

Automotive motor drives system solutions 2019

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Introduction

Nowadays, the number of electrical motors in cars is growing steadily. In the last years, the unit CAGR (Compound Annual Growth Rate) has always been in the range between 5 and 6 percent.

- › In average around 35 motors distributed in an automobile
- › About 70 motors present in premium cars
- › By 2022, 4.2 billion electrical motors are expected to be built only into cars

Over a long period, mechanical solutions in the automotive industry were state of the art for oil pumps, water pumps, fuel pumps and hydraulic pumps. These days, the trend goes to the replacement of mechanical solutions by electrical motors, due to factors such:

- › CO2 reduction, which 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 from a combustion engine, the electric motors can be switched and speed-controlled on demand.
- › Advanced safety features such as crash avoidance, driving assistants and autonomous driving in the future also drive the electrical motor market forward.
- › Increasing number of in-cabin comfort functionalities in mid-range cars and premium equipment.

The above mentioned functionalities in cars require high-tech, reliable, cost-effective, smaller and flexible semiconductor solutions for Motor Control.

Infineon provides these semiconductor solutions and steadily extends the portfolio of semiconductors needed for smart and modern Motor Control, such as MOSFETs, Intelligent Motor Control ICs, 32-bit Embedded Power ICs based on ARM® Cortex™-M, System Basis Chips, Microcontrollers, Sensors, Automotive Transceivers, Driver ICs and OPTIREG- Power Supplies IC.



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.

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.

Image 1: The four main criteria influencing the design

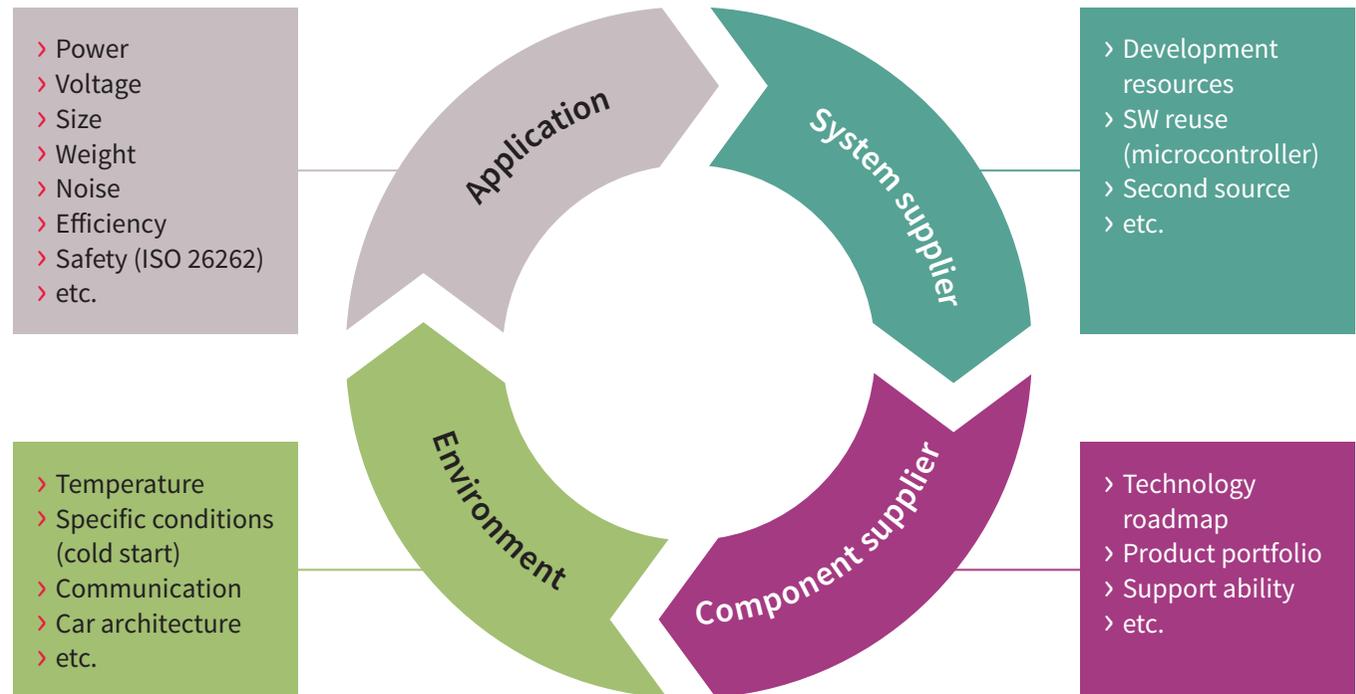
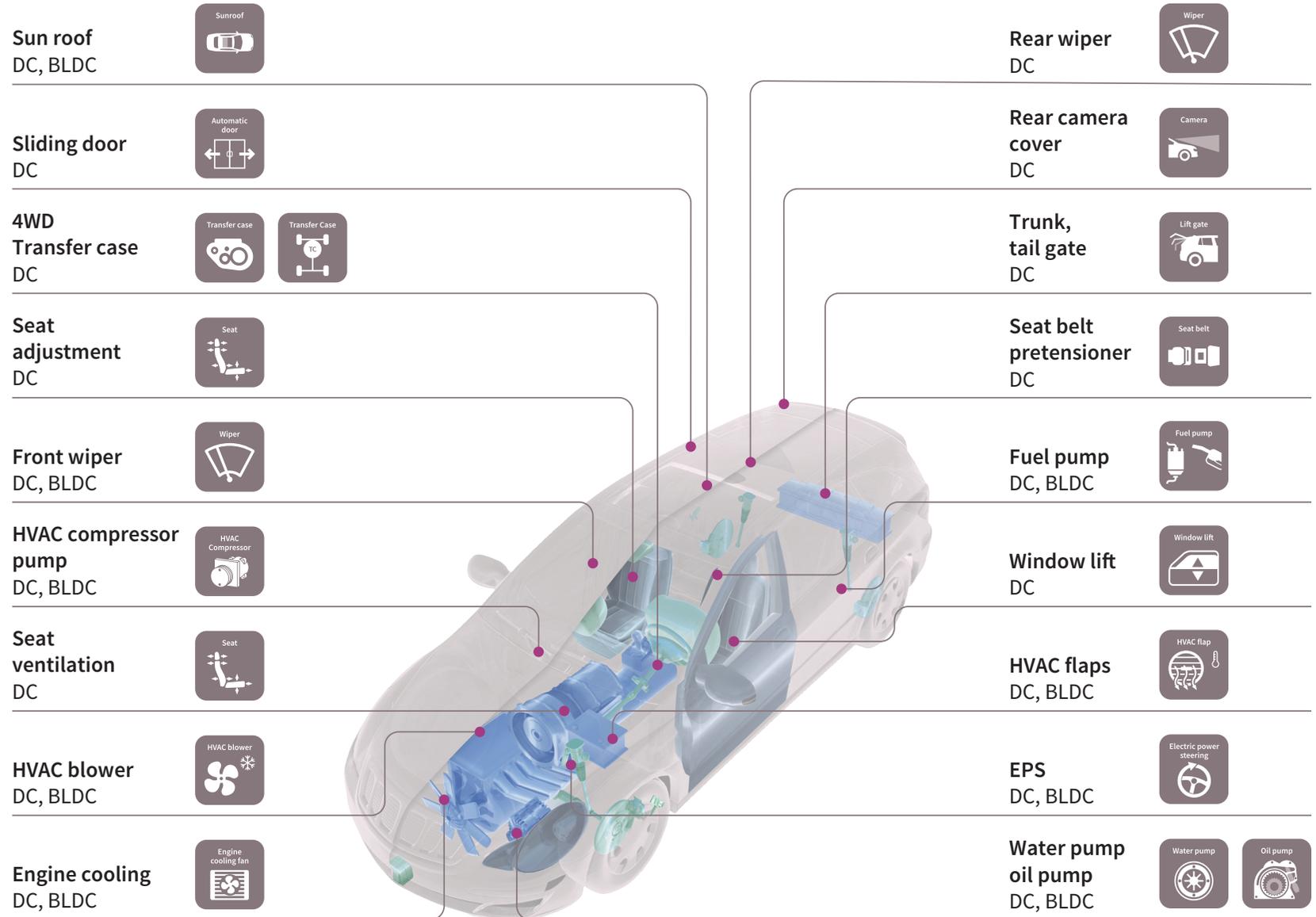


Image 2: Typical applications for DC and BLDC motors in a car

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



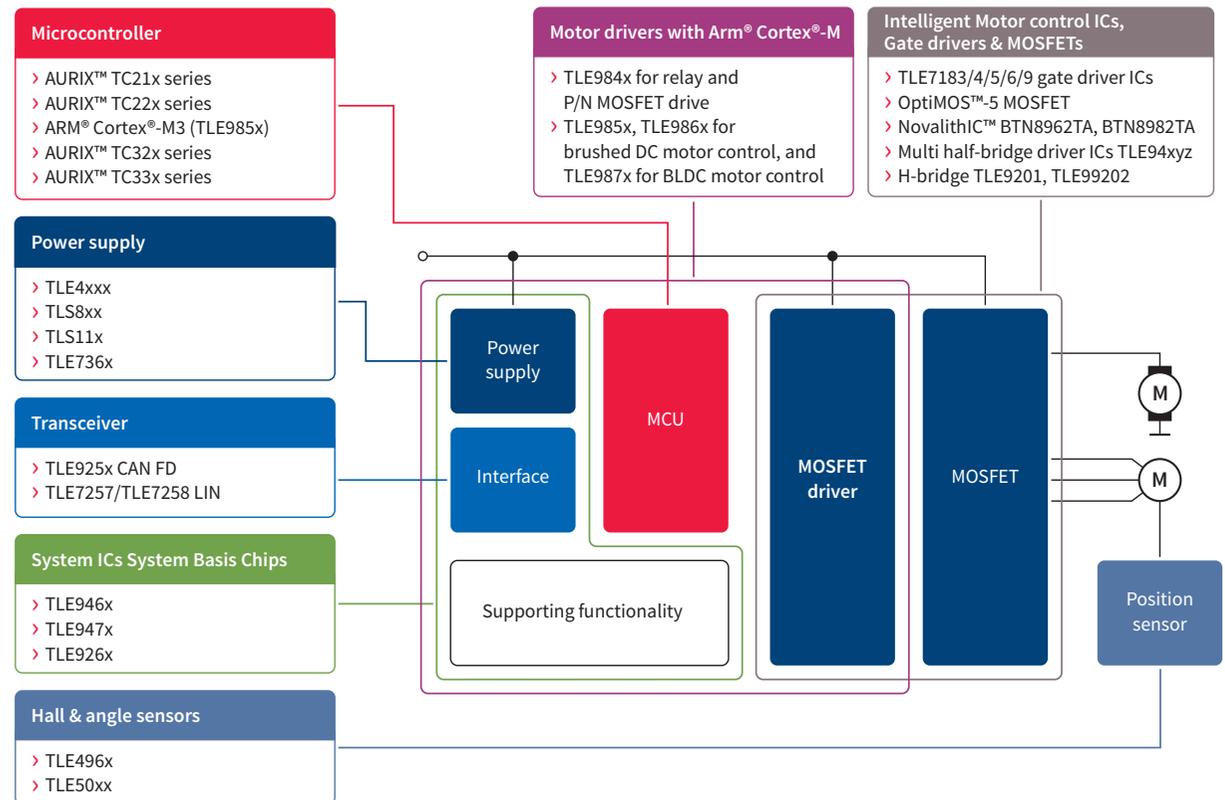
1.3. Seamless motor control offerings powered by Infineon

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 3: Levels of integrations and their benefits

	Low integration			Medium integration		High integration	
	Microcontroller	Bridge driver	MOSFET Sensor	Microcontroller/ Embedded Power	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: Motor driver ICs with motor driver with Arm® Cortex®-M

Infineon's monolithic Embedded Power ICs 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 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.

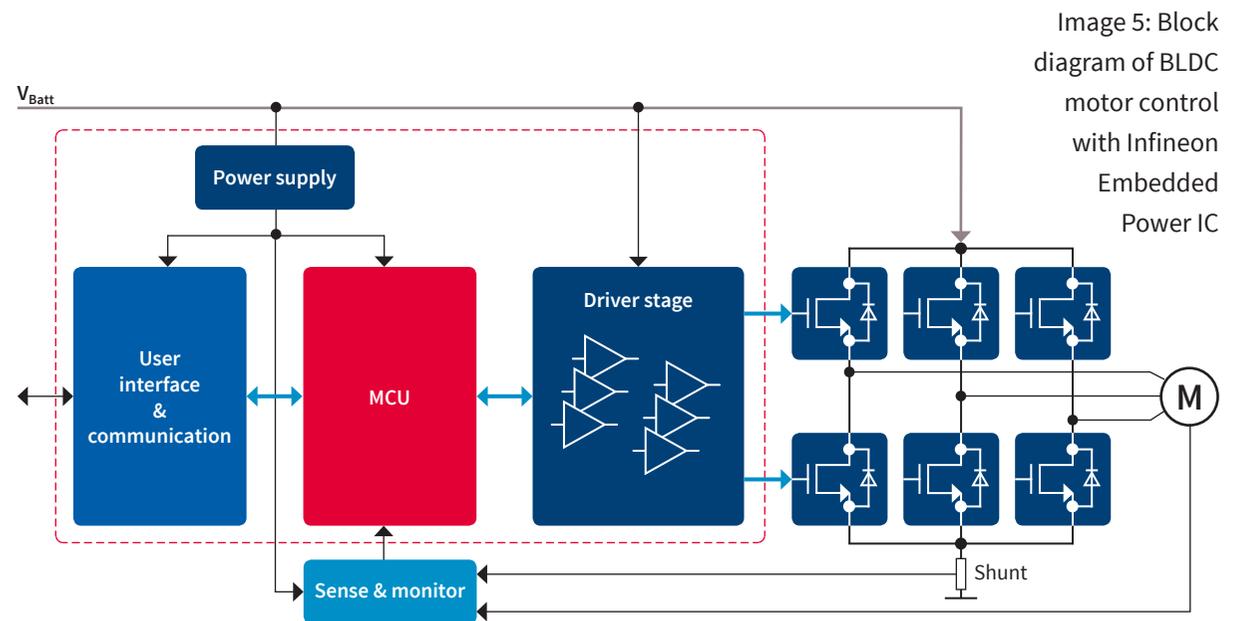


Image 5: Block diagram of BLDC motor control with Infineon Embedded Power IC

Key features & benefits

- › **Enable cost and board space improvements** – our system-on-chip solution integrates data processing, actuation and sensing. The chip comes in a leadless VQFN package with 7 x 7 mm footprint and enables PCB space saving. The Embedded Power IC families allow driving of relays and MOSFETs at $V_{Batt} > 6\text{ V}$ without external components, providing very cost effective solution on a system level.
- › **Enabling high levels of system reliability** – extensive diagnostics and protections are embedded within the system-on-chip, more than a discrete approach can offer. In addition both the Embedded Power IC and the external MOSFETs can be protected.
- › **Support multiple and flexible designs with minimal effort** – all Embedded Power IC are software compatible, maximizing a single design through scalability.

