We are the link between the real and the digital world.

The race for highest efficiency in server applications

Infineon's virtual show 2020

The race for highest efficiency in server applications Optimizing the power flow from Grid to PoL

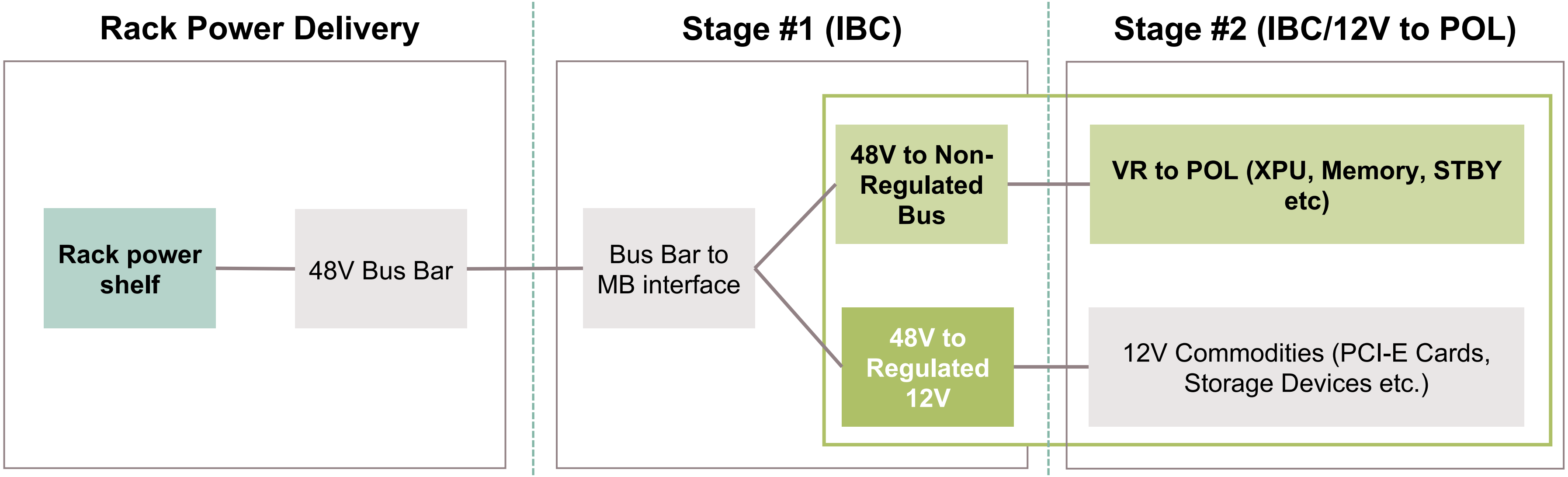
Industry 4.0, Autonomous driving, Artifician Intelligence and the IoT push for an ever **increasing performance of processor power** in servers and require comprehensive intelligent frameworks and plattforms **to scale serverfarms** while keeping **capital investment** and **operational costs** low. The digital transformation urges server farms to process an ever **increasing amount of data** faster and more efficient.

With **new architectures** as defined within the **Open Compute Project (OCP)** and **state-of-the art semiconductors** the computing power per server rack can be increased significantly, boosting **efficiency** levels to a maximum keeping CAPEX and OPEX low.

As **#1 in Power**, Infineon offers a **broad** Si, SiC and GaN based **best-in-class** semiconductor **portfolio** enabling state-of-the art solutions for OCP compliant server architectures. Infineon's leading power technologies, and reference designs paired with Infineon's **system understanding** and **know-how** enables faster time to market ranging from AC-DC SMPS to DC-DC conversion down to PoL solutions**,** at outstanding **power density** at highest **efficiency.**

Three Highlights for Data Center Architecture with 48V Bus

SMPS solutions & Hybrid Intermediate Bus: Non-Regulated IBC Voltage and Regulated 12V



Solution highlights

- Si, SiC and GaN based SMPS
- HSC 48V converter
- 500W IBC conveter

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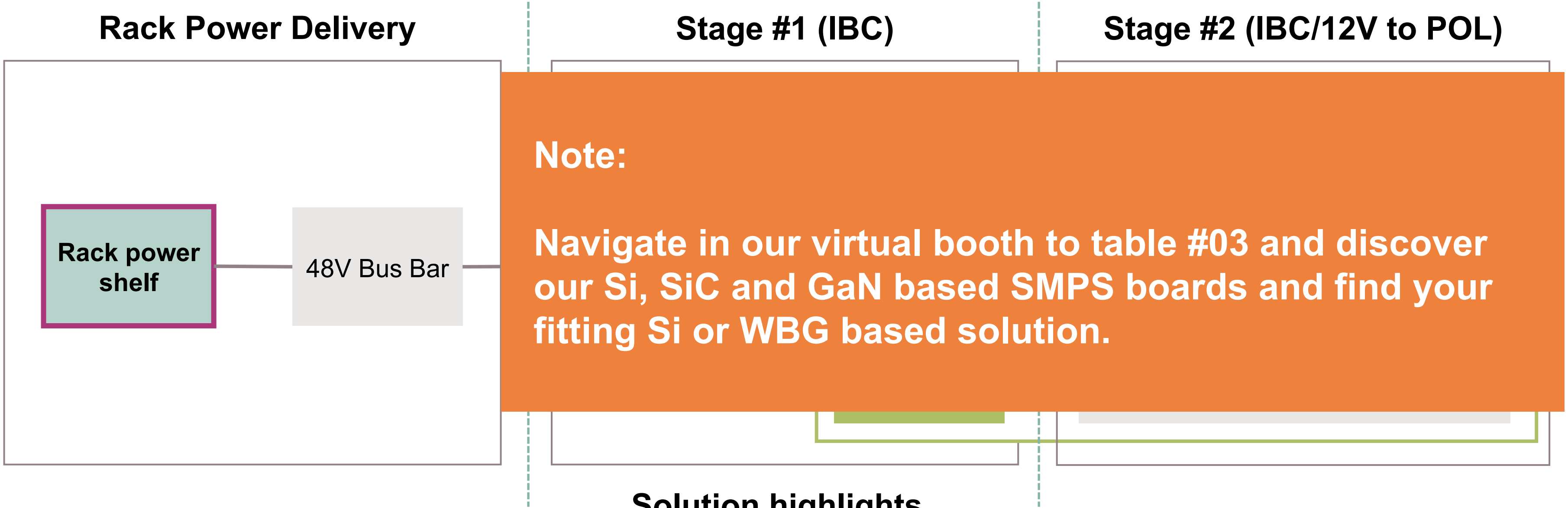

Note:

Navigate in our virtual booth to table #03 and discover our Si, SiC and GaN based SMPS boards and find your fitting Si or WBG based solution.

Solution highlights

- **Si, SiC and GaN based SMPS**
- HSC 48V converter
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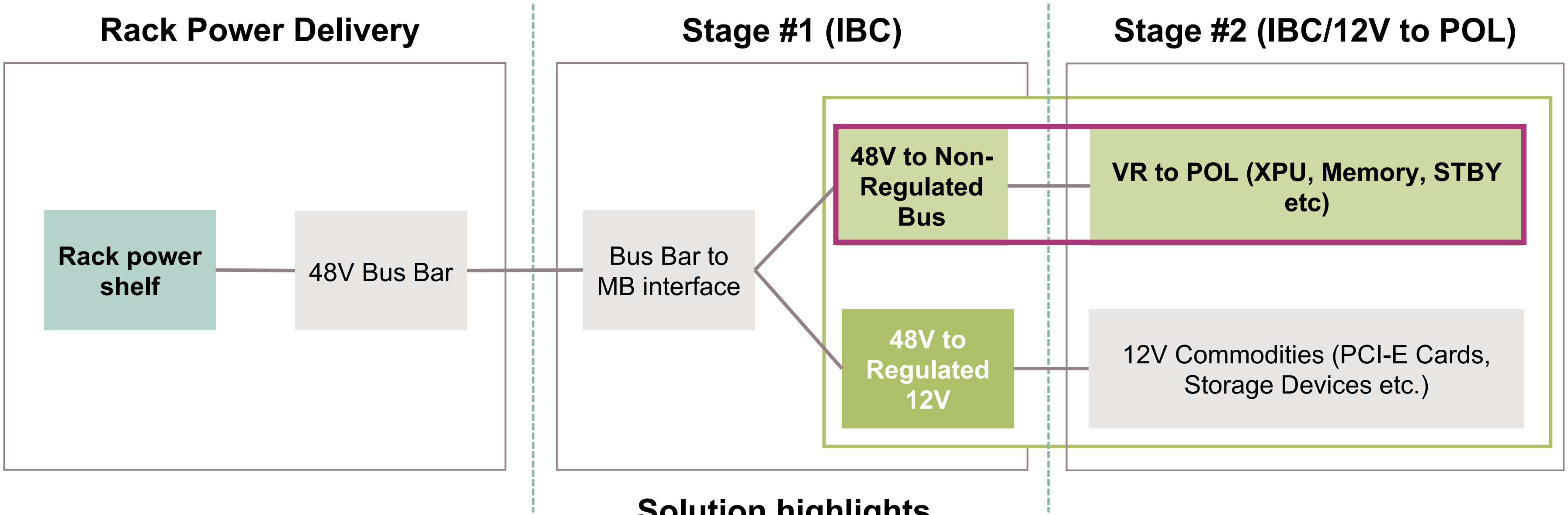
Three Highlights for Data Center Architecture with 48V Bus

