



May 2011

Freescale Sensors Update

Freescale Offers a Full Portfolio of MEMS & Sensors

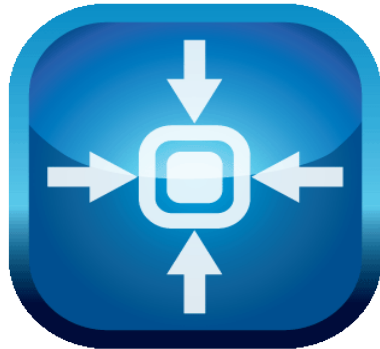
eCompass



Magnetometers



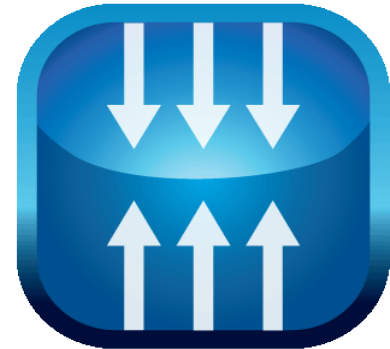
Accelerometers



Touch Sensors



Gyro



Altimeter / Pressure

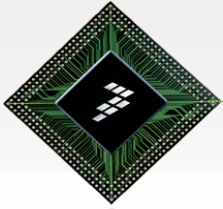
Freescale announcing Xtrinsic brand in 2010

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



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 80 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



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

November 2008

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

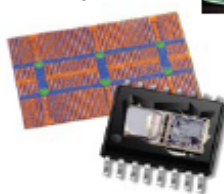


1985
Sensor products release a Temperature Compensated Pressure Sensor.



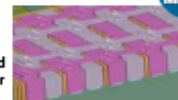
Late 1980s
Freescale* begins developing the first surface micromachined inertial sensors for the automotive airbag market

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

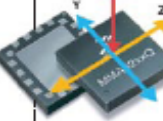


July 2006
First HARMEMs technology MMA82xxEG products are shipped for airbags with robust accuracy



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

500 MILLION



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



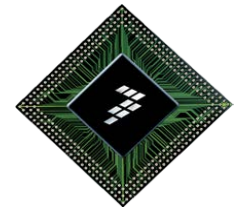
2008
TPMS MPKY8300 highly integrated single-package low-power solution:
• Pressure sensor
• 8-bit MCU
• RF transmitter
• 2-axis X- and Z axis accelerometer

April 2009
MMA7880 intelligent 3-axis digital accelerometer introduced for advanced mobile phone interfaces

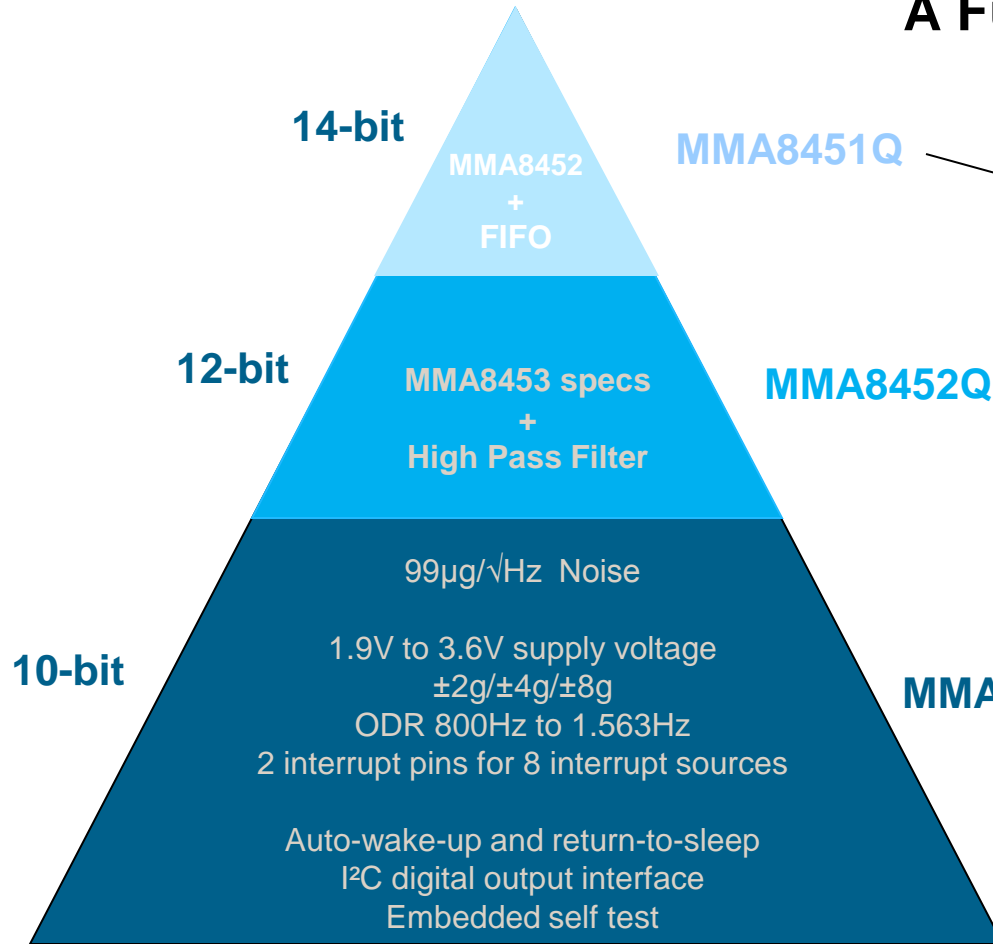




Xtrinsic MMA845xQ Accelerometer



New MMA845xQ Accelerometers A Full Family with Expandable Features

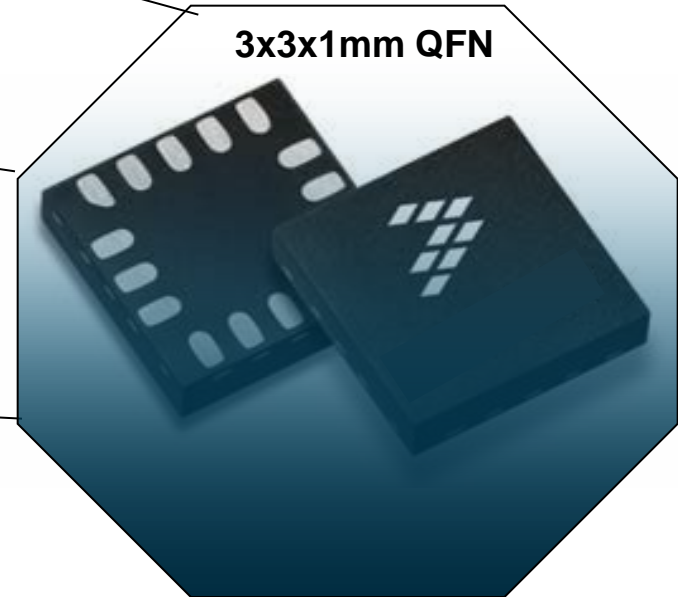


MMA8451Q

MMA8452Q

MMA8453Q

3x3x1mm QFN



Pin to Pin Compatible
Register Mapping Compatible

In Production

Product Focus

MMA8451Q Digital Accelerometer

FUNDAMENTALS

3-AXIS DIGITAL	14-BIT 8-BIT	±2,4,8g	I2C interface	3x3x1 QFN16	NEW g-CELL
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EMBEDDED FEATURES

TILT orientation	TAP 2TAP detection	MOTION threshold	FREE FALL detection	TRANS- IENT detection	HIGH PASS FILTER	32 SAMPLE FIFO	→	2 INTERR- UPTS
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POWER SAVING

SLEEP	AUTO SLEEP	AUTO WAKE	POWER SELECT	SYSTEM POWER SAVE
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*No motion
timer*

motion

*1.563-800
samples/s*

*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)	
	Current μ A	OS Ratio	Current μ A	OS Ratio	Current μ A	OS Ratio	Current μ A	OS Ratio
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

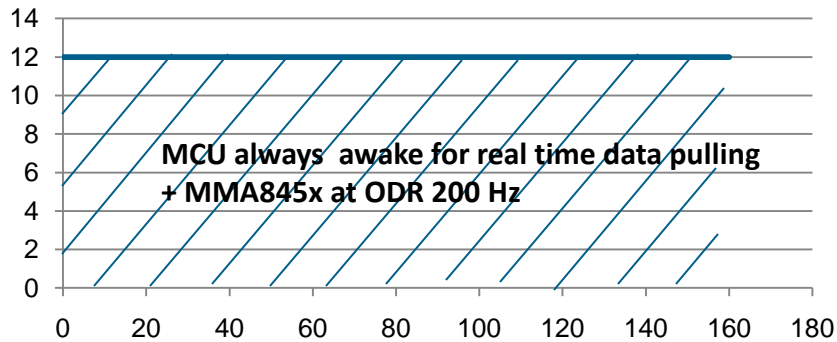
Using the **FIFO** to increase the battery life up to 23x

=

Ultra low system power consumption

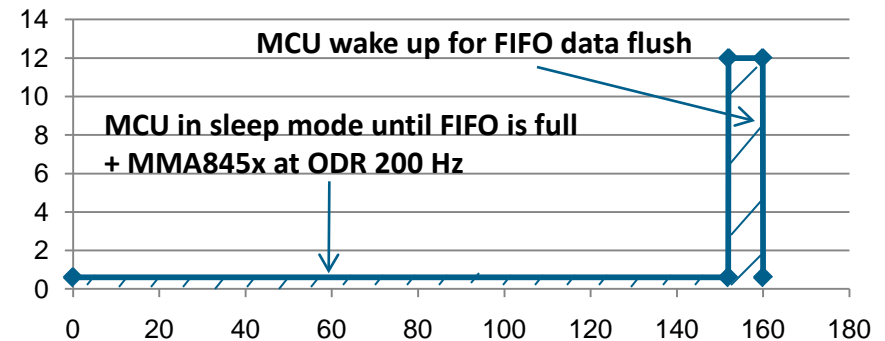
MMA8451 Value in Low Power Application : The 32 bits FIFO & System Power Consumption

