Advanced MEMS sensors in the sustainable onlife era

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Smart sensors making our world a better place

Offline Era

2000
A paradigm change in the man-machine interface
MEMS technology: from a concept to a product.

Online Era

2010
Sensor proliferation and connections to the Cloud
Performance improvement and technology fusion.

Onlife Era

2020
The fusion of technology and life
MEMS sensors able to sense, process, and act.

Sustainable Onlife

Sustainable sensorization of the world
MEMS sensors sending only the meaningful data to the cloud
Sensors at the heart of our interactions with the digital world

**Human centered**

Sensors are the key components to **bridge** the **physical** and the **digital** worlds

**Sustainable**

Sensors becoming **smart** answer **human expectations** while ensuring a **sustainable** future
Track and monitor orientation in 3D space

Detect and track device orientation with the **embedded low power sensor fusion** algorithm with **30 µA**

**Plug and play** solution that provided **6x game rotation vector** (accelerometer + gyroscope) & **Gyro-bias calibration**

**Ultra-low power** operation
50% power reduction vs. external MCU\(^{(3)}\) processing

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**Static accuracy**\(^{(1)}\): 0.5, 1.5, 1.5 deg
**Low dynamic accuracy**\(^{(1)}\): 0.7, 0.5, 0.5 deg
**Calibration time**\(^{(2)}\): 0.8 s
**Orientation stabilization time**: 0.7 s
**Extra power**: 30 µA @ 120 MHz
Adding intelligence in the edge with MLC and FSM

**Embedded MLC and FSM** process XL & Gyro data to detect usage conditions with **no interaction required** with external processor.

**Few examples***

<table>
<thead>
<tr>
<th>Power Consumption</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 µA</td>
<td>Identify activity and inactivity (i.e., wake up the system only when needed)</td>
</tr>
<tr>
<td>6 µA</td>
<td>Gym activity recognition</td>
</tr>
<tr>
<td>6 µA</td>
<td>Wrist tilt detection for display wake up</td>
</tr>
<tr>
<td>From 1 µA to 35 µA</td>
<td><strong>Scalable</strong> solution to detect <strong>free fall, shock</strong> and fall <strong>height estimation</strong> (or Man Down)</td>
</tr>
</tbody>
</table>

* Power consumption values related to MLC & FSM only.
Adaptive self configuration (ASC)

From “Always-On” to “Smart, Always-Aware”

The device automatically reconfigures itself, based on the actual context, maximizing the system efficiency.

MLC and FSM detect the context without the need of additional data processing.

ASC allows to independently configure Gyro and XL channels. No tradeoff required!
Qvar electrodes to improve UI: Touch and Swipe

- Sensor fusion between Qvar and 6x IMU improves the user experience accuracy reducing false positives
- Support for single/long and multiple touch and swipe
Free fall height estimation

Beware: LSM6DSV16X can track your shock!

Scalable solution to detect shock, free fall, and estimate height of the free fall

Embedded processing and FSM detect the context without the need of additional data processing at system level

From free fall height exceedance detection, to the accurate height estimation, from 1 μA to 35 μA, always the right algorithm

* Power consumption values are related to the embedded processing
Moving the intelligence at the edge

**ISPU**

**Sensor + MCU**

- **Microcontroller**
  - Sensor → MCU
  - MCU standalone or hosted in the sensor package
  - Standard: MCU runs the algorithms
  - Runs any kind of SW provided it matches the MCU specs

**MLC**

- reconfigurable Processing Unit (rPU)
  - rPU+ Sensor → MCU
  - Optimized: reconfigured through register setting
  - Constrained: runs same model/mapping (MLC, FSM)

**ISPU**

- Intelligent Sensor Processing Unit
  - ISPU + Sensor → MCU
  - Programmable: ANSI-C plus AI dedicated instruction set
  - Runs several AI algorithms: full precision to 1-bit NN
Highly specialized DSP* for machine learning and processing

Unique solution for TinyML with machine learning (ML), binary neural network (BNN), and processing capabilities

Lowest power consumption IoT node in the market with AI in the edge

Productivity: empowers 10M+ C language developers
Complement STM32 MCU portfolio for AI

*DSP: Digital Signal Processing
vAFE, because the world is analog

**MEMS sensing**

- We use a **high performance AFE** in MEMS sensors: it reads and converts capacitance change \( \sim 0.1\text{aF}^* \)
- We have developed **specific low noise IP and silicon technologies**

**an additional AFE: vAFE**

- An auxiliary AFE enables reading of analog signals, that are complementary to motion signal

**vertical AFE**

vAFE and Motion signals are intrinsically **synchronous**.

