## 2000-06 TRANSMISSION

## xDrive (Transfer Box) - SI Techniques - E53 & E83

# TRANSFER BOX

### XDRIVE

#### E83, E53

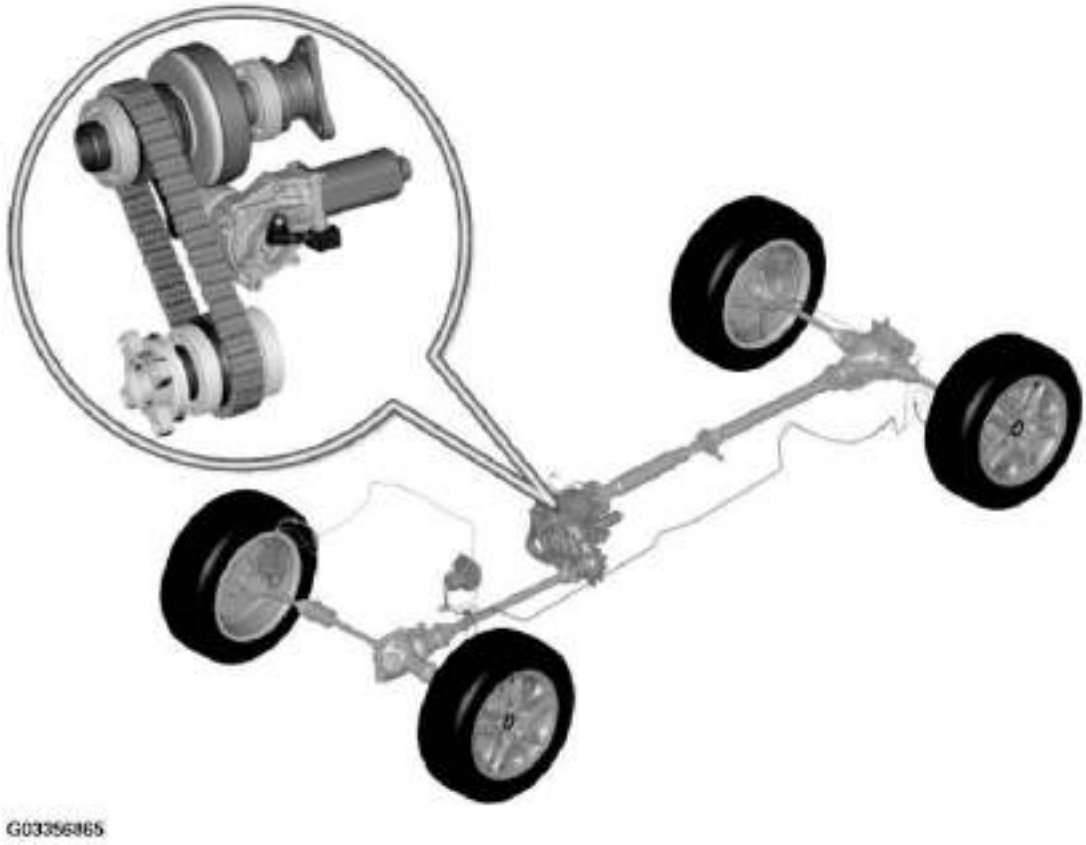
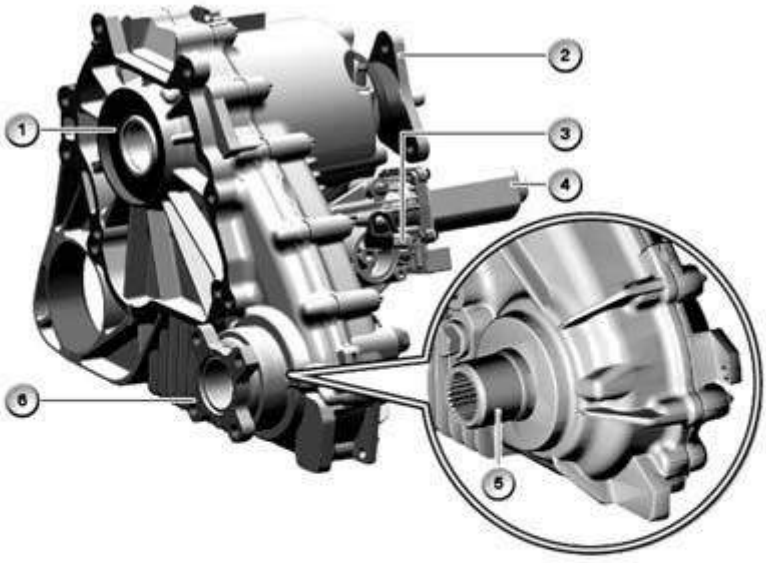



**Fig. 1: Identifying xDrive Transfer Box**
**Courtesy of BMW OF NORTH AMERICA, INC.**

#### Introduction

xDrive is a new four-wheel-drive system that delivers continuously variable input torques to the front and rear axles. xDrive comprises Dynamic Stability Control (DSC) and an electronically controlled multi-plate clutch in the transfer case.