MCU power consumption



No FIFO

MCU power consumption

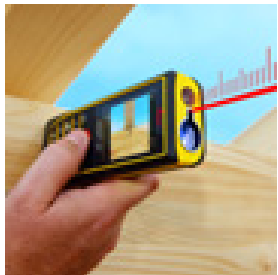


FIFO = 91% current saving

- 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
a) Offset	0.11	0.13	0.16
b) Sensitivity	0.00	0.00	0.00
c) TCO	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
Angular Error	0.53	0.58	0.76

Temperature range 20° - 80°C

Best in class on ALL major parameters for high accuracy

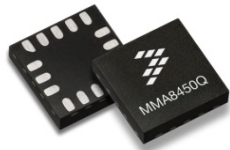
MMA845x Collateral

Buy Direct

Distributor

Launch Date Planned

Product Launch	14 th September 2010
Production	Early October 2010



Part Numbers

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



Development Boards

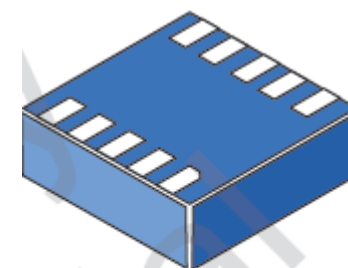
LFSTBEB845x	\$75: September 2010 Stock
LFSTBUSB:	\$50: September 2010 Stock
RDMMA845x*:	\$99: September 2010 Stock

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 1st measurement 330 us.
- ▶ One shot mode (1Hz) allows 0.35 μA of current consumption.
- ▶ Measurement time $< 600\text{ us}$.
- ▶ 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: 150µg/√Hz
- Extremely low power operation possible
 - Less than 1uA average in low power application
 - 200uA 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

±2g/±8g, 150µg/√Hz noise
.65mm pitch
-40 to +105deg Temp

MMAxxxxQ

±4g/±16g, 150µg/√Hz noise
.65mm pitch
-40 to +105deg Temp

2x2mm Analog Accelerometers

MMAxxxxFC

±2g/±8g, 150µg/√Hz noise
.4mm pitch
-40 to +85deg Temp

MMAxxxxFC

±4g/±16g, 150µg/√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

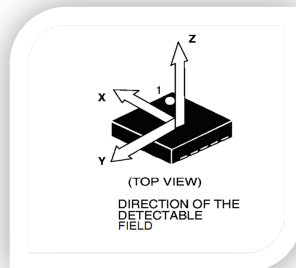
- ▶ 1.95V to 3.6V supply voltage
- ▶ Position independent high accuracy compass function
- ▶ Magnetometer resolution down to 0.12uTesla = 1.2 mGauss
- ▶ Noise down to 0.05 uTesla rms
- ▶ Output data rates (ODR) from 2.5Hz to 80Hz
- ▶ Maximum field of 10G (1mTesla)
- ▶ Multiple Selectable Oversampling Options
- ▶ Current Consumption down to 24uA at 1.25Hz
- ▶ Standby Mode Current Consumption 2uA typical
- ▶ I²C 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

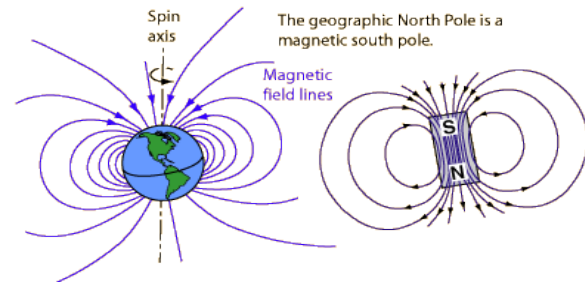


MAG3110 Advanced Features and Benefits

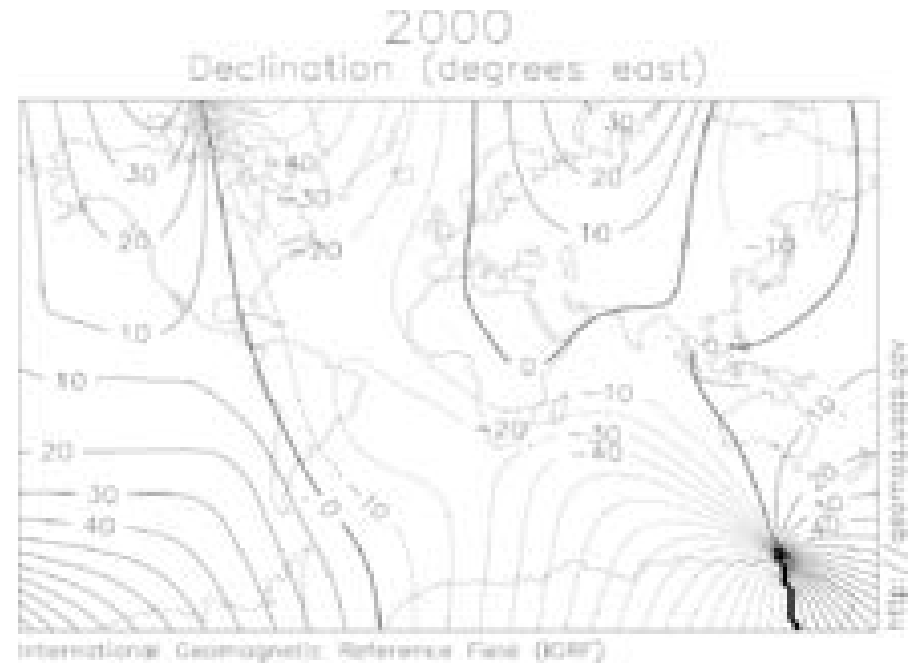
Features	Specification	Benefits
Wide Dynamic Range	+/- 1000 μ T	Allows operation in PCBs with high extraneous magnetic fields and flexibility in PCB placement.
High resolution in full dynamic range	Down to 0.1 μ T	Allows for the full specification resolution in all ranges
Low Noise (at 80 Hz ODR)	0.1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

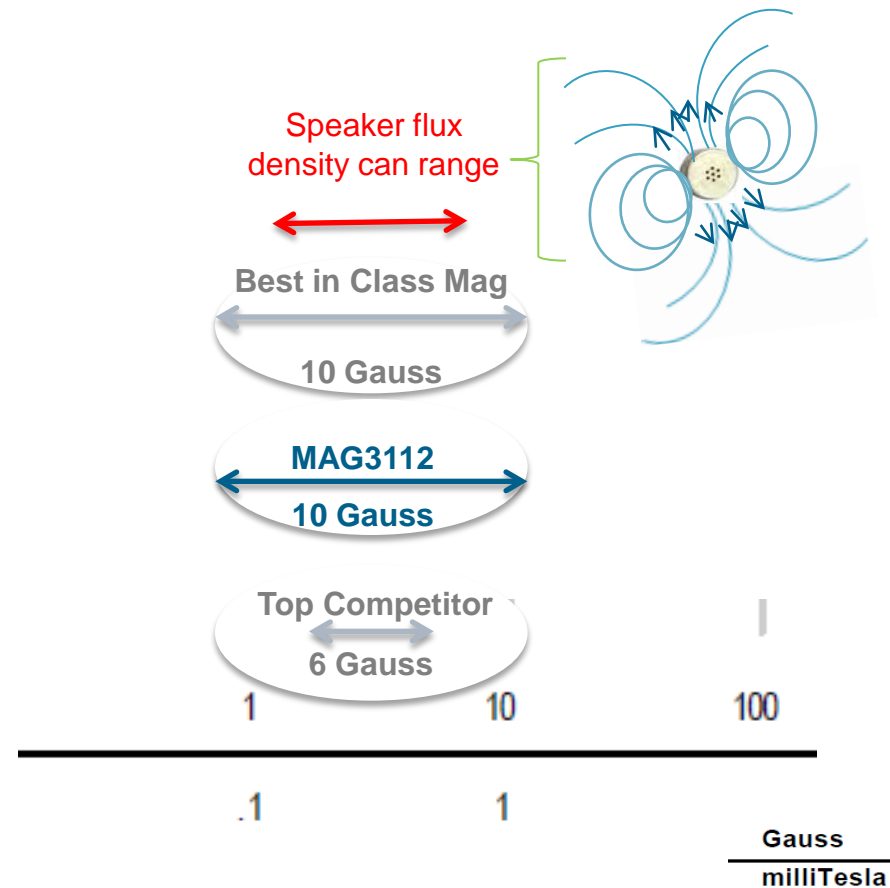


Importance of a Wide Dynamic Range

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**.

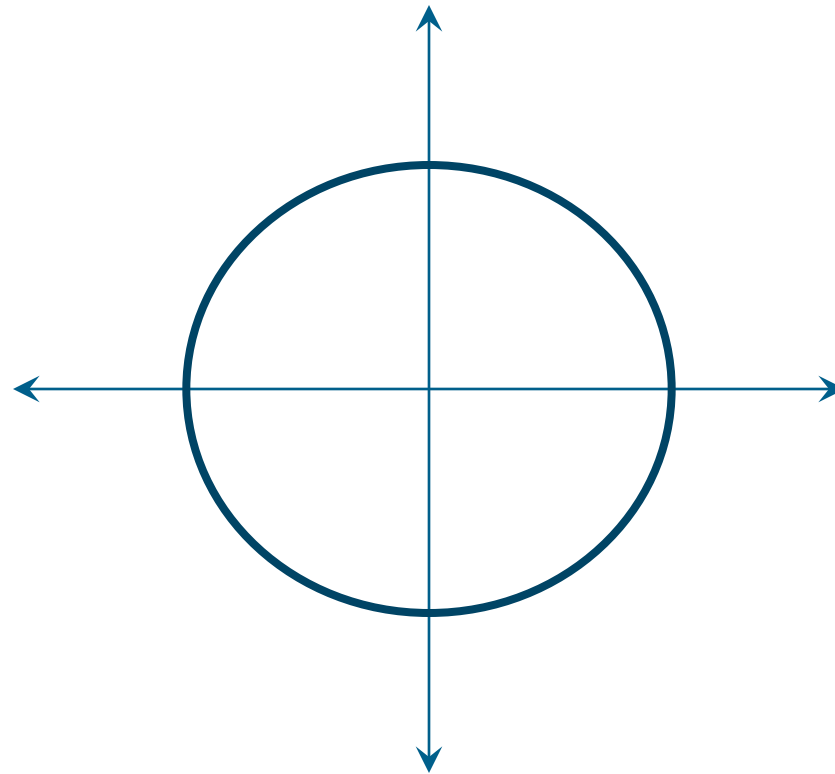
A high dynamic range with allow for high Sensitivity of changes in earths magnetic field when compensating for hard iron and soft iron effects to the magnetic field.



