Intelligent **Sensor Solutions**

EUF-INS-T1582

Marc Osajda | Business Development Manager

J U N E . 2 0 1 5

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Agenda

- Introduction

- Pressure Sensors

  - Product development update

  - TPMS solutions

- Motion Sensors

  - Product development update

  - New collaterals

- Conclusion & Q&A

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- **Introduction**

- Pressure Sensors

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  - TPMS solutions

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- Conclusion & Q&A

Quick Introduction: Marc Osajda

- Freescale Semiconductor
  - Automotive Business Development Manager Analog & Sensor Group, EMEA

- 20+ years experience in MEMS sensors
  - Design, Application, Marketing, Business Development, Automotive

- MD from "Ecole National d'Arts et Métiers", Paris, France

- Multiple publication and patents on Sensors

We Are a Global Leader in
Embedded Processing Solutions
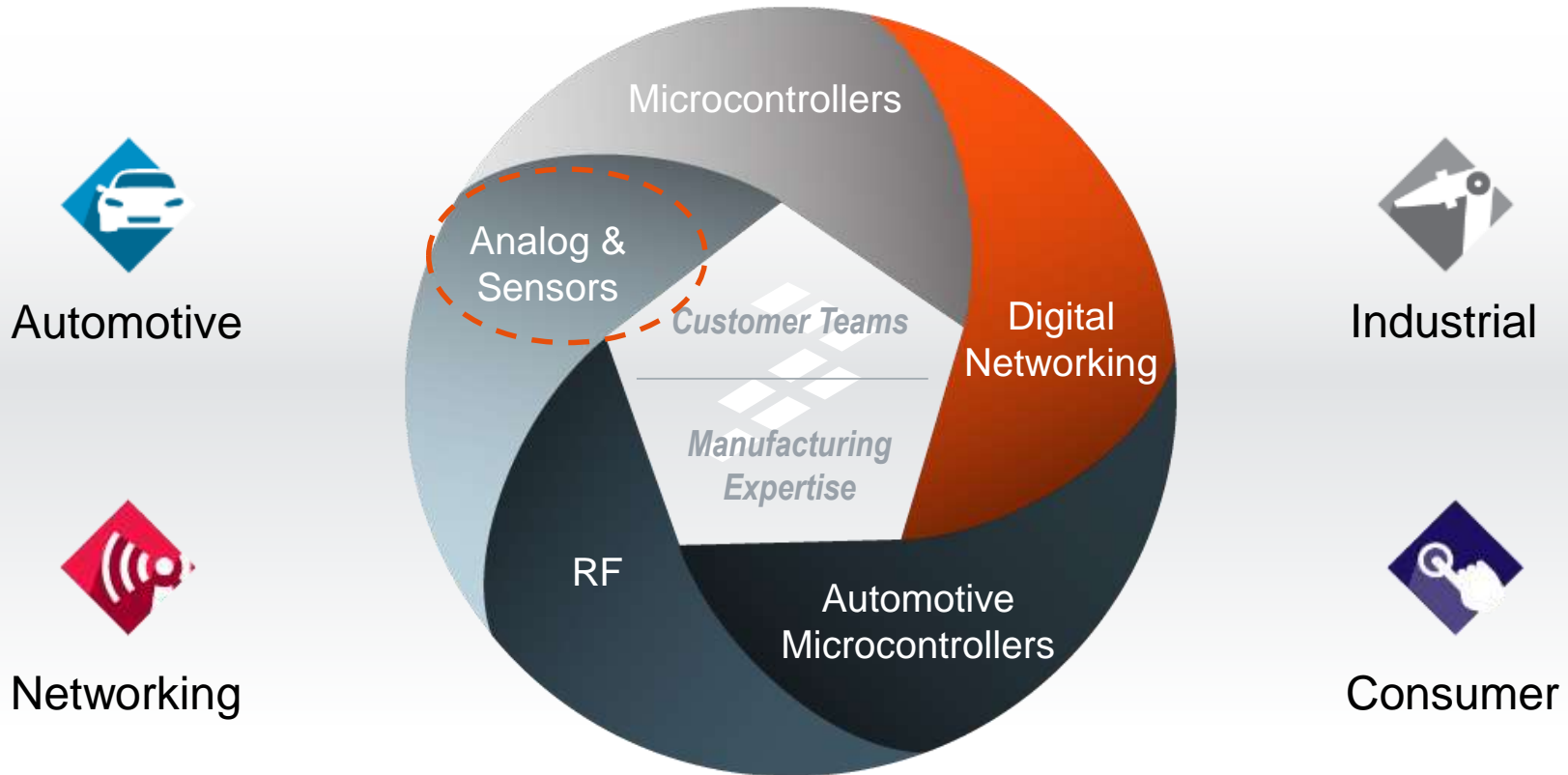
Five Core Product Groups

