

Infineon high voltage Inverter
Application Presentation

Traction Inverter trends



More efficiency

Cost optimization

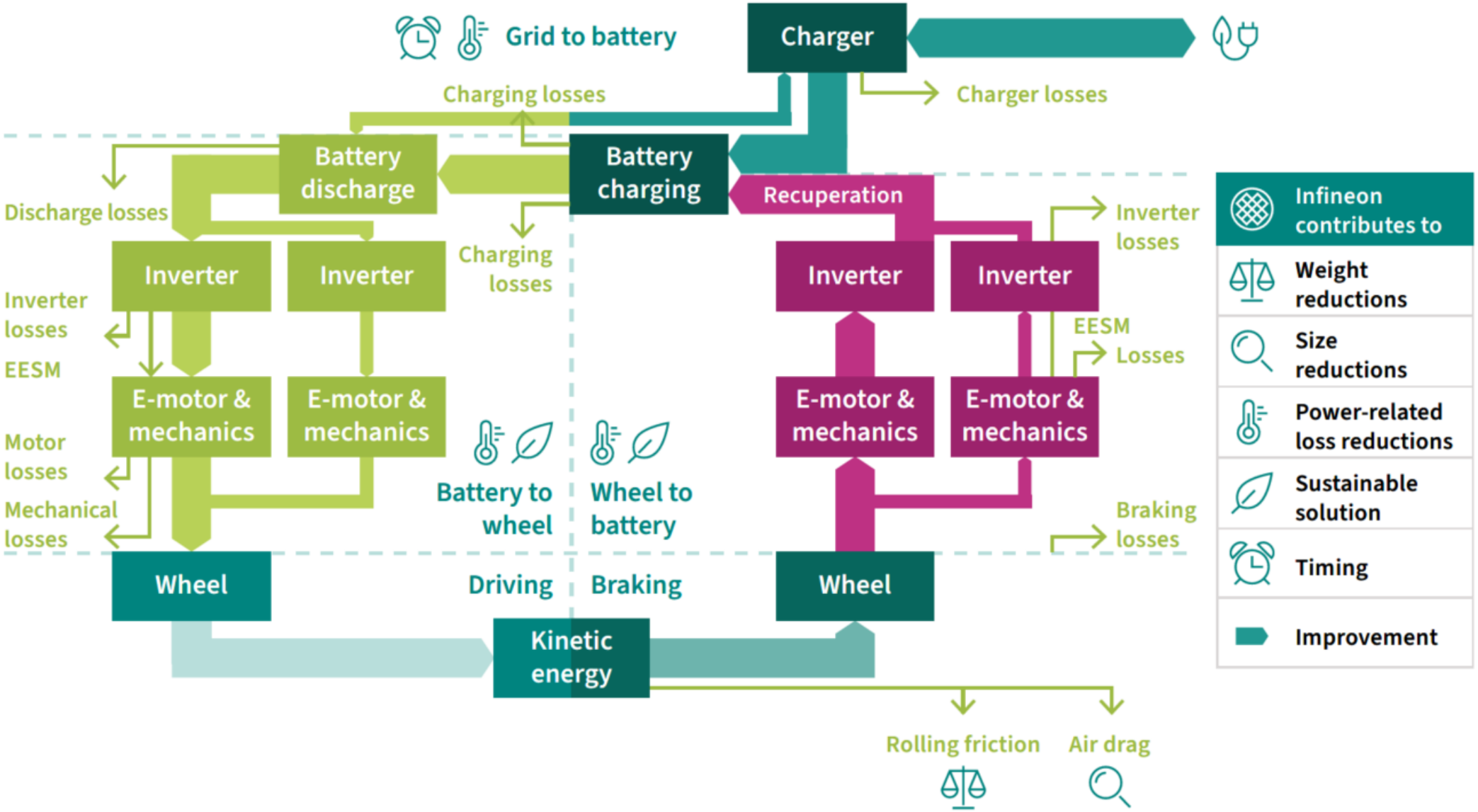
Right performance

Volume production

Vehicle integration

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Semiconductors contribute to improved energy efficiency, but also to size and weight reduction, to improve the vehicle dynamics



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Vision: How to get there





Smart Charging
Right timing and performance



Energy Management
Energy handling predictive driving



Semiconductor Efficiency
Reduce power losses



Rolling resistance and air drag
Reduce size and weight



Connected Environment
V2x and Infrastructure

10 kwh

100 km

Higher energy utilization of renewable energies

10% smaller battery
10% more vehicles

Less dependability in supply e.g. on rare earths

Less weight for less PM2.5 & better driving performance

Vehicle to x (V2x):
new business models

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Through technology excellence and long term supply security Infineon and Stellantis collaborate on 1Billion EURO business



Advantage of Infineon SiC

For EV traction inverter, **more efficiency and right performance** are key. While IGBT is ideal for cost-optimized drive-train, SiC demonstrates higher efficiency under WLTP partial load scenario.

Infineon offers the **best scalability in market** between IGBT and SiC, allowing customers to freely choose the technology for their needs, **reduce platform migration effort while achieve fast time to market.**

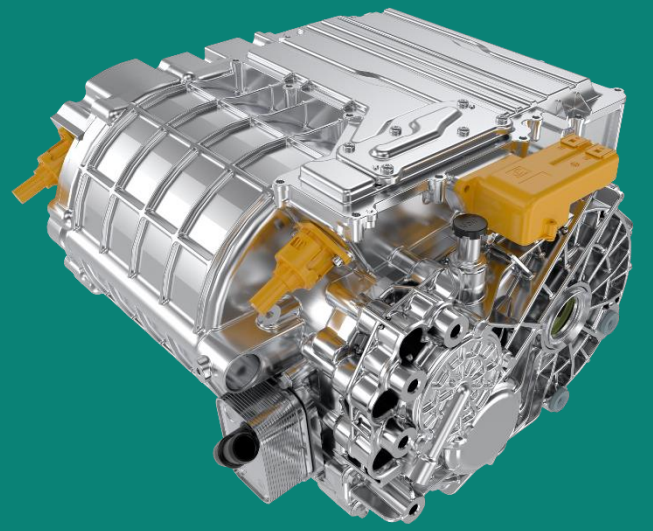
Collaboration with Stellantis

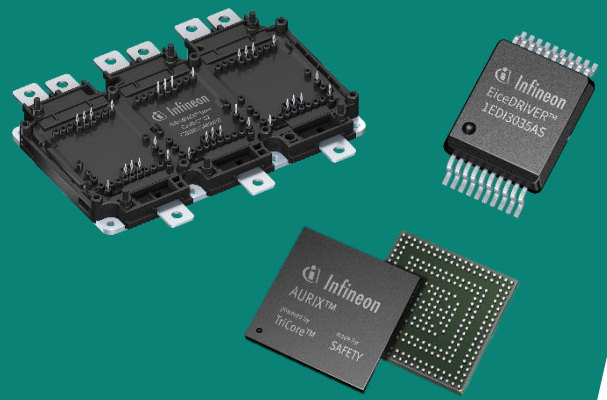
Infineon and Stellantis have agreed on MoU of multi-year delivery of silicon carbide chips. The potential sourcing volume and capacity reservation have a value of more than €1 billion.

Infineon's 2nd generation CoolSiC chips are chosen by Stellantis, owing to its **unmatched performance, reliability and quality leadership**. Stellantis will hence build highly efficiency electrical vehicles **with longer range and less power consumption**, eventually support the company's pursuit to **standardize, simplify and modernize** platforms.

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Suzhou Inovance selects 2nd generation HybridPACK Drive CoolSiC with optimized gate-driver in its 4-in-1 e-axle





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Collaboration with Suzhou Inovance automotive

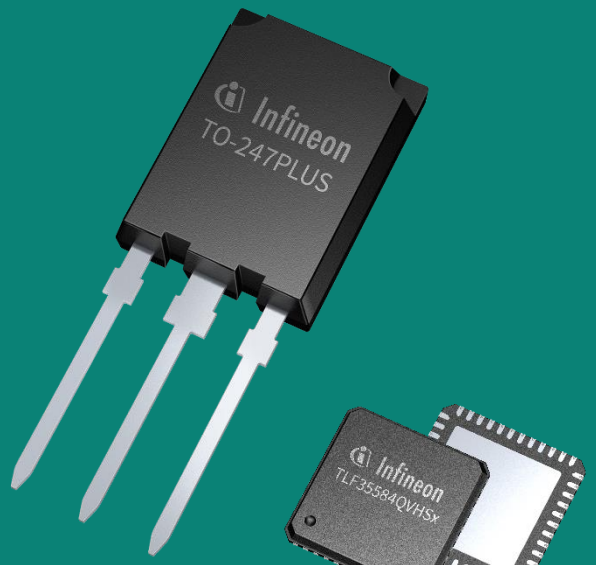
Inovance has chosen Infineon for its **complete system solution** due to **superior performance, high scalability and quality leadership**, this includes 2nd generation of HybridPACK drive in SiC, SiC optimized gate-driver as well as AURIX microcontroller.

our **'One Inverter, One Infineon'** approach helps Inovance to reduced design-in effort and achieve faster time to market.

Testmonial video

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Empower uses discrete IGBT & AURIX MCU in Traction inverter





Advantage of Infineon Discrete IGBT (TO247-PLUS)

Infineon's industry-leading discrete IGBTs are compatible with Empower's latest generation inverter in terms of packaging. Together with the high current density, ultra-low saturation voltage drop and superior parallel performance, Discrete products has increased power density by more than 20%.

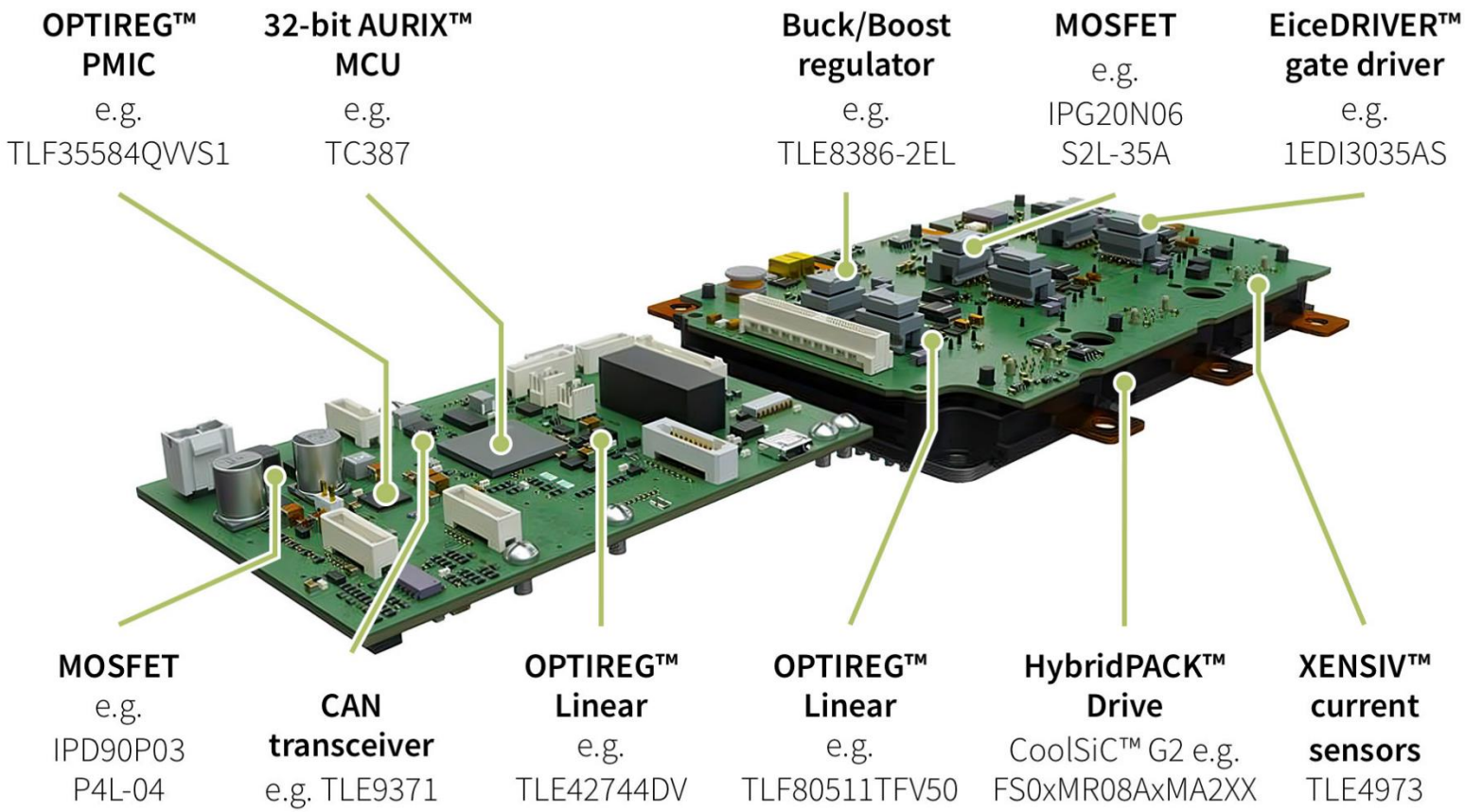
Aside from power components, Infineon's market leading Microcontroller AURIX (TC38x) and power supply PMIC (TLF35584) offer Empower one-stop-shop experience, enabling fast time to market.



Press release

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One Inverter: One Infineon



One inverter, one Infineon

- System solution for easy, fast design

Fast time to market

- Reference design <=300 KW inverter

Freedom of choice

- IGBT& SiC in 750/1200 V scale up to your preferred power class
- HybridPACK™ Drive CoolSiC™ G2 continuous operation at 175°C
- EiceDRIVER™ gate driver G3 optimized for CoolSiC™

Space optimization

- Integration of coreless current sensor (without magnetic concentrator)

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Infineon offers all components for Traction Inverters
The one-stop shop for competitive application solutions

Functional Safety

- Complementing and interoperable chip set
- ISO26262 compliance
- Harmonized Documentation

Traction Inverter

- Overview
- Products
- Documents
- Videos
- Training
- Support

Products

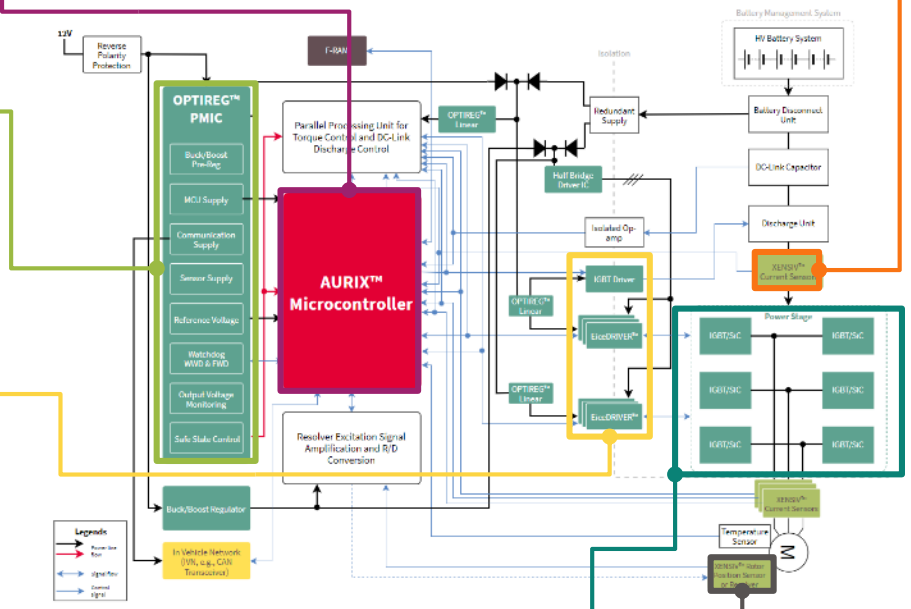
- Microcontroller
- Driver Stage
- PMIC
- CAN Transceiver
- Memory
- IGBT Modules / SiC Modules
- Position Sensor

Microcontrollers	IFX product offering
AURIX™	Multi-core device Safety & security Scalable across xEV

Power Supply	IFX product offering
OPTIREG™ PMIC	Functional Safety OPTIREG™ PMIC TLF35584 – for safety relevant applications

Gate Driver	IFX product offering
EiceDRIVER™	Increase system efficiency and lifetime Reduction of system cost

Current sensors	IFX product offering
XENSIV™	AC current measurement ADC interface Standalone sensor

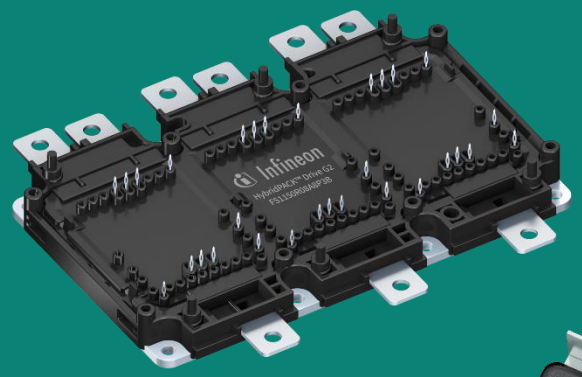


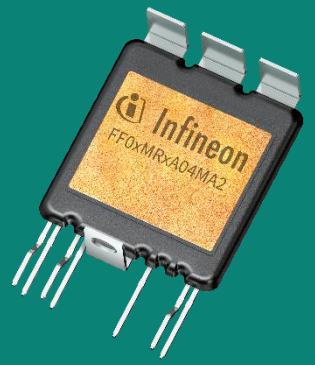
Power Switches	IFX product offering
Modules, Discretes, Bare Dies	Broad product family WBG: Si, SiC High volume experience

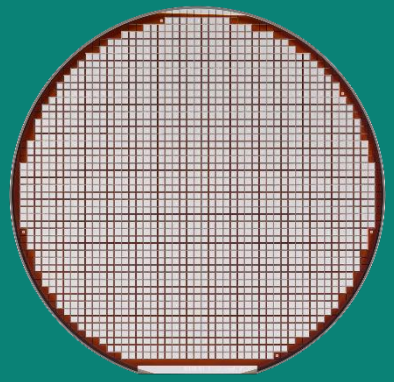
Current Sensor
Highly accurate & core-less Enables compact designs Module from partner Swoboda in development

