Electrifying commercial, construction and agricultural vehicles

March 2021

Agenda

1. Market trends in CAV
2. Challenges and Infineon solutions
3. Infineon components for electrification in CAV
4. Focus product tables
5. Summary

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Agenda

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Infineon focuses on the Commercial, Construction & Agriculture Vehicle (CAV) market and Megatrends

Infineon focuses on CAV and enables clean, safe and smart vehicles

Commercial vehicles

Construction vehicles

Agricultural vehicles

Semiconductors are essential to realize the megatrends in CAV

Electrification

Safety & ADAS

Connectivity & Security

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Megatrends of the CAV market are similar to those of passenger cars

Electrification

- Enhanced energy recuperation
- Electrification of side loads and powertrain
- Electrification of powertrain

- Powerful energy storage
- Efficient drive train

Safety & ADAS

- Enhanced emergency braking
- Enhanced highway pilot
- V2V – platooning
- Remote control maneuver

- Sensor fusion
- System redundancy

Connectivity & Security

- Networked information, navigation information
- Vehicle to infrastructure connectivity

- Increased data output &
- secure data- and energy supply

Challenges

IT-security | Functional safety | Energy recuperation | Diagnosis

Energy distribution | Increasing E/E complexity | Fail operational

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Application requirements and technology challenges

Application requirements	Technology challenges	Infineon enabling solutions
CO^2 reduction due to increasing regulations globally	Enable designs with environment-friendly solutions to reach efficient consumption	Highly efficient switches: Si+SiC MOSFETs, and IGBTs, both discrete and power modules
A system that aids the driver or even replaces the operator	Safe sensing, safe computing, safe actuation	ISO 26262 ready and compliant microcontrollers, gate drivers, sensors and power supplies
The lowest possible total cost of ownership (TCO)	Electronic-based and fuel-saving solutions with outstanding technology	XENSIV™ hall and angle sensors to fulfill state-of-the-art functional safety requirements at system level. AURIX™ functional safety support up to ASIL-D/ SIL3 and DC-DC converters for safe power supply.
Functional safety / fail-safe operation	Meet ISO26262 and ASIL levels	
Quality	High reliability coupled with dependable manufacturing supply	Microcontrollers and 3-phase drivers with extensive diagnostics, built-in diagnostics and sensor redundancy. Low failure rate components (dppm < 0.2)

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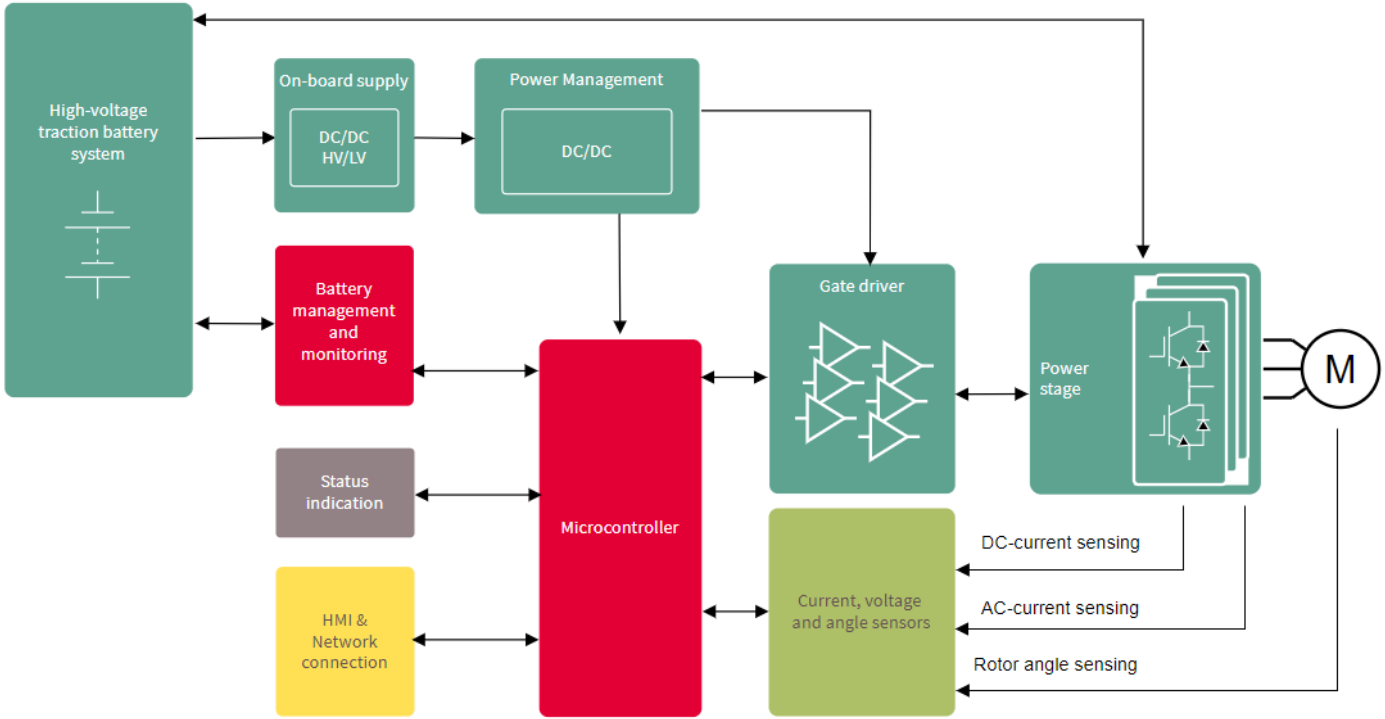
Typical block diagram in CAV



