

Artificial intelligence at the Edge

How Infineon’s technologies and models enable and provide AI in key applications

21 May 2024

Today’s speakers



Nico Kelling

Vice President
Head of AI Centre of Excellence | Infineon



Steve Tateosian

Senior Vice President, Microcontroller
IoT, Compute & Wireless | Infineon

Infineon and you - driving the AI revolution.



Nico Kelling

Vice President

Head of AI Centre of Excellence, Infineon

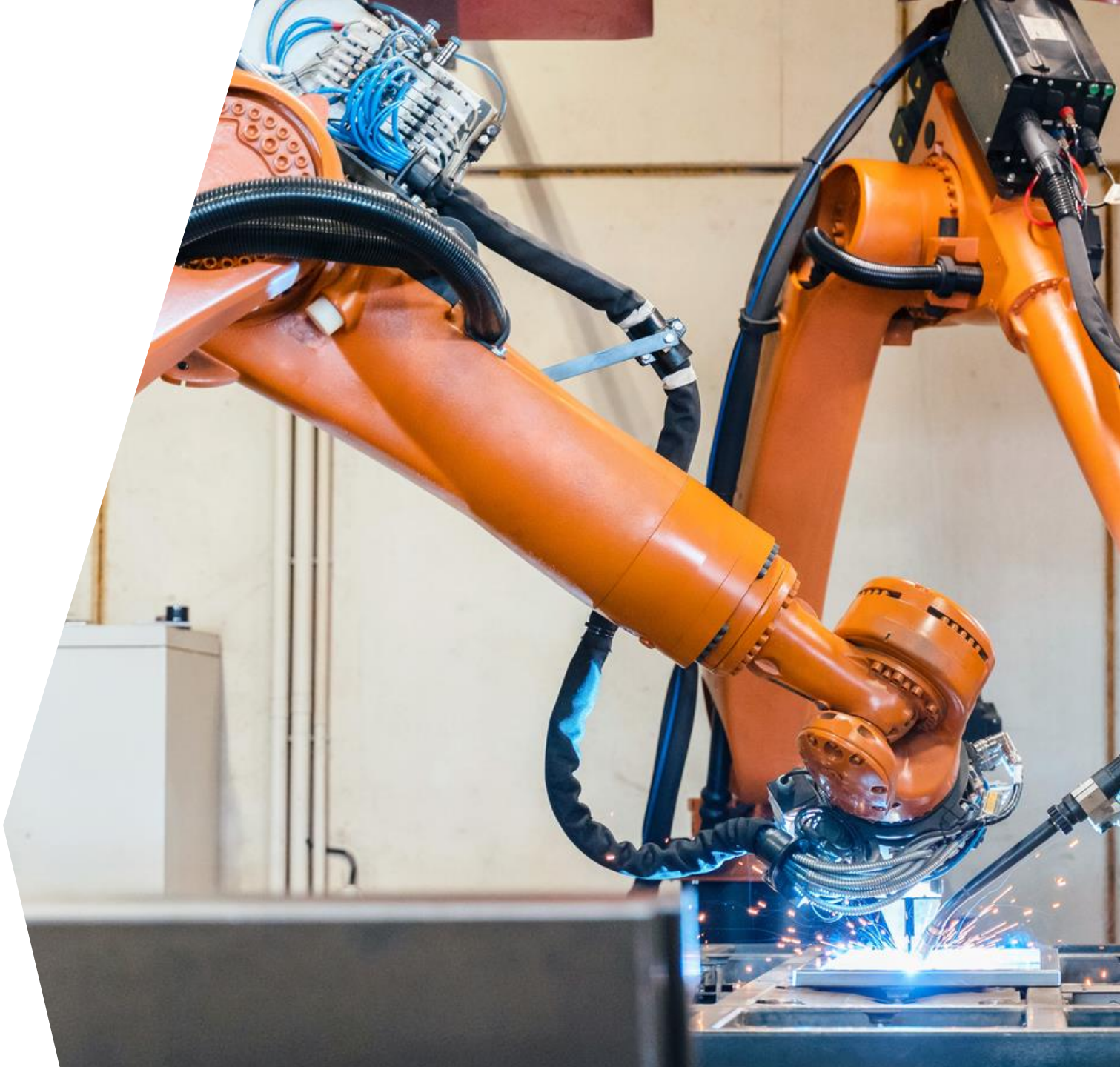
Cars that can feel, assist and protect you.





Consumer devices that can intuitively understand and support your ideas.

Adaptive industrial machines that can predict and communicate their own needs.



What used to be a dream is becoming reality.

Infineon is actively shaping the opportunities of AI since many years, leveraging AI for all areas of our business.

We use AI



We provide & enableAI



We power AI



We use AI in our processes for the benefit of our customers and to ensure competitive manufacturing based in Europe.



Research
& Development



Manufacturing
& Supply Chain



Central Functions

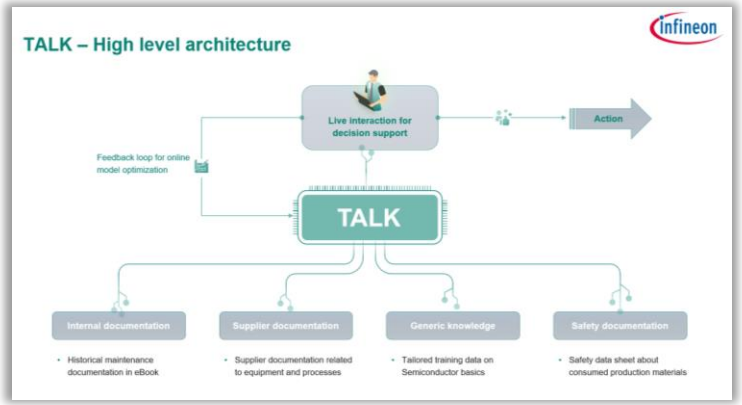


Go-to-Market and
Customer Support

AI at
Infineon

Knowledge Management & Retrieval
Coding Support
Chatbots and Virtual assistants
Content Generation

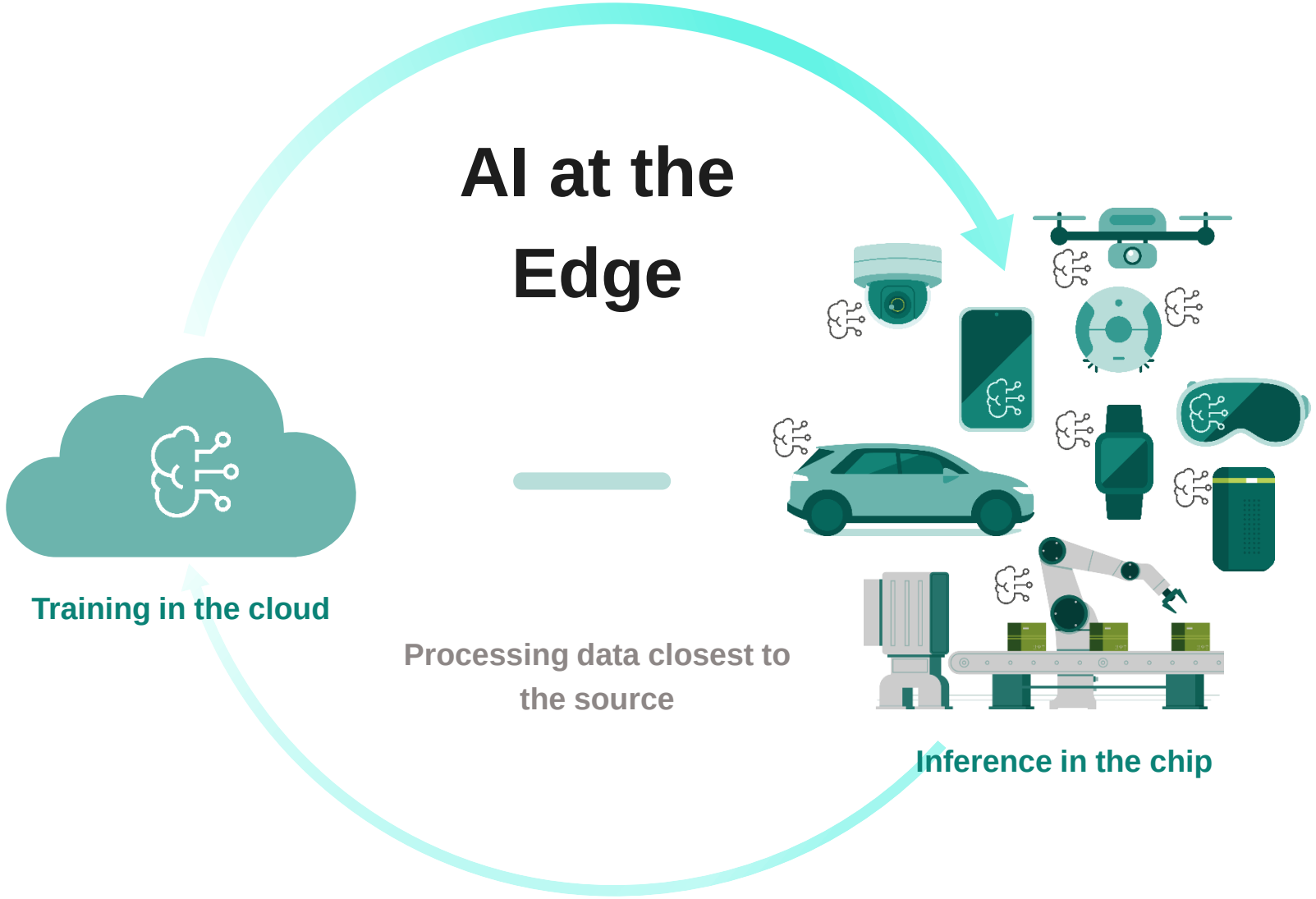
Example: Shopfloor Maintenance Assistant



