How to Design a 12 V to 48 V / 500 W 2-Phase Boost Converter Using eGaN® FETs and the Renesas ISL81807 Controller

Motivation

48 V is being adopted in many applications including AI systems, data centers, and mild hybrid electric vehicles. However, the conventional 12 V ecosystem is still dominant and so the need of a high power density 12 V to 48 V boost converter is required. The fast-switching speed and low $R_{DS(on)}$ of eGaN FETs can help address this challenge. This application note will look into designing a 12 V to 48 V, 500 W DC-DC power module using eGaN FETs directly driven by eGaN FET compatible ISL81807 controller IC from Renesas in the simple and low-cost synchronous boost topology.

Design of a 2-phase eGaN FET-based synchronous boost converter

The multi-phase synchronous boost topology, shown in Figure 1, is popular in DC-DC step-up converter design for its simplicity, ease in control, and low cost.

In this design, the 100 V rated **EPC2218** with $R_{DS(on)}$ of 3 mΩ as shown in Figure 2 is selected for the 12 V to 48 V, 500 W power stage. The ISL81807 is an 80 V boost controller that can drive eGaN FET directly. Compared to a digital controller solution, the analog controller solution does not need the driver IC, current sense IC, housekeeping power IC, and thus greatly reduces complexity and Bill of Material count. The controller employs current mode control with full protection features such as UVLO and over-current protection. The ISL81807 also allows the designer to choose between constant current mode (CCM) or diode emulation, to improve light load efficiency. The switching frequency of the converter is set at 500 kHz, and a 2 µH inductor (SER2011-202 Coilcraft) with 1.3 mΩ DCR and 37 A saturation current is chosen.

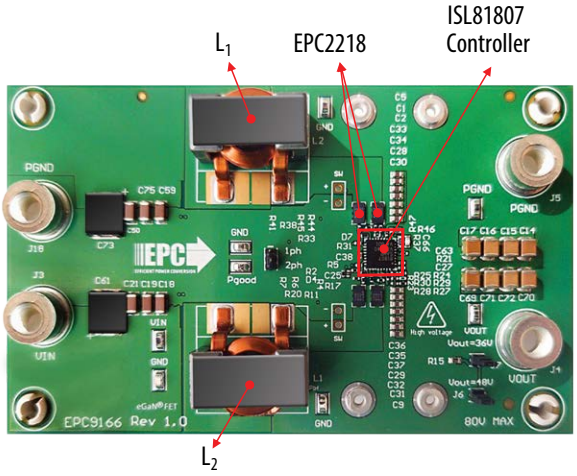

Figure 3. Photo of the EPC9166 synchronous boost converter designed for 12 V to 60 V, 500 W operation.

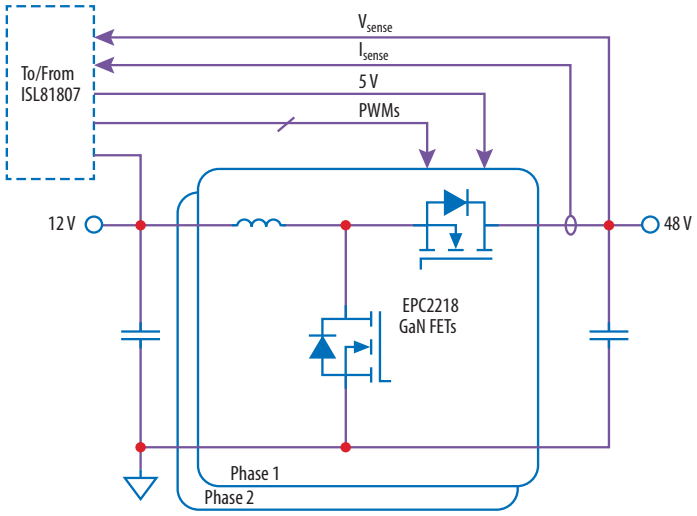

Figure 1. Simplified schematic block diagram of the EPC9166 eGaN FET-based synchronous boost converter.

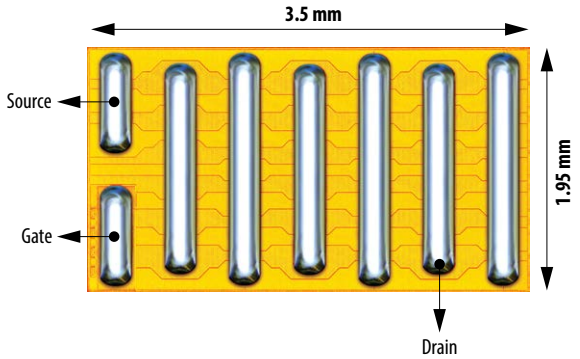

Figure 2. Photo of the bump side of EPC2218 (die area 6.8 mm²).

Experimental validation

The **EPC9166** synchronous boost converter is shown in Figure 3. The switch-node voltage v_{SW} waveform at 5 A output current is shown in Figure 4; the switching is seen to be fast and clean.

The overall power efficiency and power loss of the synchronous boost converter are shown in Figure 5 with a peak efficiency of 96.6% at 12 V input and 48 V output.

The thermal image of the converter operating at 12 V to 48 V, 10 A output current with moderate cooling (around 400 LFM forced air cooling) is shown in Figure 6. A temperature rise of 72 °C is observed.