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CoolSiC™ MOSFETs

CoolSiC™ MOSFETs
Power modules mainly for auxiliary drives

FS45MR12W1M1_B11
F4-23MR12W1M1_B11

Easy 1B

≤ 23 mΩ

Sixpack
Fourpack

FF11MR12W1M1_B11
FF23MR12W1M1_B11
FF45MR12W1M1_B11

Easy 1B

≤ 11 mΩ

Half-Bridge

F4-15MR12W2M1_B76
F4-11MR12W2M1_B76
FF8MR12W2M1_B11
FF6MR12W2M1_B11

Easy 2B

≤ 6 mΩ

Fourpack Half-Bridge

FF6MR12KM1
FF8MR12KM1
FF11MR12KM1

62 mm

≤ 2 mΩ

Half-Bridge

Inverter power

2 kW

200 kW

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Evaluation boards for CoolSiC™ Easy modules

CoolSiC™ MOSFET motor drives evaluation board for 7.5 kW

204 mm x 259 mm

Benefits

- MADK is optimized to GPD / Servo drives with very high f_{sw}
- Including the Easy 1B with CoolSiC™ MOSFET in sixpack configuration
- Equipped with all assembly groups for sensorless field oriented control (FOC)
- Overtemperature and overcurrent protection as well as short circuit protection

Features

- Complete evaluation board including a 3-phase SiC power module for motor drive applications (FS45MR12W1M1_B11)
- Equipped with all assembly groups for sensorless field oriented control (FOC)
- Overtemperature and overcurrent protection as well as short circuit protection

Eval-M5-E1B1245N-SiC

click here for more information

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Evaluation boards for CoolSiC™ Easy modules

Evaluation board for CoolSiC™ Easy1B half-bridge modules

133 mm x 175 mm

Benefits

- Double pulse characterization
- Functional testing of the buck-boost operation using electrical loads at the input or output stage

Features

- Bi-directional buck-boost converter combination with the EiceDRIVER™ 1EDI60IH12AH driver.
- The configuration of the board allows to do double-pulse characterization and functional testing using electrical loads at the input or output stage

EVAL-PS-E1BF12-SiC

click here for more information

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Power modules for CAV main inverters