Applications

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

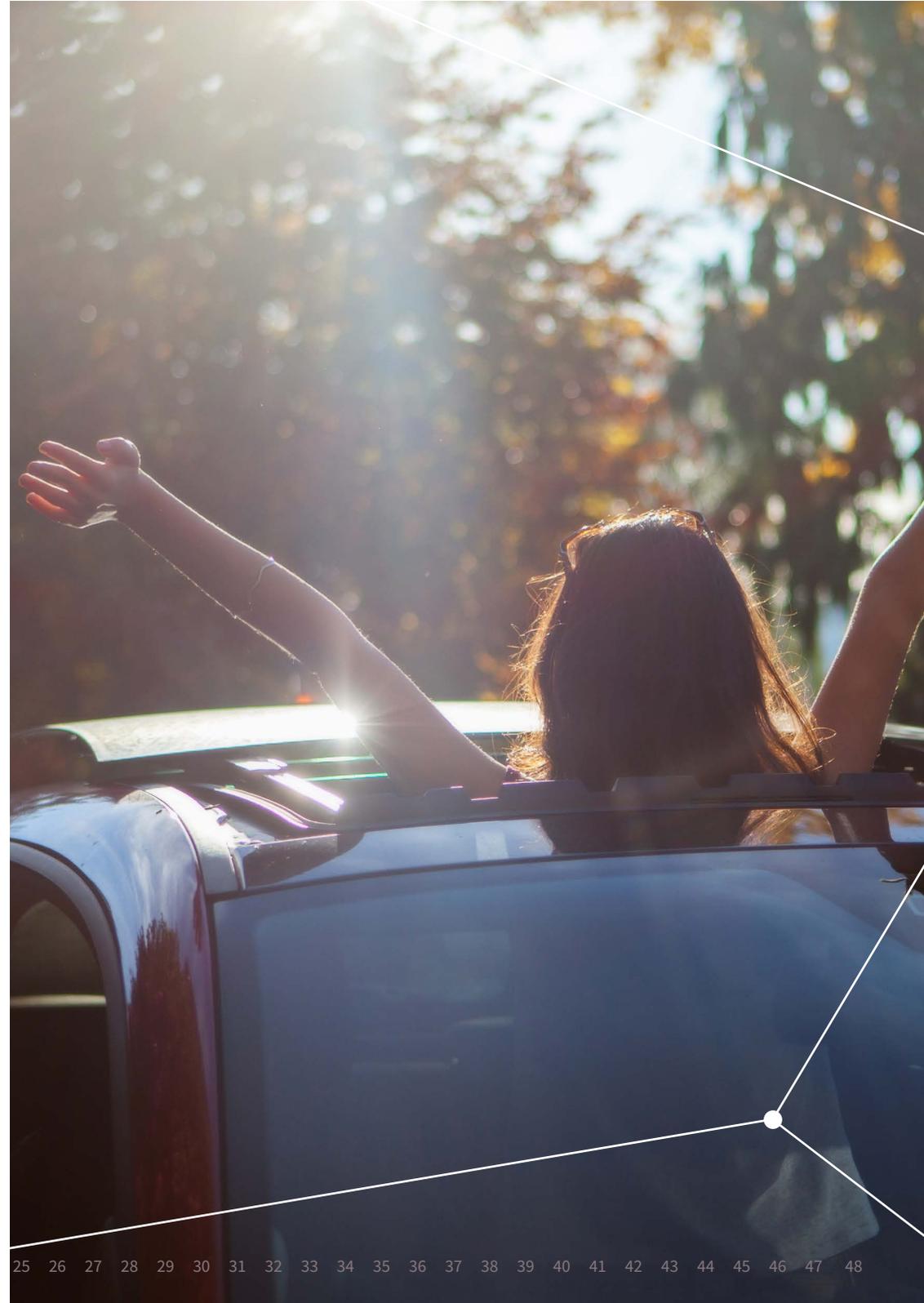
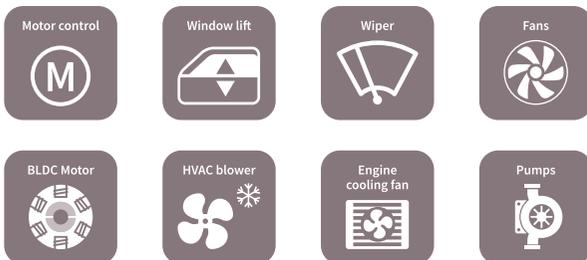


Image 6: The decision tree helps you to find the best fit: An Embedded Power-device or a less integrated solution.

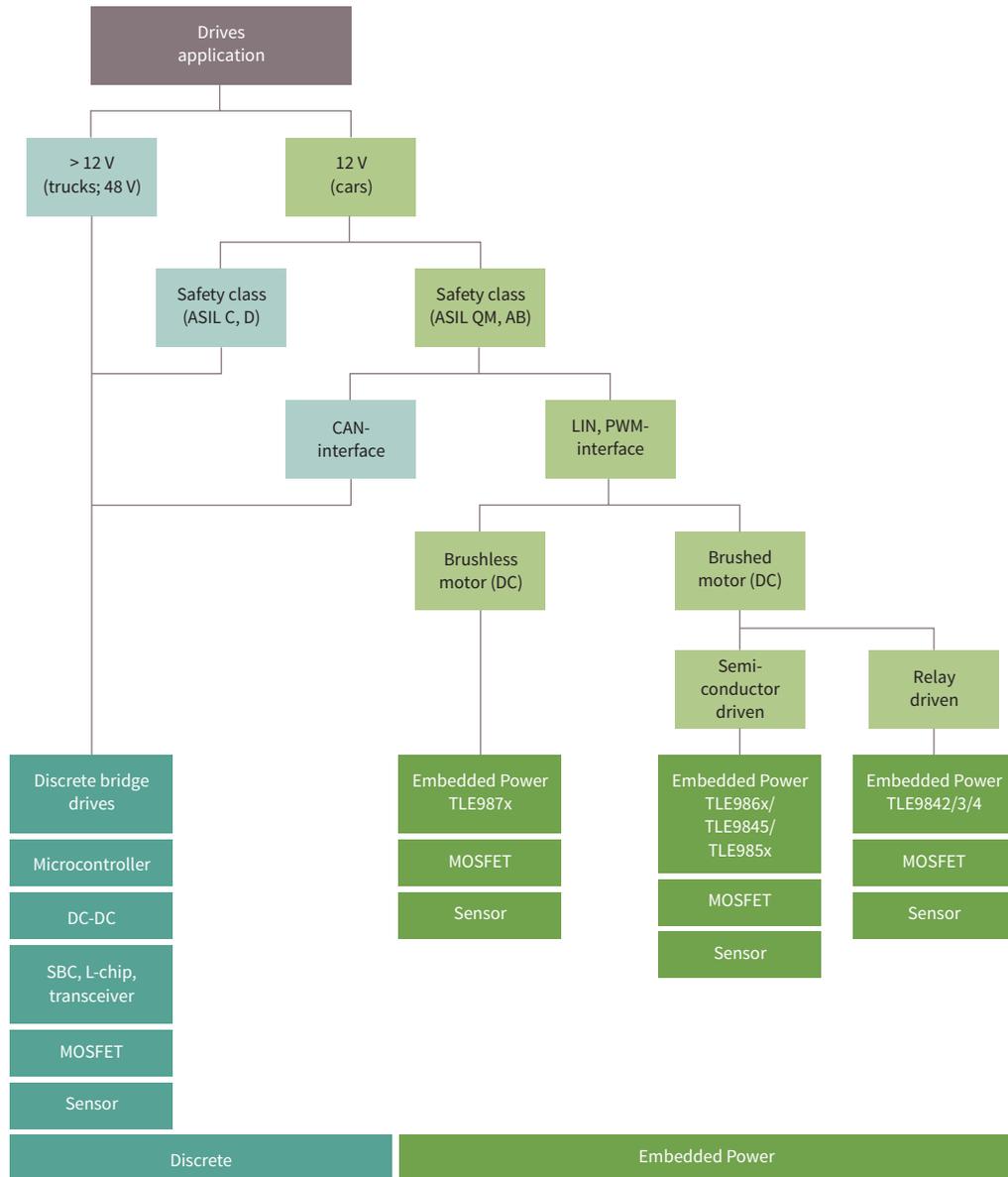


Image 7: Embedded Power ICs TLE984xQX: smart window lift application diagram

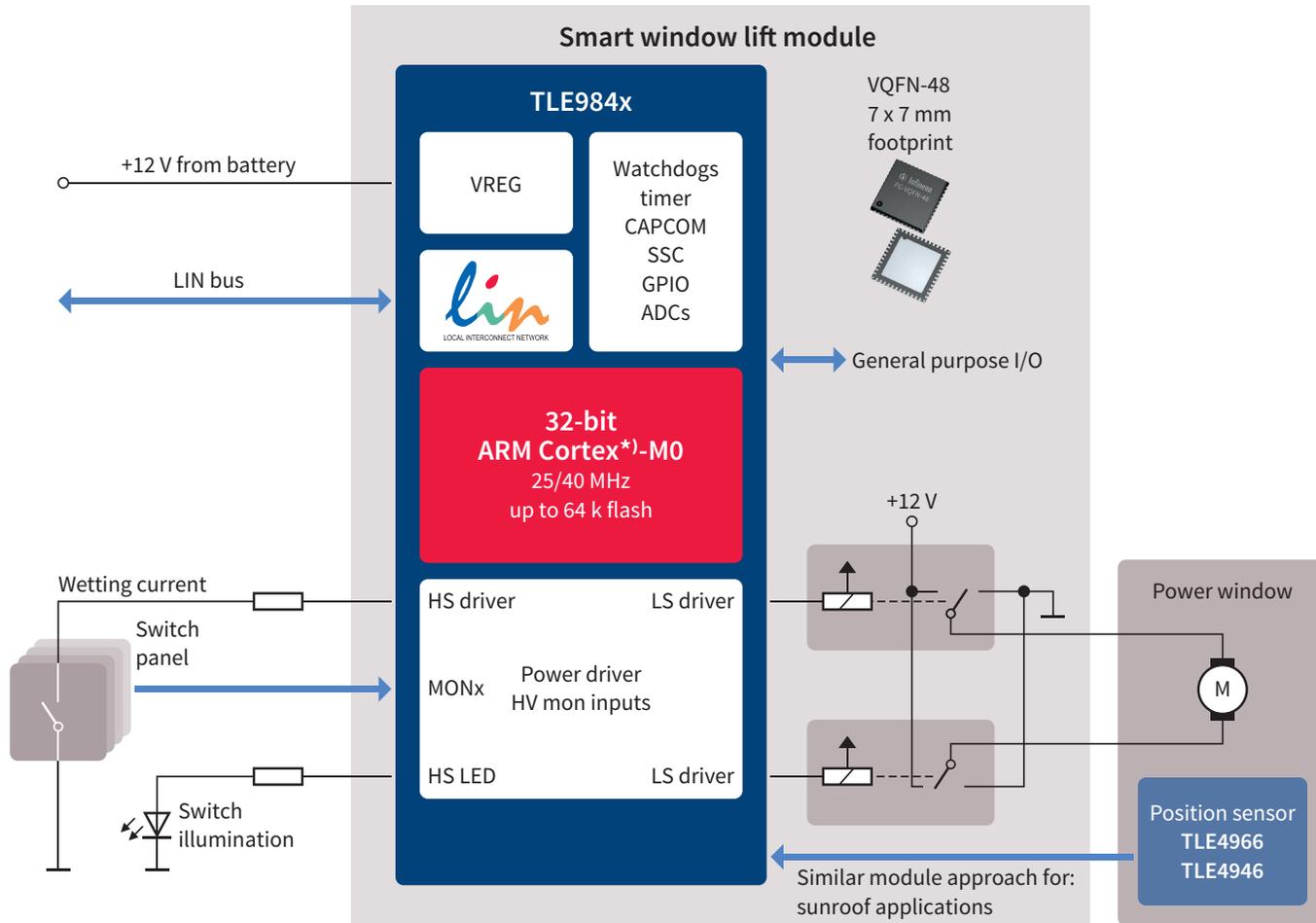


Image 8: TLE987x Infineon Embedded Power IC: 3-phase motor driver with integrated ARM® Cortex™-M3 MCU

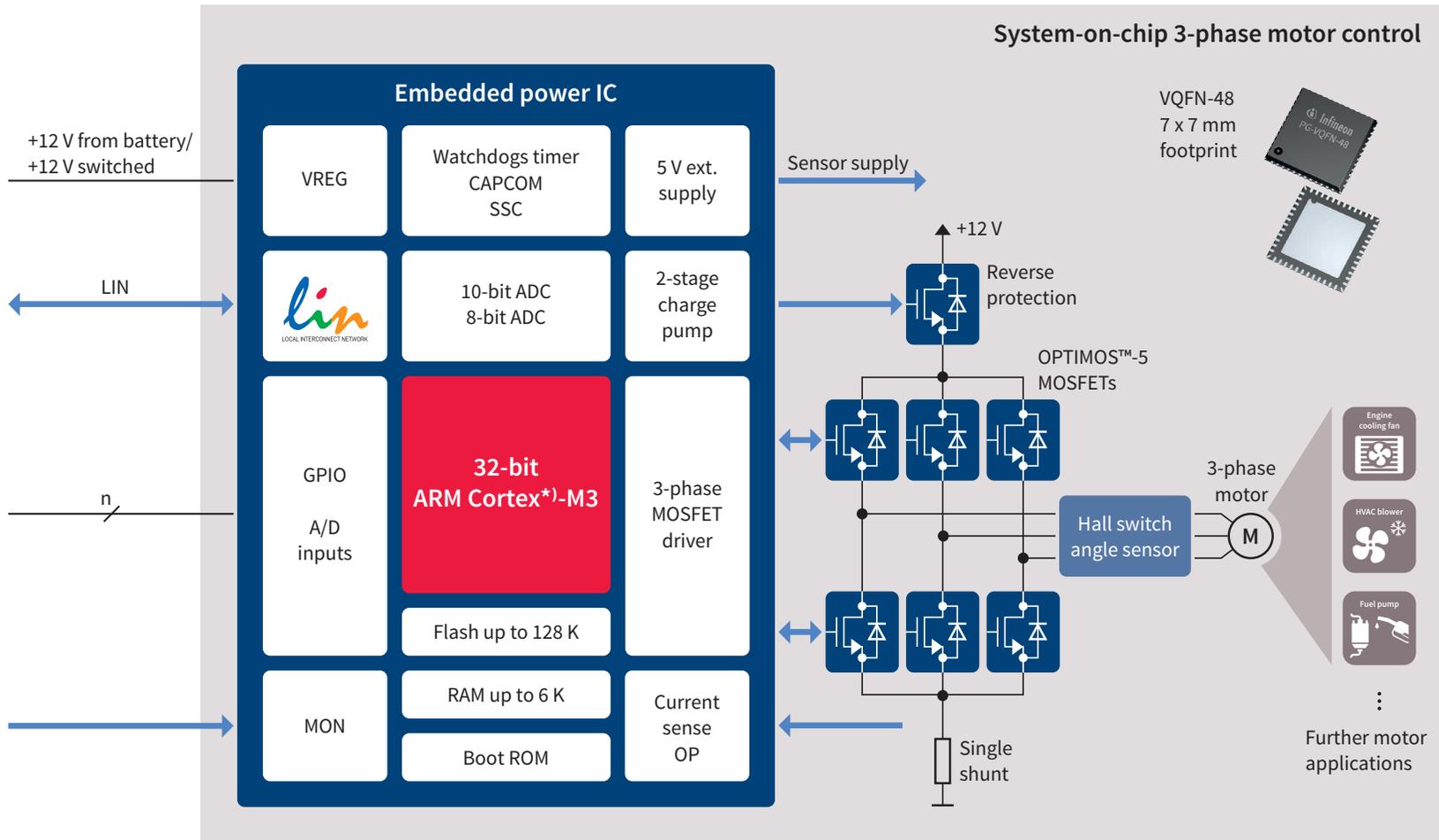


Table 1: Embedded power ICs family selection table

Criteria	TLE984x	TLE9845QX	TLE9850QX	TLE9851QXW	TLE985x	TLE986x	TLE987x
Controller	ARM Cortex-M0					ARM Cortex-M3	
Core frequency	25/40 MHz	40 MHz				24/40 MHz	
Flash size	36–64 KB	48 KB	48/64 KB	64 KB	48–96 KB	36–128 KB	
Driver stage	Relay	Half-bridge			H-bridge		B6-bridge
		PN FET	NN FET	NN FET	N FET		N FET
High-voltage monitor inputs	4 – 5	5	4			1	
Junction temperature levels	150°C	150°C	150°C/175°C	175°C	150°C/175°C	150°C/175°C	
Package	VQFN-48-31		VQFN-48-29 VQFN-48-31	VQFN-48-29	VQFN-48-29 VQFN-48-31	VQFN-48-29 VQFN-48-31	
Applications	Window lift Sunroof	Engine cooling fan Auxiliary water pump HVAC blower Fuel pump			Window lift Sunroof Wiper Power lift gate	Engine cooling fan Oil/water/fuel pump HVAC blower Power tools	

