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Enabling Smart Sensor Cluster Solutions

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Objectives

At the end of this session you should …

► Know the functionality of the MMA9550L
► Understand its role in Intelligent Contextual Sensing
► Be familiar with its hardware capabilities
► Be familiar with the software enablement
► Recognize applications that benefit from the MMA9550L
Agenda

- The Sensing Environment
  - The MMA9550L
  - Example Applications
  - Internal Hardware
  - Software Enablement
  - Summary
The Evolving Sensor Environment

A multitude of sensor inputs, such as:
- Accelerometer for motion and gesture detection
- Magnetometer for direction
- Pressure for altitude or weather

These increase the number of drivers in the software and the board area

Higher data rates and processing power:
- Accelerometer needs fast precision samples for accurate gesture recognition
- Sensor fusion such as tilt compensation of the magnetometer can be offloaded

Use of battery power:
- Dynamic configuration of the sensor operations to minimize power consumption
- Applications processor has to ‘wake-up’ to handle sensor inputs
Xtrinsic Sensor Key Messages

**Freescale is defining a new era of sensing experience**

Our Xtrinsic sensors offer the right combination of intelligent integration, logic and customizable software to help you deliver smarter, more differentiated applications.

<table>
<thead>
<tr>
<th>Contextual Sensing</th>
<th>Intelligent Integration</th>
<th>Customizable Software</th>
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<tbody>
<tr>
<td>► Contextual sensing is more than a sensor translating a signal—it’s extracting the maximum context from your environment to help make intelligent decisions.</td>
<td>► Increasing levels of modular integration combine with multiple sensor inputs, logic and other building blocks to bring greater value and decision making to the overall sensing solution.</td>
<td>► Freescale Xtrinsic sensors feature customizable software that allows you to design exactly what you want and need the application to be.</td>
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Freescale Dimensions of Intelligent Contextual Sensing

- Strong foundation of multiple sensor types
- Sensor with algorithm/logic
- Sensing integration/fusion
- Sensing platform
- Increasing levels of integration: multiple sensor types, connectivity, power management, logic, actuator, etc.
- Increasing levels of intelligence: decision making, software enablement, programmability, applications, third-party software
Agenda

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► The MMA9550L
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► Summary
MMA9550L At-a-Glance

MMA9550L Sensor

- Host Applications Processor
- ColdFire V1 32-Bit Processor
- Power Management
- Inertial Sensor
- Connectivity: I²C/SPI

Sensing Software
- Gyro
- Pressure
- Touch
- Magnetics

Customer / Third-Party Innovation

Applications

Scheduler | Communications
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
Agenda

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MMA9550L 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

MMA9550L:
• ±2g, ±4g, ±8g sensitivity modes
• 8- to 14-bit ADC
• 0.24 to 1953 samples/s
• 3 x 3 x 1 mm LGA package
MMA9550L while the Applications Processor Sleeps

**Benefits:**

► **Wake from sleep** –
  - Low sample rate
  - 8- and 10-bit ADC resolution available
  - Configurable processing vs. power tradeoff
  - Wake up interrupt to applications processor

► **Continuous processing** –
  - Pedometer functionality
  - Inertial navigation

**MMA9550L:**
- ±2g, ±4g, ±8g sensitivity modes
- 8- to 14-bit ADC
- 0.24 to 1953 samples/s
- 3 x 3 x 1 mm LGA package
MMA9550L 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

MMA9550L:
• 32-bit CPU + Hardware MAC
• Hardware Slave I/F (I2C / SPI)
• Hardware Assisted I2C Master
• 3-axis accelerometer (2, 4, 8 g)
• 14-bit ADC

Applications processor

Driver

MMA9550L:
- 32-bit CPU + Hardware MAC
- Hardware Slave I/F (I2C / SPI)
- Hardware Assisted I2C Master
- 3-axis accelerometer (2, 4, 8 g)
- 14-bit ADC

Other Sensor Peripherals

- Mag
- Cap Touch
- Pressure
- Other

Benefits:

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Other Sensor Peripherals

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- Cap Touch
- Pressure
- Other
MMA9550L processing:
- Tilt compensation (uses accelerometers)
- Calibration
- Angular position information

MMA9550L advantages:
- Offload processing from applications processor
- FIFO reduces sensor data transactions
- Enables e-compass and pedometer functionality
MMA9550L as the Main Processor

**MMA9550L autonomous operation:**
- Internal clock generation
- Low power standby
- Responds to motion
- Dynamic power consumption

**MMA9550L advantages:**
- Single system processor
- Reduced system power
- Small component count and size
- Lower system size and cost

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Up to 400KBps (Master)

$I^2C$
Agenda

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Analog Front End

25u thick poly 3-axis MEMS accelerometer
► High aspect ratio for better sensitivity
► Differential output for lower noise

