Automotive motor drives system solutions



www.infineon.com

Contents

Introduction	**3**
1. Automotive motor control at a glance and Infineon offering	**4**
1.1. Motor control architecture and offering depend on multiple criteria	4
1.2. Infineon offers solutions for all kinds of automotive motor control	4
1.3. Seamless motor control offerings powered by Infineon	5
1.4. Infineon offers the most complete range of solutions for motor control	6
2. High-integrated solutions for compact motor control designs	**7**
2.1. Infineon Embedded Power ICs — System-on-Chip motor control	7
3. Medium-integrated solutions for motor control	**14**
3.1. Single half-bridges	14
3.2. Multi-half-bridge ICs	16
3.3. Full- or h-bridge	17
4. Low-integrated solutions for high-power motor control	**18**
4.1. Gate driver ICs for external MOSFETs	19
4.2. MOSFETs	21
4.3. Power supply	25
4.3.1. Linear voltage regulators	26
4.3.2. DC/DC converters	27
4.4. User interface and communications: transceivers	28
4.5. Sensors: hall switches	30
4.6. Angle sensors	31
4.7. Microcontrollers: introduction to TC21x, TC22x	33

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 CO2 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.



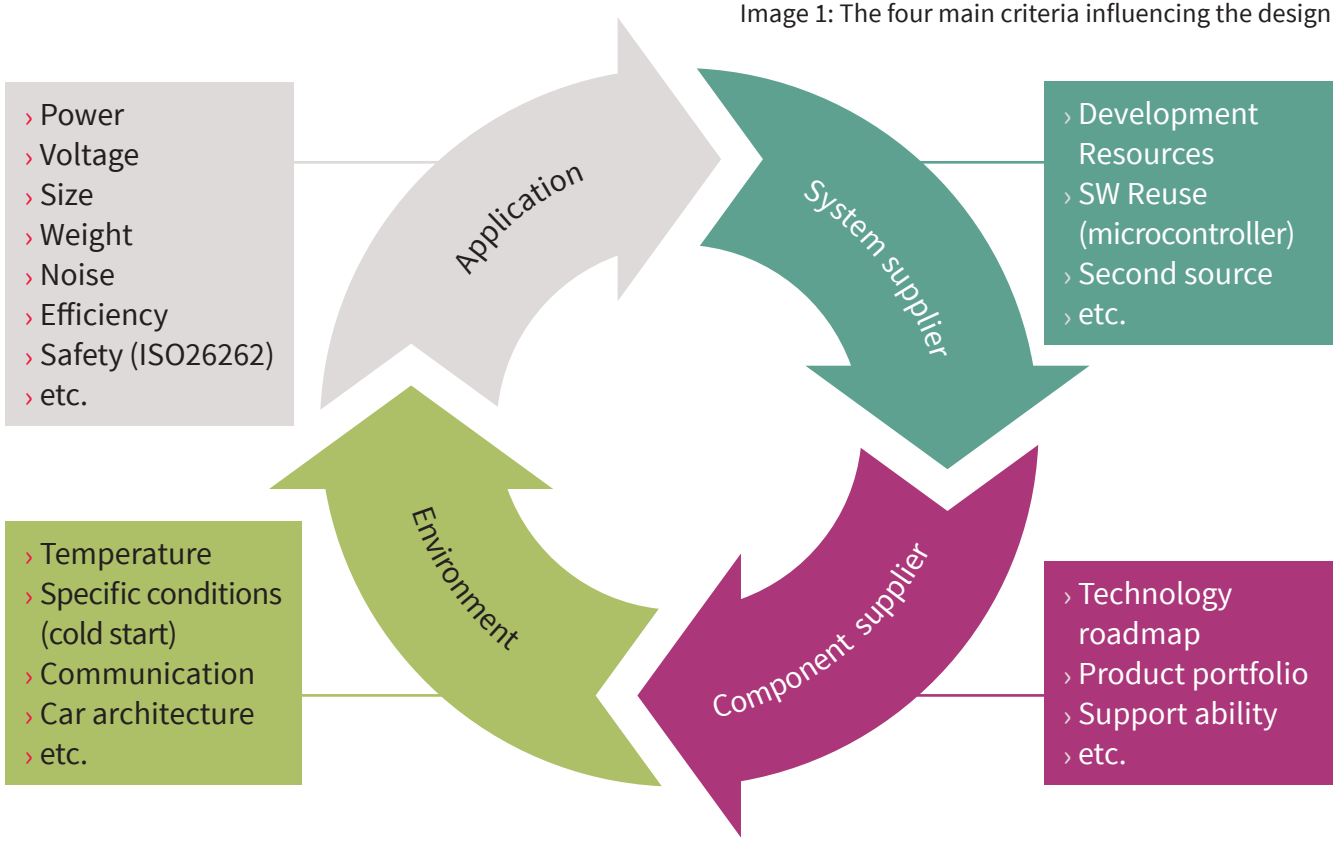
1. Automotive motor control at a glance and Infineon offering

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.

Image 1: The four main criteria influencing the design



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.

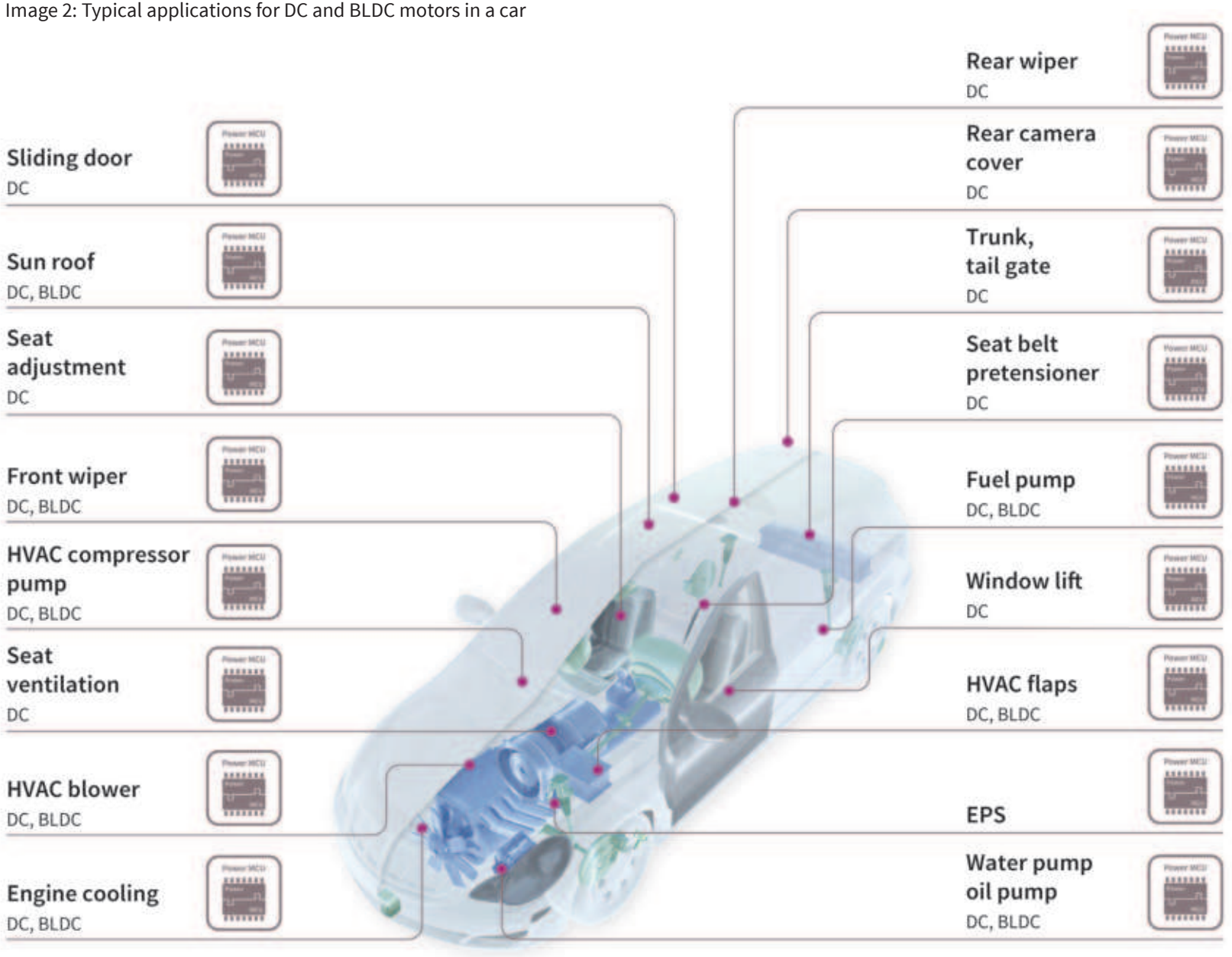
Brushless DC (BLDC) motors have less wear but need a complex control algorithm and, therefore, higher computing power than a DC motor drive. BLDC motors are most suitable for applications demanding long-term continuous duty like fuel pumps.

