Road Sense - the growth of intelligent sensing in automotive electronics

Article, 27 February 2006

In automotive applications there has been a huge growth in electronic systems of all kinds. Much of this growth has been piecemeal and driven by the needs of the particular system whether it be engine control, transmission, safety or information, for example.

Price and performance are key factors in the adoption of any new feature within vehicles. In recent years, the development of smart sensing based on novel manufacturing technologies has lowered prices while bringing new levels of intelligence and control to a wide range of applications.

Following the introduction of airbag systems in vehicles from the early 90s, original equipment manufacturers, OEMs, have been particularly interested in the introduction of stability control and related active safety systems. Electronic stability control systems are no longer the preserve of luxury cars, but are becoming more established within the general car market.

Two important factors are supporting the continued growth of sensing technology in these electronic safety applications. One is the size and cost of the sensors and the second is the integration of sensors into complete modules which makes them easier to incorporate into systems.

Underlying technology

Supporting this technological breakthrough is the dramatic improvement in sensing designs made using silicon micro machining techniques at a cost competitive price. VTI Technologies sees these developments from the perspective of a company with more than 20 years' experience in designing and making silicon sensors and is currently the market leader in low g sensors for automotive applications. More than 35 million of the company's sensors are already on the road and it is the clear market leader as a supplier of high performance low g sensors with more than 50% of the total market. The company invests 16 per cent of its sales revenue in research and development in order to stay as a technology forerunner in this and other expanding fields such as tyre pressure monitoring. The automotive industry has been an excellent proving ground for the company's own sensor

manufacturing technology, 3D MEMS, because of the stringent performance and quality criteria expected in this industry.

VTI's 3D MEMS technology is used in sensing devices that measure basic parameters - pressure, acceleration, inclination - that can also be translated into other parameters such as position, six degrees of movement and vibration. Between them, they open up an enormous range of sensing possibilities needed for current and future automotive applications such as electronic stability control, electrically controlled suspension, electronic parking brakes, hill start assistant, tire pressure monitoring, roll stability control and roll over systems. All of these applications require the ability to sense direction and orientation as well as movement.

VTI's 3D MEMS fabrication method is a powerful approach to sensor manufacturing. 3D MEMS allows thicker true three-dimensional structures rather than making thin structures only on the surface of a silicon substrate.

All VTI's sensors rely on a change in capacitance for their operation. In VTI's sensing technology, the capacitor elements are made from single crystal silicon, glass and air isolation and metal electrodes. The acceleration sensing elements use a double capacitor. In this design, a slice of silicon, which provides a moving mass, moves in a gap between two outer plates or surfaces. The measurement principle follows the basic relationship that force is mass multiplied by acceleration. When the proof mass experiences a force, it is displaced and moves closer to one of the outer electrodes so changing the capacitance of both capacitors. By using a simple mathematical relationship, it is possible to obtain a linear measure of the force acting on the mass from which the acceleration can be calculated. The relatively wide change in capacitance makes measurement relatively easy and also results in low noise. The sensing elements are small, highly accurate and stable over a wide temperature range and allow also low power consumption whenever this feature is needed for the application.

System integration

In automotive applications, the trend is to combine the sensors with the electronics control units into complete modules that are easy to incorporate into larger control systems. In VTI's approach, the sensing elements are manufactured separately from the processing electronics and the sensors are so called two chip solutions. This allows components to be optimally designed for each application by developing the sensing element for the transition from the physical phenomena to change of

capacitance. ASIC (application specific integrated circuits) are used to amplify and calibrate the capacitance signal into standard signals that can be interpreted by other equipment. It can also provide temperature compensation, setting calibration parameters, signal processing, and communication protocols for connec-tion to external equipment. Both the sensing elements and the ASIC are integrated into a standard size housing which makes migrating to new generations of sensor families relatively easy.

It also gives a high degree of flexibility in the range of products that the company can offer from individual sensing elements to complete modules with on-board electronics. The company can quickly respond to market or technology changes.

Multi-axis sensing for vehicles

In vehicle stability control systems, sensors are needed to provide information about acceleration and braking. VTI has families of multi-axis sensors, e.g. the SCA series 1000, which can be incorporated into automotive electronics systems. In these products, sensing elements provide the multi-axis measurements while a custom ASIC provides analogue or digital outputs and carried out all the temperature compensations, offset control and self-diagnostics.

The SCA1000 series, for example, is designed for accurate two-axis acceleration measurements; these products show excellent reliability and performance in harsh automotive applications and industrial environment including a high resistance to vibration and mechanical shocks. The sensors are insensitive to vibrations due to the over damped sensing elements. These accurate sensors have outstanding overload and shock durability withstanding mechanical shocks of more than 20,000g.

Today, two-axis measurement is used in Electronic Stability Control (ESC) systems with integrated Hill Start Aid (HSA) or Electronic Parking Brake (EPB) function. This is because information is needed in the longitudinal direction to measure the inclination of the car while the second sensor measures in the lateral direction. ESC or any other vehicle stability and dynamic control system corrects for under and oversteering. Yaw rate from an angular rate sensor and a lateral accelerometer are compared to those calculated from wheel speed and steering wheel angle. A typical measuring range is +/-1,5 to 2,0g and the offset stability would be smaller than 100mg over temperature and life time.

The EPB and HSA replace the conventional mechanical lever and wire rope used in today's vehicles and will provide better assistance to the driver.

It also frees up the space between the front seats for other use in most car models. The braking power is adjusted to match the need set by longitudinal inclination. It locks and releases either automatically or with push bottom when parking or starting. It also provides a low-speed-traction control and prevents the vehicle from backsliding on inclines, especially in conjunction with an automatic gearbox. The signal can be connected to the distance sensor systems for safe parallel parking even in very tight spots. The sensors for EPB and HSA require an extremely good offset stability (better than 50mg) in all conditions.

Roll Stability Control and Roll Over control are other applications where dual axis measurements come into play.

Active Suspension systems

Active suspension systems aim to provide the highest safety and comfort level for the driver in different driving and road conditions. In essence, sensors in active suspension measure pitch, roll and vertical movement of the car body. This information is used to control the car damping. In a simple system, the control is based on an average movement of the car body while, in more advanced systems, the movement of the wheels is also measured and the each damper is controlled almost in real time.

For these systems, the most common solution employs three body accelerometer modules and two wheel acceleration modules to measure the car body movement. The control unit processes this information and controls the damper actuators. VTI is the leading supplier of accelerometer modules for ECS (Electronically Controlled Suspension) applications based on this principle. Integrating sensors and processing electronics with dampers reduces costs by cutting the need for cabling and separate sensor modules. The introduction of 2 or 3-axis accelerometers also gives additional freedom in the mounting position because the acceleration vectors can be calculated based on sensor coordinates.

Other sensing applications

These are just a few of the applications that are coming into fruition thanks to the added dimension that multi-axis sensors offer when incorporated into automotive electronics.

More information

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