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E60/E61 xDrive with DSC8+

Subject Page

Initial Print Date: 03/05 Revision Date: 04/05

E60/E61 xDrive with DSC8+

Model: 525xi, 530xi, 530xiT

Production: From April 2005

OBJECTIVES

After completion of this module you will be able to:

- Familiarize yourself with DSC8+ features
- Explain the xDrive mechanical operation
- Describe the xDrive power flow

xDrive with DSC8+

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

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.

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 wheel drive system offers traction advantages not only on snow and ice but also on unsurfaced roads.

Note: 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

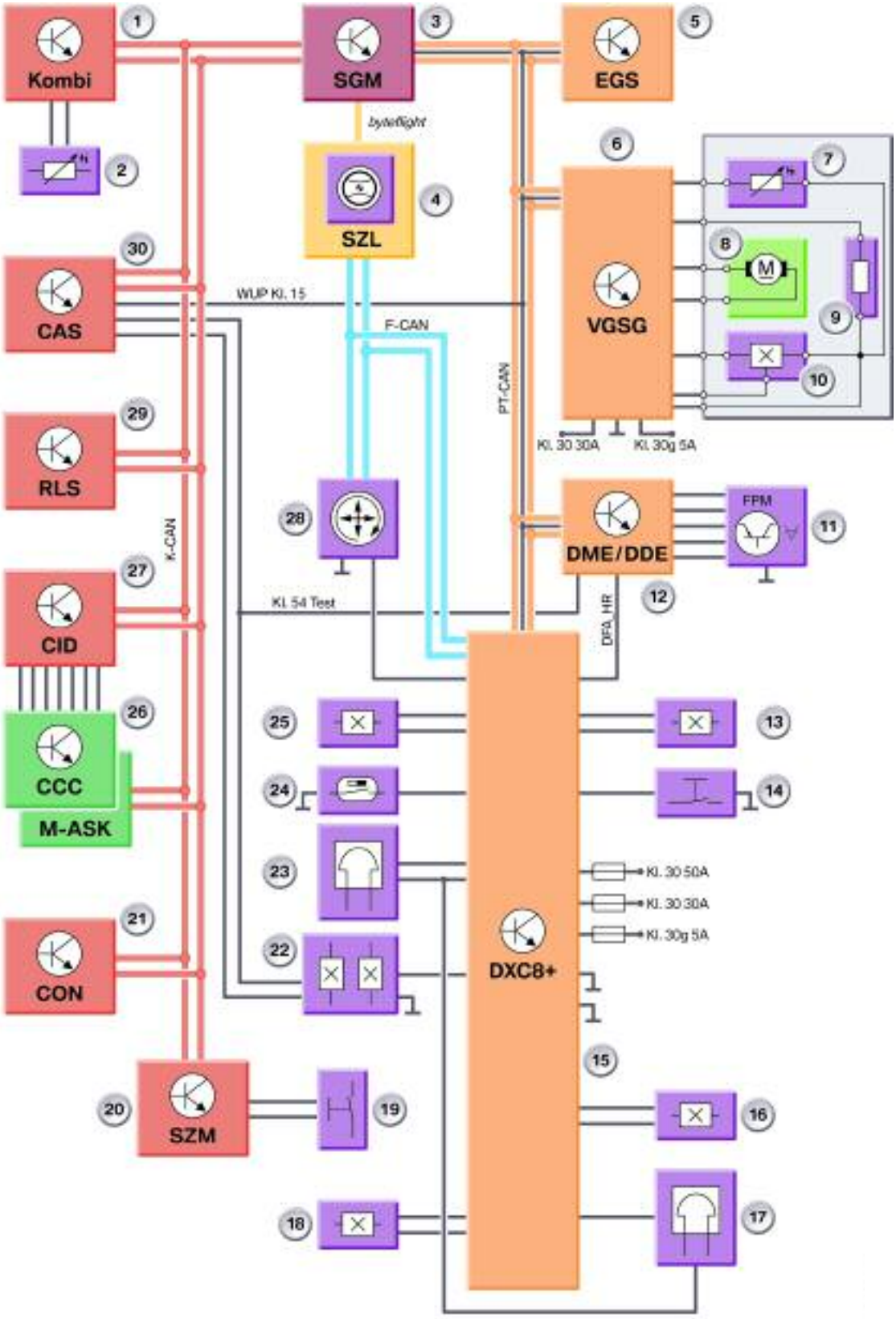
Present DSC functions:

- 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

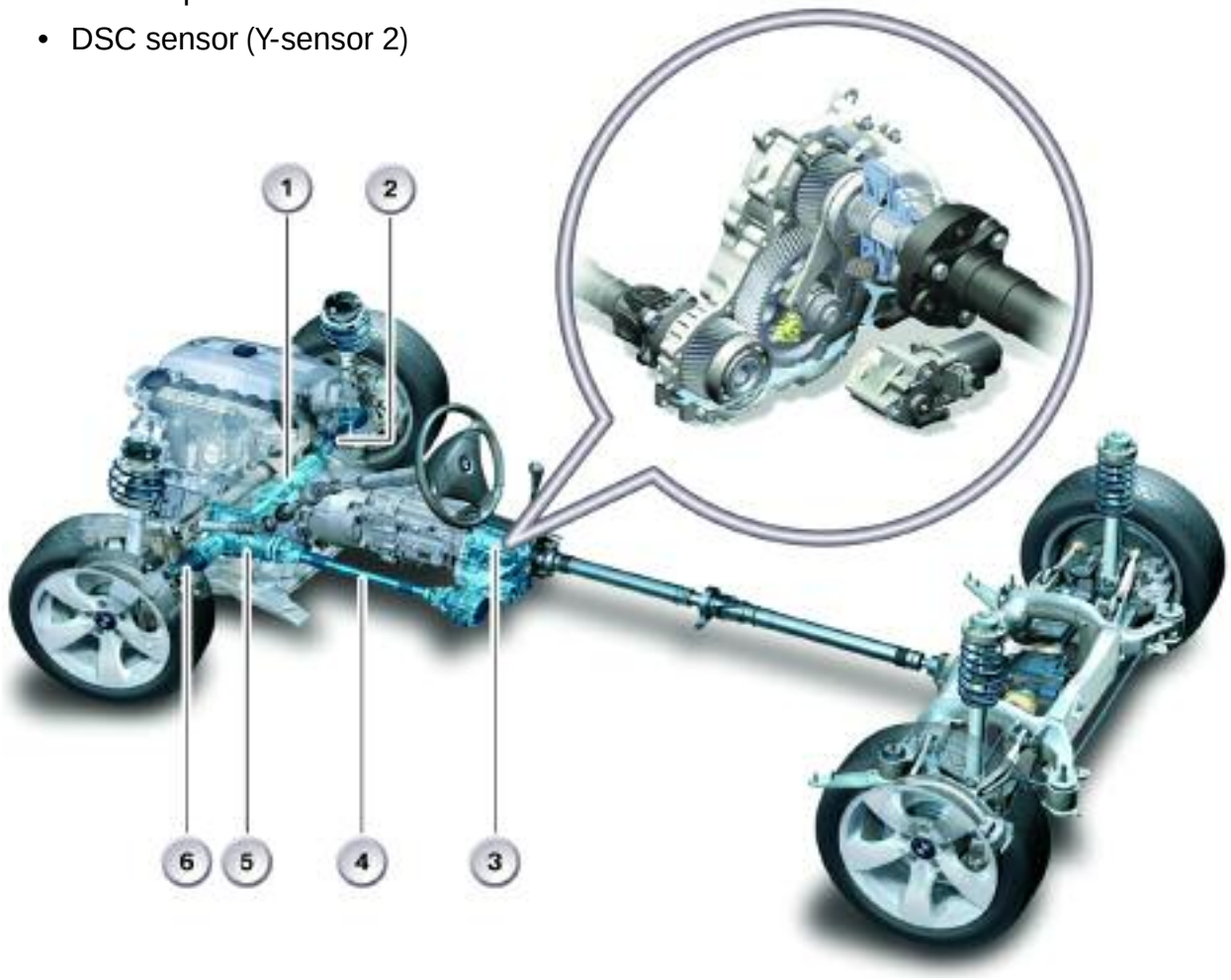
Index	Explanation
1	Instrument cluster
2	Outside temperature sensor
3	Safety and gateway module (SGM)
4	Steering column switch cluster (SZL) with HDC button
5	Electronic transmission control module (EGS)
6	Transfer case control unit (VGSG)
7	Temperature sensor
8	Electronic motor, actuator drive
9	Coding 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)

NOTES PAGE

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.

