

Humanoid robotics

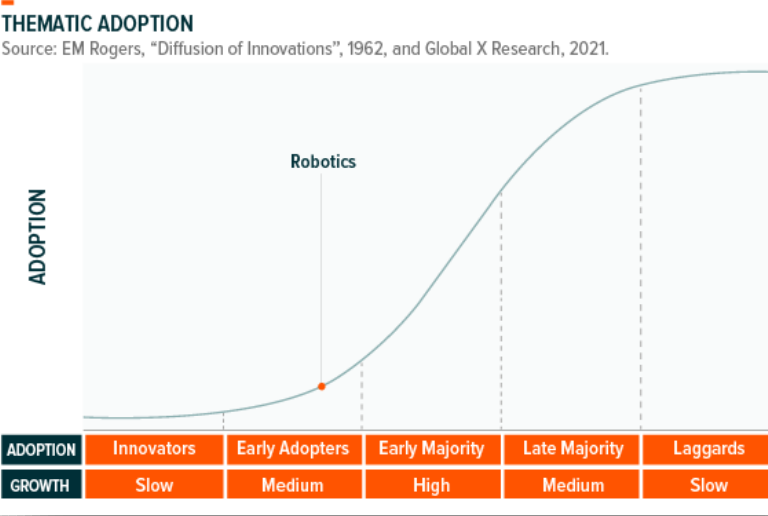
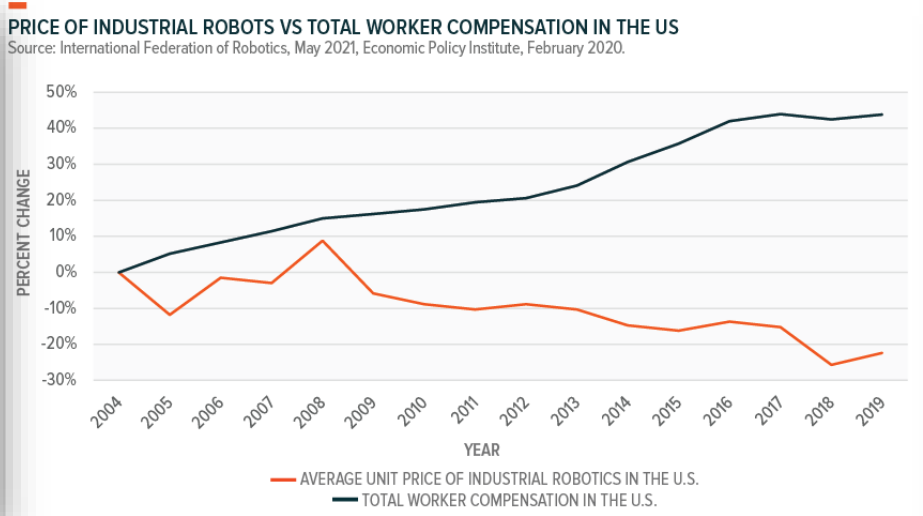
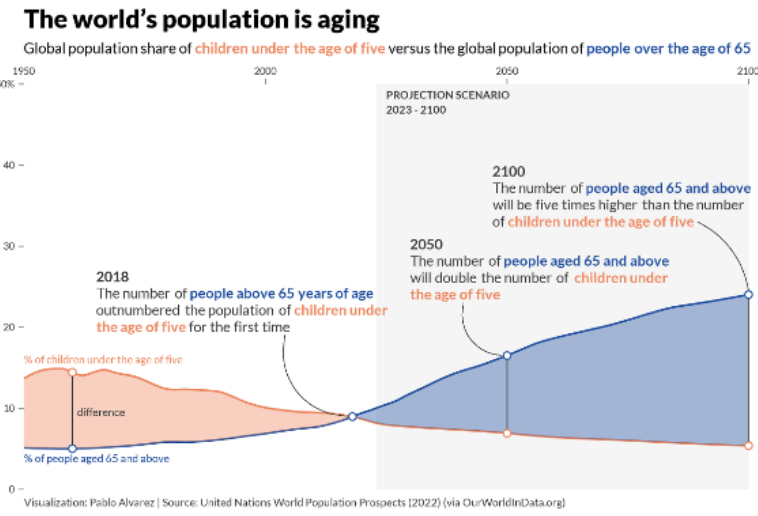
Unlocking the full potential of humanoid robots with cutting-edge semiconductor solutions

June 2025

Nenad Belančić



Compelling reasons why we will need more robots



Robotics - a multi-billion market!

