FTF 2016
TECHNOLOGY FORUM

# AUTOMOTIVE SENSORS PORTFOLIO

## SESSION FTF-AUT-N1821

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FTF-AUT-N1821

MAY 17, 2016

# AGENDA

- Automotive sensors overview
  - Motion sensors
  - Pressure sensors
  - Magnetic sensors

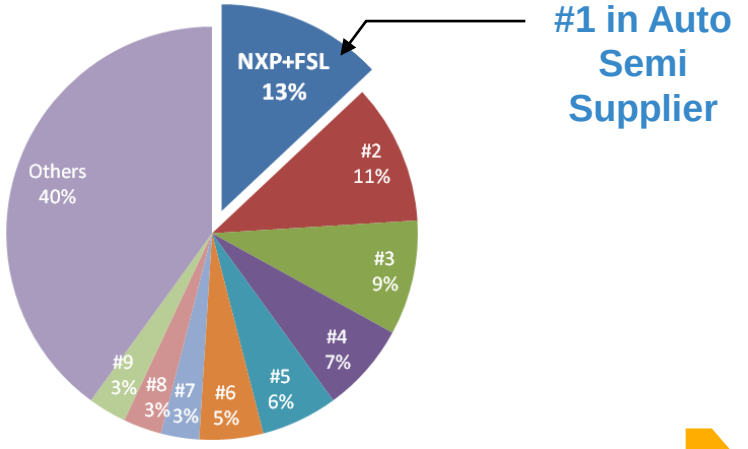
# The “New” NXP = NXP + FSL

## A Great Environment for our Team

- Almost **45,000** employees in >**25** countries
- Well over **12,000** engineers
- Over **9,800** patent families

- Doubling our R&D strength
- Access to broader product & IP portfolio
- Access to a broader customer base
- Access to more advanced process technology

| | |
|---|---|
| | World Leader in Automotive semiconductors<br>➔ Strengthen Position in High Growth Focus Markets |
| | Leveraging Operational Excellence & Cost Synergies<br>➔ Strong Cash Generation<br>➔ 3x Net Debt/TTM adj. EBITDA at close; reducing to 2x within 6 quarters |
| | World-Class Team Globally<br>➔ Customer-Focused Passion to WIN |
| NXP+ | **Will drive Significant Additional Shareholder Value** |




**#1 in Auto Semi Supplier**

# NXP Sensor Technology Supports Key Applications

## Automotive


**3**

**BILLION UNITS SHIPPED**

- Magnetic (MR)
- Motion (MEMS)
- Pressure (MEMS)

## Medical & Industrial

# BL Sensors: Introduction

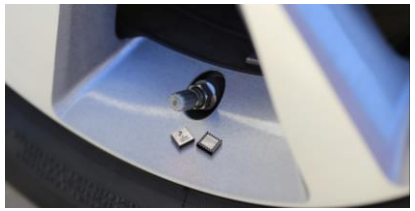
## Automotive Sensors one Foundation to Safety & Highly Autonomous Driving

### Motion Sensor

**Airbag Accelerometers, Active Safety Combos & IoT**

- All passive safety Tier-1's using NXP
- Next generation discrete & integrated UMEMS foundational for Auto & IoT future
- Active safety motion sensors (gyro+accel)

### Pressure Sensors



**TPMS, Engine Mgnt, Medical & Airbag Satellite Pressure**

- Investing lowest power, smallest size solutions
- High accuracy pressure - flow measurements
- Complementing airbag-motion solutions

### Magnetic Sensors

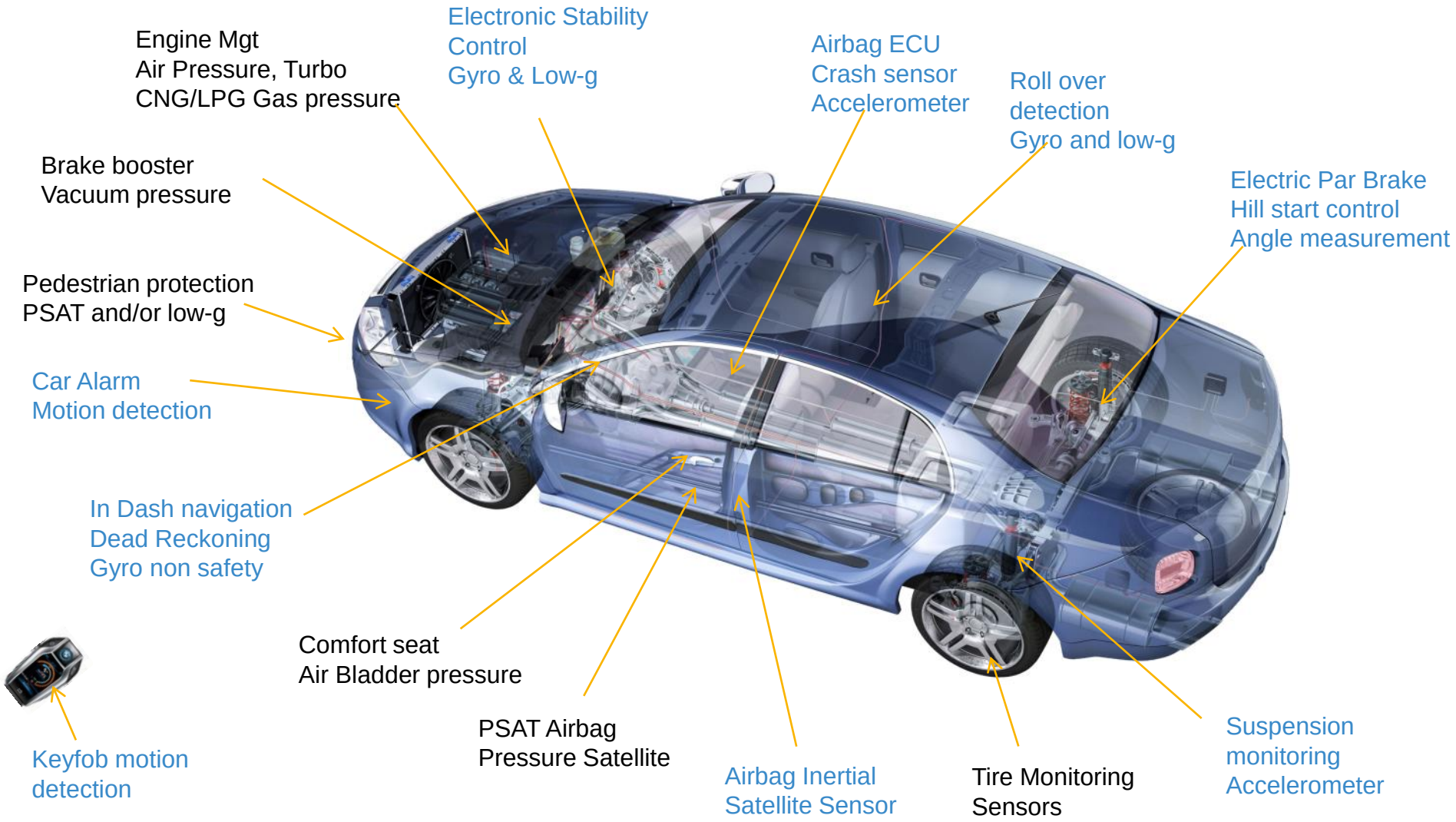
**Angular for Engine Control ABS Speed Sensors**

- Angular sensors: engine control & steering
- Speed wheel sensors for ABS
- AMR→TMR transition foundational for long term revenue preservation & EBIT expansion

***#1 in Automotive Safety Sensors***

# SAFETY MOTION SENSORS SOLUTION

# NXP MEMS Sensors in Automotive Applications



# VEHICLE SAFETY

# Evolution of Vehicle Safety

**Passive Safety**

**Injury Free**
2000-2010

**Active Safety**

**Accident Free**
2010-2020

**Predictive Safety**

**Semi-Autonomous Driving**
2020-2030

- Safe comfort
- No fatalities
- Higher degree of automation

# Safety for Everyone

- **1.3 million people** around the world are killed on roads every year
- **50 million** are injured
- Passive safety & active safety to be deployed in developing countries
- **Advanced Driver Assistance Systems (ADAS)** regulation/NCAP requirements in preparation for Europe, US and Japan

| |  |  |  |  |  |
|---|---|---|---|---|---|
| **Country** | **USA** | **Germany** | **Japan** | **China** | **India** |
| Population | 306 million | 83 million | 128 million | 1.3 Billion | 1.1 billion |
| Car Park | 251 million | 56 million | 91 million | 145 million | 72 million |
| Road fatalities | ~ 40,000 | ~ 5,000 | ~7,000 | ~ 90,000 | ~ 105,000 |
| Death / 100k people | 13.9 | 6.0 | 5.2 | 6.7 | 8.8 |
| **Death / 100k cars** | **17.0** | **9.0** | **7.3** | **61.6** | **145** |
| Trend in road fatalities |  |  |  |  |  |

## What do you / our customers need to succeed?

- Cost effective passive safety system in emerging countries: Airbags, ABS, TPMS
- ADAS solutions in developed markets – scalable family of high performance MCUs, multicore lockstep, fast and deterministic communication, SiGe radar technology, vision & ethernetAVB
- Functional safety ISO26262 compliant solutions

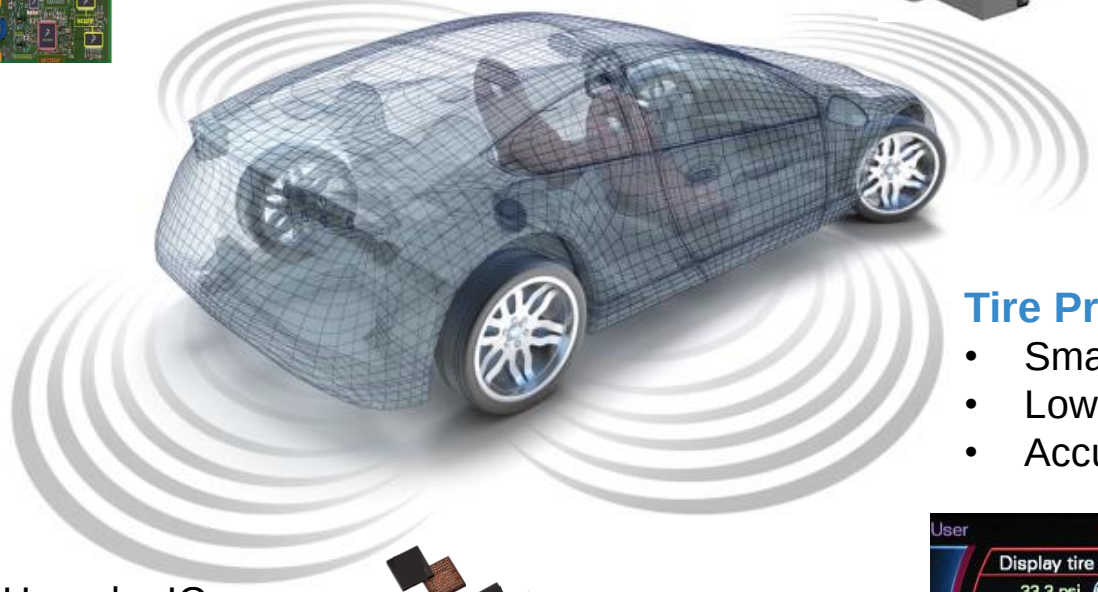
# NXP Solutions in Automotive Safety Applications

## Airbag Solutions

- High integration including PMU and sensor interface
- Accelerometers, satellite crash sensors and pressure
- Leadership in both DSI and PSI standards

## Braking ESC and ABS

- Precision valve control
- Advanced motor drive

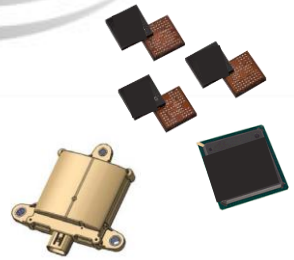


## Tire Pressure Monitoring Module

- Small 7x7 mm system footprint
- Low power consumption
- Accurate measurement over wide range

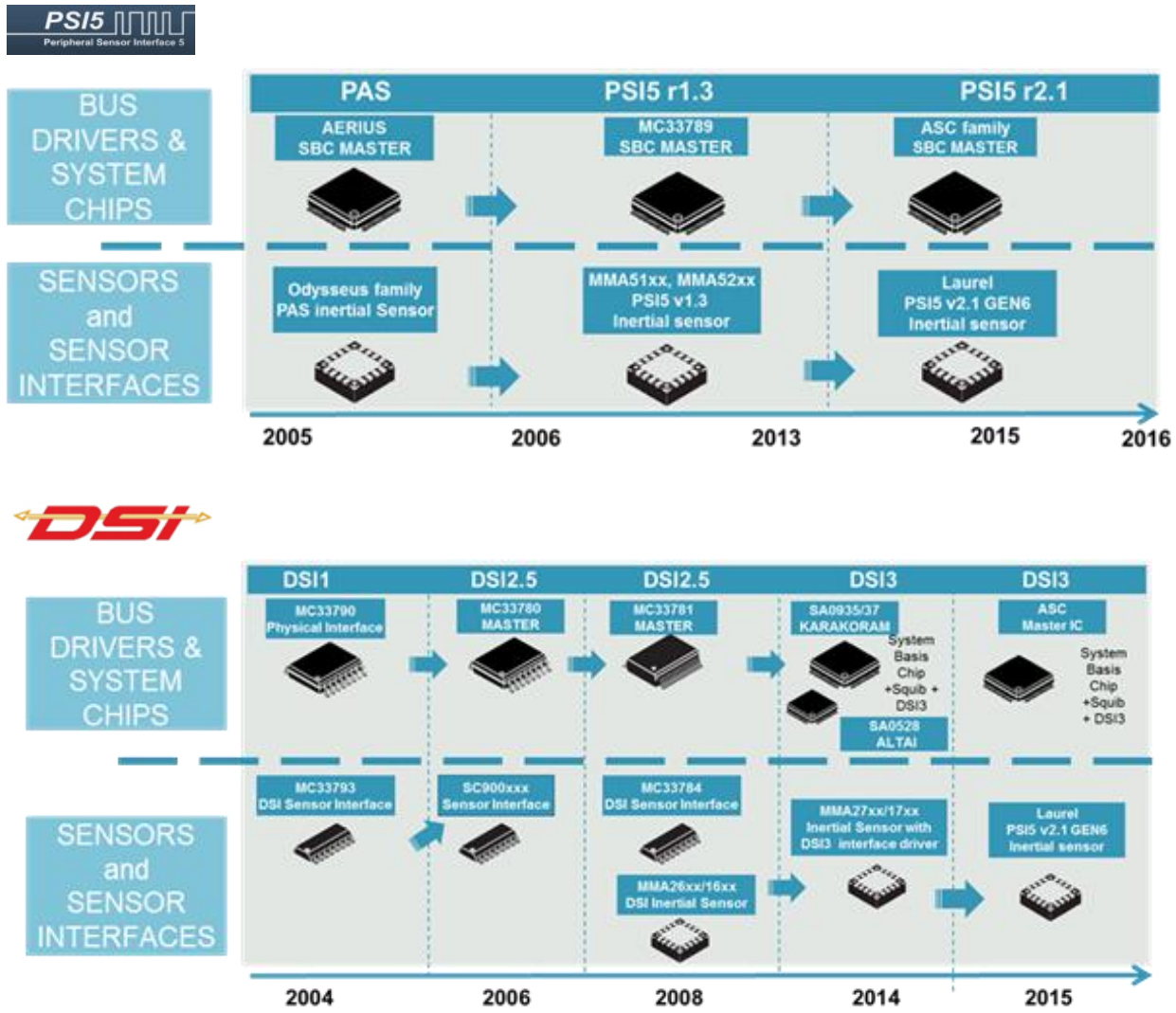

## ADAS 77 GHz Radar

- Scalable packaged 77 GHz radar ICs
- Radar processor with optimized API
- Next generation high integration ICs



# NXP: Leader in Motion Sensor For Automotive Safety Application

- Over 1.1 BU shipped since 2000
  - Over 50 Motion Sensor Family ICs
- Total solution including Sensors, Analog ICs, and MCUs
- Leadership for both DSI, PSI, SPI, and I2C standards
- Comprehensive integrated functional safety in ISO26262



# First Certified of Semiconductor Industry

## Applicable Part Requirements

ISO 26262 Functional Safety Standard Certification for Analog & Sensors Hardware Development Process

SGS TÜV SAAR

CERTIFICATE NO.: FS/71/220/15/0078 PAGE 1/1

LICENCE HOLDER

FREESCALE SEMICONDUCTOR INC.
ANALOG & SENSOR GROUP
2100 EAST ELLIOT ROAD
TEMPE, ARIZONA 85284, USA

| Project-No/-ID | LICENSED TEST MARK | Report No. |
|---|---|---|
| H0AE | SGS TÜV SAAR FUNKTIONALE SICHERHEIT GEPRÜFT FUNCTIONAL SAFETY APPROVED | H0AE0002 |

| | |
|---|---|
| Tested according to | ISO 26262 : 2011 |
| Certified Product(s) | SafeAssure™ companywide Analog & Sensors hardware development process for Functional Safety related components . |
| Technical Data/Parameter | The audited SafeAssure development process for hardware product components complies with the ISO 26262 standard part requirements<br>ISO 26262-2:2011<br>ISO 26262-5:2011<br>ISO 26262-7:2011<br>ISO 26262-8:2011<br>ISO 26262-9:2011 |
| Specific Requirements | The certificate is created for the purpose of providing conformity of the development and support process in accordance with ISO 26262. Changes which are not covered in the Audit Report have to be reconsidered. |

Certification Body for Functional Safety SGS-TÜV Saar GmbH

Munich,26.01.2015

Marcus Rau

The test mark regulation is an integral part of this certificate.

SGS-TÜV Saar GmbH, Hofmannstr. 50, D-81379 München, Deutschland / Germany.

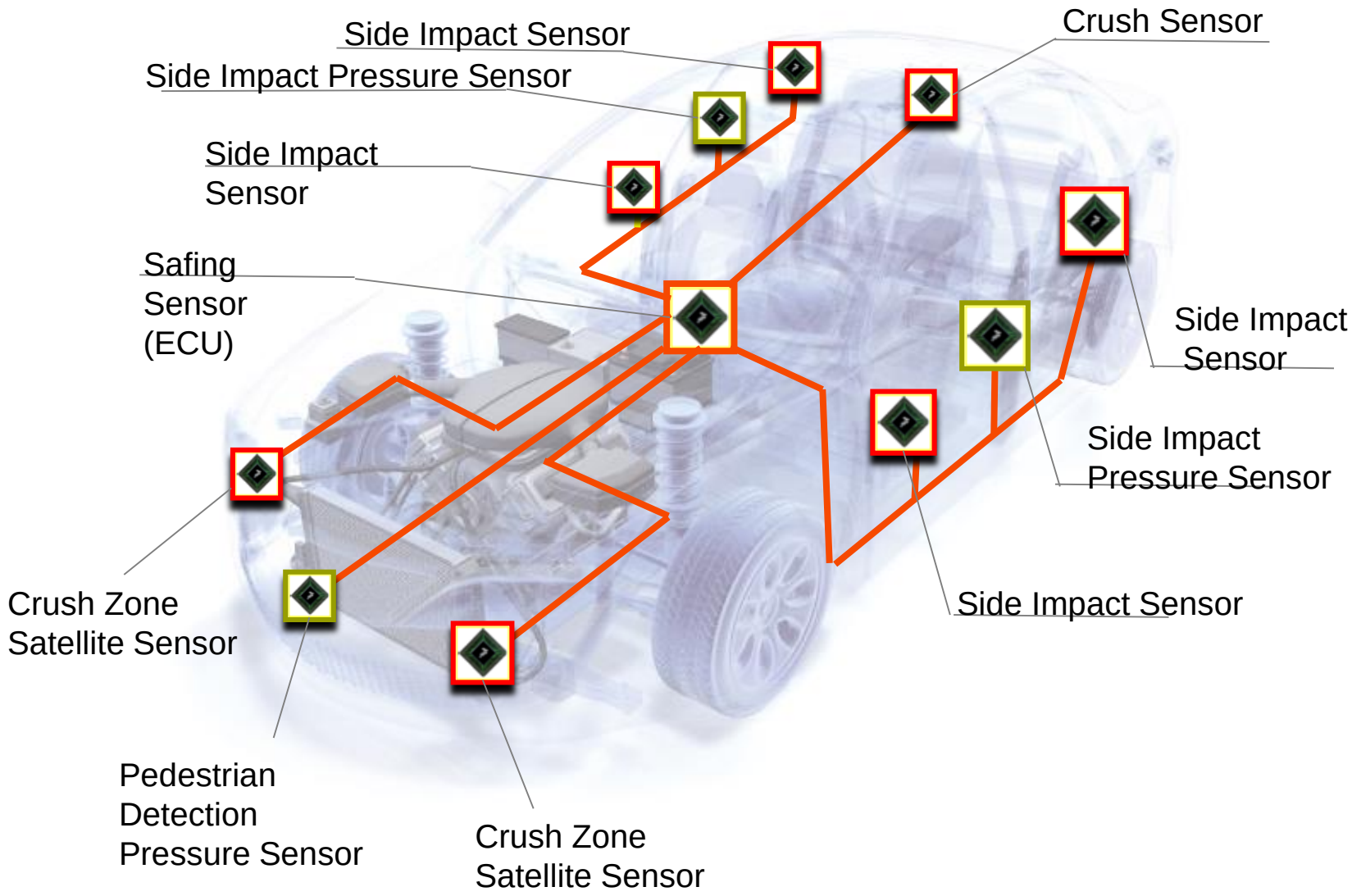
Website: www.sgs-tuv-saar.com/fs E-Mail: fs@sgs.com

