional designs (Figure 3). Its significantly reduced footprint and wide operational temperature range also makes it a good fit for industrial and automotive applications, including automated engine control, anti-locking braking systems, airbag deployment, and various telecom and automated safety systems.

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Fig. 3 - The R3T2FPHM3 combines a 3 A, 600 V standard rectifier with a 200 W TRANSZORB® TVS in the compact FlatPAK 5 x 6 package. By combining these two technologies in a single package, the dual-chip solution saves PCB space, simplifies layouts, and lowers overall costs in automotive and industrial applications.

Vishay continues to explore new ways to innovate semiconductor packaging to provide engineers with more reliable components and greater component density on the board. The eSMP, DFN, and FlatPAK 5 x 6 packaging solutions provide engineers with unmatched reliability in a smaller form factor for increasingly compact designs with robust operational requirements. A continuous investment in developing semiconductor packaging solutions meets the ever-evolving needs of engineers in a rapidly changing technological landscape.