

HiPE

High performance power electronics integrations

Medina Ćustić, Virtual Vehicle Research GmbH



High Performance Power Electronics Integrations



With the support of



Funded by
the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

Overall project presentation



Project Overview



FORD OTOSAN



TENNECO



SKODA nexperia



November 2022 - April 2026



13 Partners, 7 Countries



€ 5.481.273

coordinated by



funded under HORIZON-CL5-2021-D5-01-02

HiPE Objectives



OBJECTIVE 1

Improve the **efficiency** of integrated WBG-based power electronics (PE) components and systems



OBJECTIVE 2

Reduce the **cost** of power electronics components and systems



OBJECTIVE 3

Reduce **size and weight** of power electronics and electric powertrains



OBJECTIVE 4

Increase **reliability and dependability** through integrated design and intelligent control



OBJECTIVE 5

Implement WBG-based power electronics meeting **automotive quality levels**

Results presentation



HiPE Outputs

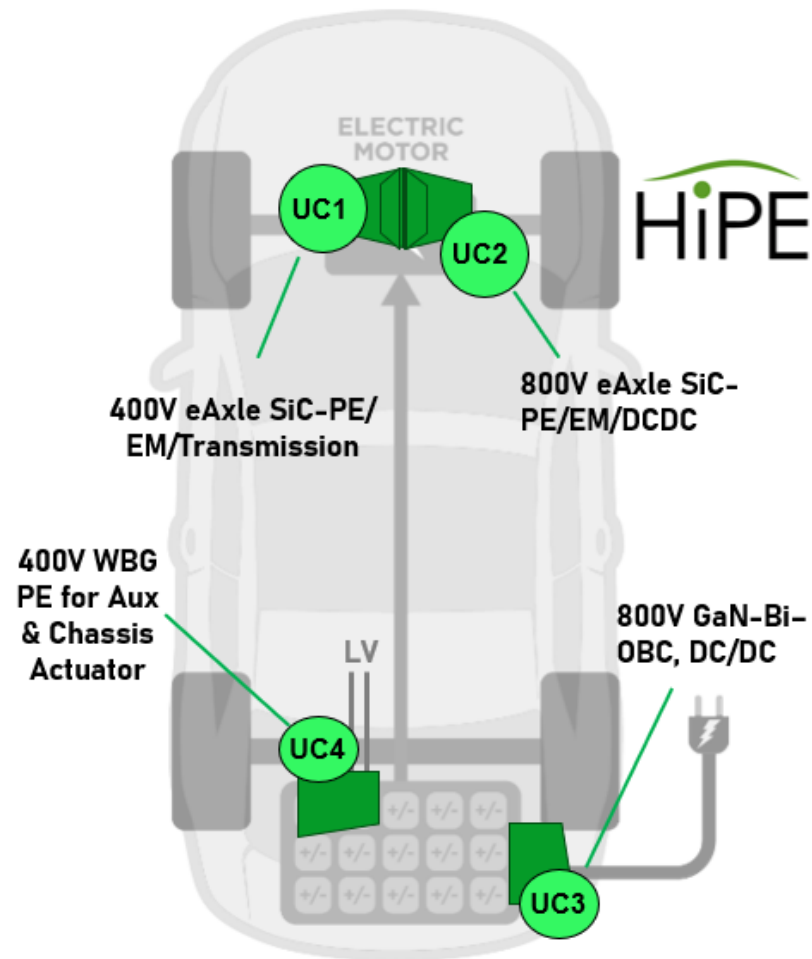
HiPE is delivering a family of highly efficient, cost-effective and compact WBG power electronics solutions for the next generation of battery electric vehicles.

The project outputs will include:

- i) **A scalable and modular family of WBG-based traction inverters** with significantly improved specific cooling performance, suitable for 400V, 800V and 1200V applications, with power ratings from 50 to 250 kW, integrated into electric drives including the high-to-low voltage (HV/LV) DC/DC converters, thus enabling drastic size and weight reductions;
- ii) **a family of integrated WBG-based bidirectional on-board chargers (OBCs) and HV/LV DC/DC converters**, with optimised innovative topologies, including use of GaN; and
- iii) **integrated, fault-tolerant and cost-effective GaN-based power electronics for high-voltage ancillaries and chassis actuators.**

Use Cases for passenger cars & commercial vehicles

Use Case 1 & 2: two examples of integrated 400V and 800V WBG-based electric axles



Use Case 4: for the WBG-based actuation of ancillaries and chassis components

Use Case 3: as well as high performance power electronics for integrated WBG-based OBCs and HV/LV DC/DC converters

