THE EXPERT
STEWART SANDERSON

Having worked as a tuner for 17 years, Stewart 'Stu' Sanderson is one of the most-respected names in the business.

A Level 5-trained fuel-injection technician, Stu has worked for a Ford Rallye Sport dealer, a well-known fuel-injection specialist and various tuning companies.

Eight years ago he joined forces with Kenny Walker and opened up Motorsport Developments near Blackpool (01253 508400, www.remapping.co.uk), specialising in engine management live remapping, as well as developing a range of Evolution chips which are now sold all over the world.

He is the creator and administrator of www.passionford.com, which he started in 2003. It has grown rapidly from a few friends contributing, to one of the biggest Ford communities on the web.

Stu's enviable knowledge of the workings of modern-day Ford performance engines means that every month he's just the man to explain how and why things work, and importantly how they can be improved.

Words: Stewart Sanderson

STU GIVES YOU THE LOWDOWN ON ALL YOUR CAR'S FEATURES KEEPING YOU SAFE ON THE ROAD.

UNDER CONTROL

In modern cars we often hear technical feature abbreviations such as SRS, ABS and ESP. To a lot of us these letters don't mean much so I thought it would be interesting to have a look at these systems and explain what the letters mean and how the systems work from a technical point of view.

ESP

More and more cars these days have ESP either as standard or as an option, but few people understand what it is and what it does. ESP stands for Electronic Stability Programme and was the end result of BMW working with Bosch for five years to develop 'a lateral slippage control system'.

The ESP system is integrated with the ABS system on your vehicle and not only has the ability to redistribute your braking effort when braking, but also to apply braking effort to the wheels when you are not!

ESP systems work with the ABS system to help prevent the car sliding out of control

The system uses a number of sensors and its own control unit to monitor what the vehicle and driver are doing. It performs this monitoring a staggering 25 times per second. The ESP system simply makes sure the car is going where the driver has asked it. If for example the ESP detects that the driver has turned the steering wheel but the car is still moving in a straight line, then it can calculate that the vehicle is under steering and intervenes. To do this the ESP relies on sensors feeding this information to the control unit. The sensors normally consist of:

Steering wheel angle sensor: mounted on the back of the steering wheel, this allows the control unit to see what steering input the driver has given by turning the steering wheel.

Yaw rate sensor: also known as a 'G Sensor', it is normally mounted in the very centre of the vehicle and measures the rotation rate of the car. This monitors cornering loads created when the vehicle is turning.

Lateral acceleration sensor: also known as an accelerometer, this is used to measure the lateral acceleration of the vehicle.

Wheel speed sensor: as the name suggests, is used to measure the wheel speed. There are normally four wheel speed sensors so the control unit can monitor what each wheel is doing.

ESP IN ACTION

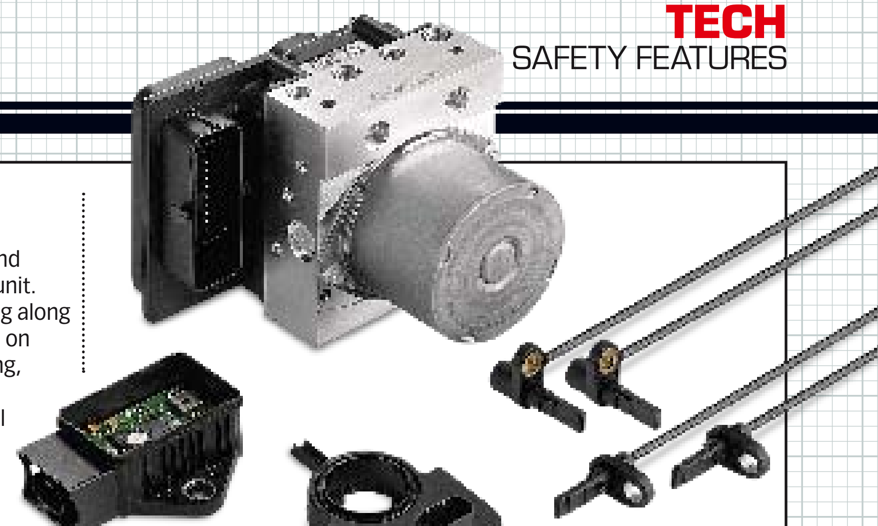
So, let's look at how this information is processed and acted upon by the control unit. For example, you are driving along at a constant steady speed on a country road. While driving, all the sensors are feeding information into the control unit 25 times per second. As you turn round a bend in the road, a large animal steps into the road in front of you. You sharply turn the steering wheel to the right to swerve around the animal and as you turn the steering wheel, the signal is fed into the control unit from the steering angle sensor.

