Reference Manual

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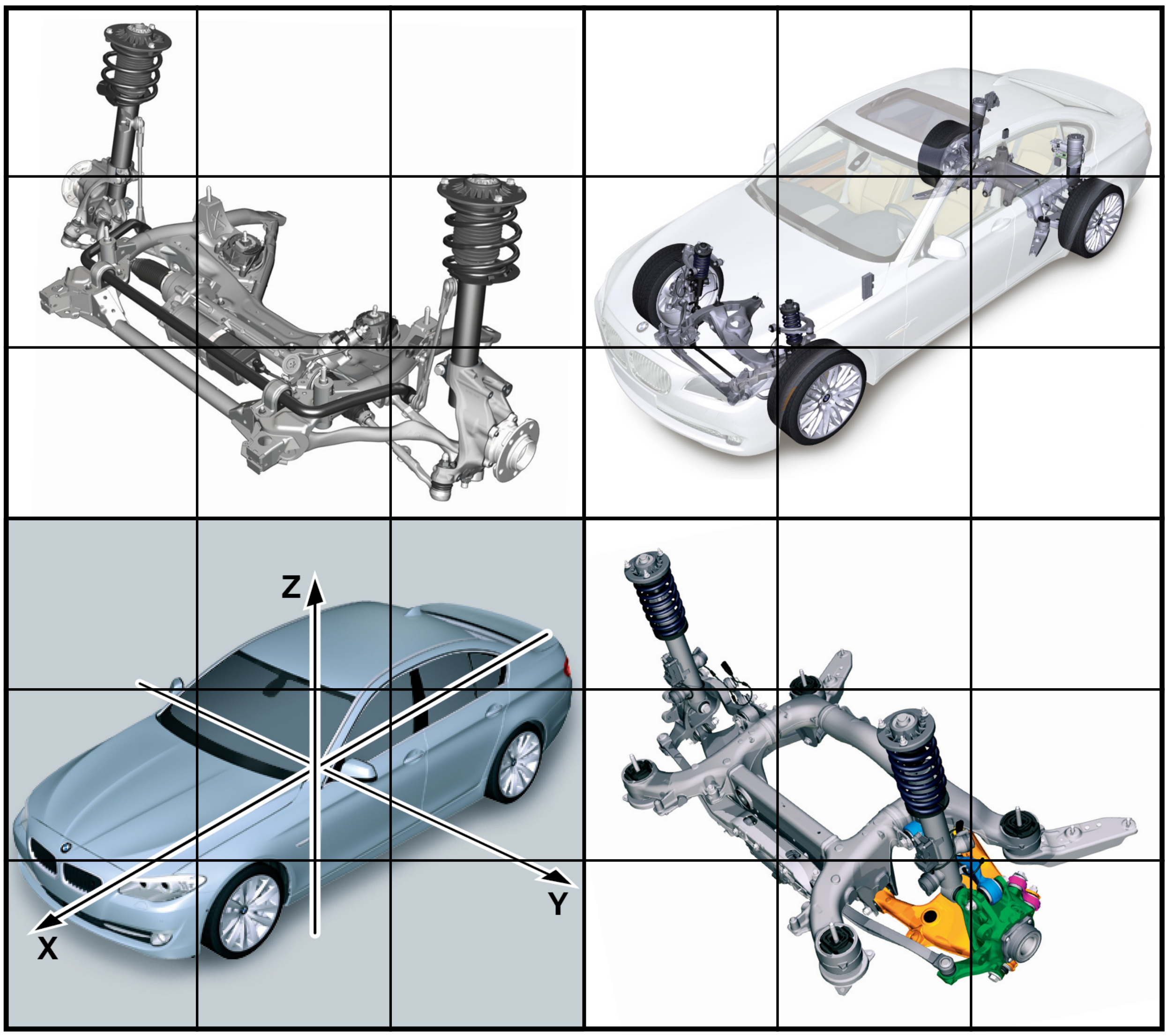
Technical Training

Chassis Dynamics



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Longitudinal Dynamics (X Axis)

Model: All

Production: All

OBJECTIVES

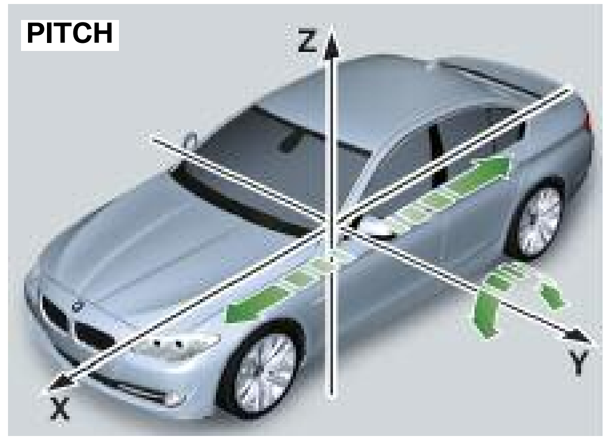
After completion of this module you will be able to:

- Understand basic ABS operation
- Understand ASC concepts and applications
- Understand DSC operation and differences between ASC and DSC

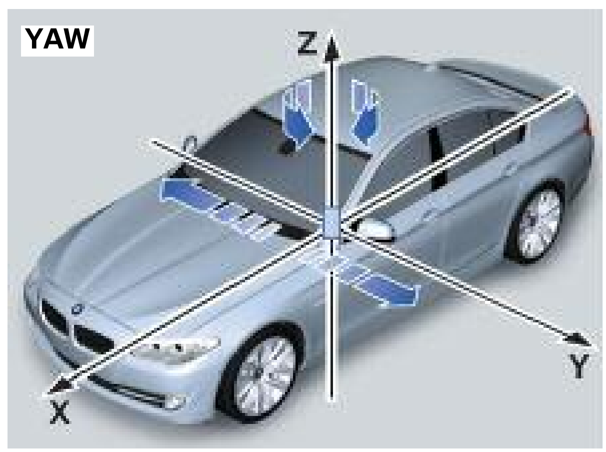
Introduction

The driving stability control systems can be distinguished by their basic force-transfer directions. Driving stability control systems can act both along and around an axis of the vehicle-fixed coordinate system X, Y and Z.

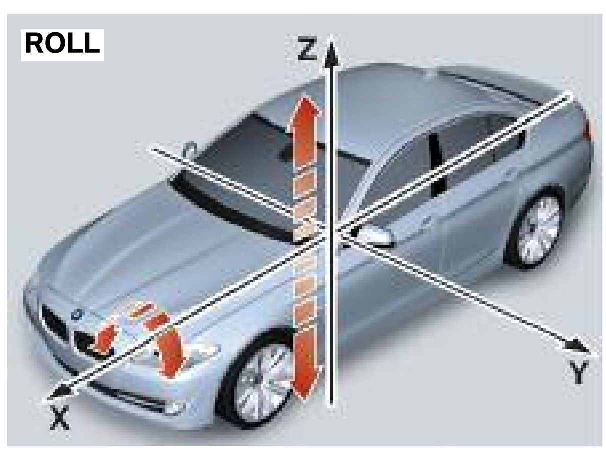
Longitudinal Forces
Longitudinal / Pitch forces act on the vehicle along the centerline or X axis. These forces are created by acceleration and braking. They are refered to as "Pitch" due to the up or down movement that influence the hight of the front and rear of the vehicle.



Lateral Forces
Lateral / Yaw forces are also known as transverse forces which act to deviate the vehicle along the Y axis. These forces are most prevalent during turns. Loss of traction, excessive steering angle and even crosswinds will contribute to increased lateral forces which will tend to veer the vehicle off its intended path.



Vertical Forces
Vertical / Rotational forces more commonly known as body "Roll". The motion created as the vehicle deviates from its vertical (Z) axis and rotates along the X axis. These forces are also experienced during turns. The speed of this force indicates the degree of turning force.



Anti-lock Brake System Theory

The ability to slow or stop a vehicle depends upon the braking forces applied to the wheels and the frictional contact that exists between the tires and the road surface. Very low frictional forces exist when the tire is locked (or skidding). A locked tire also causes a loss or the lateral locating forces that effect directional control of the vehicle. The result of a locked tire (or tires) is the loss of steering control and stability.

The major forces that affect how easy a tire will lock include:

- The braking force applied from the vehicles braking system.
- Environmental factors - rain - ice - snow - etc.
- Type and condition of the road surface.
- Condition of the tires (tread and design).

The anti-lock braking system is designed to allow the maximum amount of braking force to be applied to the wheels without allowing the wheels to lock or skid.

The advantages that ABS provides includes:

- Driving stability - by maintaining the lateral locating forces between the tires and the road surface.
- Steerability - allowing the driver to continue to steer the vehicle while stopping (even during panic stops) or accident avoidance maneuvers.
- Provides optimum braking distances - the rolling wheels transfer higher frictional forces to slow the vehicle.

Brake Regulation

In order to prevent the wheels from locking during braking, yet provide the optimum braking force for maximum braking efficiency, the ABS braking system must:

- Have the ability to monitor the wheel rotation rates.
- Be able to regulate the braking forces applied to the wheels.

The ABS system carries out these functions with an electronic control system. The components of the ABS system include:

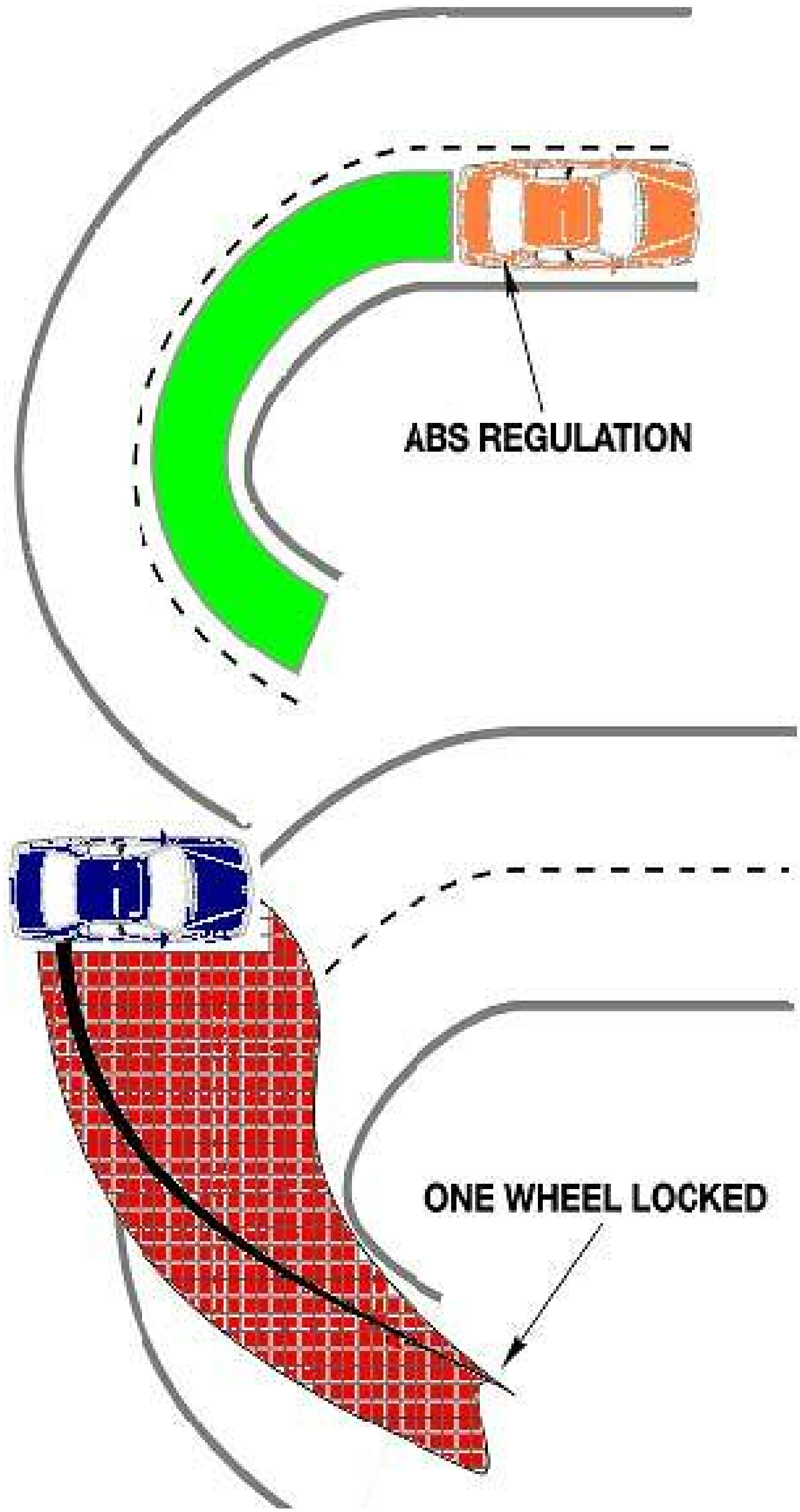
- The electronic control module
- The wheel speed sensors
- The brake hydraulic unit
- The brake master cylinder

The four wheel speed sensors are used as inputs to the control module. The module uses these signals to determine wheel speed, wheel acceleration and deceleration. ABS controlled braking starts when the module detects that one or more wheels are about to lock.

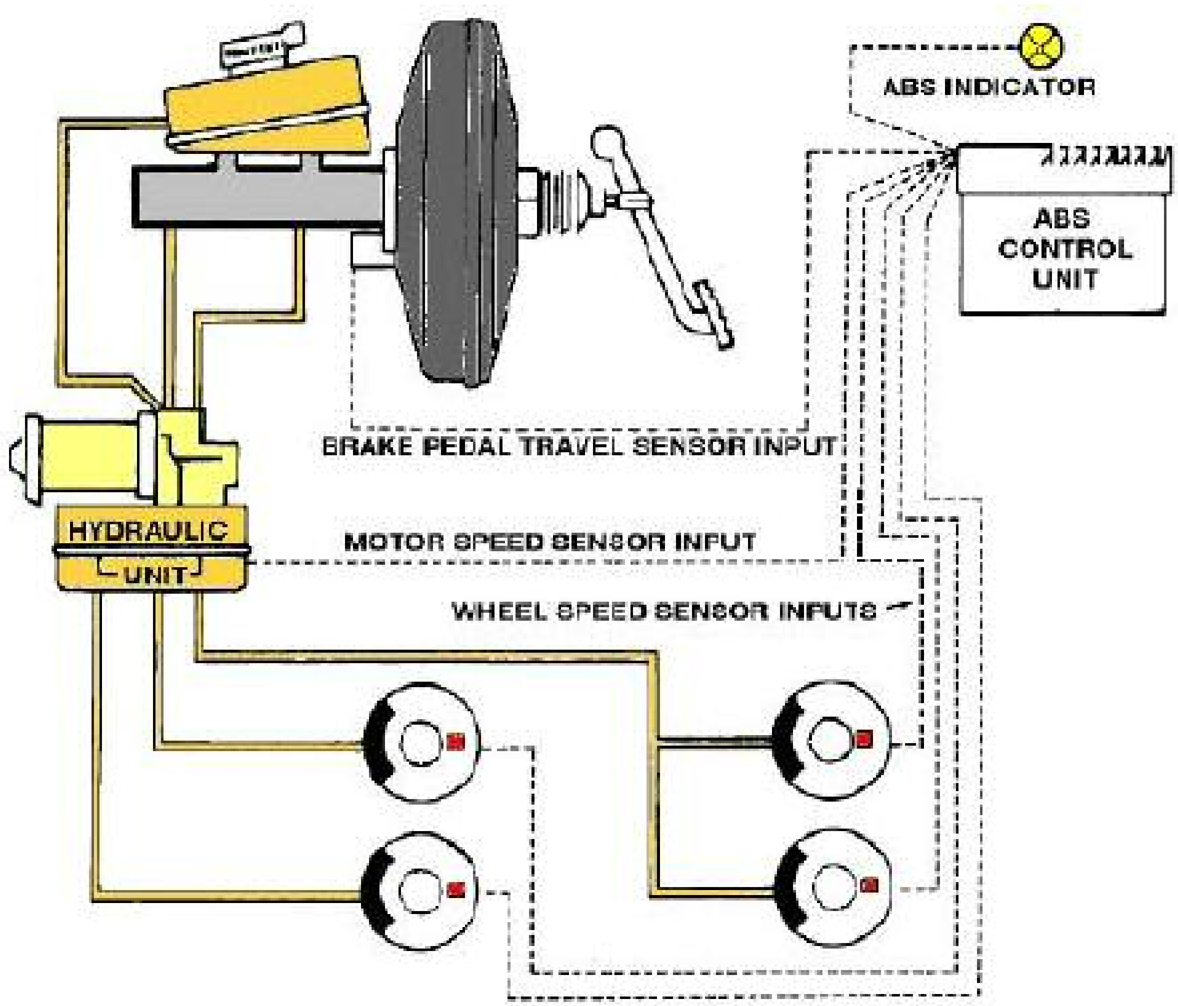
Once activated, the ABS control module rapidly pulses the brakes on the affected wheel This allows the vehicle to be slowed down while still maintaining steerability and directional stability.

The ABS pulses the brakes through solenoids mounted in the hydraulic unit. The solenoids regulate the pressure to the affected wheel through three phases of control:

- Pressure Hold
- Pressure Drop
- Pressure Build


ABS REGULATION
ONE WHEEL LOCKED

ABS System Overview



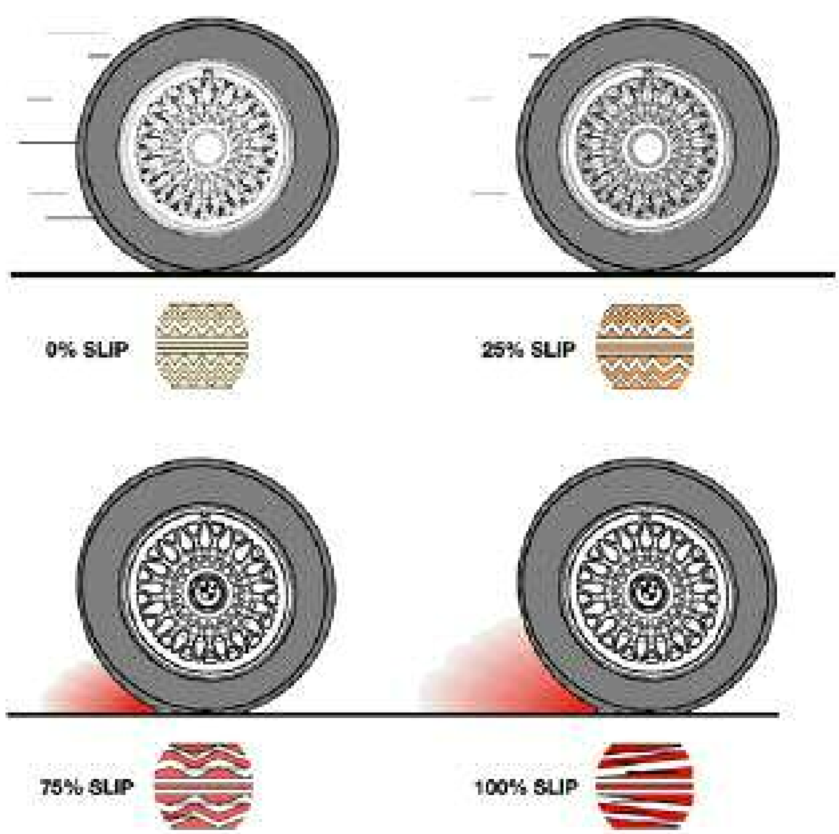
Braking Forces

When the brakes are applied, brake force counters the inertia of the moving vehicle. This force is created by the brake pads acting on the rotors and through the wheel and tire to the roadway. Even in the best of conditions, some wheel slip occurs. Up to a point this wheel slip is acceptable and in most cases it can even be helpful.

When braking, the transmitted brake force concentrates at the tire "foot print", where the rubber meets the road. This causes a distortion which, when excessive, promotes wheel slip.

When controlled, the distortion can actually enhance the transmission of brake force.

Therefore, the ABS logic allows wheel slip up to 20-25%. Beyond that the ABS system limits the application of additional brake force. This allows the transmission of maximum brake force while reducing the stopping distance.



The transmission of braking forces and the retention of Lateral Locating Forces are inverse. That is to say as braking forces increase the locating forces decrease.

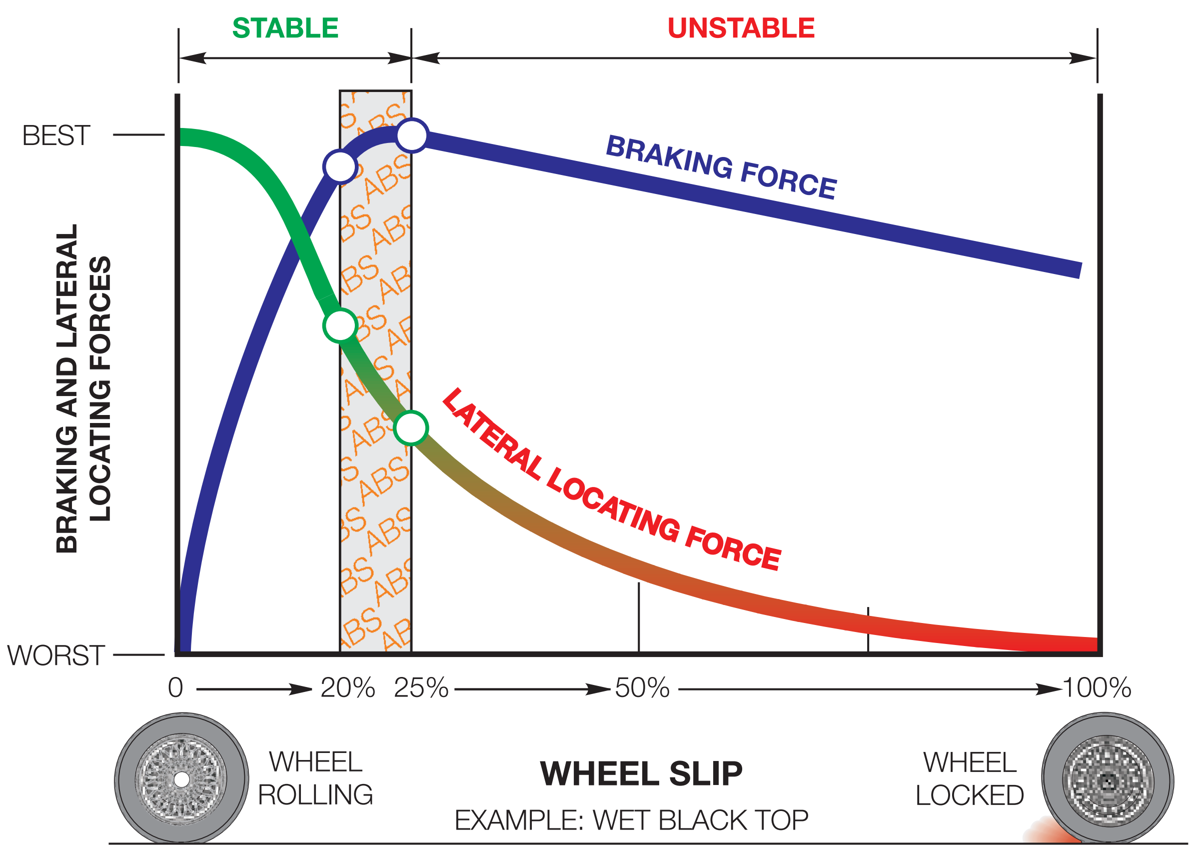
As indicated in the chart, the rolling wheel has a wheel slip value of 0% which provides the best Lateral Locating Forces.

As the applied brake force increases the locating force decreases. Depending on the prevailing road surface friction, the optimum transmission of brake force is at the end of the "stable range" with a wheel slip value of 20-25%.

Additional brake force at this point is clearly counter-productive as the additional brake force only increases wheel slip and reduces Lateral Locating Forces.

Therefore the ABS system limits wheel slip by regulating the application of brake force while providing the shortest possible stopping distance.

Braking Analysis Graph



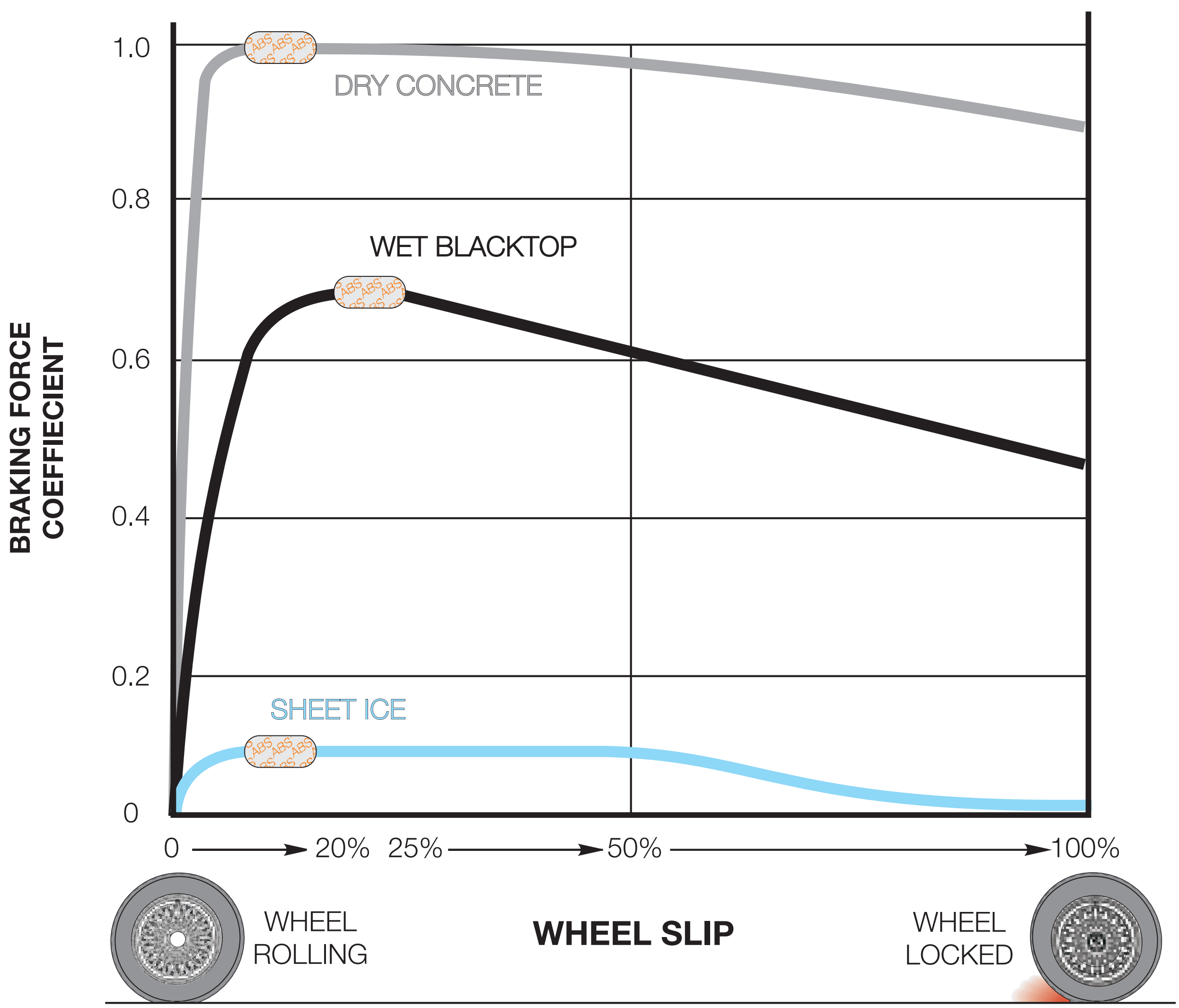
Road Surface
Clearly the condition of the roadway and weather conditions are significant influences regarding wheel slip and the retention of Lateral Locating Forces.

As road surfaces vary and weather conditions impact the tire's ability to maintain good rolling contact, the function of the ABS remains unchanged. Only the stopping distances increase due to the regulated transmission of braking force.

Whatever the road surface or weather, the wheel slip will still be limited to 20-25%.

Regardless of the ABS system, good judgement and common sense are still required.

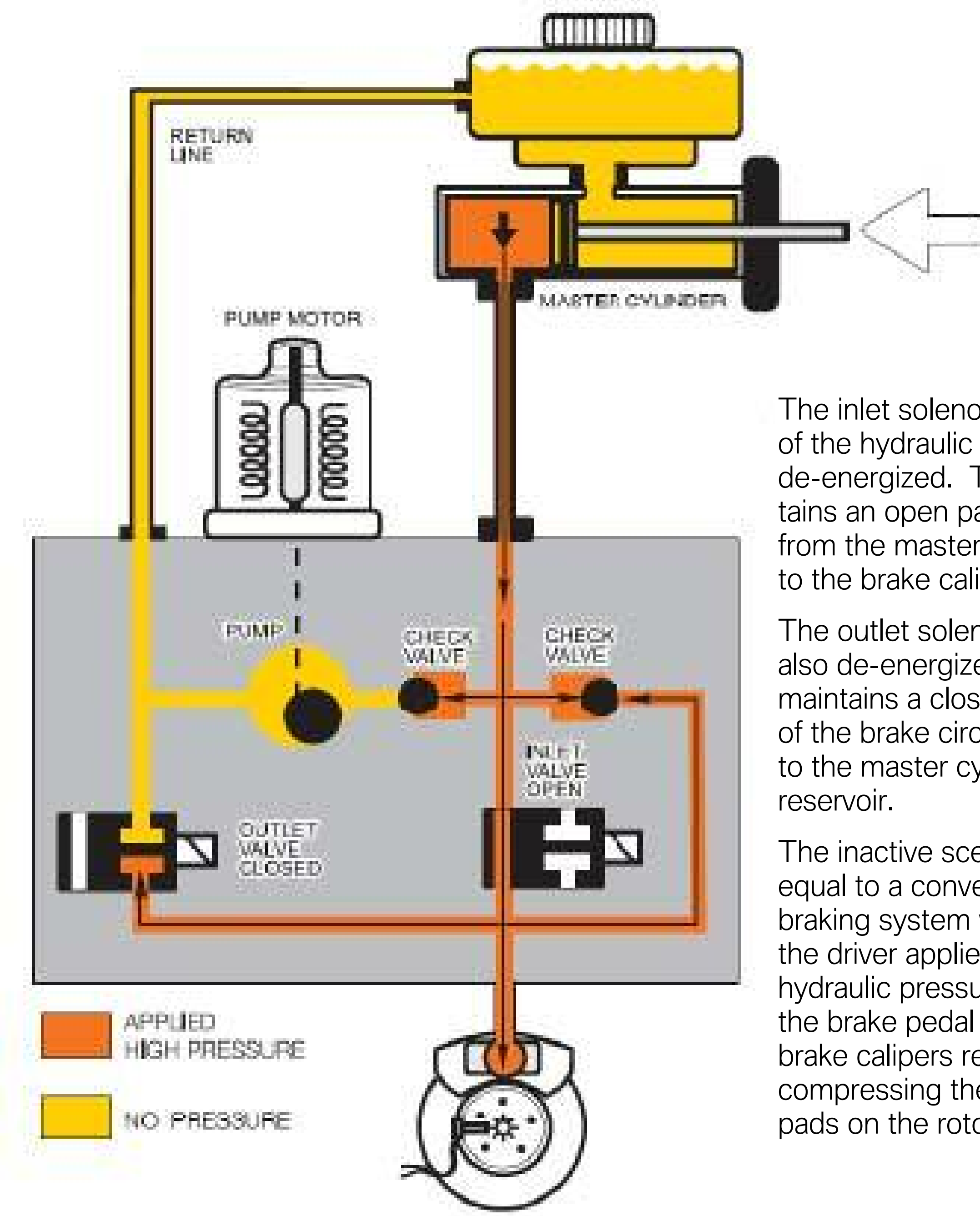
Grip Analysis Graph



ABS Operation

Normal Braking

The ABS control module constantly monitors and compares the wheel speed sensor signals. When all four signals are at the same frequency within a small window of tolerance, the ABS system is not active and normal braking takes place.



The inlet solenoid valves of the hydraulic unit are de-energized. This maintains an open passage from the master cylinder to the brake calipers.

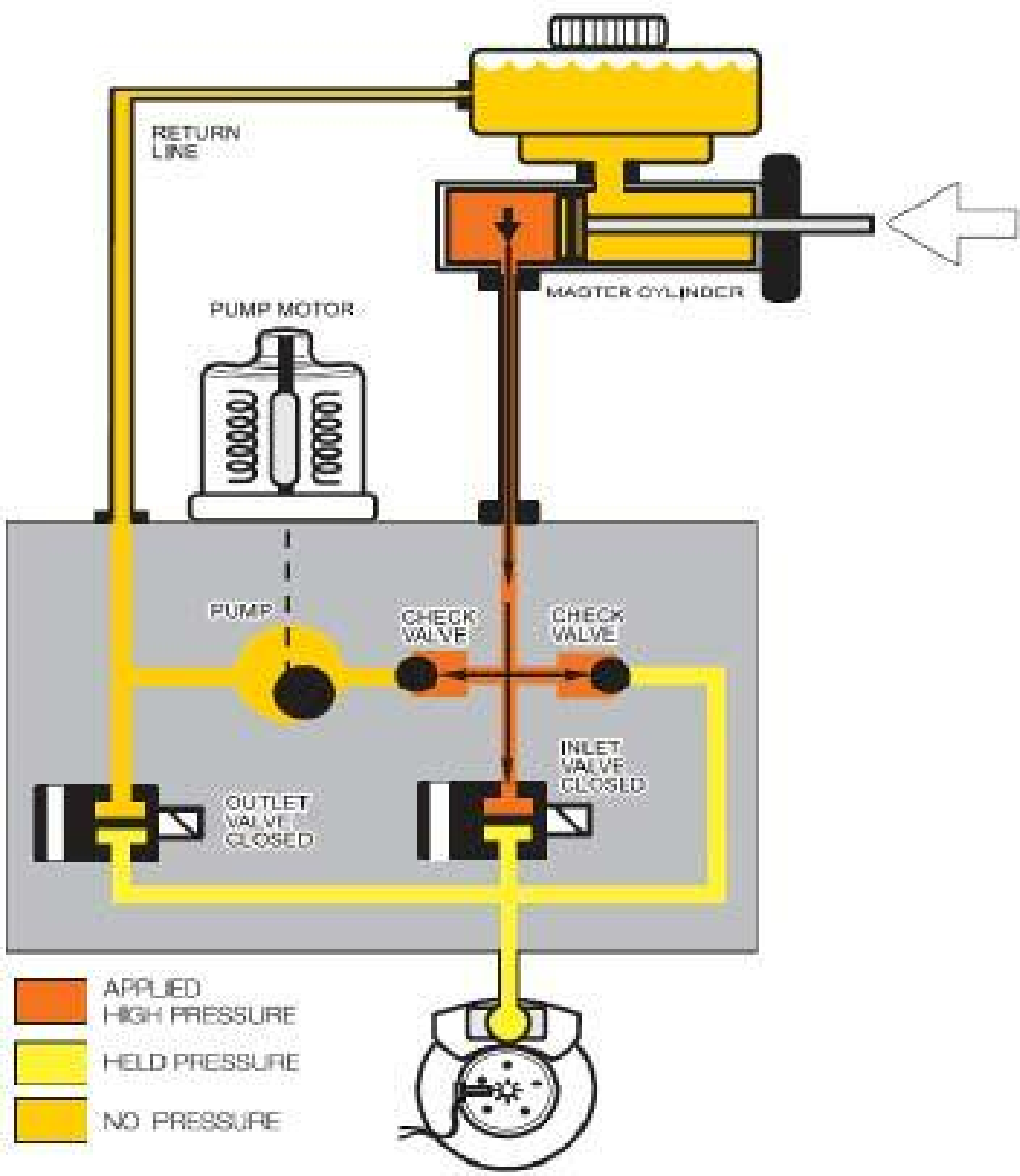
The outlet solenoids are also de-energized. This maintains a closed outlet of the brake circuit back to the master cylinder reservoir.

The inactive scenario is equal to a conventional braking system where the driver applies hydraulic pressure from the brake pedal and the brake calipers react by compressing the brake pads on the rotor.

Pressure Hold

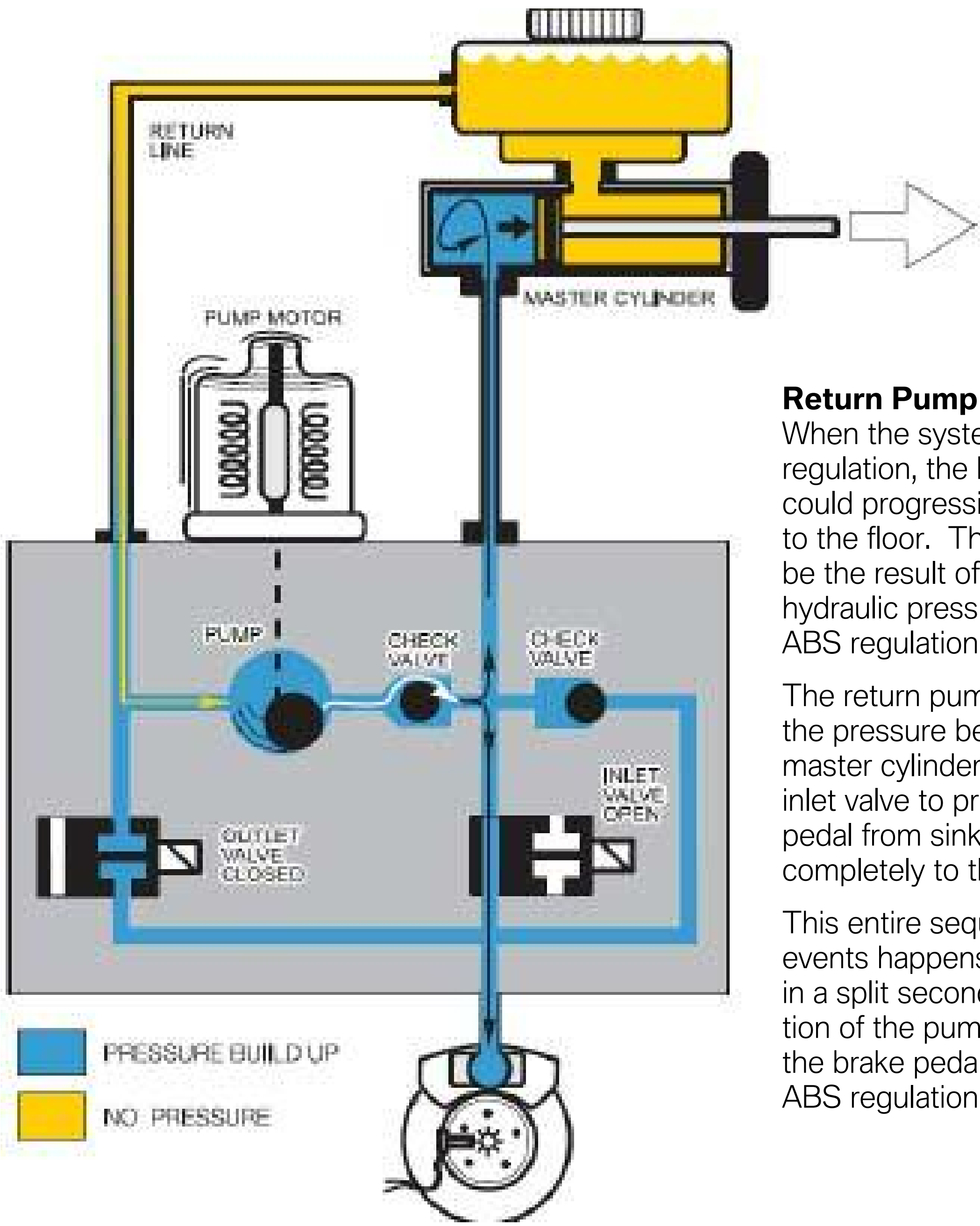
If the control module detects a decrease in the frequency (rate of deceleration) of one or more of the individual signals it perceives this as possible wheel lock.

The control module energizes the inlet valve for that specific brake circuit. This closes the inlet port and prevents any additional hydraulic pressure from being exerted on the brake caliper by the driver.



Pressure Build
The control module de-energizes the inlet and outlet valves. This returns the brake circuit back to normal braking and the hydraulic pressure is once again determined by the driver's pedal force.

This sequence continues rapidly until the wheel speed signals are once again acceptable and the contact of the road and the tire surfaces are restored.



Return Pump Activation
When the system is in regulation, the brake pedal could progressively sink to the floor. This would be the result of bleeding hydraulic pressure during ABS regulation.

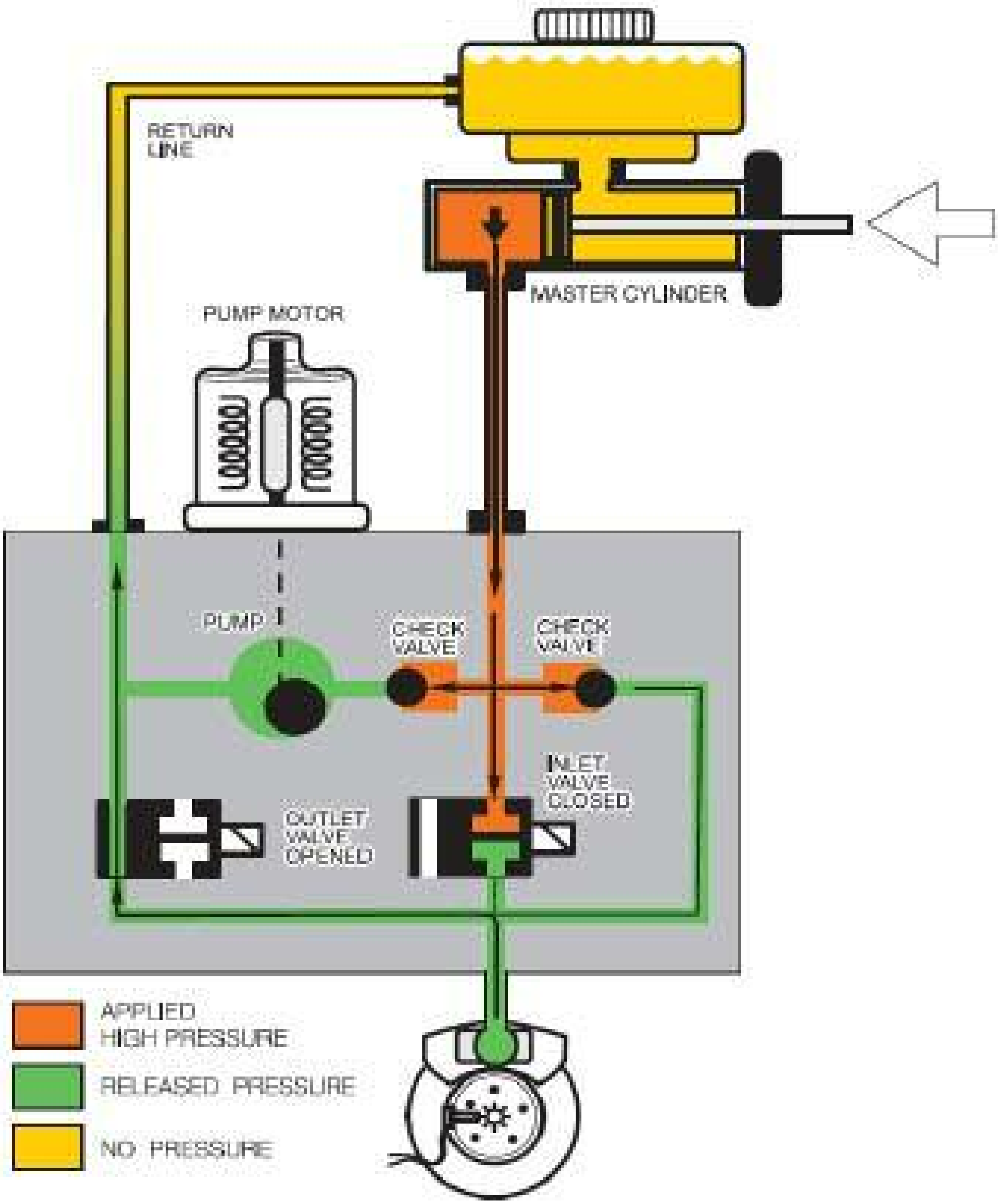
The return pump maintains the pressure between the master cylinder and the inlet valve to prevent the pedal from sinking completely to the floor.

This entire sequence of events happens repeatedly in a split second. The function of the pump is felt in the brake pedal during ABS regulation.

