Boosting Power Density in 48 V to 5-12 V DC to DC Converter Using EPC2053, with up to 25 A Output

EFFICIENT POWER CONVERSION

Motivation

The smallest, most cost effective, highest efficiency and 25 A capable non-isolated 48 V to 5-12 V converter, suitable for high-performance computing and telecommunication applications, can be accomplished by employing eGaN® FETs such as the **EPC2053**. The **EPC9093** GaN development board configured as a synchronous buck converter yields a main power stage area of only 10 mm x 9 mm, at least 2x smaller than its Si equivalent, and is capable of producing an output voltage ranging from 5 V to 12 V.

Introducing the EPC2053 eGaN FET

The EPC2053, shown in figure 1, is a Generation 5 eGaN FET rated at 100 V with 4 mΩ on-resistance that is capable of carrying a continuous current of 32 A and operating at up to 150°C junction temperature. The EPC2053 has lower parasitic capacitances and on-resistance than its silicon counterparts, yielding faster switching speed and lower power losses even at higher switching frequency. These characteristics enable increasing the output power while shrinking the volume of the converter.

EPC9093 GaN development board

The EPC9093 development board, with the block diagram schematic shown in figure 2, is configured as a synchronous buck converter that is fitted with two EPC2053 eGaN FETs. The EPC9093, with the main power stage shown in Figure 3, also features the new uP1966A half-bridge gate driver IC from uPI Semiconductor Corp. The main power stage occupies only 10 mm x 9 mm, and is at least 2x smaller than an equivalent Si MOSFET power stage. The high frequency capability of eGaN FETs greatly reduces the filtering requirements, allowing for a significant size and loss reduction in the output filter inductor as well.

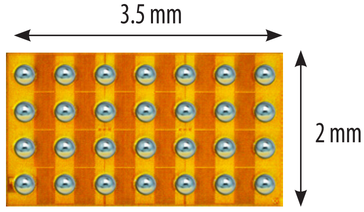

Figure 1: EPC2053 100 V eGaN FET with 4 mΩ on-resistance

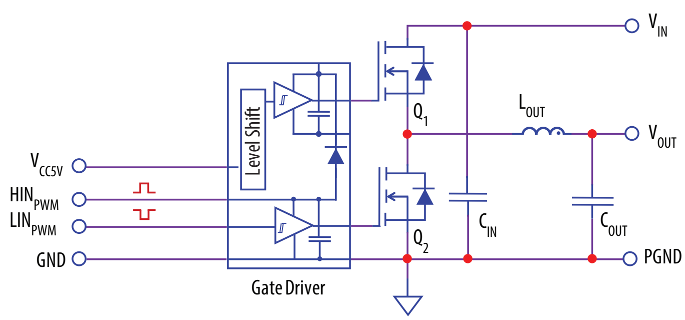

Figure 2: Block diagram schematic of the EPC9093 development board for evaluating 48 V to 5 - 12 V, and 25 A intermediate bus conversion

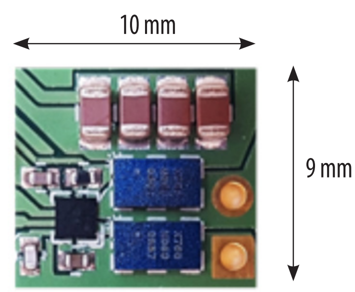

Figure 3: The EPC9093 development board fitted with EPC2053

EPC9093 experimental performance validation

When stepping down 48 V to 12 V at 700 kHz switching frequency, the EPC9093 achieves a peak efficiency of 97% at 15 A load and maintains the efficiency above 96.5% at 25 A load. Figure 4 shows the power efficiency up to 25 A output current for 5 V, 9 V, and 12 V output at 700 kHz operating frequency. A thermal image of the EPC9093 operating at 500 kHz, 12 V and 20 A output with 400 LFM airflow is shown in figure 5. The temperatures of the top and bottom eGaN FETs under this condition are 103°C and 87°C respectively.

The peak efficiency is still above 96% when the operating frequency is increased to 1 MHz. Figure 6 shows the efficiency as a function of the load current for 5 V, 9 V, and 12 V output at 1 MHz operating frequency.

