Freescale's Sensors for Low-Power Applications – WISH 2011

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Freescale Focus

Four **Product Platforms**

+ Software

Focused on **Growth Markets**

- Automotive
- Networking
- Industrial
- Consumer

Leveraging Three **Growth Trends**

- The Net Effect
- Health & Safety
- Going Green

Connect (RF)

Sense (Sensors)

Embedded Processing (MCU, MPU, DSP)

Control (Analog)

Software
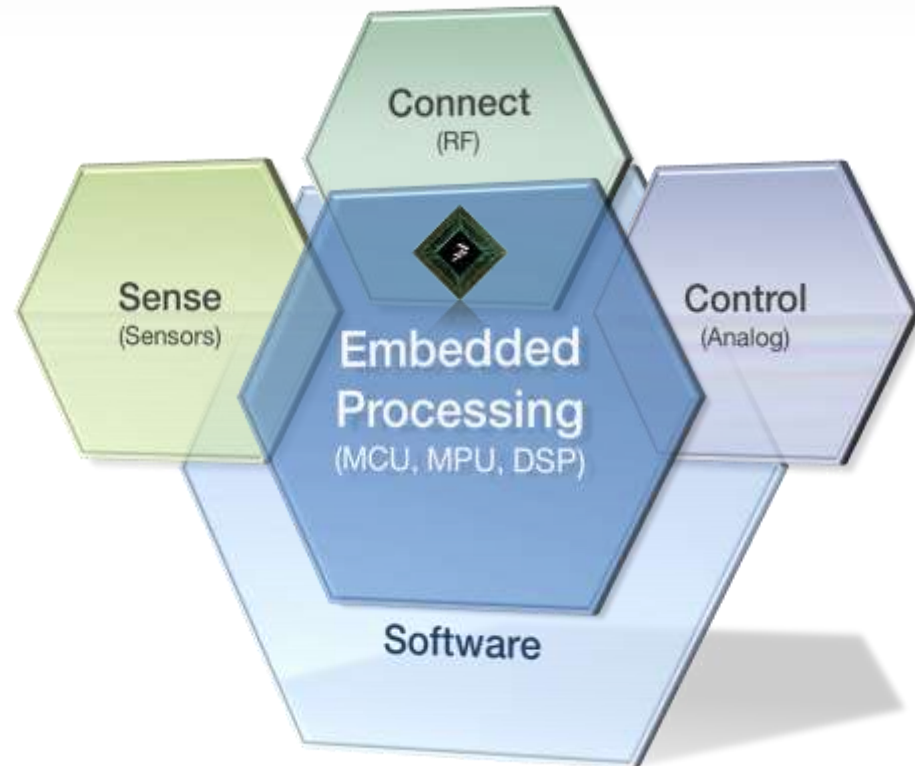
Over **One Billion** Freescale MEMS Devices Shipped Since June 2010

100 Million

200 Million

400 Million

800 Million

1 Billion Units Shipped

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

April 2009
MMA7660FC Intelligent 3-axis digital accelerometer introduced for advanced mobile phone interfaces

Late 1980's
Freescale begins developing the first surface micro-machined inertial sensors for the automotive airbag market

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

Nov. 2008
Synerject announces its ongoing use of Freescale pressure sensors for robust, cost-effective ECUs for two- and four-stroke engine management

1980
We manufacture our first uncompensated pressure sensor

30 Years of Commercial MEMS Design and Production Expertise

*iSuppli 2011

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Sensing at the Forefront

Slick UI

Reduced shake

Adapt to lighting

3D motion

eCompass

Touch screen

Reduced camera-shake

Adapt to lighting

3D Motion Point-to-control

Auto-wake

Gaming

Improved UI

Capacitive Touch

3D Motion

In-device Sensors

Body Area Sensor Network
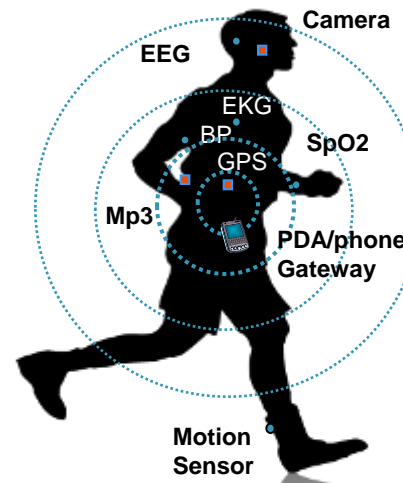
Sensor Enabled Sports Equipment

Camera

EEG

EKG

BP

GPS

SpO2

Mp3

PDA/phone Gateway

Motion Sensor

Bluetooth **ZigBee**

low energy

SMART SENSOR

Wireless Sensor Node/Network

INNOVATION

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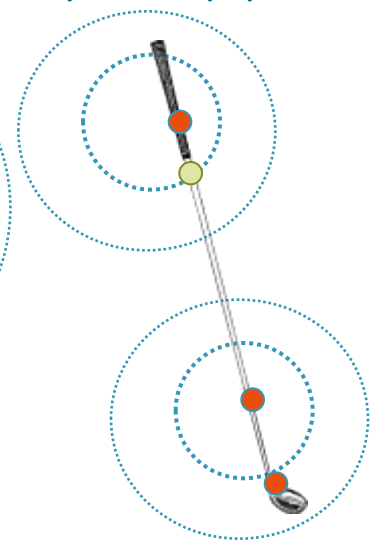
Sensors: Applications Trends

