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Forschungsarbeit
Masterarbeit

Leistungs-elektronik

Optimierung der Totzeit durch adaptive Gate-Steuerung für GaN-HEMTs

Abstract

Um eine maximale Leistungsdichte zu erreichen, werden in der Leistungselektronik typischerweise hohe Schaltfrequenzen mit weich-schaltenden Übergängen (ZVS) kombiniert. Um weich zu schalten ist in der Regel eine Totzeit von einigen zehn Nanosekunden für GaN-HEMTs nötig, welche stark vom Arbeitspunkt abhängt und somit individuell eingestellt werden muss.

Ziel dieser Arbeit ist die Implementierung einer adaptiven Gate-Steuerung für GaN-HEMTs zur automatischen Optimierung der Totzeit für minimale Verluste. Mithilfe eines „Zero-Voltage Switching Detectors (ZVSD)“ soll dadurch die Regelung der optimalen Totzeit für den jeweiligen Arbeitspunkt erfolgen und somit ein manuelles Einstellen der Totzeit überflüssig machen. Dabei gibt es unterschiedliche Konzepte (bspw. Slope-Sensing), welche hinsichtlich ihrer Performance evaluiert werden sollen.

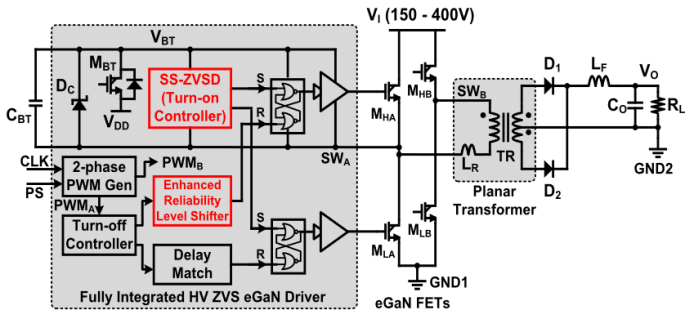
Zeitplan

- Einarbeitung & Literaturrecherche (15%)
- Simulation und Auslegung eines geeigneten Detection Circuits (30%)
- Aufbau und Vermessung (30%)
- Ausarbeitung & Vortrag(25%)

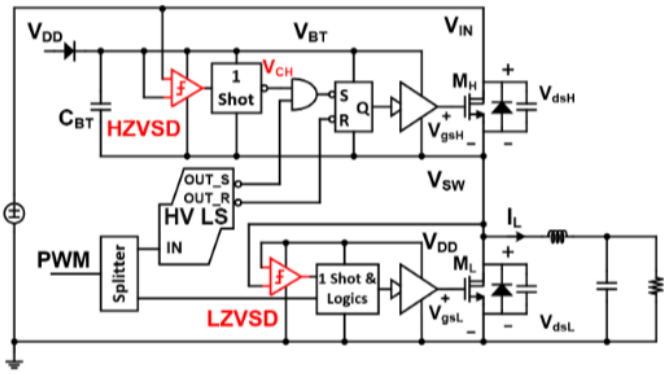
Vorkenntnisse

- Schaltungs-/Layoutdesign in Altium/Eagle
- Erfahrung in praktischen Aufbauten
- Kenntnisse in Schaltungssimulation

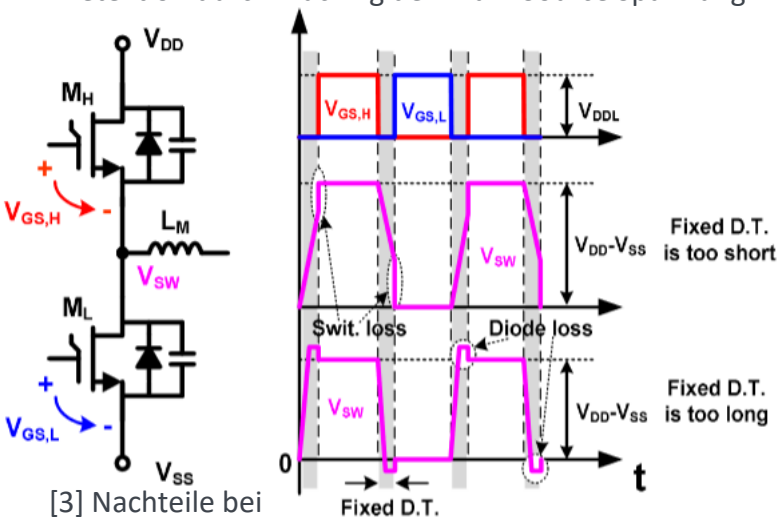
English description



[1] Schaltplan für einen isolierten ZVS Halbbrückentreiber mit Slope-Sensing



[2] Schaltplan für einen on-Chip Treiber mit ZVS Detektion durch Tracking der Drain-Source Spannung



[3] Nachteile bei fixierter Totzeit

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[1] L. Cong and H. Lee, "A 1–2-MHz 150–400-V GaN-Based Isolated DC–DC Bus Converter With Monolithic Slope-Sensing ZVS Detection," in IEEE Journal of Solid-State Circuits, vol. 53, no. 12, pp. 3434-3445, Dec. 2018.
[2] L. Cong and H. Lee, "A 150V monolithic synchronous gate driver with built-in ZVS detection for half-bridge converters," 2018 IEEE Applied Power Electronics Conference and Exposition (APEC), San Antonio, TX, 2018, pp. 1861-1864.
[3] Q. Cheng and H. Lee, "A high-frequency non-isolated ZVS synchronous buck-boost LED driver with fully-integrated dynamic dead-time controlled gate drive," 2018 IEEE Applied Power Electronics Conference and Exposition (APEC), San Antonio, TX, 2018, pp. 419-422.

