2012 KIA Sportage

Electronic stability control and Brake system
Presentation by:

David Everidge: Theory of operation
Chris Graham: Components
John Seeders: Troubleshooting
Theory of Operation

- ESC system
- EBD system
- DBC system
Electronic stability control system description

- ESC recognizes critical driving conditions, such as panic reactions in dangerous situations, and stabilizes the vehicle by wheel-individual braking and engine control intervention.

- ESC adds a further function known as Active Yaw Control (AYC) to the ABS, TCS, EBD and ESC functions.

- Active yaw control stabilizes the vehicle about its vertical axis. This is achieved by wheel individual brake intervention and adaptation of the momentary engine torque with no need for any action to be taken by the driver.

- ESC essentially consists of three assemblies: the sensors, the electronic control unit and the actuators.

- In the event of a failure of the stability control function, the basic safety function, ABS, is still maintained.
Vehicle directional movement

- Driving force control
- TCS
- ESC Drift-out Control
- ESC Yaw-moment Control
- ABS
- Brake force control
ESC system control

• ESC system includes ABS/EBD, TCS and AYC function.

• ABS/EBD function : The ECU changes the active sensor signal coming from the four wheel sensors to the square wave. By using the input of above signals, the ECU calculates the vehicle speed and the acceleration & deceleration of the four wheels.

• AYC function prevents unstable maneuver of the vehicle. To determine the vehicle maneuver, AYC function uses the maneuver sensor signals which include the Yaw Rate Sensor, Lateral Acceleration Sensor, Steering Wheel Angle Sensor. If vehicle maneuver is unstable (Oversteer or Understeer), AYC function applies the brake pressure on certain wheel, and send engine torque reduction signal by CAN.
Input and output vehicle diagram
ESC operation mode inputs and outputs

- Input:
  - Active Wheel speed sensor (FL)
  - Active Wheel speed sensor (FR)
  - Active Wheel speed sensor (RL)
  - Active Wheel speed sensor (RR)
  - Steering Wheel Angle sensor
  - Yaw-rate & Lateral Acceleration sensor
  - Brake switch
  - ESC OFF switch

- ESC HECU

- Output:
  - Hydraulic unit integrated with HECU
  - Warning Lamp (ABS, EBD, ESC)
  - Diagnosis CAN
  - Function Lamp (ESC)
  - Wheel speed sensor output
  - CAN
  - ECU TCU
ESC Non-operation: Normal braking

<table>
<thead>
<tr>
<th>Solenoid valve</th>
<th>Continuity</th>
<th>Valve</th>
<th>Motor pump</th>
<th>TC Valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN (NO)</td>
<td>OFF</td>
<td>OPEN</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>OUT (NC)</td>
<td>OFF</td>
<td>CLOSE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solenoid valve</td>
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</tr>
<tr>
<td>---------------</td>
<td>------------</td>
<td>-------</td>
<td>------------</td>
<td>----------</td>
</tr>
<tr>
<td>Understeering (Only inside of rear wheel)</td>
<td>IN(NO)</td>
<td>OFF</td>
<td>OPEN</td>
<td>ON</td>
</tr>
<tr>
<td></td>
<td>OUT(NC)</td>
<td>OFF</td>
<td>CLOSE</td>
<td></td>
</tr>
<tr>
<td>Oversteering (Only outside of front wheel)</td>
<td>IN(NO)</td>
<td>OFF</td>
<td>OPEN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OUT(NC)</td>
<td>OFF</td>
<td>CLOSE</td>
<td></td>
</tr>
</tbody>
</table>

ESC operation

![Diagram of ESC operation]
Electronic brake force distribution

• The EBD system (Electronic Brake force Distribution) as a subsystem of the ABS system is to control the maximum braking effectiveness by the rear wheels.

• The proportioning valve, because of a mechanical device, has limitations to achieve an ideal brake force distribution to the rear wheels as well as to carry out the flexible brake force distribution proportioning to the vehicle load or weight increasing. And in the event of malfunctioning, driver cannot notice whether it fails or not.