Power modules for CAV main inverters

Easy 1B
10 A-50 A
600 V / 1200 V
SixPACK / PIM

Easy 2B
15A-75 A
600 V / 1200 V
SixPACK / PIM

Econo 2 / Econo 3
15A-200A
650 V / 1200 V / 1700 V
SixPACK / PIM
Half-bridge

EconoDUAL™ 3 IGBT4
100A-600A
650 V / 1200 V / 1700 V
Half-bridge

EconoDUAL™ 3 IGBT7
900 A
1200 V / 1700 V
Half-bridge

HybridPACK™ Drive
200 – 950 A
750 V/ 1200 V
SixPACK
Si & SiC

FS380R12A6T4B
FS820R08A6P2B
FS05MR12A6MA1B
FS03MR12A6MA2B

Module current

10 A → **950 A**

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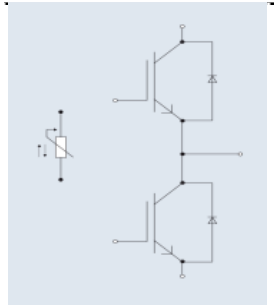
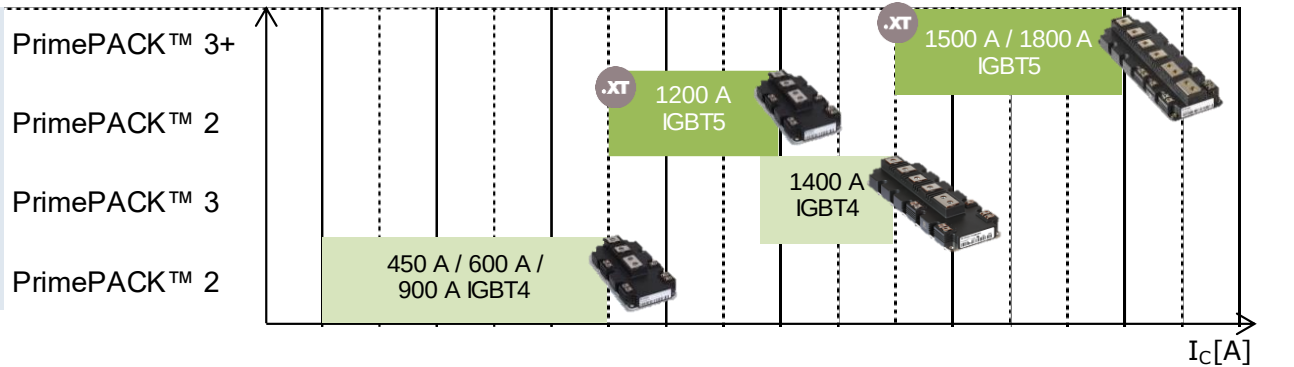
Infineon Proprietary

PrimePACK™ IGBT5 portfolio extend power range and lifetime

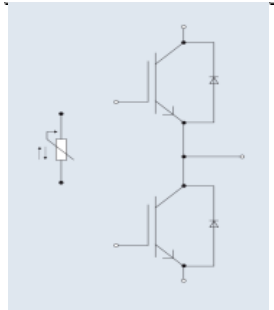
1200 V PrimePACK™



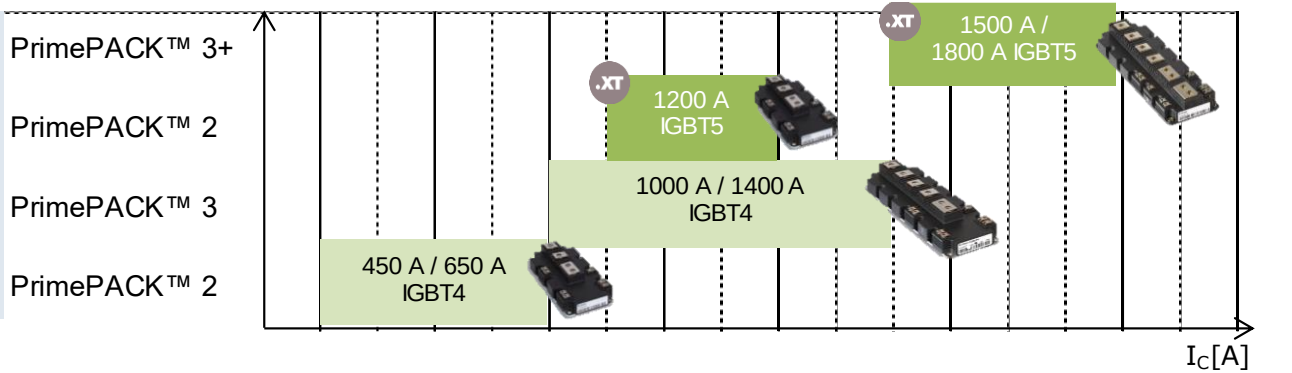
half-bridge



1700 V PrimePACK™



half-bridge



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Automotive HybridPACK™ product families – full performance spectrum of traction inverters for electric vehicles

~ Power Class*	60 kW	Medium 80 kW	100 kW	120 kW	High 150 kW	180 kW	Ultra high >180 kW
HybridPACK™ Drive Gen 1	1200V				Performance 1200 V FS380R12A6T4B		
	750V		Flat Base FS660R08A6P2FB		Wave FS770R08A6P2B	PinFin FS820R08A6P2B	Performance FS950R08A6P2B
HybridPACK™ DC6	705/750V	Flat Base FS400R07A3E3	Wave FS400R07A3E3_H6	DC6i FS650R08A4P2			

