

Freescale Sensor Overview for Industrial, Consumer and Medical Market

EUF-IND-T1234

Francois Villeneuve



November 2013

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- Sensor 2013 activity
- Product roadmap update :
 - Linear Inertial Sensors - Accelerometers
 - Linear Inertial Sensors - Intelligent sensor hub
 - Rotational Inertial & magnetic sensors - Gyro & magnetometers.
 - Pressure Sensors
- Enablement support
- Application deep dive



Freescal Q3 Sensor Business Overview

New Products Snapshot:

MMA865x (2x2 Accelerometer)

- Full production

FXLS8471Q (3x3 Accelerometer w/SPI)

- Full Production in November

FXLN83xxQ (3x3 Accelerometer – Analog)

- Samples now, Qual in July, Production in Nov '13

MMA955x (3x3 Accelerometer + 16kB MCU)

- Full production

FXLC95000 (3x5 Accelerometer + 128kB MCU)

- Samples now, Qual in August, Production in August '13

FXOS8700CQ (3x3 6-axis eCompass)

- Full production

FXAS21000 (3-axis Gyroscope)

- Samples now, Qual Oct, Production in Oct'13



EDN announced the FXOS8700 as one of the Hot 100 Products of 2012 in components.



Roadmap & Product Update

[illegible]

Accelerometer Family



MMA865x

- Digital Output
- Cost Efficient
 - 1mg/count sensitivity
- High Perf.
- Rich Features
 - P/L detection
 - High Pass Filter
 - Transient Detect
- 2x2 mm package



MMA845x
FXLS8471Q

- Digital Output
- Extreme Perf.
 - .25mg/count sensitivity
- Extended Features
 - FIFO
 - Configurable P/L trip angles
 - High Pass Filter
 - Transient Detect



MMA8450

- Digital Output
- Low Voltage
 - 1.71-1.89V



MMA8491

- Digital Output
- Extreme Low Power
 - 0.35uA/Hz
- Cost Efficient
 - 1mg/count sensitivity
- Industrial Package



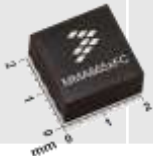
FXLN83xx

- Analog Output
- High Bandwidth
 - 4.9KHz
- Low Voltage
 - 1.71-3.6V
- Industrial Package
- Extended Temp Range: 105C

Industrial

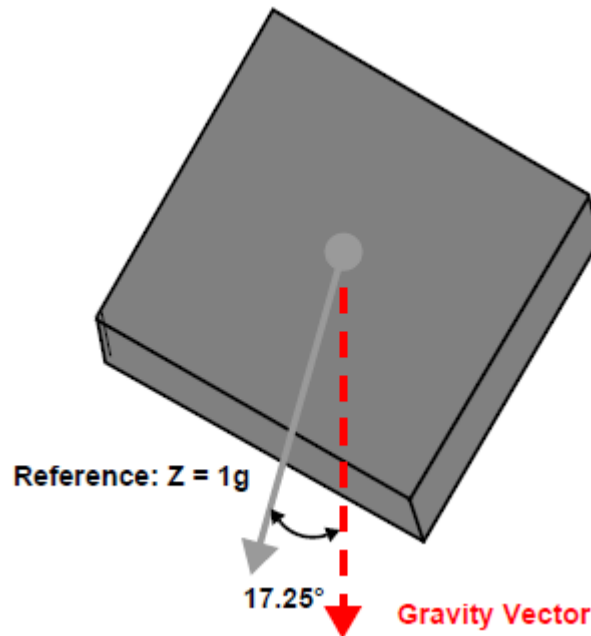
Consumer



	Sample	Prod	SRP\$	Applications
MMA8451/52/53 3-axis $\pm 2, \pm 4, \pm 8$ g 10/12/14-bit Digital I²C - Embedded function and interrupt : (FIFO, High pass filter, P/L,...) - Ultra low noise (99 $\mu\text{g}/\sqrt{\text{Hz}}$), low TCO (0.15mg/°C) - High performance Consumer & Industrial - Down to 0.25mg/LSB sensitivity 1.95...3.6 Volt, 3 x 3 x 1 mm QFN	Web	ok	0.86 0.68	Tilt Measurement Pedometer Power Management eCompass Asset Tracking Activity Monitor DECT Phones Sports Watch Fleet Management Remote Controls Appliance
FXLS8471 3-axis $\pm 2, \pm 4, \pm 8$ g 14-bit Digital SPI/I²C - Embedded functions and interrupts (all + Vector magnitude) - High performance industrial grade 1.95...3.6 Volt, 3 x 3 x 1 mm QFN	Now	now	0.95	
				
MMA8652/53 3-axis $\pm 2, \pm 4, \pm 8$ g 10/12-bit Digital I²C - Embedded functions and interrupts (8652 same than MMA8451) - Software compatible with the MMA845x family - Low cost, 1.95...3.6 Volt, 2 x 2 mm DFN	Web	Now	0.55	
				
MMA8491 3-axis Tilt Sensor 14-bit Digital I²C + 3 Logic Out - Ultra low power down to 400 nA/hz, 3 logic outputs to flag tilt on the 3 axis - I²C interface to read raw acceleration data 1.95...3.6 Volt, 3 x 3 x 1 mm DFN	Now	Now	0.77	Ball-in-a-Box Tamper Sensor Alarm/Security Freefall Detect Remote Control Low Power Wake-up
				

Accelerometer Vector-Magnitude Function Use Case (see AN4458)

- Detection of a linear acceleration exceeding a threshold (completely independant from the mounting orientation)
- Detection of change of tilt angle exceeding a threshold



Accelerometer

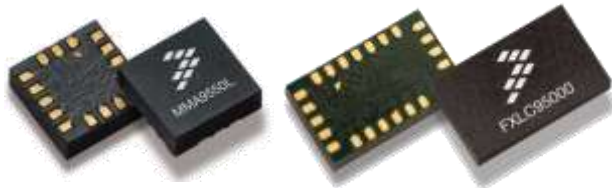
Key Products 2013



	Sample	Prod	SRP\$	Applications
FXLN8361 3-axis $\pm 2/\pm 8$ g Analog Out, low bandwidth	Now	Nov-13	1.03	-Vibration Monitoring -High Precision -Industrial Control -Sport Applications -Preventive Maintenance
FXLN8362 3-axis $\pm 8/\pm 16$ g Analog Out, low bandwidth	Now	Nov-13	1.03	
FXLN8371 3-axis $\pm 2/\pm 8$ g Analog Out, high bandwidth	Now	Nov-13	1.03	
FXLN8372 3-axis $\pm 8/\pm 16$ g Analog Out, high bandwidth	Now	Nov-13	1.03	
- High Bandwidth: up to 4.9 KHz on XY and 2.1 KHz on Z axis - Low Bandwidth : up to 1.7 KHz on XYZ axis - Low power 200 μA in running mode, low voltage - High performance industrial grade 1.7...3.6 Volt, 3 x 3 x 1mm , 0.65mm pitch 12 QFN				
MMA6900Q 2-axis XY, ± 3.5 g, 11 bits, SPI, AECQ100	Now	Now	4.77	-Vehicule stability control -Electronic parking brake -Car alarm - trailer tilt control -Absolute tilt measurement - noisy environnement
MMA6901Q 2-axis XY, ± 5 g, 11 bits, SPI, AECQ100				
- AECQ100 qualified, -40°C;+105°C - Low pass filters for noisy environment - Low TCO over the wide temperature window. - QFN 6x6mm, 16 pins QFN 				



			Sample	Prod	SRP\$	Applications
MMA955xL 32-Bit 16K Flash CPU and 3-axis Accelerometer						Tilt Measurement
FXCL95000LC 32-Bit 128K Flash CPU and 3-axis Accelerometer						Vibration Monitor
• Embedded ±2, ±4, ±8 g 3-axis 16-Bit accelerometer module • 32-Bit CF V1 CPU with MAC multiply and accumulate block • 16K or 128K on-chip Flash, 2K or 16K on-chip SRAM • SPI, I²C (master and slave), GPIO, ADC, PWM • 1.8V , 3 x 3 x 1 mm QFN, or 3 x 5 x 1 mm QFN • Pre-flashed Freescale firmware (3 Versions) or MQX • CodeWarrior CW10.x supported						Pedometer
						Home Health
						Power Management
						eCompass
						Asset Tracking
						Collision Recorder
Part Number	Firmware	User Memory Size				starting at 1.79
MMA9559L	Basic	14K Flash 1.5K SRAM	Now	Now		
MMA9550L	Infrastructure	6.5K Flash 0.5K SRAM	Now	Now		
MMA9551L	Infrastructure and Gesture	4.5K Flash 0.5K SRAM	Now	Now		
MMA9553L	High end pedometer	1.5K Flash 0.2K SRAM	Now	Now		
FXLC95000L	MQX enabled	128K Flash 16K SRAM	Now	July-13		
						3-Axis MEMS



3-Axis MEMS Accelerometer	
ROM	ColdFire 32-Bit V1 Core
Flash	
RAM	
ADC	SPI
GPIO	I2C

