Accurate motion tracing capabilities of AH-6100LR six-axis sensors

1. Accurate motion tracing capabilities of AH-6100LR six-axis sensors open up a world of possibilities

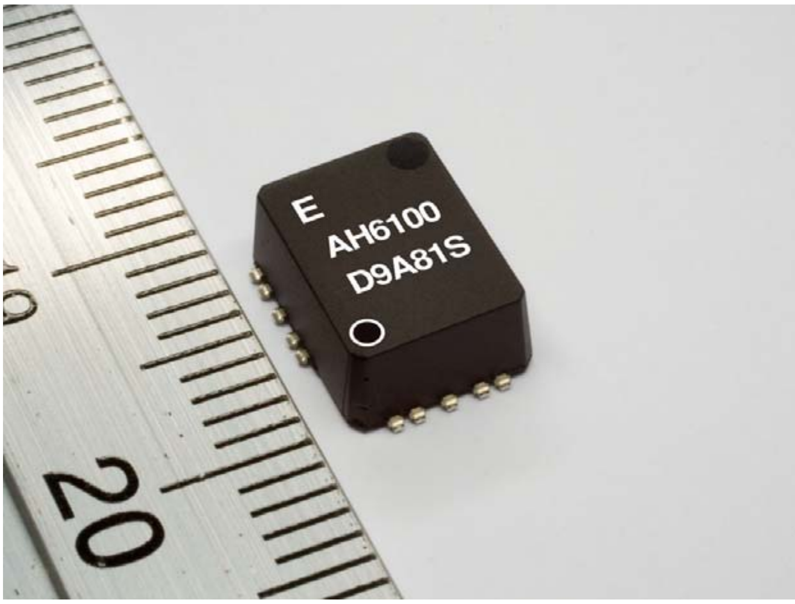


Fig.1 AH-6100LR

Epson Toyocom Corporation has been shipping piezo-electric gyro-sensors (XV-3500CB) to consumer markets since 2005. Our gyro-sensors have an innovative structure that makes them exceptionally accurate and stable, characteristics that have made them a key component in camera-shake correction for digital cameras. While different companies use different ways to denote camera-shake correction performance, every camera manufacturer that currently claims performance good enough to allow photographers to shoot at shutter speeds four or more stops slower uses an XV-3500CB. The XV-8000CB and XV-8000LK that followed the XV-3500CB are also expanding their customer base, largely due to a combination of outstanding stability and excellent reliability, including superb shock resistance, that make them ideally suited for highly accurate dead reckoning in car navigation systems.

2. New sensor possibilities delivered by the XV-3500CB

We develop our sensors based on the following three concepts:

(1) Rapidly respond to changes in physical magnitude.
(2) Respond dramatically to changes in physical magnitude.
(3) Respond only to the required physical quantity.

The fact is that the effects of Earth's gravitational acceleration make sensing the physical quantity that is supposed to be output (angular velocity) extremely difficult. In addition, sensors are subject to the effects of changes in the external environment. These and numerous other hurdles need to be cleared. Epson Toyocom's gyro-sensors are one of the few devices to satisfy these three concepts at a high level. The double-T (hammerhead) structure employed by Epson Toyocom is symmetrical and cancels the effects of acceleration by sensing the difference in electrical charge generated by the effects of the Coriolis force (Fig. 2). Meanwhile, Epson Toyocom's package technology goes a long way in attenuating the effects of changes in the external environment. We have also been able to successfully exploit our semiconductor technology to minimize noise.

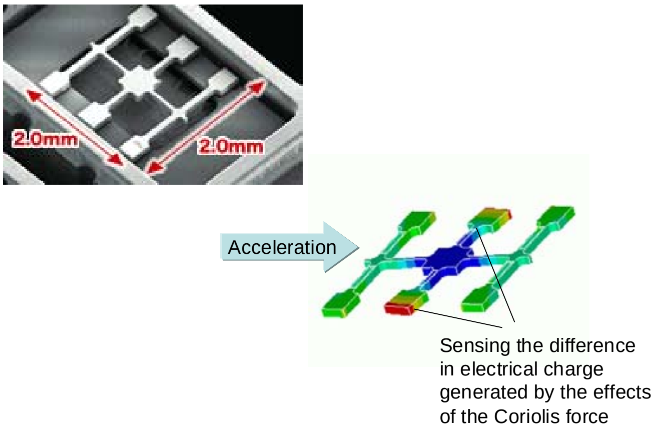


Fig.2 double-T (hammerhead) structure

Early consumer applications of gyro-sensors were limited almost exclusively to camera-shake correction and car navigation systems. In recent years, however, gyro-sensors have found their way into game systems and new user interfaces. This change, in which the customer experience has become the starting point for developing greater sophistication, is on the verge of creating new customer value.

