

Infineon Computing Solution for IoT based Applications

Chu Voon Fui

Burapha University
Infineon Innovation
Launchpad

Infineon

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Future Made Possible by IoT



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Business growth in the semiconductor market is driven by four key trends

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Energy efficiency



Mobility



Security



IoT & big data



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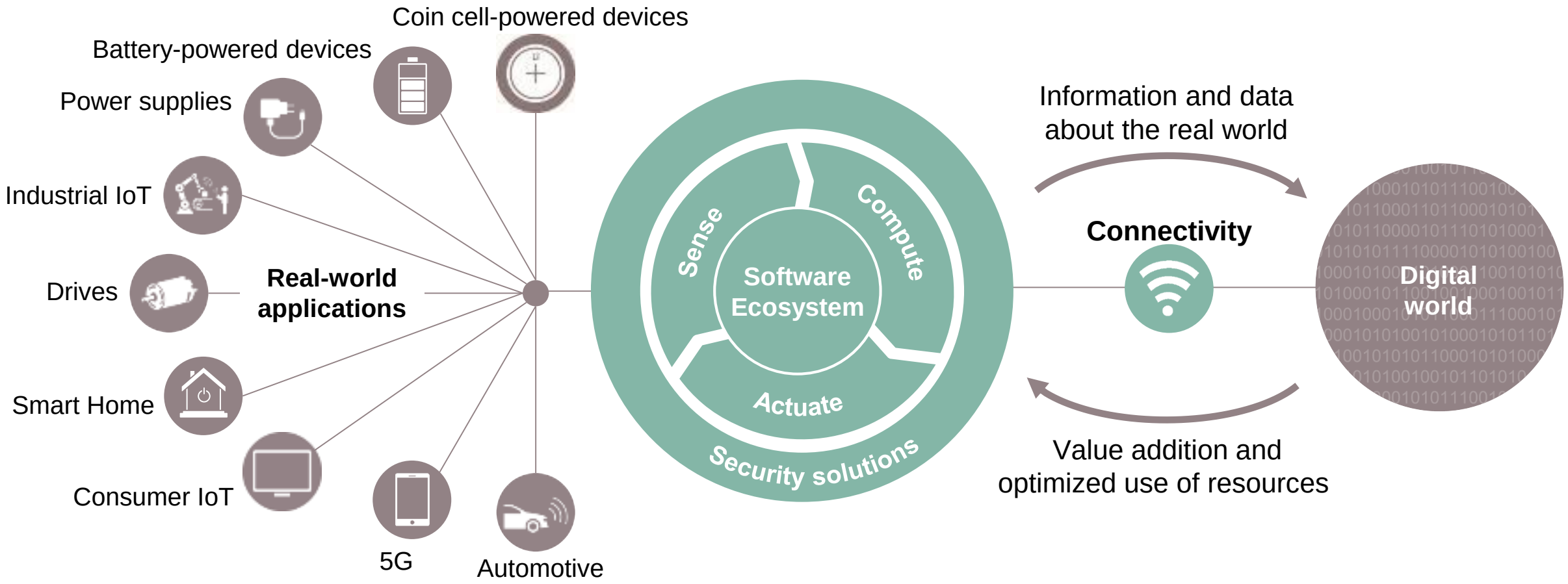
Infineon offers a unique portfolio that links the real and the digital world



Sense: sensors

Compute: microcontrollers, memories

Actuate: power semiconductors

Connectivity: Wi-Fi, Bluetooth, USB

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We empower the
world to easily
connect through smart
and trusted solutions

CSS empowers the world to easily connect through smart and trusted solutions

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Applications

Industrial and Consumer IoT

Industrial



Automotive



Smart Home



Gaming



Wearables



Payment, ID, Ticketing

Payment



Identification



CSS capabilities

- Compute
- Wireless Connectivity
- Security
- Software

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IoT Compute & Wireless (ICW) - General purpose MCUs and wireless solutions for a connected world

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Category Leading Products

- Delivering compute, Wi-Fi, Bluetooth, and sensing products
- Flexible, secure, low-power MCU family
- Low-power, robust Wi-Fi and Bluetooth optimized for IoT
- Rich, easy-to-use software

Longstanding IoT Leader

- Growing PSoC MCU family since 2002
- Acquired Broadcom IoT business in 2016 then more than doubled the business
- Acquired Cirrent to augment Wi-Fi with cloud services

Trusted Partner

- Compelling roadmap focused on the IoT
- Proven track record of commitment and quality
- Core supplier to 8 of top 10 IoT companies

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Wan Chai (N)
Lung Wan Road
Kowloon
North Point
Tim Mei Avenue
Kowloon (E)
SLOW

ICW Portfolio – Our Core Capabilities mapped to products

COMPUTE

- Arm® Cortex® Processors
- Mixed Signal MCU Architectures
- Application Co-processors

PSoC®4
PSoC®6
XMC™1000
XMC™4000
Next-gen MCU

ENHANCE

- Graphics
- Machine Learning

PSoC®6
Next gen MCU

CONNECT

- Wi-Fi / BT Combo
- BT / BLE

AIROC™

› CYW43/55xxx

› CYW20xxx, PSoC®4/6-BLE CYW30xxx

CONTROL

- Capacitive / Inductive Sense
- Wireless Charging
- Motor Control
- Power Conversion

PSoC®4
PSoC®6

XMC™1000 (Spark)

XMC™1000
XMC™4000
Next-gen MCU

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Broad portfolio covering range of capabilites, with unified developer experience

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Portfolio Extension

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)

IoT / Consumer

PSoC 6 MCUs for the broad-base of IoT and Consumer applications, bringing best in class low power, connectivity, and security
PSoC 4 delivers unique software-defined peripherals and industry leading capacitive sensing designs



PSoC 3
8051 CPU
67 MHz, 64KB Flash
Up to 19 PAB, 30 PDB, 72 I/Os

PSoC 1
M8C CPU
24 MHz, 32KB Flash
16 PAB, 16 PDB, 64 I/Os

8FX
8-bit RISC MCU
16 MHz, 32–50KB Flash

PSoC 4
Cortex-M0/M0+
48 MHz, 384KB Flash
Up to 13 PAB, 20 PDB, 98 I/Os

FM0+ MCUs
Cortex®-M0+
40 MHz, 512KB Flash, 102 I/Os

XMC1000 MCUs
Cortex®-M0
32-48 MHz, 200KB Flash, 55 I/Os

PSoC 5LP
Cortex-M3
80 MHz, 256KB Flash
20 PAB, 30 PDB, 72 I/Os

FM3 MCUs
Cortex-M3
144 MHz, 1.5MB Flash, 154 I/Os

PSoC 6
150 MHz Cortex-M4/100 Mhz M0+
2MB Flash
7 PAB, 56 PDB, 104 I/Os

FM4 MCUs
Cortex-M4
200 MHz, 2MB Flash, 190 I/Os

XMC4000 MCUs
Cortex®-M4
80-144 MHz, 2MB Flash, 119 I/Os
Industrial Comms, Ta 125C

MCU Next
Multi-core Cortex-Mx
ML-Ready, HMI Rich

Industrial Evolution
Multi-core Cortex-Mx
Industrial Quality, ECC Memories

Industrial

XMC is a family of high-performance Arm Cortex-M-based
MCUs for industrial applications, with industrial control peripherals and extended temp range
FM is a portfolio of high-performance Arm Cortex-M-based MCUs for industrial and consumer applications



Other

Specialized and Legacy



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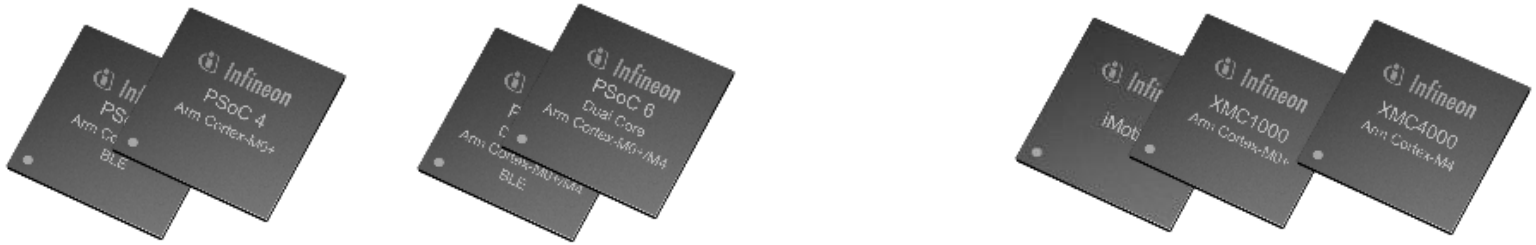
The Right MCU for the Job – **Focus Families**



By Segment	Consumer / IoT	Industrial
PSoC		
XMC		

Feature / Performance Requirements

Feature / Performance Requirements

By Function	Low Power	Human Machine Interface (Touch, Display, Voice)	Wireless Connectivity (BT, BLE, WiFi)	Motor Control	Power Conversion	Industrial Comms
PSoC						
XMC						

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Infineon MCUs: Enabling more developers to get products to market



Integrated ModusToolbox™ software for lower total cost of ownership in development and ongoing maintenance

High-reliability, low-power networking for higher-quality, differentiated products

Tools and documentation for simplifying new product development, certification

Integrated compute and connectivity for faster time-to-market

Unique capabilities for differentiated products

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What is XMC™

XMC™ - Microcontroller

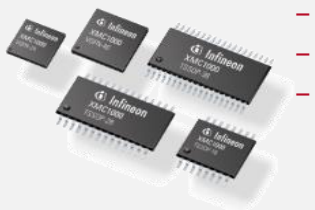
are characterized by….



- **Industry Standard Core** - ARM® Cortex® M
- **Application specific peripherals** for Lighting, Motor Control, Power Conversion, Industrial Communication (EtherCAT)
- **Performance & real-time** with hardware acceleration
- **Quality and robustness**: Long-term availability (through 2040 or longer), up to T_A 125°C (XMC4000)

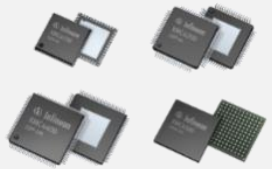
- **XMC™ comprises of 2 major families**

XMC1000



- Cortex® M0 based
- Up to 200kB Flash
- Applications:
  - Low cost motor control
  - Lighting
  - Power conversion

XMC4000



- Cortex® M4 based
- Up to 2MB Flash
- Applications:
  - Automation (Industrial Drives, PLC, I/O)
  - Power conversion

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XMC™ Application View : What makes XMC™ the perfect fit

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XMC™ Entry	LED Lighting	Digital Power	Motor Control	Ind. Automation
XMC4000 ARM® Cortex®-M4F up to 144MHz core 64KB - 2MB Flash up to 125°C T_{amb}			**XMC4700** Industrial Drives, Hall & Encoder I/F, ΔΣ Demodulator LQFP-100/144, LFBGA-196	**XMC4800/4300** EtherCAT,+Drives MultiCAN - 6 nodes, LQFP-100/144, LFBGA-196
XMC4100 Basic control & Connectivity VQFN-48 LQFP-64		**XMC4200** Server power 150ps HRPWM LQFP-64/100	**XMC4100/4400** Industrial Drives, Hall & Encoder I/F ΔΣ Demodulator LQFP-64/100/144 LFBGA-144	**XMC4500** MultiCAN - 3 nodes Ethernet, +Drives ext.Memory,SD/MMC LQFP-100/144, LFBGA-144
XMC1000 ARM® Cortex®-M0 up to 48MHz core/ 96MHz peripheral 8 - 200KB Flash up to 105°C T_{amb} 1.8V-5.5V	**XMC1400** Flicker-free, 4-Ch LED, DALI SMPS VQFN-40/64 LQFP-64	**XMC1300/1400** SMPS control Connectivity TSSOP-16/38 VQFN-24/40/64 LQFP-64	**XMC1400** Hall & Encoder I/F, MATH,CAN VQFN-40/64 LQFP-64	**XMC1400** MultiCAN - 2 nodes VQFN-48/64 LQFP-64
XMC1100 Basic control & Connectivity TSSOP-16/38 VQFN-24/40	**XMC1200/1300** Flicker-free, 3-Ch LED, SMPS, Connectivity TSSOP-16/28/38 VQFN-24/40	**XMC-SC** Wireless Charging, incl. SW from Spark Connected Support for Qi, AirFuel VQFN-24/40	**XMC1300** Hall & Encoder I/F MATH Co-processor TSSOP-16/38 VQFN-24/40	

