



# Mobile Robots: Motor Control

AGV – Automated Guided Vehicles

AMR – Automated Mobile Robots

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Application Manager Robotics

Edition 2022





# Infineon is a globally leading semiconductor player



**top 10**

- › semiconductor company

**~46,700**

- › total employees

**~7,800**

- › R&D employees

**leading player**

- › in automotive, systems for power management and drives, sensor systems, connected secure systems, wireless combos, differentiated memories

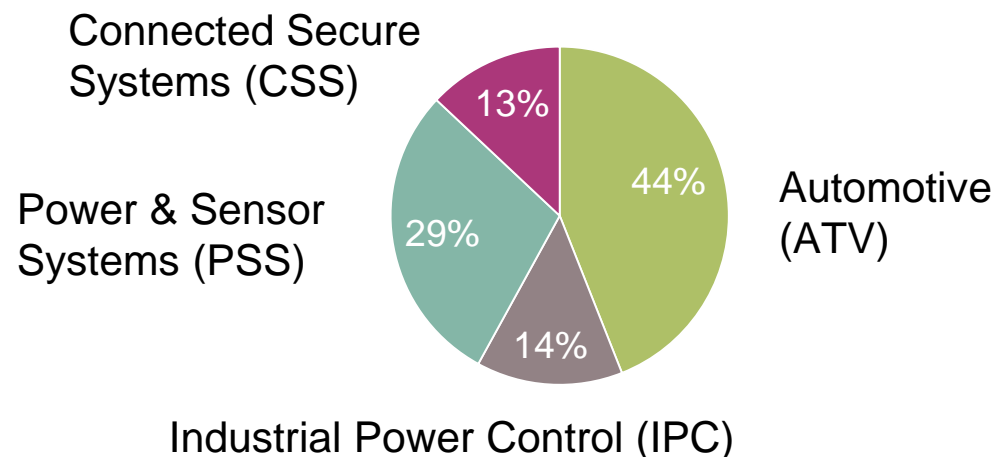
**9%+ | 19% | 13%**

- › target operating model\*

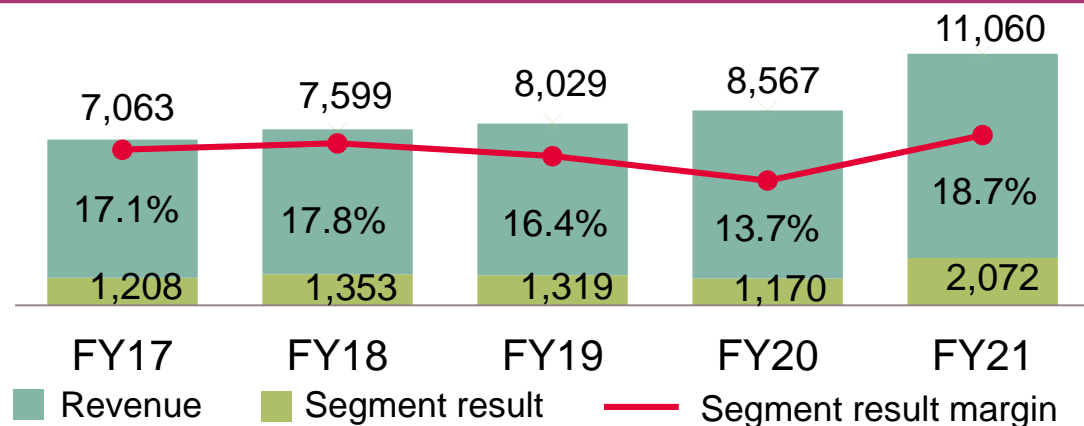
\* over the cycle 9%+ revenue growth; 19% Segment Result margin; investment-to-sales ratio of 13%; targets to be approached as integration progresses

# Infineon at a glance

## Business segments revenue\*



## Financials

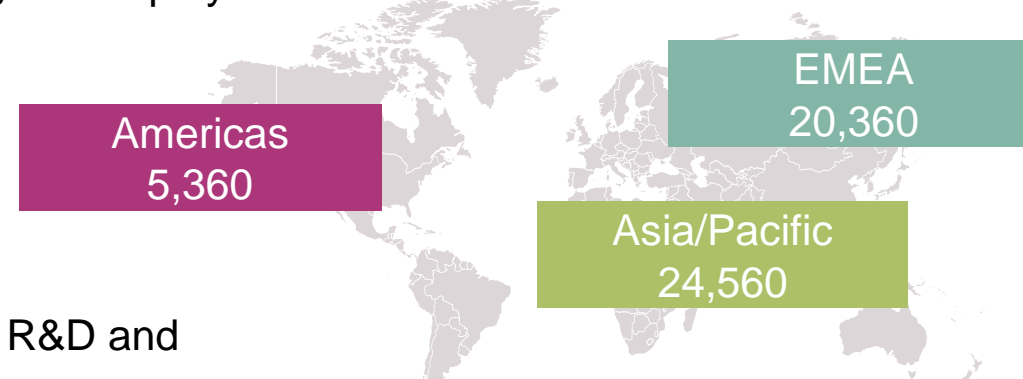


\*2021 Fiscal year (as of 30 September 2021)

\*\*as of 30 September 2021

## Employees\*

**50,280** employees worldwide



**56** R&D and  
**20** manufacturing locations\*\*

## Market position

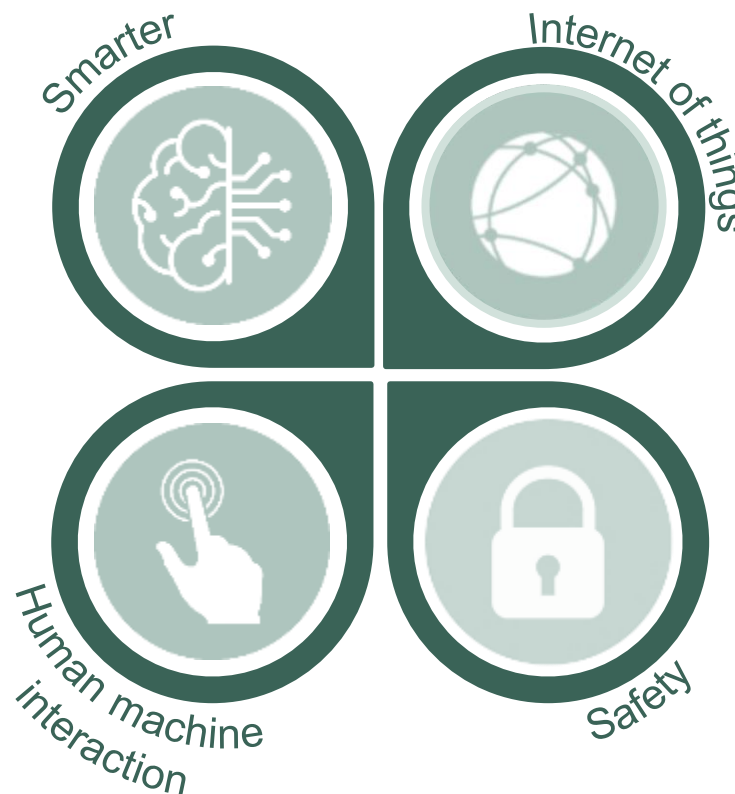


For further information: [Infineon Annual Report 2021](#)

# Main trends and challenges in robot applications

Robots are moving toward Industry 4.0. This brings the need for robots to be smarter and interconnected but also calls for the need for standardization.

Human-robot collaboration is one important trend in robotics. The ability to work mutually with humans, enables robots to adapt to a rapidly changing environment.



Connectivity level and the need of data security correlate, so security must be integrated into all existing and new systems, but once again calls standardization needs for diverse robots & systems to interact properly.

Safety is key when robots interact with their environment with a special focus on human safety, work safety, routing accuracy and collision avoidance

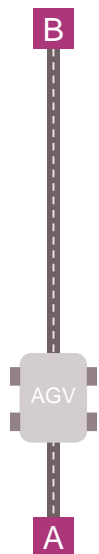
# Types and deployment of mobile robots

On high level mobile robots can be categories into AGVs and AMRs

## AGV

### Automated Guided Vehicle

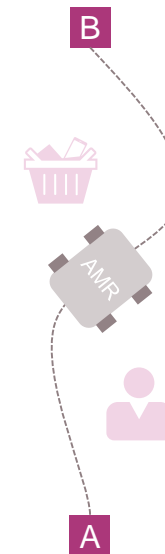
AGVs are “fixed”. They follow predefined paths using lasers, beacons, barcodes or magnetic tape.



## AMR

### Autonomous Mobile Robot

AMRs are not “fixed” and don’t need external paths. Autonomously mapping and navigating by using sensors



**Potential use cases:** warehouse & logistic, last mile delivery, robots in hotels, banks, airports etc.



# Mobile robots are a fast growing market and need sophisticated system solutions for each functional block

## Application requirements

Different types of mobile robots require unique and appropriate solutions

**Precise, efficient & compact motor drives**

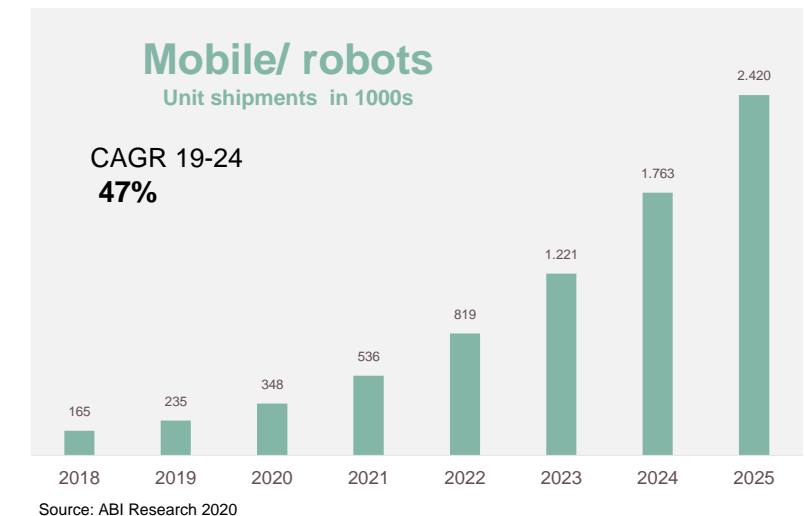
**Fast charging reducing charging and idle time**

**Environmental sensing for navigation and safety**

**Connectivity enabling AI, real time monitoring and IoT**

**Connectivity enabling AI and IoT**

## Market outlook

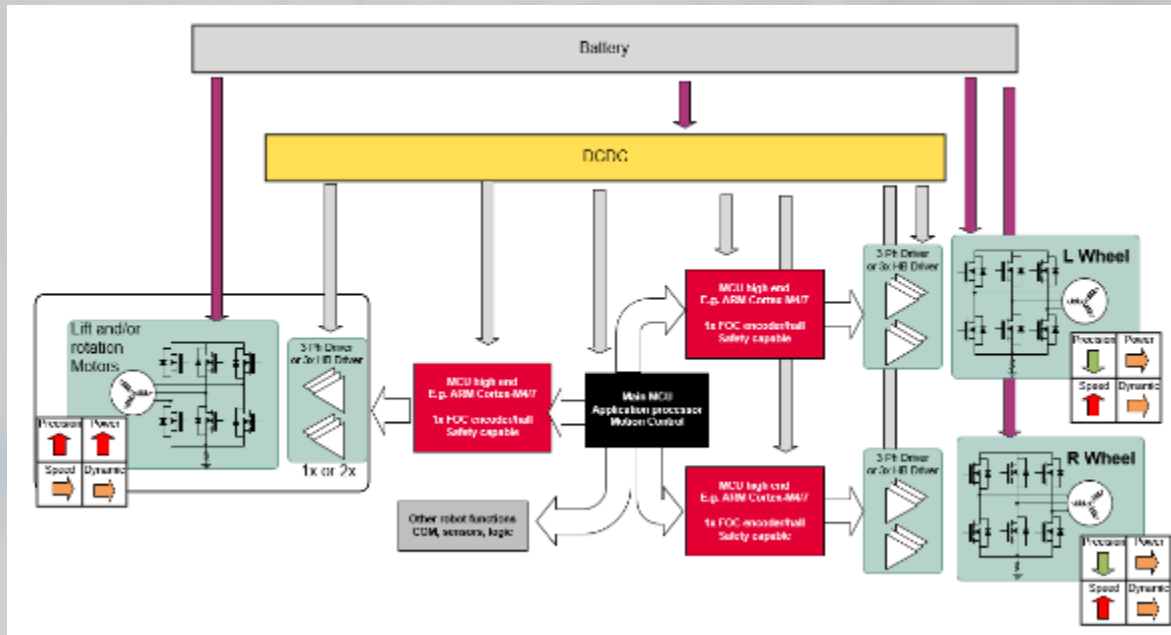


# Motor Control

[Back to overview](#)



Saving costs and design effort with efficient & compact motor drive solutions



## Power switches

- > OptiMOS™ & StrongIRFET™ MOSFETs
- > EiceDRIVER™ Gate Driver

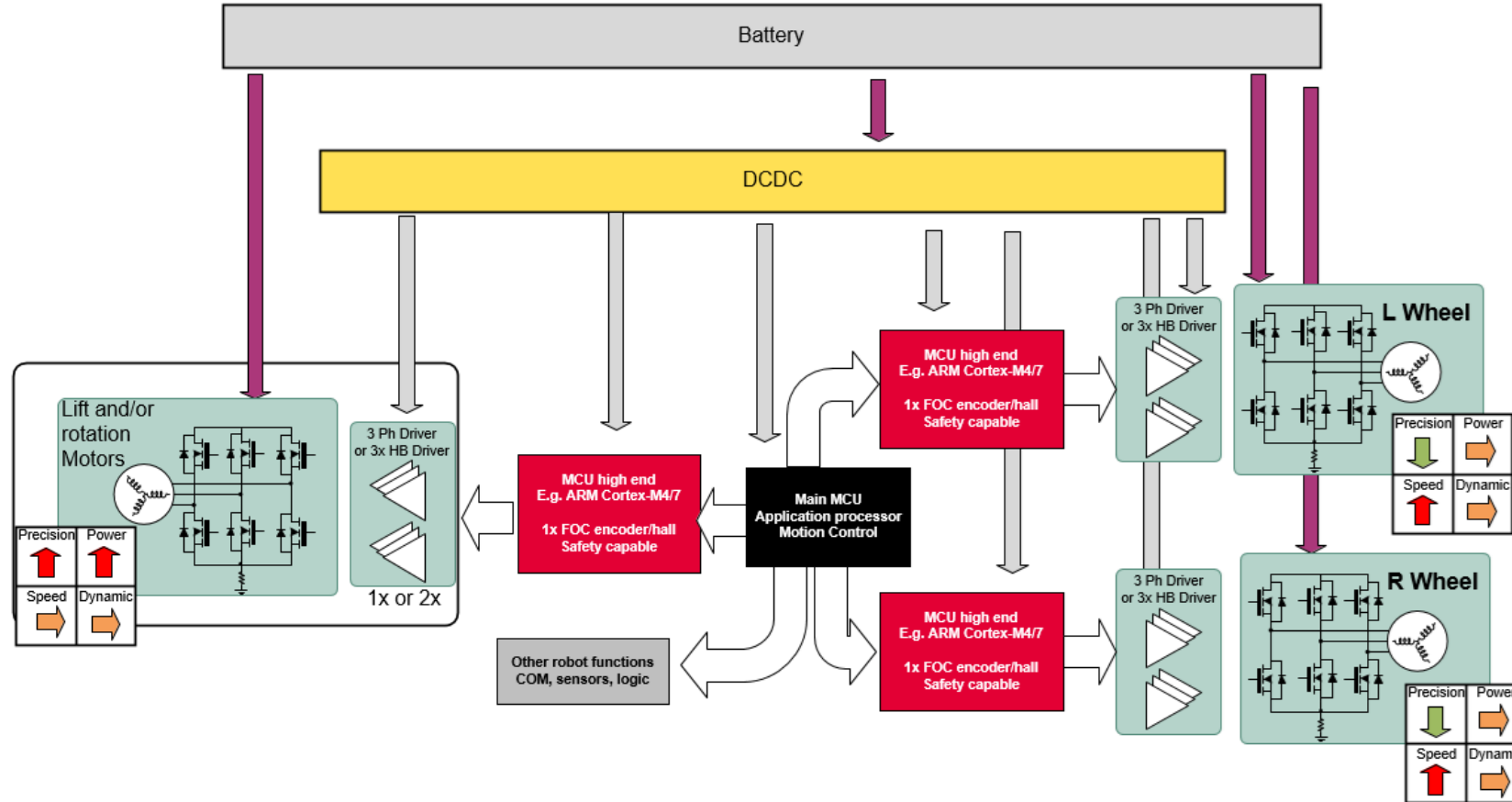
## MCU & Memory

- > XMC
- > PSoC

## Sensing

- > Hall Sensor
- > Angle Sensor
- > Current Sensor

# Motor drive specs in mobile robots



**Up to 4 motors**, 2 wheels, 1 lift motor, 1 optional rotation of lifting platform

**BLDC** up to 1kW

**High accuracy control with FOC** using encoders and other sensors

**Best in class MOSFETs** for efficiency and power density

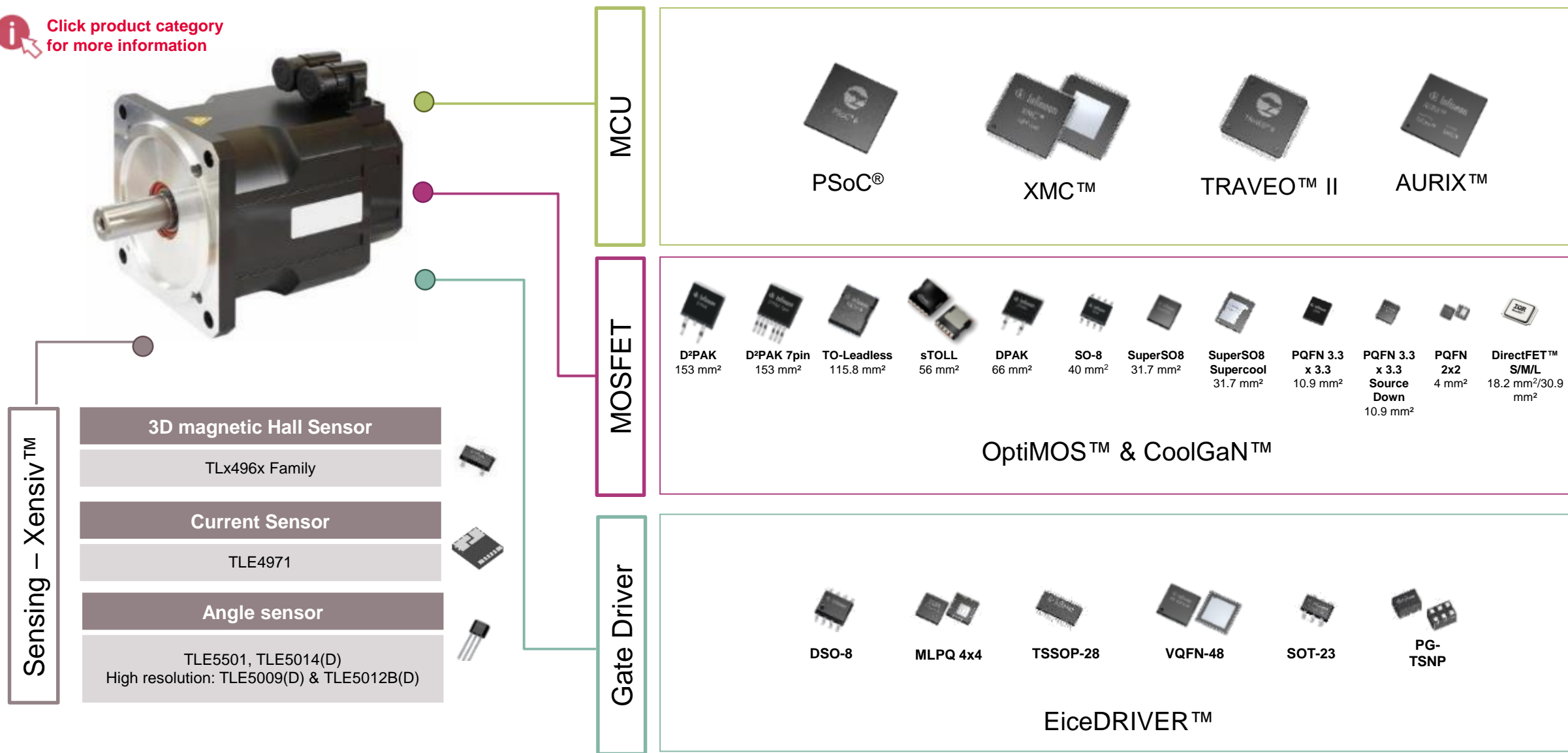
**3x half bridge driver** or 3 phase driver integration with safety functions (e.g. safe disconnect)