Robotics: An evolving application across different industries



Established robot categories

- Cobots (industrial)
- Drone (Agriculture, Inspection)
- Lawn mowing robot
- Vacuum Cleaning Robot
- Logistic robots
- Drone (Consumer)

Next level of automation

- Drone (Transportation)
- Hospitality robots
- Cobots (consumer)



Assistance & Complex human tasks

- Humanoid robots
- Exoskeletons
- Logistic robots (outdoor)



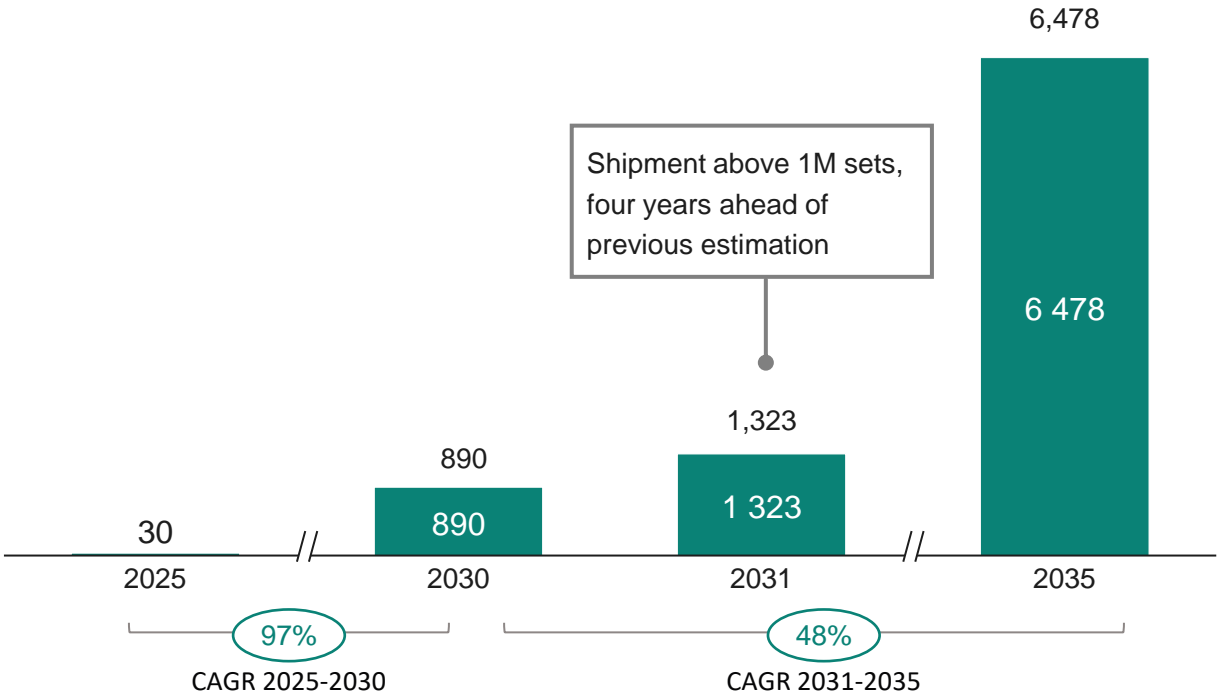
Time

Humanoid robots: The rising robotics segment

Goldman has upwardly revised its global humanoid robotics forecast recently...

...driven by the changes of technology, cost and policy

Global Humanoid Robot Market Size Estimation, 2025-2035
Unit: K sets



AI & Tech Innovations

- End-to-End AI Integration, streamlining AI development with a direct input-to-output model
- Unprecedented progress e.g., Established OEMs vs. Startup Culture

Cost Reductions on Hardware

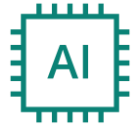
- Notable reduction in BOM costs, likely by 40% according to Humanoid Robotics makers
- Optimization in design and manufacturing techniques

Industrial spillover

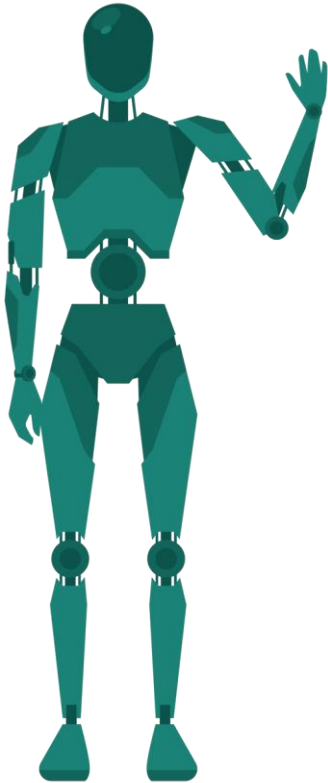
- Poised to leverage technological advancements and economies of scale developed in the EV sector, particularly in areas such as actuator control and ADAS and Functional Safety (FuSa)

Data source: Goldman humanoid robotics report

Humanoids need reliable and accurate solutions! Infineon has it all to serve current and future robotics designs



Safety (FuSa) & Security



Motor control



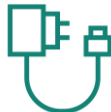
Motor

Power management & Battery (BMS)