CERTIFICATE

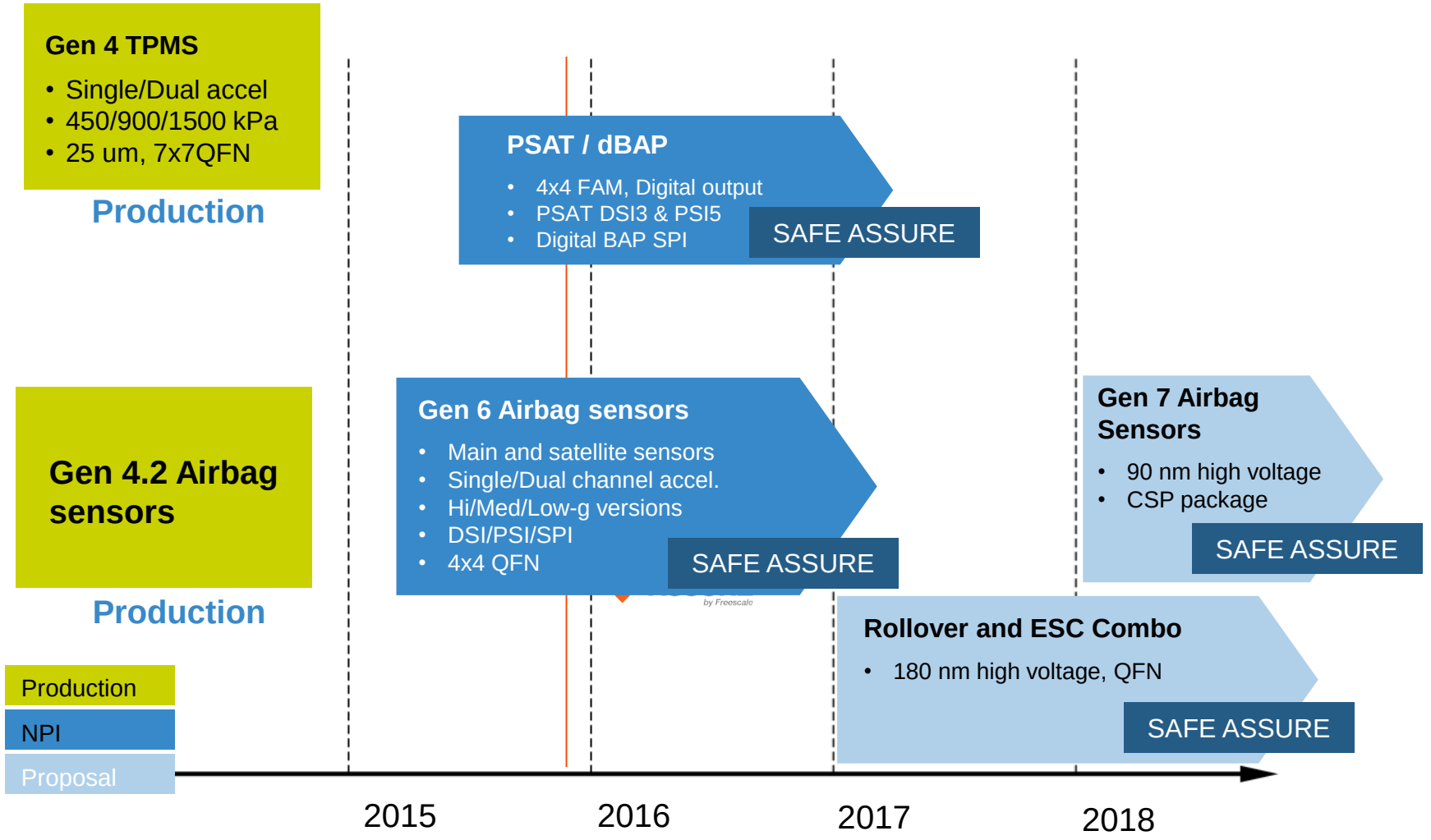
25 Feb **NEWS**

# MOTION SENSORS APPLICATIONS AND ROADMAP

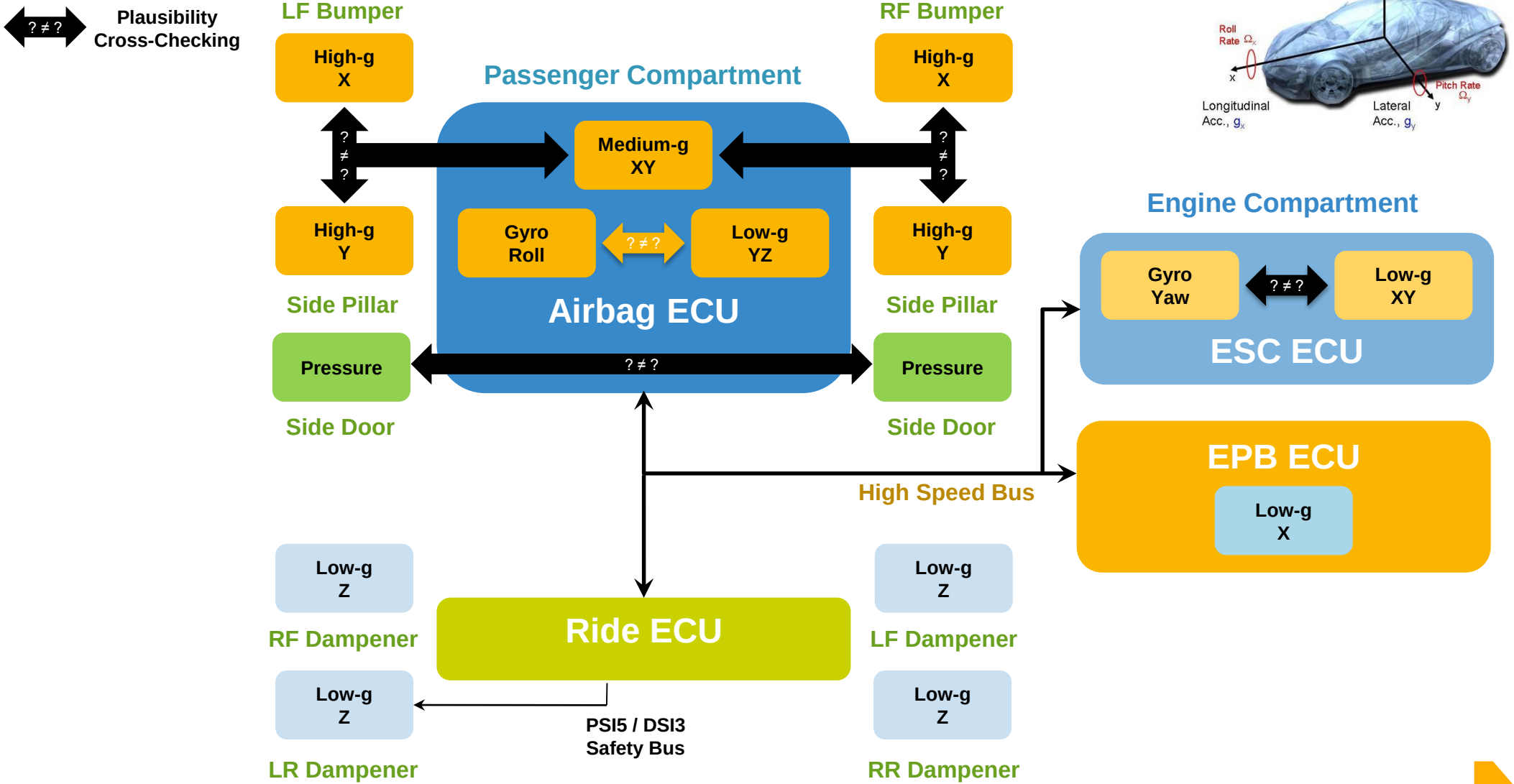
# PSI5 / DSI3 Airbag System



# Automotive Sensor Product Roadmap Overview



# NXP Solution in Current Architecture



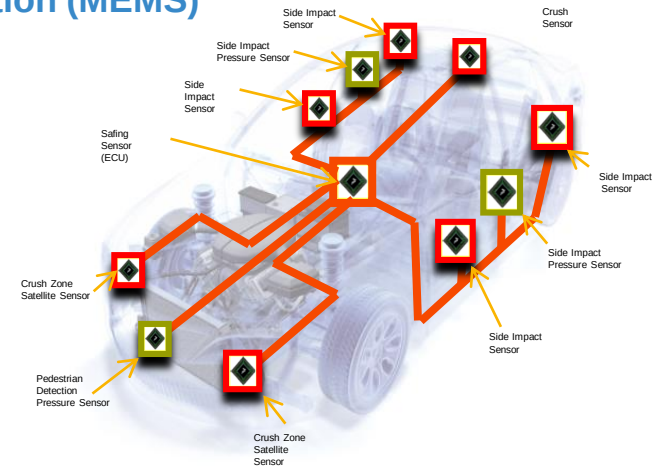
# Key MEMS Figures

- More than 3.0 billion MEMS sensors shipped
- **1.5 billion** MEMS sensors shipped in automotive applications
  - **1.2 billion** Airbag sensors
  - **140 million** pressure sensors for engine mgmt
  - **75 million** tire pressure sensor
  - **50 million** pressure sensor die

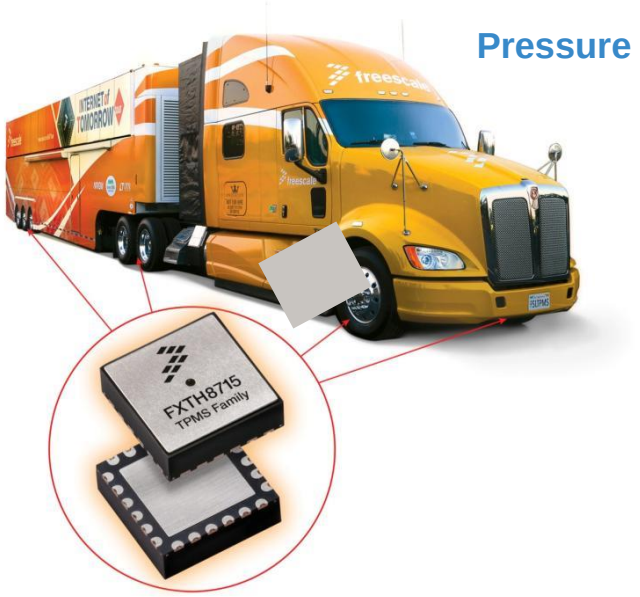
- Shipping 300 million MEMS sensors annually*, **200 million are going into automotive applications**

- **1 billion** Magnetic (MR) Sensors

**Motion (MEMS)**

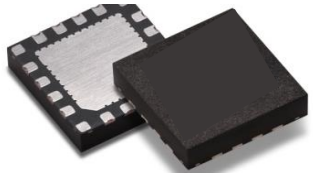



**Pressure (MEMS)**



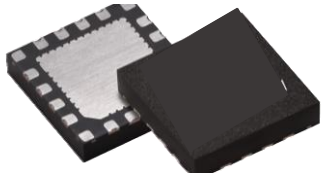
# ACCELEROMETERS

# Gen 4 Automotive Accelerometer Family



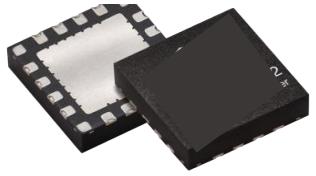
**MMA26xx / MMA16xx**

- Digital Output
  - DSI 2.5 compliant
- G range:
  - ±50 g to ±312.5 g
- Axis
  - X-axis, or Z-axis
- Selectable LPF
- QFN 6x6 package
- Operating temp:
  - -40C to 125C



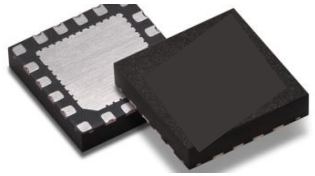
**MMA52xx / MMA51xx**

- Digital Output
  - PSI5
- G range:
  - ± 60g to ± 480g
- Axis
  - X-axis, or Z-axis
- Selectable LPF
- QFN 6x6 package
- Operating temp:
  - -40C to 125C



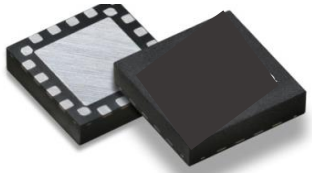
**MMA27xx / MMA17xx**

- Digital Output
  - DSI3
- G range:
  - X-Axis 25g, 125g, 187g, 250g and 375g
  - Z-Axis 250g
- Selectable LPF
- QFN 6x6 package
- Operating temp:
  - -40C to 125C



**MMA65xx / MMA6555x**

- Digital Output
  - SPI
- G range:
  - ± 20g to ± 120g
  - ± 80g to ± 120g
- Axis
  - XY-axis
- Arming function
- Selectable LPF
- QFN 6x6 package
- Operating temp:
  - -40C to 125C



**MMA69xx**

- Digital Output
  - SPI
- G range:
  - ± 3.5g or ± 5.0g
- Axis
  - XY-axis
- QFN 6x6 package
- Operating temp:
  - -40C to 105C

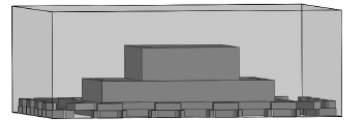
# Gen6 Project Scope – Covering All Airbag Requirements

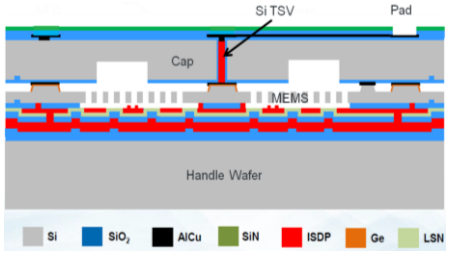
- **8 UMEMS designs**
  - Three g-ranges (low,med,high)
  - Three orientation (x, y, z)
- **2 ASIC designs (LL18UHV)**
  - Single channel PSI5/DSI3/SPI
  - Dual channel PSI5/DSI3/SPI
- **1 package type**
  - QFN 4x4 mm
- **4 core projects**
  - Single Chanel Med/High
  - Dual Channel Med/High
  - Accel Low G single
  - Accel Low G dual

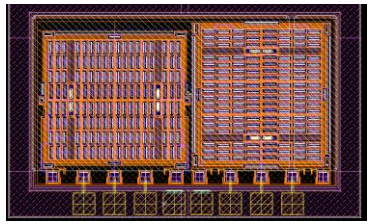
**Product Matrix**

| UMEMS | Single Axis | | | Dual Axis | | | |
|---|---|---|---|---|---|---|---|
| **Gen 6** | **X** | **Y** | **Z** | **XY** | **XZ** | **YZ** | **XX** |
| **Low g** | ● | | ● | ● | ● | | |
| **1.5g to 20g** | L | | L | LL | LL | | |
| | ● | ● | ● | ● | ● | ● | ● |
| **Medium g** | | | | MM | MM | MM | |
| **15g to 150g** | | | | ML | ML | ML | |
| | M | M | M | LM | LM | LM | MM |
| | ● | ● | ● | ● | ● | ● | |
| **High g** | | | | | HH | HH | |
| **50g to 500g** | H | H | H | HH | HM | HM | |

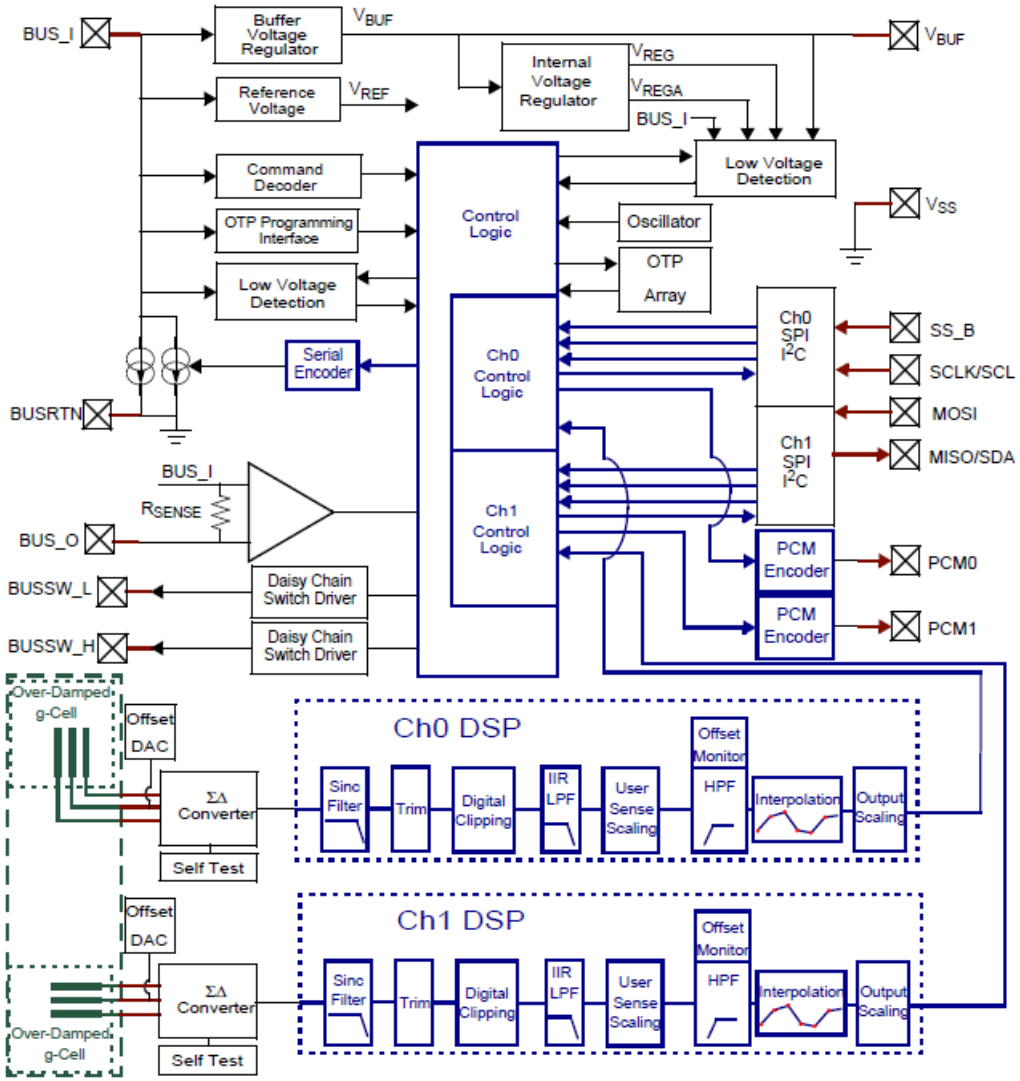
**L: Low; M: Medium; H: High**





# Dual Channel Inertial Sensors




## Features

### ASIC

- 180 nm CMOS
- Maximum operating voltage:  -0.3V - 20V
- Digital Signal Processing
- DSI3 Compatible
- PSI5 V2.1 Compatible, AKLV27 Compatible, Airbag Substandard
- HVST, IDDQ, Analog IDDQ, Scan, Logic BIST

### Transducer

- 2 Independent transducers in a common cavity
- X-Axis and Z-Axis UMEMS (Unique Range for each Channel)
- Bidirectional Self Test, Independently Controlled for each Channel

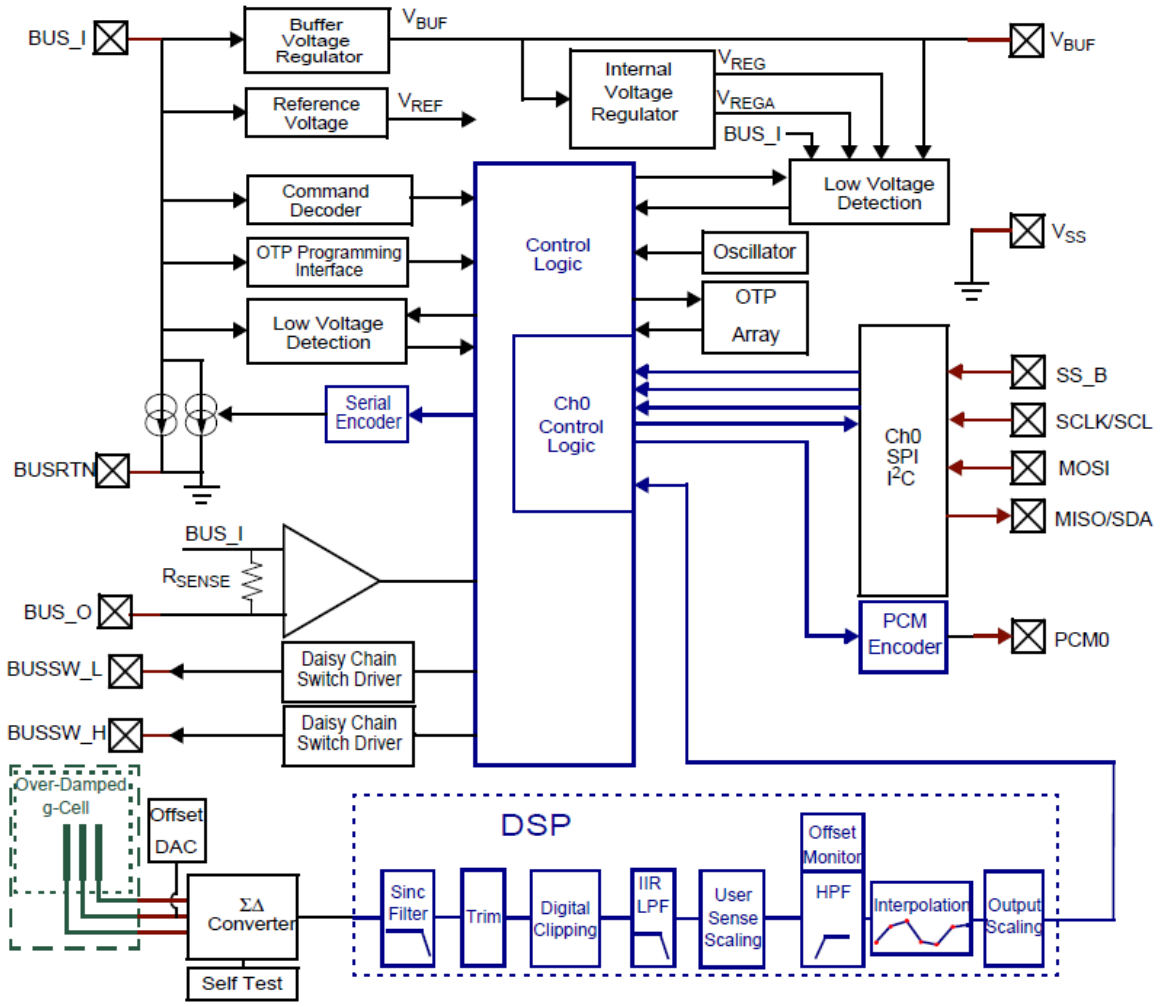
### Operating temperature

- -40C to 125C

### Package

- 16 pin QFN 4 mm x 4 mm x 1.45 mm
- Inspectable Solder Joints

# Single Channel Inertial Sensors




## Features

### ASIC

- 180 nm CMOS
- Maximum operating voltage:  -0.3V - 20V
- Digital Signal Processing
- DSI3 Compatible
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- HVST, IDDQ, Analog IDDQ, Scan, Logic BIST