Selectable 4\textsuperscript{th} channel input
► Temperature sensor
► External ADC input

4 Channel ADC
► Integrated switch-cap anti-alias filter
► Up to 1953 samples/s (before decimation)
► Configurable 8-, 10-, 12-, 14-bit resolution
► Configurable ±2g, ±4g, ±8g sensitivity
► Conversion begins at start of each acquisition frame or under software command
ColdFire V1 Processor Subsystem

Established ColdFire 32-bit CISC Architecture
► 32-bit core and arithmetic unit
► 16 general purpose 32-bit registers
► 32-bit PC and 8-bit condition register
► 2-stage instruction fetch pipeline + 2-stage operand execution pipeline
► 7.8 MIPS performance

Hardware MAC
► Un/signed Fractional/Integer 32-bit MAC
► Single cycle 16x16 multiply / accumulate

Integrated Background Debugging Capability
► Single pin interface
► Run control with 4 address breakpoints
► Flash erase and programming (can be limited by SSC bits)

Internal Clock Generator
► Factory trimmed 8 MHz and 62.5 KHz clocks
► Slow clock and CPU STOP mode for lower power
Communication Interfaces

Shared dual port interface
- 32 byte size bi-directional mailboxes
- 2 binary semaphore registers
- Accessible by SPI or I2C interface up to 2Mb/s
- Runs independent of MMA9550L clock

CPU Interrupts
- End of Write transaction
- End of Read transaction
- Passed mailbox 15 watermark
- Passed mailbox 31 watermark
- Interrupt registers identify which mailboxes were written or read
- Watermark interrupts enable 'unlimited' data streaming reads from MMA9550L

External INT_O (interrupt) pin
- Used to indicate completion of command
- Active High or Low
- Settable by MMA9550L software
- Cleared by hardware on Slave access

Hardware IIC Master
- Up to 400 Kb/s
- Supports 10-bit addressing
- Programmable input glitch filter
Timer Blocks

Programmable Delay Block
► Creates 2 independent output pulses at specified delay after the trigger
► Triggers on:
  • Start of data acquisition frame, or
  • Completion of data conversions, or
  • Software trigger

2 Channel Timer / PWM
► Measure timing of external events
► Create programmable delays
► Generate PWM output signals

16-bit Modulo Timer
► Free running or Modulo limit
► Generates interrupt on overflows
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Internal Bootloader

Reset always starts execution of the internal bootloader

- Based upon the flash configuration it:
  - Enables hardware debugger access
  - Jumps to the internal Command Interpreter or to the Flash Code

- Command Interpreter provides:
  - Flash Erase and programming functions
  - Secure Firmware downloads
Software Architecture

Optional Software
- 3rd Party code
- Customizations

Applications
- AFE Hardware I/F
- Motion processing
- Data conditioning
- Event recognition

Infrastructure
- Scheduler
- Communications

- Lightweight Task Scheduler
- Mailbox Control
- Event & Data FIFOs
- Interrupt / GPIO Control

- Tap & Double Tap Detect
- Jolt & Directional Jolt Detect
- Tilt Detection
- Freefall Detect

- AFE Capture, Trim & Offset
- High / Low Pass Filter
- Portrait / Landscape
- Activity Detect, Power Controller

- Pedometer and other 3rd party SW
- User Code & Algorithms

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Freescale integrated development tool suite for ColdFire that is within the MMA9550L sensing platform

- Project Wizard creates a new project in as few as 9 clicks
- CodeWarrior optimizing C/C++ compilers for ColdFire included
- Trace and profile support for on-chip trace buffers to provide emulator-like debug capability without additional hardware
- CodeWarrior Special Edition is a complimentary version

Accelerate the development of the most complex embedded applications

www.freescale.com/codewarrior to download
Software Development Hardware

- MMA9550L evaluation software runs on computer (Windows XP)
- MMA9550L evaluation board connects to a USB port for communications and power
- MMA9550L evaluation board converts USB serial communications to I²C command sequence to / from MMA9550L device
- MMA9550L daughter board carries MMA9550L device
- P&E Micro USB BDM Multilink BDM Hardware Debugger
MMA9550L Demonstration Tool
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Benefits of the MMA9550L

► Lower system power
  • MMA9550L can sample data with a current consumption < 20 µA
  • Main applications processor can sleep until woken by MMA9550L
  • MMA9550L can be the main system processor

► More useful data
  • High precision MEMS sensor and ADC
  • Higher data sampling rate
  • Intelligent sensor fusion

► Enabled customization
  • Foundation software and applications provided
  • User programmability adds customer value
  • Industry leading tool chain and debugging environment

► Release to production - Q1 2011