Welcome

SIA POWERTRAIN 2025

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Integrated Electronics for Electric Vehicles: Advancing Efficiency, Scalability, and Sustainability with the N-in-1 Concept

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IAV GmbH

International Congress & Exhibition

SIA POWERTRAIN 2025

PORT MARLY - FRANCE

With the support of

“N-in-1 Powerbox marks the initial step towards the integration of the e-axle and the energy system as a unified entity.”

topology

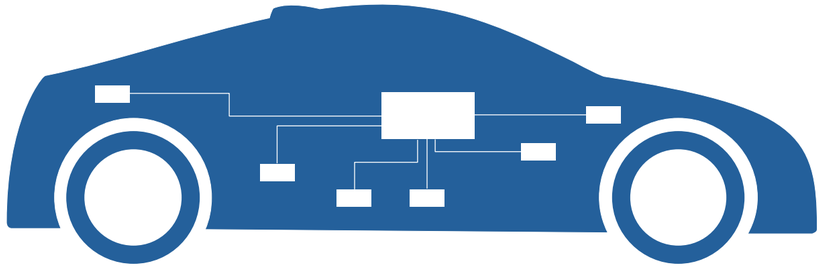
Agenda

1. Market, architecture, and SDV
2. Methodology and choice of components
3. System block diagram and architecture
4. Advanced control to enable high level integration
5. Quality level of integration
6. Cost effectiveness

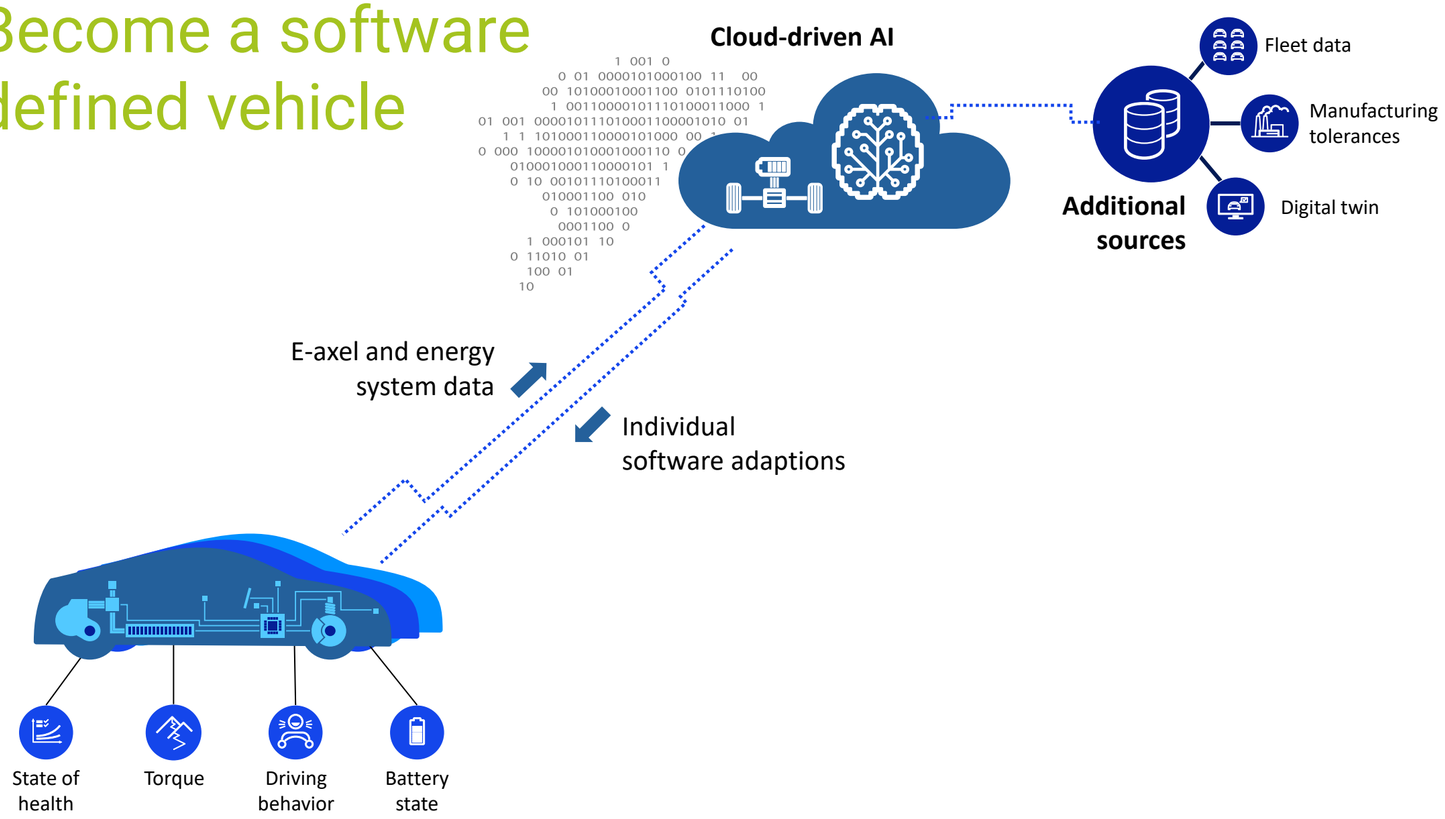
E-axle and the energy system integration beyond 3-in-1

