Sensors: PAS CO2 & Radars

September, 2022

XENSIV™ PAS CO2 Sensor

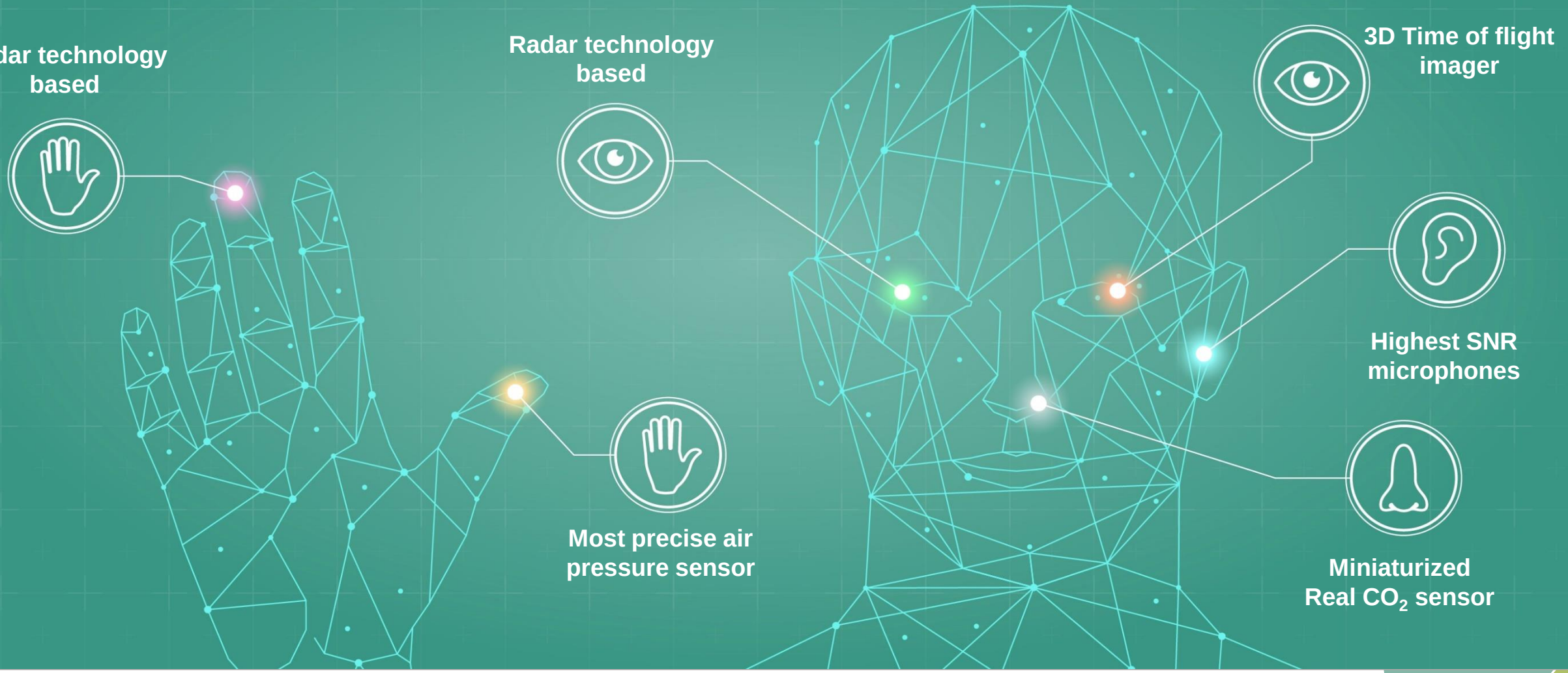
Measure what matters

Agenda

1. Infineon XENSIV™ sensors & vision of smart nose
2. Why does CO_2 measurement matter?
3. Introducing XENSIV™ PAS CO2

Infineon's broad sensor portfolio makes our lives easier by synchronizing devices to human needs

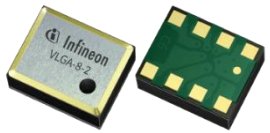
Infineon XENSIV™ sensors are exceptionally precise thanks to industry-leading technologies.
They are the perfect fit for various customer applications in automotive, industrial and consumer markets.



The Smart Nose – track your environment anytime, anywhere, in a smart, easy-to-use and affordable way – for a better and healthier life!

Infineon XENSIV™ sensors – simulate the human senses

Smart feel

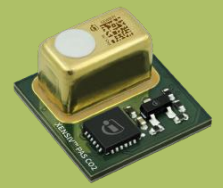


Most precise air pressure sensor

Smart eyes^{R}

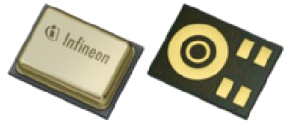
3D Radar technology based

Smart nose



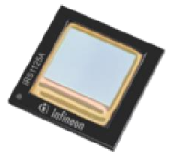
Environmental Sensing

Smart ears



Highest SNR Microphones

Smart eyes^{T}



3D Time of flight camera based

1 Growing health concerns due to air pollution

2 Demand for indoor- and outdoor comfort and well-being

3 Need for energy efficiency in buildings (HVAC systems, on demand ventilation)

Missing cost-effective, miniaturized and accurate sensor solutions & technologies in the market as of today

Vision: Everyone can track the environment they are in anytime, anywhere, in a smart, easy-to-use and affordable way – for a better and healthier life!

Focus on environmental sensors for indoor-, outdoor air quality sensing and breath & food analysis

Vision

Everyone can track the environment they are in anytime, anywhere in a smart, easy-to-use and affordable way – for a better and healthier life!

	Target gases	Applications	Use cases
Indoor air quality monitoring		Air purifier Aircon Ventilation	› Comfort & well-being › Health – reducing risk of virus transmission › Demand controlled ventilation
Outdoor air quality monitoring		Re-route Pollution heat maps City management	› Accurate pollution exposure notifications › Navigation support & Traffic control › Data selling: gyms (indoor training), cosmetic companies
Breath and food analysis		Fitness tracking Asthma monitoring Food quality	› Recommendations for oral/breath hygiene e.g. Alco-test (automotive) › Fitness condition tracking › Food screening

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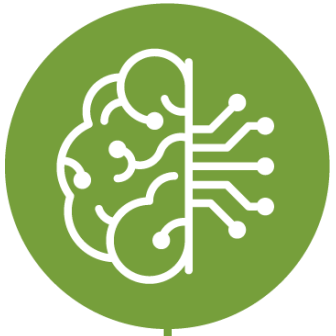
3. Introducing XENSIV™ PAS CO2

Why does CO_2 measurement matter?

