

GaN High Density 300W AC-DC Converter

300 W, 29 W/in³, 95.4%

Tom Ribarich¹, Peter Bredemeier², Stephen Oliver³

^{1,3} Navitas Semiconductor, USA

² ONgineer GmbH, Germany

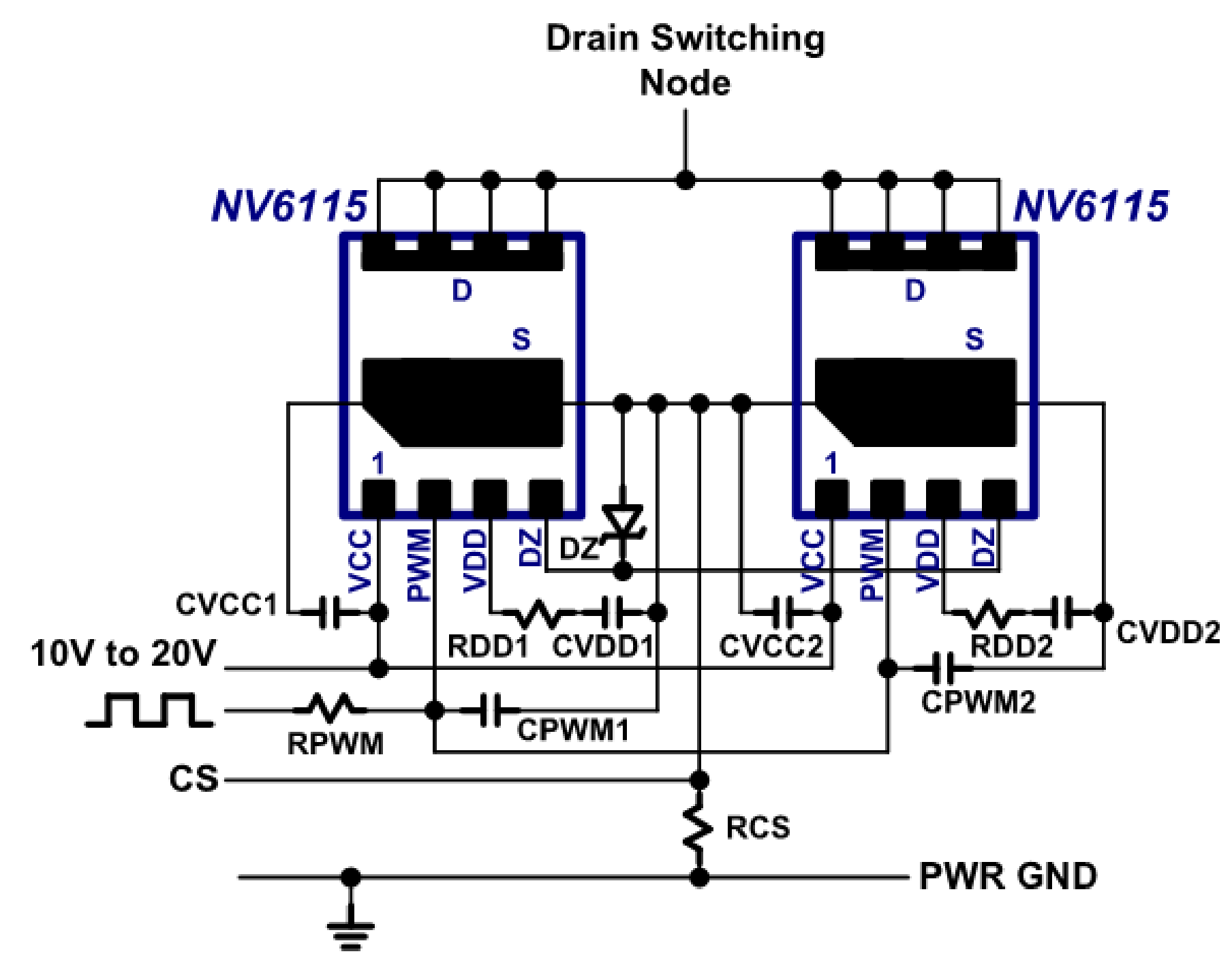
Abstract

A 300W AC-to-DC high-density and low-profile converter has been designed and demonstrated.

The circuit topology includes a 2-phase interleaved PFC input stage, an LLC dc-dc stage, and a synchronous rectification output stage. The design includes GaN power ICs and off-the-shelf controllers running at 500kHz.

