



Sensors

Freescale overview



freescale.com/sensors



Building on a Heritage of Innovation

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Overview

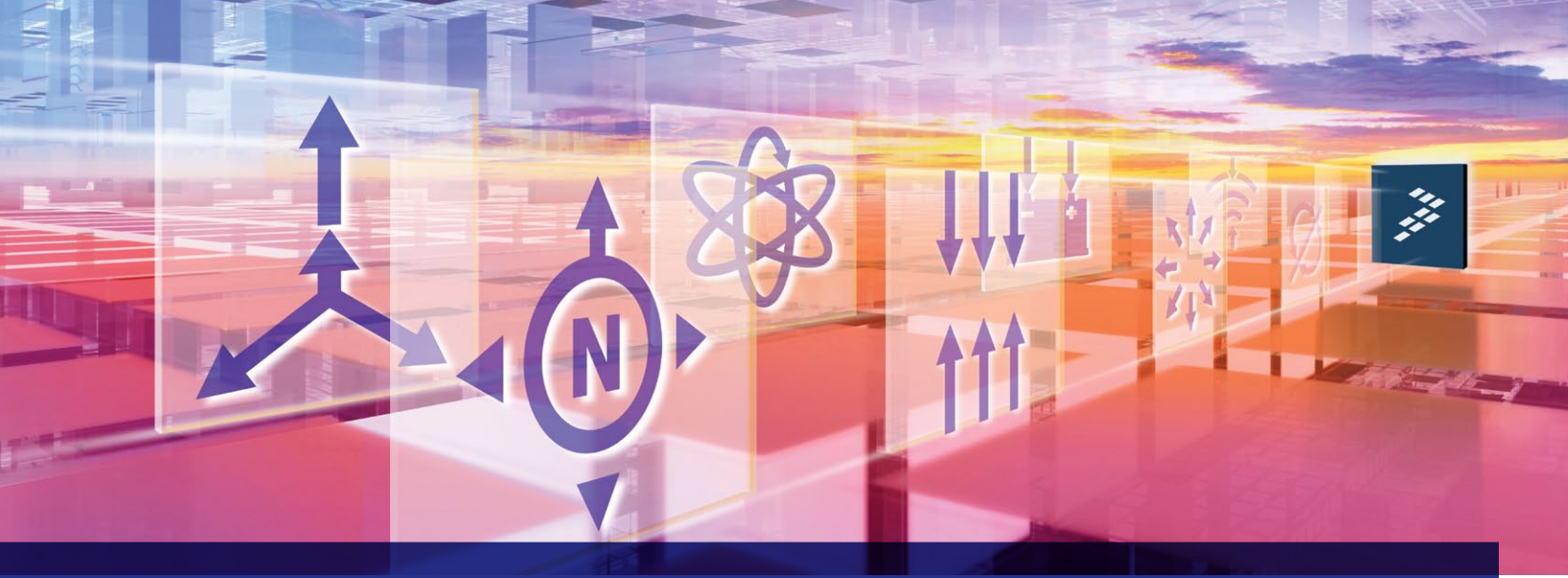
For over thirty years, Freescale sensor products have helped make the world a safer and more interactive place with continuous sensor innovation. Globally, we have delivered more than 2 billion micro-electromechanical systems (MEMS)-based and complementary metal-oxide semiconductor (CMOS) state machine-based touch-sensing components and touch-sensing software on hundreds of MCUs. Building on our heritage of innovation, we continue to expand our sensor portfolio—supporting your development of smarter and lower power solutions.

Freescale has announced a new era of sensing experience with Xtrinsic sensing solutions that offer the right combination of intelligent integration, logic and customizable software to deliver smarter, more differentiated applications. Xtrinsic solutions involve intelligent contextual sensing where a sensor has decision making capabilities within the context of its environment, enabling a variety of use cases.

The MAG3110 magnetometer marks our expansion into magnetic sensors, complementing our broad portfolio of inertial, pressure and touch sensors. Freescale is a leading provider of sensors for the appliance, automotive, consumer, industrial and health care markets. The sensor ICs complement our broad portfolio of ZigBee® technology, MCUs, MPUs, DSPs, analog ICs, CodeWarrior and other development tools to offer system solutions to customers.

Our principle objective is to meet your market needs. We listen to you and turn your ideas into products. Our core competency is new product development using processes that shorten your development cycle time. As we work with you to meet your rapidly changing needs for small, cost-effective sensors, our technology is continuously expanding and evolving. We also leverage complementary technologies from within Freescale to strengthen your global competitiveness.

Creating new technologies that can sense and interact with the systems around them is essential to continually service the way we live, work and play. With designers facing new challenges to create smarter products, Freescale is dedicated to meeting the needs of constantly evolving and expanding markets with intelligent acceleration, pressure, touch and magnetic sensor solutions.



Xtrinsic Sensing Solutions

Intelligent Contextual Sensing

Xtrinsic sensors go far beyond a sensor translating a signal—they're enabling greater levels of sensing context and intelligence. By increasing levels of modular integration with multiple sensor inputs, logic and other building blocks, Freescale brings greater value and decision making to the overall sensing solution. We've put our expertise at your fingertips, making it easy to tailor our sensing capabilities to your needs—your imagination is the only limiter.

Freescale Xtrinsic sensors can help improve yields and drive down manufacturing costs. These highly integrated, multifunctional single-package solutions can help you simplify new product development and reduce your time to market. For example, a combination of pressure sensor, MCU and radio frequency (RF) circuitry can be used in a wide range of remote sensing applications, such as direct tire pressure monitoring systems (TPMS). An integrated TPMS is a flexible and highly accurate safety system that can be more easily incorporated into the overall vehicle design. What's more, tire localization capabilities can be added by integrating a dual-axis (X/Y) accelerometer into the package.

Dimensions of Intelligent Contextual Sensing

Building on a Strong Portfolio of Diverse Sensor Types

- Inertial, magnetic, pressure and touch sensors
- Provide a multiplicity of sensor inputs for greater value to the overall solution
- Extract the maximum context from the environment

Amplifying Sensing

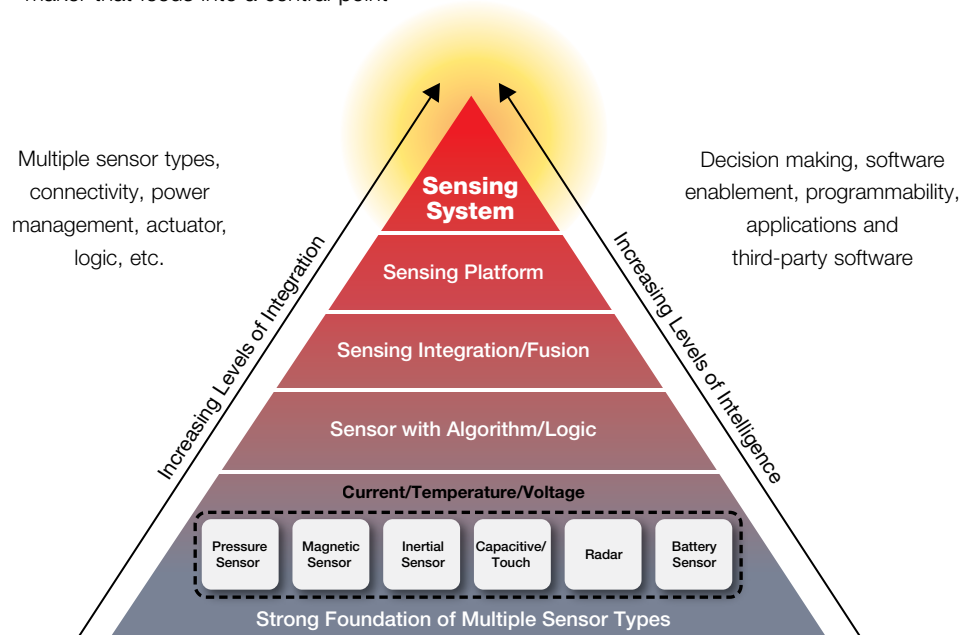
- Add contextual analysis to sensor performance by including algorithms to make a decision
- Sensor can be a final or sub-level decision maker that feeds into a central point

Increasing Levels of Intelligence

- Decision making
- Software enablement
- Programmability
- Applications
- Third-party software

Increasing Levels of Integration

- Sensor fusion
- Non-volatile storage
- Connectivity
- Power management
- Logic
- Actuation





Freescale Xtrinsic Accelerometers

Scalable Intelligence in Motion

Our micro-electromechanical system (MEMS)-based acceleration sensors are designed for end products and embedded systems that require measurement of forces resulting from fall, orientation, tap, double tap, tilt, jolt, motion, positioning, shake, shock or vibration. We offer a broad portfolio of acceleration sensors from 1.5 to 250g for applications ranging from highly sensitive seismic detection to robust collision detection. Target markets include consumer, appliance, automotive, industrial, health care and computer peripherals.