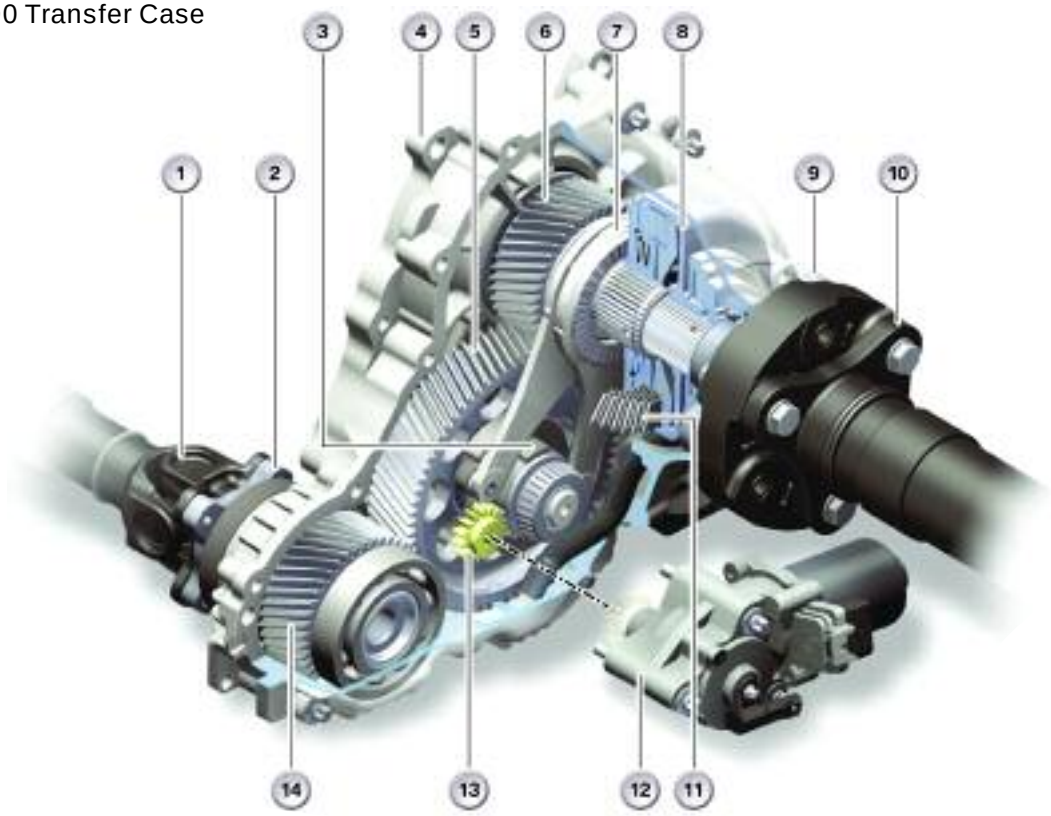
In view of the restricted package space of the transmission tunnel in the BMW 5 Series, it was not possible to adopt the transfer case from the BMW X3 (ACT400) with the same torque rating.