BMS

Charger



Charger

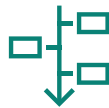


Connectivity & Communication



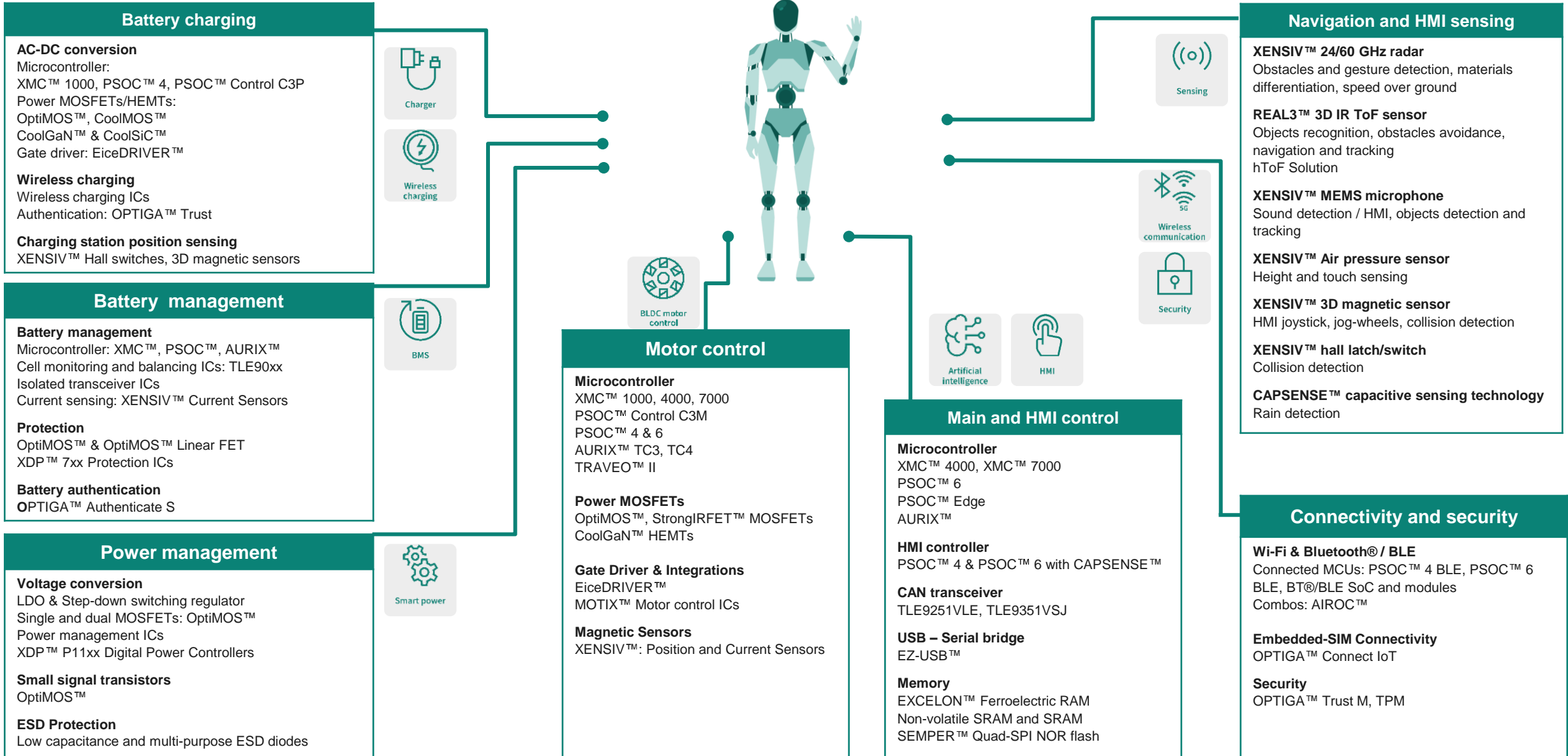
Sensor system

Environmental Sensors



Edge Compute
(Edge AI, Physical AI, Sensor Hub)

Infineon solutions for every humanoid robot functional block



Battery charging

AC-DC conversion
 Microcontroller: XMC™ 1000, PSOC™ 4, PSOC™ Control C3P
 Power MOSFETs/HEMTs: OptiMOS™, CoolMOS™
 CoolGaN™ & CoolSiC™
 Gate driver: EiceDRIVER™

Wireless charging
 Wireless charging ICs
 Authentication: OPTIGA™ Trust

Charging station position sensing
 XENSIV™ Hall switches, 3D magnetic sensors

Battery management

Battery management
 Microcontroller: XMC™, PSOC™, AURIX™
 Cell monitoring and balancing ICs: TLE90xx
 Isolated transceiver ICs
 Current sensing: XENSIV™ Current Sensors

Protection
 OptiMOS™ & OptiMOS™ Linear FET
 XDP™ 7xx Protection ICs

Battery authentication
 OPTIGA™ Authenticate S

Power management

Voltage conversion
 LDO & Step-down switching regulator
 Single and dual MOSFETs: OptiMOS™
 Power management ICs
 XDP™ P11xx Digital Power Controllers

Small signal transistors
 OptiMOS™

ESD Protection
 Low capacitance and multi-purpose ESD diodes

Motor control

Microcontroller
 XMC™ 1000, 4000, 7000
 PSOC™ Control C3M
 PSOC™ 4 & 6
 AURIX™ TC3, TC4
 TRAVEO™ II

Power MOSFETs
 OptiMOS™, StrongIRFET™ MOSFETs
 CoolGaN™ HEMTs

Gate Driver & Integrations
 EiceDRIVER™
 MOTIX™ Motor control ICs

Magnetic Sensors
 XENSIV™: Position and Current Sensors

Main and HMI control

Microcontroller
 XMC™ 4000, XMC™ 7000
 PSOC™ 6
 PSOC™ Edge
 AURIX™

HMI controller
 PSOC™ 4 & PSOC™ 6 with CAPSENSE™

CAN transceiver
 TLE9251VLE, TLE9351VSJ

USB – Serial bridge
 EZ-USB™

Memory
 EXCELON™ Ferroelectric RAM
 Non-volatile SRAM and SRAM
 SEMPER™ Quad-SPI NOR flash