E-axle and the energy system integration beyond 3-in-1

Transition from distributed to zonal E/E architecture



Become a software defined vehicle

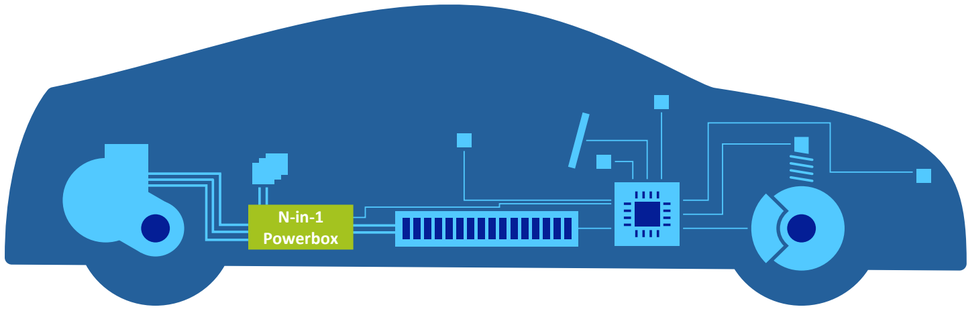


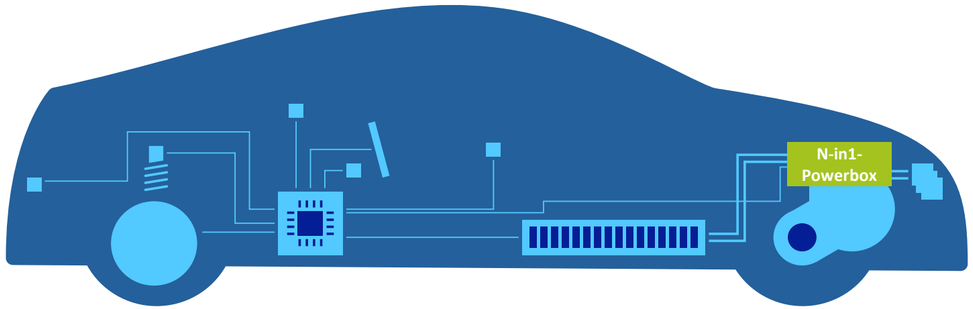
2. Methodology and choice of components

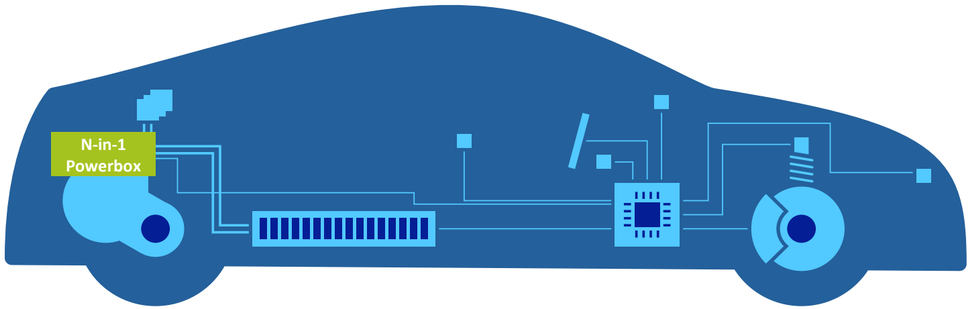
Integration strategy, battery or e-axle

While a location near the **battery or the e-axle** could be suitable, we opted for the **e-axle** based on the following requirements:

1. Segment C passenger vehicle (<3.5 t)
2. 150 kW e-axle, and
3. 11 kW on-board charger







2. Methodology and choice of components

Integration strategy, battery or e-axle

State of the art

Emerging

Potential

Electrical Machine	Three-phase Drivetrain Inverter	Reducer/Gearbox			
On-board charger	HV-DC to LV-DC	Power distribution			
HV-battery	Battery management system	DC battery charging	AC-compressor power electronics		
Oil or coolant pump	Vehicle control unit	HV-DC to HV-DC	Passenger AC voltage supply outlet	PTC heater power electronics	

