



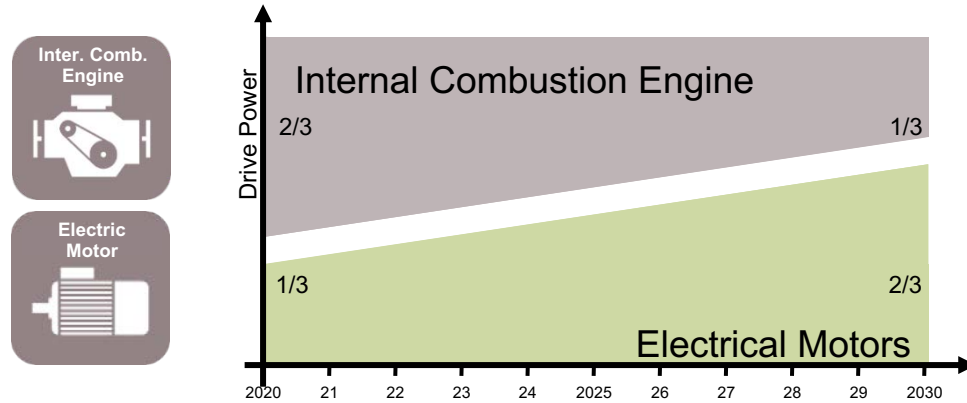
We are the link
between the real and
the digital world.

Main Inverter

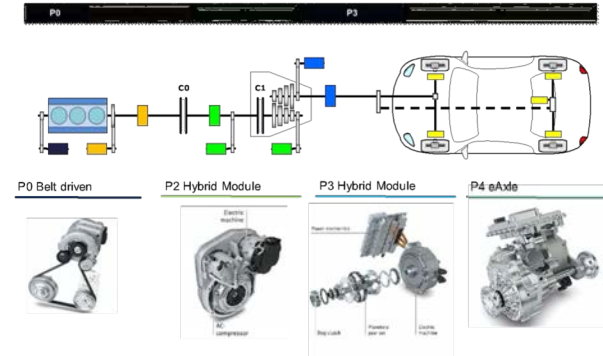


Electrification – the way forward to Zero CO2

Let's make E-Mobility work!



- › **Regionally different** approaches to grow xEV share. Legislations and subsidies are vital.
- › Cost delta of **ICE / xEV is getting closer**, quickly. xEV now in mainstream market segments.
- › **Charging infrastructures** are growing fast (7m WW.2019).
- › Improvements on **driving range and efficiency** are ongoing. Further declines in battery cost expected.

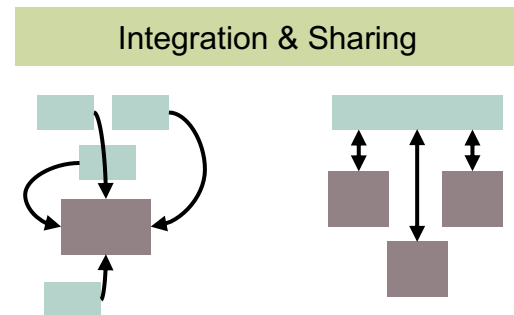
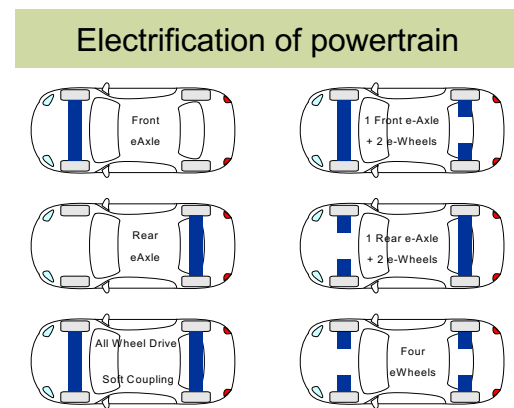
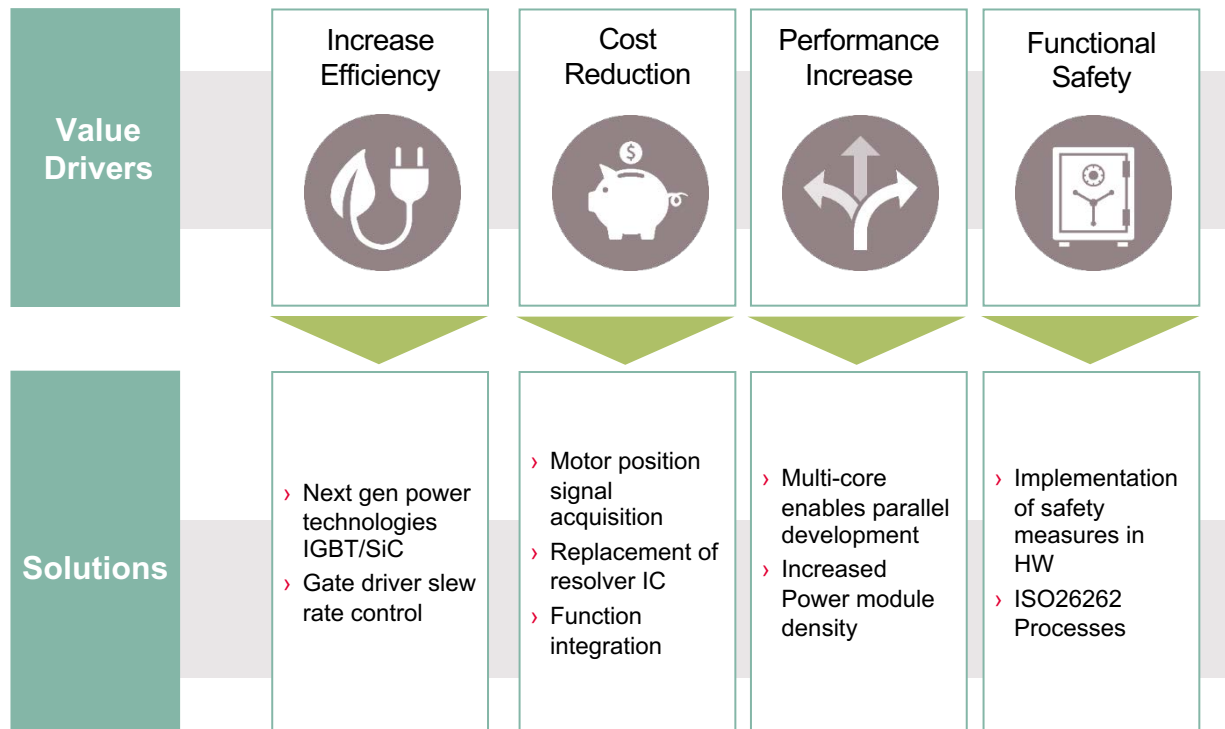


