# "Is one gyroscope enough?" for Nanotech 2012

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## ABSTRACT

The current market trend is a push on small, lightweight portable devices with advance features for User Interface and gesture recognition, as well as camera features.

This new generation of portable devices require Gyroscope sensing capability to enable advanced gaming, high-performance motion detection, gesture recognition, and optical image stabilization. Nowadays, these functions are implemented using two dedicated gyroscopes for OIS (Optical Image Stabilization) and UI (User Interface), each to address specific requirements.

The new technology breakthrough is the new dual-core gyroscope capable of handling both user-motion recognition and camera image stabilization in one single device. With the innovative architecture, only a single sensor is needed for these two functionalities at the same time, or separately. This allows space saving, and the reduction of system complexity opens new frontiers in terms of the possibilities to implement gaming, gesture recognition, and image stabilization in ultra portable devices.

***Keywords***: MEMS, gyroscope, dual-core, image stabilization, user interface.

## 1 INTRODUCTION

For portable devices, new market trends require sensing capabilities to implement gesture recognition and gaming.

Moreover, mobile devices and tablets integrate advanced camera features for photo, video, navigation and location based services. One of the critical items to address is the camera's shake due to natural handshake movements that can insert disturbing blurs that reduce the image sharpness. Camera shake stabilization is also critical when slow shutter speeds or telephoto with long focal length lenses are used.

The same problem is also present with video. Camera shake often produces visible frame-to-frame jitter in recorded video.

Market trends require small, lightweight digital cameras and mobile phones that are naturally affected by handshake effects. These features combined with higher megapixel sensor features require image stabilization systems to produce sharper pictures and jitter-free videos.

Motivated by the increasing demand of integrated inertial-sensing solutions for motion processing and dead-reckoning navigation in handheld devices and low cost GPS navigation systems, this article introduces the new, dual core gyroscope that integrates with an innovative system architecture, the two different functions in a single device. This breakthrough reduces the size, system complexity, and cost in mobile phones, tablets, and other smart consumer devices. At the same time, the solution addresses motion and gesture recognition as well as optical image stabilization for sharper mobile-camera photos.

## 2 DUAL CORE GYROSCOPE ARCHITECTURE

The dual core gyroscope is based on a standard dual die approach system: a single MEMS sensor and a single ASIC.

The compact mechanical design combines a triple tuning-fork structure with a single vibrating element to ensure high performance in terms of thermal stability and acoustic noise immunity. The structure includes 4 suspended plates coupled to each other by means of 4 folded springs connected to their outer corners and elastically connected to a central cross-shaped hinge by an additional set of central coupling springs.

The micro-mechanical element is fabricated with the STMicroelectronics (ST) proprietary thick-film epitaxial polysilicon surface-micromachining process (ThELMA). The small size of the package (16 $mm^3$) has been achieved by MEMS and ASIC dies stack-assembled.

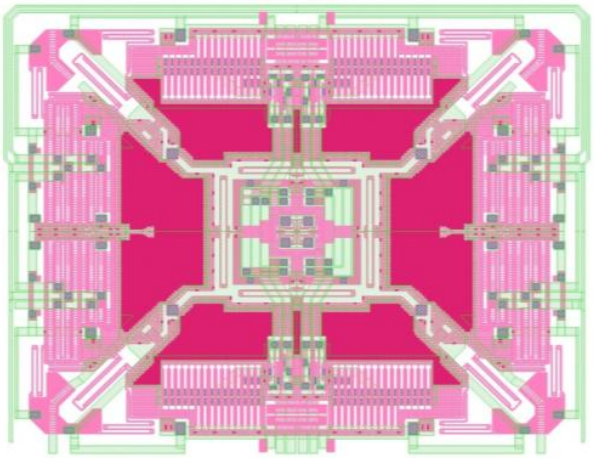

Figure 1: MEMS gyroscope

## 2.1 UI and OIS requirements

Gyroscopes for User Interface and Optical Image Stabilization available in the market are designed with different features to match specific requirements.

The user interface and gaming applications typically require high full-scales (i.e.,2000 degrees per second), output data rate in the order of one hundred Hertz and a bandwidth around tens of Hertz.

For Image Stabilization applications, the gyroscope is usually dedicated to detect the movement of the camera, mobile phone, or portable devices to prevent unwanted motion or handshake effects. Generally, this kind of device needs a full-scale, in the range of 60 degrees per second, very low noise performances, high bandwidth, and low phase delay to ensure a real time correction of the camera movement.

Up until now, in order to satisfy UI and OIS applications, two devices have been necessary.

