



May 2011

## Freescale Sensors Update

# Freescale Offers a Full Portfolio of MEMS & Sensors

eCompass



Magnetometers



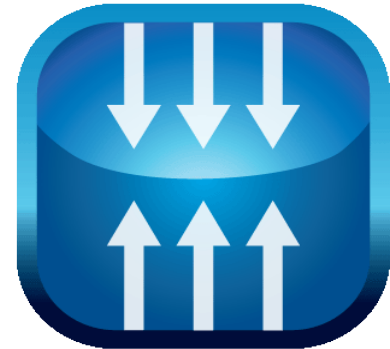
Accelerometers



Touch Sensors



Gyro



Altimeter / Pressure

# Freescale announcing Xtrinsic brand in 2010

## A New Era of Sensing Experience

- ▶ Sensing continues to get more complicated
- ▶ New levels of sensing innovation are required
- ▶ Freescale offers greater levels of **sensing context and intelligence** for richer applications
  - It's no longer about what each sensor does, but how you unlock the **potential of sensors**
  - It's more than a sensor translating a signal
- ▶ Freescale's strong foundation of sensing technology is optimally combined with other system building blocks, such as connectivity and logic for **integrated interpretation** and **decision making**
- ▶ We've put our expertise at your fingertips so it's **easy to tailor** our sensing capabilities for exactly what you *want* and *need* the application to be



**With Freescale Xtrinsic solutions,  
the world makes sense.**



# Freescale Product Longevity Program

- ▶ The embedded market needs **long-term product support**
- ▶ Freescale has a longstanding track record of **providing long-term production support** for our products
- ▶ Freescale is pleased to introduce a **formal product longevity program** for the market segments we serve
  - For the automotive and medical segments, Freescale will make a broad range of program devices available for a minimum of **15 years**
  - For all other market segments in which Freescale participates, Freescale will make a broad range of devices available for a minimum of **10 years**
  - **Life cycles** begin at the time of launch
- ▶ A list of participating **Freescale products** is available at:  
[www.freescale.com/productlongevity](http://www.freescale.com/productlongevity)



**Sensors in this program: MMA7660, MMA845x, MPR121, MPR031, MPL115A...**



# Freescale reaches 1 billion sensor units since June 2010



## Freescale Sensor Timeline

### One Billion and Counting ...

From 1980 to 2009 Freescale has designed, produced and shipped a wide world of innovative sensing solutions

**1980**  
We manufacture our first uncompensated pressure sensor



**1982**  
Pressure sensors are supplied for manifold absolute pressure (MAP) to significantly reduce exhaust emissions and fuel consumption



**1991**  
Bipolar integrated pressure sensor production begins

**1992 to present**  
Dedicated supplier to the critical care medical market through shipment of over 60 million units for the invasive blood pressure market



**2002**  
Began providing pressure sensors for respiratory medical equipment

**2003**  
The pressure sensor portfolio expands with the tire pressure monitoring system utilizing capacitive technology to save power



**May 2005**  
Freescale introduces its first 3-axis MMA7260Q low-g inertial sensor alleviating the need for multiple devices.



**June 2007**  
Spalding uses the ZSTAR Wireless Sensing Triple Axis Reference design for an intelligent basketball that tracks trajectory



**November 2008**  
Synerject announces its ongoing supply of Freescale pressure sensors for robust, cost-effective ECUs for two- and four-stroke engine management

**December 2008**  
3-axis accelerometers offer reliable, cost-effective freefall detection to help protect data stored on laptop hard disks

**June 2009**  
MPL115A first digital barometric pressure sensor with easy-to-use digital interface, small package and low power



**1985**  
Sensor products release a Temperature Compensated Pressure Sensor.



**Late 1980s**  
Freescale\* begins developing the first surface micromachined inertial sensors for the automotive airbag market

**1996**  
Inertial sensors start volume production



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

**Early 2000s**  
Inertial sensor portfolio expands with X-, XY- and Z-axis low-g products for the consumer market



**2003**  
Satellite accelerometers introduced for airbags provide smarter, faster response time deployment



**July 2006**  
First HARMEMS technology MMA82xxEG products are shipped for airbags with robust accuracy

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



**2008**  
TPMS MPKY8900 highly integrated single-package low-power solution:  
• Pressure sensor  
• 8-bit MCU  
• RF transmitter  
• 2-axis X- and Z axis accelerometer

**April 2009**  
MMA7680 intelligent 3-axis digital accelerometer introduced for advanced mobile phone interfaces

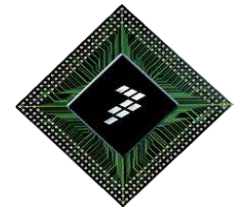


\*The Semiconductor Products Sector of Motorola, Inc. became Freescale Semiconductor, Inc. in 2004.

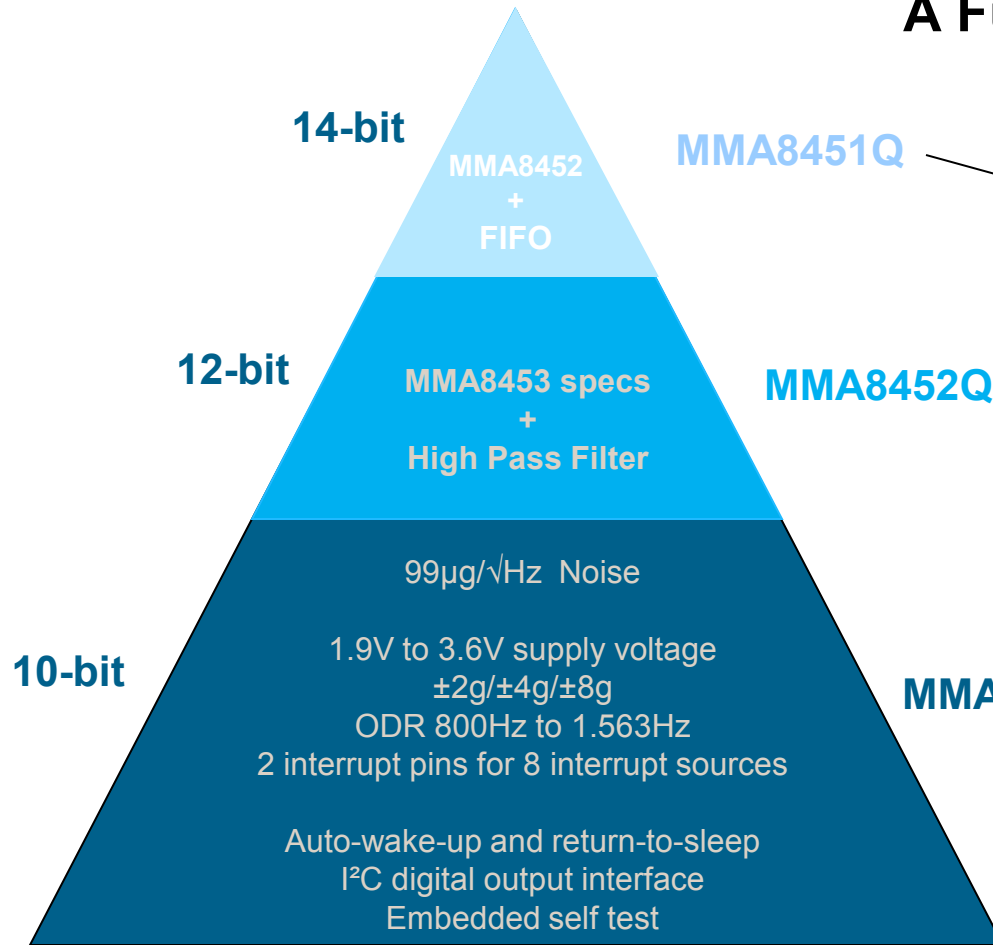




## Xtrinsic MMA845xQ Accelerometer



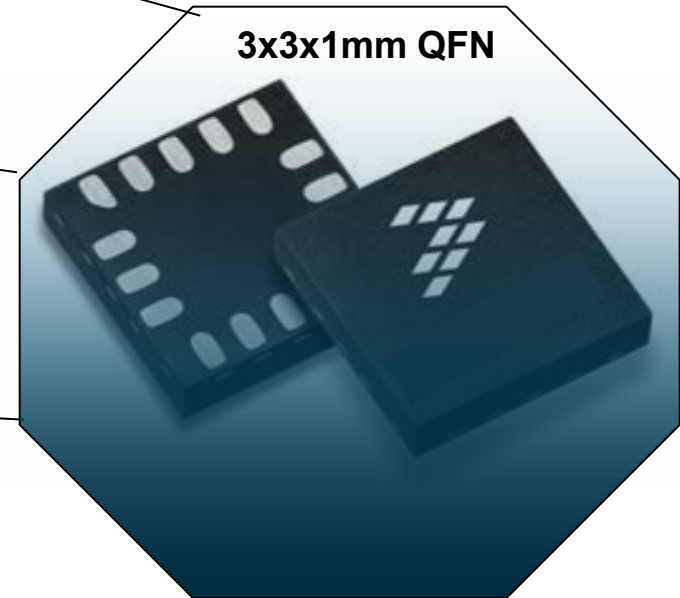
# New MMA845xQ Accelerometers A Full Family with Expandable Features



MMA8451Q

MMA8452Q

MMA8453Q



**Pin to Pin Compatible**  
**Register Mapping Compatible**

**In Production**

# Product Focus

## MMA8451Q Digital Accelerometer

### FUNDAMENTALS

3-AXIS  
DIGITAL

14-BIT  
8-BIT

$\pm 2, 4, 8g$

I2C  
interface

3x3x1  
QFN16

NEW  
g-CELL

### EMBEDDED FEATURES

TILT  
orientation

TAP  
2TAP  
detection

MOTION  
threshold

FREE  
FALL  
detection

TRANS-  
IENT  
detection

HIGH  
PASS  
FILTER

32  
SAMPLE  
FIFO



2  
INTERR-  
UPTS

### POWER SAVING

SLEEP

AUTO  
SLEEP

*No motion  
timer*

AUTO  
WAKE

*motion*

POWER  
SELECT

*1.563-800  
samples/s*

SYSTEM  
POWER  
SAVE

*INTERRUPT on  
EMBEDDED EVENT*





# MMA845x – High Power Efficiency + High Accuracy

❑ Power consumption is linked to different parameters :

- Oversampling ratio (between 2 to 1024) : ↗ OS, ↗ power consumption
- Output data rate (between 1.56Hz to 800Hz). ↗ ODR, ↗ power consumption

➔ Power consumption  $\propto$  ODR  $\times$  OS  $\propto$  ADC internal sampling frequency

❑ Noise is linked to oversampling ratio: ↗ OS ratio, ↘ noise level

❑ Hence, at a fixed ODR, decreasing the noise means increasing power : TRADE-OFF

## Oversampling Scheme :

Mode	Normal (00)		Low Noise Low Power (01)		High Resolution (10)		Low Power (11)	
	ODR	Current $\mu$ A	OS Ratio	Current $\mu$ A	OS Ratio	Current $\mu$ A	OS Ratio	Current $\mu$ A
1.56 Hz	24	128	8	32	165	1024	6	16
6.25 Hz	24	32	8	8	165	256	6	4
12.5 Hz	24	16	8	4	165	128	6	2
50 Hz	24	4	24	4	165	32	14	2
100 Hz	44	4	44	4	165	16	24	2
200 Hz	85	4	85	4	165	8	44	2
400 Hz	165	4	165	4	165	4	85	2
800 Hz	165	2	165	2	165	2	165	2

# MMA845x – High Power Efficiency + High Accuracy

Mode Vdd=2.5V, Vddio=1.8V	ODR (Hz)	Idd typ (µA)
Low-Power	1.563	6
	6.3	6
	12.5	6
	50	14
	100	24
	200	44
	400	85
	800	165
Normal	1.563	24
	6.3	24
	12.5	24
	50	24
	100	44
	200	85
	400	165
	800	165
Standby		2

## Ultra low power consumption

Best in class Power consumption at high resolution  
Best in class measured power consumption at low power modes.