Our acceleration sensors incorporate a surface micromachined structure. The g-cell is coupled with an application-specific integrated circuit (ASIC), which provides the accelerometer with amplification, signal conditioning, low-pass filter and temperature compensation. This two-die design serves as a system-in-package solution.

Analog and Digital Solutions for Design Flexibility

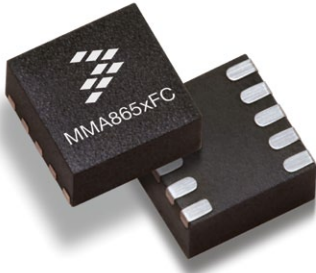
- X, XY, XZ, XYZ and Z axes of sensitivity
- 1.5 to 250g for a wide variety of applications
- High sensitivity
- Signal conditioned with internal filter
- Calibrated self-test for functional verification
- Linear output
- Ratiometric, ideally suited to interface with analog-to-digital converters

- Hermetically sealed g-cell
- Digital output with I²C/SPI for processor system performance
- Customer assigned registers for offset calibration
- Programmable bandwidth and data rate
- Single-board 3D sensing
- Bidirectional multi-axis sensing
- Direction detection
- Adaptable functionality
- Design flexibility
- Lower power, higher function in smaller footprints
- G-Select products offer flexibility to select acceleration level for multifunctional applications
- Click and double click recognition
- Low power for extended battery life
- Low component count saves cost and space
- Highly sensitive with low noise
- High frequency and resolution for accurate fall, tilt, motion, positioning, shock and vibration sensing
- Two-die solution utilizes partitioning, allowing greater design flexibility and maximizing product performance
- Cost-effective packages

Typical Applications

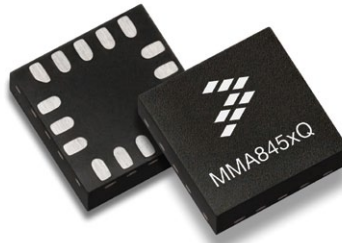
- Mobile phones/PMP/PDA/digital cameras
 - Orientation detection (portrait/landscape)
 - Tilt control enabled with higher resolution
 - Gesture dialing enhanced with HPF
 - Tap to control
 - Auto wake/sleep for low power consumption
- Smartbooks/e-readers/netbooks/laptops
 - Anti-theft
 - Freefall detection for hard disk drives
 - Orientation detection
 - Tap detection
- Activity monitoring in medical applications
- Security
 - Small motions detected with extremely high resolution
 - Tilt
- Fleet monitoring, tracking
 - Dead reckoning
 - Shock recording
 - Anti-theft
 - Toll payment
- Unbalance detection for washers
- Power tools and small appliances
 - Tilt
 - Safety shutoff

Choose the Right Xtrinsic Accelerometer for Your Design



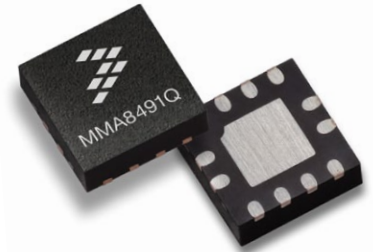
MMA865xFC Features

- High performance
 - Well rounded
- Cost competitive
- Industry-leading power consumption
- Low-voltage compatibility
- Rich features
 - P/L detection
 - High pass filter
 - Transient detect
- Low-profile 2 x 2 x 1.0 mm DFN package
- 12- and 10-bit digital output
- High sensitivity: 1 mg per LSB
- Low noise: 150 micro g per root Hz (independent of resolution)
- Low-power mode: 7 micro amps
- Interrupt and I²C interface supply: 1.62 to 3.6 V
- Supply voltage: 1.95 to 3.6 V
- Output data rate: 1.5 to 800 Hz
- Two programmable interrupt pins for seven interrupt sources
- MMA8652FC embedded motion detection features:
 - Freefall or motion detection
 - Pulse and jolt detection
 - Orientation (portrait/landscape) detection with hysteresis
 - Automatic output data rate change for auto-wake/sleep
 - Self test
- MMA8652FC embedded 32-sample FIFO buffer
- High pass filtered data available per sample and through the FIFO



MMA845xQ Features

- High performance
- Extended features
 - FIFO (14-bit only)
 - Configurable P/L trip angles
 - High pass filter
 - Transient detect
- Lowest voltage
 - 1.71 to 1.89 V
- 14- and 12-bit digital output
- Resolution: (14-bit)—0.25 mg, (12-bit)—1 mg
- Low noise: 99 micro g per root Hz (independent of resolution)
- Low-power mode: 6 micro amps
- I/O interface supply: 1.62 to 3.6 V
- Supply voltage: 1.95 to 3.6 V
- Output data rate: 1.5 to 800 Hz
- Two programmable interrupt pins for seven interrupt sources
- Embedded motion detection features:
 - Freefall or motion detection
 - Pulse detection
 - Jolt detection
 - Orientation (portrait/landscape) detection with hysteresis
 - Automatic output data rate change for auto-wake/sleep
 - Self test
- Embedded 32-sample FIFO buffer
- High pass filtered data available per sample and through the FIFO
- Low-profile 3 x 3 x 1.0 mm QFN package



MMA8491Q Features

- Lowest power
 - 1 μ A at 1 Hz sample rate
- Cost efficient
 - 1 mg/count sensitivity
- Industrial package
- Miniature 3 mm x 3 mm QFN 12-pin package
 - 0.65 mm lead pitch
 - Visual solder joint inspection capable
- 3-axis MEMS tilt sensor
- Tilt threshold of 46.5° on each axis
- Fast turn on time
- 1.95 to 3.6 V VDD supply range
- -40 °C to +85 °C operating temperature range



Xtrinsic Sensing Platforms

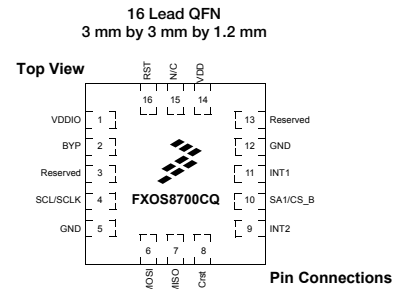
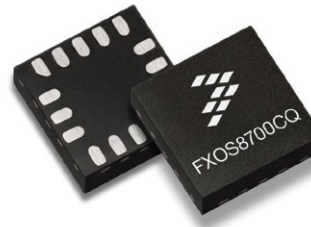
FXOS8700CQ 6-Axis Sensor

Single-Package 3-Axis Accelerometer and Magnetometer

The Freescale FXOS8700CQ 6-axis Xtrinsic sensor combines industry-leading accelerometer and magnetometer sensing in a small 3 x 3 x 1.2 mm QFN plastic package. Applications include e-compass, enhanced user interface, augmented reality and location-based service applications (static geographic heading). Target products include smartphones, tablets, personal navigation devices, remote controls for smart TVs, watches, gaming controllers, robotics and unmanned air vehicles (UAVs).

In addition, Freescale is developing a 12-axis Xtrinsic sensor platform for Windows® 8 integration into tablets, slates, convertible/non-convertible laptops and other portable devices. The FXOS8700CQ combines a 14-bit accelerometer and 16-bit magnetometer with an optimized ASIC to enable a high-performance e-compass solution capable of a typical orientation resolution of 0.1 degrees and sub-5-degree compass heading accuracy for most applications.