SMPS solutions & Hybrid Intermediate Bus: Non-Regulated IBC Voltage and Regulated 12V



Solution highlights

- Si, SiC and GaN based SMPS
- **HSC 48V converter**
- 500W IBC conveter

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48V hybrid switched capacitor converter

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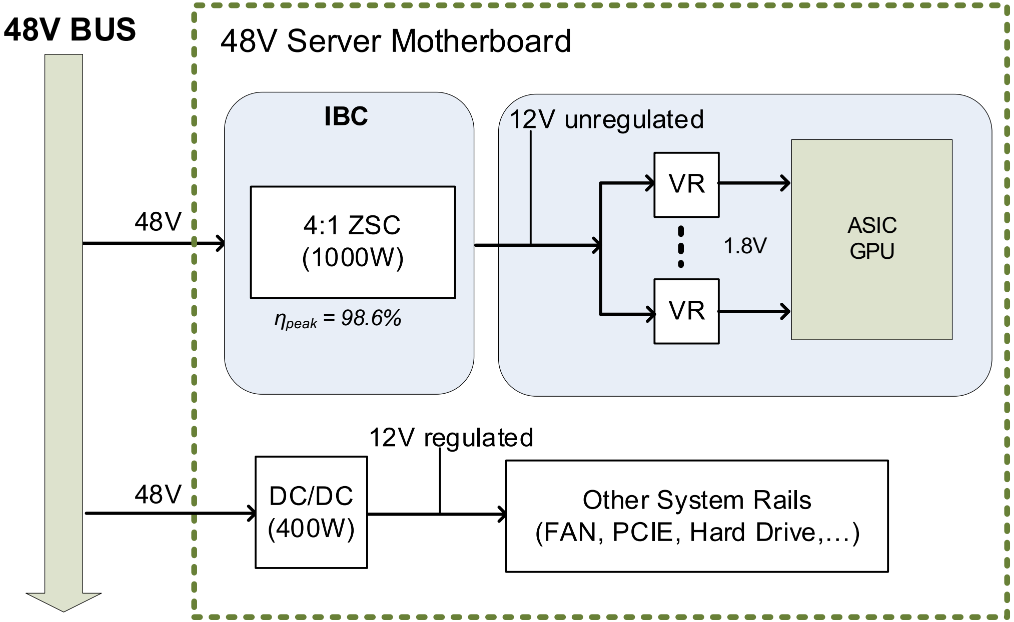
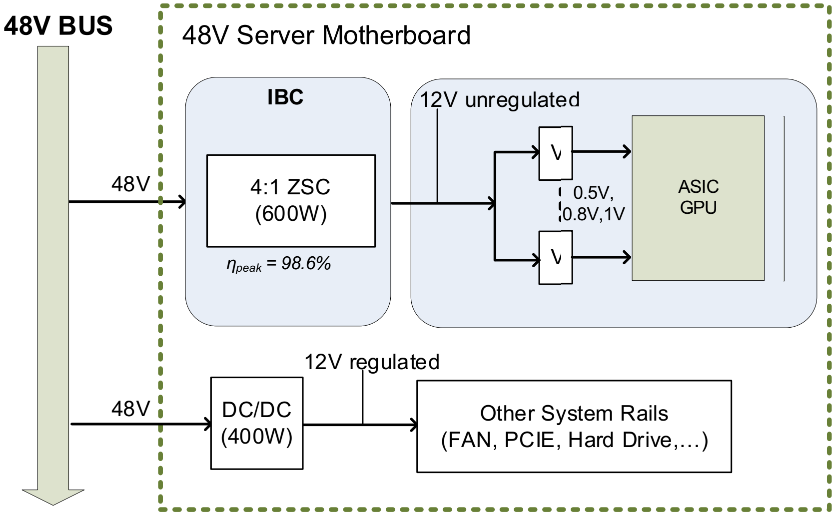
48V power architecture for data centers

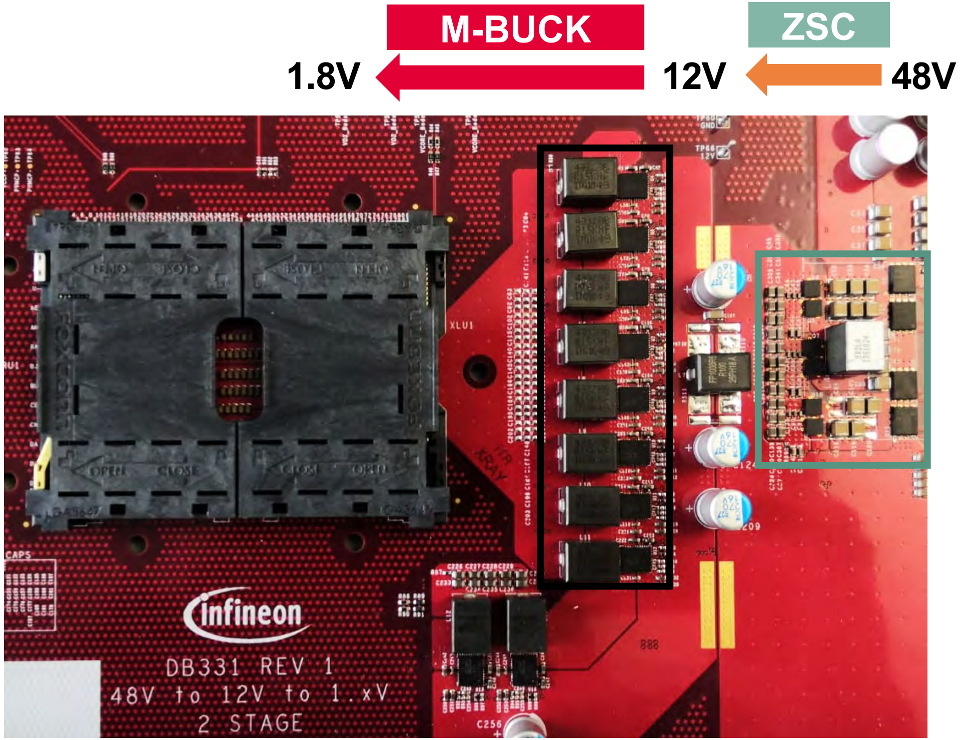
Why 48V power architecture?

- Less distribution losses @ bus level reduced by 16x the I2R
- Higher power capability for the rack
- Higher overall efficiency
- Is a 48V telecom ecosystem
- Implementation of UPS in-rack

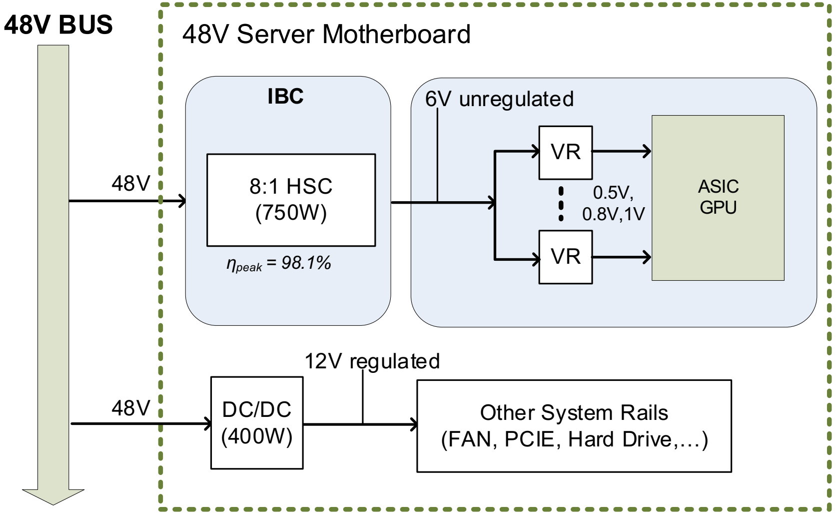


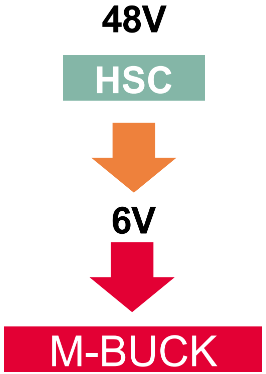
Data centers & AI servers Infineon 48V solutions