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 at right compares three levels of function integration: low, medium, and high. Every level has its own characteristic set of benefits. Image 3 on page 6 can serve as a first-decision help in which direction to go for your application.

Image 2: Typical applications for DC and BLDC motors in a car



1.4. Infineon offers the most complete range of solutions for motor control

Infineon supports all three levels of integration with state-of-the-art components. The choice is yours.

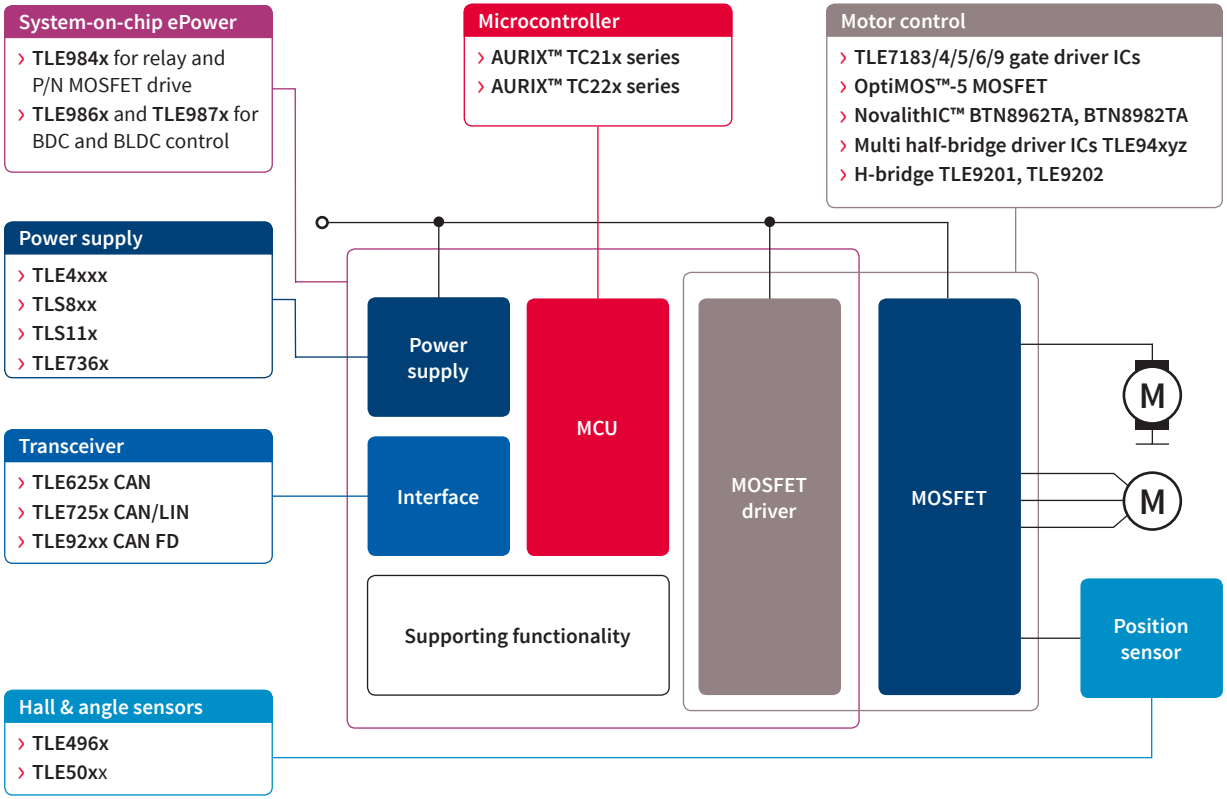
Image 4 shows the major function blocks of a motor control design with Infineon's key components for each block. Chapters 3, 4 and 5 go into further detail regarding the component proposals for each of the three levels of integration.

Image 3: Levels of integrations and their benefits

	Low integration			Medium integration		High integration	
	Micro-controller	Bridge Driver	MOSFET Sensor	Micro-controller /ePower	Integrated Motor Bridge Sensor	Embedded Power	MOSFET Sensor
Current	★★★			★		★★	
Protection	★★			★★★		★★	
Space constraint	★			★★		★★★	
Flexibility	★★★			★★		★	
Benefits	Higher Ambient Temperatures			Low Development Effort		Least Wiring Smallest Space	

Infineon offers most comprehensive chipsets for all integration types

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



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.

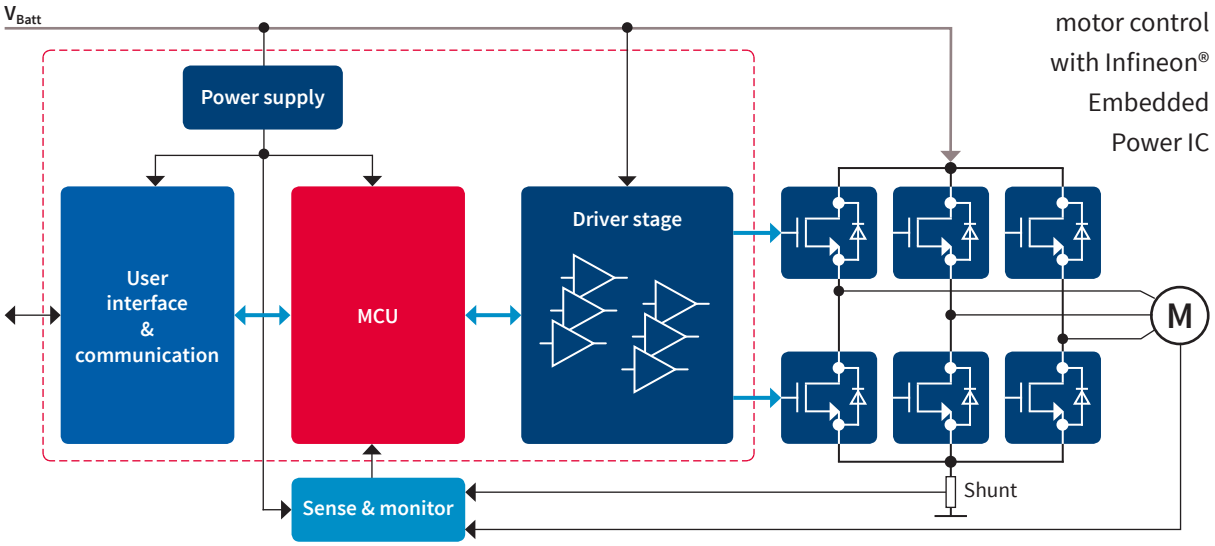


Image 6: Block diagram of BLDC motor control with Infineon® Embedded Power IC

Applications, key features & benefits

Applications

- Window lift
- Sunroof
- Wiper
- Engine cooling fan
- Fuel pump
- Oil pump
- Water pump
- HVAC blower

Key features & benefits

- Complete system-on-chip for DC and BLDC motor control
- Minimum number of external components reduce BOM cost, e.g. with wide operating range, Vs=5.4V to 28V
- Platform solution for a wide range of motor control algorithms with scalable flash memory from 36kB to 128kB
- With ARM Cortex M3 sensor-less field-oriented control motor control algorithm can be supported
- Simplifies EMC design based on slope programmable MOSFET driver
- Intelligent power saving modes including stop and sleep mode, supports energy management (on demand)
- PG-VQFN package with 7 x 7mm footprint enable PCB space saving
- Reduce the motor size and weight
- Single die solution improves module reliability