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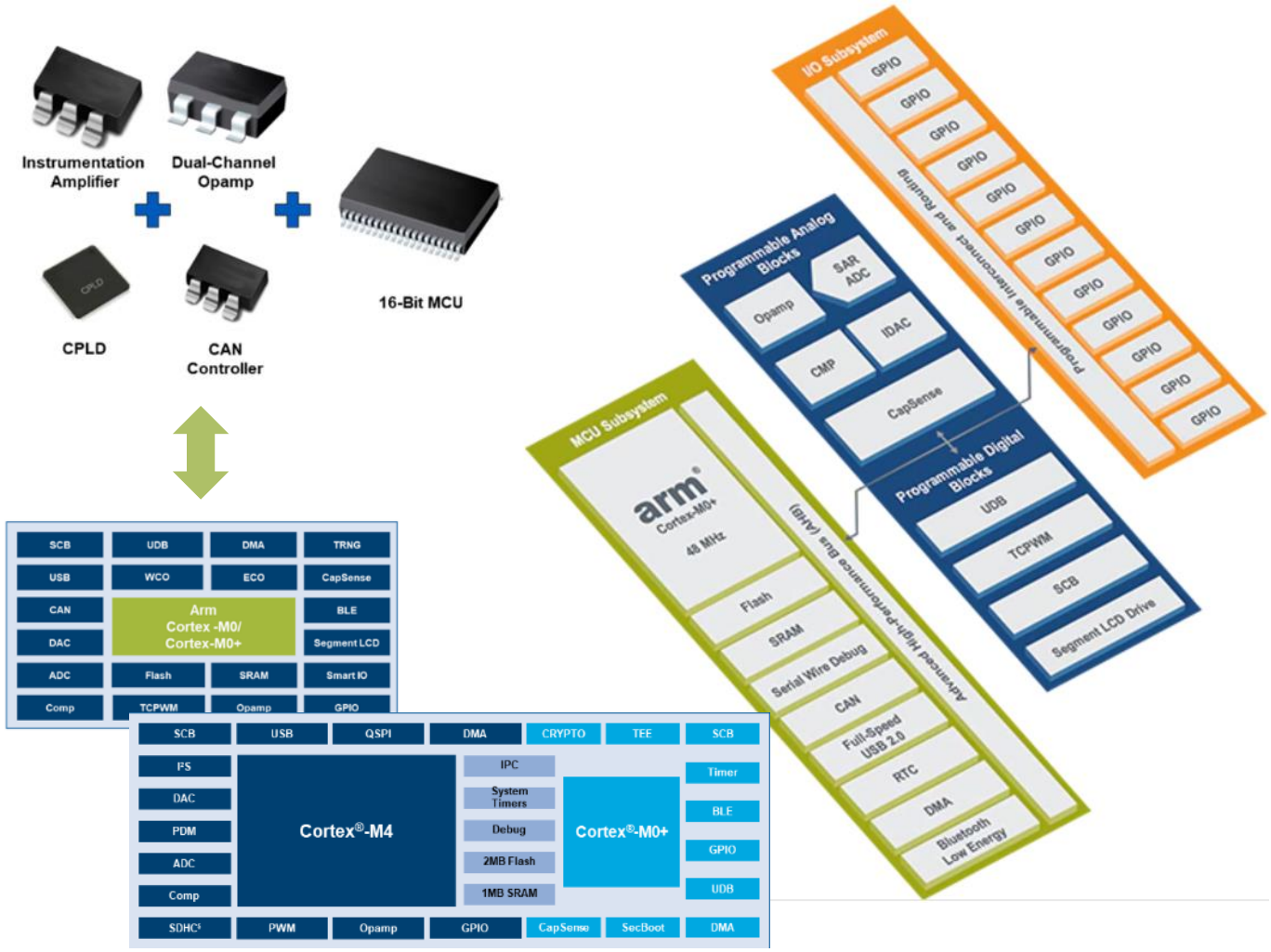
PSoC™ – Maximum Flexibility



Capacitive Sensing
Cypress' CapSense® is the industry-leading capacitive-sensing solution for touch, proximity sensing, and liquid-level sensing applications. CapSense is a dedicated peripheral found across the entire PSoC portfolio.

Programmable Analog Blocks
Customize your analog front end to interface to any analog sensor through programmable analog blocks, which are composed of an assortment of opamps, comparators, ADCs, and DACs, enabling complex analog signal flows.

Programmable Digital Blocks
Programmable digital blocks are composed of Universal Digital Blocks (UDBs), Serial Communication Blocks (SCBs), and Timer/Counter/Pulse Width Modulators (TCPWM). These blocks can be configured to set-up custom digital interfaces, state machines, and custom logic functions.

Wired and Wireless Connectivity
Wired connectivity interfaces, such as CAN and USB, are available in the PSoC portfolio. For wireless connectivity, Bluetooth Low Energy is also available.

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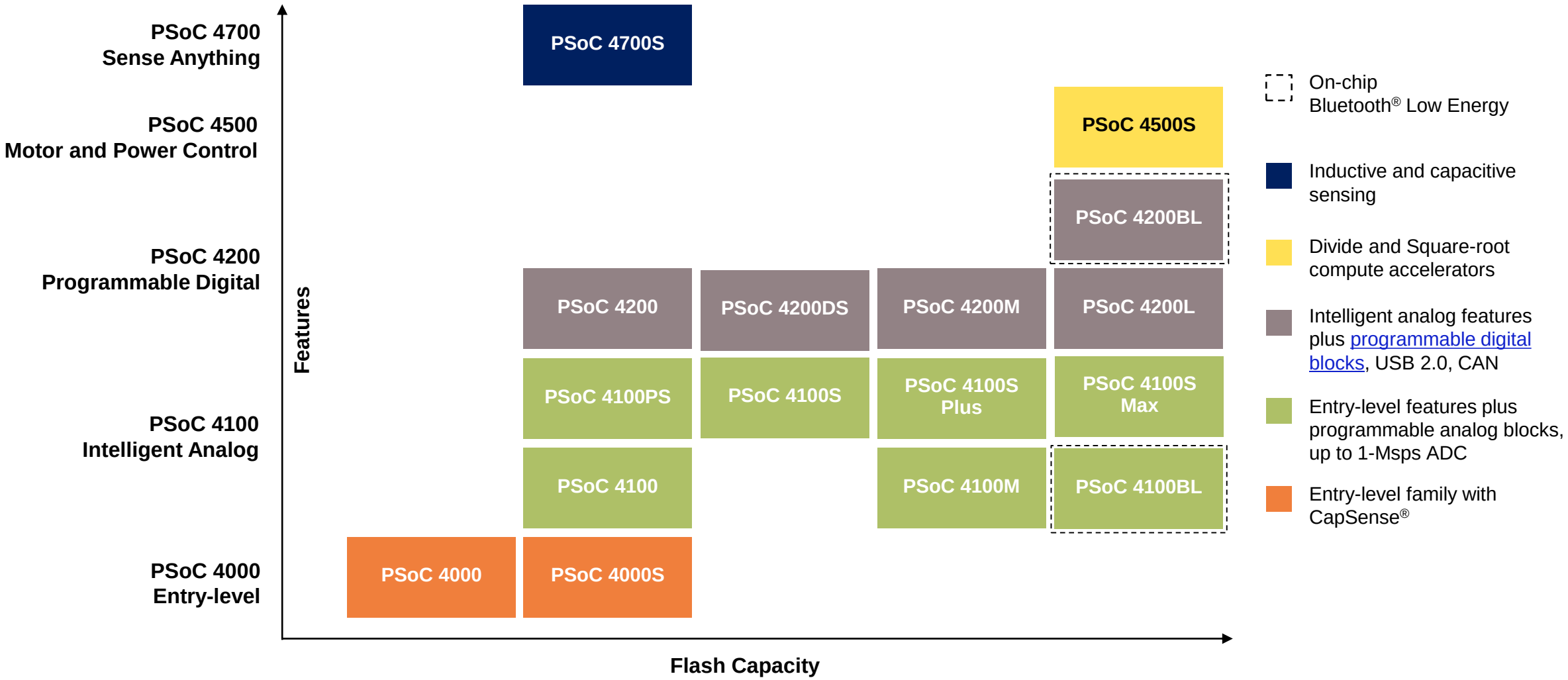
PSoC™ 4 portfolio



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PSoC™ 6: Purpose-built for the IoT

Emerging IoT devices require connectivity with increased processing and security without a power or cost penalty



Application Processors
Expensive, High-Power Consumption

Microcontrollers
Limited Processing Capacity

- The PSoC 6 portfolio bridges the gap between application processors and standard microcontrollers
  - High performance 150-MHz and 100-MHz dual-core Arm® Cortex®-M4 and Arm Cortex-M0+ architecture
  - Ultra-low-power 40-nm technology and design that consumes as little as 22-µA/MHz in active power mode
  - Best-in-class Wi-Fi connectivity options enabled with ModusToolbox and cloud services support like Amazon Web Services
  - Integrated, hardware-based Secure Execution Environment with secure data storage

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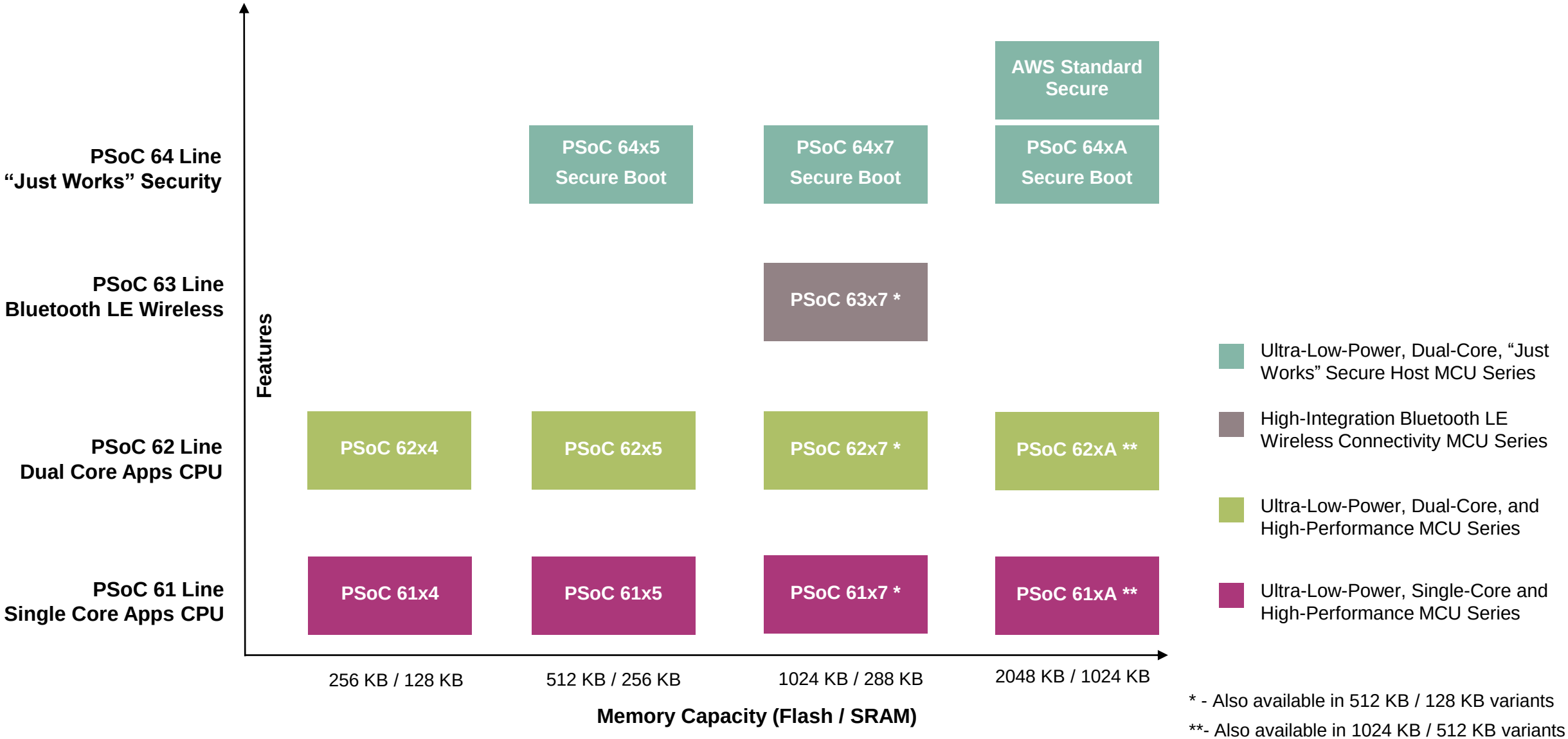
PSoC™ 6 Portfolio – High Level View



