FTF | FREESCALE TECHNOLOGY FORUM 2015

Introduction to **Sensor** Product Portfolio – **Sensors 101**

FTF-INS-F1223

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Agenda

- Introduction and Session Overview

- Brief History and Market

- Freescale's Sensor Portfolio

  – Acceleration Sensors

  – Gyroscope

  – Magnetic Sensors

  – Pressure Sensors

  – Sensing Platforms

- Development Tools

- Session Review and Wrap-up

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Introduction to Sensor Product Portfolio

During this session you will learn about Freescale's sensor portfolio, key sensor applications, and ways to help solve problems with Freescale sensors

Benefits of attending this session are:

- Greater knowledge of a strong portfolio of diverse sensor types
- Awareness of intelligent integration with the right combination of leading sensor types
- Greater value and decision making to the overall sensing solution
- Seed ingenuity of designs to find novel solutions

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Introduction to Sensor Product Portfolio

- **Technology problems and solutions covered in this session framed around Intelligent Contextual Sensing:**
  - General understanding of multiple sensor inputs leveraged to perform multiple application functions
  - Perceptive intelligence of scalable products, varying levels of integration and performance
  - Awareness of customizable software that extend sensor use cases
  - Consciousness of common software platforms and common tools that shorten design time

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Session Objectives

- After completing this session you will:
  - Know the Freescale Sensor portfolio
  - Be familiar with Freescale Sensor Solutions
  - Locate, acquire and begin using our dev tools

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Brief History and Market

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Freescale Focus

Four **Product Platforms**

+ Software

Focused on **Growth Markets**

- Automotive
- Networking
- Industrial
- Consumer

Leveraging Three **Growth Trends**

- The Net Effect
- Health & Safety
- Going Green

YOU ARE HERE

Connect (RF)

Sense (Sensors)

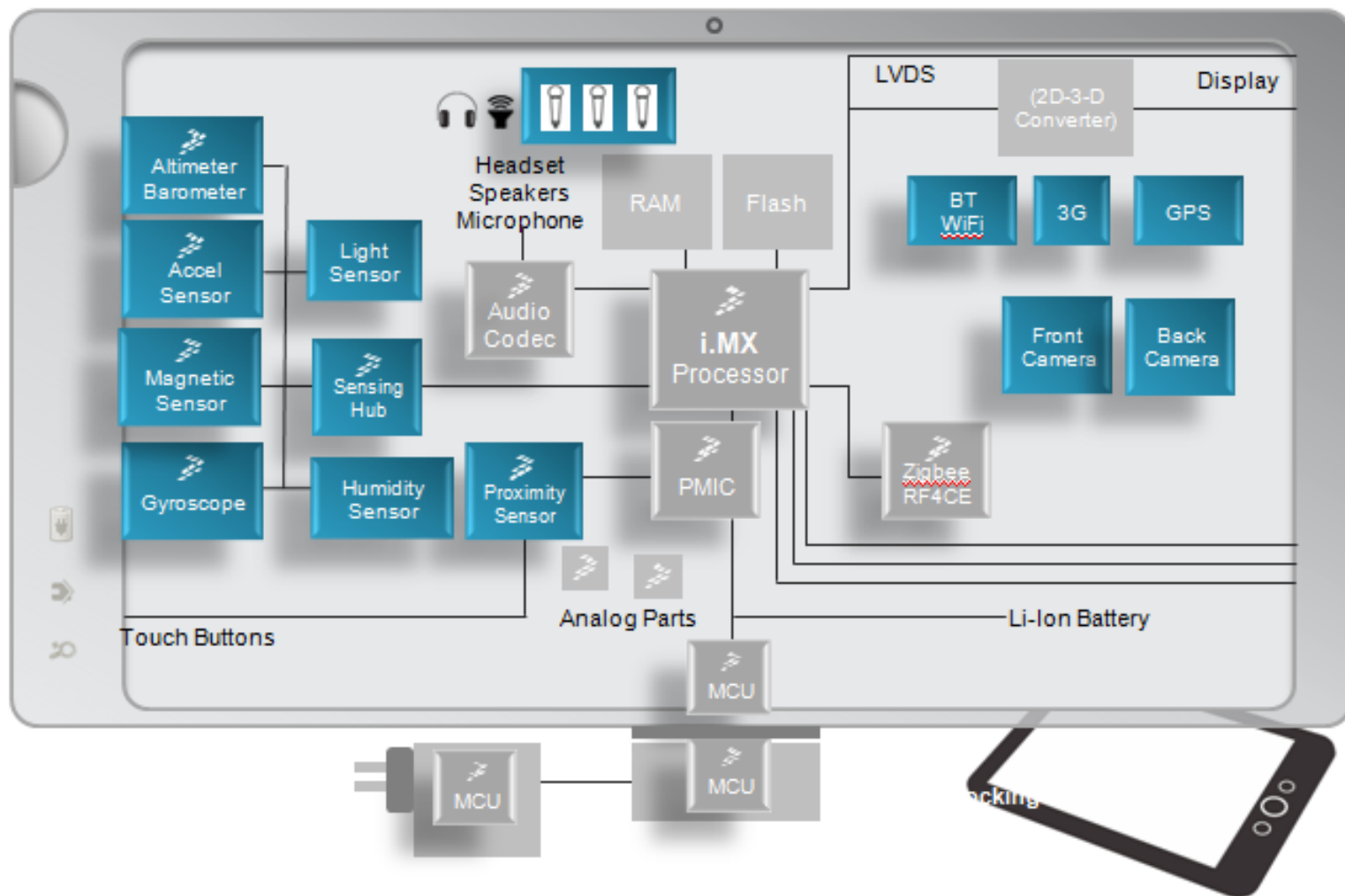Embedded Processing (MCU, MPU, DSP)