The control unit then looks for a signal from the yaw sensor to confirm that the vehicle is actually turning to the right. If the signal from the yaw sensor then suggests that the vehicle is not turning, the ESP control module will act by applying the driver's side rear brake for a split second. This will apply a braking force to the right rear wheel while still allowing both front and the left rear wheel to move freely. By doing this, a pivoting effect is created, pulling the car into the right turn and breaking out of the under steer.

As you enter the turn to pass the animal, you will then turn to the left to return to the correct side of the road. Again, the ESP will be monitoring to ensure that this action is performed correctly as you are in fact performing a Scandinavian flick, which is used by rally drivers to deliberately unsettle the car when entering a corner. By monitoring wheel speeds, steering angle and yaw, the ESP control module can activate independent braking effort in individual corners of the car to correct driver input.

If you had been driving a car that was not fitted with ESP, the outcome of the animal encounter could have been very different. There would have been the chance of under steering directly into the animal, or had the vehicle responded to the sharp change in direction, the back end of the vehicle may well have 'gone light' and taken you into a spin when attempting to turn back to the correct side of the road.

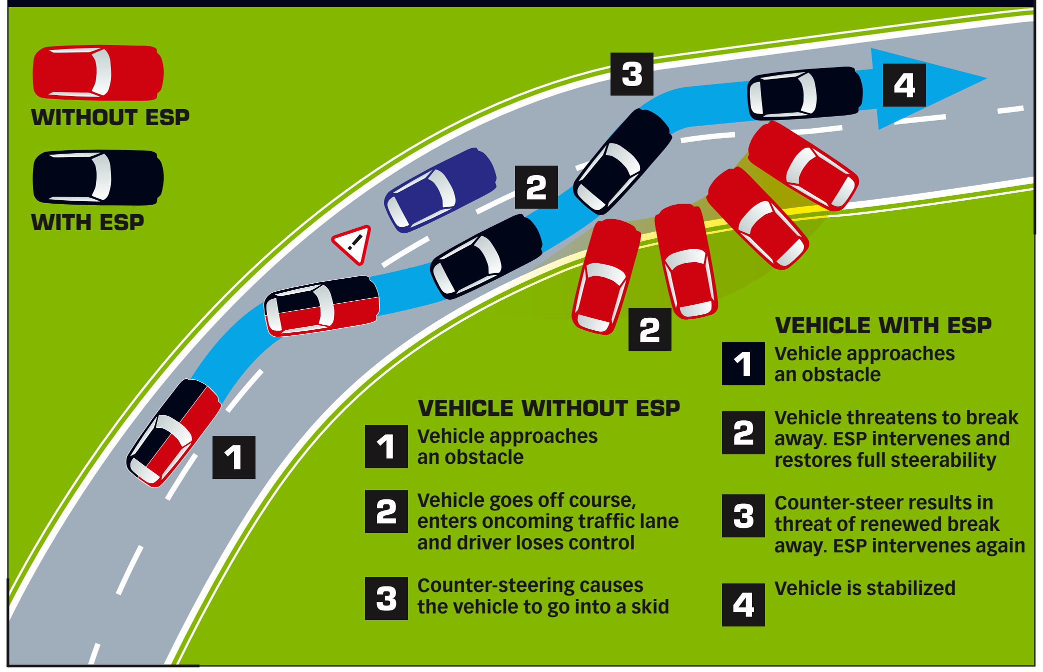
ESP is not contained to scenarios like the one we have just looked at. ESP intervention can help drivers recover control of a vehicle sliding in wet or icy conditions and on some vehicles, the ESP can be integrated to work with active suspension and electronically controlled 4wd systems to allow even greater control recovery.



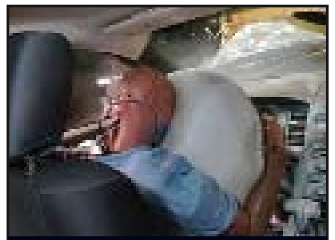
Wheel speed sensors are similar to those used in conventional ABS systems

ESP uses input from wheels and steering wheel angle sensors

CRITICAL MANOEUVRE WITH/WITHOUT ESP



Airbags are life saving devices which now come as standard fitment on nearly all new cars



Airbags are deployed in just 0.04seconds

SRS

SRS stands for Supplementary Restraint System, the title comes from the fact that the system is a supplement to another system, and in this case it's the passenger restraint system, or seatbelts!

The SRS system has evolved over the last 20 years to now cover many aspects of the interior of the vehicle. It operates in both a passive and an active way, passive in so much as the airbags require no activation from the user, active in that you need to physically put your seatbelt on and engage the buckle for some of the systems to work. The most well-known areas include driver/passenger airbags and seatbelt pre-tensioners, so let's look at each of these systems in more depth.

