Reference Manual

F48
COMPLETE VEHICLE

Technical Training

Reference Manual

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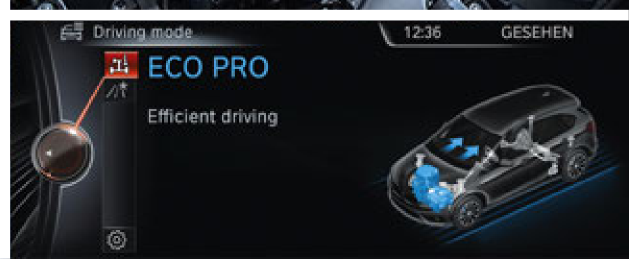
BMW
Technical Training

F48 Complete Vehicle



BMW of North America, LLC
Technical Training
ST1508
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Course Code: **ST1508** **F48 Complete Vehicle**

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Technical training.
Product information.

F48 Introduction

Edited for the U.S. market by:
BMW Group University
Technical Training
ST1508 3/1/2016

BMW Service

General information

Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:

⚠

Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

Information status and national-market versions

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This document basically relates to the European version of left-hand drive vehicles. Some operating elements or components are arranged differently in right-hand drive vehicles than shown in the graphics in this document. Further differences may arise as a result of the equipment specification in specific markets or countries.

Additional sources of information

Further information on the individual topics can be found in the following:

- Owner's Handbook
- Integrated Service Technical Application.

Contact: conceptinfo@bmw.de

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Information status: **June 2015**
Technical Training

F48 Introduction
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F48 Introduction

1. Introduction

From October 2015 the new BMW F48 X1 will be available. Since the European introduction of the E84 in 2009 and the US introduction in August of 2012, the F48 represents the second generation of the X1 Sports Activity Vehicle.

The F48 will be offered with sDrive and xDrive.
All engines in the F48 will be transversely mounted.

The F48 is the first BMW based on a front-wheel drive system.

The F48 comes with an xDrive system that works with a clutch instead of a transfer box for the longitudinal torque distribution.

BMW X1 – F48

In addition to the optional equipment, the F48 can also be individualized with the following equipment packages:

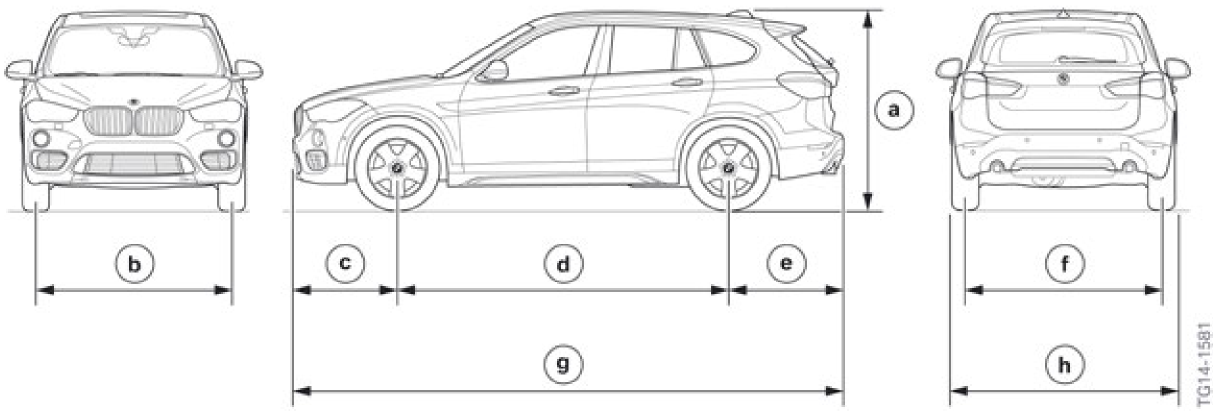
- Luxury package
- M sport package

The model BMW X1 xDrive28i was made available for the market introduction. Later in production the X1 sDrive version was made available as a front wheel drive vehicle.

F48 Introduction
1. Introduction

1.1. Dimensions

Below you see the outer dimensions of the F48 compared to the E84 using the example of the BMW X1 xDrive28i.



F48 Outer dimensions

Index	Explanation		F48	E84	Change
a	Vehicle height, empty	[mm]	1598	1545	**+ 53**
	ground clearance		183	161	**+ 22**
b	Front track width, basic wheels	[mm]	1561	1500	**+ 61**
c	Front overhang	[mm]	842	817	**+ 25**
d	Wheelbase	[mm]	2670	2760	**– 90**
e	Rear overhang	[mm]	927	907	**+ 20**
f	Rear track width, basic wheels	[mm]	1562	1529	**+ 33**
g	Vehicle length	[mm]	4439	4484	**– 45**
h	Width excluding exterior mirrors (vehicle width including exterior mirrors)	[mm]	1821 (2060)	1798 (2058)	**+ 23 (+ 2)**

1.2. Weights and payload

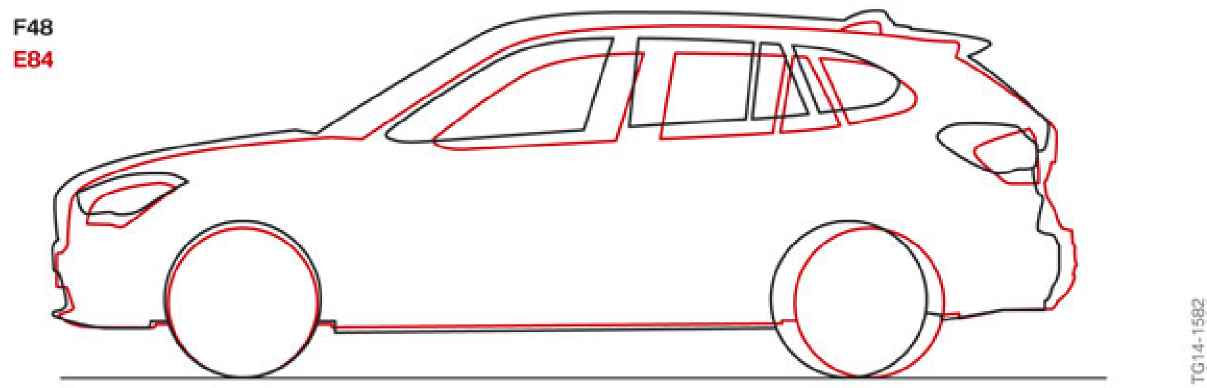
Vehicle curb weights and payloads of the F48 are set out in the following table:

		F48	E84
Vehicle curb weight	[kg] lbs	1660 / 3660	1600 /3527
Permissible total weight	[kg] lbs	2140 / 4720	2040 / 4497
Payload	[kg] lbs	408 / 900	550 / 1212
Roof load	[kg] lbs	75 / 165	75 / 165

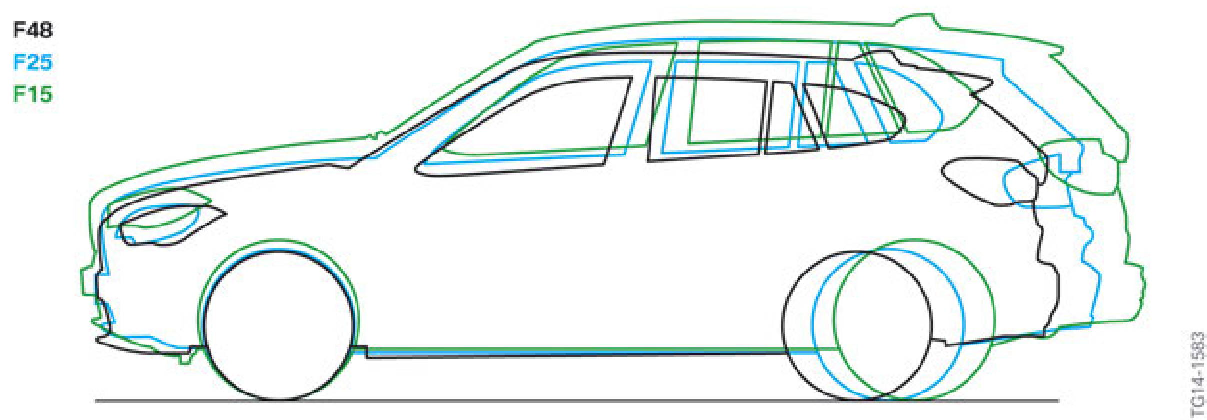
F48 Introduction

1. Introduction

1.3. Silhouette comparison



F48 silhouette comparison with BMW X1 E84



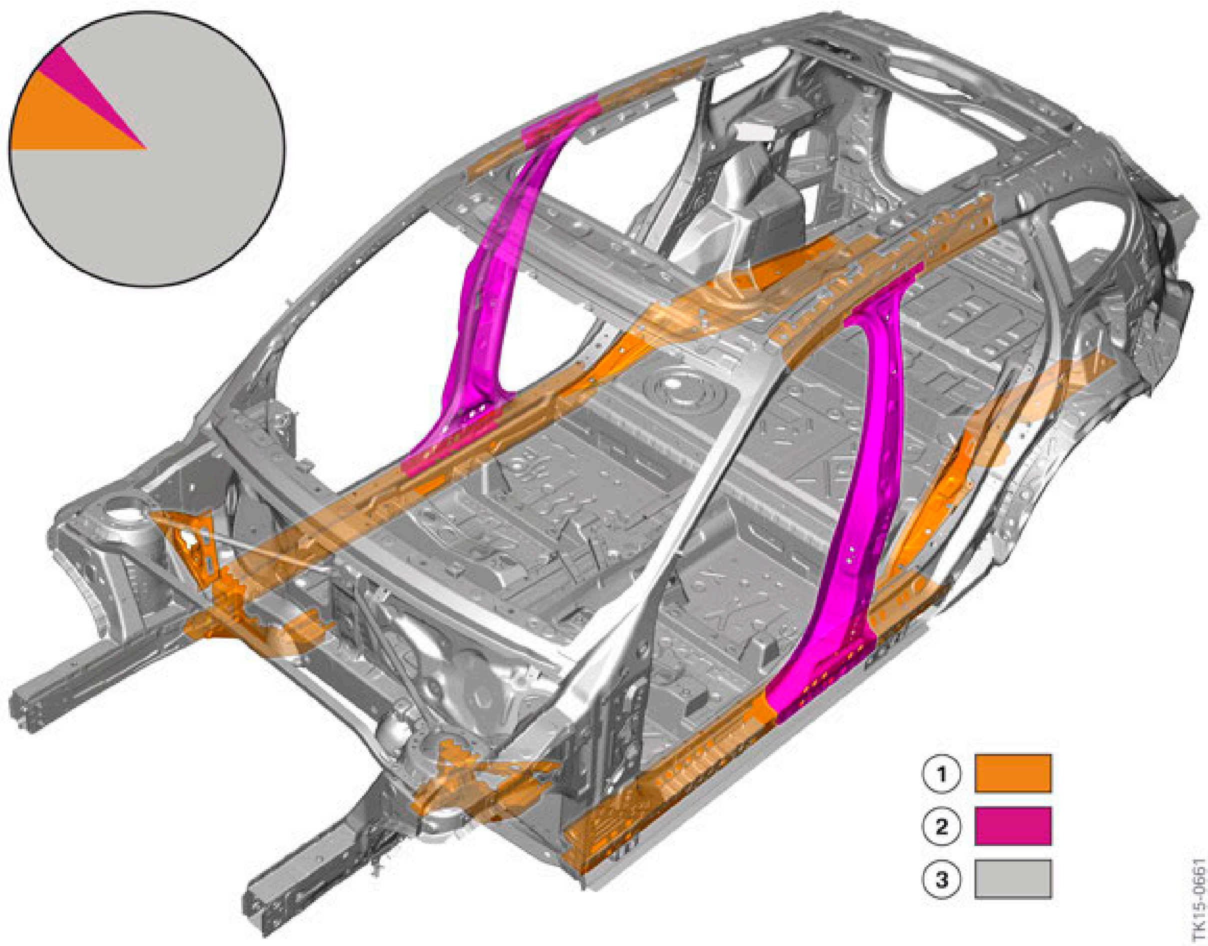
F48 silhouette comparison with BMW X3 F25 and BMW X5 F15

F48 Introduction

2. Bodyshell

2.1. Material properties of bodyshell

The use of state-of-the-art steels, as well as the intelligent material mix, has a positive effect on the vehicle weight. The distinctive body rigidity ensures the driving dynamics typical of BMW.



F48 Material properties of bodyshell

Index	Explanation
1	Multi-phase steels (> 300 MPa), 9 % of the body weight
2	Hot-formed steels (> 900 MPa), 4 % of the body weight
3	Other steels (< 300 MPa), 87 % of the body weight

Multi-phase steels are steels where the structure consists of a number of phases. Higher-strength multi-phase steels with a yield strength $R_{p0.2}$ of 300 to 600 MPa are, for example, dual-phase steels or TRIP steels. Super-strength multi-phase steels with a yield strength $R_{p0.2}$ in excess of 600 MPa are, for example, complex-phase steels or martensitic-phase steels.

Hot-formed manganese-boron steels are super-strength steels with a yield strength $R_{P00.2}$ in excess of 900 MPa.

F48 Introduction
3. Emissions Reduction

In addition to the measures in the drive and chassis and suspension area, the weight reduction of the body, as well as the aerodynamics measures, help reduce the CO_2 emissions of the F48.

A low body weight was also able to be achieved with the following measures:

- Bulkhead, carrier support and B-pillar made from Taylor Rolled blanks (optimized material thickness).
- Bumper support, front and rear, made from aluminium.
- Engine compartment lid made from aluminium
- High use of high-strength and super-strength multiphase steels and super-strength, hot-formed steels

The following measures ensure a low drag:

- Air ducts in front of the front wheel arches ("Air Curtain").
- Aeroblades and air guides in front of the front wheels ("Displacer").
- Rear spoiler and aeroblades at the side at the tailgate

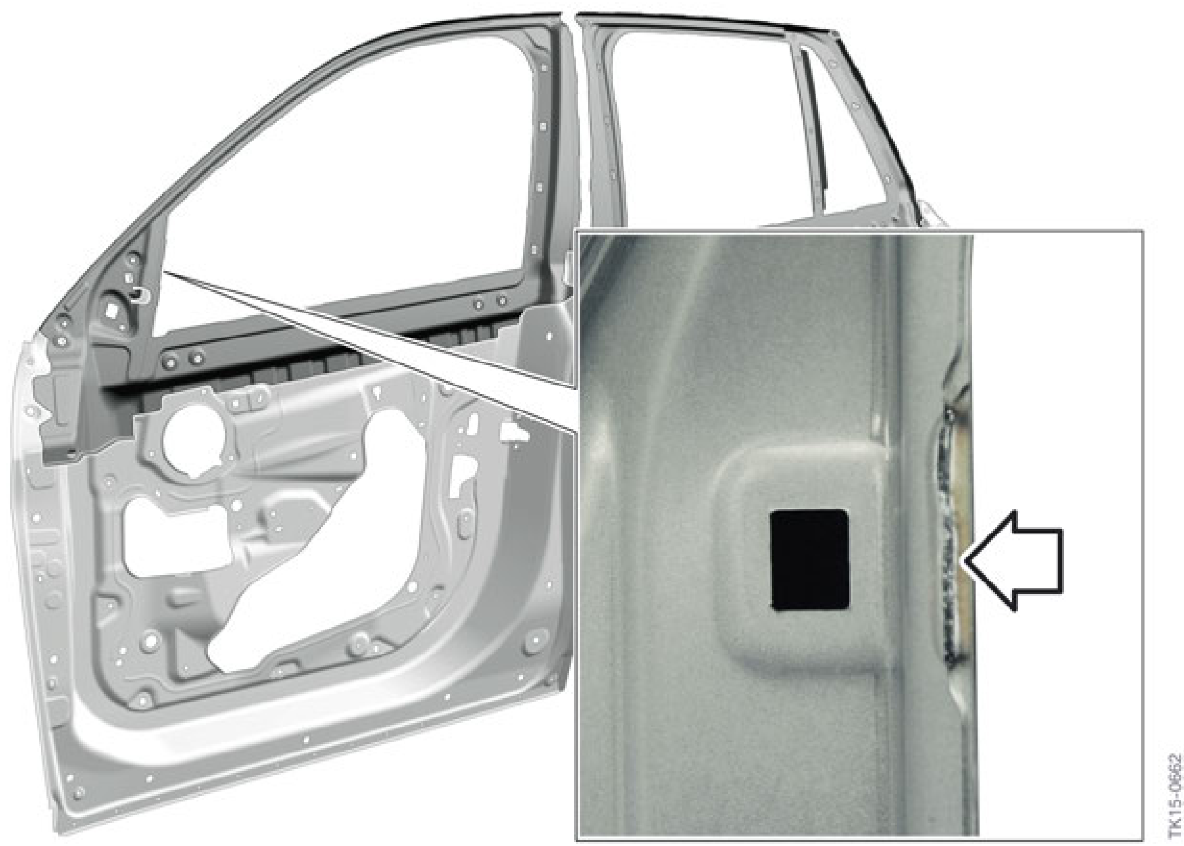
F48 Introduction

4. Doors, Lids and Hatches

4.1. Doors

The F48 outer door skin is welded to the inner door panel, in order to increase the rigidity of the doors.

A further increase of the rigidity is achieved by additional laser welded seams between the inner door panels and the end plates:



F48 laser weld seams, doors

4. Doors, Lids and Hatches

F48 sealing tape, doors

In order to reduce the noise level in the passenger compartment, additional sealing tape is clipped on to the inner door panels. The tape also helps reduce contamination in the sill areas.

4.2. Tailgate

F48 aeroblades, tailgate

Index	Explanation
1	Rear spoiler
2	Aeroblades

Like in the F15, aeroblades are also attached at the side of the tailgate in the F48. Tear-off edges occur as a result of the side aeroblades and the rear spoiler, which cause the specific stall at the D-pillar. This lowers the total drag of the vehicle.

4.2.1. Automatic operation of tailgate

F48 Automatic operation of tailgate

An automatic operation of tailgate (SA 316) is standard for the F48. As is known from current BMW models, the tailgate is opened or closed by an electric spindle on the drivers side.

Two hall effect sensors are installed in the spindle drive to detect the position of the tailgate. These are read out from the control unit for the automatic operation of the tailgate.

The tailgate opens or closes automatically when it is actuated by one of the following buttons:

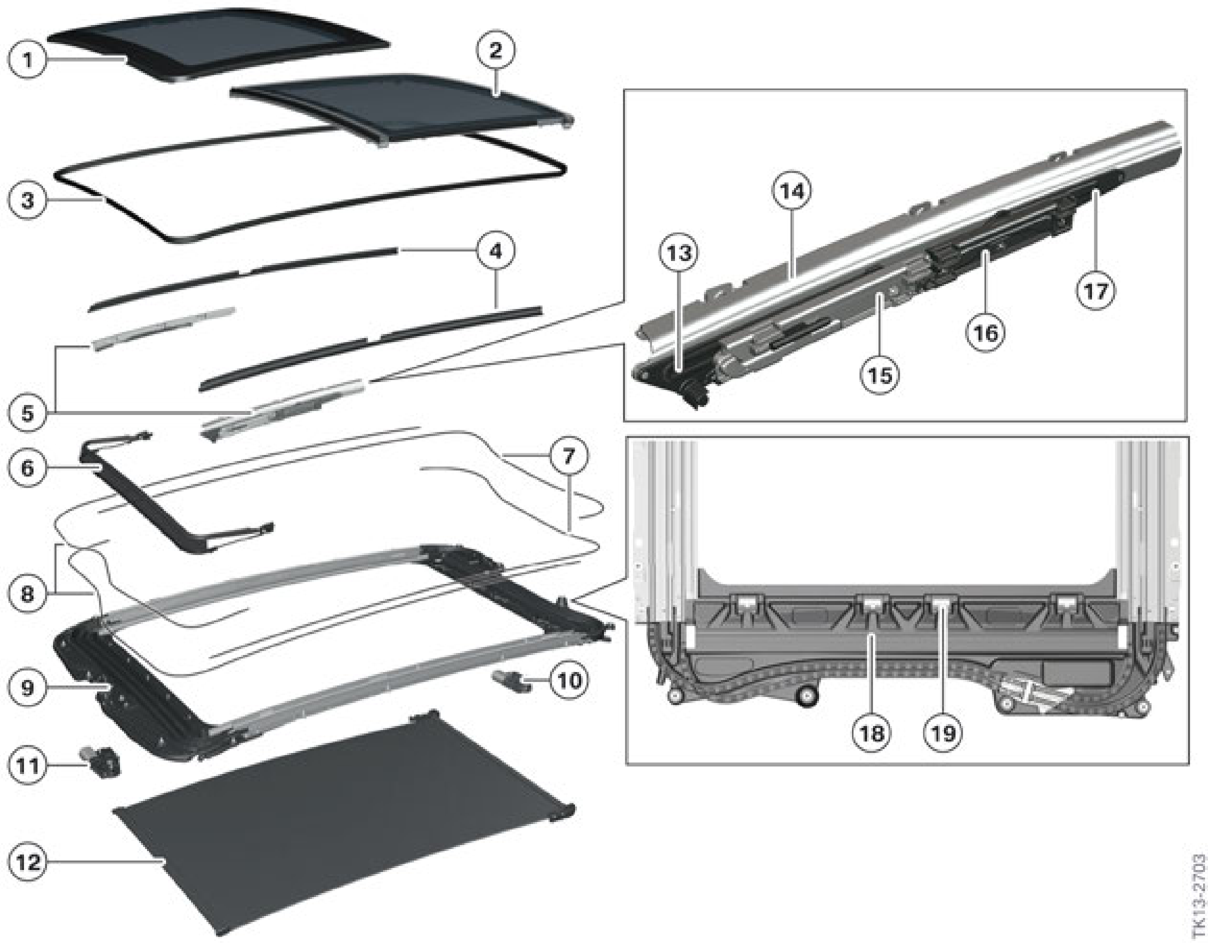
- Button for the remote control or ID transmitter
- Button on the tailgate, outer or inner
- Button on the driver's door

In conjunction with the optional equipment Comfort Access (SA 322), the tailgate can also be opened hands free by means of targeted foot movement. Two sensors detect the movement contactlessly via capacitive measurement.

F48 Introduction

5. Exterior Trim

5.1. Panorama glass roof



F48 panorama glass roof

Index	Explanation
1	Glass slide/tilt sunroof panel (moveable)
2	Glass slide/tilt sunroof panel (tightly screwed)
3	Gasket
4	Side panel
5	Kinematics
6	Wind deflector
7	Bowden cable (roller sunblind)
8	Bowden cable (glass slide/tilt sunroof panel)
9	Frame
10	Electric motor (roller sunblind)
11	Electric motor (glass slide/tilt sunroof panel)

5. Exterior Trim

Index	Explanation
12	Roller sunblind
13	Positioning lever, front
14	Sliding carriage
15	Gate, front
16	Gate, rear
17	Positioning lever, rear
18	Rear part of frame
19	Steel inlay

The optional panorama glass roof (SA 402) allows greater outside light in the vehicle when the roller sunblind is open. For the first time at BMW, when fully opening the panorama glass roof, the front glass slide/tilt sunroof panel is pushed outwards across the rear glass slide/tilt sunroof panel.

The roller sunblind is electrically adjustable. If the glass slide/tilt sunroof panel is put into a vent position, the roller sunblind moves back for the necessary air circulation. Side panels cover the area between the frame and the glass slide/tilt sunroof panel.

The rear and front parts of the frame are made from plastic with steel inlays in order to reduce the weight and lower the vehicle's center of gravity.

The following components of the panorama glass roof can be replaced without removing the roof liner:

- Side panel, left
- Side panel, right
- Wind deflector
- Glass slide/tilt sunroof panel, front
- Glass slide/tilt sunroof panel, rear

An emergency operation of the glass slide/tilt sunroof panel is possible using a hexagon socket wrench at the front drive.

F48 Introduction
6. Interior Equipment

6.1. Instrument panel

F48 instrument panel, center console

All F48 vehicles come standard with automatic air conditioning (SA 534), the glove box is also equipped with additional ventilation.

A fold-down compartment on the driver's side dashboard below the headlight switch adds additional storage.

F48 Introduction

6. Interior Equipment

6.2. Front door trim panel

F48 front door trim panel

Index	Explanation
1	Fiber-optic conductor
2	Button, tailgate activation

The door trim panel on the drivers side also incorporates the button for the tailgate activation.

Depending on the vehicle equipment, the door trim panels are also equipped with fibre-optic conductors over the decorative strips.

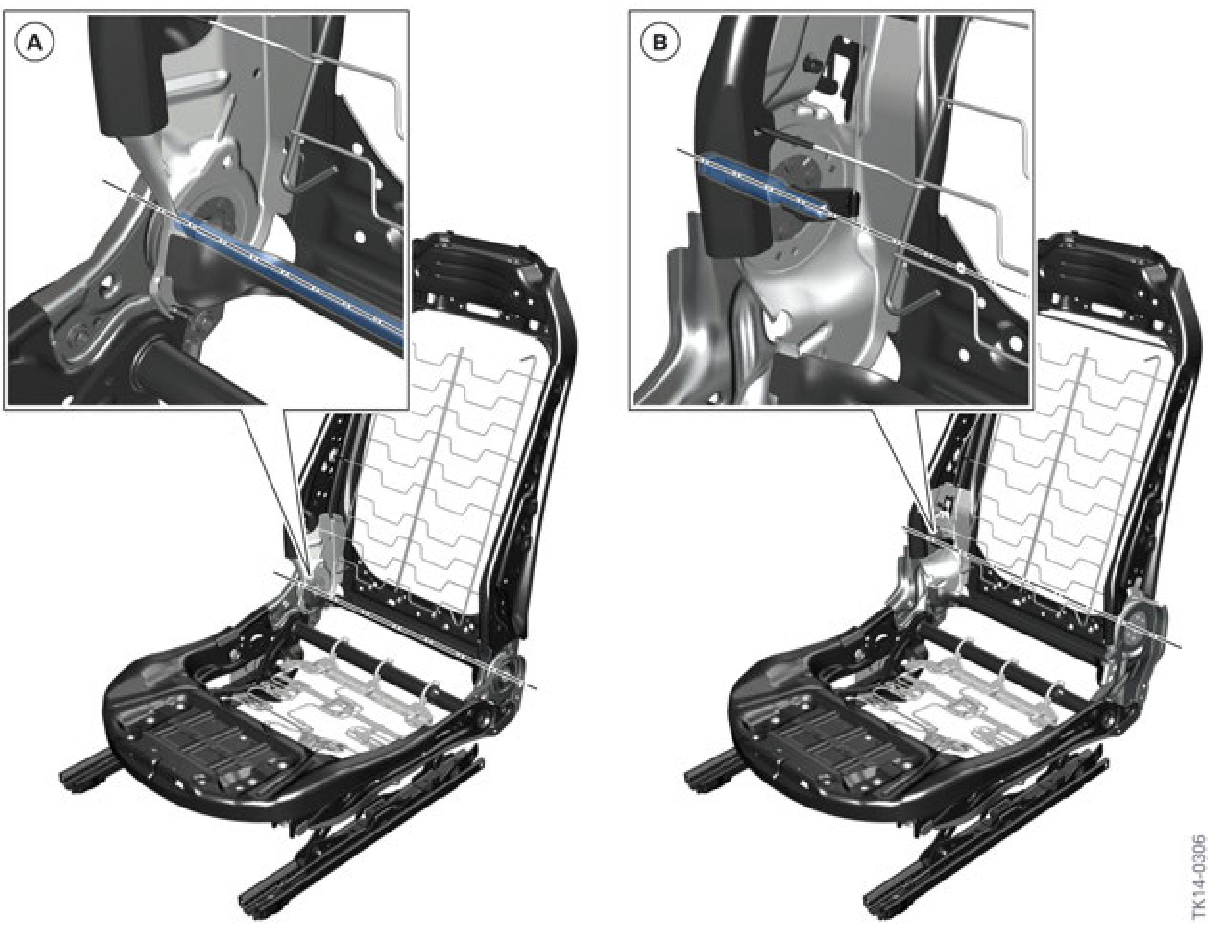
6. Interior Equipment

6.3. Front seats

Power front seats with drivers side memory is standard. Along with ISOFIX child seat mountings.

An integrated side airbag, as well as a seat belt system with belt tensioner, are used for all front seat versions of the F48. The following equipment can be ordered:

- Sport seats for driver and front passenger (SA 481)
- Lumbar support for driver and front passenger (SA 488)
- Seat heating for driver and front passenger (SA 494)
- Heated front seats (SA 494)



F48 backrest at front passenger seat

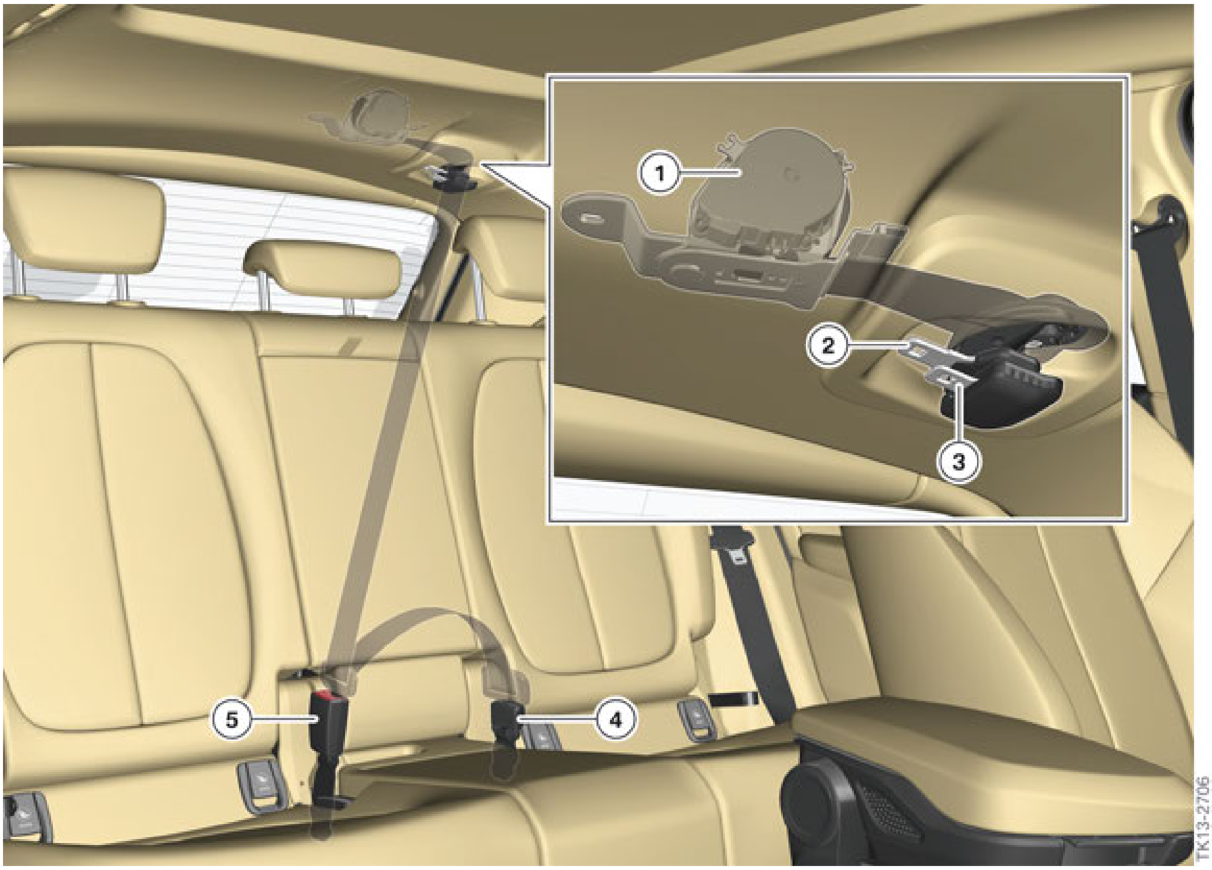
Index	Explanation
A	Basic seat
B	Folding-down front passenger backrest (Not For US)

6.4. Rear seats

F48 rear seats

The rear seat backrest is divided as standard into three sections in the ratio 40:20:40. Each individual section can be folded forwards separately via a loop at the rear seat backrest lower section. In the F48 the rear seat backrests are no longer secured to the body using a connection, but are only secured at the pivot points via the latch mechanism.

The rear head restraints can be adjusted very far downwards thanks to their L-shape, thus offering an optimal view of the rear.



F48 middle seat belt in the rear passenger compartment

Index	Explanation
1	Inertia reel
2	Top buckle
3	Bottom buckle
4	Seat belt buckle (for bottom buckle)
5	Seat belt buckle (for top buckle)

Another new feature at BMW concerns the middle seat belt in the rear passenger compartment, whose inertia reel is housed between the roof and roof-liner. There are two buckles at the end of the seat belt, which are retained magnetically at the belt holder. To close the middle seat belt, the bottom buckle (3) must be inserted in the left seat belt buckle (4) and the top buckle (2) in the right seat belt buckle (5).

The right seat belt buckle (5) is released using the red button in the buckle. The left seat belt buckle (4) is released using the belt end.

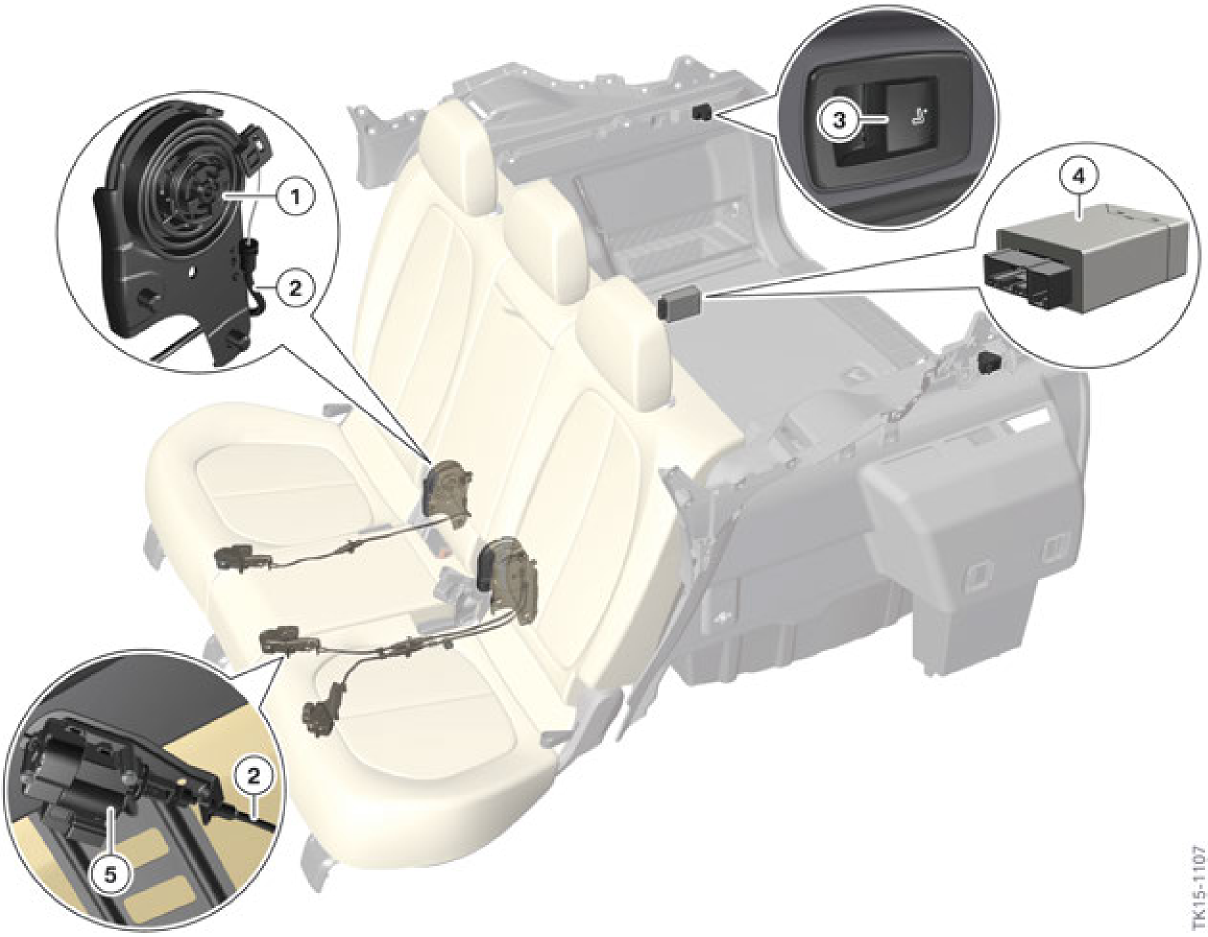
6.4.1. Seat adjustment

F48 examples of seat adjustment for rear seat

With the optional equipment "Sliding and Reclining rear seat adjustment" (SA 4FD), the seat bench is divided in the ratio 60:40. Both sides can be adjusted 130 mm in a longitudinal direction, independent of each other.

In addition, the inclination of the rear seat backrests can be adjusted in 2° steps. For instance, the seating comfort in the rear passenger compartment or the size of the luggage compartment can be optimized, depending on requirements.

6.4.2. Backrest remote unlocking



F48 Backrest remote unlocking

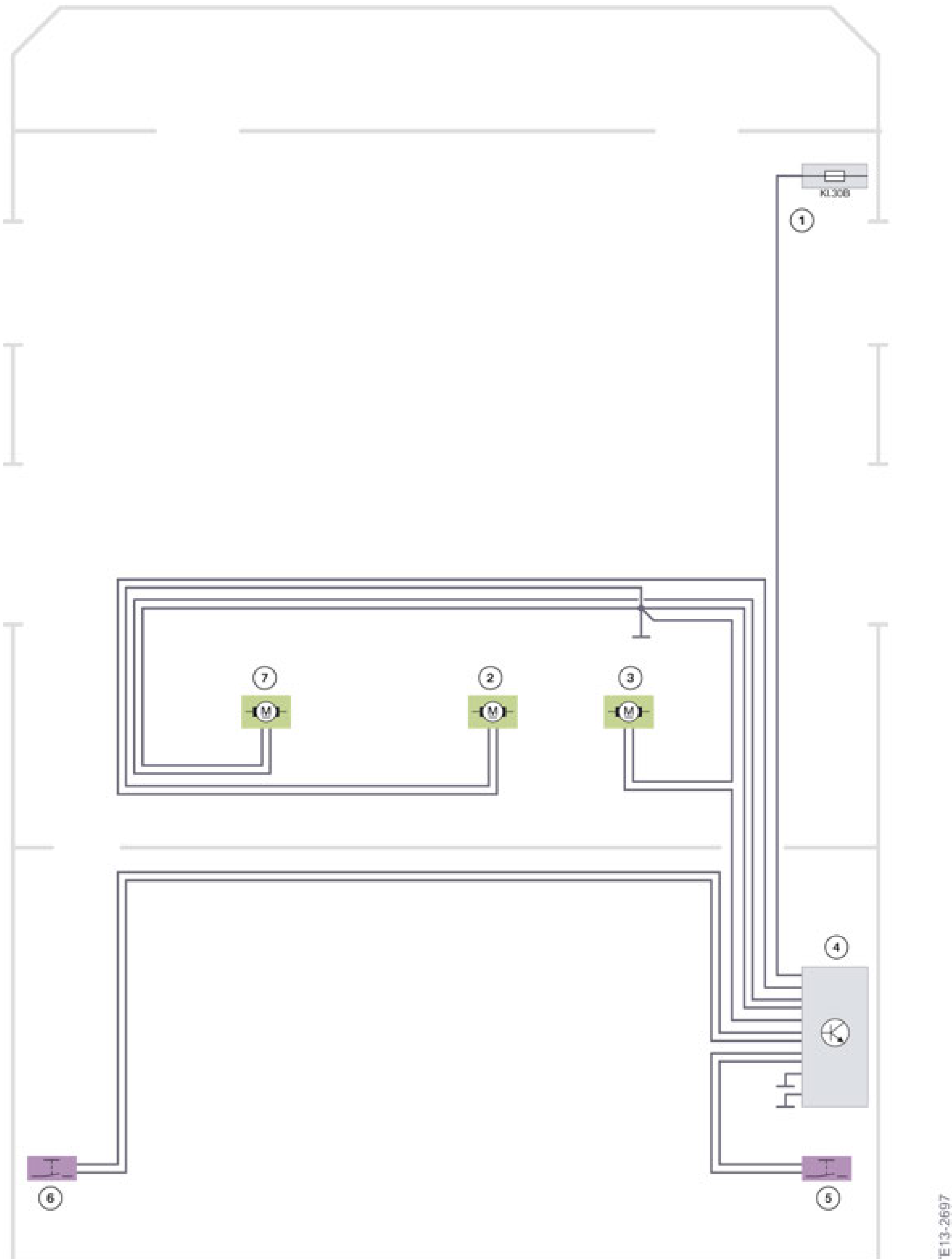
Index	Explanation
1	Latch mechanism (at the pivot points)
2	Bowden cable
3	Button, backrest remote unlocking
4	Control unit, backrest remote unlocking
5	Motor, backrest remote unlocking

In conjunction with the optional equipment "Sliding and Reclining rear seat adjustment" (SA 4FD), an electric remote unlocking of the rear seat backrests is also used. The corresponding rear seat backrests are unlocked electrically and then fold forwards by spring tension.

The two buttons of the backrest remote unlocking are located in the luggage compartment on the left and right. By pressing the left button, the left and middle section of the rear seat backrest folds forward. By pressing the right button, the right section of the rear seat backrest folds forwards.

The control unit for the backrest remote unlocking reads the two buttons and activates the three motors of the backrest remote unlocking with a time delay. The control unit is located under the right storage compartment in the luggage compartment and does not have diagnostic capability.

System wiring diagram



F48 system wiring diagram for backrest remote unlocking

Index	Explanation
1	Power distribution box, passenger compartment
2	Motor, backrest remote unlocking, middle
3	Motor, backrest remote unlocking, right
4	Control unit, backrest remote unlocking
5	Button, backrest remote unlocking, right
6	Button, backrest remote unlocking, left
7	Motor, backrest remote unlocking, left

7. Luggage Compartment

F48 examples of functional spatial concept

The luggage compartment capacity of the F48 is 505 liters and can be extended up to 1550 liters.

The spatial offering can be used variably thanks to the functional spatial concept. Depending on the vehicle equipment, the following options are offered to change the luggage compartment capacity:

- Folding down the rear seat backrest (separated in the ratio 40:20:40)
- Tilt adjustment of the rear seat backrests (separated in the ratio 40:20:40) (Sliding and Reclining rear seat adjustment (SA 4FD)
- Forward/back adjustment of the seat bench (separated in the ratio 60:40) (Sliding and Reclining rear seat adjustment (SA 4FD)

A foldable luggage compartment floor enables easy access to the storage room underneath.

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Technical training.
Product information.

B46 Engine

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Information status: **June 2014**
Technical Training

B46 Engine
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B46 Engine
1. Introduction

This document describes the special features of the new 4-cylinder engine and serves to support the technical service. Due to the huge similarities, between the B38 Top engine and B46, the two engines are described in this one document. Some images shown relate to the 3-cylinder engine. The differences compared to the 4-cylinder engine are shown and described separately. However, the similarities are not repeated. The engines are distinguished as follows in this document:

- B38 = 3-cylinder engine
- B46 = 4-cylinder engine
- Bx8 = 3 and 4-cylinder engine

1.1. Engine designation

In the technical documentation, the engine designation is used to ensure unambiguous identification of the engine. Frequently, only a short designation is used, which is explained in the following table.

Position	Meaning	Index	Explanation
1	Engine developer	B	BMW Group engine
2	Engine type	3 4	3-cylinder in-line engine 4-cylinder in-line engine
3	Change to the basic engine concept	6 8	SULEV/Turbo-Valvetronic Direct Injection (TVDI) Turbo-Valvetronic Direct Injection (TVDI)
4	Working method or fuel and installation position	A	Gasoline engine, transversal installation
5 + 6	Displacement in 1/10 liter	15 20	1.5 liter displacement 2.0 liter displacement
7	Performance classes	K U M O T S	Lowest Lower Middle Upper Top Super
8	Revision relevant to approval	0 1 2	New development First revision Second revision

B46 Engine

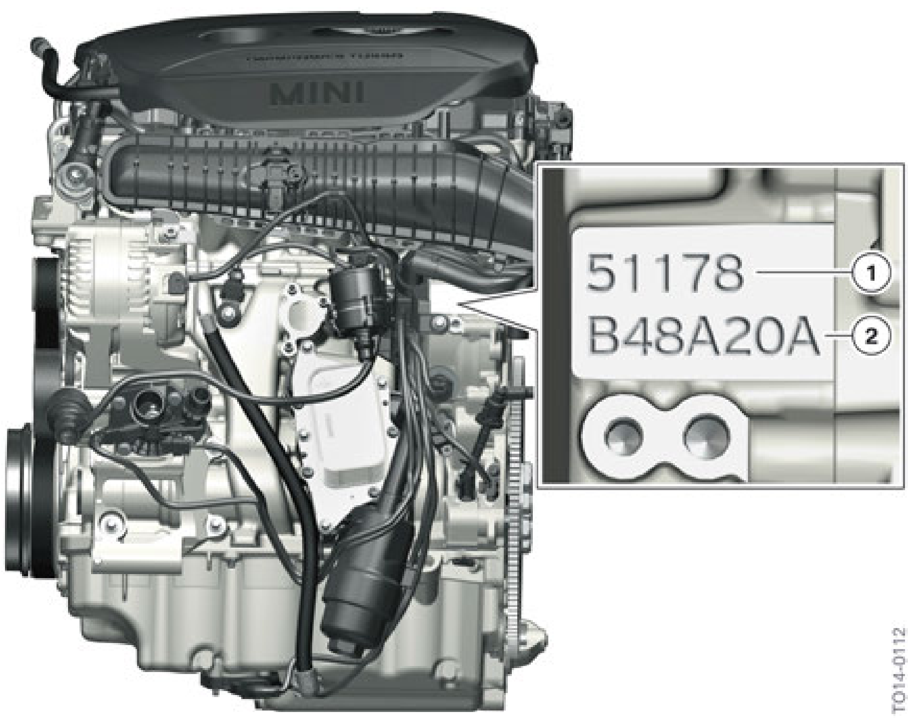
1. Introduction

1.2. Engine identification

The 7-digit engine identification is on the crankcase. The first six digits of the engine identification are derived from the engine type. Only the seventh digit is different. The seventh digit of the engine identification is the test number of the type approval certification.

The consecutive engine number is embossed above the engine identification. Using these two numbers the engine can be clearly identified by the manufacturer.

1.2.1. 4-cylinder engine



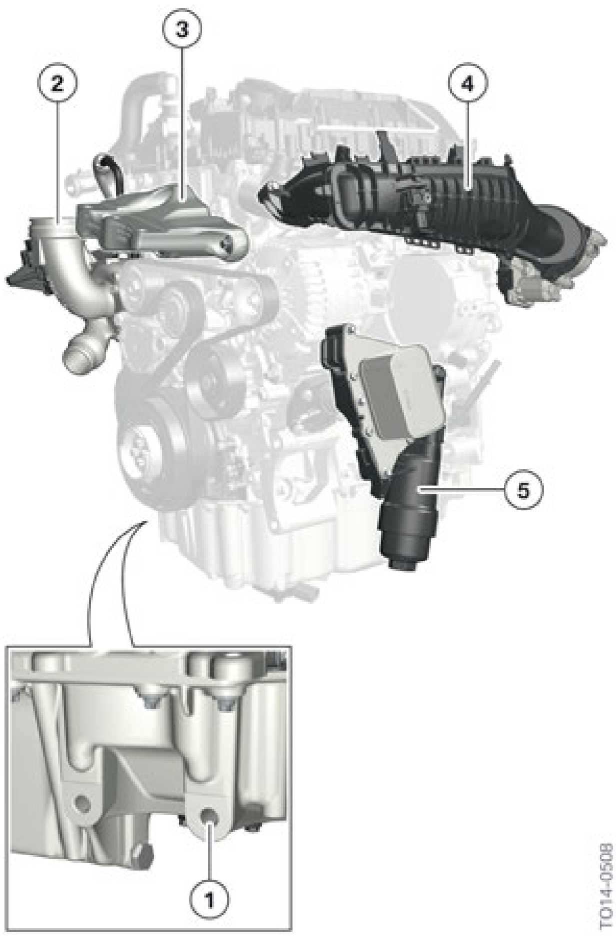
Engine identification for B46 engine

Index	Explanation
1	Engine number
2	Engine identification

1.3. Highlights

1.3.1. Installation positions

Depending on the drive concept, the installation positions of the new engines vary in the different vehicles.



Transverse mounting position, B38 Top engine

Index	Explanation
1	Connection for anti-roll bar link
2	Compressor on intake side, curved
3	Engine mount
4	Intake system in the direction of the transmission
5	Oil filter module, suspended

B46 Engine
1. Introduction

This following drive and installation variants are available:

- Transverse mounting
  Front-wheel drives
  Four-wheel drives
- Automatic transmission

1.3.2. Advantages

Benefits due to lower number of cylinders:

- less weight
- fewer moving masses
- less spatial requirement
- reduction of internal engine friction

The B46 engine is based on the familiar N20 engine. The familiar TVDI[1] technology is used in all new engines. An offset or axial offset, as used in the N20 engine, is not used with the new B46 engine.

The new engine generation is mainly characterized by lower fuel consumption and fewer exhaust emissions (ULEV II). To achieve low fuel consumption, a map-controlled oil pump, characteristic map thermostat and injection system with direct-rail and electric arc wire-sprayed cylinder barrels, among others, are used. All engines also receive an automatic engine start-stop function and intelligent alternator control as a further EfficientDynamics measure.

[1]TVDI technology consists of:

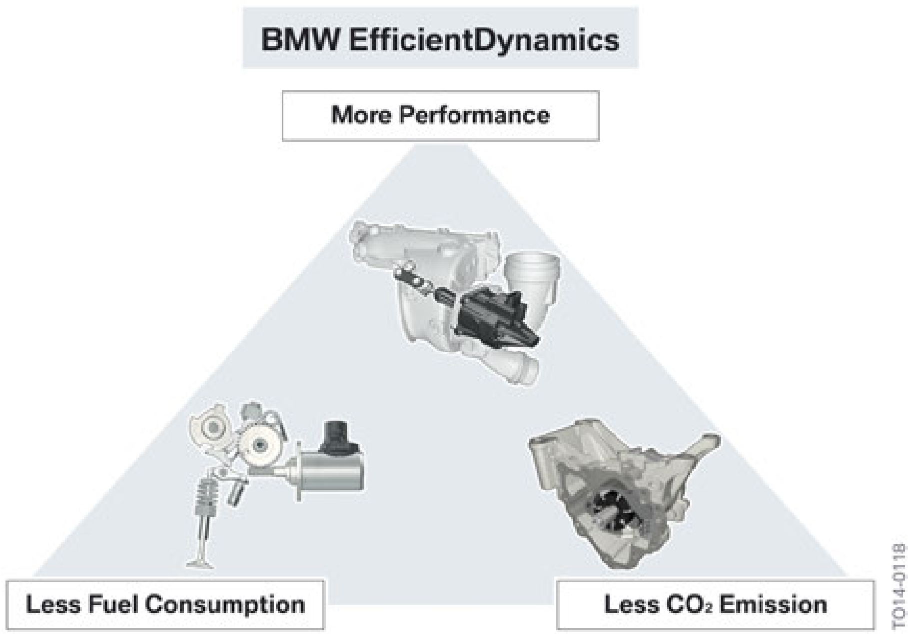
- T = Turbocharger
- V = Valvetronic
- DI = Direct-Injection (direct fuel injection)

1.3.3. Overview of technical features

	B46A20
Map-controlled oil pump	Yes
Electric arc wire-sprayed cylinder barrels	Yes
Twin-scroll exhaust turbocharger	Yes
Electrically adjustable wastegate valve	Yes
Direct rail	Yes
Double VANOS	Yes
Valvetronic	Yes

1.4. Modular design

The EfficientDynamics strategy of the N engine generation has resulted in a large number of different technologies finding their way into the BMW engine world. The strategy for the simplification of inspection work is also pursued with the B engine generation.

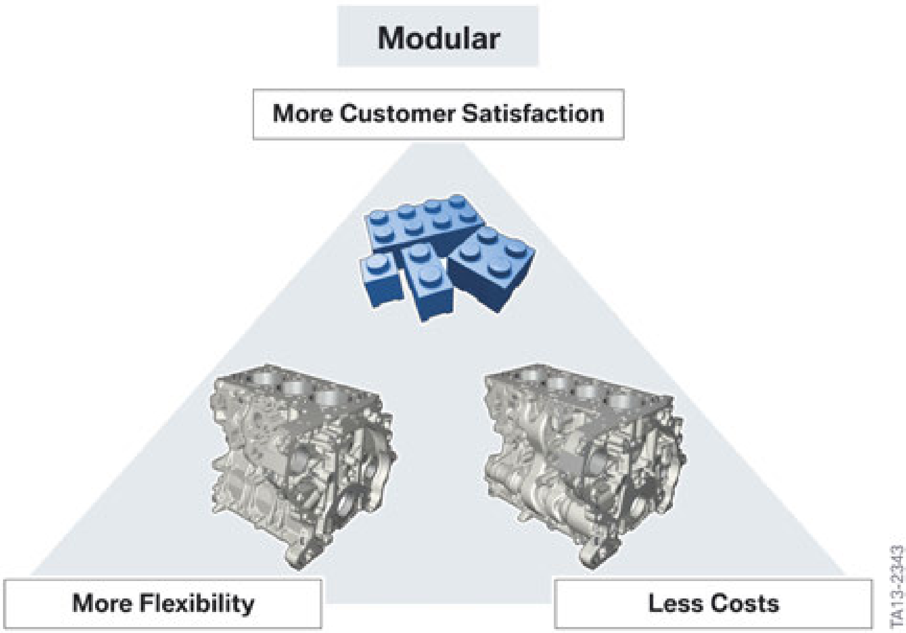


BMW EfficientDynamics strategy of the Bx8 engine generation

Designation	Explanation
BMW EfficientDynamics	BMW EfficientDynamics strategy
More performance	More performance
Less fuel consumption	Less fuel consumption
Fewer CO_2 emissions	Less carbon dioxide emissions

BMW EfficientDynamics also stands for more power, less consumption and less carbon dioxide emissions in the new engine generation. With the additional modular strategy, other objectives such as lower costs, greater production flexibility, as well as enhanced customer satisfaction, are now also being pursued.

B46 Engine
1. Introduction



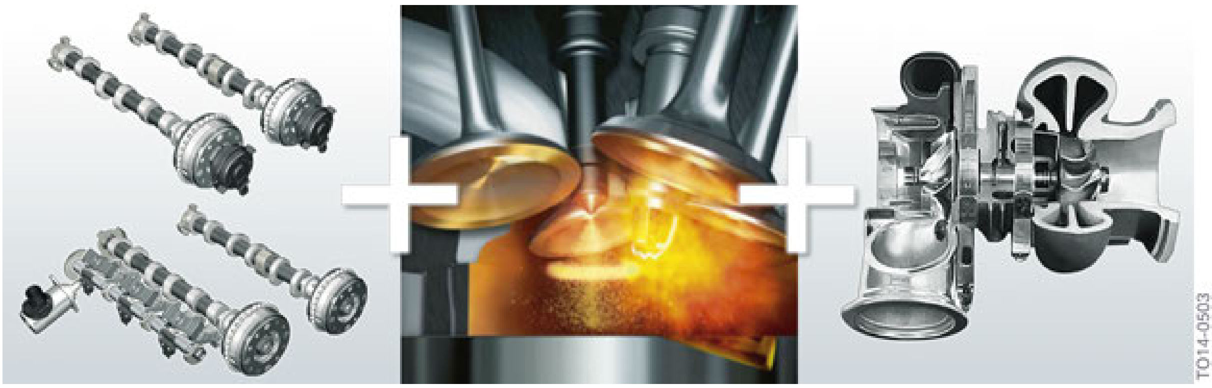
Modular strategy of Bx8 engine generation

Designation	Explanation
Modular	Modular strategy
Enhanced customer satisfaction	Enhanced customer satisfaction
Greater flexibility	Greater flexibility
Less costs	Less costs

The modular strategy aims for different effects throughout the product development process and product life cycle. This allows development and manufacturing costs, for example, to be lowered by using uniform processes. In production, the complexity of the manufacturing process planning and implementation is reduced. In Service, the warehousing is simplified as a result of the reduction of part variety, and the safe handling of products is increased.

1.4.1. TwinPower Turbo

All B46 engines are equipped with the established TwinPower Turbo Technologies.



