CONTENTS

Introduction

1. ATV Motor Control at a Glance and Infineon Offering
   1.1. Motor Control Architecture and Offering Depend on Multiple Criteria
   1.2. Infineon Offers Solutions for All Kinds of Automotive Motor Control
   1.3. Seamless Motor Control Offerings Powered by Infineon
   1.4. Infineon Offers the Most Complete Range of Solutions for Motor Control

2. High-Integrated Solutions for Compact Motor Control Designs
   2.1. Infineon Embedded Power ICs — System-on-Chip Motor Control

3. Medium-Integrated Solutions for Motor Control
   3.1. Single Half-Bridges
   3.2. Multi-Half-Bridge ICs
   3.3. Full- or H-Bridge

4. Low-Integrated Solutions for High-Power Motor Control
   4.1. Gate Driver ICs for External MOSFETs
   4.2. MOSFETs
   4.3. Power Supply
   4.3.1. Linear Voltage Regulators
   4.3.2. DC/DC Converters
   4.4. User Interface and Communications: Transceivers
   4.5. Sensors: Hall Switches
   4.6. Angle Sensors
   4.7. Microcontrollers: Introduction to TC21x, TC22x
Introduction

The number of electrical motors in cars is growing steadily. Nowadays, on average, there are about 30 motors distributed in an automobile. This number rises to about 70 motors in premium cars. In the last years, the unit CAGR (Compound Annual Growth Rate) has always been in the range between 5 and 6 percent. It is expected that in 2019, there will be 3.5 billion electrical motors built only into cars. This development is being caused by various factors. Over a long period, mechanical solutions were state of the art for oil pumps, water pumps, fuel pumps and hydraulic pumps. Since CO$_2$ reduction has become a very high priority in the field of transportation, these mechanical pumps were gradually replaced by smart, electrically controlled motors. Instead of continuously using energy with a combustion engine, the electric motors can be switched and speed-controlled on demand. Another impulse to increase the number of electrical motors in cars is comfort and premium equipment, which is now increasingly requested in mid-range cars. Last, but not least, advanced safety features such as crash avoidance, driving assistants and autonomous driving in the future also drive the electrical motor market forward. This growing number of functionalities in cars requires reliable, cost-effective, smaller and flexible semiconductor solutions for Motor Control. Infineon provides such semiconductor solutions and steadily extends the portfolio of semiconductors needed for smart and modern Motor Control, such as MOSFETs, Bridge Drivers, Integrated Bridges, Smart Power Controllers, Microcontrollers, Sensors and Power Supplies.
1. ATV MOTOR CONTROL AT A GLANCE AND INFINEON OFFERING

1.1. Motor Control Architecture and Offering Depend on Multiple Criteria

The application and environmental requirements have to be fulfilled with the available components and resources of the component supplier and the supporting ecosystem.

In order to achieve an Automotive Safety Integrity Level (ASIL) according to ISO 26262, Functional Safety is getting ever more important. Infineon has partially outsourced the safety support for AURIX™ microcontrollers to a selection of Preferred Design Houses. In this way, even small- and medium-sized customers can implement support-intensive safety applications.

1.2. Infineon Offers Solutions for All Kinds of Automotive Motor Control

Whatever you touch in a car, there is an electric motor close by. Brushed DC motors are easy to control and often serve as actuators with an overall short operating time. Torque control down to zero speed is easy to achieve.
Brushless DC (BLDC) motors have less wear but need a complex control algorithm and, therefore, higher computing power than a DC motor drive. BLDC motors are most suitable for applications demanding long-term continuous duty like fuel pumps.

As Image 2 shows, DC and BLDC drives are widely spread in a car.

1.3. Seamless Motor Control Offerings Powered by Infineon

The matrix below compares three levels of function integration: low, medium, and high. Every level has its own characteristic set of benefits. Image 3 can serve as a first-decision help in which direction to go for your application.
1.4. Infineon Offers the Most Complete Range of Solutions for Motor Control

Infineon and Rutronik ABU support all three levels of integration with state-of-the-art components. The choice is yours.

The picture below shows the major function blocks of a motor control design with Infineon’s key components for each block. Chapters 3, 4 and 5 go into further detail regarding the component proposals for each of the three levels of integration.

<table>
<thead>
<tr>
<th>Integration Type</th>
<th>Low Integration</th>
<th>Medium Integration</th>
<th>High Integration</th>
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- **Current**: ⭐⭐⭐
- **Protection**: ⭐⭐⭐
- **Space constraint**: ⭐⭐⭐
- **Flexibility**: ⭐⭐⭐
- **Benefits**: Higher Ambient Temperatures, Low Development Effort, Least Wiring Smallest Space

**Image 4**: Components from Infineon cover each function of the application

- **System-on-chip ePower**
  - TLE984x for relay and P/N MOSFET drive
  - TLE986x and TLE987x for BDC and BLDC control

- **Power supply**
  - TLE4xxx
  - TLS8xx
  - TLS11x
  - TLE736x

- **Transceiver**
  - TLE625x CAN
  - TLE725x CAN/LIN
  - TLE92xx CAN FD

- **Microcontroller**
  - AURIX™ TC21x series
  - AURIX™ TC22x series

- **Motor control**
  - TLE7183/4/5/6/9 gate driver ICs
  - SFETS 40/80 V MOSFETs
  - NovalithIC™ BTN8962TA, BTN8982TA
  - Multi half-bridge driver ICs TLE94xy
  - H-bridge TLE9201

- **Hall & angle sensors**
  - TLE496x
  - TLE50xx

- **Position sensor**
2. HIGH-INTEGRATED SOLUTIONS FOR COMPACT MOTOR CONTROL DESIGNS

Infineon’s monolithic Embedded Power ICs (ePower) offer both the benefits of function integration and the flexibility that is needed to have the optimal power MOSFETs for the load.

2.1. Infineon Embedded Power ICs — System-on-Chip Motor Control

Infineon® Embedded Power ICs are specifically designed to enable mechatronic motor control solutions for a range of motor control applications in which a small package form factor and a minimum number of external components are essential. Such applications include window lift, sunroof, wiper, fuel pump, HVAC fans, engine cooling fan and water pumps, to name but a few. Produced on Infineon’s first-in-industry automotive-qualified Smart Power technologies, the Infineon Embedded Power System-on-Chip (SoC) solutions offer an unmatched Infineon® Embedded Power ICs level of integration of all functions required to sense, control and actuate a motor. The Infineon® Embedded Power ICs integrate on a single die the...
microcontroller, the non-volatile flash memory, the analog and mixed signal peripherals, the communication interfaces along with the driving stages needed for either relay, half-bridge or full-bridge DC and BLDC motor applications.