From 100% ICE to electrification

Impact to developing an xEV
as well as the supply chain roles

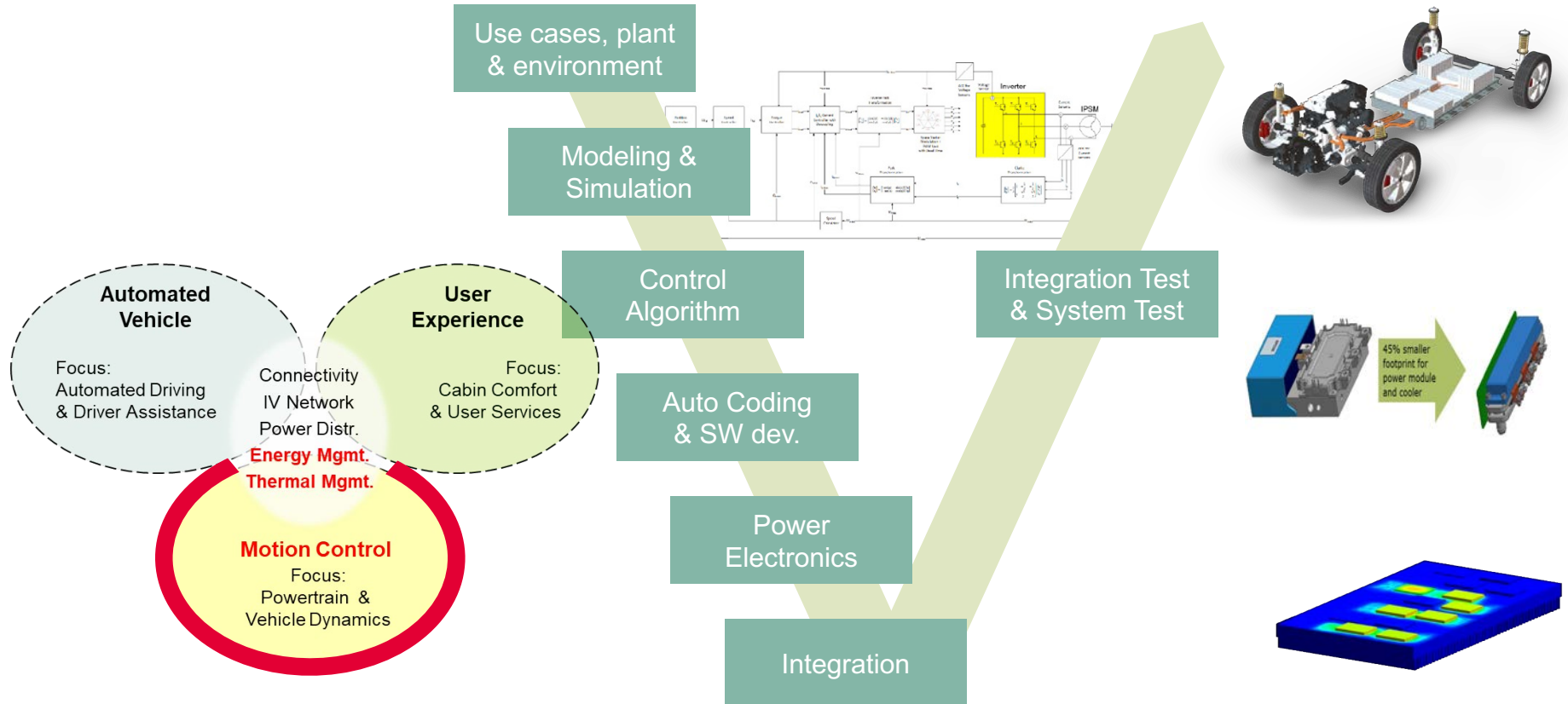
... to 100% EV with ICE extension

Main Inverter Value Drivers

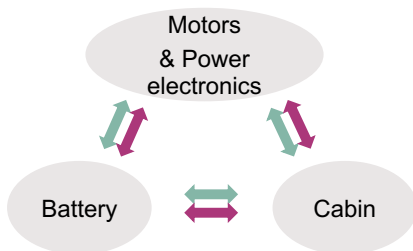
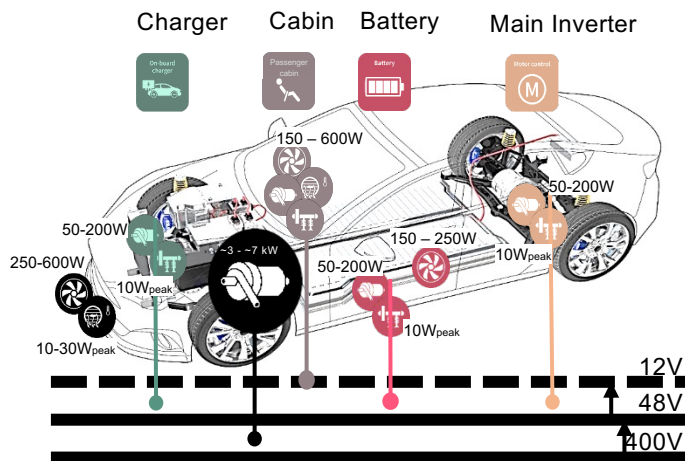


Motion Ctrl., Electric Energy Mgmt., and Thermal Mgmt.

The "application" is the complete drive train



Thermal Management Challenge or Opportunity?



3 heating-cooling systems

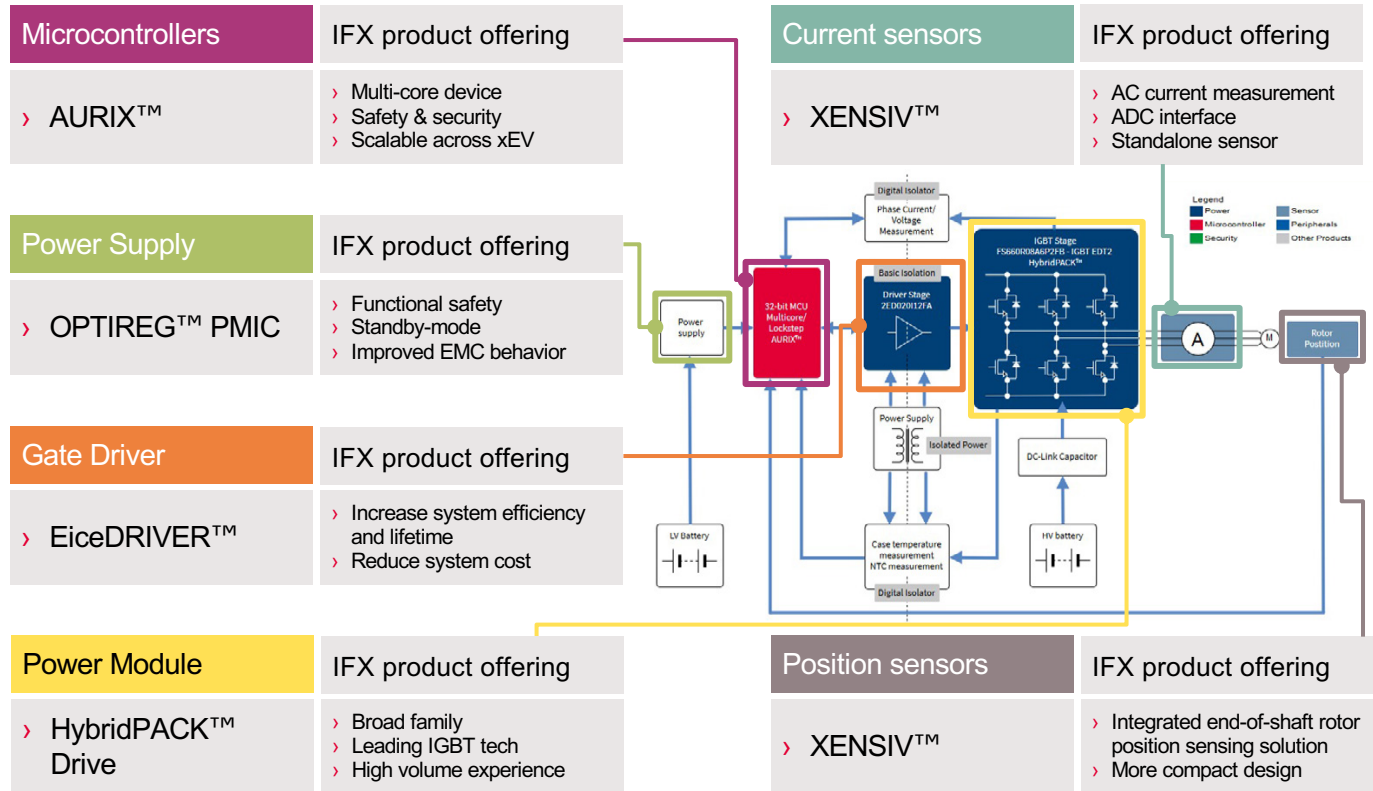
Thermal management challenges

- › **Heat is shared** in mainly 3 areas: e-Motor & Power electronics, Battery, and Cabin.
- › Thermal management is a **distributed architecture** that should heat and also cool
- › Zone type with many sensors and virtual sensors many actuators: compressor, PTC, valves, pumps, fans, flaps...

Infineon contribution

- › Make the most suitable product offering for our customer success that comprises:
 - **Connectivity**
 - **Compute**
 - **Sense**
 - **Actuate**
 - **System sharing & integration**

Infineon offers key components for traction motor inverters translating into strong system understanding



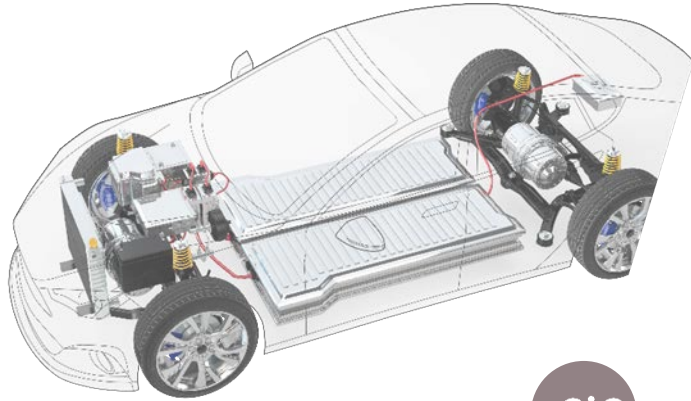


We are the link
between the real and
the digital world.

Right Sizing – the right technology
for the requirement Si & SiC

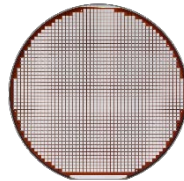
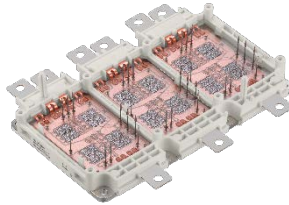


CoolSiC™ Module, Bare Die & Discrete enable longer drive range in e-Mobility Main Inverter



Reduced battery size, less cooling effort, lower cost in passive components, longer drive range, are a few of the benefits embracing SiC based solution in electric drive train. In 800V system, SiC based main inverter can achieve appr. 7% more range vs. its Si counterpart. OEMs adopt topologies where SiC is used in the main inverter with rear wheel drive while Si-based secondary inverter in front wheel drive, achieving good balance between efficiency & cost.