TwinPower Turbo Technology, B46 engine

TwinPower Turbo means that the following technologies are used:

- VANOS
- Valvetronic
- Direct fuel injection
- Turbocharging

1.5. Technical data

	B46A20M0
Power output in [hp] at [rpm]	231 4700 – 6000
Torque in [Nm] at [rpm]	350 1250
Design/Number of cylinders	Row 4
Displacement in [cm³]	1998
Bore / stroke in [mm]	82/94.6
Compression ratio	11 : 1
Valves per cylinder	4
Used as of	07/2014
Model	X1

1.5.1. Model overview

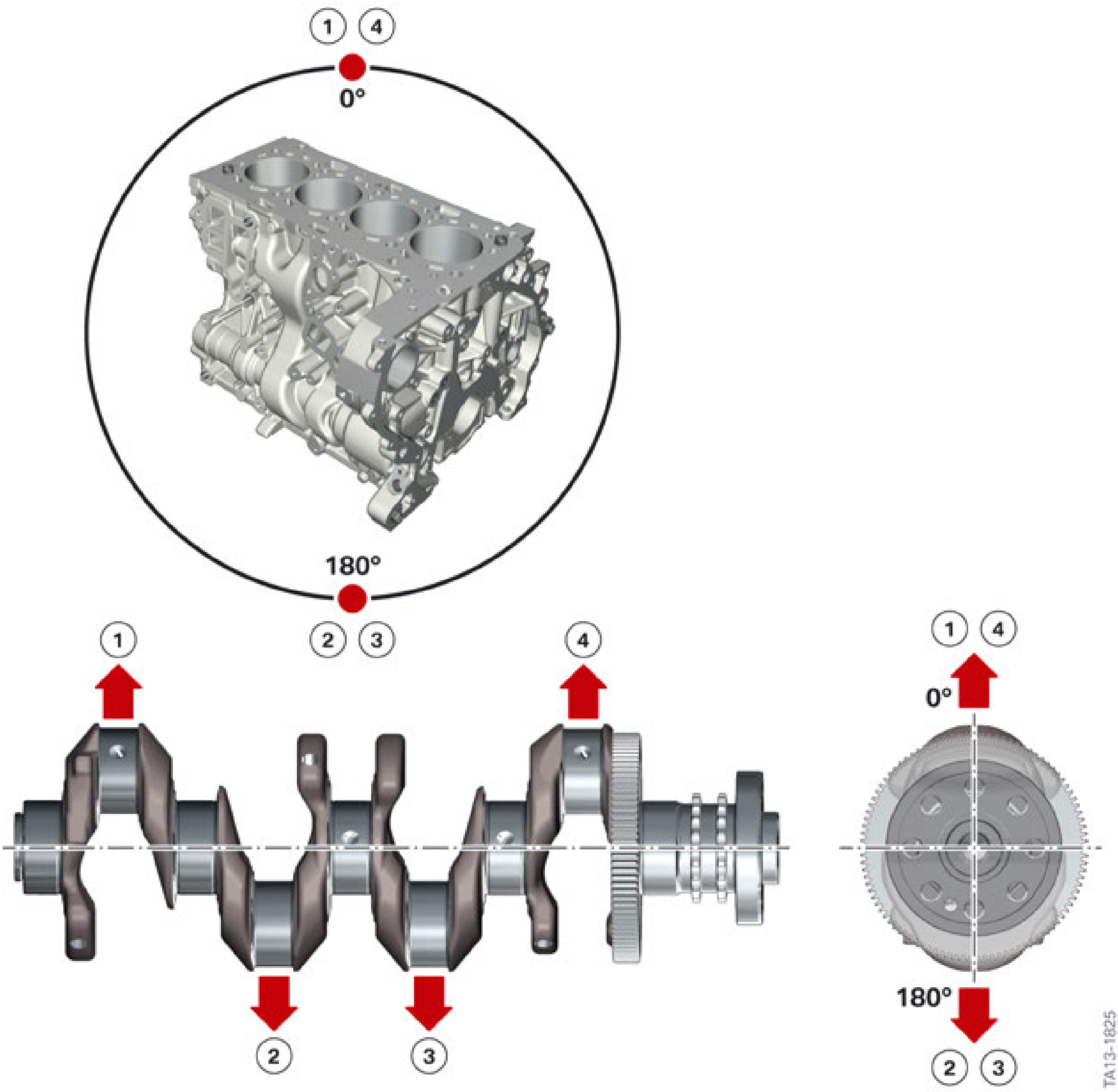
The table below provides an overview of the BMW models in which the new engines are used:

BMW models	Engine
X1	B46A20M0

1.6. Engine acoustics

In order to understand the origin of the acoustic differences, we must take a look at the engine mechanics and compare the design features of the engine. The following graphics illustrate the origin of the different acoustics.

1.6.1. Comparison



Firing interval of B46 engine

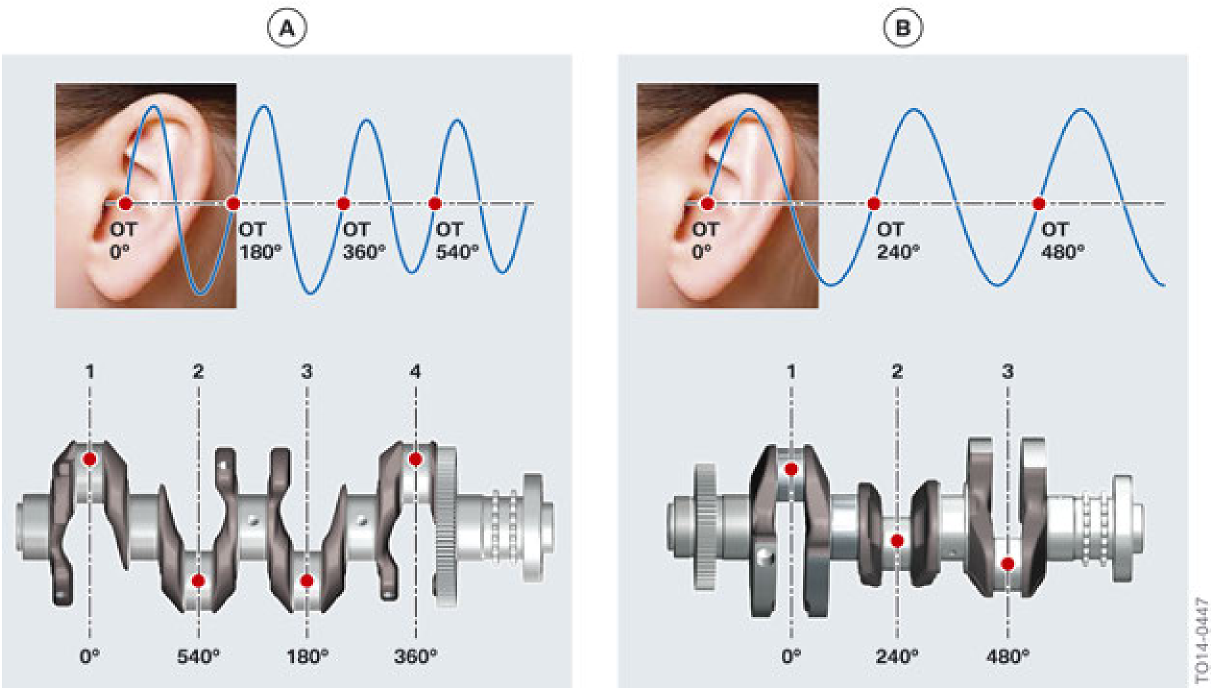
Index	Explanation
1	Connecting rod bearing journal, cylinder 1
2	Connecting rod bearing journal, cylinder 2
3	Connecting rod bearing journal, cylinder 3
4	Connecting rod bearing journal, cylinder 4

B46 Engine

1. Introduction

The graphic shows a 4-cylinder in-line engine with a firing interval of 180° and a firing order of 1–3–4–2. One crankshaft revolution (360°) results in two work cycles for the 4-cylinder in-line engine.

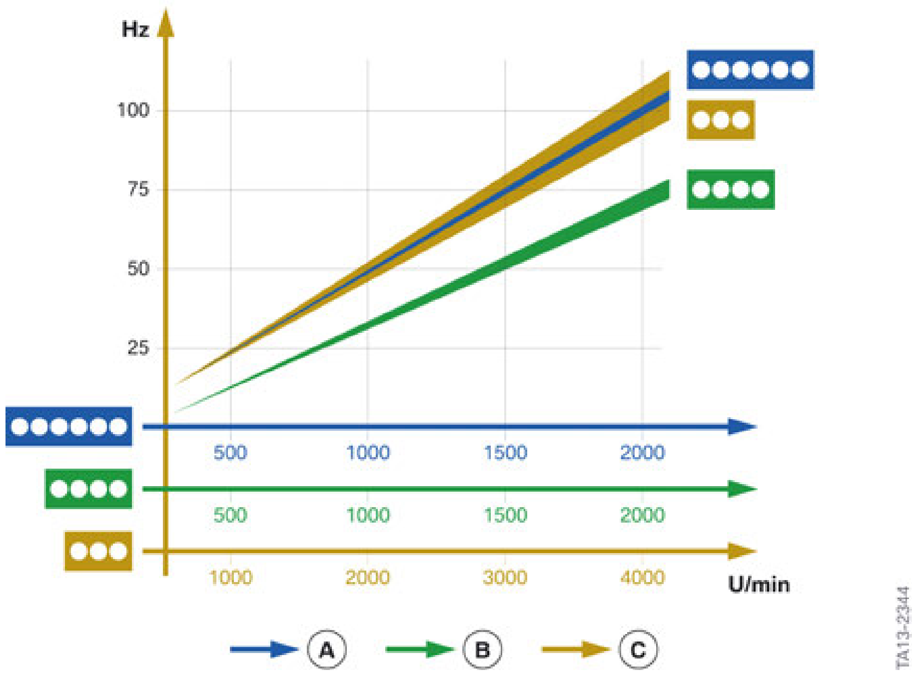
The acoustic differences therefore have their origin in the different firing intervals.



Acoustic oscillations of the Bx8 engines

Index	Explanation
A	Acoustic oscillation of the 4-cylinder in-line engine
B	Acoustic oscillation of the 3-cylinder in-line engine

If one compares the acoustic oscillations of the two engines as a result of the ignition process, there are two different engine sounds. The sound of the 4-cylinder in-line engine is perceived as harmonious and smooth.



Acoustic diagram showing comparison between 3, 4 and 6-cylinder engine

Index	Explanation
A	6-cylinder in-line engine
B	4-cylinder in-line engine
C	3-cylinder in-line engine
Hz	Dominant firing frequency [f]
rpm	Revolutions per minute

The dominant firing frequencies [f] can be calculated as follows:

- 6-cylinder in-line engine (firing order 3)
  f = Engine speed : 60 · 3
- 4-cylinder in-line engine (firing order 2)
  f = Engine speed : 60 · 2
- 3-cylinder in-line engine (firing order 1.5)
  f = Engine speed : 60 · 1.5.

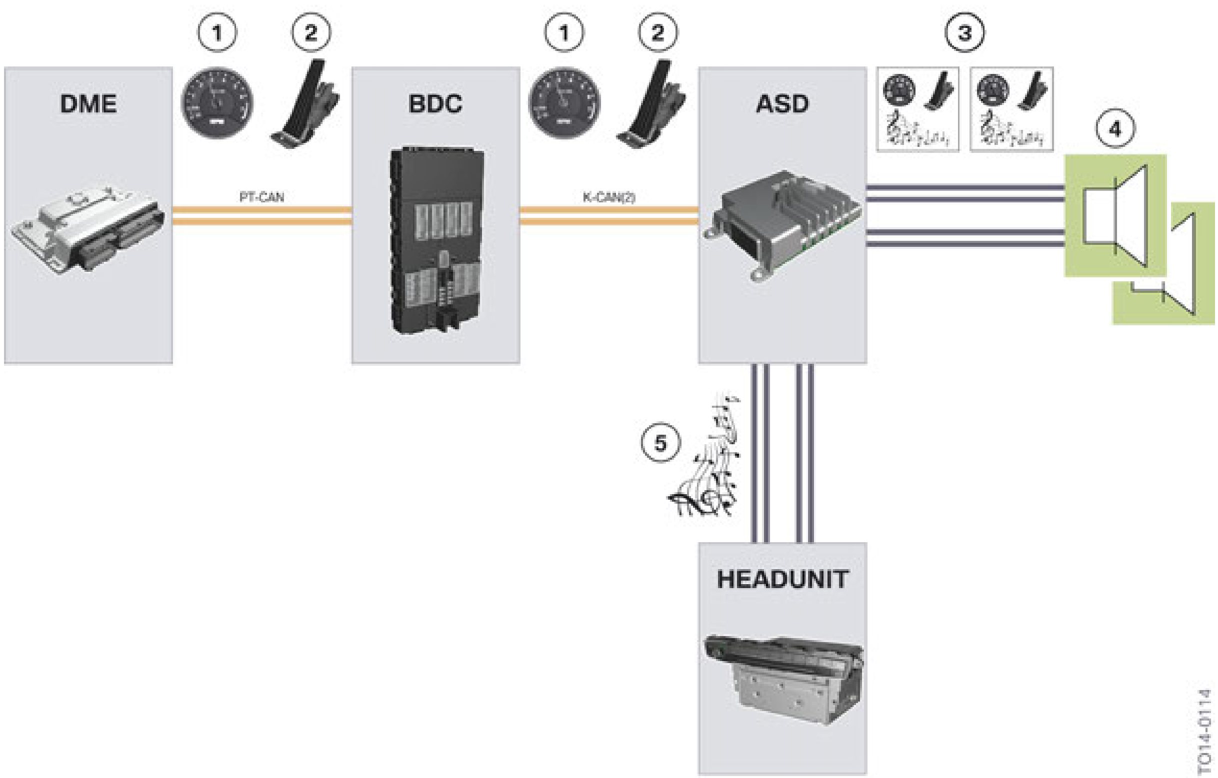
Overview of firing interval

Engine	Number of cylinders	Firing order	Firing interval
4-cylinder engine (B46)	4	1–3–4–2	180°

1.6.2. Active Sound Design

The acoustics of the engine can be adapted using the hi-fi system. With the help of the audio system installed in the vehicle, the vehicle sound pattern is supported by the use of the Active Sound Design. The sound pattern is achieved with the reinforcement of the acoustic components, which are generated by the engine.

The following graphic provides a system overview.



Bus structure of Active Sound Design

Index	Explanation
1	Engine speed
2	Load
3	Audio signal of the Active Sound Design (ASD)
4	Speaker
5	Audio signal of the headunit
ASD	Active Sound Design
BDC	Body Domain Controller
DME	Digital Motor Electronics
Headunit	Control unit for entertainment and infotainment functions
K-CAN/K-CAN2	Body controller area network (2)
PT-CAN	Powertrain controller area network

B46 Engine

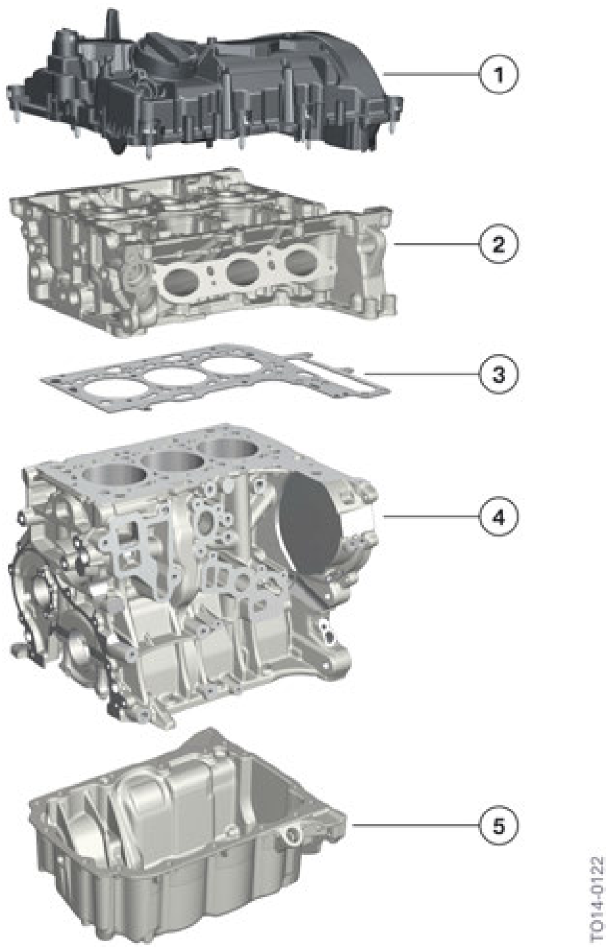
1. Introduction

The Digital Motor Electronics (DME) engine control unit sends information about the engine speed and load via the PT-CAN to the Body Domain Controller (BDC). The Body Domain Controller (BDC) transmits this information from the PT-CAN to the K-CAN/K-CAN2. Via the K-CAN/K–CAN2 the information reaches the Active Sound Design (ASD) control unit. The Active Sound Design (ASD) control unit generates an audio signal with this information. This audio signal is modulated to the audio signal of the headunit and forwarded to the loudspeakers. An engine sound corresponding to the driving condition is output to the driver via the speaker.

The Active Sound Design (ASD) can be muted up to the next terminal change via the ISTA diagnosis system. It is not possible to deactivate the Active Sound Design permanently.

B46 Engine
2. Engine Mechanical

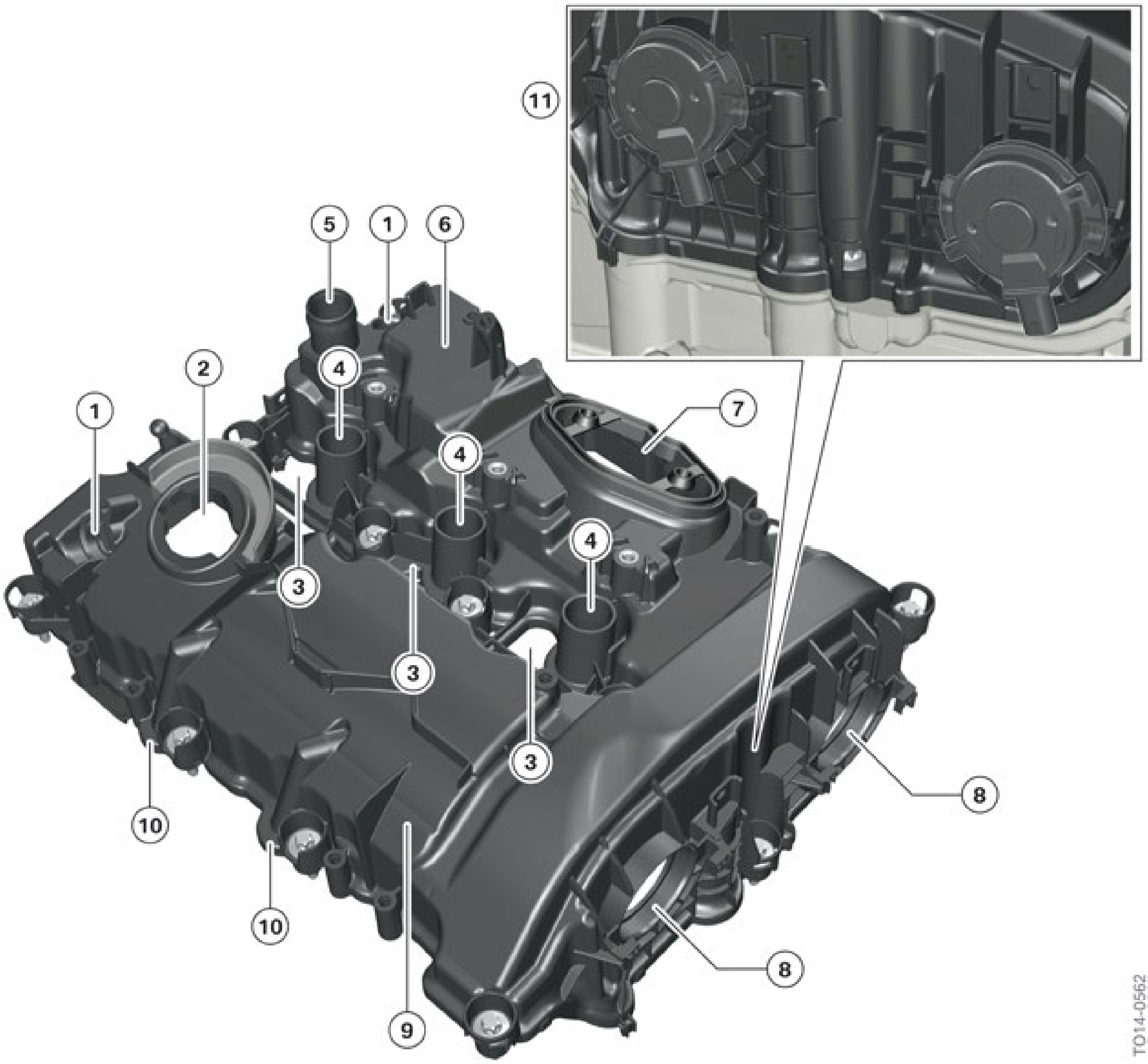
2.1. Engine housing



Engine housing of B38 engine

Index	Explanation
1	Cylinder head cover
2	Cylinder head
3	Cylinder head gasket
4	Crankcase
5	Oil sump

2.1.1. Cylinder head cover



Cylinder head cover B38 engine

Index	Explanation
1	Mountings of camshaft sensors
2	Oil filler neck
3	Recesses for injectors
4	Mountings for ignition coils
5	Blow-by channel, turbocharged operation
6	Oil separator, turbocharged operation
7	Mounting for high pressure pump

Index	Explanation
8	Mountings of VANOS solenoid valve actuators
9	Oil separator, naturally aspirated engine operation
10	Blow-by channel, naturally aspirated engine operation
11	Bayonet fitting with retaining clips

As is the case with the existing N20 engine, the B46 engine also has a recess for mounting the VANOS solenoid valve actuators in the cylinder head cover. In contrast to the N20 engine, the VANOS solenoid valve actuators are not screwed on, and instead are fastened using a bayonet fitting and retaining clips.

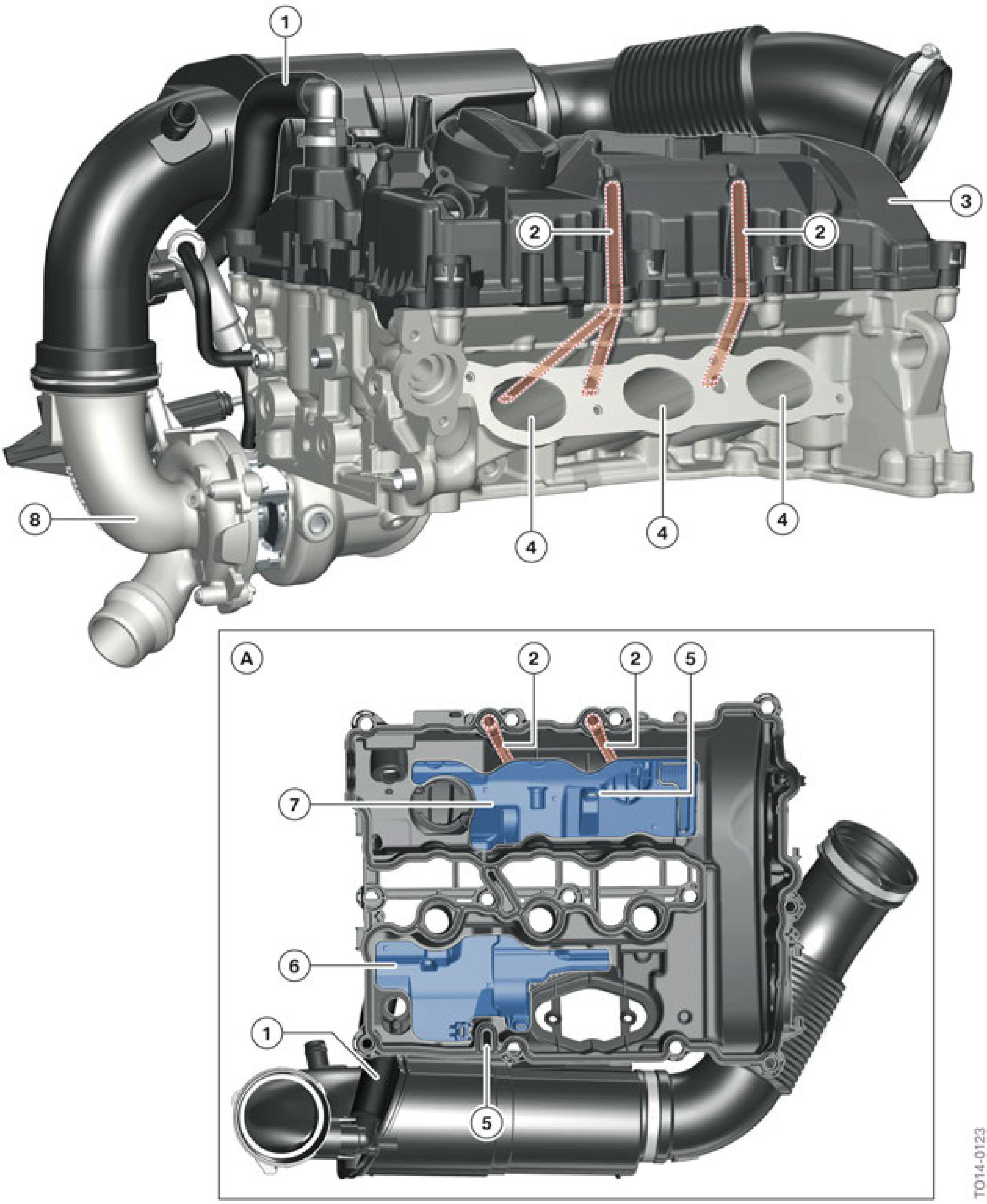
Tasks of crankcase ventilation:

- Regulation of the internal engine pressure.
- Cleaning the blow-by gases to remove engine oil.
- Recirculation of the cleaned blow-by gases in the intake area.

When the engine is in operation, gases (referred to as "blow-by gases") from the combustion chamber pass through the cylinder walls and enter the crankcase. These blow-by gases contain unburned fuel and all elements of the exhaust gas. In the crankcase they are mixed with engine oil which is available there in the form of oil mist.

The volume of the blow-by gases is dependent on the engine speed and the load. Without crankcase ventilation excess pressure would arise in the crankcase. This excess pressure would be present in all cavities connected to the crankcase (e.g. oil return duct, chain shaft, etc.) and lead to oil leakage at the seals.

The crankcase ventilation prevents this. It routes the extensively engine oil-free blow-by gases to the clean air pipe and the separated droplets of oil flow back to the oil sump via an oil return pipe. In addition, the crankcase ventilation, in combination with a pressure control valve, ensures a low vacuum in the crankcase.



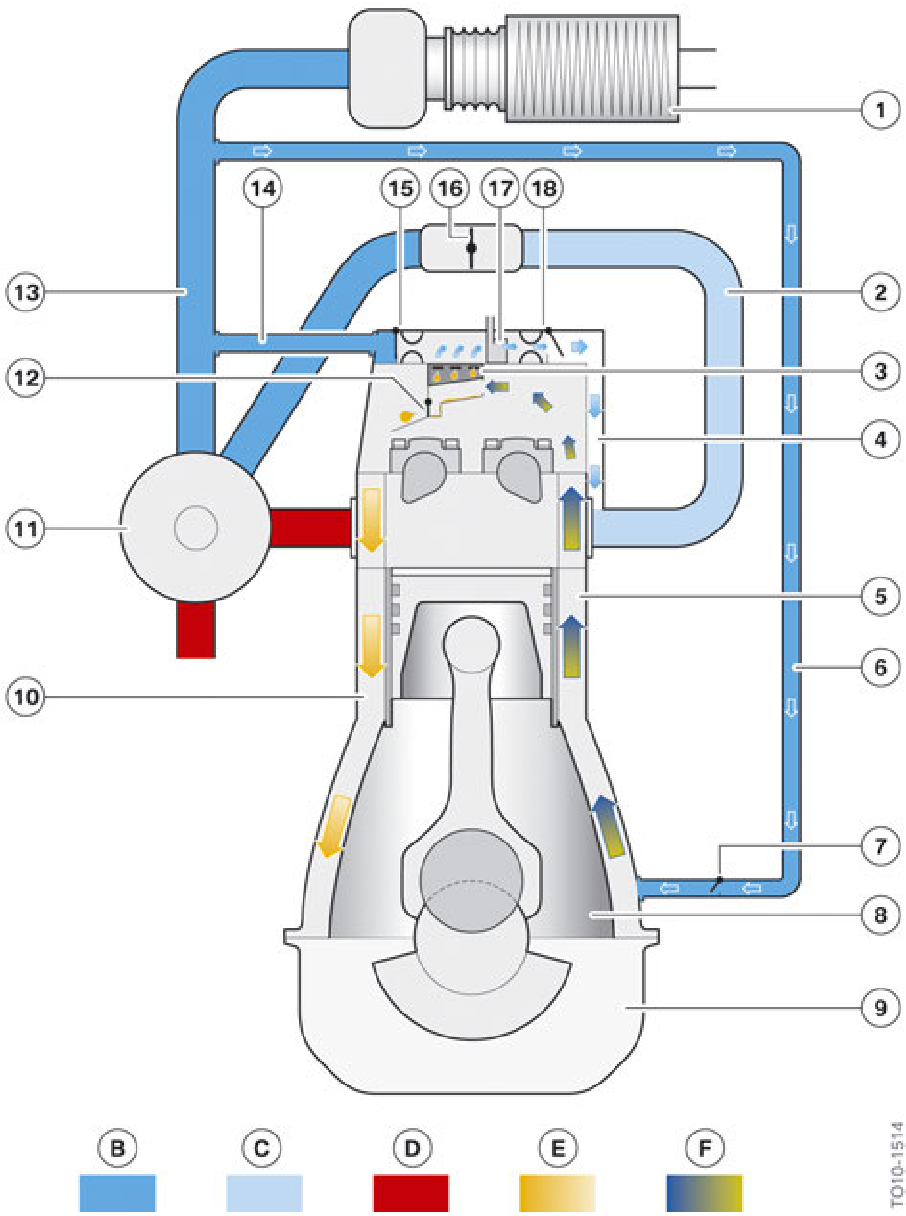
Crankcase ventilation, B38 engine

Index	Explanation
A	Cylinder head cover, view from below
1	Blow-by channel into clean air pipe (turbocharged operation)
2	Blow-by channel upstream of the intake valves (naturally aspirated engine operation)
3	Cylinder head cover
4	Intake ports
5	Oil return
6	Oil separator (turbocharged operation)
7	Oil separator (naturally aspirated engine operation)
8	Exhaust turbocharger

The crankcase ventilation in B46 engine has a two-stage design. This means that, depending on the load condition, the blow-by gases are routed via different channels.

Naturally aspirated engine operation

During naturally-aspirated engine operation, the blow-by gases upstream of the intake valves are routed to the intake port.



Crankcase ventilation, naturally aspirated operation of Bx8 engine

Index	Explanation
B	Ambient pressure
C	Vacuum
D	Exhaust gas
E	Oil
F	Blow-by gas
1	Air filter
2	Intake manifold

Index	Explanation
3	Separator
4	Blow-by channel upstream of the intake valves
5	Blow-by channel upstream of crankcase
6	Purge air line
7	Non-return valve
8	Crank chamber
9	Oil sump
10	Oil return
11	Exhaust turbocharger
12	Non-return valve, oil return
13	Clean air pipe
14	Hose to clean air pipe
15	Non-return valve with restrictor
16	Throttle valve
17	Pressure control valve
18	Non-return valve with restrictor

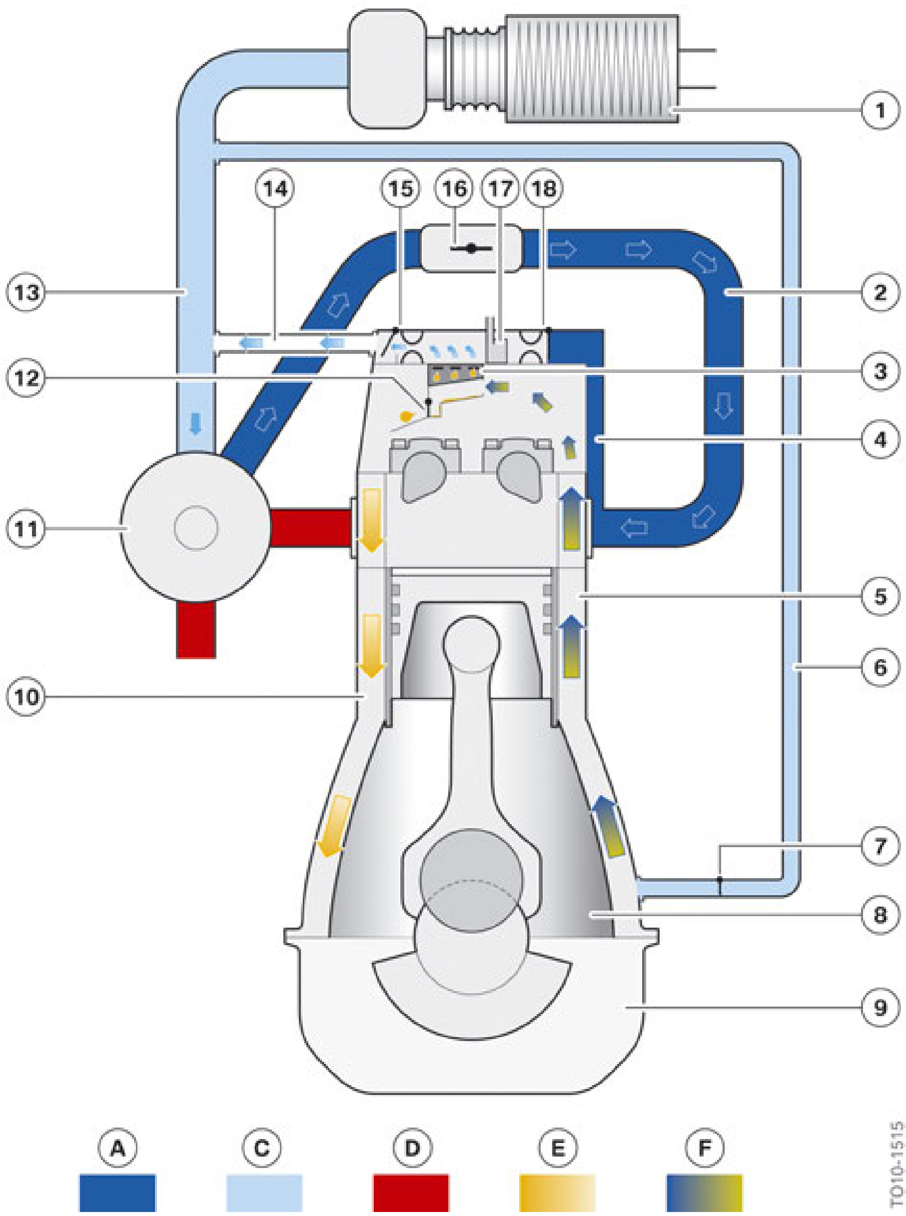
The fine oil mist is separated from the blow-by gases with the assistance of a separator and the oil droplets formed are routed back to the oil sump via the oil return.

The throttle valve is closed during naturally-aspirated engine operation. This produces a vacuum in the intake system. which draws in the blow-by gases via blow-by channels cast into the cylinder head directly upstream of the intake valves. In systems controlled by Valvetronic, the throttle valve is also lightly shut in these operating conditions to guarantee the engine ventilation function.

A purge air line, which is connected to the clean air pipe ahead of the exhaust turbocharger and to the crankcase, routes fresh air via a non-return valve directly into the crankcase chamber. The bigger the vacuum in the crankcase, the bigger the air mass introduced into the crankcase. This purging prevents the pressure control valve from icing up.

Charged operation

As a significant overpressure prevails in the intake pipe during turbocharged operation, the blow-by gases cannot be introduced upstream of the intake valves in the intake port. The blow-by gases are therefore introduced into the clean air pipe in this operating condition.



Crankcase ventilation with turbocharged operation of B46 engine

Index	Explanation
A	Charging pressure
C	Vacuum
D	Exhaust gas
E	Oil
F	Oil and blow-by fuel-air mixture
1	Air filter
2	Intake manifold

Index	Explanation
3	Separator
4	Blow-by channel upstream of the intake valves
5	Blow-by channel upstream of crankcase
6	Purge air line
7	Non-return valve
8	Crank chamber
9	Oil sump
10	Oil return
11	Exhaust turbocharger
12	Non-return valve, oil return
13	Clean air pipe
14	Hose to clean air pipe
15	Non-return valve with restrictor
16	Throttle valve
17	Pressure control valve
18	Non-return valve with restrictor

The fine oil mist is separated from the blow-by gases with the assistance of a separator and the oil droplets formed are routed back to the oil sump via the oil return.

The cylinder head cover is connected to the clean air pipe by a hose. During turbocharged operation, a vacuum is produced in the clean air pipe. This vacuum draws the blow-by gases into the clean air pipe via the hose.

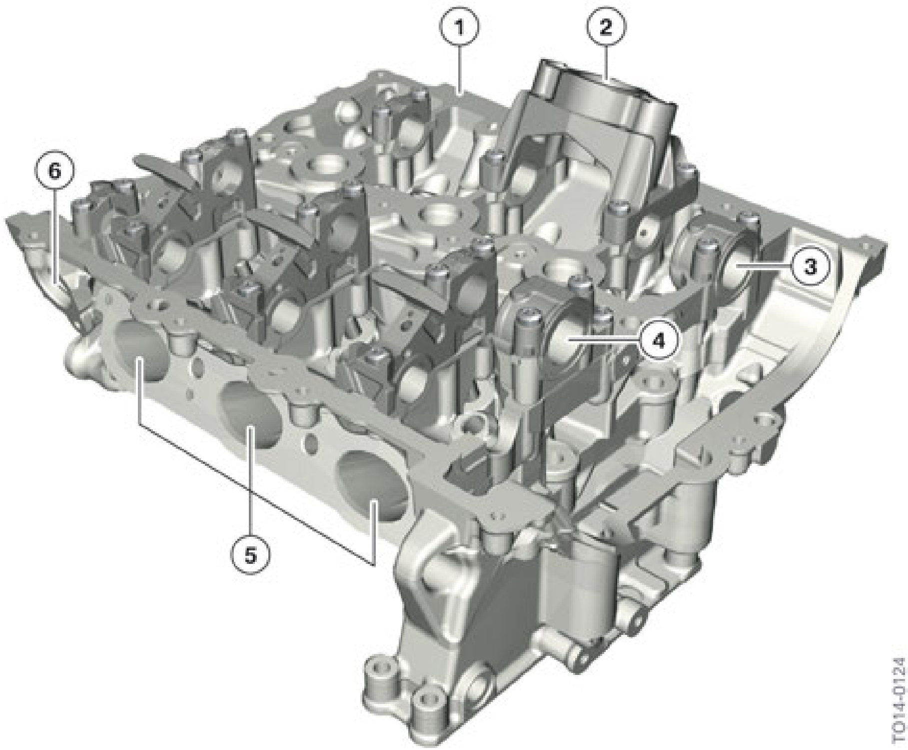
⚠

Always ensure absolute cleanliness when filling the engine with engine oil. Clean the oil filler neck before you screw on the sealing cap. Engine oil residue at the sealing cap may lead to misdiagnosis at the crankcase ventilation.

2.1.2. Cylinder head

Technical features:

- Material: AlSi7MgCU0.5
- Coolant cooling according to the cross-flow principle
- Four valves per cylinder
- Mounting of the valve gear
- Mounting of the Valvetronic and the Valvetronic servomotor
- Mounting of the high pressure pump



Cylinder head of B38 engine

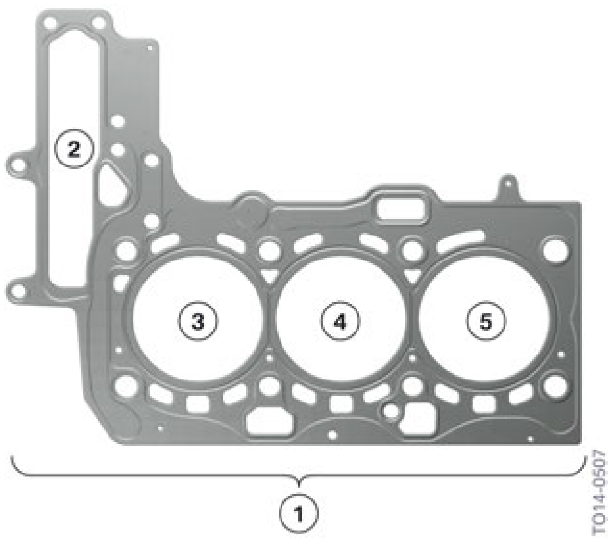
Index	Explanation
1	Cylinder head
2	Mounting, high pressure pump
3	Axial bearing, exhaust camshaft
4	Axial bearing, intake camshaft
5	Intake ports
6	Mounting, Valvetronic servomotor

Cooling concept of cylinder head

The B46 engine has a cylinder head with cross-flow cooling. In the case of cross-flow cooling, the coolant flows from the hot exhaust side to the cooler intake side. This has the advantage of providing uniform heat distribution in the overall cylinder head. Loss of pressure in the cooling circuit is also prevented.

Cylinder head gasket

In order to satisfy the high demands of the B46 engine, a triple-layer spring steel gasket is used as the cylinder head gasket.



Cylinder head gasket in B38 engine

Index	Explanation
1	Spring steel gasket
2	Sealing area of the chain shaft
3	Sealing area, combustion chamber, cylinder 3
4	Sealing area, combustion chamber, cylinder 2
5	Sealing area, combustion chamber, cylinder 1

The cylinder head gasket is produced in two different thicknesses. The thickness of the gasket can only be checked via the part number.

⚠

If a cylinder head gasket has already been used it must not be used again.

2.1.3. Crankcase

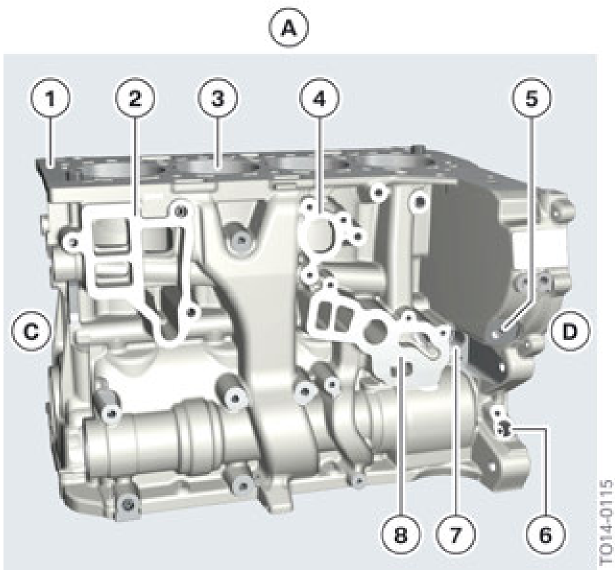
Overview

	Unit	B46A20M0
Displacement	[cm³]	1998
Hole	[mm]	82
Stroke	[mm]	94.6
Single cylinder volumes	[cm³]	499.6
Compression ratio		11 : 1
Distance between cylinders	[mm]	91

B46 Engine

2. Engine Mechanical

Overview



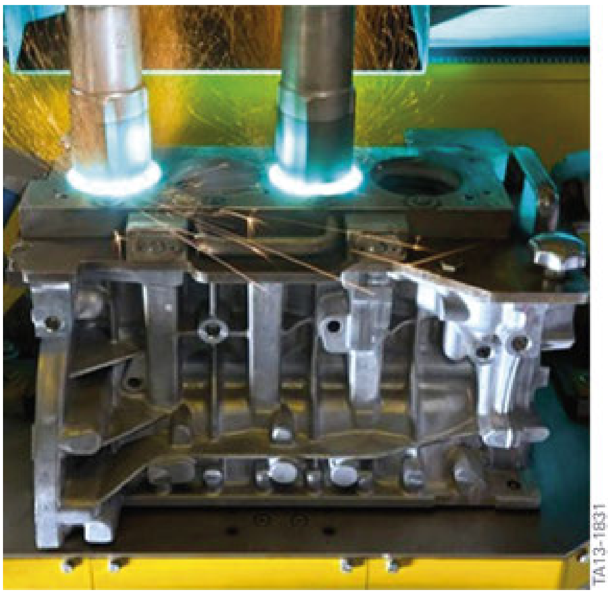
Side view of crankcase, B46 engine

Index	Explanation
A	Crankcase of B46 engine
C	Belt drive side
D	Transmission side
1	Closed Deck
2	Sealing surface, coolant pump (transverse installation)
3	Cylinder barrels (LDS = electric arc wire sprayed)
4	Coolant outlet
5	Bore hole for oil pressure sensor
6	Bore hole for vacuum duct
7	Bore hole, solenoid valve
8	Sealing surface, oil filter module

Characteristics of crankcase:

- Heat-treated all aluminium crankcase made from AlSiMgCu 0.5
- Electric arc wire-sprayed cylinder barrels
- Weight-optimized main bearing cap of crankshaft with embossing teeth
- Closed-deck design
- Deep Skirt
- Oil ducts for the use of a map-controlled oil pump
- Support of counterbalance shaft(s) in cored tunnel

Electric arc wire spraying (LDS)



Electric arc wire spraying method, Bx8 engine

The cylinder barrels of the B46 engine are coated by means of an electric arc wire spraying process. In this procedure a conductive metal wire is heated until it melts. The melt is then sprayed onto the cylinder barrels at high pressure. This layer of ferrous material is roughly 0.3 mm thick, extremely wear-resistant and facilitates an efficient transfer of heat from the combustion chambers to the crankcase, and from there to the coolant ducts.

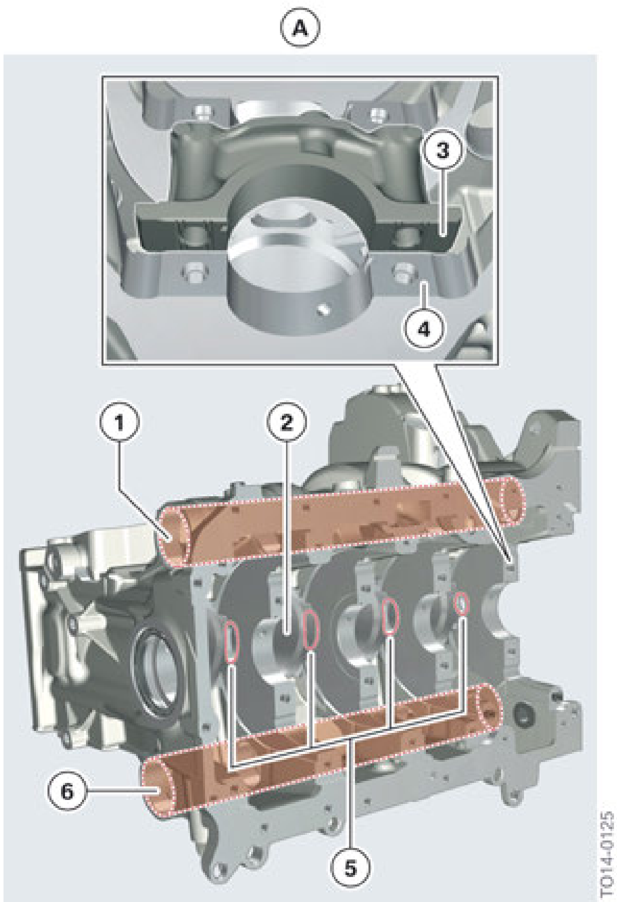
Advantages:

- Lower weight
- High wear resistance
- Good heat dissipation to the crankcase
- Lower internal engine friction thanks to excellent sliding properties

⚠

Due to the thin material application during the electric arc wire-spraying procedure, subsequent processing of the cylinder barrels is not possible.

Bearing, counterbalance shaft



Crankcase from below, Bx8 engine

Index	Explanation
A	Crankcase of B46 engine
1	Position of counterbalance shaft 1
2	Cylinder barrel (coated by electric arc wire spraying)
3	Embossed main bearing cap
4	Main bearing seat
5	Ventilation holes
6	Position of counterbalance shaft 2

In the 4-cylinder engine, these forces are reduced by two counter-rotating counterbalance shafts. For more information, refer to the chapter on Counterbalance shafts.

Closed Deck

With the closed-deck design, the coolant ducts around the cylinder are closed from above and provided with coolant bore holes.

Deep Skirt

With the "deep skirt" concept, the side walls extend far downwards. This lends the crankcase a high degree of stability and considerable flexibility in terms of the piston stroke length.

Embossed crankshaft bearing cap

The weight of the main bearing cap of the crankshaft has been further optimized for the new B46 engine. When the impression connection is made the main bearing cap is designed with a profile. When the main bearing bolts are tightened for the first time, this profile pushes into the surface of the bearing block on the crankcase side.

⚠

Exchange of the main bearing cap, or positioning in another bearing position on the crankshaft, is not permitted and will lead to engine damage.

Ventilation holes

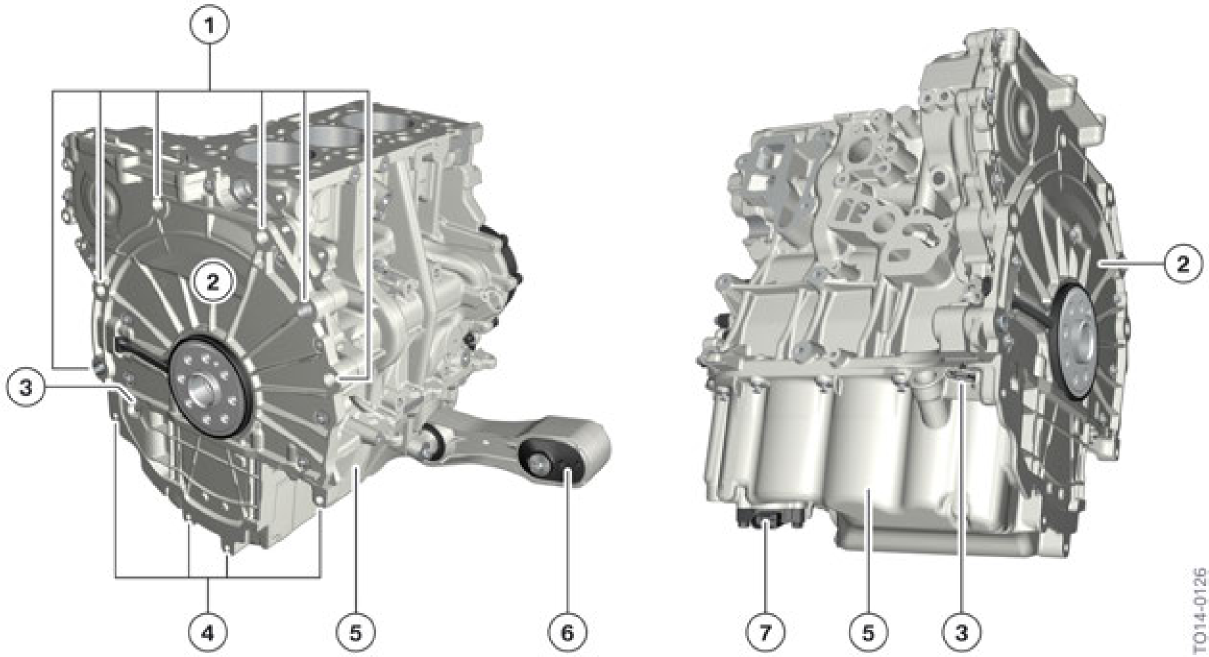
The combustion chambers are connected via ventilation bore holes at the bottom end of the cylinder barrels. The air flows, which arise as a result of the upward and downward movement of the pistons, can thus escape easier via the ventilation bore holes. In addition, as the displacement of air volume has been simplified by using the ventilation bore holes, the piston can move up and down more easily. This reduces the internal friction of the engine and ensures the engine operates more efficiently.

2.1.4. Oil sump

The oil sump is manufactured from die-cast aluminium.

Tasks:

- Collecting vessel for engine oil.
- Collection area for returning engine oil.
- Reinforcing component in the engine-transmission combination.
- Fixture for the oil-level sensor and oil drain plug.
- Connection of the anti-roll bar link for transverse mounting.

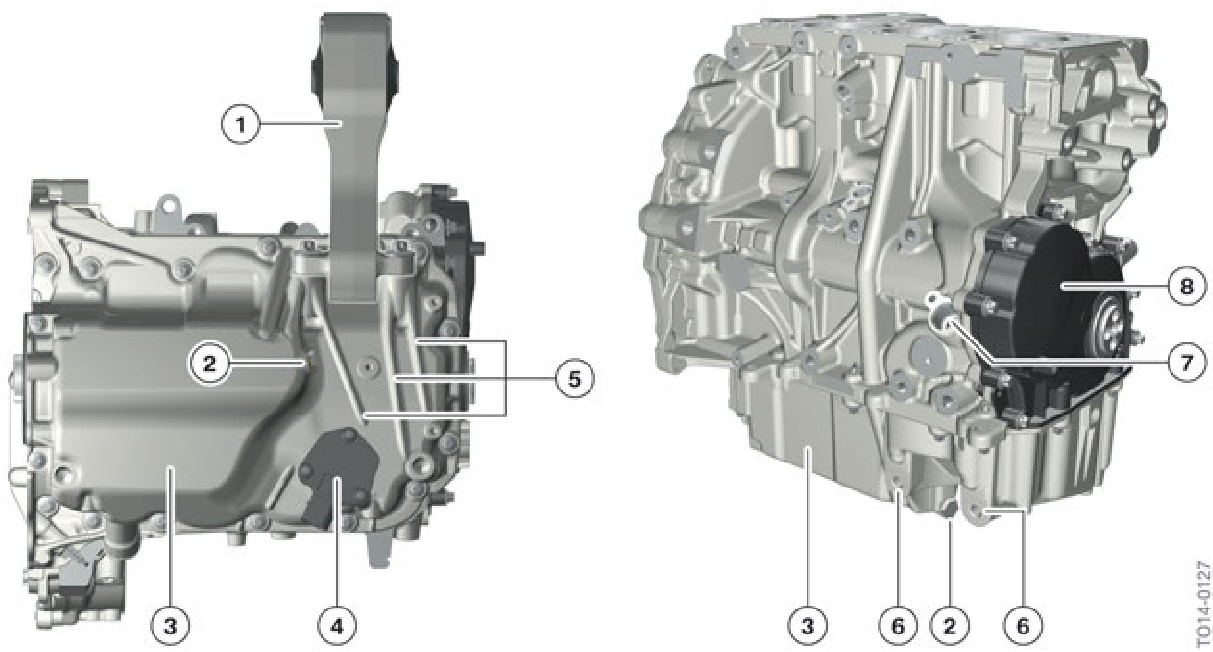


Side view of B38 engine

Index	Explanation
1	Attachment points, crankcase at transmission
2	Timing case cover
3	Seal plug for bore hole of the holding fixture
4	Attachment points, oil sump at transmission
5	Oil sump
6	Anti-roll bar link (only for transverse mounting)
7	Oil level sensor

The engine can be disconnected via a bore hole in the oil sump for adjusting the timing. When installing the oil sump with the transmission removed, make sure that the transmission contact surface of the oil sump and the timing case cover are in one plane. Always use the corresponding special tool. If a gap arises between the two areas when tightening the mounting bolts of the transmission, it causes damage to the oil sump.

2. Engine Mechanical



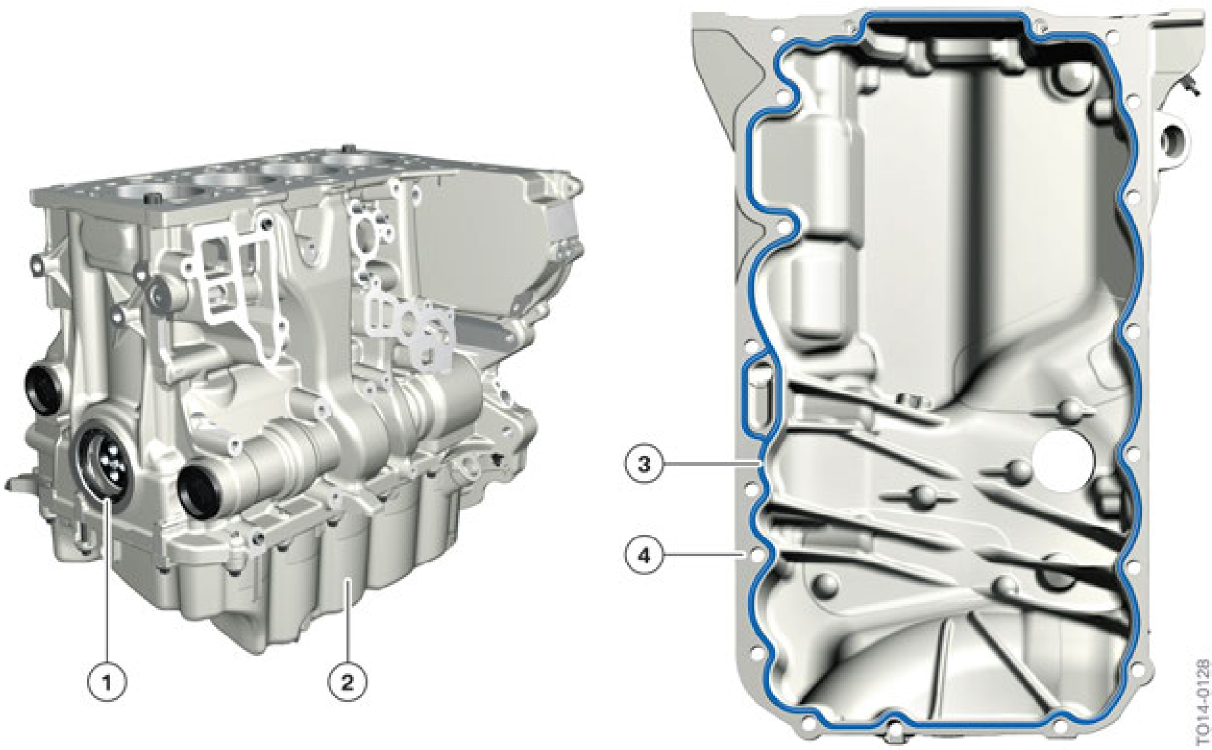
Oil sump of B38 engine

Index	Explanation
1	Anti-roll bar link (only for transverse mounting)
2	Oil drain plug
3	Oil sump
4	Oil level sensor
5	Reinforcing ribs
6	Connection of anti-roll bar link at oil sump
7	Oil return to oil sump
8	Crankcase end cover (belt side)

The engine oil flows from the oil circuit back to the oil sump via the return line of the exhaust turbocharger.

The B46 engine does not have an oil dipstick. The oil level is monitored electronically at all times with the assistance of the oil-level sensor and can be requested via the on-board computer.

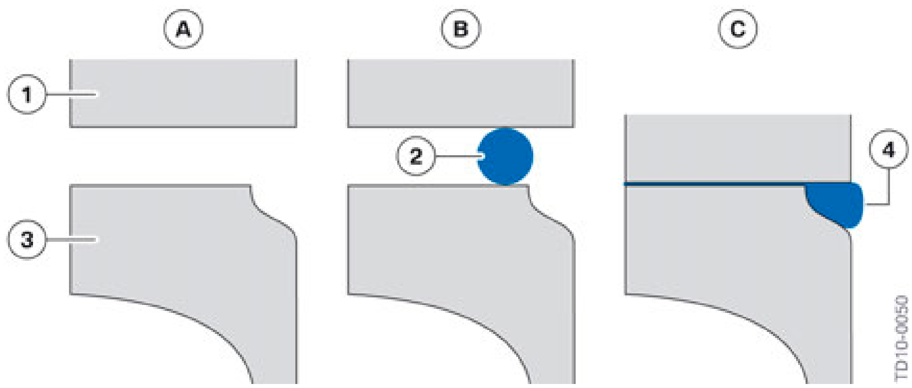
Sealing B46 engine



Oil sump gasket B46 engine

Index	Explanation
1	Radial shaft seal
2	Oil sump
3	Silicone bead
4	Sealing surface, oil sump

A crankcase end cover is not required with the B46 engine. The silicone bead must be applied around the entire sealing surface area of the oil sump.