- Location-Based-Services

- Intuitive User Interface

- Augmented reality

- Consumer medical

- Wireless Sensor Networks (WSN)

- Automotive safety

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Freescale: A Platform For Smart Mobile Devices

Example: Tablet   = **Freescale solution**

**Mechanical
Or capacitive
Touch buttons**

**Watt Saver
AC adapter**

**Wireless
charging/docking
station**

SD
USB
HDMI
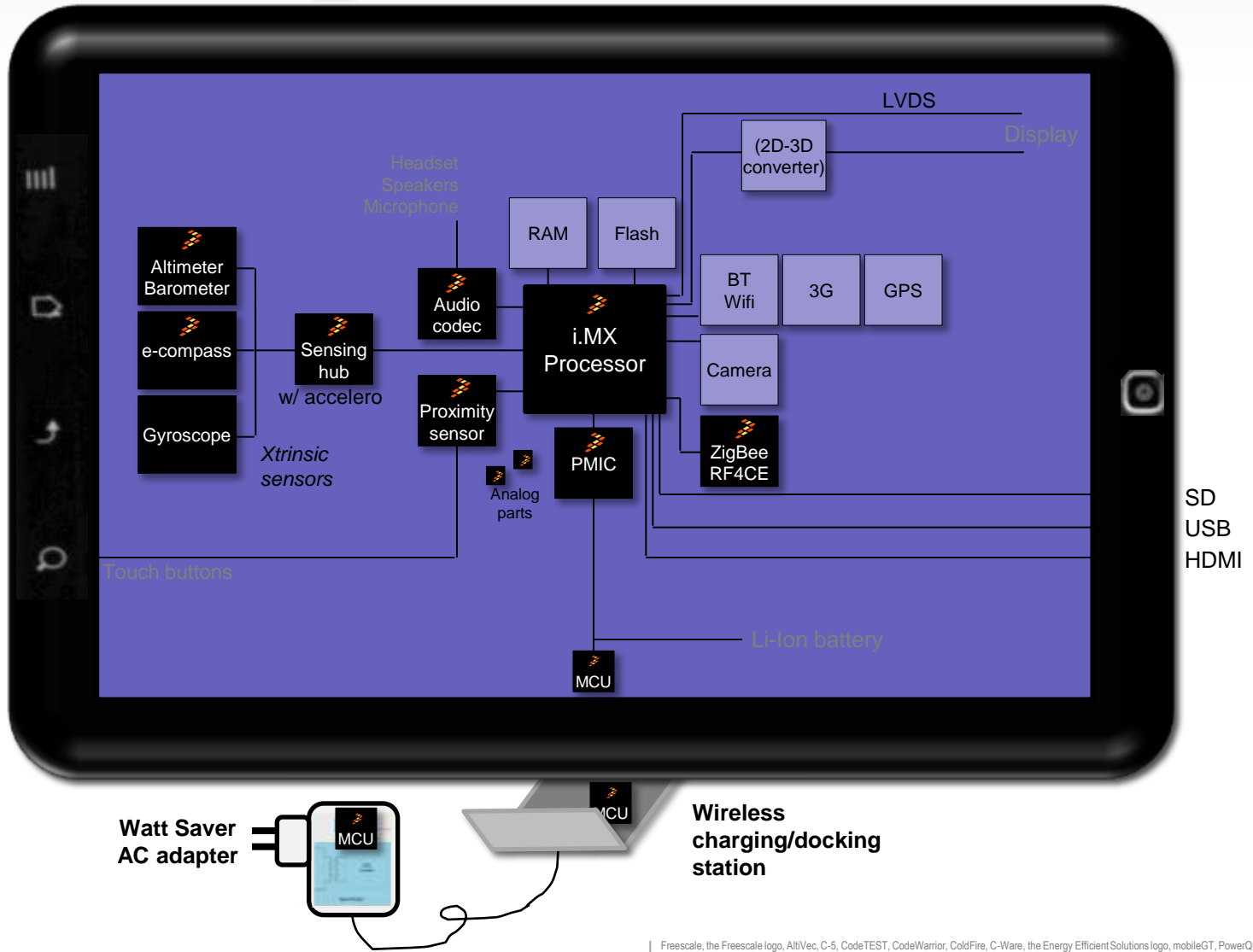
Freescale's Sensors Offer for Tablets & Mobile Applications
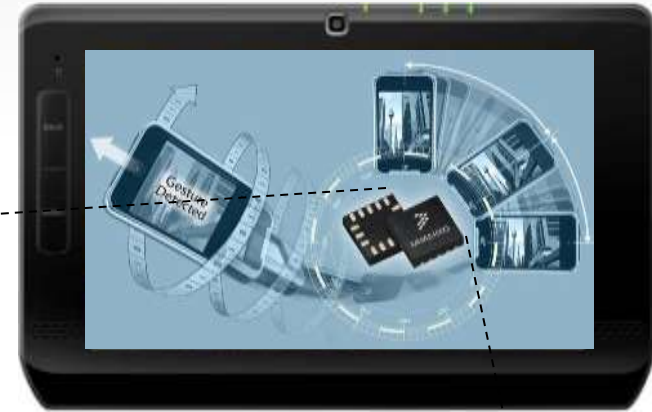
Accelerometer

