Safety EHPS: Steering systems for CAV with Infineon components

Andre Roger, Vincent Usseglio
July 2019
# Agenda

1. Introduction, market trends
2. CO\textsubscript{2} reduction with EHPS
3. Steering with lane keep assist
4. Fail-operational steering
5. Infineon components for steering
6. Fusion ECU for lane keep assist and AEB
7. Summary
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</table>
Megatrends of CAV market: similar to passenger car

Megatrends for commercial vehicles

- **Fuel efficiency**
  - Enhanced energy recuperation
  - Electrification of side loads and powertrain

- **Safety & ADAS**
  - Enhanced emergency braking
  - Enhanced highway pilot
  - V2V – platooning
  - Remote control maneuver

- **Connectivity**
  - Networked information, navigation information
  - Vehicle to infrastructure connectivity

Powerful energy storage
Efficient drivetrain

Sensor fusion
System redundancy

Increased data output
Secure data and energy supply

Challenges for CAV OEMS

- IT security
- Functional safety
- Energy distribution
- Increasing E/E complexity
- Energy recuperation
- Fail-operational
- Diagnosis
Market trends – commercial vehicles 1/2
Steering for commercial vehicles is changing

Moving from belt-driven to power on demand due to:

- CO₂ reduction regulations
- Safety regulations
- Level 3 - 4 automated driving
Steering with lane keep assist
› Using EHPS for base functionality up to level 2
› Adding one 3ph motor to generate torque overlay
› Motivation: reduced accident and insurance costs

Fail-operational steering for automated drive
› Full fault-tolerant steering
› Different variants in design
› Variants using hydraulic power
› Variants using electric-only power steering
› Synergies with fault-tolerant EPS for cars
› Motivation: highly automated trucks: level 3 / level 4
How is truck system architecture changing to enable automated drive levels?

<table>
<thead>
<tr>
<th>Level</th>
<th>Features</th>
<th>Automation Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No automation</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>Driver assistance</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Partial automation</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Conditional automation</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>High automation</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Full automation</td>
<td>5</td>
</tr>
</tbody>
</table>

- **ADAS**: automated driving assistance system
- **ADS (AD)**: automated driving system
System variants of EHPS for commercial vehicles

<table>
<thead>
<tr>
<th>System</th>
<th>Level</th>
<th>Description</th>
<th>ASIL of electronics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure hydraulic steering</td>
<td>Level 0-1</td>
<td>Mechanical pump directly on engine</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Up to 7 kW</td>
<td></td>
</tr>
<tr>
<td>Basic EHPS</td>
<td>Level 0-1</td>
<td>3-ph variable pump + hydraulic valves using a 500 Watt motor</td>
<td>ASIL-B (pressure reservoir)</td>
</tr>
<tr>
<td>Variable EHPS</td>
<td>Level 0-1</td>
<td>3-ph variable pump + additional sensors (torque, angle, vehicle speed) for variable assist</td>
<td>ASIL-B to ASIL-D (depends on minimum assistance)</td>
</tr>
<tr>
<td>EHPS with active lane keep assist</td>
<td>Level 2</td>
<td>EHPS + additional 3-ph motor to generate torque overlay</td>
<td>ASIL-D</td>
</tr>
<tr>
<td>Fail-operational steering for automated vehicles</td>
<td>Level 3-5</td>
<td>Fail-operational EHPS + fail-operational overlay</td>
<td>ASIL-D + fault-tolerant</td>
</tr>
</tbody>
</table>

Reduced CO₂
Driver assistance
Automated driving
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Variable assist 24 V EHPS for trucks – level 0-1

- **Load dump protection**
  - Active clamping
  - Pre-regulator (TLE6389)

- Same safety concept as 12 V system

- **Scalable MCU family for all variants**
  - Basic EHPS
  - Variable steering assist
  - Up to EHPS with lane keep assist (security over CAN)

- Proven platform for EPS and EHPS

- Additional feedback from torque (variable) enables energy saving through optimized pump control
# Safety goals for EHPS

## Safety goals with EHPS

- As using limited sensors, basic EHPS has lower safety requirements compared to more complex steering systems.

