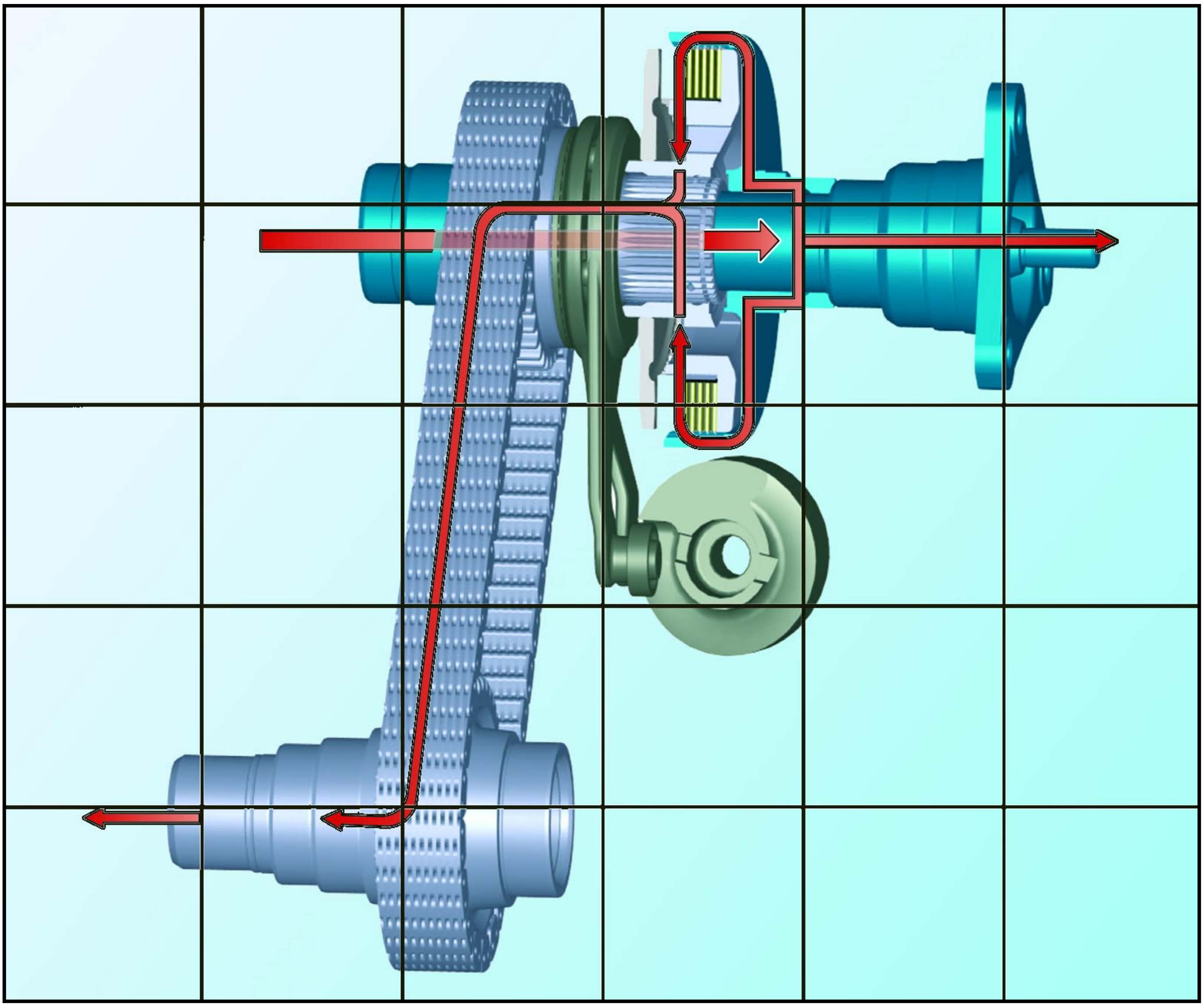
BMW Group
Aftersales Training

E83 xDrive
Participant Manual



NOTE
The information contained in this participant's manual is intended for participants of the Aftersales Training.
Refer to the relevant "BMW Service" information for any changes/ supplements to the Technical Data.

VS-12/VS-42 MFP-HGK-BRK-E83_0500

Contents

xDrive / DSC

Introduction

The innovative xDrive four-wheel drive is a system for controlling and regulating 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.

By using the controlled multi-disc clutch, it has been possible with the xDrive to resolve the target 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.

System overview

- Mechanical / hydraulic components

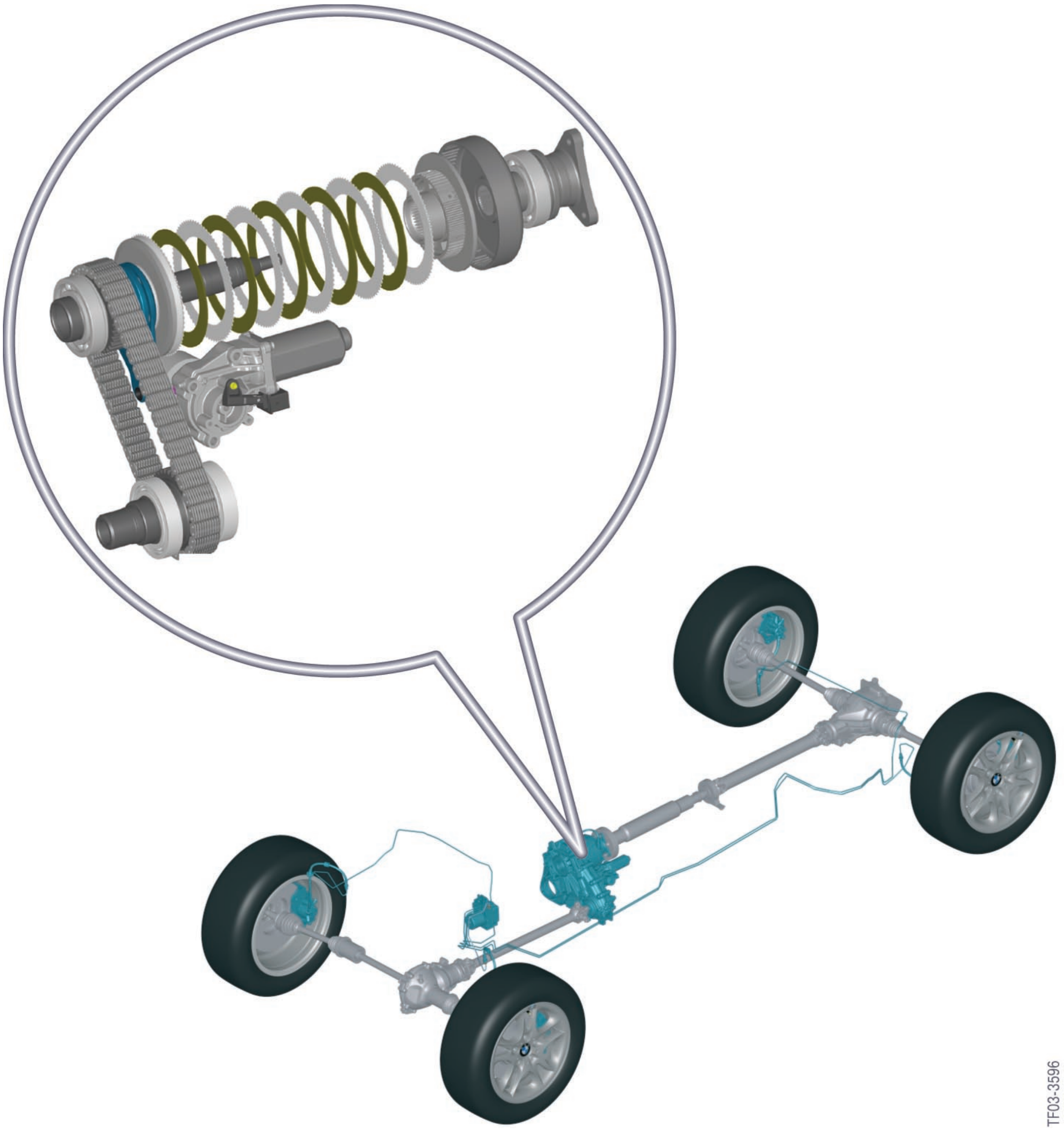


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Fig. 1: xDrive / transfer case