Schematic diagram for oil sump sealing

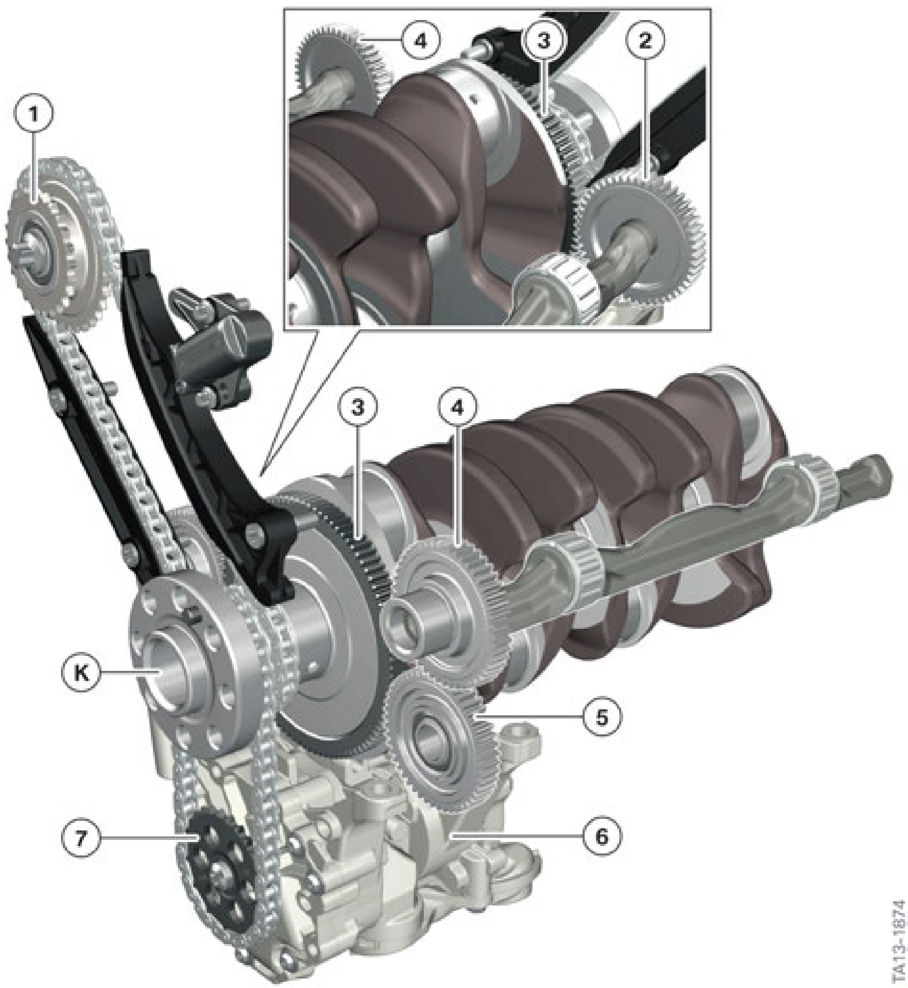
Index	Explanation
A	Components without silicone bead
B	Components with silicone bead
C	Components bolted with silicone bead
1	Crankcase
2	Silicone bead
3	Oil sump with bevel
4	Silicone discharge

In order to seal with sealant, a bevel is required around the inner edge of the flange. Excess sealing compound can be discharged in a controlled manner into the space provided when screwing. Removal of the sealing compound by oil splashes is thus prevented.

2.2. Crankshaft drive

2.2.1. Crankshaft

Overview of crankshaft of B46 engine



Crankshaft of B46 engine

Index	Explanation
K	Transmission side, crankshaft
1	Camshaft sprocket, intermediate shaft
2	Gear, counterbalance shaft 1
3	Crankshaft gear

B46 Engine
2. Engine Mechanical

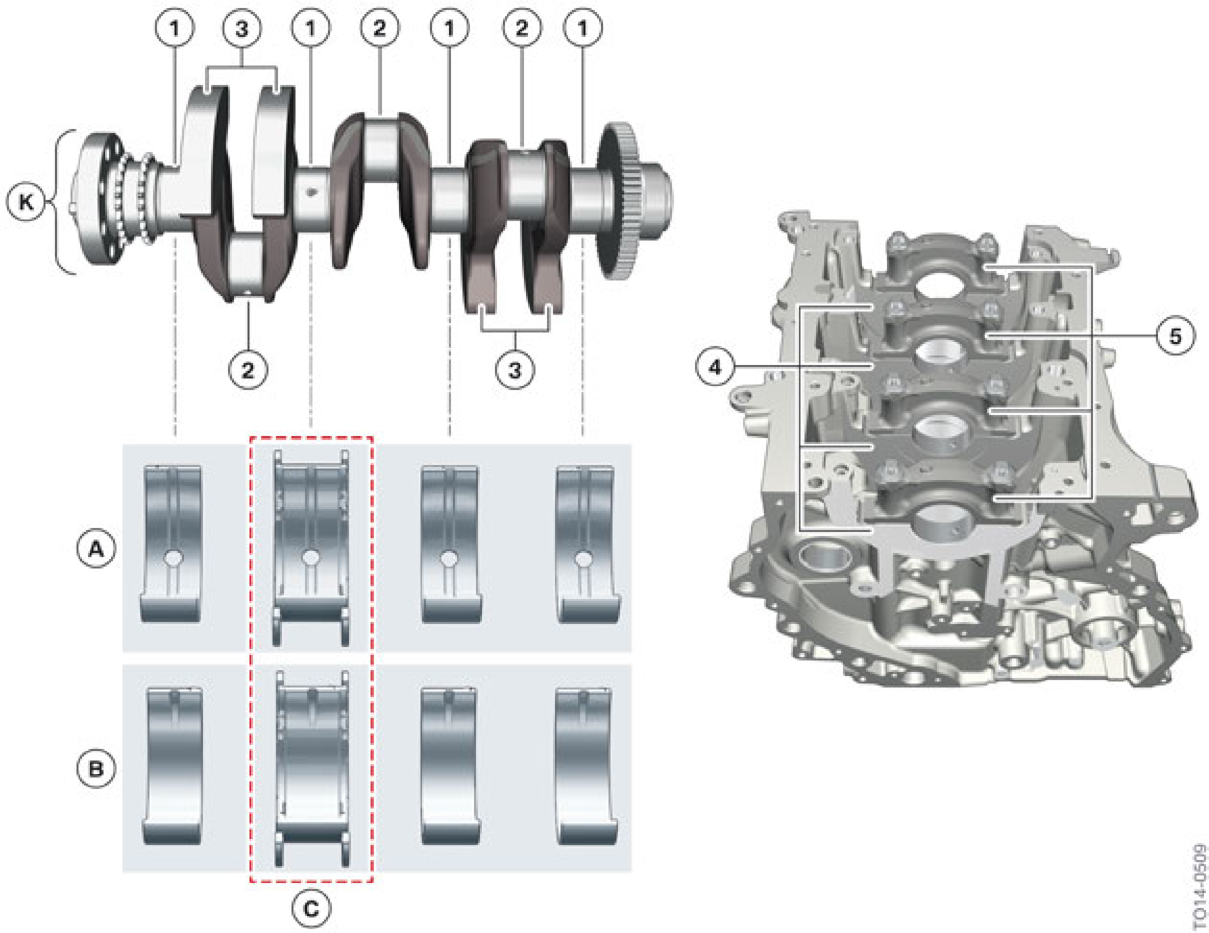
Index	Explanation
4	Gear, counterbalance shaft 2
5	Intermediate gear (change in direction of rotation of counterbalance shaft 2)
6	Oil and vacuum pump
7	Oil pump sprocket

In the B46 engine both the timing chain and the drive for the counterbalance shafts are located on the transmission side of the crankshaft.

Technical data, crankshaft

Characteristics	Unit	B46 engine
Material		C38+N2
Manufacture		Forged
Diameter of the main bearing journal	[mm]	50
Width of the main bearing journal	[mm]	25
Diameter of the connecting rod bearing journal	[mm]	50
Width of connecting rod bearing journal	[mm]	24
Stroke of the connecting rod bearing journal	[mm]	94.6
Throw angle	[°]	180
Number of counterweights		4
Number of main bearing positions		5
Position of the thrust bearing		Bearing 3

Crankshaft bearing in B38 engine



Overview of bearing shells at the B38 engine

Index	Explanation
A	Bearing shell in main bearing seat
B	Bearing shells in main bearing cap
C	Axial guide bearing
K	Transmission side
1	Crankshafts, main bearing
2	Connecting rod bearing journal
3	Counterweights
4	Main bearing seat
5	Main bearing cap

The crankshaft is mounted using different bearing shells. The bearing shells in the low-load zone of the bearing seat have oil holes and a peripheral groove for fresh oil supply. The highly stressed bearing shells in the area of the main bearing cap have no oil holes or grooves.

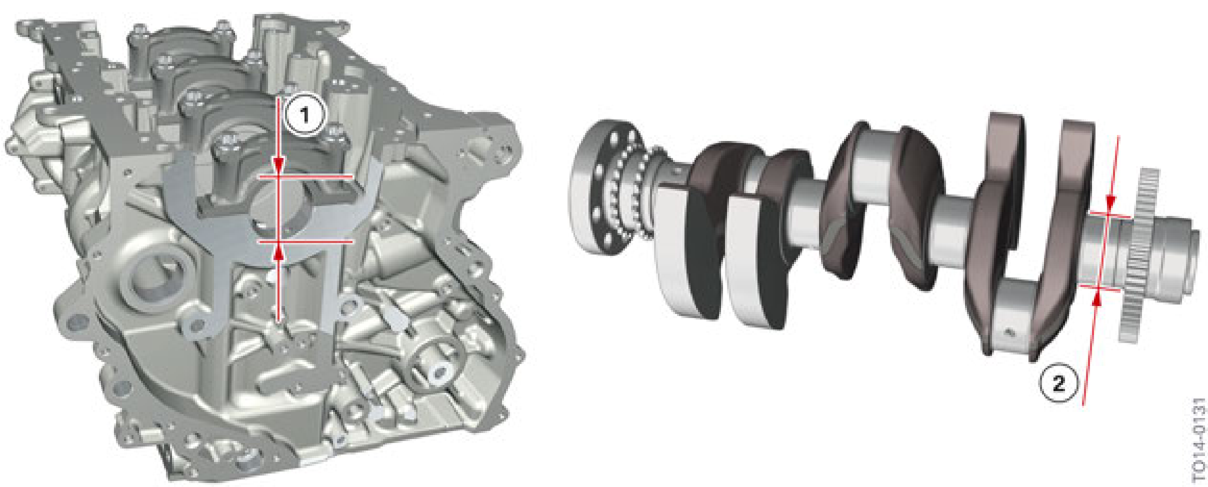
Due to the very low tolerances, special attention must be paid to cleanliness when handling bearing shells.

The axial guide bearing is located in the center bearing area of the crankshaft. This bearing holds the crankshaft in the axial direction and must absorb forces in the longitudinal direction which, for example, can arise during the operation the clutch.

Before the completion of the engine, check the side clearance in accordance with the repair instructions. Excessive side clearance may cause electrical faults or damage to the components.

Identifying the bearing shells

So that the crankshaft can carry out its main task effectively, incorporation of the lifting movement and conversion to a rotational movement, it must be positioned correctly. The dimension to be adjusted can also be called a fit and is generated using crankshaft bearing shells with varying degrees of thickness.



Crankshaft bearing in B38 engine

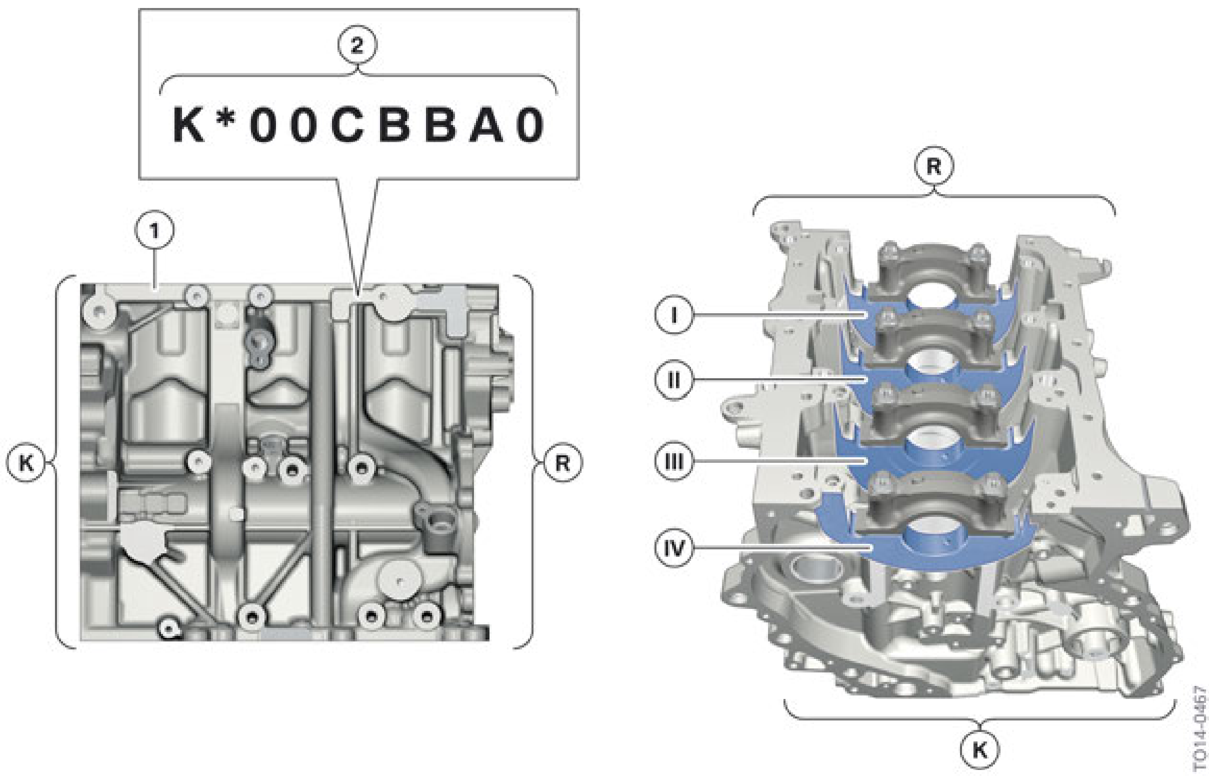
Index	Explanation
1	Hole
2	Shaft

A distinction is made between three types of fit in the design:

- Clearance fit
- Transition fit
- Interference fit

The fit is viewed as an accurate relationship between the bore hole and the shaft. The crankcase represents the bore hole and the crankshaft represents the shaft. This is why the numbers for the classification of the bearing shells are located on the crankcase and the crankshaft. In the case of a dimension being adjusted, this is a so-called clearance fit. A clearance fit is characterized by the fact that in each case the minimum dimension of the bore hole is greater than the maximum dimension of the shaft. This creates the necessary play between the shaft and the bore hole, which is needed for the bearing of the crankshaft.

Bearing shell classification on the bearing seat



Bearing shell classification on the bearing seat, B38 engine

Index	Explanation
I	Bearing seat 1
II	Bearing seat 2
III	Bearing seat 3
IV	Bearing seat 4
K	Transmission side
R	Belt side
1	Crankcase
2	Stamped letters

The stamped letters on the crankcase are used to determine the bearing shell sizes of the bearing seat.

The following letters are used for the classification:

- A = highest possible play (thinnest bearing shell)
- B = medium play (medium bearing shell)
- C = lowest possible play (thickest bearing shell).

The letter K stands for the transmission side of the crankcase. It also specifies the counting order for the assignment.

If there is a K before the stamped letters, then the first letter of the code refers to the bearing shell of bearing seat 4, which is located on the transmission side. The subsequent letters, read from left to right, refer to the bearing seat 3, 2 and 1. The positions marked with "0" are placeholders for larger engines and are simply omitted.

Using the previous graphic for reference, the following combination is obtained:

Assignment:

- Transmission side = K
- Bearing seat 4 = C
- Bearing seat 3 = B
- Bearing seat 2 = B
- Bearing seat 1 = A.

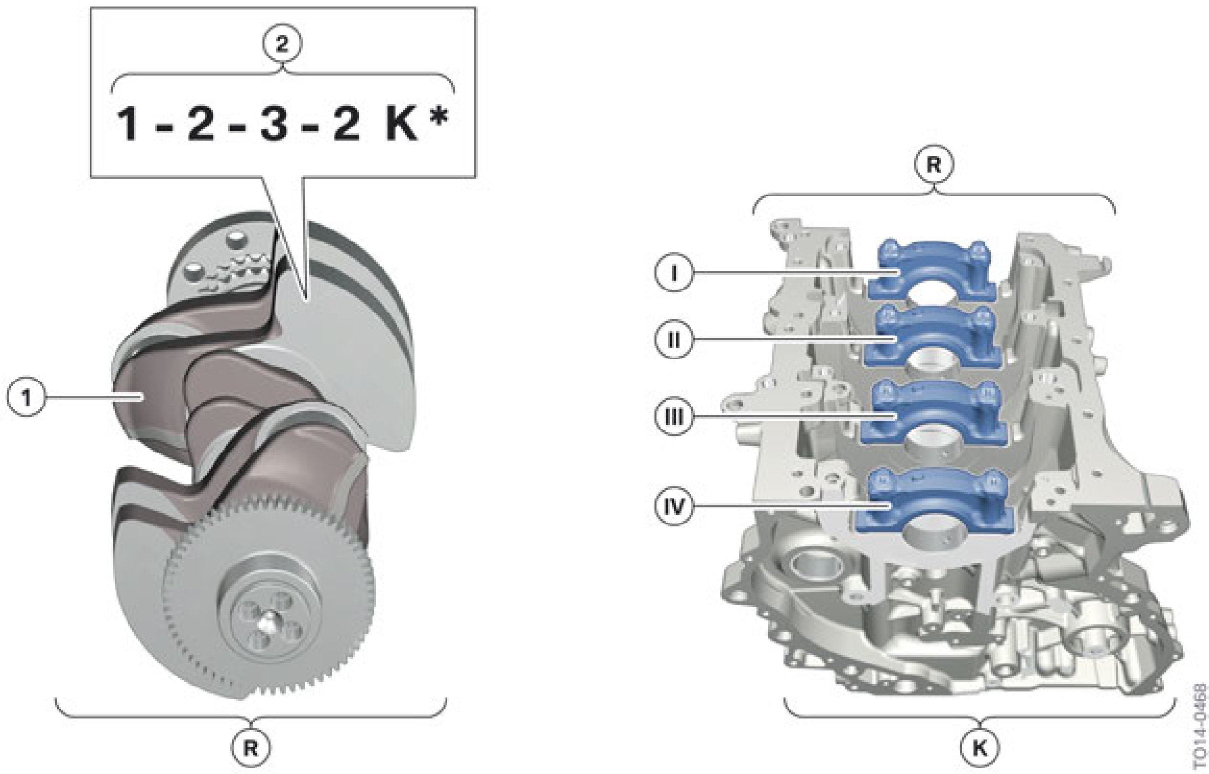
If the stamped letters are not preceded by "K", then the first letter of the code refers to the bearing shell of bearing seat 1, which is located opposite the transmission side on the belt side. The subsequent letters, read from left to right, refer to bearing seat 2, 3 and 4.

When assigning the letters without "K", the following combination is obtained:

Assignment:

- Bearing seat 1 = C
- Bearing seat 2 = B
- Bearing seat 3 = B
- Bearing seat 4 = A.

Bearing shell classification on main bearing cap



Bearing shell classification on main bearing cap, B38 engine

Index	Explanation
I	Main bearing cap 1
II	Main bearing cap 2
III	Main bearing cap 3
IV	Main bearing cap 4
K	Transmission side
R	Belt side
1	Crankshaft
2	Stamped digits

The stamped digit on the crankshaft determines the bearing shell sizes of the main bearing cap.

The following numbers are used for the classification:

- 1 = highest possible play (thinnest bearing shell)
- 2 = medium play (medium bearing shell)
- 3 = lowest possible play (thickest bearing shell).

In the case of the crankshaft, the letter K also defines the assignment of the bearing position. The digit next to the K is to be assigned to the main bearing cap 4 which is on the transmission side. The subsequent digits, read from left to right, refer to the main bearing cap 3, 2 and 1.

Using the previous graphic for reference, the following combination is obtained:

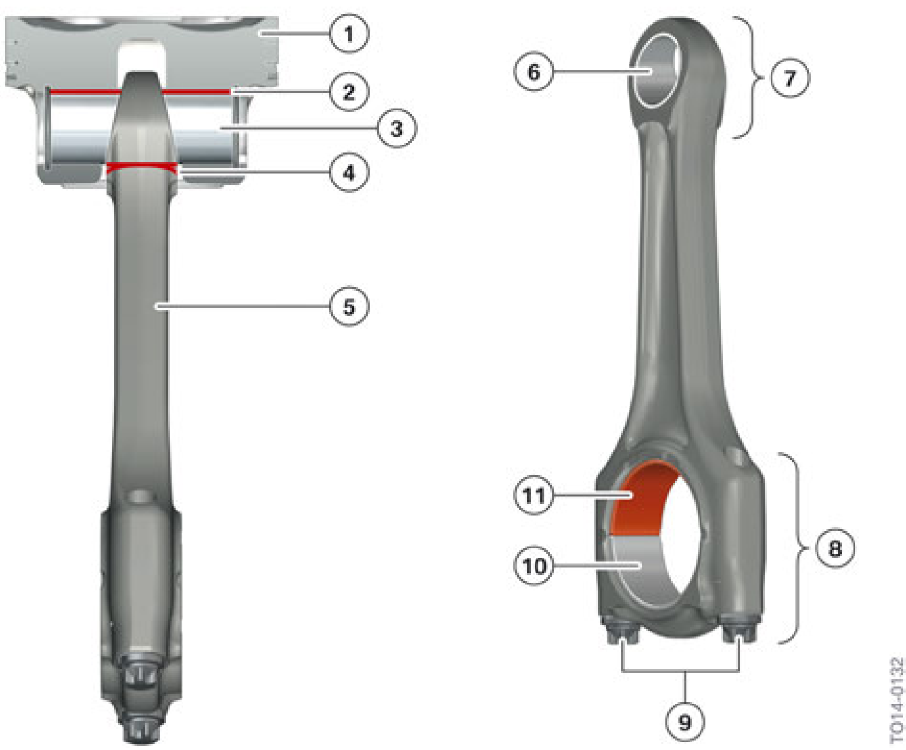
Assignment:

- Main bearing cap 1 = 1
- Main bearing cap 2 = 2
- Main bearing cap 3 = 3
- Main bearing cap 4 = 2
- Transmission side = K.

Deciphering the combination of letters and digits

The letter and digit combination of the main bearing shells can be decrypted using a table in the repair instructions. The correct bearing shell sizes are determined with help of the color codes.

2.2.2. Connecting rod



Connecting rod of B46 engine

Index	Explanation
1	Piston
2	Force-transmitting surface
3	Wrist pin
4	Connecting rod bearing bush with shaped bore hole
5	Connecting rod
6	Connecting rod bush
7	Small connecting rod eye (trapezoidal shape)
8	Large connecting rod eye (cracked)
9	Connecting rod bolts of the connecting rod bearing cap
10	Connecting rod bearing shell of the connecting rod bearing cap
11	Connecting rod bearing shell of the connecting rod (IROX-coated)

The familiar drop-forged cracked connecting rods are used.

⚠

If a connecting rod bearing cap is mounted the wrong way round or on another connecting rod, the fracture structure of both parts is destroyed and the connecting rod bearing cap is not centerd. In this event the entire connecting rod set must be replaced with new parts. In Service please observe the specified jointing torques and angle of rotation specifications in the repair instructions.

Weight classification

To guarantee smooth engine running, the connecting rods are divided into weight classes. The large and small connecting rod eyes are weighed separately and divided into various classes according to their weight.

⚠

In Service only connecting rods of the same weight class can be used. This is why only a full set of connecting rods is available in the event of a replacement. This set comprises the corresponding number of connecting rods of a weight classification.

Irox-coating

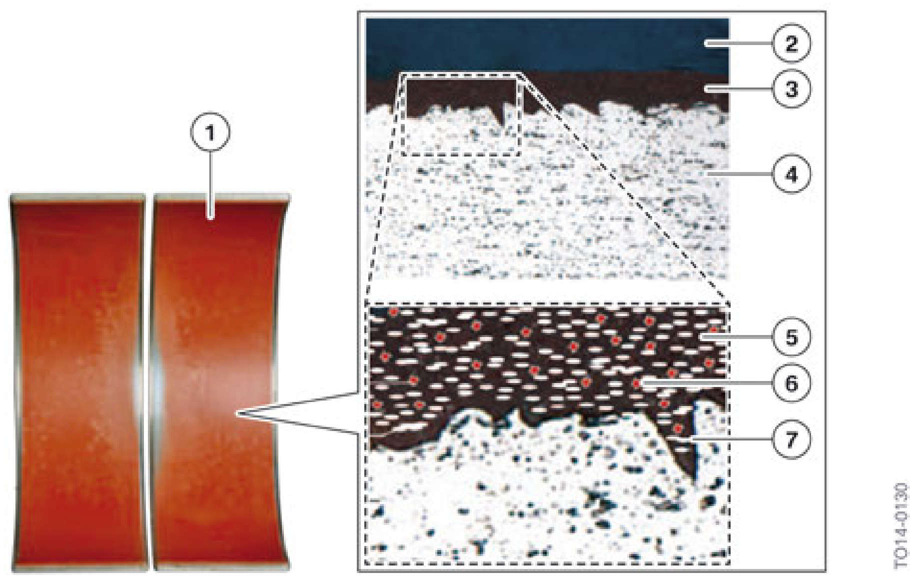
In order to comply with the increasingly stringent exhaust emission regulations, most combustion engines nowadays are equipped with an automatic engine start-stop function. This has led to a huge increase in starting cycles.

To ensure the engine runs smoothly, it is important that sufficient lubricating oil is supplied to the bearing positions of the crankshaft. If the oil supply can be ensured, solid body contact will not occur between the connecting rod bearing journal and connecting rod bearing shell due to the thin lubricating film.

If the engine is now stopped, it will not be possible for the mechanically-driven oil pump to maintain the oil supply. The oil film between the bearing positions flows off. Solid body contact occurs between the connecting rod bearing journal and connecting rod bearing shell. Once the engine is restarted, it takes a certain amount of time for the lubricating film to fully re-establish itself. The connecting rod bearing shell may be subject to wear in this short period. The Irox-coating reduces this wear to a minimum.

The IROX-coated bearing shells are only located on the connecting rod side as here the load acts mainly on the bearing shells. The bearing shell caps are equipped with a bearing shell without IROX coating.

The IROX ball bearings are red due to their special coating.



Detailed magnification of the Irox-coating of the Bx8 engine

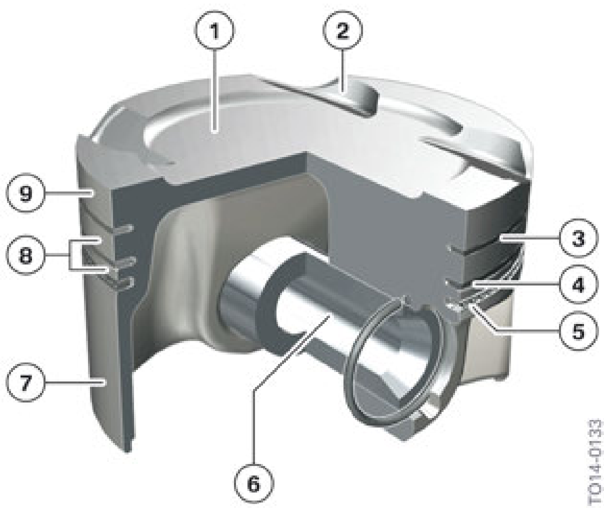
Index	Explanation
1	Irox-coated bearing shell
2	Oil film
3	Irox-coating
4	Bearing shell
5	Binding resin
6	Hard particle
7	Solid lubricant

The Irox-coating is applied to a conventional bearing shell. It consists of a binding resin matrix made of polyamide-imide with embedded hard particles and solid lubricants. The polyamide-imide ensures, in combination with the hard particles, that the bearing shell surface is so hard that material loss is no longer possible. The solid lubricants reduce surface friction and replace the oil film which briefly no longer exists between the bearing shell and the connecting rod bearing journal during the starting phase.

Bearing shell classification of connecting rod bearing

The connecting rod bearing shells are available in one standard size. It is therefore not necessary to follow a procedure similar to that used with the main bearing shells of the crankshaft.

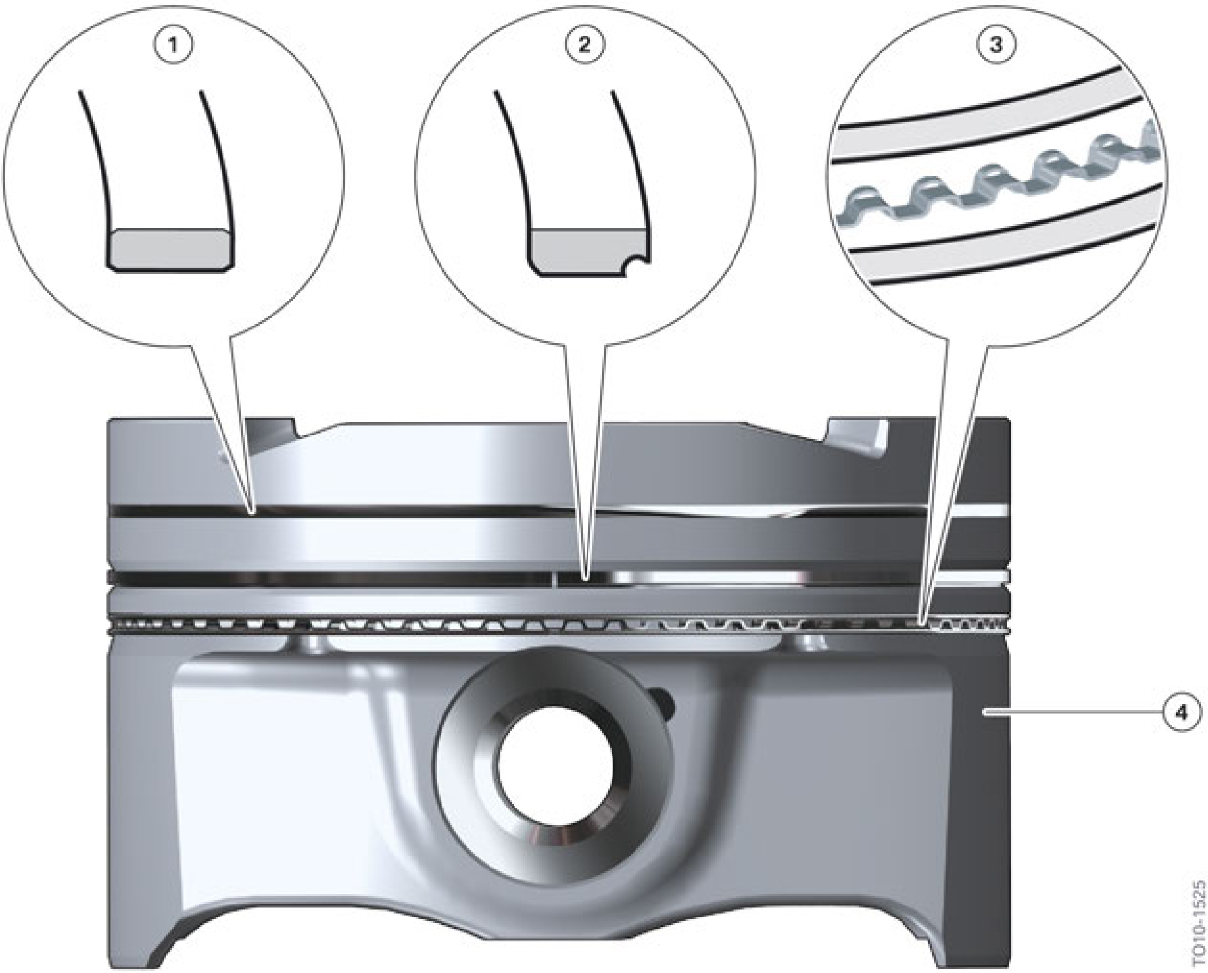
2.2.3. Piston



Piston of Bx8 engine

Index	Explanation
1	Piston crown
2	Valve relief
3	1st piston ring
4	2nd piston ring
5	3rd piston ring
6	Gudgeon pin
7	Piston skirt
8	Ring bar
9	Fire land

Piston rings



Piston rings of Bx8 engine

Index	Explanation
1	Plain compression ring
2	Stepped compression ring
3	Oil scraper ring
4	Piston

To perform their functions, it is necessary for the piston rings to touch the cylinder wall and the edge of the piston groove. Contact with the cylinder wall is effected by the radially acting spring force of the ring. The oil scraper ring is supported by an additional ring.

The piston rings rotate in the grooves while the engine is running and thereby alter the position of the gap. This stems from the lateral force which acts on the piston rings during change of contact. This process removes deposits from the ring grooves. It also prevents the piston ring gap from cutting into the cylinder barrel.

The B46 engine has two compression rings and one oil scraper ring.

The plain rectangular compression ring sits in the first piston ring groove and is used as a plain compression ring.

The taper faced piston ring is also a compression ring. A sharp wiper edge develops through the lug for controlling the oil supply. The undercut of the lug implies that the oil scraped from the running edge is diverted and an oil blockage does not form there, which would otherwise reduce the scraping effect.

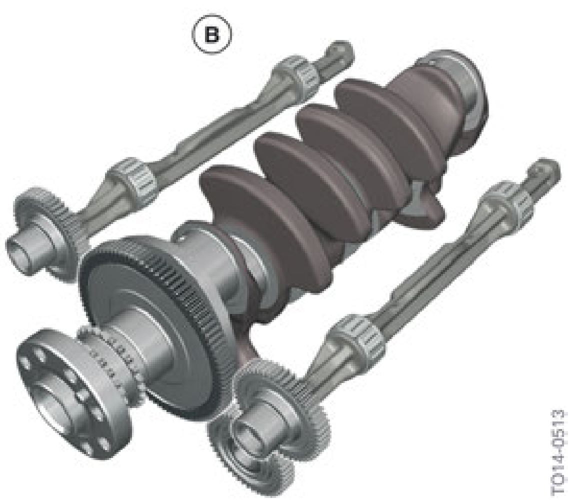
The oil scraper ring is a steel band ring with spring. The two lands and in particular the chamfer create a high surface contact pressure, which promotes the oil-scraping effect.

⚠

The plain rectangular compression ring and the taper faced piston ring have a Top mark. When installing the two piston rings the Top mark must be facing in the direction of the piston crown.

2.2.4. Counterbalance shafts

Due to the operating principle of the piston engine, undesired oscillations occur at the engine housing when driving, which can be transmitted to the vehicle interior. To counteract this negative effect, BMW has already been installing so-called counterbalance shafts in more recent engine generations. Up till now, their role was to cancel out free inertia forces and therefore increase ride comfort. In addition to the inertia forces, so-called 'free moments of inertia' also exist, which can also adversely effect ride comfort. Depending on the engine design and number of cylinders, varying degrees of free inertia forces and free moments of inertia occur.

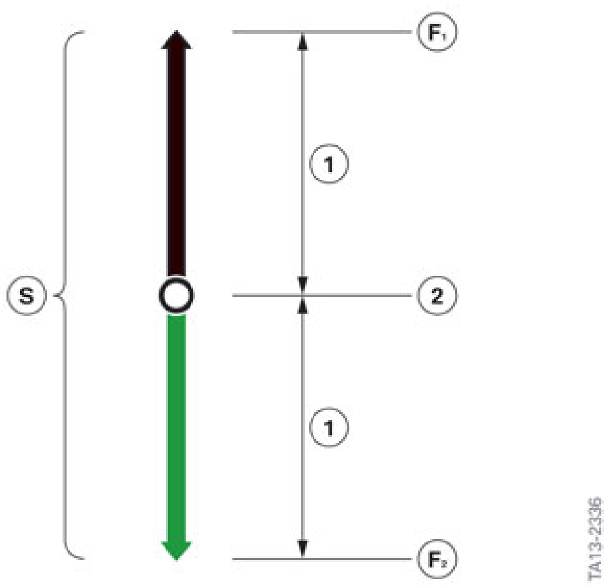


Counterbalance shaft system of the B46 engine

Index	Explanation
B	Counterbalance shafts for the reduction of free inertia forces in the B46 engine

The mass balance is used to offset structural imbalances. The task of the mass balance is to improve the running and noise characteristics of the engine, by neutralizing the free inertia forces and torques. For this reason a brief description of the special features of forces and torques is provided below.

Forces



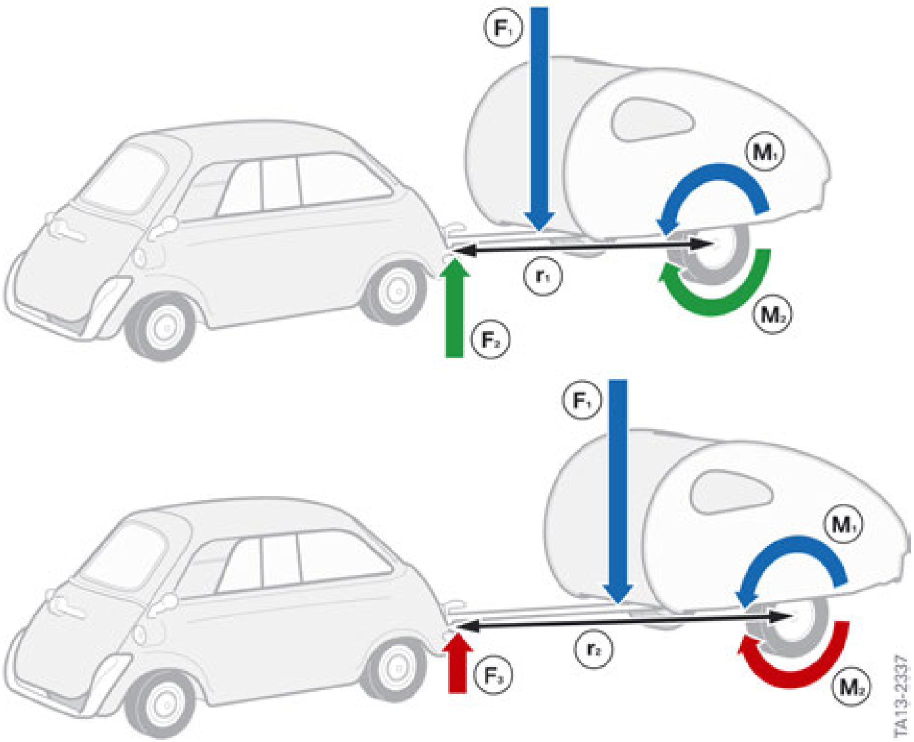
Static force

Index	Explanation
F_1	First force with upwards operating direction
F_2	Second force with downwards operating direction
S	Static
1	Intensity of force
2	Point of action

Forces are invisible and can only be noticed by their effects. They consist of a point of action and an operating direction. Their state can be dynamic or static. The forces are shown as an arrow (vector). The arrowhead provides information on the operating direction of the force. At the other end of the arrow (vector), opposite the arrowhead, is the point of action. The intensity of the force is determined by the arrow length (vector length). The physical unit of force is [N] and the symbol is [F].

The previous graphic shows two forces acting in exactly opposite directions with the same intensity. The system is balanced (static) as both forces cancel each other. When observed from the outside, a reaction cannot be determined.

Torques



Static torque

Index	Explanation
F_1	Contact force [F]
F_2	Large counterforce [F]
F_3	Small counterforce [F]
M_1	Contact torque [M]
M_2	Counter-torque [M]
r_1	Small lever arm [r]
r_2	Large lever arm [r]

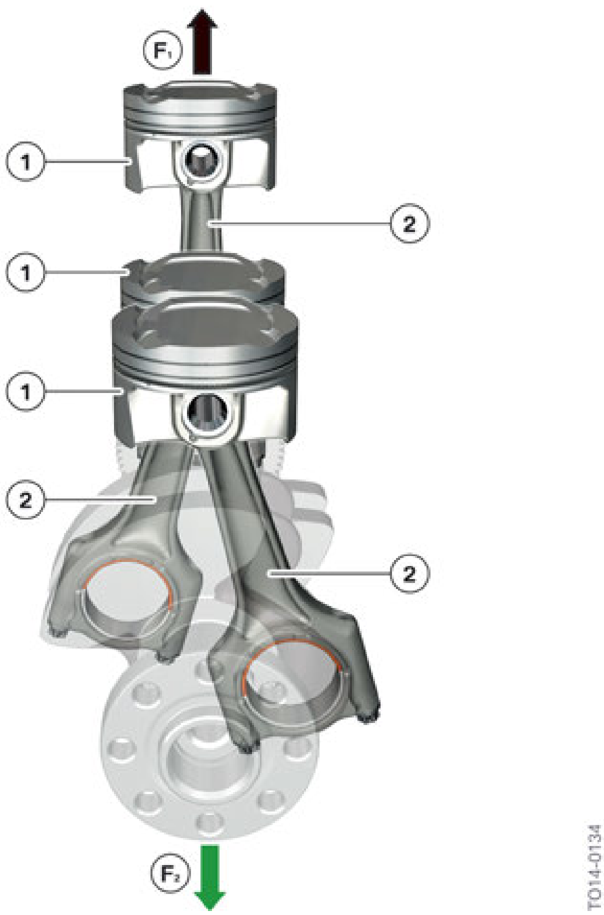
Torques occur if a force is transmitted at its point of action via a lever arm. The physical unit of torque is [Nm] and its symbol is [M]. The lever arm and the force acting at the point of action are decisive for the size of the torque. The following mathematical context emerges:

- $M = F \cdot r$

The previous graphic shows two torques which cancel each other out. If the contact force is increased, without increasing the counterforce to the same degree, the two torques are no longer at equilibrium. The pendant would fall to the floor. To re-establish the static equilibrium of the system, either the counterforce has to be increased or the lever arm extended at which the counterforce acts.

Oscillating and rotating forces

The upwards and downwards movement of the pistons, as well as the connecting rods, is called an oscillating force and the rotational movement of the crankshaft is called a rotating force. These two different forces also cause the undesired oscillations when the engine is running.

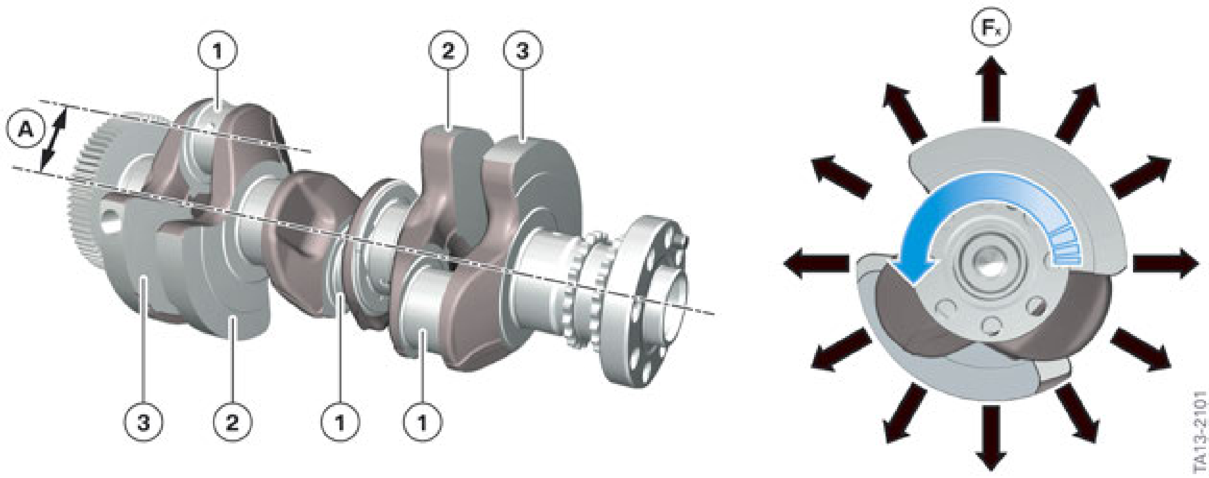


Oscillating forces in the B38 engine

Index	Explanation
F_1	Force directed upwards
F_2	Force directed downwards
1	Piston
2	Connecting rod

Oscillating forces occur in the piston engine when the direction changes at bottom and top dead center. Due to the inertia of the piston and the connecting rod, the force is directed either upwards or downwards. The following therefore applies: the lower the mass of the piston and the connecting rod, the lower the corresponding oscillating forces will be.

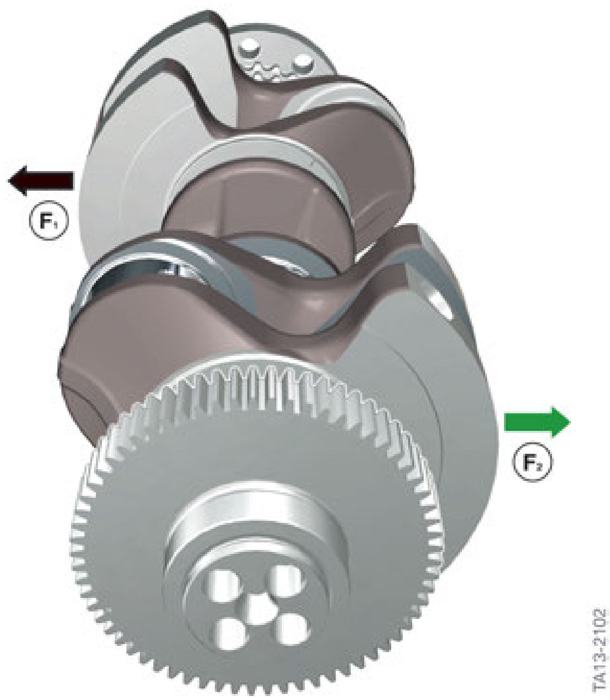
In order to reduce the fuel consumption according to the EfficientDynamics strategy, the power output per liter is increased. Through the use of exhaust turbochargers more power is obtained from the same displacement. This means the pistons and the connecting rod are exposed to higher ignition pressures and must have a more solid design. The masses of the components subsequently increase, and thus the oscillating forces.



Rotating forces in the B38 engine

Index	Explanation
A	Piston stroke (offset of connecting rod bearing journal)
F_x	Rotating forces
1	Connecting rod bearing journal
2 + 3	Counterweights

To produce a rotating movement of the crankshaft from the stroke of the piston, the connecting rod bearing journals that support the large connecting rod eye are not located on the axis of rotation of the crankshaft. An imbalance when turning the crankshaft occurs by the offset of the connecting rod bearing journals. The arising imbalance is counteracted by the use of counterweights.



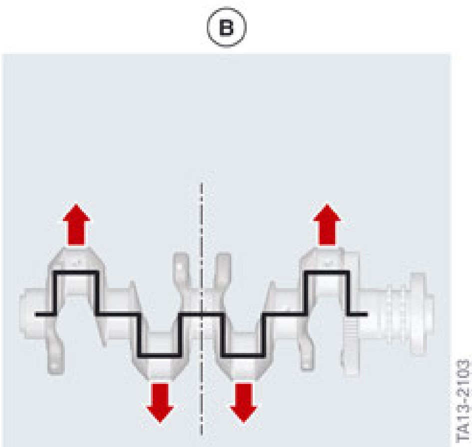
Counterweights of crankshaft of B38 engine

Index	Explanation
F_1	Force of the crankshaft weight directed to the left
F_2	Force of the crankshaft weight directed to the right

The rotating inertia forces can be completely neutralized with help of the counterweights at the crankshaft. Some of the weight at the crankshaft is also used to reduce the oscillating inertia forces (change of direction of the piston and connecting rod). If the entire oscillating inertia forces are reduced by counterweights at the crankshaft, the forces or torques (depending on the design and number of cylinders) in the top and bottom dead center of the pistons are neutralized. However, this would also mean that in the piston intermediate position (piston between top dead center and bottom dead center) the inertia forces of the counterweights work in a lateral direction. The result would be vibrations which are transmitted via the crankshaft bearing to the crankcase and finally to the entire vehicle.

This conflict can be resolved through the use of counterbalance shafts, as well as clever weight classification of the counterweights at the crankshaft.

Oscillating torques



Oscillating torques

Index	Explanation
B	4-cylinder engine

This example shows why the design plays a role in which forces or torques occur during engine operation.

In contrast, the forces which occur at the crankshaft of the 4-cylinder engine when the engine is running cancel each other out. Free moments of inertia therefore do not occur.

Order

The inertia forces are divided into "orders". The more frequently an inertia force occurs during each crankshaft revolution (360°), the greater its order of magnitude will be.

The free inertial forces and torques categorized as follows:

- Inertia forces, 1st order
- Inertia forces, 2nd order
- Inertia torques, 1st order
- Inertia torques, 2nd order.

The following table provides an overview of the arising forces and torques depending on the design and number of cylinders

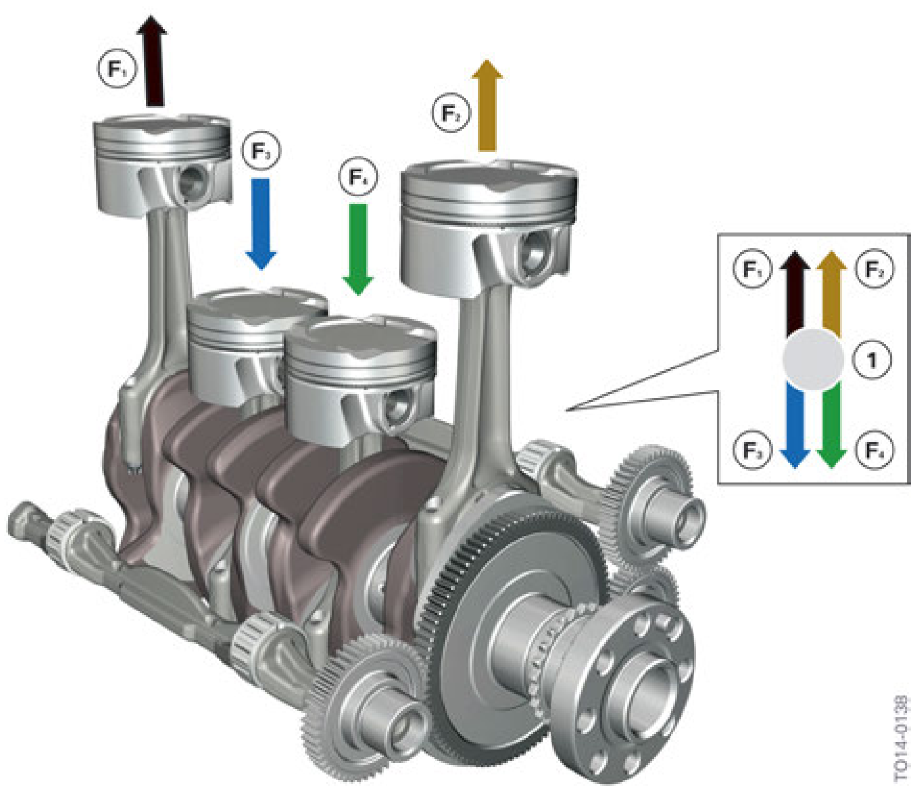
	Inertia forces, 1st order	Inertia forces, 2nd order	Inertia torques, 1st order	Inertia torques, 2nd order
4-cylinder in-line engine	—	X	—	—
6-cylinder in-line engine	—	—	—	—

The table provides information on which forces and torques occur and their order of magnitude. Free inertial forces and moments of inertia of the first order are the most noticeable. Free inertia forces and moments of inertia of the second order are perceived is much less troublesome. The greater the order of magnitude is therefore, the more it can be disregarded for the purposes of mass balancing.

The table shows that the best engine design in terms of smooth running is the 6-cylinder in-line engine. All forces cancel each other out. Therefore, with this engine design no additional measures for neutralizing the rotating or oscillating masses have to be implemented.

2.2.5. Counterbalance shaft of B46 engine

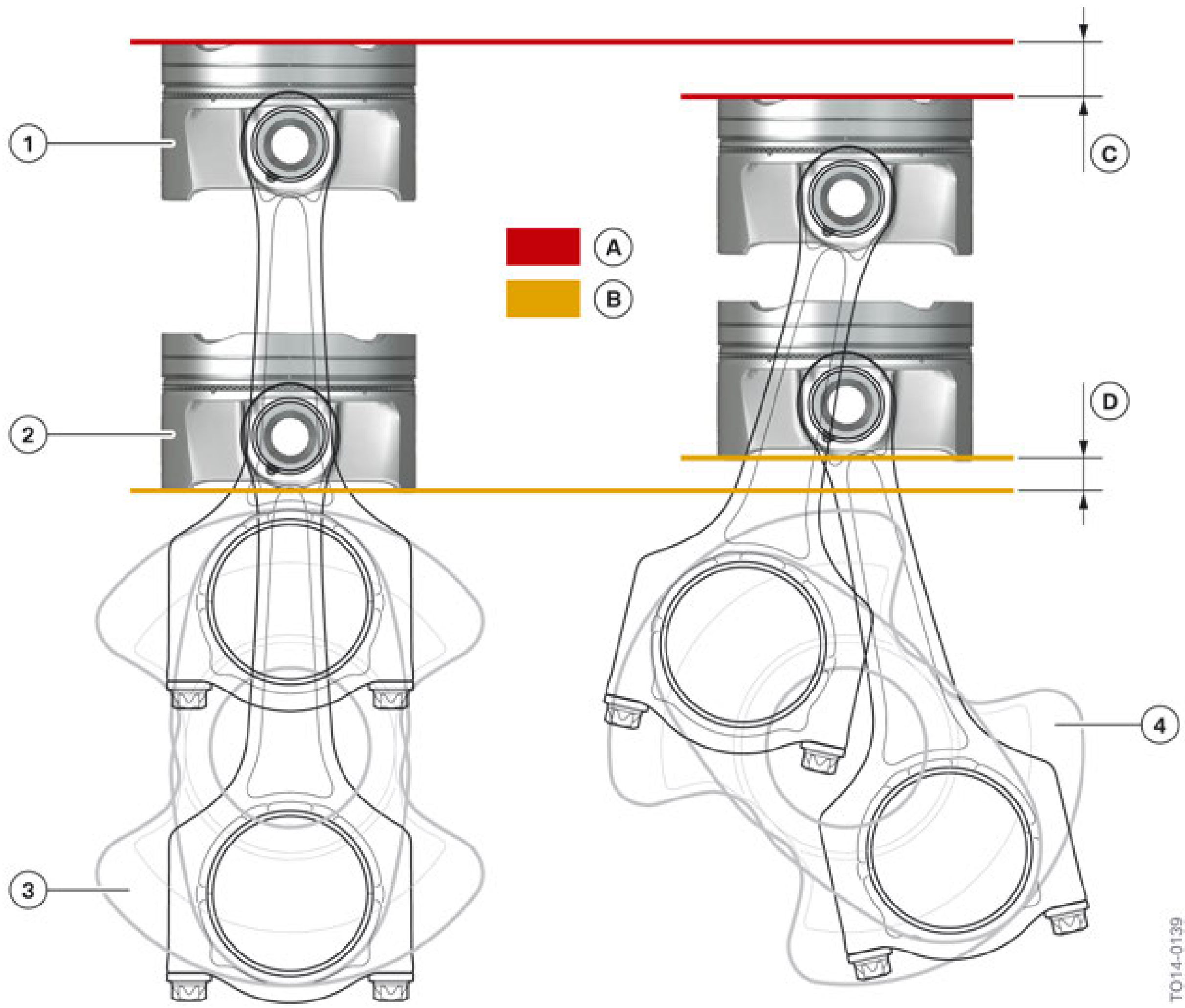
Free inertia forces of the 2nd order occur in the 4-cylinder in-line engine. The following graphic shows how the forces of the 1st order cancel each other.



Free inertia forces, 1st order, B46 engine

Index	Explanation
F_1	Oscillating and rotating inertia force with operating direction 0° crank angle
F_2	Oscillating and rotating inertia force with operating direction 0° crank angle
F_3	Oscillating and rotating inertia force with operating direction 180° crank angle
F_4	Oscillating and rotating inertia force with operating direction 180° crank angle
1	Inertia forces in equilibrium (static)

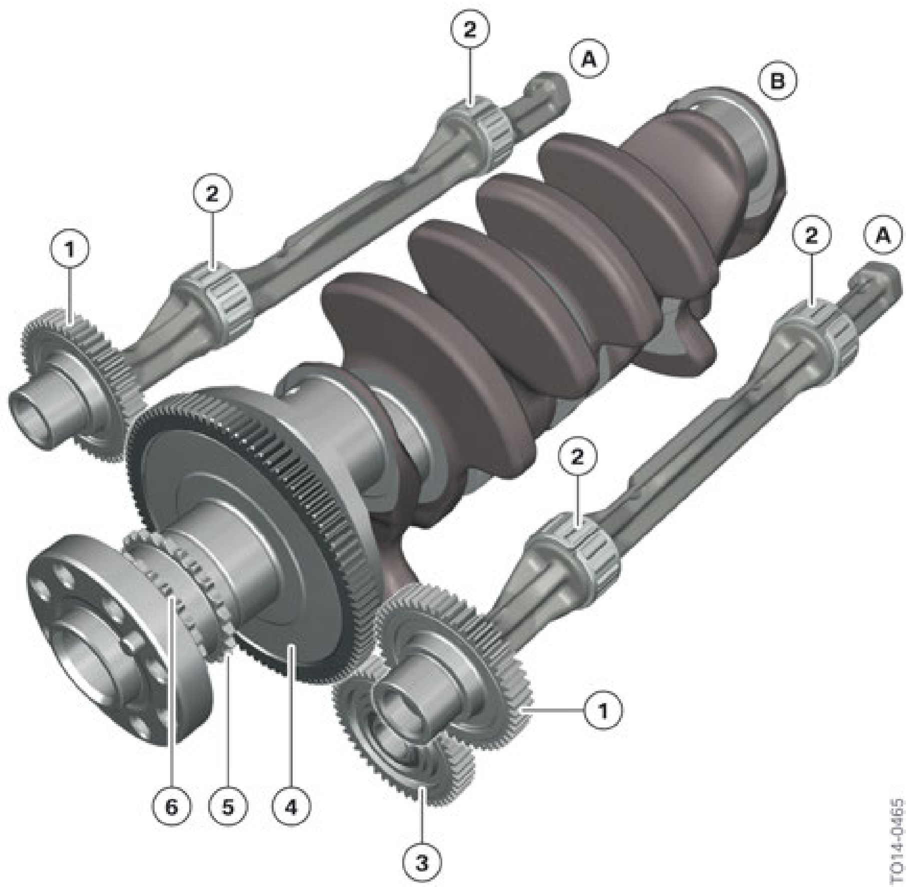
If you take a look at the crankshaft from the front, then all forces of the 1st order cancel each other. However, inertia forces of the 2nd order occur, which can be explained as follows:



Free inertia forces, 2nd order, B46 engine

Index	Explanation
A	Position line, piston 1
B	Position line, piston 2
C	Stroke, piston 1
D	Stroke, piston 2
1	Piston 1
2	Piston 2
3	Crankshaft angle 0°
4	Crankshaft angle 45° after top dead center

As can be seen in the previous graphic, both pistons are at top or bottom dead center at the same time. If the crankshaft is rotated 45° counter-clockwise and the two piston positions are compared, it becomes clear that the paths covered by both pistons differ. Piston 1, which started from the top dead center position, covers a greater distance than piston 2 from the bottom dead center position. As both pistons cover a different distance in the same period, they must have travelled at different speeds. This speed difference affects the acceleration and deceleration of the oscillating masses, thus leading to undesired oscillations. As this process occurs twice per crankshaft revolution, these are referred to as free inertia forces of the 2nd order.