Table 2: TLE984x product overview

Product name	Flash [kB]	RAM [kB]	EEPROM in Flash included [kB]	Frequency [MHz]	High-side switch	High-voltage monitor input	GPIO	Analog inputs	PNMOS driver	T _j [°C]	Interface	Package
TLE984xQX, Arm® Cortex®-M0 relay driver IC with integrated microcontroller												
TLE9842QX	36	2	4	25	1	4	10	6	No	150	PWM + LIN	VQFN-48
TLE9842-2QX	40	2	4	40	2	5	10	6	No	150	PWM + LIN	VQFN-48
TLE9843QX	48	4	4	25	1	4	10	6	No	150	PWM + LIN	VQFN-48
TLE9843-2QX	52	4	4	40	2	5	10	6	No	150	PWM + LIN	VQFN-48
TLE9844QX	64	4	4	25	1	4	10	6	No	150	PWM + LIN	VQFN-48
TLE9844-2QX	64	4	4	40	2	5	10	6	No	150	PWM + LIN	VQFN-48
Half-bridge driver IC with integrated microcontroller												
TLE9845QX	48	4	4	40	2	5	10	6	Yes	150	PWM + LIN	VQFN-48

Table 3: TLE985x product overview

Product name	Flash [kB]	RAM [kB]	EEPROM in flash included [kB]	Frequency [MHz]	High-side switch	Low-side MOSFET drivers	High-side MOSFET drivers	High voltage monitor input	T _j [°C]	Interface	Package
TLE985xQX, Arm® Cortex®-M0 based 2-Phase NFET Gate Driver DC Motor Control, Grade-1											
TLE9850QX	48	4	4	40	1	1	1	4	150	PWM + LIN	VQFN-48-31
TLE9852QX	48	4	4	40	1	2	2	4	150	PWM + LIN	VQFN-48-31
TLE9853QX	48	4	4	40	1	2	2	4	150	PWM + LIN	VQFN-48-31
TLE9854QX	64	4	4	40	1	2	2	4	150	PWM + LIN	VQFN-48-31
TLE9855QX	96	4	4	40	1	2	2	4	150	PWM + LIN	VQFN-48-31
TLE985xQXW, Arm® Cortex®-M0 based 2-Phase and Single Phase NFET Gate Driver for DC Motor Control, Grade-0											
TLE9851QXW	64	4	4	40	1	1	1	4	175	PWM + LIN	VQFN-48-29
TLE9854QXW	64	4	4	40	1	2	2	4	175	PWM + LIN	VQFN-48-29

Table 4: TLE986x product overview

Product name	Flash [kB]	RAM [kB]	Frequency [MHz]	EEPROM emulation [kB]	OP-AMP	Low-side MOSFET drivers	High-side MOSFET drivers	T _j [°C]	Interface
TLE986x 32-bit microcontroller with 2-phase NFET gate driver for DC motors (grade-1, T _j =150°C)									
TLE9861QXA20	36	3	24	4	Yes	2	2	150	PWM
TLE9867QXA20	64	6	24	4	Yes	2	2	150	PWM + LIN
TLE9867QXA40	64	6	40	4	Yes	2	2	150	PWM + LIN
TLE9869QXA20	128	6	24	4	Yes	2	2	150	PWM + LIN
TLE986x Arm® Cortex®-M3 2-phase NFET gate drive for DC motors (grade-0, T _j =175°C)									
TLE9867QXW20	64	6	24	4	Yes	2	2	175	PWM + LIN

Table 5: TLE987x product overview

Product name	Frequency [MHz]	Interface	RAM [kB]	Flash [kB]	EEPROM emulation [kB]	OP-AMP	2x14-bit Sigma-delta ADC	Low-side MOSFET drivers	High-side MOSFET drivers	T _j [°C]
TLE987xQXA, ARM® Cortex™-M3 based 3-phase NFET Gate Driver BLDC Motor Control, Grade-1										
TLE9871QXA20	24	PWM	3	36	4	Yes	No	3	3	150
TLE9877QXA20	24	PWM + LIN	6	64	4	Yes	No	3	3	150
TLE9877QXA40	40	PWM + LIN	6	64	4	Yes	No	3	3	150
TLE9879QXA20	24	PWM + LIN	6	128	4	Yes	No	3	3	150
TLE9879QXA40	40	PWM + LIN	6	128	4	Yes	No	3	3	150
TLE9879-2QXA40	40	PWM + LIN	6	128	4	Yes	Yes	3	3	150
TLE987xQXW, ARM® Cortex™-M3 based 3-phase NFET Gate Driver BLDC Motor Control, Grade-0										
TLE9873QXW40	40	PWM + LIN	3	48	4	Yes	No	3	3	175
TLE9877QXW40	40	PWM + LIN	6	64	4	Yes	No	3	3	175
TLE9879QXW40	40	PWM + LIN	6	128	4	Yes	No	3	3	175

Tools and software for Embedded power ICs

Infineon Embedded Power ICs are supported by a complete development tool chain provided by Infineon and third-party vendors. The tool chain includes compilers, debuggers, several evaluation boards, LIN low level drivers and configuration tools as well as various software code examples. Additional tools supporting the design-in process are available via the Infineon Toolbox.

For each Embedded Power IC family we offer evaluation boards to evaluate all functions and peripherals providing access to all device I/Os. In addition, evaluation and applications kits are available which are space- and cost-optimized to demonstrate near-application solutions.

More information concerning Embedded Power ICs tools and evaluation boards, are found on page 43.

3. Medium-integrated solutions for motor control: Intelligent Motor Control ICs

The medium-integrated devices combine gate-drivers with the MOSFET power stage in a single package. A small foot-print 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 9 shows an application example.

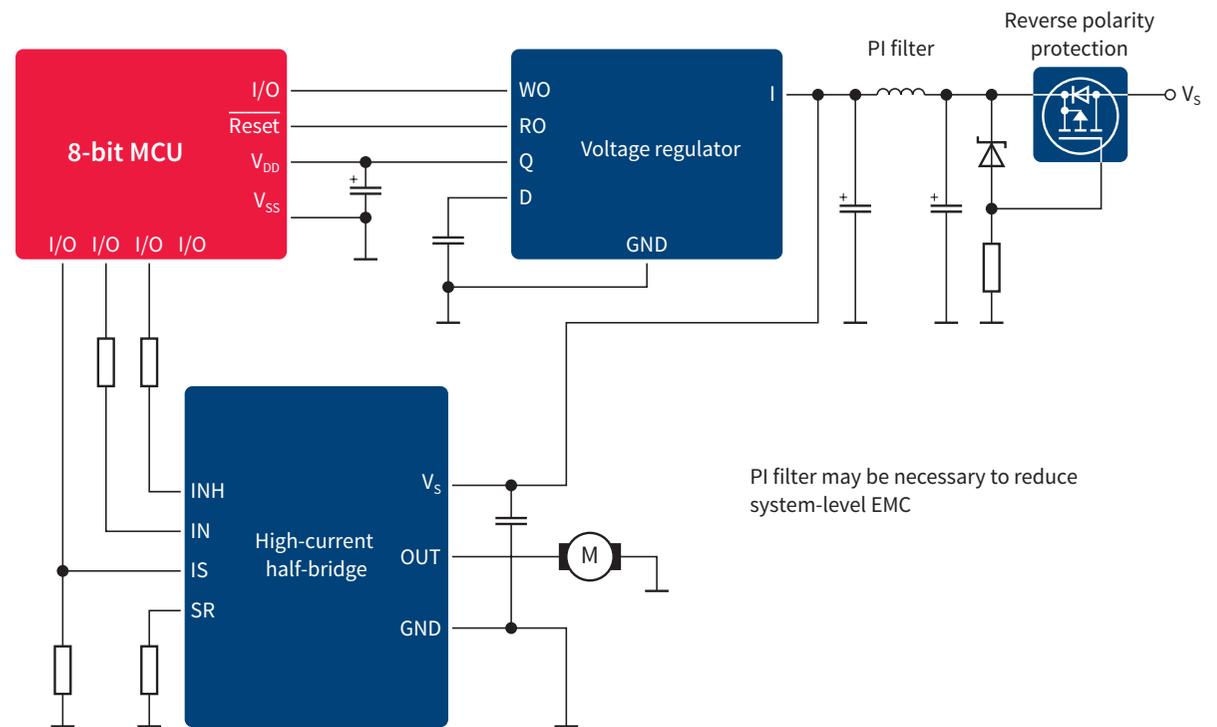
3.1. Single half-bridges

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. Other benefits of the NovalithIC™ are:

- > High reliability
- > Current sense
- > Small footprint
- > High currents (up to 55 A)
- > Scalability due to family concept (BTN8962 and BTN8982)
- > Adjustable slew rate

The NovalithIC™ family offers cost-optimized solutions for protected high-current PWM motor drives with very low board-space consumption — scaled to your needs.

Image 9: Application example of fuel pump partitioning with high current integrated Half-Bridge



PI filter may be necessary to reduce system-level EMC

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

Applications

- › Fuel pump
- › Sun roof
- › Electric parking brake
- › Fans
- › HVAC blower
- › Body control module
- › Engine cooling fan
- › Wiper
- › Tail gate
- › Sliding door
- › Seatbelt pretensioner
- › 4WD transfer case

More information: www.infineon.com/novalithic



Table 6: NovalithIC™ product overview

NovalithIC™ product overview								
Product name	Operating range [V]	R _{DS(on)} path (typ) [mΩ]	I _{D(lim)} (typ) [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	77	7	0.25	OT, OC, CS	UV, OT, OC	TO263-7-1 (TO220-7 (SMD))

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.

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

Applications

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

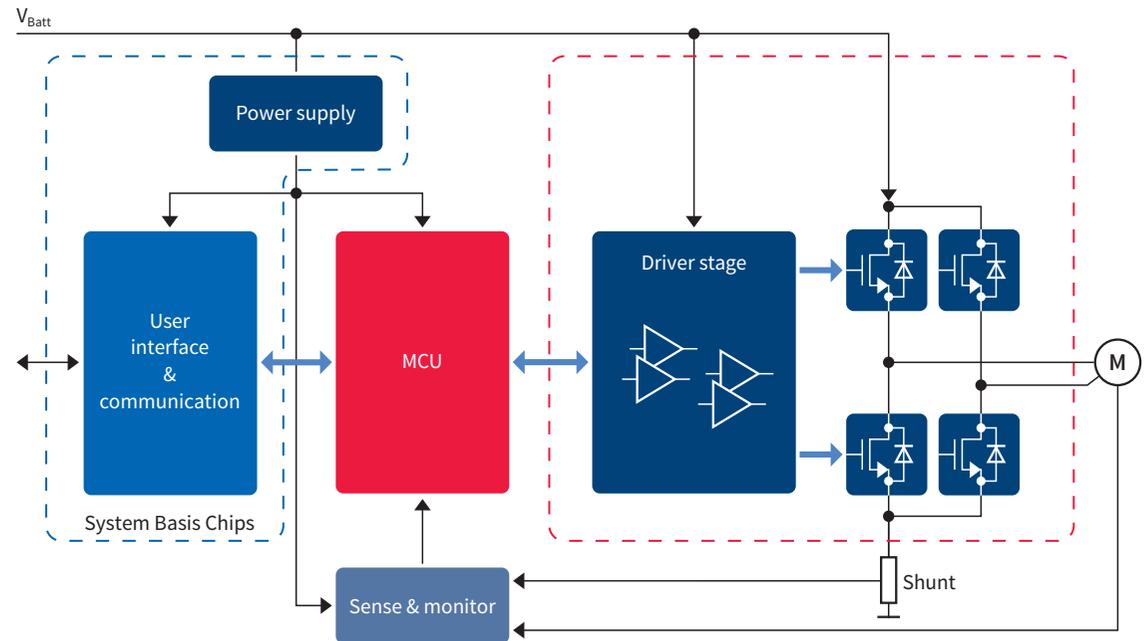
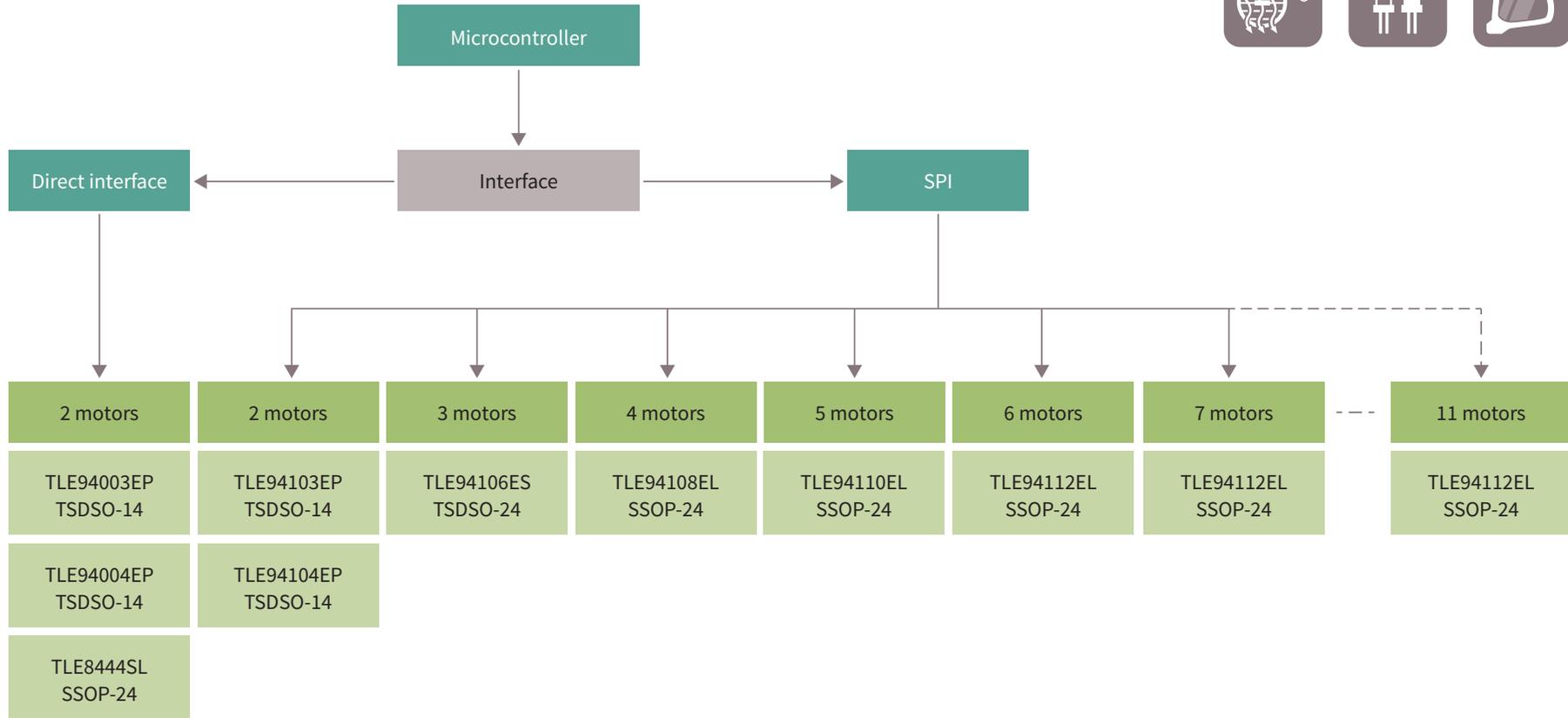


Image 10: Block diagram of DC motor control using components for medium integration

Image 11: Product selection tree for multi Half-Bridges or multipurpose bridges



3.3. Full- or H-bridge

TLE9201SG and TLE9202ED are general-purpose 6 A 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.

