Integration to make MEMS leap in performance

Vishal Goyal
Manager, Technical Marketing, STMicroelectronics

Micro Electro-Mechanical Systems [MEMS] have become widely popular sensors for measuring motion, acceleration, inclination, and vibration. MEMS sensors are System-in-Package solutions, delivering high resolution and low power consumption, in an extremely small size.

MEMS are radically different technology from other silicon ICs, which primarily exploit the electrical properties of silicon. The heart of MEMS uses actually miniature mechanical structures made up entirely of silicon instead of the traditional source-gate-drain of transistors. A typical MEMS structure contains moving masses, springs, and dampeners, which work in a way similar to the mass-spring model.

The sensors can add an intuitive man-machine interface to a mobile phone, MP3/MP4 player, PDA, or game controller, creating interaction by linking the user's movements to applications, navigation, gaming, and much more.

MEMS accelerometers are also commonly integrated as vibration detectors in today's electronic home appliances, such as washing machines or dryers, to alert users to unbalanced loads and to protect against the excessive wear of parts, before a failure occurs.

One- and two-axis accelerometers are widely used in the automotive market for passive safety systems, like frontal and lateral air-bags. Accelerometers and gyroscopes are also used in navigation systems and active safety systems, like ABS and Vehicle Dynamic Control.

In the last few years MEMS "Consumerization" has begun to emerge. MEMS have started to penetrate the consumer market to address many new applications.

The consumer market is looking for tiny, inexpensive, low-voltage, and low power-consumption devices. Mobile phones, MP3 and MP4 players, and portable PCs are all battery operated and are becoming smaller and thinner. Moreover, in the consumer market, multi-

axis solutions are mandatory since consumers want to activate any function from any initial physical position. In a handheld application, there is no constant frame of reference.

Besides, the product life cycle of consumer devices is getting shorter so product designers need MEMS to be integrated into the end application quickly and seamlessly.

At the forefront of the MEMS technology development, ST has started integrating multiple sensors – accelerometers, gyroscopes, and magnetometers - into one package, leading to leaps in functionality and performance in a wide variety of applications besides motion monitoring. Integrated sensors enable autonomous and automated systems, monitoring specific conditions and turning them into actions with no or minimal user intervention.

The development of a sensor which accurately measures angular rates along three orthogonal axes has enabled 360° angular-rate detection for high-precision 3D gesture and motion recognition in mobile phones, game controllers, personal navigation systems, and other portable devices. Besides, the combination of a 3-axis accelerometer with a gyroscope has enabled the creation of Inertial Measurement Units, devices that track and deliver complete information on the type, rate, and direction of motion of humans, vehicles, and other objects.

New accelerometers also embed a host of enhanced features, including click and double-click recognition, motion-detection/wake-up, and 4D/6D orientation detection. Other important features include a programmable FIFO (first-in, first-out) and two programmable interrupt signals that enable immediate notification of motion detection, click/double-click events, and other conditions also introduced in new MEMS devices.

A revolution in handsets has been triggered by the integration of compass modules for advanced location-based services. With compassing and GPS capabilities, consumers are able to identify and retrieve information on nearby points of interest, such as restaurants or shops, by simply pointing their mobile devices in the direction of the object concerned.

The combination of accelerometers and magnetic sensing can enhance the mobile-user experience in a number of ways. Application developers can improve the use of the limited display size of a phone or PDA for maps by putting the current user position at the bottom of the map with the rest of the display in the forward ('up ahead') direction. The user can get accurate heading information, to indicate the direction in they or their vehicle is moving, when the GPS signal is not available. Dead-reckoning applications, including pedestrian navigation in places with little or no GPS signals, such as inside buildings and structures or in mountainous and forested terrain, are also possible.

ST has integrated a 3-axis digital accelerometer with a 3-axis digital magnetic sensor in a single module – the LSM303DLH. The digital compass module combines high accuracy with a small form factor and low power consumption, meeting the growing market demand for advanced navigation capabilities and emerging smart location-based services. ST's high-performance system-in-package digital compass uses magneto-resistive technology from Honeywell and aims to accelerate the adoption of enhanced electronic compassing in portable consumer applications, including direction finding, map/display orientation, location-based services and pedestrian dead reckoning. The device has a linear acceleration full-scale of ±2/±4/±8g and a magnetic field full-scale from ±1.3 up to ±8 gauss, both fully selectable by the user.

Many technical and business experts believe that wireless sensor networks, domestic robots, smart pills, and Labs-on-Chips represent the next big commercial wave for appropriate MEMS products. Silicon Labs-On-Chips for personalized drug development and research purposes, and Tire Pressure Monitoring Systems, simple 5-node wireless pressure sensor networks, are just the first market examples.

MEMS experts are now focusing their efforts on the development of ‘smart sensors’. These are MEMS devices with integrated processing capability, able to run the sensing-related algorithms independently of the main processor unit, decreasing power consumption at the system level, which is especially crucial in battery-hungry portable devices.

For more information: www.st.com/mems