+SiC



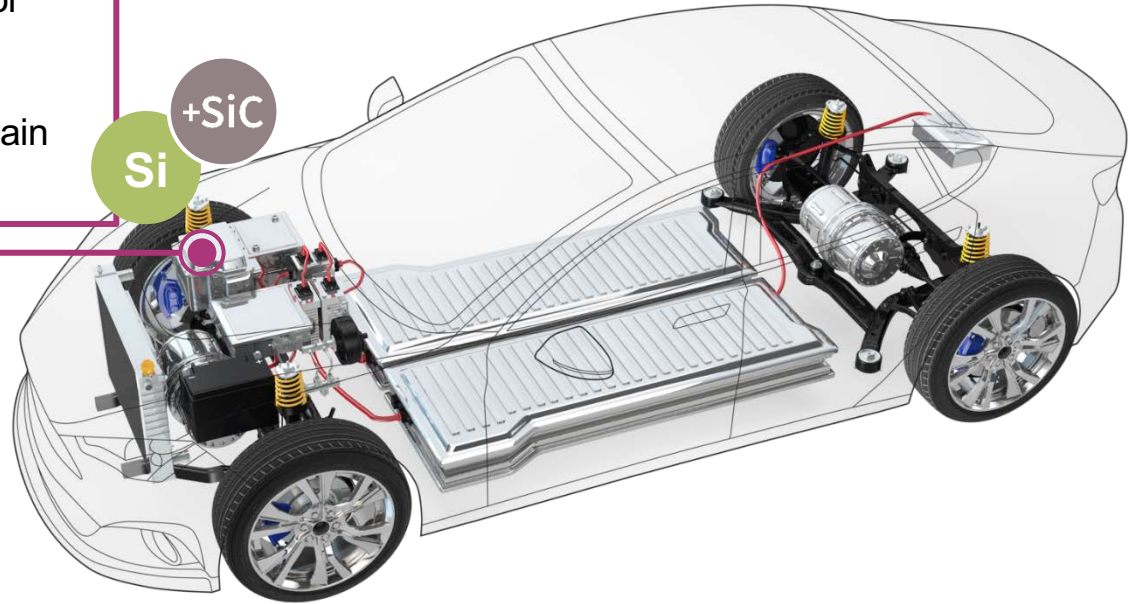
Advantages of SiC

- › Increasing battery utilization by 5-10%
- › Higher power density for system size reductions of up to 50%
- › Lower conduction losses in light load condition and lower switching losses compared to Si IGBTs
- › IFX CoolSiC™ offers superior performance without jeopardizing quality

Si & SiC co-exist in main Inverter application depending on their own characteristics and system requirements

Main inverter

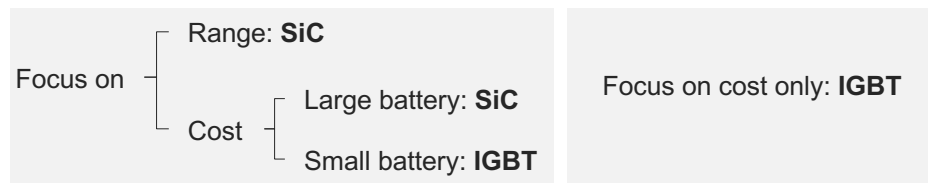
- › Main source of power components dominated by **Si**-based solutions for the next decade
- › **SiC** solutions are adopted from premium EVs, and extend to the main stream of EVs since 2020.



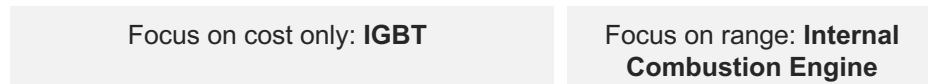
To meet best cost-performance ratio in xEV drivetrain, IGBT and SiC technologies will co-exist

Selected examples of IGBT versus SiC

Example: All-wheel drive BEV



Example: Axle split PHEV



Source: Infineon

Technology and market development

Choice of power semiconductor technology in main inverter

- › More and more OEMs are considering SiC as an alternative to IGBTs
- › OEMs' choice of main inverter technology depends on the choice of
 - range versus cost, and
 - size/cost of the battery

Market development

- › Higher-volume platforms to be launched in ~2025 are being awarded over the next quarters
- › To address range anxiety, OEMs shift focus to sufficient reach (for mid- to high-end cars preferably)
- › To improve their CO₂ footprint online retailers need to operate fully electrified delivery vehicles

System size and cost benefit with CoolSiC™ technology

Shrink battery size and cost – **by up to 10%** – thanks to improved efficiency

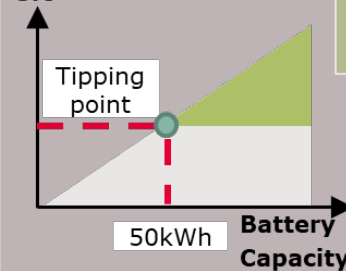
Smaller battery

Up to 10% times smaller
Up to 800 euros cheaper ¹⁾



Battery

Savings using SiC



SiC enables system cost savings for batteries >50kWh

Higher autonomy

Up to 600 hrs saved in charging ²⁾
Up to 1864 kg CO₂ saved per vehicle ³⁾



Si



SiC



+5% to 10%



1) For a 80kWh battery, assuming 100 € / kWh

2) Example based on 15000 km/year, 40kWh battery and on a 7kW charging point

3) Source [Environmental Progress](#)

With our broad product portfolio, customers can develop and scale their platforms fast



"Develop the best solution for your strategy based on industry's only complete xEV power portfolio:"
Performance, cost, time to market, support, high volume capability @ Infineon Quality



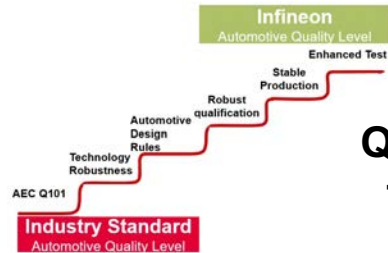
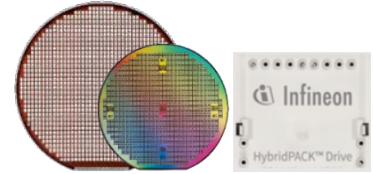
Infiniteon is the dependable partner with leading technologies and industry's broadest portfolio for electric vehicle inverters



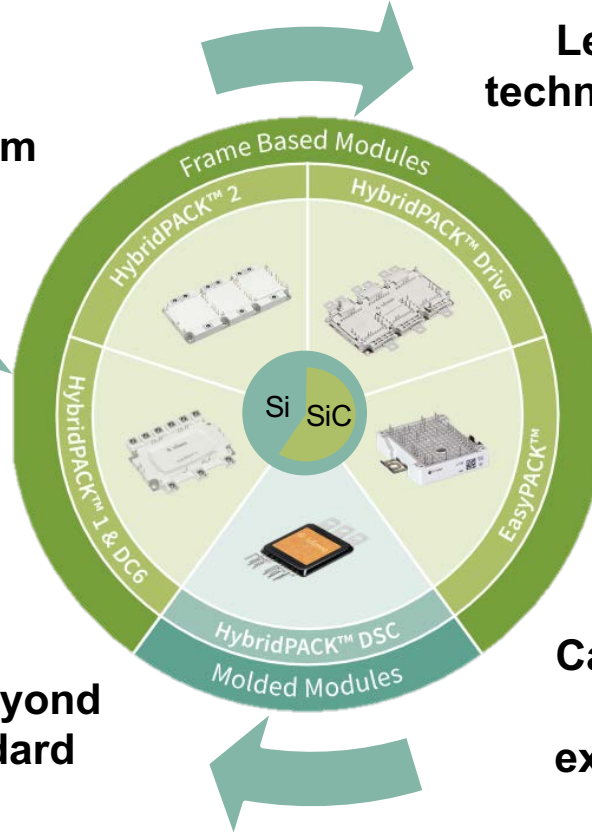
Technical expertise & inverter system support

Leading technologies & IP

15+ years
experience in
electromobility



Quality beyond the standard

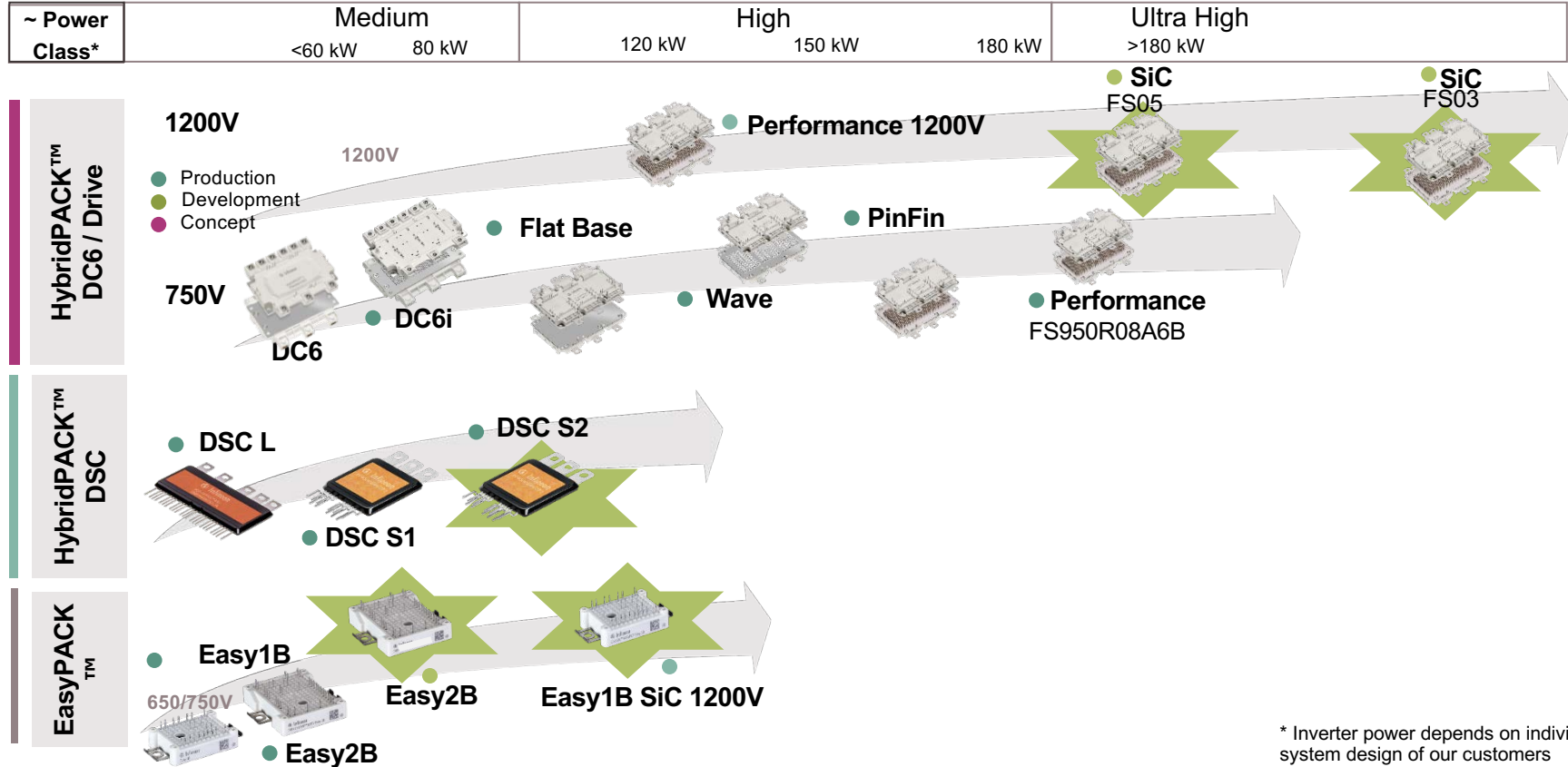


Capacity & ramp experience

18 Mio
pcs Automotive Power
Modules shipped to date

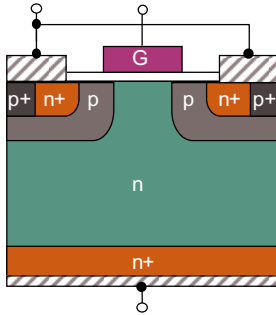
15 out of 20
top-selling NEV of 2019
powered by Infineon

