www.eenewseurope.com

eeNews europe

electronics europe News

December 2018

Infineon´s answer for flyback topologies

european business press

Elevate the performance of flyback topology to the next level

Introducing Infineon's new 950 V CoolMOS™ P7

MSc Stefan Preimel, Application and Concept Engineer -
High Voltage MOSFET, Infineon Technologies AG

Designers of low power switched-mode power supplies (SMPS) have challenges on their agenda due to the fact that market trends - such as ever smaller, smarter and more powerful devices – undoubtedly and unignorably impact their daily job. Thus, more compact form factor enabling higher power density, intelligent system-to-system/system-to-human communication that ensures environment- and human-friendly operation, and the need of outputting more power have been and will remain in the focus for SMPS designs.

These market trends lead to more compact designs resulting in more portable systems and devices. Electricity bills will be reduced due to less energy consumed and environmental footprint will also improve as a result of the fact that less power supplies are needed at home consequently less pollution in production will be, and less waste when it comes to end-of-life disposal.

But first of all to realize all of these benefits, a semiconductor solution is needed that enables improved thermal management, higher output power and smaller form factors leading to higher power densities hand in hand with high reliability that guarantees longer product lifetime.

High voltage (HV) MOSFETs play a fundamental role in flyback topology so finding the right MOSFET is critical to overcome the challenges posed by market requirements. Infineon's 950 V CoolMOS™ P7 offers compelling benefits in SMPS flyback topologies in adapters and chargers, LED lighting, smart metering, auxiliary power and industrial power.

In this technical article Infineon will have a closer look at the most important design criteria for flyback topologies, as well as the promise of CoolMOS™ P7 in terms of efficiency.

Design considerations for flyback topology with high voltage MOSFETs

To identify the best-fit MOSFETs, designers have to have a solid, system-level understanding of flyback topologies and of how to use the MOSFET in their application. State-of-art flyback designs switch high voltage (HV) MOSFETs at 40 kHz – 100 kHz to reduce the need for EMC optimization, while other designs switch at higher frequencies in order to achieve size reduction associated with smaller magnetic components. Better light-load efficiency requires lower switching losses, whilst high full-load efficiency requires lower conduction losses.

Gate charge (Q_g) and energy stored in the output capacitance (E_{oss}) are important MOSFET device parameters because they have significant contribution to switching losses. Q_g is closely linked to the effort to drive MOSFETs - smaller values lead to lower driving losses. E_{oss} is the energy consumed by the MOSFET when it switches on. Also $R_{DS(on)}$ (drain-source on-resistance) is an important device parameter, it determines conduction losses and has a critical role at full-load condition.

Another area that have increasing importance in selecting the right MOSFET is ESD ruggedness. It helps to improve production yield, thus to reduce field returns.

Engineers who are under pressure to reduce time-to-market also have to consider robustness, ease of driving and design-in. The $V_{GS(th)}$ (gate-to-source threshold voltage) and its deviation need to be taken into account: lower $V_{GS(th)}$ makes MOSFETs easier to drive, while a smaller $V_{GS(th)}$ deviation gives designers more freedom in SMPS design.

950 V CoolMOS™ P7 – a new benchmark in efficiency and thermal performance

The latest 950 V CoolMOS™ P7 from Infineon sets a new benchmark in the 950 V-rated Superjunction technology combining best-in-class performance with ease-of-use.

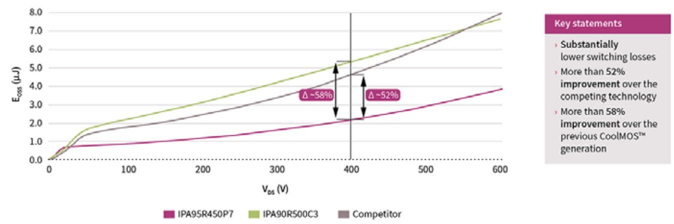

Figure 1: Key parameter (E_{oss}) comparison for TO-220 FullPAK 450 mΩ equivalent part from different suppliers (test specification according to datasheet)

Figure 1 gives an overview of key parameters for TO-220 FullPAK products with a maximum $R_{DS(on)}$ rating of between 450 mΩ and 500 mΩ.