Intelligent Motion Sensor Hub

ecompass

Magnetometer

Capacitive touch

Temperature

Barometer Altimeter

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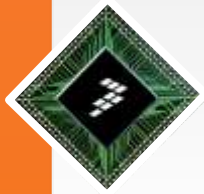# Sensor portfolio Highlights for improved user interface and navigation

Accelerometers:

– Wide portfolio 8 to 14bit accuracy, less than 99µg/√Hz noise, down to 6µA and smart features dedicated to phone use cases – *MMA7660, MMA845x*

Magnetometer

– 0.1µT accuracy, ODR up to 80Hz, 24µA @ 1.25Hz in a 2x2 package – *MAG3110*

Pressure sensors:

– Low-power, high precision barometer and altimeter - *MPL3115A2*

Capacitive touch

– Very low-power and up to 12 multiplexed capacitive touch – *MPR031, MPR121*

Intelligent Sensor Hub:

– First dedicated microcontroller embedded with accelerometer

– Specific architecture for sensor fusion: Saving system power consumption – *MMA955x*

Xtrinsic MMA845xQ 14/12/10-bit 3-axis Accelerometer Family
Low Power High Level of Embedded Function

- 3-AXIS DIGITAL
- 14-BIT 8-BIT
- 2,4,8g
- AUTO WAKE
- POWER SELECT
- SYSTEM POWER SAVE
- HIGH PASS FILTER
- 32 SAMPLE FIFO
- SLEEP
- AUTO SLEEP
- TILT orientation
- TAP 2TAP detection
- MOTION threshold
- FREE FALL detection
- TRANS-IENT detection

TAP – Compass ON

30.567087° N   114.269455° E

MMA8451Q 14-bit

MMA8453Q 10-bit

In production Since Sept. 2010

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Product focus MMA8451Q Digital Accelerometer

FUNDAMENTALS

3-AXIS DIGITAL	14-BIT 8-BIT	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	AUTO WAKE	POWER SELECT	SYSTEM POWER SAVE
	No motion timer	*motion*	*1.563-800 samples/s*	*INTERRUPT on EMBEDDED EVENT*

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MMA845Q – 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

Function: → 1.9V to 3.6V supply voltage
→ ODR up to 800Hz
→ All the power modes and features like the MMA8450Q

Benefits: → Wide power supply range
→ Combining most advanced features with the lowest power
→ One platform with very low-power (down to 6 µA) good (8-bit) to high accuracy (14-bit, 99µg/√Hz), and rich features (FIFO, embedded functions…)

Applications:
→ High accuracy gesture recognition
→ Pedestrian navigation
→ Gaming
→ Image stabilization

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Features and Benefits

Accelerometer Product Feature Comparison

Feature	MMA8451	MMA8450	MMA8452	MMA8453	Benefit
Digital Capability					
Supply Voltage	1.95 – 3.6	1.79 – 1.89	1.95 – 3.6	1.95 – 3.6	Wider Supply voltage to support various applications
Resolution	14	12	12	10	Higher Resolution for more precise applications
Idd Consumption	Standby: 2 uA Normal:25-175 uA Low power: 4-175uA	• Shutdown: <1 uA • Standby: 3 uA • Normal: 42-300 uA • Low power: 27-133 uA	Standby: 2 uA Normal:25-175 uA Low power: 4-175uA	Standby: 2 uA Normal:25-175 uA Low power: 4-175uA	Lower power for significant battery savings at all ODRs
Output Data Rate	1.563-800 Hz	1.563-400 Hz	1.563-800 Hz	1.563-800 Hz	Increased bandwidth to support various applications
Embedded Features					
Orientation Detection	Yes	Yes	Yes	Yes	Fast UI Response
Embedded FIFO Buffer	Yes HPF data	Yes No HPF data	No	No	Reduced I2C bus traffic System power savings
Tap Detect	Tap/Double Tap Directional Tap	Tap/Double Tap	Tap/Double Tap Directional Tap	Tap/Double Tap Directional Tap	Fast UI Response System Power Savings
Shake Detect (Motion or Transient)	Shake Directional Shake	Shake	Shake Directional Shake	Shake Directional Shake	Fast UI Response System Power Savings
High Pass Filter	Yes	Yes	Yes	No	Reduced System Cycle time
Auto-wake/sleep	Yes	Yes	Yes	Yes	System Power Savings