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Study thesis
Masterthesis

Power-electronics

Dead-time optimization of GaN-HEMTs by adaptive gate-driver

Abstract

To achieve a maximum power density, typically a high switching frequency and soft-switched transitions (ZVS) are applied in power electronics. The dead-time is typically a few several of tens nanoseconds for GaN-HEMTs and has to be adjusted for each working point individually.

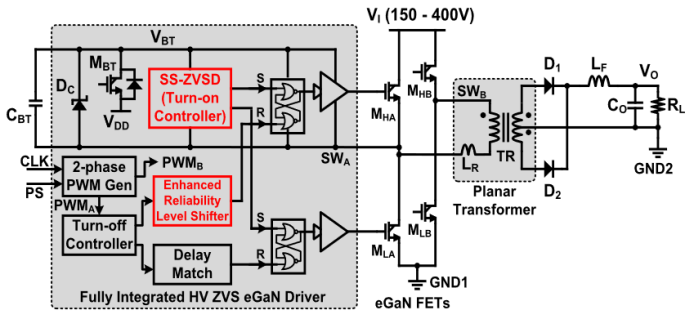
Goal of this work is the implementation of such an adaptive gate-drive for GaN-HEMTs to automatically improve the dead-time to achieve minimal losses. With the help of a "Zero-Voltage Switching Detector (ZVSD)" a regulation of the optimum dead-time should be done automatically for each working point and therefore replace the manual setting. In this frame several different approaches (for example slope-sensing) should be evaluated regarding their performance.

Timetable

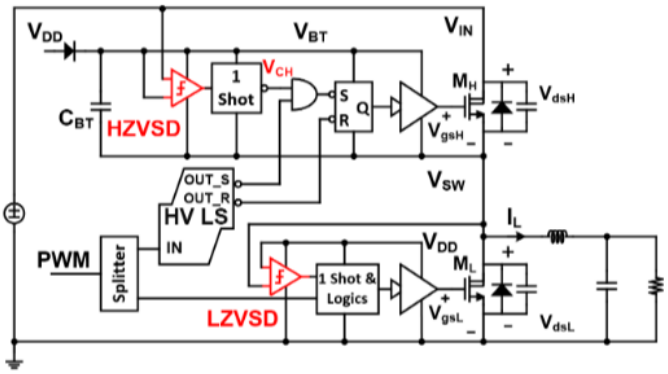
- Familiarization & literature search (15%)
- Simulation and design of a suitable detection circuit (30%)
- Assembly and measurements (30%)
- Written thesis & presentation (25%)

Previous knowledge:

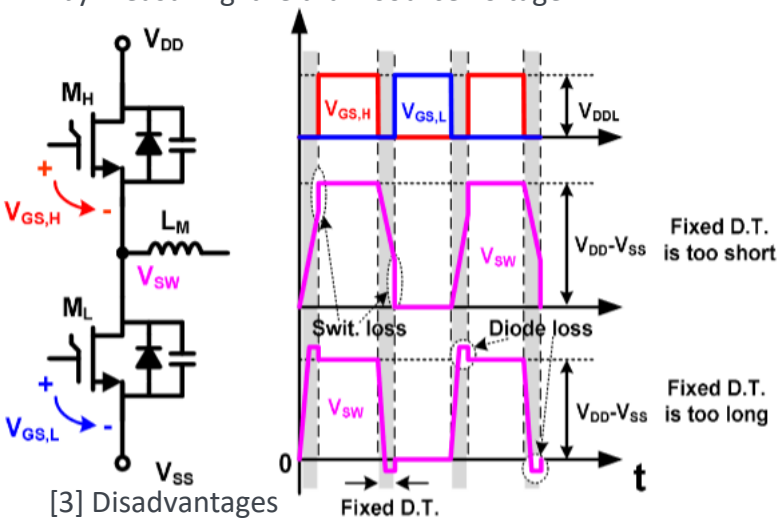
- Circuit/layout design in Altium
- Experience in practical lab work
- Experience in circuit simulation



[1] Schematic of an isolated ZVS half-bridge driver with slope sensing



[2] Schematic of an on-chip driver with ZVS detection by measuring the drain source voltage



[3] Disadvantages for fixed dead-time

[1] L. Cong and H. Lee, "A 1–2-MHz 150–400-V GaN-Based Isolated DC–DC Bus Converter With Monolithic Slope-Sensing ZVS Detection," in IEEE Journal of Solid-State Circuits, vol. 53, no. 12, pp. 3434-3445, Dec. 2018.
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[3] Q. Cheng and H. Lee, "A high-frequency non-isolated ZVS synchronous buck-boost LED driver with fully-integrated dynamic dead-time controlled gate drive," 2018 IEEE Applied Power Electronics Conference and Exposition (APEC), San Antonio, TX, 2018, pp. 419-422.