**Applications, Key Features & Benefits**

### Applications

› Power window lift  
› High-end sun roof  
› Wiper  
› Fan/blower control  
› Relay (e.g. to switch motor)

### Key Features & Benefits

› ARM® Cortex™-M3 processor, 24/40 MHz, enables field-oriented motor control (FOC)
› Scalable Flash memory: 36 kB to 128 kB
› Current programmable NFET driver with charge pump based on patented slope control for – Optimized EMC behavior – Scalable MOSFET driver

› Integrated PWM/LIN transceiver compatible with LIN standard 2.x and SAE J2602-s-supports fast programming via LIN
› 10-Bit SAR ADC for current sensing synchronized with the internal PWM signal generation unit
› Wide operating range, \(V_s=5.4\text{ V to } 28\text{ V}\)

Image 7: The decision tree helps you find the best fit: An ePower-device or a less integrated solution.
Automotive Motor Drives

Image 8: ePower selection tree for drives with brushed DC motors

- **Brushed Motor (DC)**
  - Uni-directional
    - Half-bridge with P/N-channel MOSFET
      - AEC-Q100 Grade 1
    - Half-bridge with N/N-channel MOSFET
      - AEC-Q100 *Grade 0
- **Bi-directional**
  - N/N-channel MOSFET
    - Sensorless Rotor-position (e.g. ripple-count)
    - Rotor-position sensor
      - Sensor

- **ePower TLE9845-QX**
  - P-MOSFET
  - N-MOSFET
- **ePower TLE9867-QXW20**
  - 2*N-MOSFET
- **ePower TLE9861/7/9-QXA40**
  - 2*N-MOSFET
  - Sensor
- **HVAC**
- **Fuelpump**
- **Engine Cooling Fan**
- **Window Lift**
- **Sunroof**
- **Seat**

AEC-Q100
*Grade 0
AEC-Q100
Grade 1
AEC-Q100
Grade 1
Image 9: ePower selection tree for drives with BLDC motors

- **Brushless Motor**
  - **Uni-directional**
    - **BLDC**
      - **Rotor-position sensor**
        - **Sensorless**
          - **Low dynamic requirements**
            - AEC-Q100 *Grade 0
              - ePower TLE9873/7/9 QX W40
              - 6N-MOSFET
            - AEC-Q100 *Grade 0
              - ePower TLE9871/7/9 QX W40
              - 6N-MOSFET
            - AEC-Q100 *Grade 0
              - ePower TLE9873/7/9 QX W40
              - 6N-MOSFET
            - AEC-Q100 *Grade 0
              - ePower TLE9871/7/9 QX W40
              - 6N-MOSFET
          - **High dynamic requirements**
            - AEC-Q100 *Grade 0
              - ePower TLE9873/7/9 QX W40
              - 6N-MOSFET
            - AEC-Q100 *Grade 0
              - ePower TLE9871/7/9 QX W40
              - 6N-MOSFET
            - AEC-Q100 *Grade 0
              - ePower TLE9873/7/9 QX W40
              - 6N-MOSFET
            - AEC-Q100 *Grade 0
              - ePower TLE9871/7/9 QX W40
              - 6N-MOSFET

- **PMSM (FOC controlled)**
  - **Sensorless**
  - **Rotor-position sensor**
    - AEC-Q100 *Grade 0
      - ePower TLE9873/7/9 QX W40
      - 6N-MOSFET
    - AEC-Q100 *Grade 0
      - ePower TLE9871/7/9 QX W40
      - 6N-MOSFET
    - AEC-Q100 *Grade 0
      - ePower TLE9873/7/9 QX W40
      - 6N-MOSFET
    - AEC-Q100 *Grade 0
      - ePower TLE9871/7/9 QX W40
      - 6N-MOSFET

- **Applications**
  - Gearbox-Oil Pumps
  - Engine Oil Pumps
  - Fuel Pump
  - Engine Cooling Fan
  - Aux. Water Pumps
  - HVAC Blower
  - 6N-MOSFET

- **AEC-Q100**
  - Grade 0
  - Grade 1

- **Additional Components**
  - Engine
  - Cooling Fan
  - Fuel Pump
Image 10: Selection tree depending on output bridge topology

Selection tree - Infineon Embedded Power IC motor control

- **Relay motor control**
  - TLE9842QX
  - TLE9842-2QX
  - TLE9843QX
  - TLE9843-2QX
  - TLE9844QX
  - TLE9844-2QX

- **PN half-bridge motor control**
  - TLE9845QX

- **H-bridge motor control**
  - TLE9861QXA20
  - TLE9867QXA20
  - TLE9867QXA40
  - TLE9869QXA20

- **3-phase bridge motor control**
  - TLE9871QXA20
  - TLE9877QXA20
  - TLE9877QXA40
  - TLE9879QXA20
  - TLE9879QXA40
Table 1: Product overview ePower devices

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<th>RAM [kB]</th>
<th>EEPROM in flash included [kB]</th>
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<th>Package</th>
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3. MEDIUM-INTEGRATED SOLUTIONS FOR MOTOR CONTROL

The medium-integrated devices combine gate-drivers with the MOSFET power stage in a single package. A small footprint on the PCB, diagnostic feedback and protection add to the benefits of the integration.

Infineon’s portfolio comprises Single-Half-Bridges, Multi-Half-Bridges and Full- or H-Bridges. Image 11 shows an application example.

3.1. Single Half-Bridges

The integrated high-current motor drivers family NovalithIC™ provides a complete low-ohmic-protected half-bridge in a single package. It can be combined with an additional NovalithIC™ to create an H-bridge or 3-phase bridge as well. The NovalithIC™ family has the capability to switch high-frequency PWM while providing overcurrent, overvoltage and overtemperature protection. The NovalithIC™ family offers cost-optimized solutions for protected high-current PWM motor drives with very low board-space consumption — scaled to your needs.
Applications, Key Features & Benefits

Applications
› Fuel pump
› Sun roof
› Electric parking brake
› Fans
› HVAC blower
› Body control module
› Engine cooling fan
› Wiper
› Tail gate
› Sliding door

Key Features & Benefits
› Integrated half-bridge
› PWM capability
› Logic-level input: Connects directly to MCU
› Current limitation for reduced power dissipation & short-circuit protection
› Adjustable slew rates for optimized EMI
› Current sense capability
› Overtemperature shut down
› Integrated dead-time generation

Table 2: NovalithIC™ product overview

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<th>Product name</th>
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<th>$R_{DS(on)}$ path (typ) [mΩ]</th>
<th>$I_{DSSM}$ (typ) [μA]</th>
<th>$I_{DSS}$ (typ) [μA]</th>
<th>Switch time (typ) [μs]</th>
<th>Diagnosis</th>
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</tr>
<tr>
<td>BTN8982TA</td>
<td>5.50 ... 40.00</td>
<td>10.00</td>
<td>70</td>
<td>7</td>
<td>0.25</td>
<td>OT, OC, CS</td>
<td>UV, OT, OC</td>
<td>TO263-7-1 (TO220-7 (SMD))</td>
</tr>
</tbody>
</table>

OC = Overcurrent
UV = Undervoltage
CS = Current Sense
OT = Overtemperature
3.2. Multi-Half-Bridge ICs

The TLE94xyz are protected half-bridge drivers designed for automotive motion control applications such as small DC motors for flaps in Heating, Ventilation and Air Conditioning (HVAC), as well as mirror adjustment and fold. All devices can drive DC motor loads up to 0.9 A per output in cascaded or parallel operation. They provide diagnosis of short circuit, open load, power supply failure and overtemperature for each half-bridge to ensure safe operation in HVAC or other systems. The TLE94xyz offers enhanced EMC performance, which, in combination with the low quiescent current and a small package, makes the products attractive for automotive and other applications.

