GaN for e-mobility

ST GaN e-HEMT

GaN for On Board Charging

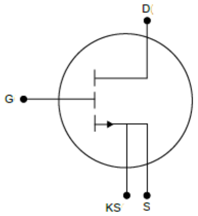
11kW, 800V DC-DC converter with STPOWER GaN

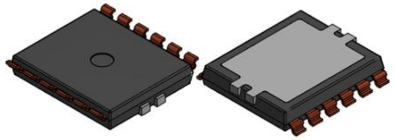
G-HEMT™ Series

A wide range of products to meet powerful and high frequency requirements

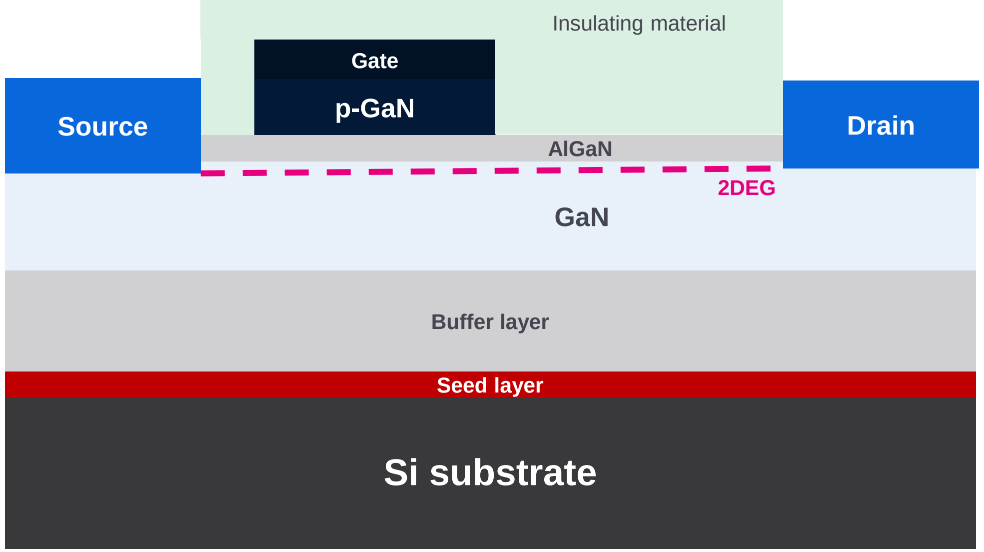
G-HEMT™

Fast and Powerful





LFPAK 12x12 TSC



BENEFITS VS. SILICON

- Lower losses (conduction and switching)
- Higher power density
- Higher operating frequency
- Enabling system miniaturization

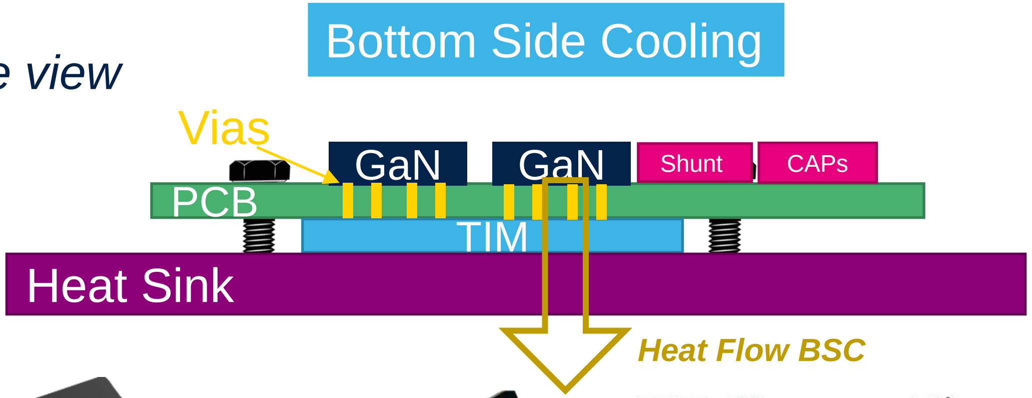
- **Enhancement mode normally off transistor**
- **Extremely low capacitances (10 times lower charges than Si)**
- **Zero recovery charge Qrr**
- **Parasitic free package technology**
- **Kelvin source pad for optimum gate driving**

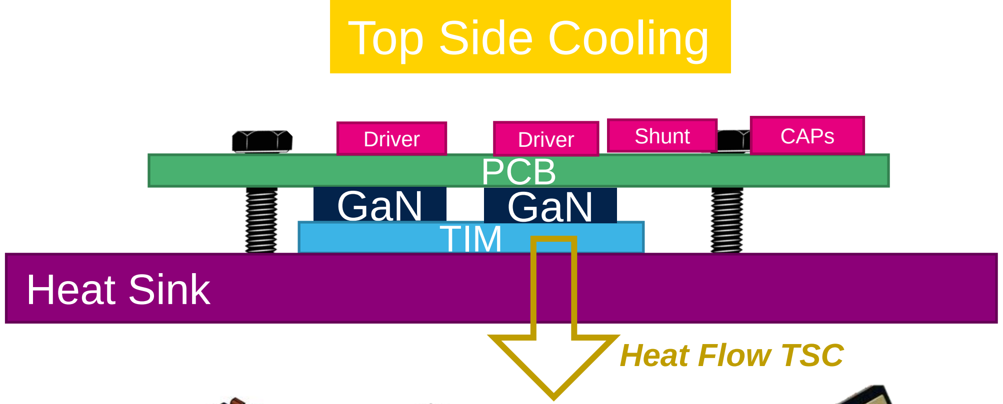
Industry Recognized Packaging with Versatile Thermal Implementations