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
- › V_S 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

Applications

- › Exhaust Gas Recirculation (EGR)
- › Variable Geometry Turbo (VGT)
- › Idle speed control
- › Swirl and tumble flaps
- › Variable intake manifold
- › Turbo charger waste gates
- › Auxiliary water pumps
- › Industrial DC motor applications



Table 7: 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

3.4. System ICs – System Basis Chip (SBC)



SBCs integrates supply and communication features in one IC

Infineon offers a broad base of integrated solutions which combine power, communication, diagnosis and supervision as well as support features in a single device. These System Basis Chips (SBC) offer high integration and high performance at an optimized system cost for motor control applications. This reduces the required board space by 80 percent, also lowers energy consumption through low-power modes offering the lowest quiescent current in the market. In addition, SBCs increase system reliability by reducing component count, integrating safety features, and lowering the bill of materials.

More information: www.infineon.com/sbc

Applications

- > Power Lift Gate
- > Sunroof Module
- > Roof Module
- > Seat Control Module
- > HVAC
- > Electric Parking Actuator
- > Steering Column Lock
- > Seatbelt pretensioner
- > 4WD Transference

Key features

- > Power supplies with low-dropout regulator or DCDC converter
- > Selectable 5 V or 3.3 V main power supply
- > CAN FD (up to 5 Mbit/s) and up to two LIN transceivers (TLE926x)
- > CAN Partial Networking as an option
- > Compelling four high-side switches 7 Ω typ. (TLE926x)
- > Effective external load switch control through integrated charge pump (TLE9461/71) that can drive an external N-FET
- > Integrated diagnostic and supervision features, supporting ECU functional safety concepts with under-voltage monitoring, window watchdog with reset, fail-safe operating mode, fail-safe outputs and more

Benefits

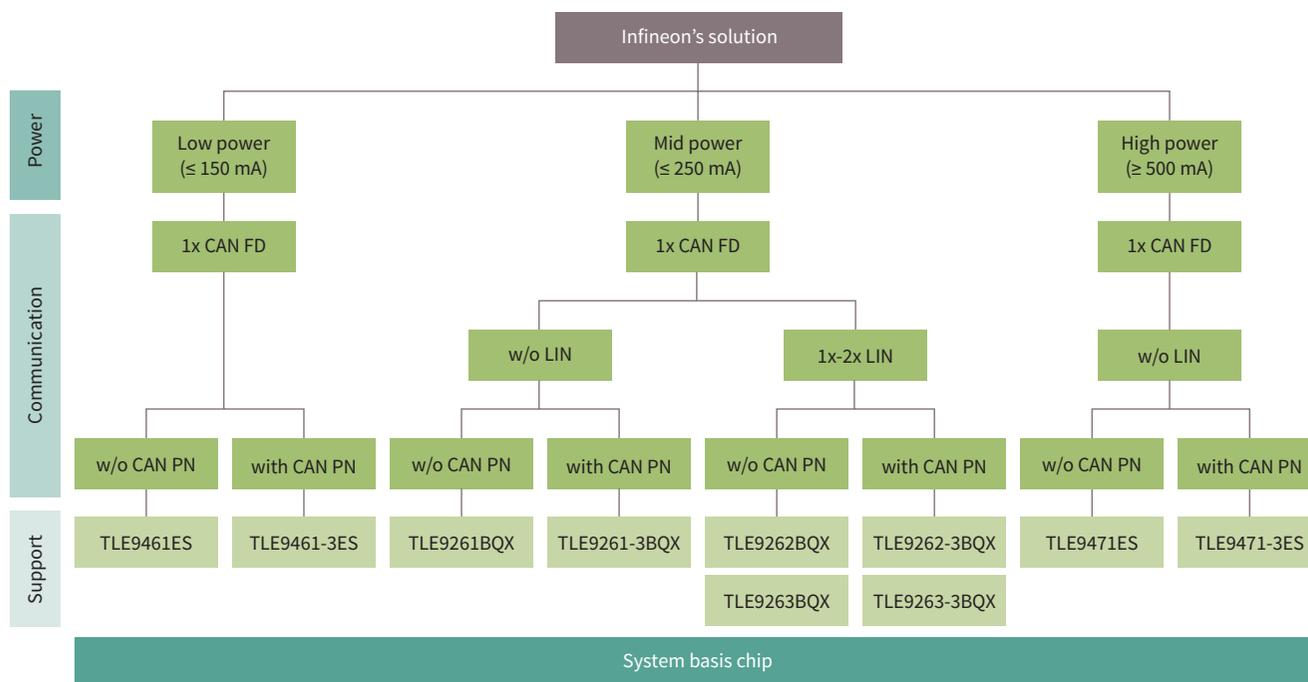
- > Reduced PCB space requirements up to 80 percent by feature integration
- > Extends battery life through low-power modes and the lowest quiescent current in the market
- > Increased system reliability by reducing component count
- > Enables design flexibility and reduces software design effort by pin-to-pin compatibility, shared state machine and common SPI access
- > Meets major car OEM requirements with excellent EMC and ESD performance
- > Safely supply off-board loads (e.g., sensors) with protected low-drop voltage regulators



Table 8: Body System ICs – System Basis Chips product overview

Product	Transceiver	Voltage Regulator output (VCC1)	Voltage Regulator output (VCC2)	Voltage Regulator output (VCC3)	Output drivers	Quiescent current	Others	Package
TLE9461ES (V33)	CAN FD	150mA (5V or 3.3V)	100 mA (5 V)	–	Charge Pump, GPIO	15 µA (typ.)	Wake, FO	TSDSO-24
TLE9461-3ES (V33)	CAN FD	150mA (5V or 3.3V)	100 mA (5 V)	–	Charge Pump, GPIO	15 µA (typ.)	Wake, FO, CAN PN	TSDSO-24
TLE9471ES (V33)	CAN FD	500mA (5V or 3.3V)	100 mA (5 V)	–	Charge Pump, GPIO	15 µA (typ.)	Wake, FO,	TSDSO-24
TLE9471-3ES (V33)	CAN FD	500mA (5V or 3.3V)	100 mA (5 V)	–	Charge Pump, GPIO	15 µA (typ.)	Wake, FO, CAN PN	TSDSO-24
TLE9261BQX (V33)	CAN FD	250mA (5V or 3.3V)	100 mA (5 V)	up to 400 mA (5 V, 3.3 V or 1.8 V)	4x High-Side Switch	15 µA (typ.)	Wake, FO	VQFN 48
TLE9261-3BQX (V33)	CAN FD	250mA (5V or 3.3V)	100 mA (5 V)	up to 400 mA (5 V, 3.3 V or 1.8 V)	4x High-Side Switch	15 µA (typ.)	Wake, FO, CAN PN	VQFN 48
TLE9262BQX (V33)	CAN FD, LIN	250mA (5V or 3.3V)	100 mA (5 V)	up to 400 mA (5 V, 3.3 V or 1.8 V)	4x High-Side Switch	15 µA (typ.)	Wake, FO	VQFN 48
TLE9262-3BQX (V33)	CAN FD, LIN	250mA (5V or 3.3V)	100 mA (5 V)	up to 400 mA (5 V, 3.3 V or 1.8 V)	4x High-Side Switch	15 µA (typ.)	Wake, FO, CAN PN	VQFN 48
TLE9263BQX (V33)	CAN FD, 2x LIN	250mA (5V or 3.3V)	100 mA (5 V)	up to 400 mA (5 V, 3.3 V or 1.8 V)	4x High-Side Switch	15 µA (typ.)	Wake, FO	VQFN 48
TLE9263-3BQX (V33)	CAN FD, 2x LIN	250mA (5V or 3.3V)	100 mA (5 V)	up to 400 mA (5 V, 3.3 V or 1.8 V)	4x High-Side Switch	15 µA (typ.)	Wake, FO, CAN PN	VQFN 48

Image 12: Selection tree

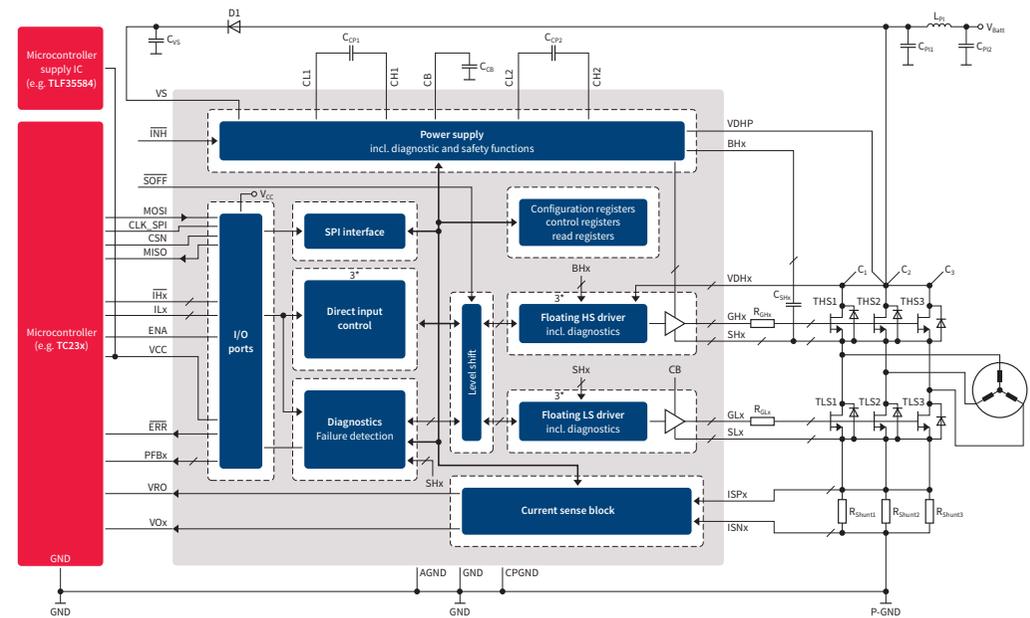
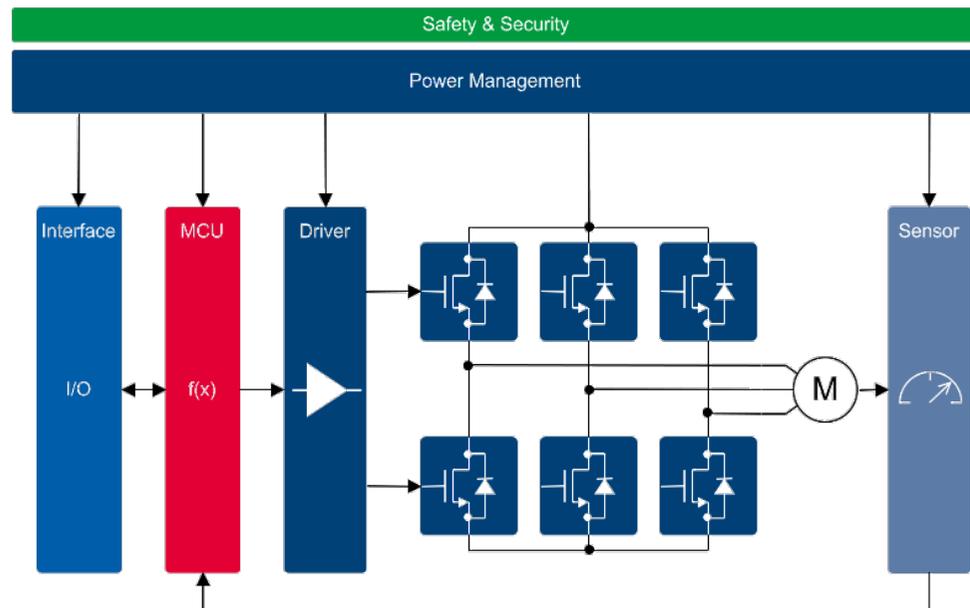


4. Low-integrated solutions for high-power motor control

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 13 shows an application example of a 3-phase motor drive using discrete components resulting in a low integration level, while providing the highest flexibility.

Image 13: Simplified block diagram of a 3-phase motor drive using discrete components



4.1. Gate driver ICs for MOSFETs

Our line-up of gate driver ICs for external MOSFETs covers everything you need for brushless DC and brush DC motors in 12 V and 48 V automotive applications, including protection and diagnostic features to meet ISO26262

The trend to advanced driver assistant systems, autonomous driving, challenging regulatory emission targets and the increasing electrification of the drivetrain spur the need for sophisticated electric motor drives in vehicles.

Applications such as HVAC compressors or engine cooling fans will be controlled by variable speed drives in the future. Electric power steering and brake booster will transition from fail safe to fail operational systems with the need for ISO26262 ASIL-D compliance on component level. The introduction of 48 V MHEV will be a game changer for traditional alternators to become integrated starter generators.

At Infineon we have a full range of motor driver ICs to provide the required performance and functional safety for the versatile use that these systems demand. Leveraging more than 15 years' experience and our strong technical resources, we have leading-edge products in place to master the automotive revolution.