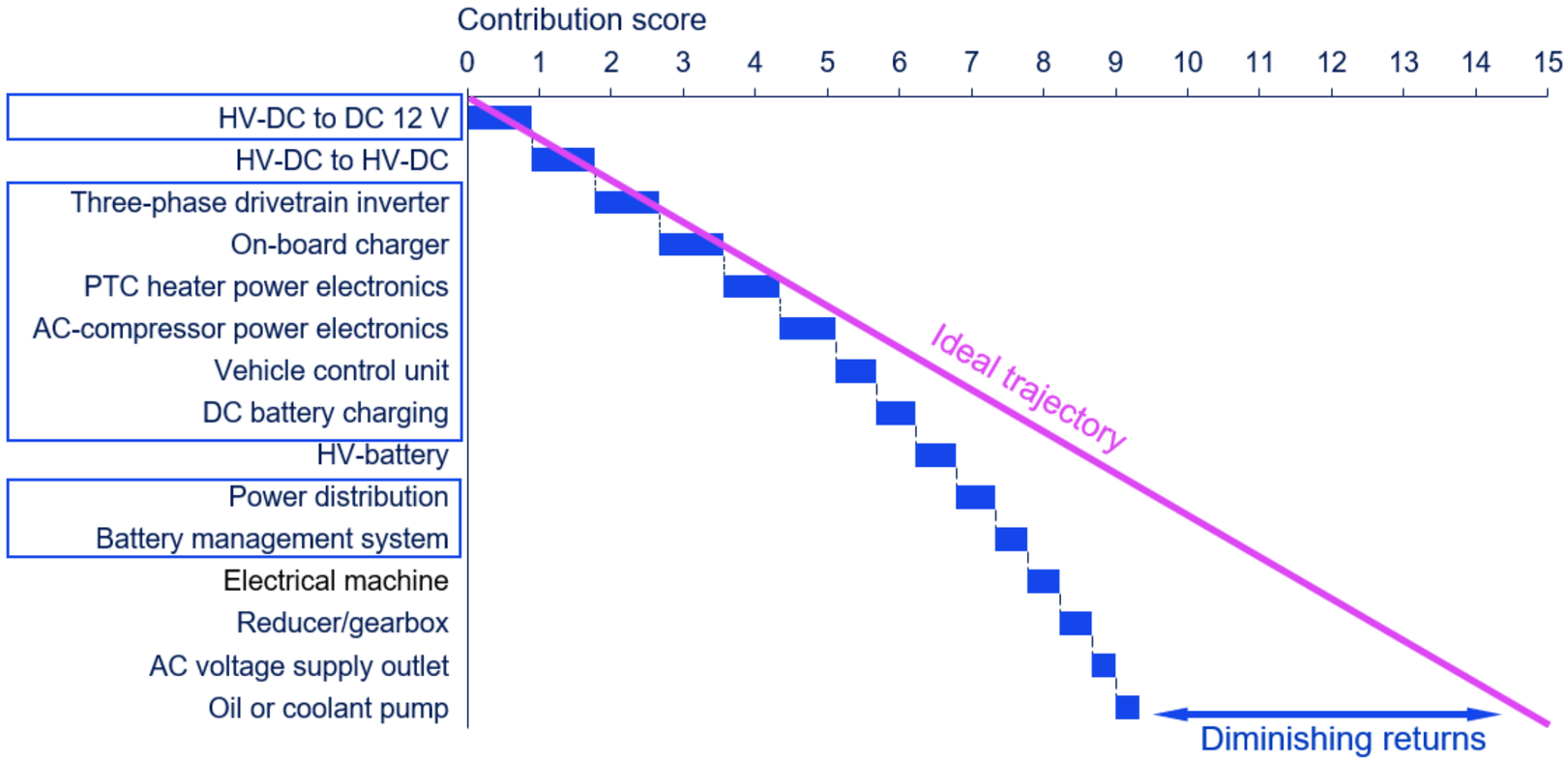
2. Methodology and choice of components

Integration strategy, battery or e-axle

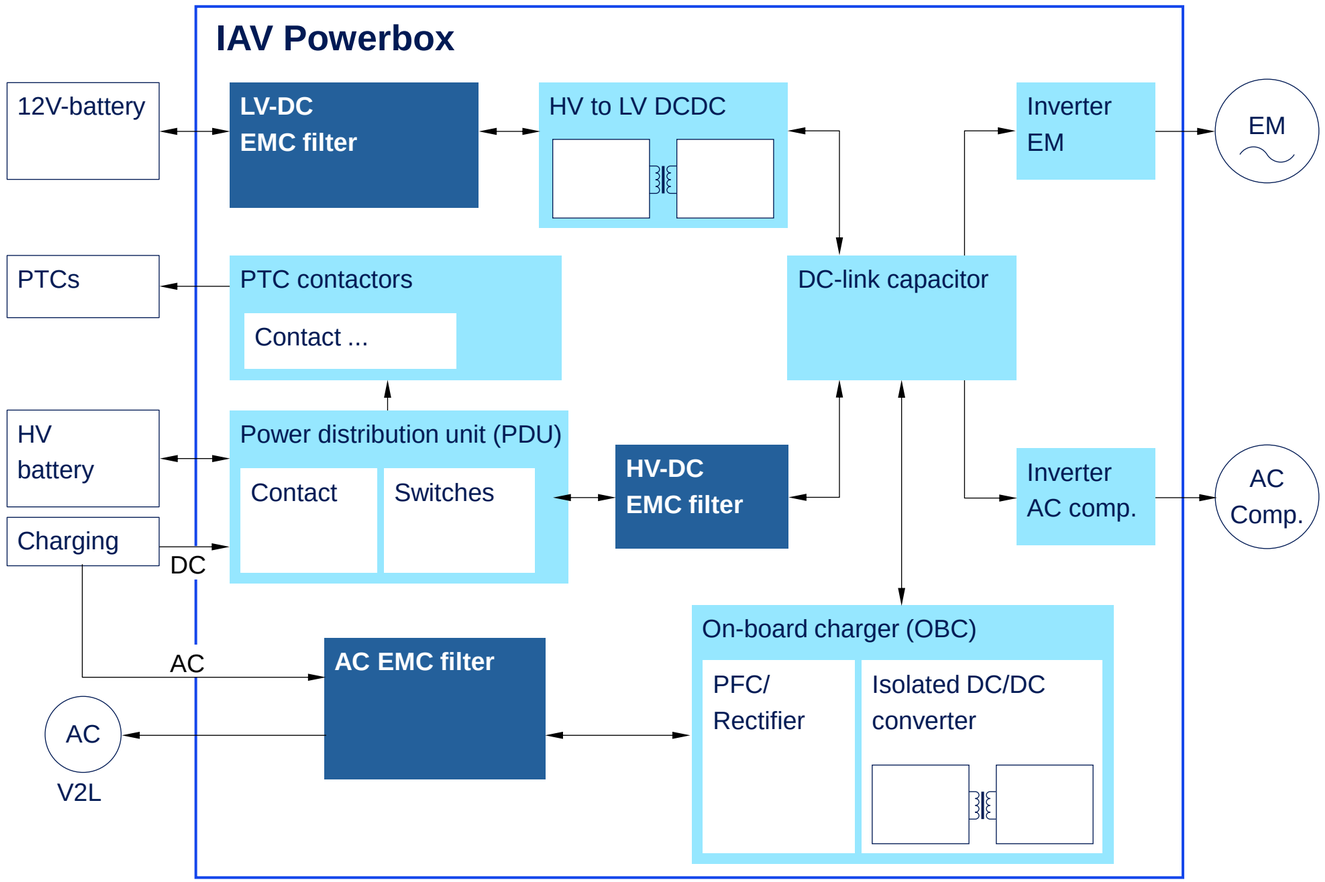
1. Enhanced power density	Resulting in systems that are both more compact and more potent.
2. Space efficiency	Integration facilitates a more streamlined design, optimizing space usage within the vehicle.
3. Fewer components	The requirement for individual housings, connectors, seals, cooling connections, and cables is significantly lessened.
4. Weight minimization	With a decrease in the number of components, the total weight of the system is reduced.
5. Cost reduction	A smaller number of components translates to decreased manufacturing expenses.
6. Improved efficiency	Minimized energy losses that often arise during power transfer between separate elements.

2. Methodology and choice of components

Integration strategy, battery or e-axle



3. System block diagram



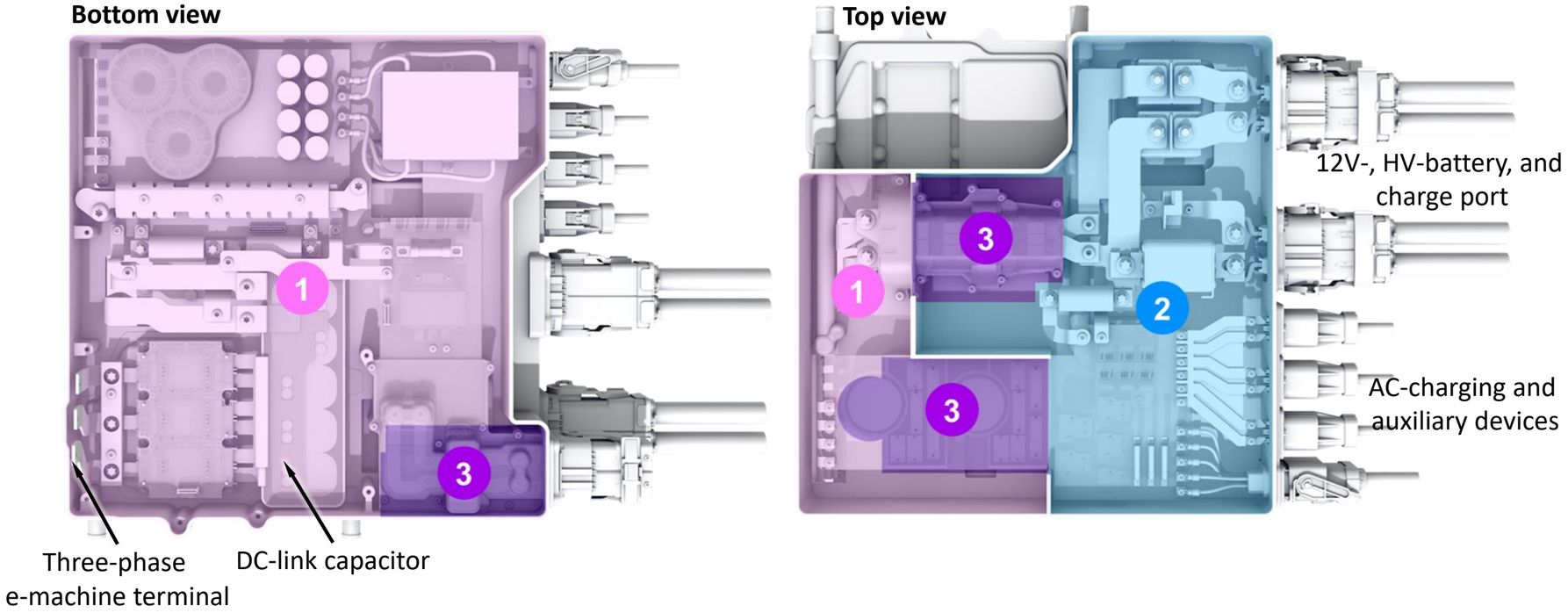
3. System block diagram

1. EMC-zone 1 for energy conversion / power electronics
2. EMC-zone 2 for external interfaces
3. Reduced of EMC-filter from 6 to 3, while maintaining the control of EMC-coupling paths.