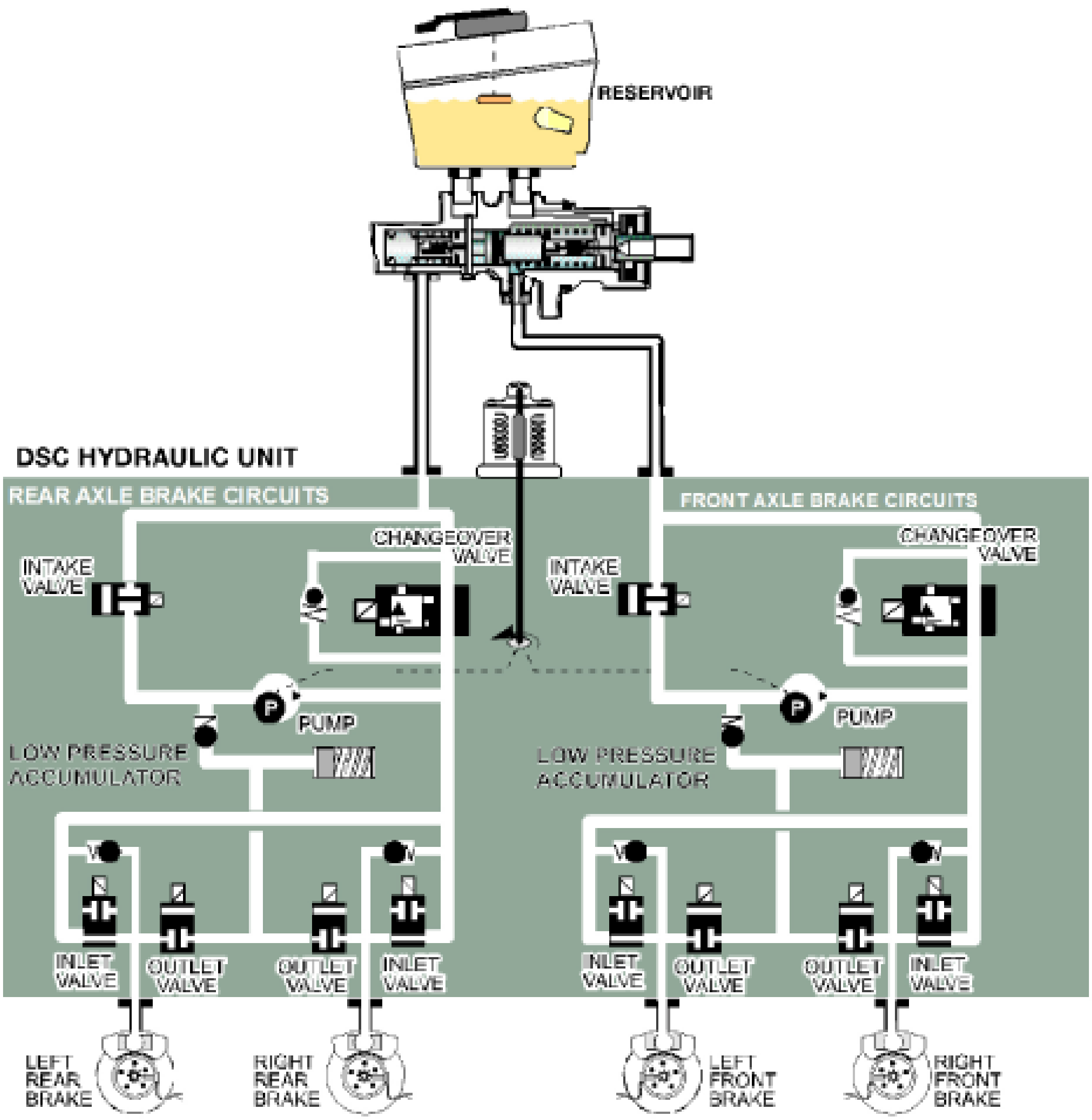
Pressure Drop

With the inlet valve closed the pressure on the caliper is stabilized and isolated. The control module energizes the outlet valve which opens the outlet port and drops the pressure in the isolated portion of the circuit.

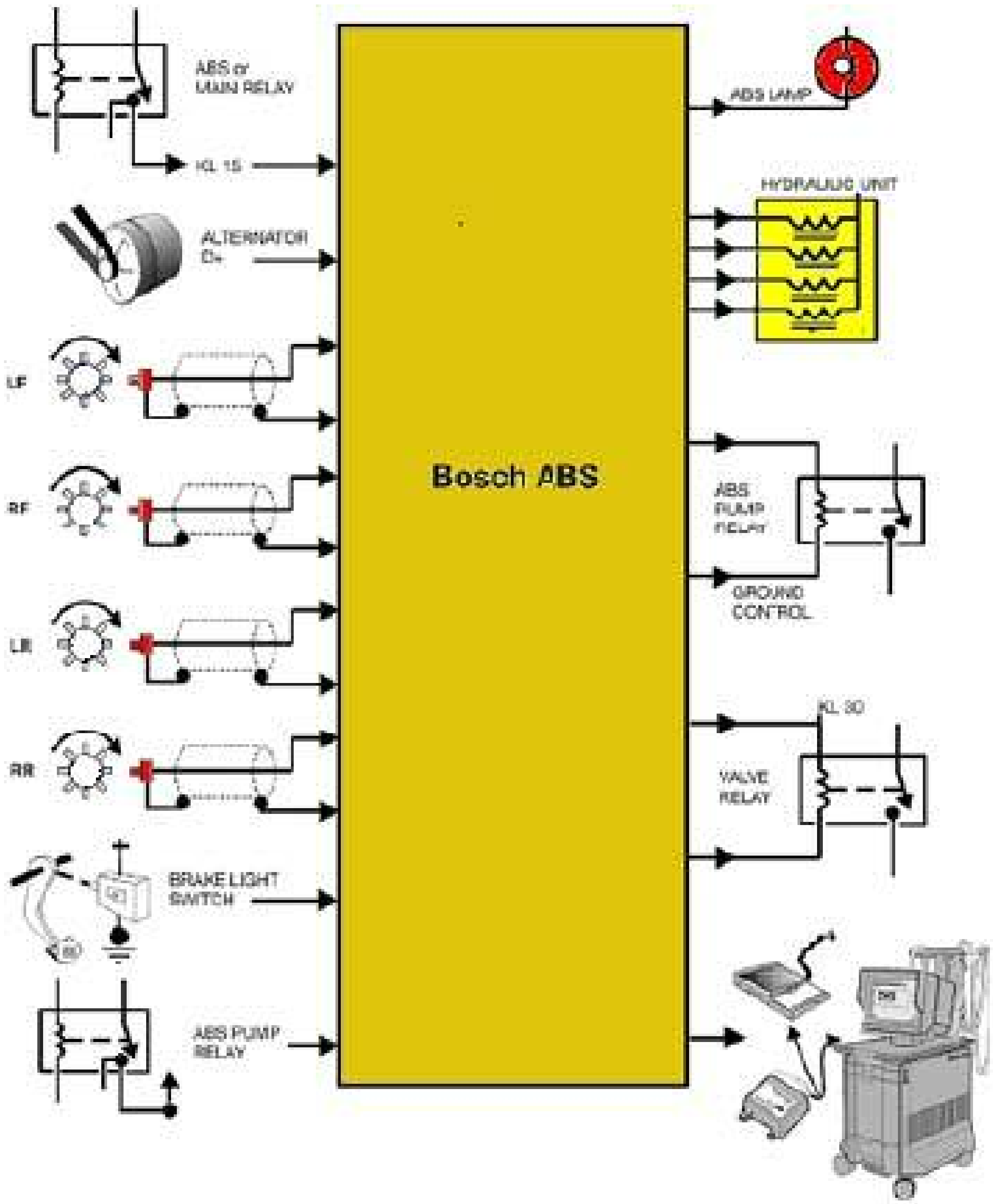
The brake fluid flows back to the master cylinder reservoir.



Typical ABS / DSC Hydraulic Schematic



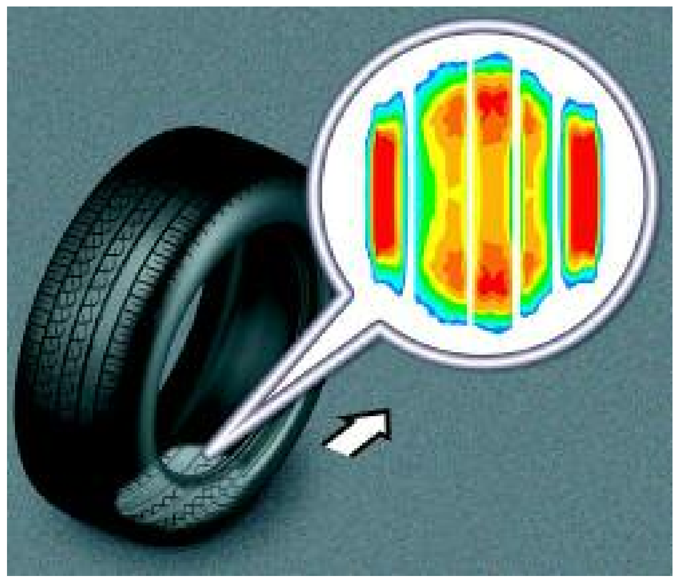
Typical ABS System I-P-O



ASC and DSC

The link between the vehicle and its driving environment is established by the frictional contact between the tires and the road surface.

If this frictional contact is compromised by excessive slip or wheel spin, the resulting loss of traction will impair the driver's ability to control the vehicle.



Automatic Stability Control (ASC)
The primary function of ASC is to maintain traction and stability at the rear wheels, regardless of the road surface condition. If either rear tire exceeds its ability to maintain traction or lateral stability, the ASC system will intervene to reestablish proper tire contact with the road. This is achieved by reducing the drive torque applied to the rear wheels or by pulsing the rear brakes to reduce wheel slip, depending upon the version installed in the vehicle.

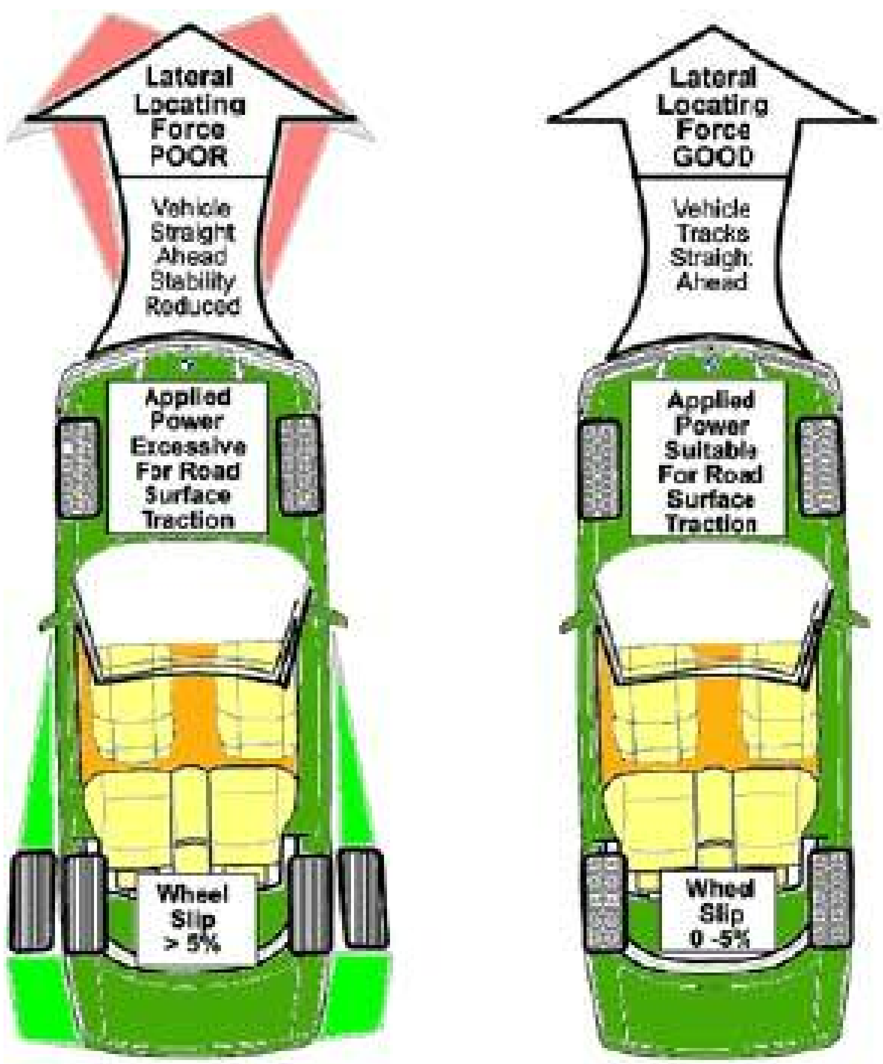
ASC Components and Operation

The electronics for traction control operation are incorporated i the ABS control module and share many of the same components and sensors. The module determines the speed of the vehicle by averaging the four wheel speed inputs. Wheel slip is determined by comparing the speed of the rear driven wheels to the speed of the front undriven wheels.

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

The ASC intervenes to reduce slip in two ways:

- Engine Intervention (ADS)
- Brake Intervention (ADB)



Engine Intervention

Engine Drive Torque Reduction (ADS)

- Reducing the throttle opening angle by interfacing with the DME, EML or ADS control module, depending upon vehicle equipment.
- Retarding the ignition timing.
- Canceling individual cylinder operation through fuel injector cutout.

Engine Drag Torque Reduction (MSR)

The traction control system can reduce the effect of engine braking on deceleration through the following:

- Opening the throttle or idle control valve depending upon application.
- Ignition timing and canceling fuel injector control decel cutoff through the interface with the DME.

Brake Intervention

ADB is an automatic differential transfer strategy that improves traction. The slipping wheel is braked by pressure generated by return pump of the hydraulic unit. The drive torque is then directed through the differential to the wheel with greater traction, which is able to transmit power to the road. This function is used in place of a limited slip differential.

Brake intervention is applied in three phases:

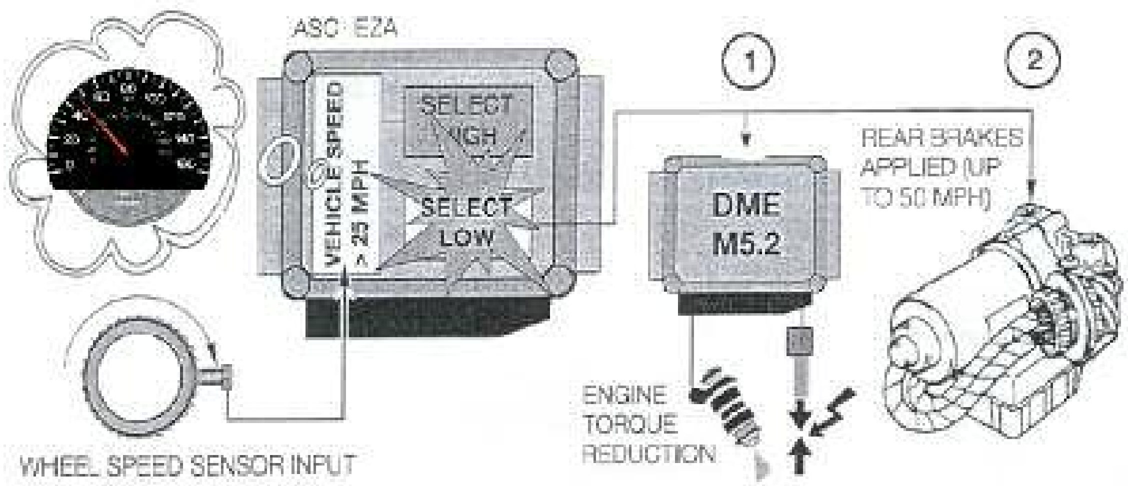
- Pressure Build
- Pressure Hold
- Pressure Drop

There are two strategies of brake intervention used in ASC:

- Select High Regulation: Which applies brake pressure to individual wheels.
- Select Low Regulation: Which applies brake pressure to both rear calipers at the same time.

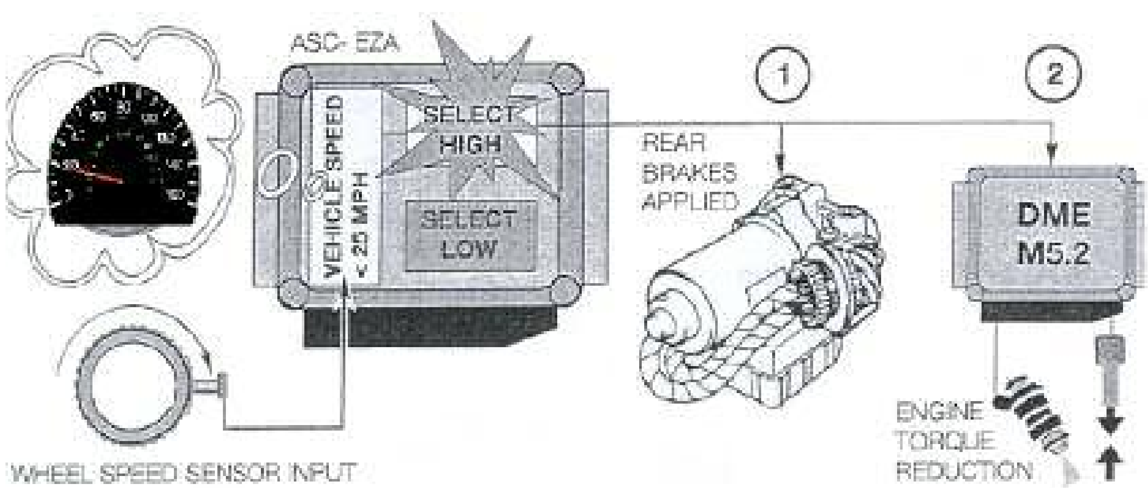
Select High Regulation

Select high regulation is employed at lower speeds, up to approximately25 MPH, when traction is the higher priority. The ASC provides individual brake application for either rear wheel. This action slows the spinning wheel, transferring torque to the wheel with the greater traction.



Select Low Regulation

Select low regulation is used at higher speeds (25 to 50 MPH) when stability is the higher priority. The ASC applies the braking force to both rear wheel at the same time, which creates a stabilizing drag on the rear axle.



ABS, ASC, ASC + T, DSC, Versions

ABS introduced in 1985, on all vehicles in 86. Bosch control unit uses inductive wheel speed sensors. Diagnosis via break out box, or SI 4 33 92 & tool# 345 110 to diagnosis.

1) **ASC only**, 1989, 750, Bulb for faults and on indicator, in the ASC switch. S.I. 04 33 92 is the tool for diagnosis of the first three "flash code" systems (90 88 6 345 110).
2) **ASC only**, Starts in mid 1990 production, and later 750, 850, 535, and 735. The bulb is in the dash for faults and off indicator. In 92 this is still used on the 535 only and is DIS and TXD compatible.
3) **ASC + T**, 1990 = 750, 1991 = 850, The bulb is in the dash for faults and off indicator. These 'T' versions (# 3,4 and 6) use a separate hydraulic unit for brake application to control rear wheel slip on acceleration. See T.I. 34 01 90 (2105) 10-90.
4) **ASC + T, diagnosable** with DIS and Modic as of 1-92. No flash codes.
5) **ASC + T with ADS**, 9-92, 740, A separate ADS control unit, actuator and throttle plate eliminates the need for EML. See T.I. 34 01 92 (2129) 9-92.
6) **ASC + T Teves** (Mark IV), all previous versions were Bosch. As of 9-93 on the E-36 only. This version uses no EML or ADS control unit. It also uses one hydraulic unit for ABS and ASC regulation. See T.I. 34 01 93 (2136) 9-93.
7) **ASC + T5** - 1994 model year on the 5 and 8 series. The E-38 uses this version in 1995, the E-39 in 97. This version is Bosch and uses only one hydraulic unit for ABS and ASC. There is not a separate ADS control unit. The master cylinder is split front and rear for this system. This is a 83 pin C.U. See T.I. 34 01 94 (2142) 9-94 As of 9-96 there is a new feature that varies brake pressure while cornering. The outside wheels have less brake pressure to compensate for the increased weight shift while in a corner.
8) **DSC II** - 95 750 The front wheel speeds are monitored and compared for slip due to understeer or oversteer. Power is controlled to stop front wheel slip also! The steering wheel angle is also an input for this new function (95 Update).
9) **Teves Mark IV G** - The E-36 ABS changed in 95 to a closed system with a 42 pin C.U. The Master cylinder now has valves for fluid transfer from the hydraulic pump (95 Update.)
10) **ASC - EPA** - Bosch, 42 pin, for the M44, without throttle regulation 96 models (M-62 book) The M44 receives throttle regulation as of 1-97 (97 Update) .

All 97 Models have ASC as Standard Equipment.

11) **Bosch DSC III** (5.3) - 98 E38 & 540. Rotation rate sensor and lateral acceleration sensor added to DSC II and located under the drivers seat. Steering angle sensor is on the can bus, charge pump and charge pressure signal new also. Front or rear brake applied by DSC to aid in cornering (97 Update II).

12) **99 Bosch DSC III Systems (5.7)** the CU is on the Hydraulic unit. V-cable 90 886 345 240 is needed. Rotational & acceleration sensor now one unit. E65 uses 3 hall sensors and microprocessor for wheel speed. This sensor signals forward, reverse and stationary. This system is also on the 2001 E46 all wheel drive. (99 Update) Charge pump deleted on the X5 in 11-01 SI 34 9 01.

13) **Teves MK 20 EI**. The 99 E46 has the CU and Hydro unit together below the master cylinder (CBC) corner braking control, (EBV) electronic braking proportioning.

14) **Teves MK 20 DSC** E46 Option in MY99 STD. MY2000 DSC III steering angle sensor, charge pump, yaw sensor, lateral acceleration sensor, brake pressure sensors.

15) **Teves DSC III MK 60** E46 MY2001(DBC) Dynamic brake control (DBS) Dynamic brake system, Magnetoresistive wheel speed sensors, CBC, EBV, MSR, ADB, Elimination of Charge pump. MK60E5 in 2006 with disk brake drying, start off assist. E90, E60 M5 SBT 34 01 04(107.)

16) **Bosch DSC8** on the E60 introduction. Eliminates the charge pump, smaller CU otherwise similar to 5.7. **DSC8 Plus** on the E60/61 has disk brake drying, start off assist. SBT 34 01 05(126).

ABS – Braking slip control

ASC – Acceleration slip control

DSC – Cornering slip control

12/05

Dynamic Stability Control (DSC)

Purpose of the System

DSC adds a further dimension to the traction control system. DSC adds lateral control to this already proven system. The traction control system was designed for longitudinal stability and providing the optimum traction for driving off.

DSC II has the ability to mildly correct for lateral instability and only at the rear brakes when braking control is necessary.

DSC III has the ability to brake any wheel during cornering maneuvers where the control module's programmed limits for vehicle oversteer and understeer are exceeded.

The DSC II system monitors the input values from the two front wheel speed sensors and the steering angle sensor. The rotational speeds of the front wheels for the given turning angle are compared to the programmed values in the DSC control module. If the values are outside the programmed limits, DSC regulation will be activated.

New sensors were added to the DSC III system to monitor the rotational rate of the vehicle around its vertical axis and a lateral acceleration sensor to monitor the side to side forces on the vehicle.

On DSC II or DSC III systems, the control regulation follows the same outputs as for traction control regulation with:

- Throttle valve regulation
- Engine intervention
- Rear brake control on DSC II
- 4 Wheel brake control on DSC III

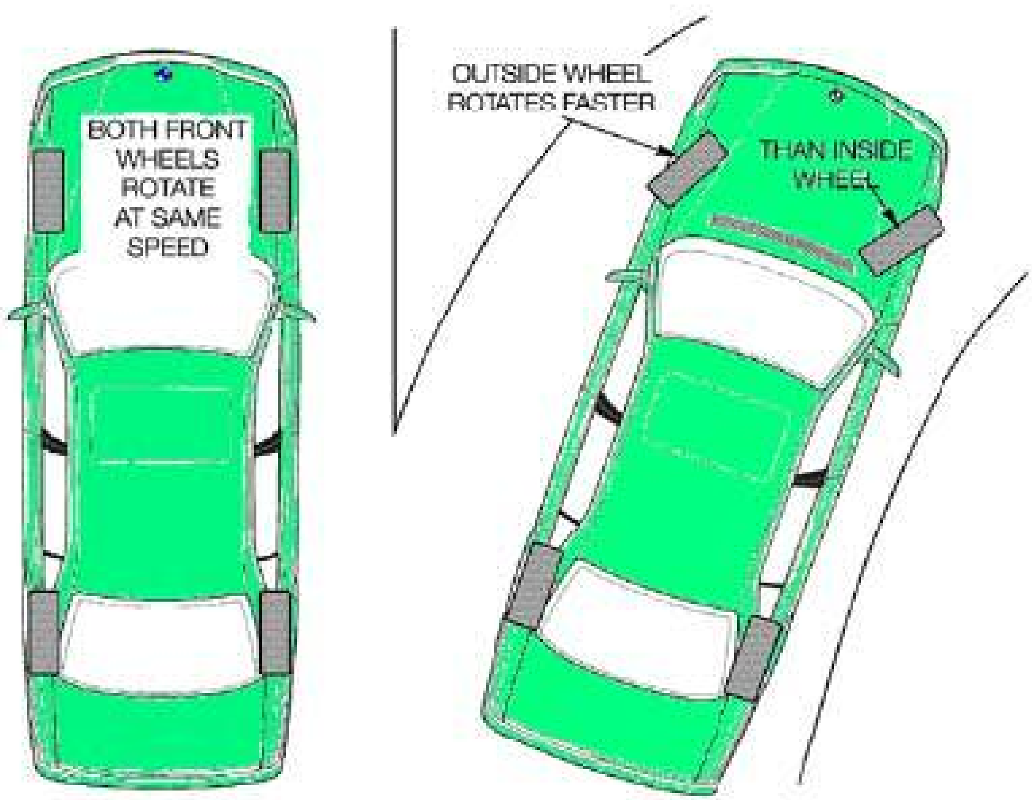
The control phases are brief and only occur long enough to correct the unstable condition.

Dynamic Stability Control (DSC II)

The DSC system is designed to improve the lateral stability of the vehicle in all driving situations. Whereas ASC 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 control for the vehicle while driving through corners or any time the vehicle is not moving straight ahead.

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



Dynamic Stability Control (DSC III)

Dynamic Stability Control III (DOSSIL) is a further development of DSC II. DSC III introduces two new inputs, lateral acceleration and yaw rate, to further refine the effectiveness of the system. 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:

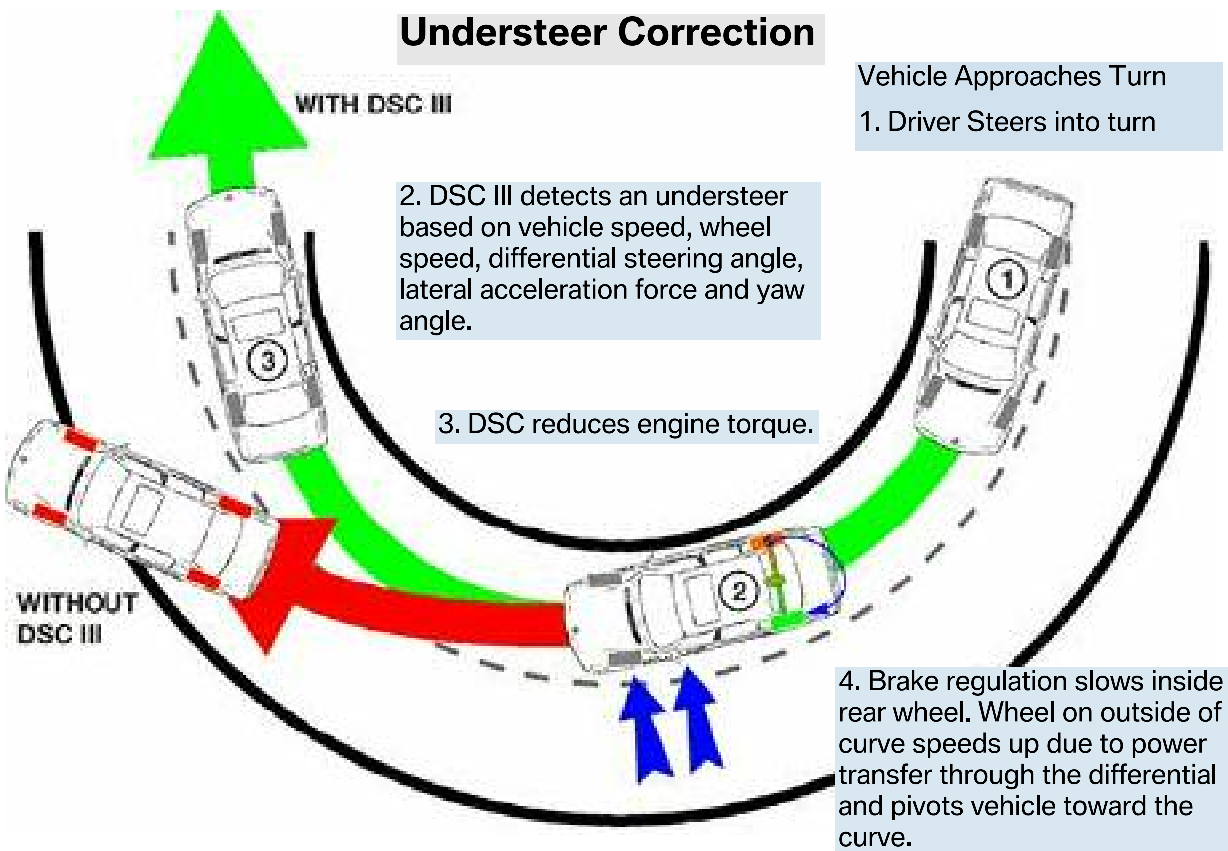
- Throttle angle reduction via CAN communication DSC III to EML or DME to minimize the throttle angle of the DK motors, or for vehicles not equipped with DK motors, this is handled by direct DSC III activation of the ADS II throttle housing.
- If additional torque reduction is necessary, DSC III informs DME over CAN to:

  a. Retard ignition timing

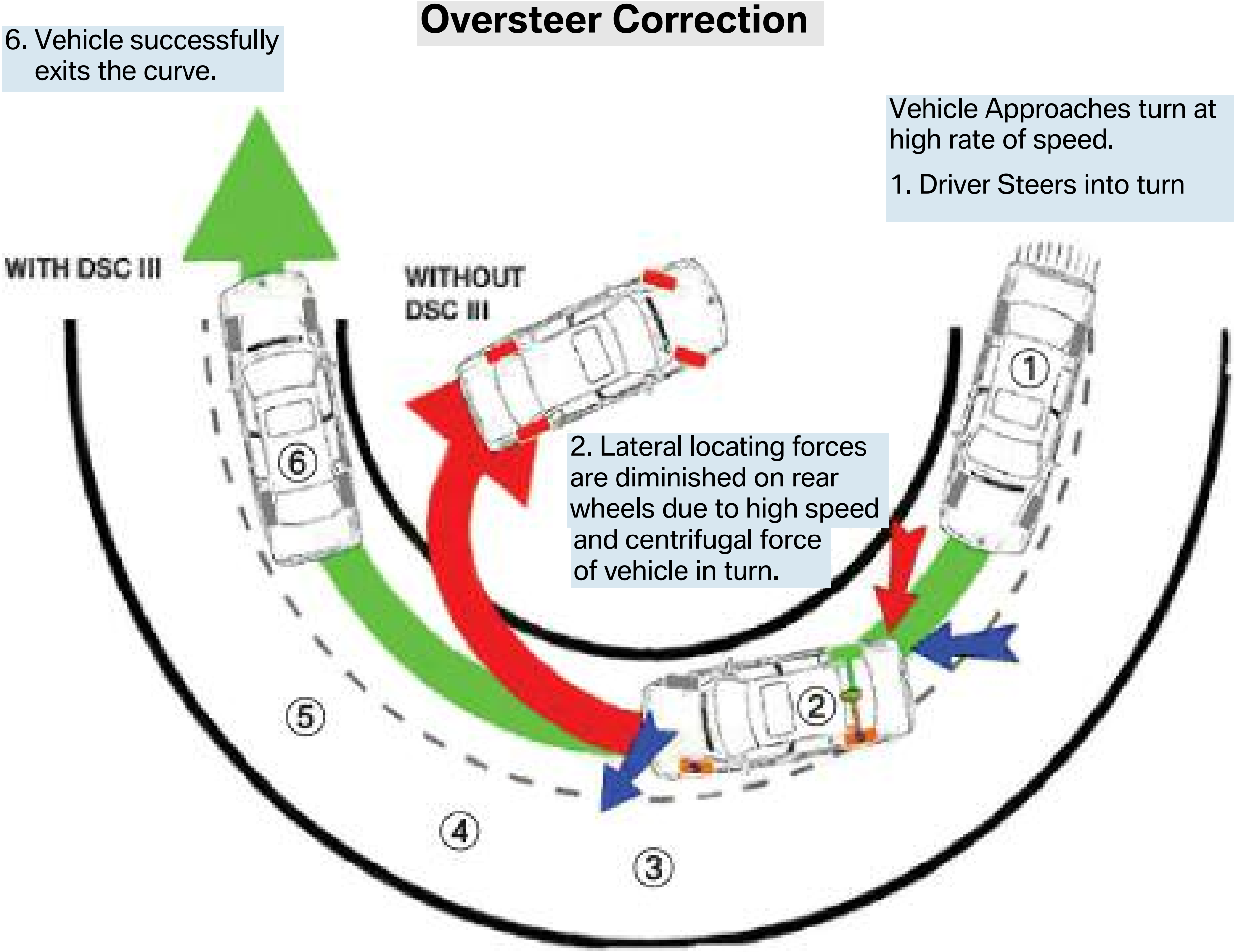
  b. Shut down the fuel injection to individual cylinders

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.



Oversteer Correction



3. The driver tries to compensate by oversteering, which further diminishes lateral locating ability. The rear of the car starts to slide toward outside of curve.

4. DSC III detects an oversteer condition and reacts by reducing drive torque via CAN bus signaling. The outside rear wheel is momentarily regulated to counteract severe yaw angle and further reduce drive torque.

5. The torque reduction and rear brake regulation should stabilize the vehicle at this point. If not, the left front is momentarily regulated. This action deliberately causes the wheel to shed a calculated degree of its locating force. This counteracts the oversteer and slows the vehicle.

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.

NOTES

System Components

Since ABS was first introduced in the E23 and E24, BMW brake and stability systems have been continuously upgraded and improved. Utilizing the latest available systems allows BMW to provide the safest vehicle possible for our customers. This section is designed to review the components and functions of previous stability systems to provide the technician with a basis for understanding current systems covered later in this course.

In this section, some components will be covered that are common to all systems, while other components will be specific to single versions. In other words, this is a general overview of BMW DSC systems evolution.

Control Module / Hydraulic Unit

Earlier ABS/ASC/DSC systems utilized control units that were separate from the hydraulic unit. With the introduction of Bosch DSCIII 5.7, the control electronics were integrated with the hydraulic unit. This reduces the wiring needed and makes the unit more space efficient. It also eliminated relays needed to operate outputs as they are now operated by solid state final stages located in the control unit.

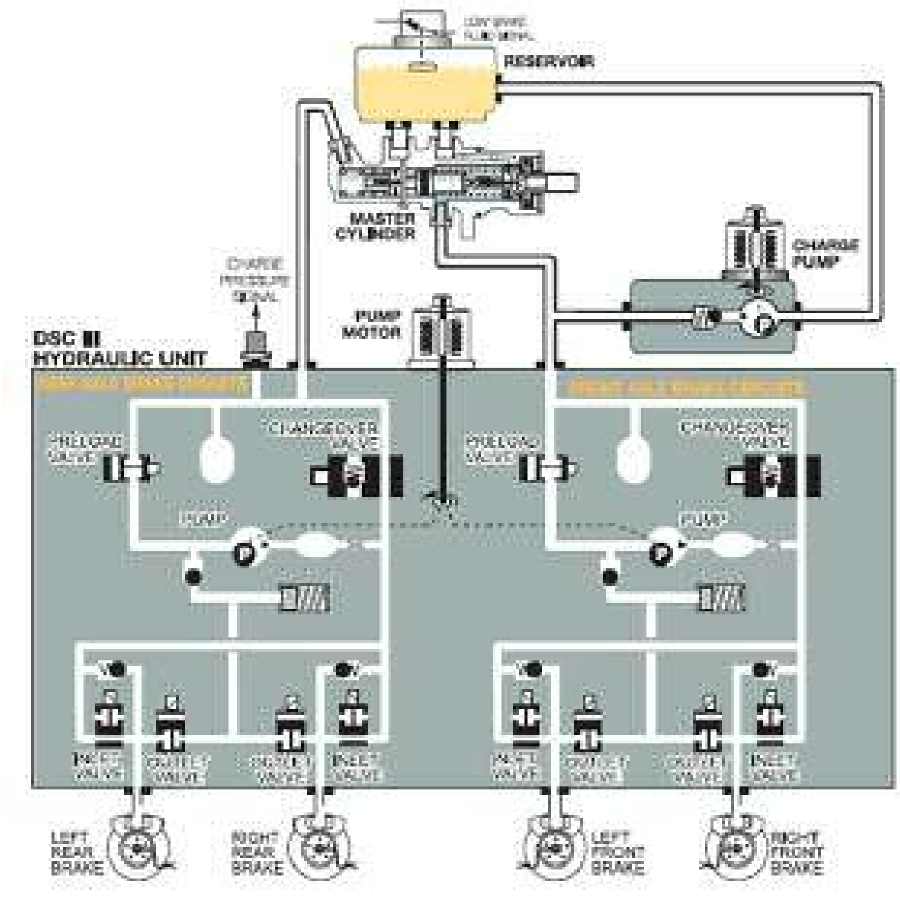
The DSC hydraulic unit contains the following components:

- Two preload solenoid valves
- Two changeover solenoid valves
- Four intake solenoid valves
- Four outlet solenoid valves
- One return pump

Control Module / Hydraulic Unit Bosch DSC III 5.7

Charge Pump / Preboost Pump

Prior to the introduction of DSC III, the return pump in the hydraulic unit was sufficient to generate pressure for brake intervention. The reason for this was that the existing systems at that time only actuated the rear brake circuit. DSCIII has the capability to actuate the front and rear brake circuits together which requires additional hydraulic fluid supply. For this reason, during ASC or DCS Brake intervention the DSCIII control module switches on the electric charge pump to provide this additional fluid. The charge pump is not activated during ABS or CBC (Corner Brake Control) operation as the driver is applying pressure to the hydraulic circuit and the return pump is maintaining the fluid supply. Advances in efficiency of the return pump and the relocation of the hydraulic unit closer to the master cylinder eventually led to the elimination of the charge pump in later systems.



The balance of the hydraulic system functions operate in the same familiar manner of all previous systems. The individual brake circuits can be isolated as needed to restore lateral locating forces through the pressure build, hold and release phases. During ASC regulation requiring rear wheel intervention only, the inlet valves to the front wheel are closed, preventing any pressure influence from the charge pump.

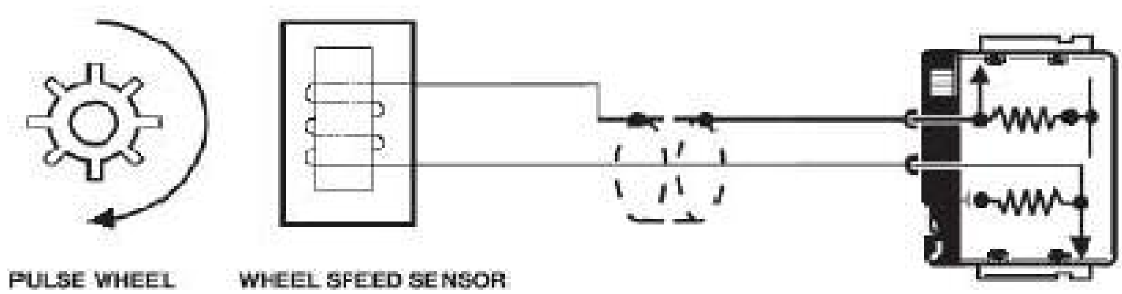
Wheel Speed Sensors

BMW has employed multiple wheel speeds sensor designs over the years.Technological advances have allowed sensors to become more accurate and to supply more information to the control module, such as direction of rotation and whether to vehicle is moving or at a standstill. This section reviews the differing types of wheel speed sensors theat have been used and their operation.

Inductive Wheel Speed Sensors

Early systems utilized inductive sensors (up to Bosch DSC III 5.3 and Teves DSC MK20).

In an inductive sensor, an AC voltage is induced in the sensor as the magnetic reluctor passes the sensor. These sensors produce an analog signal that increases in both amplitude and frequency as the speed increases. With an inductive sensor, improper air gap and interference are always a concern. The analog signal also has to be converted to a digital signal in order to be processed by the control unit.



Hall Effect Wheel Speed Sensor

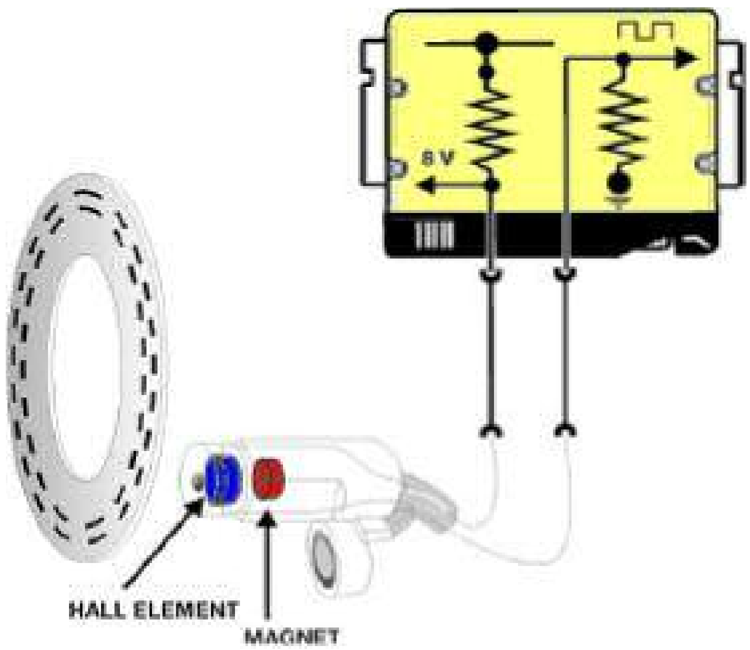
Hall Effect sensors have the following advantages over inductive sensors:

- Speed signal is available at a much lower speed (0.3 km/H).
- Signal strength is not dependent on road speed.
- Produces a digital signal, no conversion needed.

The two wire hall effect wheel speed sensors receive a stabilized 8 volt power supply from the control module through one wire. The ground path for the sensor is through the second wire back to the control unit.

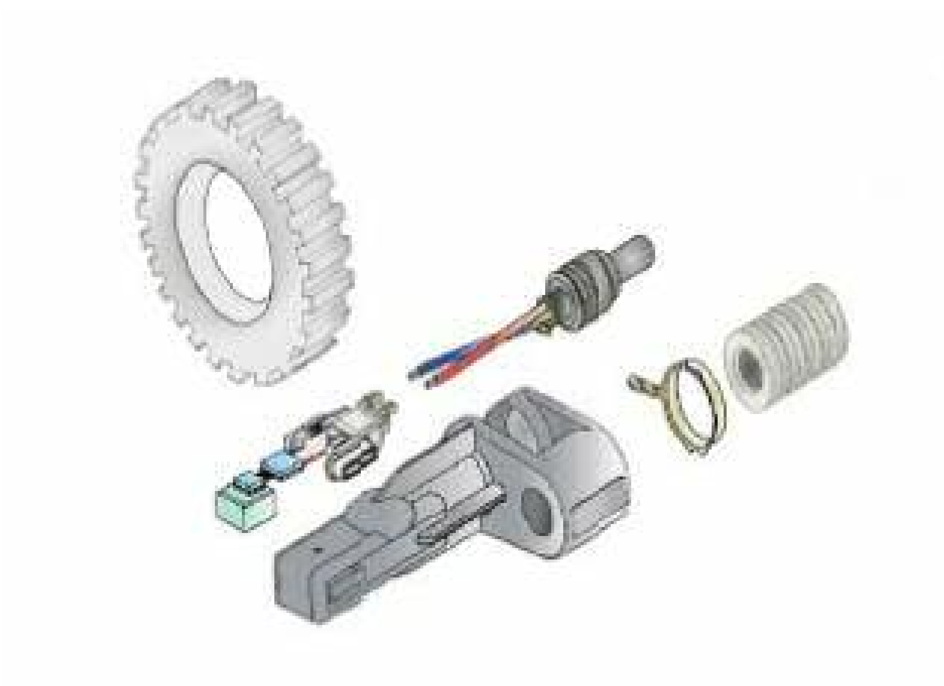
The signal is generated by a pulse wheel affecting the voltage flow through the hall element in the sensor. The pulse wheel is integrated into the wheel bearing assembly, behind the seal. This protects the trigger wheel from foreign substances which may affect the signal. The hall effect sensor creates a square wave signal with a low value of 0.35V to1.3V and a high value of 1.9V to 3.9V, depending on system version.

Hall Effect Wheel Speed Sensor



Magneto-resistive Wheel Speed Sensor

With the introduction of the Teves DSC III MK60, active wheel speed sensors that operate on the principle of magnetoresistive effect are used for the first time on BMW vehicles. The sensor element and evaluation module are two separate components within the sensor housing.

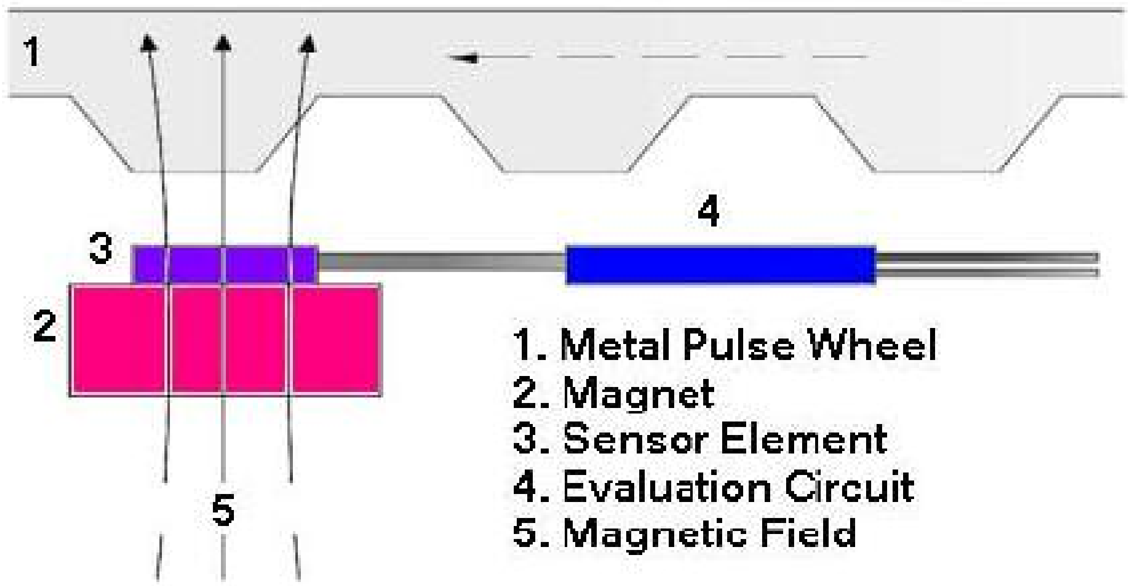


Principle of Operation of the Magnetoresistive Sensor

The active sensing of the magnetoresistive sensor is particularly suitable for advanced stability control applications in which sensing at zero or near zero speed is required.