>50 Year Legacy
>6,000 Patent Families*

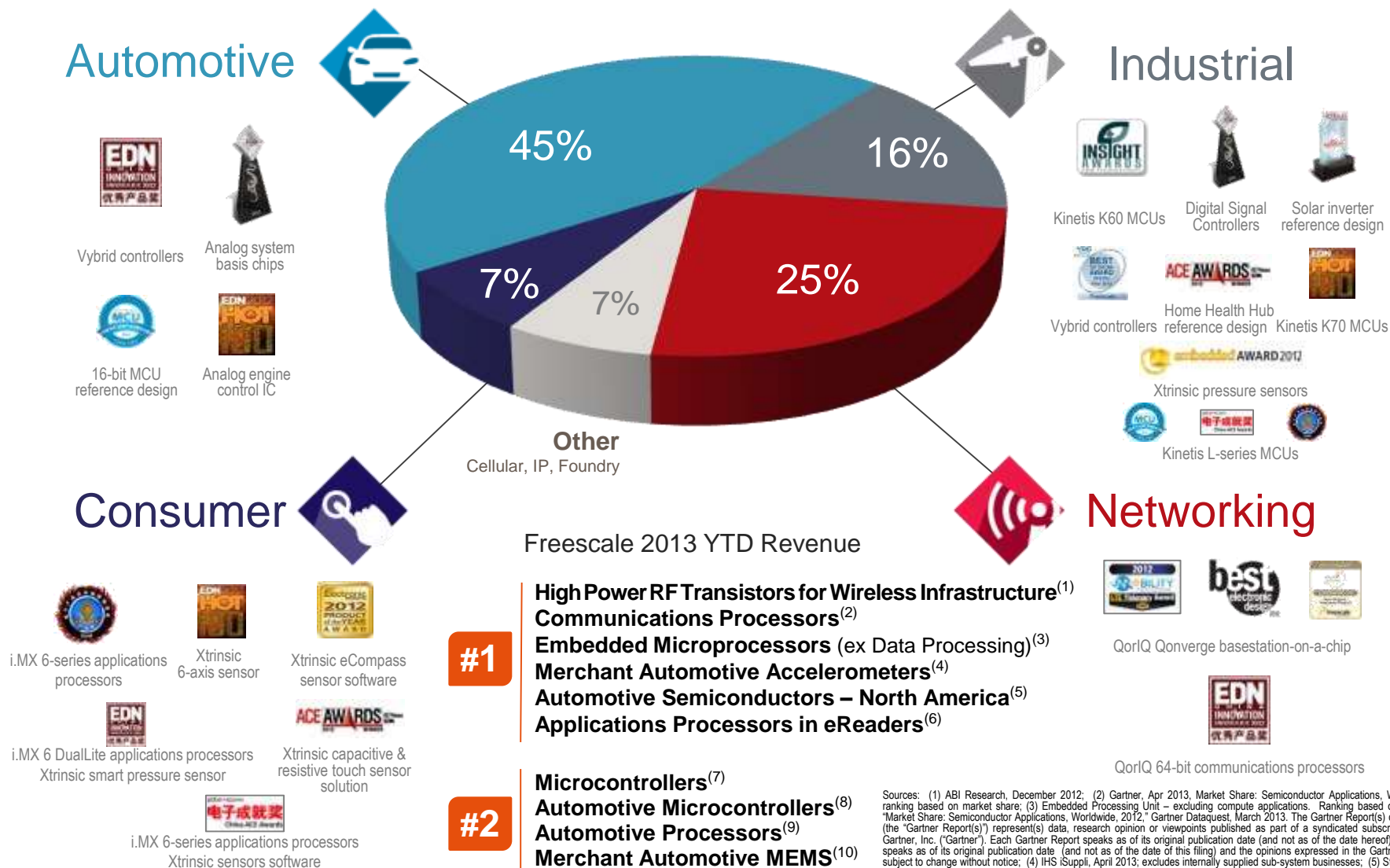**Four** Primary Markets

* a set of patents taken in various countries to protect a single invention

We Have a Significant Presence in All Segments

Automotive

Vybrid controllers

Analog system basis chips

16-bit MCU reference design

Analog engine control IC

Industrial

Kinetis K60 MCUs

Digital Signal Controllers

Solar inverter reference design

Vybrid controllers

Home Health Hub reference design

Kinetis K70 MCUs

Xtrinsic pressure sensors

Kinetis L-series MCUs

45% | **16%** | **7%** | **7%** | **25%**

Other
Cellular, IP, Foundry

Consumer

i.MX 6-series applications processors

Xtrinsic 6-axis sensor

Xtrinsic eCompass sensor software

i.MX 6 DualLite applications processors
Xtrinsic smart pressure sensor

Xtrinsic capacitive & resistive touch sensor solution

i.MX 6-series applications processors
Xtrinsic sensors software

Networking

QorIQ Qonverge basestation-on-a-chip

QorIQ 64-bit communications processors

Freescale 2013 YTD Revenue

#1
High Power RF Transistors for Wireless Infrastructure[1]
Communications Processors[2]
Embedded Microprocessors (ex Data Processing)[3]
Merchant Automotive Accelerometers[4]
Automotive Semiconductors – North America[5]
Applications Processors in eReaders[6]

#2
Microcontrollers[7]
Automotive Microcontrollers[8]
Automotive Processors[9]
Merchant Automotive MEMS[10]

Sources: (1) ABI Research, December 2012; (2) Gartner, Apr 2013, Market Share: Semiconductor Applications, Worldwide, 2012; ranking based on market share; (3) Embedded Processing Unit – excluding compute applications. Ranking based on market share. "Market Share: Semiconductor Applications, Worldwide, 2012," Gartner Dataquest, March 2013. The Gartner Report(s) described herein, (the "Gartner Report(s)") represent(s) data, research opinion or viewpoints published as part of a syndicated subscription service by Gartner, Inc. ("Gartner"). Each Gartner Report speaks as of its original publication date (and not as of the date hereof); Gartner Report speaks as of its original publication date (and not as of the date of this filing) and the opinions expressed in the Gartner Report(s) are subject to change without notice; (4) IHS iSuppli, April 2013; excludes internally supplied sub-system businesses; (5) Strategy Analytics, April 2013; (6) IDC, Tablet and eReader Application Processor Market Share Q2 2013, doc # #244035 ; (7)+(8) IHS, March 2013, Competitive Landscape Tool – Annual - 2012; Gartner, March 2013; (9) Strategy Analytics, April 2013; (10) IHS, April 2013; excludes automotive MEMS supply internal sub-system businesses.

Recent (2012+) product awards shown

Market Focus for Sensors

Automotive
- Standalone sensing systems
- Ruggedized packages
- Wide sensing ranges

Consumer
- Accelerometer
- Gyroscope
- Pressure
- Magnetometer
- MCU integrated sensors

Safe & Efficient Automobiles
Safe driving, front/side impact
Tire information system
Active driver assistance
Passenger occupancy detection

Industrial Sensor Networks
Connected intelligence
Fault monitoring/prognostication
High precision modules

Extreme Portable Electronics
Low profile packages
Low power consumption
Submersible sensors

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Full Portfolio of MEMS & Sensors

Accelerometers

Magnetometers

eCompass

Touch Sensors

Gyro

Altimeter / Pressure

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ISO 26262 Certified Hardware Development Process for Analog/Sensors
Supplier Leadership in Meeting Functional Safety Requirements

- Certified by **SGS TUV Saar** – an independent accredited assessor

- Audit assessed the capability of **Freescale product development rules, processes and tools for analog and sensor devices** in our global NPI and manufacturing sites to satisfy the ISO 26262 functional safety standard (as applicable to a semiconductor supplier)

- Our **SafeAssure** functional safety development process for analog and sensor hardware has been **certified as compliant with ISO 26262 standard part requirements**, namely,
    - ISO 26262-**2**:2011 – Safety Management
    - ISO 26262-**5**:2011 – Hardware Development
    - ISO 26262-**7**:2011 – Production
    - ISO 26262-**8**:2011 – Supporting Processes
    - ISO 26262-**9**:2011 – Safety Analysis

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

ISO 26262-2:2011
ISO 26262-5:2011
ISO 26262-7:2011
ISO 26262-8:2011
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   Munich, 26.01.2015
SGS-TÜV Saar GmbH   Marcus Rau

The test mark regulation is an integral part of this certificate.
SGS-TÜV Saar GmbH, Hofmannstr. 50, D-81379 München, Deutschland / Germany.
Internet: www.sgs-tuv-saar.com   E-Mail: fs@sgs.com

Another Billion Sensors Shipped in 5 Years

1980 — We manufacture our first uncompensated pressure sensor

1982 — Pressure sensors are supplied for manifold absolute pressure (MAP), enabling a major reduction in emissions and fuel consumption

1985 — A temperature-compensated pressure sensor is unveiled

Late 1980s — Began developing the first surface micromachined inertial...

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

1996 — Inertial sensors start volume production

Late 1990s — A new wingback/PDIP package is developed for the Z-axis inertial sensor

2002 — Began providing pressure sensors for respiratory medical equipment

Early 2000s — Inertial sensor portfolio expands with X-, XY- and Z-axis low-g products

2003 — Tire pressure monitoring system developed, utilizing capacitive technology to save power

2003 — Smarter, faster airbag deployment enabled by satellite accelerometer introduction

MA62xxEG ...pped for ...th robust

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

February 2008 — Motion-sensing accelerometer enables interactivity of Guitar Hero® and other popular video games

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...

FREESCALE SENSORS 1 BILLION UNITS SHIPPED

April 2009 — MMA7660, an intelligent 3-axis digital accelerometer and Freescale Energy-Efficient Solution, is introduced for advanced mobile phone interfaces

June 2009 — MPL115A released, the first digital barometric pressure sensor with easy-to-use digital interface and low power

June 2009 — Sensor Toolbox introduced

June 2009 — Reached 1 billion units shipped milestone

June 2009 — Tower System introduced

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 Xtrins... sensing solutions, the first... smart sensors in the market

FREESCALE SENSORS 2 BILLION UNITS SHIPPED

February 2012 — Award-winning Xtrinsic eCompass software introduced

June 2012 — Joint announcement with Kinetis introducing the MMA8491Q

June 2012 — Accelerometers for smart meter physical tamper detection debut

June 2012 — 12-axis Xtrinsic Sensor Reference Platform for Windows® 8 certified by Microsoft® for sensor fusion requirements

April 2013 — Pressure sensor collects biosignal information in BAM Labs® Touch-free Life Care™ (TLC) System

June 2013 — Xtrinsic intelligent sensing framework releases

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 — FXAS2100 Xtrinsic gyroscope released

November 2013 — Freedom Platform for Xtrinsic sensors is Arduino™ footprint compatible with support for sensor expansion boards

May 2014 — Reached 2 billion sensors shipped milestone
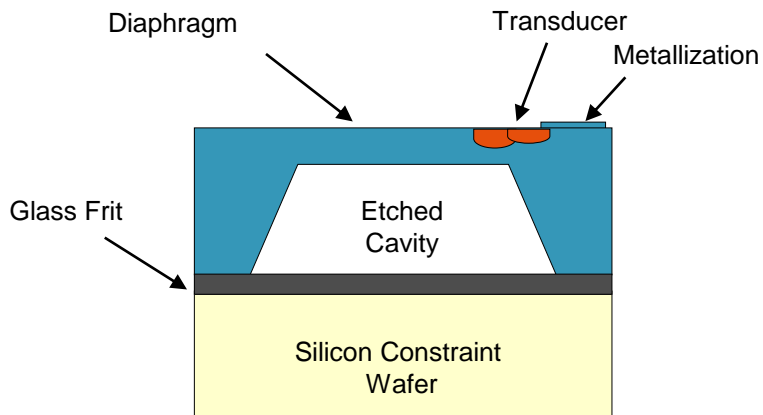