Magnetometer Enablement

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

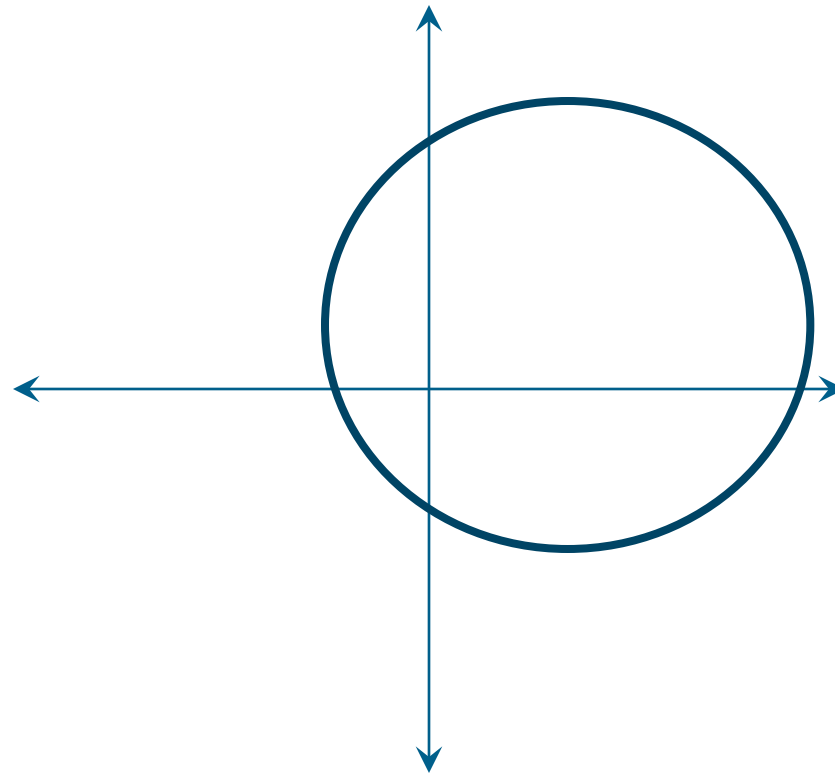
Rotating a perfect magnetometer without a distortion generates a perfect circle



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.

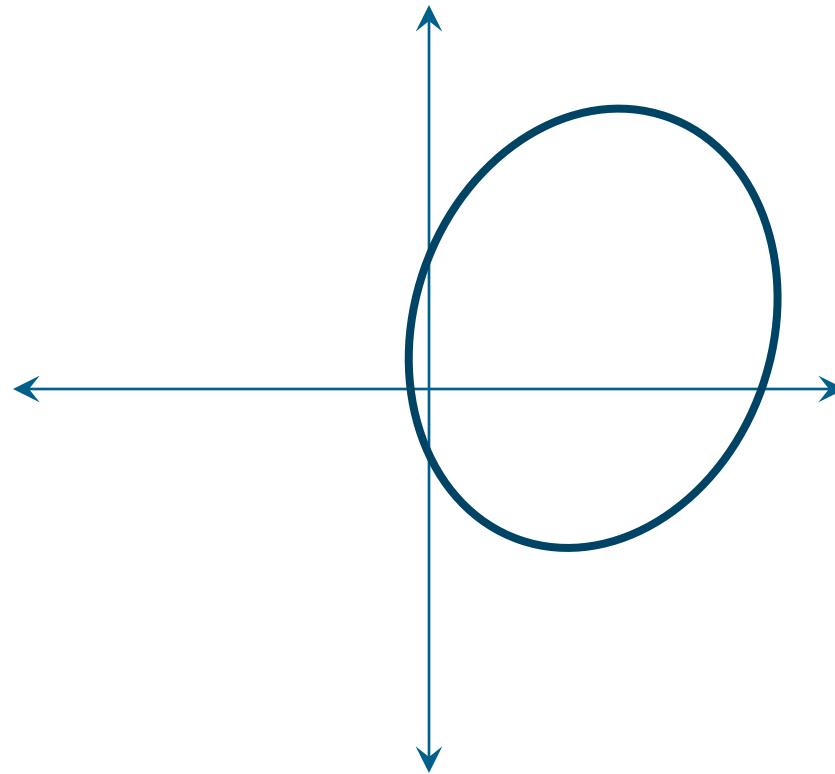
Offset and Hard Iron distortion change the center of the resulting circle



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

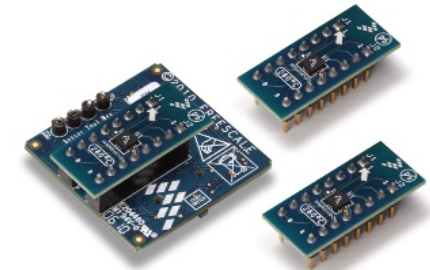


Sensor Toolbox Development Board

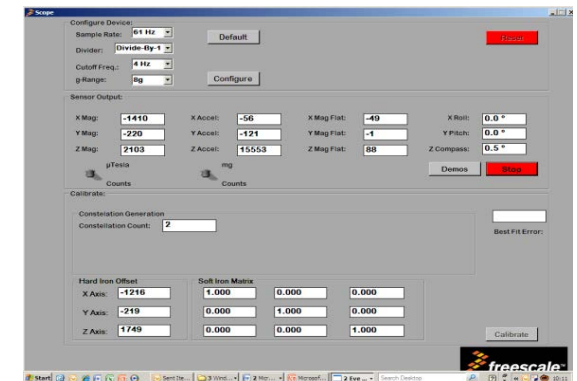
Extension to the Sensor Toolbox development suite with a accelerometer (MMA8451) and magnetometer (MAG3110) daughter card for magnetometer and 6DOF application evaluation.

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

▶ 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

▶ Xtrinsic Solution Board

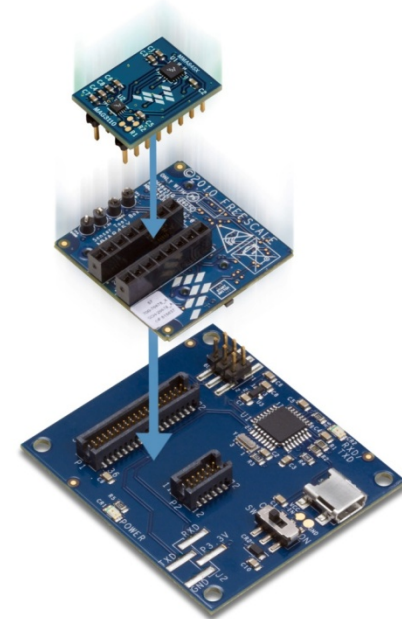
- Includes a MAG3110 magnetometer and MMA9550 Accelerometer and Smart Sensor development board
- Works with the USB communication board