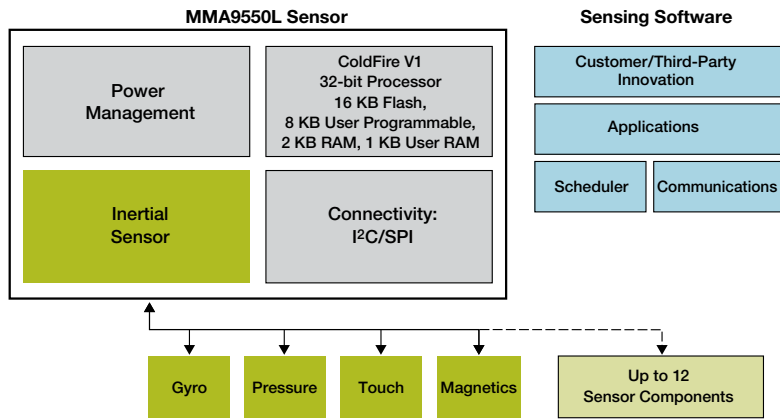
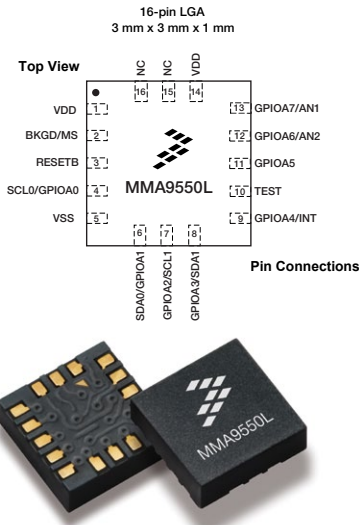
The FXOS8700CQ 6-axis sensor incorporates the industry's most advanced embedded features, allowing the entire system to be optimized for low power with substantially more savings when the application processor power modes are driven by sensor interrupt signals. Selectable output data rates (ODR) from 1.563 to 800 Hz per sensor, or up to 400 Hz in hybrid mode (simultaneous accelerometer and magnetometer data) offer significant respective power savings at lower ODRs.



Features and Benefits

Features	Benefits
Highly integrated	FXOS8700CQ 6-axis sensor combines industry-leading accelerometer and magnetometer sensors into a single 3 x 3 x 1.1 mm package
Wide dynamic range $\pm 1200 \mu\text{T}$	Flexibility in placement on PCBs that incorporate permanent magnets such as speakers and vibrator motors
Embedded vector magnitude detection	Significant system-level power savings is achieved by embedded vector magnitude detection that interrupts the host for programmable orientation change and/or magnetic interference/magnet presence detection
Embedded autonomous hard iron calibration	Low-power hard iron offset compensation for platforms dominated by hard iron magnetic interference
Low power consumption	Selectable output data rates ranging from 1.563 Hz to 800 Hz for each sensor allows for the optimum trade-off between power consumption and performance (response time). Programmable auto-wake/sleep works with all internal interrupt sources, including the magnetic event detection blocks to save significant power.
High performance	Industry-leading 14-bit accelerometer and 16-bit magnetometer are combined with a high-performance ASIC to enable a high-performance e-compass solution capable of a typical heading resolution of 0.1 degrees and sub-5-degree heading accuracy for most applications. Operates at up to 400 Hz with both sensors active in a hybrid mode. Embedded functionality using g-cell and m-cell combined data for a cost efficient, customizable and optimized solution.
Xtrinsic e-compass software	Floating point and integer code that supports all standards including Android™, Windows® 8 and other operating systems
Xtrinsic calibration software	Full range of power and performance of floating point and integer four, seven and 10 element models

MMA9550L Block Diagram



MMA9550L

Intelligent Motion-Sensing Platform

The MMA9550L is the industry's first intelligent, high-precision motion-sensing platform that manages multiple sensor inputs and makes system-level decisions to enable new applications such as gesture recognition, pedometer functionality and e-compass tilt compensation. Its highly configurable and customizable sensor decision engine enables complex calculations through interpreted sensing information and control over a number of system-level sensing decisions—rather than simply processing raw data. This is accomplished without interrupting the system application processor, reducing total system power consumption. Advanced processing is made possible in the MMA9550L through the 32-bit ColdFire V1 processor, embedded alongside the sensor to make decisions within the context of its environment and enable a variety of use cases.

Up to twelve sensor inputs are easily consolidated by the MMA9550L motion-sensing platform, which operates with a unique slave port that is configurable as either I²C or SPI, allowing calibration, compensation and sensor functions to be offloaded from the system application processor. The MMA9550L is programmed and configured with CodeWarrior Development Studio 6.3 software, enabling customers to quickly and easily shape next-generation applications that go beyond basic algorithms to exactly what they need.

Features and Benefits

Feature	Function	Benefit
Embedded functions/features	Auto-wake/sleep	Incorporates several functions such as tap, shake and motion as well as other external sensor inputs to signal the system to wake or transition to low-power mode after a period of inactivity
	Orientation detection (portrait/landscape)	Highly configurable display control to reduce system power and increase UI response time with proven algorithm
	Single, double and directional tap	Allows multiple inputs for a user input control with fast user response. Built-in noise reduction to avoid false taps, configurable noise rejection via thresholds, pattern recognition or pulse sequencing. Selectable thresholds for ±2g/±4g/±8g
	Single, double and directional shake	Allows multiple inputs for a user input control with fast user response
	Threshold detection	A foundational algorithm for various use cases
	Linear and rotational freefall	Fast user response to freefall detection with proven freefall algorithm
	Embedded smart FIFO	Saves processor cycle time where processor does not need to poll data. The FIFO can be used for power savings since an inertial event can signify motion data is available. The FIFO allows the application processor to sleep and have data collected independently as it is buffered in the FIFO Reduces I ² C bus traffic since data does not need to be continuously sent
	Flick detection	Wrist flick gesture to the device orientation can be used as a user interface with fast response time and low power consumption
	Tilt angle	Tilt angle can be compensated with additional sensor input such as a magnetic sensor for various use cases
	Filters (event-driven HP, LP)	Allows conditioned sensor data for reduced processing on applications processor
	Pedometer	Activity monitoring beyond step counting. Recognition of standing, sitting, laying down as well as walking, running, up/down stairs, escalator and other movement
	Power management	Configurable sample rate: 1–1024 samples/sec
Auto-wake monitors change in activity/position		
Auto-sleep powers down sensor when there is no activity		
Embedded smart FIFO for data processing while apps processor is asleep		
Connectivity	Low-voltage operation: 1.71–1.89 V	Flexible configuration options for easy design
	Communication protocols: I ² C/SPI	
	Communication between master and slave ports	



Freescale Xtrinsic Pressure Sensors

Diverse Packaging, Pressure Ranges and Porting Options

Since 1980, Freescale* MEMS-based sensors have been changing the world. Today, our piezoresistive pressure transducers are engineered to sense absolute or differential air pressure. And our CMOS pressure transducers are designed to sense absolute air pressure in TPMS. They make technology step into what was previously immeasurable—or untouchable. They help you sense the world.

MPXH Series: SSOP Package

- Pressure ranges up to 300 kPa
- Temperature compensated from -40 °C to +125 °C
- Amplified analog output
- Ideally suited for MCU interfacing
- Small rugged polyphenylene-sulfide (PPS) surface mount package
- High accuracy in the 0 °C to 85 °C range
- Available with axial and side port

Typical Applications

- Barometric absolute pressure (BAP)
- Manifold absolute pressure (MAP)
- Barometric and altimetric measurements
- Industrial control
- Water level measurement for washing machines and dishwashers

MPXV and MPXA Series: SOP Package /MPX5000 Series/ MPXA(z)4000 Series

- Pressure ranges up to 250 kPa
- Temperature compensated from -40 °C to +125 °C
- Amplified analog output
- Ideally suited for MCU interfacing
- Rugged PPS surface mount small outline package (SOP)
- Available with axial and side port

Typical Applications

- BAP/MAP
- Process control
- Barometric and altimetric measurements
- Industrial control
- Water level measurement