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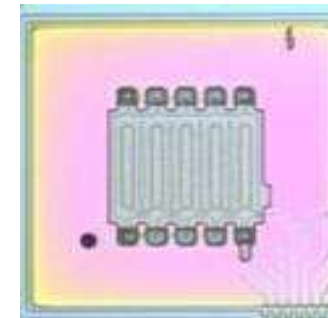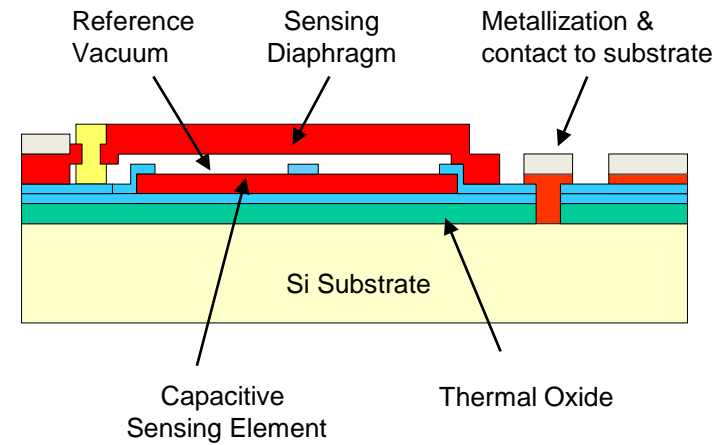 - New collaterals

- Q&A

MEMS Pressure Sensor Technology

Bulk Micro machining
Legacy technology
In volume production (engine mgt)

Surface Micro machining
Used for all new automotive sensors
In volume production (TPMS)

Diaphragm
Transducer
Metallization
Glass Frit
Etched Cavity
Silicon Constraint Wafer

Reference Vacuum
Sensing Diaphragm
Metallization & contact to substrate
Si Substrate
Capacitive Sensing Element
Thermal Oxide

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Pressure Sensors Family Overview

Pressure Sensor Family	Full scale pressure	Typical Applications
Barometric pressure	105, 110, 115, 130, 200 kPa abs.	Engine management, Altimetry, barometer, medical application
LPG and CNG	250, 300, 400 kPa abs.	Engine management LPG and CNG
Differential/Gauge low pressure	4, 6,10 kPa diff.	Industrial applications
Differential/Gauge Medium pressure	40, 50, 80, 100, 115 kPa diff.	Industrial and medical applications
Differential/Gauge High pressure	150, 200, 250, 500, 700, 1000 kPa diff.	Industrial applications
Vacuum Sensors	±2, ±7, ±25, ±50, ±115 kPa diff	Medical, Industrial applications
TPMS	450, 900, 1500 kPa abs.	Tire pressure monitoring

Unibody   SOP   Chip Pak   SSOP   M-Pak   LGA   QFN

MPL3115A2: Precision Digital Pressure Sensor

Differentiating Points

- Internally compensated, software is not needed
- Direct reading pressure in Pascals and altitude in meters
- On-board intelligence

Product Features

- Altitude resolution : < 1 foot / 0.3 m
- Pressure resolution: 1.5 Pa
- Pressure range: 20 – 110 kPa
- Calibrated pressure range: 50 – 110 kPa
- 1.95V to 3.6V supply voltage
- Variable output sampling rate (OST) up to 140 Hz
- Current Consumption:
  - Standby mode: 2 µA
  - Low-power mode: 8.5 µA at 1 Hz
- I²C digital interface

Typical Applications

- High Accuracy Altimeter
- Smartphones / Tablets
- GPS Enhancement for Location Based Services
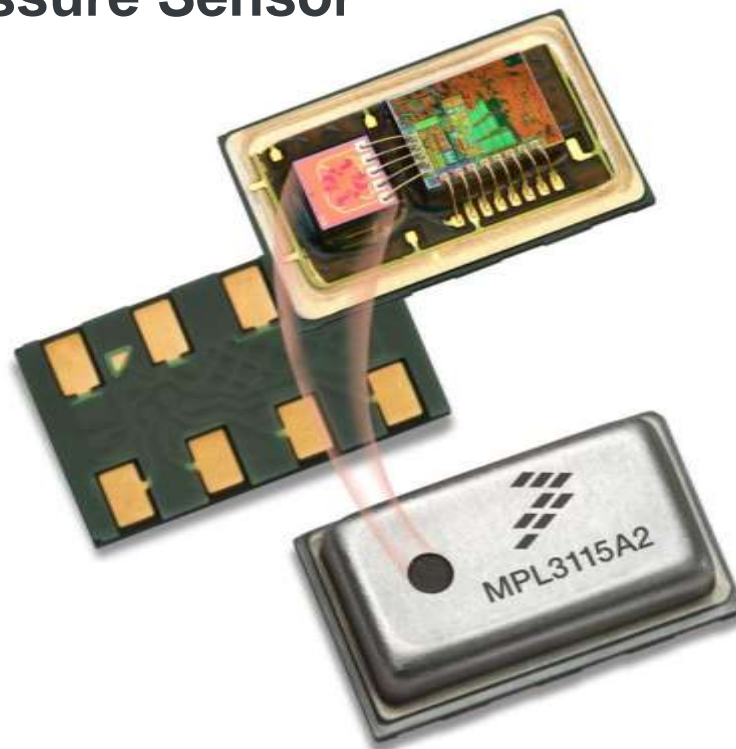
Package
3 x 5 x 1.1 mm LGA

Availability
Samples: NOW
Production: NOW

Freescale FXPQ3115BVT1
Biomedical Precision Pressure Sensor for Medical Applications

Differentiating Points

- Biomedically approved gel coating
- Currently pursuing extensive biological testing
- Internally compensated, software is not needed
- Direct reading pressure in Pascals and altitude in meters
- On-board intelligence

Product Features

- Altitude resolution : < 1 foot / 0.3 m
- Pressure resolution: 1.5 Pa
- Pressure range: 20 – 110 kPa
- Calibrated pressure range: 50 – 110 kPa
- 1.95V to 3.6V supply voltage
- Variable output sampling rate (OST)
- Current Consumption:
  - Standby mode: 2 µA
  - Low-power mode: 8.5 µA at 1 Hz
- I²C digital interface

Typical Applications

- Inhalers/Nebulizers
- Medical Tablets
- Health Activity Monitors
- Oxygen Concentrators

Package

- 3 x 5 x 1.1 mm LGA

Samples: Q2, 2015
Production: Q4, 2015

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FXPQ3115MV
I2C Submersible Precision Altimeter

Differentiating Points

- Media resistant to water and salt water; ideal for submersible applications.
- Internally compensated, software is not needed
- Direct reading pressure in Pascals and altitude in meters
- On-board intelligence

Product Features

- Altitude resolution : < 1 foot / 0.3 m
- Pressure resolution: 1.5 Pa
- Pressure range: 20 – 110 kPa
- Calibrated pressure range: 50 – 110 kPa
- 1.95V to 3.6V supply voltage
- Variable output sampling rate (OST) up to 140 Hz
- Current Consumption:
  - Standby mode: 2 μA
  - Low-power mode: 8.5 μA at 1 Hz
- I²C digital interface

Typical Applications

- Waterproof fitness watches and activity monitors
- High accuracy altimetry
- Swim tracking equipment

3mm

5mm

0.275mm

Ø1.5mm

0.275mm
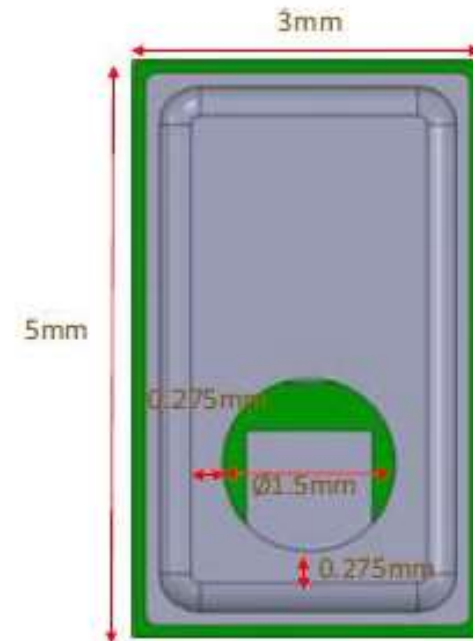
Package
3 x 5 x 1.5 mm LGA

Samples: Q2, 2015
Production: Q4, 2015

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TPMS Solutions

Why Tire Pressure Monitoring ?

