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# **DYNAMIC STABILITY CONTROL (DSC III)**

## **DSC FOR THE X5 INTRODUCTION**

The X5 is equipped with DSC III for its stability control system. The components are the same as the DSC III system (version 5.7) currently installed in the E38/E39 vehicles. However the software and programming are changed to allow for new functions associated with all wheel drive and off-road use.

New/changed functions of the DSC III include:

- New Hill Decent Control (HDC) function
- New Differential Brake Control (ABD) function
- Changed traction control function
- Changed ABS function

## **DSC - X5 OVERVIEW**

The DSC system for the X5 provides all of the functions and features of the DSC III system currently in the E38/E39 vehicles. these functions/features include:

- Maintaining traction under all driving conditions
- Maintaining the directional Control (Longitudinal Stability)
- Providing Lateral Stability (Correction for oversteer/understeer)
- Providing Corner Braking Control (CBC)
- Providing Dynamic Braking System features of - Dynamic Braking Control and Maximum Braking Control (DBC and MBC)
- Providing Electronic Brake Proportioning (EBV)

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# TRACTION CONTROL SYSTEM OVERVIEW (ASC)

## THEORY OF TRACTION CONTROL

Traction Control Systems are referred to as Automatic Stability Control (ASC), Automatic Stability + Traction Control (ASC+T), Dynamic Stability Control (DSC) or All Season Traction (marketing term). The traction control system has gone through several changes since its introduction in Model Year 1988. While each new version offered new innovations, the principle of traction control remains the same for any of these versions.

The link between the vehicle and its driving environment is established by the frictional contact between the tires and the road surface. The ability to control the vehicle while driving, is lost as a result of excessive wheel spin or slip if either rear tire exceeds its ability to:

- Maintain traction
- Accept side forces to maintain directional control (lateral locating forces)

The primary function of the traction control system is to maintain traction and stability of the vehicle regardless of the road surface condition. This is achieved by reducing the drive torque applied to the rear wheels or pulsing the rear wheel brakes to eliminate wheel slip depending on the version of traction control installed.

The electronics for traction control operation are incorporated in the ABS control module and share many of the same components and sensors. The module determines the speed of the vehicle through a calculated average of the four wheel speed sensor inputs. Wheel slip/spin is then recognized by comparing the speed of the driven wheels to the front wheels.

A critical slip ratio of greater than 5% between the wheels will cause the traction control regulation to begin. This slip ratio is established when the control module detects a wheel speed difference of 2 MPH or higher.

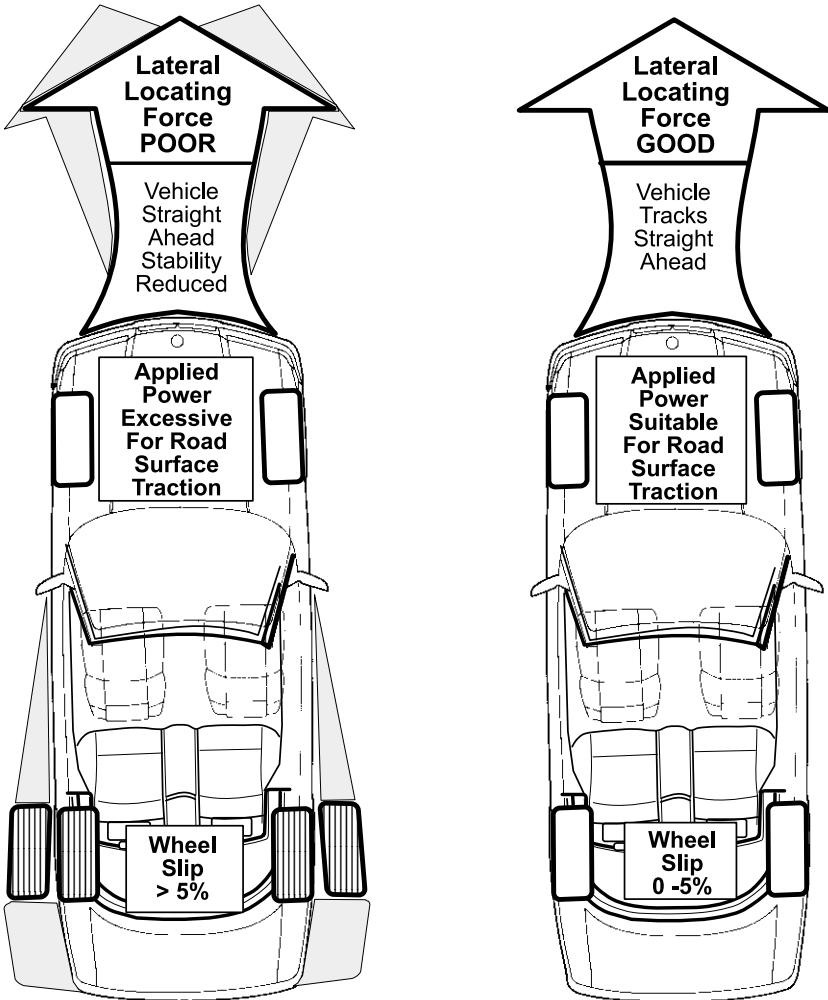
# THEORY OF ELECTRONIC CONTROL

An electronic control system is used because of its ability to react quicker and more precisely than the driver. It backs up the driver's decisions and contributes to active safety, even under extreme driving conditions.

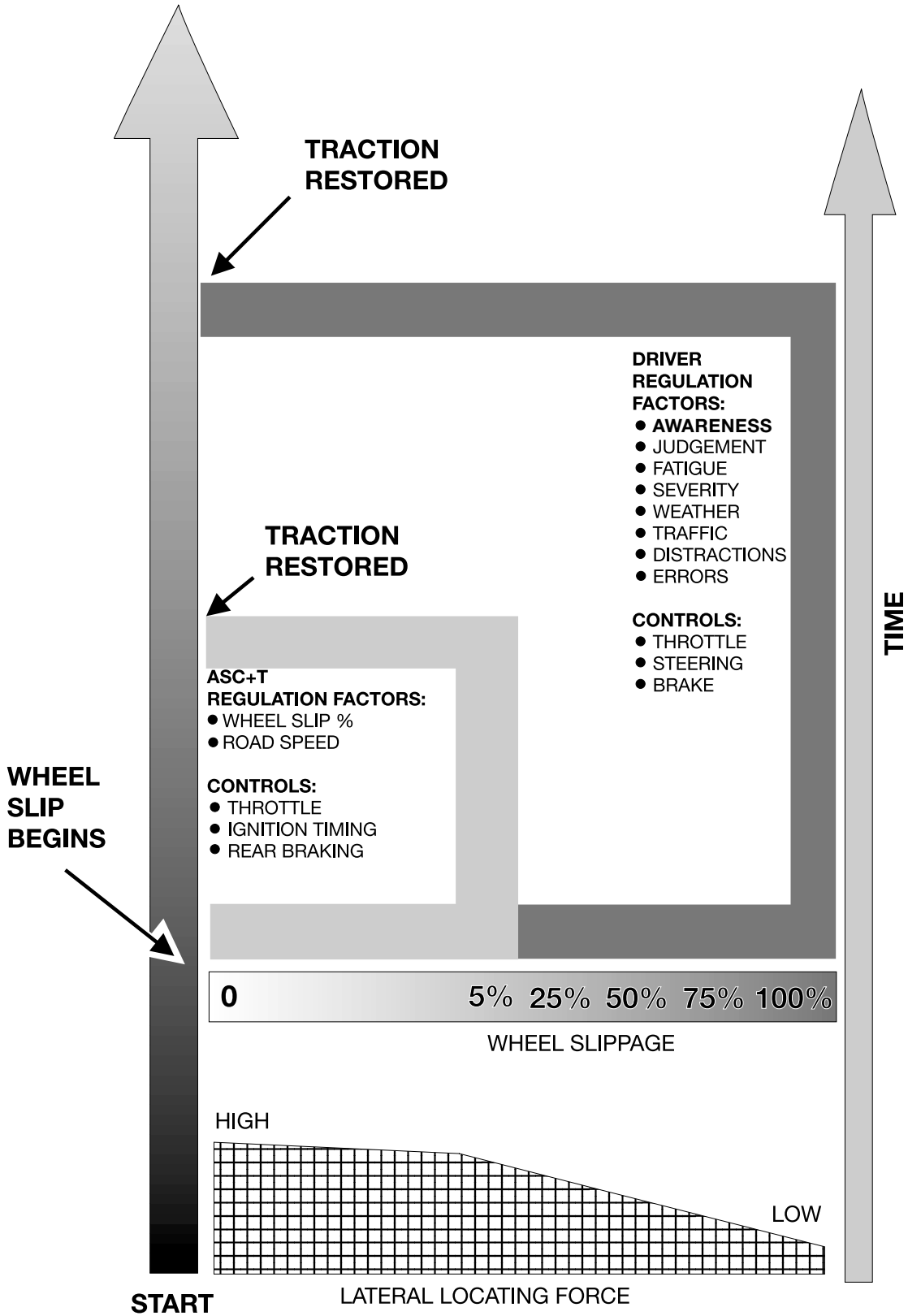
### Advantages:

- optimum traction at all speeds
- increased stability by retaining lateral (side to side) locating forces.

**NOTE: The system is limited to the extent that no system can overcome the laws of physics.**



**DRIVER'S INTENDED POINT**



# DYNAMIC STABILITY CONTROL (DSC II)

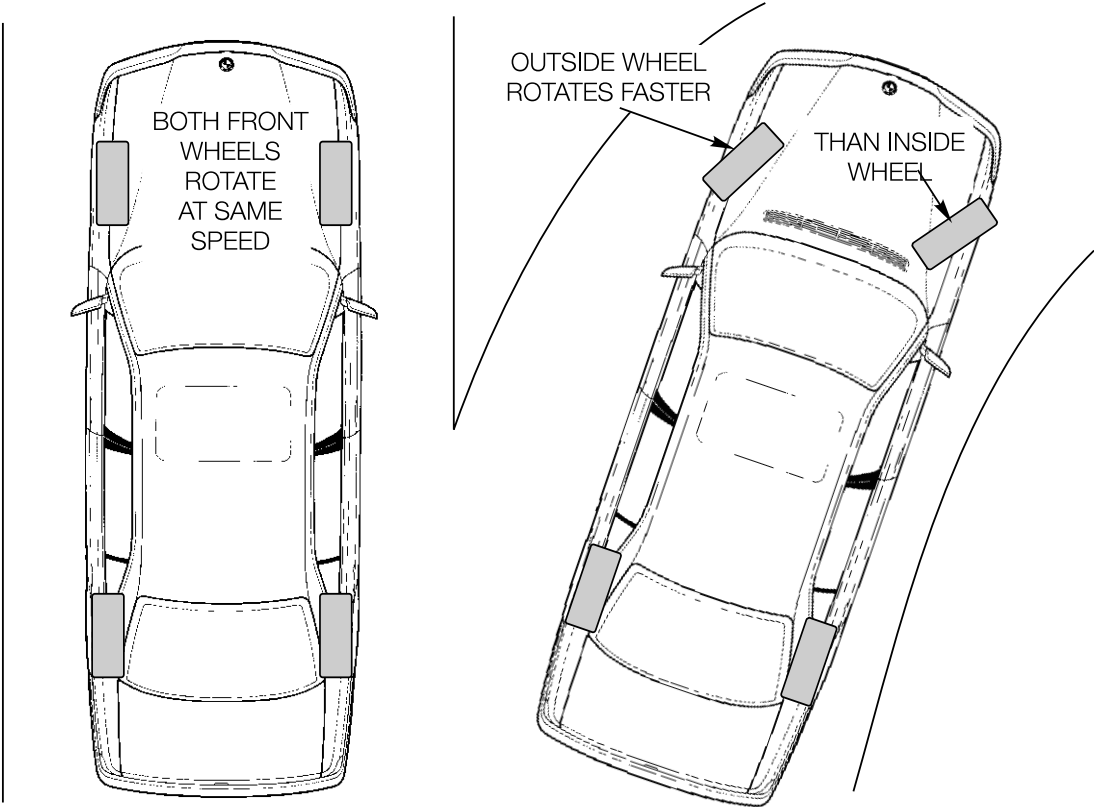
Dynamic Stability Control II (DSC II) is a further development to the ABS/ASC+T5 traction control system. DSC I was introduced in other markets on the E32 and E31 vehicles with the M70 engine.

The DSC system is designed to improve the lateral stability of the vehicle in all driving situations. Whereby ASC+T is primarily designed for longitudinal stability and providing the optimum traction for driving off, DSC adds lateral stability control to the already proven system.

For any given turning angle and speed of the vehicle, there is a set difference between the rotational speeds of the front wheels. If the rotational speeds of the front wheels vary from this set difference, it means the vehicle is understeering or oversteering through the turn. This could lead to an unstable condition and possible loss of control.

The DSC system is designed to monitor this rotational difference and react to any changes or deviations that might possibly occur. The DSC provides ASC control for the vehicle while driving through corners or any time the vehicle is not moving straight ahead.

In essence, the ASC+T5 becomes a Dynamic Stability Control System with this added feature.