FXLC9500CL- key selling points

Key Advantages

- Open system can manage multiple sensors with FSL or third party drivers for highest flexibility and usability
- Offloads application processor by controlling sensor subsystem
- Other integrated sensor “hubs” are closed; FXLC9500CL allows for differentiated programming models
- Power management via easy access to hardware low-power modes. Host processor sleeps while sensors keep working
- MAC (Multiply ACcumulate) instructions conserve CPU cycles
- ISF (Intelligent Sensor Framework) FXLC9500CL release allows customers:
 - To quickly develop applications as they focus on using sensor data, not getting sensor data.
 - To create their own applications with any market available sensor



Prinsic FXOS8700CQ

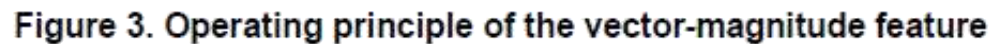
6-Axis Linear and Magnetic Sensor



- **Combo 3 Axis Digital magnetometer + 3 axis digital accelerometer**
- Lowest noise gcell and mcell
 - Embedded Functionality to allow system fast response and power savings
 - Embedded 4 channels of motion detection
 - Free fall or motion detection: 2 channels
 - Pulse detection: 1 channel & transient detection : 1 channel
 - Embedded orientation (Portrait/Landscape) detection with hysteresis
 - Automatic ODR change for auto-wake-up / return-to-sleep
 - 32 sample FIFO
 - Directional tap
 - High Pass Filter
 - Low Power Mode
 - **Magnetic Threshold Interrupt**
 - **Vector Magnitude interrupt for mcell, gcell**
- 1.95V to 3.6V supply voltage, I/O 1.6V – 3.6V
- Internal die heater functionality for improved TCO performance
- $\pm 2g/\pm 4g/\pm 8g$ accelerometer, ± 12 Gauss Field range
- **Output data rate (ODR) from 1.5Hz to 800Hz , 400Hz hybrid**
- Low power = 80 uA in Hybrid mode @ 25 Hz.
- 14-bit gcell data, 16-Bits mcell data



3x3x1.2 mm QFN package



The operating principle of this function is depicted in Figure 3. The vector-magnitude function simply compares the magnitude of the difference between the sensed field vector and the reference field vector against the magnitude specified by *A_VECM_THS* (or *M_VECM_THS*). If the former is greater than the latter for a minimum duration of time specified by *A_VECM_CNT* (or *M_VECM_CNT*), then an event is raised.

Intrinsic FXAS21000 (Leon) 3-Axis Digital Gyroscope



- **Differentiating Points**
 - Angular acceleration resolution better than 0.2 dps
 - Programmable interrupts
 - Power saving features : 5.5 mA in running mode, 3.8mA in ready mode (fast wake up), 2μA in stand by mode.
- **Product Features**
 - 1.95-3.6V supply voltage
 - Output data rates (ODR) from 1Hz to 200Hz
 - Full scale range: ±200 to 600 dps
 - **Sensitivity variation with temperature : : ±0.1%/ °C**
 - **Offset variation with temperature : ±0.3 dps / °C**
 - **Programmable interrupts :**
 - 32 samples FIFO
 - rate threshold detection function
 - New data ready



4x4x1mm QFN, 0.5 mm pitch

Package

4x4x1mm QFN, 0.5 mm pitch

Availability

Samples: Now

Production: Oct 2013

FXAS21000 Planned Enablement

Sensor Adapter Board

Freedom board platform

**Available end Q4'13**

Support with the FXCL950000

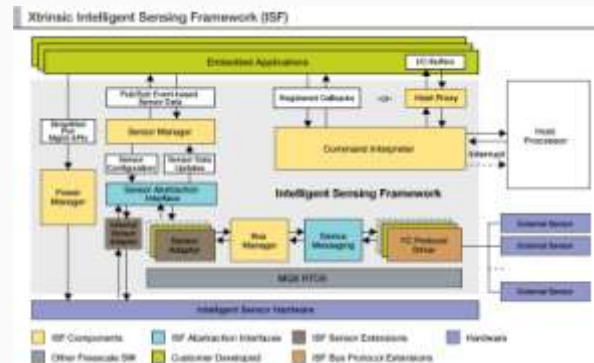


9-Axis



Available now - limited

Xtrinsic ISF Adapters available



Freescale Kinetis + Sensor Solutions

- Sensor solutions supporting the Freedom Board Platform
- <http://www.freescale.com/freedom>
- Arduino-compatible form factor



FRDM-KL25Z & FRDM-K20D50M

- Includes MMA8451Q on board.

Xtrinsic Shield FXLS-FXS-MULTI

1st sensor “shield”

- FXAS2100 (Leon) Gyro
- Newton 3-axis accelerometer
- MAG3110 (Maxwell) 3-axis magnetometer
- FXOS8700CQ (Gauss) 6-axis mag + accel
- MMA9553LR1
- MPL3115A2 Pressure Sensor/Altimeter
- Optional Bluetooth Module

Available end Q4'13

Xtrinsic Sensing Development Tools Planned

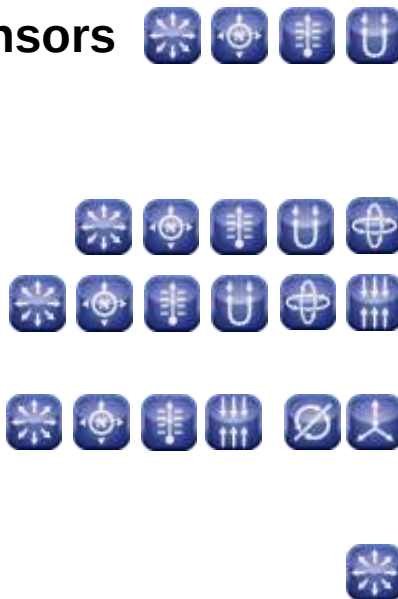
B- Bluetooth
C- Combo
D- Discrete
H-HUB

Sensors EVKS



Part Number	Description
DIP21000-6AXIS-D	MMA8652,FXAS21000 (Q4)
DIP21000-9AXIS-C	FXAS21000, FXOS8700 (limited now)
DIP21000-9AXIS-D	MMA8652, FXAS21000, MAG3110 (Q4)
DIP21000-10AXIS-C	FXAS21000, FXOS8700, MPL3315A2 (Q4)
DIP95000-9AXIS-H	FXLC95000 Dev kit 9-axis adapter DIP (Q4)

Kinetis and Sensors

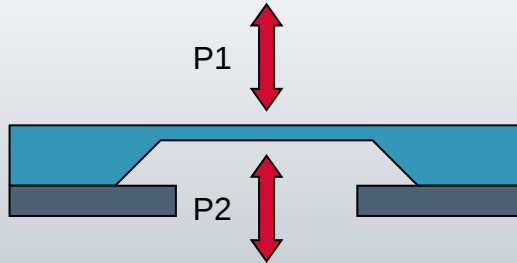


Part Number	Description
FRDM-FXS-MULTI	Xtrinsic Shield board with: (Q4) MPL3115A2 MMA8652, FXAS21000 FXOS8700 FXLS8471 MMA955x MAG3110
FRDM-FXS-MULTI-B	Same as FRDM-FXS-MULTI w/Bluetooth and Battery (Q4)
FRDM-FXS-9AXIS	Xtrinsic Shield board with: (Q4) FXAS21000 FXOS8700
FRDM-FXS-MULTI-C	Xtrinsic Shield board with: FLXN83xxQ (Q4) MMA8491, FXLS8471, MPXHZ9115A, MPL3115A2 FXMS3110DR1
FRDM-FXS-GALLA	adapter board w/FXLC95000

Technological Aspects of Pressure Sensors

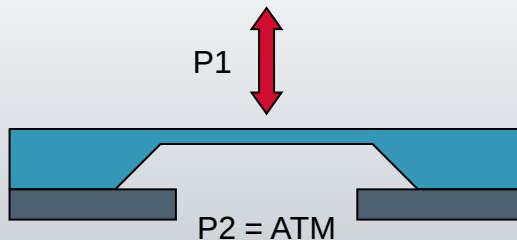
Terminology

Differential



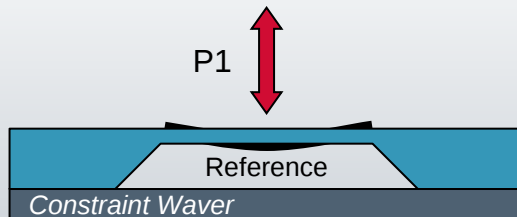
Differential – Measures differences between two pressure points (P1 and P2)

Gauge



Special type of differential measurement.
One side exposed to Atmosphere ($P_2 =$
Atmosphere Pressure)

Absolute

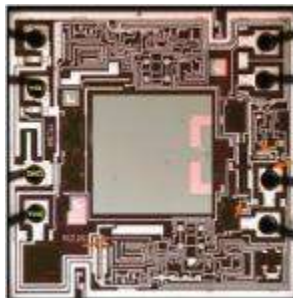
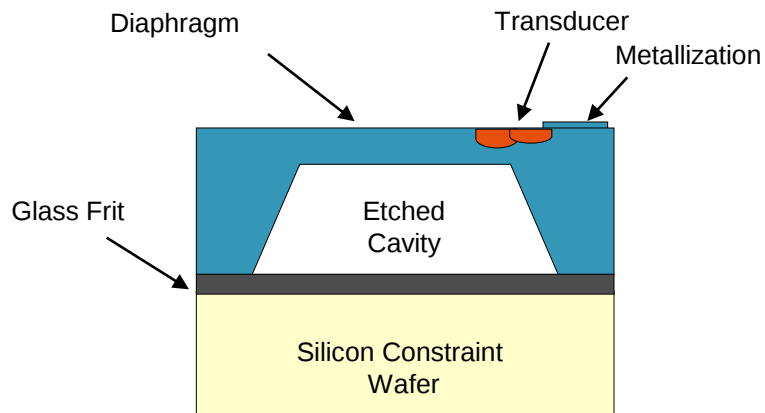


Only one side is accessible. Internal (P2) is referenced to vacuum or sealed air inside.