MPXM Series: MPAK Package

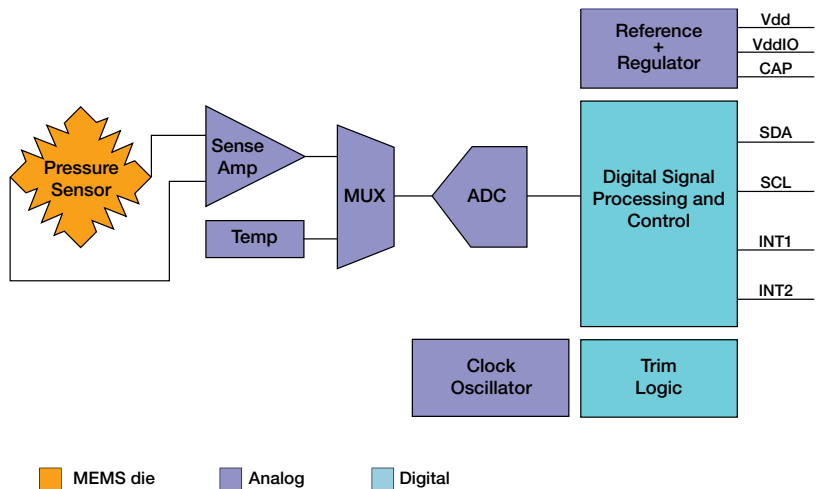
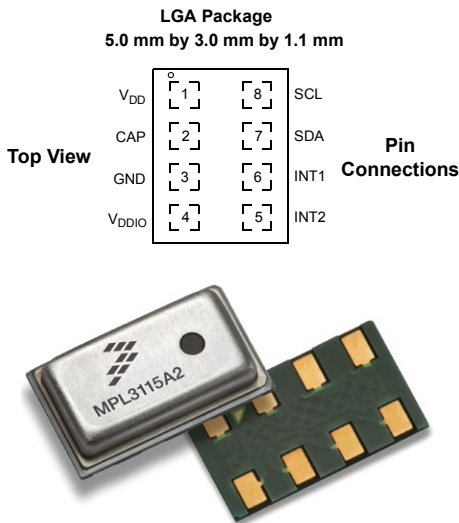
- Pressure ranges up to 200 kPa
- Temperature compensated from 0 °C to 85 °C
- 40 mV typical full scale span
- Ratiometric to supply voltage
- Unique silicon shear strain gauge
- Available in both gauge and absolute

Typical Applications

- Barometric measurements
- Vacuum cleaners
- Water level measurement for washing machines and dishwashers
- Sports diagnostic systems
- Medical equipment
- Altimeters
- Remote monitoring devices
- Weather forecasting stations
- Barometric measurements
- Vacuum cleaners
- Water level measurement for washing machines and dishwashers
- Sports diagnostic systems

*The semiconductor products sector of Motorola, Inc. became Freescale Semiconductor, Inc. in 2004.

MPL3115A2 Pressure Sensor



Xtrinsic MPL3115A2 Pressure Sensor

The Smart Choice for Precise Pressure and Altitude Detection

The Xtrinsic MPL3115A2 pressure sensor provides highly precise pressure and altitude data with variable sampling rate capability up to 128 Hz. It offers very low power consumption, smart features and requires zero data processing for mobile devices, medical and security applications.

The Xtrinsic MPL3115A2 pressure sensor smart features include digital output, two interrupts for auto-wake, minimum/maximum threshold detection and autonomous data acquisition. MCU usage can be limited since the MPL3115A2 pressure sensor can process sensor data locally, reducing communications required with the host processor.

The Xtrinsic MPL3115A2 pressure sensor provides unique performance that allows new user services at a low system cost. The device has extremely high accuracy—30 cm resolution (20-bit resolution measurement)—providing a flexible output of either meters or pascals. The MPL3115A2 pressure sensor includes with embedded functions and flexible user programmable options. With extended battery life where the MPL3115A2 pressure sensor can run as low as 8.5 μ A at 1 Hz in low-power mode, it is ideal for mobile applications. The 32 sample FIFO can offload communications with the host processor as well as regulate the auto-wake and sleep mode functions.

Key Features

- Altitude resolution: Less than 1 foot/0.3m
- Pressure resolution: 1.5 Pa
- Compensated, direct reading (software is not needed):
 - 20-bit pressure measurement (pascals)
 - 20-bit altitude measurement (meters)
 - 12-bit temperature measurement (Celsius)
- On-board intelligence:
 - Interprets meters
 - Programmable events
 - Two programmable interrupt pins for auto-wake, minimum/maximum and threshold detection
 - Autonomous data acquisition
 - Embedded 32 sample FIFO buffer
- Flexible sampling rate up to 128 Hz
- I²C digital output interface (operates up to 400 kHz)
- Low current consumption:
 - Standby mode: 2 μ A
 - Low-power mode: 8.5 μ A at 1 Hz
- I/O interface supply: 1.6 to 3.6 V
- Supply voltage: 1.95 to 3.6 V
- Low-profile 3 x 5 x 1.1 mm LGA package

Benefits

- Highly precise pressure and altitude data
- Flexible sampling rate
- Very low power consumption
- Smart features with unique performance
- Requires zero data processing
- High accuracy—30 cm resolution (20-bit resolution measurement)
- Flexibility with output in either meters or pascals
- Easy integration and development
- Direct output of vertical height measurement saving host conversion to pressure units



Freescale Xtrinsic Touch Sensors

Reliably Replace Mechanical Buttons and Switches

Overview

Freescale touch-sensing technology makes mechanical buttons and switches obsolete. Touch sensors with simple sliders, rotary wheels and touch pads offer significant advantages for more intuitive user interfaces, allowing greater freedom for designers while reducing overall system cost. Touch sensor development tools offer design evaluation examples with simple linear or rotational sliders, rotary wheels and touch pads.

Freescale touch sensors can support multiple electrodes, where several different applications can be controlled by one sensor. By multiplexing the electrodes, the single sensor becomes an extension for detection at multiple points. Capacitive touch sensors are in user interfaces that manage multiple configurations of touch pads, sliders, rotary positions and mechanical keys. Freescale offers numerous development tools to easily evaluate the capabilities of capacitive touch sensing.

Applications

- Gaming controllers
- Home entertainment
- Home appliances
- Cellular handsets
- Portable media devices

Electrode Design Examples

At right are examples of several electrode pad layouts. Electrodes in Freescale touch sensors can be widely spaced due to shield driver circuitry, which isolates the electrode signals from external interference as they are transmitted through wires or coax cables to the sensor. This allows designers to use advanced sensing technology to develop large arrays of separate electrodes that can perform identical functions over a wider area. A driver shield may be used if there is a need to remotely locate the electrodes. Traces to electrodes should be kept as small and thin as possible. See the Freescale data sheets and other documentation or contact your Freescale sales representative for further assistance.

Single Pad

- Simplest to implement
- Requires human body to be at virtual ground (For non-battery powered applications)
- Can be any shape
- Most sensitive approach



Multiplexed Pads

- Can support more pads (e.g. eight electrode connections can support up to 36 pads)
- Uses human body to complete electrical path
- Can realize slider controls



Xtrinsic Touch-Sensing Software

The Freescale Xtrinsic Touch-Sensing Software Suite (TSS)

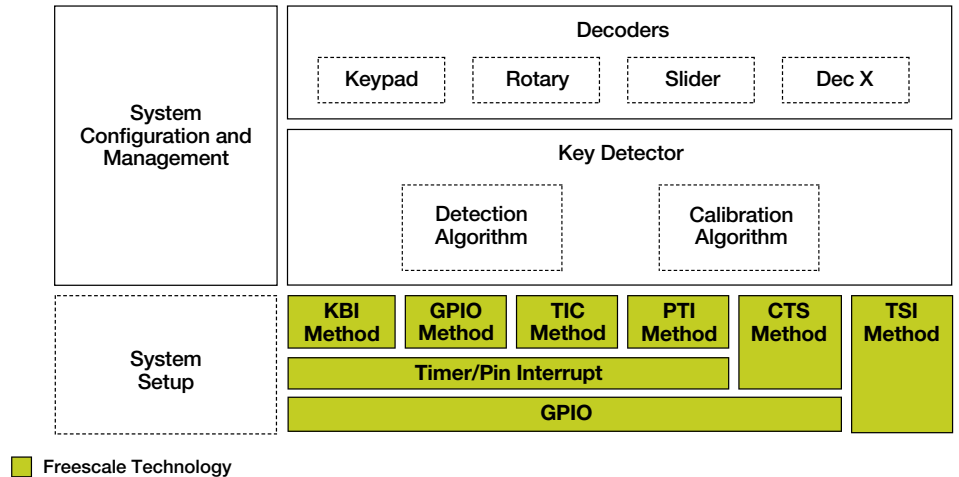
Our innovative touch-sensing software library adds value to targeted Freescale silicon. The free software library now supports a larger MCU portfolio, including the new HCS08 Kinetis ARM® Cortex™-M4 derivatives and ColdFire+ MCUs. These product families feature the recently released touch-sensing input (TSI) module for more robustness, faster sampling time and greater sensitivity in capacitive touch-sensing systems.