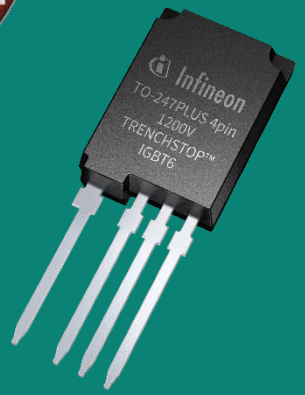
Position sensors	IFX product offering
XENSIV™	Integrated end-of-shaft rotor position sensing solution More compact design

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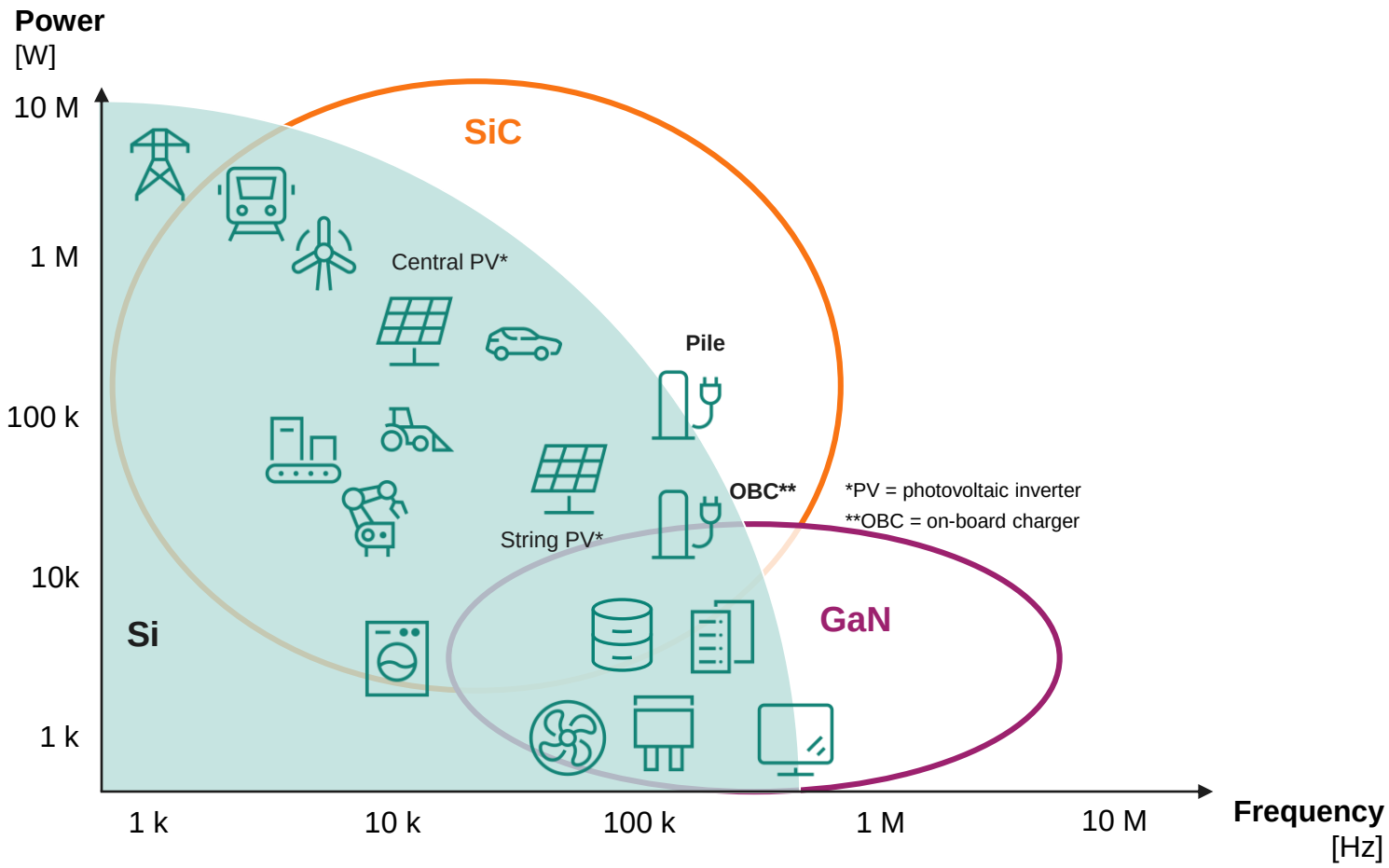
Power switches

(module, bare-die, discretes)

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Leveraging full potential based on the power ratings and switching frequency required by the application

Comparison of technologies



Si

- Si remains the mainstream technology
- Targeting 25 V – 6.5 kV
- Suitable from low to high power

SiC

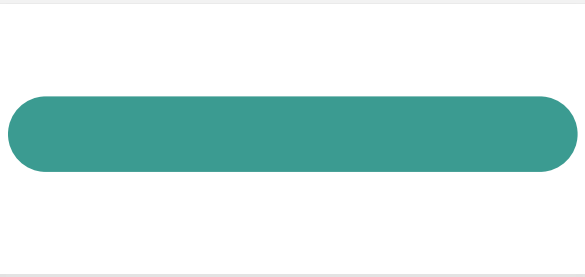
- SiC complements Si in many applications and enables new solutions
- Targeting 650 V – 3.3 kV
- High power – high switching frequency

GaN

- GaN enables new horizons in power supply applications and audio fidelity
- Targeting 80 V – 600 V
- Medium power – highest switching frequency

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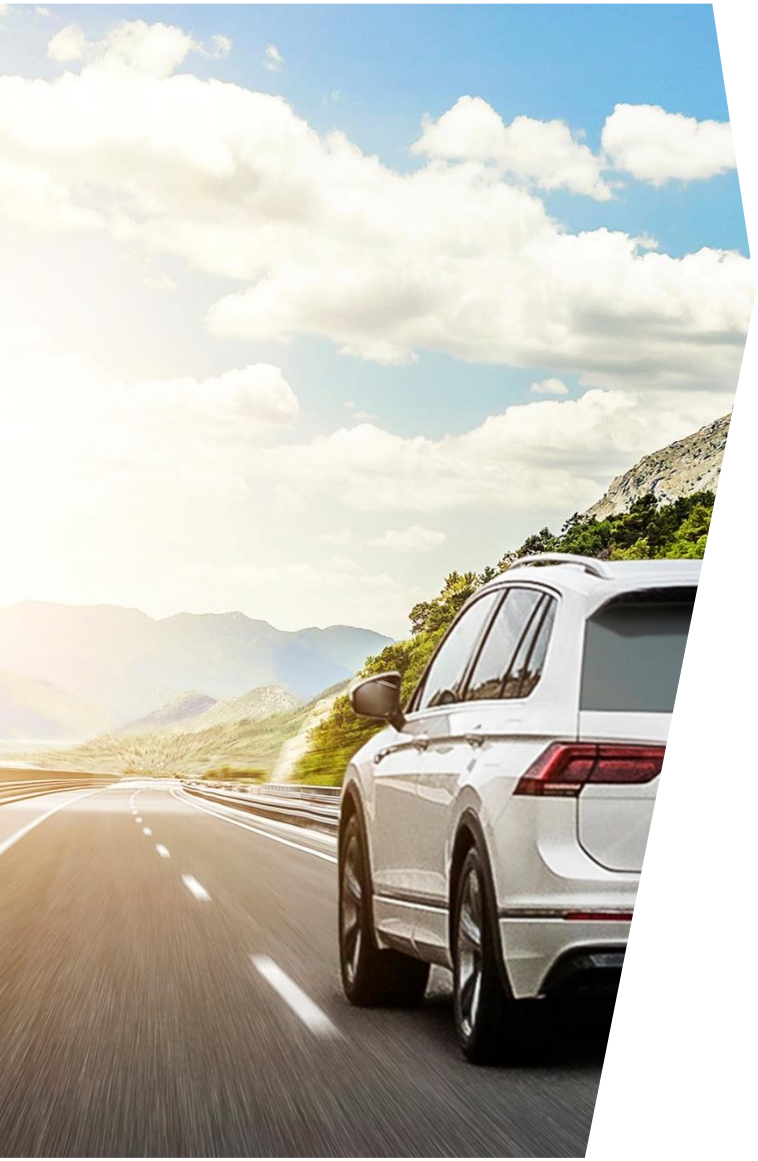
Transition to WBG will vastly differ by application with Si expected to remain technology of choice for many of them

Key automotive applications	2020	2030	Technologies
xEV traction inverter			**SiC** with advantage in **high power** switching performance and **power density**
DCDC HV-HV DCDC HV-LV On-board charger			**GaN** superior switching performance results in **higher efficiency** and **lower system cost**
Power distribution DC motor control Smart Power Switching LED lighting			**Si** is 3-4 times **cheaper than WBG**, will remain competitive in many applications where top performance and form factor are secondary

Si SiC GaN

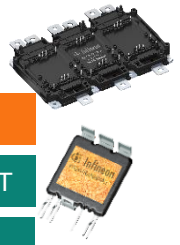
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SiC will be main material for traction inverter, complemented by Si-IGBTs wherever focus on cost is key



HybridPACK™ CoolSiC™
for rear axle

Focus
- Range: **SiC**
- Cost
  - Large battery: **SiC**
  - SiC mixed with IGBT
  - Small battery: **IGBT**



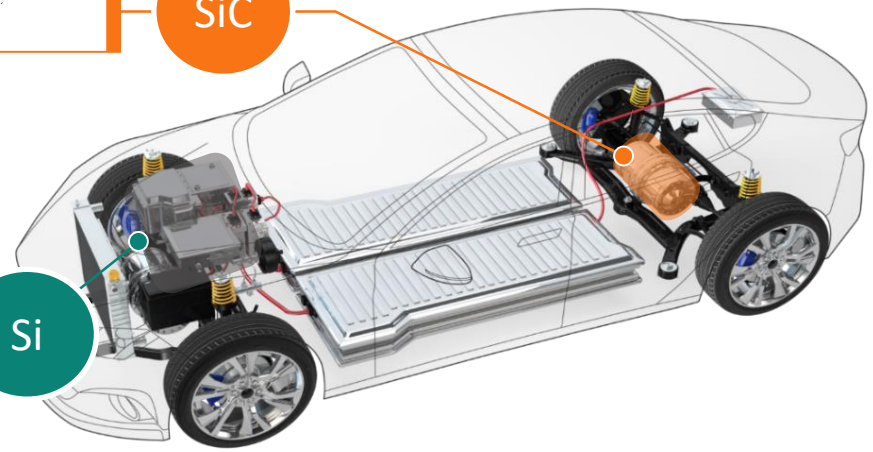
SiC

HybridPACK™ IGBT
for front axle

Focus on cost: **IGBT**



Si

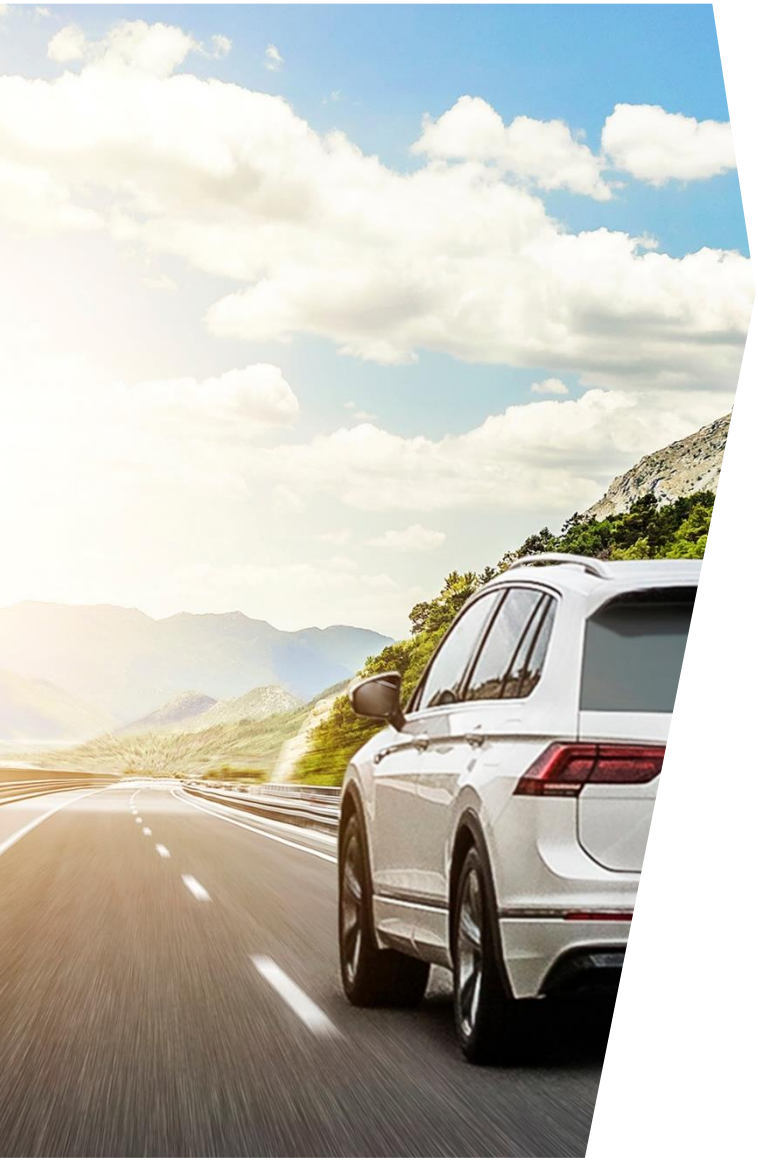


2020 2030

Si SiC GaN

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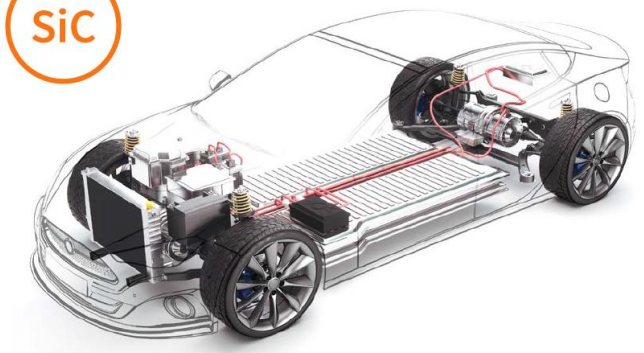
SiC will be main material for traction inverter, complemented by Si-IGBTs wherever focus on cost is key



Single eAxle vehicle performance or cost focused

Main INV	1	**Performance & Range: SiC** Efficiency for propulsion / recuperation, size, weight	SiC SiC SiC SiC
	2	**Right sizing: SiC** Performance as to use case requirement	SiC SiC
	3	**Focus on cost: IGBT** Entry level segments	Si Si

SiC



Si



5 Drive cycle optimized performance and cost

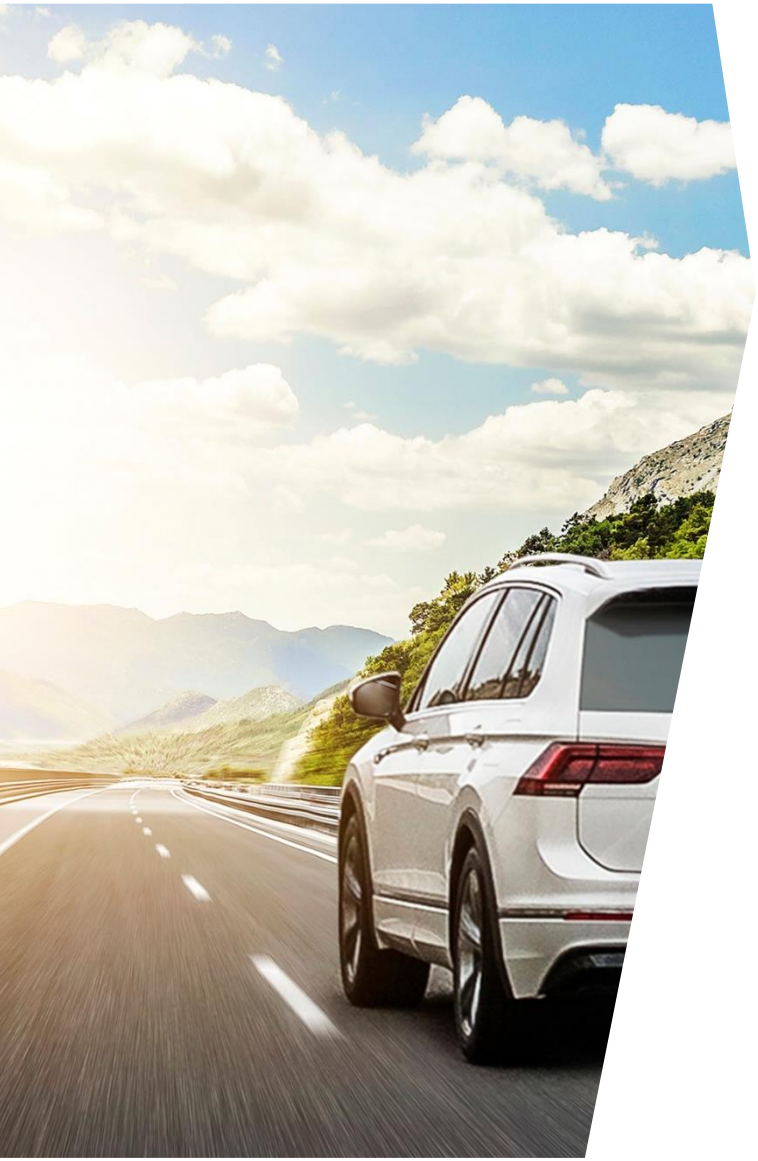
Fusion INV Open Winding	**Fusion Inverter: SiC + IGBT** Efficient permanent drive: SiC Peak performance: SiC + IGBT	SiC Si Si Si

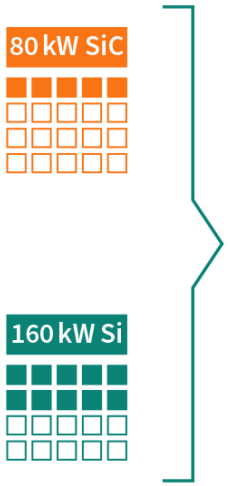
4 Dual eAxle vehicle 2nd eAxle: boost or permananet

