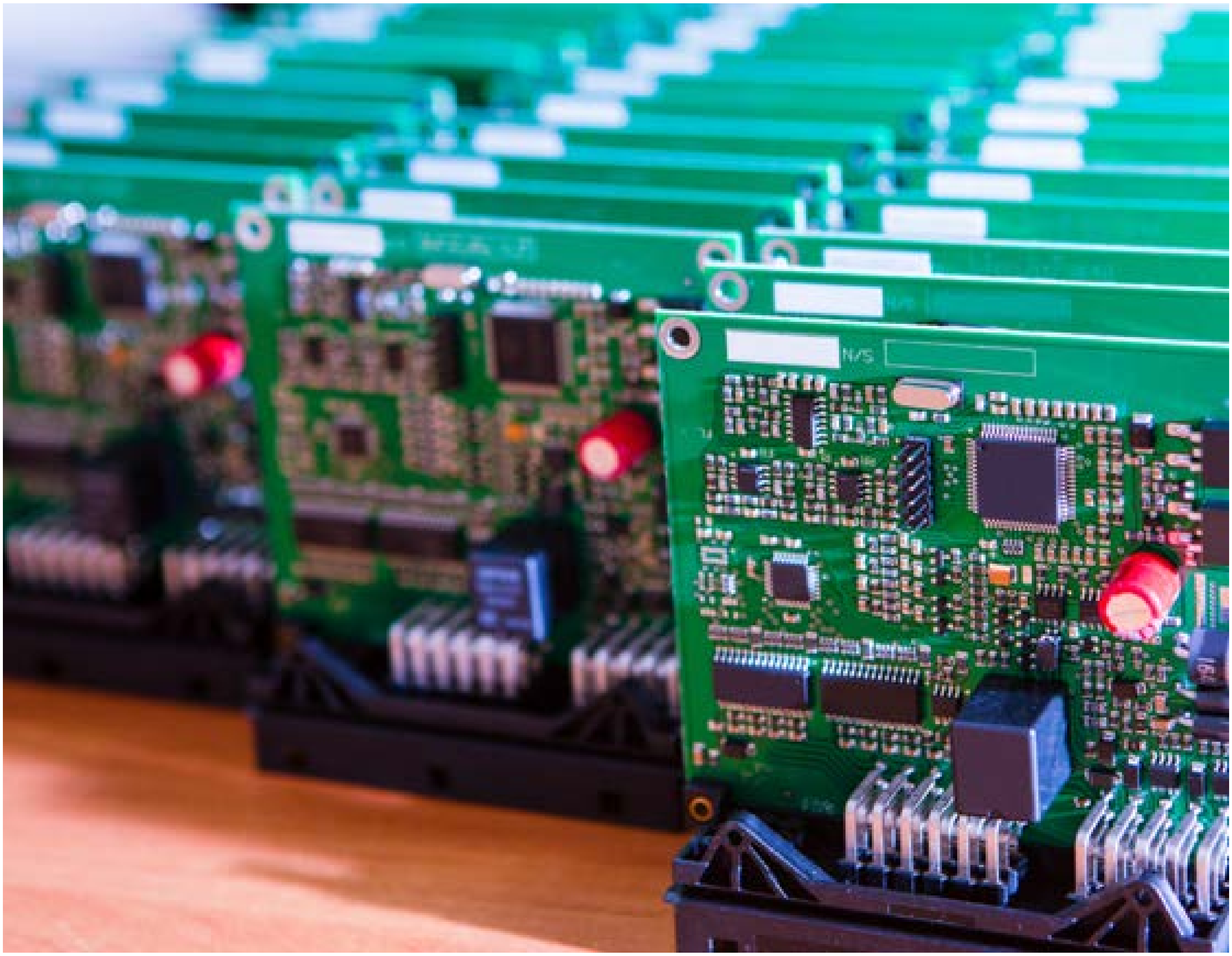
New Surface-Mount Packaging Standards

Vishay Continues to Set Industry Standards for Surface-Mount Packages

By Alex Pluemer for Mouser Electronics



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Semiconductor technology was at the root of the technological revolution that changed the world in the second half of the twentieth century. The development of naturally occurring elements and compounds like silicon or gallium arsenide (GaAs), with conductivity values that fell between conductors and insulators, enabled the creation of the transistor and the integrated circuit. Though powerful and ubiquitous, these semiconductor devices are delicate components whose functionality and life cycles may be impaired by an electrical short, overheating, or exposure to particulate matter. Therefore, they require protective packaging solutions to ensure optimal performance. Certain metals like aluminum, high-temperature plastics like siloxane polyimide, organic substrates like epoxy resin, and some ceramic composites can all be used to construct durable protective casings for semiconductors that don't adversely affect conductivity or performance.

As electronic applications and devices continue to evolve, so too has printed circuit board (PCB) design and manufacturing. The demand for greater component density on PCBs has driven the development of innovative packaging methods and attachment techniques, enabling the use of both sides of a PCB and significantly enhancing functionality within a compact form factor. Through new soldering methods and advancements in automated manufacturing processes, PCB design and assembly have become so intricate that automated inspection systems are often required to ensure the integrity and reliability of components and connections.