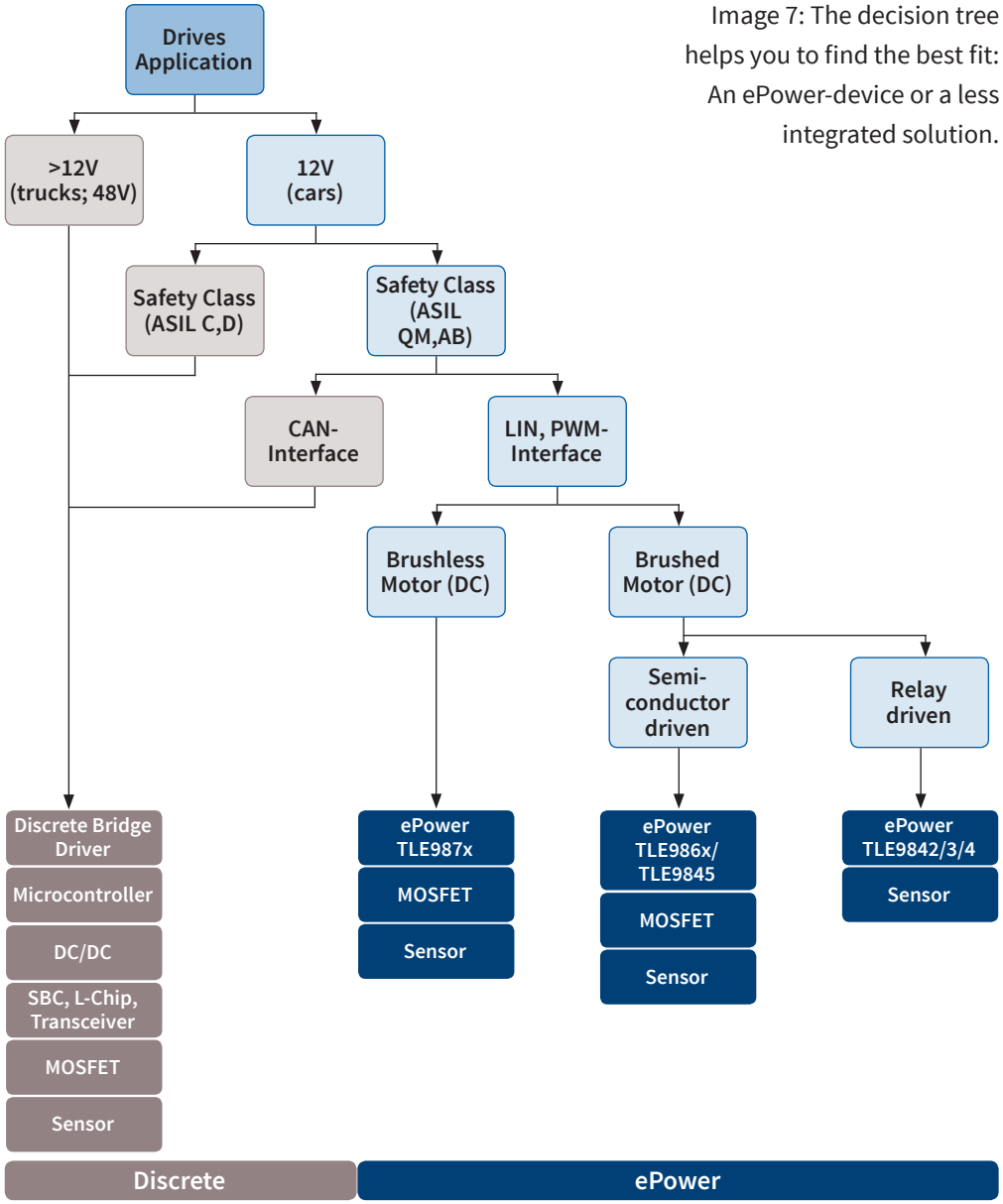


Image 7: The decision tree helps you to find the best fit: An ePower-device or a less integrated solution.