Indoor air quality monitoring



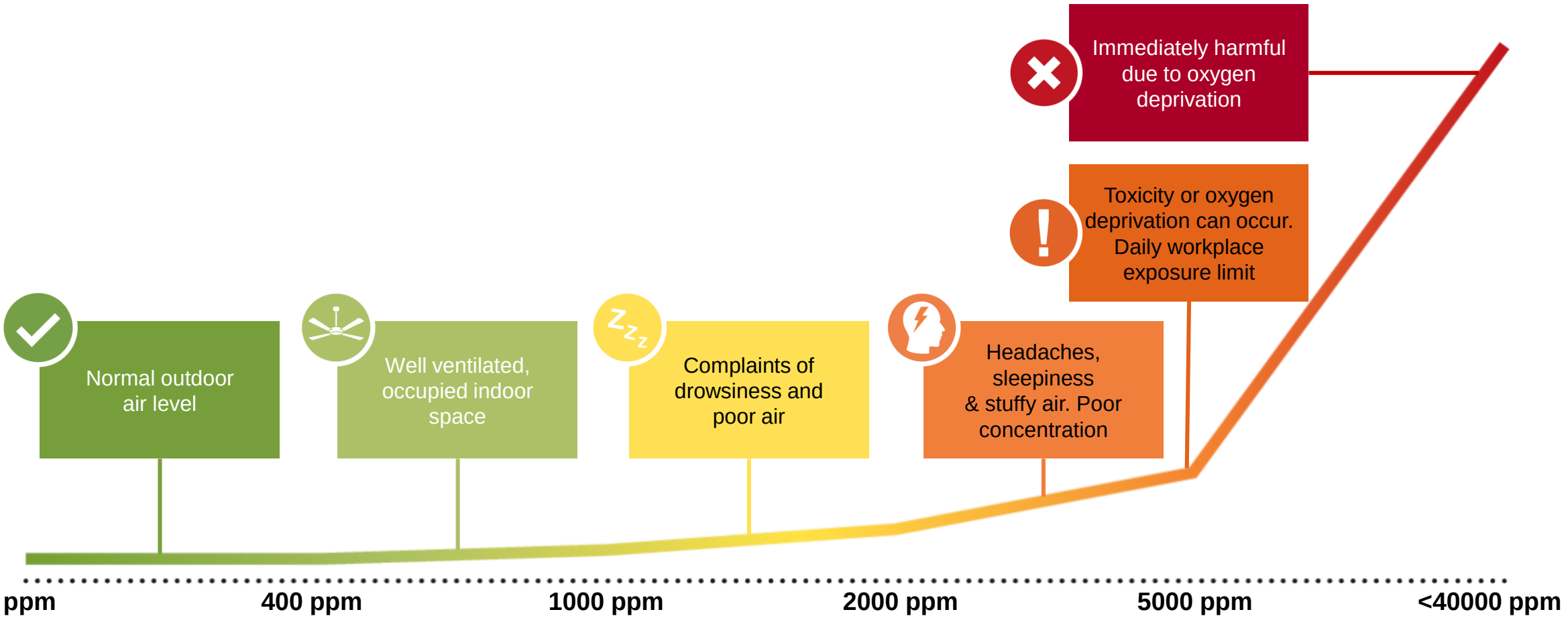
...for our comfort & well-being

...for health – reducing the risk of virus transmission

…for demand controlled ventilation & energy (cost) savings

CO_2 measurement matters, because CO_2 is a key parameter in indoor air quality and thus for our comfort & well-being

...for our comfort & well-being



Source: Wisconsin Department of Health Services; Fisk et. al.

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Introducing a disruptive real CO_2 sensor based on the photoacoustic spectroscopy (PAS) principle

Measure what matters – XENSIV™ PAS CO2

XENSIV™ PAS CO2

- **Real CO_2 sensor ensuring high data quality**
- **Small form factor in SMD package for easier assembly**
- **Plug & Play for fast customer design-to-market**
- **Infineon's quality and supply guarantee**

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

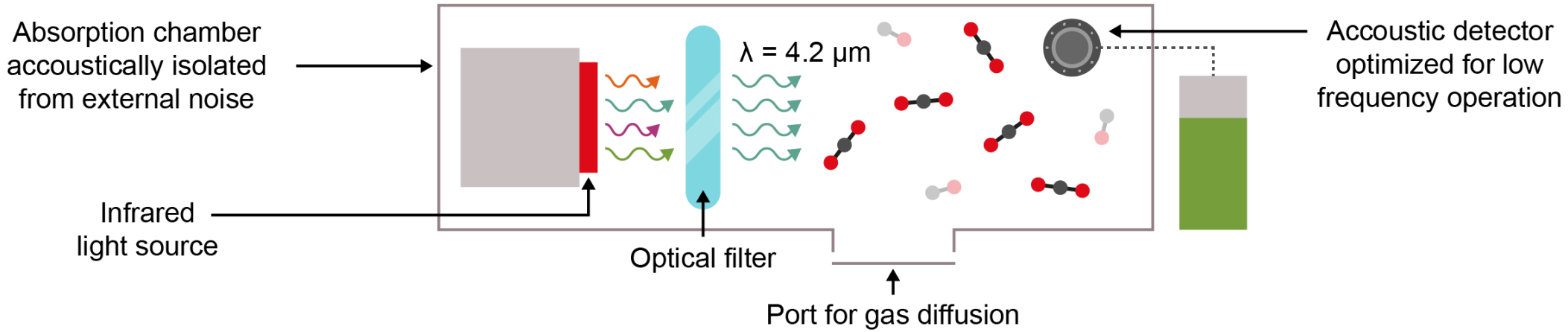
HVAC	Air quality devices	Consumer devices	Smart home / Building appliances
			

Customer benefits

- **Air quality awareness**
- **Higher comfort levels**
- **Healthier life**
- **Lower energy consumption**
- **Increased productivity**
- **Energy cost savings**

XENSIV™ PAS CO2 makes use of the photoacoustic principle to disrupt established NDIR technology for CO_2 detection

PAS – Photoacoustic Spectroscopy principle for CO_2 detection



Principle

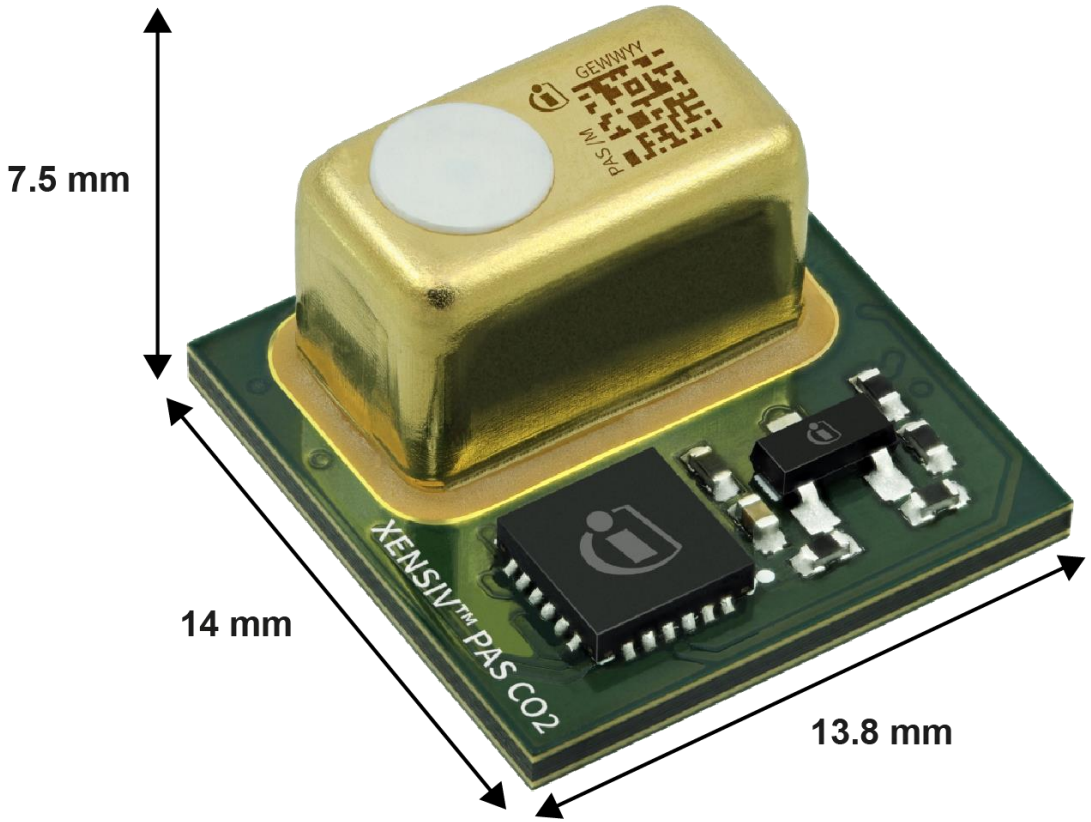
- Infrared emitter with blackbody radiation characteristic – periodically chopped
- Optical filter to filter wavelength related to specific gas (λ = 4.2 µm for CO_2)
- Low frequency acoustic detector acting as a pressure sensor
  - CO_2 molecules absorb light
  - Absorption causes a periodic local change of temperature and pressure
  - Change in pressure detected by the acoustic detector