Applications

- > Electric power steering
- > Electric brake booster
- > Engine cooling fan
- > 48 V starter generator
- > Transfer case
- > Double clutch transmission
- > Active roll control
- > Water pump
- > Oil pump
- > Seat belt pretension
- > Power lift gate
- > Electric parking brake

Basic features

- > Supply range from 5.5 – 60 V
- > Powerful driver stage with typ. 2 A output current per channel
- > 0 to 100 percent duty cycle range
- > Integrated current sense amplifier for shunt signal conditioning
- > Extended protection & supervision

Image 14: Selection tree gate drivers ICs

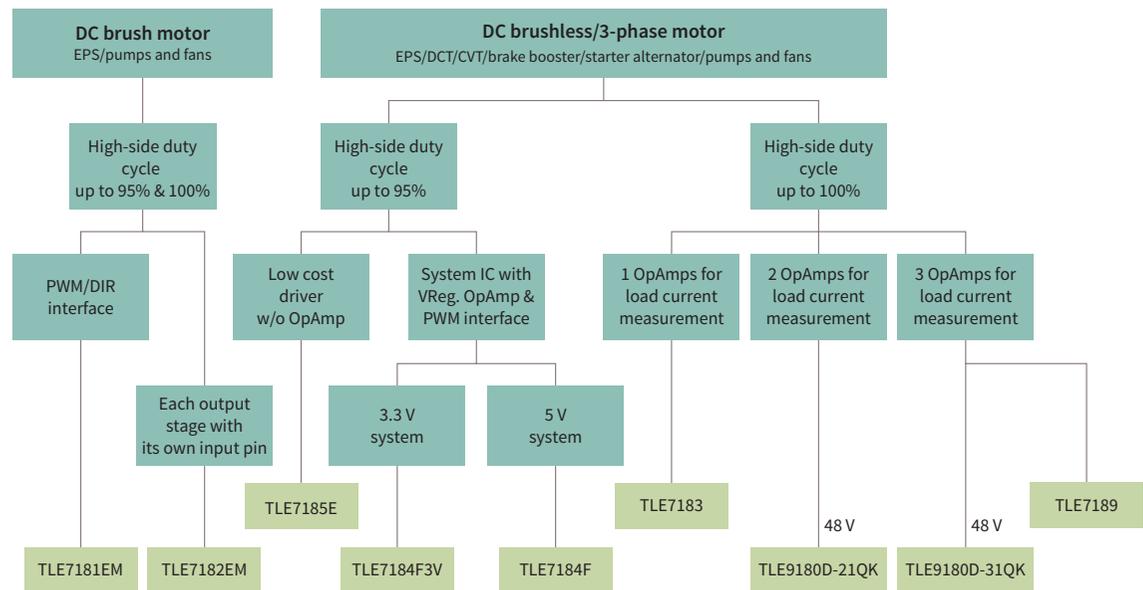


Table 9: H-bridge/dual half-bridge drivers family

Product name	Operating range [V]	OpAmp	PWM/DIR input	Reverse polarity protection	Diagnosis	Package
TLE7181EM	7 ... 34	1		●	UV, OV, OC, SCD, OT	SSOP-24
TLE7182EM	7 ... 34	1		●	UV, OV, OC, SCD, OT	SSOP-24

Table 10: 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	ISO 26262 ready	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⁾	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
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)
TLE9180D-21QK	5.50 ... 60.00	2.00/2.20 A	0 ... 100	2	●	●	UV, OV, SCD, OT, diagnostic, limp mode	LQFP-64
TLE9180D-31QK	5.50 ... 60.00	2.00/2.20 A	0 ... 100	3	●	●	UV, OV, SCD, OT, diagnostic, limp mode	LQFP-64

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

LO = Lockout
OL = Open-Load
OV = Overvoltage
OC = Overcurrent

UV = Undervoltage
OT = Overtemperature
SCD = Short-Circuit Detection

4.2. MOSFETs

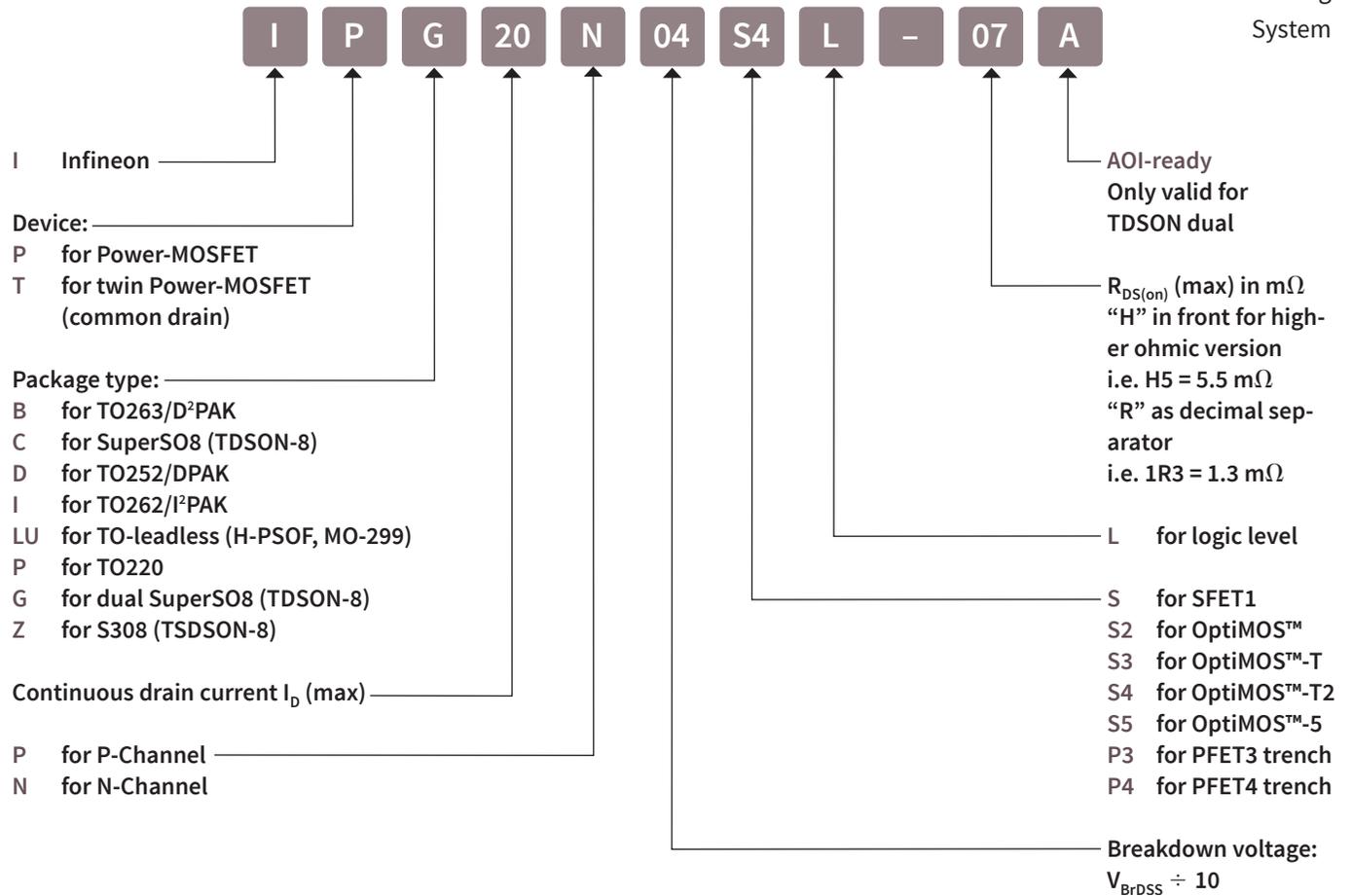
Automotive MOSFETs

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 mm² in S308)
 - High current capability (up to 300 A in TOLL)

Infineon Automotive MOSFET naming system



Part Numbering System for new MOSFETs

Infineon Automotive MOSFET naming system

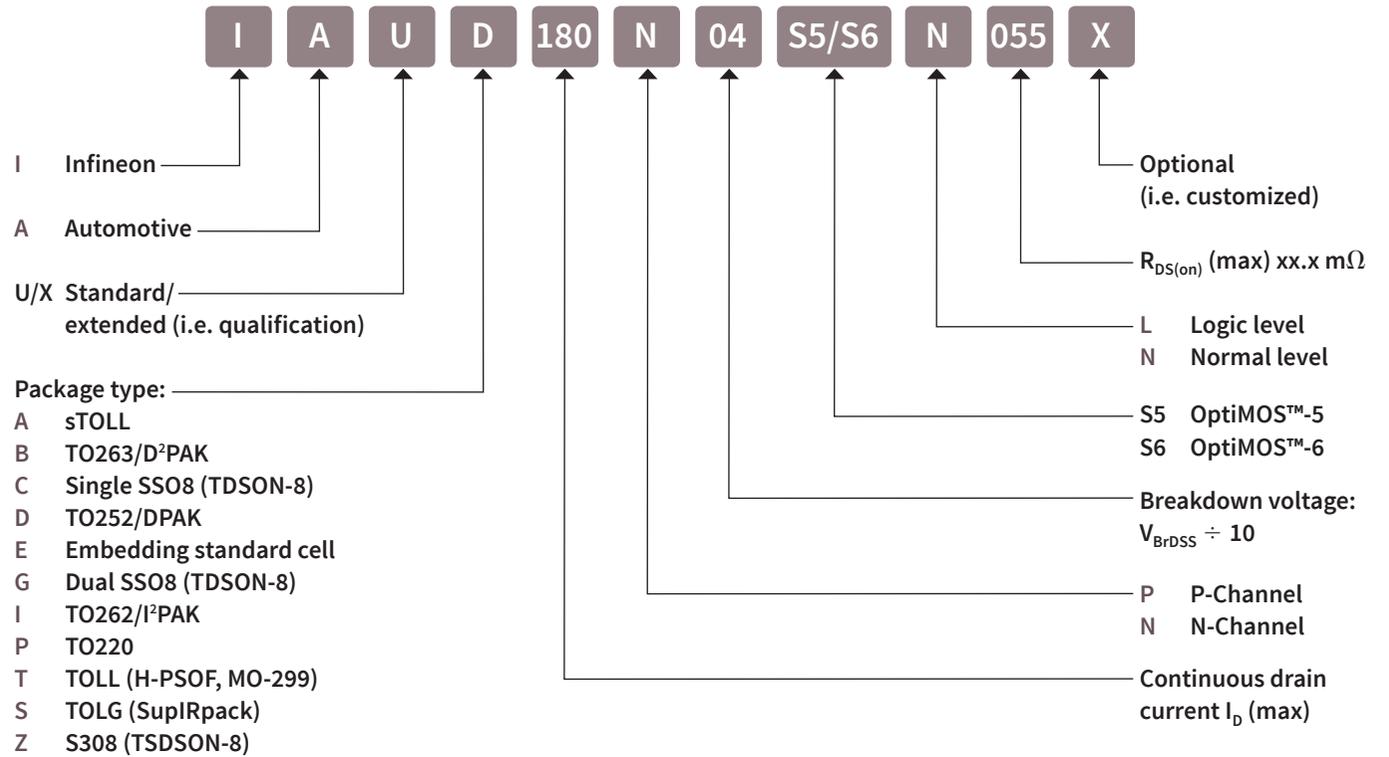


Table 11: 40 V, 80 V & 100 V single N-Channel MOSFET overview in SS08 package

	Sales name	Technology	$R_{DS(on)}$ max 10 V [mΩ]	I_b [A]	LL/NL	Package
NEW	IAUC120N04S6L008	OptiMOS™ 6	0.8	120	LL	Single SS08
NEW	IAUC120N04S6N009	OptiMOS™ 6	0.9	120	NL	Single SS08
NEW	IAUC120N04S6L009	OptiMOS™ 6	0.9	120	LL	Single SS08
NEW	IAUC120N04S6N010	OptiMOS™ 6	1.0	120	NL	Single SS08
NEW	IAUC120N04S6L012	OptiMOS™ 6	1.2	120	LL	Single SS08
NEW	IAUC120N04S6N013	OptiMOS™ 6	1.3	120	NL	Single SS08
NEW	IAUC100N04S6L014	OptiMOS™ 6	1.4	100	LL	Single SS08
NEW	IAUC100N04S6N015	OptiMOS™ 6	1.5	100	NL	Single SS08
NEW	IAUC100N04S6L020	OptiMOS™ 6	2.0	100	LL	Single SS08
NEW	IAUC100N04S6N022	OptiMOS™ 6	2.2	100	NL	Single SS08
NEW	IAUC100N04S6L025	OptiMOS™ 6	2.5	100	LL	Single SS08
NEW	IAUC100N04S6N028	OptiMOS™ 6	2.8	100	NL	Single SS08
NEW	IAUC80N04S6L032	OptiMOS™ 6	3.2	80	LL	Single SS08
NEW	IAUC80N04S6N036	OptiMOS™ 6	3.6	80	NL	Single SS08
NEW	IAUC60N04S6L039	OptiMOS™ 6	3.9	60	LL	Single SS08
NEW	IAUC60N04S6N044	OptiMOS™ 6	4.4	60	NL	Single SS08
NEW	IAUC100N10S5L040	OptiMOS™ 5	4.0	100	LL	Single SS08
NEW	IAUC100N10S5N040	OptiMOS™ 5	4.0	100	NL	Single SS08
NEW	IAUC100N08S5N031	OptiMOS™ 5	3.1	100	NL	Single SS08
NEW	IAUC100N08S5N043	OptiMOS™ 5	4.3	100	NL	Single SS08
NEW	IAUC70N08S5N074	OptiMOS™ 5	7.4	70	NL	Single SS08
	IPC100N04S5-1R2	OptiMOS™ 5	1.2	100	NL	Single SS08
	IPC100N04S5L-1R1	OptiMOS™ 5	1.1	100	LL	Single SS08
	IPC100N04S5-1R7	OptiMOS™ 5	1.7	100	NL	Single SS08
	IPC100N04S5L-1R5	OptiMOS™ 5	1.5	100	LL	Single SS08
	IPC100N04S5-1R9	OptiMOS™ 5	1.9	100	NL	Single SS08
	IPC100N04S5L-1R9	OptiMOS™ 5	1.9	100	LL	Single SS08
	IPC100N04S5-2R8	OptiMOS™ 5	2.8	100	NL	Single SS08
	IPC100N04S5L-2R6	OptiMOS™ 5	2.6	100	LL	Single SS08
	IPC90N04S5-3R6	OptiMOS™ 5	3.6	90	NL	Single SS08
	IPC90N04S5L-3R3	OptiMOS™ 5	3.3	90	LL	Single SS08
	IPC70N04S5-4R6	OptiMOS™ 5	4.6	70	NL	Single SS08
	IPC70N04S5L-4R2	OptiMOS™ 5	4.2	70	LL	Single SS08
	IPC50N04S5-5R8	OptiMOS™ 5	5.8	50	NL	Single SS08
	IPC50N04S5L-5R5	OptiMOS™ 5	5.5	50	LL	Single SS08