* - Also available in 512 KB / 128 KB variants

**- Also available in 1024 KB / 512 KB variants

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CAPSENSE™

Your trusted partner in Touch Human Machine Interface (HMI) Solutions



Decades of Innovation & Leadership in Touch HMI Solutions

#1
Touch HMI Solution

100+
Patents

> 6Bn
Conventional Buttons Replaced

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Capacitive Sensing applications

Replaced **more than six billion mechanical buttons**

Enables hundreds of diverse types of sensing applications

Capacitive Sense Buttons



Capacitive Sense Slider



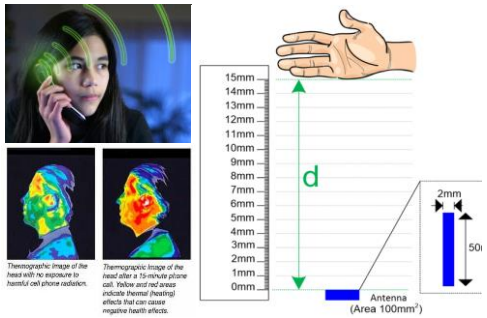
Metal Proximity



Proximity Detection



Specific Absorption Rate



Capacitive Liquid Level Sense



Capacitive Force sensing



Absolute Capacitance sensing



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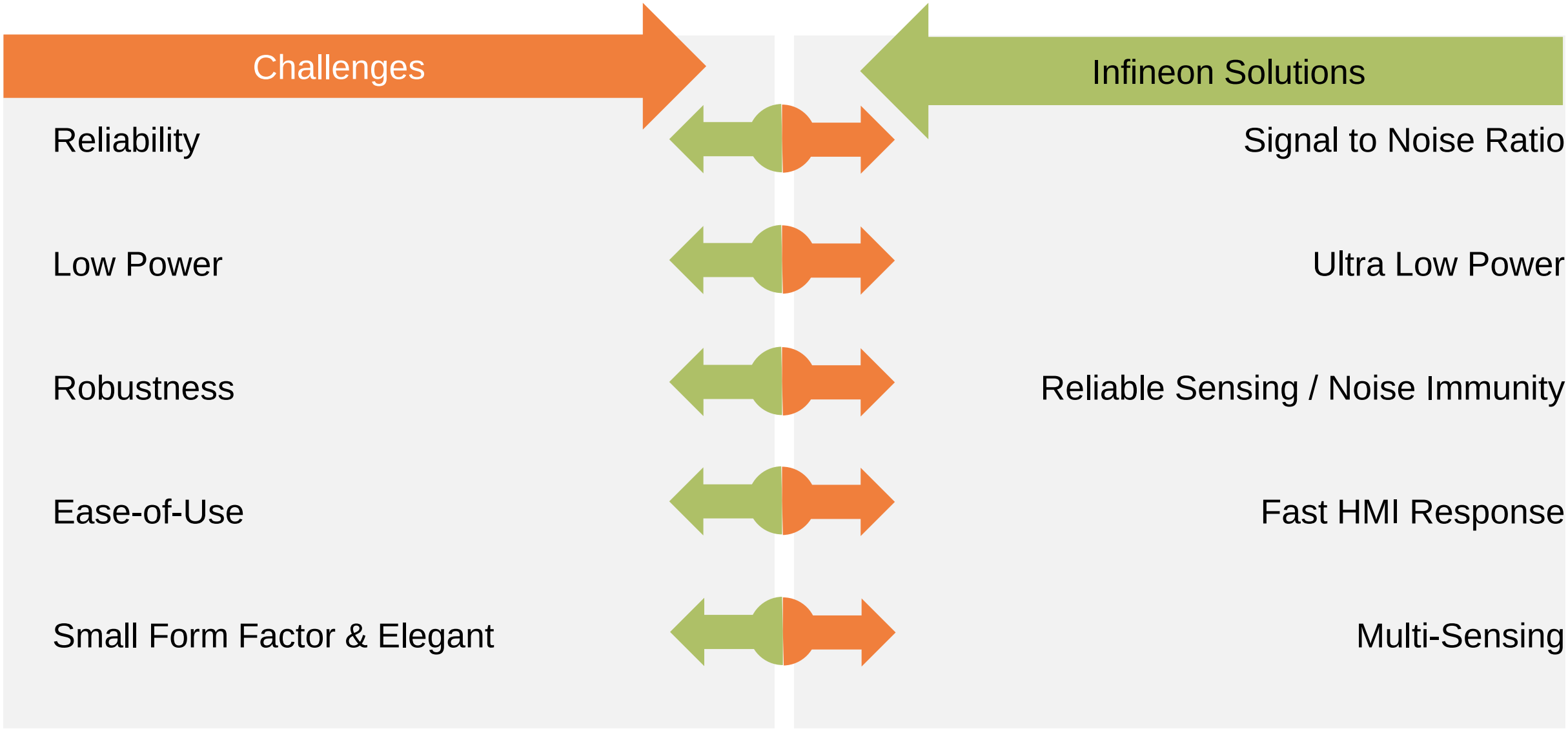
Touch HMI Design challenges & Infineon's Solution: CAPSENSE™ Touch-Sensing Technology



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Portfolio of CAPSENSE™ enabled MCUs

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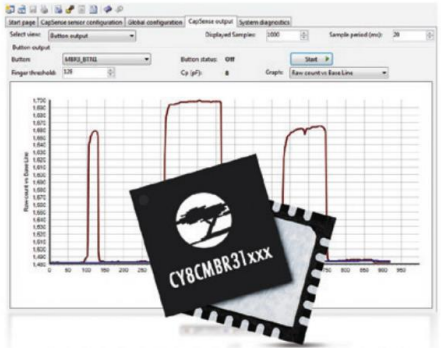
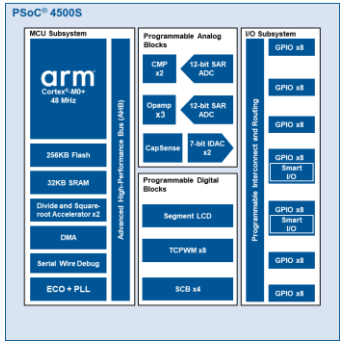
MBR3 – Configurable Touch Controllers



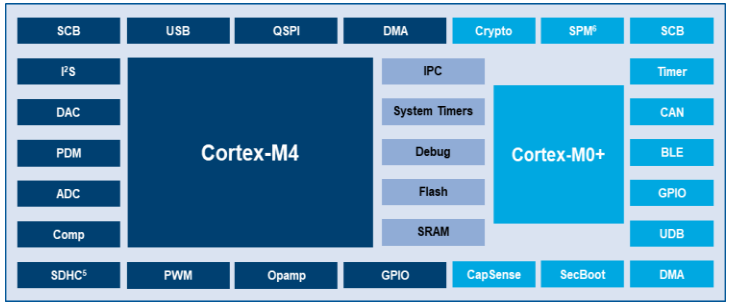
World's Easiest Touch Sensing Solution – no FW; no manual tuning!

PSoC 4 – Touch HMI enabled Microcontrollers



Industry-leading solution in MCU platform

PSoC 6 – Purpose Built IoT Host Microcontrollers



2-in 1 Ultra Low Power

IoT Host MCU + HMI platform for IoT

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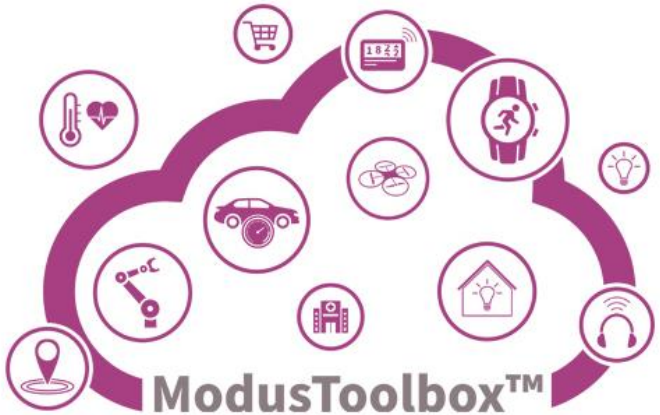
ModusToolbox™

ModusToolbox™ Software – Overview



- 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.

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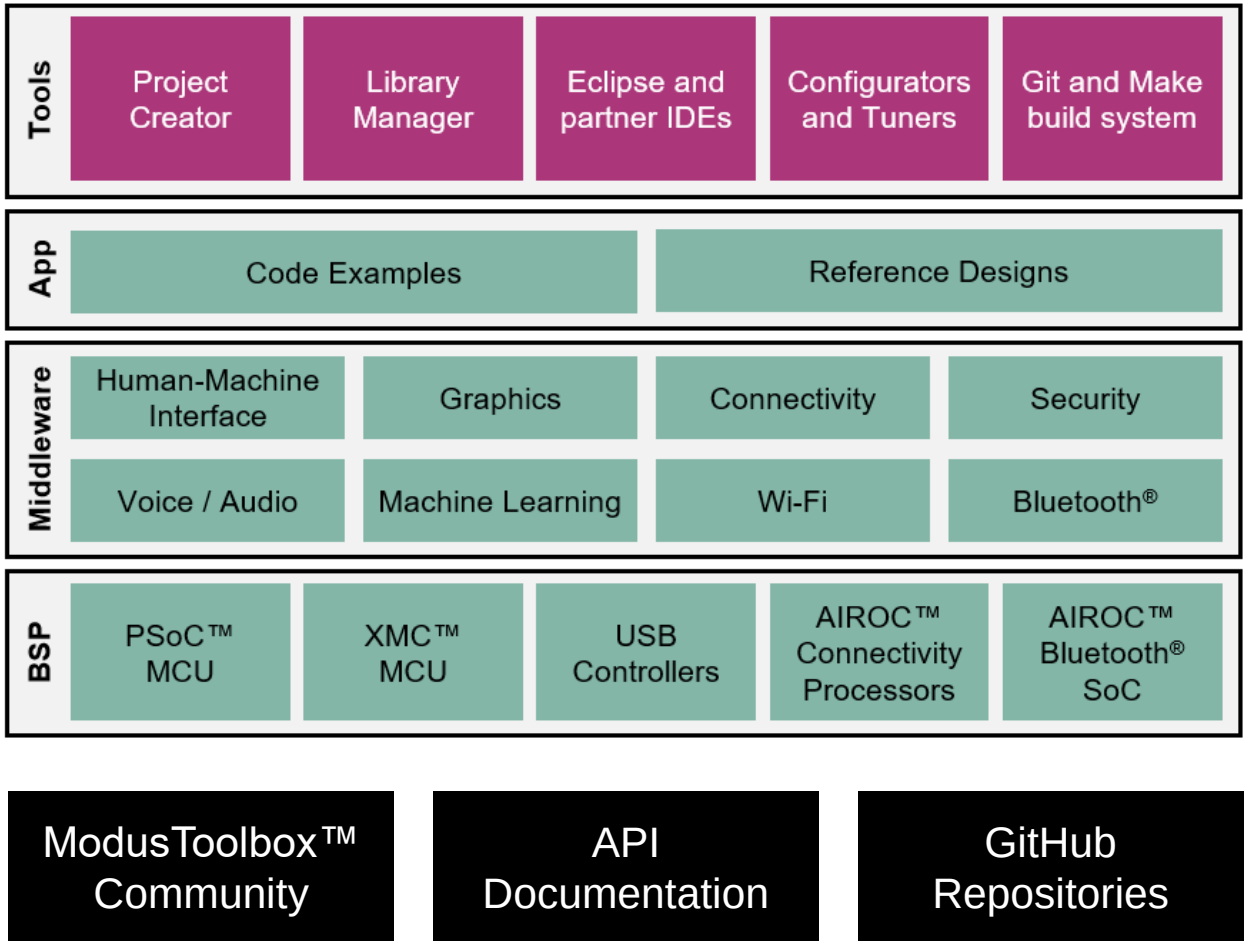
ModusToolbox™ Software – Enabling Efficient Development



ModusToolbox™ provide enablement throughout the application development process.