The TSS library offers a complete solution for capacitive touch-sensing-enabled projects using low-cost development tools and a complementary license for development and distribution, providing flexible solutions for a wide variety of human-machine interfaces (HMIs).

TSS Advantages

- Reliable touch detection using the TSI module provides extremely high sensitivity
- Enhances reliability and increases product longevity by replacing mechanical button wear and tear
- Can be integrated with MQX™ and Kinetis MCUs
- User interface controllers manage multiple keypad layout configurations
- Improved touch detection algorithm for reduced false touches under electrical noise
- Simplifies user interface designs, enabling customers to develop an application within minutes using a broad range of tools, including development board kits and demonstration software
- Gives greater flexibility for product designers to select from more than 1000 options in our broad 8- to 32-bit portfolio, including ColdFire+ and Kinetis MCUs
- Reduces overall system cost by simplifying mechanical design and assembly

Touch-Sensing Software Library Architecture



Key Features

- Support for S08 TSI (for S08 MCU families)
- MQX support
- KwikStik support
- Shielding
- Memory usage optimization

Benefits

- Touch added to one-chip solution to reduce overall system cost and size
- Improved touch detection algorithm for reduced false touches under electrical noise
- Enables over 1,000 Freescale 8-bit and 32-bit MCU as touch sensors, including ColdFire+ and Kinetis MCUs
- Free license software with cost-effective development tools
- Enhances reliability by eliminating mechanical wear and tear
- Increases product longevity

TSS Design and Development Tools

The TSS library supports different kinds of hardware designs, printed circuit boards (PCB), capacitive film, flex PCB and more. For guidance on best practices for electrode and layout design, download the application note, "Designing Touch Sensing Electrodes" (document AN3863) from freescale.com/touchsensing.

Freescale has a full set of development tools that include the capacitive touch Tower plug-in starter kit (TWRPI-TOUCH-STR) which, in conjunction with Freescale Tower boards for Kinetis, ColdFire+ and S08 MCUs, enables advanced development through rapid prototyping. TSS includes development support using FreeMASTER graphical interface for sensitivity calibration and library configuration GUI.

Development and Evaluation Tools

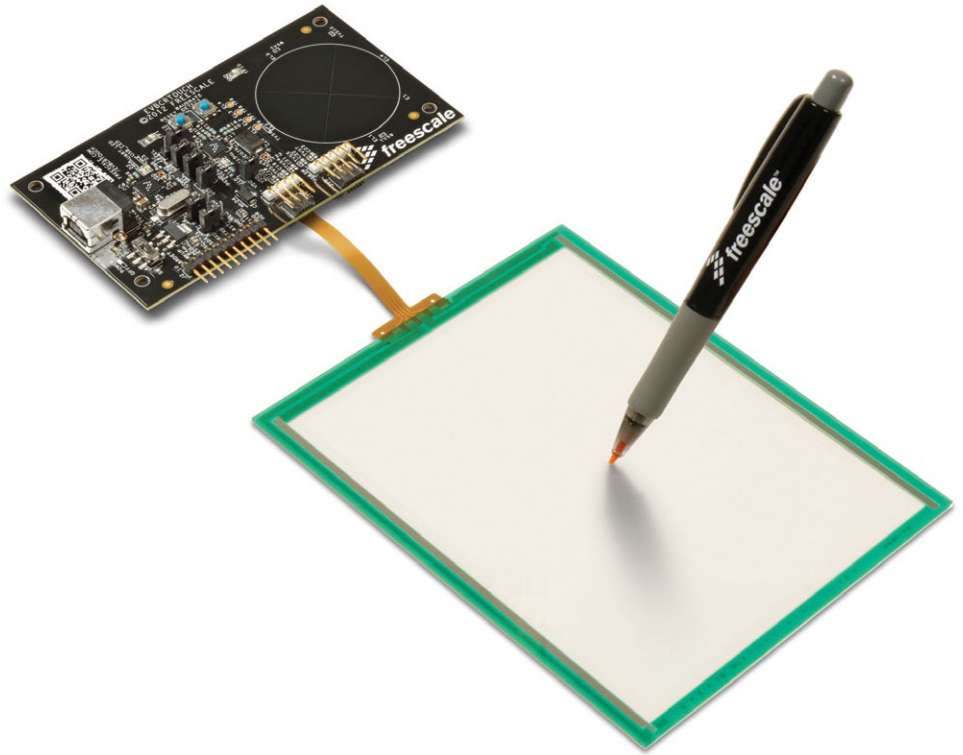
- ColdFire+ TWR-MCF51QM and TWR-MCF51JF
- Kinetis TWR-K40X256-KIT, TWRK60N512-KIT, TWR-K53N512-KIT and KWIKSTIK-K40
- TWRPI-TOUCH-STR

CRTouch

Xtrinsic Capacitive and Resistive Touch-Sensing Platform

Freescale Ready Play solutions integrate functionality in different applications, allowing customers to add features while reducing development cost—simplifying design cycles and enabling scalability in applications and systems.

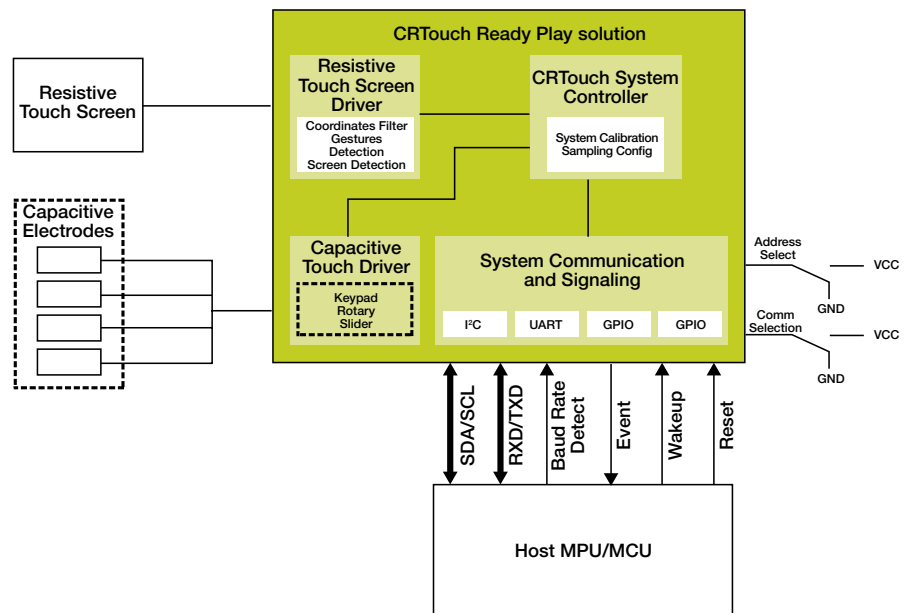
The Xtrinsic capacitive and resistive touch-sensing platform (CRTouch) enables resistive touch screens to handle basic gesture recognition and allows the addition of up to four capacitive electrodes to your system, all packaged on a 5 x 5 mm lead-free 32-pin QFN. It supports four- and five-wire touch screens and communicates over UART and I²C communication protocols. The implementation of these technologies enables the CRTouch to help reduce space, cut software development costs and speed time to market.