**Distributed control** – main controller does motion control







# Infineon has the full solution for motor drive & control systems

Click product category for more information

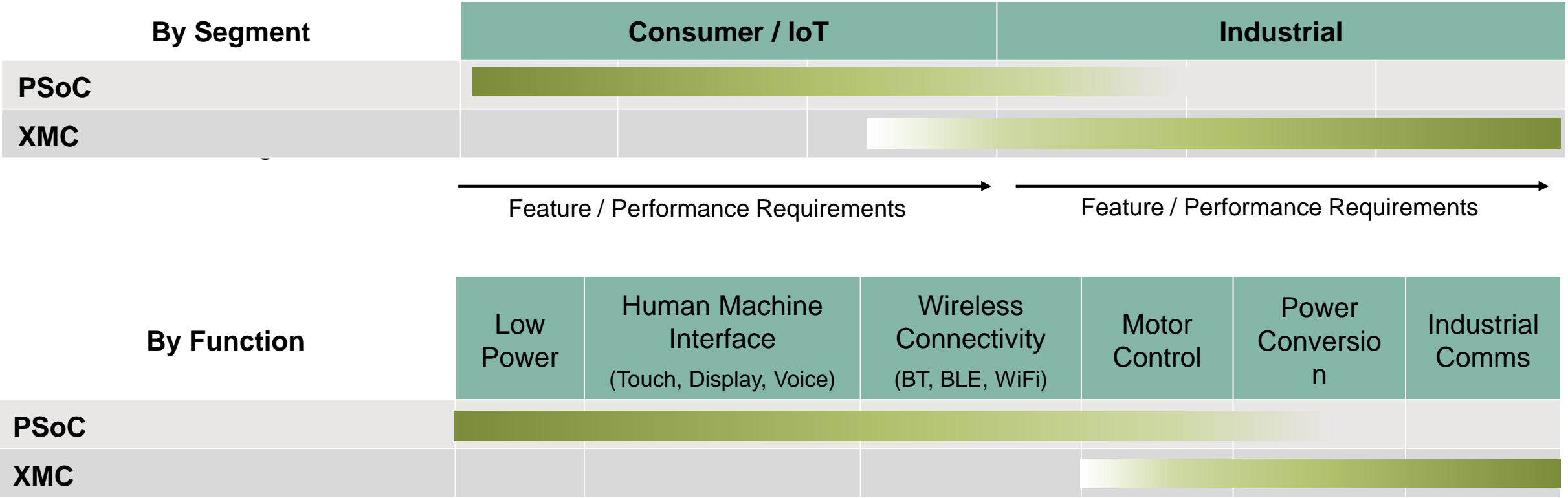


# Microcontroller Product Portfolio

Note: Automotive, AURIX™ for Industrial, iMOTION™ covered separately

8-Bit	32-Bit Arm® Cortex®-M0/M0+	32-Bit Arm Cortex-M3	32-Bit Arm Cortex-M4 / Arm Cortex-M0+	32-bit Arm Cortex-Mx (next generation)
<p><b>IoT / Consumer</b></p> <p><b>PSoC 6</b> MCUs for the broad-base of IoT and Consumer applications, bringing best in class low power, connectivity, and security</p> <p><b>PSoC 4</b> delivers unique software-defined peripherals and industry leading capacitive sensing designs</p> 	 <div> <p><b>PSoC 4</b> Cortex-M0/M0+ 48 MHz, 384KB Flash Up to 13 PAB, 20 PDB, 98 I/Os</p> <p><b>FM0+ MCUs</b> Cortex®-M0+ 40 MHz, 512KB Flash, 102 I/Os</p> <p><b>XMC1000 MCUs</b> Cortex®-M0 32-48 MHz, 200KB Flash, 55 I/Os</p> </div>	<div> <p><b>PSoC 5LP</b> Cortex-M3 80 MHz, 256KB Flash 20 PAB, 30 PDB, 72 I/Os</p> <p><b>FM3 MCUs</b> Cortex-M3 144 MHz, 1.5MB Flash, 154 I/Os</p> </div> <div> <p><b>Industrial</b></p> <p><b>XMC™</b> is a family of high-performance Arm Cortex-M-based MCUs for industrial applications, with industrial control peripherals and extended temp range</p> <p><b>FM</b> is a portfolio of high-performance Arm Cortex-M-based MCUs for industrial and consumer applications</p>  </div>	<div> <p><b>PSoC 6</b> 150 MHz Cortex-M4/100 MHz M0+ 2MB Flash 7 PAB, 56 PDB, 104 I/Os</p> <p><b>FM4 MCUs</b> Cortex-M4 200 MHz, 2MB Flash, 190 I/Os</p> <p><b>XMC4000 MCUs</b> Cortex®-M4 80-144 MHz, 2MB Flash, 119 I/Os Industrial Comms, Ta 125C</p> </div>	<div> <p><b>Next Gen IoT MCU</b> Multi-core Cortex-Mx ML-Ready, HMI Rich</p> <p><b>Industrial Evolution</b> Multi-core Cortex-Mx Industrial Quality, ECC Memories</p> <p><b>Other</b> Specialized and Legacy</p>  </div>

# The Right MCU for the Job – Focus Families



# Choosing the right MCU: XMC™, PSoC, Traveo II or AURIX™

## XMC™

- ✓ Cortex ARM M based MCU
- ✓ XMC1000 – Cortex M0 MCU (48MHz-)
- ✓ XMC4000 – Cortex M4F MCU (144MHz-)
- ✓ DAVE 4.0 Apps available for Motor Control FOC, BLDC, PMSM and more
- ✓ SW security libraries protection



## PSoC™ 4

- ✓ CM0+ 48MHz
- ✓ Up to 384k Flash, 32k SRAM
- ✓ Customer have the knowledge of motor control SW



## PSoC™ 6

- ✓ Dual Core - CM4F 150MHz, CM0+ 100MHz
- ✓ Up to 2M Flash, 1M SRAM
- ✓ Enhanced TCPWM (P6-256k)
- ✓ Customer have the knowledge of motor control SW

## Traveo II

- ✓ Cortex ARM M based MCU
- ✓ CYT2Bx – Cortex M4 MCU (80 MHz or 160MHz-)
- ✓ CYT3/4x – Dual Cortex M7F MCU (250MHz or 350MHz)
- ✓ HSM (Hardware Security Module)
- ✓ ASIL-B (SIL-2)
- ✓ ECC memory, MPU, Self test Libs
- ✓ Up to 320 pins



## AURIX™

- ✓ TriCore™ based MCU
- ✓ AURIX™ – Up to 3x multicore (300MHz-)
- ✓ AURIX™ – Up to 6x multicore (300MHz-)
- ✓ SW security libraries protection
- ✓ Functional Safety ASIL-x



	XMC™	PSoC™ 4	PSoC™ 6	Traveo II	AURIX™
Does the customer write their own motor control SW?	Yes	Yes	Yes	Yes	Yes
Does the customer want standalone driver and controller?	Yes	Yes	Yes	Yes	Yes
Does the customer need SW update and security features?	Yes	Yes / No	Yes / Yes	Yes	Yes
Is functional safety required (e.g. SIL-x) for the application?	IEC60730 Class B	IEC60730 Class B	IEC60730 Class B	Yes – up to ASIL-B	Yes – up to ASIL-D
Low power consumption	Low power	Low power	Ultra low power	No	No
CPU performance	Medium to High	Medium	High to Very High	Highest	Highest
Especial Features	Robustness Peripherals tailored for motor control	IoT features	IoT features	Security and safety in ARM Cortex, high processing power	Automotive qualified, high processing power



# Recommended MCUs for the right fit solution



MCU



PSoC®



XMC™



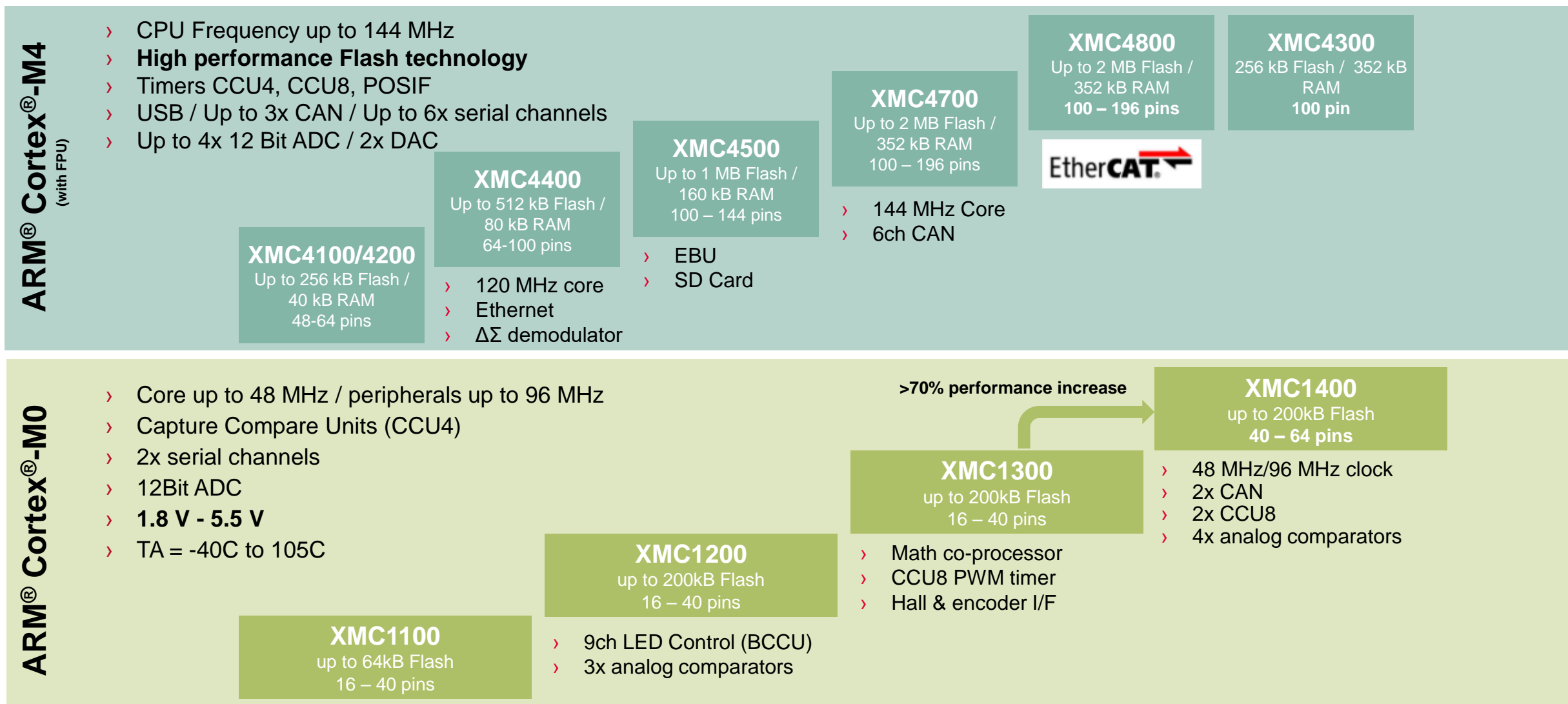
TRAVEO™ II



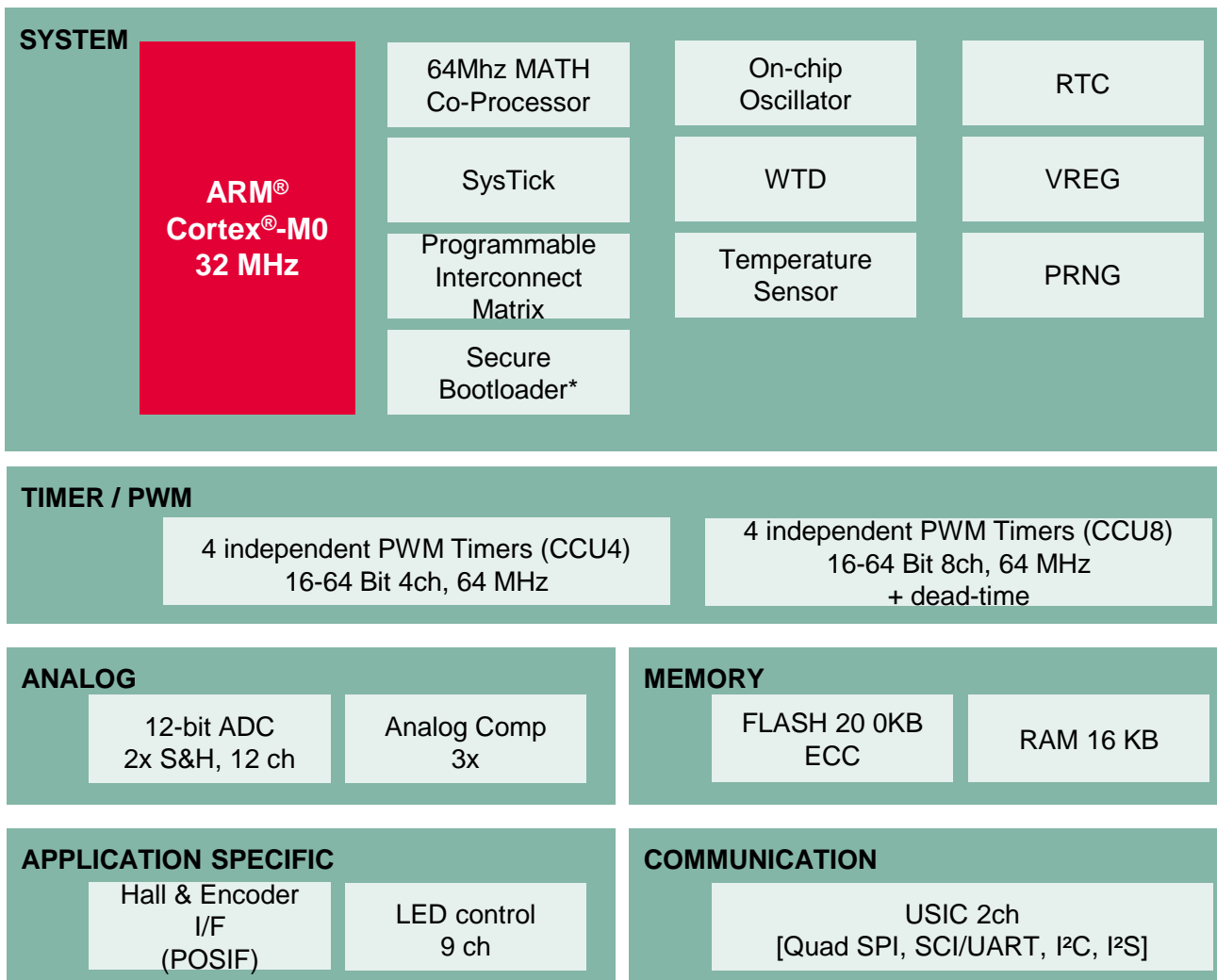
AURIX™

	Part number	Core	Core Frequency	Package	Memory Flash/RAM	Safety/Security	Rational
PSoC	CY8C61x8	ARM Cortex M4F+M0	150MHz 100MHz	TQFP128, BGA124, 100-WLCSP (4.1x3.9mm)	Up to 2MB / 1kB	Class B Lib	General Purpose, flexible dual
XMC	XMC4800	ARM Cortex M4F	144MHz	LQFP100, LQFP144, LFBGA196	Up to 2MB / 325kB	Class B Lib	EtherCAT support
Traveo II	CYT4BF8CD	ARM Cortex M7 Dual Core + ARM Cortex M0+	350MHz 350 MHz	TEQFP-176, BGA272, BGA320	Up to 8MB / 1kB	ASIL B (SIL 2) / eSHE-HSM	Ethernet support
AURIX	TC337	TriCore	Up to 300MHz	TQFP80 till LFBGA292	2MB / 248kB	ASIL-D (SIL 3) / HSM	Robust, TriCore, ATV qualified, 150C


# XMC™ MCU product portfolio



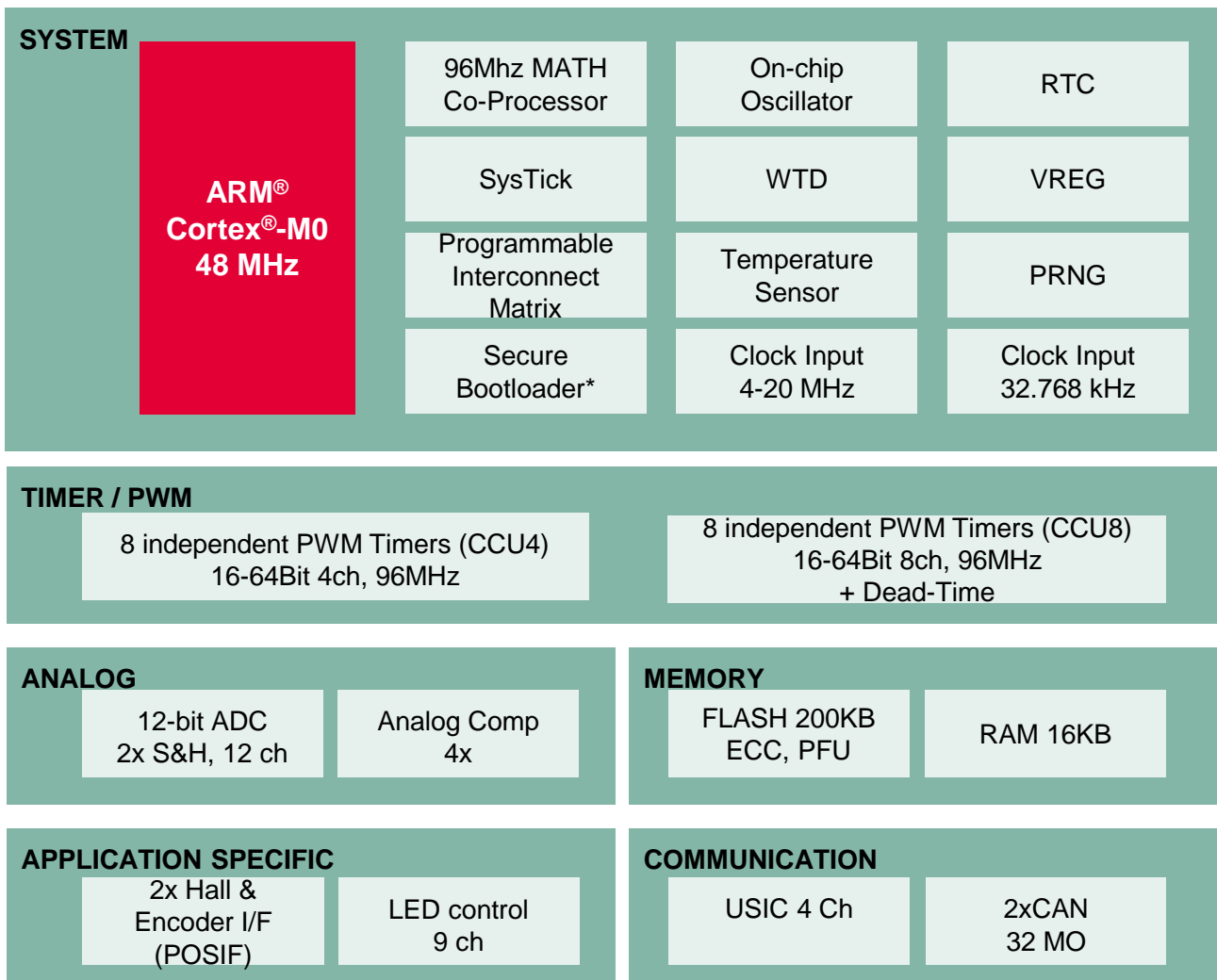
# XMC™ 1300 series




\* On request

Description
<b>Application / target markets</b> <ul style="list-style-type: none"> <li>› Motor Control</li> <li>› Digital Power/Wireless Charging</li> <li>› LED Lighting</li> </ul>
<b>Key features</b> <ul style="list-style-type: none"> <li>› <b>On-chip connectivity</b> of peripherals offloads CPU and improves real time performance</li> <li>› <b>MATH Co-processor</b> boosts Cortex®-M0 core performance by adding complex math computing engine running in parallel to the main core</li> <li>› Motor control <b>Hall</b> and <b>Encoder Interface</b></li> <li>› Extended <b>1.8 – 5.5 V</b> supply range</li> <li>› High control performance: <b>64 MHz PWM</b>, <b>1 MS ADC</b> and <b>25 ns Comparators</b></li> <li>› Best in class <b>LED dimming &amp; color control unit</b>, flicker-free, easy to use</li> <li>› <b>IEC 60730 class B</b> compliant LIB</li> </ul>
Packages
 <div> TSSOP16  TSSOP38  VQFN24  VQFN40 </div>

