Technical Article

How to Use Gallium Nitride Technology in Switch-Mode Power Supplies

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Abstract

This article explains the unique considerations and challenges associated with utilizing GaN switches in switch-mode power supplies. A solution is presented in the form of a specialized GaN driver that provides the necessary functions for a robust and reliable design. Additionally, the article suggests the use of LTspice® as a suitable tool chain for a successful deployment of GaN switches.

Introduction

Gallium nitride (GaN), a III-V semiconductor, offers exceptional properties for switch-mode power supplies (SMPS). With high dielectric strength, lower switching losses, and high power density, GaN technology has become increasingly popular.

Nowadays, there are numerous switches available that are based on GaN technology. However, the use of these switches is partially limited due to the need for a different driving approach compared to conventional silicon MOSFETs.

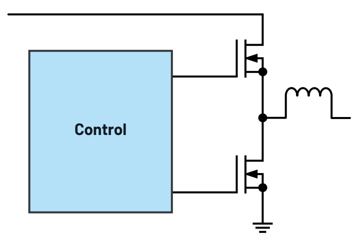

Figure 1. Driving of power switches in an SMPS.

Figure 1 shows the power stage of a half-bridge configuration commonly used in switch-mode step-down converters (buck technology). When employing GaN switches in this setup, it is crucial to consider that they typically have a lower maximum gate voltage tolerance compared to their silicon counterparts. Therefore, it is essential to strictly adhere to the maximum gate voltage limit during the driving process.

In addition, it is important to account for the rapid switching of the switching node, which connects the high-side and low-side switches. This rapid switching should not result in unintended turn-on of the GaN switches, a failure mode that is uncommon for conventional silicon switches. This can be mitigated by implementing separate gate control lines for the rising and falling edges.

Furthermore, in bridge topologies, GaN switches exhibit increased line losses during dead times. Consequently, when using GaN switches in a bridge application, it is necessary to minimize the dead time to ensure optimal performance.

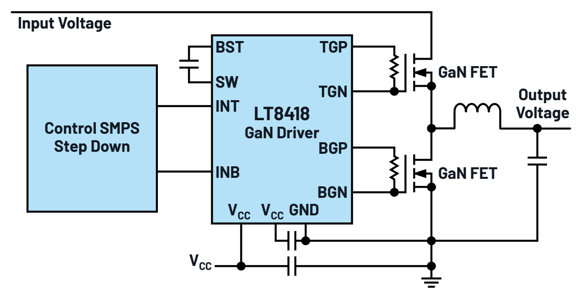

Figure 2. The LT8418, a 100 V half-bridge driver for GaN switches.

To effectively address the specific control requirements of GaN switches, specialized GaN driver ICs such as the LT8418 are recommended. Figure 2 shows an application of this driver in a downconverting switching regulator. The LT8418 GaN bridge driver offers a driver strength of up to 4 A for gate charging and up to 8 A for gate discharging during shutdown. By utilizing separate control lines for charging and discharging, different rise and fall times can be achieved, ensuring robust operation.

The circuit in Figure 2 achieves a conversion efficiency of approximately 97% at 48 V input voltage, 12 V output voltage, and 12 A load current. Notably, this high efficiency is attained at a 1 MHz switching frequency.

When building a power stage with GaN switches, careful attention must be given to optimizing the board layout. The fast switching edges, combined with parasitic inductances, can result in undesirable high electromagnetic radiation. To minimize these parasitic inductances, a compact design of the circuit is essential. This is why the LT8418 bridge driver is packaged in a compact wafer-level chip scale package (WLCSP) measuring only 1.7 mm by 1.7 mm.

For quick and efficient experience with the control of GaN switches, the free simulation environment LTspice is highly recommended. LTspice includes a comprehensive simulation model of the LT8418 GaN driver, complete with external circuitry. Figure 3 shows a schematic of the LT8418 for evaluation within LTspice.