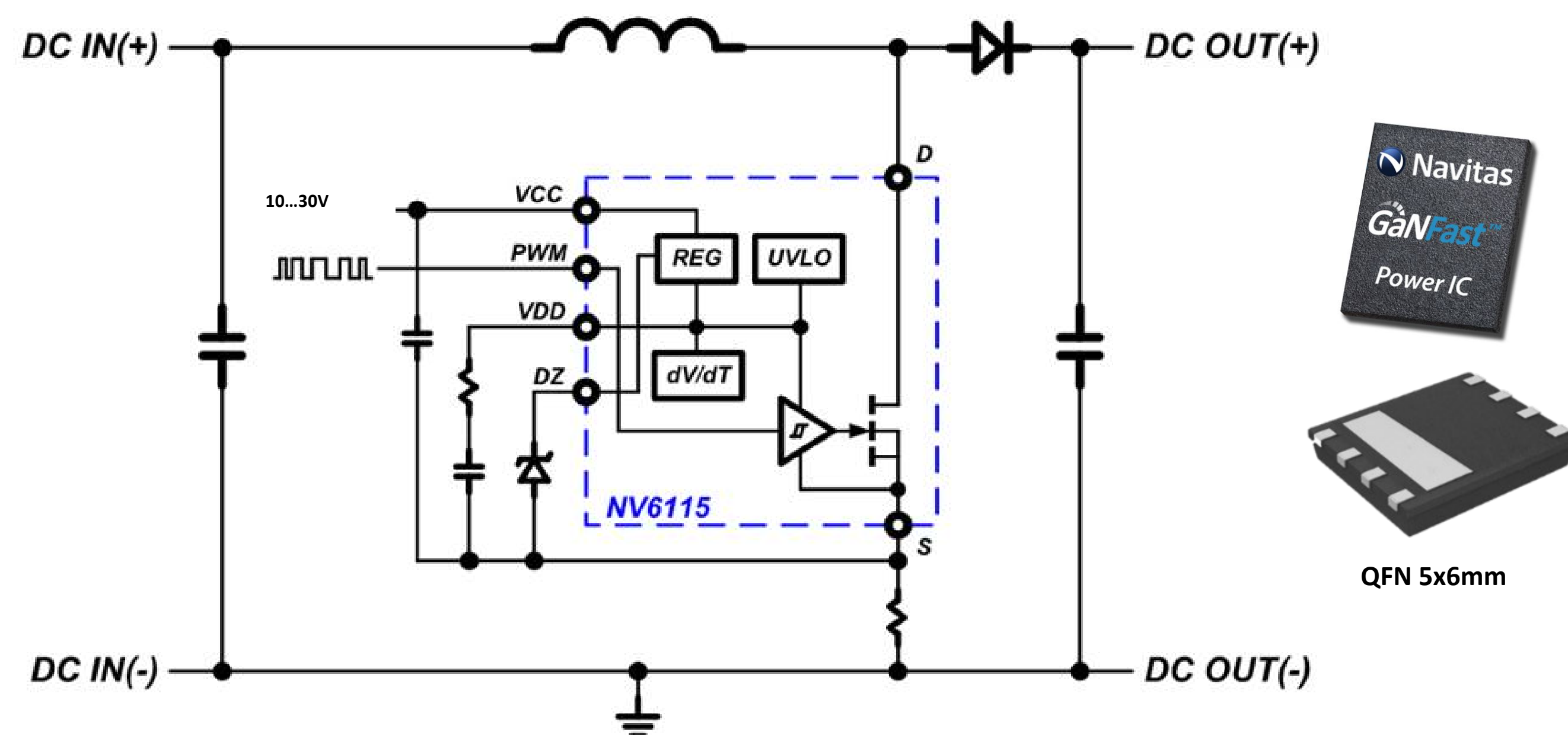
This new design has resulted in a power density of 29W/in³.

The waveforms demonstrate zero-voltage switching in all stages and the performance results show high efficiency and acceptable component temperatures.

