ESC Background Paper

Milestone of active safety systems

ESC Electronic Stability Control

Today's electronic safety systems open up new dimensions in driving safety. After many years of successful development, passive safety systems such as seat belts and airbags have achieved high standards in today's cars. Crash avoidance technologies are now increasingly taking center stage. Electronic Stability Control (ESC) is a key technology in this respect, and was recently described by the U.S National Highway Traffic Safety Authority (NHTSA) as the safety technology with the greatest life-saving potential since the introduction of seat belts.

The Evolution of Active Safety Systems

The Electronic Stability Control (ESC) is an active safety system for vehicles, and was launched into the market in 1995. ESC is designed to help drivers maintain control of their vehicles in critical situations.

All active safety systems are based on the pioneering ABS technology, which was launched in 1978. In critical driving conditions, the wheels of a vehicle may lock during braking, reducing the adhesion between tires and the road surface. This may mean that the vehicle becomes uncontrollable, since the vehicle no longer reacts to the steering input of the driver. In a vehicle equipped with ABS, wheel-speed sensors detect the speed of rotation of the wheels and relay this information to the ABS control unit. This calculates the degree of slip between the wheels and the road surface and detects whether any of the wheels are about to lock. If this is the case, the ABS intervenes to stabilize or decrease brake pressure. In doing so, it prevents the wheels from locking and the vehicle remains steerable, allowing the driver to avoid obstacles.

Critical driving situations can occur not only while braking, but also whenever there is a need to transfer strong longitudinal forces to the contact area between the tire and the ground: when starting off and accelerating, particularly on slippery roads, on hills, and when cornering. Based on ABS technology, the Traction Control System (TCS) was launched in 1986. By adding an engine management interface to the ABS, TCS prevents the wheels from spinning by reducing the drive torque at each driven wheel. TCS therefore provides a logical extension of ABS but in acceleration mode.

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The Electronic Stability Control ESC integrates ABS and TCS, but has the added feature of a “yaw torque control” – a functionality that prevents skidding. It is designed to help drivers maintain control of their vehicles in sudden manoeuvres such as rapid steering and counter steering, sudden lane changes, and obstacle-avoidance manoeuvres.

ESC is always active. 25 times a second, it compares whether the driver’s steering input corresponds to the actual direction in which the vehicle is moving. If the vehicle moves in a different direction – either understeering or oversteering – ESC detects the critical situation and reacts immediately. To do this, it uses the vehicle’s braking system as a tool for “steering” the vehicle back on track. Specific braking intervention is directed at individual wheels, such as the inner rear wheel to counter understeer, or the outer front wheel during oversteer. These selective braking interventions generate the desired counteracting force, so that the car reacts as the driver intends. For optimum implementation of stability objectives, ESC not only initiates braking intervention, but can also intervene on the engine side to accelerate the driven wheels. ESC substantially reduces the complexity of the steering process and lessens the demands placed on the driver. ABS, TCS, and ESC were all introduced to the market by Bosch.

ESC increases road safety

Loss of vehicle control, or skidding, has been demonstrated to be the dominant risk factor in the pre-crash phase. An international comparison of the occurrence of skidding in the pre-crash phase proved beyond any doubt that at least 20 percent of all accidents resulting in injury are related to skidding of the vehicle in the pre-crash phase, and in the case of fatal accidents this figure rises to 40 percent. As these statistics are by nature global, they should be regarded as being at the lower limit. For example, an analysis of the German in-depth accident study (GIDAS) data showed that the proportion of skidding in accidents resulting in severe injuries is as high as 48 percent.

The wider proliferation of ESC across the vehicle fleet has allowed evaluation of its effects in actual crash situations in many countries. Studies to assess the effectiveness of ESC now have been conducted in Japan, Germany, Sweden, France, the United Kingdom, the United States and Australia. All these studies confirm the benefits of ESC on different road surfaces, using different analytic methods, and different makes and models of vehicles, including both cars and SUVs. Findings of the earliest studies now have been replicated as additional data have become available, and more refined analyses have enabled a more detailed understanding of the effects of ESC under a range of conditions. There is little doubt that ESC is highly effective in reducing single vehicle accidents in cars and SUVs. Studies have estimated that it reduces fatal single vehicle crashes by between 30 to 50 percent among cars and 50 to 70 percent among SUVs.

Market development of ESC in Europe

Manufacturers first began equipping vehicles with ESC in the mid 1990s in Europe, and the technology appeared in other markets several years later. As with many technologies, ESC first appeared as an option in more expensive, luxury vehicles, but within a few years was being offered as standard equipment in these cars.