Detector

- The absorption chamber is acoustically isolated from the external environment to provide accurate CO_2 sensing information, otherwise the function of CO_2 would be significantly disrupted
- The detector is optimized for the low frequency range outside of the most important frequencies for speech and language

All key components of the XENSIV™ PAS CO2 module are developed in-house in accordance with Infineon's high-quality standards

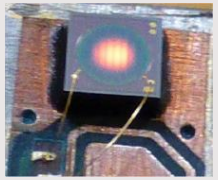
Key building blocks of XENSIV™ PAS CO2 Sensor Module



Sensing Chamber:

Emitter package (Filter & IR Emitter):

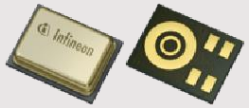
Optical Filter for 4.26um light wavelength



MEMS Heater for light beam

Acoustic Detector: optimized for low frequencies

XENSIV™ MEMS Microphone



MOSFET to drive MEMS Heater supplying stable 12 V supply

PAS CO2 Microcontroller running compensation firmware delivering CO_2 levels in PPM level supporting I2C, UART, PWM interface

XENSIV™ PAS CO2 beats NDIR in size and cost, with the same or even better performance

Comparison of CO_2 sensing technologies

Parameter	XENSIV™ PAS CO2	NDIR	EC	eCO_2
Size	🟡	🔴	🟡	🟢
Cost	🟡	🔴	🟡	🟢
Accuracy	🟢	🟢	🟡	🔴
Long term drift	🟡	🟡	🔴	🔴
Warming time	🟢	🟢	🔴	🟡
Response time	🟢	🟢	🟡	🟢
Selectivity	🟢	🟢	🔴	🔴
Humidity impact	🟢	🟢	🔴	🔴
Power consumption	🟡	🔴	🔴	🟢

worst 🔴 🟡 🟢 best

PAS = Photo Acoustic Spectroscopy
NDIR = Non Dispersive Infrared Light
EC = Electrochemical
eCO_2 = equivalent CO_2

Specifications of XENSIV™ PAS CO2 sensor

Range	0 – 32,000 ppm
Op temp & relative humidity	0°C – 50°C (Storage: -30°C – 85°C) / RH: 0 % to 85 % (no condensation)
Voltage	12.0 V for the emitter & 3.3 V for other components
Accuracy	+/-30 ppm +-3 % of reading (up to 5,000 ppm at ambient conditions)
Pressure dependence	0.1 %/ hPa without compensation
Power Consumption	30 mW at 1 readout / min
Response time T63 %	90 sec
Signal Update	On-Demand or Continuous: 1 readout / 5 sec to 1 readout / 4095 sec
Drift	< 1 % per year with compensation algorithms enabled
Lifetime	10 years (in continuous mode: 1 readout / min)
Interface	UART, PWM, I^2C
Size & package	SMD; ~13.8 x 14 x 7.5 mm^3

Disclaimers: The specifications are not final. These are targeted spec. and might change in the course of the development.

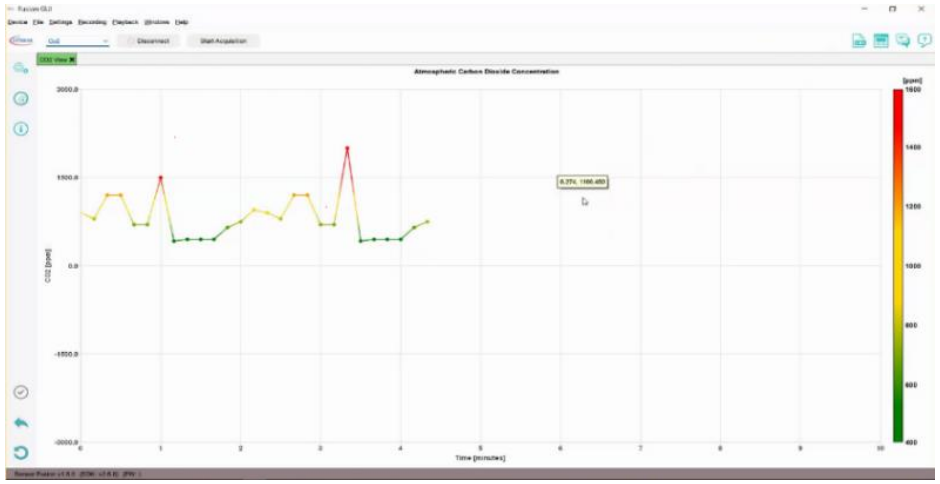
XENSIV™ PAS CO2 Sensor2Go Evaluation Kit

- The **XENSIV™ PAS CO2 Sensor2Go Evaluation Kit** has been developed to enable the fast evaluation of Infineon's revolutionary **P**hoto **A**coustic **S**pectroscopy CO_2 sensor.
- **FEATURES**
  - Plug and play: direct connection to PC via micro USB
  - All power supplies generated on board
  - Logging of the sensor history
  - All key functionalities of the sensor available
  - Multiple XENSIV™ PAS CO2 Mini Evaluation Boards can be connected to the motherboard
  - Device can also be accessed via I2C
- **The XENSIV™ PAS CO2 Sensor2Go Evaluation Kit includes:**
  - XENSIV™ PAS CO2 Evaluation Motherboard
  - XENSIV™ PAS CO2 Mini Evaluation Board
  - Micro-USB cable
  - Graphic user interface (GUI)

