Good Vibrations from Epson's New Gyro-Sensor

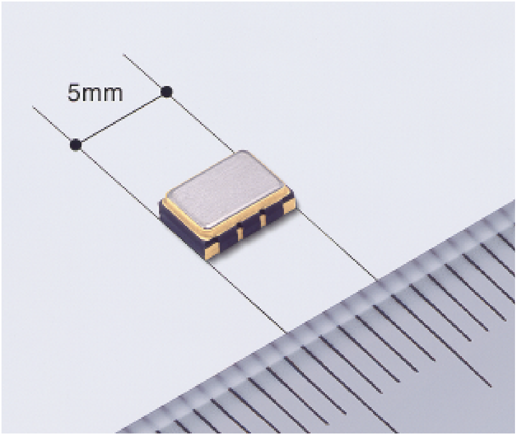
By John Boyd

With the unveiling of the world's smallest gyro-sensor last year, Epson decisively expanded the range of its quartz device business. Since its invention of the quartz crystal watch—the Seiko Quartz Astron 35SQ—in 1969, Epson has led the industry in the application of quartz resonators, used in maintaining precisely timed operations in products like personal computers, mobile phones and consumer electronics goods, as well as clocks and watches. Now Epson aims to make a similar impact in the field of sensors, beginning with its XV-3500CB angular velocity gyro-sensor, which will initially be used to correct the shaking of handheld digital still and video cameras.

The new sensor is the result of collaboration between Epson and Nagoya-based NGK Insulators, the world's largest producer of insulators for power utilities. "We began development work with NGK in 2000," says Takeshi Miyazawa, manager of Epson's Quartz Device Sales-Engineering Group. "They have the basic patents for this gyro-sensor, we have the crystal technology and precision engineering. So we've proved to be a good match."

The new sensor incorporates a number of leading features. Operating temperatures range between -20 and +80 degrees Celsius, typical current consumption is 2.1 milliamps at operating voltages of between 2.7 and 3.3 volts, while a sleep mode ensures low overall power consumption. But most striking is the sensor's tiny size: 5 × 3.2 × 1.3 millimeters, or just 20.8 mm^3 overall.

"It's about one-tenth the size of our competitors' ceramic-based sensors and one-seventh the size of silicon sensors," Miyazawa points out. "This makes it attractive for use in products where space is at a premium, and also for mobile products where weight and low-power consumption are critical factors, as well as size."



Epson has utilized its precision engineering skills to exploit the inherent stability of quartz crystal, which makes it an ideal material for use in a gyro-sensor. "Quartz is resistant to temperature fluctuations," says Miyazawa. "In other words, it is very stable and highly reliable."

By comparison, ceramic-based gyro-sensors are influenced by changes in temperature. This can result in a less stable device. Temperature changes may also result in fluctuating voltages, leading to degradation of the ceramic material.

At the center of the new sensor is a specially designed gyro element made of monocrystalline quartz crystal. It is fabricated using photolithography.

The element is enclosed in a vacuum-sealed ceramic container. This is no easy process, given it requires specialized manufacturing equipment and the experience that only comes from decades of working with quartz crystal at the micro-engineering level. The gyro unit (together with the addition of low-power analog circuitry) is then housed in a package used for integrated circuit chips.

"The shape of the gyro element is unique," says Miyazawa. "Sensors used by competitors employ a vertical design that can be affected by external vibrations. But we use a horizontal or flat design. This makes for a much thinner unit, and it also improves balance."

Another feature of the design is the engineered grooves that run along the two outer T arms. This design feature substantially improves piezoelectric efficiency, and so plays a significant role in realizing the sensor's small dimensions. The symmetry of the design