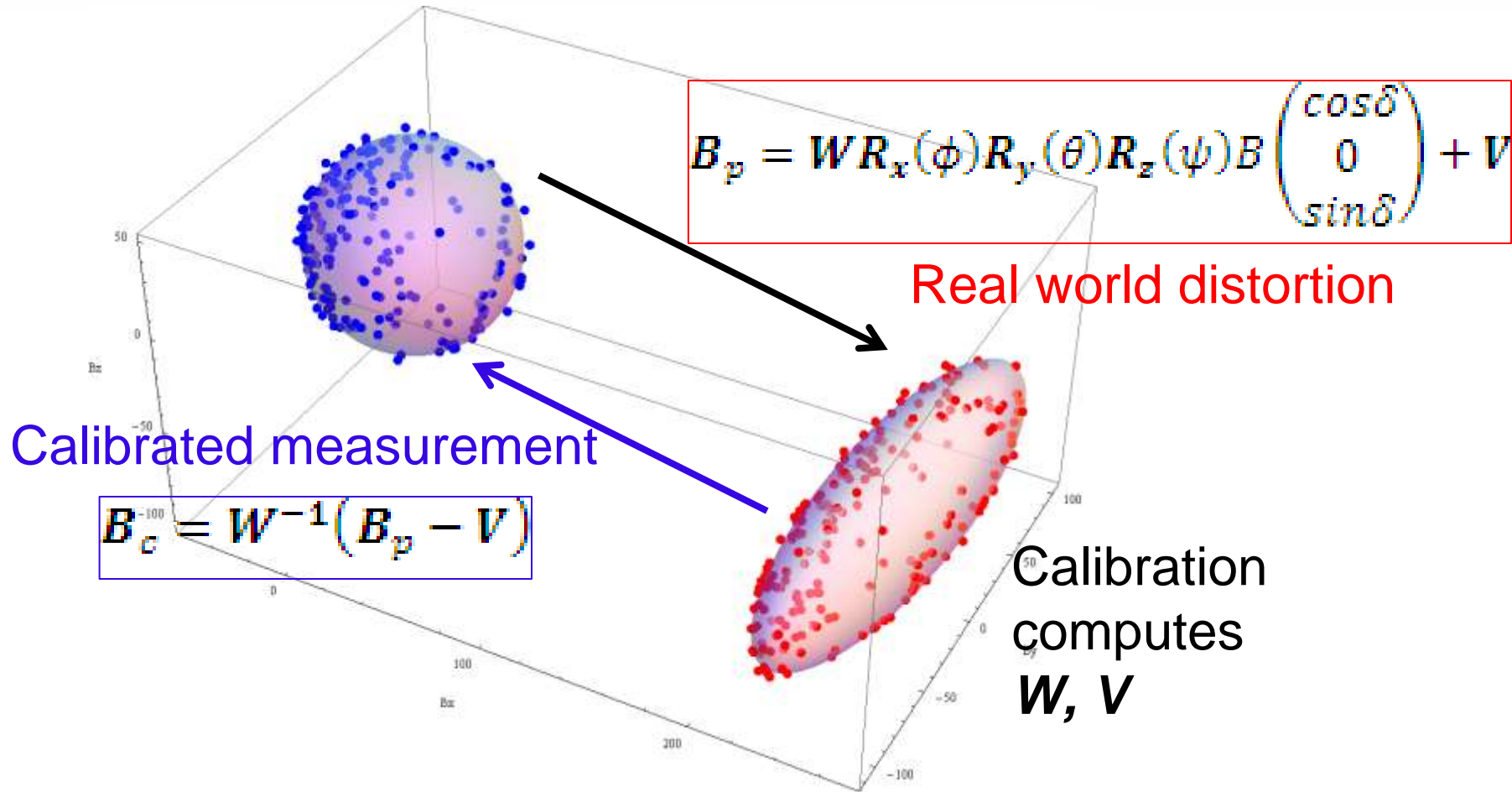# MAG3110 Magnetic Sensor Details

Features

- High resolution in full dynamic range: 0.1 μT

- Lowest noise

- Low power consumption:
  24 μA at 1.25 Hz in normal mode

- Selectable Output data rate (up to 80 Hz)

- I^{2}C interface at 400 kHz

- Supply voltage: 1.95 to 3.6 V

- Small 2 x 2 x 0.8 mm 10-pin μDFN package

In production

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MAG3110 Hard & Soft iron Calibration

$$B_p = WR_x(\phi)R_y(\theta)R_z(\psi)B\begin{pmatrix} \cos\delta \\ 0 \\ \sin\delta \end{pmatrix} + V$$

Real world distortion

Calibrated measurement

$$B_c = W^{-1}(B_p - V)$$

Calibration computes *W, V*

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MPL3115A2 High Precision Digital Barometer & Altimeter