WEBSITE & Docs
GET STARTED VIDEO

Sensor2Go Kit overview

Sensor2Go Kit Graphical User Interface



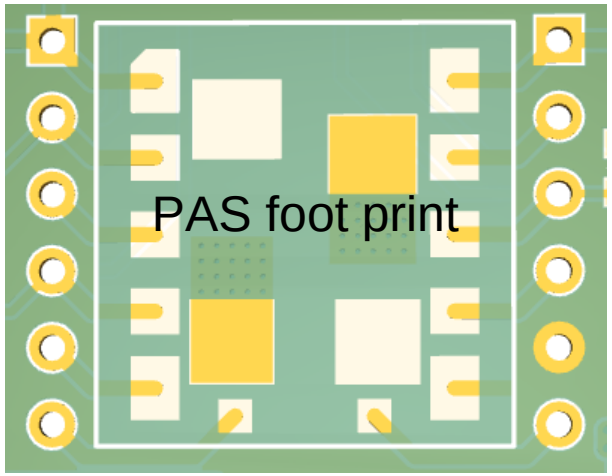
XENSIV™ PAS CO2 Mini Evaluation Board

- The **XENSIV™ PAS CO2 Mini Evaluation Board** enables the fast prototyping of a CO_2 sensing application using Infineon's revolutionary **P**hoto **A**coustic **S**pectroscopy CO_2 sensor
- Using a standard pin header, it can be plugged-in very easily in a target application board, providing flexibility to PCB designers
- The XENSIV™ PAS CO2 Mini Evaluation Board can be ordered in smaller quantities: this is more convenient in the early stage of an application development compared to a standard Reel.
- **FEATURES:**
  - Easy connection to application board with standard 2.54mm pin header – no reflow process needed
  - Access to all signals and functions of the product
  - Compatible with a combined PCB layout supporting reflow assembly for later use
  - Compatible with PAS CO2 Sensor2Go Evaluation Kit for easy lab evaluation

WEBSITE & Docs
GET STARTED VIDEO

Mini Evaluation Board overview

Example of combi PCB layout



Order information I Sensor2Go Evaluation Kit & Mini Evaluation Board

	Environmental Sensor Group	
Board/ Kit	XENSIV™ PAS **CO2 Sensor2Go Evaluation Kit**	XENSIV™ PAS CO2 **Mini Evaluation Board**
Meant for…	Customers - Plug & Play Performance assessment	Customers – Design In & Prototyping
Includes	› XENSIV™ PAS CO2 Evaluation Motherboard › XENSIV™ PAS CO2 Mini- Evaluation Board › Micro-USB cable › GUI (Graphical USER Interface) & software	XENSIV™ PAS CO2 Mini Evaluation Board (Compatible with PASCO2 Sensor2Go Evaluation Kit)
Available for Distributors	**July 2021**	**July 2021**
Sales Name	**EVAL_PASCO2_SENSOR2GO**	**EVAL_PASCO2_MINIBOARD**
SP (Sales Part code)	**SP005582413**	**SP005577475**
OPN (Orderable Part Number)	**EVALPASCO2SENSOR2GOTOBO1**	**EVALPASCO2MINIBOARDTOBO1**

XENSIV™ Radar Sensors

Agenda

1. Radar Introduction
2. Application Overview
3. Product Overview
4. Evaluation Board Overview
5. Application Examples
6. Support

Among all sensing technologies RADAR offers the most opportunities

Radar detects any motion

- Radar can detect even the smallest kind of motion including vital signs
- No need to wave in front of motion triggered lighting systems or similar devices
- **Radar feels presence!**

Radar detects through obstacles

- Radar waves penetrate all non-conductive materials
- Radar sensors can be hidden in the end product allowing design flexibility
- **Radar sensing is anonymous!**

Radar is powerful

- Radar can sense distance, velocity, breathing & heart rate, gestures, track people and much more!
- Radar performance para-meters can be adjusted
- **Radar is versatile and flexible!**

Radar is robust

- Radar works in dark and all other lighting conditions
- Radar is robust to fog, dust and temperature
- Radar sensors do not require maintenance
- **Radar is environmentally resilient**

Infineon market leader in all relevant radar segments

Infineon has sold more than 200 million radar chips until now!

Automotive radar

- Market leader in automotive radar*
- Main applications:
  - Advanced Driver Assistance Systems
  - Smart Trunk Opener
  - Blind Spot Detection
  - Cabin sensing

*Yole Radar and
Wireless for Automotive Market and Technology Trends 2020

Industrial / IoT radar

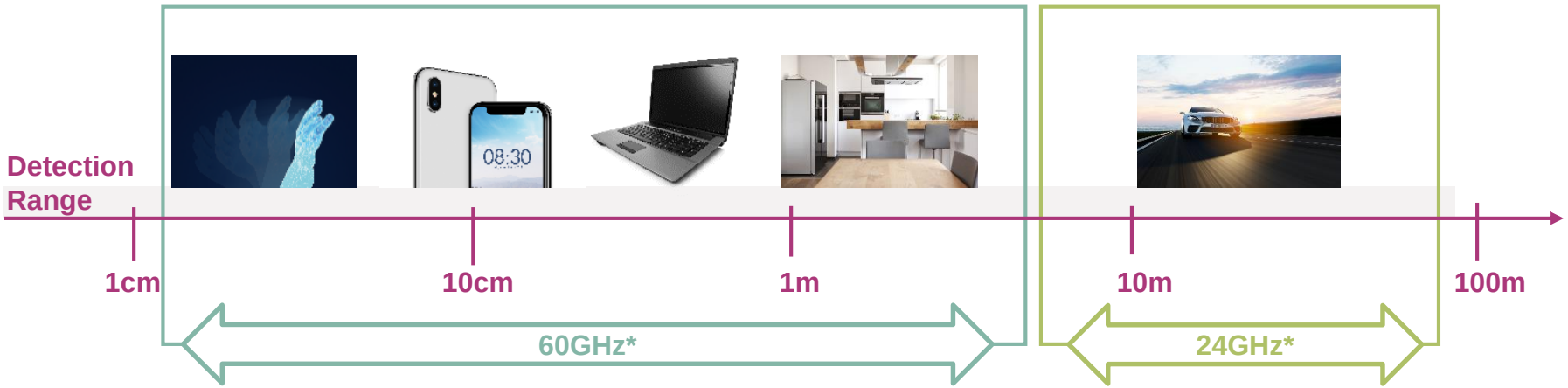
- First company to have a pure industrial radar product in the market
- Low cost, low size 24GHz addresses applications such as drones, lighting and security with presence detection, tracking and distance measurement
- Addressing presence detection&motion sensing market with new low cost 60GHz solution

Consumer radar

- Google's Pixel 4 is the first consumer product using radar technology for gesture sensing and presence detection
- Several ongoing projects for desgin-in into further consumer goods