In this paper, we'll explore the genesis and evolution of semiconductor packaging technology, from the early days of through-hole assembly to the advent of surface-mount technology like enhanced surface-mount power (eSMP®), dual flat no-leads (DFN), and FlatPAK™ 5 x 6 packaging solutions from Vishay Intertechnology, Inc.

Overview of Packaging Technologies

Historically, packaged semiconductors were attached to PCBs by running leads (or pins) through apertures in the board **(Figure 1)** and then soldering them to either side—a method known as through-hole assembly. By plating these apertures with conductive materials, developers could make connections between different components on the board, even if they were not directly next to each other. Although through-hole technology has largely been phased out of PCB design and manufacturing in the last thirty years, it's still employed in more robust designs and components that require increased mounting strength, better heat dissipation, and greater resistance to mechanical stress

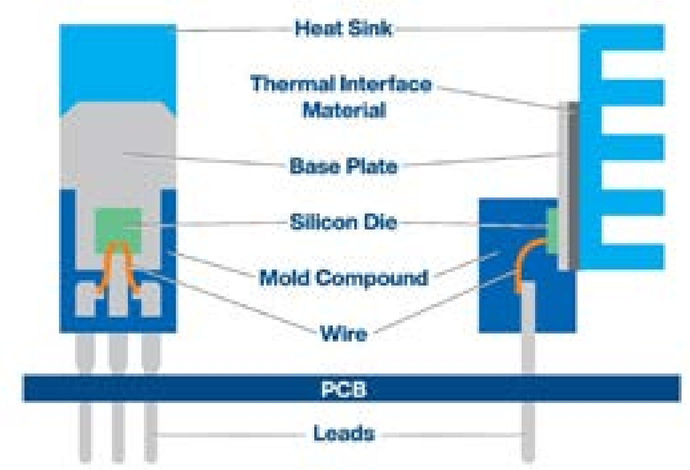

Figure 1: *View of a typical through-hole package with a heat sink. (Source: Mouser Electronics)*

As technology advanced, the need for more compact and efficient designs led to the development of surface-mount technology (SMT) in the 1960s. Through gradual growth and development, SMT became widely adopted across the industry in the 1980s. The advent and proliferation of SMT allowed developers to fit more components onto a single PCB and reduce the overall size of their complete design. Surface-mount devices (SMDs) are now the standard in PCB manufacturing, and the technology **(Figure 2)** is constantly evolving to meet the needs of engineers looking for optimal performance in increasingly smaller form factors.

