MEMS & Sensors

EMEA Technical Marketing Team

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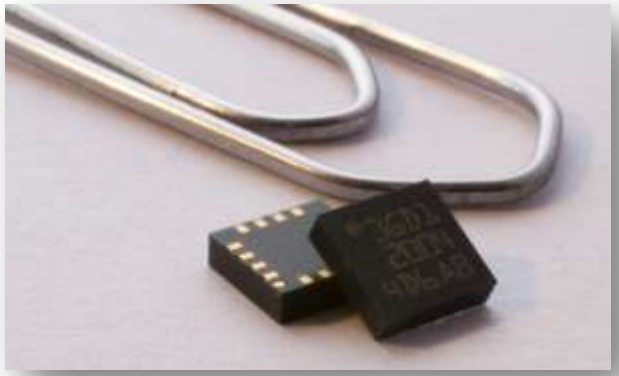
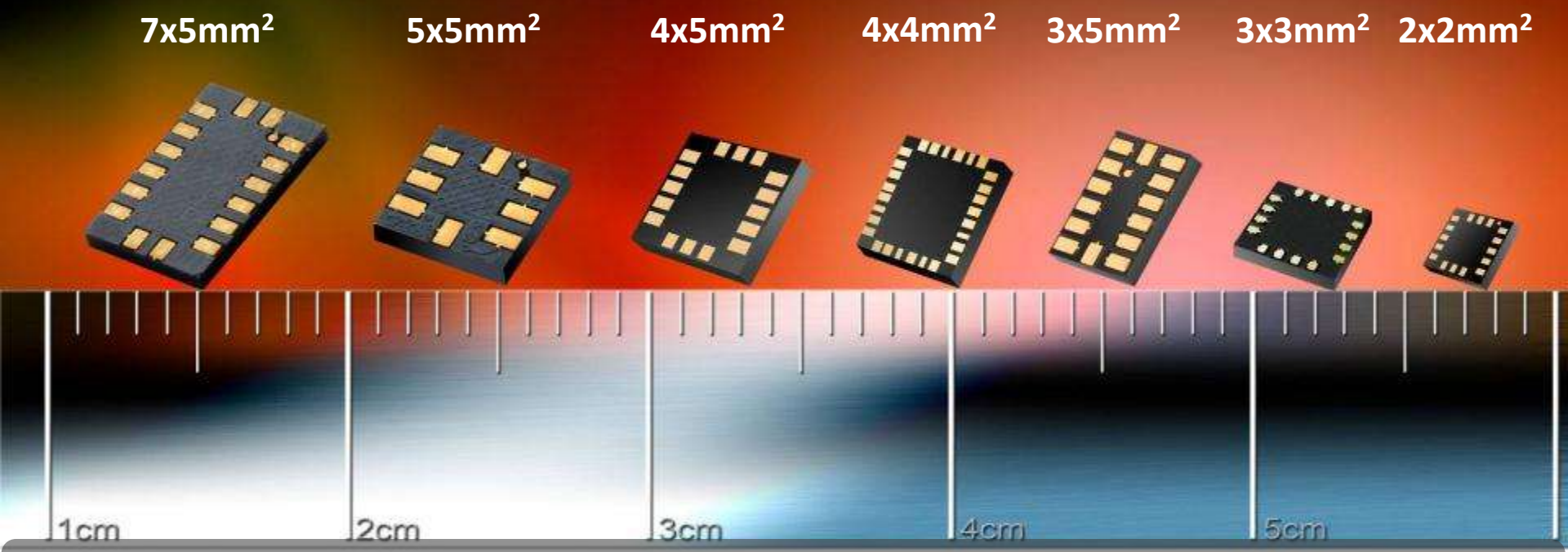
What are MEMS?

- MEMS is an acronym for Micro Electro Mechanical Systems
- They contain 3-dimensional structures realized through a specific process called Micro-Machining
- They are micron-size devices that interact with external world for sensing and actuation