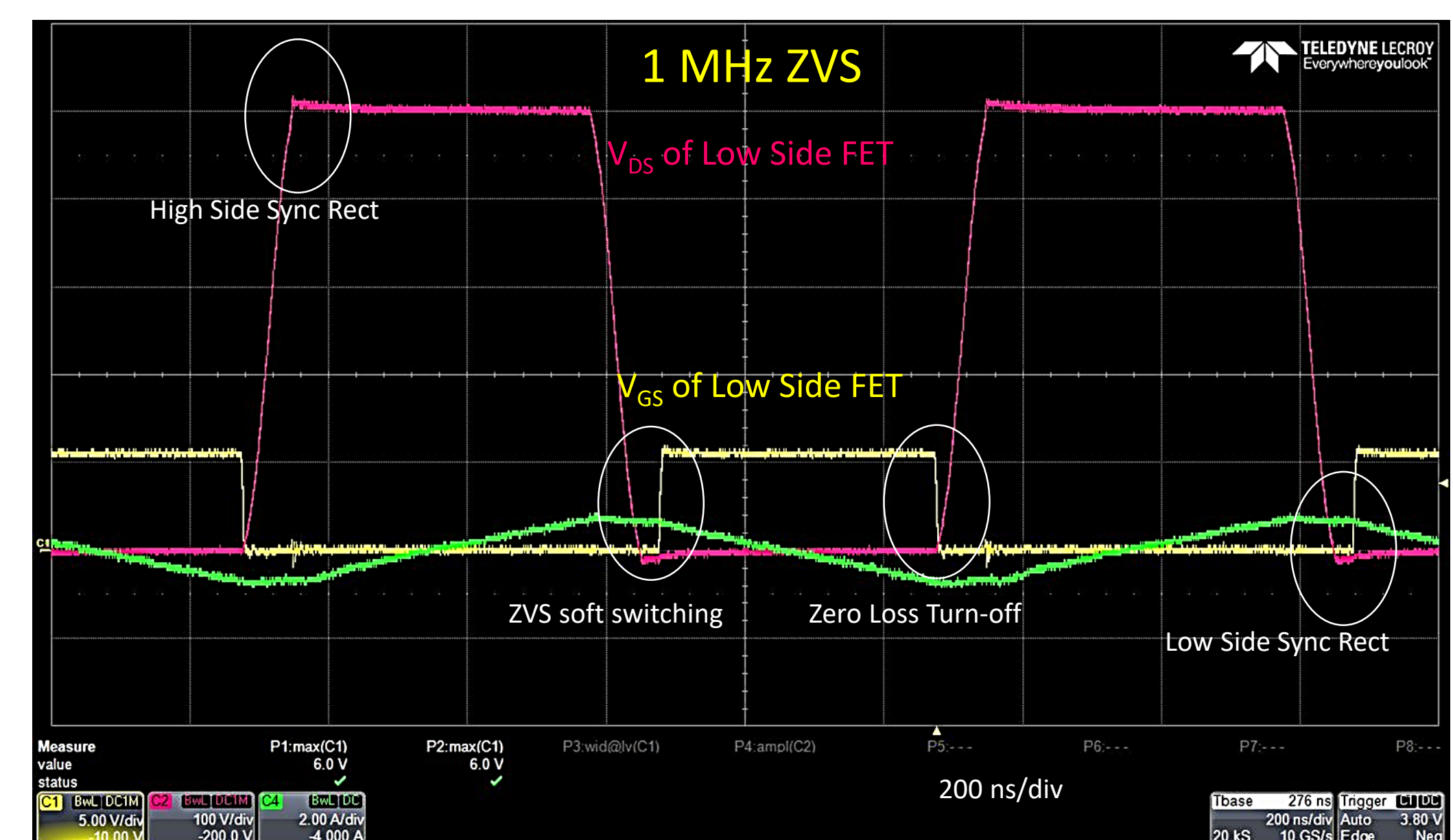


Easy-to-Parallel
GaN Power ICs

GaNFast™ Power IC



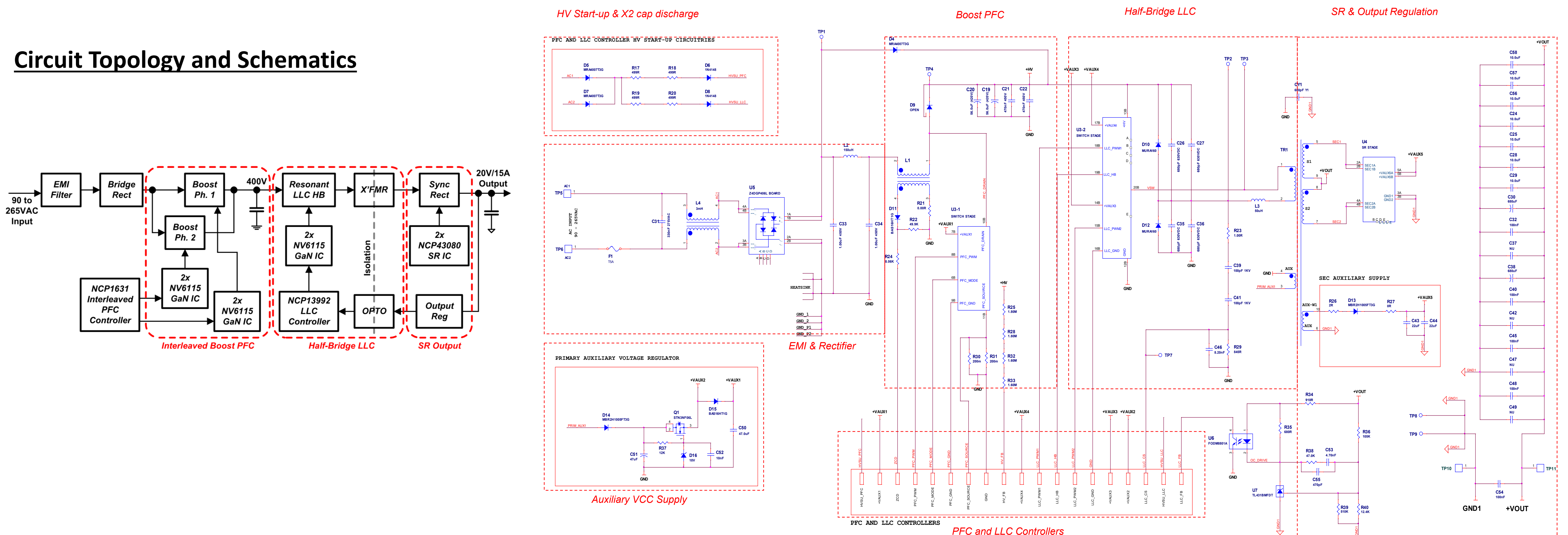
MHz Half-Bridge Performance



Proprietary Navitas technology = **monolithic** integration of 650V eMode GaN FET, GaN Driver, GaN Logic

Mass production GaNFast Power ICs are “Digital-in, Power-out” with 20x lower drive loss than silicon (<35 mW at 1 MHz). Zero impedance between driver output and FET gate means stable, high-efficiency, high-speed operation. Very fast prop delay and turn-on/off of 10-20 ns (from PWM input to change in FET V_{DS}) and high dV/dt immunity (200 V/ns) with slew-rate programmability mean easy high-frequency operation. Switching performance is fast, smooth and predictable with no overshoot, no spikes, no oscillations and smooth ‘S-curves’ transitions for easy EMI compliance. Note the zero-loss turn-on and zero-loss turn-off at 1 MHz.