We bring AI to the edge to enable our customers to differentiate with new solutions and features.



Real-time requirements and the need for power-efficiency, security and privacy drives AI-processing at the edge



Key benefits of Edge AI

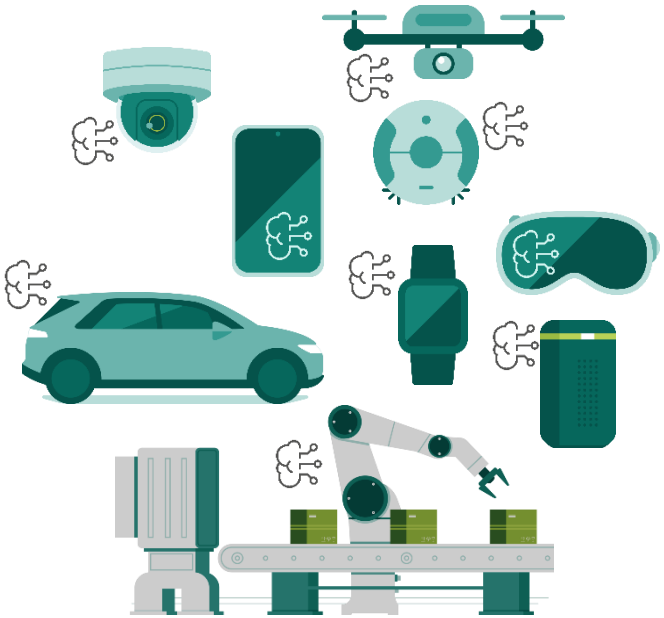
Low latency and real-time response

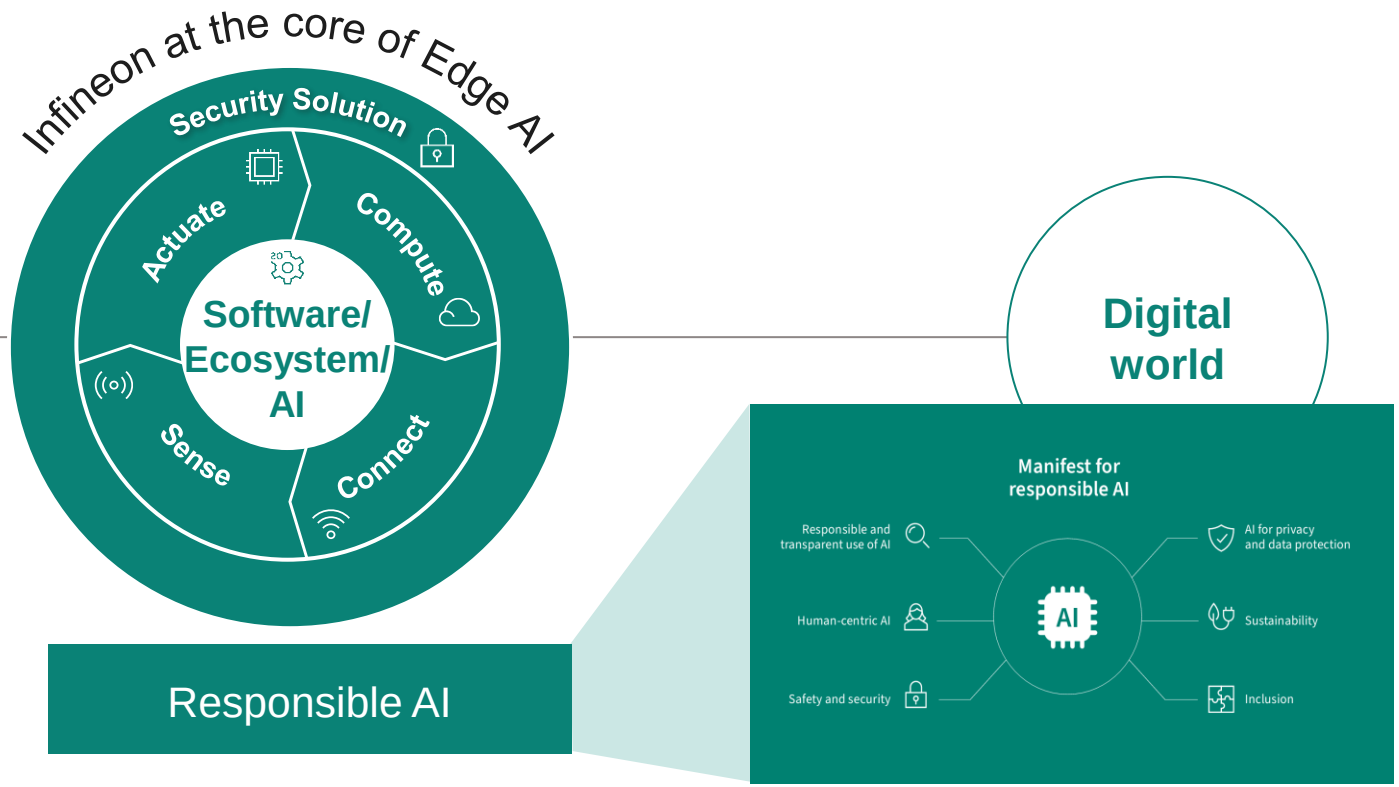
Higher power efficiency

Improved security and data privacy

Reduced cost

We provide & enable a wide range of technology-solutions for our customer‘s AI solutions – for every level of AI knowledge





Infineon at the core of Edge AI: Infineon's complementary set of AI-specific products and solutions, an end-to-end ML platform as well as an extensive application knowledge and a broad network of experienced AI partners allows our customers to get their AI application to market quickly – without having to be a proven AI expert.