A permanent magnet in the sensor produces a magnetic field with the magnetic field stream at a right angle to the sensing element.

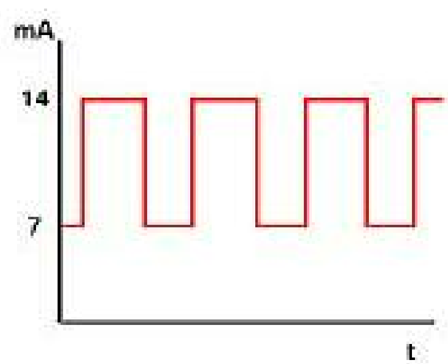
The sensor element is a ferromagnetic alloy that changes its resistance based on the influence of magnetic fields. As the high portion of the pulse wheel approaches the sensing element, a deflection of the magnetic field stream is created. This causes the resistance to change in the thin film ferromagnetic layer of the sensor element.



The sensor element is affected by the direction of the magnetic field, not the field strength.The field strength is not important as long as it is above a certain level. This allows the sensor to tolerate variations in the field strength caused by age, temperature or mechanical tolerances.

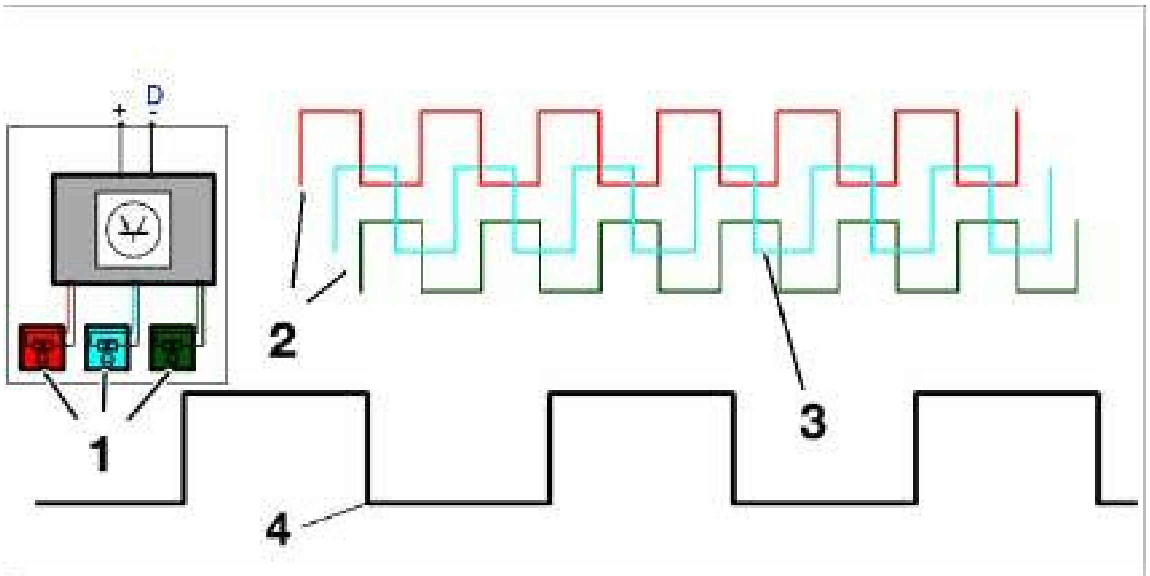
The resistance change in the sensor element affects the voltage that is supplied by the evaluation circuit. The small amount of voltage provided to the sensor element is monitored and the voltage changes (1 to 100mV) are converted into current pulses by the evaluation module.

- Signal High - **14mA**
- Signal Low **- 7mA**



Active Wheel Speed Sensors

Active direction sensing wheel speed sensors were first used on the E65. A special feature of this sensor is that forward and reverse rotation is detected. The sensor contains three Hall effect elements located next to each other in one housing. The signals of the first and third Hall element form a raw differential signal for determining the signal frequency (speed) and the air gap clearance to the impulse wheel.



1. Hall-effect elements
2. Differential signal (magnetic)
3. Center Hall element signal (magnetic rotational direction)
4. Output signal to DSC control module

Clockwise or counterclockwise rotation is detected by the phase offset of the signal from the middle (second) element as compared to the differential signal. The phase will shift (left or right) depending on the impulse wheel’s approach to the Hall element from the left or the right.

The direction of rotation phase (3) will shift to the left or to the right (as shown) of the differential signal (2). These signals are processed in the sensor and are represented in the output pulse width digital signal (4) that is monitored by the DSC control module.

This sensor contains two external wires and the digital signal is transmitted over the combined ground and data line (D) to the DSC control module. The second wire is the power supply for the wheel speed sensor.

The flow of current is the influencing factor, not the voltage level. This provides a reoccurring data message that uses two different amp ratings. The 14 mA level contains the information of speed, direction of rotation and air gap. The 7 mA level is the evaluation for the fault code memory. When the vehicle is stationary, a pulse is sent every 740 ms to the DSC module.

Rotation Rate and Lateral Acceleration Sensors

DSC III introduced the rotation rate (or yaw) and Lateral acceleration sensors, 2 new sensors that had not been utilized on previous systems. Originally, these were individual sensors but were later combined in a single housing and referred to as the DSC sensor.

It is important to note that in some applications, these two sensors will need to be coded and calibrated separately, even though they are both housed in a single component.

Lateral Acceleration Sensor

The lateral acceleration sensor is a capacitive sensor with two plates. One plate is rigidly mounted, the other plate is mounted on a spring. Under the effect of transverse forces acting on the sensor the distance between the plates changes. This change of distance between the plates affects the capacitance of the sensor. The evaluation circuitry converts the signal into an analog voltage that is transmitted to the control unit. The output signal of the sensor is between the range of 0.5 to 4.5 Volts.

The transverse acceleration signal is used in the DSC III control unit along with the rotation rate and steering angle signal to determine if DSC regulation is required to maintain the vehicles stability.

Lateral Acceleration Sensor
under passenger front seat

Rotation Rate Sensor

The Rotation Rate Sensor is mounted on a metal bracket under the drivers seat. The sensor provides information to the DSC Control Unit concerning the vehicles speed around its main axis (yaw).

The sensor has a three pin connector with the following connections:

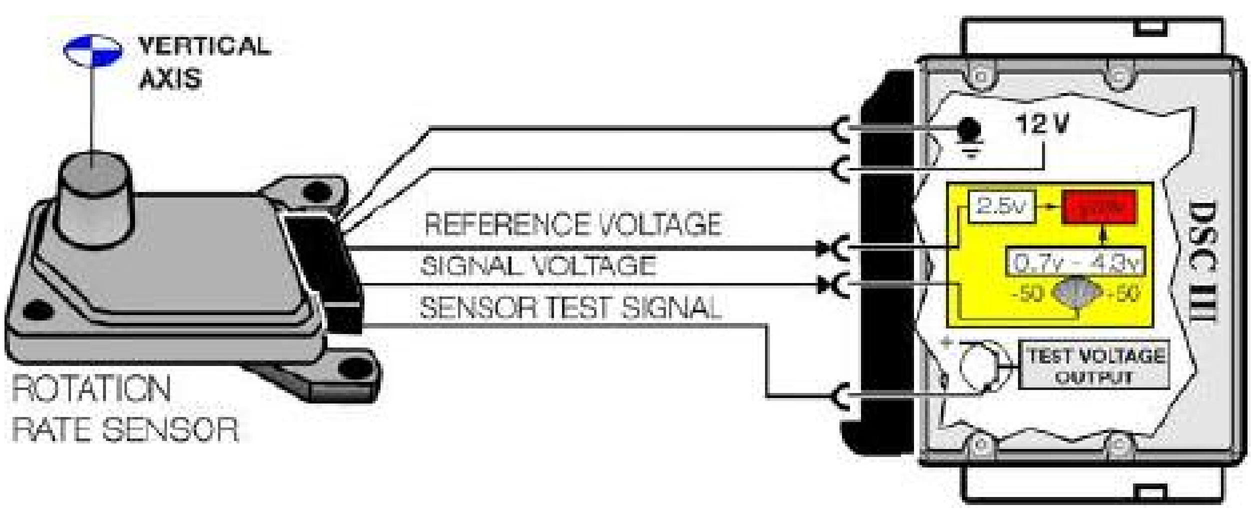
- 5V reference
- Signal
- Ground

The sensor receives a reference voltage of 5V from the DSC control unit and provides a signal output of approximately 0.25 to 4.65V depending on the amount and direction of yaw. If the sensor is defective a constant voltage will be sent to the DSC control unit.

The sensor element is a micro-mechanical double quartz tuning fork. A frequency of 11 Hertz is applied to one side of the fork and as the vehicle turns on it's axis, vibrations are induced on the other end. The sensor analyzes the signal produced by the fork and produces an analog voltage signal that is proportional to the amount of yaw.

The rotation (yaw) rate is compared to the signal from the Steering Angle Sensor and the Transverse Acceleration Sensor. If physical limits are beginning to be exceeded, the DSC will begin regulation by engine and brake intervention to attempt to stabilize the vehicle. This is referred to as a GMR regulation.

DSC III for M.Y. 2002 incorporates a combined Rotation rate and Transverse Acceleration Sensor. The Sensor is connected to the DSC control unit by the CAN bus.



Steering Angle Sensors

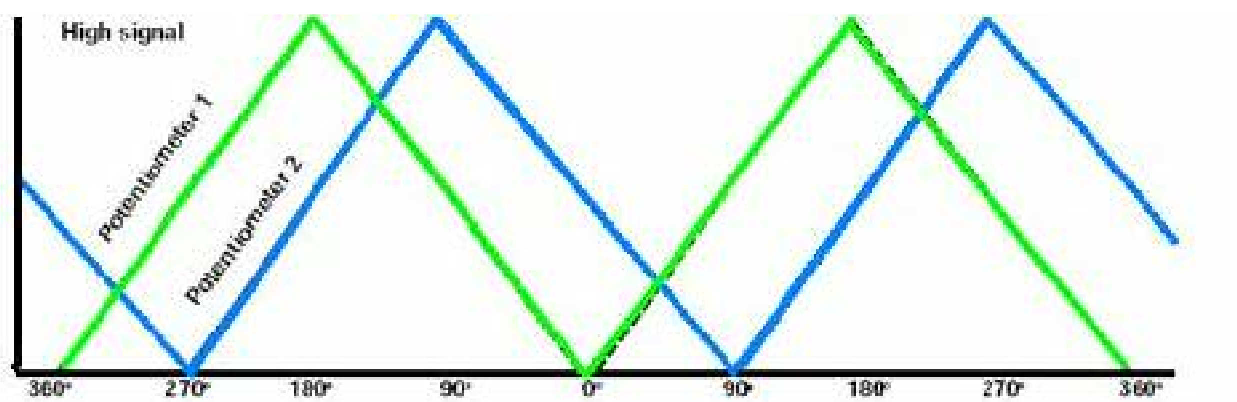
Just as other components of the DSC system changed and evolve, so have steering angle sensors. Early steering angle sensors (LEW) were potentiometer based, current systems use optical sensors that are incorporated into the steering column switching center (SZL). In this section we examine the development of steering angle sensors.

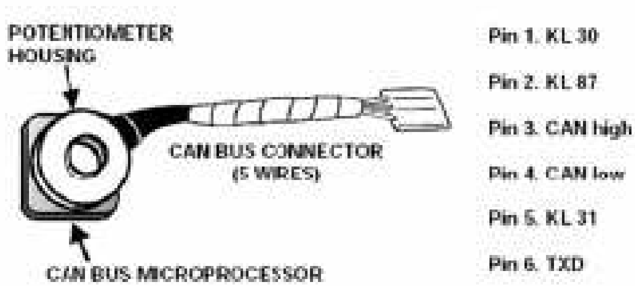
LEW

The Steering Angle Sensor is mounted towards the lower end of the steering column, above the flexible coupling. The LEW consists of a potentiometer and a built in micro-processor. The potentiometer has two pickups offset at 900 to one another. The raw potentiometer signal is processed and converted into a digital signal that is transmitted over the CAN bus to the DSC control unit.

The sensor requires initialization in-order to create a zero point default. Once initialized, the LEW sends an ID number to the DSC control unit. The ID provides confirmation that the LEW is properly initialized.

The total steering wheel angle is determined by combining the CAN telegram signal, the stored zero point default and the actual number of turns to the wheel. In order to prevent the LEW from loosing count, KL 30 is provided to the sensor and it continues to record even after the ignition has been switched off. The DSC calculates the drivers desired rate of turn from the steering angle signal.

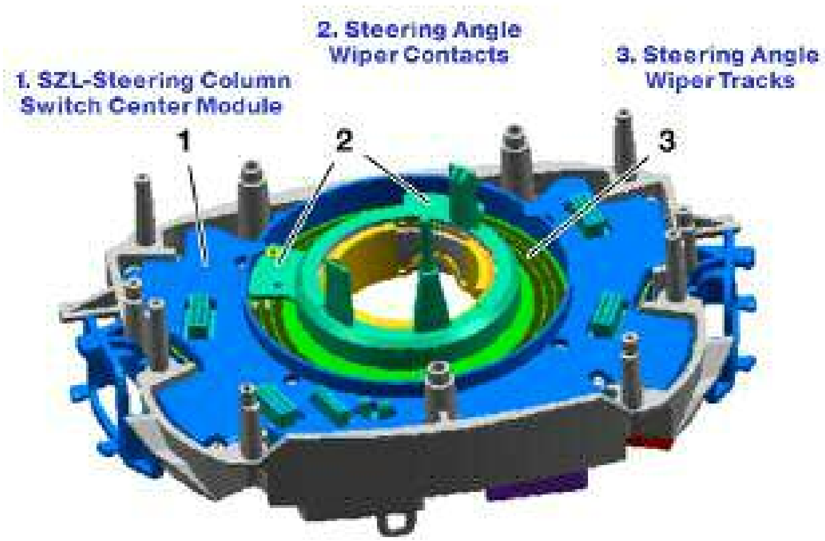




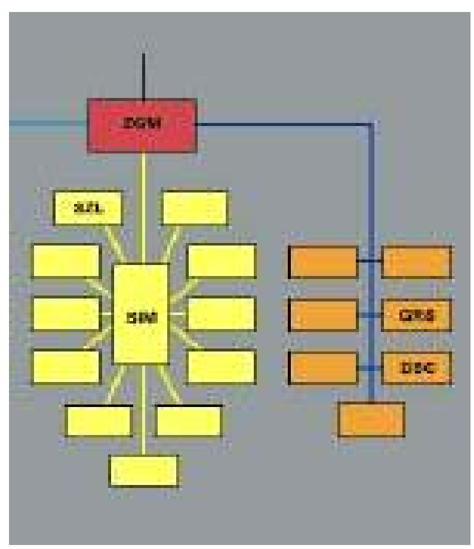
Refer to the Workshop Hints for instructions on coding and initializing the sensor.

E65 SZL

The steering angle sensor is integrated in the Steering Column Switch Center (SZL) module. The steering angle positions are transferred by Bus signals to other control modules. The steering angle sensor is a 3.4 kOhm potentiometer with two wipers offset by 90 degrees. From the two wiper signals and a reference signal, the SZL calculates the steering angle sensor position and transfers it over the Byteflight and CAN Bus to other control modules. Shorts to B+ or ground are detected as faults.



When replacing the SZL with the integrated steering angle sensor, the coil spring cassette must be installed in the center position with the wheels set in the straight ahead position. The wiper does not have an electrical reference point and steering angle matching must be performed with ISTA after repairs. After performing the steering angle matching, self-learning with the front wheel speed signals is necessary to determine the number of steering wheel turns. The number of steering wheel turns is necessary for determining the exact steering angle.



Index	Explanation
SZL	Steering Column Switch Center
DSC	Dynamic Stability Control
SIM	Safety Information Module
GRS	Rotational Rate Sensor

E6x Steering Angle Sensors

Prior to 9/05 production, the E6x Steering angle sensor was the same as the E65. Beginning with 09/05 production, the E6x switched to an optical sensor of the same design as the E9x.

The steering angle sensor is designed as a contactless, optical angle measuring system.The system consists of a code disc and an optical sensor. The code disc is connected via a drive element directly to the steering wheel. The code disc turns within the optical sensor when the steering wheel is moved.

Coil Spring Assembly

The coil spring assembly can be replaced only as a complete unit. The task of the coil spring is to transmit the following electrical signals from and to the multifunction steering wheel:

- Activation of driver airbag
- SMG control buttons
- Multifunction buttons
- Horn and steering wheel heating

Locking

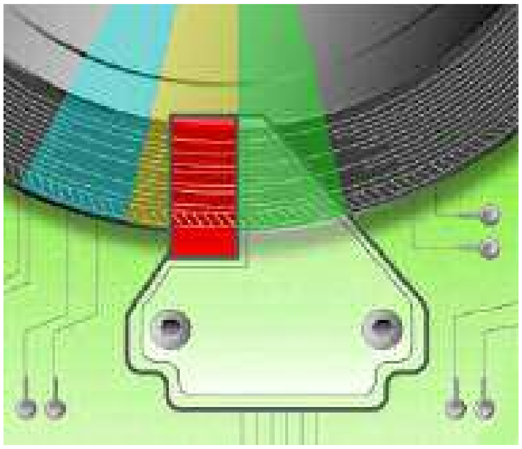
To avoid damaging the coil spring assembly, it must be set to the correct position when dismantling the steering wheel and coil spring assembly. The front wheels and steering wheel must be set to the straight-ahead position as the prerequisite for disassembly. During disassembly of the steering wheel, the load on the lock pin of the coil spring assembly is relieved and the pin can lock in the straight ahead position.

When the steering wheel is reinstalled, this arrangement ensures that the coil spring is not damaged when the steering wheel is turned to full left and right lock.

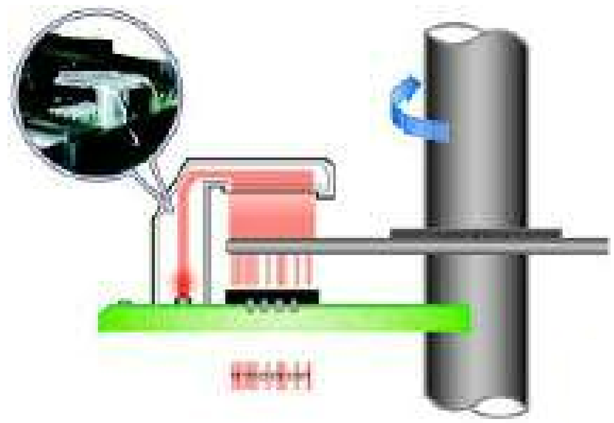
Steering Column Switches

As on the E65/E60, the steering column switches are designed as electrical switches, which include switching mats and microswitches.

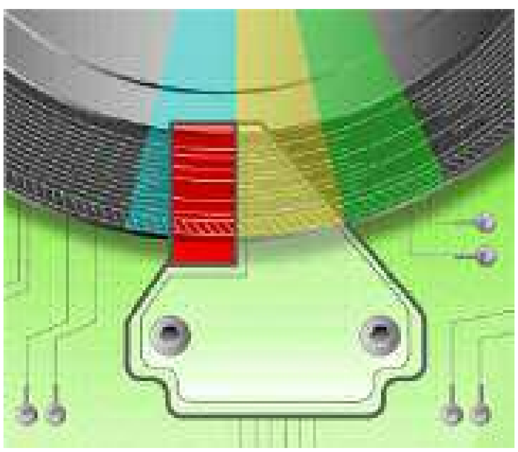
Differing from the predecessor models, the connectors to the SZL control unit have been modified.



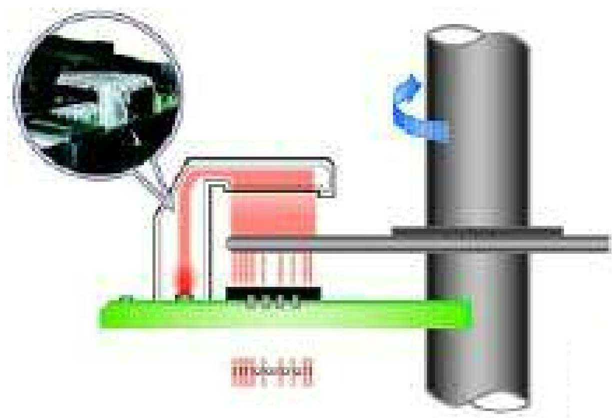
The code disc rotates depending on the steering wheel angle. The pattern on the code disc changes in 2° steps.



The light beams hit the photo transistor. The light pulses are converted to electrical pulses in the photo transistor.



The pattern on the code disc changes as the disc continues to turn. The light passes through the code disc in a different pattern.



The position of the light beams are displaced. The photo transistor detects the change and transfers this information to the SZL.

Relative Steering Angle

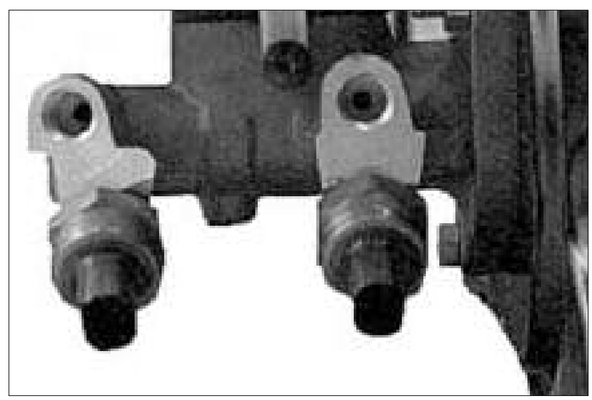
The relative steering angle indicates the angle position of the steering wheel. The information relating to the relative steering angle is always retained even when power to the control unit is disconnected. Renewed zero adjustment is necessary only after the steering column switch cluster SZL has been replaced.

Brake Pressure Sensors

The hydraulic system pressure sensor provides a 0-5 volt linear voltage signal to the DSC control module. The linear voltage is a proportionate indication of how hard the driver is pressing on the brake pedal. The signal is provided as an additional determining factor for the DSC control module to monitor the hydraulic pressure present during all phases of operation, including:

- No Braking
- Partial Braking
- Near ABS regulation state

The sensor has three pins, power, ground and the 0-5 volt signal. The sensor is capable of monitoring pressure from 0-250 bar. The sensor is located in the front brake hydraulic circuit., the actual location varies by application:

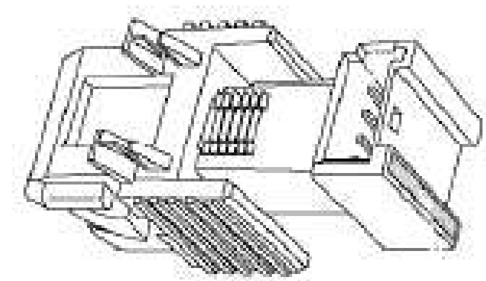


As DSC systems become more sophisticated, more pressure sensors have been added, for instance, some vehicles will have 2 additional sensors for ACC functions, and newer Teves MK60E5 systems have 5 pressure sensors.

Brake Light Switch

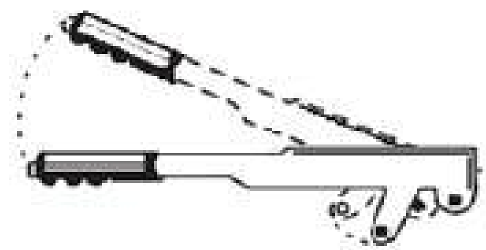
The brake switch is used to activate the ABS functions in the DSC module. If the system receives a brake switch signal when in ASC mode and regulating, ASC regulation is cancelled.

The ABS regulating phase is also cancelled when the brake switch signal is not present.



Parking Brake Switch

The hand brake switch is a ground input to the DSC module. MSR regulation is cancelled when there is a “hand brake On” signal present.



DSC Button

On earlier systems, The DSC or ASC was active whenever the ignition switch was on. When the button was pressed, the system was deactivated and the DSC warning light would be illuminated.

With the introduction of Teves MK60 and Bosch 5.7, a new function, Dynamic Traction Control (DTC), was added. The system switches from full DSC control, to DTC control, to DSC off, depending upon how long the DSC button is pressed. On newer systems, the DSC button has been replaced by the DTC Button. The functions remain the same.

DSC Button Functions

Button Activation	Function	Display
Short Press: Less than 2.5 seconds	Only the yaw control of the DSC is deactivated. The ADB function and the DBC functions remain active. A higher slip ratio is allowed up to 42 mph for the purpose of improving traction in slippery conditions ASC intervention will also use different thresholds.	DSC light is illuminated.
Long Press: More than 2.5 seconds	All ASC, ADB and DSC control function are deactivated. Used for service and on dynamometers.	DSC light and general brake warning light (yellow Brake) Illuminated.

Pressing the button again returns the system to normal status. It is not possible to go directly from one function to the next without first returning to normal status.

DSC Button on Bosch 5.7 AWD

The function of the button is different than for 2WD vehicles. Brake intervention remains active for the ADB function after pressing the button to turn off the DSC. Only ASC engine intervention and DSC yaw intervention are deactivated.

The DSC warning lamp will be illuminated to remind the driver that these functions have been disabled. Pressing the button again returns the system to normal status.

DSC Subfunctions

The scope of control for Stability Control is comprised of three systems:

- ABS
- ASC+T
- DSC

Based on signals coming from the various sensors the DSC will determine which function is best suited to maintain control of the vehicle.

In addition to the three basic systems, there are several sub-functions which are activated during very specific circumstances.

Anti-lock Braking System (ABS) Subfunctions
The ABS system can prevent wheel lock when braking by comparing the four active wheel speed sensors to the average vehicle speed. If a wheel is locking during braking or has dropped below a speed threshold programmed in the control unit ABS, braking will begin.

All Wheel Drive Vehicles
The function of ABS for All-Wheel Drive use has an additional variation. During braking on loose surfaces the wedge effect is helpful. Gravel or dirt will build up in front of the tire when the wheel is locked, creating an increased braking effect. The system allows the locking of one or both front wheels up to approx. 20km/h (12mph). This “poor road surface logic” does not affect steerability. As soon as the control unit detects steering wheel change, the ABS system regulates normally again.

Electronic Brake Force Distribution (EBV)
EBV will adjust brake pressure to the rear axle based on the rate of slow-down of the rear wheels, ensuring even brake force between the front and rear of the vehicle. The control unit monitors the wheel speed when the brakes are applied and compares the deceleration rate of the front and rear axle to determine required regulation.

If the vehicle is moderately to fully loaded, the rear axle will take longer to slow down, rear wheel brakes then can be applied at a higher pressure.

If the vehicle is lightly loaded, a similar brake pressure would be too great and result in an unstable situation.

If EBV control intervention is required, the control unit cycles the intake valve on the rear brake calipers to prevent further build-up.

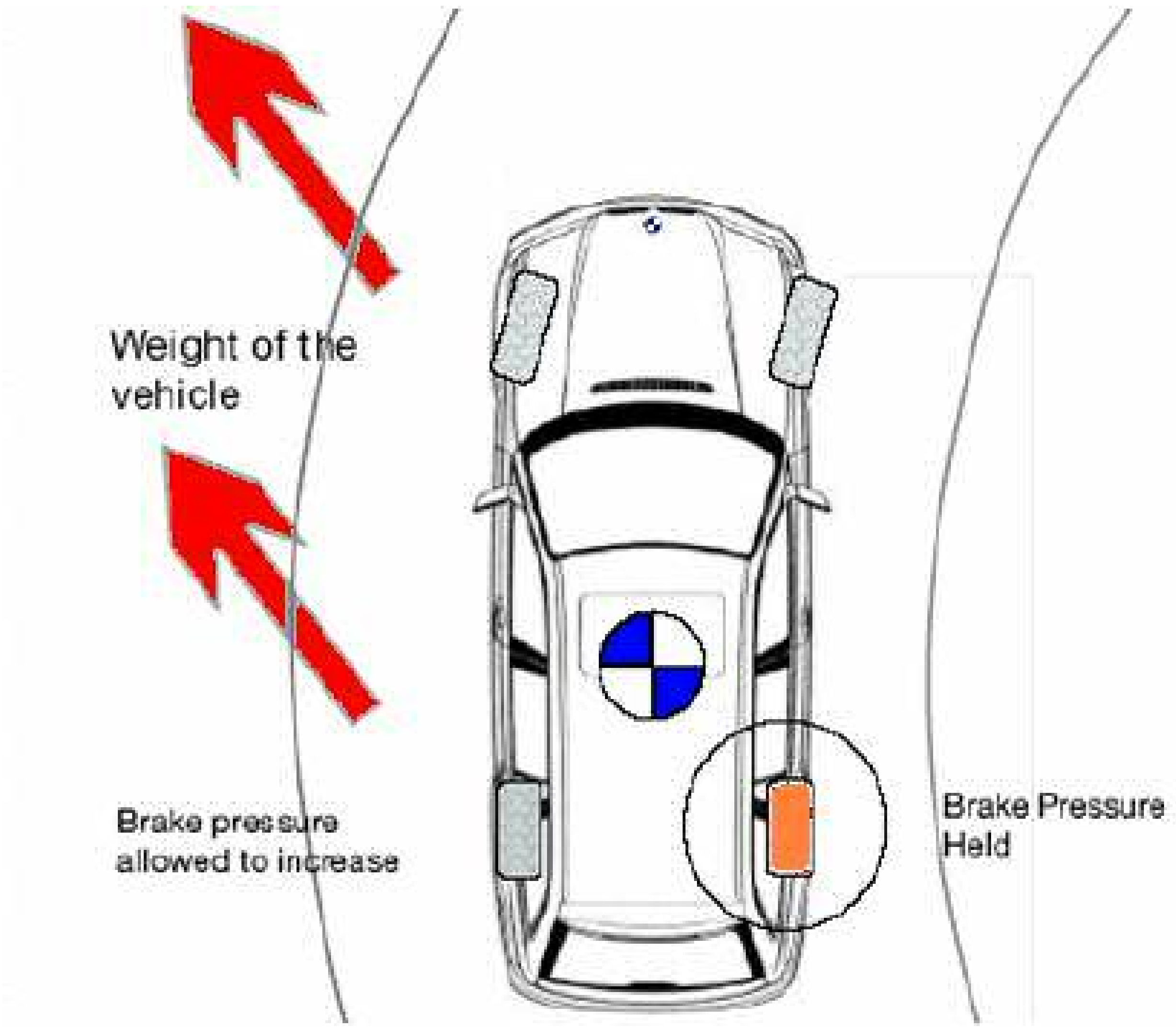
Benefits of EBV are:

- Enhanced braking due to an even distribution of brake force.
- Rear wheel brake size can be increased.
- Front and rear brakes wear at a similar rate.

Corner Brake Control (CBC)

If the control unit detects transverse acceleration in excess of 0.6g and the brakes are applied, CBC prevents a build up in brake pressure to the inside rear wheel. This prevents the vehicle from entering into an unstable situation that can lead to Oversteer.

DSC accomplishes this by closing the Inlet Valve, thus not allowing brake pressure to increase at the brake caliper. The difference in braking force between the two rear wheels creates a yaw force that opposes the oversteer and allows the vehicle to handle neutrally.



Dynamic Brake Control (DBC)
The DBC function is designed to provide an increase in braking pressure up to the ABS threshold during rapid (emergency) braking situations. The DSC III control unit monitors the inputs from the brake light switch and the brake pressure sensor. The triggering criteria for activation of DBC is, how rapidly is the brake pressure increasing with an application of the brake pedal.

The triggering conditions are:

- Brake light switch on.
- Brake pressure in the master cylinder above threshold.
- Brake pressure build-up speed above threshold.
- Vehicle road speed above 3mph (5km/h).
- Pressure sensor self test completed and sensor not faulted.
- Vehicle traveling forward.
- Not all of the wheels in ABS regulation range.

If the threshold for DBC triggering is achieved, the DSC III control unit will activate a pressure build-up intervention by activating the pre-charge and return pump. The pressure at all wheels is increased up to the ABS regulation point. This ensures that the maximum brake force is applied to the vehicle. During DBC the rear axle is controlled with Select-Low logic and the front wheels are regulated individually.

DBC will continue until:

- The driver releases the brake pedal.
- Brake pressure falls below threshold.
- Vehicle road speed below 3mph.

DBC will also be switched off if a fault occurs in with any of the necessary input sensors.

A fault in DBC will illuminate the "BRAKE" (ABL) lamp yellow to warn the driver, depending on the failure the DSC lamp may be illuminated as well.

Maximum Brake Control (MBC)
The MBC function is designed to support driver initiated braking by building up pressure in the rear brake circuit when the front wheels are already in ABS regulation. The additional braking pressure is designed to bring the rear wheels up to the ABS regulation point shortening the stopping distance. The MBC function is triggered when the brakes are applied more slowly than the threshold needed for a DBC regulation.

The triggering conditions are:

- Both front wheels in ABS regulation.
- Vehicle road speed above 3mph (5km/h).
- DBC and pressure sensor initialization test successful.
- Vehicle traveling forward.
- Rear wheels not in ABS regulation.

If the threshold for MBC triggering is achieved, the DSC III control unit will activate a pressure build-up intervention by activating the return pump. The pressure at the rear wheels is increased up to the ABS regulation point. This ensures that the maximum brake force is applied to the vehicle.

The MBC function will be switched off if:

- Front wheels drop out of ABS regulation.
- The driver releases the brake pedal.
- Brake pressure falls below threshold.
- Vehicle road speed below 3mph.

MBC will also be switched off if a fault occurs in with any of the necessary input sensors. A fault in MBC will illuminate the “BRAKE” (ABL) lamp yellow to warn the driver, depending on the failure the DSC lamp may be illuminated as well.

ADB Brake Intervention
The ADB is an automatic differential lock that improves traction. The slipping wheel is braked by pressure built up in the hydraulic unit. The drive torque can be transferred to the wheel with the greater traction, which can transmit drive power to the road. This function acts much like a limited slip differential.

Brake intervention is applied to the individual wheel which is losing traction by regulating the brake calipers in three phases:

- Pressure Build
- Pressure Hold
- Pressure Release

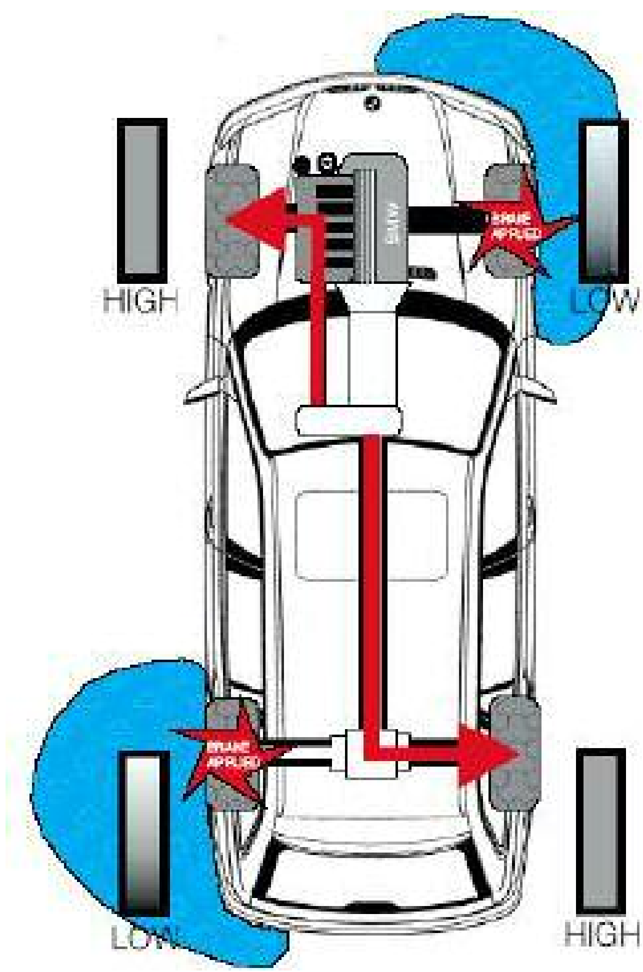
When brake intervention is necessary, the axle not being regulated must be isolated from the Pressure Build sequence in the hydraulic unit. This is accomplished by closing both Inlet Solenoid Valves for that axle.

Here is an example of an ADB brake intervention at the left rear wheel:

- The Changeover Valve for the rear brake circuit, the right rear and both front Inlet Valves are energized and closed.
- The rear brake circuit Intake Valve is energized and opened.
- The Return/Pressure pump is activated and draws brake fluid through the open Intake Valve from the Master Cylinder (via the Central Valve) and delivers the pressurized fluid to the open Inlet Valve braking the left rear wheel.
- Pressure Hold and Pressure Release are done by cycling the Inlet and Outlet Valves similar to the ABS sequence described previously.

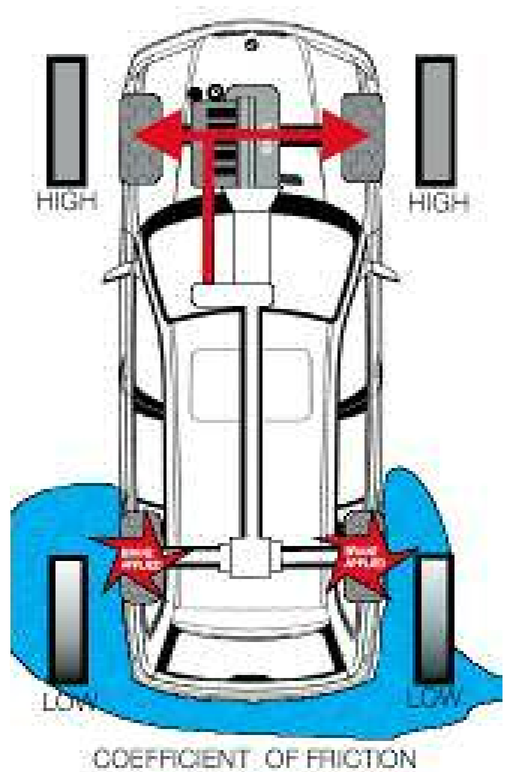
The drive torque can be distributed to the wheels with high friction coefficients (traction).

Transversal Differential-lock Function.



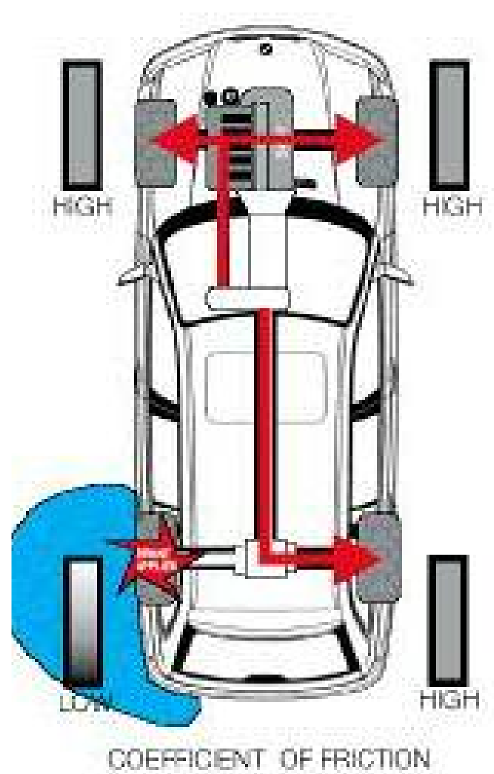
Longitudinal Differential-lock Function**

By performing brake intervention at the axle with a low friction coefficient, drive torque can be transmitted to the front wheels.



Longitudinal and Transversal Differential-lock Function

By performing brake intervention at the diagonally opposing wheels with a low friction coefficient, drive torque can be transmitted to the two wheels with more traction.



Hill Descent Control (AWD drive vehicles only)

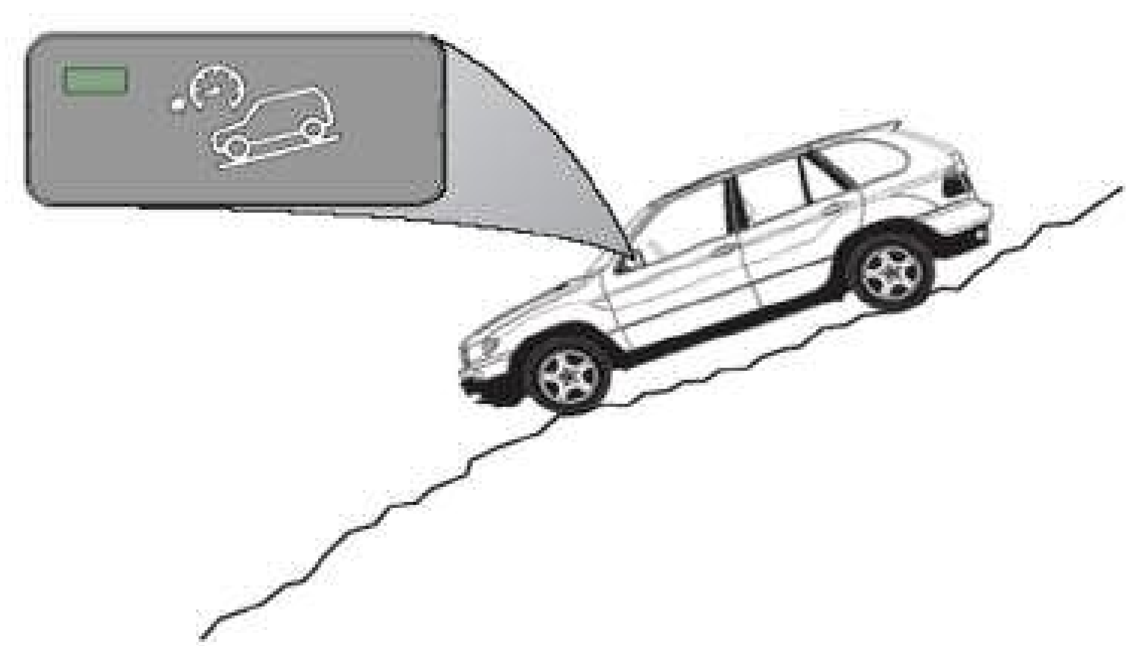
Hill Decent Control (HDC) is designed for off road use to automatically slow the vehicle and maintain a steady speed on steep gradients. This function allows the driver to focus on steering and controlling the vehicle without having to use the brakes to slow the vehicle.

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.



Bosch DSC8+

The Bosch traction control and stability system DSC8+ was phased-in on the E6x model series as from 09/2005. E6x all-wheel drive model series are equipped with DXC8+.

The main differences between the DSC8 and the DSC8+ are in the software of the DSC control unit and the further-optimized components within the DSC module.

Further comfort and safety functions have been achieved with the introduction of the DSC8+.

Overview of expanded functions:

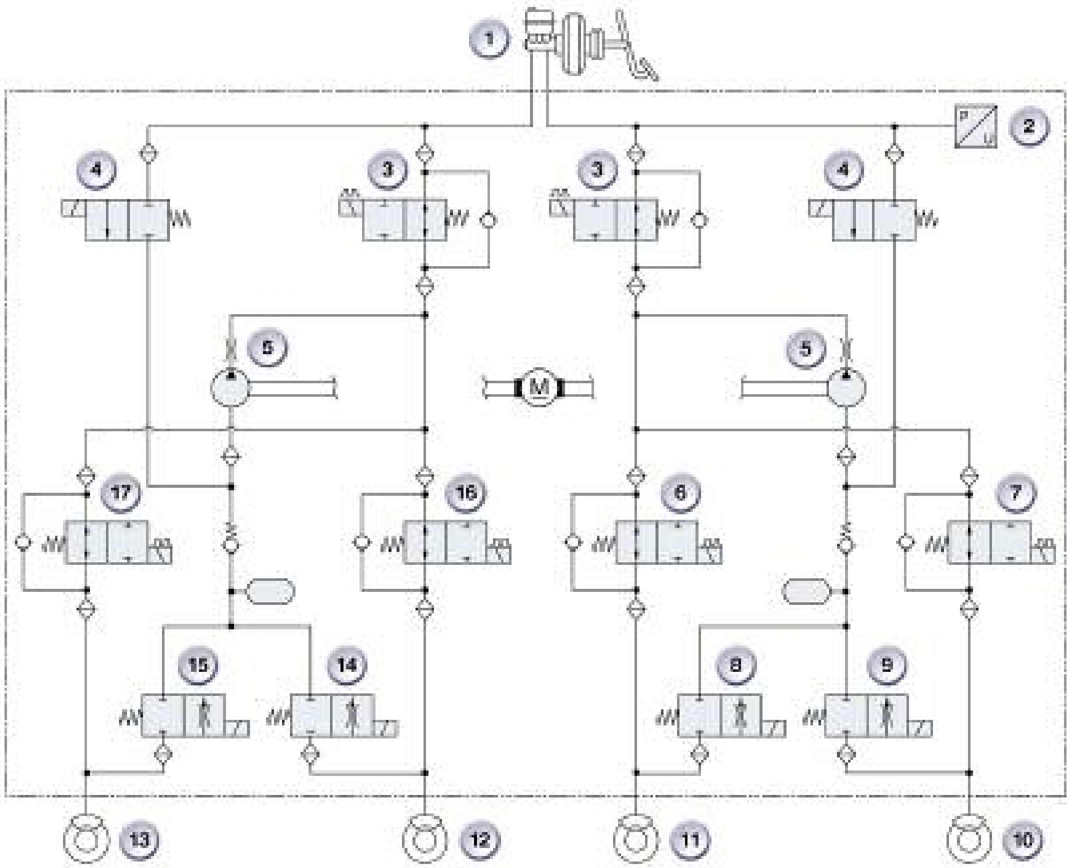
- Dry Braking
- Brake Standby
- Automatic Soft-Stop Function
- Fading Assistance
- Start Assistant

For the first time, activation of the fading-brake support function is indicated by a yellow indicator in the instrument cluster.

System Overview

Index	Explanation
1	DSC8+ Control Module
2	DSC Sensor Cluster (3.22 or 3.8)
3	Steering Column Switch Cluster
4	Wheel Speed Sensors
5	DTC Button

DSC8+ Hydraulic System Circuit Diagram



Index	Explanation	Index	Explanation
1	Tandem Brake Master Cylinder	10	Wheel Brake, front left
2	Pressure Sensor	11	Wheel Brake, front right
3	Changeover Valves	12	Wheel Brake, rear right
4	High Pressure Shift Valve	13	Wheel Brake, rear left
5	Return Pump	14	Outlet Valve, rear right
6	Inlet Valve, front right	15	Outlet Valve, rear left
7	Inlet Valve, front left	16	Inlet Valve, rear right
8	Outlet Valve, front right	17	Inlet Valve, rear left
9	Outlet Valve, front left		

System Components

Bosch DSC8+ Module

The DSC8+ module essentially consists of two components:

- Add-on control unit.
- Valve block with integrated pressure sensor.