### Mechanical Construction Of The Transfer Case




| Key | Explanation | Key | Explanation |
|---|---|---|---|
| 1 | Connection to the manual-shift gearbox or automatic gearbox | 2 | Connection to the rear axle |
| 3 | Classification resistor | 4 | Electric servomotor |
| 5 | E53: Connection to the front axle | 6 | E83: Connection to the front axle |

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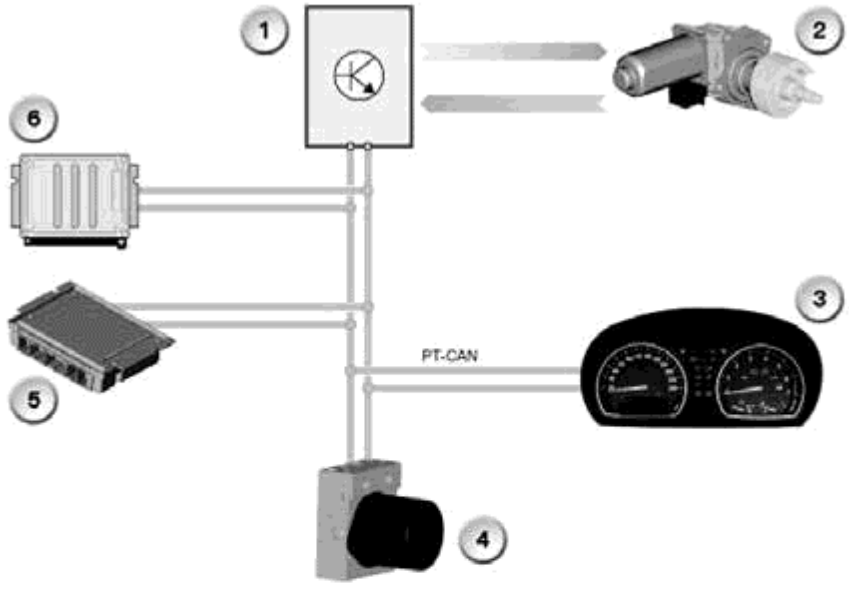
**Fig. 2: Identifying Mechanical Construction Of xDrive Transfer Box**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**Input/Output**




| Key | Explanation | Key | Explanation |
|---|---|---|---|
| 1 | Transfer case control unit | 2 | Electric servomotor with control cam |
| 3 | Instrument cluster | 4 | Dynamic Stability Control (DSC) |
| 5 | Electronic transmission control (EGS) | 6 | Digital engine electronics (DME) or Digital diesel electronics (DDE) |
| PT-CAN | Powertrain controller area network | | |

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**Fig. 3: Identifying xDrive Components**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**System Circuit Diagram**

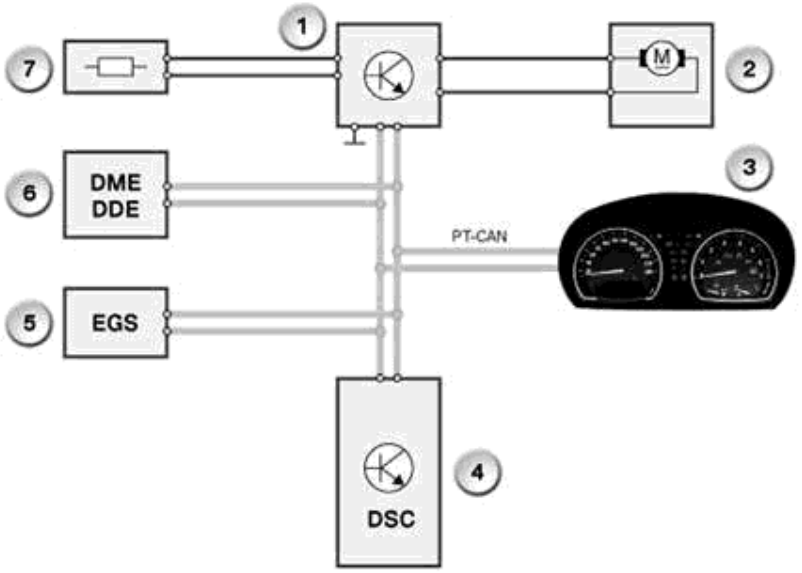


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**Fig. 4: xDrive Circuit Flow Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**

The DSC triggers the electronically controlled multi-plate clutch to supply continuously variable and power-oriented input torques to the front and rear axles.

The rear axle is always powered. All of the input torque is applied to the rear axle when the multi-plate clutch is separated.

xDrive communicates permanently with the DSC and receives from it, for instance, the following information:

- Whether the accelerator is pressed or released
- Whether the engine torque is increasing or decreasing
- Whether the car is driving straight ahead or in a curve

xDrive continuously evaluates this information to detect whether the car can respond to the driver's requirements. xDrive intervenes to counter the threat of any tendency for wheelspin, oversteer or understeer. xDrive regulates input torque distribution between the two axles to meet driving demands.

DSC only ever engages (by reducing engine power output and selective braking of individual wheels) should xDrive need assistance to keep the car on course.

The input torque is delivered to the axle that has better traction when road conditions change, such as on snow, ice or a loose road surface.

The two transfer cases are matched to cars as follows:

- E83 with transfer case ATC 400 (ATC = Active Torque Control)
- E53 with transfer case ATC 500

The two transfer cases differ in the following points:

- Different number of plates in the multi-plate clutches
- Different clearance between the input and output shafts to the front axle
- Propeller shaft inserted into the front axle differential on the E53, and flange-mounted on the E83

The transfer case is designed to be stronger on the E53 in order to match the higher engine torques.

**The Advantages:**

xDrive delivers the following advantages through demand-oriented input torque distribution:

- Outstanding driving stability fully up to the limit range
- Optimal forward momentum
- Excellent traction in all road situations

xDrive is standard equipment on the E83 and on the E53 from October 2003 with the new model version.