Infineon offers end-to-end technology solutions for the AI market entry of our customers

Digital Services and AI solution platforms

INDUSTRIAL ANALYTICS

Hybrid AI-based services

In-field Power Analytics

e.g. RUL*

XENSIV™ sensor solutions

e.g. Sleep quality service

And others…

AI-models for a wide variety of applications

imagimob
An Infineon Technologies Company

Ready Models

- Baby cry detection
- Siren detection
- Surface detection
- Wearing detection (for headphones, helmets, etc.)
- Coughing detection
- Alarm detection
- Yelling & commotion detection
- ...
- Snoring detection
- Gesture detection
- Arc Fault Circuit Interrupters

End-to-end software solutions for easy training & deployment

TensorFlow

Keras

ONNX

imagimob
An Infineon Technologies Company

Imagimob Studio

ModusToolbox™

AI partner ecosystem:

SYNOPSYS®

DesignWare ARC MetaWare Toolkit

EKHONO AI

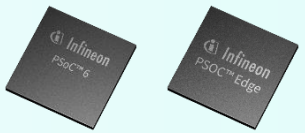
Cyberon
Leading Speech Solution Provider

SensiML™

Micro.ai

The right hardware for your Edge AI model

MCUs:



PSOC™



AURIX™



TRAVEO™



XMC™

XENSIV™ smart sensors portfolio for automotive, industrial and consumer

**Remaining useful life*

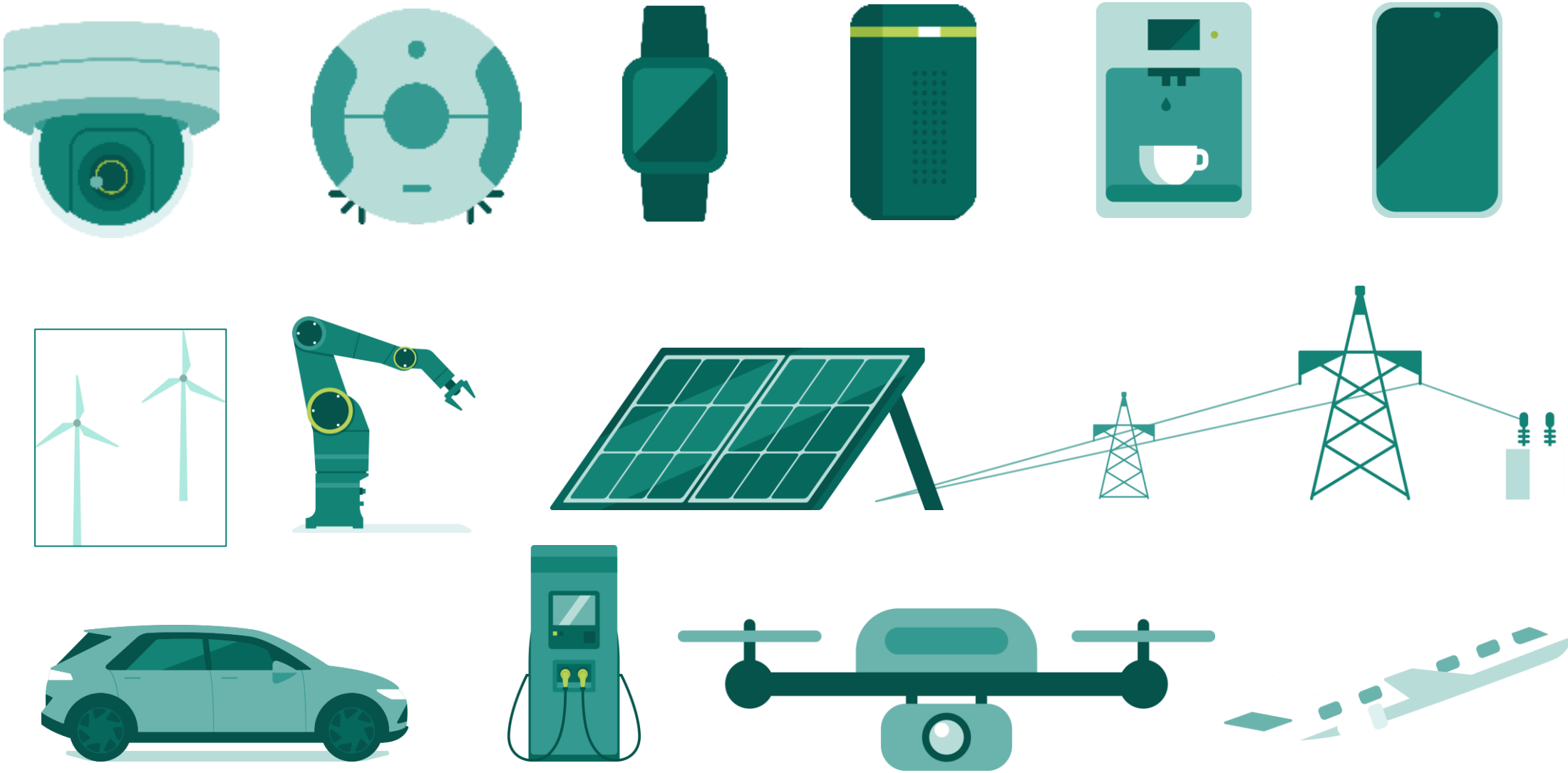
Imagimob Studio helps our customers take their Edge AI ideas to production quickly and easily



- **State-of-the art, end-to-end ML development platform:** Collect & annotate data directly from your target hardware. Create, train, evaluate & deploy great ML models fast.
- **Own your own data:** Data is only used by Imagimob to train your models. Data is stored offline on your machine.
- **Not locked into the Ecosystem:** Build a custom model, or bring your own to optimize for the edge, and deploy on the hardware of your choice.
- **AutoML functionality**: Auto-generates high performance AI models optimized for speed and low footprint.
- **Visualization is king**: No more "black box": Follow your machine learning model creation journey with our Graph UX.

- Imagimob Studio supports all INFINEON Microcontrollers (PSoC™, AURIX™, TRAVEO™, XMC™)
- Imagimob in cooperation with INFINEON can develop customer specific AI-Models

Our advanced technological solutions allow a wide range of Edge AI applications



AI in Automotive



Ushering in a new era of connected and autonomous vehicles with reliable, safe, and secure systems for real-time safety critical applications.

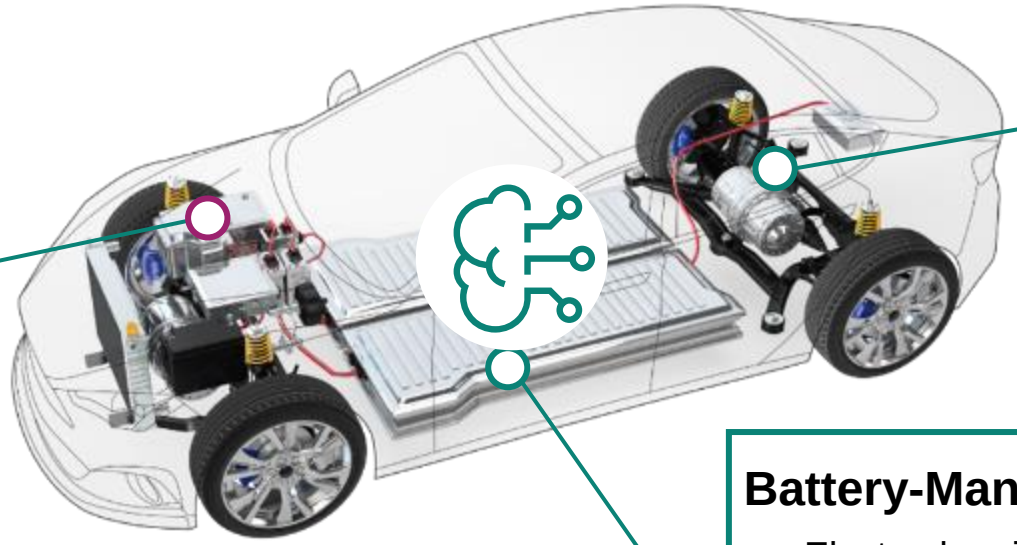
For instance, AURIX™ TC4x PPU empowers the e-Drivetrain of the future for best-in-class system efficiency and cost-innovation