Navigation and HMI sensing

XENSIV™ 24/60 GHz radar
 Obstacles and gesture detection, materials differentiation, speed over ground

REAL3™ 3D IR ToF sensor
 Objects recognition, obstacles avoidance, navigation and tracking
 hToF Solution

XENSIV™ MEMS microphone
 Sound detection / HMI, objects detection and tracking

XENSIV™ Air pressure sensor
 Height and touch sensing

XENSIV™ 3D magnetic sensor
 HMI joystick, jog-wheels, collision detection

XENSIV™ hall latch/switch
 Collision detection

CAPSENSE™ capacitive sensing technology
 Rain detection

Connectivity and security

Wi-Fi & Bluetooth® / BLE
 Connected MCUs: PSOC™ 4 BLE, PSOC™ 6 BLE, BT@BLE SoC and modules
 Combos: AIROC™

Embedded-SIM Connectivity
 OPTIGA™ Connect IoT

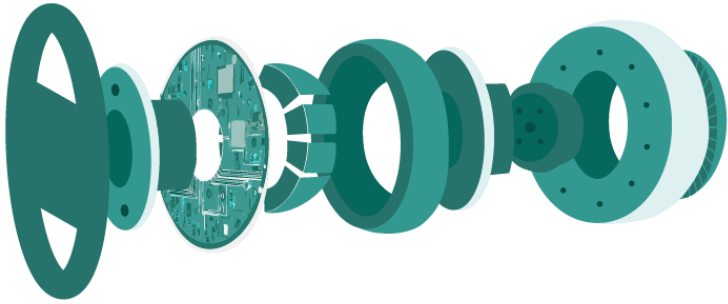
Security
 OPTIGA™ Trust M, TPM

Motor control

Compact, efficient and precise



Motor



Switches

OptiMOS™, StrongIRFET™

CoolGaN™

& many more packages

Gate Driver

EiceDRIVER™ & MOTIX™

& many more packages

MCU

PSOC™ Control C3

XMC™

TRAVEO™ II

AURIX™

Sensing – XENSIV™

Angle sensor

TLE501, TLE5014(D)
High resolution: TLE5009(D) & TLx5012B(D)

Current sensor

TLI4971, TLx5570/72

Hall latch & switch

TLx496x Family

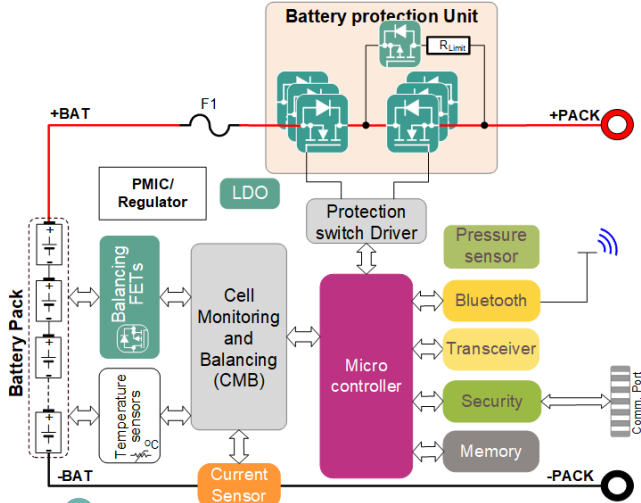


Battery Management Systems (BMS)