- I2C digital output interface (operates up to 400 kHz)
- Altitude resolution: less than 1 foot/0.3m
- Pressure resolution: 1.5 Pa
- **Internally compensated**, direct reading (up to 128Hz):
    - 20-bit pressure measurement (0.25 pascal/LSB)
    - 20-bit altitude measurement (0.0625 meter/LSB)
    - 12-bit temperature measurement (0.0625 °C/LSB)
- **Low current consumption:**
    - Standby mode: 2 µA
    - Low-power mode: 8.5 µA at 1 Hz
- **On-board intelligence:**
    - Integrated Altitude Computation based on Pressure and Temperature (NASA standard atmosphere model)
    - Two highly configurable interrupt pins to auto-wake Host MCU on Programmable events (minimum/maximum and threshold detection, data ready, Fifo watermark, etc…)
    - Autonomous data acquisition with programmable rate and averaging
    - Embedded 32 samples FIFO buffer
- Supply voltage: 1.95V to 3.6V (1.6V to 3.6V for digital I/O)
- 50kPa to 115kPa absolute pressure range, -40°C to +85°C operating temperature
- Low-profile 3 x 5 x 1.1 mm LGA package

Samples now
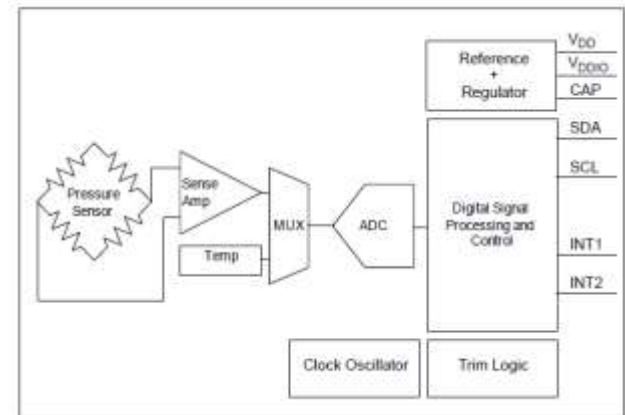
MPL3115A2 Measurement with Demo GUI

# 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
- -40 C to +85 C operating temp range

Feature Improvements
- **New Auto-configuration system**
- **2nd generation filtering system**
- **Increased voltage range**
- **100% independent electrode control**

Launched since Dec 09 In Production
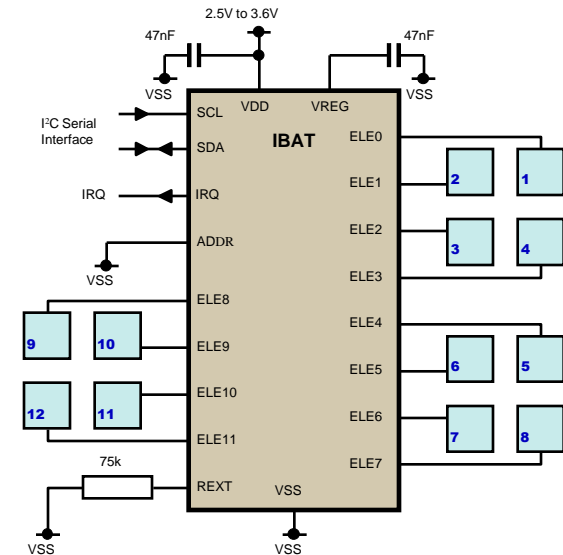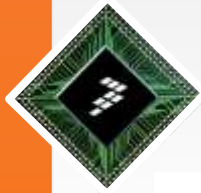
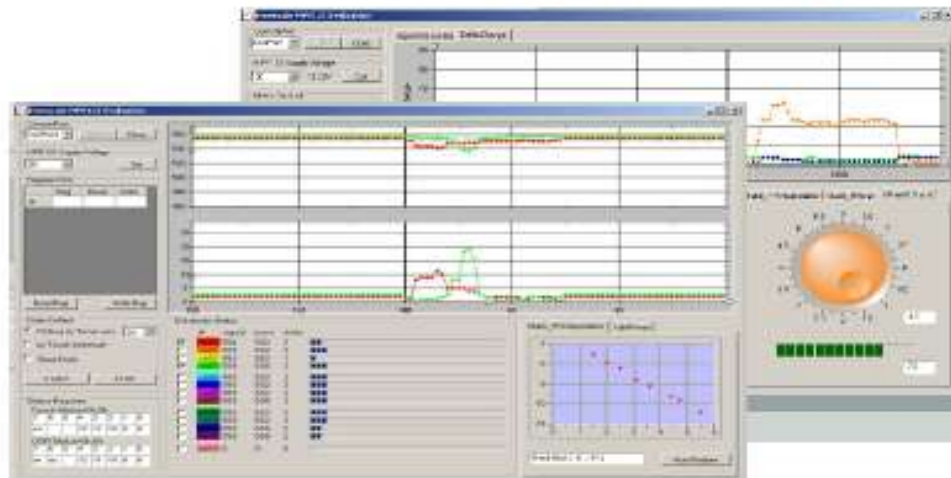# MPR121 Demo and Evaluation Kit

- MPR121QFN to DIP transfer board

- On board I2C to UART to PC USB bridge

- Provide basic electrode sets

- Provide other electrodes upon request

- Can connect with customer touch proto board

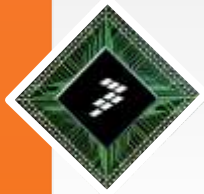- Provide PC GUI for easy evaluation and demo