# XMC™ 1400 series

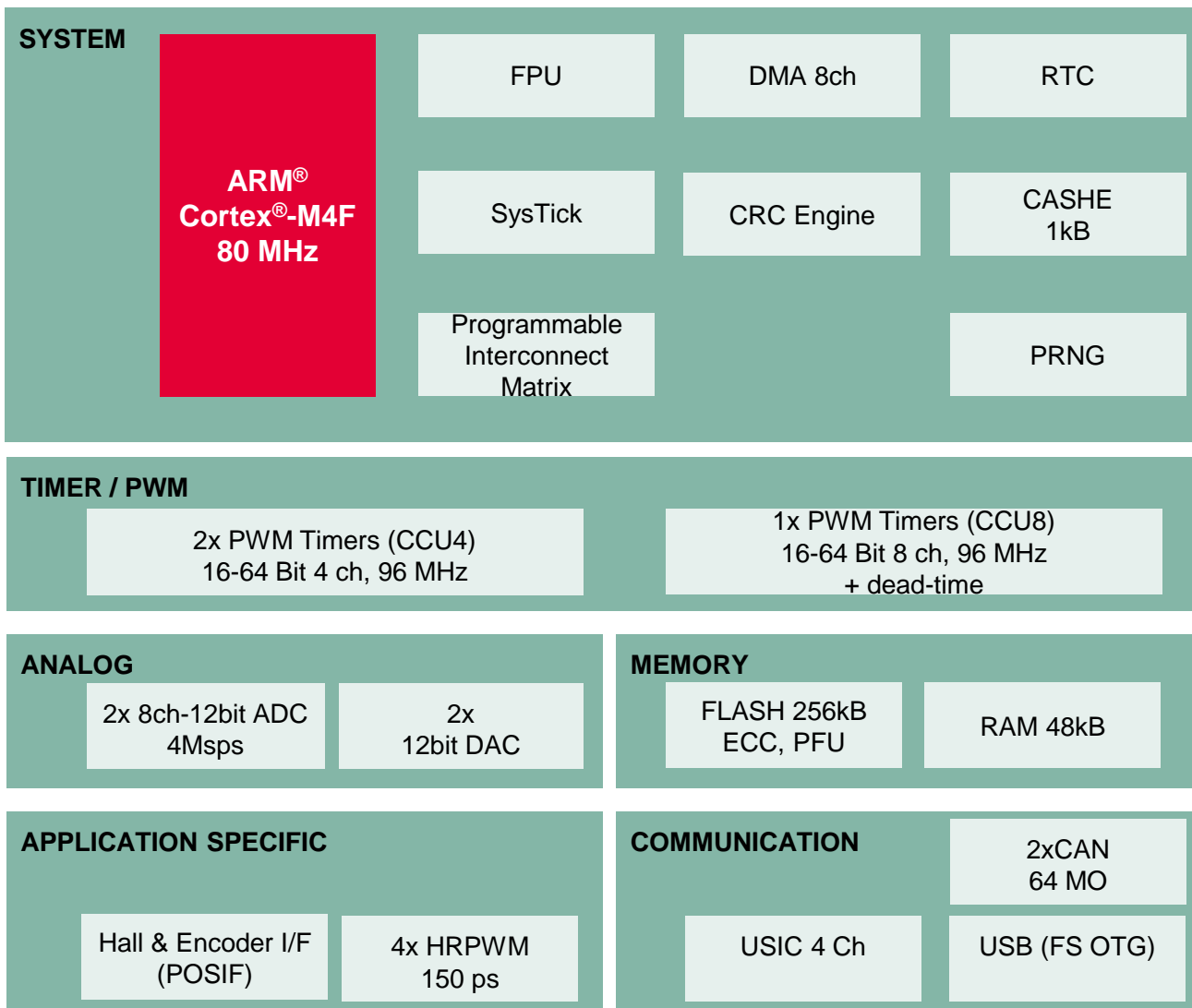


\* On request

Description
<b>Application / target markets</b> <ul style="list-style-type: none"> <li>› Motor Control</li> <li>› Digital Power / LED Lighting</li> <li>› I/O Modules</li> </ul>
<b>Key features</b> <ul style="list-style-type: none"> <li>› Designed for best in-class performance: <b>MATH co-processor</b> featuring CORDIC, <b>96 MHz PWM</b> timer dedicated to motor or engine control w/ dead time and <b>Hall &amp; encoder I/F</b></li> <li>› <b>On-chip connectivity</b> of peripherals offloads CPU and improves real time performance</li> <li>› <b>1 MS ADC</b> with add. internal reference multiple signal processing features</li> <li>› Peripheral for <b>LED dimming &amp; color control</b>, flicker-free, easy to use</li> <li>› Extended <b>1.8 – 5.5 V</b> supply range</li> <li>› <b>IEC 60730 class B</b> compliant LIB</li> <li>› <b>2 CAN</b> nodes control</li> </ul>
Packages
 <div> LQFP64  VQFN40  VQFN48  VQFN64 </div>



# XMC™ 4200 series

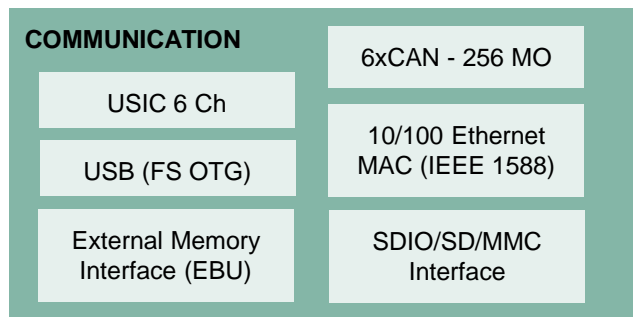
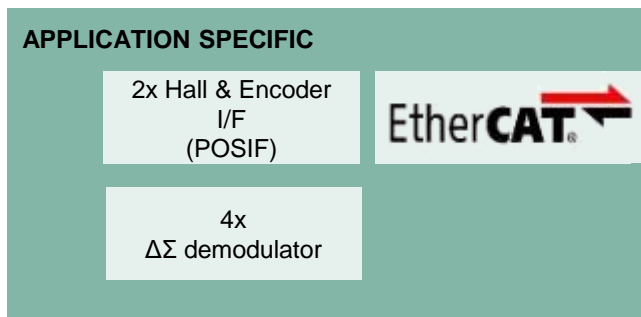
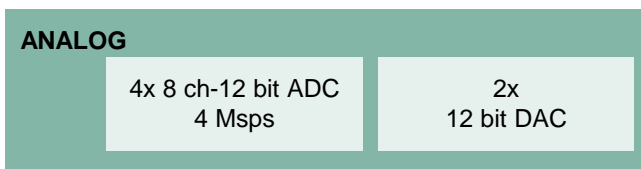
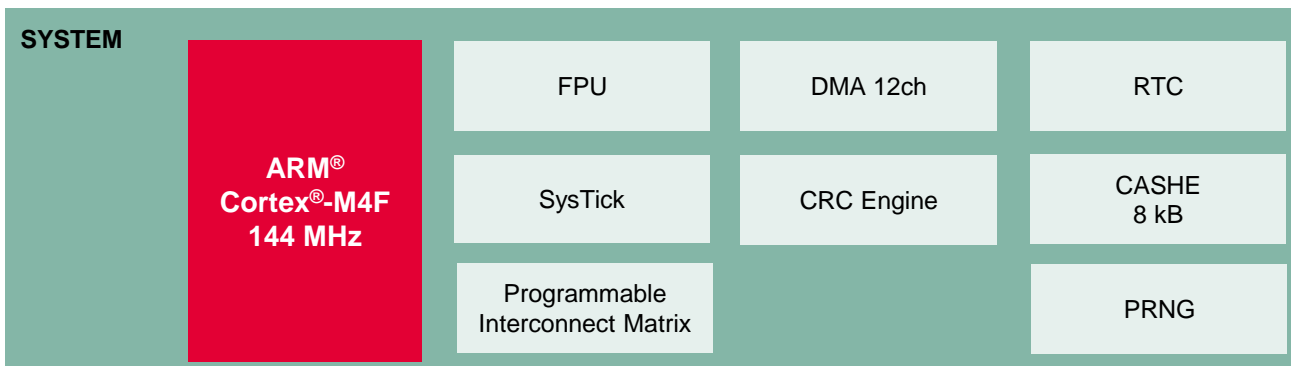


Description
<b>Application / target markets</b> <ul style="list-style-type: none"> <li>› Low to Medium-end Industrial Drives</li> <li>› Digital Power</li> </ul>
<b>Key features</b> <ul style="list-style-type: none"> <li>› Cortex-M4F @ 80 MHz with FPU</li> <li>› 256 kB Flash, 40 kB RAM on-chip memories</li> <li>› High resolution PWM 150 ps</li> <li>› Motor control Hall and encoder interface</li> <li>› Industrial connectivity</li> <li>› 125°C extended temperature range</li> <li>› Long term availability with &gt;15 years</li> <li>› IEC 60730 class B compliant LIB</li> <li>› Free DAVE™ IDE and DAVE Apps</li> </ul>

Packages

VQFN48 LQFP64

# XMC™ 4800 series with EtherCAT®



## Description

### Application / target markets

- > Medium to higher-end industrial control
- > Industrial communication
- > Transportation

### Key features

- > **ARM® Cortex®-M4 at 144 MHz**
- > **EtherCAT®**
- > Large on-chip memories up to **2 MB Flash, 352 kB RAM**
- > **Up to 6 CAN nodes with 256 message objects**
- > Rich industrial and external media connectivity
- > **125°C** extended temperature range
- > Long-term availability with >15 years
- > IEC 60730 class B compliant LIB
- > Free DAVE™ IDE and DAVE Apps

## Packages



LQFP100  
LQFP144  
LFBGA19  
6

# PSoC 4: Problem Solver on Chip

## Sense anything

Programmable analog and digital blocks in PSoC 4 enable you to customize your analog-front-end, apply simple glue logic and easily integrate intelligent analog sensors into an application



**Intelligent sensor integration**

## Easy-to-use HMI

PSoC 4 simplifies complex HMI interfaces such as capacitive and inductive sensing enabling sleek, robust, and easy-to-use interfaces



**Capacitive and inductive sensing**

## Connected

Bluetooth Low Energy (BLE) integrated into some PSoC 4 devices simplifies RF design. Additional wired interfaces such as USB and CAN are also available



**Wired and wireless connectivity**

## Touch-sensing technology leadership

Touch Buttons: 2003



LG Chocolate  
(First Generation)

Liquid Tolerance: 2008



Whirlpool Dishwasher  
(Second Generation)

SmartSense: 2010



HP TouchSmart Printer  
(Third Generation)

PSoC 4 S-Series: 2016



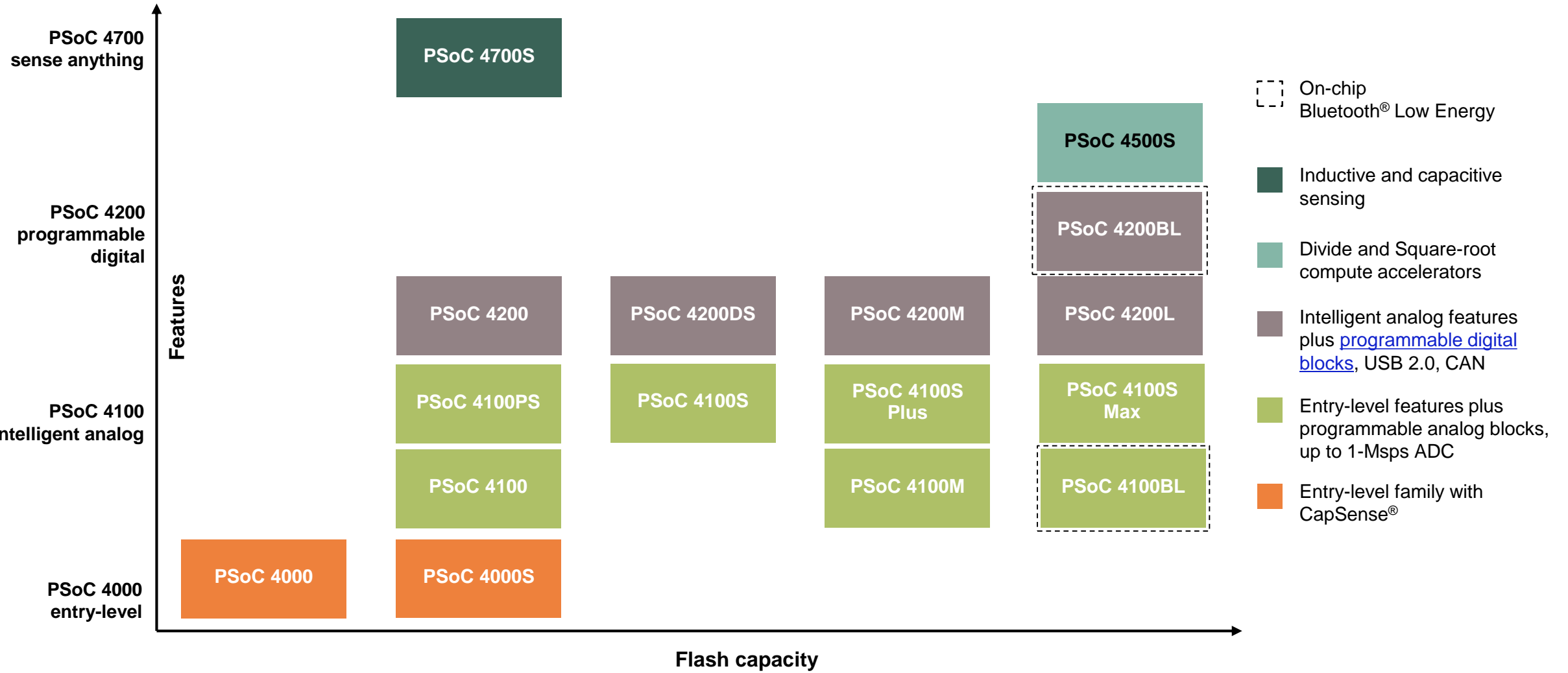
PSoC 4 S-Series  
(Fourth Generation)

Multi-Sense Converter: 2020



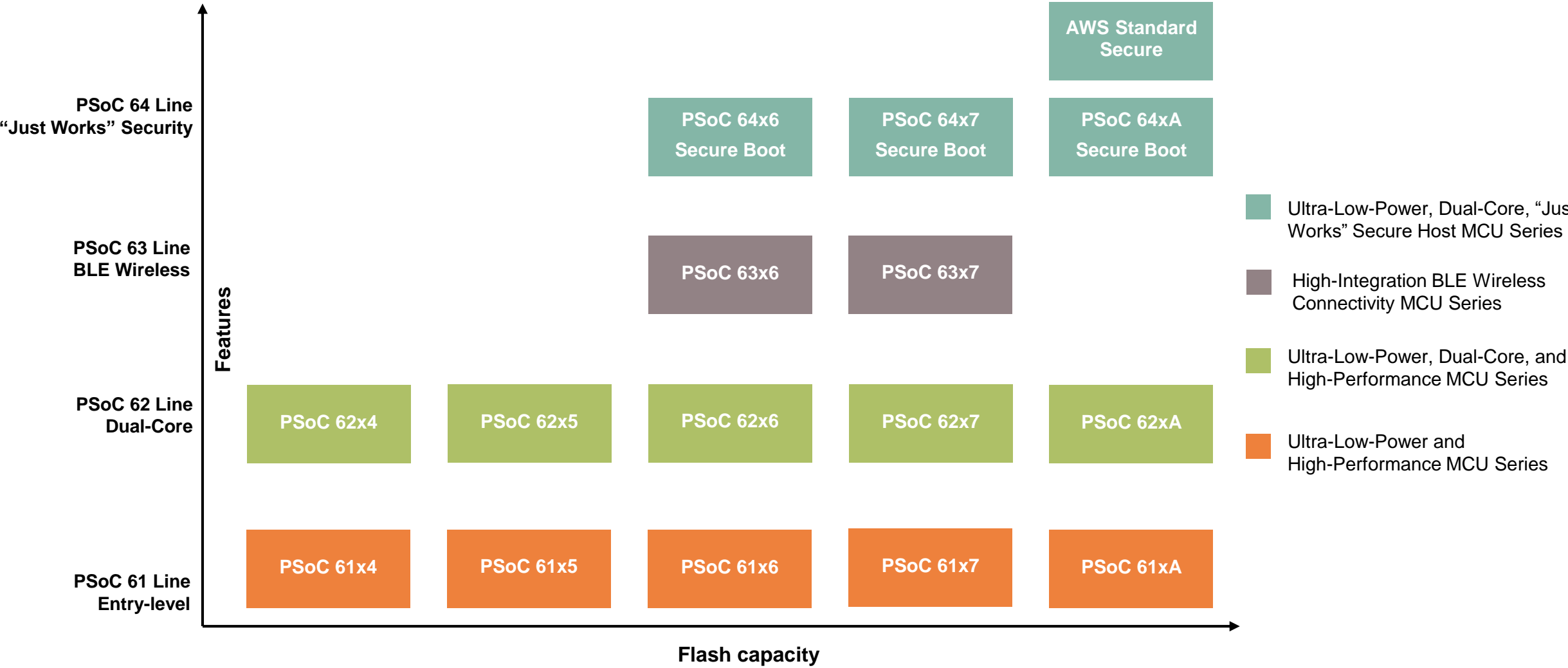
PSoC 4100S Max  
(Fifth Generation)