Table 12: 40 V, single N-Channel MOSFET overview in S308 package

Sales name	Technology	$R_{DS(on)}$ max 10 V [mΩ]	I_b [A]	LL/NL	Package
IPZ40N04S5L-2R8	OptiMOS™-5 40V	2.8	40	LL	S308
IPZ40N04S5-3R1	OptiMOS™-5 40V	3.1	40	NL	S308
IPZ40N04S5L-4R8	OptiMOS™-5 40V	4.8	40	LL	S308
IPZ40N04S5-5R4	OptiMOS™-5 40V	5.4	40	NL	S308
IPZ40N04S5L-7R4	OptiMOS™-5 40V	7.4	40	LL	S308
IPZ40N04S5-8R4	OptiMOS™-5 40V	8.4	40	NL	S308

Table 13: 40 V, 80 V & 100 V, N-Channel MOSFETs in TOLL package

Sales name	Technology	$R_{DS(on)}$ max 10 V [mΩ]	I_b [A]	LL/NL	Package
IPLU300N04S4-R8	OptiMOS™-T2 40V	0.77	300	NL	TOLL
IPLU300N04S4-1R1	OptiMOS™-T2 40V	1.1	300	NL	TOLL
IPLU50N04S4-1R7	OptiMOS™-T2 40V	1.7	250	NL	TOLL
IAUT300N08S5N012	OptiMOS™ 5 80V	1.2	300	NL	TOLL
IAUT165N08S5N029	OptiMOS™ 5 80V	2.9	165	NL	TOLL
IAUT300N08S5N014	OptiMOS™ 5 80V	1.4	300	NL	TOLL
IAUT240N08S5N019	OptiMOS™ 5 80V	1.9	240	NL	TOLL
IAUT200N08S5N023	OptiMOS™ 5 80V	2.3	200	NL	TOLL
IAUT300N10S5N015	OptiMOS™ 5 100V	1.5	300	NL	TOLL
IAUT150N10S5N035	OptiMOS™ 5 100V	3.5	150	NL	TOLL
IAUT260N10S5N019	OptiMOS™ 5 100V	1.9	260	NL	TOLL

Table 14: 40 V, N-Channel MOSFETs in sTOLL package

	Sales name	Technology	$R_{DS(on)}$ max 10 V [mΩ]	I_b [A]	LL/NL	Package
	IAUA200N04S5N010	OptiMOS™ 5	1.0	200	NL	sTOLL
NEW	IAUA180N04S5N012	OptiMOS™ 5	1.2	180	NL	sTOLL
NEW	IAUA120N04S5N014	OptiMOS™ 5	1.4	120	NL	sTOLL

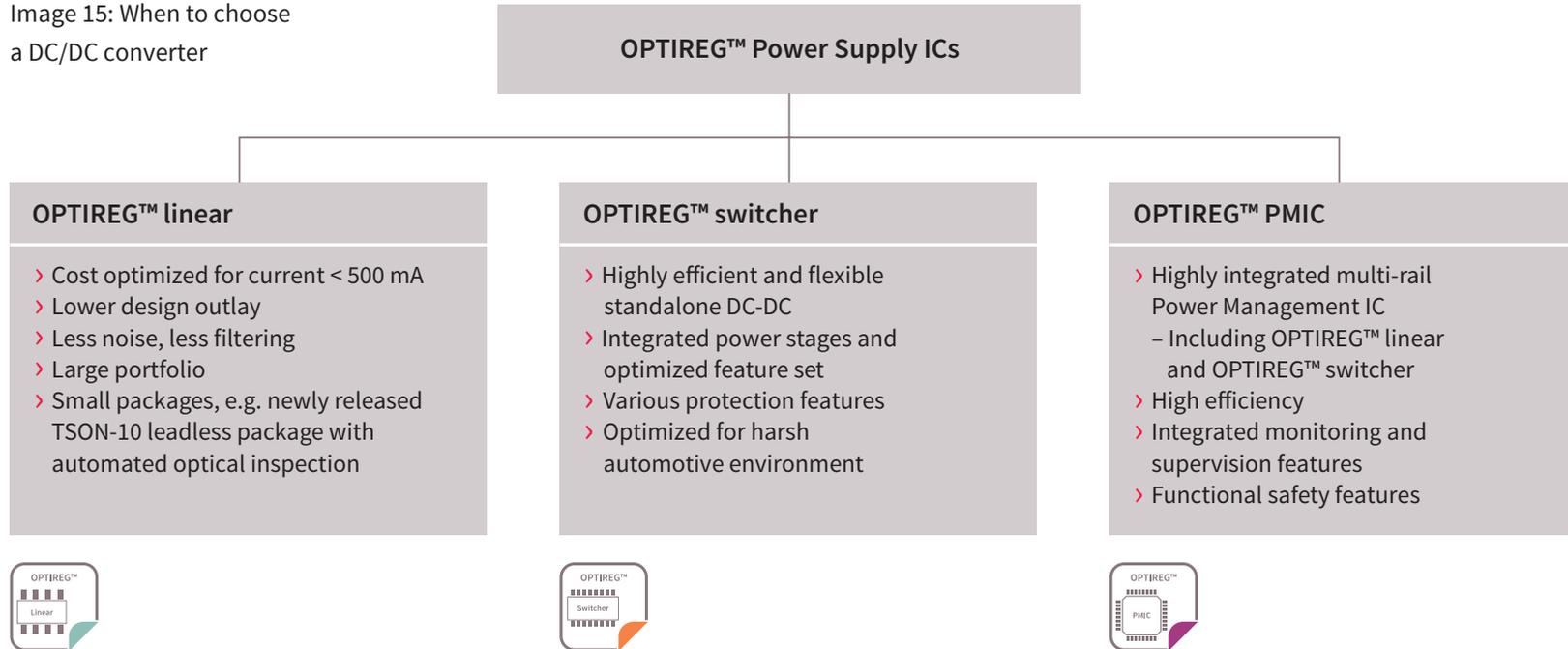


4.3. OPTIREG™ Automotive Power Supply IC – unregulated input, optimally regulated output

OPTIREG™ Linear, OPTIREG™ Switcher & OPTIREG™ PMIC

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 15: When to choose a DC/DC converter



4.3.1. OPTIREG™ Linear

Table 15: Product overview linear voltage regulators

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

4.3.2. OPTIREG™ Switcher

Table 16: 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: automotive 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 17: Product overview bus transceivers for LIN, CAN and CAN-FD

Product name	Transmission rate (max)	Low-power mode I _q [mA] (max)	Bus wake-up	V _{io}	Number of channels	Bus failure management	Fast programming	Family	Quiescent current	Package
Single LIN										
TLE7257SJ	20 kbit/s	< 15 sleep mode	●		1	●				DSO-8
TLE7258SJ	20 kbit/s	< 15 sleep mode	●		1	●				DSO-8
TLE7259-3GE	20 kbit/s	< 10 sleep mode	●		1	●				DSO-8
TLE9252VLC	5 MBit/s		●					CAN FD 5MBit/s	< 25 μA @ sleep mode	TSON-14
TLE9251VLE	5 MBit/s		●					CAN FD 5MBit/s	< 15 μA @ 5V standby	TSON-8
TLE9250LE	5 MBit/s							CAN FD 5MBit/s	< 20 μA @ 5V standby	TSON-8
TLE9250VLE	5 MBit/s							CAN FD 5MBit/s	< 15 μA @ 5V standby	TSON-8
TLE9250VSJ	5 MBit/s			●				CAN FD 5MBit/s	< 15 μA @ 5V standby	DSO-8
TLE9250XLE	5 MBit/s			●				CAN FD 5MBit/s		TSON-8
TLE9250XSJ	5 MBit/s			●				CAN FD 5MBit/s		DSO-8
TLE9250SJ	5 MBit/s							CAN FD 5MBit/s	< 20 μA @ 5V standby	DSO-8
TLE9251LE	5 MBit/s		●					CAN FD 5MBit/s	< 18 μA @ 5V standby	TSON-8
TLE9251SJ	5 MBit/s		●					CAN FD 5MBit/s	< 18 μA @ 5V standby	DSO-8
TLE9252VSK	5 MBit/s		●	●				CAN FD 5MBit/s	< 25 μA @ sleep mode	DSO-14
TLE9251VSJ	5 MBit/s		●	●				CAN FD 5MBit/s	< 15 μA @ 5V standby	DSO-8
TLE9254SK	5 MBit/s		●		2			CAN FD 5MBit/s	< 18 μA @ 5V standby	DSO-14
TLE9254VSK	5 MBit/s		●	●	2			CAN FD 5MBit/s	< 18 μA @ 5V standby	DSO-14
TLE9254LC	5 MBit/s		●		2			CAN FD 5MBit/s	< 18 μA @ 5V standby	TSON-14
TLE9254VLC	5 MBit/s		●	●	2			CAN FD 5MBit/s	< 18 μA @ 5V standby	TSON-14

Table 18: Product overview bus transceivers for LIN, CAN and CAN-FD (cont'd)

Product name	Transmission rate (max)	Low-power mode I_q [μ A] (max)	Bus wake-up	Wake-up inputs	Number of channels	Bus failure management	CAN FD	Package
High-speed CAN ISO 11898-2								
TLE9250SJ	5 Mbit/s	< 20 @ 5 V power save mode			1		●	DSO-8
TLE9250LE	5 Mbit/s	< 20 @ 5 V power save mode			1		●	TSON-8
High-speed CAN ISO 11898-5								
TLE6251-2G	1 Mbit/s	< 30 sleep mode	●	●	1	●		DSO-14
TLE6251-3G	1 Mbit/s	< 30 sleep mode	●	●	1	●		DSO-14

Table 19: Automotive FlexRay™, LIN transceivers

Product name	Transmission rate (max)	Low-power mode I_q [μ A] (max)	Bus wake-up	Additional Features	Package
Automotive FlexRay™ Transceivers					
TLE9222LC	10 MBit/s	< 45 μ A standby mode (Vcc & Vio)	●	STBN, ERRN, BGE, Vio	TSON-14
TLE9222PX	10 MBit/s	< 45 μ A standby mode (Vcc & Vio)	●	STBN, ERRN, BGE, Vio	TSSOP-14
TLE9221SX	10 MBit/s	< 65 μ A sleep mode	●	STBN, EN, WAKE, ERRN, BGE, INH, Vio, RxEN	SSOP-16
Automotive LIN Transceivers					
TLE7268SK	20 kBit/s	< 20 μ A sleep mode	●	Multiple channel, 2 x LIN trx, INH, EN	DSO-14
TLE7257SJ	20 kBit/s	< 10 μ A sleep mode	●	INH, EN	DSO-8
TLE7257LE	20 kBit/s	< 10 μ A sleep mode	●	INH, EN	TSON-8
TLE8457DLE	20 kBit/s	< 10 μ A sleep mode	●	3.3 V output VREG, EN, RESET	TSON-8
TLE7258LE	20 kBit/s	< 10 μ A sleep mode	●	INH, EN	TSON-8
TLE7268LC	20 kBit/s	< 20 μ A sleep mode	●	2 x LIN trx, INH, EN	TSON-14
TLE8457CSJ	20 kBit/s	< 10 μ A sleep mode	●	Multiple channel, 2 x LIN trx, INH, EN	DSO-8
TLE8457CLE	20 kBit/s	< 10 μ A sleep mode	●	5.0 V output VREG, EN, RESET	TSON-8
TLE7258SJ	20 kBit/s	< 10 μ A sleep mode	●	INH, EN	DSO-8
TLE7259-3LE	20 kBit/s	< 10 μ A sleep mode	●	INH, EN, WK	TSON-8
TLE7259-3GE	20 kBit/s	< 10 μ A sleep mode	●	INH, EN, WK	DSO-8
TLE7258D	20 kBit/s	< 10 μ A sleep mode	●	EN	TSON-8
TLE8457DSJ	20 kBit/s	< 10 μ A sleep mode	●	3.3 V output VREG, EN, RESET	DSO-8

4.5. XENSIV™ hall switches

Broadest energy saving portfolio of high precision Hall switches for automotive, industrial and consumer applications

TLE/TLI/TLV4961/64/68 – Energy-efficient Hall switch family for up to 32 V

The TLE/TLI/TLV496x-xM/L family of Hall switches saves energy and enables designers to create precise, compact systems. With an operational current consumption of just 1.6 mA, TLE/TLI/TLV496x-xM/L products can cut energy consumption by up to 50 percent compared with similar competitor products. Thanks to its small magnetic hysteresis, the family paves the way for precise switching points in systems. The integrated temperature profile compensates magnetic drifts and enables stable performance over temperature and lifetime.

TLE/TLI/TLV496x-xM products come in the smallest SOT23 package, thus reducing height by 10 percent compared with predecessor products. The sensors also feature an integrated functionality test for better system control.

Table 20: Product overview

Product	Type	Operating point B_{OP}	Release point B_{RP}	Hysteresis ΔB_{HY}	Automotive	Industrial	Consumer	Package
TLE4961-1M/L	Latch	2.0	-2.0	4.0	●	●	●	SOT23/SSO-3-2
TLE4961-2M	Latch	5.0	-5.0	10.0	●	●	●	SOT23
TLE4961-3M/L	Latch	7.5	-7.5	15.0	●	●	●	SOT23/SSO-3-2
TLE4964-1M	Switch	18.0	12.5	5.5	●	●	●	SOT23
TLE4964-2M	Switch	28.0	22.5	5.5	●	●	●	SOT23
TLE4964-3M	Switch	12.5	9.5	3.0	●	●	●	SOT23
TLE4964-5M	Switch	7.5	5.0	2.5	●	●	●	SOT23
TLE4968-1M/L	Bipolar	1.0	-1.0	2.0	●	●	●	SOT23/SSO-3-2
TLE4961-5M	Latch	15.0	-15.0	30.0	●	●	●	SOT23
TLE4961-4M	Latch	10.0	-10.0	20.0	●	●	●	SOT23
TLE4964-4M	Switch	10.0	8.5	1.5	●	●	●	SOT23
TLE4964-6M	Switch	3.5	2.5	1.0	●	●	●	SOT23
TLI4961-1M/L	Latch	2.0	-2.0	4.0	–	●	●	SOT23/SSO-3-2
TLV4961-1M	Latch	2.0	-2.0	4.0	–	–	●	SOT23
TLV4961-3M	Latch	7.5	-7.0	15.0	–	–	●	SOT23
TLV4964-1M	Switch	18.0	12.5	5.5	–	–	●	SOT23
TLV4964-2M	Switch	28.0	22.5	5.5	–	–	●	SOT23

Applications

- › Window lifter (index counting)
- › Power closing (index counting)
- › Gear stick (position detection)
- › Seat belt (position detection)
- › BLDC commutation
(e.g. wiper, seat belt pretensioner, pump, seating)
- › Service robots
- › Power tools
- › White goods

Features

- › Current consumption of just 1.6 mA
- › 3 to 32 V supply voltage range
(over voltage up to 42 V)
- › 7 kV ESD protection (HBM)
- › Overtemperature and overcurrent protection
- › Temperature compensation
- › Smallest SOT23 package
- › Dedicated products for industrial applications
(TLI496x)
- › AEC-Q100 qualified

4.6. XENSIV™ angle sensors

Compact designs in small outline packages – at highest functional safety

Highest variety – low end to high end, standardized and specialized in all three xMR magnetic technologies: GMR, AMR and TMR

Infineon offers a broad variety of high-precision angle sensors in all common technologies such as AMR (Anisotropic Magneto-resistive), GMR (Giant Magneto-resistive) and also TMR (Tunnel Magneto-resistive). The xMR technologies are complementary. Addressing any kind of rotation applications Infineon’s sensor portfolio consists of analogue and digital outputs, as single and dual-chip channel variants and as products for safety-relevant applications. The two-channel analogue TMR angle sensors TLE5501, the digital GMR angle sensor family TLE5014 and the high-precision AMR-based TLE5109 products are among the latest additions to the growing sensor portfolio, which includes all common technologies and is designed for both industrial and automotive applications.