TC4x PPU is enabling

Power-Conversion

› Combining control and communication functions and reducing number of system MCUs from up to 7 to 1

clear cost-down path and further efficiency increase



HV Traction Inverter

› Motor Position Sensing
› Health Observing
› Temperature Estimation
› Model Predictive Control

best-in-class system efficiency and cost-innovation

Battery-Management

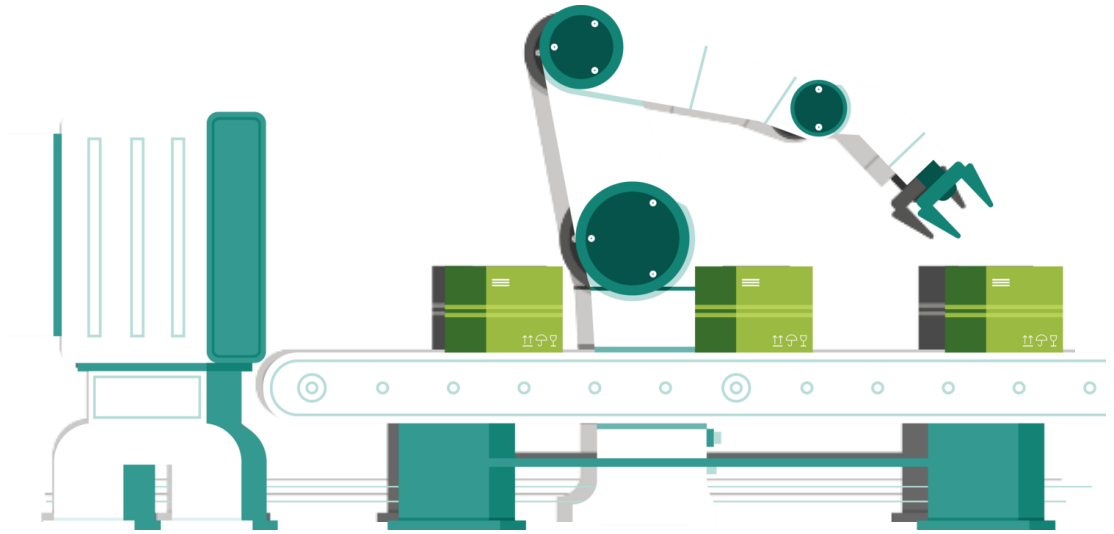
› Electrochemical models
› Hybrid ML accelerated models
› Artificial intelligence

optimized Charging, extended vehicle range and battery life

Up to **12x**

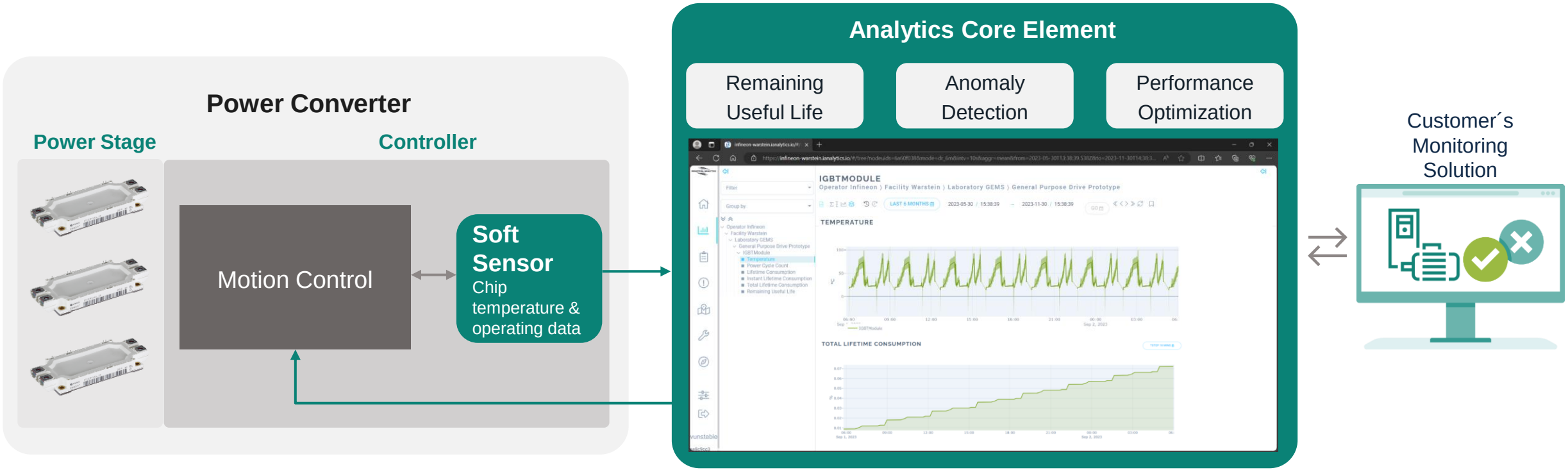
TriCore performance, eg. for AI-applications based on 256 bit PPU

Industrial AI



Creating self-learning systems for greater productivity, quality, and efficiency and supporting the adoption of sensor-based predictive maintenance models.

For instance, predicting Lifetime, Anomaly Detection and Performance Optimization in Power Converters



Infineon GIP
Power Electronics expertise

Industrial Analytics
SW and Analytics expertise

AI in IoT and Consumer Devices



Democratizing AI by bringing the computational power of AI algorithms closer to the source data with smarter and greener devices for intuitive real-time interaction.

For instance, making sleep measurable with the XENSIV™ Sleep Quality Service



XENSIV™ Sleep Quality Service

Key analytics

Sleep Attributes: *Distinguishing between sleep and wakefulness*	Sleep Stages: *Detecting and monitoring different sleep stages*	Respiratory Factor: *Detects breathing events by analyzing relative changes in breathing intensity*
• Total sleep time • Sleep efficiency • Time to sleep • No. of awakes	• Absence • Presence /awake • Sleep • REM • NREM	• Breathing rate • Breathing patterns • No. of respirational anomalies

XENSIV™ Sleep Quality Service

Product details

- **Embedded Sensor:** IFX **60GHz Radar** for precise sensing
- **Compute and Connect:** IFX **PSoC™** and **Wifi+BT module** for edge compute and cloud connectivity
- **Cloud AI:** Globally accessible, near real-time analytics
- **OEM Data Ownership:** Secure, exclusive consumer data control and anonymized user data for on-boarding (BirthYear, Timezone, Gender)
- **Sleep Analytics API:** Instant access to sleep and other SQS insights

So, why are Infineon‘s AI solution a perfect fit for our customers?

Enabling our customers to develop their own AI applications by providing world-leading semiconductor products, software, tools, and services.



End to end ML software solution

End-to-end solutions from data preparation, training to deployment.



AI simplified

Tools and ecosystem for a simplified NN training and deployment for all level of skills.



Application specific solutions

Infineon’s HW-/SW-/Services solutions and domain knowledge covering broad range of applications in IoT, Automotive and Industrial.



Low power and high performance at the Edge

Infineon offers application-specific optimization of inference stacks for lowest power-consumption at the edge.



Reliable, safe and secured AI solutions

Offering high-quality AI systems that provide highly reliable, safe and secured AI solutions for use in real-time critical applications.



The right option for your design

One stop shop, ranging from data, ML pipe-line and chips to high-performance, low-power AI-enabled MCUs, modern sensors and easy-to-integrate AI solutions.