• EBD controlled by the ABS Control Module, calculates the slip ratio of each wheel at all times and controls the brake pressure of the rear wheels not to exceed that of the front wheels. If the EBD fails, the EBD warning lamp (Parking brake lamp) lights up.
Comparison between Proportioning Valve and EBD

[With P-Valve]

Rear pressure

Front pressure

Fixed distribution
Ideal distribution
Cut-in point

[With EBD]

Rear pressure

Front pressure

Ideal distribution
EBD starting point
Downhill brake control function

- The DBC function is the acronym word of Downhill Brake Control function. When a vehicle goes down the hill, just pushing the DBC switch enables the car to keep its vehicle's speed at a constant value without operating the brake pedal. The DBC function is operated when the vehicle is on the decline and its velocity is under the predetermined speed.
Component location and description

1. ABS(HECU) module
2. Front WSS
3. Rear WSS
4. Yaw rate, lateral, longitudinal G sensor
5. Steering angle sensor
6. Abs Warning lamp
7. Parking brake/EBD warning lamp
8. ESC off lamp
9. ESC function/Warning lamp
10. DBC warning lamp
ABS (HECU) module

• The ABS HECU is composed of a ECU (Electronic Control Unit) and an HCU (Hydraulic Control Unit), so the HECU hardware includes all solenoid valves inside the unit as well as the ECU.

• Solenoid valves are switched to ON, OFF by HECU when the ABS is activated. Solenoid valves function is to increase, decrease or maintain the hydraulic pressure supplied to a wheel cylinder.
ABS (HECU) location

46. Right Rear of Engine Room

Right side of cowl top cover

GHG06(G4KE)
GHTG06(G4KH)

CHG40(G4KE)
CHTG40(G4KH)
ESC MODULE (38-BLK)
Wheel speed sensors

- The wheel speed sensor is the essential component the ABS ECU uses to calculate vehicle speed and to determine whether wheel lock occurs.

- For example, rear wheel speed signal is used as a reference value, for vehicle speed, in front wheel drive vehicles, and if a difference between front and rear wheel speed occurs, then ABS control is performed.

- Wheel speed sensor is active hall-sensor type.

\[\text{V}_{\text{low}} : 0.59V \sim 0.84V\]
\[\text{V}_{\text{high}} : 1.18V \sim 1.68V\]
Frequency range : 1 ~ 2,500Hz
Wheel speed sensor connector locations

4. Left Front Wheel Housing

- CHTG54(G4KH)
- CHG54(G4KE)
- FRONT WHEEL SENSOR LH(2-BLK)
- Wheel guard removed

89. Under of Left C-pillar

- F09 REAR DOOR SWITCH LH (2-WHT)
- CHTG51(G4KH)
- CHG51(G4KE)
- EXTERNAL BUZZER(2-BLK)
- Z01 DIODE (2-BLK)
- F30 REAR WHEEL SENSOR LH (2-WHT)
Yaw rate, lateral, longitudinal G sensor

• When the vehicle is turning with respect to a vertical axis the yaw rate sensor detects the yaw rate electronically by the vibration change of plate fork inside the yaw rate sensor.

• If yaw velocity reaches the specific velocity after it detects the vehicle's yawing, the ESC control is reactivated.

• The lateral G sensor senses vehicle's lateral G. A small element inside the sensor is attached to a deflectable lever arm by later G.

• Direction and magnitude of lateral G loaded to vehicle can be known with electrostatic capacity changing according to lateral G.
**Yaw rate, lateral, longitudinal G sensor**

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating voltage</td>
<td>10 ~ 16V</td>
<td></td>
</tr>
<tr>
<td>Output signal</td>
<td>CAN Interface</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-40 ~ 85°C (-40 ~ 185°F)</td>
<td></td>
</tr>
</tbody>
</table>
| Yaw-rate sensor   | Measurement range  
(°/sec) | -75 ~ 75°/sec |
|                   | Frequency response   
(Hz)                 | 15 ~ 45Hz |
| Lateral G sensor  | Measurement range  
(g)                  | -14.715 ~ +14.715g |
|                   | Frequency response   
(%)                   | 50Hz ± 60% (-3dB) |

(Yaw-rate & Lateral & Longitudinal G sensor's) [Harness Connector]

![Diagram of sensor connections](image)
Yaw rate sensor Location
Steering angle sensor

• The Steering Angle Sensor (SAS) is installed in MDPS (Motor Driven Power Steering) and it sends messages to HECU through CAN communication line.

• The SAS is used to determine turning direction and speed of the steering wheel.

• The HECU uses the signals from the SAS when performing ESC-related calculations.

• Components (Steering Angle Sensor, Torque Sensor, Failsafe relay, etc.) of the EPS system are located inside the steering column & EPS unit assembly and the steering column & EPS unit assembly must not be disassemble to inspect or replace them. (Refer to “ST (Steering system) Gr.”)
Steering angle sensor location
Standard Flow of Diagnostic Troubleshooting

Gathering information from customer

Reoccurs

Check diagnostic code

No trouble code

Basic brake system is normal or not

Abnormal

Refer to BR-Troubleshooting

Normal

Problem is intermittent or was repaired and memory was not cleared.