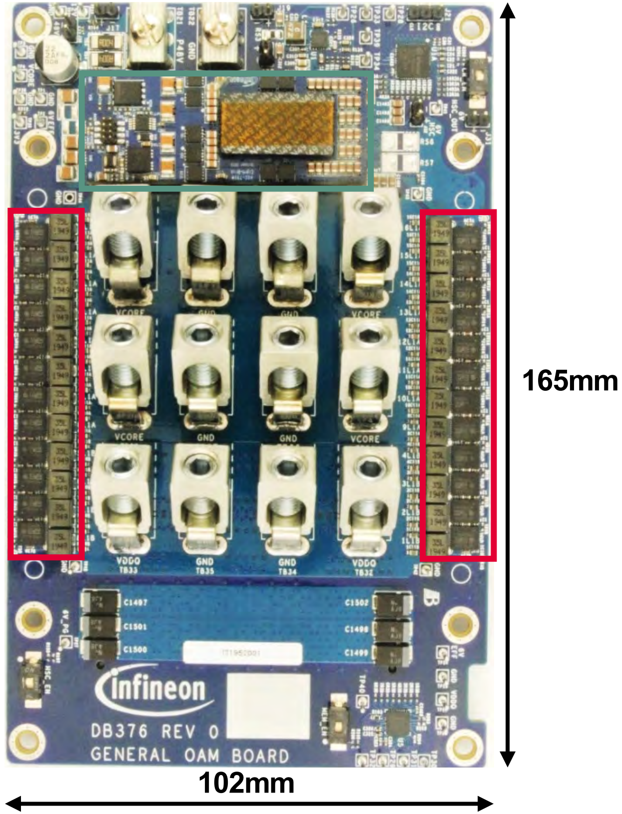


Data centers & AI servers Infineon 48V solutions



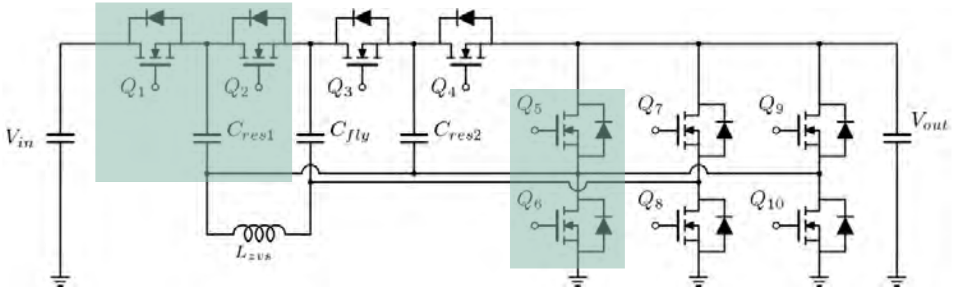


- 0.8V @600A
- 1V @270A



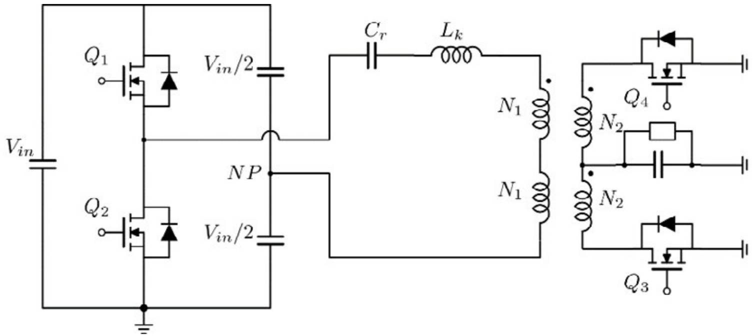
From switched capacitor to hybrid switched capacitor converters

Zero-Voltage switching switched capacitor converter

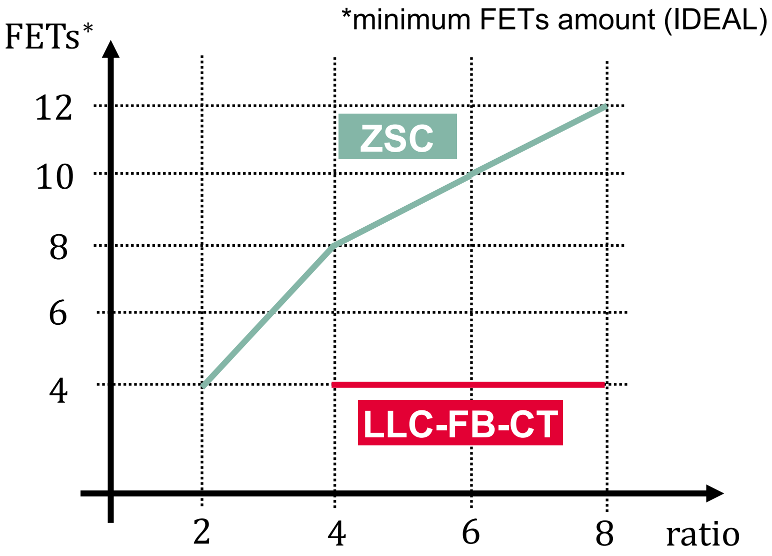


SC based topology, ratio given from SC cells

LLC HB-CT

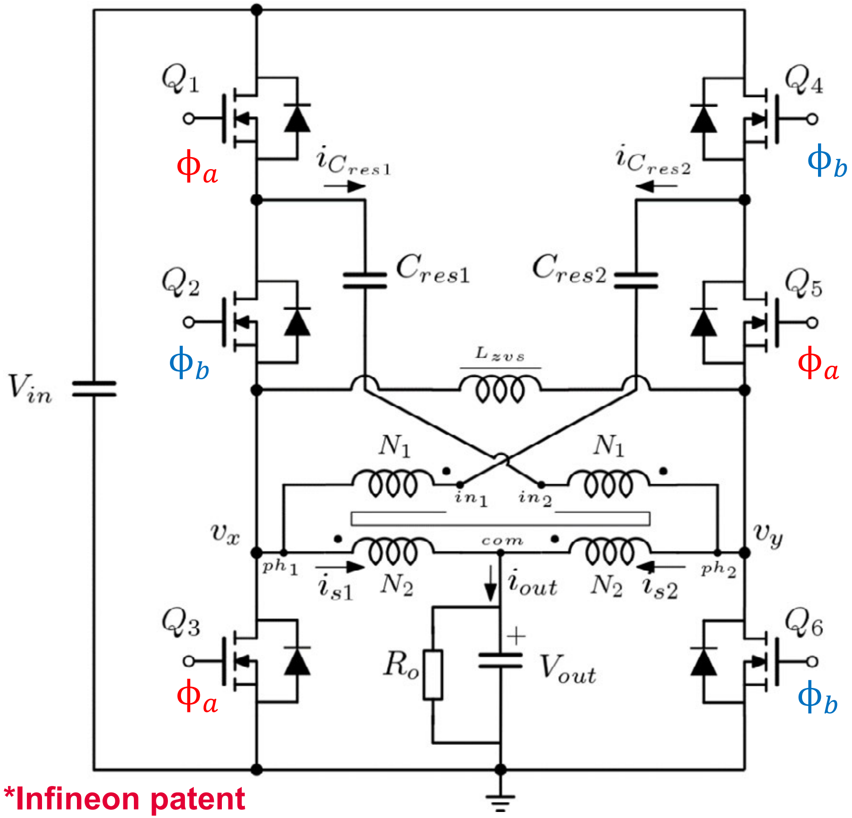


Transformer based topology, ratio given transformer ratio



Hybrid switched capacitor is combining SC cells with magnetic device

Hybrid switched capacitor converter (HSC)



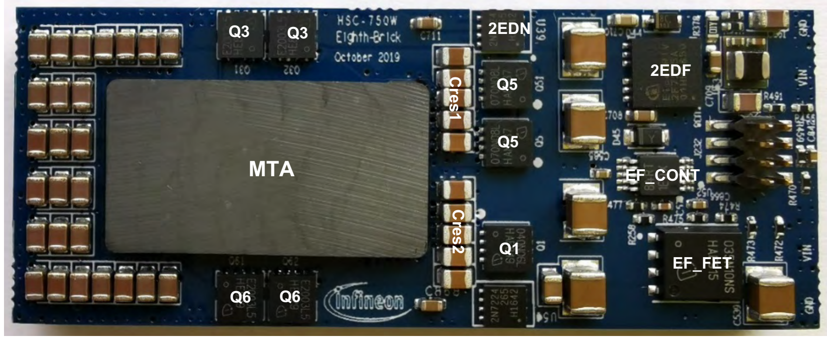
***Infineon patent**

- **Different ratios** are possible maintaining the same number of FETs 5:1 6:1 8:1
- **Soft-switching** operation regardless tolerance components and input voltage variation (L_m of the **Multi-Tapped Autotransformer** provides soft-switching capability)
- L_k of the **Multi-Tapped Autotransformer** ensure **soft-charging** of the C_{res1}, C_{res2} and C_{out}
- **Simplified driving system** (no need charge pump)
- **Symmetric operation** (less input current ripple)
- Q_2 and Q_5 have to block V_{in} in their off state
- Q_1 and Q_4 have to block $\frac{V_{in}}{2} + V_{out}\frac{N_1}{N_2}$
- Q_3 and Q_6 have to block $2V_{out}$ voltage in their off state