Basic sets

Customer electrode board

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Limitations of Existing Sensors

- Adapting system to specificity of each new sensor types

- Level of complexity to implement more sensors

- Sensor data aggregation

- Power consumption of the system is increasing by adding more sensors
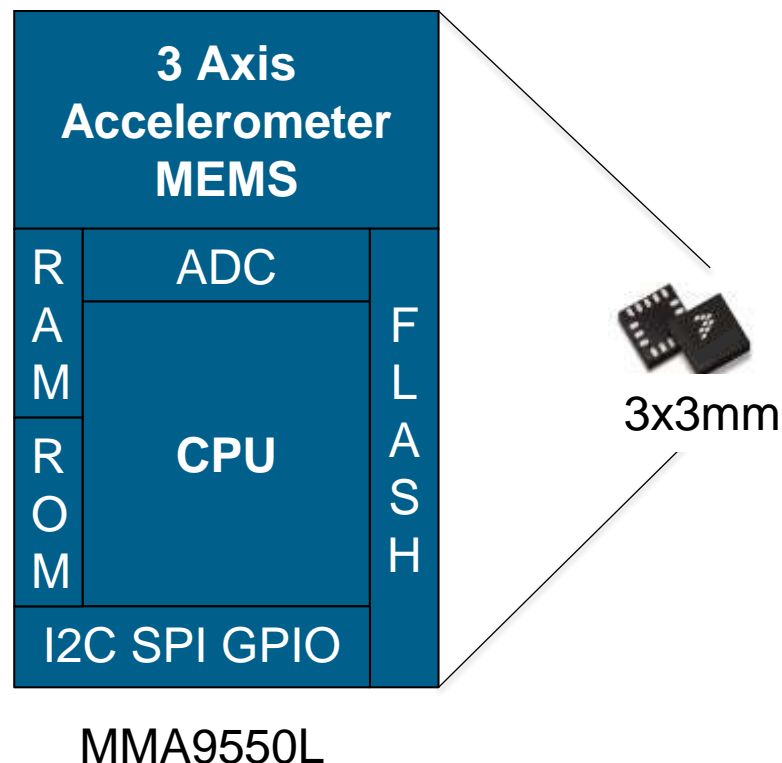
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MMA9550L
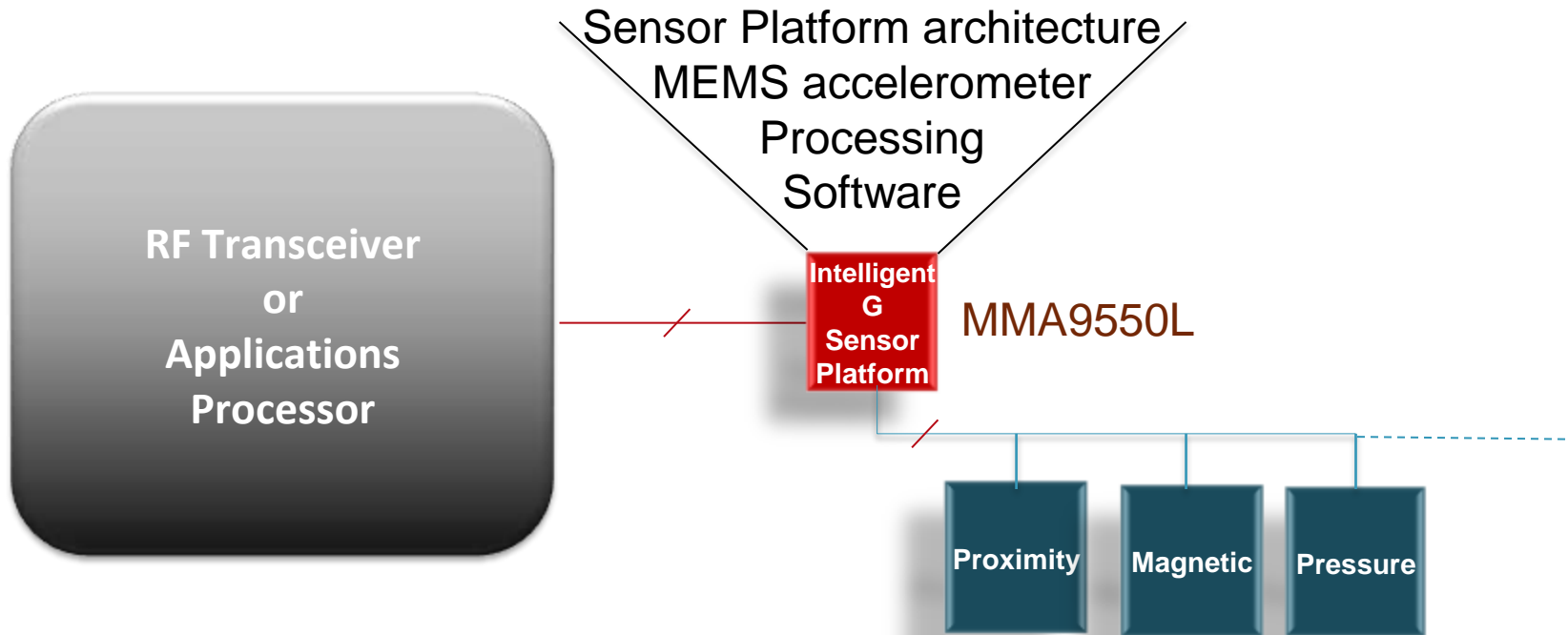## "Intelligent High Precision Motion Sensing Platform"

