Building the Smallest and Most Efficient 48 V to 5 - 12 V DC to DC Converter using EPC2045 and ICs

Motivation

The smallest, most cost effective and highest efficiency non-isolated 48 V to 5 - 12 V converter, suitable for high-performance computing and telecommunication applications, can be achieved by employing eGaN® FETs such as the EPC2045. The EPC9205 DrGaN power module configured as a synchronous buck converter yielded a power density of 1400 W/in^3 when operating at 48 V input, 12 V output and 10 A load, and is capable of producing an output voltage ranging from 5 V to 12 V and delivering 14 A output current.

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 has lower parasitic capacitances and can switch much faster than equivalent silicon devices, yielding lowest switching loss even at higher switching frequency.

EPC9205 power module

The EPC9205 power module, with the block diagram schematic shown in figure 3, is configured as a synchronous buck topology that is fitted with two EPC2045 eGaN FETs. The EPC9205 power module, shown in figure 2, 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. 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

When stepping down 48 V to 12 V at 700 kHz, the EPC9205 achieves a peak efficiency of 96% at 10 A load, with a maximum FET temperature of 100ºC under 400 LFM airflow. Figure 4 shows the power efficiency curve for 12 V load up to 15 A output current.

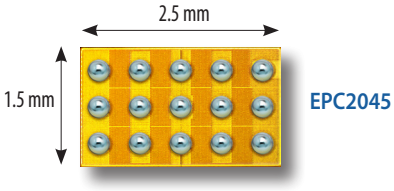

Figure 1. EPC2045 100 V eGaN FET with 7 mΩ on-resistance

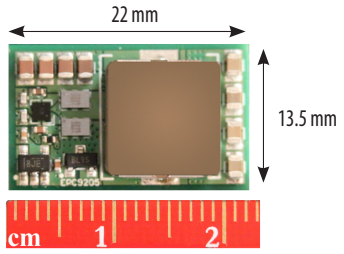

Figure 2: EPC9205 development board boasts a power density of 1400 W/in^3 when operating at 48 V input, 12 V output at 10 A load

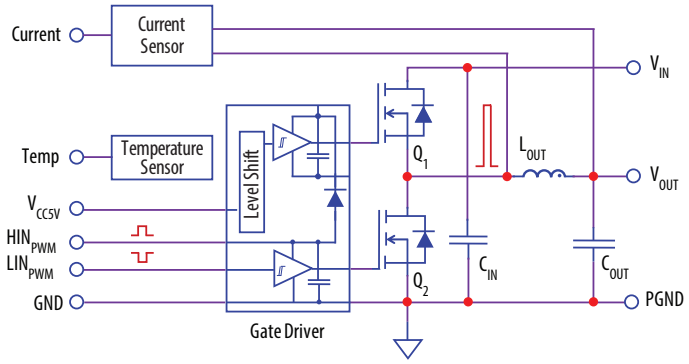

Figure 3. Block diagram schematic of the EPC9205 development board, fitted with EPC2045, is ideal for 48 V to 5 - 12 V intermediate bus conversion

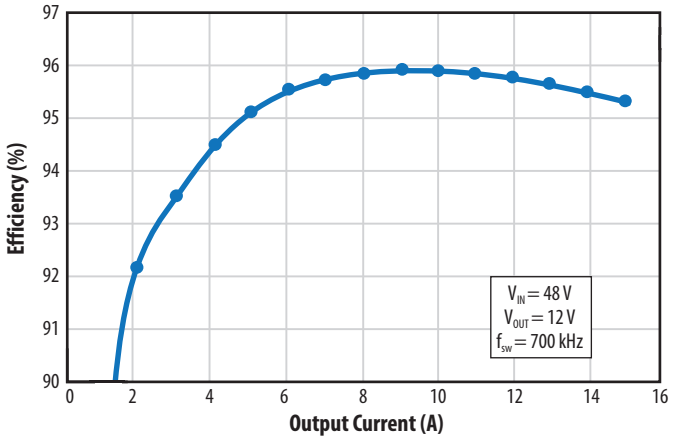

Figure 4. EPC9205 efficiency vs. output current for 48 V_{IN} to 12 V_{OUT} when operating at 700 kHz and using EPC2045 eGaN FETs

The same EPC9205 is also capable of producing output voltages as low as 5 V. Figure 5 shows the efficiency as function of load current at 5 - 12 V output when operating at 500 kHz.

