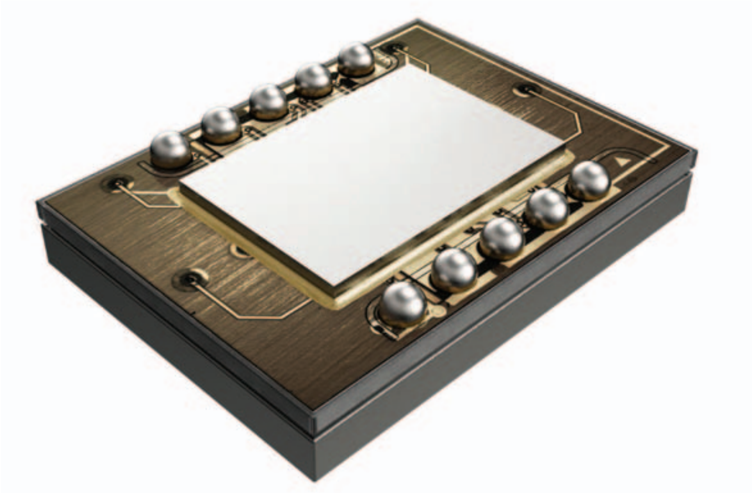


A sense of purpose

MEMS technology is enabling smaller, more accurate sensors. **By Graham Pitcher.**

Sensors were once the exclusive property of industrial applications, measuring such physical parameters as temperature and pressure. But the devices have seen their application field broaden considerably to encompass automotive and consumer products, as well as the aerospace and medical sectors.

Accelerometers have been a staple of the automotive world for some time, performing a central role in airbag deployment and in navigation systems. But the sophistication of the applications is such that accelerometers are not always up to the job. Now, companies are looking to design gyros into their systems. But price, performance and size requirements of these applications are seeing the adoption of MEMS technology.

Established in the late 1970s, Finnish company VTI has been making accelerometers since the early 1990s, but has recently moved into the gyro market. Juhari Pelttari, sales manager, said the main market for its products was automotive, but that it was also active in industrial and medical applications. "We have a range of sensors in applications ranging from consumer to high end avionics. For example, our sensors are used in the A380 to create the artifical horizon."

In the medical market, its accelerometers are being used in pacemakers. "These devices used to enable a steady pulse," he said. "But accelerometers can be used to change the pulse rate according to the conditions."

Pekka Kostiainen, product manager for VTI's consumer electronics business, said the requirements of consumer electronics companies were different, for example, to automotive companies. "Product life cycle is one example and there is also greater cost pressure. Meeting that pressure means we now manufacture products for consumer applications in Asia, where we can use standard processes and can scale products more easily."

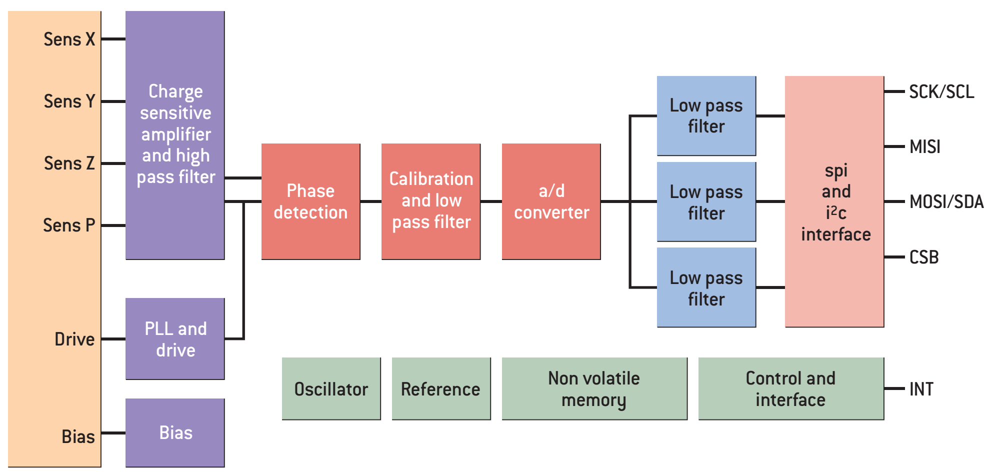
So while the CMA3000, a three axis accelerometer continues to be made in Finland, the CMR3000 – said by Kostiainen to be the smallest three axis gyro currently available – is the first VTI product to run through the new supply chain.

