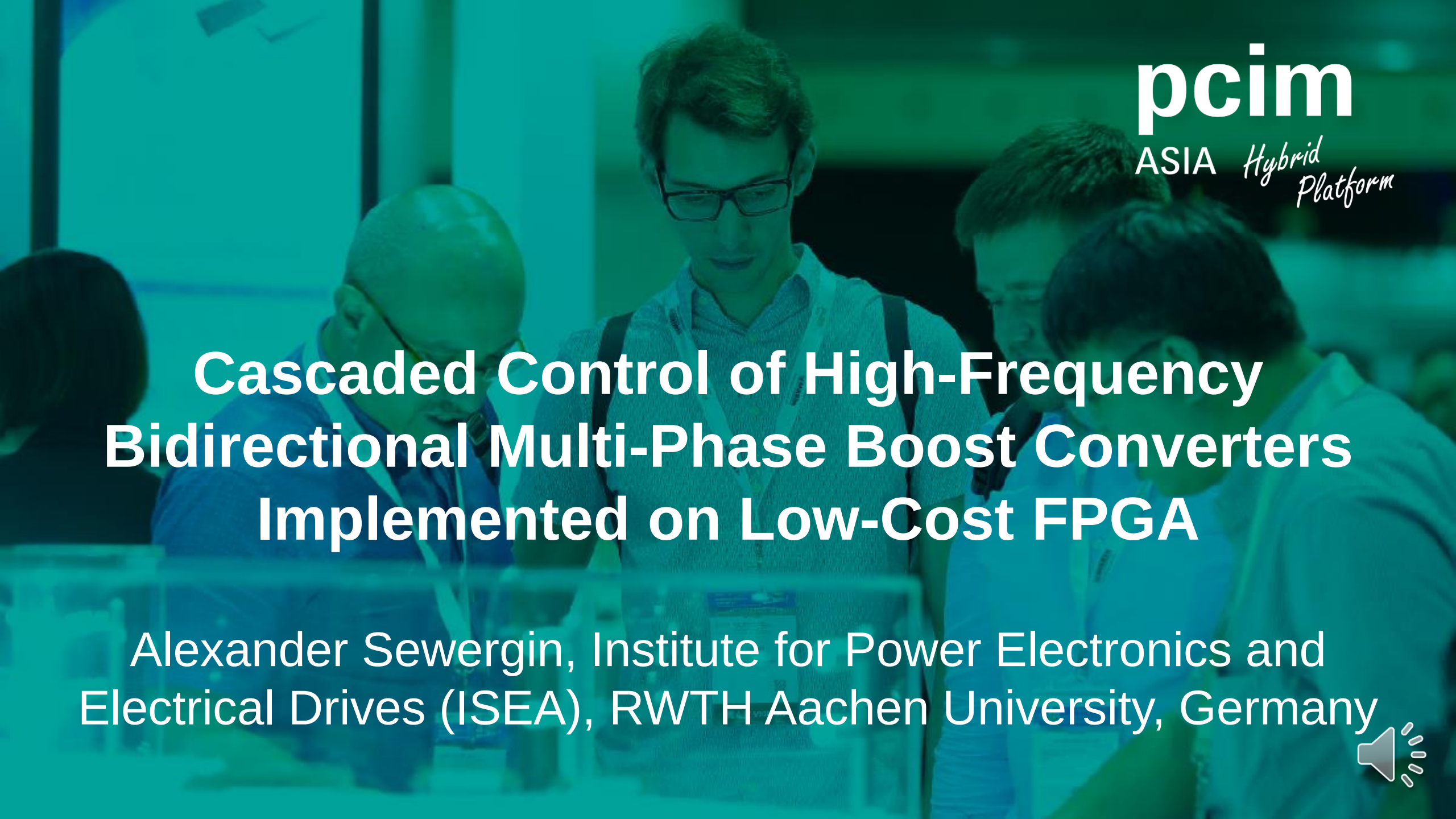


Cascaded Control of High-Frequency Bidirectional Multi-Phase Boost Converters Implemented on Low-Cost FPGA

Alexander Sewergin, Institute for Power Electronics and Electrical Drives (ISEA), RWTH Aachen University, Germany

Cascaded Control of High-Frequency Bidirectional Multi-Phase Boost Converters Implemented on Low-Cost FPGA