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

- **Cleaner world for everyone**
  - TPMS allows **optimum tire inflation** and thus fuel consumption and **CO_2 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: enables better **tire management**

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Freescale TPMS are used by the following brands*

*Not an exhaustive list – Status May 2015

Tire Pressure Monitoring System Application Diagram
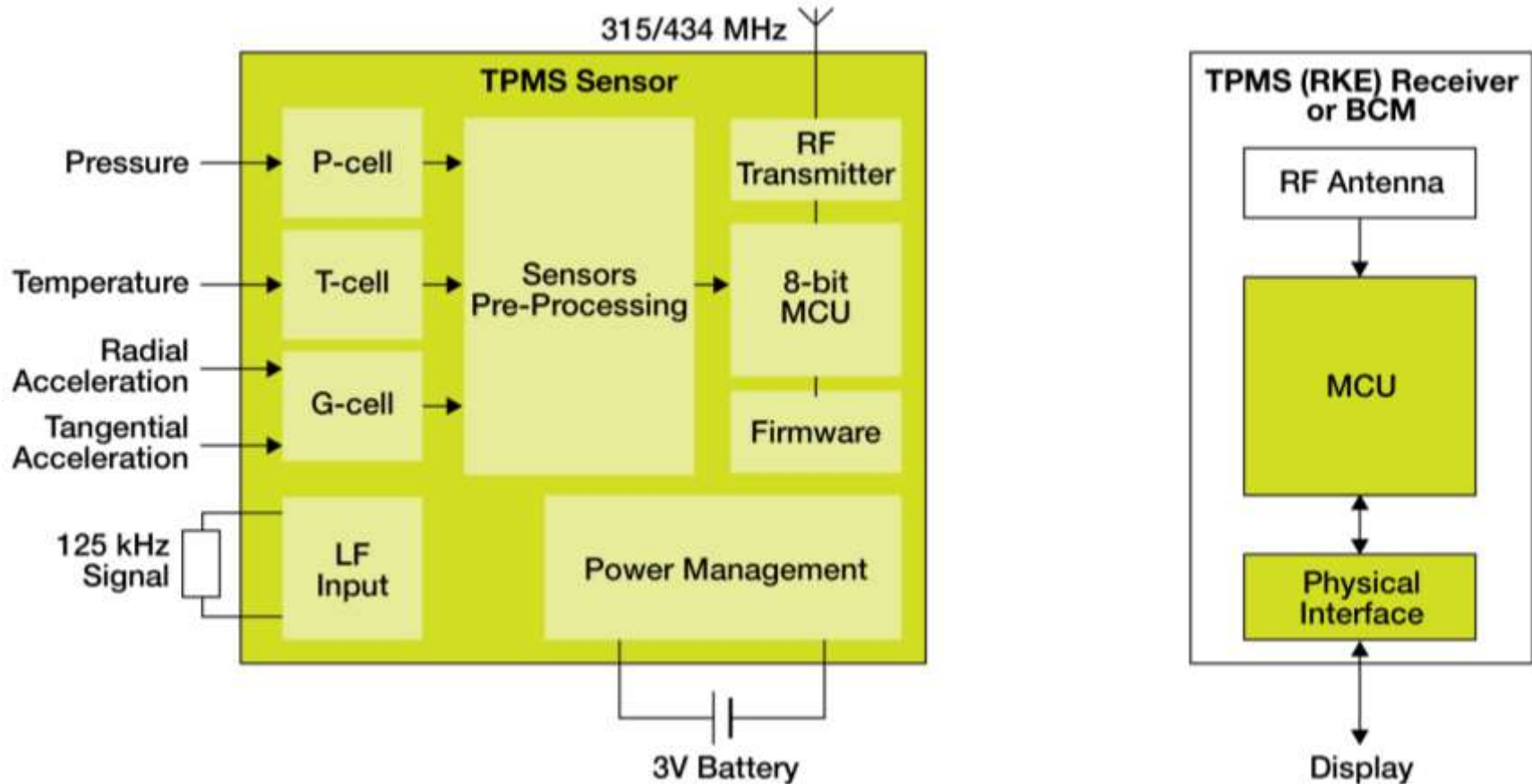
FXTH87 Summary – World Smallest TPM Sensor

- **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 fur
- Embedded **MCU** and **dedicated TPMS Library**
  - Large Memory space for customer application
- **LF and RF** wireless interface
- Ultra low power consumption
- **Volume production now**
  - 450, 900kPa and 1500kPa released

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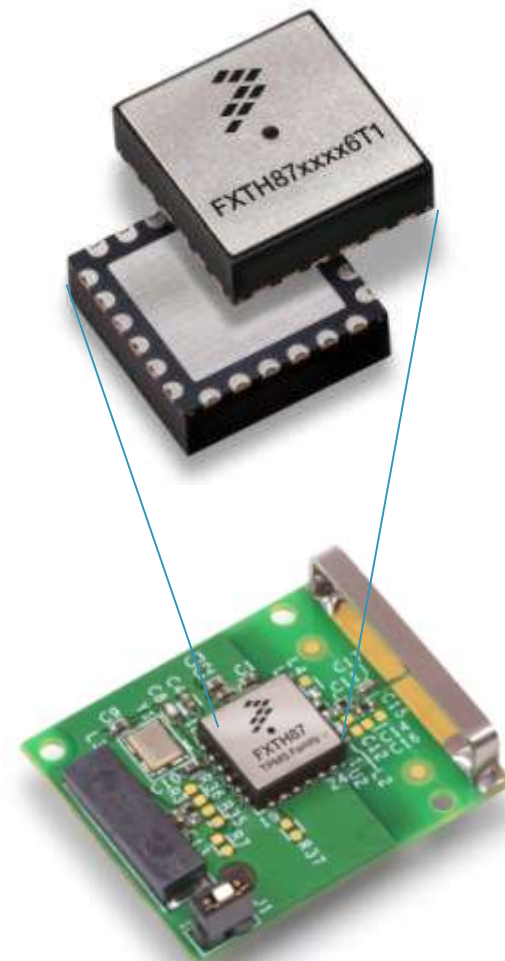
Industry's Best In Class Truck TPMS Sensor

- Highest level of integration
  - Up to 1500 kPa pressure sensor
  - 1-/2-axis accelerometer
  - MCU with 315/434 MHz RF transmitter and LF receiver
  - **Most accurate device on the market**
- Compact and Light weight
  - 7 x 7 x 2.2 mm, 0.3g
  - Enable weight and space constrained TPMS modules
- Single and Dual axis accelerometer
  - Easy after market installation
  - Support all tire localization methods
- 8 kB flash for customer application
  - Enable differentiated module features
- **In Production Now**

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FXTH87 Tire Pressure Monitoring Sensor Enablement

- **Evaluation Boards: emulate typical customer wheel unit module containing FXTH87 sensor, LF coil, RF antenna, battery, and all passives.**
  - TPMS870911-315 (900 kPa – 315 MHz)
  - TPMS870911-434 (900 kPa – 434 MHz)

- **Application Notes / Reference Manuals for FXTH87 TPMS family**
  - FXTH87xx **Design Reference** Manual (EVB description)
  - FXTH87xx22 Embedded **Firmware User Guide** (FXTH87XX22FWUG)
  - Interfacing to Freescale's FXTH87xx In-Flash Firmware Routines Using C-language Constructors
  - Using the FXTH87 Family of **LF Receivers** for TPMS Application (AN4391)
  - **AN1902: Assembly Guidelines** for QFN and DFN Packages to cover the QFN7x7mm packages