CoolMOS™ P7 has been fully optimized to deliver excellent performance. Compared to Infineon's 900 V CoolMOS™ C3 and the next best competitor alternative, one can clearly see that E_{oss} (responsible parameter for "switching losses" in the application) for CoolMOS™ P7 is lowered by more than 50%. In the case of E_{oss} and C_{iss} (input capacitance), a further improvement can be observed compared to the preceding CoolMOS™ generation and the competitor device.

In Figure 2 it is depicted how a 20 W single stage flyback LED driver application can benefit in terms of efficiency and thermal performance when using a CoolMOS™ P7 MOSFET. Significant improvement in both areas at any load condition is measured.

Simply by changing to a CoolMOS™ P7 device, better efficiency of 0.15% at light load and an efficiency improvement of 0.4% at full load (see Figure 2 (b)) can be achieved. The improvement at light-load reduces system idle losses, while at full-load the observed efficiency improvement leads to 10°C lower MOSFET temperature resulting in a significantly reduced overhead for thermal management.

After discussing efficiency and thermal behaviour, let's have a look at power density. There are typically two ways to realize the high power densities that are required in today's applications.

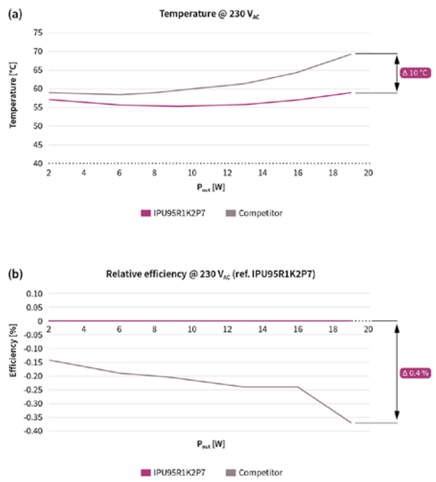

Figure 2: Thermal performance (a) and relative efficiency (b) comparison for competitor device in a 20 W LED driver; plug and replace flyback MOSFET

One way is to use a HV MOSFET at high switching frequencies. This delivers better efficiency, and the high frequency switching also allows for using smaller magnetic components to reduce overall system size. CoolMOS™ P7 is able to address such designs with significantly lower switching losses.

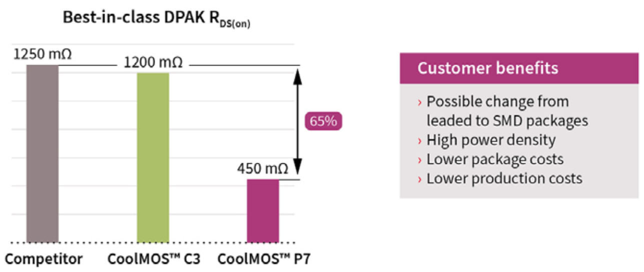

Figure 3 Overview of lowest DPAK $R_{DS(on)}$ of 950 V-rated Superjunction MOSFETs

The other method is to use a HV MOSFET with a smaller footprint. CoolMOS™ P7 family supports this approach as well by offering DPAK devices with lower $R_{DS(on)}$ ratings. As indicated in Figure 3, CoolMOS™ P7 has best-in-class and lowest DPAK $R_{DS(on)}$ rating of 450 mΩ, which is 65% lower than that of the next best competitor alternative. Better DPAK products help designers to save space to increase power density and to reduce production costs by utilizing fully automated assembly processes (when changing from through hole devices (THD) to surface mount device (SMD) packages).