PCIM Asia 2020

16.11.2020

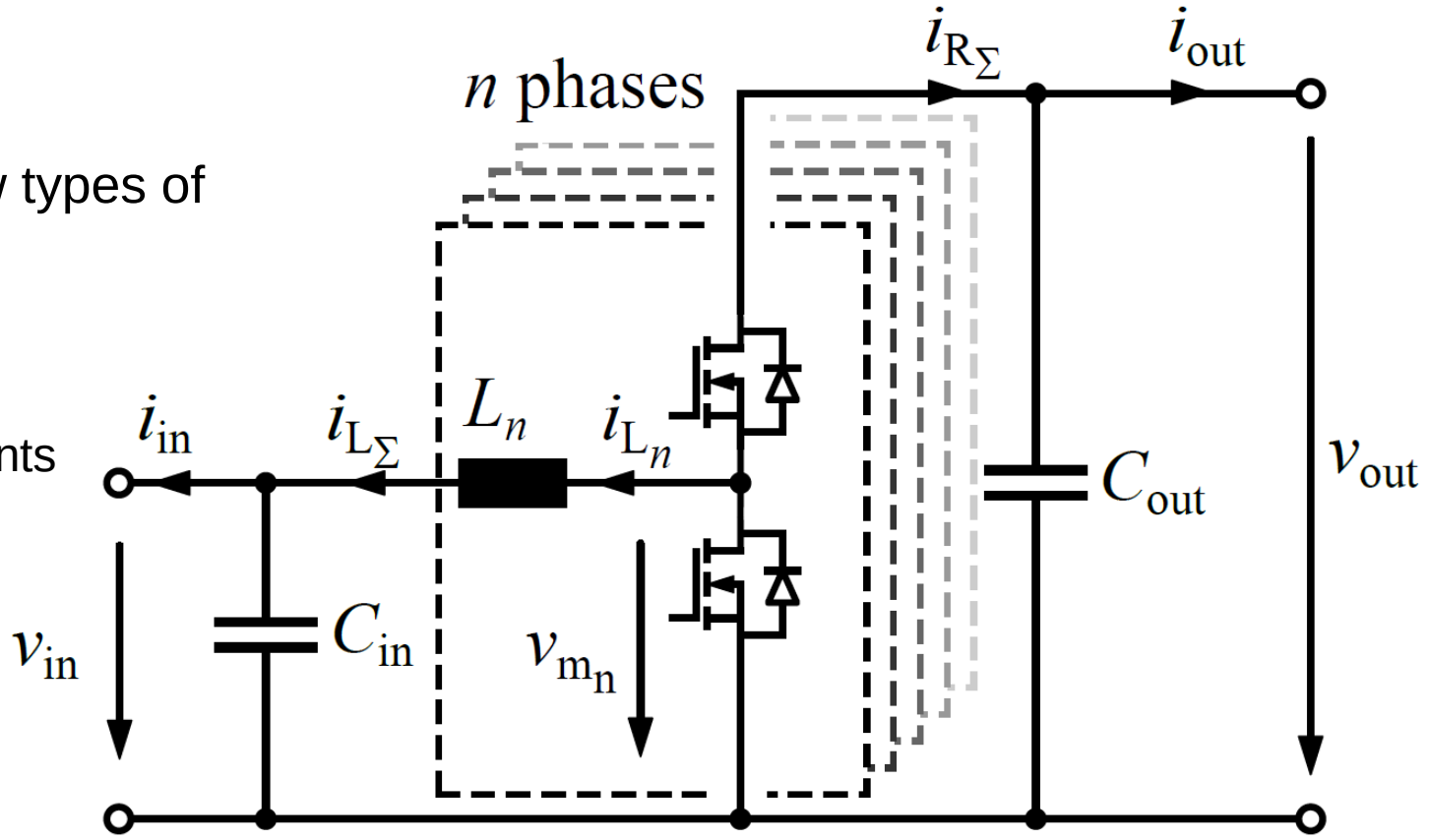
A. Sewergin, H. Wienhausen, C. van der Broeck, Rik W. De Doncker

Institute for Power Electronics and Electrical Drives

iSEA Power Electronics and Electrical Drives | RWTH AACHEN UNIVERSITY

Motivation

- New wide-bandgap semiconductors provide:
  - Lower switching losses
  - Higher switching frequencies
- Requirements for the control of these new types of fast-switching dc-dc converters:
  - Control of *n*-phases
  - Low-cost control platform
  - Dynamic, thus minimizing passive components