Safe, secure, and reliable



BMS



Bluetooth

- AIROC™ Bluetooth® LE
- CYW20820
- CYW4373E

Security

- OPTIGA™ - SLE95401

Current sensor

- XENSIV™ TLI4971, TLx5570//72

Protection

Cell Balancing & Monitoring

MCU

Balancing MOSFETs

SOT23 SOT323 SOT363 SC59

Small Signal MOSFET

Protection FETs

TOLT TOLL D2PAK SS08

OptiMOS™ 6, LinearFET™, CoolGaN™

High-side Drivers

DSO-8 DSO-16

EiceDRIVER™

& many more packages

TLE9012DQU

– 12-Cell Voltage monitoring

TQFP-48

TLE9018DQU

– 18-Cell Voltage monitoring

TQFP-80

PSOC™ 4 & 6

XMC™ 7000

AURIX™

TLE925X

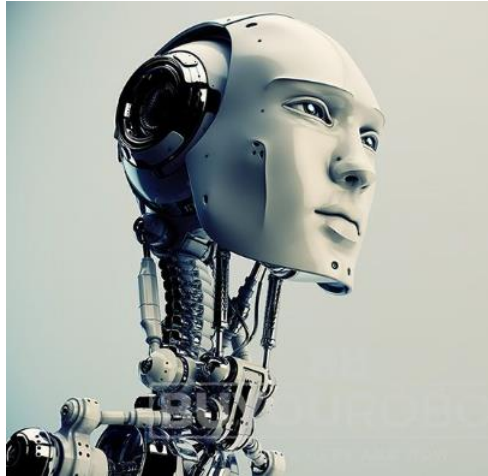
CAN Transceiver

& many more packages



Robotics brain

Compute, connectivity, and HMI



Wireless Connectivity



Wi-Fi 5



Wi-Fi 6



Module Partners

MPU Brain



NVIDIA Jetson™



Raspberry Pi™



Rockchip™

Main Control MCU



XMC™ 7000



TRAVEO™ II



AURIX™

Ample GPIOs and peripherals, covering industrial-grade and automotive-grade MCUs

HMI

Cap-sense

PSOC™ 4 family



Display

PSOC™ 6 family and PSOC™ Edge family



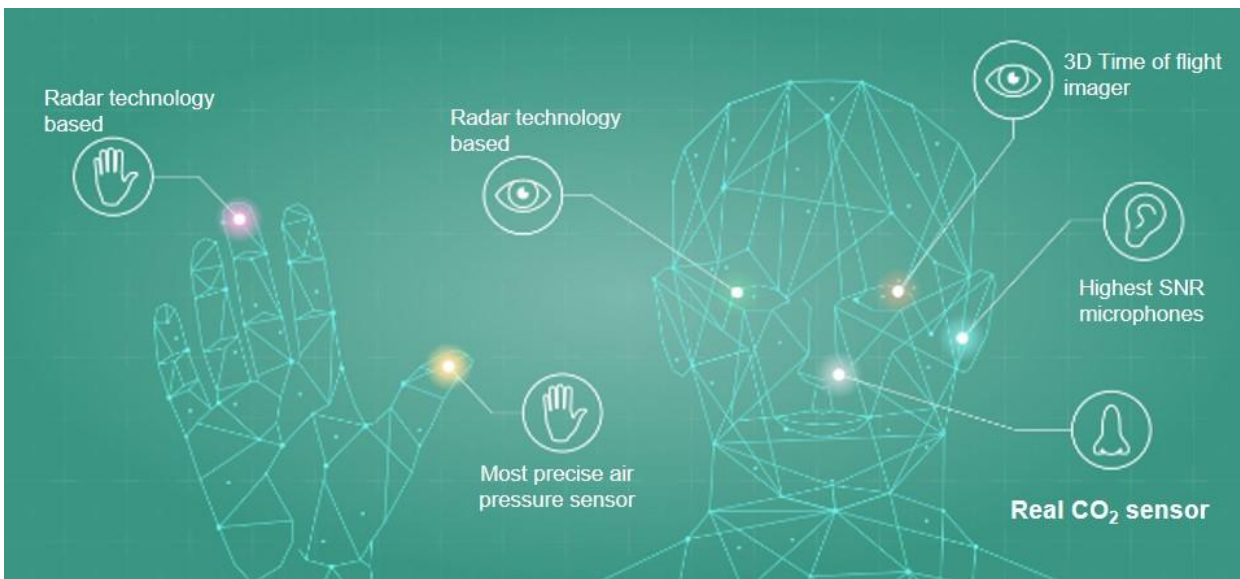
Audio/Vision AI Accelerator

PSOC™ Edge family



Advanced sensor solutions


Eyes and ears for robots



Other sensors

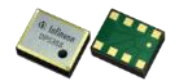
CO2 sensors

- Air quality monitoring for smart air purifier & controlled ventilation




Pressure sensors

- Touch sensing for Grippers
- Height / altitude sensing



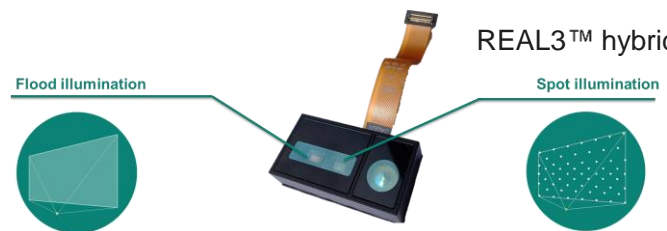
Radar



BGT24LTR22 BGT60TR13C BGT60ATR24C

- XENSIV™ 24 & 60 Ghz radar

Time-of-Flight




Flood illumination Spot illumination