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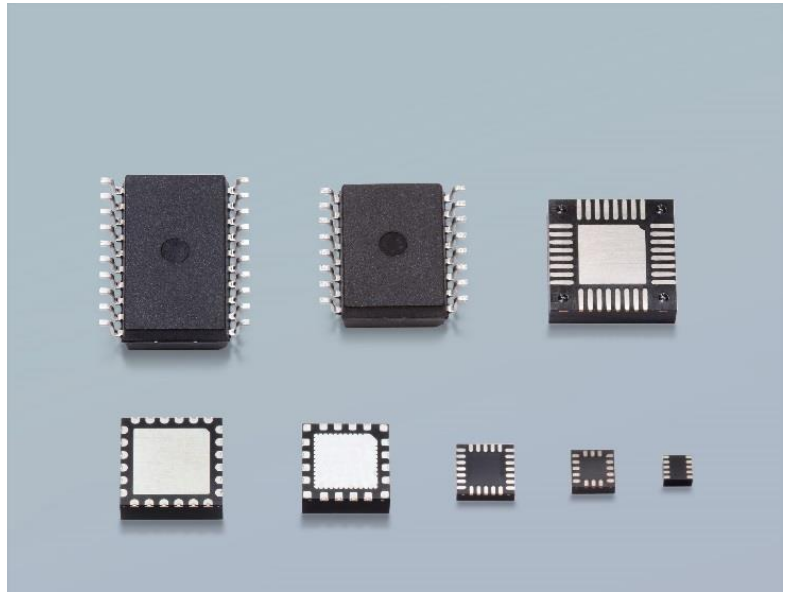
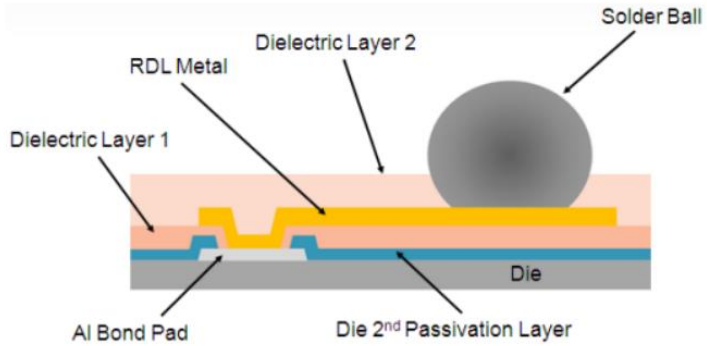
# PACKAGING AND ECOSYSTEMS

# Package Evolution Enabled By UMEMS



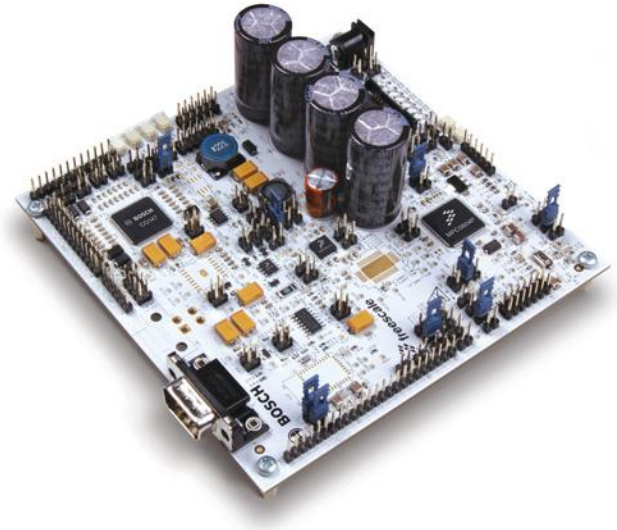
| Products | Package |
|---|---|
| TPMS Gen 4 | QFN 7x7 |
| Airbag accelerometer Gen 4.2 | QFN 6x6 |
| Airbag accelerometer Gen 6<br>PSAT, dBAP | QFN 4x4 |
| Automotive Gyroscope | QFN 6x6 (tentative) |
| Airbag Gen 7 | WLCSP proposed |



# Gen 4 and Gen 6 EcoSystem

## DSI, PSI, SPI, and I2C airbag system

- Airbag hardware evaluation platform
- Software for evaluation

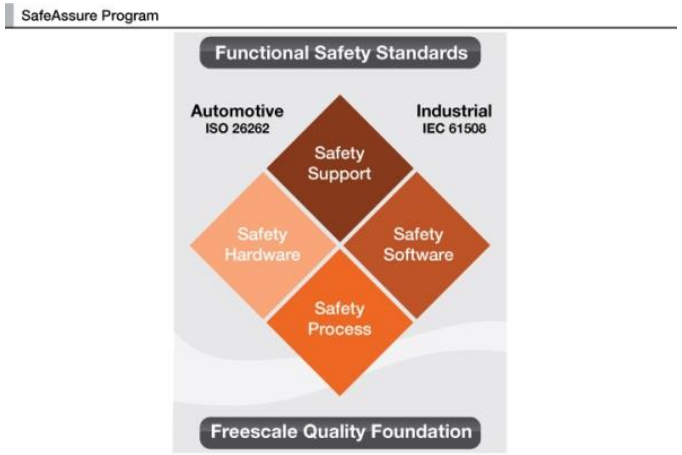


## Complete technical documentation available to ease design

- Datasheets
- Application notes
- Reference design manual
- Official PPAP reports

## Easy to use tools: Support design wins

- SafeAssure, functional Safety Program
- Technical training and hands on training on demand
- Fact sheet
- FAQ and other technical marketing presentations




Note: Gen 6 EcoSystem will be available Q4, 2016

# MOTION SENSORS
# Q&A

# PRESSURE SENSORS

# Tire Pressure Monitoring

# TPMS – Safety and Environment In Mind

- **Safety for everyone**
  - TPMS **prevent roadside breakdown** and risk of road congestion
  - 2007 US TREAD act to **prevent roll over accidents**
  - **Regulation & TPMS implementation** around the world

- **Cleaner world for everyone**
  - TPMS allows **optimum tire inflation** – fuel consumption and **CO2 emission reduction**
  - Maximizes tire life

- **Intelligent tires: A potential to be exploited**
  - Link tire information with chassis and **ADAS** system
  - Necessary building block for **automated driving**
  - Provides accurate **tire data** to the driver
  - **Filling assistant** app on smartphones
  - Fleets & Truck: optimizes **tire leasing models**

# TPMS Market Evolvement

- OEM: 100 million new cars sold per year by the end of the decade
  - TPMS mandated in USA, Europe, Japan
  - China car production about 15Mu per year *4 = 60 Mu TPMS sensors
- After Market: 1 billion cars on the road worldwide today!
  - TREAD Act (Sep, 2007) replacement (EOL of first generation sensors)
  - Potential for tire mounted solutions: Advanced tire-health diagnostics
- Heavy trucks, buses, motorcycles, any vehicle with aired tires
  - No government mandates yet
  - Safety: Motorcycles
  - Fuel savings, increased service life: Trucks

# TPMS Implementation In Light or Heavy Vehicles

### Modules installed on the valve stems

- Rim or valve stem mounted
- Pressure and temperature sensing
- Roll switch, wheel localization
- Battery operated
- Independent from the tires

### Modules installed on the tire treads

- Tire mounted sensors
- Pressure, temperature, radial and tangential tire acceleration
- Battery operated or battery less
- Linked to the tire

### Modules installed on the tip of the valves

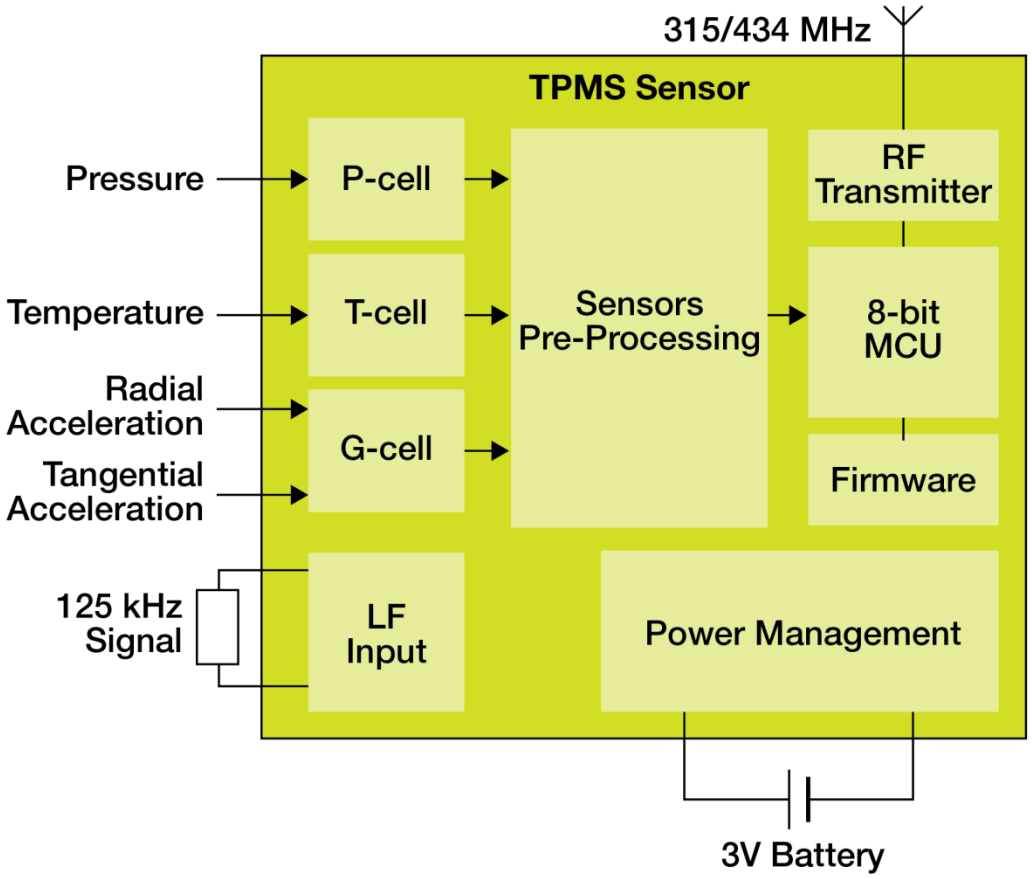
- Sensors mounted on top of the tire valves
- Pressure, temperature, radial tire acceleration
- Battery operated
- Common in aftermarket solutions

# NXP PRODUCT OFFERING

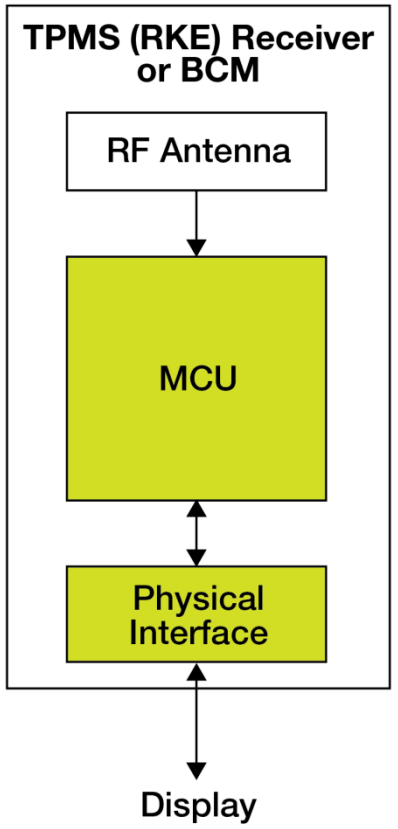
# NXP TPMS Are Used By the Following Brands*


*Not an exhaustive list – Status May 2015

# Tire Pressure Monitoring System Application Diagram

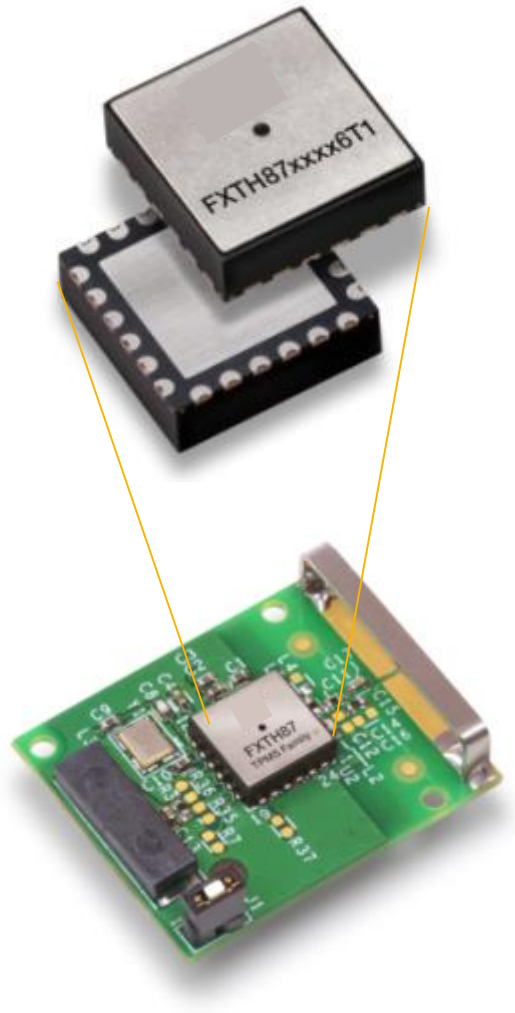






# FXTH87(E) Summary – World's Smallest TPM Sensor

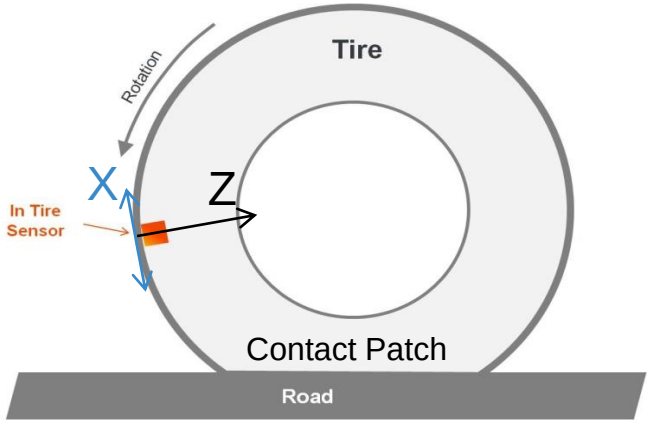
- **Smallest TPMS sensor on the market**
  - QFN 7x7x2.2 mm
- **Multiple pressure sensor ranges**
  - 450, 900 and 1500kPa
  - Ideal for passenger cars, trucks, aftermarket
- **Dual axis accelerometer** for extended sensing functionalities
- Embedded **MCU** and **dedicated TPMS Library**
  - Large memory space for customer application
- **LF and RF** wireless interface
- Ultra low power consumption
- **Volume production**
  - 450, 900kPa and 1500kPa released



# NEW TPMS APPLICATIONS & FUNCTIONS

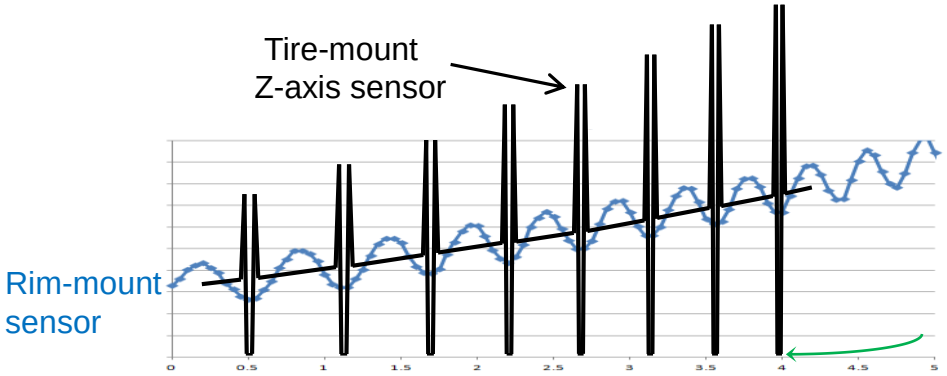
# Tire Tread Mounted Application

- Very high mechanical stress (up to 2 shocks per rotation) with potential impact on accelerometer, wires and package
- Temperature extreme (cold start to self heating from driving to high speeds)
- Withstand liquid/sand/dust in tire over temperature and g-force
- OEM end-of-line or tire shop in: full understanding of installation procedure




**Z**: radial acceleration
**X**: tangential acceleration

**Peaks of acceleration of around 3000 g**



# Tire Localization – X and Z-axis Accelerometer Advantages

- Utilizing X & Z **together** allows identification of Left Side or Right Side within **1st rotation of the wheels** (Clockwise or Counterclockwise)

- Utilizing X or Z at high sample rate allows determination of rotation rate within **2nd or a few subsequent cycles**

- Allows the RF receiver to **localize the wheels in less time**
  - Relies on low speed & large steering angle typical of the 1st portions of any normal driving cycle

- **Lower power consumption** due to reduced amount of time the sensor would remain in a high sampling mode
  - Less time in high sampling mode (i.e. high current consumption) **improves overall battery life.**

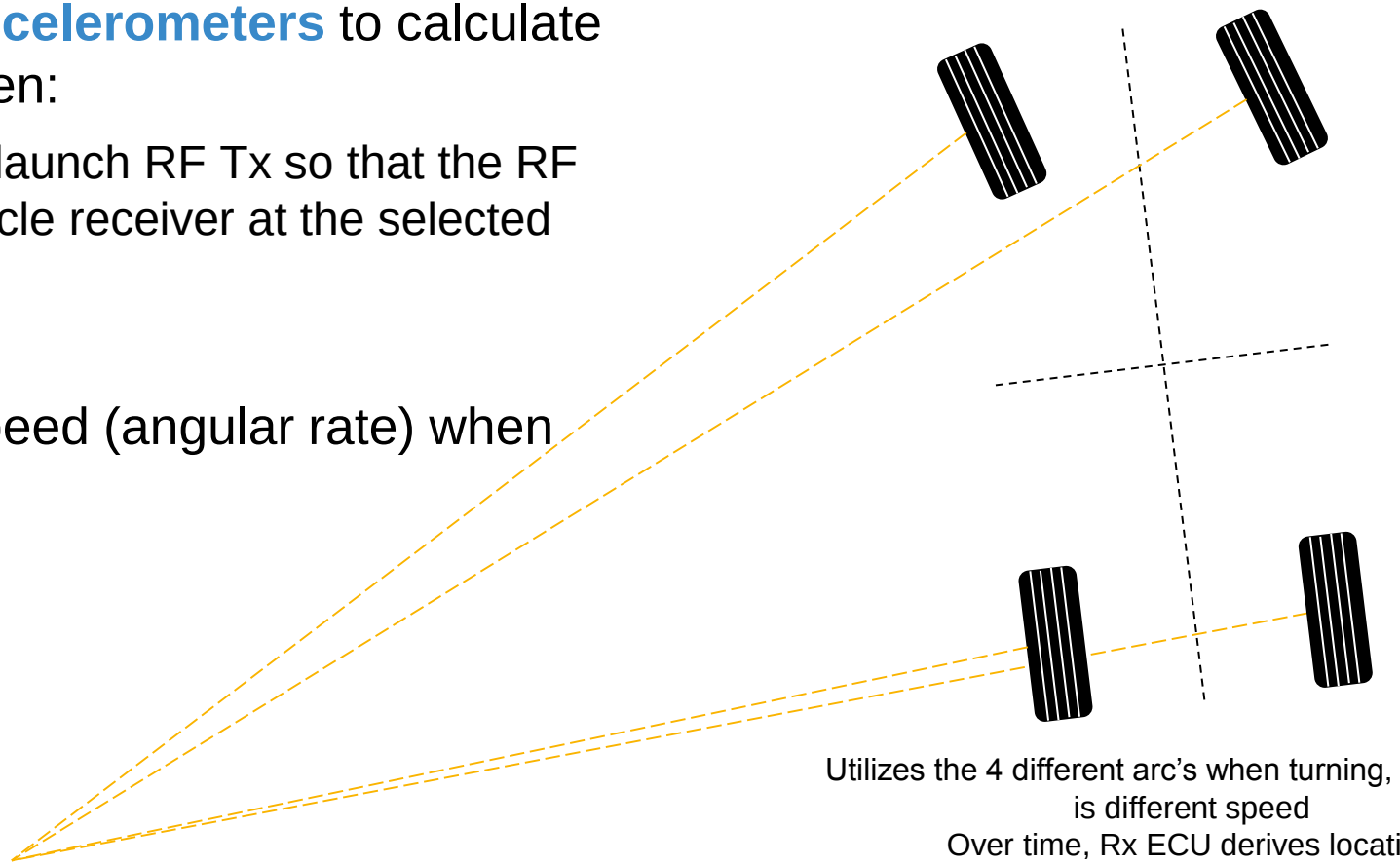
# Faster Tire Localization Extends Battery Life