<table>
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<tr>
<th>Safety goal</th>
<th>ASIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid sudden loss of steering assist</td>
<td>ASIL-B (with pressure accumulator)</td>
</tr>
</tbody>
</table>

## Additional safety goals with variable assist using EHPS

- Safety goals
  - More safety goals as electronics can create several dangerous situations
  - ASIL depends on minimum torque available under failure

<table>
<thead>
<tr>
<th>Safety goal</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Avoid too low steering assist</td>
<td>ASIL-B up to ASIL-D</td>
</tr>
<tr>
<td>Avoid erroneous torque assist</td>
<td>ASIL-B up to ASIL-D</td>
</tr>
<tr>
<td>Avoid sudden loss of steering assist</td>
<td>ASIL-B (with pressure accumulator)</td>
</tr>
</tbody>
</table>

Note: Most frequently reported safety goals
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Graphic: EHPS with active lane keep assist – level 2

- 24V active steering for trucks
  - Scalable MCU family for all steering variants
  - Proven platform for EPS and EHPS
  - Same safety concept as 12V system

- 24V EHPS for trucks
  - Scalable MCU family for all variants
  - Proven platform for EPS and EHPS
  - Same safety concept as 12V system
EHPS with lane keep assist

3

Principle

› The EHPS unit is complemented by a 3ph motor to generate torque overlay
  
  – Torque overlay is computed based on the vehicle’s position in the lane

› The added system is like an EPS
  
  – 3ph motor but low torque (typically 100 W)
  
  – Has inputs from torque sensor and steering angle
  
  – Similar safety goals to EPS for cars (see details)
EHPS with lane keep assist

→ Motivation

› Lane departure is a significant cause of accidents for commercial vehicles
  - Sleepy driver
  - Unintentional movement

› EHPS allows systems to be implemented to reduce fatalities caused by lane departure
  - Detection of sleepy driver using torque sensing
    - Technique proven already in cars
    - Low-cost overhead: requires only a torque sensor
  - Driving lane detection and self-centering of steering within lanes (or vibration only on steering wheel)
    - Requires front camera + torque sensor + low power EPS

Regulation
Since end of 2015 in Europe, all new commercial vehicles weighing more than 3.5 tons and buses weighing more than 5 tons sold in the EU must be equipped with a lane departure warning system.
Additional safety goals with lane keep assist

Safety goals
› Several ASIL-D safety goals as the electronics might now cause dangerous situations

<table>
<thead>
<tr>
<th>Safety goal</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Avoid unintended self-steering</td>
<td>ASIL-D</td>
</tr>
<tr>
<td>Avoid blocked steering</td>
<td>ASIL-D</td>
</tr>
<tr>
<td>Avoid erroneous torque overlay</td>
<td>ASIL-D</td>
</tr>
<tr>
<td>Avoid sudden loss of lane keep assist</td>
<td>ASIL-B</td>
</tr>
</tbody>
</table>

Sudden loss of lane keep assist
› Currently ASIL-B, as driver is in charge of monitoring the system
› Future systems likely to evolve toward ASIL-C
24 V EPS for lane keep assist in trucks

- **Load dump protection**
  - Active clamping
  - Pre-regulator (TLE6389)

- Same safety concept as 12 V system

- **Scalable MCU family for all variants**
  - Basic EHPS
  - Variable steering assist
  - Up to EHPS with lane keep assist (security over CAN)

- Proven platform for EPS and EHPS

- Difference between EHPS and EPS: EPS enables ADAS with direct assisted steering
## Bus architectures and market segmentation for SOP2020/21 driver assistance

<table>
<thead>
<tr>
<th>Subsegment</th>
<th>Fusion scheme</th>
<th>ADAS functions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advanced</strong></td>
<td>Central</td>
<td>AEB, AES, LKA, LKS, ACC with eHorizon</td>
</tr>
<tr>
<td><strong>Nominal</strong></td>
<td>Yes, decentralized</td>
<td>AEB, LDW, LKA, ACC, highway driving assist</td>
</tr>
<tr>
<td><strong>Basic</strong></td>
<td>No</td>
<td>Radar = AEB, Camera = LDW</td>
</tr>
</tbody>
</table>

![Diagram of sensor fusion and ADAS functions](image)
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Fail-operational steering for commercial vehicles

With automated trucks, full fail-operational steering required
- Driver cannot be the back-up for electronic failure
- Redundant systems required

