Package Considerations for High Frequency Power Conversion Devices

Power conversion at switching frequencies 10 MHz and above requires both high-speed transistors and high frequency capable packaging. eGaN® FETs, the first enhancement-mode gallium-nitride-on-silicon field effect transistors, have demonstrated their ability to improve high frequency power conversion compared with the aging power MOSFET by providing unmatched device performance as well as packaging [1].

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This article will discuss the newest generation of eGaN FETs, the EPC 8000 series. This latest family of eGaN FETs further pushes the frequency capability of power conversion and targets higher frequency emerging applications such as envelope tracking.

Influence of Package on Performance

As power device technology evolves, improved device packaging must be also developed. To look at the impact of packaging on performance a 1 MHZ, 20 A, 12-1.2 V point of load (POL) converter with an EPC2015 eGaN FET is considered and shown in figure 1.

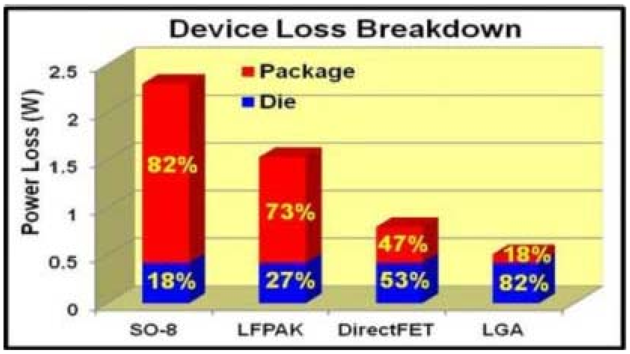

Figure 1: Device loss breakdown by package type

For an ultra-fast eGaN FET in a SO-8 package, only 18% of the switching losses are the result of the die, while 82% of the losses are introduced by the parasitics introduced by the package [2].

Evaluating an eGaN FET in a LFPAK package, an improvement to the SO-8 [3], 73% of the loss is still contributed by the package because the large common source inductance (CSI) limits the speed of the device [4].

The DirectFET [5], designed to minimize CSI, can improve performance over its predecessors and reduce the package related losses to 47% of the total loss. To fully utilize the improvements offered by gallium nitride a better package is required.

eGaN FET LGA Packaging

For the eGaN FET (Figure 2), a higher voltage lateral power device, all of the connections are contained on the same side of the die. This allows for the die to be mounted directly to the PCB, minimizing the total parasitics to the internal bussing and external solder bumps. To further decrease parasitics, the drain and source connections are arranged in an interleaved land grid array, providing multiple parallel connections to the PCB from the die.

The result of this improved packaging is a significant reduction in package related losses, with only 18% of these loss being contributed by the package and 82% from the die.

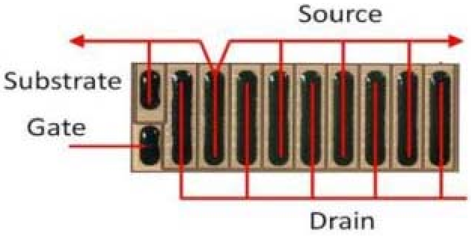

Figure 2: eGaN FET LGA connections layout

As transistor technology looks to move higher in switching frequency, the package becomes even more critical, positioning the eGaN FET to increase operating frequencies not possible with traditional MOSFETs. This is accomplished by providing improved device performance combined with an unmatched low parasitic package.

eGaN FETs for Higher Frequencies

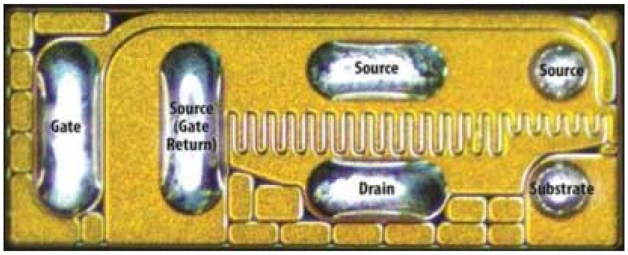

Figure 3: Gen 3 eGaN FET pin-out

The ultra-high speed switching capabilities of gallium nitride transistors have now been taken to the next level with the introduction of the third generation of eGaN FETs, the EPC8000 series [6]. In the EPC8000 family, the packaging is designed to extend the switching capability to beyond 10 MHz. Figure 3 shows the improved eGaN FET package. The key improvements made with this design are:

1. Separate gate return (source).
A separate gate return (This source terminal is dedicated to only the gate drive) for the gate circuit limits the common source inductance to inside the device itself. This reduction in common source inductance is critical to high frequency performance.