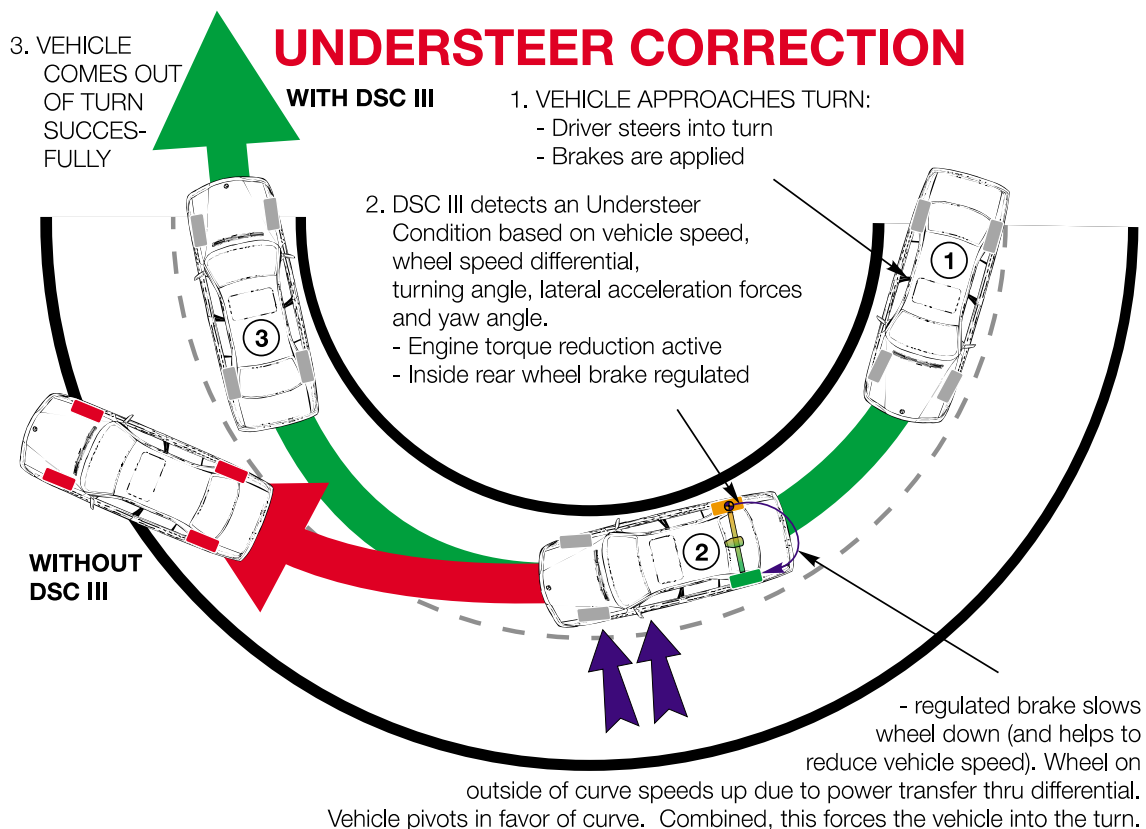
## DYNAMIC STABILITY CONTROL (DSC III)

All of the familiar braking and straight line traction control features and system communication carry over from DSC II. Based on select high/select low logic, the DSC III control module selects a vehicle stabilizing strategy based on the specific input signal values it is monitoring at the moment. For all DSC strategies this begins with engine intervention to reduce torque:

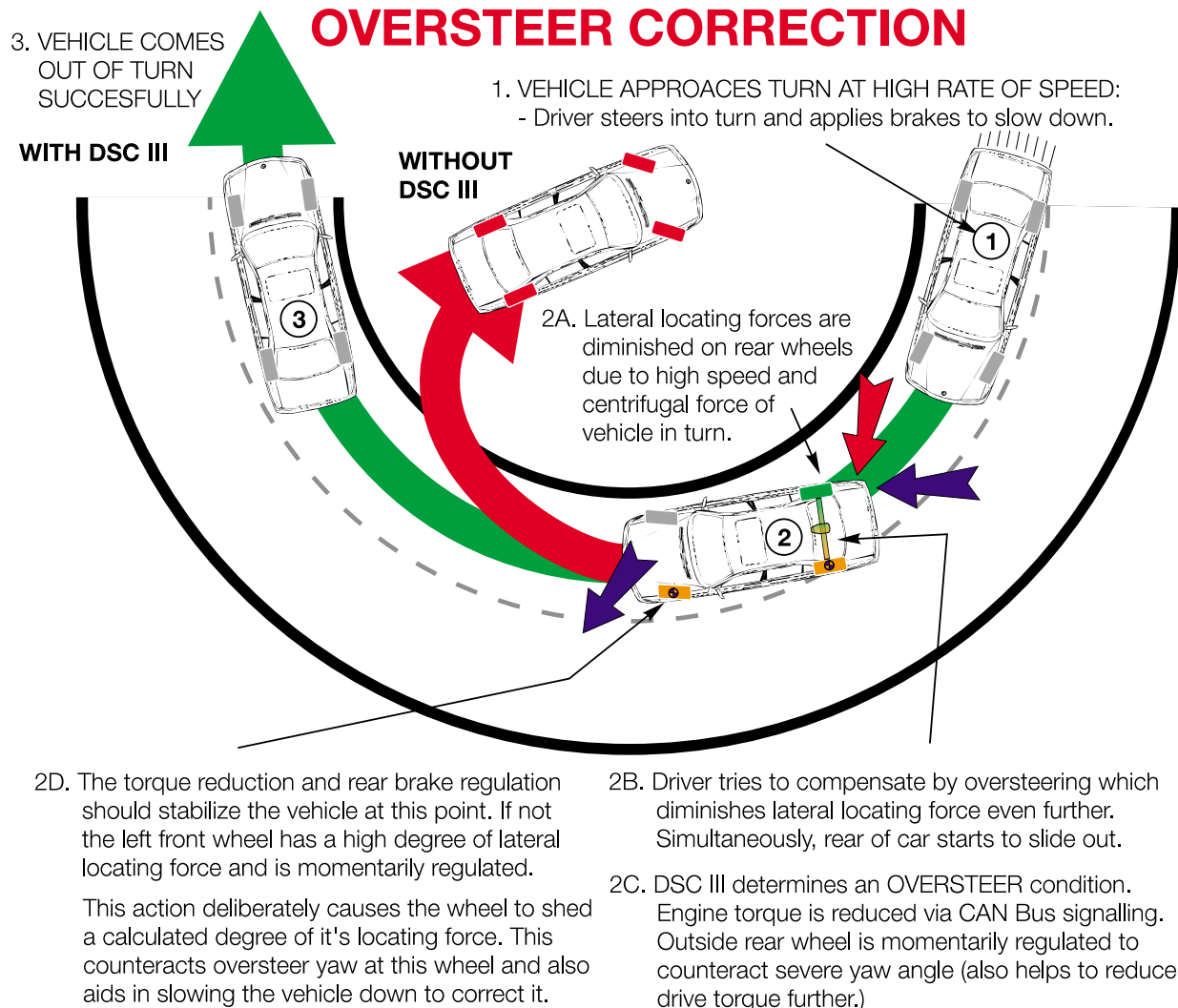
- For the 750iL this is handled via CAN communication, DSC III to EML to minimize the throttle angle of the DK motors (750iL). For the 740i/iL and 540iA this is handled by direct DSC III activation of the ADS II throttle housing.
- If additional torque reduction is necessary, DSC III informs DME over CAN to:
  - Retard ignition timing
  - Shut down the fuel injection to individual cylinders

DSC III monitors under/oversteer conditions through the following components:

- The driver's desired steering angle - steering angle signal over CAN bus.
- Vehicle speed and speed differential at front wheels - wheel speed sensors
- Dynamic forces of lateral acceleration and yaw placed on the vehicle. This is possible with two new components which are discussed further on. The results are as follows:



The expanded hydraulic control of individual wheel circuits is apparent when stabilizing a vehicle exhibiting an oversteer condition as follows:



Transmission system intervention also occurs during any ASC/DSC regulating phase. Through CAN bus communication the AGS control module is informed to delay any gear changes during regulation. This prevents any unwanted driveline dynamic changes during DSC regulation.