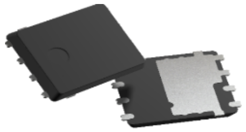
Top, Bottom and Double side cooling packaging

- Low-intrinsic parasitic elements that enable fast-switching times
- Many possibilities to explore cost reduction and thermal performances

Side view

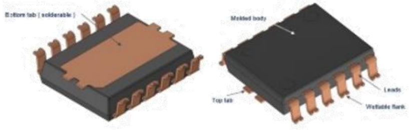




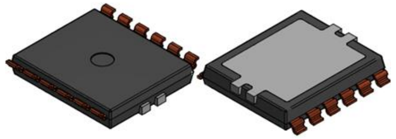


PF 5x6
PF 8x8

PF 8x8 DSC



LFPAK 12x12 BSC



LFPAK 12x12 TSC

PF 8x8 BSC

*Bottom side cooling : the heat is extracted from the side in contact with the PCB and through the PCB tracks
**Top side cooling : the heat is extract from the side that is not in contact with the PCB.

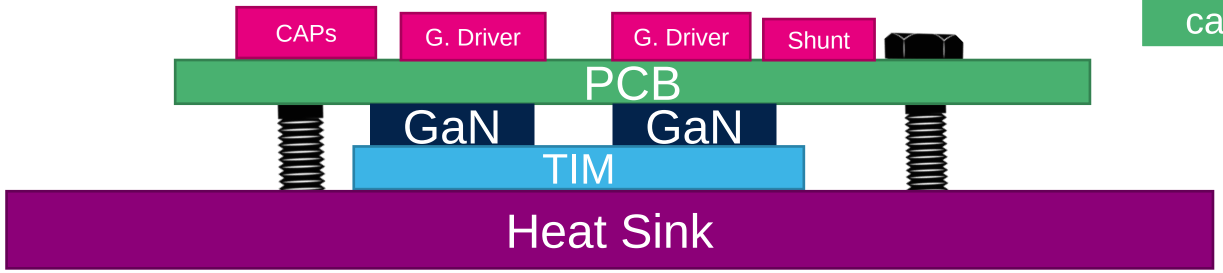
E-mode GaN in Top Side Cooling TSC Packages

Best solution for High Power Applications

- Heat-sink is placed on the top of the packaging
- The electrical and thermal path are dissociated
- Higher thermal resistance between the GaN transistor and PCB