Applications, Key Features & Benefits

Applications

› Flap motors in HVAC systems
› Mirror adjustment and fold
› Small DC motors (≤ 0.9 A/output)
› Bi-stable relays

Key Features & Benefits

› 6-, 8-, 10-, 12-half-bridges with integrated output stages and PWM
› 16-bit SPI or direct inputs for control and diagnosis
› Voltage supply range: 5.5–20 V
› Adjustable open-load threshold for two outputs
› Variable driving schemes for up to 11 motors
› Diagnosis of each output via SPI
› Device operates down to 5.5 V (supporting start-stop systems of fuel-efficient vehicles)
› OUT 1 and 2 optimized for driving HS loads (e.g., LED)

Table 3: Product overview TLE94xyz multi half bridge driver

<table>
<thead>
<tr>
<th>Product name</th>
<th>Config.</th>
<th>IL(NOM) [A]</th>
<th>IL(lim)[A]</th>
<th>Iq [μA]</th>
<th>VS(OP) [V]</th>
<th>Protection</th>
<th>Diagnostic interface</th>
<th>Highlights</th>
<th>VCE(sat) /RDS(on)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLE94106EL</td>
<td>6x H-bridge</td>
<td>6 x 0.30</td>
<td>6 x 0.90</td>
<td>0.6</td>
<td>5.5 … 21</td>
<td>OC, OT, OL, VS UV/OV</td>
<td>16-bit SPI</td>
<td>TLE94xyz family concept + backwards compatible to TLE84106EL</td>
<td>850 mΩ/sywitch</td>
<td>SSOP-24</td>
</tr>
<tr>
<td>TLE94108EL</td>
<td>8x H-bridge</td>
<td>8 x 0.30</td>
<td>8 x 0.90</td>
<td>0.6</td>
<td>5.5 … 21</td>
<td>OC, OT, OL, VS UV/OV</td>
<td>16-bit SPI</td>
<td>TLE94xyz family concept</td>
<td>850 mΩ/sywitch</td>
<td>SSOP-24</td>
</tr>
<tr>
<td>TLE94110EL</td>
<td>10x H-bridge</td>
<td>10 x 0.30</td>
<td>10 x 0.90</td>
<td>0.6</td>
<td>5.5 … 21</td>
<td>OC, OT, OL, VS UV/OV</td>
<td>16-bit SPI</td>
<td>TLE94xyz family concept + backwards compatible to TLE84110EL</td>
<td>850 mΩ/sywitch</td>
<td>SSOP-24</td>
</tr>
<tr>
<td>TLE94112EL</td>
<td>12x H-bridge</td>
<td>12 x 0.30</td>
<td>12 x 0.90</td>
<td>0.6</td>
<td>5.5 … 21</td>
<td>OC, OT, OL, VS UV/OV</td>
<td>16-bit SPI</td>
<td>TLE94xyz family concept + 12 outputs in one package</td>
<td>850 mΩ/sywitch</td>
<td>SSOP-24</td>
</tr>
</tbody>
</table>
### 3.3. Full- or H-Bridge

TLE9201SG is a general-purpose 6A H-Bridge designed for the control of small DC motors and inductive loads. It meets the harsh automotive environmental conditions and it is qualified in accordance with the AEC-Q100 standard.

#### Applications, Key Features & Benefits

**Applications**

› Exhaust gas recirculation (EGR)
› Variable eometry turbo (VGT)
› Idle speed control
› Swirl and tumble flaps

› Variable intake manifold
› Turbo charger waste gates
› Auxiliary water pumps
› Industrial DC motor applications

**Key Features & Benefits**

› \( R_{DS(on)} \) (typ.) < 100 mΩ per switch
› Operation voltage: 4.5 V to 28 V
› Fully 3.3/5.5 V compatible logic inputs
› Low standby current
› Short-circuit and overtemperature protection
› VS undervoltage protection
› Open-load detection in ON and OFF state
› Detailed SPI diagnosis or simple error flag

› Qualified according to automotive standard AEC-Q100
› Green product (RoHS compliant)
› Small package saves board space
› Includes overcurrent and overtemperature protection
› Simple design with few external components
› SPI enables for easy diagnosis

#### Table 4: Product overview TLE9201 H-bridge

<table>
<thead>
<tr>
<th>Product name</th>
<th>( R_{DS(on)} ) HS [mΩ]</th>
<th>( R_{DS(on)} ) LS [mΩ]</th>
<th>( I_{LIM} ) min. [A]</th>
<th>( I_{Q} ) max. [mA]</th>
<th>( V_{SOPP} ) [V]</th>
<th>Diagnostic IF</th>
<th>( V_{DD} ) mon.</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLE9201SG</td>
<td>100</td>
<td>100</td>
<td>6.00</td>
<td>0.03</td>
<td>5.00 ... 28.00</td>
<td>SPI and Status Flag</td>
<td>5.00 ... 28.00</td>
<td>DSO-12</td>
</tr>
</tbody>
</table>
4. LOW-INTEGRATED SOLUTIONS FOR HIGH-POWER MOTOR CONTROL

The low-integrated solution with discrete components gives you the flexibility of selecting the optimal device for each function. The result is a tailor-made design that fits the application like a glove. Especially, high-current drives benefit from the use of the latest MOSFETs with the lowest $R_{DS(on)}$ in thermally optimized packages.

Have a look at gate-drivers, power MOSFETs, voltage regulators for power supply, transceivers for communication over LIN or CAN, Hall sensors and microcontrollers. Image 12 shows an application example of DC motor control using discrete components.
4.1. Gate Driver ICs for External MOSFETs

The trend toward greater efficiency in automotive applications also applies to electric motors. Applications such as power steering, HVAC compressors and engine-cooling fans will be controlled by electronic motors in the future. Infineon’s family of configurable, H-bridge and 3-phase gate driver ICs can be combined with MOSFETs to provide the power and efficiency these systems demand.