REAL3™ hybrid ToF

- Object detection & obstacle avoidance
- SLAM capable for navigation

Silicon microphones

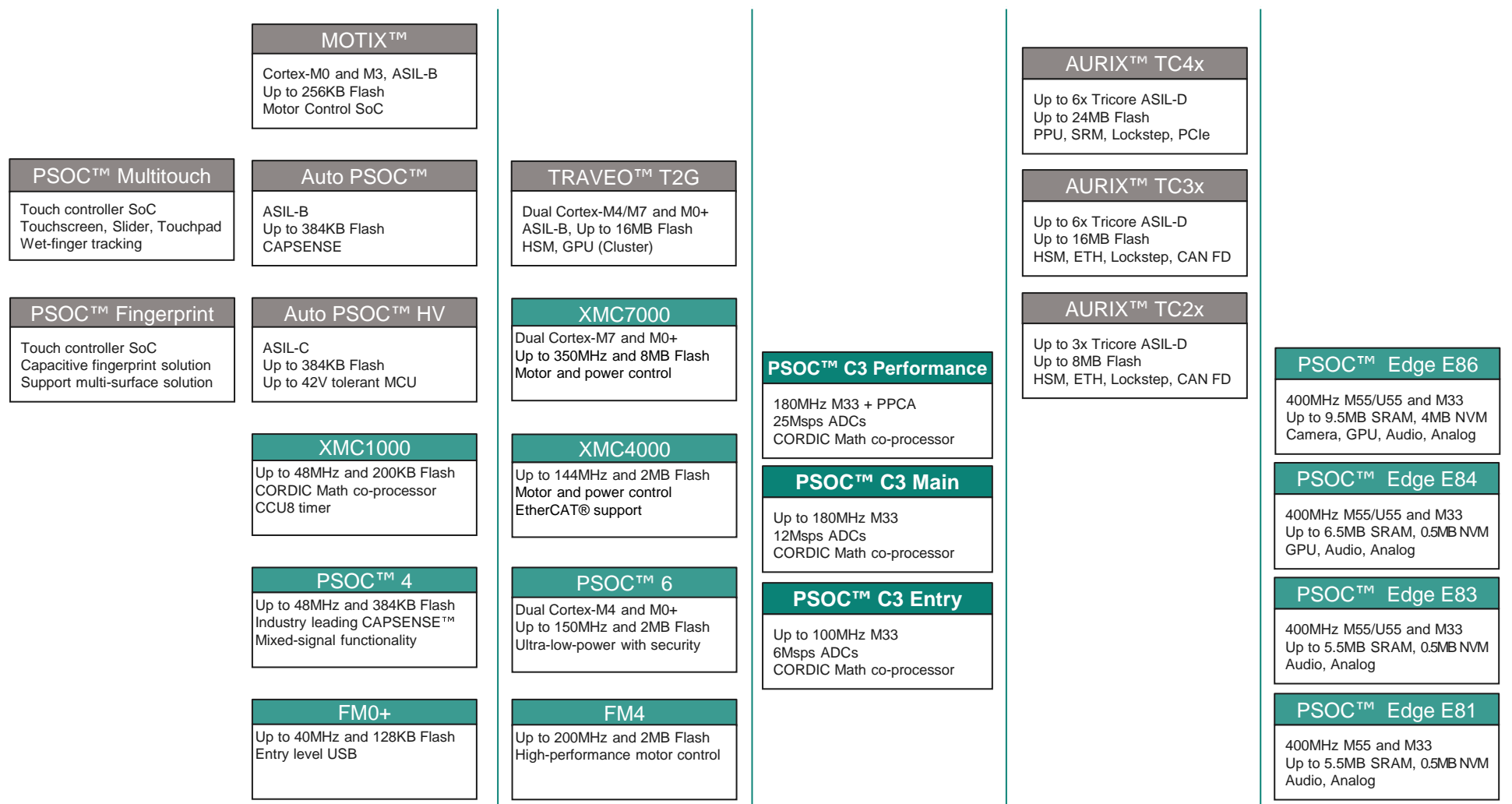
Infineon Microphone System



MEMS ASIC Package

- Sound detection for HMI
- Objects detection for navigation

Benefit from a wide range of MCUs and leverage our expertise in automotive and functional safety



32-bit Arm® Cortex®-M0/M0+

32-bit Arm® Cortex®-M4/M33/M7

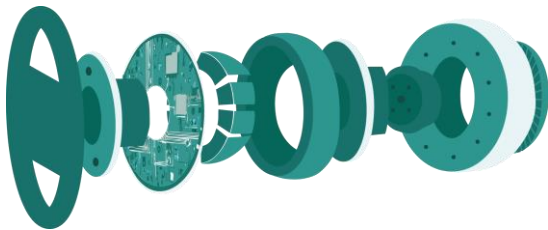
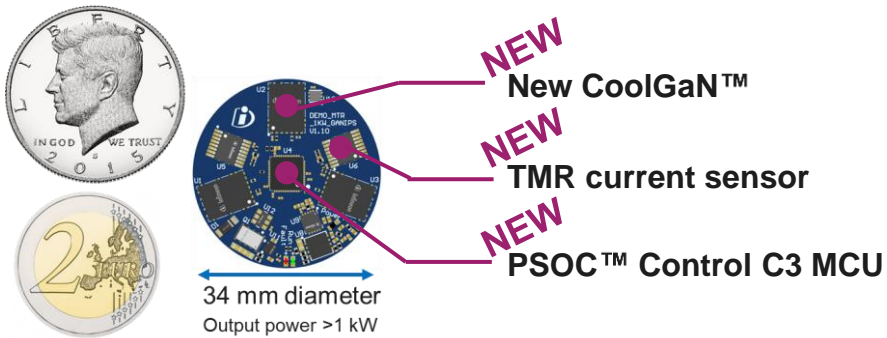
32-bit TriCore™

32-bit Arm® Cortex®-M55/M85, U55, M33 with ML accelerators

Infineon CoolGaN™ for robotics: Driving the new benchmark in power density and performance

Benefits for humanoid robot developers

Compact motor drives where
space is tight, and heat
dissipation limited



Small form factor

- ✓ Enables embedding the inverter within the motor, addressing space constraints
- ✓ Ideal for compact and tightly integrated humanoid robot designs

Improved system efficiency

- ✓ Reduces motor core losses, especially at higher switching frequencies (fsw)
- ✓ Leads to longer operational times and better performance of humanoid robots

Simplified and flexible system design

- ✓ GaN integrated power stage combined with a new controller & current sensors
- ✓ Flexible enough to fit any form factor, easing the integration process
- ✓ Reduces the complexity of system design, allowing developers to focus on other aspects of the robot

CoolGaN™ enables higher end-to-end system efficiency and decreases motor core losses, i.e. less overheated motors!