Circuit Topology and Schematics

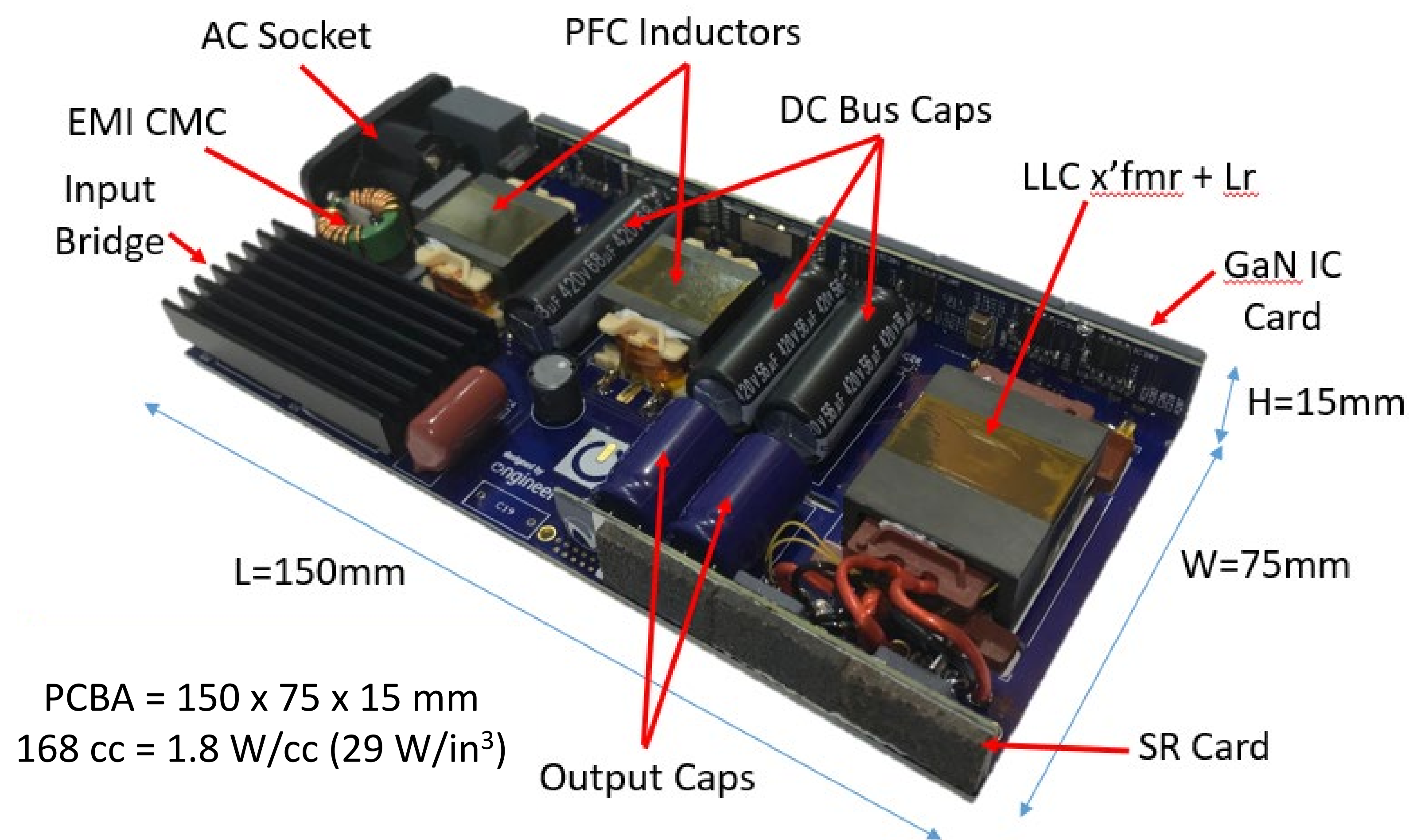


Commercial On Semiconductor controllers were pushed to their highest frequency limit.