Both product families provide scalability by thermal stack

- Same geometry
- Same architecture
- Adaptation of the cooler

* Inverter power depends on individual system design of our customers

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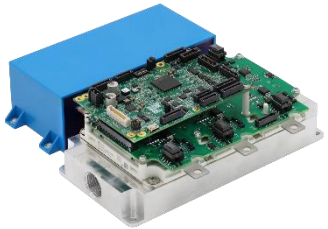
Evaluation Tools HybridPACK™ Drive - enabling customer designs

Evaluation Gate Driver Board

- Compatible to all HybridPACK™ Drive EDT2 750 V modules and 1200 V modules
- 6 channel driver PCB
- With latest Infineon EiceDRIVER™ Sense & Boost

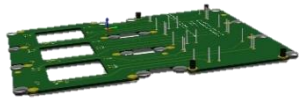


Inverter Evaluation Kit for HybridPACK™ Drive & HYBRID KIT DRIVE SENSE

- FS820R08A6P2(L)B
- With gate driver board, DC link capacitor, aluminum cooler, logic board and LEM current sensor

Inverter Evaluation Kit for "HybridPACK™ Drive 1200 V

- FS380R12A6T4B
- With gate driver board, DC link capacitor, reference aluminum cooler, logic board



HybridPACK™ Drive Thermal Test PCB

- Creepage distance designed for up to 800 V working voltage
- Easy to Use: Electric isolation due to optical measurement
- Total overview vs. single points thermo-element measurement

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Gate drivers

Infineon automotive gate driver as part of a functional safety concept
Automotive EiceDRIVER™ SIL and Boost

Functional safety at Infineon

- Organization adapted to comply with ISO26262 requirements
- ASIL C/D is a requirement at system / function level, not at IC level.
- IFX provides solutions making the implementation of a safety concept more cost efficient

PRO SIL

EiceDRIVER™ SIL - 1EDI200xAS provides a variety of safety features

- Short circuit protection e.g.: DESAT & CSENSE
- Integrated monitoring & supervision functions with failure injection (verification mode)
- Programmable two-level turn on/off or switchable DESAT blanking times
- Miller clamp output or digital isolated channel
- ISO26262 ready or compliant

EiceDRIVER™ BOOST **1EBN100xAE**

- Supports ASC & ACLI strategies
- Up to 15 A source/sink current
- Supports two-level switching
- Integrated clamping enables split output for less complex circuitry

AEC Qualified

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Customer enablement: HybridKIT™ for HybridPACK™ and high-voltage IGBT gate driver

HybridKIT™ for HybridPACK™

Features:

The new HybridKIT™ drive is an easy to use evaluation kit for a B6-bridge xEV main inverter application. It is equipped with the latest Infineon power module setting a new market benchmark: **HybridPACK™** drive **FS820R08A6P2B**.

The evaluation kit HybridKIT™ drive is intended to demonstrate the outstanding performance of the latest Infineon IGBT generation EDT2 combined with the latest module package technology **HybridPACK™** drive.

1EDI2002AS EVALKIT

Features:

- Full functionality of EiceDRIVER™ SIL or EiceDRIVER™ SENSE available (1EDI2002AS, 1EDI2010AS)
- Testing and configuring of all 1EDI2002AS/1EDI2010AS features

Benefits:

- Support for active short circuit strategies also in combination with the EiceDRIVER™ BOOST (1EBN1001AE)
- Cost effective implementation of ASIL C/D on system level
- Software Driver (source code) for 1EDI2002AS

1EDI2010AS EVALKIT

Features:

- Simple IGBT connection and testing
- Includes GUI for user friendly operation
- 12 V DC input power supply
- Communication via AURIX™ TC277

Benefits:

- Embedded ADC reduces significantly system costs
- Two-level turn-on increases the system's efficiency

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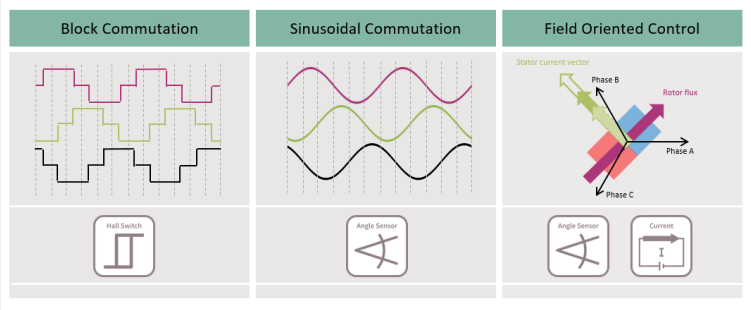
Sensors