+

## Advanced power saving methods

### **Automatic Auto-Wake/Sleep modes**

### **Low Power Mode Oversampling Scheme**

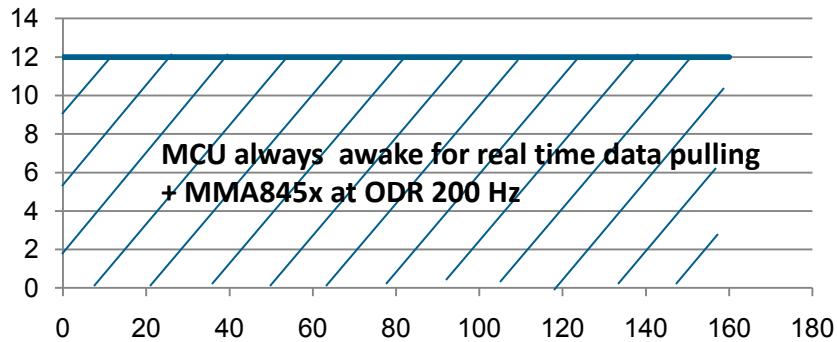
Using the **FIFO** to increase the battery life up to 23x

=

## Ultra low system power consumption

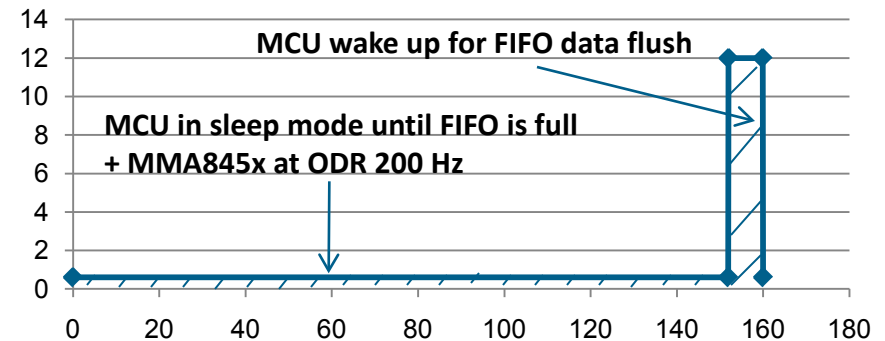
# MMA8451 Value in Low Power Application : The 32 bits FIFO & System Power Consumption

## MCU power consumption



**No FIFO**

## MCU power consumption

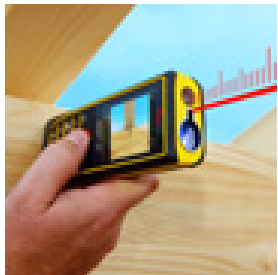


**FIFO = 91% current saving**

- 8 bits MCU wake current consumption = 12 mA
- 8 bits MCU sleep current consumption = 0.6 mA
- Veyron ODR = 200 Hz @ 14 bits

- **The FIFO allows to save ~ 90% of the MCU current consumption**
- **Only FSL offers a FIFO @ 14 bits resolution : ultra low system power & high resolution**
- **Target applications : pointing devices - remote control- cell phone – gaming...**

# Security, Safety and HMI Tilt Measurement



- ▶ Use case:
- ▶ **Measure accurately tilt orientation of a device**
  - ▶ Use static acceleration on 2 or 3 axis
  - ▶ Need high resolution and low noise

- ▶ Key benefits of using the new MMA8451:
  - ▶ 3 axis accelerometer with 2g mode
  - ▶ Noise (N) down to 99  $\mu\text{g}/\sqrt{\text{Hz}}$  in low noise mode
  - ▶ 14-bit output resolution

$$R = N \times \sqrt{BW_{LPF} \times 1.6} \Rightarrow \text{Max resolution is 13.7 effective bit}$$

- ▶ Extra functions with the accelerometer
  - ▶ Antitheft and anti-tampering
  - ▶ Free-fall detection
  - ▶ Shock recording

**FREESCALE ACCELEROMETER CAN ACHIEVE LESS THAN 1° OF ACCURACY**



# Accuracy Calculation Tilt Measurement

► **Accuracy** determined by all sources of errors from the accelerometer

- Resolution Limitations/Noise: (1.56Hz) 0.25mg, (6.25Hz) 0.6mg
- **Zero-g Offset Error: +/-2mg**
- Sensitivity Error: +/-2% 0.244mg (2g range: 4096 counts/g)
- **Temperature Coefficient Offset Error: 0.15mg/°C**
- Temperature Coefficient Sensitivity Error: 0.008%/°C
- Non-Linearity Error: 0.2%

**Total Error:** Root Sum of Squares of all Errors



Angular Error	0	24	45
<b>a) Offset</b>	0.11	0.13	0.16
b) Sensitivity	0.00	0.00	0.00
<b>c) TCO</b>	0.52	0.57	0.73
d) TCS	0.00	0.00	0.00
e) Noise	0.03	0.04	0.05
f) Non Linearity	0.00	0.05	0.11
<b>Angular Error</b>	<b>0.53</b>	<b>0.58</b>	<b>0.76</b>

*Temperature range 20° - 80°c*

**Best in class on ALL major parameters for high accuracy**

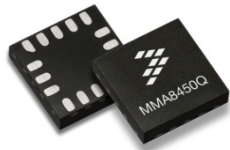
# MMA845x Collateral

Buy Direct

Distributor

## Launch Date Planned

Product Launch	14 <sup>th</sup> September 2010
Production	Early October 2010



## Part Numbers

MMA845xQT	(Tray) - bulk orders
MMA845xQR1	(7 inch reel) – MPQ: 1000



## Development Boards

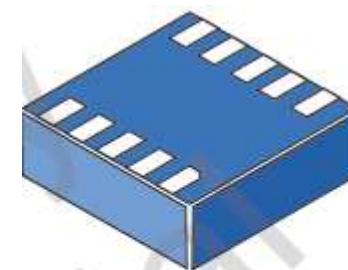
LFSTBEB845x	\$75: September 2010 Stock
LFSTBUSB:	\$50: September 2010 Stock
RDMMA845x*:	\$99: September 2010 Stock

***RDMMA845x = LFSTUSB + LFSTBEB845x***

# MMA865x Digital Accelerometer 10/12 bit 2x2 mm Package

## Features

- 12 bits (MMA8652) and 10 bits (MMA8653)
- 3 Axis, +/-2,4,8 g
- 1.95V – 3.6V voltage supply range
- Noise @ 150 ug/sqr(Hz), TCO = 0.4 mg/°C
- 2 interrupts pin programmable over 8 interrupts events
- High pass filter & FIFO (only on MMA8652)
- Orientation detection (programmable only on MMA8652)
- Shake interrupt & directional shake (only on MMA8652)
- Automatic ODR change for auto wake-up and return-to-sleep
- Programmable ODR from 1.5Hz to 800 Hz
- 6 uA power consumption @ 1.5 Hz
- Low cost derivative from MMA845x
- Register mapping compatible with MMA845x on the basic functions



COL DFN, 10ld 2x2x1mm

**Samples April 2011**  
**Launch December 2011**

# MMA8491Q - PLUTINO

## Tilt Sensor for Extreme Low Power Application



- ▶ **3 Axis, 1.95V-3.6V, 0-16g programmable g range**
- ▶ Small size 3x3 mm QFN Package 0.65mm pitch
- ▶ Fast Turn On Time ( $\ll 1\text{ms}$ ). Time from active to 1<sup>st</sup> measurement 330 us.
- ▶ One shot mode (1Hz) allows 0.35 $\mu\text{A}$  of current consumption.
- ▶ Measurement time < 600 us.
- ▶ 3-axis Logic outputs (above/below threshold). 14 bits internal ADC: Steps of 63 mg.
- ▶ 2 Interrupt pin triggered on : data ready, transient detect, ..
- ▶ Output data rate up to 3500Hz with a 1-128 decimation ratio.

***Samples June 2011***  
***Qualification: October 2011***



# Pluto 3-Axis Analog Accelerometer

## ► Features

- 1.71V to 3.6V supply voltage
- 2/8g and 4/16g devices
- Available Sensitivities
  - from 228.98 mV/g (2g mode)
  - to 28.62 mV/g (16g mode)
- Low Noise: 150 $\mu$ g/ $\sqrt{\text{Hz}}$
- Extremely low power operation possible
  - Less than 1 $\mu$ A average in low power application
  - 200 $\mu$ A continuous
- Fast start up time
  - Less than 1ms to valid output
- Ultra miniature 2mm x 2mm DFN 10 package with 0.4mm lead pitch
  - 3x3mm .65mm package also available
- 2.0kHz (3db point) max bandwidth on Z-axis
- 3.5kHz (3db point) max bandwidth on X/Y-axis
- G-select pin
  - 8g mode on 2g base device
  - 16g mode on 4g base device

## ► Applications

- Game Controllers
- Asset Tracking
- Remote Controls
- Toys
- Factory Automation

### 3x3mm Analog Accelerometers

#### MMAxxxxQ

$\pm 2\text{g}/\pm 8\text{g}$ , 150 $\mu\text{g}/\sqrt{\text{Hz}}$  noise  
.65mm pitch  
-40 to +105deg Temp

#### MMAxxxxQ

$\pm 4\text{g}/\pm 16\text{g}$ , 150 $\mu\text{g}/\sqrt{\text{Hz}}$  noise  
.65mm pitch  
-40 to +105deg Temp

### 2x2mm Analog Accelerometers

#### MMAxxxxFC

$\pm 2\text{g}/\pm 8\text{g}$ , 150 $\mu\text{g}/\sqrt{\text{Hz}}$  noise  
.4mm pitch  
-40 to +85deg Temp

#### MMAxxxxFC

$\pm 4\text{g}/\pm 16\text{g}$ , 150 $\mu\text{g}/\sqrt{\text{Hz}}$  noise  
.4mm pitch  
-40 to +85deg Temp

*Samples November 2011*  
*Qualification June 2012*

2011 launch plan overview

Inertial sensor family overview

▶ MAG3310 magnetometer

MMA955x family

MPL3115 altimeter & Pressure sensors

Proximity sensors overview

Q & A



# Units of Measurement

$$T = 10,000 \text{ G}$$

$$1 \text{ G} = 1 \times 10^{-4} \text{ T} = 100 \text{ microTesla}$$

Some typical values of magnetic field that you might expect to encounter would be:

Item being measured	cgs Units*	SI Units
Earth magnetic field at zip code 85284 (Tempe, Arizona) on 1/1/2011	0.482 gauss**	48.2 microTesla
typical refrigerator magnet	50 gauss	5,000 microTesla
small iron magnet	100 gauss	10,000 microTesla
small neodymium-iron-boron (NIB) magnet	2000 gauss	200,000 microTeslas

\* Some of the magnetic field source values come from Wikipedia.

\*\* The strength of the earth's magnetic field varies from less than 30 microTeslas to over 60 microTeslas around the magnetic poles.

# Magnetometer Applications



## Mobile phones

- Next Gen User Interface
- Electronic compass (eCompass)
- Map orientation
- Gaming
- GPS assist with dead-reckoning
- Location tracking assist in mobile applications
- Flip/display position



## Remote Controls/Air Mouse/Pointers

- Virtual, low-cost gyroscope replacement
- 3D motion control and heading



## Navigation / Localization

- Electronic compass (eCompass)
- Map orientation
- GPS backup with dead-reckoning
- Location tracking in mobile applications
- Asset tracking & orientation/rotation measurement



## Smartbooks/eReaders/Netbooks/Laptops

- Location tracking assist in mobile applications
- Gaming
- User interface

## Contactless Current measurement



# MAG3110 – 3 Axis Magnetometer

3-axis, digital magnetometer with 120nT resolution



## Features

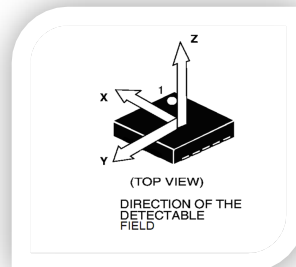
- ▶ 1.95V to 3.6V supply voltage
- ▶ Position independent high accuracy compass function
- ▶ Magnetometer resolution down to 0.12uTesla = 1.2 mGauss
- ▶ Noise down to 0.05 uTesla rms
- ▶ Output data rates (ODR) from 2.5Hz to 80Hz
- ▶ Maximum field of 10G (1mTesla)
- ▶ Multiple Selectable Oversampling Options
- ▶ Current Consumption down to 24uA at 1.25Hz
- ▶ Standby Mode Current Consumption 2uA typical
- ▶ I<sup>2</sup>C digital interface output
- ▶ Calibrated DC offset and gain
- ▶ Internally temperature compensated
- ▶ Capable of measuring geomagnetic field accelerations
- ▶ Hard iron offset registers
- ▶ Available in extremely small 2x2x0.85 DFN package
- ▶ Extended temperature range of -40°C to +85°C.
- ▶ RoHS compliant

## Applications

- ▶ Electronic Compass
- ▶ Enhanced User Interface
- ▶ Dead-reckoning GPS backup and Location Based Services
- ▶ Enhanced Gaming Interface