On exceeding a speed of approximately 4 mph (6 km/h), an electronic self-test is started, involving brief activation of the pump motor and all solenoid valves.

If the brake is operated at a driving speed of 4 mph (6 km/h) the self-test will be performed at approximately 9 mph (15 km/h).

The check of the wheel speed signals is already started at approximately 1.5 mph (2.75 km/h).

The analog-controlled valves provide even more exact control particularly in the low pressure range.

Advantages:

- Reduced control noise.
- Improved control quality and control convenience.
- Improved brake intervention through active/dynamic cruise control ACC/DCC.

DSC Sensor

The DSC sensor MM 3.8 registers following parameters:

- 1x Transverse acceleration
- 1x Yaw rate
- 1x Longitudinal acceleration
  (uphill gradient, downhill incline)

The DSC sensor MM 3.22 is used on vehicles with active steering.

This sensor redundantly measures the most important variables for the active steering.

- 2x Transverse acceleration
- 2x Yaw rate
- 1x Longitudinal acceleration (uphill gradient, downhill incline)

Initially, the plausibility of each measured value is checked in the sensor before this value is sent on the CAN.

Yaw Rate

The sensor element for the yaw rate consists of a surface mounted micro-mechanical measuring element and a digital sensor evaluation circuit. The sensor is based on the CVG principle (Coriolis Vibratory Gyroscope).

An electrostatic diaphragm drive generates the opposite phase oscillation of the seismic masses. One rotation about the x-axis of the vehicle, i.e. one rotation rate, generates a Coriolis force on the acceleration sensors that is measured capacitively. Synchronous demodulation of the Coriolis acceleration, utilizing the velocity of the seismic masses, generates a signal that is proportional to the rotation rate.

Acceleration / Gradient

The sensor element for acceleration also consists of a surface-mounted micro-mechanics element and a digital sensor evaluation circuit and is used for measuring the transverse and longitudinal acceleration of the vehicle. Likewise, its operating principle is based on capacitive measurement.

Wheel Speed Sensors

Active wheel speed sensors with an integrated evaluator circuit are used in connection with the DSC8+.

The active wheel speed sensors require a supply voltage for their operation and output a square-wave signal that is dependent on the wheel speed.

The output signal is transmitted as a data protocol using the pulse width modulation method (PWM). The PWM signal is used to determine the speed while the pulse width contains additional information on the direction of rotation, standstill detection, location detection and air gap (clearance) reserve to sensor ring.

Detection of the direction of rotation is made possible by the internal signal offset of 3 correspondingly arranged Hall elements in the sensor IC.

When the wheel is stationary, the wheel speed sensor outputs a pulse every 0.75 seconds. It is therefore possible to check the operational readiness of the sensor even when the vehicle is stationary.

Detection of the installation location indicates whether the change in the magnetic field strength is sufficient to ensure reliable operation.

Wheel Speed Sensor

Index	Explanation
1	Sensor Ring
2	Sensor IC with Hall Sensors
3	Sensor Housing

Functions

Operating Modes

The DSC 8+ offers the customer 3 different operating modes:

- DSC ON
- DSC OFF
- DTC

The various functions in the individual operating modes are illustrated in the following:

Function	DSC ON	DTC	DSC OFF
ABS	X	X	X
ASC Engine intervention	X	X[1]	
ASC Brake intervention	X	X	X
MSR	X		
EBV	X	X	X
DBC	X	X	X
CBC	X	X	X
Dry braking	X	X	X
Start assistant	X	X	X
Brake standby	X	X	X
Soft-stop	X	X	X
Fading assistance	X	X	X
Trailer stabilization logic	X	X	
Yaw moment control	X	X[2]	X[3]

1 = Thresholds increased
2 = Control thresholds increased
3 = Only active when brake light switch closed

Dry Braking

In wet conditions, a film of water is formed on the brake discs, resulting in delayed response of the brakes.

In connection with previous systems it was therefore recommended to operate the brake from time to time in wet conditions to wipe off the water film.

This dry braking function is dependent on the activity of the windscreen wiper.

When the windscreen wiper is operating in continuous wipe mode, the wheel brakes are lightly applied against the brake disc cyclically every 90 seconds in order to wipe off the water film.

Dry braking takes place under following conditions:

- Speed > 70 km/h
- In continuous wipe mode

This applies only if the driver does not apply the brake himself during this period of time.

A delay of operating noises are not perceivable for the driver.

Left disc with water film before dry braking

Right brake disc after dry braking

Brake Standby

The brake pads are applied against the brake disc when the accelerator pedal is released quickly thus reducing the emergency braking stopping distance (by approx. 30 cm/100 km/h). The DSC module builds up a low braking pressure (approx. 2.5 bar) within a short space of time (approx. 0.5 s) in order to eliminate the clearance between the brake pad and brake disc by applying the brake pads.

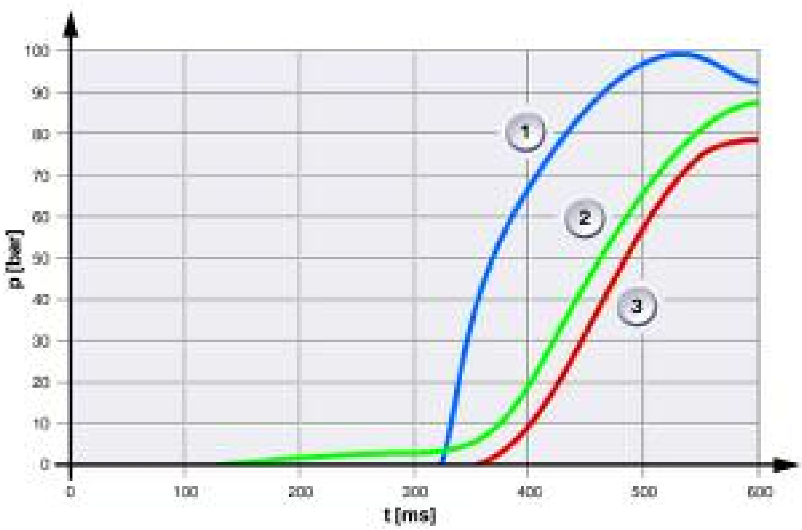
The brake standby function is activated under following conditions:

- Speed > 70 km/h.
- Minimum time between brake application 8s.
- The brake standby function is not activated in response to performance-oriented driving.

The signal indicating quick release of the accelerator pedal is made available by the DME/DDE control unit via the PT-CAN.

The sensitive driver may perceive a slightly harder brake pedal. A delay of operating noises are not perceivable for the driver.

Brake Pressure Curves



Index	Explanation
p	Brake Pressure in bar
t	Time in milliseconds
1	Brake Pressure at Tandem Master Brake Cylinder
2	Brake Pressure Curve with Brake Standby at Wheel
3	Brake Pressure Curve without Brake Standby at Wheel

Soft Stop

When braking to a standstill, a so-called stopping jerks occurs where the occupants perceive increased deceleration as a result of the transition from sliding friction to adhesion friction on the brake disc.

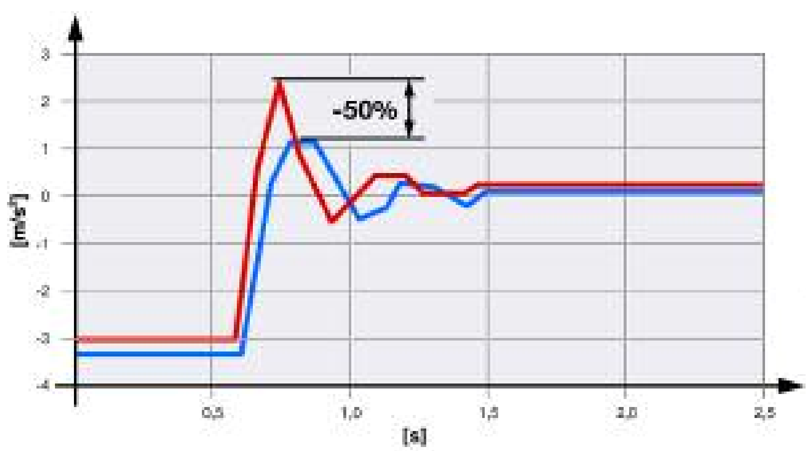
When braking lightly (< 25 bar) at constant pressure to standstill, the soft-stop function automatically reduces the braking pressure on the rear axle just before reaching standstill.

Consequently, the deceleration peak perceived by the occupants is reduced by approx. 50% and extended over time.

The function is inactive at medium to high deceleration or during ABS control in order not to extend the braking distance.

The speed and standstill status are detected via the wheel speed sensors.

Deceleration with and without Soft Stop



Index	Explanation
m/s2	Deceleration
s	Time in seconds
Red	Deceleration without soft stop
Blue	Deceleration with soft stop
-50%	Reduction of occupant deceleration

Fading Compensation

High temperatures (> 550 °C) can occur at the brake discs when driving downhill for longer periods of time or as the result of multiple braking operations (> 80 bar). These high temperatures result in a change in the coefficient of friction of the brake pads, causing the braking effect to diminish (fading).

The brake disc temperature is calculated based on a temperature model contained in the DSC8+ software. The braking pressure applied by the driver is measured by the pressure sensor and compared with the current vehicle deceleration (setpoint/target value).

If the braking effect diminishes, the driver is assisted by the fading compensation with additional pressure build-up of the DSC module.

A warning lamp in the instrument cluster informs the driver of the overheated brake.

The DSC control unit enters information in the fault code memory in response to activation of the facing compensation function.

Function triggered at temperatures above 500 °C

- HFC (Hydraulic Fading Control) is active for longer than 500 ms and the brake disc temperature is above 500 °C.

Function triggered at temperatures above 700 °C (multiple braking)

- HFC is active and the brake disc temperature is above 700 °C. The warning light in the instrument cluster is activated if the fading compensation function is triggered at brake disc temperatures above 700 °C. A check control message is additionally output on vehicles equipped with a display.

Start Assistant

This function provides assistance when driving off on uphill gradients by temporarily maintaining brake pressure in the wheel brakes.

Based on the gradient, the DSC calculates the holding pressure required in the wheel brakes in order to hold the vehicle.

When the brake pedal is released, the pressure at the wheel brakes is immediately reduced to the holding pressure calculated by the DSC. After a further 0.7 seconds, the DSC reduces the pressure in the wheel brakes in stages to 0 bar and the vehicle starts off slowly providing the accelerator pedal is not pressed.

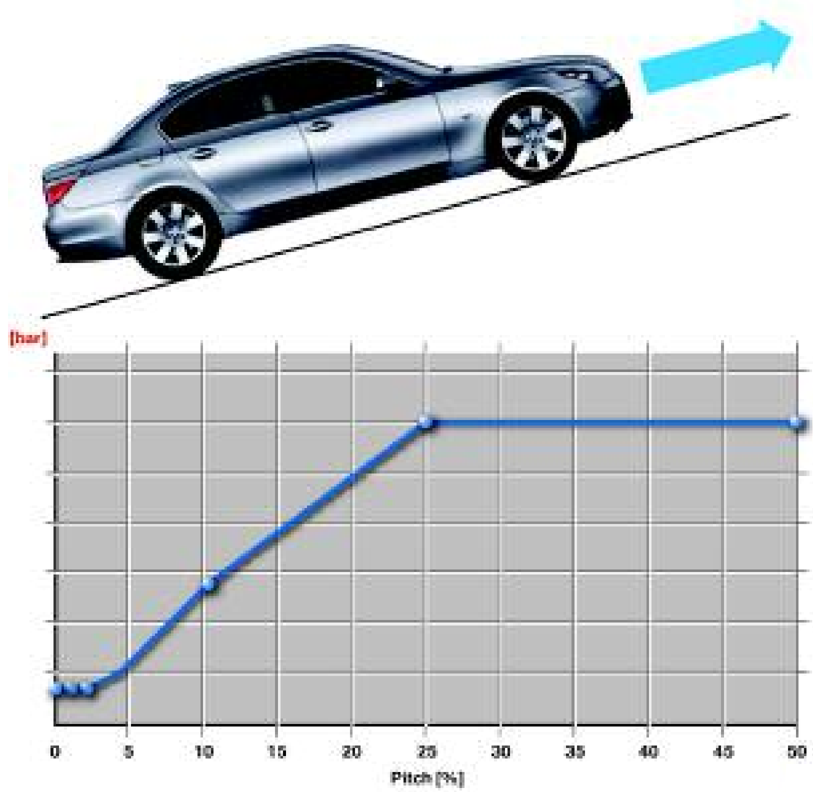
Reducing the pressure at the wheel brakes decreases the breakaway noise of the brakes.

This function is not active when the parking brake is applied.

The angle of inclination is measured by the longitudinal acceleration sensor in the DSC sensor and made available in the form of a telegram on the CAN.

This function is also effective on a downhill incline with reverse gear engaged.

Brake Pressure at the Wheels



Electric Steering Column Lock (ELV)

The ELV safety concept includes the monitoring of the vehicle status. The CAS will not permit the steering column to be locked if the speed signal from the DSC is not plausible or there is no signal. The CAS deactivates terminal 15 when none of the wheel speed sensors send a valid signal while the vehicle is stationary.

The DSC8+ informs the CAS of the vehicle status with regard to:

- Standstill
- Vehicle moving
- Validity of speed signal

The information is transmitted redundantly via the CAN and hard wiring between the control units. As from terminal position "R", the CAS supplies system voltage on the DFA CAS line to the DSC.

When the DSC is operational, the voltage applied by the CAS is connected to ground in various frequencies.

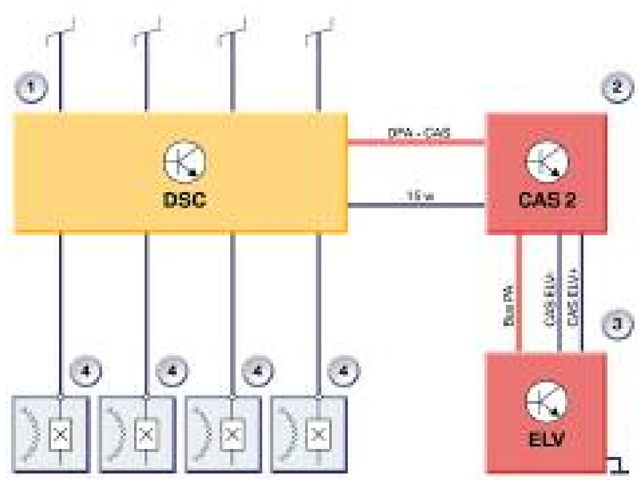
- 10 Hz vehicle stationary < 5 km/h
- 50 Hz driving speed > 5 km/h

This function is a part of the safety concept of the electric steering column lock.

The CAS does not permit locking of the ELV if it does not receive a valid speed signal.

The DSC must detect at least 3 wheel speed sensors as valid for the control unit to apply a frequency on the DFA CAS line.

System Schematic ELV



Index	Explanation	Index	Explanation
1	DSC8+ Dynamic stability control	3	ELV Electric steering lock
2	CAS2 Comfort access system	4	Wheel speed sensors

Service Information

Some jobs on the DSC sensor system require adjustments in the DSC module as well as the LWS and DSC sensors to ensure correct operation.

IMPORTANT!!! **All DSC systems without a pre-charge pump require the low-viscosity DOT4 brake fluid. Observe regulations governing fluids and lubricants.**

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xDrive with DSC8+

From 04/2005, the BMW 5 Series wagon and sedan (optional) will have all wheel drive capability utilizing the tried and tested all-wheel drive system xDrive of the X3 and X5.

The innovative all-wheel xDrive is a system for controlling and regulating the “infinitely” variable drive torque distribution over the front and rear axle. The xDrive uses the system functions of the DSC to positively influence the vehicle handling by specifically distributing the power in the event of understeer or oversteer.

With the controlled multi-disc clutch in connection with the xDrive it is now possible to resolve the conflict between traction and vehicle handling.

This is been achieved in that the xDrive does not predefine the torque distribution by a fixed transmission ratio as is the case with the previous systems. Instead, distribution of the drive torque is dependent on the clutch lockup torque of the controlled multi-disc clutch in the transfer case and on the transmitted torque at the front and rear axle.

This section only contains changes to xDrive for the E60, 61, 90, 91. Detailed information on xDrive is covered in the E83/E53 xDrive training material.

Driver Benefits

In addition to the previous functions, a series of additional safety and comfort functions will now be available to the driver with the introduction of the DSC8+ in the E60/E61.

The expanded DSC8+ functions include:

- Dry braking
- Brake standby
- Automatic soft-stop
- Fading warning and assistance
- Drive-off assistant
- Hill descent control HDC

Besides the outstanding chassis characteristics of the BMW 5 Series, the all whee drive system offers traction advantages not only on snow and ice but also on unsurfaced roads.

Because many system components and functions and are shared between the xDrive and DSC8+ system, they will be discussed together in this section.

xDrive

The innovative xDrive four-wheel drive is a system that controls and regulates the distribution of driving torque to the front and rear axles. The measured variables of DSC are used by xDrive but are also influenced by modified handling performance.

The multi-disc clutch is the heart of the xDrive. By using the controlled multi-disc clutch, it is possible to resolve the conflict between traction and handling performance.

This is achieved through the fact that torque distribution is not determined by a fixed gear ratio in the xDrive as was the case in the previous systems. Instead, the distribution of driving torque is dependent on the locking torque of the controlled multi-disc clutch in the transfer case and on the transferable torque to the front and rear axles.

DSC8+

The DSC8+ system adds features to the DSC8 system already in use in the E60 sedan and combines features used in other DSC systems (E53/83). Due to the mechanical composition of the xDrive system, the programming for DSC regulation has also been changed.

Present DSC8 Functions:

- ABS Anti-lock Braking System
- ADB Automatic Differential Brake
- EBV Electronic Braking Force Distribution
- CBC Cornering Brake Control
- ASC Automatic Stability Control
- DSC Dynamic Stability Control
- DBC Dynamic Brake Control
- MSR Engine Drag Torque Control

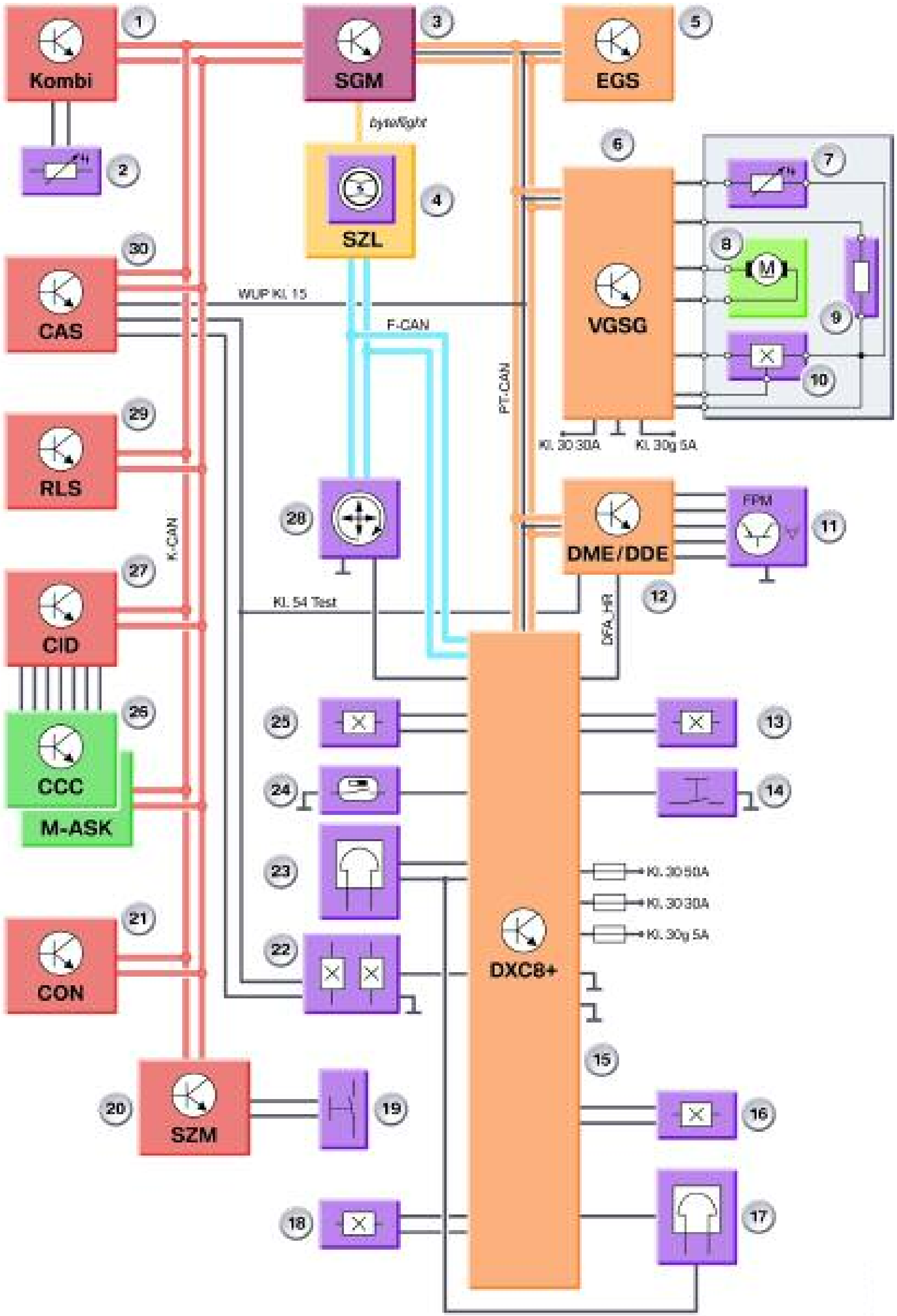
Present DSC Functions:

- TCC Transfer Case Control (control of multi-disc clutch in transfer case)
- ASC-X Automatic Stability Control X (special function for all-wheel drive vehicles)
- ADB-X Automatic Differential Brake X (special function for all-wheel drive vehicles)
- HDC Hill Decent Control

New DSC/DSC8+ Functions

- Dry braking
- Automatic soft stop
- Drive-off assistant
- Hill descent control HDC
- Brake standby
- Fading assistance
- Trailer stabilization control

System Circuit Diagram



System Circuit Diagram Legend

Index	Explanation
1	Instrument cluster
2	Outside temperature sensor
3	Safety and gateway module (SGM)
4	Steering column switch cluster (SZL) with HDC button
5	Electronic transmission control module (EGS)
6	Transfer case control unit (VGSG)
7	Temperature sensor
8	Electronic motor, actuator drive
9	Coding resistor
10	Motor position sensor
11	Accelerator pedal module (FPM) - (not for US)
12	Digital motor electronics (DME) control unit
13	Wheel speed sensor, front right
14	Handbrake switch
15	Dynamic traction control (DSC8+)
16	Wheel speed sensor, rear right
17	Brake wear sensor, rear right
18	Wheel speed sensor, rear left
19	DSC button
20	Center console switching center (SZM)
21	Controller (CON)
22	Brake light switch (BLS)
23	Brake wear sensor, front left
24	Brake fluid level sensor
25	Wheel speed sensor, front left
26	CCC or M-ASK
27	Central information display
28	Yaw rate/longitudinal/transverse acceleration sensor (Y-sensor-2)
29	Rain light sensor (RLS)
30	Car Access System (CAS)

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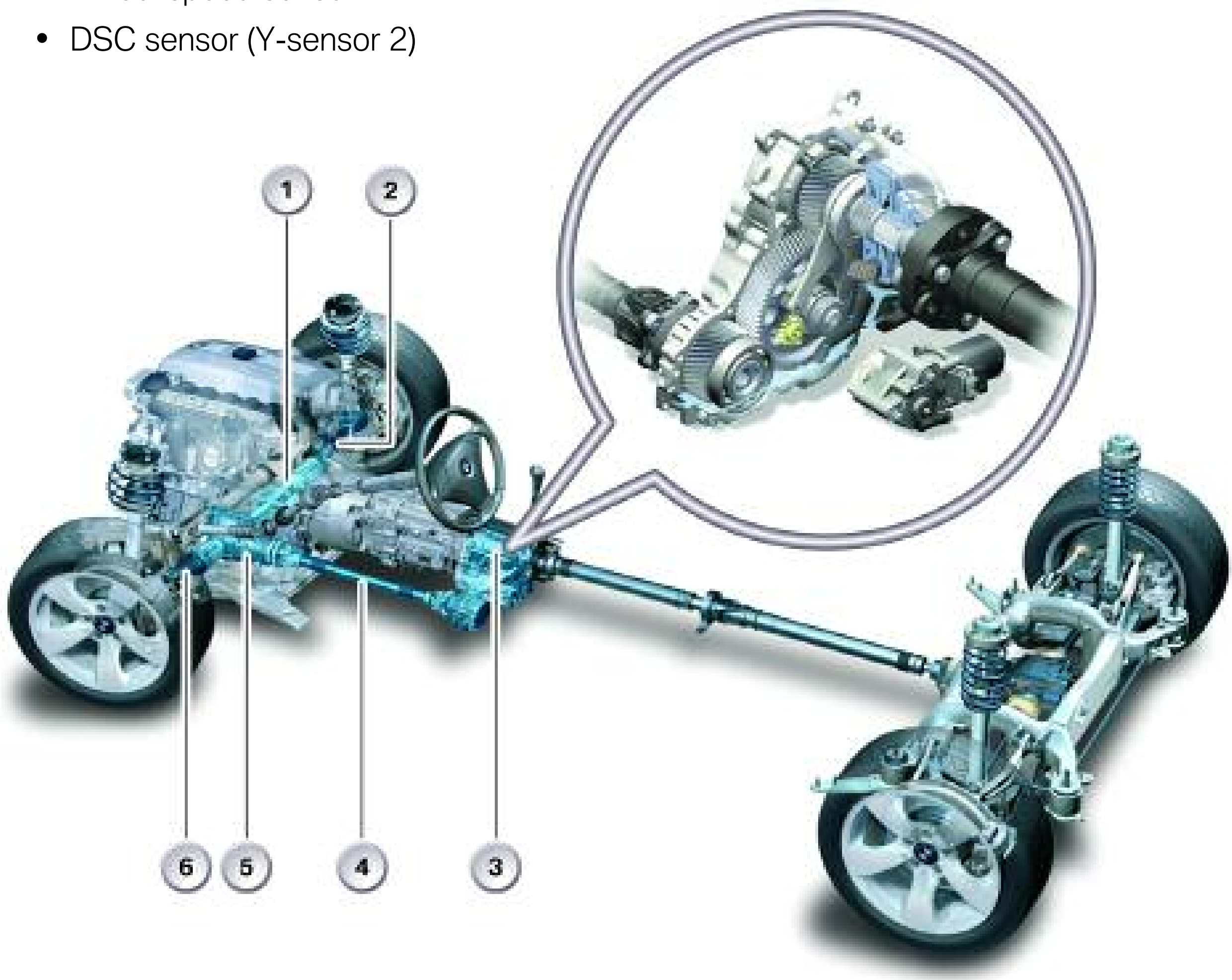
System Components

The xDrive/DSC8+ system is composed of the following major components:

- ATC 300 transfer case
- Adjusting levers
- Servomotor with motor position and temperature sensor
- Coding/classification resistor
- Transfer case control unit
- DSC8+ control unit
- Wheel speed sensor
- DSC sensor (Y-sensor 2)



Index	Explanation	Index	Explanation
1	Oil Pan lead through	4	Propeller shaft to front axle
2	Right drive shaft, front	5	Front axle differential
3	Transfer case	6	Left drive shaft, front

ATC 300 Transfer Case

The transfer case ATC 300 (Active Torque Control) is used on the E60/E61.

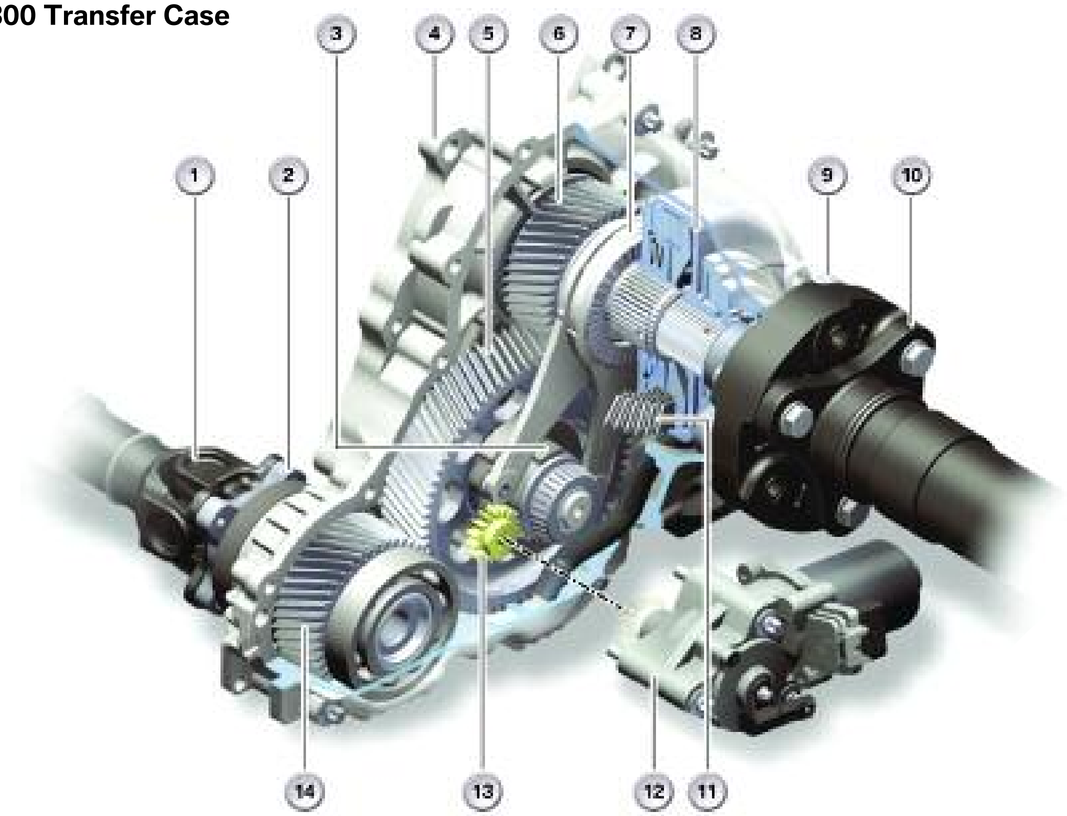
In view of the restricted package space of the transmission tunnel in the BMW 5 Series, it was not possible to adopt the transfer case from the BMW X3 (ACT400) with the same torque rating.

On the BMW 5 Series it was not possible to drive the forward power flow diagonally as is the case on the X3 with a chain, but rather it is necessary to divert it L-shaped with the aid of spur gears (pinions), resulting in a modified design of the transfer case.

The actuator drive and the actuation of the control lever were also modified. The clutch package remains unchanged. The forward connection is provided by a bolted on drive shaft.

The flange of the ATC transfer case is the same for automatic and manual transmissions.

ATC 300 Transfer Case



Index	Explanation	Index	Explanation
1	Propeller shaft to front axle	8	Clutch housing
2	Drive flange to front axle	9	Output flange to rear axle
3	Control cam	10	Propeller shaft to rear axle
4	Transfer case	11	Disc package
5	Idler gear	12	Actuator drive
6	Drive gear	13	Drive pinion
7	Control lever	14	Output gear

The ATC 300 is installed in the E61 and E60 all wheel drive models. The ATC 400 is installed in the E83 and the ATC 500 in the E53 MU.

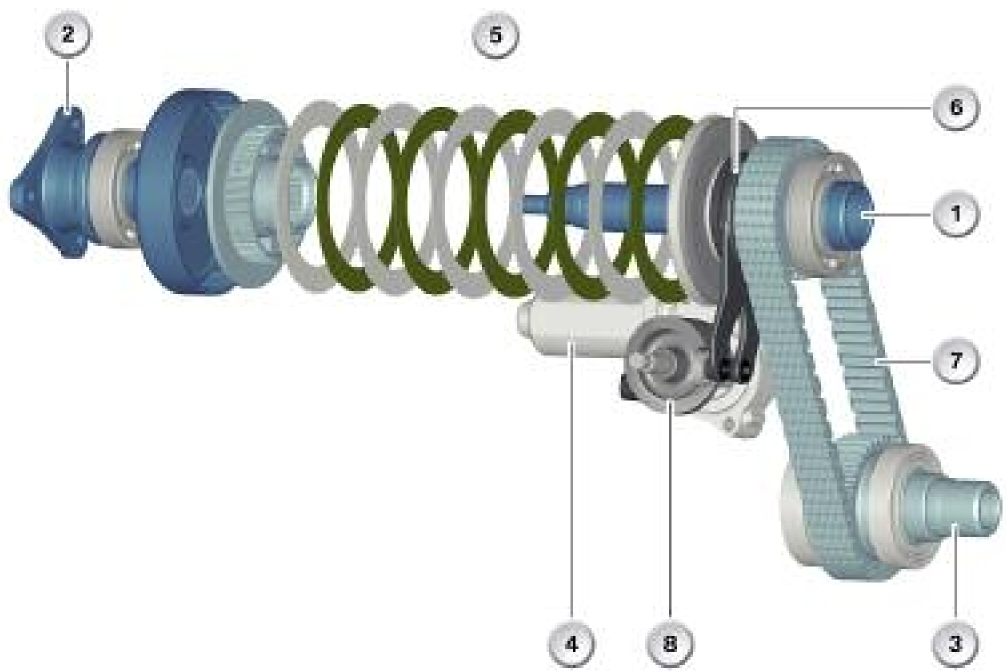
The ATC 300 differs from the other transfer cases because it is gear driven instead of chain driven. The basic functions and operations remain unchanged.

The difference between the transfer cases are:

- ATC 400 & 500 are chain driven vs. ATC 300 which is gear driven.
- ATC 300 & 400 uses a four bolt flange to connect to the front propeller shaft vs. ATC 500 which uses a splined connection.
- ATC 500 utilizes one more disc in the multi-disc clutch than the ATC 300 & 400.
- ATC 500 has 19mm greater length between the input shaft and the output shaft to the front axle than the ATC 400.

See the end of this chapter for more information regarding the most current transfer cases and their installation.

ATC 500 Transfer Case



Index	Explanation	Index	Explanation
1	Input from manual / automatic transmission	5	Clutch discs
2	Output to rear axle prop. shaft	6	Adjusting levers with ball ramp
3	Output to front axle prop. shaft	7	Chain
4	Servomotor	8	Disc cam

DSC8+ Control Unit

The DSC8+ control unit is installed in the engine compartment essentially consists of three components:

- Add-on control unit
- Valve block with integrated pressure sensors
- Pump motor

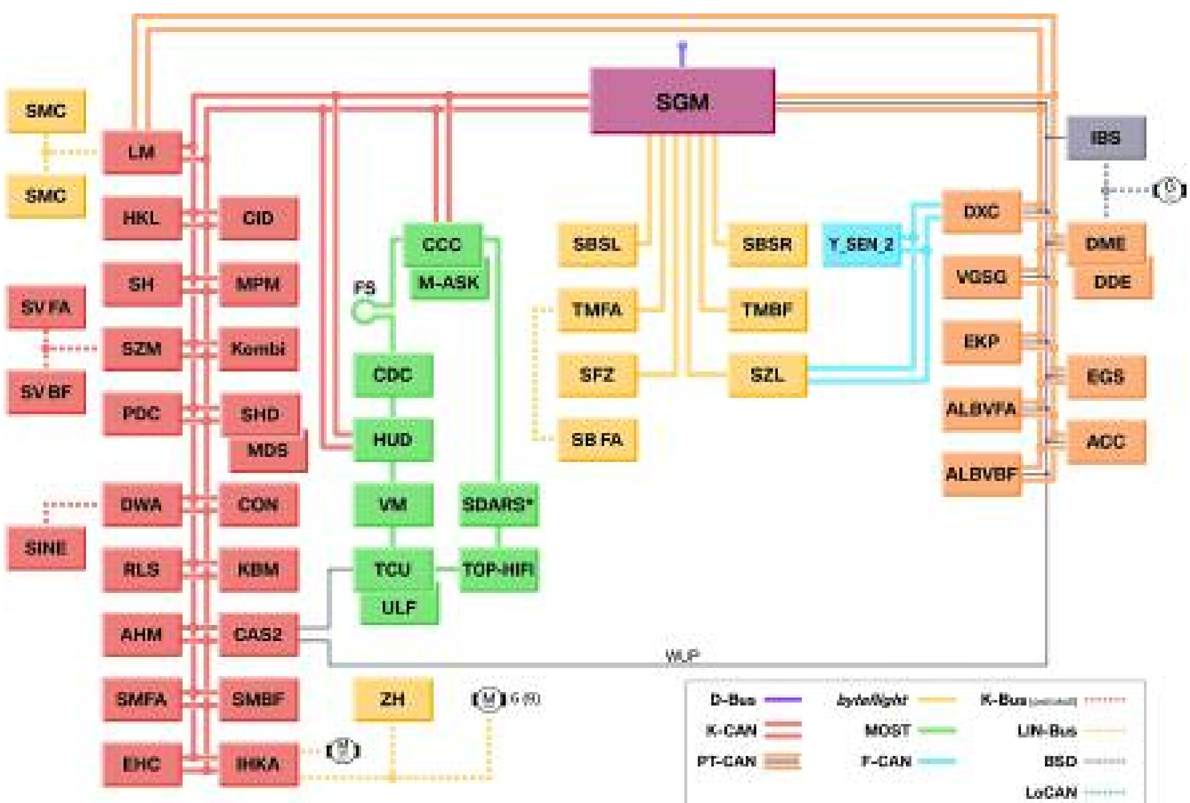
The newly developed changeover valves permit even more exact control in the low pressure range, resulting in the following advantages:

- Reduction of control noise.
- Improvement in control quality and control comfort.
- Improvement in automatic brake intervention by the active/dynamic cruise control ACC/DCC.
- Improvement in the control accuracy of the HDC function.
- Realization of additional brake functions.

Bus Overview

The transfer case control unit (VGSG) is on the PT-CAN. VGSG shares information with DSC for overall xDrive control and has diagnostic communication.

Bus Topology Chart of E61 Sports Wagon (530xiT)



Principles of Operation

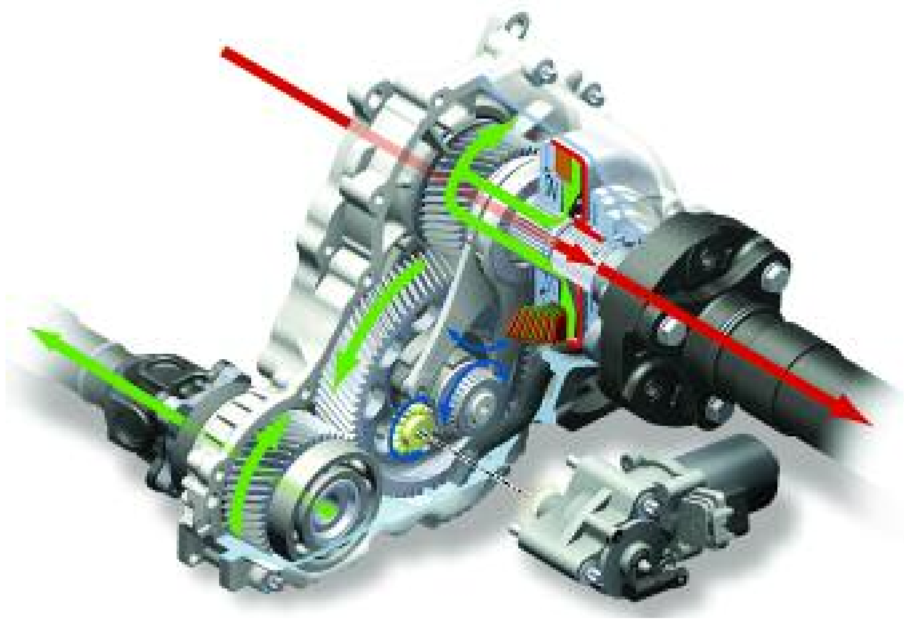
Power Flow

When the multi-disc clutch in the transfer case is disengaged, no driving torque is transmitted to the front axle. All of the driving torque is then distributed to the rear axle. This is because the input shaft (1) is splined providing a permanent connection to the rear axle propeller shaft output flange (2). The multi-disc clutch couples the rear axle propeller shaft output flange to the front propeller shaft output (3).

The driving torque on the front axle is increased or decreased by regulating the locking pressure of the multi-disc clutch, providing a stepless coupling of the front axle to the drivetrain. This depends on driving situations and road conditions. When the multi-disc clutch is fully engaged, the front and rear axles turn at the same speed.

Driving torque distribution (front/rear) is based on available traction at each axle. For example, when traction is identical on the front and rear axles and a driver accelerates from a stop in first gear at full throttle, the rear axle is capable of sustaining greater driving torque as the vehicle weight shifts from the front to the rear.

Another example is when the front axle is on a high traction surface and the rear axle is on ice. In this case, virtually 100% of the available driving torque is transmitted to the front axle. Based on available traction, virtually no driving torque can be supported by the rear axle . Obviously, when more driving torque is transmitted to the front axle, driving torque on the rear axle is proportionally reduced due to lack of traction.



Color	Explanation
Red	Torque from engine to rear axle
Green	Controlled torque to front axle
Dark Blue	Rotation to drive multi-disc clutch

DSC / DSC8+ Control Unit

As in the earlier DSC control units, there are two microprocessors incorporated in the add on DSC8+ control unit. The difference is that in the DSC8 and DSC8+ both processors do not calculate the same algorithms but rather one processor is responsible for performing control and monitoring calculations and checking the plausibility of the wheel speeds.

There are also two semiconductor relays integrated in the DSC8+ control unit, one for the pump motor and the other for the solenoid valves.

On exceeding a road speed of 6 km/h, an electronic self-test is started, during which the pump motor and all solenoid valves are briefly actuated. If the brake is operated at a driving speed of 6 km/h, as may be the case with "two-foot drivers", the self-test will be performed at a speed of 15 km/h.

The check of the wheel speed signals is already started at a speed of 2.75 km/h.

In connection with the xDrive, the DSC8+ control unit also undertakes the task of calculating the lockup torque for the multi-disc clutch in the transfer case.

The lockup torque is always optimally set and controlled to suit the corresponding driving situation.

The drive torque distribution over the front and rear axles is based on the lockup torque. The lockup torque to be set is derived from the pilot control and from a higher-ranking traction and vehicle dynamics regulator corresponding to the driving situation.

The DSC8+ control unit sends the data, concerning the lockup torque, on the PT-CAN to the transfer case control unit VGSG.

Conversely, the transfer case control unit signals the lockup torque actually set as well as the load on the transmission fluid, electric motor and multi-disc clutch.

Dynamic Stability Control

DSC8+ offers several new features from April 2005 production vehicles.
They are:

- ASC-X / ADB-X
- Hill descent control HDC
- Dry braking
- Brake standby
- Automatic soft stop
- Fading assistance
- Drive-off assistant
- Trailer stabilization control

ASC-X / ADB-X

Unlike regular road vehicles, SAVs are also meant to demonstrate satisfactory handling characteristics and appropriate traction on unconventional roads. In order to provide optimum propulsion with sufficient cornering stability on both normal roads and other road surfaces, Automatic Stability Control X (ASC-X) contains a detection function to distinguish between them.

When off-road terrain is detected, wheel slip threshold is increased to provide sufficient traction force with the increased levels of traction loss.

ASC-X is supplemented by the Automatic Differential Brake (ADB-X) function, which applies the brakes to the wheels per axle, for side to side torque transfer. For example, when a wheel is spinning on one side (up to the slip setpoint), the brakes are applied to that wheel and the driving torque is transferred through the axle differential to the wheel with the higher traction. This provides superb capabilities when there are diagonal traction losses (ie. left front/right rear).

ADB-X remains active when DSC is deactivated. Furthermore, ADB-X can develop full capability because the engine power is not reduced, even during extreme four wheel drive operation. Only that wheel which has a low traction receives the brake application.

The brake disc can overheat with excessive ADB-X intervention with DSC deactivated. In this situation, the operation is discontinued at a disc temperature of approx. 700 °C and is resumed when this temperature drops below approx. 400 °C. This is a calculation performed by the DSC control unit based on brake application time, pressure, wheel speed, etc.

Hill Decent Control (HDC)

As on previous all wheel drive vehicles in the BMW line, the E61 all-wheel drive also features the hill descent control facility for safe vehicle operation on steep downhill inclines. The HDC stabilizes the vehicle and prevents the wheels locking. The DSC8+ module controls the build-up of braking pressure at all four wheels so that the vehicle drives downhill at a speed of approx. 7.5 mph (12 km/h).

The HDC function is activated in the central information display via the menu:

Settings => Vehicle settings => HDC

The HDC ON function can be activated by setting a tick in the menu and deactivated by removing the tick.

Furthermore, the HDC ON/OFF function can be selected with one of the two free buttons (asterisk, hash) in the steering wheel button menu.

Menu HDC ON / Active

Dry Braking

The water spray produced in wet conditions coats the brake discs with a water film, causing delayed response of the brakes. In connection with previous systems it was therefore recommended to operate the brakes from time to time.

The dry braking function is dependent on the position of the wiper switch and therefore on the signal of the rain/lights sensor. The brake discs are kept dry by lightly applying the brake pads cyclically as required, this achieving improved braking response in wet conditions.

While doing so, the pressure in the brake system is increased by approx. 1 bar and the brake pads are applied for approx. 1.5 seconds.

Dry braking takes place under following conditions:

- Driving speed > 70 km/h
- Continuous wipe operation in stage 1 or 2

The repeat interval depends on the wiper stage:

- Continuous wipe stage 1 - 200 s
- Continuous wipe stage 2 - 120 s
- Generally 90 s as from 09/2005

This applies only when the driver himself does not apply the brake during this time.

The driver notices no deceleration or noise.

