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Bring your design to the next level of efficiency with OptiMOS™ 6 100 V power MOSFET technology

Key features, benefits, and application examples of Infineon's novel design concept

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Introducing a game changer for high switching frequency applications.

High efficiency, power density, and better thermal behavior are the key trends when it comes to power management. Infineon is constantly working on introducing highly innovative power MOSFET technologies able to meet the requirements for all applications.

Recently, Infineon introduced the latest OptiMOS™ 6 100 V power MOSFET technology which, together with OptiMOS™ 3 and OptiMOS™ 5, comprise the industrial power MOSFET portfolio. In addition, the StrongIRFET™ power MOSFET family complements the portfolio when ease of use and broad availability are the key requirements (**Figure 1**).

OptiMOS™ 6 100 V power MOSFET technology comes with a novel cell design, exploiting a full tri-dimensional charge compensation principle and enabling remarkable improvements in lowering on-state resistance. The new cell structure also comes with a completely redesigned gate trench, leading to an outstanding reduction of the gate-to-drain charge Q_{gd} and total gate charge Q_g.

Finally, the introduction of the metal gate technology brings several advantages in MOSFET

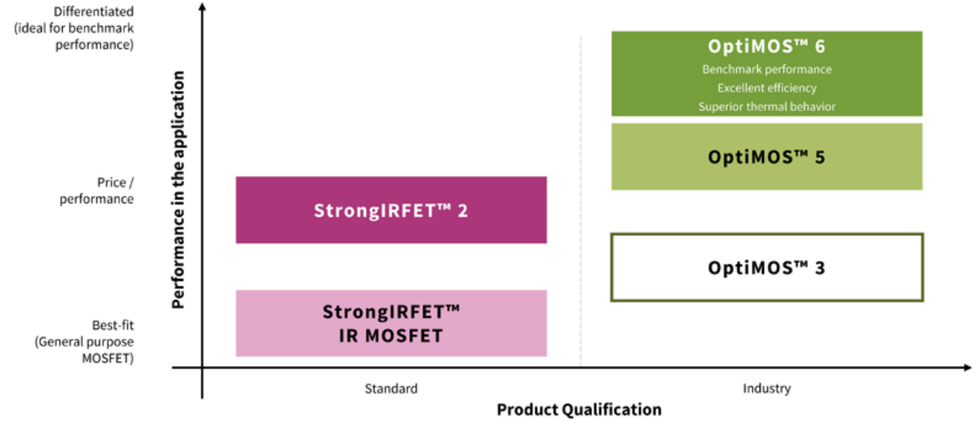


Figure 1: Infineon StrongIRFET™ and OptiMOS™ power MOSFET 20-300 V technologies

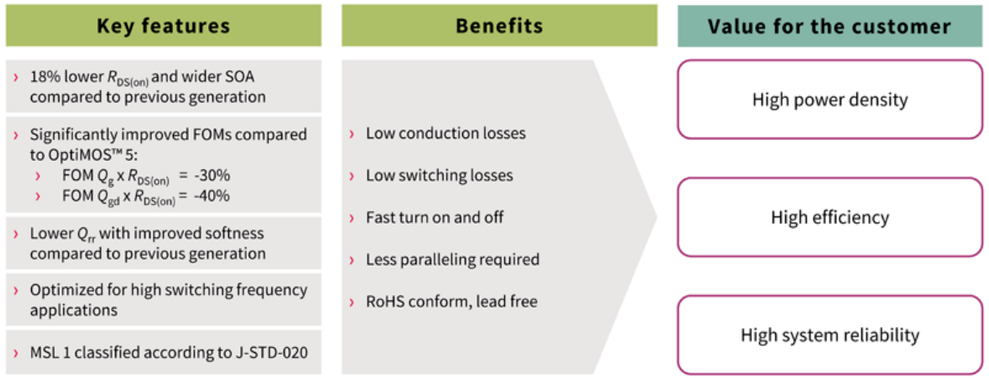


Figure 2: Key features and benefits of OptiMOS™ 6 100 V power MOSFET technology

commutation like excellent immunity against induced return-on.

Compared to the well-established OptiMOS™ 5, Infineon's leading thin wafer technology enables significant performance benefits (**Figure 2**):

- $R_{DS(on)}$ reduced by 18 percent,
- Improved Figure of Merit (FOM) Q_g×$R_{DS(on)}$ of about 30 percent,
- Improved FOM Q_{gd}×$R_{DS(on)}$ by 42 percent,
- Wider Safe Operating Area (SOA)

Thanks to the significant improvements, OptiMOS™ 6 100 V technology allows lower conduction and switching losses, faster turn-on and off as well as lead-free and RoHS compliant products.