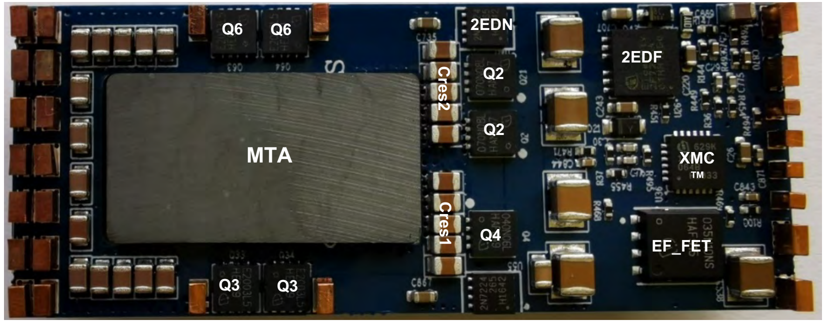
$$V_{out} = \frac{V_{in}}{4 + 2\frac{N_1}{N_2}}$$

Hybrid switched capacitor 8:1 – 750W

TOP SIDE



H=10,2mm **BOTTOM SIDE** **18 layers PCB 3oz**



23,3mm

58,8mm

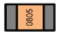
Q1, Q4: 2 X BSZ040N06LS5

Q2, Q5: 4 X BSZ070N08LS5

Q3, Q6: **8 x IQE006NE2LM5**

2x 2EDF7275K + 4x 2EDN7524G

$C_{r1,2}$= 2.2µF*10 **X7R**



E23/5/13+E 23/5/13 N49

V_{in} **= 48V**

V_{aux} **= 12V**

V_{out} **= 6V**

f_{sw} **=440kHz**

$$PD = 940\, {}^{W}/_{in^3}$$

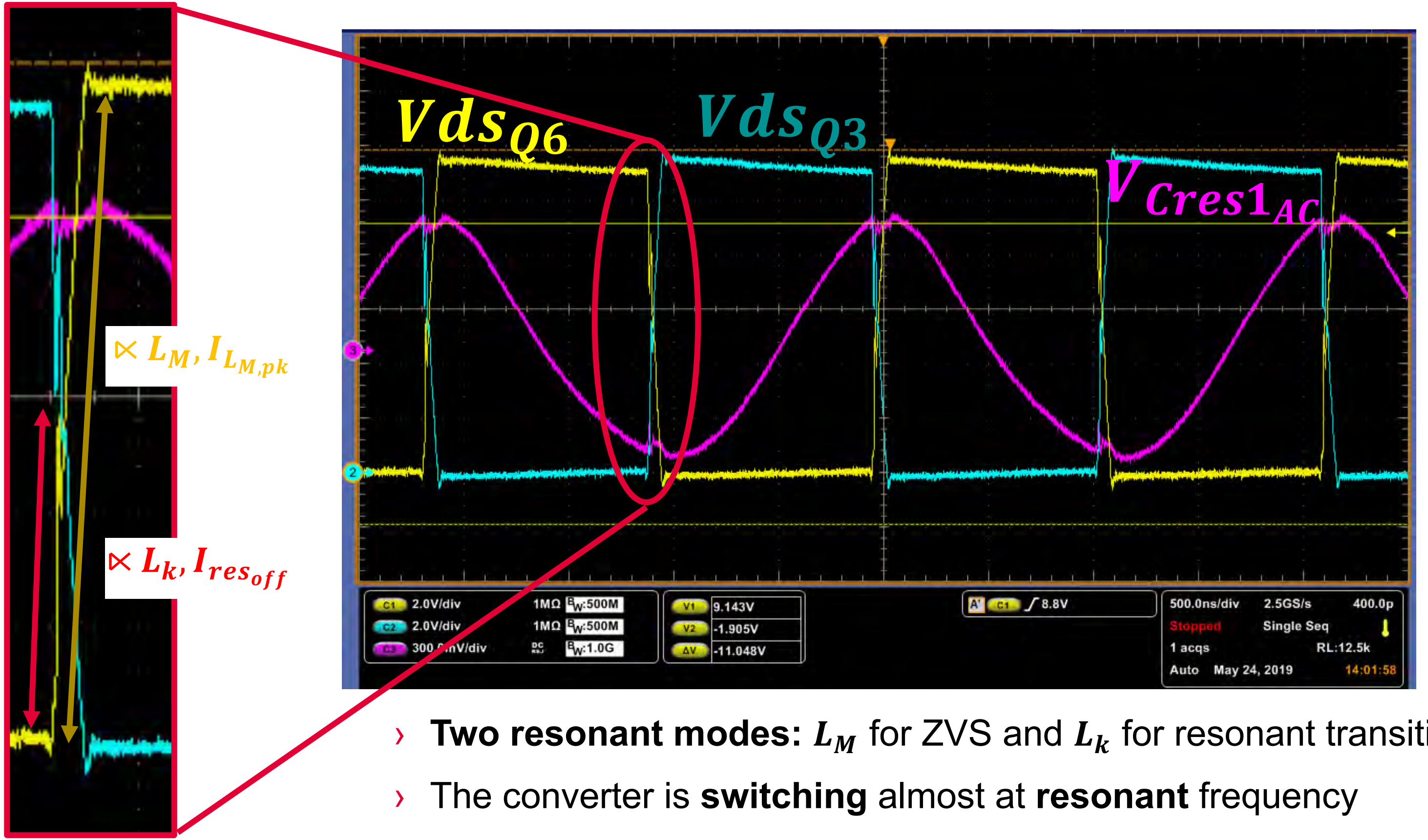
1 x XMC™ 1300

E-Fuse Controller LM5060

E-Fuse 2 x BSC035N10NS5

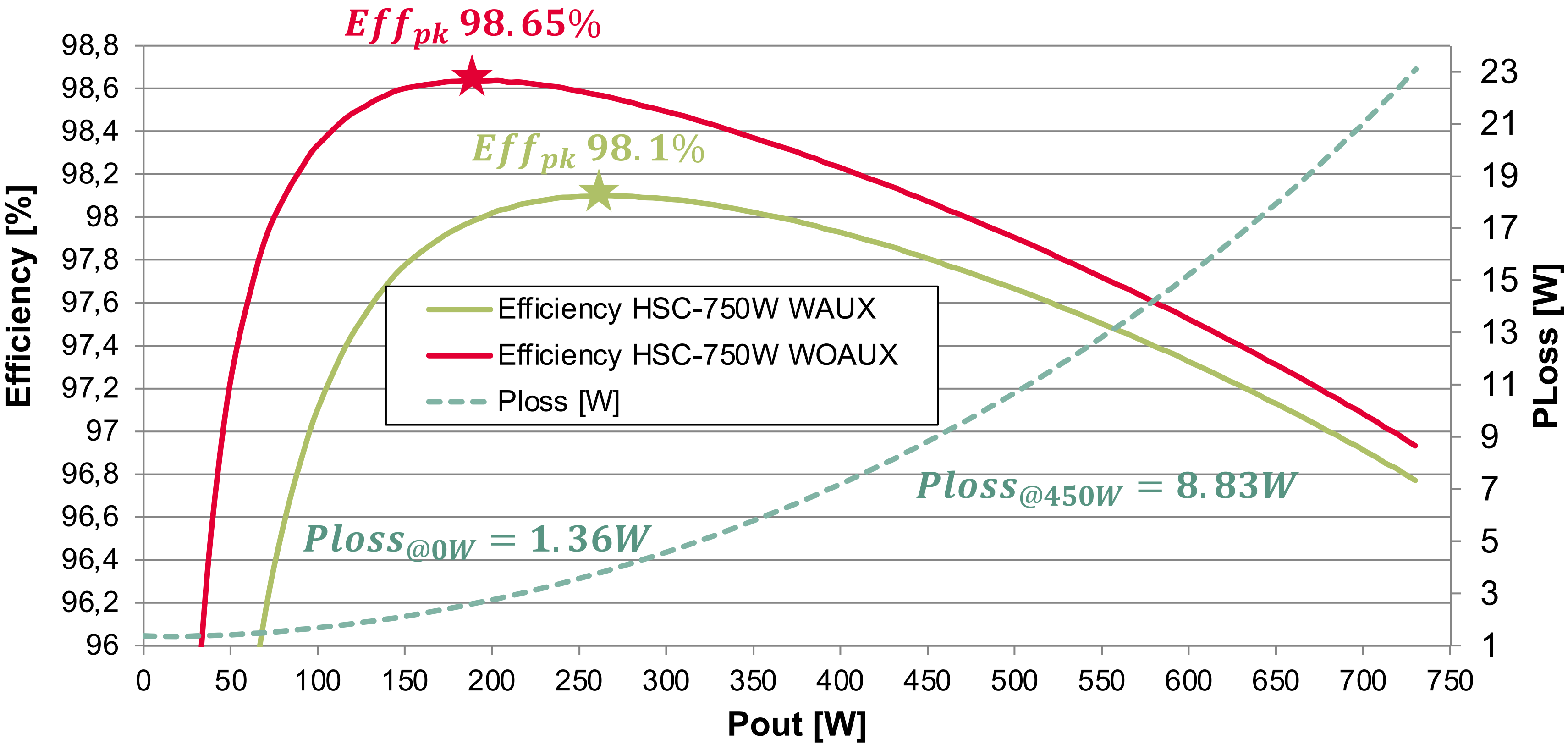
12V to 6V LMZM23601

Main experimental waveforms
$(V_{in} = 48V\ V_{out} = 6V\ I_{out} = 40A)$



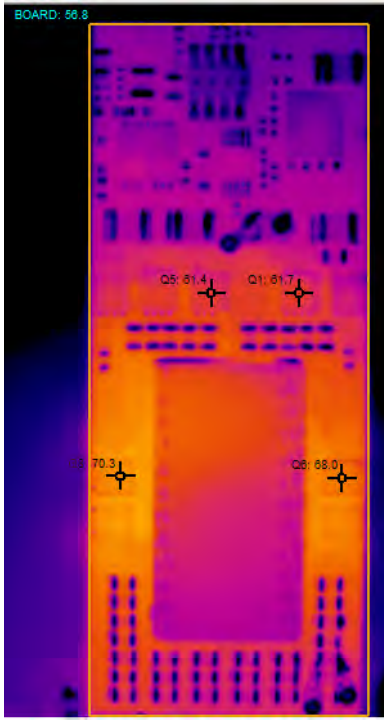
- **Two resonant modes:** L_M for ZVS and L_k for resonant transition with $C_{res1,2}$
- The converter is **switching** almost at **resonant** frequency

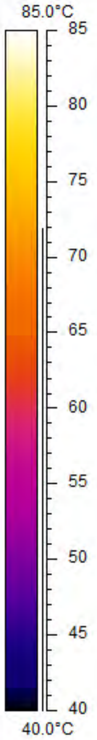
Efficiency
($V_{in} = 48V$ $V_{out} = 6V$ $f_{sw} = 440kHz$)



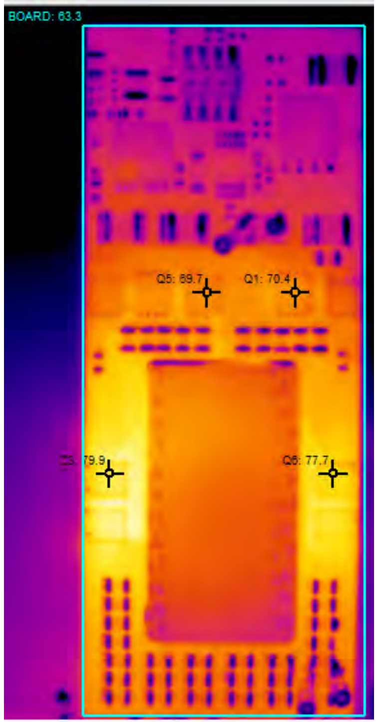
Thermal performance HSC 8:1 with fan

$@V_{in} = 54$ and $P_{out} = 700W$





$@V_{in} = 48$ and $P_{out} = 700W$

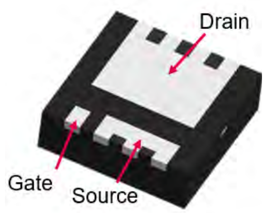


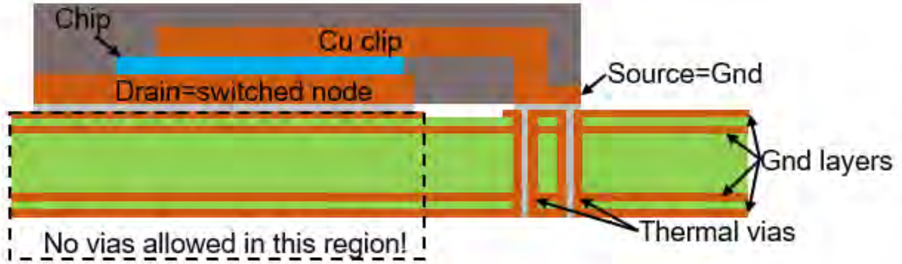
- By using **IQE006NE2LM5** the thermal pad to GND ensures superior thermal performance