- Tools, IDEs, and Configurators
- Application Development Resources
- Middleware from Infineon and the ecosystem
- Board Support Packages / Device Packages
- Support and Documentation Resources
- Training Manuals – host in GitHub repo

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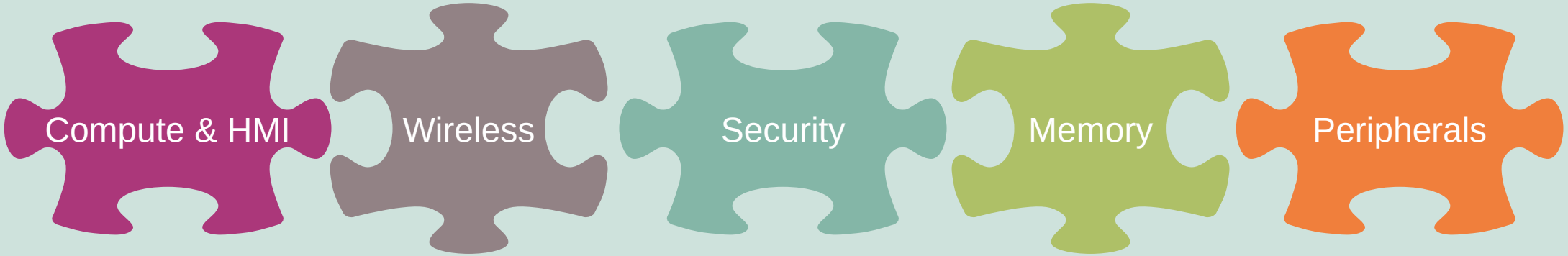
Next-gen platform for Compute and Connectivity



- ❑ Processors (M7, M55, M33)
- ❑ Industrial Comm & Peripherals
- ❑ Machine Learning (U55)
- ❑ Graphics
- ❑ CapSense®
- ❑ Audio (DSP, SoD etc.)
- ❑ Camera

- ❑ BT/BLE 5.x/6
- ❑ Wi-Fi 6/6E/7
- ❑ 802.15.4

- ❑ Secure Enclave with Physical and Logical Security
- ❑ Security Life Cycle Management
- ❑ M33 with Trust Zone
- ❑ HW protection contexts
- ❑ True Random Number Generator
- ❑ Secure Key Storage (RRAM, EFUSE)
- ❑ FIPS Compliance

- ❑ RRAM
- ❑ Flash, RAM

- ❑ I/O choices
- ❑ Power Supply
- ❑ Interconnects
- ❑ Wireless Accelerators

PSoC ™ & XMC ™
MCU families

AIROC™
Wi-Fi Combo & MCU

AIROC™
Bluetooth®
Bluetooth LE & 802.15.4

One platform, one developer experience

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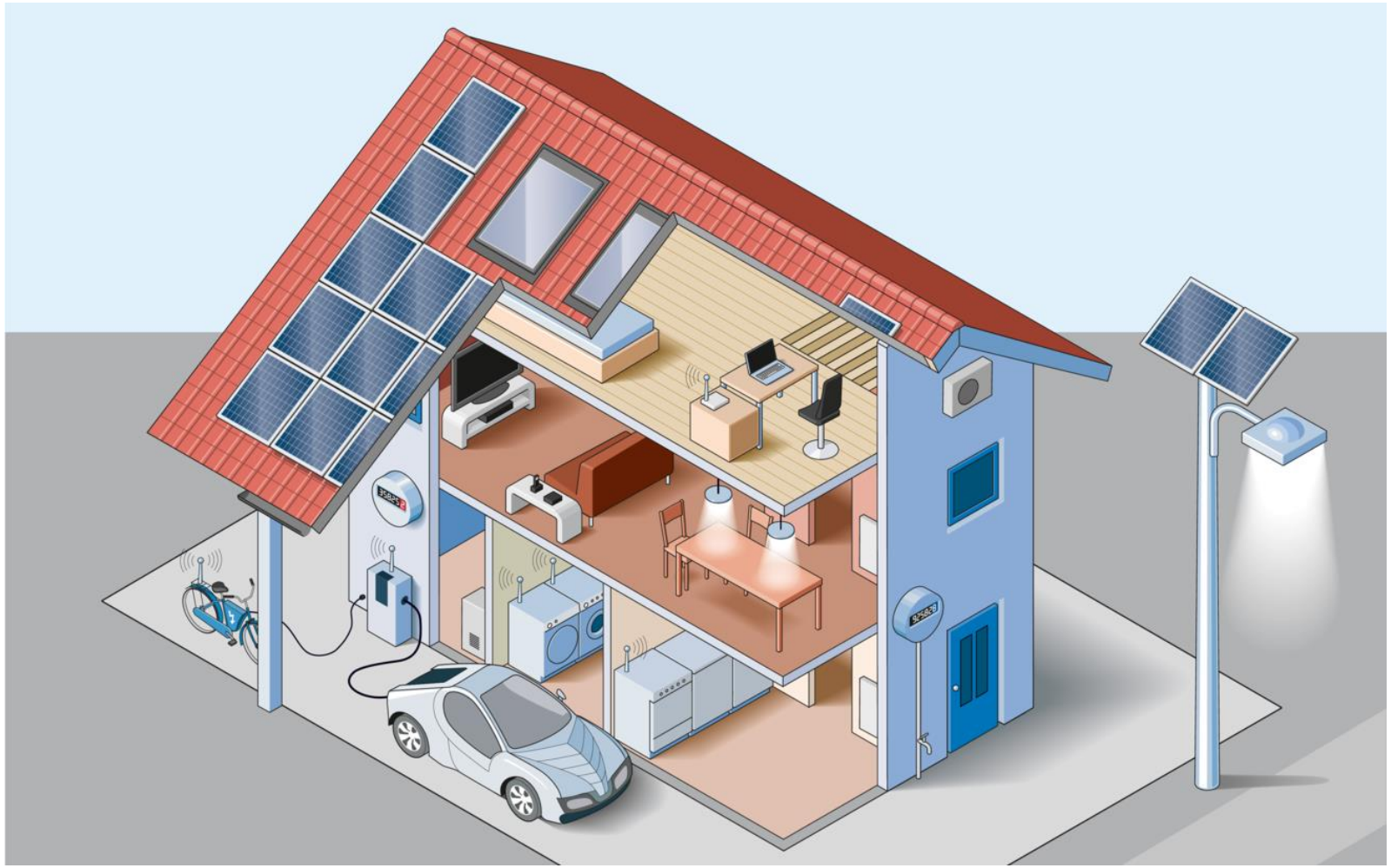
Smart Home

Enabling All Aspects of Tomorrow’s Smart Home



Infineon, your leading partner for Smart Home Solutions!

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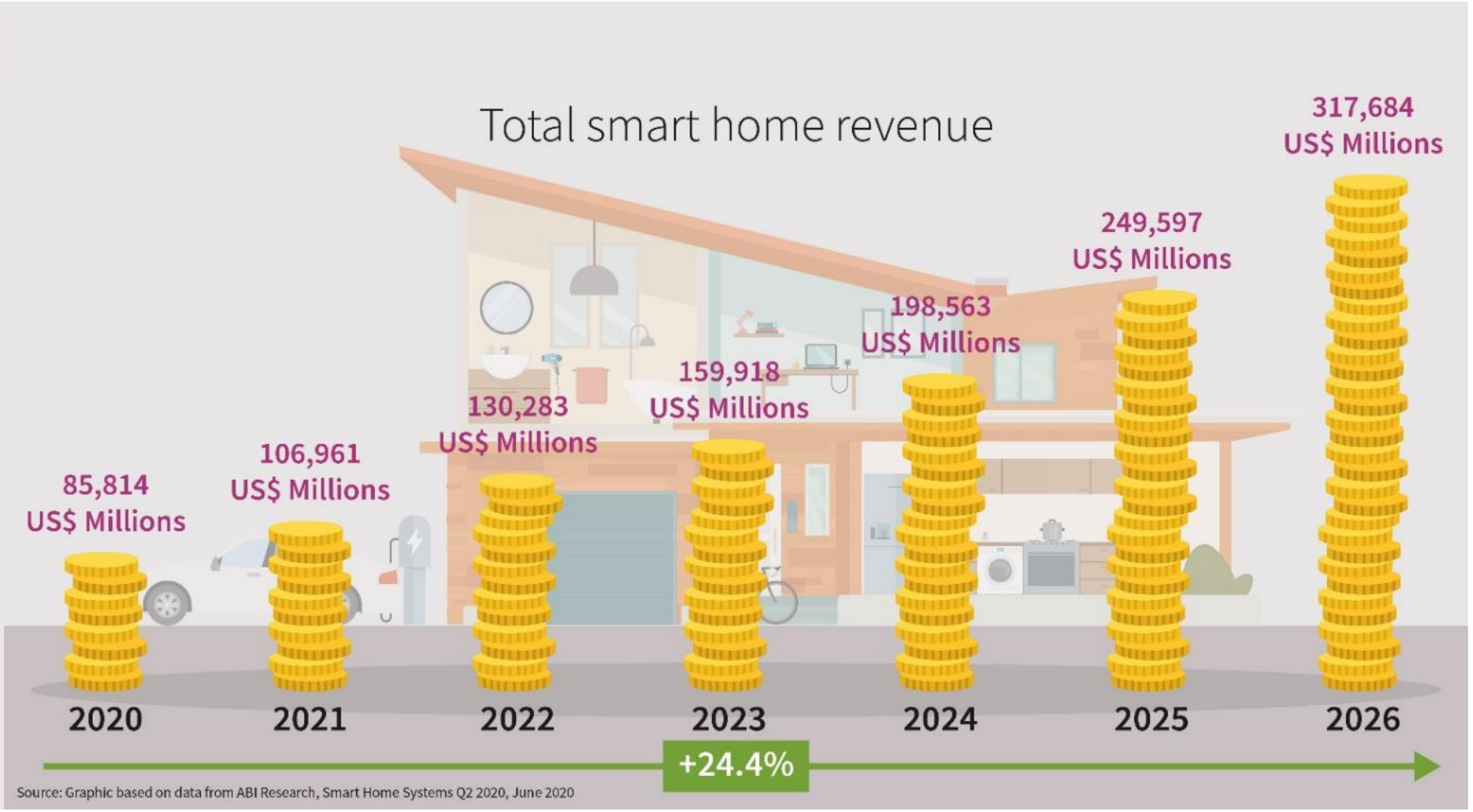
Smart Home Market: A huge potential for growth

According to the study "**ABI Market Data, Q2 2020**", the smart home market is continuously growing. The annual growth rate of total smart home revenue in the coming years is predicted to average 24.4 percent.

For the market, this means that many innovative smart home elements will be in high demand over the next few years.

With Infineon, you have peace of mind that you can find every component required – today and tomorrow.