Technology Milestones

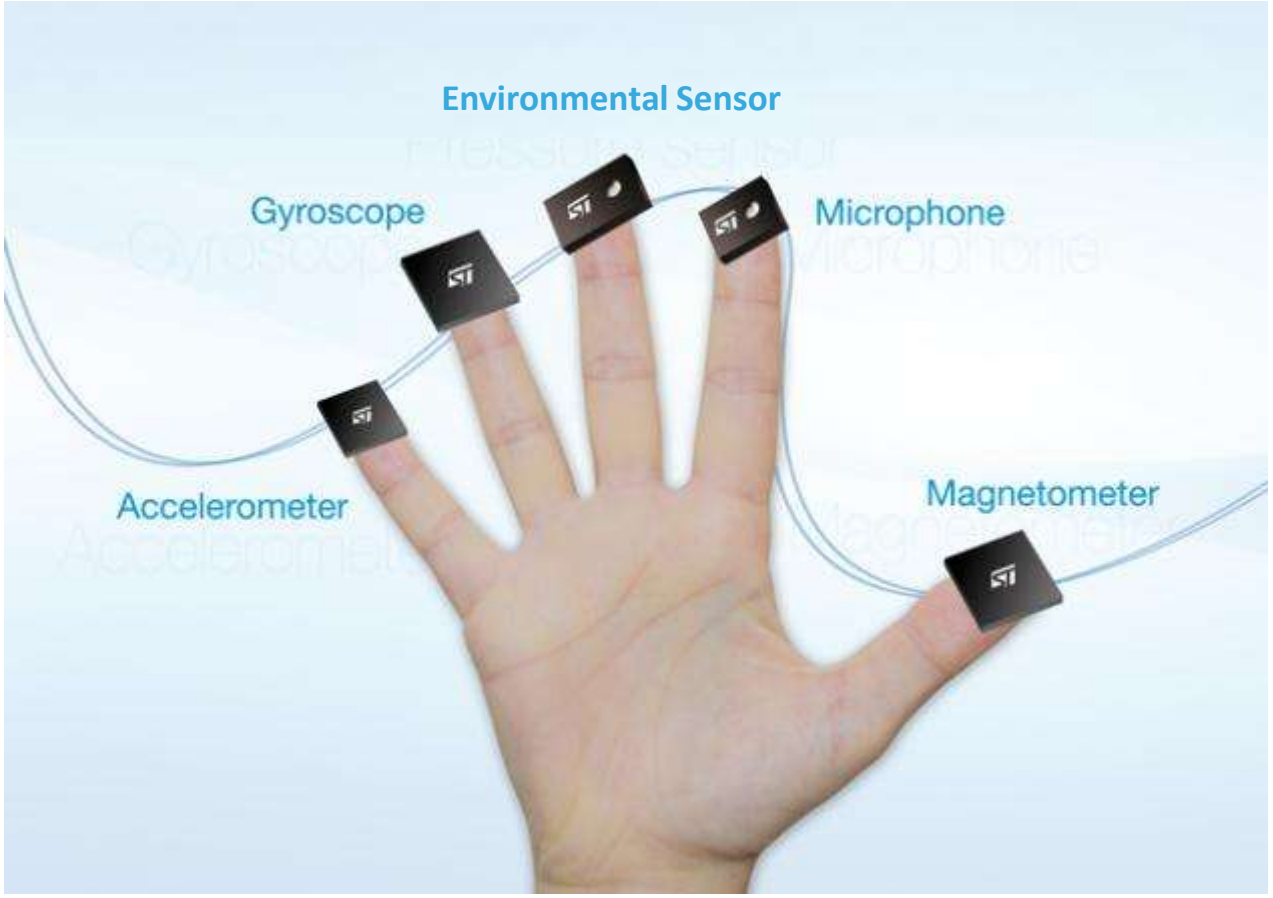
More than 3 Bpieces



ST has manufactured more than 3,000M units of Accelerometers, Gyroscopes and eCompass

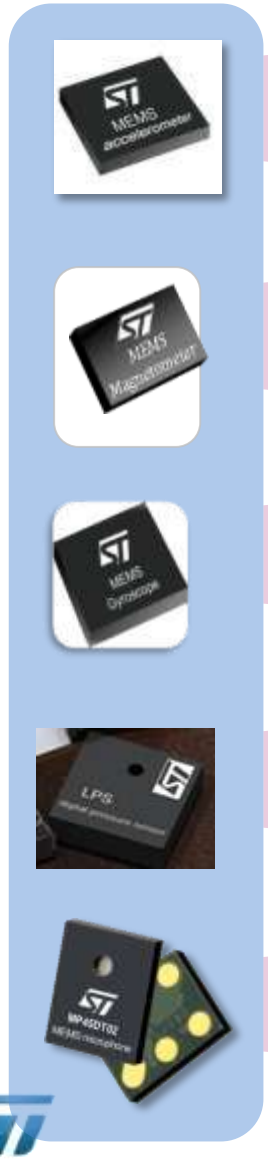
A robust and scalable manufacturing process is key to sustain the demand of the consumer market

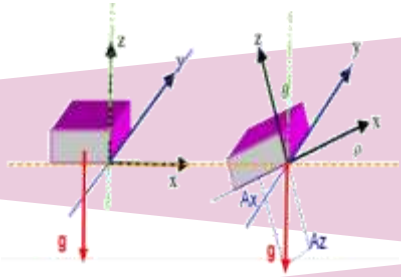
ST: the one-stop MEMS supplier



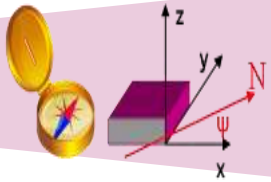
ST MEMS technology is at the heart of a fast growing family of sensors

MEMS Sensors: Several Sensors for Adding Features

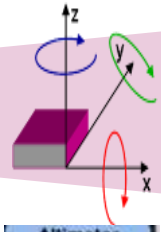




Accelerometer :
Senses the linear acceleration (m/s^2), tilt, shocks, Free fall, direction detection, vibrations, linear displacement

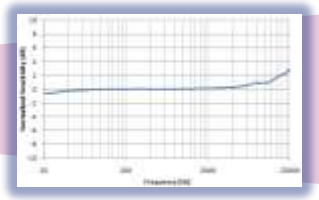


Magnetometer:
Senses the magnetic field (gauss), pointing absolute positioning



Gyroscope :
Measures the angular rate (°/s, dps), number of revolution(spin), rotation of mechanical part

Environmental sensor, Pressure sensor:
Measures Abs atmospheric pressure (mbar), altitude variation, Free fall



Microphone:
Measures sound and noise (dB) with a high level quality

ST Investing heavily in MEMS

Global & Outstanding Manufacturing Capability

Catania

Crolles (France)

Rousset (France)

Agrate (Italy)

Catania (Italy)

Kirkop (Malta)

Agrate

Calamba (Philippines)

Increase manufacturing capacity

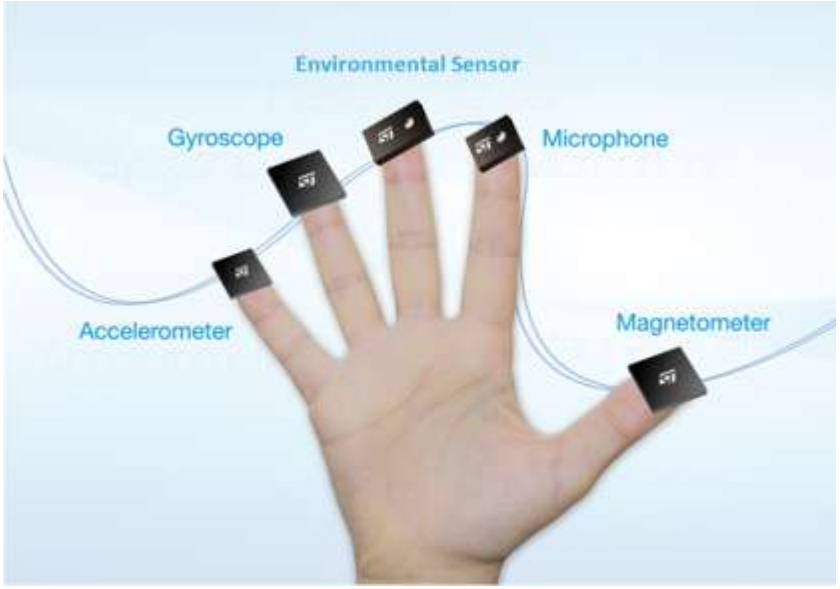
>3Mpcs/day

(since end of 2011)

- Sensors (8" MEMS dedicated line)
- ASIC Front-end
- Assembly & Testing

Where ST MEMS are used?

