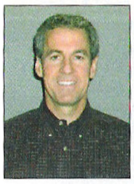
Integrated MEMS Sensors for Industrial Control



By Bob Scannell, Analog Devices

Recent developments in sensorsmight allow revolutionary improvements in industrial system designs. Applications where inertial sensors could be useful include platform stabilisation, motion control for industrial machinery, security devices, robotics, navigation and mechanical levelling. The motion information provided by such sensors can be invaluable in improving performance, reliability, safety, and cost of ownership.

There are barriers to be overcome to obtain these benefits, particularly in the tough physical environment (i.e., temperature, vibration, tight spacing) of many industrial applications. Extracting consistent data from the sensor, translating it into useful information, and reacting to it within the timing and power budget requires expertise on the part of the engineer in many technology domains, as well as careful design practice.

⇨ MEMS technology

MEMS (Micro Electro Mechanical System) sensor technology is well-established, and has brought benefits to a wide range of applications. MEMS accelerometers revolutionised the automotive-airbag-system industry 15 years ago. Since then they have enabled unique features and applications ranging from hard-disk protection on laptops to game controllers. More recently, the same sensor-core technology has become available in fully integrated, full-featured devices suitable for industrial applications (Figure 1). This has provided an attractive alternative to uncalibrated sensor cores, or high-priced options originally optimised for defence applications. For detecting motion such as vibration, shock, angular rotation, linear motion, and tilt, MEMS accelerometers and gyros provide lower power, compact and robust sensing. Multiple sensors are often combined to provide multi-axis sensing and more accurate data.

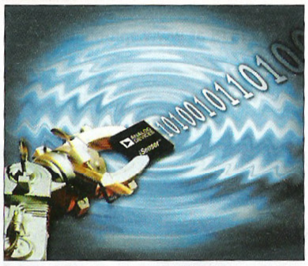


Figure 1: The integrated MEMS sensor in robotics application.

⇨ Angular sensors

An angular-rate sensor based on a MEMS gyroscope operates on the principle of a resonator gyro. Two polysilicon sensing structures each contain a "dither frame", which is electrostatically driven to resonance. This produces the necessary movement to create a Coriolis effect during rotation. At two of the outer extremes of each frame, orthogonal to the dither motion, are movable fingers that are placed between fixed fingers to form a capacitive pick-off structure that senses Coriolis motion. When the MEMS gyro sensor is rotated, the change in position of the movable fingers is detected via a change in capacitance, and the resulting signal is fed to a series of gain and demodulation stages that produce the electrical-rate signal output. In an integrated device such as the iSensor intelligent sensor from Analog Devices, the base-sensor output signal is also sampled using an analogue-to-digital converter; then the digital data is fed into a proprietary digital calibration circuit. This circuit contains factory calibration coefficients, along with user-defined calibration registers that can be used for further in-system improvements.

⇨ Integrating the signal conditioning

Each application has unique needs and places unique conditions on the sensor. In the iSensor products, these can be accommodated via embedded tunable features such as digital filtering, sample-rate control, condition monitoring and power-management options, as well as application-specific auxiliary I/O functions. One sensor is often not enough. Temperature sensors are a useful addition either for enhanced sensor-output stability over temperature, or for providing additional data in applications such as condition monitoring of goods through the delivery chain. Some sensors have cross-sensitivities (such as angular-rate sensors being sensitive to linear motion). By combining sensors and embedding compensation routines, a more stable signal is provided. Further, where one sensor type may be optimised for response time, another may provide better accuracy. Application-focused solutions, which combine the appropriate sensors with the necessary signal processing and interfaces, are now becoming available (Figure 2). If made cost-effectively and with standard system-ready interfaces, they can remove the implementation and production barriers that many industrial customers have faced in the past. With the right feature set to allow in-system tuning, users can also gain significant advantages in time-to-market.

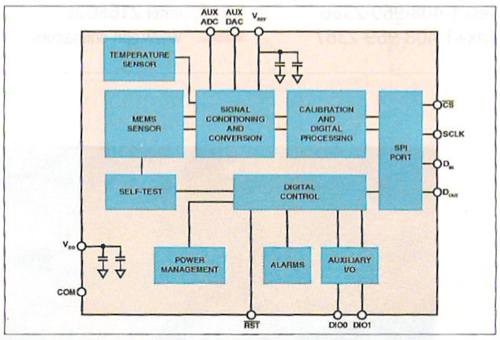


Figure 2: Block diagram of the iSensor integrated device.

⇨ The industrial context

Applications such as vibration analysis, platform levelling, and general motion control need highly integrated and reliable solutions where it would be optimal to embed the sensing element directly into the existing equipment. It is also important to provide sufficient control, calibration, and programming features to make the device truly self-contained. In robotics, gaining an accurate reading for the position and motion of a robotic arm makes it possible to control the arm more precisely, while speeding up its operation. In image stabilisation, feedback from motion sensors allows a camera or camera platform to be stabilised, and can also be used in software to improve the captured images. For mobile satellite communications at sea or on land vehicles, antenna positioning must maintain a very high degree of accuracy to establish and retain the communications link, and allow accurate receipt and transmission of data. Compensating for sea motion or a vehicle's movement over rough terrain is critical. The integration of multiple MEMS sensors and the improvement in the sensor accuracy via embedded calibration are providing significantly enhanced solutions to these problems.

⇨ Not just future expectation

An example of a iSensor device is the ADIS16204, a fully integrated and programmable high-g impact sensor, 90% smaller than previous solutions. The MEMS provides dual-axis inertial sensing, with ±35 or ±70g full-scale range, and embeds all required signal conditioning and processing. Programmable features, including peak sample and hold, shock-profile recording, filtering, trigger points and power management, make the device in-system tunable.

⇨ Low-power gyro sensors

One of the primary application classes for a small, low-power gyro is as a navigational aid. The actual end use can range from industrial robotics to personnel locators to vehicle-tracking systems to remote medical microprobes. In terms of sophistication, existing solutions range from basic magnetometers to video/image-guided solutions to Global Positioning Systems (GPS); with even the most sophisticated solutions having their limitations. Gyroscopes can enhance such systems by providing a faster and more reliable response. With GPS systems, gyros provide "dead reckoning" to help fill in the gaps where GPS information is unavailable. This significantly improves the overall accuracy of the system. Here again, by combining multiple gyros and accelerometers into a single unit, not only can you achieve accurate sensing across multiple axes, but with sensor fusion you can combine sensor outputs to eliminate cross-sensor sensitivities. In the medical field, research is progressing rapidly into wearable sensors, which allow doctors to monitor the movements of patients undergoing physical rehabilitation, or improve the performance of prosthetic devices.

By integrating application specific sensor conditioning and sensor processing directly with the sensor core, sensors can now be put much closer to the phenomena being sensed; for example you can embed vibration sensors directly into motors or large continuously operating industrial machines. Solutions today range from periodic "listening" (trained operator) to externally mounted sensors capable of detecting gross shifts in performance. With a fully integrated solution, extremely subtle vibrations can be detected, and much earlier - thus triggering predictive maintenance, and perhaps eventually active compensation.

ANALOG DEVICES,
Tel+33-1-46744500
Fax+ 33-1-46744501

INFO @ enter **21359** at **www.epn-online.com**