Intelligent Motion Sensor

- MEMS (3-axis accelerometer)

- ADC

- 32-bit microcontroller

- Flash

- RAM

- ROM

- SPI, I2C interfaces

- PWM (Pulse Width Modulation)

- GPIOs

3x3mm

MMA9550L

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MMA9550L: Intelligent Sensor Platform

RF Transceiver
or
Applications
Processor

Sensor Platform architecture
MEMS accelerometer
Processing
Software

Intelligent
G
Sensor
Platform

MMA9550L

Proximity
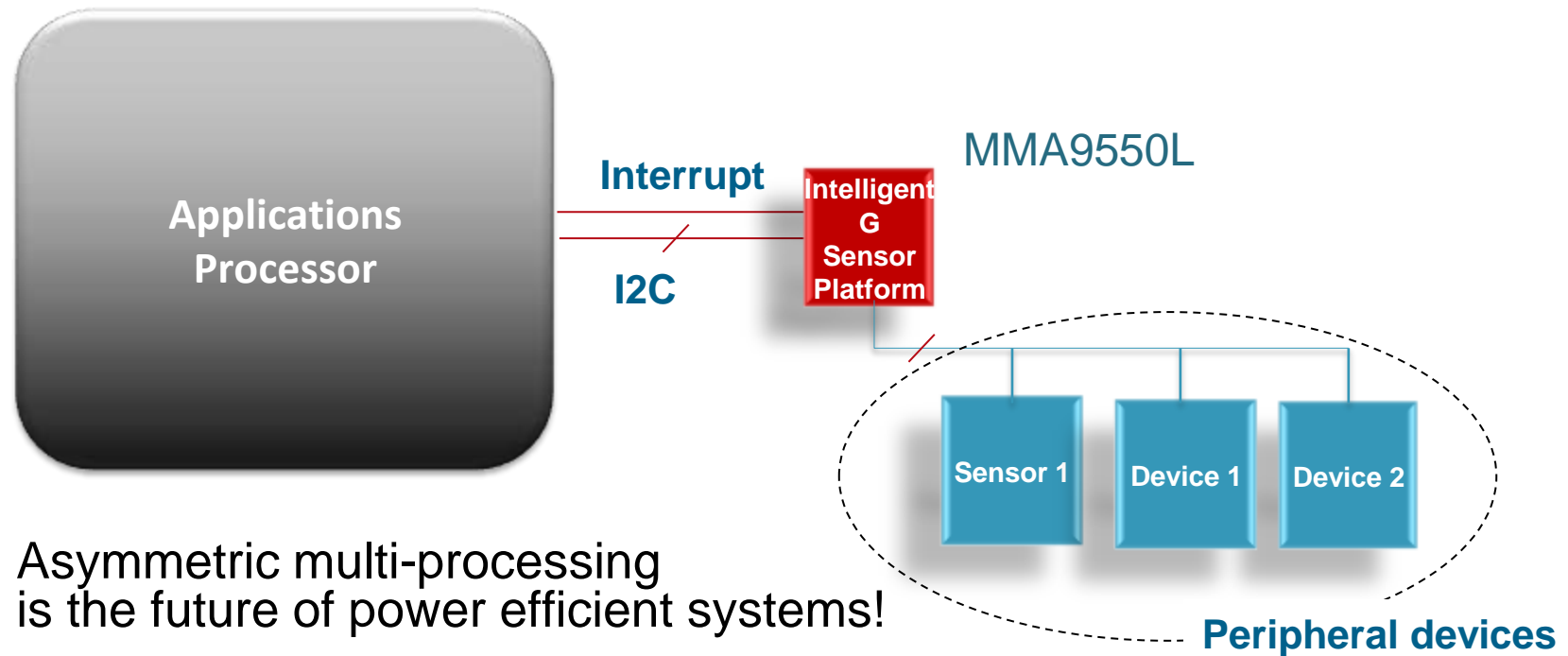
Magnetic

Pressure

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Example: More than 90% System Power Saving

- Automatic wake-up and sleep mode
- Detect any user or device activity/no-activity
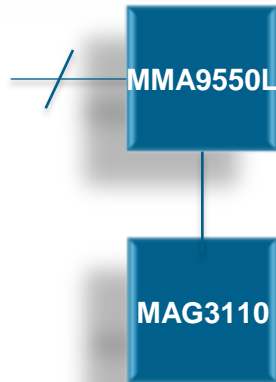
12mA in low-power mode   **~100μA**

MMA9550L

Applications Processor

Interrupt

I2C

Intelligent G Sensor Platform

Sensor 1   Device 1   Device 2

Peripheral devices

- Asymmetric multi-processing is the future of power efficient systems!