- Low side FETs Q_3 and Q_6 have almost the **same temperature** → **Perfect current balancing** between phases H and L
- Q_1 and Q_5 are facing **low current** as well as for **resonant caps**
- The **output AC current** is **well-spread between output caps**

$$T_{amb} = 24°C \ v = 3.3m/s$$

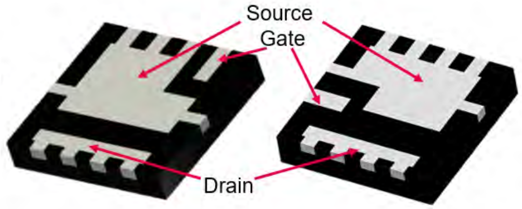
Source-Down technology in HSC converter

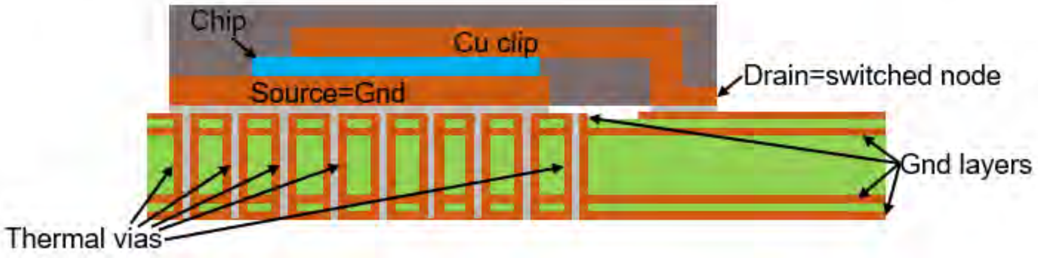
Drain-Down





Source-Down





Source-Down can improve the design of synchronous rectifier on an SMPS secondary side

Summary

- A new family of **unregulated** converter is presented called **hybrid switched capacitor**
- **HSC** combines the benefit of **SC** and **transformer** based converters
- HSC is enabling **high step-down** voltage capability at **high power** with **best in class efficiency**
- HSC **overcome** the main **limitations** of a classic **LLC-CT** topology
  - High efficiency is kept high regardless **components tolerances**
  - **ZVS** for all switches in the converter
  - Better **FOM** MOS can be used in HSC
  - **Less current stress** on both magnetic and FETs side in HSC comparing with LLC-CT
- **Source-Down technology** enables high efficiency, small footprint and superior thermal performance

High-Density 500 W Buck IBC using CoolGaN™ HEMTs

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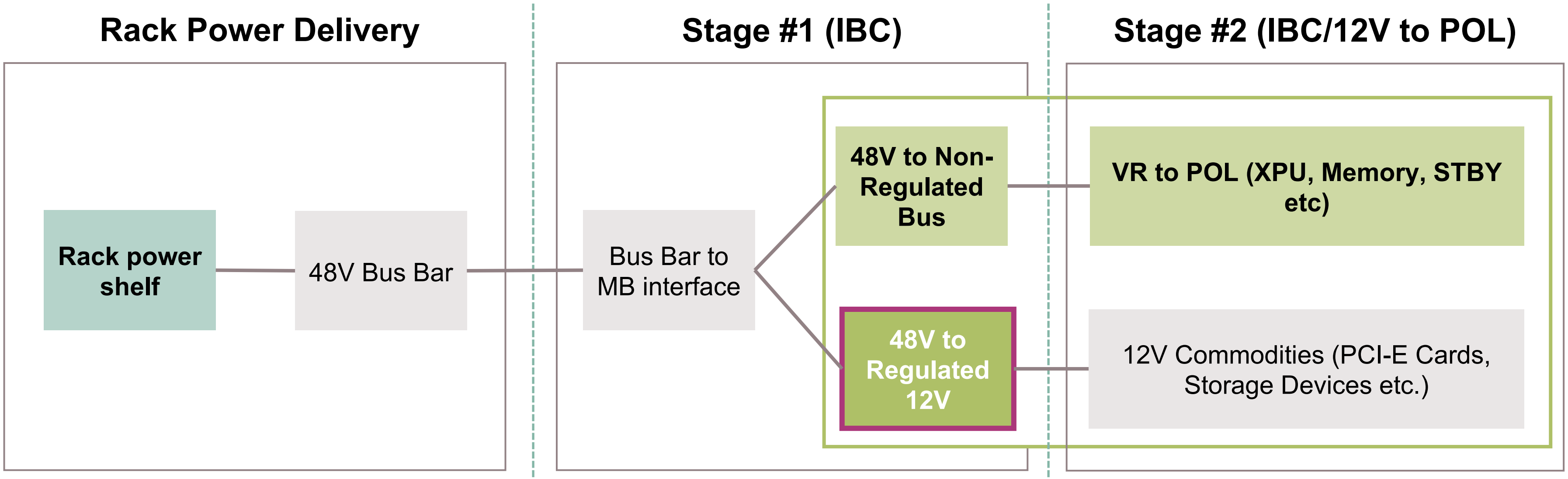
Data Center Architecture with 48V Bus