Left disc with water film before dry braking | **Right brake disc after dry braking**

Brake Standby

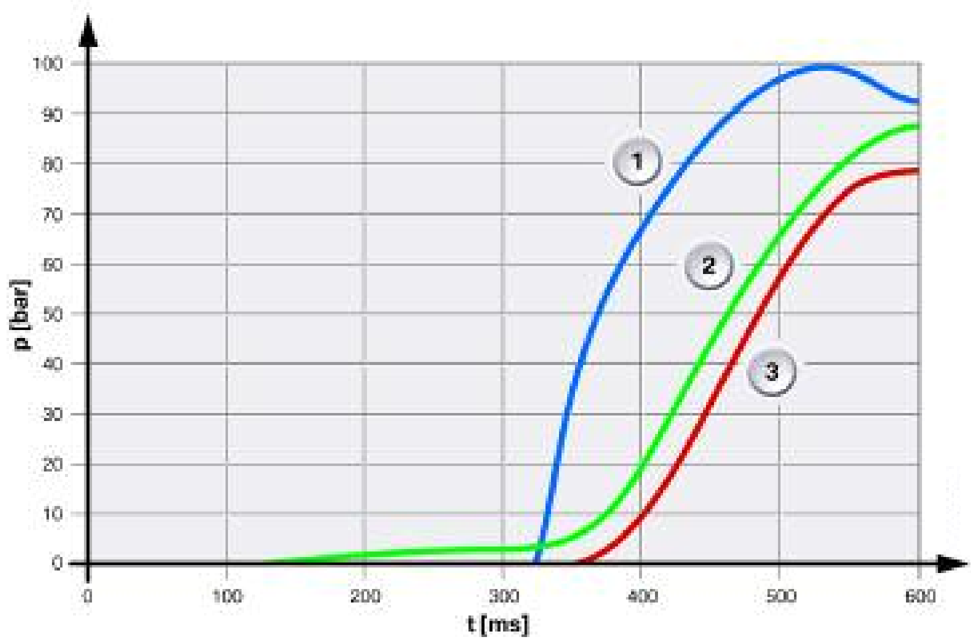
Quick release of the accelerator pedal causes the brake pads to be applied against the brake disc thus reducing the stopping distance (by approx.. 30 cm/100 km/h) during emergency braking. The DSC module builds up slight brake pressure (approx. 2.5 bar) temporarily (approx. 0.5 seconds) in order to eliminate the clearance between the brake pad and brake disc by applying the brake pads.

The brake standby function is activated under following conditions:

- Driving speed > 70 km/h.
- Minimum time between brake application 8s.
- The brake standby function is not activated in connection with sudden acceleration (sports driving style).

The DME/DDE control unit makes available the signal indicating quick release of the accelerator pedal via the PT-CAN.

The sensitive driver may perceive a slightly harder brake pedal. No delay or noise is discernible for the driver.



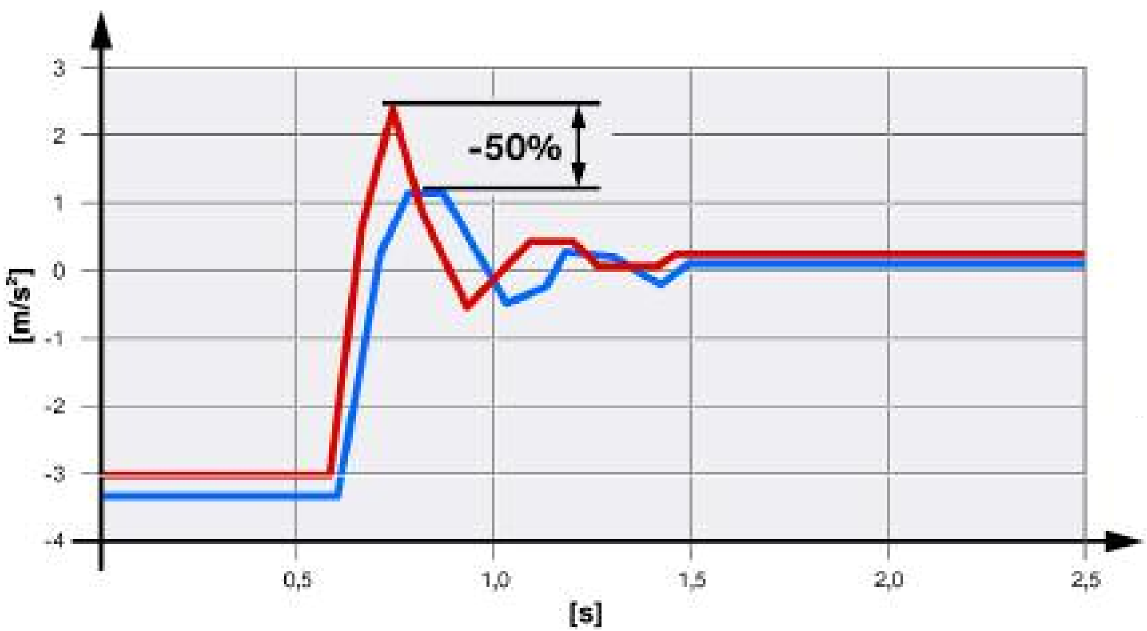
Index	Explanation
P	Braking pressure in Bar
T	Time in milliseconds
1	Pilot pressure applied by driver
2	Braking pressure progression with brake standby
3	Braking pressure progression without brake standby

Automatic Soft Stop

Due to the transition from sliding friction to static friction on the brake disc, a stopping jolt occurs when braking to a standstill where the occupants perceive an increased feeling of deceleration.

When braking lightly (< 25 bar) at constant pressure to bring the vehicle to a halt, the soft stop function automatically reduces the braking pressure at the rear axle just before the vehicle comes to a stop. This consequently reduces the positive acceleration peak perceived by the occupants by approx. 50% while extending the action time.

The speed and standstill status are recognized by way of the wheel speed sensors.



Index	Explanation
m/s^2	Deceleration
s	Time in seconds
Red	Deceleration without soft stop
Blue	Deceleration with soft stop
-50%	Reduction of occupant deceleration

This function is inactive at medium to high deceleration or in the event of ABS control in order not to lengthen the stopping distance.

Fading Compensation

High temperatures (> 550°C) can occur at the brake discs when driving downhill over long periods or as the result of extreme multiple braking operations (> 80 bar). These high temperatures cause a change in the coefficient of friction of the brake pads resulting in the braking effect diminishing (fading).

For this purpose, the temperature of the brake disc is calculated by means of a temperature model contained in the DSC8+ software. The braking pressure applied by the driver is measured by the delivery pressure sensor and compared with the current vehicle deceleration (target/actual value).

When the braking effect diminishes, the fading compensation provides assistance for the driver in that pressure is additionally built up by the DSC module.

Brake Disc with Fading

Drive-off Assistant

When negotiating uphill gradients, the drive-off assistant holds the vehicle for a short time (approx. 1.5 s) after releasing the brake so that the vehicle drives off comfortably without the need to use the handbrake. The braking pressure required by the driver to hold the vehicle is maintained automatically in the system.

When driving off, the braking pressure is not reduced before the torque is sufficient for the vehicle to drive off. The holding pressure in the brake system (10 to max. 70 bar) is dependent on the uphill gradient.

Uphill gradients are detected by the DSC sensor with the aid of a longitudinal acceleration sensor.

The function is active both when driving forwards (transmission in Drive) and when reversing (transmission in Reverse) on uphill gradients (up to 50 %).

Drive-off Assistant Function

Service Information

Safety Notice!!!

On a vehicle equipped with an automatic transmission, when driving onto brake analyzers, move the selector lever to the "N" position . On a vehicle equipped with a manual transmission, do not release the clutch pedal once on the brake analyzer.

This keeps the transfer case clutch open and the vehicle cannot be pulled off the analyzer.

Towing: Use only a flatbed carrier for all xDrive vehicles!

Oil, Transfer Case, and Clutch Monitoring

Oil

All xDrive transfer cases use Shell Gear oil part number 83 22 0 306 816.

There is no scheduled service for the transfer case oil. Oil Monitoring is performed by the VTG control module to determine when a service (change) is due. The VTG calculates transfer case and clutch wear based on the amount of slip, engagement pressure (torque), speed and mileage.

This calculation accounts for:

- normal "dry" road driving (Integrator 1)
- "adverse" road driving (Integrator 2)
- "other" road extreme driving (Integrator 3)

Depending on individual vehicle use - driving styles and driving conditions, the transfer case oil service interval will vary.

When a service is due, this will be indicated by a Fault Code and additional details are available using ISTA. Service functions provide directions on changing the transfer case oil and updating the VTG control module with the necessary reset and adaption procedure. This is extremely important for CBS.

Transfer Case and Clutch

The transfer case and clutch have separate monitoring characteristics. These values are stored as adaptive values in the VGSG control unit and must be transferred to a new control unit if replaced.

The value for both can be obtained using the diagnostic software under:

Control Unit Functions => VTG => Diagnosis requests => Transmission

Control Unit Functions => VTG => Diagnosis requests => Clutch

Diagnosis
Diagnosis is available for fault repairs and service procedures using ISTA.

The test plan for the VGSG contains valuable information on:

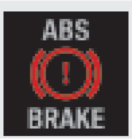
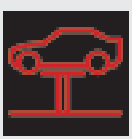
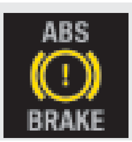
- Replacing control unit
- Replacing transfer case
- Transferring adaptation values
  - Automatic
  - Manual
- Reading out adaptation values

Programming (flashing)
Both the transfer case control unit (VTG) and the DSC control unit are programmable and the new control unit(s) must be programmed when replaced. The wear values stored in the VTG control module (to be replaced) must be transferred to the replacement VTG.

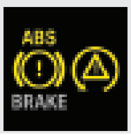
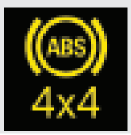
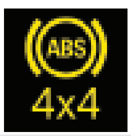
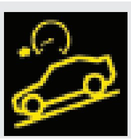
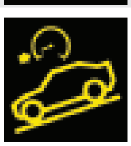
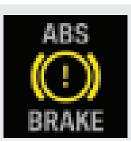
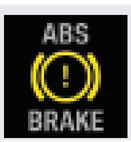
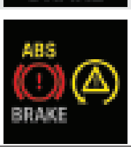
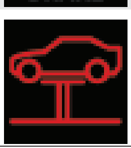
Warning Indicator Lamps
The warning indicator lamps for the xDrive / DSC are found in the instrument cluster as shown on the bottom of this page.

The warning indicator lamps and acoustic signals (gong) are assigned to the xDrive / DSC system states of malfunction described on the next two pages.

Check Control Messages Relating to xDrive / DXC8+

Fixed indicator lamp	Variable indicator lamp	Check control message	Information in central information display
		DSC disabled!	You have disabled DSC. Restricted vehicle stability while accelerating and cornering.
		DTC enabled, DSC restricted!	DTC enabled. Dynamic traction control DTC increases forward propulsion on unpaved surfaces, however, it decreases vehicle stability.
		DSC failed! Drive with moderation	DBC failed. No additional braking assistance from DBC in emergency braking situations. Drive with moderation. Have checked by your BMW dealer as soon as possible.
		DSC failed! Drive with moderation	DSC failed. Restricted vehicle stability while accelerating and cornering. Drive with moderation. Have checked by your BMW dealer as soon as possible.
		Control systems! Drive with moderation	Brake and vehicle control systems failed. Reduced braking and vehicle stability. Avoid abrupt braking where possible. Have checked by nearest BMW dealer.
		Control systems! Drive with moderation	Brake and vehicle control systems failed. Drive with moderation, avoid abrupt braking where possible. Have checked by nearest BMW dealer.
		Brake pads! Replace	The brake pads are worn. Have replaced by nearest BMW dealer.
		Brake fluid! Stop cautiously	Brake fluid level too low. Reduced braking efficiency. Stop cautiously. Contact nearest BMW dealer.
		Brakes too hot! Allow to cool down	Brakes too hot Critical temperature as a result of permanent heavy load. Danger - reduced braking efficiency. Allow brakes to cool down. Stop if necessary.

Check Control Messages Relating to xDrive / DXC8+ (cont'd)

Fixed indicator lamp	Variable indicator lamp	Check control message	Information in central information display
		Brakes overheated! Allow to cool down	Brakes overheated Critical temperature exceeded. Braking efficiency no longer guaranteed. Stop at the next opportunity and allow to cool down substantially.
		4x4 system and DSC failed!	4x4 system and DSC failed! Vehicle stability restricted. Drive with moderation. Have checked by your BMW dealer as soon as possible.
		4x4 system defective! Drive with moderation	4x4 system defective Vehicle stability restricted. Drive with moderation. Have checked by your BMW dealer as soon as possible.
		4x4 system, DSC and ABS failed!	4x4 system, DSC and ABS failed! Vehicle stability restricted. Drive with moderation. Have checked by your BMW dealer as soon as possible.
		4x4 System, DSC, ABS and emergency EBV failed!	4x4 System, DSC, ABS and emergency EBV failed! Vehicle stability restricted. Drive with moderation. Have checked immediately by your BMW dealer.
		HDC enabled!	
		HDC disabled!	HDC disabled. Hill descent control HDC is disabled at speed above 60 km/h (37 mph). System can be re-enabled at speed below 35 km/h (22 mph).
		No HDC control! Drive slower	HDC not possible! Control range ends at 35 km/h (22 mph). To use HDC, reduce speed accordingly.
		HDC currently not available!	HDC not available. Automatic brake intervention interrupted for safety reasons as brakes are overheated. Shift down and drive carefully in order to reduce temperature.
		Drive-off assistant inactive!	Drive-off assistant inactive Caution, vehicle can roll back! Have checked by your BMW dealer at next opportunity.
		Electronics fault! Stop cautiously	Central vehicle electronics failed. Continued journey not possible. Contact nearest BMW dealer.

Transfer Case Installation Chart

Transfer Case	Installed in	Chain Driven	Gear Driven	Integrated transfer case module	Coding Resistor
ATC 300	E60/E61, E90, E91, E92	–	X	–	X
ATC 400	E83	X	–	–	X
ATC 500	E53	X	–	–	X
ATC 700	E70, E71, E72 (SOP)	–	–	–	X
ATC 350	E84, F01, F02, F07(to 09/11), F10 (to 09/11)	–	X	X	–
ATC 450	F25 (to 10/11), E70, E71 LCI up to 04/12	X	–	X	–
ATC 35L	F10 (from 09/11), F07(from 09/11) F06, F12, F13, F30, F01/F02 LCI	X	–	X	–
ATC 45L	E70, E71 LCI (from 04/12) F25 (from 10/11)	X	–	X	–

ATC 700:

- is based on the ATC500
- is chain driven
- Installation position coding resistor
- optimized lifetime gear oil
- enhanced ventilation system
- transfer case control unit (VGSG).

See E70 training material (available on TIS and ICP) for more information regarding ATC 700.

ATC 350:

- is based on ATC 300
- is gear driven
- uses a splash type lubrication system
- uses a integrated actuator motor/control module (mounted on the case)

See E84 training material (available on TIS and ICP) for more information regarding ATC 350.

ATC 450:

- Is based on the ATC 400
- is chain driven
- 2 kg weight reduction
- uses a splash type lubrication system
- uses a integrated actuator motor/control module (mounted on the case)

See F25 training material (available on TIS and ICP) for more information regarding ATC 450.

ATC 45L:

- is based on the ATC 450
- is chain driven
- 1.5 kg weight reduction
- uses a splash type lubrication system
- uses a integrated actuator motor/control module (mounted on the case)

ATC 35L:

- is based on the ATC 350
- is chain driven
- 1.4 kg weight reduction
- uses a splash type lubrication system
- uses a integrated actuator motor/control module (mounted on the case)

See F01/F02 LCI training material (available on TIS and ICP) for more information regarding ATC 35L.

While previous transfer cases (up to the introduction of the ATC 350) used to have a "coding and service resistor", it has been eliminated in the new transfer boxes. The compensation of the production tolerances in the transfer case which was previously achieved by the coding resistor is now accomplished via an internal classification that can also be found on the type plate.

NOTES PAGE

Dynamic Driving Systems

History of Dynamic Driving Systems

Since the introduction of the E65 (7 Series) there have been many developments in the area of dynamic driving systems on all BMW models.

With the introduction of the F01, these past developments were combined with the latest innovations to make for a truly “Dynamic” driving experience.

For example, the introduction of the longitudinal dynamics management system in the BMW 3 Series (E9x) was the first step in this direction. The longitudinal dynamics control functions, Dynamic Cruise Control and Active Cruise Control, were integrated into one control unit called the LDM. These integrated functions considerably enhanced the harmony and coordination of drive and brake actuation.

The Vertical Dynamics Management made its debut in the BMW X5 (E70) with the VDM control unit: the integrated Vertical Dynamics Control (VDC) function was implemented to control the adjustable dampers.

In contrast to the earlier system, where only ride-level heights and vertical acceleration are used as the input signals, the higher-level control strategy of the VDC takes all signals relevant to driving dynamics into account including, for example, road speed, and longitudinal/lateral acceleration.

The VDM control unit also coordinates the Vertical Dynamic Control and Active Roll Stabilization (ARS) functions. Overall, this meant that wheel contact with the road surface was improved and the vertical movement of the body reduced for a wider variety of road situations.

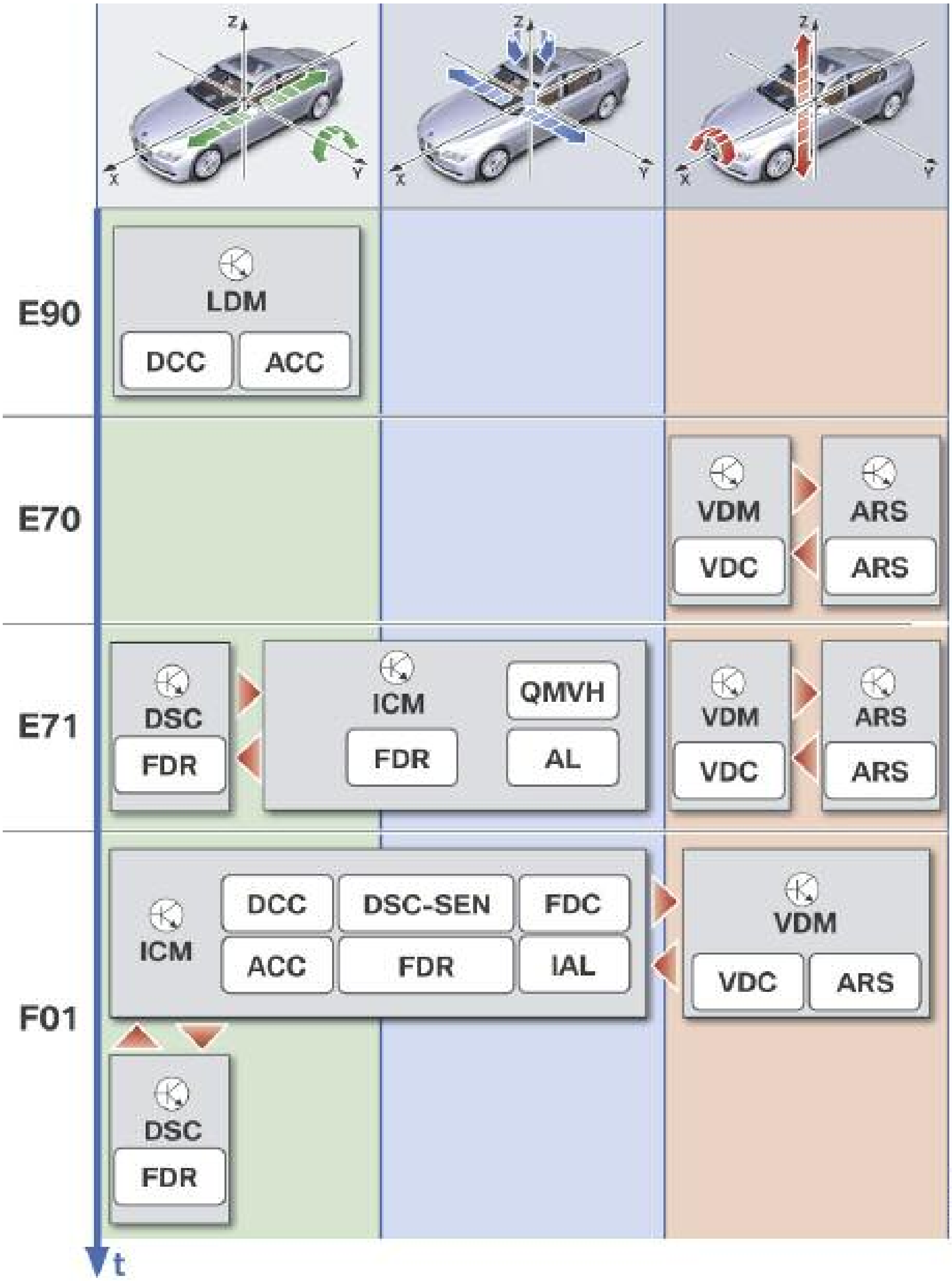
In addition to the VDM control unit, the BMW X6 (E71) was also equipped with an ICM control unit that for the first time incorporates both the longitudinal and lateral dynamics control functions.

The longitudinal and lateral motion of the vehicle is evaluated centrally in the ICM control unit. Following on from this development, the dynamic driving systems Active Steering and Dynamic Performance Control (QMVH) are now used and their interaction is of course also coordinated by the ICM control unit.

Significant at this stage is the definition of the ICM as the main control unit for the control functions. The actuators on the other hand are activated by control units specially intended for this purpose.

Although introduced on the E71 X6, the ICM is the centerpiece of control for all Driving Dynamics and Driver Assistance Systems and its installed on all BN2020 BMW vehicles.

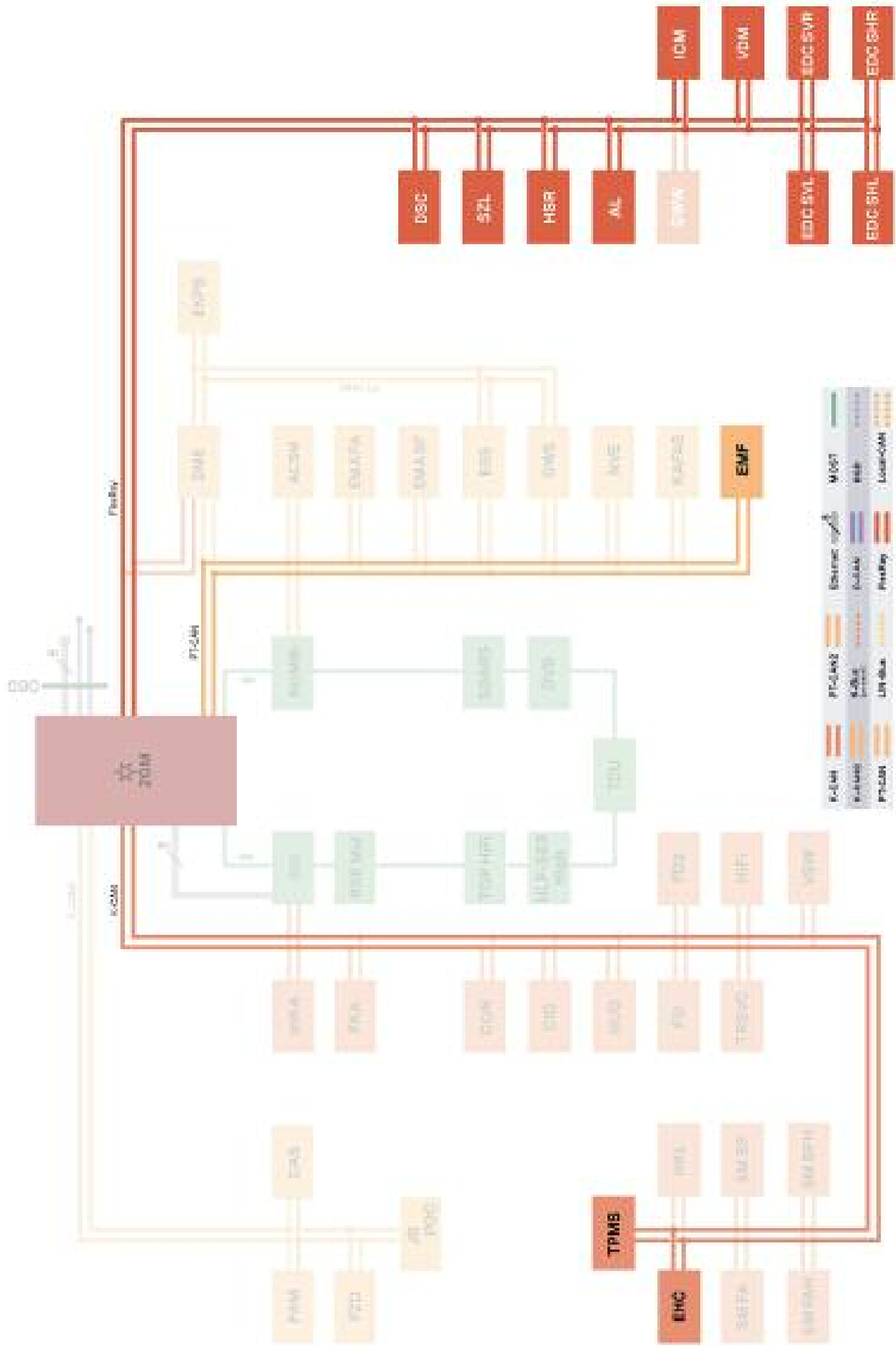
Evolution Stages of Integrated Chassis Management



The red triangles denote interaction between the control units and functions. This is not always purely be an exchange of sensor signals. Control signals and reference values may be also used (for example) to influence the driving dynamics control in the ICM control unit or the Active Roll Stabilization in the VDM control unit.

Index	Explanation
LDM	Control unit, Longitudinal Dynamics Management
DCC	Dynamic Cruise Control function (cruise control with braking function)
ACC	Active Cruise Control function
VDM	Control unit, Vertical Dynamics Management
VDC	Vertical Dynamics Control function
ARS	Control unit or function, Active Roll Stabilization (Dynamic Drive)
DSC	Control unit, Dynamic Stability Control
FDR	Driving dynamics control function
ICM	Control unit, Integrated Chassis Management
QMVH	Lateral torque distribution at rear axle (Dynamic Performance Control)
AL	Active Steering function
DSC-SEN	DSC sensor in the ICM control unit
FDC	Driving dynamics control switch
IAL	Integral Active Steering function

Bus System Overview for Dynamic Driving Systems



Index	Explanation
AL	Active Steering
DSC	Dynamic Stability Control
EHC	Electronic ride-height control
EDC SHL	Electronic Damping Control satellite, rear left
EDC SHR	Electronic Damping Control satellite, rear right
EDC SVL	Electronic Damping Control satellite, front left
EDC SVR	Electronic Damping Control satellite, front right
EMF	Electromechanical parking brake
ICM	Integrated Chassis Management
HSR	Rear axle slip angle control
TPMS	Tire Pressure Monitoring System
SZL	Steering column switch cluster with steering angle sensor
VDM	Vertical Dynamics Management
ZGM	Central gateway module

Changes to Driving Dynamics Control

From its introduction in the F01/02, the management of chassis systems has been further developed to improve the performance and interaction of the individual dynamic driving systems.

The integration of the ICM module allows the desired dynamic effect in each road situation. Also, the most suitable actuator can now be selected and activated.

For example, in some instances it might be necessary to activate the brakes for individual wheels (DSC) while superimposing a steering angle using the Integral Active Steering (IAL).

A further task of the ICM control unit is to make the driving dynamics condition available throughout the entire vehicle through in the form of signals. This is why the DSC sensor in the F01/F02 (which was previously fitted separately) was integrated into the ICM control unit.

This means that all systems have access to the same information provided by the ICM control unit. As a consequence, the potential for errors, particularly in networked systems, is reduced and the system reliability of systems is increased.

This also simplifies the diagnosis of the interconnected system as the fault code memory entries for the driving dynamics signals are stored centrally in the ICM control unit and are no longer distributed between many control units.

The result for the customer is perfect harmony in terms of vehicle handling - irrespective of the equipment specification and road situation. This uses the possibilities for maximizing convenience, agility and stability to the fullest.

The customer's experience of this harmony in terms of vehicle handling is especially enhanced by the new **Driving Dynamics Control** function.

This offers several particularly distinctive vehicle characteristics that determine how the vehicle handling as a whole is perceived by the driver and passengers.

The driver can use the driving dynamics switch to select a characteristic that perfectly matches the specific driving requirement or section of road.

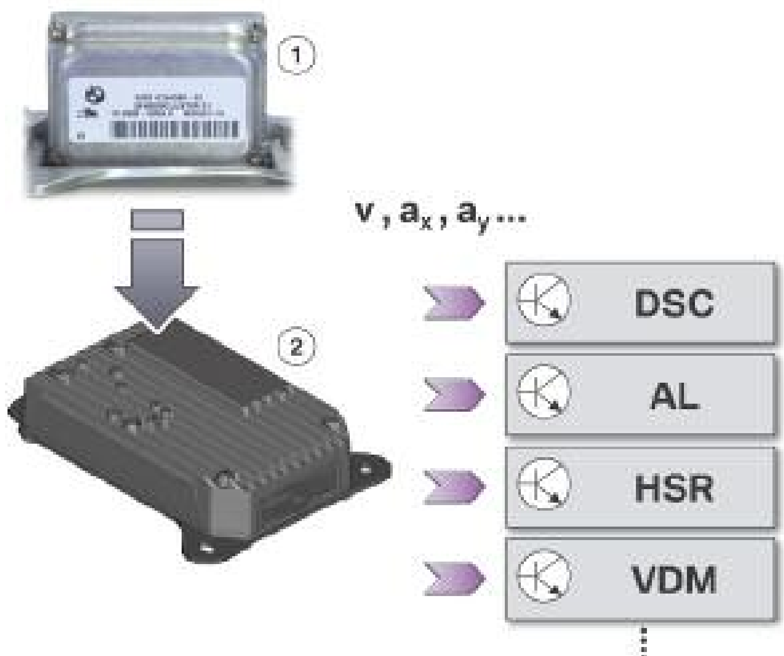
New Control Units

Two newly developed control units for dynamic driving systems will also be used in the F01/F02:

- Integrated Chassis Management (ICM).
- Vertical Dynamics Management (VDM).

Although their names are already familiar from the E70/E71, they differ considerably in their functional range and design. A multitude of driving dynamics functions are concentrated in these control units.

Driving Dynamics Signals Provided by the ICM



Index	Explanation	Index	Explanation
1	DSC sensor integrated into the ICM	DSC	Dynamic Stability Control
2	ICM control unit	AL	Active Steering
v	Road speed	HSR	Rear axle slip angle control
a_x	Longitudinal acceleration	VDM	Vertical Dynamics Management
a_y	Lateral acceleration		

In addition to central signal provision, the essential functions of the ICM control unit are concerned with longitudinal and lateral dynamics. These include the control function for the new Integral Active Steering, for example.

The vertical dynamics functions on the other hand are incorporated in the VDM control unit.

These include:

- Vertical Dynamics Control 2 (2nd generation).
- Active Roll Stabilization (ARS a.k.a Dynamic Drive).

Although both control units are standard equipment, two expansion stages are available in each case, depending on the options fitted to the vehicle.

Expansion Stages of ICM Control Unit

The basic version of the ICM control unit is fitted as standard in the F01/F02. In this case, the vehicle is provided with the Servotronic steering system and cruise control driver assistance function with braking function (DCC).

The high-performance version of the ICM control unit is used if one or both of the following options are ordered by the customer:

- Integral Active Steering
- Active Cruise Control with Stop & Go function

Expansion Stages of VDM Control Unit

The basic version of the VDM control unit contains the Vertical Dynamics Control function. This is included in the standard equipment of the F01/F02.

The high-performance version of the VDM control unit is fitted if the customer also orders the optional ARS. The high-performance version also incorporates the output stages required for activation of the hydraulic valves in the ARS.

Integrated Chassis Management (FXx)

ICM Control Unit

An ICM control unit is installed in every (FXx) BN2020 vehicle. Each ICM control unit contains the following, irrespective of the equipment installed in the vehicle:

- Two microprocessors.
- A FlexRay controller.
- Output stages for activating valves in the steering system.
- Integrated sensor system for driving dynamics variables (previously: DSC sensor).

The essential tasks of one of the microprocessors are the calculation of control functions, communication processing and activation of the output stages.

The main task of the second processor is to monitor safety relevant functions and bring about a system shut down in the event of a fault.

The other components of the ICM control unit listed above are described in the following chapters.

Two versions of the ICM control unit exist. The version installed in the vehicle depends on the vehicle model and its equipment.

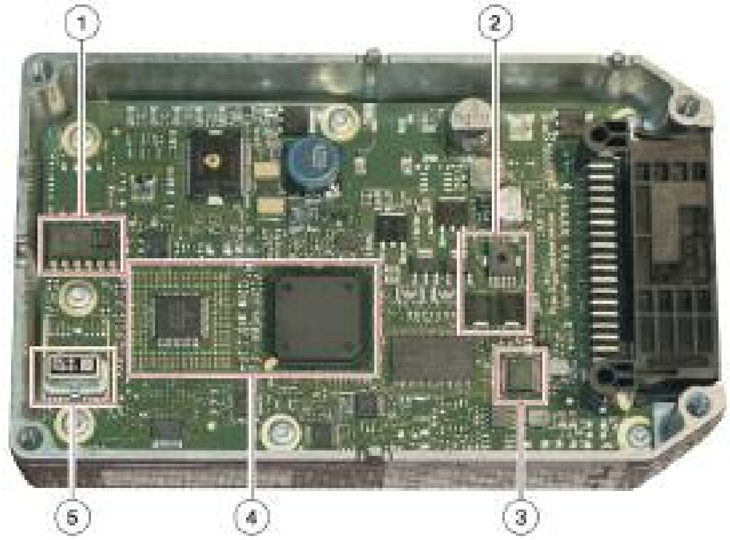
The internal layout of the high-performance version differs from the internal layout of the basic version in the following ways:

- Larger microprocessor (required to calculate the Integral Active Steering control and active speed control).
- Redundant sensor system for lateral acceleration and yaw rate (safety requirement for Integral Active Steering).

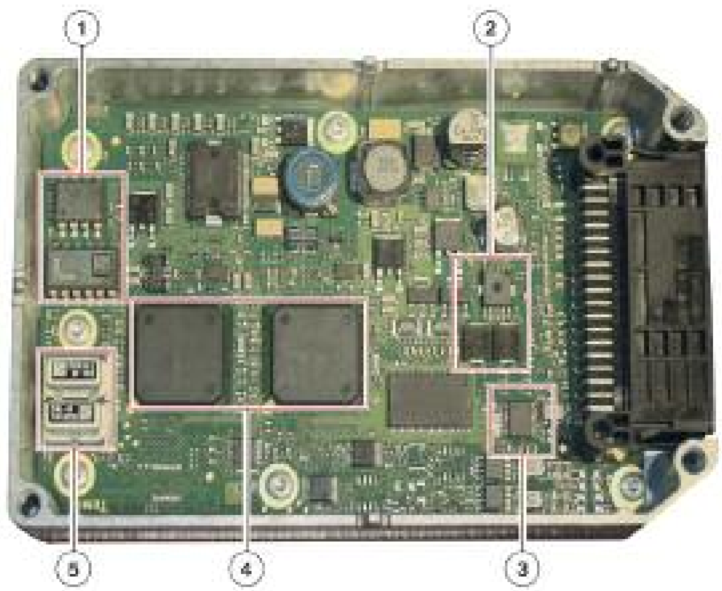
The sensors that were previously accommodated in the DSC sensor are now housed in the ICM. Therefore there are no independent DSC sensors on BN2020 vehicles.

The following graphics make these differences clear.

ICM Control Module, Basic Version



ICM Control Module, High Performance Version

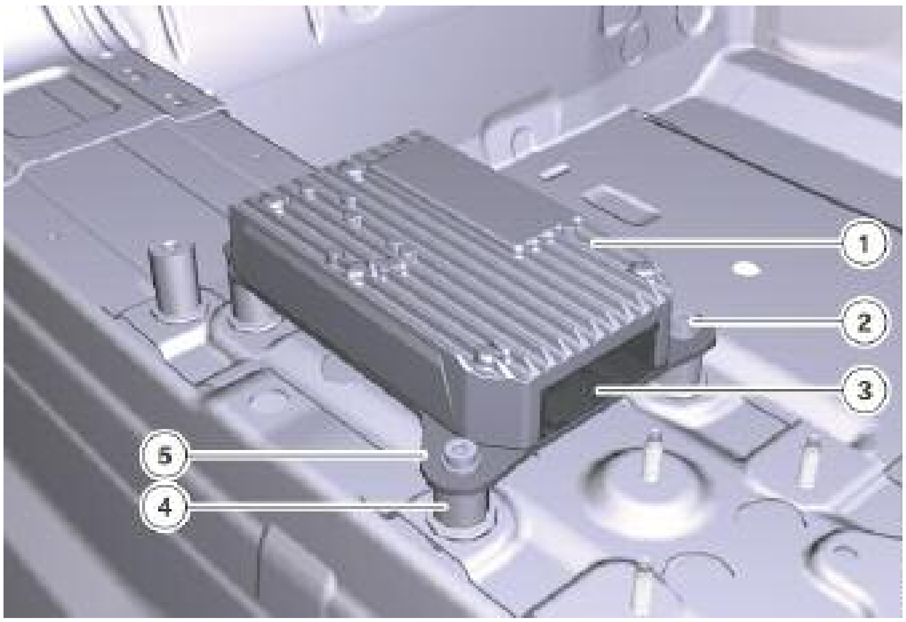


Index	Explanation
1	Acceleration sensor (longitudinal and lateral acceleration)
2	Output stages for Servotronic and EVV valves
3	Controller for FlexRay connection
4	Two microprocessors
5	Yaw rate sensor (2 for HP version)

Location and Mounting of the ICM Module

The ICM control unit is installed in the center console behind the central sensor for the ACSM. This means that the position of the control unit and its integrated sensor system in the vehicle, near to its center of gravity, is ideal from the point of view of driving dynamics.

The mounting points on the body are precisely determined and are measured when the vehicle is manufactured and must not be replaced with any other mounting points.



Index	Explanation	Index	Explanation
1	Upper section of housing	4	Spacer sleeve
2	Mounting bolt	5	Lower section of housing
3	Connector		

The housing of the control unit is connected to the metal body of the transmission tunnel with four screws and spacer sleeves made of aluminum. The control unit must be mounted on the vehicle body free of play as otherwise vibrations may be induced in the control unit housing which would severely impair the operation of the integrated sensor system.

A secondary task of this mounting is to conduct heat away from the control unit to the body.

For the mounting to be able to perform these tasks, the following points must be observed when mounting and replacing the ICM control unit:

- Use only the correct spacer sleeves and mounting bolts.
- The mounting bolts must be tightened in the correct order (See repair instructions).
- The tightening torque specified in the repair instructions must be observed without fail.
- A check must then be carried out to make sure the control unit is mounted securely and free of play.
- To ensure sufficient heat dissipation and to avoid vibrations, the sides and top of the control unit housing must not come into contact with other vehicle components.
- In the center console, where the ICM is located, the provided “air space” must be maintained. Harnesses and cables should be routed correctly and must not contact the ICM.
- Aftermarket accessories should not be in the vicinity of the ICM.
- The wiring harness that runs in the center console in particular must never be routed in, or even pushed into, the spaces on either side of the ICM control unit.

Ride-height Sensors

Design and Principle of Operation

The angle of a pivoting arm is converted to a voltage signal via the ride-height sensors. The greater the angle (with reference to a defined starting position), the greater the output voltage generated by a Hall sensor element.

Versions

Two to four ride-height sensors are installed in every FXx vehicle depending on optional equipment installed. However, the ride-height sensors installed in the vehicle are in different versions. Different ride-height sensors are used on the left and right of the front axle and different ride-height sensors are also used on the rear axle.

The reasons for this is the available installation space and the starting position of the pivoting arm.

Double or single-type ride-height sensors are used at the rear axle, depending on whether the vehicle is equipped with electronic ride height control (EHC). Single-type ride-height sensors are always used at the front axle.

Interface with ICM Control Unit

Each ride-height sensor (irrespective of the version) is connected to the ICM control unit by three wires. The double-type ride-height sensors at the rear axle are also connected to the EHC control unit according to the same principle via three additional lines.

Power is supplied by the ICM control unit to the ride-height sensor via one of the lines. The sensor uses the second line to deliver its measurement signal (0-5 V DC voltage). The third line is connected to a common earth inside the ICM control unit.

The measurement signal is evaluated by means of voltage measurement in the ICM control unit. The ICM control unit cannot calculate the actual ride-level heights in millimeters on the basis of this information alone.

To perform this calculation, the ICM control unit must be able to map the voltage signals it receives to reference values. This is the only way to establish a relationship between the measurement signals and the actual ride-level heights.

These reference values are determined during a synchronization procedure.

The ride-height signals in the ICM must be synchronized in the following cases:

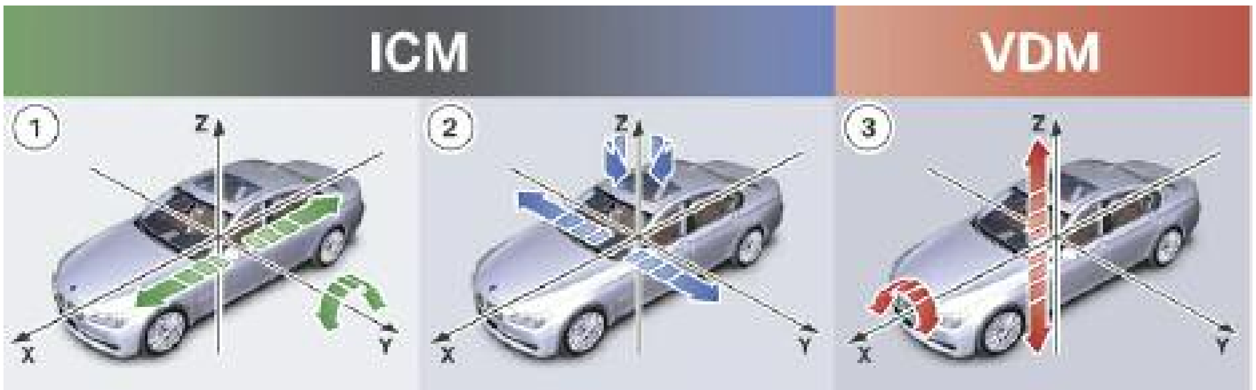
- following replacement of the ICM control unit.
- following replacement of a ride-height sensor.
- if prompted to do so by the test schedule of the diagnostic system (due to a fault code memory entry in the ICM).

The synchronization does not have to be carried out if a wheel has been changed.

Integrated Chassis Management Operation

With the E71, the notion of a higher-level driving dynamics control system was implemented for the first time in a standard model. This central function is also referred to as "Integrated Chassis Management" ("ICM" for short) and is integrated in the control unit of the same name in the E71.

The previous strategy was to use one control unit to perform the control tasks for each main movement direction. This approach was not employed in the E71 or the F01/F02.



Index	Explanation	Index	Explanation
1	Longitudinal dynamics	ICM	Integrated Chassis Management
2	Lateral dynamics	VDM	Vertical Dynamics Management
3	Vertical dynamics		

As is the case in the E71, the new ICM control unit in the F0x vehicles essentially performs the calculations for the control functions that influence the longitudinal and lateral dynamics.

The actuators are activated by separate control units (e.g. AL control unit). The functional range of the ICM control unit has grown considerably when compared to the E71.

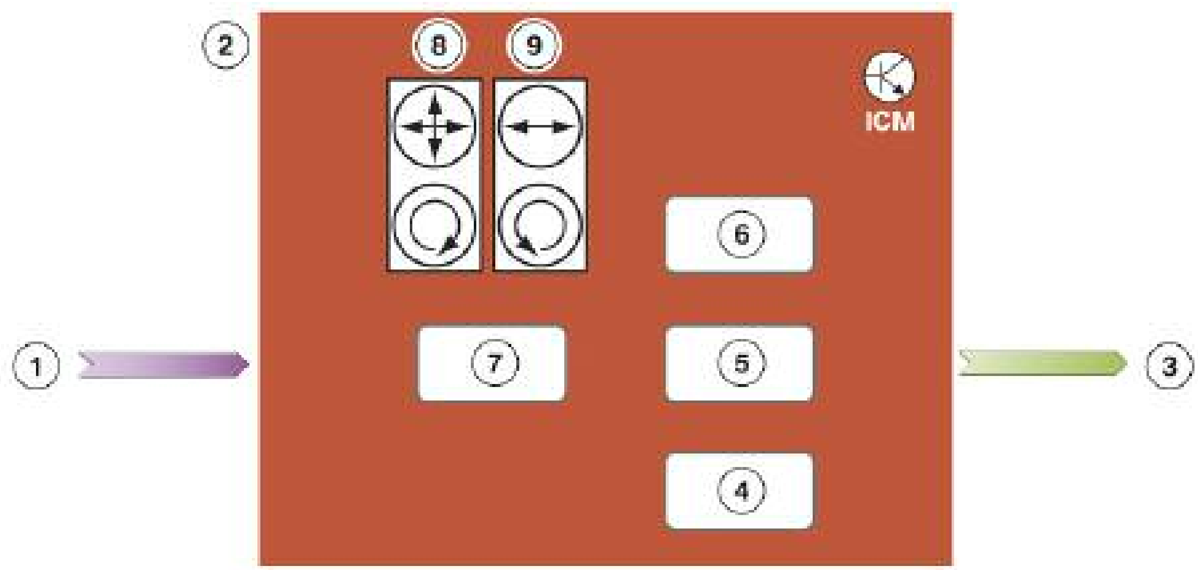
The Vertical Dynamics Management (VDM) is still responsible for controlling the vertical dynamics. The vertical dynamic control and dynamic drive functions are therefore accommodated in the VDM control unit.

Signals that provide information on the current driving situation are obviously exchanged between the ICM and VDM.

The main focus of this section is to describe the functions of the ICM control unit. An introductory overview of these functions is provided in the following sections.