Anticipating the market, Epson Toyocom decided to commercialize the AH-6100LR for high-integrity motion tracing and motion tracking applications.
The basic sensor specifications describe a six-degrees of freedom (DOF) inertial sensing device comprising three gyro-sensors having a wide detection range (rate range) of 1000 deg/s and three 3G-type accelerometers (Table 1).

	Parameter	Unit	
Over all	Operating temperature	℃	-20 ～ +80
	Supply voltage	V	2.7 ～ 3.3
	Current consumption	mA	6.1
Gyroscope	Scale Factor	mV / (° ・s^{-1})	1
	Reference output (Vr)	mV	1350
	Detection range	deg/s	±1000
	Noise density (@10Hz)	(° ・s^{-1}) /$\sqrt{Hz}$	0.006
Accelerometer	Sensitivity	mV / G	400
	0g output	mV	1500
	Detection range	G	±3
	Noise density (@10Hz)	μg/$\sqrt{Hz}$	75

Table.1 Main Specifications

Motion tracing and tracking are being researched and developed as core technologies for next-generation applications that will be used to sense things such as object or human motion or movement, for use in a variety of analyses and controls. Human movement and object behavior are starting to come under intense study in industries where they are seen as critical elements in future user interfaces and equipment designs.
Human motion and actions are expressed as a combination of states in which there is motion and motionlessness. The ability to correctly detect the difference between these two states is critical for a sensor. What must be considered here is that human perception has an extremely wide dynamic range; that is, the difference between the smallest and the largest values of motion that we can discern is extremely wide. Humans unconsciously adjust the dynamic range to adapt to changes in the surrounding environment, giving us a very wide dynamic range.
Another factor that must be considered is that unconscious movements by humans are extremely rapid. Think, for example, about the rotation of your head when you hear your name called or the motion of your wrist when you flip your palm up. These unconscious movements are said to produce very high angular velocity (in excess of 600-800 deg/s).
The tracking and tracing of human motion thus requires a sensor with an extremely high dynamic range that enables sensing of the full range of movements, from motionlessness to high speed, in order to accommodate sensory adaptations and unconscious movements.

3. The AH-6100LR has a huge dynamic range

The recently developed AH-6100LR has a wide dynamic range (81 to 83 dB at 200 Hz output) that will help enable high-precision control via accurate tracing and help improve the certainty of motion recognition in systems. A wide sensing range is not enough to realize a wide dynamic range; it is also extremely important to attenuate noise within the bandwidth and demonstrate resistance to environmental changes.
Two of the indicators used to express performance in these areas are the bias temperature characteristic (bias is the voltage output when the sensor is stationary) and Allan Variance. The bias temperature characteristic is an extremely important performance parameter in applications such as camera-shake correction and car navigation, and it was here that the XV-3500CB excelled, enabling it to build a large market (Fig. 3).

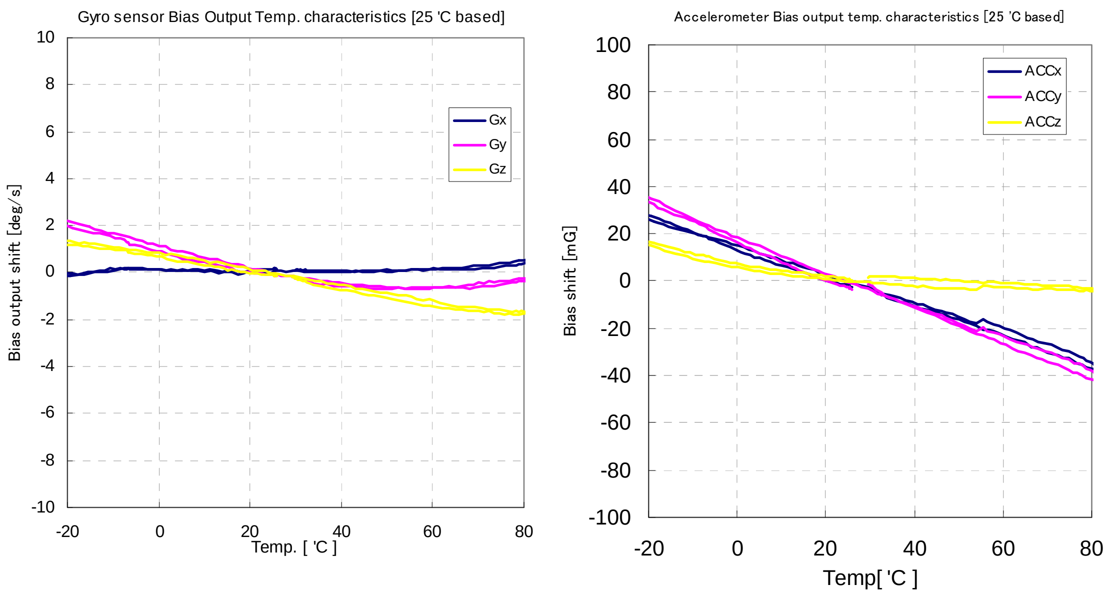
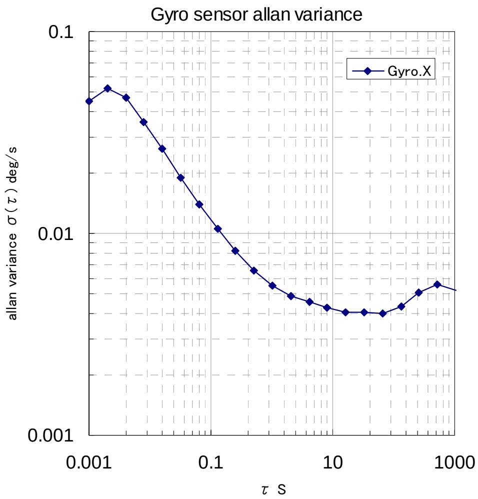