The new technology shows well-balanced improvements across all the FOMs, leading to significant advantages for high-frequency Switched Mode Power Supplies (SMPS) operation, as well as for solar energy systems, where losses are associated with both charges (switching) and on-state resistance (conduction).

The best-in-class (BiC) $R_{DS(on)}$ also enables OptiMOS™ 6 100 V to be used in low-voltage motor drives in battery-powered applications (BPAs) such as drones, e-bikes, and power tools, as well as for the disconnect switch in battery management systems (BMSs) (**Figure 3**).

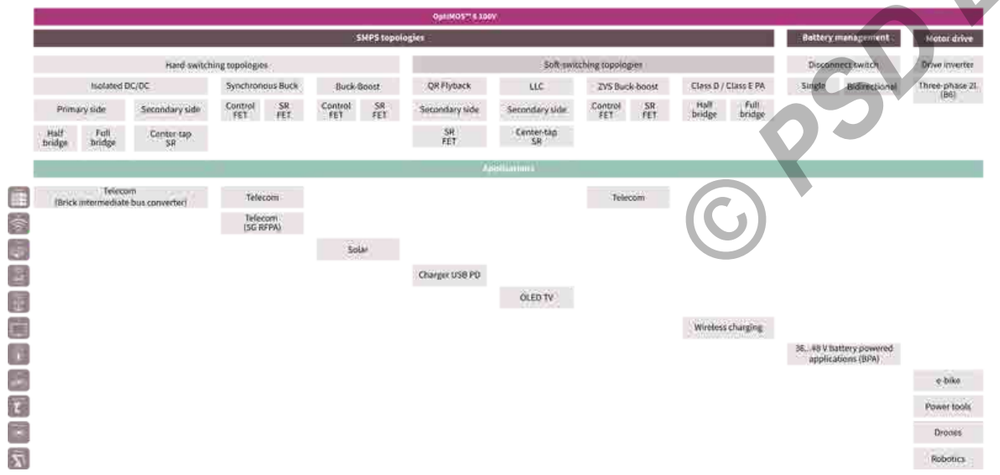


Figure 3: OptiMOS™ 6 100 V target applications

OptiMOS™ 6 vs. OptiMOS™ 5: Technology comparison

On-state resistance

$R_{DS(on)}$ is one of the key parameters of a MOSFET and denotes the on-state resistance measured between drain and source terminals. A lower value for $R_{DS(on)}$ value yields lower conduction losses and reduces or even eliminates the need for parallel devices. This saves costs and PCB real estate and leads to increased power density.

OptiMOS™ 6 technology in 100 V achieves roughly 20 percent lower $R_{DS(on)}$ comparing the best-in-class product (ISC022N10NM6) to OptiMOS™ 5 (BSC027N10NS5) in a SuperSO8 package. The improvement in specific on-state resistance brought by OptiMOS™ 6 allows moving to a smaller package (PQFN 3.3x3.3) for the same $R_{DS(on)}$, leading to higher power density.

Gate charge

Gate charge is the amount of charge that needs to be supplied to the gate to turn on (drive) the MOSFET. A small value of Q_g denotes low driving losses and higher switching speed. The innovative gate trench design leads to an outstanding reduction of both gate-to-source and gate-to-drain specific capacitances resulting in 35 percent lower Q_g and 45 percent better Q_{gd}. This is reflected in the gate figures of merit, FOM_g and FOM_{gd}. These FOMs, usually expressed in mΩ×nC, summarize conductivity and switching performances for a technology. The new OptiMOS 6 100 V shows an improvement of 30 percent and 43 percent, respectively, compared to the previous generation of OptiMOS™ 5 100 V MOSFETs (see **Figure 4**).

Safe operating area (SOA)

SOA is a diagram defined by the absolute maximum values for voltage and current the MOSFET is able to withstand when its case temperature is held steadily at T_c = 25°C. The MOSFET must never be exposed to conditions outside the safe operating area.