Control (Analog)

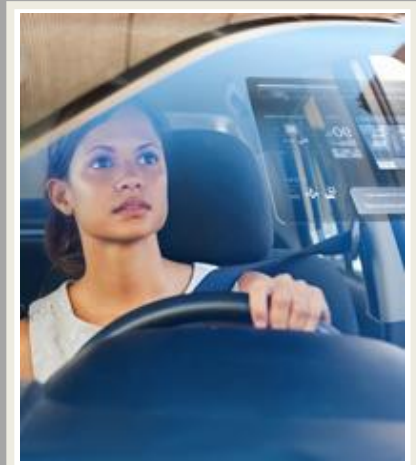Software

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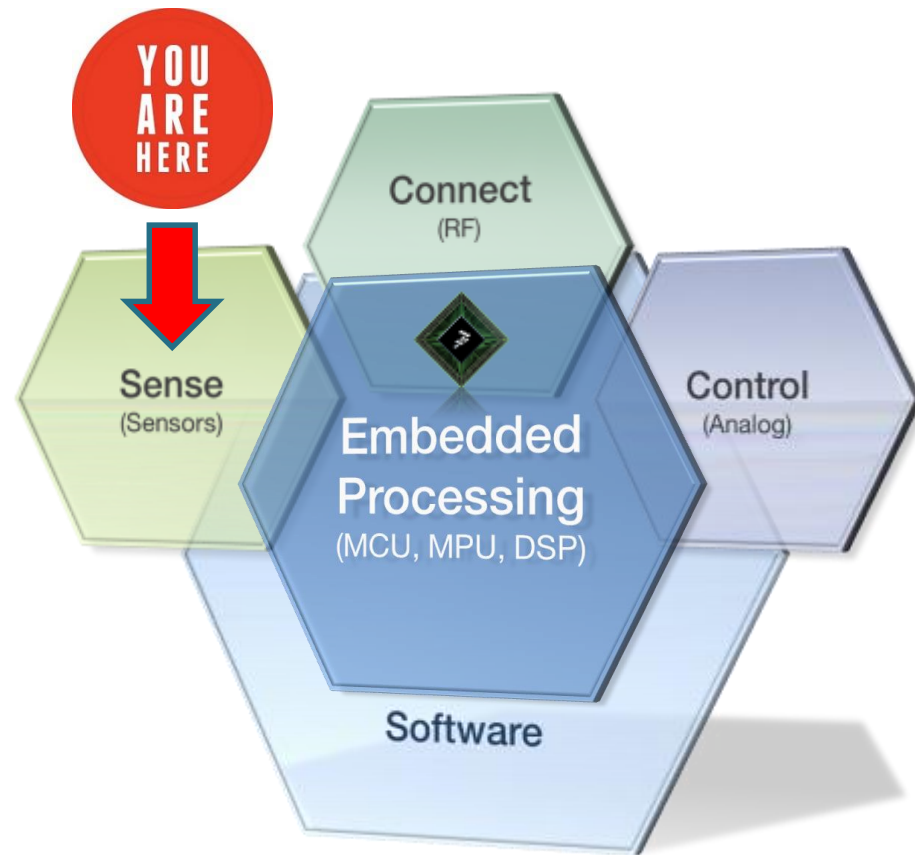
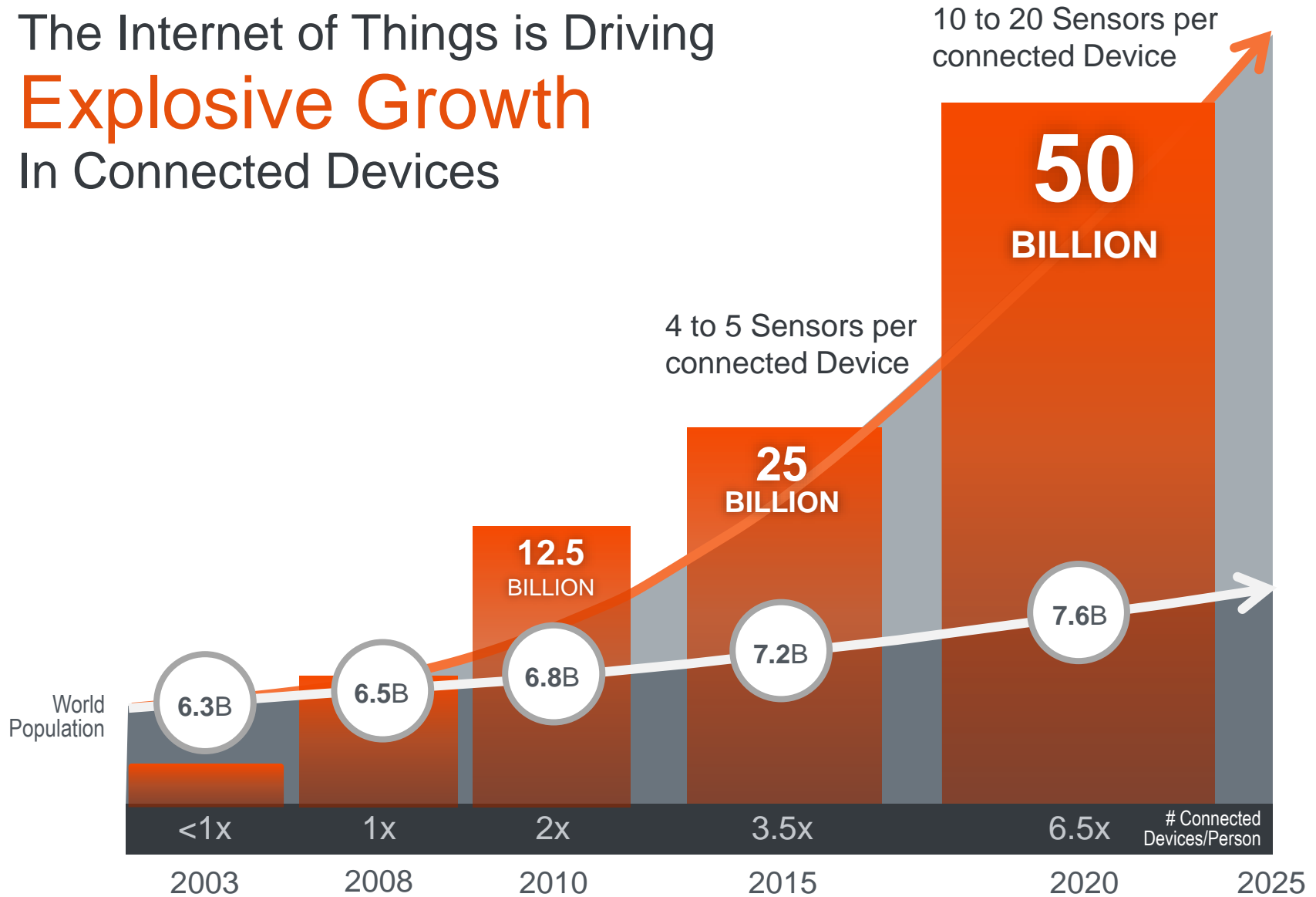# Sensors Are More Pervasive Than You Might Think – Just Check Your Pocket…