Overview of counterbalance shafts, B46 engine

Index	Explanation
A	Counterbalance shaft
B	Crankshaft
1	Straight tooth gearing
2	Needle bearing
3	Intermediate gear
4	Output drive gear, crankshaft
5	Output pinion, timing chain
6	Output pinion, chain, oil pump

The B46 engine has two counterbalance shafts which rotate at twice the speed of the crankshaft. The gears of the counterbalance shafts have 48 teeth. The gear of the crankshaft has 96 teeth.

A correct setting of the two counterbalance shafts is a prerequisite for reduction of the oscillations. Using a special tool the counterbalance shafts can be secured in their specified installation position in Service.

A gear between the crankshaft and the counterbalance shaft effects the change of rotational direction of the right counterbalance shaft. In the new condition, the tooth flanks of the idler gear have a special coating. This coating helps adjust the tooth backlash between the counterbalance shaft and the crankshaft during installation in Service. An incorrectly adjusted tooth backlash can lead to running noises of the gears when the engine is running.

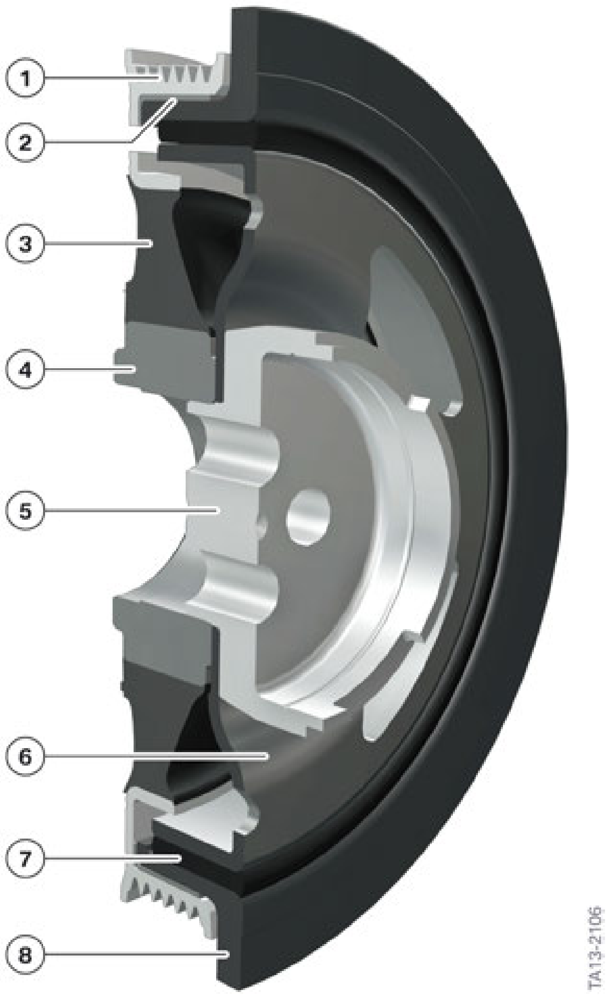
⚠

A newly coated idler gear must be installed for setting the counterbalance shafts.
The repair instructions must be followed.

2.2.6. Torsional vibration damper

A torsional vibration damper is used on the belt drive of B46 engine. The torsional vibration damper assumes the following tasks:

- Reduction of the torsional oscillations of the crankshaft.
- Reduction of the rotational deformity of the supporting components.



Variant of a torsional vibration damper, B46 engine

Index	Explanation
1	Belt pulley
2	Plain bearing
3	Belt pulley rubber isolation element
4	Uncoupled belt pulley hub
5	Pressure hub
6	Vibration damper hub
7	Vibration damper rubber part
8	Flywheel

Vibration damper

The vibration damper comprises a hub, a rubber element, which acts as a spring, and a flywheel, which serves as weight. The rotary oscillations of the crankshaft are reduced by the combined action of the spring and mass element. This reduces the load of the crankshaft and the noises emitted by the engine.

Uncoupled belt pulley

The uncoupled belt pulley is important for smooth low-wear drive of supporting components. The belt pulley is uncoupled from the hub by the rubber isolation element. The rubber isolation element permits greater rotation, and reduces the remaining rotational imbalance and thereby the load on the drive belt. The belt pulley is supported by the plain bearing.

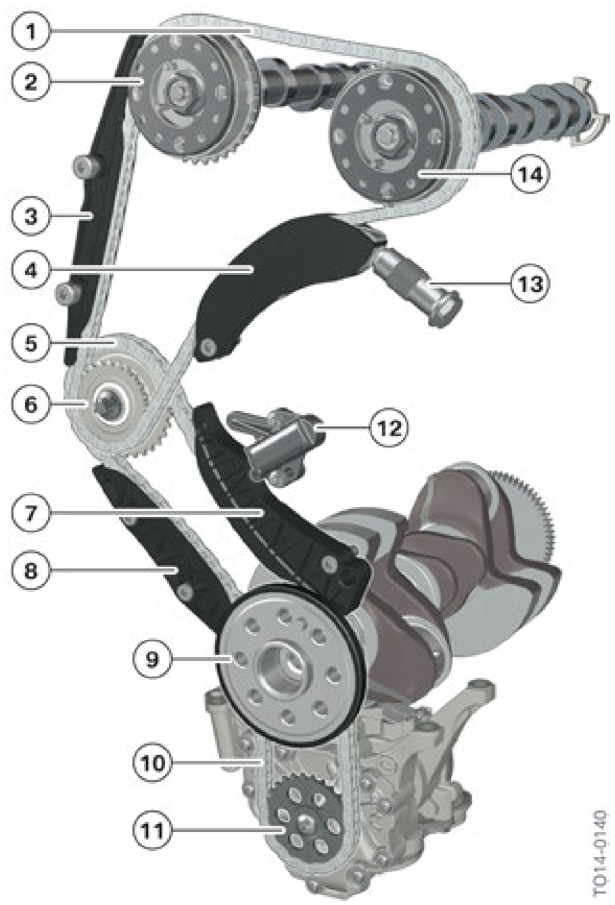
⚠

To avoid damage to the torsional vibration damper, the engine must not be operated without drive belts.

2.2.7. Chain drive

Features:

- Chain drive at the side of the engine emitting the forces.
- Two-part chain drive for drive of camshafts, synergy parts for the diesel engines.
- Simple sleeve-type chains.
- Electric motor of the combined oil-vacuum pump via a separate chain.
- Plastic tensioning rails and guide rails.
- Hydraulic chain tensioner with spring preload.



Chain drive, Bx8 engines

Index	Explanation
1	Upper timing chain
2	VANOS with intake camshaft sprocket
3	Upper guide rail
4	Top tensioning rail
5	Lower timing chain
6	Camshaft sprocket, intermediate shaft
7	Bottom tensioning rail
8	Lower guide rail
9	Crankshaft
10	Chain oil-vacuum pump
11	Oil-vacuum pump camshaft sprocket
12	Lower chain tensioner
13	Upper chain tensioner
14	VANOS with exhaust camshaft sprocket

The chain drive is on the transmission side. The inertia of the transmission at this engine end significantly reduces the rotary oscillations and also therefore the loads acting on the chain drive.

The B46 engine is equipped with a two-part chain drive. With this arrangement, the bottom timing chain drives the camshaft sprocket of the intermediate shaft. The drive torque is simply diverted to the top timing chain via the intermediate shaft.

Sufficient lubrication of the bottom timing chain is ensured by the oil mist in the crankcase and the engine oil that drips off.

The combined oil-vacuum pump is also driven by the crankshaft via a separate drive chain.

⚠

The screw connection of the oil and vacuum pump camshaft sprocket has a left-hand thread.

Lubrication of top chain drive

Lubrication of top chain drive, B46 engine

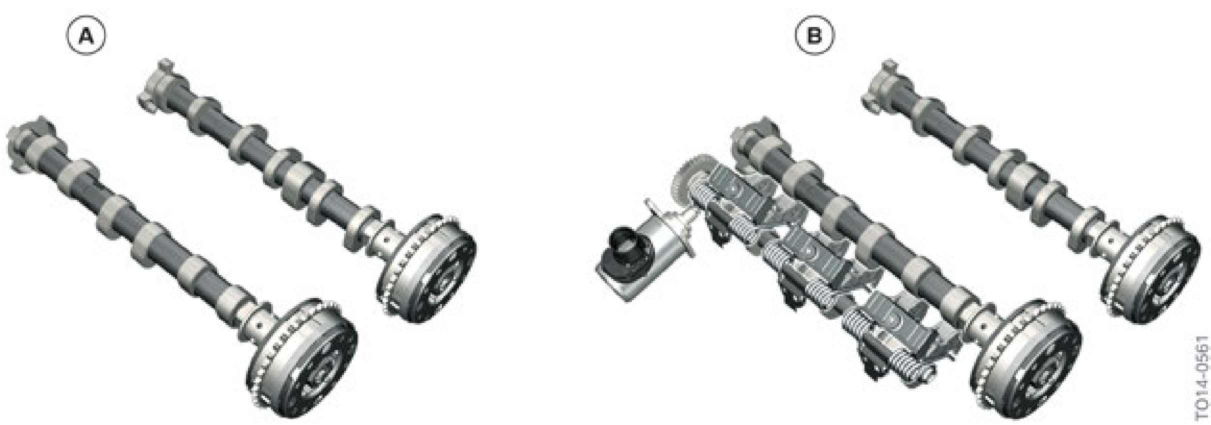
Index	Explanation
1	Upper guide rail
2	Top tensioning rail
3	Upper timing chain
4	Top chain tensioner with oil spray nozzle
5	Spray pattern

The timing chain is always tensioned on the unloaded side. This is performed by a tensioning rail on which a chain tensioner acts. The upper timing chain is lubricated by an oil spray nozzle in the top chain tensioner. There is an opening in the tensioning rail to ensure that oil reaches the top timing chain.

2.3. Valve gear

2.3.1. Variants

Two different technologies are used in the area of the valve gear.



Valve gear, B38 B46 engine.

Index	Explanation
A	Double VANOS
B	Valvetronic

The following table provides an overview of the technology used in the B46 engine:

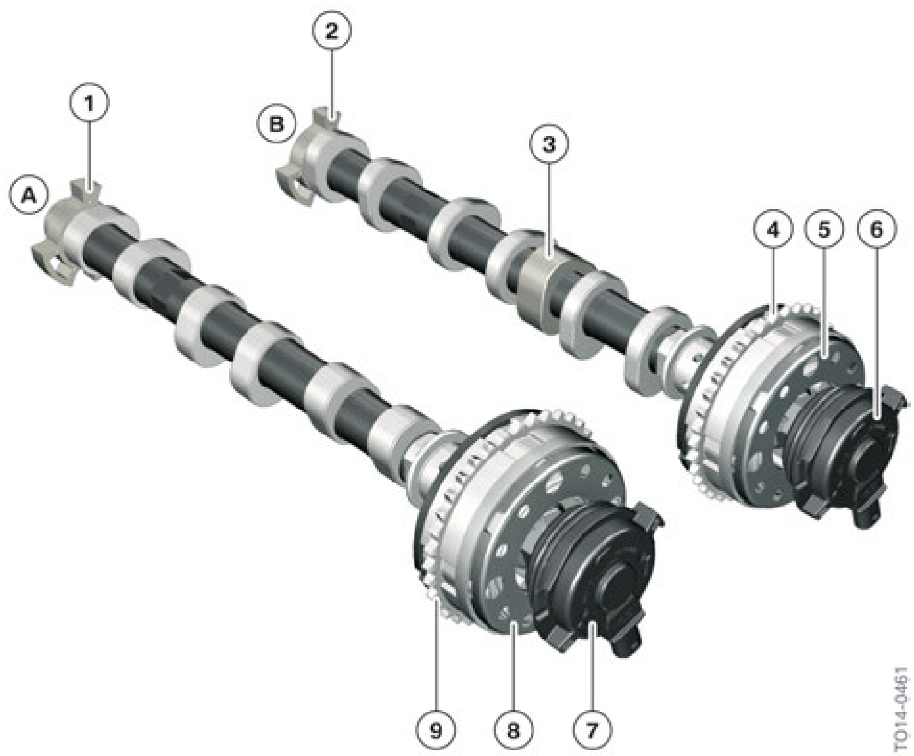
Engine	Double VANOS	Valvetronic
B46A20M0	Yes	Yes

2.3.2. VANOS

The valve overlap times have a significant impact on the characteristics of the engine. An engine with smaller valve overlap therefore tends to have a high maximum torque at low engine speeds but the maximum power which can be achieved at high engine speeds is low. The maximum power achieved with a large valve overlap on the other hand is higher, but this is at the expense of the torque at low engine speeds.

The VANOS provides a solution. It makes a high torque possible in the low and medium engine speed range and a high maximum power in the higher engine speed ranges. A further benefit of the VANOS is the option of internal EGR. This reduces the emission of harmful nitrogen oxides NOx, particularly in the partial load range. The following is also achieved:

- Faster heating up of catalytic converter.
- Lower pollutant emissions during cold start.
- Reduction in consumption.



Double VANOS, Bx8 engine

Index	Explanation
A	Intake camshaft
B	Exhaust camshaft
1	Increment wheel, intake camshaft
2	Increment wheel, exhaust camshaft
3	Triple cam for high pressure pump drive system

Index	Explanation
4	Exhaust camshaft sprocket
5	VANOS unit, exhaust side
6	VANOS solenoid valve actuator, exhaust
7	VANOS solenoid valve actuator, intake
8	VANOS unit, intake side
9	Intake camshaft sprocket

Reason for using the double VANOS

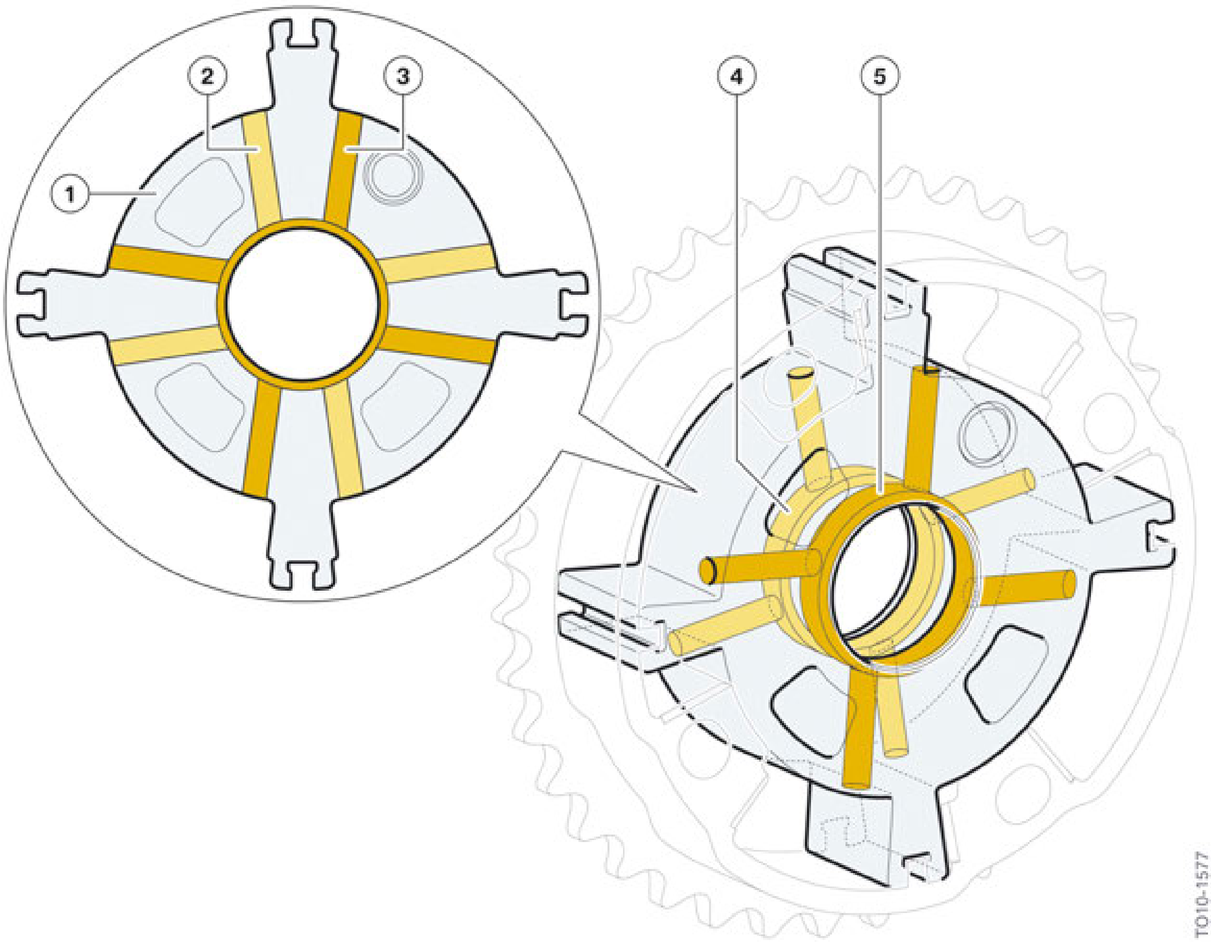
The advantages of a Valvetronic are lower charge cycle losses and therefore potential for reducing fuel consumption by adopting an appropriate driving style. However, in contrast to throttle valve-controlled systems, Valvetronic cannot reduce charge-cycle losses in the full load range.

VANOS unit

With older VANOS systems, such as that used in the N55 engine, the VANOS units were controlled by separate VANOS solenoid valves integrated into oil ducts in the cylinder head.

The oil ducts in the cylinder head are reduced and the adjustment speed is increased by using a VANOS solenoid valve unit and a mechanical VANOS central valve, which is located inside the VANOS unit.

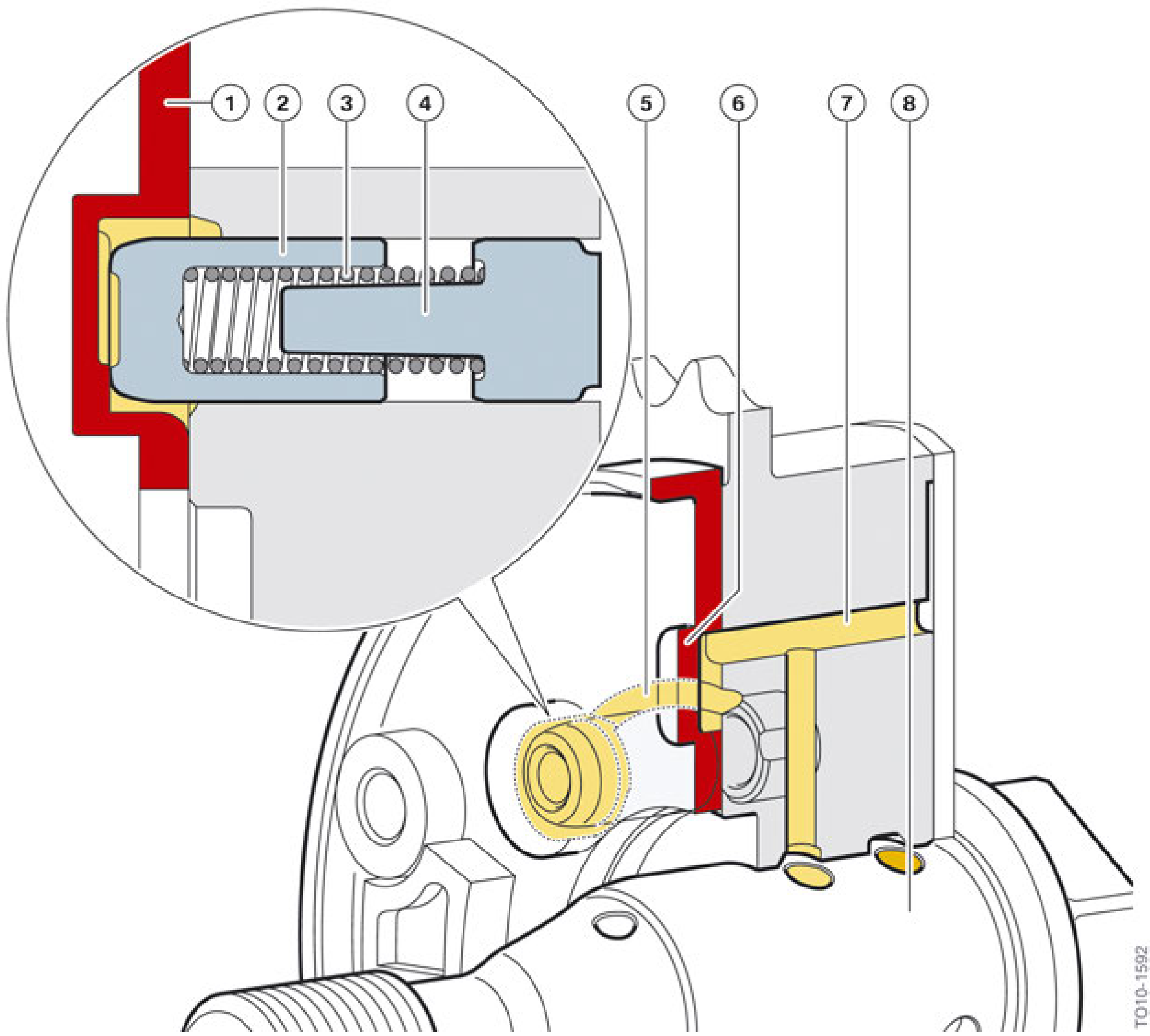
The following graphic shows the oil ducts in the VANOS unit:



VANOS unit, intake camshaft, Bx8 engine

Index	Explanation
1	Rotor
2	Oil duct for timing advance
3	Oil duct for timing retardation
4	Oil duct for timing advance
5	Oil duct for timing retardation

The intake camshaft can be “advanced” with the ducts shaded light yellow; the VANOS unit can be “retarded” with the ducts shaded dark yellow.

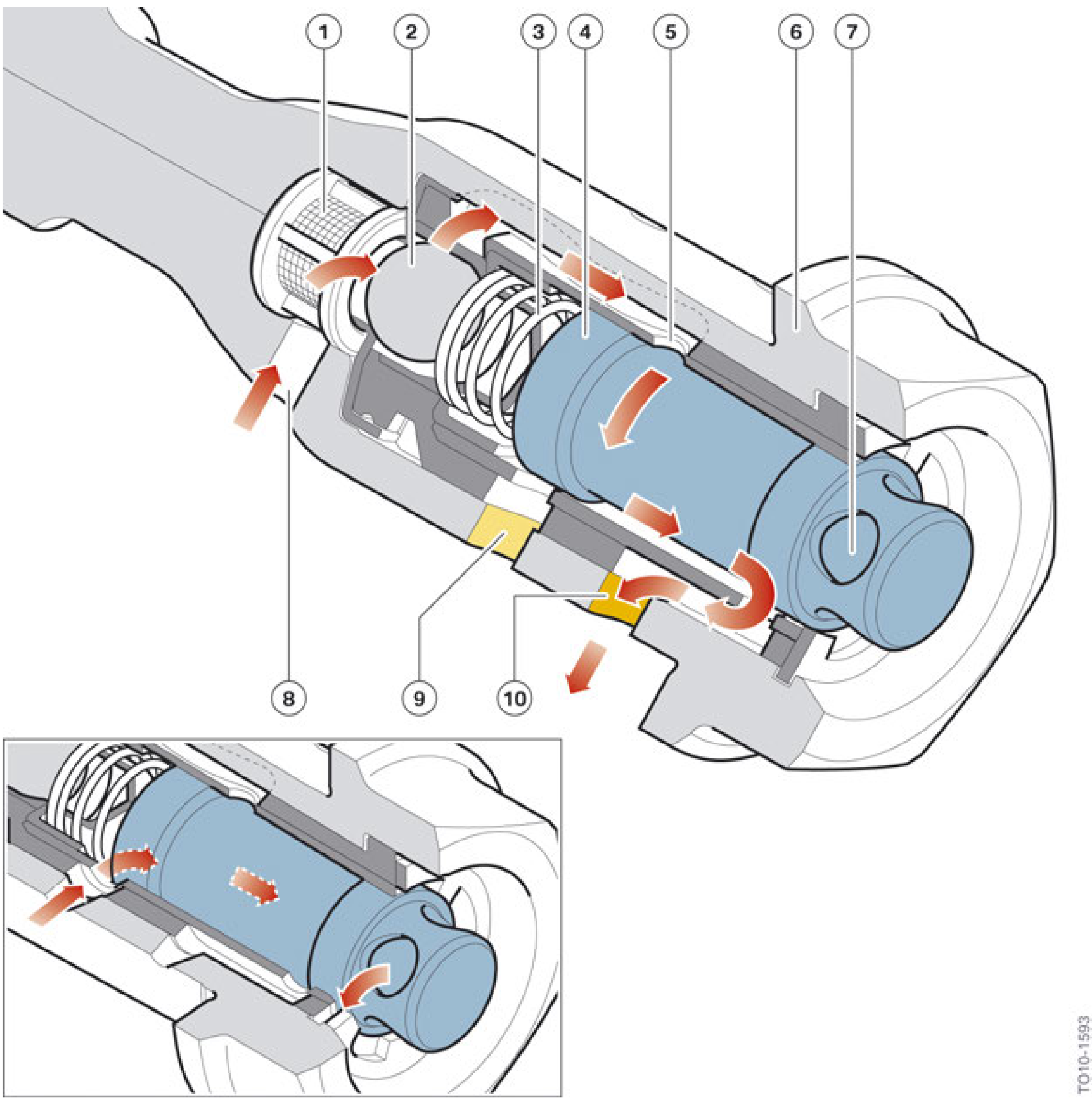


Locking pin, Bx8 engine

Index	Explanation
1	Locking cover
2	Locking pin
3	Locking spring
4	Cartridge
5	Oil duct
6	Locking cover
7	Oil duct
8	VANOS central valve

The locking pin ensures that the VANOS unit adopts a clear, locked position in the depressurized state. The locking spring ensures the unit is locked by continuously pushing the locking pin into the locked position when the actuator is de-energized. The VANOS unit is blocked in this condition. The timing can be adjusted in this way. This is important when the engine is started to ensure exact timing. The oil pressure which is present for timing advance simultaneously unlocks the locking pin via oil ducts in the VANOS unit. If the camshaft is to be “advanced”, the locking pin is then forced by the applied oil pressure against the locking spring towards the cartridge and the locking cover is released for VANOS adjustment.

The following graphic shows the oil flow rate in the VANOS central valve which is used to control the camshaft adjustment:



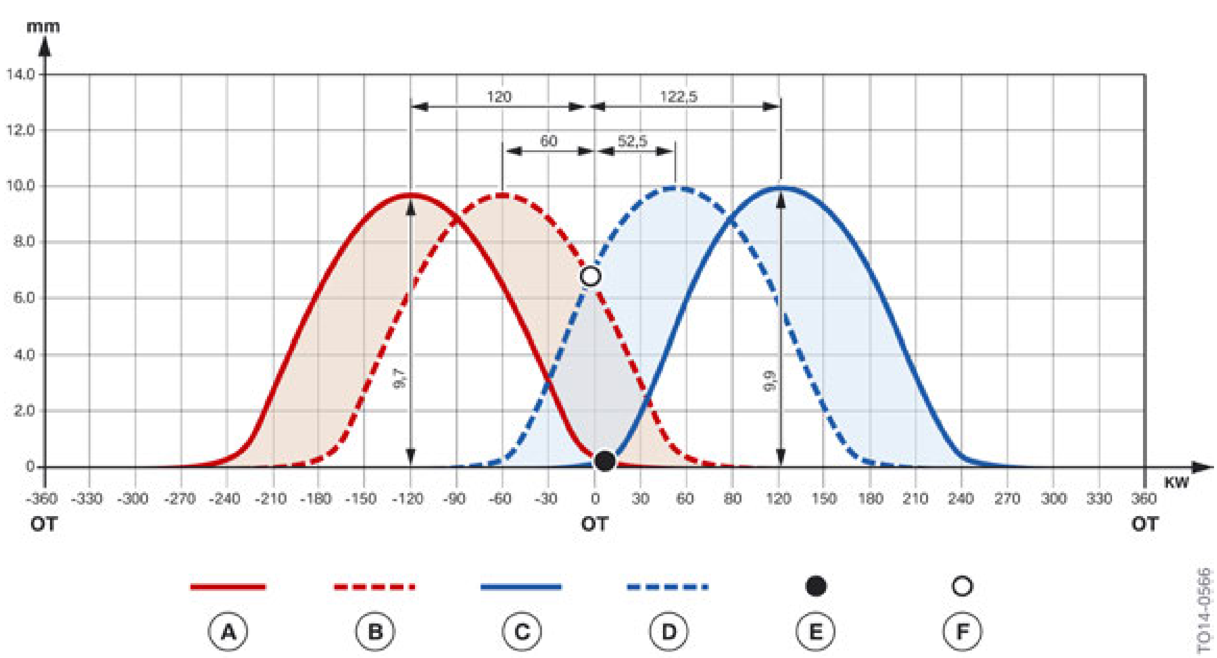
VANOS central valve, intake camshaft, Bx8 engine

Index	Explanation
1	Filter
2	Ball
3	Spring
4	Piston
5	Sleeve
6	Housing
7	Opening in plunger
8	Oil supply from main oil duct
9	Bore to oil duct in VANOS (timing advance)
10	Bore to oil duct in VANOS (timing retardation)

The VANOS unit is secured to the camshaft by the VANOS central valve. The oil flow into the VANOS unit is simultaneously controlled by this VANOS central valve. The system is actuated by a solenoid actuator with its own piston that pushes on and displaces the piston of the VANOS central valve. The oil flow is controlled by means of the plunger.

The previous graphic shows the de-energized VANOS central valve. The locking pin blocks the VANOS unit.

Timing diagram



Variable valve overlap, Bx8 engine

Index	Explanation
1	Valve travel
2	Spread, exhaust camshaft
3	Spread, intake camshaft
4	Degree crankshaft
A	VANOS solenoid valve, exhaust, de-energized
B	VANOS solenoid valve, exhaust, duty cycle 100 %
C	VANOS solenoid valve, inlet, de-energized
D	VANOS solenoid valve, inlet, duty cycle 100 %
E	Smallest valve overlap in idle
F	Maximum valve overlap in partial load

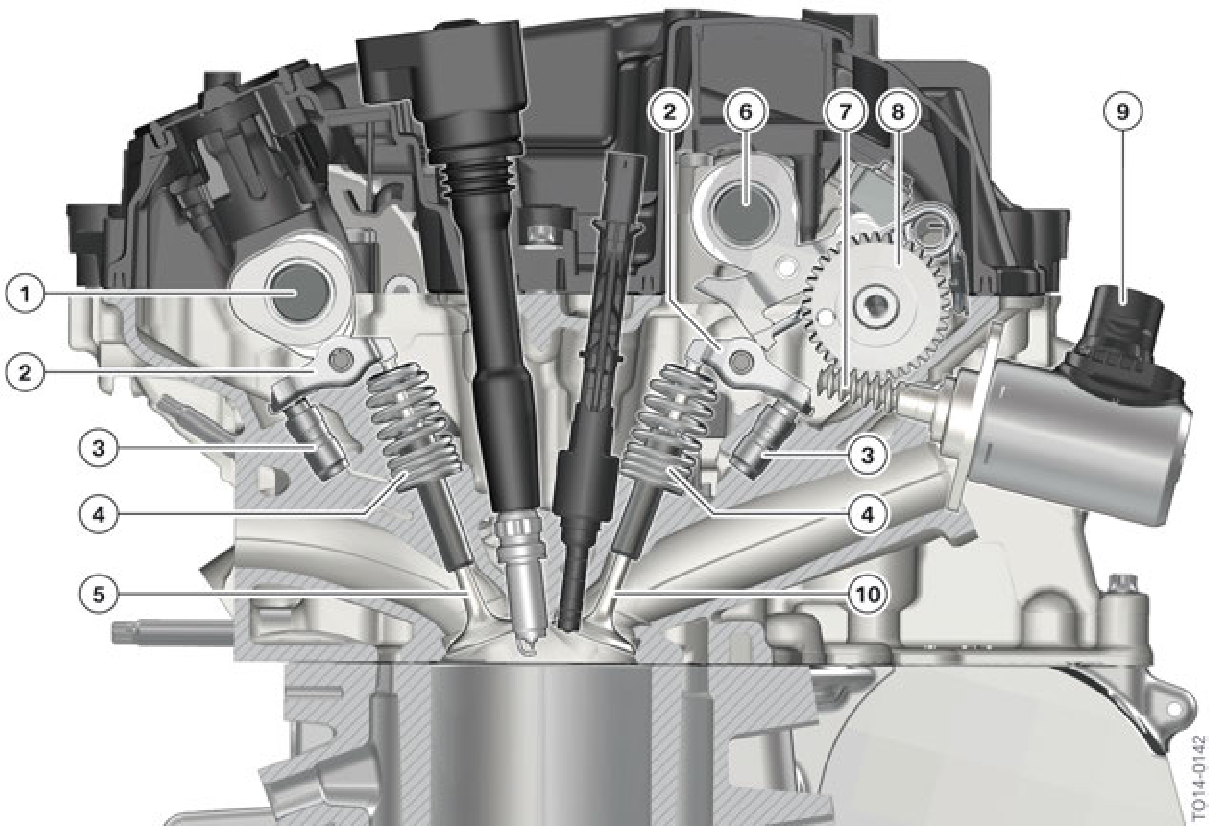
⚠

The following is to be expected if the VANOS unit drops out:

- Emergency operation.
- Fault code entry in the Digital Motor Electronics (DME).

2.3.3. Valvetronic

The Valvetronic has been further developed for use in the new B46 engine. The fourth-generation Valvetronic is used in the engine. A distinguishing feature is the Valvetronic servomotor which is visible from the outside.

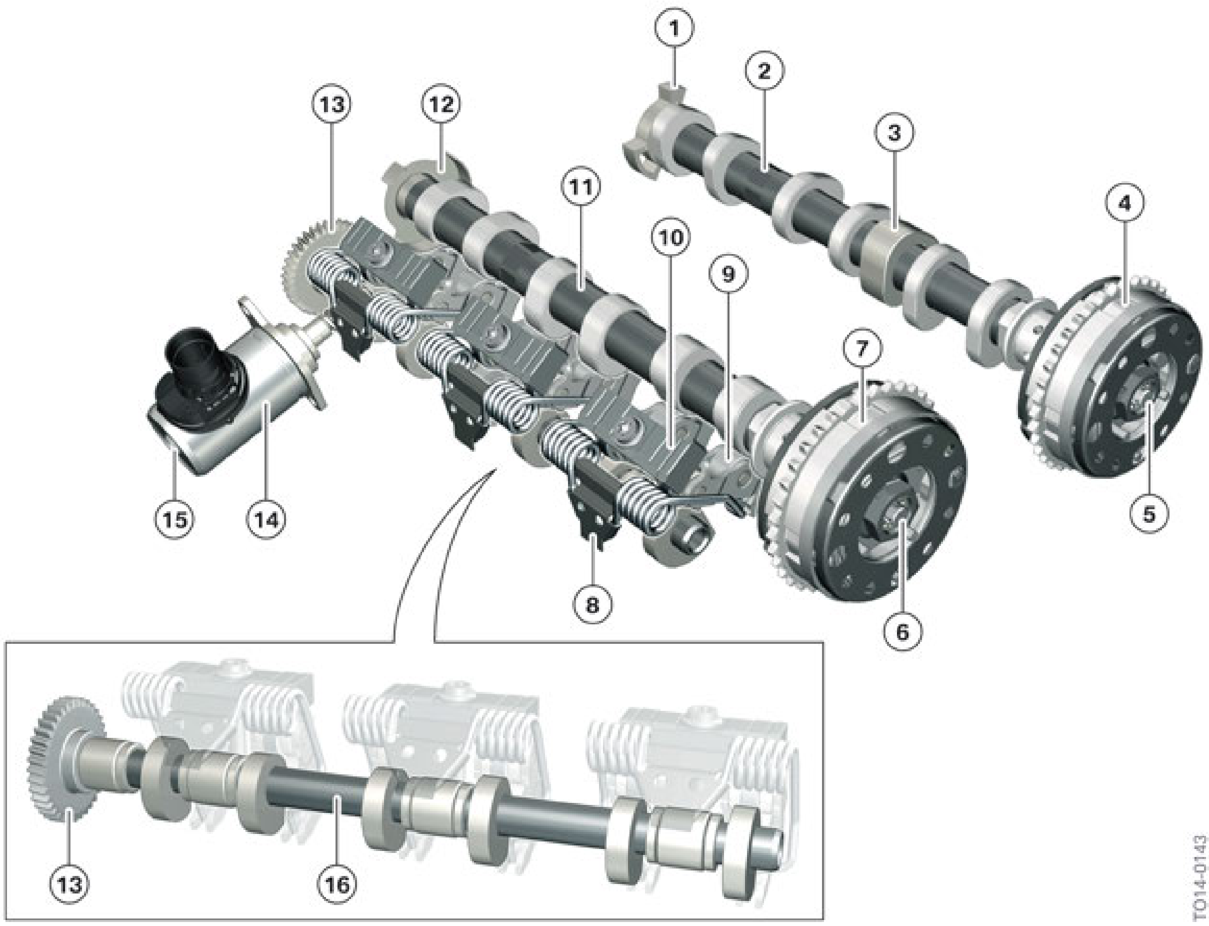


Valvetronic 4th generation, Bx8 engine

Index	Explanation
1	Exhaust camshaft
2	Roller cam follower
3	Hydraulic valve clearance compensation element
4	Valve spring
5	Exhaust valve
6	Intake camshaft
7	Worm gear
8	Eccentric shaft
9	Electrical connection, Valvetronic servomotor
10	Intake valve

The Valvetronic comprises a fully-variable valve lift control and a double VANOS. It operates according to the principle of throttle-free load control. With this system, a throttle valve is only used to stabilize the engine operation at critical operating points and to ensure a slight vacuum for the engine ventilation. A very small vacuum can be produced in the intake pipe by slightly tilting the throttle valve, which allows treated blow-by gases to be introduced into the intake port during naturally-aspirated engine operation.

The following graphic provides an overview of the design of the Valvetronic:



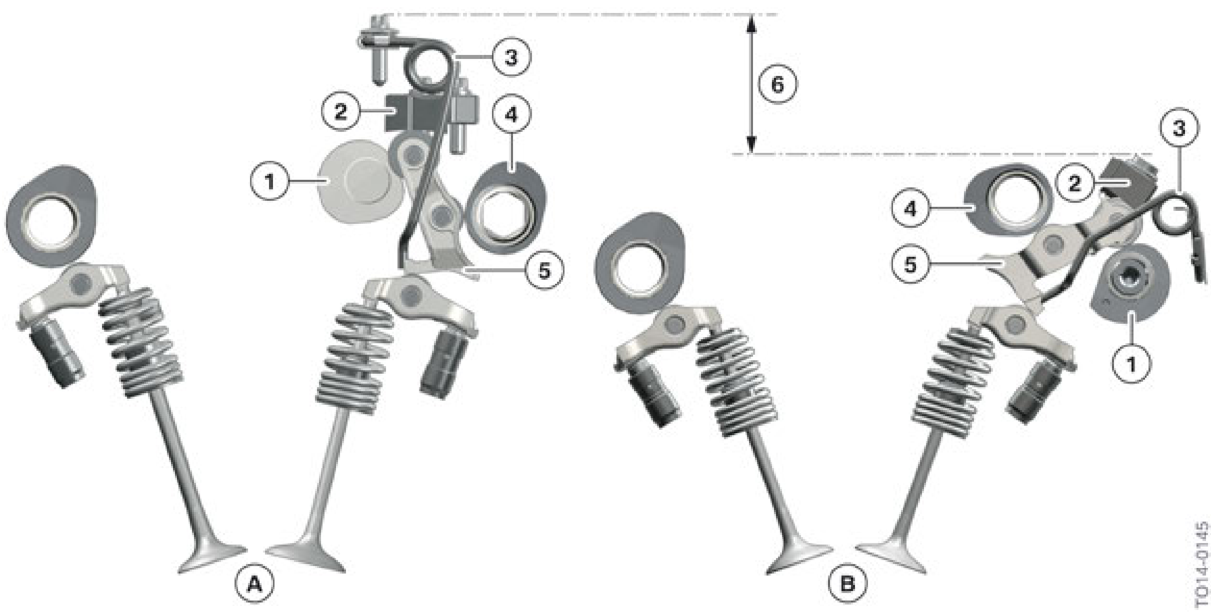
Valvetronic, Bx8 engine

Index	Explanation
1	Increment wheel, exhaust camshaft
2	Exhaust camshaft
3	Triple cam for high pressure pump drive system
4	VANOS unit with exhaust camshaft sprocket
5	VANOS central valve, exhaust side
6	VANOS central valve, intake side
7	VANOS unit with intake camshaft sprocket
8	Return spring with insert plate
9	Intermediate lever
10	Gate
11	Intake camshaft
12	Increment wheel, intake camshaft

Index	Explanation
13	Drive pinion, eccentric shaft
14	Valvetronic servomotor
15	Hexagon socket (Inbus)
16	Eccentric shaft

The following components of the Valvetronic were reworked for use in the B46 engine:

- Assembled eccentric shaft
- Adjustment range increased from 190 ° (N20/N55) to 253 ° (B46)
- Smaller worm gear ratio of 37:1
- Thinner lighter sliding blocks with only one screw connection
- Return spring inserted and not screwed
- Oil spray nozzle for lubrication of worm gear omitted
- Smaller more powerful Valvetronic servomotor.



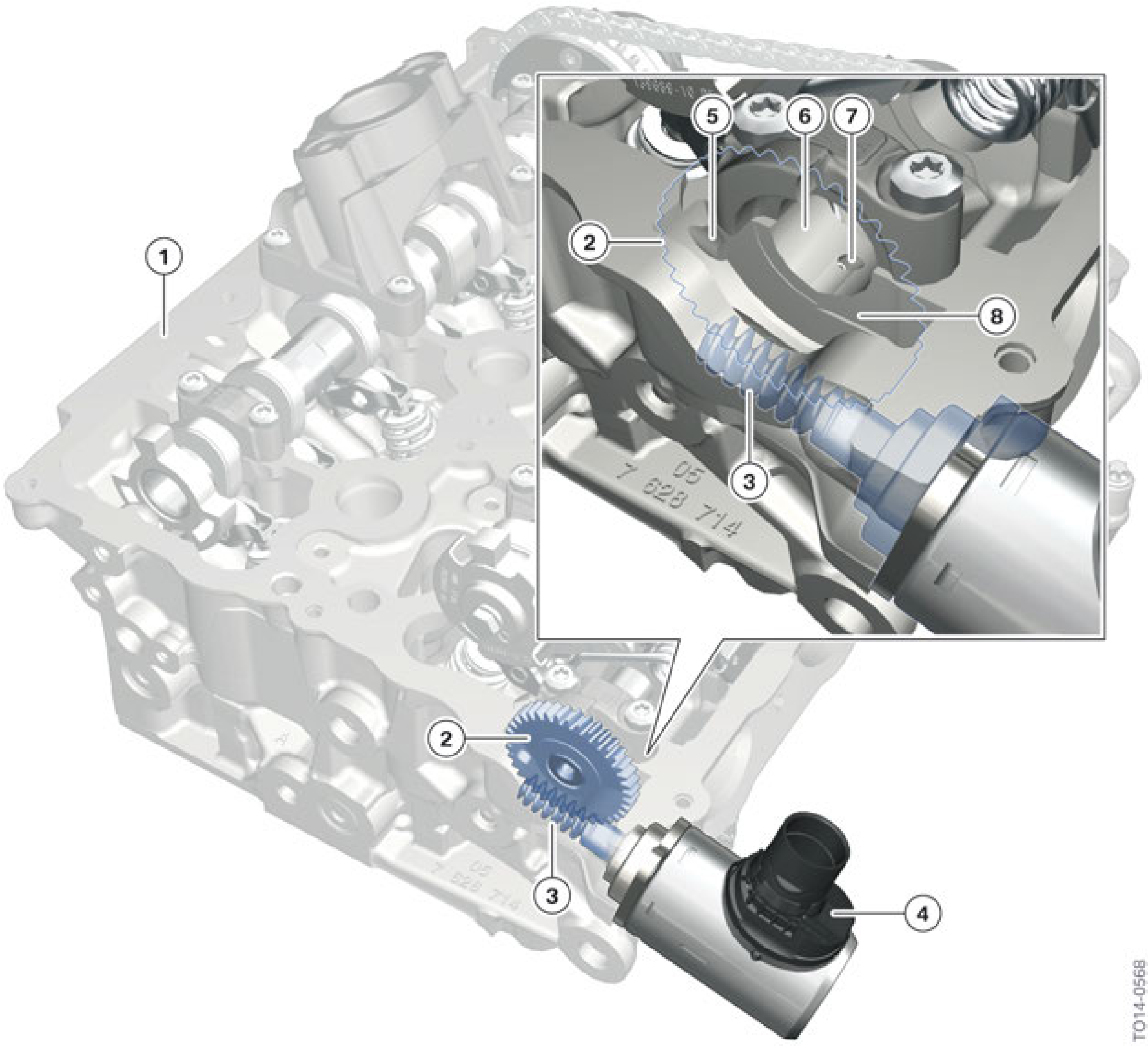
Comparison of Valvetronic N20 with B46 engine

Index	Explanation
A	Valvetronic, N20 engine
B	Valvetronic, B46 engine
1	Eccentric shaft
2	Gate

Index	Explanation
3	Return spring
4	Camshaft
5	Intermediate lever
6	Height of installation space

By reworking the Valvetronic, it has, most importantly, been possible to significantly reduce the installation space. A considerable height advantage has been gained by swapping round the intake camshaft and the eccentric shaft. The new position of the intermediate lever and gate simplifies the application of force in the cylinder head. The gate is therefore only attached to the bearing support with one screw and is positioned via two precise contact surfaces in the cylinder head. The return spring for the intermediate lever between the cylinder head and bearing position is self-supporting and does not require its own attachment point. The eccentric shaft is, as is already the case with the camshaft, an "assembled" design.

Lubricating oil supply to the Valvetronic worm gear



Lubricating oil supply to the Valvetronic worm gear, B46 engine

Index	Explanation
1	Cylinder head
2	Drive pinion of the eccentric shaft
3	Worm gear of Valvetronic servomotor
4	Valvetronic servomotor
5	Outlet bore hole
6	First bearing position of eccentric shaft
7	Inlet bore hole
8	Oil chamber

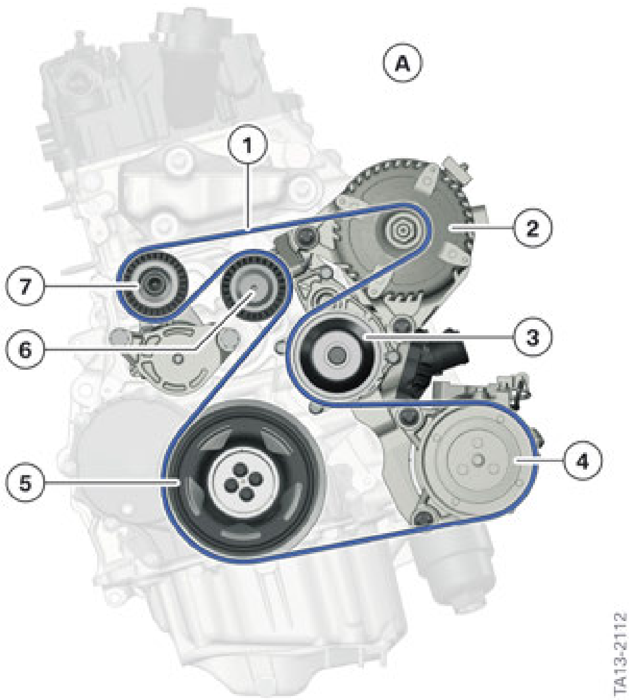
Due to the fast adjustment speeds of the eccentric shaft of less than 300 milliseconds from minimum to maximum stroke and the wide adjustment range from 0.2 millimeters (minimum) to 9.9 millimeters (maximum) valve lift with a small transmission ratio, sufficient lubrication between the worm gear of the Valvetronic servomotor and drive pinion of the eccentric shaft must be ensured. The lubricating oil reaches the oil chamber via an inlet bore hole at the first bearing position of the eccentric shaft. Here, the oil volume rises to the lower edge of the outlet bore hole. The excess oil flows back to the oil circuit via the outlet bore hole. The gearing of the worm gear is now supported in the oil bath and is therefore lubricated at all times.

Information on disassembly and installation work

As numerous changes have been made, a new special tool is used to remove the return springs.

The hexagon socket on the Valvetronic servomotor is for manual adjustment of the worm gear. This is necessary if the Valvetronic servomotor needs to be removed, for example. To avoid damage to the worm gear, it must be greased prior to start-up using a special lubricant (Longtime PD part number: 83 19 2 160 340). The Valvetronic in the Digital Motor Electronics (DME) can be taught-in using the teach-in routine in ISTA. During this process, the limit positions of the system are determined once again and stored in the Digital Motor Electronics (DME). The precise procedure for removing the Valvetronic is described in the current repair instructions.

2.4. Belt drive



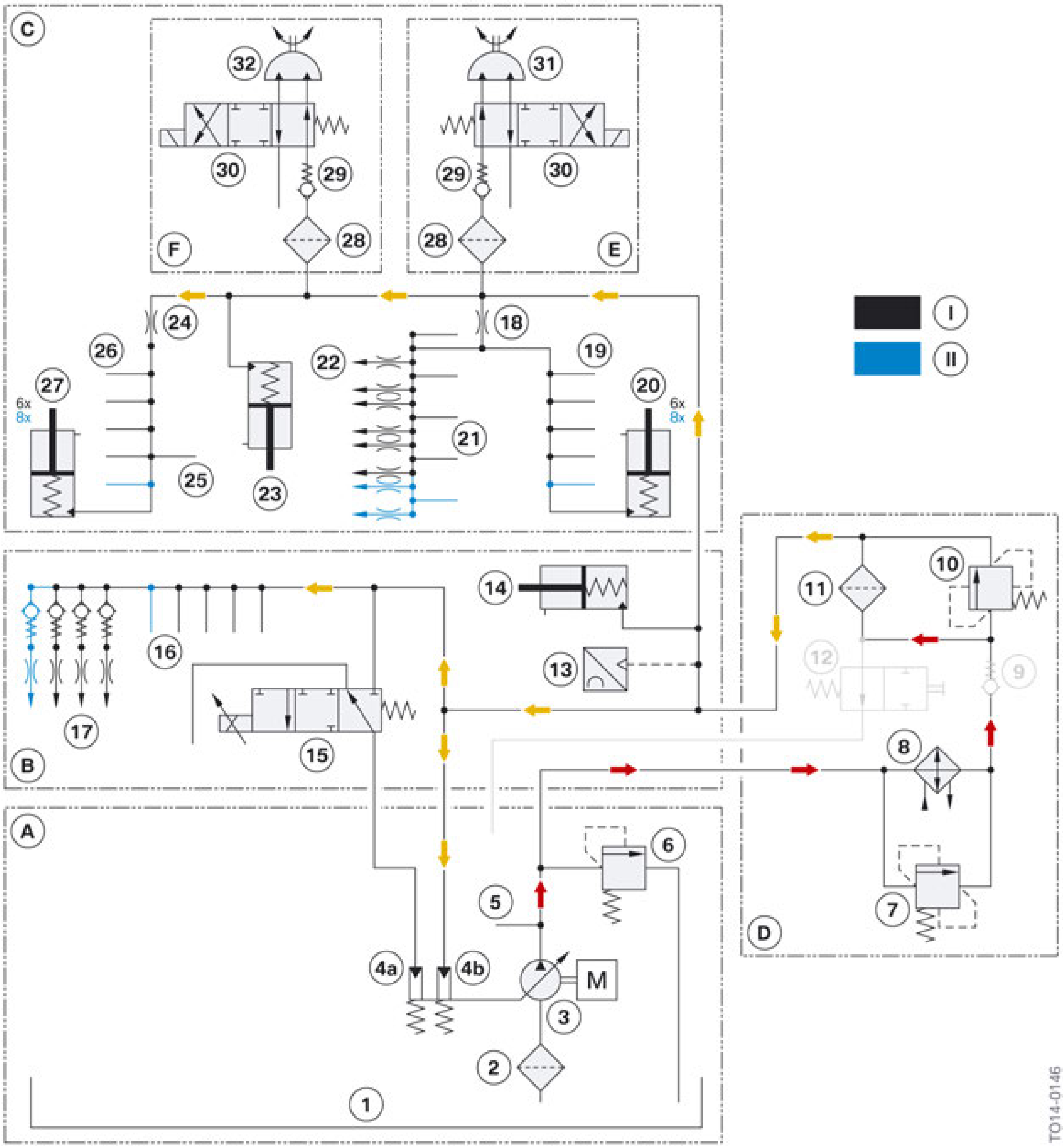
Belt drive, transverse-mounted B46 engine

Index	Explanation
A	With air conditioning compressor
1	Ribbed V-belt
2	Alternator
3	Coolant pump
4	Air conditioning compressor
5	Torsional vibration damper
6	Deflecting element
7	Tensioning pulley

The length of the drive belt changes due to thermal expansion and ageing. So the drive belt can transmit the required torque, it must be continuously in contact with the belt pulley at a defined pressure. To this end the belt tension is exerted by an automatic tensioning pulley which compensates for belt elongation over the full service life.

A standard belt with 6 ribs is used.

3.1. Oil circuit



Hydraulic circuit diagram, B38 engine

Index	Explanation
A	Oil pump
B	Crankcase
C	Cylinder head
D	Oil filter module

B46 Engine

3. Oil Supply

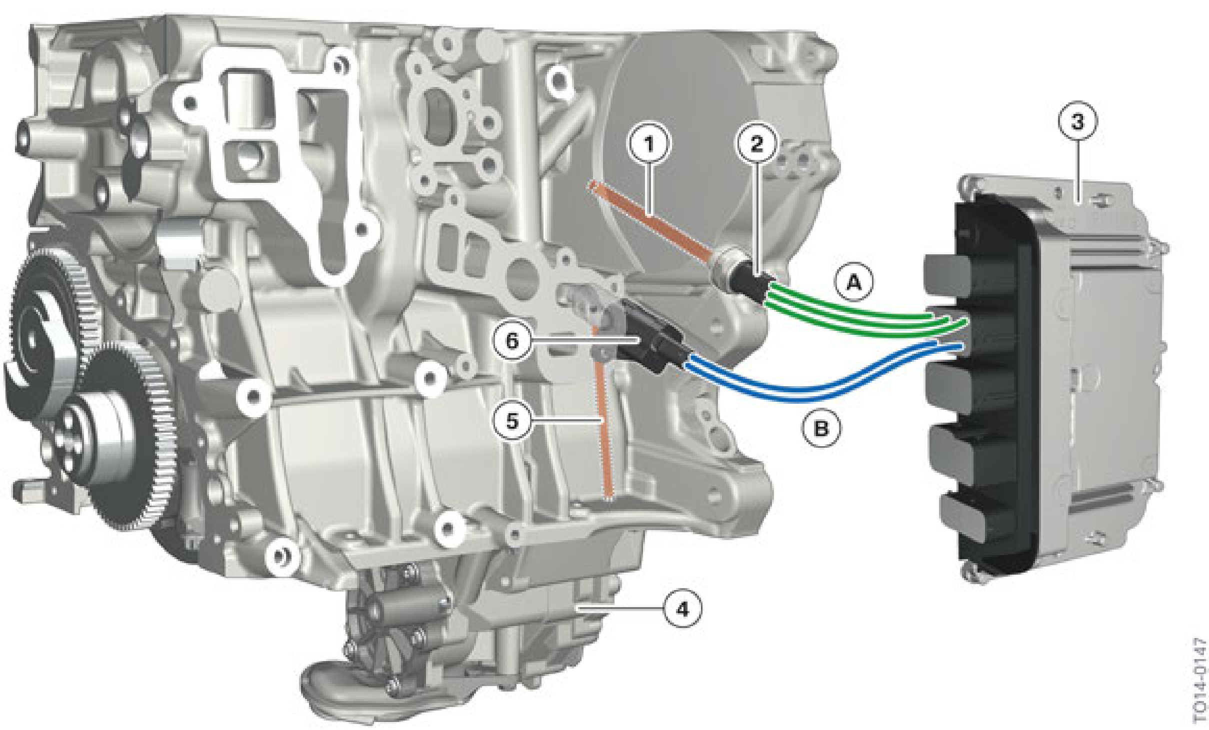
Index	Explanation
E	VANOS unit, intake camshaft
F	VANOS unit, exhaust camshaft
I	3-cylinder engine
II	4-cylinder engine
1	Oil sump
2	Intake pipe with filter
3	Oil and vacuum pump
4 a	Map-controlled control chamber (normal operation)
4 b	Second-level control chamber (emergency operation)
5	Oil supply of vacuum pump
6	Pressure limiting valve (built-in to pump)
7	Oil-to-water heat exchanger, bypass valve
8	Engine oil-to-coolant heat exchanger
9	N/A
10	Filter bypass valve
11	Oil filter
12	N/A
13	Oil pressure sensor
14	Chain tensioner, bottom
15	Map-controlled valve
16	Lubricating oil supply to crankshaft bearing shells of bearing seat
17	Oil spray nozzles for piston cooling
18	Throttle
19	Lubrication points on intake camshaft
20	Hydraulic valve clearance compensation
21	Lubricating points, eccentric shaft
22	Oil spray nozzles, intermediate lever
23	Chain tensioner, top
24	Throttle
25	Lubrication point, high-pressure pump
26	Lubricating point, exhaust camshaft
27	Hydraulic valve clearance compensation
28	Oil strainer, solenoid valve

Index	Explanation
29	Non-return valve
30	Solenoid valve
31	VANOS swivel rotor (intake camshaft)
32	VANOS swivel rotor (exhaust camshaft)

With force-fed circulation lubrication the oil is drawn out of the oil sump by the oil pump through an intake pipe and forwarded into the circuit. The oil passes through the engine oil cooler with an integrated full-flow oil filter and from there into the main oil duct, which runs in the engine block parallel to the crankshaft. Branch ducts lead to the crankshaft main bearings. There are bore holes between the main bearings of the crankshaft and the connecting rod bearing journal which admit the oil to the lubricating points of the connecting rod bearing.