1 EMC-zone 1

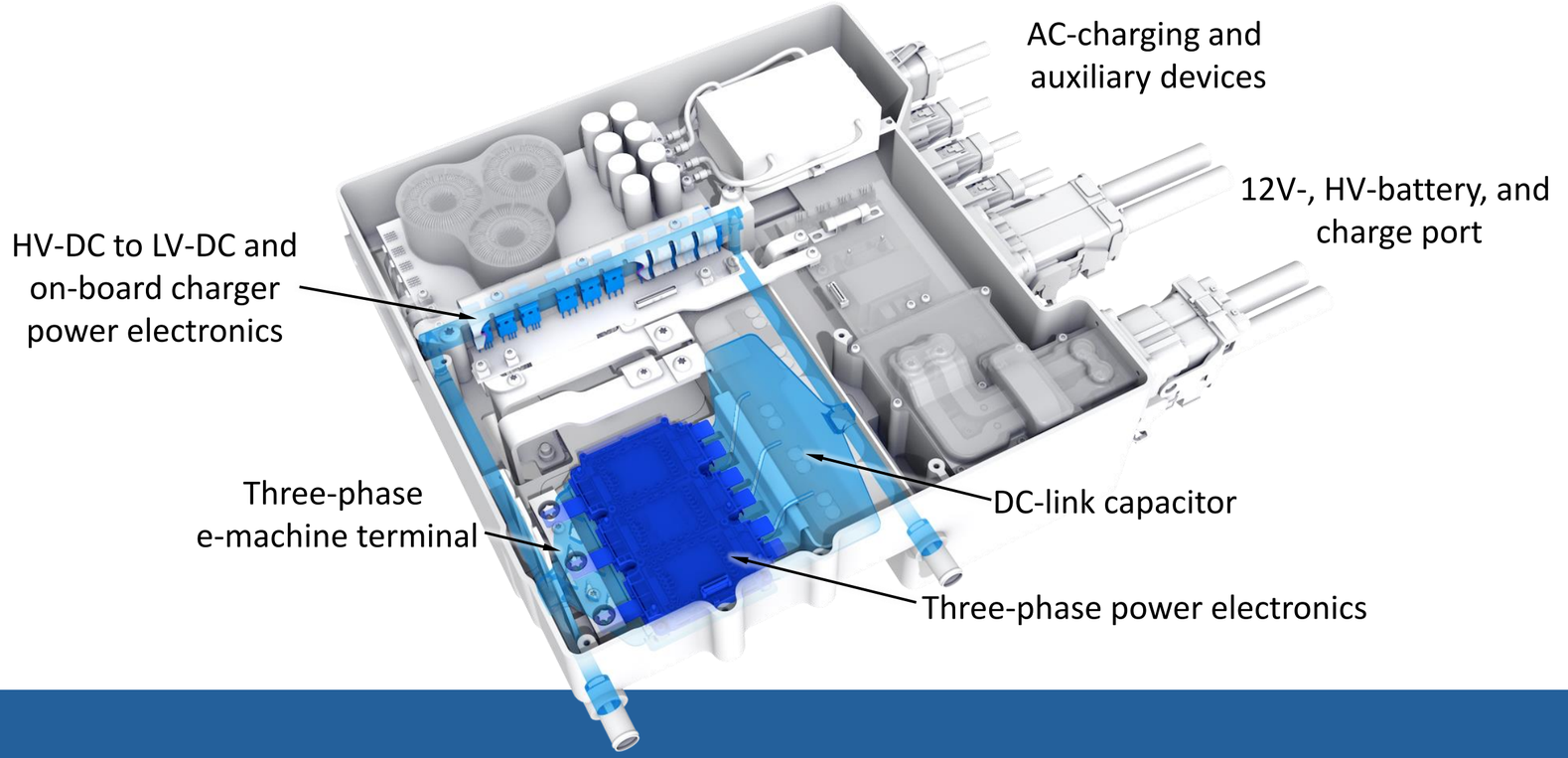
2 EMC-zone 2

3 EMC-filter



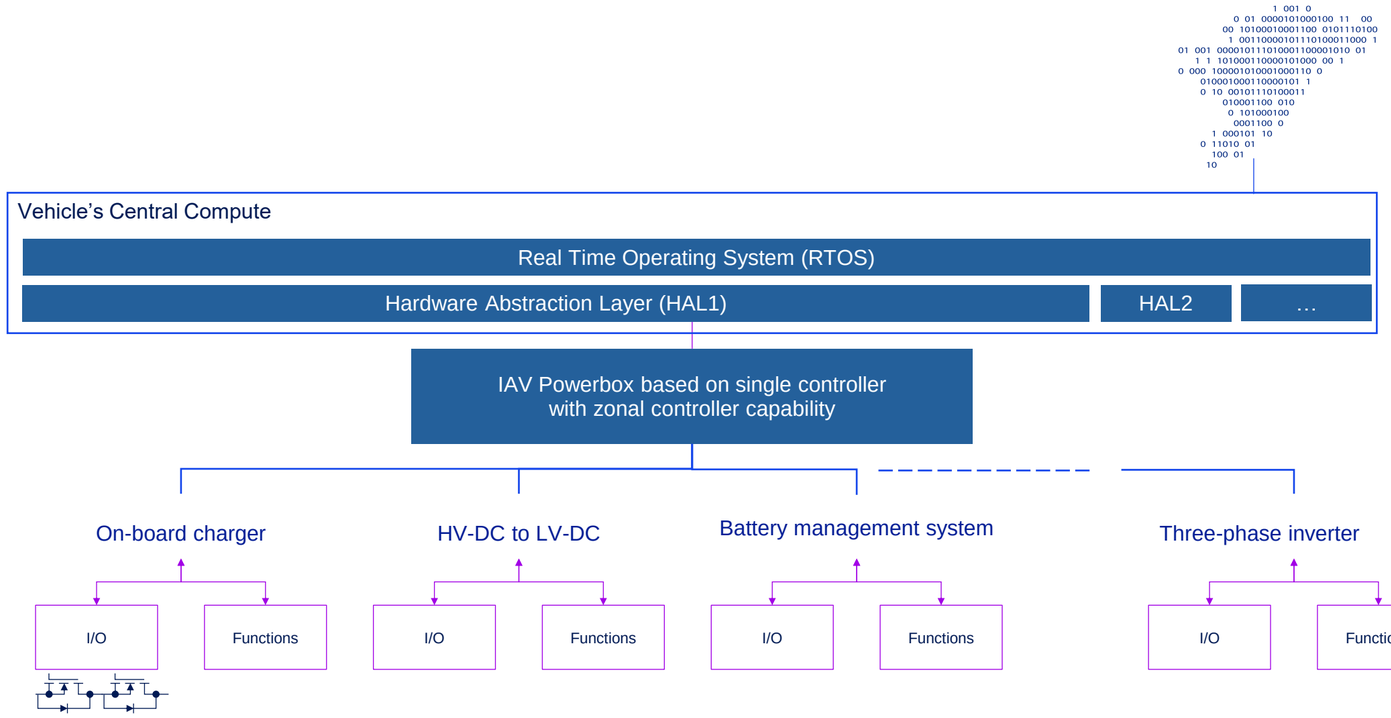
3. System block diagram

1. Consideration of boundary conditions, limitations, and constraints.
2. A shared cooling system, optionally integrated with the e-machine’s cooling system.
3. Thermal performance requirements for power electronics are most demanding.

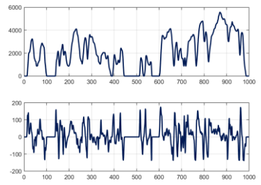


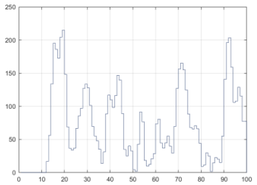
3. System block diagram

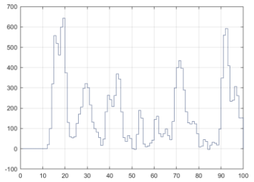
1. The Powerbox acts as a zonal controller, enabling data connectivity for the vehicle's central computing unit and, in turn, the cloud.
2. Software-defined vehicle functions are independent of hardware due to the hardware abstraction layer.
3. Rapid closed-loop control processes are performed by the IAV Powerbox.

