How to Design a 12 V-to-60 V Boost Converter with Low Temperature Rise Using eGaN® FETs

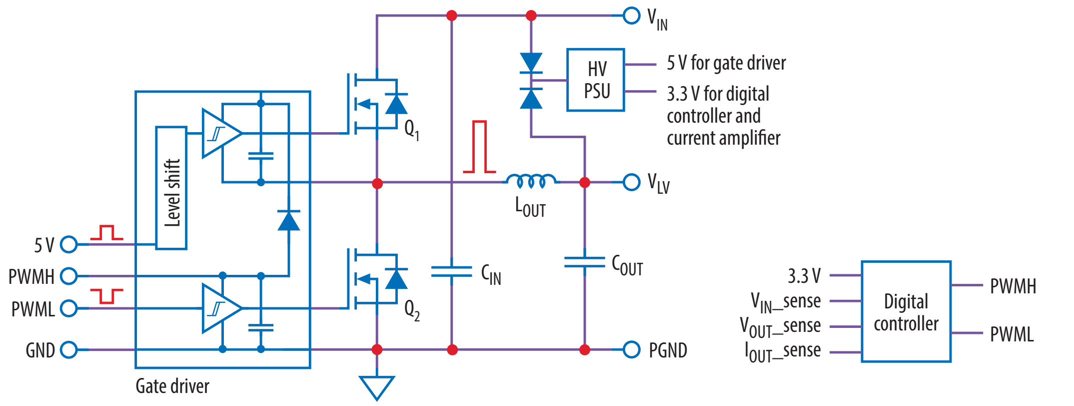

Figure 1. Simplified schematic of the EPC9162 eGaN FET-based synchronous boost converter. The design is also bi-directional capable.

Motivation

Modern displays typically require a low power boost converter. In this application, the screen intensity is low to moderate and the converter operates at light load most of the time, so the light load efficiency is very important. The low switching loss of eGaN FETs can help address this challenge. This application note will look into designing a 12 V to 60 V, 50 W DC-to-DC power module with low temperature rise using eGaN FETs in the simple and low-cost synchronous boost topology.

Design of a Small and Highly Efficient eGaN-FET-Based Synchronous Boost Converter

The synchronous boost topology is popular in DC-to-DC step-up converter designs for its simplicity, ease of control, and low cost. The schematic diagram of the eGaN FET-based synchronous boost converter is shown in Figure 1. The 100 V rated eGaN FET **EPC2052** with $R_{DS(on)}$ of 6 mΩ as shown in Figure 2 is selected for the 12 V to 60 V, 50 W power stage. The **uP1966E** gate driver featuring high driving strength is used to drive the FETs. The synchronous bootstrap circuit with **EPC2038** ensures a 4.9 V gate voltage is used for the high-side gate drive. Digital control that allows sub-10 ns dead-time and flexibility in control scheme development is used. In order to optimize the efficiency, two small on-board switch-mode power supply circuits are used to generate the housekeeping 5 V and 3.3 V voltages for the gate driver and the digital controller respectively. The house keeping power can also be powered from either high or low voltage port using the simple diode "OR" circuit, which enables bi-directional operation.

The switching frequency of the converter is designed to operate at 500 kHz and the inductor is a 10 µH TDK ferrite inductor. At light load, the inductor core and AC copper losses are dominating factors. Therefore, a larger inductance improves the light load efficiency due to the decreased ripple and thus lower core losses and AC copper losses.

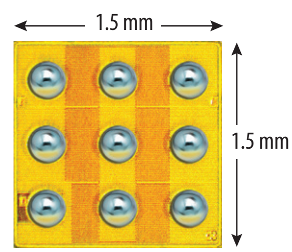

*Figure 2. Photo of the bump side of **EPC2052** (die area 2.25 mm^2).*

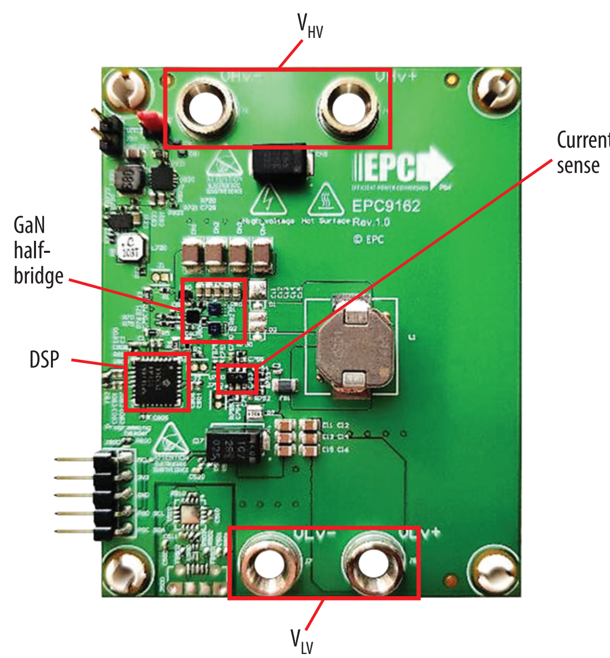

*Figure 3. Photo of the 12 V to 60 V, 50 W synchronous boost converter **EPC9162**.*

Experimental Validation

The switch-node voltage (V_{SW}) waveform at 0.15 A output current is shown in Figure 4; the switching is fast and clean.