Driving Market Trends

- Proliferation of **connected intelligence**
- **Safe** and **intelligent automation**
- **Energy efficiency** and **resource conservation**
- **Quantified lifestyles**
- **Contextual awareness** and **intuitive human interface**

The Internet of Things is Driving
Explosive Growth
In Connected Devices

10 to 20 Sensors per connected Device

50 BILLION

4 to 5 Sensors per connected Device

25 BILLION

12.5 BILLION

World Population

6.3B   6.5B   6.8B   7.2B   7.6B

<1x	1x	2x	3.5x	6.5x	# Connected Devices/Person
2003	2008	2010	2015	2020	2025

Freescale's Sensor Portfolio

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<u>M</u>icro<u>E</u>lectro<u>M</u>echanical <u>S</u>ystems or MEMS
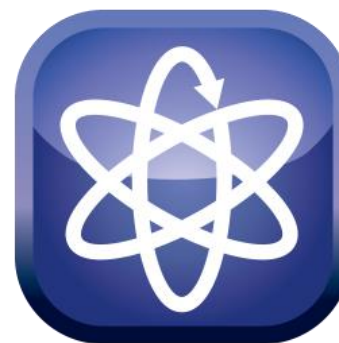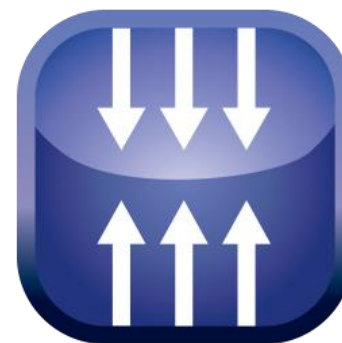
eCompass

Magnetometers
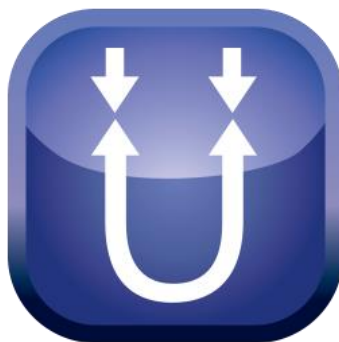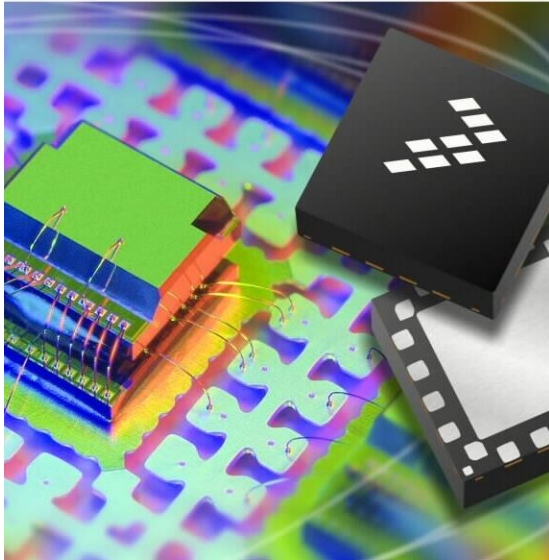
Accelerometers

Touch Sensors

Gyro

Altimeter / Pressure

Freescale's Sensor Portfolio: Accelerometers

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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 1.5 g to 250 g

- 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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Accelerometers: Key Products