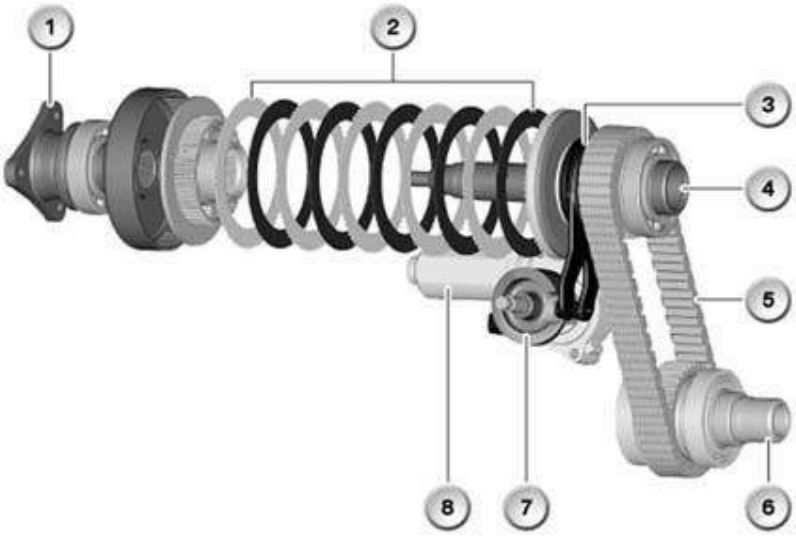
## BRIEF DESCRIPTION OF COMPONENTS

xDrive consists of the following components:

#### Transfer Case With Multi-Plate Clutch

The electronically controlled multi-plate clutch is housed in the transfer case. The multi-plate clutch distributes the input torques **continuously variably and demand oriented** between the front and rear axles.

#### Construction




| Key | Explanation | Key | Explanation |
|---|---|---|---|
| 1 | Output to the rear axle | 2 | Disc set |
| 3 | Actuator lever | 4 | Drive from manual-shift gearbox or automatic gearbox |
| 5 | Chain | 6 | Output to the front axle |
| 7 | Control cam | 8 | Electric servomotor |

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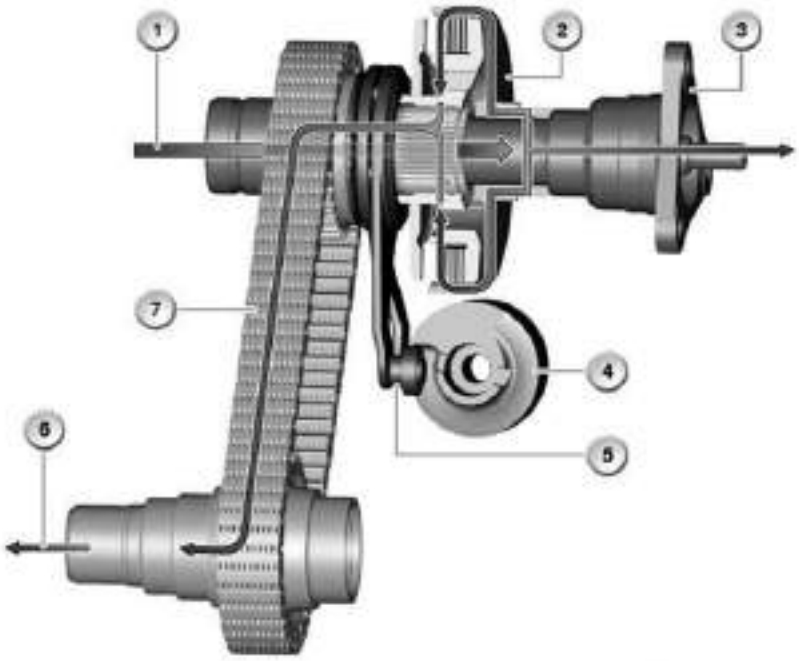
**Fig. 5: Identifying xDrive Transfer Case Multi-Plate Clutches**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**How It Works**

The rear axle is always powered. The rear and front axles are rigidly connected with one another when the multi-plate clutch is fully closed.




| Key | Explanation | Key | Explanation |
|---|---|---|---|
| 1 | Drive from manual-shift gearbox or automatic gearbox | 2 | Multi-plate clutch |
| 3 | Output to the rear axle | 4 | Control cam |
| 5 | Actuator lever | 6 | Output to the front axle |
| 7 | Chain | | |

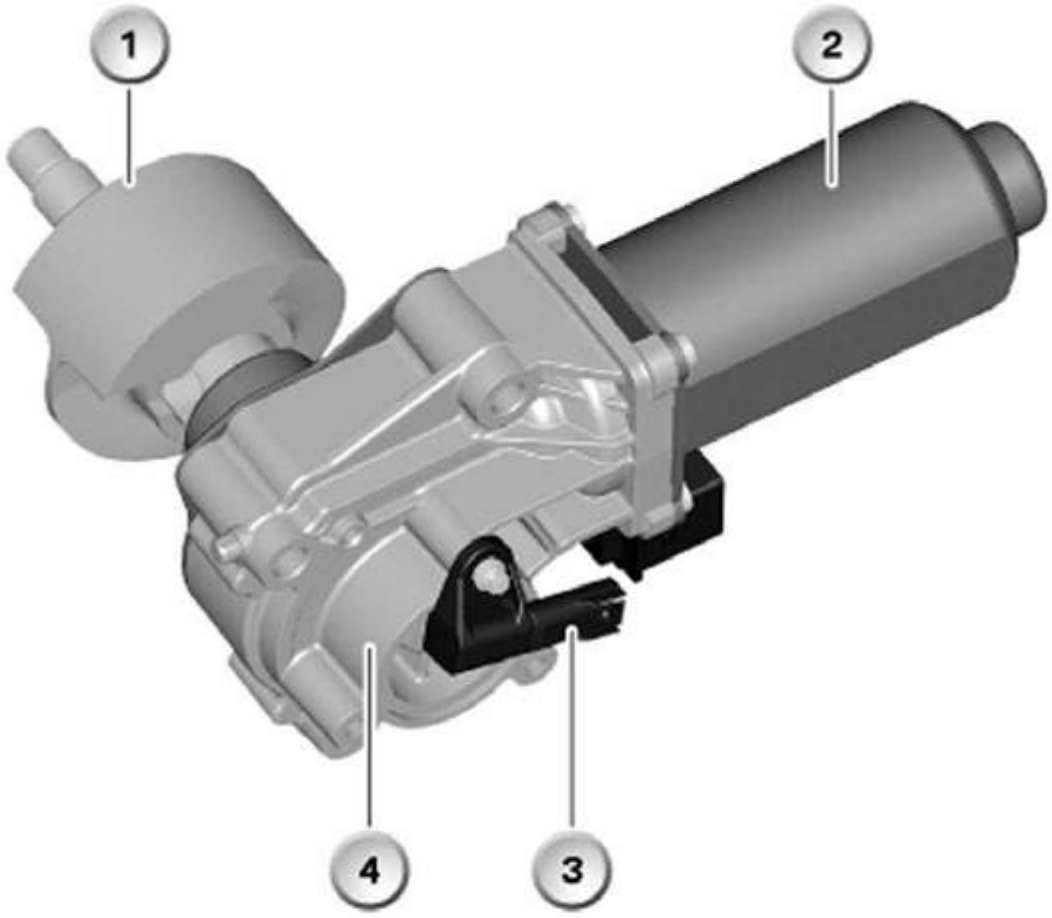
**Fig. 6: Identifying Power Flow Through xDrive Transfer**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**Electric Servomotor With Incremental Sensor And Classification Resistor**