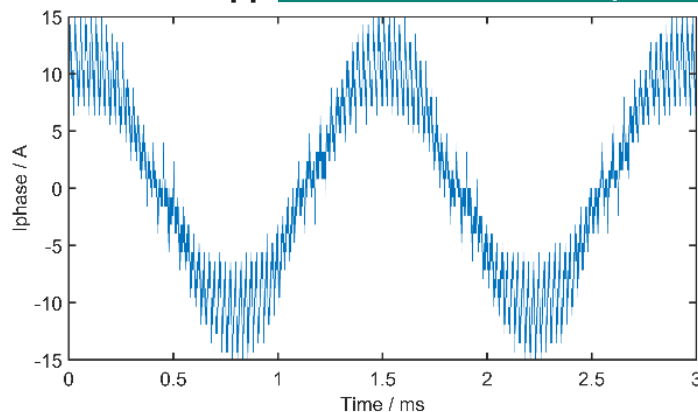


Switching frequency: 20 kHz

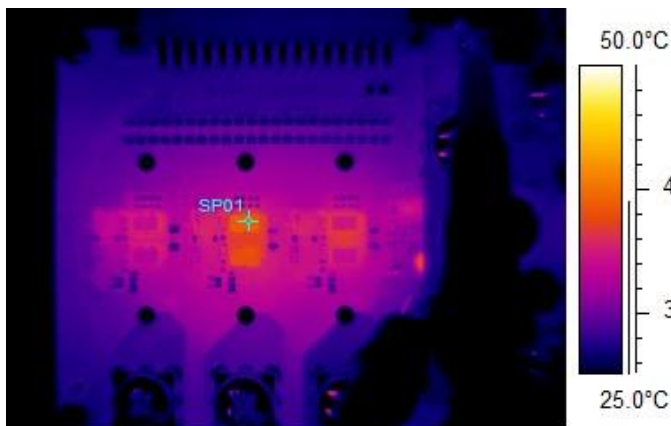
- › Overall system efficiency: **89%**
- › Motor temperature: **68°C**
- › Motor current ripple: **10 A_{pp}**

Motor runs 13°C cooler
with 5x less torque ripple

Phase current waveform:



CoolGaN™ board thermal image:

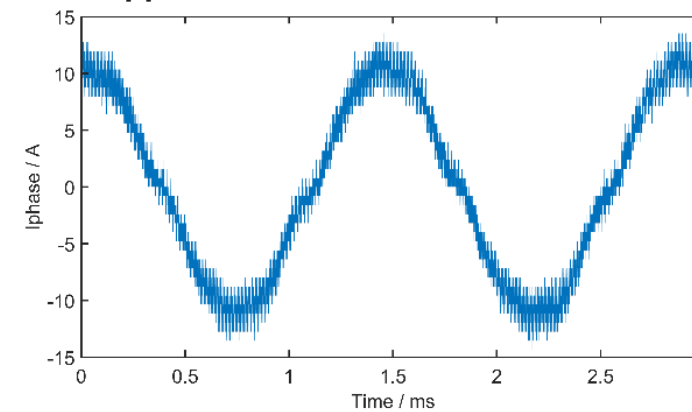


Switching frequency: 100 kHz

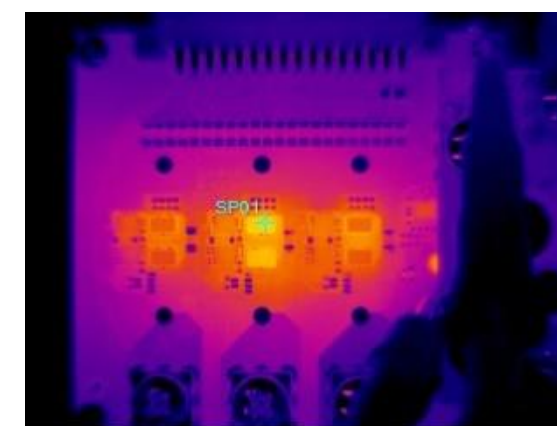
- › Overall system efficiency: **96%**
- › Motor temperature: **55°C**
- › Motor current ripple: **2 A_{pp}**

Motor loss ↓↓↓
Inverter loss ↑
System loss ↓↓

Phase current waveform:



CoolGaN™ board thermal image:



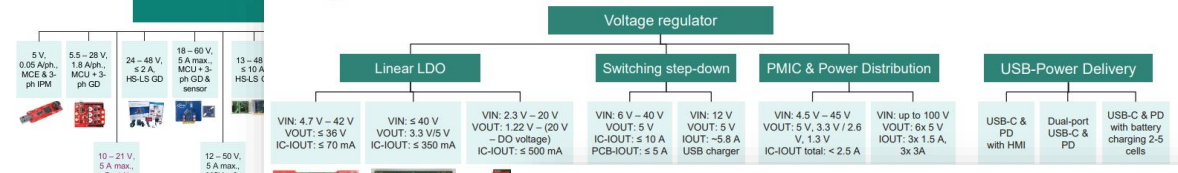
Support Material

Collection of demo boards to speed up your Go-2-Market

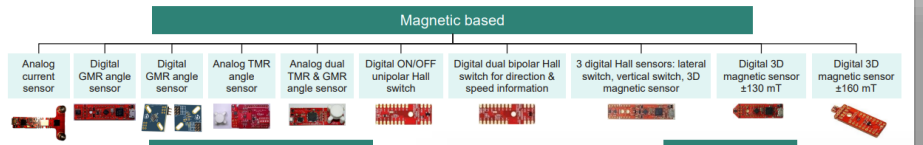
Motor Control selection



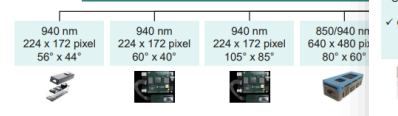
Charger, Power & Battery Management selection



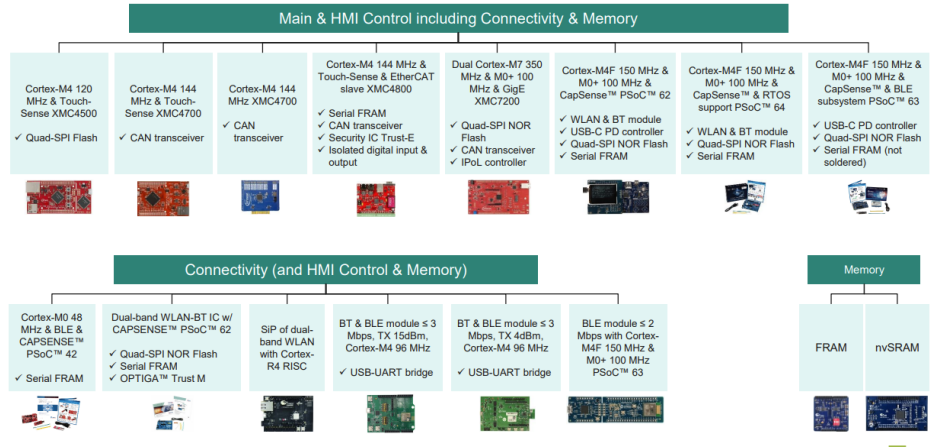
Navigation & Other Sensors selection



3D Infra-Red Time



Main & HMI Control including Connectivity & Memory selection



Evaluation board compilation
Robotics & Drones

<h3>Microcontrollers</h3> <ul style="list-style-type: none"> - XMC1000 - XMC4000 - XMC7000 - PSOC™ 4 - PSOC™ 6 - PSOC™ Control C3 - PSOC™ Edge - AURIX™ TriCore™ - TRAVEO™ 	<h3>Sensors</h3> <ul style="list-style-type: none"> - XENSIV™ - XENSIV™ magnetic sensors - XENSIV™ current sensors - XENSIV™ radar sensors - XENSIV™ MEMS microphones - XENSIV™ pressure sensors - REAL3™ ToF 3D image sensors 	<h3>ICs</h3> <ul style="list-style-type: none"> - Wireless charging ICs - OPTIREG™ PMICs - Cell monitoring & balancing ICs - Isolated UART transceiver ICs - ISOFACE™ digital isolators - LDO voltage regulators 	<h3>Discrete switches</h3> <ul style="list-style-type: none"> - OptiMOS™ MOSFETs - StrongIRFET™ MOSFETs - CoolGaN™ HEMTs - CoolMOS™ MOSFETs - CoolSiC™ MOSFETs - TRENCHSTOP™ IGBTs
<h3>Memory</h3> <ul style="list-style-type: none"> - SRAM - nvSRAM - EXCELON™ FRAM - SEMPER™ Quad-SPI NOR flash 	<h3>Gate driver ICs</h3> <ul style="list-style-type: none"> - EiceDRIVER™ - MOTIX™ 3-phase BLDC 	<h3>Security</h3> <ul style="list-style-type: none"> - OPTIGA™ Trust - OPTIGA™ Connect - OPTIGA™ Authenticate 	<h3>Connectivity</h3> <ul style="list-style-type: none"> - AIROC™ combos - AIROC Wi-Fi - AIROC Bluetooth® - PSOC™ 4 BLE - PSOC™ 6 BLE
<h3>Diodes</h3> <ul style="list-style-type: none"> - ESD protection - AF Schottky diodes 			
<h3>Controllers</h3> <ul style="list-style-type: none"> - EZ-USB™ serial bridge - CAPSENSE™ - XDP™ Protection ICs - XDP™ Digital power controllers 	<h3>Integrated solutions</h3> <ul style="list-style-type: none"> - MOTIX™ Motor control ICs - CIPOS™ IPMs 	<h3>Modules</h3> <ul style="list-style-type: none"> - Si/SiC modules - IGBT modules 	<h3>Infineon robotics application</h3> <ul style="list-style-type: none"> - Robotics landing page - Robotics development platform

