NXP SENSORS SOLUTIONS

FRANÇOIS VILLENEUVE
SENSOR MARKETING

SECURE CONNECTIONS
FOR A SMARTER WORLD

AGENDA

- Product update
- Enablement
- Market engagement in :
  - Medical
  - Wearable
  - Industrial
  - Automotive

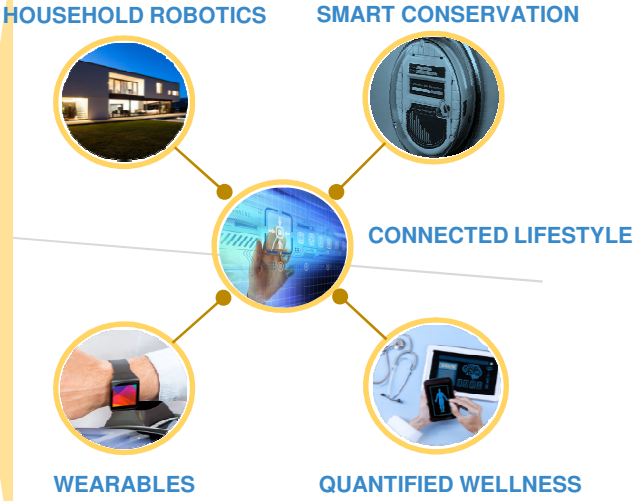
NXP Sensor Technology Supports Key Applications

Automotive

3
billion units shipped

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

Medical & Industrial



NXP Sensors

Why Customers Choose Us

- Low power
- Small size
- High performance
- Precision sense and control
- Broad sensor portfolio
- Robust and reliable designs over temperature and harsh media
- Functional safety and 30+ year auto experience
- Software and algorithm enablements
- NXP portfolio for complete system solutions
- Trusted supplier with long term product commitments

Applications

Safety Systems
- Airbag deployment sensors
- Tire pressure monitoring sensor system

Automotive Systems
- Wheel rotation speed sensing
- Power train and engine management
- Steering angle and BLDC rotor position detection

Industrial & Medical
- Industrial IoT applications
- Surveillance & monitoring
- Smart hospital
- Medical equipment

Performance Consumer
- Activity and asset tracking
- Intuitive human interface
- Quantified wellness and personal fitness
- Connected and smart home

Market Leadership

#1	**Merchant Automotive MEMS**
#4	**Inertial and Pressure MEMS sensors**

PRODUCT UPDATE

Accelerometers

- Detect acceleration resulting from tilt, motion, shock, and vibration
- Single, dual, or triple axis sensing capability with wide g ranges
- Applications
  - Activity monitors
  - Anti-tampering
  - Asset tracking
  - Crash detection
  - Human machine interface
  - Inclinometer
  - Pedometer
  - Vehicle stability
  - Vibration monitoring
  - Wake up on motion detect

Accelerometers for the IoT / Industrial

MMA845x

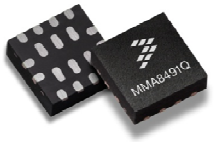
- **3 x 3 x 1 mm QFN**
- I²C output
- 0.25mg/count sensitivity
- Extended Features
  - FIFO
  - Configurable P/L trip angles
  - High Pass Filter

MMA865x

- **2 x 2 x 1 mm QFN**
- I²C output
- 1 mg/count sensitivity
- Extended Features
  - FIFO
  - Configurable P/L trip angles
  - High Pass Filter

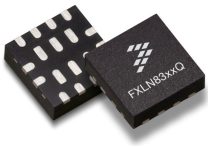
FXLS8962/72AF

- **2 x 2 x 1 mm**
- SPI/I²C/ one wire output
- Lowest Power
- Cost Efficient
- High Performance
- Rich Features
  - P/L detection
  - High Pass Filter
- 1.7V to 3.6V
- Production 2H17



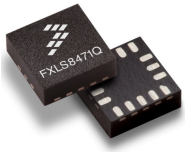
MMA849x

- **3 x 3 x 1 mm QFN**
- I²C output
- XYZ tilt detection outputs
- 700µs detection latency
- Trigger able sampling: 0.4µA/Hz



MMA83xx

- **3 x 3 x 1 mm QFN**
- Analog output
- Up to ±16g
- Up to 2.7kHz bandwidth
- 150 µg/√Hz noise density
- -40° to 105°C
- 1.7V to 3.6V



MMA8471

- **3 x 3 x 1 mm QFN**
- SPI /I²C output
- 0.25mg/count
- Extended Features
  - FIFO
  - Configurable P/L trip angles
  - High Pass Filter
  - Vector magnitude

Highest performance → Low cost → Lowest power → Lowest power → Analog Industrial → Highest Performance

Gyroscopes

- Measure angular rate of a moving object, insensitive to linear motion
- 3-axis sensing capability with configurable ranges up to 4000 dps
- Applications
  - Activity tracking
  - Gyro-compensated compass
  - Human machine interface
  - Image stabilization
  - Inertial measurement unit
  - Inertial navigation
  - **Robotics**
  - Virtual reality and augmented reality
  - Vehicle stability
  - **Sport applications**

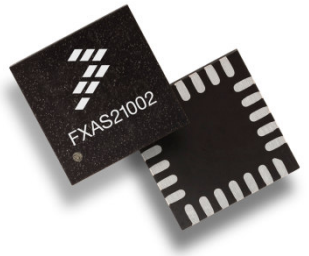
FXAS21002C

3 Axis Gyro with Market leading power consumption (over **40% better** than the leading competitors)
Part of Freescale's 9-axis Sensor Fusion Solution.

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**
- Full scale range boost function enables up to **+/-4000 dps**
- Sensitivity from **7.8 mdps/LSB to 125 mdps/LSB**
- Zero rate offset **+/- 1.5 dps in 2000dps mode**.
- Fast Transition from Standby to Active Mode **(60 ms),** from ready to Active **(5ms)**
- Expanded Output data rates (ODR) from **12.5 Hz to 800Hz**
- Programmable interrupts, Power saving features, FIFO
- 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

Gyroscopes for Robotics

- Single axis gyroscopes are often used in robotics
  - One typical use case involves a wheeled robot where translational motion is controlled with wheel encoders and turning is controlled by a z-axis gyro
  - Power consumption and package size are not critical in these applications.
  - Performance is important (Offset, Sensitivity, TCO, TCS, Noise, Linearity)

- The z-axis of FXAS21002 is significantly better than xy
  - Z-axis sensor is a higher performance design compared to the xy sensor
  - This can help us in robotics as shown on next slide

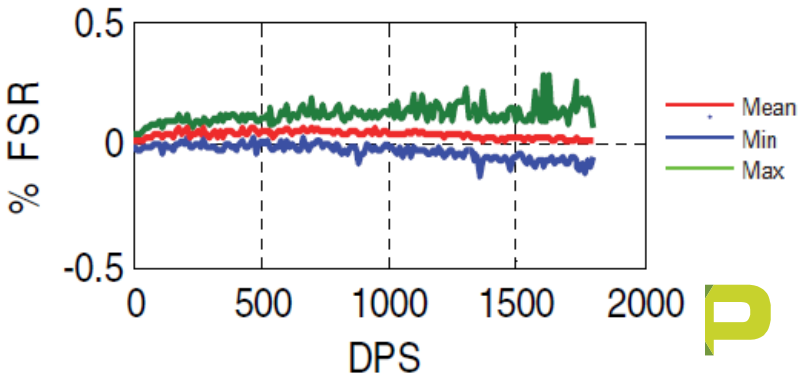
FXAS21002 Z-axis Performance

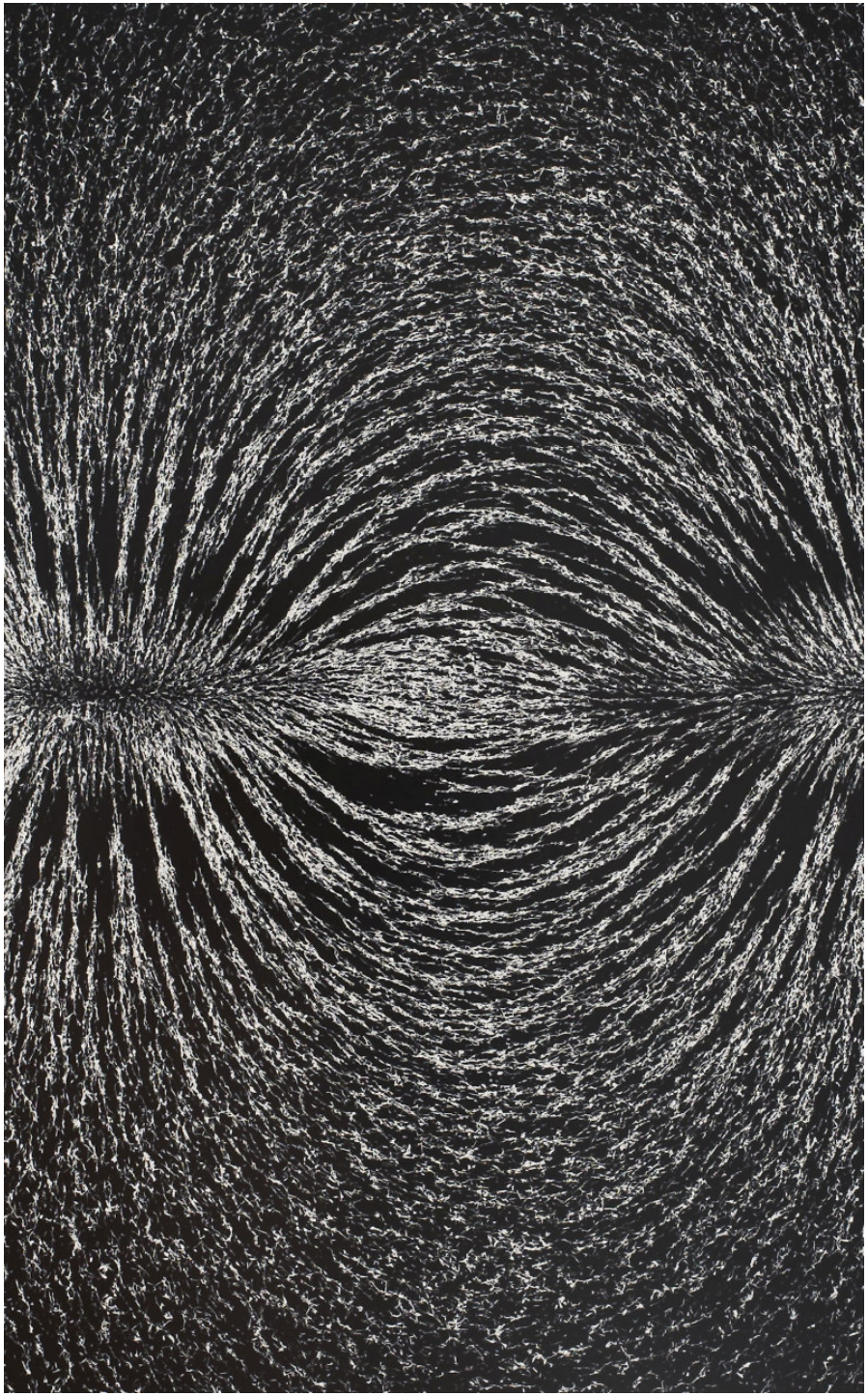
- Z-axis is better than xy axes in critical parameters such as zero-rate offset, TCO, TCS, Cross Axis Sensitivity, Noise, and Linearity (See table and graph below)
- More details provided in Comprehensive CZ Report (Request from PLM, share under NDA)