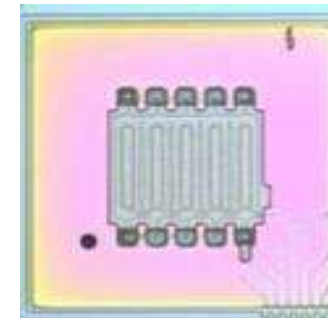
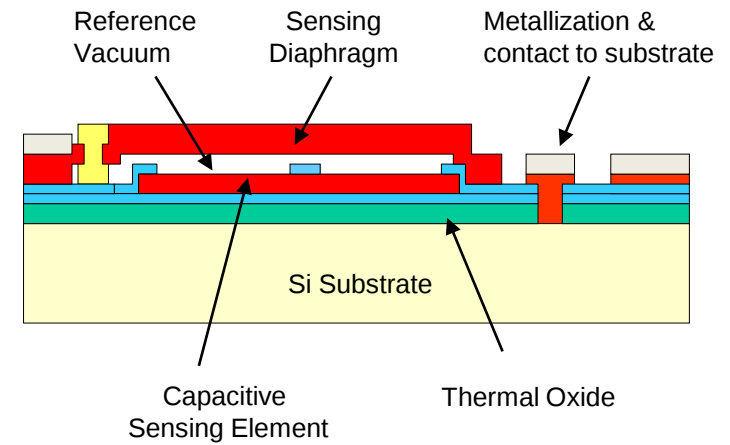
For All: $P_1 > P_2$ for positive voltage output

MEMS Pressure Sensors Technology

Bulk Micro machining



Surface Micro machining





			Sample	Prod	SRP\$	Applications
MPXHZ9 Series 15...400 kPa Absolute Pressure Sensor • 1.5% max error over 0° to 85°C • 5 V power supply • Media resistant gel • AECQ100 qualified • Drop in replacment of the MPXHZ6xxx series 						Fuel Injection Comfort Seating LPG Gas Market
MPXHZ9115A6T1	15...115 kPa	No port	Now	Q1-14		
MPXHZ9115AC6T1	15...115 kPa	Port	Now	Q1-14		
MPXHZ9250A6T1	15...250 kPa	No port	Now	Q1-14		
MPXHZ9250AC6T1	15...250 kPa	Port	Now	Q1-14		
MPXHZ9400A6T1	15...400 kPa	No Port	Now	Q1-14		
MPXHZ9400AC6T1	15...400 kPa	Port	Now	Q1-14		
MPY8600DK6T1 Tire pressure monitoring system 100-900kpa • S08, 8 Bit MCU , 16k Flash, 512 b Ram • RF transmitter PLL-based 315/434 MHz, ASK/FSK, Manchester						TPMS RF pressure sensor RF accelerometer
MPL3115A 20...115 kPa Digital Absolute Pressure Sensor • Compensated sensor • Direct readings in Pressure, Altitude and Temperature • typ 25 cm altimeter resolution • Embedded software providing real data • Embedded interrupts and pre-programmed functions • 3 x 5 x 1 mm LGA package 			Web	Now	1.43	Altimeter Sport Watch Medical Monitoring Breath Analyzer Air Conditioning Vacuum cleaner

A – Absolute
D – Differential
G – Gauge
V – Vacuum

D G

Uncompensated

High sensitivity analog output

Need external circuit for compensation and amplification

ADGV

Temperature Compensated

Integrated temperature compensation

Need external circuit for amplification

D G

Integrated Pressure Sensor

Integrated signal conditioning for temperature compensation, linearization and amplification

A D G

6...250 kPa
SOP, SSOP, Unibody

ADGV

4...1'000 kPa
SOP, SSOP, Unibody

A

100...400 kPa
SOP, SSOP

A

115 kPa Smart Baro/Pressure
3 x 5 mm LGA

SOP
Side
Port

SOP
Axial
Port

Unibody
Dual
Port

SSOP
Basic
Case

Medical ChipPak Case

LGA
3 x 5 mm
Case

MPL3115A Digital Altimeter/ Pressure Sensor



- I2C interface slave device
 - Low Power $1\mu\text{A}$ Sleep, $8.5\mu\text{A}$ Active
 - Factory calibrated
 - 1.95V - 3.6V supply
 - 50kPa to 115kPa calibrated range
 - 20 kPa – 115 kPa range.
 - **1.5 Pa resolution (25cm accuracy)**
 - Variable output sampling rate up to 140 Hz.
 - **Internal temperature compensation and altitude conversion**
 - **Direct reading in Pascal or meters , software not needed**
 - Limit Alarms (2 interrupt pins) : Range and delta
 - Data Storage: FIFO for altitude/pressure and temperature
 - -40°C to $+85^{\circ}\text{C}$ operating temperature
 - **Package 5 x 3 x 1.1 mm**
- 
- 



Embedded world award 2012

Axtrinsic MPXHZ9115A6 Barometric Pressure Sensor



- **Differentiating Points**

- Uses the same pin-out as existing MPXx6115x pressure sensors
- Wide pressure range to cover a variety of engine control applications
- Package porting and mounting options enable tube attachment for LPG or remote sensing applications



- **Product Features**

- Pressure range: 15 to 115 kPa
- Maximum pressure: 400 kPa
- 5 volt power supply
- 1.5% maximum error over 0° to 85°C
- Temperature compensated from -40°C to +125°C
- Fully calibrated and compensated
- Ideally suited for microprocessor or microcontroller-based systems



- **Typical Applications**

- Fuel Injected Car Engines
- Small Engines
- Comfort Seating
- Alternative Fuel Vehicles



Package

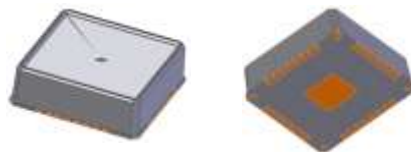
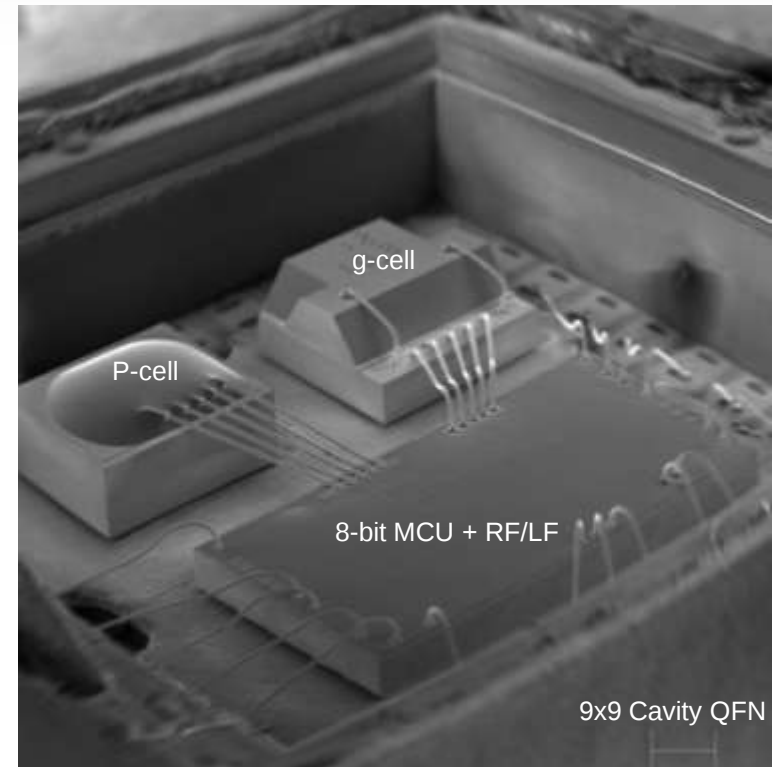
8-pin SSOP with gel