Applications, Basic Features

Applications

› Power steering
› Fan and pump control
› Starter alternator
› Seat belt pretensioner
› VVT
› Electric park brake
› ECMT
› E-turbo

Basic Features

› Strong output stage up to 1.5 A
› Precise OpAmp for current shunt monitoring
› Operation down to 5.5 V
› Duty cycle adjustable

Selection tree - Gate drivers
### Table 5: Product overview
3-phase bridge driver ICs

<table>
<thead>
<tr>
<th>Product name</th>
<th>Operating range [V]</th>
<th>Drives stage</th>
<th>D.C.-range @20 kHz [%]</th>
<th>Numbers of integrated OpAmps for load current measurement</th>
<th>Adjustable dead time</th>
<th>SIL3 features</th>
<th>Diagnosis</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLE7183F</td>
<td>5.50 ... 28.00</td>
<td>1.50/1.50 A</td>
<td>0 ... 100</td>
<td>1</td>
<td>✔</td>
<td></td>
<td>OT, UV, OV, OC, OCD</td>
<td>VQFN-48</td>
</tr>
<tr>
<td>TLE7183QU</td>
<td>5.50 ... 28.00</td>
<td>1.50/1.50 A</td>
<td>0 ... 100</td>
<td>1</td>
<td>✔</td>
<td></td>
<td>OT, UV, OV, OC, SCD</td>
<td>TQFP-48 EP</td>
</tr>
<tr>
<td>TLE7184F</td>
<td>7.00 ... 32.00</td>
<td>12.50/9.00 Ω</td>
<td>0 ... 95</td>
<td>1</td>
<td>✔</td>
<td></td>
<td>UV, OV, OC, SCD, OT, VDD supervision</td>
<td>VQFN-48</td>
</tr>
<tr>
<td>TLE7184F-3V</td>
<td>8.00 ... 17.00</td>
<td>12.50/9.00 Ω</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLE7186F</td>
<td>7.00 ... 32.00</td>
<td>12.50/9.00 Ω</td>
<td>0 ... 95</td>
<td>0</td>
<td>✔</td>
<td></td>
<td>UV, OV, SC, OT</td>
<td>DSO-36 EP</td>
</tr>
<tr>
<td>TLE7188F</td>
<td>5.50 ... 28.00</td>
<td>1.50/1.50 A</td>
<td>0 ... 100</td>
<td>3</td>
<td>✔</td>
<td></td>
<td>UV, OV, OC, SC, OT</td>
<td>VQFN-48</td>
</tr>
<tr>
<td>TLE7189F</td>
<td>5.50 ... 28.00</td>
<td>1.50/1.50 A</td>
<td>0 ... 100</td>
<td>3</td>
<td>✔</td>
<td></td>
<td>UV, OV, SC, OT, VDD supervision</td>
<td>VQFN-48</td>
</tr>
<tr>
<td>TLE7189QK</td>
<td>5.50 ... 28.00</td>
<td>1.50/1.50 A</td>
<td>0 ... 100</td>
<td>3</td>
<td>✔</td>
<td></td>
<td>UV, OV, SC, OT, VDD supervision</td>
<td>LQFP-64</td>
</tr>
<tr>
<td>AUIRS20302</td>
<td>8.00 ... 17.00</td>
<td></td>
<td>0.20/0.35 A</td>
<td>1 (SC protection)</td>
<td></td>
<td></td>
<td>One error flag for OTW, UV, SC</td>
<td>DSO-28</td>
</tr>
</tbody>
</table>

1) System IC for fans and pumps with integrated LDO and PWM interface
4.2. MOSFETS

Automotive MOSFETs

Infineon’s automotive MOSFET portfolio offers benchmark quality, wide voltage range and diversified packages.

Key Features & Benefits
- Best-in-class $R_{DS(on)}$ performance for increased system efficiency
- Lowest switching and conduction power losses for increased thermal system reliability
- Benchmark for quality and reliability
- Wide voltage range from 24 V to 300 V for N-Channel FET, and from 20 V to 150 V for P-Channel FET
- Robust green package for easy process handling
- Diversified package portfolio for easy process handling
  - Package size minimization (down to 11 mm$^2$ in S308)
  - High current capability (up to 300 A in TOLL)

Infineon automotive MOSFET naming system

- **I**: Infineon
- **P**: for Power-MOSFET
- **G**: for twin Power-MOSFET (common drain)
- **20**: Continuous drain current $I_D$(max)
- **N**: for N-Channel
- **04**: Breakdown voltage $V_{BrDSS}$
- **S4**: for OptiMOS™
- **L**: for logic level
- **07**: AOI-ready only valid for TDSON dual
- **A**: Legacy Part Numbering System
- **-**:  $R_{DS(on)}$(max) in mΩ
  - “H” in front for higher ohmic version
  - i.e. H5 = 5.5 mΩ
  - “R” as decimal separator
  - i.e. 1R3 = 1.3 mΩ
- **B**: for TO263/D²PAK
- **C**: for SuperSO8 (TDSON-8)
- **D**: for TO252/DPAK
- **I**: for TO262/I²PAK
- **LU**: for TO-leadless (H-PSOF, MO-299)
- **P**: for TO220
- **G**: for dual SuperSO8 (TDSON-8)
- **Z**: for shrink SuperSO8 (TSDSON-8)
- **P**: for P-Channel
- **N**: for N-Channel
- **L**: for logic level

Legacy Part Numbering System

- **S**: for SFET1
- **S2**: for OptiMOS™
- **S3**: for OptiMOS™-T
- **S4**: for OptiMOS™-T2
- **S5**: for OptiMOS™-5
- **P3**: for PFET3 trench
- **P4**: for PFET4 trench
Automotive MOSFET naming system for new products

Part Numbering System for new MOSFETs

- **I**: Infineon
- **A**: Automotive
- **U/X**: Standard/extended (i.e. qualification)
- **Package type:**
  - A: sTOLL
  - B: TO263/D²PAK
  - C: Single SSO8 (TDSON-8)
  - D: TO252/DPAK
  - E: Embedding standard cell
  - G: Dual SSO8 (TDSON-8)
  - I: TO262/1²PAK
  - P: TO220
  - T: TOLL (H-PSOF, MO-299)
  - S: SUPiRPAK
  - Z: S308 (TSDSON-8)

- Optional (i.e. customized)
- \( R_{DS(on)} \) (max) xx.x mΩ
- **Logic level**
  - L: Logic level
  - N: Normal level
- **S5**: OptiMOS™-5
- **Breakdown voltage:** \( V_{BRDS} + 10 \)
- **P**: P-Channel
- **N**: N-Channel
- **Continuous drain current** \( I_D \) (max)
Table 6: 40 V, single N-Channel MOSFET overview in SSO8 package

<table>
<thead>
<tr>
<th>Sales Name</th>
<th>max Ron 10V (mOhm)</th>
<th>ID (A)</th>
<th>LL/NL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPC100N04S5-1R2</td>
<td>1.2</td>
<td>100</td>
<td>NL</td>
</tr>
<tr>
<td>IPC100N04S5L-1R1</td>
<td>1.1</td>
<td>100</td>
<td>LL</td>
</tr>
<tr>
<td>IPC100N04S5-1R7</td>
<td>1.7</td>
<td>100</td>
<td>NL</td>
</tr>
<tr>
<td>IPC100N04S5L-1R5</td>
<td>1.5</td>
<td>100</td>
<td>LL</td>
</tr>
<tr>
<td>IPC100N04S5-1R9</td>
<td>1.9</td>
<td>100</td>
<td>NL</td>
</tr>
<tr>
<td>IPC100N04S5L-1R9</td>
<td>1.9</td>
<td>100</td>
<td>LL</td>
</tr>
<tr>
<td>IPC100N04S5-2R8</td>
<td>2.8</td>
<td>100</td>
<td>NL</td>
</tr>
<tr>
<td>IPC100N04S5L-2R6</td>
<td>2.6</td>
<td>100</td>
<td>LL</td>
</tr>
<tr>
<td>IPC90N04S5-3R6</td>
<td>3.6</td>
<td>90</td>
<td>NL</td>
</tr>
<tr>
<td>IPC90N04S5L-3R3</td>
<td>3.3</td>
<td>90</td>
<td>LL</td>
</tr>
<tr>
<td>IPC70N04S5-4R6</td>
<td>4.6</td>
<td>70</td>
<td>NL</td>
</tr>
<tr>
<td>IPC70N04S5L-4R2</td>
<td>4.2</td>
<td>70</td>
<td>LL</td>
</tr>
<tr>
<td>IPC50N04S5-5R8</td>
<td>5.8</td>
<td>50</td>
<td>NL</td>
</tr>
<tr>
<td>IPC50N04S5L-5R5</td>
<td>5.5</td>
<td>50</td>
<td>LL</td>
</tr>
</tbody>
</table>
### Table 7: 40 V, single N-Channel MOSFET overview in S3O8 package