Drivers Available on request

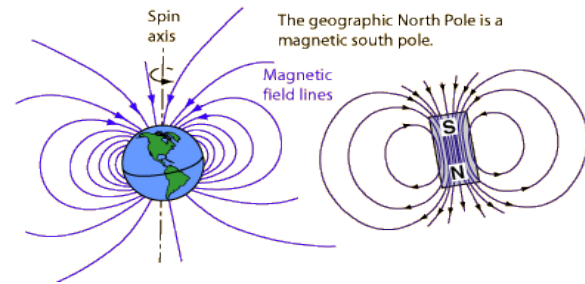


# MAG3110 Advanced Features and Benefits

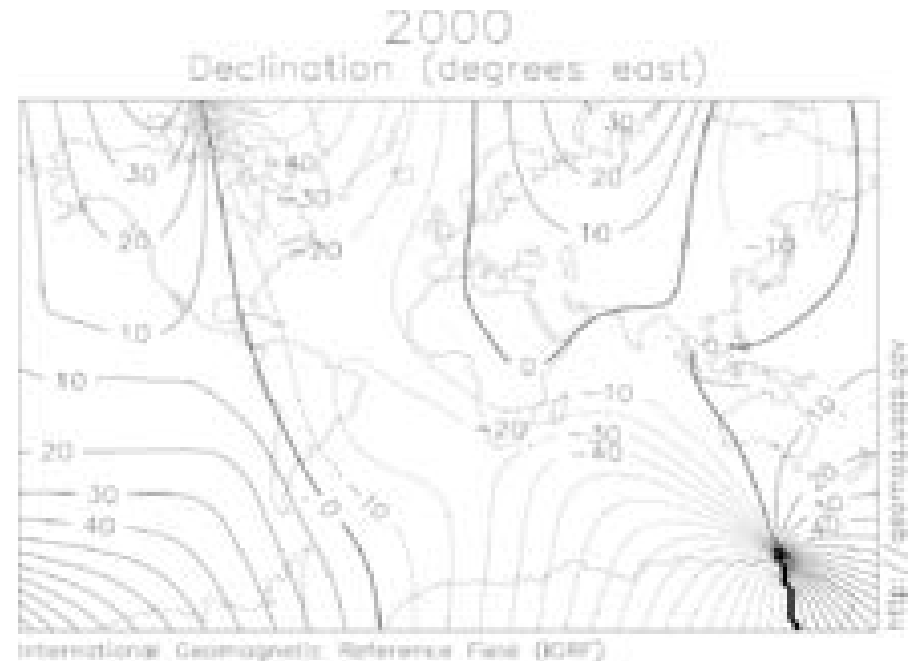
Features	Specification	Benefits
<b>Wide Dynamic Range</b>	+/- 1000 $\mu$ T	Allows operation in PCBs with high extraneous magnetic fields and flexibility in PCB placement.
<b>High resolution in full dynamic range</b>	Down to 0.1 $\mu$ T	Allows for the full specification resolution in all ranges
<b>Low Noise</b> (at 80 Hz ODR)	0.1 $\mu$ T	Enables high resolution applications with low averaging requirements for decreased latency
<b>Power Consumption</b>	Normal Mode: 24 $\mu$ A at 1.25 Hz	Lower power for significant battery savings
<b>Sample rate</b>	80 Hz maximum	Increased bandwidth to provide higher data rates
<b>Supply voltage</b>	1.95 to 3.6 V	Wide range for various applications

**Freescale's MAG3110 magnetometer has phenomenal performance due to the combination of TMR (Tunnel Magneto Resistive) technology, high resolution analog design and dedicated embedded logic**

# Measuring Earth's Magnetic Field



The strength of the field at the Earth's surface ranges from less than 30 microteslas (0.3 gauss) in an area including most of South America and South Africa to over 60 microteslas (0.6 gauss) around the magnetic poles in northern Canada and south of Australia, and in part of Siberia.

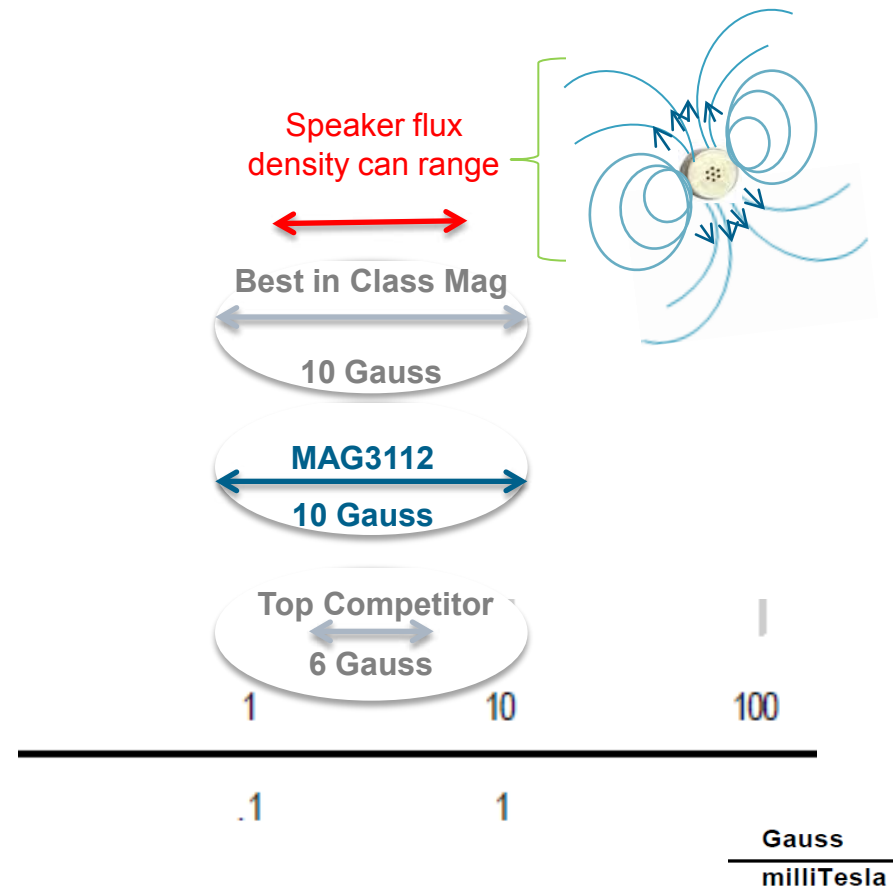


# Importance of a Wide Dynamic Range

The targeted applications such as: position, dead reckoning, and motion control measure changes in Earth's magnetic field. However, in the application environment, there is a lot that can affect the magnetic field.

A wide dynamic range with high resolution through the full dynamic range allows for **flexibility in placement on the PCB**.

A high dynamic range with allow for high Sensitivity of changes in earths magnetic field when compensating for hard iron and soft iron effects to the magnetic field.

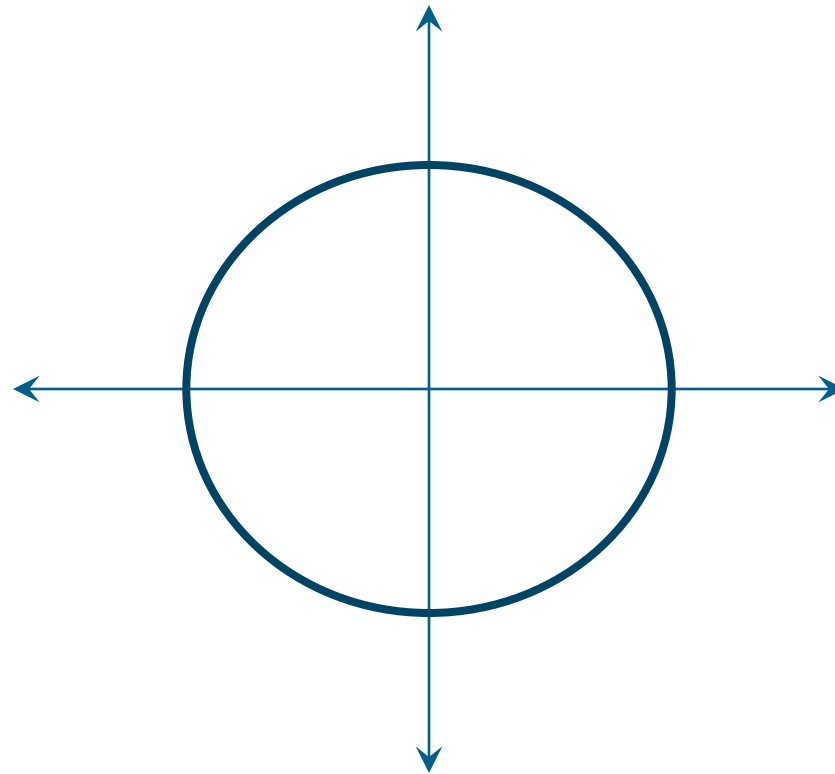




# Magnetometer Enablement

- ▶ Higher complexity than other sensor enablement
- ▶ Requires on-going compensation for Offset and Hard / Soft Iron

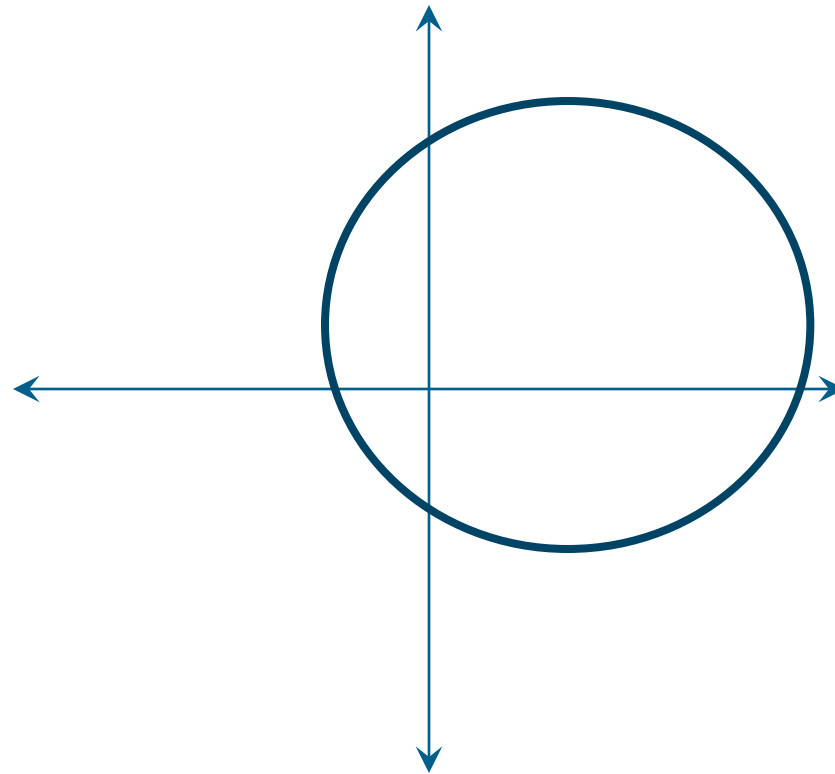
Rotating a perfect magnetometer without a distortion generates a perfect circle



# Magnetometer Offset and Hard Iron Distortion

- ▶ Basic Offset and Hard Iron corrections can be determined by taking the minimum and maximum values in each axis, and halving the difference.

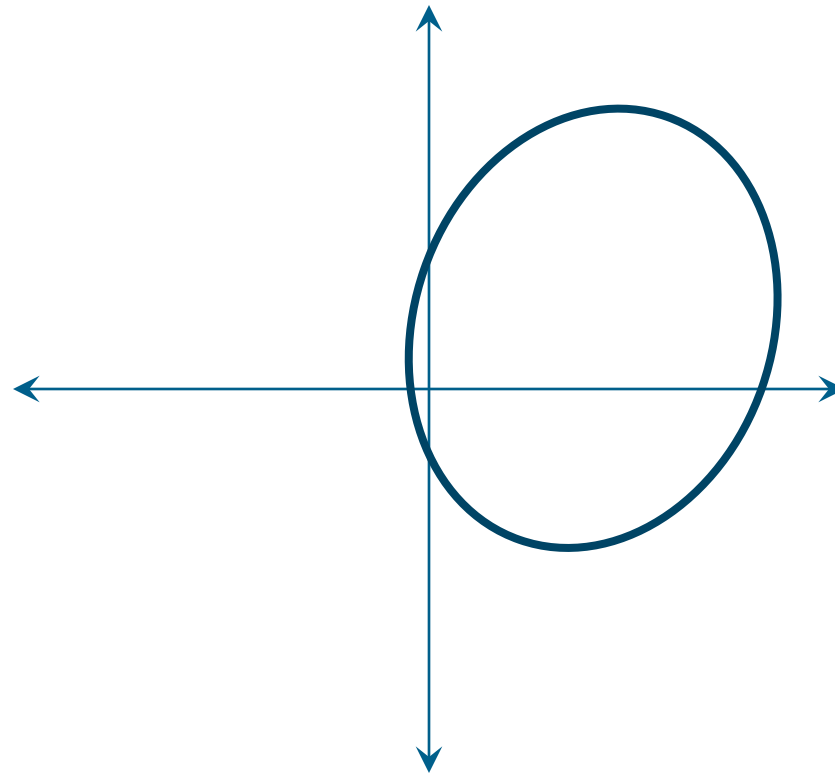
Offset and Hard Iron distortion change the center of the resulting circle



# Magnetometer Soft Iron Distortion

- ▶ Soft Iron correction is more complex and requires removal of the hard iron / offset to center the ellipse, then rotate it to align with the axis, and apply correction scale factors in each axis.

Soft Iron distortion changes the shape of the pattern from a circle into an ellipse

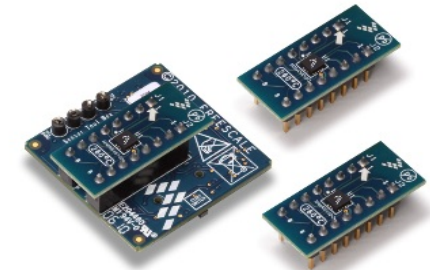


# Sensor Toolbox Development Board

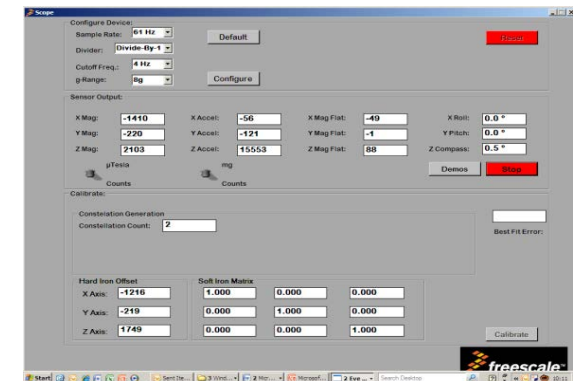
Extension to the Sensor Toolbox development suite with a accelerometer (MMA8451) and magnetometer (MAG3110) daughter card for magnetometer and 6DOF application evaluation.