The number of cars equipped with ESC has increased steadily. In 2003, 29 percent of newly registered cars in Europe had ESC on board. In 2004, this number climbed to 37 percent, reaching 40 percent in 2005, and 43 percent in 2006. For 2007, the installation rate in Europe stands at 50 percent.

	2003	2004	2005	2006	2007
Europe	29%	37%	40%	43%	**50%**
Sweden[2]	15%	69%	85%	91%	96%
Germany[1]	55%	67%	72%	77%	79%
Luxemburg[1]	N.a.	44%	50%	52%	56%
Spain[1]	25%	32%	41%	50%	57%
Belgium[1]	N.a.	33%	41%	42%	47%
UK[1]	20%	29%	36%	43%	48%
France[1]	35%	39%	42%	43%	46%
Netherlands[1]	N.a.	29%	37%	37%	43%
Italy[1]	14%	24%	31%	35%	42%

(Source: Bosch)

Up to now, only a small share of buyers chooses ESC as optional equipment when purchasing a car. The reason why the share of vehicles equipped with ESC still continues to rise is the increasing number of compact-class models sold outside Germany that feature the system as standard equipment. In the high-volume small car segment, by contrast, this active safety system hardly features as standard equipment anywhere in Europe, and in some models is not even available as an option.

From 2009, ESC fitment will be incorporated into Euro NCAP's "Overall Star Rating" in an effort to increase the levels of standard fitment.

ESC Policy Developments

On 26th of June 2008, the UN World Forum for Harmonization of Vehicle Regulations (UNECE WP29) has adopted a Global Technical Regulation (GTR) on ESC for light duty vehicles and passenger cars. This regulation is a critical step for the international legislative efforts on ESC and the European Commission intends to use the GTR as the technical foundation for future legislation on ESC.

The Commission has presented in May 2008 a draft proposal for a regulation concerning new safety requirements for vehicles. This draft document comes to

support the take-up of safety technologies and makes ESC mandatory on all new car series starting from 29th of October 2012, with all new vehicles being equipped by 2014. In other efforts to make roads safer, the European Parliament has adopted an own-initiative report that calls on car manufacturers to make safety technologies, including ESC, cheaper and available to all.

The Australian state of Victoria will make ESC mandatory for all new cars by 2011. The decision is a cornerstone of the Victorian Government's "arrive alive 2008-2017" road safety strategy which was unveiled on February 6, 2008. In Canada all light vehicles sold after September 2011 will be required to be equipped with ESC as standard. Furthermore, there are currently negotiations being conducted with the Canadian car manufacturers to increase the fitment of ESC on Canadian vehicle models before 2011.

In the US, ESC will also become mandatory from 2012 for all new vehicles, such as passenger cars, multipurpose passenger vehicles, trucks and buses with a gross vehicle weight ratio of 4,536 kg or less.

ESC nomenclature

The Electronic Stability Control has been marketed by carmakers under many different names, such as ESP (Electronic Stability Program), DSC (Dynamic Stability Control), VDC (Vehicle Dynamic Control), VSC (Vehicle Stability Control), or Vehicle Stability Assist (VSA). The functionality and operation of the ESC, as well as the gain it provides in driving safety, is the same.

ESC comprises the following components:

Hydraulic modulator unit with attached ECU

The hydraulic modulator has input and output solenoid valves for controlling the pressure in the individual wheel brakes. The integrated ECU assumes all electrical and electronic tasks as well as the control functions of the system. The unit is located in the engine compartment between the brake master cylinder and the wheel brake cylinders, so that the hydraulic lines to the brake master cylinder and the wheel brake cylinders can be kept short.

Wheel-speed sensor

The ECU processes the signals from the wheel-speed sensors to compute the speeds of the wheels. Two different operating principles are used: passive (inductive) and active (Hall) speed sensors. Active sensors are becoming more and more widespread. They use a magnetic field for the contactless detection of wheel speed and are capable of recognizing the direction of rotation as well as standstill.

Yaw-rate and lateral acceleration sensor

A yaw-rate sensor records all yawing movements of the vehicle around its vertical axis. Together with the information from an integrated lateral acceleration sensor, the status of the vehicle ("actual state") can be determined and compared with the driver's wishes.

Steering-angle sensor
The task of the steering-angle sensor is to measure the position of the steering wheel by determining the steering angle. This figure, together with the vehicle speed and desired braking pressure or position of the accelerator, is used to calculate the driving manoeuvre that the driver wishes to perform (“desired state”).

Communication with engine management
A data bus enables the ESC control unit to communicate with the engine control unit. In this way, the engine torque can be reduced if the driver accelerates too hard in a particular driving situation. Similarly, it can compensate for excessive slip of the driven wheels provoked by the engine drag torque.

26th of June 2008