- Hydraulic schematic

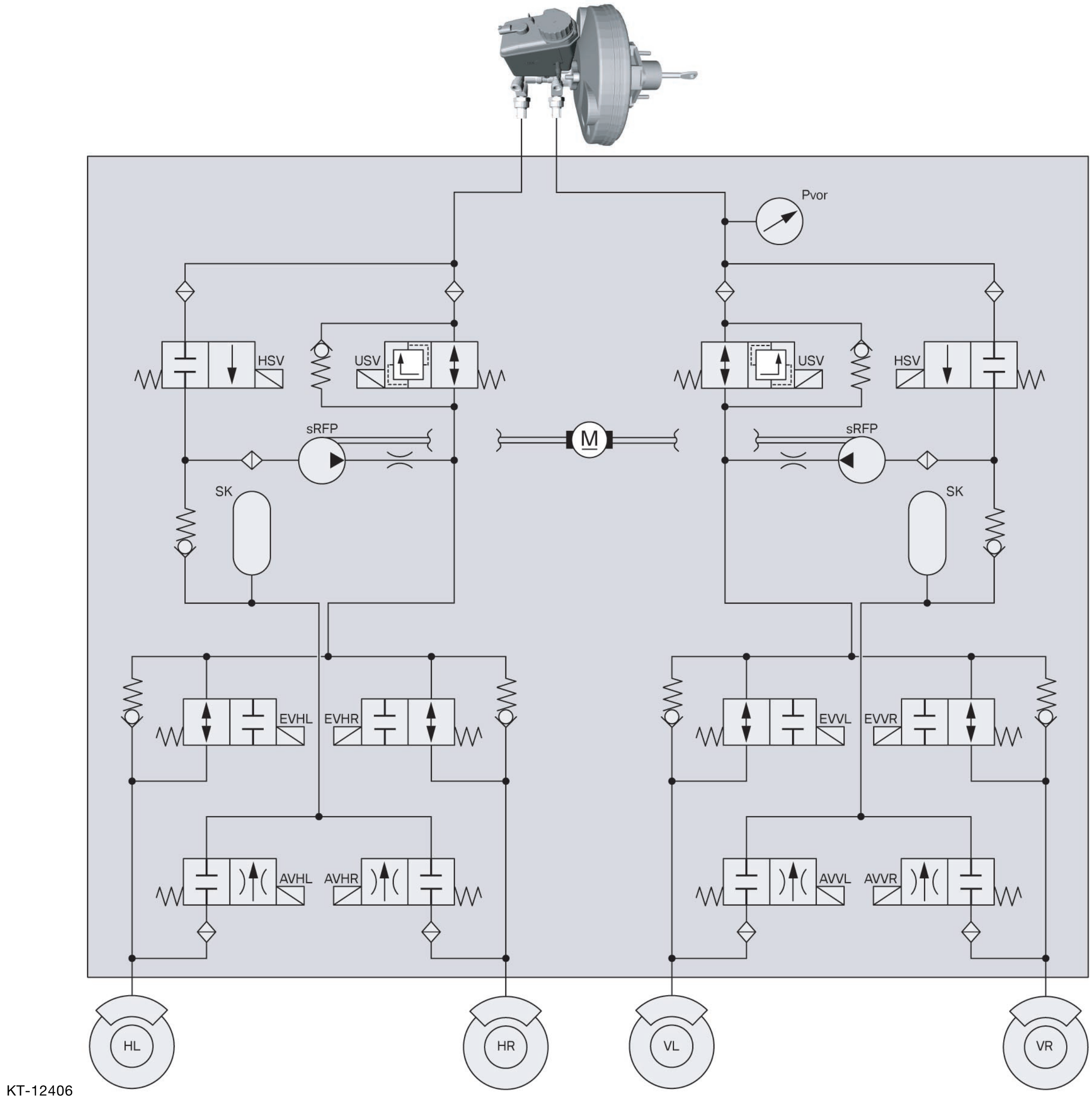

Fig. 2: DSC 8

Index	Explanation	Index	Explanation
Pvor	Admission pressure sensor	EVVL	Inlet valve, front left
HSV	High-pressure switching valve	EVVR	Inlet valve, front right
USV	Changeover valve	AVVL	Outlet valve, front left
sRFP	Self-priming return pump	AVVR	Outlet valve, front right
SK	Accumulator chamber	HL	Wheel brake, rear left
EVHL	Inlet valve, rear left	HR	Wheel brake, rear right
EVHR	Inlet valve, rear right	VL	Wheel brake, front left
AVHL	Outlet valve, rear left	VR	Wheel brake, front right
AVHR	Outlet valve, rear right		

