ELECTRONIC STABILITY PROGRAMME [ESP]

Vijay Krishnan

S3-ICTM
• ESP is the abbreviation for *Electronic stability programme*.
• It is a computerized technology that may potentially improve the safety of a vehicle by detecting and minimizing skids.
• When ESC detects loss of steering control, it automatically applies the brakes to help "steer" the vehicle where the driver intends to go.
• Braking is automatically applied to wheels individually, such as the outer front wheel to counter oversteer or the inner rear wheel to counter understeer.
• Some ESC systems also reduce engine power until control is regained.

**Introduction**
ESP monitors the vehicle’s traction and handling, using sensors to detect wheel speed, understeer and oversteer.

**Understeer**

Vehicle does not turn as sharply as desired. The vehicle seems to “plow” straight ahead. ESP will brake the inside rear wheel.

**Oversteer**

Vehicle turns in more sharply than desired. The rear of the vehicle swings outward. ESP will brake the outside front wheel.
• **ABS: Anti-lock Braking System:** This system prevents the wheels from locking while braking. Despite the system’s powerful braking effect, track stability and steerability are retained.

• **TCS - Traction Control System:** This system prevents the driven wheels from spinning, e.g. on ice or gravel, by intervening in the brake and engine management systems.

• **EBD - Electronic Brake Pressure Distribution:** This system prevents overbraking of the rear wheels before ABS takes effect or if ABS is unavailable, due to specific fault states.

• **EDL - Electronic Differential Lock:** This system makes it possible to drive away on road surfaces where each wheel has a different degree of traction by braking the wheel which is spinning.
• Mechanical ABS systems were introduced as early as 1929 for aircrafts. Was popularised in 1970s after advent of Electronic ABS
• Mercedes-Benz and BMW introduced TCS in 1987.
• From 1987 to 1992, Mercedes-Benz and Robert Bosch GmbH co-developed a system called Elektronisches Stabilitätsprogramm [Ger]. Implemented this with their W140 S-Class model in 1995.
• BMW, provided by Bosch and ITT Automobile introduced Dynamic Stability Control (DSC).
• GM introduced its version of ESC called "StabiliTrak" in 1997
• Volvo also introduced Dynamic Stability and Traction Control (DSTC) in 1998 in s80.
Advantages

- Improved starting and acceleration capability
- Improved stability when:
  - braking
  - accelerating
  - coasting
  - cornering
- Shortens stopping distances in corners or on slippery surfaces
- Informs driver of slippery conditions
- ABS, ASR, EBR and ESP functions are combined in one control unit
- ABS, ASR, EBR and ESP basic components are combined in one hydraulic unit
• **Electronic stability control (ESC)** is the generic term recognised by the European Automobile Manufacturers Association.

• Other Trade Names are:
  - **Electronic Stability Program (ESP):** Volkswagen, Suzuki, Audi, Bentley, Skoda, Mercedes Benz, Tata, Daimler, Dodge etc.
  - **StabiliTrak:** GM, Buick, Chevrolet, Pontiac etc.
  - **Dynamic Stability Control (DSC):** BMW, Mini
  - **AdvanceTrac with Roll Stability Control (RSC) and Interactive Vehicle Dynamics (IVD):** Ford
  - **Controllo Stabilità (CST):** Ferrari
  - **Vehicle Stability Assist (VSA):** Honda
ESC system manufacturers include:

- Robert Bosch GmbH
- Aisin Advics
- Bendix Corporation
- Continental Automotive Systems
- BeijingWest Industries
- Hitachi
- ITT Automotive, since 1998 part of Continental AG
- Johnson Electric
- Mando Corporation
- Nissin Kogyo
- Hyundai Mobis
- Knorr-Bremse
The important sensors in ESC are:

- **Steering wheel angle sensor**: determines the driver's intended rotation; i.e. where the driver wants to steer.
- **Yaw rate sensor**: measures the rotation rate of the car; i.e. how much the car is actually turning. The data from the yaw sensor is compared with the data from the steering wheel angle sensor to determine regulating action.
- **Lateral acceleration sensor**: often based on the Hall effect. Measures the lateral acceleration of the vehicle.
- **Wheel speed sensor**: measures the wheel speed.
- Other sensors can include:
  - **Longitudinal acceleration sensor**: similar to the lateral acceleration sensor in design but can offer additional information about road pitch and also provide another source of vehicle acceleration and speed.
  - **Roll rate sensor**: similar to the yaw rate sensor in design but improves the fidelity of the controller's vehicle model and correct for errors when estimating vehicle behaviour from the other sensors alone.
• **Hydraulic Modulator**: assure that each wheel receives the correct brake force. A similar modulator is used in ABS.