# PSoC<sup>®</sup> 4 portfolio





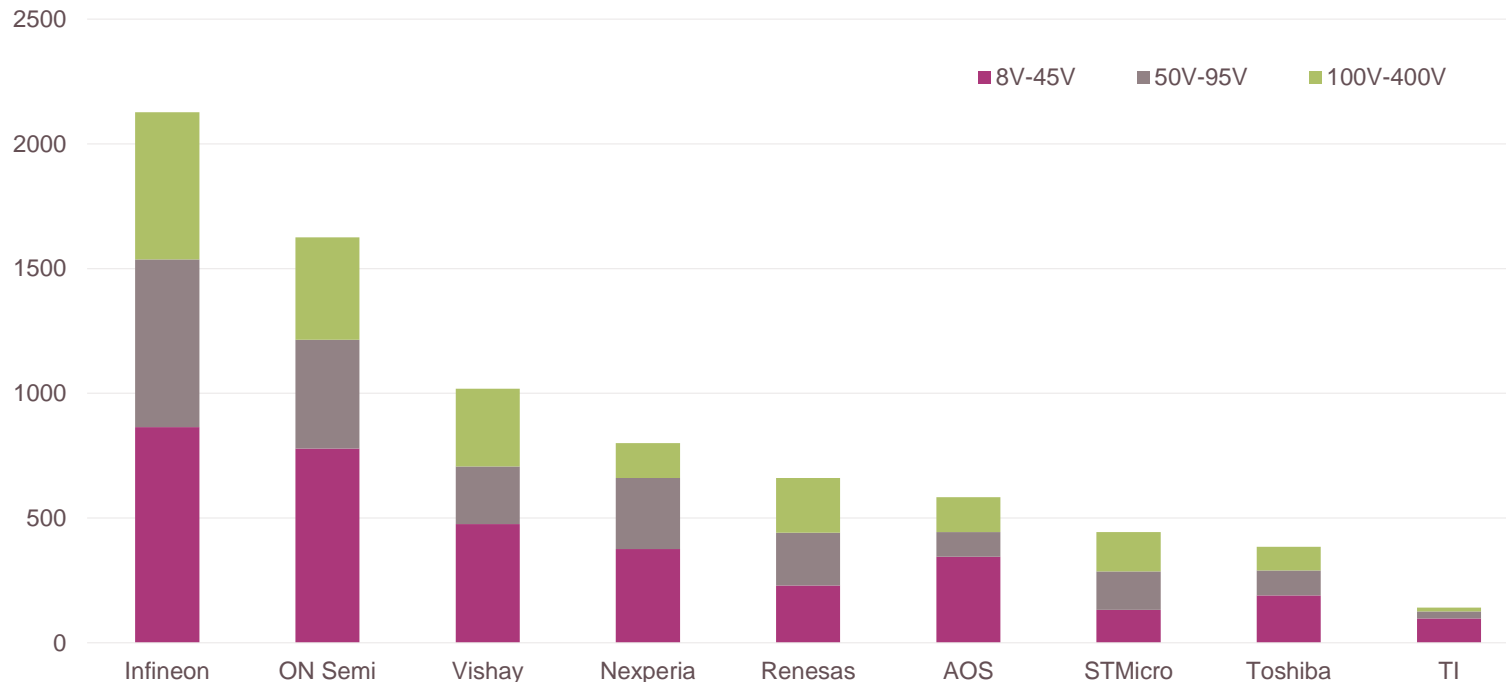
# PSoC® 6 portfolio



# Infineon 20 V - 300 V portfolio size

## Product portfolio vs. competition by voltage classes

Number of products by voltage class



<sup>1</sup>Automotive & industrial products included

**\* Be aware that the essential product portfolios start  $\geq 20$  V**  
**Only a few products can be found for 8 V, 12 V and 16 V**

**Source:** Aug 2019 IHS Markit & competitor database

**Note:** Sorting based on the number of products (largest to smallest), not related to revenue or market share

- › Infineon has the largest 20 V – 300 V MOSFET portfolio in the world with over 2K part numbers
- › Infineon offers both differentiated technical solutions, as well as Right Fit Products to meet any price and performance budget

# OptiMOS™ and StrongIRFET™

## Product portfolio and technology roadmap



### StrongIRFET™

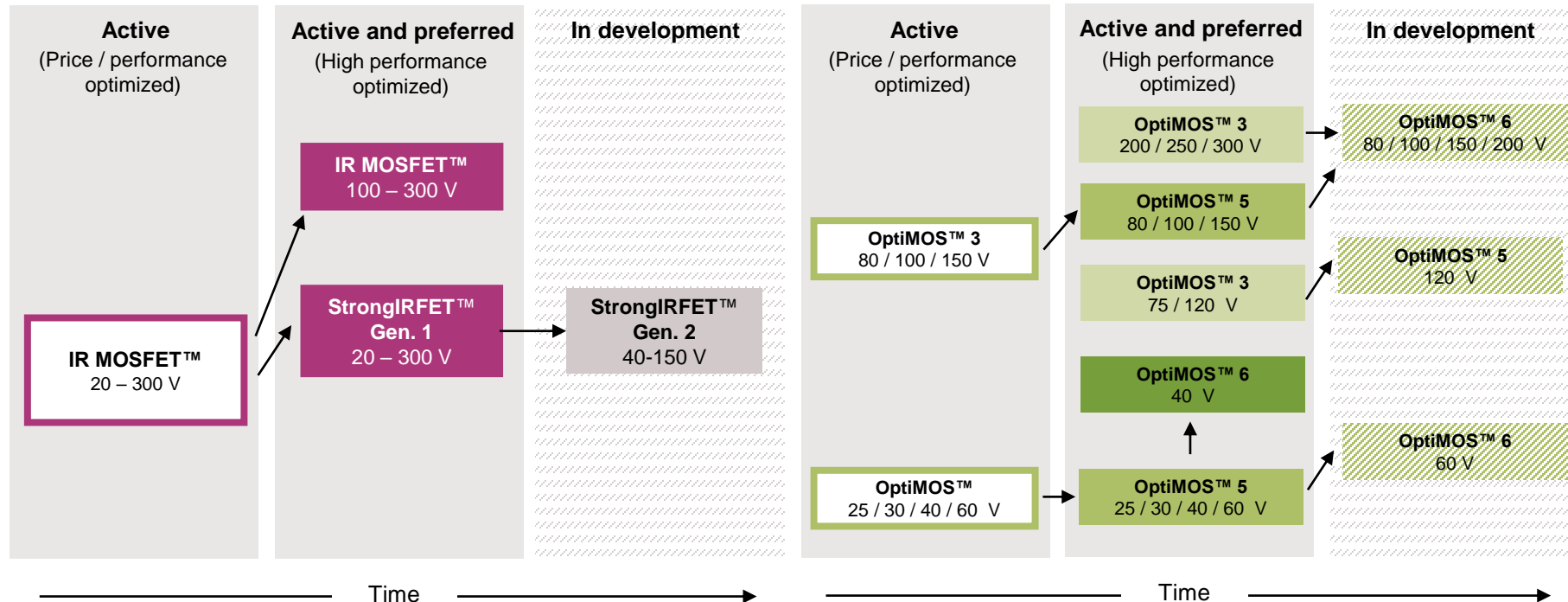
#### Robust and excellent price / performance ratio

Optimized for switching frequency < 100 kHz  
Designed for industrial applications  
High current carrying capability  
Rugged silicon

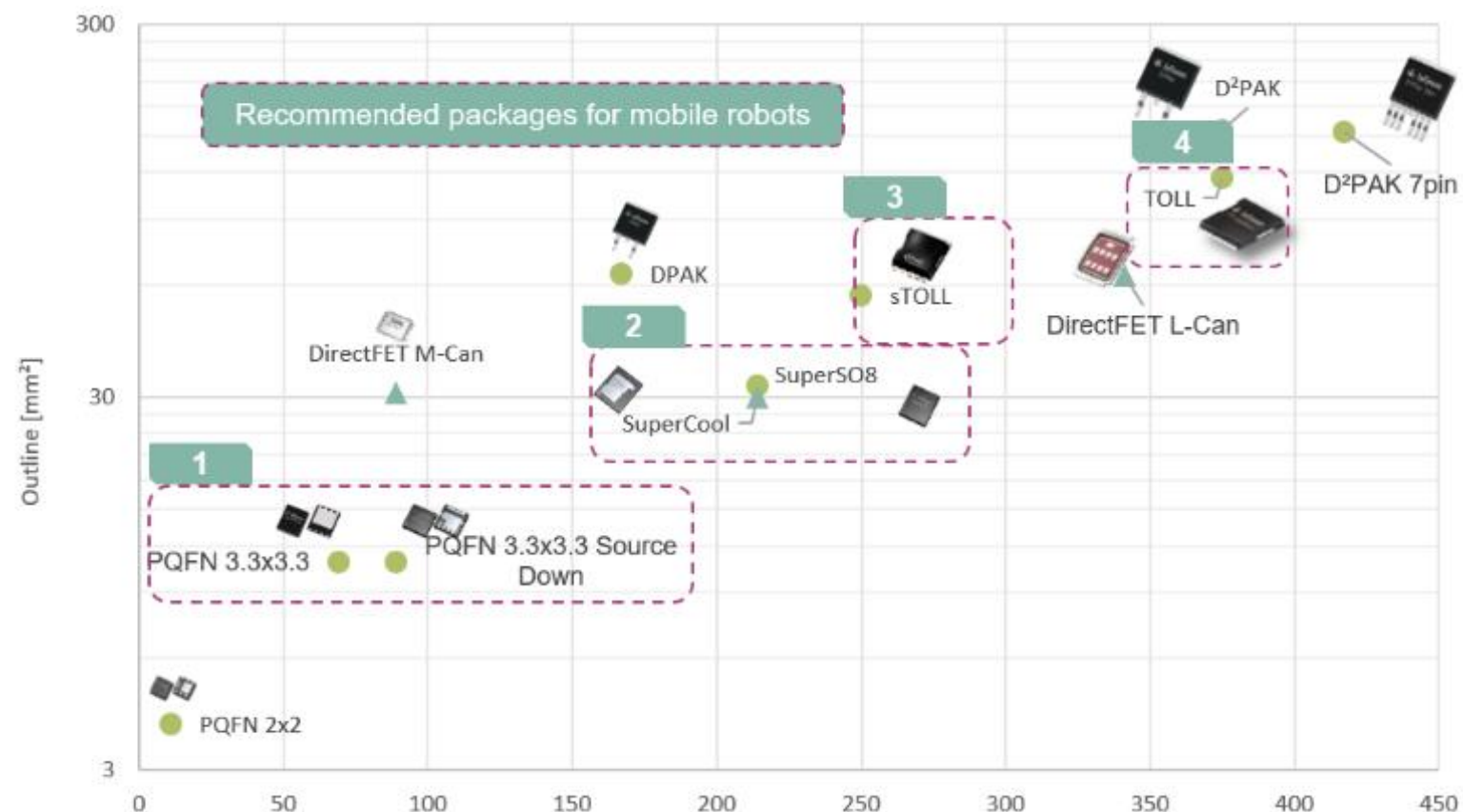
### OptiMOS™

#### Best-in-class technology

Optimized for broad switching frequency  
Designed for high performance applications  
Industry's best figure of merit  
High efficiency and power density



# Recommended MOSFETs for efficient and power dense motor drives



Major market driver for Power MOSFETs continue to be **higher power density**. This can be achieved by either:

- Same power level in a smaller footprint, or
- Higher power level in a similar footprint

Preferred package types addressing higher power density requirements include the 3x3, SuperSO8, sTOLL, and TOLL



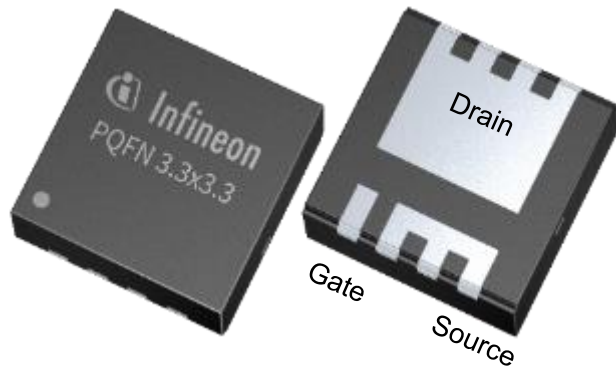
POWER

- SMD
- ▲ Dual Side Cooling



# New PQFN 3.3x3.3 Source-Down (SD) MOSFET package

## The Drain-Down Industry Standard

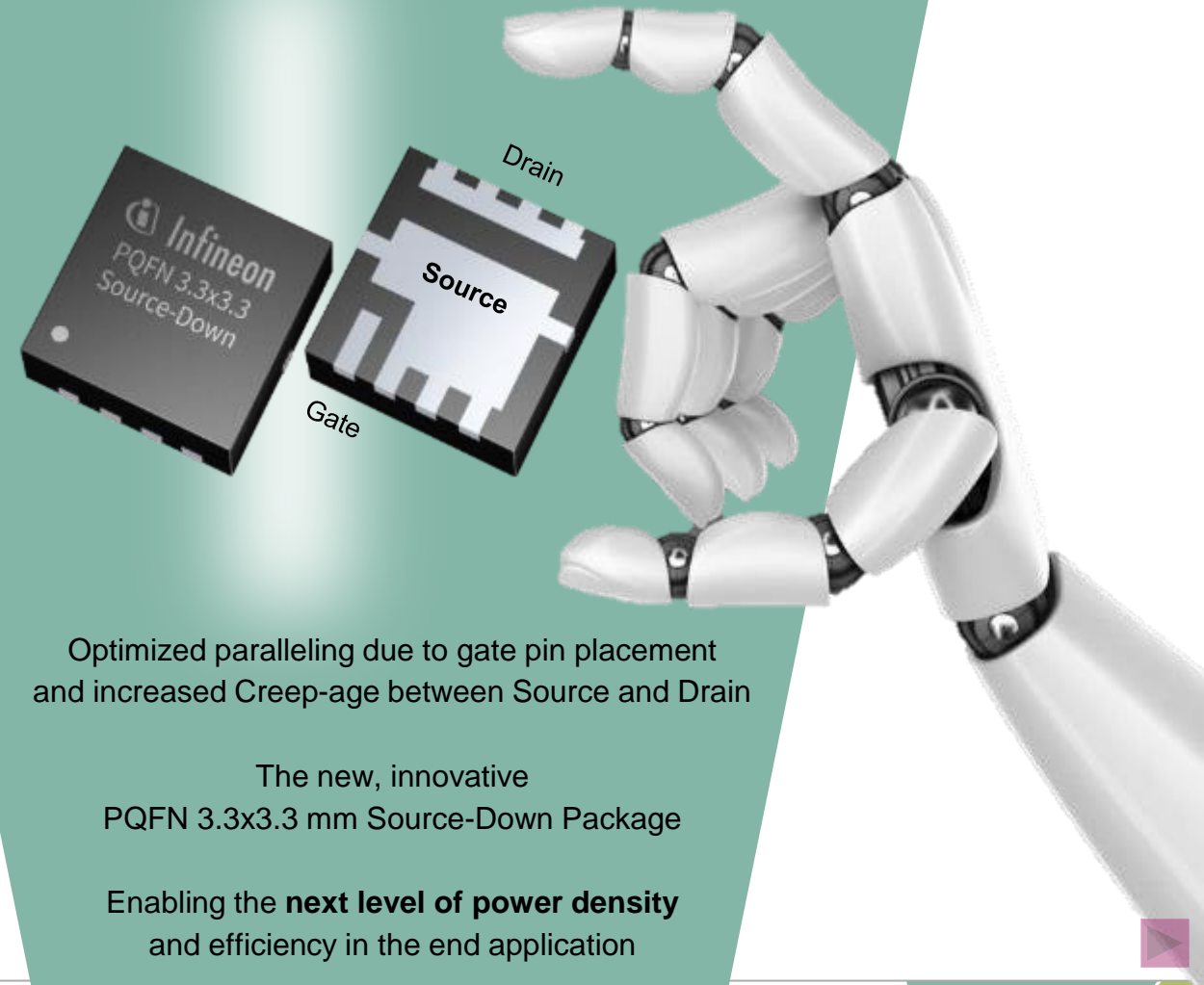


Easy adoption to existing designs

Today's industry standard  
PQFN 3.3x3.3 mm package

Power MOSFETs in a small package to realize  
high power densities in end applications

## The Source-Down Innovation



Optimized paralleling due to gate pin placement  
and increased Creep-age between Source and Drain

The new, innovative  
PQFN 3.3x3.3 mm Source-Down Package

Enabling the **next level of power density**  
and efficiency in the end application

# Source down configuration - Improved thermal PCB design

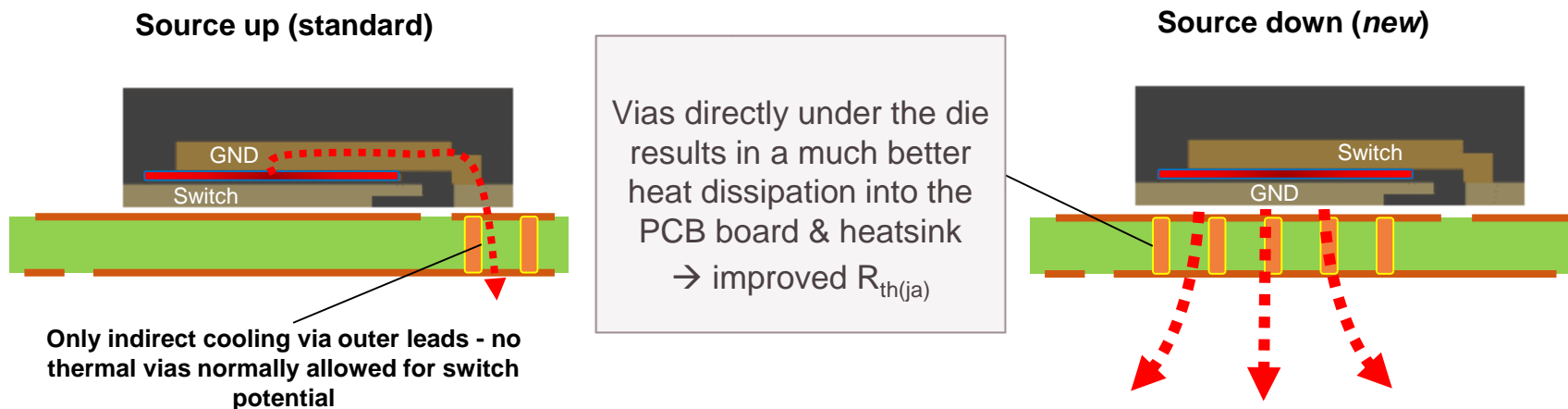
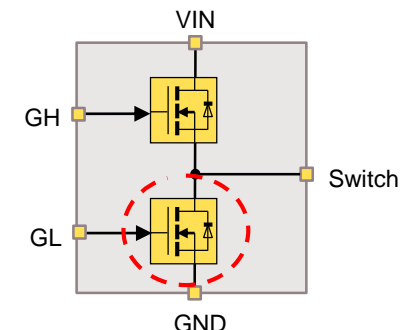
## Thermal PCB design for half-bridge switches

Power supply ( $V_{IN}$  & GND) are mainly used as cooling area

@ PCB - e.g. buck converters:

- No thermal vias @ switch node
- Thermal vias only allowed @  $V_{IN}$  and GND

→ **Source down configuration for the low side-switch enables usage of thermal vias directly under the MOSFET chip** which results in a lower  $R_{th(ja)}$



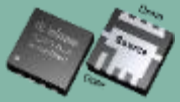
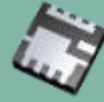
Cross section of a MOSFET in source up/ source down configuration mounted on a PCB