The aim of this paper is to introduce a new, single, compact device, dedicated to providing for the specific requirements of both OIS and UI data.

In this gyroscope, the UI data are managed by an I2C digital interface while the OIS data use an SPI interface to ensure high speed communication. The two independent readout chains are described in the following paragraph.

## 2.2 UI and OIS readout chain

The dual core gyroscope architecture is based on a single MEMS sensing structure with two independent readout chains dedicated to the UI and OIS function [Figure 2].

The two readout chains have a similar block diagram structure including:

- A multiplexer and converter system to translate the capacitance change due to a motion displacement in a voltage signal;
- A filter system and an ADC converter for voltage signal processing;
- An integrated low and high-pass filter with user-selectable bandwidth.

Nevertheless, each of the single chain element designs in the block diagram in the two readout architecture has completely different specifications and characteristics.

The UI readout chain provides a selectable full-scale, from 250 up to 2000 degrees per second, for the best matching of the end user application; the OIS readout chain has a single full-scale of 65 degrees per second for accurate optical correction that cancels out image shifts.

The OIS readout chain has been designed for better performances in terms of noise compared to a readout chain dedicated to UI applications.

The UI readout chain embeds a 32-slot FIFO that works for five different modes: Bypass, FIFO, Stream, Bypass-to-Stream, and Stream-to-FIFO.

Following the typical approach for mobile phones and portable devices, the I2C interface has been selected for the UI chain, while for OIS applications, the SPI interface has been chosen to ensure fast and reliable communication. Therefore, this dual core gyroscope provides two different output interfaces to reach standard compliance end user systems at the same time.

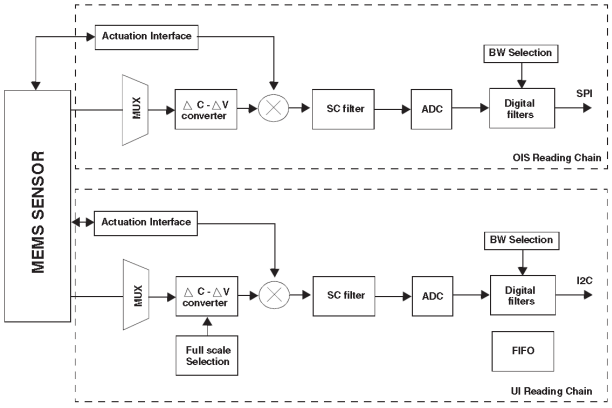


Figure 2: Dual core gyroscope readout chain block diagram

## 2.3 Smart power saving

As described in the previous paragraphs, this dual core gyroscope can be used for user interface and image stabilization applications separately. The independent power supply of the single chain benefits smart power savings through power-down and sleep mode features.

Depending on the power supply provided and the configuration of dedicated internal bits, this gyroscope is able to keep both reading chains active, which allows the user to concurrently exploit the advantages of high resolution on low full-scale and low current consumption on high full-scale at the same time through the SPI and I2C digital interfaces.

As shown in Table 1, the separate power supply allows the user to selectively activate the UI or OIS modes or both at the same time. Through only the SPI interface, the user can access both UI and OIS parts using a dedicated register configuration. In particular, each reading chain, and the corresponding full-scale, can be activated by powering two separate pins. The internal ASIC blocks automatically detect and enable the selected device configuration.

Moreover, the FIFO management in the UI readout chain allows additional power saving for the system. In fact, the host processor does not need to continuously poll data from the gyroscope but can wake up only when needed and burst the significant data out from the FIFO according to the FIFO mode selected.

| AVdd | AVdd_OIS | Operating mode | I2C interface | SPI interface |
|---|---|---|---|---|
| OFF | OFF | Gyro OFF | N.A. | N.A. |
| ON | OFF | UI | R/W UI | N.A. |
| OFF | ON | OIS | N.A. | R/W OIS |
| ON | ON | OIS/UI | R/W UI | R/W OIS |

Table 1: Dual core gyroscope operating mode setting

## 3 CONCLUSION

Because of the pressing market requirements for portable devices, the introduction of gyroscopes is necessary to support new generations of consumer electronics applications such as advanced gaming, high-performance motion detection, gesture recognition, and optical image stabilization.

*"Is one gyroscope enough?"*

In this paper we have described a new three-axis dual core gyroscope that concurrently enables both User Interface and image stabilization applications at the same time with separate power supply systems.

Since there are two different independent reading chains and digital interfaces, this gyroscope can deliver previously unseen levels of flexibility to the end user.

## REFERENCES

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