Does not reoccur

Check diagnostic code

Trouble code displayed

Recheck trouble code(s) then erase

Recheck trouble symptom

Check trouble codes

Trouble code displayed

Inspection chart for diagnostic trouble codes

Intermittent malfunction

No trouble code

* Using the customer problem analysis check sheet for reference, ask the customer as much detail as possible about the problem.
Notes With Regard To Diagnosis
The phenomena listed in the following table are not abnormal.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>System check sound</td>
<td>When starting the engine, a thudding sound can sometimes be heard coming from inside the engine compartment. This is because the system operation check is being performed.</td>
</tr>
<tr>
<td>ABS operation sound</td>
<td>Sound of the motor inside the ABS hydraulic unit operation (whine). Sound is generated along with vibration of the brake pedal (scraping). When ABS operates, sound is generated from the vehicle chassis due to repeated brake application and release (Thump: suspension; squeak: tires)</td>
</tr>
<tr>
<td>ABS operation (Long braking distance)</td>
<td>For road surfaces such as snow-covered and gravel roads, the braking distance for vehicles with ABS can sometimes be longer than that for other vehicles. Accordingly, advise the customer to drive safely on such roads by lowering the vehicle speed.</td>
</tr>
</tbody>
</table>

Diagnosis detection conditions can vary depending on the diagnosis code. When checking the trouble symptom after the diagnosis code has been erased, ensure that the requirements listed in "Comment" are met.
# ABS Check Sheet

<table>
<thead>
<tr>
<th>Customer's Name</th>
<th>Registration No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration Year</td>
<td>/ /</td>
</tr>
<tr>
<td>VIN.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date Vehicle Brought In</th>
<th>Odometer</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ /</td>
<td>Km Miles</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date the Problem First Occurred</th>
<th>/ /</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Frequency of Occurrence of Problem</th>
<th>Continuous</th>
<th>Intermittent ( times a day)</th>
</tr>
</thead>
</table>

| Symptoms | |
|----------||
| □ ABS does not operate. | |
| □ ABS does not operate efficiently. | □ Intermittent ( times a day) |
| □ ABS Warning Light Abnormal | □ Remains ON | □ Does not light up |

<table>
<thead>
<tr>
<th>Diagnostic Trouble Code Check</th>
<th>1st Time</th>
<th>2nd Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>□ Normal Code</td>
<td>□ Malfunction Code (Code )</td>
</tr>
<tr>
<td></td>
<td>□ Normal Code</td>
<td>□ Malfunction Code (Code )</td>
</tr>
</tbody>
</table>
Possible DTC's

- C1101 Battery Voltage High
- C1102 Battery Voltage Low
- C1112 Sensor source voltage
- C1206 Wheel Speed Sensor Rear-LH Open/Short
- C1207 Wheel Speed Sensor Rear-LH Range / Performance / Intermittent
- C1208 Wheel Speed Sensor Rear-LH Invalid/no Signal
- C1209 Wheel Speed Sensor Rear-RH Open/Short
- C1200 Wheel Speed Sensor Front-LH Open/Short
- C1201 Wheel Speed Sensor Front-LH Range / Performance / Intermittent
- C1202 Wheel Speed Sensor Front-LH Invalid/no Signal
- C1203 Wheel Speed Sensor Front-RH Open/Short
- C1204 Wheel Speed Sensor Front-RH Range / Performance / Intermittent
- C1205 Wheel Speed Sensor Front-RH Invalid/no Signal
- C1210 Wheel Speed Sensor Rear-RH Range / Performance / Intermittent
Possible DTC's Cont.

- C1211 Wheel Speed Sensor Rear-RH Invalid/no Signal
- C1235 Primary Pressure Sensor-Electrical
- C1237 Primary Pressure Sensor-Signal
- C1260 Steering Angle Sensor Circuit-Signal
- C1261 Steering Angle Sensor Not Calibrated
- C1282 Yaw Rate & Lateral G Sensor-Electrical
- C1283 Yaw Rate & Lateral G Sensor-Signal
- C1285 Sensor Cluster Change Detection/Uncalibrated
- C1503 TCS/ESC(ESP) Switch error
- C1513 Brake switch error
- C1520 Clutch switch
- C1526 DBC Switch Error
- C1527 Gear R Switch Error
- C1604 ECU Hardware Error
Possible DTC's Cont.