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eCompass: Comparison with a Standard Solution

MMA9550L

MAG3110

MMA845x

MAG3110

Only one digital interface

One set of drivers

Embedding:
  . Magnetometer calibration*
  . Tilt compensation
  . Automatic sampling rate

0.16Kbps of <u>processed</u> data

Two digital interfaces

Two drivers

Need to add:
. Magnetometer calibration *
. Tilt compensation

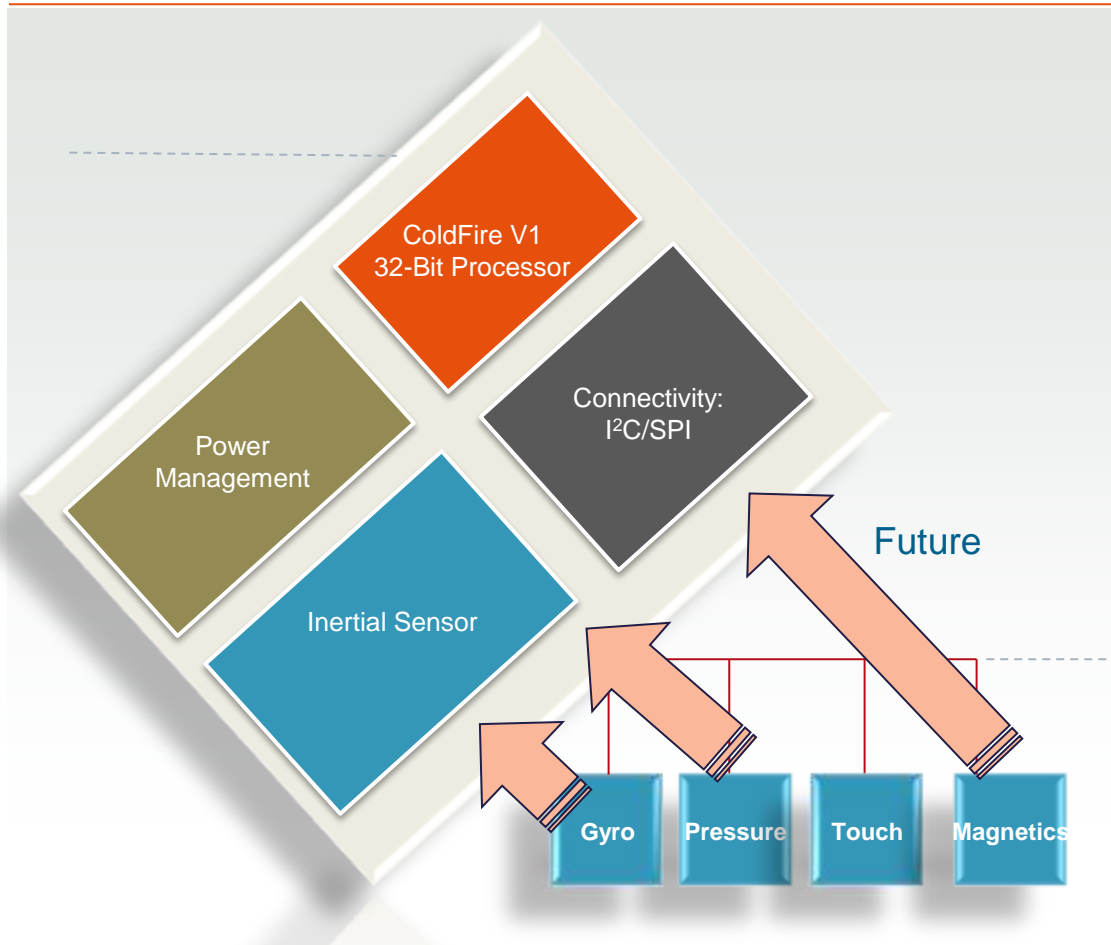**3.36Kbps of <u>unprocessed</u> data**

*soft and hard iron

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Performance, Fusion & Application Content

Xtrinsic Differentiation Example - MMA9550L

MMA9550L Sensor

ColdFire V1 32-Bit Processor

Power Management

Connectivity: I²C/SPI

Inertial Sensor

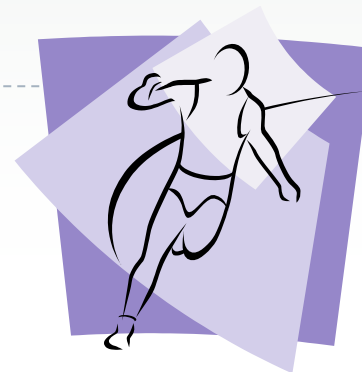Future

Gyro

Pressure

Touch

Magnetics

Sensing Software / Enablement

Compass - Mag

Gestures

Pedometer (3rd party)

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New Sensor Generation

By Adding Intelligence to MEMS

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semiconductor

A New Era of
Sensing Experience
Enabling higher levels
of intelligence

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