Key Features

- Standard X, Y resistive touch screen detection with optional calibration and built-in filter for improved stability
- Four- and five-wire pressure detection
- Two touch gesture detection on a four wire screen
- Zoom in/out
- Rotate direction indication and angle measurement
- Four capacitive electrodes independent from touch screen may be configured as keypad, rotary or slider
- UART and I²C communication available
 - Two selectable I²C addresses
 - UART baud rate auto detection mechanism
- Event indicator signal for host processor
- Configurable sample rate with up to 200 points per second
- Linux®, Android™ and PEG integration example code available
- 1.8- to 3.6-volt operation
- 32-pin QFN package
- -40 °C to +105 °C operating temperature
- Normal run, sleep and shutdown modes for reduced power consumption

Xtrinsic Capacitive and Resistive Touch-Sensing Platform



Target Applications

- Control panels
- Human-machine interface
- Keyboard replacement
- Point-of-sale terminals
- Signature capture devices
- Kiosks

MPR121/MPR031

12-Pad Touch Sensor Controller

The MPR121 capacitive touch sensor controller simplifies design in the user interface of choice—touch sensing. Embedded developers require design simplicity and power conservation in a small form factor for compact system designs. The MPR121 solution replaces mechanical buttons, switches and other moving parts that typically wear out and are less reliable.

The MPR121 capacitive touch sensor controller is a CMOS-based state machine that simplifies designing numerous touch applications for lighting controls, mobile phones, MP3 players, remote controls and other low-power, hand-held, electronic products. The MPR121 operates with extremely low power at 29 μA average supply current—contained in a small, low-profile 3 x 3 x 0.65 mm 20-lead QFN package.

The MPR121 next-generation device provides 12 electrodes with increased internal intelligence such as a flexible independent calibration feature, increased electrode count, hardware configurable I²C address, expanded filtering system with debounce and completely independent electrodes with built-in auto configuration.

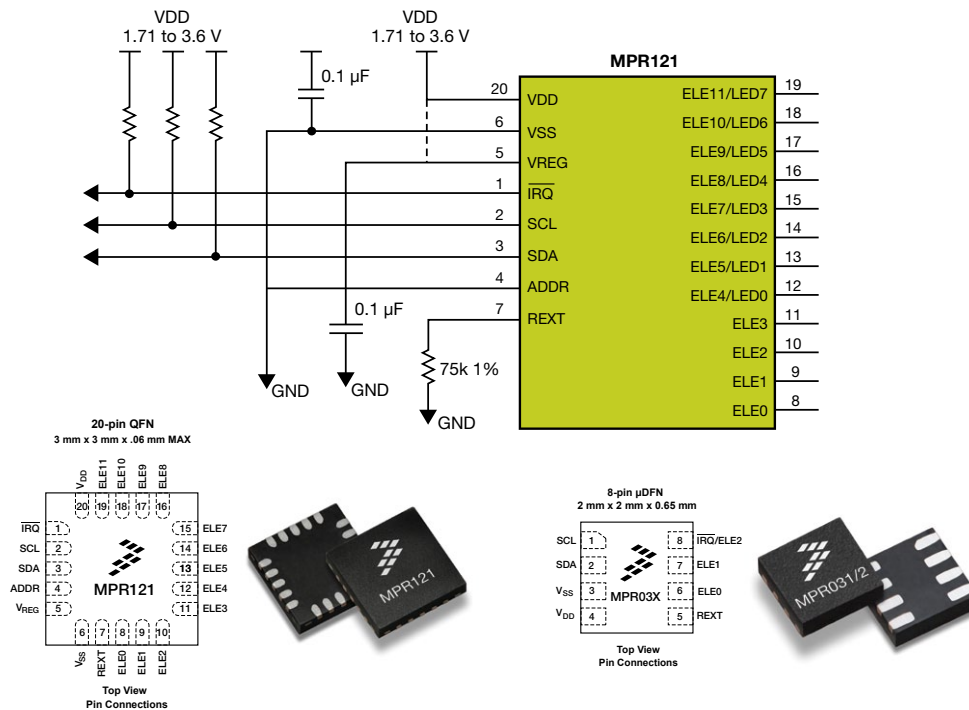
Typical Applications

- PC peripherals
- MP3 players
- Remote controls
- Mobile phones
- Lighting controls

Features

- Supports up to 12 touch electrodes
- 1.71–3.6 V operation
- 29 μA average supply current
 - All twelve electrodes monitored:
 - At 16 ms sample rate
 - At 64 ms response time
- Continuous independent auto calibration for each electrode
- Separate touch and release trip thresholds for each electrode
 - Provides hysteresis and electrode independence
- Drives up to eight LEDs or provides up to eight logic I/Os in any combination
- 3 μA maximum shutdown current
- I²C interface with IRQ output to advise electrode status changes
- 3 x 3 x 0.65 mm 20-lead QFN package
- –40 °C to +85 °C operating temperature range

MPR121 Implementation Diagram



Freescle Touch Sensor Product Feature Comparison

Feature	MPR03x	MPR121	Benefit
Capacitance Sensing			
High dynamic range	•	•	Measures electrodes from 1 to 2000 pF from the same device
Independent electrode configuration		•	Even in a single design, electrodes can vary in shape and size using a single device
Automatic configuration		•	Automatic independent setup for each electrode
Automatic reconfiguration		•	Customizable reconfiguration if baseline falls outside of range
Two-stage filtering system	•	•	Allows for simple data conditioning through averaging filter
Configurable sample rate	•	•	Sampling rate can vary between 1 and 128 ms
Touch Sensing			
Increasing and decreasing thresholds	•	•	Prevents bounce on touch recognition by providing hysteresis
Touch and release threshold IRQ	•	•	Touch and release are both reported by interrupt assert
Baseline tracking system	•	•	Maintains baseline by filtering out touch signals
Bidirectional baseline tracking system		•	Independent baseline tracking for positive and negative capacitance changes
Baseline filter delay		•	Filtering speed can be reduced for applications requiring fast response time and long-term baseline averaging
Stuck key removal baseline tracking		•	Stuck keys are detected and calibrated out with customizable system
Proximity Sensing			
Proximity sense mode	•		Detects proximity by combining electrodes as a separate configurable mode
Proximity sensing pseudo electrode		•	Detects proximity by combining electrodes as a pseudo electrode, allowing for simultaneous proximity and touch detection
Proximity detect IRQ	•	•	Proximity detection is reported by interrupt assert
GPIO/LED			
Eight shared LED driving pins		•	Electrodes can be purposed as touch sensor or GPIO LEDs
GPIO extender		•	If all pins are not used as electrodes, remainder can be simple GPIO extenders



Freescal e Xtrinsic Magnetic Sensors

Our Latest Innovation

Overview

Our latest innovation is in the category of smart magnetic sensors. We have expertise in micro-magnetic technology as well as MEMS technology to create our latest intelligent Xtrinsic sensing solutions. These smart magnetic sensors combine extremely high-resolution, low-power and efficient software for portable navigation, smartphones, tablets and e-reader applications. In addition, the magnetic sensors can work in conjunction with Freescale accelerometers for accurate compass heading information.

Typical Applications

Consumer

- Mobile phones
- e-compass
- Location-based services
- GPS backup with dead reckoning
- Pointing devices

Medical

- Hospital location tracking
- Navigation
- Fall detection

Industrial

- Asset tracking
- Advanced HMI
- Factory automation

MAG3110 Magnetometer

Highest Resolution, Low Noise and Ultra-Small Size

The MAG3110 3-axis magnetometer is the latest addition to our extensive family of inertial, pressure and touch sensors. Our MAG3110 magnetometer can measure magnetic fields in three dimensions with a wide dynamic range of $\pm 1000 \mu\text{T}$. Flexible output data rate and oversampling options allow for noise as low as $0.25 \mu\text{T}$ and current consumption as low as $8.6 \mu\text{A}$.