# OptiMOS™ 60 V – 150 V in PQFN 3.3 x 3.3 source down (wave 2)

## Value proposition

- BiC  $R_{DS(on)}$  with reduction by 30-50% depending on the voltage class
- Highest power density and performance
- Improved thermal capability especially for low-side switches
- Higher current capability
- Easy adaption on existing PCB layout (pin-to-pin compatibility, no PCB re-routing)
- Support double-side cooling for improved thermal management

## Target specifications

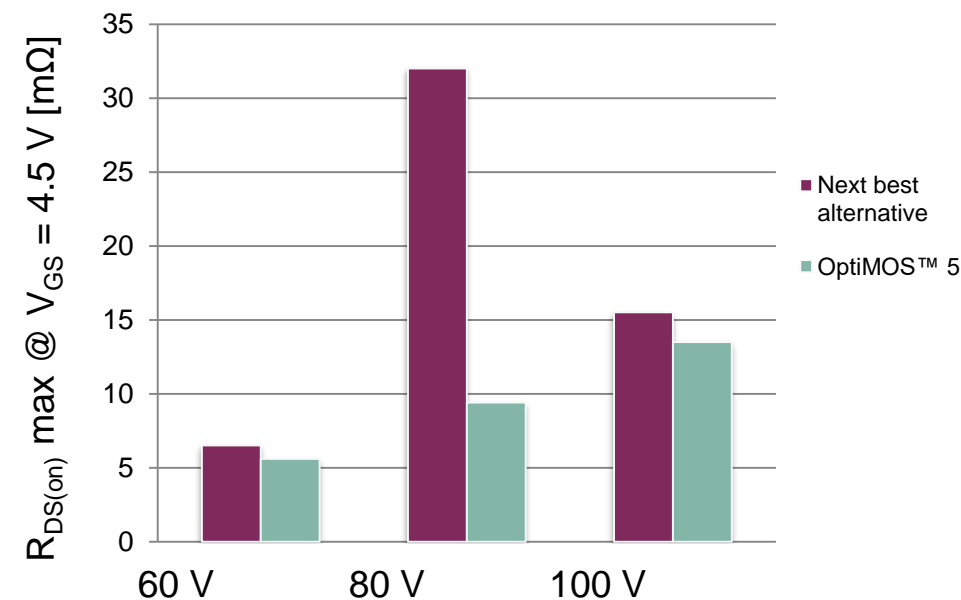
		Standard-Gate		Center-Gate	
					
Voltage class	Target $R_{DS(on)}$ [mΩ]	Sales name (Standard-Gate)	Target release schedule	Sales name (Center-Gate)	Target release schedule
60 V	≤3,0	IQE03XN06NM5	Q3/CY2021	IQE03XN06NM5CG	Q3/CY2021
80 V	≤6,0	IQE06XN08NM5	Q3/CY2021	IQE06XN08NM5CG	Q3/CY2021
100 V	≤8,0	IQE08XN10NM5	Q3/CY2021	IQE08XN10NM5CG	Q3/CY2021
150 V	≤22	IQE2X0N15NM5	Q3/CY2021	IQE2XXN15NM5CG	Q3/CY2021

# OptiMOS™ 5 60 V - 100 V SuperSO8 - Logic level gate drive



## Value proposition

- Low  $R_{DS(on)}$  in small package
- Lower gate charge
- Lower output charge
- Logic level driven (Will operate at 4.5  $V_{GS}$ )



## Specifications

Part number	V <sub>DS</sub> [V]	R <sub>DS(on)</sub> max. @V <sub>GS</sub> = 10 V [mΩ]	I <sub>D</sub> max. @25 °C [A]	Package	Release schedule
BSC027N06LS5	60	2.7	134	SuperSO8	Released
BSC065N06LS5		6.5	64		
BSC094N06LS5		9.4	47		
BSC025N08LS5	80	2.5	100		
BSC034N10LS5	100	3.4	156		
BSC146N10LS5		14.6	44		

# Super Cool SuperSO8 vs. Standard SuperSO8 Comparison Data

SuperCool

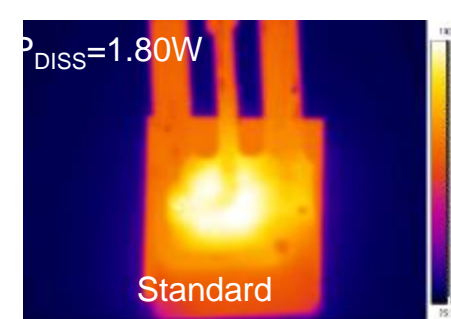
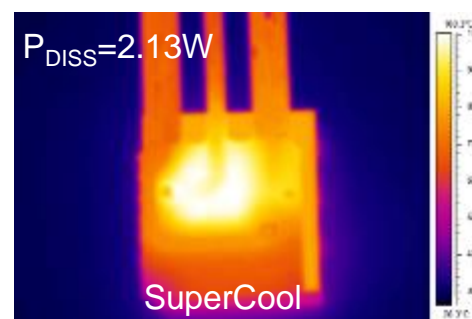
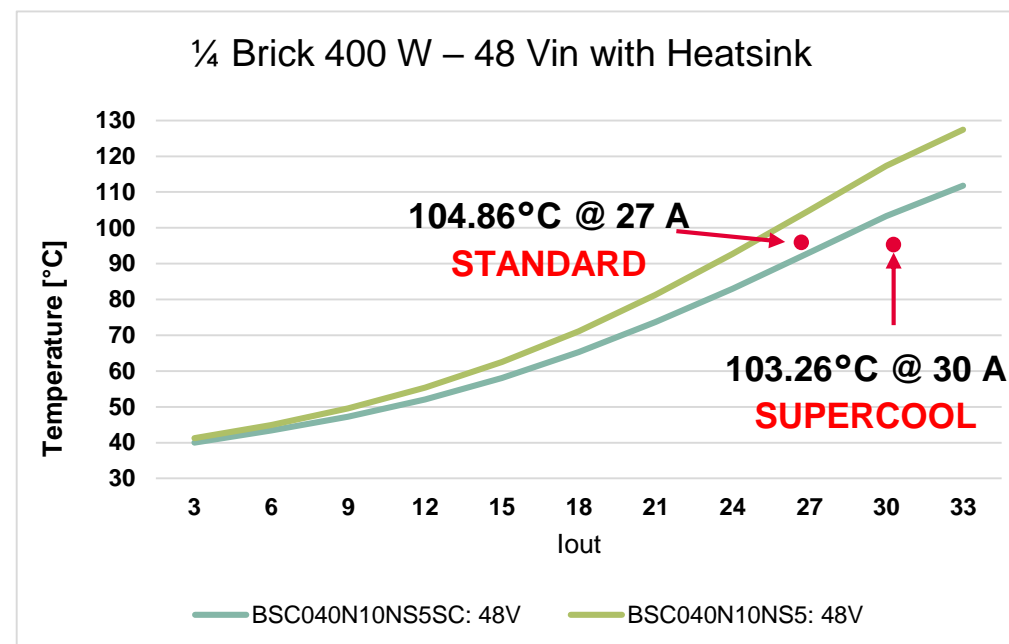


Standard SSO8



## SuperCool vs Standard SSO8

- Drop-in replacement (compatible footprint)
- Superior thermal performance through top-side ( $R_{thJC} < 1 \text{ K/W}$  in BiC parts)
- SuperCool can drive **10% higher current** at same temperature and offers **20% more power density** than standard SSO8





# OptiMOS™ 5 SuperCool SSO8 60 V, 100 V (release Wave 1)



## Value proposition

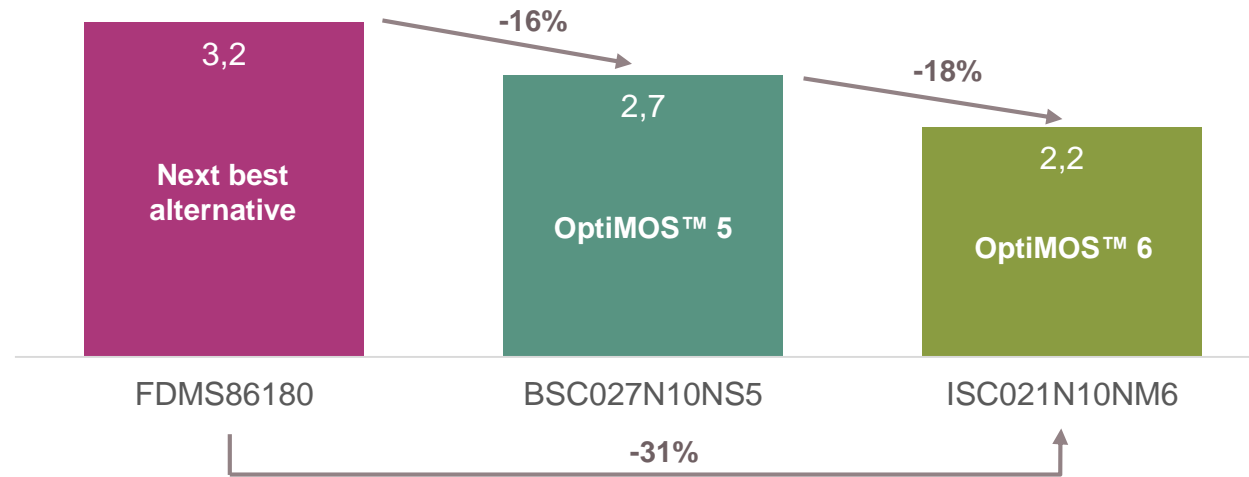
- Increased power density leading to highest system efficiency over standard 5x6 PQFN
- Provides double-sided cooling possibilities
- Relief thermal requirements on PCB designs
- Achieve a next level of thermal performance, especially when forced airflow and heatsink are used
- Standard SuperSO8 footprint means drop-in replacements to standard designs

## Specifications

Part number	$V_{DS}$ [V]	$R_{DS(on)}^{max.}$ @10 V [mΩ]	$I_D$ [A]	$R_{thJC\_top}$ [K/W]	Release schedule
BSC014N06NSSC	60	1.4	261	0.72 K/W	Released
BSC016N06NSSC	60	1.6	234	0.86 K/W	Released
BSC028N06NSSC	60	2.8	137	1 K/W	Released
BSC040N10NS5SC	100	4.0	140	0.9 K/W	Released
BSC070N10NS5SC	100	7.0	82	1.4 K/W	Released

# Technology highlight: OptiMOS™ 6

## $R_{DS(on)}$ max @10V [mΩ]



OptiMOS™ 6 in SuperSO8 package achieves:  
**31% better** ON-state-resistance compared to the **next best alternative**  
and **18%** compared to **OptiMOS™ 5**

**This results in lower conduction losses and increased power density.**

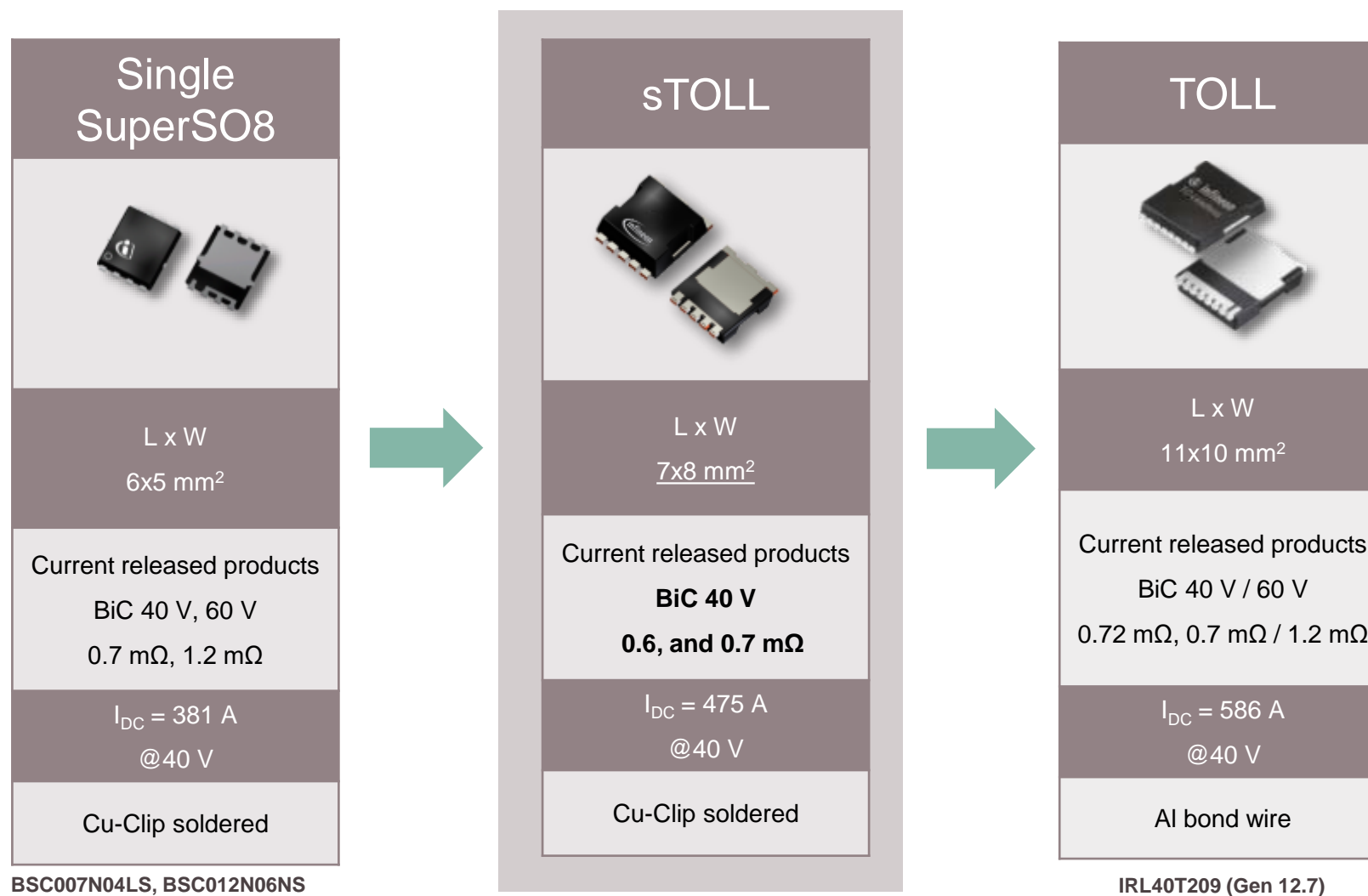
**Source:** Comparison based on  $R_{DS(on)}$  max @10V.

Product datasheet available on the webpage for OptiMOS™ 5 and ON Semiconductor and Preliminary datasheets available for OptiMOS™ 6.

# OptiMOS™ 6 – Product portfolio in 100V


Package	Sales name	$R_{DS(on)}$ max @10V	QS samples	Mass production
SuperSO8 5x6	ISC022N10NM6	2.2	Available	Q4 CY2021
	ISC027N10NM6	2.7	Available	Q4 CY2021
	ISC030N10NM6	3.0	May 2021	Q4 CY2021
	ISC060N10NM6	6.0	May 2021	Q4 CY2021
	ISC080N10NM6	8.0	April 2021	Q4 CY2021
	ISC220N10NM6	22.0	March 2021	Q4 CY2021
PQFN 3.3x3.3	ISZ080N10NM6	8.0	April 2021	Q1 CY2022
	ISZ220N10NM6	22.0	March 2021	Q1 CY2022

# NEW sTOLL: (Shrink TOLL) Fill the gap for leadless packages (PQFN)



# OptiMOS™ 5/6 sTOLL in 40 V – 100 V for high current density

## Package features

	$L \times W \times H$ 7.0 x 8.0 x 2.3 mm <sup>2</sup>
	$I_{DC} = >200 \text{ A}$
	Cu Clip

## Value proposition

- > Targeted at LV Drive Applications
- > Super low ohmic high current capability with latest state of the art silicon technology
- > Reduced form factor compared to traditional DPAK/D<sup>2</sup>PAK/TOLL resulting in reduction of PCB space (7x8 mm<sup>2</sup> reduce system costs)
- > Reduced conduction losses & optimized switching behavior
- > Package JEDEC listed (Industry package standard (JEDEC MO-319A))

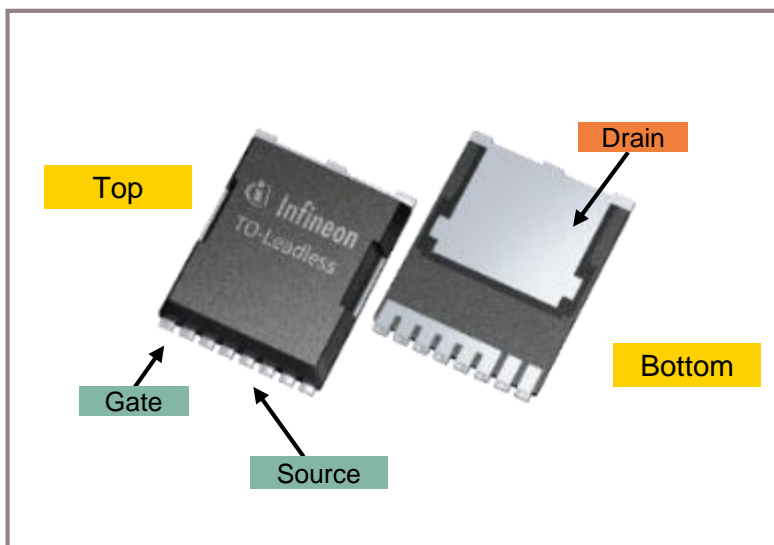
## Target specifications

$V_{DS}$ [V]	Part number	$R_{DS(on)}$ max. @ $V_{GS} = 10 \text{ V}$ [mΩ]	$I_D$ @ $T_C = 25 \text{ °C}$ [A]	Gate drive*	Package	ES Sample Availability	Release schedule
40	IST006N04NM6	0.6	475	NL	sTOLL	Available	Released
	IST007N04NM6	0.7	440				
60	IST011N06NM5	~1.1	~412				Q2 CY21
80	IST019N08NM5	~1.9	~299				
100	IST026N10NM5	~2.6	~256				