	Sample	Production	Applications
MMA8451/52/53 3-axis ±2, ±4, ±8 g 10/12/14-bit **Digital I²C**			Tilt Measurement
• Embedded function and interrupt : (FIFO, High pass filter, P/L,…) • Ultra low noise (99 µg/√Hz), low TCO (0.15mg/°C) • High performance Consumer & Industrial • Down to 0.25mg/LSB sensitivity • 1.95...3.6 Volt, 3 x 3 x 1 mm QFN	Now	Now	Pedometer Power Management eCompass Asset Tracking
FXLS8471 3-axis ±2, ±4, ±8 g 14-bit **Digital SPI**	Now	Now	Activity Monitor
• Embedded functions and interrupts (all + **Vector magnitude**) • High performance industrial grade • 1.95...3.6 Volt, 3 x 3 x 1 mm QFN			Sports Watch Fleet Management Remote Controls Appliance
MMA8652/53 3-axis ±2, ±4, ±8 g 10/12-bit **Digital I²C**	Now	Now	
• Embedded functions and interrupts (8652 same as MMA8451) • Software compatible with the MMA845x family • Low cost • 1.95...3.6 Volt, 2 x 2 mm DFN			
MMA8491 3-axis Tilt Sensor 14-bit **Digital I²C + 3 Logic Out**	Now	Now	Tamper Sensor
• Ultra low power down to 400 nA/hz, • 3 logic outputs to flag tilt on the 3 axis • I²C interface to read raw acceleration data • 1.95...3.6 Volt, 3 x 3 x 1 mm DFN			Rolling Ball Switch Alarm/Security Freefall Detect Remote Control Low Power Wake-up

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Accelerometers: Key Products

	Sample	Production	Applications
FXLN8361 3-axis ±2/±8 g **Analog Out, low bandwidth**	Now	Now	Vibration Monitoring High Precision Industrial Control Sport Applications Preventive Maintenance
FXLN8362 3-axis ±8/±16 g **Analog Out, low bandwidth**	Now	Now	
FXLN8371 3-axis ±2/±8 g **Analog Out, high bandwidth**	Now	Now	
FXLN8372 3-axis ±8/±16 g **Analog Out, high bandwidth**	Now	Now	
• High bandwidth, 2.7 kHz (XY axes), 600 Hz (Z axis), • Low bandwidth, 1.1 kHz (XY axes), 600 Hz (Z axis), • Low power 200 µA in running mode, low voltage • High performance industrial grade • **1.7...3.6 Volt**, 3 x 3 x 1mm, 0.65mm pitch 12 pins QFN			

|	Sample	Production	Applications
MMA6900Q 2-axis XY, ±3.5g, 11 bits, SPI, AECQ100	Now	Now	Vehicle stability control Electronic parking brake Car alarm Trailer tilt control Absolute tilt measurement Noisy environment
MMA6901Q 2-axis XY, ±5g, 11 bits, SPI, AECQ100			
• AECQ100 qualified, -40°C;+105°C • Low pass filters for noisy environment • Low TCO over the wide temperature window. • QFN 6x6mm, 16 pins QFN			

Freescale's Sensor Portfolio Gyroscopes
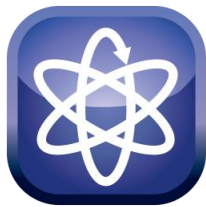
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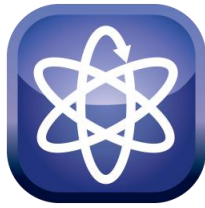
Sensor Type: Gyroscopes
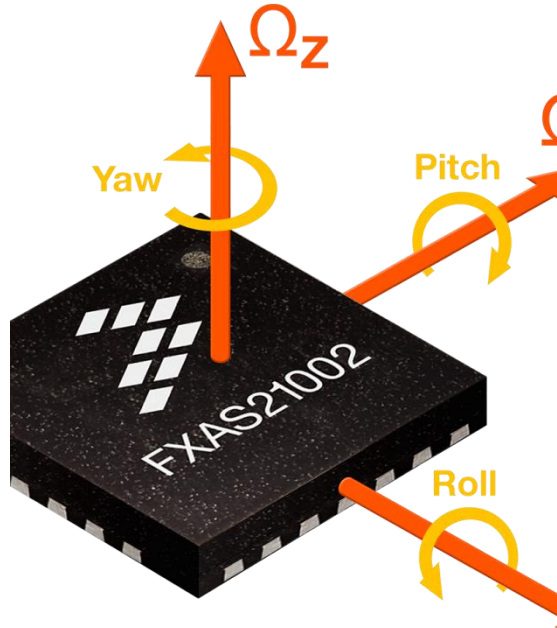
- MEMS gyroscopes reliably sense and measure the angular rate of an object, under complex and severe operating conditions