- Bus overview

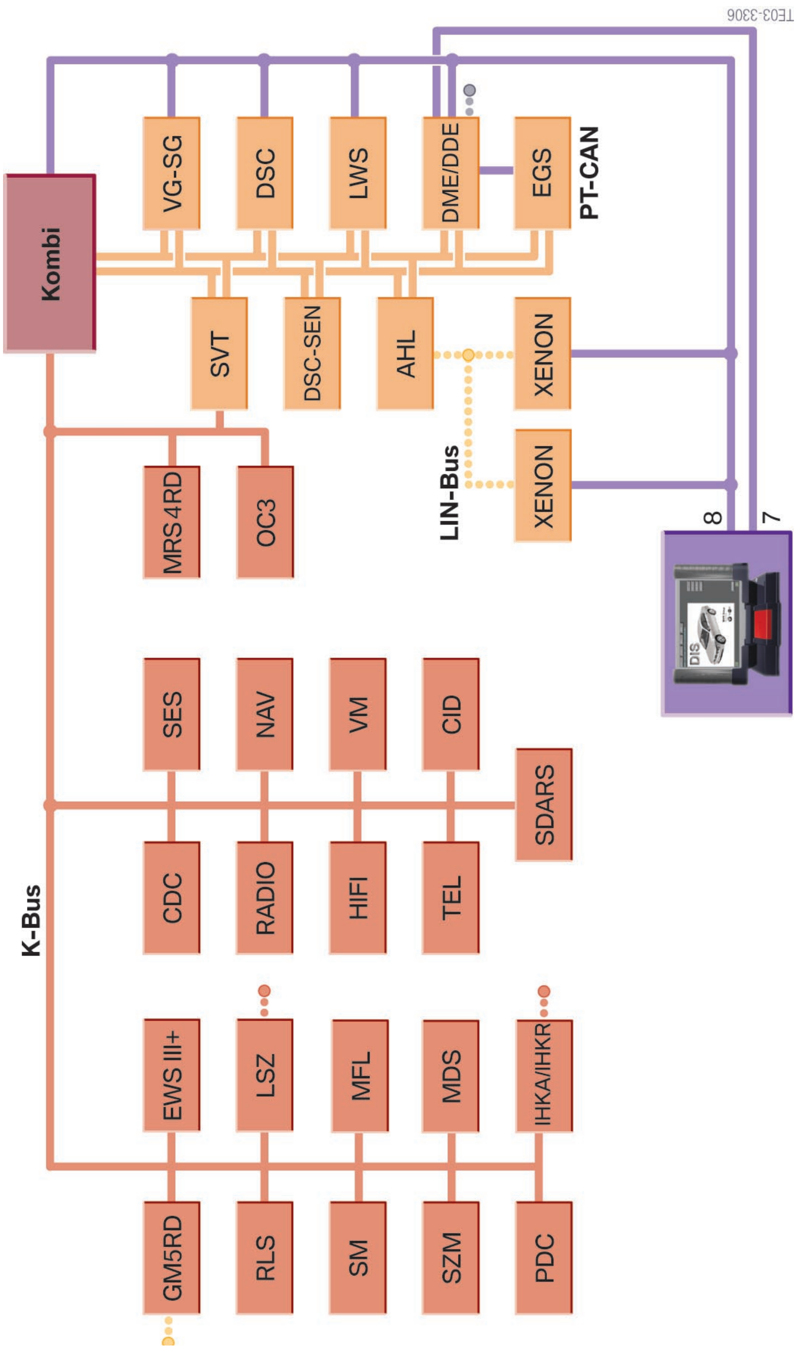

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Fig. 3: E83 bus overview

Index	Explanation	Index	Explanation
AHL	Adaptive headlight	NAV	Navigation computer
AHM	Trailer module	OC3	Occupation Classification 3
CDC	CD Changer (Compact Disc Changer)	PDC	Park Distance Control
CID	Central Information Display	RADIO	Radio
DME	Digital Motor Electronics	RLS	Rain/light sensor
DSC-SEN	Dynamic Stability Control	SES	Voice input system
EGS	Electronic transmission management	SDARS	Satellites
EWS III+	Electronic immobilizer III	SM	Seat Memory
GM5RD	General Module 5 Redesign	SMG	Sequential Manual Gearbox
HIFI	Top-HiFi amplifier (DSP)	SVT	Servotronic
IHKA	Integrated automatic heating and air conditioning	SZM	Switch cluster, centre console
IHKR	Integrated heating and air conditioning control	TEL	Telephone control unit
LSZ	Light switch cluster	VG-SG	Transfer case electronic control unit
LWS	Steering-angle sensor	VM	Video Module
MDS	Multi Drive Sunroof	XENON	Xenon light electronic control unit
MRS4RD	Multiple Restraint System 4 Redesign		

- Inputs/outputs

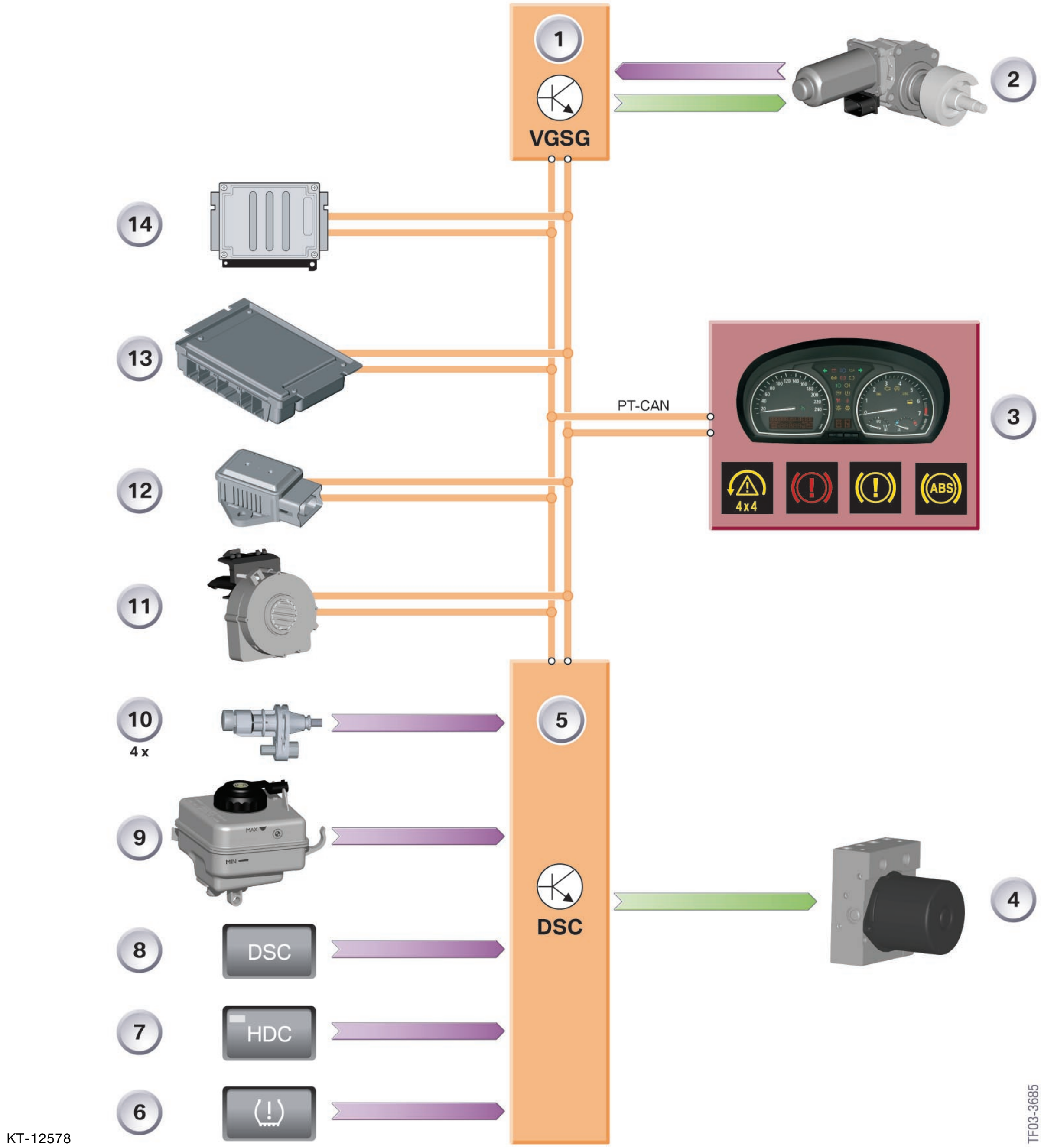

Fig. 4: xDrive/DSC inputs/outputs

Index	Explanation	Index	Explanation
1	Transfer case electronic control unit	8	DSC button
2	Servomotor, transfer case clutch	9	Brake-fluid level
3	Instrument cluster	10	Wheel-speed sensor
4	DSC hydraulic modulator	11	Steering-angle sensor
5	DSC mounted control unit	12	Yaw and transversal acceleration sensors
6	RPA button	13	EGS
7	HDC button	14	DME / DDE

The DSC module is the unit that comprises the DSC hydraulic modulator (4) and DSC mounted control unit (5).