## Key Features

- Multiple toolsets that work on a unified set of development software
- Hardware (including interchangeable daughter cards), documentation and accessories for Freescale acceleration, pressure, touch sensors and NOW magnetic sensors.
- Complimentary GUI software installer
- New tools will continue to be introduced and added to the Sensor Toolbox with upgraded GUI, backwards compatible to previous tools.



Daughter board with MMA8251 and MAG3110



# Collateral Launch Plan

## ▶ LFSTBEB3110 Sensor Toolbox Kit

- Includes a self identifying MAG3110 + MMA8451 magnetometer development board
- Works with the USB communication board
- Includes Sensor Toolbox demo and evaluation software
- Will be available at: [www.freescale.com/sensortoolbox](http://www.freescale.com/sensortoolbox)

## ▶ RD4247MAG3110 Sensor Toolbox Bundle

- This Sensor Toolbox kit comes with the MAG3110 + MMA8451 magnetometer development board and the USB board
- Will be available at: [www.freescale.com/sensortoolbox](http://www.freescale.com/sensortoolbox)

## ▶ Xtrinsic Solution Board

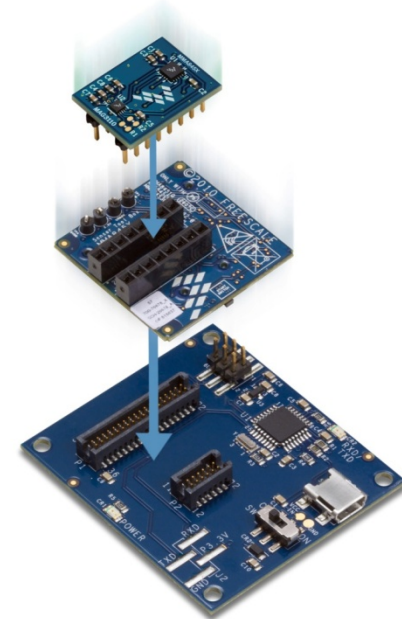
- Includes a MAG3110 magnetometer and MMA9550 Accelerometer and Smart Sensor development board
- Works with the USB communication board

## ▶ Documentation

- Calibrating for Soft Iron and Hard Iron Distortions (AN4246)
- PCB Layout Guidelines and Recommendations (AN4247)
- Using the MAG3110 Magnetometer for an eCompass Application (AN4248)
- Using the MAG3110 Magnetometer for an Air Mouse Application (AN4249)
- 6-Pack slides, CIA & Freescale Ready portal promotion,

## ▶ Software

- Automatic & continuous Calibrating for Soft Iron + Hard Iron Distortion + tilt compensation + heading. Basic C code.





2011 launch plan overview

Inertial sensor family overview

MAG3310 magnetometer

▶ MMA955x family

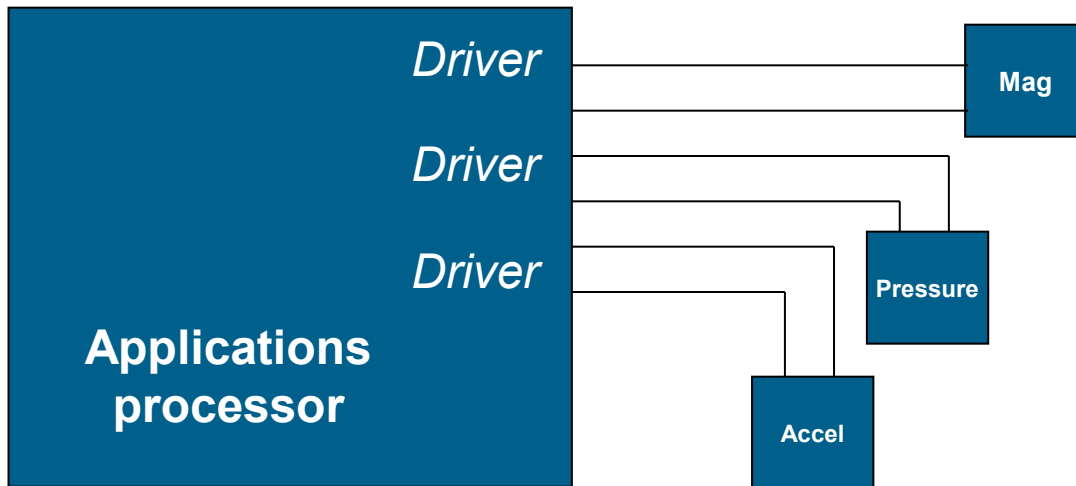
MPL3115 altimeter & Pressure sensors

Proximity sensors overview

Q & A



# Sensors are Becoming Pervasive

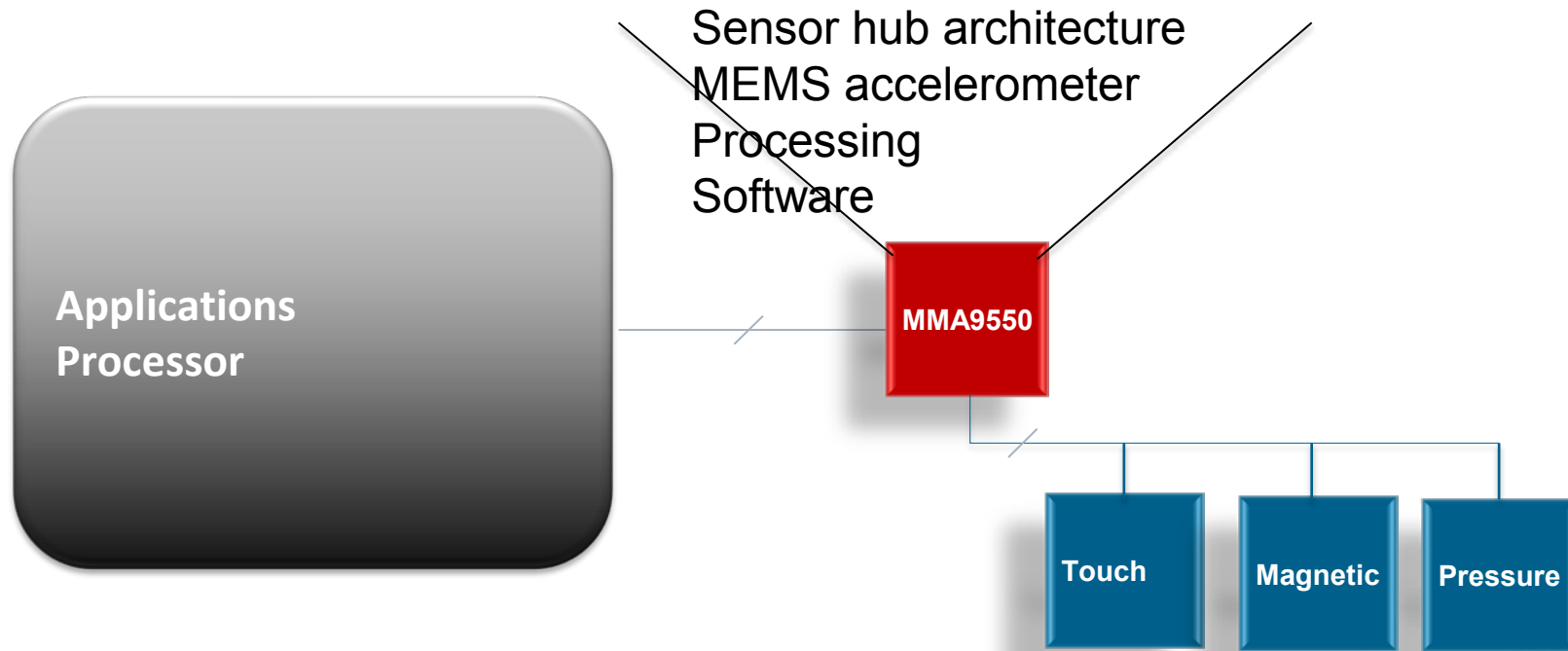


## Example sensor system

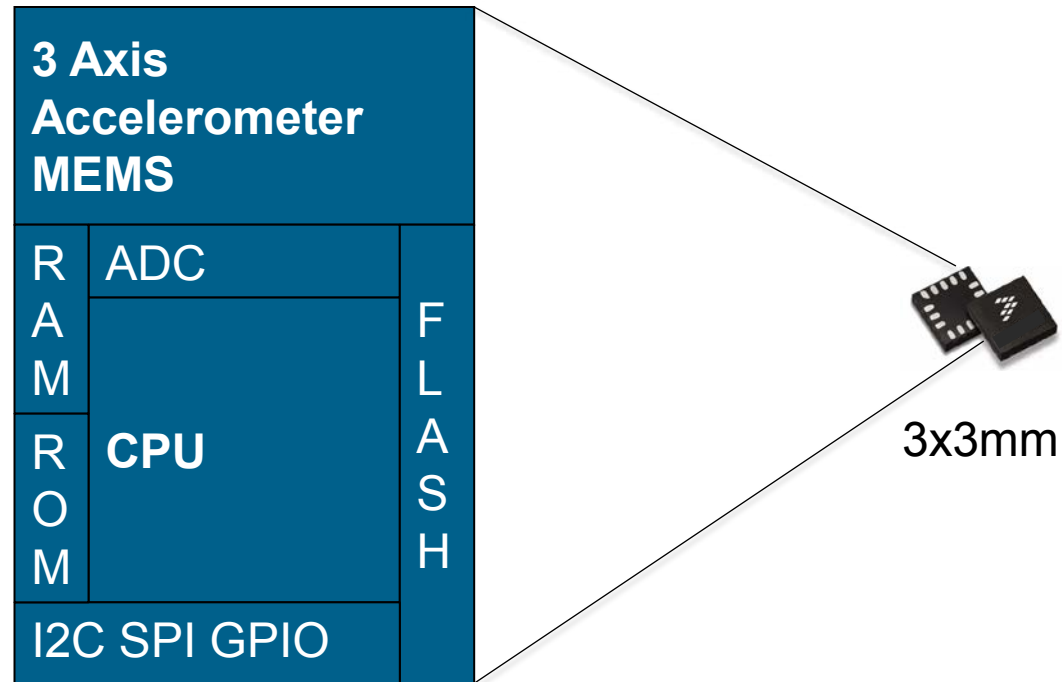
The upcoming challenges from the increasing number of sensors :

- Each sensor request its own set of interface (I2C, SPI, level shifter...), driver and software (offset compensation, specific setting...)
- Increasing data flow to be processed by the Apps processor
- Power budget management and optimization
- Higher software complexity to manage and adapt to each sensor

# Intelligent Sensor Hub: The New Sensor Generation with the MMA9550L



# Smart Sensor Hub: The Implementation – MMA9550L

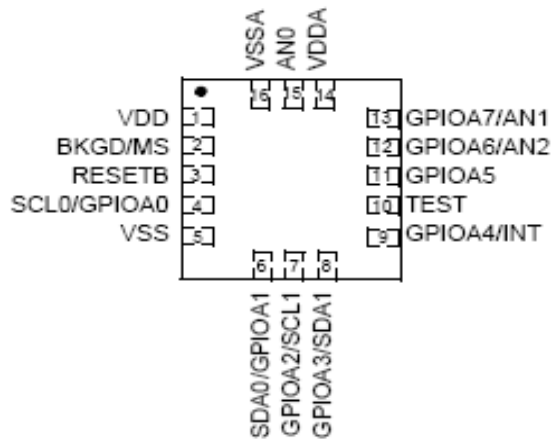


# MMA9550L Specification Overview



## Features

- ▶ +/-2g, 4g, 8g configurable dynamic ranges available
- ▶ Configurable 8-, 10-, 12-, 14-bit resolution
- ▶ Configurable sample rate 0.24 to 1953 sample/s
- ▶ 1.71 – 1.89V for AVdd and DVdd or single supply
- ▶ 2 uA standby current (I<sup>2</sup>C active)
- ▶ 20 uA operating current at 14-bit, 1 samples/s
- ▶ < 150 uA operating current at 14-bit, 64 samples/s
- ▶ Internal low power oscillator
- ▶ Slave I<sup>2</sup>C and SPI
- ▶ Master I<sup>2</sup>C
- ▶ 32-bit CPU core with multiply accumulator block
- ▶ Full enablement suite of tools
- ▶ Software libraries of sensor algorithms
- ▶ Downloadable software upgrades