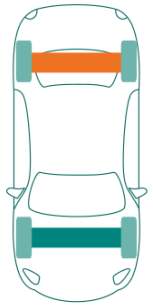
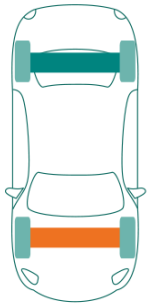
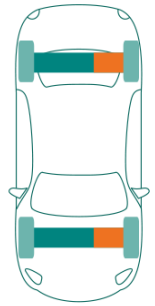
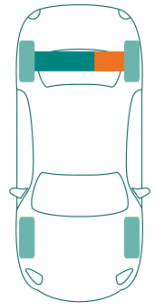
2nd INV	**Performance & Range: SiC** Permanent AWD, recuperation	SiC SiC SiC
	Focus on cost: IGBT Performance boost	Si Si Si

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Si/SiC FUSION:
Example configuration of Front / Rear wheel drive

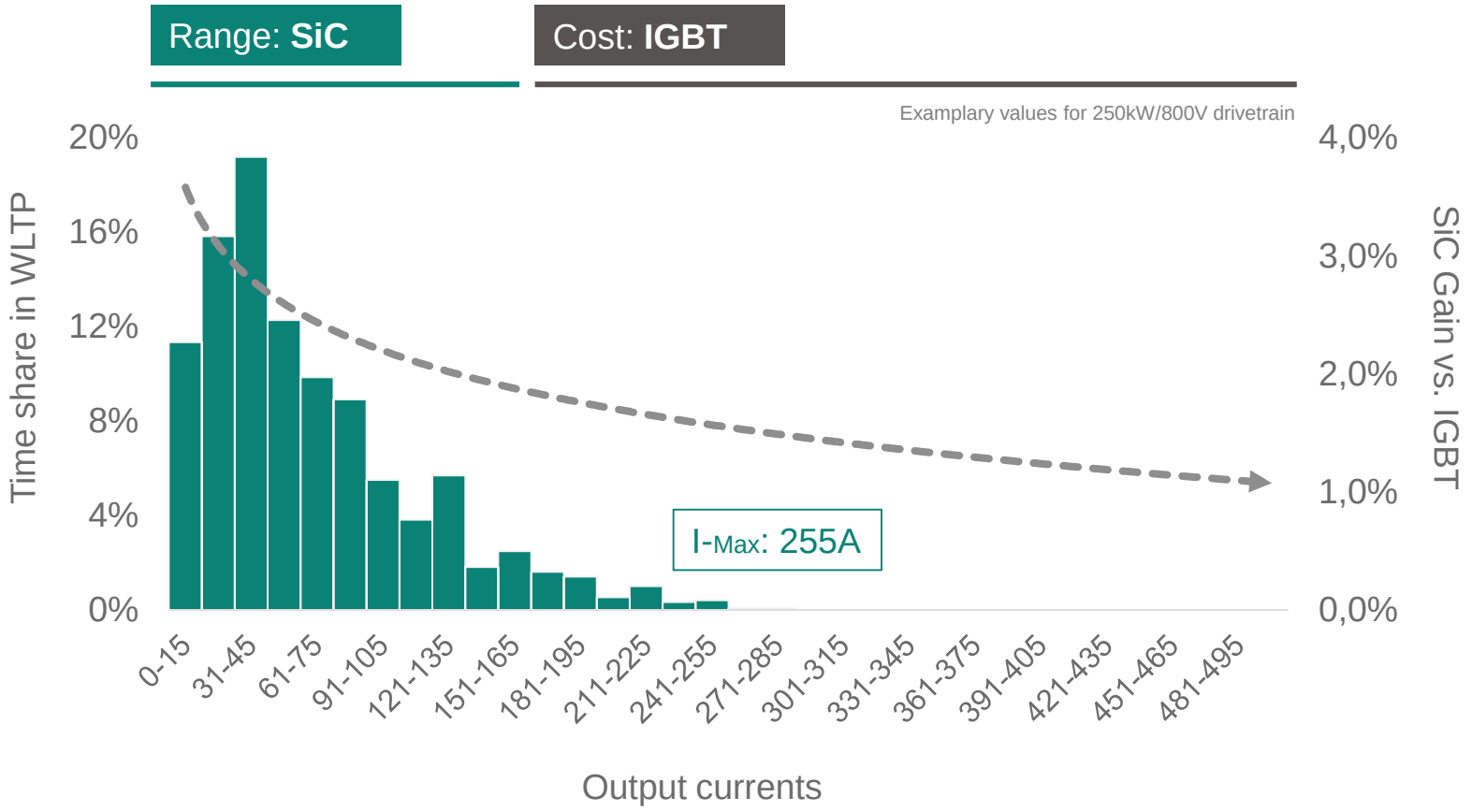




	Config. 1	Config. 2	Config. 3	Config. 4	…
Rear Inverter	80 kW SiC	160 kW Si	**Fusion Inv.** 40 kW SiC 80 kW Si	**Fusion Inv.** 80 kW SiC 160 kW Si	
	100 % SiC	100 % Si	2/3 Si | 1/3 SiC	2/3 Si | 1/3 SiC	
					
	100 % Si	100 % SiC	2/3 Si | 1/3 SiC		
Front Inverter	160 kW Si	80 kW SiC	**Fusion Inv.** 40 kW SiC 80 kW Si	no inverter	

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SiC benefit



Partial load dominates WLTP use cases, where **SiC enables higher efficiency** for EV inverter

Lower efficiency penalty under full load & relevance of full load on range are key to **select IGBT**

Combine SiC & IGBT to optimize between efficiency and peak power competence

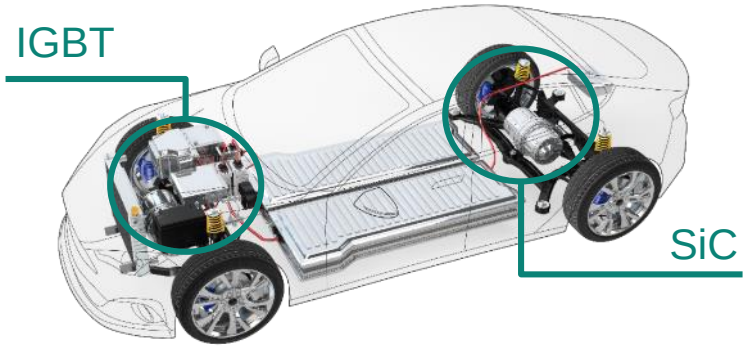
Examplary values for 250 kW/400 V drivetrain

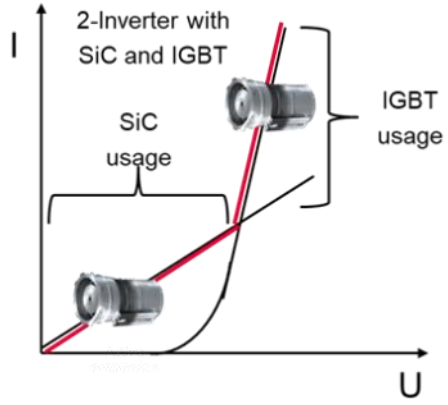
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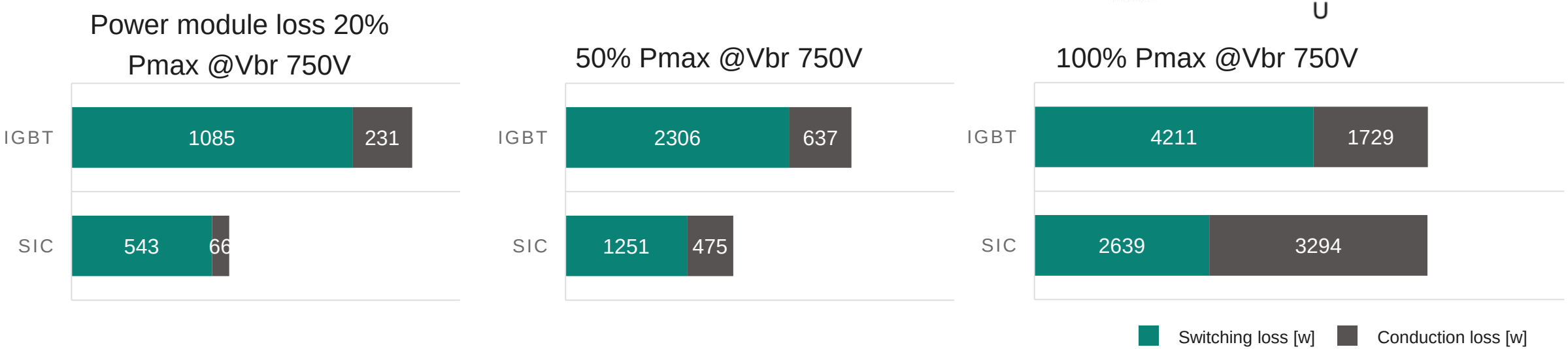
Scaling vehicle peak performance by adding a IGBT based 2nd axle is a common solution to balance efficiency and cost

2nd axel approach

- SiC for higher efficiency
- Si for cost effective peak power







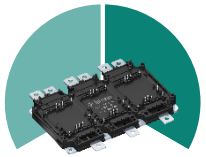
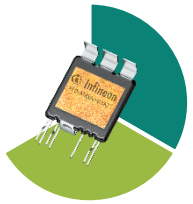
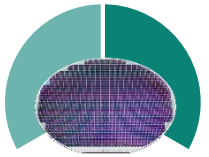
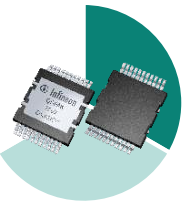
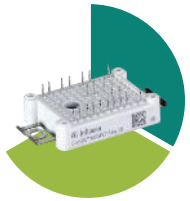
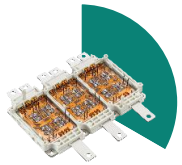
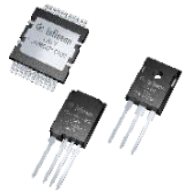
Design considerations

- Primary axle always engaged and sufficiently dimensioned to cover >90% of WLTP drive cycle
- 2nd axle provides additional torque to provide 4 wheel drive capability and maximum performance

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Most scalable power portfolio



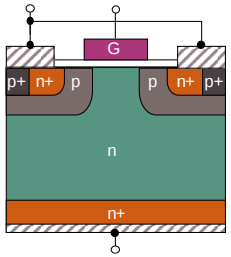
	EasyPACK™	HybridPACK™ Drive	HybridPACK™ DSC	Bare die	Discrete
SiC GEN2/2p					
SiC GEN1					
Si IGBT					

1200 V
750 V
650 V

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Infineon's fine tuned SiC Trench technology out-performs Planar demonstrating more protection vs. traditional Trench

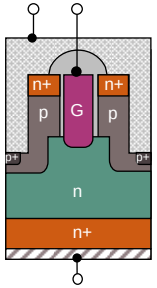
SiC Planar



- ✓ Low complexity process
- ✓ Good shielding of oxide possible

- x Very low channel mobility
- x Limited shrink options

SiC TRENCH

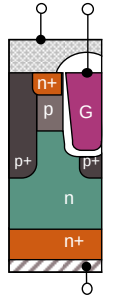


- ✓ Low channel resistance
- ✓ Shrink potential higher than in planar DMOS

- ○ Sophisticated process know-how needed

- x Protection of oxide corners needed

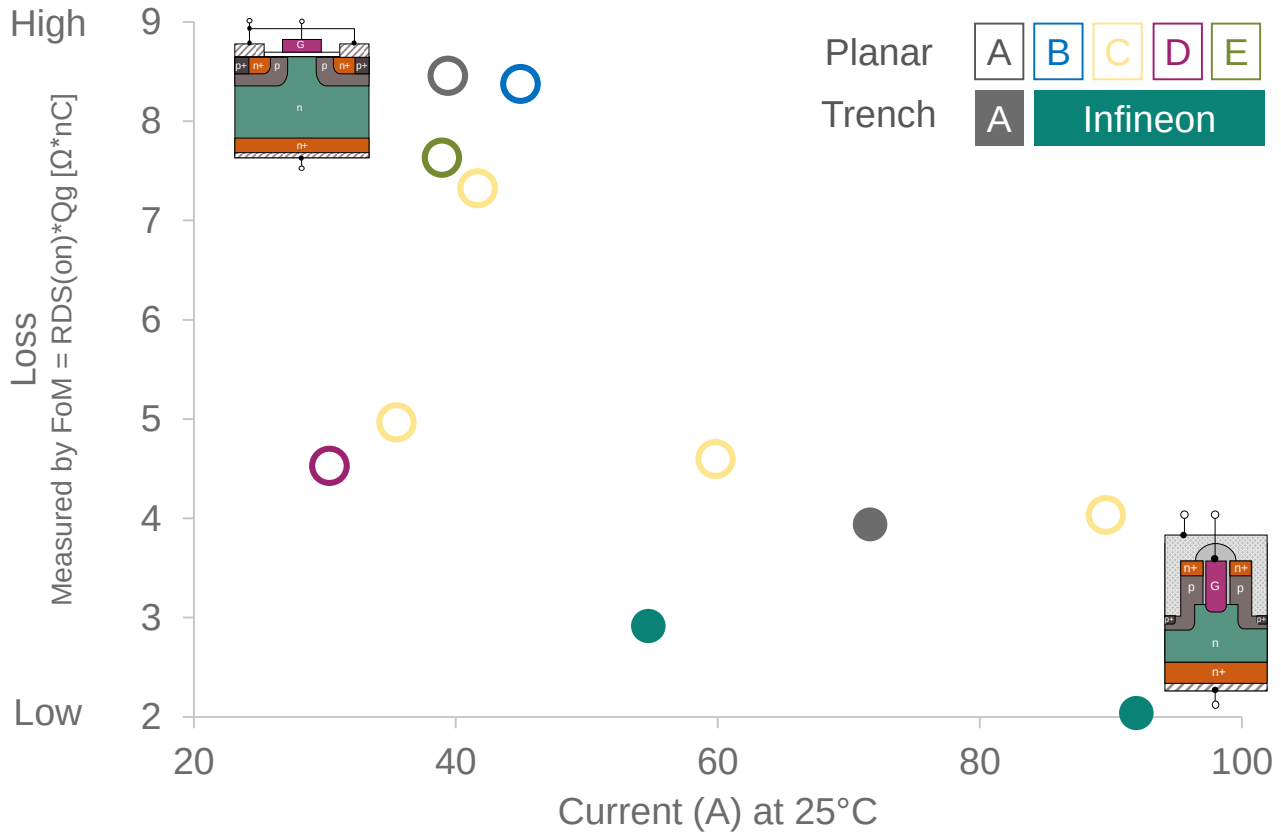
Infineon TRENCH



- ✓ Low channel resistance
- ✓ Shrink potential higher than in planar DMOS
- ✓ Oxide corners shielded by folded double trench
- ✓ Long experience in trench know-how

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Trench out-performs Planar it is THE technology to go for



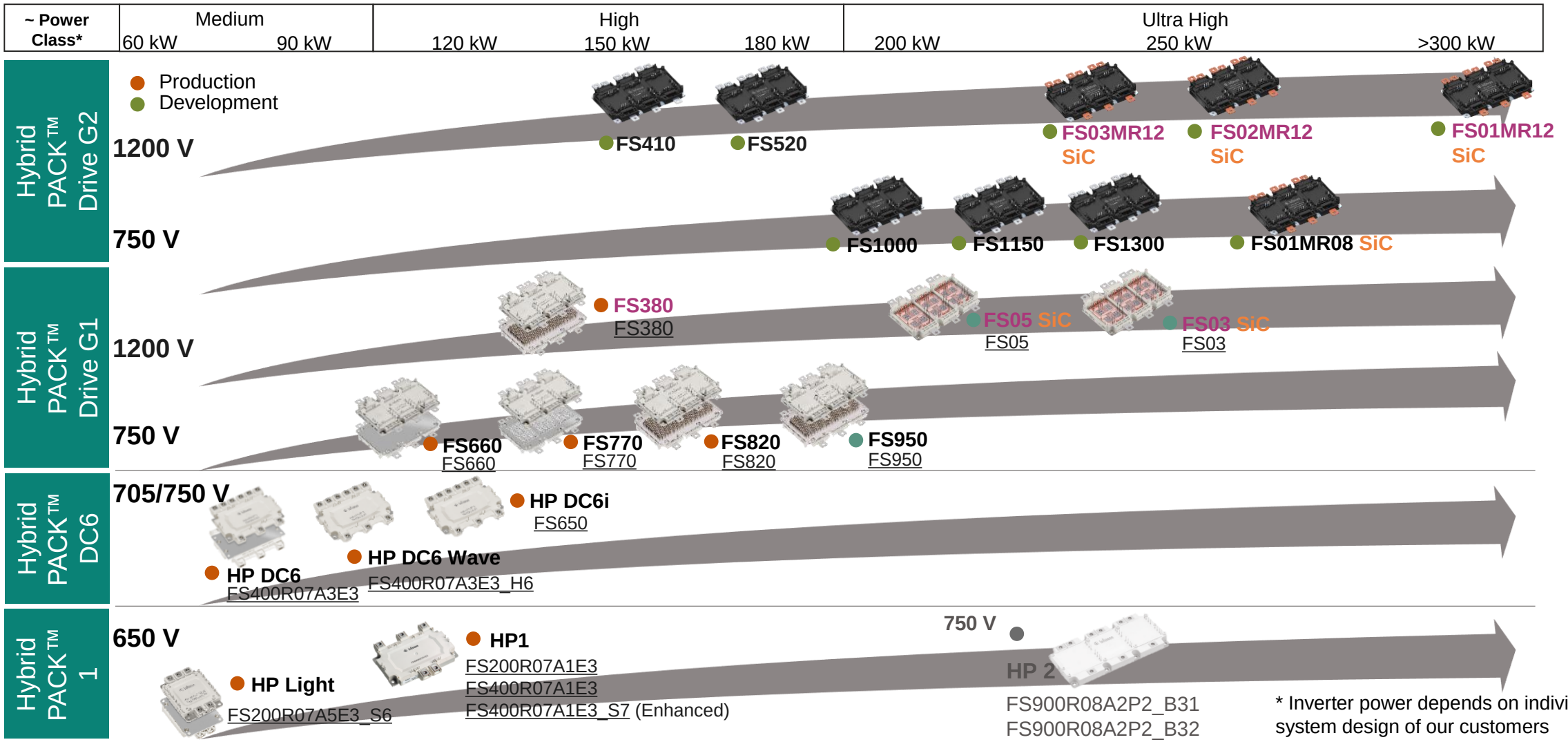
Source: System-Plus Consulting: "SiC Transistor Comparison 2020". November 2020