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

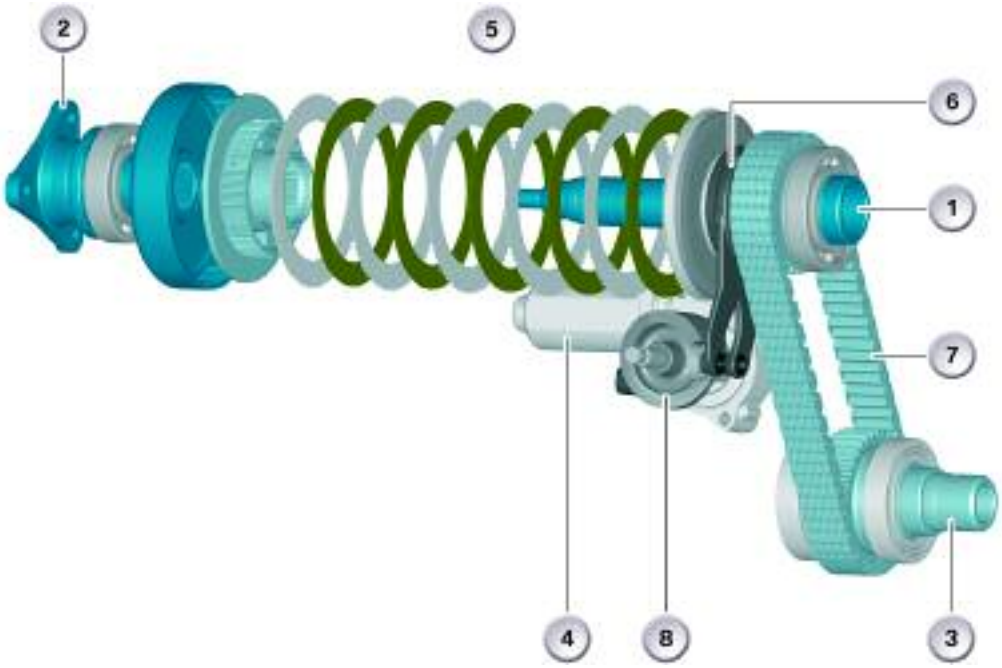
The ATC 300 is installed in the E61 and E60 all wheel drive models. The ATC 400 is installed in the E83 and the ATC 500 in the E53 MU.

The ATC 300 differs from the other transfer cases because it is gear driven not 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. (the ATC 300 uses gears not a chain)

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:

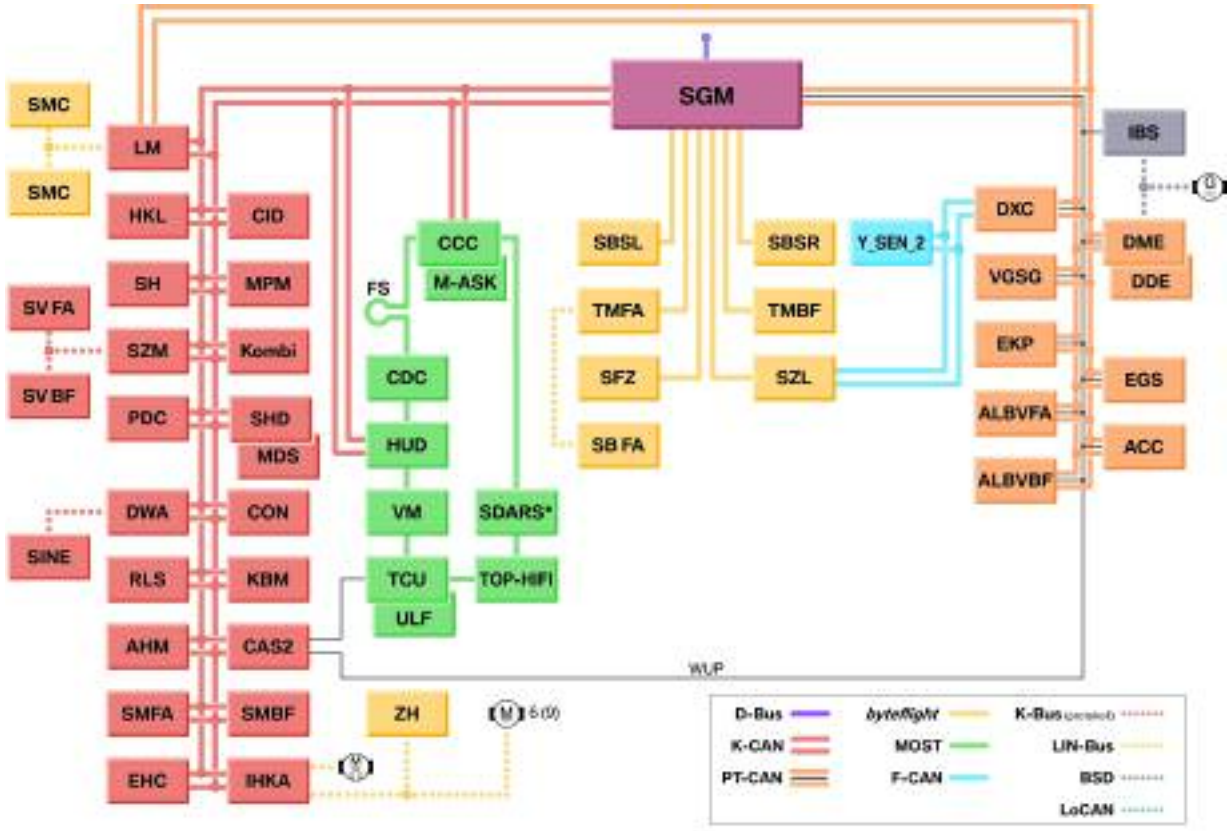
- Add-on control unit
- Valve block with integrated pressure sensors
- Pump motor