Though DSC III provides state of the art, electronic correction of undesirable vehicle handling characteristics, it is important to remember vehicle stability is always subject to the physical laws of centrifugal force and extreme road conditions. **Good judgement and common sense on the part of the driver are still required.**



## CORNER BRAKING CONTROL (CBC)

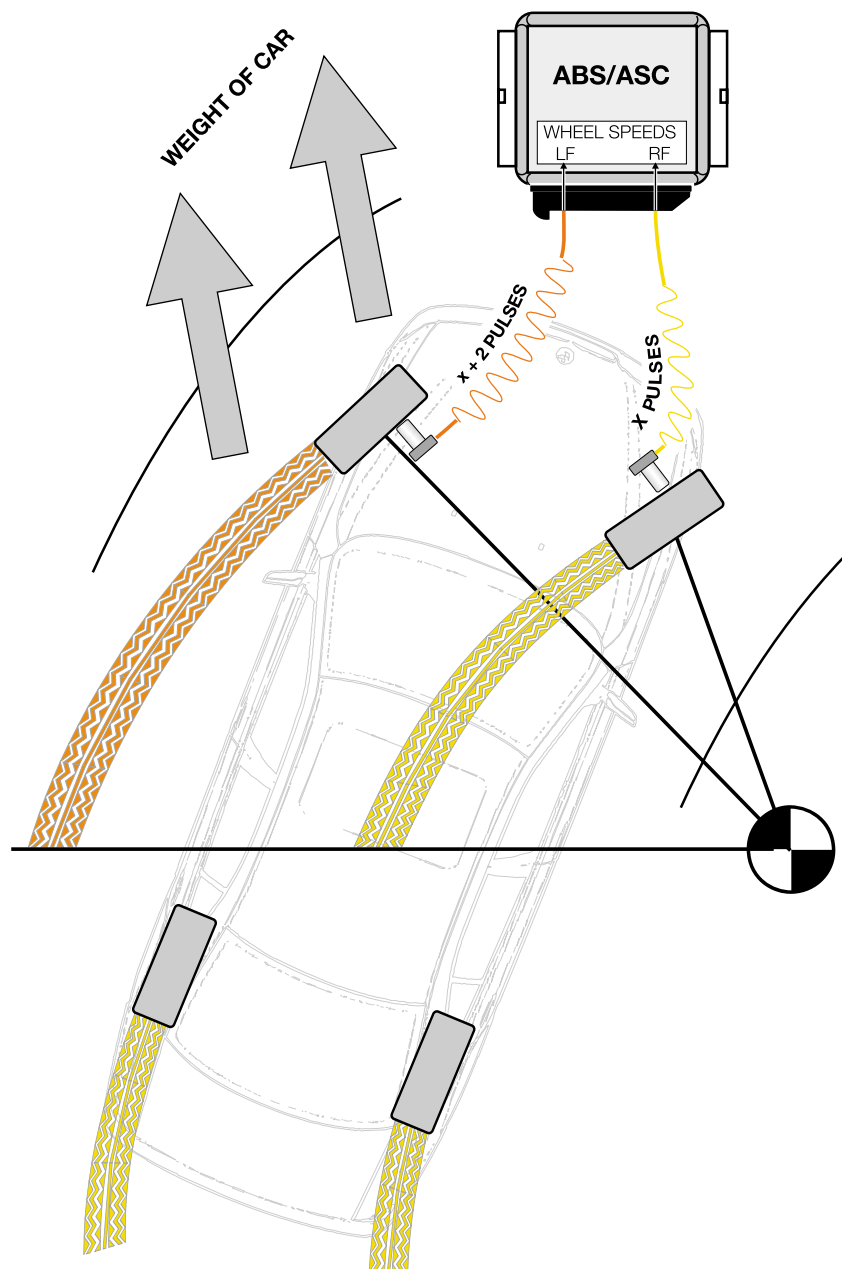
Corner Braking Control (CBC) was an additional feature first added to the ASC/5 system of the E39 at introduction. CBC improves stability control while braking through curves.

As the vehicle enters a curve, the weight of the car shifts to the outside of the curve. With non CBC equipped vehicles if the driver brakes while driving through a curve an equal hydraulic force is applied to each wheel. Though the pressure is equal, the braking effort is unequal at the tire footprint due to the increased weight of the vehicle on the outside curve.

With a CBC equipped system, the feature regulates the apply pressure to the wheels based on the turning angle (curve recognition). When the driver brakes in the same situation, an unequal hydraulic pressure is applied to each side of the vehicle. Though the apply pressure is unequal, the dynamic of the vehicle's weight transfer compensates for the unequal apply pressure, as a result braking effort is equal at the tire footprint.

The ASC control module monitors the speed signals from all four wheels to determine when this regulation is required.

This is a feature found on vehicles equipped with the Dynamic Stability Control System (DSC), however this ASC/5 system does not incorporate full DSC control.



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## **ELECTRONIC BRAKE PROPORTIONING (EBV)**

Electronic brake proportioning allows the DSC system to adjust the braking force to the rear wheels based on the vehicle's loading to maximize the braking force at all wheels.

The DSC control module monitors the wheel speed sensors inputs when the brakes are applied, for activation of this feature. The control module compares the speed at which the front and rear axles are slowing down to determine vehicle loading.

If the rear axle is slowing at a similar rate to the front, it indicates that the vehicle is loaded and more braking force can be applied to the rear calipers to slow and stop the vehicle.

If the decel rate of the rear axle is much less than the front, the vehicle is lightly loaded and less force can be applied to the rear. If the same force were applied, then the vehicle could become unstable.

### **OPERATION**

The values for the decel rate are programmed in the DSC control module. Equal force will be applied to the front and rear axles until the threshold values are exceeded. At this point, the DSC control module will cycle the inlet valves at the rear calipers to reduce the braking force on the rear axle.

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## **DYNAMIC BRAKING SYSTEM**

The dynamic braking system is designed to enhance the braking control of the DSC for the driver of the vehicle. The dynamic braking control and maximum braking control are functions that are programmed into the control electronics of the DSC with no additional hardware changes.

### **DYNAMIC BRAKING CONTROL (DBC)**

The DBC function is designed to provide the maximum braking force available during rapid (panic) braking situations. The DSC control module looks at the inputs from the brake pedal switch and the signal from the brake pressure sensor on the master cylinder. The criteria for activation of DBC is how rapidly is the brake pressure built up with the brake pedal depressed. The total criteria required for DBC activation includes:

- Brake switch ON
- Brake pressure build up > threshold value
- Vehicle road speed > 5MPH
- Vehicle not in reverse
- Not all wheels in ABS regulation

If the threshold for DBC activation is achieved, the DSC control module will activate a pressure build up regulation phase through the hydraulic unit. The pressure at all wheels is increased up to the ABS regulation point. This occurs even if the driver does not achieve the ABS regulation point with the pedal.

The rear axle brakes are controlled with select-low regulation and the front axle brakes are controlled individually. ABS regulation will continue until the driver releases the pedal and the pressure in the master cylinder drops below the threshold value stored in the DSC control module.

### **MAXIMUM BRAKE CONTROL (MBC)**

The MBC function is also designed to enhance a driver initiated braking procedure. The MBC will build up the pressure in the rear brake circuit when the front brakes are already in an ABS regulation cycle. The additional braking pressure at the rear wheels will shorten the stopping distance. The following criteria must be met before the DSC control module will activate MBC:

- Both front wheel brakes in ABS regulation
- Vehicle speed > 5 MPH
- Vehicle not in reverse
- DBC and pressure sensor initialization test OK
- Rear wheels not in ABS regulation

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## DSC NEW FUNCTIONS

### HILL DECENT CONTROL (HDC)

Hill Decent Control (HDC) is designed for off road use to automatically slow the vehicle and maintain a steady speed on steep gradients. This function allows the driver to focus on steering and controlling the vehicle without having to use the brakes to slow the vehicle.

