



# Infineon XENSIV™ sensors

## At the forefront of the sensorization of things

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# The future is here



Human Machine Co-existence



Smart homes



Generative AI and AR/VR



Intelligent and autonomous cars

# Infineon sensors have applications in every industry

## Smart home and building



- Activity recognition
- Attention monitoring

## Retail, PoS, digital signage



- Traffic monitoring
- Attention monitoring
- Voice interface

## Surveillance and safety



- Intrusion detection, alarm systems
- Safety systems, social distancing
- People counting, traffic monitoring

## Smartphone



- Voice pick up, voice detection
- 3D authentication, AR

## Notebooks, tablets, conferencing



- Audio communications
- Human presence, anti-peeking
- Augmented reality

## Hearables and wearables



- Bio sensing
- Contextual awareness, AR/MR
- Voice UI, ANC, touch/gesture UI

## Service robots



- Navigation
- Contextual awareness
- User interface

## Car and mobility

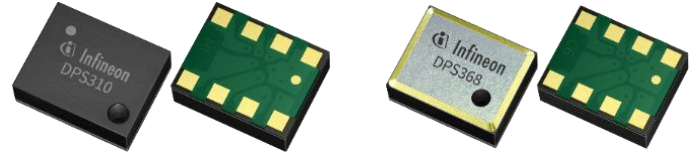


- Occupancy monitoring
- Safety
- User interface

# XENSIV™ consumer and industrial sensors

## Touch sensors

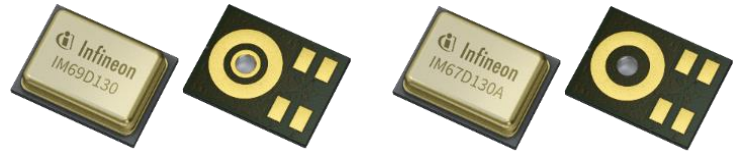
Pressure and CAPSENSE™



## CO<sub>2</sub>-based gas sensor

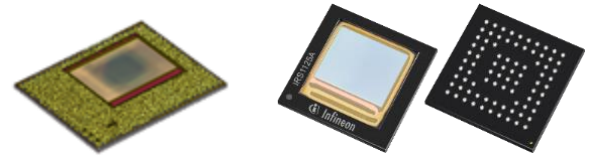


## Microphones

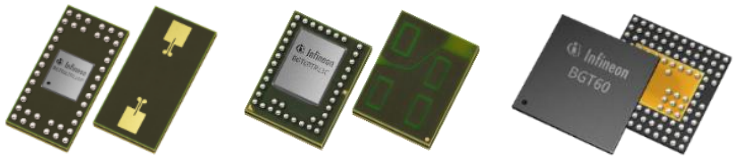


## 3D time-of-flight (ToF) camera

High resolution depth



## 3D RADAR technology



# XENSIV™ microphones

# High performance XENSIV™ microphones enable new audio use cases

Advanced audio functionality	Low self-noise to capture the faintest and far-field sounds	High SNR		Robustness	Ingress protection (IP57) and filters for RF suppression reduce integration cost and manufacturability	
	Enables best-in-class transparent hearing and active noise cancelling functionality				Low power consumption	Ultra-low power digital microphones and selectable power modes for long-lasting battery life
	Low signal distortions even at high sound pressure levels	High AOP		Low part variability	Tight sensitivity, phase and LFRO matching for beamforming applications and ANC control loop design	
	Handling of high signal peaks for reliable ANC performance					

**Automated speech recognition**

Connecting the real to the digital world  
(for digital assistants, talk-to-text)

**Active noise cancellation**

Suppression of unwanted sounds  
(for advanced earbuds, headsets)

**Beamforming and audio zoom**

Changing audio recording directivity  
(for cameras, smart glasses, conference devices)

**Transparent / Advanced hearing**

Adaptive audio experience  
(for hearables and headphones)