Parameter	Datasheet Typical Spec	x-axis			y-axis			z-axis		
		Mean	Sigma	μ + 1σ "Typical"	Mean	Sigma	μ + 1σ "Typical"	Mean	Sigma	μ + 1σ "Typical"
Zero-Rate Offset	± 50 LSB	4.1	11.9	± 16 LSB	-5.2	14.3	± 20 LSB	1.4	7.8	**± 9 LSB**
TCO	XY: ± 0.02 dps/°C Z: ± 0.01 dps/°C	0.004	0.01	± 0.014 dps/°C	0.001	0.011	± 0.012 dps/°C	0.003	0.007	**± 0.010 dps/°C**
TCS	XY: ± 0.08 %/°C Z: ± 0.01 %/°C	0.046	0.008	± 0.05 %/°C	-0.066	0.012	± 0.08 %/°C	0.002	0.004	**± 0.006 %/°C**
Cross-Axis Sensitivity	± 1.5%	-0.19	0.72	± 0.9%	0.6	0.78	± 1.4%	0.74	0.24	**± 1.0%**
Noise	25 mdps/√Hz	Median = 29.5 mdps/√Hz			Median = 25.1 mdps/√Hz			**Median = 16.9 mdps/√Hz**		
Bias Stability	Not specified	**Included in CZ report and can be shared under NDA**								

TCO and TCS are computed over range -40°C to 85°C
Zero-Rate Offset, Cross-Axis Sensitivity, and Noise are measured at 25°C
All parameters are Post Boardmount except Cross-Axis Sensitivity
Cross-Axis Sensitivity shown in table is worst case of 2 cross-axis values
Sample sizes are roughly 3 lots x 30 parts for all tests

Integral non-linearity (z-axis @ 25℃)





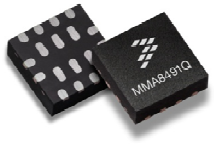
Magnetometers

- Measure direction and/or magnitude of a magnetic field
- Can be used to measure radial distances, angular positions and rates
- Applications
  - **Angular position monitor**
  - Angular rate monitor
  - Anti-tampering
  - Dosimeter
  - Electronic compass
  - Magnetic field measurements
  - Wheel speed detection

Magnetometers for the IoT

MAG3110

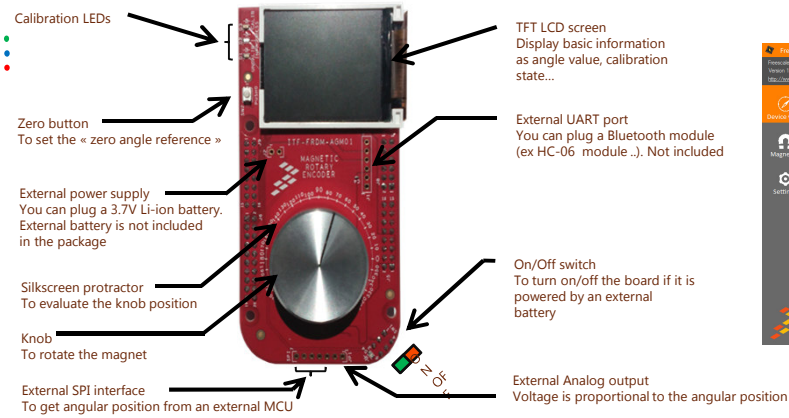
- **2 x 2 x 0.85 mm DFN**
- I²C output
- 0.10µT sensitivity
- 0.25 µT rms noise
- Magnetic calibration S/W support
- Up to 80Hz output data rate

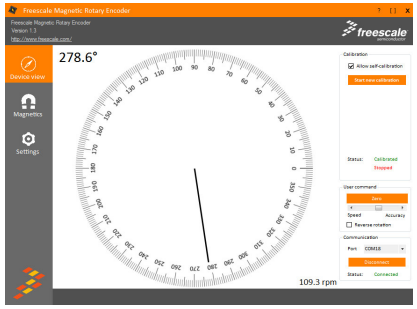


FXOS8700

- **3 x 3 x 1.2 mm QFN**
- I²C output
- Accel + Mag combo
- 1.6 to 800Hz output data rate
- Low power: 80µA @25 Hz
- Magnetic calibration S/W support
- Vector magnitude trigger

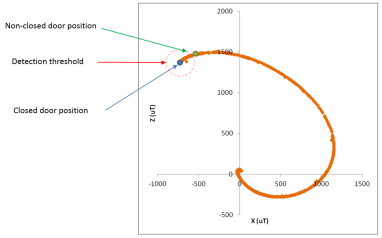
- Electronic compass (open source calibration library)
- Rotary encoder (open source library + Reference design)

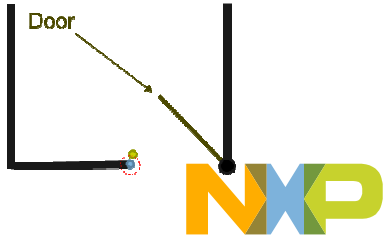


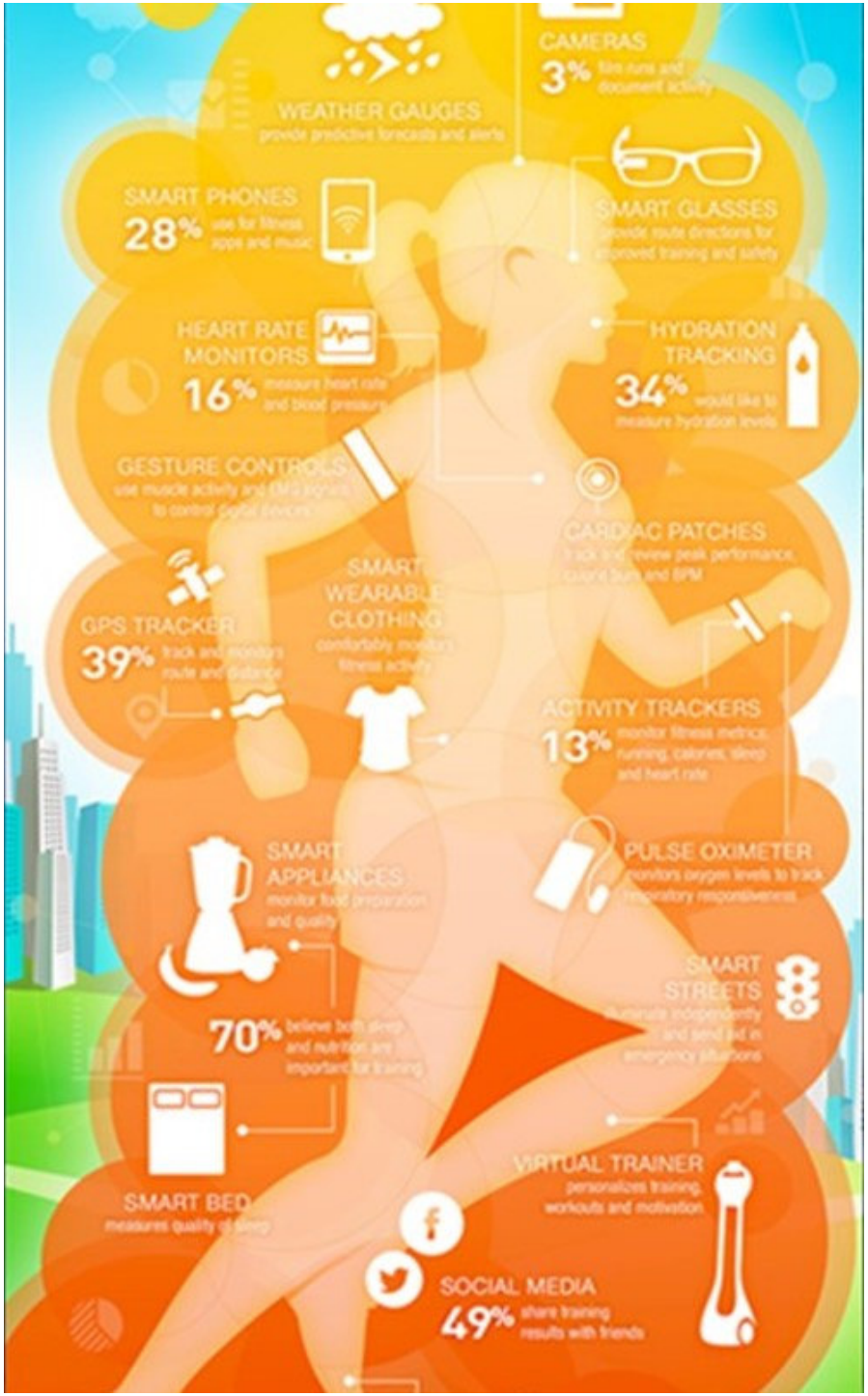


RD-KL46Z-MRE

- Door state detection (open source library + Reference design based on RD-KL25-AGPM01)







Processor Integrated Smart Sensors

- Provide algorithmic processing integrated with sensing
  - Pedometer algorithm embedded
  - System power management
  - Partitioning real time algorithms from user interface software
  - Smaller footprint
  - Inclinometer calibration library
- Applications
  - Watches
  - Patient monitors
  - Ear buds
  - Inclinometer

MMA955x Sensor Products

Products	MMA9550	MMA9551	MMA9553	MMA9555	MMA9559	FXLC95000 CL
Silicon	Accel + MCU	Accel + MCU	Accel + MCU	**Accel + MCU**	Accel + MCU	Accel + MCU
Package	3x3 LGA	3x3 LGA	3x3 LGA	**3x3 LGA**	3x3 LGA	3x5 LGA
User Flash	6.5 KBytes	4.5 KBytes	1 KBytes	**-**	14 Kbytes	128 Kbytes
User RAM	576 Bytes	452 Bytes	0.2 KBytes	**-**	1.5 Kbytes	16 Kbytes
Preloaded Functions	Infrastructure only functions	Infrastructure + Gestures	Infrastructure + Pedometer	**Orientation + Pedometer**	Lightweight Infrastructure	Open Platform / Sensor Hub

- MMA955xL devices are pre-loaded with application at the factory
- User can add custom software using the remaining portion of Flash memory
  - MMA9555: Full turnkey Pedometer Software and Orientation Detection
  - MMA9553: Full turnkey Pedometer Software with 1KBytes for other functions
  - MMA9559: Lightweight infrastructure for customer designed Pedometer
- FXCL95000CL new inclinometer library

Pedometer Benchmarking

MMA9555 Pedometer Compared against high quality pedometers in the market
No addition processing needed

Actual	MMA9555L	Product N	Product i
50 steps	51	47	49
100 steps	101	95	97
200 steps	201	199	192
400 steps	401	401	402
Held flat	101	95	98
Held 90	101	96	98
Held 180	101	95	97
Var angle	101	95	98
Up stairs (27)	28	27	28
Dwn stairs (27)	27	21	27
Running (.5mi)	893	836	865
Distance	0.493	n/a	0.54

Competitive Pedometer Sensor

Comparable to high quality pedometer end products in the market.

Drop in a pedometer to your application today.