The electric servomotor closes and separates the multi-plate clutch. The electric servomotor location and adjustment rate are detected by the incremental sensor.

The classification resistor takes mechanical tolerances in the transfer case into account, and therefore ensures optimum function.

**Construction**




| Key | Explanation | Key | Explanation |
|---|---|---|---|
| 1 | Control cam | 2 | Electric servomotor |
| 3 | Classification resistor | 4 | Worm gear |

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**Fig. 7: Identifying xDrive Electric Servomotor**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**How It Works**

**Electric Servomotor And Incremental Sensor:** The electric servomotor is a DC motor. The incremental sensor in the electric servomotor is used to record the adjustment rate and position of the servomotor shaft. The recorded data are necessary to activate and control the multi-plate clutch.

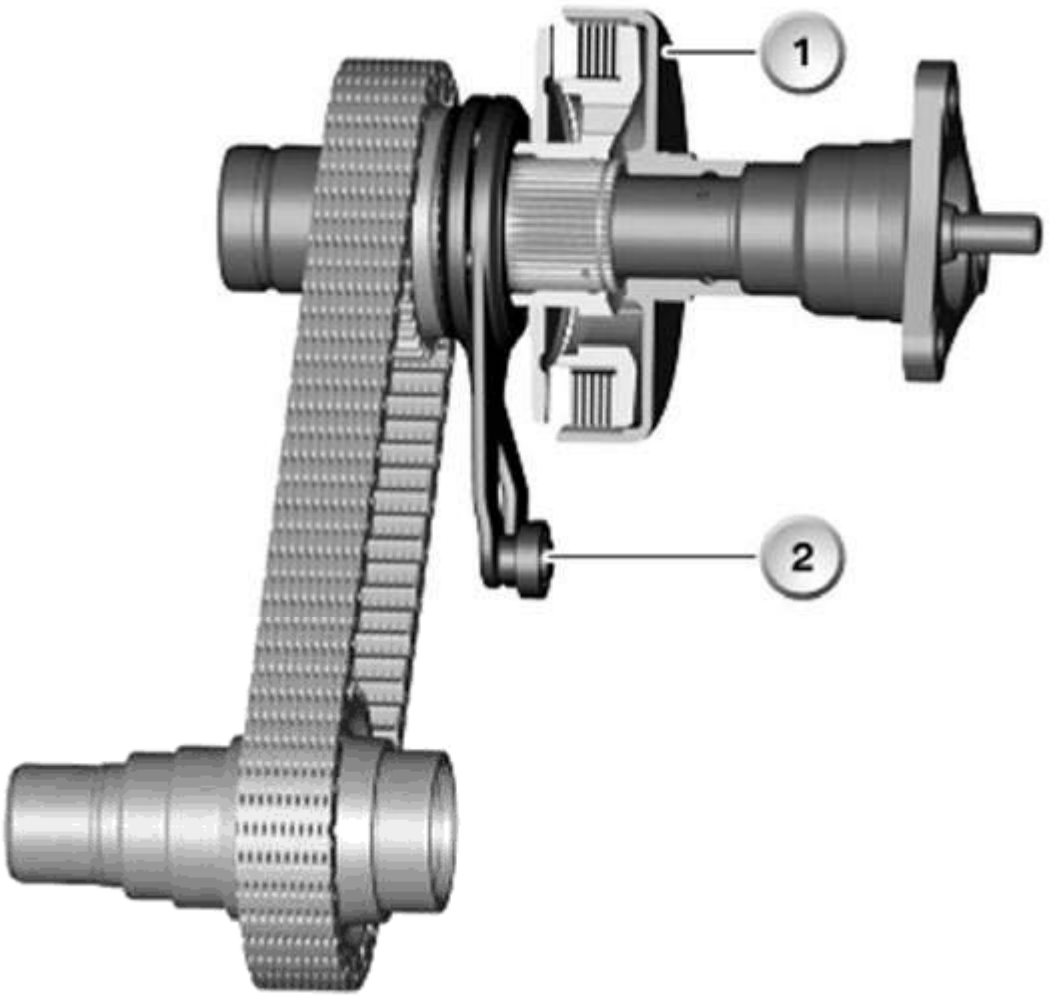
**Classification Resistor:** Locking torque characteristic curve of the multi-plate clutch may vary slightly due to mechanical tolerances during manufacture. The characteristic curve actual value for a transfer case is recorded by means of clutch test stand after assembly. The actual value is compared with the stored nominal values and the most optimum nominal value is chosen. There is a classification resistor for each nominal value as recognition. After completion of assignment the classification resistor is installed on the transfer case. In the car the resistance value is imported from the transfer case control unit. The software automatically sets the established characteristic curve. This setting is made the first time whenever the engine is started or is checked whenever the engine starts.