- System circuit diagram

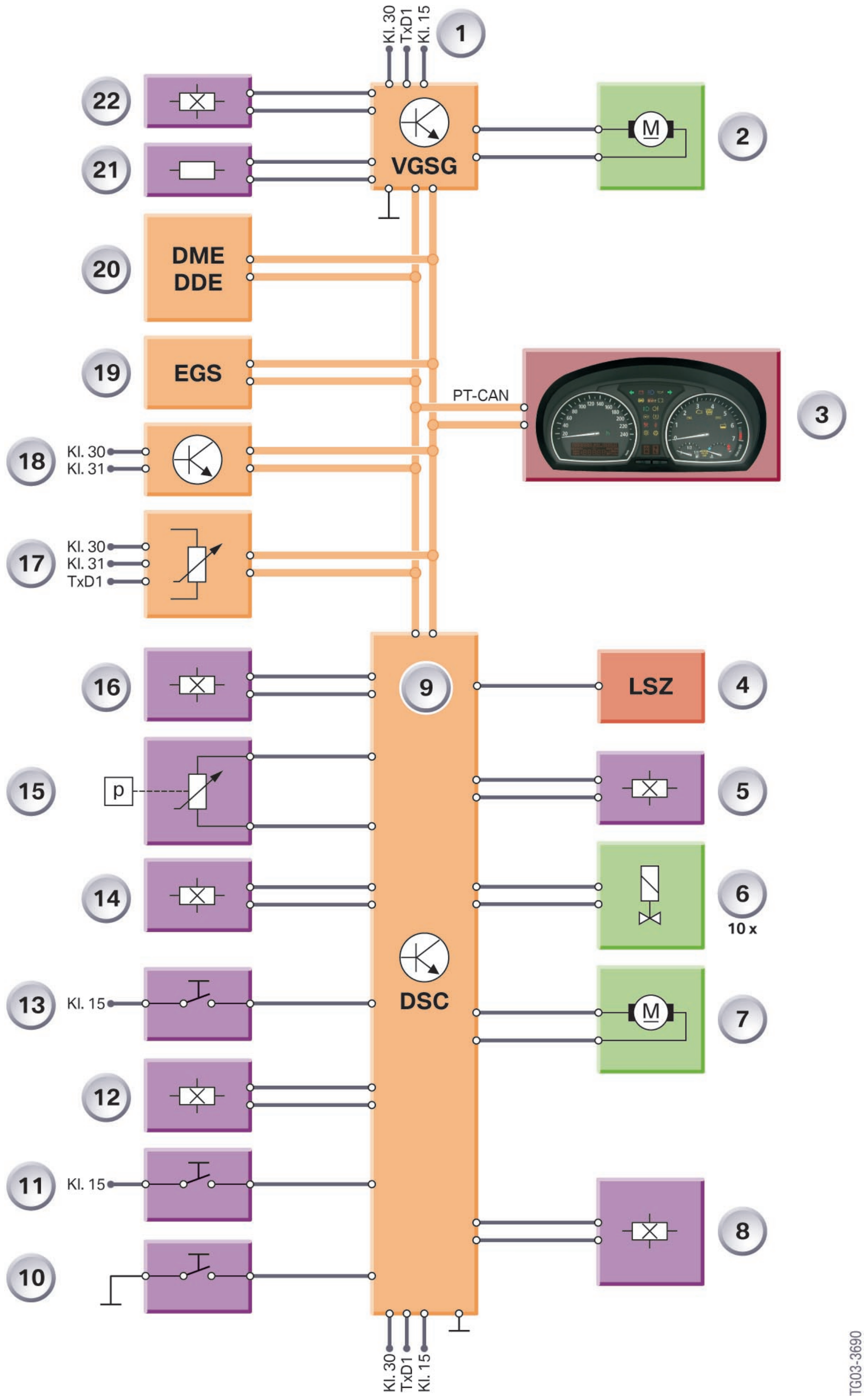

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Fig. 5: xDrive / DSC system circuit diagram

Index	Explanation	Index	Explanation
1	Transfer case electronic control unit	12	Brake-fluid level
2	Servomotor	13	HDC button
3	Instrument cluster	14	Wheel-speed sensor
4	Light switch cluster	15	Admission pressure sensor
5	Wheel-speed sensor	16	Wheel-speed sensor
6	Solenoid valves, DSC module	17	Steering-angle sensor
7	Pump motor, DSC module	18	Yaw and transversal acceler-ation sensors
8	Wheel-speed sensor	19	EGS
9	DSC mounted control unit	20	DME / DDE
10	RPA button	21	Coding resistor
11	DSC button	22	Motor position sensor

Components

The xDrive / DSC system consists essentially of those components familiar from DSC8. The controllable multi-disc clutch in the transfer case is a new feature.

- DSC8 module
- Transfer case electronic control unit
- Yaw and transversal acceleration sensors
- Wheel-speed sensor
- Pressure sensor
- Steering-angle sensor
- Brake-fluid warning switch
- Brake-light switch
- DSC button
- Motor position sensor, transfer case
- Transfer case servomotor

The following components are described in detail in this chapter:

- ATC (Active Torque Control) 400 / ATC 500 transfer case
- Transfer case servomotor with motor position sensor
- Transfer case electronic control unit

- ATC 400 / ATC 500 transfer case

The ATC 400 is installed in the E83 and the ATC 500 in the E53 MU respectively. They differ in respect that the ATC 500 is attached to the propeller shaft to the front differential and the ATC 400 is secured to a flange with four bolts. In addition, there is one more disc fitted in the multi-disc clutch of the ATC 500 and the distance between the input shaft and the output shaft to the front axle is 19 mm greater in the ATC 500 than in the ATC 400.

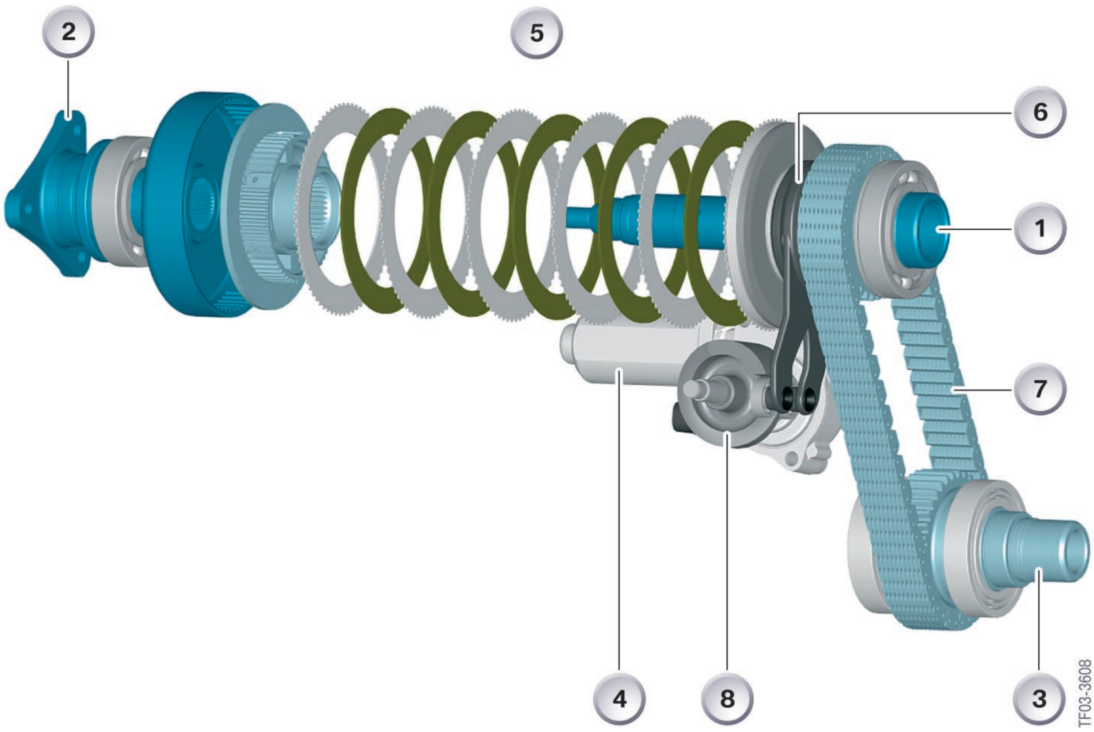

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Fig. 6: ATC 500 exploded view

Index	Explanation	Index	Explanation
1	Input from manual or automatic gearbox	5	Set of discs
2	Output to rear axle	6	Adjusting levers with ball ramp
3	Output to front axle	7	Chain
4	Servomotor	8	Disc cam

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

Power flow

When the multi-disc clutch in the transfer case is open, no driving torque is transmitted to the front axle; instead, the entire driving torque is directed to the rear differential.

When the multi-disc clutch is fully closed, the front and rear axles turn at the same speed. Torque distribution is dependent on the torque that can be supported on each axle. If, for example, the driver moves off from traffic lights in first gear at full throttle, there is a higher load placed on the rear axle as a result of dynamic axle-load transfer. Through this increased driving-torque support can be proportionately effected on the rear axle accordingly. This means that the transmittable driving torque corresponds to the axle-load distribution when the coefficient of friction is identical on the front and rear axles.