Some of the oil is diverted from the main oil duct and directed to the cylinder head to the relevant lubricating points and adjustment units. When the engine oil flows through the consumers, it either returns to the oil sump via the return ducts or it drips back freely.

3.2. Map control



System overview of map-controlled oil supply of Bx8 engine

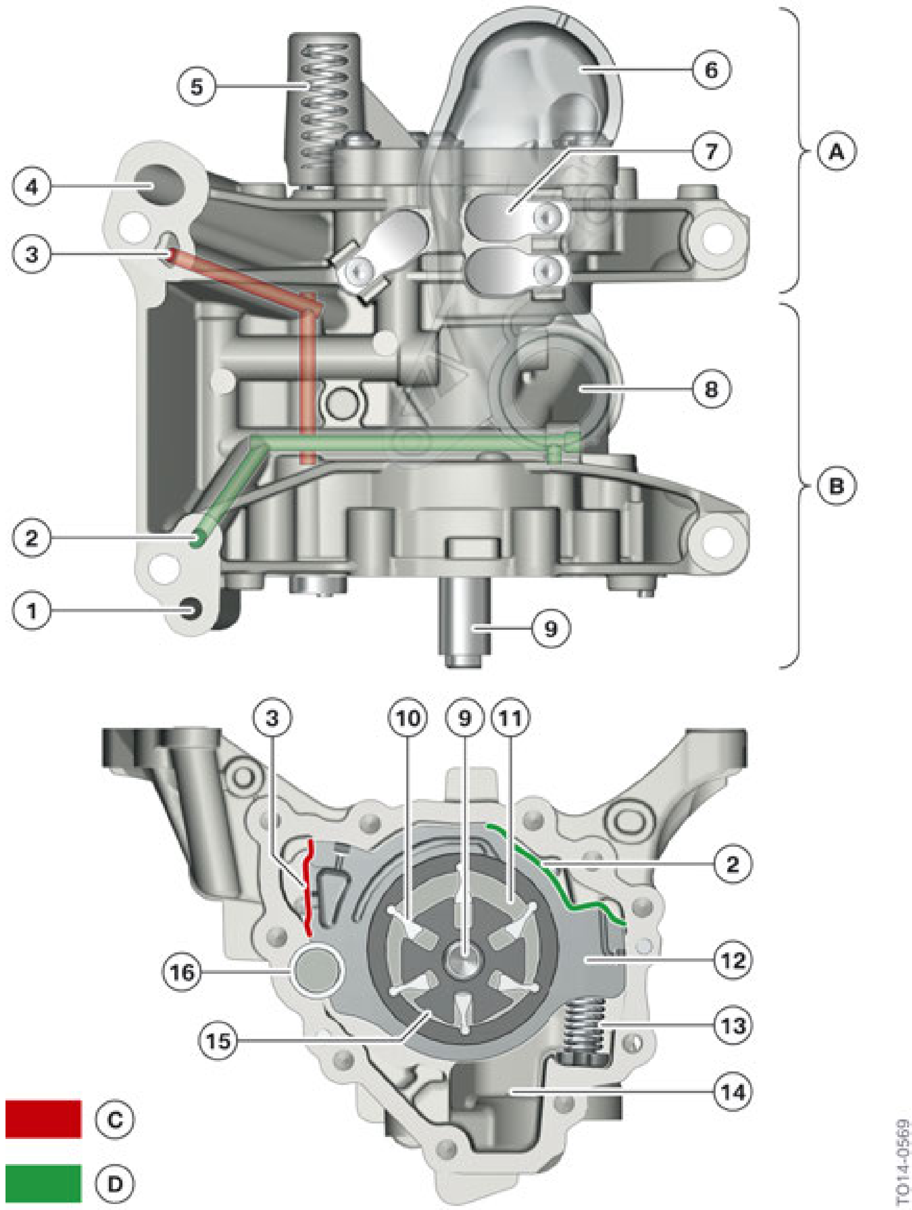
Index	Explanation
A	Oil pressure sensor signal
B	Activation of map-controlled control valve
1	Main oil duct to the oil pressure sensor
2	Oil pressure sensor
3	Digital Motor Electronics (DME)
4	Oil pump
5	Oil duct to map-controlled control chamber of oil pump
6	Map control valve

The B46 engine is equipped with the familiar map-controlled oil pump which is already used. The actual oil pressure is recorded via an oil pressure sensor and forwarded to the Digital Motor Electronics (DME). The Digital Motor Electronics performs a target/actual comparison based on the stored characteristic maps. The map-controlled control valve is activated by means of a pulse-width modulated signal until the nominal pressure stored in the characteristic map has been reached. During this process, the delivery rate of the oil pump varies according to the oil pressure in the oil duct to the map-controlled control chamber.

3.3. Oil pump

The oil pump plays a central role in modern combustion engines. Due to the high power and enormous torque which is present even at low engine speeds, it is necessary to ensure a reliable oil supply. This is necessary on account of the high component temperatures and heavily loaded bearings. To achieve low fuel consumption, the delivery rate of the oil pump must be adapted to the requirements.

The oil pump is driven by the crankshaft via a chain.



Design of oil pump, B46 engine

Index	Explanation
A	Vacuum pump
B	Oil pump
C	Second-level control area (emergency operation)
D	Map-controlled control area (normal operation)
1	Vacuum duct to vacuum pump
2	Oil duct to map-controlled control chamber
3	Oil duct to second-level control chamber

Index	Explanation
4	Oil pressure channel, pump output
5	Pressure-limiting valve
6	Intake pipe with filter
7	Discharge valves, vacuum pump
8	Oil intake port
9	Pump shaft
10	Rotor with pendulum
11	Suction side
12	Adjusting ring
13	Adjusting ring spring (2x)
14	Pump input
15	Major thrust face
16	Bearing tube (center of rotation)

A vacuum pump is integrated into the oil pump housing.

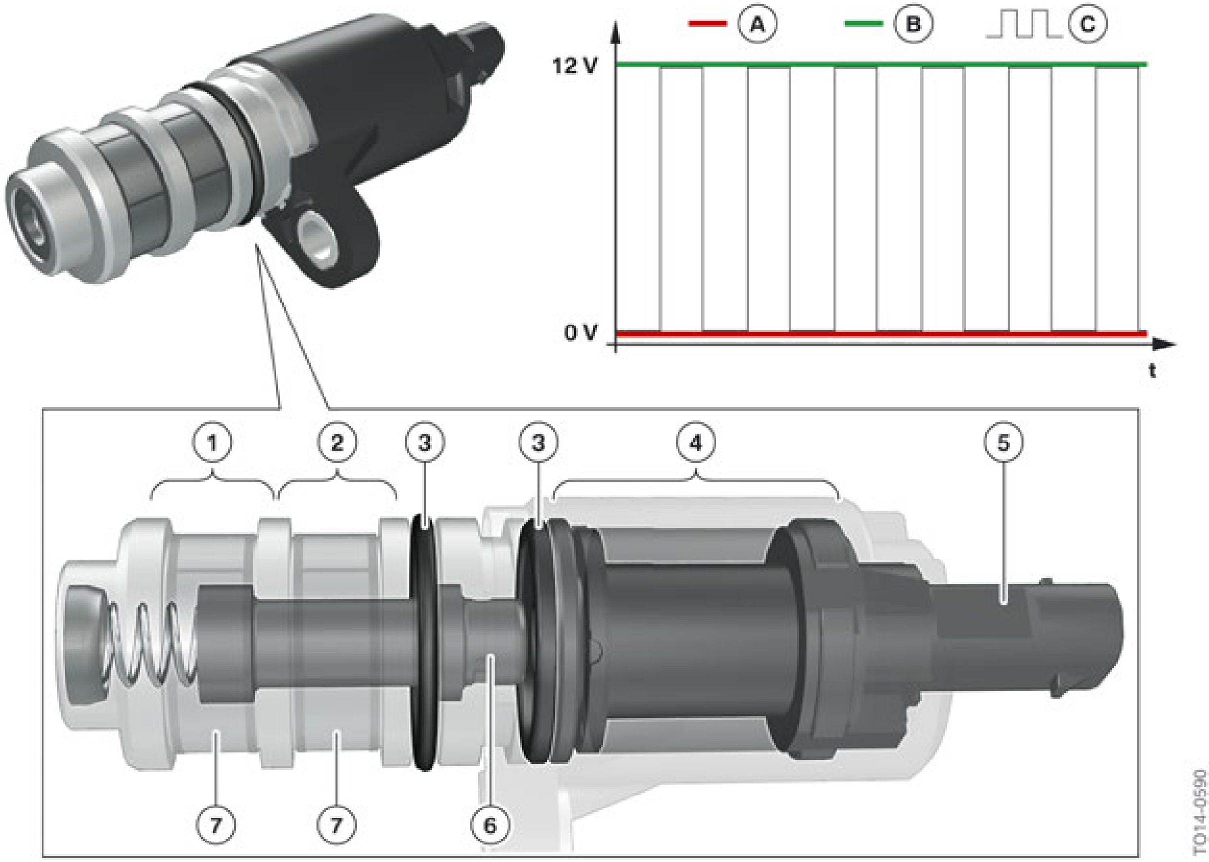
A rotor with pendulum rotates as shown in the graphic on the pump shaft. A crescent-shaped cavity arises through the eccentric position. During this process, the oil is drawn into the expanding chamber (intake side) and is delivered via the contracting chamber (pressure side).

When the engine is in operation, oil pressure is admitted to the map-controlled control surface and the second-level control surface of the oil pump. Depending on the oil pressure, the adjusting ring is pushed via the center of rotation at the bearing tube to varying degrees of force against the adjusting ring springs. The change in eccentric position of the adjusting ring changes the size of the chamber, and therefore also the intake and pressure power of the oil pump.

To prevent overloading of the oil pump, a filter is installed upstream of the pump inlet. The maximum oil pressure of the oil circuit at the pump outlet is restricted by a pressure limiting valve. The opening pressure of the pressure limiting valve is 11.4 +/– 1.4 bar.

3.3.1. Map control valve

The map-controlled control valve is a proportional valve which can control the oil pressure steplessly.



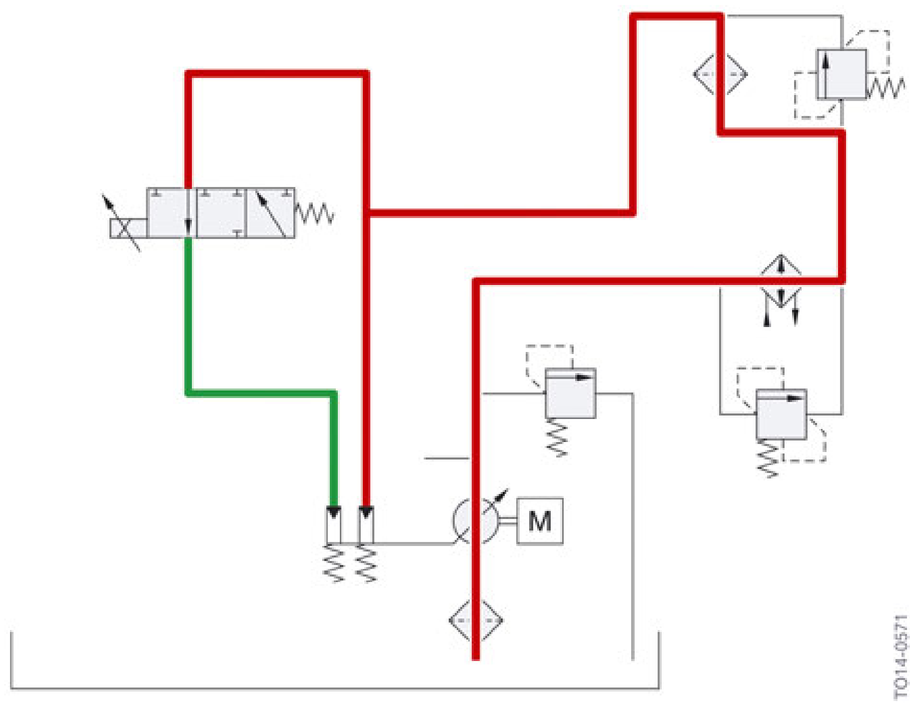
Map-controlled control valve, B46 engine

Index	Explanation
A	Voltage curve, maximum delivery rate
B	Voltage curve, minimum delivery rate
C	Voltage curve, 50 % delivery rate
1	Oil duct from the oil filter
2	Oil duct to oil pump
3	Sealing ring
4	Solenoid coil
5	Electrical connection
6	Valve spool
7	Filter

The oil pressure sensor is connected to the main oil duct and delivers the actual oil pressure at the Digital Motor Electronics (DME). The Digital Motor Electronics calculates the required nominal oil pressure based on the engine speed and fuel injection rate. A pulse-width modulated signal is sent to the map-controlled control valve based on the determined setpoint deviation. Depending on the pulse-width modulated signal, the width of the valve spool opening in the map-controlled control valve varies. Depending on the available opening cross-section, more or less engine oil can flow from the oil duct of the oil filter into the oil duct and to the oil pump. This oil flow changes the position of the adjusting ring in the oil pump, and therefore the delivery rate of the pump.

3.3.2. Normal operation

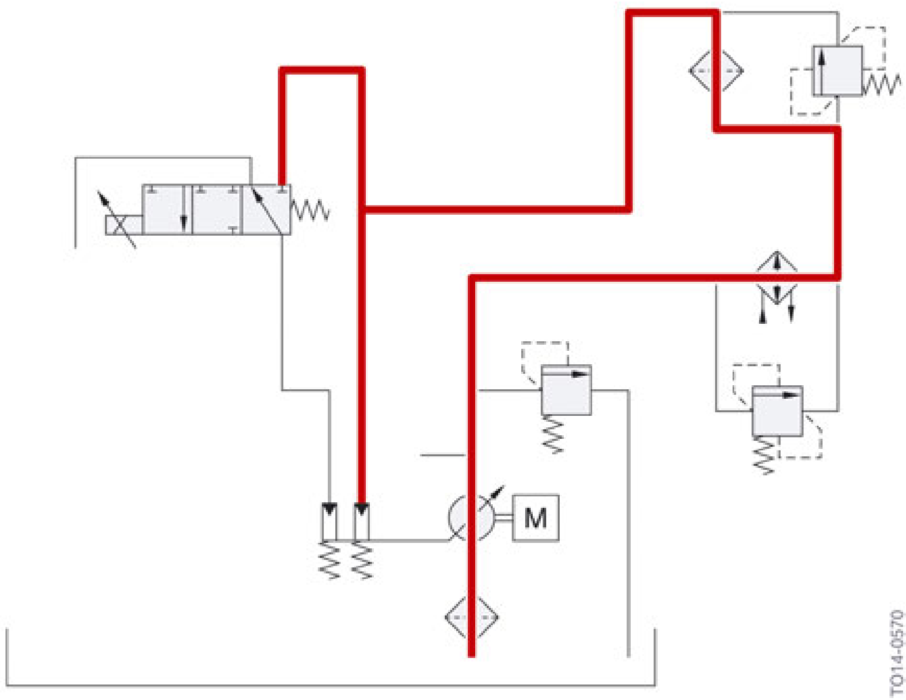
The oil pump has two separate control loops in order to guarantee normal operation (map-controlled control operation) and emergency operation (second-level control operation).



Oil circuit during normal operation, B46 engine

This control loop operates with an external map-controlled valve. The map-controlled control valve controls the oil pressure in the map-controlled control chamber via a software in the Digital Motor Electronics. If the oil pressure in the map-controlled control chamber increases, the adjusting ring further compresses the adjusting ring spring and the pump eccentricity is reduced. This results in a lower volumetric flow.

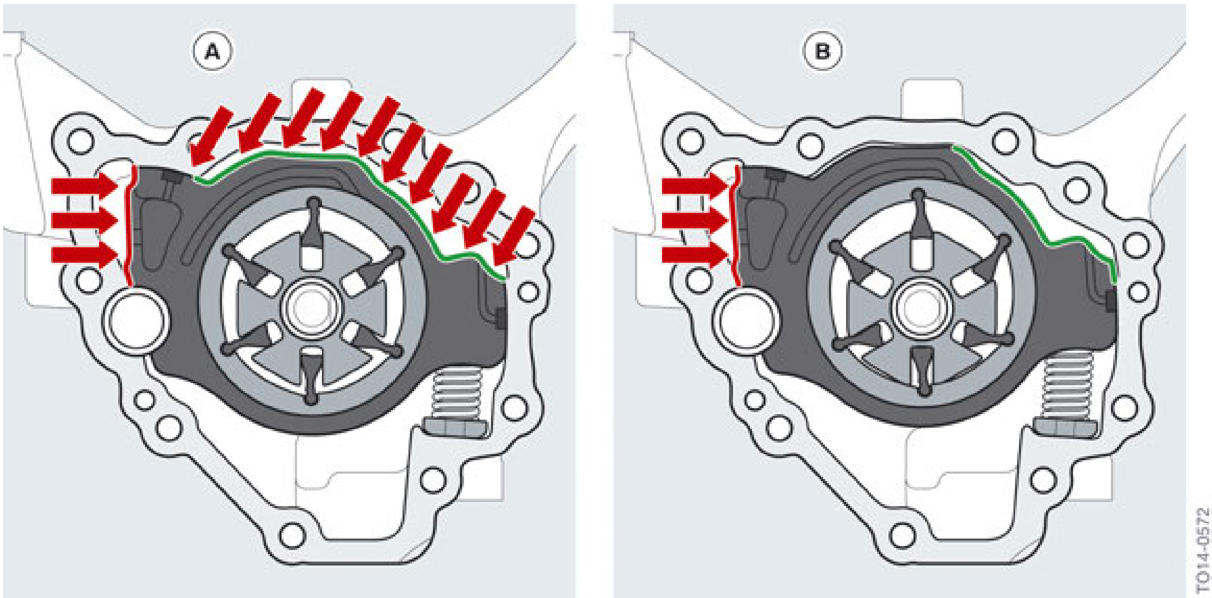
3.3.3. Emergency operation



Oil circuit during emergency operation, B46 engine

During emergency operation, the system operates without the map control by the Digital Motor Electronics. The map-controlled control valve is de-energized in this operating condition and is therefore closed. The purpose of the emergency operation is to maintain the oil pressure in the oil pump at a consistently high level. The oil pressure is guided directly from the main oil duct to the second-level control chamber. This leads to an adjustment of the adjusting ring against the adjusting ring spring and thus a reduction of the volumetric flow. As it contains no actuators, intervention in this control system is not possible and it also cannot be switched off.

B46 Engine
3. Oil Supply



Operating principle of oil pump control system, B46 engine

Index	Explanation
A	Normal operation
B	Emergency operation

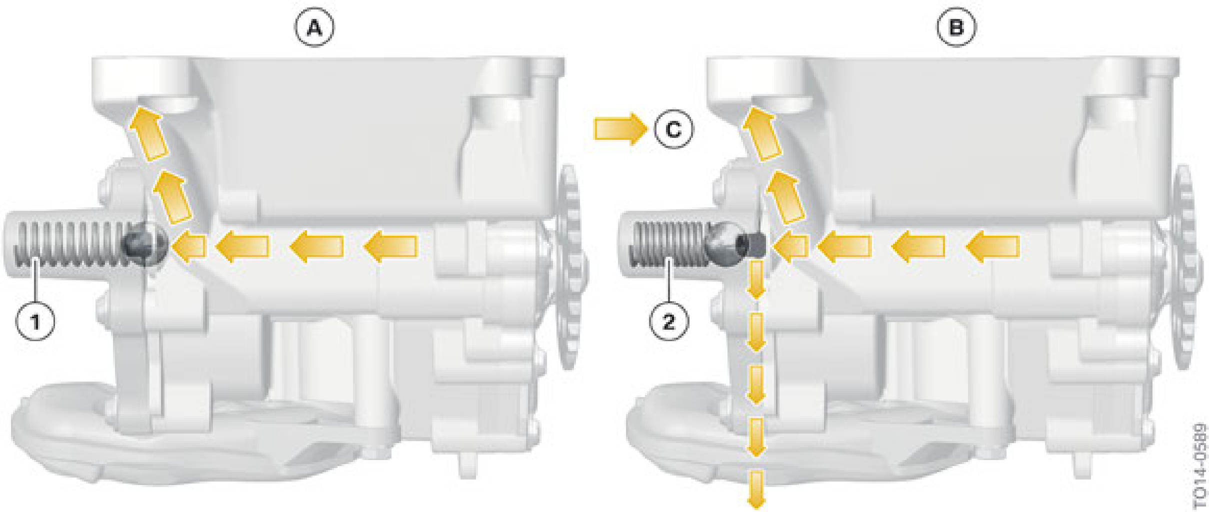
3.4. Suction pipe

The oil pump draws oil from the oil sump through the intake pipe. The suction pipe is positioned so that the suction opening is below the oil level under all operating conditions. The intake pipe incorporates an oil strainer, which prevents coarse dirt particles from getting into the oil pump.

Intake pipe in B46 engine

The intake pipe is a separate component which is screwed on to the oil pump.

3.5. Pressure-limiting valve

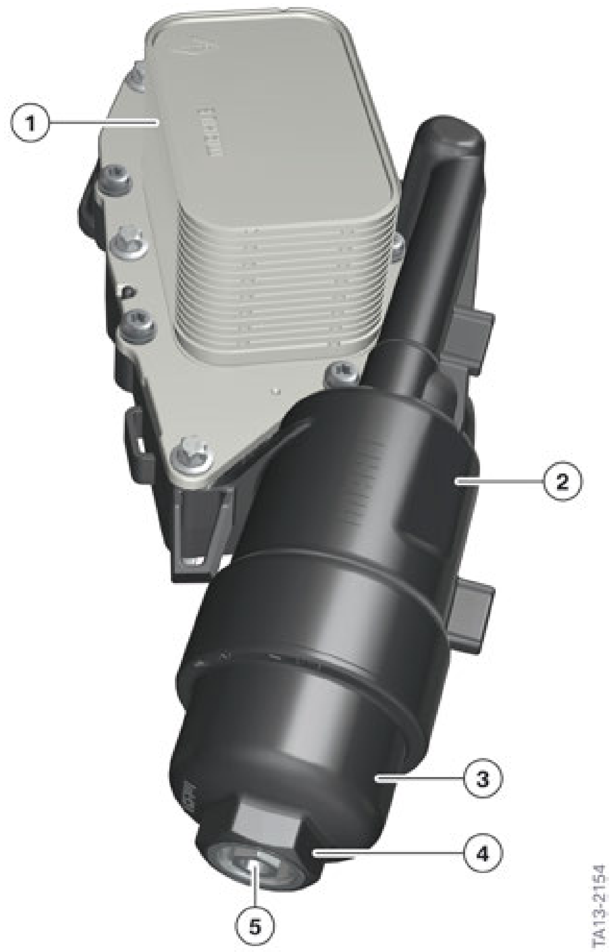


Pressure limiting valve in oil circuit in B46 engine

Index	Explanation
A	Oil pressure < 11.4 +/– 1.4 bar
B	Oil pressure > 11.4 +/– 1.4 bar
C	Engine oil volumetric flow
1	Pressure limiting valve closed
2	Pressure limiting valve open

The pressure limiting valve is responsible for protecting the oil pump and the oil circuit against overloading. This valve opens at an oil pressure of > 10 bar and directs the excess engine oil back to the oil sump. This valve is used if necessary when starting the engine at cold ambient temperatures (values < 0 °C), as the viscosity of the engine oil is very high here.

3.6. Oil filter module



Oil filter module

Index	Explanation
1	Engine oil-to-coolant heat exchanger
2	Oil filter housing
3	Oil filter cover
4	Hexagon head for opening the oil filter cover
5	Hexagon head for opening the oil drain plug

Due to the construction space, the oil filter housing is suspended in the transverse mounting. The inspection is carried out from the bottom of the vehicle. Using an oil drain plug the Service employee can drain the engine oil from the oil filter module before opening the oil filter cover.

B46 Engine

3. Oil Supply

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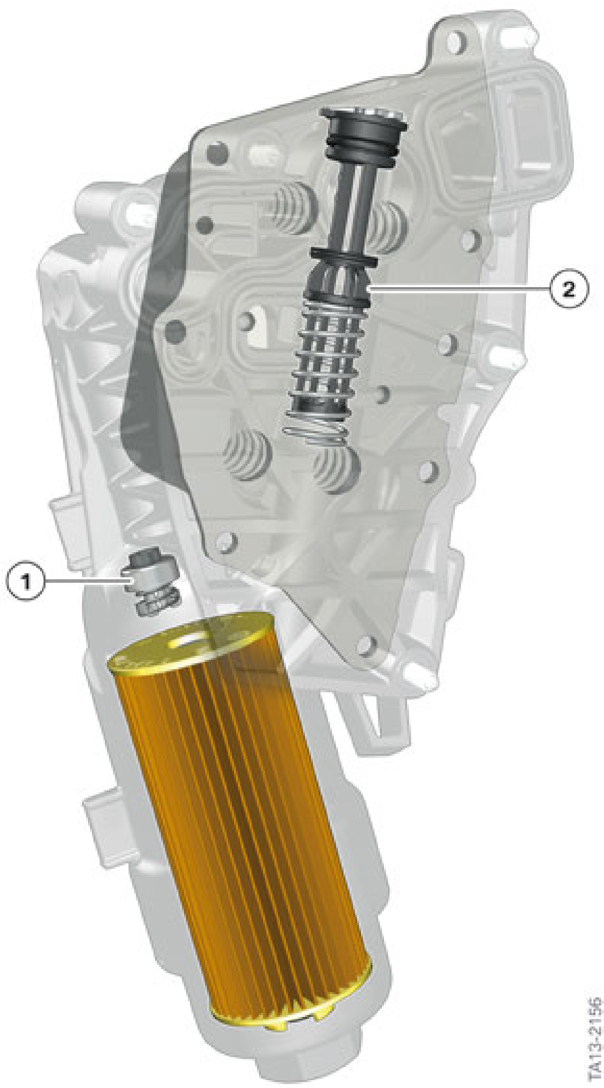
In Service, the specified torques for the oil drain plug and the oil filter cover must be observed. The two O-rings must be replaced each time the oil filter cover and the oil drain plug are opened. Both O-rings are included in the oil filter service kit.



Valves of the oil filter module

Index	Explanation
1	Filter bypass valve
2	Heat exchanger bypass valve

A non-return valve is not required thanks to the suspended mounting. The filter cannot run empty after the engine is stopped due to its position.

3.6.1. Filter bypass valve

When a filter is blocked, the filter bypass valve ensures that engine oil reaches the lubrication points of the engine. It opens when the differential pressure upstream and downstream of the oil filter is 2.5 bar ± 0.3 bar.

3.6.2. Heat exchanger bypass valve

The heat exchanger bypass valve has the same function as the filter bypass valve. If, on account of a blocked oil-to-water heat exchanger, the oil pressure rises, the heat exchanger bypass valve opens at an oil pressure of 2.5 bar ± 0.3 bar and the lubricating oil can flow uncooled to the lubrication points.

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To ensure the engine runs perfectly, only engine oils approved by BMW can be used.

B46 Engine

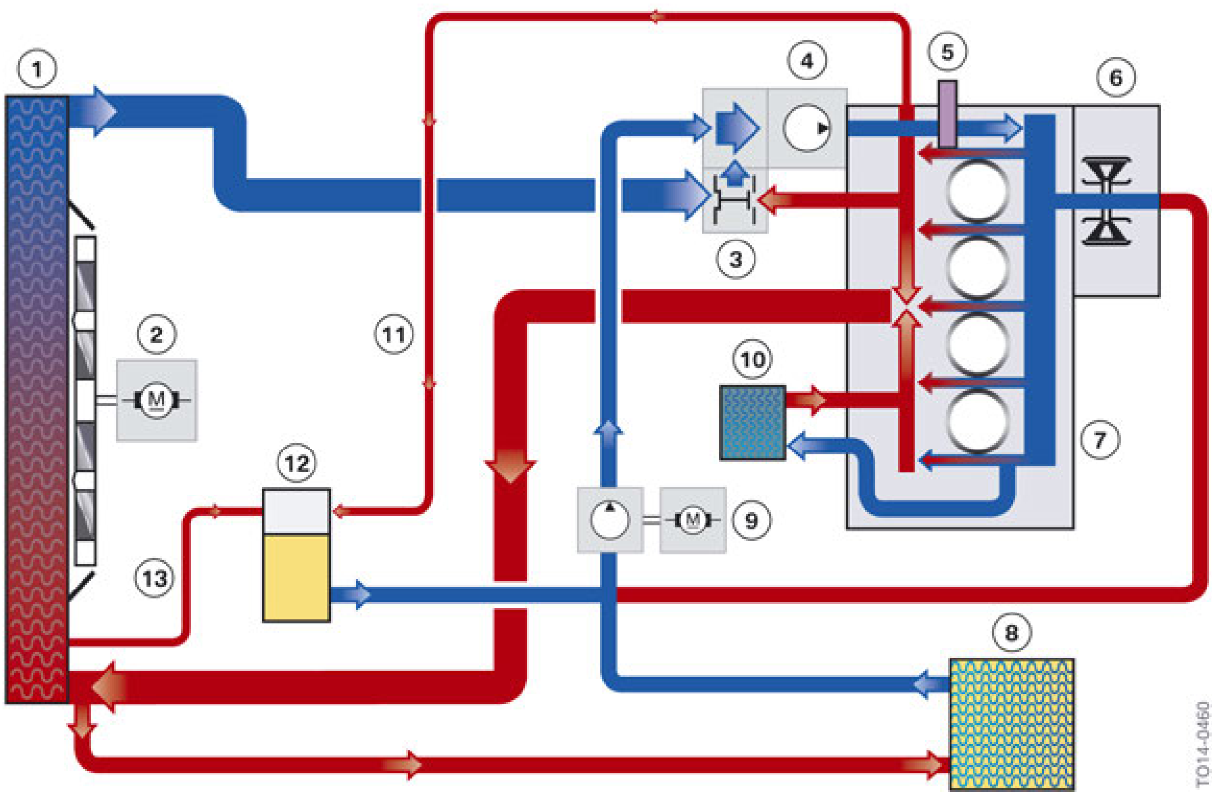
4. Cooling System

In order to protect the thermally loaded engine components, the engine oil and the transmission oil from overheating, they are cooled using coolant. A mechanical coolant pump circulates the coolant in the cooling circuit. The heat quantities introduced to the coolant are emitted to the ambient air again using a radiator. An electric fan assists the radiator output.

The coolant in the B46 engine is mainly circulated via a mechanical coolant pump. Several engines are also equipped with an electrical overrun pump which maintains a trickle of coolant to the bearing seat cooling system of the exhaust turbocharger.

The following graphics provide an overview of the different cooling circuits.

4.1. Cooling circuit, B46 engine



Cooling circuit, B46 engine

Index	Explanation
1	Radiator
2	Electric fan
3	Map thermostat
4	Coolant pump
5	Coolant temperature sensor
6	Coolant-cooled exhaust turbocharger
7	Engine housing

Index	Explanation
8	Heat exchanger
9	Electric coolant pump (20 W)
10	Engine oil-to-coolant heat exchanger
11	Tank ventilation line from the cylinder head
12	Expansion tank
13	Ventilation line of the radiator

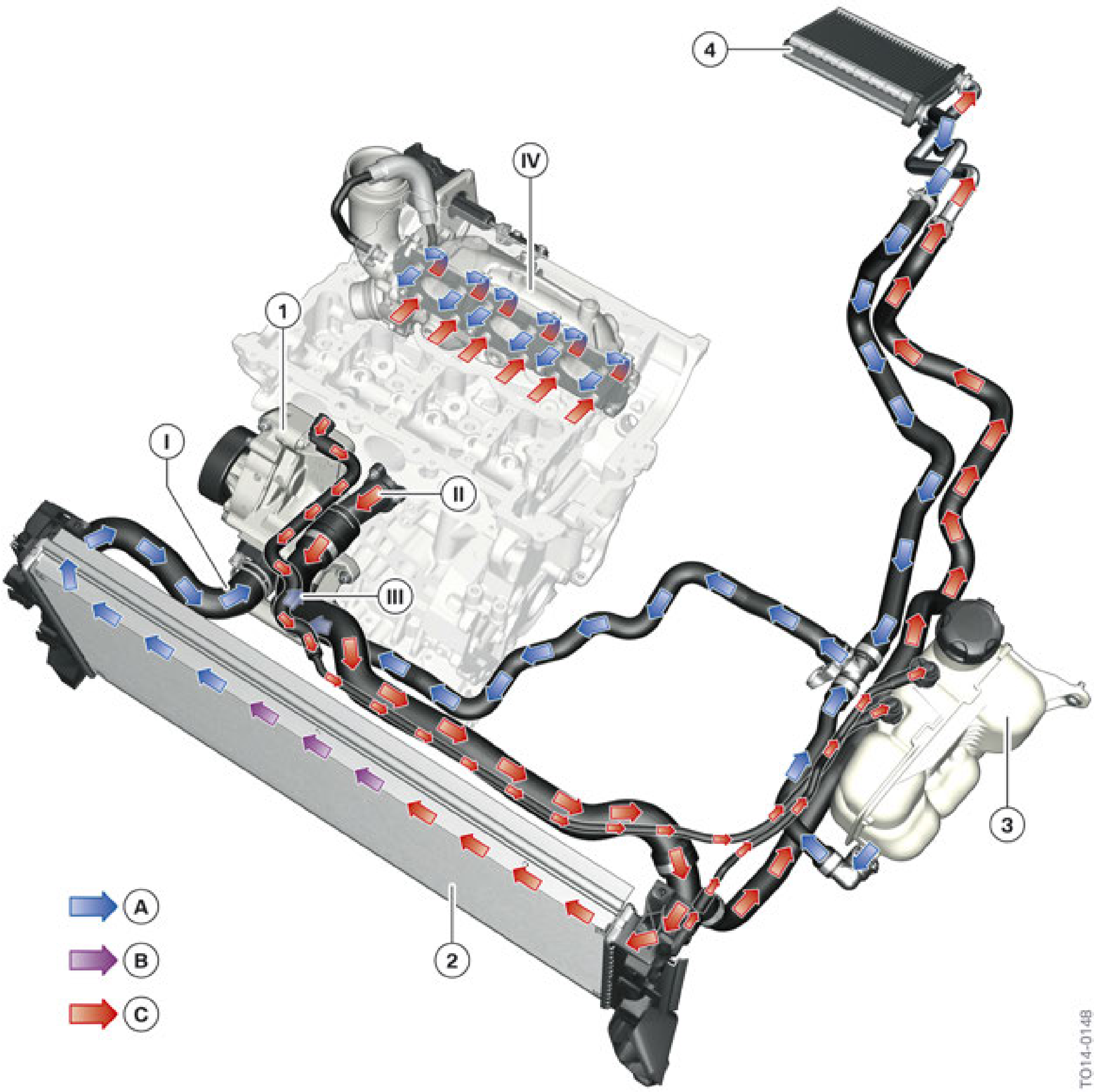
4.1.1. Special features

- Coolant-cooled exhaust turbocharger
- Mechanical coolant pump
- Electric coolant pump
- Characteristic map thermostat

Due to the twin-scroll technology, the B46 engines are equipped with a steel manifold. 'Twin-scroll' means that the exhaust flows are routed via two separate channels to the exhaust turbocharger. The heat produced is absorbed by the coolant which is supplied via a coolant connection on the exhaust turbocharger. When the motor is not running, post-cooling of the exhaust turbocharger is possible with the assistance of an electric coolant pump (20 W). This prevents a build-up of heat in the area of the exhaust turbocharger.

For more in-depth explanations on the exhaust turbocharger, refer to the chapter Intake air and exhaust emission system.

4.2. System overview, vehicle

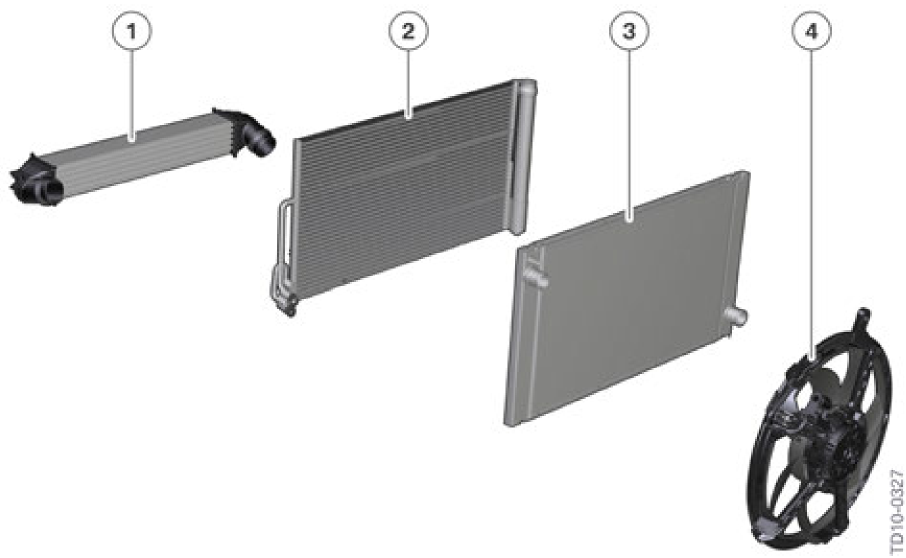


Vehicle cooling circuit, B38 engine

Index	Explanation
A	Coolant cooled down
B	Coolant warmed up
C	Coolant heated up
I	Cooled coolant to coolant pump
II	Heated coolant from engine to radiator
III	Cooled coolant to thermostat

Index	Explanation
IV	Coolant flow via exhaust turbocharger
1	Coolant pump
2	Radiator
3	Expansion tank
4	Heat exchanger

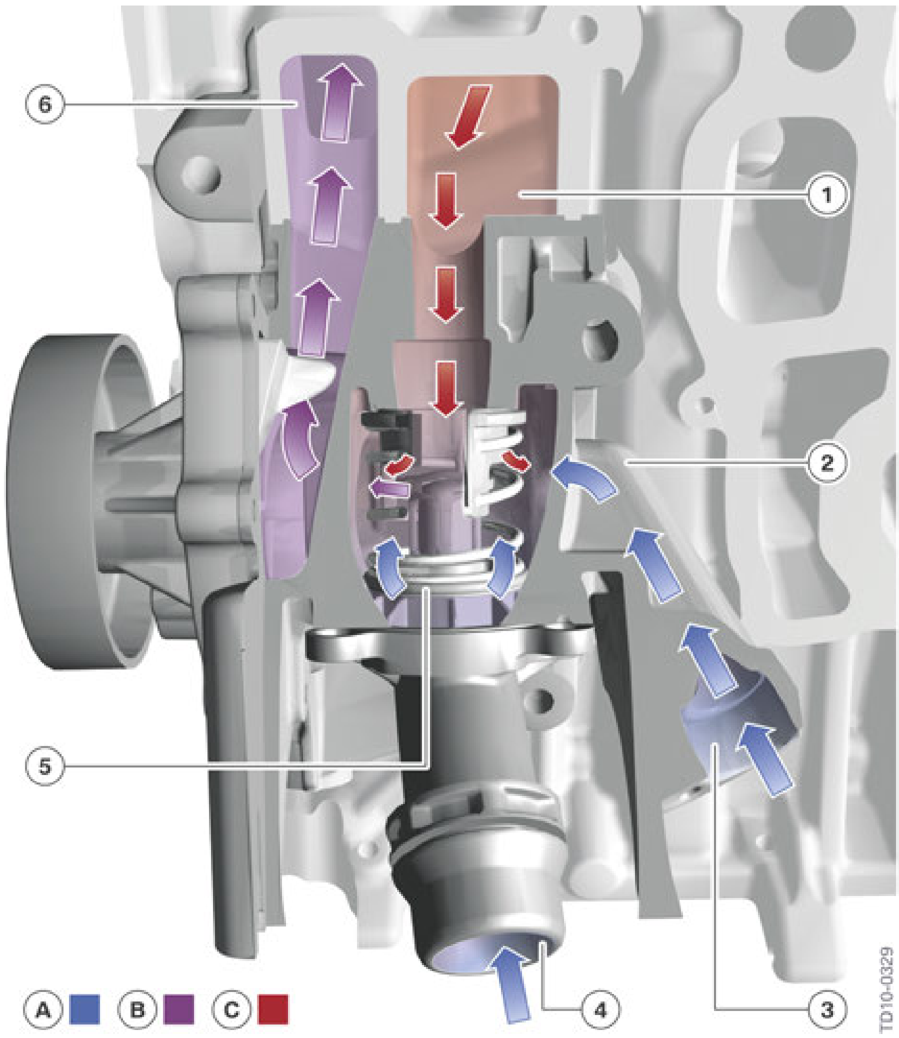
4.3. Cooling module



Cooling module

Index	Explanation
1	Charge air cooler
2	A/C condenser
3	Radiator
4	Electric fan

4.4. Coolant pump



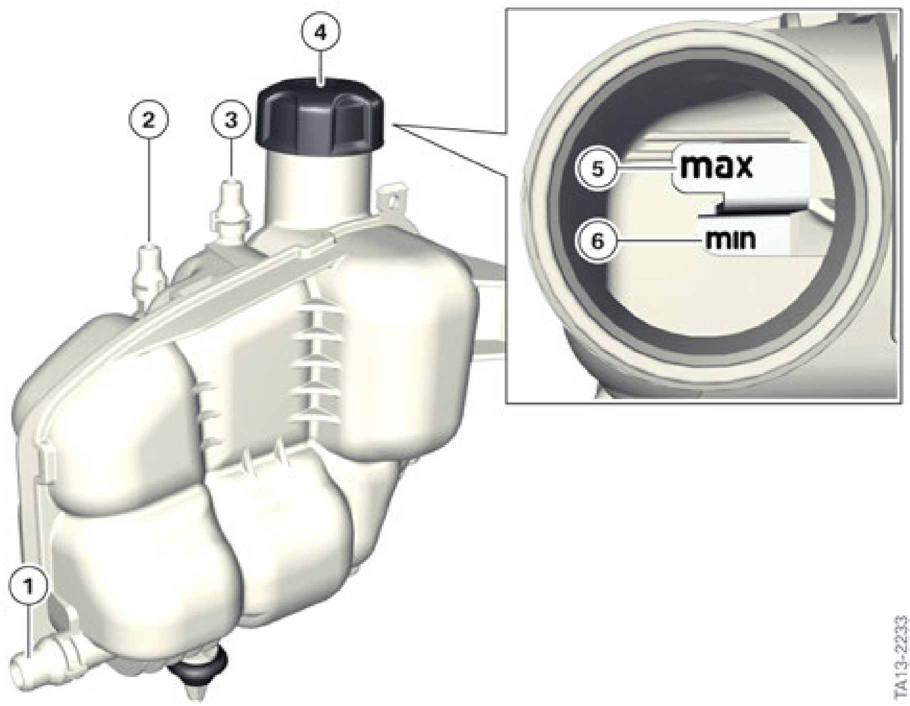
Coolant pump with characteristic map thermostat

Index	Explanation
A	Cooled coolant
B	Warmed coolant
C	Heated coolant
1	Coolant duct from the crankcase
2	supporting component carrier
3	Inlet from expansion tank and heat exchanger
4	Feed from radiator
5	Map thermostat
6	Coolant duct to the crankcase

The coolant pump forms one unit with the characteristic map thermostat. The coolant pump housing is made from the aluminium alloy ALSi9Cu3, the impeller and the thermostat cover are made of plastic.

The Digital Motor Electronics controls the cooling circuit via a map-controlled thermostat.

4.5. Expansion tank



Expansion tank

Index	Explanation
1	Coolant line, coolant expansion tank output
2	Tank ventilation line from the cylinder head
3	Ventilation line of the radiator
4	Sealing cap
5	Visible filling level indicator "Maximum"
6	Visible filling level indicator "Minimum"

The expansion tank is used as a reservoir for the coolant. The expansion tank ensures that there is always a sufficient quantity of coolant available in the cooling circuit.

In the sealing cap there is a pressure relief valve which restricts the pressure in the system.

The sealing cap must never be opened when the engine is hot. The reason for this is not just the risk of burning. In higher areas of the cooling circuit, such as the cylinder head, gas bubbles may form as a result of the loss of pressure. Sufficient heat dissipation is no longer guaranteed at these points.
This would result in overheating.

There is a visible filling level indicator in the expansion tank. The filling level can be read when the tank is open. The filling level should be between maximum and minimum for correct filling.

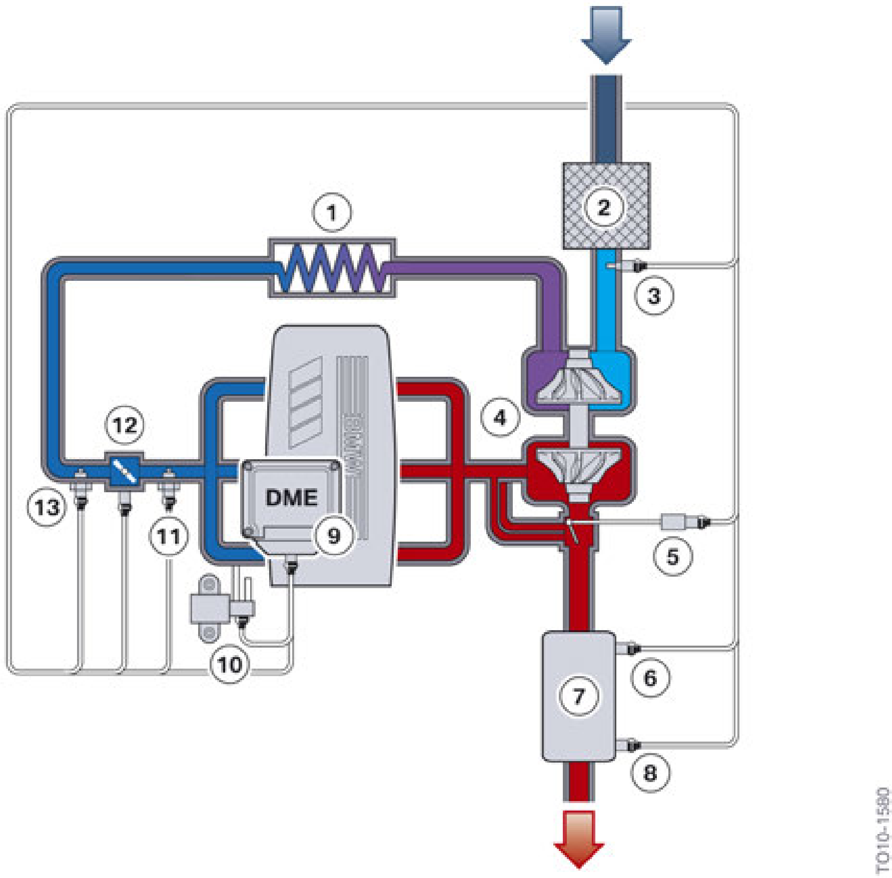
4.6. Coolant

The familiar coolant with a silicone base is used. The coolant is not subject to a change interval. The filling is designed for the entire service life of the engine. For work which requires an opening of the cooling circuit the coolant must be replaced. The precise procedure for ventilating the cooling circuit can be found in the current repair instructions.

⚠

The cooling system must only be filled with BMW-approved coolant. If the wrong coolant is used, damage to the coolant pumps, coolant hoses, radiators and cylinder head gasket may subtly creep in.

5. Intake Air and Exhaust System

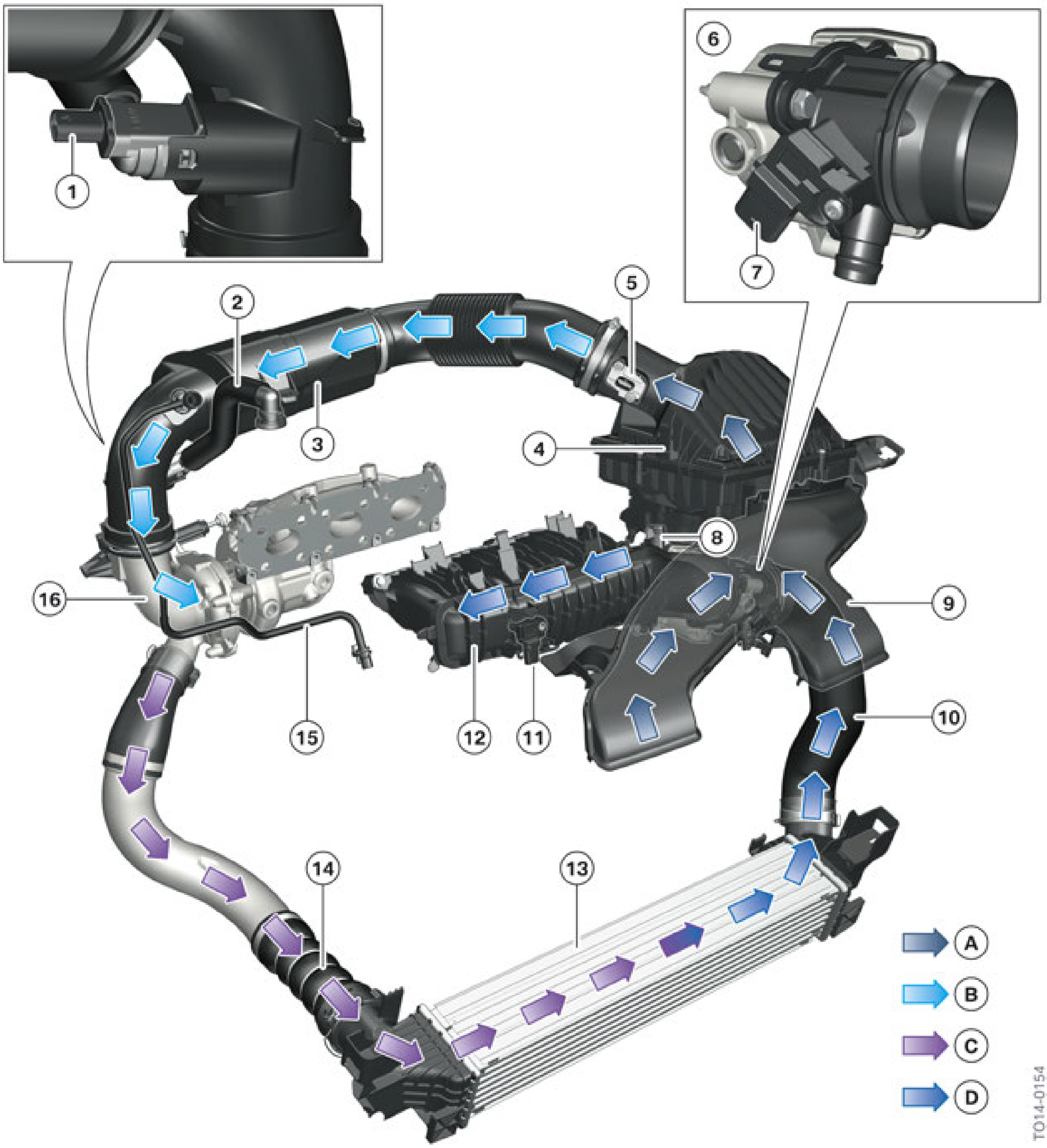


System overview of intake air and exhaust emission system in the B38 engine

Index	Explanation
1	Charge air cooler
2	Intake silencer
3	Hot film air mass meter
4	Exhaust turbocharger
5	Actuator of electrically adjustable wastegate valve
6	Broadband oxygen sensor upstream of catalytic converter (control sensor)
7	Catalytic converter
8	Voltage-jump sensor downstream of catalytic converter (monitoring sensor)
9	Digital Motor Electronics (DME) (MEVD 17.2.3)
10	Tank vent valve
11	Intake manifold pressure sensor
12	Throttle valve
13	Charge-air temperature and charge-air pressure sensor

5. Intake Air and Exhaust System

5.1. Intake air system



Air intake system, transverse mounting

Index	Explanation
A	Fresh air
B	Purified air
C	Heated charge air
D	Cooled charge air
1	Engine ventilation heating (only with cold-climate version)
2	Blow-by channel into clean air pipe (turbocharged operation)
3	Clean air pipe with resonator
4	Air filter housing
5	Hot film air mass meter
6	Throttle valve unit
7	Charge air temperature and charging pressure sensor
8	Connection for carbon canister regeneration line
9	Unfiltered-air snorkel
10	Charge air hose
11	Intake manifold pressure sensor
12	Intake manifold
13	Charge air cooler
14	Charge air hose
15	Purge air line
16	Exhaust turbocharger compressor, inlet side

The air duct of the differentiated air intake system differs depending on the installation position. This documentation only deals with the air duct in the transverse-mounted Bx8 engine.

The intake unfiltered air reaches the intake silencer with air cleaner via the unfiltered air line with intake air grille. The unfiltered air is filtered in the intake silencer with air cleaner and becomes clean air. Then the clean air is directed to the exhaust turbocharger via the hot film air mass meter and the clean air pipe with resonator. The blow-by gases from the crankcase are also introduced, depending on the load condition, into the clean air pipe upstream of the exhaust turbocharger, or into the intake ports directly.

The clean air is compressed and heated in the exhaust turbocharger. The compressed, warm charge air is further directed to the charge air cooler in the charge air hose. From the charge air cooler the now cooled charge air is directed to the throttle valve via an additional charge air hose and the adapter pipe with charge air temperature and charging pressure sensor. The cooled charge air is taken to the intake air system via the throttle valve.

5.1.1. Intake silencer

The intake silencer is mounted on the engine and contains the air cleaner. Air which has been inducted up to the air filter is referred to as fresh air. After leaving the air filter the cleaned air is referred to as clean air.

5.1.2. Charge air cooling

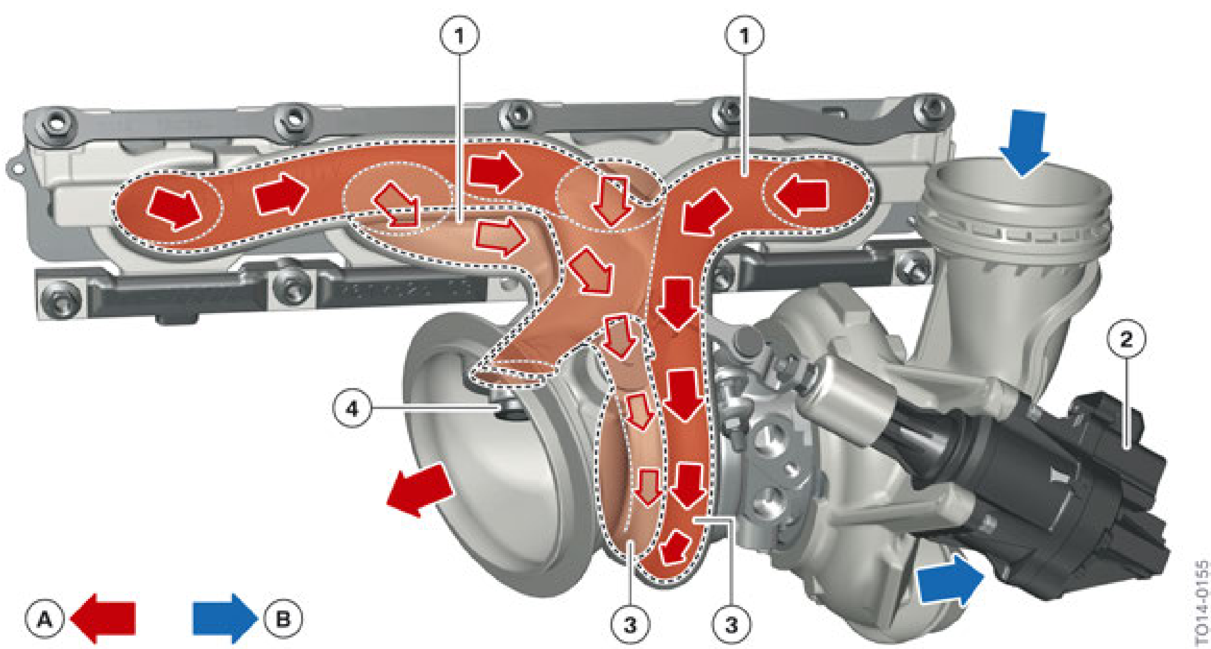
Charge air cooler

Because the air heats up during compression in the exhaust turbocharger and thus expands, the amount of oxygen which can be routed into the combustion chamber is reduced again. The charge air cooler has a counteractive effect in that it cools the compressed air. The density is thus increased and the oxygen content per volume is also increased. The charge air cooler is located in the cooling module below the radiator. It is an air-air heat exchanger. The compressed air flows through the charge air cooler in several plates, around which for their part the cooling air flows.

5.2. Exhaust emission system

5.2.1. Exhaust turbocharger

Exhaust turbocharger in the B46 engine



Exhaust turbocharger in the B46 engine

Index	Explanation
A	Turbine side
B	Compressor side
1	Exhaust duct
2	Actuator of electrically adjustable wastegate valve
3	Twin-scroll
4	Electric wastegate valve

The exhaust turbocharger of the B46 engine is a twin-scroll exhaust turbocharger. To facilitate a fast and direct response, the exhaust flows from cylinders 1 and 4, and 2 and 3 are merged and routed to the compressor via two separate channels. This principle is referred to as pulse turbocharging.

The exhaust manifold and exhaust turbocharger housing have been designed as one common cast part and cannot be replaced individually.

The charging pressure is adjusted via an electrical actuator.