Achievements – Overview

400 V SiC-Inverter/EM Integration into eAxle with transmission

- UC1 – gearbox development and integration
 - Model and DWG
 - Prototyping

Advanced chassis actuators with 400 V GaN power electronics

- Design of a 400 V GaN-based inverter for suspension actuation
 - Control board
 - Power Stage + Gate Driver
 - DC-link
 - Prototyping
 - Characterization

800 V WBG-Bi OBC/ DC/DC

- Bi-directional On-Board Charger (OBC) (with On Board Generating Inverter (OBGI) features)
- HV/LV DC-DC Converter

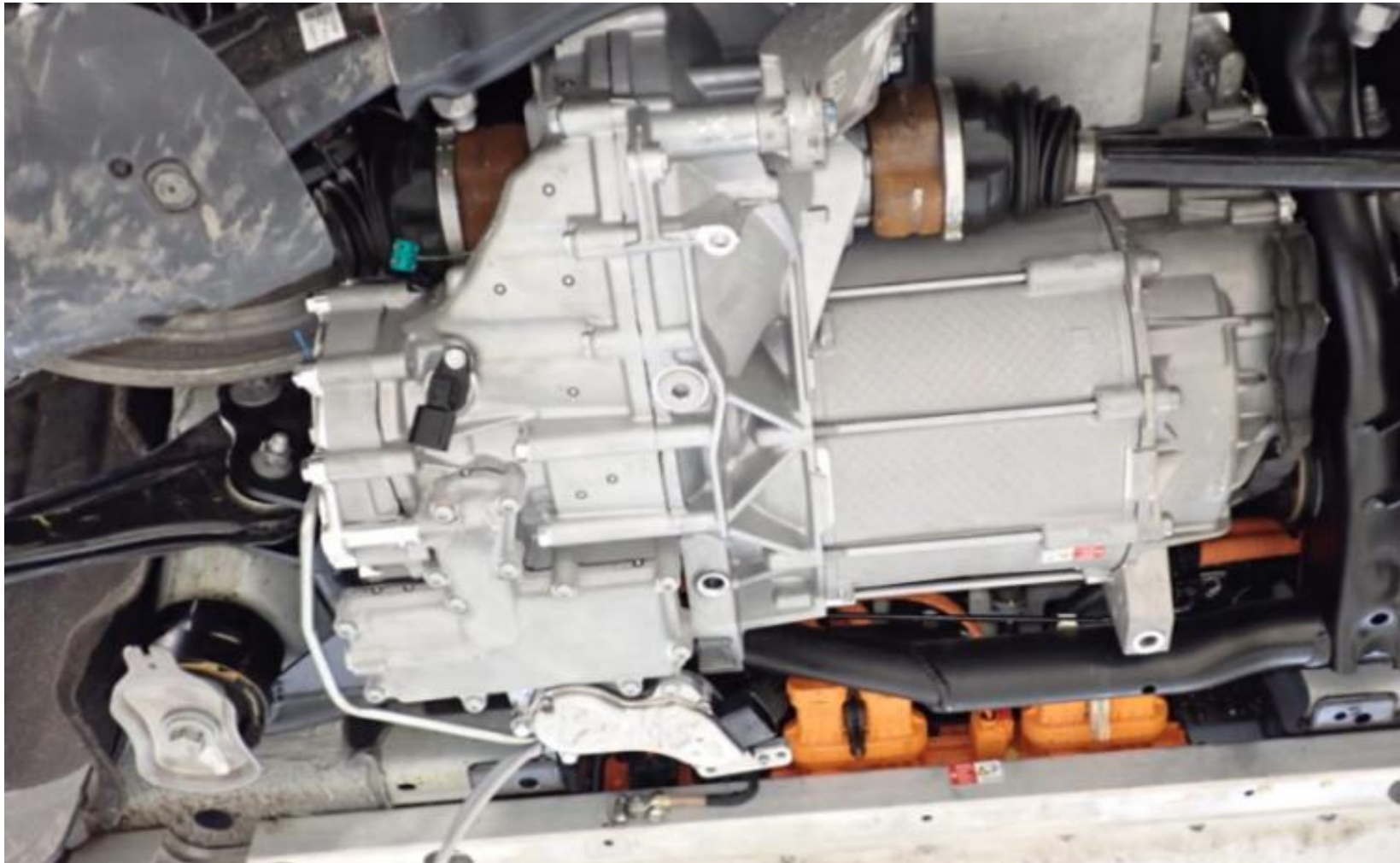
800 V SiC Inverter/EM & DC/DC

- Characterization of inverter key components: **Completed**
- Characterization of Full Inverter + eMotor **Completed**
- Mechanical simulation (FEM) **Completed**
- DC-DC converter: **Completed**
- Prototyping: **completed**
- DC-DC converter Characterization at test bench **completed**