Sport & Fitness



Home appliances

Industrial

Portable

Automotive

- Navigation assistance
- Anti-theft systems
- Telematics
- Tolling Systems …

Where ST MEMS are used: **Sport & Fitness**

- Applications:
  - **Airbag** Helmet for bikers, skier
  - **Technical Watches** (Altimeter, mountain watches)
  - **Body Monitoring** (Heart Rate Monitors, Weight Scales and Blood Pressure Monitors, Fitness Computers)
  - **Positioning Tracking**, Activity and performances evaluation (Sport GPS, Pedometers, Speed & Distance, Compass)
  - **Reeducation** improvement and activity measurement

Where ST MEMS are used: **Industrial**

- Applications:
  - **Vibrations measurement** and **Tilt inclination** (to adjust rotation speed, circuit breaker security, fault prediction),
  - Professional and domestic **Alarms**
  - **Maintenance management** and **Asset Tracking** for shocks monitoring
  - Alarm and **Anti Tamper** function

Where ST MEMS are used: **Home Appliances**

Vibration measurement
Accelerometer

Motion tracking
Inertial modules

Humidity control
Humidity sensor

Temperature control
Temperature sensor

Wake Up motion
Accelerometer

Tilt compensation
Accelerometer

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Where ST MEMS are used: **Portable Devices markets**

- Applications:
  - Battery powered devices for **Smart Power management**
  - Devices with screens (portrait / Landscape)
  - **Dead Reckoning** functions for fleet management and indoor services
  - **Human interface** management
  - Free fall and shocks monitoring
  - **Electronic Compass**

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Where ST MEMS are used: **Automotive**

- Applications:
  - Navigation assistance
  - Alarms, Anti-theft systems,
  - Telematics
  - Tolling Systems

MEMS Accelerometers

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Accelerometer – LIS3DH

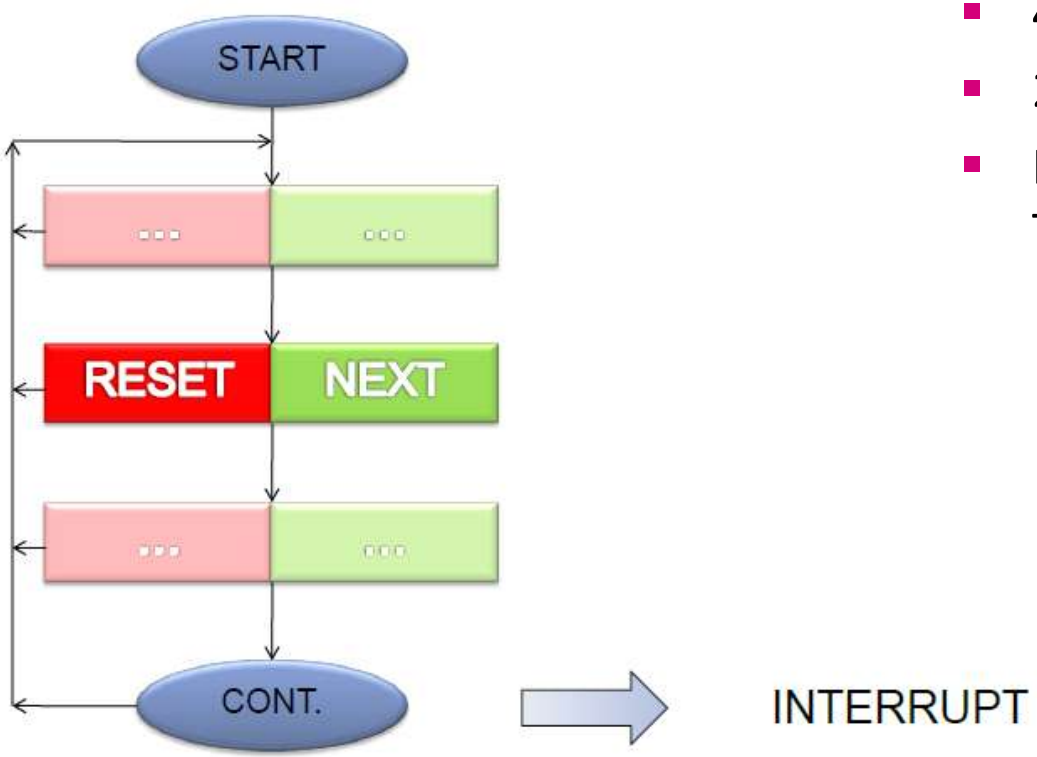
- 3-Axis Digital SPI/I2C Accelerometer
- 4 selectable Full Scales: 2, 4, 8 and 16g
- Up to **12 bit** resolution
- **Very low power consumption:**
  - 2µA in Low power mode (1Hz),
  - 11µA in Normal mode (50Hz)
  - 0.5µA in Power down mode
- High number of features for a Higher Flexibility
- Small size package 3x3x1 (in mm)