# MEMS, ASIC and package: Building blocks of a MEMS microphone



Infineon Microphone System – Head Quarter in Munich, Germany

## MEMS

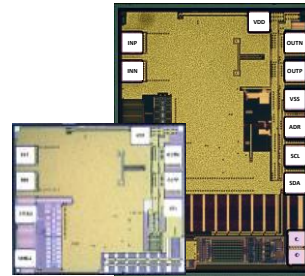


Micro electro-mechanical system

Membrane and backplate forming a capacitor

Capacitor is modulated by acoustic waves

## ASIC



ASIC contains circuitry for MEMS

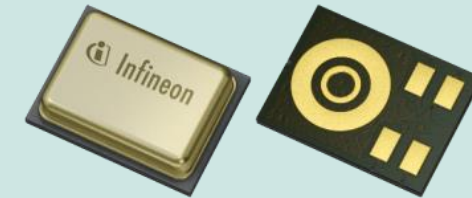
Charge pump for membrane

Amplifier stages

LDO for clean supply

Calibration logic

## Package



Package protects the device and enables pick-and-place

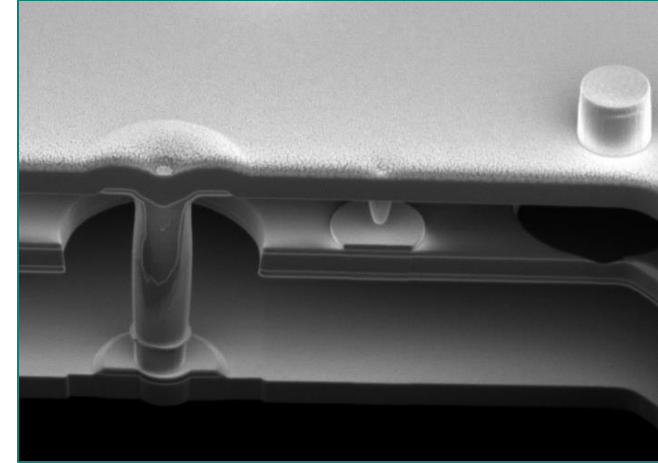
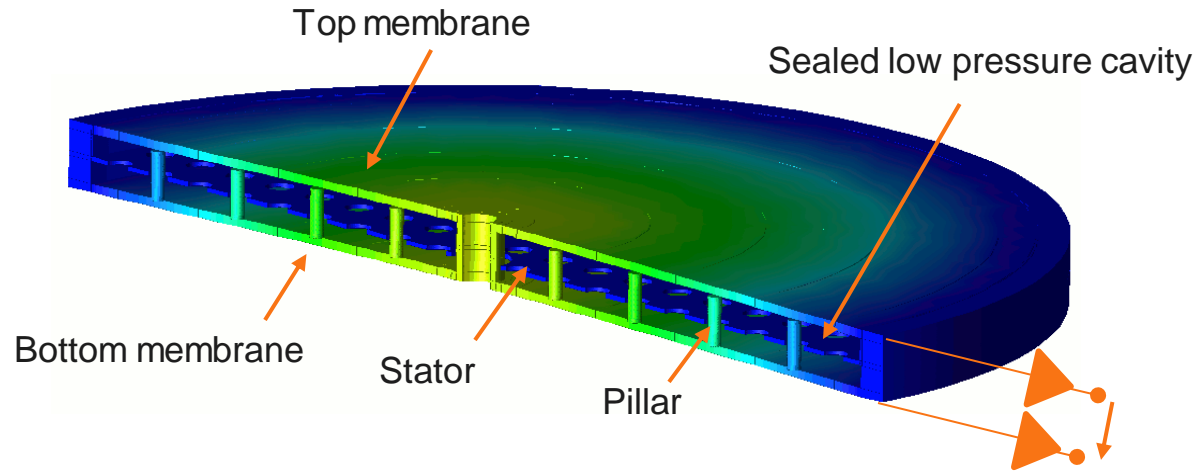
Shielding (EMI)

Package volume is forming an acoustical back volume

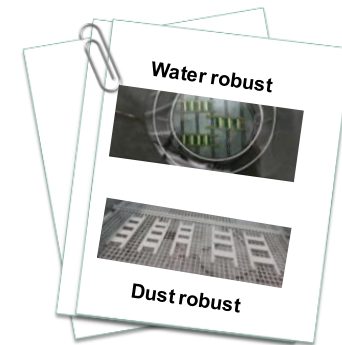
Infineon owns all building blocks of MEMS microphones – allowing to identify and develop MEMS, ASIC and package combinations optimized to each application



# Infineon's sealed dual membrane technology is a revolutionary step forward for capacitive MEMS microphones



- True-differential topology
  - Enables ultra-high SNR of up to 75 dB SNR (80 dB for dual MEMS)
  - Distortion improvement by cancellation of even order distortion
- IP57 environmental robustness leads to less field returns and better manufacturability



# XENSIV™ radar

# Smart presence detection with Infineon radar sensors

Reducing energy consumption while improving user experience



## Smart thermostats & displays



- Activation by proximity sensing
- Enhance booting time & user experience
- Support gesture control

## Smart lighting systems



- Activate only where people are located
- Indoor & outdoor
- Higher sensitivity than PIR sensors

## Room air conditioners



- Turn on & off devices based on presence & vacancy detection
- Steer airflow away from people's position

## Security systems



- Start camera & recording only by movements inside the covered area
- Reduce number of false alarms

## Laptops & monitors



- Turn off / reduce brightness by absence detection
- Increased battery lifetime
- Lock the screen to protect data

## TV



- Turn off screen by absence detection
- Pause & resume streaming content based on presence & absence

# Radar solutions – Helping companies reduce carbon footprint

## Radar sensor for smart devices – huge energy-saving potential

By using highly sensitive Infineon radar sensors<sup>1</sup>, smart devices are able to detect the presence and absence of people. Thus, radar-supported smart devices can automatically switch between on mode and energy-saving deep sleep mode.