Gate driver and power module integration

- Generic Concepts and Cost Assessment
- Gate driver integration

2-Speed transmission for UC1



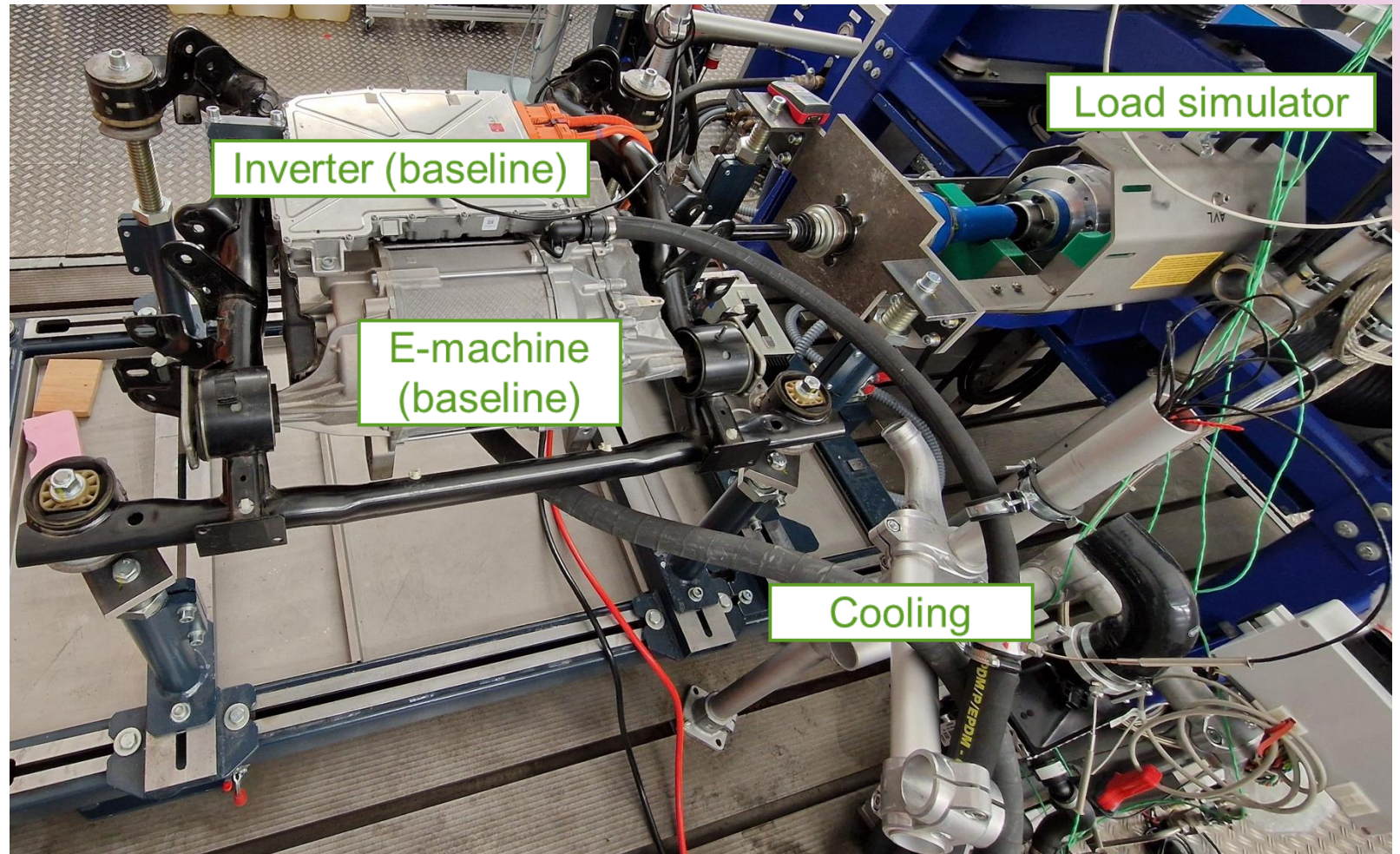
UC1 Testing

Part I:

Test rig setup with series SKO E-axle at TUIL facilities

Part II:

E-axle with new HiPE gearbox (SKO)



