How GaN-based power can smooth the road ahead for smaller, more efficient, cost-effective automotive infotainment systems

In-vehicle infotainment systems poses a challenge to vehicle power design, explains **Renee Yawger, Marketing Director at Efficient Power Conversion (EPC)**

In the rapidly evolving landscape of automotive technology, in-vehicle infotainment systems have become more than just a luxury – they are an integral part of the driving experience and becoming increasingly critical as the demand for connected and autonomous vehicles increases. In-vehicle infotainment systems are tasked with providing better connectivity solutions, improved vehicle safety and enhanced in-vehicle user experiences. Modern infotainment systems offer a plethora of advanced features, ranging from touch screen capabilities and Bluetooth communication to digital and high-definition TV, satellite radio, GPS navigation and even gaming. The integration of these features poses a challenge to the vehicle's power system, demanding more efficient and compact power solutions. Gallium nitride (GaN)-based solutions can provide the higher power density, higher efficiency and lower cost designs that these systems require.

The combination of GaN devices and analogue controllers that are optimised to extract the peak performance of GaN are addressing this challenge by providing designers with high power density and cost-effective solutions.

FET selection

GaN devices are characterised by their smaller size and lower capacitance compared to conventional silicon MOSFETs. This characteristic has significant implications for power efficiency and performance. The figure of merit (FoM) of GaN transistors compared to silicon (Si) MOSFETs enables the design of systems that can operate at much higher efficiency levels, leading to smaller, more efficient, cooler-running, and cost-effective solutions. All these features are critical to in-vehicle infotainment systems.

To illustrate the practical implications of this improvement in FoM for the design of an in-vehicle infotainment system, consider the example of the EPC9160. This design is a dual output synchronous buck converter that operates at a 2MHz switching frequency, converting an input voltage of 9.0 to 24V to either a 3.3 or 5V output voltage, delivering up to 15A continuous current for both outputs. The design's high switching frequency contributes to its compact size; measuring