5.2.2. Blow-off valve

A blow-off valve is not used in current models. Pressure peaks, caused by sudden load shedding due to the inertia of the turbine of the exhaust turbocharger, can be avoided by careful tuning of the Digital Motor Electronics software. With foresighted charging pressure control, pressure peaks can be predicted and reduced by quick adjustment of the electrically-adjustable wastegate valve. Assisted by a delayed load control of the Valvetronic (in the minimum lift direction) or the throttle valve (in the closed direction), the remaining charge air which is produced can be routed to the exhaust emission system via the engine. This form of control thus prevents the exhaust turbocharger shaft from being exposed to excessive torsional stress due to high pressure peaks.

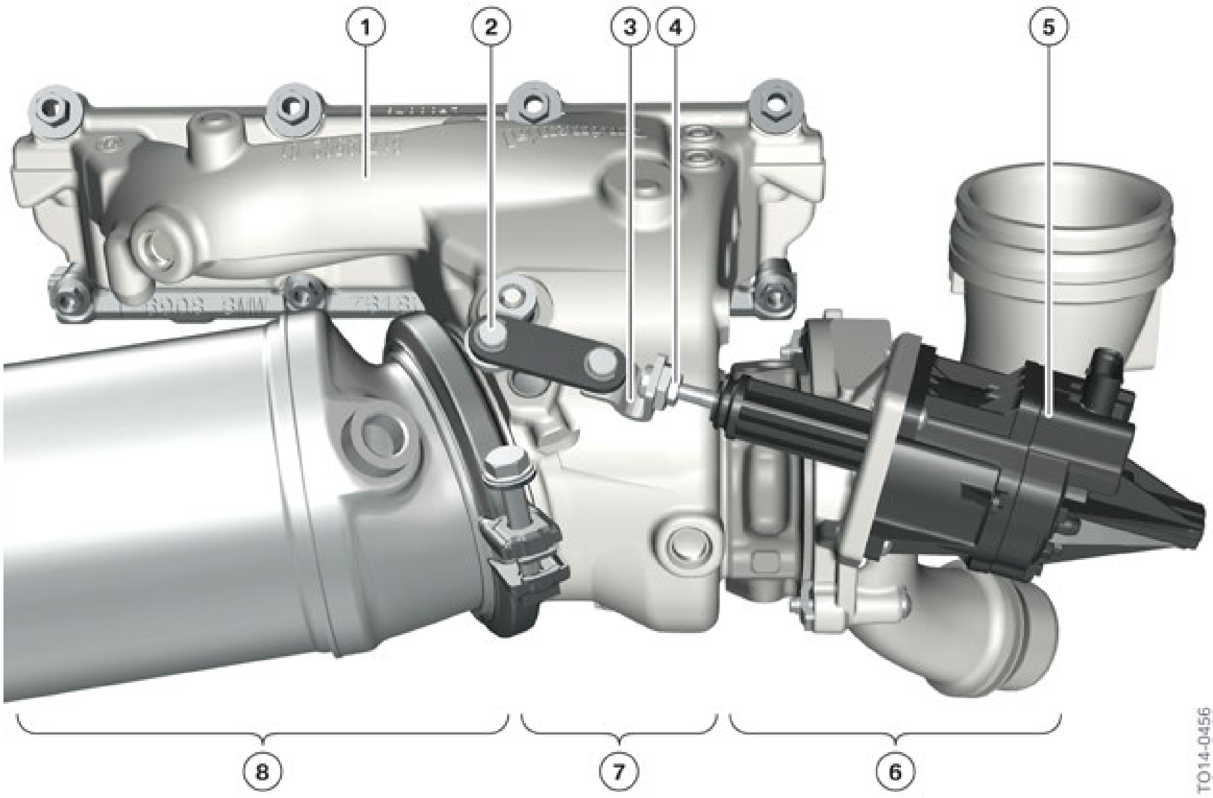
5.2.3. Charging pressure control

The charging pressure in B46 engines is controlled via an electrically adjustable wastegate valve.

Electrified adjustment

In contrast to a vacuum-controlled charging pressure control, the following components are not required:

- Vacuum unit
- Vacuum lines
- Electro-pneumatic pressure converter
- Vacuum reservoir



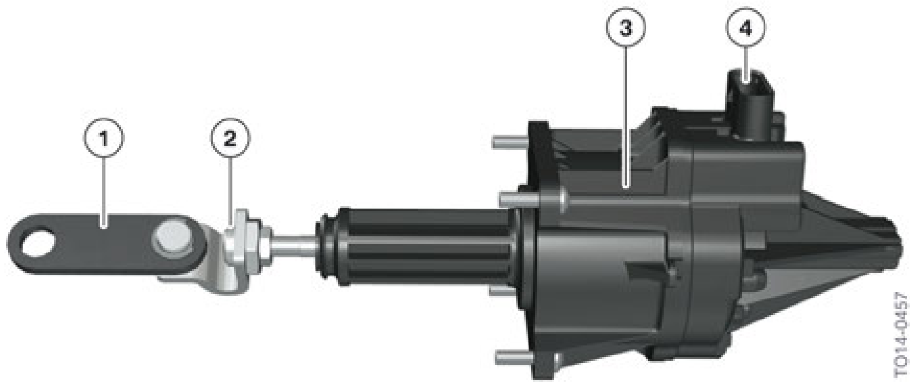
Overview of electrically adjustable wastegate valve, B38 engine

Index	Explanation
1	Exhaust manifold
2	Wastegate valve
3	Adjusting linkage
4	Lock nut
5	Actuator of electrically adjustable wastegate valve
6	Exhaust turbocharger, compressor side
7	Exhaust turbocharger, turbine side
8	Catalytic converter

Advantages of electrical activation

- Faster control speed
- More precise control
- Simpler diagnosis
- Fewer components
- Larger opening angle of wastegate valve

Operating principle



Actuator of electrically adjustable wastegate valve

Index	Explanation
1	Stroke linkage
2	Adjustment linkage
3	Actuator
4	Electrical connection

A direct current motor and a sensor are located in the actuator of the electrically adjustable wastegate valve, resulting in a total of five electrical connections. The wastegate valve is opened or closed by a lifting movement of the linkage.

The actuator of the electrically adjustable wastegate valve can be replaced separately in Service. Each time the adjusting linkage is activated, the system must be re-adjusted with the assistance of the BMW diagnosis system ISTA. This measure is not required when replacing the entire exhaust turbocharger as the linkage is supplied preset.

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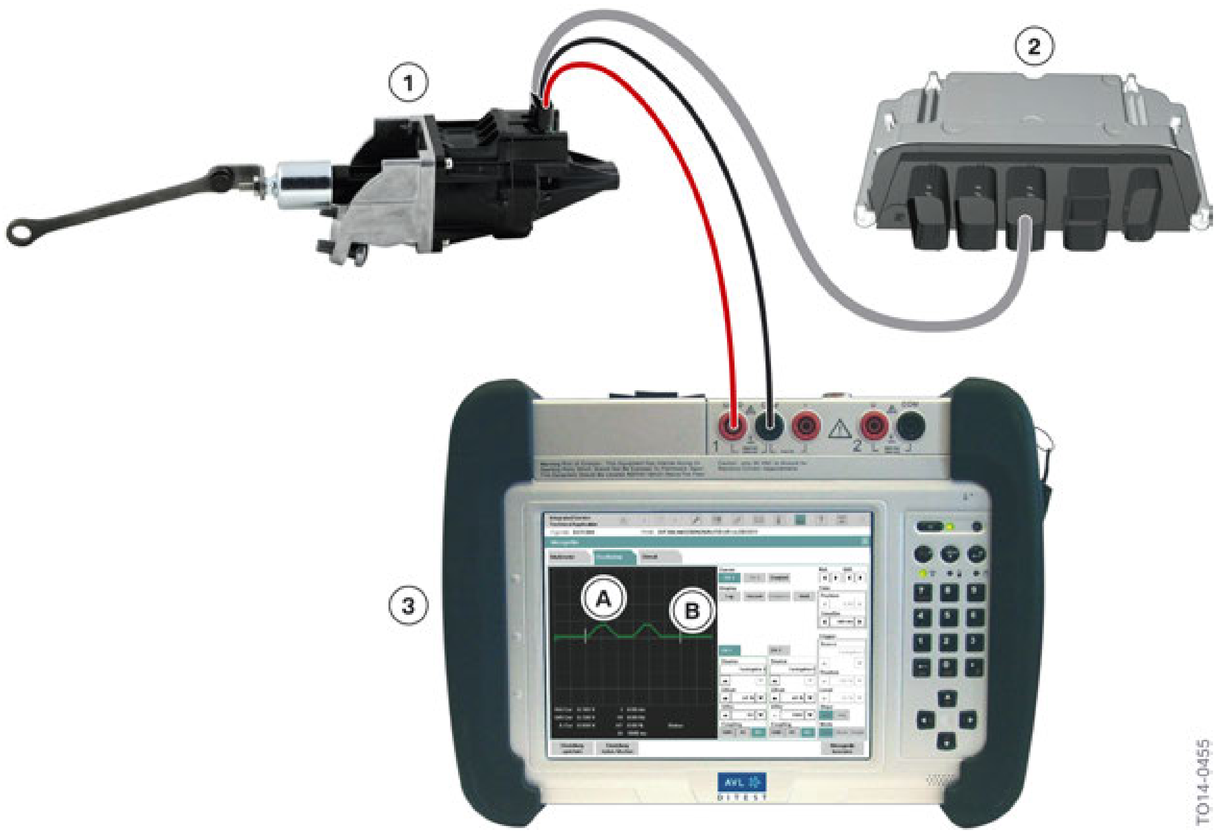
If the actuator is replaced individually, a teach-in routine must be performed using the BMW diagnosis system ISTA.



Sensor signal to electrically adjustable wastegate valve

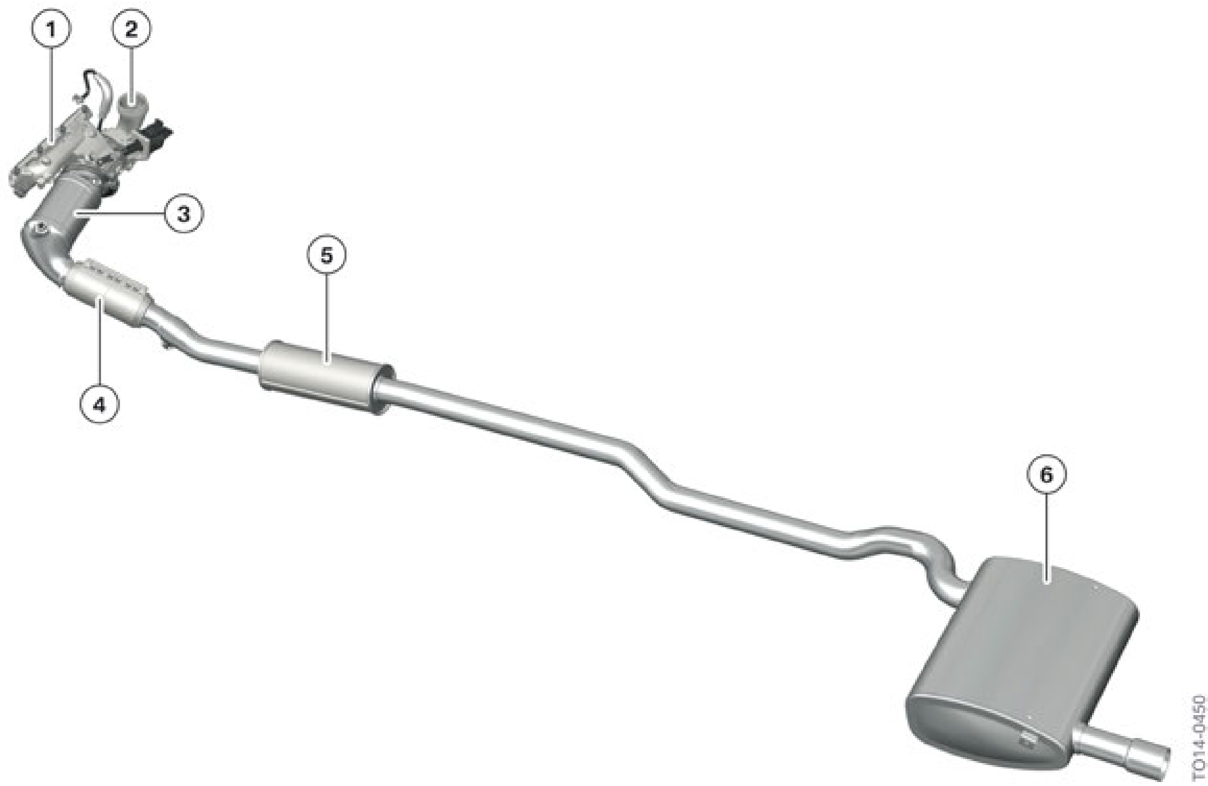
Index	Explanation
A	Wastegate valve closed
B	Wastegate valve opened
1	Actuator of electrically adjustable wastegate valve
2	Digital Motor Electronics (DME)

The sensor is used to determine the position of the wastegate valve. The wastegate valve can move to any required position between maximum open and maximum closed. When the sensor signal or actuator drops out, the wastegate valve adopts the open position to allow charging pressure to build up. This ensures the journey continues with reduced engine performance.

⚠

As the position sensor is a linear Hall sensor, a resistance measurement for testing the sensor is not permitted.

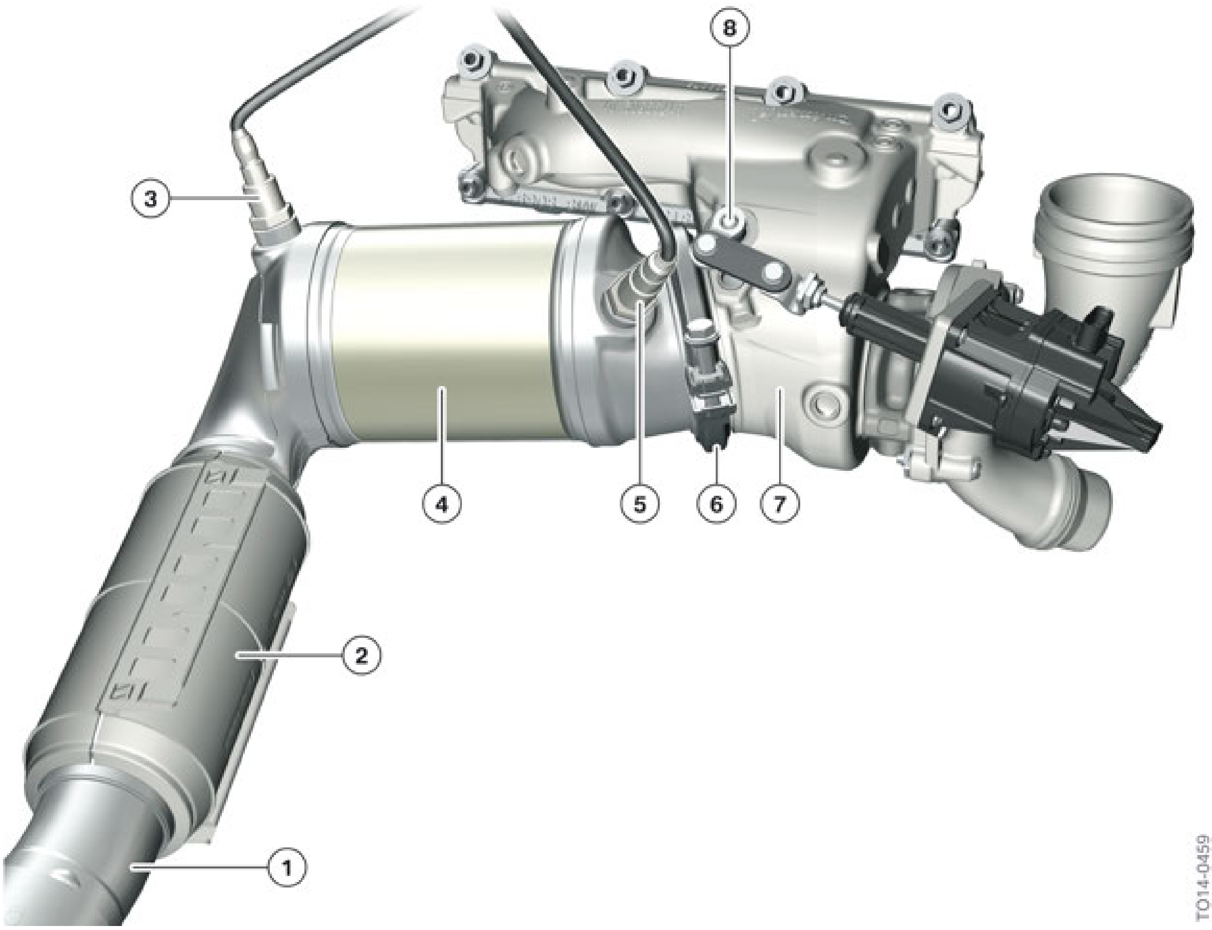
5.2.4. Exhaust system



Overview of exhaust emission system of the Bx8 engine in the F48

Index	Explanation
1	Exhaust manifold
2	Exhaust turbocharger
3	Catalytic converter
4	Decoupling element
5	Center silencer
6	Rear silencer

The B46 engine satisfies the exhaust gas emission regulations of the ULEV II exhaust emission standards when introduced on the market.



Exhaust gas treatment, B38 engine

Index	Explanation
1	Exhaust pipe
2	Decoupling element
3	Monitoring sensor (voltage-jump sensor)
4	3-way catalytic converter
5	Control sensor (broadband oxygen sensor)
6	Clamp
7	Turbine housing
8	Wastegate valve

Measures for reduction of exhaust gas emissions

- Precise and fast charging pressure control.
- Catalytic converter heating during cold start.
- Positioning of catalytic converter near engine.
- New LSF Xfour voltage-jump sensor by Bosch.

Catalytic converter heating

When starting the combustion engine from cold, the wastegate valve is opened as wide as possible and the ignition point is adjusted to retard. The retarded ignition point delays the combustion process which in turn supports the heat input for heating of the catalytic converter. As the turbine housing is short, it has been possible to position the catalytic converter very close to the wastegate valve. As the exhaust gas flows into the catalytic converter at the perfect angle and because of its position close to the engine, the catalytic converter reaches its operating temperature very quickly. If the wastegate valve is opened when cold, pulsation of the exhaust gas may cause vibrations in the wastegate valve, which are perceived as noise. This is not due to a defective component, and is normal running noise. This noise becomes less audible as the temperature of the component increases.

Control sensor

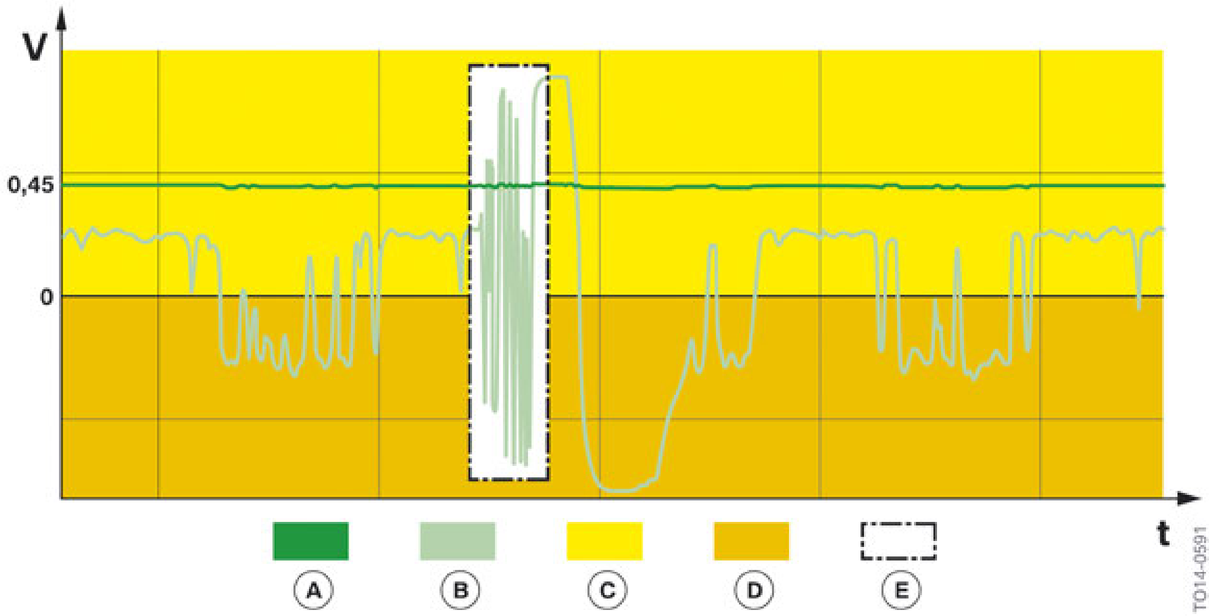
With a stoichiometric air/fuel ratio (λ=1), the proportion of oxygen in the exhaust gas is ideal for conversion of the pollutants in the 3-way catalytic converter. By measuring the oxygen content in the exhaust gas, the oxygen sensor of the Digital Motor Electronics delivers important information for mixture preparation.

A broadband oxygen sensor with the designation LSU ADV has been specially developed for engines with exhaust turbochargers and is used as the control sensor. One of the major characteristics of broadband oxygen sensors is their extensive measuring range. The measuring range of the LSU ADV is from a lambda of λ=0.65 to λ=air.

The broadband oxygen sensor LSU ADV is a combination of a measuring cell and pump cell. There is a small diffusion gap between these two cells which serves as a measuring chamber and is connected to the exhaust gas duct. The measuring cell operates according to the principle of a voltage-jump sensor and measures the residual oxygen content in the exhaust gas. If the fuel-air mixture is too lean ($\lambda > 1$), the control electronics applies voltage to the pump cell so that oxygen ions are pumped out of the diffusion gap. If the mixture is too rich ($\lambda < 1$), oxygen ions are pumped into the diffusion gap by activating the pump cell accordingly. The pump flow required to control the pump cell is directly proportional to the oxygen concentration and therefore serves as the control variable for the air ratio.

The control strategy has been devised so that the oxygen concentration in the area of the diffusion gap corresponds to an air ratio of $\lambda = 1$. As this control method is extremely fast and incredibly accurate, the voltage value of the measuring cell always remains at a constant level (450 mV).

The following graphic shows the two voltage curves of the measuring cell and the pump cell when the engine is in operation:



Voltage signal, LSU ADV broadband oxygen sensor

Index	Explanation
A	Signal voltage, measuring probe
B	Control voltage, pump sensor
C	Positive control voltage
D	Negative control voltage
E	Press on accelerator
t	Time
V	V

In the positive range of the control voltage (U > 0 V), there is excess oxygen in the area of the diffusion gap ($\lambda > 1$). The engine is running slightly too lean. The pump cell pumps oxygen out of the diffusion gap in order to maintain the level of 450 mV in the measuring cell constant.

In the negative range of the control voltage (U < 0 V), there is insufficient oxygen in the area of the diffusion gap ($\lambda < 1$). The engine is running slightly too rich. The pump cell pumps oxygen into the diffusion gap in order also to maintain the level of 450 mV in the measuring cell constant.

An integrated heating element ensures that the broadband oxygen sensor quickly reaches its operating temperature.

Connections, broadband oxygen sensor

- Positive terminal of pump cell
- Negative terminal of pump cell and measuring cell
- Heating minus
- Heating plus
- Positive terminal of measuring cell

Monitoring sensor

A new voltage-jump sensor with the designation LSF Xfour is used as the monitoring sensor. The new oxygen sensor has the following benefits:

- Sturdier design
- Small installation space
- Higher measuring accuracy
- Faster control readiness

The oxygen sensor is suitable for engine start-stop operation. In this case, the sensor must be heated throughout the entire stop phase. The voltage required during the heating phase is 7.5 volts and the heating current is around 1 ampere.

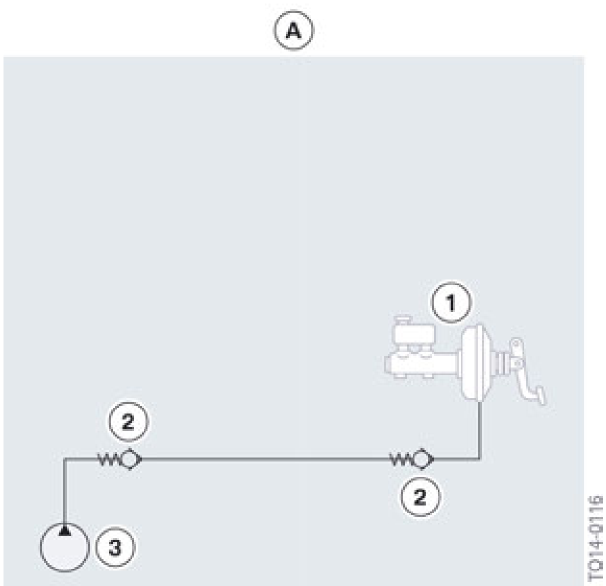
Engine operation	Air ratio	Sensor voltage
Rich operating phase	λ=0.98	0.9 V
Lean operating phase	λ=1.02	0.1 V

B46 Engine

6. Vacuum Supply

The main purpose of the vacuum system is to generate the vacuum for the brake servo.

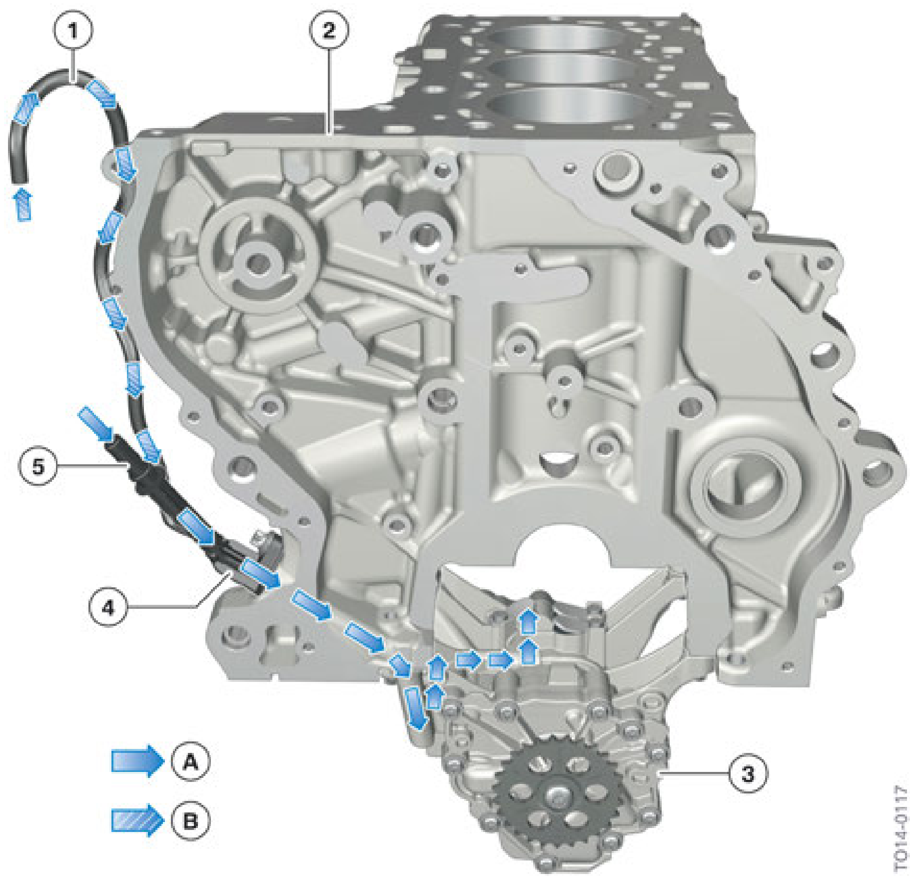
6.1. System overview



Schematic representation of vacuum supply

Index	Explanation
A	B46 engine
1	Brake servo
2	Non-return valve
3	Vacuum pump

6.2. Vacuum pump



Installation location of vacuum pump, Bx8 engine

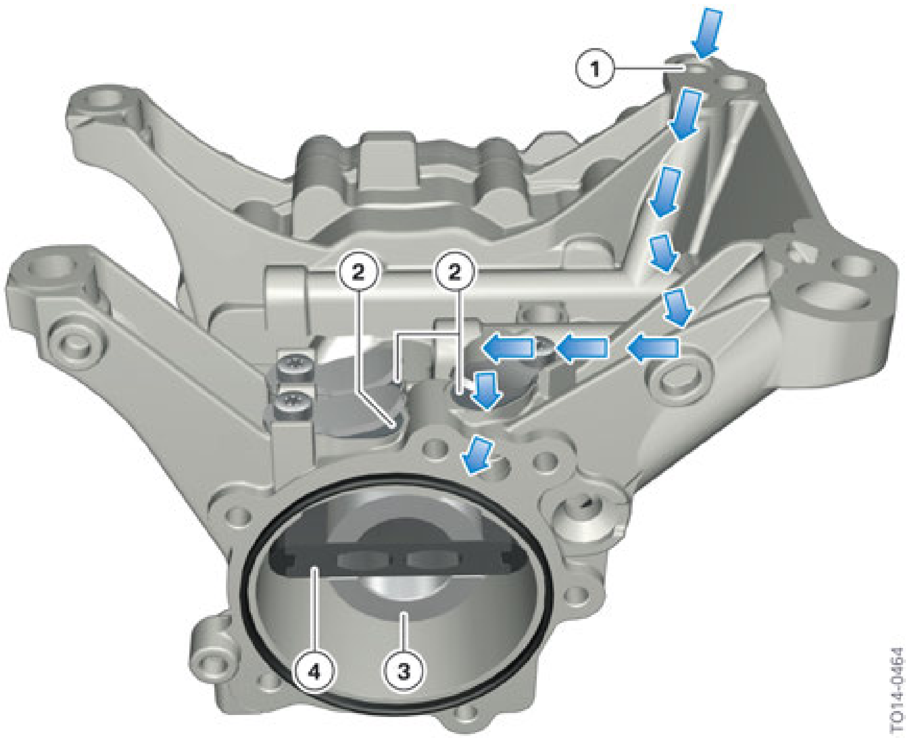
Index	Explanation
A	Vacuum, secondary volume
B	Vacuum, main volume
1	Vacuum line for auxiliary consumer
2	Crankcase
3	Oil pump
4	Non-return valve
5	Vacuum line for main consumer (brake servo)

With the B46 engine, the low pressure pump and oil pump are installed together in one housing.

The vacuum duct leads to the vacuum pump, passing through the transmission end of the crankcase. There is a plastic connection at the output of the crankcase to which the various consumers are connected. There is a non-return valve inside the plastic connection.

B46 Engine

6. Vacuum Supply



Vacuum pump in the B46 engine

Index	Explanation
1	Vacuum duct
2	Exhaust valves
3	Steel rotor
4	Plastic vane

There is a steel rotor with a plastic vane on the inside of the vacuum pump. It is driven together with the oil pump by the crankshaft via a chain.

The evacuating output of the vacuum pump is 500 mbar vacuum (absolute) in less than six seconds.

As the running surfaces of the vacuum pump are coated with oil, the volume of air drawn in cannot be released into the atmosphere. The air volume delivered by the vacuum pump is transferred to the crankcase via discharge valves. From here, it reaches the air intake system via the crankcase ventilation.

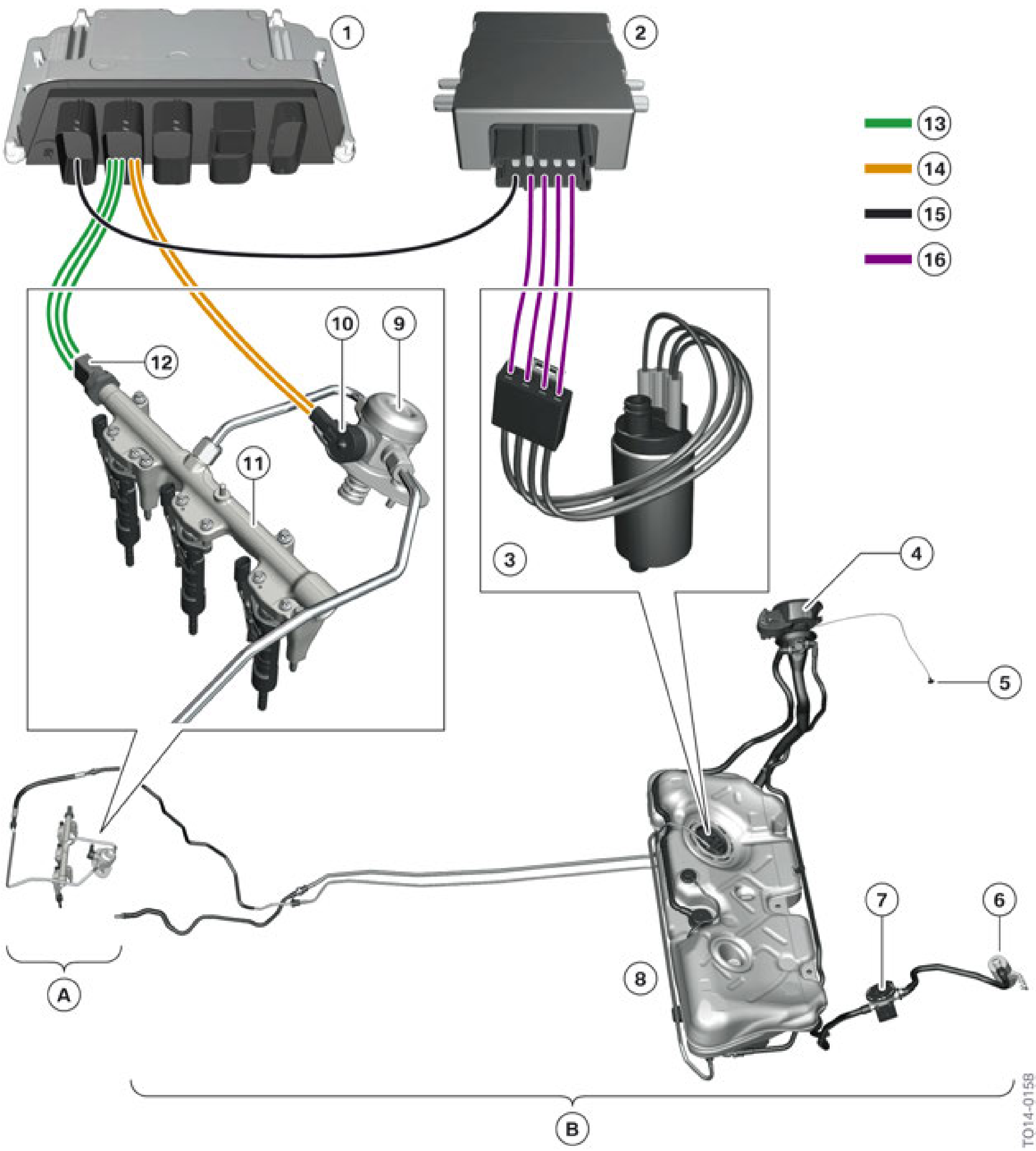
⚠

Leaks in the vacuum system lead to a reduced brake power assistance.

The fuel system is made up of the fuel supply and fuel preparation systems. The fuel supply includes the fuel tank with all mounted parts and the fuel lines up to the engine compartment.

The fuel filter lines in the engine compartment and all the fuel system parts on the engine belong to the fuel preparation system.

The fuel supply is described in the respective product information bulletins for the models.



Fuel system, Bx8 engine in the F56

Index	Explanation
A	Fuel preparation
B	Fuel supply
1	Digital Motor Electronics (DME)
2	Fuel pump control module
3	Electric fuel pump
4	Fuel filler neck
5	Emergency release
6	Dust filter
7	Fuel tank leak diagnosis system
8	Fuel tank
9	High-pressure pump
10	Quantity control valve
11	Rail (high-pressure accumulator)
12	High-pressure sensor
13	Sensor line, rail pressure sensor
14	Actuating wire, quantity control valve
15	PWM data line
16	Actuating wire, electric fuel pump (three-phase line U, V, W)

7.1. Fuel pump control module

In contrast to the EKPS control unit previously used, the new gas engines have a fuel pump control module. The fuel pump control module is not shown in the control unit overview. The fuel pump control module is responsible for processing information about the necessary fuel pressure from the Digital Motor Electronics (DME) and for activating the electric fuel pump according to these requirements via a three-phase AC voltage.

7.2. Electric fuel pump

The electric fuel pump is activated as required. The requirements are calculated by the Digital Motor Electronics (DME). The request regarding the extent of the fuel low pressure is sent to the fuel pump control module with the assistance of a pulse-width modulated signal (PWM signal). The fuel pump control module processes the pulse-width modulated signal and with help of an inverter generates a three-phase AC voltage U, V, W to activate the three-phase motor of the electric fuel pump according to requirements.

If the PWM data line is disconnected, the electric fuel pump is activated with the maximum system performance. If a PWM data line is interrupted, this only leads to a fault code entry. The customer is not informed about this status, by the illumination of a warning and indicator light, for example. The electric fuel pump is designed for continuous full load operation and is also not damaged if the PWM data line is interrupted for an longer period.

7. Fuel System

There is no fuel pressure sensor in the low-pressure range of the fuel system. The fuel low pressure is calculated in the Digital Motor Electronics based on a mathematical model. The power consumption of the electric fuel pump also provides information on the fuel low pressure. If the power consumption is high, this means that a high fuel - low pressure exists and if the power consumption is low, this means that a lower fuel - low pressure prevails.

The following table provides information on the technical data of the electric fuel pump.

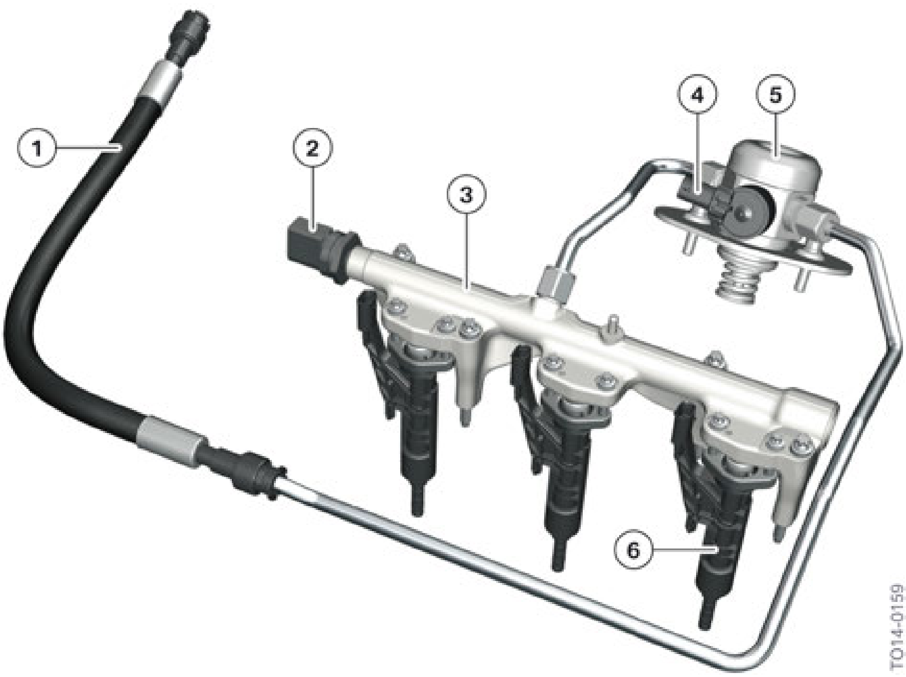
	Technical data
Engine speed range	2600 – 6000 rpm
Pressure area	2.0 - 6.5 bar
Supply voltage	12 V
Delivery rate at 3200 rpm and 3.5 bar	> 80 liters/60 minutes
Delivery rate at 4250 rpm and 6.3 bar	> 105 liters/60 minutes
Delivery rate at 5600 rpm and 5.3 bar	> 190 liters/60 minutes

⚠

The electric fuel pump becomes impermissibly hot with excessive dry running > 1 minute.
There is a risk of a component fault!

7.3. Fuel preparation

The fuel preparation has been modified to meet the requirements of emission legislation. A new direct rail which has been developed to which the injectors are now screwed.



Overview of fuel preparation

Index	Explanation
1	Fuel delivery line
2	Rail pressure sensor
3	Direct rail
4	Quantity control valve
5	High-pressure pump
6	Solenoid valve injector

The direct injection system is similar to the N20 and N55. A single-piston reciprocating pump with integrated quantity control valve is used.

The direct rail represents a departure from the familiar systems used up till now. With this system, the high pressure lines have been omitted and the injectors are attached to the rail directly.

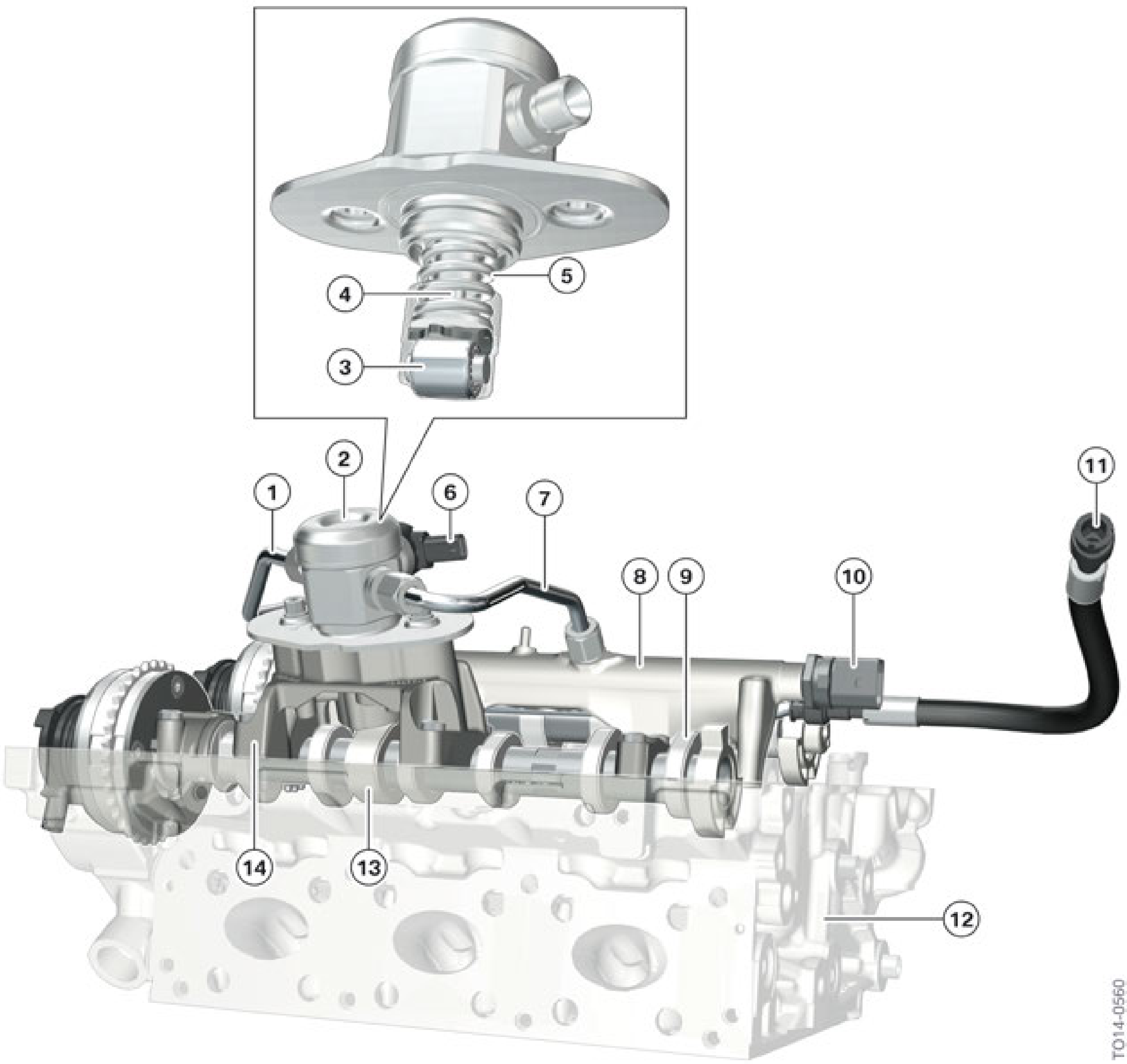
Directly connecting the solenoid valve injectors to the rail has the following advantages:

- Less volume needs to be available for high-pressure injection.
- Fewer interfaces and therefore less problematic with respect to leaks.
- Short cycle times during production due to compact design.

⚠

Strict cleanliness must be observed when carrying out any work on the fuel system!

7.3.1. Fuel high-pressure pump



Overview of fuel high-pressure pump

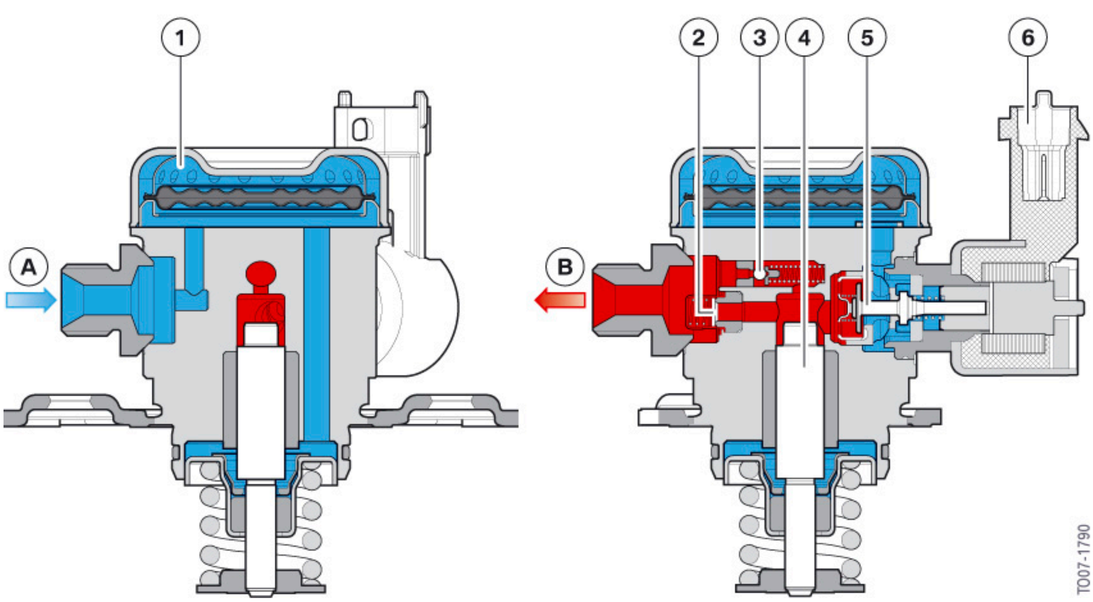
Index	Explanation
1	Fuel feed line to high pressure pump
2	High-pressure pump
3	Roller tappet
4	Pump piston

Index	Explanation
5	Spring
6	Quantity control valve
7	High pressure line to rail
8	Rail
9	Exhaust camshaft
10	Rail pressure sensor
11	Snap fastener, fuel feed line
12	Cylinder head
13	Actuating cam, high pressure pump
14	Bearing bracket, high pressure pump

The familiar single-piston high pressure pump by Bosch is used. The high pressure pump is driven by a triple cam which is attached to the exhaust camshaft. Fuel low pressure is supplied to the high pressure pump via the fuel feed from the electric fuel pump.

⚠

Due to the high fuel pressures, the fuel lines must never be detached when the engine is in operation. When removing the high pressure pump, follow the specifications in the current repair instructions. Excessive tilting of the pump can damage the pump piston!



Bosch high-pressure pump

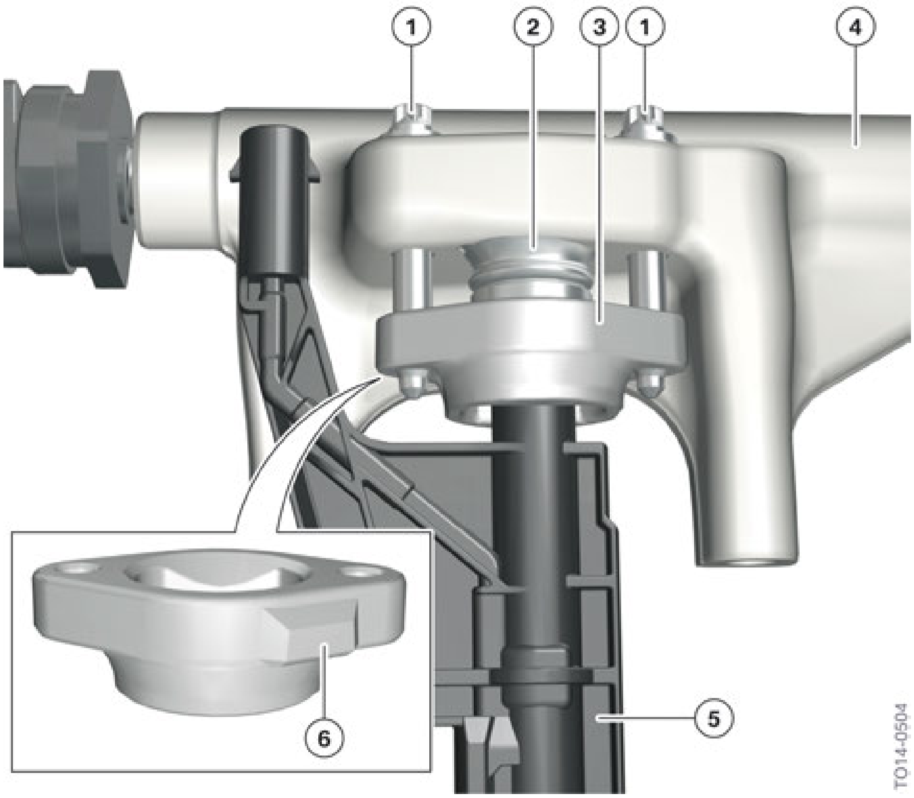
Index	Explanation
A	Low-pressure connection
B	High-pressure connection
1	Balancing chamber
2	High-pressure non-return valve
3	Pressure-limiting valve
4	Pump piston
5	Quantity control valve
6	Electrical connection of quantity control valve

The quantity control valve at the high pressure pump adjusts the fuel pressure in the rail. The maximum pressure in the rail is 200 bar. The high pressure pump contains a pressure limiting valve which opens at a pressure of 245 bar. The quantity control valve is activated via a pulse-width-modulated (PWM) signal and assumes the open position in the de-energized state. This means the pump piston of the high pressure pump cannot compress the fuel.

It follows that the high pressure pump cannot build up pressure in the high-pressure fuel system when the quantity control valve is removed. In this situation, the maximum fuel low pressure (6.5 bar) would be present in the rail during an engine start. The system would be in emergency operation. To ensure the engine remains capable of running in this state, the opening period of the solenoid valve injectors has been extended and the idle speed increased. Although the vehicle remains drivable, the maximum engine performance is not available.

The quantity control valve is not resistant to continuous current. A permanent current supply with 12 V direct current voltage would render the component defective.

7.3.2. Direct rail



Mounting the injectors

Index	Explanation
1	Mounting bolts
2	Plastic sleeve
3	Holding clamp with bayonet fitting
4	Rail
5	Solenoid valve injector
6	Casting lug

The solenoid valve injectors are fastened to the holding clamp with a bayonet fitting. There is a plastic sleeve between the holding clamp and direct rail. This is not designed to collect escaping fuel. Its only purpose is to carry out a helium pressure test during pre-assembly at the factory in order to check the tightness. After the initial assembly, this plastic sleeve is of no relevance to the engine operation. When the solenoid valve injectors are replaced, the plastic sleeves are no longer required and do not need to be reinserted.

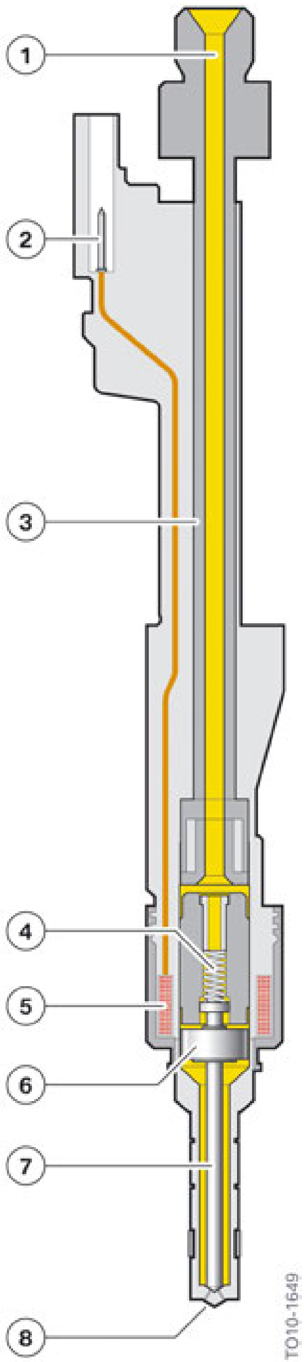
When manufacturing the holding clamp, casting lugs are produced when the component is detached from the tool. Due to the low installation tolerances, when installing the solenoid valve injectors it must be ensured that these casting lugs point in the direction of the exhaust manifold. If they are pointing in the wrong direction (towards the intake pipe), this can lead to mechanical contact between the holding clamp and cylinder head cover.

The mounting bolts of the holding clamp must be replaced each time they are released.

⚠

The shank of the solenoid valve injectors is sensitive to high tensile forces and rotational angles. When removing and installing the solenoid valve injectors, the procedure in the current repair instructions must be followed! If the solenoid valve injectors are damaged, fuel may be discharged.

7.3.3. Solenoid valve injector



Solenoid valve injector HDEV 5.2

Index	Explanation
1	Fuel line connection
2	Electrical connection
3	Stem
4	Compression spring
5	Solenoid coil
6	Armature
7	Nozzle needle
8	6-hole nozzle

As is already the case with the N55 and N20 engines, the new B46 engine is equipped with the Bosch HDEV 5.2 solenoid valve injector. The designation of the injectors is a combination of the following:

- HDEV = high-pressure fuel injection valve
- 5 = generation designation
- 1 = maximum fuel injection pressure of 150 bar
- 2 = maximum fuel injection pressure of 200 bar

If current is supplied to the solenoid coil, a magnetic field is produced which attracts the magnet armature. The magnet armature runs upwards on the nozzle needle. The linear travel of the magnet armature in the direction of the solenoid coil carries the nozzle needle along with it and the nozzle bores are released in the direction of the combustion chamber.

The repair instructions that are currently valid must be followed when removing and installing the injectors in Service. If the rotational angle at the shank of the injector is too large, this can lead to damage and therefore leaks in the fuel system.

A special fuel additive is recommended in markets with a poor fuel grade to prevent coking of injectors in direct injection systems. The additive is added to the fuel in the fuel tank from where it arrives at the injectors.

⚠

Coking at the injectors is reduced by using a BMW-approved additive (part no. 83 19 2 183 738).

ULEV II measures at the solenoid valve injector

Due to the more stringent exhaust gas emission regulations which are required to meet the ULEV II exhaust emission standards, technical changes had to be made to the solenoid valve injectors.

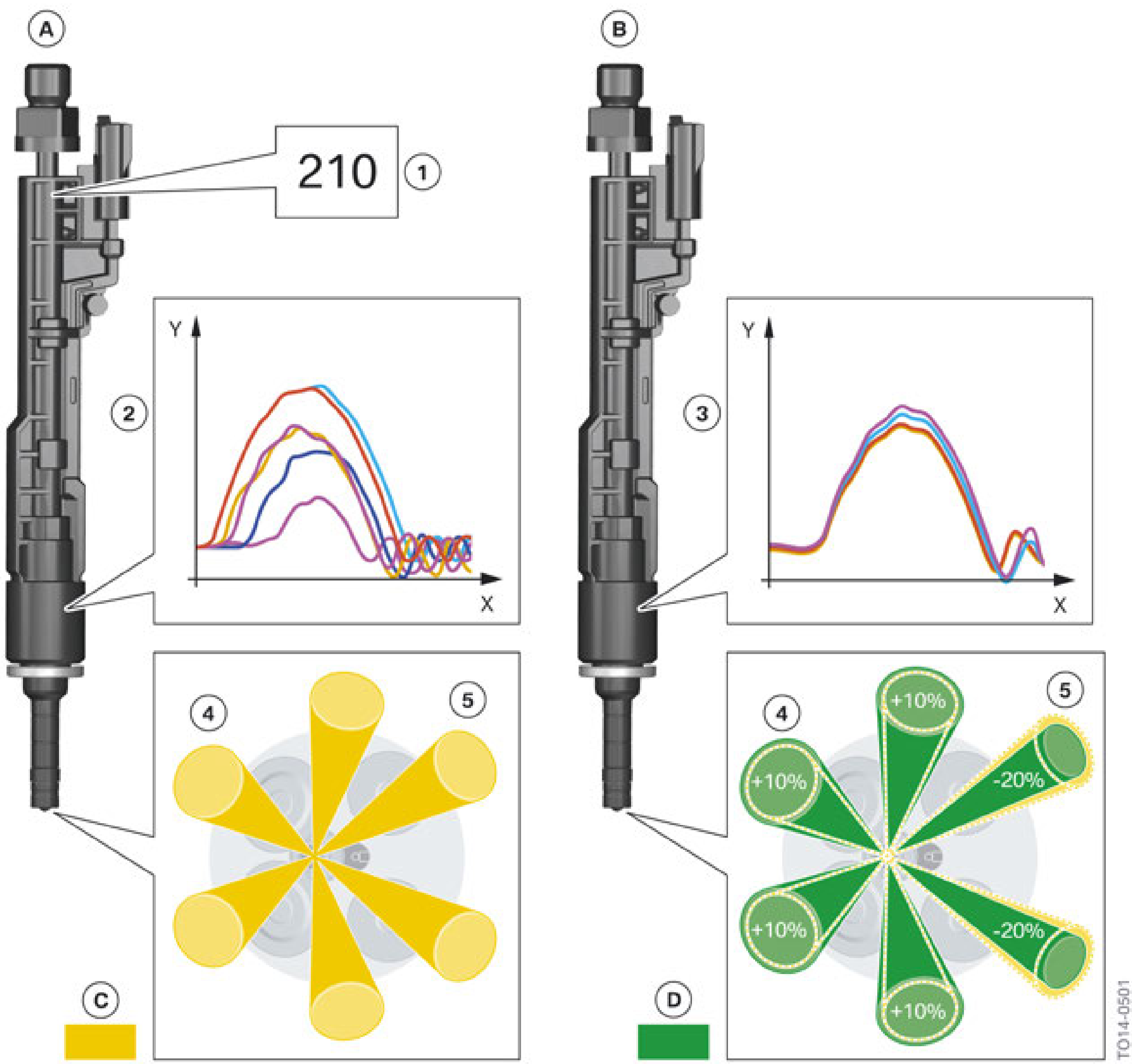
As is the case with diesel fuel passenger cars which has been dealt with previously, in addition to the limit value for particulate mass (PM), the limit value for the particle concentration (PN) is also stipulated in the ULEV II exhaust emission standards for gas passenger cars.