Kostiainen: "While accelerometers may measure femtoFarads, the gyros are measuring attoFarads."

The CMR3000, pictured above, is a three axis gyroscope targeted at high volume products which require small size, low price and low power consumption. The device consists of a 3d MEMS sensing element and a signal conditioning asic, housed in a wafer level package (see fig 1).

The sensing element is manufactured using a proprietary bulk 3d MEMS process, which enables robust capacitive sensors which are stable with low noise and power consumption. The sensing element consists of a primary resonator and three secondary resonators. The primary resonator is driven by the asic and the resultant Coriolis force will couple to the secondary resonators. The detected signal is first converted into a phase difference, then into a voltage in the

Fig 1: Block diagram of the CMR3000 gyroscope



signal conditioning asic. An internal oscillator, reference and non volatile memory allows the sensor to operate autonomously within a system.

Sensitivity is an important design parameter. "While the device is getting smaller," Kostiainen said, "detection technology is also developing. While accelerometers may measure femtoFarads, the gyros are measuring attoFarads (10^{-18}F) and there are different types of detection that can be used."

Operating from a supply ranging from 2.5 to 3.6V, the device can measure rotations of up to 2000°/s to a resolution of 0.75°. It comes in a wafer level package measuring 3.1 x 4.2 x 0.8mm, with the asic flipped on top of the MEMS sensing element. The high angular rotation suits the part to gaming applications, while the size is attractive to mobile phone developers.

According to Kostiainen, price and size are important for the consumer world. "If your product doesn't meet the price point, it will take longer to get to market. And there is the challenge of meeting size constraints."

Kostiainen said the CMR3000 will typically be used for motion control and measurement. "Accelerometers use an algorithm to measure speed and distance," he said, "but gyros use different parameters, including angular rate."

Accelerometers can use their three axes to estimate speed and, with the knowledge of elapsed time, distance can be calculated. "Gyros measure angular rotation," Kostiainen continued, "which accelerometers cannot do."

Pelttari added: "Gyros have always been used in aircraft in association with accelerometers because of the need to distinguish between tilting and other motions."

In the consumer market, gaming giant Nintendo was first to use accelerometers and is now using gyros to improve the user experience. But that's just one application. Pelttari continued: "Now set top boxes are becoming internet enabled, you need more than buttons to control them. People want to control the interface by movement."

Pelttari sees the automotive sector as holding opportunities. "Electronic stability control needs both accelerometers and gyros," he claimed, "with the gyro used to measure heading." Another consumer application is image stabilisation in digital still cameras. Notable consumer products featuring gyros include the iPhone 4 and the iPad 2, with more applications emerging.

Front ends fast track signal conditioning design

Designing a sensor system isn't getting easier as engineers have more sensors and signal conditioning devices from which to choose. Looking to ease this task, National Semiconductor launched two configurable analogue front ends earlier this year, claiming the part will fast track signal path designs for sensors from a range of leading manufacturers.

Anita Ganti, director of National's precision systems business unit, said: "Designers have a complex task which involves a lot of research and optimisation. The process starts with choosing the sensor and finding out how it behaves over time and with temperature. Then they have to select the components which will drive the sensor, amplify its signal and perform data conversion. After that, they have to lay out a board and validate the design.

"We're looking to make this process easier so system designers can focus on differentiating their products."

The two AFEs introduced so far are the LMP91000 (see diagram), for use with chemical and gas sensors, and the LMP90100, for use most other sensor devices. According to National, the chips are the first in a range of AFEs. Both offer such features as sensor drive, reference selection, diagnostics, offset and sample rate selection.

Both parts are configured using National's Webench online tool. "Design starts with sensor selection," Ganti noted. "Webench has preloaded sensor data but, for user specific sensors, the data can be entered manually."

The LMP90100 has a multiplexer, allowing its 24bit $\Delta\Sigma$ a/d converter to access any combination of differential or single ended input. A programmable gain amplifier allows signal gain to be set between unity and 128, while two matched current drives are available for sensor drive.

The LMP91000 measures current in a potentiostat whose output is proportional to gas concentration. An output voltage proportional to the cell current is generated using a transimpedance amplifier. Cell voltage and cell output gain are user selectable.

Ganti claimed more AFEs will be developed to work with different classes of sensor, including medical.

Fig 2: Block diagram of the LMP91000 analogue front end