

# Keeping Ahead Through Higher Power Density

## Infineon Presents New MOSFET Generation in 40V and 60V

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The trend in electronics to higher performance and power densities continues in 2012. Depending on application, the focus is either on package miniaturization or on increasing output currents and hence output power in unchanged package volumes.

Another frequent wish is to be able to finally dispense with through-hole devices, such as TO220 or even TO247.

The latest-generation INFINEON MOSFETs with 40V and 60V blocking voltage now enable design engineers to meet these requirements.

The OptiMOS™3 technology developed by Infineon a few years ago already succeeded in significantly reducing the on-state resistance  $R_{DS(on)}$  by as much as 60% compared to established MOSFET technologies. A significant reduction in the  $C_{GS}$  (gate to source) and  $C_{GD}$  (gate to drain) capacitances was also achieved. This permitted far faster switching with substantially reduced switching losses.

Whereas large through-hole devices in TO220 or even TO247 were still needed in many applications before this technology was developed, it was now often possible to dispense with a complex and costly heat dissipation system.

Instead, it was now possible to use a SMD package, such as D2PAK and SuperSO8 (5x6mm<sup>2</sup>), without an additional heat sink, significantly simplifying the thermal management.

As a result, an increase in the power density of the switch mode power supplies could be achieved, accompanied by a reduction in system costs.

On the heels of the new 30V silicon technology which last year revealed great benefits in the lowest voltage range, work on the development of the new 40V and 60V MOSFETs has now been completed.

A direct comparison with OptiMOS™3 technology displays not only a dramatic reduction in the on-state resistance  $R_{DS(on)}$ , but also a huge improvement in the switching characteristics.

The  $R_{DS(on)}$  has been reduced by 40% in the new MOSFETs with 40V blocking voltage, by even over 48% with 60V blocking voltage.

INFINEON is the first semiconductor manufacturer in the world to now launch a 40V MOSFET having a maximum  $R_{DS(on)}$  of less than 1mΩ in SuperSO8.

In addition, the integration of a Schottky-like diode results in higher system efficiency and smaller voltage spikes. It is a monolithically integrated cell structure offering key advantages in a wide load range over the normally effective body diode of the MOSFET. On the one hand, the on-state voltage is significantly lower (at 10A diode current e.g. 0.45V instead of 0.65V). On the other, the reverse recovery charge ( $Q_{rr}$ ) is negligibly small, precisely because no body diode has to be recharged.

These variants are identified by the last letter "I" (e.g. BSC010N04LSI).

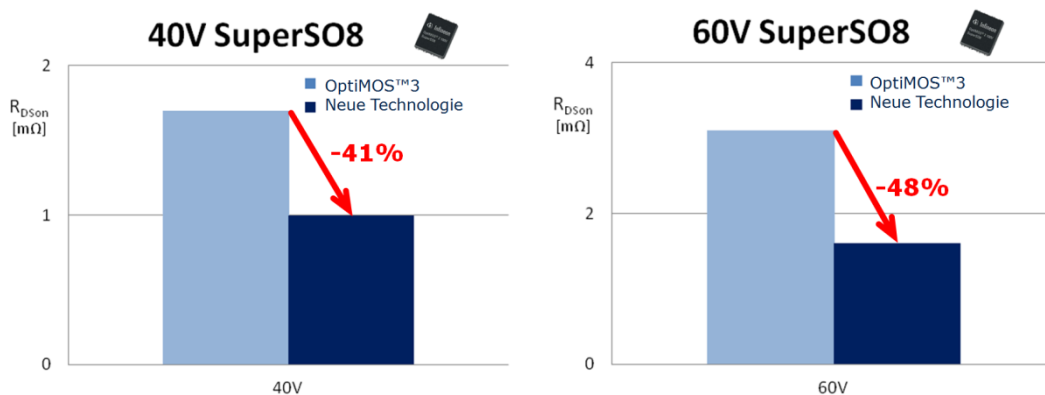


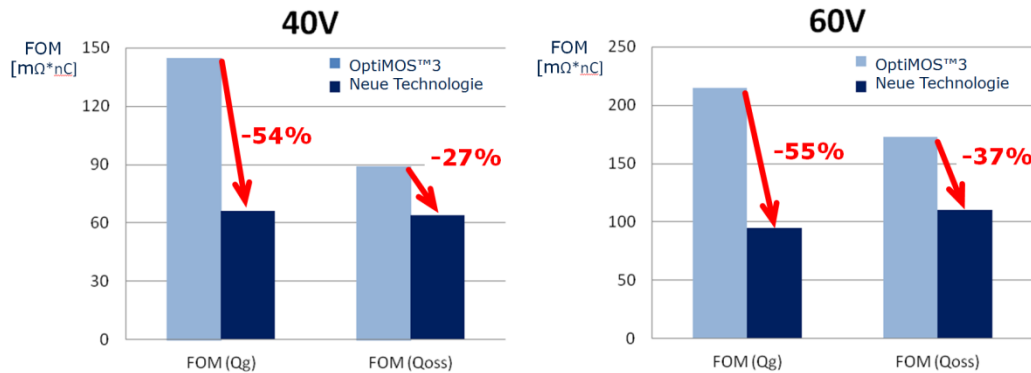
Fig. 1: Improvement of the on-state resistance  $R_{DS(on)}$  with the new generation of INFINEON MOSFETs

While the  $R_{DS(on)}$  is one of a MOSFET's most important parameters, other values are usually of equal importance or sometimes of even greater importance to the design engineer.