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

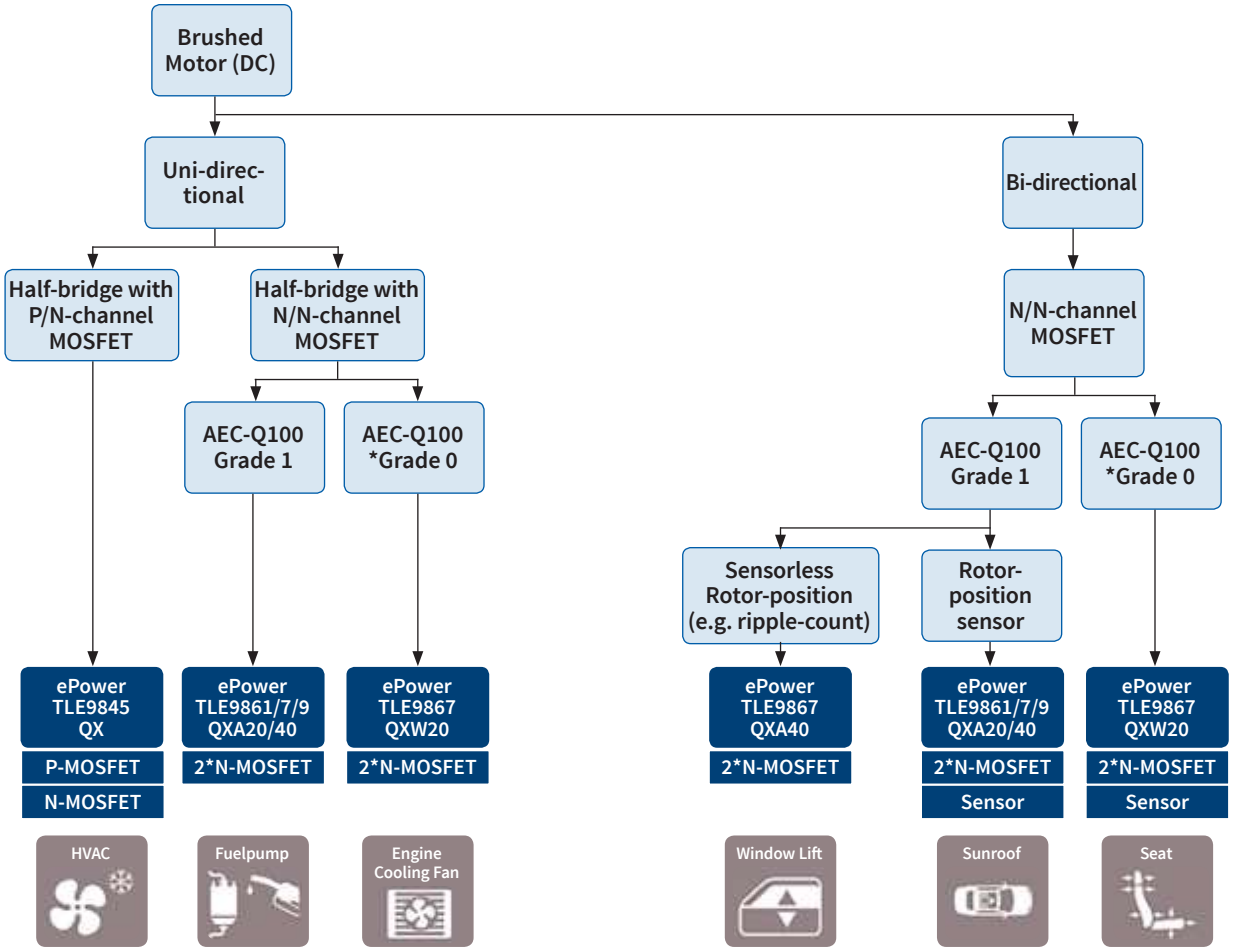


Image 9: ePower selection tree for drives with BLDC motors

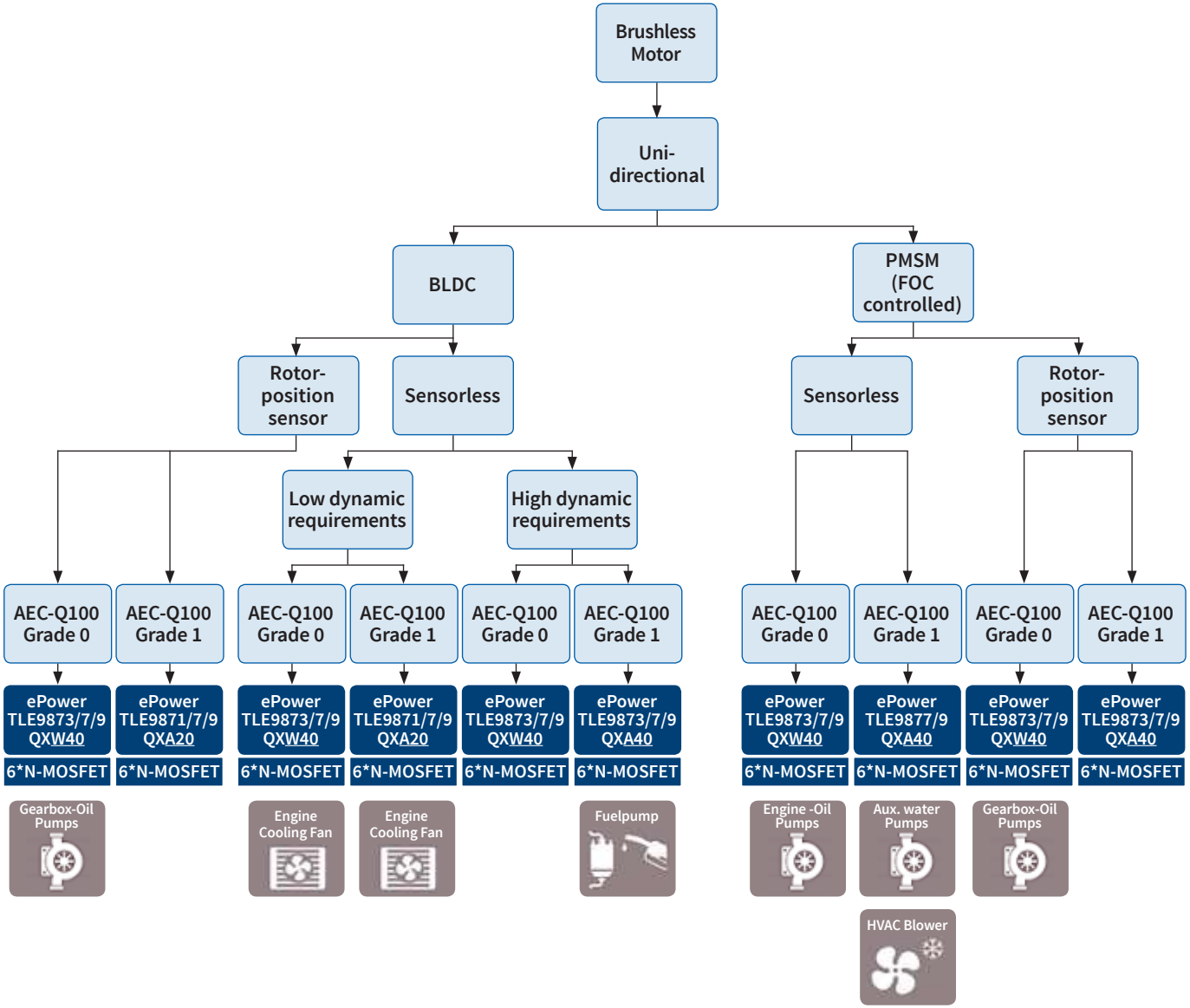


Image 10: Selection tree depending on output bridge topology

Selection tree - Infineon Embedded Power IC motor control

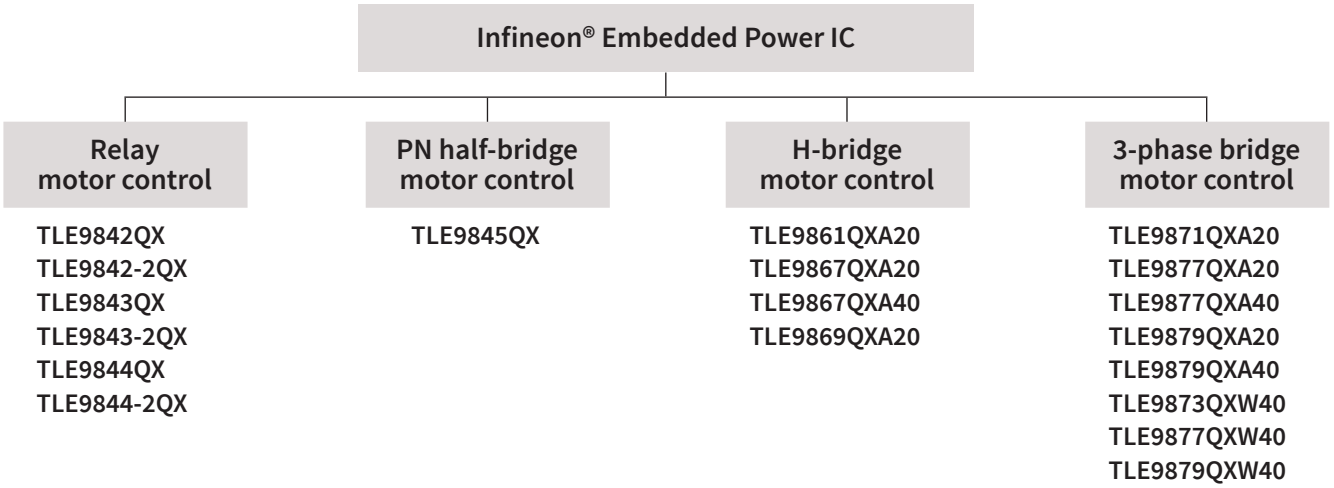


Table 1: Product overview ePower devices

TLE984x product overview												
Product name	**Core**	**Flash [kB]**	**RAM [kB]**	**EEPROM in flash included [kB]**	**Freq [MHz]**	**High-side switch**	**High-voltage monitor input**	**GPIO**	**Analog inputs**	**PNMOS driver**	**Interface**	**Package**
Relay driver IC with integrated microcontroller												
TLE9842QX	Cortex®-M0	36	2	4	25	1	4	10	6	No	PWM + LIN	VQFN-48
TLE9842-2QX	Cortex®-M0	40	2	4	40	2	5	10	6	No	PWM + LIN	VQFN-48
TLE9843QX	Cortex®-M0	48	4	4	25	1	4	10	6	No	PWM + LIN	VQFN-48
TLE9843-2QX	Cortex®-M0	52	4	4	40	2	5	10	6	No	PWM + LIN	VQFN-48
TLE9844QX	Cortex®-M0	64	4	4	25	1	4	10	6	No	PWM + LIN	VQFN-48
TLE9844-2QX	Cortex®-M0	64	4	4	40	2	5	10	6	No	PWM + LIN	VQFN-48
Half-bridge driver IC with integrated microcontroller												
TLE9845QX	Cortex®-M0	48	4	4	40	2	5	10	6	Yes	PWM + LIN	VQFN-48

Table 1, continued: Product overview ePower devices

TLE986x & TLE987x product overview

Product name	Frequency [MHz]	Interface	RAM [KB]	Flash [KB]	EEPROM emulation [KB]	OP-AMP	Low-side MOSFET drivers	High-side MOSFET drivers
TLE986x 32-bit µC with 2-phase NFET gate driver for DC motors (grade-1, T_j=150°C)								
TLE9861QXA20	24	PWM	3	36	4	y	2	2
TLE9867QXA20	24	PWM + LIN	6	64	4	y	2	2
TLE9867QXA40	40	PWM + LIN	6	64	4	y	2	2
TLE9869QXA20	24	PWM + LIN	6	128	4	y	2	2
TLE986x 32-bit µC with 2-phase NFET gate driver for DC motors (grade-0, T_j=175°C)								
TLE9867QXW20	24	PWM + LIN	6	64	4	y	2	2

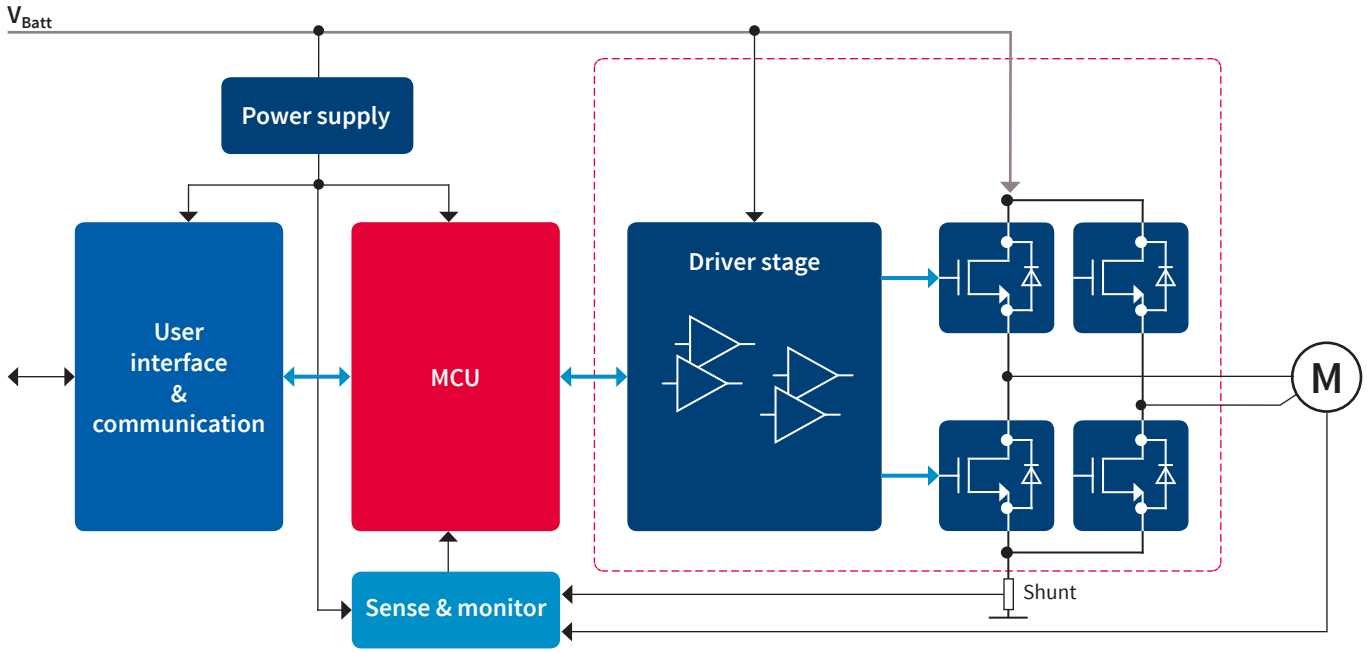
Product name	Frequency [MHz]	Interface	RAM [KB]	Flash [KB]	EEPROM in flash included [KB]	OP-AMP	Low-side MOSFET drivers	High-side MOSFET drivers
TLE987x 32-bit µC with 3-phase NFET gate driver for DC motors (grade-1, T_j=150°C)								
TLE9871QXA20	24	PWM	3	36	4	y	3	3
TLE9877QXA20	24	PWM + LIN	6	64	4	y	3	3
TLE9877QXA40	40	PWM + LIN	6	64	4	y	3	3
TLE9879QXA20	24	PWM + LIN	6	128	4	y	3	3
TLE9879QXA40	40	PWM + LIN	6	128	4	y	3	3
TLE987x 32-bit µC with 3-phase NFET gate driver for DC motors (grade-0, T_j=175°C)								
TLE9873QXW40	40	PWM + LIN	3	48	4	y	3	3
TLE9877QXW40	40	PWM + LIN	6	64	4	y	3	3
TLE9879QXW40	40	PWM + LIN	6	128	4	y	3	3