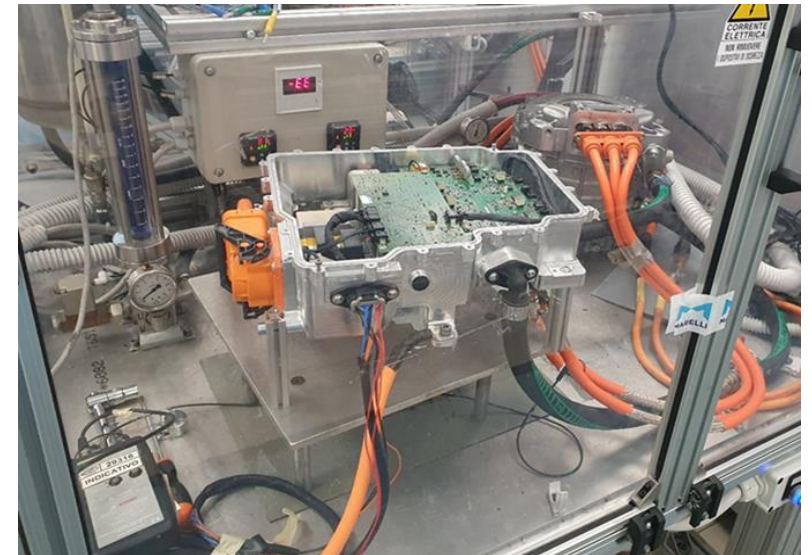
UC2 - Achievements

800 V SiC Inverter :

- ✓ Characterization of the inverter subcomponents **completed (D4.6)**
- ✓ Assembly of the full Inverter: **completed**
- ✓ SW interface for test bench: **available**
- ✓ Embedded SW compatible with new inverter architecture: **available**