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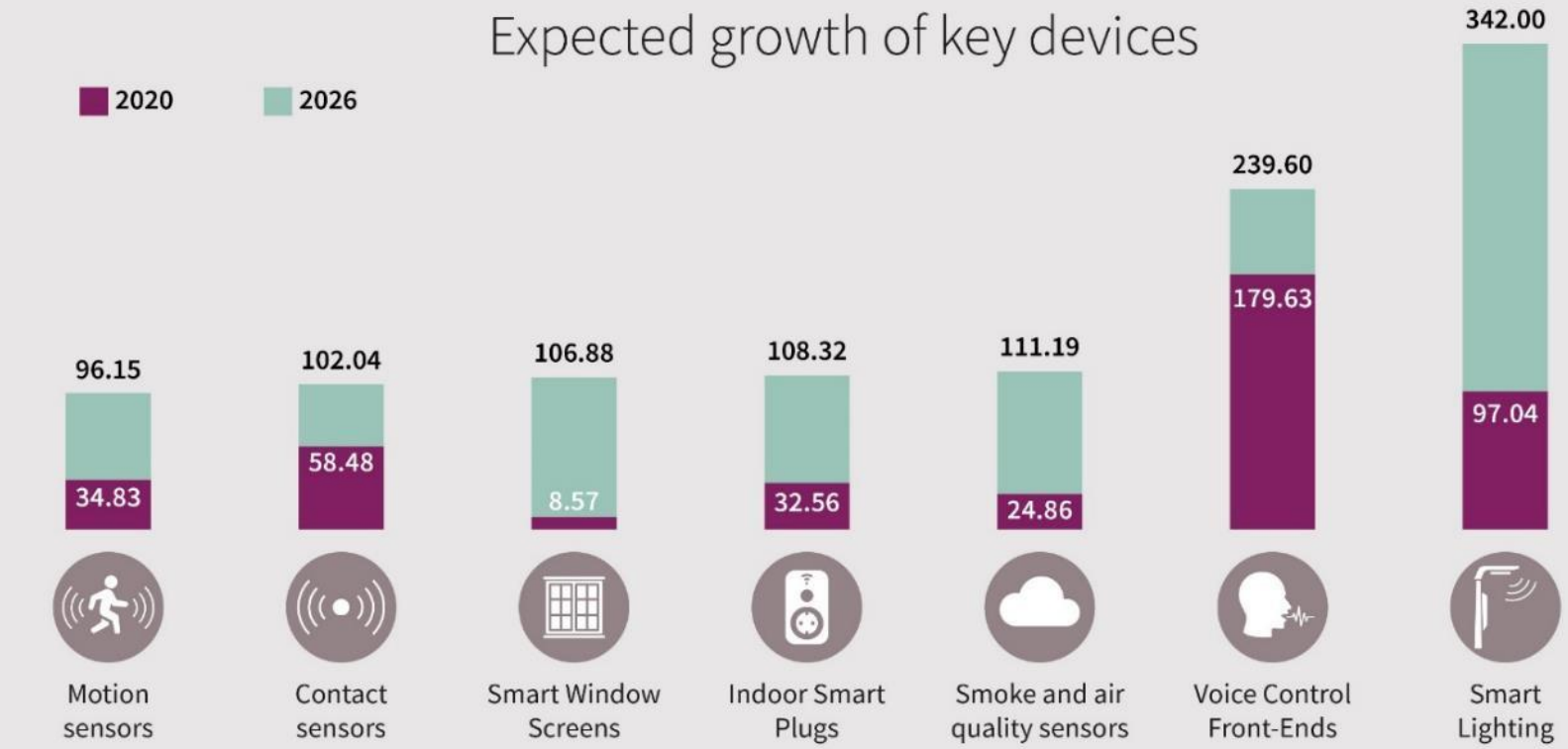
Smart Home Market: Desire for more comfort and new functionalities

The increasing demand for comfort, convenience and simplicity, but also the growing desire for more functions in the areas of entertainment, security and energy efficiency will increase interest and commitment to the smart home.

Smart home providers and system vendors can benefit from this and emphasize the function of voice and other smart home implementations that simplify the daily processes within a home.



Shipments by product type (in millions)

Source: Graphic based on data from ABI Research, Smart Home Systems Q2 2020, June 2020

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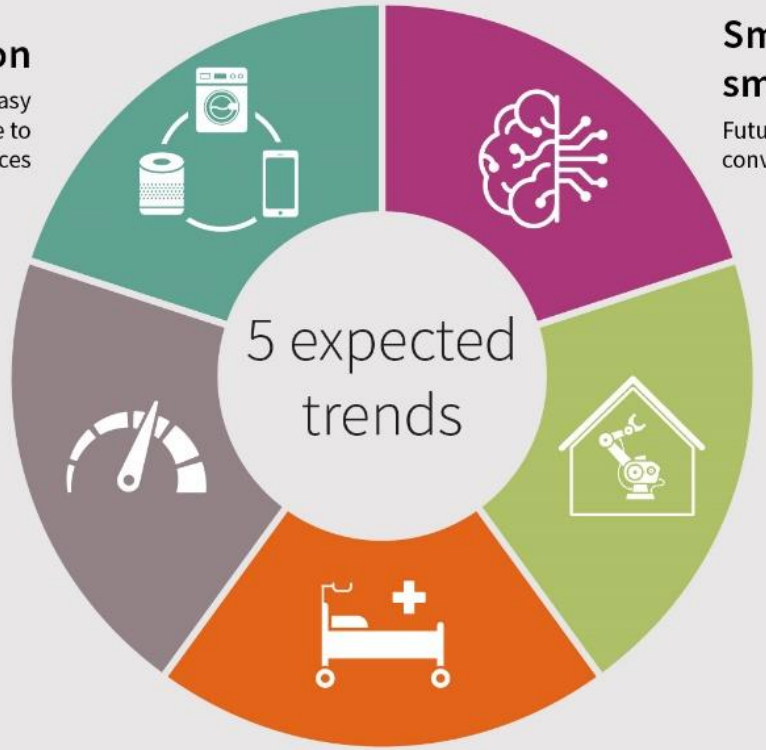
Smart Home Market: **Expected** Trends



Increasing standardization

Need for seamless connectivity and easy integration of smart home devices due to an increasing number of devices

Smart homes actually become smart, thanks to machine learning

Future AI novelties will increase convenience in smart homes

Faster networks mean smarter homes

More powerful networks lead to better access to data & processing resources and help to realize more demanding applications

Robots in the home

They can be assigned more and more tasks that help elderly and disabled people to cope with their daily lives

In-home healthcare gets smarter

Devices that track health or offer interventionist services are playing an increasingly important role due to growing life expectancy

Source: www.forbes.com, "The 5 Biggest Smart Home Trends In 2020"

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The Challenge: Making Smart Home Products is Hard

Creating a delightful user experience

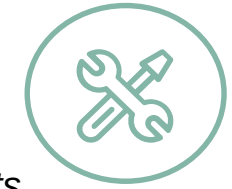
- *100% of consumers want smart-home products and services that make life safer and easier*
- *Small shift in customer reviews has a large impact on sales.*
- *“One positive star on Amazon increases sales by 20%.”*



BETTER EXPERIENCE AND EASIER PRODUCTS 100%

Improving connectivity of your products

- *“60% of consumers fail to onboard smart home devices.”*
- *On average, 40% of onboarding failures last between 8 min – 60 min*
- *Most customers give up trying to connect their device after 2 failed attempts*



CONNECTIVITY PROBLEMS 60%

While reducing costs

- *“43% of organizations fail to finish a project within the original budget.”*
- *“Number of product managers who want more resources for their projects: 100%”*



FAIL TO FINISH ON BUDGET 43%



MATTER is an open source connectivity standard for smart home and IoT devices which aims to improve their compatibility and security.

Infineon + Matter : Delivers **Matter** Compliance for Your Application

Matter over Thread

- **Future Proof Design**- CYW30739 w. 2MB ROM pre-programmed with BT core stack frees up flash for application code. Matter code is growing in size, but we will put more of it into ROM when it is more stable.
- **User Experience - Best interoperability** with installed base of Access Points and phones sharing IP heritage
- **Memory efficient program execution** Code runs in RAM at full processor speed (96MHz).





Matter over Wi-Fi

- **Flexible scalable secure platform** - PSoC6 + CYW43xxx Wi-Fi/BT Combo family
- **Ultra low power by design** – very low sleep, transmit, and receive current
- **Low power system architecture** – host offloads for keep-alive functions allowing host processor to sleep for longer periods
- High-performance RF ensures the **most robust connection** which substantially reduces power consumption





Enhanced Security

- Any Matter certified device needs to be provisioned with the set of credentials, **OPTIGA Trust M** will act as (productive) Trust Anchor for customer specific Matter credentials
- Certificates / keys need to be personalized and securely stored in a trust anchor, Infineon will provide a **Matter certified Root CA* and PKI* infrastructure** for customers
- Trust anchor for higher cryptographic operations required, OPTIGA™ Trust M **hardware cryptographic accelerators** will **support Host MCU with Matter onboarding**

PKI – Private Key Injection CA – Certificate Authority

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Smart Watch

New Trends Changing the Business Model

Immersive Interactive Experience

- Synchronized multi-modal HMI
  (voice, graphics, touch, personal recognition, gesture)
- Situational awareness
  Person, object, event, movement, and presence detection with intelligent real-time response
- Autonomous operation
  Efficiently operating, maintaining and supporting themselves via capability such as ML real-time control

Advance Sensing

- Motion, movement and fall detection
- Fitness and sleep evaluation
- Healthy monitoring (ECG, SPO2, blood pressure, blood glucose)
- Imaging, presence, awareness in new use cases



Longer Battery Life

- Ultra low power request for each component
- New architecture to extend battery life in smart watch
- Keeping same usage time but more features and functions in feature watch

Smartphone autonomy

- Cellular network become more prevalent
- Classic BT for audio streaming
- Low power Wi-Fi for data transmit
- GNSS
- NFC
- UWB

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Smart Watch and Wristband – Key Features

Graphic and HMI
Fancy and interactive display
Perfect touch experience

Edge-Event Computing
Situational awareness, Detect types of workouts, voice commands, motions, audio, etc.

Sensor Fusion
Different kind sensors with the dedicated movement, HRM, health and fitness algorithms



Ultra-Low-Power
Longer battery life in weeks.
Efficient computing with low power

Payment and Security
Contactless payment experience.
Secure data storage and transfer

Wireless Connectivity
BLE, Bluetooth Audio, Cellular Network, Low power Wi-Fi, GPS, UWB & NFC