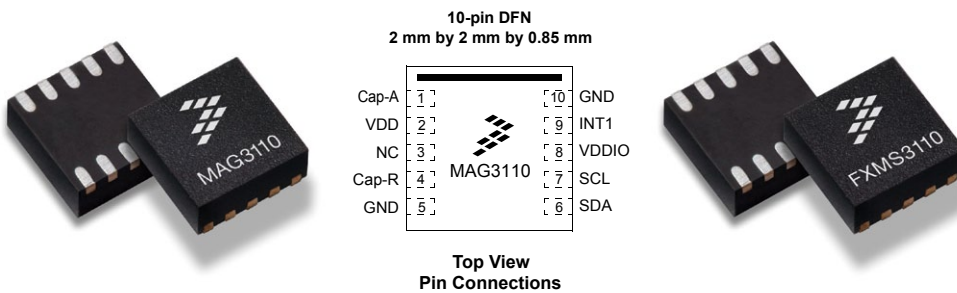
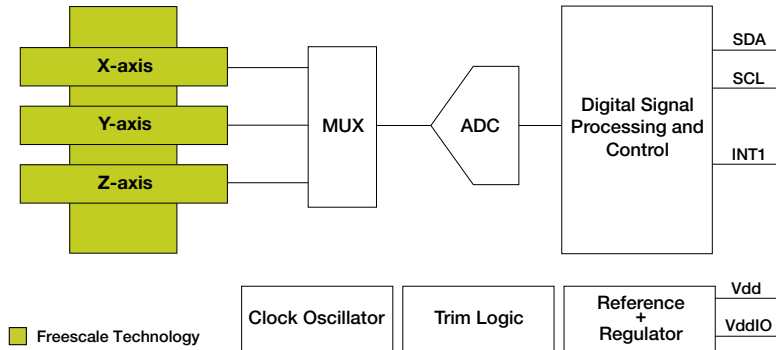
The combination of our Xtrinsic MAG3110 magnetometer, MMA8451Q accelerometer and advanced e-compass software enables a full tilt compensated electronic compass solution. When the e-compass subsystem is coupled with a GPS or other location aware subsystem, direction-dependent location-based services can be enabled in end products.

The MAG3110 is ideally suited for smartphones, tablets and any portable devices requiring e-compass capability.

MAG3110 Consumer Applications

- E-compass
- Map orientation
- Location-based services
- GPS assist
- Remote controls/3D pointers
- 3D motion control and heading
- Navigation
- Smartphones
- Tablets
- Gaming
- User interface

Xtrinsic MAG3110/FXM3110 Magnetometer Block Diagram



FXMS3110 Magnetometer

Smart, Highly Accurate Magnetic Sensor for the Industrial Market

Applications for the Xtrinsic FXMS3110 magnetometer include factory automation, industrial control, ruggedized hand-held devices, smart meters, current sensing, torque control and safety applications.

The FXMS3110 has unmatched performance and integration that allows for the efficient control of infrastructure and autonomous real-time systems. It enables efficient software development in terms of software size and efficiency of sensor data re-use for a variety of applications.

The FXMS3110 has very low noise and high resolution to provide highly accurate and reliable heading information. The Xtrinsic FXMS3110 magnetometer measures the magnetic field in all three axes with ranges up to 1000 μT , at data rates up to 80 Hz, with resolution down to 0.1 μT and with noise as low as 0.05 μT .

The Xtrinsic FXMS3110 magnetometer has been added to our formal Product Longevity program that makes a broad range of devices available for a minimum of 10 or 15 years from the time of introduction.

FXMS3110 Industrial Applications

- Factory automation
- Industrial control
- Torque control
- Safety applications
- Ruggedized hand-held devices
- Smart meters
- Current sensing

MAG3110 and (FXMS3110) Magnetometer Features and Benefits

Features	Specifications	Benefits
Wide dynamic range	+/- 1,000 μT	Provides flexibility in PCB placement within compact form factor devices that incorporate strong permanent magnets such as vibrator motors and speakers
Low noise	As low as 0.25 μT (FXMS down to 0.05 μT rms at 80 Hz ODR)	Hardware-based oversampling options enable high-resolution heading determination without the need for host side sample averaging. User can optimize the power vs. noise trade-off in hardware
Power consumption	17.2 μA at 1.25 Hz (FXMS 24 μA at 1.25 Hz)	Flexible low-power options for significant power savings in mobile applications. Current can be further reduced to 8.6 μA at sub 1 Hz ODRs
Digital output	I ² C interface at 400 kHz	Works well with other sensors, MCUs and devices
Sample rate	80 Hz maximum	Wide signal bandwidth of up to 40 Hz
Supply voltage	1.95 to 3.6 V	Wide operating voltage to cover many applications
Operating temperature	-40 °C to +85 °C	Wide temperature range to cover many applications
High sensitivity over the full dynamic range	0.1 μT	Full heading resolution over the entire dynamic range
Small package	2 x 2 x 0.8 mm 10-pin uDFN	Excellent fit for ultra-compact mobile devices
Drivers available	Examples include Android™, WinCE, Windows® 7, Linux®	Operating system flexibility
Xtrinsic e-compass software		Floating point and integer code that supports all standards including Android, Windows 8 and other operating systems
Xtrinsic calibration software		Full range of power and performance of floating point and integer four, seven and 10 element models

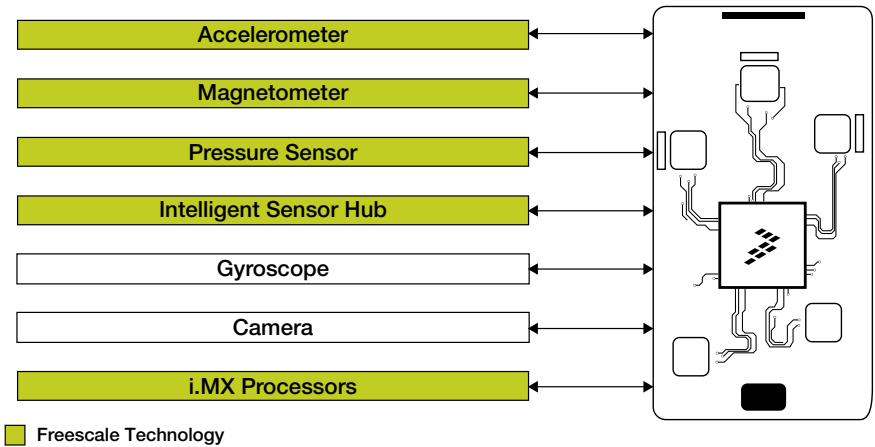
Freescale Xtrinsic Application Examples

Real-World Products that Utilize Freescale Solutions

Consumer Smartphone—Augmented Reality

Augmented reality is a compelling application that combines our i.MX multimedia processing power and Xtrinsic sensors and software to offer a new level of user experience for next-generation mobile devices in the consumer, medical and automotive infotainment markets.

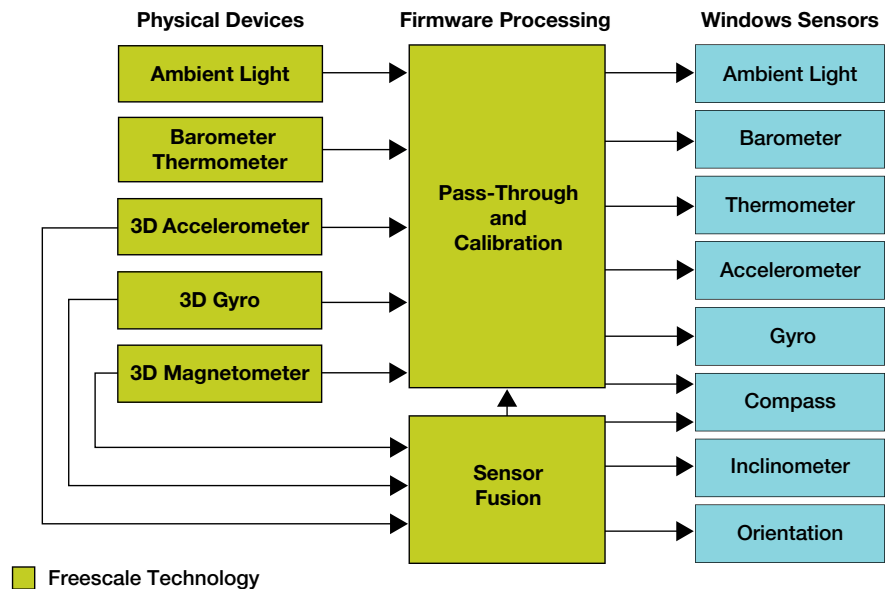
Augmented reality puts a virtual view on top of your real world, bridging the gap between the actual and digital worlds. Information, media, education, services and advertisements becomes layered content from the Internet to match specific environments and contexts in a more natural way.



Windows 8 Tablet Slates, Laptops and Other Portable Devices

Our 12-axis Xtrinsic sensor platform for Windows 8 extends sensor fusion in tablets, slates, laptops and other portable devices. This complete hardware and software solution fuses accelerometer, magnetometer and gyroscope data using a Freescale ColdFire+ MCU for high quality.