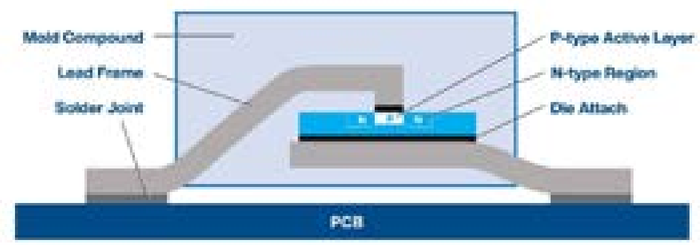

Figure 2: *Example structure of an SMD transistor. (Source: Mouser Electronics)*

SMDs are typically lighter and considerably smaller than similar through-hole devices, a significant factor in the production of handheld electronics. SMT is faster, more efficient, and less costly to manufacture than through-hole technology, as it allows for greater automation in the manufacturing process. Additionally, without the need to drill holes in the board and bend and solder pins, the manufacturing process is shorter and simpler, with fewer mechanical errors and reduced downtime. The increased rate of production and more reliable manufacturing processes make SMDs more cost-effective and more reliable than their predecessors.

Although SMT is already the standard in PCB design and manufacturing, market research still anticipates significant growth for surface-mount technology and components in the near future. The SMT market projects a compound annual growth rate of 10.8 percent over the next seven years and could exceed US$90 billion by 2030.

The Evolution of Surface-Mount Technology

Newer surface-mount technologies and packaging solutions enter the market as emerging solutions and eventually displace older, mature technologies that become obsolete **(Figure 3)**.

Figure 3: *The evolutionary life cycle of surface mount technology. (Source: Vishay)*

Innovations in SMT packaging often involve advancements in packaging materials, bonding methods, and die-supporting substrates. These improvements are sometimes complemented by advances in manufacturing techniques, such as automated optical inspection (AOI) and enhanced thermal transfer methods, as well as automated placement and soldering processes. Below are a few notable SMT packaging innovations:

- Surface-mount connections: Transitioning from gull-wing pins to under-chip surface-mount tabs has allowed for dramatic space reductions on the board.
- Inspection and Reliability: Packaging with surface mount tabs eliminates the need for AOI or X-ray verification of solder efficacy, helping to lower manufacturing costs and improve reliability.
- Heat Transfer: Expanding tabs beneath SMD components has improved heat transfer out of the die onto the PCB, thereby increasing reliability and enhancing the device's power efficiency

These SMT packaging innovations have paved the way for a number of components that offer significant enhancements over previous products

eSMP

Vishay's eSMP packages are a more compact and efficient solution than previous iterations of SMT for PCB design and manufacturing due to their reduced form factor and reliability **(Figure 4)**. The expanded cathode pad design enables maximized power ratings while still downsizing the overall form factor and saving valuable board space. Devices in the eSMP series include TMBS®; Schottky rectifiers; FRED Pt® rectifiers; ultrafast recovery, avalanche, standard- and fast-recovery rectifiers; PAR® TVS; TransZorb® TVS; ESD protection diodes; and Zener diodes. eSMP devices are an optimal solution for lighting and telecommunications applications, industrial or automotive applications requiring The low profile of

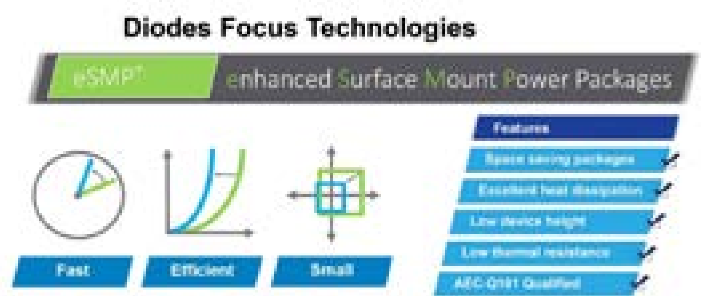

Figure 4: *Vishay's eSMP packaging solutions. (Source: Vishay)*

the eSMP series of packaging solutions is a significant upgrade for SMT. The MicroSMP, for example, is just 2.5mm × 1.3mm and only 0.65mm high, allowing for closer stacking of boards and more overall board space in multi-board designs. The MicroSMP also takes up 57 percent less board space than its predecessor, the SMA package.