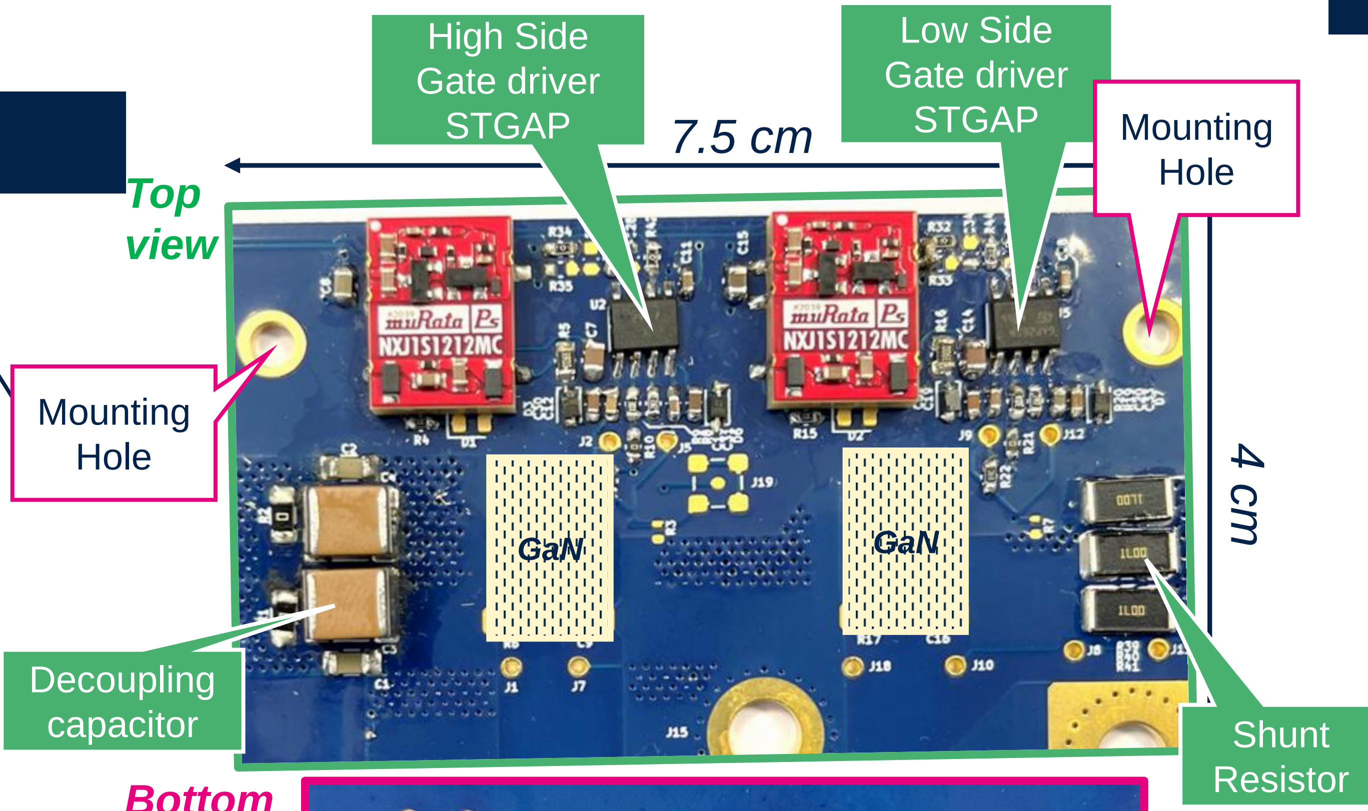
  ➔ decrease in PCB temperature

Side view

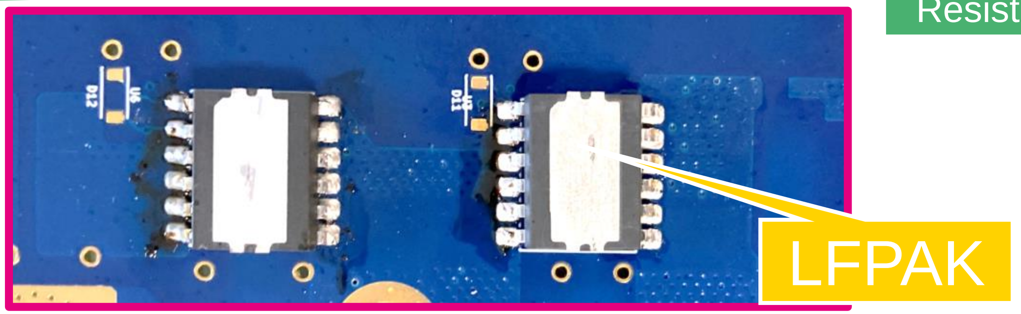


**TIM – Thermal Interface Material*

Top view



Bottom view



*LFPAK 12x12 with exposed pad populate in a 4 layers (105µm Cu) PCB

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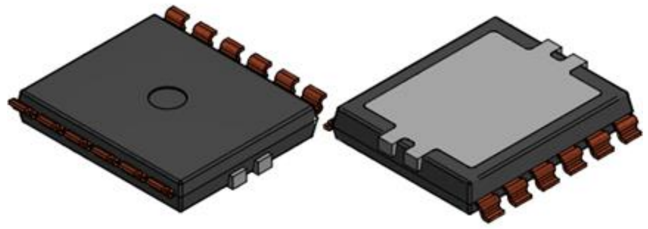
E-mode GaN in LFPAK 12x12 Thermal Performances

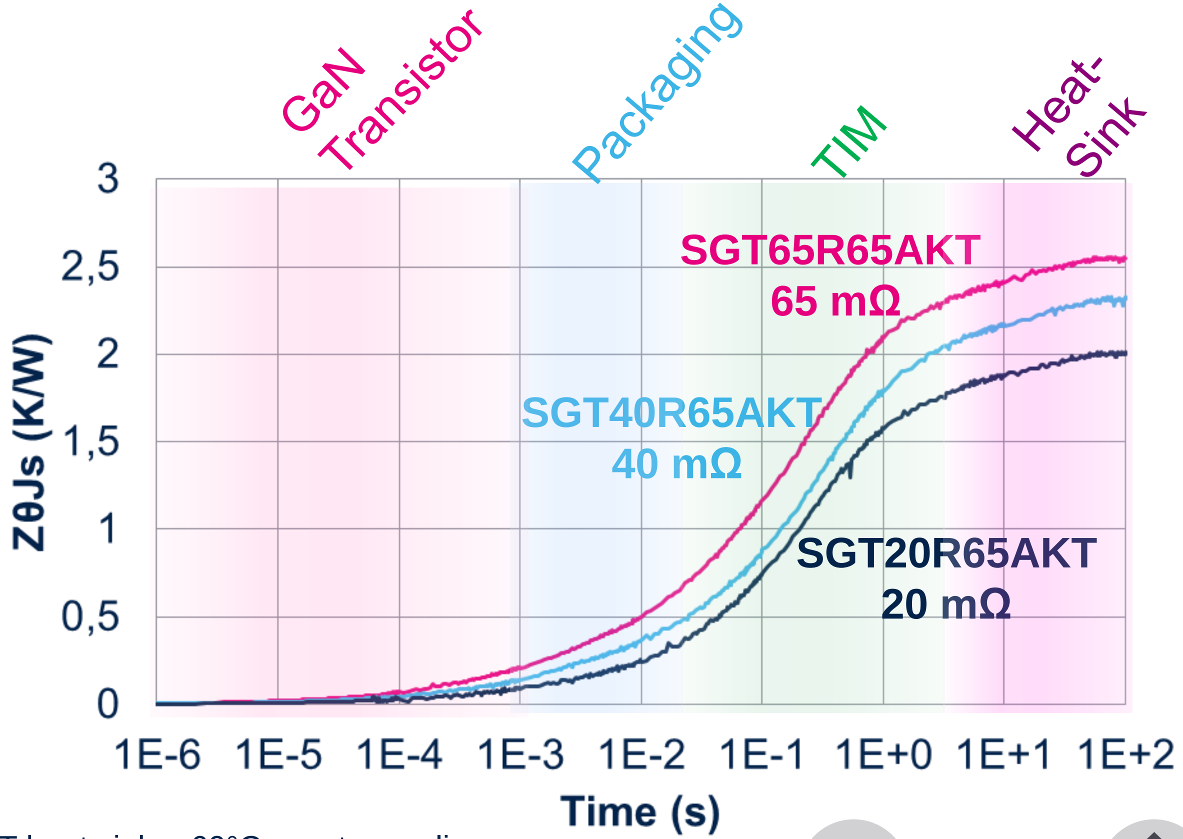
LFPAK 12x12 ➔ minimizing the number of layers for cooling path