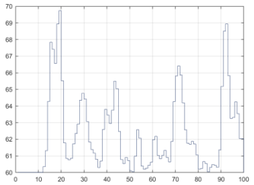


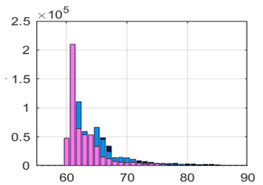
4. Advanced control to enable high level integration

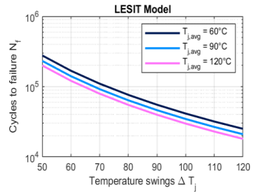












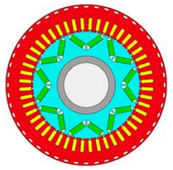
Mission Profile → **Current Profile** → **Loss Profile** → **Temp. Profile** → **Temp. Cycling** → **Lifetime Estimate**

Driving Cycles

Costumer specific cycles, 10 s max. load, WLTP-cycle

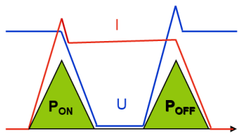
EM & INV Design

AC current, DC voltage, PWM strategy, cos(ϕ), frequency



Inverter Losses

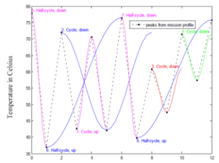
Switching losses & conduction losses



Thermal Model

Rainflow Counting

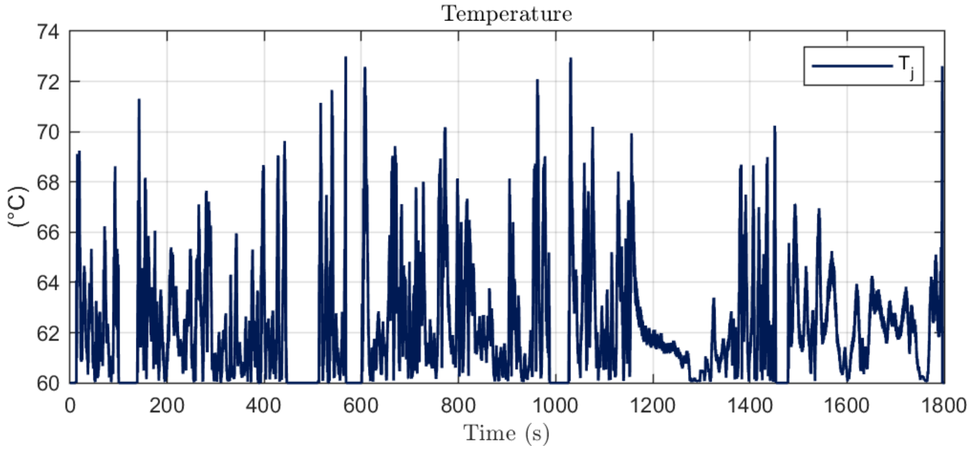
Statistic evaluation of temperature cycles



Adjustment of the target currents “derating”

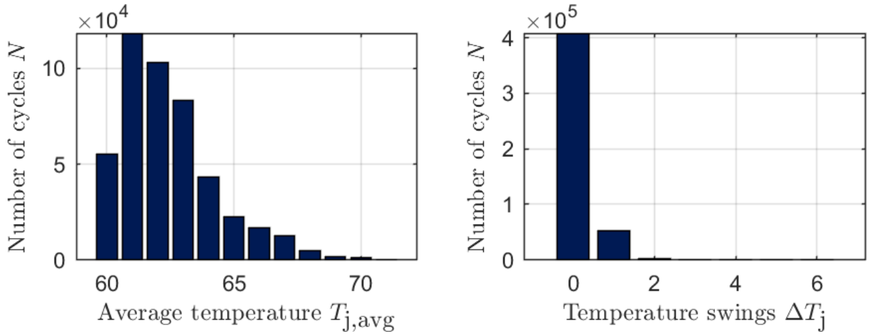
Adjustment of the switching frequency “less losses”

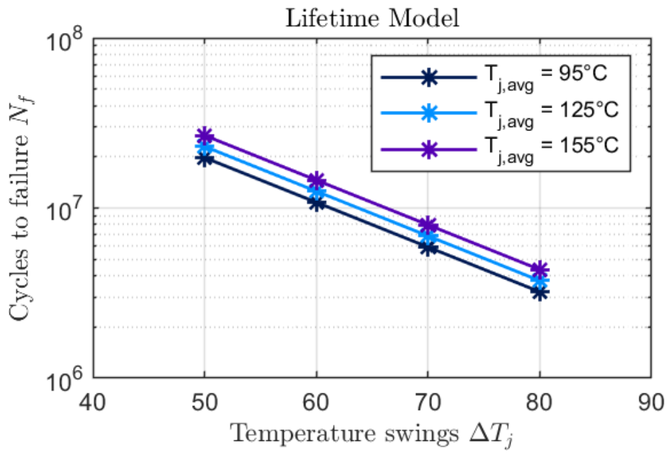
4. Advanced control to enable high level integration, **control off**



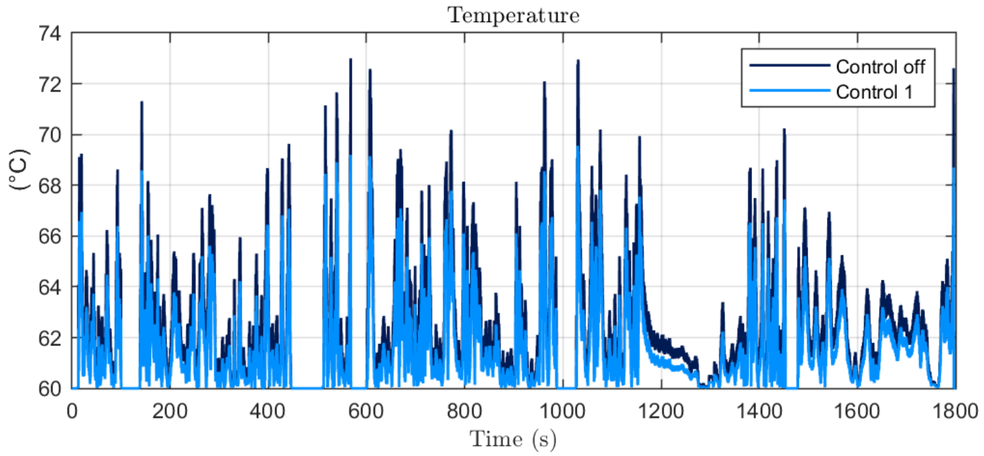
Results WLTP	Number of temperature cycles	462.921
	Lifetime consumption	0.166507 %
Extrapolation to failure	Number of WLTP cycles	600
	Max. Distance	13.957 km