Outline

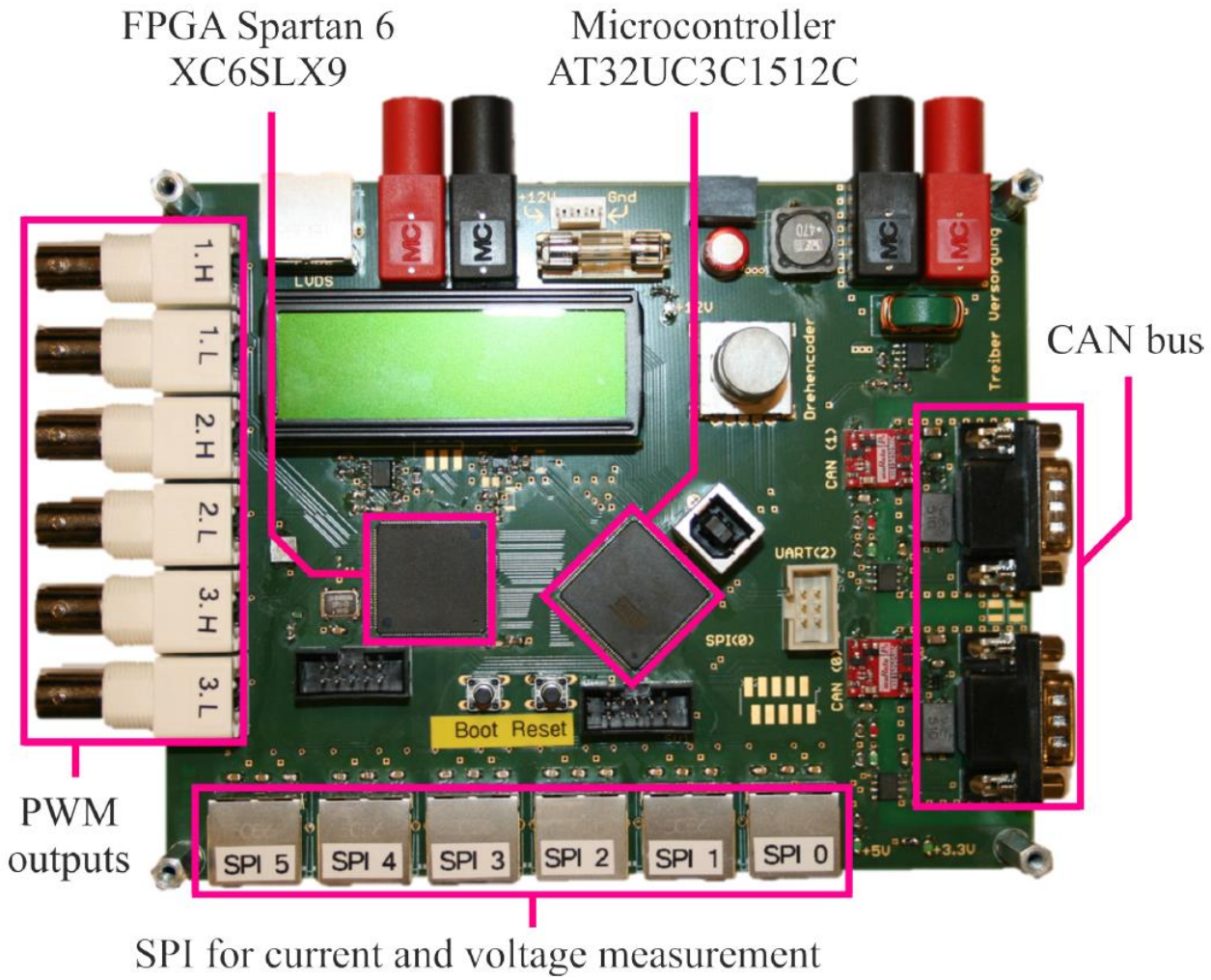
- Motivation
- DC-DC Converter Specification
- Control Platform Prototype
- Cascaded Control Structure
- Experimental Results
- Conclusions