Conclusions

Migrating an intermediate 48 V to 5 - 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 of an eGaN based 48 V to 12 V buck converter that yields a cost per watt of less than $0.05. This same bill of materials can be used for output voltages as low as 5 V.

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 Mircochip.

The eGaN FET based 48 V to 5 - 12 V, 10 A load converter was demonstrated to yield 5-12 V output with a peak efficiency of 96%, a power density of 1400 W/in^3, and a cost that can go below $0.05 per watt when operated with 12 V output.

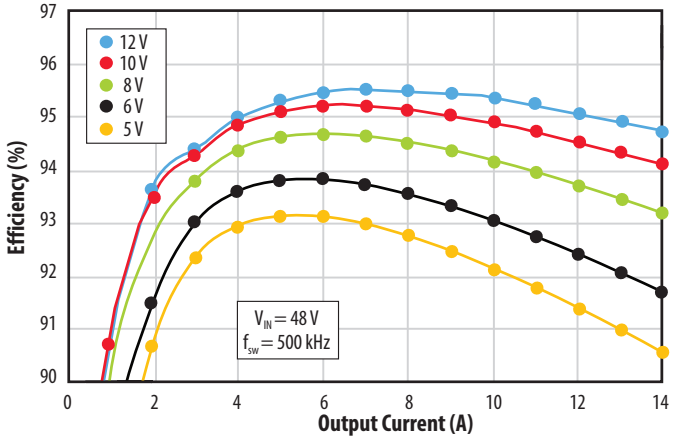

Figure 5. EPC9205 efficiency vs. output current for 48 V_{IN} to 5 -12 V_{OUT} when operating at 500 kHz and using EPC2045 eGaN FETs

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	uPI1966A
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

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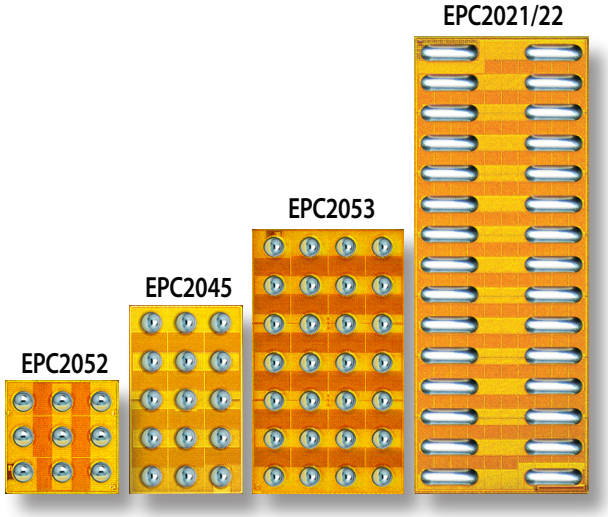

Figure 6: GaN power modules for DC-DC conversion, increasing efficiency across the 48 V to point-of-load power architecture

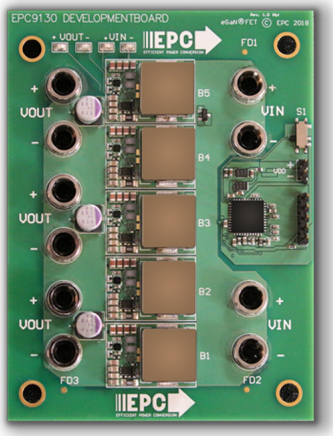

Figure 7: EPC9130 five-phase board with 12 A per phase has a maximum output current of 60 amps, making the board capable of over 700 W