XENSIV™ angle-sensors in electrification for drives in CAV

Broad product portfolio for all kind of electric motor commutation types

- Wide portfolio of magnetic position sensors
- Offering Hall, GMR, AMR and TMR sensors
- Digital and analog interfaces for angle sensors available
- Suitable for all commutation types for motor control
- ISO ready and ISO compliant versions
- Supporting up to ASIL-D on system level



Product examples & benefits:

- TLE5501 – analog TMR sensor
  - Low current consumption (~2 mA)
- TLE5014 – digital GMR sensor
  - Highest sensitivity
  - SPC, PWM, SENT and SPI interface
  - Accuracy: <1°
- TLE4961/4/8
  - Low power consumption
  - Small SOT23 package

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The growing Infineon angle sensor portfolio – A perfect fit for rotating applications

	iAMR	iGMR	iTMR
Digital angle (0110100)		TLI5012B TLE5012B(D) TLE5014S16(D) TLE5014P16(D) TLE5014C16(D) **TLE5014SP(D)**	
Digital sin/cos (0110100, 1101010)		TLE5011	
Analog sin/cos	TLE5109A16(D)	TLE5009 TLE5009A16(D)	TLE5501
		TLE5309D	

(D) = Single and dual die
D = Dual die only

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32-bit AURIX™ Microcontroller based on TriCore™

AURIX™ addresses CAV requirements and challenges

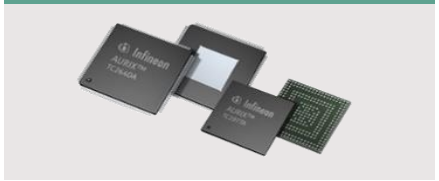
Performance

- **Multi-core technology**
- Hardware accelerators
- Floating-point unit

Functional safety & security

- Platform safety concept: ISO26262
- **IEC 61508 documentation**
- 32-bit programmable security hardware

Scalability



- Pinout compatibility
- **Scalable Hardware:**
- 1 – 6 TriCore™ cores 133 – 300 MHz
- 512 kB – 16 MB Flash
- 48 kB – 7 MB RAM

Enablement

- Expert tools
- Free tool chain
- Technical experts
- Reference designs
- **Preferred design house support**

Long-term supply availability and supply security

Automotive quality standards

OPTIREG™ PMIC power supply is the perfect fit for AURIX™

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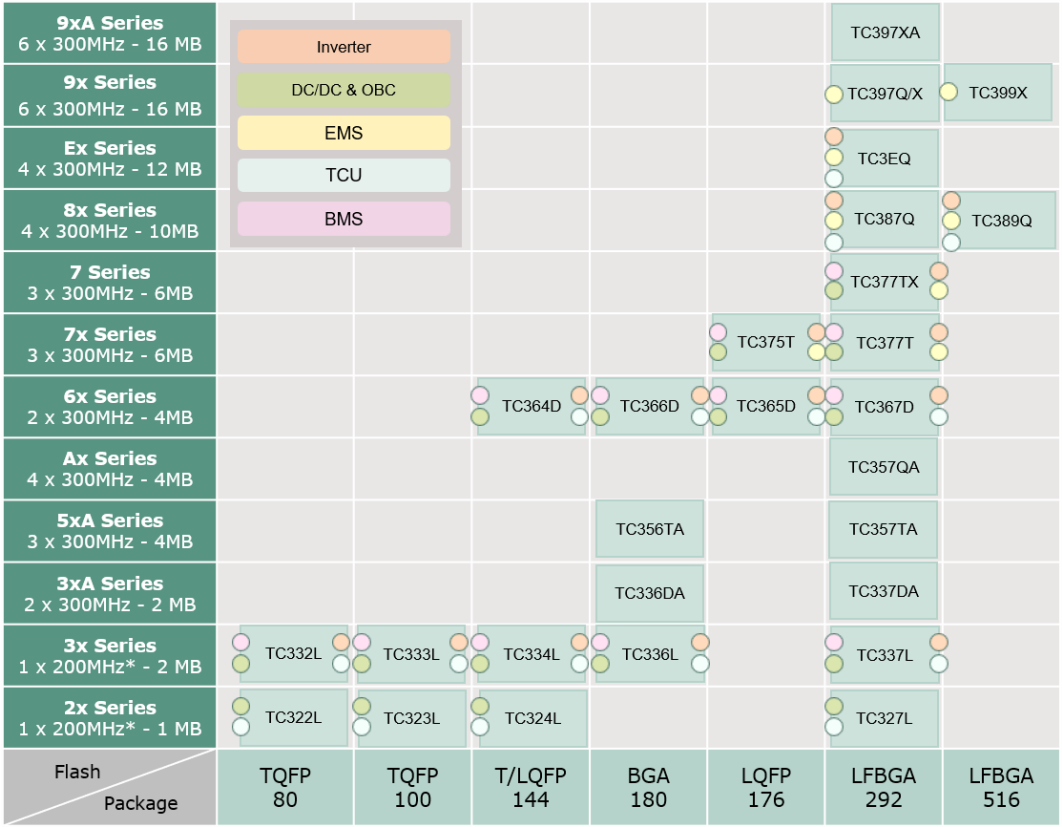
AURIX™ TC3xx – portfolio for powertrain applications