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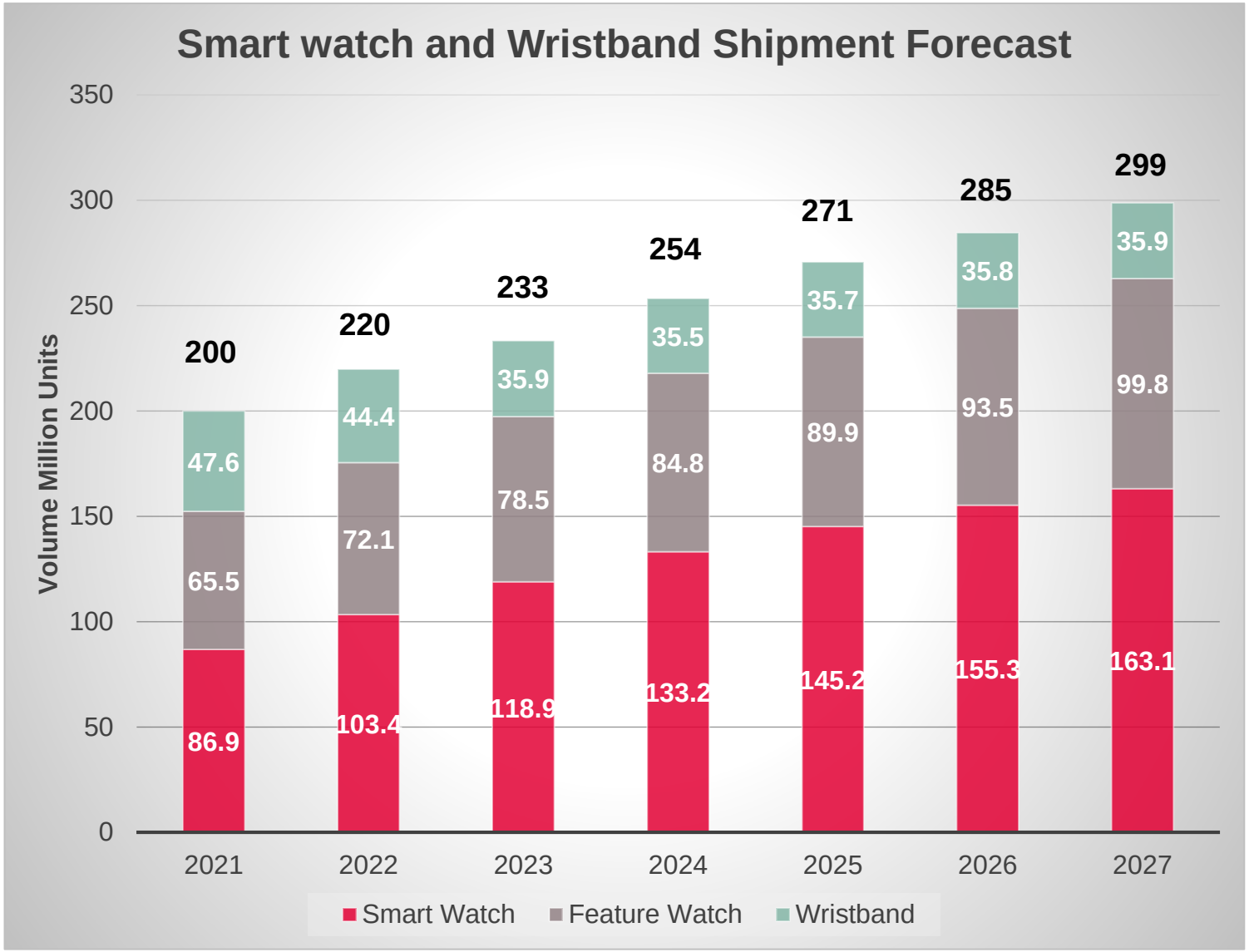
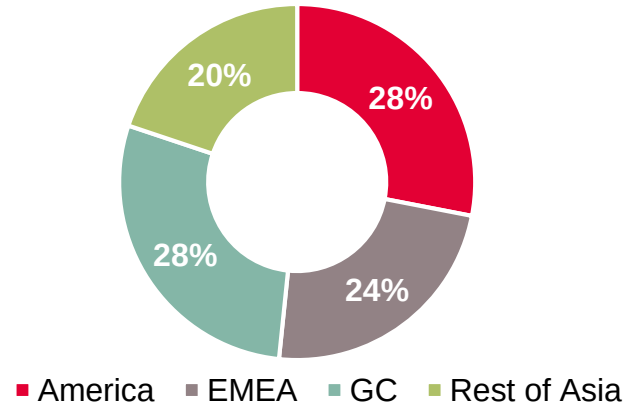
Market Insights



Source: SA - Global_Wearable_Device_Sales_Forecast_by_Type_2012-2027

- Power consumption is still critical to vendors, end customer wants longer battery lifetime.
- In 2022, NA and GC will account for half of volume.
- Smart watch and Feature watch keep growing, wristband market decline.
- Smart watch is becoming autonomous devices from the smartphone.
- More smartphone players engaged in watch market to build ecosystem with TWS and phone, such as Oppo, Vivo.
- BLE is 100% penetration in smart watch and wristband. Classic Bluetooth and Wi-Fi attach rate keep growing.

Smart watch and Wristband 2022 Shipment by Regions



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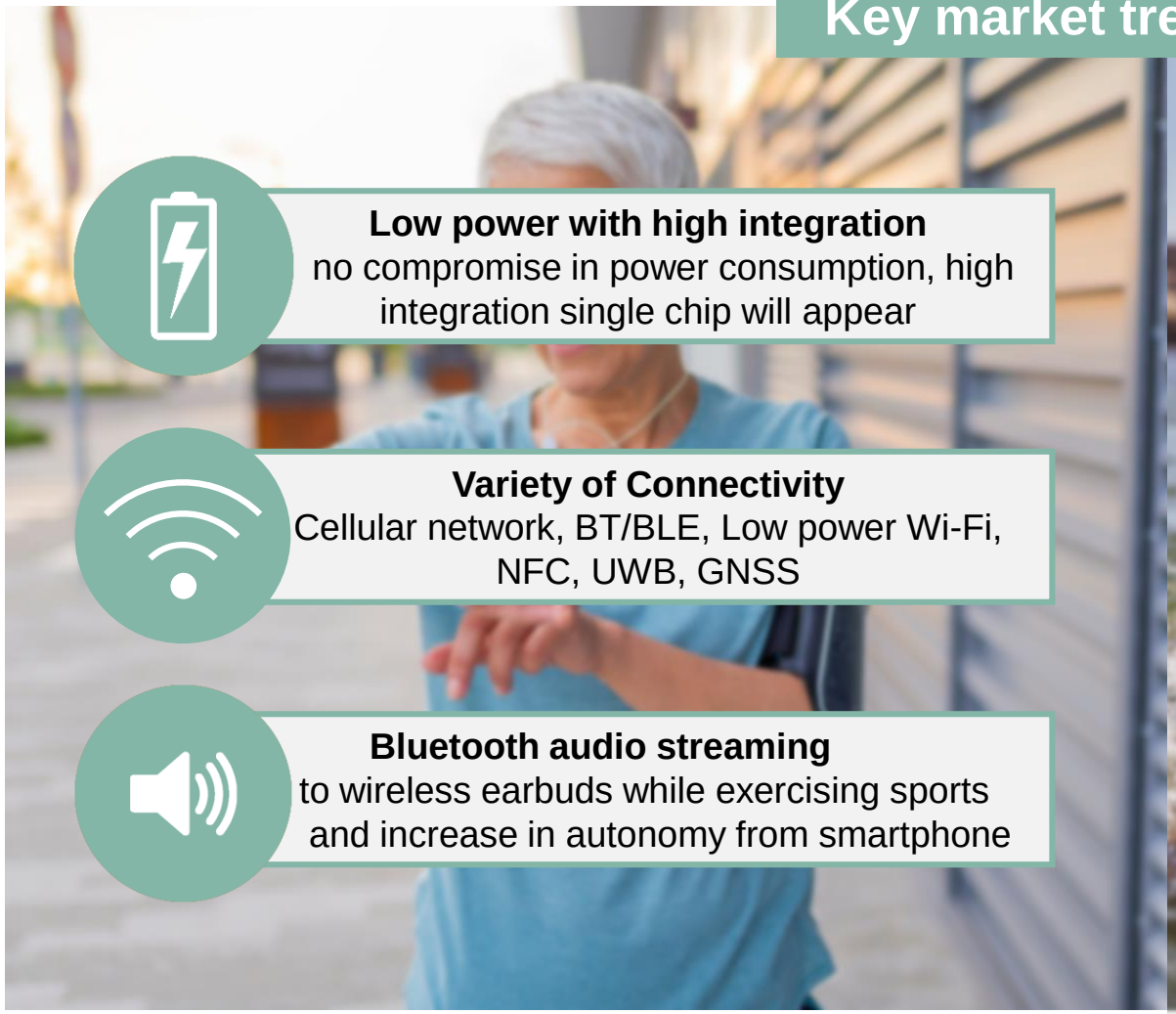
Market Trends

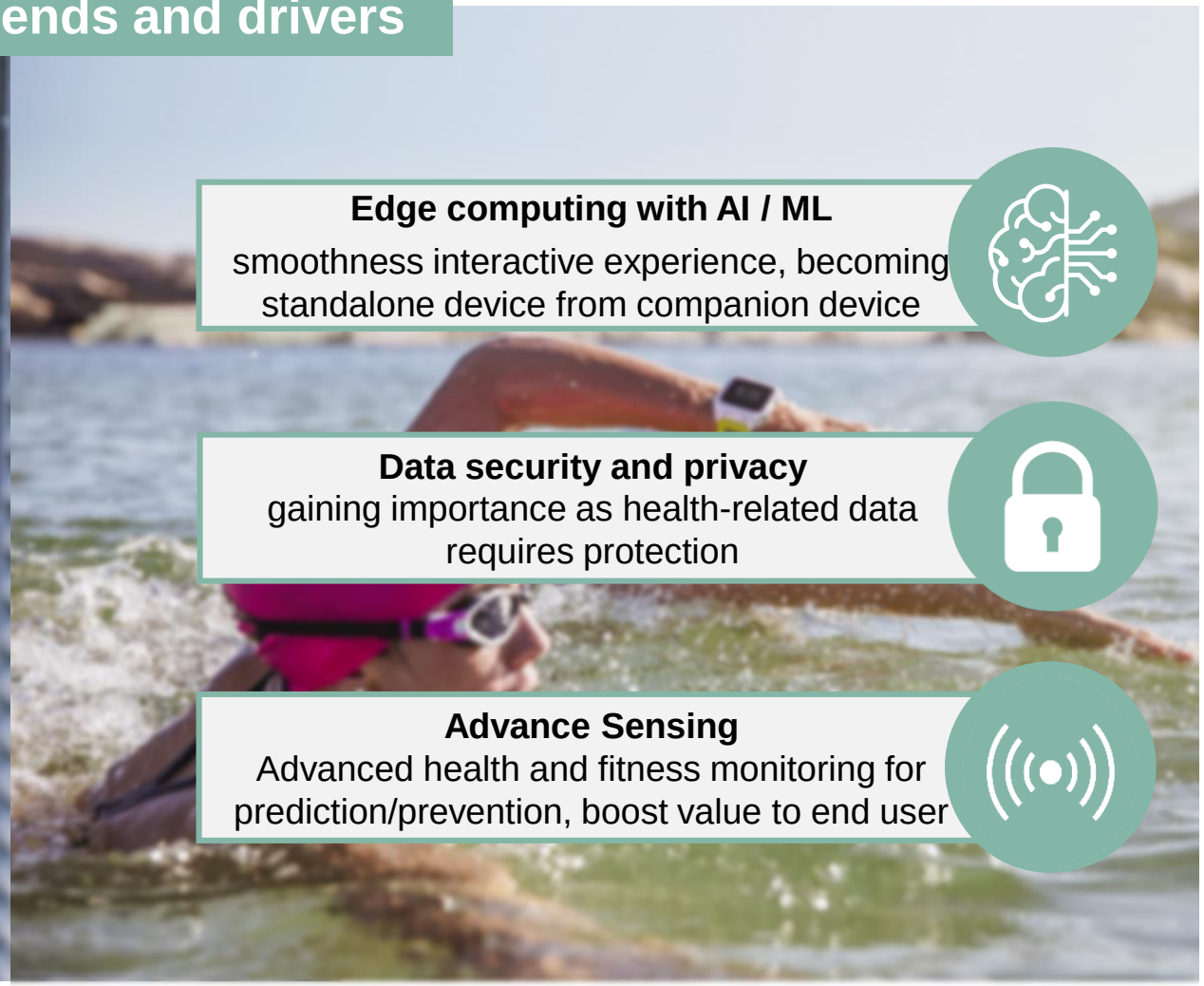
Key market trends and drivers



Low power with high integration
no compromise in power consumption, high integration single chip will appear

Variety of Connectivity
Cellular network, BT/BLE, Low power Wi-Fi, NFC, UWB, GNSS

Bluetooth audio streaming
to wireless earbuds while exercising sports and increase in autonomy from smartphone



Edge computing with AI / ML
smoothness interactive experience, becoming standalone device from companion device

Data security and privacy
gaining importance as health-related data requires protection

Advance Sensing
Advanced health and fitness monitoring for prediction/prevention, boost value to end user