HDC is activated manually through the push button switch located in the center switch panel located in the console. When activated, the vehicle's speed is held to approximately 5 MPH by the DSC system pulsing the brakes to maintain the speed.

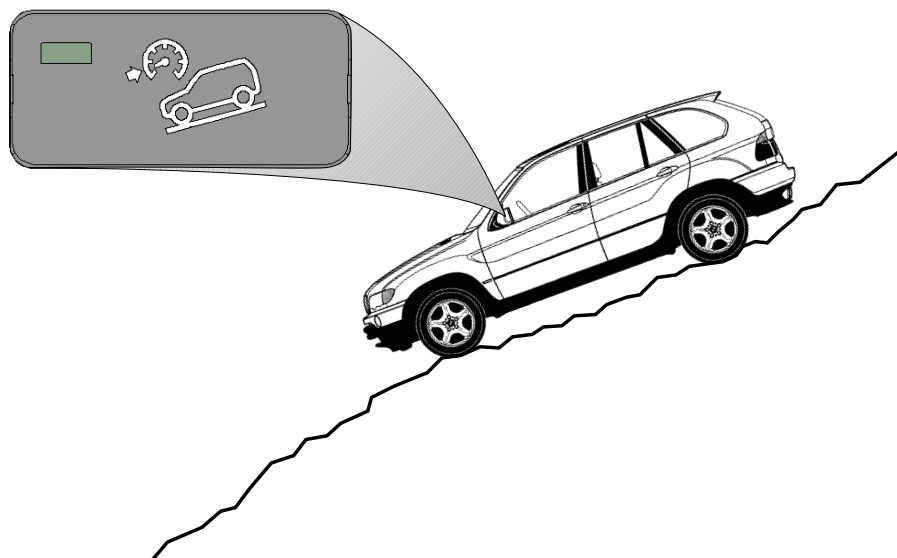
The following conditions must be met before the HDC will activate:

- Push button pressed - LED "ON"
- Vehicle speed: < 25 MPH
- Accelerator pedal pressed <15%
- Downhill driving recognized

Downhill is recognized from the vehicle's speed and engine load from the engine control module. The accelerator pedal and engine load signals are passed over the CAN bus to the DSC control module.

The HDC switch can be pressed at speeds < 37MPH and the LED will come on to indicate standby mode. However the system will not activate until the vehicle's speed is below 25.

The driver can accelerate with HDC active up to approximately 20% engine load. The HDC will stop regulating as long as the driver is requesting a speed increase. If the vehicle's speed is > 37 MPH, the HDC function is automatically switched OFF.



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## DSC - NEW FUNCTIONS

### AUTOMATIC DIFFERENTIAL BRAKE (ADB)

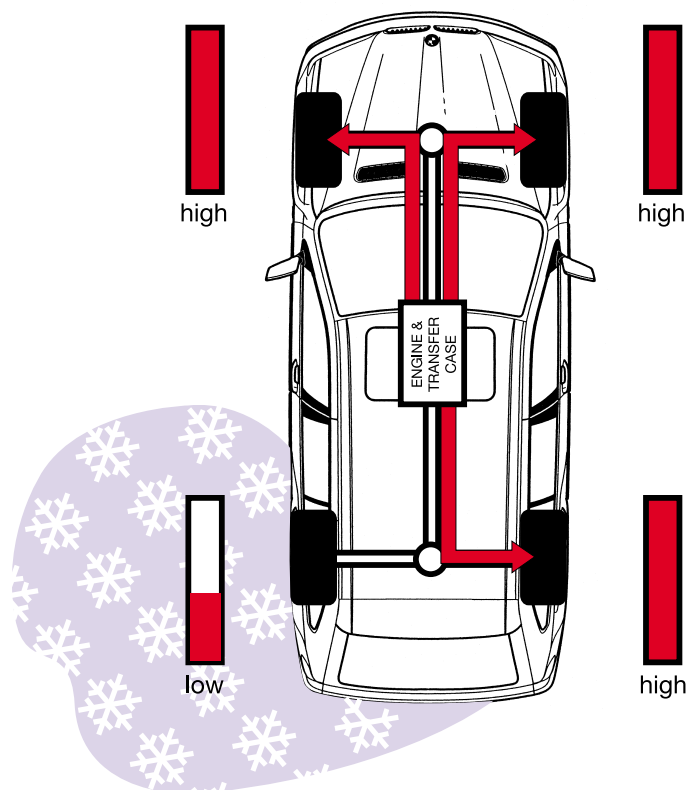
On dry pavement with no wheel slip, the vehicle's driving torque is split 68% rear and 32% front through the planetary gear differential transfer case.

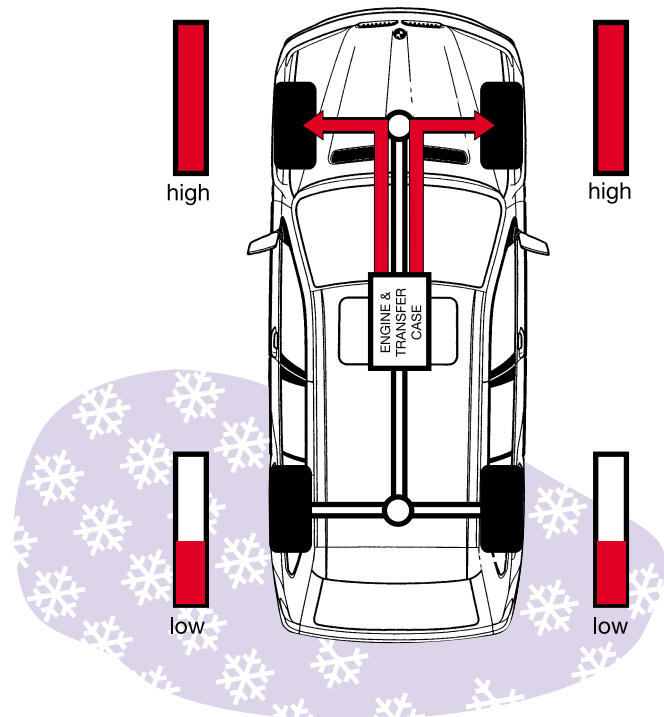
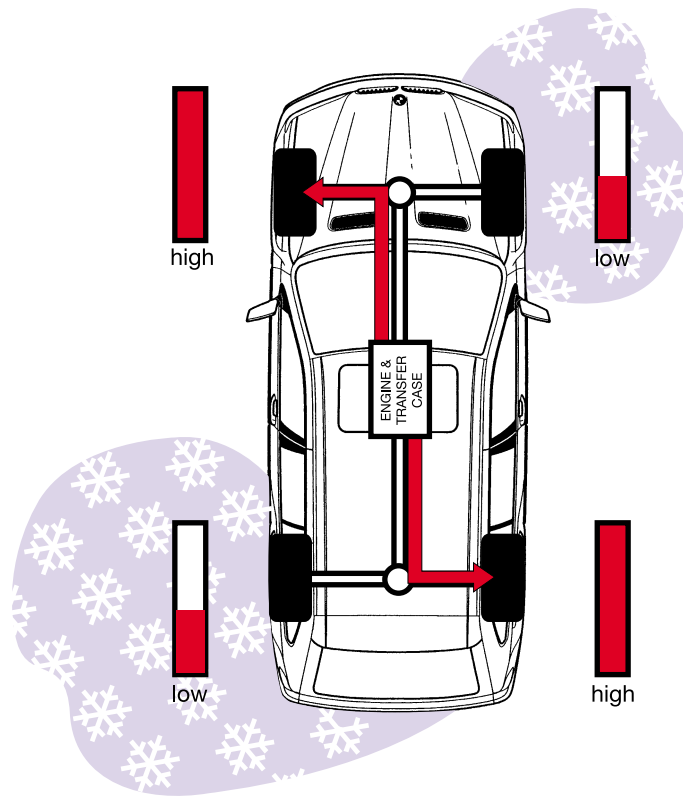
If one or more wheels spin or slip, the DSC will activate a regulation process and the brakes on the effected wheel(s) will be pulsed. The driving torque will be distributed through the differential to the remaining wheels with a good coefficient of friction

