Doctoral Dissertation
Doctoral Program in Electrical, Electronics and Communication Engineering
(37th Cycle)

GaN FET Devices in High-Efficiency Low-Voltage Power Converter Applications

By

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Politecnico di Torino
2025

Abstract

The increasing demand for high-efficiency, high-performance power electronic converters have led to the growing adoption of Gallium Nitride (GaN) FETs, a wide-bandgap semiconductor technology known for its superior properties in high-power, high-frequency applications. GaN transistors offer advantages such as higher electron mobility, reduced switching losses, and enhanced efficiency compared to traditional silicon-based MOSFETs. These features make GaN devices highly suitable for applications where power density and efficiency are critical.

This thesis explores the potential of GaN FETs by focusing on several key aspects of their implementation in power conversion systems. First, a GaN FET model is developed and validated through a combination of simulations and experimental testing, ensuring accurate replication of the device's dynamic behavior. Several measurement techniques are employed to capture high-speed switching events, revealing crucial insights into the behavior of GaN FETs under various conditions. Further, a comparative study between GaN FETs and silicon MOSFETs is conducted, assessing their performance in terms of efficiency and switching dynamics. This analysis establishes the base for comprehending the specific benefits of GaN technology in optimizing system performance. The research also investigates the optimization of switching frequency and dead time in motor drive applications, demonstrating how GaN FETs can lead to enhanced system efficiency and thermal performance. In addition, challenges related to current sharing and parasitic effects in parallel GaN FET configurations are examined, with strategies developed to address these issues through both simulations and experimental tests.

By exploring these challenges, the findings of this thesis contribute to the expanding knowledge on GaN FETs, highlighting their potential to revolutionize modern power electronics. The insights gained from this work pave the way for future advancements in high-efficiency, high-density power conversion systems.