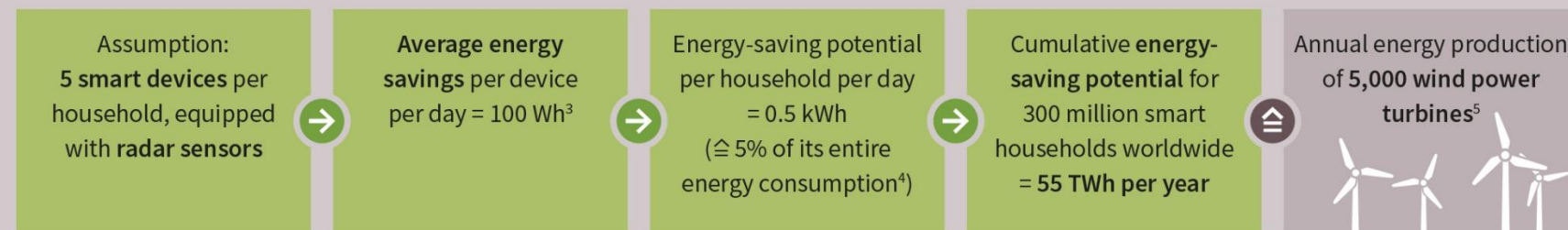


Number of smart homes worldwide will exceed 500 million by 2026.

Smart activation & deactivation based on radar presence & absence detection saves energy.

Radar sensors can add additional functionalities to increase comfort & safety in a smart environment.

300 million smart home households worldwide in 2022<sup>2</sup>



1 Infineon XENSIV™ 60 GHz radar sensor, www.infineon.com/60GHz

2 Source: Statista

3 Average out of a wide saving range. From a single watt (e.g. putting a device from stand-by to a deeper sleeping mode) to 100 watts and more (e.g. turning off a TV while nobody is in the room)

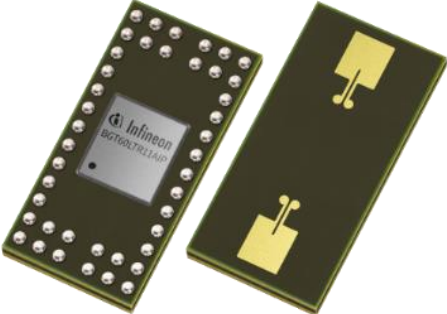
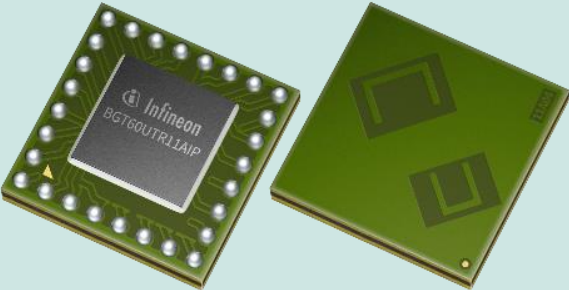
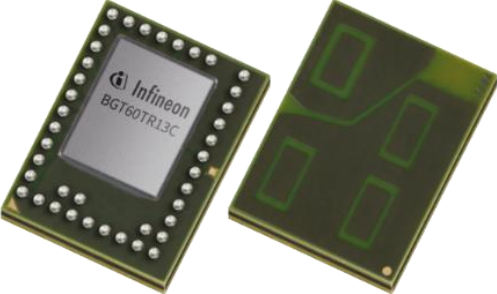
4 Assumption: 3-person household with 3,500 kWh energy consumption per year

5 Assumption: Average energy production of a wind turbine = 10 GWh

Article: [bit.ly/3CoMYUt](https://bit.ly/3CoMYUt)