Infineon’s new magnetic sensor products TLE5501, are fast analogue TMR-based angle sensors dedicated to automotive applications. Their fields of use range from steering angle applications, with the highest functional safety requirements, to motors for wipers, pumps and actuators and electric motors in general. They are also ready to be used in industrial and consumer applications like robotics or gimbal. Angle sensors detect the orientation of an applied magnetic field by measuring sine and cosine angle components with monolithically integrated magneto resistive elements.

Table 21: Diverse redundant sensor with analog and digital interface

Product	Technology	Die configuration	ISO 26262	Sin/cos output	Angle output	Second interface	Accuracy	Package
TLE5009	GMR	Single die	Ready	Analog sin/cos	–	–	0.9°	DSO-8
TLE5009A16(D)	GMR	Dual die	Ready	Analog sin/cos	–	–	1.0°	TDSO-16
TLE5011	GMR	Single die	Ready	SSC (SPI)	–	–	1.6°	DSO-8
TLI5012B	GMR	Single die	Ready	SSC (SPI)	SSC (SPI)	PWM/IIF/SPC/HSM	1.9°	DSO-8
TLE5012B(D)	GMR	Single & dual die	Ready	SSC (SPI)	SSC (SPI)	PWM/IIF/SPC/HSM	1.0°	DSO-8/TDSO-16
TLE5014C16(D)	GMR	Single & dual die	Compliant	–	SPC	–	1.0°	TDSO-16
TLE5014P16(D)	GMR	Single & dual die	Compliant	–	PWM	–	1.0°	TDSO-16
TLE5014S16(D)	GMR	Single & dual die	Compliant	–	SENT	–	1.0°	TDSO-16
TLE5014SP16(D)	GMR	Single & dual die	Compliant	–	SPI	–	1.0°	TDSO-16
TLE5109A16(D)	AMR	Single & dual die	Ready	Analog sin/cos	–	–	0.5°	TDSO-16
TLE5309D	AMR + GMR	Dual die	Ready	Analog sin/cos	SSC (SPI)	–	AMR 0.5°, GMR 1.0°	TDSO-16
TLE5501	TMR	Single die	Compliant	Analog sin/cos	–	–	1.0°	DSO-8

SPI = Serial peripheral interface

IIF = Incremental interface

PWM = Pulse width modulation

4.7. XENSIV™ 3D magnetic sensors for automotive low-power applications

TLE493D-A2B6/W2B6

The TLE493D-x2B6 enables for all kind of automotive control element applications within the passenger compartment or under the hood with a temperature range of -40 to +125°C with linear magnetic range requirements up to ±160 mT.

The TLE493D-A2B6 features include a sensor address read back feature for additional communication verification, a half range mode focusing to half of the magnetic range ensuring higher accuracy and an angular mode (for x and y read out only).

With the TLE493D-W2B6 A0-A3, a 3D sensor has been developed, which includes an enhanced dynamic wake up feature. Four pre-programmed address options (A0-A3) will be available, enabling for a fast start up initialization, when used in I2C bus configurations. It also includes enhanced test options and a safety documentation is available to enable the usage of this sensor in the context of ASIL-B systems.



Table 22: Product overview

Product	Temperature range	Qualification	Linear magnetic range	Resolution	I _{DD}	Update rate	Wake-up	Package	Ordering code
TLE493D-A2B6	-40 ... 125°C	AEC-Q100	±160 mT (min)	130 μT/LSB (65 μT/LSB) ¹⁾	7 nA – 3.3 mA	10 Hz – 8.4 kHz	No	TSOP6	SP001689848
TLE493D-W2B6 A0 TLE493D-W2B6 A1 TLE493D-W2B6 A2 TLE493D-W2B6 A3	-40 ... 125°C	AEC-Q100	±160 mT (min) ±100 mT (min)	130 μT/LSB (65 μT/LSB) ¹⁾	7 nA – 3.3 mA	0.05 Hz – 8.4 kHz	Yes	TSOP6	SP001655334 SP001655340 SP001655344 SP001655348

1) Half range mode

Applications

- › Control elements for infotainment/navigation systems, air conditions, multifunctional steering wheels, seat controls
- › Top column modules e.g. direction indicator, wiper control
- › Gear stick position sensing

Features

- › 3D magnetic sensing
- › Integrated temperature sensing
- › 2.8 to 3.5 V operating supply voltage
- › Low current consumption
 - 0.007 μA in power-down mode
 - 10 μA in ultra-low power mode
 - Up to 10 power modes
- › Digital output via a 2-wire standard I2C interface
- › Bx, By and Bz linear field measurement ±160 mT
- › AEC-Q100 qualified
- › 12-bit data resolution for each measurement direction
- › Various resolution options from 67 μT/LSB to 134 μT
- › Operating temperature range up to -40 to +125°C

4.8. AURIX™ for motor control applications

AURIX™ for high-performance, multicore and safety-demanding applications

The AURIX™ 32-bit microcontroller family is based on the Infineon TriCore™ high-performance core concept and provides a highly scalable family from single core to multicore.

The AURIX™ family enables the highest integrated safe memory sizes (SRAM up to 6.9 MB and flash memory up to 16 MB) and all memory is protected by hardware Error Correction Code (ECC). The devices reach more than 600 DMIPS at clock rates of up to 6x 300 MHz and combine MCU and DSP instructions with an integrated FPU.

The integrated peripheral set is primarily targeted toward motor control and power conversion, providing high-performance ADCs, DS ADCs and a full set of diverse high-performance timers. This is one of the very few in the industry that is able to drive the upcoming three-level inverter topologies. Furthermore, the AURIX™ family supports the latest connectivity, such as Ethernet, CAN FD, FlexRay and multiple other high-speed interfaces.

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 23: Product overview AURIX™ 32-bit microcontrollers, series TC2xx

TriCore™ microcontroller

Product type	Max clock frequency [MHz]	Program memory [KByte]	SRAM (incl. cache) [KByte]	Co-processor ¹⁾	Cores/lockstep	Timed I/O GPIO	Number of ADC channels	External bus interface	CAN/CAN FD nodes	Communication interfaces ²⁾	Temperature ranges ³⁾	Packages	Additional features/remarks ⁴⁾
AURIX™ TC2xx family													
TC237LP	200	2000	192	FPU	1/1	120	24	No	6	2x ASCLIN, 4x QSPI, 4x SENT, FlexRay, CAN FD	K	LFBGA-292	EVR, WUT, HSM
TC234LP	200	2000	192	FPU	1/1	120	24	No	6	2x ASCLIN, 4x QSPI, 4x SENT, FlexRay, CAN FD	K	TQFP-144	EVR, WUT, HSM
TC233LP	200	2000	192	FPU	1/1	78	24	No	6	2x ASCLIN, 4x QSPI, 4x SENT, FlexRay, CAN FD	K	TQFP-100	EVR, WUT, HSM
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) ASC = Asynchronous Serial Channel, ASCLIN = Asyn/Synchronous Local Interconnect Network, HSSL = High Speed Serial Link, IPC = Inter-Integrated Circuit, LIN = Local Interconnect Network, MLI = Micro Link Interface, MSC = Micro Second Channel, PSIS = Peripheral Sensor Interface 5, QSPI = Queued Serial Peripheral Interface, SENT = Single Edge Nibble Transmission, SSC = Synchronous Serial Channel

3) Ambient temperature range: K = -40 ... 125°C,

4) EVR = Embedded Voltage Regulator, HSM = Hardware Security Module, WUT = Wake-Up Timer

Table 24: Product overview AURIX™ 32-bit microcontrollers, series TC3xx

TriCore™ microcontroller

Product type	Cores/lockstep	Max clock frequency [MHz]	Program memory [KByte]	SRAM (incl. cache) [KByte]	Radar accelerator/radar interface ¹⁾	CAN/CAN FD nodes	Ethernet 100/1000 Mbit	External bus interface ²⁾	Communication interfaces	HSM	Temperature ranges ³⁾	Packages	Additional features/remarks ⁴⁾
AURIX™ TC3xx family													
TC337LP	1/1	300	2000	248	No	8	No	No	4x SPI, 1x FlexRay, 12x LIN, 6x SENT	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
TC336LP	1/1	300	2000	248	No	8	No	No	4x SPI, 1x FlexRay, 12x LIN, 6x SENT	EVITA full	K, L	BGA-180	5 V/3.3 V EVR, 8-bit SCR
TC334LP	1/1	300	2000	248	No	8	No	No	4x SPI, 1x FlexRay, 12x LIN, 6x SENT	EVITA full	K, L	TQFP-144	5 V/3.3 V EVR, 8-bit SCR
TC333LP	1/1	300	2000	248	No	8	No	No	4x SPI, 1x FlexRay, 12x LIN, 6x SENT	EVITA full	K, L	TQFP-100	5 V/3.3 V EVR, 8-bit SCR
TC332LP	1/1	300	2000	248	No	8	No	No	4x SPI, 1x FlexRay, 12x LIN, 6x SENT	EVITA full	K, L	TQFP-80	5 V/3.3 V EVR, 8-bit SCR
TC327LP	1/1	160	1000	96	No	8	No	No	4x SPI, 6x SENT, 6x LIN	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
TC324LP	1/1	160	1000	96	No	8	No	No	4x SPI, 6x SENT, 6x LIN	EVITA full	K, L	TQFP-144	5 V/3.3 V EVR, 8-bit SCR
TC323LP	1/1	160	1000	96	No	8	No	No	4x SPI, 6x SENT, 6x LIN	EVITA full	K, L	TQFP-100	5 V/3.3 V EVR, 8-bit SCR
TC322LP	1/1	160	1000	96	No	8	No	No	4x SPI, 6x SENT, 6x LIN	EVITA full	K, L	TQFP-80	5 V/3.3 V EVR, 8-bit SCR

1) SPU = Signal Processing Unit

2) HSSL = High-Speed Serial Link

3) Ambient temperature range: K = -40 ... 125°C, L = -40 ... 150°C

4) 8-bit SCR = Standby Controller for Low Power Modes, EVR = Embedded Voltage Regulator

5. Evaluation boards

5.1. Evaluation kits compatible with Arduino

- › Go to <https://www.arduino.cc/en/Main/Software> and download the latest version of the Arduino Desktop IDE for your specific OS
- › Install the IDE
- › See <https://www.arduino.cc/en/Guide/HomePage> for help with developing code for Arduino in general



BLDC shield with TLE9879QXA40 for Arduino

- › Voltage supply: typ. 12 V
- › Infineon 3-phase MOSFET driver IC (ARM® Cortex™-M3 MCU)
- › SWD interface for debugging
- › LIN Transceiver
- › Hall sensor interface
- › BLDC_SHIELD_TLE9879: SP003549500



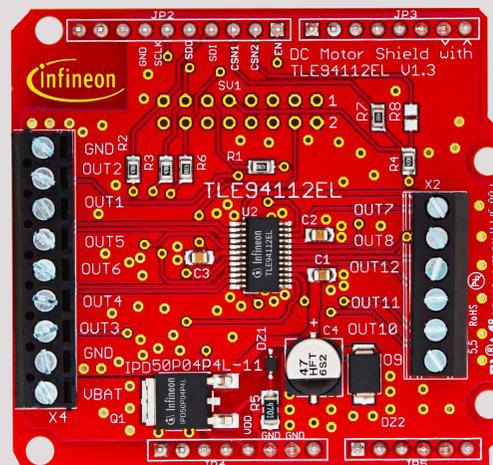
DC motor control shield with BTN8982TA for Arduino

- › Compatible with Arduino Uno R3
- › Capable of high frequency PWM e.g. 30 kHz
- › Adjustable slew rates for optimized EMI by changing external resistor
- › Driver circuit with logic level inputs
- › Diagnosis with current sense
- › Protection e.g. against overtemperature and overcurrent



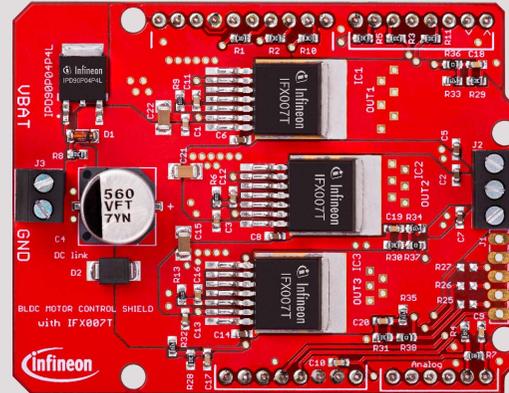
DC motor shield with TLE94112EL for Arduino

- › Driver with 12 half-bridge outputs to drive DC motors, resistive or inductive loads
- › Driver is protected against over-temperature, over-current, over-voltage, under-voltage and enables diagnosis of over-current, over-voltage, under-voltage
- › SPI interface with zero clock diagnosis
- › Enhanced EMC performance
- › Integrated PWM generator with 3 different frequencies (80 Hz, 100 Hz, 200 Hz)



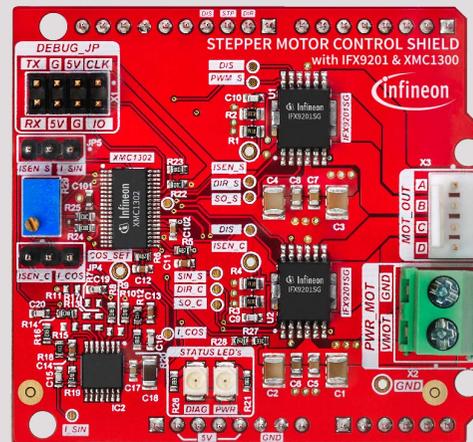
Shield with IFX007

- › 8–40 V nominal input voltage (optimized for 24 V)
- › Compatible with Arduino Uno R3
- › Capable of high frequency PWM e.g. 30 kHz
- › Adjustable slew rates for optimized EMI by changing external resistor
- › Driver circuit with logic level inputs
- › Diagnosis with current sense
- › Protection e.g. against overtemperature and overcurrent



Stepper motor shield with IFX9201 and XMC1300

- › Compatible with Arduino Uno R3
- › Capable of high performance current control
- › Microstepping degree can be adjusted by software
- › Driver circuit with logic level inputs



6. Infineon Toolbox

Infineon tools in one place.