An exception is made when the front axle is on a surface with a high friction coefficient and the rear axle is on e.g. slick ice. In this case, virtually 100% of the available driving torque is transmitted to the front axle since virtually no torque can be supported on the rear axle.

When driving onto brake analyzers, move the selector lever to the N position on vehicles with xDrive and an automatic gearbox. This keeps the transfer case clutch open and the vehicle cannot be pulled off the analyzer.

On vehicles with xDrive and a manual gearbox, do not press the accelerator after driving onto the brake analyzer: This ensures that the transfer case clutch is kept open.

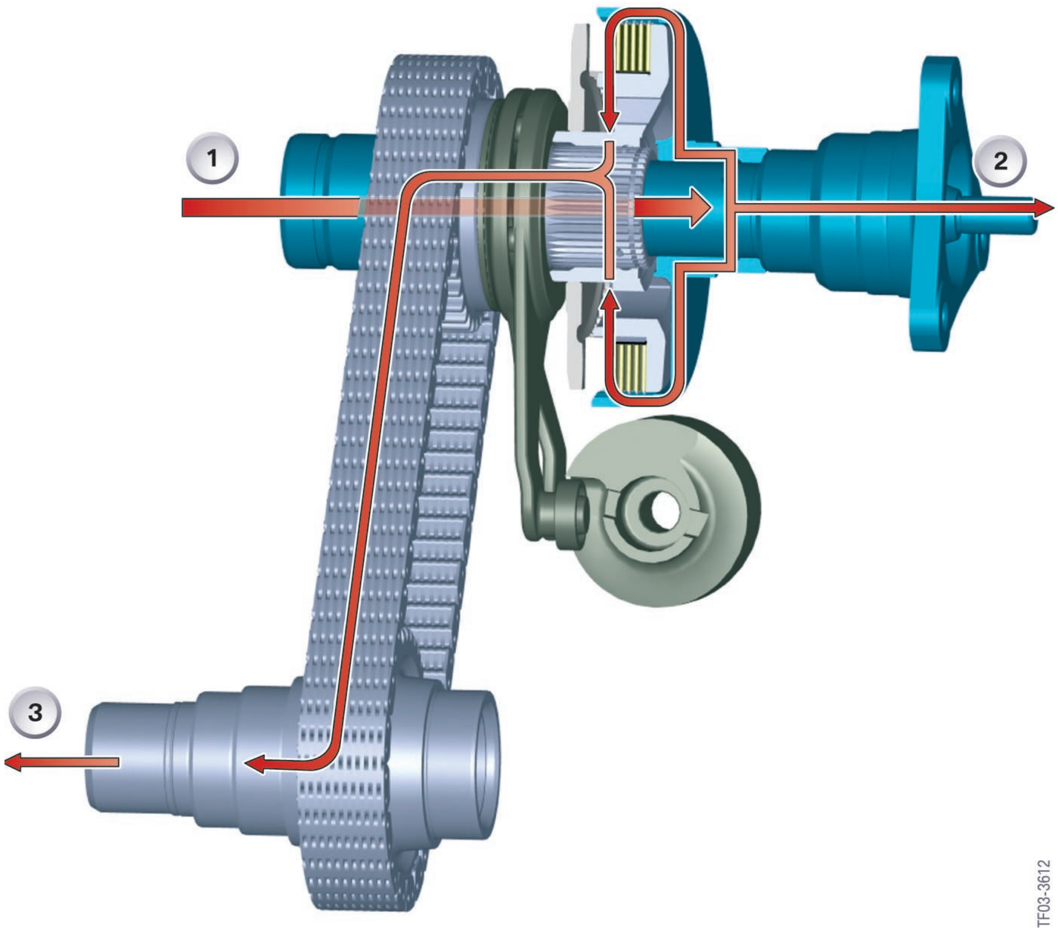

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Fig. 7: Power flow with multi-disc clutch closed

Index	Explanation
1	Input from manual or automatic gearbox
2	Output to rear differential
3	Output to front differential

- Servomotor with motor position sensor

The servomotor is a DC motor. It contains a Hall sensor which serves to detect the position and the adjusting speed of the motor shaft, which is proportional to the degree of closing of the multi-disc clutch.

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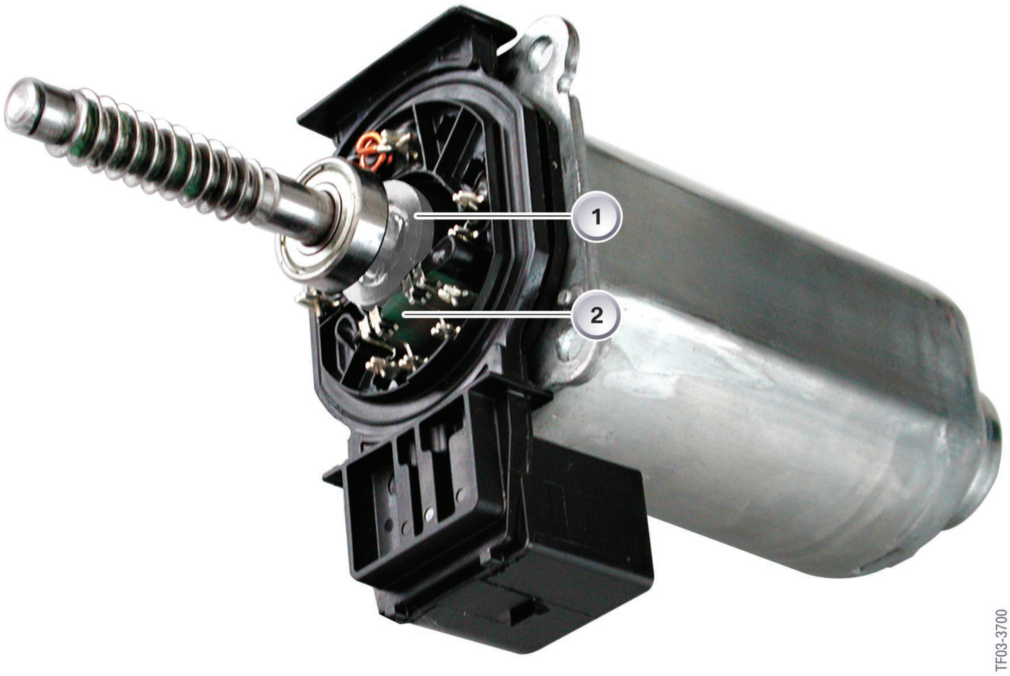

Fig. 8: Servomotor

Index	Explanation
1	Magnetic ring
2	Motor position sensor (Hall sensor)

Coding resistor

Because of mechanical tolerances in production, the characteristic curve of the multi-disc clutch locking torque can vary slightly. Once the actual locking torque has been measured on the clutch test bench, a resistor is attached to the servomotor; the resistor's value is a reference to the locking torque characteristic.

Each time the engine is started, the transfer case control unit measures the resistance value once and in such a way that the optimum program map for the transfer case fitted is selected.