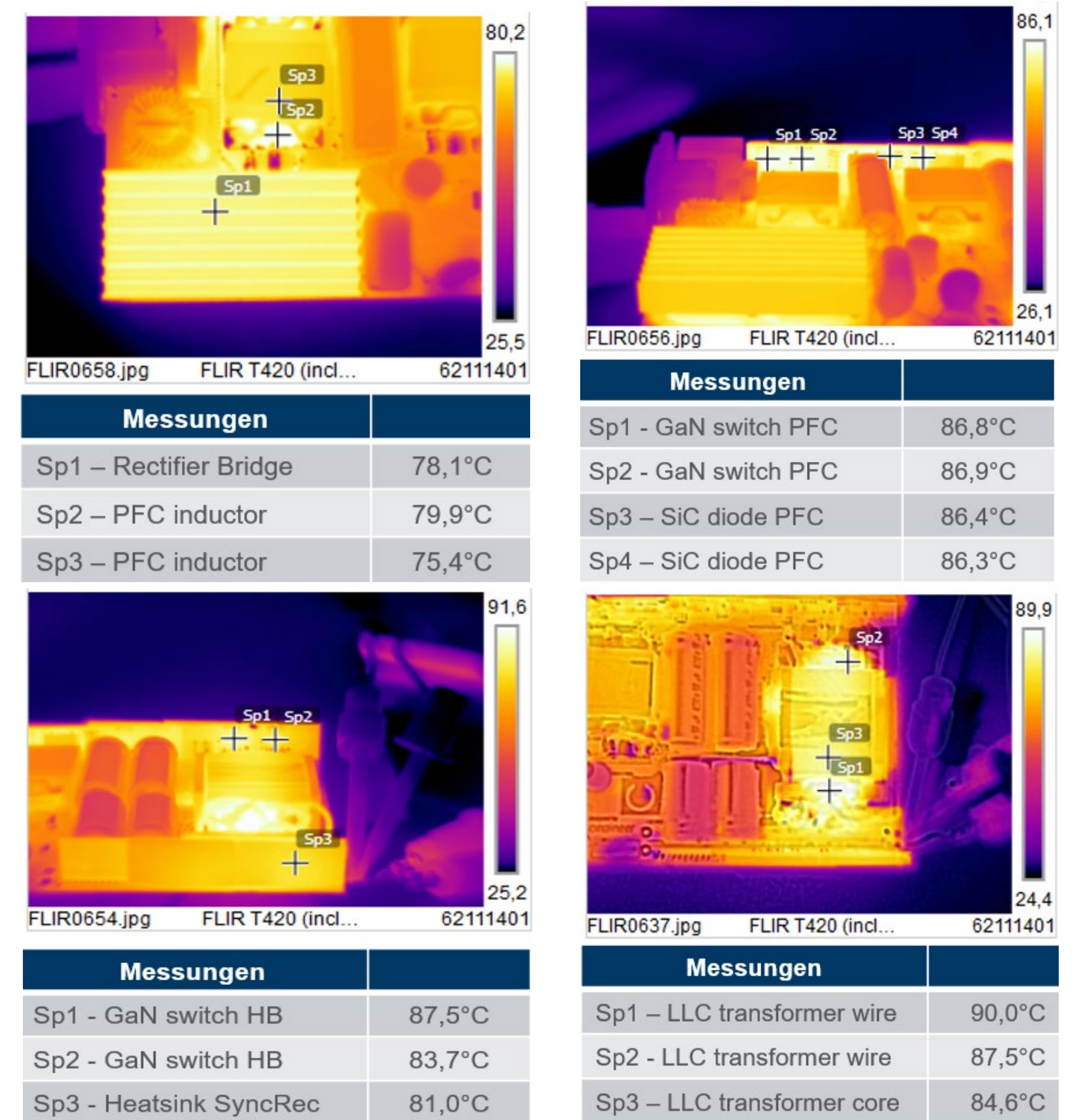
- PFC
 - Interleaved CrCM/DCM Boost using NCP1632 (with frequency-foldback function to reduce power consumption)
 - Minimum 200 kHz (90 V_{AC}, peak-of-line) to maximum 450 kHz
 - Inductors are 2x EF20 with TDK EPCOS N49 material.
- DC-DC
 - LLC using NCP1392 (with adaptive dead-time features, soft-start, comprehensive protection and HV start-up) and NCP4305/NCP43080 (SR)
 - 500 kHz normal operation (with higher frequency during load / start-up burst conditions)
 - LLC transformer is ED26 with N49