1. Use **X and Z axis accelerometers** for 1 wheel revolution to determine rotation direction
2. Then use **X or Z axis accelerometers** to calculate the wheel speed, and then:
   - Predict the pre-angle to launch RF Tx so that the RF frame arrives at the vehicle receiver at the selected angle,

   OR
   - Transmit the wheel speed (angular rate) when ready

Wheel Speed Rate

**Relies on dual-axis Z & X-axis g-cell;**
**RF Rx ECU can be anywhere in vehicle**

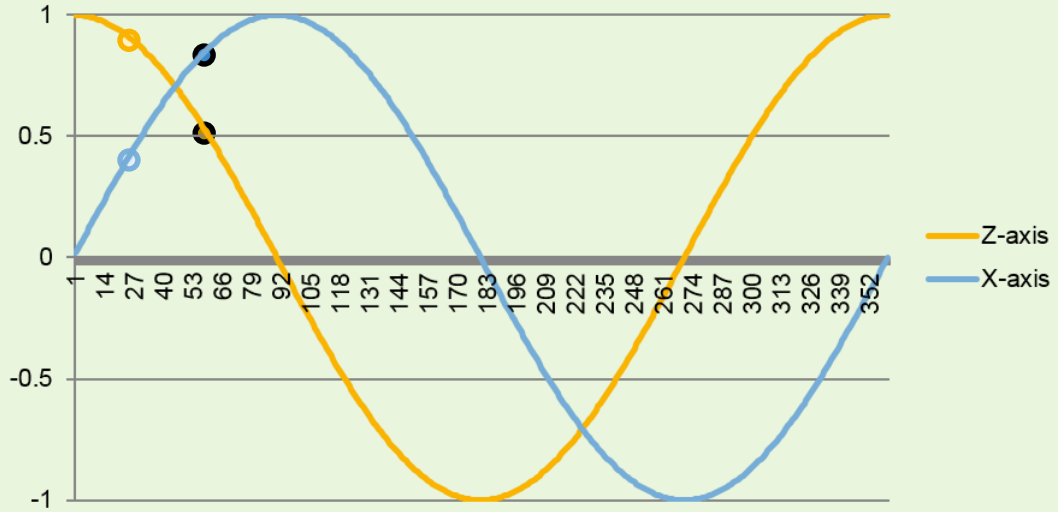


Utilizes the 4 different arc's when turning, each wheel is different speed
Over time, Rx ECU derives location

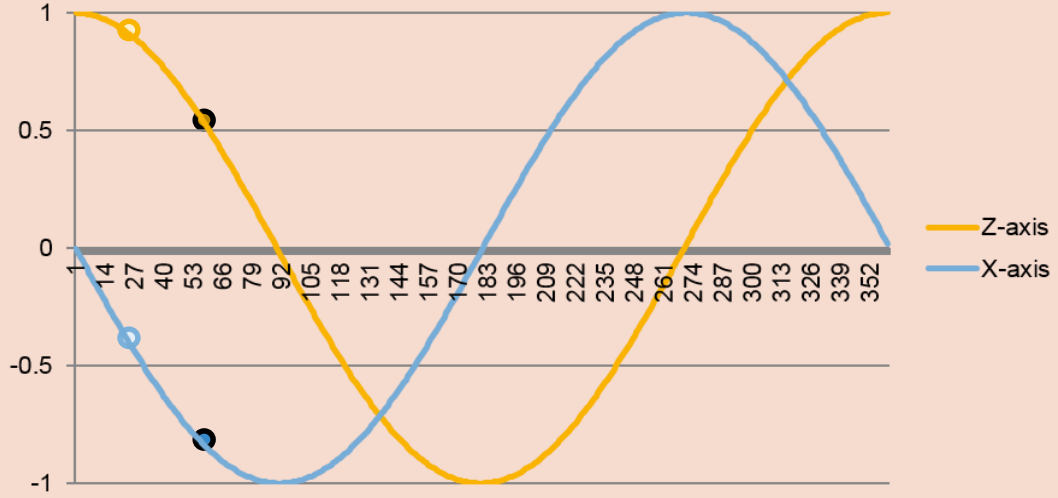
# 2-Axis Accelerometer

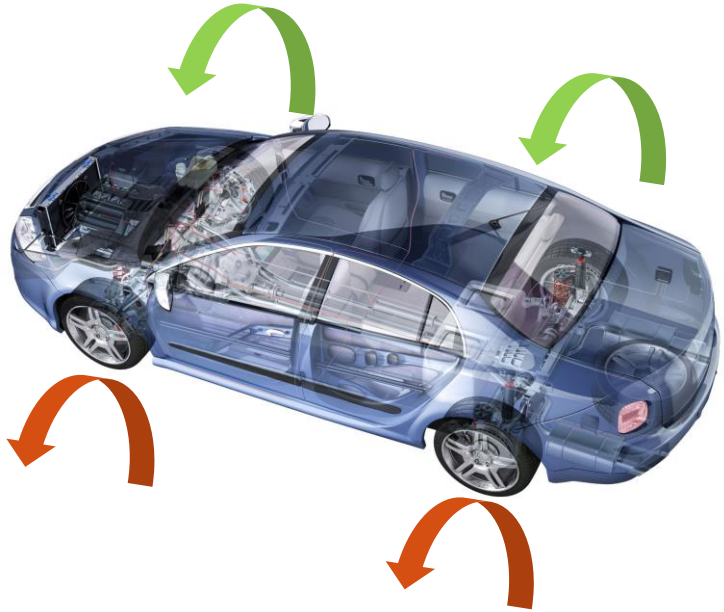
## Fast Determination of Rotation Direction

Two wheels on right side are moving forward / clockwise



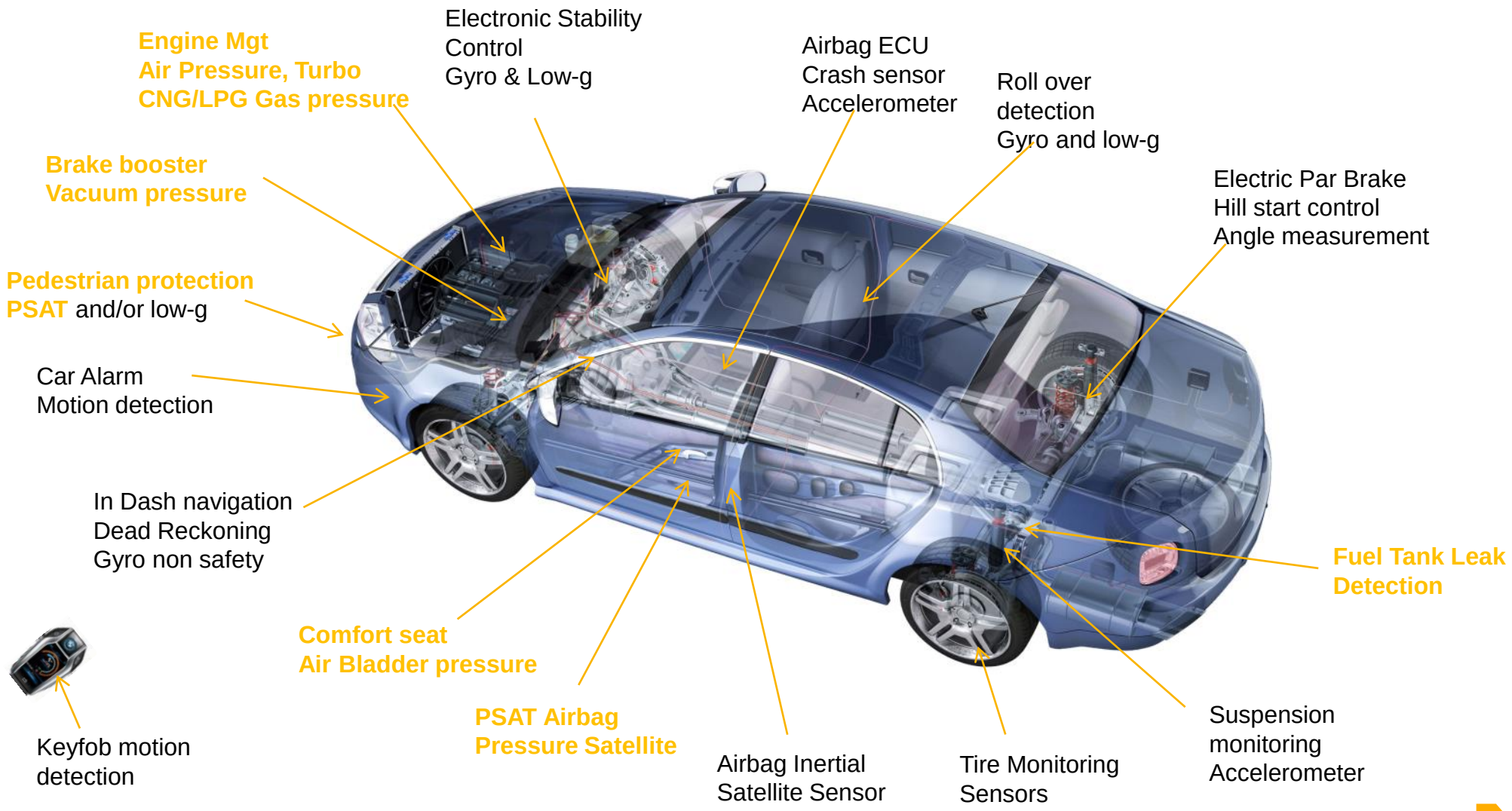

Two wheels on left side are moving forward / counter-clockwise



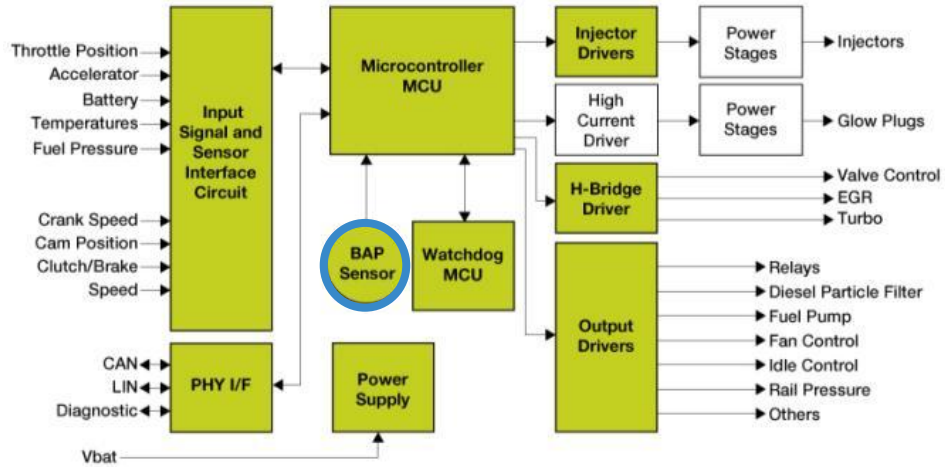
# PRESSURE SENSORS

# NXP MEMS Sensors in Automotive Applications

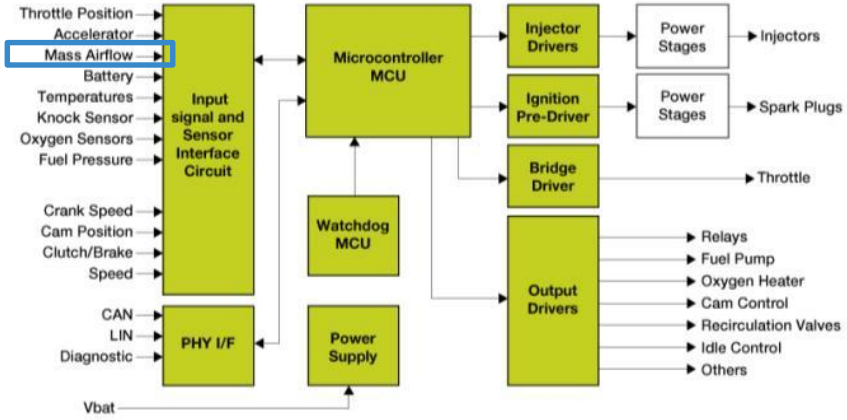


# Leading Automotive Applications

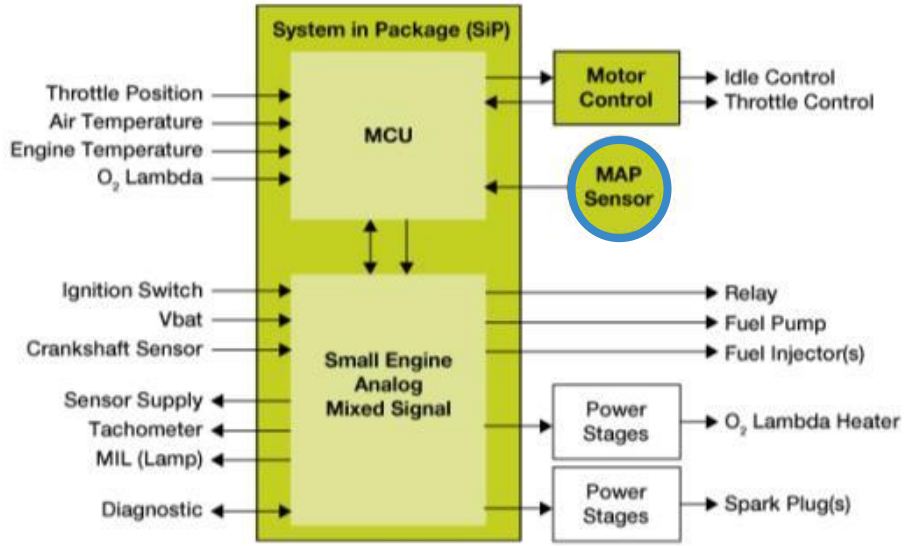
## Diesel Engine Management




## Gasoline Engine Management



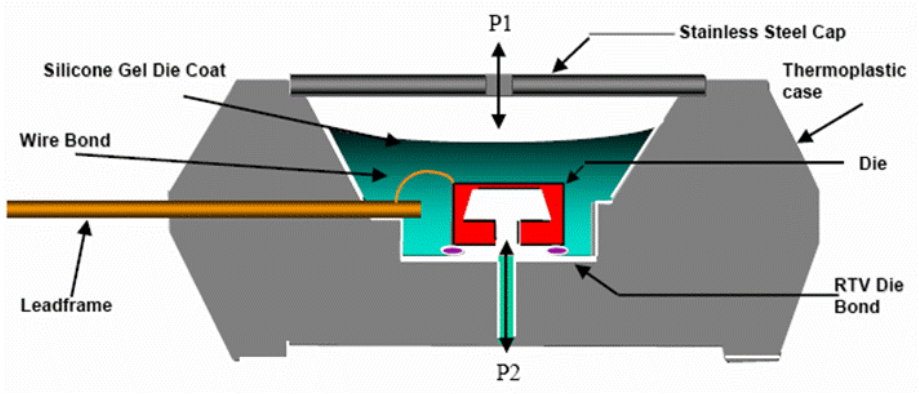

## Motorcycle Engine Management

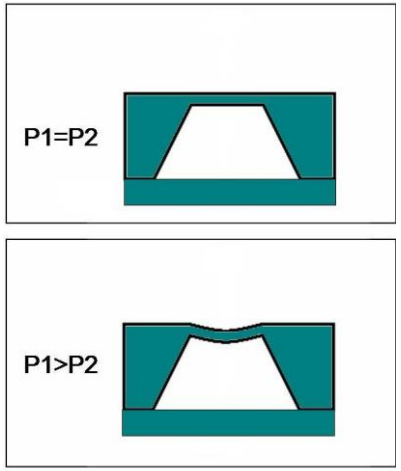


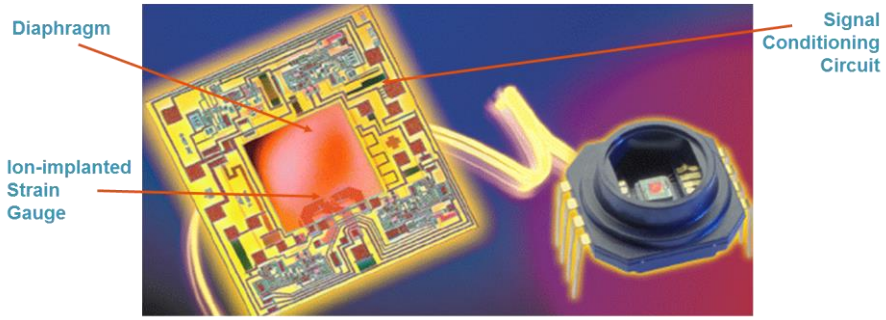

- The barometric pressure is used to provide the atmospheric pressure information to the Engine control unit.
- The atmospheric pressure is needed to compute the right amount of fuel to be injected in the cylinder to achieve optimal performances and lowest emissions.

# Pressure Sensors 101

**Micro Electro Mechanical Systems (MEMS) convert pressure (force / area) into electrical signal and is greatly sensitive to packaging stress**




Single Chip Integrated Silicon Pressure Sensor

**Two MEMS technologies**

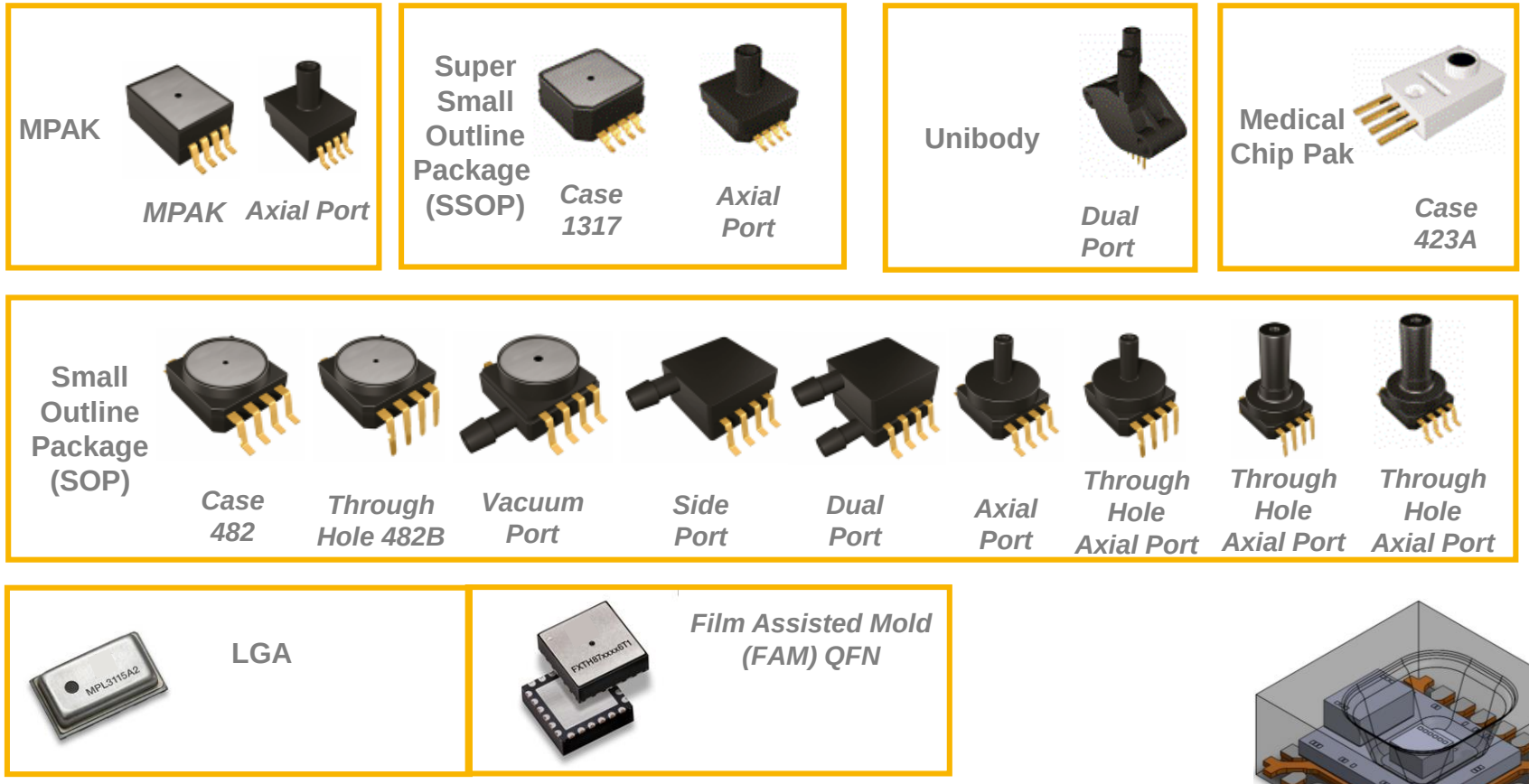
- Piezo Resistive Transducer “PRT”
- Capacitive Transducer “Pcell”

**Three sensor types**

- Differential (two pressures)
- Gauge (referenced to ambient P)
- Absolute

**Flow Measurement**

# What Is Different About Pressure Sensors?




- **Variety of packaging with hole(s) and optional port(s)**
- **Multi-Chip modules (typically 2 or 3 chips/pkge)**

# Pressure Sensor Portfolio

## In production 15+ years

**MPX10/12/53** D G
10...53 kPa
SOP, Unibody

**MPX2 Series** A D G V
10...300 kPa
ChipPak, Unibody

**MPX7 Series** D G
±2...±25 kPa
SOP

**MPX4 Series** A D G
6...250 kPa
SOP, SSOP, Unibody

**MPX5 Series** A D G V
4...1’000 kPa
SOP, SSOP, Unibody

**MPX6 Series** A
100...400 kPa
SOP, SSOP

**MPL3115** (Digital I²C) A
115 kPa Smart Baro/Pressure
3 x 5 mm LGA

**Uncompensated**
High sensitivity analog output
Need external circuit for compensation and amplification

**Temperature Compensated**
Integrated temperature compensation
Need external circuit for amplification

**Integrated Pressure Sensor**
Integrated signal conditioning for temperature compensation, linearization and amplification

**Integrated Digital Pressure Sensor**
I2C Digital Interface with digitized output in Pascals or meters.

**A – Absolute**
**D – Differential**
**G – Gauge**
**V – Vacuum**

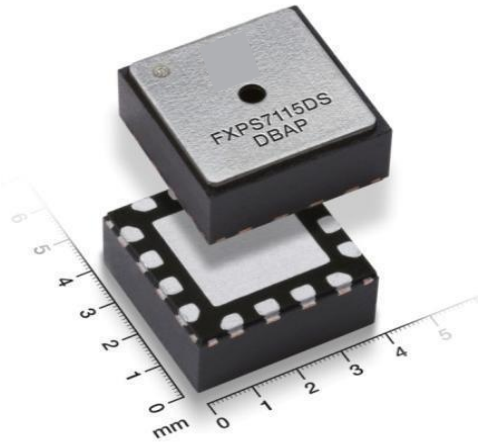
**Package Examples**

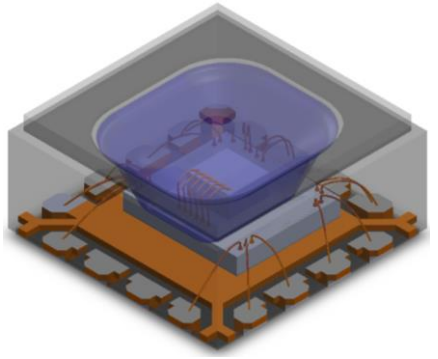
SOP Basic Case | SOP Side Port | SOP Axial Port | Unibody Dual Port | SSOP Basic Case | Medical ChipPak Case | LGA 3 x 5 mm Case

# Next Generation Pressure Sensor Platform

- PSAT – Pressure Sensor Satellite
  - Airbag satellite sensor, multi protocol

- DBAP/AMAP – digital or analog output
  - Engine management BAP application
  - Engine management MAP application
  - Engine management Turbo application
  - Engine management LPG applications
  - Comfort seating
  - Vacuum brake booster



- Multiple pressure ranges (115 kPa, 250 kPa, 550 kPa, custom
- Multi interface: SPI, I2C, PSI5, DSI3, Analog
- Film assisted molding technology
- 4x4x1.98 mm, 16 lead wettable flanks QFN
- 2 die stacked – Pcell over ASIC
- Pressure sensor encapsulated in chemical-resistant gel.