Hybrid Intermediate Bus – Non-Regulated IBC Voltage and Regulated 12V



Solution highlights

Notes: IBC = Intermediate Bus Converter
VR = Voltage Regulator

- Si, SiC and GaN based SMPS
- **HSC 48V converter**
- 500W IBC conveter

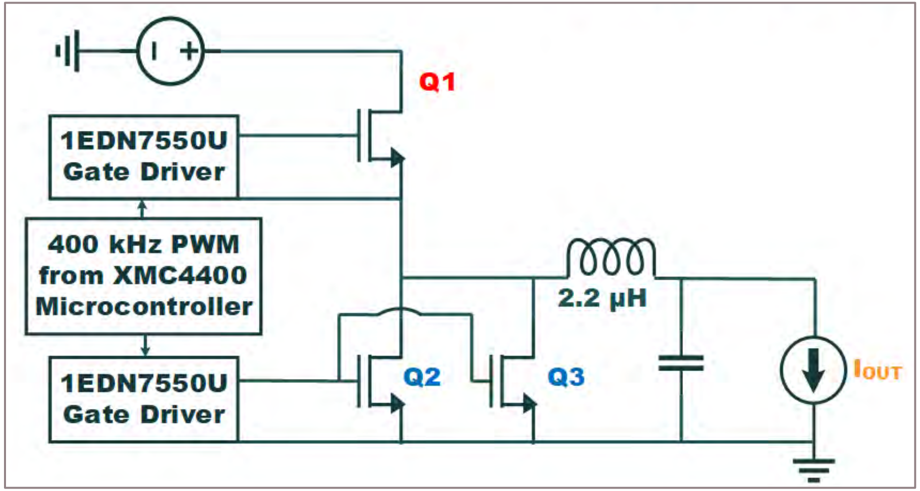
500 W Buck IBC Board Using CoolGaN HEMTs

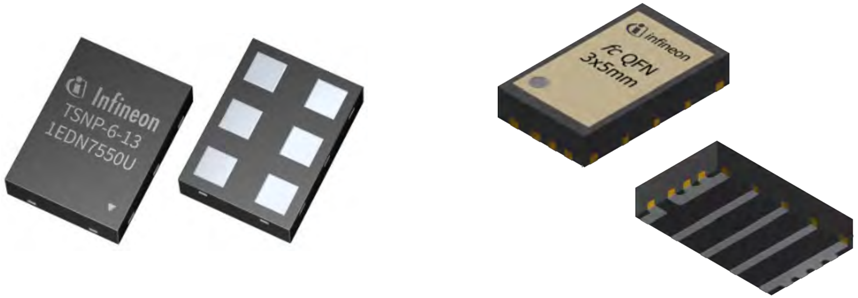
3 transistors

- 100 V, 3 mΩ enhancement-mode GaN HEMTs (EES)
- 3x5 mm lead-frame PQFN package, exposed die on top for heatsink attachment

2 gate drivers

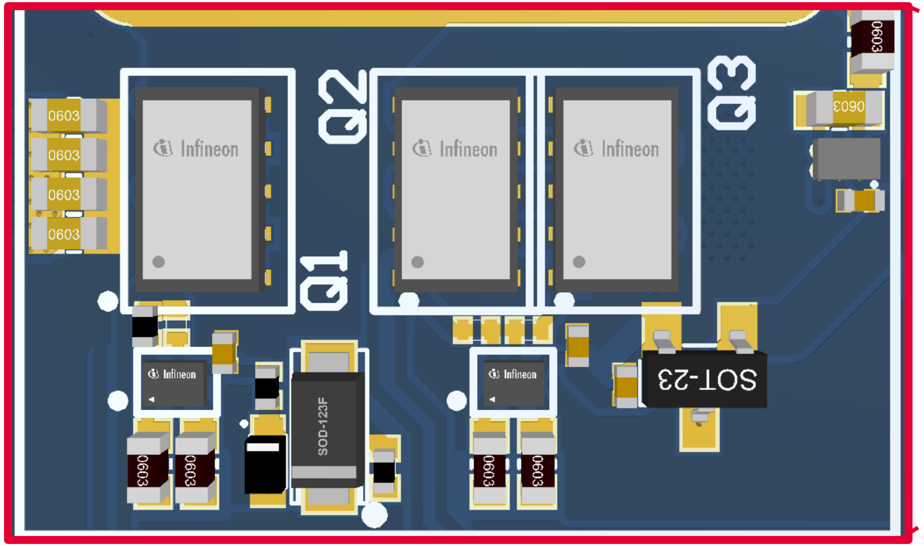
- 1EDN7550U gate driver in 1.1 x 1.5 mm TSNP-6 package
- Truly differential input (TDI) enables high-side driving and enhances ground-bounce immunity
- Driving strength suitable for GaN: 0.85 Ω pull-up, 0.35 Ω pull-down

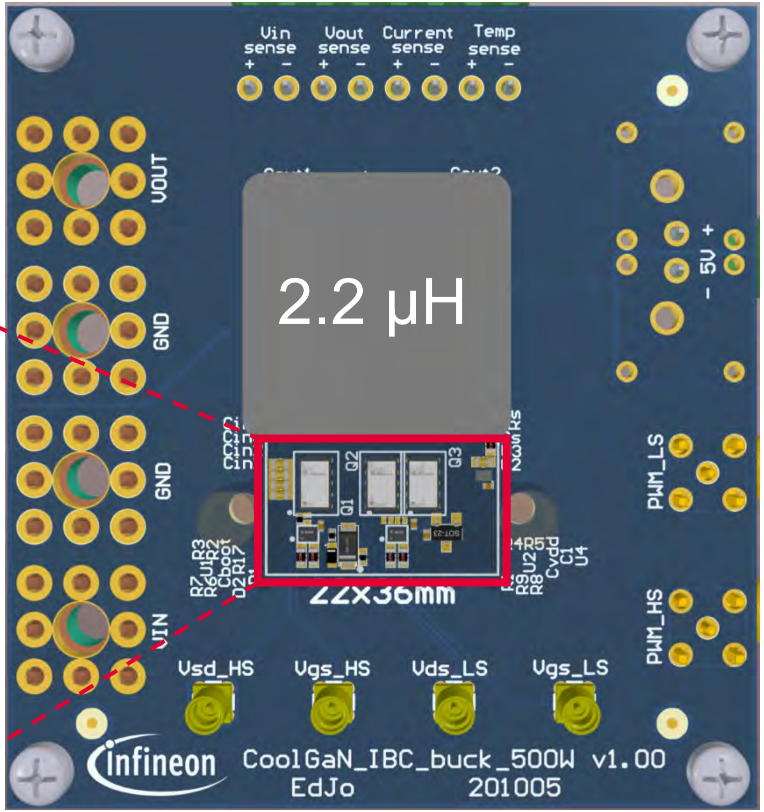




500 W Buck IBC Board Using CoolGaN HEMTs

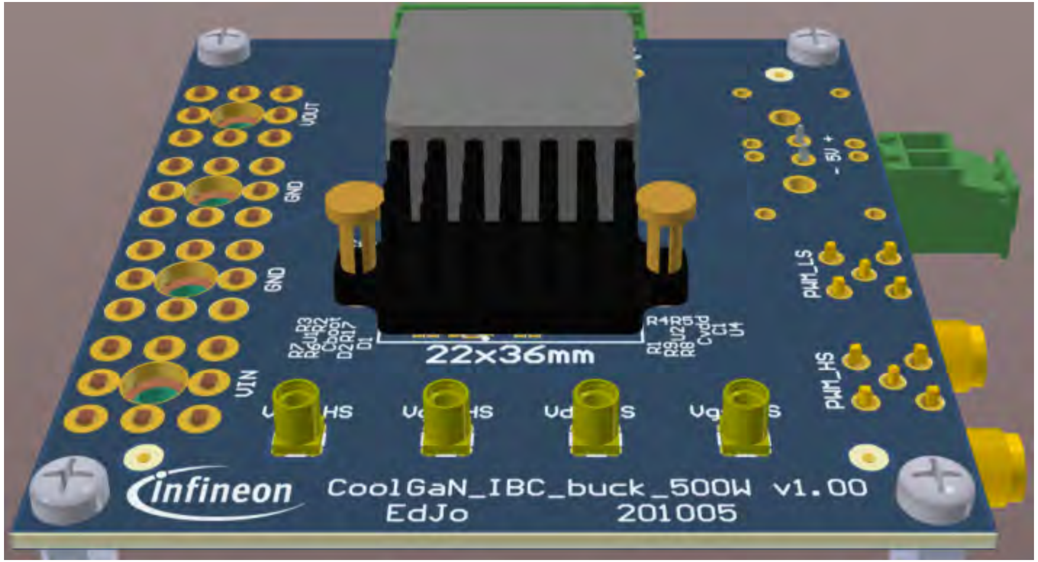
- 5 chips: 3 transistors + 2 gate drivers
- Bootstrapping with 5 V Zener regulation
- Lossless dcr current sensing
- PCB temperature sensing
- Filter inductor and input/output capacitors
- Additional bulk capacitors on opposite side
- External controller providing 400 kHz PWM