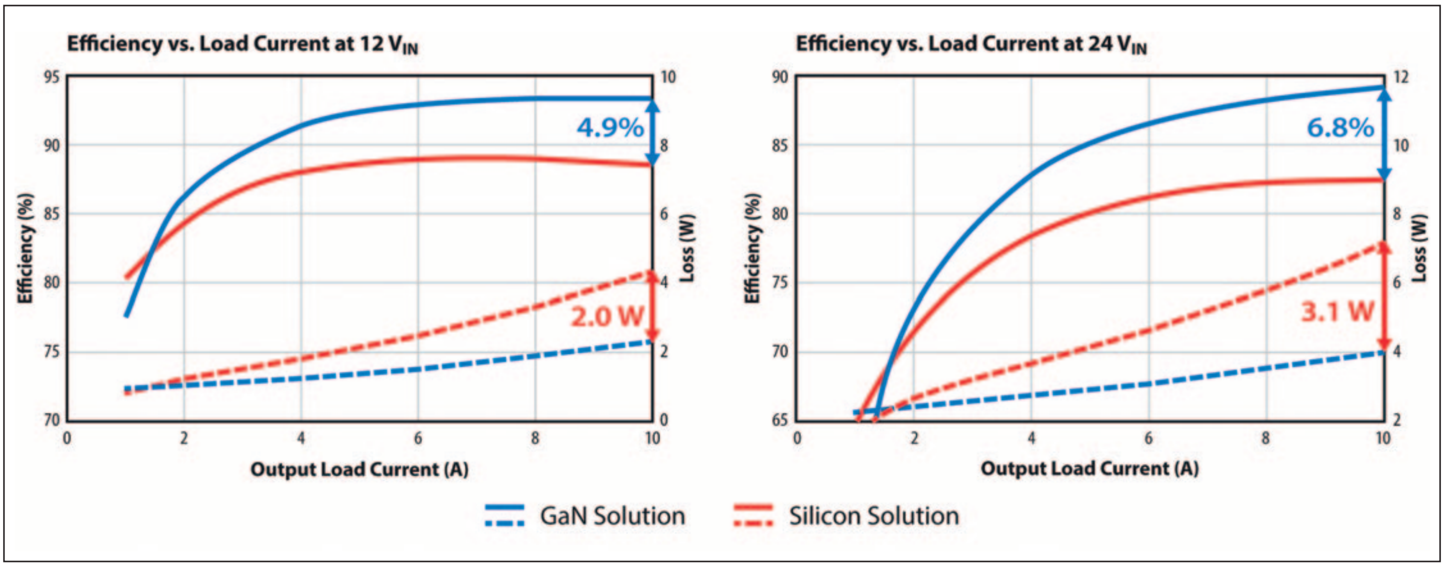

Figure 1: Efficiency and power loss comparison of GaN FET vs Si MOSFET

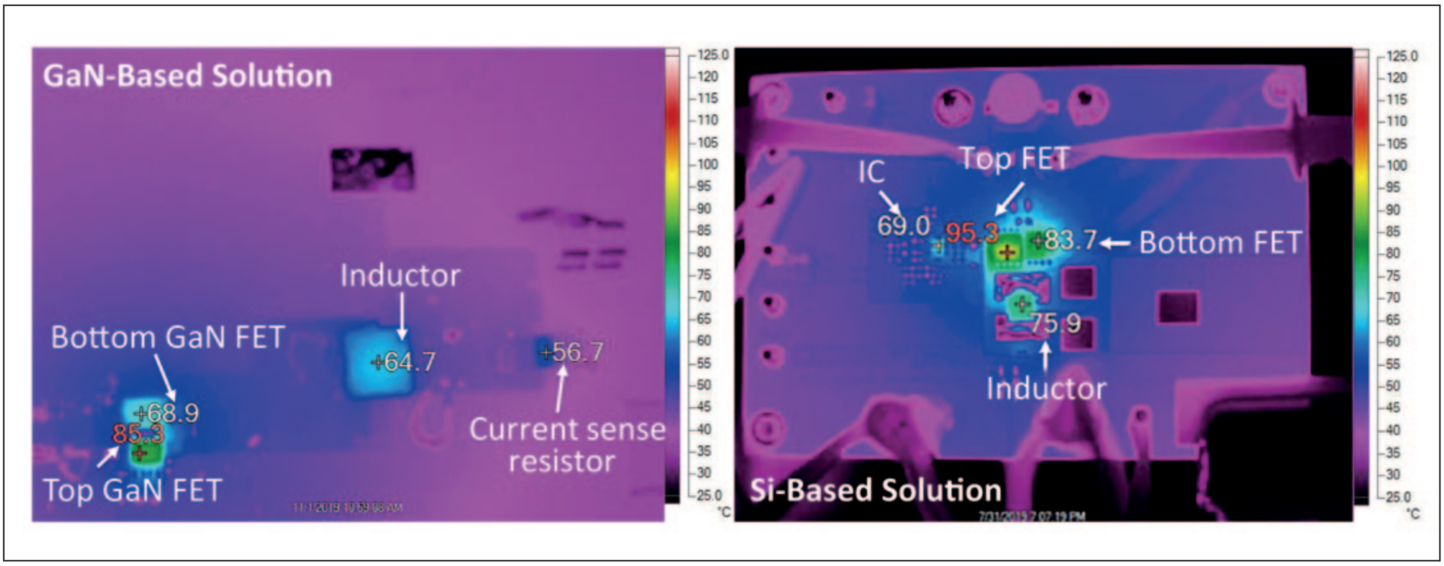

Figure 2: **Thermal performance comparison of GaN FET vs Si MOSFET**

23 x 22mm for both outputs with an inductor height of just 3mm.

The GaN FET chosen for this design is the EPC2055 40V, 3mΩ max RDS(on), 6.6nC QG, 0.7nC QGD, and 1.3nC QOSS, in a small 2.5 x 1.5mm footprint. It can deliver up to 29A continuous current and 161A peak current. It also exhibits very small switching losses at 2MHz switching frequency.

Controller selection

Conventional MOSFET analogue controller ICs are not fully compatible with GaN FETs because of the specific driving needs. For example, there is no over-voltage management for the bootstrap supply in the event where the lower FET reverse conducts, and high negative voltage spikes on the switch node during dead time can lead to unpredictable timing behaviour. As a result, digital controllers such as DSPs have been used for GaN FET-based designs but require additional support ICs such as a current sense amplifier, housekeeping power supply and a GaN FET-compatible gate driver. This approach adds to the overall bill of materials (BoM) and increases design complexity. In contrast, the LTC7890 controller from Analog Devices is a 100V, low quiescent current, dual two-phase synchronous step-down controller with dedicated driver feature for GaN FETs. The small 6.0 x 6.0mm QFN package is fully optimised to drive GaN FETs. The LTC7890 integrates a half-bridge driver and smart bootstrap diode and offers optimised near-zero deadtime or programmable deadtime and programmable switching frequencies up to 3 MHz. It also has low standby power consumption. The integration of GaN-compatible analogue controllers with integrated gate drivers eliminates the need for additional support ICs, simplifying designs and reducing the overall BoM.

Optimising layout and thermal performance

One of the design challenges in leveraging GaN FETs lies in minimising parasitic inductances in both the gate and power loops. Power loop inductances, as well as gate loop inductances, impact switching behaviour and efficiency. The internal vertical loop layout is a technique that helps minimise switching losses and ringing. High- and low-side gate loop inductances must also be minimised to prevent gate over-voltage and ensure smooth operation.

Thermal management is another critical aspect of GaN FET design. Despite their efficiency, the compact size of non-packaged GaN FETs necessitates careful attention to heat dissipation. In the absence of a heatsink, maximising the number of vias beneath the GaN FETs becomes crucial. This approach enhances thermal heat-spreading from the FETs into the PCB's copper layers, ultimately improving overall thermal performance.

Design validation

The efficiency of the EPC9160 surpasses 93% for 5V output and 24V input. High switching frequency of 2MHz was chosen based on EMI requirements in automotive applications. It further demonstrates the fast switching speed of GaN FETs together with the smaller size of the inductor and capacitors. The EPC9160 power stage fits within an area of just 506mm^2 (W = 23mm, L = 22mm).

In a comparative analysis of systems built with GaN FETs vs systems built with Si MOSFETS, both operated at 2MHz and 10A, the GaN-based solution exhibited nearly 5% higher peak efficiency and 2W lower power loss at 12V input and nearly 7% higher peak efficiency and 3.1W lower power loss at 24V input (Figure 1). The superior efficiency and reduced power loss of GaN-based solutions also translates to cooler operation, as evidenced by a 10°C lower hotspot temperature than the silicon board in a thermal performance comparison (Figure 2). The vias underneath the FETs and the six-layer PCB with 2oz copper thickness help in reducing the temperature of the FETs by utilising heat spreading of the PCB copper layers.

In summary, the automotive industry is undergoing a transformative phase, and the demand for advanced in-vehicle infotainment systems that provide better connectivity, improved vehicle safety, and enhanced in-vehicle user experiences is on the rise. GaN-based power solutions that incorporate analogue controllers offer a path forward, allowing for smaller, more efficient, and cost-effective designs that meet the demands of these sophisticated systems.

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