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.

Image 11: Block diagram of DC motor control using components for medium integration



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

NovalithIC™ product overview

Product name	Operating range [V]	$R_{DS(on)}$ path (typ) [mΩ]	$I_{D(lim)}$ [A]	I_q (typ) [µA]	Switch time (typ) [µs]	Diagnosis	Protect	Package
BTN8962TA	5.50 … 40.00	14.20	42	7	0.25	OT, OC, CS	UV, OT, OC	TO263-7-1 (TO220-7 (SMD))
BTN8982TA	5.50 … 40.00	10.00	70	7	0.25	OT, OC, CS	UV, OT, OC	TO263-7-1 (TO220-7 (SMD))

OC = Overcurrent
CS = Current Sense
UV = Undervoltage
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

- 3-, 4-, 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)
- Qualified for automotive applications according to AEC-Q100

Table 3: Product overview TLE94xyz multi half bridge driver

Product name	Config.	IL(NOM) [A]	IL(lim) (min)[A]	Iq (typ) [µA]	VS(OP) [V]	Protection	Diagnostic interface	Highlights	RDS(on)(typ) @25 °C	Package
TLE94003EP	3x H-bridge	3 x 0.30	3 x 0.90	0.2	5.5 … 20	OC, OT, VS UV/ OV	Direct interface	TLE94xyz family concept	850 mΩ/ switch	TSDSO-14
TLE94103EP	3x H-bridge	3 x 0.30	3 x 0.90	0.2	5.5 … 20	OC, OT, OL, VS UV/ OV	16-bit SPI	TLE94xyz family concept	850 mΩ/ switch	TSDSO-14
TLE94004EP	4x H-bridge	4 x 0.30	4 x 0.90	0.2	5.5 … 20	OC, OT, VS UV/ OV	Direct interface	TLE94xyz family concept	850 mΩ/ switch	TSDSO-14
TLE94103EP	4x H-bridge	4 x 0.30	4 x 0.90	0.2	5.5 … 20	OC, OT, OL, VS UV/ OV	16-bit SPI	TLE94xyz family concept	850 mΩ/ switch	TSDSO-14
TLE94106ES	6x H-bridge	6 x 0.30	6 x 0.90	0.6	5.5 … 20	OC, OT, OL, VS UV/ OV	16-bit SPI	TLE94xyz family concept + backwards compatible to TLE84106EL	850 mΩ/ switch	TSDSO-24
TLE94108EL	8x H-bridge	8 x 0.30	8 x 0.90	0.6	5.5 … 20	OC, OT, OL, VS UV/ OV	16-bit SPI	TLE94xyz family concept	850 mΩ/ switch	SSOP-24
TLE94110EL	10x H-bridge	10 x 0.30	10 x 0.90	0.6	5.5 … 20	OC, OT, OL, VS UV/ OV	16-bit SPI	TLE94xyz family concept + backwards compatible to TLE84110EL	850 mΩ/ switch	SSOP-24
TLE94112EL	12x H-bridge	12 x 0.30	12 x 0.90	0.6	5.5 … 20	OC, OT, OL, VS UV/ OV	16-bit SPI	TLE94xyz family concept + 12 outputs in one package	850 mΩ/ switch	SSOP-24

3.3. Full- or h-bridge

TLE9201SG and TLE9202ED are general-purpose 6A H-Bridges designed for the control of small DC motors and inductive loads. They meet the harsh automotive environmental conditions and are 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 Full H-bridges

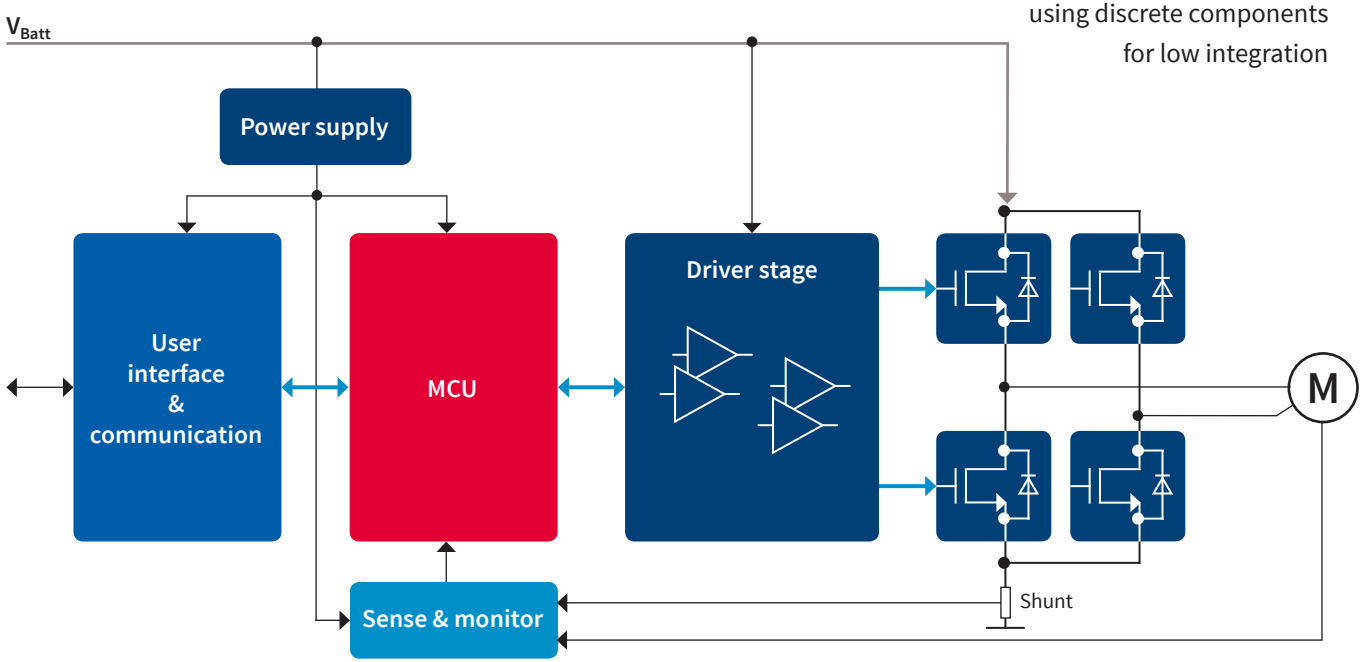
Product name	$R_{DS(on)}$ HS [mΩ]	$R_{DS(on)}$ LS [mΩ]	I_{LIM} min. [A]	I_Q max. [mA]	$V_{S(OP)}$ [V]	Diagnostic IF	V_{DD} mon.	Package
TLE9201SG	100	100	6.00	0.03	5.00 … 28.00	SPI and Status Flag		DSO-12
TLE9202ED	100	100	6.00	0.03	5.00 … 28.00	SPI and Status Flag		DSO-36

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 RDS(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.