Responsible Control Module (primary processing)	Vehicle Dynamics Systems	Specific Systems
ICM	Longitudinal Dynamics	DSC EMF
	Lateral Dynamics	Servotronic IAL
	Driver Assistance	DCC ACC Stop and Go
VDM	Vertical Dynamics	VDC ARS EHC

Function with ICM Control Module



Index	Explanation
1	Input signals from external sensors
2	ICM
3	Output signals (target values at actuators and actuator control units)
4	Driver assistance functions
5	Central driving dynamics and steering control function
6	Sensor signal processing and signal provision
7	Driving Dynamics control function
8	DSC sensor (integrated in ICM)
9	Redundant DSC sensor (integrated in ICM)

Input Signals from External Sensors

The ICM receives numerous amounts of signal data from various sources which include (but are not limited to):

- Wheel speed information from DSC via FlexRay
- Steering angle from SZL via FlexRay
- Actuator positions from IAL via FlexRay
- Ride height sensors (4) via direct analog input

Output Signals

The ICM processes all signal information and provides this information to other control modules via FlexRay. This information includes wheel speed, steering angle and ride height information. The ICM also makes available, via FlexRay, the information from the integrated DSC sensors. In addition to sensor data, the ICM provides target values for actuators and actuator control units (i.e. AL and HSR).

Driver Assistance Functions

Systems such as ACC Stop and Go and DCC are incorporated into the ICM. In addition, the ICM coordinates the activation of the vibration actuator in the steering wheel for the Lane Departure Warning and Active Blind Spot Detection via a bus signal over the FlexRay.

Central Driving Dynamics and Steering Control Function

The central driving dynamics control system in the ICM firstly evaluates the current driving condition and driver's command, also taking the dynamic driving systems installed in the vehicle into account (i.e. IAL).

On the basis of this information, the system decides whether or not to intervene in the driving dynamics, and also the extent the intervention.

The highly intelligent dynamic driving systems permit slight and barely noticeable interventions as soon as e.g. a tendency towards understeering is detected.

A coordinator function ensures that the most suitable actuator is activated in each case. Where several actuators are used simultaneously, a great deal of importance has been placed on ensuring that these interventions are in perfect harmony.

Signal Provision

The sensors that were previously accommodated separately in the DSC sensor are now installed in the ICM control unit. The following variables can be recorded with these sensors:

- Longitudinal acceleration and pitch of the road or vehicle in the longitudinal direction.
- Lateral acceleration and pitch of road or vehicle in lateral direction.
- Rotational speed around vertical axis (yaw rate).

The sensor signals are initially referenced to the sensor housing. However, to be useful to the dynamic driving systems, these variables must be referenced to the vehicle coordinate system.

The ICM control unit performs the necessary signal conversion. A synchronization process is carried out when the ICM control unit is started up during which appropriate correction values are determined and saved.

Driving Dynamics Control

The driving dynamics control provides the driver with the choice of one of four driving dynamics settings (Normal, Comfort, Sport and Sport+).

By making this choice, the driver influences the central driving dynamics control system and therefore all dynamic driving systems and drive train systems.

All systems are matched appropriately to every setting and, most importantly, their interaction with each other within one specific setting is also perfectly coordinated.

The status of the Dynamic Stability Control is also taken into account thus ensuring that two additional driving dynamics specifications are possible.

The ICM control unit is also responsible for the Servotronic function including valve actuation. This steering control function is also influenced by the driving dynamics control.

ICM Calibration

Calibration of the sensors integrated into the ICM control unit is necessary in the following cases:

- the ICM control unit has been replaced.
- if requested by the test schedule in the diagnostic system due to a fault code memory entry.

The calibration must be performed with the vehicle standing on a level surface in the longitudinal and lateral direction. The ignition must be switched to Terminal 15.

Higher-level Driving Dynamics Control

Observation of the Driving Condition

The Integrated Chassis Management (ICM) control unit calculates the current driving situation from the signals listed below. This essentially means the longitudinal and lateral dynamic driving condition:

- Wheel speed signals from all four wheels
- Longitudinal acceleration
- Lateral acceleration
- Yaw rate

The ICM control unit therefore knows how the vehicle is actually moving at this point. To be able to optimize the vehicle behavior, the dynamic driving systems require information about how the driver wishes the vehicle to move. The driver's command is determined from the following signals:

- Accelerator pedal angle and current engine torque and gear ratio.
- Application of the brake pedal and current brake pressure.
- Effective steering angle and steering-angle speed (rate).

The driving condition and driver's command are provided both internally and externally by the ICM control unit. The central driving dynamics control acts as a receiver internally in the ICM control unit. The control units of the dynamic driving systems (e.g. DSC) are the external receivers.

They receive the driving condition and the driver's command from the ICM control unit via the FlexRay bus system.

Central Driving Dynamics Control

The aim of the interventions by the dynamic driving system is to improve agility and traction. If required, they can of course also restore the stability of the vehicle.

In previous vehicles, separate systems existed that were designed to do this and although they in fact communicated with each other, they tended to have a more restricted range of tasks.

The interaction of all systems that ultimately determines the overall driving characteristics was therefore difficult to coordinate.

The Integrated Chassis Management incorporates the central driving dynamics control. This compares the command given by the driver with the actual movement of the vehicle at that point and therefore determines whether intervention of the dynamic driving system is required, and also the extent of the intervention.

The yawing force is an output variable of the central driving dynamics control system. This produces a rotation of the vehicle that is superimposed on the existing movement of the vehicle. This can be used to "readjust" the driving characteristics if the result identified does not match the driver's command.

Classic examples of this are understeering or oversteering driving characteristics. A feature of the ICM, however, is that the dynamic driving systems are already deliberately activated before a deviation of this nature is identified.

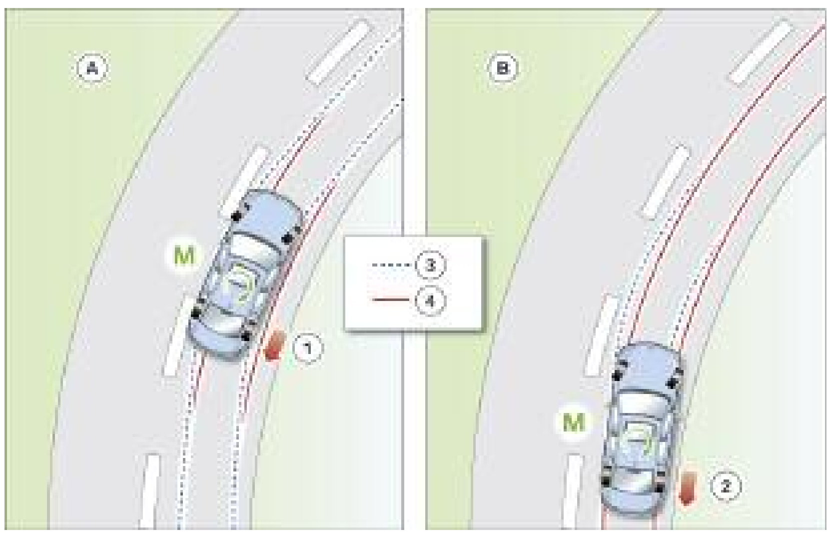
The interventions of the dynamic driving systems therefore take place long before the driving characteristics become unstable. This produces a far more harmonious effect in the vehicle than would be possible from a conventional chassis design. The vehicle reacts neutrally in many more situations and does not even begin to understeer or oversteer.

This new function is possible through the use of extremely precise computing models and new control strategies that can be used to evaluate and influence the driving characteristics.

Coordinated Intervention by the Dynamic Driving Systems

The following intervention options for producing the yawing force calculated by the central driving dynamics control system have been available up till now (and will of course remain available) - the corresponding dynamic driving systems are shown in brackets:

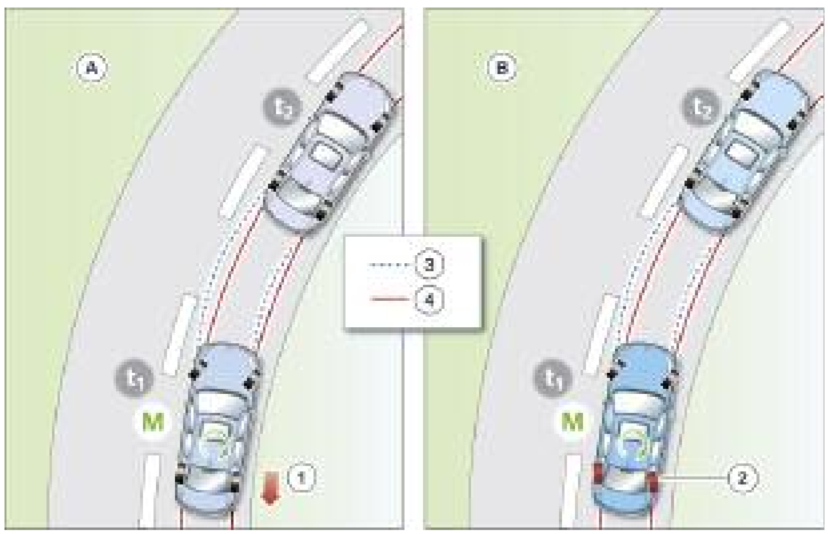
- Individual activation of the wheel brake (DSC).
- Adjustment of the current engine torque (ASC+T, DSC, MSR).
- Adjustment of the steering angle of the front wheels, regardless of the driver's input (Active Steering).



Index	Explanation
A	Correction of unstable driving characteristics
B	Intervention at an early stage to achieve neutral driving characteristics
1	Braking intervention at individual wheels in order to **correct** understeering
2	Braking intervention at individual wheels in order to **prevent** understeering
3	Course of an understeered vehicle
4	Course of a vehicle with neutral driving characteristics
M	Yawing force that acts on the vehicle due to braking intervention (at individual wheels)

Introduced with the F01/F02, the optional Integral Active Steering (IAL) makes available front as well as rear Active Steering. The rear axle slip angle control (HSR) is typically only available as an optional package with Active (front) Steering. The two systems are combined to make up IAL.

A function referred to as "Actuator coordination" follows the central driving dynamics control. This decides which dynamic driving system should be used to produce the yawing force in the specific road situation.



Index	Explanation
A	Prevention of understeering by means of braking at individual wheels
B	Prevention of understeering by means of steering intervention at rear axle
1	Braking intervention at individual wheels
2	Steering intervention at the rear axle
3	Course of an understeered vehicle
4	Course of a vehicle with neutral driving characteristics
M	Yawing force that acts on the vehicle due to braking intervention (at individual wheels)

For example, if the vehicle has a tendency to sharply understeer this can be counteracted by means of selective braking intervention at the rear wheel on the inside of the curve.

If the vehicle is equipped with Integral Active Steering, the same objective can be achieved more seamlessly by applying an appropriate steering angle at the rear axle.

As both actuating options are limited, it may also be beneficial to apply both at once. If understeering is avoided the driver becomes aware of this due to the considerable increase in agility.

The F01/F02 was the first instance where genuine functional networking between the integrated chassis management and Vertical Dynamics Management functions also takes place.

This does not simply mean that the ICM records and processes ride-height information and then delivers it to the VDM.

The ICM is also responsible for the control of the Active Roll Stabilization as an integral part of central driving dynamics control in order to influence the self-steering characteristics.

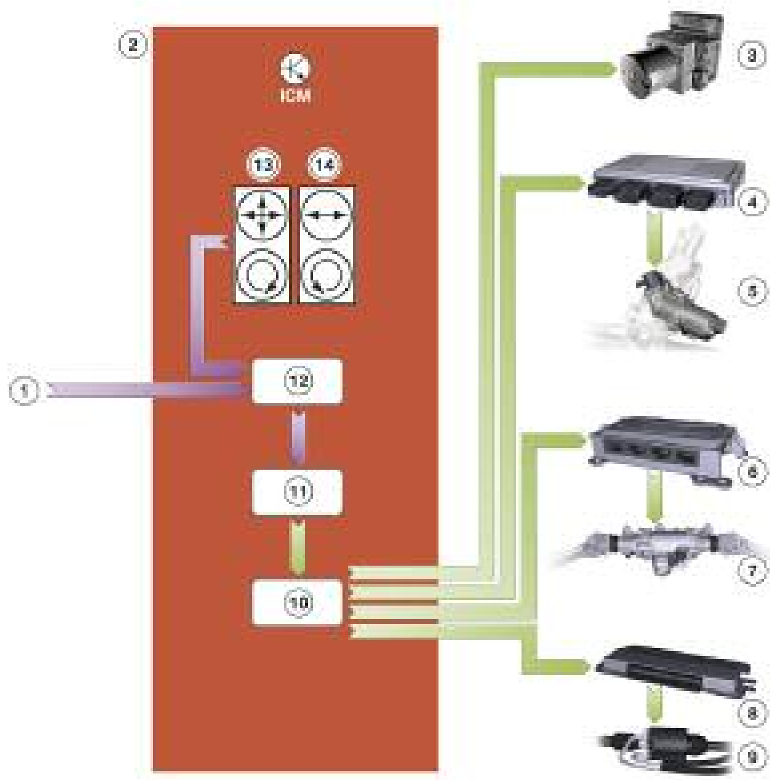
As the conventional chassis design already demonstrates, a more rigid anti-roll bar on one axle means that the overall achievable cornering stability on the same axle is lower.

The effects of more or less rigid anti-roll bars can be emulated with the aid of the hydraulic motors in the anti-roll bars of the Dynamic Drive.

This means that the central driving dynamics control of the ICM can selectively influence the degree of available lateral force on one axle via the active anti-roll bars of Dynamic Drive.

If the vehicle is currently oversteering, the cornering force at the rear axle is insufficient. The roll stabilizing torque at the rear axle tends to reduce in this case. This loss of torque is compensated for by additional cornering stability at the rear axle which helps stabilize the vehicle.

The activity of the central driving dynamics control in the ICM control unit is summarized in the input/output graphic below.



Integrated Chassis Management Input / Output

Index	Explanation	Index	Explanation
1	Input signals from external sensors	8	VDM control module
2	Integrated Chassis Management	9	Active anti-roll bar
3	Dynamic Stability Control	10	"Actuator coordination function"
4	AS (AL) control module	11	Central driving dynamics control function
5	AS (AL) actuating unit	12	"Sensor signal preparation" function
6	HSR control module	13	DSC sensor (in ICM)
7	HSR actuating unit	14	Redundant DSC sensor (in ICM)

Driving Dynamics Control

History

Over the years, there have been several versions of switches that modify some aspect of driving dynamics. Some of the earliest versions of these switches included such systems as EDC. This console mounted switch was usually used to modify the harshness of the damping and included modes such as Comfort or Sport.

More recently, these control switches allowed for the functions of multiple systems to be modified. For example, the Z4 used a SPORT switch on the center console to modify throttle response, steering effort and transmission shift characteristics. This switch was referred to as the SPORT button or FDC switch.

Index	Explanation	Index	Explanation
1	SPORT button	2	VDC control with electronically controlled dampers

There have been similar switches on various vehicles, although with different functions. For example, the E70/71 uses a SPORT button next to the shifter which influences only the damping control (VDC).

The Driving Dynamics Control switch (introduced in the F01/02) influences several systems within the vehicle for maximum control and comfort.

Driving Dynamics Switch

The driving dynamics switch and DTC button are located in the center console. Both the DTC button and driving dynamics switch are ground inputs to the ICM.

Index	Explanation
1	DTC button
2	Driving dynamics switch, SPORT selection
3	Driving dynamics switch, COMFORT selection

The driving dynamics control switch in the F01/F02 contained two groundbreaking new features when compared to the E85/E86.

All drive and dynamic driving systems installed in the vehicle are comprehensively switched over via the driving dynamics and DTC switch.

The ICM control unit imports the control signals then determines on the basis of this which new mode the driving dynamics control should adopt.

The driving dynamics switch in the center console allows the selection of 4 modes:

- Sport plus
- Sport
- Normal
- Comfort

In addition to the 4 modes available with the driving dynamics switch, the DTC button allows for 2 additional modes:

- Traction
- DSC off

The driving dynamics system is now capable of several settings.
The system affected include:

- DME - Accelerator pedal sensitivity
- EGS - Transmission shift points and shift speed
- Steering - Servotronic and IAL (AL and HSR)
- VDM - damping modes for VDC
- ARS - increased stiffness of the anti-roll bars
- DSC - modes - DTC/DSC Off

The changeover operations for many drive and driving dynamics functions are therefore bundled in the driving dynamics control of the F01/F02. The vehicle as a whole then behaves as the driver would expect in accordance with his/her chosen setting.

Conversely, many individual, and also sometimes meaningless, combinations are avoided (example: sports steering combined with comfort-oriented damping).

The ICM control unit also prompts the display of the relevant mode in the instrument cluster and also in the Central Information Display. In addition to selecting a mode, the driver can use the controller to make further settings.

Index	Explanation
1	DTC Button
2	Driving Dynamics Switch (FDC)

Since its introduction on the F01/F02 the Driving Dynamics Control Switch has been modified and enhance to the point that it is also referrered to as the Driving Experience Switch in the most current BMW vehicles (see the F01/F02 LCI training material).

The driver can use the driving experience switch to select different programs which alter various properties of the vehicle depending on the vehicle's equipment specification.

The following programs are available:

- SPORT
- SPORT+
- COMFORT
- COMFORT+
- ECO PRO

ECO PRO Mode Configuration Screen (F01/F02 LCI)

ECO PRO mode is the latest driving program (introduced with the F10) and currently available on most BMW models.

Operation and Display

After the vehicle is started, the driving dynamics control is always in "Normal" mode.

The switch will change the 4 modes of driving dynamics in a sequential manner. Each subsequent press of the switch will move through the 4 modes in either direction.

The modes will be displayed under the tachometer as shown. After a few seconds, a more compact display will be shown after the switch is no longer pressed.

Driving Dynamics Mode Display

Compact Display

The DTC button provides the driver with two additional modes, Traction (DTC) and DSC off.

The "Traction" mode can be activated by briefly pressing the DTC button. This works irrespective of which driving dynamics control mode was previously active. "DSC off" is activated by holding the DTC button pressed for a longer period.

The "Traction" and "DSC off" modes can be switched off by pressing the DTC button again. The driving dynamics control subsequently returns to "Normal" mode.

The two modes "Traction" and "DSC off" present a special case in terms of their display requirements. In addition to the text entry, the yellow DSC indicator and warning lamps must be activated.

“Traction” Display (DTC)

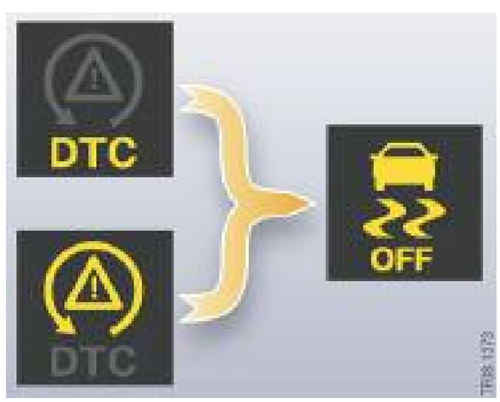
“DSC off” Display

The new DSC symbols used for the first time in the F01/F02 replace the symbols previously used.

Two different symbols were formerly used for the two states "DTC mode" and "DSC off" and were displayed in the instrument cluster.

Since the launch of the F01/F02, only one symbol has been used for both states.
The new symbols are being gradually introduced in all newly developed vehicles.

The reason for this are changes to legislation that require automobile manufacturers to produce a uniform display format. This legislation also specifies that the text message "off" must be displayed as soon as the DSC function is restricted, as is the case in the "Traction" and "Sport+" modes.



When the DTC button or the driving dynamics switch is pressed, there is an additional assistance window which appears in the CID.

The name of the newly selected mode appears there together with an explanatory text. This assistance window can be turned on or off via the Settings/Central Display option in the CID.

In the "Sport" mode, the driver also has the option of configuring which systems are affected by this selection. Assisted by the controller, the driver can choose whether to apply the "Sport" mode to the drive systems, or the dynamic driving systems or both.

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Dynamic Performance Control (QMVH)

With the E70, the BMW Group introduced a new generation of dynamic driving systems. These systems were then enhanced even further in the E71 X6. The regulating strategy of the individual systems, consistently subdivided into longitudinal, lateral and vertical dynamics, forms the basis for the wide variety of driving dynamics functions.

The X6 uses a dynamic driving system that enables a distinct increase in agility, stability and traction and safety, without compromising dynamics or efficiency.

The complete package of dynamic driving systems in the X6 includes:

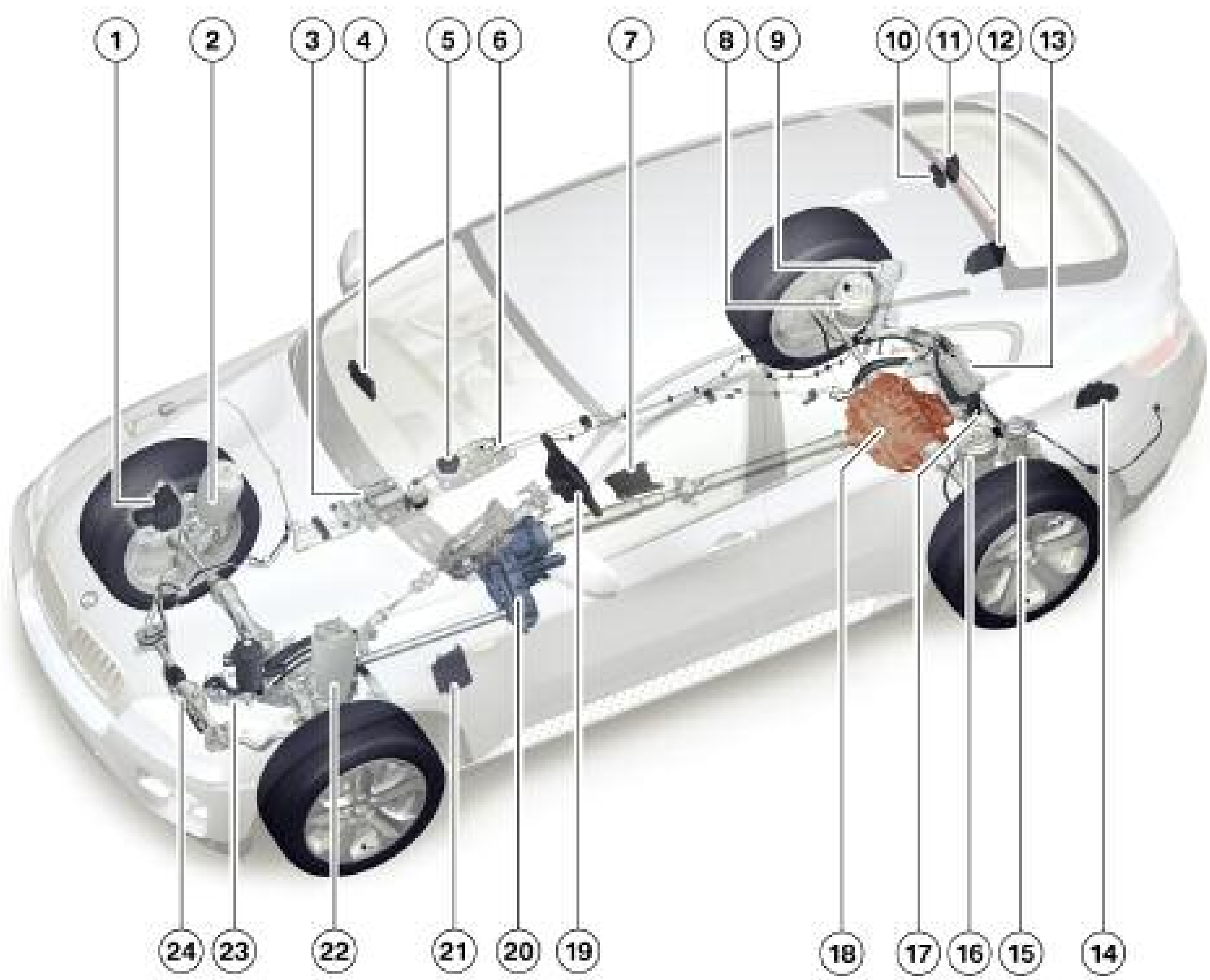
- Dynamic Drive
- Vertical Dynamic Control
- Adaptive Drive
- Electronic Height Control
- Dynamic Stability Control
- Active Steering
- xDrive
- Dynamic Performance Control

All these functions enable the highest degree of dynamic driving performance through intelligent interaction between the systems. The slogan "The Ultimate Driving Machine" is more than just an integrated policy behind the development of each BMW vehicle.

Dynamic Performance Control forms an integral part of the standard equipment and complements xDrive and Dynamic Stability Control, serving as an additional module to increase active safety and enhance the brilliant driving dynamics. As an option, the E71 customer can also order BMW innovations in the field of dynamic driving systems, e.g. Active Steering. When combined and interlinked in the E71, these individual modules create superior driving dynamics for more intense and safer enjoyment of the Ultimate Driving Machine.

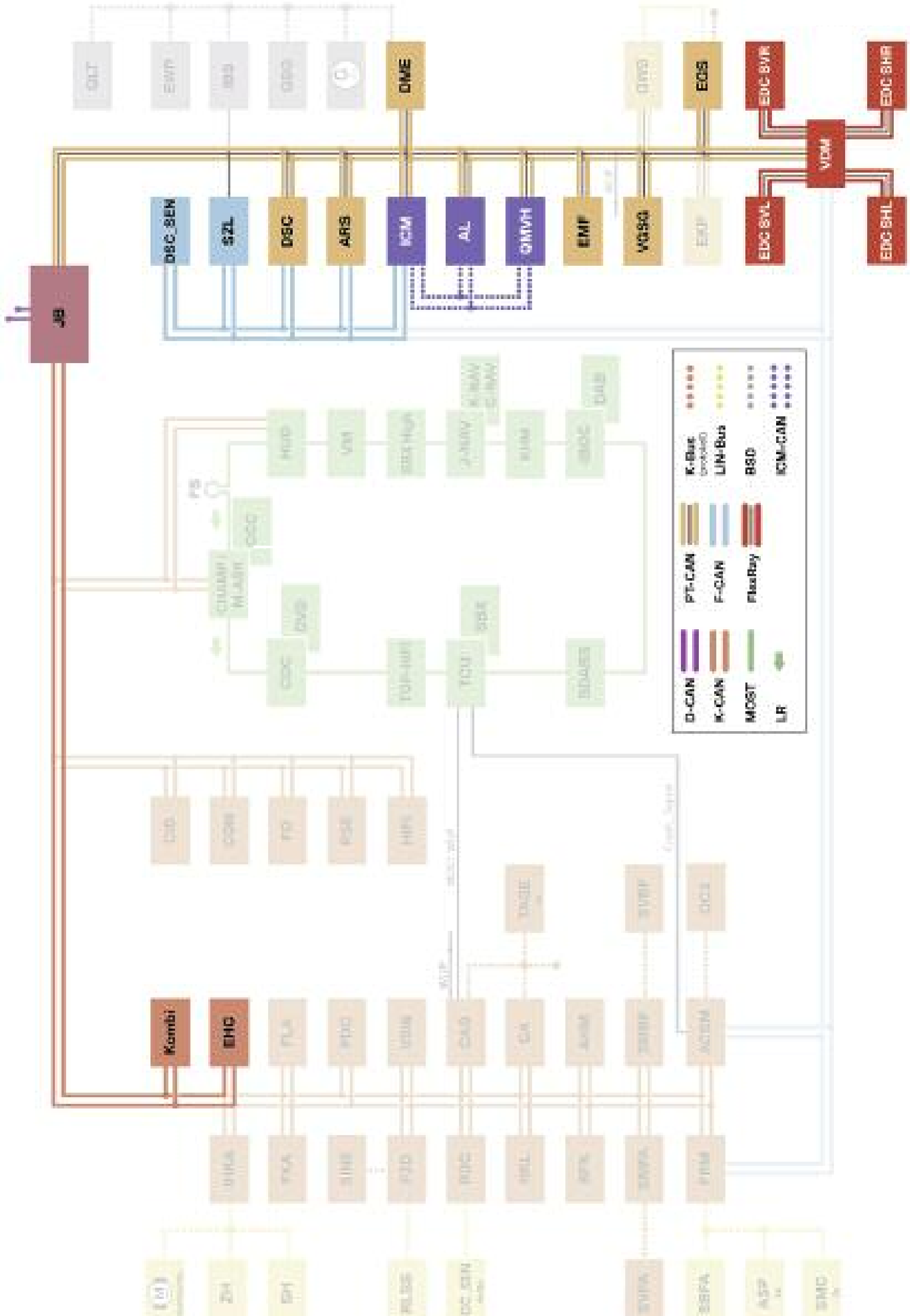
System Overview

Chassis Dynamics Components in the Vehicle



Index	Explanation
1	Dynamic stability control
2	EDC satellite, front right
3	EHC air supply unit
4	ARS control unit
5	DSC sensor
6	ARS valve block
7	ICM control unit
8	Air spring, rear right
9	EDC satellite, rear right
10	EHC control unit
11	VDM control unit
12	QMVH control unit
13	Electromechanical parking brake
14	Transfer box control unit
15	EDC satellite, rear left
16	Air spring, rear left
17	ARS hydraulic motor, rear axle
18	Rear differential with superimposing gear units [QMVH]
19	SZL with steering angle sensor
20	Transfer case
21	AL control unit
22	EDC satellite, front left
23	Power steering pump
24	ARS hydraulic motor, front axle

Bus System Overview



Index	Explanation
AL	Active Steering
ARS	Active anti-roll bar
DME	Digital Engine Electronics
DSC	Dynamic stability control
DSC_SEN	DSC sensor
EDC SHL	EDC satellite, rear left
EDC SHR	EDC satellite, rear right
EDC SVL	EDC satellite, front left
EDC SVR	EDC satellite, front right
EGS	Electronic transmission control unit
EHC	Electronic Height Control
EMF	Electromechanical parking brake
ICM	Integrated Chassis Management
JB	Junction box
KOMBI	Instrument cluster
QMVH	Lateral torque distribution on the rear axle
SZL	SZL with steering angle sensor
VDM	Vertical Dynamics Management
VGSG	Transfer box control unit
ICM-CAN	Integrated Chassis Management

The diagram shows the control units and bus systems that are related for the dynamic driving systems.

One of the differences between the E70 and the E71 is the introduction of the Integrated Chassis Management (ICM) control unit. The ICM coordinates longitudinal and lateral dynamic control functions, which include the familiar Active Steering and a new function, Dynamic Performance Control [with QMVH]. The ICM-CAN has been introduced as a new bus system especially for the ICM system network. It connects the ICM, AL and QMVH control units.

The BMW X6 is the only BN2000 BMW vehicle to use an ICM.

The dynamic driving systems communicate via the usual bus systems, such as the Powertrain CAN (PT-CAN) and the Chassis CAN (F-CAN).

The F-CAN still performs the function of transmitting pure sensor signals. The signals from the DSC sensor and the steering wheel sensor in the steering column switch cluster have top priority. Despite the fact that the PT-CAN and F-CAN work at a high bit rate of 500 kbps, they would have been overloaded by the signals from the new ICM and QMVH control units. For this reason, a new sub-bus, the ICM-CAN, has been introduced.

The ICM-CAN is a sub-bus for the dynamic driving systems and connects the ICM, AL and QMVH control units. It is a two-wire bus on which data is transmitted at 500 kbps. The two terminating resistors, each with 120 Ω, are located in the ICM and QMVH control units.

The ICM-CAN cabling in the vehicle varies considerably between the two variants with/without Active Steering.

If Active Steering is fitted, the ICM-CAN is routed from the ICM control unit to the AL control unit. The ICM-CAN is picked up in the AL control unit and forwarded to the QMVH control unit.

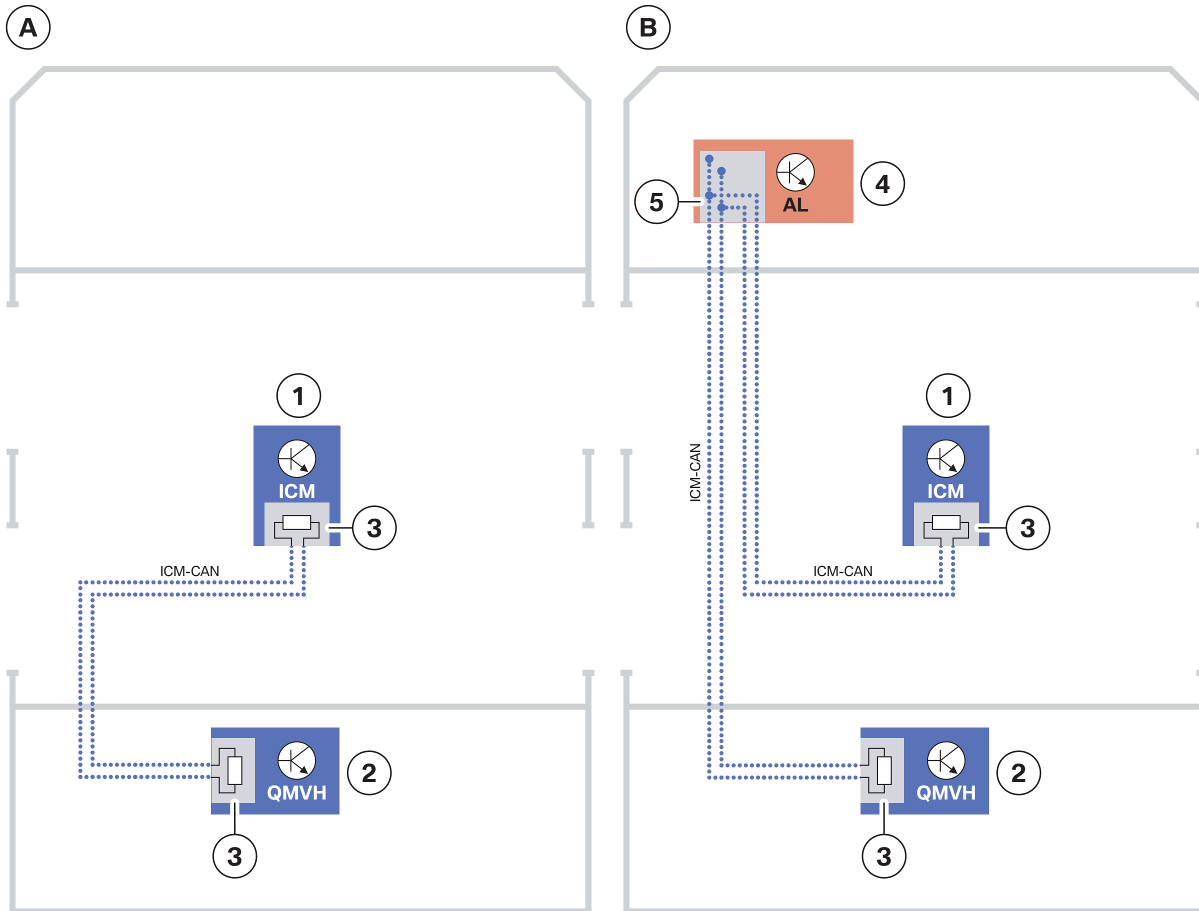
If Active Steering is not fitted, the ICM-CAN line is routed directly from the ICM control unit to the QMVH control unit.

These control units use the ICM-CAN to exchange setpoint values and actual values, as well as status signals. These signals are only required locally for implementing the Dynamic Performance Control and Active Steering functions.

In contrast, signals that the dynamic driving systems exchange with other control units are still transmitted via the PT-CAN. The PT-CAN is also the bus system via which the ICM, AL and QMVH control units communicate with the diagnostic system.

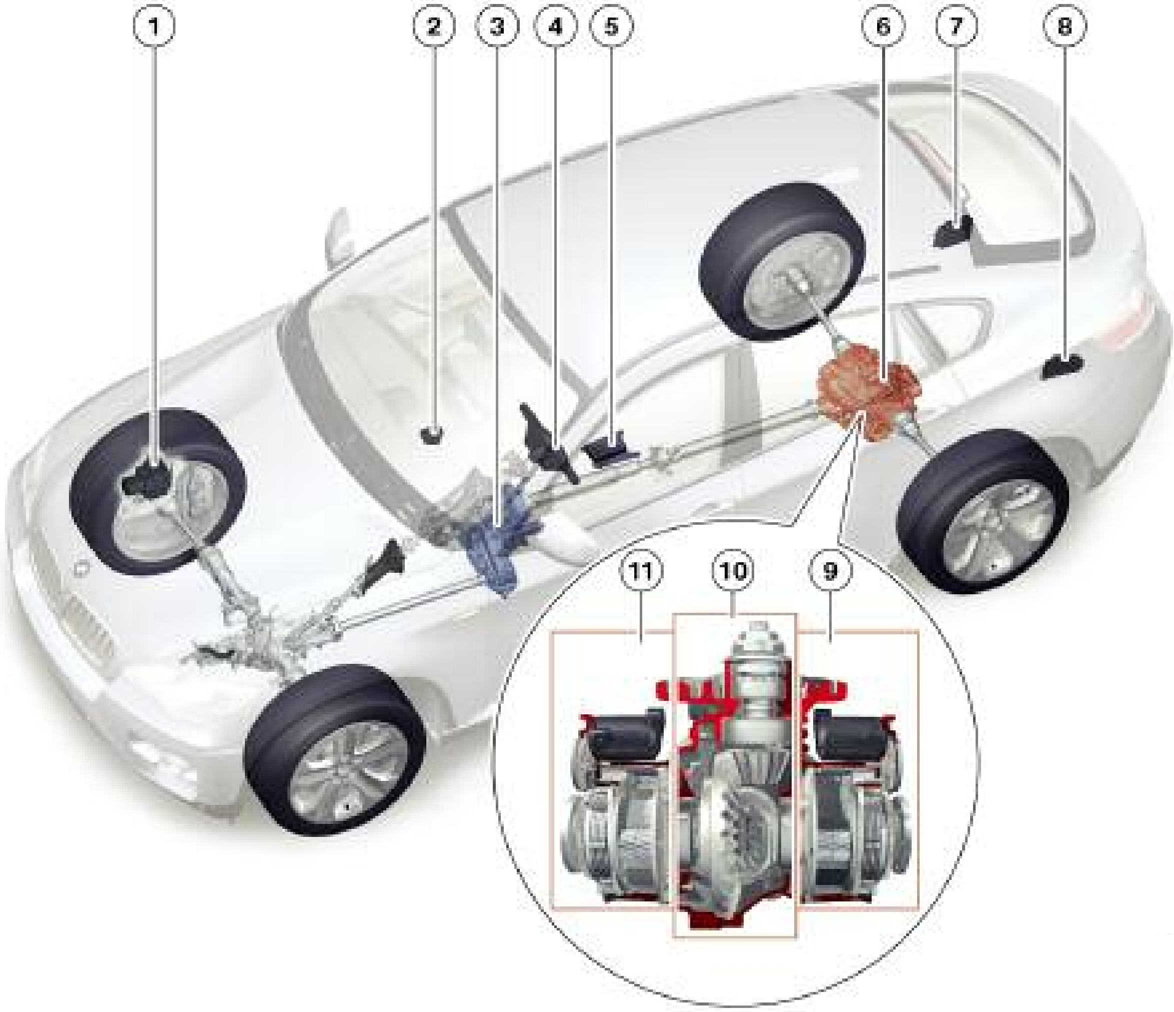
The ICM control unit does not therefore perform the function of a diagnostics gateway.

Integrated Chassis Management with and without Active Steering



Index	Explanation
A	Without Active Steering
B	With Active Steering
1	Integrated Chassis Management
2	Lateral torque distribution on the rear axle
3	ICM-CAN terminating resistor
4	Active Steering
5	ICM-CAN (picked up and forwarded)

System Overview - Dynamic Performance Control



Index	Explanation
1	Dynamic stability control
2	DSC sensor
3	Transfer case
4	SZ steering column switch cluster
5	ICM control unit
6	Rear differential with superimposing gear units
7	QMVH control unit
8	Transfer box control unit
9	Superimposing gear unit, right
10	Angle drive with differential
11	Superimposing gear unit, left

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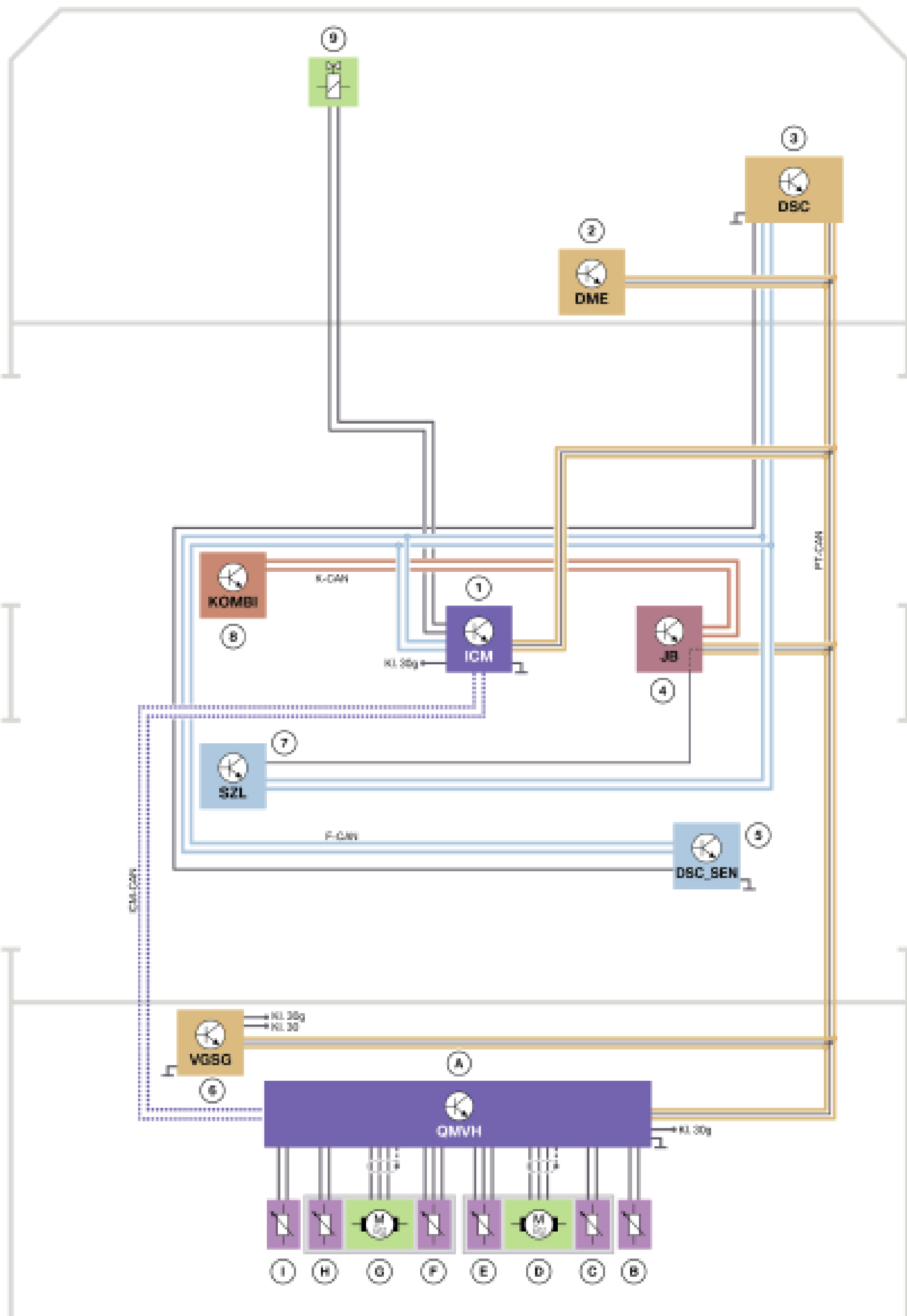
System Circuit Diagram for Dynamic Performance Control without Active Steering



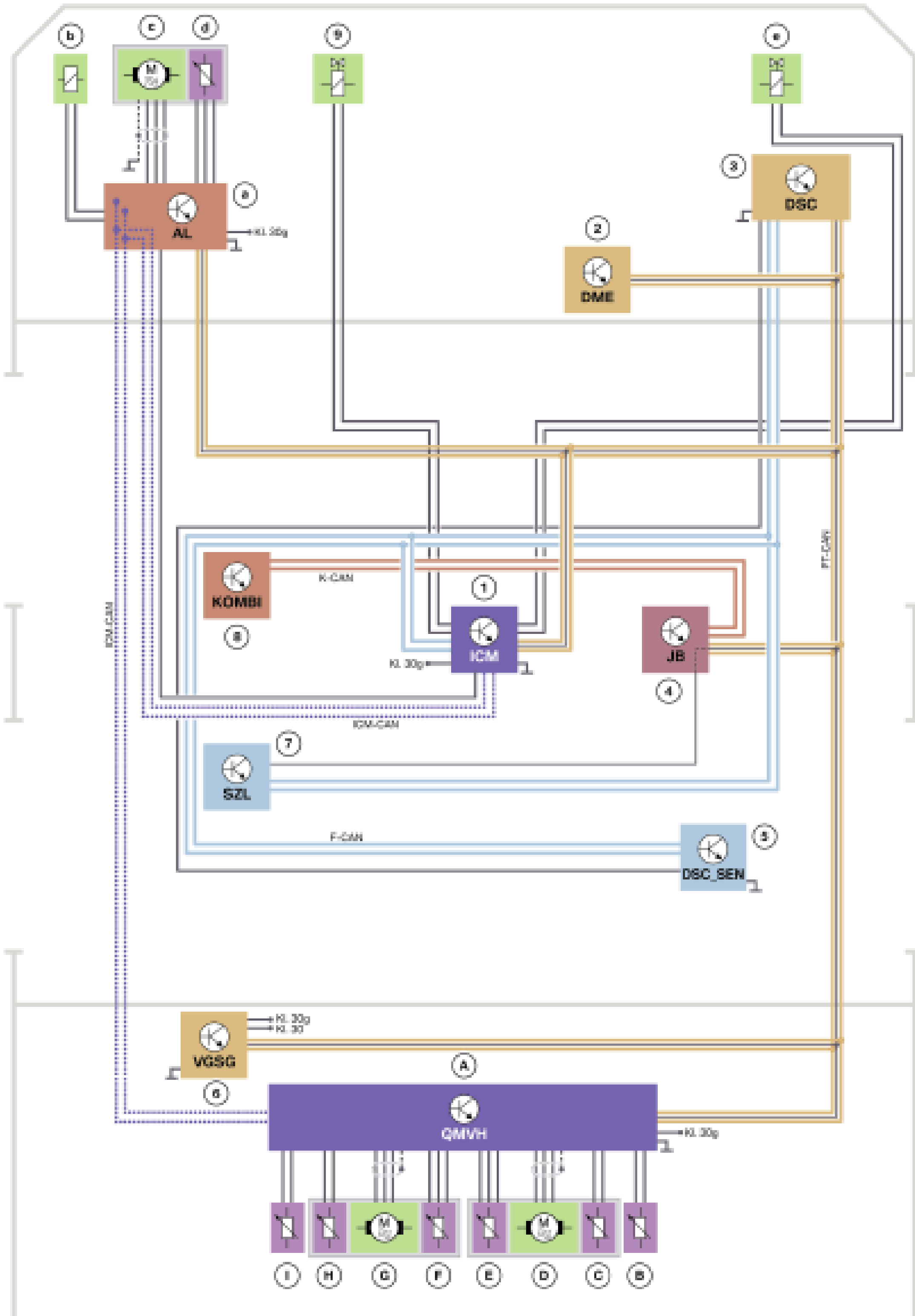
Index	Explanation
1	Integrated Chassis Management
2	Digital Motor Electronics/Digital Diesel Electronics
3	Dynamic stability control
4	Junction box
5	DSC sensor
6	Transfer box control unit
7	Steering column switch cluster with steering angle sensor
8	Instrument cluster
9	EVV valve
A	Lateral torque distribution on the rear axle
B	Temperature sensor for the transmission oil in the superimposing gear unit, right
C	Temperature sensor for the electric motor in the superimposing gear unit, right
D	Electric motor in the superimposing gear unit, right
E	Motor position sensor in the superimposing gear unit, right
F	Motor position sensor in the superimposing gear unit, left
G	Electric motor in the superimposing gear unit, left
H	Temperature sensor for the electric motor in the superimposing gear unit, left
I	Temperature sensor for the transmission oil in the superimposing gear unit, left

An electronically controlled bypass valve (EVV) is fitted on all variants of the E71 in order to control the volumetric flow in the hydraulic circuit for the power steering. It is actuated by the ICM control unit.