<table>
<thead>
<tr>
<th>Sales Name</th>
<th>Technology</th>
<th>max Ron 10V (mOhm)</th>
<th>ID (A)</th>
<th>LL/NL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPZ40N045SL-2R8</td>
<td>OptiMOS-5 40V</td>
<td>2.8</td>
<td>40</td>
<td>LL</td>
</tr>
<tr>
<td>IPZ40N045S-3R1</td>
<td>OptiMOS-5 40V</td>
<td>3.1</td>
<td>40</td>
<td>NL</td>
</tr>
<tr>
<td>IPZ40N045SL-4R8</td>
<td>OptiMOS-5 40V</td>
<td>4.8</td>
<td>40</td>
<td>LL</td>
</tr>
<tr>
<td>IPZ40N045S-5R4</td>
<td>OptiMOS-5 40V</td>
<td>5.4</td>
<td>40</td>
<td>NL</td>
</tr>
<tr>
<td>IPZ40N045SL-7R4</td>
<td>OptiMOS-5 40V</td>
<td>7.4</td>
<td>40</td>
<td>LL</td>
</tr>
<tr>
<td>IPZ40N045S-8R4</td>
<td>OptiMOS-5 40V</td>
<td>8.4</td>
<td>40</td>
<td>NL</td>
</tr>
</tbody>
</table>

### Table 8: 40 V & 80 V, N-Channel MOSFETs in Package TOLL

<table>
<thead>
<tr>
<th>Sales Name</th>
<th>Technology</th>
<th>max Ron (mOhm)</th>
<th>ID (A)</th>
<th>LL/NL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPLU300N04S4-R8</td>
<td>OptiMOS-T2 40V</td>
<td>0.77mOhm</td>
<td>300</td>
<td>NL</td>
</tr>
<tr>
<td>IPLU300N04S4-1R1</td>
<td>OptiMOS-T2 40V</td>
<td>1.1mOhm</td>
<td>300</td>
<td>NL</td>
</tr>
<tr>
<td>IPLUS0N04S4-1R7</td>
<td>OptiMOS-T2 40V</td>
<td>1.7mOhm</td>
<td>250</td>
<td>NL</td>
</tr>
<tr>
<td>IAUT300N08S5N012</td>
<td>OptiMOS 5 80V</td>
<td>1.2mOhm</td>
<td>300</td>
<td>NL</td>
</tr>
<tr>
<td>IAUT165N08S5N029</td>
<td>OptiMOS 5 80V</td>
<td>2.9mOhm</td>
<td>165</td>
<td>NL</td>
</tr>
</tbody>
</table>
4.3. Power Supply

In automotive ECUs, microcontrollers and other electronic system components have to be supplied by a stable and reliable voltage that is lower than the battery voltage (e.g., 3.3 V or 5 V) and works over the entire temperature range (from –40°C to 150°C). Depending on the application — i.e., the output current and the requested system efficiency — linear voltage regulators or DC-DC converters are ideal for use in the automotive world.

4.3.1. Linear Voltage Regulators

Table 9: Product overview linear voltage regulators

<table>
<thead>
<tr>
<th>Product</th>
<th>Packages</th>
<th>Operating Voltage min</th>
<th>Operating Voltage max</th>
<th>Output Voltage Type</th>
<th>Accuracy</th>
<th>Output Current (max.)</th>
<th>Regulator Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLS11580/D0</td>
<td>PG-DSO-8 / PG-TSON-9</td>
<td>4.0 V</td>
<td>40.0 V</td>
<td>adj.</td>
<td>0.1 %</td>
<td>150mA</td>
<td>Linear-&gt;Tracker</td>
</tr>
<tr>
<td>TLE4250-2</td>
<td>PG-SCT595-5</td>
<td>4.0 V</td>
<td>40.0 V</td>
<td>adj.</td>
<td>0.5 %</td>
<td>50mA</td>
<td>Linear-&gt;Tracker</td>
</tr>
<tr>
<td>TLE4251</td>
<td>PG-TO252-5 / PG-TO263-5</td>
<td>4.0 V</td>
<td>40.0 V</td>
<td>adj.</td>
<td>0.5 %</td>
<td>300mA</td>
<td>Linear-&gt;Tracker</td>
</tr>
<tr>
<td>TLE4252</td>
<td>PG-TO252-5</td>
<td>3.5 V</td>
<td>40.0 V</td>
<td>adj.</td>
<td>0.5 %</td>
<td>200mA</td>
<td>Linear-&gt;Tracker</td>
</tr>
<tr>
<td>TLE4253</td>
<td>PG-DSO-8 / PG-DSO-8-EP</td>
<td>3.5 V</td>
<td>40.0 V</td>
<td>adj.</td>
<td>0.5 %</td>
<td>250mA</td>
<td>Linear-&gt;Tracker</td>
</tr>
<tr>
<td>TLE4254</td>
<td>PG-DSO-8 / PG-DSO-8-EP</td>
<td>4.0 V</td>
<td>45.0 V</td>
<td>adj.</td>
<td>0.1 %</td>
<td>70mA</td>
<td>Linear-&gt;Tracker</td>
</tr>
<tr>
<td>TLE4291E</td>
<td>PG-SSOP-14</td>
<td>3.3 V</td>
<td>45.0 V</td>
<td>5.0 V</td>
<td>2.0 %</td>
<td>450mA</td>
<td>Linear</td>
</tr>
<tr>
<td>TLS820F0</td>
<td>PG-SSOP-14</td>
<td>3.0 V</td>
<td>40.0 V</td>
<td>3.3, 5.0 V</td>
<td>2.0 %</td>
<td>200mA</td>
<td>Linear-&gt;High Performance Regulators</td>
</tr>
<tr>
<td>TLS850DQ/-F0</td>
<td>PG-TO263-7 / PG-TO252-5</td>
<td>3.0 V</td>
<td>40.0 V</td>
<td>3.3, 5.0 V</td>
<td>2.0 %</td>
<td>500mA</td>
<td>Linear-&gt;High Performance Regulators</td>
</tr>
<tr>
<td>TLE4473G V55-2</td>
<td>PG-DSO-12</td>
<td>5.6 V</td>
<td>42.0 V</td>
<td>5.0 V</td>
<td>2.5 %</td>
<td>2.0 %</td>
<td>300mA</td>
</tr>
</tbody>
</table>