TRENCH is the future! All semi vendors have announced trench roadmap in 2023+

Infineon TRENCH out-performs PLANAR, enabling highest switching capability in the market

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HybridPACK™ product families cover the full performance spectrum



* Inverter power depends on individual system design of our customers

HybridPACK™ G2
Most scalable power family



	750 V			1200 V		
SiC G2	 FS02	 FS01	 FS00	 FS03	 FS02	 FS01
IGBT EDT3	 FS1000	 FS1150	 FS1300	 FS410	 FS520	 FS630

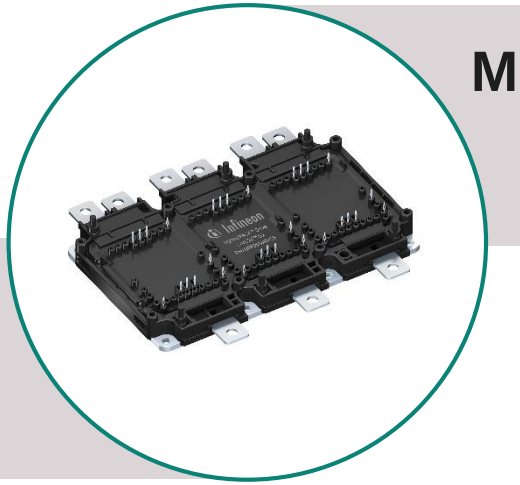
SOP Sample Concept

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Launched! HybridPACK™ Drive CoolSiC™ G2 leading device FS01 750V & FS02 1200V launched in May PCIM

Features

- B6-module Family 1200 V / 750 V
- ATV CoolSiC™ Trench MOSFET G2
- Mechanically compatible with other HPDrive derivative
- Enhanced Package (sintered, performance ceramic, direct cooling)
- Supports continuous operating at 175°C
- Supports peak operating at 190°C (target)



Million sold HybridPACK™ Package

High reliability & robustness

Full automotive qualification AQG324

Refined TRENCH technology:

Enabling highest switching in the market

Benefits

- Superior gate oxide and cosmic ray reliability
- Enable scalable inverter platform development
- Reduces inverter losses by 2/3rd vs. state of the art IGBT solutions
- Operation up to 640 Arms peak current

Source: Infineon internal accessment, Oct. 2020

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Infineon automotive discrete IGBT solutions address the key value drivers of traction inverter systems

Customers chose **discrete IGBT** for

Scalability
Up- & downscale by flexible number of parallel units

System cost
By lower piece price, standard packages

Flexible inverter form factor
Free-of-choice assembly of small package units

Customers chose **Infineon** discrete IGBT for

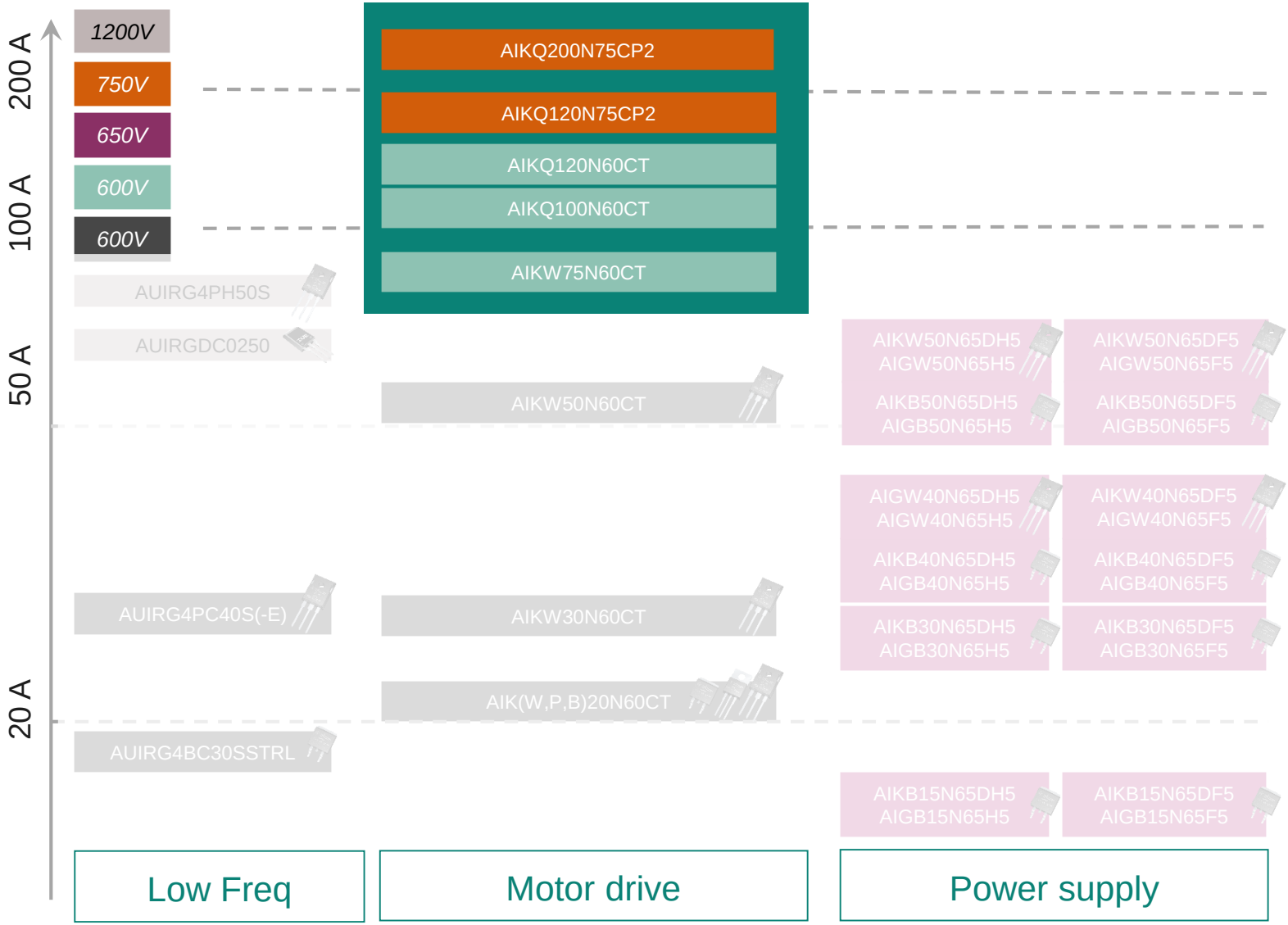
Quality Leadership
Infineon Quality seen as market leader

Dependable track record and high robustness in harsh automotive environment

Proven technology
Decades of experience in semiconductor development & production

Technical leadership
Market innovator with extensive local technical support

Infineon Automotive IGBT Discrete Portfolio



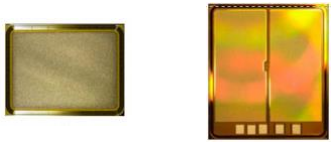


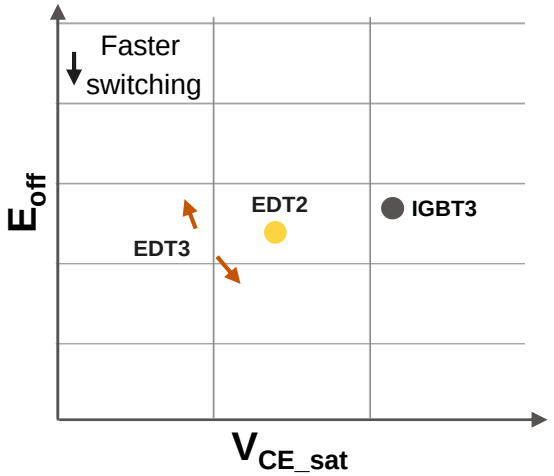
EDT3 technology enables higher current density

Chip Set Solution

New IGBT technology based on superior cell concept

Improved diode complementing IGBT





1200 V

- >15% higher output current density vs. previous generation due to reduced losses
- Drop in replacement for existing power module design

Sample available

750 V

- Lower losses due to faster switching & lower VCEsat
- Better Si utilization: extended junction temperature range up to 185°C
- Up to 25% higher output power
- Higher current with same module size: enable addressing higher performance vehicles

Sample available

IPOSIM ATV – Power Modules
Key Features

Live since August 2020



- DC-AC topology for HybridPACK™ modules
  more are coming for next product generations…
- New control algorithms including Discontinuous PWM and new parameter of load type selection
- Fast but accurate online power loss and temperature simulation powered by PLECS engine
- Easy to use with defined user interface and clear simulation flow
- Separation for device selection and application data settings, quick to share and archive with deep-link
- Advanced functions: sophisticated load cycle, multi-selection of up to 5 products, extended scope functions

ATV IPOSIM
Updates 2022

- NEW Adaptions on GUI:
-
  - Updated data base for parameter filtering @150°C
  - Package name preselection/filtering
  - Gate Driver recommendation for simulated device

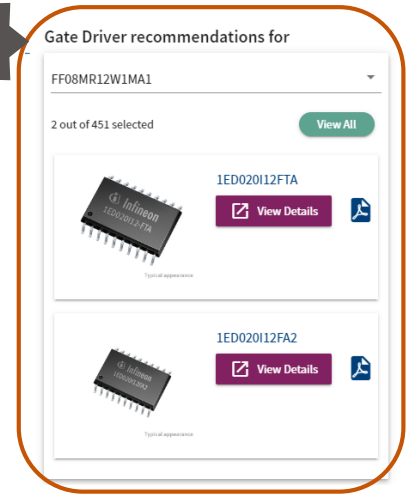
NEW

$E_{on} + E_{off,150°C}$ [mWs]	R_{thJH} [K/W]	T_{vjmax} [°C]	$V_{F,150°C}$ [V]	$E_{rec,150°C}$ [mWs]	R_{thJH} [K/W]	T_{vjmax} [°C]
8.05	0.46	150	1.59	1.35	0.46	150
19.1	0.34	150	1.15	8.51	0.53	150

NEW

Device name	TIM	Package
FF08MR12W1MA1		EasyPACK™1B
FF300R08W2P2		EasyPACK™2B
FS380R12A6T4B		HybridPACK™Drive
FS550R08A4P2		HybridPACK™DC6i
FS03MR12A6MA1B		HybridPACK™Drive
FS03MR12A6MA1LB		HybridPACK™Drive
FS820R08A6P2B		HybridPACK™Drive
FS770R08A6P2B		HybridPACK™Drive
FS660R08A6P2FB		HybridPACK™Drive
FS[illegible]0R08A6P2B		HybridPACK™Drive

NEW



› LINK: IPOSIM

› Deep-LINK: Simulation Product Comparison

› Deep-LINK: Simulation Product Comparison Load Cycle

IPOSIM ATV – Power Modules
Infineon Power Simulation Tool Video

https://www.infineon.com/cms/media/eLearning/Automotive/IPOSIM-for-automotive/story.html





Sensors

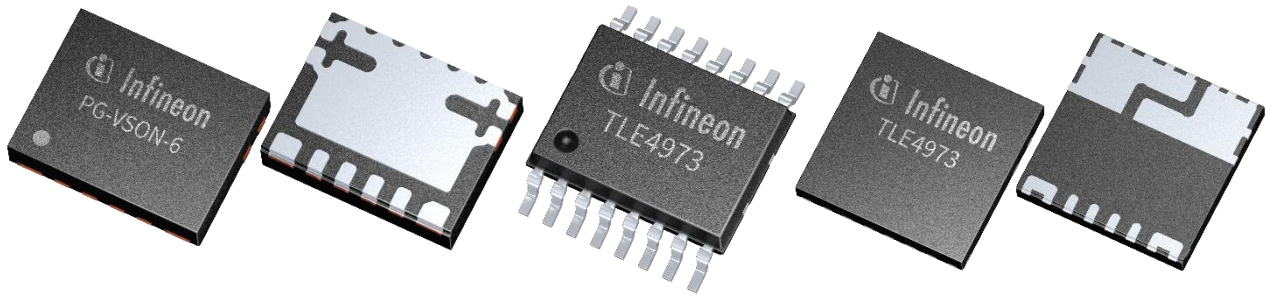
(current sensor, position sensor)

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Customer value – Current sensor family TLE4972/TLE4973

Scalability

- One package with integrated current rail (PG-TISON-6) for up to 132A
- Two packages with external current rail for up to 2kA
- Fully scalable with complete HPD G2 family to address various power classes



FuSa

- Enables high ASIL on system level
- Integrated and programmable solution for overcurrent protection
- Diagnosis mode for AOUT and OCD pins implemented

Depend-ability

- Low total error over temperature and lifetime allow for reliable performance over time

Accuracy

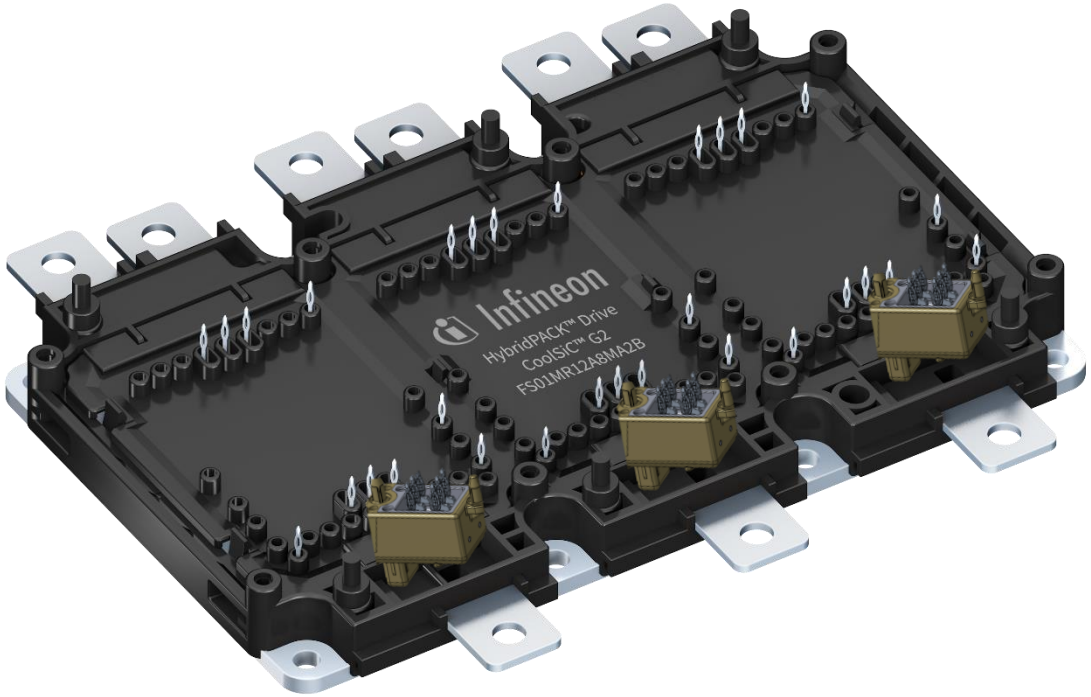
- Highly accurate over temperature and lifetime due to high linearity, stray-field robustness and lack of hysteresis
- in-system, end-of-line calibration (±15%)
- Low phase shift at fundamental frequency (<2° @1kHz)

Optimize Space

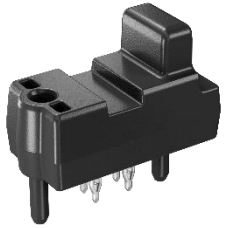
- No need for magnetic concentrator nor a shield
- Based on differential sensing concept

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Swoboda current sensor module scalable for complete HybridPACK™ Drive G2 portfolio

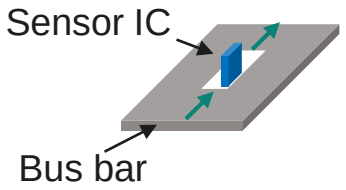


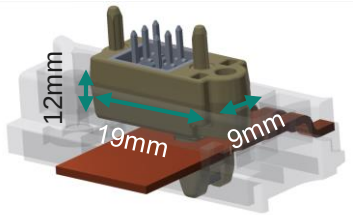




QS available

Core-less

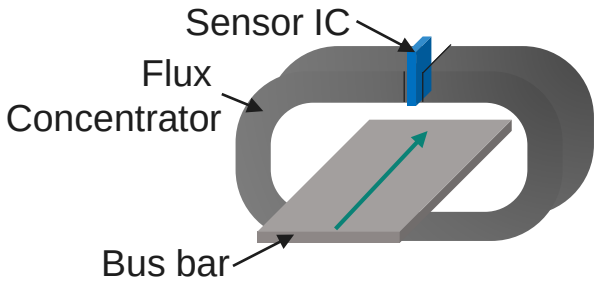


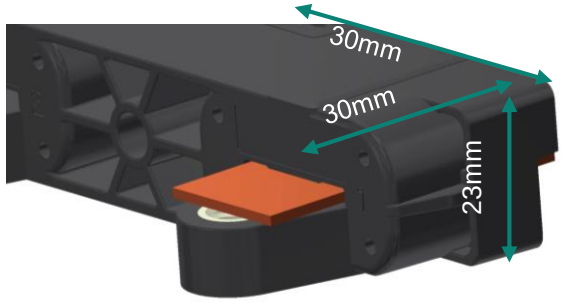


Based on TLE4973 **core-less** technology

Scalable for **complete** HybridPACK™ Drive G2 portfolio

Core-based



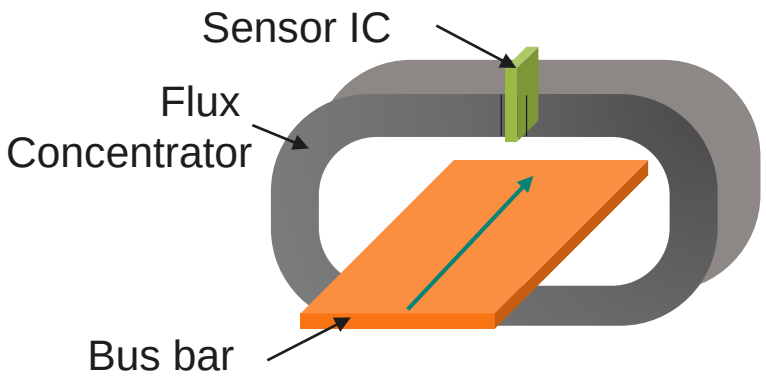


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Space optimization
Swoboda current sensor