If Active Steering is not fitted, the ICM-CAN is routed directly from the ICM control unit to the QMVH control unit.

The topology of the ICM-CAN bus system differs greatly between the two variants with/without Active Steering. If Active Steering is fitted, the ICM-CAM is routed from the ICM control unit to the AL control unit. The ICM-CAN is picked up in the AL control unit and forwarded to the QMVH control unit.

System Circuit Diagram for Dynamic Performance Control with Active Steering



Index	Explanation
1	Integrated Chassis Management
2	Digital Motor Electronics/Digital Diesel Electronics
3	Dynamic stability control
4	Junction box
5	DSC sensor
6	Transfer box control unit
7	Steering column switch cluster with steering angle sensor
8	Instrument cluster
9	EVV valve
A	Lateral torque distribution on the rear axle
B	Temperature sensor for the transmission oil in the superimposing gear unit, right
C	Temperature sensor for the electric motor in the superimposing gear unit, right
D	Electric motor in the superimposing gear unit, right
E	Motor position sensor in the superimposing gear unit, right
F	Motor position sensor in the superimposing gear unit, left
G	Electric motor in the superimposing gear unit, left
H	Temperature sensor for the electric motor in the superimposing gear unit, left
I	Temperature sensor for the transmission oil in the superimposing gear unit, left
a	Active Steering
b	Solenoid lock
c	Active Steering electric motor
d	Active Steering motor position sensor
e	Servotronic valve

System Components

Rear Differential with Superimposing Gear Units

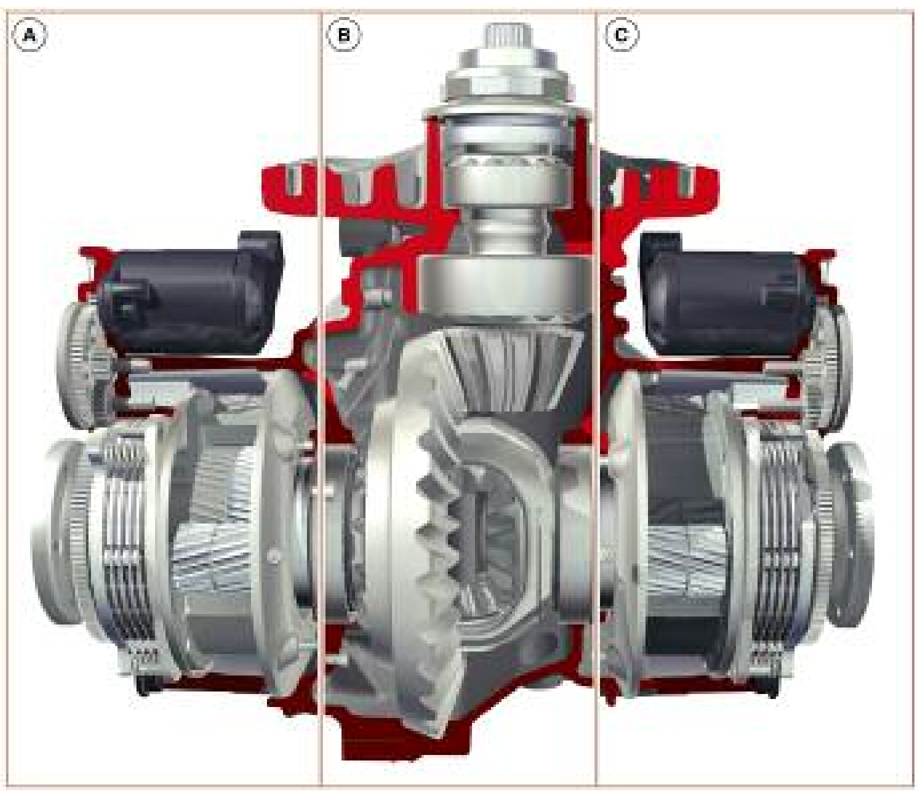
For Dynamic Performance Control, a conventional rear differential supplemented by superimposing gear units on the left and right is used.

The only difference with the E71 rear differential is the welded ring gear which is bolted on E70.

The two superimposing gear units are identical in terms of their structure, but differ slightly in terms of their detail. For example, the electric motors and planetary trains on the left or the right are different.

This rear differential also has three oil reservoirs, subdivided in a similar way to in the picture, which are vented by a common duct

Design of the Rear Differential with Superimposing Gear Units



Index	Explanation
A	Superimposing gear unit, left
B	Angle drive with differential
C	Superimposing gear unit, right

Therefore, there are three filler plugs and three drain plugs on this rear differential.

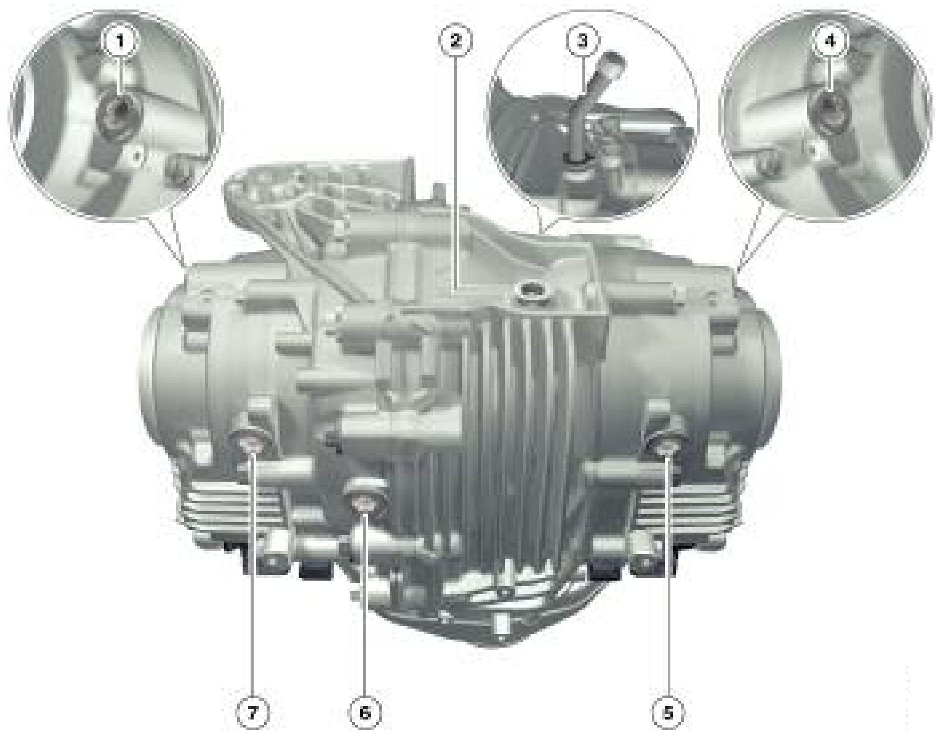
In the center part (angle drive with differential gear), the standard oil (hypoid oil) is used and, in the left and right superimposing gear units, a special ATF is used.

Longlife oils are provided as standard in the rear differential with superimposing gear units. There are some exceptions dependent on the service life/use of the unit.

All three reservoirs have a common vent on the top of the transmission case.

When the rear differential unit is removed and reinstalled the angle must not exceed 45°. This could potentially cause the two types of oil to cross contaminate through the common vent.

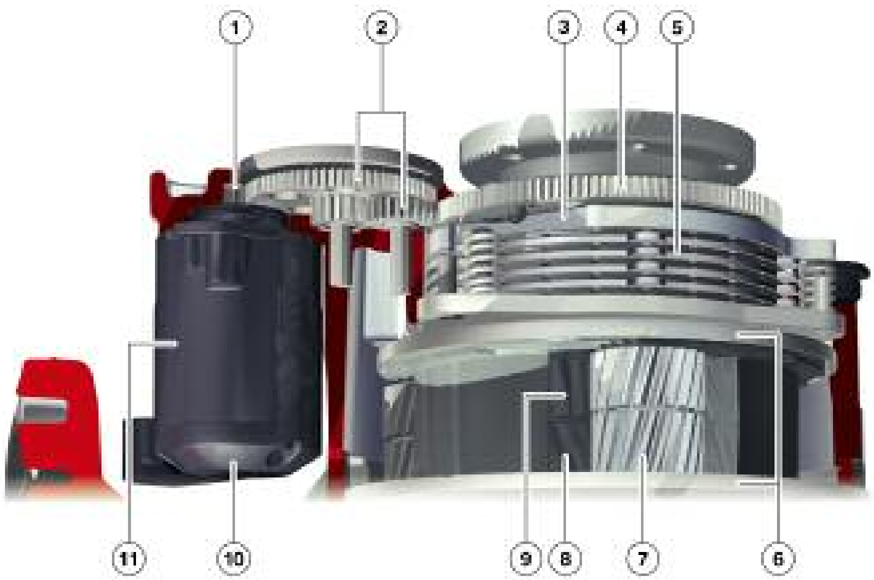
Oil Reservoirs of the Rear Differential with Superimposing Gear Units



Index	Explanation
1	Filler plug for the left superimposing gear unit
2	Filler plug for the angle drive with differential gear
3	Vent
4	Filler plug for the right superimposing gear unit
5	Drain plug for the right superimposing gear unit
6	Drain plug for the angle drive with differential gear
7	Drain plug for the left superimposing gear unit

Construction of the Superimposing Gear Units

The two superimposing gear units essentially consist of an actuator (electric motor), transmission gearing, a ball ramp, a multi-plate clutch and a planetary gear set.
In contrast to standard planetary gear sets, this one does not contain a ring gear.



Index	Explanation
1	Electric motor drive pinion
2	Transmission gears
3	Ball-ramp pressure plate
4	Ball-ramp drive gear
5	Multi-plate clutch assembly
6	Planet carrier
7	Planetary gear
8	Inner sun gear
9	Outer sun gear
10	Motor position sensor
11	Right electric motor

Multi-plate Clutch and Ball Ramp

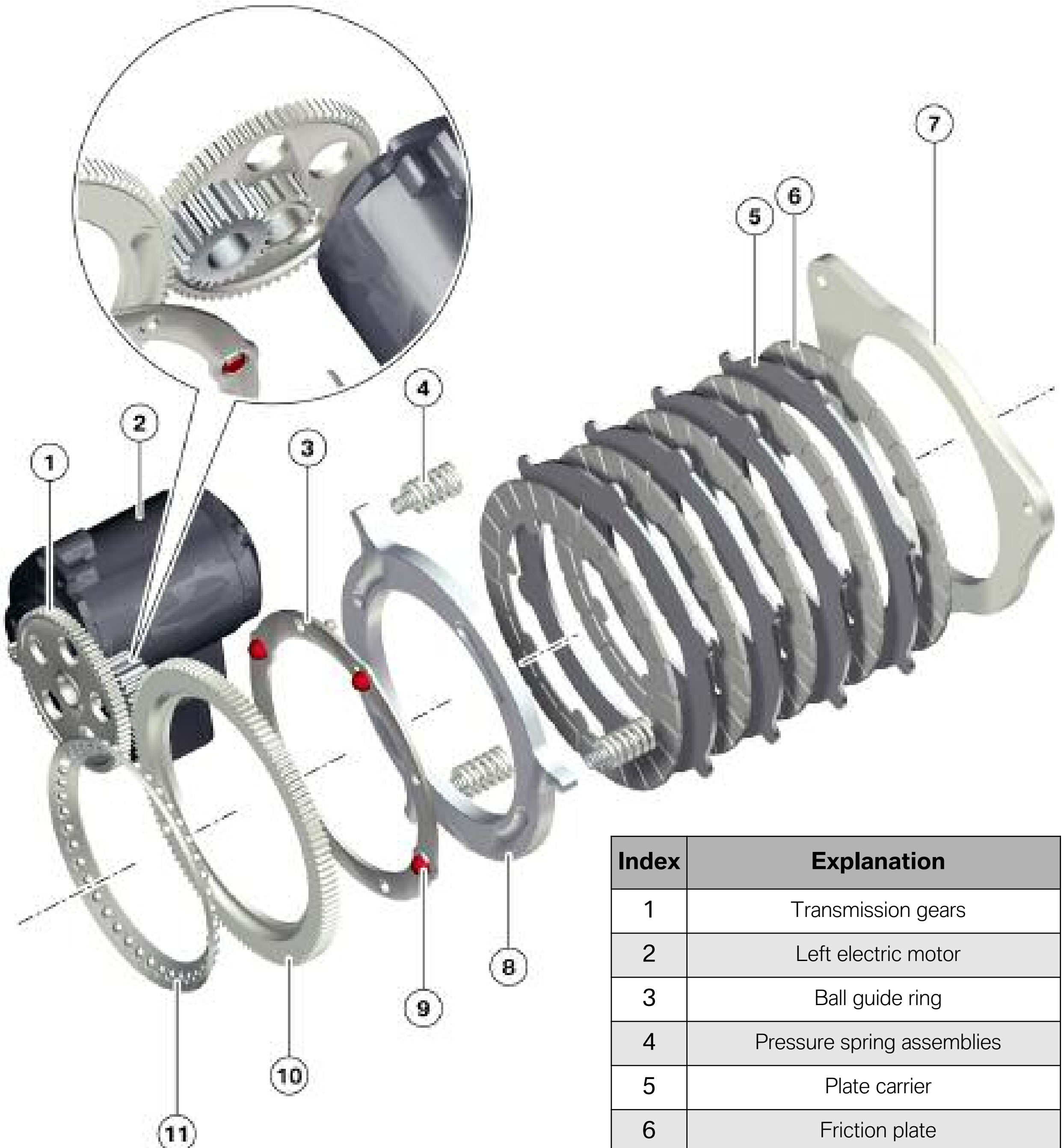
The multi-plate clutch and the ball ramp are designed in such a way that they are always de-energized if there is fault in the electric motor. In this event, the pressure spring assemblies now take on an important role between the ball ramp and the support plates.

The pressure spring assemblies open the multi-plate clutch via the ball ramp and the freely rotating electric motor and hold it fully open. This ensures, among other things, that the loss of torque distribution is established in the event of a fault.

Construction of the Multi-plate Clutch

Index	Explanation
1	Plate carrier
2	Friction plate

Exploded View of the Multi-plate Clutch



Index	Explanation
1	Transmission gears
2	Left electric motor
3	Ball guide ring
4	Pressure spring assemblies
5	Plate carrier
6	Friction plate
7	Support plate
8	Ball-ramp pressure plate
9	Balls (4x)
10	Ball-ramp drive gear
11	Ball bearing for left output shaft

Electric Motors

These are three-phase asynchronous motors.

The three-phase voltage is generated by the QMVH control unit. This creates a rotating electromagnetic field around the metallic rotor which generates torque in the rotor.

An asynchronous-motor design was selected because it guarantees a high level of power with a simple construction.

Furthermore, the shaft of an asynchronous motor can be moved freely when the phase voltage is switched off. This is an integral part of the safety concept, because the phase voltage is switched off in the event of a fault.

The left and right electric motors have different constructions. The phase voltage and temperature sensor connectors (2) are also coded differently. This will prevent the two motors from being mixed up or incorrectly connected.

The two electric motors are connected to the superimposing gear units via the screw connections for the motor mounting (4). The electric motors thus have contact with the oil supply for the superimposing gear units.

Because the bearing (6) is not sealed, not only the pinion but also the entire rotor for the electric motor rotate in the oil. For this reason, the following housing seals are fitted to the electric motors:

- Sealing ring (5).
- Sealing ring at the join with the motor position sensor (not shown).
- Seal at the connector for the phase voltage and temperature sensor (2), see the Sensor system section.

Left Electric Motor

Index	Explanation
1	Motor position sensor connector
2	Connector for phase voltage and temperature sensor
3	Screw connection for bearing cap
4	Screw connection for motor mounting
5	Seal
6	Bearing
7	Electric motor pinion

Sensor System

The following sensors, integrated in the Dynamic Performance Control components, are therefore an integral part of the system.

- Temperature sensors for the electric motors.
- Temperature sensors for the superimposing gear unit transmission oil.
- Motor position sensors.

There is one of the sensors mentioned above for each superimposing gear unit and each electric motor.

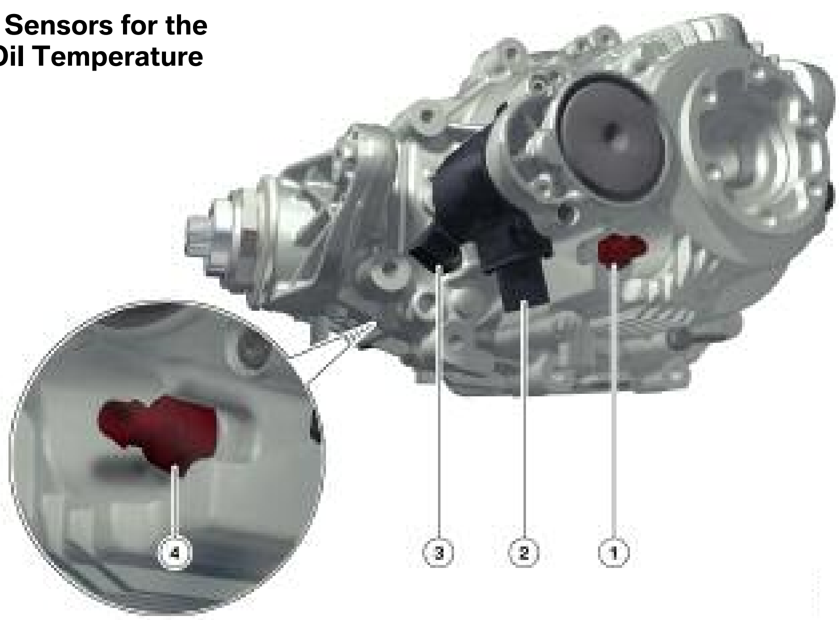
Motor Position Sensor

The motor position sensor is located on the rear of the electric motor (the side opposite the pinion). The sensor is identical to the one used for the Active Steering actuating motor. The sensor thus works according to the magnetoresistive principle and transmits the data digitally to the QMVH control unit via a two-wire line.

Oil Temperature Sensors

The two sensors for determining the temperature of the transmission oil in the two superimposing gear units are arranged symmetrically on the two sides.

Connector and Sensors for the Transmission Oil Temperature



Index	Explanation
1	Connector for the left transmission oil temperature sensor
2	Connector for phase voltage and temperature sensor for the left electric motor
3	Connector for the left motor position sensor
4	Connector for the right transmission oil temperature sensor

Electric Motor Temperature Sensor

The temperature sensor for the electric motor is located in the immediate vicinity of the connector through which the electric motor is supplied with the phase voltage.

The temperature sensor for the electric motor (1) is a temperature-dependent resistor. The QMVH control unit measures the resistance and thus determines the temperature that is present in the electric motor. In the diagram, you can see the sealant (2) that was mentioned earlier which seals the housing to the connector. This prevents oil from escaping at this location. At the same time, the sealant performs the task of a heat conductor, so that the temperature sensor is exposed to practically the same temperature as the rest of the components of the electric motor.

Temperature Sensor for the Electric Motor

Index	Explanation
1	Temperature sensor for the electric motor
2	Sealant

Mechanical Interfaces

The rear differential with superimposing gear units for Dynamic Performance Control is bolted onto the rear axle carrier in the same way as the conventional rear differential.

The propeller shaft is fixed to the rear differential with a double nut as on the E70.

The output shafts are fitted in different ways on the E71 and E70.

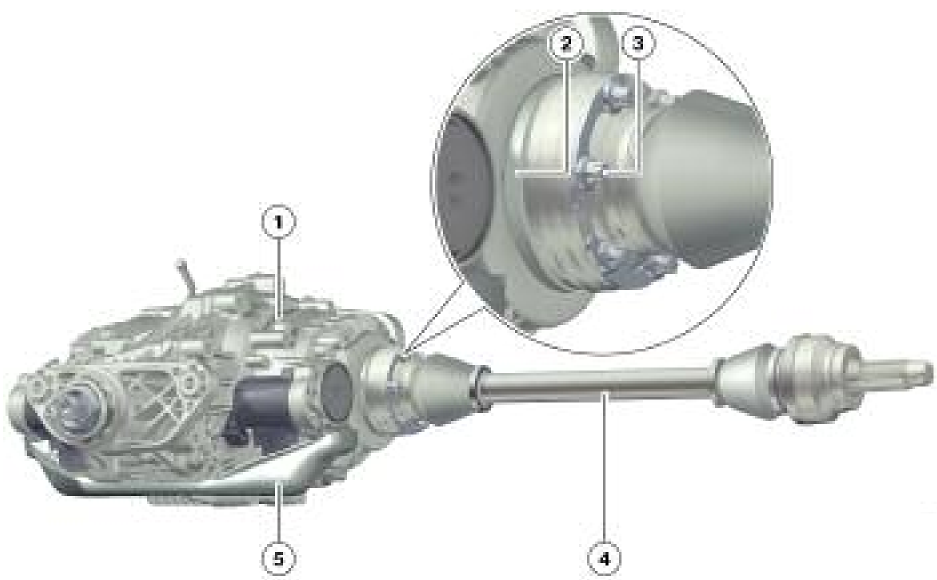
On the E70, the output shafts are inserted in the rear differential.

On the E71, the actual output shafts are bolted to the output shaft flange.

The heat conduction and protective plate (5) shown in the diagram has the following tasks:

- Protects the connectors on the electric motors from stone impact.
- Diverts heat from the exhaust system so that it does not heat up the rear differential too much.

Fitting of the Left Output Shaft in the E71



Index	Explanation
1	Rear differential with superimposing gear units
2	Output shaft flange
3	Bolting of output shaft to output shaft flange
4	Output shaft
5	Heat conduction and protective plate

QMVH Control Unit

The QMVH control unit is fitted at the rear right of the luggage compartment.

As you can see from the following diagram, it is a dual-processor control unit. Power semiconductors are also integrated in the control unit which function as output stages.

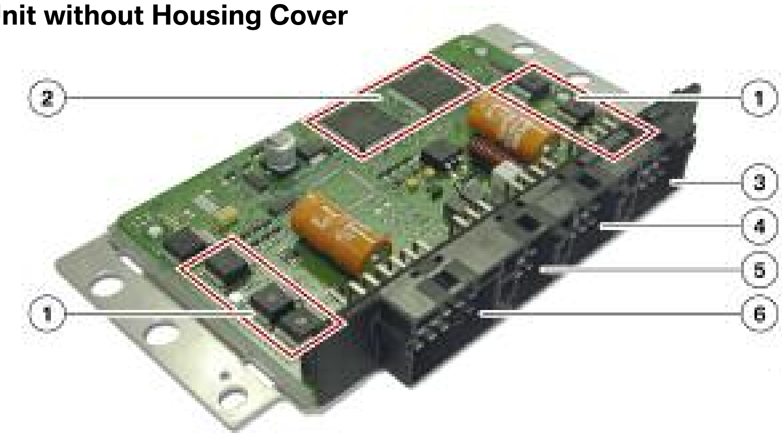
Each processor is responsible for controlling one of the electric motors. In addition, each processor monitors the computed results of the other in order to meet the high safety requirements. The output stages can be separated before a fault has any critical effects.

The output stages are used to generate the phase voltages and transport the energy required to control the electric motors.

Because the electric motors are three-phase asynchronous motors, the three phases must be operated with alternating voltage. The phases are generated by high-frequency pulsing of the DC voltage present in the vehicle electrical system.

The high-frequency pulsing creates the risk that electromagnetic interference will be emitted. This would have a detrimental effect on radio reception, because the associated aerials are located near to the installation location of the QMVH control unit.

QMVH Control Unit without Housing Cover



Index	Explanation
1	Output stages from power semiconductors
2	Two processors
3	Pin socket [right superimposing gear unit]
4	Pin socket [vehicle electrical system]
5	Pin socket [unassigned]
6	Pin socket [left superimposing gear unit]

For this reason, the lines along which the electric motor phases are actuated are shielded. The ground connection is located on the connector for the QMVH control unit.

There is also an ground connection from the wiring harness to the rear axle carrier.

The two outer pin sockets (3) and (6) are used to connect the wiring harnesses that lead to the superimposing gear units.

Pin socket (4) connects the control unit to the vehicle electrical system: the supply voltage, PT-CAN and ICM-CAN are connected here.

Pin socket (5) is not assigned and remains unused.

Operation

The QMVH control unit receives a request from the ICM control unit to transfer a certain amount of torque to the left or right rear drive wheel. The control unit must convert this setpoint value into phase voltages for the electric motor to be actuated. The following calculation steps are required for this:

- Deciding which superimposing gear unit needs to be activated. The side that should receive more of the available torque must be activated.
- Converting the torque to be transferred into a braking force at the superimposing gear unit.
- Determining the necessary adjustment path of the plates from the braking force that the plate assembly must generate.
- Calculating the motor rotation angle to achieve the required adjustment path of the plates.
- Determining the amplitude and progression of the three phase voltages.

During the adjustment process, the QMVH control unit uses the motor position sensor to measure whether and how far the electric motor has already moved. Once the calculated specified angle is reached, the actuation is changed so that the rotational angle achieved is maintained. A motor position regulation therefore takes place. The regulation principle is similar to that for Active Steering.

The QMVH control unit also carries out monitoring functions. This allows faults in the electronics and in the actuating elements to be detected which cause the function to be deactivated. In the event of a fault, the lines to the electric motors are disconnected. They are then de-energized and can no longer execute undesirable adjustment processes.

The multi-plate clutches also open, so that a previously active torque transfer is withdrawn.

The rear differential (and therefore the entire system) thus behaves like a conventional differential in the event of a fault.

As well as detecting faults, the QMVH control unit also monitors the signals from the temperature sensors on the rear differential. A protective function is thus implemented, which reduces the actuating element controls if the temperature is too high. This is intended to counteract any further heating (see also the Functions section). Both the temperatures in the electric motors and the temperatures of the transmission oils in the two superimposing gear units are taken into consideration.

ICM Control Unit

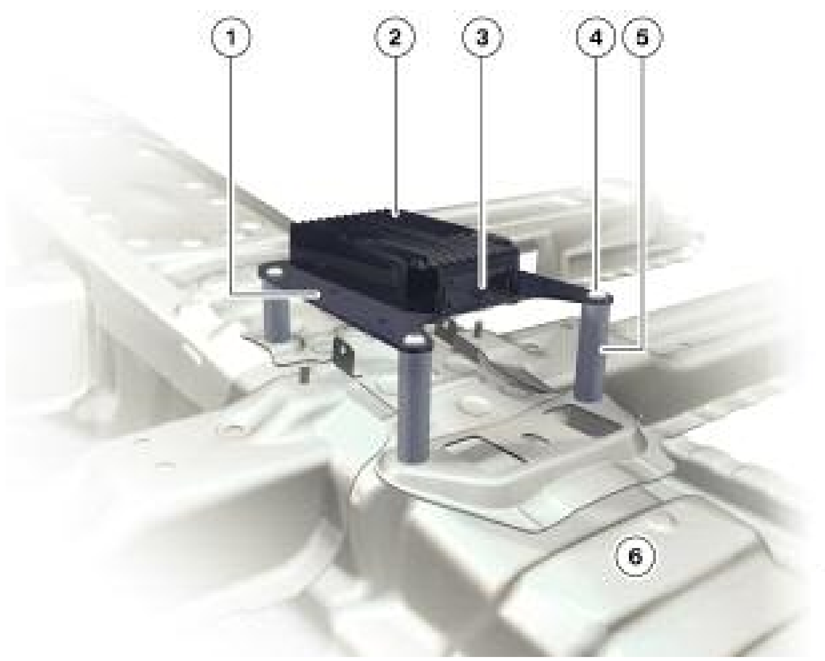
The ICM control unit is installed on the transmission tunnel (6). The lower section of the housing is bolted to the body work using spacer sleeves (5). The upper section of the housing has a ribbed structure for better heat dissipation. The ICM control unit has only one pin socket, which is used to make contact with the supply voltage, the bus systems and the control lines.

The ICM control unit only contains output stages for the steering proportional valve (EVV - electronically controlled bypass valve) and the Servotronic valve.

The ICM control unit is connected to three bus systems: the PT-CAN, the F-CAN and the new ICM-CAN.

The ICM control unit makes calculations that have a decisive influence on the vehicle behavior. This results in both high safety requirements and a need for a large calculating capacity. For these two reasons, the ICM control unit is equipped with two processors.

Installation Location of the ICM Control Unit



Index	Explanation
1	Lower section of housing
2	Upper section of housing
3	Connector
4	Mounting bolt
5	Spacer sleeve
6	Transmission tunnel

Active Steering

Virtually all of the components of Active Steering in the E71 are identical to those in the E70. To be precise:

- The electric motor with motor position sensor.
- The proportional valve (electronically controlled bypass valve, EVV).
- The Servotronic valve are identical in the two vehicle models. The AL control unit has a different construction in the E71 and is only designed as an actuating control unit.

Active Steering Control Unit
The AL control unit is located at the front left in the A-pillar extension under the wheel arch trim.

It is a dual-processor control unit. Power semiconductors are also integrated in the control unit which function as output stages. The dual-processor concept was selected in order to meet the high safety requirements.

The output stages (2), consisting of power semiconductors, are used to generate the phase voltages and transport the energy required to control the actuating motor.

Because this is a three-phase synchronous motor, the three phases must be operated with alternating voltage.

The phases are generated by high-frequency pulsing of the DC voltage present in the vehicle electrical system. For this reason, shielding is also used here. The shielding connects the electric motor to ground via the wiring harness to the body work.

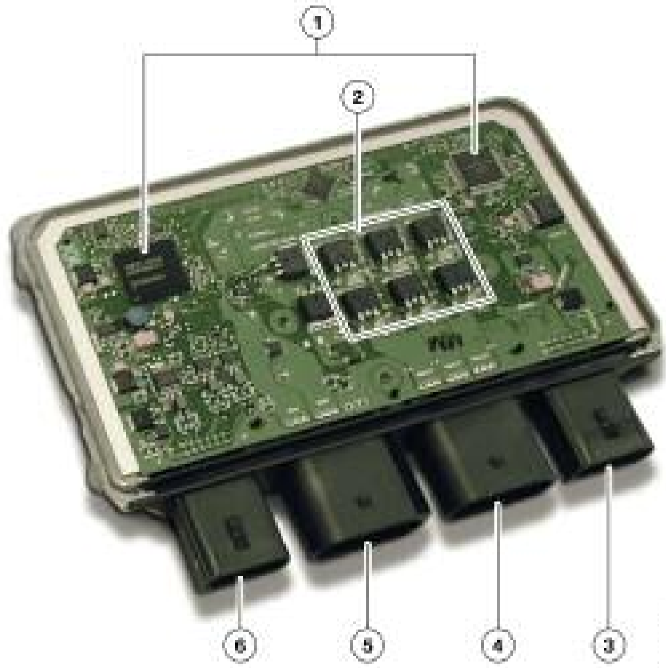
Connector (3) accommodates signal lines between the control unit and actuating element for Active Steering. These are the control lines to the solenoid lock and the signal lines for the motor position sensor.

Load is supplied to Active Steering via the connector (4). This DC voltage is converted into the phase voltages by the output stages in the control unit and sent to the electric motor at connector (5).

Connector (6) contains the contacts via which the control unit is supplied with power and those for connecting the two bus systems, PT-CAN and ICM-CAN.

The control units of the E70 and E71 cannot be interchanged.

Active Steering Control Unit without Housing Cover



Index	Explanation	Index	Explanation
1	Processors	4	Connector [voltage supply]
2	Output stages	5	Connector [phase voltages]
3	Connector [signal lines]	6	Connector [vehicle interface]

ARS

At SOP for the E71 in April 2008, certain alterations will also be made simultaneously in the E70.

Key modifications to the ARS:

- Discontinuation of the additional ARS lateral acceleration sensor.
- Discontinuation of the two pressure-relief valves on the front axle oscillating motor.
- Discontinuation of the two exterior pulsation dampers on the front axle oscillating motor.

Control Unit

The ARS control unit is located in the vehicle interior near the right-hand A-pillar.

The ARS control unit is supplied with power via terminal 30 and is protected by a 10A fuse. The ARS control unit is activated exclusively by the Car Access System (CAS) on a CAN wake-up line after "ignition ON".

A vehicle authentication process takes place when the system is started. This compares the vehicle identification number from CAS with the vehicle identification number which is encoded in the ARS control unit.

Then the ARS control unit's hardware and software are checked.

All outputs (valve solenoids and sensors) are subjected to a comprehensive check for short circuits and circuit breaks. If there is a fault, the system switches the actuators to a safe driving mode.

The ARS control unit switches off if there is undervoltage or overvoltage.

The ARS control unit learns the offset for the steering angle and the lateral acceleration during start-up and during driving.

Active Anti-roll Bar

The oscillating motor and the oscillating motor housing are joined by one half of the anti-roll bar.

The active anti-roll bar consists of the oscillating motor and the anti-roll bar halves fitted to the oscillating motor, with press-fitted roller bearings for their connection to the axle carriers. The use of roller bearings ensures optimum comfort thanks to better response and reduced control forces.

A thin coating of grease on the roller bearing does not impair the function of the active anti-roll bar.

Similarly, a totally new inner pulsation damping system is introduced, which is integrated into the construction of the oscillating motor shaft. This eliminates the need for the two pressure relief valves on the front motor.

Index	Explanation
1	Oscillating motor housing
2	Inner pulsation damping system
3	Oscillating motor shaft

Integrated Chassis Management (QMVH)

The introduction of the ICM control unit in the E71 was rather secondary. Of more significance, is the fact that all the dynamic driving systems in the vehicle can be coordinated more efficiently by using the ICM.

Instead of the previous approach of using one control unit for each main direction of movement the ICM control unit coordinates both longitudinal and lateral dynamic processes. In concrete terms, this means that Active Steering and the new Dynamic Performance Control function are controlled by the ICM.

However, this does not mean that the ICM has exclusive decision-making powers over the type and degree of the intervention of all the dynamic driving systems. One reason for this is that the DSC and xDrive systems used in the E70 are to be largely adopted in the E71. The E71 therefore shares the following similarities with the E70:

- If the vehicle needs to be restabilized when it is in its limit range, the DSC calculates the need for the brakes to be applied and applies them. This is also the case in the E71 despite the coordination function of the ICM.
- The DSC calculates the longitudinal distribution of the drive torque for xDrive and transmits the setpoint value to the transfer case control unit. There, the drive torque is distributed between the front and rear axles through activation of the multi-plate clutch.

The DSC therefore remains the determining control unit in the E71 when it comes to stabilizing the vehicle's behavior in the limit range. In this case, the DSC sends commands to the ICM to cease control by Dynamic Performance Control. However, while the vehicle is stable, the ICM has full decision making authority over the activation of Dynamic Performance Control.

The Active Steering functions (in particular the yaw-rate control) are not affected by this withdrawal of control. They continue to be implemented even if the vehicle's behavior is unstable, because they help to stabilize it.

The Vertical Dynamics Management (VDM) is still responsible for controlling the vertical dynamics. Signals regarding the current driving situation are naturally exchanged between the ICM and VDM.

Monitoring the Vehicle Status

The Integrated Chassis Management (ICM) control unit calculates the current driving situation from the signals listed below. This refers only to the longitudinal and lateral dynamic driving status.

- Wheel speed signals from all four wheels
- Longitudinal acceleration
- Lateral acceleration
- Yaw rate

The ICM control unit thus knows how the vehicle is actually moving at that moment.

To be able to optimize the vehicle behavior, the dynamic driving systems require information about how the driver wishes the vehicle to move. The driver's command is determined from the following signals:

- Accelerator pedal angle, current engine torque and gear ratio
- Application of the brake pedal and current brake pressure
- Steering angle

The ICM control compares the driver's command and the current actual movement of the vehicle and calculates whether intervention from the Active Steering and Dynamic Performance Control systems is necessary and what form this should take.

Coordinated Intervention by the Dynamic Driving Systems

Intervention by dynamic driving systems that operate in the longitudinal and lateral directions have the following objectives:

- To optimize the rotational motion of the vehicle about the vertical axis by effecting a yaw moment. This will increase the stability and/or the agility, depending on the driving situation.
- To improve the traction of the vehicle.

The Integrated Chassis Management allows these objectives to be achieved to a greater extent. The ICM acts as a coordinator and distributes the tasks to one or more systems.

To date, the following options have been available (and continue to be) for intervention to achieve the objectives stated above. The corresponding dynamic driving systems are indicated in brackets:

- Individual application of the wheel brakes (ASC+T, DSC)
- Adjustment of the current engine torque (ASC+T, DSC, MSR)
- Distribution of the drive torque between the rear and front axles (xDrive)

- Adjustment of the steering angle of the front wheels, regardless of the driver's input (Active Steering).In the E71, a further option for improving the traction and optimizing the rotational motion is available for the first time. The Dynamic Performance Control allows the drive torque to be distributed in a controlled way between the driven rear wheels.

The coordinated interventions by the systems with the help of the Integrated Chassis Management bring about several advantages.

In some driving situations, it can prevent more than one system providing the same intervention.

For example, systems such as Dynamic Performance Control act as an enhancement to xDrive before the unstable driving situation even occurs. This happens without the driver being aware of it and avoids further intervention by Active Steering or Dynamic Stability Control.

Active Steering in the ICM Network

The functions of Active Steering that are perceptible to the customer in the E71 are identical to those in the E70. Active Steering also provides:

- a variable steering-transmission ratio that changes according to the vehicle's road speed.
- Yaw-Rate Control Plus (GRR+), which is used to stabilize steering interventions, not only when the vehicle is oversteering, but also when it is being braked on surfaces with various friction coefficients.

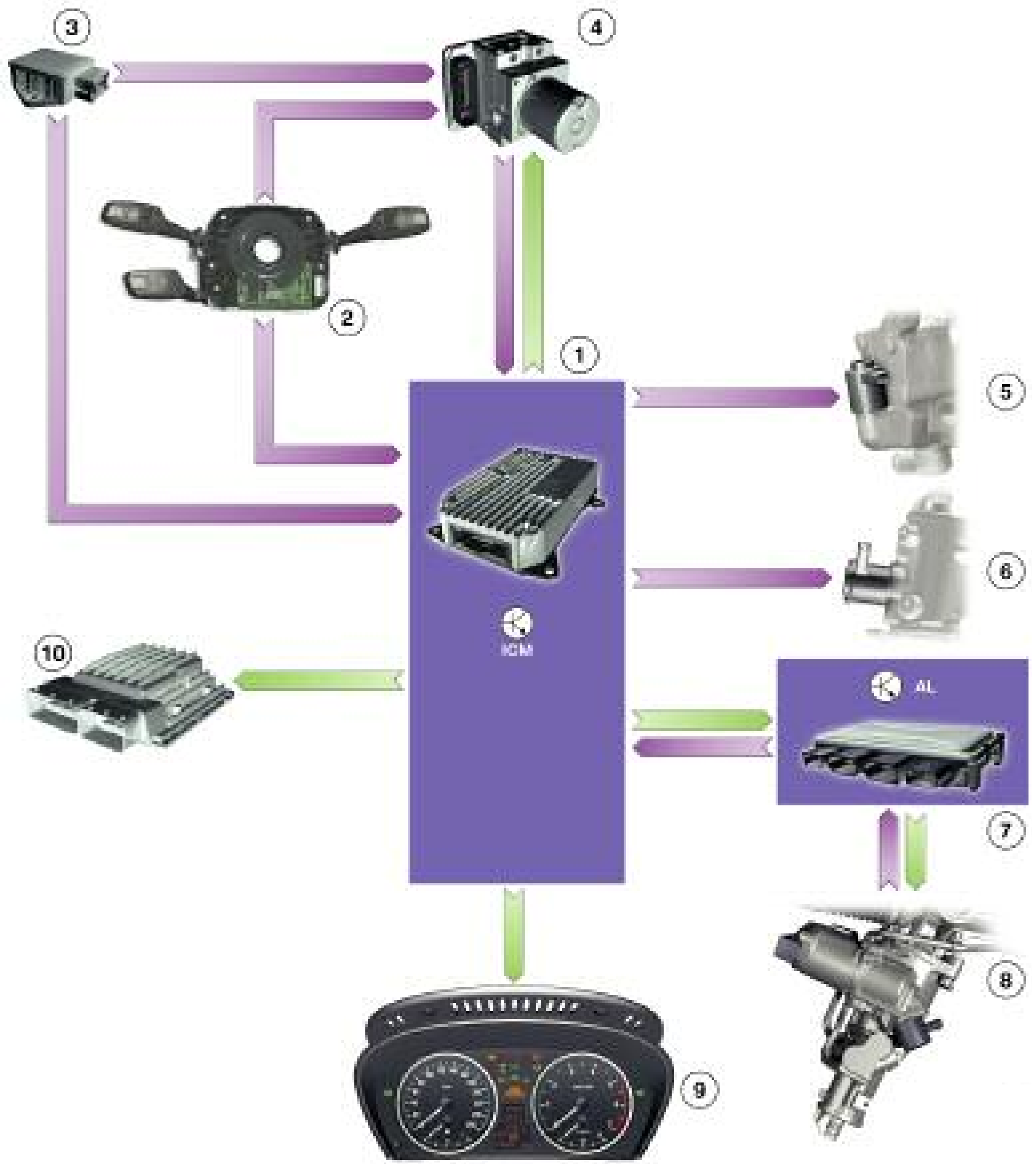
Just some of the parameters have been specifically adapted for the new E71 vehicle type.

The distribution of the functions between the control units and thus their interaction have changed. This is due to the new ICM control unit network in the E71.

The Integrated Chassis Management is the control unit in which the higher-level dynamic driving functions for Active Steering are calculated. As already described, the current driving situation is analyzed. The input variables for this are provided by:

- the steering column switch cluster (steering angle and steering-angle speed).
- the DSC sensor (yaw rate, lateral acceleration and longitudinal acceleration).
- Dynamic Stability Control (wheel speeds) In addition, the driver's directional input is analyzed using the steering angle and the steering-angle speed (both signals from the steering column switch cluster).

Active Steering IPO



Index	Explanation	Index	Explanation
1	Integrated Chassis Management	6	Servotronic valve
2	SZL with steering angle sensor	7	Active Steering (control unit)
3	DSC sensor	8	Active Steering (actuator)
4	Dynamic stability control	9	Instrument cluster
5	Proportional valve (EVV)	10	Engine control system (DME)

The Integrated Chassis Management uses the current driving situation and the driver's directional input to calculate the individual setpoint values for the variable steering transmission ratio and the Yaw-Rate Control Plus. Once these have been prioritized, the ICM provides a resulting setpoint value. This is a specified angle to which the front wheels should be adjusted.

The Active Steering control unit receives this setpoint value and has the principal task of controlling the actuating elements such that the setpoint value is achieved. The Active Steering control unit is therefore purely an actuating control unit. This is the main difference from the previous implementation of Active Steering. There, the control unit not only controlled the actuators, but also calculated the higher-level regulating functions.

In order to ensure that the setpoint value is applied, Active Steering control unit reads the signal from the motor-position sensor. This additional steering angle for Active Steering is also communicated to the ICM control unit and then to the DSC control unit.

To remain consistent with the E70, the DSC control unit in the E71 also calculates the cumulative steering angle from the steering angle and the Active Steering steering angle.

The DSC control unit provides the cumulative steering angle to the other control units via the PT-CAN.

All variants of the E71 equipped with Active Steering automatically receive the Servotronic function. This function is controlled by the ICM control unit.

All variants of the E71 steering system also contains a proportional valve that is also controlled by the ICM control unit. The valve is known as an electronically controlled bypass valve (EVV).

The volumetric flow generated by the power steering pump is distributed between the steering valve and a bypass valve according to the level of power steering assistance required. This distribution is infinitely variable.

The less power steering assistance required, the more hydraulic fluid is diverted to the bypass circuit. Because the hydraulic fluid in the bypass circuit has no task to perform, it means that the power steering pump consumes less power. In this way, the proportional valve has a hand in reducing fuel consumption and CO2 emissions.

ICM Interfaces

The ICM control unit has two further interfaces with partner control units for the Active Steering function. These are:

- Instrument cluster
- Engine control system

Instrument Cluster

If the ICM control unit detects a fault in the Active Steering system (faulty input signal, faults in the control unit or in the Active Steering actuator), it activates the usual steering warning lamp and the associated Check Control message. This request is implemented by the instrument cluster.