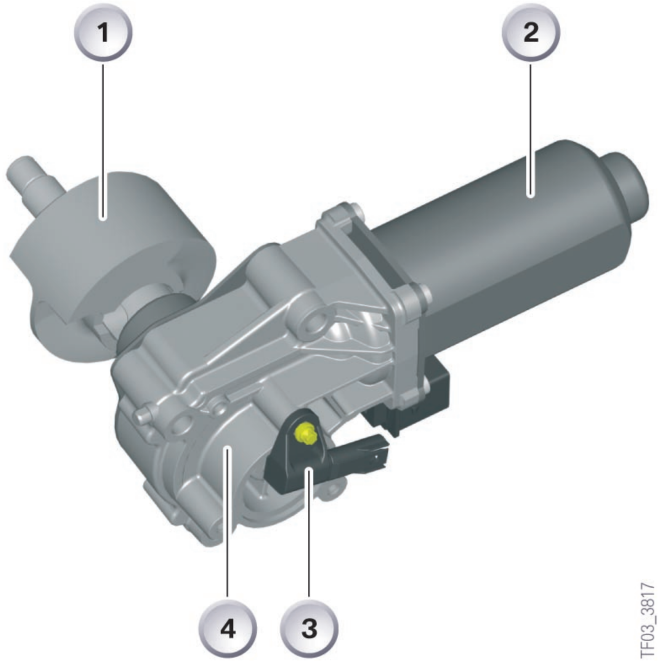

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Fig. 9: Servomotor

Index	Explanation
1	Disc cam
2	Electric motor
3	Coding resistor
4	Worm gear

- Adjusting levers

As the electric motor rotates, the disc cam forces the adjusting levers apart (see following graphic). The ball ramps create an axial movement which compresses the multi-disc clutch.

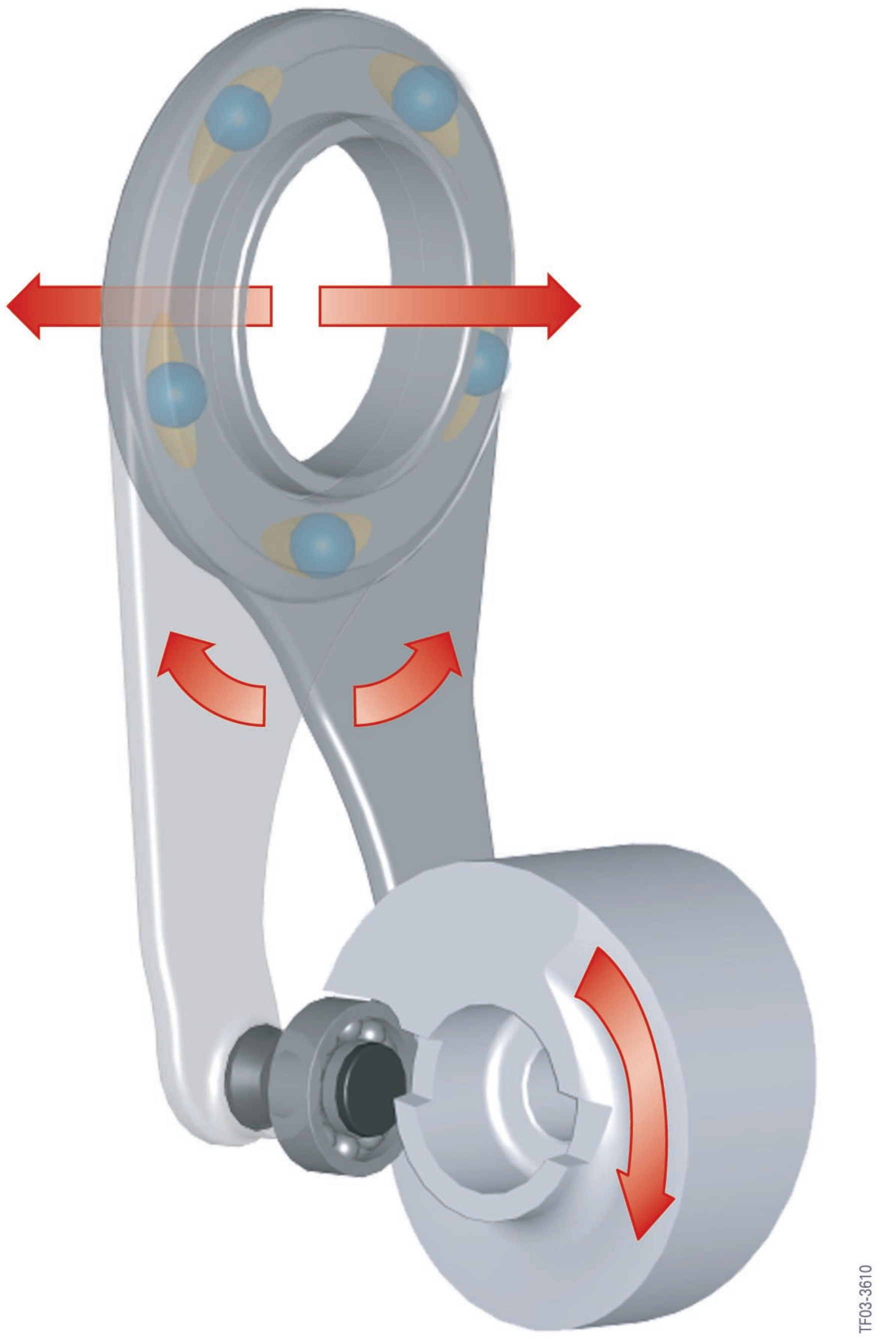

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Fig. 10: Adjusting levers with ball ramp and disc cam

- Transfer case electronic control unit

The transfer case control unit is installed in the E83 on the rear floor panel under the luggage compartment trim. In E53 MU, it is located underneath the rear bench seat on the left.

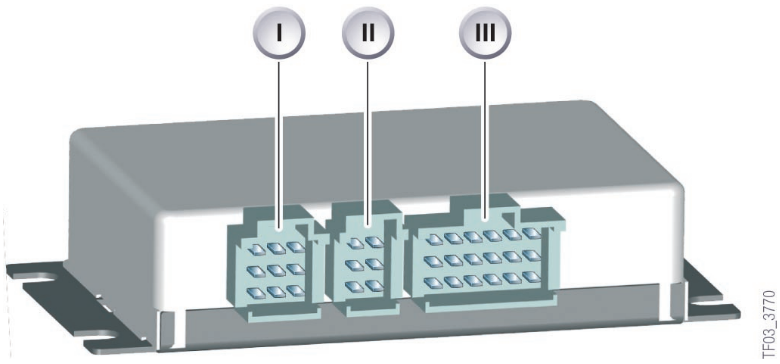

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Fig. 11: Transfer case electronic control unit

Index	Explanation
I	9-pin ELO connector (unassigned)
II	6-pin ELO connector
III	18-pin ELO connector

Operating principle

The transfer case control unit serves to regulate the locking torque of the multi-disc clutch in the transfer case. The control and power electronics required for this task are integrated in the transfer case control unit.

The transfer case control unit receives from the DSC mounted control unit the information on the clutch locking torque currently required. This information is converted in a corresponding rotary motion of the servo-motor.

The locking torque produces the distribution of driving torque to the front and rear axles. The locking torque to be set is calculated from the driver's command and from a higher-level traction-slip and driving-dynamics controller.

In order to be able to assign a corresponding clutch locking torque to the angular position of the servomotor and thus also to take wear influences into account, a reference run is carried out each time the engine is switched off. In this reference run, the clutch is closed and opened completely once. While the clutch is opened and closed, the current consumption is measured for the relevant servomotor angular position and thus the beginning and end of the clutch closing procedure are determined. The angular position is determined by means of a Hall sensor integrated in the servomotor.

A clutch and oil wear model is also calculated in the transfer case control unit. It limits the locking torque where necessary in order to reduce frictional work.

In the event of DSC failure, the transfer case control unit incorporates as a fallback level an emergency strategy for activating the transfer case clutch in order to maintain the four-wheel drive function even in such an event as this.

System functions

The xDrive / DSC systems comprise the following functions:

DSC:

- **ABS** Antilock Braking System
- **ASC-X** Automatic Stability Control X
- **DSC** Dynamic Stability Control
- **EBV** Electronic brake force distribution
- **DBC** Dynamic Brake Control
- **CBC** Cornering Brake Control
- **MSR** Engine drag torque control
- **HDC** Hill Descent Control
- **ADB-X** Automatic Differential Brake

xDrive:

- **TCC** Transfer Case Control

The following functions are described in detail in this manual:

- **TCC**

- **ASC-X**

- **ADB-X**

- TCC

Regulation of the locking torque of the multi-disc clutch in the transfer allows stepless coupling of the front axle to the drivetrain.