The reason for this is that in modern gas engines with direct injection no homogeneous fuel/air mixture arises in comparison to engines with intake pipe fuel injection. There are therefore more particles in the exhaust gas (particulate matter).

Different diameters of laser-manufactured bore holes are used with the new high-pressure fuel injection valves, for example. The fuel quantity of the two spray jets in the exhaust direction is reduced by 20 %, which increases the other spray jets by 10 % respectively.

The solenoid valve injectors can only be used in a predefined position in the injector shaft of the cylinder head. This ensures correct alignment of the injection pattern in the combustion chamber.

The following graphic illustrates the differences between the ULEV and ULEV II version:



ULEV II measures, solenoid valve injector

Index	Explanation
A	Solenoid valve injector ULEV
B	Solenoid valve injector ULEV II
C	Even nozzle bore geometry
D	Uneven nozzle bore geometry
X	Opening period
Y	Needle travel
1	Injection quantity compensation code
2	Conventional operation
3	Automatic operation
4	Spray pattern, intake valve side
5	Spray pattern, exhaust valve side

High-pressure fuel injection valves with solenoid coils do not have a linear behavior pattern across the entire service life, mainly in the area of minimal quantity fuel injection. This means over the service life the fuel injection rates vary from one injector to another injector. Although the high-pressure fuel injection valves are adapted during start-up via the injection quantity compensation code in the Digital Motor Electronics, in order to compensate for possible manufacturing tolerances of the individual high-pressure fuel injection valves in the Digital Motor Electronics, and to adapt all injectors in relation to one another, this only happens once during start-up (injection quantity compensation). During conventional operation, the parameters for activation of the injectors, such as current and activation duration, are the same for all injectors throughout the entire operating time and cannot be individually adapted. Another adaptation during the entire operating time is no longer possible. This would lead to breaches of the strict exhaust gas emissions legislation, such as ULEV II, during the operating time.

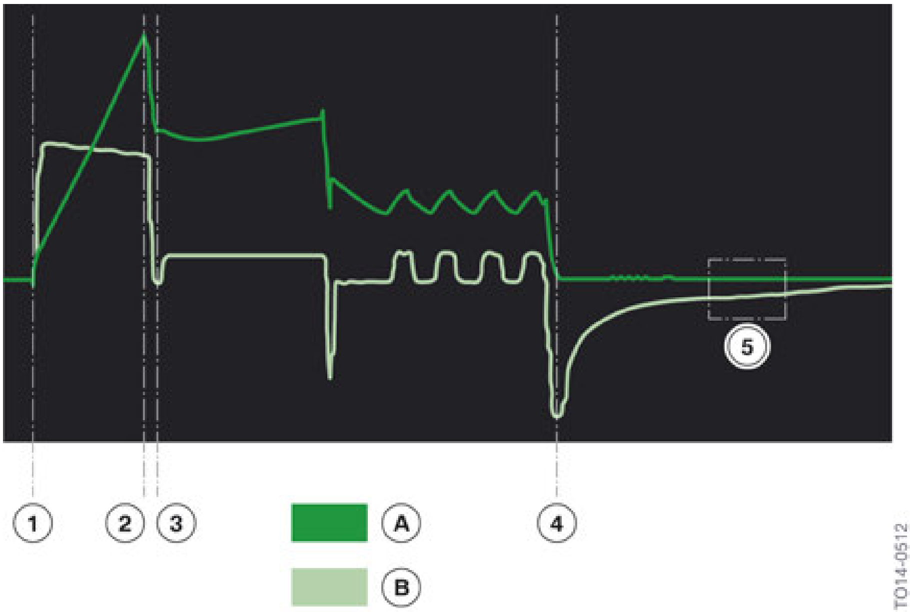
An automatic operation allows precise dosing of fuel, particularly when using extremely small injection quantities. Analysis of the voltage and current curve in injector mode allows conclusions to be drawn about the movement of the needle. The most important information in relation to the movement of the needle is the needle travel and opening period. The fuel injection rate can be determined from these two variables. It has therefore been possible to omit printing of a injection quantity compensation code on the ULEV II solenoid valve injectors.

Controlled Valve Operating (CVO)

A software in the Digital Motor Electronics permanently ensures automatic operation of the solenoid valve injectors throughout the entire operating time.

The basic principle of this CVO function is that the precise opening period of the high-pressure fuel injection valves is determined. The Digital Motor Electronics can determine the precise opening period based on the following parameters:

- Power consumption of the high-pressure fuel injection valve
- Voltage of the high-pressure fuel injection valve



Current and voltage curve of the solenoid valve injector

Index	Explanation
A	Current flow
B	Voltage curve
1	Start of activation
2	Nozzle needle, opening start
3	Nozzle needle, fully open
4	End of activation
5	Nozzle needle closing

These current and voltage values change in the event of a needle movement in the high-pressure fuel injection valve, for example:

- Armature mists up - when the needle valve is withdrawn from the valve seat.
- Armature moves - needle valve moves in direction of open position.
- Armature stationary - needle valve comes to rest at the maximum open position.
- Reverse movement.
- Armature moves - needle valve moves in direction of closed position.
- Armature suffers impact and is braked hydraulically - needle valve closed.

With these values, calculated from current and voltage values from the above mentioned needle movements, the Digital Motor Electronics can determine the actual opening period of the high-pressure fuel injection valves. If the precise opening periods are known, the Digital Motor Electronics can also determine the exact fuel injection rate based on this information.

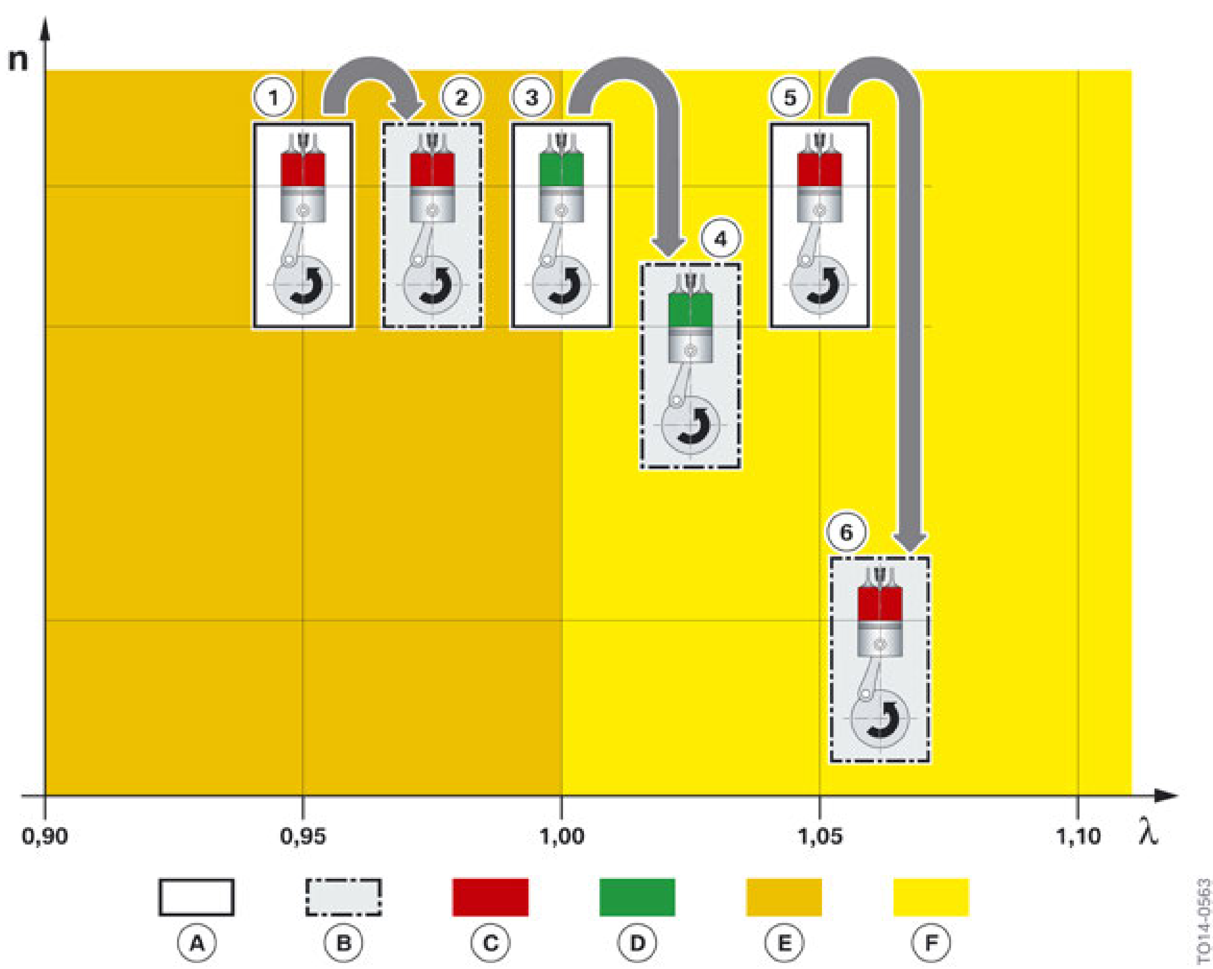
If variable fuel injection rates are now to be used, the Digital Motor Electronics can vary the fuel injection rate throughout the opening period by activating the respective high-pressure fuel injection valve individually. The Digital Motor Electronics thus has the option to adjust all high-pressure fuel injection valves to the same nominal fuel injection rate.

This measure guarantees the same nominal fuel injection rate in all cylinders, especially in the range where extremely small amounts are injected, as well as at idle speed, so that the exhaust re-treatment can always work efficiently. This measure inside the engine reduces exhaust emissions and therefore ensures compliance with the existing exhaust emission standards.

Cylinder Imbalance Monitoring (CIM)

The "Cylinder Imbalance Monitoring" function is an additional software function in the Digital Motor Electronics which monitors the correctness of the mixture preparation. The primary aim is to determine, with the assistance of this function, age-related operating time impairments of the fuel and intake area. Conclusions can be drawn about the air flow differences and different fuel injection rates, for example. These kind of differences are normally attributable to age-related leaks of the intake-components and pressure fluctuations in the rail or coking of the injectors.

The following graphic illustrates the operating principle of the Cylinder Imbalance Monitoring software:



Cylinder Imbalance Monitoring function

Index	Explanation
A	Cylinder in normal operation
B	Test cylinder with higher air/fuel ratio
C	Cylinder outside the tolerance
D	Cylinder inside the tolerance
E	Rich range
F	Lean range
n	Speed of crankshaft
λ	Air ratio
1	Cylinder in rich range
2	Test cylinder speed constant
3	Cylinder in ideal range
4	Test cylinder speed slightly slower
5	Cylinder in lean range
6	Speed of test cylinder significantly slower

The function is cyclically actuated by the Digital Motor Electronics. During this process, the air/fuel ratio is increased for each cylinder in succession during engine operation. At the same time as the air/fuel ratio in the test cylinder is increased, the remaining cylinders are enriched in order to maintain the overall lambda value of the exhaust gas passage within the range $\lambda=1$. This ensures perfect functionality of the 3-way catalytic converter.

If a test cylinder is operated when the air/fuel ratio is too low, a slight increase will not bring about a change in the crankshaft speed.

When the air/fuel ratio in a test cylinder is increased in the ideal range, this brings about a slight change in speed at the crankshaft.

If a test cylinder is operated when the air/fuel ratio is too high, the speed at the crankshaft drops rapidly.

The engine speed variations at the crankshaft are not evaluated directly, but rather the changes in smooth running during engine operation. Rough running of the cylinders in relation to one another is balanced out by a so-called 'cylinder balancing control'. The test cylinder in the rich range therefore brings about a minor change in rough running and the test cylinder in the lean range brings about a major change in rough running.

Mixture errors determined are stored as a fault code entry in the Digital Motor Electronics. The fault code entry provides information about which cylinder is affected and the rich or lean value determined. The driver is informed about the error via a malfunction indicator lamp.

Service note

When replacing the injector, the taught-in values of the CVO function and CIM function must be reset. This is done with the assistance of the BMW diagnosis system ISTA. Adjustment functions are available in the service functions. In order to inform the Digital Motor Electronics about the injector replacement, every ULEV II solenoid valve injector with the same dummy value (215) is taught in. Once the teach-in procedure has been successfully completed, the stored adaptations are reset and new adaptations are taught in via the CVO and CIM function.

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When the solenoid valve injectors are replaced, they must be started up with the assistance of the BMW diagnosis system ISTA.

B46 Engine
8. Engine Electrical System

8.1. Digital Motor Electronics (DME)

Different variants of the Digital Motor Electronics MEVD 17.2.3 are used, depending on the charge cycle method. The hardware of the throttle valve-controlled engine control units is therefore not the same as the hardware of the Valvetronic-controlled engine control units.

The control unit number is made up of the following:

- M = engine electronics
- E = electrical load control (without cable)
- V = Valvetronic control
- D = direct fuel injection
- 17 = control unit generation
- 2 = Bosch-internal project number for BMW
- 3 = control unit index

The Digital Motor Electronics is the computing and switching center. Sensors on the engine and the vehicle deliver the input signals and actuators implement the commands. The Digital Motor Electronics calculates the corresponding activation signals for the actuators from the input signals, and also the computing models and characteristic maps stored.

The operating voltage range of the Digital Motor Electronics is between 6 and 16 volts.

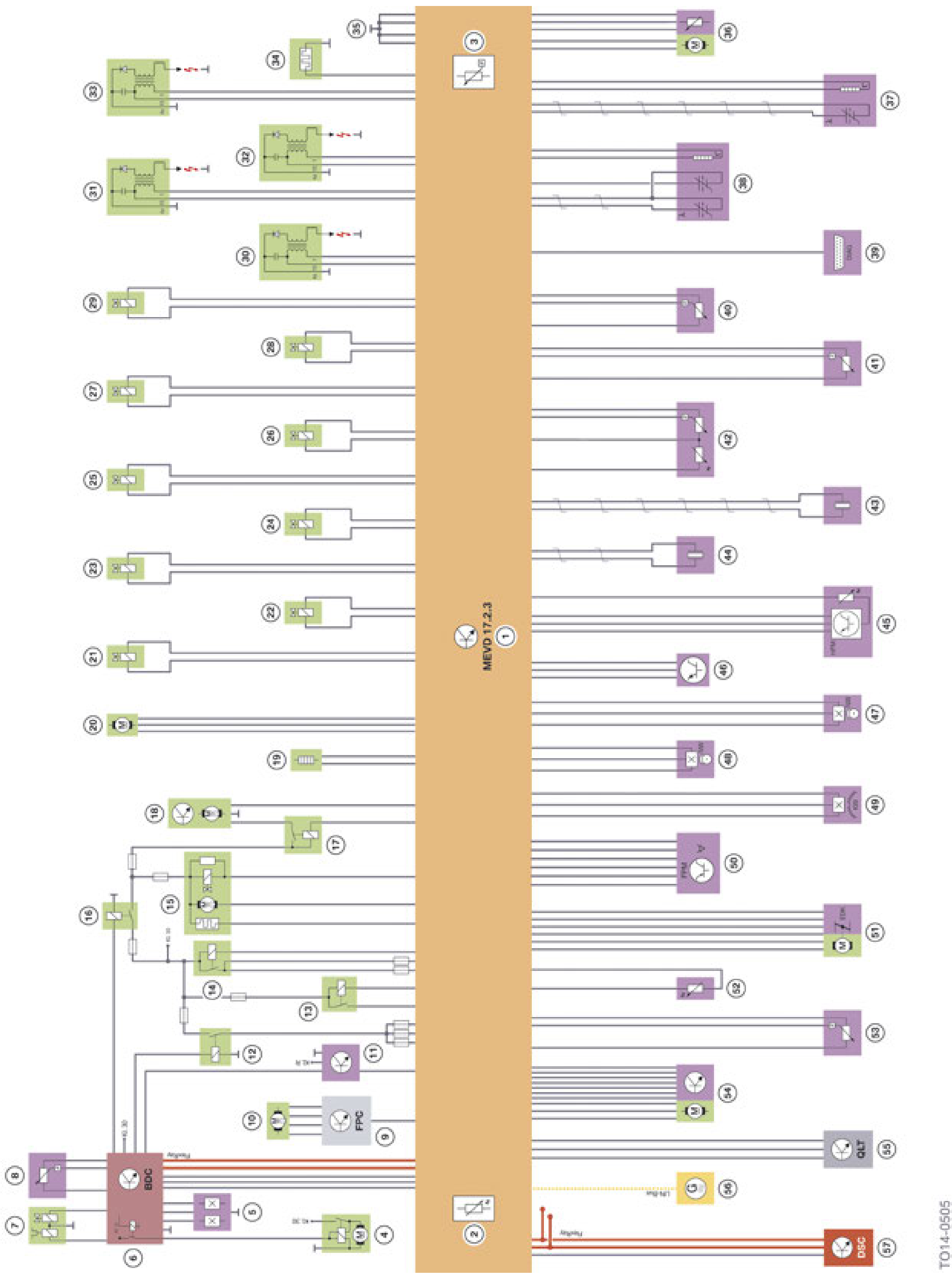
An ambient pressure sensor and a temperature sensor are integrated in the Digital Motor Electronics.

The ambient pressure sensor permits precise determination of the density of the ambient air. This information is required for various diagnostic functions. In addition, in the event of a failure of the hot film air mass meter, a precise substitute value can be calculated for the cylinder filling with the help of additional input variables.

The temperature sensor measures the temperature inside the control unit. If the temperature there rises too sharply, multiple fuel injection is reduced for example, in order to cool the output stages slightly and to keep the temperature inside the control unit in a non-critical range.

8. Engine Electrical System

8.2. System wiring diagram, B46 engine



System wiring diagram (ULEV II version), Bx8 engine

Index	Explanation
1	Engine electronics Valvetronic direct fuel injection MEVD 17.2.3
2	Temperature sensor
3	Ambient pressure sensor
4	Starter motor
5	Brake light switch
6	Body Domain Controller (BDC)
7	Air conditioning compressor
8	Refrigerant pressure sensor
9	Fuel pump control module
10	Electric fuel pump
11	N/A
12	Relay, terminal 15N
13	Relay, Valvetronic
14	Relay, ignition and fuel injection
15	Diagnostic module for tank leaks (DMTL)
16	Relay, terminal 30B
17	Relay for electric fan
18	Electric fan
19	Map thermostat
20	Electric coolant pump (20 W)
21	Tank vent valve
22	VANOS solenoid valve, intake camshaft
23	VANOS solenoid valve, exhaust camshaft
24	Map-controlled valve, oil pump
25	Quantity control valve
26 – 29	Injectors, 4-cylinder engine
30 – 33	Ignition coils, 4-cylinder engine
34	Engine ventilation heating (cold-climate version only)
35	Earth connections
36	Actuator for electrically adjustable wastegate valve
37	Oxygen sensor after catalytic converter (LSF Xfour voltage-jump sensor)
38	Oxygen sensor before catalytic converter (LSU ADV broadband oxygen sensor)
39	Diagnostic socket
40	Intake-manifold pressure sensor after throttle valve

Index	Explanation
41	Rail pressure sensor
42	Charge air temperature and charging pressure sensor upstream of throttle valve
43	Knock sensor
44	Knock sensor
45	Hot film air mass meter
46	Gear sensor
47	Camshaft sensor, intake camshaft
48	Camshaft sensor, exhaust camshaft
49	Crankshaft sensor
50	Accelerator pedal module
51	Electromotive throttle actuator
52	Coolant temperature sensor
53	Oil pressure sensor
54	Valvetronic servomotor
55	Oil level sensor
56	Alternator
57	Dynamic Stability Control (DSC)

8.3. Map ignition

The B46 engine is equipped with an inductive ignition system with static ignition distribution. Each cylinder has a separate ignition coil which is inserted directly into the cylinder head cover.

To achieve optimum consumption and minimum pollutant emissions and the highest possible torque, the ignition point must be perfectly adjusted.

The following factors influence the ignition point:

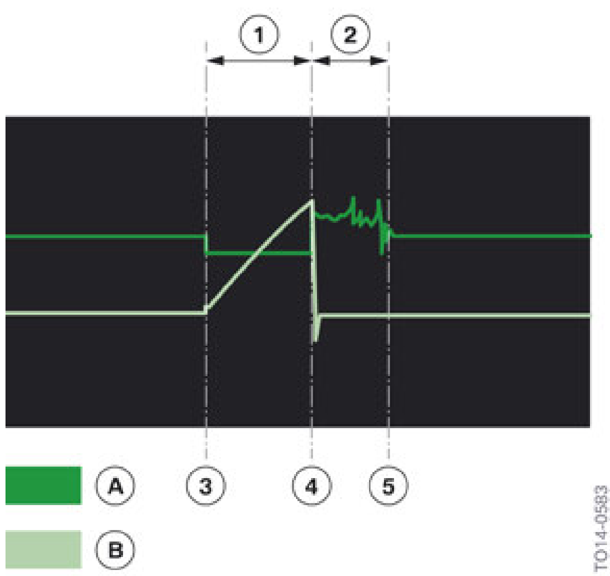
- Engine speed
- Engine torque
- Charging pressure
- Current air ratio
- Coolant temperature
- Intake air temperature
- Fuel grade
- Operating condition (engine start)

These variables are recorded by the Digital Motor Electronics via sensors, processed with the assistance of different characteristic maps and output as control signals to the ignition coils.

8.3.1. Diagnostic functions

As faults in the area of the ignition system directly affect the quality of the exhaust gas, the ignition processes are monitored by the Digital Motor Electronics. During this process, the combustion period for the ignition of each individual cylinder is evaluated as a priority. The voltage difference of the primary coil at terminal 1 and terminal 15 is determined and evaluated by carrying out a measurement within the Digital Motor Electronics. An increased voltage difference is measurable while an ignition spark is present. The period of this voltage difference is referred to as 'combustion period'.
The combustion period is not evaluated during the following operating conditions:

- During the starting operation
- Vehicle voltage < 12 volts



Current and voltage curve of ignition

Index	Explanation
A	Voltage curve
B	Current flow
1	Charging time of primary coil
2	Combustion period of ignition spark
3	Start of charging of primary coil
4	Start of ignition
5	End of ignition

Combustion period too short

The minimum thresholds for the combustion period are determined by the Digital Motor Electronics depending on the engine speed and load. When these minimum thresholds are undercut and misfiring also occurs, a fault code entry "Combustion period too short" is stored in the Digital Motor Electronics.

Combustion period outside the tolerance

The current combustion period of all individual cylinders is read in and combined to obtain a mean value. As the speed and load is the same in all cylinders, the calculated mean value is similar to the individual values read in. By comparing the individual values with the mean value obtained, the Digital Motor Electronics (DME) can draw conclusions about the combustion period. If an individual value exceeds or undercuts the minimum thresholds stored, a fault code entry "Combustion period outside the tolerance" is stored in the Digital Motor Electronics.

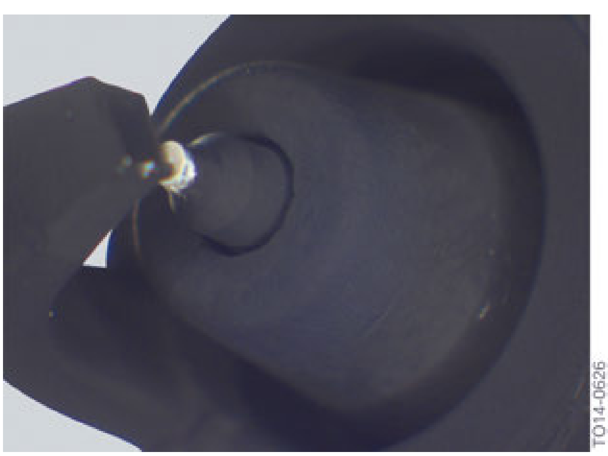
Note for Service

Fault code entries with the note "Combustion period too short" or "Combustion period outside the tolerance" are not necessarily always attributable to a defect in one or several ignition coils. Combustion period abnormalities can be identified via the diagnosis entry in the Digital Motor Electronics, their causes can be found in many different engine systems.

The following can cause deterioration of the combustion period:

- Contact resistances at the engine wiring harness of the ignition coil.
- Poor plug-in contact at the connector of the ignition coil.
- Coil resistance of ignition coils outside the permissible range.
- Ignition sparks inside silicone hose of the ignition coil.
- Heavily carbon fouled spark plug(s).

The following graphic shows a heavily sooted spark plug.



Heavily carbon fouled spark plug

The fault code entry "Combustion period too short" is frequently caused by one or several heavily carbon fouled spark plug(s). The carbon loading leads to deterioration of the ignition spark and therefore a very short combustion period.

Increased soot loading at the spark plugs accompanied by a reduction in the combustion period may be caused by the following:

- Fault in the mixture preparation
  - leaks at the air intake system
  - fault at the injector
  - fault at the high pressure pump
  - deposits in the area of the intake valves
- Fault in the engine electrical system
  - fault in the area of the coolant temperature sensor
  - fault in the area of the oxygen sensor
  - fault in the area of the hot film air mass meter
- Large number of cold starts
  - frequent catalytic converter heating phases
  - few self-cleaning phases of the spark plugs

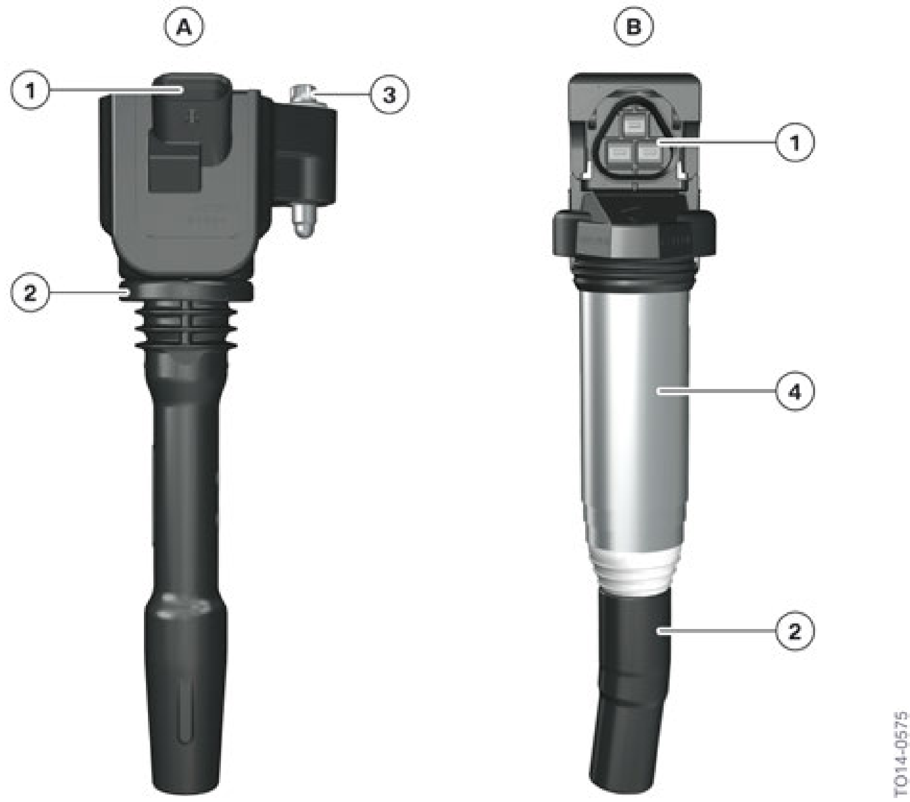
With the fault code entry "Combustion period", a potential component fault at the relevant coil can be confirmed or disproved by cross-swapping the ignition coil.

If misfiring occurs following component errors, different test modules in the workshop and diagnosis system ISTA can be processed. As the causes of faults in the ignition system are many and varied, the various test and diagnosis instructions in the test module must be followed. If a faulty component is replaced without eliminating the actual cause, this will only remedy the problem in the short term.

8.3.2. Ignition coils

Overview of ignition coils

The following graphic provides an overview of the different ignition coils currently used with the various BMW engines:



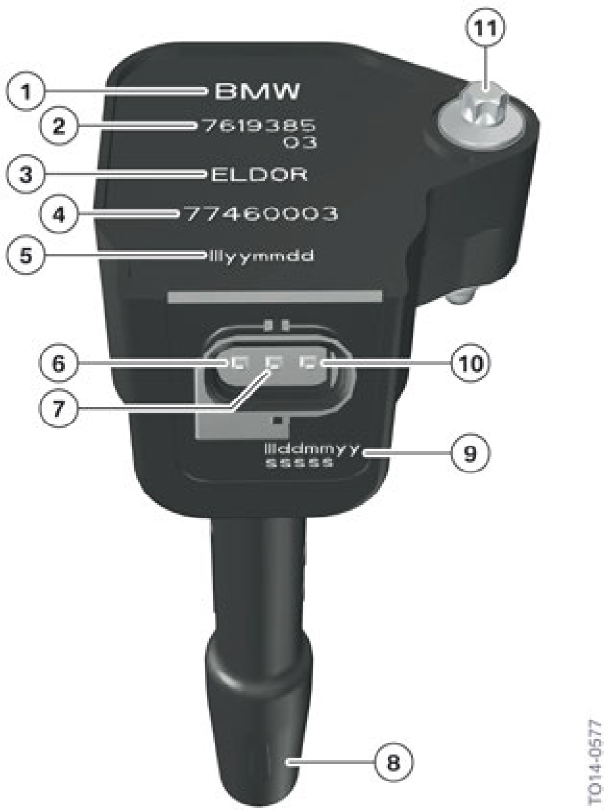
Overview of ignition coils

Index	Explanation
A	Compact ignition coil (manufacturer: Eldor)
B	Rod ignition coil (manufacturer: Delphi)
1	Electrical plug-in contact
2	Silicone hose
3	Mounting bolt
4	Rear closure plate

The table below provides an overview of the engines in which the various ignition coils are used:

Engine	Compact ignition coil	Rod ignition coil
B46	X	
N20		X
N55		X
N63 TU2		X
N74 TU		X

Compact ignition coil



Ignition coil, Bx8 engine

Index	Explanation
1	Manufactured for BMW
2	BMW part number
3	Supplier
4	Supplier code
5	Production date
6	Terminal 15
7	Terminal 4a
8	Silicone hose
9	Serial number
10	Terminal 1
11	Mounting bolt

The primary and secondary coil required to raise the ignition voltage can be found in the area of the electrical plug-in contact. The transfer factor achieved by both coils is around 1:80.

When servicing the ignition coils, observe the following:

- A slight rotational movement when pulling out and inserting the ignition coils makes disassembly and installation easier.
- There must be no sign of contamination by oil or other fluids in the area of the electrical plug-in contact.
- The pins of the electrical plug-in contact must not be bent.
- There must be no sign of cracking on the silicone hose.
- The spring which transmits the ignition spark must be positioned at the center of the silicone hose.
- The silicone hose of the ignition coils must not come into contact with fuel or mineral oils.
- The specified torque of the mounting bolt must be observed.
- Prior to disassembly of the ignition coil, remove the plug-in contact from the engine wiring harness, as the ignition coils cannot be operated without spark plugs.

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The ignition coils are not fuel-resistant. All ignition coils should therefore be removed before opening the fuel system. Fuel residues must be removed before inserting the ignition coils in the spark plug shaft.

8.3.3. Spark plugs

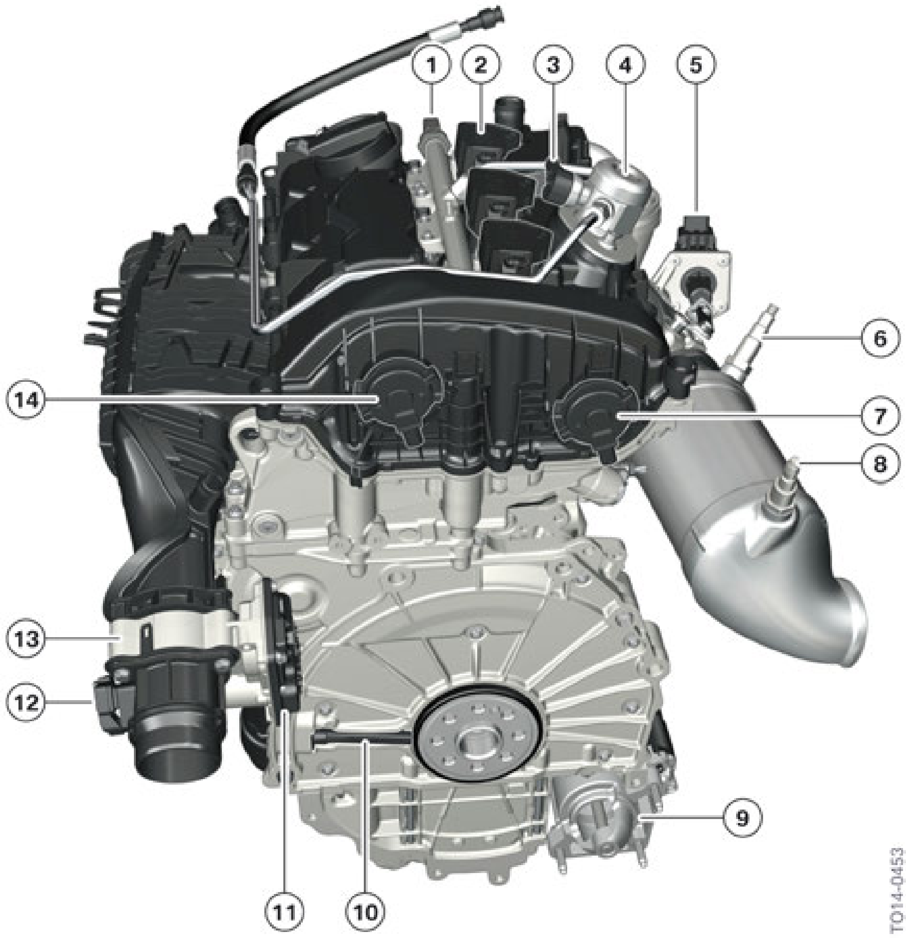
The position of the spark plug electrode in the combustion chamber is therefore particularly important. To avoid coating the spark plug electrode with fuel, it is positioned geometrically between the fuel-injection spray of the injector.

A change interval applies for spark plugs and they must be renewed in accordance with the manufacturer's specifications. To avoid damage and ensure perfect function of the spark plugs, the prescribed tightening torques must be observed.

8.4. System overview for engine electrical system

The sensors and actuators are already known from other engines and are therefore not described in detail in this documentation. The following graphics provide an overview of the different installation positions of the sensors.

8.4.1. Transmission side

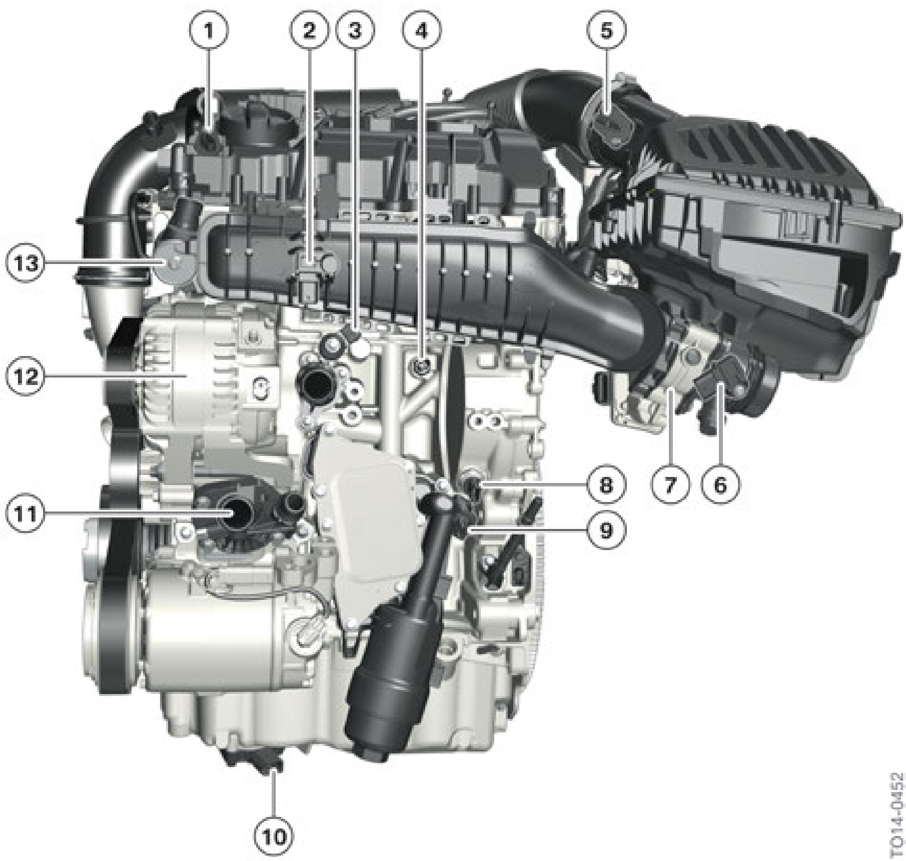


System overview for electrical system in the B38 engine, transmission side

Index	Explanation
1	Rail pressure sensor
2	Ignition coil
3	Quantity control valve
4	High-pressure pump
5	Actuator of electrically adjustable wastegate valve
6	Broadband oxygen sensor before catalytic converter
7	VANOS exhaust camshaft
8	Voltage jump, oxygen sensor after catalytic converter
9	Pinion starter
10	Crankshaft sensor, crankshaft

Index	Explanation
11	Electromotive throttle controller
12	Combined charging pressure and temperature sensor
13	Throttle valve unit
14	VANOS intake camshaft

8.4.2. Side view

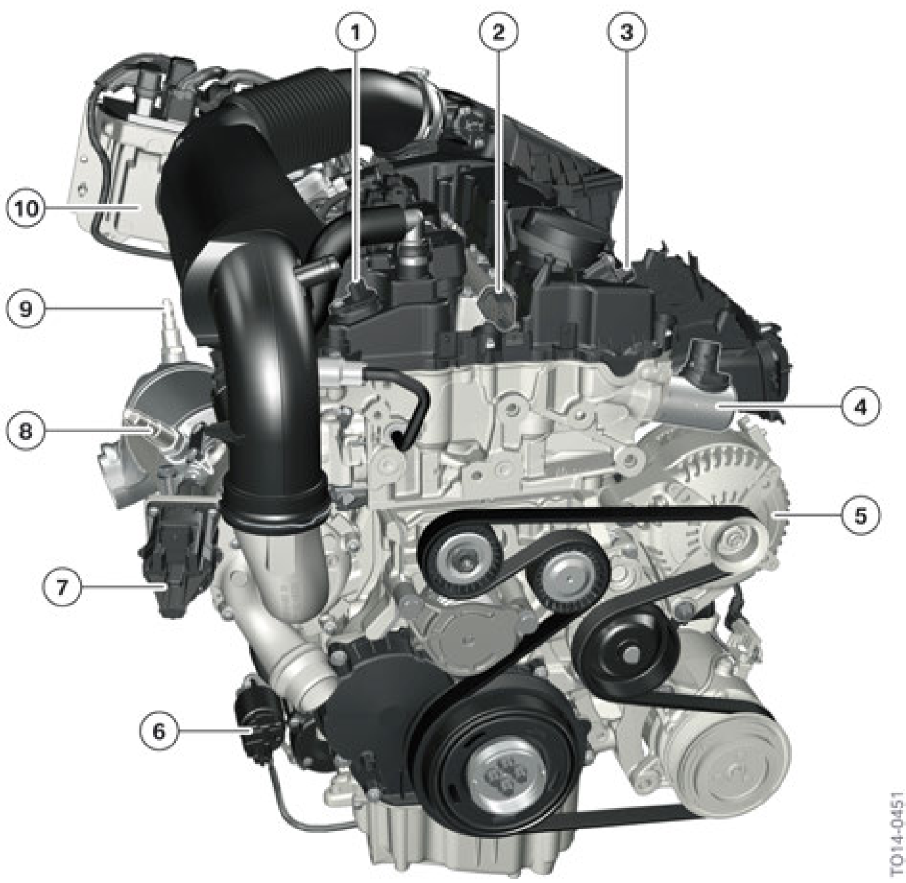


System overview for electrical system in the B38 engine, top view

Index	Explanation
1	Camshaft sensor, intake camshaft
2	Intake manifold pressure sensor
3	Knock sensor
4	Coolant temperature sensor
5	Hot-film air mass meter
6	Combined charging pressure and temperature sensor
7	Throttle valve unit

Index	Explanation
8	Oil pressure sensor
9	Map-controlled control valve of the vane-type compressor
10	Combined oil quality and oil-level sensor
11	Map thermostat
12	Local interconnect network bus connection
13	Valvetronic servomotor with integrated position sensors

8.4.3. Belt side



System overview for electrical system in the B38 engine, belt side

Index	Explanation
1	Camshaft sensor, exhaust camshaft
2	Rail pressure sensor
3	Camshaft sensor, intake camshaft
4	Valvetronic servomotor with integrated position sensors
5	Generator with intelligent generator control

8. Engine Electrical System

Index	Explanation
6	Solenoid switch, pinion starter
7	Actuator of electrically adjustable wastegate valve
8	Broadband oxygen sensor before catalytic converter
9	Voltage jump, oxygen sensor after catalytic converter
10	Digital Motor Electronics (DME)

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Technical training.
Product information.

F48 Powertrain

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BMW Group University
Technical Training
ST1508 3/1/2016

BMW Service

General information

Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:

⚠

Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

Information status and national-market versions

BMW Group vehicles meet the requirements of the highest safety and quality standards. Changes in requirements for environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between the contents of this document and the vehicles available in the training course.

This document basically relates to the European version of left-hand drive vehicles. Some operating elements or components are arranged differently in right-hand drive vehicles than shown in the graphics in this document. Further differences may arise as a result of the equipment specification in specific markets or countries.

Additional sources of information

Further information on the individual topics can be found in the following:

- Owner's Handbook
- Integrated Service Technical Application.

Contact: conceptinfo@bmw.de

The information contained in this document forms an integral part of the technical training of the BMW Group and is intended for the trainer and participants in the seminar. Refer to the latest relevant information systems of the BMW Group for any changes/additions to the technical data.

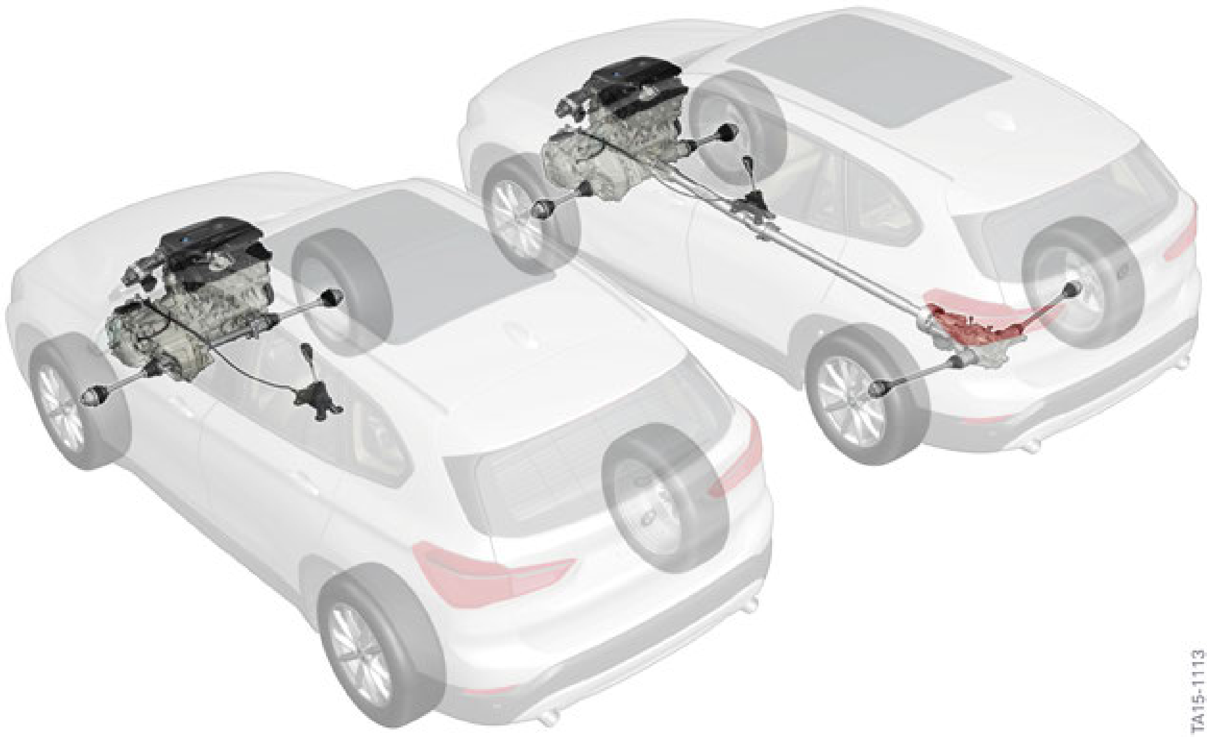
Information status: **June 2015**
Technical Training

F48 Powertrain
Contents

F48 Powertrain

1. Drive Variants

The F48 is available in sDrive and xDrive. The following graphic shows the layout of the version.



F48 Drive

In the F48 a completely new drive unit is used, which fits perfectly with the spatial functional concept of the BMW X1 thanks to its model-specific design.

The new BMW X1 is one of the first vehicles of BMW which will be driven by the brand new 4-cylinder engine. It is a part of the newly developed modular engine family. It is a lightweight, powerful and economical engine, which is equipped with BMW TwinPower Turbo technology.

Special features

- New 4-cylinder engines
- Engine with transverse mounting
- sDrive and xDrive available
- All engines satisfy the exhaust emission standards SULEV

F48 Powertrain
1. Drive Variants

The following list shows the advantages of the different drive concepts (for vehicles with a front engine):

Front-wheel drive	Rear-wheel drive
• The drive unit is comparatively compact and is integrated between the axle mounting, steering and footwell. • Large and variable spatial offering thanks to reduction or deletion of the transmission tunnel and rear axle differential. • Weight and cost reductions, due to deletion of propeller shaft and rear axle differential, as well as integration of the differential in the transmission. • Good traction on smooth roadway, independent of the load status of the vehicle, due to higher axle load at the driven axle. • Reasonable behavior in the event of a head-on collision (engine and transmission intrude the passenger compartment less).	• Small turning circle possible, as no rear view of the drive required with the steered front axle. • No annoying drive influences in the steering. • Good power transmission to the roadway during acceleration, as the driven axle is loaded (primarily when driving off on inclines). • Balanced axle-load distribution possible. • Excellent dynamic cornering behavior.

1.1. Model

The following model is offered for the market introduction of the F48:

Model		**BMW 28i**
Engine		B46A20O0
Cylinders		4
Displacement	[cm³]	1998
Power	[kW (HP)]	170 (231)
Torque	[Nm]	350
Automatic transmission		GA8F22AW
Manual gearbox		–

F48 Powertrain
1. Drive Variants

1.2. Engine designation

In the technical documentation, the engine designation is used to ensure unambiguous identification of the engine. In the following table the engine designations used in the F48 are explained.

Position	Meaning	Index	Explanation
1	Engine developer	B	BMW Group
2	Engine type	4	4-cylinder in-line engine
3	Change to the basic engine concept	8	Turbo-Valvetronic direct injection (TVDI)
4	Working method or fuel and installation position	A	Gas engine, transversal installation
5 + 6	Displacement in 1/10 liter	20	2.0 liters displacement
7	Performance class	U M O	Lower Middle Upper
8	Revision relevant to approval	0 1 – 9	New development Redesign

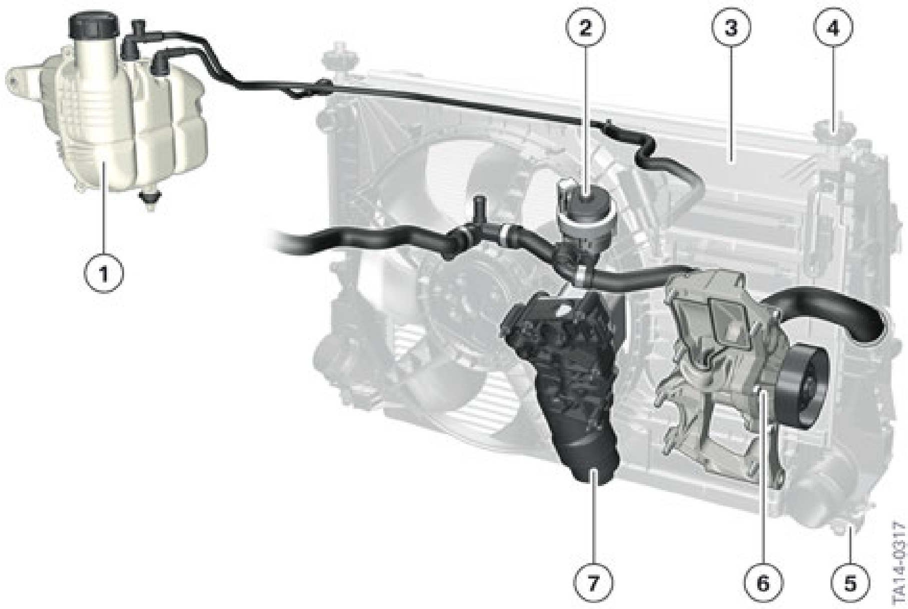
1.2.1. Engine identification

The 7-digit engine identification is on the crankcase. The first 6 digits of the engine identification are deduced from the engine type. Only the seventh digit is different. With the engine identification the test number of the type approval certification is located at the 7th position.

F48 Powertrain

2. Cooling System

2.1. Cooling module



F48 cooling system for B48 engine

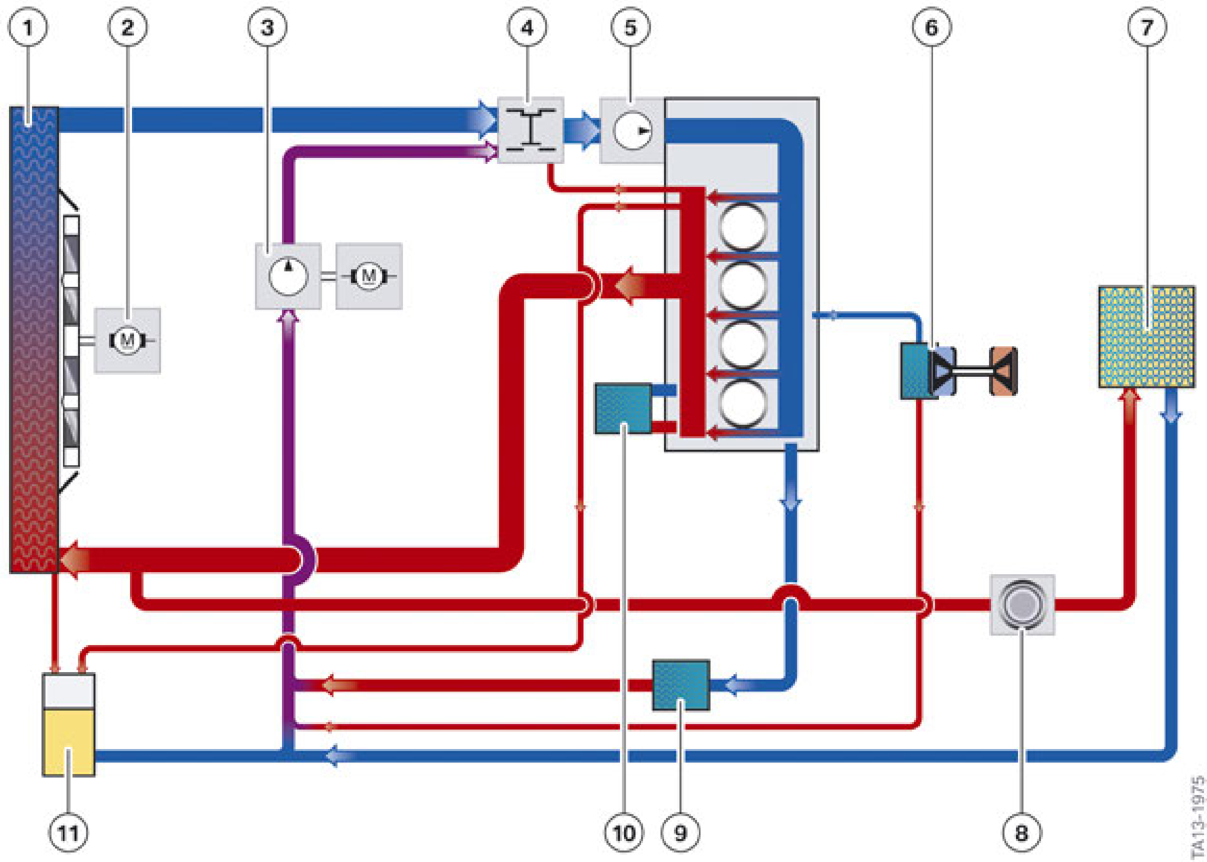
Index	Explanation
1	Expansion tank
2	Electric coolant pump
3	Cooling module
4	Cooling module bearing, top
5	Cooling module bearing, bottom
6	Coolant pump
7	Engine oil-to-coolant heat exchanger

A frameless cooling module is installed in the F48. This is made possible by a concept with different separation points between radiator and charge air cooler, using, joint interfaces for body and coolant hoses.

In vehicles with an automatic transmission, a transmission oil-coolant-heat exchanger is also flange-mounted at the transmission. This is supplied with coolant via the crankcase and adapted coolant hoses.

In the following diagram you see the connection of the cooling module at the cooling circuit using the example of the B46 engine.

2. Cooling System

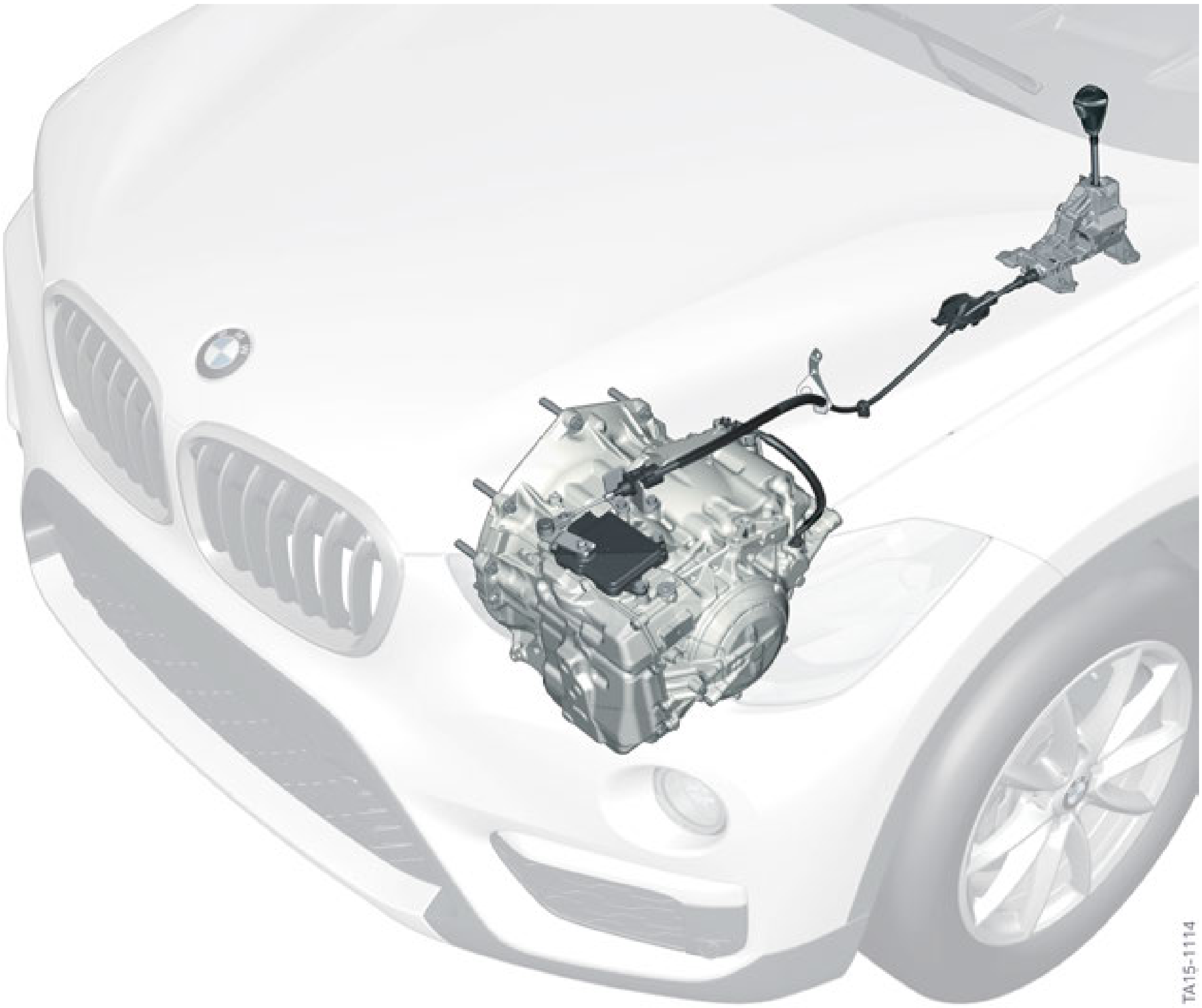


F48 cooling circuit, B46 engine

Index	Explanation
1	Radiator
2	Electric fan
3	Electric coolant pump
4	Thermostat
5	Coolant pump
6	Exhaust turbocharger
7	Heat exchanger
8	Coolant shutoff valve
9	Transmission oil-to-coolant heat exchanger
10	Engine oil-to-coolant heat exchanger
11	Expansion tank

F48 Powertrain

3. Automatic Transmission



F48 automatic transmission

In the F48 a new 8-speed automatic gearbox GA8F22AW are used:

Designation	Gears	Transferable torque	Use in engine
GA8F22AW	8-speed	350 Nm	B46A20O0

3. Automatic Transmission

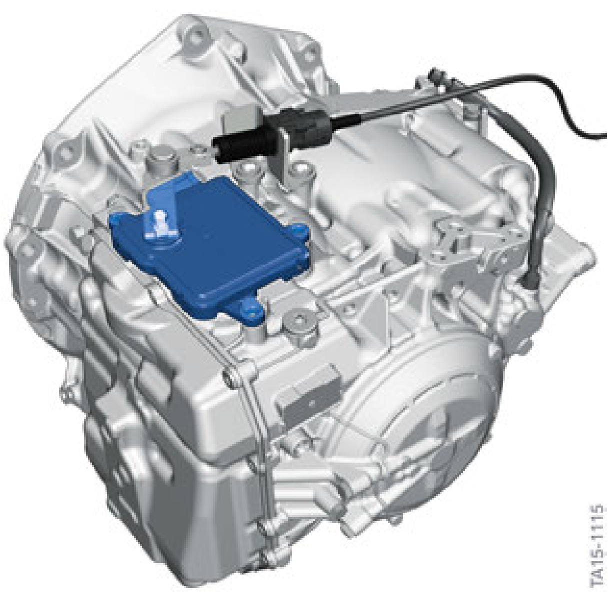
The excellent efficiency was able to be achieved by the following measures:

- Small oil pump
- Lower transmission oil main pressure
- Optimal lubricating oil quantity
- Transmission oil with low viscosity
- Large steering axis inclination
- Very accurate control of the multidisc converter lockup clutch at low loads by three-line activation
- Designed for automatic engine start-stop function (there is also an electric oil pump in the hydraulic block in order to maintain the minimum oil pressure)
- Designed for idle speed coasting

Good ride and shifting comfort was able to be realized with the following measures:

- Newly developed mechanical torsional vibration damper
- Efficient hydraulics with new valves
- Efficient clutch and brake control
- Excellent direct shifting capability (multiple downshifts, explained in the following)

In the Sport program and Manual mode the shift point and shift speed have a more sporty dimension.