Image 12: Block diagram of DC motor control using discrete components for low integration



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

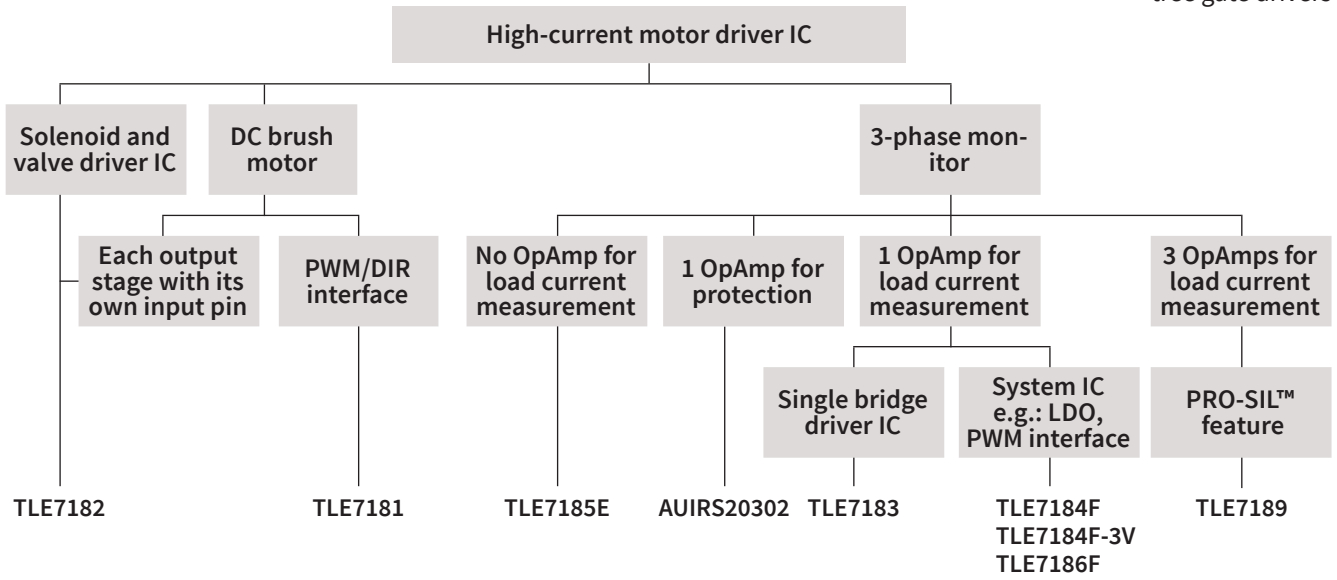


Image 13: Selection tree gate drivers

Table 5: Product overview 3-phase bridge driver ICs

3-phase bridge driver IC								
Product name	**Operating range [V]**	**Drives stage**	**D.C.-range @20 kHz [%]**	**Numbers of integrated OpAmps for load current measurement**	**Adjustable dead time**	**SIL3 features**	**Diagnosis**	**Package**
TLE7183F	5.50 … 28.00	1.50/1.50 A	0 … 100	1	●		OT, UV, OV, OC, OCD	VQFN-48
TLE7183QU	5.50 … 28.00	1.50/1.50 A	0 … 100	1	●		OT, UV, OV, OC, SCD	TQFP-48 EP
TLE7184F TLE7184F-3V[1] TLE7186F	7.00 … 32.00	12.50/9.00 Ω 12.50 Ω	0 … 95	1	●		UV, OV, OC, SCD, OT, VDD supervision	VQFN-48
TLE7185E	5.50 … 32.00	12.50/9.00 Ω	0 … 95	0	●		UV, OV, SCD, OT	DSO-36 EP
TLE7188F	5.50 … 28.00	1.50/1.50 A	0 … 100	3			UV, OV, OC, SCD, OT	VQFN-48
TLE7189F	5.50 … 28.00	1.50/1.50 A	0 … 100	3		●	UV, OV, SCD, OT, VDD supervision	VQFN-48
TLE7189QK	5.50 … 28.00	1.50/1.50 A	0 … 100	3		●	UV, OV, SCD, OT, VDD supervision	LQFP-64
AUIRS20302	8.00 … 17.00 Output offset 200 V	0.20/0.35 A	0 … 95	1 (SC protection)			One error flag for OTW, UV, SC	DSO-28 (28 lead SOIC)

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

4.2. MOSFETs

Automotive MOSFETs

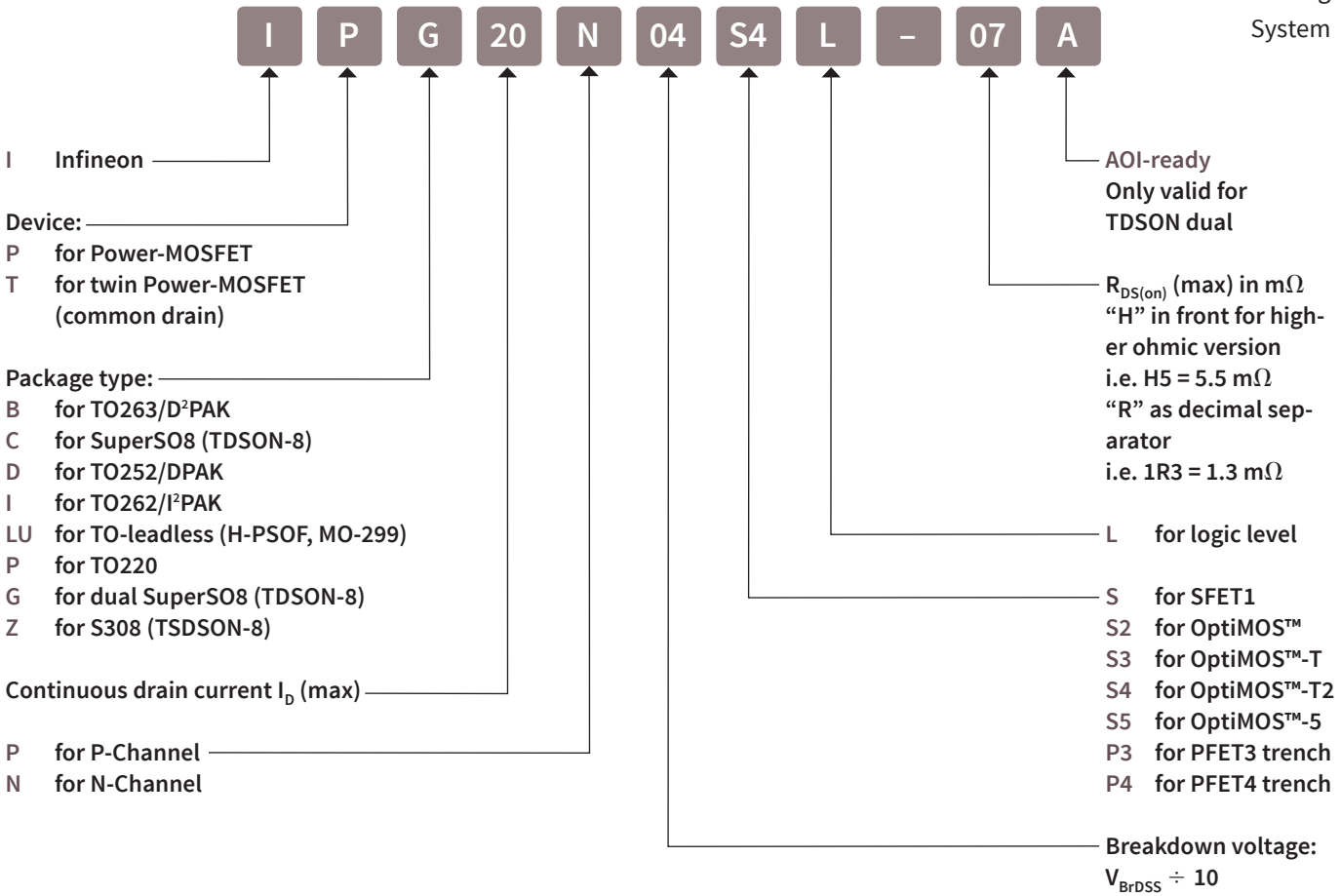
Infineon's automotive MOSFET portfolio offers benchmark quality, wide voltage range and diversified packages.