Result



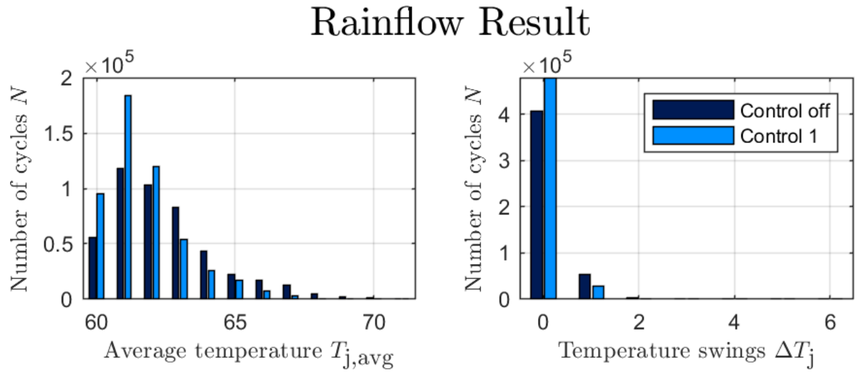


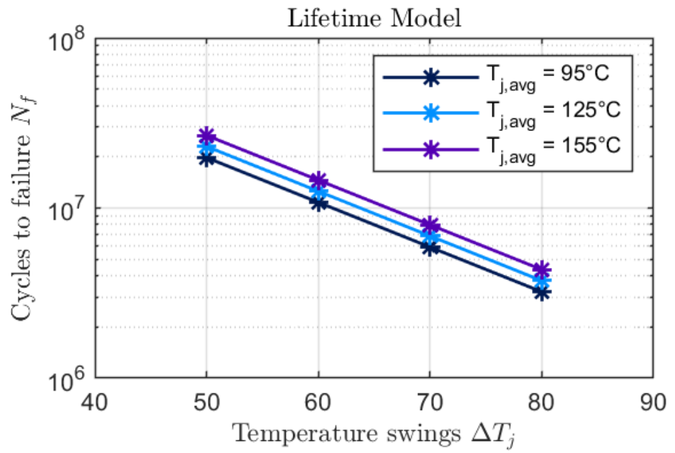
4. Advanced control to enable high level integration, **control on**



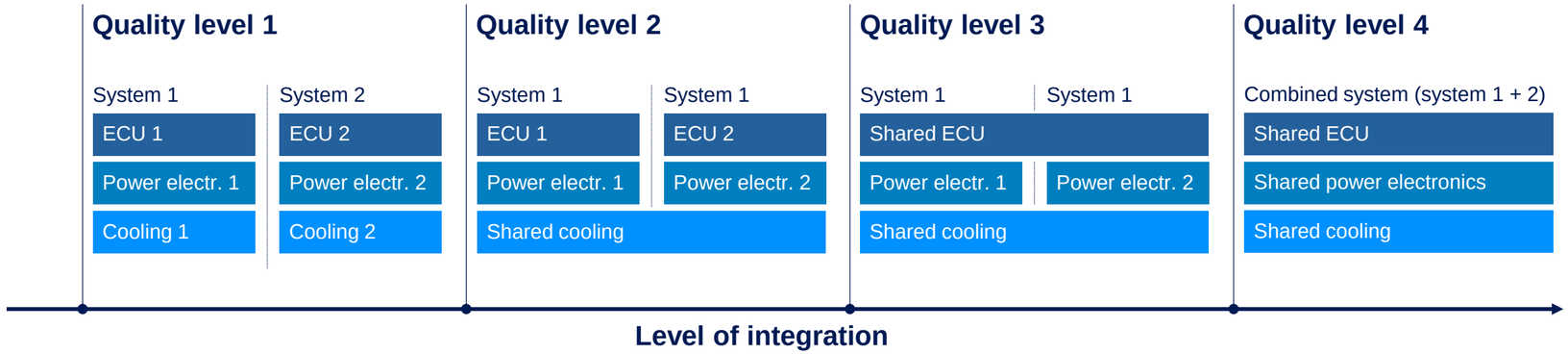
Results WLTP	Number of temperature cycles	506.407
	Lifetime consumption	0.082236 %
Extrapolation to failure	Number of WLTP cycles	1216
	Max. Distance	28.287 km

Increased by 103 %





5. Quality level of integration

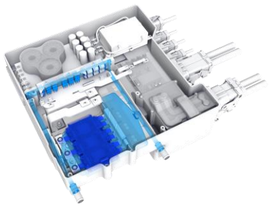


System 1 and System 2 function independently of each other.

A shared cooling system is introduced, as it is state of the art for 3-in-1 e-axel systems

Microcontrollers and PCBAs cover more then one system need, thus reducing the part count and software complexity

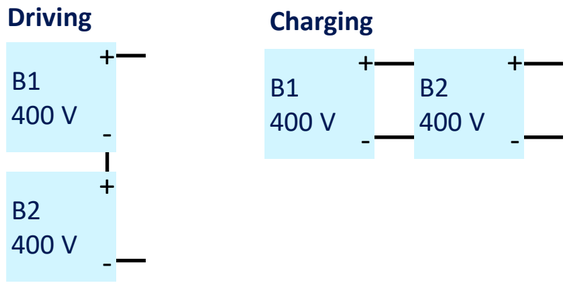
Power electronic components are intentionally shared across various functions.



5. Quality level of integration

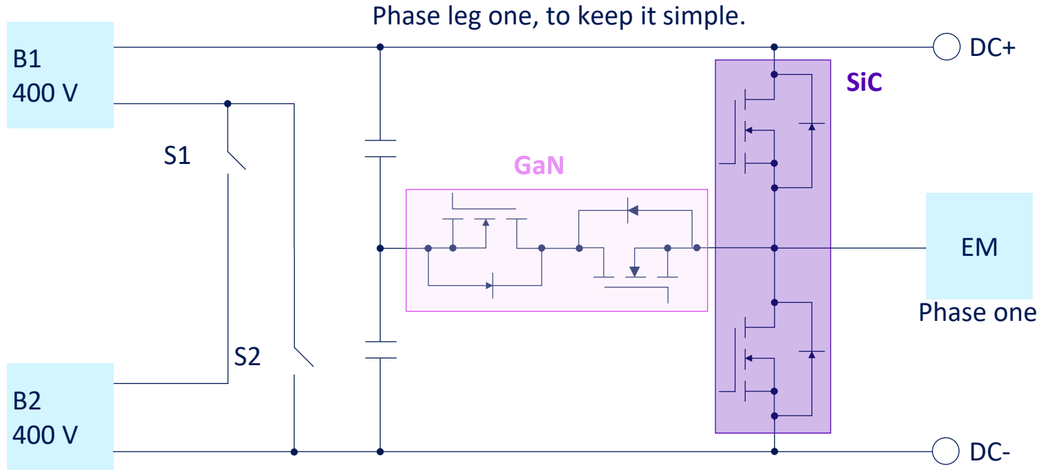
Use Case: Battery bank charging

Bank charging involves dividing the pack into two sections for charging purposes (B1 and B2). This way, an 800 V battery pack is configured into two parallel 400 V packs for the charging process.