Fig.3 bias temperature characteristic

In contrast, the Allan Variance was not commonly used for gyro-sensors in earlier consumer applications. The Allan Variance shows a correlation between measurement time intervals and the distribution of data averaged for those time intervals. The characteristics of a sensor can be determined by examining a graph on which the measurement time intervals are plotted on the horizontal axis and the Allan Variance data on the vertical axis. If the measurement time intervals are short, the Allan Variance shows white noise (angle random walk), and as the measurement time intervals increase, it shows the time fluctuation [1/f noise (bias stability)]. By making these values sufficiently small, it is possible to prove that noise is low and output stable. The AH-6100LR is based on normalized characteristic indicators that show high stability and a wide dynamic range Fig. 4).



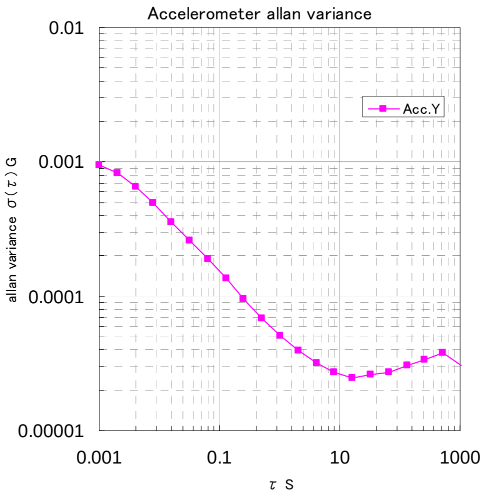


Fig.4 Allan Variance

In addition, by outputting a high-integrity analog signal, the AH-6100LR has the flexibility to meet the need for mixed signal processing in customer systems. Customers can thus process signals in the best way for any given application, and realize designs with low noise and broadband output.

The new six-axis sensor packs critical application performance features into a small package (10.0 x 8.0 x 3.8t mm). Among these features are 5,000 G's of shock resistance and 6.1 mA of current consumption, a more than sufficiently low power draw to meet the requirements of low power systems.

The AH-6100LR is unearthing hidden new markets

The AH-6100LR, which blends existing sensor performance on a high level, was launched onto the market as the industry's first six-axis sensor (comprising three gyro-sensors and three accelerometers). Motion tracing and tracking are being targeted as potential applications that are closer to end users. Following the announced development of the AH-6100LR in February, we were astounded by the influx of inquiries from familiar markets that we had never considered, and about uses we had never dreamed of. A considerable number of these applications were developed some time ago but advances had stalled due to limitations imposed by factors such as accuracy, size, and current consumption. There is little doubt but that the AH-6100LR can dramatically increase the performance threshold limits of sensors that customers have already developed and, moreover, harbors extremely high potential for further development of advanced applications.

Epson Toyocom intends to continue expanding its sensor product lineup to meet evolving sensor needs in an increasingly diverse range of sensor applications.

About Epson Toyocom

Epson Toyocom Corporation was formed through the integration of the quartz business of Seiko Epson Corporation and Toyo Communication Equipment Co., Ltd. in October 2005. Epson Toyocom follows a “3D strategy” designed to drive both horizontal growth through expansion in three device categories—timing devices, sensing devices and optical devices—and vertical growth through combinations of products in these categories. With this strategy, Epson Toyocom aims to be the leading company in the quartz device industry, selling a wide range of products to customers worldwide, from cellular phones for consumer fields, to industrial fields such as core network systems and automotive systems.

The company's timing devices are extremely accurate, stable crystal products that serve as reference signal sources in all manner of devices. The lineup currently includes products in frequencies ranging from the kilohertz band up to 2.5 GHz range. In the kilohertz range, Epson Toyocom offers tuning forks. At frequencies up to about 100 MHz, Epson Toyocom offers AT-crystal products that use thickness-shear vibration. In the hundreds of megahertz range, the company applies its AT vibration technology to provide crystal products that use an HFF (high-frequency fundamental) or SAW (surface acoustic wave).

Epson Toyocom website : http://www.epsontoyocom.co.jp/english
Gyro Sensor Portal Site : http://www.epsontoyocom.co.jp/english/gyroportal/index.html