Easy platform migration

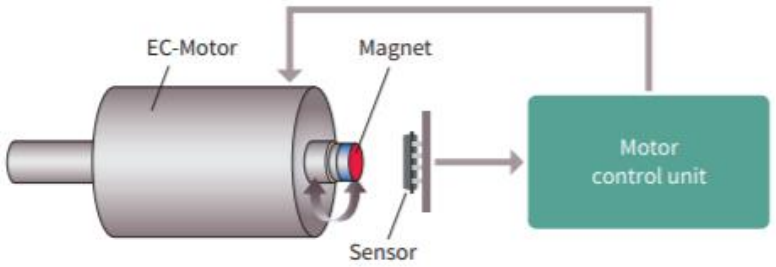
- Scalability cross whole HybridPACK™ Drive G2 portfolio
- Easy migration for preferred power segments

Less cost & complexity

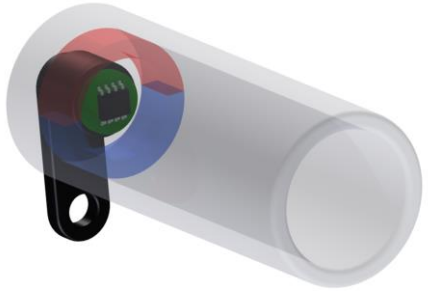
- Eliminate long tab
- No magnetic concentrator
- Reduce assembly time

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Electric main drive – solution based on magnetic sensors
Magnetic angle sensor resolver replacement reduces system cost



TLE5309D End of Shaft (EoS)



TLE5309D integrated End of Shaft (iEoS)

SYSTEM COST REDUCTION –
No carrier Gen. & Demod. circuit

DIVERSE ANALOG ANGLE SENSOR (AMR & GMR)

FUNCTIONAL SAFETY-
ASIL-D Ready

HIGH ACCURACY & HIGH SPEED

REDUCED CONSTRUCTION SPACE -with iEoS

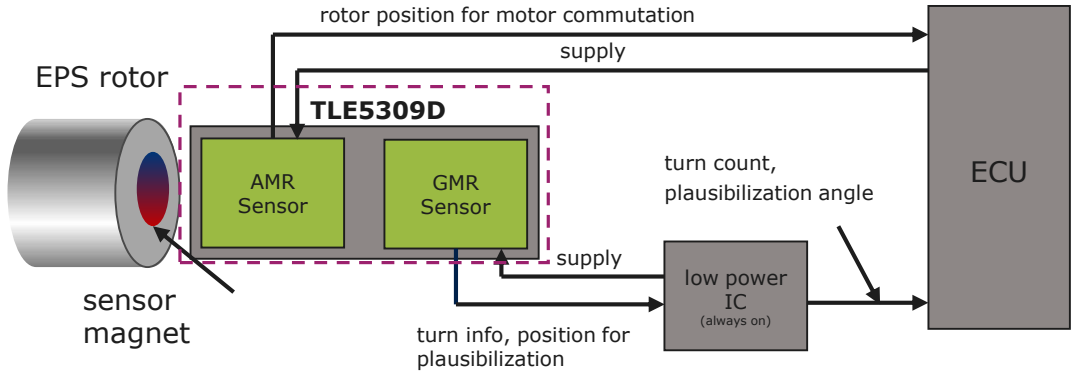
TDSO Pkg. Grade 1 today ,Grade 0 in 2023

TLE5309D together with Infineon integrated end of shaft (iEoS) system solution saves cost on system level and provides stray field immunity

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TLE5309D - rotor position sensor with analog outputs

Target Application



Diagnostic functions in combination with iAMR and iGMR diversity supports ASIL-D applications

Product Highlights

- Analog output of sine and cosine
- **Up to 30,000rpm**, ~9µs delay time
- Combination of AMR and GMR sensor
  - AMR for high accuracy (180° angle)
  - GMR for 360° range
  - Supports functional safety ASIL C (D) Intrinsic diversity

Tools & Support

› Documents
- TLE5x09A16_D-DataSheet-v02_00-EN.pdf
- Infineon-TLE5x09A16(D)-Eval_Kit-UserManual-v01_00-EN.pdf

› Evalulation-Kit
- TLE5309 EVAL KIT

For more information see: https://www.infineon.com/sensors and check MyInfineon

Status And Derivatives

› Products in volume production



RoHS

(PG-TDSO-16)

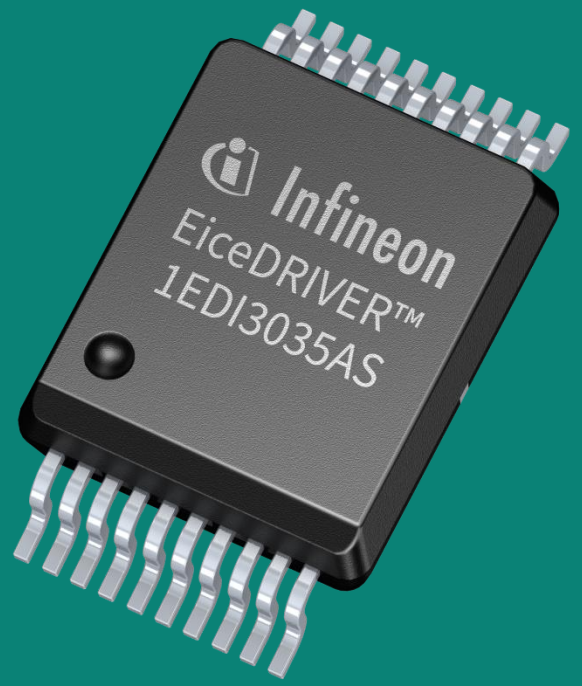
› TLE5309D E1211: 3.3 V, dual die, AMR (bottom) and GMR (top), with TCO*

› TLE5309D E2211: 5.0 V, dual die, AMR (bottom) and GMR (top), with TCO*

› TLE5309D E5201: Dual die, 5.0V AMR (bottom), 3.3V GMR (top), w/o TCO*

*Temperature Compensation Offset

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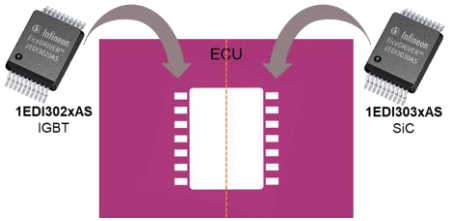
Gate-driver

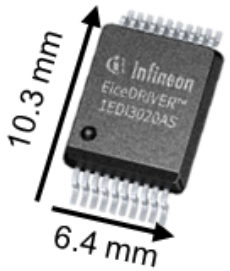
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EiceDRIVER™ 1EDI302xAS / 1EDI303xAS (3rd GEN)
Leanest ISO-26262 compliant gate driver on the market

Infineon's lean and powerful gate drivers tailor made for SiC or IGBT power devices used in several HV Applications (**Traction Inverter**, HV-AUX, EESM[1])

- Plug & play, no programming needed, diagnosis via PWM
- **Leanest ISO-26262 ASIL-B(D) compliant** driver on the market
- **Pin compatible** variants for **SiC** and **IGBT**







Existing product variants
Released in Q1/2021, parts are in mass production

Product variant	IGBT/SiC	ADC/ASC
1EDI3020AS	IGBT	ADC for temp
1EDI3021AS	IGBT	ASC
1EDI3023AS	IGBT	ADC for DC-Link measurement
1EDI3030AS	SiC	ADC for temp
1EDI3031AS	SiC	ASC
1EDI3033AS	SiC	ADC for DC-Link measurement

NEW further optimized products are on its way!
Samples available under NDA

NEW Product variant	IGBT/SiC
1EDI3025AS	IGBT
1EDI3026AS	IGBT
1EDI3035AS	SiC
1EDI3036AS	SiC

[1]EESM = Externally Excited Synchronous Motor

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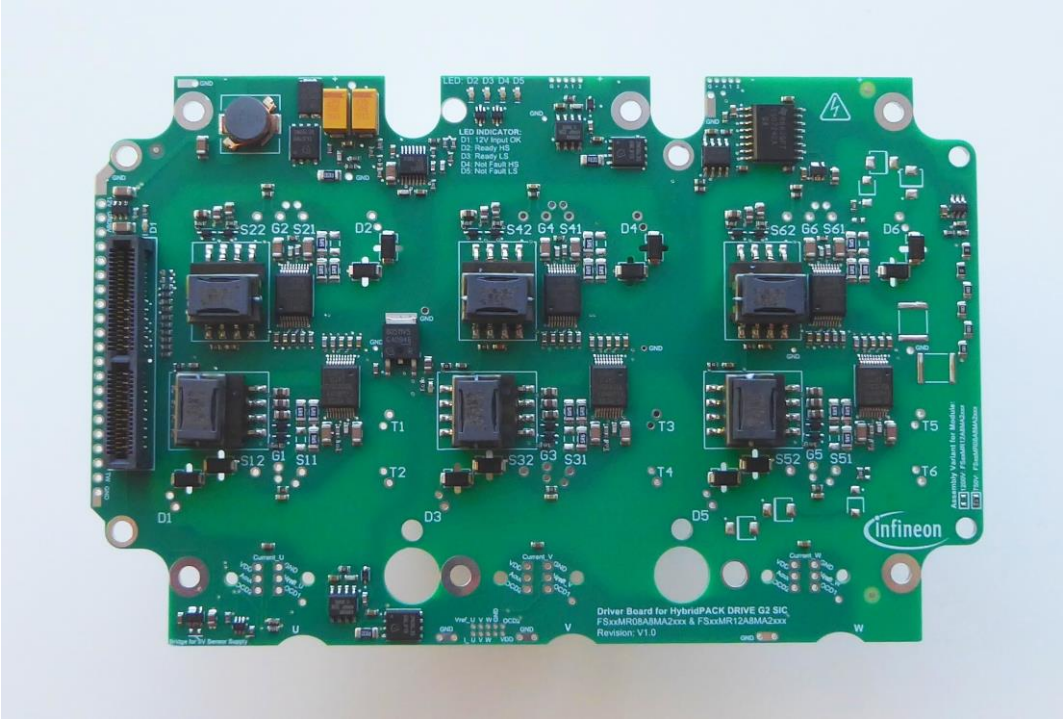
Evaluation Boards / Kit available to kick off the design activities with IFX gate driver

3rd Generation Gate Driver



Board Name	Remark
1EDI30XXAS EVALBOARD	No device mounted
1EDI302XAS EVALBOARD	1EDI3020AS/1EDI3021AS mounted
1EDI303XAS EVALBOARD	1EDI3030AS/1EDI3031AS mounted

3 Phase Gate Driver Board



Various half bridge gate driver boards are available!

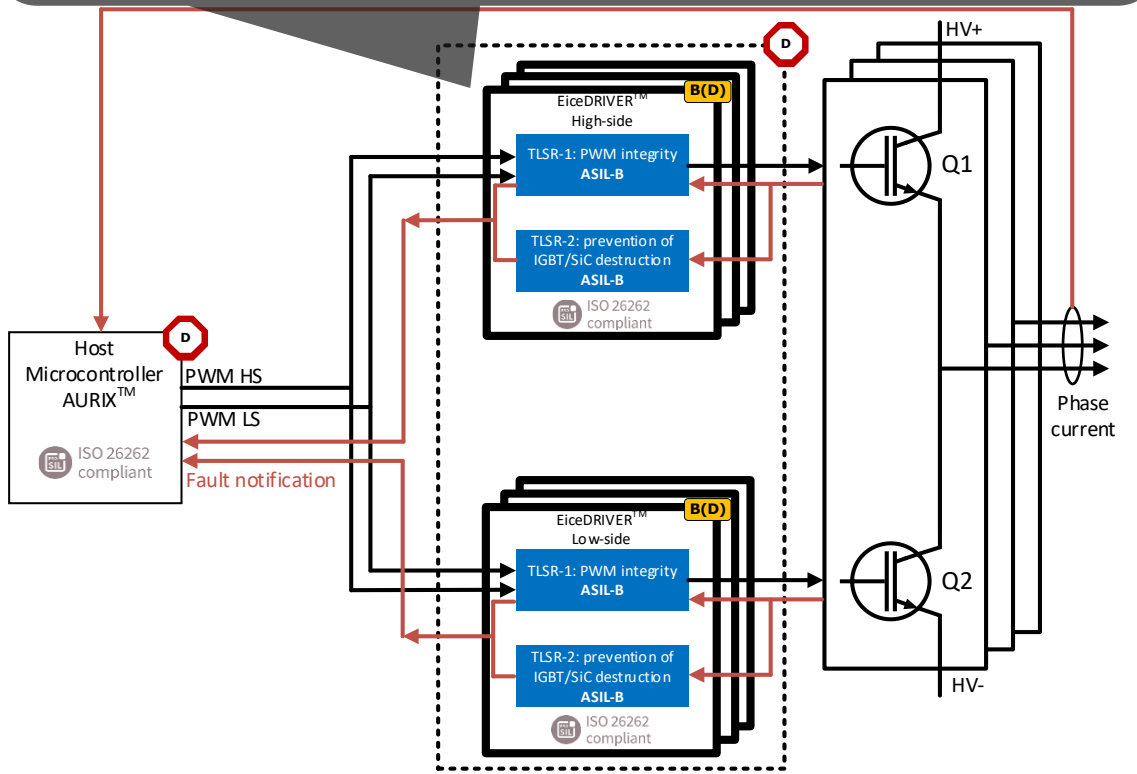
3 phase gate driver board is also available for system evaluation!

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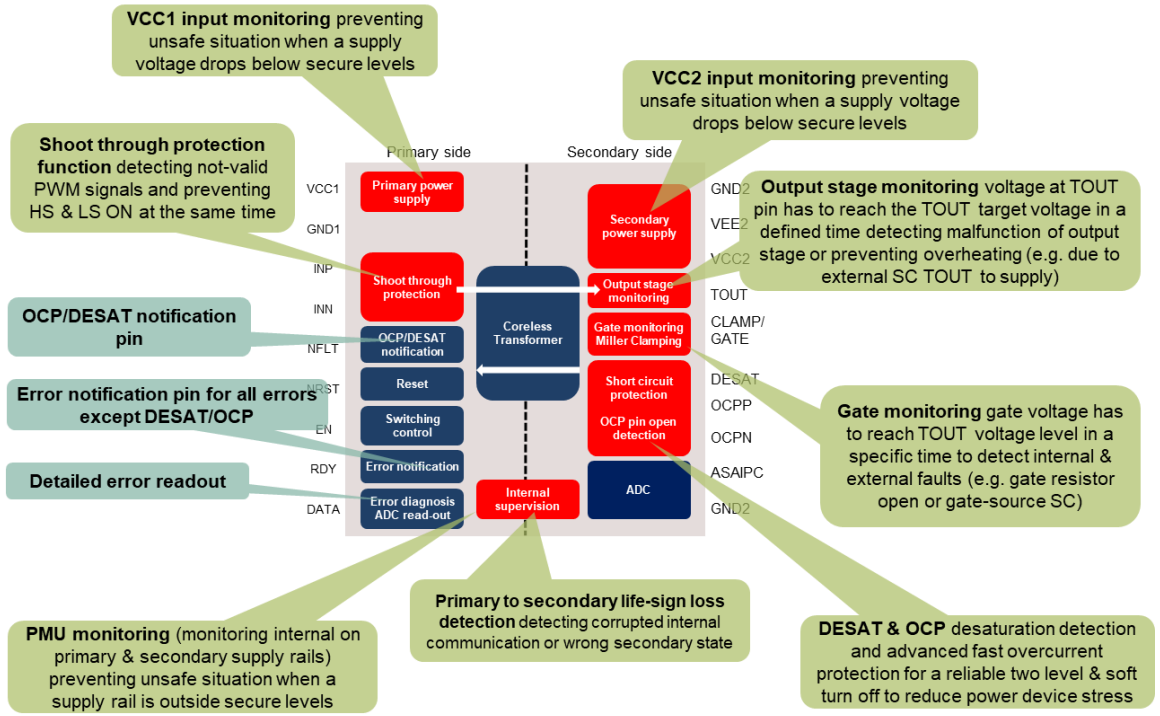
EiceDRIVER™ 3rd Generation
ISO-26262 compliant gate drivers for ASIL-D traction inverters

Decomposition half bridge overview

- Each error on device level leading to a FSR violation on system level (wrong torque) is covered by the device itself through with ASIL-B. Additionally each error on device level is covered by:
- Complementary ASIL-B driver via DESAT (for all critical errors leading to short circuit events in the half bridge)
- External phase current plausibility check over the MCU



Safety features reaching ASIL-D on system



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Born for SiC EiceDRIVER™ GEN 3
Teaser Slide for the New further optimized products



Born for SiC

- Best fit for Infineon SiC, available technologies in the market (e.g. OVLO to protect higher gate oxide abs. ~23 V)

Efficient & Robust

- Enhanced ADC accuracy for temperature measurement
- Dedicated soft-off pin & **Super fast DESAT** incl. BIST to protect power device



FuSa up to ASIL-D (on system level)

- Dedicated safety input (SI1/SI2) **increases interoperability** with Infineon PMIC
- More safety features such as **VEE2 monitoring** implemented

Cost optimized

- Separated TON/TOFF pin allows removal of diode
- **Reduces external safety** logic circuit