MCU scalability

- Performance & flash
- Software compatibility
- Pin-compatibility

Safety/security concept

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

Connnectivity

- Ethernet: up to 2x 1GBit/s
- CAN FD: up to 16 ch
- LIN: up to 24 ch
- eMMC IF: for external flash
- IPC: up to 2x 320MBit/s

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

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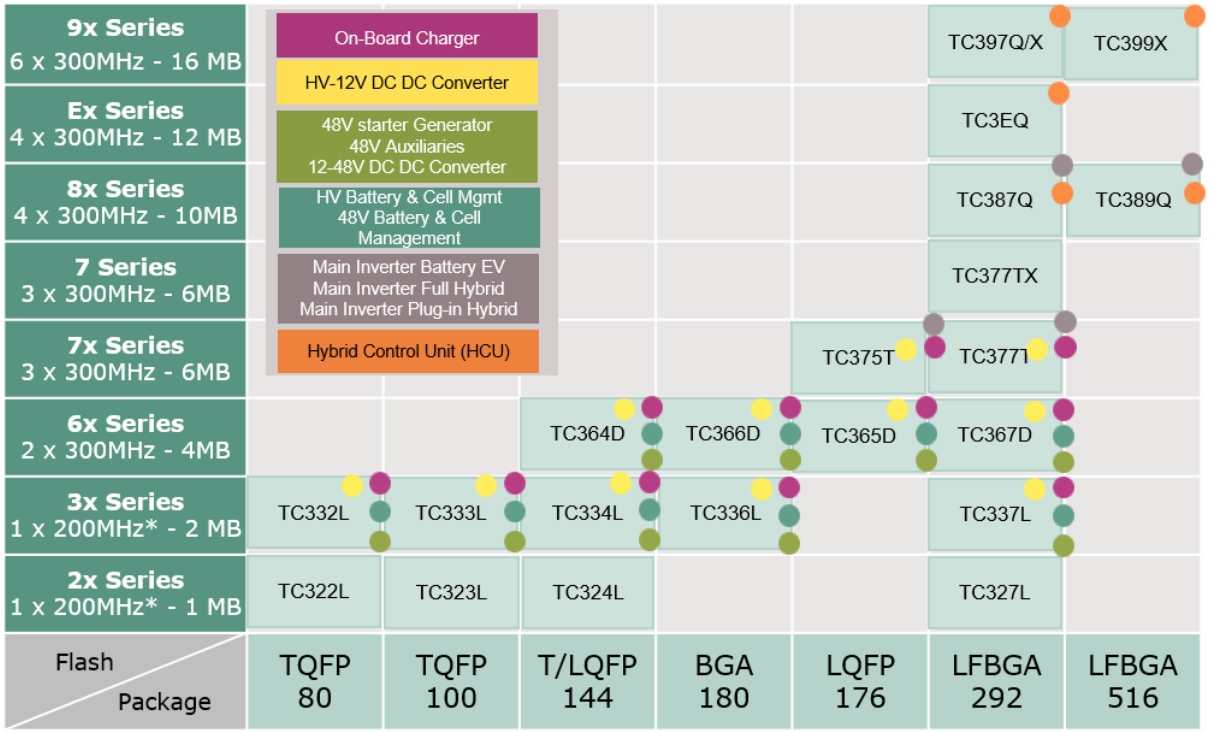
AURIX™ TC3xx family portfolio covering all applications for eMobility