FXTH87 Typical Application Schematic
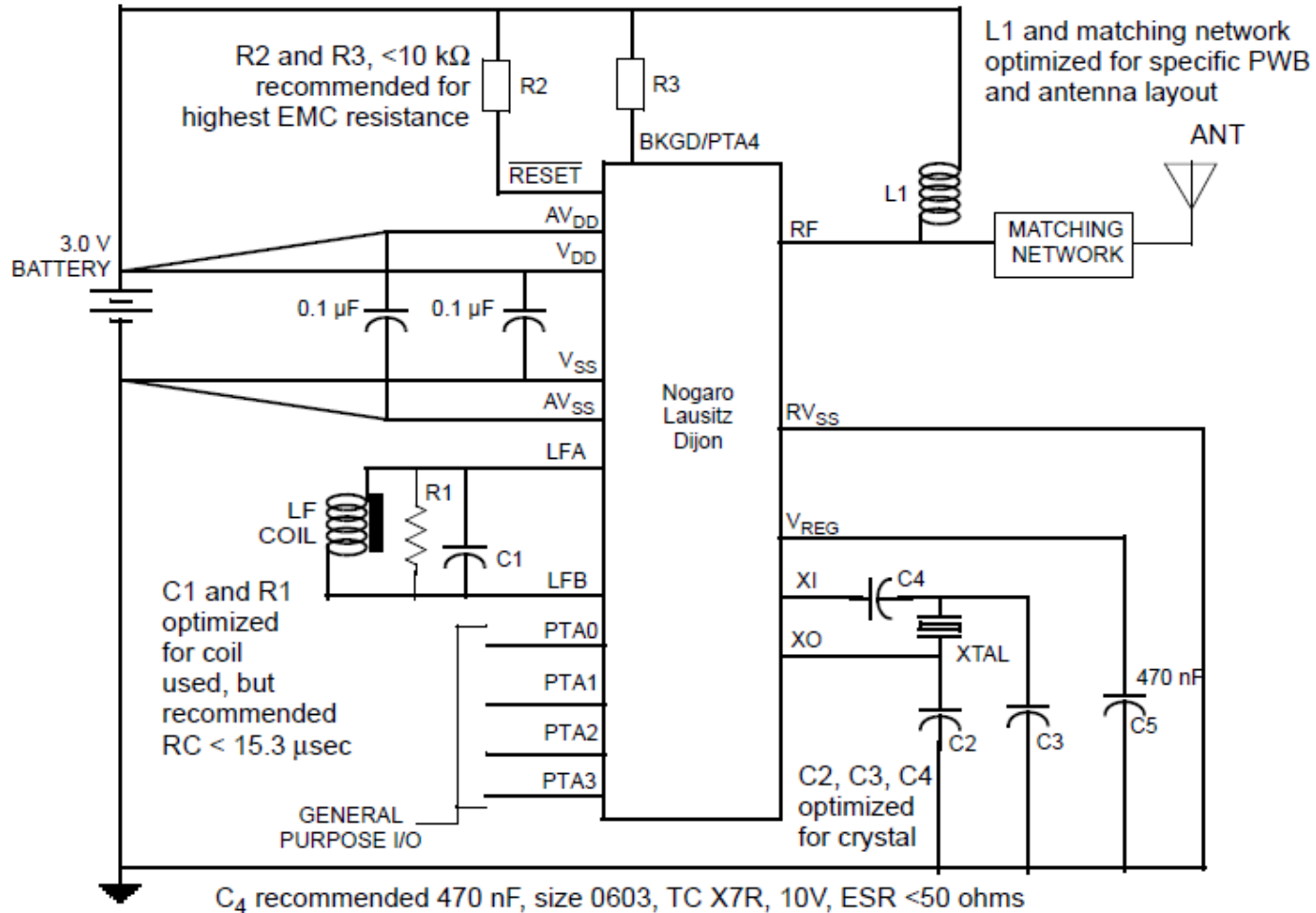
Please refer to product specification for full details

FXTH87 Firmware Example

Address	Routine	Description
E000	TPMS_RESET	Master reset of complete device
E003	TPMS_READ_VOLTAGE	10-bit uncompensated bandgap voltage reading
E006	TPMS_COMP_VOLTAGE	8-bit compensation of 10-bit voltage reading
E009	TPMS_READ_TEMPERATURE	10-bit uncompensated temperature reading
E00C	TPMS_COMP_TEMPERATURE	8-bit compensation of 10-bit temperature reading
E00F	TPMS_READ_PRESSURE	10-bit uncompensated pressure reading
E012	TPMS_COMP_PRESSURE	9-bit compensation of 10-bit pressure reading
E015	TPMS_READ_ACCELERATION_X	10-bit uncompensated X-axis accel reading
E018	TPMS_READ_DYNAMIC_ACCEL_X	10-bit uncompensated X-axis accel reading with dynamic offset adjustment.
E01B	TPMS_COMP_ACCELERATION_X	9-bit compensation of 10-bit X-axis accel reading
E01E	TPMS_READ_ACCELERATION_Z	10-bit uncompensated Z-axis accel reading
E021	TPMS_READ_DYNAMIC_ACCEL_Z	10-bit uncompensated Z-axis accel reading with dynamic offset adjustment.
E024	TPMS_COMP_ACCELERATION_Z	9-bit compensation of 10-bit Z-axis accel reading
E027	TPMS_READ_ACCELERATION_XZ	10-bit uncompensated X-axis and Z-axis accel readings
E02A	TPMS_READ_DYNAMIC_ACCEL_XZ	10-bit uncompensated X-axis and Z-axis accel readings with dynamic offset adjustment.
E02D	TPMS_COMP_ACCELERATION_XZ	9-bit compensation of 10-bit X-axis and Z-axis accel readings

Please refer to product specification for full details

FXTH87 Portfolio (450 kPa- 900 kPa)

Part Number	Pressure range(kPa)	Pressure offset accuracy (0C ≤ Ta ≤ 70C)	Axis of Acceleration	Z-range Sensitivity	Z-offset accuracy	X-range Sensitivity	X-offset accuracy
Standard Tolerances							
FXTH870502**D**T1	100-450	±7 kPa	Z	-270g/+350g 40g sensitivity	±6 g		
FXTH870511**D**T1	100-450	±7 kPa	XZ	-210g/+240g 60g sensitivity	±5 g	-70g/+80g, 10g sensitivity	±4 g
FXTH870902**D**T1	100-900	±10 kPa	Z	-270g/+350g 40g sensitivity	±6 g		
FXTH870911**D**T1	100-900	±10 kPa	XZ	-210g/+240g 60g sensitivity	±5 g	-70g/+80g, 10g sensitivity	±4 g
FXTH870912**D**T1	100-900	±10 kPa	XZ	-270g/+350g 40g sensitivity	±6 g	-70g/+80g, 10g sensitivity	±4 g
Precision Tolerances (Accelerometer)							
FXTH870502**6**T1	100-450	±7 kPa	Z	-270g/+350g 40g sensitivity	±3 g		
FXTH870511**6**T1	100-450	±7 kPa	XZ	-210g/+240g 60g sensitivity	±3 g	-70g/+80g, 10g sensitivity	±3 g
FXTH870902**6**T1	100-900	±10 kPa	Z	-270g/+350g 40g sensitivity	±3 g		
FXTH870911**6**T1	100-900	±10 kPa	XZ	-210g/+240g 60g sensitivity	±3 g	-70g/+80g, 10g sensitivity	±3 g
FXTH870912**6**T1	100-900	±10 kPa	XZ	-270g/+350g 40g sensitivity	±3 g	-70g/+80g, 10g sensitivity	±3 g