## Package

- ▶ 3x3x1mm LGA package
- ▶ -40°C to 85°C operating temp
- ▶ RoHS compliant



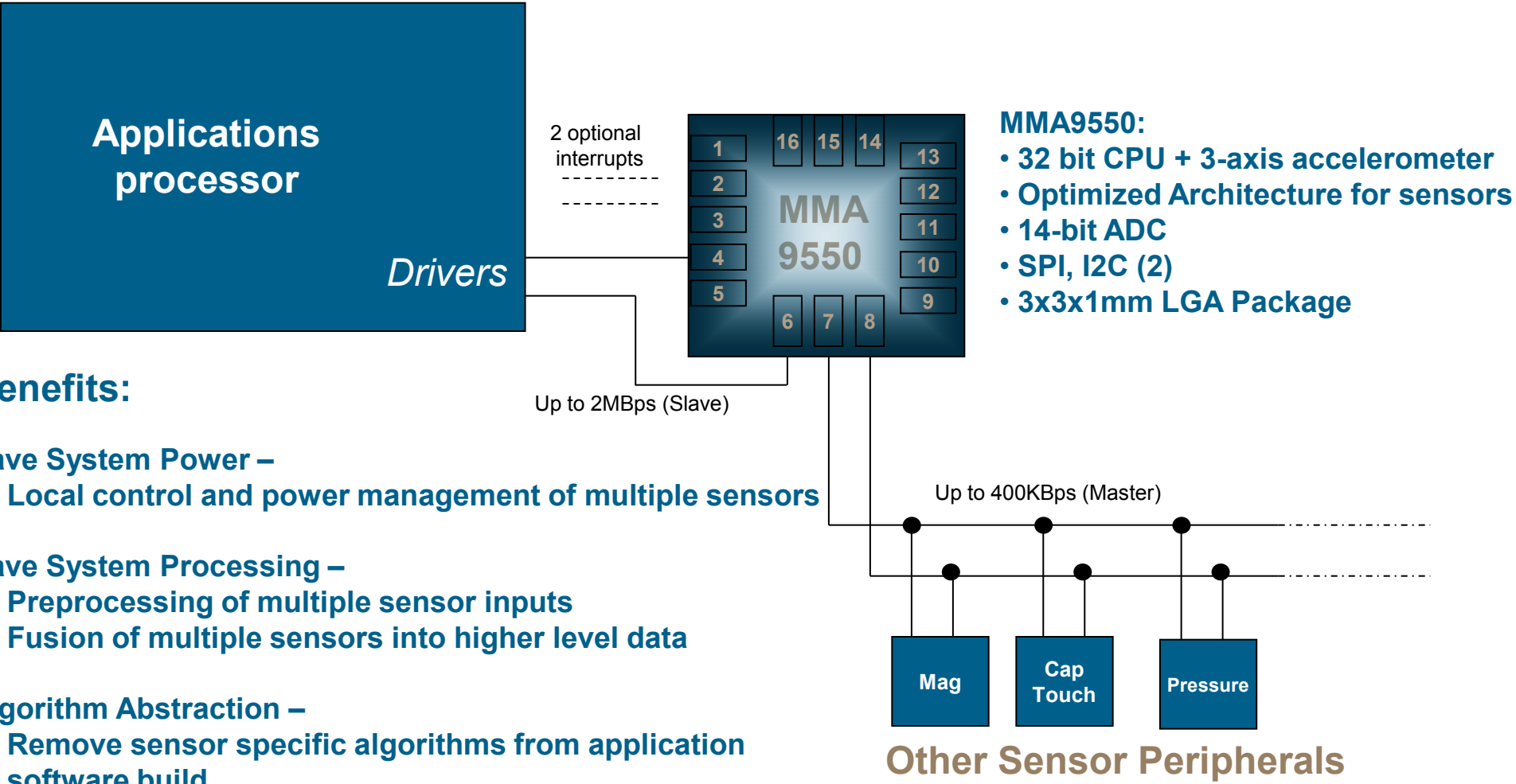
# MMA955xL Family Schedule

Products Major SW Releases	MMA9550 (Accelerometer) (Base)	MMA9551 (Base + Gestures)	MMA9552 (Base + Magnetometer)	MMA9553 (Base + Pedometer)
Production Release	Mar 2011	Mar 2011	End-2Q11	End-2Q11
Key Elements	Infrastructure only functions	Infrastructure + Gestures	Infrastructure + eCompass	Infrastructure + Pedometer
User Flash	6.5 KBytes	4.5 KBytes	1.5 KBytes*	1.5 KBytes*
User RAM	576 Bytes	452 Bytes	0.2 KBytes*	0.2 KBytes*
Firmware Flash	9.5 KBytes	11.5 KBytes	14.5 KBytes*	14.5 KBytes*
Firmware RAM	1.5 KBytes	1.5 KBytes	1.8 KBytes*	1.8 KBytes*

\* All values are approximate projections based on current information



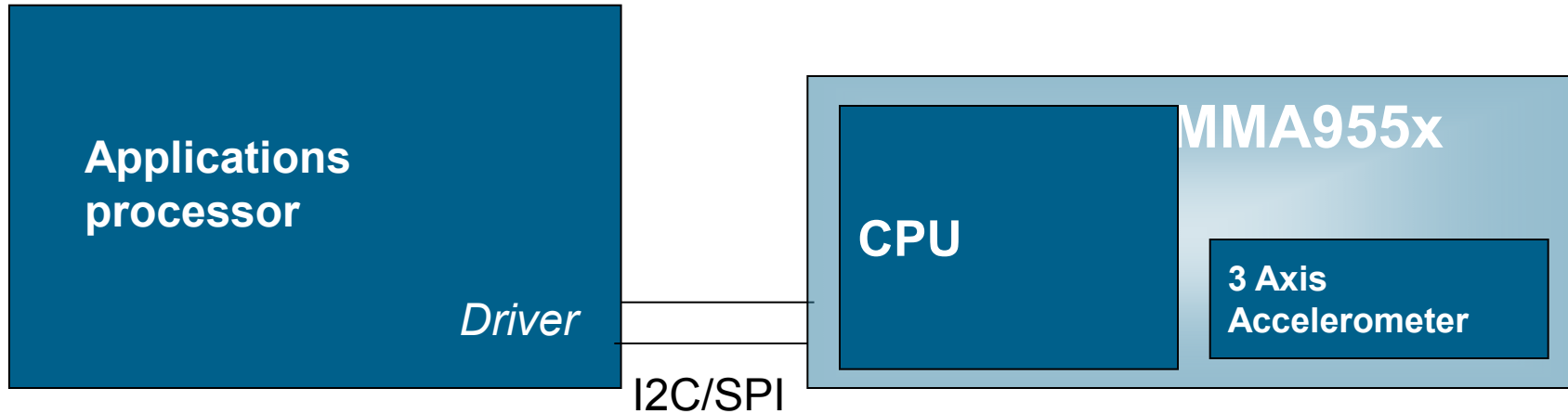
# MMA9550 as the Smart Sensors Hub



**Benefits:**

- Save System Power –**
  - Local control and power management of multiple sensors
- Save System Processing –**
  - Preprocessing of multiple sensor inputs
  - Fusion of multiple sensors into higher level data
- Algorithm Abstraction –**
  - Remove sensor specific algorithms from application software build

# MMA955x as the Motion Preprocessor



## Benefits:

### Improved algorithmic processing –

- High precision samples, up to 14 bit
- High data rate samples, up to 1953 samples/s
- 7.8 MIPS CPU with hardware MAC

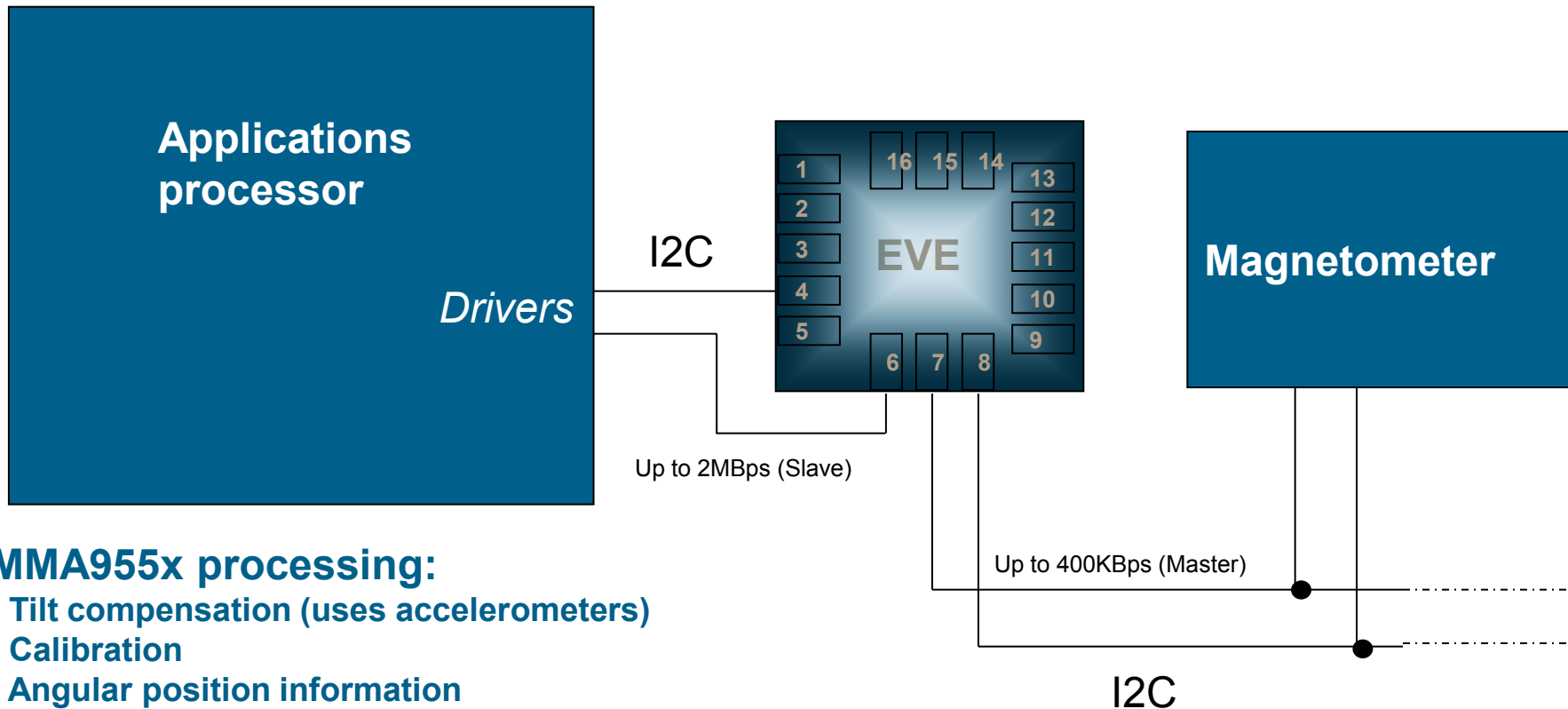
### Save System Power –

- Interrupt when events are recognized
- FIFO stores and coalesces events

## MMA955x:

- 2 / 4 / 8 G sensitivity modes
- 8 to 14-bit ADC
- 0.24 to 1953 Samples/s
- 3x3x1mm LGA Package

# MMA955x with Magnetometer



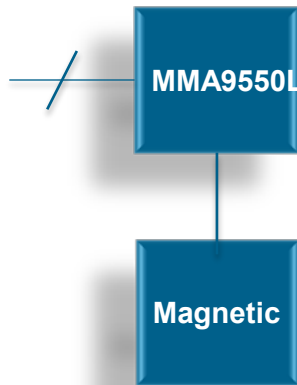
## MMA955x processing:

- Tilt compensation (uses accelerometers)
- Calibration
- Angular position information

## MMA955x advantages:

- Offload processing from applications processor
- FIFO reduces sensor data transactions
- Enables e-compass, pedometer, ...

# eCompass: Comparison with a Standard Solution



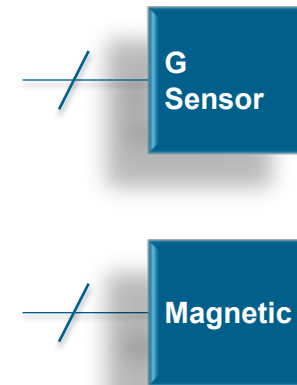
Only one digital interface

One set of drivers

Embedding:

- . Magnetometer calibration\*
- . Tilt compensation
- . Automatic sampling rate

**0.16Kbps of processed data**



Two digital interfaces

Two drivers

Need to add:

- . Soft iron calibration
- . Hard iron calibration
- . Tilt compensation

**3.36Kbps of unprocessed data**

\* soft and hard iron

## Key Benefits

- ▶ Provide the calibrated and tilt compensated ecompass heading
- ▶ Calibration (soft & hard iron) automatic and continuous
- ▶ Agnostic to magnetometer through embedded SW
- ▶ Accuracy equivalent to the best solution on the market
- ▶ Lower power consumption at sensors level and system level
- ▶ Lower data communication
- ▶ Higher flexibility: Customization by SW even after production

