Sensational systems

Sensors are the fundamental enablers of a fast-growing range of vehicle refinements. Jeff Daniels looks at leading edge technologies and applications, and how the incoming tide of information is being handled

Today’s subtle and precise control needed in almost every aspect of automotive engineering demands that measurement and transmission of information be electronic. This has led to the development of sensors that, as often as possible, employ solid state devices and exploit such phenomena as the Hall effect and surface acoustic wave (SAW) technology.

Reducing moving parts to the absolute minimum and eliminating sliding contact joints is a key element in ensuring long term stability and durability even in those sensors that detect physical movement, such as acceleration and yaw rate. Here optical sensing has the attraction of zero inertia and hence optimum response, as seen in Bosch’s latest torque sensor for electric power steering systems.

The last few years have also seen a burgeoning of interest in remote sensing which began with radar-based sensors for automatic cruise control and now extends to ultrasonic parking obstruction warnings, keyless vehicle entry and, ultimately, the creation of an extended ‘safety cocoon’ around the vehicle. One downside to this growth in sensor technology is the sheer volume of information produced and it is leading to the development of ‘intelligent sensors’ which in many cases avoid the need to transmit data to a high capacity central computer which then (among all its other tasks) calculates and returns the necessary control signal. Distributed intelligence, tying together the sensor, the transducer and a relatively low level set of instructions on a local integrated circuit (IC), has a great appeal to engineers faced with a rapid increase in data processing and transmission demand.

Much current work on sensors is devoted to safety and safety related applications. In ESP-type chassis systems, for example, the purpose is simply to determine the car’s trajectory which can then be compared with the driver’s steering input demand. However, applying sensor outputs to decide whether the car is about to overturn is more complicated.

Bosch uses both horizontal and vertical acceleration sensing, plus yaw determination, and a carefully developed algorithm, to determine not only that a rollover is imminent, but what kind of rollover it will be, leading to the timing of airbags and belt pretensioners in anticipation of the actual event.

Although pre-emptive sensing is a major area of concern, Bosch feels that there is still scope for improvements in conventional contact crash sensing and now offers a system with two accelerometers, one mounted on either side of the nose, plus two each side of the car. Processing of their signals by a central safety computer provides a reliable indication of impact type and severity as little as 15ms after contact, compared with 50ms with current systems. Analysis of signals from the twin side sensors triggers the side airbags.

In an altogether different area, there is growing interest in engine oil condition sensing, working on the basis of now proven links between the physical parameters of oil (such as its electrical conductivity) and its effectiveness as a lubricant. Early in 1999, Delphi made a first presentation of its Intellieck sensor, developed at its Mexico Technical Centre. Applications of this sensor are expected to allow oil change intervals to be extended by 50-70 per cent and ultimately, perhaps, to ‘lubricate for life’ engines. Meanwhile, Hella announced at the 2001 Frankfurt show that it has developed its established thermal oil level sensor technology for true oil condition sensing.

Combined light level and rain sensing devices, linked to the automatic operation of headlamps and windscreens wipers, have in no more than three years spread from their first (Japanese) applications, to widespread use in European cars as modest as the Renault Clio. Here, Valeo has established itself as one of the major innovators with its RLT (Rain, Light, Tunnel) system that now offers a system with two accelerometers, one mounted on either side of the nose, plus two each side of the car. Processing of their signals by a central safety computer provides a reliable indication of impact type and severity as little as 15ms after contact, compared with 50ms with current systems. Analysis of signals from the twin side sensors triggers the side airbags.

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Radar and video

It is fair to say that development of radar and remote sensing including video image processing is a priority with all the Tier One systems suppliers. As already mentioned, initial applications are in the first generation cruise control (ICC), in reverse parking obstruction warning and keyless entry—all of which are now in volume production. The aim now is to extend from this base into systems that will allow automatic lane-keeping; ‘second generation’ ICC; with stop-start capability and the creation of a ‘safety cocoon’ around the car, based on the analysis of information from several linked sensors.

Certainly Bosch, Delphi, Denso, Valeo and Visteon have all announced such ambitions, working either in-house or with specialist Tier Two sensor suppliers. Valeo, for example, points to its German-based in-house radar development facility, whose demonstration units can now offer 360deg coverage (and thus cocoon ability) plus hybrid park-assist systems combining radar and ultrasonic technology Valeo says that one of its priorities, especially for the European market, is the development of systems to eliminate blind spots and that are able to detect “difficult” targets such as motor cyckes.