GaN High Density 300W AC-DC Converter

Simple Construction



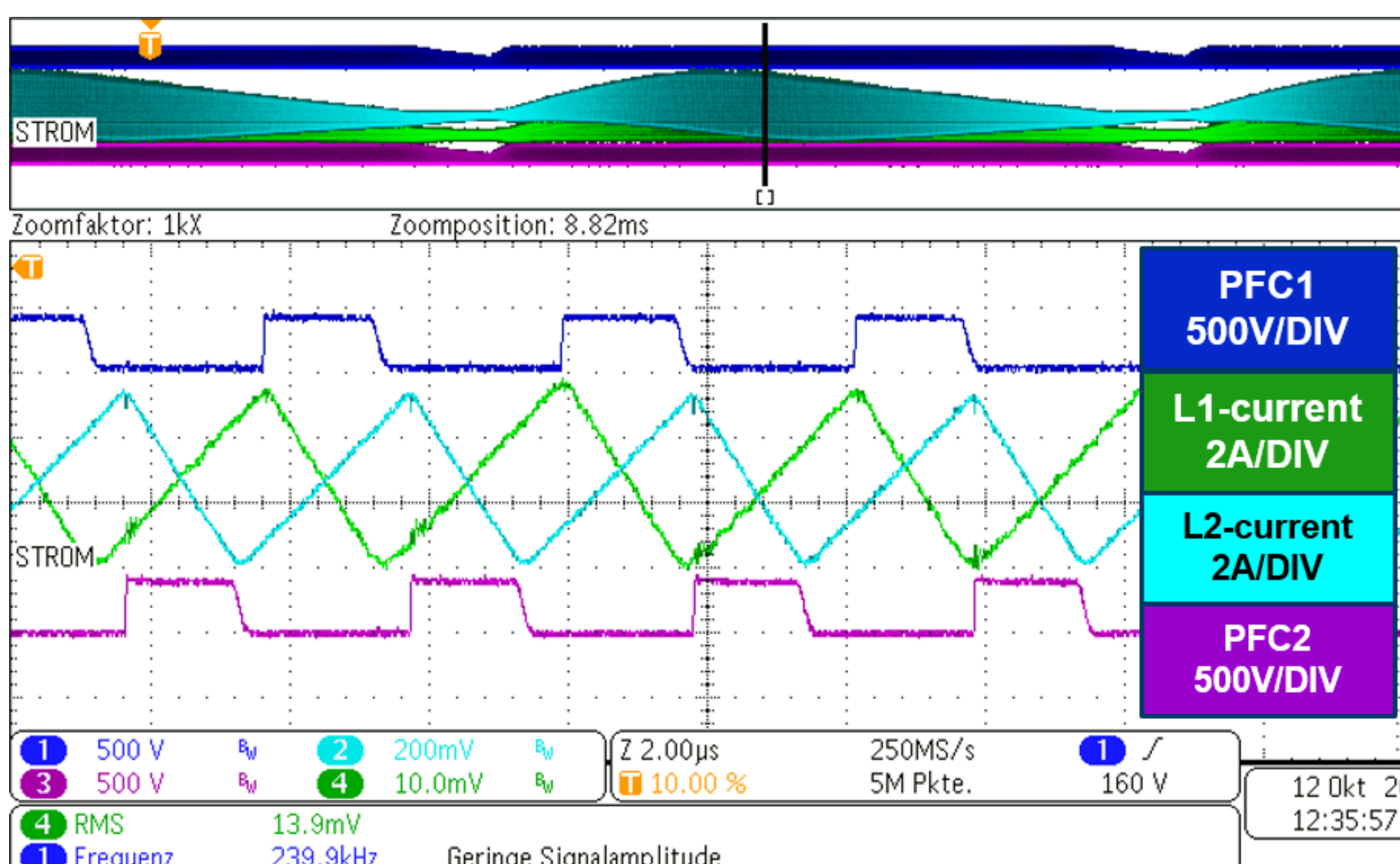
Cool Operation



Modular construction maximizes design flexibility. Low-cost, 2-layer motherboard for bulk caps, magnetics, etc. and 4-layer daughtercards for the powertrain (extra Cu for thermal management). Additional thermal management required (heat spreading, Cu wrapper, etc.).

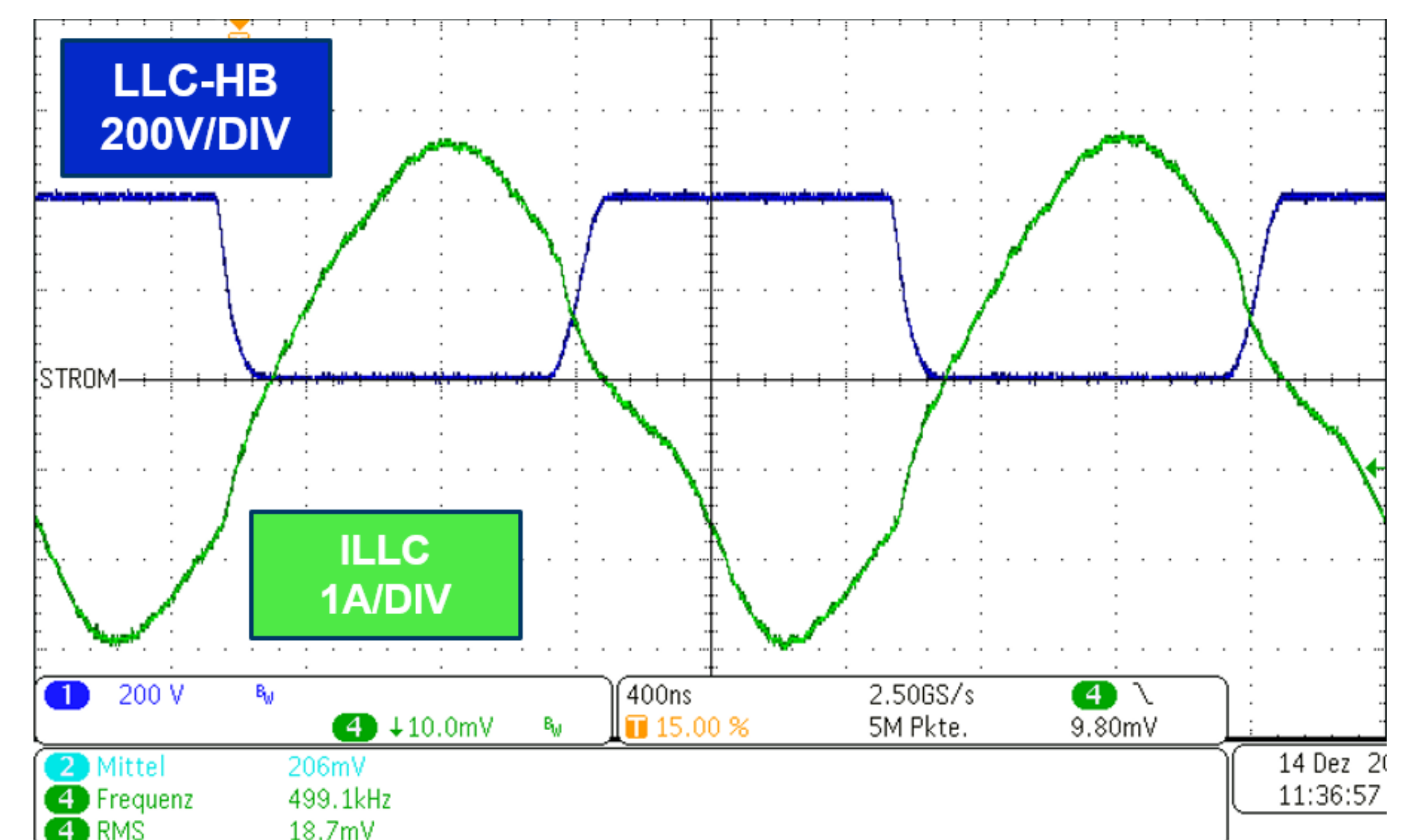
Worst-case condition (90 V_{AC}, full load, 25°C, open-frame). Images highlight the balanced power dissipation across the main passive components and GaNFast Power ICs (85-90°C).