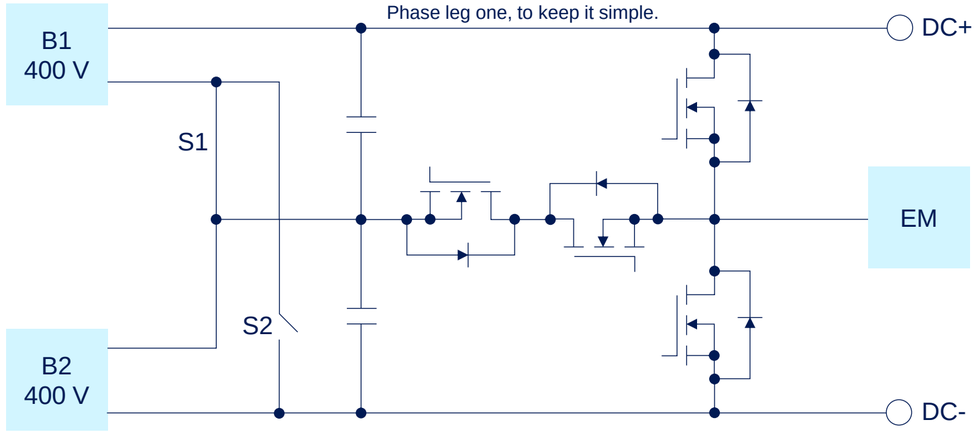


Assumption:

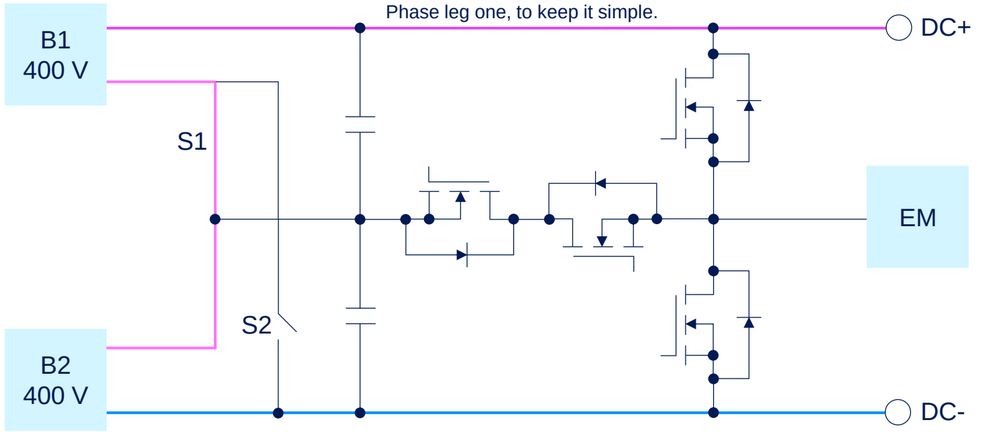
Thee-Level- Type-Inverter with SiC and GaN power semiconductors for increased driving efficiency.



5. Quality level of integration, **driving and charging 800 V**

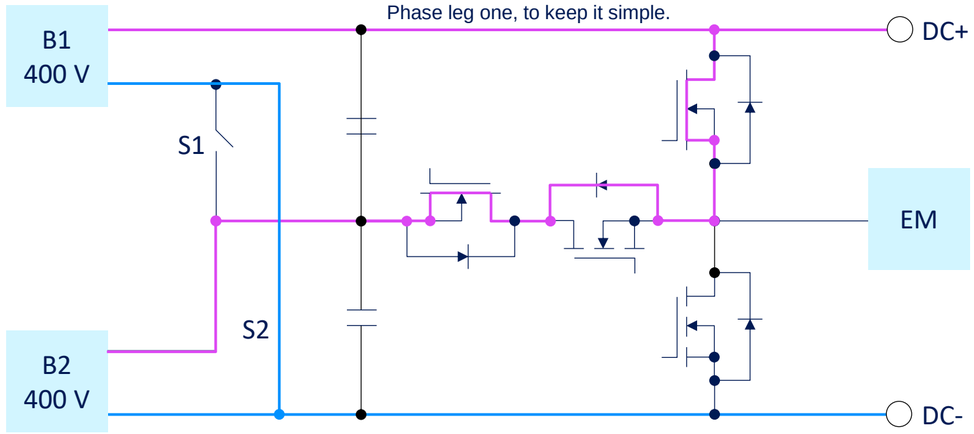


1. The switch S1 is in the closed position,
2. The connection between B1 and B2 is in series,
3. The inverter is functioning normally.



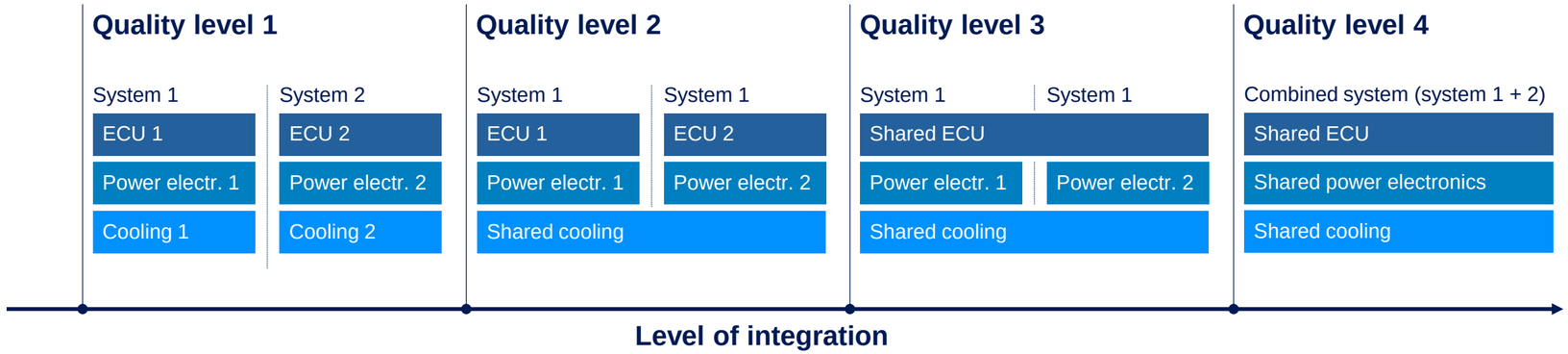
1. The switch S1 stays in the closed position,
2. B1 and B2 are connected in series, and
3. A charging voltage of 800 V DC is applied.

5. Quality level of integration, **charging 400 V**



1. Now switch S2 is in the closed position,
2. The inverter circuit acts as additional switch to establish a parallel circuit of B1 and B2, and
3. A charging voltage of 400 V DC is applied.

5. Quality level of integration, **increased**

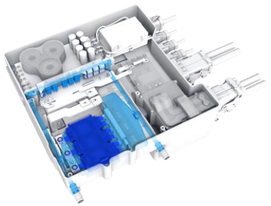


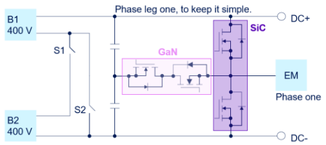
System 1 and System 2 function independently of each other.