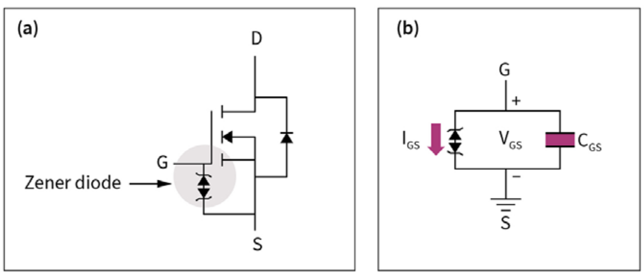

Figure 4 (a) Schematic of CoolMOS™ P7, (b) a zoom in view of the area between gate and source as highlighted in (a)

Another important feature of the CoolMOS™ P7 product family is its integrated Zener diode between the gate and the source (see Figure 4 (a)). Its function is to provide ESD protection. As shown in Figure 4 (b), during an ESD event the voltage between the gate and the source (V_{GS}) is clamped by the Zener diode. This reduces ESD related failures, therefore improves quality and reliability.

This ESD protection feature also helps to reduce ESD related failures during assembly, leading to lower production costs. A reduction in field returns can be achieved too by avoiding gate oxide overstress which is an issue that leads to reduced lifetime of a MOSFET; making it possible for a MOSFET that does not fail during assembly to fail in the field. When classifying the 950 V CoolMOS™ P7 based on the human body model (HBM), ESD ruggedness is class 1C for the 3.7 Ω $R_{DS(on)}$ device, while for the devices below 2 Ω is class 2. Based on the charge device model (CDM) model, ESD ruggedness is class C3.

The new enabler of another variant of driving flybacks more efficient

Most of the known flyback converters are designed with a RCD snubber network for clamping the V_{DS} at a certain level. By removing the snubber network and switching to a snubberless design, the efficiency can be further improved. 950 V CoolMOS™ P7 is an enabler of snubberless designs enablig additional efficiency improvement compared to well-known RCD snubber flybacks.

In addition to $R_{DS(on)}$ losses at full load, switching and snubber losses play a significant role in the overall losses of low power supplies. This is because of the high voltage operation up to 305 $V_{AC(in)}$ (and even higher input and bus voltages are possible).

Further improving the system efficiency, the snubberless flyback converter makes it possible to reduce the required PCB area and save the cost of the RCD network.

By removing two key loss mechanisms, the losses of the system can be reduced in a snubberless design. The first mechanism is that the RCD network charges up to the reflected voltage every switching cycle regardless of the system load. The leakage inductance energy increases this voltage too and leads to further losses across the snubber resistor. The second loss mechanism comes from the additional capacitance added to the switching node from the RCD network and from the need for charging the capacitance across the RCD diode junction. Both of these loss mechanisms can be eliminated by removing the RCD snubber network.

To keep the MOSFET V_{DS} from getting too high (in the case of 950 V, farther headroom/safety margin is present compared to an 800 V or a 900 V-rated solution), an additional drain-source capacitance (C_{DS}) can be added across the drain node of the MOSFET.

For more information on losses and special snubberless design criteria, a reference design is available from Infineon, demonstrating the benefits of a snubberless design in a 40 W adapter.

Designing with a new CoolMOS™ P7 family member

CooMOS™ P7 offers five $R_{DS(on)}$ classes in four package variants for the six main target applications listed in the introduction (i.e., adapter and charger, LED driver, smart metering, auxiliary and industrial power supplies). With this fine granularity in $R_{DS(on)}$, designers can easily find a component to fine tune their designs.

As demonstrated in this article, CoolMOS™ P7 combines outstanding efficiency with ease-of-use. This product family is ideal for flyback applications with outputs up to 150 W.

Infineon supports the design-in of CoolMOS™ P7 with a variety of application notes and reference designs, including the above mentioned 40 W adapter demonstration board and a 6 W bias supply. To find out more and explore the CoolMOS™ P7 family, visit www.infineon.com/P7.