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 caters to customers' needs for:
  - Package size minimization (down to 11 mm^2 in S3O8)
  - High current capability (up to 300 A in TOLL)

Infineon automotive MOSFET naming system

Legacy Part Numbering System



Part Numbering System for new MOSFETs

Automotive MOSFET naming system for new products

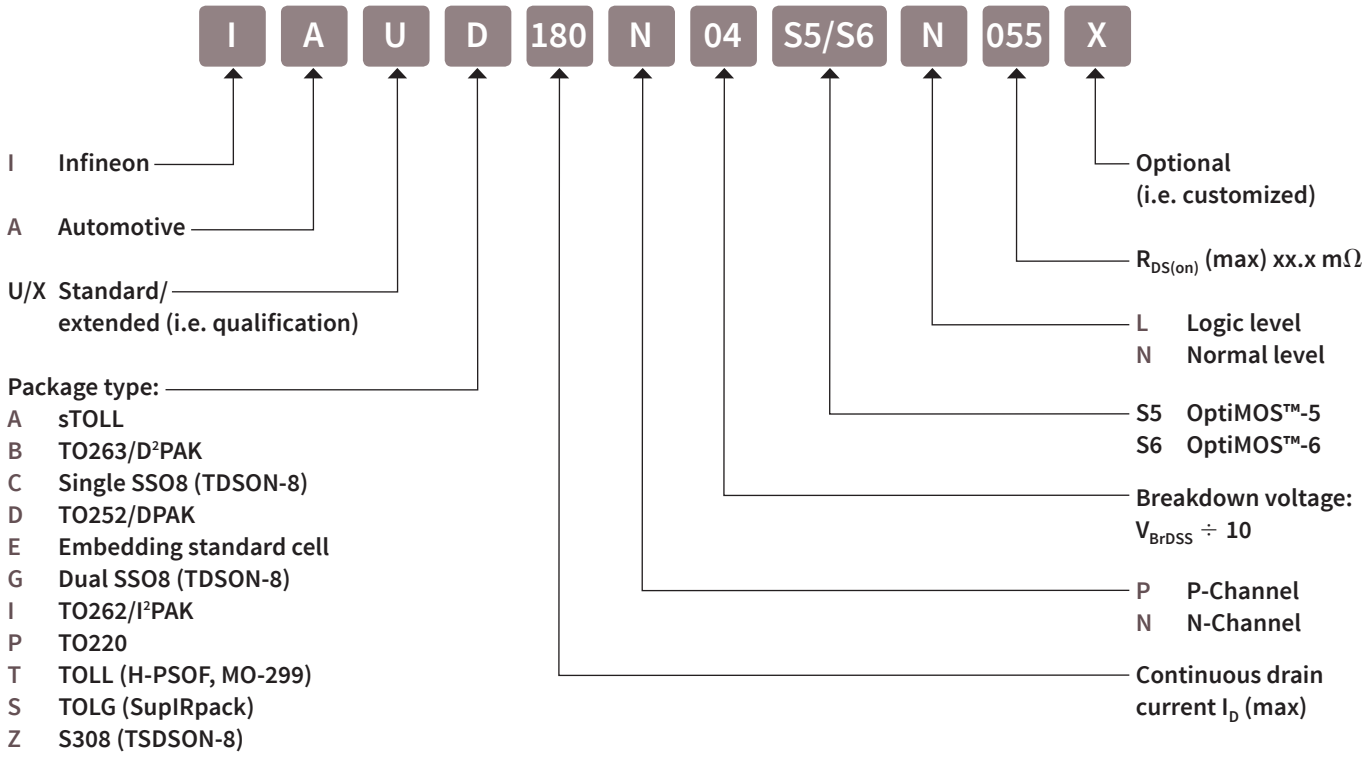


Table 6: 40 V, single N-Channel MOSFET overview in SSO8 package

Sales Name	max Ron 10V (mOhm)	ID (A)	LL/NL	Single SS08
IPC100N04S5-1R2	1.2	100	NL	
IPC100N04S5L-1R1	1.1	100	LL	
IPC100N04S5-1R7	1.7	100	NL	
IPC100N04S5L-1R5	1.5	100	LL	
IPC100N04S5-1R9	1.9	100	NL	
IPC100N04S5L-1R9	1.9	100	LL	
IPC100N04S5-2R8	2.8	100	NL	
IPC100N04S5L-2R6	2.6	100	LL	
IPC90N04S5-3R6	3.6	90	NL	
IPC90N04S5L-3R3	3.3	90	LL	
IPC70N04S5-4R6	4.6	70	NL	
IPC70N04S5L-4R2	4.2	70	LL	
IPC50N04S5-5R8	5.8	50	NL	
IPC50N04S5L-5R5	5.5	50	LL	

Table 7: 40 V, single N-Channel MOSFET overview in S3O8 package

Sales Name	Technology	max Ron 10V (mOhm)	ID (A)	LL/NL	S308
IPZ40N04S5L-2R8	OptiMOS™-5 40V	2.8	40	LL	
IPZ40N04S5-3R1	OptiMOS™-5 40V	3.1	40	NL	
IPZ40N04S5L-4R8	OptiMOS™-5 40V	4.8	40	LL	
IPZ40N04S5-5R4	OptiMOS™-5 40V	5.4	40	NL	
IPZ40N04S5L-7R4	OptiMOS™-5 40V	7.4	40	LL	
IPZ40N04S5-8R4	OptiMOS™-5 40V	8.4	40	NL	

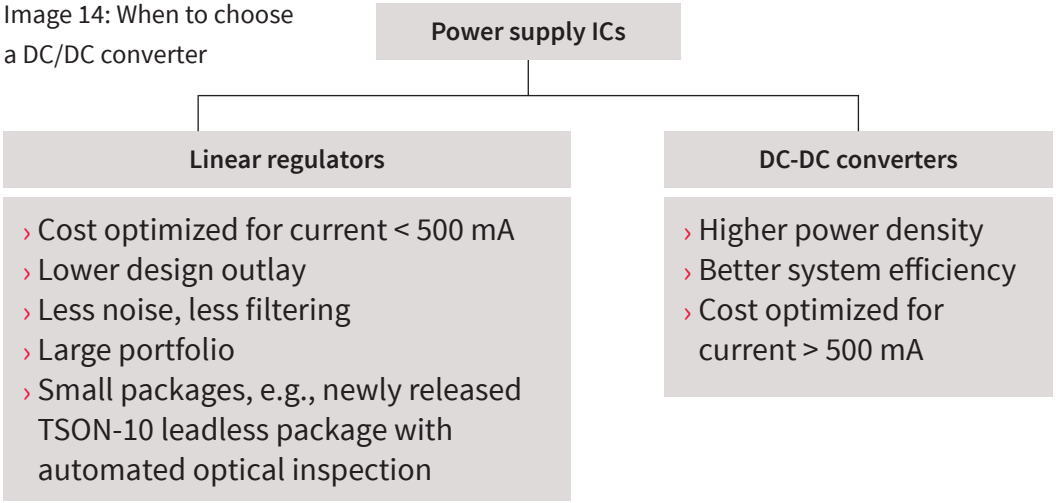
Table 8: 40 V & 80 V, N-Channel MOSFETs in Package TOLL

Sales Name	Technology	max Ron (mOhm)	ID (A)	LL/NL	TOLL
IPLU300N04S4-R8	OptiMOS™-T2 40V	0.77mOhm	300	NL	
IPLU300N04S4-1R1	OptiMOS™-T2 40V	1.1mOhm	300	NL	
IPLU50N04S4-1R7	OptiMOS™-T2 40V	1.7mOhm	250	NL	
IAUT300N08S5N012	OptiMOS™ 5 80V	1.2mOhm	300	NL	
IAUT165N08S5N029	OptiMOS™ 5 80V	2.9mOhm	165	NL	
IAUT300N08S5N014	OptiMOS™ 5 80V	1.4mOhm	300	NL	
IAUT240N08S5N019	OptiMOS™ 5 80V	1.9mOhm	240	NL	
IAUT200N08S5N023	OptiMOS™ 5 80V	2.3mOhm	200	NL	

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.