2011 launch plan overview

Inertial sensor family overview

MAG3310 magnetometer

MMA955x family

▶ MPL3115 altimeter & Pressure sensors

Proximity sensors overview

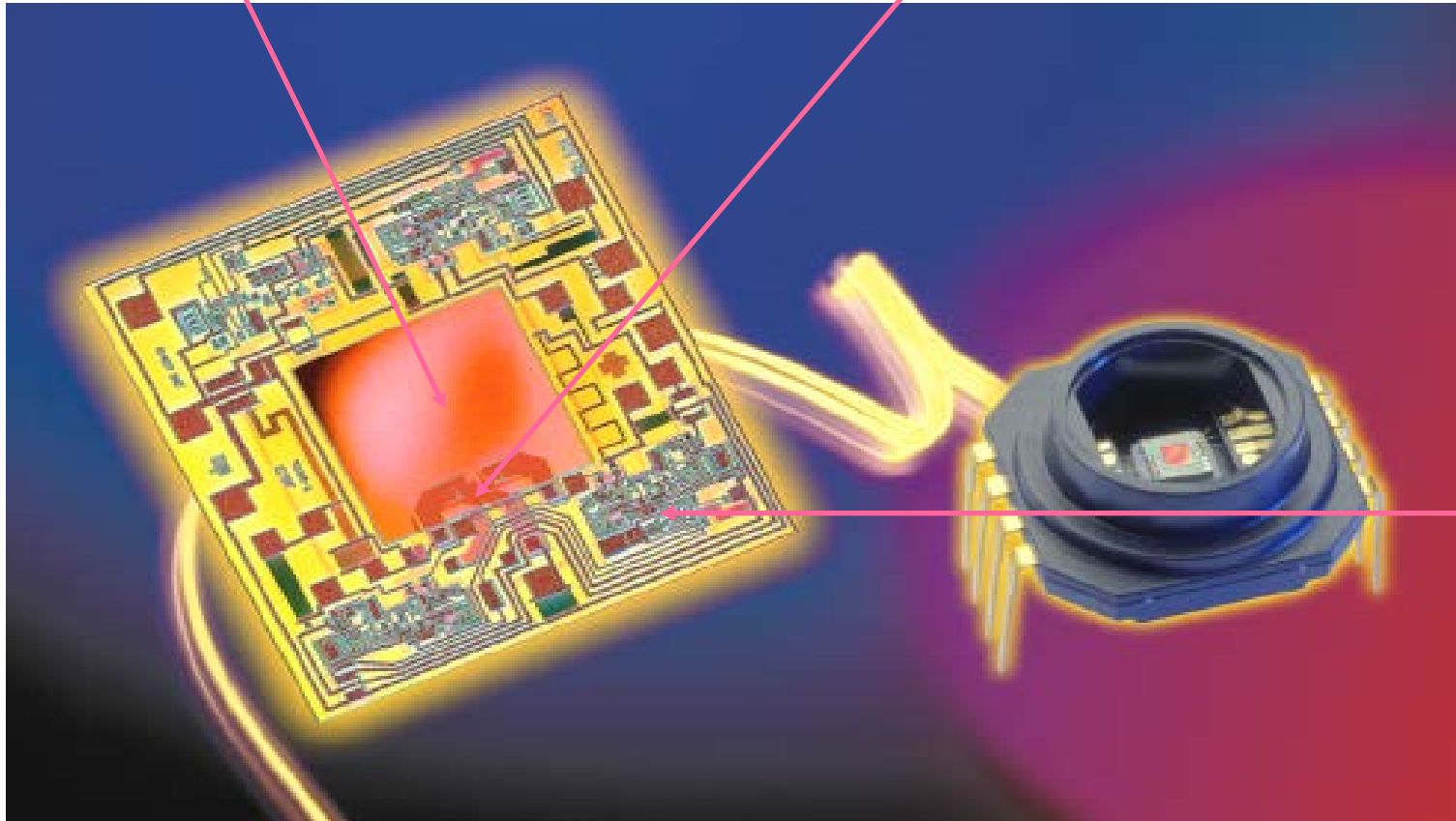
Q & A





Diaphragm

Diffused Strain Gauge



Signal  
Conditioning

Single Chip Integrated Pressure Sensor

# PRESSURE SENSORS

## Package Options

**MPAK**




*MPAK*    *Axial Port*

**Super Small Outline Package (SSOP)**



*Case 1317*    *Tire Pressure Monitor*    *Axial Port*

**Unibody**




*BASIC ELEMENT*    *Dual Port*    *GAUGE PORT*

**Medical Chip Pak**



*Case 423A*

**Small Outline Package (SOP)**



*Case 482*    *Through Hole 482B*    *Vacuum Port*    *Side Port*    *Dual Port*    *Axial Port*    *Through Hole Axial Port*    *Through Hole Axial Port*    *Through Hole Axial Port*



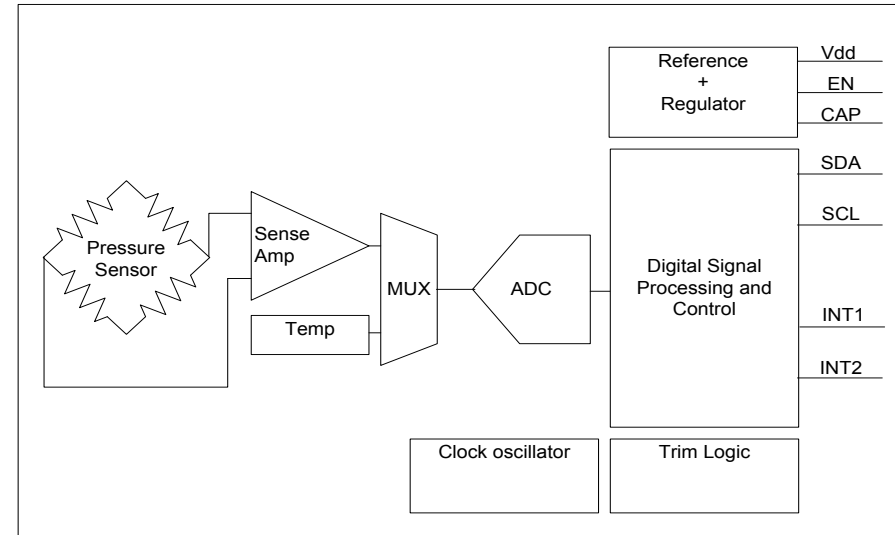
*LGA*

# Barometer & Precision Altimeter

Digitized altitude/pressure and temperature  
Fully compensated internally

- Cost Effective
- I<sup>2</sup>C interface slave device
- Low Power 1 $\mu$ A Sleep, 8.5 $\mu$ A Active(1Hz sampling)
- Max data rate reading 160 Hz
- Factory calibrated
- 1.95V - 3.3V supply
- 50kPa to 115kPa calibrated range
- 1Pa resolution = 25cm in altitude
- Pressure 20 bits internal ADC
- Temperature 12 bits internal ADC
- Internal compensation and conversion
- Limit Alarms: Range and delta
- Data Storage: FIFO for altitude/pressure and temperature
- -40°C to +85°C operating temperature
- Package 5 x 3 x 1 mm

M2 samples April 2011  
Launch June 2011



# MPL115 & MPL3115: Barometer & Altimeter

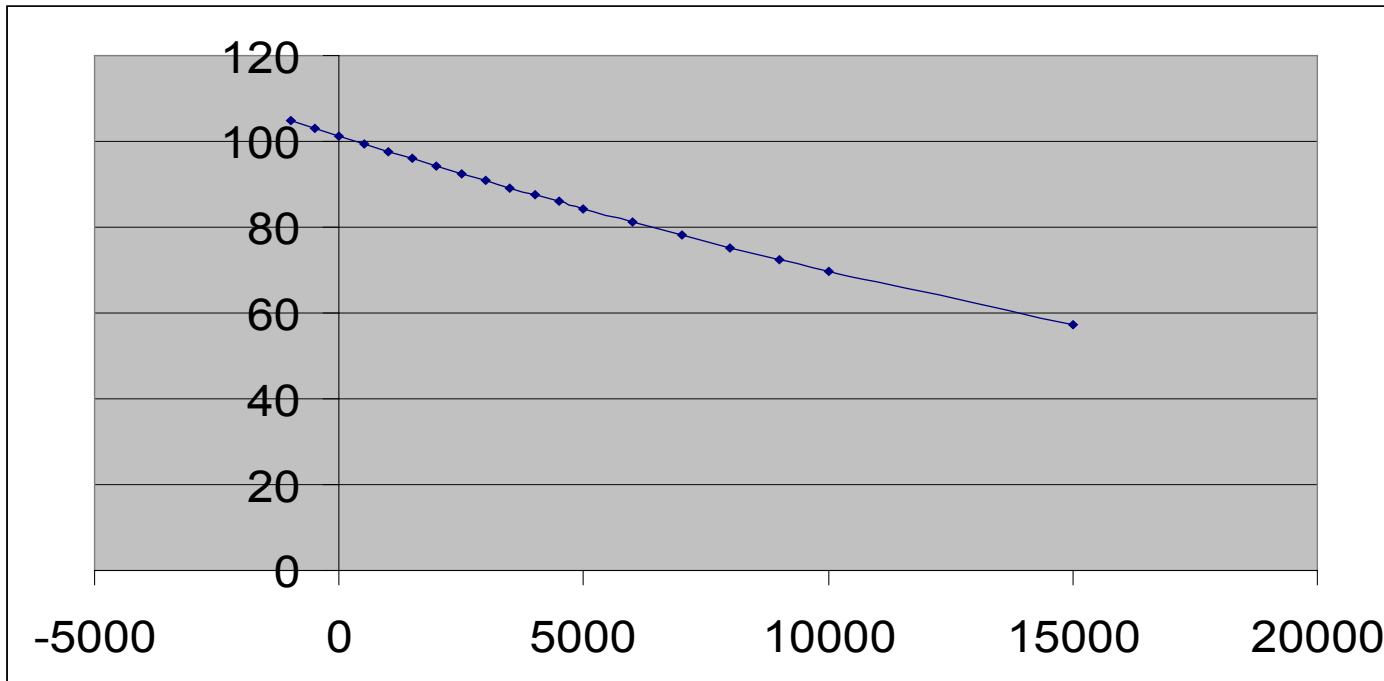


<b>MPL3115 (10Ku resale : 1.63\$)</b>	<b>MPL115 (10Ku resale : 1.05\$)</b>
High resolution: 25cm , 0.2 Pa rms noise	10 bit ADC 3m resolution
All compensation calculations internal, enabling alarm functions, minimizing needed host intervention	Internal coefficients, external calculation
Selectable data type: Altitude (LSB=6.25cm), Compensated pressure (Pascal), temperature (DegreesC)	Altitude and compensated pressure calculation on host
0.3 kPa accuracy with no customer cal. 0.1 kPa accuracy over range with one point pressure cal	1kpa
Programmable Pressure, temperature and status hardware interrupts (window, delta)	
Autonomous operation: can gather up to 32 measurements readings prior to interrupt	Directed operation
Smart barometer/altimeter: Min/max recording altitude/pressure and temperature. Interrupt when only pre-defined change occurs (save power consumption system)	
Low Power: 8.5µA at 1 reading per second 1m resolution	6 µA max @ 1 Hz
Wide power supply voltage range: 1.62/1.95V to 3.3V	2.4V to 5V

# Pressure as a Function of Distance

Pressure is not linear in nature.

For a short distance(20ft), it can be assumed to be linear.



$$p_h = p_0 \times e^{-h/7990m}$$

$$h = 18400m \times \log p_0/p_h$$

$$p_0 = 101.3kpa$$

# Temperature Shift over Altitude

Altitude (m)	Altitude (ft)	Pressure (mmHg)	Pressure (kPa)	Temp Avg (C)
0	0	706	94.13	15
305	1000	732.9	97.7	13
610	2000	706.6	94.2	11
914	3000	681.1	90.81	9.1
1220	4000	656.3	87.5	7.1
2133	7000	586.4	78.18	1.1
2743	9000	543.2	72.42	-2.8
3353	11000	502.6	67.01	-6.8
4572	15000	428.8	57.17	-14.7
6096	20000	349.9	46.65	-24.6

Table of Pressure and Temperature world-wide at that Altitude.

For large range measurements, temperature shifts become important as the temperature coefficient of the pressure sensor comes into a dramatic role.

## ALTIMETRY

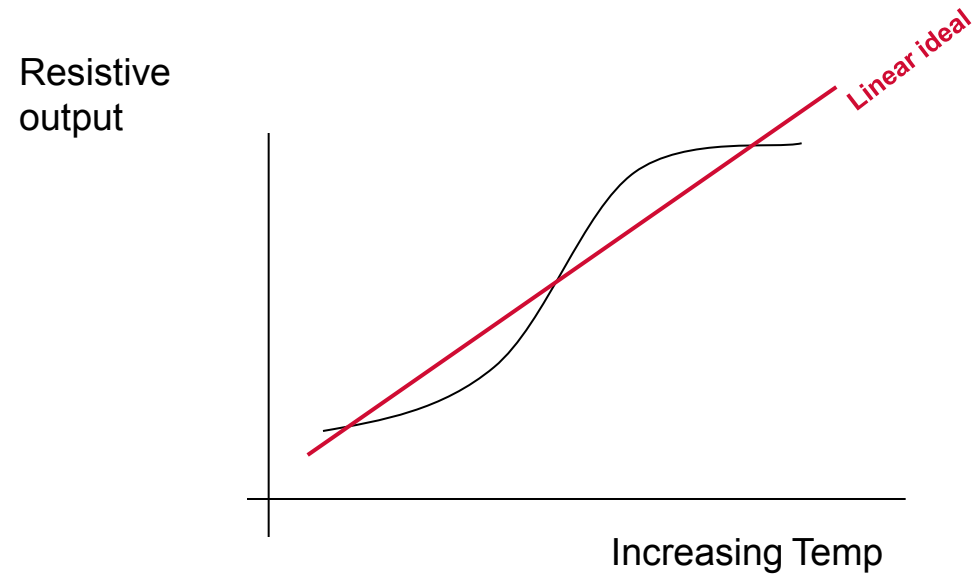


# Advantages of Integrated Compensation and Calculation

- ▶ To enable limit alarms, the following functions must be completed:
  1. Temperature Compensation
  2. Offset Calibration
  3. Scale Calibration
  4. Altitude Calculation
  
- ▶ These functions could be handled in the host, but communications, power consumption and calculation overhead are significant
  
- ▶ Horizon includes all these functions
  - + Interrupts for smart communication
  - + FIFO of 32 samples for data recording

# Sensor Basics –Temperature

## ► Temp Compensation- Linearize a 2<sup>nd</sup> Order Pressure Die.



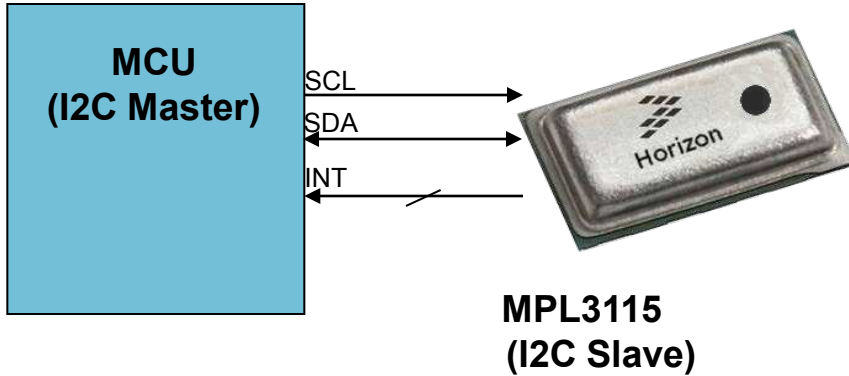
Second Order or higher curve

Cannot use simple trim resistors.