# Portfolio that caters to all use cases

Increasing functionality

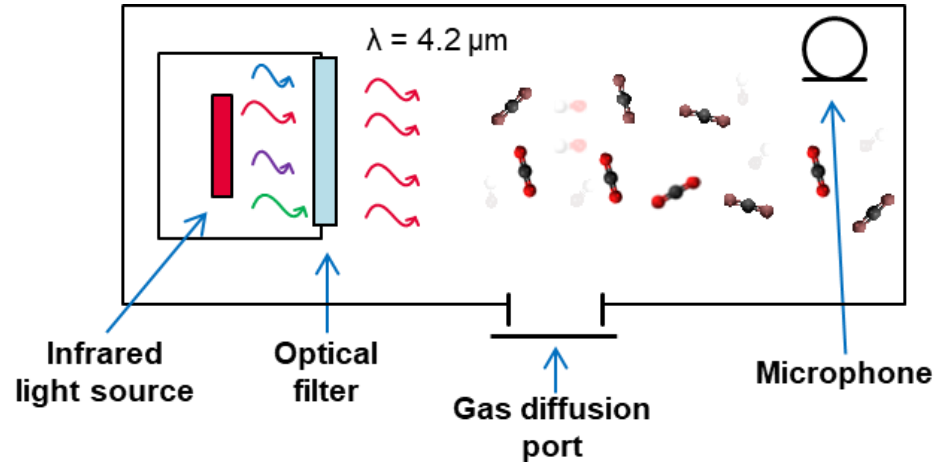
	BGT60LTR11AIP	BGT60UTR11AIP	BGT60TR13C
	 <p style="text-align: right;"><b>6.7 x 3.3 mm</b></p>	 <p style="text-align: right;"><b>4.05 x 4.05 mm</b></p>	 <p style="text-align: right;"><b>6.5 x 5.0 mm</b></p>
<b>Positioning</b>	Smart & cost-effective <b>PIR replacement</b>	<b>Compact and cost-efficient</b> radar chip for FMCW operations	Enable <b>advanced radar sensing</b> including presence, tracking and gesture control
<b>Operating mode</b>	<b>Doppler Radar</b> with integrated detectors	<b>FMCW</b> (5.5 GHz BW)	<b>FMCW</b> (5.5 GHz BW)
<b>Value proposition</b>	<b>Completely autonomous mode:</b> Most convenient way to implement radar in your system	<b>Smallest 60 GHz chip</b> with integrated antennas on the market	<b>Maximum functionality and flexibility:</b> Develop the most demanding radar use cases
<b>Target use cases</b>	<b>Motion detection,</b> Presence detection (short range)	Presence detection, gesture control, vital sensing, 1D ranging, material classification	Presence detection, gesture control, vital sensing, segmentation, tracking, distance
<b>Target applications</b>	Lighting, monitors, TV, cameras, IoT/smart-home applications, door openers, toilets, ...	Smart Home, Smart appliances, health care devices, TVs, laptops, Service robots, ...	Smartphones, laptops, smart home applications, health- & baby care devices, ...

# XENSIV™ CO2 sensors

# Thanks to our leadership in MEMS technologies, we have realized a new generation of miniaturized CO<sub>2</sub> sensors



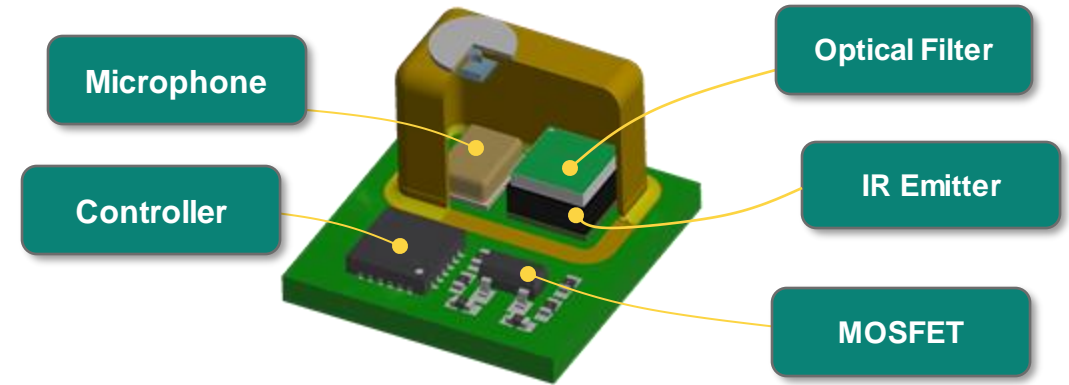
## From photoacoustic spectroscopy principle...