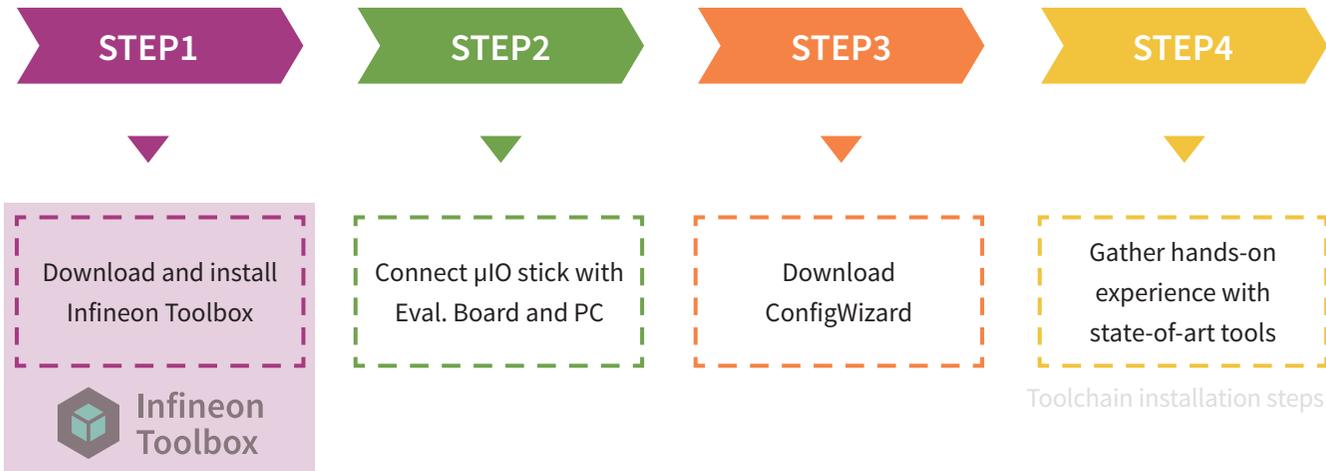
The Infineon toolbox is a desktop application for easy discovery, download and installation of Infineon tools.

Please follow the link:

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



7. System Basis Chips (SBC) design in support & tool chain

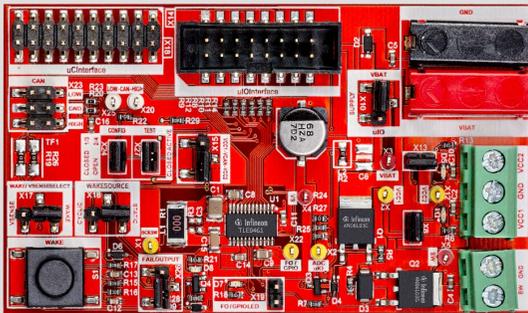


Development tools/software

- > SBC config wizard (configuration tool)
 - > SBC microcontroller library
 - > Bode plot
 - > CAN PN configurator
 - > Power dissipation tool
 - > Application notes
 - > User manual
 - > eLearnings for SBC, Lite and MR+
 - > FIT rates & module/area breakdown
- www.infineon.com/sbc

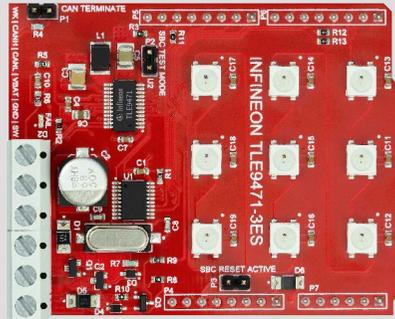
Lite SBC evaluation board with TLE94x1-3ES (V33)

- > Device evaluation and configuration via µIO stick
- > Intuitive graphical user interface



Lite SBC shield for arduino with TLE9471-3ES

- > 9 RGB LEDs
- > Microchip MCP2515 and
- > Power MOSFETs driven by the integrated charge pump



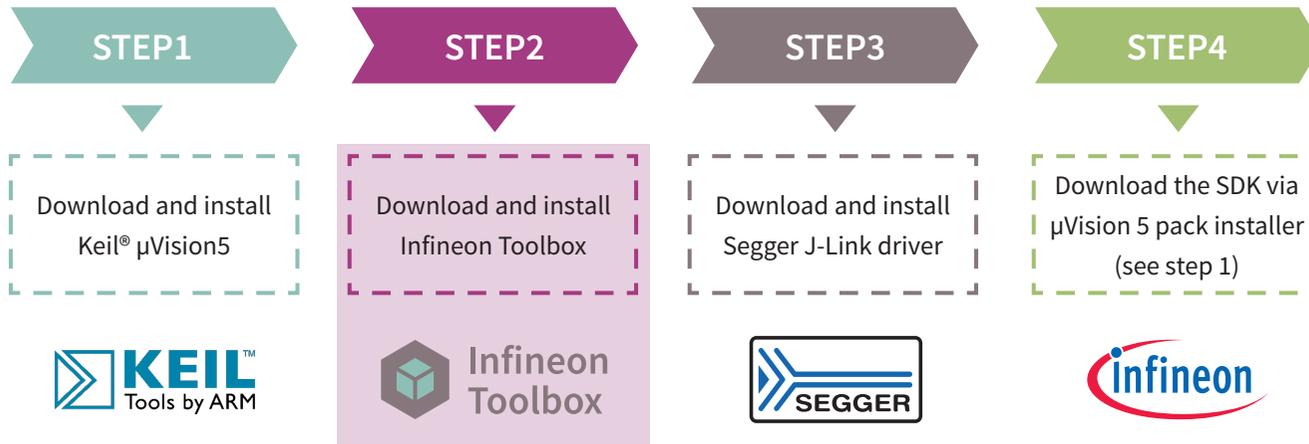
MR+ SBC eval. board with TLE9263-3BQX (V33)

- > Device evaluation and configuration via µIO stick
- > Intuitive graphical user interface



8. Embedded software development for Embedded Power ICs

Infinion Embedded Power ICs are supported by a complete development tool chain provided by Infineon and third party vendors. The tool chain includes compilers, debuggers, evaluation boards, LIN low level drivers and configuration tools as well as variety of example software code.



Arm® Keil® μVision is an integrated development environment which consists of code editor, compiler and debugger.

Infineon provides the Infineon Toolbox which is designed to install and use Infineon plugins and tools.

SEGGER J-Link is a widely used driver for “on-board” or “stand-alone” debugger.

The embedded power Software Development Kit (SDK) is a low level driver library which can be downloaded within “Keil® μVision” via the “Pack Installer”.

Development tools/software

- > Embedded Power ICs config wizard
- > Power dissipation
- > Boot strap loader support via μIO stick
- > Application notes
- > User manual
- > eLearnings for Embedded Power ICs

www.infineon.com/embeddedpower

TLE9869QX – Evaluation kit

- > 2-phase N-MOS bridge
- > Single shunt in GINO path
- > Integrated LIN (inside device)
- > Virtual com port via J-Link
- > Debug LEDs
- > Onboard Segger J-Link debugger
- > TLE9869 EVALKIT: SP001388252

TLE986x – 2-phase board with socket

- > H-bridge N-MOS bridge
- > Integrated LIN
- > External LIN Trx
- > RS232
- > Debug LEDs
- > Debug connector SWD
- > J-link Lite debugger
- > TLE986x EVALB_JLINK: SP001253678

STEP 1

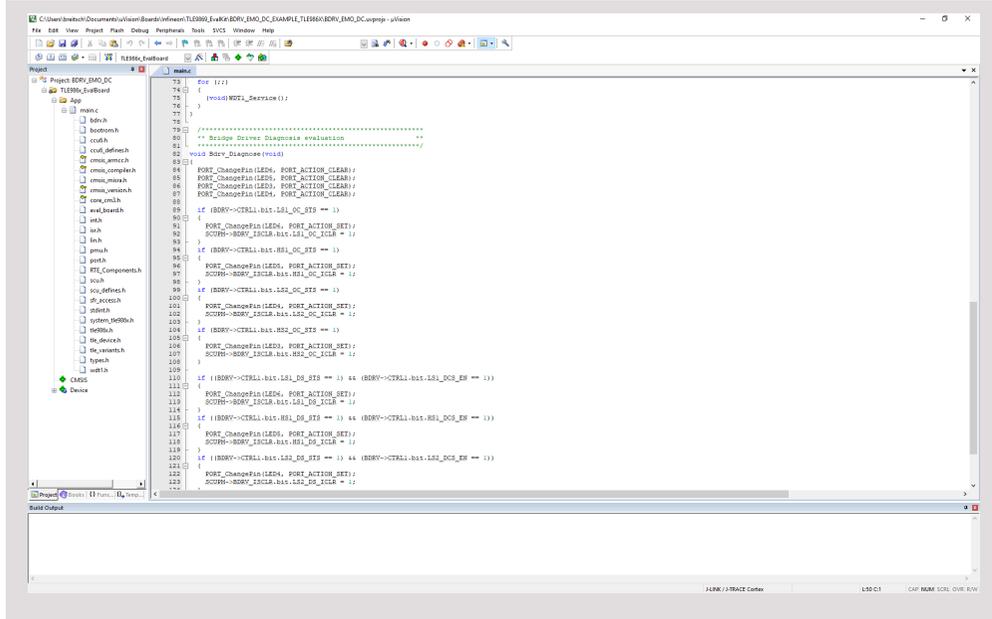
8.1. Peripheral IDE & drivers for Embedded Power ICs

Keil® µVision5

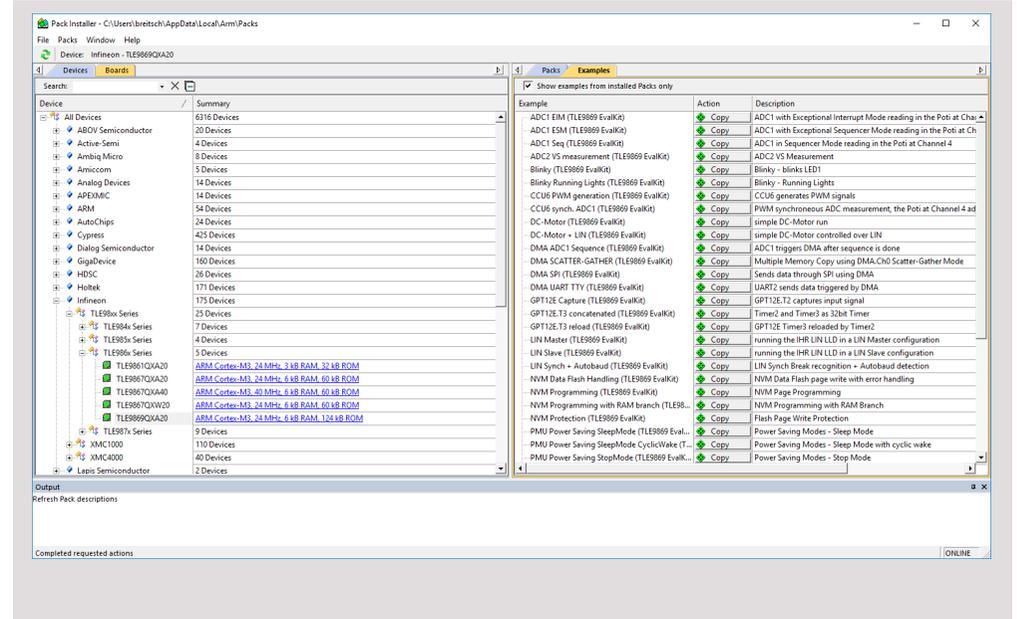
- > Code editor and online debugger
- > Evaluation version can handle up to 32 K
- > Download from: <https://www.keil.com/demo/eval/arm.htm>



Main window



Pack installer



<https://confluencewikiprod.intra.infineon.com/display/ATVSAMBA/Config+Wizard+-+Customer+Help>



8.2. Chip configuration for Embedded Power ICs

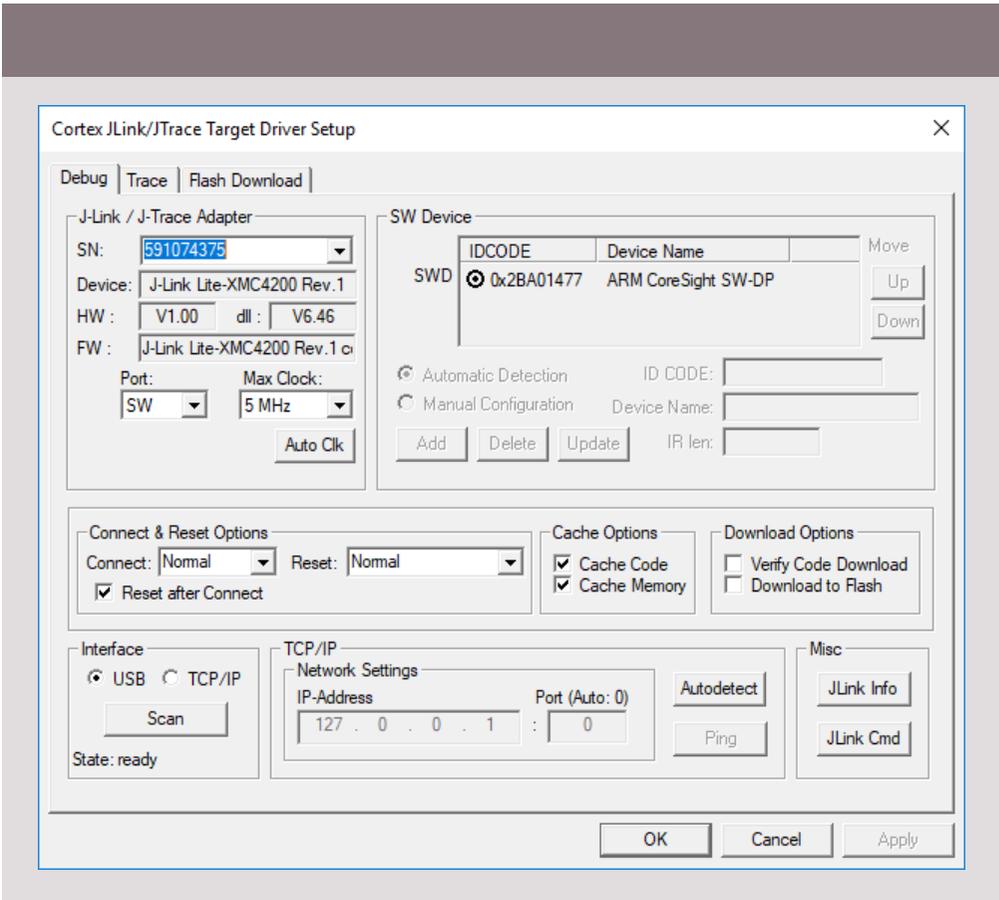
- > Infineon ConfigWizard
- > Configuration of chip modules
- > Device description for TLE986x/TLE987x included
- > Installation from Infineon Toolbox
- > TLE986x/7x supported by Keil® µVision5



8.3. Debugging for Embedded Power ICs

Segger J-LINK-Lite driver

- > Driver for “on-board“ or “stand-alone“ debugger
- > Install driver from: https://www.segger.com/downloads/jlink/JLink_Windows.exe



9. AURIX™ motor control application kit with TFT display

With the application kit TC2x4 it allows to drive a 3-phase brushless motor. Applications can be developed easily. The eMotor drive kit is equipped with a variety of interfaces for position detection and current measurement. Additionally a driver IC (TLE9180) and a complete B6 bridge driver allow spinning a motor up to 50 W.



Benefits

- › Easy to getting started on motor control supporting multiple control schemes
- › Easy system evaluation based on Infineon motor control solution
 - Microcontroller: AURIX™
 - Bridge driver: TLE9180
 - Safety supply: TLF35584



Where to buy

Infiniteon distribution partners and sales offices:

www.infineon.com/WhereToBuy

Service hotline

Infiniteon 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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