HybridPACK™ & EasyPACK™ product families: right product for each system cost-performance requirement



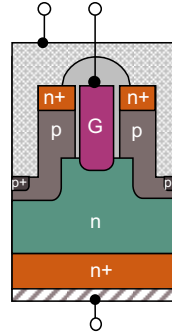
Infineon's fine tuned SiC Trench technology out-performs Planar demonstrating more protection vs. traditional Trench

SiC Planar



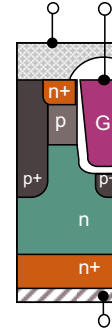
- ✓ Low complexity process
- ✓ Good shielding of oxide possible

SiC Trench



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

Infineon Trench



- ✓ Low channel resistance
- ✓ Shrink potential higher than in DMOS
- ✓ Oxide corners shielded by folded double trench

○ Sophisticated process know-how needed

○ Sophisticated process know-how needed

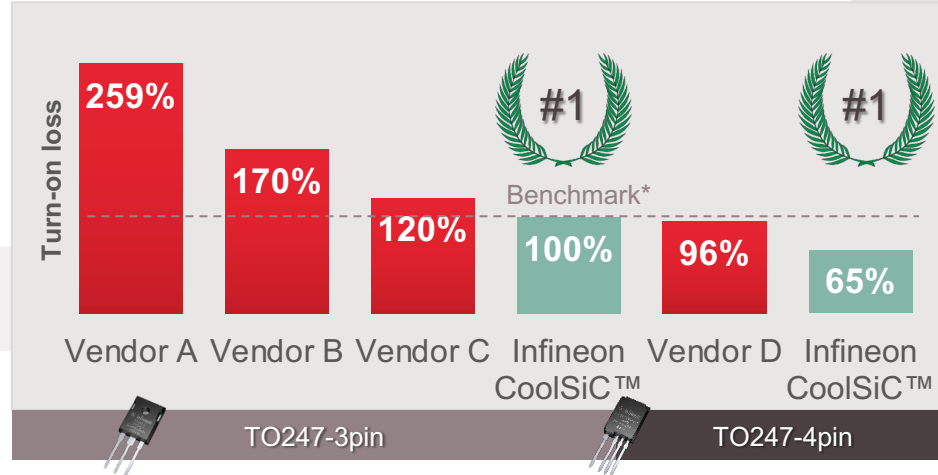
x Very low channel mobility
x Limited shrink options

x Protection of oxide corners needed

2nd generation CoolSiC™ Trench MOSFET aiming to enhance the target market significantly



1st Gen. CoolSiC™ MOSFET Infineon is champion: lowest loss in market



2nd Gen. CoolSiC™ MOSFET

Continue leadership & Enlarge market significantly



› Enhanced power handling capability by **25% – 30%**



› Enhanced **safe operating** area w.o. compromising **Quality**



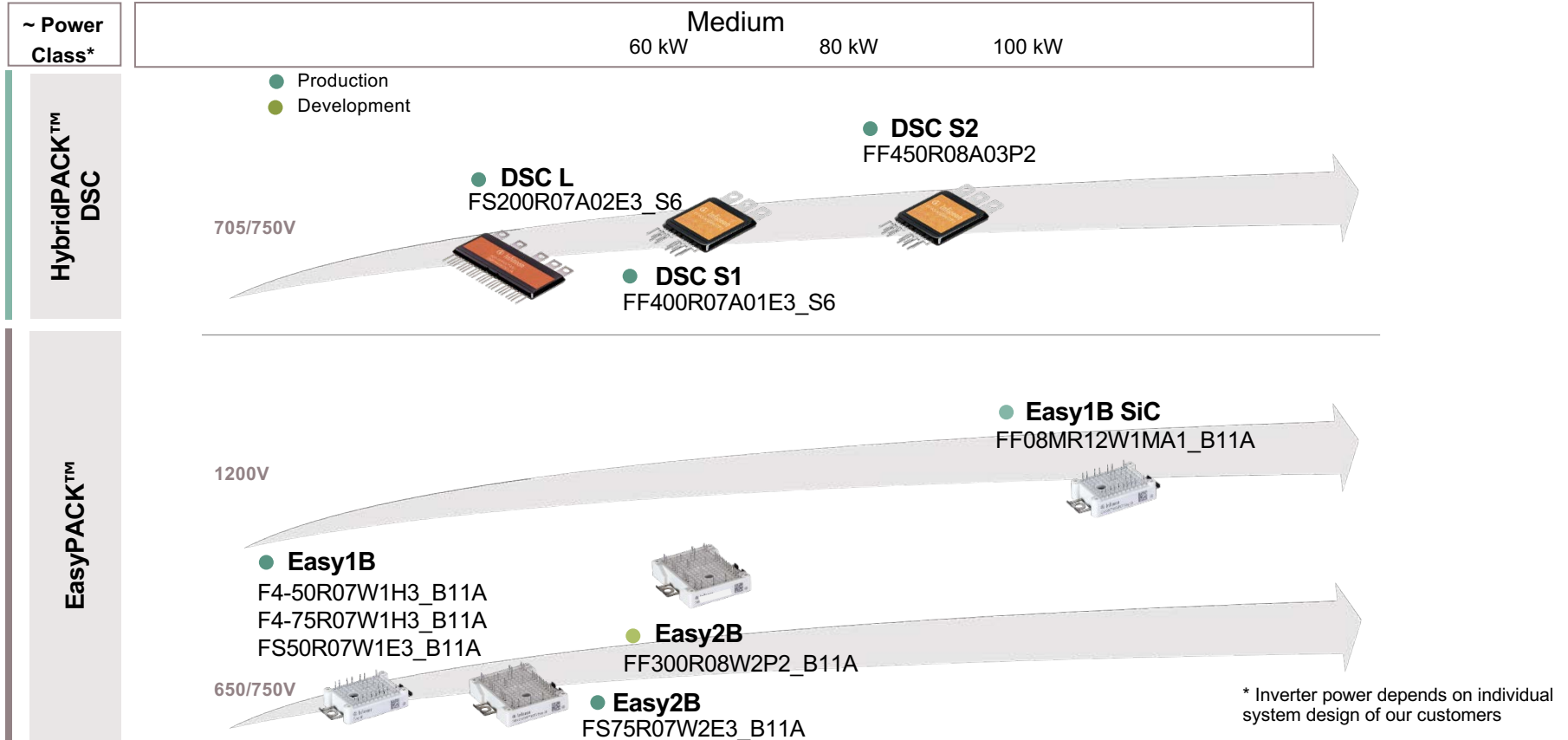
› Enabling SiC in further **high volume** applications

In development

*Value is calculated in terms of loss. Higher value shows lower efficiency.

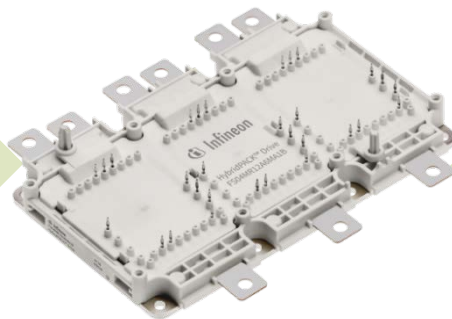
Source: Infineon, datasheets on supplier web pages, September 2019.