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

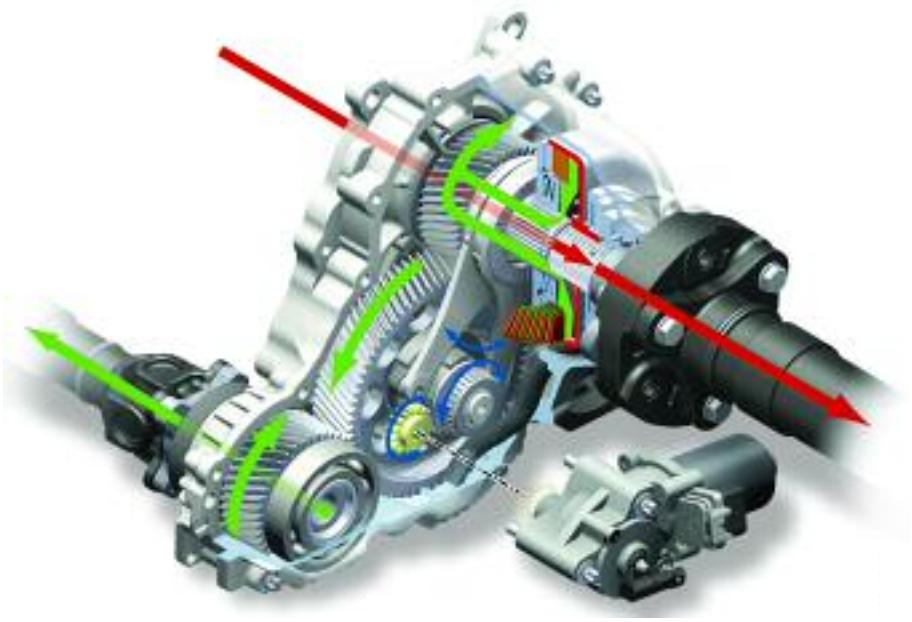
Power Flow

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 pumpmotor 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 ºC and is resumed when this temperature drops below approx. 400 ºC. 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