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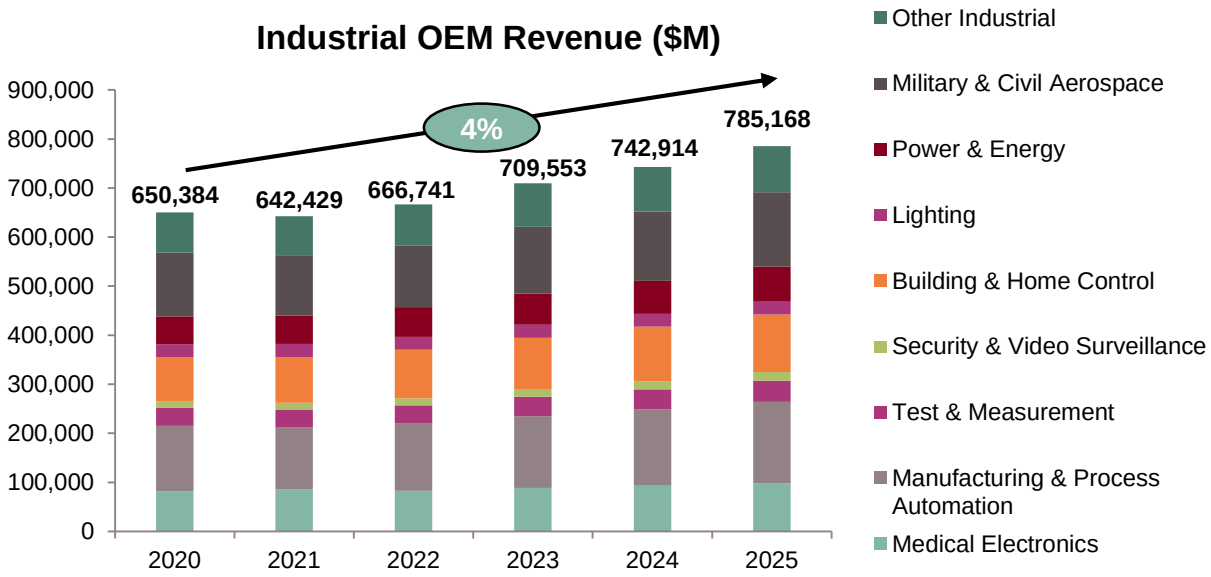
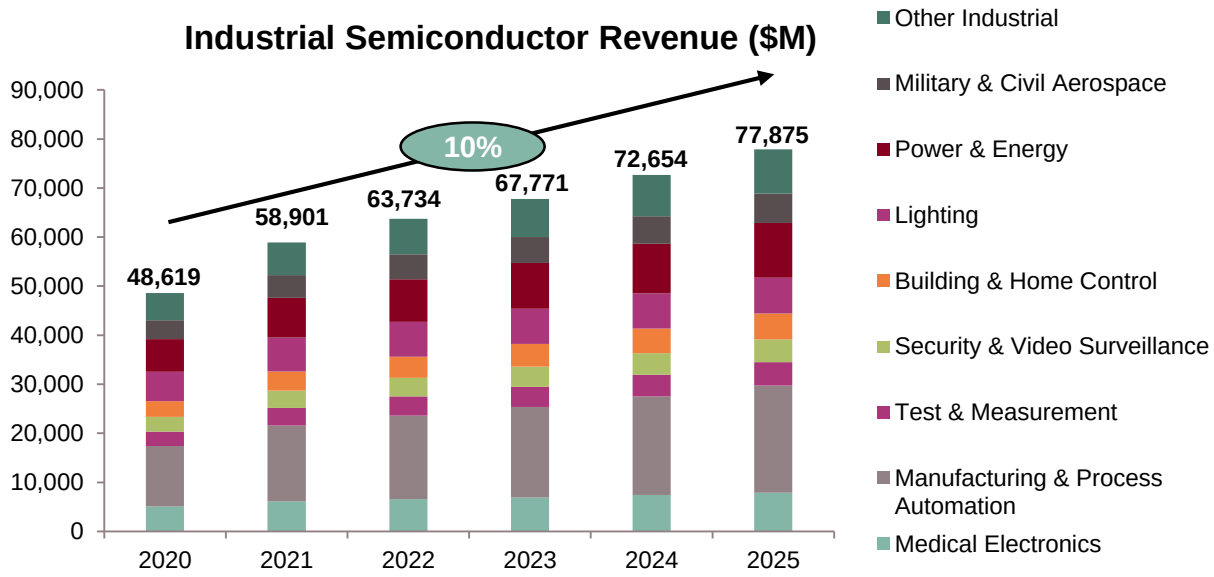
Industrial Applications

Industrial: Large Market with continued growth





- The Industrial market is forecasted to continue growing at a steady annual rate of 4%
- Large application segments leading the growth are Manufacturing & Process Automation, Power & Energy and Building & Home Control
- The semiconductor content in the Industrial market is forecasted to grow faster, with all of the leading application segments growing at a CAGR of >10%

Source: Omdia Industrial Semiconductor Market Tracker Q4'2021

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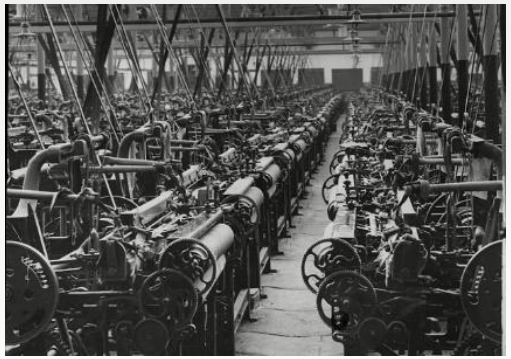
Industrial Mega Trends: Industry 4.0, the Smart Factory

Industry Mechanization



1st

Mechanization, water power, steam power

Mass Production



2nd

Mass production, assembly line, electricity

Computer and Automation



3rd

Computer and Automation

Cyber Physical Systems

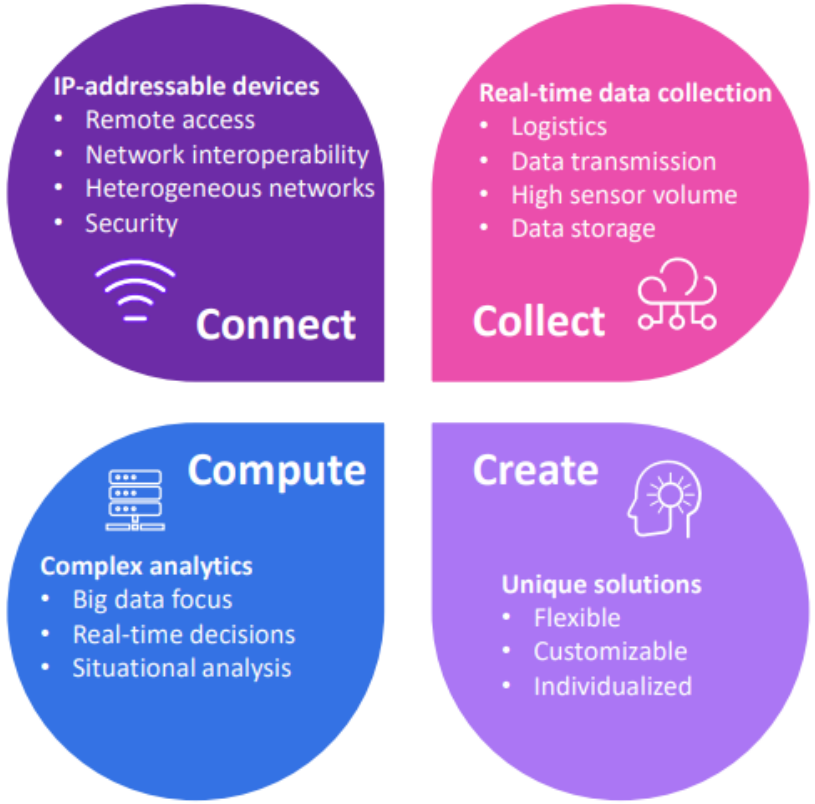


4th

Industry 4.0 includes cyber-physical systems, Internet of Things and cloud computing. Cyber-physical systems monitor physical processes and make decentralized decisions. They communicate through IoT and cooperate with each other and humans in real-time.

Pillars of Industry 4.0

› Industrial IoT



› Connected Industrial Sensors

› Convergence of Edge & Cloud Computing
› Distributed intelligence

› AI/ML, Industrial Software
› Predictive Maintenance & Sustainable Production

Drive the growing need for secure, reliable and flexible Microcontroller and Connectivity (wired, wireless) solutions

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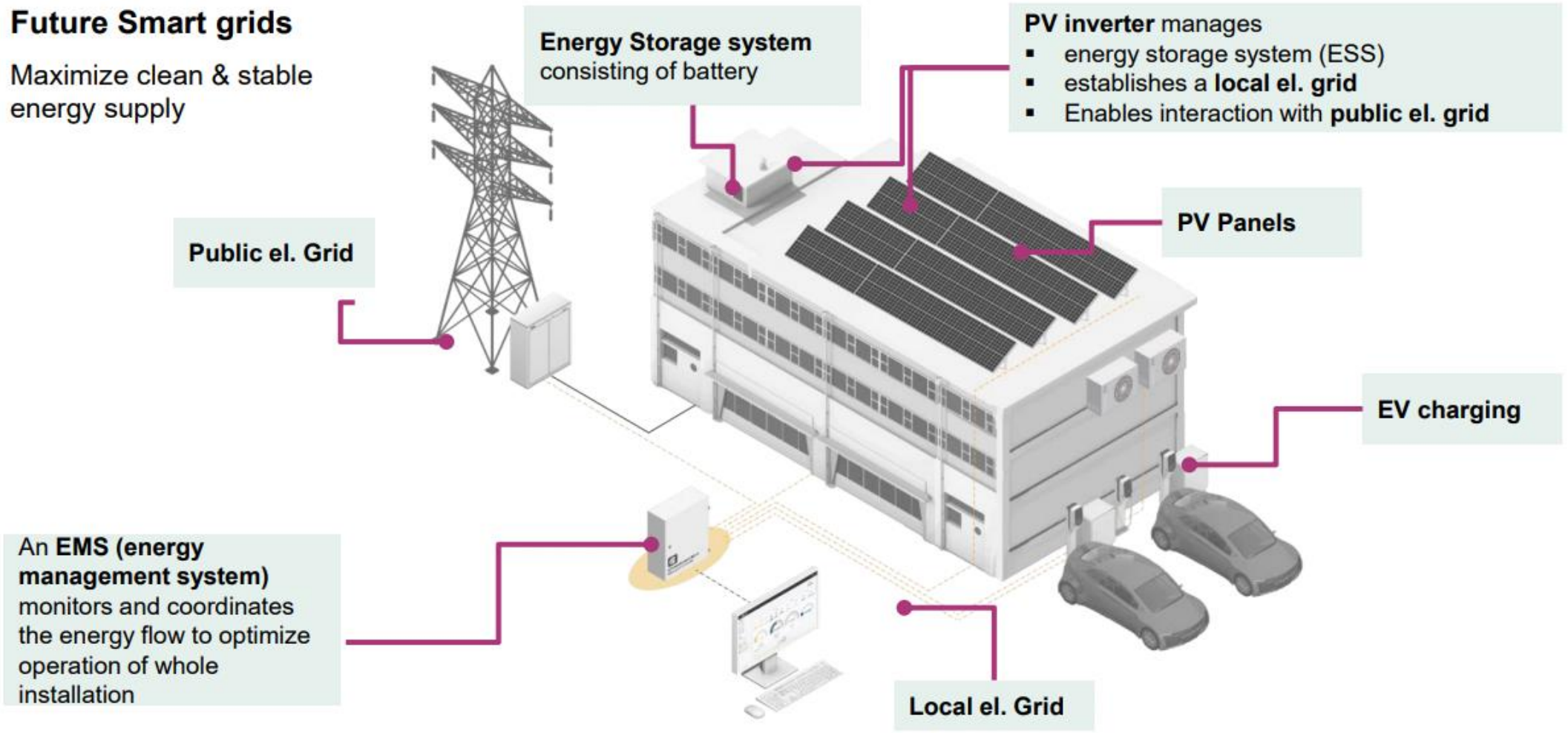
Industrial Mega Trends: Renewable Energy & Smart Energy Management



Microcontroller and Connectivity (wired, wireless) solutions are critical across all applications in this connected microgrid infrastructure

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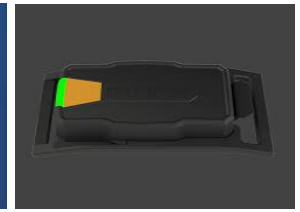
Industrial Target Applications