Technology created for you

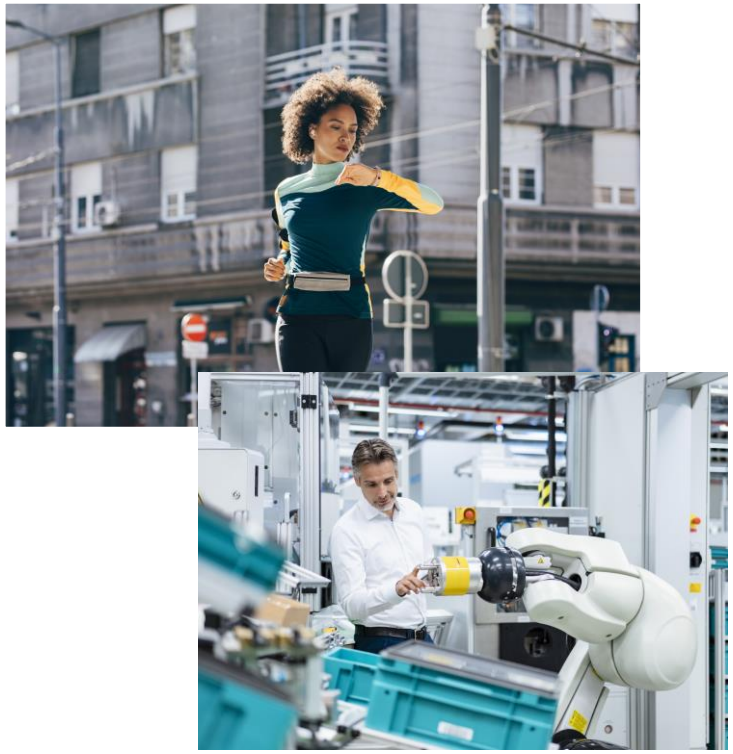
Making edge AI easy with our PSOC™
Edge and software from Infineon

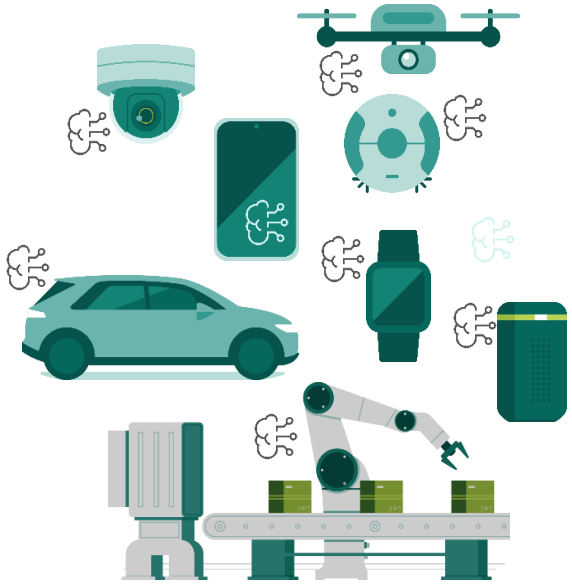


Steve Tateosian

Senior Vice President, Microcontroller
IoT, Compute & Wireless | Infineon

We enable the edge for your effortless IoT experience







Our comprehensive AI hardware and software portfolio enables easy development and implementation into various applications





In-house AI Software

imagimob
An Infineon Technologies Company

Development & AI Ecosystem

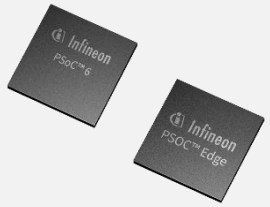
ModusToolbox™ Software

SensiML

Cyberon
Leading Speech Solution Provider

Micr.ai

PSOC™ Edge Microcontroller

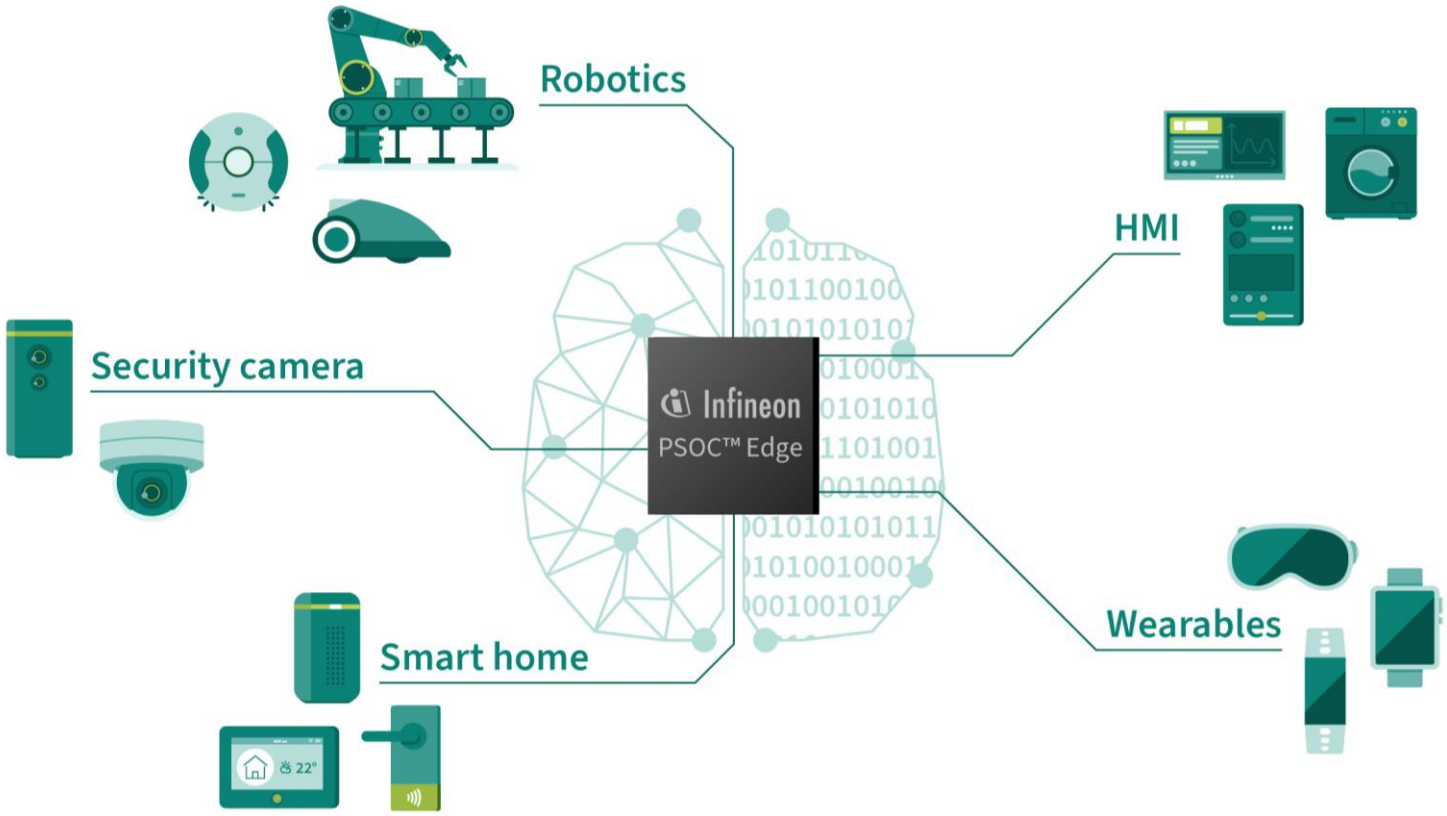


Infineon sensors

Connectivity
& security solutions

PSOC™ Edge
One microcontroller, endless possibilities. What will you create?

Portfolio: PSOC™ Edge E81, E83 and E84 MCUs



Fully integrated MCU devices supported with comprehensive system design tools and software.

Based on the high-performance Arm® Cortex-M55.

Quick move from concept to product.

Fast time-to-market for IoT and consumer applications.