- ✓ Definition of HW verification tests: **completed**
- ✓ Definition of the Characterization (Inverter + eMotor): **completed**
- ✓ FEM pre-processing: **completed**

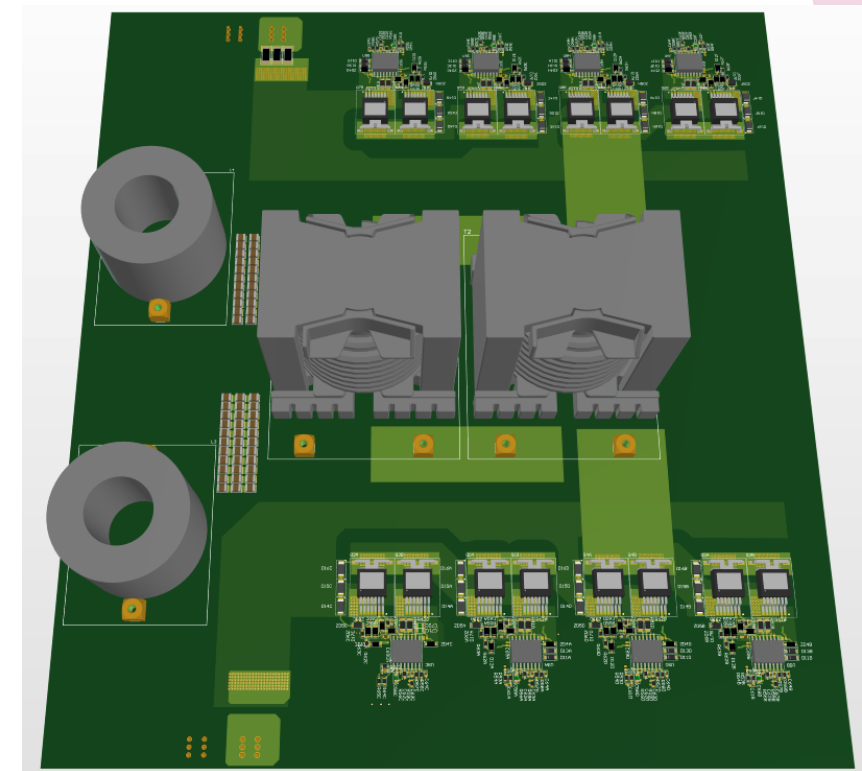
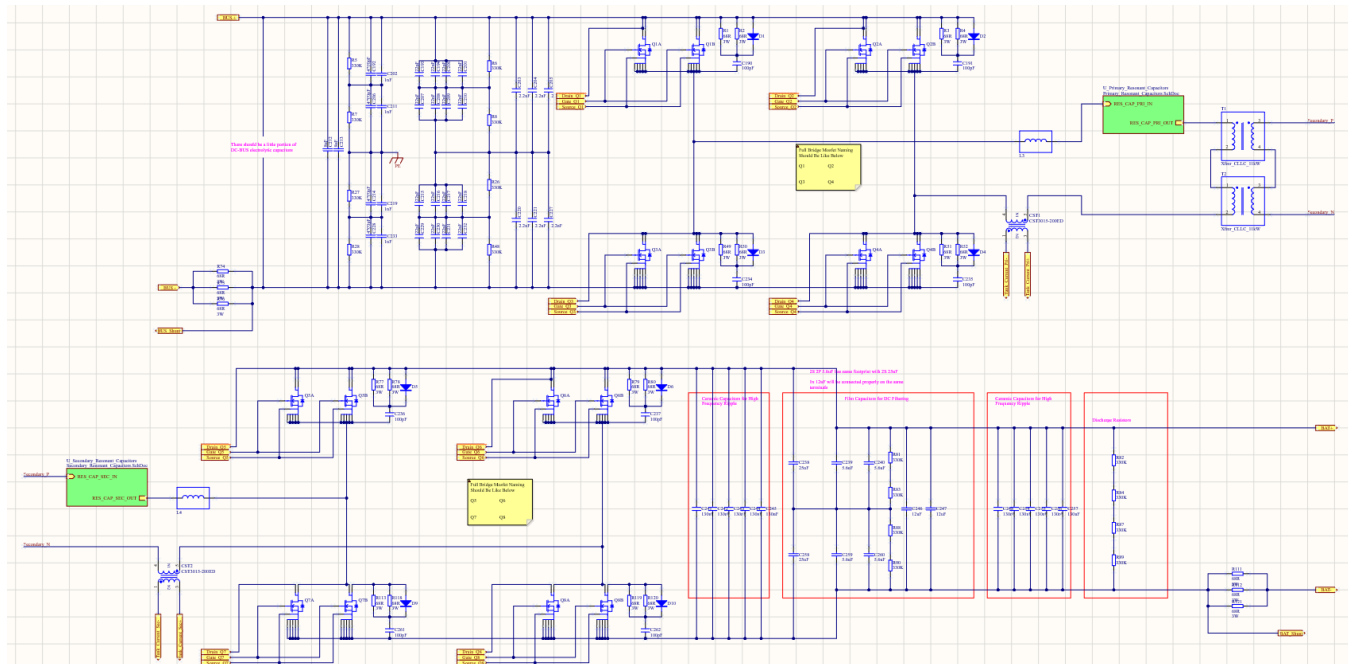
DC-DC converter:

- ✓ Assembly of 1st prototype: **completed**
- ✓ Efficiency characterization: **competed**



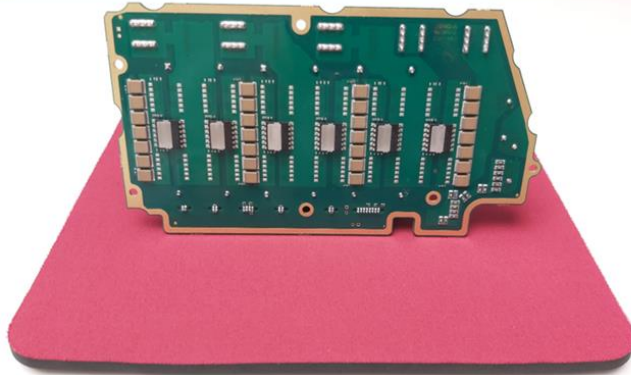
UC3 DCDC Converter and OBC

- OBC schematics and layout

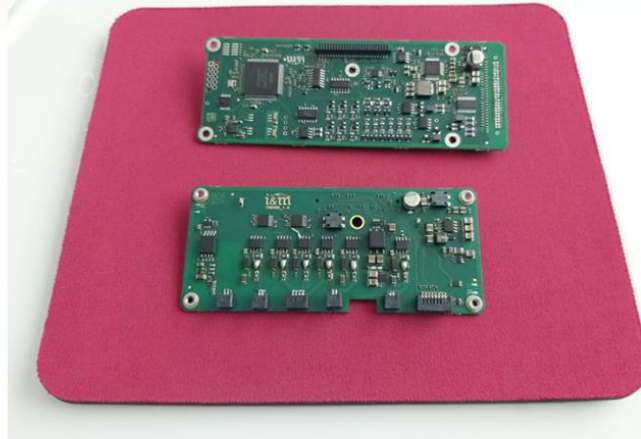


UC4 Prototypes Pictures for Electronics for Chassis Actuator

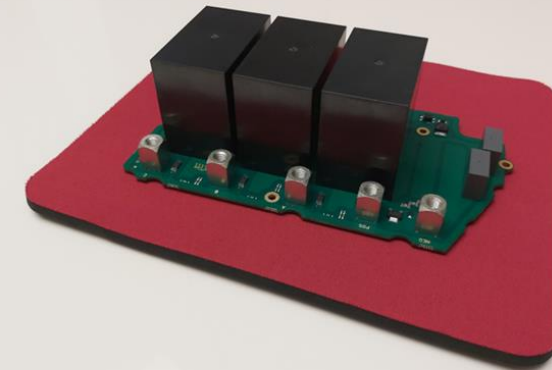
GaN-Based Power Stage



Control board (top) and gate driver



DC-Link



UC4 Testing

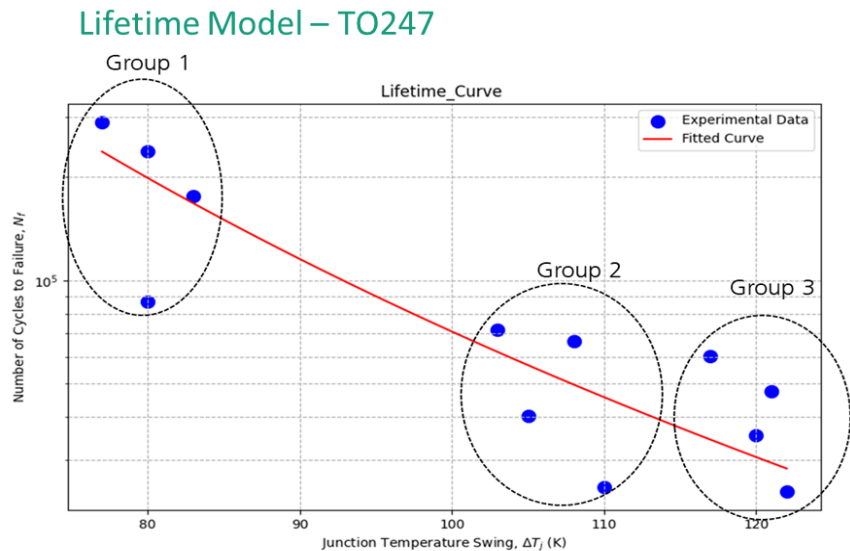
- TEN & I&M → Testing on experimental instrumented vehicle demonstrator
 - Actuator, inverter and RCP system integration (mechanical, E/E) completed
 - Rear axle calibration done, front axle calibration ongoing
 - Full vehicle validation expected to be finalised by Feb 2026



Lifetime of Components

- Digital Twins

Lifetime Model: HiPE Nexperia TO247 Module Power Cycling Test



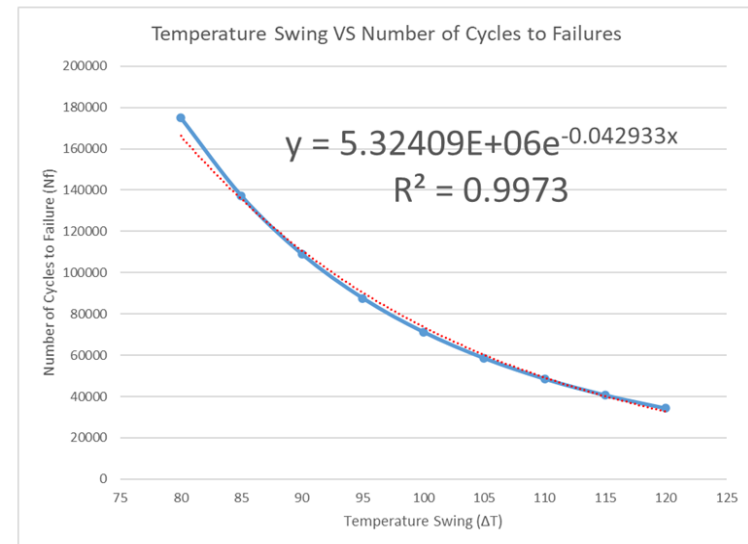
- Lifetime models are just first rough estimations – Much more lifetime data is required!
- For lower temperature swings, this effect might change
- A significant increase in Von measurements, T_j , and temperature swings was recorded.
- Module is either dead or alive; there is no in between.
- The reason behind this is having only a single bond wire.