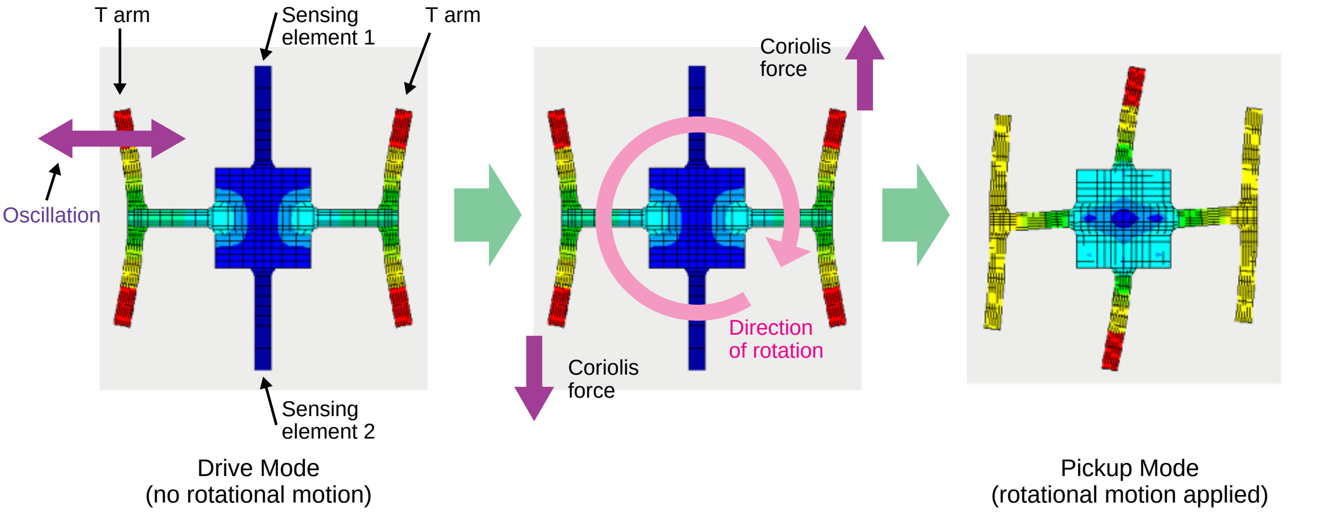
Features of XV-3500CB Gyro Sensor

- Subminiature surface mounted device structure with built-in drive and detection circuits
- Outstanding stability provided by a quartz crystal as the sensor element
- Sleep mode achieves both low power consumption and a short startup time
- Vacuum-sealed structure for excellent environmental resistance and 100% lead-free applications

General specifications

Item	Specification	Unit
Operating voltage	2.7 to 3.3	V
Output in stationary state	1.35	V
Detection range	±100	deg/sec
Sensitivity	0.67	mV/deg/sec
Linearity	±5	%FS
Package size	5.0 × 3.2 × 1.3	mm

Principle of Operation of the Gyro Element



Ordinarily, in the Drive Mode, the sensing elements are stable and only the T arms on either side are oscillating. When a rotational motion is applied, the sensing elements vibrate, and the sensor detects the signal differential.

also enhances the element's balance and helps reduce the effects of vibration.

There are several types of gyroscopes, including spinning gyroscopes and laser gyroscopes. Epson's gyro-sensor (which measures how quickly an object turns) is a kind of vibrating gyroscope that works by making use of the piezoelectric effect. When a force or pressure is exerted on such a material as quartz crystal, it produces a voltage. Conversely, the opposite state can also be induced. If an alternating current is applied to the crystal, it resonates or vibrates at a certain frequency. This is known as the reverse piezoelectric effect.

When an alternating current is applied to the gyro element, it causes the two outer T arms of the element to oscillate and move towards and away from one another at a high frequency. At the same time, should the gyro unit be even minutely rotated (motion that occurs when a handheld camera shakes), a secondary force called the Coriolis force comes into play.

The Coriolis force acts perpendicularly on the oscillating gyro element from above and underneath, causing the middle sensing elements to vibrate and thereby produce a current proportional to the rate of rotation or angular velocity. The current is amplified inside the gyro-sensor, and a voltage corresponding to the angular velocity is generated. This signal is calculated electronically and sent to an actuator, which uses the data to move the camera lens or charged-coupled device so as to negate the camera movement.

Currently, two motion-correction methods are used to stabilize the shaking of video cameras: One is software based, the other uses a combination of optoelectronics and a gyro-sensor. While these have worked well enough with video moving at 30 frames per second, they are not effective in dealing with the shaking of a digital camera, which uses only one frame for each picture.

As well as targeting the digital camera market, Epson believes its approach to motion correction is also more efficient than the current technologies used in the video camera market, and expects to compete strongly in this segment too. Looking further ahead, Miyazawa sees camera-equipped mobile phones and personal digital assistants as promising markets.

"And when you also consider the different types of industrial sensors used today, the potential of this market is huge," says Miyazawa. "We've been looking to expand our business beyond timing devices, and the sensor field is a good place to start."

John Boyd is a freelance writer based in Yokohama. He writes for a number of publications and covers technology and business news and issues in Japan and Asia.