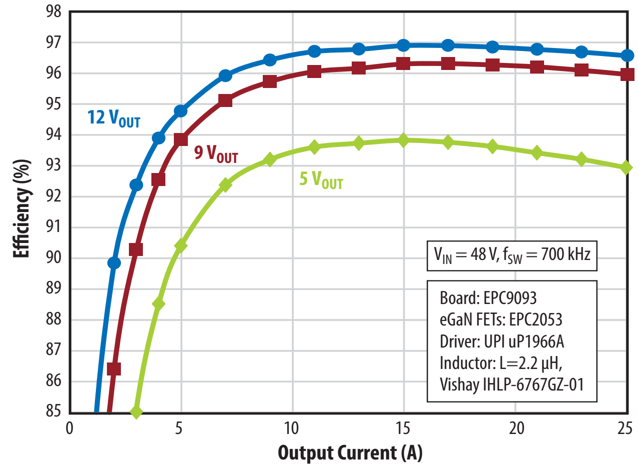

Figure 4: EPC9093 efficiency vs. output current for 48 V_{IN} to 12 V_{OUT} when operating at 700 kHz and using EPC2053 eGAN FETs

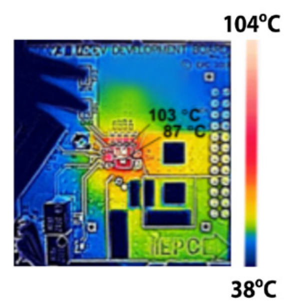

Figure 5: Thermal image of the EPC9093 operating at 500 kHz, 12 V and 20 A with 400 LFM airflow

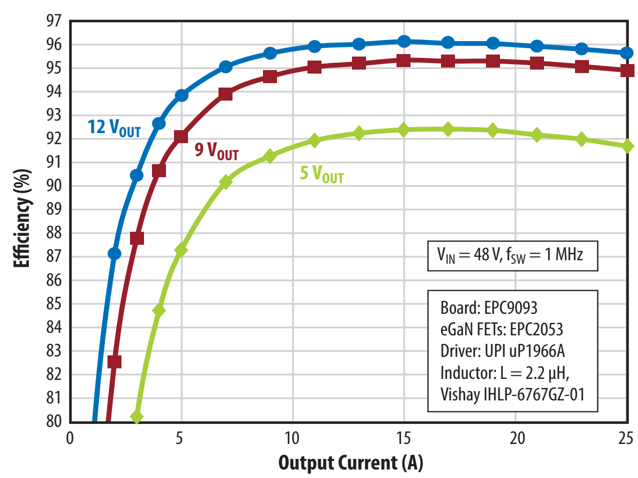

Figure 6: EPC9093 efficiency vs. output current for 48 V_{IN} to 5, 9 and 12 V_{OUT} when operating at 1 MHz and using EPC2053 eGaN FETs

Conclusions

Migrating an intermediate 48 V to 5 – 12 V bus converter design from silicon MOSFETs to eGaN FETs offers a boost in power density, while maintaining or exceeding efficiency targets. Table 1 shows the bill of materials of an eGaN based 48 V to 12 V, 25 A buck converter that yields a cost per watt of less than $0.03. This same bill of materials can be used for output voltages as low as 5 V.

Suitable controllers for the EPC9093 include the TPS53632G from Texas Instruments and when the EPC9093 is configured in a multi-phase system for higher output current capability, as demonstrated in the EPC9130, the dsPIC33EP128GS704 from Mircochip can be used.

The eGaN FET based 48 V to 5 - 12 V, 25 A load converter was demonstrated to yield 5 V, 9 V and 12 V output with a peak efficiency of 97%, a main power stage at least 2x smaller than the Si equivalents, and a cost that can go below $0.03 per watt when operated with 12 V output.

48 V - 12 V 25 A Buck Converter		
Component	**Qty**	**eGaN FET**
Control Transistor	1	EPC2053
Rectifier Transistor	1	EPC2053
Inductor	1	IHLP-6767GZ-01 2.2uH
Input Capacitors	4	C2012X7S2A105M125AB
Output Capacitors	5	C2012X5R1E226M125AC
Gate Driver	1	uP1966A
Total		**Less than $0.03 per Watt**

Table 1: Bill of Materials for an eGaN FET based 48 V to 12 V, 25 A converter based on 500 k unit pricing

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