HOW AIRBAGS WORK

Airbags rely on sensors providing information to an Airbag Control Unit that monitors a number of sensors specifically fitted to the vehicle. These include accelerometers and wheel speed sensors (independent of the ESP ones mentioned previously), impact and pressure sensors and seat occupancy sensors.

The seat occupancy sensor allows the control unit to establish where people are sitting in the vehicle to avoid activating airbags unnecessarily. These sensors provide a constant stream of data to the control unit, which is then checked against manufacturer-defined limits. If any of these limits are exceeded, then the control unit will trigger relevant airbags for activation.

While that might sound like quite a simple process, we aren't really doing the control unit justice. The airbag control unit is actually capable of analysing the data to the point where it can establish from what angle the impact has occurred and how severe the impact was. The decision to activate the airbags is normally made by the control unit between 15 and 30milliseconds (1ms = 1 thousandth of a second) after the moment of impact!

Typically, to trigger the activation of the airbags, there needs to be an impact speed into a solid object at a speed higher than 12-14mph.

WHAT HAPPENS NEXT

Once the Airbag Control Unit has decided which airbags require activation, a pulse is sent to the initiator, or the electric match as it is sometimes known. The initiator is a conductor wrapped in a combustible material that takes less than 2milliseconds to activate. In turn this then lights the solid propellant, which burns to create an inert gas. The solid propellant burns so quickly that it will inflate the airbag in around 25milliseconds!

The airbag is normally made from a nylon fabric with a number of small vent holes in, these holes allow the bag to inflate at maximum speed due to being no vacuum in the bag but also, as the airbag rapidly inflates, it is immediately starting the deflation process to still provide a cushion for the driver or passengers, but not a rigid one or one that would hinder their exit or others' access to the vehicle.

What makes this even more impressive is that the start to finish time for all of this to happen is around 0.04seconds. To put this into some sort of perspective, it takes the average human 0.3seconds to blink!

Many cars now feature airbags in seats, A and B-pillars and along the roof line

ABS

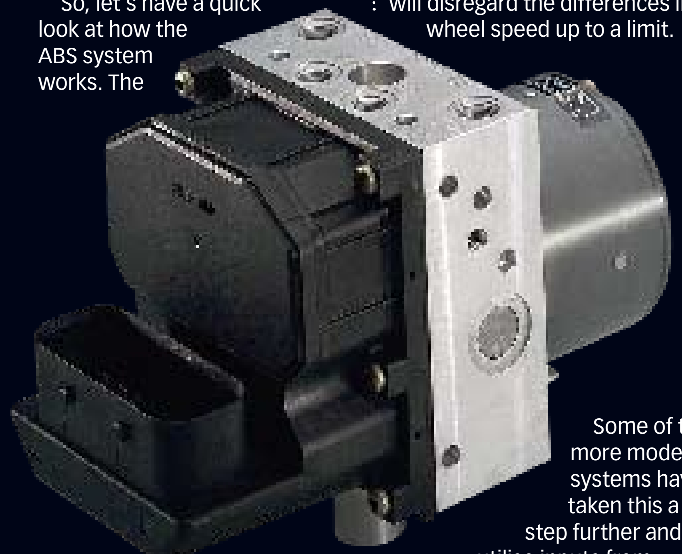
This is probably the most commonly known safety system, standing for Anti-Lock Braking System. The first variation of the four-channel ABS that we know today was seen in the very late '70s on a Mercedes S Class after the involvement once more of Bosch.

Some of us might have experienced ABS first hand as a strange pulsing sensation through the brake pedal if we have braked hard on wet roads. It's quite an unnerving feeling if you're not prepared for it or even aware of its existence. We see many customers who explain their brakes felt very odd during a harsh braking manoeuvre.

So, let's have a quick look at how the ABS system works. The system utilises yet another complex control unit, four individual wheel speed sensors and a minimum of two hydraulic valves within the braking system. In the same way as the other systems we've looked at, the sensors are providing the control unit with information all the time. If the control unit sees that one wheel is rotating slower, suggesting it is close to locking the wheel, it will instruct the hydraulic valves to reduce the pressure to the affected wheel/s.

This reduction in pressure will prevent the wheel from locking and allow it to rotate at the same speed as the other wheels. Once the control unit detects the wheel speed has returned to normal then the hydraulic valves will be instructed to increase the pressure and reapply the brake. This sequence of events is repeated continuously until the driver takes their foot off the brake pedal.