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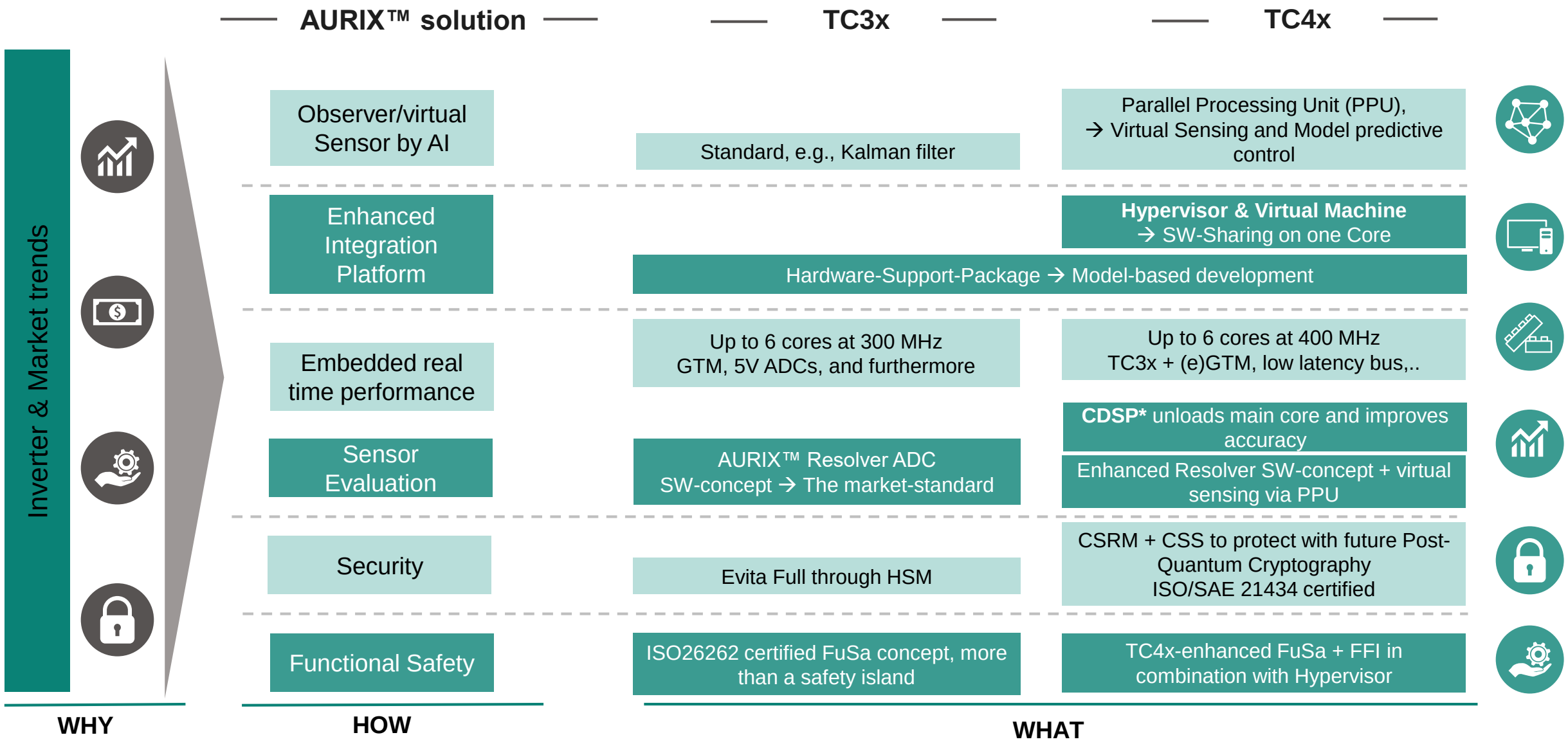


Microcontrollers

For Inverter application

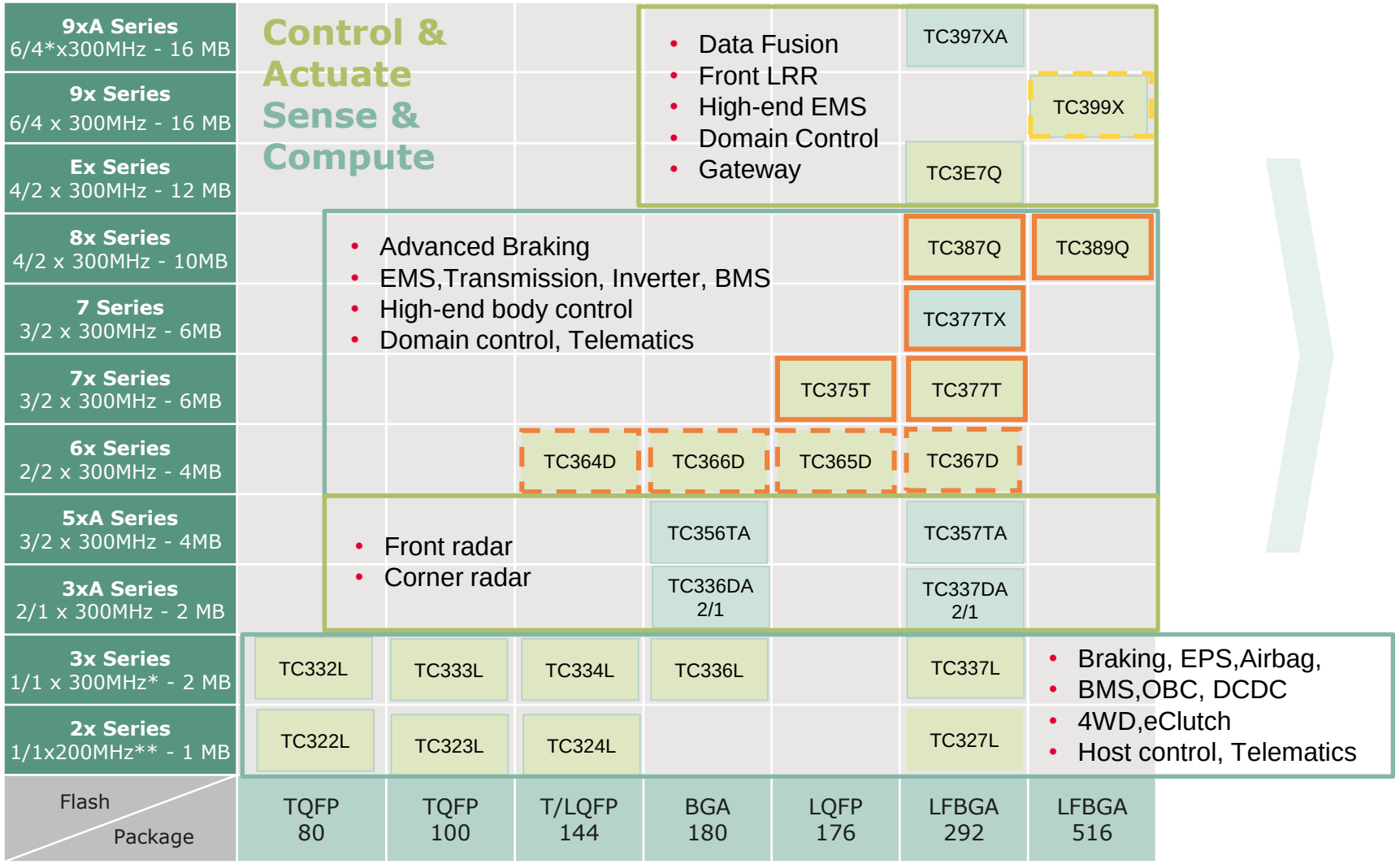
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AURIX™ TC3x is the-state-of-the art solution for Inverters
The Inverter of the future is enabled by AURIX™ TC4x



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** Converter-Digital Signal Processing

AURIX™ TC3x device overview at glance
Most common Inverter-devices are TC37x and TC38x families



MCU Scalability

- Up to 6 cores + 4 lock-steps, 300 MHz
- Up to 16 MB P-Flash
- A/B swap for FOTA
- Software & Pin-compatibility

Safety/Security Concept

- ISO26262 ASIL-D compliance
- EVITA Full hardware security support on all devices

Connectivity Highlights

- Ethernet: up to 2x 1GBit/s
- CAN FD: up to 20 ch
- LIN: up to 24 ch
- eMMC IF: for external Flash
- IPC: up to 2x 320MBit/s

Inverter mainstream

Inverter options

L - Single Lockstep Core
D - Dual Core
T - Triple Core
Q - Quadruple Core
X - Sextuple Core

* Number of cores /lockstep
** 300MHz upgrade available

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The start of a new era…

Automotive market is facing two simultaneous, fast paced, paradigm shifts:

- **E/E architecture innovation has brought new requirements to microcontrollers**
  - More ASIL-D performance
  - Increased security & connectivity
  - New SW development methods
- **Trend toward Electrification further accelerates**
  - Emissions legislations towards Zero Emission
  - Major OEM with clear focus on Battery Electric Vehicle
  - Strong reduction of hybrid vehicles expected
  - Development of next generation of Engine & Transmission questionable

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AURIX™ TC4x offers a unique feature-set for Inverters from Hardware to SW-ecosystem

Performance increase
- TriCore™ 1.8 with performance increase to 400 MHz for electrification specific devices of TC4x portfolio

Converter-Digital-Processing (CDSP) incl. SW-offering

Matlab/Simulink Hardware-Support-Package (HSP)

Parallel Processing Unit (PPU)
- Co-processing unit scalar core and vector DSP



AURIX™ SW ecosystem
Virtual Prototyping
Software-Development-Kit (SDK)
Compilers/Debugger
MCAL and AUTOSAR
and furthermore

Highlights of new real-time control features
- New eGTM timers, High Resolution PWMs
- Low latency Interface (LLI) for fast processing

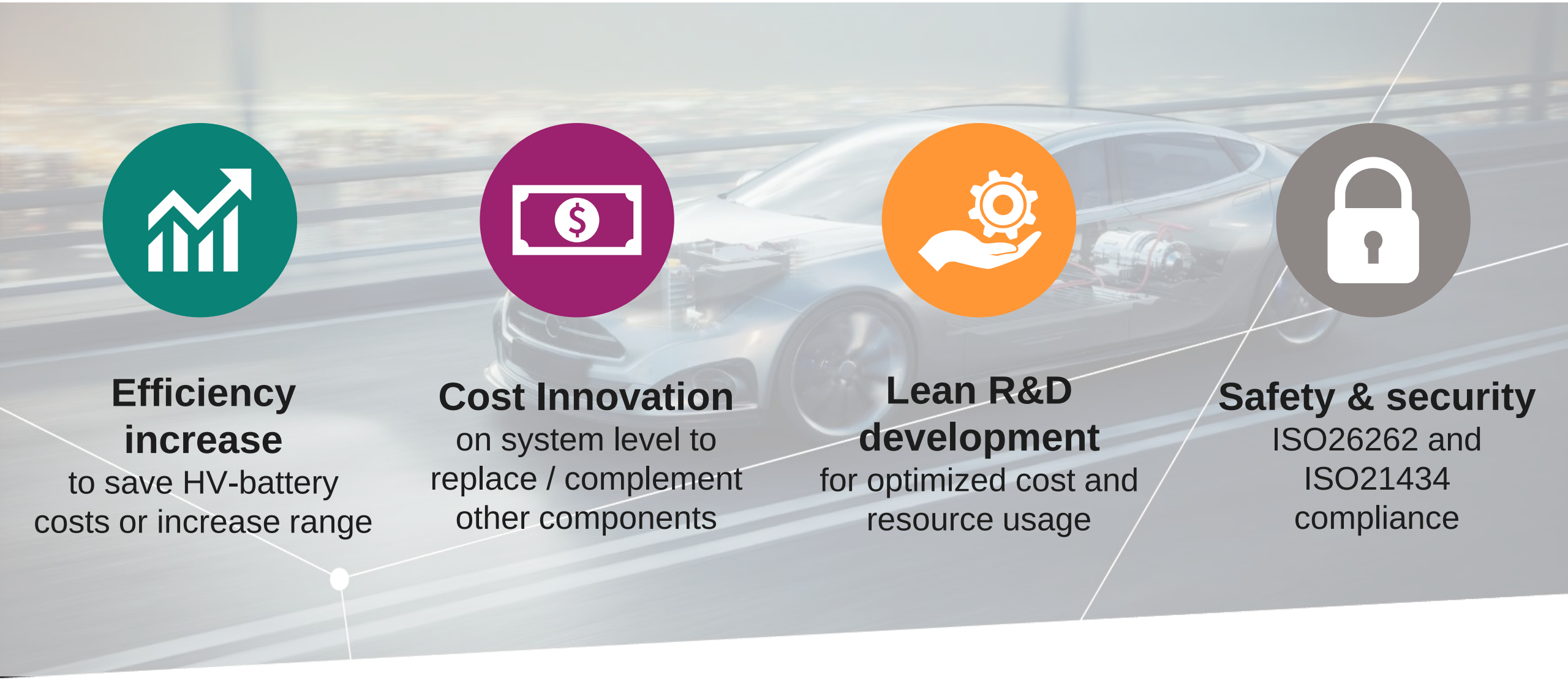
Functional Safety concept
- 100 % Lock-step Main CPU-cores
- Safety Element out of Context (SEooC)
- SW offering and documentation

Hypervisor & Virtualization
- Fine grained access protection

Security concept
- Certified ISO 21434 process and product development
- New Cybersecurity cluster

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AURIX™ successfully covers Inverter customer needs & market trends to differentiate from competition in a challenging market environment



Efficiency increase
to save HV-battery costs or increase range

Cost Innovation
on system level to replace / complement other components

Lean R&D development
for optimized cost and resource usage

Safety & security
ISO26262 and ISO21434 compliance

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AURIX™ TC4x for Inverter is empowering cost-innovation, best-in-class efficiency, fast time-to-market and latest ISO compliance

Efficiency increase

Increased **ASIl-D perfomance of main-CPU** to implement optimized control strategies, eg. for Electric Excited Synchronous Machines	• Main-CPUs in Lock-step @ 400 MHz
Best in-class accuracy with strong AURIX peripherals	• 5 V TM-ADC • DS-ADC
High switching frequency control loop could be **offloaded** from Main-CPU **for further optimization**	• Parallel Processing Unit (PPU) • eGTM w/ HR-PWM • Low latency interface
Improved robustness and accuracy also of distorted signals	• Converter-Digital-Processing (CDSP) + SW Filter-chains
Reduced Main-Core utilisation or **replacement of external ASICs (e.g. „Tamagawa sensor“)**	
Enabling **of SW-sharing on same core with ensured Freedom For Interference**	• Hypervisor & Virtualization • Fine grained access protection
Virtual Sensing replaces/complements physical sensors (eg. Rotor-position sensing, temperature sensing)	• Parallel Processing Unit (PPU) • AI with NN

Cost Innovation

Lean R&D development

AURIX™ optimized (TriCore™, PPU, peripherals) **model-based-development** for a **fast time-to-market, reduced development effort**	• Matlab/Simulink Hardware-Support-Package (HSP)
Unique SW-ecosystem simplifies development activities and saves further R&D costs and resources	• AURIX™ SW ecosystem
Accelerated Inverter application development with production ready **Complex-Device-Drivers** (CDD) Autosar and ASPICE conform	• Infineon & KPIT partnership

Safety & Security

ISO 26262 compliance is part of AURIX™ DNA. helps customers to **reduce risk, keep reputation and meet latest regulations** with strong system approach.	• 100 % Lock-step Main CPU-cores • Safety Element out of Context (SEooC)
Compliance with ISO 21434 is certified by TÜV. Cutting edge security concept **p**repares with **post-quantum cryptography**	• Certified ISO 21434 process and product development • CSRM & CSS*

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* Cybersecurity-Realtimemodule CyberSecuritySatellite

AURIX™ TC4x unique and proven SW-ecosystem enables fast time-to-market and minimized R&D effort

– SW-Ecosystem

Compiler / Debugger

> 10 partner

Software Development KITs (SDK)

3 partner

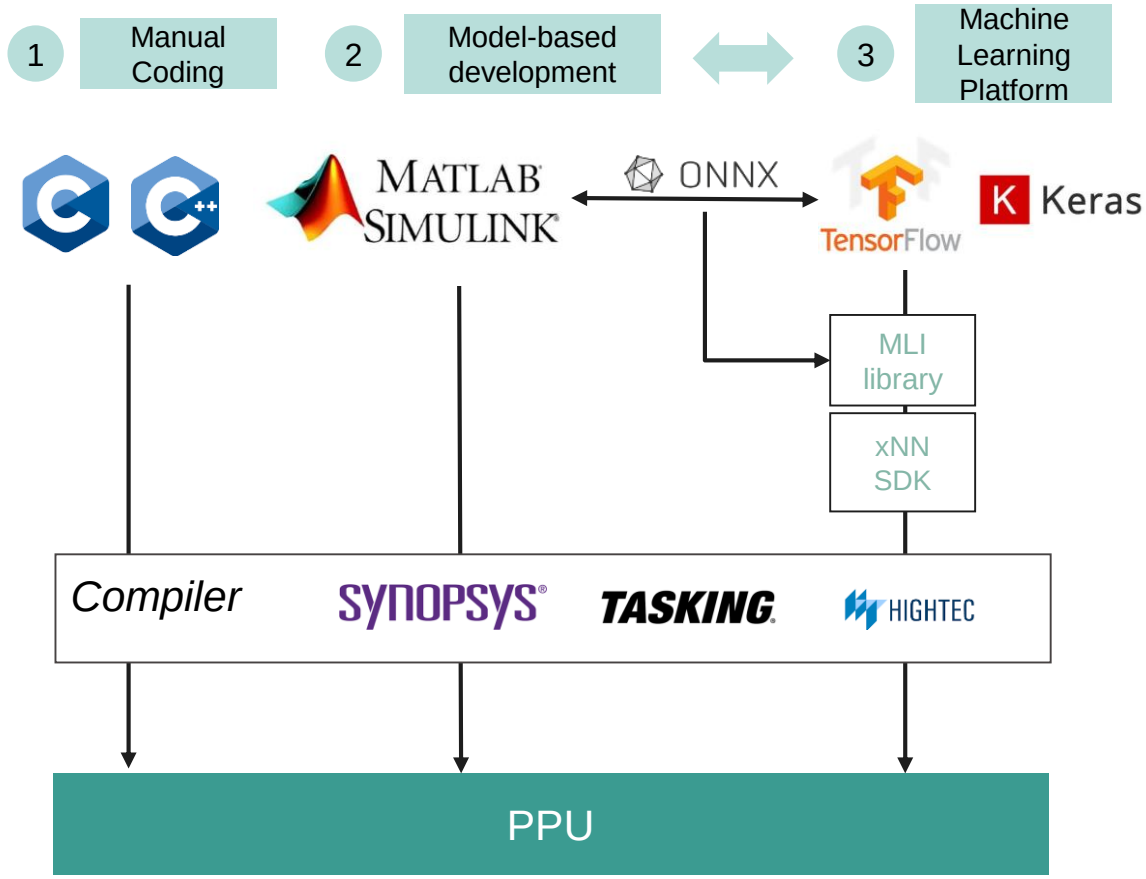
Virtual Prototyping (VP)