Sampling: NOW
Production: Q1 2014

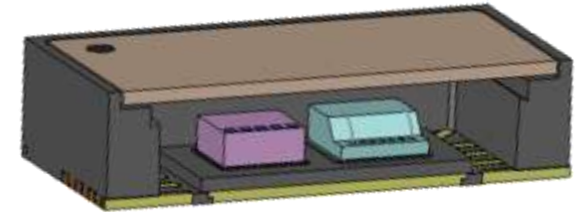
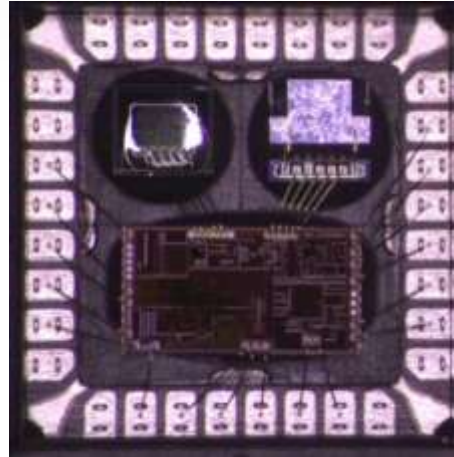
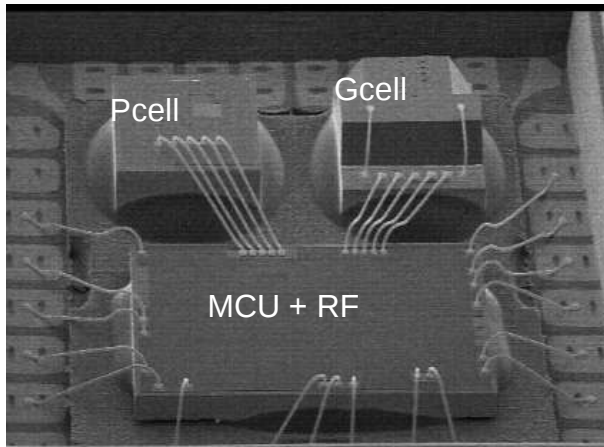
Freescal e TPMS MPXY8600D at a Glance

- **System-in-Package TPMS**

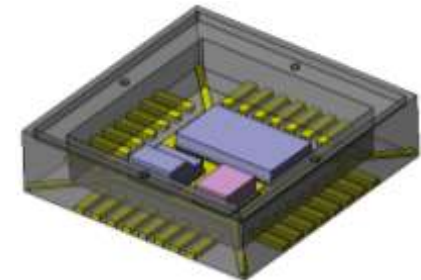
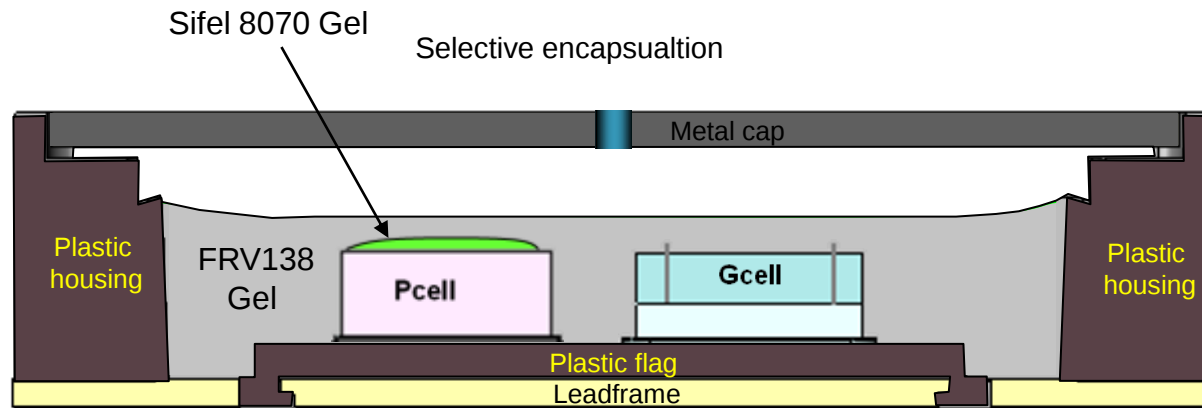
- **Pressure sensor** with two pressure range options:
 - Passenger cars: 100-900 kPa
- **Accelerometer** for motion detection
 - Options include: dual-axis (XZ), single-axis (Z), or no accelerometer
- **8-bit Microcontroller + RF transmitter**
 - Low power 512b RAM, 16KB flash
 - PLL-based 315/434 MHz, ASK/FSK, Manchester
 - Data
- **Package**
 - QFN 9x9 cavity with media protection



TPMS MPXY8600D Packaging



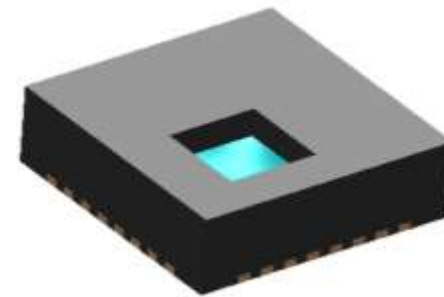
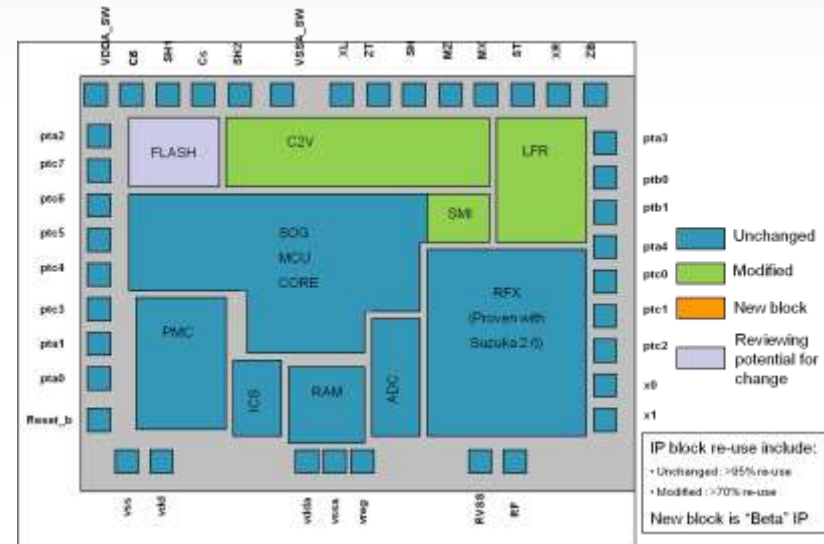
QFN 9 x 9 mm
Cavity Package
(Cross Section)



Not to scale!!!

TPMS Gen4 – High Level Overview

- **System-in-Package TPMS**
 - Multiple pressure ranges (up to 1500 kPa) for Truck market
 - Accelerometer for motion detection - Options include: dual-axis (XZ), single-axis (Z), or no accelerometer
- **8-bit MCU with embedded firmware**
 - Low power 512b RAM, 16 KB flash
 - RF transmitter, PLL-based 315/434 MHz, ASK/FSK
 - LF 125 KHz interface
- **Package**
 - QFN 7x7 FAM
- **Samples (up to 900 Kpa) : Limited Now**
- **Production (up to 900 Kpa): Q1/2014 (low pressure)**
- **Samples (1500 Kpa) : June 2014**
- **Production (up to 1500 Kpa) : Q2 2015**



QFN 7x7 FAM

Enablement Support



Note:

green	the sensor works well on the model of platform
blue	remark or more information
yellow	ongoing
red	planned
white	no customer requirement or plan

eCompass Software - Magnetic Calibration

- Freescale Xtrinsic e-compass sensor fusion software awarded Product of the Year by Electronic Products Magazine



- Key Features: Tilt compensated eCompass with best in class hard and soft iron calibration.
- 3 versions:
 1. Hard iron only
 2. Hard iron and on-diagonal soft iron scale terms
 3. Full hard and soft iron calibration

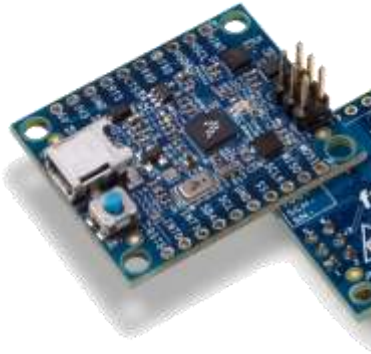
(1) and (2) are available in source form via click through licenses. (3) is available under NDA.
- Available @ Freescale.com Key Word Search: ECOMPASS_SW
 - [Click Here for Direct Link](#)

Freescal[®] 12-Axis Xtrinsic Sensor Platform

global  sources

电子成就奖

China ACE Awards

- **Freescale's parts:**
 - Xtrinsic MMA8451Q 3-axis accelerometer
 - Xtrinsic MAG3110 3-axis magnetometer
 - Xtrinsic MPL3115A2 precision altimeter
 - ColdFire+ MCF51JU128VHS MCU
 - Xtrinsic FXAS21000 3 axis Gyroscope (H2)
 - **Other parts:**
 - Ambient light sensor
 - **12-axis solution** with IMU plus additional axes including ambient light sensor and temperature sensor
- 
- 电子成
China AO



Learn more at www.freescale.com/Windows8

Sensor Fusion Demonstrator

Xtrinsic Sensor Fusion Toolbox for Android

- free at <https://play.google.com/store/apps/details?id=com.freescale.sensors.sfusion>
- demonstrates 3, 6 and 9-axis sensor fusion tradeoffs
- works with
 - the sensors in your Android device
 - Avnet Wi-Go
 - Freescale KL25Z and K20D50M Freedom boards coupled with FRDM-FXS-MULTI sensor shield (available Q4 2013)
- supports Bluetooth and Wi-Fi interfaces