A shared cooling system is introduced, as it is state of the art for 3-in-1 e-axel systems

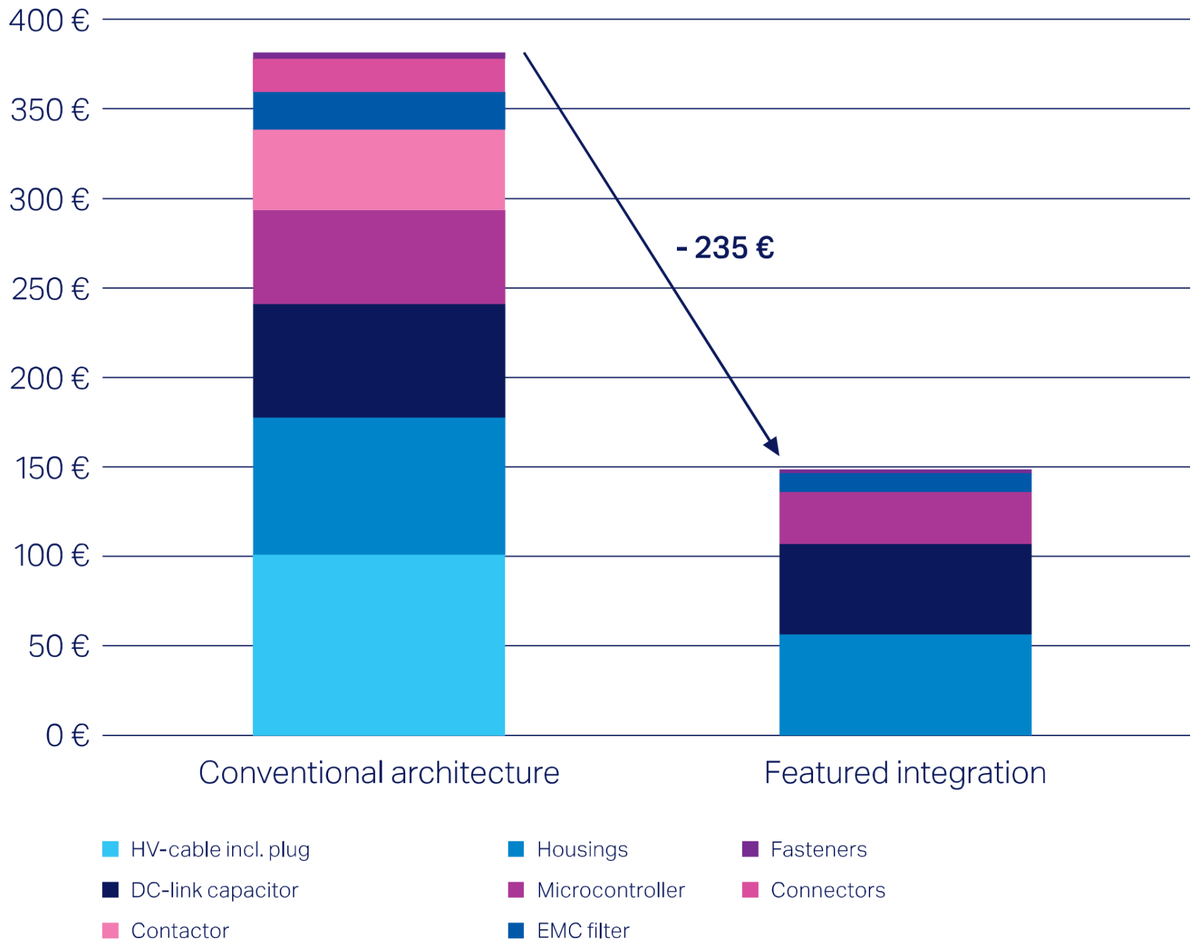
Microcontrollers and PCBAs cover more then one system need, thus reducing the part count and software complexity

Power electronic components are intentionally shared across various functions.





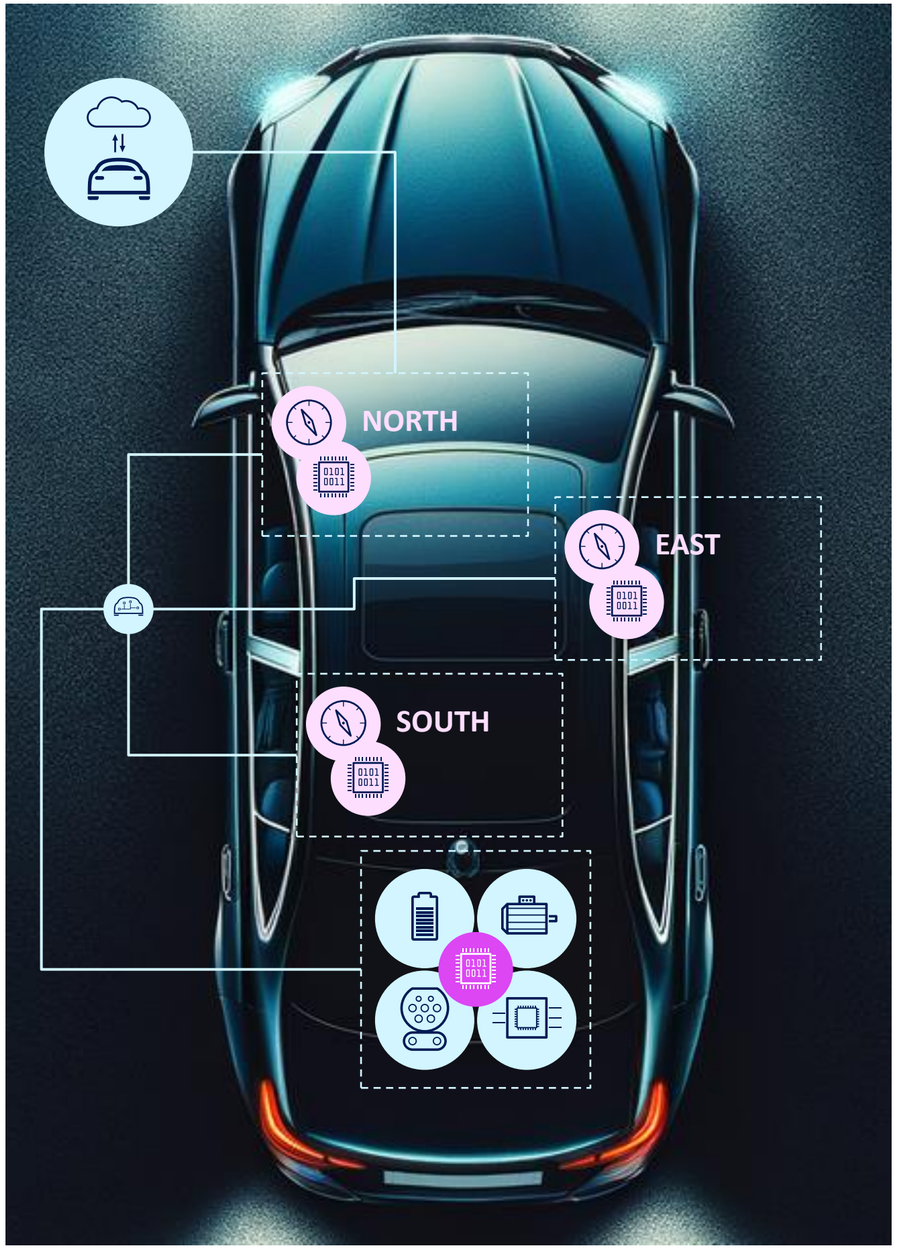
6. Cost effectiveness



1. Analysis performed on reference architecture
2. This integrated solution primarily reduces system costs by minimizing components such as housings, fasteners, connectors, seals, EMC-filter, and HV-cables.
3. Analysis indicates a per part cost reduction of 235 €
4. The streamlined base software development is anticipated to lower development costs.

Summery

1. The IAV Powerbox serves as the cloud gateway for the e-axle and energy systems.
2. A single microcontroller simplifies architectural choices.
3. An EMC strategy that reduces the number of EMC filters by half.
4. Achieving a 70% reduction in costs for housings, fasteners, connectors, seals, EMC-filter, and high-voltage cables.
5. Enables shared use of power electronics for even higher integration levels.



THANK YOU FOR YOUR ATTENTION

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