Image 14: When to choose a DC/DC converter



4.3.1. Linear voltage regulators

Table 9: Product overview linear voltage regulators

Product Table							
Product	**Packages**	**Operating Voltage min**	**Operating Voltage max**	**Output Voltage Type**	**Accuracy**	**Output Current (max.)**	**Regulator Type**
TLS115B0/D0	PG-DSO-8 / PG-TSON-9	4.0 V	40.0 V	adj.	0.1 %	150mA	Linear->Tracker
TLE4250-2	PG-SCT595-5	4.0 V	40.0 V	adj.	0.5 %	50mA	Linear->Tracker
TLE4251	PG-TO252-5 / PG-TO263-5	4.0 V	40.0 V	adj.	0.5 %	300mA	Linear->Tracker
TLE4252	PG-TO252-5	3.5 V	40.0 V	adj.	0.5 %	200mA	Linear->Tracker
TLE4253	PG-DSO-8 PG-DSO-8-EP	3.5 V	40.0 V	adj.	0.5 %	250mA	Linear->Tracker
TLE4254	PG-DSO-8 PG-DSO-8-EP	4.0 V	45.0 V	adj.	0.1 %	70mA	Linear->Tracker
TLE4291E	PG-SSOP-14	3.3 V	45.0 V	5.0 V	2.0 %	450mA	Linear
TLS820F0	PG-SSOP-14	3.0 V	40.0 V	3.3, 5.0 V	2.0 %	200mA	Linear->High Performance Regulators
TLS850D0/-F0	PG-TO263-7 / PG-TO252-5	3.0 V	40.0 V	3.3, 5.0 V	2.0 %	500mA	Linear->High Performance Regulators
TLE4473G V55-2	PG-DSO-12	5.6 V	42.0 V	5.0 V	2.5 % 2.0 %	300mA	Linear->Multiple output

4.3.2. DC/DC converters

Table 10: Product overview DC/DC converters

DC-DC system supplies																		
Product name	VS(op) Σ	VQ Σ	VQ2 Σ	VQ3 Σ	VQ4 Σ	VQ additional Σ	Accuracy 1 [%]	Accuracy 2 [%]	Accuracy 3 [%]	Accuracy 4 [%]	Additional output accuracy	IQ [mA]	IQ 2 [mA]	IQ 3 [mA]	IQ 4 [mA]	IQ additional [mA]	Iq [mA]	fsw [kHz]
Buck plus linear																		
TLE7368	4.50 … 45.00	5.50	5.00	2.60 or 3.30	1.50	2 x 5	-2.00 … +9.00	2	2	2	1.50	2500	800	700	Adj.	105 and 50	120	280 … 425
TLE7368-2	4.50 … 45.00	5.50	5.00	2.60 or 3.30	1.20	2 x 5	-2.00 … +9.00	2	2	2	1.50	2500	800	700	Adj.	105 and 50	120	280 … 425
TLE7368-3	4.50 … 45.00	5.50	5.00	2.60 or 3.30	1.30	2 x 5	-2.00 … +9.00	2	2	2	1.50	2500	800	700	Adj.	105 and 50	120	280 … 425

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 CO_2 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

Product name	Transmission rate (max)	Low-power mode Iq [µA] (max)	Bus wake-up capability	Wake-up inputs	Number of channels	Bus failure manage-ment	Fast pro-gramming	Package
Single LIN								
TLE7257SJ	20 kbit/s	< 15 sleep mode	I		1	I		DSO-8
TLE7258SJ	20 kbit/s	< 15 sleep mode	I		1	I		DSO-8
TLE7259-3GE	20 kbit/s	< 10 sleep mode	I	I	1	I		DSO-8

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

Product name	Transmission rate (max)	Low-power mode Iq [µA] (max)	Bus wake-up capability	Wake-up inputs	Number of channels	Bus failure management	CAN FD	Package
High-speed CAN ISO 11898-2								
TLE7250SJ	2 Mbit/s	< 12 @ 5 V power save mode			1		I	DSO-8
TLE7250LE	2 Mbit/s	< 12 @ 5 V power save mode			1		I	TSON-8
TLE9250SJ	5 Mbit/s	< 20 @ 5 V power save mode			1		I	DSO-8
TLE9250LE	5 Mbit/s	< 20 @ 5 V power save mode			1		I	TSON-8

Product name	Transmission rate (max)	Low-power mode Iq [µA] (max)	Bus wake-up capability	Wake-up inputs	Number of channels	Bus failure management	CAN FD	Package
High-speed CAN ISO 11898-5								
TLE6251-2G	1 Mbit/s	< 30 sleep mode	I	I	1	I		DSO-14
TLE6251-3G	1 Mbit/s	< 30 sleep mode	I	I	1	I		DSO-14

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)

Table 12: Product overview Hall switches

Product Table

Product	Group	Packages	Type	Bop (25°C)	Brp (25°C)	Direction Detection
TLE4961-1M	Latch	PG-SOT23-3	Latch	2.0 mT	-2.0 mT	no
TLE4961-2M	Latch	PG-SOT23-3	Latch	5.0 mT	-5.0 mT	no
TLE4961-3M	Latch	PG-SOT23-3	Latch	7.5 mT	-7.5 mT	no
TLE4961-4M	Latch	PG-SOT23-3	Latch	10.0 mT	-10.0 mT	no
TLE4961-5M	Latch	PG-SOT23-3	Latch	15.0 mT	-15.0 mT	no
TLE4968-1M	Latch	PG-SOT23-3	Latch	1.0 mT	-1.0 mT	no

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

Applications

- BLDC Rotor position sensing for electric motor commutation (motors, actuators)
- Steering angle sensing
- General angular sensing
- TLE5012BD particularly suitable for a wide range of functional safety-critical applications

Key features & benefits

- Designed for 3.3 V & 5 V systems
- 15-bit absolute angle resolution
- 42 µs update-rate of calc. angle
- SPI with 8 Mbit/s
- Interfaces: HSM, IIF, SPI, PWM, SPC
- ≤1° angle error over all
- Automotive qualified (Tj-40 °C /150 °C)
- Supports ISO 26262

Table 13: Product overview angle sensor TLE5012

Product Table

Product	Group	Packages	Package	Interfaces
TLE5012B E1000	Angle Sensors	PG-DSO-8	SMD	SPI, IIF
TLE5012B E3005	Angle Sensors	PG-DSO-8	SMD	SPI, HSM
TLE5012B E5000	Angle Sensors	PG-DSO-8	SMD	SPI, PWM
TLE5012B E9000	Angle Sensors	PG-DSO-8	SMD	SPI, SPC
TLE5012BD E1200	Dual Angle Sensor — for Functionally Safe Systems (ISO26262)	PG-TDSO-16	Dual SMD	SPI, IIF
TLE5012BD E9200	Dual Angle Sensor — for Functionally Safe Systems (ISO26262)	PG-TDSO-16	Dual SMD	SPI, SPC

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

Product Table

Product	Group	Description	Packages	Package	Interfaces
TLE5009 E1000	Angle Sensors	Vdd: 3.3V; static offset compensation	PG-DSO-8	SMD	Analog
TLE5009 E1010	Angle Sensors	Vdd: 3.3V; temperature compensated offset	PG-DSO-8	SMD	Analog
TLE5009 E2000	Angle Sensors	Vdd: 5V; static offset compensation	PG-DSO-8	SMD	Analog
TLE5009 E2010	Angle Sensors	Vdd: 5V; temperature compensated offset	PG-DSO-8	SMD	Analog

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

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

1) FPU = Floating Point Unit

2) ASCLIN = Asyn/Synchronous Local Interconnect Network, QSPI = Queued Serial Peripheral Interface, SENT = Single Edge Nibble Transmission

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

Product Table

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

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!

Mobile product catalog

Mobile app for iOS and Android.

> Back to top

Published by
Infineon Technologies AG
81726 Munich, Germany

© 2017 Infineon Technologies AG.
All rights reserved.

Order number: B000-H0000-X-X-7600
Date: 04 / 2017

Please note!
THIS DOCUMENT IS FOR INFORMATION PURPOSES ONLY AND ANY INFORMATION GIVEN HEREIN SHALL IN NO EVENT BE REGARDED AS A WARRANTY, GUARANTEE OR DESCRIPTION OF ANY FUNCTIONALITY, CONDITIONS AND/OR QUALITY OF OUR PRODUCTS OR ANY SUITABILITY FOR A PARTICULAR PURPOSE. WITH REGARD TO THE TECHNICAL SPECIFICATIONS OF OUR PRODUCTS, WE KINDLY ASK YOU TO REFER TO THE RELEVANT PRODUCT DATA SHEETS PROVIDED BY US. OUR CUSTOMERS AND THEIR TECHNICAL DEPARTMENTS ARE REQUIRED TO EVALUATE THE SUITABILITY OF OUR PRODUCTS FOR THE INTENDED APPLICATION.

WE RESERVE THE RIGHT TO CHANGE THIS DOCUMENT AND/OR THE INFORMATION GIVEN HEREIN AT ANY TIME.

Additional information
For further information on technologies, our products, the application of our products, delivery terms and conditions and/or prices, please contact your nearest Infineon Technologies office (www.infineon.com).

Warnings
Due to technical requirements, our products may contain dangerous substances. For information on the types in question, please contact your nearest Infineon Technologies office.

Except as otherwise explicitly approved by us in a written document signed by authorized representatives of Infineon Technologies, our products may not be used in any life-endangering applications, including but not limited to medical, nuclear, military, life-critical or any other applications where a failure of the product or any consequences of the use thereof can result in personal injury.