HybridPACK™ and EasyPACK™ product families cover the full performance spectrum



HybridPACK™ Drive CoolSiC™: efficiency and robustness in a benchmark package

- › 1200V B6 module for main inverters
- › Field-proven HybridPACK Drive package
 - PressFIT, PinFin Baseplate, Si3N4 baseplate
- › 2 variants: 3mOhm/5mOhm (800A / 400A rated)



- › Infineon CoolSiC™ Gen1 technology
 - Short circuit robustness
 - Superior gate oxide and cosmic ray reliability

FS05MR12A6MA1(L)B: SOP H2 2020

FS03MR12A6MA1(L)B: SOP H2 2020

Key system benefits:

Same mechanical outline as HybridPACK Drive Si → scalability up to >400Arms peak current

Superior reliability on chip and package level

Reduces inverter losses by ~60% vs. state of the art IGBT

Infiniteon's HybridPACK™ Drive family of power modules enabling scalable inverter designs in the range of 100 kW to 180 kW*

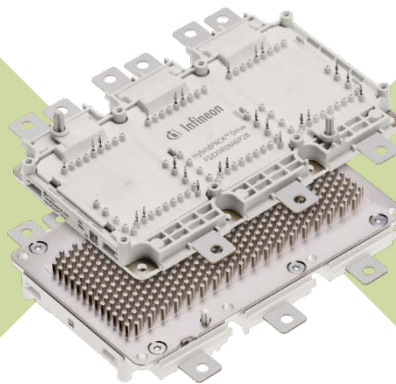


New product
highlight video:

<https://www.youtube.com/watch?v=VMEUZevTZyA>

HybridPACK™ Drive product family:

- › IGBT power modules for battery or hybrid electric vehicles
- › Success story with close to 1 million parts shipped
- › HybridPACK™ Drive has defined an industry standard footprint
- › Complete module family with 5 variants available



Highest flexibility and scalability:

- › Blocking voltages of 750V and 1200V
- › Performance variations for inverter designs between 100 kW and 180 kW* through material stacks with different base plates

Key product benefits:



Scalability

→ Lower development costs through reuse of mechanical and electrical inverter design



Quality excellence

→ State of the art Infineon quality proven in volume ramps



Best in class EDT2 chipset regarding performance and efficiency

→ Higher efficiency increase the driving range of battery electric vehicles



Press-fit for reduced mounting time of signal pins

→ Reduced total costs

* Inverter power depends on individual system design of our customers

Infineon's EDT2 IGBT technology:

- › Benchmark efficiency and ruggedness
- › Blocking voltage 750V
- › I_c nom: 650A
- › T_{vj} op = 150°C
- › Short-time extended Operation
Temperature T_{vj} op = 175°C



HybridPACK™ DC6i:

- › Combines latest technologies available offering an upgrade path to the HP1 and DC6 families
- › For inverters up to 100 kW

- › Full qualification acc. to AQC324 guideline
- › In production

Key product benefits:



Direct cooling

→ Improved heat dissipation through ribbon bond structure



25% smaller size than HybridPACK™ Drive

→ Enables very compact & light inverters



Benchmark current density combined with short circuit ruggedness and increased blocking voltage

→ Highest reliability



Press-fit for reduced mounting time of signal pins

→ Reduced total costs

* Inverter power depends on individual system design of our customers

Infiniteon's HybridPACK™ DSC S2 – FF450R08A03P2

Benchmark IGBT technology meets compact package



Infineon's EDT2 IGBT technology:

- › Excellent light load power losses for superior efficiency
- › 750V blocking voltage



Infineon's Double Sided Cooling package:

- › Very compact & lightweight mold package
- › 175°C short-term chip junction temperature capable for increased power density

- › Full qualification acc. to AQC324 guideline
- › In production

Key product benefits:



Flexible half-bridge module

→ enables different inverter geometries and further motor integration



High power density

→ enables very compact & light inverters



Built-in current and temperature sensors

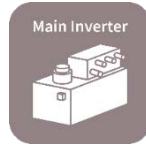
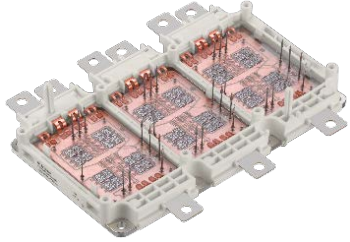
→ efficient and safe inverter



Low parasitic stray inductance and 750V blocking voltage

→ improved system efficiency

Automotive CoolSiC™ MOSFET 1200 V HybridPACK™ Drive Released portfolio



On-resist. R_{DS_on} [mOhm]	Voltage [V]	I_c [A]	Product	Package
2.75	1200V	400A	FS03MR12A6MA1B	HybridPACK™ Drive
5.7	1200V	200A	FS05MR12A6MA1B	HybridPACK™ Drive

+SiC

Infiniteon HybridKITs give you a headstart in the inverter design phase

Key benefits

- › Available for almost all power modules
- › Design reference for new inverter designs
- › Fast lab evaluation of the capabilities of our power modules
- › Speeds up the R&D process
- › Saves R&D effort



HybridKIT Drive



HybridKIT DSC



HybridKIT 1+



HybridKIT Drive Sense



EasyKIT DC-DC

Orderable online:

hitex
EMBEDDED TOOLS & SOLUTIONS
[Hitex Online Shop](#)

infineon
[ISaR Tool](#)

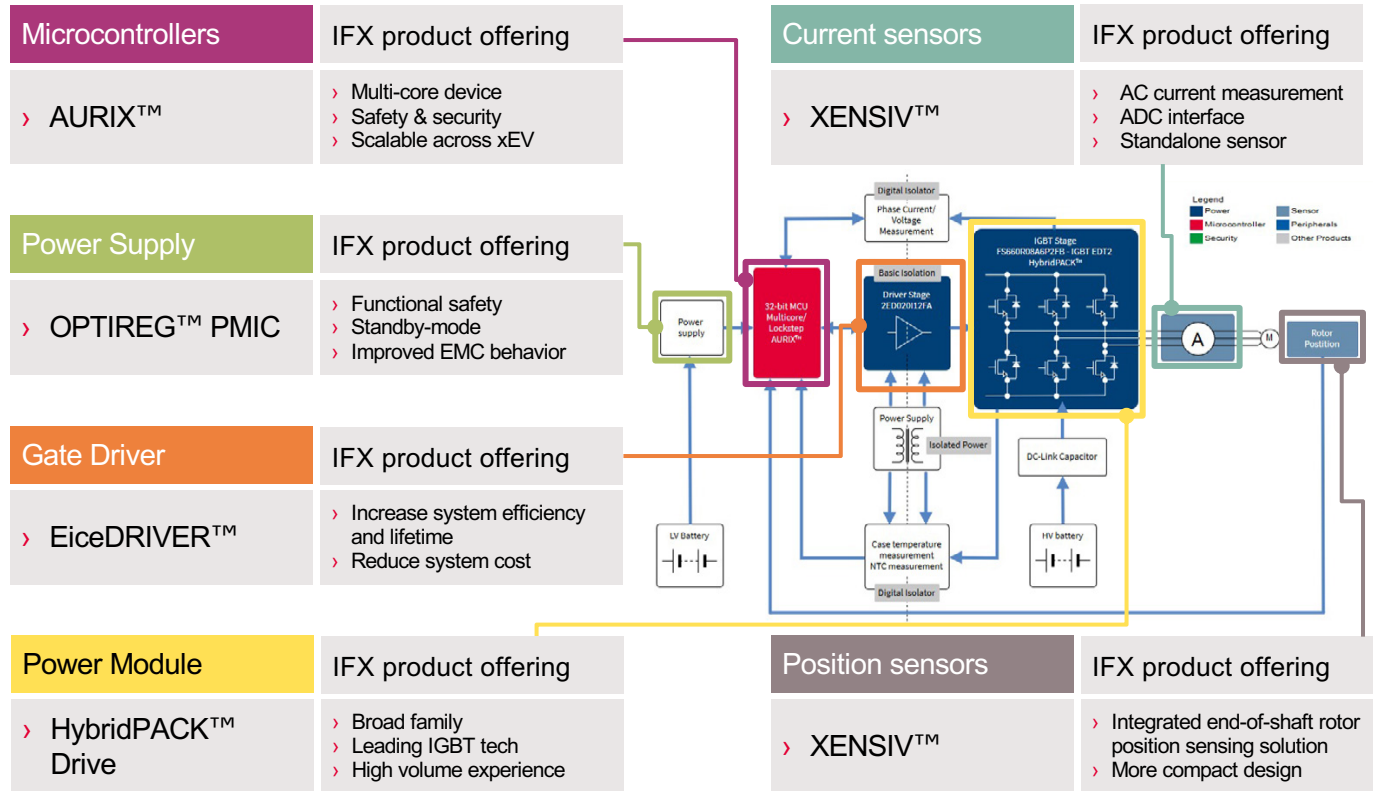


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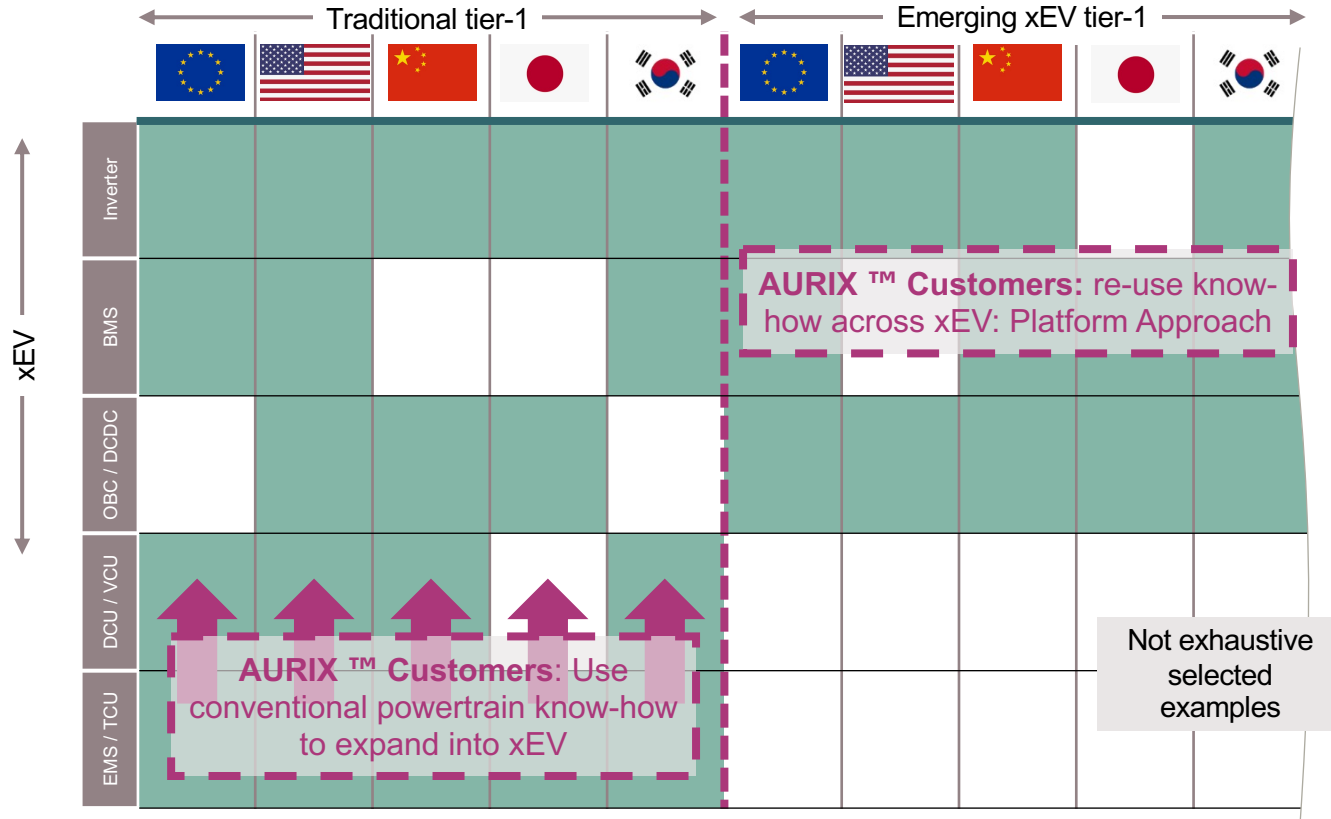
Sense & Control & Supply