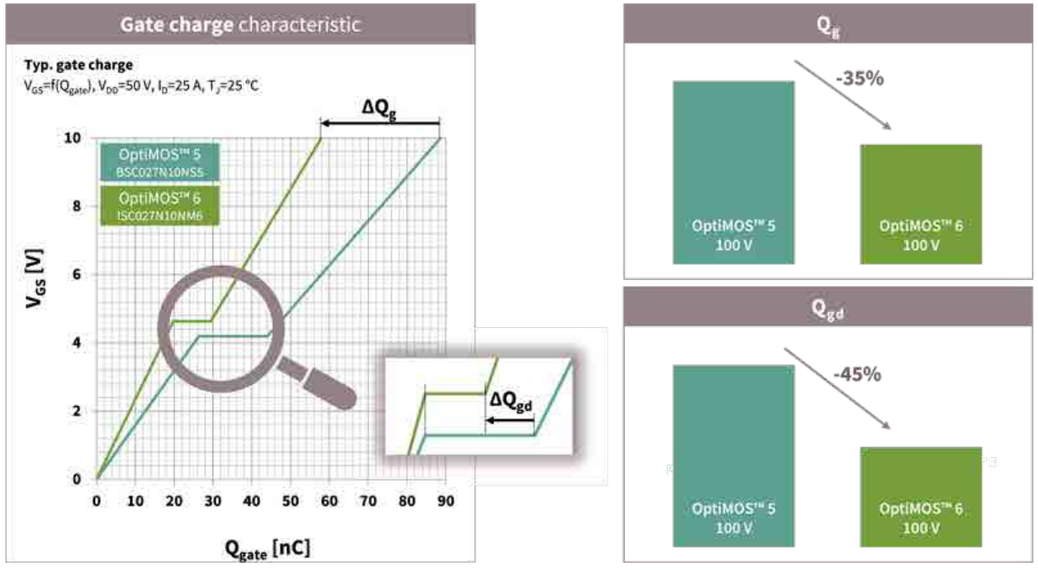


Figure 4: OptiMOS™ 6 vs. OptiMOS™ 5 gate charge characteristics

Application	Trend	OptiMOS™ 6 value proposition
Telecom	5G requires a reduction of operating and maintenance costs for both macro and small cells	New products with best-in-class figures of merit for high-power, high-switching frequency applications. Improved reliability due to reduced power losses and lower temperature
Solar	Reduce the overall cost of solar installation by using one optimizer or micro-inverter for 2 or 4 photovoltaic modules instead of only one	Best-in-class figures of merit enable high efficiency with the lowest power losses (conduction, switching)
Battery-powered applications (BPA)	Improvement in thermal performance and power density	Best-in-class products with low $R_{DS(on)}$
Battery management systems (BMS)	Replacement of lead-acid batteries Li-ion for higher energy density, lighter weight, and better environmental capabilities	Best-in-class products with low $R_{DS(on)}$ and wide SOA

Table 1: Application trends and OptiMOS™ 6 solution to bring your design to the next level