**Reference Run:** A reference run is performed at terminal 15 OFF in order to be able to assign a suitable locking torque for the multi-plate clutch when the electric servomotor has a specific angular position. The effects of wear are also taken into account when this is done. The multi-plate clutch is closed fully and separated once during this reference run. The current consumption is measured for each electric servomotor angular position during this closing and separating. This determines the beginning and end of the closing movement for the multi-plate clutch. The angular position is recorded by means of the integral incremental sensor in the electric servomotor. These values are stored and are used as data when the car restarts.

#### Actuator Lever

The actuator lever converts the rotational motion of the electric servomotor into an axial motion.

#### Installation Location




| Key | Explanation | Key | Explanation |
|---|---|---|---|
| 1 | Multi-plate clutch | 2 | Actuator lever |

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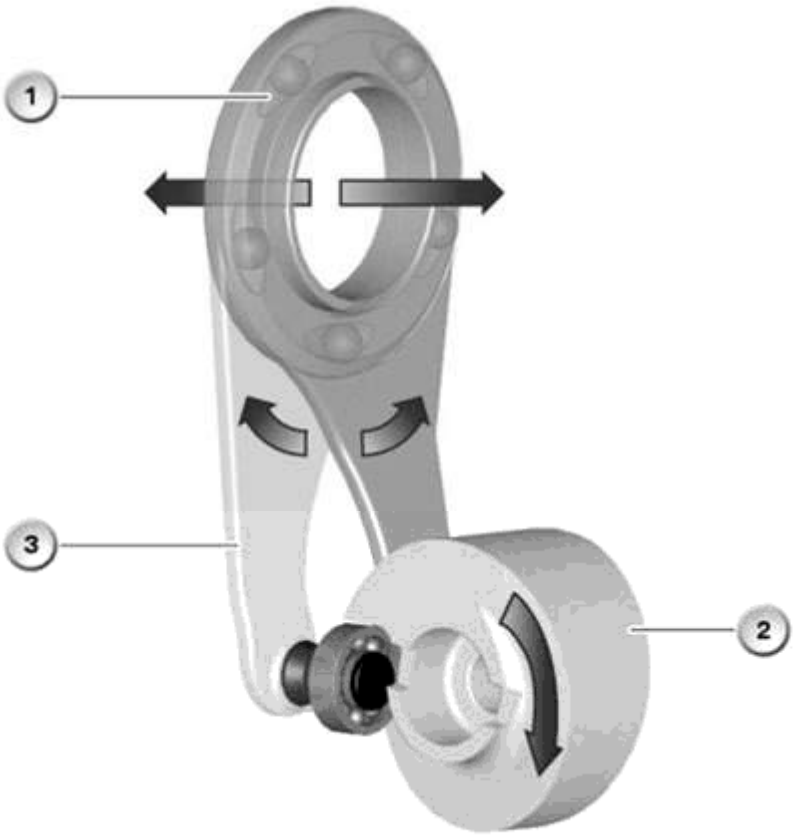
**Fig. 8: Identifying xDrive Actuator Lever**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**How It Works**




| Key | Explanation | Key | Explanation |
|---|---|---|---|
| 1 | Bearing ramp | 2 | Control cam |
| 3 | Actuator lever | | |

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**Fig. 9: xDrive Actuator Lever Operation**
**Courtesy of BMW OF NORTH AMERICA, INC.**

When the electric servomotor is running the control cam turns and pushes apart the two leverages of the actuator lever. The bearing ramps cause an axial movement as the leverages are pushed apart. This axial movement of the actuator lever pushes the plates together in the multi-plate clutch. The multi-plate clutch is closed.

**Transfer Case Control Unit**

The control unit in the transfer case regulates the locking torque at the multi-plate clutch in the transfer case in response to the following factors:

- Demand for required locking torque (comes from the DSC control unit)
- Condition of the transmission oil (calculated in the transfer case control unit)
- Multi-plate clutch wear (calculated in the transfer case control unit)

- Electric servomotor load (calculated in the transfer case control unit)
- Transmission-oil temperature (calculated in the transfer case control unit)

The transfer case control unit supplies the following information to the DSC control unit:

- The locking torque currently set
- All calculated data

The locking torque is limited whenever needed in order to reduce the frictional work.

