Better cooling performance in a compact design

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For effective component performance, continuous advancements in both MOSFET and package technology are essential. The new OptiMOS series in the SSO10T package is a robust solution for optimizing performance and reliability.

According to Infineon, more than 120 MOSFETs will be installed in every passenger car with a combustion engine by 2025 [1]. Key drivers of growth are legislation in CO2 reduction, the expansion of driver assistance systems, and applications aimed at enhancing occupant comfort. Reasons enough for suppliers to increase their production capacities and advance MOSFET technology.

Package and semiconductor chip determine the properties of MOSFETs

The properties of a packaged MOSFET are determined both by the package and the MOSFET die, i.e. the actual semiconductor chip. The overall electrical resistance of the component is the combination of the $R_{DS(on)}$ of the die (chip) and the electrical resistance of the package connection. The smaller the $R_{DS(on)}$ of the MOSFET die, the greater the percentage of the electrical resistance of the package connection in relation to the overall resistance. The respective spice models provide an indication of the distribution of the overall resistance between the actual $R_{DS(on)}$ of the chip and the power resistance of the package. The spice models of Infineon MOSFETs are generally unencrypted and available on the home page.

As soon as current flows through the component, conductivity losses arise according to the following equation:

$$P_{tot} = I^2 \times R_{DS(on)}$$

The resulting heat must be dissipated into the environment. This requires the lowest possible thermal resistance R_{thJA} between the die and the outer surface of the package.

Efficient cooling is crucial for performance and reliability

In the automotive industry, MOSFET dies are frequently engineered to withstand high temperatures and harsh environments, ensuring they meet the demands of vehicle operation.

Nevertheless, cooling the MOSFETs is crucial for performance and reliability. This is often accomplished through the use of highly conductive materials, optimized heat sink designs, and efficient heat dissipation methods. Top-side cooling is ideal for automotive MOSFETs, as the active components that generate heat during operation are situated on top of the chip. Effective top-side cooling can be achieved using thermal pastes, thermal films, heat sinks, and various other thermal solutions. By dissipating heat from the top-side of the MOSFET, the operating temperature is

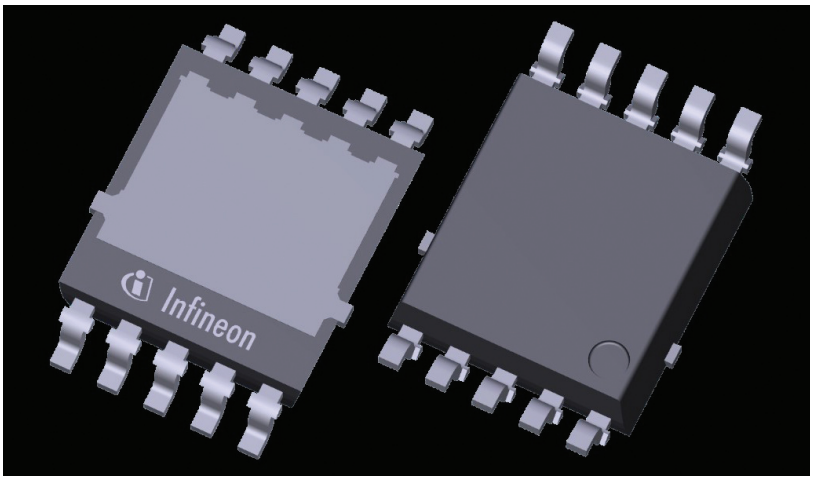

Figure 1: The SSO10T 5x7 package with top-side cooling (source: Infineon)

OptiMOS™6/7 – 40V - SSO10T 5x7 Top Side Cooling Product Portfolio

Group	Product	max $R_{DS(on)}$ [mΩ]	I_D (DC current) [A]	I_D (chip limitation) [A]	Q_G typ. [nC]	$V_{GS(th)}$ [LL/NL]
2	IAUCN04S7N006T	0.62	165	540	122	NL
1	IAUCN04S6N007T	0.75	120	390	100	NL
1	IAUCN04S6N009T	0.90	120	330	85	NL
1	IAUCN04S6N013T	1.32	120	230	52	NL
1	IAUCN04S6N017T	1.73	120	200	37	NL

Figure 2: Infineon's product portfolio for 40 V MOSFETs of the OptiMOS 6/7 series with an SSO10T package (source: Infineon)

OptiMOS™ 7 - 80V - SSO10T
Leading Edge Product Portfolio

Group	Product	max $R_{DS(on)}$ [mΩ]	I_D (DC current) [A]	I_D (chip limitation) [A]	Q_G typ. [nC]	$V_{GS(th)}$ [LL/NL]
1	IAUCN08S7N016T	1.6	165	235	20	NL
2	IAUCN08S7N019T	1.9	165	203	TBD	NL
2	IAUCN08S7N024T	2.4	165	167	TBD	NL
2	IAUCN08S7N046T	4.6	100	100	TBD	NL

Figure 3: Infineon's product portfolio for 80 V MOSFETs of the OptiMOS 7 series with an SSO10T package (source: Infineon)

reduced, thereby improving the performance, reliability, and service life of the component.