Infineon offers key components for traction motor inverters translating into strong system understanding



AURIX™ serves inverter requirements very well and customers can use it across multiple applications



All traction motor inverter topologies are addressed by AURIX™ - the MCU market leader



AURIX™ addresses all traction motor inverter topologies

48V Mild Hybrid

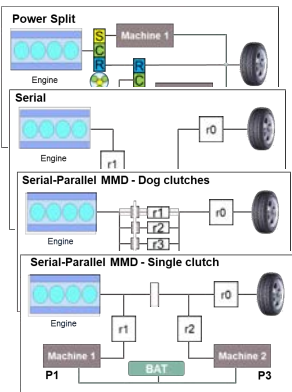


P2

P0 BSG

AURIX™ #1:
Market leader

Full Hybrid & PHEV

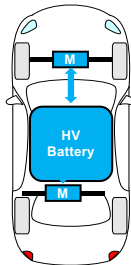


Power Split, Serial &
Serial-Parallel

AURIX™ #2:
Growing strongly

BEV & FCEV

Front
eAxe



Rear
eAxe

AURIX™ will be #1:
in next 3-5 years

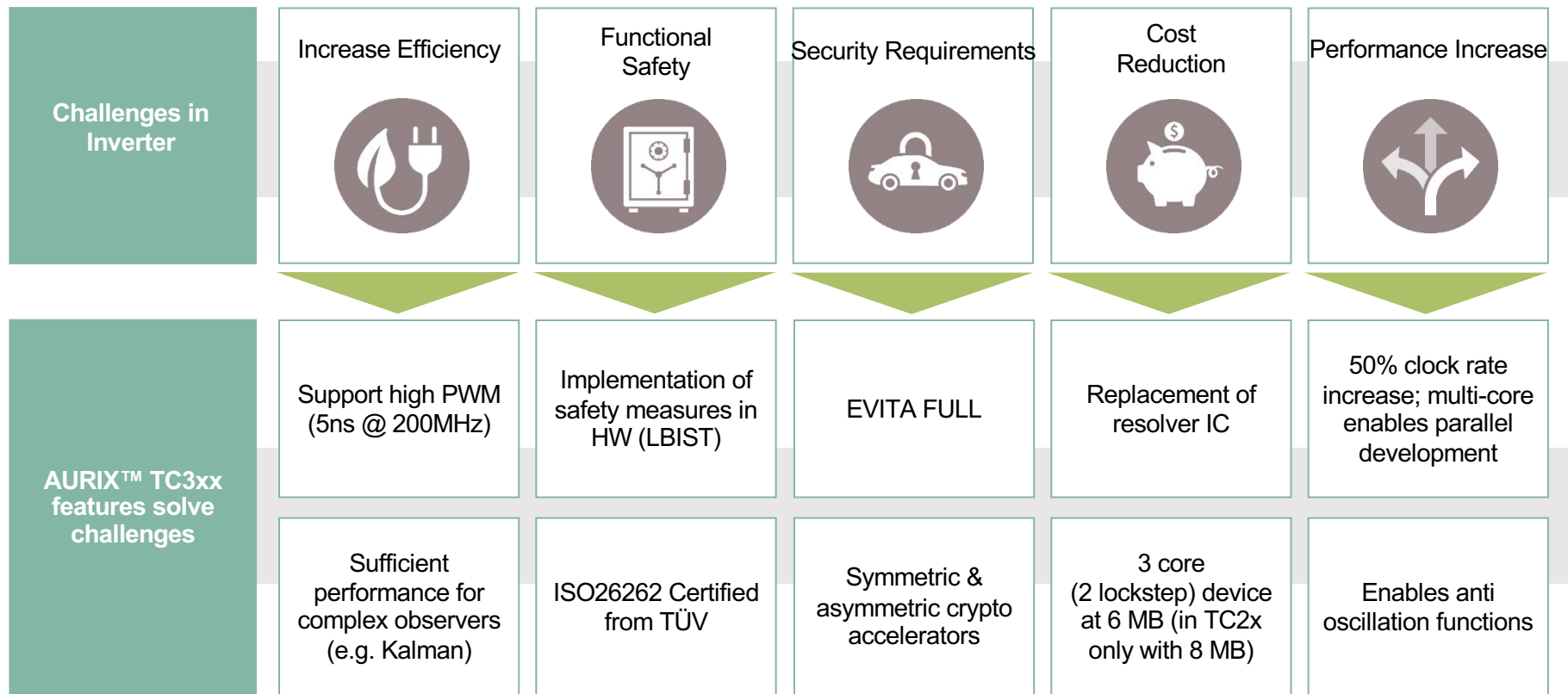
Why AURIX™?

#1

30-40% inverter
market share by 2025

- › **Strong position at EU & US OEMs** who increase their inverter competence
- › **Scalable family concept** enables re-use across different inverter types
- › **Strong product roadmap** provides access to innovation
- › **Proven quality & powertrain knowhow** from conventional applications

Our new generation AURIX™ TC3x provides the right features to solve challenges for traction motor inverter

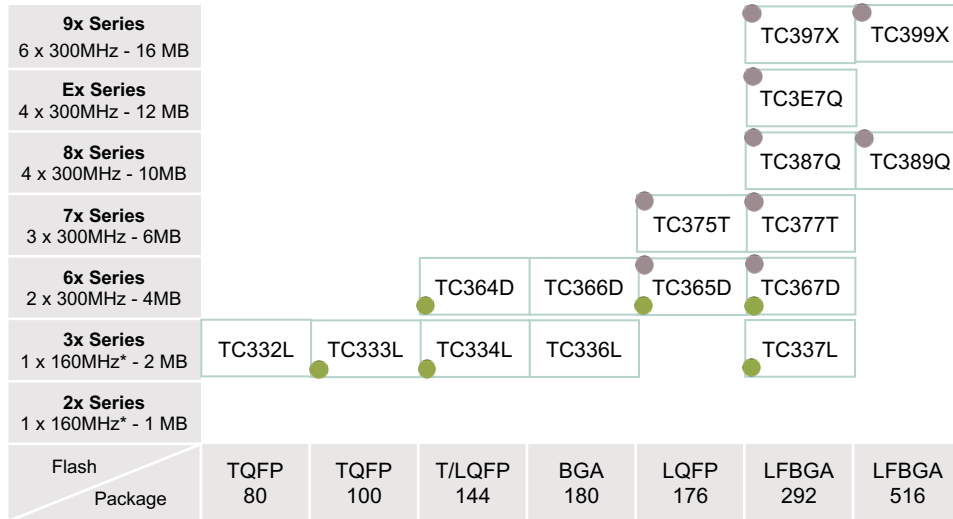


AURIX™ TC3xx: the scalable portfolio of choice for control and safety computing in xEV



xEV

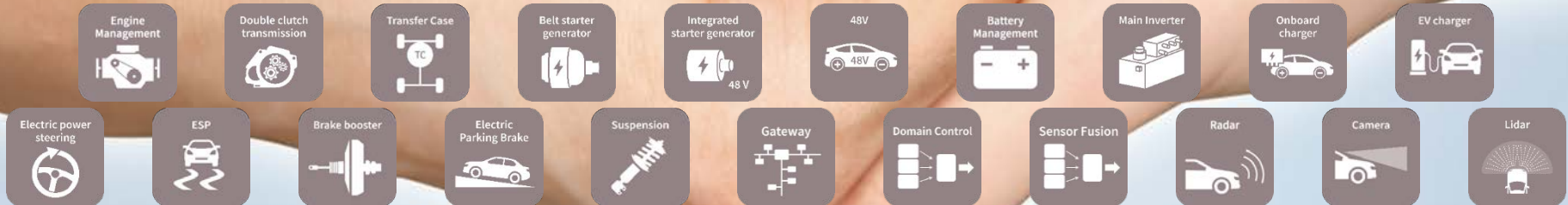
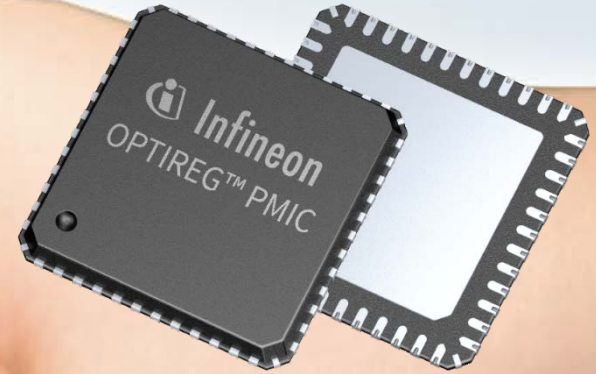
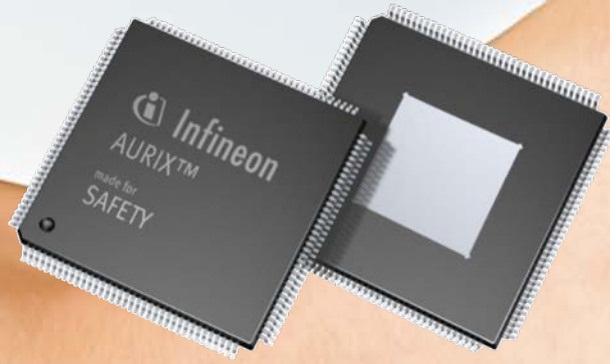
Growing to >30% in xEV