DFN

Vishay's DFN packaging solutions also offer a reduced footprint while providing much lower thermal resistance **(Figure 5)** and overall package inductance. The DFN 1006 package is only 1mm × 0.6mm, providing more available board space with a reduced size profile, significantly lower thermal resistance, and reduced inductance due to shorted leads.

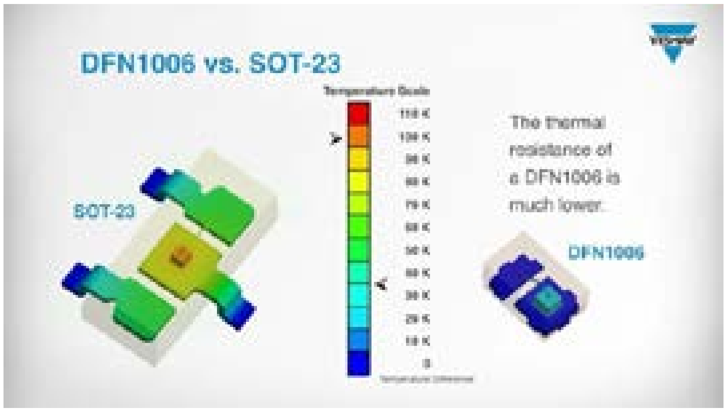

Figure 5: *DFN packages deliver significantly lower thermal resistance than SOT packages. (Source: Vishay)*

These properties make DFN packages optimal for high-power density and mid-range switch frequency applications **(Figure 6)**.

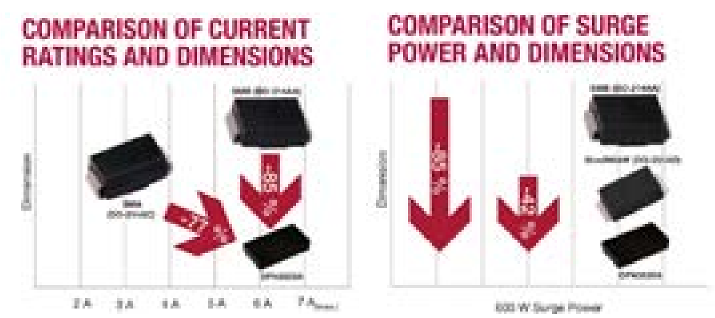

Figure 6: *DFN packaging solutions provide greater efficiency in a smaller form factor than their predecessors. (Source: Vishay)*

Without visible solder joints to inspect, DFN packages implement wettable flanks on the sides of the package to make the soldering connections. Specific DFN packages also boast an automated optical inspection (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 of packages is highlighted by the DFN3820A, designed primarily for rectifiers and transient voltage suppressors. With a 3.8mm × 2.0mm footprint and a height of just 0.88mm, it's significantly smaller than an SMP package case while delivering up to double the performance of an SMP under equivalent thermal conditions. Rectifiers in a DFN3820A package have a maximum 7A rating, and DFN-packaged components are AEC-Q101 certified for automotive applications and have applications in industrial settings, computers, consumer electronics, and telecommunications.

Like the Power DFN series, Vishay's Signal DFN packages also provide reliable performance in a smaller form factor than the competition. The DFN Ultra Compact model for small signal Zener and Schottky switching diodes takes up only 10 percent 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 **(Figure 7)**. Their leadless, compact packaging (1mm × 0.6mm × 0.45mm) delivers extreme reliability and better power dissipation than its predecessors while reducing noise and current leakage.