The driving torque will be applied through the differential as follows:

- Three wheels - with one wheel spinning.
- On two diagonal wheels with two wheels spinning on different axles.
- One axle only with two wheels spinning on the same axle.

Once the spin or slip is under control, the drive torque will again be applied to all wheels.





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## **DSC - NEW FEATURE**

### **TRACTION CONTROL**

The traction control feature of the DSC III on the X5 cannot be switched OFF with the DSC switch. Pressing the button will only switch off the dynamic stability control function of the DSC.

The traction control feature is needed at all times to provide anti-spin control especially when driving the vehicle off road. The DSC warning lamp in the instrument cluster will still come on when the system is switched off manually or there is a fault in the system.

Off road traction control or HDC regulation places an additional load on the brakes. To prevent overheating of the brakes and rotors, the temperature of the rotors is calculated over time from the road speed and amount of brake application. If the temperature of one or more rotors goes above 600<sup>o</sup> C, the traction control or HDC function for that wheel will be cancelled temporarily. Once the temperature of the rotor goes below 500<sup>o</sup> C, the traction application will be re-activated.

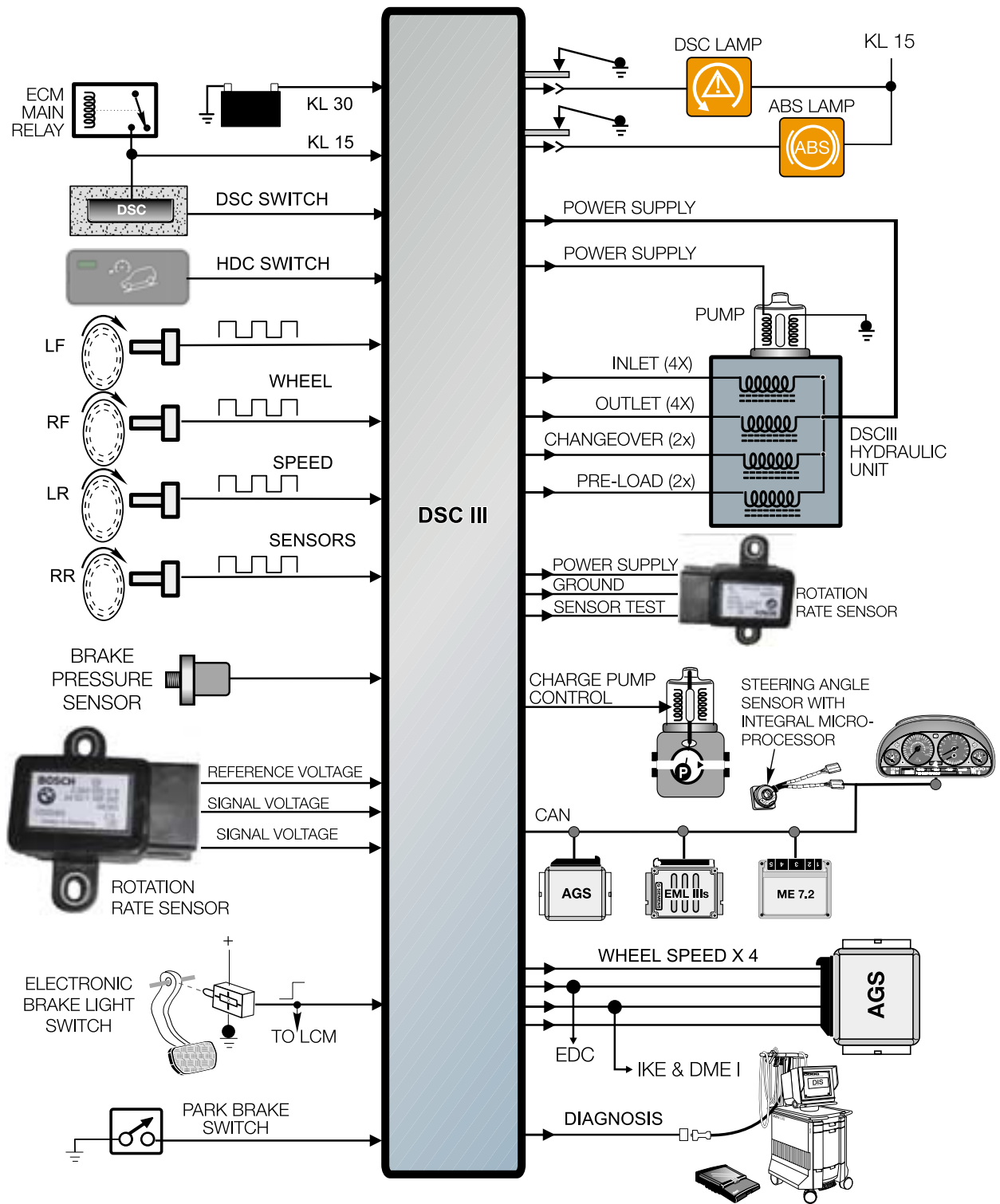
The normal braking function (including ABS) is always active at any temperatures.