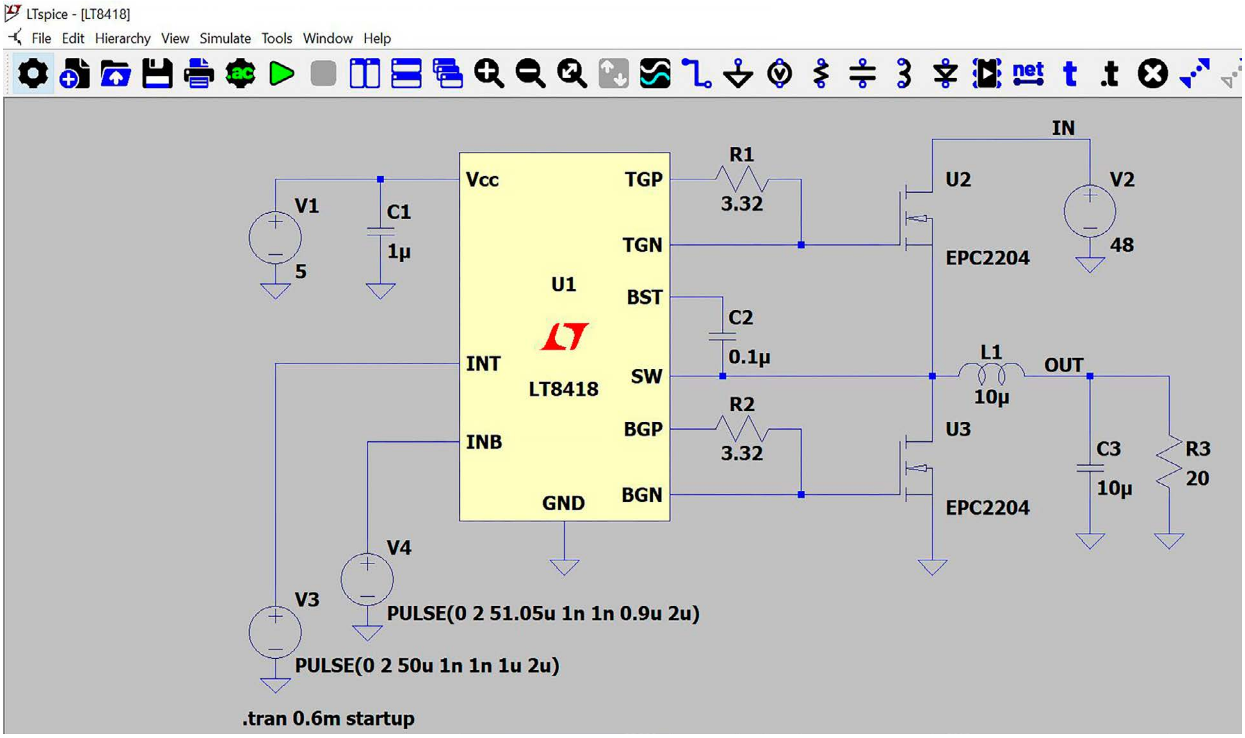

Figure 3. Evaluating an SMPS with GaN power switches within the LTspice simulation environment.

Conclusion

GaN switches have transitioned from niche products to becoming prominent in power electronics. Their efficiency and power density advantages make them appealing for various applications, including voltage conversion, electric motor driving, and Class-D audio amplifiers. With the availability of optimized driver modules such as the LT8418, controlling this new circuit technology has become straightforward and reliable. As a result, GaN switches offer significant potential for advancing power electronics.

About the Author

Frederik Dostal is a power management expert with more than 20 years of experience in this industry. After his studies of microelectronics at the University of Erlangen, Germany, he joined National Semiconductor in 2001, where he worked as a field applications engineer, gaining experience in implementing power management solutions in customer projects. During his time at National, he also spent four years in Phoenix, Arizona (U.S.A.), working on switch-mode power supplies as an applications engineer. In 2009, he joined Analog Devices, where he has since held a variety of positions working for the product line and European technical support, and currently brings his broad design and application knowledge as a power management expert. Frederik works in the ADI office in Munich, Germany.

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