SiC DC-DC Converter Specification

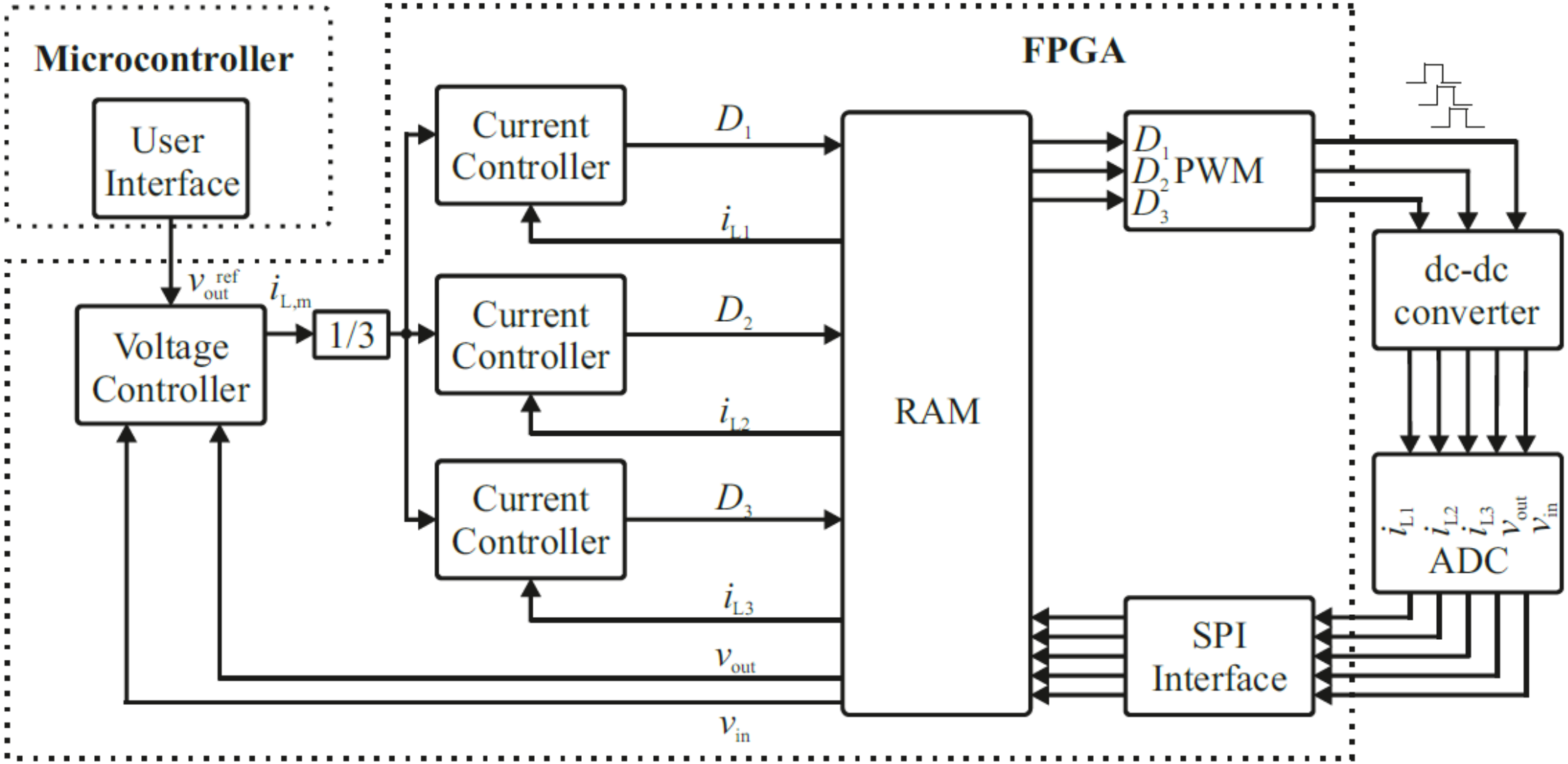
- Key Parameters:
  - Input voltage V_{in} = 80 V … 500V
  - Output voltage V_{out} = V_{in} … 800V
  - Switching frequency f_{sw} = 150 kHz
  - Number of phases = 3
  - Maximum output power = 42 kW
  - Maximum phase current = 35 A