Pressure sensors

- Measure absolute pressure or differential pressure
- Gauge pressure sensor is a differential
- Applications
  - Barometric pressure measurement
  - Altitude measurement
  - Liquid level
  - **Inhalers**
  - CPAP system
  - Gaz flow measurement
  - **Gaz pressure measurement**
  - Tyre pressure monitoring

FXPQ3115BVT1: Biomedical Precision pressure sensor

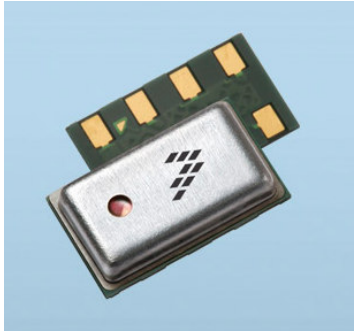
Differentiating Points

- **Biomedically approved gel coating**
- Internally compensated, software is not needed
- Direct reading pressure in Pascals
- On-board intelligence

Product Features

- 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)
- I²C digital interface
- Interrupt driven events (window for breath in /out detect)
- 32-Sample FIFO

EV Samples: Now Upon Request
Production: Q4, 2016



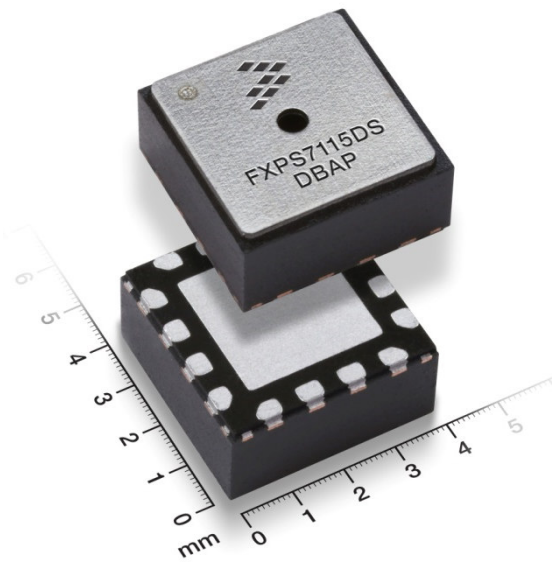
Typical Applications

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

Package

- 3 x 5 x 1.1 mm LGA

Automotive Pressure Sensors – Products in Development



QFN FAM Pressure Sensor Package

- **dBAP –** Digital Barometric Air Pressure
  - Engine Management BAP application
  - Engine Management MAP application
  - Engine Management Turbo application
  - Engine Management LPG applications
  - Comfort seating
  - Vacuum Brake booster
  - Water proof sensor (under validation)
  - Gaz compatible sensor (under validation) for metering
- **PSAT –** Pressure Sensor Satellite
  - Airbag Satellite sensor, Multi protocol

Digital Barometric Air Pressure Sensor

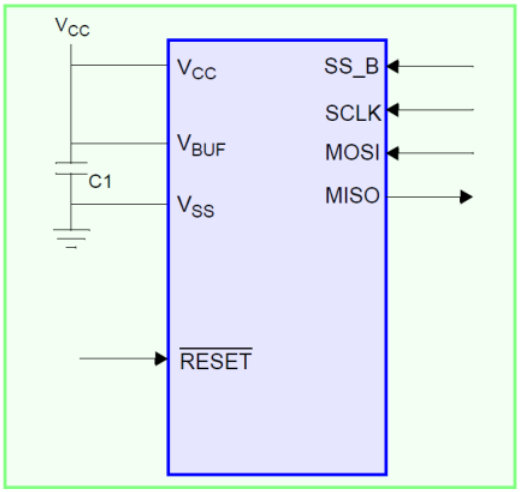
- **Product features**
  - Pressure Ranges
    - 15kPa to 115kPa, 40kPa to 115kPa
    - 15Kpa to 550Kpa high pressure
    - Custom pressure range on demand
  - Maximum voltage range: -0.3V – 5.5V
  - Temperature Range: -40C to 130C
  - Accuracy: ±1.5% over full Pressure and Temperature Range
  - Digital Signal Processing
  - Standby current of 0.5mA
  - Low Power Sleep Mode with Wake on Select

- **32-Bit SPI Compatible Interface**
- **I2C Compatible Interface**
- **Analog Output**

- **Package: 4 mm x 4 mm x 1.98 mm Cavity QFN**
- **Automotive Qualified (AEC-Q100)**

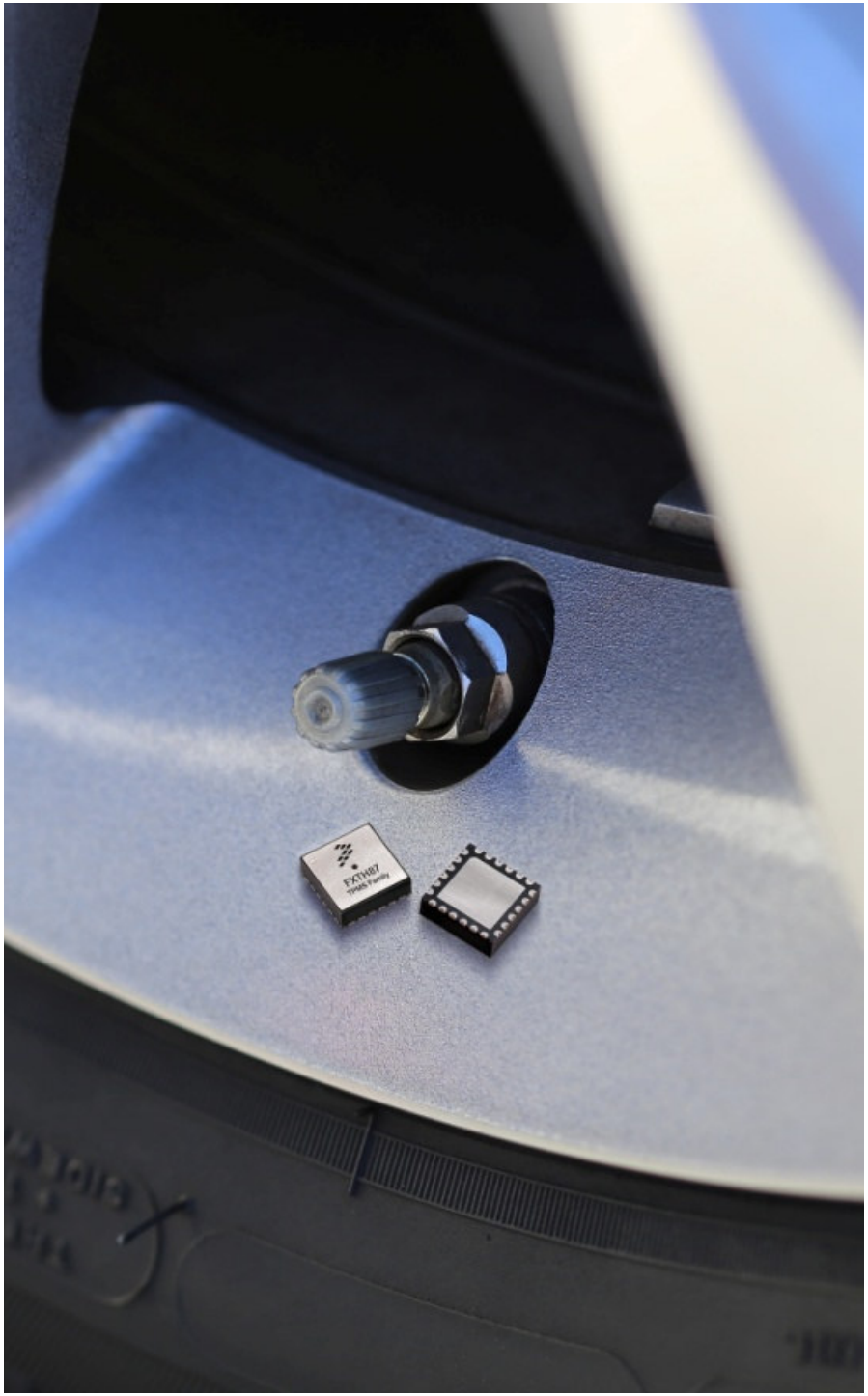
Low pressure : EV Samples: Now Upon Request
March PPAP Q2017
High pressure : samples Q4 2016, end of 2017
mass production

SPI Application Diagram



Portfolio Part Numbers

Logical Name	Part Numbers	Description
aMAP	FXPS7015A4T1	15-115 kPa, Analog Output
dBAP	FXPS7115DS4T1	40-115 kPa, BAP Product Digital SPI Output
dBAP	FXPS7115DI4T1	40-115 kPa, BAP Product Digital I2C Output
dBAP	FXPS7015DS4T1	15-115 kPa, BAP Product Digital SPI Output
dBAP	FXPS7015DI4T1	15-115 kPa, BAP Product Digital I2C Output
aMap	FXPS7250A4T1	up to 250 kPa, analog
aMap	FXPS7400A4T1	up to 400 kPa, analog
aMap	FXPS7550A4T1	up to 550 kPa, analog



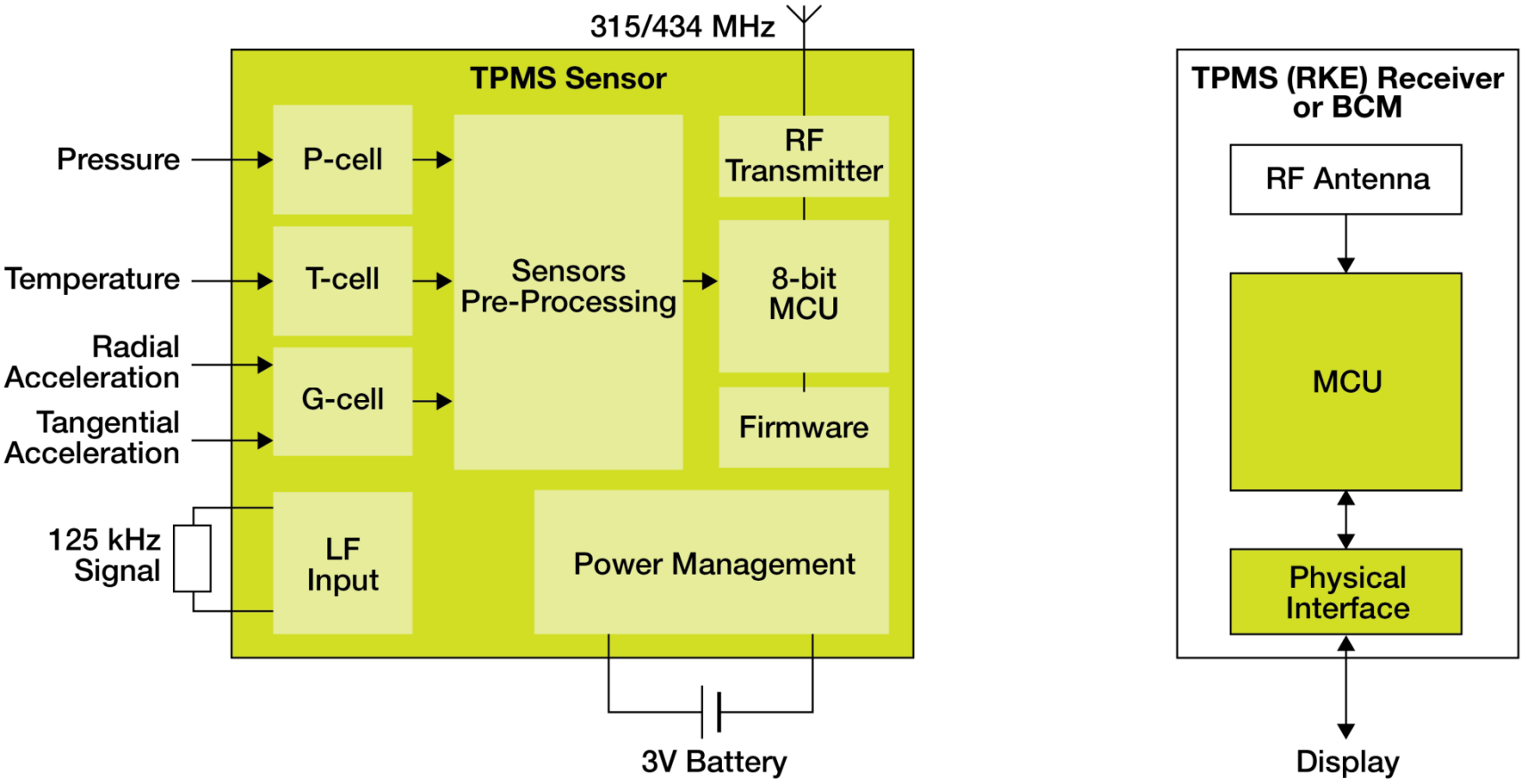
TPMS Solutions

- **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 **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: enables better **tire management**