Application Deep Dive



Sensor Medical Market Focus

Medical targeted Applications



- Activity monitoring device (ultra low power Accelerometer MMA8491Q, MMA8452, MPL3115A2)
- Hospital bed (High precision Tilt – MMA8451)
- Invasive Blood pressure monitors (MPX2300 - Bio-medically approved)
- Non Invasive Blood pressure monitors (Pressure MPX2051GS, MPXV5050G+MMA8451)
- Electronic Alcohol breathalyzer (Digital pressure sensor MPL3115)
- Sleep apnea (CPAP machines MPXV5004G)
- Inhalers and ventilators (digital pressure MPXV5004, MPL3115)
- Endoscopic capsule (Smart sensor, Magnetometers, ..)
- Insulin nebulizer (MPXV5004GP,)

- Application specific requirement :
 - low power (replaceable battery : 3-5 years life time)
 - Accelerometer sampling frequency between 1 Hz – 25 Hz
 - Reasonable sensitivity 1 mg/LSB
 - Low voltage, small form factor
 - Altimeter with 30cm resolution
- Freescale unique solution MMA8491Q (in the HHH reference design) :
 - 0.35 μ A/ Hz : best in class up to 20 Hz.
 - 1 mg/LSB
 - 1.95V-3.6V supply voltage range
 - 3x3 mm QFN package
- Freescale MPL3115A2 – 30cm altitude resolution altimeter
 - Required for soft fall detection
 - Can reach 30 cm resolution in the 128 oversampling mode

New
Best in class power consumption

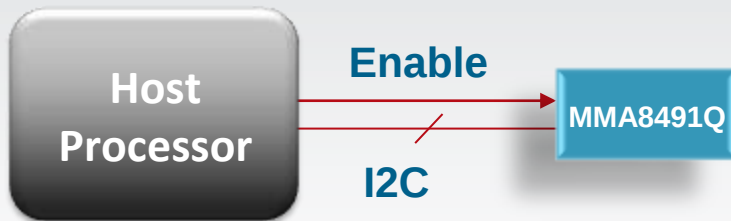


(2/2)

UNIQUE MMA8491Q

Host MCU triggers Sensor

- Host MCU powers-up MMA8491Q for a Measurement Slot



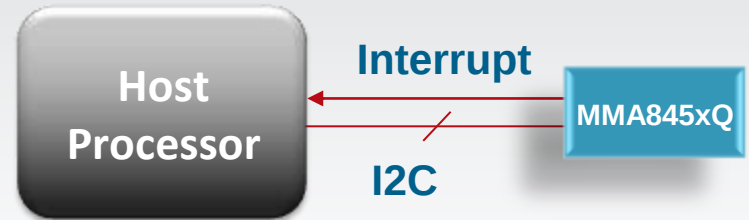
- Power consumption @ 1 Hz:
0.6μA 0.35μA

Total = 0.95 μ A

Classical accelerometer

Sensor wakes up Host MCU

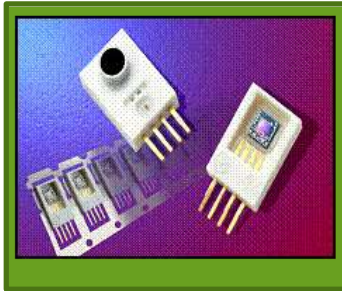
- MMA845xQ raises INT line when data ready

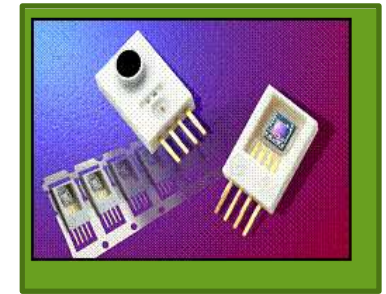
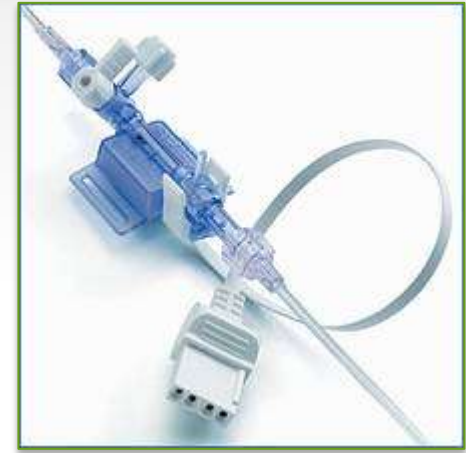


- Power consumption @ 1 Hz :
10nA 6μA

Total = 6 μ A

...vasive Blood pressure MPX2300DT

- Application specific requirement :
 - Gauge sensor, 0-40 kpa Range
 - Low Cost – Disposable application
 - Safe & bio-medically approved.
 - Accurate
 - Integrated Temperature Compensation and Calibration
 - Freescale unique solution MPX2300DT:
 - 0-40kpa Range
 - Low Cost – Disposable application.
 - Safe - Polysulfone Case Material (Medical, Class V Approved)
 - Withstand defibrillation testing, as specified in the proposed Association for the Advancement of Medical Instrumentation (AAMI) Standard for blood pressure transducer.
- 
- 



Non Invasive Blood Pressure MPX5050VG, MMA8451

- Application specific requirement :
 - Gauge sensor, 0-50 kpa Range
 - Low Cost – high accuracy
 - Monitor Arm tilt with accelerometer

- Freescale unique solution MPXV5050VG + MMA8451 :
 - 0-50 kpa Range, 2.5% accuracy
 - MMA8451 Unique accuracy : 0.5° tilt accuracy over 20-80°C. Best in class

Electronics Breath Analyzer MPL3115A

- Application specific requirement :
 - Breathalyzer pressure range : single point measure 10kpa differential or 2 points measurements absolute pressure 110 kpa
 - Pressure sampling frequency up to 50 Hz
 - Good resolution close to 2 Pa
 - Low voltage, low power and small form factor
 - No software or hardware compensation
 - Freescale unique solution MPL3115A :
 - 50 kPa to 110 kPa pressure range
 - Sampling frequency up to 140 Hz
 - Resolution down to 1.5 Pa rms
 - Fully compensated, no software needed, direct reading
 - Down to 8.5 μ A
 - 1.95V-3.6V supply voltage range
 - 3x5 mm LGA package
- 
- A small, rectangular, gold-colored surface-mount package of the MPL3115A2 pressure sensor. The package is oriented diagonally, showing its top surface with a black square area containing the part number 'MPL3115A2' and a small circular mark. The gold pins of the package are visible on the right side.

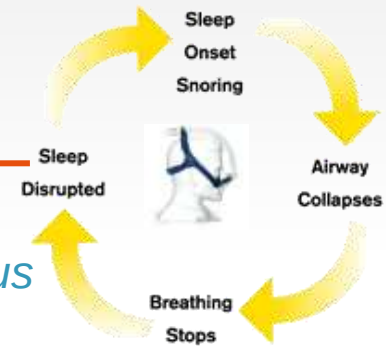


Sleep Apnea (CPAP)

MPXV5004G

Sleep apnea equipment shows solid growth linked with diabetes and obesity rising health issues. C.P.A.P (continuous positive air pressure) is an airflow generator with pressure monitor system to deliver a continue pressure. It is used for treating sleep apnea.

Cycle of Obstructive Sleep Apnea



- Application specific requirement :
 - Gauge sensor, low pressure 0-2/4 kPa can be positive pressure
 - Accuracy is critical. Between 1.5% and 2.5% typical error.
 - Analog output
 - Compensated and integrated (no hardware, software compensation)
- Freescale unique solution MPXV5004G, MPX700xG :
 - Up 4 kpa range for MPX5004
 - Down to 1.5% accuracy
 - Fully compensated and integrated



NXP Respiratory Machine

System to support patient breathing during times of diminished lung capacity

- Application specific requirement :
 - Gauge sensor, low pressure 2/4 /6/10 kPa
 - Negative and positive pressure +/- 2 Kpa
 - Analog output
 - Compensated and integrated (no hardware, software compensation)
 - Barometer to offset altitude influence
- Freescale unique solution MPXV5004G, MPX7002G :
 - MPX7002G monitors +/-2 Kpa
 - Down to 1.5% accuracy
 - Fully compensated and integrated