Need ASIC or MCU compensation.

Temperature compensation needed for high accuracy is not trivial.

# MPL3115 – Interrupt Controller

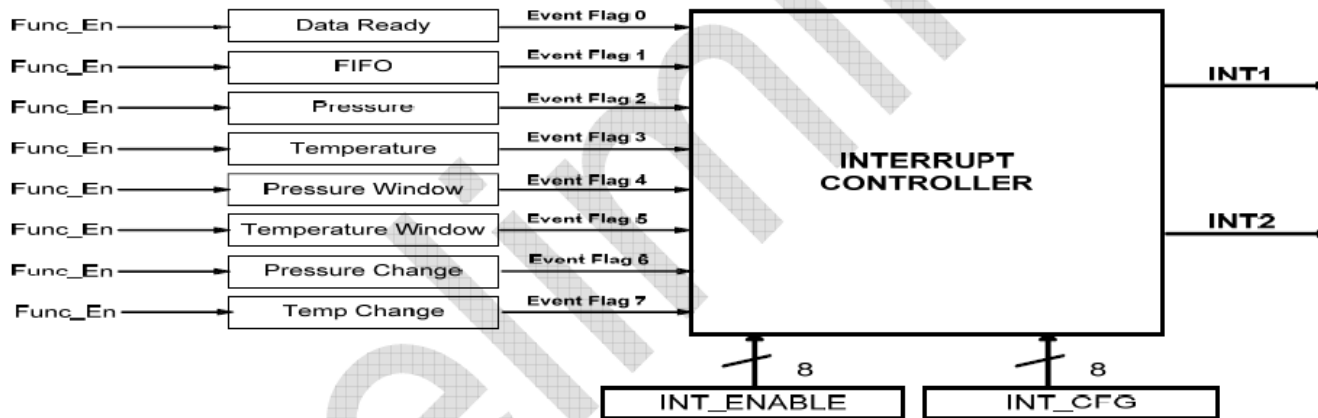


*Slave responds by executing command or outputting Data*

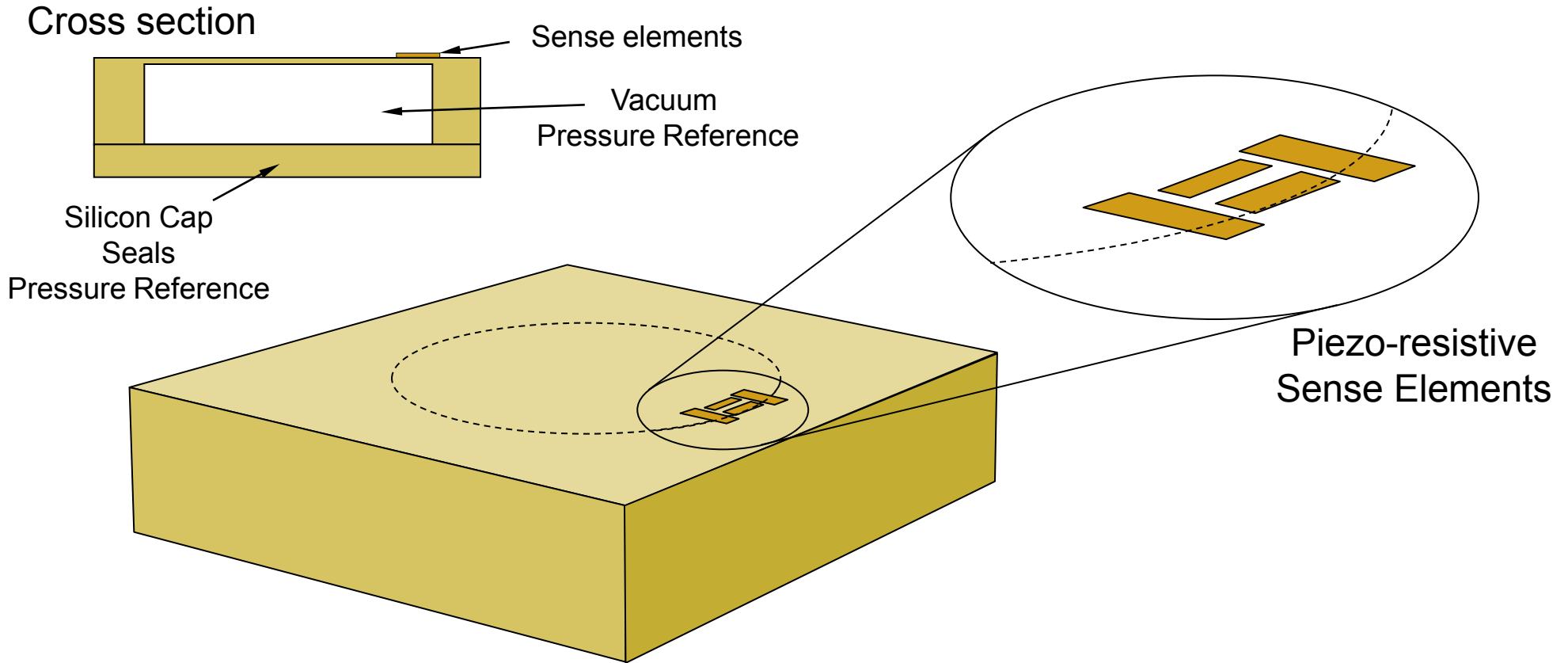
Horizon interrupt when programmed altitude exceed given value/window

Horizon interrupt when programmed temperature exceed given value/window

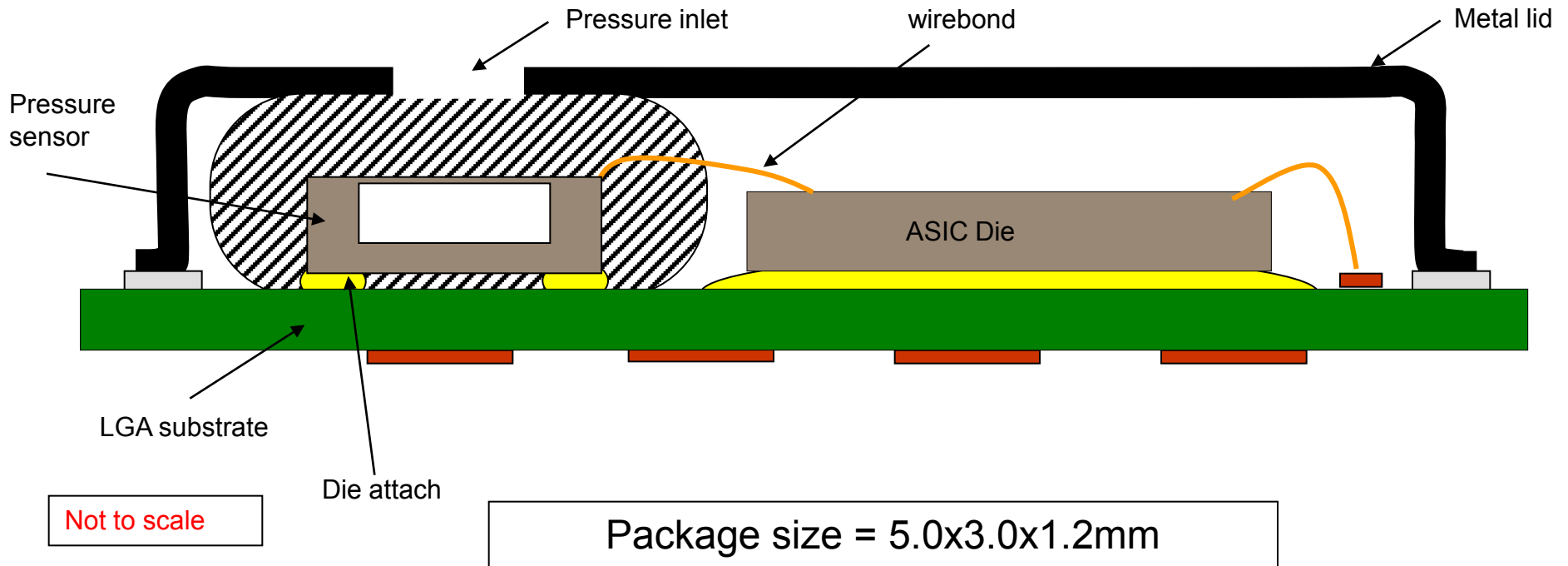
Horizon interrupt when programmed pressure exceed given value/window



# Piezo-Resistive Absolute Pressure Transducer (PRT)



# MPL3115A- Pressure Sensor Package



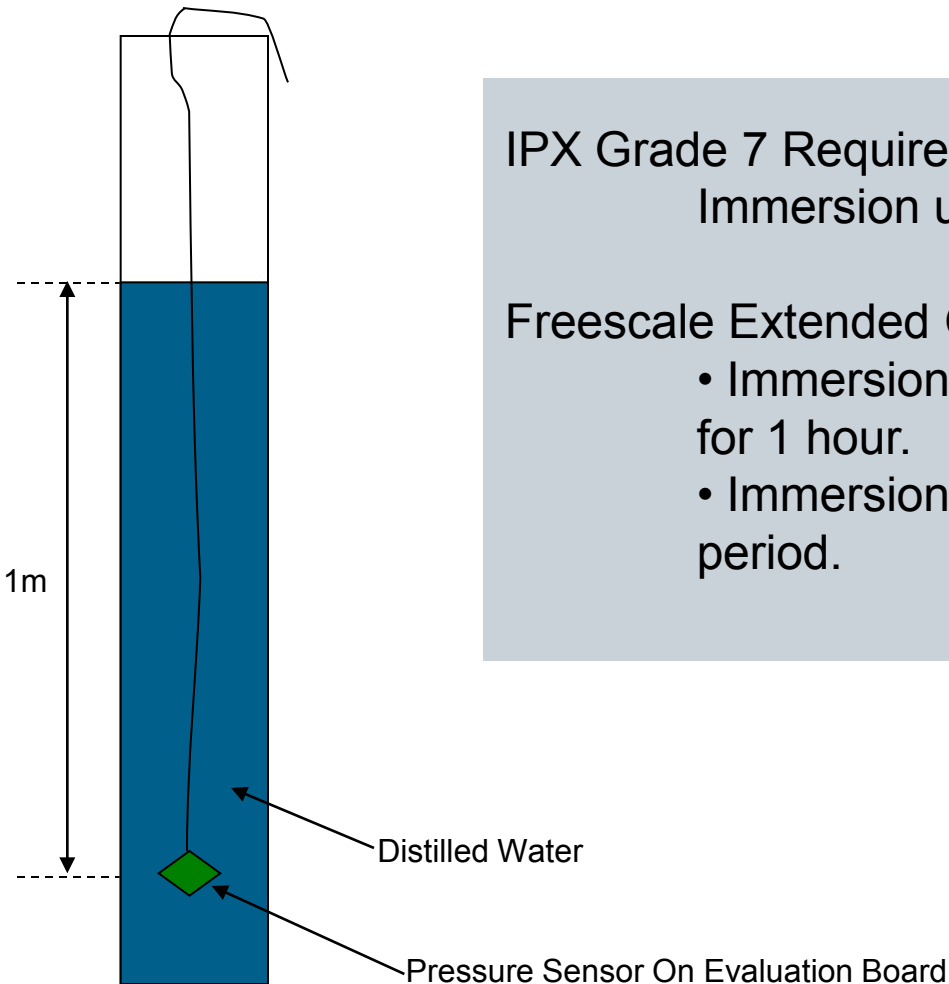
# Water Resistance Tests

## Overview of IEC 60529 Ed2.1, IPX 7

IPX Grade 7 Requirement:  
Immersion under 1m Water for 30 min.

Freescale Extended Grade 7 test:

- Immersion under 15cm Distilled Water for 15min increments for 1 hour.
- Immersion under 1m Distilled Water for a continuous 1hour period.



MPL115A

# Water Resistance Tests

## Freescale Result of IEC 60529 Ed2.1, IPX 7

### ► Results:

- All Tests **PASSED**.
- Standard Package and modified experimental Package Passed.
- Feasibility Study Sample Size: 14 experimental trials.
- Standard packages were tested repeatedly for a total of 3 hours of immersion without any significant ADC shifting.