Different variants in design
- Variants based on hydraulic system
- Variants based on electric motor only
Future steering for automated trucks (example)

4 Fully electric 24 V EPS: 2.5 kW

System benefits

- Powerful, scalable, small footprint
- Proven interoperability
- Support of nx3 phase-based fail-safe and fail-operational EPS systems
- Aligned safety concept focused on power supply and microcontroller
- Adaptable via software to suit a range of car models and driving modes
- Upgradable to meet future requirements, such as steer-by-wire for automated driving
Fail-operational architecture demonstrator

**Goal:** Understand and work on next-generation challenges in fail-operational EPS

- PCB size
- Power dissipation
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AURIX™ addresses CAV requirements and challenges

AURIX™ – safety meets performance

**Performance**
- Multi-core technology
- HW accelerators
- Floating-point unit

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

**Scalability**
- Pinout compatibility
  - **Scalable HW:**
    - 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

Automotive quality standards

Long-term supply availability and supply security
# AURIX™ TC2xx

**From low-cost to high-performance EPS applications**

<table>
<thead>
<tr>
<th>Series</th>
<th>Flash (MB)</th>
<th>Package</th>
<th>TC297T 300 MHz</th>
<th>TC298T 300 MHz</th>
<th>TC299T 300 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>9x series</td>
<td>8 MB</td>
<td>TQFP 80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7x series</td>
<td>4 MB</td>
<td>TQFP 100</td>
<td>TC275T 200 MHz</td>
<td>TC277T 200 MHz</td>
<td></td>
</tr>
<tr>
<td>6x series</td>
<td>2.5 MB</td>
<td>T/LQFP 144</td>
<td>TC264D 200 MHz</td>
<td>TC265D 200 MHz</td>
<td>TC267D 200 MHz</td>
</tr>
<tr>
<td>3x series</td>
<td>2 MB</td>
<td>LQFP 176</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2x series</td>
<td>1 MB</td>
<td>LFBGA 292</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1x series</td>
<td>512 kB</td>
<td>BGA 416</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flash</td>
<td>TQFP 80</td>
<td>LFBGA 516</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package</td>
<td>TQFP 100</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**System solution**
- AURIX™ microcontroller
- Pre-driver & MOSFETs
- Power supply

**MCU scalability**
- Performance & Flash
- Software compatibility
- Pin compatibility
- Diverse timer architecture

**Power consumption**
- On-chip DC/DC high-efficiency power supply

**Safety/security concept**
- ISO26262 / IEC61508 compliance
- HW redundancy options
- Hardware security support

Hardware security enabled

All devices are CAN FD enabled based on DIS2015
AURIX™ TC3xx – scalable family
From low-cost to high-performance EPS and braking

<table>
<thead>
<tr>
<th>Series</th>
<th>6x series</th>
<th>3x series</th>
<th>2x series</th>
<th>Flash</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 MB</td>
<td>TC364D 300 MHz</td>
<td>TC366D 300 MHz</td>
<td>TC367D 300 MHz</td>
<td>TC322L 160 MHz</td>
</tr>
<tr>
<td>2 MB</td>
<td>TC332L 200/300 MHz</td>
<td>TC333L 200/300 MHz</td>
<td>TC334L 200/300 MHz</td>
<td>TC333L 200/300 MHz</td>
</tr>
<tr>
<td>1 MB</td>
<td>TC322L 160 MHz</td>
<td>TC323L 160 MHz</td>
<td>TC324L 160 MHz</td>
<td>TC322L 160 MHz</td>
</tr>
</tbody>
</table>

- **MCU scalability**
  - Performance & Flash
  - Pin compatibility
  - Binary compatible cores

- **Power consumption**
  - On-chip DC/DC high-efficiency power supply

- **Safety/security concept**
  - ISO26262 compliance
  - Hardware security support – eVita Full

- **Connectivity**
  - **Ethernet**: 100/1000 bps
  - **CAN FD**: up to 8 channels

- Small packages for dual-MCU architectures
- High-performance 300 MHz
- TC3xx is chosen for next platforms by lead Tier 1 players in **US, Europe, Japan, Korea and China**
- EPS and braking roadmap to be continued with TC4xx to address future trends and requirements
TLF35584 safety supply for 24 V applications