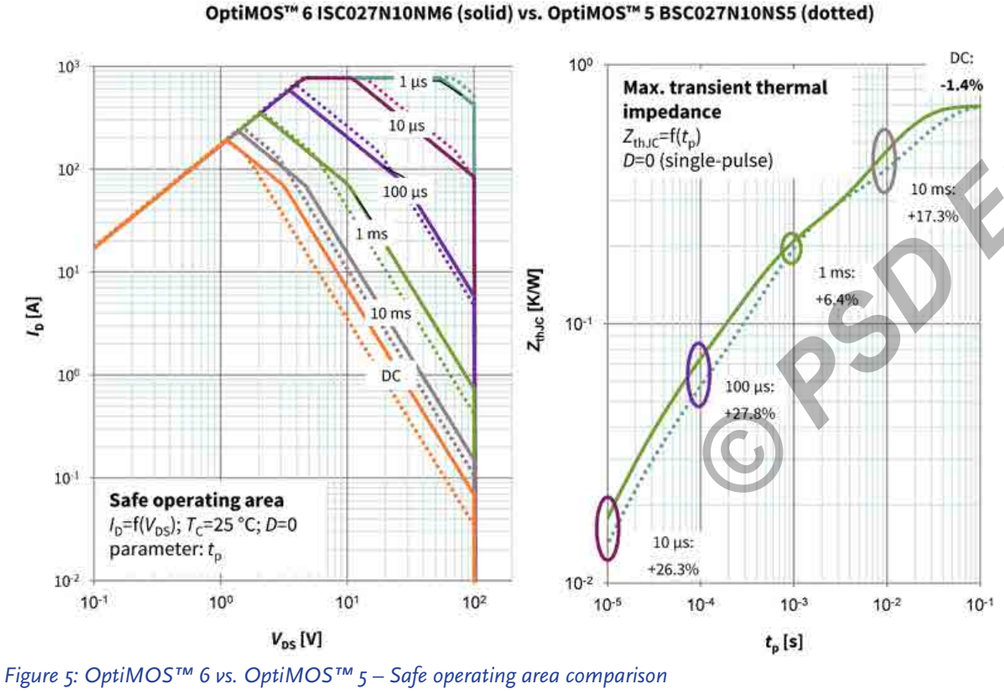
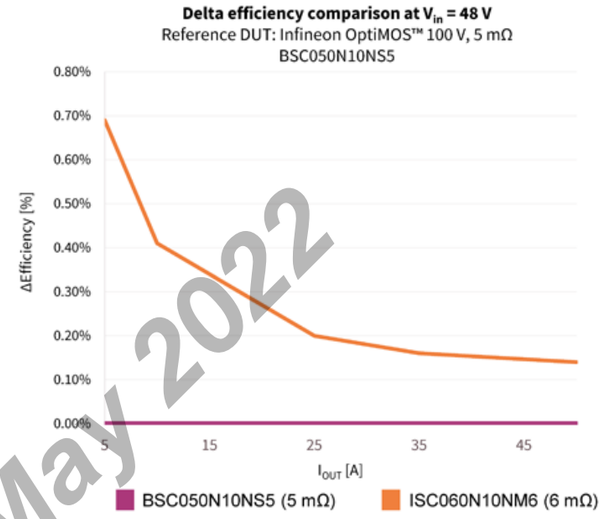


Figure 5: OptiMOS™ 6 vs. OptiMOS™ 5 – Safe operating area comparison



Efficiency comparison		
Load [A]	OptiMOS™ 5 BSC050N10NS5	OptiMOS™ 6 ISC060N10NM6
5	87.80 %	88.49 %
10	92.14 %	92.55 %
25	95.37 %	95.57 %
35	95.64 %	95.80 %
50	95.37 %	95.51 %

Temperature comparison		
Load [A]	OptiMOS™ 5 BSC050N10NS5	OptiMOS™ 6 ISC060N10NM6
5	44.6°C	43.7°C
10	50.2°C	47.3°C
25	57.1°C	54.9°C
50	87.7°C	85.5°C

Figure 6: Efficiency and temperature comparison of ISC060N10NM6 and BSC050N10NS5 on 600 W 48-12 V FB/FB CDL telecom quarter brick

When a new technology node is introduced, a narrowing in the SOA is expected. In the power-limited region, the current capability depends on the transient thermal impedance that usually increases for new technologies. Despite this, the new OptiMOS™ 6 100V, thanks to the technology improvements, still shows a wider SOA in the thermal stability-limited region compared to OptiMOS™ 5. At DC, OptiMOS™ 6 shows a wider SOA in all regions, thanks to the lower R_{thJC} (see **Figure 5**)

How can OptiMOS™ 6 100 V technology bring your solution to the next level

Different applications have different requirements depending on the markets and trends. OptiMOS™ 6 100 V technology can bring your design to the next level of efficiency and power density, as shown by the measurement results for the telecom, solar, and power tools applications. **Table 1** summarizes the key trends and how OptiMOS™ 6 can bring advantages to the designs intended for these applications.

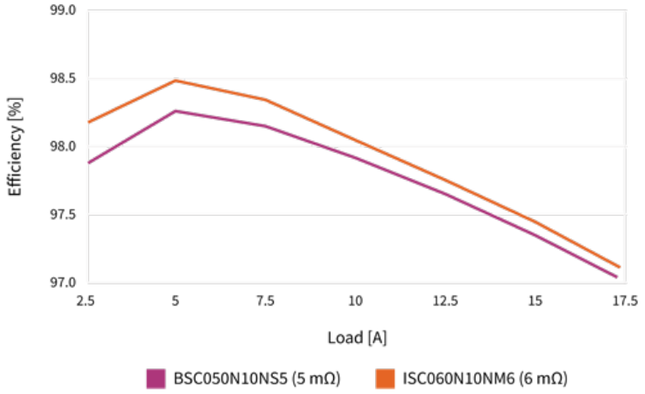
Application benefits in real-life examples

Telecom infrastructure

The first application is a telecom DC-DC intermediate bus converter (IBC) in a distributed-power open standards alliance (DOSA) quarter-brick form factor. The converter is based on a full-bridge topology with full-bridge rectification. As a hard-switched topology, both conduction and switching losses impact the overall system efficiency.