- Large thermal interface pad
- Low thermal resistance with classical thermal interface (TIM)
  - Up to 42 W dissipation in application*, **
- Great performance in case of surge current events



LFPAK 12x12

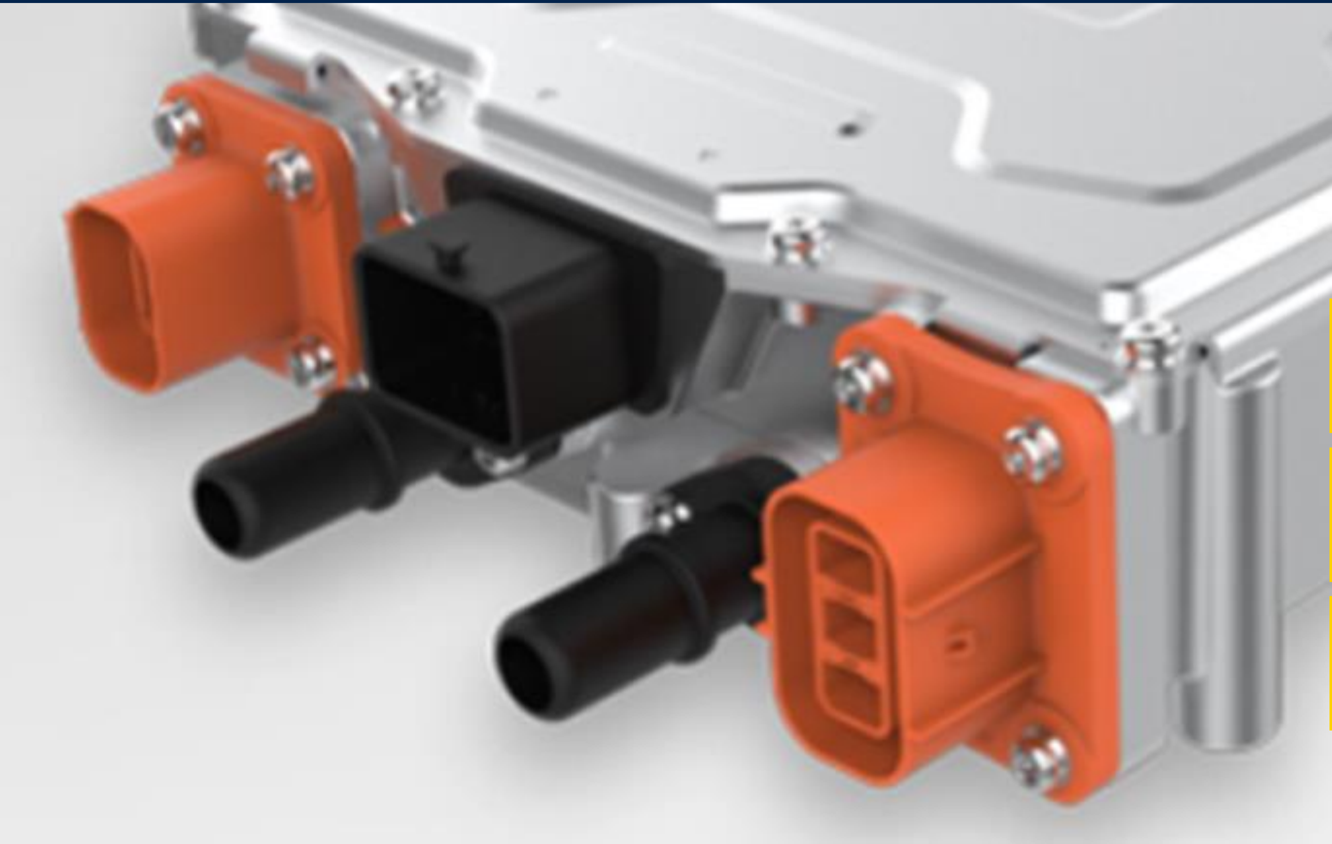
- Thermal impedance: representative of the mechanical structure and the thermal proprieties of the materials used on the stack of the cooling path.