1. **Active clamping**
   - Limits input voltage to max. 40 V on input of TLF35584
   - Efficiency: -
   - Cost: ++
   - Complexity: ++
   - Flexibility: -

2. **DC-DC pre-regulator**
   - Active DC-DC pre-regulator
   - Regulates from 60 V → 15-24 V
   - Efficiency: ++
   - Cost: +
   - Complexity: +
   - Flexibility: ++
3-phase drivers
Product overview: TLE9180D-31QK/21QK

Features

› 12/24 and 48 V high-power 3-phase bridge driver
› 0-100% duty cycle
› Operating voltage range: 5.5 V to 70 V
› Logic operation down to 3 V
› High robustness: -15 V to 90 V on motor pins
› Highly configurable by SPI
› Adjustable error criteria & error reactions
› Temperature detection of external FET
› Low quiescent current
› Works in 12 V / 24 V and 48 V applications
› 2 versions:
  – TLE9180D-21QK: 2 high-performance OpAmps
  – TLE9180D-31QK: 3 high-performance OpAmps

Safety features:

› QM product with “Safety Manual” and “Safety Analysis Summary Report” up to 28 V
› High diagnostic coverage / detailed diagnosis and extended protection
› Limp-home functionality of diagnostic and failure behavior
› 2 switch-off paths by pins ENA and SOFF
› Independent phase voltage feedback
› Output for phase cut-off circuit activation

Block diagram

Package
LQFP-64

Body size
LQFP: 10mm x 10mm

In production
Global leader in automotive MOSFETs

More than 5 billion automotive MOSFETs sold since 2010

Robust
Quality level below 0.1 ppm for all automotive power MOSFETS

1.5 billion pieces shipped in FY15/16
## Product table – focus

<table>
<thead>
<tr>
<th>Component</th>
<th>Type</th>
<th>Description</th>
<th>Features</th>
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</thead>
</table>
| **AURIX™ TC2xx family:** TC23x, TC26x | TC233LP, TC234LP, TC237LP, TC264D, TC265D, TC267D | AURIX™ is Infineon's current family of 32-bit microcontrollers combining easy-to-use functional safety support (up to ASIL-D/ SIL3), a high real-time performance and a future-proven integrated Hardware Security Solution (HSM) in a highly scalable product family. | › Scalability over flash, RAM and peripherals offering the best cost/performance ratio  
› Small package for dual MCU architectures  
› High-performance 300 MHz  
› Proven safety concept to support ISO 26262 up to ASIL-D  
› Innovative supply concept leads to best-in-class power consumption |
| **OPTIREG™ DC-DC Converter:** Safety Power Supply with integrated WD TLF35584 | TLF35584QVVS1, TLF35584QVVS2, TLF35584QKVS1, TLF35584QKVS2 | The TLF35584 is a multiple output PMIC for safety-relevant applications supplying µC, transceivers and sensors with an efficient and flexible pre/post regulator concept. The wide switching frequency range allows optimization in respect of efficiency and usage of small filter components. A dedicated reference regulator supplies the ADC independent from µC load steps and acts as tracking source for the 2 independent sensor supplies. The flexible state machine, wake-up concept including timer, and the stand-by regulator makes it suited to numerous applications. Multiple safety features (watchdogs, monitoring and supervision) enable easy realization of functional safety. | › Pre-/post regulator concept: boost and buck/LDOs and trackers for  
– µC (main, ADC/reference, StBy)  
– Transceivers  
– Sensors  
› Integrated features for FuSa  
– UV/OV monitoring  
– Flexible watchdogs  
– Error monitoring  
– Safe state controller with 2 outputs  
– BIST |
| **Driver IC:** TLE9180 | TLE9180D-21QK, TLE9180D-31QK, EVALTLE9180D-31QK | The TLE9180D-21QK and TLE9180D-31QK are 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. | › Supply range from 5.5 V - 60 V  
› Powerful driver stage with typically a 2 A output current per channel  
› 0 to 100% duty cycle range  
› Two integrated current sense amplifiers for shunt signal  
› Extended protection & supervision  
› LQFP-64 exposed pad package |
| **OptiMOS™ – 80 V** | IAUT165N085N029ATMA2, IAUS165N085N029ATMA1, IAUC100N085N031ATMA1 | The portfolio combines best-in-class OptiMOS-5™ frontend technology with a leadless TOLL (PCB or Cu-based IMS) or – as an alternative – the TOLG package, targeting Al core IMS substrates but also to be used with improved TCOB performance on PCB level, both offering the highest current capability on a 10x11 mm² footprint. Additionally, the SS08 package variant offers an even smaller footprint, providing scalability to support different current and power requirements. | › TOLL package for Cu-based substrates  
› TOLG package with gullwing design for Al-based IMS or for improved TCOB performance on FR4 substrates  
› SS08 package for small footprint with lower power capability |