▶ 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

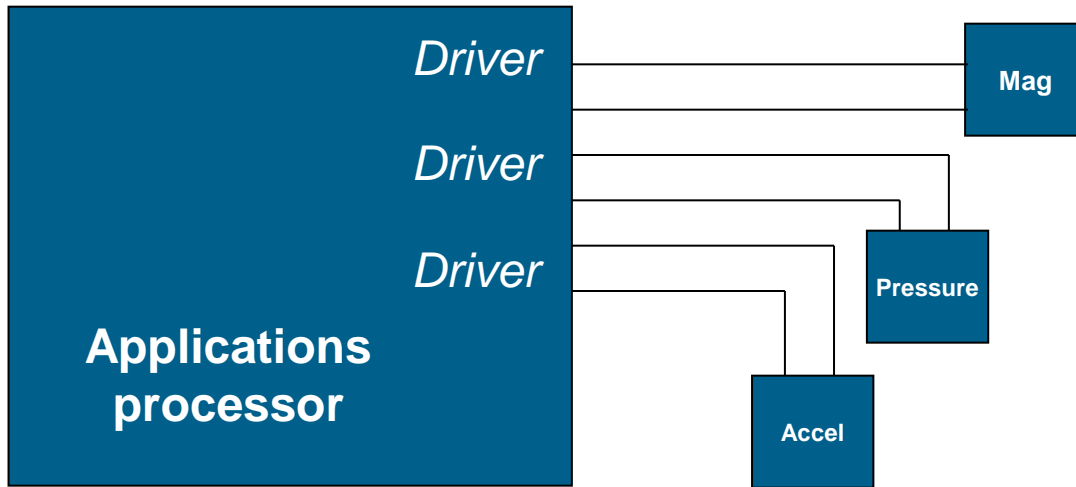
MPL3115 altimeter & Pressure sensors

Proximity sensors overview

Q & A



Sensors are Becoming Pervasive

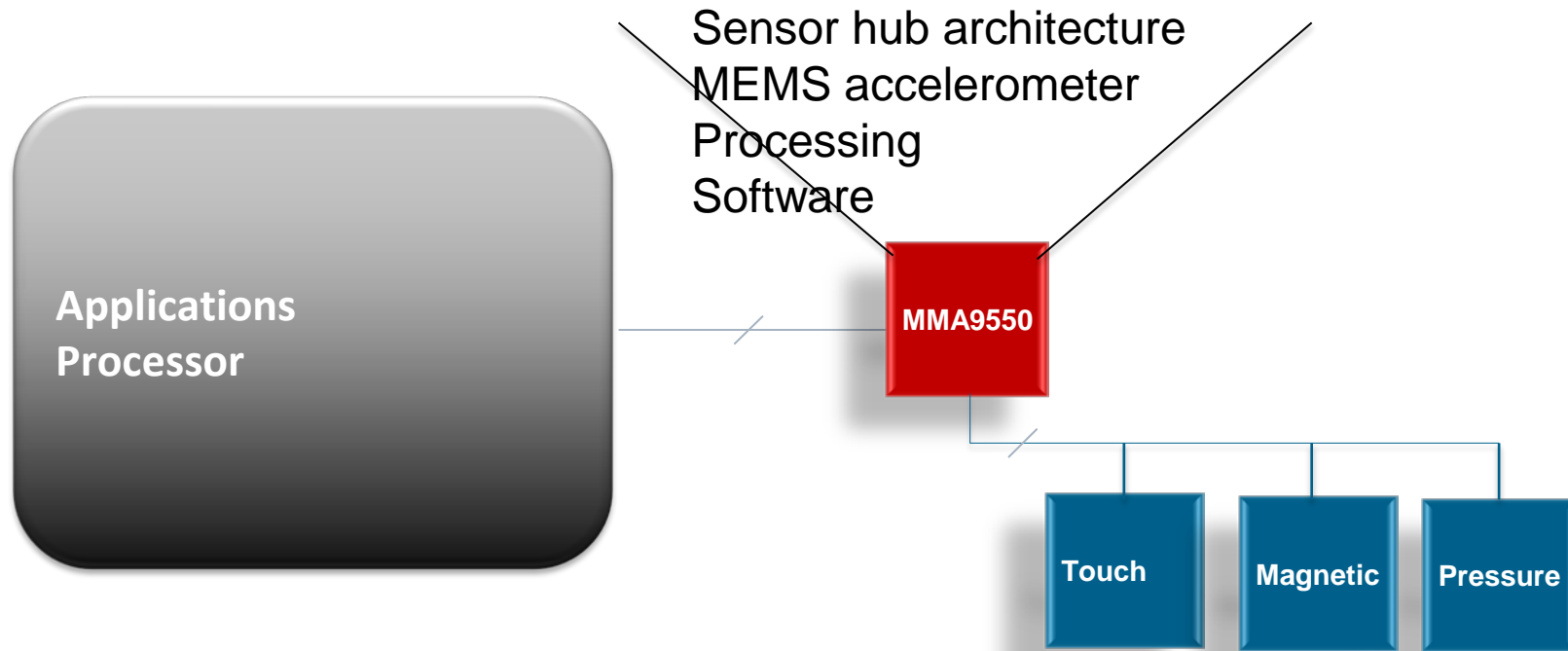


Example sensor system

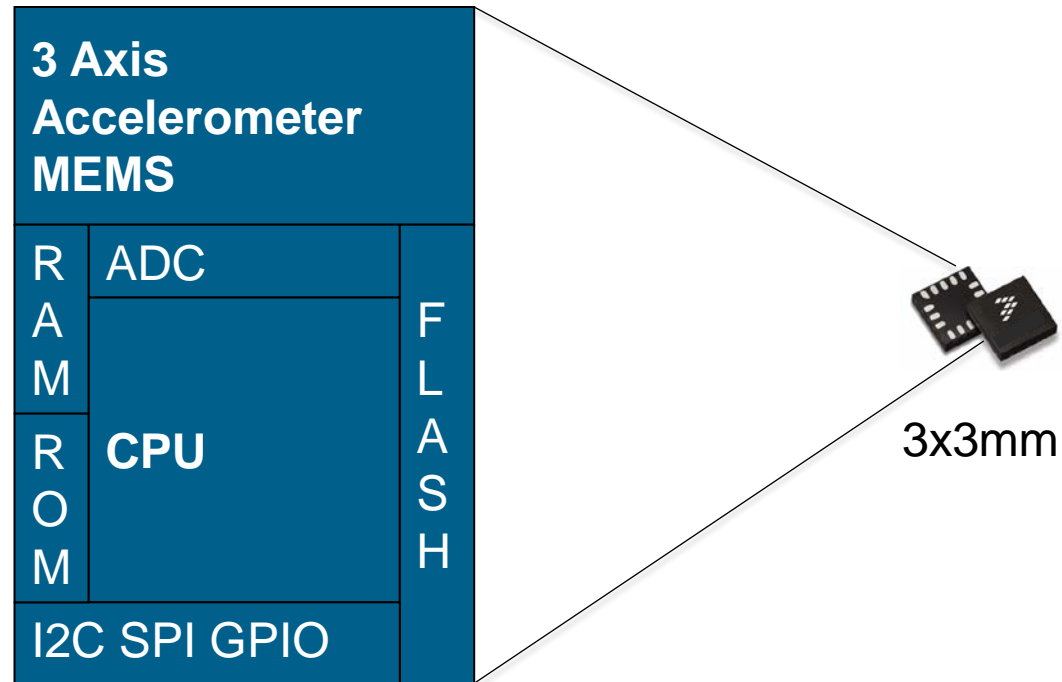
The upcoming challenges from the increasing number of sensors :

- 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

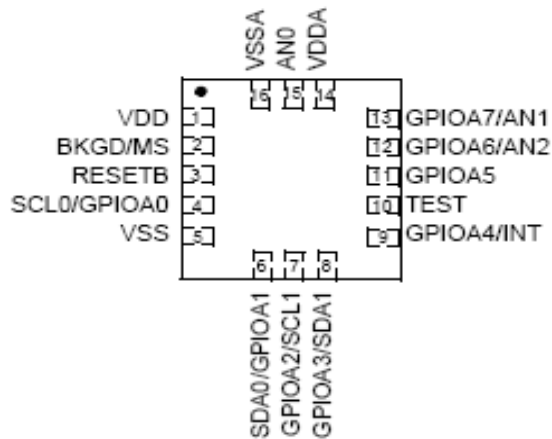


MMA9550L Specification Overview



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 (I²C 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 I²C and SPI
- ▶ Master I²C
- ▶ 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