* T heat sink = 60°C – water cooling
** Gap Pad : GP3000S3 – 1 mm – 3 W/mK
*** Max Rdson @ 25°C

GaN resolves the needs of on board charging(OBC)

Excellent efficiency in hard- and soft-switching topologies



Lower conduction losses

- Low on-resistance ($R_{DS(on)}$)
- Low capacitances (C_{rss}, C_{oss})
- Unbeatable recovery charge Q_{rr}

Better R_{DS} x Q_G vs silicon

Lower power losses & smaller & lightweight passive filters

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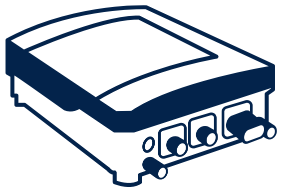
Generic information for OBC

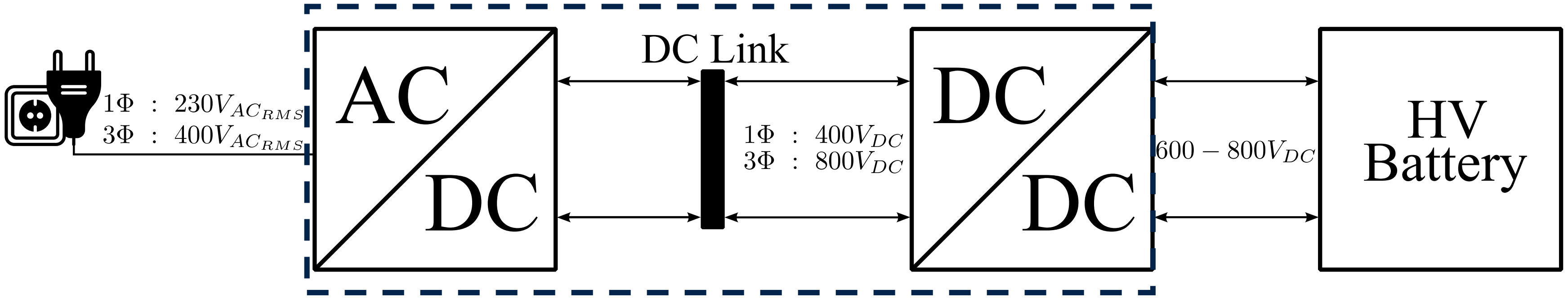
Power level	Type	Voltage supply	Power rate	Charging time (from 20% to 80%)
Level 1 (USA only)	On-Board	120 V 1-Ph AC	1.4 to 1.9 kW	4-11 hours
Level 2 (EU & USA)	On-Board	208 or 240 V (1-Ph AC) 400 V (3-ph AC)	4 to 44 kW	1-4 hours
Level 3 (DC Fast charging)	Off-board DC charger	400 or 800 V (Dc supply)	50 to 240 kW	30 minutes

OBC*



Dc Charging Station

**** On-Board Charger** charges HV Battery, main power source of electrified vehicles (PHEV & BEV), via widely accessible AC Charging Stations.*



Active front-end Rectifier

Dc-dc

Main stage to improve the power density & total system efficiency with 650-V GaN devices

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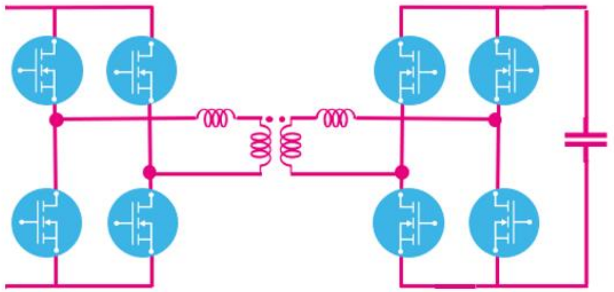
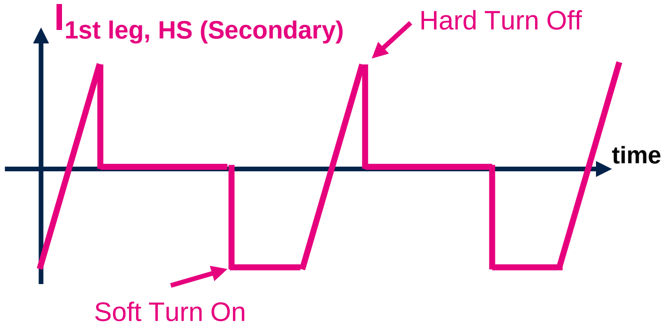
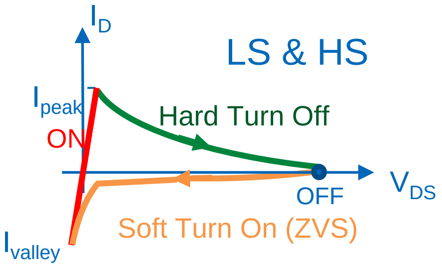
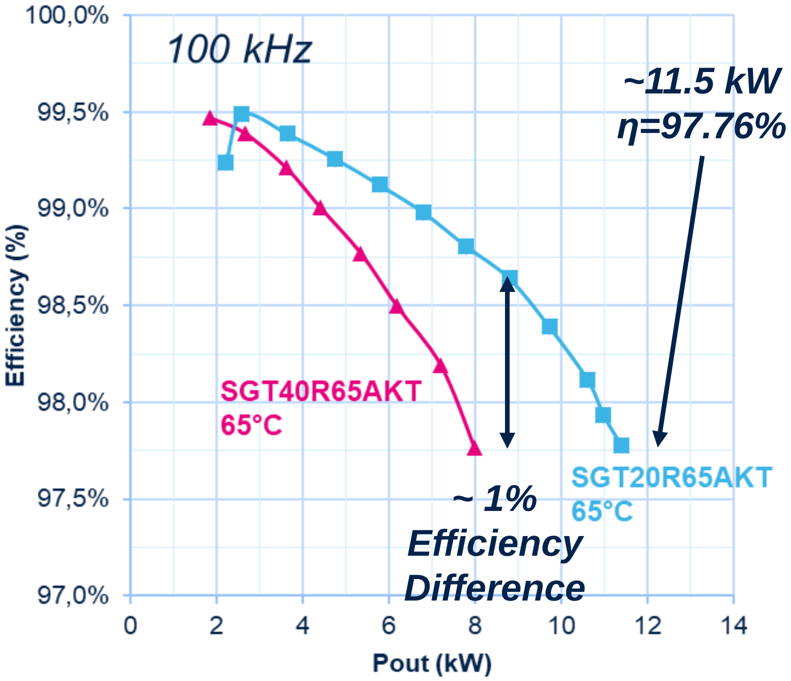
Benchmarking GaN in OBC