One partner with interface to standardtools

IFX-MCAL and AUTOSAR providers incl. hypervisor

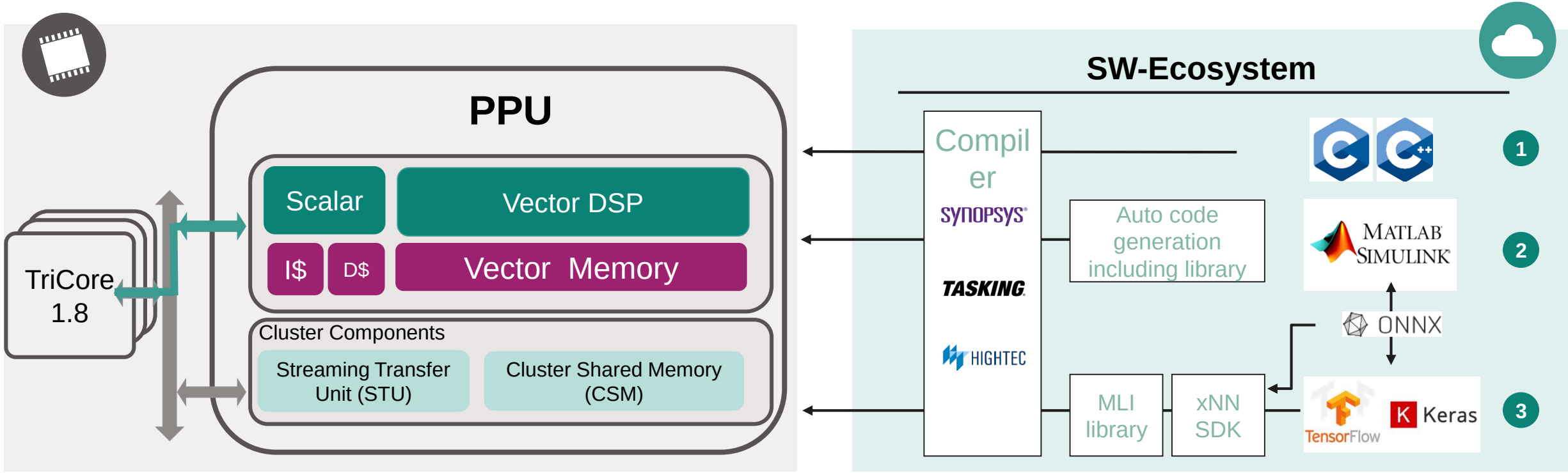
> 10 partner

– Example PPU ecosystem



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AURIX™ TC4x Parallel Processing Unit (PPU): a scalable SIMD Vector DSP & scalar core with a dedicated SW-tool-chain



- **Execution 3x faster** than comparable solutions on the market, **enabling Neural network based** algorithms and **High-speed-control implementations**
- **Unique SW Ecosystem**: Model-based development, connected with latest Machine-learning-tools like Tensor-flow is enabling **easy usage and fast time-to market**

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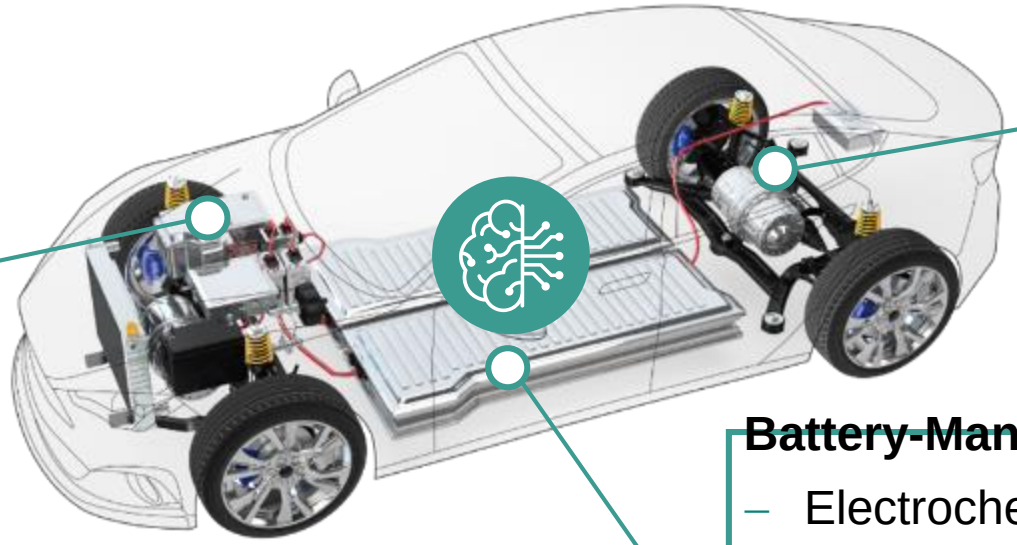
AURIX™ TC4x PPU empowers the e-Drivetrain of the future for best-in-class system efficiency and cost-innovation

TC4x PPU is enabling

Power-Conversion

- Combining control and communication functions and reducing number of system MCUs from up to 7 to 1

clear cost-down path and further efficiency increase



HV Traction Inverter

- Motor Position Sensing
- Health Observing
- Temperature Estimation
- Model Predictive Control

best-in-class system efficiency and cost-innovation

Battery-Management

- Electrochemical models
- Hybrid ML accelerated models
- Artificial intelligence

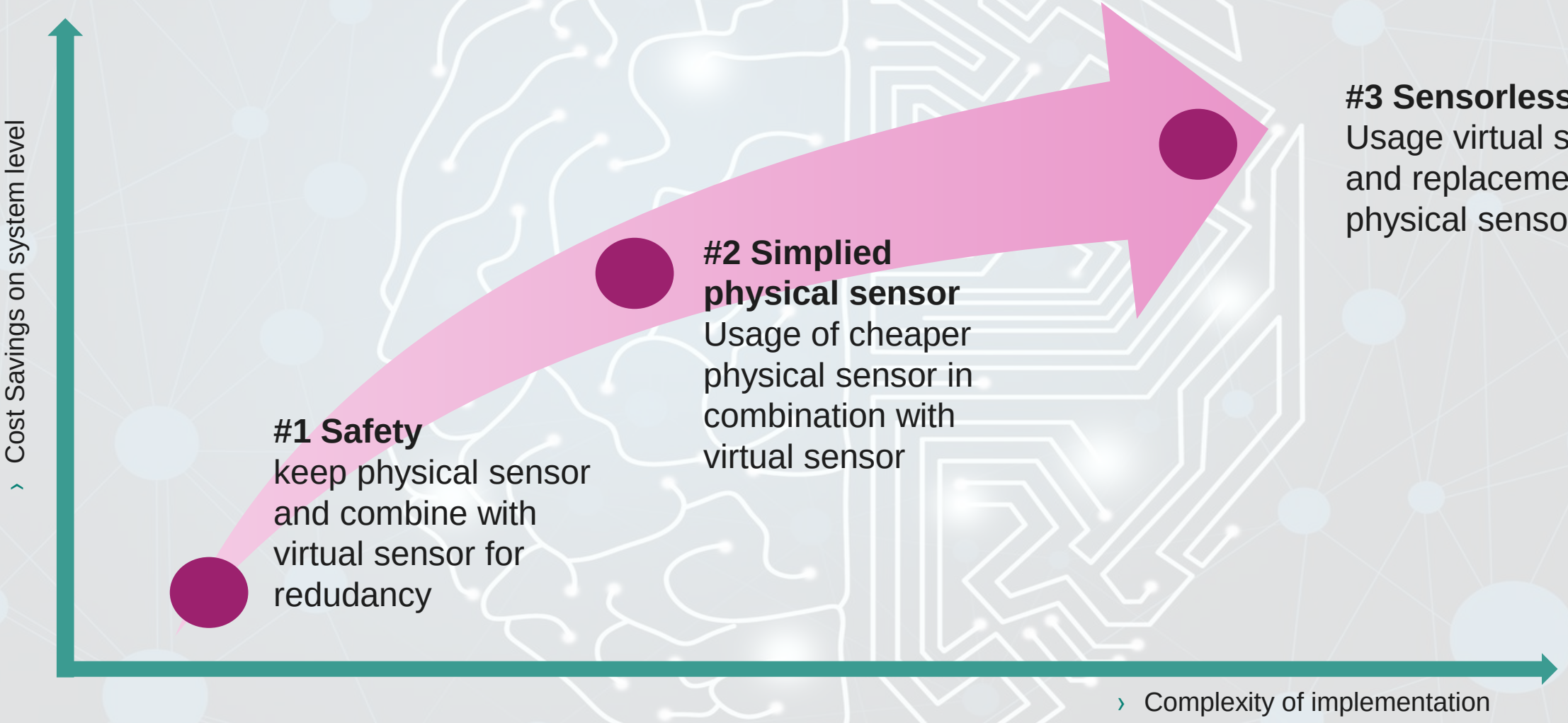
optimized Charging, extended vehicle range and battery life

More than **12x**

TriCore performance, eg. for AI-applications

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AURIX™ TC4x PPU virtual sensor based on NN
Different use cases depending on customer need

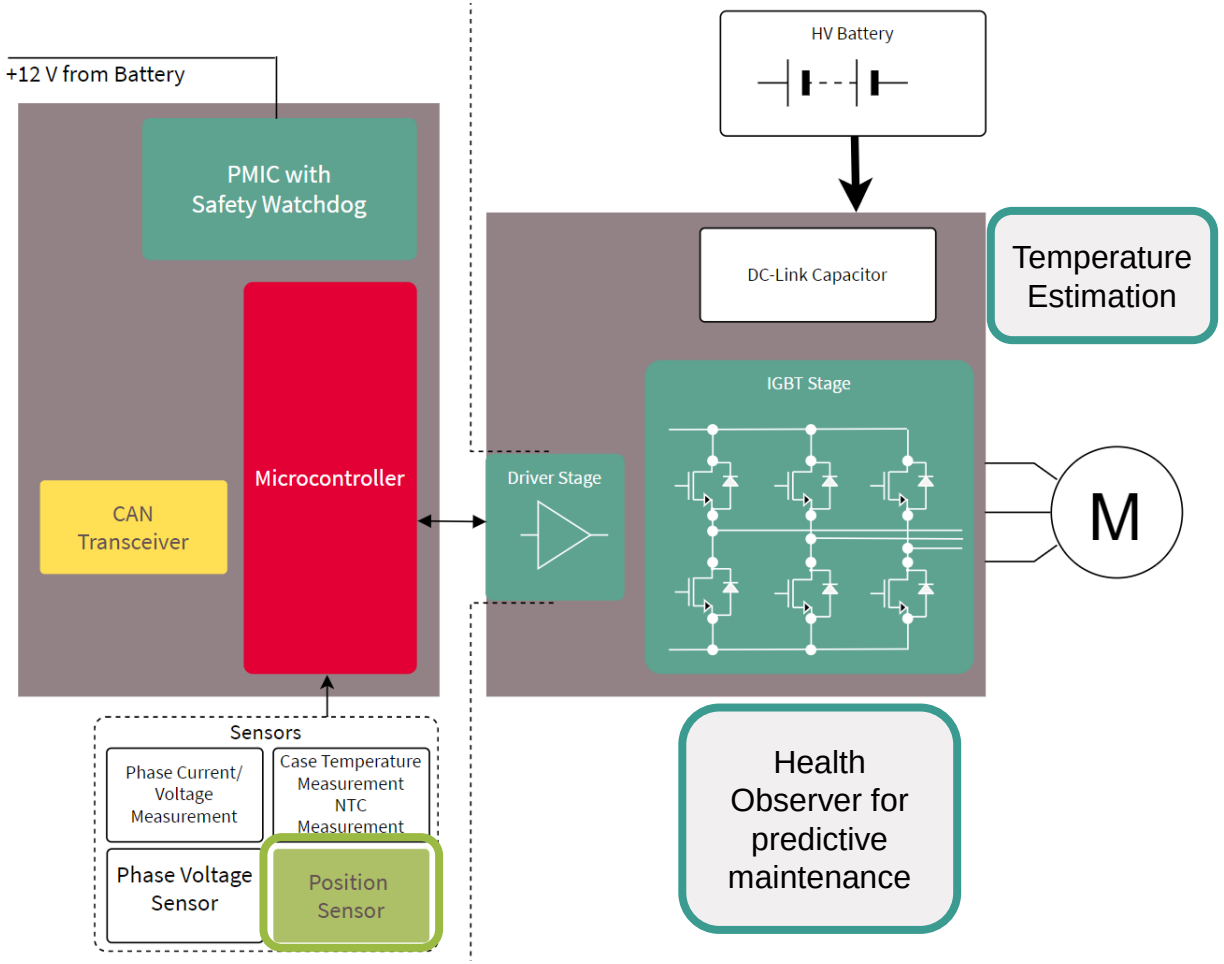


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Observers in AURIX™ TC4x
PPU enables Artificial Intelligence in Inverter-Applications

* Neuronal Network (NN)

Example: B6-bridge and Motors

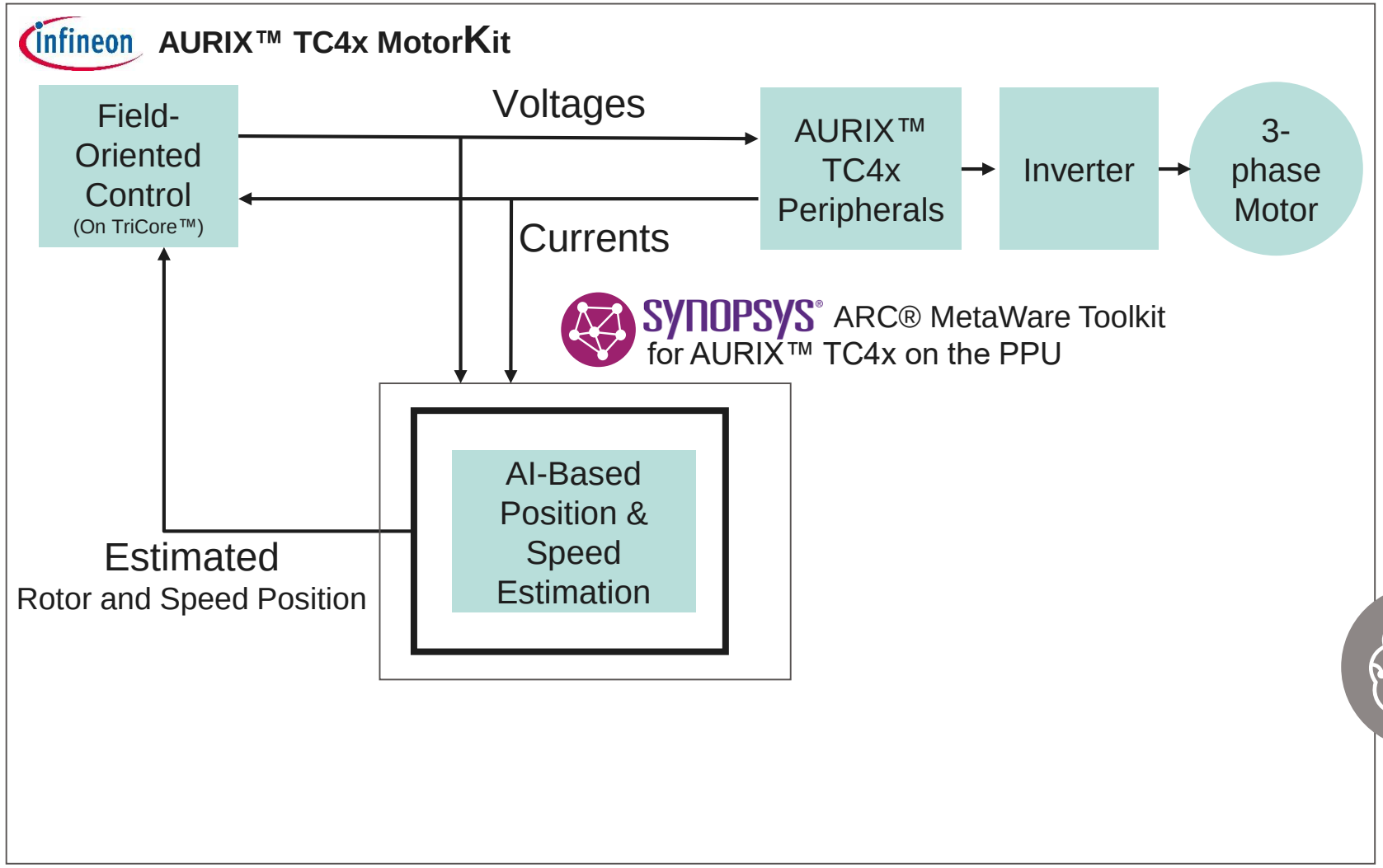


AI Application Benefits

- **AI-possibilities in Inverter-applications:** Position Sensor, Health Observer, Temperature Estimation
- **Virtual Sensors**
  - **Cost-savings**: Virtual sensor replacing physical
  - **Accuracy/Efficiency**: NN* instead of Kalman Filter
  - **Enabling**: Real sensor not applicable or not available
  - **Availability**: Virtual sensor as redundancy
- **Observers**
  - **Safety**: “is the system output close to the expected output?”
  - **Anomaly**: “is the system output different than the normal output?”
  - **Health**: “is the system still operating as intended?”
- **Computational Efficiency Increases**
  - **Reduce memory**: NN* instead of LUT
  - **Reduce execution time**: NN* instead of complex algorithm