## **DSC - NEW FEATURE**

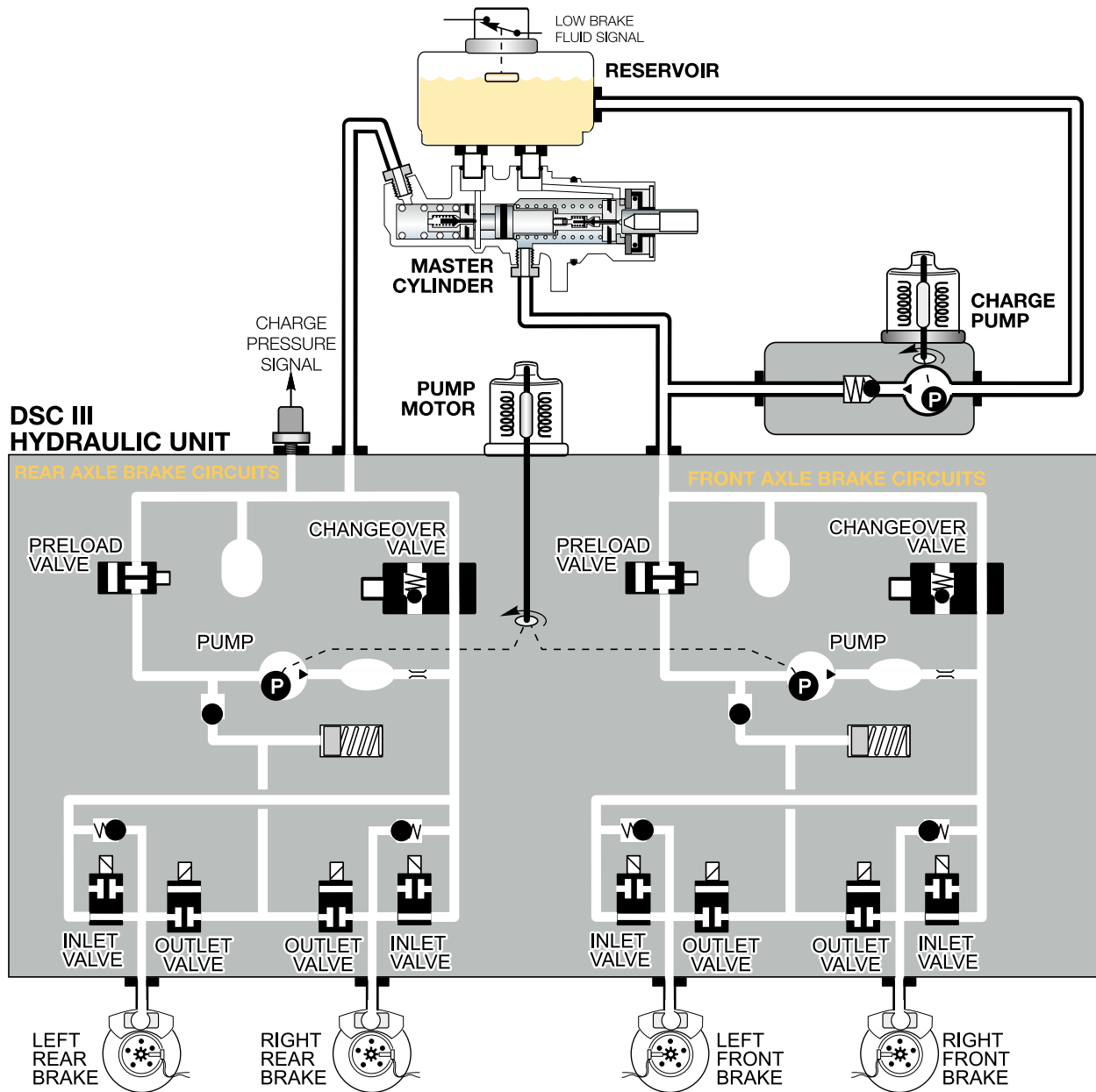
### **OFF-ROAD ABS Control Module Programming**

The programming for ABS regulation have changed to allow a higher threshold for ABS regulation when driving off-road in loose gravel or dirt. A locked wheel is more effective in slowing or stopping the vehicle because of the wedge that is built up in front of the tire.

The programming in the DSC control module allows one or both front wheel(s) to lock up to a speed of 12 MPH as long as the vehicle is traveling straight ahead. If the DSC control module receives a signal from the steering angle sensor indicating a turn, ABS regulation will activate to prevent the lock and allow the vehicle to be steered.







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## COMPONENTS

### CONTROL MODULE HYDRAULIC UNIT

The control module is integrated into the hydraulic unit as one compact unit. This reduces the size and wiring required for DSC operation. Additionally the motor relay and valve relay have been replaced by solid state final stages in the control module. The hydraulic unit continues to use:

- Two pre-charge solenoid valves
- Two changeover solenoid valves
- Four intake solenoid valves
- Four outlet solenoid valves
- One return pump

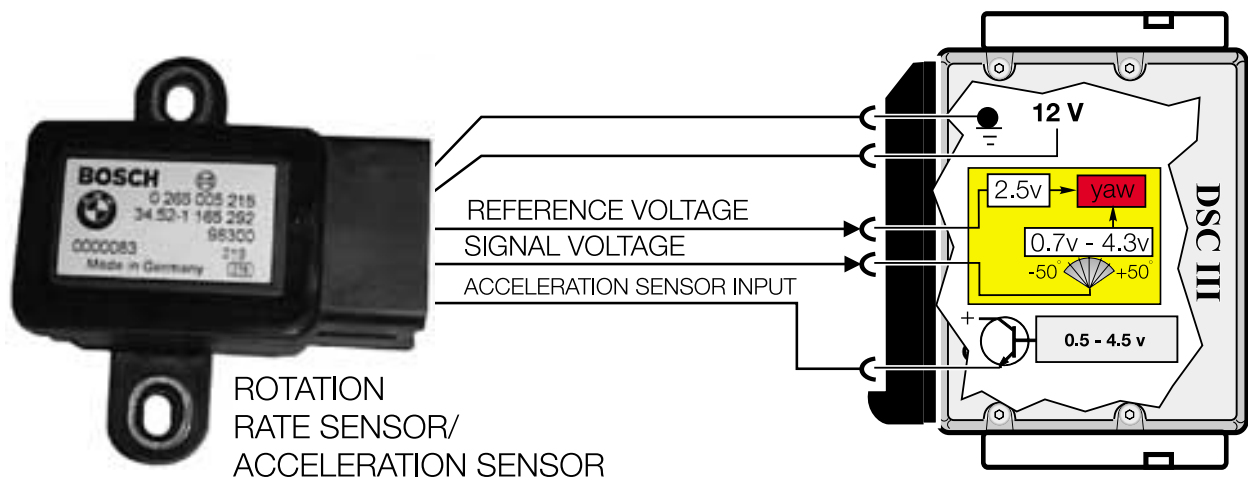


## ROTATION RATE/TRANSVERSE ACCELERATION SENSOR

Located under the center console behind the MRS III control module, the rotation rate and transverse acceleration sensor provides two inputs to the DSC control module. The sensor is isolated from body/chassis vibrations through its rubber mounting.

For rotational speed, the sensor produces a reference signal of 2.5 volts and a linear voltage signal from 0.7 to 4.3 volts. This linear voltage input signal is used by the DSC control module as the degree of rotational rate (yaw).

The sensor also produces a linear voltage signal for the lateral acceleration (G-force) that ranges from 0.5 to 4.5 volts. The DSC control module uses this input to determine the side forces acting on the vehicle for DSC regulation.



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## **BRAKE PRESSURE SENSOR**

A brake pressure sensor is installed in the hydraulic unit to determine the degree of pressure build-up for Dynamic Brake Control. It is installed in the front axle brake circuit.

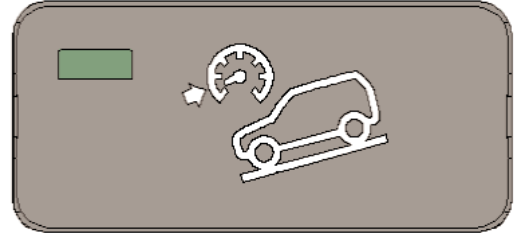
The sensor receives its power supply from the DSC control module and produces a linear voltage input signal ranging from 0.5 to 4.5 volts depending on how hard the brakes are applied.