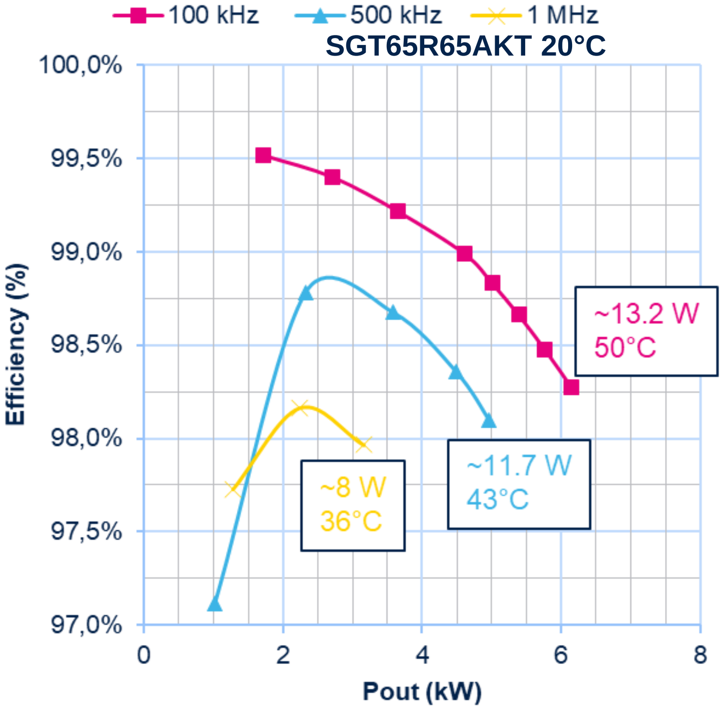
Bi-directional and Megahertz switching ready











- ➔ 11.5-kW reached with 20 mΩ (SGT20R65AKT (Auto)) with good thermal management
- ➔ 20 mΩ vs 40 mΩ R_{DSon}: ~1% Added Efficiency achieved at 8 kW Power Level
- ➔ The best device for this topology is the 20 mΩ (starting at 3 kW)
  - ➔ <u>*Conduction losses*</u> are dominant at fsw=100 kHz in DAB topology

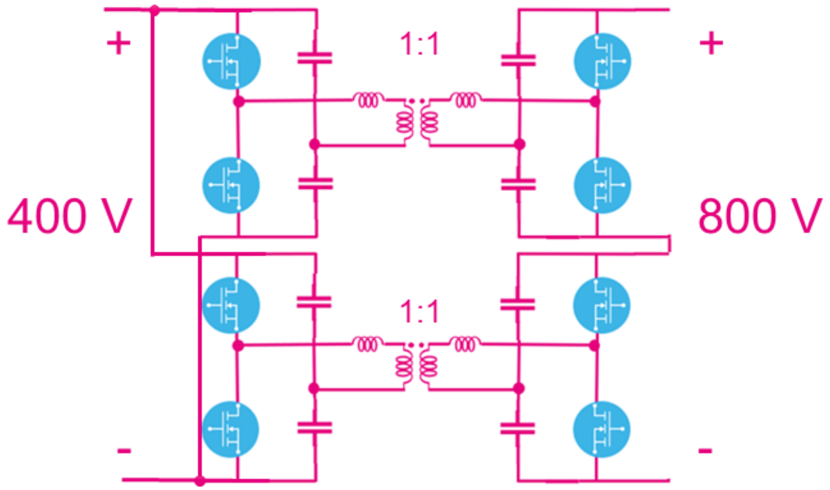
*Efficiency measurement considering only the GaN transistor losses