Accelerometer – LIS3D**S**H

- 3-Axis Digital SPI/I2C Accelerometer
- 5 selectable Full Scales: 2, 4, 6, 8, 16g
- 2 programmable embedded **finite-state machines** for interrupt generation
- Very High Resolution (up to **14 bit**) and low noise (**150µg/vHz**)
- Low power consumption: 11µA in Active mode (3.1Hz) and 2µA in Power down mode
- High Flexibility
- P2Pcompatible with LIS3DH

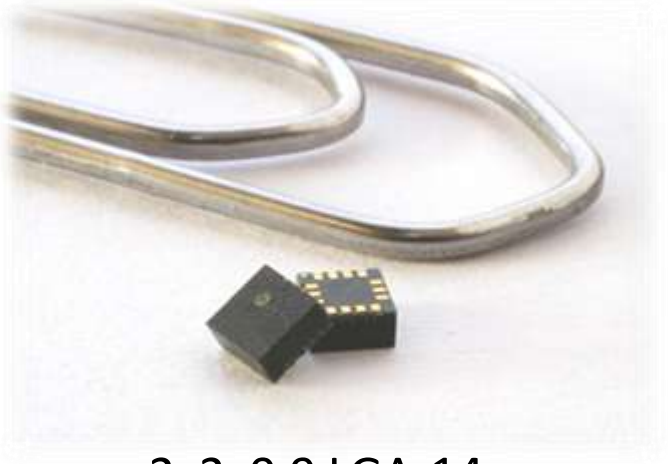
LIS3DSH - Finite State Machine

- 2 Powerful embedded Finite State Machines to implement action motion recognition



- 4 independent Timers
- 2 Independent Masks (x, y, z, v)
- Independent acceleration Thresholds:
  - Threshold1 @8bit (Signed, Unsigned)
  - Threshold2 @8bit (Signed, Unsigned)
  - Threshold3 (can't be evaluated with code and it is automatic guardian)
- Highest Peak Detection

2x2 3-axis Accelerometers - LIS2DM / 2DH



2x2x0.9 LGA-14

LIS2DM: 8 bit resolution

LIS2DH: up to 12 bit resolution

2 Interrupt generators

Activity / Inactivity

- Full-scale ranges of ±2g/±4g/±8g/±16g
- Temperature sensor
- FIFO memory block
- 4D/6D orientation detection
- Programmable interrupt signals that enable immediate notification of motion detection, click/double-click events, and other conditions
- **Small size & Low power** targeted applications
- **Available in Q2 2013**

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Accelerometer Medium-g – H3LIS331

- 3-Axis Digital Accelerometer
- 3 selectable Full Scales: **100, 200, 400g**
- **12bit resolution**
- Low power: 300µA in Active mode, **10µA in low power** and 1µA in Power down mode
- ODR user selectable: from 0.5 to 1000 Hz
- Targeted applications:
  - **Impact measurements in sports** (American football, hockey, boxing, ….) to monitor events that could determine a concussion,
  - **Shock detection in tools**, equipment, portable instrumentation (like medical instruments, laptops, tablets, …)
  - **Parcel Monitoring** for insurance purposes
- **Available in Q2 2013**

Automotive Accelerometer – AIS328DQ

Automotive **I**nertial **S**ensor – **3** axes – **2/4/8**g full scale –
Digital Output – **Q**FPN package

- **12 bit resolution**, low power consumption (<10µA at 10Hz ODR)
- **AEC-Q100 - PPAP available**
- Temperature Extended range: **-40 to 105 C**
- Stacked-die assembly in a small QFPN 4x4x1.8 24L package
- Target applications: security systems, inertial navigation, telematic boxes, intelligent power saving, motion activated functions, …

MEMS Gyroscopes

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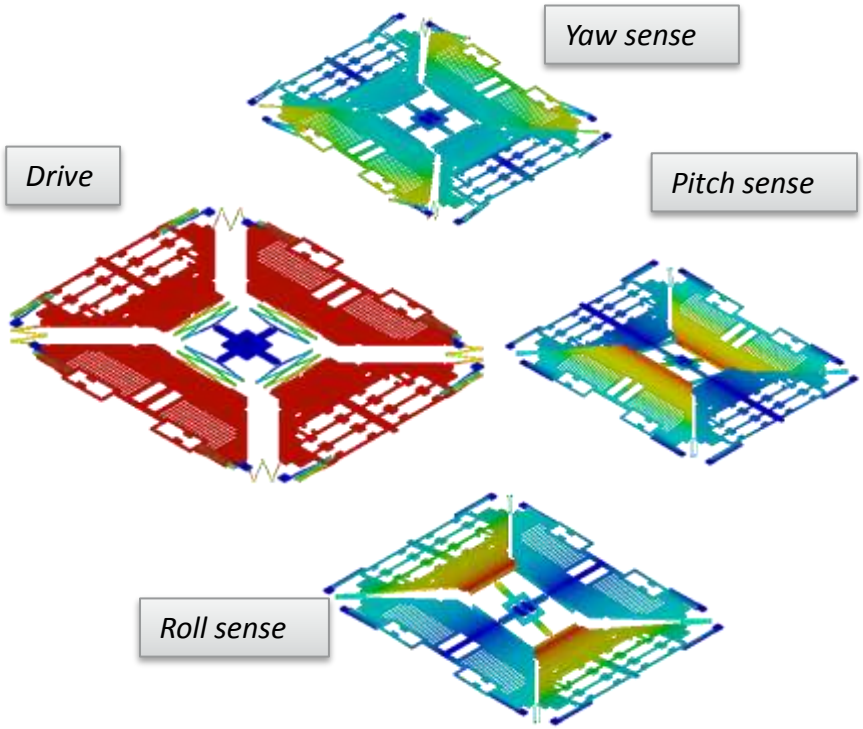
Gyroscope – L3GD20

- **3-Axis** Gyroscope, **Digital** SPI/I2C output
- **High precision**, 16 bit resolution
- Able to measure rotations with **3 selectable Full Scales**: 250, 500, 2000dps
- Power down (5µA) and Sleep (2mA) modes
- **Interruption** and Data Ready output lines
- High number of **embedded Features**