NXP TPMS are used by the following brands*

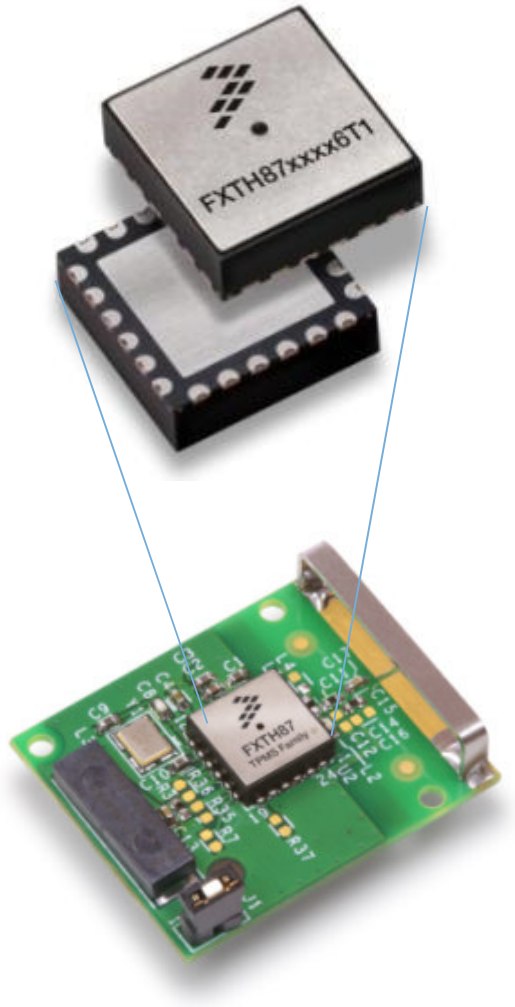
*Not an exhaustive list – Status May 2015

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 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



FXTH8705 and FXTH8709 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 /+ 400g	±6 g		
FXTH870511**D**T1	100-450	±7 kPa	XZ	-210g/+300g	±5 g	-80g/+90g	±4 g
FXTH870902**D**T1	100-900	±10 kPa	Z	-270g/+400g	±6 g		
FXTH870911**D**T1	100-900	±10 kPa	XZ	-210g/+300g	±5 g	-80g/+90g	±4 g
FXTH870912**D**T1	100-900	±10 kPa	XZ	-270g/+400g 85g sensitivity	±6 g	-80g/+90g	±4 g
Precision Tolerances (Accelerometer)							
FXTH870502**6**T1	100-450	±7 kPa	Z	-270g/+400g	±3 g		
FXTH870511**6**T1	100-450	±7 kPa	XZ	-210g /+300g	±3 g	-80g/+90g	±3 g
FXTH870902**6**T1	100-900	±10 kPa	Z	-270g/+400g	±3 g		
FXTH870911**6**T1	100-900	±10 kPa	XZ	-210g/+300g	±3 g	-80g/+90g	±3 g
FXTH870912**6**T1	100-900	±10 kPa	XZ	-270g/+400g	±3 g	-80g/+90g	±3 g

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

Ordering Information: FXTH8715xx 1500kPa Portfolio

Part Number	Pressure Range (kPa)	Pressure accuracy (0°C ≤ T_A ≤ 70°C)	Temperature Range (°C)	Temperature accuracy (0°C ≤ T_A ≤ 70°C)	Z-axis Accelerometer Range (g)	Z-axis Accel accuracy (0°C ≤ T_A ≤ 70°C)	X-axis Accelerometer Range (g)	X-axis Accel accuracy (0°C ≤ T_A ≤ 70°C)
Standard Tolerances								
FXTH871502**D**T1	100-1500	±20 kPa	-40 to 125	±3°C	-270 to 400	±6g	--	--
FXTH871511**D**T1					-210 to 300	±5g	-80 to 90	±4g
Precision Tolerances								
FXTH871502**6**T1	100-1500	±20 kPa	-40 to 125	±3°C	-270 to 400	±3g	--	--
FXTH871511**6**T1					-210 to 300	±3g	-80 to 90	±3g
High Precision Tolerances								
FXTH871502**7**T1	100-1500	+/- 17 kPa	-40 to 125	±3°C	-270 to 400	±3g	--	--
FXTH871511**7**T1					-210 to 300	±3g	-80 to 90	±3g

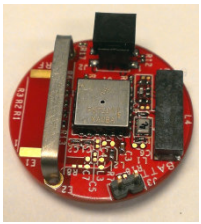
- All the products above are released for production.
- Fact sheet available on the web. Datasheets available through customer registration

FXTH87 Eco-System

Evaluation Boards (*) **:** Emulate typical customer wheel unit module containing FXTH87 sensor, LF coil, RF antenna, battery, and all passives

- TPMS870911-434 (900 kPa – 315 MHz)
- TPMS870911-315 (900 kPa – 434 MHz)
- TPMS871511-315 (1500 kPa – 315 MHz)
- TPMS871511-434 (1500 kPa – 434 MHz)

NEW !



Application Notes / Reference Manuals for FXTH87 TPMS family

- **FXTH87EDRM:** FXTH87 Family Evaluation Design Reference Manual
- **FXTH87XX22FWUG:** FXTH87xx22 Embedded Firmware User Guide
- **AN4277:** Interfacing to NXP's FXTH87xx In-Flash Firmware Routines Using C-language Constructors
- **AN4391:** Using the FXTH87 Family of LF Receivers for TPMS Application
- **AN1902:** Assembly Guidelines for QFN and DFN Packages to cover the QFN7x7mm packages
- **AN5136:** Applying the Kinetis MKW01 as the receiver for the FXTH87 Tire Pressure Monitoring Sensor.

General support topics:

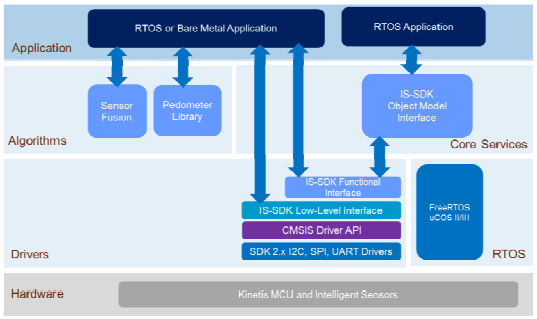
- **Assistance with implementing a wireless (LF/RF) boot-loader** to re-program customer application memory space.
- **Assistance with selectively increasing customer application memory space** with the FXTH8715117T1 and FXTH8715027T1.
- **Assistance with tuning RF matching network** to suit customer specific antenna choices

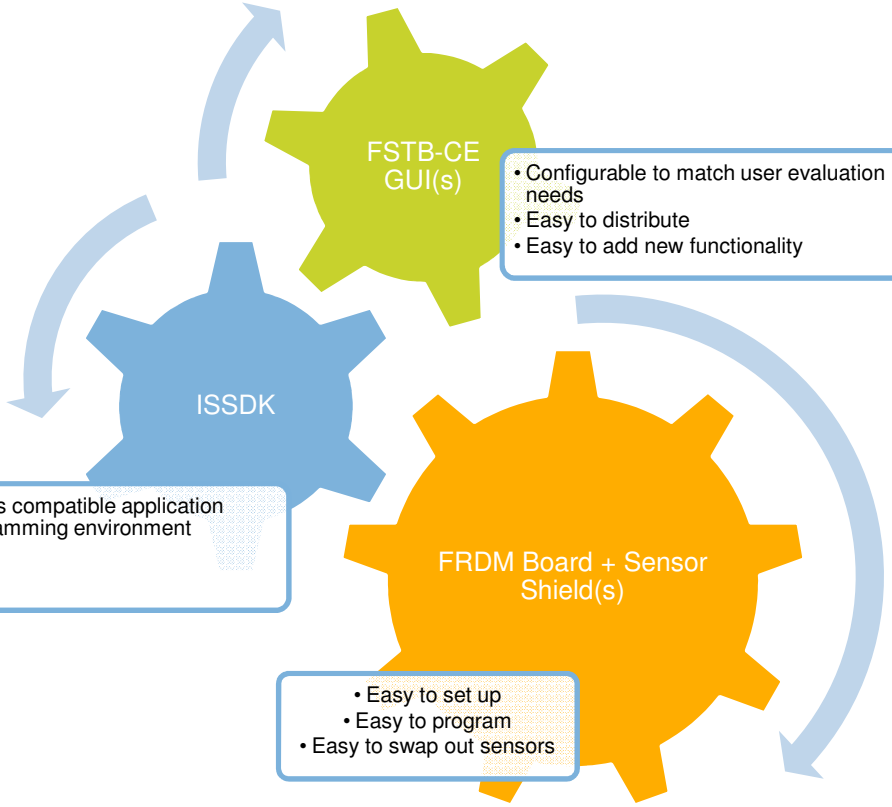
For further information please refer to: http://www.nxp.com/products/interface-and-connectivity/interface-and-system-management/advanced-automotive-safety/tire-pressure-monitoring-sensors:TPMS?cof=0&am=0

(*) = Contact NXP Sales Representative for availability.