Reduced BOM cost

Power efficiency

Software portability and easy integration into different designs

Security is key in the context of AI and in our portfolio

Security is crucial for Edge AI + **Security is part of our DNA** › **New PSOC™ EDGE E8X product family**

- Multiple points of attack
- Critical IP
- Sensitive data

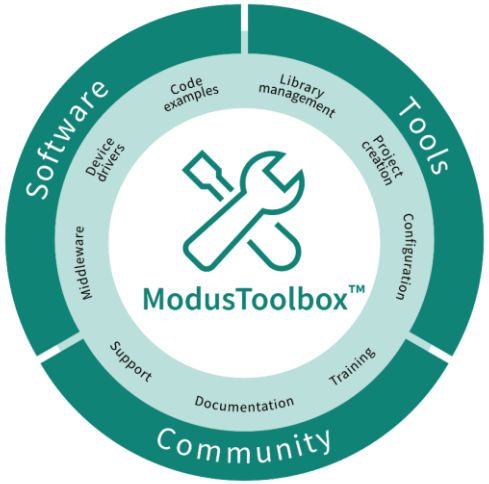


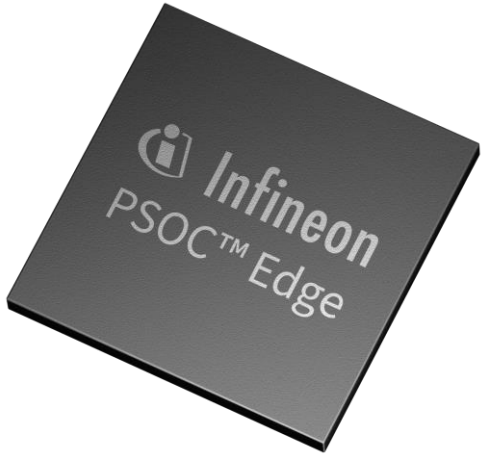
- Designed to meet highest certification level provided in the Platform Security Architecture (PSA) PSA L4 iSE
- Integrated secure enclave to support boot-time and run-time security services
- Isolation of security protection and AI acceleration computation

Customized Machine Learning on PSOC™ Edge with Imagimob Studio and ModusToolbox™

With the seamless integration of **Imagimob Studio** and **ModusToolbox™** companies can build and deploy robust machine learning models. When paired with **PSOC™ Edge**, companies can optimize power consumption and improve efficiency while adding intelligence to products.





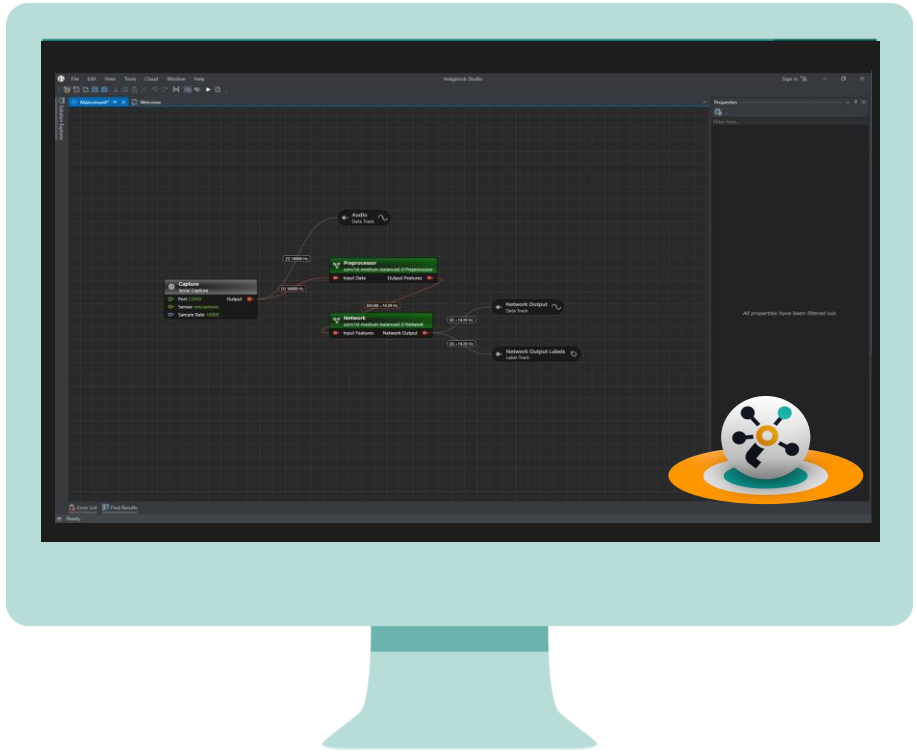


Imagimob Studio, Infineon's platform for machine learning development, makes it easier to create Edge AI models

ModusToolbox™ Software is a modern, extensible development ecosystem

PSOC™ Edge is the next generation Machine Learning-enhanced sensing, low power, secured, and advanced HMI high-performance microcontroller family

Imagimob Studio helps you take your edge AI ideas to production quickly and easily



State-of-the art, end-to-end ML development platform: Collect & annotate data directly from your target hardware. Create, train, evaluate & deploy great ML models fast.

Own your own data. Data is only used by Imagimob to train your models. Data is stored offline on your machine.

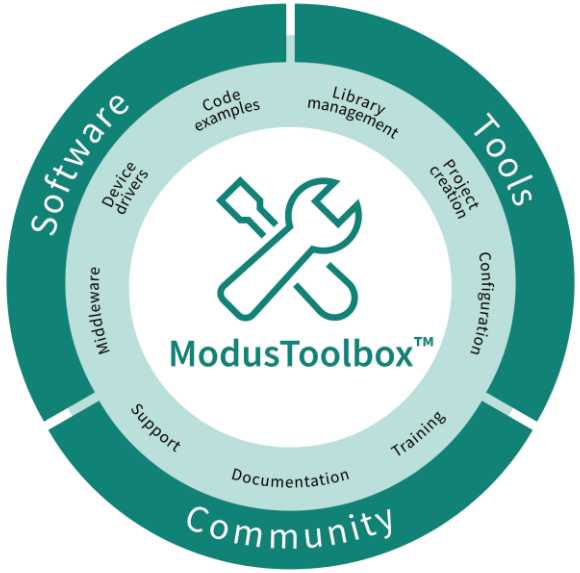
Not locked into the Ecosystem: expand for your needs or with us. Python based, allowing expansion for own pre-processors & functions. Deploy your own models.

AutoML functionality: Auto-generates high performance AI models optimized for speed and low footprint.

Visualization is king: No more "black box": Follow your machine learning model creation journey with our Graph UX.

Collect & annotate high quality data | Manage data into different datasets | Build & train great models | Evaluate and find the best model | Optimize and package application | Deployment and Maintenance

ModusToolbox™ – Development Platform for PSoC™ Edge



- ModusToolbox™ Software is a modern, extensible development environment supporting a wide range of Infineon microcontroller devices.
- Provided as collection of development tools, libraries, and embedded runtime assets architected to provide a flexible and comprehensive development experience.

Development Tools

The ModusToolbox™ tools package includes desktop programs that enable the creation of new embedded applications, managing software components, configuring device peripherals and middleware, and embedded development tools for compiling, programming, and debugging.

Run-Time Software

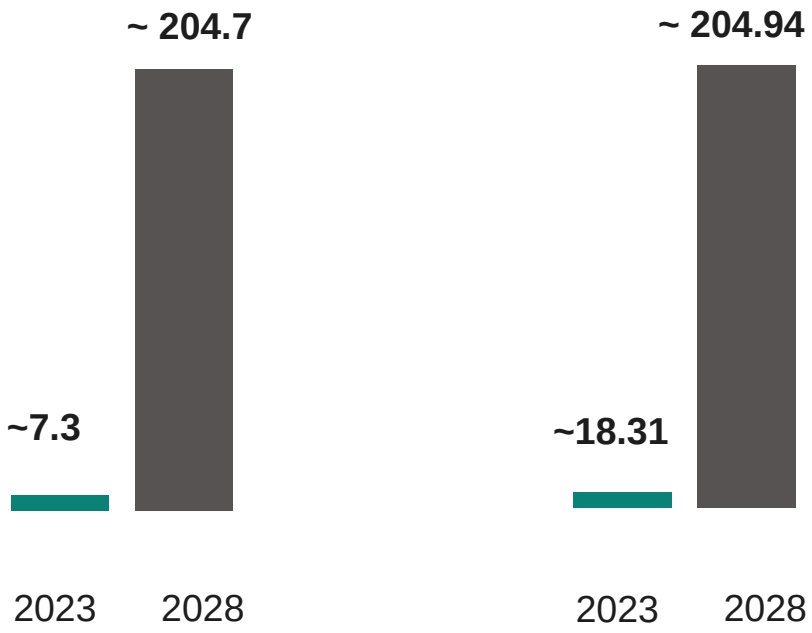
The ModusToolbox™ software includes an extensive collection of GitHub-hosted repositories comprised of code examples, board support packages, middleware, and application support.