- All the products above are released for production.
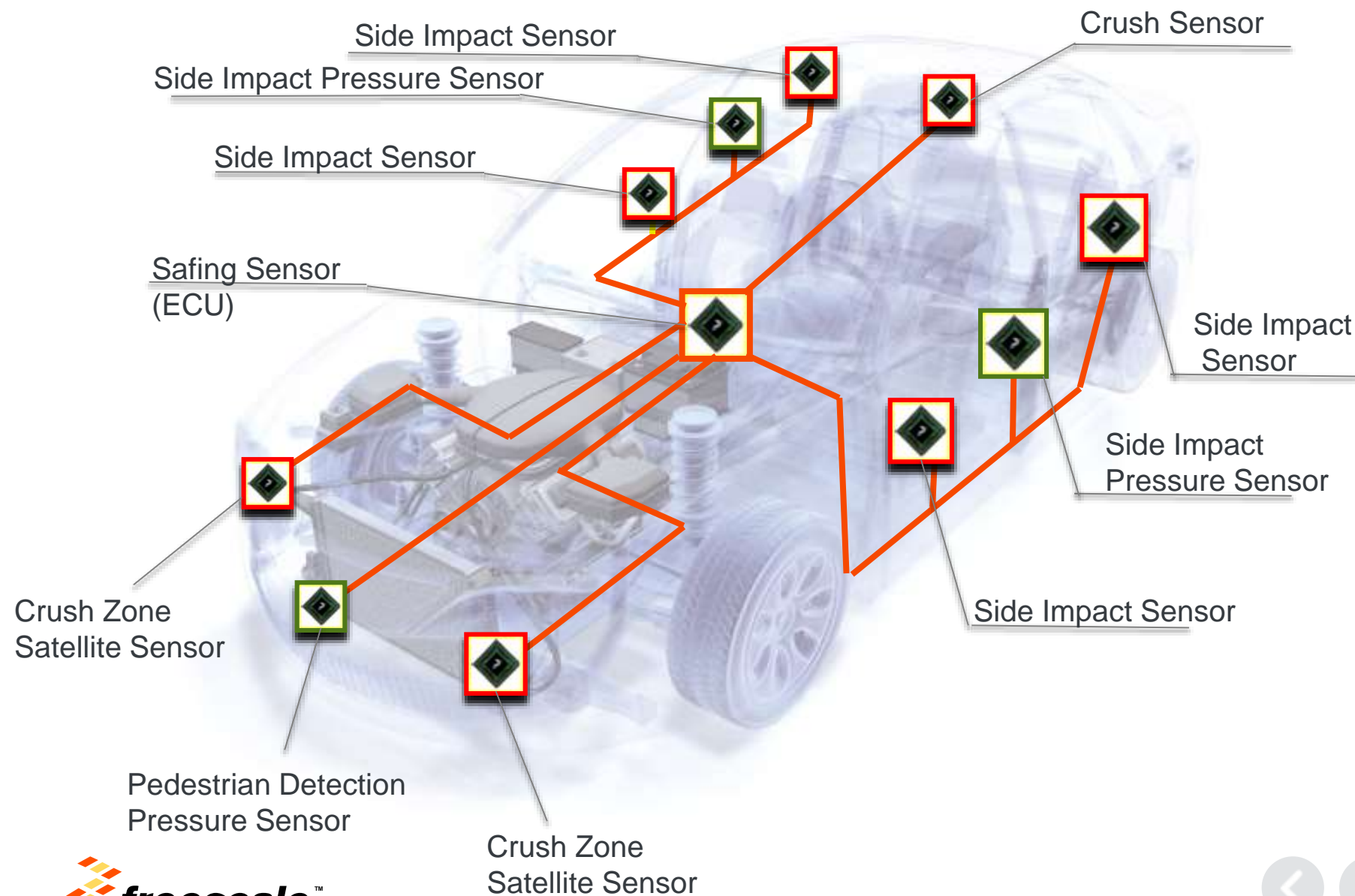- Fact sheet already available on the web. Datasheets available through customer registration

FXTH8715xx 1500kPa Portfolio

Part Number	Pressure range(kPa)	Pressure offset accuracy (0C ≤ Ta ≤ 70C)	Axis of Acceleration	Z-range Sensitivity	Z-offset accuracy	X-range	X-offset accuracy
Standard Tolerances							
FXTH871502**D**T1	100-1500	±20 kPa	Z	-270g/+350g, 40g sensitivity	±6 g		
FXTH871511**D**T1	100-1500	±20 kPa	XZ	--210g/+240g, 60g sensitivity	±5 g	-70g/+80g, 10g sensitivity	±4 g
Precision Tolerances accelerometer							
FXTH871502**6**T1	100-1500	±20 kPa	Z	-270g/+350g, 40g sensitivity	±3 g		
FXTH871511**6**T1	100-1500	±20 kPa	XZ	-210g/+240g, 60g sensitivity	±3 g	-70g/+80g, 10g sensitivity	±3 g
High Precision Tolerances pressure and accelerometer							
FXTH871511**7**T1	100-1500	±17 kPa	XZ	-210g/+240g, 60g sensitivity	±3 g	-70g/+80g, 10g sensitivity	±3 g

- All the products above are released for production.
- Fact sheet already available on the web. Datasheets available through customer registration

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Sensor Type: Accelerometers
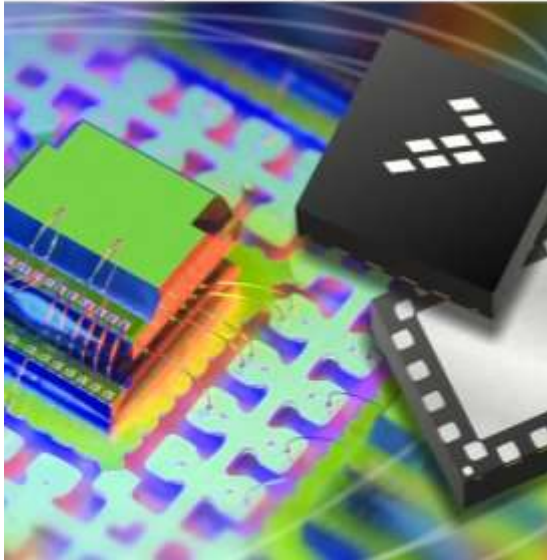
- Freescale's acceleration sensors detect changes in force resulting from tilt, motion, positioning, shock, and vibration
- Capable of single, dual, or triple axis sensing capability with range from 1.5g to 480g
- Devices are system-in-a-package (two chip) solutions comprised of:
  - g-cell: surface micro-electromechanical systems (MEMS) capacitive sensing cells modeled as a set of beams attached to a central mass that moves between fixed beams
  - Control IC: measures g-cell capacitance and extracts acceleration data, provides amplification, signal conditioning, low pass filtering and temperature compensation

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Accelerometer in Automotive Airbag Applications

Side Impact Sensor

Crush Sensor

Side Impact Pressure Sensor

Side Impact Sensor

Safing Sensor (ECU)

Side Impact Sensor

Side Impact Pressure Sensor

Crush Zone Satellite Sensor

Side Impact Sensor

Pedestrian Detection Pressure Sensor

Crush Zone Satellite Sensor

Freescale Automotive Accelerometer Sensors (Production)

Device Family	Axis/Axes	G Ranges	Communications Protocol	Package
MMA65xx	X, Y	+/- 80 to +/- 120 g	12 Bit SPI	6x6 QFN
MMA68xx	X, Y	+/- 20 to +/- 120 g	10 Bit SPI	6x6 QFN
MMA655x	X	+/- 105 to +/- 120 g	12 Bit SPI	6x6 QFN
MMA685x	X	+/- 20 to +/- 120 g	10 Bit SPI	6x6 QFN
MMA16xx	Z	+/- 50 to +/- 312 g	DSI 2.5	6x6 QFN
MMA26xx	X	+/- 25 to +/- 312 g	DSI 2.5	6x6 QFN
MMA17xx	Z	+/- 25 to +/- 375 g	DSI3	6x6 QFN
MMA27xx	X	+/- 250 g	DSI3	6x6 QFN
MMA51xx	Z	+/- 60 to +/- 480 g	PSI5	6x6 QFN
MMA52xx	X	+/- 60 to +/- 480 g	PSI5	6x6 QFN
MMA12x0	Z	+/- 2.5 to +/- 5g	Analog	16 SOIC
MMA69xx	X, Y	+/- 3.5 to +/- 5g	11 Bit SPI	6x6 QFN

HARMEMS overdamped g-cell

Peripheral Sensor Interface 5 (PSI5)

6x6 QFN Package
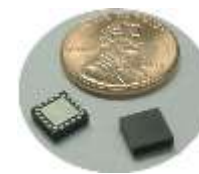
But Also Non Airbag Application in Automotive

Application	Product type
Suspension monitoring	Low-g accelerometer, single axis
Car Alarm (movement detection)	Low-g accelerometer, 2- or 3-axis
Electric Parking Brake	Low-g accelerometer 2-axis
Vehicle tracking box Anti tampering sensor	Low-g accelerometer
eCall box – extra crash sensor	Medium g accelerometer
Infotainment / Touch screen (road bumps detection)	Medium to low-g accelerometer
Remote keyless entry (wake up function)	Low-g, low power accelerometer
Wearable connected to Driver Monitoring Systems	Consumer grade sensors

Consumer and Industrial Grade Accelerometer

3 x 5 x 1.2mm	3 x 3 x 1.2mm	3 x 3 x 1.2mm	2 x 2 x 1mm	0.83 x 1.2 x 0.77mm
MMA745x	**MMA8450**	**MMA845x** **SX8452**	**MMA865X**	**FXLS895xC**