**Sample now**
**SOP Q4 2016 for PSAT**
**SOP Q1 2017 for DBAP/AMAP**

# PRESSURE SENSORS Q&A

# AUTOMOTIVE MAGNETIC SENSORS

# INTRODUCTION

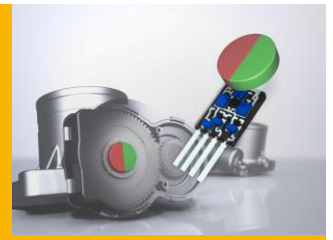
# What Do Magnetic Sensors Measure?

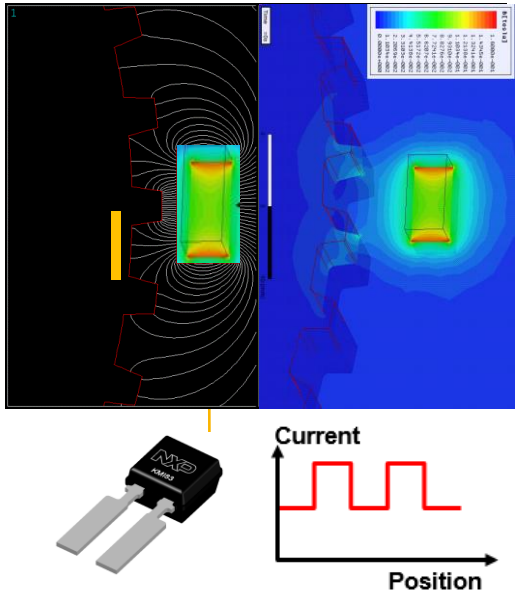
## Rotational speed movement

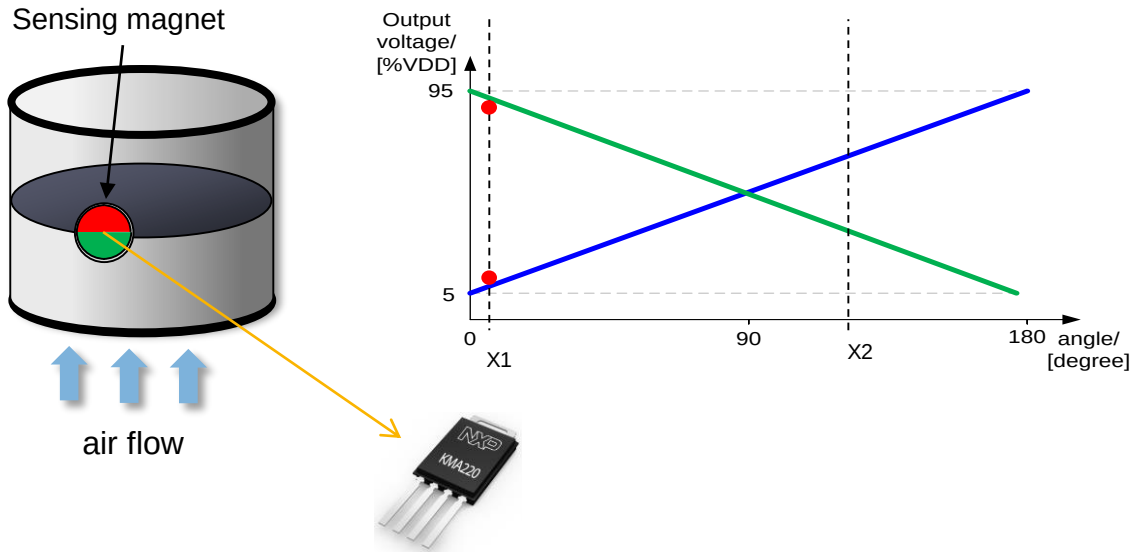
- Current pulse output, digital info signals
- Direction recognition
- Air gap information
- Vibration suppression
- Diagnostic functions

## Mechanical angular position

- Analog voltage, digital output signals
- Customer output adjustments
- Magnet loss detection
- Temperature information
- Diagnostic functions

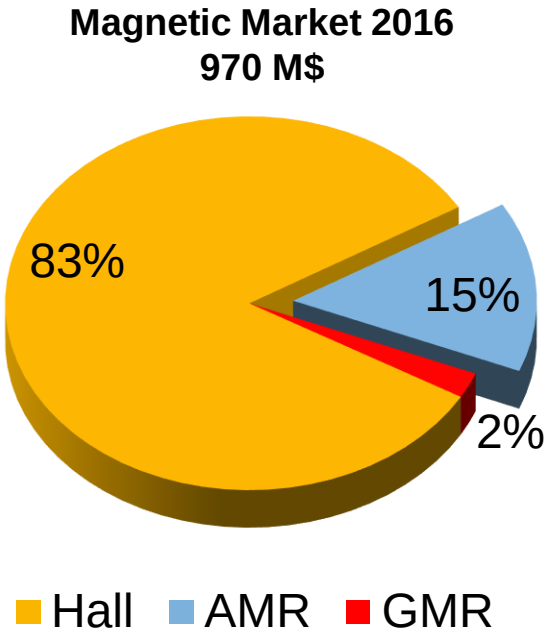




# Magnetic Sensor Technologies

## For Automotive Applications



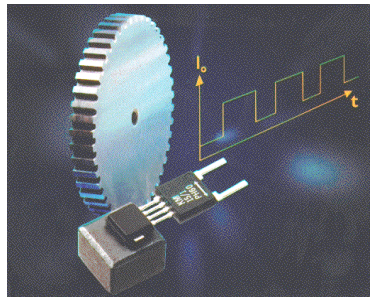

Source: IHS 2015

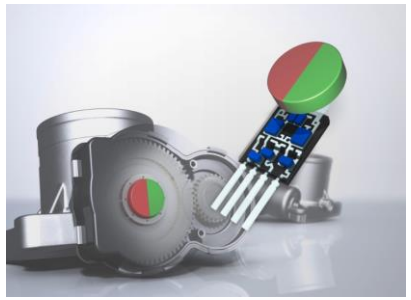
| Supplier | Technology |
|---|---|
| Allegro | Hall |
| Infineon | Hall, GMR |
| Melexis | Hall |
| Micronas | Hall |
| Sensitec | AMR |
| NXP | AMR |

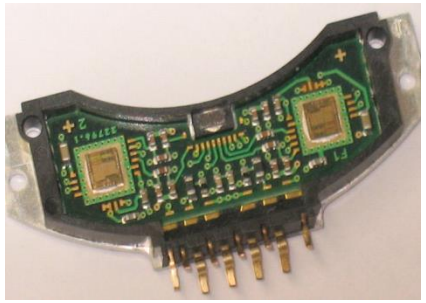
70% of total AMR sales was supplied by NXP

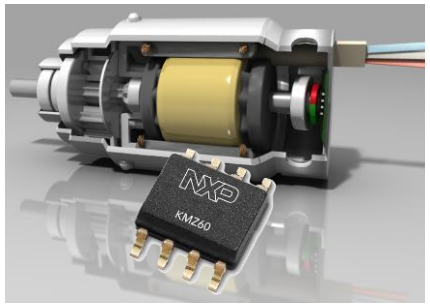
NXP supplies all major car OEMs

# NXP Magnetic Sensors In Automotive










**Speed**

ABS, Engine &Transmission

**Angular**

ETC, EGR, SAS, Wiper Control Brushless DC /Elec. Power Steering

**Based on proven high volume technologies**

**Magneto-Resistive (MR)**

- 800 Million speed sensors
- 400 Million angular sensors

**Si-spreading resistance**

- 400 Million Temperature sensors

supplied via Tier1‘s into

# Product Line Magnetic Sensors

## More than 1B Sensors Sold to Market

- PL headquarters in Hamburg, Germany
  - MR wafer fab and test
  - Process and product development
  - Product quality and engineering
  - Application support and innovations
  - Product and commercial marketing


Tier-1s, EMS & Distributors are our customers

# What Does Magnetic Sensors Make Unique?

**NXP offers Magneto-Resistive (MR) technology** while main competitors offers Hall technology

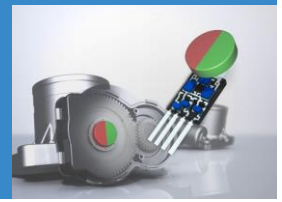
Value Proposition over Hall:

**Rotational speed sensors:**

- Ferrite magnets - no rare earth magnets required
- Best in class jitter performance

**Angular sensors:**

- Robust against parametric degradation over lifetime ( insensitive to aging of magnet )
- Outstanding accuracy (±1˚ over full Temperature range and lifetime)
- wide operating temperature range up to 180°C
- For KMA product family no PCB required - no external components



- All new products incorporate automotive CMOS 14 SOI technology (ABCD9) and provide best in class EMI and ESD performance
- Proven high volume, low PPM, automotive grade industrial capabilities
- Established trusted partnerships with the market leaders

# WHEEL SPEED SENSORS

# Focus App of Wheel Speed Sensors: ABS

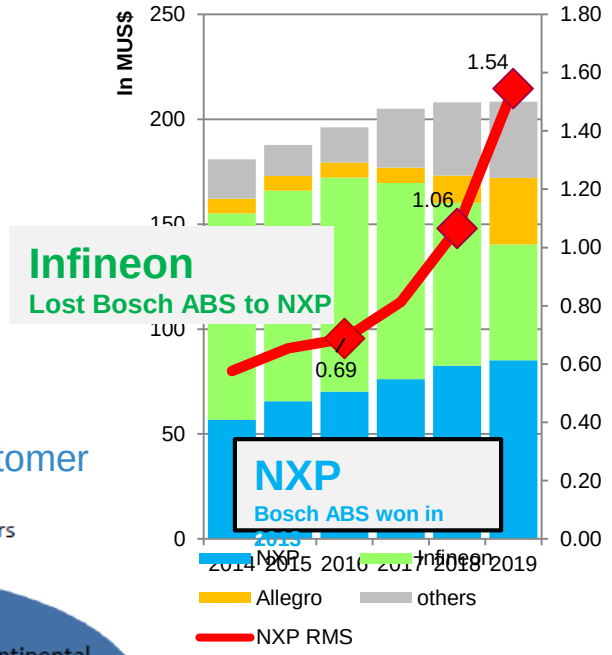
Up to now

- Supply to Continental exclusively (except one type)
- 800 Mill ABS sensors supplied since 1995
- Wide product range from low to high-end ABS

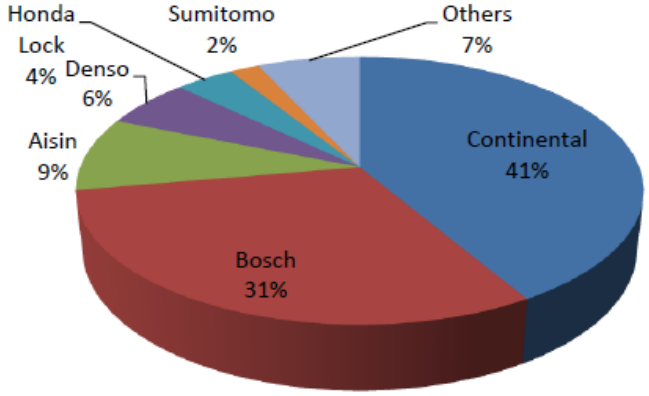
This year onwards

- Ramping up ABS supply to Bosch
- Promotion of ABS sensors to all customers

NXP will take market leadership in ABS




Market share ABS customer




Source: Yano Research 2013

# Product Cluster

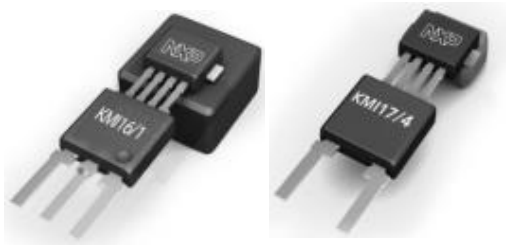
## AMR speed sensors

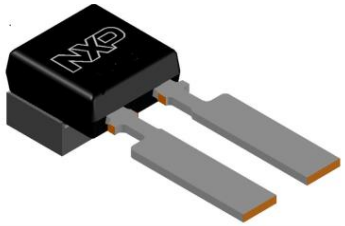
### Standard ABS sensors

| LE WSS [1] | KMI16/1 | KMI17/4 |
|---|---|---|
| 1st Gen/2nd Gen | 1st Gen | 2nd Gen |
| (active/passive) current output | open collector output | (passive) current output |

### High-end ABS sensors

| HE WSS [1] | HE WSS [1] | KMI8x |
|---|---|---|
| 1st Gen | 2nd Gen | 2nd Gen |
| (active/passive) digital output | (active/passive) current/digital | (active/passive) current/digital |