The right fit for this application is a device combining the lowest possible $R_{DS(on)}$ with the need for low charges, and the best fit – for a typical 600 W converter – is found in devices in the near 6 mΩ range. The new OptiMOS™ 6 100 V (ISC060N10NM6, $R_{DS(on),max}$ = 6 mΩ),, packaged in SuperSO8, is compared in this application with the BSC050N10NS5 from the previous generation of OptiMOS™ 5 MOSFETs.

The results (**Figure 6**) show the new OptiMOS™ 6 achieving up to 0.4 percent better efficiency and lower temperature compared to BSC050N10NS5 ($R_{DS(on),max}$ = 5 mΩ), even through the device under test shows 20 percent higher $R_{DS(on)}$. The benefits are higher system reliability as well as lower system cost.



Efficiency comparison		
Load	OptiMOS™ 5 BSC050N10NS5	OptiMOS™ 6 ISC060N10NM6
25%	98.21 %	98.46 %
50%	98.04 %	98.19 %
100%	97.05 %	97.12 %

Temperature comparison (T_c [°C])		
Load	OptiMOS™ 5 BSC050N10NS5	OptiMOS™ 6 ISC060N10NM6
100%	77°C	71°C

Figure 7: Solar system comparison between OptiMOS™ 5 and OptiMOS™ 6 for power optimizer.

Solar energy systems
Switching losses represent a large share of the total losses in solar optimizers. For this reason, a good balance between $R_{DS(on)}$ and charges is required. Fitting products for a power optimizer (synchronous buck stage) are 100 V power MOSFETs in SuperSO8 package, with $R_{DS(on)}$ of about 5-6 mΩ.

A comparison is carried out between OptiMOS™ 5 (BSC050N10NS5, $R_{DS(on),max}$ = 5 mΩ) and OptiMOS™ 6 (ISC060N10NM6, $R_{DS(on),max}$ = 6 mΩ) (**Figure 7**). With about 18 percent higher $R_{DS(on)}$, OptiMOS™ 6 achieves better efficiency compared to OptiMOS™ 5, by lowering switching losses. Thanks to the excellent switching performances, the new product showcases about 6°C lower temperature at full load compared to the OptiMOS™ 5 version.

Power tools
Thermal performance and power density are the key challenges for motor control applications. Best-in-class products with low $R_{DS(on)}$ are beneficial to achieving high efficiency in power tools.

In the comparison between OptiMOS™ 5 (BSC027N10NS5) and OptiMOS™ 6 at high-torque condition, OptiMOS™ 6 achieves about 0.5 percent higher efficiency resulting in 12 percent lower power losses in the system (**Figure 8**). This enables improved thermal designs with a longer lifetime.

Figure 8: Power tools comparison between OptiMOS™ 5 and OptiMOS™ 6

OptiMOS™ 6 100 V: Energy-efficient solution contributing to a green environment
Costs are not the only drivers of change. Since the 2015 Paris agreement on climate change mitigation, the telecom industry has proven to be one of the private sectors leading the trend toward carbon neutrality by gradually committing to science-based targets (SBTs) in line with limiting global heating to 1.5°C above pre-industrial levels.

The new Infineon OptiMOS™ 6 100 V supports the trend toward increased efficiencies, helping customers in the telecom industry reduce emissions to net-zero, making life greener. With OptiMOS™ 6 power MOSFET technology, it is possible to reduce the energy consumption by 1 million euros over 10 years (based on telecom IBC at nominal line voltage considering a European country of roughly 80 million people). The electricity saved over one year of operation equals the yearly electricity consumption of about 170 households.

Conclusion
OptiMOS™ 6 100 V brings the industry standard to the next level: lower conduction losses and increased power density to provide the highest performance in applications meeting contemporary requirements. The new technology is available in a broad portfolio of SuperSO8 and PQFN 3.3x3.3 packages covering from best-in-class to more price/performance-optimized products. To learn more, make sure to visit the OptiMOS™ 6 webpage. Scan the QR code.

In addition, applications and test results are available for you on our OptiMOS™ 6 100 V tech insights page. Scan the QR code.

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