Image from: https://store.google.com/us/product/pixel_4

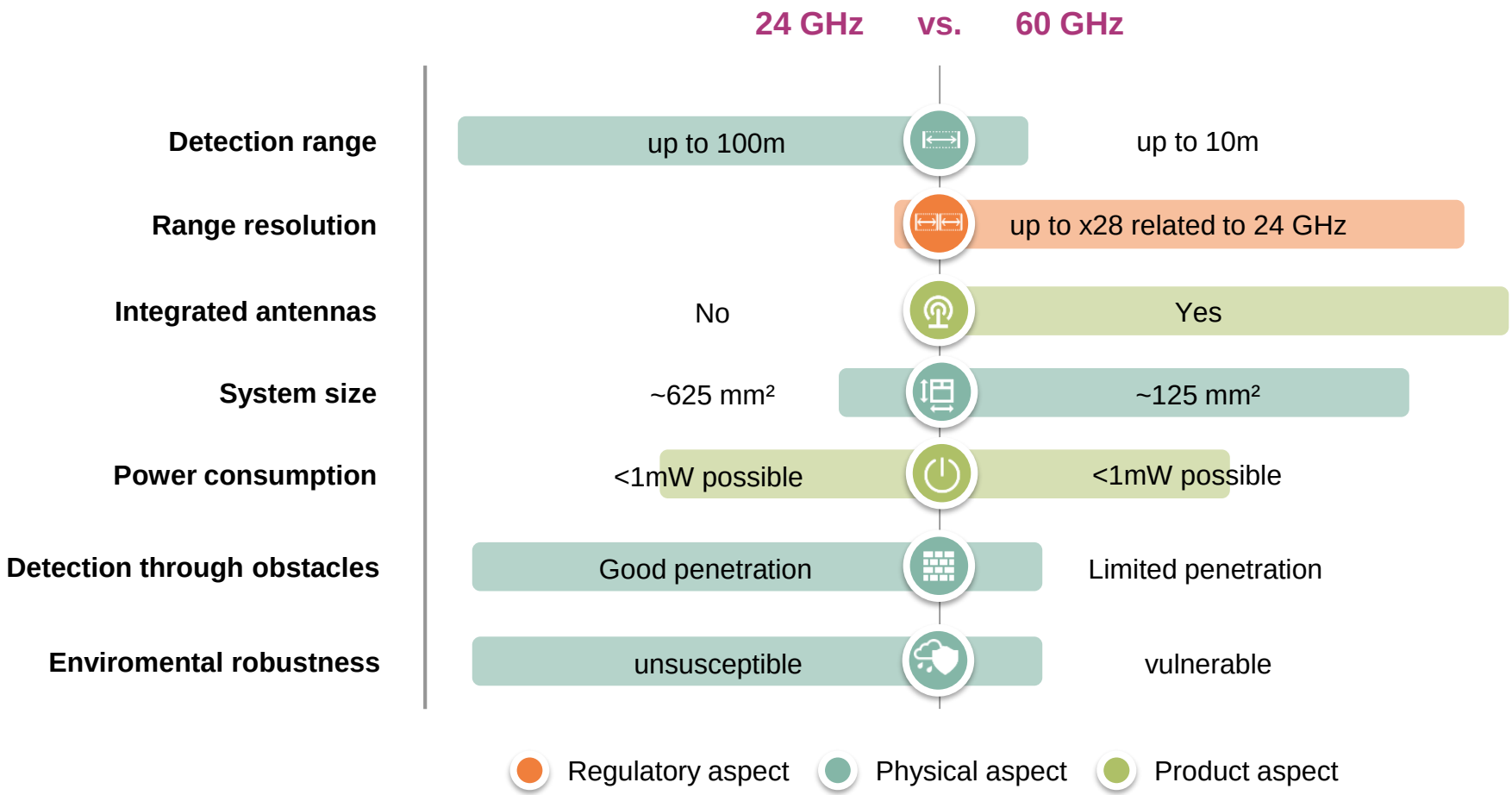
With our 60 GHz radar sensors we address different segments than with our established 24 GHz portfolio



	60GHz Radar BGT 60TR13C & BGT 60LTR11AIP	24GHz Radar BGT 24xTRxx Series
Range Resolution (Target separation)	High (up to 2,5cm)	Medium (up to 75cm)
RF System Size	20mm x 6.25mm	25mm x 25mm
Antenna Integration	Integrated Antennas	External Antennas
Environmental Factor Robustness	Weak	Moderate
Material Penetration	Lower (indoor usage)	Higher (outdoor usage)
Sensitivity	Higher (sub-mm)	Lower

*Dependent on Application and System

Decide on the right frequency depending on your personal requirements towards the radar system



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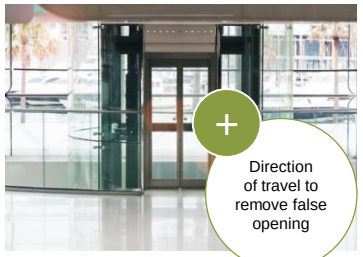
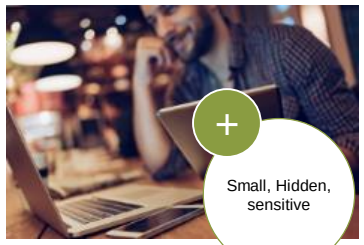
Use cases for radar sensors are versatile.

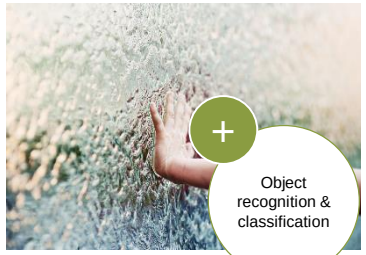
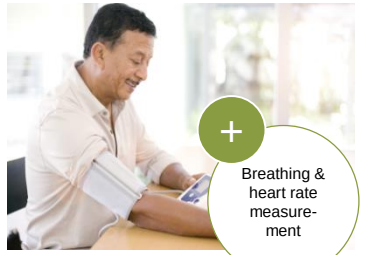
→ Radar can be deployed in many different applications.

Applications for Radar

Motion detection

Smart Home	Door opening	Security	Lighting	Monitors & Laptops
				
+ Robust, Discreet, small	+ Direction of travel to remove false opening	+ Privacy protection, and increased accuracy	+ Indoor, & outdoor. Resistant to harsh weather	+ Small, Hidden, sensitive

Advanced sensing

Gesture control	Material detection	Smart Appliances	Robotics	Vital sensing
				
+ Additional gesture package available	+ Object recognition & classification	+ Robust, small footprint, accurate	+ Safety, accuracy and efficiency	+ Breathing & heart rate measure-ment

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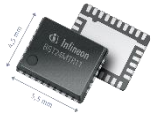
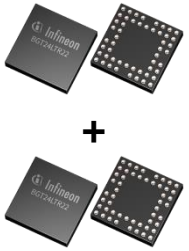
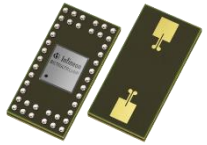
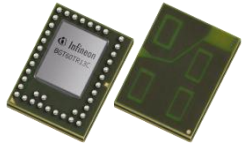
Broad Product Portfolio for 60GHz and 24GHz

	1Tx / 1Rx	1Tx / 2Rx	1Tx / 3Rx	2Tx / 2Rx	2Tx / 4Rx
60GHz	PIR replacement 3.3x6.5 mm² BGT60LTR11AIP Doppler Radar Antenna-in-Package Demo Kits available, SOP 2021		Consumer 5 x6.5 mm² BGT60TR13C FMCW Radar Antenna-in-Package Available		
24GHz	 *2.4 x 2.4 mm* **BGT 24LTR11**  *4.5 x 5.5 mm* **BGT 24MTR11**	 *4.5 x 5.5 mm* **BGT24MTR12**	 **BGT24MTR11** **+ BGT24MR2**	 *3.6 x 3.6 mm* **BGT24LTR22**	 **Cascading** **BGT24LTR22**

Broad Product Portfolio for 60GHz and 24GHz

	1Tx / 1Rx	1Tx / 2Rx	1Tx / 3Rx	2Tx / 2Rx	2Tx / 4Rx
60GHz	PIR replacement  3.3x6.5 mm² **BGT60LTR11AIP** Doppler Radar **Antenna-in-Package** **Demo Kits available, SOP 2021**		Consumer  5 x6.5 mm² **BGT60TR13C** FMCW Radar **Antenna-in-Package** **Available**		
24GHz	 *2.4 x 2.4 mm* BGT 24LTR11 *4.5 x 5.5 mm* BGT 24MTR11	 *4.5 x 5.5 mm* BGT24MTR12	 BGT24MTR11 + BGT24MR2	 *3.6 x 3.6 mm* BGT24LTR22	 Cascading BGT24LTR22

BGT60LTR11AIP – Infineon‘s most integrated, smallest and simplest motion sensor solution

A real PIR replacement

- Our 1st low cost radar sensor for motion detection without a microcontroller.
- Doppler radar with integrated analog baseband and detectors.
- Adding a MCU allows to increase distance.