## The PAS principle allows for a direct, accurate and selective measurement of CO<sub>2</sub>

- A MEMS-based IR emitter generates a light pulse at a specific wavelength selective to CO<sub>2</sub>
- CO<sub>2</sub> molecules absorb the light and vibrate, creating a sound wave with an amplitude directly related to the concentration
- The sound wave is detected by a MEMS microphone

## ...to mass produced XENSIV™ PAS CO<sub>2</sub> sensor



## All key components are developed by Infineon

- The PAS CO<sub>2</sub> sensor achieves **the accuracy & stability of high-end NDIR CO<sub>2</sub> sensors** in a 4x smaller size
- **Compliant with major standards and regulations** for indoor air quality (e.g.: WELL, LEED, ASHRAE)
- Suitable for **high volume standard assembly processes** with surface mount assembly

# XENSIV™ PAS CO2 is targeting many applications for indoor air quality monitoring and energy saving



**HVAC**



**Air quality devices**



**Consumer devices**



**Smart home & building**



Air quality awareness



Higher comfort levels



Healthier life



Lower energy consumption



Increased productivity



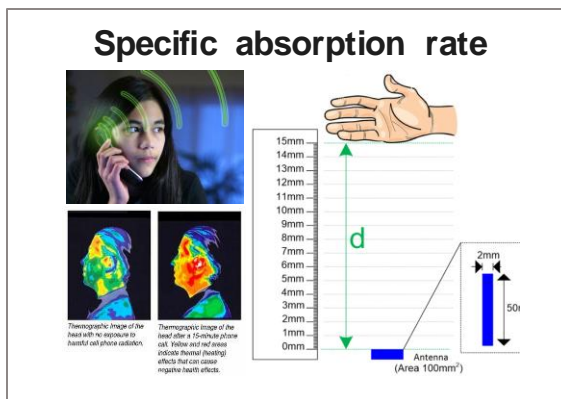
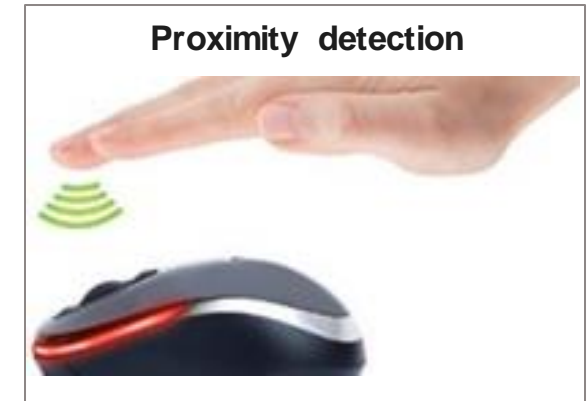
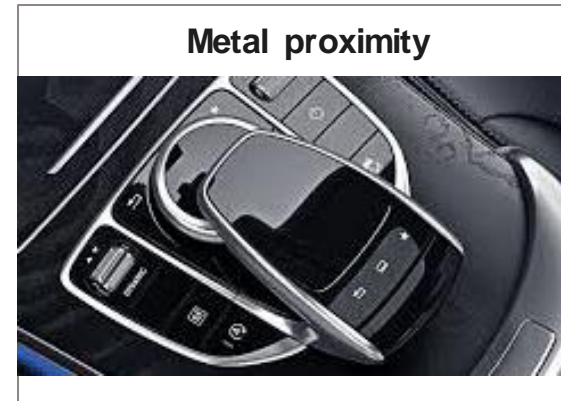
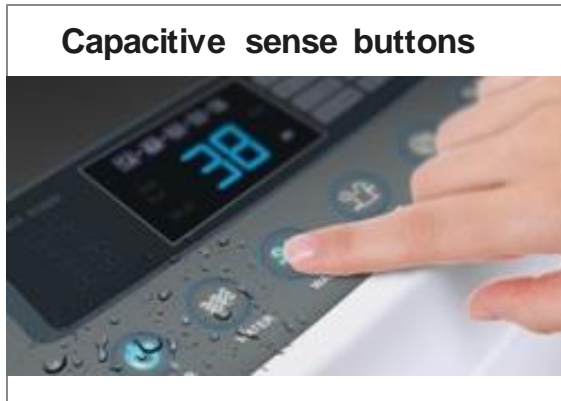
Energy cost savings