Thus the driving torque on the front axle can be increased or reduced depending on the driving situation and road conditions. Naturally, in the event of a higher torque on the front axle, the driving torque on the rear axle is reduced by this level of torque.

The advantages of variable distribution of driving torque to the front and rear axles are:

- Optimum utilization of the cornering and longitudinal wheel forces on the front and rear axles.
- DSC brake interventions only become necessary at a significantly later stage, thus giving rise to increased comfort.
- Compared with an open differential and DSC, xDrive significantly improves driving-torque distribution where the friction coefficients on the front and rear axles are markedly different.

The transfer case clutch is controlled by the DSC mounted control unit. Nevertheless, even when DSC is deactivated, TCC remains active for the purpose of maximum traction and driving dynamics.

Permanent four-wheel drive is only discontinued extensively or completely in three control situations:

- During very tight cornering with little engine torque in order to permit speed compensation between the front and rear axles (e.g. parking)
- At speeds in excess 180 km/h
- When the vehicle understeers markedly

The control algorithm of transfer-case clutch control can be described in three main modules:

- Pre-control
- Traction-slip control
- Tyre tolerance logic

Pre-control

The pre-control algorithm reflects the driver's command and calculates as a function of

- accelerator pedal value,
- engine torque,
- engine speed,
- vehicle speed,
- gear,
- and steering angle

the required locking torque while taking into account the maximum clutch, transfer case and axle drive loads.

In normal driving, the clutch is operated with minimum slip so that a permanent four-wheel drive with a driving-torque distribution of 40% on the front axle and 60% on the rear axle is available.

Even where the friction coefficients on the front and rear axles are markedly different, e.g. when the rear axle is over a patch of ice, the pre-control ensures that the system responds very quickly, as can be seen in the following graphic.

Furthermore, in contrast to an open central differential, the xDrive ensures that no brake intervention is required on the rear axle since no slip can occur.

In the case of the open differential, the brake is closed after slip is detected on the rear axle. Thus 62% of the driving torque is supported on the two rear brake discs. Therefore only 38% of the driving torque can be used on the front axle to drive off the patch of ice.

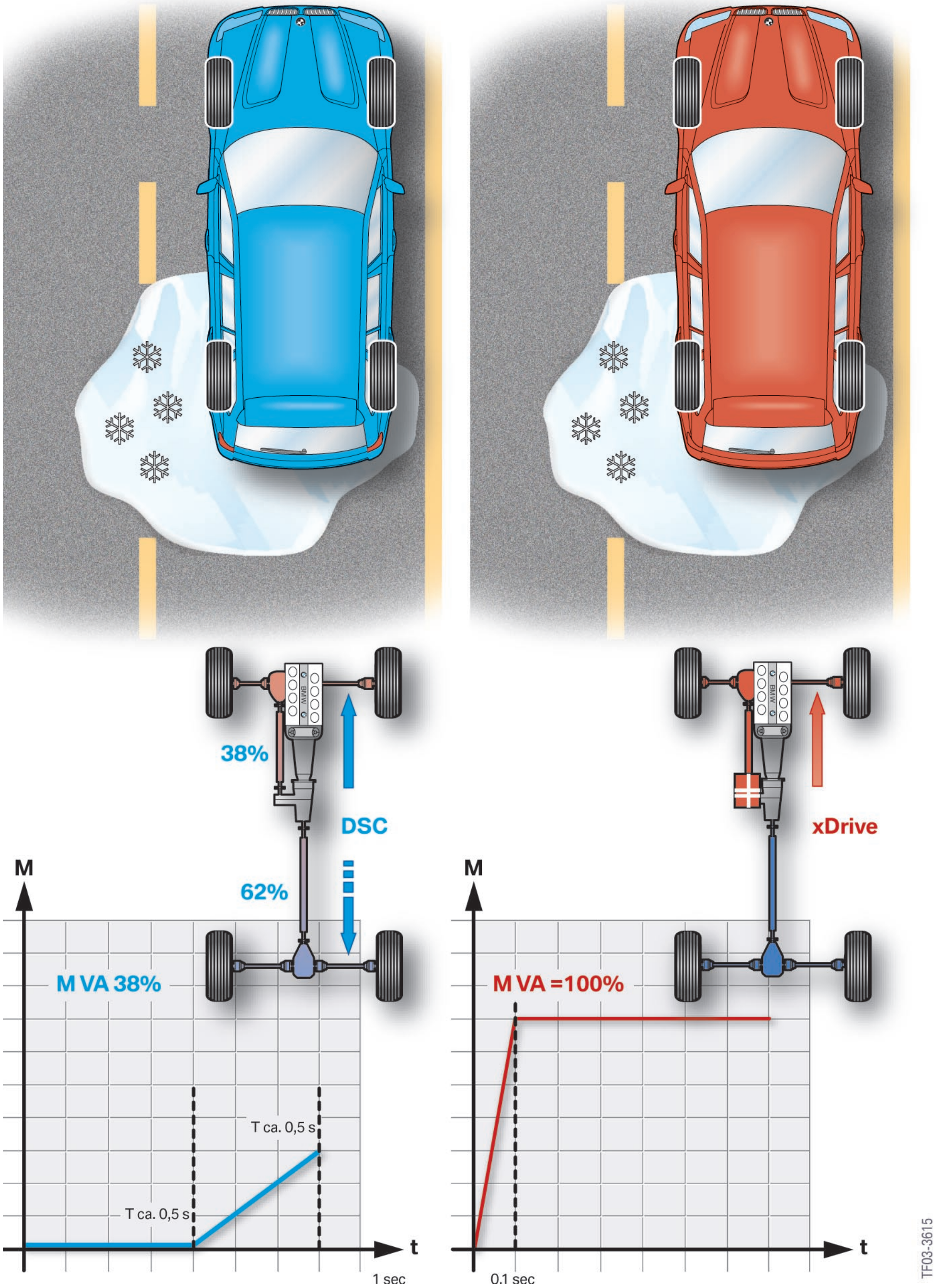

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Fig. 12: Pre-control

Index	Explanation
M	Driving torque
M VA	Driving torque on front axle
t	Time

Traction control / driving-dynamics control

Traction control/driving-dynamics control monitors the slip conditions on the front and rear axles. The wheel speeds, yaw rate and transversal acceleration serve as the input signals here.

The function of traction control/driving-dynamics control is to achieve optimum traction and to keep or render the vehicle stable.

As can be seen in the following graphics, in the event of an oversteer tendency, the transfer case clutch is completely closed and thus the maximum supportable driving torque on the front axle is transmitted.