• First Digital Output
• 3-Axis
  – I^{2}C
• Cost Efficient
• High Performance
• Rich Features
  – P/L detection
  – High Pass Filter
	• Digital Output
	  – I^{2}C
	• Extreme Performance
	  – .25mg/count sensitivity
	• Extended Features
	  – FIFO
	  – Configurable P/L trip angles
	  – High Pass Filter
		• Digital Output
		  – I^{2}C
		• Extreme Performance
		  – .25mg/count sensitivity
		• Extended Features
		  – FIFO
		  – Configurable P/L trip angles
		  – High Pass Filter
			• I2C Output
			• Cost Efficient
			  – 1mg/count sensitivity
			• High Perf.
			• Rich Features
			  – P/L detection
			  – High Pass Filter
			  – Transient Detect
			• 2x2 mm package
				• Smallest Footprint
				• Lowest Power
				• Digital Output
				• I2C
				• Cost Efficient
				• High Performance
				• Rich Features
				• P/L detection
				• High Pass Filter

(Ion)	**(Proton)**	**(Veyron)**	**(Newton)**	**(Einstein)**

2008	< 6 years, 5000% package decrease>	2015

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Consumer, Industrial and Automotive Grade

	FXLS8471	MMA8451	FXLN8361	MMA6900
Freescale Family	*VeyronSPI*	*Veyron*	*Pluto*	*Opuntia*
Type	3axis 2g/4g/8g Digital High Resolution	3axis 2g/4g/8g Digital High resolution	3axis 2g/8g Analog / Industrial High bandwidth	2axis 3.5g/5g Digital Automotive
	14 bit ADC 0.244 mg/LSB	14 bit ADC 0.244 mg/LSB	229mv/g (2g range)	11 bits 3mg/LSB
Voltage	1.95 to 3.6V	1.95 to 3.6V	1.71 to 3.6V	5.0V
Operating Temp	-40 to 85C	-40 to 85C	-40 to 105C	-40 to 105C
Storage Temp	-40 to 125C	-40 to 125C	-40 to 125C	-40 to 125C
Interface	I2C & SPI	I2C Only	Analog	SPI
Package	QFN 3x3x1mm	QFN 3x3x1mm	QFN 3x3x1mm	QFN 6x6x1.98
Qualification	**Consumer**	**Extended consumer**	**Industrial grade**	**Automotive AEC-Q100**
Samples	Now	Now	Now	Now
Production	Now	Now	Now	Now
Longevity program	5 years life time	10 years life time	10 years life time	>10 years life time

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Qualification Stresses Comparison – More Than Consumer

	FXLS8471	MMA8451	FXLN8361	MMA6900
Freescale Family	*VeyronSPI*	*Veyron*	*Pluto*	*Opuntia*
Qualification	Consumer	Extended consumer	Industrial grade	Automotive AEC-Q100
THB	504h	168h Passed 1008h	1008h	1008h
Temp cycles	200cycles	200cycles Passed 1000cycles	850cycles	1300cycles
HTSL	-	168h Passed 1008h	-	1008h
UHAST	96h	96h	96h	96h
HTOL	504h Passed 1008h	168h Passed1008h	1008h	1008h
ELFR	-	24h	48h	500h
Longevity program	5 years life time	10 years life time	10 years life time	>10 years life time

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Magnetometers & Gyroscopes

Magnetometer/Gyro
Key Products

	Sample	Prod	Applications
MAG3110G 3-axis Digital **Magnetometer**	Web	Now	Industrial Compass
Capable of measuring geomagnetic fields • Wide dynamic range +/- 1000 µT (10 Gauss) • Low power in measurement mode 8.6 µA . • Interrupt pin trigger when new data available • Tilt compensation and Soft/Hard Iron calibration SW available • 1.95...3.6 Volt, 2 x 2 x 0.85 mm DFN			Current Sensing Presence Detection Car Detect Industrial Safety Magnetic Tamper Sports Watch Diving Watch Home automation
FXOS8700CQ COMBO 6-axis **Magnetometer** and **Accelerometer**	Now	Now	
• Capable of measuring geomagnetic fields with Tilt compensation • Wider dynamic range +/- 1200 µT • ODR up to 800 Hz by sensors, or 400Hz in Hybrid mode • Embedded interrupts and pre-programmed functions • Low power 7µA for accelero only, 36µA for magnetometer • 1.95...3.6 Volt, 3 x 3 x 1.2 mm QFN			
FXAS21002 3-axis Digital Gyroscope I²C/SPI, QFN 4x4mm • **2.6 mA running mode power, 60 ms turn on time**	Now	Now	Inertial Navigation Gaming Remote Control Smart Phones

2 x 2 mm + 3 x 3 mm = 3 x 3 mm

NEW

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FXAS21002C – 3 Axis Consumer Gyroscope

Differentiating Points

- **Best-in-class power performance**: **2.7mA (Active), 1.6mA (Ready),   2uA (Standby)**
- Complete sensor fusion enablement suite

Product Features

- Enhanced Selectable Full Scale ranges: **+/-250, +/-500, +/-1000, +/-2000**
- Fast Transition from Standby to Active Mode **(60 ms)**
- Expanded Output data rates (ODR) from **12.5 Hz to 800Hz**
- Zero Rate Change over temperature: **±0.02dps/°C (XY), ±0.01dps/°C (Z)**
- Improved Noise: Angular Random Walk = **0.025 dps/rt(Hz).**
- Angular velocity resolution <0.2°/s
- Programmable interrupts, Power saving features
- 1.95-3.6V supply voltage

Typical Applications

- Controllers: Remotes, Games
- Ruggedized Industrial and Medical Handhelds and Tablets
- Sports Monitoring, Remote control toys, Robots

Package
4x4x1mm QFN, 0.5mm pitch

Availability
NOW

Intelligent Motion Sensor Hubs

MEMS and Sensors Fusion
"The Whole Is Greater Than the Sum of Its Parts"
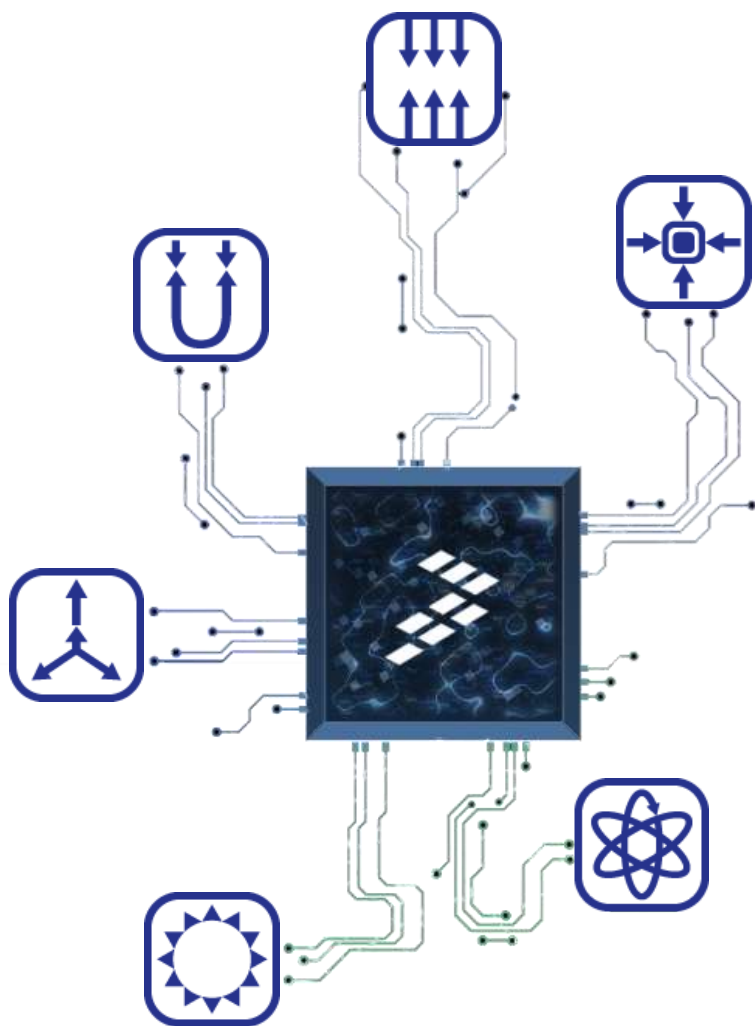
- Individual sensors have inherent limitations and/or errors that can be corrected or compensated for by complementary sensing nodes:
  - **Accelerometer**: x, y & z linear motion sensing - sensitive to vibrations
  - **Gyroscope:** pitch, roll & yaw rotational sensing - zero bias drift
  - **Magnetometer:** x, y & z axis magnetic field sensing - sensitive to magnetic interference