Lifetime model:

$$N_f = a \cdot (\Delta T)^{-n}$$

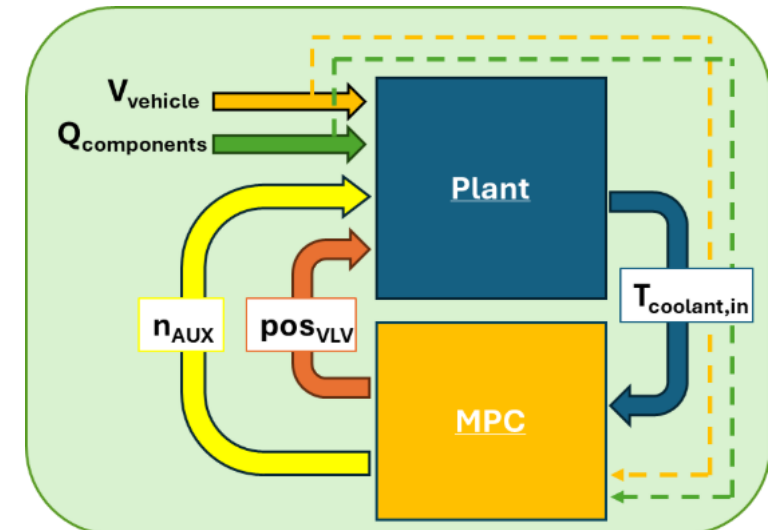
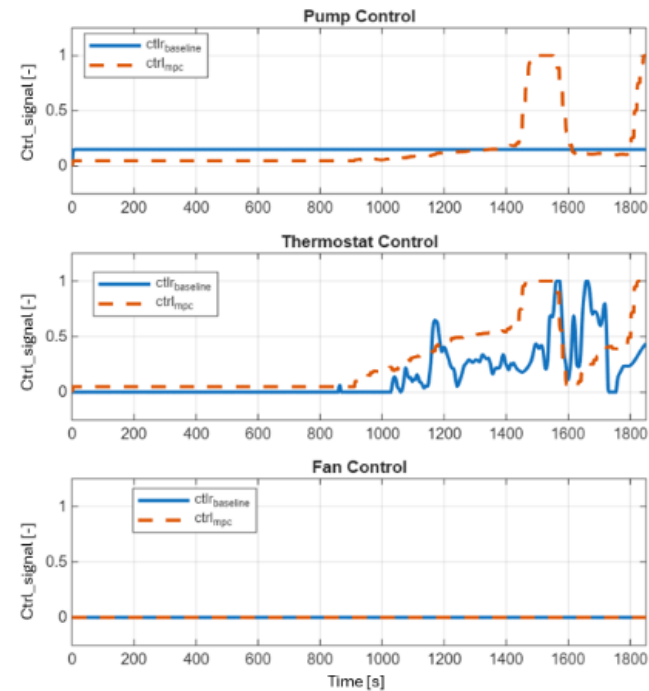
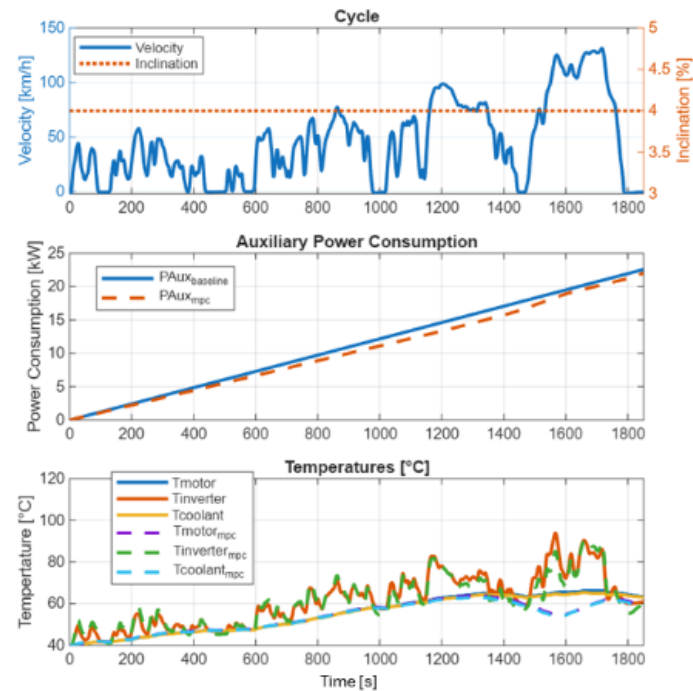
Where,