• **Electronic Control Unit (ECU)**:
  • Brain of the ESC system.
  • Often, the same ECU is used for diverse systems at the same time (ABS, Traction control system, climate control, etc.).
  • The controller computes the needed brake or acceleration force for each wheel corresponding to input signals from various sensors and directs via the driver circuits the valves of the hydraulic modulator.
ESP Block Diagram

Power Circuit 31
Terminal 61
Stop lamp switch
Parking Brake sw.
Front VSS
Rear VSS
Yaw Sensor
Lateral Sensor
Steering Angle
Pressure Sensor

Return pump Relay K40/
Hydraulic control unit A7/
ESP warning lamp
ESP MIL
ABS MIL
CAN-C (VSS)
Data Link (X11/4)
Control cycle

1. ABS control unit with EDL/TCS/ESP
2. Hydraulic unit with charge pump
3. Brake pressure sender
4. Lateral acceleration sender
5. Yaw rate sender
6. Button for TCS/ESP
7. Steering angle sender
8. Brake light switch
9-12. Speed sensor
13. Diagnosis wire
14. Warning lamp for brake system
15. ABS warning lamp
16. TCS/ESP warning lamp
17. Vehicle and driver behaviour
18. Intervention in engine management
19. Intervention in gearbox control unit (vehicles with automatic gearbox only)
• The ABS control unit comprises a high-performance microcomputer.

• Since a high level of fail-safety is required, the system has two processing units as well as its own voltage monitoring device and a diagnostics interface.

• Dual-processor systems of this type have what is known as active redundancy.

**ABS control unit with EDL/TCS/ESP J104**
• The Steering angle is measured using the principle of the light barrier.
• The basic components are:
  • a light source (a)
  • an encoding disc (b)
  • optical sensors (c+d) and
  • a counter (e) for full revolutions
• The encoding disc comprises two rings:
  • the absolute ring and the incremental ring.
  • Both rings are scanned by two sensors each.
• For physical reasons, this sensor should be located as closely as possible to the vehicle’s centre of gravity. This is why it is installed in the footwell below the driver's seat.

• **Task:** G200 determines whether and to what extent lateral forces are causing the vehicle to lose directional stability.

**Lateral acceleration sensor**

**G200**
• **Design:** Expressed in simple terms, the lateral acceleration sender comprises a permanent magnet (1), a spring (2), a damper plate (3) and a Hall sensor (4).

• The permanent magnet, spring and damper form a magnetic system. The magnet is securely connected to the spring and can oscillate back and forth over the damper plate.
• This sensor should also be located as closely as possible to the vehicle's centre of gravity.

• Its task is to determine whether torque is acting on a body. Depending on its installation position, it can detect rotation about one of the axes in space. In the ESP, the sensor must determine whether the vehicle is rotating about its vertical axis.

**Yaw rate sensor G202**
• **Design and function:**

An integral component is a small, metallic hollow cylinder (1). Eight piezoelectric elements (2) are attached to the hollow cylinder. Four of these elements induce resonance vibration (a) in the hollow cylinder. The other four elements observe whether the vibration nodes of the cylinder change. The vibration nodes shift under torque (b). This is measured by the piezo elements and is signalled to the control unit which calculates the yaw rate based on this data.
Task:
- The brake pressure sensor signals the momentary pressure in the brake circuit to the control unit.
- The control unit calculates the wheel braking forces and the longitudinal forces acting on the vehicle. If ESP intervention is necessary, the control unit allows for this value when calculating the lateral forces.

Design
- The core of the sensor is a piezoelectric element (a) on which the brake fluid pressure can act plus the sensor electronics (b).
• It is mounted on a support in the engine compartment.

Task:
• The individual wheel brake cylinders are activated by the valves in the hydraulic unit. Three states are possible by activating the intake and exhaust valves of a wheel brake cylinder in the hydraulic unit:
  • Raise pressure
  • Hold pressure
  • Reduce pressure

The hydraulic unit
Effectiveness

• Highly effective in helping the driver maintain control of the car, thereby saving lives and reducing the severity of crashes.
• National Highway and Traffic Safety Administration in United States concluded that ESC reduces crashes by 35%.
• SUVs with stability control are involved in 67% fewer accidents than SUVs without the system.
• Insurance Institute for Highway Safety (IIHS), USA issued its own study in June 2006 showing that up to 10,000 fatal US crashes could be avoided annually with ESC equipped on all vehicles.
• ESC reduces the likelihood of all fatal crashes by 43%, fatal single-vehicle crashes by 56%, and fatal single-vehicle rollovers by 77-80%.
• Sweden used public awareness campaigns to promote ESC use.

• Canadian province of Quebec made ESC compulsory for carriers of dangerous goods (without data recorders) in 2005.

• United States issued regulations requiring ESC for all passenger vehicles under 10,000 pounds from 2012.

• Canada will require all new passenger vehicles to have ESC from 1 September 2011.

• Australian Government made ESC be compulsory from 1 November 2011 for all new passenger vehicles sold in Australia.

• The European Commission has confirmed a proposal for the mandatory introduction of ESC on all new cars and commercial vehicle models sold in the EU from 2012.
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