ENABLEMENT

The Sensor Evaluation Ecosystem in a Nutshell





- Configurable to match user evaluation needs
- Easy to distribute
- Easy to add new functionality

- Kinetis compatible application programming environment

- Easy to set up
- Easy to program
- Easy to swap out sensors

Freedom Sensor Toolbox Ecosystem Overview

Evaluation

- Kits - FRDM board + shield
- Example Applications
- Freedom Sensor Toolbox GUI

Prototyping

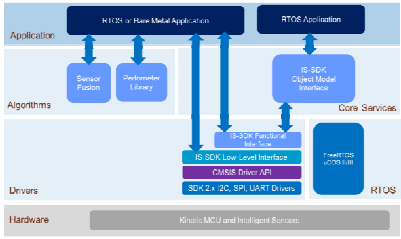
- Breakout boards
- ISSDK + Kinetis SDK + Driver Examples + Application Examples
- Algorithms + Examples

Product

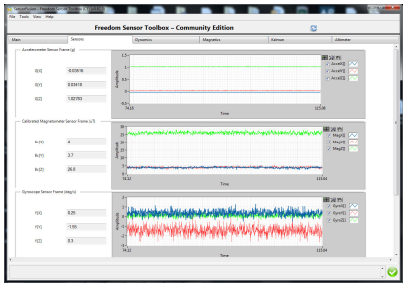
- Customer Hardware
- Derived Applications & Algorithms
- ISSDK/ Kinetis SDK

Freedom Sensor Toolbox

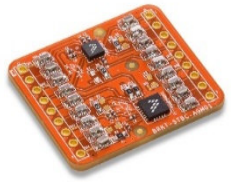
- Your complete ecosystem for product development with NXP's sensors.
- Includes demo kit, Shield development board and breakout board.
- Each board is enabled by ISF and Freedom Sensor Toolbox-Community Edition (STB-CE).
- Powerful and convenient development & evaluation platform across NXP's broad sensor portfolio.
  - 'Out of the box' demonstration enabled by demo kits and STB-CE. (plug and play)
  - Sensor evaluation enabled by Shield boards, compatible FRDM boards, ISSDK and STB-CE.
  - Development of sensor applications enabled by Kinetis MCU's and ISSDK.
  - Prototyping your sensor designs enabled by breakout boards, ISSDK and STB-CE.
- Full enablement from a demo to sensor prototyping (to design win ☺)



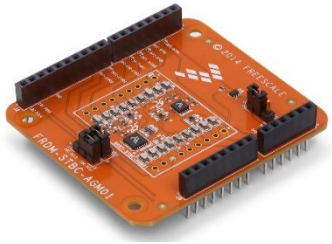
ISSDK



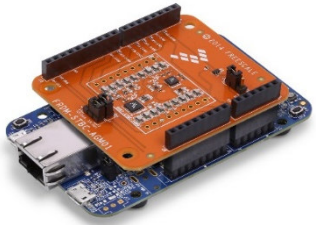
STB-CE



Breakout Board



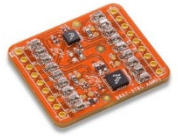
Shield Board



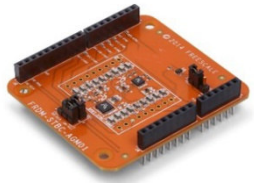
Demo KIT(Shield + MCU)

Sensor Toolbox Board Repository

Sensor Toolbox Name	Board Type	Board Name
Sensor Toolbox for 9-Axis Solution	Demo Kits	FRDM-K22F-AGM01
		FRDM-K64F-AGM01
	Shield Board	FRDM-STBC-AGM01
	Breakout Board	BRKT-STBC-AGM01
Sensor Toolbox for FXLC95000CL Intelligent Motion Sensor	Demo Kit	FRDM-K22F-SA9500
	Shield Board	FRDM-STBC-SA9500
	Breakout Board	BRKT-STBC-SA9500
Sensor Toolbox for FXLS8471Q 3-Axis linear Accelerometer	Demo Kit	FRDMKL25-A8471
	Shield Board	FRDMSTBC-A8471
	Breakout Board	BRKTSTBC-A8471
Sensor Toolbox for MMA8491Q 3-Axis Digital Accelerometer	Demo Kit	FRDMKL25-A8491
	Shield Board	FRDMSTBC-A8491
	Breakout Boards	BRKTSTBC-A8491
Sensor Toolbox for MPL3115A2 Pressure Sensor/ Altimeter	Demo Kit	FRDMKL25-P3115
	Shield Board	FRDMSTBC-P3115
	Breakout Boards	BRKTSTBC-P3115
Sensor Toolbox for MPXV5004DP Analog Pressure Sensor	Shield Board	FRDMSTBCDP5004
	Breakout Boards	BRKTSTBCDP5004
Sensor Expansion board for multiple sensors	Shield Board	FRDM-FXS-MULT2-B



Breakout Board



Shield Board

KIT(Shield + MCU)

Integrated with MCU

- Freedom Sensor Toolbox Shields are compatible with Kinetis and LPC Arduino development boards
- Development with Kinetis SDK 2.0 and LPC Open SDK

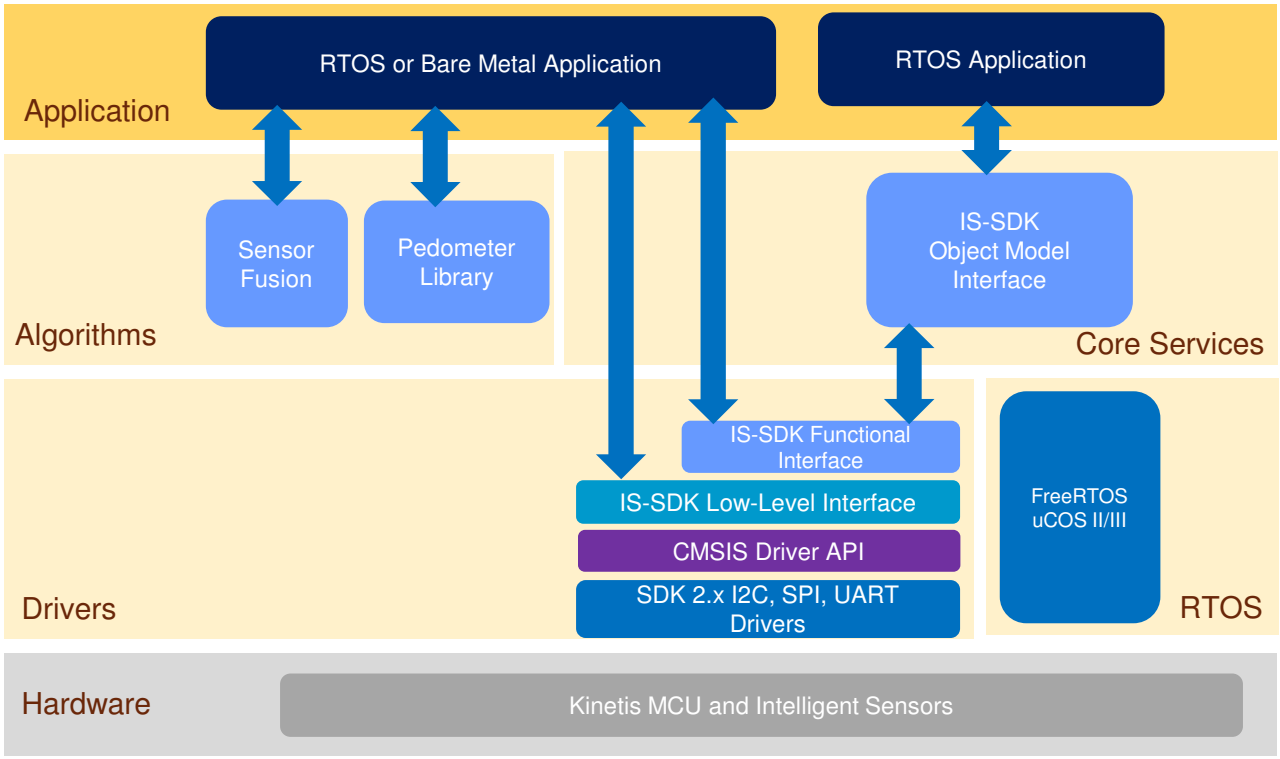
Slide 34

MD4 Would like to replace this picture with LPC54102 board and our FRDM-STBC-AGM01 shield. I think this is a Bosch shield.
Munsinger David-B46330; 12/04/2016

IoT Sensing SDK (ISSDK)

- Leverage Kinetis SDK 2.0
  - Drivers, Tools, Release Infrastructure
- Leverage Open APIs based on CMSIS Driver standards (ARM) for portability
- Focus on the Rapid Prototyping and Small Profile Production Applications
- A La Carte Model for Software Delivery and Usage
  - From Register Level to Object Oriented APIs
- Supports Bare Metal development and all RTOS supported by SDK 2.0
- Supports all IDEs supported by SDK 2.0
- Targets all Kinetis MCUs supported by SDK 2.0