Optimal sensor fusion provides ease of integration for streamlined development including hardware and software that supports Microsoft® products.

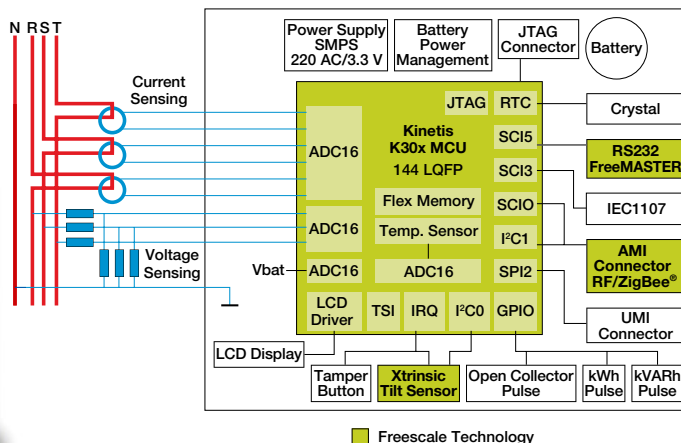


Electronic Tamper Detection Smart Meter Reference Design

The smart grid needs to physically secure all elements that may include smart meters, data concentrators, intelligent electronic devices and secure gateways. Freescale provides a high-performance electronic tamper detection smart meter reference design that integrates an ultra-low-power Xtrinsic 3-axis tilt sensor used for electronic tamper detection.

This reference design has the ability to connect to a ZigBee® network through an internal daughter card, allowing it

to easily become part of the smart grid network. Firmware for this reference design is based on the MQX real-time operating system. All standard metering values are displayed on the built-in LCD and selectable via the push button. A variety of communication interfaces are available for remote data collecting, making this an ideal solution for advanced residential metering.



Blood Pressure Monitor

Blood pressure monitors (BPMs) help make precise diagnoses of patients who suffer from hypertension by implementing techniques such as oscillometric methods and Korotkoff's measurements. They measure mean arterial pressure and use algorithms to derive systolic and diastolic values.

Blood pressure monitors display readings on an LCD screen and are driven by a low-power, 8-bit or 32-bit MCU and incorporate a pressure sensor in either an arm or wrist cuff.

The Xtrinsic CRTouch, named a 2012 Ace Award HMI product of the year, and the TSS are key examples of the solutions that enable customers to develop and align with the market needs for touch sensing.



Digital Still Cameras

Our accelerometers are used to sense the fall if the user drops their digital still camera. The data is sent to the MCU that runs the algorithm to determine a freefall event. The MCU then initiates action to retract the extended lens into the case of the digital still camera body where it is better protected than when it is extended. The accelerometer will also help with picture viewing whether in landscape or portrait mode.

Digital still cameras are now able to steady and level the photo capture. This is done through an overlay display to show how level the shooter is taking the picture.



Software Solutions

E-Compass Software

Tilt-Compensated E-Compass with Magnetic Calibration

Xtrinsic e-compass software is compatible with any Freescale three-axis accelerometer and three-axis magnetometer for applications requiring an electronic compass (e-compass). It is written in ANSI C for maximum compatibility across processors and operating systems.

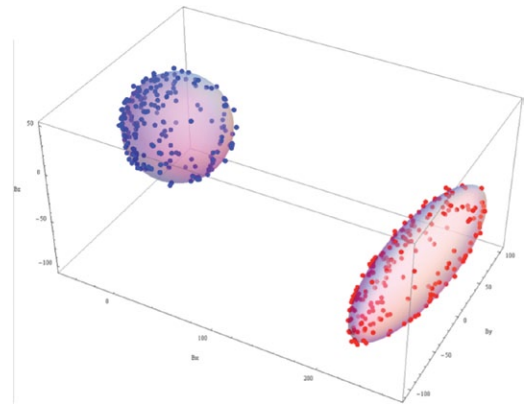
The accelerometer provides roll and pitch orientation used to de-rotate the magnetometer readings to the horizontal plane for calculation of the yaw, or compass heading, angle. The e-compass can therefore operate accurately at any tilt angle.

Xtrinsic e-compass software includes the ability to simulate the accelerometer and magnetometer data at random angles for a user-defined magnetic field vector and hard and soft iron magnetic interference. The user can verify that the software can accurately compute the magnetic interference parameters

and the e-compass orientation and compass heading information on a processor board before interfacing an actual accelerometer and magnetometer. Once actual sensors are connected to the processor over I²C, the sensor simulation driver is simply replaced by the actual sensor driver.

The magnetic calibration algorithms are provided with three levels of sophistication. The four parameter version is suited for applications with hard iron interference only or where minimal power consumption is required. The seven parameter model adds support for soft iron gain distortion and is suitable for the vast majority of consumer e-compass applications. The 10 parameter model adds support for cross-axis soft iron distortion and is targeted at the most complex smartphone PCBs.

The four and seven parameter versions of the software are provided as ANSI C source code while the 10 parameter software is provided only in object code format.



Combination plot showing uncalibrated and calibrated magnetometer measurements

Drivers for Smart Devices

For Android™, Linux® and other Operating Systems

Carrying a smartphone or other smart portable device has become the norm in our daily life, and sensors are becoming essential components in these smart devices. To help reduce development time and shorten time to market, we offer a series of software drivers that support Android, Linux and other operating systems. These drivers support Xtrinsic sensors for both consumer and industrial applications, and can be easily ported into your design.

For a more complete and ready solution, we recommend a layered approach with the right selection of components to interface with the platform software stack. The code can also easily be modified based on our reference code. Drivers run by Xtrinsic sensors provide an excellent platform for building a high-performance, low-power and cost-effective mobile device that successfully passes the Android Compatibility Test Suite.

Key Features

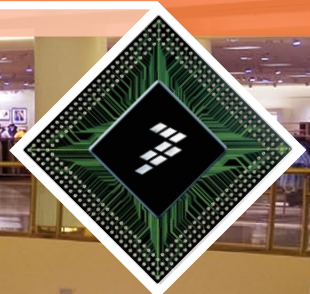
- Based on the latest Android and Linux kernel release
- Tested and implemented on the Freescale i.MX application processor platform, can be ported easily to other platforms
- Highly optimized for Freescale sensors
- Maximizes capabilities of sensor embedded features
- Source code for selected drivers and middleware



make it PRECISE

Smartphones, tablets and other smart devices help guide us through the complex world around us and sensors enable them to help us find the way. Freescale is building on 30 years of MEMS sensing technology success with its new Xtrinsic sensor lineup. By integrating multiple highly precise, energy-efficient sensing functions with the right logic and customizable software, you'll be able to touch, tap, tilt and transmit your way into next-generation designs. A smarter, more interactive world. Let's make it.

[Learn more at freescale.com/Xtrinsic](http://freescale.com/Xtrinsic)



Xtrinsic Sensor Family Best-in-Class Features

- Diverse sensor types: Inertial, magnetic and pressure sensors
- Highly precise pressure and altitude data
- Higher resolution, lower noise accelerometers
- Magnetometers that provide highly accurate and reliable headings
- Multiplicity of sensor fusion inputs for greater value
- Increasing levels of intelligence
- Flexible sampling rate
- Software development for a variety of applications
- Customizable Sensor Toolbox evaluation platform



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How to Reach Us

Freescale Semiconductor prides itself on world-class support. Assistance is just a click away at freescale.com/support.

Technical Information Center

The engineers in our Technical Information Center offer assistance via phone or online to meet the specific needs of customers around the world.

Local Technical Support

Our field application engineers are located close to our direct customers and are available for direct contact and visits to customer sites.

FAQs

Our vast knowledge base of frequently asked questions (FAQs) is online to offer support 24 hours a day, seven days a week and is updated and maintained by product experts.

Technical Documents

Available at freescale.com

- Engineering bulletins
- Reference manuals
- Data sheets

Freescale Forums

Our forums are moderated by product experts and feature discussions on Freescale MCUs and development tools, allowing our customers to communicate their ideas on a global scale.

This brochure is not intended to represent the entire Freescale portfolio of sensor products. Contact us to discuss what we can do for your application.

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