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**Recommended products for specific use cases, please contact Infineon sales reps.**
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<tr>
<td>CAN</td>
<td>TLE9250XSJ</td>
<td>The TLE9250XSJ is the latest Infineon High Speed CAN transceiver generation, used inside HS CAN networks for automotive and also for industrial applications. It is designed to fulfill the requirements of the current ISO11898 standard (ISO11898-2 from 2003) and also the upcoming new version of ISO 11898-2 (2016) physical layer specification. Potential applications: Engine Control Unit (ECUs) Electric Power Steering Transmission Control Units (TCUs) Chassis Control Modules</td>
<td>Fully compliant to ISO 11898-2 (2016) and SAE J2284-4/-5 Reference device and part of Interoperability Test Specification for CAN Transceiver Guaranteed loop delay symmetry for CAN FD data frames up to 5 MBit/s Very low electromagnetic emission (EME) allows the use without additional common mode choke VIO input for voltage adaption to the μC interface (3.3V &amp; 5V) Wide common mode range for electromagnetic immunity (EMI) Excellent ESD robustness +/-8kV (HBM) and +/-11kV (IEC 61000-4-2) Extended supply range on the VCC and VIO supply CAN short circuit proof to ground, battery, VCC and VIO TxD time-out function Very low CAN bus leakage current in power-down state Over temperature protection Protected against automotive transients according ISO 7637 and SAE J2962-2 standards Receive-only mode Green Product (RoHS compliant) Small, leadless TSON8 package designed for automated optical inspection (AOI) AEC Qualified</td>
</tr>
</tbody>
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High Speed CAN FD Transceiver

**Recommended products for specific use cases, please contact Infineon sales reps.**
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<th>Features</th>
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<tr>
<td><strong>Sensors:</strong> Hall sensors: TLE4999C</td>
<td>TLE4997A8D</td>
<td>The XENSIV™ TLE4999I3 provides everything necessary to fulfill state-of-the-art functional safety requirements at a system level. It has been developed in full compliance with ISO 26262. The device provides high redundancy on one chip by means of two sensor elements included within one monolithic silicon design. The two diverse Hall sensor elements (“main” and “sub”) have internally separated signal paths within the chip. A plausibility check secures the high diagnostic coverage required for premium functional safety compliant systems up to ASIL-D.</td>
<td><strong>Hall sensors</strong></td>
</tr>
<tr>
<td>TLE4998P8D</td>
<td>TLE4998S8D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLE4998C8D</td>
<td>TLE4999I3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angle sensors: TLE5014D</td>
<td>TLE5014S16D</td>
<td></td>
<td></td>
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<tr>
<td>TLE5014C16D</td>
<td>TLE5014P16D</td>
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</tbody>
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**Hall sensors**
- Two highly accurate redundant Hall measurement channels (main and sub) integrated on one chip
- Developed in compliance with ISO 26262 for safety requirements rated up to ASIL-D
- PSi5 v2.1-compatible interface in synchronous mode with high-speed P10P-400/4H protocol
- Bi-directional interface for programming via fast SICI interface
- 13-bit output signals, protected by CRC and rolling counters
- Digital temperature and stress compensation
- 3-pin leaded package for mounting in PCB-less modules
- Operating junction temperature range -40°C to 150°C
- Main and sub channel independently programmable in EEPROM
- 16-bit user configurable ID in EEPROM
- Supply voltage 5.5 to 7 V