The result is a unique **context aware analysis** done in-the-edge, thus low power and with the minimum possible latency.
And we do it in standard package dimensions.

\[ * \text{1aF} = 10^{-18}\text{F} \]
vAFE: opening new application frontiers

<table>
<thead>
<tr>
<th>Smartphone &amp; Camera</th>
<th>TWS</th>
<th>Wearable</th>
<th>IoT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence detection</td>
<td>In-Ear detection</td>
<td>Presence detection</td>
<td>Presence detection</td>
</tr>
<tr>
<td>Activity tracking</td>
<td>Touch-Multiple Touches</td>
<td>Enhanced activity tracking</td>
<td>Energy Saving</td>
</tr>
<tr>
<td></td>
<td>Long press</td>
<td>Biometric data</td>
<td></td>
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</table>

Smart Ring: the 2023 trend runs ST sensors

Battery constrained solutions require low power, in-the-edge processing

LIS2DUX features single-digit µA power consumption with embedded AI (MLC, FSM, ASC)

LIS2DUXS also features a vAFE

LSM6DSV16X includes a gyro for more functionalities
IR sensor STHS34PF80, ready to go

STHS34PF80 IR Sensor based TMOS technology starts finally in Mass Production, we are ready to go market.

**ST IR sensing element**
Sensor measures in the wavelength range from 5 to 20 um

**Human body**
radiation is ~9.8 um, at in the center of the sensor’s range

**Biometric**
Presence detection and temperature measurement
MEMS sensors roadmap
New generation MEMS sensors

Features

**iNEMO® Inertial Module**
- Embedded ISPU N version for NEAI
- MLC, FSM, ASC, SFLP, Qvar, Audio AXL, BC

**Accelerometers**
- ULP, 12b resolution, AAF, 128 samples FIFO (i.e. 0.47µA @6Hz ODR)
- FSM, MLC, Pedometer, Qvar™

**Pressure Sensors**
- Water resistant & WP, better accuracy, lower power consumption, Dual FS Qvar™

**IR Sensor**
- Presence Detection up to 4 meter
- 80° Field Of View
- TMOS sensor

Products

- LSM6DSO16IS
- ISM330IS/N
- LSM6DSV16X
- LSM6DSV32X
- LSM6DSV16BX
- LIS2DU12
- LIS2DUX12
- LIS2DUXS12
- LPS22DF
- LPS28DFW
- ILPS22QS
- ILPS28QSW
- STHS34PF80

Applications

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FS: Full Scale
ULP: Ultra Low Power Mode
FSM: Finite State Machine
MLC: Machine Learning Core
ASC: Adaptive Self Configuration
SFLP: Sensor Fusion Low Power
Qvar: Electrostatic Charge Variation
ISPU: Intelligent Sensor Proc Unit
NEAI: Nano Edge AI
WP: WaterProof
AAF: Anti-Aliasing Filter
TDM: Time Density Modulation
Takeaway
**Takeaways**

1. **LSM6DSV16X, LSM6DSV16BX, LIS2DUXS12 and ILPS28QSW** are innovative sensing solutions with unique IP.

2. **Qvar** is a new sensing capability that opens the door to many new functions such as in ear detection, user interface, water leakage detection without the need of additional sensors.

3. **Machine learning core, finite state machine, embedded sensor fusion** low power move the processing at the edge, in the sensor, allowing great system optimization and performance improvement.
Our technology starts with You

Find out more at www.st.com/MEMS