A growing trend: Audio and Computer Vision technology

AI-driven audio & computer vision capabilities can be utilized in various applications and have a promising market potential

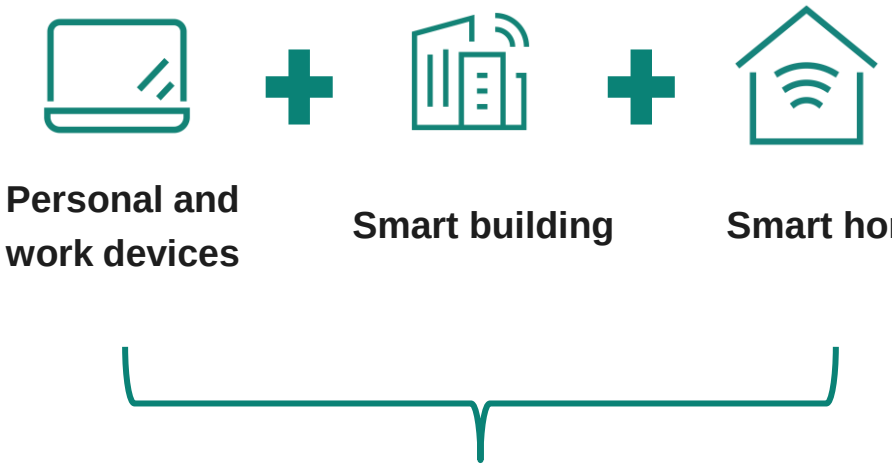
Market by revenue

[in MN USD]*



*ABI Research: Artificial intelligence and Machine Learning Market Data Q1 2023
** Computer Vision is a part of the overarching segment of Machine Vision

Applications market potential



Delivering a combined revenue of $9.73 billion* in 2028;

About 60% of total market revenue

AI-driven audio & computer vision capabilities in edge devices will enhance your user experience

Always-on audio experiences

Listen for Acoustic Events at 70uW. Manage low power wake work detection, local user voice, Multi-Mic ML Voice, and more in MCU-class device





Onlooker detection

Protect privacy in public spaces by detecting onlookers behind user

Multi-modal presence & sensing

Utilize AI-driven audio & computer vision capabilities to detect user presence & proximity in ultra-low power domain



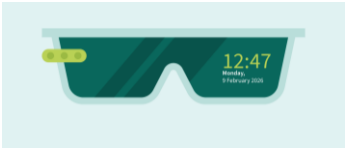


Vital detection & monitoring

Monitoring health status of user based on heart & respiration rate during session

User Identification / Authentication

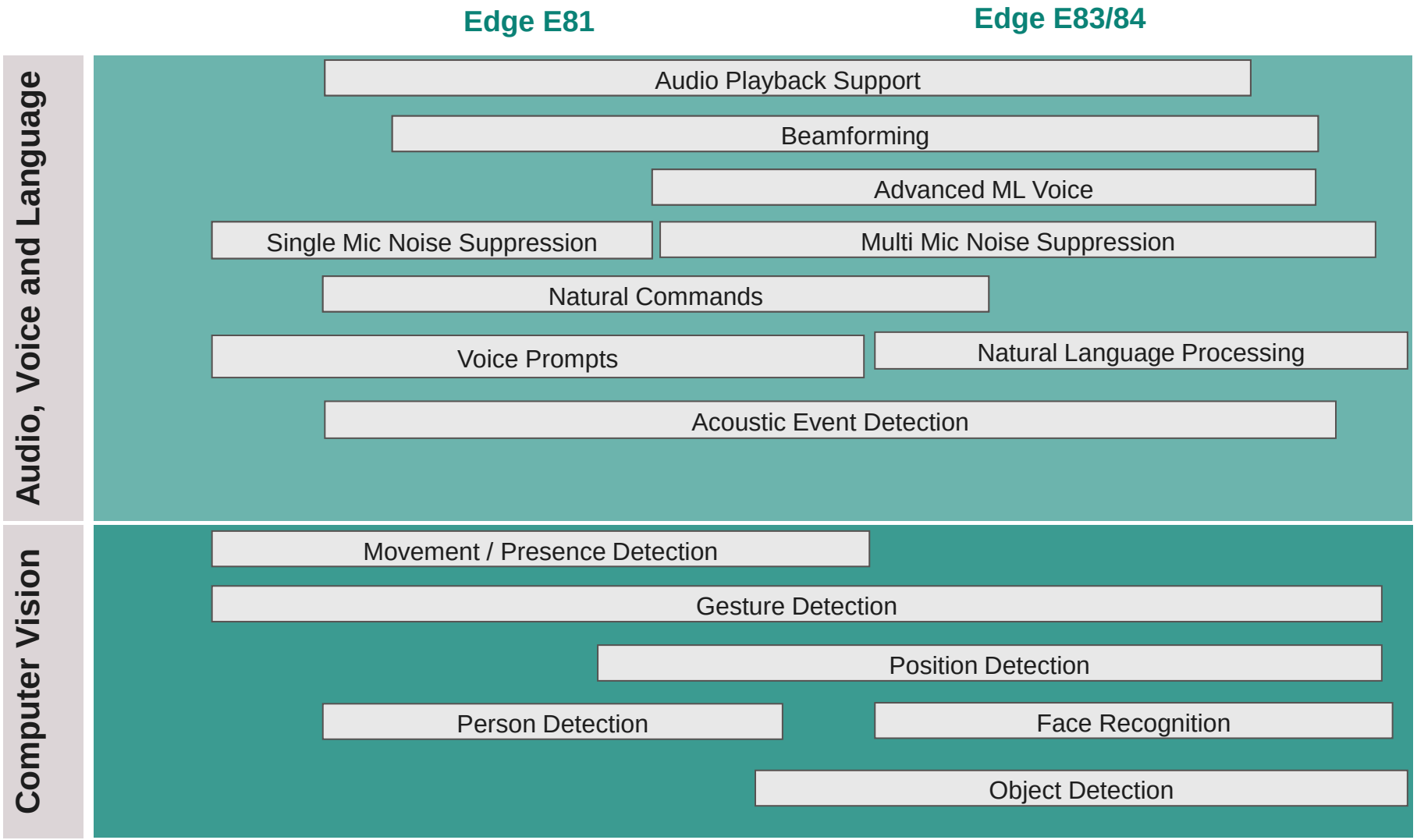
Perform user authentication via Voice ID & Face ID w/o waking primary SoC. Capabilities deliver w/ M55 + U55



Gesture Control

Macro gestures (e.g. swipes during gaming to pause) and short range microscopic gestures (e.g. finger rubbing)

Our PSOC™ Edge supports multiple audio and vision AI capabilities



PSOC™ Edge E84: Next Gen, Low Power ML MCU with GPU

Features

- **High performance, real-time compute domain**
  - Cortex®-M55 w FPU + Helium DSP + Ethos-U55 for ML
  - Up to 5 MB System SRAM, 256 KB I&D TCMs
- **Low power, real-time compute domain**
  - Cortex®-M33 and DSP + IFX NNLite for ML
  - 512 KB RRAM, 1 MB SRAM
- **HMI**
  - Traditional MCU HMI
  - Local voice, cloud voice
  - Vision for friction free interface & safety
  - Low power Graphics, up to 1024x768, MIPI-DSI/DBI
- **ML**
  - NNLite
  - Advanced ML leveraging U55 and NNLite
- **Peripherals & IO**
  - USB, 10/100 Ethernet, CAN, SPI, UART, I2C, I3C, I2S
  - Ultra-low-power always-on analog
- **Security**
  - Secured Enclave @ 25 JIL pts, fit for ARM PSA L2/L4