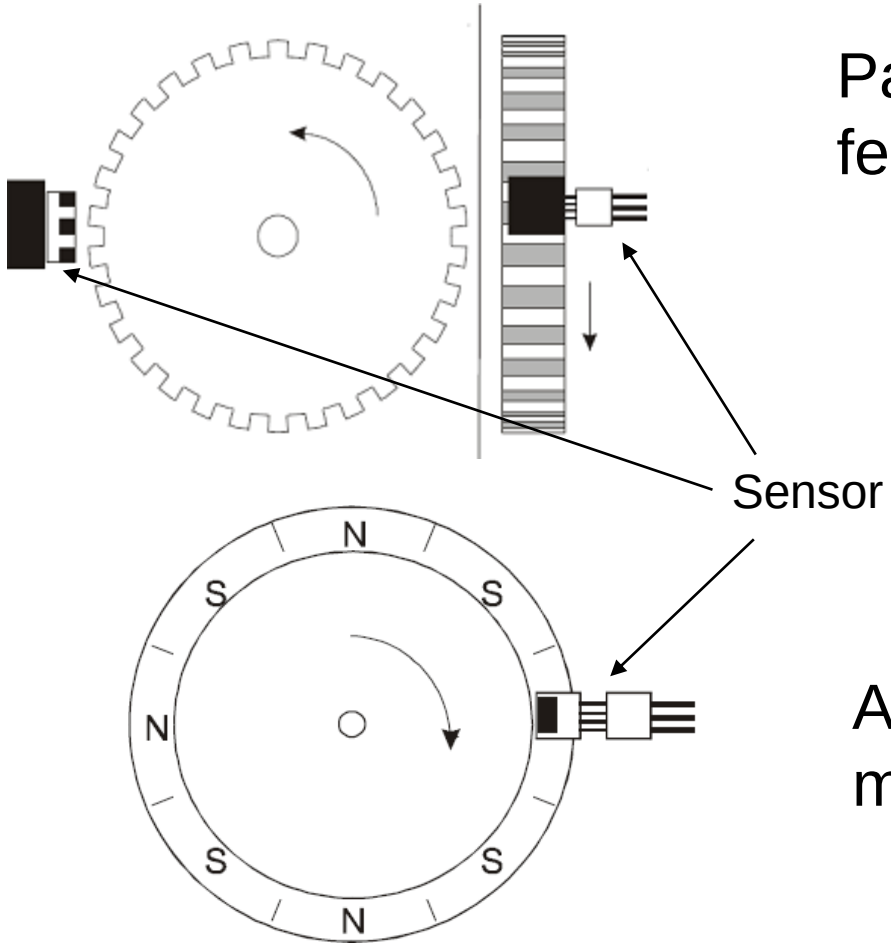


1) customer-specific, not available for open market
LE: Low End, HE: High End

# Application Setups

## With Active or Passive Encoder Wheels

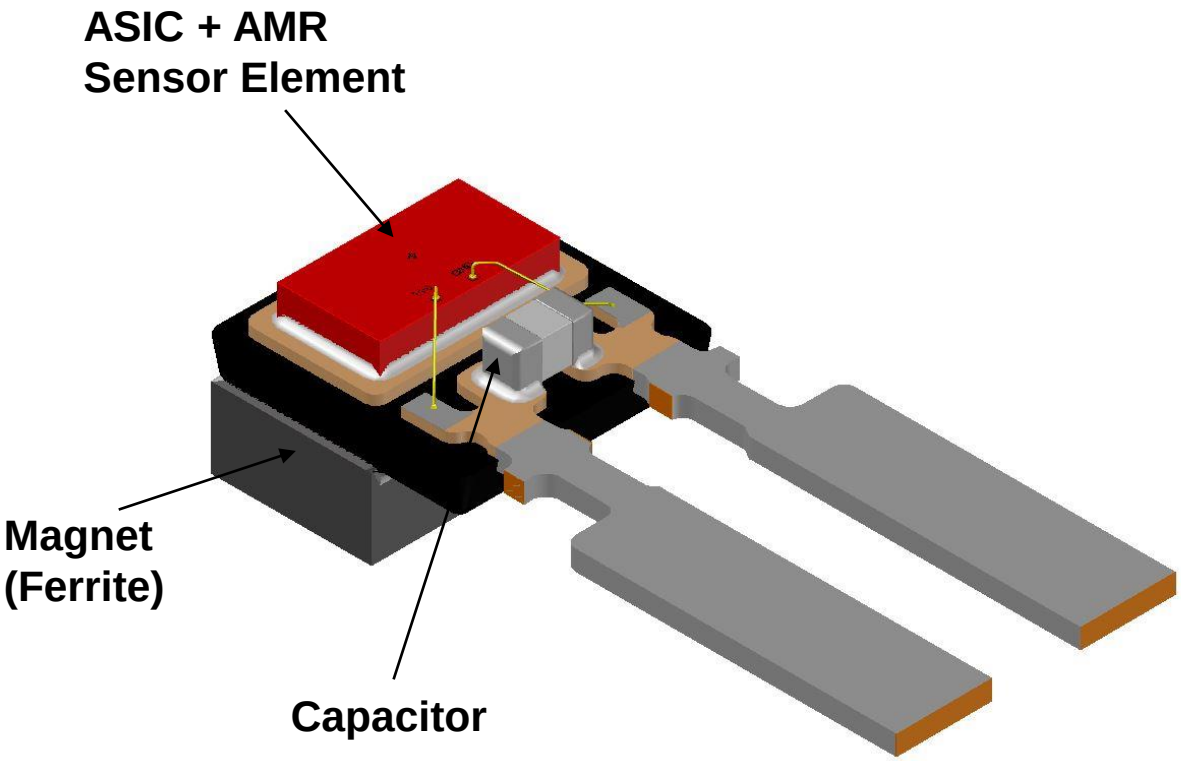


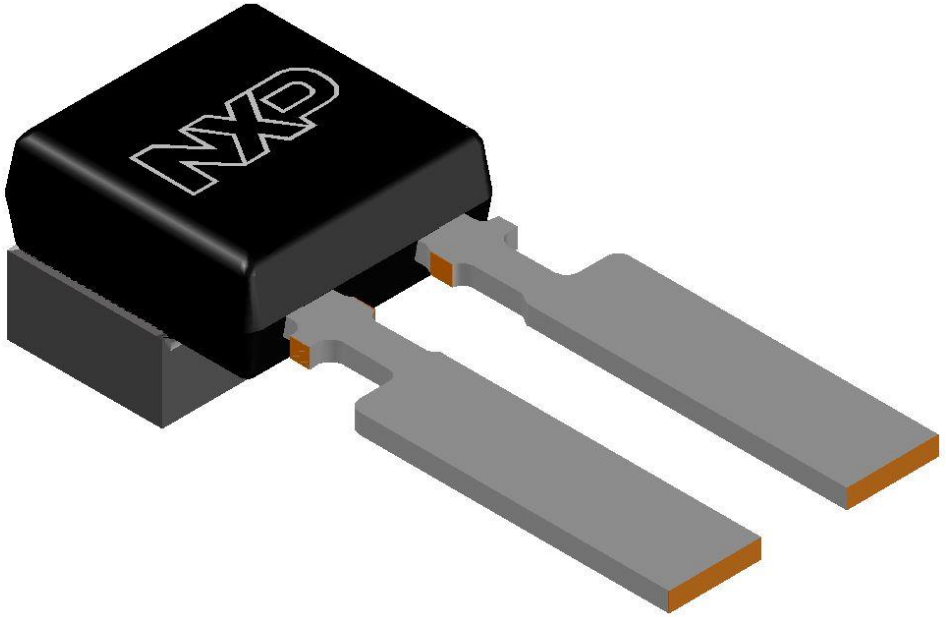

Passive encoder =
ferromagnetic gear wheel

Active encoder =
magnetized wheel

# KMI83, KMI83/P – Physical Setup and Package

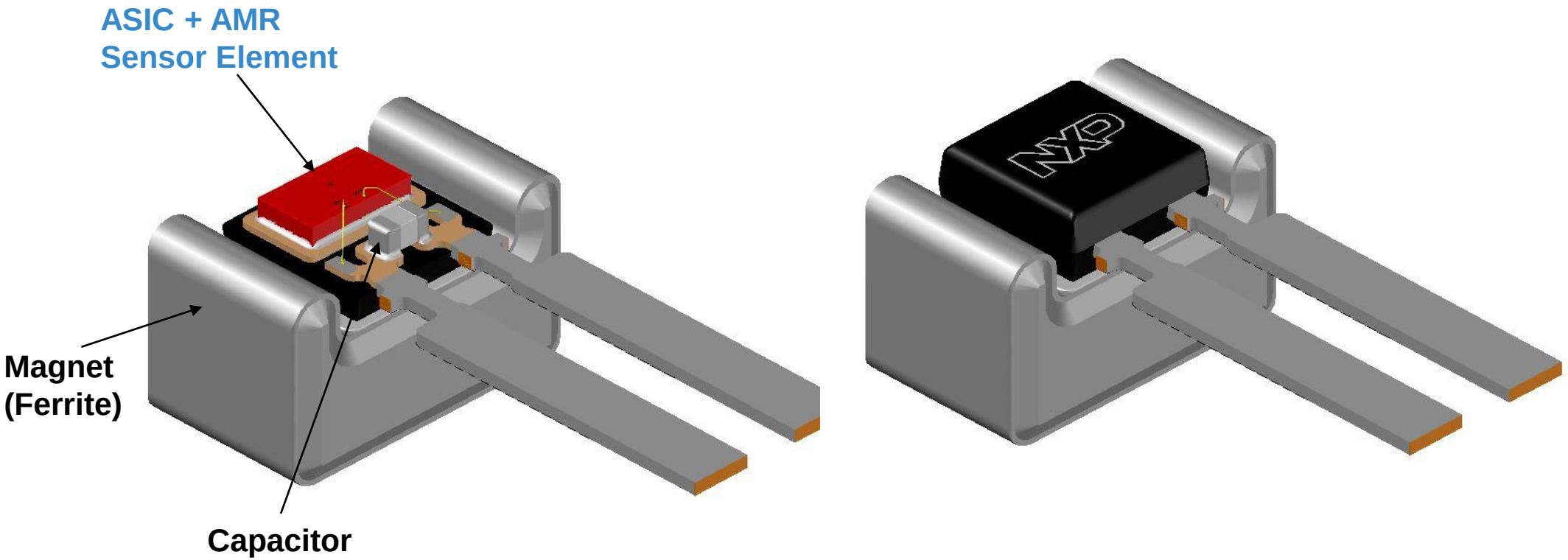
## High-end Sensor for Magnetized Encoders



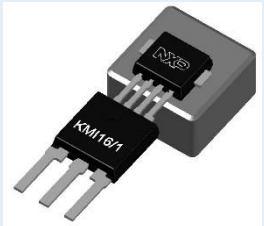
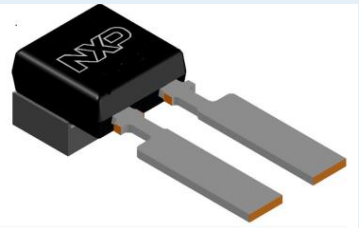
# KMI84 – Physical Setup and Package

## High-end Sensor for Ferromagnetic Encoders




**Back-biased magnet provided and assembled by chip supplier**

# WSS Technical Evolution

| Generation | Gen1 | Gen2 |
|---|---|---|
| Technology | AMR and ASIC separated<br>(2 Dies) | Monolithic Integration<br>of AMR and ASIC<br>(one die) |
| Distortion field Suppression | no | Yes |
| Functional Safety | n.a. | ISO26262 ASIL B(D) compliance<br>Diagnostic available |
| Magnet threshold for switching | 0.63 mT | 0.19 mT |
| Package |  |  |

# KMI8X – Planned Product Options

| Feature | KMI83 | KMI83/P | KMI84 |
|---|---|---|---|
| Applicable encoder | magnetized encoder | | ferromagnetic gear wheel |
| Available output protocols | standard protocol (square wave) | AK protocol (serial bit protocol) | standard protocol (square wave) |
| Direction detection | - | X | - |
| Vibration suppression | - | X | X |
| Customer production test mode (CPTM) | X | X | X |
| Failure detection and diagnostic mode | X | X | X |
| Non-volatile memory (MTP) | X | X | X |

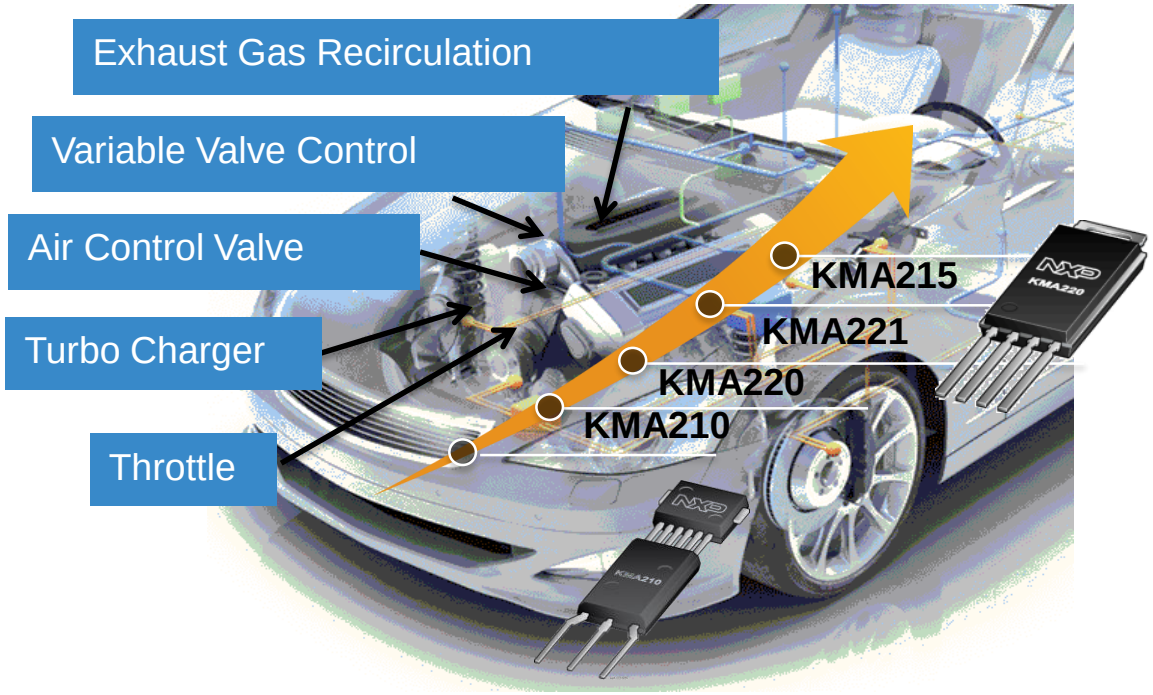
Different combinations of features are possible on request

# ANGULAR SENSORS

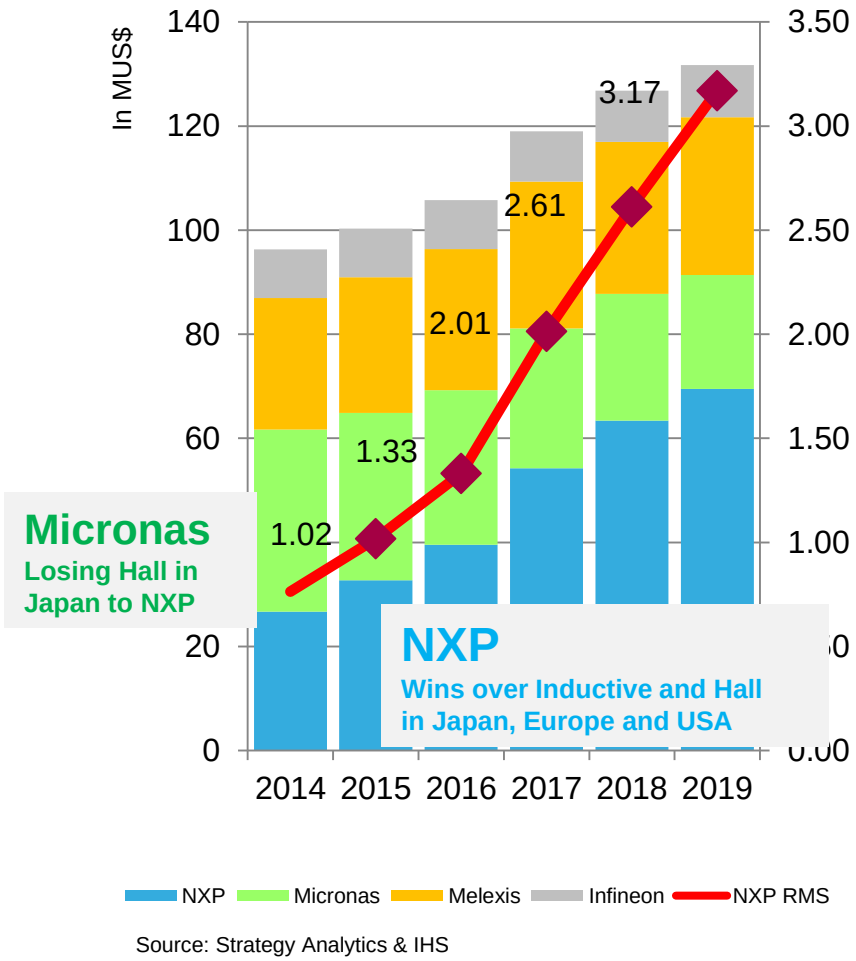
# Focus App of Angular Sensors: Engine Control

Today

- 400 M angular sensors supplied
- No exclusivity contract like ABS




**NXP leads Engine Control market**

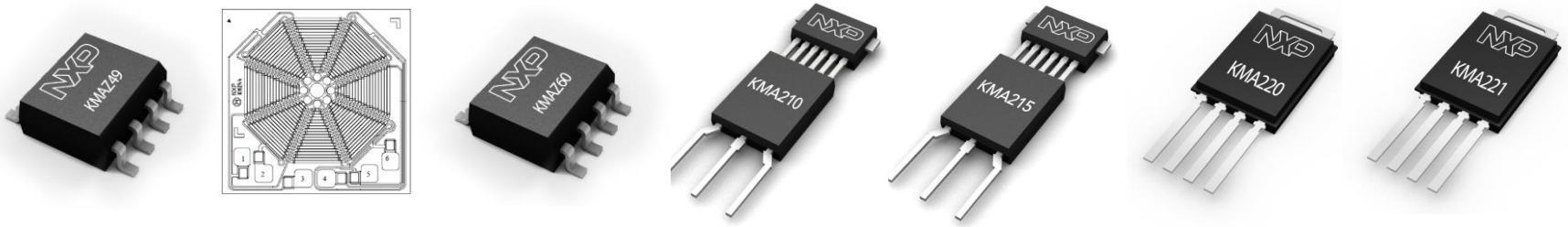



Source: Strategy Analytics & IHS

# Product Cluster

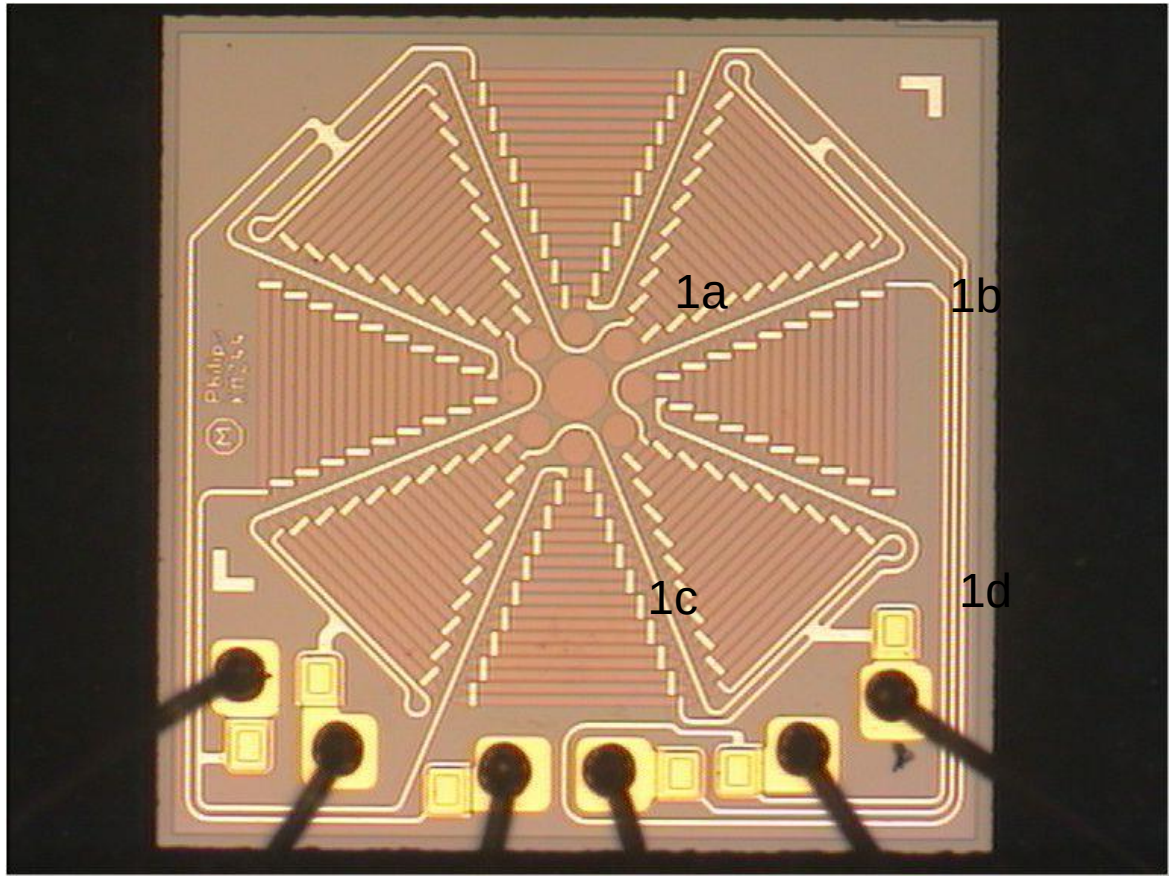
## Angular sensors

| Magnetic field sensors | | Field sensor + integrated amplifier | Programmable sensors | | | |
|---|---|---|---|---|---|---|
| KMZ49/41<br>sin/cos | X3T/G-OH047/048<br>sin/cos | KMZ60<br>amplified sin/cos | KMA210<br>1x analog | KMA215<br>1x SENT | KMA220<br>2x analog | KMA221<br>1x analog |

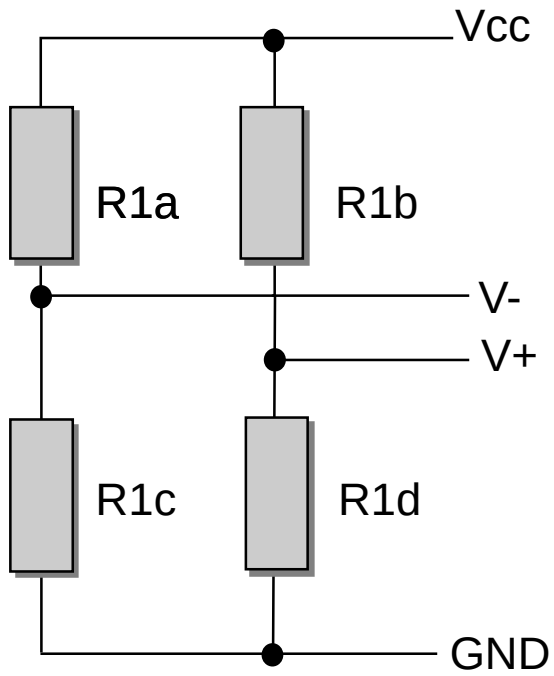


# Key Component for All Angular Sensors

## Double Magneto Resistive Sensor Bridge



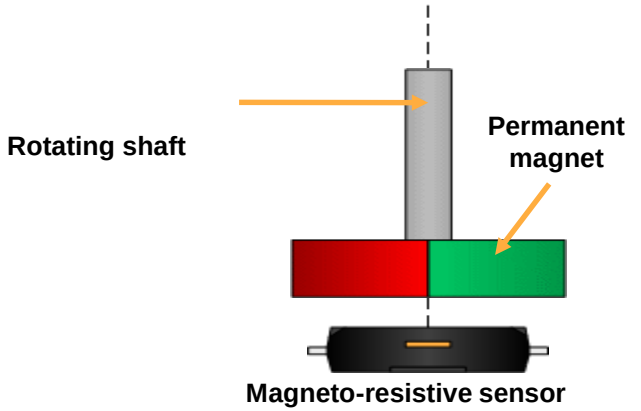

**Wheatstone Bridge**

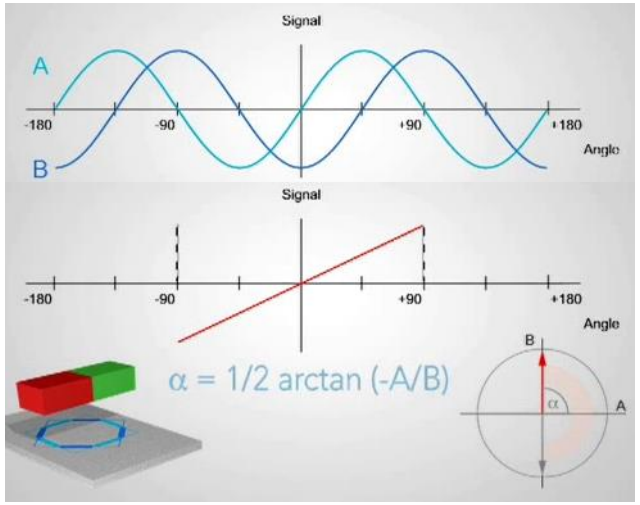


# Technology Advantage Compared to Hall Sensors

MR-sensors evaluate the direction of the magnetic field itself and not the magnetic field strength

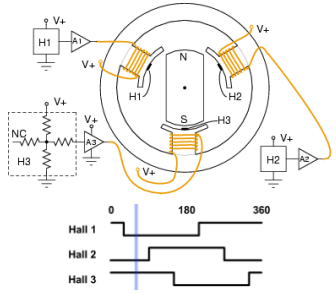
- System is independent of magnet drifts and shifts due to lifetime, thermal influences or mechanical stress
- Cost effective ferrite magnets can be used
- No upper magnetic field strength limitation
- Less sensitive on mechanical tolerances
- Less sensitive to disturbing magnetic fields ( operation in saturation)
- High air gap range
- High reliability over lifetime
- Wide ambient temperature range
- High accuracy ( excellent linearity & temp drift)

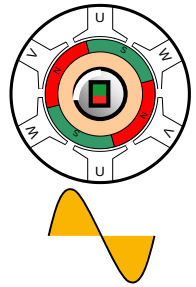


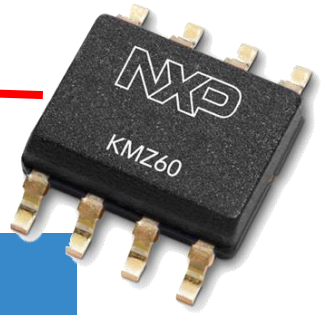



# KMZ60: Electrical Commutation of Brushless DC Motors

- Use of Brushless Direct Current (BLDC) motors rapidly grows
- Benefits
  - Integrated amplifier leads to cost savings, no external amplifiers are required
  - Space-saving, built more compact designs
  - Better signal-to-noise ratio
  - Improved TC-offset performance
  - Low power consumption using power-down mode
  - More safety due to broken bond wire detection
- Variants to electronic commutation of BLDC motors
  - Block commutation by 3x Hall sensors




KMZ60 as rotor position sensor enables very cost effective motor control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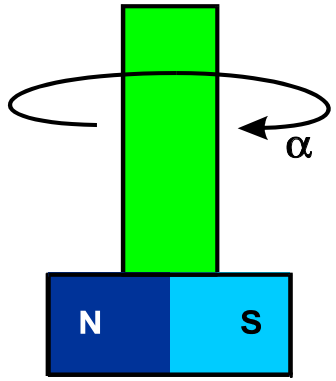
# KMZ60 Provides Two Sinusoidal Output Signals