Image 14: When to choose a DC/DC converter

<table>
<thead>
<tr>
<th>Linear regulators</th>
<th>DC-DC converters</th>
</tr>
</thead>
<tbody>
<tr>
<td>› Cost optimized for current &lt; 500 mA</td>
<td>› Higher power density</td>
</tr>
<tr>
<td>› Lower design outlay</td>
<td>› Better system efficiency</td>
</tr>
<tr>
<td>› Less noise, less filtering</td>
<td>› Cost optimized for current &gt; 500 mA</td>
</tr>
<tr>
<td>› Large portfolio</td>
<td></td>
</tr>
<tr>
<td>› Small packages, e.g., newly released TSON-10 leadless package with automated optical inspection</td>
<td></td>
</tr>
</tbody>
</table>
### 4.3.2. DC/DC Converters

Table 10: Product overview DC/DC converters

<table>
<thead>
<tr>
<th>Product name</th>
<th>VS (op)</th>
<th>VQ</th>
<th>VQ2</th>
<th>VQ3</th>
<th>VQ4</th>
<th>Accuracy 1 [%]</th>
<th>Accuracy 2 [%]</th>
<th>Accuracy 3 [%]</th>
<th>Accuracy 4 [%]</th>
<th>Additional output accuracy</th>
<th>IQ [mA]</th>
<th>IQ2 [mA]</th>
<th>IQ3 [mA]</th>
<th>IQ4 [mA]</th>
<th>IQ additional [mA]</th>
<th>IQ [mA]</th>
<th>IQ2 [mA]</th>
<th>IQ3 [mA]</th>
<th>IQ4 [mA]</th>
<th>IQ additional [mA]</th>
<th>fsw [kHz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buck plus linear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLE7368</td>
<td>4.50 ... 45.00</td>
<td>5.50</td>
<td>5.00</td>
<td>2.60 or 3.30</td>
<td>1.50</td>
<td>2 x 5</td>
<td>-2.00 ... +9.00</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1.50</td>
<td>2500</td>
<td>800</td>
<td>700</td>
<td>Adj.</td>
<td>105 and 50</td>
<td>120</td>
<td>280 ... 425</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLE7368-2</td>
<td>4.50 ... 45.00</td>
<td>5.50</td>
<td>5.00</td>
<td>2.60 or 3.30</td>
<td>1.20</td>
<td>2 x 5</td>
<td>-2.00 ... +9.00</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1.50</td>
<td>2500</td>
<td>800</td>
<td>700</td>
<td>Adj.</td>
<td>105 and 50</td>
<td>120</td>
<td>280 ... 425</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLE7368-3</td>
<td>4.50 ... 45.00</td>
<td>5.50</td>
<td>5.00</td>
<td>2.60 or 3.30</td>
<td>1.30</td>
<td>2 x 5</td>
<td>-2.00 ... +9.00</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1.50</td>
<td>2500</td>
<td>800</td>
<td>700</td>
<td>Adj.</td>
<td>105 and 50</td>
<td>120</td>
<td>280 ... 425</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.4. User Interface and Communications: Transceivers

Infineon offers a broad product portfolio of automotive transceivers — all of which are perfectly suited and designed to withstand the harsh automotive environment — for the various automotive bus segments. Different transceiver types are used in accordance with the respective vehicle network architecture and the related ECU supply path. Infineon transceivers ensure reliable communication and help minimize the current consumption and associated CO₂ emissions at the vehicle level. Thanks to their high performance, ruggedness and reliable communication, Infineon’s transceiver products offer the ultimate in value.

Table 11: Product overview bus transceivers for LIN, CAN and CAN-FD

<table>
<thead>
<tr>
<th>Product name</th>
<th>Transmission rate (max)</th>
<th>Low-power mode Iq [μA] (max)</th>
<th>Bus wake-up capability</th>
<th>Wake-up inputs</th>
<th>Number of channels</th>
<th>Bus failure management</th>
<th>Fast programming</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single LIN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLE7257SJ</td>
<td>20 kbit/s</td>
<td>&lt; 15 sleep mode</td>
<td>I</td>
<td>1</td>
<td>1</td>
<td>I</td>
<td>DSO-8</td>
<td></td>
</tr>
<tr>
<td>TLE7258SJ</td>
<td>20 kbit/s</td>
<td>&lt; 15 sleep mode</td>
<td>I</td>
<td>1</td>
<td>1</td>
<td>I</td>
<td>DSO-8</td>
<td></td>
</tr>
<tr>
<td>TLE7259-3GE</td>
<td>20 kbit/s</td>
<td>&lt; 10 sleep mode</td>
<td>I</td>
<td>1</td>
<td>1</td>
<td>I</td>
<td>DSO-8</td>
<td></td>
</tr>
</tbody>
</table>
# Table 11, continued: Product overview bus transceivers for LIN, CAN and CAN-FD

<table>
<thead>
<tr>
<th>Product name</th>
<th>Transmission rate (max)</th>
<th>Low-power mode $I_q$ [$\mu$A] (max)</th>
<th>Bus wake-up capability</th>
<th>Wake-up inputs</th>
<th>Number of channels</th>
<th>Bus failure management</th>
<th>CAN FD</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High-speed CAN ISO 11898-2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLE7250SJ</td>
<td>2 Mbit/s</td>
<td>&lt; 12 @ 5 V power save mode</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>I</td>
<td>DSO-8</td>
</tr>
<tr>
<td>TLE7250LE</td>
<td>2 Mbit/s</td>
<td>&lt; 12 @ 5 V power save mode</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>I</td>
<td>TSON-8</td>
</tr>
<tr>
<td>TLE9250SJ</td>
<td>5 Mbit/s</td>
<td>&lt; 20 @ 5 V power save mode</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>I</td>
<td>DSO-8</td>
</tr>
<tr>
<td>TLE9250LE</td>
<td>5 Mbit/s</td>
<td>&lt; 20 @ 5 V power save mode</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>I</td>
<td>TSON-8</td>
</tr>
<tr>
<td><strong>High-speed CAN ISO 11898-5</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLE6251-2G</td>
<td>1 Mbit/s</td>
<td>&lt; 30 sleep mode</td>
<td>I</td>
<td>I</td>
<td>1</td>
<td>I</td>
<td></td>
<td>DSO-14</td>
</tr>
<tr>
<td>TLE6251-3G</td>
<td>1 Mbit/s</td>
<td>&lt; 30 sleep mode</td>
<td>I</td>
<td>I</td>
<td>1</td>
<td>I</td>
<td></td>
<td>DSO-14</td>
</tr>
</tbody>
</table>
4.5. Sensors: Hall Switches

The TLE4961-xM is an integrated Hall effect latch designed specifically for highly accurate applications with superior supply voltage capability, operating temperature range and temperature stability of the magnetic thresholds.

