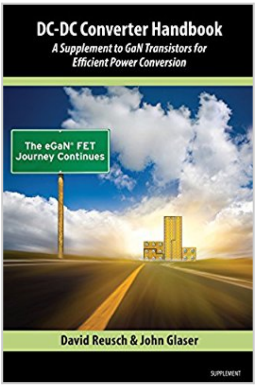

DC-DC Conversion Handbook: A Supplement to GaN Transistors for Efficient Power Conversion

By David Reusch, John Glaser

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Demand for information is growing at unprecedented rates and society s insatiable appetite for communication, computing and downloading, is putting ever-increasing demands for improved efficiencies and performance on data centers.

The first challenge - how will power conversion systems continue to improve in order to keep pace with the rapid improvements in computing power and the need for efficient data centers...

The second focus - to create power conversion solutions using GaN devices and making performance comparisons with silicon power transistors traditionally used in power conversion systems...

And, finally - to propose, create, and test a new power delivery architecture taking advantage of the superior performance attributes of GaN.

Key Features:

- Written by leaders in the power semiconductor field and industry pioneers in GaN power transistor technology and applications.

- Features practical guidance on formulating specific DC-DC conversion circuit designs when constructing power conversion systems using GaN transistors

- A valuable learning resource for professional engineers and systems designers, as well as electrical engineering students, needing to fully understand high performance GaN devices.

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Editorial Review

Review
Good technical textbooks updated regularly are critical to our engineering universities, technical schools and practicing engineers. Such a paperback supplement as this; however, holds the absolute latest in technology and research by some of the best engineering and scientific minds in the industry.

To educate power system designers about the GaN device, authors Reusch and Glaser have moved to the next logical step for which power designers need a good technical tutorial in the design architecture of DC-DC converters using the GaN power element. These authors are right in the midst of development and innovation and give the best practical and latest information to aid designers in their difficult task of constantly improving their systems to keep up with power industry needs.

Tutorial books like this strengthen design engineers understanding of how to properly implement GaN, this amazing power element technology, to create power supply architectures with performances and advantages that we have never before been able to implement as we move forward to meet the difficult needs that electronic power supplies will have in the future.

Note: For the full book review, visit EDN Network website.

--Steve Taranovich, EDN Analog and Power Management Design Centers, Senior Technical Editor

The DC-DC Converter Handbook is intended for power-system designers who employ GaN (gallium nitride) power transistors. It supplements GaN Transistors for Efficient Power Conversion, which was published in 2012. This new book emphasizes use of enhancement mode GaN, called eGaN power transistors, for dc-dc power conversion.

The introductory chapter explains the performance of low-voltage power converters and why they are a promising area for reducing power consumption in data center and telecom power systems. An overview of low-power, rack-level dc-dc power-system architectures includes an analysis of key power architecture requirements, such as power density, efficiency, and cost.

Chapter 2 compares the electrical figure of merit (FOM) for eGaN FETs and silicon MOSFETs. Each FOM provides a simple tool for evaluating performance of the related power transistor. This chapter also introduces the thermal FOM.

By establishing performance figures of merit and using real-life data, the book concludes that GaN FETs, especially eGaN FETs, provide lower on-resistance, faster switching speeds, better thermal conductivity, smaller size, and lower cost than silicon MOSFETs. Plus, the smaller size and chip-scale approach employed by eGaN transistors results in better thermal conductivity than commercially available silicon-based component packages.

Chapter 3 discusses best design practices for use with eGaN FETs, including printed circuit board (PCB) layout and thermal management. In-circuit electrical and thermal comparisons of eGaN FETs and state-of-the-art silicon MOSFETs show that eGaN FETs exhibit higher electrical efficiency, higher thermal efficiency, and higher power density than their silicon counterparts. This chapter also presents a thermal comparison of an eGaN monolithic half-bridge IC with discrete eGaN FETs.

Chapter 4 presents design details for an eGaN FET in an intermediate bus converter (IBC) with a nominal 48:12 input-output conversion ratio.

Conventional regulated, isolated PWM converters using eGaN power transistors exhibit a 70% increase in output power with no sacrifice in performance, when operating at twice the switching frequency of silicon power transistor converters. Extending this to unregulated converters provides at least another 33% increase in power density.

Design of high-performance POL (point-of-load) converters is the subject of Chapter 5. You can improve the power density of POL converters by increasing the switching frequency to allow use of smaller-size passive components as well as higher levels of integration. Besides switching frequency, POL current handling capabilities should also increase to keep up with more demanding application requirements.

Actual results of GaN-based converters used in a DC Bus Architecture (DCBA) are presented in Chapter 6.

The three-stage IBA power converters using eGaN FETs have an estimated 1.3% efficiency improvement over the direct eGaN FET-based 48 VIN to 1.8 VOUT conversion approach, however no 12 V busing losses are included. When considering the 12 V bus, whose efficiency is estimated to be 98%, the total system efficiency of the direct 48 VIN to 1.8 VOUT conversion approach is around 0.5% higher, and the estimated power density has been improved by more than 65% compared with the conventional three-stage IBA. There is a clear cost and power density advantage by removing one redundant bus conversion stage, and by having a single bus converter providing 1.8 VOUT from 48 VIN. This single-step bus architecture can become a viable architecture for increasing power density in the future.

--Sam Davis, Editor-in-Chief, powerelectronics.com

About the Author
Dr. David Reusch is currently the Executive Director of Applications Engineering at EPC Corporation. He earned a Ph.D. in electrical engineering from Virginia Tech in 2012, where he also earned his Bachelor of Science in Electrical Engineering (BSEE) and Master of Science in Electrical Engineering (MSEE) degrees. While working on his Ph.D. he was a Bradley Fellow at the Center for Power Electronics Systems (CPES).

Dr. Reusch has first-hand experience designing with GaN transistors to meet the demands for lower loss and higher power density in power converters. He is a member of the IEEE, has published over 25 papers, is a US patent holder, and is a co-author of the textbook, *GaN Transistors for Efficient Power Conversion*, second edition.

Dr. John Glaser received his BSEE (1987) from the University of Illinois, Urbana-Champaign, and his MSEE (1991) and Ph.D. (1996) in Electrical Engineering from the University of Arizona. Prior to 1998, he developed mobile RF power amplifiers for Motorola and worked on high-voltage DC-DC converters for TWT amplifiers for Hughes Missile Systems Co.

From 1998 to 2014, Dr. Glaser worked at General Electric Global Research in Niskayuna, NY, serving both technical and project leadership roles. This work included high performance switch-mode power converters, VHF amplifiers, induction heating, electronic ballasts, and magnetics, for applications ranging from lamp drivers to MRI.

In 2014, Dr. Glaser joined Efficient Power Conversion Corporation as Director of Applications Engineering, where he develops applications, circuits, and methods to maximize the benefit of gallium nitride (GaN) power transistors and to drive adoption in the power electronics community. Current interests are high efficiency VHF power processing and wide band-gap (silicon carbide and gallium nitride) power device testing, modeling and application.

Dr. Glaser has published more than 25 papers and has been granted 29 US patents, with several more pending. Dr. Glaser is a Senior Member of the Institute for Electrical and Electronic Engineers (IEEE).

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