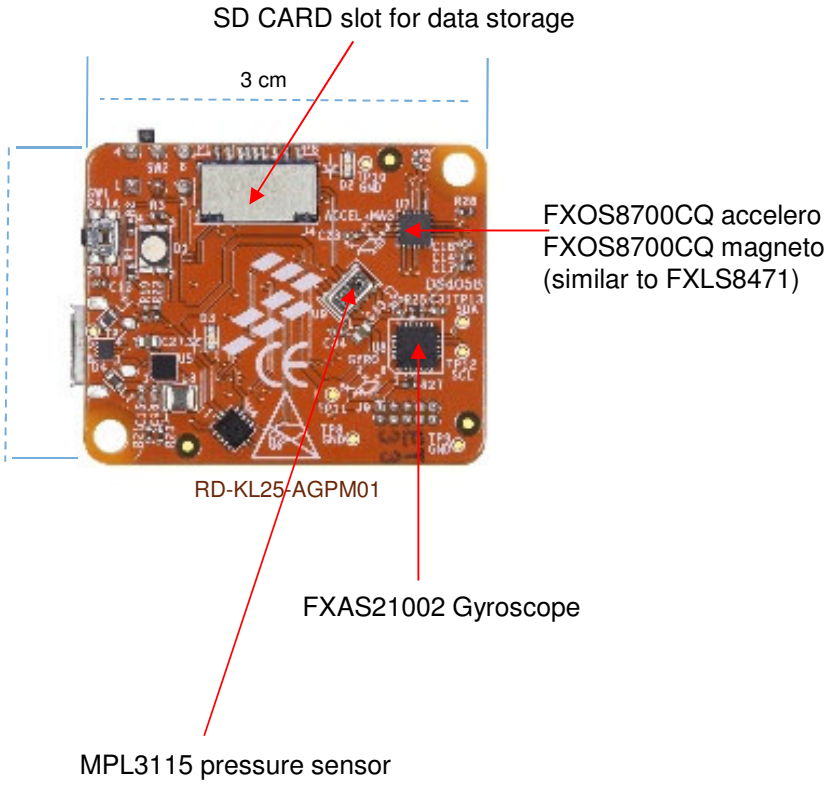
ISSDK Architecture

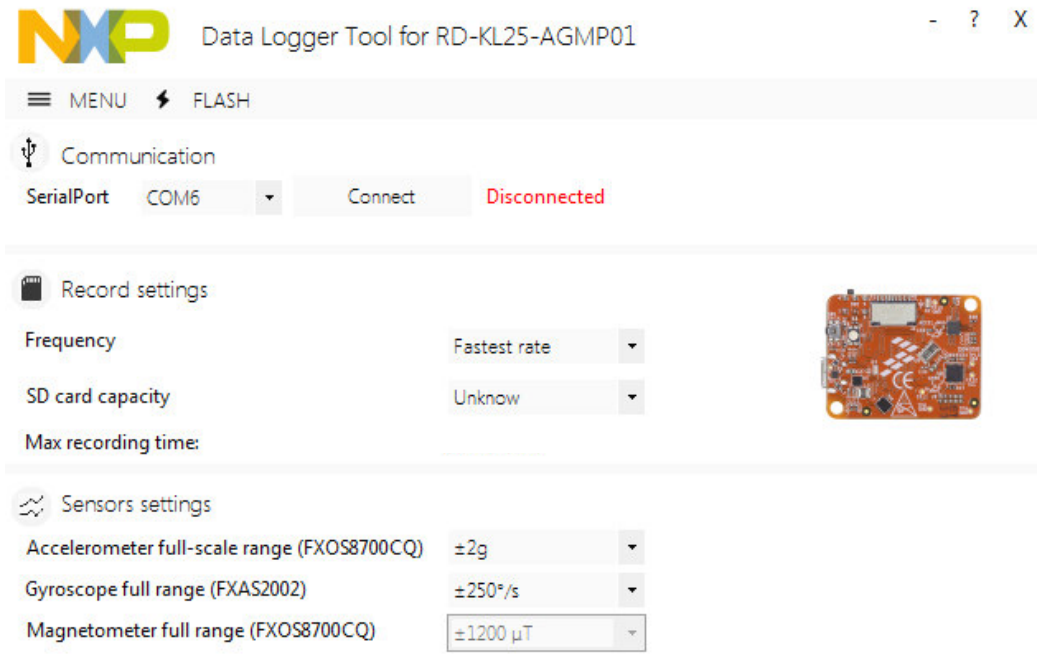


Supported Sensors

Sensor Part Number	Sensor Type	Interface
FXAS21002	Gyroscope	SPI I2C
FXLC95000	Intelligent Accelerometer	SPI I2C
FXLN83XX	Analog Accelerometer	via KSDK ADC and GPIO
FXLS8471	Digital Accelerometer	SPI I2C
FXLS8952	Digital Accelerometer	I2C
FXOS8700	Digital Accelerometer and Magnetometer	SPI I2C
MAG 3110	Digital Magnetometer	I2C
MMA845X	Digital Accelerometer	I2C
MMA8491	Digital Accelerometer	I2C
MMA865X	Digital Accelerometer	I2C
MMA9553	Intelligent Accelerometer	I2C
MPL3115	Digital Pressure	I2C

Data logger board for quick proof of concept validation

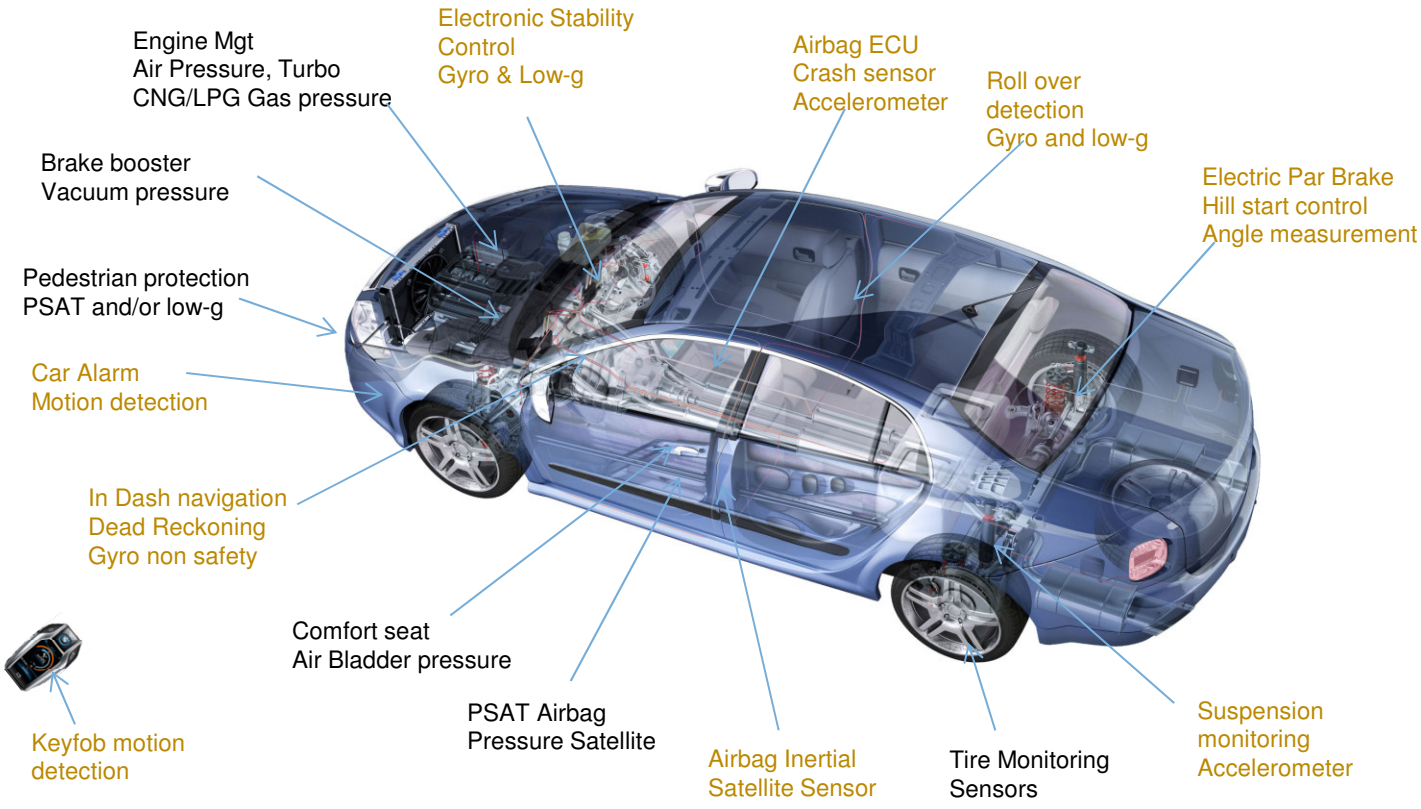




Datalogger GUI

MARKET ENGAGEMENT

NXP MEMS Sensors in Automotive Applications



Patient Activity Monitor

- **Critical parameters**
  - Active power
    - Battery life in use
  - Standby power
    - Auto shutoff when not in use
  - Size
    - Fit into a small space
  - Full scale range and bandwidth
    - Motion profile

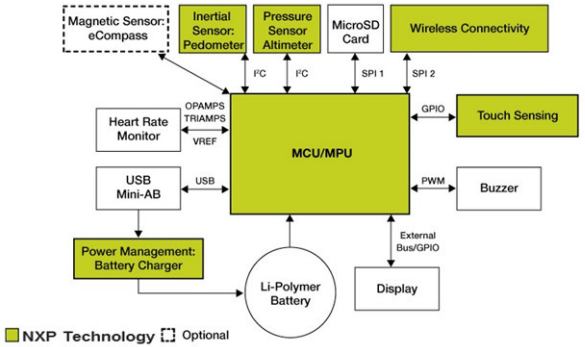
Beyond a fitness band…

Ulcer Sensor promotes Correct motion

Knee brace provides activity monitoring

Motion algorithms that sense when a person is craving nicotine to deliver medication

- **Enabled by accelerometers, gyroscopes, magnetic sensors and pressure sensors**
  - MMA9553L is the intelligent pedometer platform
  - FXLC95000 as a sensor hub and datalogger
  - MMA8652 small 2x2 mm 3-axis accelerometer with low power, good dynamic performance and fast turn on time
  - MAG3110 and MMA8491 combined in the FXOS8700, for orientation, motion, vibration, shock, fall, g-force, altitude changes etc. are present
  - FXAS21002 gyroscope provides the stability needed for drift free readings
  - MPL3115A digital pressure sensor for altimetry

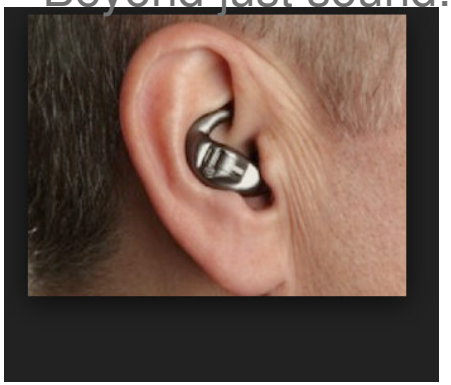


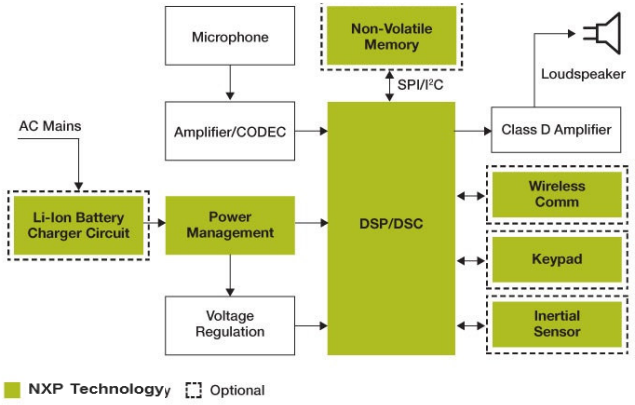
Hearing Aid/Earphones

- **Critical parameters:**
  - Tap detect to turn on/off the hearing aid
  - Low power consumption in active mode
    - Long battery life
  - Small size
  - Quick capture of the pulse (10-40ms)
  - Accurate pulse detection block
  - Full scale range
  - HPF enabled (remove static g)

- **Enabled by accelerometer**
  - MMA8652 small 2x2 mm 3-axis accelerometer with low power and fast turn on time
  - MMA8451 high performance 3-axis accelerometer with low noise, 14-bit resolution, and TCO performance or
  - MMA9555 3-axis accelerometer and intelligent pedometer sensor

Beyond just sound…



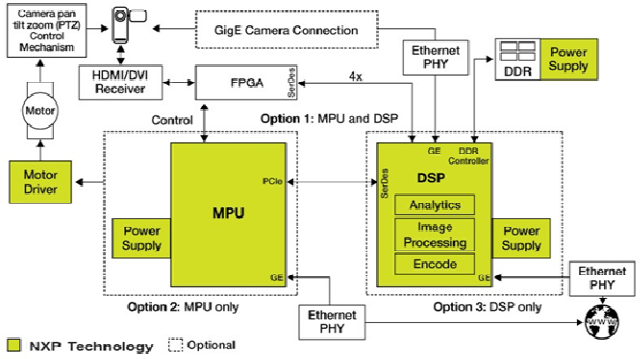


Security Cameras

- **Critical parameters:**
  - Accurate compass heading
  - Yaw detection
  - Accurate magnetic calibration
  - Tilt compensation
  - Offset change with temperature
  - Sensitivity change with temperature

- **Enabled by accelerometer + magnetometer**
  - FXOS8700, for orientation, motion, vibration, shock, fall, g-force, altitude changes etc. are present

Beyond stationary security…



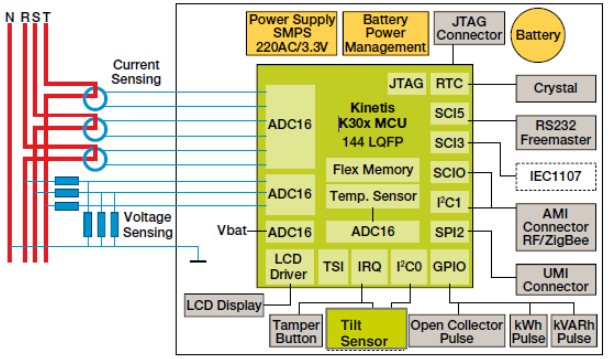
Smart Metering and Tamper Detection

- **Critical parameters**
  - Standby power (minimum power draw from the meter)
  - Low active power for always on application
  - Zero-g offset change with temperature
  - Preconfigured tilt detection trigger