### Applications, Key Features & Benefits

#### Applications

- BLDC (commutation)
- Window lifter (index counting)
- Power closing (index counting)

#### Key Features & Benefits

- 3.0 V to 32 V operating supply voltage
- Operation from unregulated power supply
- Reverse polarity protection (–18 V)
- Overvoltage capability up to 42 V without external resistor
- Output overcurrent & overtemperature protection
- Active error compensation
- High stability of magnetic thresholds
- Low jitter (typ. 0.35 s)
- High ESD performance
- Derivatives with different switching thresholds available
- Small SMD package PG-SOT23-3-15 (TLE4961-1M)

### Product Table

<table>
<thead>
<tr>
<th>Product</th>
<th>Group</th>
<th>Packages</th>
<th>Type</th>
<th>Bop (25°C)</th>
<th>Brp (25°C)</th>
<th>Direction Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLE4961-1M</td>
<td>Latch</td>
<td>PG-SOT23-3</td>
<td>Latch</td>
<td>2.0 mT</td>
<td>-2.0 mT</td>
<td>no</td>
</tr>
<tr>
<td>TLE4961-2M</td>
<td>Latch</td>
<td>PG-SOT23-3</td>
<td>Latch</td>
<td>5.0 mT</td>
<td>-5.0 mT</td>
<td>no</td>
</tr>
<tr>
<td>TLE4961-3M</td>
<td>Latch</td>
<td>PG-SOT23-3</td>
<td>Latch</td>
<td>7.5 mT</td>
<td>-7.5 mT</td>
<td>no</td>
</tr>
<tr>
<td>TLE4961-4M</td>
<td>Latch</td>
<td>PG-SOT23-3</td>
<td>Latch</td>
<td>10.0 mT</td>
<td>-10.0 mT</td>
<td>no</td>
</tr>
<tr>
<td>TLE4961-5M</td>
<td>Latch</td>
<td>PG-SOT23-3</td>
<td>Latch</td>
<td>15.0 mT</td>
<td>-15.0 mT</td>
<td>no</td>
</tr>
<tr>
<td>TLE4968-1M</td>
<td>Latch</td>
<td>PG-SOT23-3</td>
<td>Latch</td>
<td>1.0 mT</td>
<td>-1.0 mT</td>
<td>no</td>
</tr>
</tbody>
</table>
4.6. Angle Sensors

The TLE5012B, TLE5012BD are full 360° GMR-based Digital Angle Sensors with the smallest angle error over lifetime and temperature, high update rate, high resolution and prediction mode to optimize delay times for the best dynamic applications.

Applications, Key Features & Benefits

<table>
<thead>
<tr>
<th>Applications</th>
<th>Key Features &amp; Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>☺ BLDC Rotor position sensing for electric motor commutation (motors, actuators)</td>
<td>☻ Designed for 3.3 V &amp; 5 V systems</td>
</tr>
<tr>
<td>☻ Steering angle sensing</td>
<td>☻ Interfaces: HSM, IIF, SPI, PWM, SPC</td>
</tr>
<tr>
<td>☻ General angular sensing</td>
<td>☻ ≤1° angle error over all</td>
</tr>
<tr>
<td>☻ TLE5012BD particularly suitable for a wide range of functional safety-critical applications</td>
<td>☻ Automotive qualified (Tj-40 °C /150 °C)</td>
</tr>
<tr>
<td>☻ General angular sensing</td>
<td>☻ Supports ISO 26262</td>
</tr>
</tbody>
</table>

Table 13: Product overview angle sensor TLE5012

Product Table

<table>
<thead>
<tr>
<th>Product</th>
<th>Group</th>
<th>Packages</th>
<th>Package</th>
<th>Interfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLE5012B E1000</td>
<td>Angle Sensors</td>
<td>PG-DSO-8</td>
<td>SMD</td>
<td>SPI, IIF</td>
</tr>
<tr>
<td>TLE5012B E3005</td>
<td>Angle Sensors</td>
<td>PG-DSO-8</td>
<td>SMD</td>
<td>SPI, HSM</td>
</tr>
<tr>
<td>TLE5012B E5000</td>
<td>Angle Sensors</td>
<td>PG-DSO-8</td>
<td>SMD</td>
<td>SPI, PWM</td>
</tr>
<tr>
<td>TLE5012B E9000</td>
<td>Angle Sensors</td>
<td>PG-DSO-8</td>
<td>SMD</td>
<td>SPI, SPC</td>
</tr>
<tr>
<td>TLE5012BD E1200</td>
<td>Dual Angle Sensor — for Functionally Safe Systems (ISO26262)</td>
<td>PG-TDSO-16</td>
<td>Dual SMD</td>
<td>SPI, IIF</td>
</tr>
<tr>
<td>TLE5012BD E9200</td>
<td>Dual Angle Sensor — for Functionally Safe Systems (ISO26262)</td>
<td>PG-TDSO-16</td>
<td>Dual SMD</td>
<td>SPI, SPC</td>
</tr>
</tbody>
</table>
The TLE5009 is a Full 360° GMR-based Analog Angle Sensor available in single- and dual-die versions for safety-relevant applications in hysteresis-free PG-TDSO-16 pin packaging.

### Applications, Key Features & Benefits

#### Applications
- Rotor position sensing for electric motor commutation
- Rotary switches
- Steering angle sensing
- Valve or flap position sensing

#### Key Features & Benefits
- Analog output of sine and cosine
- Built in offset temperature compensation
- ~9 µs delay time, up to 30,000 rpm
- Reduced hysteresis
- 0.5° typical angle error accuracy at fully compensated mode
- Automotive qualified (Tj-40 °C /125 °C)
- Supports ISO 26262

---

**Table 14: Product overview angle sensor TLE5009**

<table>
<thead>
<tr>
<th>Product</th>
<th>Group</th>
<th>Description</th>
<th>Packages</th>
<th>Package</th>
<th>Interfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLE5009 E1000</td>
<td>Angle Sensors</td>
<td>Vdd: 3.3V; static offset compensation</td>
<td>PG-DSO-8</td>
<td>SMD</td>
<td>Analog</td>
</tr>
<tr>
<td>TLE5009 E1010</td>
<td>Angle Sensors</td>
<td>Vdd: 3.3V; temperature compensated offset</td>
<td>PG-DSO-8</td>
<td>SMD</td>
<td>Analog</td>
</tr>
<tr>
<td>TLE5009 E2000</td>
<td>Angle Sensors</td>
<td>Vdd: 5V; static offset compensation</td>
<td>PG-DSO-8</td>
<td>SMD</td>
<td>Analog</td>
</tr>
<tr>
<td>TLE5009 E2010</td>
<td>Angle Sensors</td>
<td>Vdd: 5V; temperature compensated offset</td>
<td>PG-DSO-8</td>
<td>SMD</td>
<td>Analog</td>
</tr>
</tbody>
</table>
4.7. Microcontrollers: Introduction to TC21x, TC22x

The AURIX™ 32-bit microcontroller family is based on the Infineon Tricore™ high-performance core concept and provides a very high-scalability family from single-core to multi-core. The latest diverse lockstep technology with clock delay reduces the software overhead significantly and enables fast time-to-market.

With the companion IC, TLF35584, the AURIX™ has their special voltage supply IC with supervision functions for ASIL.