Automotive Gyroscope – A3G4250D

Automotive – **3** axes – **G**yroscope – **4**x4 LGA 16L– **245**dps full scale – **D**igital Output

- Low power consumption, 245dps full-scale
- Low noise and high-stability over temperature
- AEC-Q100 - PPAP available
- Pin-to-pin compatibility with L3G4200D
- Target applications:
  - Vehicle tracking systems, rate activated functions, inertial navigation assistance, adaptive front beams, …

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Modules from 6 to 9-axis

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MEMS E-compass

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Digital Compass – LSM303DLHC

- MEMS Accelerometer (LIS3DH) + Magnetic sensor
  - 3A: 2g/ 4g/ 8g/ 16g full scale
    - 12 bit resolution ,1mg/digit sensitivity
    - ODR up to 5KHz
  - 3M: from 1.3 to 8.1gauss full scale
    - 2mgauss resolution, 0.9mgauss (x,y) and 1mgaus (z) sensitivity
    - ODR up to 220Hz
  - 110µA consumption, 1µA in Sleep mode (Accel is activated)
  - Embedded FIFO and Temperature sensor

Digital Compass - LSM303D

- MEMS Accelerometer (LIS3DSH) + Magnetic sensor
  - 3A (14bit): from 2 to 16g dynamically selectable full-scale
    - Embedded temperature sensor (12 bit output)
    - FIFO
    - Self-test
  - 3M (16bit): from 2 to 12gauss dynamically selectable full-scale
    - Resolution selectable
  - I^2C/SPI interfaces
  - LGA-16, 3 x 3 x 1 mm^3, P2P compatible with LIS3DH

2.5 mgauss typical resolution @ 12 gauss full scale

MEMS IMU (iNEMO - Inertial Movement Unit)

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iNEMO - Inertial Movement Unit

- **6-axis Digital IMU, Accelerometer + Gyroscope**
  - When application needs 3-axis Accelerometer and 3-axis Gyroscope
    - More compact solution than separated devices
    - 1 device to be soldered instead of 2
  - **LSM330DLC** (12bit accel + 16bit gyroscope) in a 4x5 package
  - **LSM330D** (12bit accel + 16bit gyroscope) in a 3x5.5 package
  - **LSM330** (14bit accel + 16bit gyroscope) in a 3x3.5 package

LSM330DLC
MEMS IMU

MEMS Module – iNEMO Inertial Module

LSM330DLC:

- MEMS Accelerometer (LIS3DH) + Gyroscope sensor (L3GD20)
  - 3-axis accelerometer, 2 4 8 16g Full Scale
  - 3-axis gyroscope, 250 500 2000 dps Full Scale
  - SPI/I²C digital interface
  - Power-down mode
  - 4x Interrupt lines (2x gyro and 2x accel)
  - 2x Embedded FIFOs and Temperature sensor
  - Small 4x5 package

LSM330DLC
MEMS IMU

Smart Sensors

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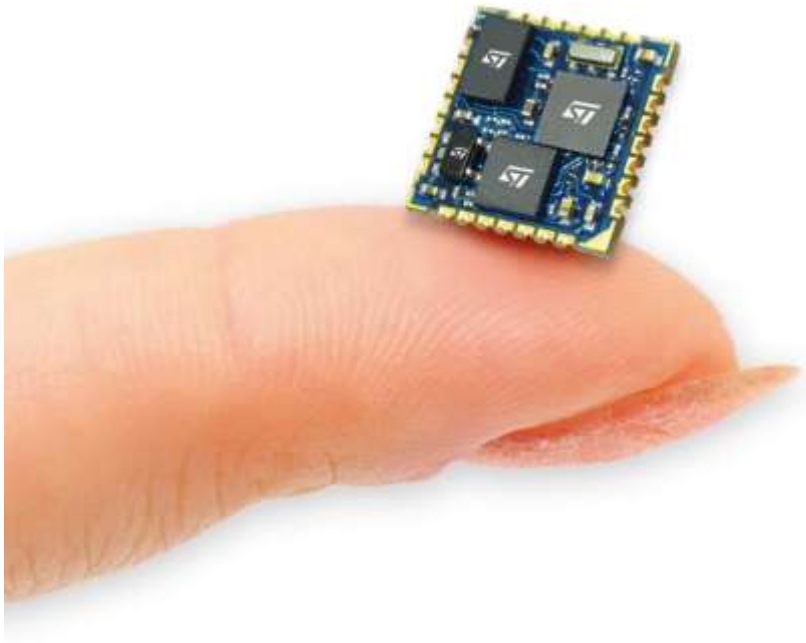
9-Axis iNEMO Module



INEMO-M1

- Compact design: 13 x 13 x 2 mm
- L3GD20: 3-axis digital gyroscope
- LSM303DLHC: 6-axis geomagnetic module
- STM32F103REY: WLCSP, ARM®-based 32-bit MCU
- LDS3985M33R: ultra low drop-low noise voltage regulator.
- Flexible interfaces: CAN, USART, SPI and I^2C serial interfaces; full-speed USB 2.0
- Free ADC channels for external inputs
- **Available in Q2 2013**

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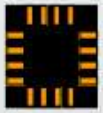
Smart Sensors

Brain

LIS331EB

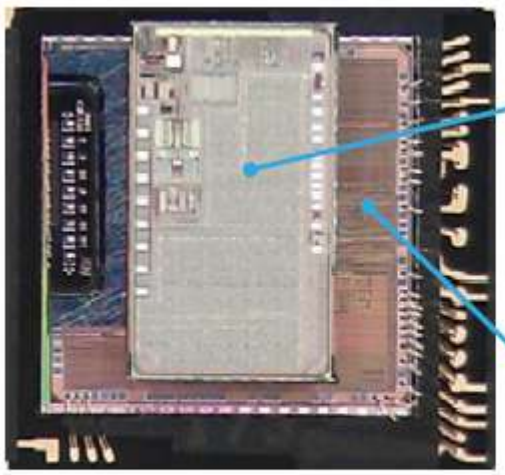


ES Q4'12

3x3

LIS3DSH + Brain (M0 Core 64K Flash 128K Ram)