The overall power efficiency and power loss of the **EPC9162** synchronous boost converter operating at different input voltages are shown in Figure 5 with a peak efficiency of 95.3% at 12 V input and 60 V / 0.85 A output.

The thermal image of the converter operating at 12 V to 60 V, 0.85 A output current without forced air cooling is shown in Figure 6. A temperature rise of only 40 °C is achieved. The eGaN FETs are capable of carrying more current given a relaxed temperature rise or with forced air cooling.

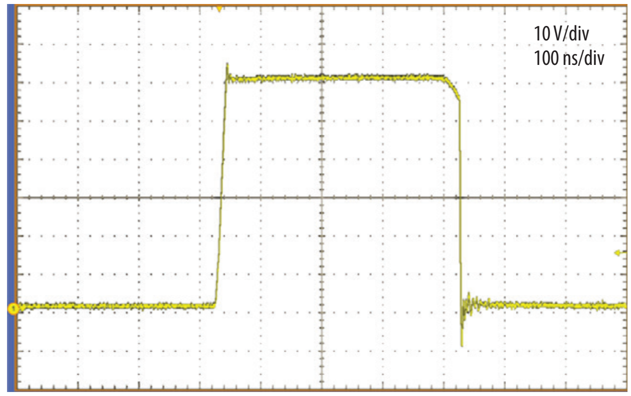

Figure 4. Switch-node voltage v_{SW} waveform at 0.15 A output current.

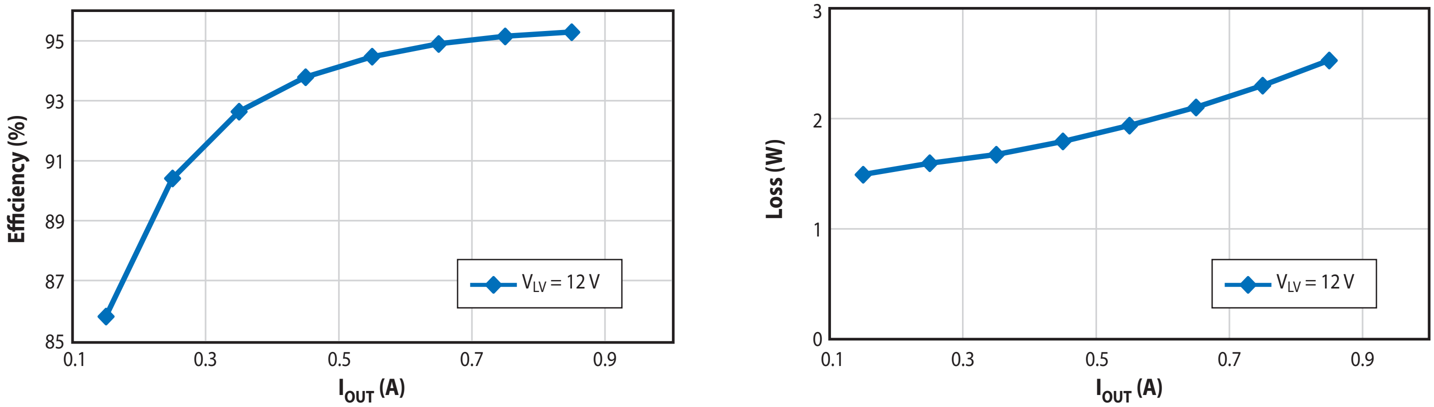

Figure 5. Total system efficiency including the housekeeping power consumption at 60 V output.

Conclusion

A 12 V to 60 V, 50 W, eGaN-FET-based synchronous boost converter is designed and achieves 95.3% peak efficiency, 86% light load efficiency and only 40°C temperature rise despite the small die size of 2.25 mm^2. In applications where light load efficiency is critical, such as LED backlighting for laptops and monitors, the fast-switching speed of eGaN FETs significantly reduces switching losses for higher efficiency operation.

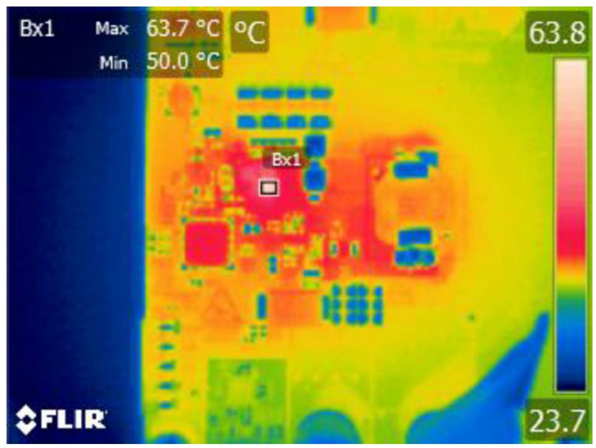

Figure 6. Thermal image of the synchronous boost converter operating from 12 V and outputting 60 V with 0.85 A output and thermal steady state without forced air cooling.

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