Features
› Dedicated peripheral set: LIN, CAN, CAN-FD, SPI, FlexRay, Ethernet
› Advanced timer unit for totally flexible PWM generation and hardware input capture
› Redundant flexible 12-bit ADC
› ISO 26262 conformance to support safety requirements up to ASIL-D
› Innovative supply concept leads to best-in-class power consumption
› Safety and development support by Infineon’s Preferred Design Houses, see list on www.infineon.com/pdh
### Table 15: TC2xx, features overview

<table>
<thead>
<tr>
<th>Product type</th>
<th>Max clock frequency [MHz]</th>
<th>Program memory [KByte]</th>
<th>SRAM (incl. cache) [KByte]</th>
<th>Co-processor$^1$</th>
<th>Cores/lockstep</th>
<th>Timed I/O GP/O</th>
<th>Number of ADC channels</th>
<th>External bus interface</th>
<th>CAN/CAN-FD nodes</th>
<th>Communication interfaces$^1$</th>
<th>Temperature ranges$^3$</th>
<th>Packages</th>
<th>Additional features/remarks$^4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC224L</td>
<td>133</td>
<td>1000</td>
<td>96</td>
<td>FPU</td>
<td>1/1</td>
<td>120</td>
<td>24</td>
<td>No</td>
<td>3</td>
<td>2x ASCLIN, 4x QSPI, 4x SENT</td>
<td>K</td>
<td>TQFP-144</td>
<td>EVR, WUT</td>
</tr>
<tr>
<td>TC223L</td>
<td>133</td>
<td>1000</td>
<td>96</td>
<td>FPU</td>
<td>1/1</td>
<td>78</td>
<td>24</td>
<td>No</td>
<td>3</td>
<td>2x ASCLIN, 4x QSPI, 4x SENT</td>
<td>K</td>
<td>TQFP-100</td>
<td>EVR, WUT</td>
</tr>
<tr>
<td>TC222L</td>
<td>133</td>
<td>1000</td>
<td>96</td>
<td>FPU</td>
<td>1/1</td>
<td>59</td>
<td>14</td>
<td>No</td>
<td>3</td>
<td>2x ASCLIN, 4x QSPI, 4x SENT</td>
<td>K</td>
<td>TQFP-80</td>
<td>EVR, WUT</td>
</tr>
<tr>
<td>TC214L</td>
<td>133</td>
<td>500</td>
<td>96</td>
<td>FPU</td>
<td>1/1</td>
<td>120</td>
<td>24</td>
<td>No</td>
<td>3</td>
<td>2x ASCLIN, 4x QSPI, 4x SENT</td>
<td>K</td>
<td>TQFP-144</td>
<td>EVR, WUT</td>
</tr>
<tr>
<td>TC213L</td>
<td>133</td>
<td>500</td>
<td>96</td>
<td>FPU</td>
<td>1/1</td>
<td>78</td>
<td>24</td>
<td>No</td>
<td>3</td>
<td>2x ASCLIN, 4x QSPI, 4x SENT</td>
<td>K</td>
<td>TQFP-100</td>
<td>EVR, WUT</td>
</tr>
<tr>
<td>TC212L</td>
<td>133</td>
<td>500</td>
<td>96</td>
<td>FPU</td>
<td>1/1</td>
<td>59</td>
<td>14</td>
<td>No</td>
<td>3</td>
<td>2x ASCLIN, 4x QSPI, 4x SENT</td>
<td>K</td>
<td>TQFP-80</td>
<td>EVR, WUT</td>
</tr>
</tbody>
</table>

1) FPU = Floating Point Unit
2) ASCLIN = Asyn/Synchronous Local Interconnect Network, QSPI = Queued Serial Peripheral Interface, SENT = Single Edge Nibble Transmission, SSC = Synchronous Serial Channel
3) Ambient temperature range: A = -40 ... 140 °C, B = 0 ... 70 °C, F = -40 ... 85 °C, H = -40 ... 110 °C, K = -40 ... 125 °C, L = -40 ... 150 °C, X = -40 ... 105 °C
4) EVR = Embedded Voltage Regulator, WUT = Wake-Up Timer
Table 16: Product overview AURIX™ 32-bit microcontrollers, series TC21x, TC22x

<table>
<thead>
<tr>
<th>Product name</th>
<th>Packages</th>
<th>Clock Frequency max</th>
<th>SRAM (incl. Cache)</th>
<th>CAN Nodes</th>
<th>A/D Input Lines (incl. FADC)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AURIX™ Family — TC21xL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAK-TC214L-8F133F AB</td>
<td>PG-TQFP-144</td>
<td>133.0 MHz</td>
<td>56.0 kByte</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>SAK-TC213L-8F133F AB</td>
<td>PG-TQFP-100</td>
<td>133.0 MHz</td>
<td>56.0 kByte</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>SAK-TC213S-8F133F AB</td>
<td>PG-TQFP-100</td>
<td>133.0 MHz</td>
<td>56.0 kByte</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>SAK-TC212S-8F133F AB</td>
<td>PG-TQFP-80</td>
<td>133.0 MHz</td>
<td>56.0 kByte</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>SAK-TC212L-8F133F AB</td>
<td>PG-TQFP-80</td>
<td>133.0 MHz</td>
<td>56.0 kByte</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>SAK-TC214S-8F133F AB</td>
<td>PG-TQFP-144</td>
<td>133.0 MHz</td>
<td>56.0 kByte</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td><strong>AURIX™ Family — TC22xL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAK-TC224L-16F133F AB</td>
<td>PG-TQFP-144</td>
<td>133.0 MHz</td>
<td>96.0 kByte</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>SAK-TC223L-16F133F AB</td>
<td>PG-TQFP-100</td>
<td>133.0 MHz</td>
<td>96.0 kByte</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>SAK-TC222L-16F133F AB</td>
<td>PG-TQFP-80</td>
<td>133.0 MHz</td>
<td>96.0 kByte</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>SAK-TC224S-16F133F AB</td>
<td>PG-TQFP-144</td>
<td>133.0 MHz</td>
<td>96.0 kByte</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>SAK-TC223S-16F133F AB</td>
<td>PG-TQFP-100</td>
<td>133.0 MHz</td>
<td>96.0 kByte</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>SAK-TC222S-16F133F AB</td>
<td>PG-TQFP-80</td>
<td>133.0 MHz</td>
<td>96.0 kByte</td>
<td>3</td>
<td>14</td>
</tr>
</tbody>
</table>
Where to buy

Infineon distribution partners and sales offices:
www.infineon.com/WhereToBuy

Service hotline

Infineon offers its toll-free 0800/4001 service hotline as one central number, available 24/7 in English, Mandarin and German.

- Germany ................... 0800 951 951 951 (German/English)
- China, mainland ....... 4001 200 951 (Mandarin/English)
- India ......................... 000 800 4402 951 (English)
- USA ......................... 1-866 951 9519 (English/German)
- Other countries .......... 00* 800 951 951 951 (English/German)
- Direct access ............ +49 89 234-0 (interconnection fee, German/English)

* Please note: Some countries may require you to dial a code other than “00” to access this international number. Please visit www.infineon.com/service for your country!

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