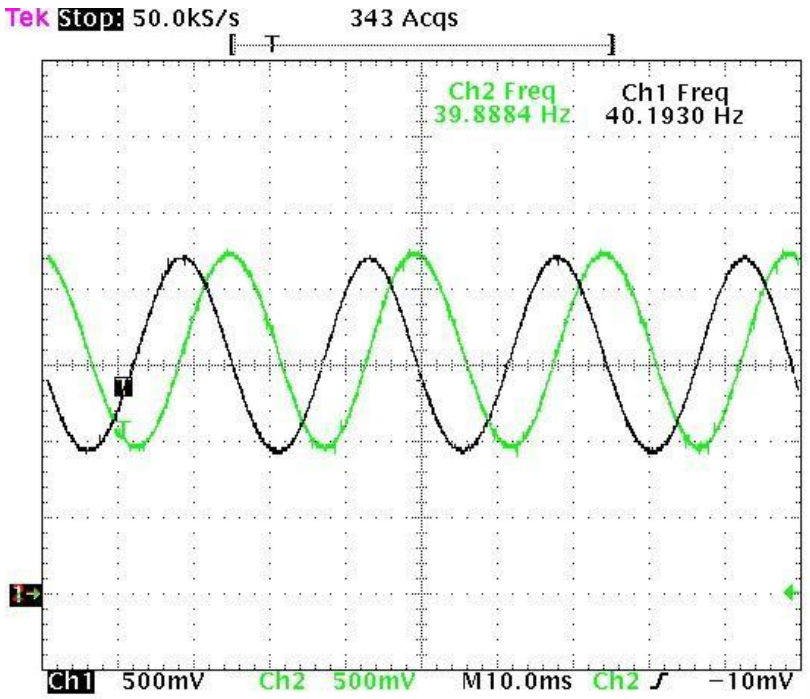
Rotating magnetic field




Power supply

2.7 V – 5.5 V

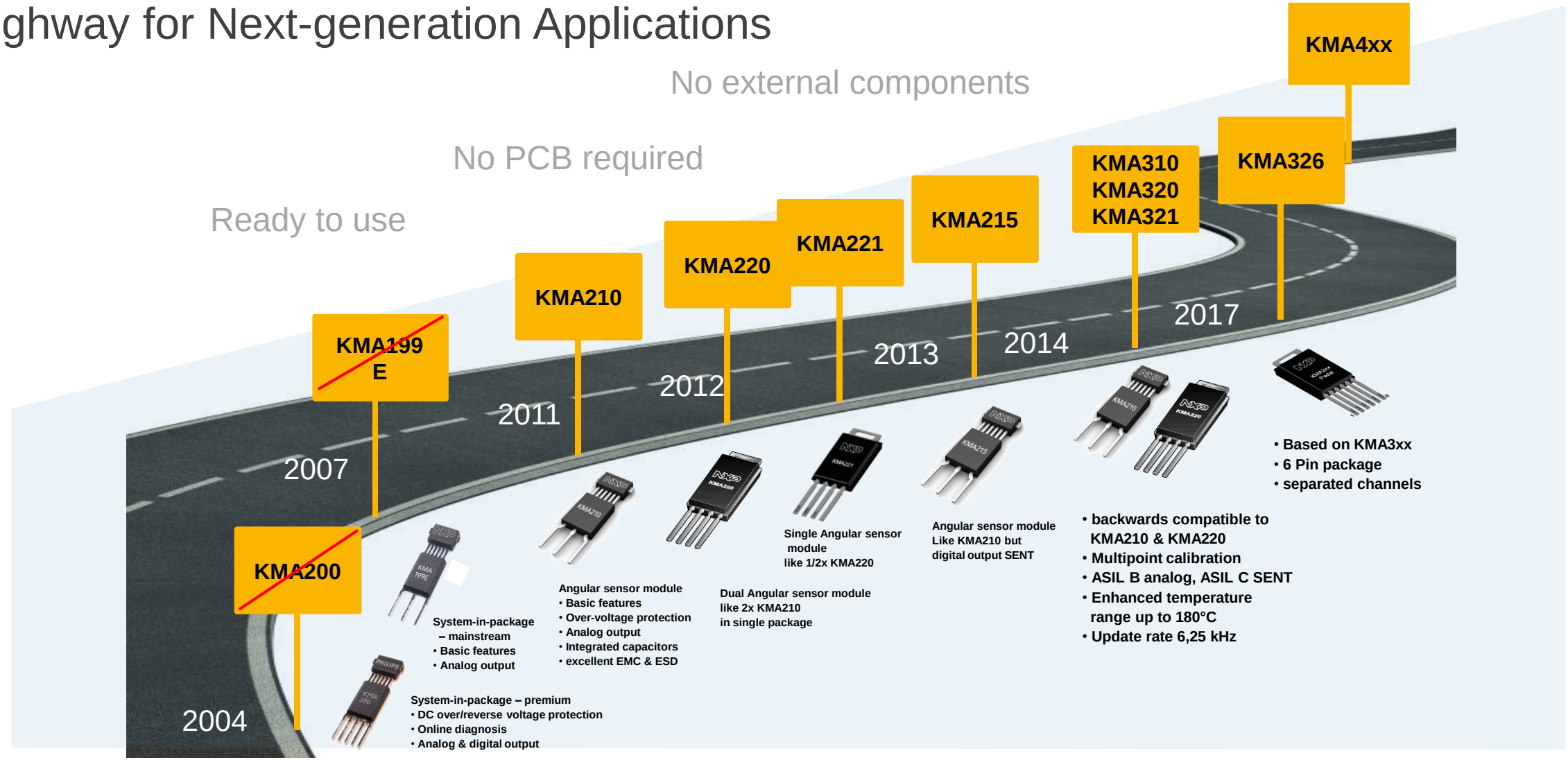

Two analogue sinusoidal output signals




The output signals are ratiometric to the supply voltage!

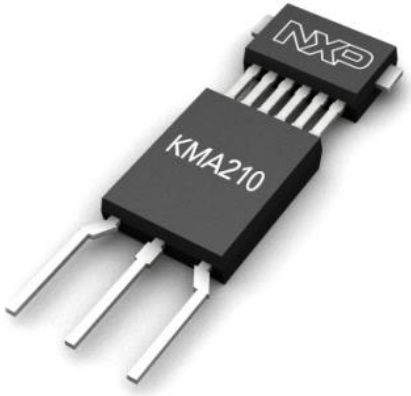
# NXP Automotive Angular Sensor Solutions

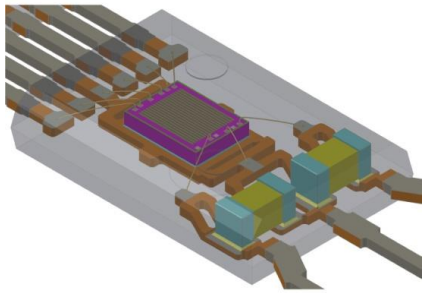
## Highway for Next-generation Applications



# KMA210: Single Angular Sensor Module

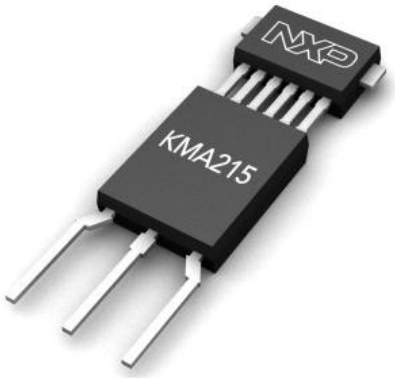
- Pre-calibrated magnetic field angular sensor system
- No external components due to integrated capacitors
- Automotive qualification according to AEC Q100 Rev G
- Released for production in May 2011
- Key features
  - 3-lead device with analog output
  - One wire digital interface for programming of customized settings
  - Standard 5 V supply
  - Overvoltage protection
  - Excellent EMC & ESD performance
  - Active power-loss functionality (RL > 5kΩ)

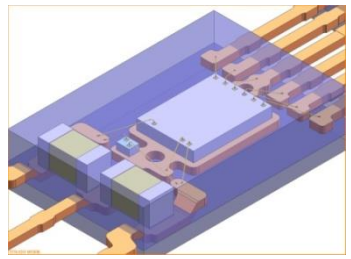


# KMA215: Angular Sensor with SENT Protocol Output

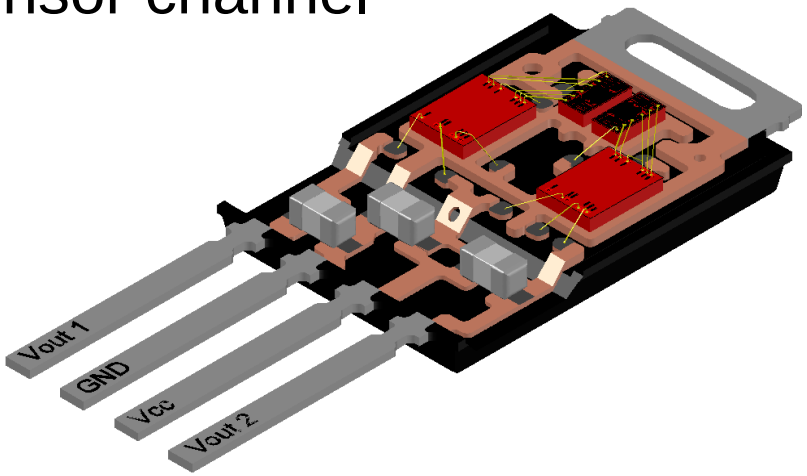
- Specification similar to KMA210 but including
- Digital output: SAE J2716 JAN2010 SENT (rev.3)
- 12bit angular resolution (16bit internal)
- Temperature information (e.g. accuracy ±10°C)
- Push-Pull output with pulse shaping
- SOT1288 package with integrated capacitors
- No external components due to pulse shaping, integrated capacitors and excellent EMC/ESD performance
- Overvoltage- & Inverse Polarity current protection
- Product configuration similar to KMA210 (zero angle, range)
- Automotive Qualification according to AEC Q100 rev G

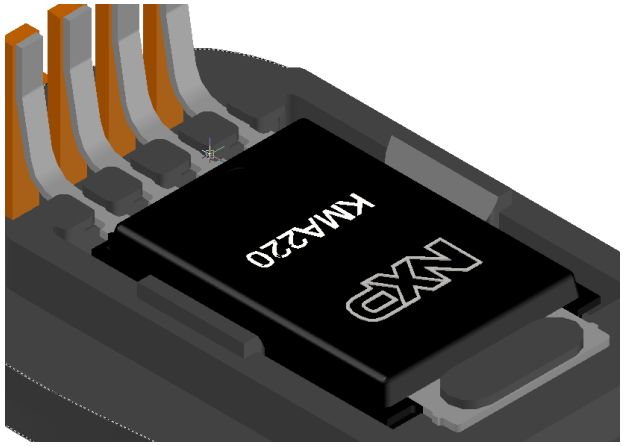


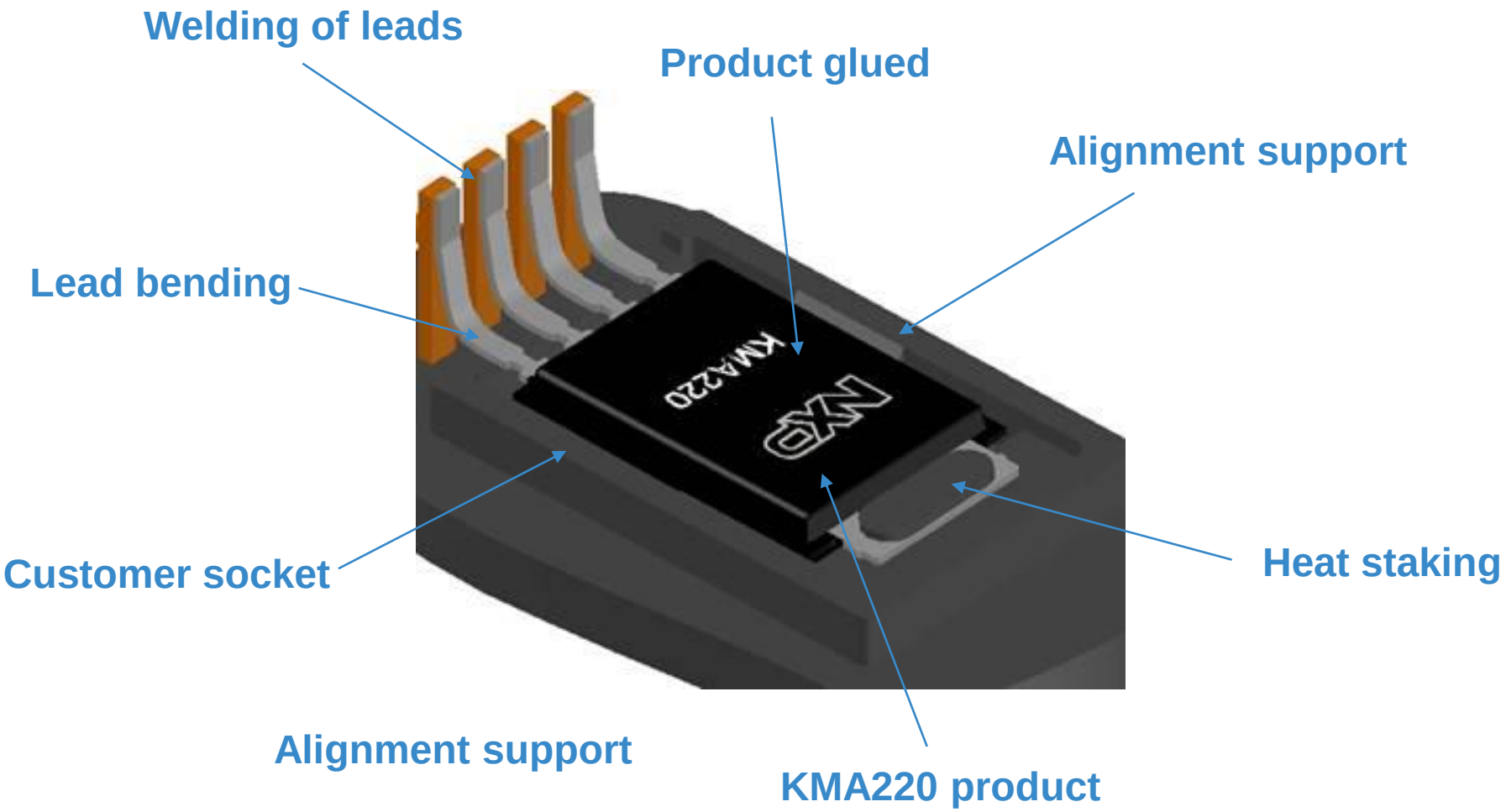
# KMA220: Double Angular Sensor Module

- Specification very similar to KMA210 for each sensor channel
- Same ABCD9 ASICs as released in KMA210
- New MR sensor design
- Lead frame for 7 components
- Single body package outline
- ‘Dark green compound