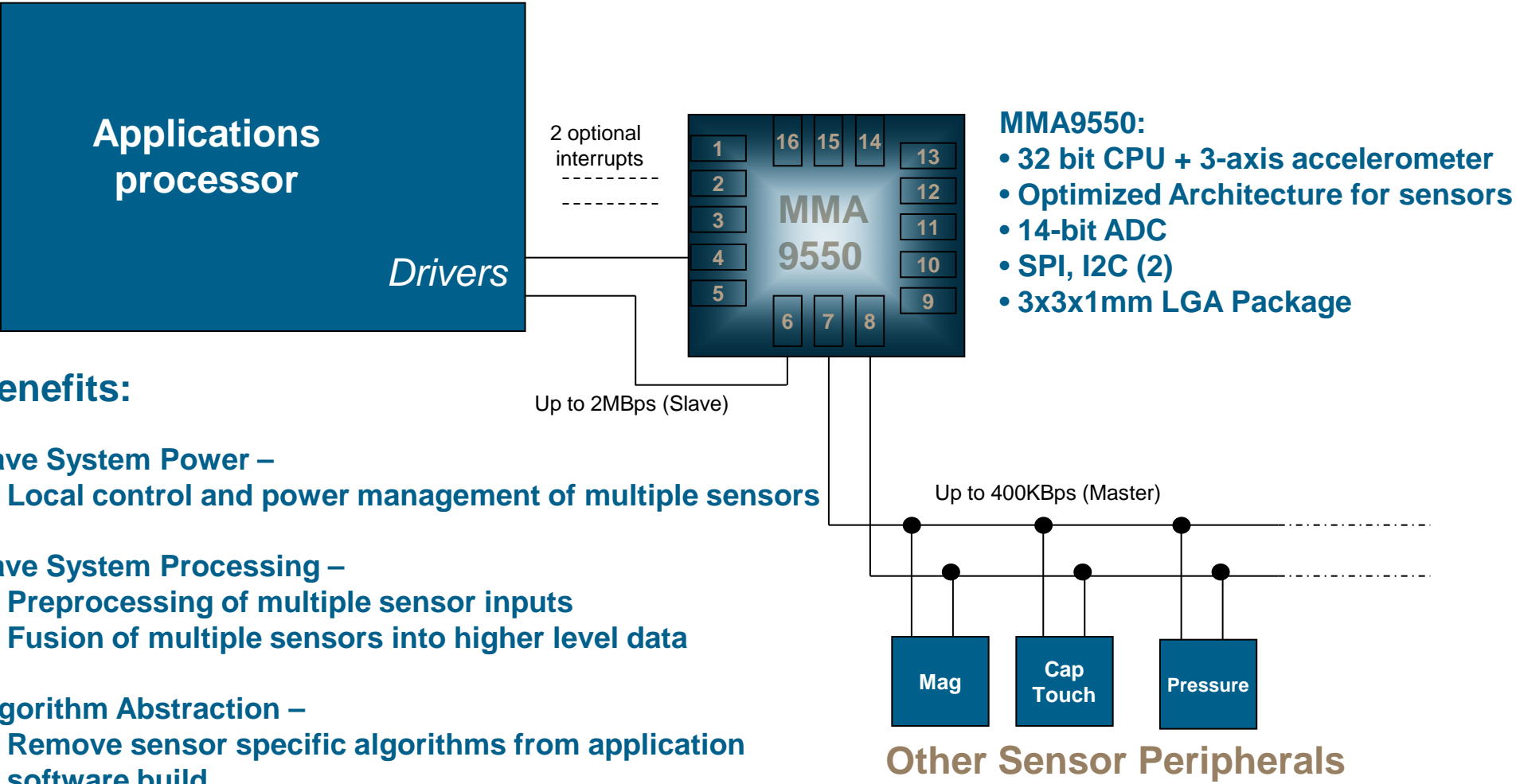


MMA955xL Family Schedule

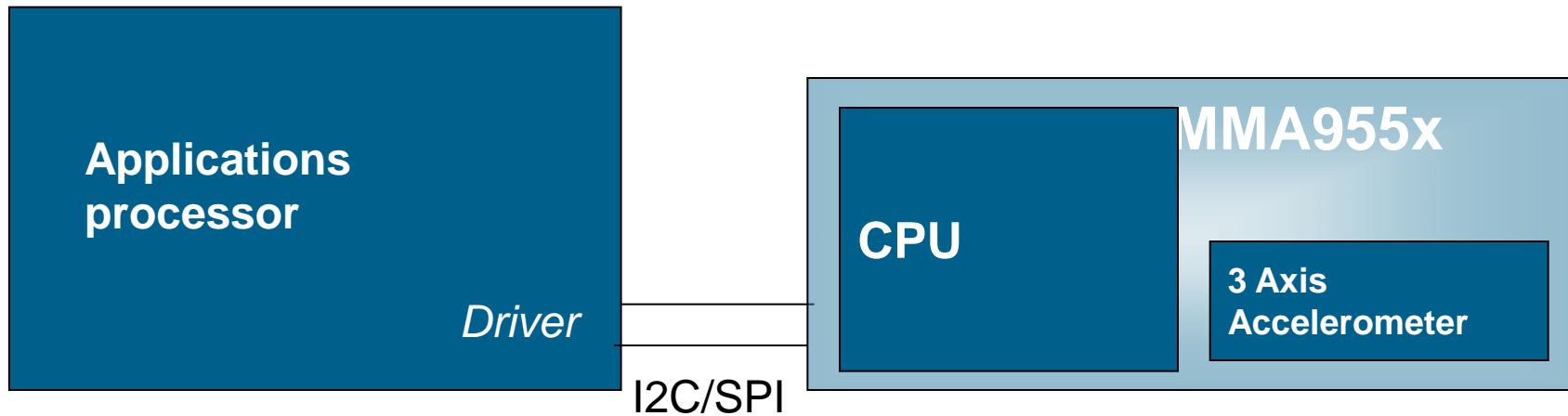
Products Major SW Releases	MMA9550 (Accelerometer) (Base)	MMA9551 (Base + Gestures)	MMA9552 (Base + Magnetometer)	MMA9553 (Base + Pedometer)
Production Release	Mar 2011	Mar 2011	End-2Q11	End-2Q11
Key Elements	Infrastructure only functions	Infrastructure + Gestures	Infrastructure + eCompass	Infrastructure + 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



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

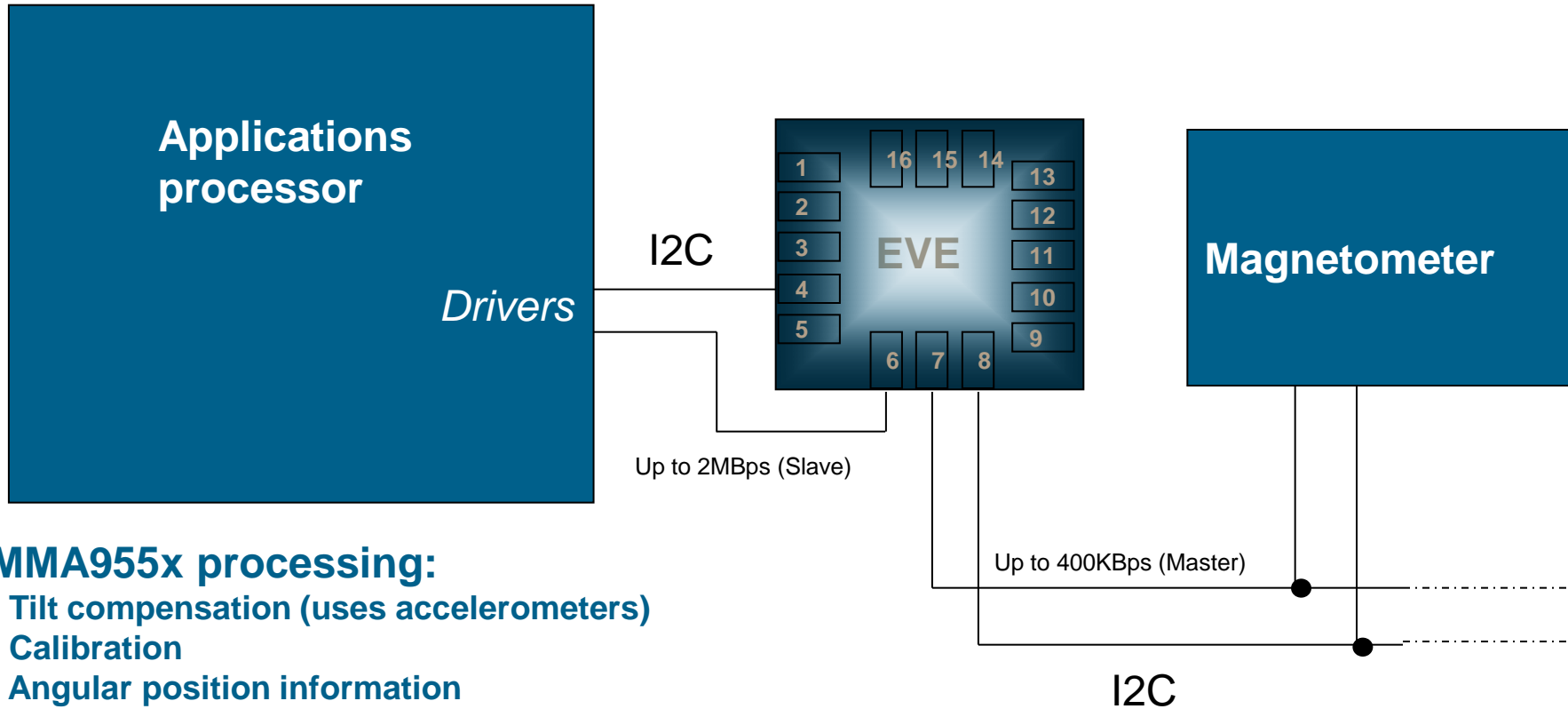
Save System Power –

- 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



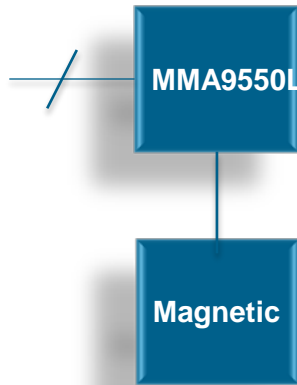
MMA955x processing:

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

MMA955x advantages:

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

eCompass: Comparison with a Standard Solution



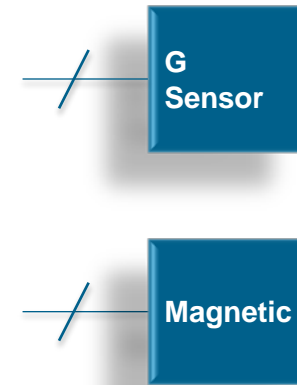
Only one digital interface

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

- ▶ 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

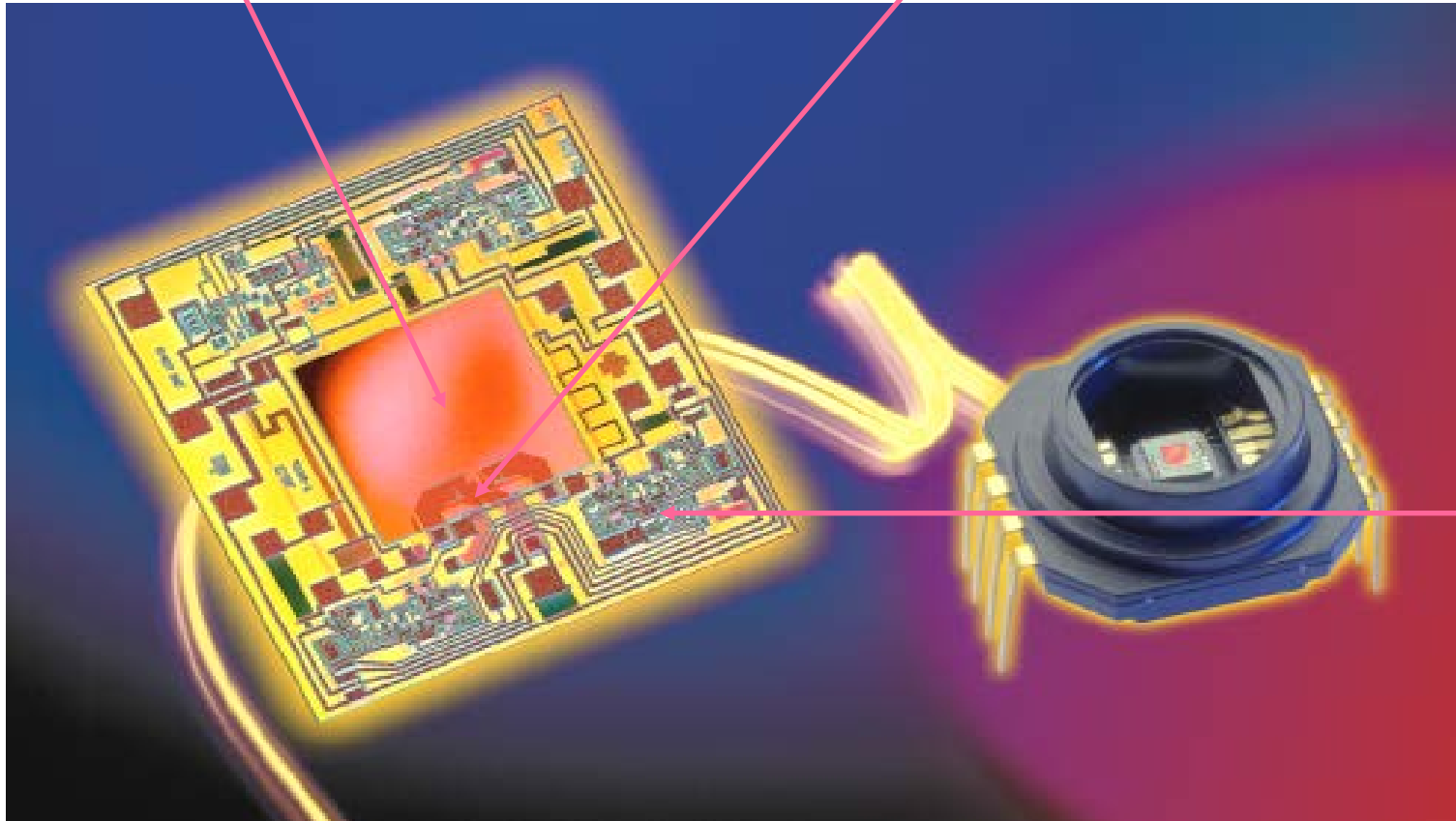
Proximity sensors overview

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

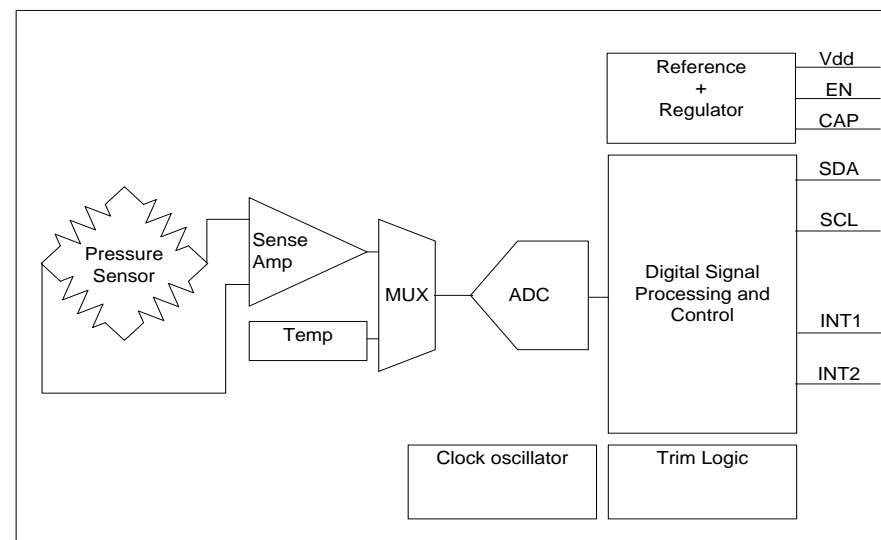
Barometer & Precision Altimeter

Digitized altitude/pressure and temperature

Fully compensated internally

- Cost Effective
- I²C interface slave device
- Low Power 1 μ A Sleep, 8.5 μ 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

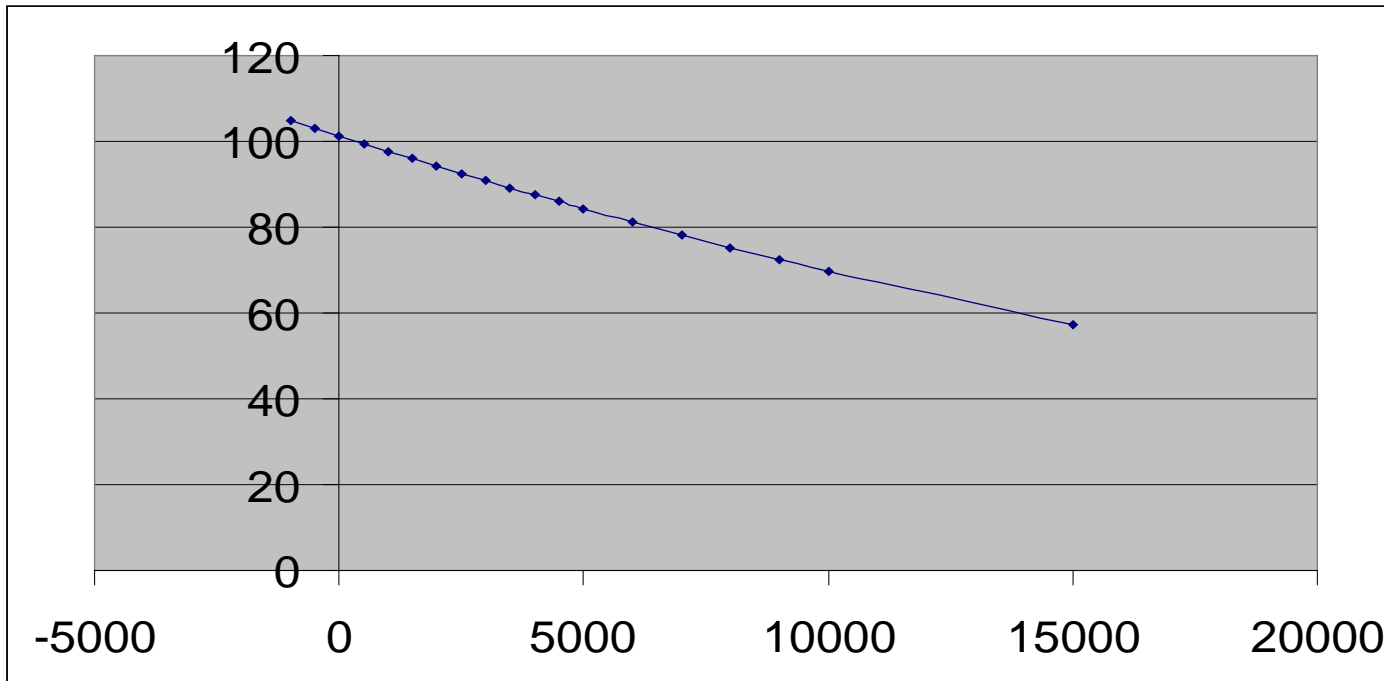


MPL3115 (10Ku resale : 1.63\$)	MPL115 (10Ku resale : 1.05\$)
High resolution: 25cm , 0.2 Pa rms noise	10 bit ADC 3m resolution
All compensation calculations internal, enabling alarm functions, minimizing needed host intervention	Internal coefficients, external calculation
Selectable data type: Altitude (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

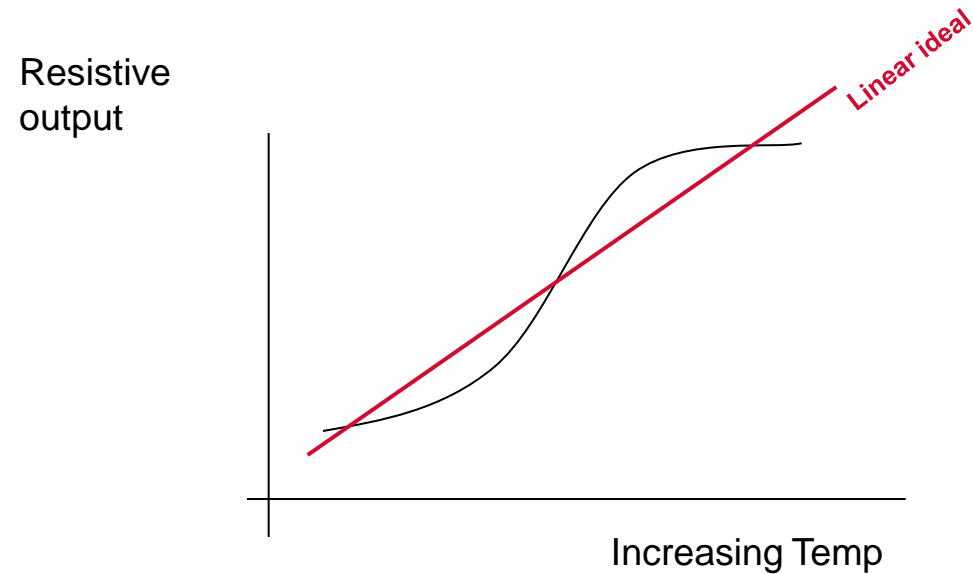
- ▶ To enable limit alarms, the following functions must be completed:
 1. Temperature Compensation
 2. Offset Calibration
 3. Scale Calibration
 4. Altitude Calculation

- ▶ 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 2nd Order Pressure Die.



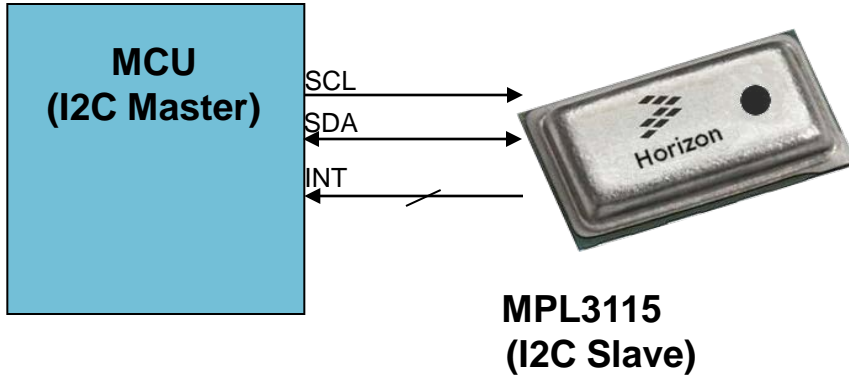
Second Order or higher curve

Cannot use simple trim resistors.

Need ASIC or MCU compensation.

Temperature compensation needed for high accuracy is not trivial.

