Building the Smallest and Most Efficient 48 V to 12 V DC to DC Converter using EPC2045

Motivation

The smallest, most cost effective and highest efficiency non-isolated 48 V to 12 V converter, suitable for high-performance computing and telecommunication applications, can be achieved by employing eGaN® FETs such as the EPC2045. The EPC9205 configured as a synchronous Buck converter yielded a power density of 1400 W/in^3 and is capable of delivering 15 A.

Introducing the EPC2045 eGaN FET

The EPC2045, shown in figure 1, is a Generation 5 eGaN FET rated at 100 V with 7 mΩ on-resistance that is capable of carrying a continuous current of 16 A. The EPC2045 is nearly one tenth the footprint of a comparable Si MOSFET and was chosen because it can switch much faster and has lower parasitic capacitances than equivalent silicon devices, yielding lowest switching loss operation even at higher switching frequency.

EPC9205 DrGaN Plus Module

The EPC9205 power module, with the block diagram schematic shown in figure 2, is configured as a synchronous Buck topology that is fitted with two EPC2045 eGaN FETs. The EPC9205 power module, shown in figure 3, also features the new uP1966A half-bridge gate driver IC from uPI Semiconductor Corp., input and output filters, as well as current and temperature sensing. A standard off-the-shelf, 4 mm high inductor is also included. The high frequency capability of eGaN FETs greatly reduces the filtering requirements, allowing for an optimized output filter inductor with much smaller size and lower loss.

EPC9205 Experimental Performance Validation

The EPC9205 achieves a peak efficiency of 96% at 10 A load, with a maximum FET temperature of 100°C under 400 LFM airflow. Figure 4 shows the load current range efficiency curve up to 15 A load when operating at 700 kHz.

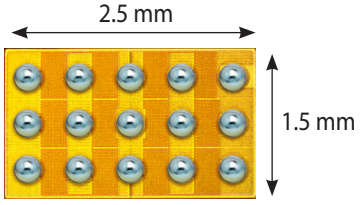

Figure 1: EPC2045 100 V eGaN FET with 7 mΩ on-resistance.

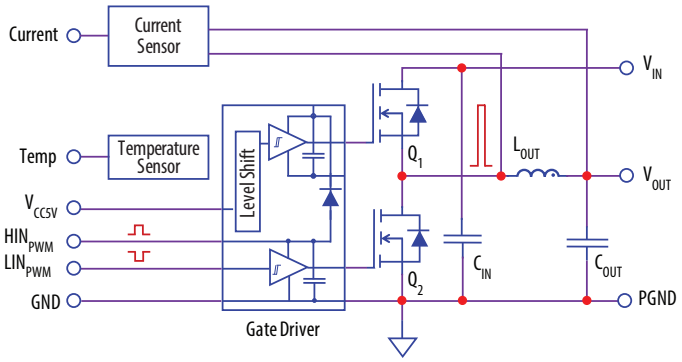

Figure 2: Block diagram schematic of the EPC9205 development board, fitted with EPC2045, is ideal for 48 V to 12 V intermediate bus conversion, and can also be used to produce output voltages as low as 5 V.

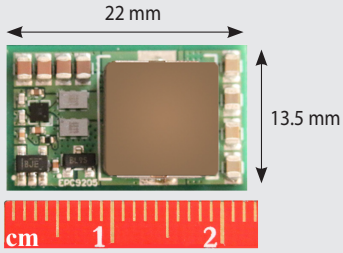

Figure 3: EPC9205 development board boasts a power density of 1400 W/in^3 when operating at 48 V input, 12 V output at 10 A load.

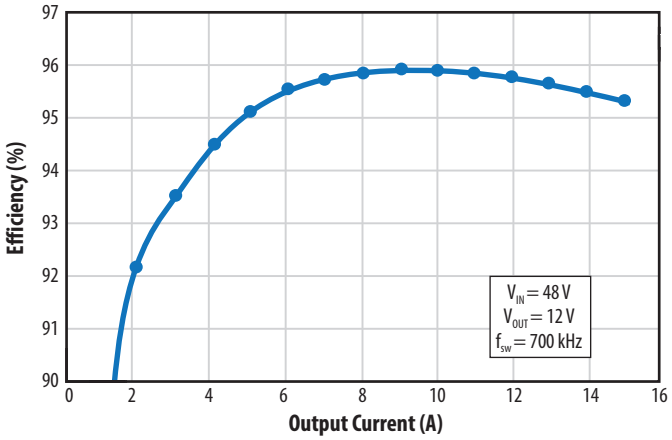

Figure 4: EPC9502 efficiency vs. output current for 48 V_{IN} to 12 V_{OUT} when operating at 700 kHz and using EPC2045 eGAN FETs.

Conclusions

Migrating an intermediate 48 V to 12 V bus converter design from Silicon MOSFETs to eGaN FETs offers reduction in both size and cost, while maintaining or exceeding efficiency targets. Table 1 shows the bill of materials that yields a cost per watt of less than $0.05.

Suitable controllers for the EPC9205 include the TPS53632G from Texas Instruments and when the EPC9205 is configured in a multi-phase system for higher output current capability, as demonstrated in the EPC9130, one can use the dsPIC33EP128GS704 from Microchip.

The eGaN FET based 48 V to 12 V, 10 A load converter was demonstrated to yield a peak efficiency of 96% with a power density of 1400 W/in^3, all with a cost below $0.05 per watt. This same bill of materials can be used for output voltages as low as 5 V.

48 V - 12 V 10 A Buck Converter		
Component	**Qty**	**eGaN FET**
Control Transistor	1	EPC2045
Rectifier Transistor	1	EPC2045
Inductor	1	IHLP-4040DZ-01 2.2uH
Input Capacitors	4	C2012X7S2A105M125AB
Output Capacitors	5	C2012X5R1E226M125AC
Gate Driver	1	uP1966A
Total		**Less than $0.05 per Watt**

Table 1:Bill of Materials for an eGaN FET based 48 V to 12 V converter based on 500 k unit pricing.