- They enable both user interface and image stabilization applications

- *When you see an accelerometer, think gyroscope too!*

Gyroscope

	Sample	Production	Applications
FXAS21002 3-axis Digital **Gyroscope**	Now	Now	Inertial Navigation Gaming Remote Control Smart Phones Stabilization
• Full scale range +/-2000°/sec • Angular speed resolution better than 0.02°/sec • Best-in-class power performance: **2.7mA (Active), 1.5mA (Ready), 2uA (Standby)** • Fast Transition from Standby to Active Mode **(50 ms)** • 1.95 V-3.6 V voltage supply, 4 x 4 x 1 mm QFN • Complete sensor fusion enablement suite			

Gyroscopes

Applications and Use Cases

- **Health and Safety**
  - Activity Monitoring, Elderly monitoring
  - Apps Based On Gesture Recognition
- **Gaming**
  - Excellent high frequency response in the presence of high g forces
  - Next Gen: 9-axis sensor fusion for rotation and precise orientation
- **Digital Cameras**
  - Improved high frequency response to orientation changes for tilt and image stabilization
- **Compass Applications**
  - Improved performance against magnetic disturbance from ferromagnetic materials
- **Internet of Things**
  - Multiple applications for accurate positioning and advanced user interface
  - Improved context awareness and control

Freescale's Sensor Portfolio Magnetometers

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Sensor Type: Magnetometers

- Magnetometers: instrument for measuring the magnitude and direction of a magnetic field
- When combined with an accelerometer to compensate the tilt, it is primarily used as an eCompass. It allows map alignment while moving

Magnetometers

	Sample	Production	Applications
MAG3110G 3-axis Digital **Magnetometer**	Now	Now	Industrial

Capable of measuring geomagnetic fields
- Wide dynamic range +/- 1000 µT (10 Gauss)
- Low power in measurement mode 8.6 µA
- ODR output data rate up to 80 Hz
- Interrupt pin trigger when new data available
- Tilt compensation and Soft/Hard Iron calibration software available
- 1.95...3.6 Volt, 2 x 2 x 0.85 mm DFN

Applications:
Industrial
Compass
Current
Sensing
Presence
Detection
Car Detect
Industrial
Safety
Magnetic
Tamper
Sports Watch
Diving Watch

6 DOF Accelerometer and Magnetometer: Key Products

	Sample	Production		Applications
FXOS8700CQ COMBO 6-axis **Magnetometer** and **Accelerometer**	Now	Now		Industrial Compass
• Capable of measuring geomagnetic fields with Tilt compensation				Current Sensing
• Wider dynamic range +/- 1200 µT				Presence Detection
• ODR up to 800 Hz by sensors, or 400 Hz in hybrid mode				Car Detect
• Embedded interrupts and pre-programmed functions				Industrial Safety
• Low power 80 µA in Hybrid mode @ 25 Hz				Magnetic Tamper
• 1.95...3.6 Volt, 3 x 3 x 1.2 mm QFN				Sports Watch
				Diving Watch

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Freescale's Sensor Portfolio
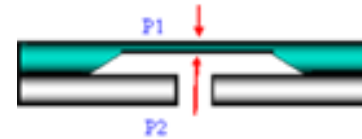# Pressure Sensors

#FTF2015
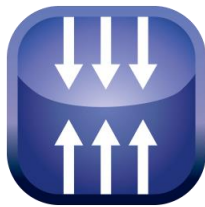
Sensor Type: Pressure Sensors

Devices are composed of single silicon, piezoresistive devices capable of monitoring processes in the industrial, medical, automotive, and avionics industries. Pressure sensors are composed of the following reference designs:

- Differential: difference in pressure between two points is measured as pressure is applied to both sides of the die/sensing element

- Gauge: bottom side is exposed to the atmosphere, while pressure is applied to top of die
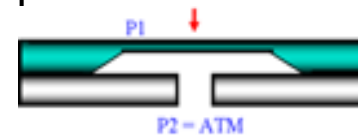
- Absolute: pressure is applied to the top of the die while the bottom of the die is a vacuum-sealed reference