Sensor Industrial Market Focus

Industrial targeted Applications



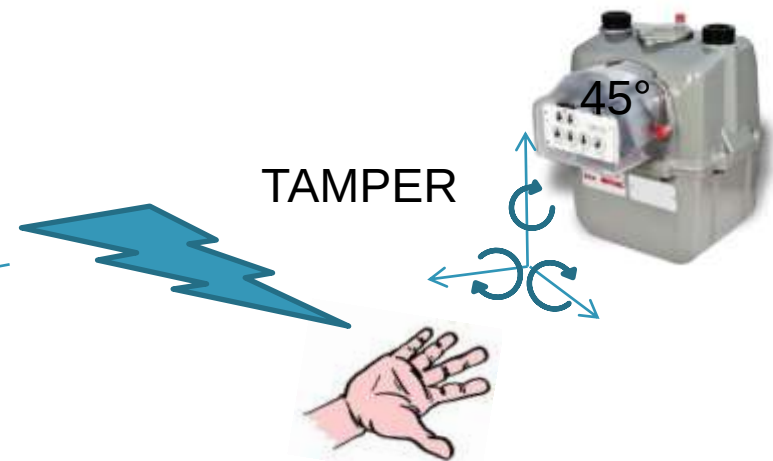
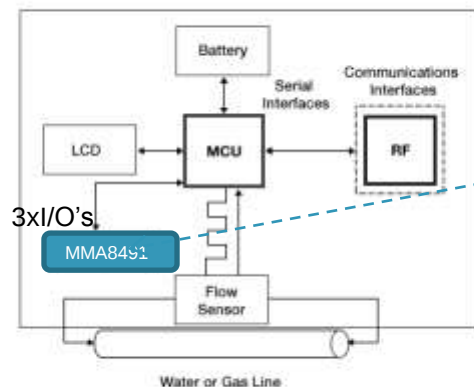
- METERING – Physical tamper detect (Tilt sensor MMA8491Q)
- APPLIANCE – Load unbalance & water level detect (FXLS8471Q + MPXV5004G)
- HIGH PRECISION TILT MEASUREMENT (MMA8451Q, MMA9959, FXLN8361)
- VIBRATION MONITORING (MMA9559, FXLN8371)

NXP Metering

MMA8491Q

- Application specific requirement :
 - Physical tamper detection
 - Improved reliability vs mechanical tilt solution (ball in a box)
 - extreme low power, low g
 - easy to use, direct tilt measurement
- Freescale unique solution MMA8491Q:
 - 2/4/8g configurable range
 - 400nA/Hz power consumption
 - 3 logic output to give tilt treshhold indication

Basic Flow Meter



MMA8451 / MMA9559 / MMA6900Q



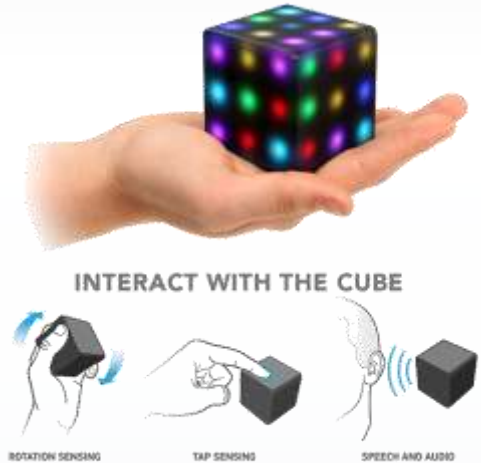
FXLN8371 or FXLN8361

- Application specific requirement :
 - vibration monitoring and control for drill speed control and better user experience
 - high bandwidth from 1 KHz to 3 KHz depending on the use cases
 - very high signal noise ratio (high sensitivity & low noise)
- Freescale unique solution FXLN83x1
 - 2g configuration preferred for better sensitivity
 - high bandwidth up to 4.9 KHz on Z axis and 2.1KHz on XY axis for FXLN8371 and higher noise $\sim 250 \mu\text{g}/\sqrt{\text{Hz}}$
 - Mid bandwidth up to 1.7 KHz on XYZ and lower noise $\sim 150 \mu\text{g}/\sqrt{\text{Hz}}$
 - High sensitivity up to 229 mV/g on 2g mode.



Sensor Consumer Market Focus

Consumer targeted Applications



- CELL PHONE: *MMA865x, MAG3110, FXOS8700CQ (orientation & e-compass)*
- TABLET: *MMA865x, MAG3110, FXOS8700CQ, MPL3115A2 (orientation, e-compass, altimeter)*
- GAMING: *FXAS21000, MMA8491 , MMA845x, MMA865x*
- REMOTE CONTROL : *FXAS21000, MMA8491 , MMA845x, MMA865x*

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



Low Power vs Low Noise in Consumer System Using MMA845x, MMA865x , MPL3115A2, MAG3110,

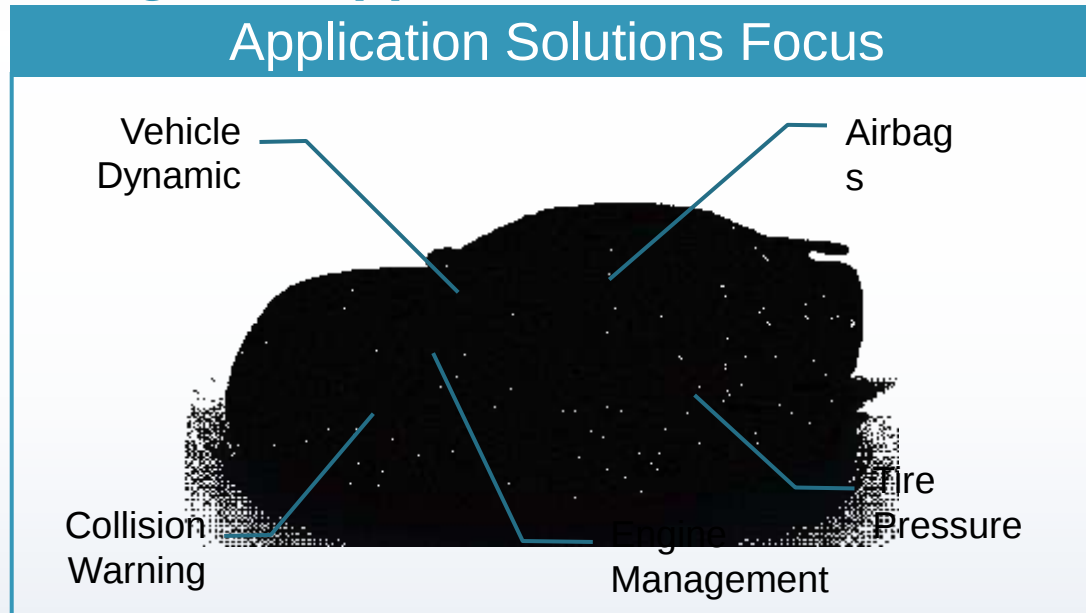
- Application specific requirement :
 - Be flexible on choosing low noise configuration or low power
 - Get the best trade-off on this 2 parameters
- Freescale unique, trade-off selectable modes :
 - Consumption is linked to different parameters :
 - Oversampling ratio (between 2 to 1024) : ↗ OS, ↗ power consumption
 - Output data rate (between 1.56 Hz to 800 Hz). ↗ ODR, ↗ power consumption
 - Power consumption $\propto$ ODR x 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

Sensor Automotive Market Focus

Automotive targeted Applications



- **Inertial Sensors:** *high g Accelerometers for Airbag / Low g for vehicle stability control*
- **Tire pressure:** *9x9mm system in package*
- **Engine management:** *Absolute Pressure sensor*

Benefit of Automotive Designed & Qualified Sensors

- Designed from step zero for automotive use
 - Zero defect methodology
 - Superior test coverage
 - 100% three temperature test insertions
 - 100% burn-in over production lifetime
 - Safe launch plans with the customer
 - AECQ100 qualification
 - Product longevity program
- Freescle makes a broad range of automotive devices available for a minimum of 15 years

www.freescale.com/productlongevity



Automotive Inertial Sensor Applications

1 to 20g - X, Z axis



ABS - ESP:
1 to 2g



**Electrical Parking
Brake: 1 to 2 g**



Roll over:
1 to 5 g



Navigation:
1 to 5 g



Tilt monitoring:
1 to 5 g



Suspension Control:
10 to 15 g

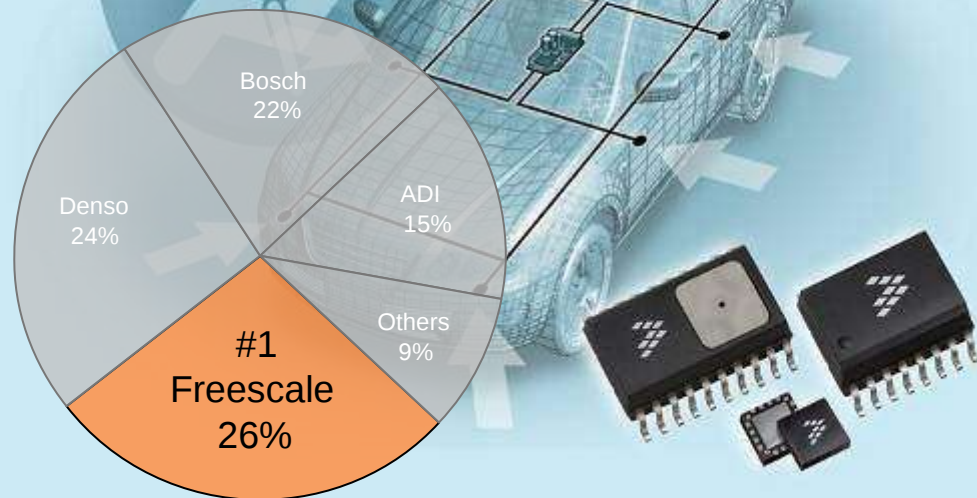
20 to 480g - X, Z, XY axis



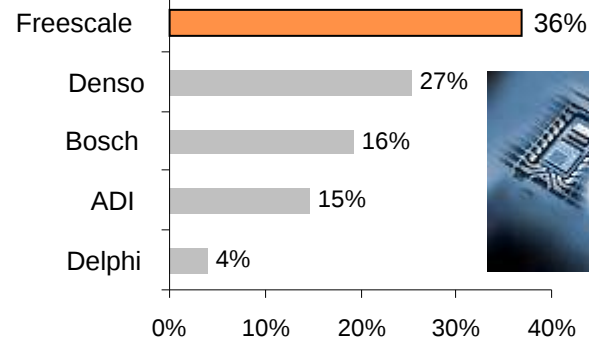
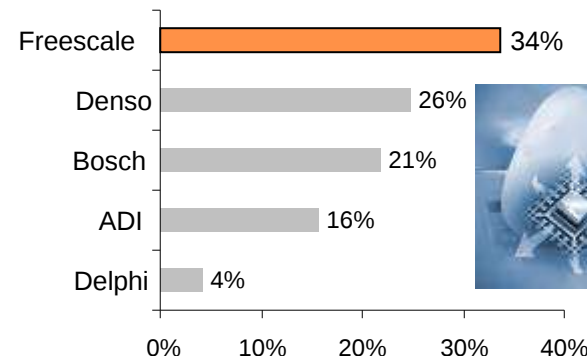
Crash detection:
20 - 100 g