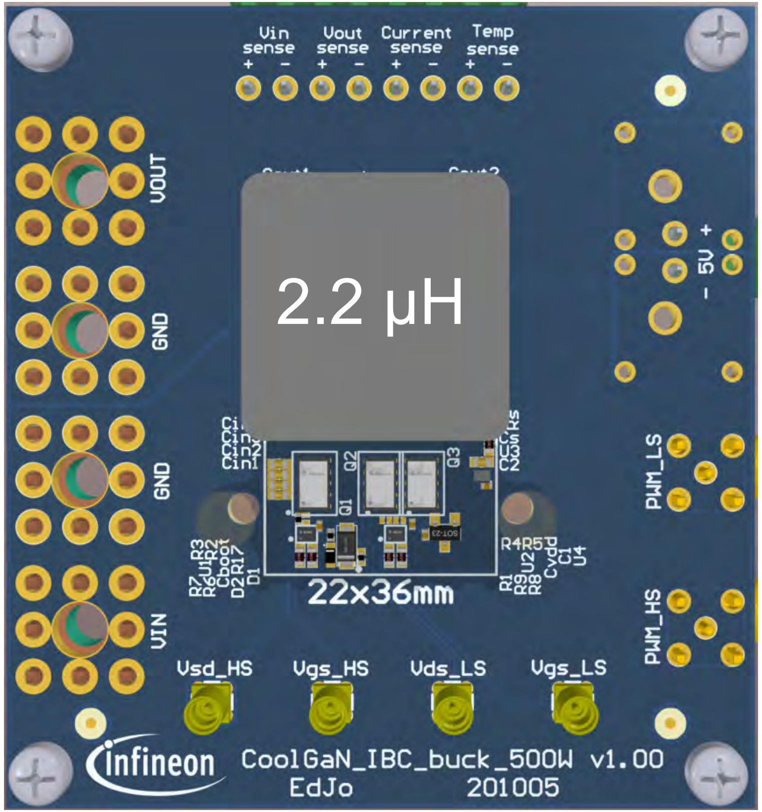




500 W Buck IBC Board Using CoolGaN HEMTs

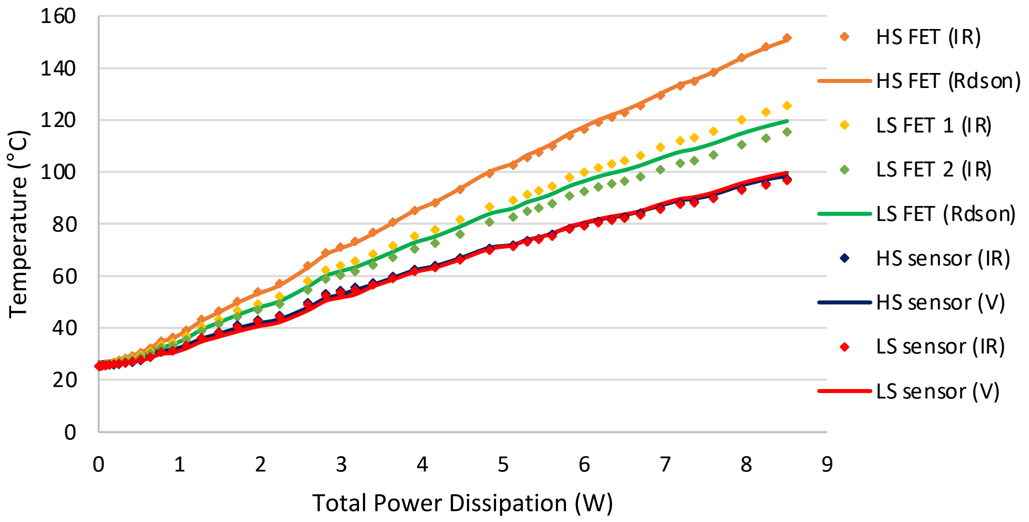
- 48V input, regulated 12V output, up to 42A
- Top-side heatsink attachment (compressed TIM)
- PCB active area 8 cm^2, height 1.6 cm
- Area power density 410 W/in^2
- Volumetric power density 650 W/in^3

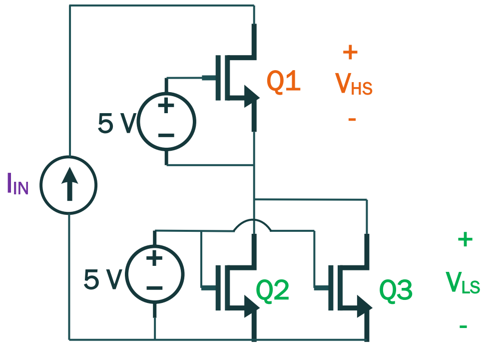


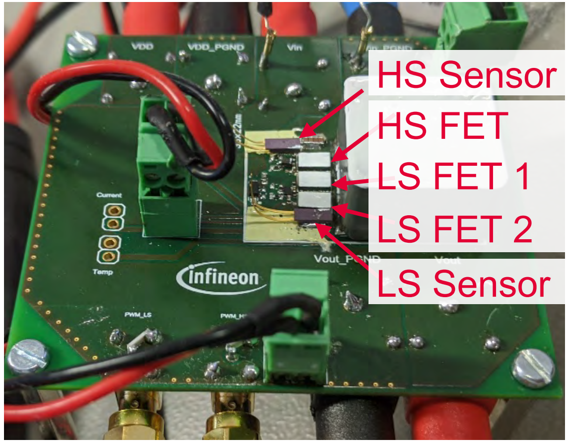


Temperature Measurement with In-Circuit Electrothermal Model

- Static testing with stepped dc input current
- Calibrate on-board temperature sensors (high-side drain, low-side source) and $R_{DS(ON)}$-T_J curves
- Thermal camera used to measure FETs and sensor cases, with FETs painted for emissivity correction
- Bottom-side cooling and PCB thermal resistances characterized