Pressure Sensors: Key Products
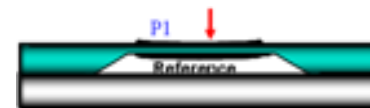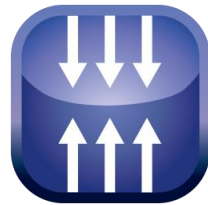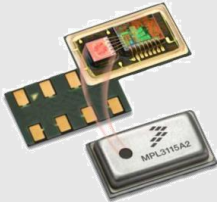
	Sample	Production	Applications
MPL3115A 20...115 kPa Digital Absolute Pressure Sensor	Now	Now	Altimeter Sport Watch Medical Monitoring Breath Analyzer Air Conditioning
• Compensated sensor • Direct readings in **Pressure**, **Altitude** and **Temperature** • **Typical 25 cm altimeter resolution** • Embedded software providing real data • Embedded interrupts and pre-programmed functions • 3 x 5 x 1 mm LGA package			
Medical Pressure Sensors			Medical
• MPXM2051xx, Blood Pressure Monitoring, 0 – 50 kPa, gauge • MPX2010xx, MPX7002xx, MPX5004xx, Respirator Machine, low pressure range family (+/-2kPa, 4kPa, 6kPa, 10kPa) • MPX5010xx, MPXM2010xx, Medical bed, Air mattress • MPX5004xx, MPXV7002xx, Sleep Aepnea	Now	Now	Blood Pressure Monitoring Respirator Machine Medical Bed Sleep Aepnea
FXTH87XXT1 Tire pressure monitoring Sensor	Now	Now	Automotive
• Absolute pressure sensor (100 to 1500kPa) • Temperature sensor • Dual axis accelerometer • Battery voltage monitoring • S08 8 bit MCU with 16kB flash, 512B RAM • TPMS firmware library • 315/434MHz RF transmitter, ASK/FSK capable • 125kHz LF communication interface • QFN 7x7x2.2 mm package			Passenger car Light Truck Trucks Motorcycle Industrial vehicles Aftermarket

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Pressure Sensor Portfolio

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

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

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

Temperature Compensated
Integrated temperature compensation
Need external circuit for amplification

MPX7 Series   **D G**
±2...±25 kPa
SOP

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

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

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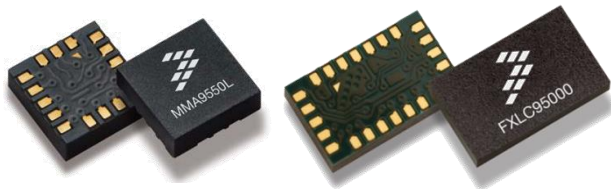
Package Examples

| SOP Basic Case | SOP Side Port | SOP Axial Port | Unibody Dual Port | SSOP Basic Case | Medical ChipPak Case | LGA 3 x 5 mm Case |
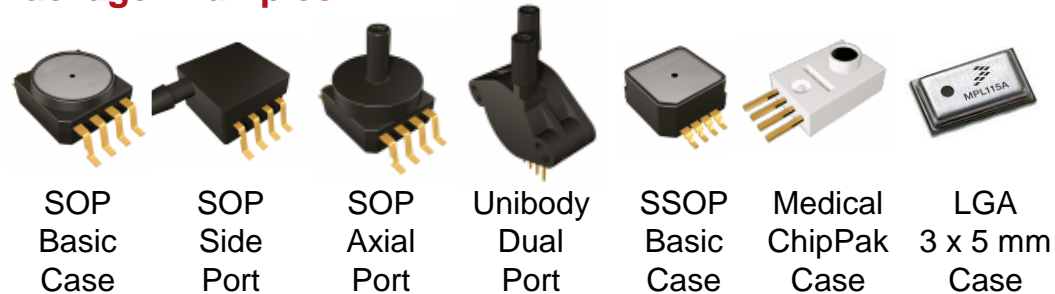
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Freescale's Sensor Portfolio Platforms

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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		
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	Now

3-Axis MEMS Accelerometer

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

Development Tools

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Sensor Fusion Development Kit

- Enables quick development and prototype of sensor fusion applications
- Includes
  - Kinetis Freedom Development board
  - Freescale Multi sensor platform
  - Link for SW download page for library
- Optional commercial support
- Part numbers
  - FRDM-SFUSION with community support (<$200)
  - FRDM-SFUSION-S with 50 hours commercial support ($10K)
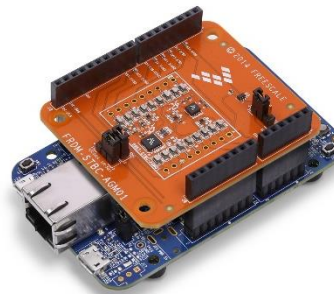
Key Development Tools