Control Platform Prototype

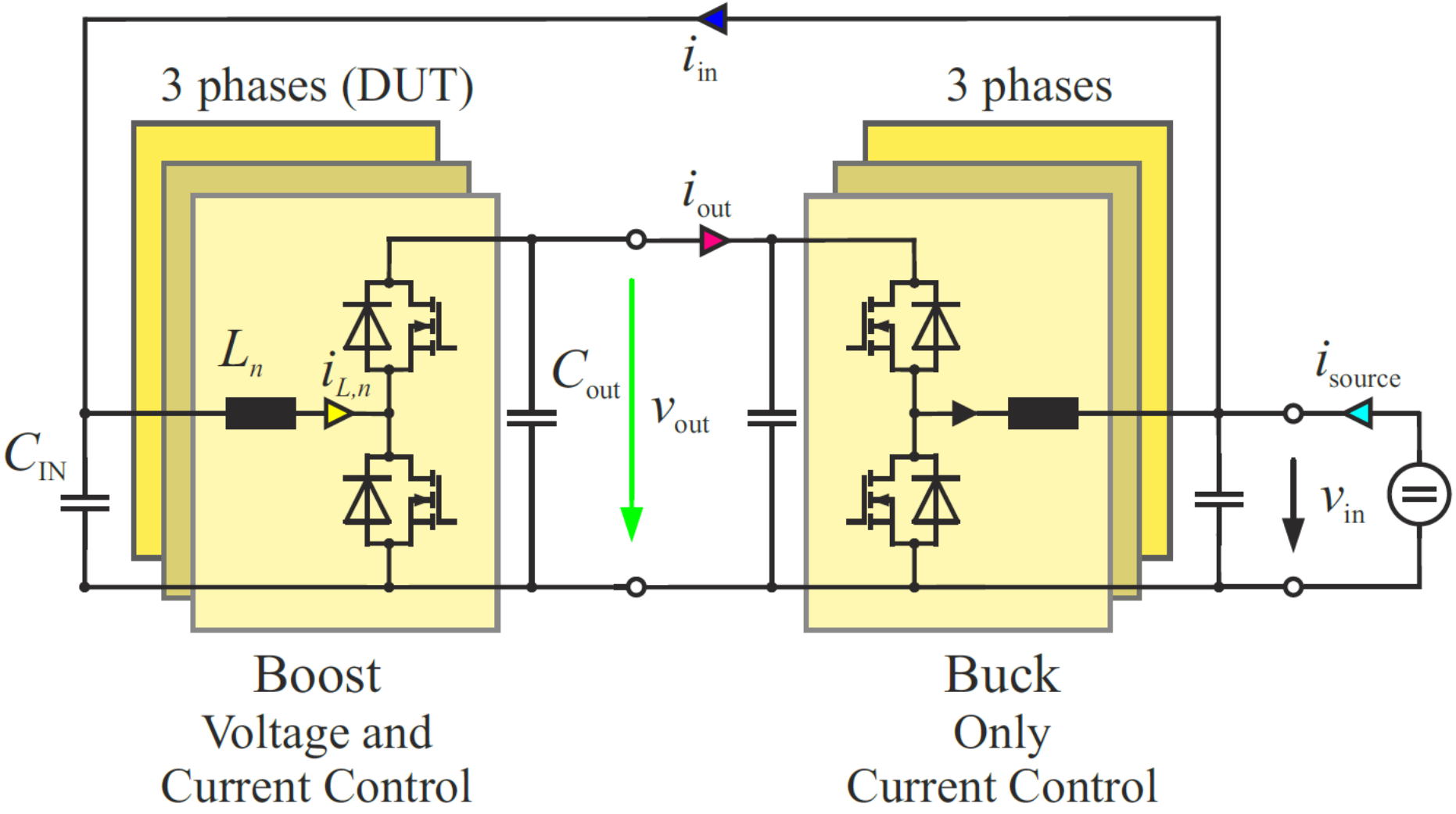
- Hybrid control board with an FPGA + µC
- Reference voltage can be set via
  - Manual user input
  - CAN-BUS
  - UART
- The three-phase control board can be scaled up to control a higher number of converter phases