LIS331EB



3x3x1 LGA-16

LIS3DSH:
- Low-power mode down to 10 µA
- ±2g/±4g/ ±6g /±8g / ±16g full-scale
- Data rate: 3Hz to 1.6kHz
- 16 bit data output
- Low noise 150µg/vHz
- Embedded FIFO and State Machine
- 10000 *g high shock survivability*

BRAIN:
- Cortex-M0 core - 72MIPS@80Mhz
- 80 MHz / 32 KHz RC / External crystal oscillator
- 64KB Flash Memory
- 128KB RAM memory
- 2x I2C (1 Master, 1 Slave)
- SPI Master/Slave
- JTAG/SWD
- 7 Programmable GPIOs
- Embedded WDG (32Khz)
- Embedded Timers/Event Counters
- Low power features

Available for MM in Q1 2014

MEMS Environmental Sensor: Pressure Sensor

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Pressure, altitude sensor – LPS331AP

- Absolute atmospheric (260-1260mbar) digital I2C/SPI Pressure sensor, **LPS331AP**
- 24bit resolution
- Temperature compensation embedded
- Low power:
  - 5.5µA Low resolution @1Hz
  - 45µA High resolution @1Hz
  - 0.5µA
- Standard 3x3 package

Tools, SW & Evaluation Kits

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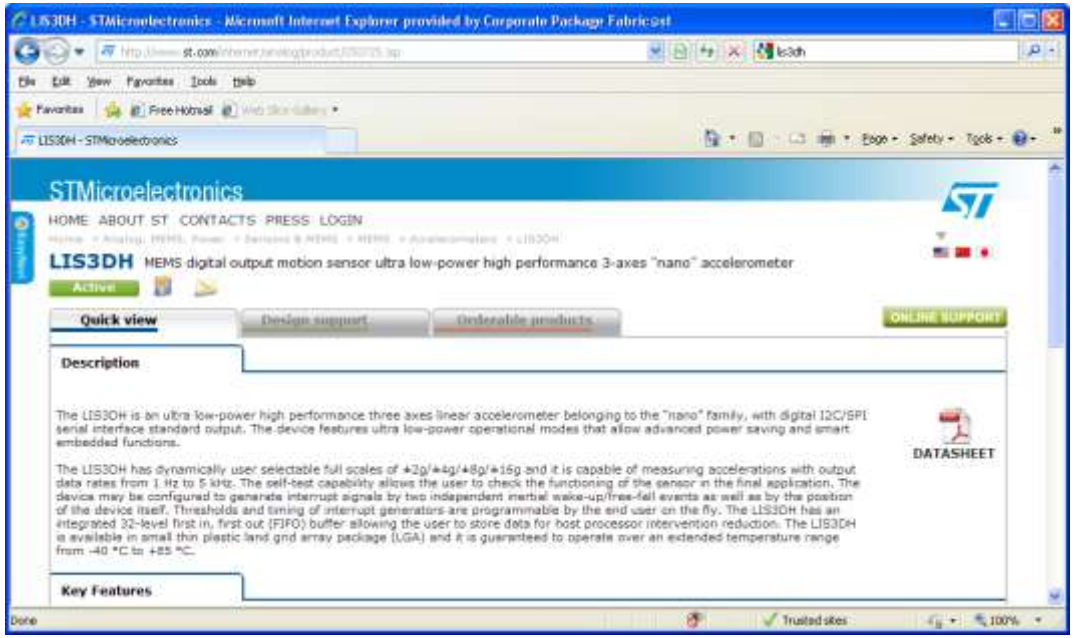
Available Software for customer development

- **Low Level Drivers include:**
  - Complete Register map of the sensor
  - Set of basic functions (e.g. register write/read)
  - Example



Software & Development Tools

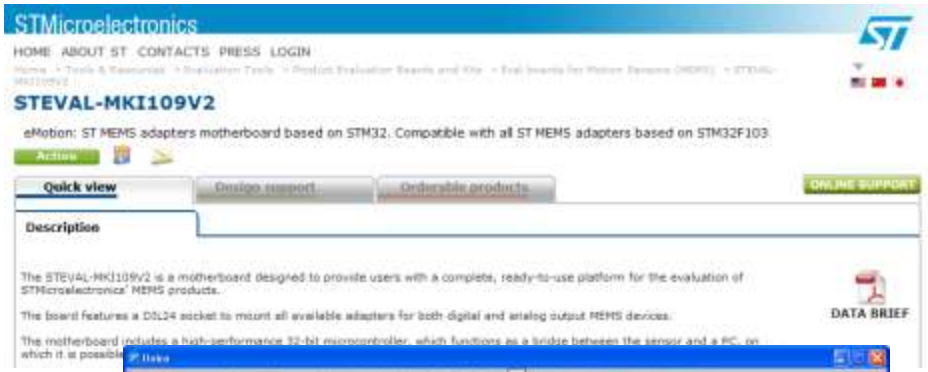
• SOFTWARE DRIVERS • DEVELOPMENT ENVIRONMENTS • FIRMWARE

SW DRIVERS

Description	Version	Size
Linux OS device driver for LIS3DH - suitable for Android-based devices	1.0.8	11KB
Platform-independent device driver for LIS3DH	1.1.0	13KB

Available Software for customer development

- **Software Libraries:**
  - Tilt compensated compass with automatic calibration
  - **Pedometer**
  - **Sensor Fusion** (iNemo engine)
  - **Quadratic compensation** & IIR filtering for Pressure Sensors
  - **Microphone** library
- **MEMS demonstration kit SW package includes:**
  - eMotion firmware in source codes (STM32F103)
  - UNICO – GUI for MEMS Demonstration kits
  - Available at www.st.com/mems