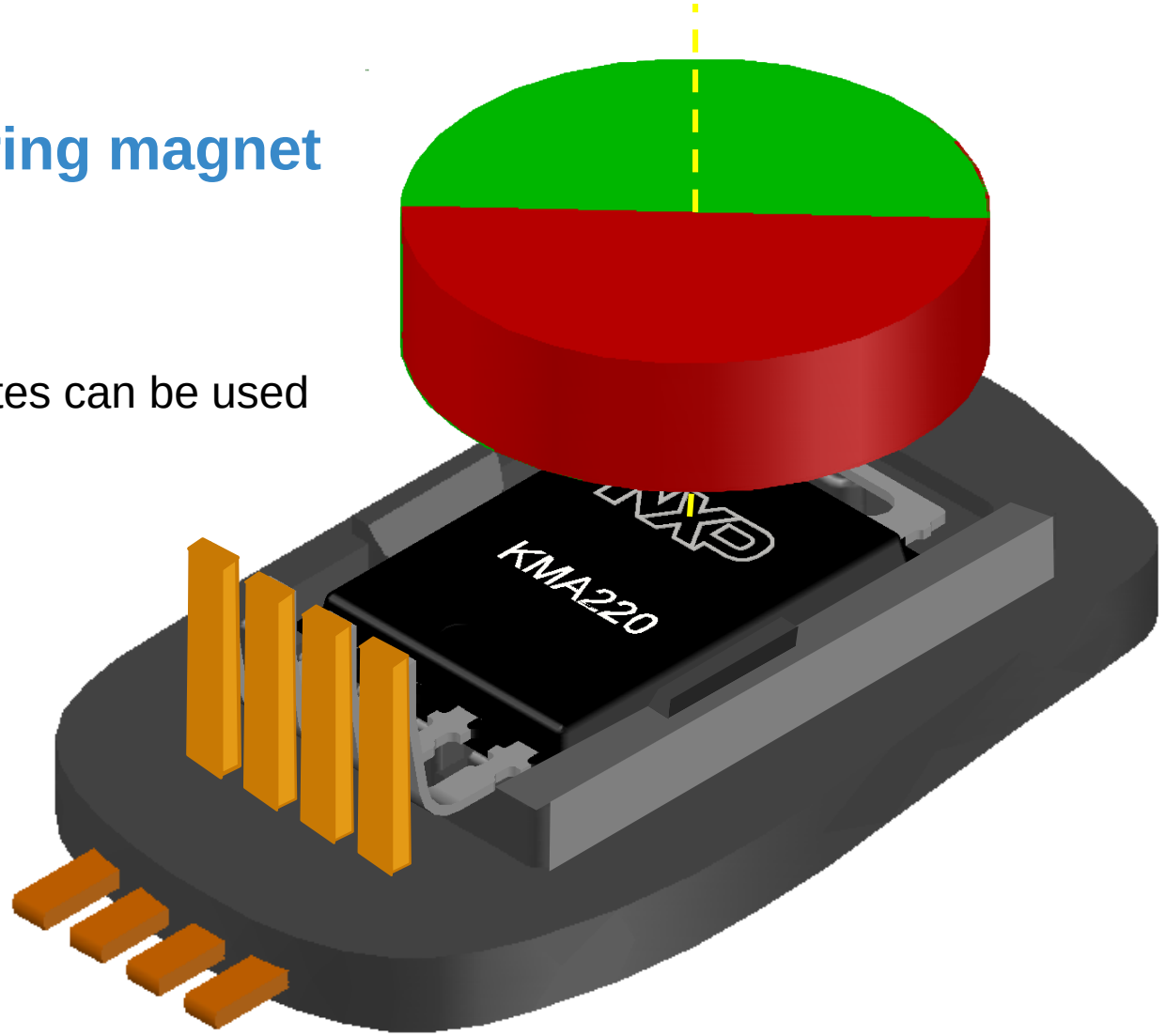
# KMA220: Assembly Proposal



# Choose Sensing Magnet

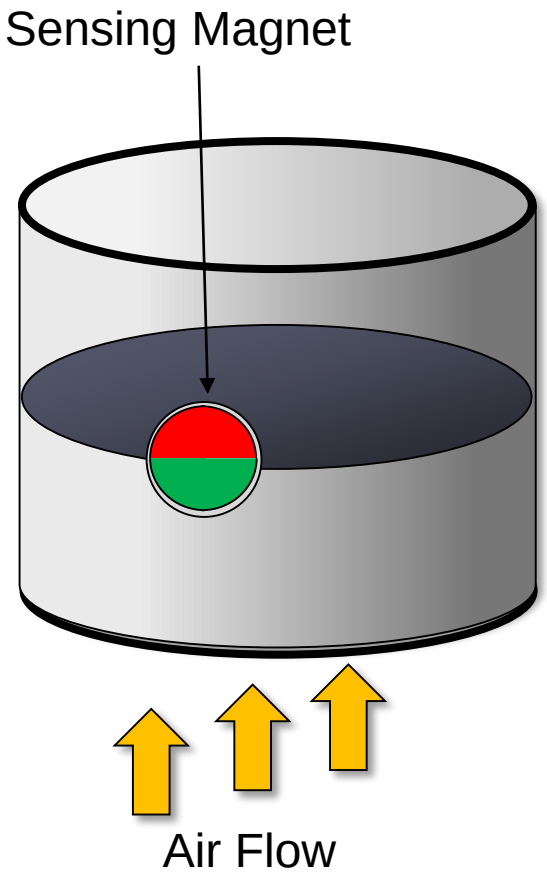
## Disc magnet instead of ring magnet

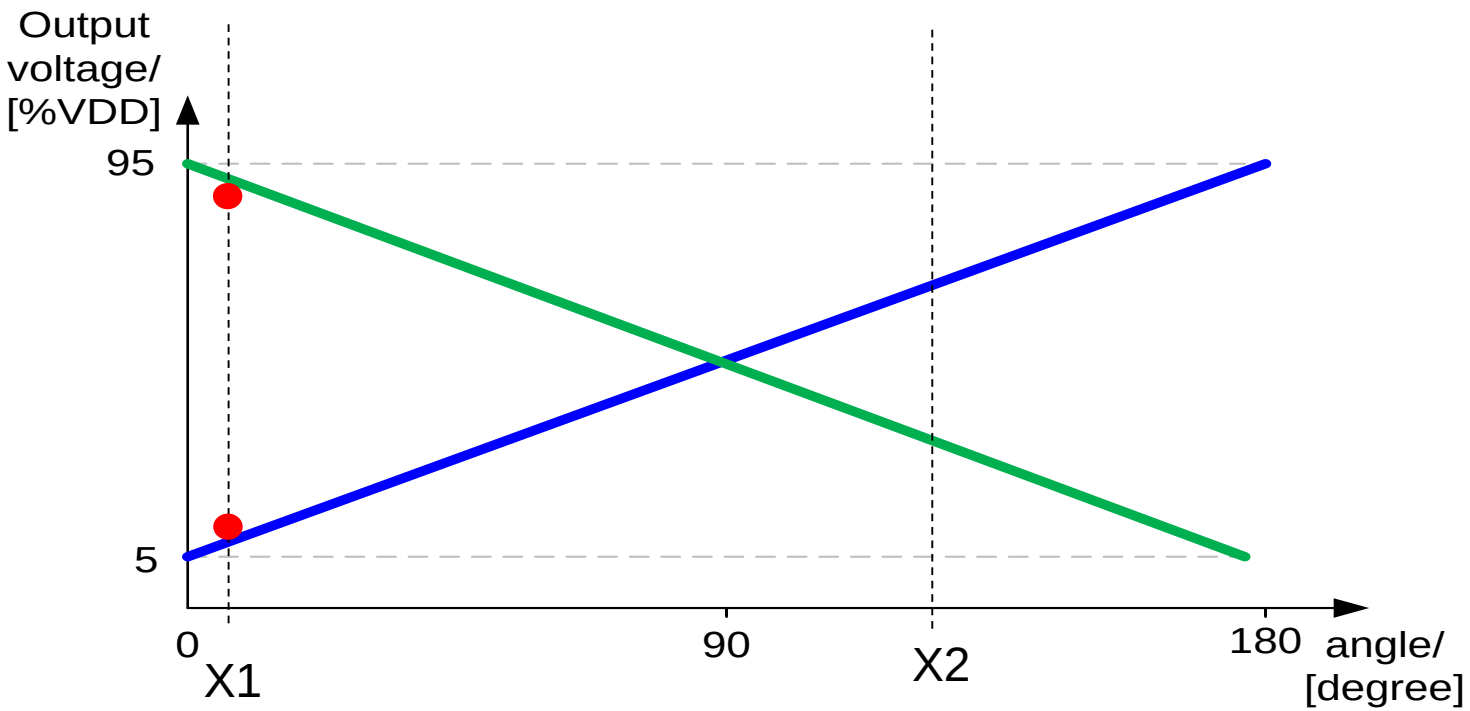
Injectable ferrites can be used



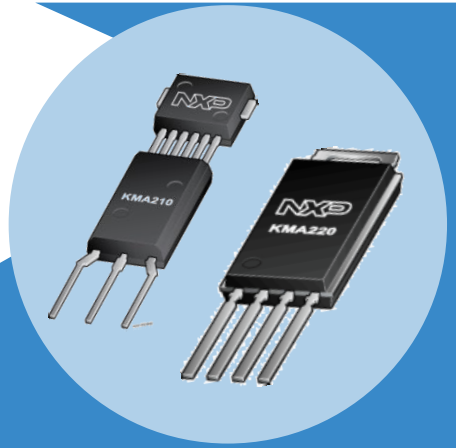
# KMA220 Angular Double Sensor Module

## Two full independent sensor ASIC with custom setting support



# Next Generation Angular Sensor System




**KMA310**
**KMA320/321**

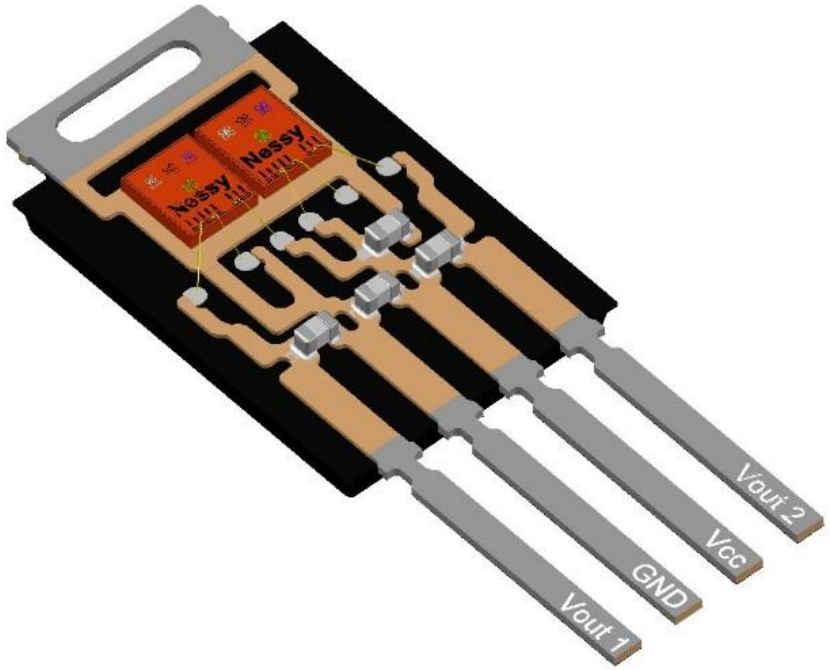
- Backwards compatible to KMA210 & KMA220/1
- Multi Point Calibration (MPC17 and MPC7)
- ASIL B ( analog ) / ASIL C ( SENT )
- Enhanced temperature range up to 180°C
- Fast update rate with 6,25 kHz
- Lower saturation field for low cost magnets
- Analog and SENT output


**KMA210**
**KMA220/221**

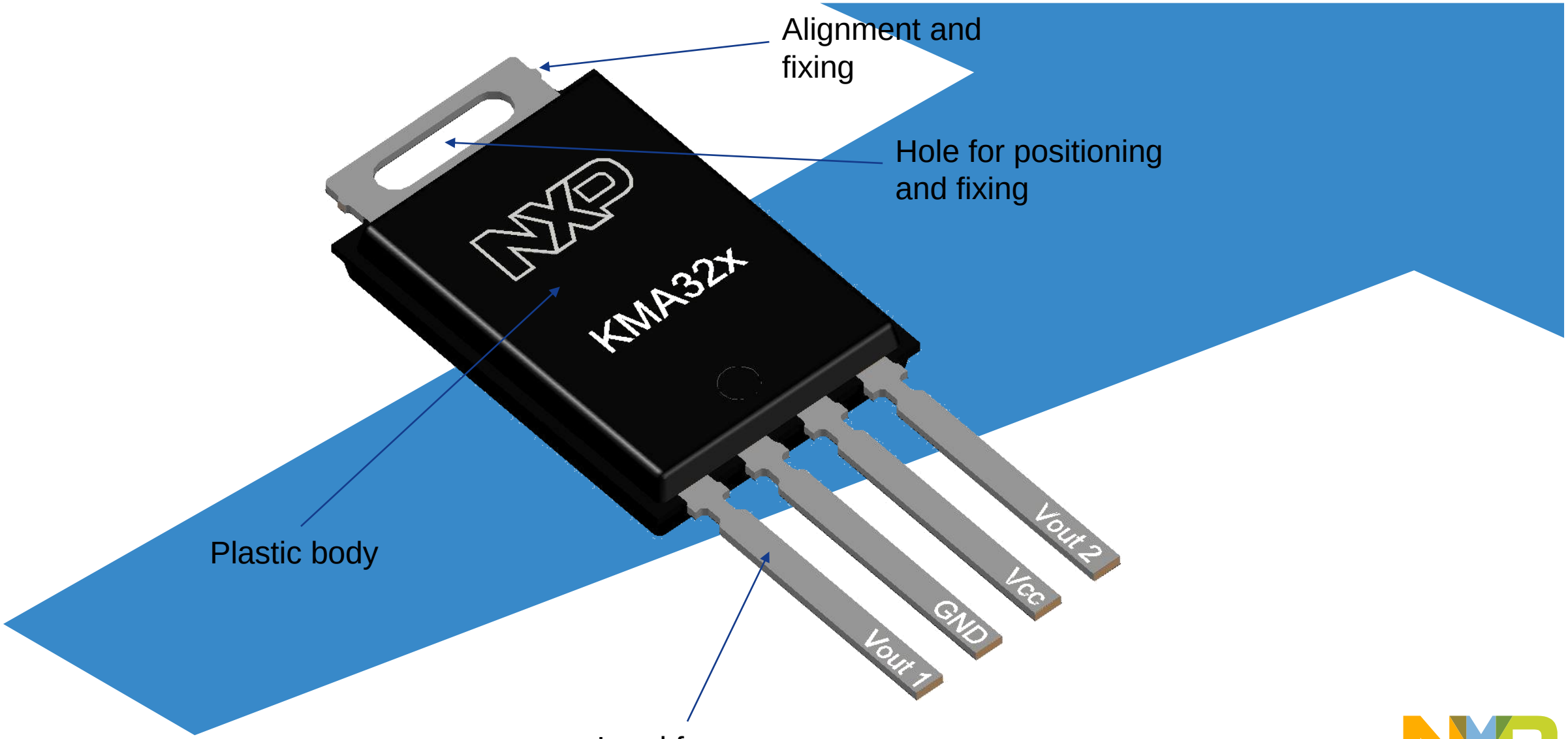
**Release 2017** **SOP**

# KMA3xx Family Key Features

- Application: angle sensing, linear measurement, off-axis measurement
- Analog output (ratio metric 5%VDD to 95%VDD)
- Fast update rate with 6.25 kHz (analog)
- SENT output (SAE J2716 rev. 4)
- Fast start-up within <1 ms
- Several output curve customization
- Low power consumption 10 mA/channel
- ASIL B (analog) and ASIL C (SENT) ISO26262 support
- Integrated capacitors
- Fully backwards compatible to KMA2xx family

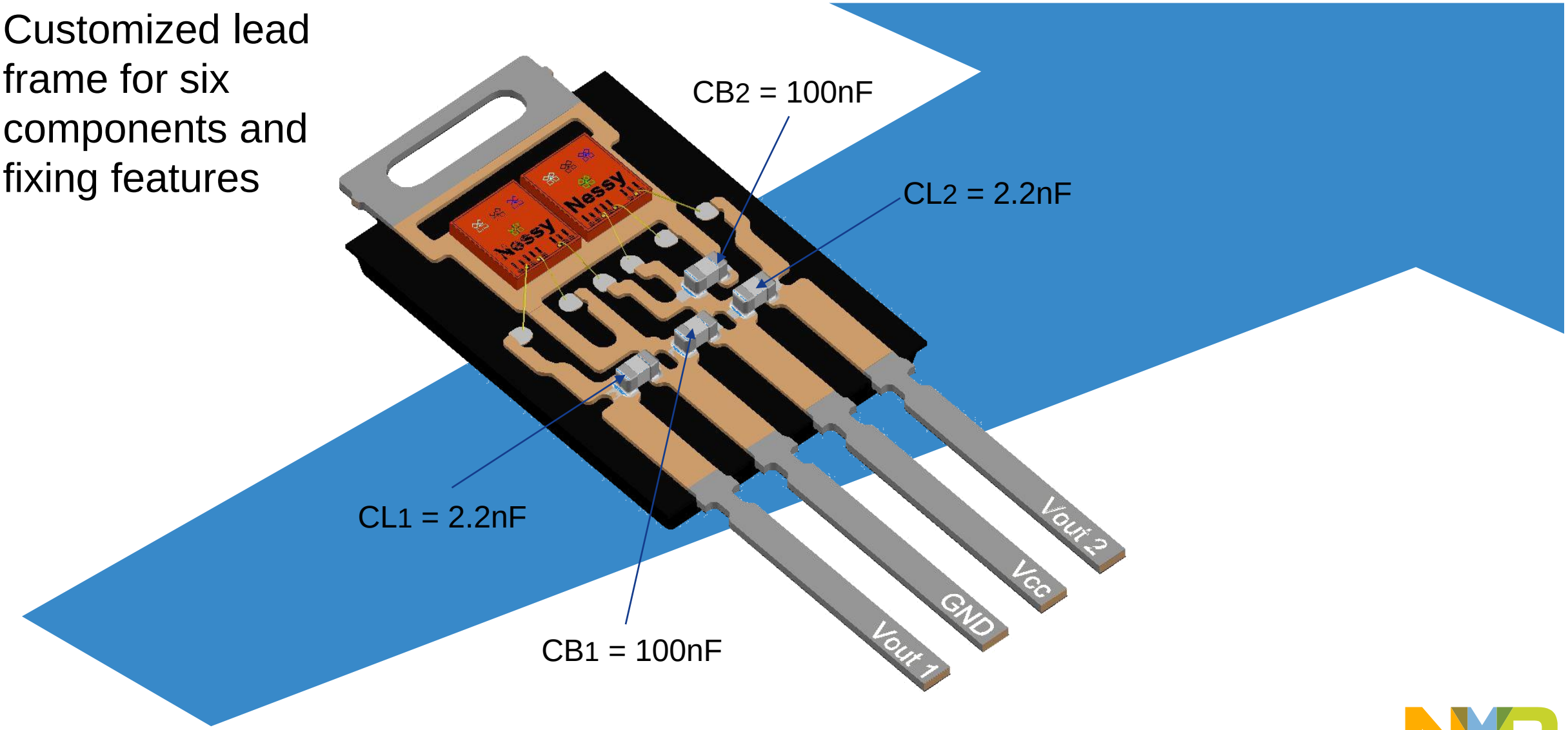


# KMA32x Angular Double Sensor System



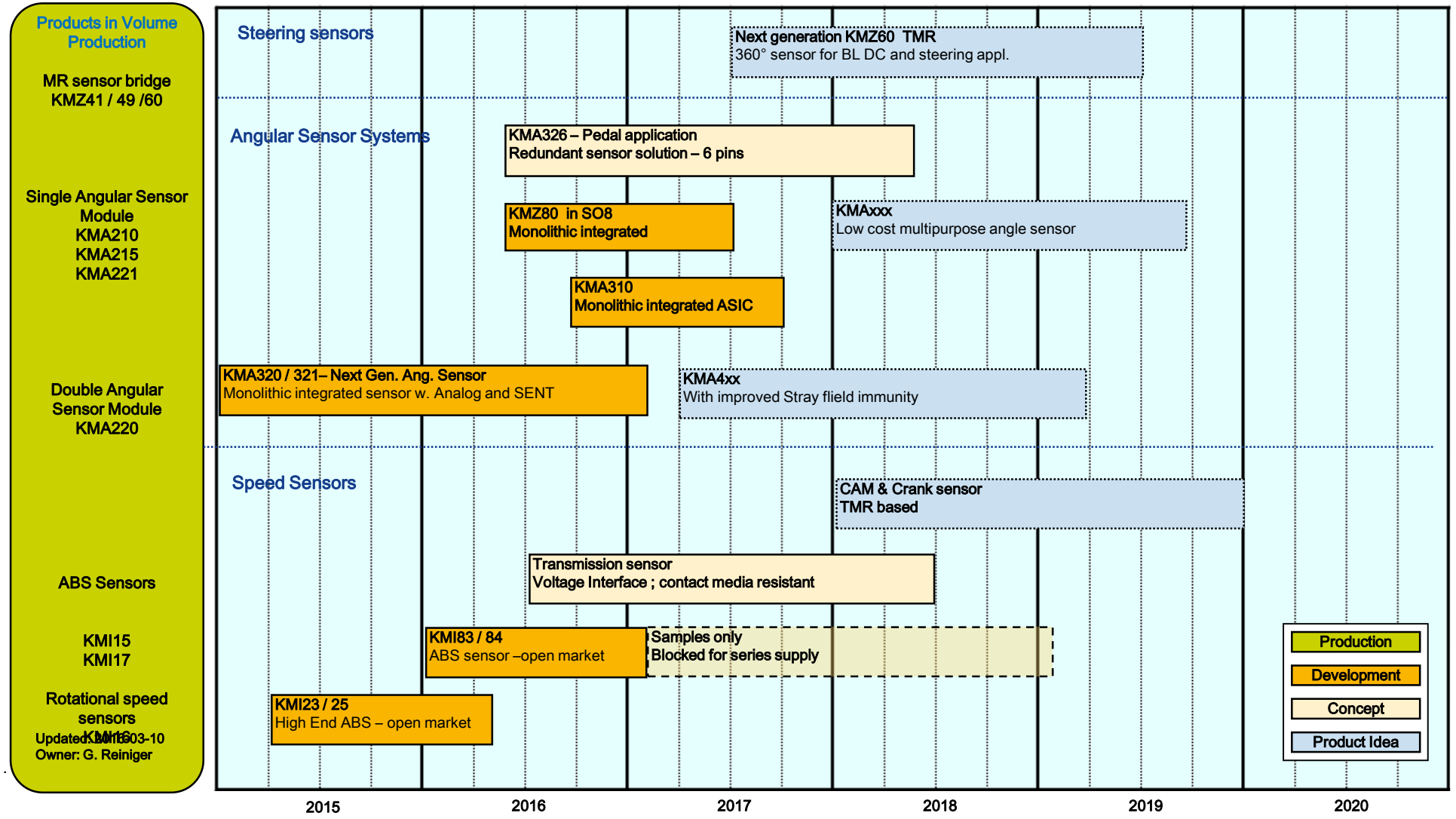
# KMA32x Angular Double Sensor System

Customized lead frame for six components and fixing features



# PRODUCT ROADMAP

# Product Roadmap Magnetic Sensors



# MAGNETIC SENSORS
# Q&A

# SENSOR PRODUCTS TIMELINE

**1980**

We manufacture our first uncompensated pressure sensor

**1981**

Production start of First Temperature Sensor KTY81

**1982**

Pressure sensors are supplied for manifold absolute pressure (MAP), enabling a major reduction in emissions and fuel consumption

**1985**

Development of first magnet sensor family KMZ10

**1985**

A temperature-compensated pressure sensor is unveiled

**1989**

Development of first ABS sensor

**1991**

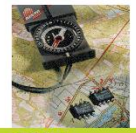
Bipolar integrated pressure sensor production begins

**1992—present**

Dedicated supplier to the critical care medical market shipping over 90 million units for the invasive blood pressure market

**1994**

Start angular sensor Production KMZ41

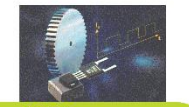


**1995**

Start production Compass sensor KMZ51

**1996**

Inertial sensors start volume production



**1996**

Start production Integrated ABS Sensor family

**Late 1990s**

A new wingback/PDIP package is developed for the Z-axis inertial sensor

**Early 2000s**

Inertial sensor portfolio expands with X-, XY- and Z-axis low-g products

**2002**

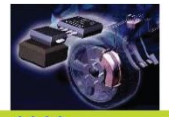
Began providing pressure sensors for respiratory medical equipment

**2003**

Tire pressure monitoring system developed, utilizing capacitive technology to save power

**2003**

Smarter, faster airbag deployment enabled by satellite accelerometer introduction



**2003**

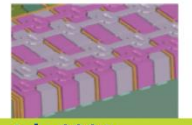
100 mill sensors shipped

**2004**

Launch integrated angular sensor system KMA200

**May 2005**

Freescale introduces its first 3-axis MMA7260Q low-g inertial senso



**July 2006**

First HARMEMS technology MMA62xxEG products shipped for airbags with robust accuracy

**2007**

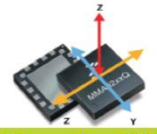
Launch integrated angular sensor system KMA199

**2008**

TPMS highly integrated, single-package, low-power solution introduced with pressure sensor, 8-bit MCU, RF transmitter, 2-axis X- and Z-axis accelerometer

**November 2008**

Synerject announces its ongoing use of Freescale pressure sensors for robust, cost-effective ECUs for two- and four-stroke engine management



**December 2008**

3-axis accelerometers offer reliable, cost-effective freefall detection to help protect data stored on laptop hard disks

**June 2009**

MPL115A released, the first digital barometric pressure sensor with easy-to-use digital interface and low power


**January 2010**

Freescale Sensors Group marks thirty years of industry innovation and leadership

**February 2010**

MMA845xQ unveiled, a very low- power 12-bit digital (I²C) resolution accelerometer with embedded functions to enable next-generation intelligent motion features

**June 2010**

Freescale launches Xtrinsic sensing solutions, the first smart sensors in the market

**January 2011**

Freescale introduces the first magnetometer in its Xtrinsic sensor portfolio

**2011**

Launch BL DC Sensor KMZ60

**2011**

Select Comfort launches production using differential pressure sensors to enable tracking & sleep optimization through SleepIQ


**February 2012**

Award-winning Xtrinsic eCompass software introduced

**2012**

MPL3115A2 altimeter released

**2012**

Launch throttle Sensor KMA220

**June 2012**

Joint announcement with Kinetis introducing the MMA8491Q

**June 2012**

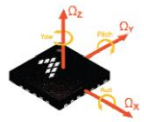
Accelerometers for smart meter physical tamper detection debut

**2013**

Wide bandwidth 3 axis accelerometer for vibration sensing applications launched

**August 2013**

Xtrinsic MMA9550L motion-sensing platform detects falls and an Xtrinsic MAG3110 3-axis magnetometer works in conjunction for accurate compass-based location information in Numera's Personal Emergency Response System



**October 2013**

Gyroscope sampling began

**2014**

Launch angular sensor with SENT output

**2014**

Alternative Fuel (LPG) after-market installs with ported pressure sensors

**2014**

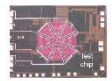
First 3 axis gyroscope launched–FXA21002

**2015**

MPL3115A2 altimeter used in inhaler applications

**2015**

Ikeg uses ported differential sensor used to detect amount of beer remaining



**2016**

Launch of first monolithic integrated MR sensor


**2016**

Reached 3 billion sensors shipped milestone

# Other Sensor Sessions This Week

| Session | Day | Time | Title | Room |
|---|---|---|---|---|
| FTF-SMI-N1946 | Monday | 16:15 | Build Better Drones with NXP Products | 301 & 302 – Level 3* |
| FTF-AUT-N1821 | Tuesday | 11:00 | Automotive Sensors Portfolio | Lone Star Ballroom E - Level 3 |
| FTF-INS-N1820 | Tuesday | 14:30 | Hands-On Workshop: Sensor Mining and Algorithm Development (Reserved Seat Required) | Griffin Hall 1 - Level 2 |
| FTF-INS-N2014 | Wednesday | 11:00 | Collecting and Analyzing Sensor Data Readily using NXP Hardware and Software Tools Including Kinetis SDK and IS-SDK | Lone Star Ballroom H - Level 3 |
| FTF-INS-N1819 | Wednesday | 14:30 | Sensor Deep-Dive Demos and Data Collection Techniques | Lone Star Ballroom H - Level 3 |
| FTF-INS-N1816 | Wednesday | 16:45 | Sensors for Industrial and Medical IoT Applications | 301 & 302 - Level 3 |
| FTF-INS-N1818 | Thursday | 9:00 | The Fundamentals of Sensor Data Analytics | 301 & 302 - Level 3 |
| FTF-INS-N1817 | Thursday | 09:00 | Introduction to Sensor Toolbox and IoT Sensing SDK | Lone Star Ballroom F – Level 3 |
| FTF-SMI-N2003 | Thursday | 11:00 | Make Your Own 3D Printer with NXP Technology | Lone Star Ballroom G - Level 3 |



* Cross BU session, intro to sensors for drones

SECURE CONNECTIONS
FOR A SMARTER WORLD

# ATTRIBUTION STATEMENT