Smooth, High-Frequency Operation



Note very fast switching of the GaN Power ICs

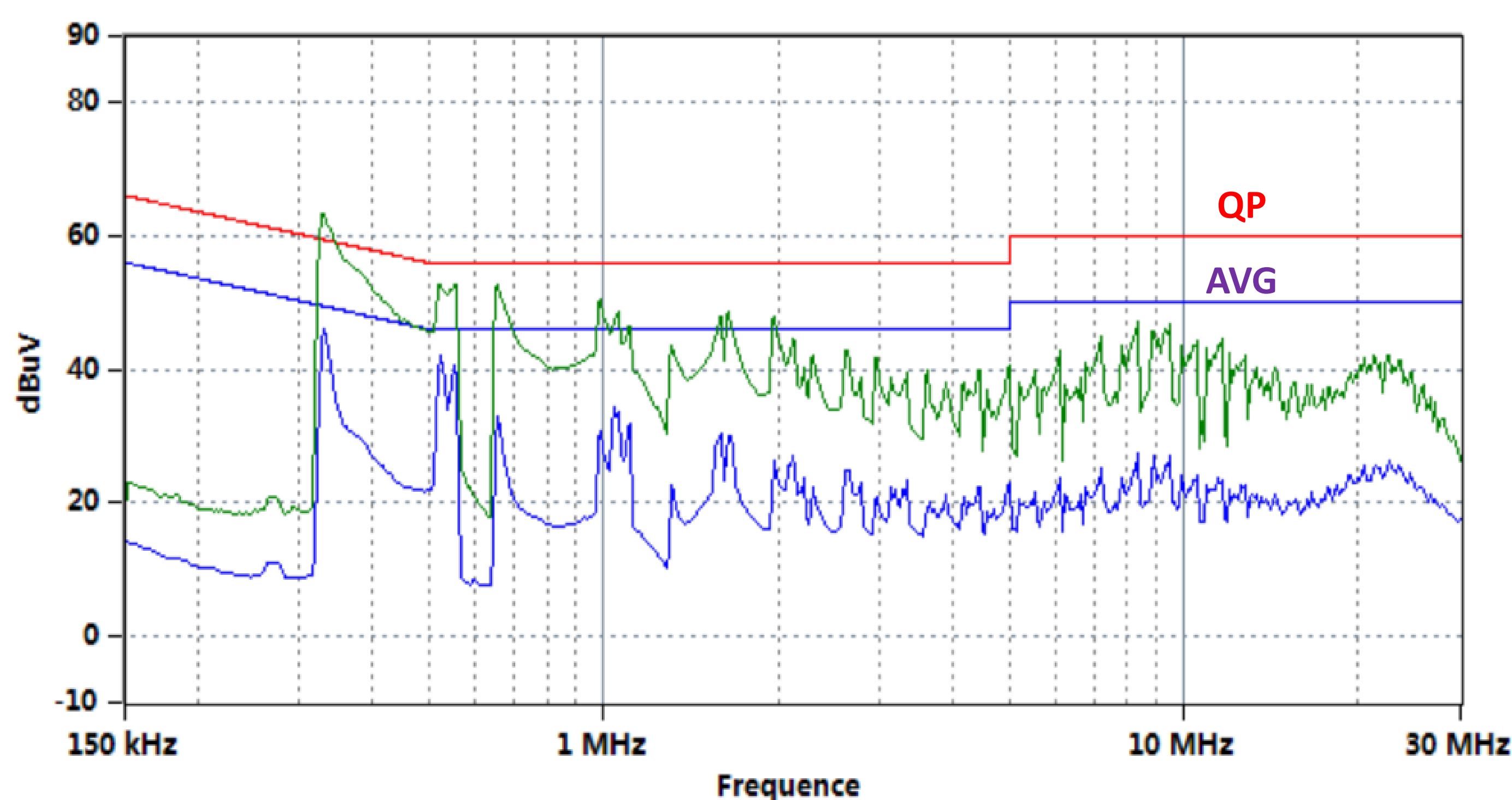
Controller timing may be accelerated to take advantage of the new technology to reduce dead-times and improve converter efficiency