Autonomous mode

- Detection range up to 5m
- Field of View: 80° (+/- 40° HPBW)
- Power consumption less than 5 mW
- Provide direct output on motion and direction of motion

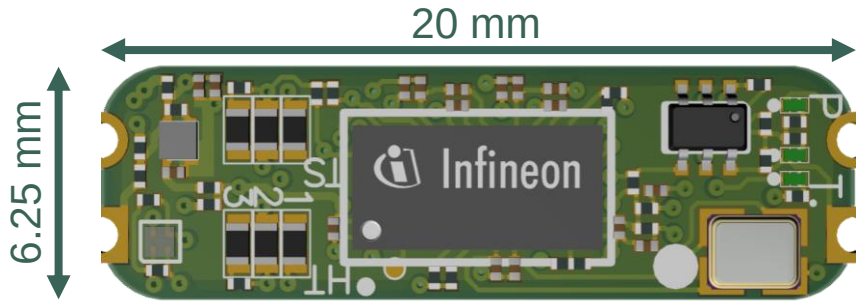
SPI mode

Same features as in autonomous mode supplemented by:

- Increased detection range up to 10 m by FFT
- Possibility to achieve < 2mW power consumption with microcontroller

Key figures

- 3.3 x 6.7 x 0.56 mm
- 1Tx 1Rx Transceiver with Antennas in Package (AIP)
- 1.5 V supply voltage
- 1-4 mA pulsed mode current consumption
- 42 pin package
- Quad states enabling flexibility in the completely autonomous mode



Shield provides the supporting circuitry to the BGT60LTR11AIP MMIC.

Even in the autonomous mode performance flexibility is provided by the implementation of four quad states

Four input pins allows to change the settings of the MMIC for up to 16 different states.

1. Radar operation mode

› Select between autonomous, pulsed, SPI with 9.6 MHz and SPI mode

2. Detector sensitivity

› Choose between 16 different sensitivity levels

3. Signal hold time after detection

› Choose between 16 different signal hold times

4. Device operating frequency

› Select 4 level between 61.1 – 61.4 GHz, resp. 60.6 – 60.9 GHz (Jp)

Infineon Toolbox

› In SPI mode, the radar raw data can be extracted for signal processing on PC or an external microcontroller unit (MCU).
› Infineon's Toolbox supports this platform with a demonstration software and a radar graphical user interface (Radar GUI).

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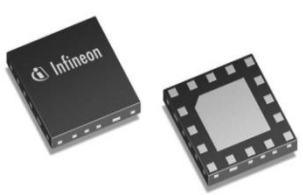
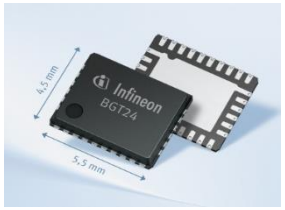
24 GHz Radar ecosystem with Infineon

Features

- 24 GHz transceivers for motion, speed, direction movement, distance, and angle measurements
- 4 MMIC chips available

IFX MMIC





MMIC

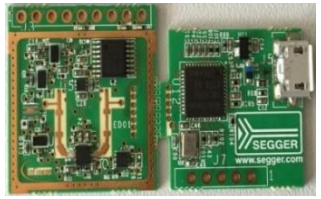
Benefits

- Wide portfolio covering your application requirements
- Long detection range
- Wide range speed detection up to more than ±100 km/h

Features

- 3 system boards available
- All include 24 GHz radar and XMC™ microcontroller
- SW available

IFX development Kit



Software

Demokit with SW, reference design

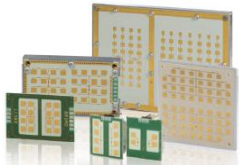
Benefits

- Reference designs enable fast prototyping reducing time to market
- SW source code enables fast debugging and customization

Features

- Complete module, including radar MMIC, antenna options, MCU signal processing options, and SW options

Partner modules using IFX Chip



Module (RF module; RF module + MCU including SW)

Benefits

- Ease of design
- Turn-key solution eliminating the need for certification and testing

Infineon Radar board & chip selection guide

Basic motion detection

- Motion
- Speed
- Direction

Boards: Sense2GoL Pulse
Products:
BGT24LTR11
Operation: doppler

Applications:
lighting, security, door openers, vital sensing

Key benefits:
- High sensitivity
- Small size
- Can be hidden
- Robust to environmental conditions
- Provides speed and direction information
- Long detection rage
- Adjustable FOV and distance with antenna design
- Extremely low power consumption

Intermediate

- Motion
- Speed
- Direction
- Distance

Boards: Distance2GoL
Products:
BGT24LTR11 & BGT24MTR11
Operation: FMCW & FSK

Applications:
- Smart toilets
- Drone soft landing
- Drone collision avoidance
- Robotics collision avoidance
- Level sensing
- Smart switches
- Vital sensing (from a distance)

Key benefits:
Basic motion PLUS+
- Insensitive to vibrations
- Resolution not degrading with target distance

Advanced 3D sensing

- Motion
- Speed
- Direction
- Distance
- Angle

Boards: Position2Go
Products:
BGT24MTR11, BGT24MR2, BGT24MTR12
Operation: FMCW & FSK

Applications:
- Drone collision avoidance
- Robotics collision avoidance
- Vital sensing (from a distance)
- HVAC, SMART Home, IOT

Key benefits:
Intermediate PLUS+
- Ability to track people
- Positioning of target(s)

For turnkey solutions please see our "Partner Module Matrix"

Evaluation Kit for 60GHz

- ✓ Plug-and-Play Experience
- ✓ Multiple Chip Compatibility/Modularity
- ✓ Fast USB connection

Radar Baseboard MCU7 + BGT60TR13C /LTR11 Shield = Demo BGT60TR13C BGT60LTR11

The BGT60LTR11AIP demo kit features Infineon's first completely autonomous radar sensor

For evaluation of the BGT60LTR11AIP MMIC, the demo kit includes the BGT60LTR11AIP shield with the radar sensor MMIC as well as the Infineon Radar Baseboard MCU7.