To ensure effective component performance, continuous advancements in both MOSFET and package technology are essential. The new OptiMOS-MOSFETs in an SSO10T package serve as a prime example of this (Fig. 1).

In the OptiMOS6 series for 40 V (Fig. 2) and OptiMOS7 series for 80 V (Fig. 3), both featuring an SSO10T package, the dies are contacted in a plane manner using copper clips rather than thin wires. This method ensures excellent thermal and electrical connection between the chip and the package. Heat is mainly dissipated via a contact surface on the top-side of the package.

Thermal interface material (TIM) can be used for the thermal connection to a cooling surface. These films or pastes level out any unevenness and roughness of the surfaces. Depending on the material, the films also provide electrical isolation between the component and the cooling surface. Rutronik stocks thermal interface materials, e.g. from Fischer Elektronik and Innotape.

High power density – even in limited installation spaces

The advantages of the top-side cooling of MOSFETs are many. In addition to an increase in overall efficiency, more compact designs are possible. This approach allows the thermal flow resulting from the power loss of the MOSFETs to be transferred directly from the component surface to a cooling surface or heat sink. There is no longer a need for diversion through the printed circuit board. This helps reduce the thermal resistance between the MOSFET and the heat sink. The printed circuit board can thus be less complex. Thermal vias and the insulated metal substrate (IMS) embedded in the PCB, which otherwise reduce the heat resistance of the printed circuit board, are no longer needed.

The effective heat dissipation enhances thermal impedance by 20 to 50 percent (Fig. 4), which boosts the operating temperature range or enables the components to achieve greater performance at the same operating temperature. The design also supports higher application currents, which can replace larger packages and provide additional space savings, for example. Top-side cooling in combination with the OptiMOS 40 V family enables higher power densities, which is crucial in applications with limited installation space.

Furthermore, the Infineon SSO10T package is listed as LHDSO-10 JEDEC, which makes it easier to interchange with components from other suppliers. The availability of second sources is a key selection criterion, enhancing the customer's supply assurance for the placement location on the PCB.

Typical automotive applications for top-side cooling MOSFETs are electric power steering, electric brakes, power distributors, and electric auxiliary drives. The design allows for a thermally optimized mechanical construction, resulting in higher power densities and system-level savings. Other suppliers offering MOSFETs with top-side cooling include, e.g., Vishay and Toshiba.

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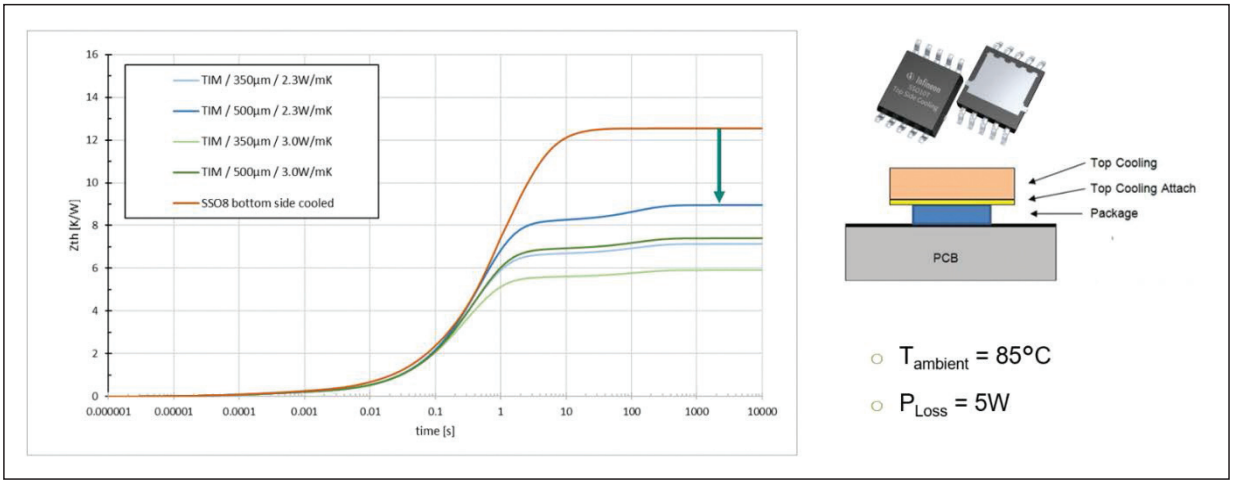

Figure 4: Comparison of thermal impedance across pulse durations with various thermal coupling methods: Depending on the material and thickness of the thermal interface, the thermal resistance is reduced by 20 to 50 percent (left). Design of the top-side cooling (right) (source: Infineon)