**Installation Location**

**E83:** The control unit is located on the floor panel below the luggage compartment trim.

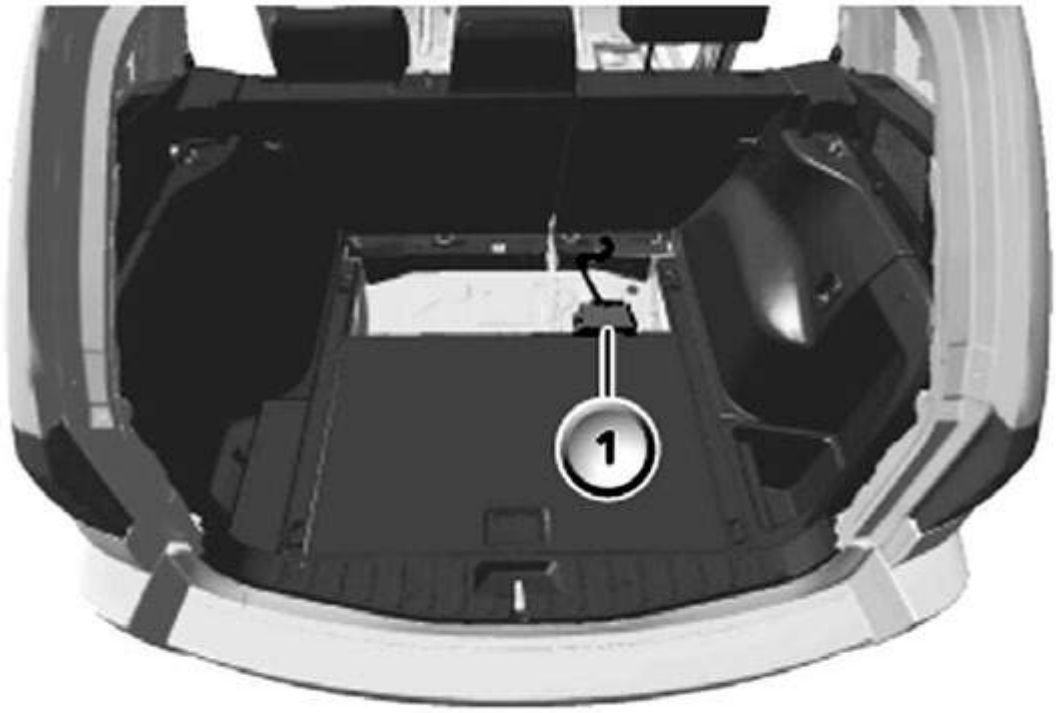
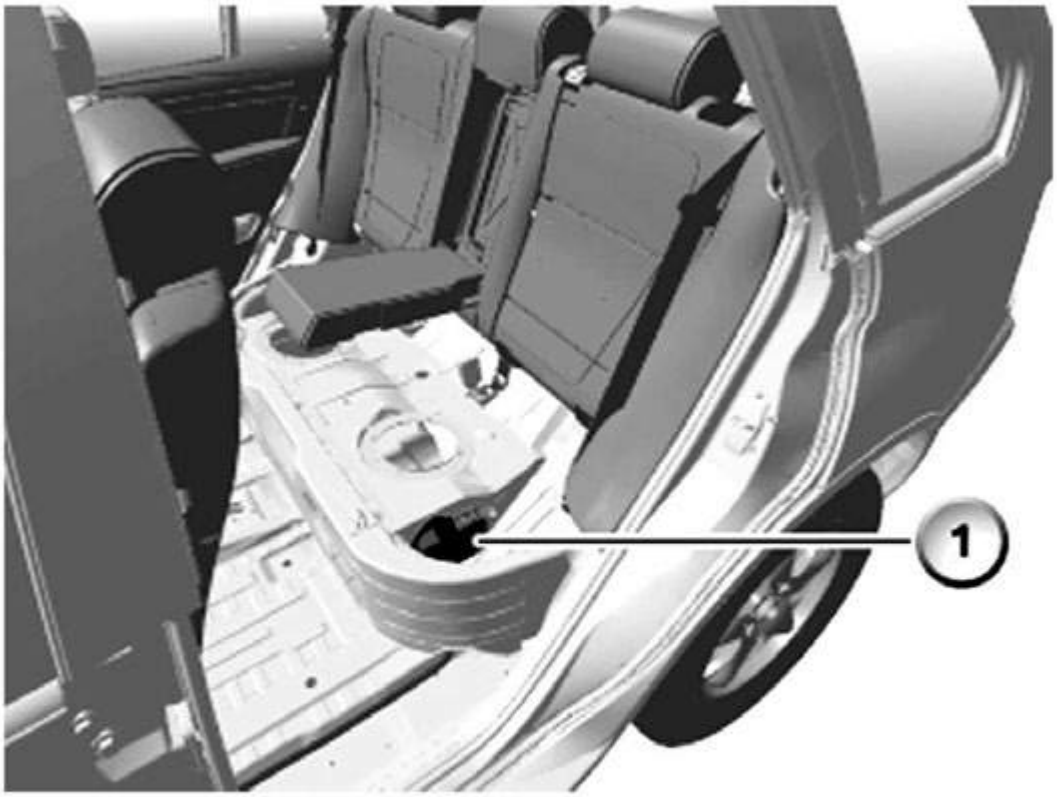



**Fig. 10: Locating Transfer Case Control Unit (E83)**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**E53:** The control unit is located on the floor panel on the left below the rear bench seat.




1) Transfer case control unit

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**Fig. 11: Locating Transfer Case Control Unit (E53)**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**Construction**