2. Low inductance gate.
The wider solder bar for the gate circuit significantly reduces the inductance of the gate circuit, thereby enhancing the speed of the connection to the gate driver.

3. Low internal parasitic Inductances.
The internal routing has been designed with high frequency applications in mind, and therefore internal parasitic inductances have been minimized for both the drain and gate circuits.

Design Example:
The EPC8000 family of devices targets compact, low power, high frequency applications. One example of this type of application is envelope tracking which requires a power supply to track the envelope of the signal transmitted to a radio frequency power amplifier (RFPA). Envelope tracking can significantly increase efficiency in the RFPA and, given the rapid expansion of wireless data transmission, This application will continue to grow.

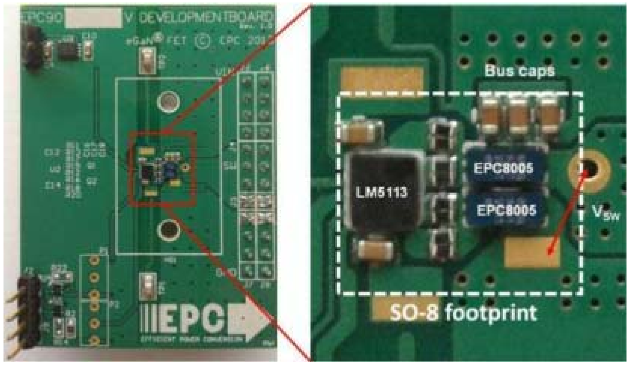

Figure 4: EPC9025 evaluation board with EPC8005 eGaN FETs and LM5113 gate driver

To demonstrate the EPC 8000 eGaN FET family in an envelope tracking application, a 42 V to 20 V, 40 W buck converter operating at 10 MHz with the 65 V, 275 mΩ EPC8005 is shown in figure 5. The board was designed using an optimal layout technique [7] to ensure the least amount of parasitic inductance and the highest efficiency. Figure 4 shows a photograph of the EPC9025 evaluation board fitted with EPC8005 devices and an LM5113 gate driver IC. It should be noted that the area occupied by the converter is smaller than the footprint of a SO-8 package.

The converter was tested at both 10 MHz and 5 MHz operations, and the efficiency is given in Figure 5. The plots show an 87% peak efficiency while operating at 10 MHz and 92% while operating at 5 MHz. The inductor used in the 5 MHz operation is the same as in the 10 MHz operation, and selecting a more optimal inductance could lead to even further improvement.

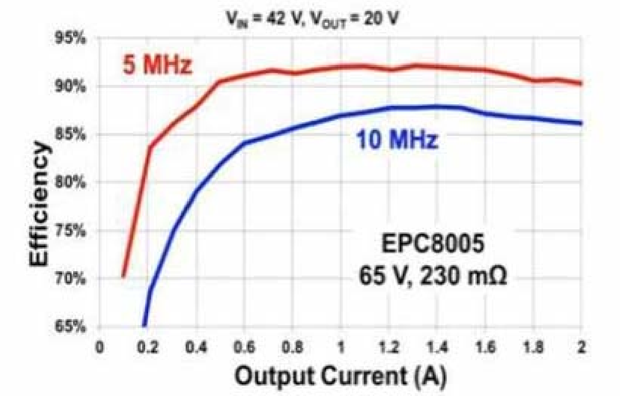

Figure 5: Efficiencies of EPC9025 operating at 5 and 10 MHz

Conclusion
Applications will continue to emerge requiring higher speed FETs, and the package becomes an essential component for achieving high performance at high frequencies. Therefore, as power transistors are designed with higher and higher switching speeds, particular attention must be paid to the package, the pin configuration and board layout. The innovative design of the eGaN FET packages allows designers to fully utilize GaN technology, offering unmatched high frequency performance.

Sources:

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