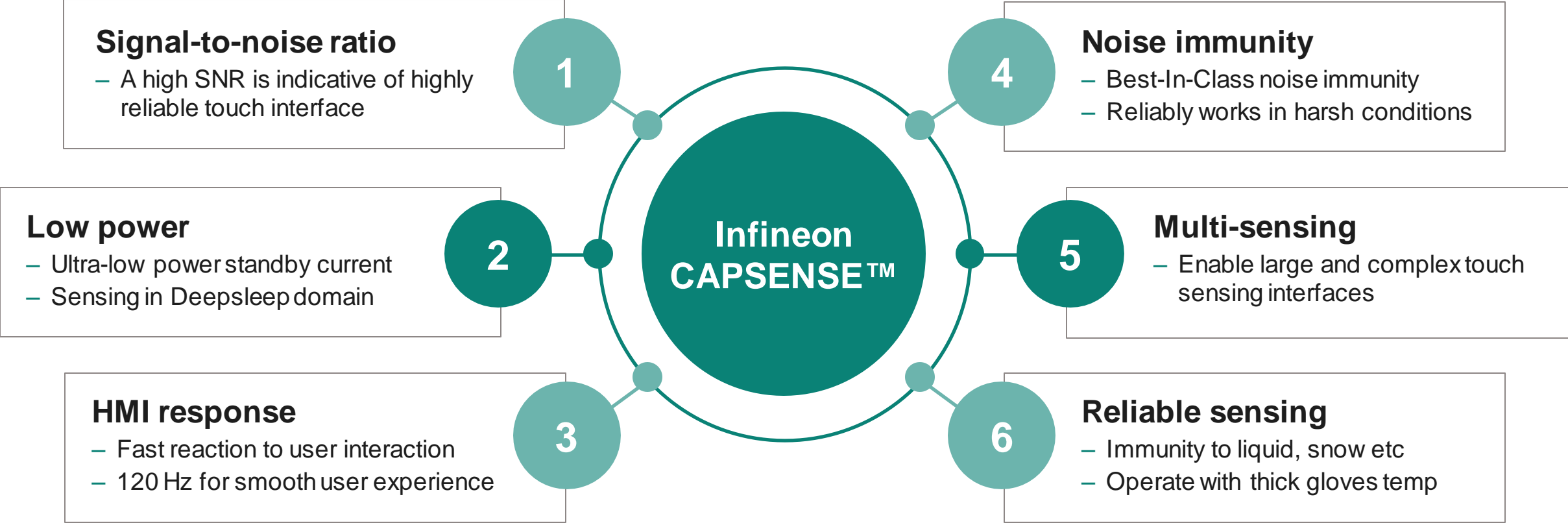
# CAPSENSE™ sensors

# CAPSENSE™ and applications

- Capacitive sensing has changed the face of the modern products and the way users interact with them
- CAPSENSE™ is Infineon's proprietary capacitive sensing technology used in touch user interfaces
- Replaced over 6+ Billion conventional buttons



# CAPSENSE™ touch-sensing technology



# 5<sup>th</sup> generation sensing technology – Multi sense converter

Feature	Higher SNR	Lower power	Higher refresh rate	Improved linearity	Supply rejection
Differential (rail-rail) sensing	✓				
Ratio metric sensing	✓				
Autonomous scanning		✓	✓		
Multi-channel	✓		✓		
Dithering				✓	
Full wave conversion (2x CMOD)					✓