Side crash detection and motorcycle airbag:
100 - 480 g



Medium and high G in Automotive



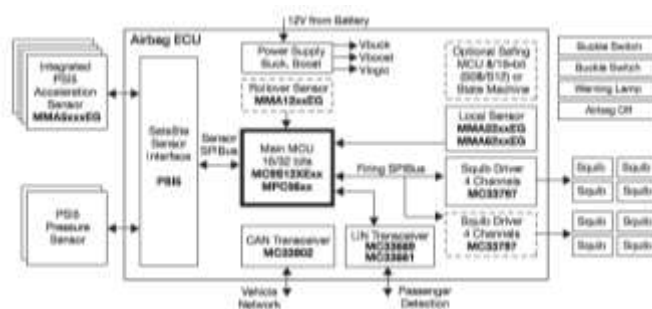
Peescale Commitment to PSI5 and DSI Airbag Protocols

Freescale is a PSI5 consortium
associated member

Technical Specification	PSI5 Peripheral Sensor Interface	Page 0/46
		V1.3



Airbag System – PSI Protocol



Peripheral Sensor Interface 5 (PSI5)

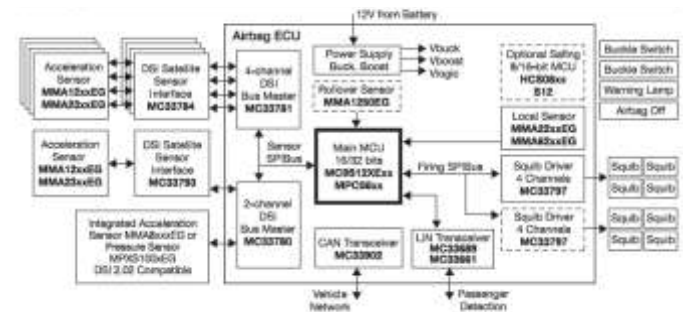
Visit: <http://www.psi5.org>

Freescale is a DSI consortium
founding member

DSI Bus Standard Distributed Sensor Interface	Version 2.5
	April 16, 2009



Airbag System – DSI Protocol

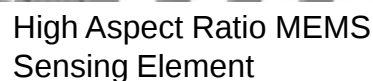


Visit: <http://www.dsiconsortium.org>

- Dual XY-axis or Single X-axis Sensors with fully digital signal processing:
 - Overdamped inertial sensing element
 - Digital output (10-bits or 12 bits)
 - 3.3 V or 5 V power supply
 - Bi-directional self-test
 - Arming pins
- Programmability



Freescale Product Offering



X Axis Range	Y Axis Range	XY Axis Part Number	Output	Package
50g	50g	MMA6813BKWR2	SPI 10 bits	QFN 6x6
120g	25g	MMA6821BKWR2	SPI 10 bits	QFN 6x6
120g	60g	MMA6823BKWR2	SPI 10 bits	QFN 6x6
120g	120g	MMA6827BKWR2	SPI 10 bits	QFN 6x6
80g	80g	MMA6519KWR2	SPI 12 bits	QFN 6x6
105g	105g	MMA6525KWR2	SPI 12 bits	QFN 6x6



Freescal Integrated Airbag Satellite Sensors

- System-in-Package (SiP) solution integrates board-level functionality in a single package:
 - Inertial sensing element
 - State machine
 - Power supply
 - Communication protocols (PSI5 or DSI)



Airbag Satellite Module



Side Airbag Curtains



Peripheral Sensor Interface 5 (PSI5)



Range	X Axis	Z Axis	Output	Package
25g	MMA2602KWR2	-	DSI 2.5	QFN 6x6
50g	MMA2605KWR2	MMA1605KWR2	DSI 2.5	QFN 6x6
62.5g	MMA2606KWR2	MMA1606KWR2	DSI 2.5	QFN 6x6
125g	MMA2612KWR2	MMA1612KWR2	DSI 2.5	QFN 6x6
187g	MMA2618KWR2	MMA1618KWR2	DSI 2.5	QFN 6x6
312g	MMA2631KWR2	MMA1631KWR2	DSI 2.5	QFN 6x6

Range	X Axis	Z Axis	Output	Package
60g	MMA5206KWR2	MMA5106KWR2	PSI5	QFN 6x6
120g	MMA5212KWR2	MMA5112KWR2	PSI5	QFN 6x6
240g	MMA5224KWR2	MMA5124KWR2	PSI5	QFN 6x6
480g	MMA5248KWR2	MMA5148KWR2	PSI5	QFN 6x6

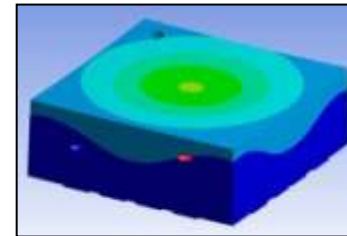
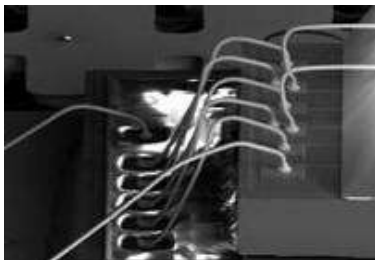
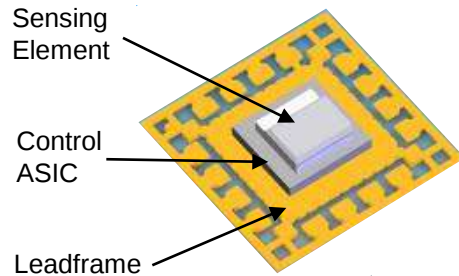
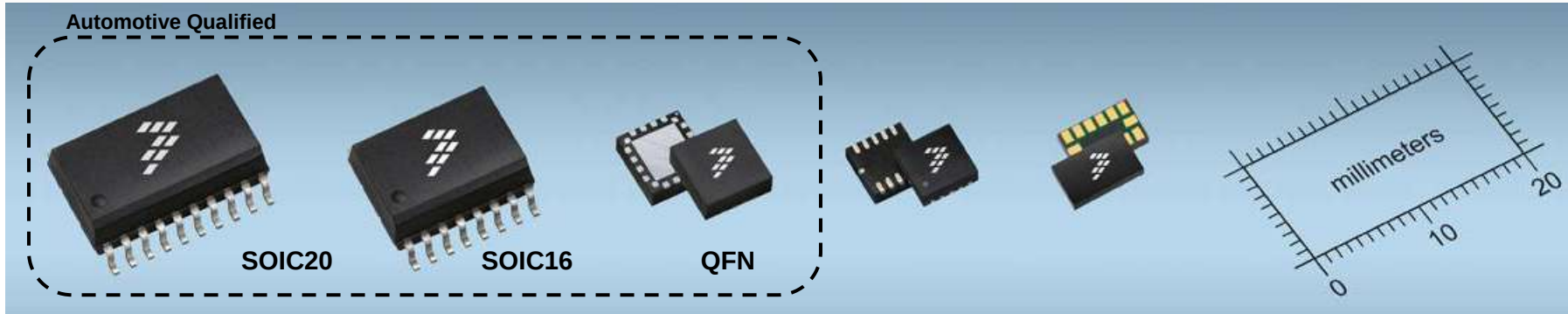


- **Electronic Damper Control**
- Resolving the conflict between high ride comfort and high driving safety and agility.
- Minimization of wheel load variation and chassis oscillation.