AURIX™ TC3xx has the most extensive eMobility MCU portfolio available today

MCU scalability

- Performance & flash
- Software compatibility
- Pin-compatibility

Safety/security concept

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

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L - Single Lockstep Core
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Q - Quadruple Core
X - Sextuple Core

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AURIX™ TC3xx features solve challenges for Inverter

Challenges in inverter	Increased efficiency 	Functional safety 	Security requirements 	Cost reduction 	Performance increase 
AURIX™ TC3xx features	Support high frequency PWM (5ns/ 200MHz)	Implementation of safety measures in HW (LBIST)	EVITA full compliant	Replacement of resolver IC	50% clock rate increase; multi-core enables parallel development
	Sufficient capacity for complex observers (e.g. Kalman)	ISO26262 Certified from TÜV	Symmetric & asymmetric crypto accelerators	3 cores (2 lockstep) device at 6 MB (in TC2x only with 8 MB)	Enables anti-oscillation functions

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Customer enablement: AURIX™ kits

Arduino Shield Buddy

- The AURIX™ TC275 / TC375 ShieldBuddy follows the Arduino standard
- Compatible with 100's of Arduino application shields
- Evaluation licenses available
- Ideal for getting started on a high end real time embedded industrial or automotive application

KIT_AURIX_TC275_ARD_SB

KIT_AURIX_TC375_ARD_SB

AURIX™ TFT

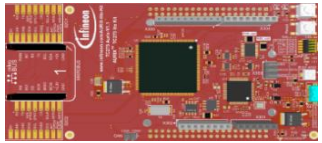
- Low cost board for early evaluation with limited access to signals
- Additional touchscreen display for convenient handling
- TFT board available

KIT_AURIX_TC2xx_TFT

AURIX™ TriBoard

- Full evaluation board for development to write and debug your 1st programs
- Includes Getting Started advice, free TriCore™ Entry Tool Chain, technical documentation, compiler and debugger
- TriBoard available for

KIT_AURIX_TC2xx_TRB



AURIX™ Lite Kit

- AURIX™ TC275 Device in LQFP-176 package
- Use of Arduino Uno/ compatible platform
- FTDI based Debugger with micro USB
- AURIX™ kit also for AURIX™ TC3xx based on the same package

KIT_AURIX_TC275_LITE

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Perfect fit for AURIX™ Supply
OPTIREG™ PMIC - TLF35584

Key features

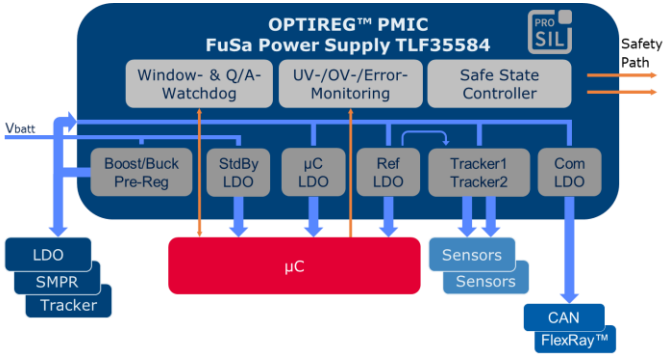
- Development acc. ISO26262
- Vin: 3V .. 40V
- Buck/Boost-Pre-Regulator
  - IQ = 1.3A; f: 300kHz-2.5MHz
- µC-Supply: 3.3V/5V @ 600mA
- Reference-LDO: 5V @ 150mA (±1%)
- 2x Tracker: 5V @ 150mA
- Communication-Supply: 5V @ 200mA
- StandBy-LDO: 3.3V/5V @ 10mA
- EN/Wake (T15 and CAN/FlexRay™)
- SPI
- Safety Features
  - Multiple bandgap (supply vs V-monitoring)
  - UV/OV-Monitoring, ERR-Monitoring
  - Functional-WD & Window-WD
  - Safe State Control/Secondary Safety Path
  - Electrically isolated/HV interconnects
  - Built In Self Test

Packages

PG-VQFN-48

PG-LQFP-64

Application block diagram



Applications

- EPS, Brake, Suspension, Domain Control
- Engine Management, Transmission, xEV
- ADAS