Engine Control Module

If there is a high level of steering activity, in particular at low road speeds, the cooling requirement in the hydraulic system increases.

To prevent overheating, the ICM control unit can ask for the speed of the electric fan to be increased. This request is sent via the PT-CAN to the engine control system, because the latter directly controls the electric fan.

Component or Function	Module responsible for Logic or Processing	Module responsible for Actuation or Output
EDC	*VDM*	*EDC SAT x4*
AL/AFS	*ICM*	*AL/AFS*
DPC/QMVH	*DSC*	*QMVH*
xDrive	*DSC*	*VTG*
DSC	*DSC*	*DSC*
ASC	*DSC*	*DSC*
ABS	*DSC*	*DSC*
MSR	*DME*	*DME*
Automatic Hold	*EMF*	*EMF/DSC*
EVV	*ICM*	*ICM*
Servotronic	*ICM*	*ICM*
ARS	*ARS*	*ARS*
EHC	*EHC*	*EHC*
Total Steering Angle	*DSC*	N/A

Dynamic Performance Control Operation

Distribution of the Drive Torque (xDrive w/o DPC)

The BMW xDrive all-wheel-drive system regulates the variable distribution of the drive torque between the front and rear axles, resulting in a longitudinal distribution of the drive torque. In the current xDrive generation, the distribution is performed by an adjustable multi-plate clutch. xDrive helps to improve the traction and stability of the vehicle.

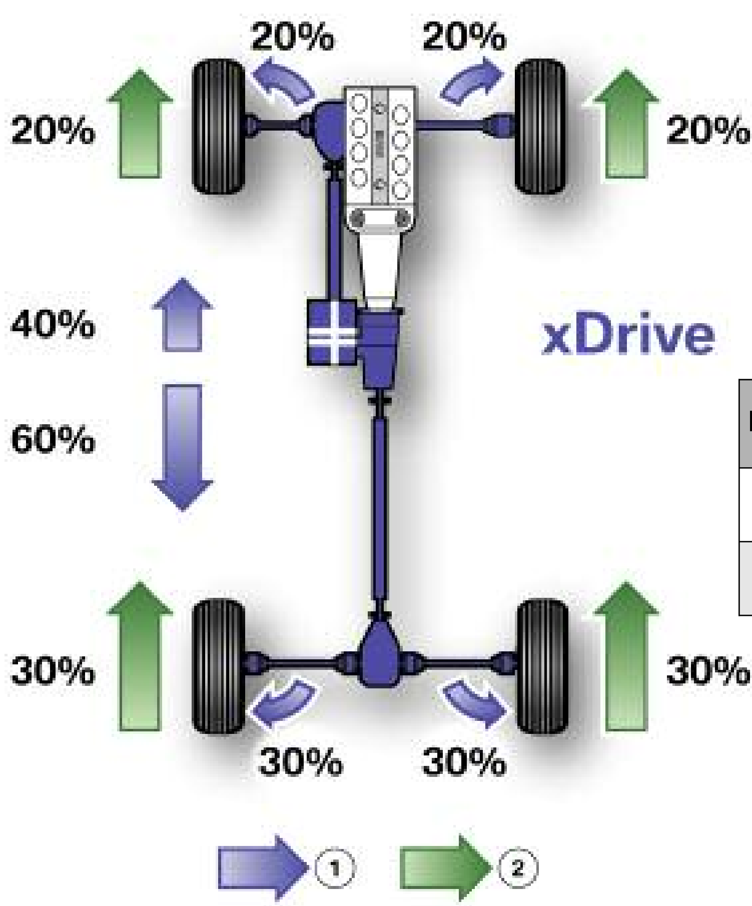
In the situation shown, the distribution of the drive torque by xDrive is the standard distribution. 40% is distributed to the front axle and 60% to the rear axle.

The front and rear axle transmissions distribute the drive torque equally to both sides. In terms of driving force, 20% is available at each front wheel and 30% at each rear wheel.

This distribution is appropriate for driving in a straight line.

Because the drive torque is equal at the left and right wheels, any differing friction coefficients on the left and right are not initially factored in (of course, ASC+T will intervene if one or more wheels are threatening to spin as a result).

Longitudinal Distribution of the Drive Torque by xDrive



Index	Explanation
1	Drive torque distributed by xDrive
2	Driving force at the wheel

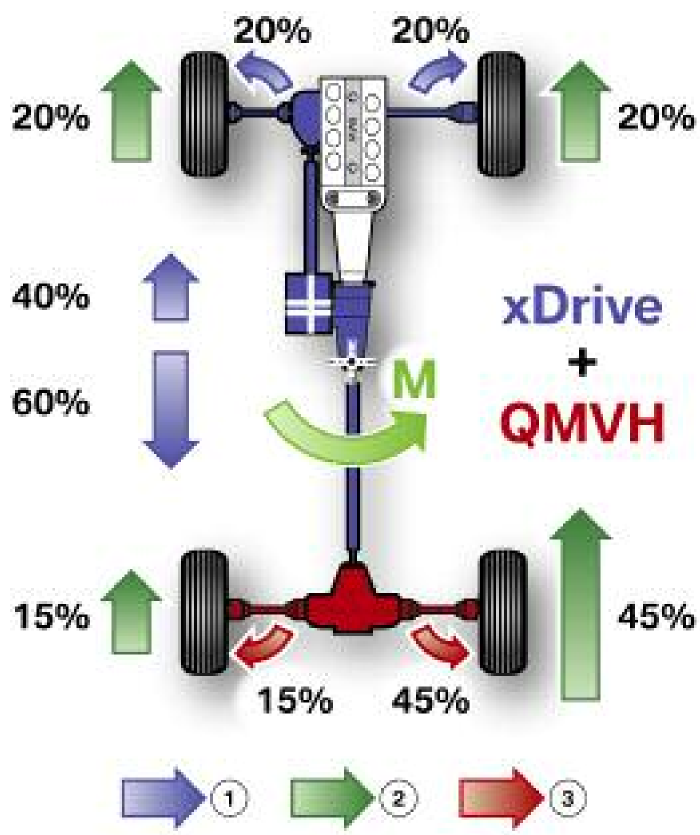
Distribution of the Drive Torque (xDrive w/ DPC)

Dynamic Performance Control now also enables infinitely variable distribution of the drive torque between the wheels on the rear axle. Instead of a longitudinal distribution, as provided by xDrive, Dynamic Performance Control provides a lateral distribution of the drive torque. That is why, in technical documentation, the term "rear axle lateral torque distribution" often appears as a synonym for the sales designation "Dynamic Performance Control".

A new rear differential developed on the basis of a conventional differential allows the torque flow to and from the wheels to be controlled.

This means that not only can stability and traction be further increased, but the vehicle's agility can also be improved.

Longitudinal Distribution by xDrive,
Lateral Distribution by Dynamic Performance Control (QMVH)



Index	Explanation
1	Drive torque distributed by xDrive
2	Driving force at the wheel
3	Drive torque distributed by Dynamic Performance Control
M	Torque about the vertical axis of the vehicle (= yaw moment)

The combination of the xDrive and Dynamic Performance Control systems is able to further improve the vehicle behavior under acceleration and on surfaces with different friction coefficients on the left and right. Lets assume that the right rear wheel is on dry asphalt and the left rear wheel is on snow. In addition to the longitudinal distribution of the drive torque by xDrive, Dynamic Performance Control allows the drive torque to be distributed between the rear wheels. In this situation, the majority of the drive torque will be transmitted to the right rear wheel, because the left rear wheel can only generate relatively little driving force due to the low friction coefficient. This can avoid ASC+T having to intervene by applying the brakes.

The uneven distribution of the torque at the rear wheels has a second effect that is also used by Dynamic Performance Control.

Torque (M) is generated about the vertical axis of the vehicle. This means that the rotational motion of the vehicle about the vertical axis when cornering can be intentionally influenced. You can use this effect to turn the vehicle harder into a corner or to dampen the rotational movement.

Fixed Distribution of the Drive Torque with Conventional Rear Differential
A conventional rear differential consists of an angle drive and a differential gear and always distributes the drive torque equally (50:50) to both sides. Different rotational speeds are balanced out.

The different gear ratios for the various vehicle models are achieved by the different number of teeth on the drive pinion and crown gear.

Distribution of the Drive Torque by the Rear Differential with Mechanical Locks (limited-slip differential)

A open/conventional differential has two beneficial features:

- The speed of the drive wheels can differ from each other because of the different distances they cover when cornering.
- The drive torque is always distributed equally to both drive wheels and does not therefore generate any yawing.

These benefits are counterbalanced by a major disadvantage if the tire-road adhesion is different at the two wheels. The propelling forces that are to be transferred to the road are then limited to the lower of the two potential adhesion levels at the drive wheels.

If the adhesion ratio is unfavorable on one side, it means that a vehicle (without electronic dynamic driving system) would not be able to move off. The drive torque would be converted into useless rotational acceleration for the wheel with the lower potential adhesion level, while the higher potential adhesion of the second drive wheel remains unexploited.

Selectable and self-locking rear differentials are fitted in order to eliminate this disadvantage of the differential gear.

Variable Distribution of the Drive Torque in the Rear Differential with Superimposing Gear Units

The new rear differential with superimposing gear units abolishes this fixed torque distribution by the differential gear. The differential gear is supplemented by a superimposing gear unit on each side. These provide a second additional path along which the drive torque can be transmitted.

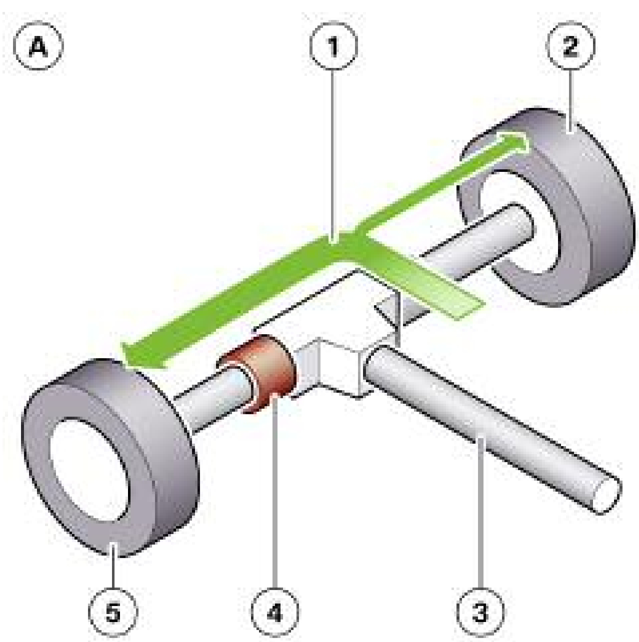
In all three load situations:

- traction
- coasting
- overrun

the BMW Dynamic Performance Control system allows the torque to be ideally distributed between the two rear wheels.

A - Torque Transfer Under Traction

The **traction** load situation means that the engine is generating a positive drive torque. In this respect, the functions of the BMW Dynamic Performance Control hardly differ from those of the competition. The BMW system can transfer up to 1,800 Nm of drive torque from one wheel to the other.

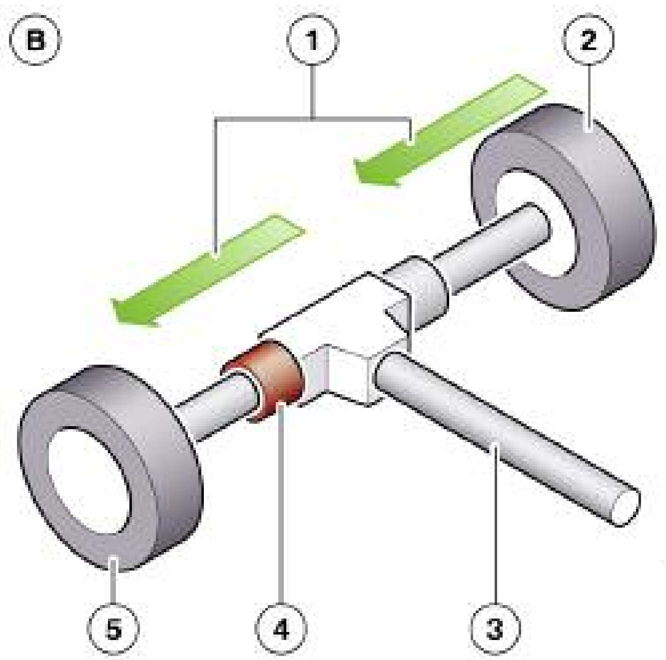


Index	Explanation
1	Lateral distribution of the torque
2	Left rear wheel
3	Propeller shaft
4	Activated superimposing gear unit
5	Right rear wheel

The competitive advantage of the BMW system becomes clear in other load situations.

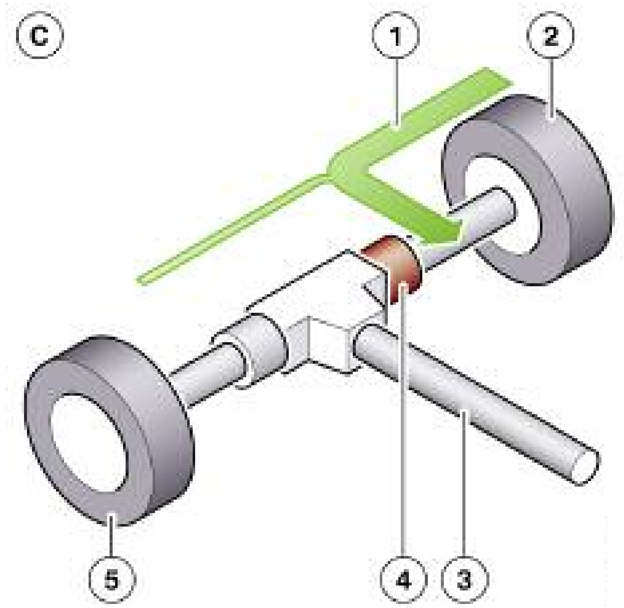
B - Torque Transfer During Coasting
During **coasting**, there is no drive torque (0 Nm).
When there is power being transmitted between the engine and transmission, this occurs when the engine torque is exactly equal to the loss torques. It also occurs if the driver disconnects the power transmission between the engine and the gearbox (selector lever in the neutral position).

There is then zero torque at the input to the rear differential. In contrast to the competitors' systems, Dynamic Performance Control can also bring about torque transfer in this load situation. If a wheel is to receive positive torque, an equal amount of negative torque will occur at the other wheel.



Index	Explanation
1	Lateral distribution of the torque
2	Left rear wheel
3	Propeller shaft
4	Activated superimposing gear unit
5	Right rear wheel

C - Overrunning: Negative Torque in the Propeller Shaft
If the engine is delivering negative torque, e.g. during overrun fuel cut-off, this is known as overrunning. Even in this case, Dynamic Performance Control allows torque transfer, i.e. a negative torque can also be distributed asymmetrically to the two wheels. The torque transfer can even be increased to such an extent that there is an extremely large negative torque at one wheel and a slight positive torque at the other wheel.



Index	Explanation
1	Lateral distribution of the torque
2	Left rear wheel
3	Propeller shaft
4	Activated superimposing gear unit
5	Right rear wheel

Improved Traction

Accelerating Out of Corners

Dynamic Performance Control enables improved cornering traction by adapting the torque distribution to the potential adhesion between each tire and the road.

The vehicle can be accelerated out of the corner more quickly without impairing directional stability.

The rolling motion of the vehicle when cornering generates different wheel contact forces. The contact forces at the wheels on the outside of the corner are greater than those at the wheels on the inside of the corner.

Therefore, the maximum forces that can be transferred to the road are greater at the wheels on the outside of the corner than at the wheels on the inside of the corner. Dynamic Performance Control has an ingenious way of using this effect. If the driver accelerates while cornering, more drive torque is distributed to the rear wheel on the outside of the corner than to the rear wheel on the inside of the corner. In this way, the adhesion potential of the rear wheels is better exploited. Overall, the vehicle can make use of a greater drive torque to accelerate in the corner.

Driving off on Surfaces with Varying Friction Coefficients

The improved traction when pulling away will be particularly noticeable to the driver when the road surface has various friction coefficients. This mixture of friction coefficients makes the variable distribution of the drive torque between the individual wheels more evident.

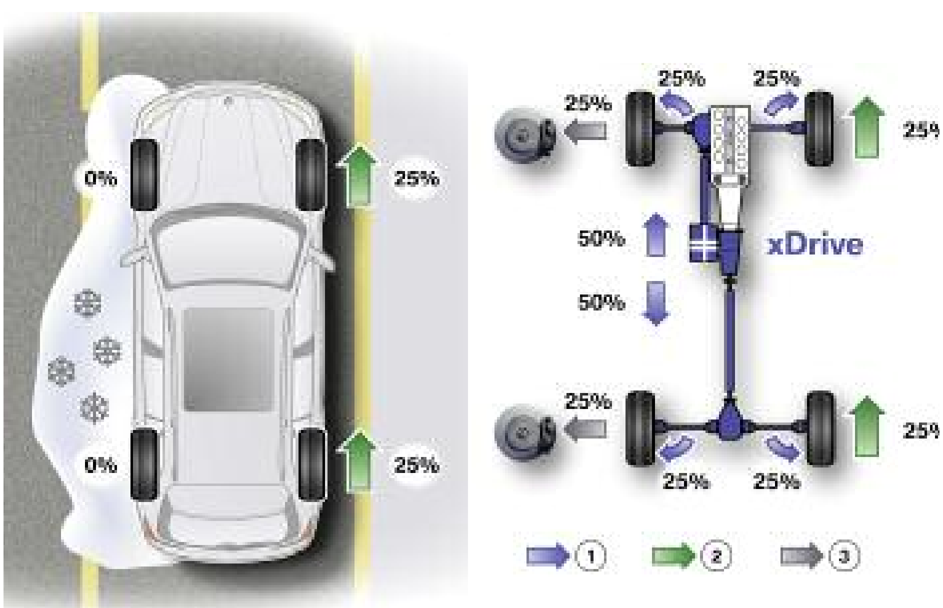
Dynamic Performance Control distributes the drive torque to the side where more power can be transferred.

Lets look at a situation where the vehicle is pulling away with different friction coefficients on the left and right sides to compare the basic principles for torque distribution in xDrive and Dynamic Performance Control.

xDrive

In this situation, the xDrive system distributes the drive torque equally to the front and rear axles. The front and rear axle transmissions transfer the drive torque evenly to the left and right sides.
The front and rear wheels on the left-hand side cannot, however, transfer any driving force to the icy road. ASC+T applies the brakes to the left wheels, converting their proportion of the drive torque into heat. The entire proportion of the drive torque transferred to the wheels on the right-hand side (25% each) is available for acceleration.

In effect, then, 50% of all the torque generated for pulling away is efficiently utilized.



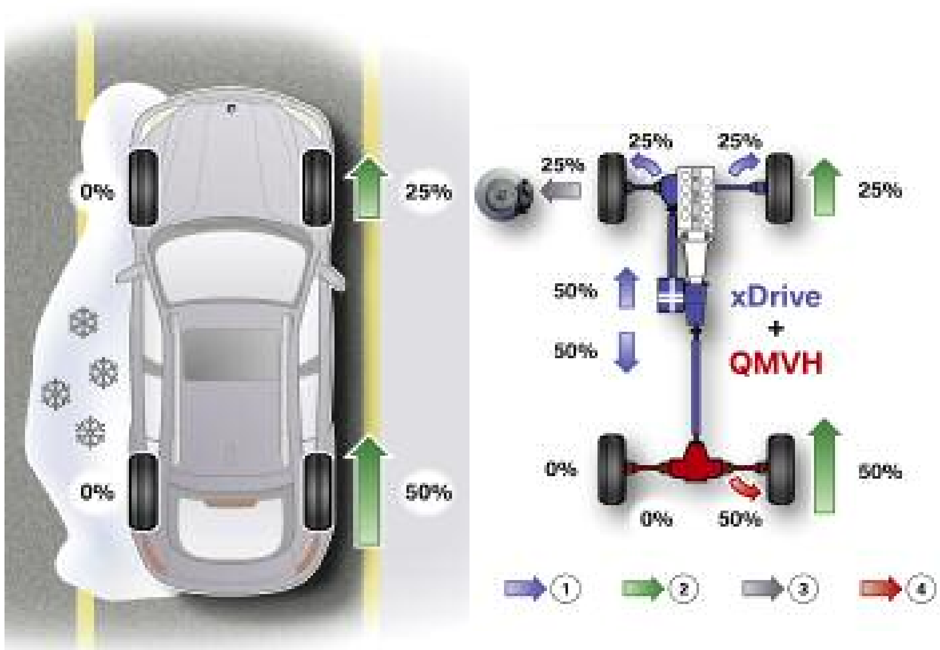
Index	Explanation
1	Drive torque distributed by xDrive
2	Driving force at the wheel
3	Driving force not available due to braking by ASC+T

xDrive with DPC
The combination of the two systems, xDrive and Dynamic Performance Control, further improves the already good pulling away performance on surfaces with various friction coefficients. Dynamic Performance Control detects that the left rear wheel is threatening to spin using the wheel speed signals (in a similar way to ASC+T). Instead of ASC+T reducing the drive torque by applying the brakes, Dynamic Performance Control diverts virtually all of the drive torque at the rear axle to the right rear wheel.

Because a QMVH differential is only used on the rear axle, the torque distribution at the front wheels remains unaffected. ASC+T still needs to apply the brakes here to prevent the left front wheel from spinning.

There is now a total of 75% of the drive torque available for pulling away (50% at the right rear wheel, plus 25% at the right front wheel).

Particularly on surfaces with various friction coefficients, a vehicle with Dynamic Performance Control will have more tractive force at its disposal and will thus be able to accelerate harder than a vehicle that is only equipped with xDrive. By laterally distributing the drive torque, Dynamic Performance Control therefore improves traction when pulling away.



Index	Explanation
1	Drive torque distributed by xDrive
2	Driving force at the wheel
3	Driving force not available due to braking by ASC+T
4	Drive torque distributed by Dynamic Performance Control

Increased Agility

The intelligent interaction between the mechatronic systems, DSC and xDrive, guarantees excellent traction and stability. However, there is a certain conflict of objectives, which generates more stability at the expense of agility.

Dynamic Performance Control, which is also a mechatronic system, is a logical enhancement to DSC and xDrive, because it can provide an infinitely variable distribution of the drive torque between the left and right wheels on the rear axle. This is pretty much regardless of how much input torque there is.

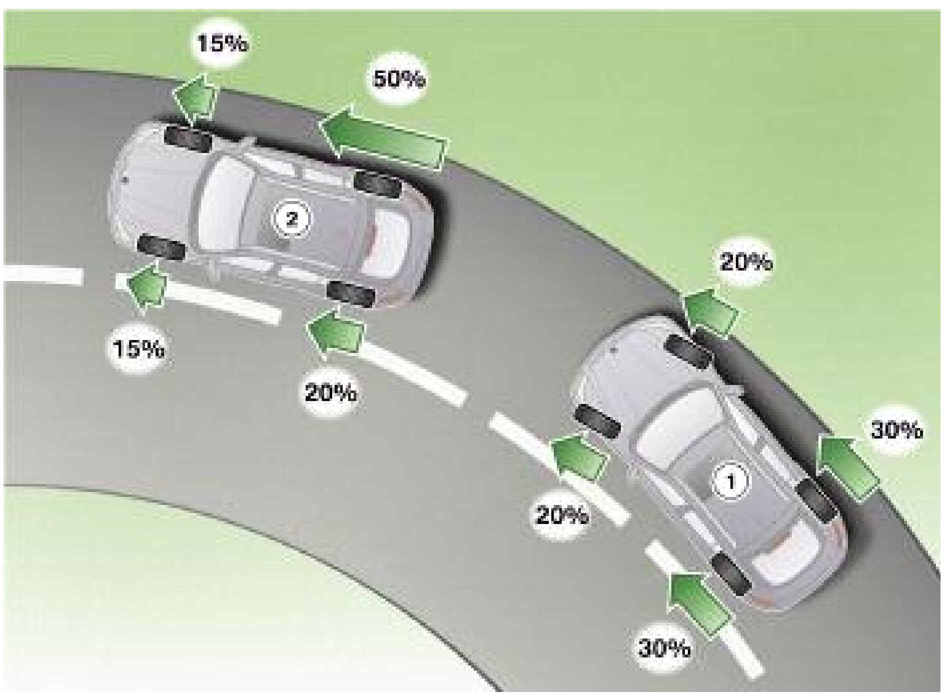
The conflict between stability and agility is therefore resolved for the first time.Increased agility can be perceived in the following dynamic benefits:

- Smaller steering angle requirement
- Less of a tendency to understeer

The vehicle responds more sensitively to steering input. With asymmetric drive torque distribution at the rear axle, Dynamic Performance Control effects an optimum yaw moment.This controlled additional torque about the vertical axis of the vehicle makes it more "willing" to turn corners and reduces the amount of steering input required.

Less steering effort means greater steering comfort, reduced understeer and more precise steering through corners.

Increased Agility in Cases of Understeer



Index	Explanation
1	Entering the corner, threatening to understeer
2	Torque distribution, understeer eliminated

Greater Directional Stability

As well as the considerably increased responsiveness of the vehicle with less steering input, any oversteer can also be noticeably controlled by the distribution of torque.

Dynamic Performance Control increases vehicle safety by appropriately damping the rotational motion of the vehicle about the vertical axis.

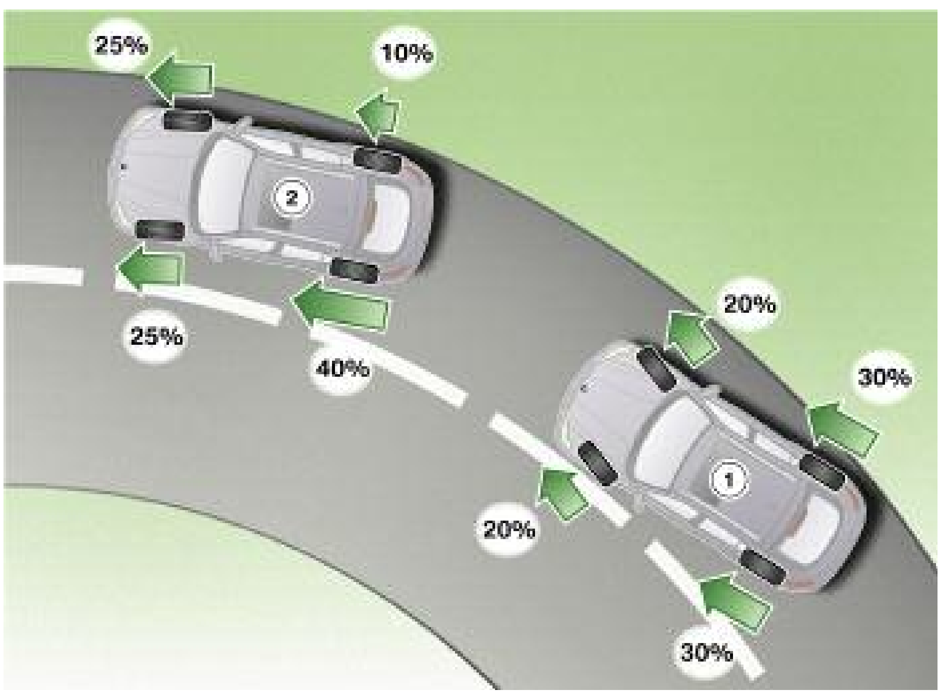
At the first sign of instability, e.g. oversteer, the drive torque at the rear axle is diverted to the wheel on the inside of the corner, thus preventing the rear of the vehicle from kicking out.

As soon as the vehicle is dynamically stable again, the torque distribution by xDrive also returns to the basic 40:60 distribution.

If the directional stability still remains close to the limit, DSC will of course also intervene. In this way, the various dynamic driving systems work together, coordinated by the Integrated Chassis Management, to achieve a common objective and to complement each other.

The result is, for example, more easily controlled vehicle behavior when you need to take evasive action.

Increase in Directional Stability for the Example of Oversteer



Index	Explanation
1	Entering the corner, threatening to oversteer
2	Torque distribution, oversteer eliminated

Operating Modes and Displays

Normal Mode

The Dynamic Performance Control functions cannot be switched on and off. The system is available once the engine is switched on.

Evidently, no torque is transferred in gear P, because the vehicle is stationary and no power is being transmitted to the wheels. However, in gears N and R, the system can affect torque transfer.

The driver will get a new functional display for Dynamic Performance Control, which can be called up as one of the on-board computer screens and make permanently visible in the instrument cluster. If the display for Dynamic Performance Control was active last time the vehicle was driven, it will automatically appear again the next time the vehicle is driven.

Due to legal requirements, the vehicle's odometer reading must always be displayed for a fixed time after the engine is started. For this reason, a small symbol for Dynamic Performance Control appears when the engine is started with the odometer reading underneath it. This small symbol is also displayed if the driver switches to the Dynamic Performance Control screen from another on-board computer screen.

After a few seconds, the symbol is switched to full size for better legibility. It shows the drive train and the vehicle wheels from above, as well as the current torque distribution by xDrive and Dynamic Performance Control.

The amount of torque at a wheel is shown by the number of narrow segments. Together, the segments form a bar, the length of which is a measurement of the amount of torque at the wheel. In this view, only positive values are possible. If the torque drops to a value of 0 Nm, the segments disappear completely from the wheel concerned. Negative values are also displayed like this and so cannot be clearly indicated.

A few typical examples of the display with the full-size symbol are shown below.

Dynamic Performance Control display with small symbol and odometer reading (displayed upon engine startup)

Dynamic Performance Control display with standard longitudinal distribution (front/rear) and even lateral distribution (left/right)

Dynamic Performance Control display with longitudinal distribution biased to the rear and even lateral distribution (left/right)

Dynamic Performance Control display with standard longitudinal distribution (front/rear) and lateral distribution biased to the right

Break-in Phase

There are no different or additional running-in instructions for the rear differential with superimposing gear units than those that already exist for the conventional rear differential. Nor is there any diminished or reduced functionality due to the new rear differential.

Wear Over the Service Life

Notable wear occurs to two system components of the rear differential: the multi-plate clutches and the transmission oil in the superimposing gear units (see also the System components section). There are mathematical models for these two components that either compensate for the wear or monitor for impermissibly high values.

Continuous wear to the multi-plate clutches is offset by appropriate control of the electric motors. Constant adaptation processes running in the background determine the position of the electric motors at which there is no torque transfer. The last detected "zero position" during a driving cycle is saved in the QMVH control unit and is available as the start value for the next driving cycle.

Wear to the multi-plate clutches can be compensated for throughout their entire service life. This is ensured by their design and the configuration of the electric motor adjustment range.

Frictional wear and loading due to high temperatures also age the transmission oil in the superimposing gear units. For this reason, a wear algorithm is calculated that takes account of the following variables:

- Age of the transmission oil in the superimposing gear units
- Number of times a superimposing gear unit has been actuated
- Temperature of the transmission oil in the superimposing gear units

If the vehicle is driven with a normal or even a dynamic driving style, the transmission oil can be used for the entire service life of the vehicle without requiring changing. The result of the wear algorithm remains in the permissible range.

Only if the vehicle is driven with an extremely sporty driving style might it become necessary to change the transmission oil during the vehicle's lifetime. The wear algorithm then generates a fault code memory entry. The diagnostic system uses this fault code memory entry to suggest a transmission oil change.

Please note that when we talk here about transmission oil and changing it, we are only referring to the two reservoirs of the superimposing gear units.

The oil in the differential is a service life supply, as before.

Driving Off with a Limited Steering Angle Signal

The steering angle sensor in the steering column switch cluster (SZL) is only able to measure the relative steering angle directly.

Its measuring range is between -180° and +180°.

The absolute steering angle can be calculated from the relative steering angle by counting the steering-wheel turns. This information is lost if the SZL not supplied with voltage (e.g. if the battery is disconnected). When the vehicle is subsequently started, only the relative steering angle is available initially. The SZL uses the signals from the wheel-speed sensors to determine the information about the steering-wheel rotation when first pulling away.

The following situation can be particularly problematic for all-wheel drive vehicles. The SZL was disconnected from the voltage supply. The vehicle is started on a snow covered road, for example. The driver depresses the accelerator pedal forcefully to pull away causing all the wheels to spin and requiring ASC+T to brake them again.

In this situation, the SZL may not be able to immediately determine the information about the steering wheel rotation. It is not possible again until the slipping stops. In the meantime, the full functions of Dynamic Stability Control and Dynamic Performance Control are not available.

During this transition period, the driver is informed of the limited availability of the stability control systems by the DSC warning lamp and a Check Control message.

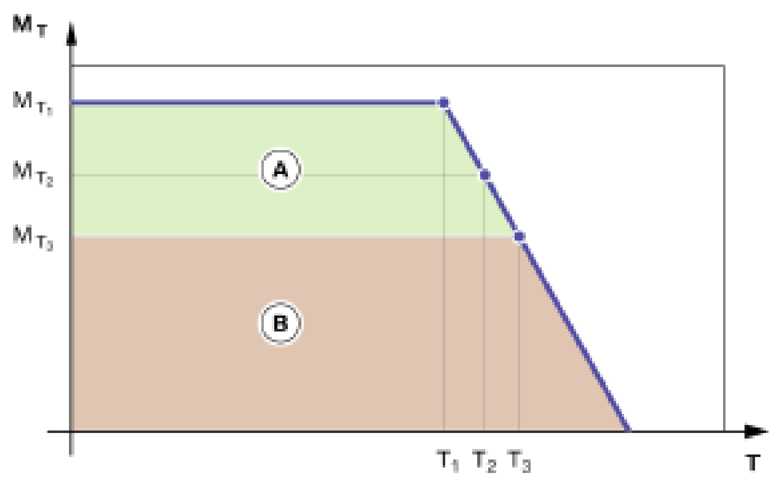
However, in this case, it is not a question of a fault, but a temporary unavailability of the systems. In the event of a complaint, the customer should be informed of this possibility.

Excessive Temperature

Excessive temperature can occur in the two electric motors or in the transmission oil in the superimposing gear units. Excessive temperature can cause damage to components or unduly high levels of wear.

The following measures are applied to prevent this.

Degradation of the Torque Transfer as a Function of Temperature



Index	Explanation
MT	Percentage performance of the required torque transfer by DPC
A	Normal operation without driver information
T	Temperature of the electric motors and/or the transmission oil in the QMVH
B	Restricted operation with driver information

The system is able to detect a "sporty driving style". If it does so, the temperature threshold is temporarily increased by approximately 25°C.

The temperature of the electric motors and the transmission oil in the two superimposing gear units is measured. The signals from the temperature sensors are analyzed by the QMVH control unit.

In the first temperature range, the QMVH control unit makes available the full amount of torque transfer (M_{T1} = 100%). If the limit value T_1 is exceeded, the QMVH control unit reduces the torque transfer performance.

In the example shown, the transmission oil in one superimposing gear unit has temperature T_2. The torque transfer is then reduced to M_{T2} = 80%. If the Integrated Chassis Management requires a torque transfer of 1,000 Nm, only 800 Nm is provided by the QMVH control unit.

The reduced performance is reported back to the ICM control unit, so that it can be taken into consideration for the higher-level dynamic driving control. The reduced work of the superimposing gear units reduces the input of frictional heat, thereby preventing further heating.

The driver is not informed of the limited function of Dynamic Performance Control until the vehicle handling is markedly altered by the reduction in torque transfer. This threshold is marked as M_{T3} in the diagram. The relevant display - see below - is not activated until this point.

xDrive and/or DPC not available

System Not Available

If xDrive or Dynamic Performance Control (or both) is not available, the function display is dimmed. Because the customer does not then benefit from the large bar display, the display is also switched to the smaller symbol size.

The driver cannot determine whether xDrive or Dynamic Performance Control is causing the fault in the system using only the dimmed function display. The distinction can be made using the associated Check Control message.

A failure of Dynamic Performance Control has a similar effect to the failure of Dynamic Stability Control. Driving stability is limited.

Therefore, if there is a system fault in Dynamic Performance Control, the same Check Control symbol is used as for DSC. An instruction in the Central Information Display asks the driver to drive carefully. In addition to this Check Control message, the fixed warning lamp in the instrument cluster is constantly lit yellow.

Display in the event of a DPC system failure

The Check Control symbol for a fault in the xDrive system shows the customer that all-wheel drive is no longer available.

Check Control symbol for xDrive fault

Dynamic Performance Control in the ICM Network

The ICM control unit's monitoring of the driving situation can be used for both systems (AL/AFS and DPC). The interpretation of the directional input at the steering wheel by the driver is also of use for the two systems. For the Dynamic Performance Control system, the engine torque requested by the driver and the torque provided at the transmission output are also analyzed. The ICM control unit therefore reads the relevant signals from the engine control system and the electronic transmission control system.

A particular feature in the ICM network is the xDrive system, which is used to help control the longitudinal distribution of the drive torque.

As in the all-wheel-drive vehicles already available on the market, the DSC control unit in the E71 continues to calculate the setpoint value for the distribution of the drive torque between the front and rear axles. The transfer case control unit applies this setpoint value and feeds back the actual value of the torque distribution. In the E71, it is no longer only the DSC control unit that receives this signal, but also the ICM control unit, so that the drive torque available at the rear axle can be determined.

Using the current driving situation, the driver's input and the drive torque available at the rear axle, the Integrated Chassis Management calculates a setpoint value for the QMVH control unit. This specifies how much drive torque should be transferred from which rear wheel to the other and is sent via the ICM-CAN.

The QMVH control unit has the task of implementing this setpoint value by energizing the actuating elements. In doing so, it must first detect which side, i.e. which of the two superimposing gear units, needs to be energized. This should occur on the side on which the greater drive torque should be applied.

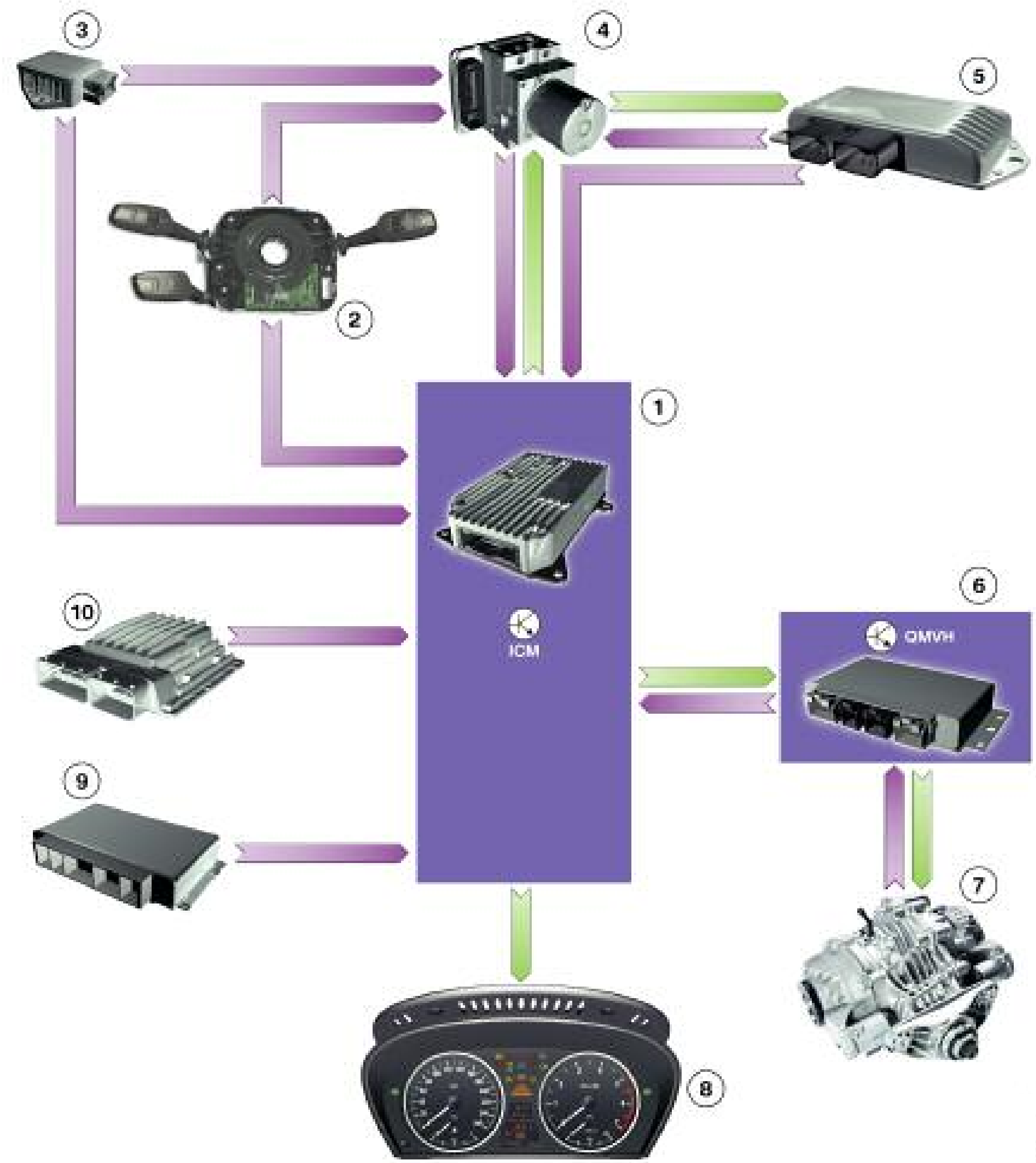
The QMVH control unit in the E71 is purely an actuating control unit, in a similar way to the Active Steering control unit.

In order to ensure that the setpoint value is applied, the QMVH control unit reads the signals from the motor position sensors. There is also motor position control for Dynamic Performance Control in the same way as for Active Steering.

The QMVH control unit uses the motor position to determine the drive torque that is actually transferred and transmits this information back to the ICM control unit.

The interface between the ICM control unit and the instrument cluster serves to activate the function displays and to indicate fault statuses. See the "Operating modes and displays" section.

Dynamic Performance Control IPO



Index	Explanation	Index	Explanation
1	Integrated Chassis Management	6	Rear axle lateral torque distribution
2	SZL with steering angle sensor	7	QMVH rear differential
3	DSC sensor	8	Instrument cluster
4	Dynamic stability control	9	Electronic transmission control
5	Transfer box control module	10	Engine control system (DME)

Service Information

Running-in Phase

There are no different or additional running-in instructions for the rear differential with superimposing gear units than those that already exist for the conventional rear differential.

Driving Off with a Limited Steering Angle Signal

If the steering column switch cluster (SZL) has been disconnected from the voltage supply, only the relative steering angle can initially be measured. The SZL does not calculate the absolute steering angle using the wheel speed signals for calibration until the vehicle has been driven for a few meters.

Until this point, only limited functions of the Dynamic Stability Control and Dynamic Performance Control dynamic driving systems are available. The driver will not normally notice this phase.

A Check Control message is only issued if the driver pulls away sharply on a surface with low friction immediately after the engine has been started. However, there is not a technical fault. Once the steering angle sensor has been calibrated with the wheel speeds, all functions of the dynamic driving systems are automatically available again.

Excessive Temperature

Excessive temperature can occur in the electric motors or in the transmission oil in the superimposing gear units. This can cause damage to components or unduly high levels of wear. To prevent this, the requested torque transfer is only implemented to a reduced extent if excessive temperature is detected.

This reduction happens without the driver noticing. A Check Control message is not issued until the vehicle's behavior is noticeably altered by the reduction. A careful driving style will automatically result in the components being cooled, so that the full functionality is soon available again.

The system is able to detect a "sporty driving style". If it does so, the temperature threshold is temporarily increased by approximately 25°C.

QMVH Unit

The angle when the rear differential with superimposing gear units is removed and refitted must be no more than 45° due to risk of the oils mixing together through the common vent.

Electric Motors

The following must be observed when one or both of the electric motors are being replaced:

- When an electric motor is removed, small quantities of oil may escape.
  This volume of oil is so small in relation to the overall volume that it is not necessary to top up the transmission oil.
- Only the correct left/right motor may be used for the replacement.
  Identify the electric motor correctly using the Electronic Parts Catalogue.
- Following the replacement of one or two new electric motors, a set-up process must be started using the diagnostic system. This will transfer data from the motor position sensor to the QMVH control unit.

Control Unit

The QMVH control unit continuously calculates wear data for the transmission oil and multi-plate clutches during normal operation. The control unit also reconciles the control unit data with the fitted electric motors.

A digital interface with the motor position sensors is used for this purpose. This results in the following particularities if the QMVH control unit needs to be replaced during the course of a repair.

Before The QMVH control unit is removed, all data regarding the status of the rear differential with superimposing gear units must be read out, if possible, using the diagnostic system.

Once the new QMVH control unit has been fitted, programmed and coded, the diagnostic system must be used to work through a set-up procedure.

During this, the data that was previously read out regarding the status of the rear differential with superimposing gear units will be written to the new control unit. The control unit will also be set to a mode which restarts all adaptation processes, so that perfect interaction between the control unit and the superimposing gear units can be established as soon as possible.

ICM Control Unit

When the ICM control unit is coded, the vehicle identification number is written to the control unit. This means that a simple exchange between two vehicles does not provide a solution to a fault. Following the programming or replacement of an ICM control unit, coding must therefore be carried out. This is part of the set-up process conducted by the diagnostic system.

During normal driving, the ICM control unit carries out calibration processes on the sensor signals. The offset of the steering wheel angle is determined in this way, for example. Values of this type are required for the higher-level dynamic driving regulation. Following the programming or replacement of an ICM control unit, these calibration processes must be explicitly initiated. The diagnostic system has a corresponding Service function.

The actual calibration process does not take place until the next trip. The sensor signals cannot be calibrated to each other until the dynamic situations actually occur. This process takes place in the background, so that the customer will not realize it is happening.

As you were already able to see from the bus overview and the distributed functionality, the ICM control unit is not an independent control unit. Instead, it is in a close network with the QMVH and AL control units and, of course, the DSC. All these control units use similar or identical sensor signals (e.g. wheel speeds, yaw rate, steering wheel angle). Take this background information into consideration when performing diagnostics on the dynamic driving systems, for example, do not only check the fault memories of the individual control units, but the fault memories of all the control units in the network.