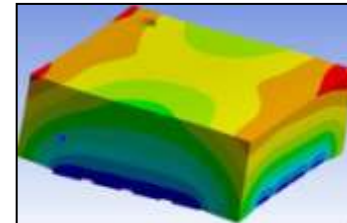
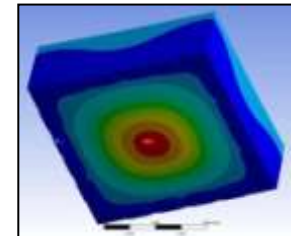


- Family from 7g up to 10g
- 2 pole filter
- Low voltage detect
- Clock monitor
- EPROM parity check status
- Calibrated Self-test
- SOIC16 package

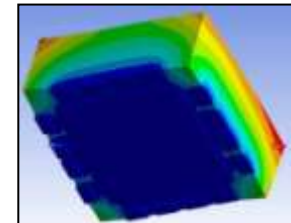
Auto Inertial Sensor Package Evolution



Without the flag attached, first drum mode is at **~162 KHz**



With the flag attached first, twisting mode is at **~244 KHz**



=> Resonance out of the band of interest for car vibration

...MA65xxKWR2 (Sycamore) XY-Axis, Main ECU Accelerometer

- **Differentiating Points**

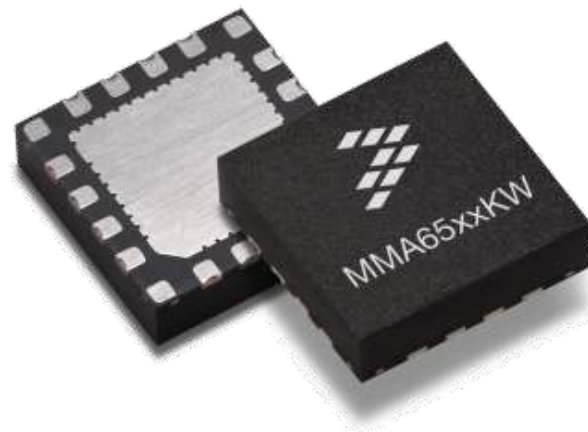
- 80g, 105g, 120g Full Scale Ranges
- 300 Hz, 400 Hz, or 800 Hz 4 Pole LPF
- Independent Self Test Activation per Axis

- **Product Features**

- SMOS8MV
- 80g, 105g, 120g Full Scale Ranges
- 12 bit Digital Output
- 3.3V, 5V Operation
- SD Data Converter and Digital Signal Chain
- 300 Hz, 400 Hz, or 800 Hz 4 Pole LPF
- Offset cancellation with < 0.25 LSB/s slew rate and Bypass Option
- Sensitivity accuracy: $\pm 4\%$, 25degC, $\pm 5\%$, -40 to 105degC
- SPI interface
- SPI Data Output Verification
- Arming Outputs for Each Axis
- Programmable Pos and Neg Thresholds

- **Typical Applications**

- Automotive : airbag



Package

- 16 pin QFN-6x6
- -40 C / +105 C operating temperature

Availability

Samples: NOW

Production: NOW

...MA68xxBKWR2 (Mesquite)

XY-Axis and Single Axis, Main ECU Accelerometer

- **Differentiating Points**

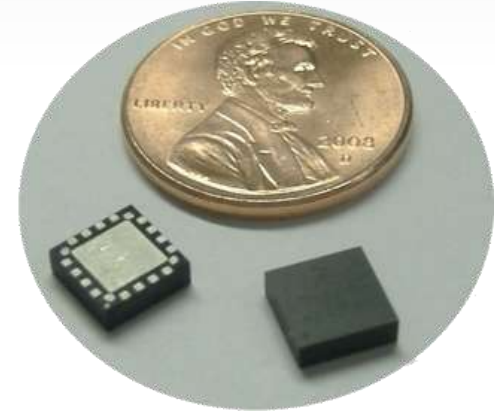
- 80g, 105g, 120g Full Scale Ranges
- 300 Hz, 400 Hz, or 800 Hz 4 Pole LPF
- Independent Self Test Activation per Axis

- **Product Features**

- SMOS8MV
- 20g - 120g Full Scale Range
- 10 bit Digital Output
- 3.3V, 5V Operation
- SD Data Converter and Digital Signal Chain
- 300 Hz, 400 Hz, or 800 Hz 4 Pole LPF
- 1500 Hz 4 Pole LPF (single axis)
- Offset cancellation with < 0.25 LSB/s slew rate and Bypass Option
- Sensitivity accuracy: $\pm 4\%$ 25degC, $\pm 5\%$ -40–105degC
- SPI interface - Open Digital Protocol
- SPI Data Output Verification
- Independent Self Test Activation per Axis

- **Typical Applications**

- Automotive : airbag



Package

- 16 pin QFN-6x6
- -40 C / +105C operating temperature

Availability

Samples: NOW

Production: NOW

- +3.5g , +5g range
- +50 mg / +75 mg offset over life and temperature

- MMA6900KQ / MMA6901KQ
- 3.43mg / lsb , 4.91mg / lsb typical sensitivity
- 3.3 or 5V Operation
- SMOS8MV IC
- Digital Signal Processing
- Sigma Delta ADC
- Simplified anti-aliasing SINC filter
- 50 Hz, 4-pole digital low-pass filter
- Power on Self Test, including deflection of MEMs
- Internal Temperature Sensor
- SPI Compatible Interface
- Unsigned 11-bits digital data output

- Automotive : vehicle stability control



- 6x6x1.98 Green package
- -40 C / +105C operating temperature

Availability

Samples: NOW

Production: NOW

**MMA27xxWR2 (Agave3 X),
MMA1725WR2 (Agave 3 Z): DSI3 Inertial Sensor**

- **Differentiating Points**

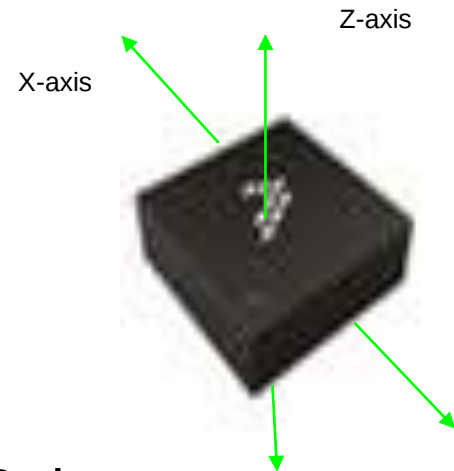
- Z-Axis 250g Transducer
- Four Low Pass Filter options from 180 Hz to 800 Hz, up to 4-pole.

- **Product Features**

- X-Axis 25g Transducer, 125g, 187g, 250g, 375g Transducer
- (Unique trim for each range)
- Z-Axis 250g Transducer
- Four Low Pass Filter options from 180Hz to 800Hz, up to 4-pole.
- Optional digital offset cancellation via High Pass Filter and rate limiting.
- 10-Bit output
- DSI3 Compliant
- Discovery Protocol for physical location identification
- Command Response Mode for device configuration
- Periodic Data Collection Mode for normal acceleration data transfers.
- Optional Background Diagnostics during Periodic Data Collection Mode
- IDDQ + scan test

- **Typical Applications**

- Automotive : airbag



Package

- 16 pin QFN 6mmx6mmx1.98mm
- Wetable Flanks
- Temperature Range: -40 to 125degC

Availability

- MMA27xxWR2
 - Samples: NOW
 - Production: April, 2013
- MMA1725WR2
 - Samples: NOW
 - Production: October, 2013

PR031 Proximity Capacitive Touch Sensor Controller

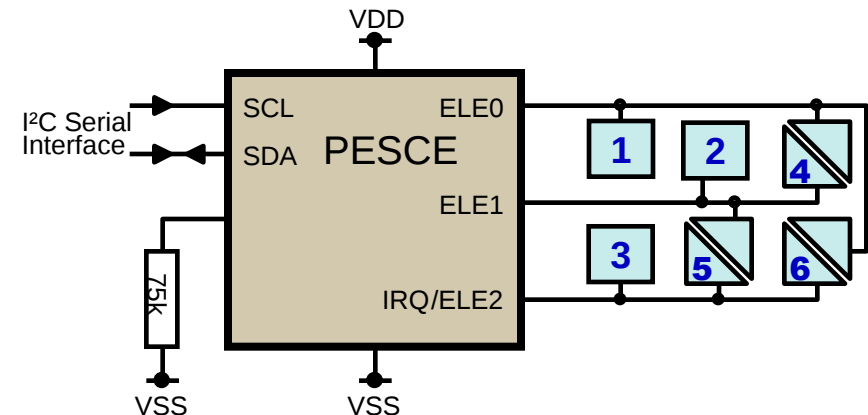
- **Features**

- 1.71V to 2.75V operation
- 14 μ A supply current (all 3 electrodes being monitored with 96 ms response time)
- 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
- -40°C to +70°C operating temperature range

- **Implementations**

- Key replacement - navigation
- Switch replacements

Typical Application with 6 Touch Pads





- Controls up to 12 touch pads
- 1.71–2.75 V operation (investigating 3.3volt support)
- 29 μA average supply current (all touch pads being monitored)
- 3 μA standby current
- Constant DC current and charge time capacitive sensing scheme (independent for each electrodes)
- Continuous independent auto-calibration of each electrode input
- Separate touch and release trip thresholds for each electrode, providing hysteresis and electrode independence
- Digital output (with optional IRQ outputs to advise electrode status change)
- LED driver functionality with maximum of 8 LEDs
- 13th virtual electrode for proximity detect
- 3x3x0.65mm, μDFN and SOP packages

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

