SMART SENSORS TECHNOLOGY AS THE FOUNDATION OF THE IOT

OPTICAL MICROSYSTEMS ENABLE INTERACTIVE LASER PROJECTION

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CEO BOSCH SENSORTEC GMBH
“Do you know how often you encounter MEMS sensors in your daily life?”
MEMS sensors – key technology for the connected world

...at your workplace

...in your city

...at your home

....in your vehicle

...during your free time
How did MEMS develop?
Waves of MEMS sensor proliferation

1st wave
Automotive

2nd wave
Consumer Electronics

3rd wave
Internet of Things (IoT)
Bosch Sensortec
More than 50 MEMS sensors in 1 car

<table>
<thead>
<tr>
<th>Engine Management</th>
<th>Safety</th>
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<tbody>
<tr>
<td>1 Mass flow sensor</td>
<td>2 High-g acceleration sensors [Airbag]</td>
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<tr>
<td>1 Pressure sensor [Barometric air pressure]</td>
<td>1 Angular rate sensor, 1 Low-g acceleration sensor [Roll-over sensing],</td>
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<tr>
<td>2 Pressure sensors [Manifold air pressure, oil]</td>
<td>1 Acceleration sensor (Structure-borne sound sensor) [Airbag]</td>
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<td>1 High pressure sensor [Common Rail]</td>
<td>4 Acceleration sensors, 2 Pressure sensors [Peripheral airbag sensors]</td>
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<td>1 Pressure sensor [Tank pressure]</td>
<td>2 Pressure sensors [Pedestrian safety]</td>
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<tr>
<td>1 Pressure sensor [Start/stop function]</td>
<td>1 Angular rate sensor, 1 Low-g acceleration sensor, 1 High pressure sensor [ESP (incl. ACC)]</td>
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<td>2 Acceleration sensors [Active engine mounting]</td>
<td>1 Angular rate sensor [Active steering]</td>
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<td>1 Pressure sensor [Diesel particulate filter]</td>
<td>1 Acceleration sensor [eCall]</td>
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<th>Comfort</th>
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<tr>
<td>2 Pressure sensors [Automatic transmission]</td>
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<tr>
<td>5 Acceleration sensors [Active suspension]</td>
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<tr>
<td>1 Pressure sensor, 1 Humidity sensor,</td>
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<td>2 Gas sensors [Air conditioning, air quality]</td>
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<tr>
<td>1 Angular rate sensor, 1 Acceleration sensor [Navigation]</td>
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<tr>
<td>3 Microphones [telephone]</td>
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<tr>
<td>1 Bolometer Array [Night vision]</td>
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<tr>
<td>1 Acceleration sensor [Car alarm]</td>
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<tr>
<td>(Seldom: 16 Pressure sensors (up to 8 pressure sensors per seat)</td>
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CE MEMS sensors in mobile devices

- **Inertial Measurement Unit**: Integrates accelerometer and gyroscope
- **Accelerometer**: Detects acceleration and orientation
- **eCompass**: Combines accelerometer and geomagnetic sensor
- **Gyroscope**: Measures yaw rates
- **Software**: Intelligently fuses raw data from multiple sensors
- **Microphone**: Highly integrated MEMS-based microphone solution
- **Environmental Unit**: Measures pressure, humidity and temperature
- **Absolute Orientation**: Integrates accelerometer, gyroscope and magnetometer
MEMS sensors – a multitude of devices

Mobile
CE devices
Industrial and logistics
Smart home and building
Fitness and well-being

MEMS sensors are used in a multitude of devices, including mobile, CE devices, industrial and logistics, smart home and building, and fitness and well-being.
Overview / MEMS markets by application

Source: IHS Markit – MEMS & Sensors Intelligence Service
June 2017, courtesy of IHS Markit
MEMS sensors – enablers for the Internet of Things

- Parking spot detection
- Indoor/outdoor navigation
- Indoor air quality
- Sleep monitoring
- Intrusion detection
- Asset tracking
- Augmented reality
- Calorie tracking
- Step counting
- Indoor/outdoor navigation
- Navigation
- Calorie tracking
- Step counting
- Sleep monitoring
- Intrusion detection
- Asset tracking
- Augmented reality
- Calorie tracking
- Step counting
Role of smart sensors in the IoT

Everything will be connected

Today, about 6bn* devices are connected worldwide.

By 2020, about 21bn* devices will be connected.

By 2020, the global market for IoT solutions is expected to be worth some 250bn USD.

Source: *Gartner
IoT is about making life simpler and more exciting.

Everything should be “Simply. Connected“ for the user.

But sensing everything in **multiple and complex environments** bears a lot of challenges...
Role of smart sensors in the IoT

Challenges and barriers

IoT is...

... technologically demanding

CE sensor technology

- Many technologies available...
- ...but not always adapted for IoT
- Power (always-on applications), size, scalability, cost
Role of smart sensors in the IoT
Challenges and barriers

**IoT is...**

...**fragmented**

**System/application customization**

- Different applications: home, vehicle, city, industry, entertainment
- Deep application know-how needed
- Small volume customers
- Lack of synergies & standardization
Role of smart sensors in the IoT
Challenges and barriers

Cooperation and collaboration

- Value is in end-to-end solution
- Large and diverse eco-system
- Business models not yet established
- Fast time to market (fast prototyping)

IoT is...
... complex
Role of smart sensors in the IoT

Smart sensor hubs

Integrated sensor hubs BHI160 and BHA250

SmartHub solutions combine Bosch Sensortec’s...

- lowest power sensors (IMU < 1mA)
- best-in-class sensor data fusion software
- optimized microcontroller, “FUSER Core“
- ... to provide the lowest power solution without compromising features or performance.
Role of smart sensors in the IoT
Driving innovation and cooperation: Smart sensor hubs

▶ Overcoming the challenge of TECHNOLOGY
  - Leverage CORE MEMS- and system know-how
  - Size, power, performance, embedded intelligence

▶ Overcoming the challenge of FRAGMENTATION
  - Platform solution with hardware and software
  - APPLICATION know-how in the Bosch Group
  - Application-specific software, e.g. AR/VR/PDR

▶ Overcoming the challenge of COMPLEXITY
  - From components to systems and solutions
  - Simple design and TURN-KEY solution
  - COOPERATION with third parties, reference designs

Smart sensors are sensing our world in multiple and complex environments, allow things to be “Simply.Connected” and act as the enablers of the IoT.
SMART SENSOR technology is the foundation of the IoT

...at your home

...in your vehicle

...in your city

...at your workplace

...during your free time
We enable not only SENSING, but also INTERACTING with our world.
Bosch microscanner BML050 for interactive laser projection
Transforming any surface into a virtual user interface
MEMS scanner – interactive projection for the automotive industry

Operating ATMs

Ticket machines

Virtual keyboards

Assistant robots

Home robots

Gaming

Head-up displays (HUD)

Home appliances

Ticket machines

Smart goggles

Gaming

Head-up displays (HUD)
Joint research project PICOLO

Laser projection in low-cost, building space reduced HUD modules
MEMS scanner – virtual user interfaces in your everyday life

Operating ATMs
Ticket machines
Virtual keyboards
Head-up displays
Assistant robots
Smart goggles
Gaming
Home robots
Home appliances
Ticket machines
Virtual keyboards
Head-up displays
Assistant robots
Smart goggles
Gaming
Home robots
Home appliances
THANK YOU!