# XENSIV™ automotive sensors



Child presence detection



Car security



Vital sensing



Seat Occupancy

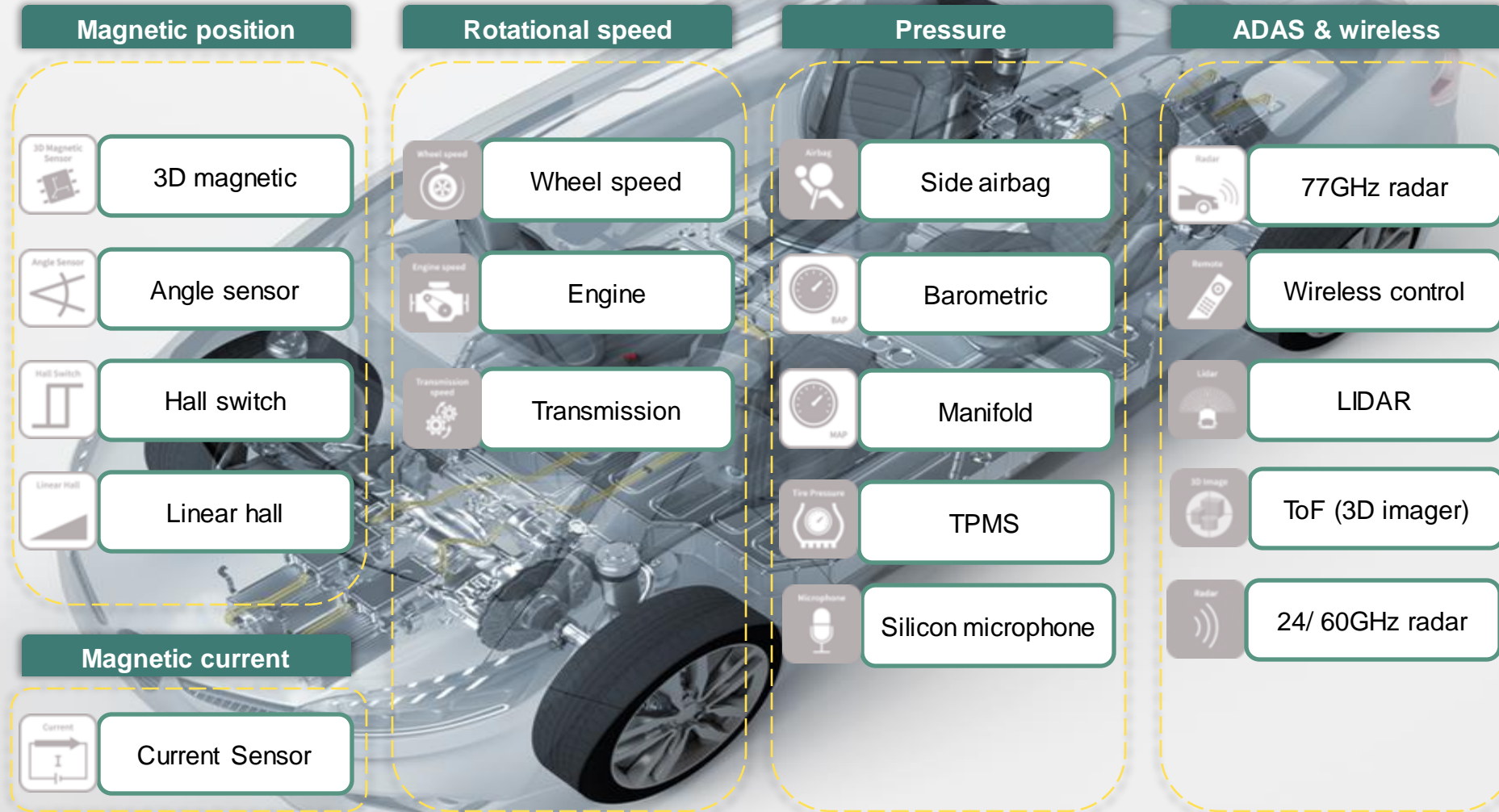


Gestures



# A broad sensor portfolio for automotive

## Leading market positions in key applications



# From 'sensor' to 'sensor system solutions'

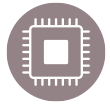


# An holistic sensor systems approach is required to successfully create new use cases



## Co-development & co-optimization challenge

- Skills and organizational challenge
- Cross functional teams
- Partners and ecosystem



### Sensor and IC technology

- Sensor technology, heterogeneous packaging, power management



### Edge AI

- Tools, DNN, edge NPU



### Layers of analytics from sensor to cloud

- Runtimes, containerization, load balancing, OTA

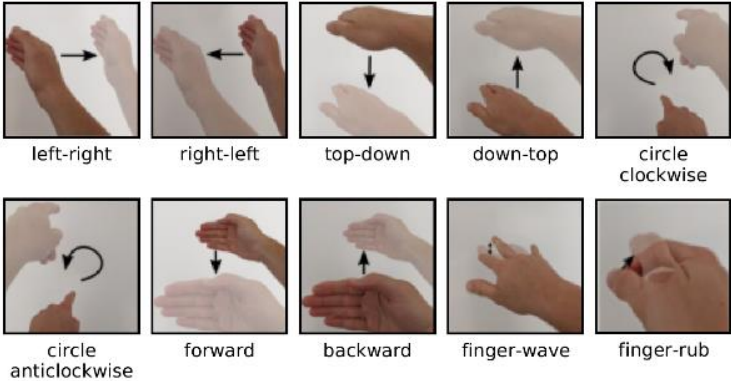
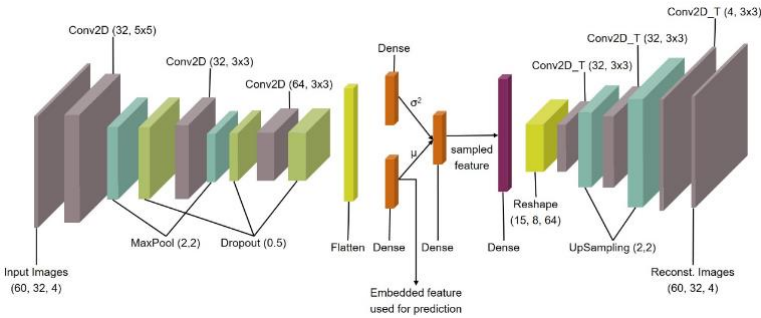