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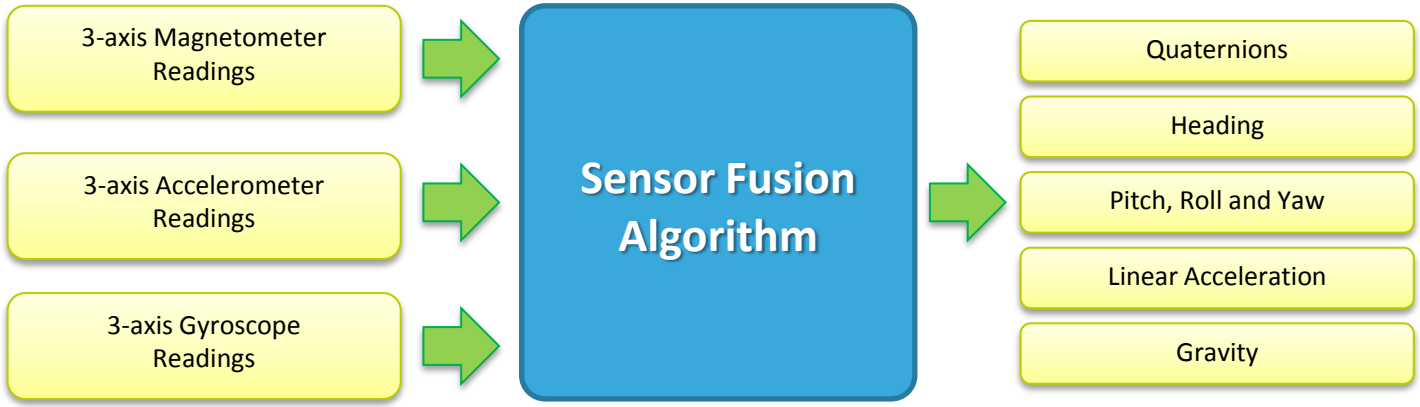
iNEMO Sensor Fusion Engine API

- Applications:
  - Localization-Based Services and Pedestrian navigation
  - **Smart gaming**
  - Enhanced user-interfaces
  - **Gesture recognition**
- The API initializes devices and compensates the non idealities of standalone sensors
- Available for WIN8, Android and other Operating System



MEMS support tools

eMotion: STEVAL-MKI109V2

STM32-based MEMS motherboard compatible with ST MEMS adapters

High Runner

- Possible Daughter boards:

LIS3DH
MKI105V1
LIS3DSH
MKI134V1

LSM303DLHC
MKI106V1
LSM303D
MKI133V1

L3GD20
MKI107V2

LSM303DLHC
+
L3GD20
MKI108V2

And many others

LPS331AP
MKI120V1

STM32F3 – Discovery Kit

New Discovery STM32 (M4) kit which embed 9-axis sensors:

- **LSM303DLHC**
- **L3GD20**

Key Messages & Conclusion

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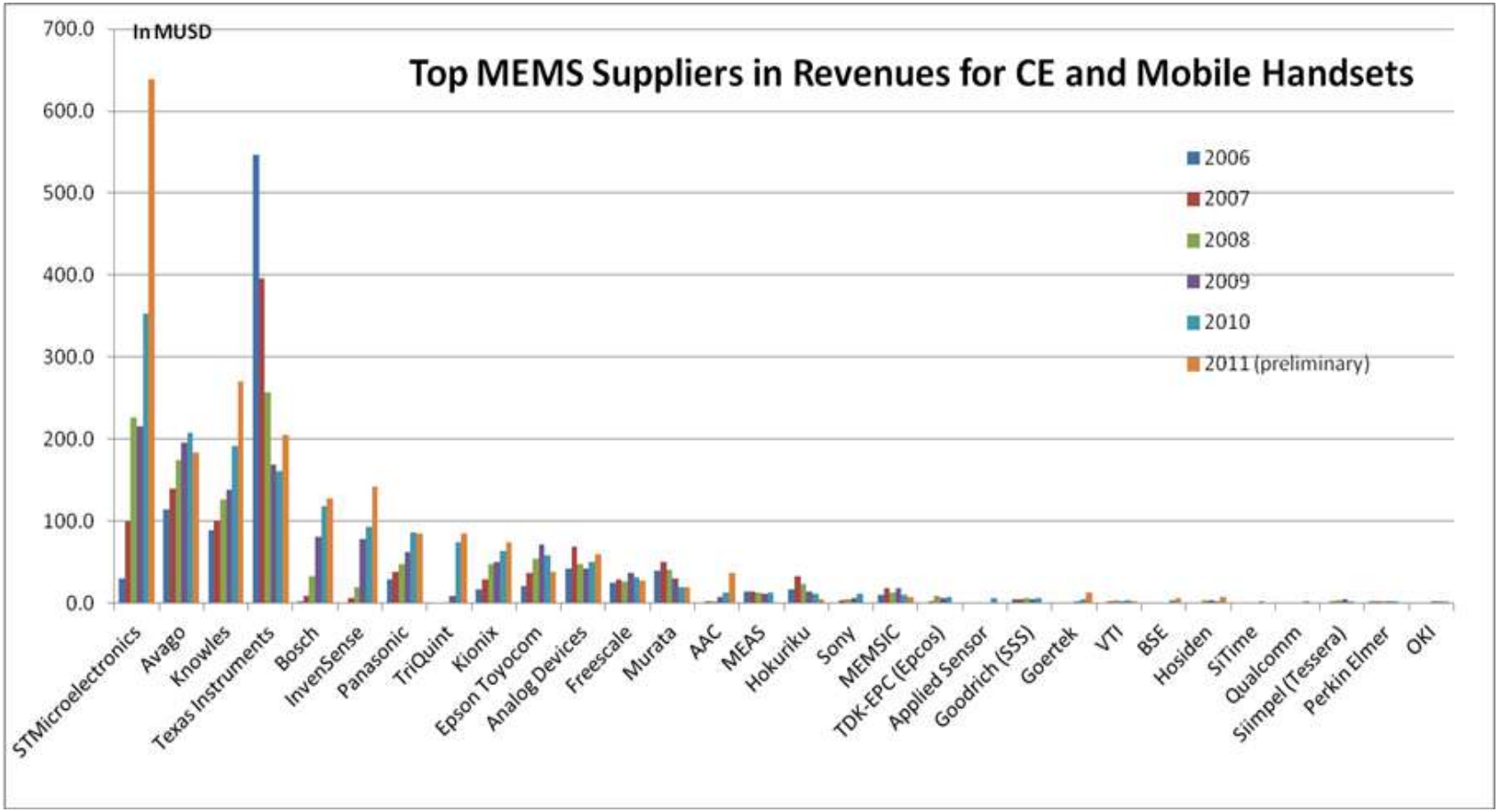
Top MEMS Suppliers in Revenues for Consumer Equipment & Mobile Handset