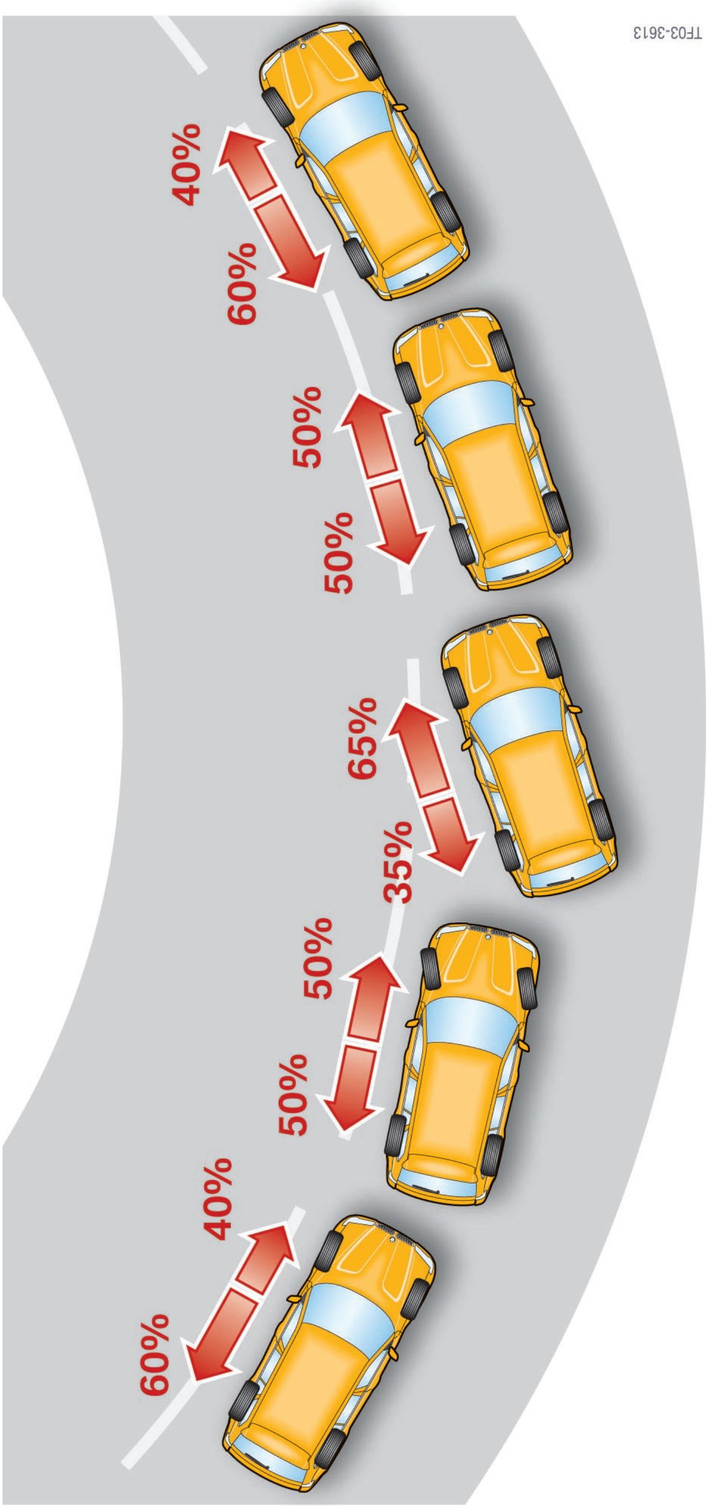

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Fig. 13: Driving-torque distribution with oversteer tendency

In the event of an understeer tendency, the clutch can be fully opened if necessary. In this way, the front axle is separated from the drivetrain and the driving torque can only be transmitted to the rear axle.

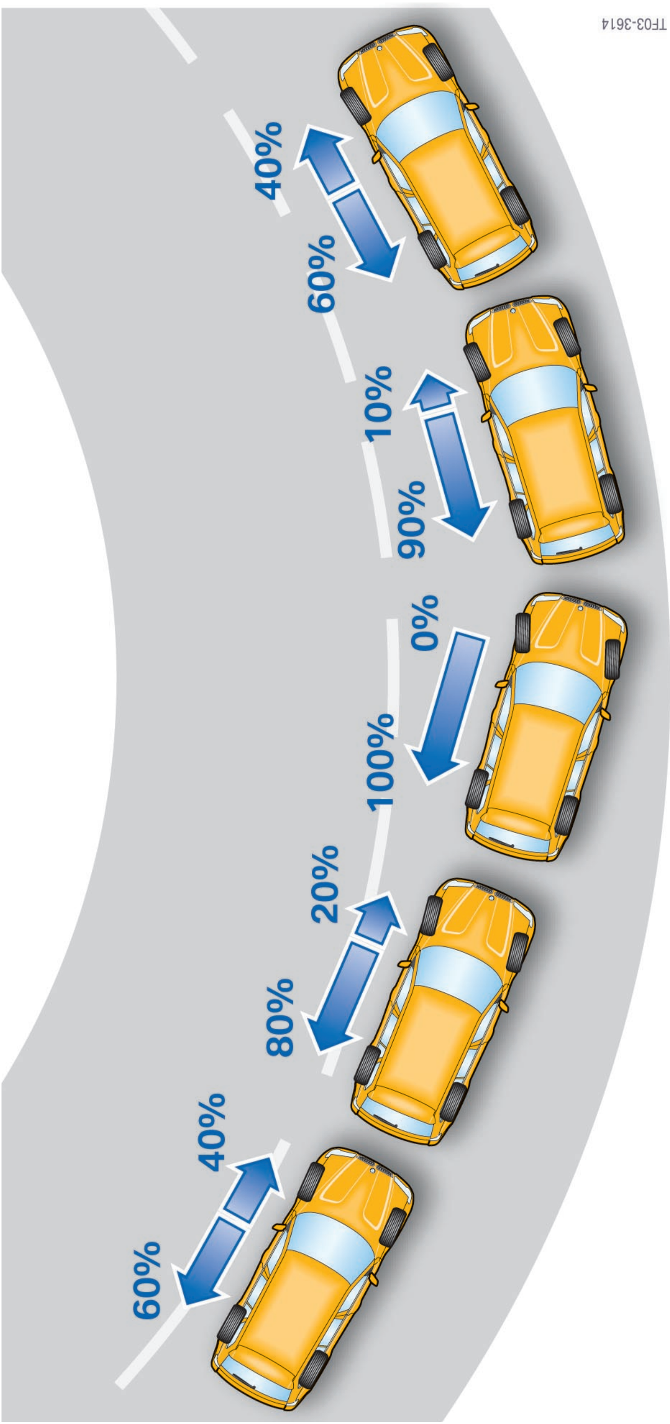

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Fig. 14: Driving-torque distribution with understeer tendency

Tyre tolerance logic

The tyre tolerance logic detects different tyre-tread circumferences on the front and rear axles. This can occur where:

- Mixed tyres are used
- An inflatable spare tyre is fitted
- Tyres are used that have been worn down to markedly different levels

With a normally pre-controlled multi-disc clutch, tyre circumference deviations result in drivetrain torque bias. The tyre tolerance logic prevents this torque bias by reducing accordingly the locking torque, which is determined by the pre-control. However, the required locking torque is always established in driving-dynamics and slip control operations.

Limp-home operation

In order to maintain the four-wheel drive function for as long as possible even in the event of drop-out of important sensor signals or failure of the DSC control unit, a limp-home controller is integrated in the transfer case control unit.

This controller operates in redundancy to the transfer case clutch control in the DSC control unit.

The limp-home controller contains only two control modules, pre-control and traction-slip control.

The wheel speed signals are of prime importance to traction-slip control.

Engine signals, steering angle a yaw are used predominantly for pre-control.

If individual sensor signals drop out, substitute values are calculated and the relevant functions operated with extended control thresholds. This strategy is continued until useful four-wheel drive control is no longer possible. In this event, the driver is alerted by the DSC/xDrive lamp coming on in the instrument cluster and also by acoustic warning signal.

- ASC-X / ADB-X

Unlike normal road vehicles, SAVs are also meant to demonstrate satisfactory handling characteristics and appropriate traction away from conventional roads with good foundations.

In order to provide on both normal roads and off-road surfaces optimum propulsion with sufficient cornering stability, ASC-X contains a detection algorithm for distinguishing between road and off-road terrain.

When off-road terrain is detected, setpoint wheel slip is increased in order to provide sufficient traction force with the increased levels of tractive resistance.

ASC-X is supplemented by the ADB-X function, which brakes wheels which are spinning on one side to setpoint slip and thus makes extra driving torque available to the wheels which rest on one pad with a higher friction coefficient. In SAVs, the control interventions are extended to diagonally raised wheels.

ADB-X remains active when DSC is deactivated. Furthermore, ADB-X can first develop its full capability here as the engine power is no longer reduced but rather only that wheel which has a low friction coefficient is braked.