### Connectivity and security

- Interoperability, ease of use, reliability, energy efficiency

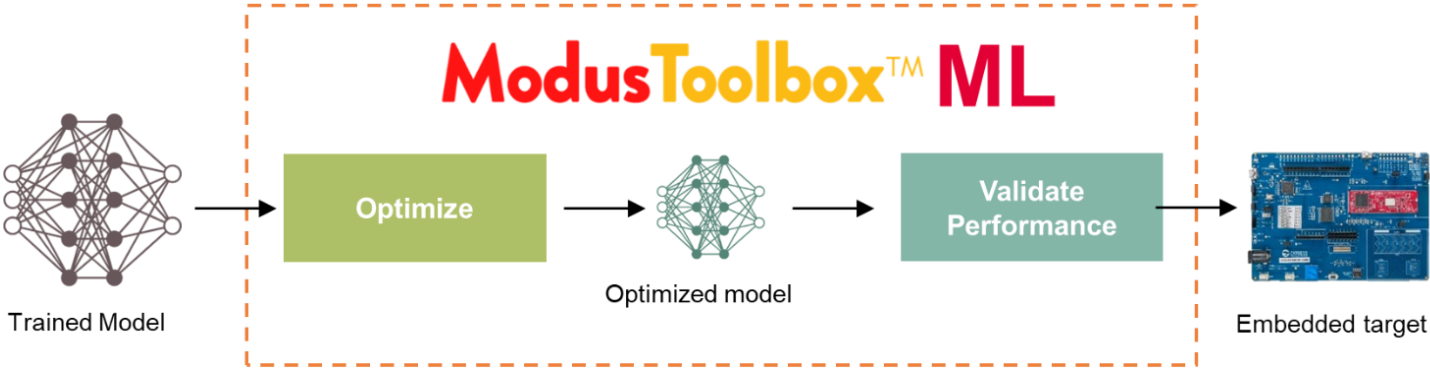
# Edge analytics and AI

## Radar gesture recognition example (Cortex M4, DNN 30KB)

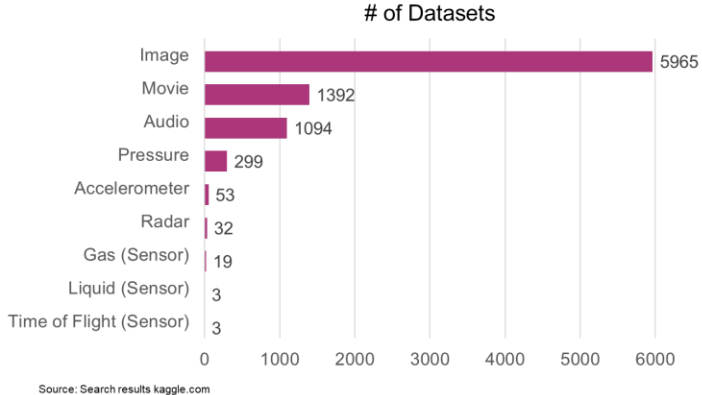


Large deep neural networks can be adapted to small embedded systems

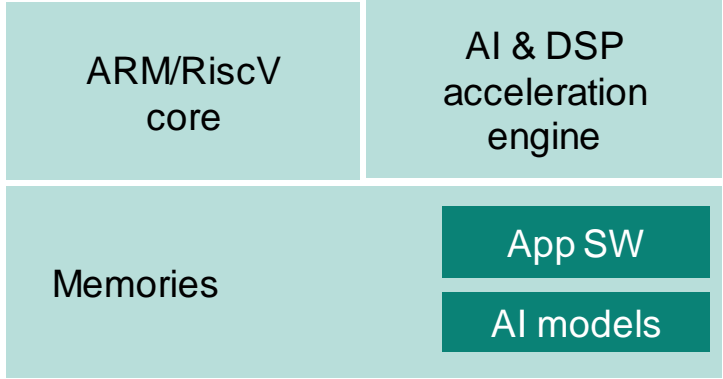
## Embedded NN development framework



## Datasets creation and management



## Embedded NPU and signal processing



# Layers of analytics from edge to cloud

## Load balancing sensor-edge-hub-cloud



**A critical business choice:** cost of ownership, upgradability, energy consumption, user experience depend on it



- Energy efficiency
- Privacy
- Latency

A mix of analytics layer which can be moved dynamically

- Complexity
- Flexibility
- Upgradability
- Data fusion



OTA upgrades,  
Edge containerization  
runtime (incl. MCU)



Interoperable  
connectivity & security  
frameworks (eg. Matter)

# Sensor system in action

## XENSIV™ connected sensor kit (CSK)



### Selected use cases...

Entrance counter

Presence detection

CO<sub>2</sub> monitoring

### ...being extended.