Segment	Applications
Industrial Automation	 PLC  HMI  Circuit Breaker  I/O Module  Gateways  Sensors
Motor Control & Drives	 Servo Drives  Medium Voltage Drives  Low Voltage Drives  Cordless Power Tools  Corded Power Tools
Power & Energy	 EV Charging  PV Inverter  Energy Storage System  Server PSU  Comm/Horticultural Lighting  Smart Meter
Transportation, Object & Vehicle Trackers	  Light Electric Vehicles     Object & Vehicle Trackers

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Smart Speaker

Market insights



GLOBAL SHIPMENTS 2021 to 2027

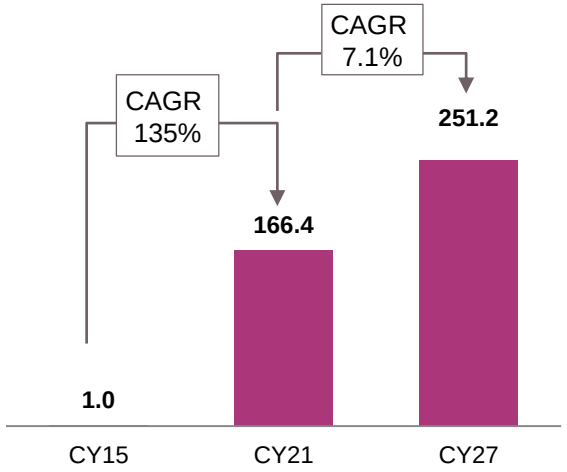
166m to 251m

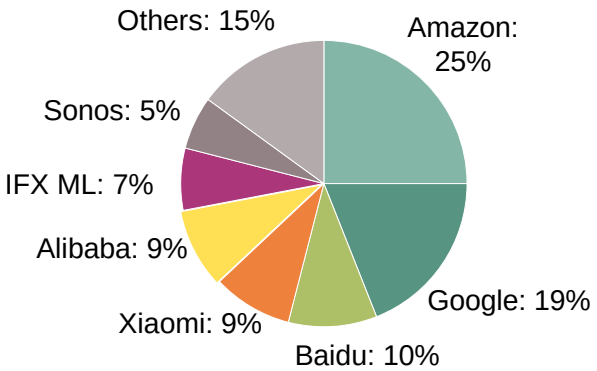
CAGR 7.1%

GLOBAL SALES REVENUE 2021 to 2027

13.9bn USD to 20.2 bn USD

CAGR 6.4%





CY 2021

Source: SAR Insight, June 2022

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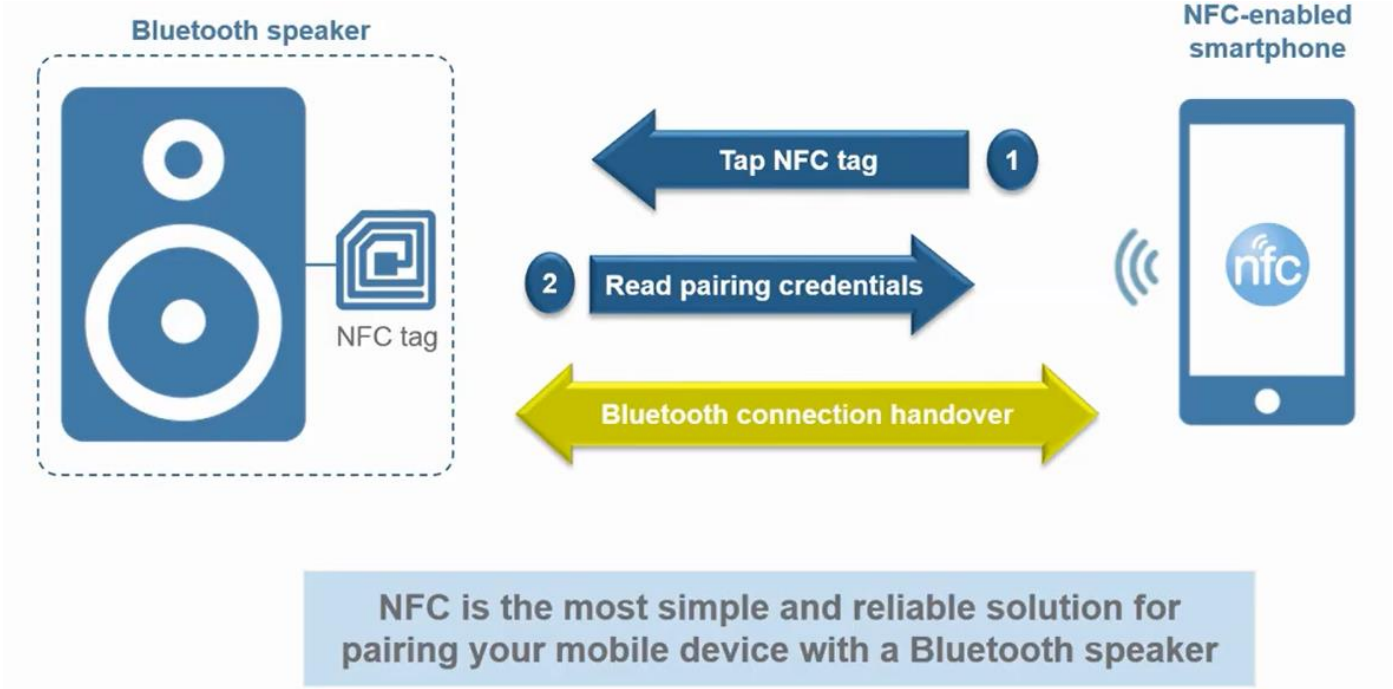
Tap to Pair: convenient Bluetooth paring via NFC

Ease of Use

- Bluetooth pairing via NFC
- Data transmission by pointing - UWB





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UWB for more accurate localization and secure communication

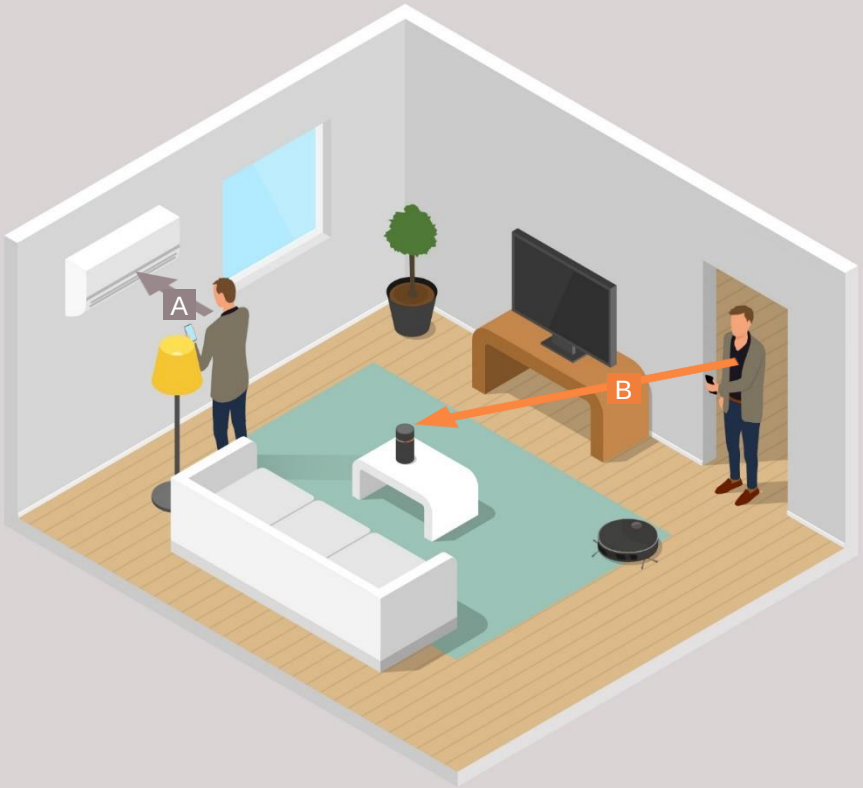


Ease of Use

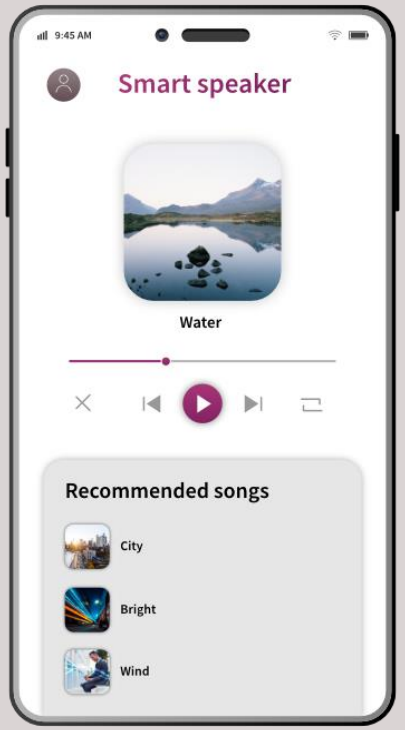
- Bluetooth pairing via NFC
- Data transmission by pointing - UWB

A User points the phone towards the Smart AC





B User points the phone towards the Smart Speaker





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Detection enabled by Capsense and radar

Advanced Sensing

- Proximity/Gesture detection
- Radar enabled presence detection, sleep / baby / elderly monitoring

	Capsense	Radar
Technology		
Range up to	15 cm	1 m
Internal algorithm available	Swipe, hold	Swipe, push, circle
MCU	Integrated in PSoC4	PSoC6 / M4
Use cases	Adjust volume, play/pause/change playing song	

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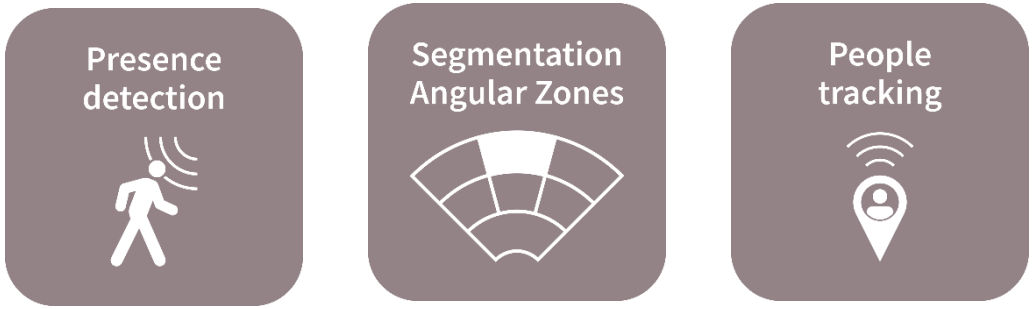
Macro and micro motion detection – from movement tracking to health care



Advanced Sensing

- Proximity/Gesture detection
- Radar enabled presence detection, sleep / baby / elderly monitoring

Macro detection



- Detecting human presence from up to 15m
- Ability to detect direction of movement (angle-of-arrival)
- Calculate range and velocity of human target(s)
- People counting
- Sound beamforming

Health care



- Analyze sleeping status -> sleep monitor
- Body movement -> fall detection
- Tracking of heartbeats / respiration rate -> baby monitor

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Application scope evolves for the diversification of smart speaker

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Diversification

Portable smart speakers, VUI built-in HA, Health-care monitor, office , hotel, in vehicles…

Initial application scope

Active room speakers



- hub of smart home
- Bluetooth pairing via NFC
- Voice commerce enabler

Enhanced application scope (2017~2022)

Portable smart speakers



- Bluetooth pairing via NFC
- UWB for finding my speaker
- Wireless Charging

Smart Display



- Smart speaker with touchscreen and secure camera for video calling/streaming, web browsing
- E-Commerce security
- Enable more personalized services and get customized content...

Additive application scope (2023 ~future)

Smart Speaker built-in HA



- Matter-compliant devices with VUI(Smart speaker built-in) for voice command

in Vehicles



- Voice command for music play and calling
- Voice control smart home in vehicles
- More services related to driving…

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Key Takeaway



Category Leading Products

Longstanding IoT Leader

Trusted Partner



Part of your life. Part of tomorrow.