Bosch, Delphi and Visteon all have safety cocoon programmes; Delphi making its first announcement of principle in 1999. Bosch is working on the principle of a three-phase detection system that would allow ‘preset’, ‘prefire’ and ‘predict’ operation of safety systems, according to the severity and imminence of the detected threat. In such systems, of course, the sensor technology is only part of the whole: the most sophisticated engineering comes in the analysis of data and the automatic taking of decisions.

Meanwhile, the miniature television camera is becoming a sensor in its own right, feeding images into systems that analyse visual cues and that can increasingly (for example) allow automated lane-keeping even in the absence of the distinct and specially applied lane markings needed by pioneering demonstration vehicles. CMOS camera technology is usually more suitable than traditional CCD cameras for both interior and exterior applications. Meltca, a leader in this field, says the inherent ultrahigh (up to 1000 frames/s) speed of CMOS-based camera systems is due to the CMOS process itself which also supports
In Hella’s ambient light sensor system one sensor measures general light intensity at as great an angle as possible (as illustrated) and a second sensor measures intensity at a narrow angle directly in front of the vehicle. From this data, a special algorithm calculates the lighting conditions, e.g., day, night, twilight, or tunnel.

integrated image processing on the same piece of silicon. They also have excellent anti-bloom (anti-sun/headlight blinding) capability. It remains to be seen whether image processing can provide the necessary response time to compete with radar sensors for safety cocoon applications. Interest also continues in night vision enhancement systems based on infra-red technology. This is an area in which the sensors themselves are highly developed, the real challenge coming in the means adopted to present the information to the driver.

An altogether different technology is that of surface acoustic wave (SAW) devices which are finding a number of automotive applications. Specialist EPCOS already supplies passive radio frequency components in large numbers for use in remote operated and “keyless” vehicle security systems, and now increasingly for tyre pressure monitoring systems—a growth area backed by coming legal requirements. UK-based Transense has studied the application of SAW technology for load and torque sensing requirements, with very small devices that in effect fulfil the same purpose as strain gauges. Possible applications include “intelligent” transmissions with active control of torque distribution.

Distributing information

While some control operations can be handled locally, using a suitably integrated sensor, actuator and IC, there is often a need for information to be shared. For example, electric window operation (including anti-pinch control, operating load checking and other safeguards) can be independent but may help the air condition system to know that a window is open. In fact, Alcatel—one of the specialised (but very large) Tier Two suppliers in this area, points to a large “family” of operations, mostly relating to passenger comfort, with shared interests and requirements. In general these operations are not time-critical (unlike safety or engine management functions, for instance). This has led to the definition of a new communications protocol, the LIN (Local Interconnected Network) to link such devices. It has been estimated by PSA that from 2005 onwards, up to 10 LIN nodes may be installed in production cars. Last year, Alcatel announced an extremely low-cost, single-chip LIN transceiver built around an MTC-30000 chip, notably providing unlimited short-circuit protection following an overload.

At the same time, Alcatel has been active in developing new chip technologies that offer increased performance—not least through the use of higher density component packing—plus compatibility with 12V electrical systems. The company’s new 1.3T technology, based on 0.35 micron density compared with the 0.7 micron standard of its 1.2T predecessor—will appear in devices in the second half of this year. Alcatel also points out that the decision to adopt distributed rather than central intelligence is not always easy or clear cut. The cost, and the improved reaction time, of a “local” chip has always to be balanced against the cost and weight of additional cabling to serve a centralised system. Needless to say, Alcatel sees its 1.3T technology as helping to tilt decisions towards intelligence distribution, but it admits that such decisions depend on many factors including physical position. It would make little sense, for example, to apply the principle to under-bonnet units rather than leaving their control to the engine management unit (EMU).

Melexis, another player in the LIN market, already has qualified automotive LIN transceiver parts available, including an on-board voltage regulator for the slave function. Melexis also claims it will be the first with a fully integrated LIN µC with on-chip transceiver using its 16-bit MLX16 core which is for a door system application.

Whatever the factors involved, some sensor information is more suited to local processing. The raw signal from a forward-looking radar sensor, to take one instance, would be of little use to a central safety systems computer. The computer needs the signal processed at least into target position and relative speed before it can begin to make rational decisions, which means that any radar sensors consist not only of a power supply, signal generator and transceiver but must also include a relatively complex ASIC (application specific integrated circuit) to carry out minimum processing in the shortest possible time. In other cases, as already pointed out, it makes little sense to involve a central computer at all, especially when the sensor and the transducer are (or can be) adjacent. In such cases, as so often seen in door-mounted systems, an ASIC can take full responsibility for operation—though obviously with an input from the driver and with the facility to link to other systems as needed.