MPL3115 – Interrupt Controller

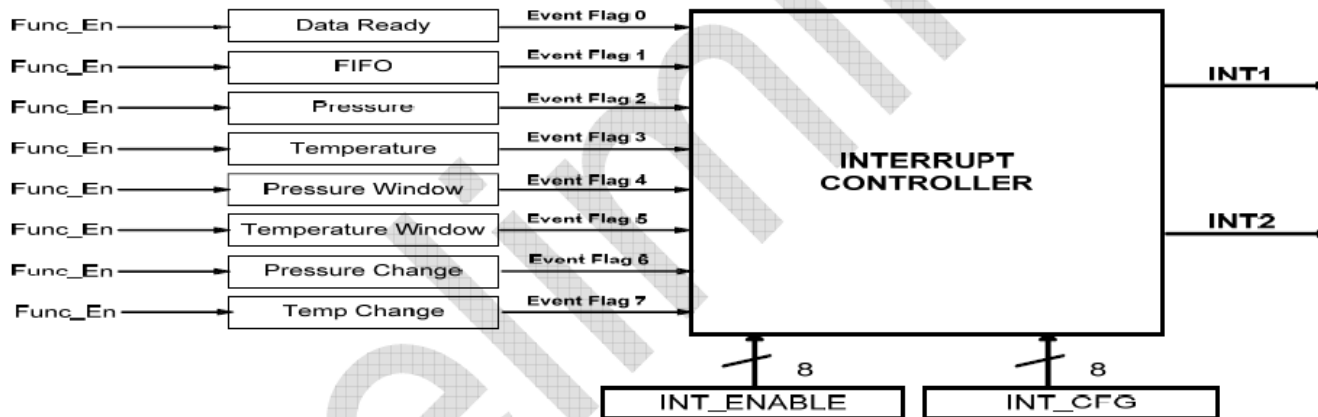


Slave responds by executing command or outputting Data

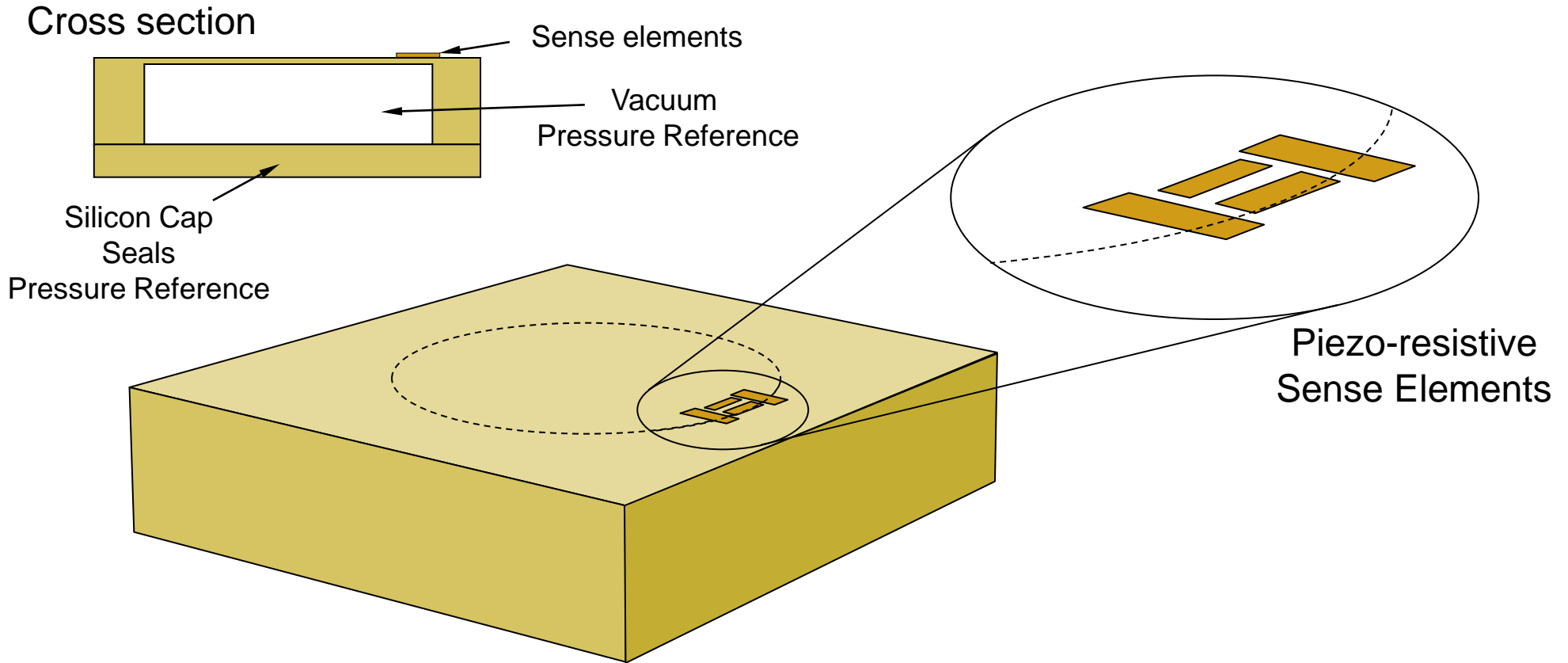
Horizon interrupt when programmed altitude exceed given value/window

Horizon interrupt when programmed temperature exceed given value/window

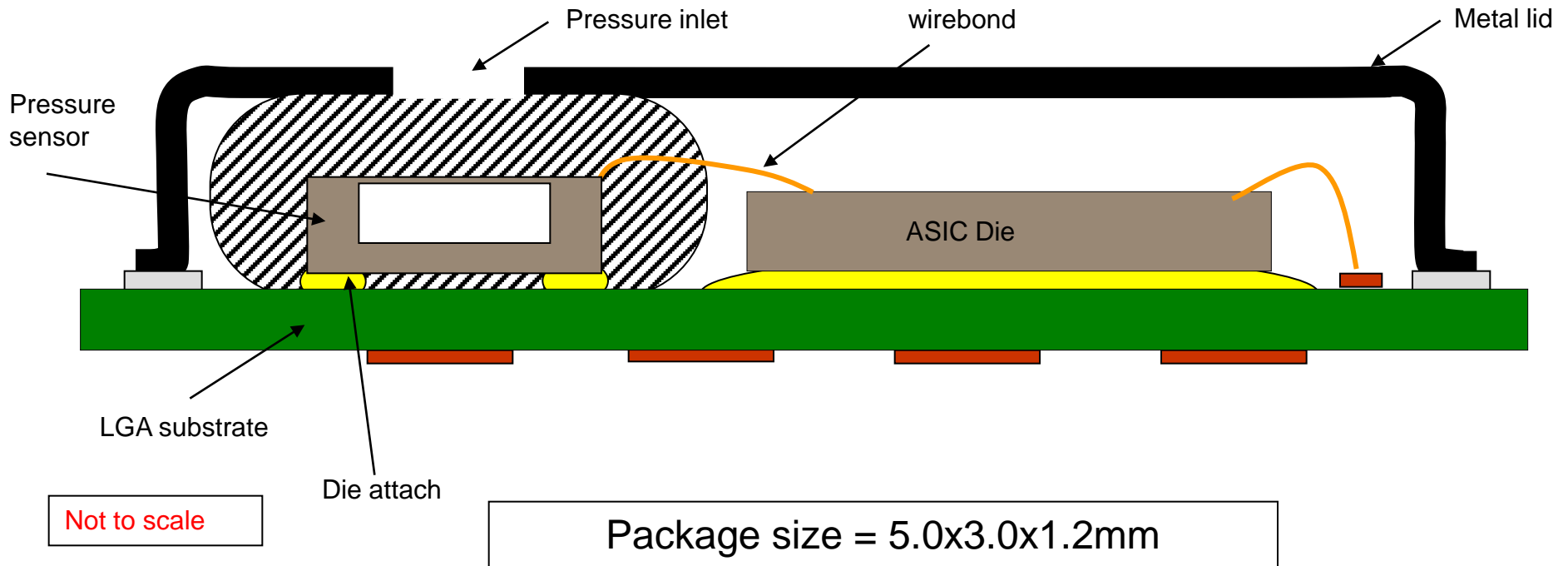
Horizon interrupt when programmed pressure exceed given value/window



Piezo-Resistive Absolute Pressure Transducer (PRT)