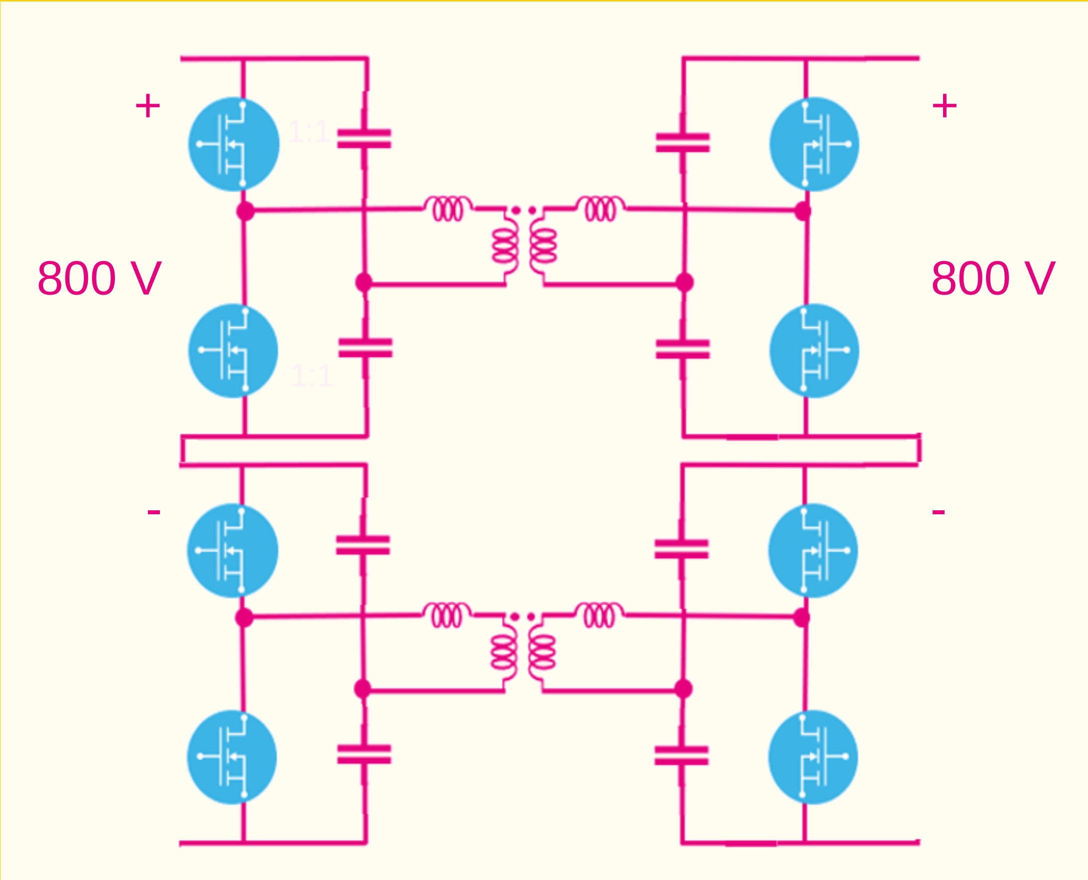
* 650 V, LFPAK 12x12 TSC are under development

How to handle 800 V with 650 V GaN?

Cascaded Dual-Active Half-Bridge – DAHB

- Switch stress: · ½· V_{bus}, I_{out}
  - Lower EMI Behaviour
- Bidirectional for Vehicle-to-Grid (V2G)
- Reconfigurable between 400 V & 800 V
- 2 transformers, 8 capacitors, 8 switches
- Very high peak efficiency > 98.5%





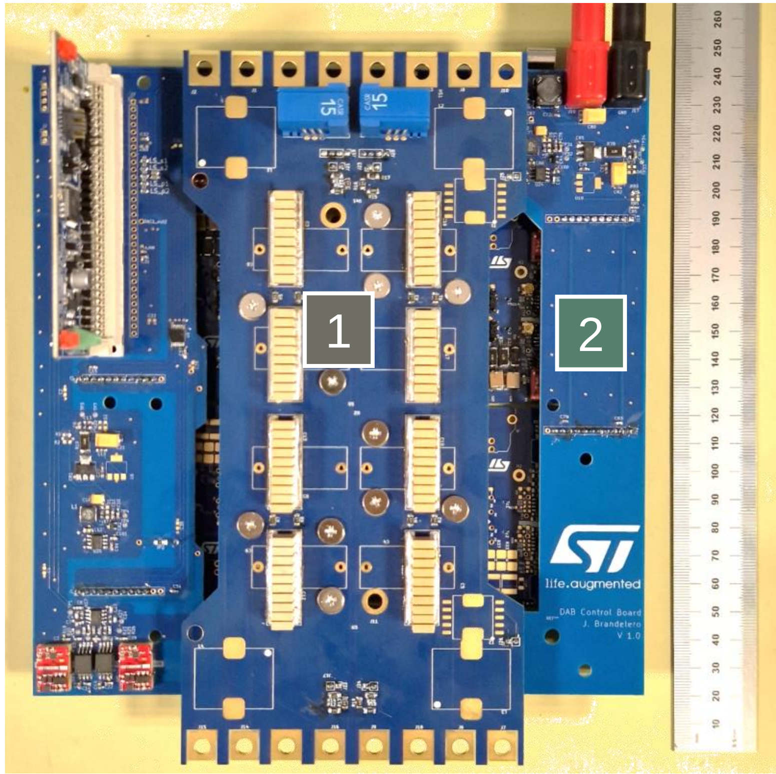
11 kW version

Proposal
11 kW (800 Vdc) with 650-V STPOWER GaN

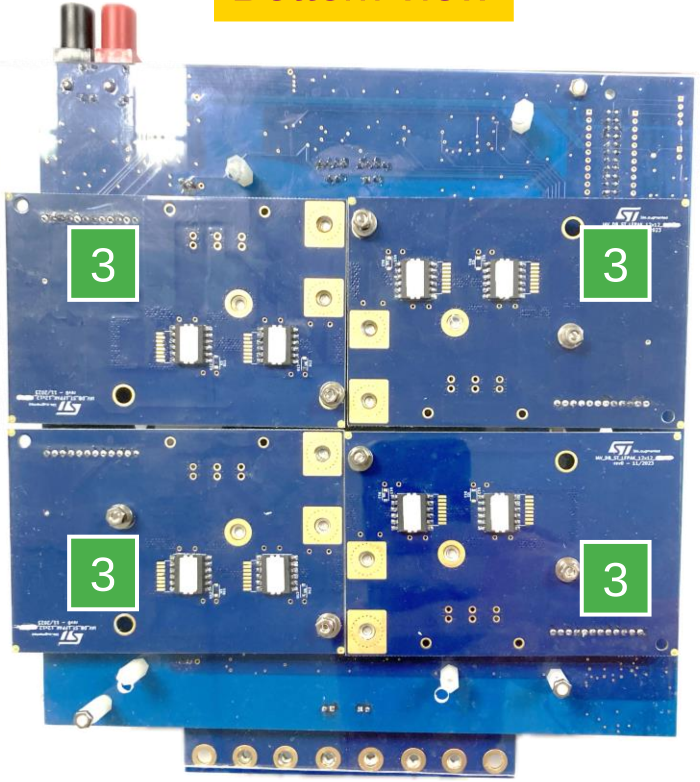
- 800 V topology
- Reduced voltage stress compared to 2L dc-dc
- Very high peak efficiency > 98.5%
- Power Density of 60kW/in^3 without transformer