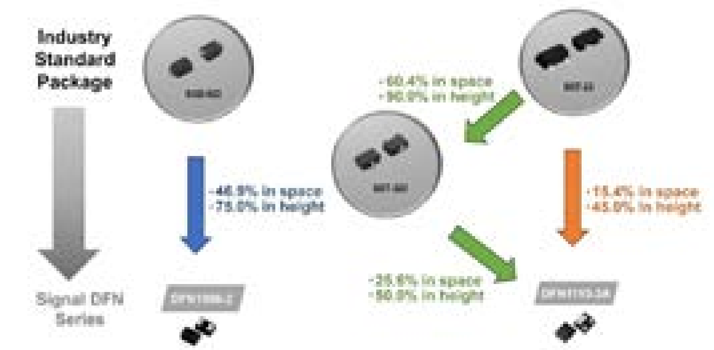

Figure 7: *DFN packaging solutions reduce chip height by up to 75% and nearly 50% in overall space. (Source: Vishay)*

FlatPAK 5x6

Vishay's FlatPAK 5 x 6 package offers a reduced form factor that distinguishes it from other package designs. This package saves board space by providing equivalent functionality in a single package that typically requires two SMC-size packages in more conventional designs **(Figure 8)**. FlatPAK 5 x 6 packages use oxide planar technology to deliver more efficient performance in an even smaller package. Their significantly reduced footprint and wide operational temperature range also make them 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 applications.

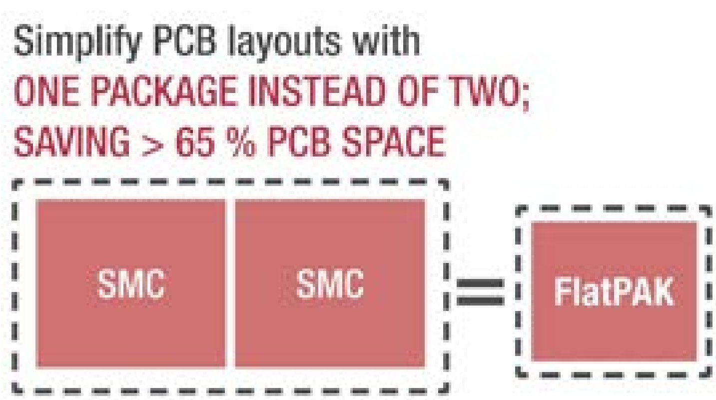

Figure 8: *FlatPAK packaging solutions can bundle two SMCs into a single, slimmer package with a smaller footprint. (Source: Vishay)*

Vishay's Role in the Evolution of SMT

Vishay has been designing and manufacturing electronic components for over sixty years, developing products ranging from high-power capacitors to small light-emitting diodes—The DNA of tech®. As applications and use cases continue to change and expand, semiconductor packaging solutions must evolve with them to provide the improved thermal resistance, power efficiency, and resistance to mechanical stress that modern industrial or automotive applications require. Developing slimmer packaging with smaller form factors is also key to increasing component density in mobile devices that get smaller with each new iteration. Vishay's optimal semiconductor packaging solutions play a role in growth areas, including factory automation, electric and hybrid automobiles, wireless networking technology, and the industrial Internet of Things.

Conclusion

Since their pivotal role in the technological revolution of the mid-twentieth century, semiconductors have driven innovation across a wide range of electronic applications, from the smallest handheld devices to large-scale industrial and automated manufacturing systems. Semiconductors have been at the forefront of innovation in electronic components, meeting the needs of new use cases and packaging solutions and delivering lower thermal resistance and better protection from physical stressors like heat and vibration.

Vishay continues to explore new ways to innovate semiconductor packaging to provide engineers with more reliable components and greater component density on the board. Vishay's 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. Vishay's continuous investment in developing semiconductor packaging solutions meets the ever-evolving needs of engineers in a rapidly changing technological landscape.

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