$$a = 1.23e+14, n = 4.62$$



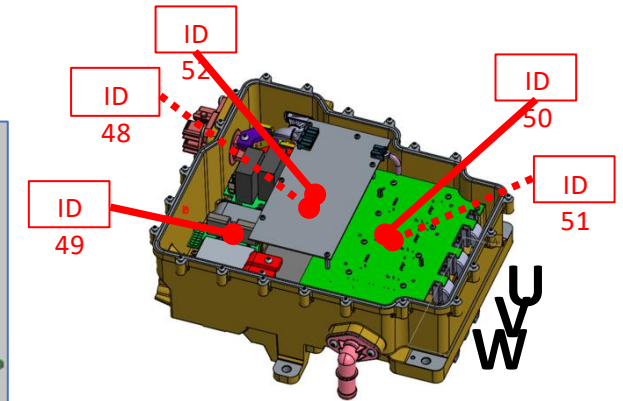
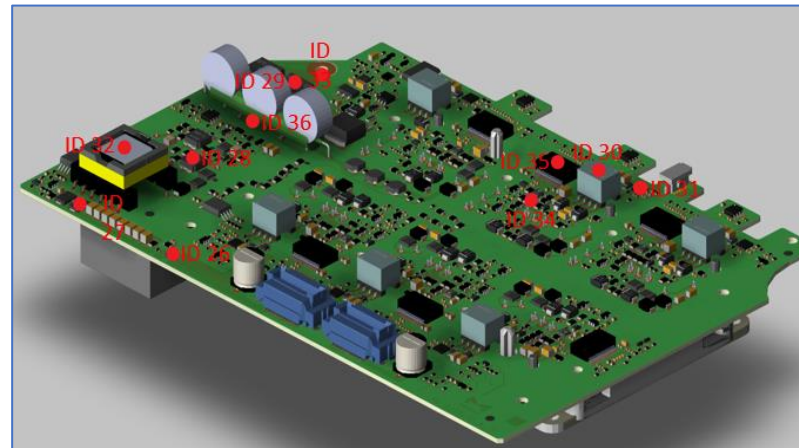
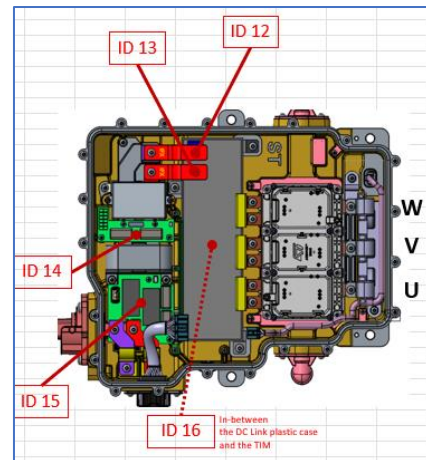
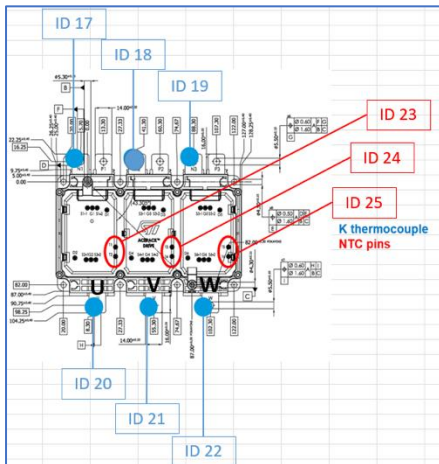
Lifetime of Components

- Model Predictive Controllers



Lifetime of Components

- Thermal Management (Peak & Continuous Performance and Temperature Monitoring)
 - Thermal Performance Testing
 - Real-Time Temperature Monitoring
 - Cooling System Effectiveness
 - Thermal Dynamics Insights



Mid to long term expected impacts of the project



HiPE Impact

▪ **Faster Uptake of Zero-Emission Mobility**

- Smaller, lighter and more efficient electric powertrains
- Lower Total Cost of Ownership (TCO) makes EVs more affordable and encourages faster adoption

▪ **Innovative Vehicle Design & Deployment**

- SoA inverters and highly integrated eAxles combine multiple functions in a compact design
- Smaller, lighter and more efficient components extend driving range and reduce energy losses
- GaN-based electronics support high-performance control for auxiliaries and chassis systems
- Cost-benefit and TCO tools help OEMs make informed deployment decisions

▪ **Improved User Acceptance & Environmental Benefits**

- Reduced energy losses → longer driving range
- Lower costs → improved affordability and encourage adoption
- Cleaner air and reduced emissions → benefit urban environments and public health

All of this adds up to more efficient, compact and affordable EVs, contributing directly to EU goals for sustainable mobility, competitiveness, and climate action.

HiPE is part of E-VOLVE Cluster





www.hipeproject.eu

#RTR2026



THANK YOU!

For questions, please contact:
bernhard.brandstaetter@v2c2.at &
medina.custic@v2c2.at



With the support of