MPL3115A- Pressure Sensor Package



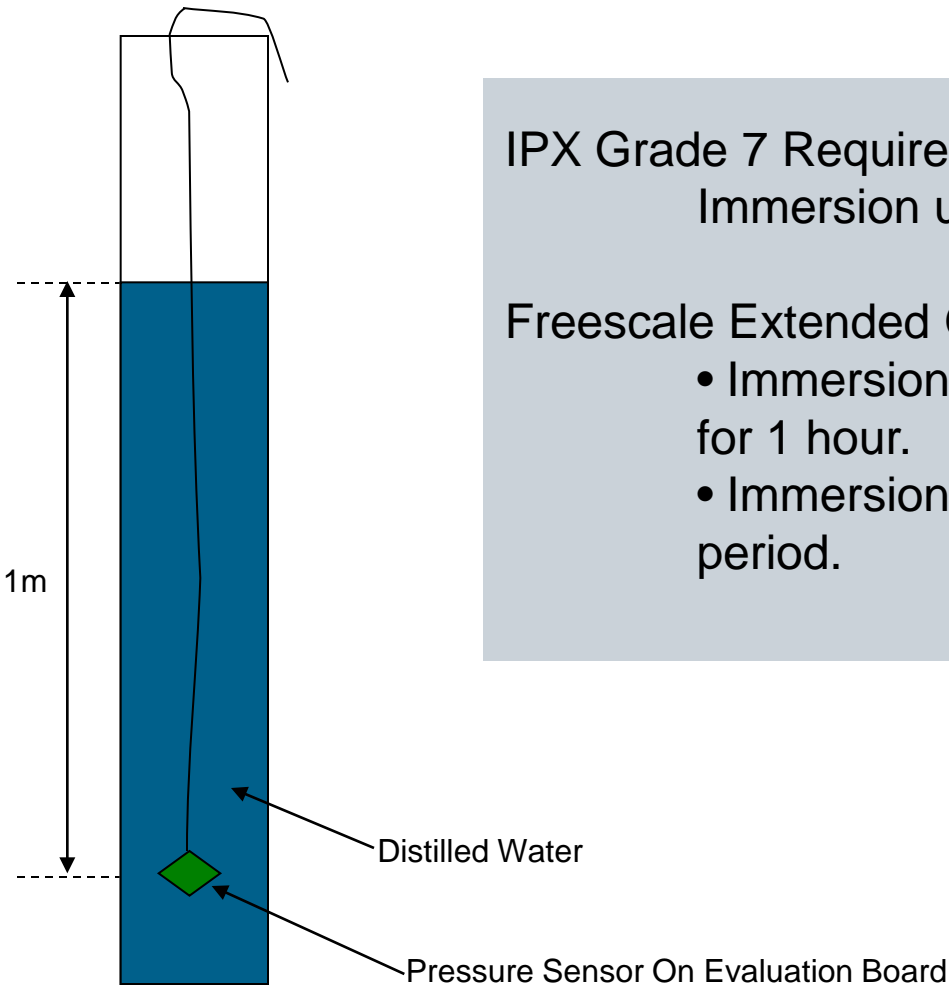
Water Resistance Tests

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

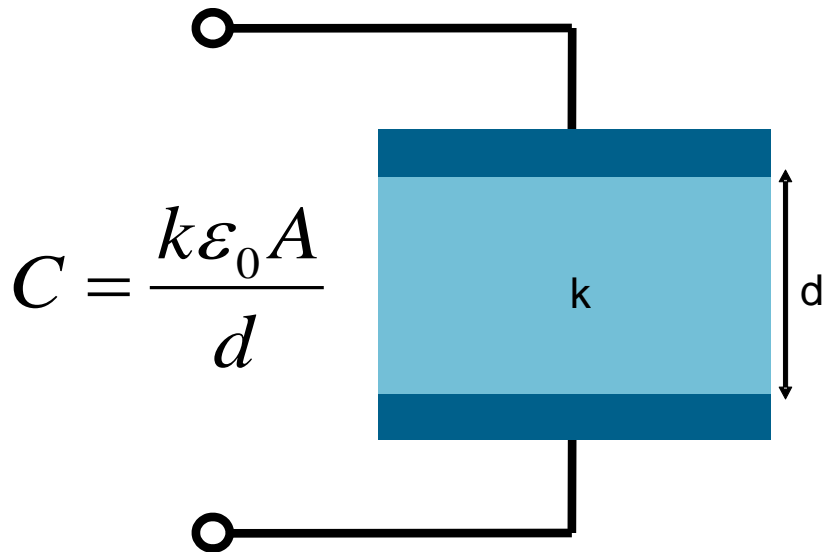
MPL3115 altimeter & Pressure sensors

► Proximity sensors overview

Q & A



Capacitor Model



C = the capacitance in farads (F)

A = the area of the plates in square meters (m²)

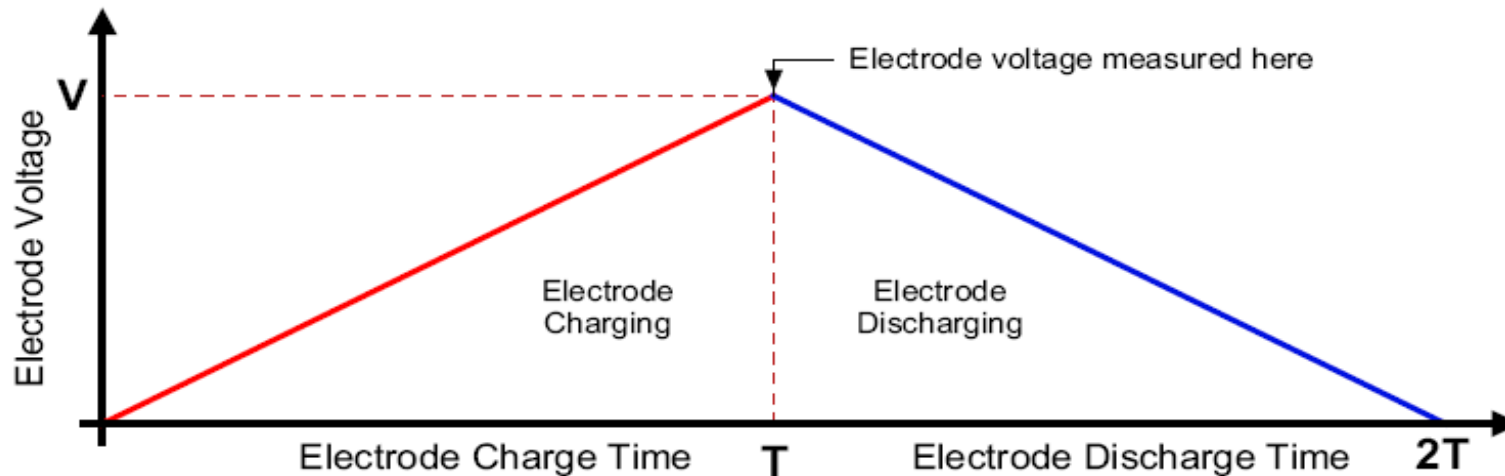
d = the distance between the plates in meters (m)

k = the dielectric constant of the material separating the plates

ϵ_0 = is the permittivity of free space (8.85 x 10⁻¹² 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 μ 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 μ A and 63 μ 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

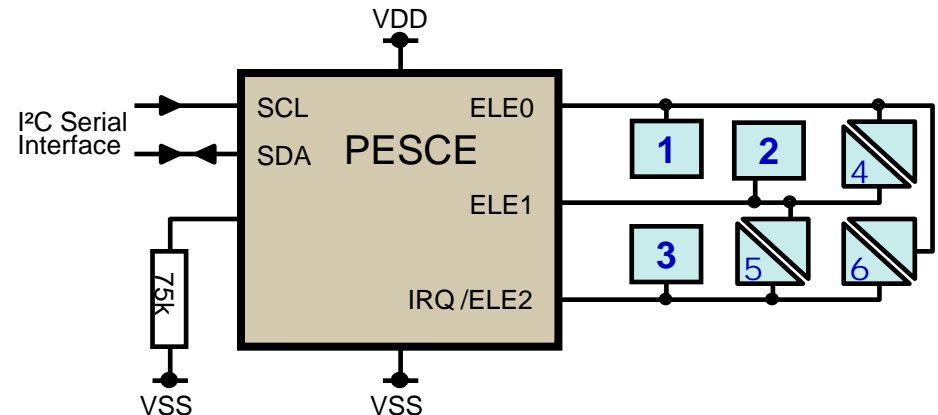
► Features

- 1.71V to 2.75V operation
- 14 μ A supply current (all 3 electrodes being monitored with 96ms response time)
 - -> Key feature – lowest supply current on the market
- 3 μ 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
- I²C 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 ² 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

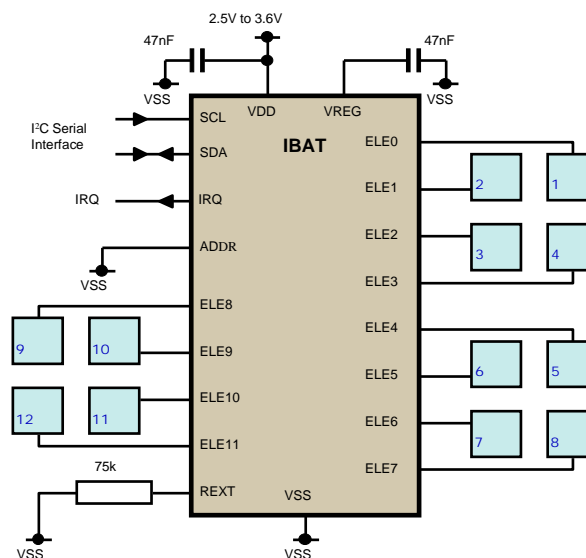
MPR121 Proximity Capacitive Touch Sensor Controller

Features

- 29 μA 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 μA 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

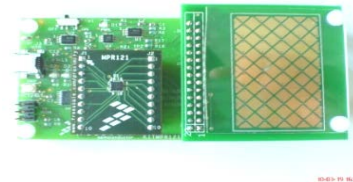
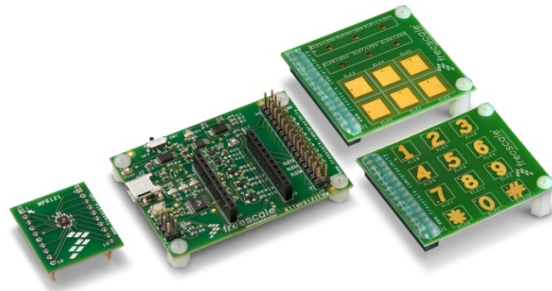
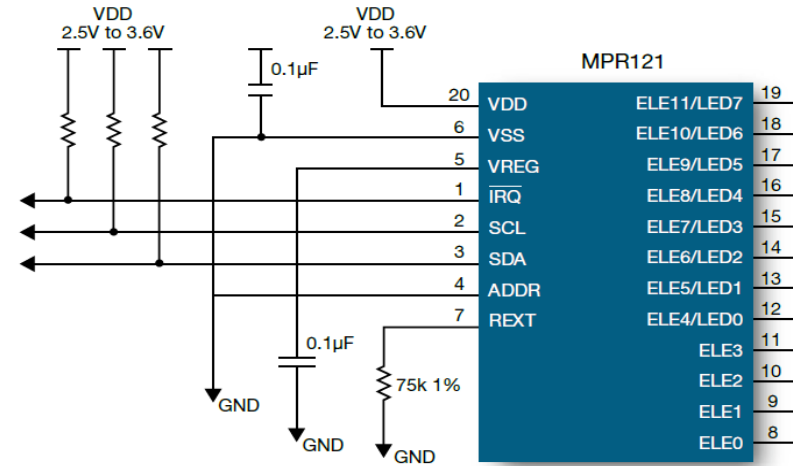
- Configurable I²C address
- New Auto-configuration system
- Continuous independent auto calibration for each electrode
- Separated touch & release threshold
- Debounce filter (jitter , false touch)
- 2nd generation filtering system
- Increased voltage range
- 100% independent electrode control



MPR121 Touch Pad Demo

Features

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- 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 μA maximum shutdown current
- 1.71 V to 3.6 V operation
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- 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 μ 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
- I²C 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: I²C, LIN, CAN, SPI, USB
- Have other peripherals working at the same time: LCD, LEDs, buzzer, ADC, other sensors, and more