- C1605 CAN Hardware error
- C1611 CAN Time-out ECM
- C1612 CAN Time-out TCM
- C1613 CAN Wrong Message
- C1616 CAN Bus off
- C1623 CAN Time-out Steering Angle Sensor
- C1627 CAN time-out 4WD
- C1647 CAN Hardware Error - Sensor Channel
- C1687 CAN Time-out MDPS
- C1688 MDPS signal error
- C1702 Variant Coding Error
- C2112 Valve Relay Error
- C2130 Brake Lamp Relay Error
- C2227 Excessive Temperature Of Brake Disc
- C2380 ABS/TCS/ESC(ESP) valve error
- C2402 Motor Failure
<table>
<thead>
<tr>
<th>Item</th>
<th>Detecting Condition</th>
<th>Possible cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTC Strategy</td>
<td>• Signal monitoring</td>
<td></td>
</tr>
<tr>
<td>Case1 (wrong exciter)</td>
<td>• Max. wheel velocity exceeds 20km/h and the wheel velocity is 40% of max. wheel velocity. if this condition is lasted for 2 minutes.</td>
<td>1. Improper installation of wheel speed sensor</td>
</tr>
<tr>
<td></td>
<td>• Max. wheel velocity exceeds 40km/h and the wheel velocity is 60% of max. wheel velocity. if this condition is lasted for 2 minutes.</td>
<td>2. Abnormal Rotor and wheel bearing</td>
</tr>
<tr>
<td>Enable Conditions</td>
<td>• Controller counts the number of the wheel acceleration of 100g[(25km/h) for 7ms]. When the numbers at one wheel exceed 56 times, or When the numbers at more two wheels exceed 5 times, controller recognize the failure.</td>
<td>3. Faulty Wheel speed sensor</td>
</tr>
<tr>
<td>Case2 (Speed jump)</td>
<td>• Controller counts the number of the wheel acceleration of 70g[(17.5km/h) for 7ms]. When the numbers at one wheel exceed 126 times, or When the numbers at more two wheels exceed 20 times, controller recognize the failure.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Controller counts the number of the wheel deceleration of -100g[(-25km/h) for 7ms]. When the numbers at each wheel exceed 56 times, controller recognize the failure.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The wheel deceleration of -100g[(-25km/h) for 7ms] causes the controller to start monitoring this failure and to compare the wheel velocity with the vehicle velocity from next cycle. When its difference of -100g is continued for more than 140msec, controller recognize the failure.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• In case that any sensor failure at other wheel was already detected, When the numbers of 100g at each wheel exceed 5 times, or When the numbers of 70g at each wheel exceed 20 times, controller recognize the failure.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The counter of speed jump is cleared every 30min.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• This monitoring is performed for the period that the velocity of each wheel exceeds 2km/h.</td>
<td></td>
</tr>
<tr>
<td>Fail Safe</td>
<td>1. Only one wheel failure : Inhibit the ABS/ESC/DBC control, allow the EBD control. The ABS/ESC/DBC warning lamps are activated, the EBD warning lamp is not activated.</td>
<td></td>
</tr>
</tbody>
</table>
DTC C1201

The ABS ECU monitors the wheel speed sensor circuit continuously. If the sensor signal current is continuously out of the specified range for 140 msec, then the HECU determines that the circuit is open/short, and sets this code. Warning lamp is turned OFF unless additional faults are detected when the IG KEY is turned ON again, and wheel speed is more than 10 Km/h (6.2mph).
Wheel speed sensor electrical diagram
Signal Circuit Inspection

- Wheel speed sensor circuit check

1. Lift the vehicle. 2. IG "ON".
3. Turn the wheel by hand.
4. Measure waveform between wheel speed sensor signal terminal of the HECU harness connector and chassis ground with oscilloscope.

**Specification**
- High: 1.18~1.68V
- Low: 0.59~0.84V
Is the measured waveform within specifications?

Yes: Fault is intermittent caused by poor connection in wheel speed sensor harness (FL) and/or HECU's connector or was repaired and HECU memory was not cleared. Thoroughly check connectors for looseness, poor connection, bending, corrosion, contamination, deterioration, or damage. Repair or replace as necessary and then go to "Verification of Vehicle Repair" procedure.

No: Repair open or short in signal circuit between HECU harness connector and wheel speed sensor harness connector, and then go to "Verification of vehicle Repair" procedure. If there is no problem in signal circuit, go to "Component Inspection" procedure.
Sample waveform
Actual Waveform
Verification inspection

After a repair, it is essential to verify that the fault has been corrected.

1. Connect GDS and select "Diagnostic Trouble Codes (DTCs)" mode.
2. Using a GDS, Clear DTC.
3. Operate the vehicle within DTC Detecting Condition in General Information. (Start and drive vehicle in gear and maintain vehicle speed at or above 12km/h. (7.5mph)
4. Are any DTCs present?
   Yes: Go to the applicable troubleshooting procedure.
   No: System performing to specification at this time