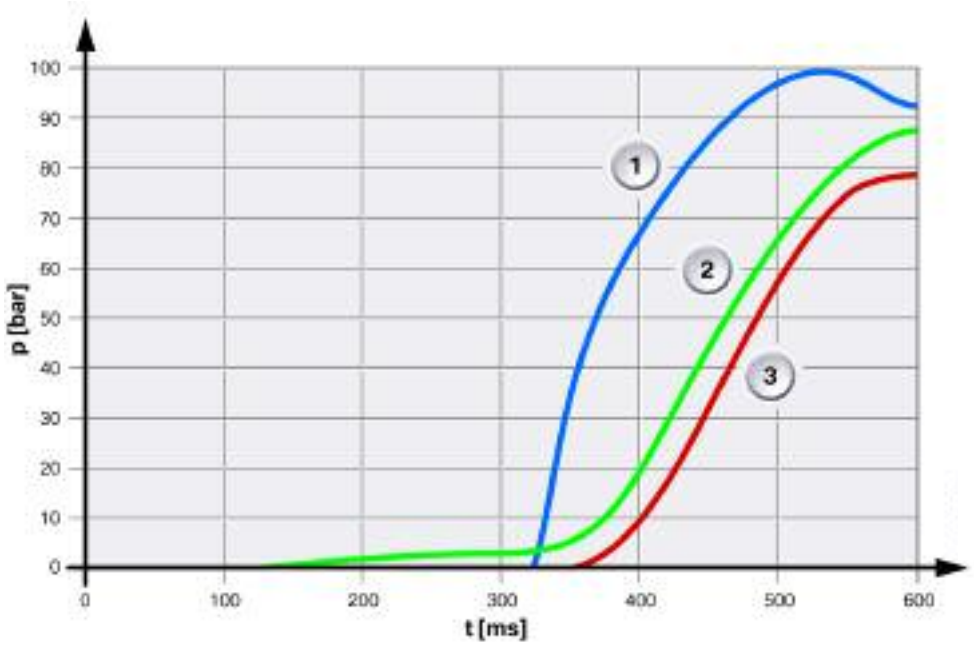
Quick release of the accelerator pedal causes the brake pads to be applied against the brake disc thus reducing the stopping distance (by approx.. 30 cm/100 km/h) during emergency braking. The DSC module builds up slight brake pressure (approx. 2.5 bar) temporarily (approx. 0.5 seconds) in order to eliminate 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 8 s
- 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.



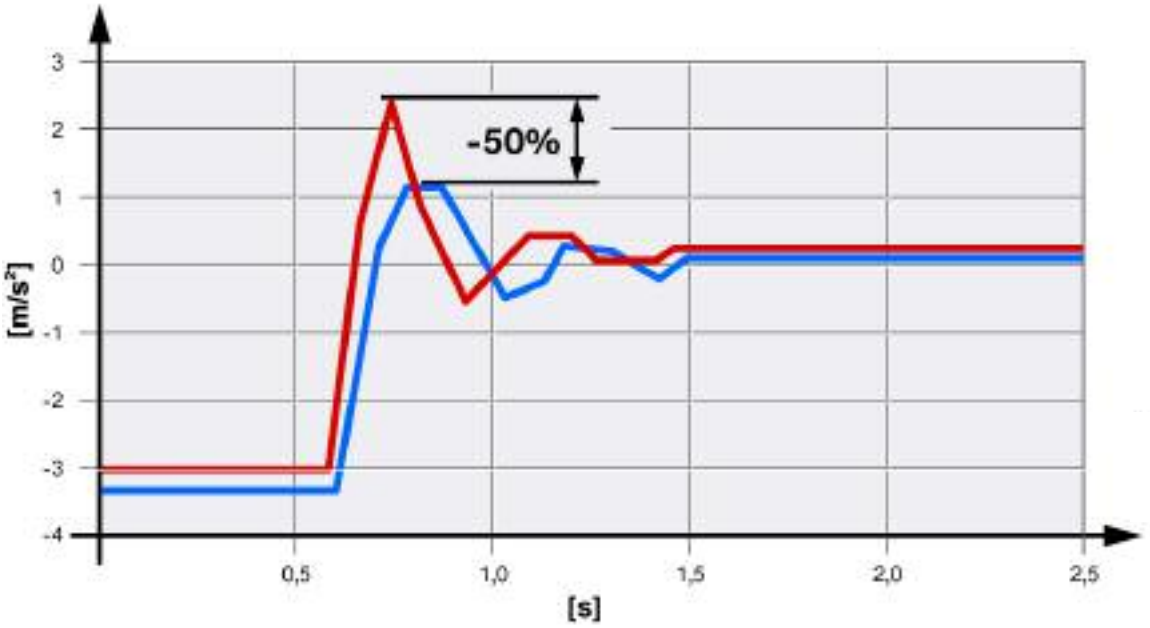
Index	Explanation
P	Braking pressure in Bar
T	Time in milliseconds
1	Pilot pressure applied by driver
2	Braking pressure progression with brake standby
3	Braking pressure progression without brake standby

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

Note: 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 the DISplus/ GT1. 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 the DISplus/GT1.

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

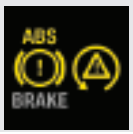
The warning indicator lamps for the xDrive / DSC are found in the instrument cluster as shown on the bottom of this page.

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.