Source: IHS – January 2012

Products focus for 2013

- 3-axis Digital Accelerometer: **LIS3DH** / **LIS3DSH**
- 3-axis Automotive Digital Accelerometer: **AIS328DQ**

- 3-axis Digital Gyroscope: **L3GD20**
- 3-axis Automotive Digital Gyroscope: **A3G4250D**

- 6-axis Digital e-Compass: **LSM303DLHC** / **LSM303D**

- 6-axis iNEMO Module: **LSM330DLC**

- Absolute Pressure Sensor: **LPS331AP**

Key Messages

- Manufacturing capabilities
  - ST has delivered 3 Billions MEMS units
  - In 2012, ST Manufacturing capacity > 3Mu per day (2 manuf sources)
- Innovation through key words
  - Technology, products performances, features, level of integration, tools, competitivity
- Our positioning
  - ST is the only one in the market to propose a complete solution sensors based
  - Sensors + MCU + SW Fusion + Power management
- Our support
  - Full availability of material to support promotion
  - Dedicated and regional technical support: AMS-support-EMEA@st.com
- The future is in our hands since many applications & domains are still to investigate for MEMS

ST is definitely your partner

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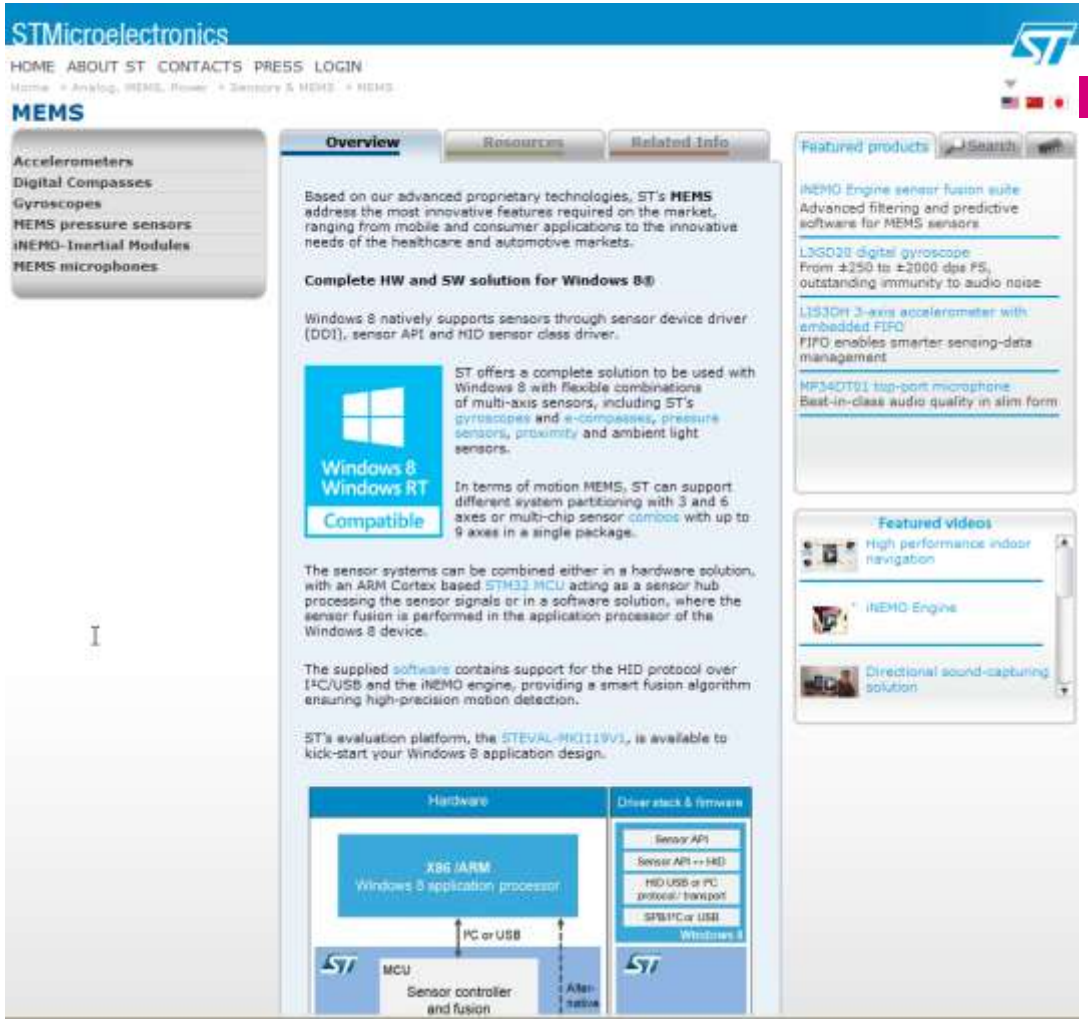
For more information:

- Web site

www.st.com/mems



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