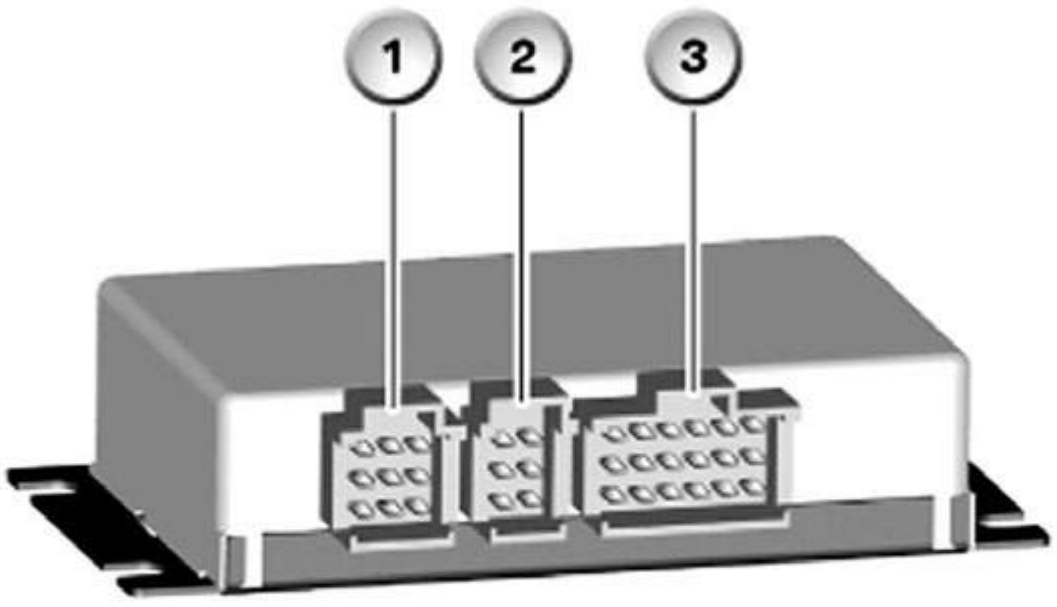


**Fig. 12: Identifying Transfer Case Control Unit Harness Connectors**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**TCU CONNECTOR PIN ASSIGNMENT X2153, 6-PIN**

| Pin | Type | Description |
|---|---|---|
| 1 | E/A | Powertrain CAN Low |
| 2 | E/A | Diagnosis bus |
| 3 | E | Terminal 15 (wake-up wire) |
| 4 | E/A | Powertrain CAN High |
| 5 | M | Terminal 31 (earth) |
| 6 | V | Terminal 30 (power supply) |

E = Input
E/A = Input/Output
M = Earth
V = Supply
For current specifications regarding pin assignment, please refer to BMW diagnosis system.

**TCU CONNECTOR PIN ASSIGNMENT X70006, 18-PIN**

| Pin | Type | Description |
|---|---|---|
| 1 | E | From the incremental sensor, indicates the direction of rotation of the electric servomotor |
| 2 | E | Negative lead from the incremental sensor and classification resistor |
| 3 | A | Positive lead for the incremental sensor |
| 4 | - | |
| 5 | E | Classification resistor |
| 6 | E | From the incremental sensor, indicates the frequency of the electric servomotor |
| 7 | - | |
| 8 | - | |
| 9 | - | |
| 10 | - | |
| 11 | - | |
| 12 | - | |
| 13 | - | |
| 14 | - | |
| 15 | A | Positive lead to the electric servomotor |
| 16 | - | |
| 17 | - | |
| 18 | E | Negative lead from the electric servomotor |

A = Output
E = Input
For current specifications regarding pin assignment, please refer to BMW diagnosis system.

**Dynamic Stability Control (DSC)**

In addition to the DSC 8 features (see SBT 340203042 "Dynamic Stability Control DSC 8, E60") the DSC contains the following functions with xDrive:

- All-Wheel Control
- Automatic Differential Brake (ADB-X)
- Hill Descent Control (HDC)

**All-Wheel Control**

The Dynamic Stability Control (DSC) provides the nominal value for all-wheel control with xDrive in response to tendencies to oversteer and understeer the car as well as wheelslip.

The transfer case / the transfer case control unit changes the input torque ignition distribution between the front and rear axles dependent upon this nominal value.

**Automatic Differential Brake (ADB-X)**

ADB-X simulates the function of conventional limited-slip differentials by selectively applying brakes on individual wheels (well-known from the E53 and the E46 four wheel drive car).

Whenever a wheel displays a tendency to spin the ADB-X brakes it automatically down to a preset slip. This effect of this is to increase the input torque on those wheels that have a higher friction coefficient on a lining.

**Hill Descent Control (HDC)**

HDC is a cruise control on four-wheel drive cars for driving downhill (well-known from the E53 and the E46 four-wheel drive car).

The HDC can be engaged and disengaged at a separate button.

Whenever the HDC-button is pressed the HDC reduces the roadspeed automatically to a little higher than walking speed (approx. 8 kph) solely by applying the brakes on all four wheels. The HDC holds this speed constant (all DSC functions remain active).

The car's road speed can be infinitely varied within the specified values by pressing down on the accelerator pedal, brake pedal or the buttons for the cruise-control system.

**Digital Engine Electronics (DME) Or Digital Diesel Electronics (DDE)**

**NOTE: The following control units and switches are incorporated in xDrive functions:**

The DME or DDE modifies the engine behaviour as required by the DSC control unit (such as power reduction to prevent the driven wheels from spinning).

**Accelerator Pedal Position Transmitter**

The pedal sensor position is needed to monitor the driving condition.

**Instrument Cluster Display**

System states are displayed as follows:

- DSC/xDrive telltale and warning lights light up:

  DSC/xDrive not activated

- DSC/xDrive telltale and warning lights light up and acoustic signal:

  DSC defective, ABS not affected, control unit in transfer case OK

  or

  DSC OK, control unit in transfer case defective

All-wheel drive in emergency operation

- DSC/xDrive telltale and warning lights, ABS telltale and warning lights and general brake warning lamp light up and acoustic signal:

  Total failure of the DSC and/or malfunction of the control unit in the transfer case

  All-wheel drive in emergency operation

**SYSTEM FUNCTIONS**

xDrive comprises the following functions:

- Control Of The Locking Torque For The Multi-Plate Clutch
- Emergency Operation

**Control Of The Locking Torque For The Multi-Plate Clutch**

Control of the locking torque for the multi-plate clutch in the transfer case allows the front axle to be coupled infinitely variably to the drive train. The input torque at the front axle can be increased or reduced in response to the road situation and conditions.

The DSC control unit calculates the locking torque for the multi-plate clutch as follows:

- Pre-activation = driver's command
- Driving dynamic control
- Detection of different tyre rolling circumferences

**Pre-Activation**

Pre-activation reflects the driver's command and is used to calculate the required locking torque.