- Fused sensor information is more accurate and reliable than individual sensor data:
  - e.g. Gyros suffer from offset drifts over time. A companion accelerometer's data compensates for the offset drift

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Motion Sensing Platforms

Key Products

	Sample	Production		Applications
MMA955xL 32-Bit 16K Flash CPU and 3-axis Accelerometer	Now	Now		Tilt Measurement
FXLC95000CL 32-Bit 128K Flash CPU and 3-axis Accelerometer	Now	Now		Vibration Monitor

- Embedded ±2, ±4, ±8 g 3-axis 16-Bit accelerometer module
- **32-Bit CF V1 CPU** with MAC multiply and accumulate block
- 16K or 128K on-chip Flash, 2K or 16K on-chip SRAM
- SPI, I²C (master and slave), GPIO, ADC, PWM
- 1.8V , 3 x 3 x 1 mm QFN, or 3 x 5 x 1 mm QFN
- Pre-flashed Freescale firmware (3 Versions) or MQX
- CodeWarrior CW10.x supported

Applications (continued):
- Pedometer
- Home Health
- Power Management
- eCompass
- Asset Tracking
- Collision Recorder

Part Number	Firmware	User Memory Size	Sample	Production
MMA9559L	Basic	14K Flash 1.5K SRAM	Now	Now
MMA9550L	Infrastructure	6.5K Flash 0.5K SRAM	Now	Now
MMA9551L	Infrastructure and Gesture	4.5K Flash 0.5K SRAM	Now	Now
MMA9553L	High end pedometer	1.5K Flash 0.2K SRAM	Now	Now
FXLC95000	MQX enabled	128K Flash 16K SRAM	Now	

3-Axis MEMS Accelerometer

ROM	ColdFire 32-Bit V1 Core
Flash	
RAM	
ADC	SPI
GPIO	I2C

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Freescale's Sensor Enablement

Collateral (Boards, Kits)

New Boards/Kits to Support FXAS21002

Part Number	Freescale Devices	Online Availability	Price	Comments
BRKT-STBC-AGM01	FXAS21002, FXOS8700	NOW	$11.95	Breakout board with access to all I/O
FRDM-STBC-AGM01	FXAS21002, FXOS8700	NOW	$15.95	Sensor Shield Board. Pairs with a variety of Kinetis MCU boards including KL25Z, KL26Z, K22F, K64F
FRDM-K64F-AGM01	FXAS21002, FXOS8700, FRDM-K64F	NOW	$52.95	Sensor Shield + MCU sold as a single kit
FRDM-FXS-MULT2-B	FXAS21002, FXOS8700, MPL3115, MAG3110, MMA955x, MMA8652, FXLS8471	May 2015	$99.00	Sensor shield board with Bluetooth. Replaces FRDM-FXS-MULTI-B which included prior version of Gyro (FXAS21000)

| BRKT-STBC-AGM01 | FRDM-STBC-AGM01 | FRDM-K64F-AGM01 | FRDM-FXS-MULT2-B |

NEW! Freescale provides support through your entire product development cycle
Demo, Evaluation, Development, Prototyping

Sensor Expansion Board : FRDM-FXS Options & Features

Pricing:

- FRDM-FXS-9AXIS ($30)
- FRDM-FXS-MULTI ($50)
- **FRDM-FXS-MULTI-B** ($125) includes Bluetooth module and LiPo battery

Compatible Freedom boards:

- ARM Cortex-M0+ (**FRDM-KL25Z**)
- ARM Cortex-M4 (FRDM-K20D50M)
- support OpenSDA
- broad range of development tools:
  - CodeWarrior
  - Processor Expert
  - IAR / Keil / mbed

Out of box demos for:

- 3/6/9 DOF Sensor Fusion
- Pedometer
- 3 axis Gyroscope
- 3 axis Accelerometer
- Vibration Analysis
- Altimeter/Pressure Sensor
- Intelligent Sensing Framework

Freedom Xtrinsic FRDM-FXS development hardware

	FRDM-FXS-MULTI-B	FRDM-FXS-MULTI	FRDM-FXS-9AXIS
Compatible Freedom Development Hardware	FRDM-KL25Z FRDM-KL20D50M	FRDM-KL25Z FRDM-KL20D50M	FRDM-KL25Z FRDM-KL20D50M
Arduino R3-compatible board	√	√	√
FXAS21000 Gyroscope	√	√	√
FXOS8700CQ	√	√	√
MMA8652FC Accelerometer	√	√	
MPL3115A2 Altimeter/ Barometer Sensor	√	√	
FXLS8471 Accelerometer	√	√	
MMA9553L Pedometer	√	√	
MAG3110 Magnetometer	√	√	
Bluetooth Module and Battery	√		

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Freescale <u>Open Source</u> Sensor Fusion Library

Product Features

- Functionality

  - 3-axis, 2-axis heading, 6-axis eCompass,6-axis indirect Kalman filter, 3-axis relative rotation, and 9-axis indirect Kalman filter

  - Programmable sampling, fusion rates, and frame of reference

- Included projects

  - Kinetis K20, KL25Z, KL26Z, KL46Z, and K64F Freedom boards

  - Use of Freescale Multi sensor boards

  - CodeWarrior and Kinetis Design Studio IDEs
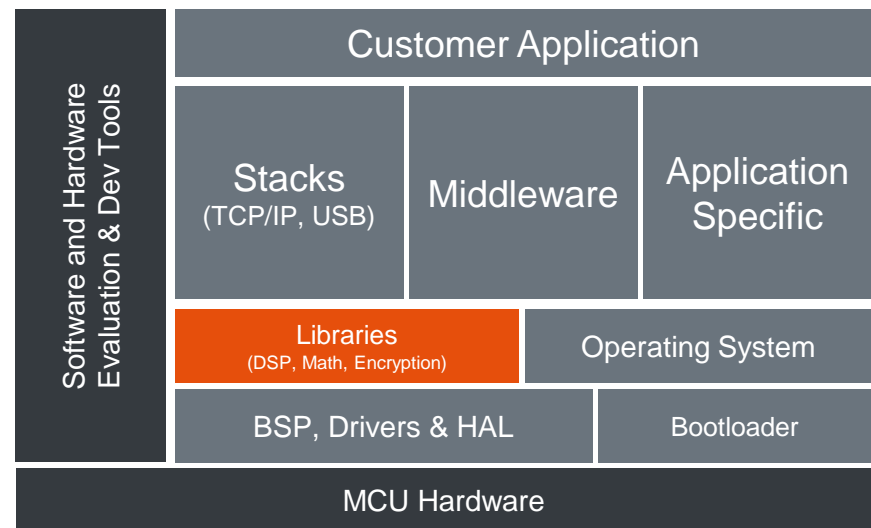
- Additional commercial support and services available

Learn more at: www.freescale.com/sensorfusion

Full featured sensor fusion library, including the award winning e-compass software

Fully open source, eliminating proprietary constraints, increasing flexibility, and decreasing time-to-market

Software and Hardware Evaluation & Dev Tools	Customer Application		
	Stacks (TCP/IP, USB)	Middleware	Application Specific
	Libraries (DSP, Math, Encryption)	Operating System	
	BSP, Drivers & HAL	Bootloader	
	MCU Hardware		

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Agenda

- Introduction

- Pressure Sensors

  - Product development update

  - TPMS solutions

- Motion Sensors

  - Product development update

  - New collaterals

- **Conclusion & Q&A**

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Summary: Why Freescale

- **Unique technical capabilities**
  - Broad technical portfolio and sensing ranges
  - Packaging capabilities and varieties
  - 30+ years of sensor design experience
  - ISO26262 compliant design flow
- **Robust design**
  - Stability over temperature
  - Linearity over sensing range
  - Datasheet specified max. zero level offsets
  - Extensive media compatibility
- **Assurance of continued product availability**

Secure, embedded processing solutions for the Internet of Tomorrow.

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