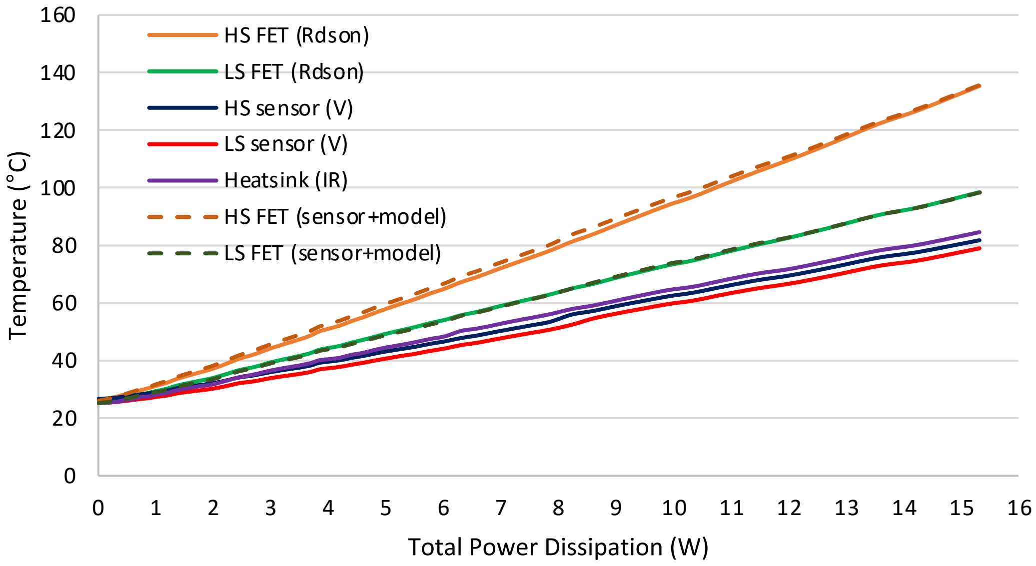


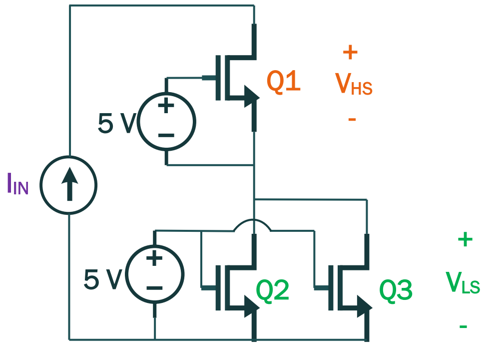


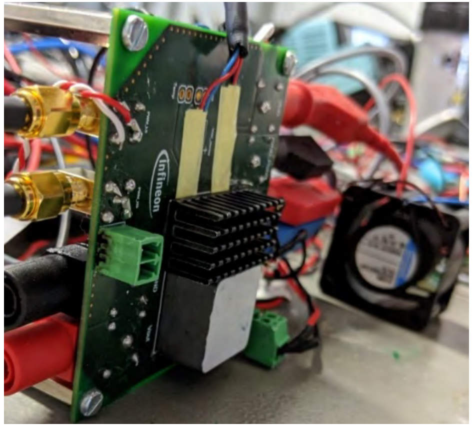


Temperature Measurement with In-Circuit Electrothermal Model

- Static thermal characterization repeated with heatsink, with and without air flow
- Calibrated $R_{DS(ON)}$-T_J curve used for junction temperature measurement
- Electrothermal model developed for complete system with 1 m/s air flow

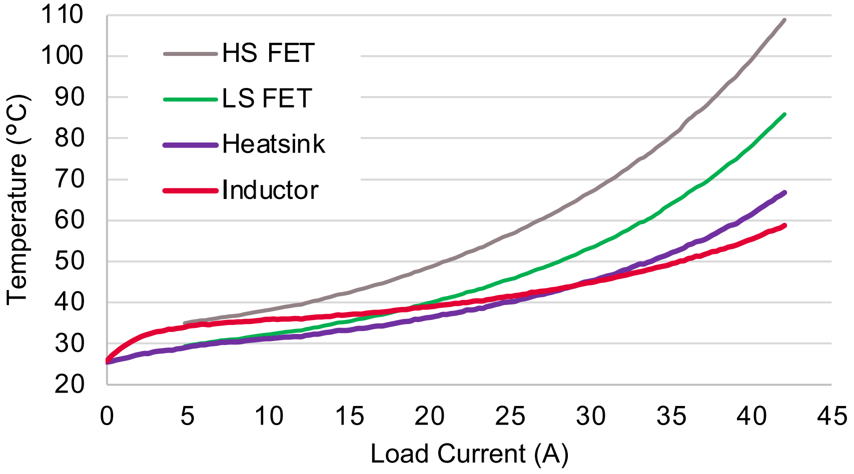


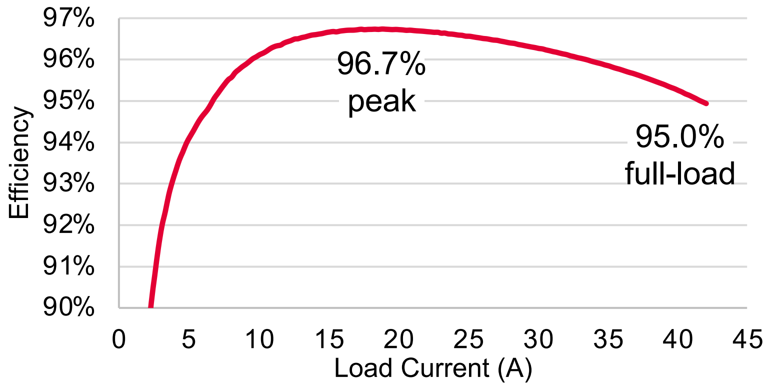


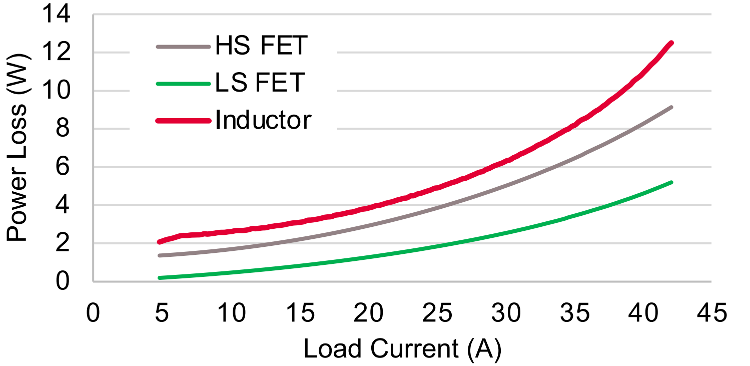


Experimental Results of Prototype

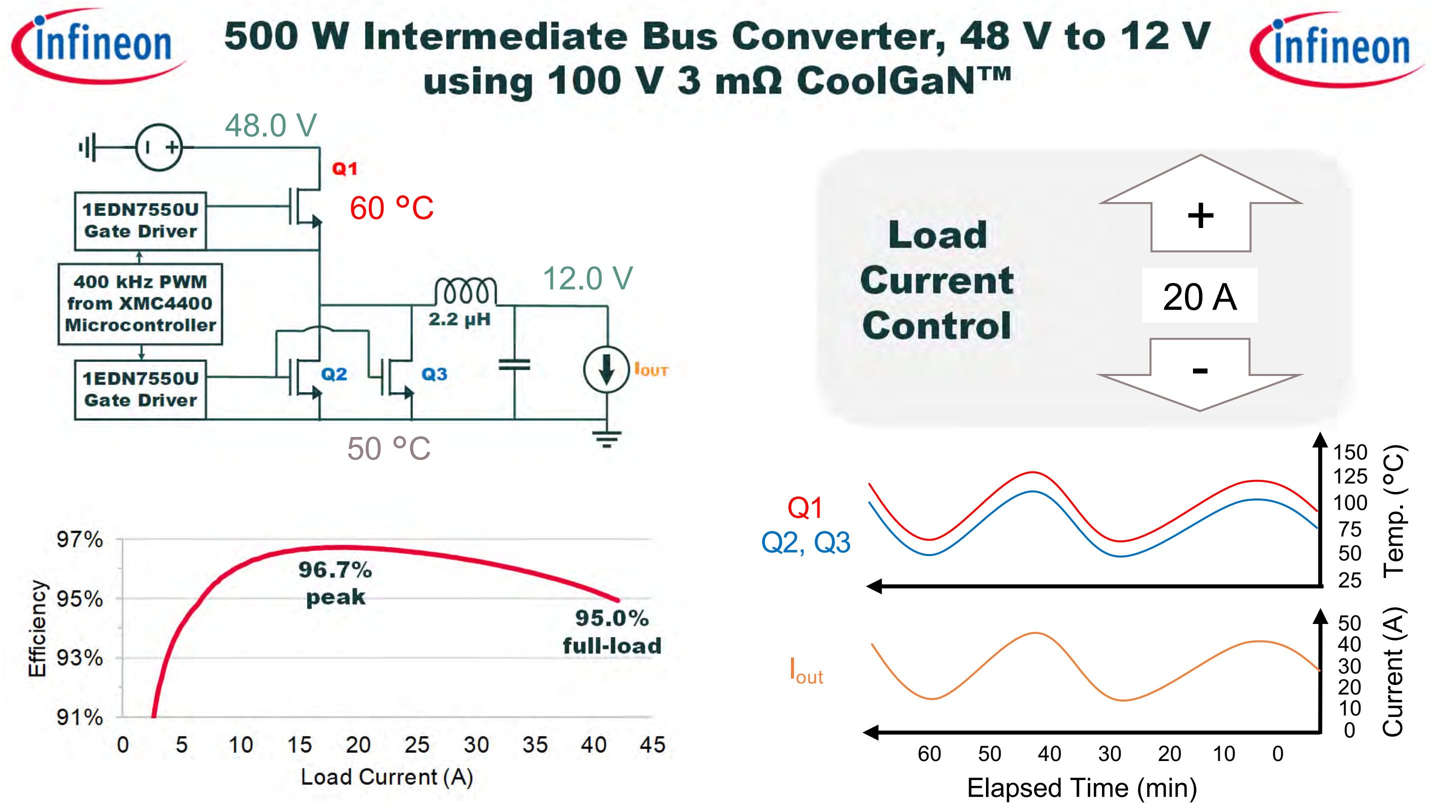
- Results of static electrothermal characterization applied to top-side cooled operating converter
- FET temperatures calculated based on two board temperatures and one heatsink temperature
- Operation up to 42A (500 W) output with 110 °C max FET temperature







Live Demo with Interactive Load Cycling



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