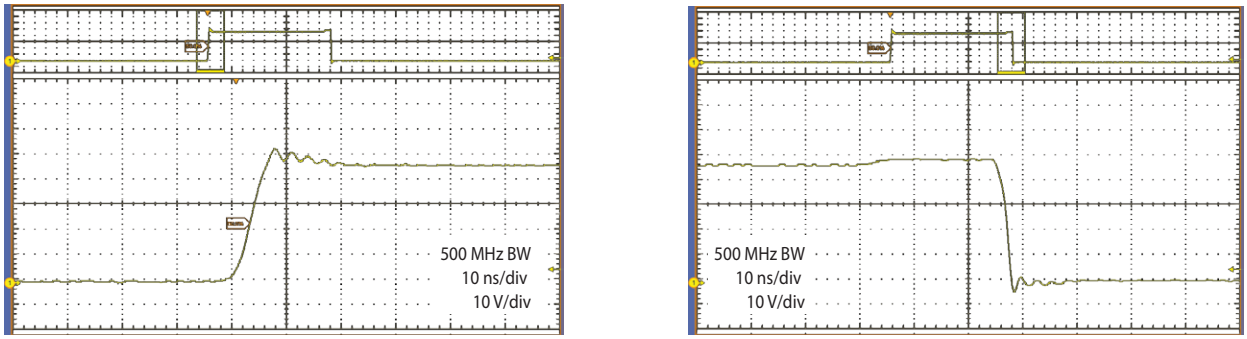

Figure 4. Switch-node voltage v_{SW} waveform at 5 A output current.

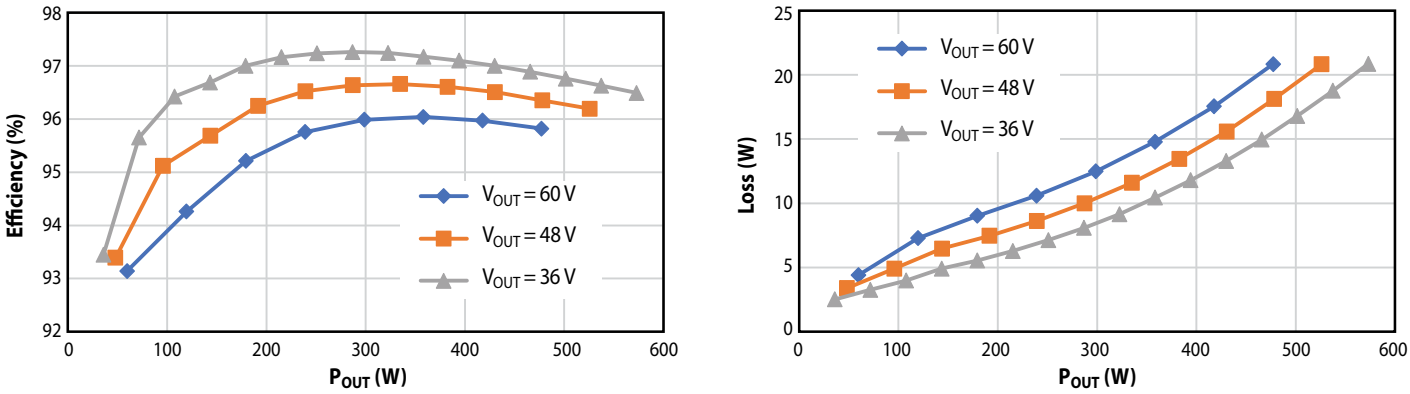

Figure 5. Total system efficiency and loss of the EPC9166 operating at 12 V input and with various output voltages.

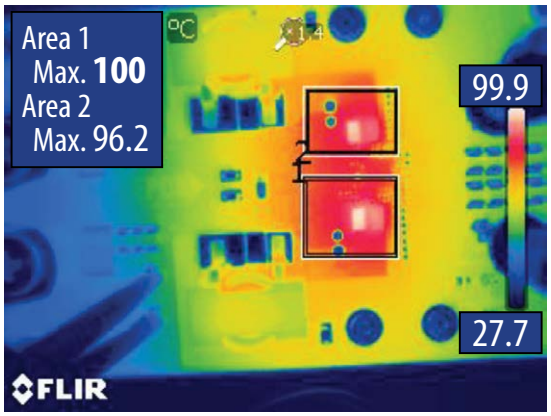

Figure 6. Thermal image of the EPC9166 synchronous boost converter operating at 12 V to 48 V and 10 A output and thermal steady state with 400 LFM forced air cooling.

Conclusion

The EPC9166, an eGaN FET-based 2-phase synchronous boost converter, designed around the ISL81807 controller, is introduced. At 12 V input and 48 V output it can deliver 500 W, and achieves 96.6% peak efficiency and 72°C temperature rise with moderate cooling. The whole solution comprises of four eGaN FETS with total die size of only 27.3 mm^2. The introduction of eGaN compatible IC ISL81807 can drive eGaN FETs directly by integrating the gate drivers, controller, housekeeping power and current sense amplifier function in a single chip, which greatly reduced the complexity and cost [1].

References

[1] A. Lidow, M. De Rooij, J. Strydom, D. Reusch, and J. Glaser, GaN Transistors for Efficient Power Conversion, 3rd ed. John Wiley & Sons, 2019. ISBN: 978-1119594147.