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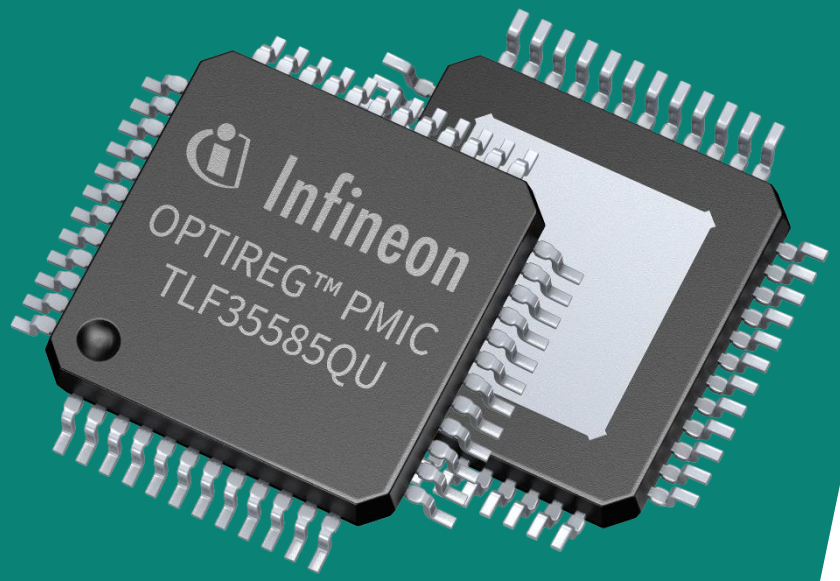
AURIX™ TC4x PPU and Synopsys MetaWare SDK
AI virtual sensing



- By combining **AURIX™ PPU** and the and **Synopsys ARC® MetaWare Toolkit for AURIX™ TC4x** the position sensor has been replaced entirely with AI

AI can replace or enhance physical sensors, saving BOM costs

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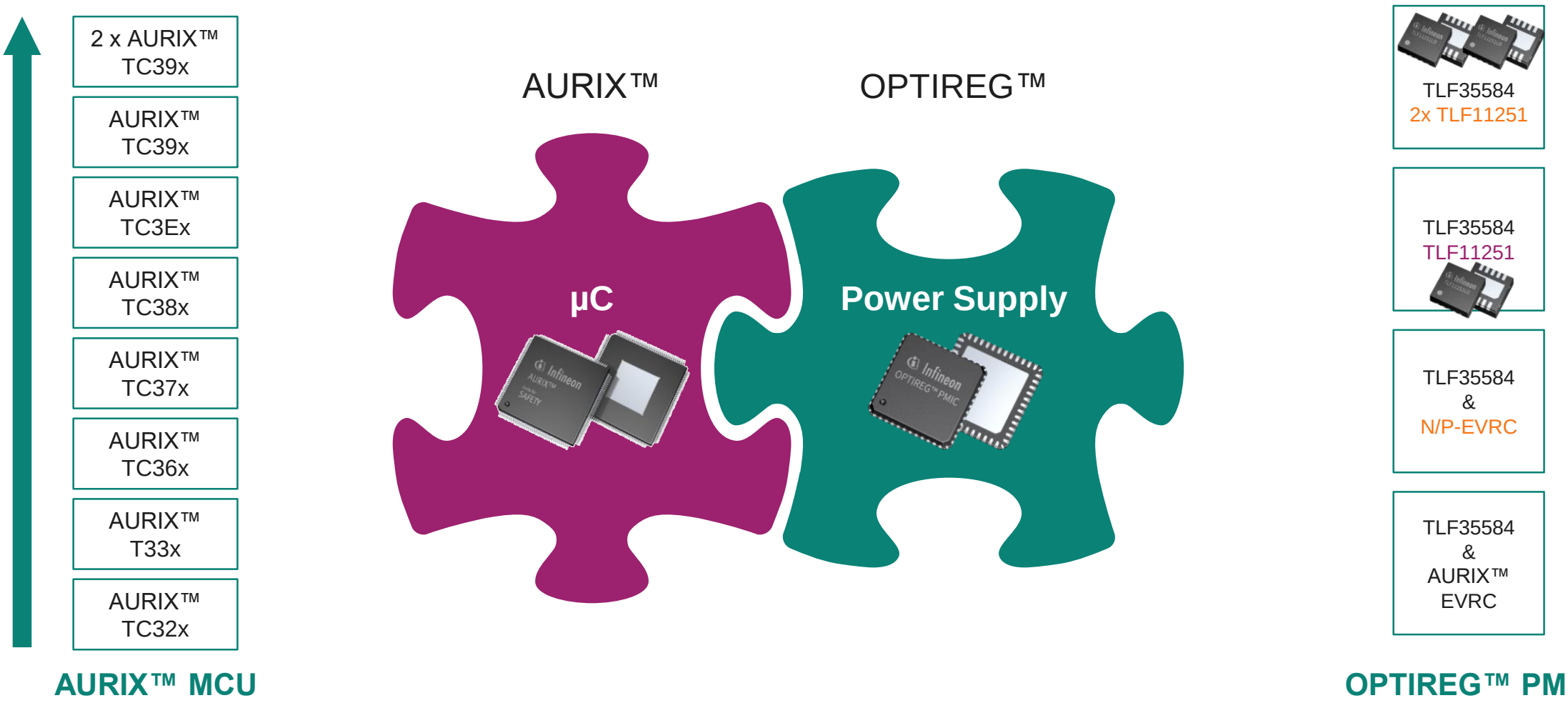
OPTIREG PMIC

For Inverter application

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OPTIREG™ PMIC together with OPTIREG™ TLF11251 for a safe and optimized multi-channel power supply of Infineon µC families

IFX offers a scalable PMIC portfolio which can cover the complete AURIX™ TC2x/TC3x portfolio

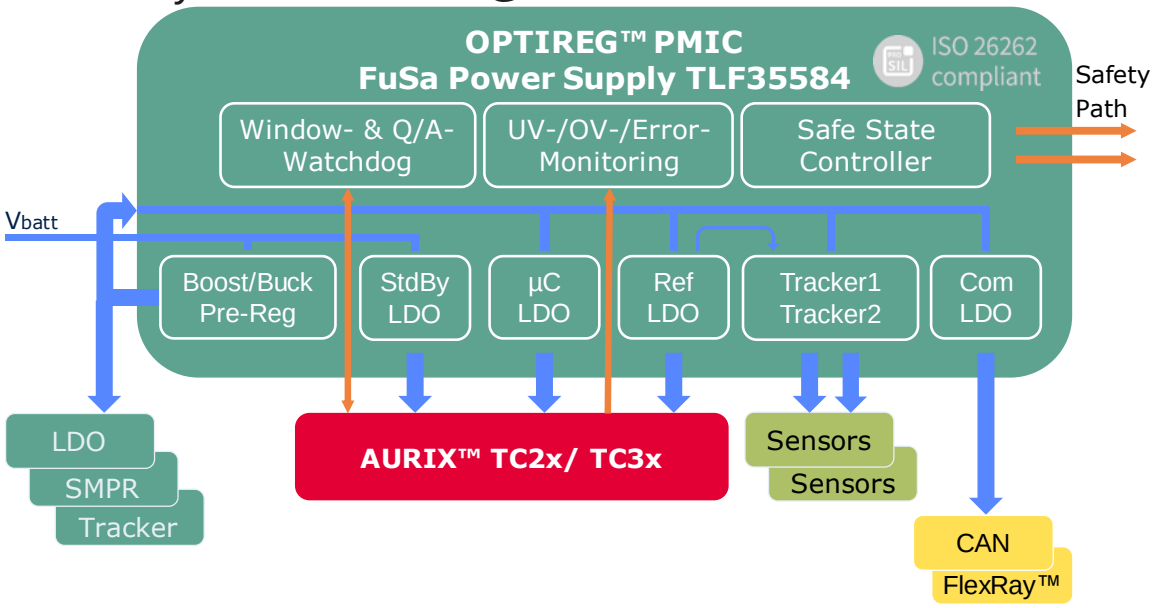


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TLF35584QVVSx/KVSx
OPTIREG™ PMIC Functional Safety

Key Features

- Buck/Boost-Pre-Regulator
  - I_{load} = 1.3A; f: 300kHz-2.5MHz
- µC-Supply: 3.3V/5V @ 600mA
- Reference-LDO: 5V @ 150mA (±1%)
- 2x Tracker: 5V @ 150mA
- Communication-Supply: 5V @ 200mA
- StandBy-LDO: 3.3V/5V @ 10mA



- EN/Wake (T15 and CAN/FlexRay™)
- SPI
- Safety Features
  - Multiple bandgap (supply vs V-monitoring)
  - UV/OV-Monitoring, ERR-Monitoring
  - Functional-WD & Window-WD
  - Safe State Control Secondary Safety Path
  - Protected safety area
  - Built In Self Test
  - Development acc. ISO26262
- Vin: 3V .. 40V

ISO 26262 compliant

Package



PG-VQFN-48



PG-LQFP-64

AEC Qualified

RoHS

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OPTIREG™ TLF35584 PMIC Functional Safety
Features - Benefits

Features	Benefits
ISO 26262-compliant	Usage in applications with ASIL-requirement
Boost capability	Ensure operation in cold cranking condition
Pre-/Post-Regulator architecture	High Efficiency
Multiple voltage supplies	System supply: µC, communication, sensors
Dedicated reference voltage supply	ADC-supply independent of µC-load
Bandgap for both safety and supply plus electrical isolation	Avoid common cause failures
WWD & Q/A-WD	Flexible WD to achieve proper ASIL-level
BIST (analog & logic)	Ensuring “safe” operation
UV/OV-monitoring	Flexible RESET/interrupt management
Flexible safe state control	Ensuring “safe” operation
Enable/Wake	Flexible wake-up management

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OPTIREG™ PMIC: Strong commitment to General Purpose and Application Specific PMIC solutions

















POWERTRAIN

ICE – PMICs

e.g. T-PMIC

- System Safety Functions
- System Power Supply Functions
- ICE Base Functions

Product idea

xEV – PMICs

e.g. I-PMIC

- System Safety Functions
- System Power Supply Functions
- xEV Base Functions

AEC Qualified

ISO 26262 compliant

RoHS



General Purpose PMICs

- System Safety Functions
- System Power Supply Functions



SAFETY

ADAS – PMICs

e.g. R-PMIC

- System Safety Functions
- System Power Supply Functions
- ADAS Base Functions

Product idea

Chassis – PMICs

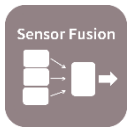
e.g. M-PMIC

- System Safety Functions
- System Power Supply Functions
- Chassis Base Functions











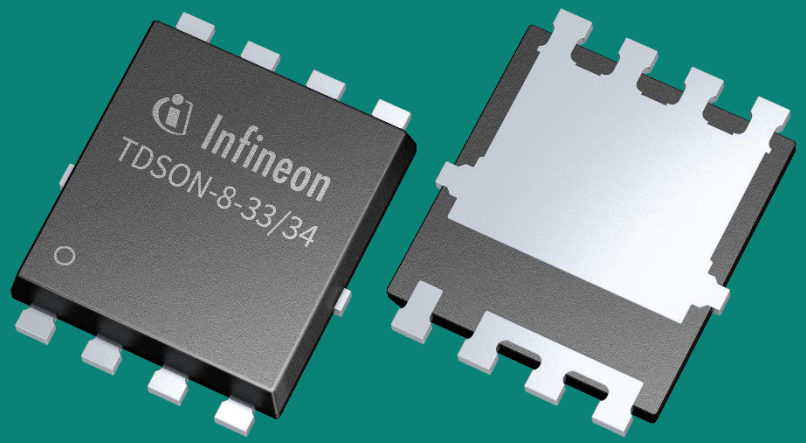






MOTOR DRIVES

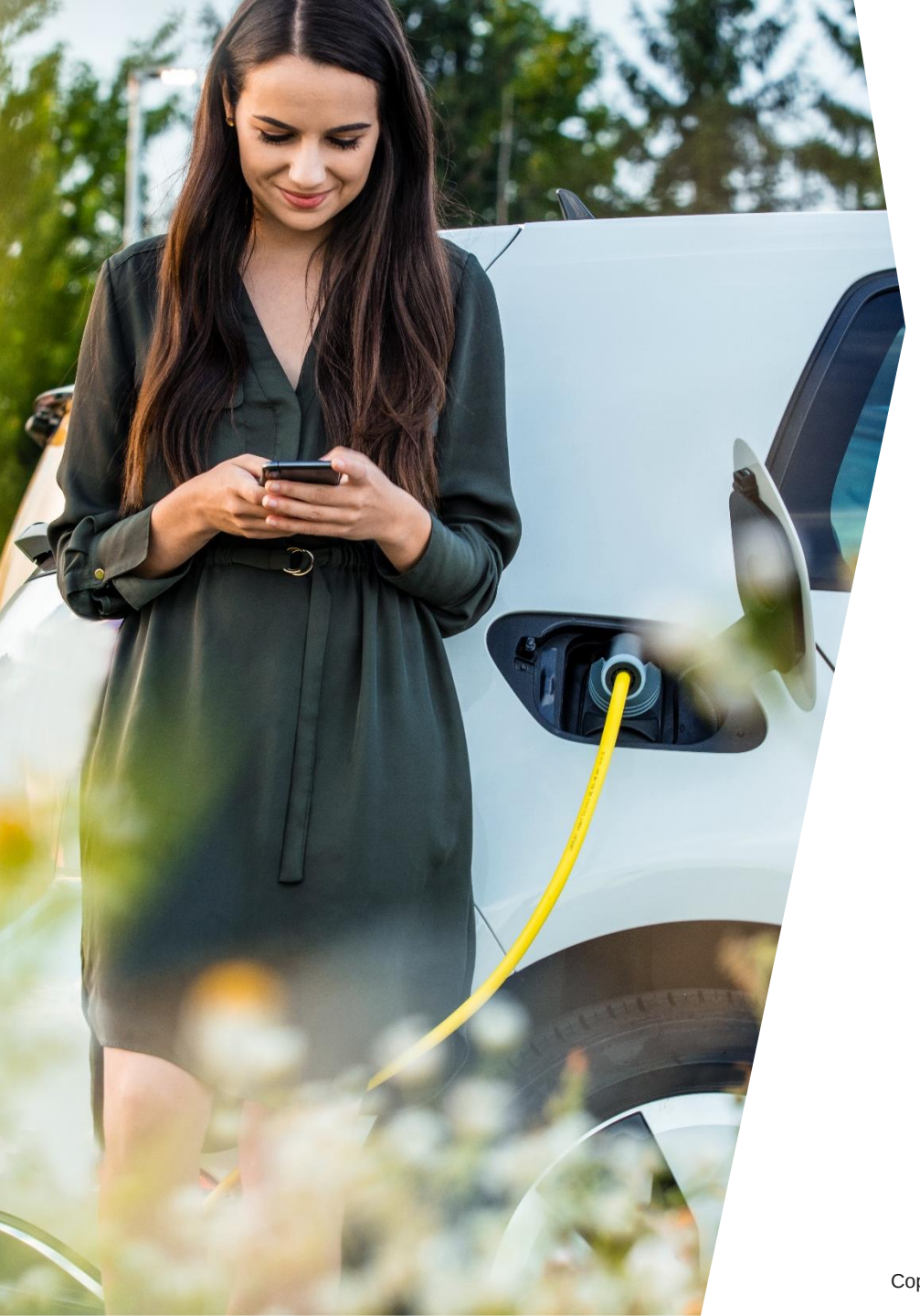
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MOSFET

For Inverter application

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EPS

HVAC

Inverter

Battery Disconnect

DC-DC converter

A hybrid car has

180 MOSFETs

in 2025

INFINEON can cover them all

Pumps

Seat Control

ABS Control

Window Lift

Belt Starter Generator

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OptiMOS™ 7:
setting industry standard with lowest $R_{DS(on)}$ X Area

- Outstanding electrical & thermal conductivity
- Less switching losses
- Unique copper metallization
- Ruggedness improvement
- High avalanche current capability

2015
OptiMOS™ 5

2019
OptiMOS™ 6

2023
OptiMOS™ 7

-25%

$R_{DS(on)}$ vs.
OptiMOS™ 6

-40%

$R_{DS(on)}$ vs.
OptiMOS™ 5

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Infineon offers the most comprehensive automotive MOSFET portfolio featuring a large range of voltages and packages

OptiMOS™ 7
OptiMOS™ 6
OptiMOS™ 5
OptiMOS™ T, T2, Gen 12.7
latest available
in development

New packages									
Standard leadless						Leaded		Top-side Cooled (TSC)	
S3O8 Single (TSDSON-8)	SSO8 Half-Bridge (TDSON-8)	SSO8 Dual (TDSON-8)	SSO8 Single (TDSON-8)	sTOLL Single (HSOF-5)	TOLL Single (HSOF-8)	mTOLG	TOLG	SSO10T (new)	TOLT



40V										
60V										
80V										
100V										
120V										
150V										

Low / medium power

S3O8, SSO8, SSO10T

mTOLG and sTOLL for auxiliaries

Medium power

mTOLG, sTOLL, TOLL

TOLG for auxiliaries and DC/DC

High power

TOLL, TOLG and TOLT for paralleling at Starter Generators and Battery Disconnect Switches

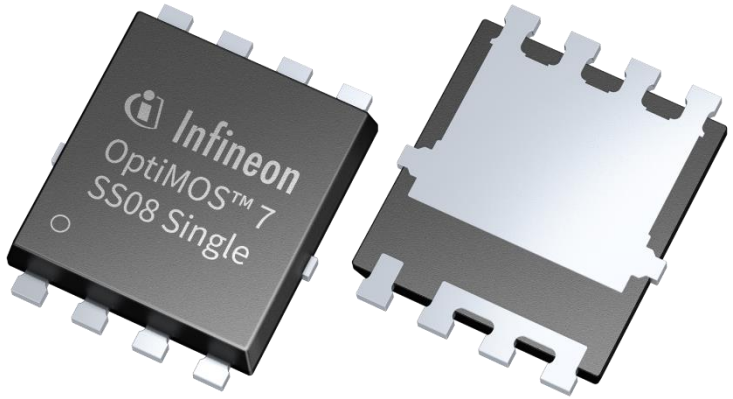
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OptiMOS™ 7: leading products in mass production more in sample phase

In Production

40V family for 12V board-net

IAUCN04S7N004 (SSO8, 0,44mOhm)
IAUCN04S7N005 (SSO8, 0,55mOhm)



In development

80&100V family for 48V board-net

Engineering sample available
SOP 2024

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10 kwh 100 km

1 Inverter

1 Infineon