Target Applications: Wearables, Appliances, Thermostats, Residential AC, Speakers, Industrial HMI…

System Power Modes: Active/Sleep | DeepSleep | Hibernate

High Performance CPU System

Compute Memory ML DSP

Arm® Cortex®-M55, Ethos™-U55, 50-400 MHz		
Helium™ DSP	FPU	MPU
NVIC	32 kB I-Cache	32 kB D-Cache
HPDMA	256 kB I-TCM	256 kB D-TCM

Up to 5 MB SRAM	512 kB RRAM

Low Power CPU System

Compute Memory ML DSP

Arm® Cortex®-M33, 50-200 MHz		
NNLite	DMA	64 kB ROM
	1 MB SRAM	16 kB I-Cache

External Memory

2x Serial Memory IF, xSPI/Hyperbus, On-the-fly Encrypted XIP
2x SD Host Controller (SD/SDIO/eMMC)

ML Enhanced Next Gen HMI

Local Voice	Keyword Spotting	Vision
Cloud Voice	Wake Word Detection	Friction Free Interface and Safety
	2.5D GPU	

Peripherals & IO

12b ADC * 5/0.2 Msps	11x SCB (UART,I²C,SPI)	MIPI-DSI/DBI
2x 12b DAC	1x SCB (I²C,SPI)	10/100 Ethernet
2x 4b Prog. Ref.	2x TDM/I2S	2x CAN FD
2x PTCOMP	1x I3C	2x Smart IO
2x LPCOMP	6x PDM	USB HS/FS w/ PHY
4x Amplifiers	32x TCPWM	

Secure Enclave 25 JIL Pts.

Secure Key Storage	Side Channel Resistance
TRNG	Crypto Accel.
OTP	Secure JTAG
Secure Boot	Tamper Protect

System Resources

Power Mgmt.	Clock Mgmt.
Sleep Control	Clock Control
POR BOD	PILO IHO
LVD	WCO ECO
Reset Control	3x DPLL
Retention LDOs	WDT | RTC
Active LDOs	3x LPTimer
Buck Converters	16x HFCLK DIV

* 5 Msps in Active/Sleep, 200 ksps in DeepSleep

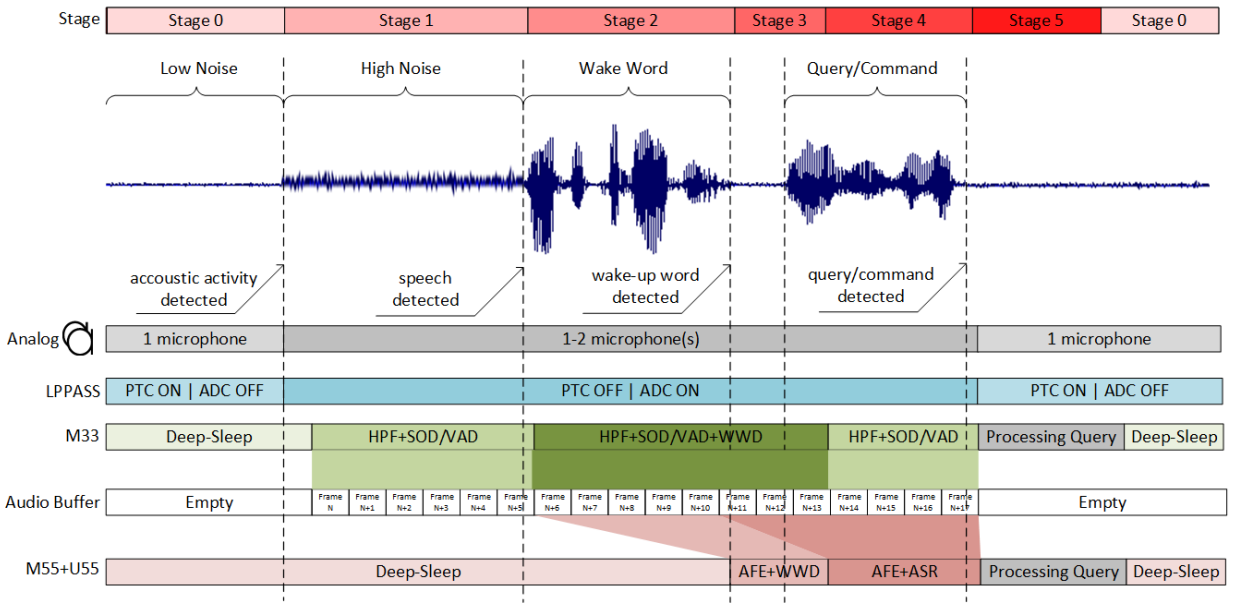
Noise Suppression & Echo Cancellation as part of ModusToolbox™ Speech Package

- **Broad range of use cases:** Smart appliances, home control, wearables, … due to **variety of noise profiles supported** [e.g. kitchen, music, traffic, …]
- **Accelerated for Infineon HW** for optimal performance (PSOC™ Edge). Full Infineon solution (HW + SW) **speeding up time to market**
- **Low power audio chain** including **speech onset detection** [SOD] and **ultra low-power WakeUp Phrase Word Detection** [WUPD] accelerated on lightweight NPU
- **Thoroughly tested using variety of datasets & testing standards**
- Using ML and traditional techniques to **deliver best-in-class speech quality** in all kinds of **noisy environments**

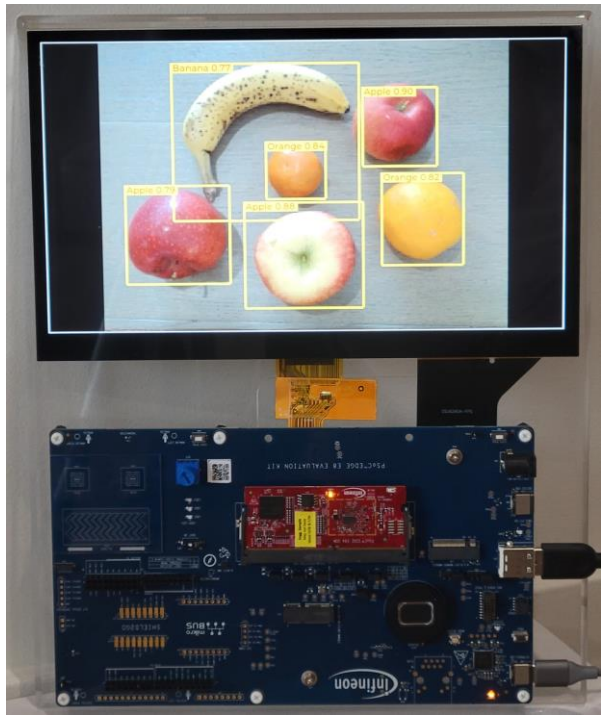








PSOC™ Edge - Low Power Vision AI Microcontrollers
Breaking the Mold for Vision Applications



PSOC™ Edge MCU running a vision application to detect numerous real-world objects

Wake up motion / people detection

Face recognition / identification, Object recognition

Environmental sensing (low energy)	Motion /activity detection (low res image)	Face detection (high res image)	Face normalization (high res image)	Feature engineering (high res image)	Face identification (high res image)

Performance: Approaching GHz MPU/CPU capability

Power: > 200x energy savings

Cost: ½ total system cost

Camera	**PSOC™ Edge** Image resize (41.68gms) NMS filtering	**PSOC™ Edge** LVGL/VGLite	**Display** Image + Object Detect overlay

Summary

Summary

Edge AI is part of our everyday life

Enabling edge devices with AI capabilities will take the IoT to the next level

We make you ready for the edge

Our PSOC™ Edge in combination with our ModusToolbox™ and Imagimob solutions offers endless opportunities to utilize AI

We put you at the center of our technology

By ensuring ease of use, high performance and short time-to-market, we optimize development and usage of our solutions



ANY QUESTIONS?

Please contact

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