Essentially they are the switching losses:

The Figure of Merit – gate charge (FOM  $Q_g$ ) indicates how much charge and hence energy has to be brought to the MOSFET gate for defined switching, whereas the Figure of Merit – output capacitance (FOM  $Q_{oss}$ ) is an indication of the energy lost in non-resonant switching.

These two values are shown for the 40V and 60V MOSFETs in Figure 2.



**Fig. 2: Improvement of the FOM  $Q_g$  and FOM  $Q_{oss}$  parameters important to switching for 40V and 60V blocking voltage with the new OptiMOS™ technologies**

The significant reduction of all 3 parameters, i.e.  $R_{DS(on)}$ , FOM  $Q_g$  and FOM  $Q_{oss}$ , in the new OptiMOS™ 40V and 60V devices can be clearly seen.

This becomes particularly clear with the 60V MOSFETs where the total  $R_{DS(on)}$ , i.e. including the not insignificant package resistance, was almost halved.

Infineon offers a broad portfolio (Fig. 3) in both voltage ranges, enabling the design engineer to easily find an optimal solution for his application.

40V	SuperSO8	S308					
	1 - 2 mΩ	BSC010N04LS BSC010N04LSI BSC014N04LS BSC014N04LSI					
	2 - 3 mΩ	BSZ023N04LS					
60V	TO-220	TO-262 (I <sup>2</sup> PAK)	TO-263 (D <sup>2</sup> PAK)	TO-263 (D <sup>2</sup> PAK 7-pin)	TO-252 (DPAK)	SuperSO8	S308
	1 - 2 mΩ	IPI020N06N	IPB014N06N	IPB010N06N		BSC016N06NS BSC028N06NS BSC039N06NS	
	2 - 4 mΩ	IPP020N06N IPP029N06N	IPB025N06N		IPD024N06N		BSZ042N06NS
	4 - 5 mΩ	IPP040N06N					
	5 - 6 mΩ		IPB056N06N		IPD053N06N		
	6 - 8 mΩ	IPP060N06N					

**Fig. 3: 40V and 60V portfolio**

### From the practical perspective

Why the improvement of all three parameters is so important is to be shown below on the basis of secondary-side rectification in a typical server power supply.

However, the values shown can easily be transferred to other applications as well. Using the new Infineon MOSFET generation substantially simplifies thermal management and hence saves cost in practically all applications in which 40V or 60V Schottky diodes have so far still been used.

A typical server power supply delivers at a 12V output between 600W and 2400W at 100% output load. Secondary-side rectification is effected as standard using synchronous rectifiers, i.e. MOSFETs. Depending on topology and design of the transformer, 40V, 60V or even 75V/80V MOSFETs are necessary.

If one considers the distribution of the losses in such a power supply with 50A output current at 12V output voltage, it is immediately evident that other loss mechanisms are dominant in the different load ranges.

The losses in the MOSFET are essentially

- 1) Gate drive losses
- 2) Output capacitance losses
- 3) Conduction losses /  $R_{DS(on)}$  losses)

Viewed across the entire load range, there is a considerable variation in the percentage of the various loss mechanisms in the total losses.

The conduction losses constitute the lion's share at a high output power and hence maximum current. The  $R_{DS(on)}$  losses here account for about 80% of the total losses. As output power becomes lower, another power loss mechanism becomes increasingly dominant though: output capacitance losses.

It accounts for more than half the total losses at 20% load.

Added to this are the gate drive losses (almost unchanged across the entire range), which contribute about another 30% to the total losses of the synchronous rectification.

Hence a large part of the losses occurs not during the conduction phase of the synchronous rectifier MOSFETs, but only during the few nanoseconds of the turn-on or turn-off operations.

The reason for this is easy to understand: both gate drive power and the output capacitance losses are almost independent of output current, hence have a constant value throughout the load range. In contrast, the conduction losses increase with the square of the current and are therefore mostly dominant even at medium output currents.

The conduction losses could be reduced relatively simply (naturally with far higher cost) by the parallel connection of a further MOSFET. In fact the conduction losses are then halved.

Since, however, now two MOSFETs would have to be driven and together they also have double the output capacitance, there is a clear deterioration of the situation in the lower power range: the dominant losses there are likewise doubled.

A decrease of the losses at high output power hence results in an increase of losses in the low load range.

In introducing the new MOSFETs with 40V and 60V blocking voltage, Infineon provides a possibility of significantly reducing the losses throughout the load range.

A direct comparison of measured curves reveals further benefits of the new MOSFET generations. Even though the results with the current MOSFET generation are already close to optimal, deployment of the new technology can significantly improve them yet further.

Not only is the maximum voltage spike considerably lower, the oscillations after the switching operation proper are far smaller and hardly present.

### Conclusion

Both the new 40V and the 60V technology now offer the design engineer the possibility to significantly increase the power density. The switching performance has been optimized, enabling a lower MOSFET voltage class to be selected in many applications with all the benefits in terms of  $R_{DS(on)}$ , cost, power loss etc.

A 1000W power supply is now possible without parallel connection of MOSFETs in synchronous rectification.

Now a single MOSFET in SuperSO8 suffices per rectifier branch. The result is an increase in power density accompanied by reduced cost.