LLC Half-Bridge voltage and LLC tank current (20 V_{OUT}, 15 A)

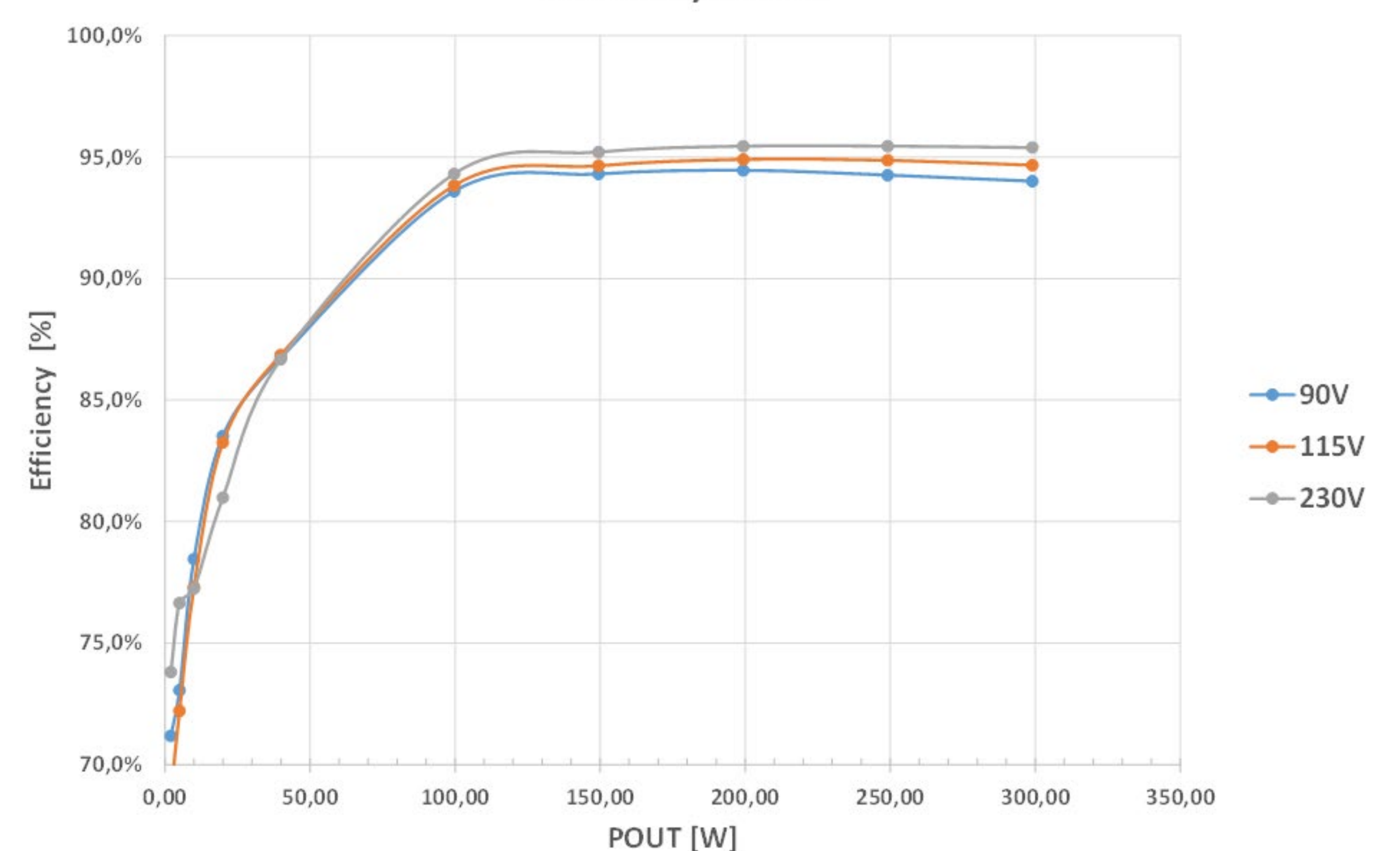
CrCM Interleaved PFC Boost 90 V_{IN}, 400 V_{OUT}, 300 W, 240 kHz (peak of AC line)

Quiet Operation



Predictable, smooth-switching, high-performance GaNFast Power ICs, plus correct layout ensure good EMI spectra performance vs. EN55022.

High Performance Efficiency vs load



Full load, 25°C, open-frame, no air-flow. US DoE "Level VI" ave. 94%. Curves are extremely high and flat, from ~25%-100% load.

Acknowledgements

Thank you to the ONgineer team in Espelkamp, Germany, for their collaboration and design support. Thanks also to the ON Semiconductor teams in Rožnov, Czech Republic and Phoenix, AZ for their collaboration and support.

Let's go GaNFast™