- **Enabled by accelerometers**
  - FXLC95000 accelerometer/32-bit processor for vibration detection
  - MMA8491 accelerometer for tilt detection

Beyond digital metering…

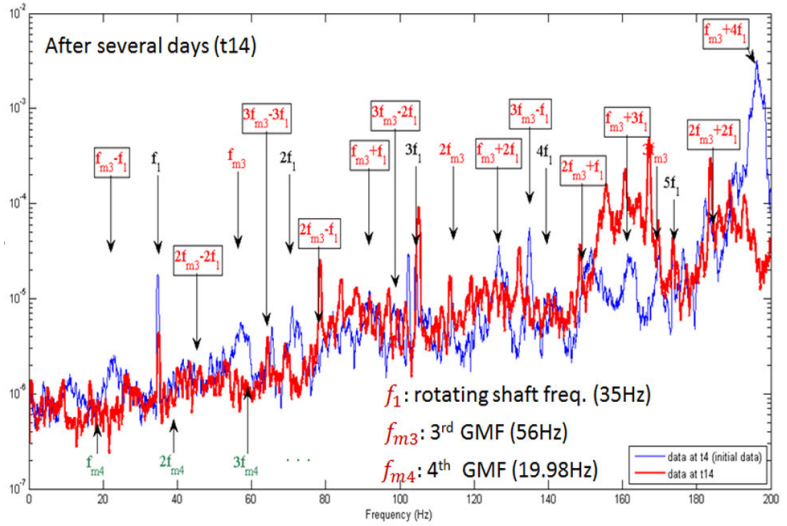
Electronic Tamper Detection Smart Meter Reference Design

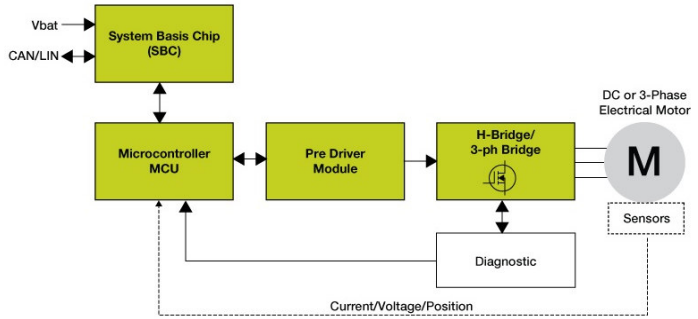


Motor Monitoring

- **Critical parameters**
  - High bandwidth
  - Non-linearity
  - Noise
  - Active power(battery powered)

- **Enabled by accelerometers and FFT algorithms (in Sensor Fusion library)**
  - FXLC95000 accelerometer/32-bit processor for vibration detection
  - MMA8491 3 axis accelerometer
  - FFT algorithms (in Sensor Fusion library)





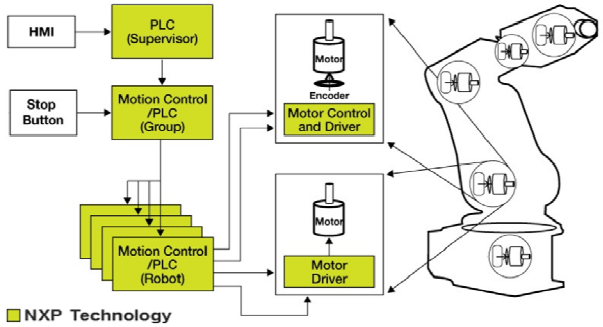
Door/Window Open Detection

- **Critical parameters:**
  - Magnitude of magnetic field
  - Magnetic calibration
  - Standby power
    - Battery enabled
  - Offset change with temperature
- **Enabled by accelerometers and magnetic sensors**
  - MMA8451 high performance 3-axis accelerometer with low noise, 14-bit resolution, and TCO performance.
  - MAG3110 magnetometer or FXOS8700, for orientation, motion, vibration, shock, fall, g-force, altitude changes

Robotics

- **Critical parameters:**
  - Angle random walk and bias stability
    - 3-axis angular rate detection
  - Sensitivity
  - Temperature variation of offset(Z axis)
  - Temperature variation of sensitivity

- **Enabled by accelerometers, gyroscopes, and magnetic sensors**
  - MMA8451 High performance 3-axis accelerometer with low noise, 14-bit resolution, and TCO performance.
  - FXAS21002 angular acceleration detection with the ability to determine yaw, pitch and roll that complements NXP's broader sensor portfolio.
  - MAG3110 magnetometer or FXOS8700, for orientation, motion, vibration, shock, fall, g-force, altitude changes

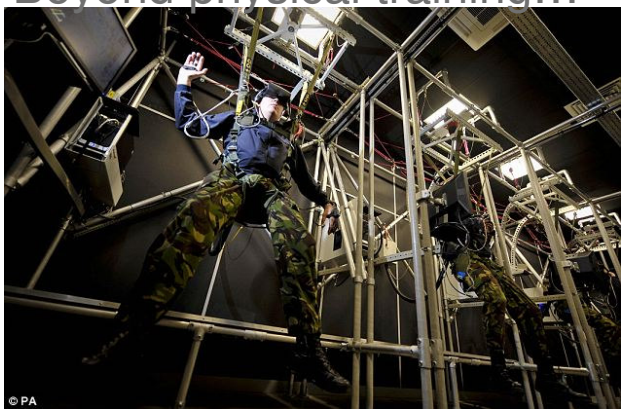


Virtual Reality for First Responder Training

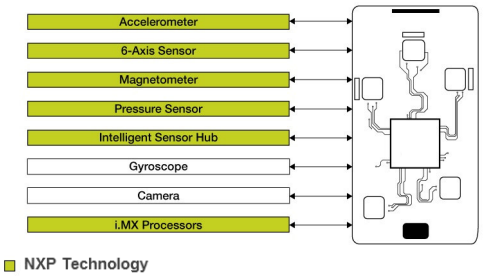
- **Critical Parameters:**
  - Accurate head orientation(Static)
    - Sensor Fusion
  - Linear displacement
    - Gyro offset correction
  - Zero-g offset
  - Phase/group delay

- **Enabled by accelerometers, gyroscopes, and magnetic sensors**
  - MMA8451 high performance 3-axis accelerometer with low noise, 14-bit resolution, and TCO performance.
  - MAG3110 magnetometer or FXOS8700, for orientation, motion, vibration, shock, fall, g-force, altitude changes
  - FXAS21002 angular acceleration detection with the ability to determine yaw, pitch and roll that complements NXP's broader sensor portfolio.

Beyond physical training…



Military and First Responder Simulation Training



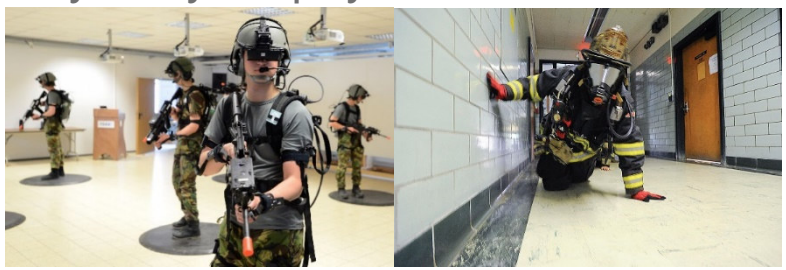
Augmented Reality for First Responders “Bionic Vision”

(10-Axis Inertial Solution)

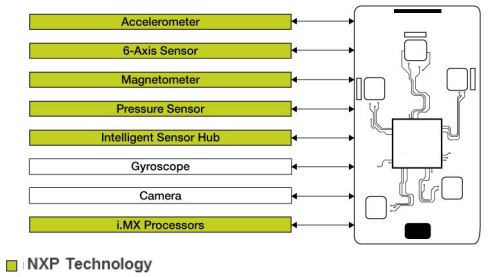
- **Critical parameters:**
  - Accurate Sensor Fusion algorithm
  - Noise(resolution)
  - Angle random walk, velocity random walk and bias stability
  - Offset correction for gyroscope, accelerometer
  - Accurate magnetic calibration
  - Accurate altitude detection using digital pressure sensor
  - Accurate roll, pitch and yaw under linear acceleration and magnetic interference
  - Inter axis alignment

- **Enabled by accelerometers, gyroscopes, and magnetic sensors**
  - MMA8451 high performance 3-axis accelerometer with low noise, 14-bit resolution, and TCO performance.
  - MAG3110 magnetometer or FXOS8700, for orientation, motion, vibration, shock, fall, g-force, altitude changes
  - FXAS21002 angular acceleration detection with the ability to determine yaw, pitch and roll that complements NXP's broader sensor portfolio.
  - MPL3115A digital pressure sensor for altimetry

Beyond your physical limitations…



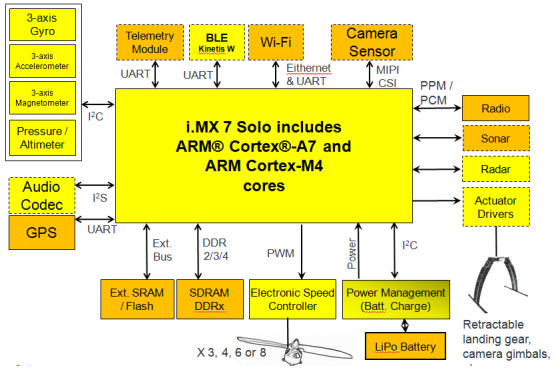
Enabling technology to provide firefighters, police and military with data about their surroundings, including oxygen levels, temperatures, possible contaminants, exit paths, and even video of the other members in their team.



Unmanned Vehicles/Drones (10-Axis Solution)

- **Critical parameters:**
  - Accurate Sensor Fusion algorithm
  - Minimum ARW and offset in gyroscope
  - Offset correction for accelerometer
  - Accurate magnetic calibration
  - Accurate roll, pitch and yaw under linear acceleration and magnetic interference

- **Enabled by accelerometers, gyroscopes, and magnetic sensors**
  - MMA8451 high performance 3-axis accelerometer with low noise, 14-bit resolution, and TCO performance.
  - MAG3110 magnetometer or FXOS8700, for orientation, motion, vibration, shock, fall, g-force, altitude changes
  - FXAS21002 angular acceleration detection with the ability to determine yaw, pitch and roll that complements NXP's broader sensor portfolio.
  - MPL3115A digital pressure sensor for altimetry



Smart Inhalers: Pressure Sensor

Use case

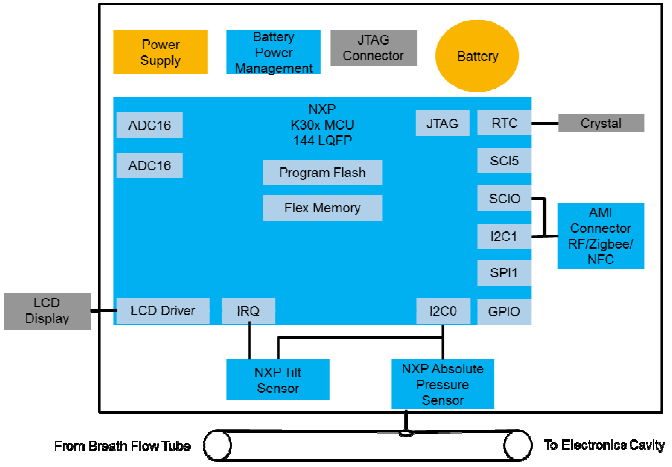
- Detect when a patient has activated their inhaler
- Allow the patient to easily measure the right amount of medication to be inhaled
- Eliminate the requirement to align breathing with the release of medication.