**Angle sensor**
- Giant Magneto Resistance (GMR)-based principle
- Two identical dies in one package (providing channel 1 and channel 2 output)
- Fully redundant 2-channel solution for highest functional safety requirements
- High voltage and reverse polarity capability
- EEPROM for storage of configuration (e.g. zero angle) and customer-specific ID
- 12-bit representation of absolute angle value on the output
- Max. 1° angle error over lifetime and temperature range
- Developed according to ISO 26262 with process complying with ASIL-D
- Internal safety mechanisms with diagnostic coverage >97% for each channel
- Interfaces: PWM, SPC, SENT (based on SAE J2716-2010)
- 32-point look-up table to correct for systematic angle errors (e.g. magnetic circuit)
- 112-bit customer ID (programmable)
- Automotive qualified Q100, Grade 1: -40°C to 125°C (ambient temperature)

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**Recommended products for specific use cases, please contact Infineon sales reps.**
**Product table – focus**

<table>
<thead>
<tr>
<th>Component</th>
<th>Type</th>
<th>Description</th>
<th>Features</th>
</tr>
</thead>
</table>
| Rotor position – iGMR angle sensor TLE5309D or TLE5012BD | Redundant angle sensor | The TLE5309D is a diverse redundant angle sensor with analog outputs. It combines a Giant Magneto Resistance (GMR) sensor for full 360° angle range with an Anisotropic Magneto Resistance (AMR) sensor for high precision in a flipped configuration in one package. Sine and cosine angle components of a rotating magnetic field are measured by Magneto Resistive (MR) elements. The sensors provide analog sine and cosine output voltages that describe the magnetic angle in a range of 0 to 180° (AMR sensor), and 0 to 360° (GMR sensor), respectively. | › Separate supply pins for AMR and GMR sensor  
› Diverse redundant design with one GMR sensor (top die) and one AMR sensor (bottom die) in one package  
› Low current consumption and very fast start-up  
› 360° contactless angle measurement  
› Immune to air gap variations due to MR-based sensing principle  
› Operating temperature: -40°C to 125°C (ambient temperature) |
| TLE5012BD | Fully redundant angle sensor | The TLE5012BD is a fully redundant 360° angle sensor that detects the orientation of a magnetic field. This is achieved by measuring sine and cosine angle components with monolithic integrated Giant Magneto Resistance (iGMR) elements. Highly precise angle values are determined over a wide temperature range and a long lifetime using an internal auto calibration algorithm. Data communications are accomplished with a bi-directional Synchronous Serial Communication (SSC) that is SPI-compatible. | › GMR-based principle  
› Fully redundant design with two sensor ICs in one package  
› Integrated magnetic field sensing for angle measurement  
› 360° angle measurement with revolution counter and angle speed measurement  
› Two separate highly accurate single-bit SD-AD  
› 15-bit representation of absolute angle value on the output (resolution of 0.01°)  
› 16-bit representation of sine/cosine values on the interface  
› Max. 1.0° angle error over lifetime and temperature range with activated auto-calibration  
› Bi-directional SSC interface up to 8 Mbit/s  
› Supports Safety Integrity Level (SIL) with diagnostic functions and status information  
› Interfaces: SSC, PWM, Incremental Interface (IIF), Hall Switch Mode (HSM), Short PWM Code (SPC, based on SENT protocol defined in SAE J2716)  
› Output pins can be configured (programmed or pre-configured) as push-pull or open-drain  
› Bus mode operation of multiple sensors on one line is possible with SSC or SPC interface in open-drain configuration  
› 0.25 μm CMOS technology  
› ESD > 4kV (HBM) |

**Recommended products for specific use cases, please contact Infineon sales reps.**
Agenda

1. Introduction, market trends
2. CO₂ reduction with EHPS
3. Steering with lane keep assist
4. Fail-operational steering
5. Infineon components for steering
6. Fusion ECU for lane keep assist and AEB
7. Summary
New steering systems for commercial vehicles

**EHPS steering**
- Benefit: CO₂ reduction
- Required by more and more country regulations

**Electrified EHPS**
- Benefits: Lane assistance functions
- Insurance cost reductions; regulations starting to change

**Fail-operational steering**
- Benefits: Automated driving
- Several variants in design for 2020

**1-stop shop**
- Infineon is covering 100% of the BOM

**Optimized engineering efforts**
- Infineon organization worldwide to support you
- Safety and electronic experts across the globe
Part of your life. Part of tomorrow.