*Preliminary Information. Subject to change.*



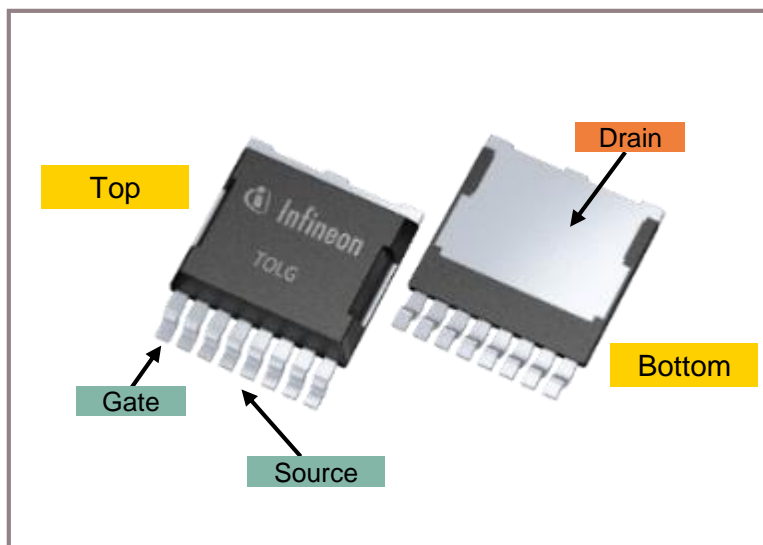
# TOLT vs TOLL and TOLG



**TOLL**

**TO-Leadless**

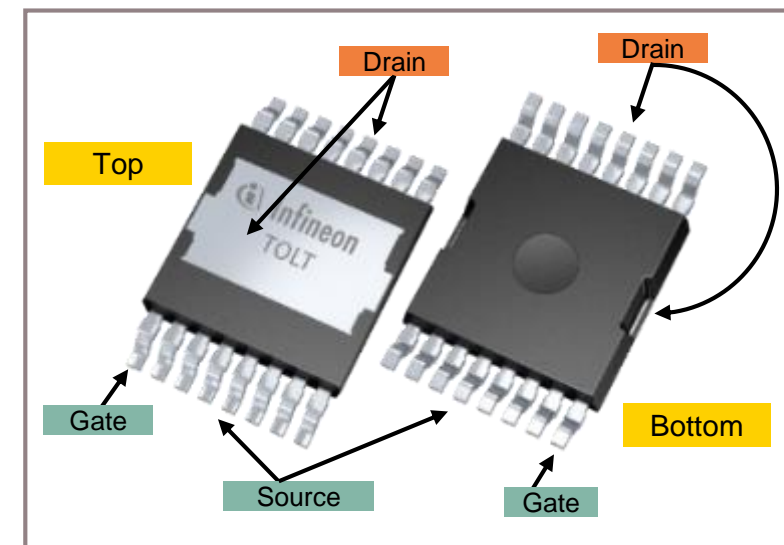
Optimized for high power applications



**TOLG**

TO-Leadless with **Gullwing leads**

Optimized for better TCoB robustness



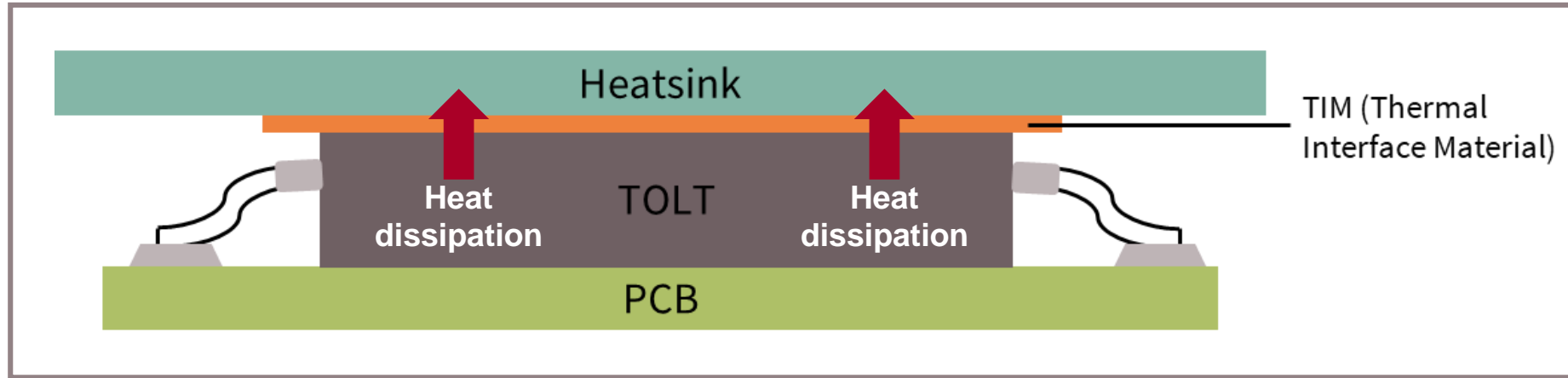
**TOLT**

TO-Leadless **Top Side Cooling**

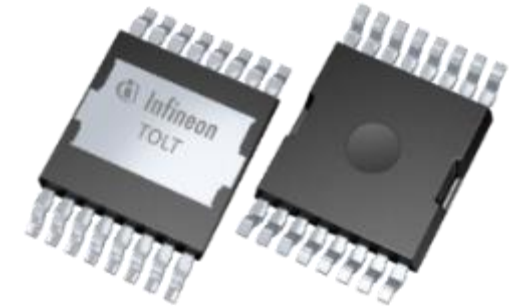
Optimized for superior thermal performance

# TOLT – Cooling concept

## Mechanical structure of inverter board

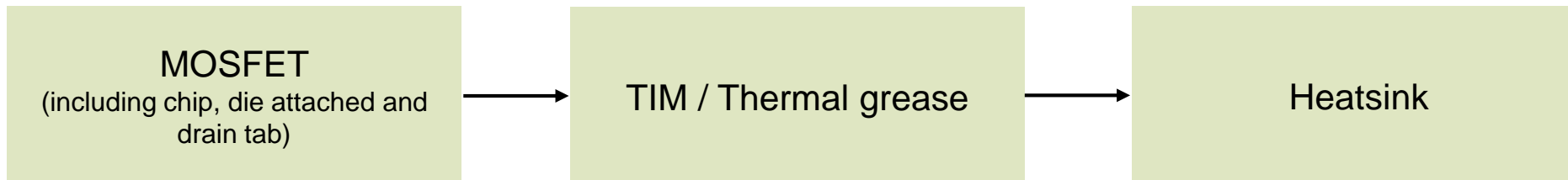


### TOLT

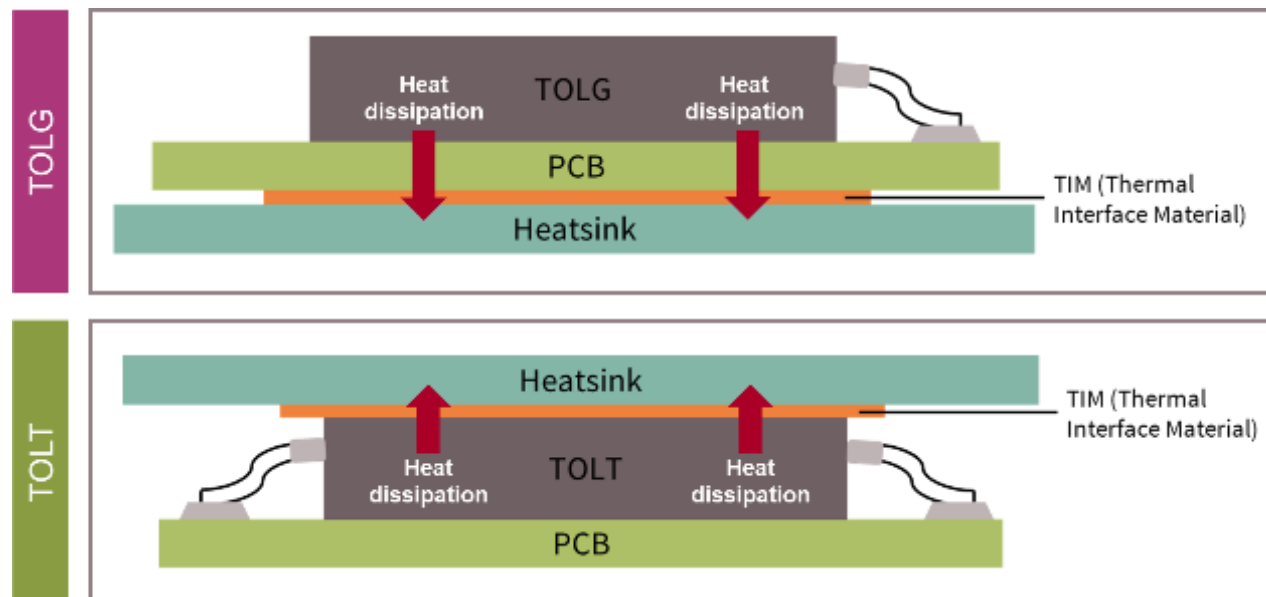
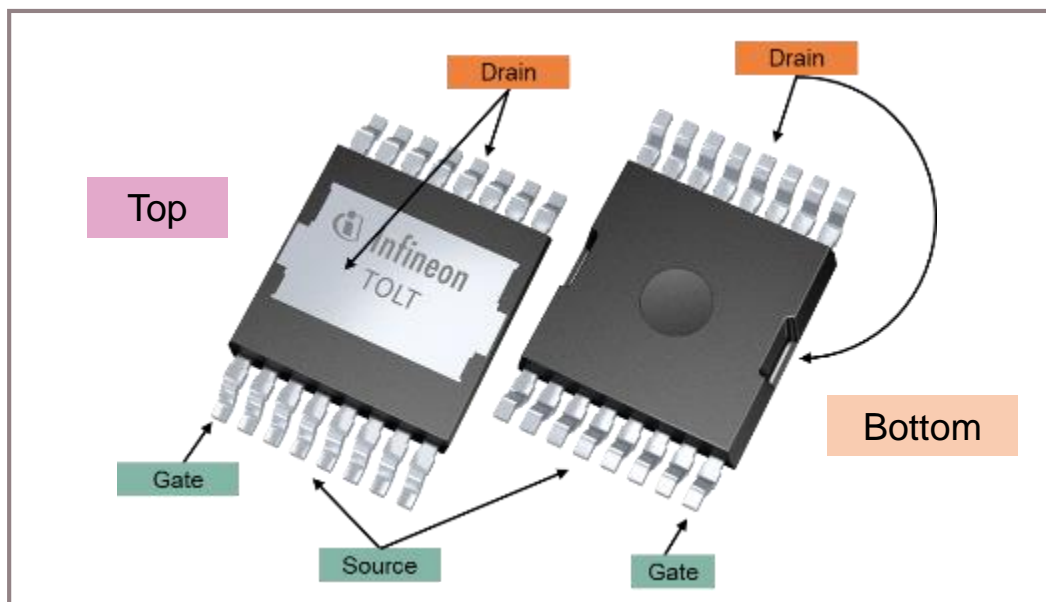


With top side cooling setup, the drain is exposed at the surface of the package.

For this reason, **heat dissipation** can be **promoted directly to the heatsink** achieving at least 20% better  $R_{thJA}$  compared to TOLL.



# OptiMOS™ 5 in TOLT – Top side cooling



## Value proposition

- > BiC performance (very low  $R_{DS(on)}$  and high current capability)
- > Heat dissipation promoted directly to the heatsink → 20% better  $R_{thJA}$  compared to bottom side cooling packages
- > Only 5% of the heat is getting dissipated through the PCB

## Product portfolio

Voltage class	Part number	$R_{DS(on)}$ max. @10V [mΩ]	ES & SOP
80V	IPTC012N08NM5	1.2	Q2 CY2021
	IPTC014N08NM5	1.4	
100V	IPTC015N10NM5	1.5	
	IPTC019N10NM5	1.9	

Preliminary information. Subject to change

# CoolGaN™ - opening new possibilities in motor control designs

## Advantages of CoolGaN™ ...

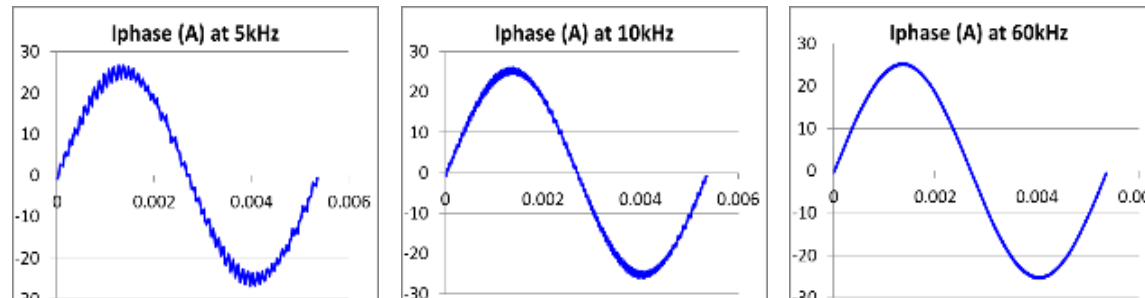
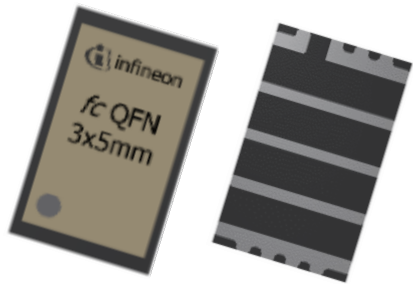
- › Low specific on-resistance
- › Lower & more linear  $C_{OSS}$
- › Lower  $Q_{GS}$
- › No  $Q_{rr}$
- › Low inductance package

## Combine with FOC to produce ...

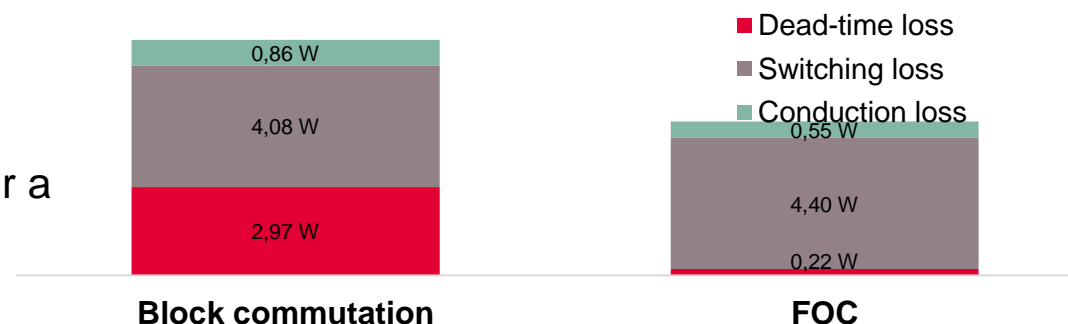
- › **Lower** switching loss
- › **Smaller** power devices
- › **Higher** switching frequency
- › **Cleaner** switching waveforms
- › **Fewer** distortions

## ... new possibilities!

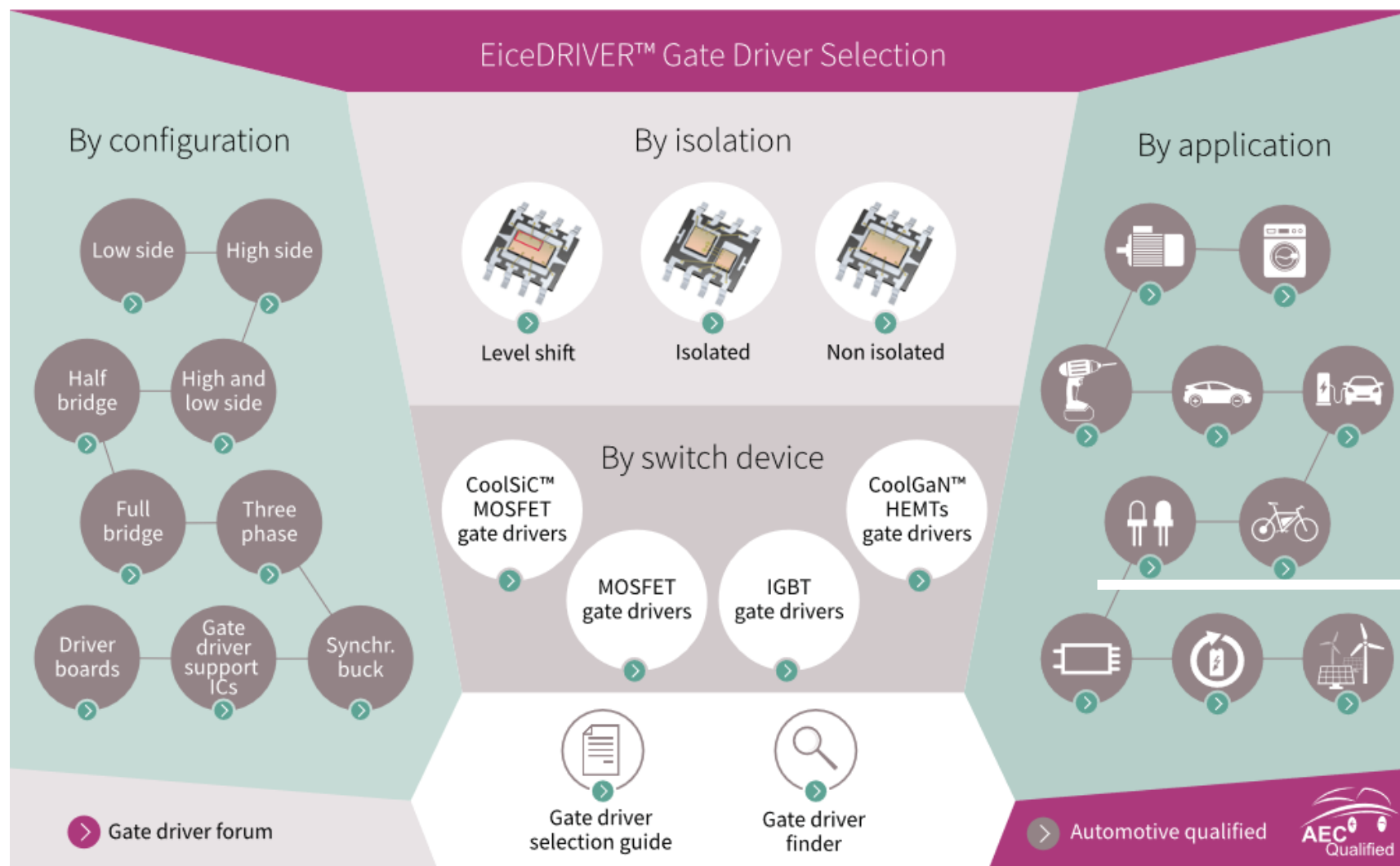
- › **Higher power density**
  - › Smaller bulk capacitance
  - › Smaller heatsink
  - › Reduced power loss
- › **Increased motor efficiency**
  - › More sinusoidal current increases motor efficiency and extends motor lifetime
- › **Lower current ripple**
  - › THD and EMI reduction
- › **Lower torque ripple**
  - › Smoother and more accurate motor movement
- › **Motor control dynamics**
  - › Higher control loop bandwidth
  - › Faster step response
- › **Lower acoustic noise**
  - ›  $f_{sw} > 20$  kHz avoids audible modulation
  - › Shorter dead-time further reduces noise



Example loss breakdown for a power tool motor drive:



# A gate driver portfolio that leaves no wishes open – EiceDRIVER™

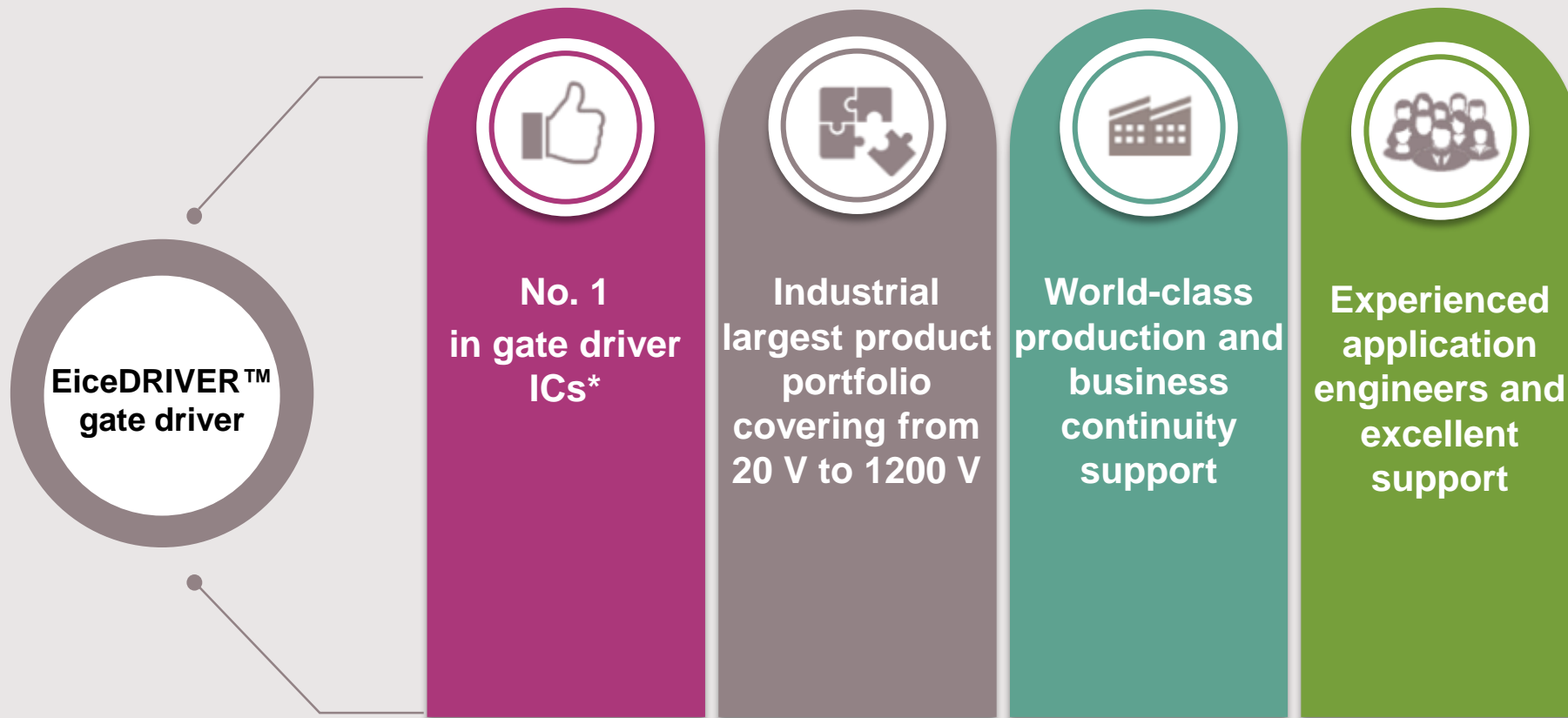


Please visit [www.infineon.com/gatedriver](http://www.infineon.com/gatedriver) for entire gate-driver IC portfolio

# Why EiceDRIVER™ gate driver?



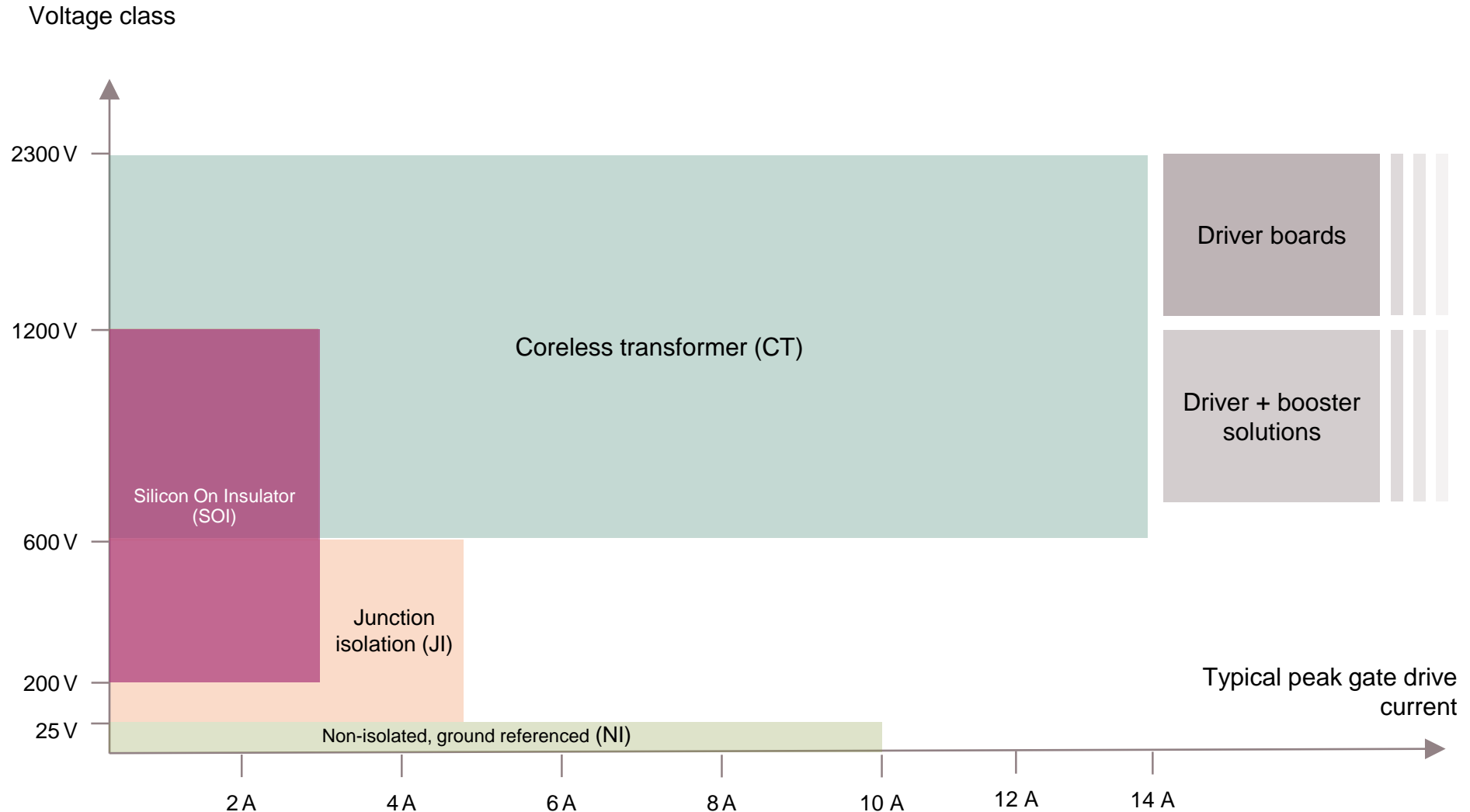
[www.infineon.com/gatedriver](http://www.infineon.com/gatedriver)



\*IHS market report 2019



# Infiniteon provides a comprehensive portfolio of gate driver solutions in the market

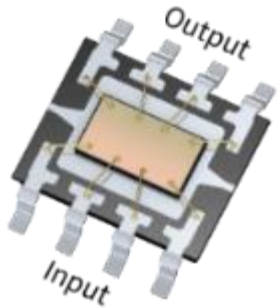


# Gate driver IC technology overview

## Wide portfolio to best fit with application requirements

### Non-isolated GD

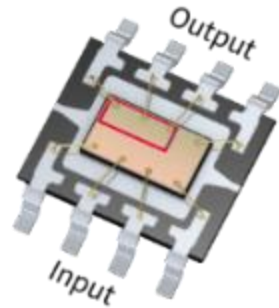
#### Low-side



- **Comprehensive families** of single- and dual-low-side drivers with flexible options for output current, logic configurations and UVLOs (plus non-isolated TDI)
- **Rugged technology** of the high-voltage gate drivers, and on the latest state-of-the-art 130-nm process
- **Industry-standard** DSO-8 and small form-factor SOT23, WSON and TSNP packages

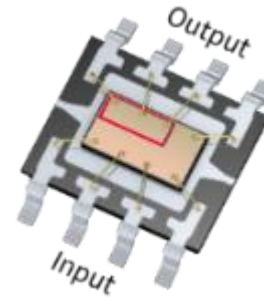
### Level-shift GD

#### Junction isolation (JI)



- **Proven technology** trustfully used in all high-voltage gate drive applications for over 20 years
- **Largest portfolio** of 120V, 200 V, 600 V, and 1200 V industry standard gate drivers using rugged proprietary HVIC process
- **Solution-specific** motor-control and switch-mode power applications

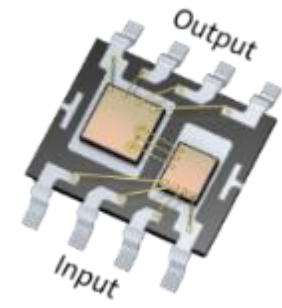
#### Silicon on insulator (SOI)



- **Infineon SOI technology** for high-voltage applications with **inherent integrated boot-strap diode** capability and lower level-shift losses
- Industry **best-in-class robustness against negative VS transient spikes**
- Higher level of integration reduces BOM and total system cost

### Isolated GD

#### Coreless transformer



- **Magnetically-coupled isolation technology** provides galvanic isolation for industrial applications
- **Strongest gate-drive output currents** (up to 14 A) reducing need for external booster circuits
- **Reliable and accurate protection** precise & fast on-/off-switching, desat protection, active Miller clamp, isolation rating in different packages, VDE 0884-11 certification

# Selected Gate-Driver ICs for BL-DC motor drives

Supply Voltage	Product	Description	Use-Case
up to 60 V*	1EDN7550B	1-ch TDI 4A/8A 4V UVLO, SOT-23	Half-bridge with “low-level” MOSFETs
	1EDN8550B	1-ch TDI 4A/8A 8V UVLO, SOT-23	Half-bridge with “normal level” MOSFETs
	1EDN7550U	1-ch TDI 4A/8A 4V UVLO, TSNP	For ultimate space savings
up to 48 V	6EDL7141	3~ 60 V smart motor driver with Programmable slew-rates and dead-times Integrated current sense amplifiers, ADC, protection features	3-phase battery powered BL-DC
up to 200 V	6ED2742S01	SOI, 12 – 140 V flexible PMU operation, 1 A / 2 A, OCP, CSA, integrated bootstrap diodes, programmable gain and OCP	Wide voltage range BL-DC platforms
	2ED27xxS01	SOI, 160 V, separate power and logic grounds, 1 A / 2 A to 4 / 8 A, and HB or High-side and Low-side options	Wide voltage range BL-DC platforms, higher power, superior noise immunity
	6EDL04N02	SOI ruggedness, 3-phase, OCP, integrated bootstrap diodes	Wide voltage range BL-DC platforms
Up to 650	2ED2106/8/9/91 2ED2181/2/3/4	SOI ruggedness, 290 mA / 700 mA and 2.5 A / 2.5A Half-bridge and High-side and Low-side options	Wide voltage range BL-DC platforms, higher power, superior noise immunity
	6EDL04N(I)	SOI, 3-phase, OCP, integrated bootstrap diodes	Wide voltage range BL-DC platforms
up to 800 V	2EDB8259F (ES: Q2CY21)	2-ch galv. isolated gate-driver with shot-through protection and dead-time control option	For kW-range systems
up to 2300 V	1ED312x	1-ch galv. isolated gate-driver	For kW-range systems

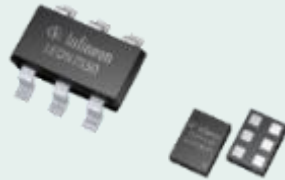
\* function of common mode resistor configuration



### 1EDN-TDI

1-channel gate-driver ICs:

- 6-pin SOT23
- 6-pin TSNP

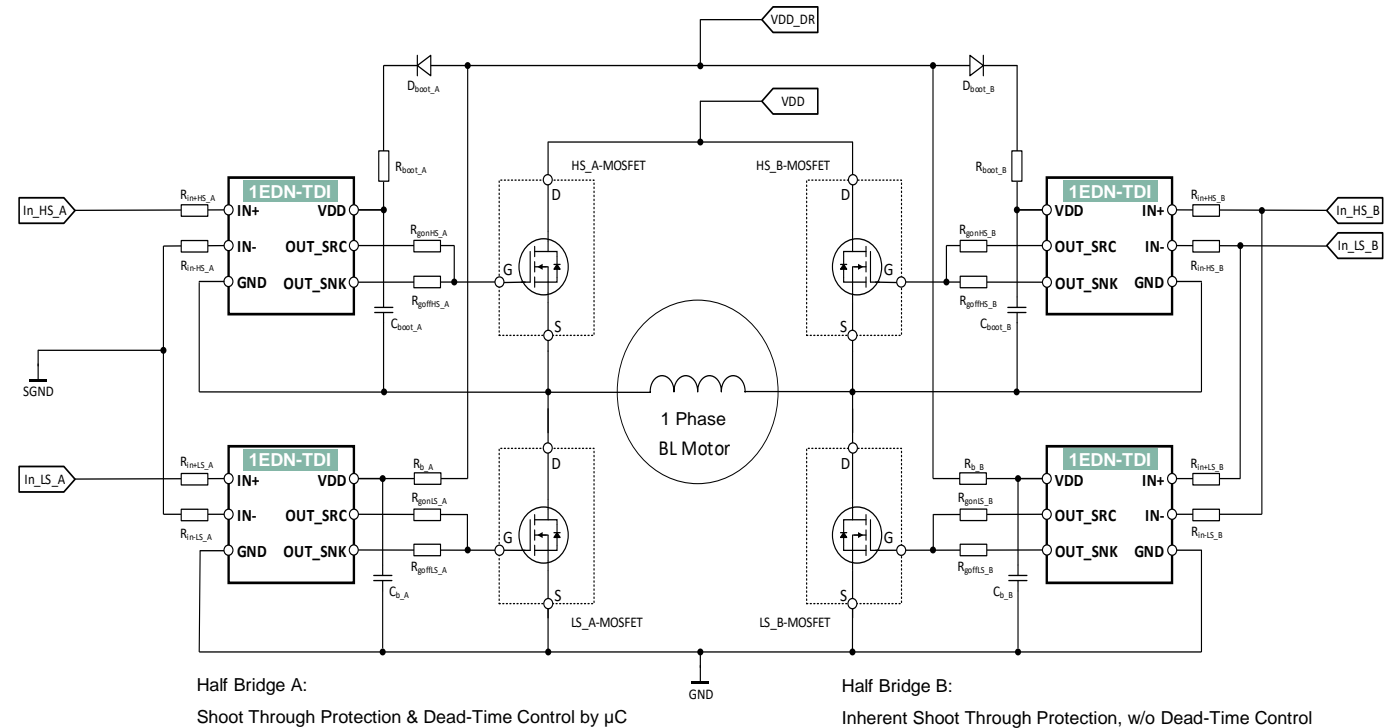


Truly differential inputs:

- +/- 80 V common mode rejection

Low ohmic source/sink outputs:

- 4 A source / 0.85  $\Omega$
- 8 A sink / 0.35  $\Omega$



### Half-bridge gate-driver

*Typ. challenges*

Asymmetric high- and low-side gate-drive PCB-layout

Bipolar output stages

### 1EDN-TDI Advantage

Feature	Benefit	System Value
<b>PCB layout symmetry</b>	Shorter dead-times required	<b>Better efficiency</b>
<b>Short gate-drive loops</b>	Less voltage overshoots from parasitics	<b>Lower MOSFET stress</b>
<b>Low-ohmic rail-to-rail outputs</b>	Fast transition through Miller plateau	<b>Less switching losses</b>

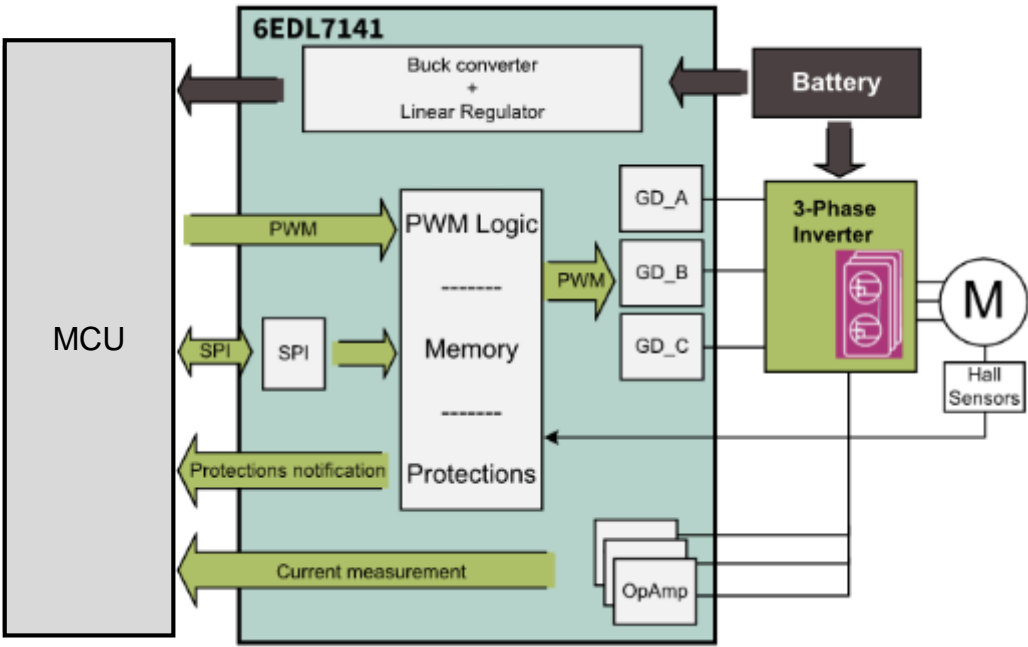
# 6EDL7141

## Smart 3~ 60V motor driver for power tools, garden tools and robotics



### 6EDL7141

- 3~ motor driver IC
- 60V operating voltage
- 1.5 A sink/source driver currents
- 1 or 3 or 6 PWM inputs
- Programmable slew-rates and dead-times
- 3 integrated high performance OpAmps
- Integrated buck regulator
- 300 mA LDO integrated
- Protection features: OTW, OTS, OCP, UVLO
- VQFN-48



### 6EDL7141 Advantage

6EDL7141 Features	Best in Class Competitor	6EDL7141 System Value
5.5V to 60V voltage range	6V to 60V voltage range	up to 48V
3 high performance OpAmps integrated	External OpAmp required	3~ feedback loop for accurate motor drive
Integrated buck regulator	External boost-diode and capacitor required	Small foot-print
300 mA LDO integrated	30 mA LDO only	

# Increasing Power Density by Integration

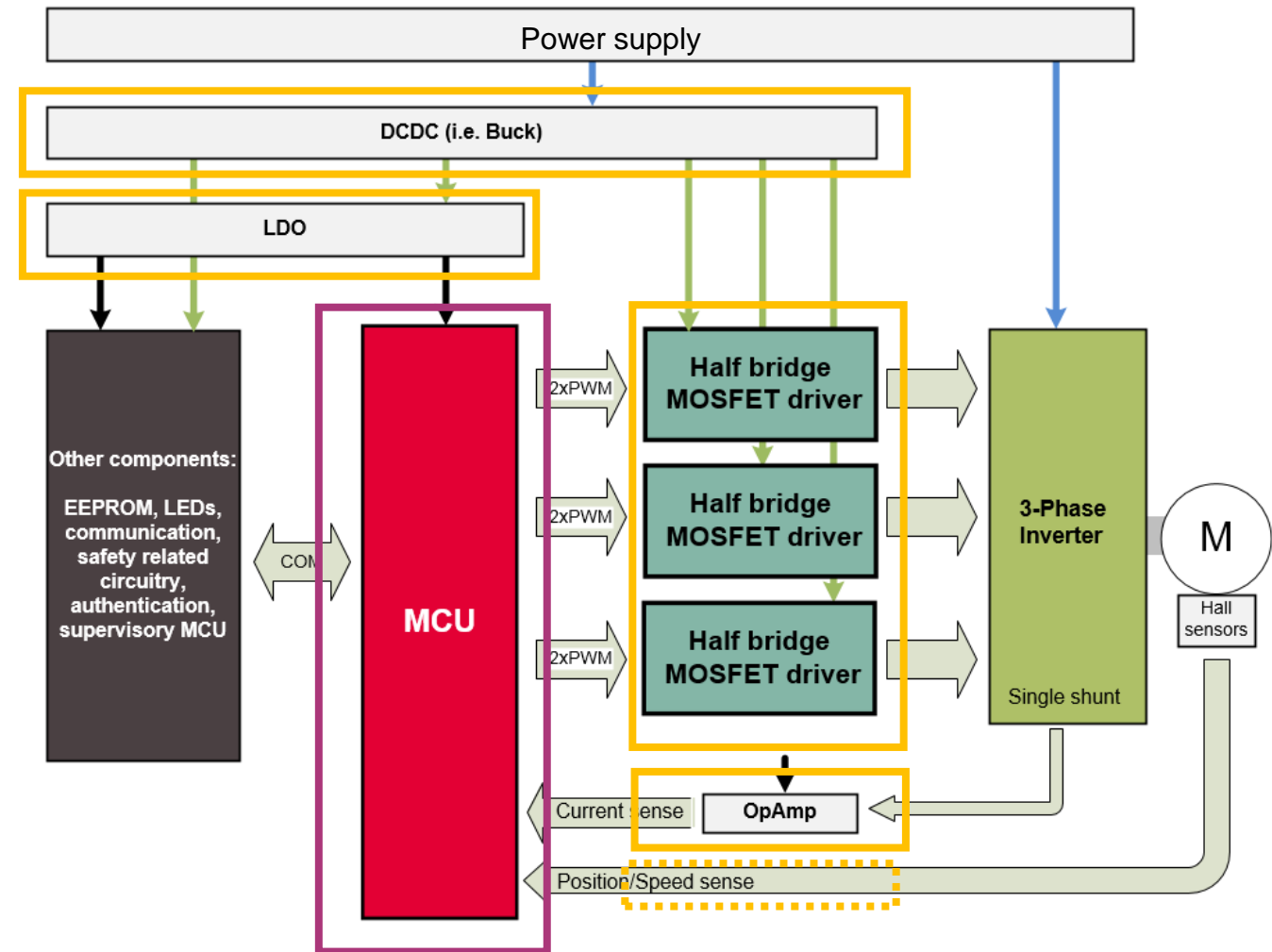
## Electronic system overview (BLDC)