Critical factors

- Biomedical compatible components
- Pressure range
- Critical temperature range
- Accuracy
- Repeatability
- Active power consumption
- ODR (100 Hz)
- Sensitivity

Enabled by pressure sensors and tiltmeters

- FXPQ3115BV
- MMA8491



Sleep Apnea: Pressure Sensor

Use case

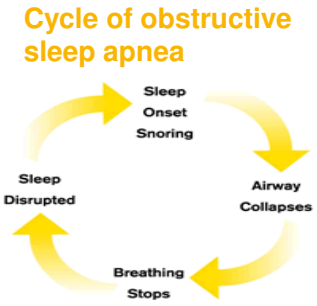
- Positive airway pressure (PAP) is a method of respiratory ventilation used primarily in the treatment of sleep apnea.
- Barometric measurement is also critical in some applications to avoid altitude deviation.

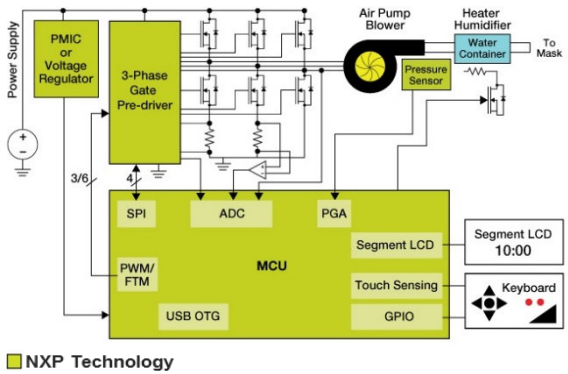
Critical factors

- Media compatibility
- Biomedical compatible component (in contact with body)
- Gauge
- Sensitivity
- Accuracy
- Pressure range
- ODR(~100 Hz)

Enabled by pressure sensors

- MPXV5004GC6T1 and MPXV7002DP for air pressure management
- MPL3115A2 or FXPQ3115BV for barometric measurement





Blood Pressure Package: Pressure Sensor

Use case

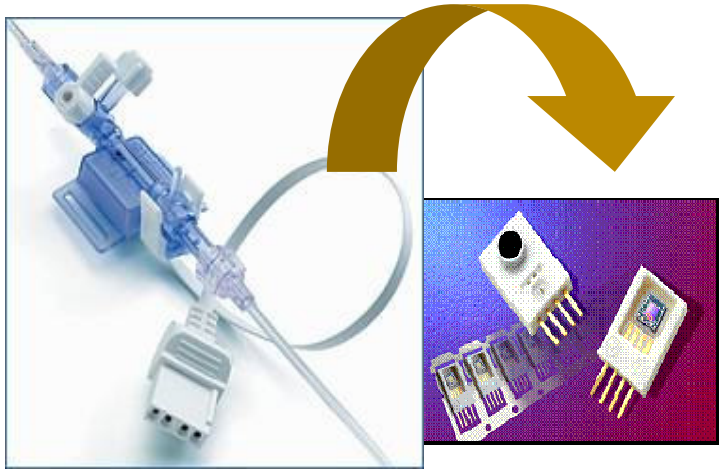
- A standard invasive blood pressure monitoring kit - sterile, single-use kits that relay blood pressure information from a pressure monitoring catheter to a patient monitoring system.

Critical factors

- Integrated temperature compensation and calibration
- Ratiometric to supply voltage
- Polysulfone case material (medical, class V approved)

Enabled by pressure sensors

- MPX2300DT1



Blood Pressure Monitors: Pressure Sensor

Critical factors:

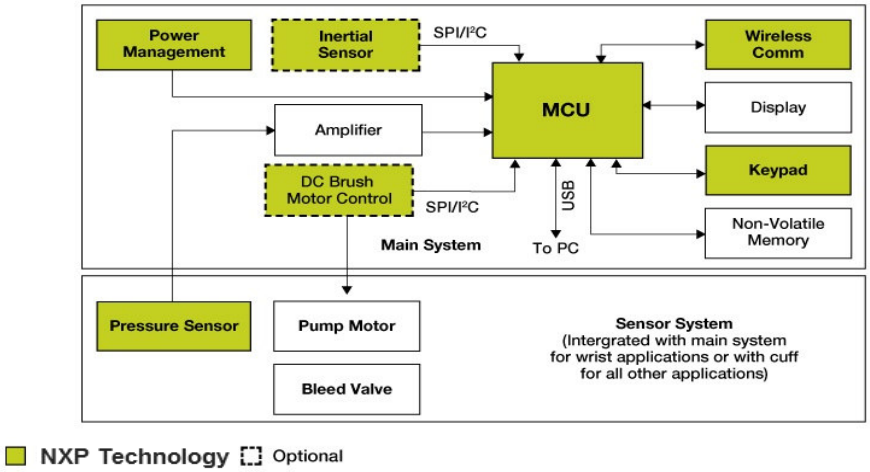
- Accurate tilt detection
  - Linearity
  - Offset change with temperature
  - Embedded tilt detection blocks

Pressure sensor parameters:

- Pressure range
- Accuracy
- Power consumption
- Gauged sensor
- Sensitivity

Enabled by pressure sensors

- MPXV5050
- MPXM2053GS
- MMA8491



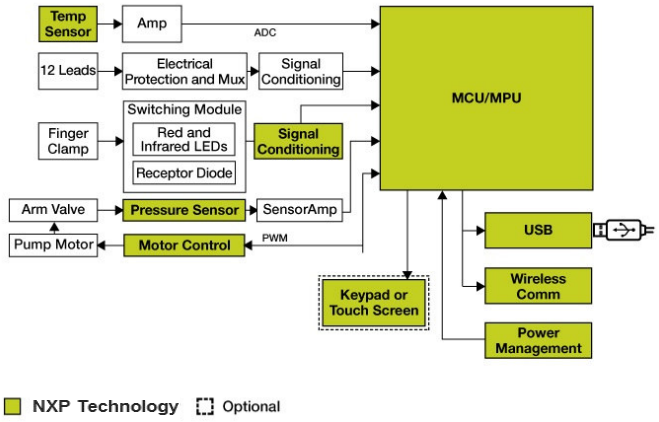
Patient Monitoring: Pressure Sensor

Critical factors:

- Pressure range
- Temperature compensated over 0°C to +85
- Linearity
- Full scale span
- Offset
- Sensitivity
- Gauge ported

Enabled by pressure sensors:

- Blood pressure monitor module:
- MPXM2051 enables measurement
- MPXM2053 provides protection
- CO2 module:
- MPXV2010 for flow measurement
- MPL3115A2 for barometric measurement



Medical Beds

Use case

- Prevention of necrosis of the muscle, pressure sores or ulceration

Critical factors

- Pressure range

Enabled by pressure sensors

- MPX5010 DP
- MPXM2010GS

Negative Pressure Wound Management: Pressure Sensor

Use case:

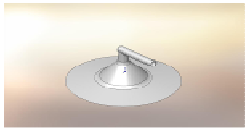
- Negative pressure wound management or closed wound suction is a non-invasive treatment by which controlled localized negative pressure is delivered to a wide variety of acute, sub-acute, and chronic wounds.

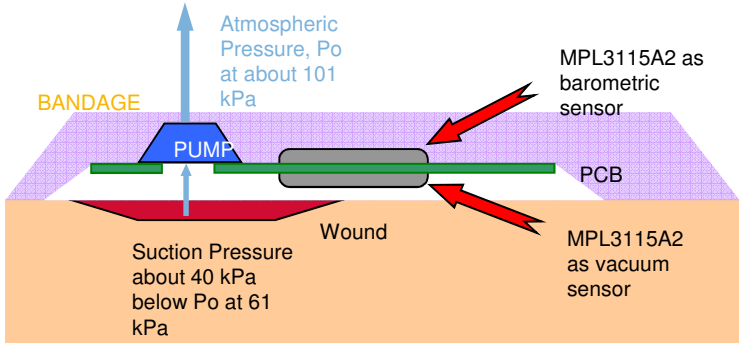
Critical factors:

- Media compatibility
- Biomedical compatible components (in contact with body)
- Disposable
- Gauge/absolute
- Sensitivity
- Accuracy
- Pressure range

Enabled by pressure sensors

- MPL3115A2 or FXPQ3115BV acting as a vacuum sensor or for barometric measurement
- MPXM2053GS, MPXV5100GC6U





Smart Utility Meter: Pressure Sensor + Accelerometer

Use case

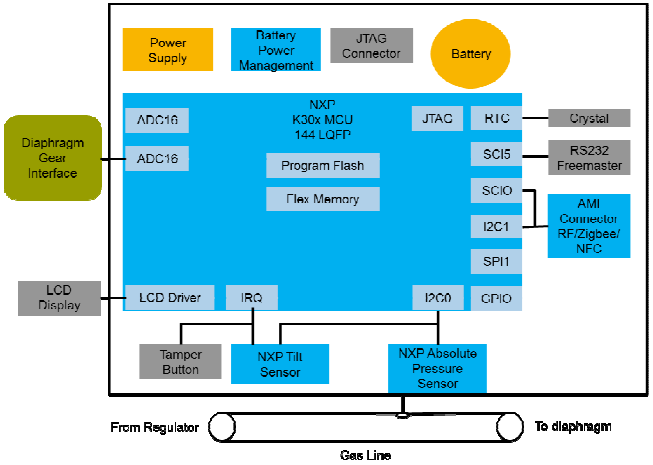
- Absolute pressure sensors are able to derive the standard volume at the meter and wirelessly transmit the reading to the utility company.

Critical factors

- Media compatibility(LPG, natural gas)
- Absolute
- Sensitivity
- Accuracy
- Pressure range
- Temperature range
- Power consumption (standby and active)

Enabled by pressure sensors and accelerometers

- MPVZ4006 media resistant differential flow sensor
- MPL3115A2 barometric measurement for standard volume delivered to customer
- MMA8491 for tamper detection



HVAC: Pressure Sensor

Use case

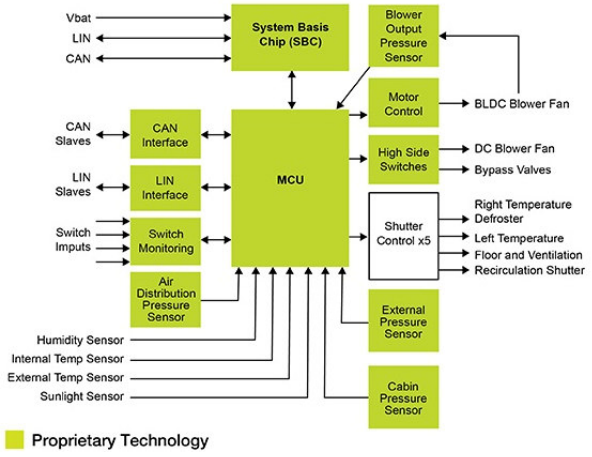
- A differential sensor can be used as a system monitoring device to regulate fan speed, fan performance and filter life. The device is typically located inside the duct work, filter housing or fan housing. Two pressures sources are measured as for example pre-filter and post-filter to determine filter performance.

Critical factors

- Pressure range
- Resolution
- Repeatability
- Gauge/differential
- Sensitivity

Enabled by pressure sensors

- MPX2010 high performance
- MPXV5004
- MPX10



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