If the control unit is looking for variation in wheel speed, what happens when you go round a corner and the inside wheels travel slower than the outside ones? The control unit is programmed with threshold limit values in much the same way as the airbag unit, as such when cornering the control unit will disregard the differences in wheel speed up to a limit.



Some of the more modern systems have taken this a step further and utilise inputs from vehicle suspension sensors so they can also take account of cornering force or uneven road surfaces by looking at the position of the road springs or anti roll bars in relation to the chassis. Most vehicles with automatic headlamp dipping have these sensors a standard so the ABS system is just utilising existing data.

Remember at the beginning we talked about how some of you may have experienced ABS intervention and felt a pulsing in the brake pedal? That is because most ABS systems can reduce and reapply the braking force an amazing 20 times per second!

"SOME OF US MIGHT HAVE EXPERIENCED ABS FIRST HAND AS A STRANGE PULSING SENSATION THROUGH THE BRAKE PEDAL."

ABS systems are not new technology, but are still a crucial driver aids

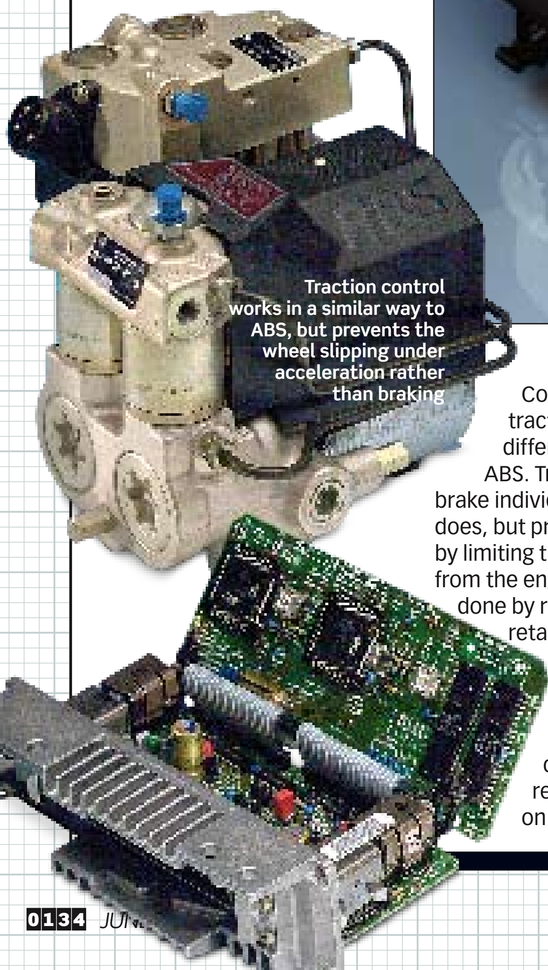
SEATBELT PRE-TENSIONERS

We talked about how the airbags used a control unit, well the seat belt pre-tensioners usually share this same control unit. When the control unit decides how severe the impact is and which airbags it is going to activate it will also decide whether the seatbelt pre-tensioners require activation too. If so, it will send a pulse to the initiator in much the same way as it does an airbag. This time though, the initiator fires what is called the gas generator. It is this gas that drives a piston inside the pre-tensioner and pulls any available slack out of the seatbelt. This means that your seatbelt is now behaving more like a racing car harness and no longer has the ability to move thus stopping you moving forward as a result of the impact.

Modern seats feature many safety devices, including airbags and seat belt pre-tensioners

TRACTION CONTROL

This is really a sub division of the ABS system and might have shown itself to you as a spinning wheel symbol on your dashboard if you've ever tried accelerating hard in modern fwd or rwd cars. The system is designed to monitor wheel speeds under acceleration and restore traction to any wheel that breaks traction.



Traction control works in a similar way to ABS, but prevents the wheel slipping under acceleration rather than braking

How the Traction Control restores the traction is where it differs from ESP and ABS. Traction control can brake individual wheels, like ESP does, but primarily intervenes by limiting the torque output from the engine. This can be done by reducing fuel delivery, retarding the ignition (in some cases even cutting it), reducing the boost pressure on turbocharged cars or closing or reducing the throttle on fly-by-wire cars.

Complex systems can actually predict the outcome of a set of criteria and limit power before you even apply it. For example, in a BMW M5 if you turn the wheel to over 90degrees and floor the throttle from a standstill the car gently pulls away, and as you straighten the steering wheel the power gently feeds back in until you have the requested full throttle. In that situation the computer knew that too much steering plus rwd plus 400bhp would equal wheelspin and dangerous tail-end action, so it simply ignores your input until such time as it computes the power could be put down safely. Thank god we can turn that system off!

NEXT MONTH
STU EXPLAINS ALL YOU NEED TO KNOW ABOUT FUEL INJECTORS