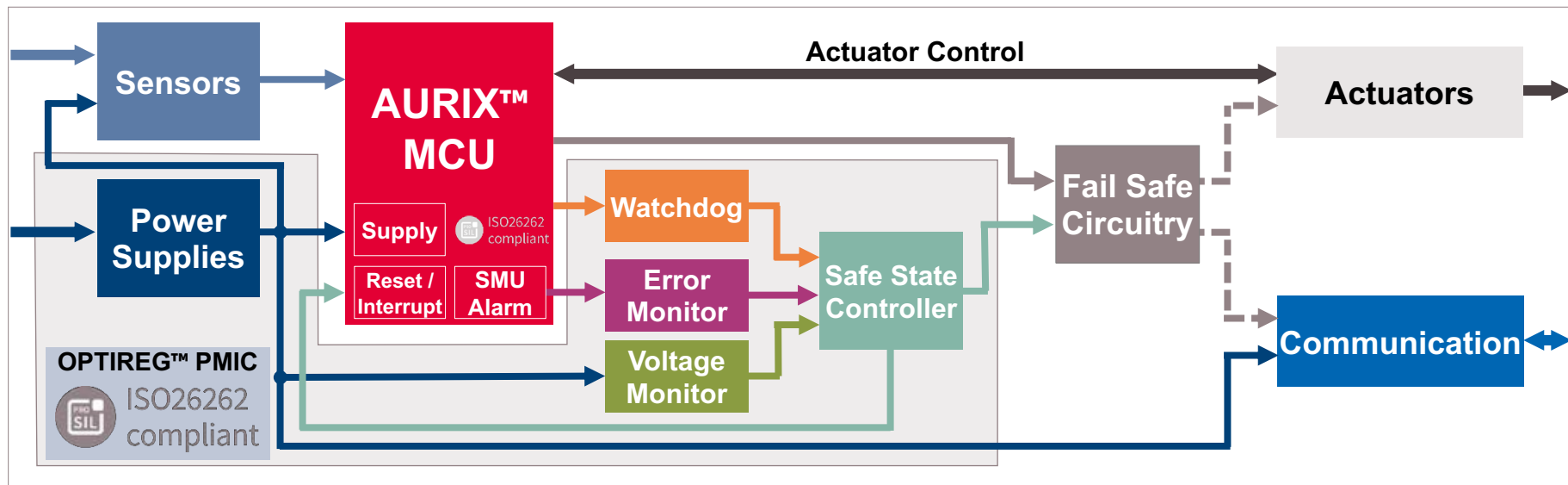
L - Single Lockstep Core
D - Dual Core
T - Triple Core
Q - Quadruple Core
X - Sextuple Core

Key AURIX™ TC3xx feature by application	Inverter
High Multicore. Perf.	<input checked="" type="checkbox"/>
Rich peripheral set	<input checked="" type="checkbox"/>
CAN-FD (up to x20)	
Gb Ethernet (up to x2)	
High RAM content	
Timer across family	<input checked="" type="checkbox"/>
Low power modes	
Safety (ASIL-D)	<input checked="" type="checkbox"/>
Security	<input checked="" type="checkbox"/>
Resolver-less sol.	<input checked="" type="checkbox"/>
SOTA support	<input checked="" type="checkbox"/>
High temp. support	<input checked="" type="checkbox"/>
High RAM/flash ratio	<input checked="" type="checkbox"/>

AURIX™ microcontroller & OPTIREG™ PMIC teaming up for Functional Safety



Automotive system



Safety MCU:
System level hardware
requirements



Safety path activated by
microcontroller as main
decision maker



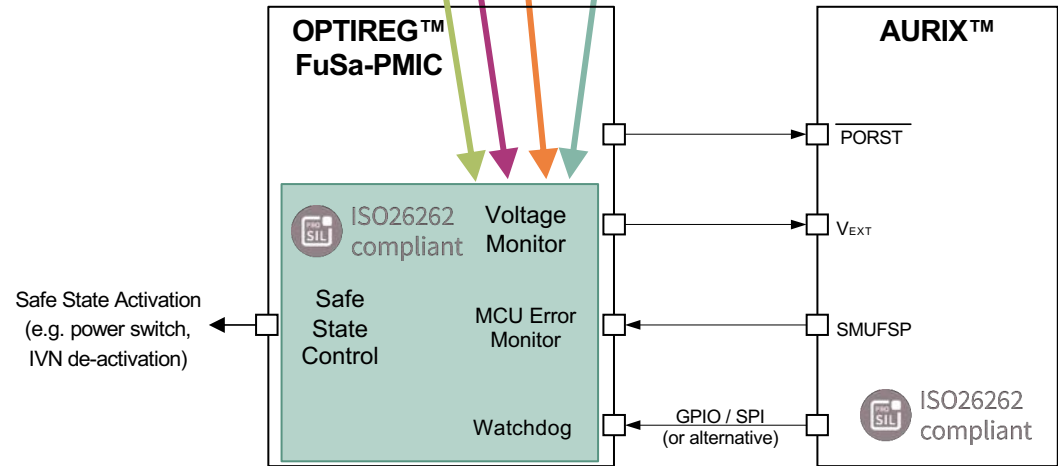
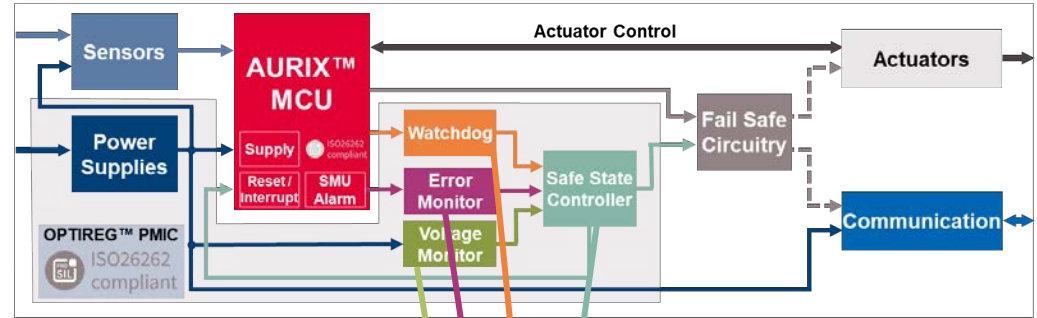
Secondary safety path
for faults that may lead
to an unreliable MCU

OPTIREG™ FuSa-PMIC

Genesis of Safety Requirements



- › OPTIREG™ FuSa-PMICs have been defined based on AURIX™ requirements for external monitoring
- › Those requirements have then been extended to support also other MCUs
 - Choice between different types of flexible watchdogs (Window- & Functional-Watchdogs)
 - Ability to monitor MCU core supply
- › OPTIREG™ FuSa-PMICs are developed as Safety Element out of Context (SEooC) supporting ASIL-D acc. ISO26262



TLF35584 / TLF35585 (in development)

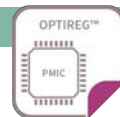
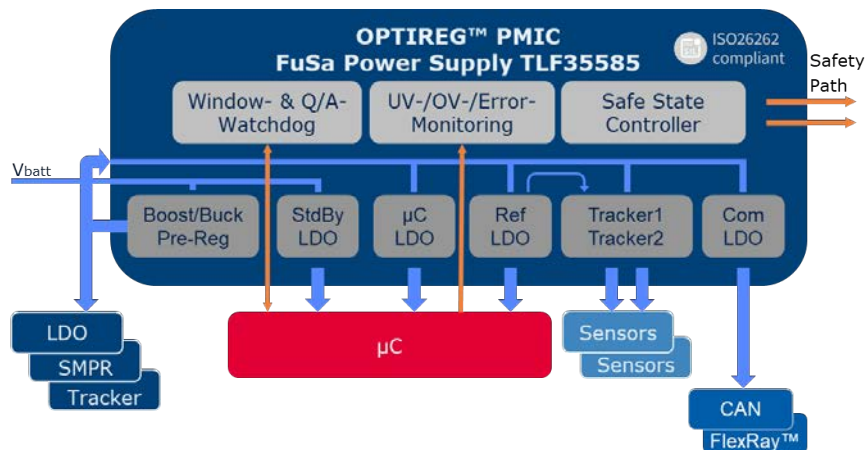
OPTIREG™ Functional Safety PMIC



Key Features

- › Buck/Boost-Pre-Regulator
 - IQ = 1.3A (1.5A for TLF35585); f: 300kHz-2.5MHz
- › μ C-Supply: 3.3V/5V @ 600mA
- › Reference-LDO: 5V @ 150mA ($\pm 1\%$)
- › Communication-Supply: 5V @ 200mA
- › 2x Tracker: 5V @ 150mA
- › StandBy-LDO: 3.3V/5V @ 10mA