BGT60LTR11AIP MMIC

State machine **enables operation of the BGT60LTR11AIP without any external microcontroller**

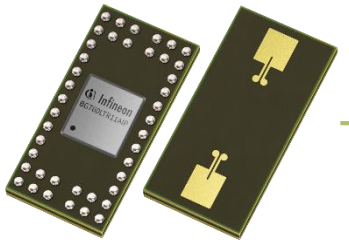
MCU7 Radar baseboard

Infineon's Toolbox supports the demo kit with a demo software and a radar graphical user interface (Radar GUI) to display and analyze acquired data in time and frequency domain.

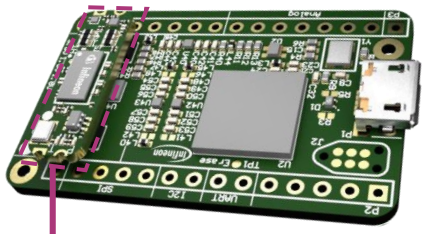
BGT60LTR11AIP shield

Two LEDs illustrate the output of the radar sensor

- Green LED for target detection
- Red LED for direction of motion

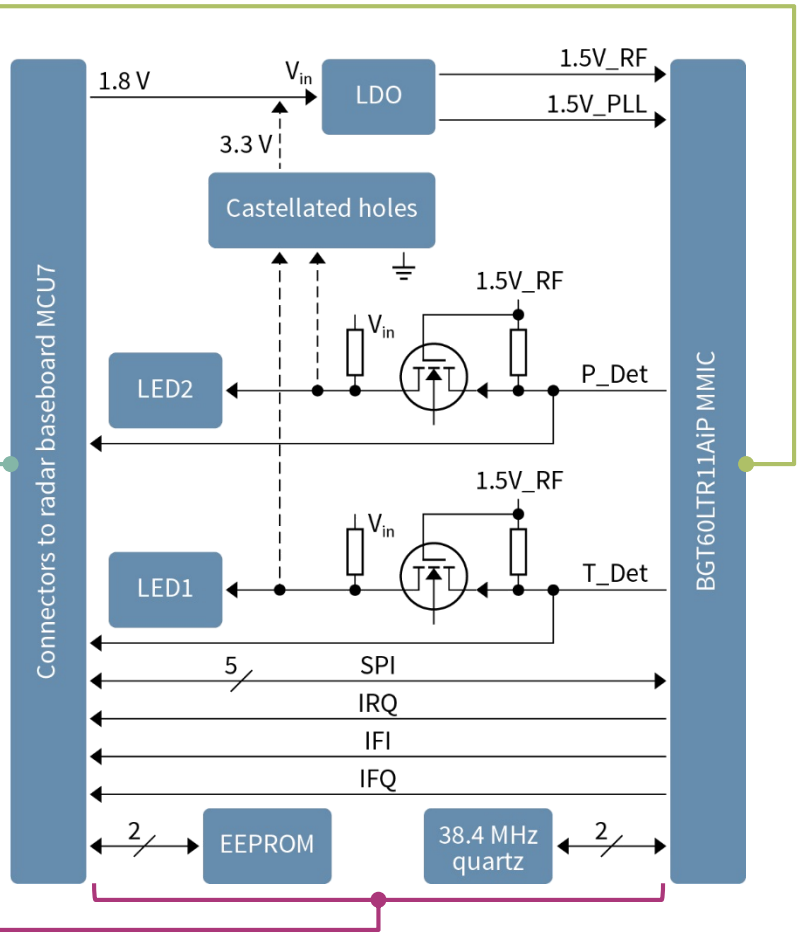


3.3 x 6.7 x 0.56 mm



25.4 x 40.6 mm

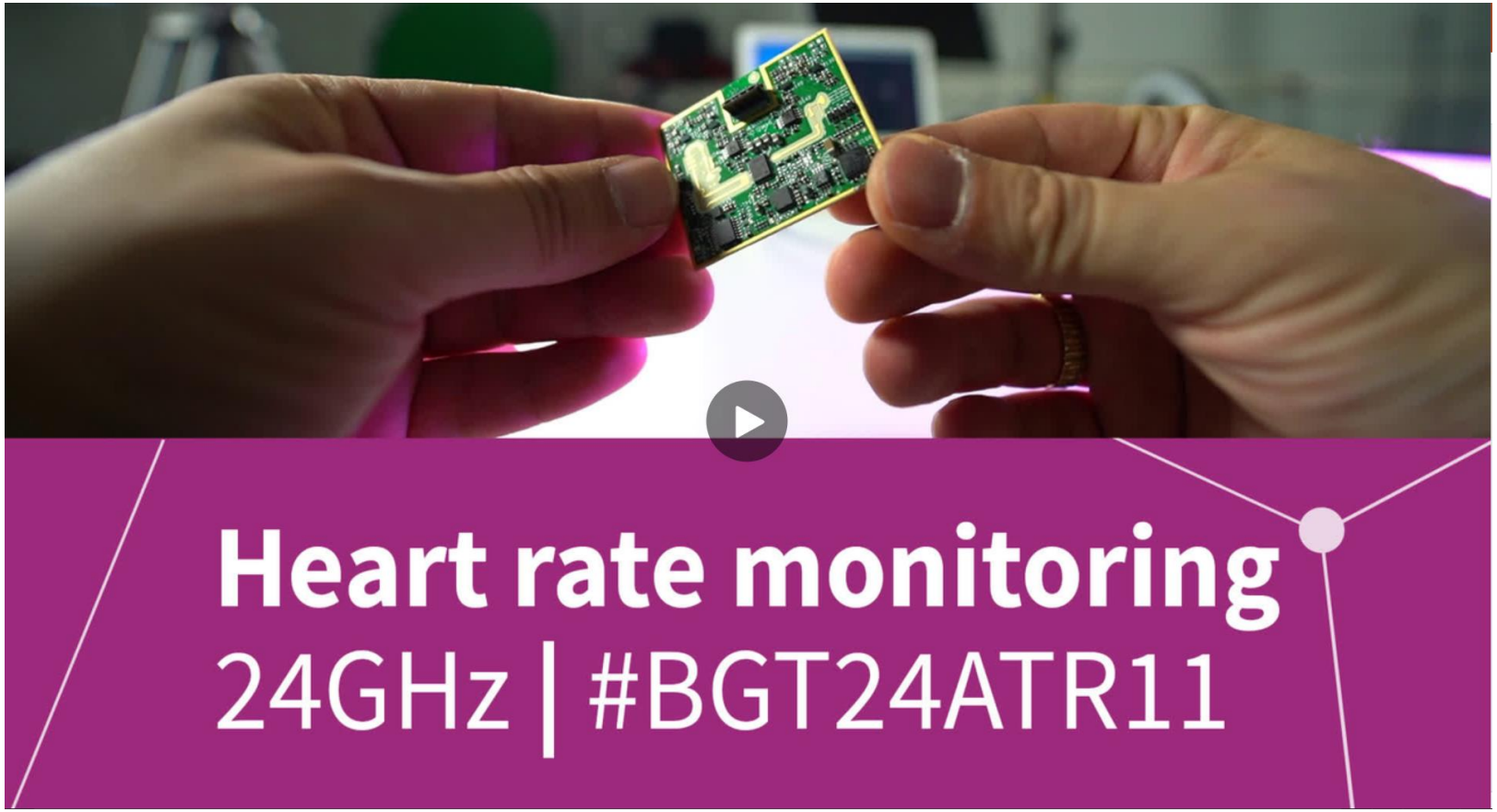
6.5 x 20.0 mm



Agenda

1. Radar Introduction
2. Application Overview
3. Product Overview
4. Evaluation Board Overview
5. Application Examples
6. Support