### 3 phase gate driver: 6EDL7141

- › **Integrates** power supply, gate driver and current sensing
- › **Extends** features: flexibility, protections, system support (braking, stall detection)

### Controller: IMD700A

- › **6EDL7141+MCU**: ARM® Cortex-M0+Co-Pro
- › **Peripherals** tailored for motor control- ADC, timers, comparators, positioning, co-processor







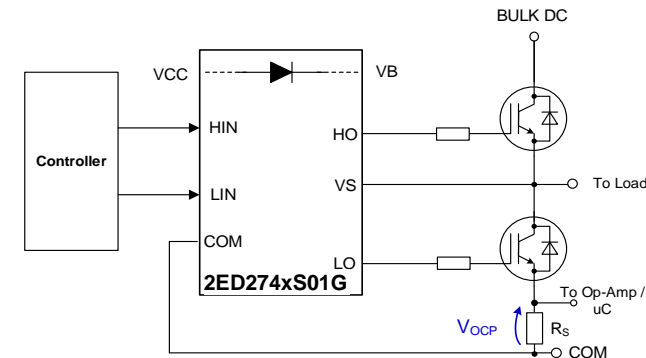
# 2ED2742 / 44 / 48S01G 160 V SOI Half-bridge gate driver family

## With integrated bootstrap diode, separate logic and power grounds

### Key features

- › 160V SOI Half-bridge drivers
  - $I_{O+}$  /  $I_{O-}$  Peak source / sink current drive: 1A / 2A, 2A / 4A, 4A / 8A
- › Bootstrap voltage support up to 160 V max.
- › Separate VSS / COM grounds for improved noise immunity
- › Three current drive versions as noted in table below
- › Integrated ultra-fast, low  $R_{DS(on)}$  bootstrap diode
- › Independent, per channel under voltage lockouts (UVLO)
- › Integrated dead time
- › Integrated shoot-through protection logic
- › Schmitt trigger inputs with hysteresis
- › Integrated short pulse / noise rejection input filter
- › 2kV HBM ESD compliance
- › 3x3 mm DFN10 with thermal pad
  - Footprint compatible with MP1921 series

### Sample system block diagram (HB)



### Value proposition

- › Lower system level BOM cost with integrated, monolithic bootstrap diodes,
- › Superior latch-up immunity with SOI
- › Small, simple, low-cost solution for multiple applications
- › High current drive for parallel MOSFET applications
- › High current drive for higher frequency or power applications
- › Thermal pad for more efficient heat transfer

Part No.	Package	Drive current source / sink	Input logic	Cross conduction prevention logic	Dead-time (ns)	Ground pins	$t_{ON}$ / $t_{OFF}$
2ED2742S01G	DFN10 3 x 3 mm	+ 1 A / - 2 A	HIN, LIN	Yes	100 ns	VSS / COM	50 ns / 50 ns
2ED2744S01G		+ 2 A / - 4 A					
2ED2748S01G		+ 4 A / - 8 A					

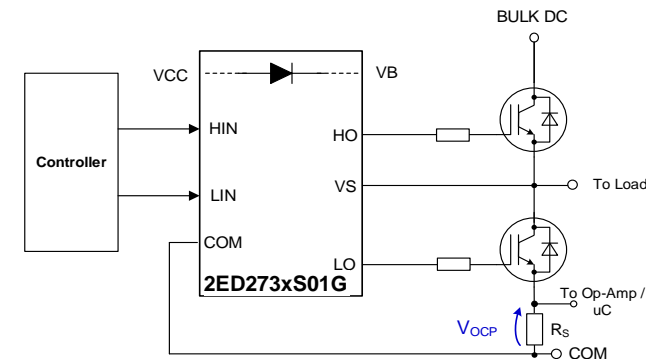
# 2ED2732 / 34 / 38S01G 160 V SOI HS+LS gate driver family

## With integrated bootstrap diode, separate logic and power grounds

### Key features

- › 160V SOI High-side and low-side drivers
  - $I_{O+}$  /  $I_{O-}$  Peak source / sink current drive: 1A / 2A, 2A / 4A, 4A / 8A
- › Bootstrap voltage support up to 160 V max.
- › Separate VSS / COM grounds for improved noise immunity
- › Three current drive versions as noted in table below
- › Integrated ultra-fast, low  $R_{DS(on)}$  bootstrap diode
- › Independent, per channel under voltage lockouts (UVLO)
- › Schmitt trigger inputs with hysteresis
- › Integrated short pulse / noise rejection input filter
- › 2kV HBM ESD compliance
- › 3x3 mm DFN10 with thermal pad
  - Footprint compatible with MP1921 series

### Sample system block diagram (HS+LS)



### Value proposition

- › Lower system level BOM cost with integrated, monolithic bootstrap diodes,
- › Superior latch-up immunity with SOI
- › Small, simple, low-cost solution for multiple applications
- › High current drive for parallel MOSFET applications
- › High current drive for higher frequency or power applications
- › Thermal pad for more efficient heat transfer

Part No.	Package	Drive current source / sink	Input logic	Cross conduction prevention logic	Dead-time (ns)	Ground pins	$t_{ON} / t_{OFF}$
2ED2732S01G	DFN10 3 x 3 mm	+ 1 A / - 2 A	HIN, LIN	No	None	VSS / COM	50 ns / 50 ns
2ED2734S01G		+ 2 A / - 4 A					
2ED2738S01G		+ 4 A / - 8 A					

# Recommended gate drivers for easy and efficient MOSFET switching



## Gate Driver



DSO-8



MLPQ 4x4



TSSOP-28



VQFN-48



SOT-23



PG-TSNP

## EiceDRIVER™

& many many more

Voltage Class	Package	Part Number	Type	Peak Current (A)	Features	Rational
200 V	DSO-8 MLPQ4x4	IRS2005	High-side and Low-side	290 mA / 600 mA	-	DSO-8: cost effective MLPQ 4x4: space-saving
		IRS2007	Half-bridge	290 mA / 600 mA	Deadtime	
		IRS2008	Half-bridge	290 mA / 600 mA	Deadtime, Shutdown	
	DSO-8	IRS2011	High-side and Low-side	1 A / 1 A	60 ns typ. propagation delay	Faster on/off
	TSSOP-28	6EDL04N02	3 Phase	165 mA / 375 mA	SOI, integrated bootstrap diode, integrated OCP, fault reporting, EN, deadtime	Performance, Space saving
160V	VQFN-48	6ED2742S01Q	3 Phase	1A / 2A	SOI, charge pump, Isense, integrated OCP, integrated bootstrap diode	Performance, 100% duty cycle
	DFN10	2ED2738S01G	High-side and Low-side	4A / 8A	SOI, integrated bootstrap diode	performance
		2ED2748S01G	Half-bridge			
120V	VDSON-8	2EDL8124G	Half-bridge	4A	TDI, shoot-through protection	High current , 4x4mm2
70V	VQFN-48	6EDL7141	3 Phase smart	1.5A / 1.5A	>60 SPI programmable parameters. Slew rate control, 3 OpAmps, Buck+LDO, dual Charge Pump	High performance, highly integrated, programmable, PSU integrated, space saving, slew rate control
20V	PG-TSNP-6	1EDN7550	Single channel	4A / 8A	TDI (150V dynamic, 72V static)	1.1x1.5 mm2, strong gate driver, flexible

# Sensors for efficiency & safety in motor drives

## Current sensing

### TLI4971

- › Up to 70 A<sub>RMS</sub> (120 A FSR)
- › **High bandwidth** >120 kHz
- › Intrinsic strayfield cancellation
- › Superior **linearity and overload capability**
- › **Analog output signal PLUS** 2x digital **fast overcurrent detection**
- › Integrated Functional Isolation Supporting 1150 V V(IORM)
- › SMD sensor package with **integrated Low sensing resistance current rail (220 µΩ)**

## High resolution rotor position sensing

### TLE5009(D) – Angle Sensor

iGMR

- › iGMR based angle sensor with full 360° Analog Sin/Cos output
- › Pre-amplified temp. compensated signals
- › Very short signal delay
- › For speed up to 30.000 rpm

### TLE5012B(D) – Angle Sensor

iGMR

- › iGMR based angle sensor with full 360°
- › 1° accuracy over Temperature and lifetime
- › Integrated angle calculation
- › Interfaces: SPI, IIF, PWM, SPC, HSM
- › Temp. compensation and auto-calibration

## Lower resolution rotor position sensing

### TLE4961 - Hall Switch

- › High precision Hall Switch
- › Very low current consumption (1.6mA)
- › High supply voltage + overvoltage up to 42 V
- › Versions in leaded packages (SSO) as well as SMD with smallest footprint (SOT23)

### TLE5501 – Angle Sensor “Single Dual Die”

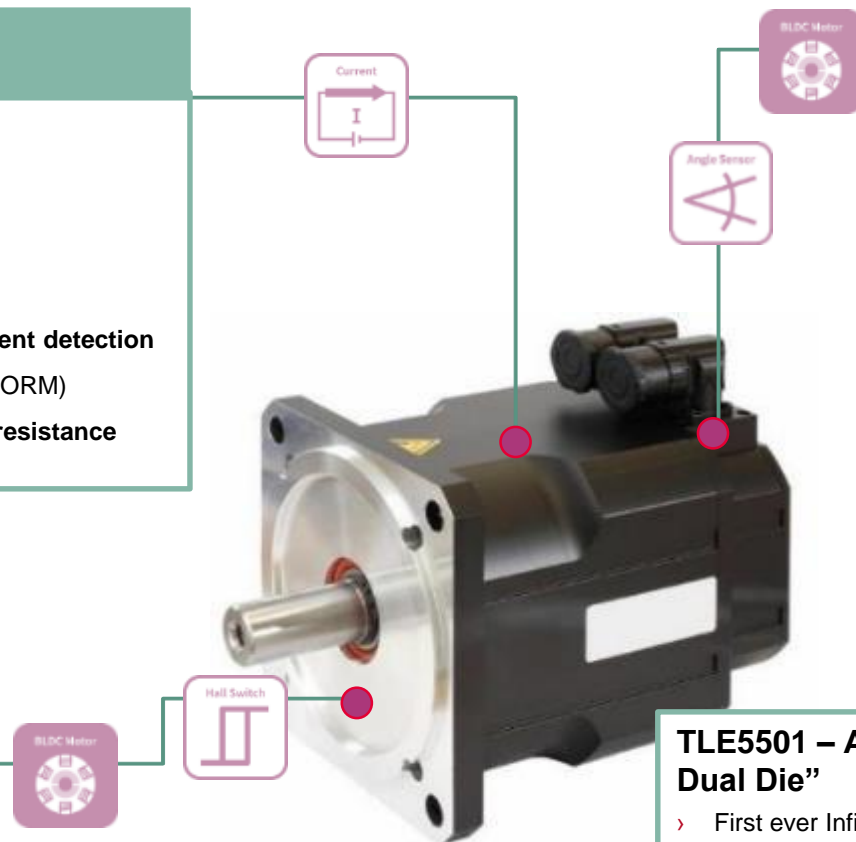
- › First ever Infineon TMR
- › Analog sin/cos
- › ISO26262-compliant development targeting ASIL D(D)

iTMR






### TLE5014(D) – Angle Sensor - Single & Dual

- › Programmable iGMR digital angle sensor, E2PROM and look-up table
- › SENT, SPC, PWM, SPI Interface
- › High accuracy (<1° error)
- › ISO26262-compliant dev. targeting ASIL C(D)

iGMR



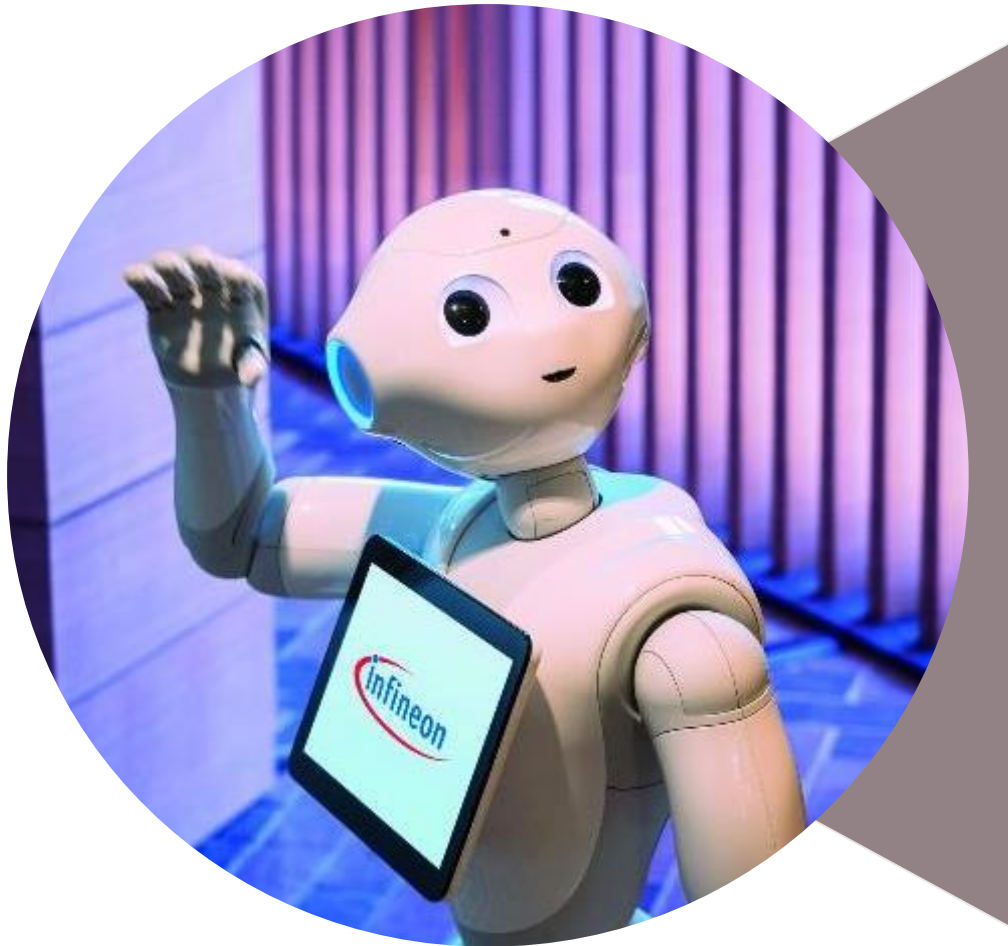
# Overview magnetic sensors

	Position				Current
	Hall Switch	Angle Sensor	3D Hall	Linear Hall	Current Sensor
Features	<ul style="list-style-type: none"> <li>&gt; Halogene free SoT23/TO92 package</li> <li>&gt; Leadless package for BLDC applications</li> <li>&gt; 1.6 mA current consumption</li> <li>&gt; Overvoltage capability up to 42 V</li> <li>&gt; 3 V to 32 V or 5V operating supply voltage</li> <li>&gt; Integrated temperature compensation of magnet characteristics</li> </ul>	<ul style="list-style-type: none"> <li>&gt; PG-DSO-8 package</li> <li>&gt; High accuracy, short delay times ideal for fast turning BLDC application</li> <li>&gt; Signal output is independent from magnet field strength and temperature</li> <li>&gt; On chip temperature compensation</li> <li>&gt; Multiple interfaces (SPI, PWM, Incremental, Analog)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Min. Power Consumption: 7 nA</li> <li>&gt; Temp-Range: -40°C to +125°C</li> <li>&gt; Max. magnetic field +/- 130 mT</li> <li>&gt; Data resolution 12 bit</li> <li>&gt; Interface: 1°C digital</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Fully digital signal processing</li> <li>&gt; EEPROM for end-of-line programming</li> <li>&gt; Various leadless and SMD packages available</li> </ul> <p>TLE4997</p> <ul style="list-style-type: none"> <li>&gt; Analog ratiometric DAC-output</li> <li>&gt; Potentiometer Replacement</li> </ul> <p>TLE4998</p> <ul style="list-style-type: none"> <li>&gt; Integrated stress compensation</li> <li>&gt; Interfaces: PWM, SENT, SPC</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Galvanic isolated</li> <li>&gt; Easy to implement: package with integrated current rail</li> <li>&gt; No hysteresis due to coreless concept</li> <li>&gt; Inherent suppression of magnetic stray field</li> <li>&gt; AC &amp; DC range: <math>\pm 120</math> A</li> <li>&gt; Overcurrent detection</li> <li>&gt; No external components required</li> </ul>
Benefits	<ul style="list-style-type: none"> <li>&gt; Small form factor package</li> <li>&gt; Energy efficiency</li> <li>&gt; ESD robustness</li> <li>&gt; Compact system design</li> <li>&gt; Reliable system operation</li> <li>&gt; Design flexibility</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Small form factor package</li> <li>&gt; Full turn -360° resolution</li> <li>&gt; Highest motor efficiency</li> <li>&gt; Stable and reliable operation</li> <li>&gt; Low BOM count</li> </ul>	<ul style="list-style-type: none"> <li>&gt; High flexibility – allowing 1-3 dimensions and angle measurement</li> <li>&gt; Small 6pin SMD package</li> <li>&gt; Extremely small WLB package available</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Easy implementation</li> <li>&gt; High Accuracy</li> <li>&gt; Single and Dual Die versions available</li> <li>&gt; Portfolio offers high flexibility for Safety critical applications</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Electronic torque &amp; speed control</li> <li>&gt; Remaining battery lifetime Remaining charging time</li> <li>&gt; Increased battery use cycles</li> </ul>
Products	<p>TLx496x Hall switch</p> 	<p>Angle sensor TLx5012B, TLE5501</p> 	<p>3D Sensor TLx493D</p> 		<p>TLI4971 miniature magnetic current sensor</p> 





## Further Material – Motor Control



**Portfolio and further information can be found here:**



- [Link](#) → MCU
- [Link](#) → MOSFET
- [Link](#) → Gate Driver
- [Link](#) → Gallium Nitride (GaN)
- [Link](#) → Magnetic sensors



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