Block Diagram



- › EN/Wake (T15 and CAN/FlexRay)
- › SPI
- › TLF35585 enhancement vs. TLF35584
 - E.g. features: additional diagnostics information, extended timer functionality
 - Ultra low current consumption ($< 10\text{-}15\mu\text{A}$)
- › 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



Package



PG-VQFN-48
(TLF35584 & TLF35585)



PG-TQFP-48
(TLF35585)



PG-LQFP-64
(TLF35584)

EiceDRIVER™ Enhanced: continuing the Success Story of Infineon Automotive Gate Drivers



2009

2015

2021

Meeting the key success factors as the market develops

1st Generation

Robust product available
in automotive quality



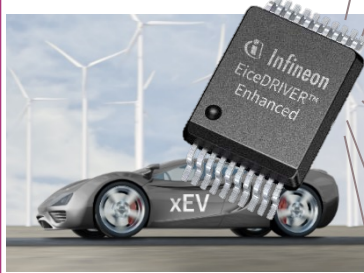
2nd Generation

Supporting system
optimization & flexibility



3rd Generation

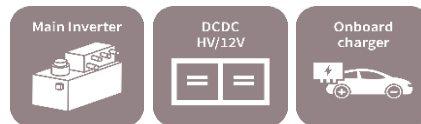
Maximizing system
performance/cost ratio
Functional Safety
Driving IGBT & SiC



EiceDRIVER™ Enhanced
launching in **Q1 2021!**

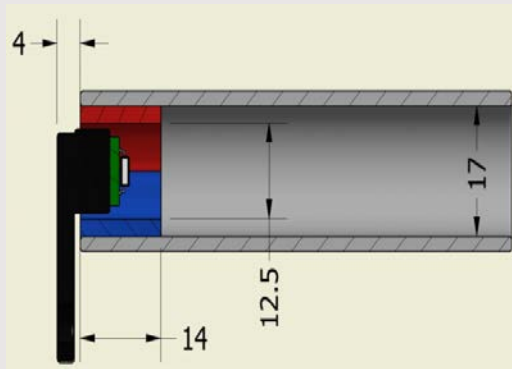
- Pin-compatible product variants for IGBT & SiC switches
- Easy to use, no programming
- Integrated booster stage
- Advanced safety features
- Accurate Delta-Sigma ADC
- Suiting various HV xEV applications:

Infineon EiceDRIVER™ for automotive main inverter applications are in **volume production** since **2009**. Used in many automotive **(PH)EV** platforms **worldwide**. **Coreless transformer** galvanic isolation technology is **mature** and **certified**.



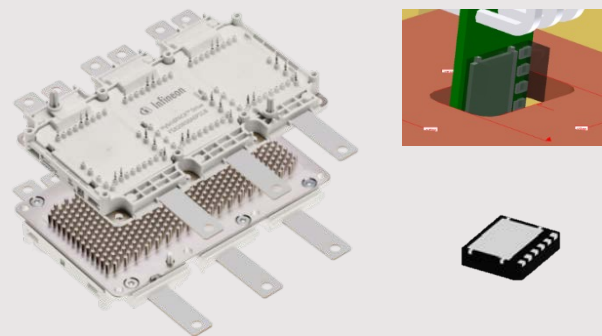
Sensors for Main Inverter

Position Sensor Resolver replacement



- › Very good system performance
- › Sensor module
- › Signed with magnetic circuit
- › Small construction space
- › High robustness & reliability
- › Small construction space
- › ASIL-D implementation

Current Sensor Integrated on the Power Module



- › Device name: TLE4972
- › Current 400+ A
- › eCR Vertical mounting
- › Package: SON
- › Massive Copper Bus-bar
- › External isolation

TLE5309D Analog Angle sensor with iEoS(Integrated End of Shaft *) –Targets Resolver replacement to reduce system cost



TLE5309D in iEoS



SYSTEM COST REDUCTION –
No Excitation generator & carrier filter required

DIVERSE SENSING TECHNOLOGY
(AMR & GMR)

FUNCTIONAL SAFETY –
ASIL-D Ready

HIGH ACCURACY & HIGH SPEED

REDUCED CONSTRUCTION SPACE -with
iEoS

TDSO Pkg. Grade 1 today ,Grade 0 in 2022 °

TLE5309D together with Infineon iEoS system solution reduces system cost & provides Stray field immunity

* Infineon IP , Available for Licensing

New! IFX Hybrid Kit

Fast track your Main Inverter development

Updated TC3xx Logic Board Design



Hybrid-Kit DSC



Hybrid-Kit Drive Sense



Get started quickly with IFX for inverter applications!

New! Hybrid Kit Includes

- › **IFX products** such as power modules, gate drivers, current and position sensors to develop inverter systems
- › **Hardware** Optimized logic board for testing different Hybrid-Kits for inverter applications
- › **Software** to start development of inverter for 3-phase motors

Logic Board Enhancements compared to AURIX™ TC2xx Hybrid Kit

- › Improved interface placements on logic board for compact design
- › Improved programming and debugging via on board USB miniWiggler
- › New AURIX™ TC387 features include resolver signal acquisition through DS-ADC, GTM with MCS and DTM, safety & security measures, 4 core + 2 lockstep architecture, increased CPU performance enabling complex observer
- › Board layout also supports 6-phase motors

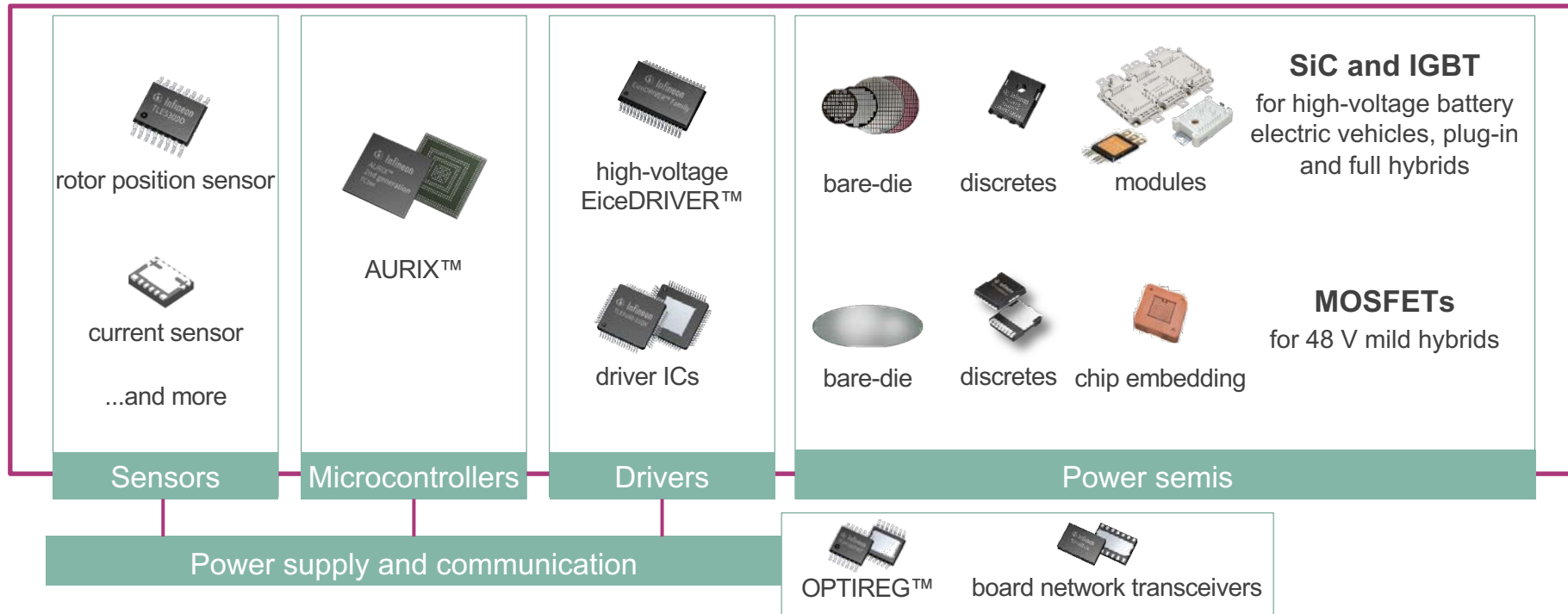
TC387 Hybrid Kit Logic Board \$950

Available for order through ISAR

Search for: HYBRID KIT LOGIC B A2G(SP005353774)

Infiniteon offers full system solutions addressing all xEV segments:
pure EV and all types of hybrid EVs

Infiniteon offers full portfolio for the control loop of an electric car





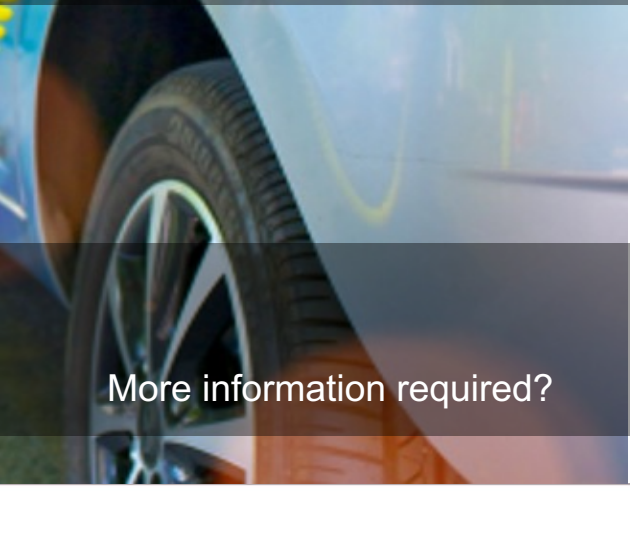
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More information required?



<https://www.infineon.com/emobility>





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