24 GHz Radar



› Restoration- and heart-rate monitoring by Caaresys & Infineon

60 GHz Radar

› Motion Detection for Smart Home Applications

Agenda

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Partner offering eco-system

Objective and benefits of partner offering

Turnkey Radar solutions

- Faster time to market
- Leverage design house experience
- Utilize partner manufacturing capabilities

Radar / Antenna design

- Access to software
- Testing and certification
- Joint project development

Module manufacturing

Global network of partners

- **Explore global partner network:**
  ind. Radar partners

From distributors to Radar design houses through to module manufacturers

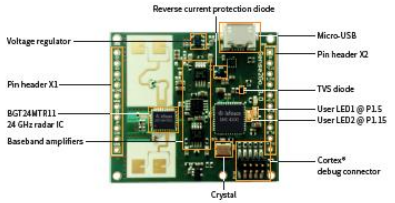
Regional module and/or system design house partners

Examples only: more partners available here

For details please contact your regional application & marketing team

Online support

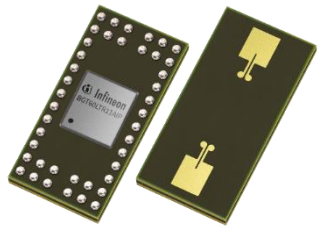
Collaterals and brochures	› Product briefs › Selection guides › Application brochures › Presentations › Press releases, ads	› www.infineon.com/24GHz
Technical material	› Application notes › Radar FAQ › Technical articles › Datasheets	
Evaluation boards	› Evaluation boards › Demoboards › Reference designs	› Ind. Radar Evaluation Boards
Videos	› Technical videos › Product information videos	› Infineon Radar Video Library



Online support

Marketing collaterals	– Product Brief – Product Presentation – Technical journal articles
Technical Documentation	– User Manual for BGT60LTR11AIP MMIC – Application Note for BGT60LTR11AIP shield – Preliminary datasheet on request – Radar wave propagation Whitepaper – BGT60LTR11AIP Radome Design cookbook
Hardware & Software files	– PCB Design Data & Altium Project file – Schematics – SW/FW binaries – Python Wrapper
Hardware	– Demo kit (SP005422969) – Final chip samples exp. for 06/2021 – Certified autonomous shield exp. for end ‘21
Videos & Trainings	– Product introduction/Unboxing Video – Online Training – BGT60LTR11AIP Demos – BGT60LTR11AIP vs. PIR Demos

– BGT60LTR11AIP documents
(All documents are visible after Log-In to myInfineon)



– Microwave Journal (11/2020)

– EETimes (02/2021)

– Webinar (01/2021; available on demand)

– Infineon Toolbox Tool “Radar Sensor BGT60LTR11AIP” incl. “Radar GUI” support

Documents
› Application Notes
› User Manuals

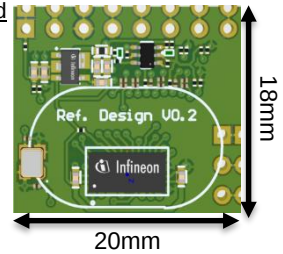
Firmware and Software
› Binary files

Hardware
› Altium Project
› Schematics
› Bill of Materials (BOM)
› Gerber data

› Download

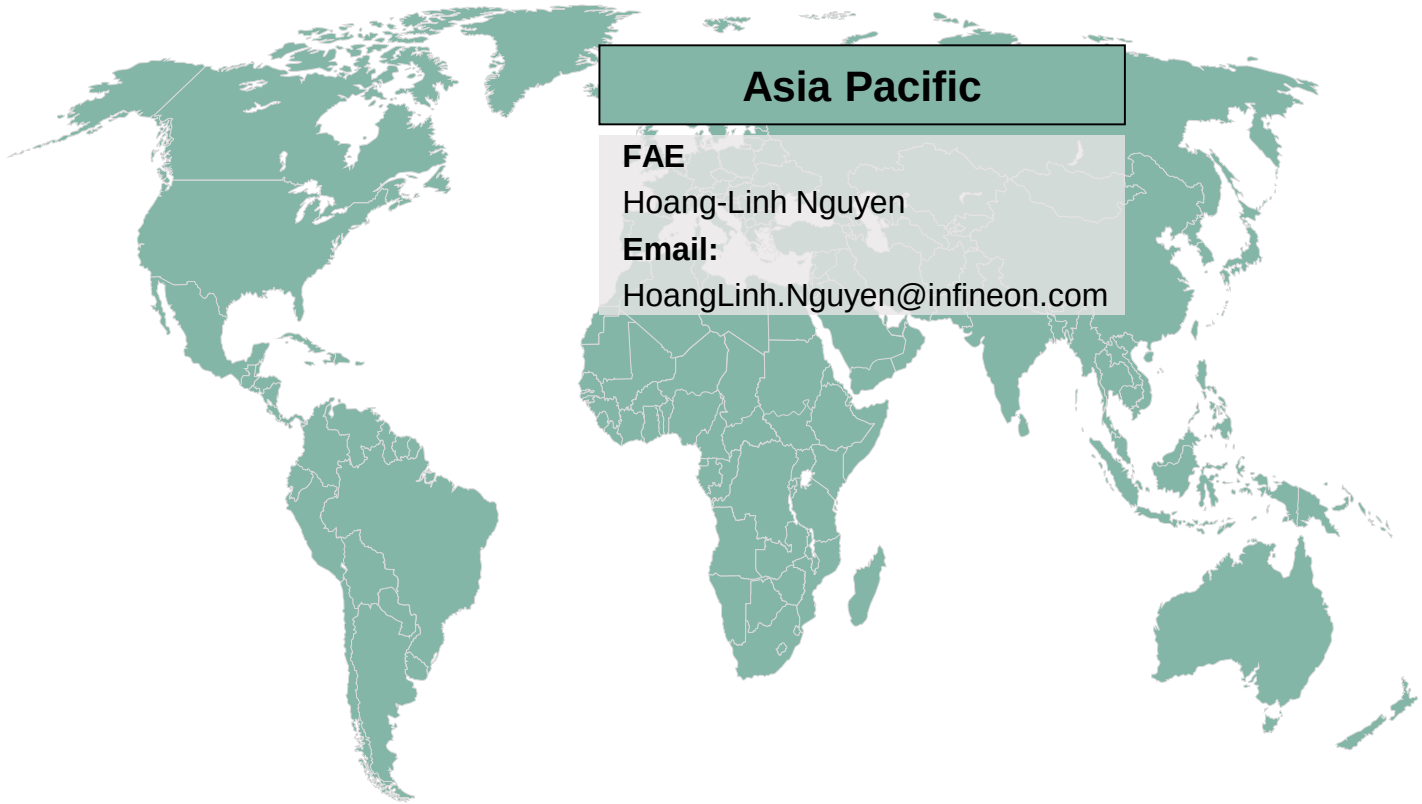
– BGT60LTR11AIP demo kit

Certified autonomous shield



– Product introduction video
– Online Training
– BGT60LTR11AIP demos

Technical Support



Asia Pacific

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Part of your life. Part of tomorrow.