2011 launch plan overview

Inertial sensor family overview

MAG3310 magnetometer

MMA955x family

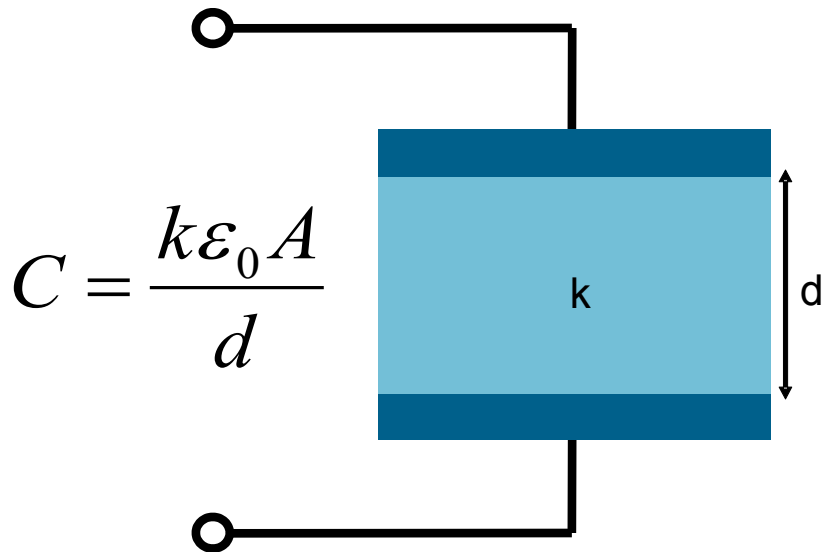
MPL3115 altimeter & Pressure sensors

► Proximity sensors overview

Q & A



## Capacitor Model



**C = the capacitance in farads (F)**

**A = the area of the plates in square meters (m<sup>2</sup>)**

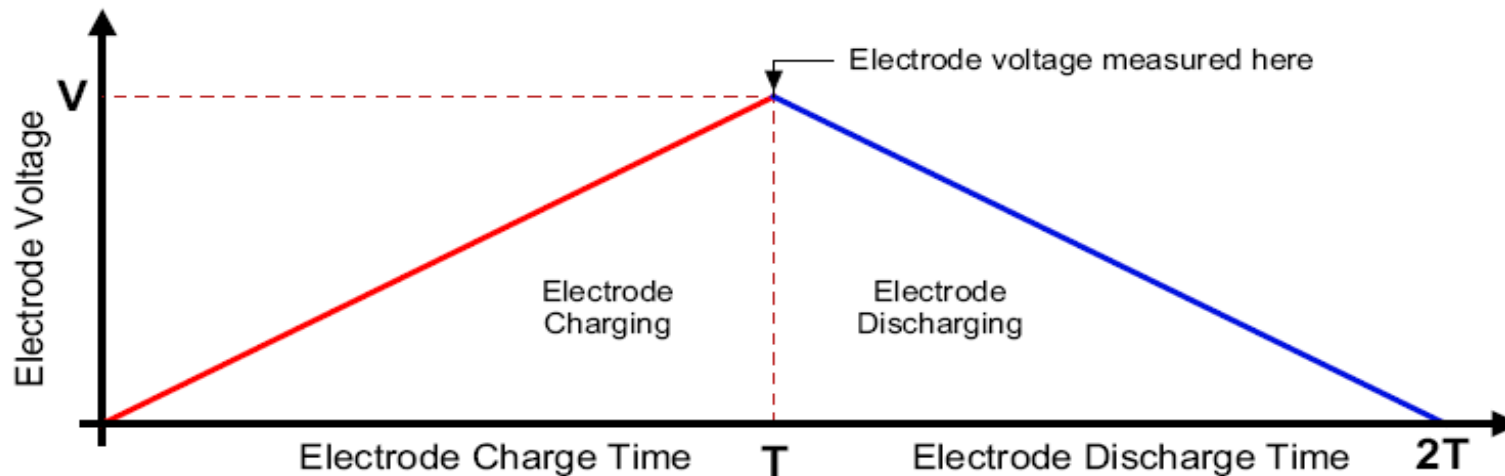
**d = the distance between the plates in meters (m)**

**k = the dielectric constant of the material separating the plates**

**$\epsilon_0$  = is the permittivity of free space (8.85 x 10<sup>-12</sup> F/m)**

- Almost any object which is somewhat conductive and/or has a different dielectric constant than its surroundings can be sensed by its effect on the E-Field

# Theory of Operation Sensitivity Impact



The basic measurement technique used by the MPR03X is to **charge up the capacitor C on one electrode input with a DC current I for a time T.**

$$V = \frac{I \times T}{C}$$

The **electrode charge time** can be configured to equal a range of values between 500 ns and 32  $\mu$ S (This value is set in the CDC in the AFE Configuration register).

The **electrode charge current** can be configured to equal a range of values between 1  $\mu$ A and 63  $\mu$ A (still AFE Configuration Register).

This results in a capacitance measurement range of 0.5 nF to 2000 nF, which is wide enough to cover door-sized electrodes to finger-tip buttons with the change of just two parameters.

# Introducing the MPR031 Proximity Capacitive Touch Sensor Controller

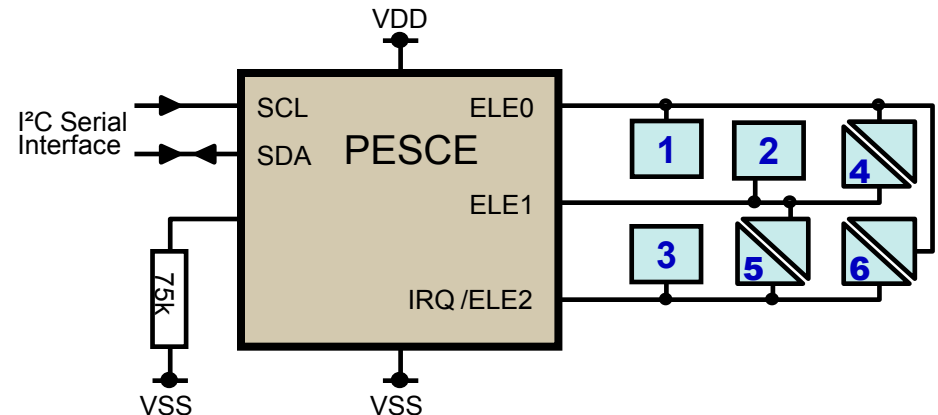
## ► Features

- 1.71V to 2.75V operation
- 14 $\mu$ A supply current (all 3 electrodes being monitored with 96ms response time)
  - -> Key feature – lowest supply current on the market
- 3 $\mu$ A maximum standby current
- With 2 electrodes plus IRQ, scans 2 full touch pads or an array of 3 split touch pads
- With 3 electrodes and no IRQ, scans 3 full touch pads or an array of 6 split touch pads
- Continuous independent auto-calibration for each electrode input
- I<sup>2</sup>C interface, with optional IRQ output to advise electrode status changes
- 2mm x 2mm x 0.65mm 8 lead DFN package
- -> Key feature – smallest package on the market
- -40°C to +70°C operating temperature range

## ► Implementations

- Key replacement - navigation
- Switch replacements

Typical Application with 6 Touch Pads



# MPR031 Features/Benefits

Product Features	Benefits
3 electrodes	Supports up to 6 touch pads
Operating 1.7 to 2.75volts	Very good for proximity applications on cellular Phones
14µA Supply; 3µA Standby ; 1µA idle current	Low power
Interrupt Driven (IRQ Pin)	No polling required
Buffered Output (FIFO)	Stores the last 6 touches
Configurable	Multiple configurations
Digital Output (I <sup>2</sup> C communicates with the host at 400kbits/s)	Very simplified interface to be used with MCU of choice Standard portable electronics interface
Capacitive (Proximity) Sensing	Durable sensing of ground body part
-40°C to 85°C	Temperature range allows for a wide range of applications
8-pin uDFN TSSOP or PDIP Packaging, 2x2x0.65mm, RoHS Compliant	Very flexible design and board layout This allows for operation world-wide
3 External Passives Parts	Small part count when compared to other sensor implementation

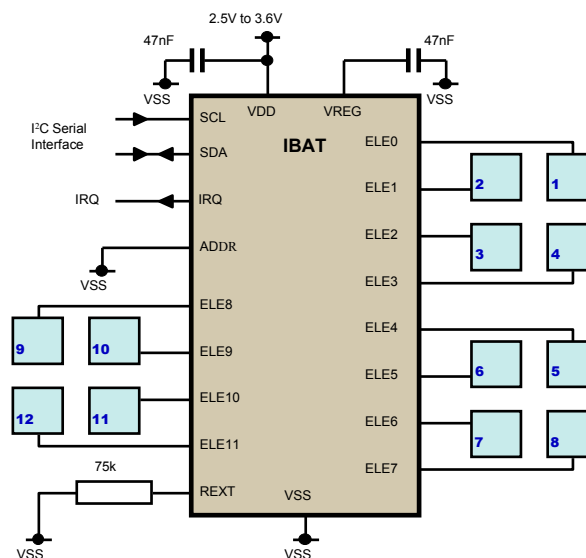
# MPR121 Proximity Capacitive Touch Sensor Controller

## Features

- 29  $\mu$ A supply current
- Compact 3 x 3 x 0.85 mm 20-lead QFN
- Supports up to 12 touch pads
- Only one external component needed
- Intelligent touch detection capacity
- 4  $\mu$ A maximum shutdown current
- 1.71 V to 3.6 V operation
- Threshold based detection with hysteresis
- I2C interface, with optional IRQ
- (4) I2C addresses allow up to 48 electrodes
- Response time programmable from 1ms to 128 ms
- 8 electrodes configurable as LED driver or GPIO
- -40 C to +85 C operating temp range

## Feature Improvements

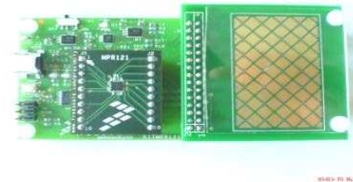
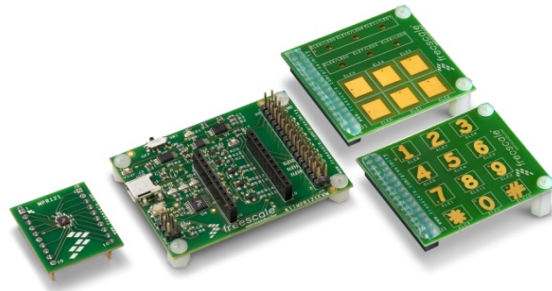
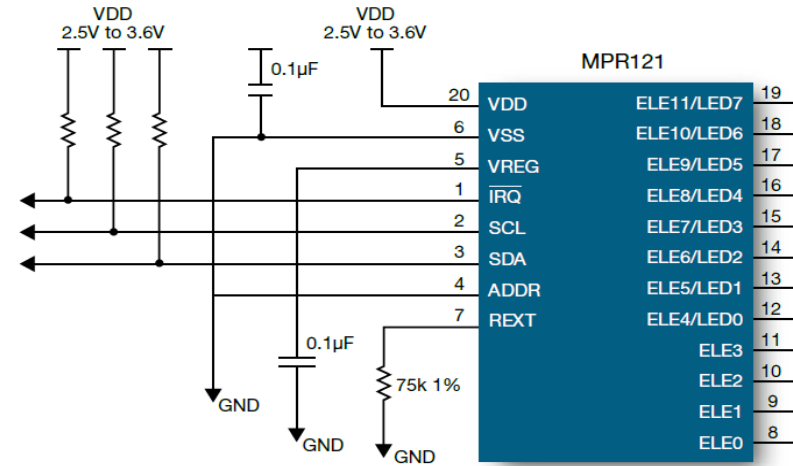
- Configurable I<sup>2</sup>C address
- New Auto-configuration system
- Continuous independent auto calibration for each electrode
- Separated touch & release threshold
- Debounce filter (jitter , false touch)
- 2nd generation filtering system
- Increased voltage range
- 100% independent electrode control



# MPR121 Touch Pad Demo

## Features

- 29  $\mu\text{A}$  supply current
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- Supports up to 12 touch pads
- Only one external component needed
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- 4  $\mu\text{A}$  maximum shutdown current
- 1.71 V to 3.6 V operation
- Threshold based detection with hysteresis
- I2C interface, with optional IRQ
- (4) I2C addresses allow up to 48 electrodes
- -40 C to +85 C operating temp range





# Freescale New Touch Sensing Solutions

## MPR121 Touch Sensor

### ► Extremely low power at 29 $\mu$ A

- Supports up to 12 touch electrodes w/Proximity detect pseudo electrode
- 1.71 V to 3.6 V operational voltage
- Second generation optimized independent auto-calibration and auto-configuration system
- I<sup>2</sup>C communication & touch/prox interrupt
- Only 1 external passive necessary, no passives per channel!



## Touch Sensing Software

### ► Enables 8-bit S08 MCUs as a touch sensor

- Supports up to 64 electrodes
- 1.8 V to 5.5 V operational voltage
- Keypad, slider, rotary, matrix, touch-pads
- Supports multiple communication protocols: I<sup>2</sup>C, LIN, CAN, SPI, USB
- Have other peripherals working at the same time: LCD, LEDs, buzzer, ADC, other sensors, and more