The evaluation criteria below are taken into account to in determining the driver's command:

- Accelerator-Pedal Value
- Engine Torque
- Engine Speed
- Car Road Speed
- Gear Engaged
- Steering Angle

**Driving Dynamic Control**

Driving dynamic control monitors the slip behaviour on the front and rear axles. Driving dynamic control has the task of achieving optimum traction and keeping the car stable or to stabilise it.

The following evaluation criteria are taken into account by the monitoring system:

- Wheel speeds
- Yaw rate
- Lateral acceleration
- Steering angle

The input torque is distributed as follows in normal driving with all-wheel drive:

- 40 % to the front axle
- 60 % to the rear axle

Distribution of the input torque is oriented upon the torque that can be supported by each axle. For instance, if the car is fully accelerated in 1st gear from a standing start the distribution of the dynamic axle-load creates a higher axle load on the rear axle. Therefore, the rear axle can convey a higher input torque.

If, for instance, the front wheels are on a surface that has a high friction coefficient and the rear wheels are on sheet ice, for instance, (lower friction coefficient), then nearly 100 % of the available input torque is conveyed over the front axle. The rear axle is under hardly any load any can support only a low input torque.

When driving in a curve, the lateral acceleration causes centrifugal force that forces the car to the outside. The car leaves the stable driving condition when the centrifugal force is stronger than the maximum possible wheel lateral guiding forces. "Understeer" is the phrase used when the car presses outwards over the front wheels. Oversteer, on the other hand, is when the rear wheel adhesion becomes lower. The rear of the car presses outwards.

xDrive minimizes the tendency to understeer or oversteer by optimally distributing the driving power between the rear axle and front axle.

**Input Torque Distribution During A Tendency To Understeer** The multi-plate clutch separates fully during a tendency to understeer. This completely relocates the input torque to the rear axle, and the front axle is relieved from driving forces. Therefore a higher lateral cornering force can be conveyed to the front wheels. The tendency to understeer is reduced.

**Input Torque Distribution During A Tendency To Oversteer** The multi-plate clutch closes during a tendency to understeer. This relocates the input torque more to the front axle, and the rear axle is relieved from driving forces. Therefore a higher lateral cornering force can be conveyed to the rear wheels. The tendency to oversteer is reduced.

#### Detection Of Different Tyre Rolling Circumferences

If the tyre rolling circumferences are not the same the drive train twists due to different rotary speeds (when the multi-plate clutch is closed). The tyres are worn away faster.

Different rotary speeds may be caused by the effect of the following:

- When tyres of different makes and types are fitted:

  The tyre rolling circumference may fluctuate by up to 1 % due to tyres of different makes and types being fitted or the tyres are worn very differently.

- When an emergency wheel is fitted
- When the tyres are worn very differently

  Slip in the multi-plate clutch may compensate for differences in rotary speed when different tyre rolling circumferences are detected.

  Compensation is produced by reducing the locking torque in situations that do not have great driving dynamic control.

**Emergency Operation**

Driving dynamic control and the ADB-X function are not possible in emergency operation.

The transfer case control unit has an integral regulator for emergency control. The regulator provides redundancy for controlling the multi-plate clutch in the DSC control units.

The regulator is used to attempt to maintain all-wheel drive for as long as possible when the DSC control unit malfunctions or important sensor signals drop out.

Substitute values are calculated when individual sensor signals drop out. Functions are operated by using the substitute values until it is no longer possible to control the all-wheel drive effectively.

## NOTES FOR SERVICE STAFF

Service staff should note the following points:

- General information: Refer to **E83, E53 - XDRIVE, GENERAL INFORMATION FOR SERVICE STAFF** .
- Diagnostics: -
- Encoding/programming: -
- Car and Key Memory: -

Subject to change.

**E83, E53 - xDrive, General Information For Service Staff**

The following general information is provided for service staff:

- Towing cars with xDrive
- Using brake test stands

**Towing Cars With xDrive**

**IMPORTANT: Always raise cars with xDrive at both axles during towing.**

Do not attempt to tow the car with the wheels of one axle lifted off the ground (this applies equally to the front or rear axle). It is important that not a single wheel has any contact with the road surface on cars fitted with xDrive when they are towed. Even the if the electric servomotor is de-energised this does not ensure that the clutch has fully separated. The car could move out of the towing device. The transfer case will be damaged if the wheels on the raised axle in the towing device are blocked by lashing. Comply with the information as stated on the warning notice affixed to the left-hand B-pillar and the notes in the Owner's Handbook.

**IMPORTANT: It is permissible to pull cars with xDrive, but with restrictions.**

It is technically possible to pull on all wheels, however with the following limitations:

- Towing speed: maximum 70 kph
- Towing distance: maximum 150 km

Comply with the information in the Owner's Handbook.

**Using Brake Test Stands**

**IMPORTANT: Switch off the Hill Descent Control (HDC) before operating the brake test stand and do not switch it on again.**

The HDC indicator lamp must not be illuminated! It is possible that the HDC indicator lamp will go out or will not light up, even if the HDC mode has been activated. One possible reason for this is that the HDC is temporarily unavailable because of a high brake temperature.

**Cars With xDrive And Automatic Transmission**

**IMPORTANT: Only check the brakes when the select position is "N" (Neutral) and do not accelerate when the rollers start up.**

This keeps the multi-plate clutch separated in the transfer case and the car cannot be driven out of the brake test stand.

**Cars With xDrive And Manual Transmission**

**IMPORTANT: Do not engage a gear and do not accelerate on the brake test stand.**

Applying throttle leads to the multi-plate clutch closing in the transfer case, even in if a gear is not engaged. As a result, the stationary axle is also activated, and the car is pushed out of the brake test stand.