# DSC III COMPONENTS

## HDC SWITCH

The hill decent control function is activated by pressing the HDC switch located in the center console. The LED will come on steady when the function is in standby and flash when HDC is regulating



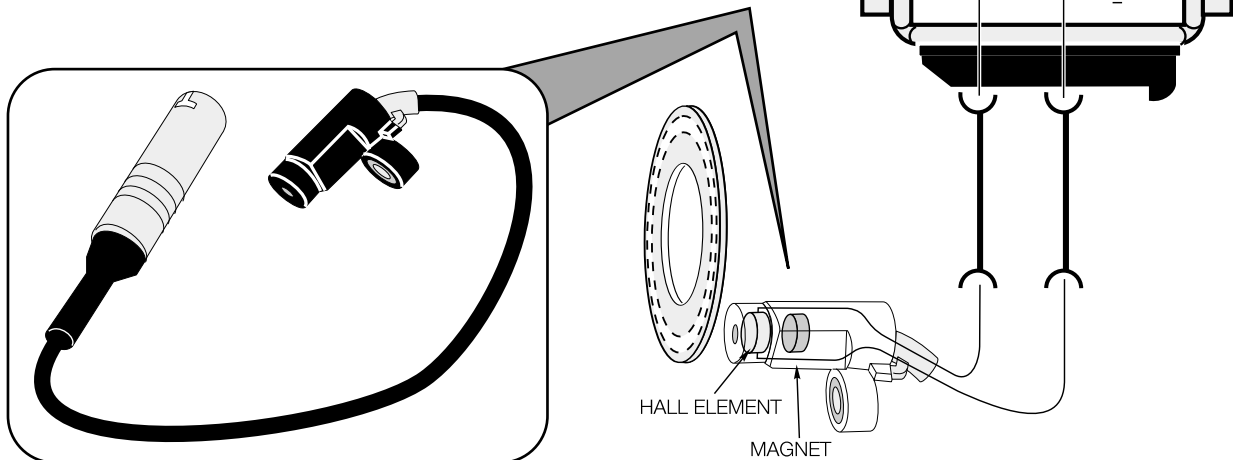
## DSC SWITCH

The system is active whenever the ignition is switched on. When pressed, the switch provides a momentary 12 volt signal to the DSC III control module to switch the system off (DSC indicator in cluster illuminated.) When pressed again, the system switches back on (DSC Indicator in cluster goes off.)



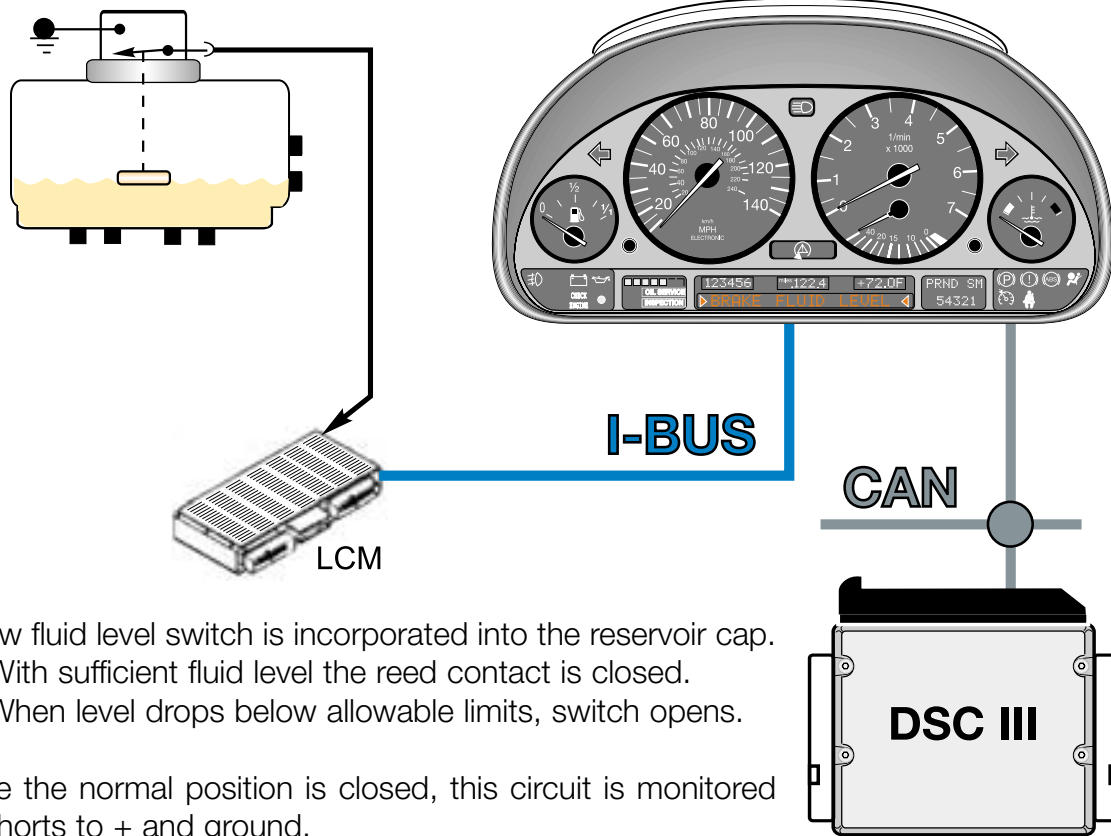
## WHEEL SPEED SENSORS

- 2 wire Hall Effect Sensor - "Square wave generator".
- 48 pulse incremental wheel incorporated in wheel bearing cover for contaminant protection. 48 pulses = one complete wheel revolution.
- Stabilized 8 volt power supply to hall element on one wire, ground path for sensor through second wire back to control module. Signal is generated by the pulse wheel affecting voltage flow through hall element creating a low of .75 and a high of 2.5 volts.
- Sensors identical to DSC II and ASC V systems.
- Sensors provide immediate vehicle speed recognition.





## BRAKE FLUID LEVEL WARNING SWITCH



A new fluid level switch is incorporated into the reservoir cap.

- With sufficient fluid level the reed contact is closed.
- When level drops below allowable limits, switch opens.

Since the normal position is closed, this circuit is monitored for shorts to + and ground.

The LCM constantly monitors the input. If the ground signal is **momentary**, the LCM signals the Instrument cluster of the condition. The instrument cluster then informs the DSC III control module over the CAN bus. If the signal is received just prior to the activation of the charge pump, the charge pump activation is delayed.

If the signal is present for more than 25 seconds, the LCM issues two I BUS message for the Instrument Cluster:

1. Post "Brake Fluid Level" in the Matrix display
2. Notify the DSC III via CAN that the Fluid level has been low for more than 25 seconds.

The DSC III control module immediately switches DSC III functions off and continuously illuminates the DSC indicator in the cluster.

## DIAGNOSIS

Diagnosis and troubleshooting of the DSC III system is carried out using the DIS Tester or MoDiC. The DSC control module performs a self check every time the ignition is switched on. The warning lamps for DSC and ABS will remain on during the self check.

Any faults with the system will cause the lamps to remain on when the engine is started. Faults that only effect the DSC operation will cause the DSC warning lamp to remain on, however ABS can still function.

If the battery has been disconnected, the DSC warning lamp will remain on until the vehicle receives road speed signals front the front wheel speed sensors and the steering angle sensor can calculate the direction of travel.