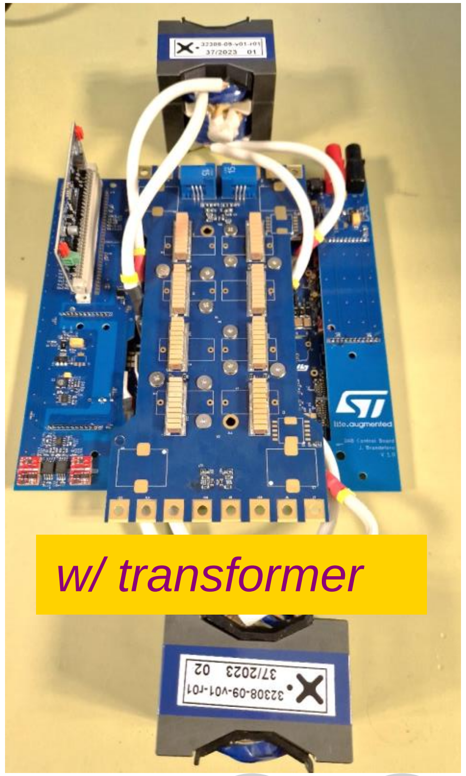
1 BUS BAR
2 Control Board
3 4 Demo Boards
Half-bridge

Top view



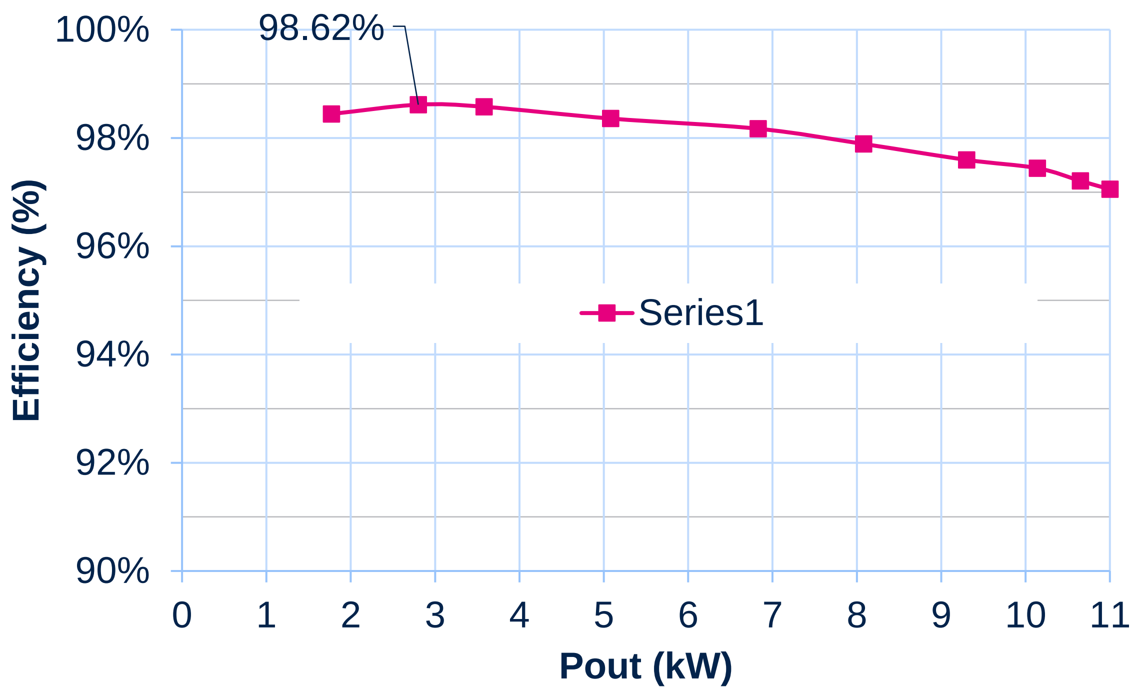
Bottom view





11 kW (800 Vdc) series-input series-output DC-DC converter with 650 V STPOWER GaN

Cascaded Dual-Active Half-Bridge – DAHB



Key Features

- 800 Vdc Cascaded half-bridge topology
- Reconfigurable between 400 V and 800 V
- Reduced voltage stress compared to 2L DCDC
- Lower di/dt & dv/dt for better EMI behavior
- Very high peak efficiency > 98.5%

- **Key products**
- SGT20R65AKTAG* 20 mOhm , 650 V G-HEMT in LFPAK 12x12 TSC package
- STM32G474
- STGAP2S

HVHV DC-DC Converter

On board Charger

BEV & FCEV