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-MULTI-B FRDM-FXS-MULT2-B	FXAS2100x, FXOS8700, MPL3115, MAG3110, MMA955x, MMA8652, FXLS8471	Now	$99.00	Sensor shield board with Bluetooth. MULT2-B updates gyro from pre-production version (FXAS21000) to released version (FXAS21002)

BRKT-STBC-AGM01   FRDM-STBC-AGM01   FRDM-K64F-AGM01   FRDM-FXS-MULT2-B
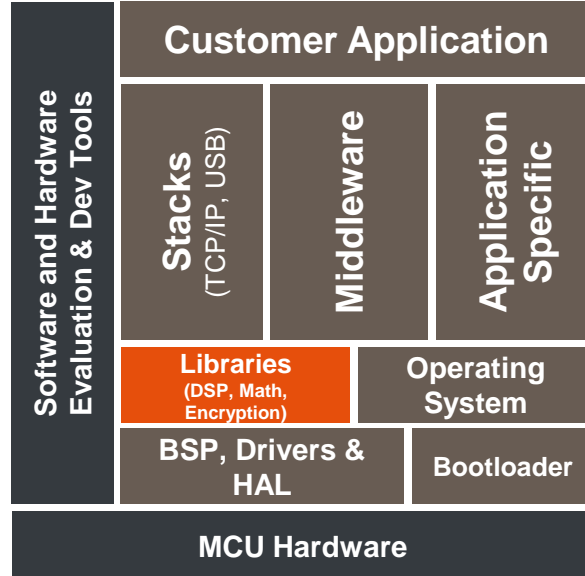
Freescale Sensor Fusion Library

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

Customer Application

Software and Hardware Evaluation & Dev Tools

Stacks (TCP/IP, USB)

Middleware

Application Specific

Libraries (DSP, Math, Encryption)

Operating System

BSP, Drivers & HAL

Bootloader

MCU Hardware

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
- Additional commercial support and services available

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Intelligent Sensor Framework 2.1 for Kinetis MCUs

ISF 2.1 for Kinetis MCUs allows you to write an embedded sensor application in less than 30 minutes without writing a single line of code using Processor Expert technology

- **Differentiating Points**
  - Sensor application code auto-generation using Processor Expert technology
  - Deployable across entire line of Freedom development platforms
  - Sensor Fusion library has been integrated as an "Orientation" sensor
  - Register Level Interface allows low-level access to sensor registers
- **Product Features**
  - Projects available for FRDM-KL25Z, FRDM-K22F and FRDM-K64F
  - Supports a broad set of Freescale sensors including MMA8652/8653, MAG3110, FXOS8700, FXAS21002, FXLS8471, MPL3115 and others
  - Example projects available for both CodeWarrior 10.6 and Kinetis Design Studio 2.0 Integrated Development Environments

Applications

- Sensor Data Analytics
- Internet of Things
- Consumer Electronics
- Wearable Electronics
- Medical Devices

Session Review and Wrap-up

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Freescale Product Programs

SafeAssure Functional Safety Program	Energy-Efficient Solutions Program	Product Longevity Program
Functional Safety Simplified	**Energy Efficient by Design**	**Supply Assurance**
The Freescale SafeAssure functional safety program is designed to help simplify the process of achieving system compliance with functional safety standards in the automotive and industrial markets	The Energy-Efficient Solutions mark highlights selected products that excel in effective implementation of energy-efficient technologies	For the automotive and medical segments, a broad range of products are made available for a minimum period of 15 years and 10 years for other market segments

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Summary

- Freescale offers a strong portfolio of diverse sensor types
- Intelligent integration with the right combination of sensor types become human machine interfaces (HMI)
- Hopefully with this knowledge, ingenuity has been seeded in a quest to find novel solutions
- Multiple sensor inputs leveraged to perform multiple application functions can solve design challenges
- Awareness of customizable software can extend sensor use cases
- Consciousness of common software platforms and common tools will shorten design time

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