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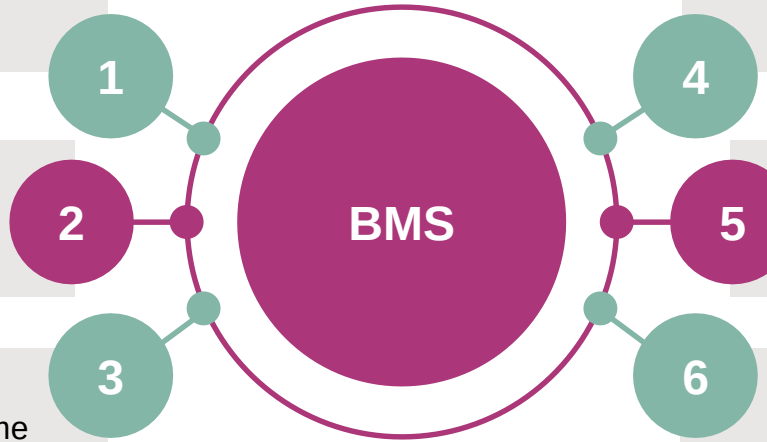
Battery management system in CAV

Every Li-Ion battery needs a “Battery management system”

Cell protection
From out of tolerance operation conditions

Cell Balancing
Equalizing the change on all the cells in the chain



SOC (State of Charge)
Estimate capacity left in the battery; range indicator

Security
Authentication and battery usage recoring

SOH (State of Health)
Estimate remaining useful lifetime of the battery

Charge control
Charging optimization, interface to charger

Capacity:

- ~200 kWh Light duty truck
- >600 kWh Bus/Truck

Usual Voltage >800 V
Usually LFP chemistry

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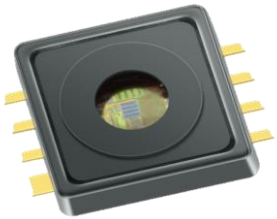
BAP sensors for Battery Management Systems (BMS)

- BMS Thermal Runaway



KP25x – barometric air pressure sensor with digital interface

Products

- Analogue interface: KP236N6165
- Digital interface: KP256, KP253

Features

- 10-bit & 12bit* SPI interface for µC
- High accuracy absolute pressure sensing
- Integrated temperature sensor
- Operating temperature up to 140°C
- Customer specific transfer functions
- Self diagnosis capability
- Automotive qualified (AEC-Q100)

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Technology / Market solutions: Links to product pages

Microcontroller

AURIX™

- ATV Quality & Temp
- Functional Safety
- Cyber Security & Authentication

TC2xx

TC3xx

OPTIREG™ PMIC

OPTIREG™

TLF35584 Family

- Multiple output PMIC for safety-relevant applications supplying µC, transceivers and sensors
- Efficient and flexible pre-/post regulator concept.

Sensor

Hall Sensors

- High redundancy on one chip
- Premium functional safety compliant systems up to ASIL-D

TLE4999I3

- Developed compliant to ISO 26262 for safety requirements rated up to ASIL-D

Angle Sensors

- Giant Magneto Resistance (GMR) – based principle

Absolute Pressure Sensors

KP253

- The KP253 is a miniaturized Digital Barometric Air Pressure Sensor IC based on a capacitive principle

Driver ICs

Automotive:

TLE9180D-21K

TLE9180D-31QK

- Advanced gate driver ICs dedicated to controlling 6 external N-channel MOSFETs forming an inverter for high current 3-phase motor drive applications in the automotive sector.

OptiMOS™ 80 V

OPTIMOS™ 80 V

IAUC100N08S5N031

IAUS165N08S5N029

- TOLL, TOLG and SS08 packages with several advantages

Transceivers

Automotive CAN Transceivers

- For flexible data rates up to 2 Mbit/s

TLE9250XSJ

Automotive EiceDRIVER™

Automotive Gate Driver ICs

1EDI2002AS

Modules

Automotive IGBT Modules

FS380R12A6T4B

FF450R08A03P2

IGBT Modules

FF600R12ME4_B11

FF900R12ME7_B11

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Summary: Get your share with Infineon's system solution excellence

- **CAV** includes truck, buses, forklift, agriculture and construction vehicles
- Infineon is responding to the megatrend **Electrification (CO2 regulations)** with our system solution excellence (TCO)

- Long term **growth drivers**: electrification and autonomous driving; a truck remains a truck
- Growing production of CAV with **growing electronic content**

- **Innovation**, **safety** and **reliability**
- Long-term **availability** of products & long-term **business**
- Infineon has the **largest portfolio** for the CAV market: **Sense – Control – Actuate** & **Enablement** solutions

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Further information on the dedicated website

www.infineon.com/cav

- Application notes
- Presentations
- Articles
- Boards
- eLearnings
- Eval kits
- Online simulation tools & product finders
- Podcasts
- Reference designs
- White papers

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