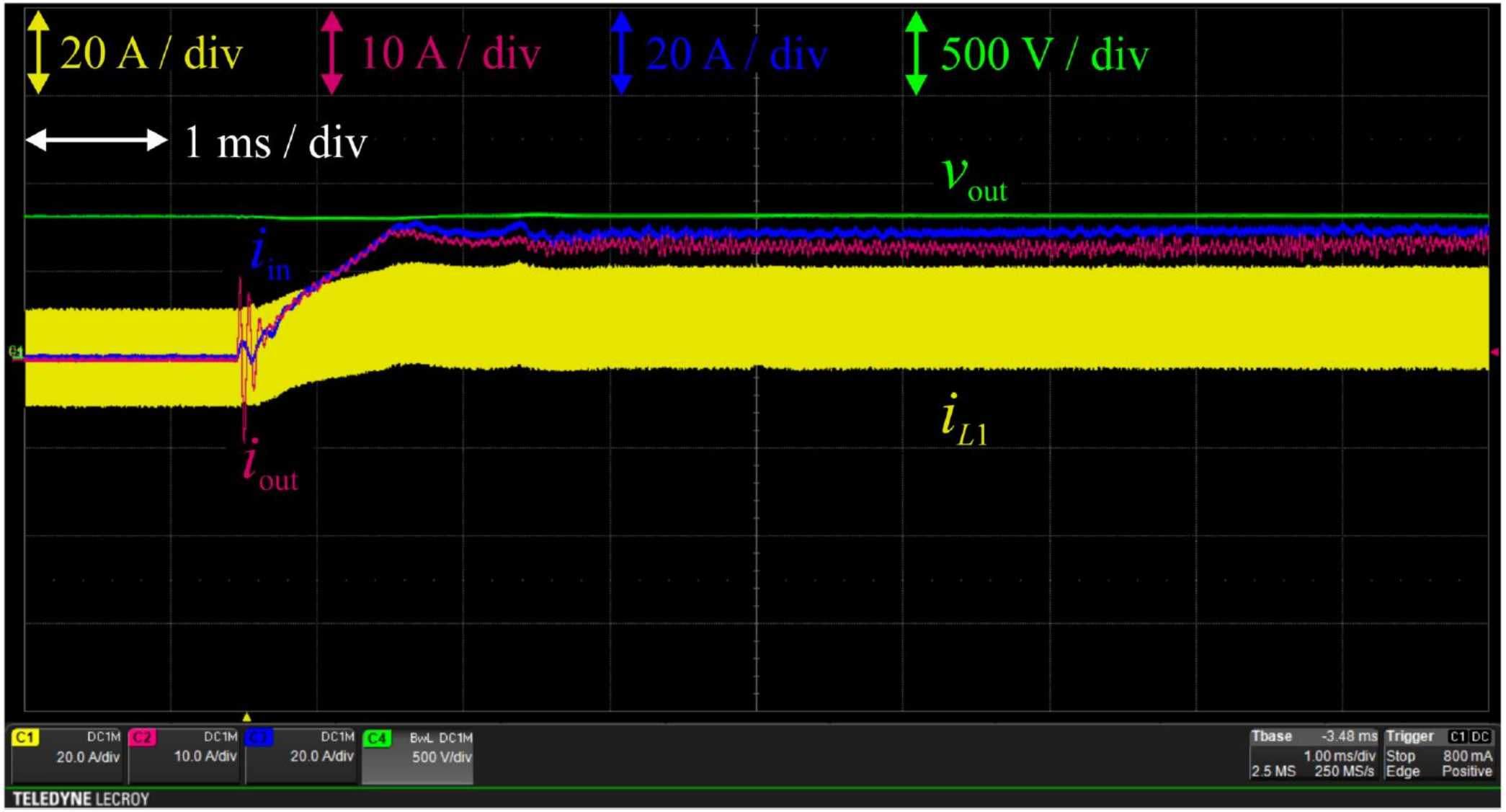
Control Platform Prototype



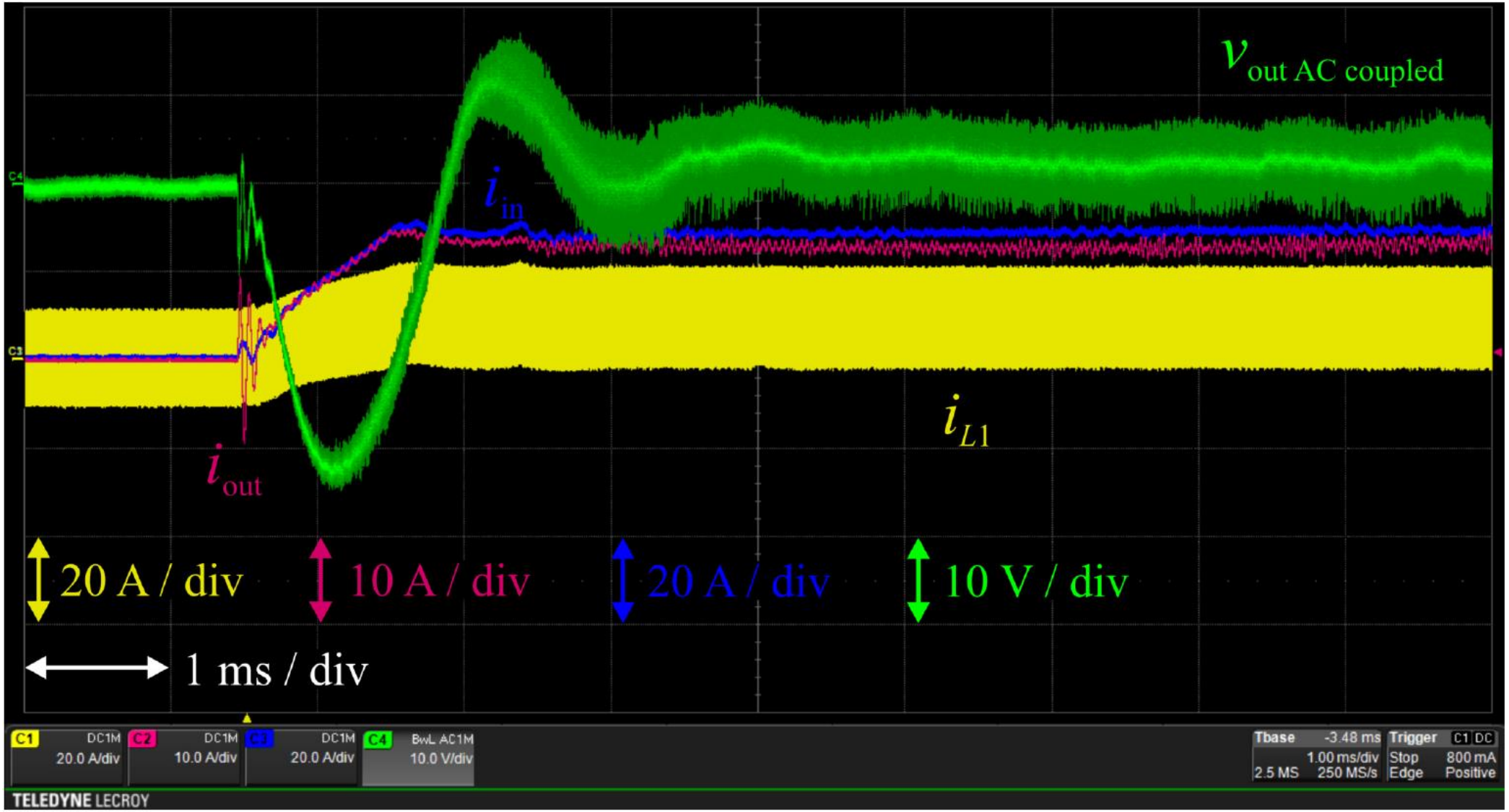
Experimental Results
Back-to-Back Connection of two DC-DC Converters



Experimental Results
Back-to-Back Connection of two DC-DC Converters



Experimental Results
Back-to-Back Connection of two DC-DC Converters



Conclusions

- A high-bandwidth model-based cascaded control of multi-phase bidirectional boost converters operating at high switching frequencies has been introduced.
- The model-based control is executed synchronously to the switching frequency, resulting in high-bandwidth control dynamics that allow to minimize passive components and thus converter size.
- To achieve the required tremendous calculation effort for the control algorithm within one switching period, the control algorithms are implemented on an inexpensive Spartan-6 FPGA.
- Experimental results of a 42 kW 3-phase bidirectional SiC boost converter operated at 150 kHz were presented to demonstrate the performance of the control algorithm.

Cascaded Control of High-Frequency Bidirectional Multi-Phase Boost Converters Implemented on Low-Cost FPGA

Thank you for your attention!