F48 EGS, 8-speed automatic transmission

The electronic transmission control is located in the F48 on the transmission housing. The selector lever position switch is designed as a hall effect sensor and integrated in the EGS. The outer wiring between EGS, selector lever position switch and transmission was discontinued, whereby the susceptibility to faults was also reduced.

3. Automatic Transmission

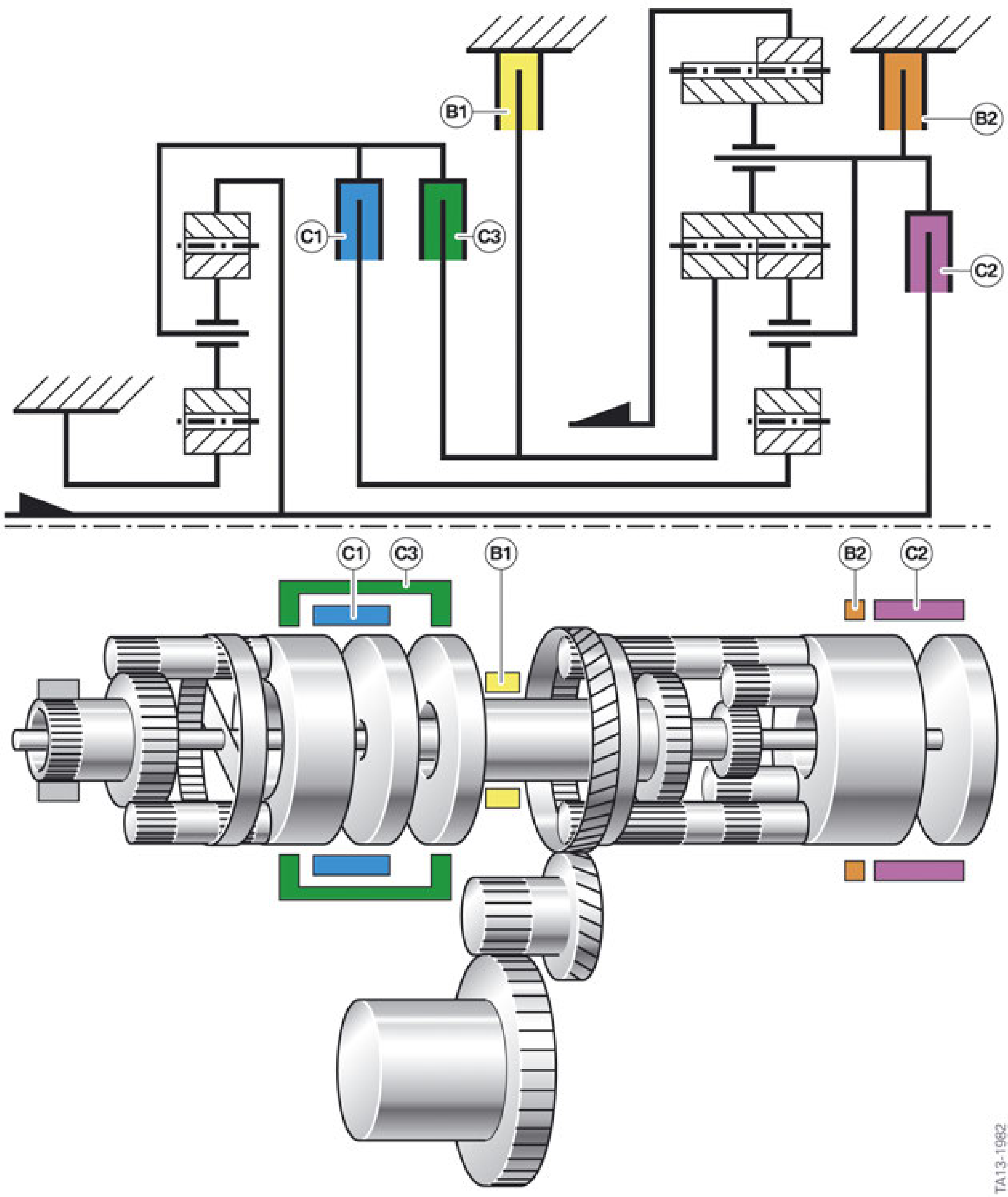
3.1. Designation

The transmission designation in the technical documentation allows it to be uniquely identified. In frequent cases, however, only a short designation is used. This short form is used so the transmission can be assigned to a transmission family. The GA8HP transmission family, consisting of several transmissions such as the GA8HP45Z, the GA8HP70Z and the GA8HP90Z, is often mentioned.

Position	Meaning	Index	Explanation
1	Designation	G	Transmission
2	Type of transmission	A	Automatic transmission
3	Number of gears	8	Eight forward gears
4 – 7*	Individual designations*	HP L R 19 F21A 26 32 45 (Zahnradfabri Friedrichshaf 45 (General Motors Powertrain) 70 90 390	Hydraulic planetary gear Designation of General Motors Powertrain Designation of General Motors Powertrain 300 Nm gas engine Designation of AISIN Warner 600 Nm 720 Nm 450 Nm 350 Nm 700 Nm 900 Nm 390 Nm, 4th gear 410 Nm,
8	Manufacturer	A G J K R Z H	AISIN Getrag Jatco GKN General Motors Powertrain Zahnradfabrik Friedrichshafen In-house part

* Numbers 4 – 7 serve for individual designation. A transmission variant, size, transferable torque and technical update can be represented here.

3.2. Function diagram



Function diagram using the example of a 6-speed automatic transmission

3. Automatic Transmission

Index	Explanation
B1	Brake band B1 (blocks the front sun gear of the rear planetary gear set)
B2	Brake clutch B2 (blocks the planet carrier of the rear planetary gear set)
C1	Drive clutch C1 (connects the planet carrier of the front planetary gear set to the rear sun gear of the rear planetary gear set)
C2	Drive clutch C2 (connects the intermediate shaft to the planet carrier of the rear planetary gear set)
C3	Drive clutch C3 (connects the planet carrier of the front planetary gear set to the front sun gear of the rear planetary gear set)

3.3. Ratios

	GA8F22AW
Ratio, 1st gear	5.25
Ratio, 2nd gear	3.029
Ratio, 3rd gear	1.95
Ratio, 4th gear	1.457
Ratio, 5th gear	1.221
Ratio, 6th gear	1
Ratio, 7th gear	0.809
Ratio, 8th gear	0.673
Ratio, reverse gear	4.015

F48 Powertrain

3. Automatic Transmission

3.4. Direct shifting

With the new automatic transmission of the F48, in most cases direct shifting to the desired gear is possible. This also applies if gears are skipped.

A direct gear change is always possible if the status has to change for one of the switched clutches or brakes. Otherwise, a two-stage gear change is performed. However, in general the customer does not notice this due to the optimized transmission control unit.

The following table shows the switched brakes and clutches for each gear using the example of the GA6F21AW.

Gear	Brake B2	Brake B1	Clutch C2	Clutch C1	Clutch C3
N	X				
1	X			X	
2		X		X	
3				X	X
4			X	X	
5			X		X
6		X	X		
Rw	X				X

Examples:

- Direct shift is possible from 4th to 2nd gear, as the clutch C1 does not have to be shifted.
- Direct shift is not possible from 5th to 2nd gear as both the brake B1 and the clutch C1 have to be switched.

3.5. Coasting in idle

For the F48 the "Coasting in idle position" function is available. Under certain prerequisites the engine is automatically disconnected from the transmission in gear selector switch position D. The engine runs here at idle speed.

Further information on "Coasting" is available in the product information bulletin "F01/F02 LCI Displays and Operation".

3.6. Launch Control

For vehicles with Sports automatic transmission (SA 2TB), launch control enables optimal acceleration when driving off. Forced upshifts are also performed without a reduction of the engine torque. This enables additional acceleration during the gearshifts.

In order to avoid premature component wear, the drive-off with launch control is only available 100 times over the service life of the Sports automatic transmission and cannot be reset by Service.

3.6.1. Activation of launch control

Step	Responsibility
1	Press the DSC button and select SPORT using the driving experience switch. – In the instrument cluster TRACTION is displayed in combination with SPORT. The indicator light DSC OFF illuminates.
2	Engage drive position S.
3	Firmly press the brake using the left foot.
4	Press the accelerator pedal beyond the resistance at the kick-down pressure point and hold. – Flag symbol appears in the instrument cluster and the engine speed for pulling away is adjusted.
5	Release the brake within 3 seconds and hold the accelerator pedal. – Vehicle accelerates optimally.

3.7. ConnectedShift

ConnectedShift uses navigation data for a forward-thinking shift strategy of the automatic transmission. If, for example, a sharp bend is detected, the automatic transmission shifts down early and the gear is retained in the bend.

The route guidance of the navigation system does not need to be activated for the function. However, the identification of a turn-off request, for example by the active route guidance or operating the turn indicator, helps to control the system more accurately. Up-to-date navigation map data also influences the control accuracy.

3.7.1. Characteristics and availability

In SPORT and COMFORT modes, the characteristics of ConnectedShift are adapted to the respective driving program, in ECO PRO mode ConnectedShift is not available. ConnectedShift is also not available during control operation of cruise control.

ConnectedShift is used in the F48, depending on the equipment, specifically in vehicles with gas engine, automatic transmission and navigation system.

A prerequisite is that the map data and the required additional information for the country are available. This is dependent on the navigation map provider and is not available worldwide for all countries.

3.8. Notes for Service

3.8.1. Special tools

Two new diagnostic cables were designed for the automatic transmission as special tools:

- Adapter cable 15-pin: 83 30 2 352 734
- Adapter cable 33-pin: 83 30 2 352 718

3.8.2. Manually unlocking the drive position lock

F48 Manually unlocking the drive position lock

If the gear selector switch is blocked in selector lever position P despite the ignition being switched on, brake being applied and the Unlock button being pressed, the drive position lock can be manually unlocked. There is a release lever under the sleeve for the gear selector switch, which can be operated using the screwdriver from the toolkit, for example.

3.8.3. Available replacement parts

The following components of the automatic transmission are created as replacement parts in addition to various retaining and sealing elements:

- Cable holder (at transmission housing)
- Gearshift lever (at gearshift shaft)
- Electronic transmission control (EGS)
- Oil filler plug
- Electrical wiring set
- Gearbox input-speed sensor
- Hydraulic shift unit
- Cover (hydraulic shift unit)
- Transmission oil cooler
- Oil drain plug (with overflow)
- Torque converter
- Radial shaft seals for transmission input shaft, as well as left and right axle shaft

4. xDrive

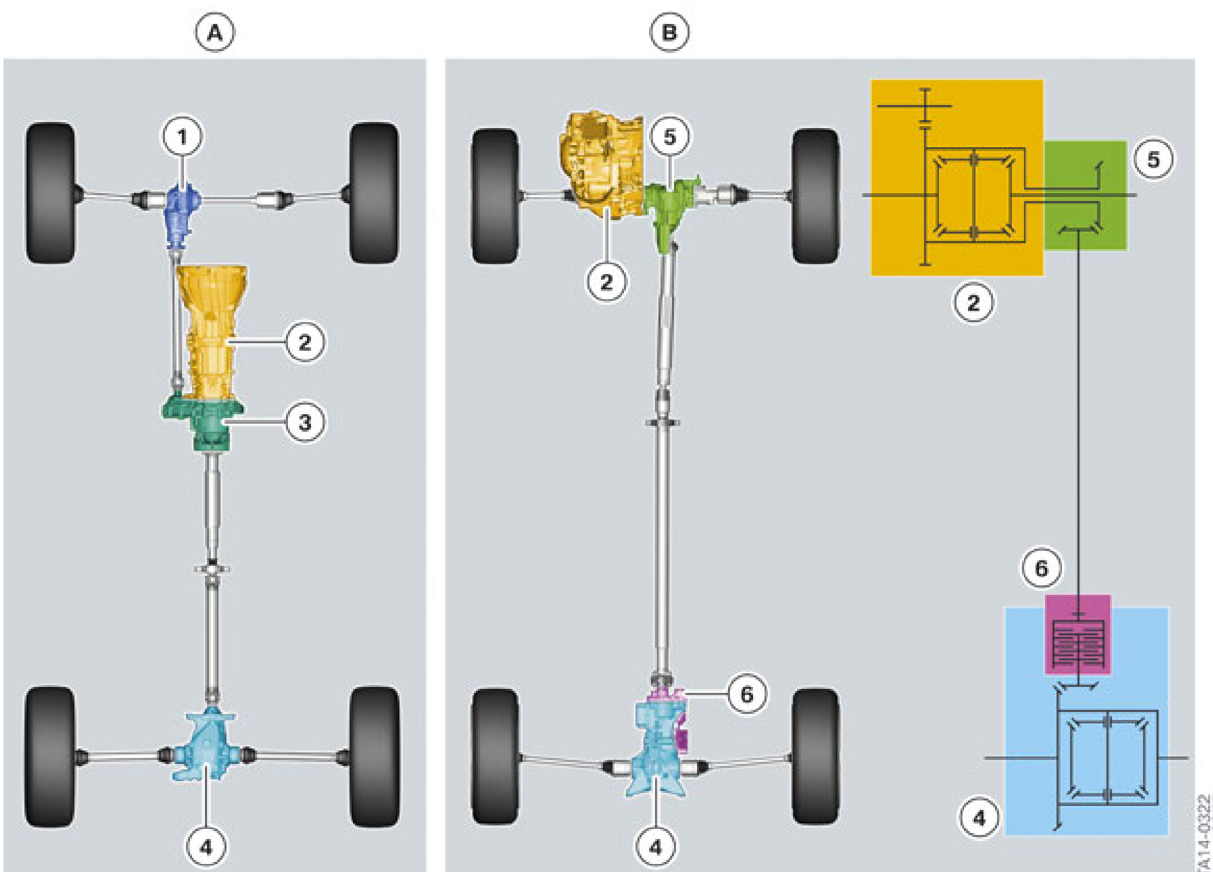
4.1. Introduction

The xDrive system in the F48 was redeveloped and for the first time at BMW. Although this all-wheel drive system is also called xDrive, it is considerably different from the versions previously installed, which were based on a rear-wheel drive.

The differences of the xDrive versions are listed in the following section.

4.1.1. Comparison of xDrive systems

The following graphic shows the xDrive system of the F48 compared to the F25.



Comparison of the xDrive system: F25 – F48

Index	Explanation
A	xDrive F25
B	xDrive F48
1	Front axle differential
2	Automatic transmission

4. xDrive

Index	Explanation
3	Transfer box
4	Rear axle differential
5	Angular gearbox
6	Longitudinal torque distribution (integrated in the rear axle differential)

The following table shows the key differences of the xDrive systems in the F25 and in the F48.

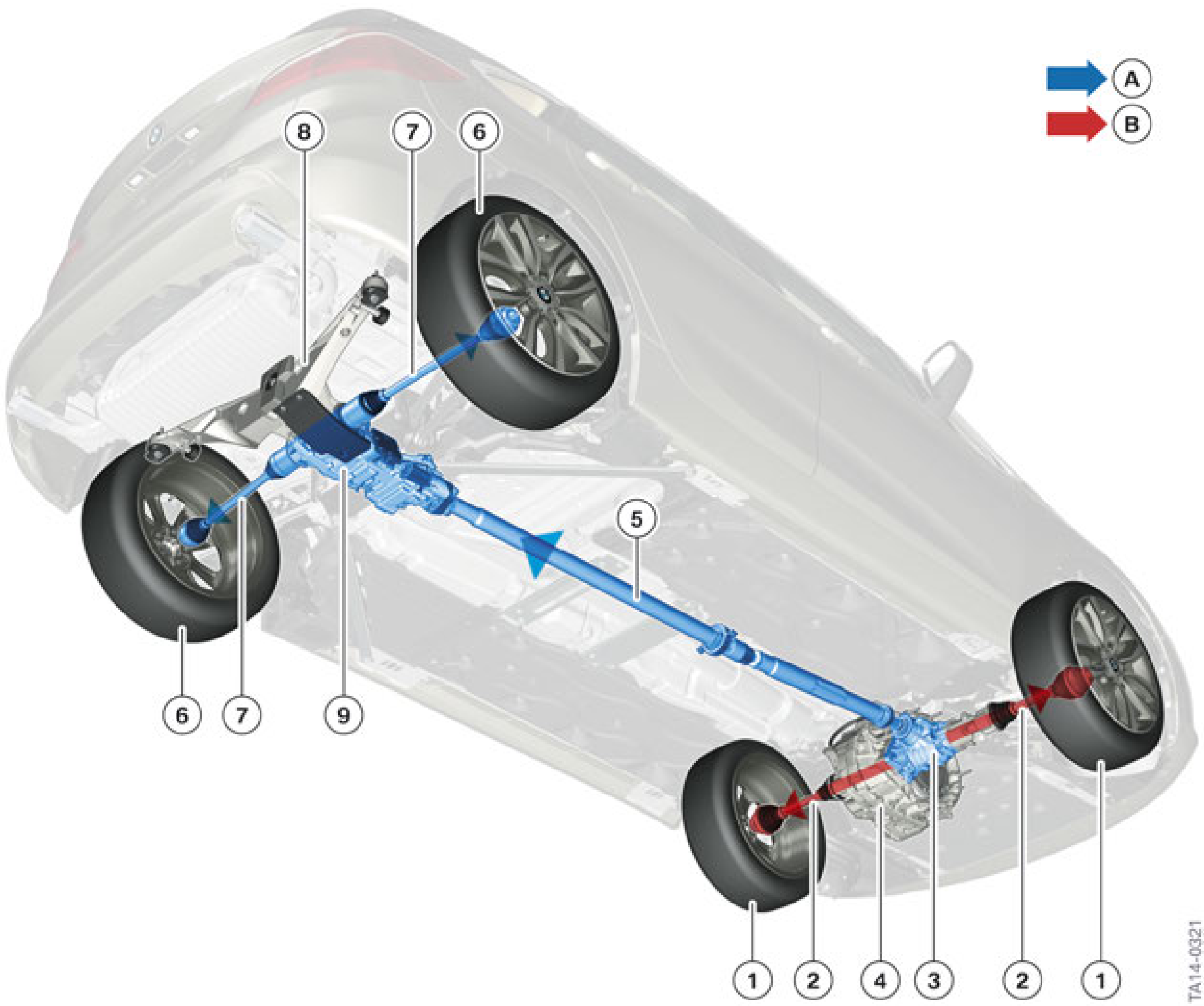
	F25	F48
Longitudinal torque distribution requirement (setpoint torque)	DSC	DSC
Control of the longitudinal torque distribution	VTG control unit	Longitudinal torque distribution control unit
Longitudinal torque distribution	Multidisc clutch in the transfer box	Multidisc clutch of the longitudinal torque distribution
Drive torque when multidisc clutch open	100 % at rear axle	100 % at front axle
Activation of multidisc clutch	Via electric motor and ball ramp	Via EHPS and hydraulic operating pressure

The new xDrive system with longitudinal torque distribution clutch has the following advantages in comparison to the xDrive system with transfer box:

- Low space requirement
- Low weight
- Low splashing losses in the multidisc clutch (thanks to "Efficient mode")
- CO_2 reduction

F48 Powertrain
4. xDrive

4.2. System components



F48 overview of four-wheel drive

Index	Explanation
A	Driving power to the rear wheels
B	Driving power to the front wheels
1	Front wheel
2	Output shaft, front
3	Angular gearbox
4	Automatic transmission
5	Propeller shaft

F48 Powertrain
4. xDrive

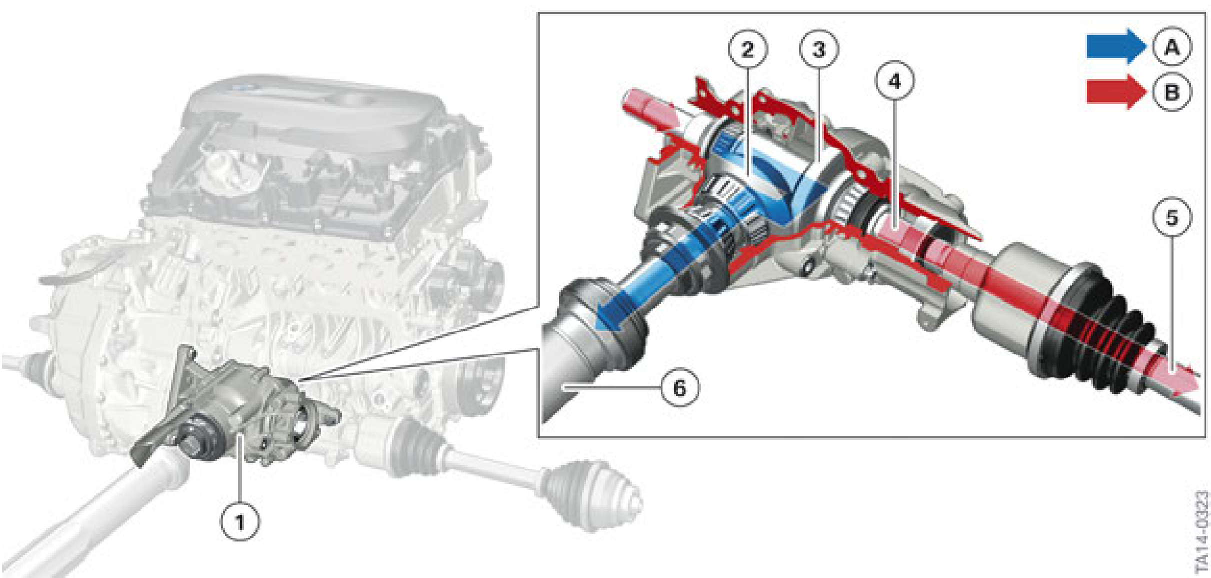
Index	Explanation
6	Rear wheel
7	Output shaft, rear
8	Cross member
9	Rear axle differential (with integrated longitudinal torque distribution)

With xDrive some of this driving power is transmitted to the rear output shafts (7) via the angular gearbox (3), the propeller shaft (5) and the rear axle differential (9). The gear ratio in the angular gearbox is 1.74 : 1 and in the rear axle differential 1 : 1.74.

The engine speed is increased and, at the same time, the torque is reduced, as a result of the ratio in the angular gearbox. The propeller shaft can therefore be designed with smaller dimensions. The weight reduction helps the fuel consumption and the fewer moving masses benefit the smooth running.

In the rear axle differential the ratio is then reversed, so that the same engine speed is applied to the front and rear output shafts.

4.2.1. Angular gearbox



F48 Angular gearbox

Index	Explanation
A	Driving power to the rear wheels
B	Driving power to the front wheels
1	Angular gearbox
2	Pinion shaft

Index	Explanation
3	Input shaft (hollow shaft) with crown wheel
4	Intermediate shaft
5	Output shaft, front right
6	Propeller shaft

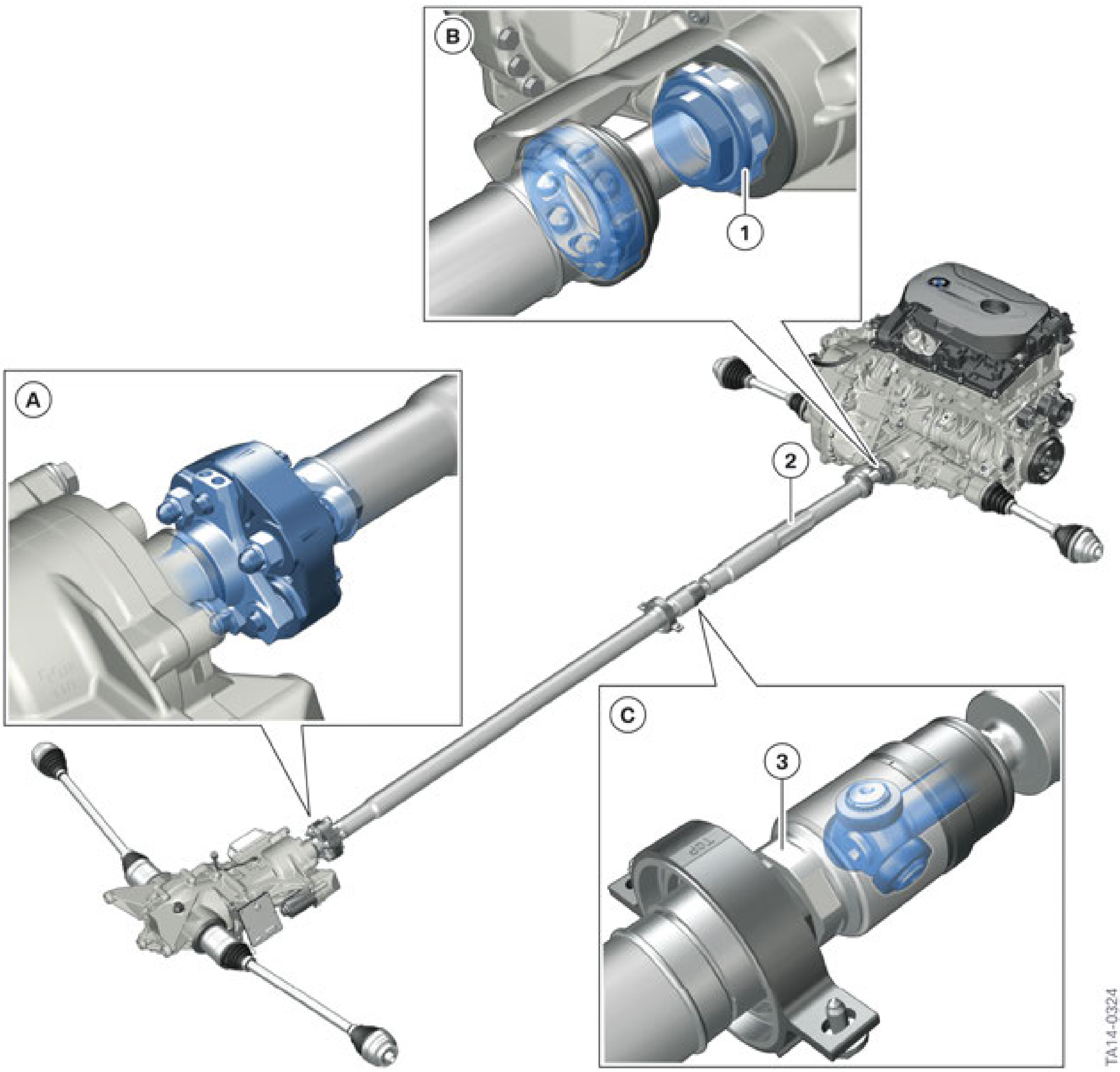
The angular gearbox is located behind the engine and is secured at the automatic transmission and at the crankcase. It transmits some of the driving power to the propeller shaft and is designed as a single-stage, i.e. only has one fixed ratio.

The input shaft of the angular gearbox is designed as a hollow shaft and is connected directly to the differential housing of the front axle differential. The driving power is transmitted from the differential housing to the propeller shaft via the hollow shaft, the crown wheel and the pinion shaft.

As a power interruption in the angular gearbox is not possible, the propeller shaft is driven continuously via the pinion shaft during the journey.

Irrespective of this, the intermediate shaft is guided to the front right output shaft through the hollow shaft and the crown wheel in the angular gearbox.

4.2.2. Propeller shaft



F48 propeller shaft

Index	Explanation
A	Connection to rear axle differential via flexible disc
B	Connection to angular gearbox via a fixed ball joint with flange and inlay nut
C	Propeller shaft center bearing with tripod joint
1	Inlay nut
2	Shift unit
3	Hexagon head (for slackening the inlay nut at the angular gearbox)

4. xDrive

The propeller shaft is responsible for transmitting driving power provided by the angular gearbox in the form of torque and engine speed to the rear axle differential. With help of the tripod joint, it offsets the deflection angle and linear variations resulting from the assembly movements.

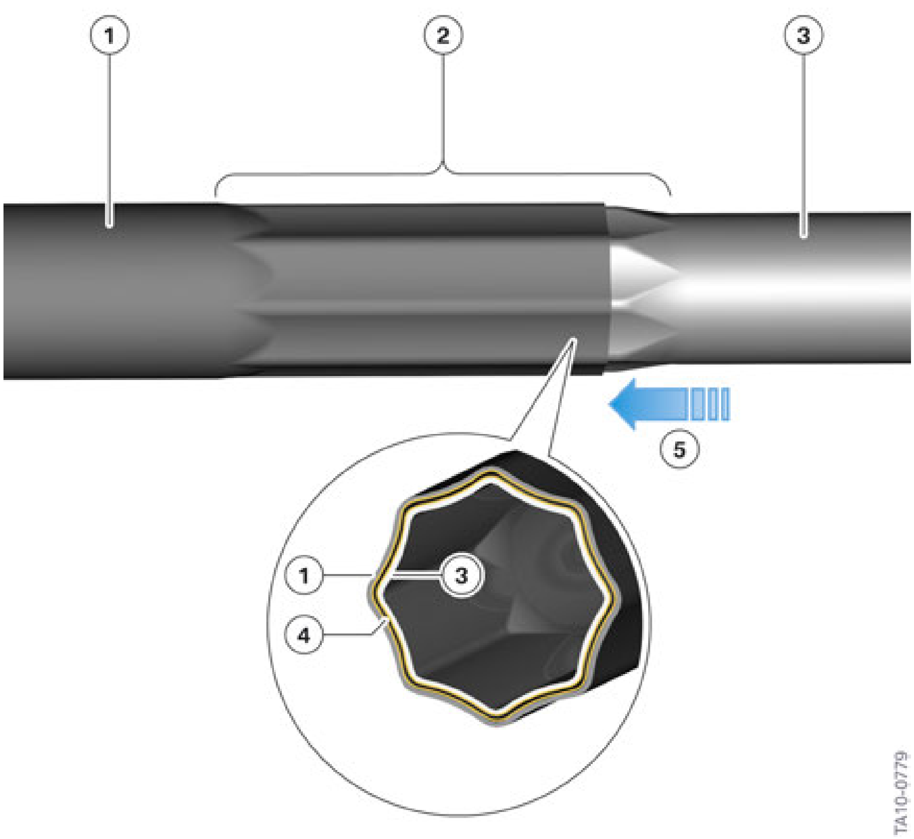
In front of the propeller shaft center bearing is a hexagon head (3), at which the propeller shaft can be rotated. As a result, for left-hand drive vehicles there is the option to remove the propeller shaft from the angular gearbox, if the inlay nut (1) is held over the right wheel arch at the same time.

In the F48 with xDrive, the currently longest propeller shaft of all current BMW models is installed. It is 2.2 m long. It is designed as a two-piece tubular shaft and is secured to the body in the area of the middle joint via the flexible center mount.

⚠

The propeller shaft can be bent a maximum of 10°. Otherwise, the gaiter in the tripod joint will incur damage!

Support the propeller shaft during removal and installation and secure the gaiter with anti-kink protection. It is imperative the current repair instructions are observed when working at the propeller shaft.



F48 Shift unit of the propeller shaft

Index	Explanation
1	Outer pipe (in direction of travel, rear)
2	Shift unit
3	Inner pipe (in direction of travel, front)
4	Coating (to achieve a defined low static friction force)
5	Shift direction

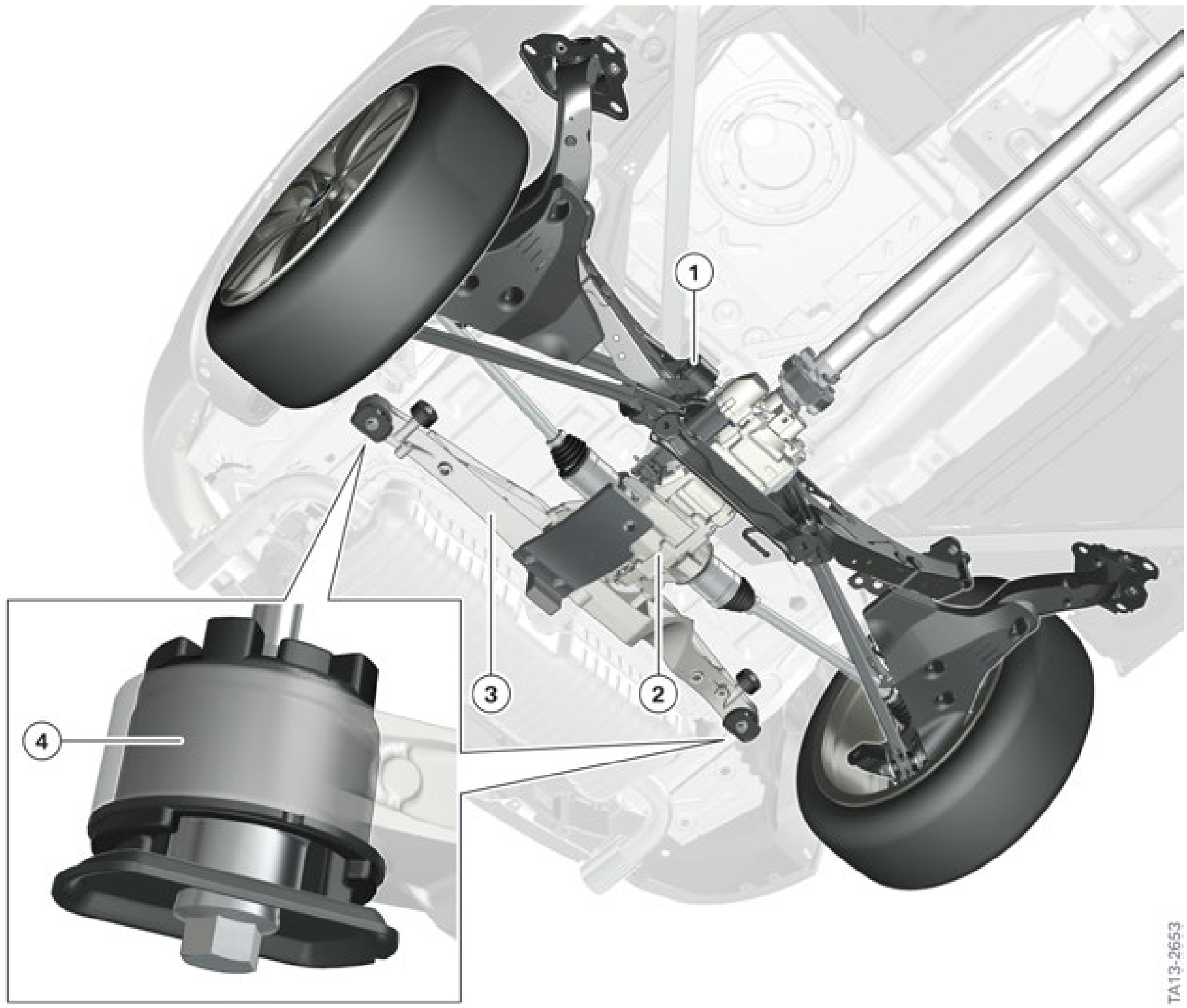
In the front propeller shaft sections, two contoured pipe sections are inserted in one another.
The contour of the two pipe sections means it is possible to transfer the drive torque. In addition, the two pipe sections can be adjusted towards each other, whereby a coating generates a defined friction force of 20 kN.

In the event of a front-end collision, a counterforce of maximum 20 kN is generated, so that an additional load path is not created.

⚠

Following an accident, the shift unit of the propeller shaft must be checked. If the two pipe sections have shifted into one another, the propeller shaft must be replaced. The criteria for checking and replacing specified in the repair instructions are to be complied with precisely.

4.2.3. Rear axle differential

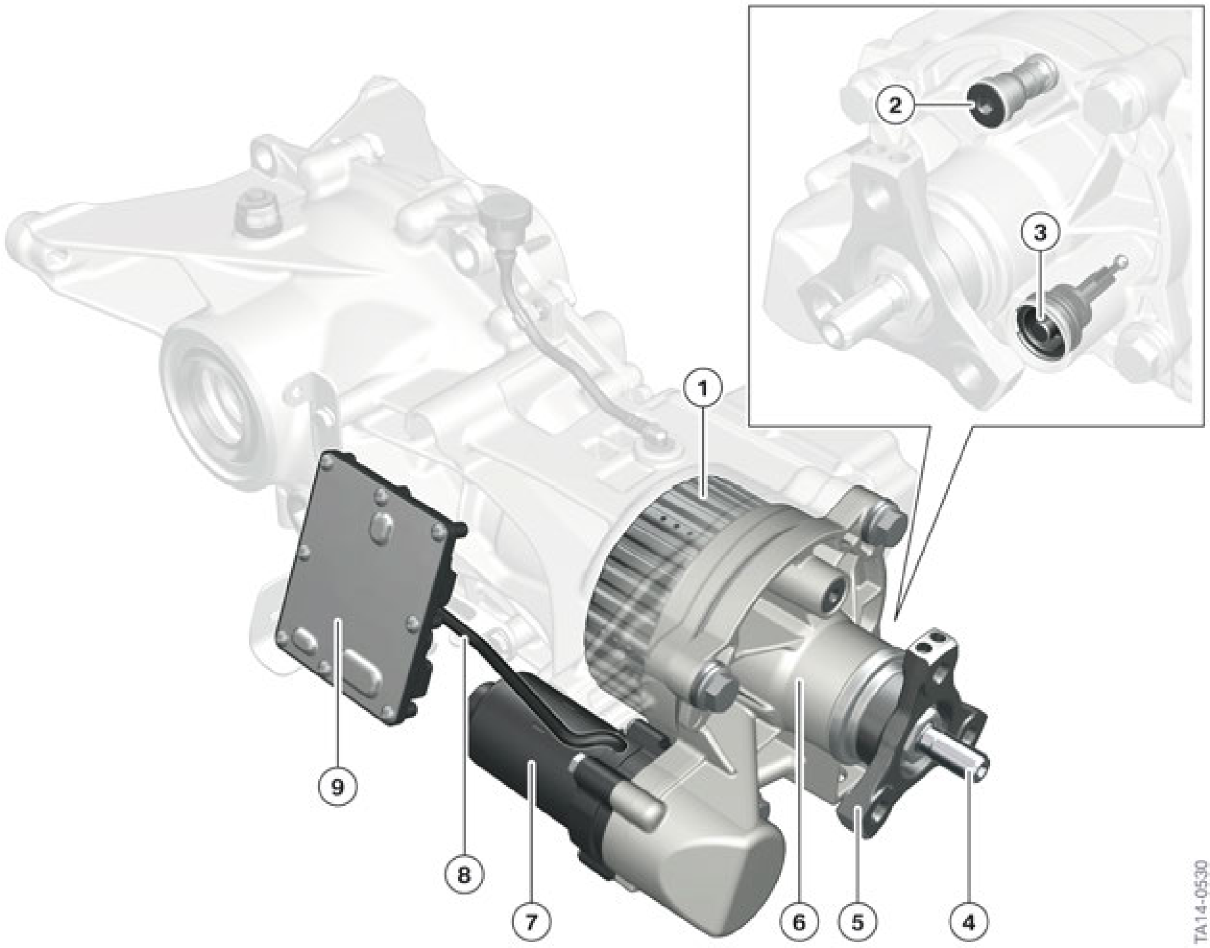


F48 Rear axle differential

Index	Explanation
1	Bearing (rear axle differential to rear axle support)
2	Rear axle differential
3	Cross member
4	Bearing (cross member to body)

The rear axle differential in the F48 with xDrive is secured at the front to the rear axle support and at the rear to an additional cross member. In order to decouple noises and vibrations of the drive train from the vehicle body, both the rear axle differential at the rear axle support, and the additional cross member at the body, are secured via rubber mountings.

Longitudinal torque distribution



F48 Longitudinal torque distribution

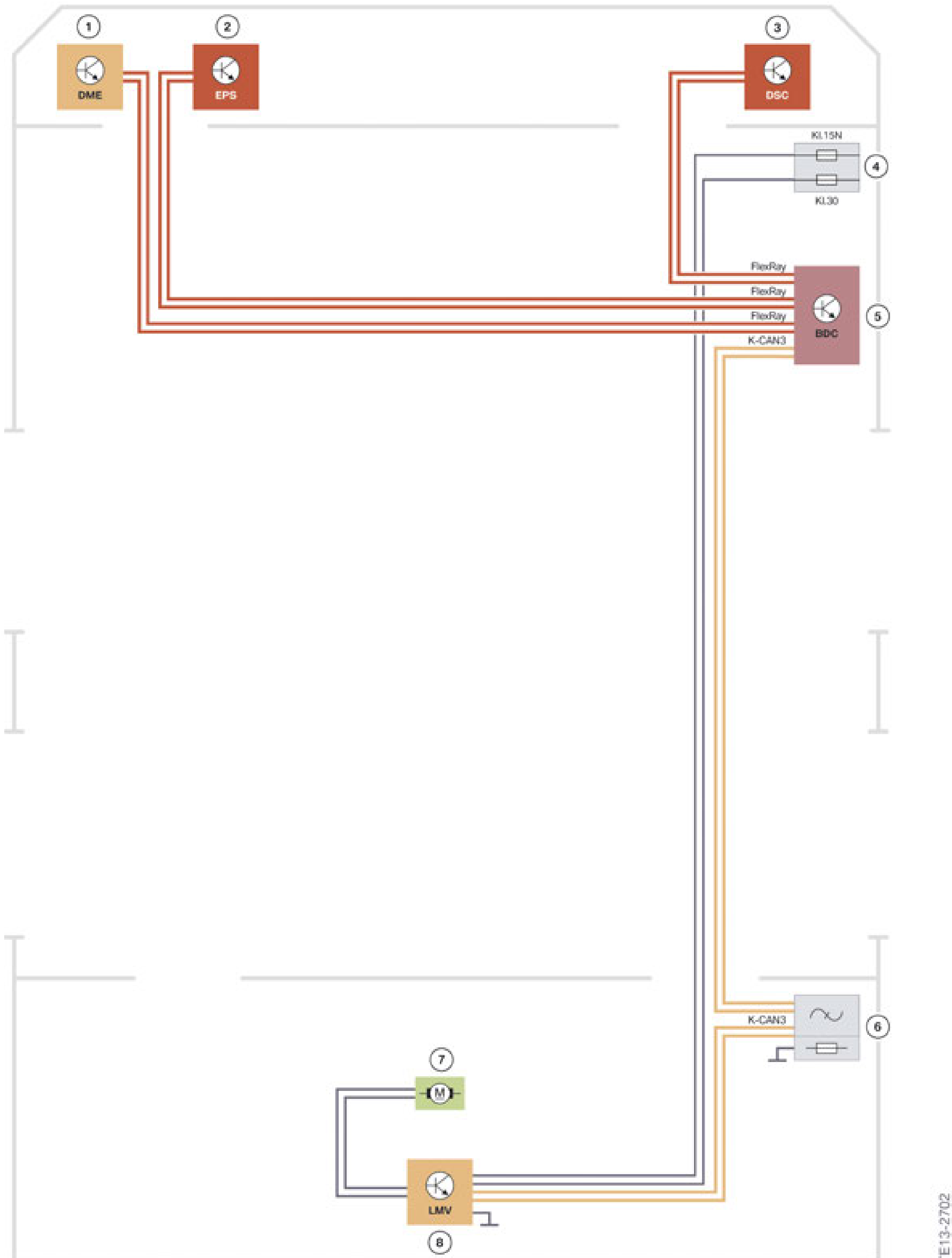
Index	Explanation
1	Multidisc clutch
2	Vent valve
3	"Efficient valve"
4	Input shaft
5	Input flange
6	Clutch housing
7	EHPS
8	Electrical line
9	Longitudinal torque distribution (LMV) control unit

The longitudinal torque distribution in the F48 distributes the drive torque variably to the front axle and rear axle. It comes from the industrial modular system of the 5th generation of the Haldex system from BorgWarner.

Both the longitudinal torque distribution control unit and the EHPS pump unit are secured at the side at the transmission.

The longitudinal torque distribution clutch is integrated in the rear axle differential. The input shaft is driven by the propeller shaft via the input flange. The output flange drives the differential, depending on requirements.

4.2.4. System wiring diagram

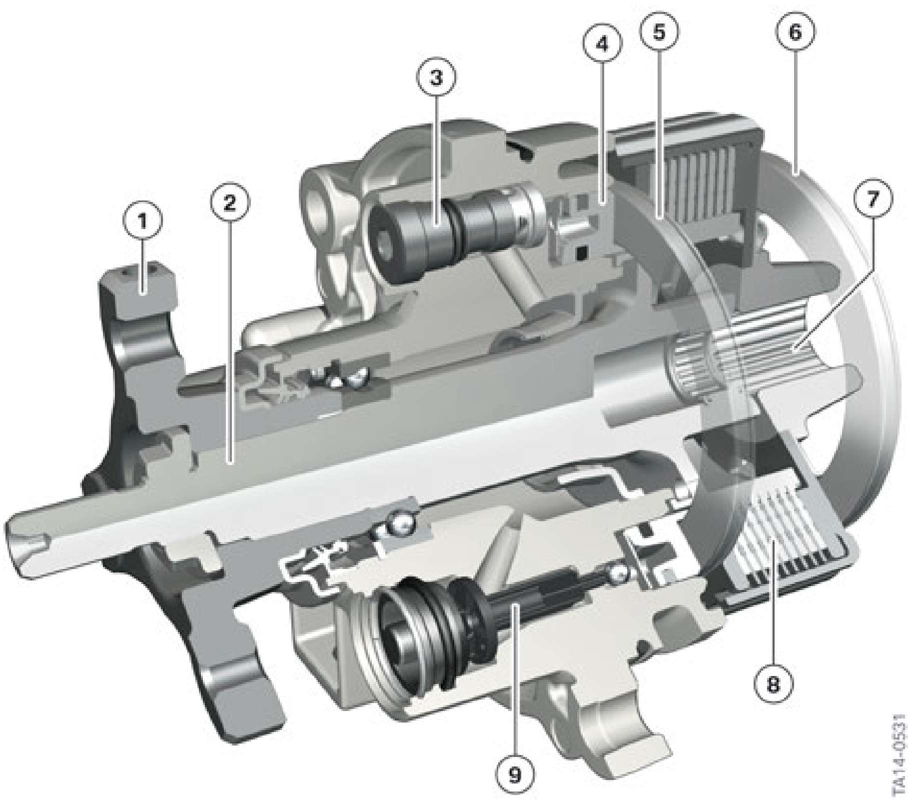


F48 system wiring diagram for longitudinal torque distribution

Index	Explanation
1	Digital Motor Electronics (DME)
2	Electronic Power Steering (EPS)
3	Dynamic Stability Control (DSC)
4	Power distribution box, passenger compartment
5	Body Domain Controller (BDC)
6	K-CAN terminator
7	Actuator, longitudinal torque distribution
8	Longitudinal torque distribution control unit (LMV)

4.3. Function

4.3.1. Longitudinal torque distribution



F48 clutch, longitudinal torque distribution

F48 Powertrain
4. xDrive

Index	Explanation
1	Input flange
2	Input shaft
3	Vent valve
4	Working piston
5	Axial needle bearing
6	Axial needle bearing
7	Output flange
8	Multidisc clutch
9	"Efficient valve"

Depending on the driving situation, the longitudinal torque distribution can direct some of the driving power (up to maximum torque of 1300 Nm) to the rear axle, sometimes before the wheels even spin.

The DSC sends information about the clutch torque to be adjusted to the BDC via FlexRay and to the longitudinal torque distribution control unit via the K-CAN3. The longitudinal torque distribution control unit controls the speed of the EHPS using pulse-width modulations. Depending on the speed, the EHPS applies an operating pressure of 0 to 40 bar to the clutch longitudinal torque distribution.

The pressure is not measured by a pressure sensor, but checked via a voltage/current comparison.

In driving situations in which the xDrive is not required, the system switches to "Efficient mode". The "Efficient valve" lowers the oil level in the clutch, thus reducing the splashing losses. If the xDrive is required again, the maximum torque can be provided within 250 ms. The spring-loaded "Efficient valve" is operated by the oil pressure.

Adaptations, which monitor the system behavior and ensure position precision, are constantly performed in the longitudinal torque distribution control unit. A calibration is performed once during the driving cycle (terminal 15 ON) and stored.

Together with the calibration, a system ventilation is also carried out. The pressure is increased briefly to approximately 45 bar in order to open the vent valve. The ventilation procedure guarantees quick pressure build-up in every regulating situation.

4.3.2. Operating strategy

The operating strategy ensures that the xDrive is operated as required and in an energy efficient manner. The traction requirement is detected in a proactive manner and the drive torque redirected accordingly.

In most driving situations only the front wheels are driven. Only in certain situations is some of the drive torque also transmitted to the rear wheels. The distribution of the drive torque between the front and rear wheels is defined by the DSC. The following criteria are taken into account:

- Speed
- Lateral and longitudinal acceleration
- Brake control
- Steering angle
- Wheel speeds
- Vehicle longitudinal inclination
- Pedal sensor position
- Active driving program (SPORT, COMFORT, ECO PRO)
- DSC status (DSC activated/deactivated, DTC activated/deactivated)

Depending on the driving situation, some of the drive torque is transmitted to the rear wheels. The exact ratio of the torque distribution is dependent on the activation of the multidisc clutch, as well as the slip of the wheels. Some factors on the activation of the multidisc clutch are listed below.

The xDrive is activated in the following situations, if there are no other criteria present which prevent this:

- Understeering vehicle
- Increased difference in speed between front and rear wheels
- Large vehicle longitudinal inclination (e.g. on inclines)
- Kick-down position
- Sporty driving style
- Respective environmental conditions, roadway conditions and type of terrain

The xDrive is switched off in the following situations, if there are no other criteria present which prevent this:

- Large steering angle and driving speeds
- Strong braking (ABS)

To assess the road condition and thus for effective, proactive longitudinal torque distribution, the coefficients of friction between the tires and roadway are calculated by the DSC. The wheel slip, as well as the longitudinal and lateral acceleration, are evaluated.

If wheel speed information received by the DSC suggests different tire rolling circumferences of the wheels (e.g. for tires with varying degrees of wear), the multidisc clutch is no longer closed 100 %. Differences in speed, resulting from different wheel speeds at the front and rear axle, are reduced in this case via the multidisc clutch, so that high torques are not transmitted to the drive train.

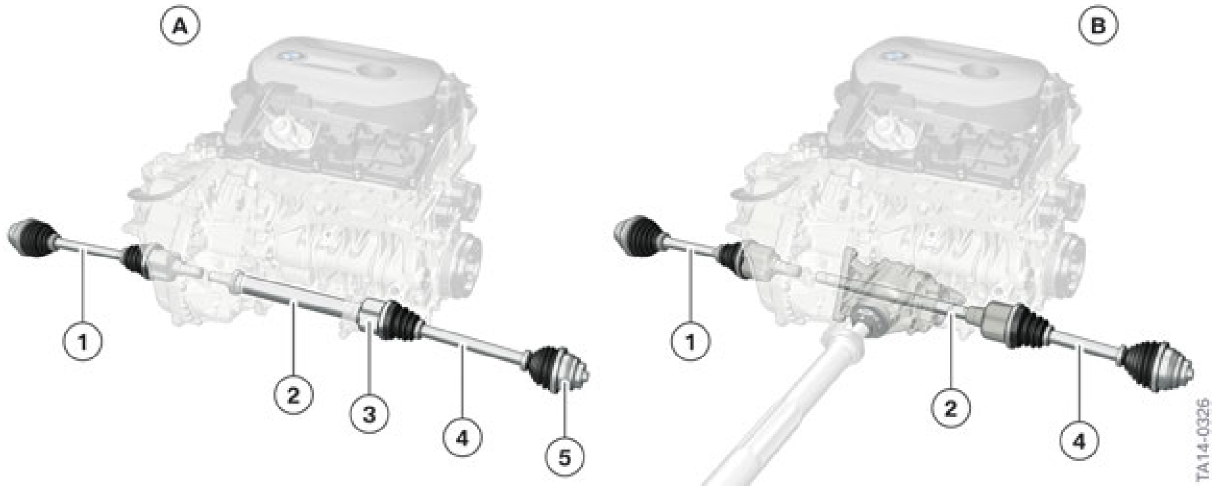
As the multidisc clutch is not closed 100 % in this situation, the maximum transmittable drive torque to the rear axle is reduced.

4.4. Notes for Service

- The vehicle cannot be towed away if only one axle is raised.
- Both the angular gearbox and the rear axle differential have an oil filling that lasts the entire service life of the assembly.
- Using the diagnosis system, both the mechanics and the tightness of the EHPS can be checked (here the pressure is checked via a voltage/current comparison).
- In order to remove the angular gearbox, the starter motor also has to be removed.
- Similar to the previous xDrive system, tires with very different tread depths cannot be used at the front and rear axle.
- The maximum permissible deflection angle of the propeller shaft cannot be exceeded.

F48 Powertrain

5. Output Shaft, Front



F48 Output shafts, front

Index	Explanation
B	F48 with xDrive
1	Output shaft, front left
2	Intermediate shaft
3	Output shaft, front right

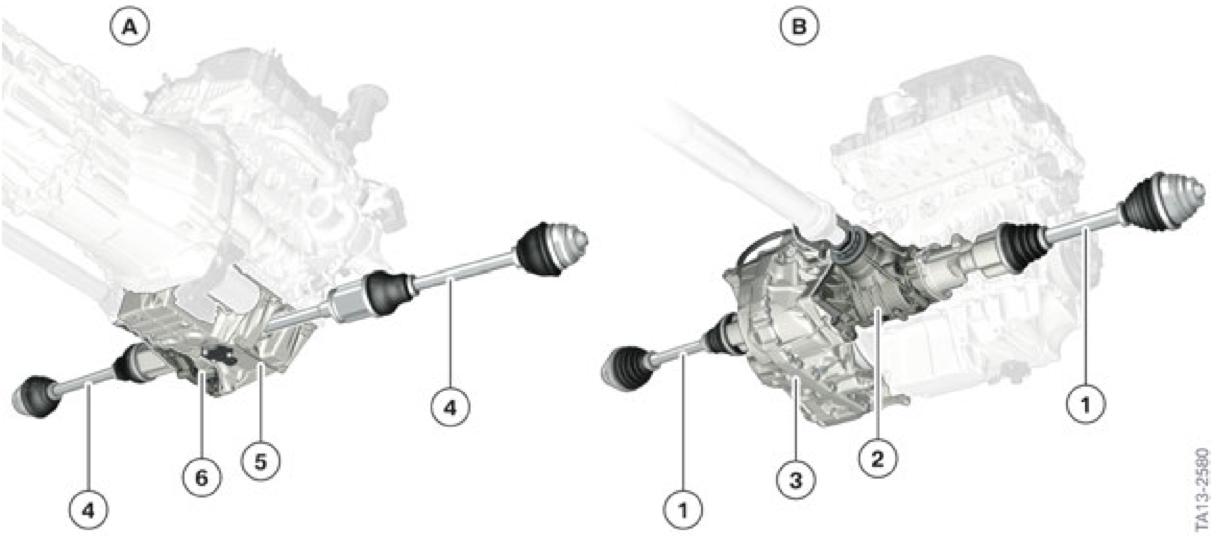
The left output shaft is designed as a single piece. The right output shaft consists of an intermediate shaft at the engine and the actual right output shaft. Both output shafts are roughly the same length and have similar torsional rigidity.

The front output shafts are designed according to the maximum transmittable torque, in order to achieve minimal component weight.

The transmission-end tripod joints offset differences in length and deflection angles, the wheel-side fixed ball joints only offsets the deflection angles. The interfaces for the transmission or the intermediate shaft are defined as a journal solution and are designed depending on the respective transmission. The interface for the wheels is designed as a spur gearing solution and is identical for all sizes.

F48 Powertrain

5. Output Shaft, Front



Comparison of front output shafts for vehicles with four-wheel drive: F25 – F48

Index	Explanation
A	F25
B	F48
1	Output shaft, front
2	Angular gearbox
3	Transmission
4	Output shaft, front
5	Oil sump
6	Front axle differential

Due to the transversal installation of the engine and transmission, in the F48 the front output shafts no longer have to be guided through the oil sump, as for example in the BMW X3 xDrive. In F48 vehicles with xDrive, however, the front right output shaft is connected to the angular gearbox.

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Technical training.
Product information.

F48 Chassis and Suspension

Edited for the U.S. market by:
BMW Group University
Technical Training
ST1508 3/1/2016

BMW Service

General information

Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:

⚠

Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

Information status and national-market versions

BMW Group vehicles meet the requirements of the highest safety and quality standards. Changes in requirements for environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between the contents of this document and the vehicles available in the training course.

This document basically relates to the European version of left-hand drive vehicles. Some operating elements or components are arranged differently in right-hand drive vehicles than shown in the graphics in this document. Further differences may arise as a result of the equipment specification in specific markets or countries.

Additional sources of information

Further information on the individual topics can be found in the following:

- Owner's Handbook
- Integrated Service Technical Application.

Contact: conceptinfo@bmw.de

The information contained in this document forms an integral part of the technical training of the BMW Group and is intended for the trainer and participants in the seminar. Refer to the latest relevant information systems of the BMW Group for any changes/additions to the technical data.

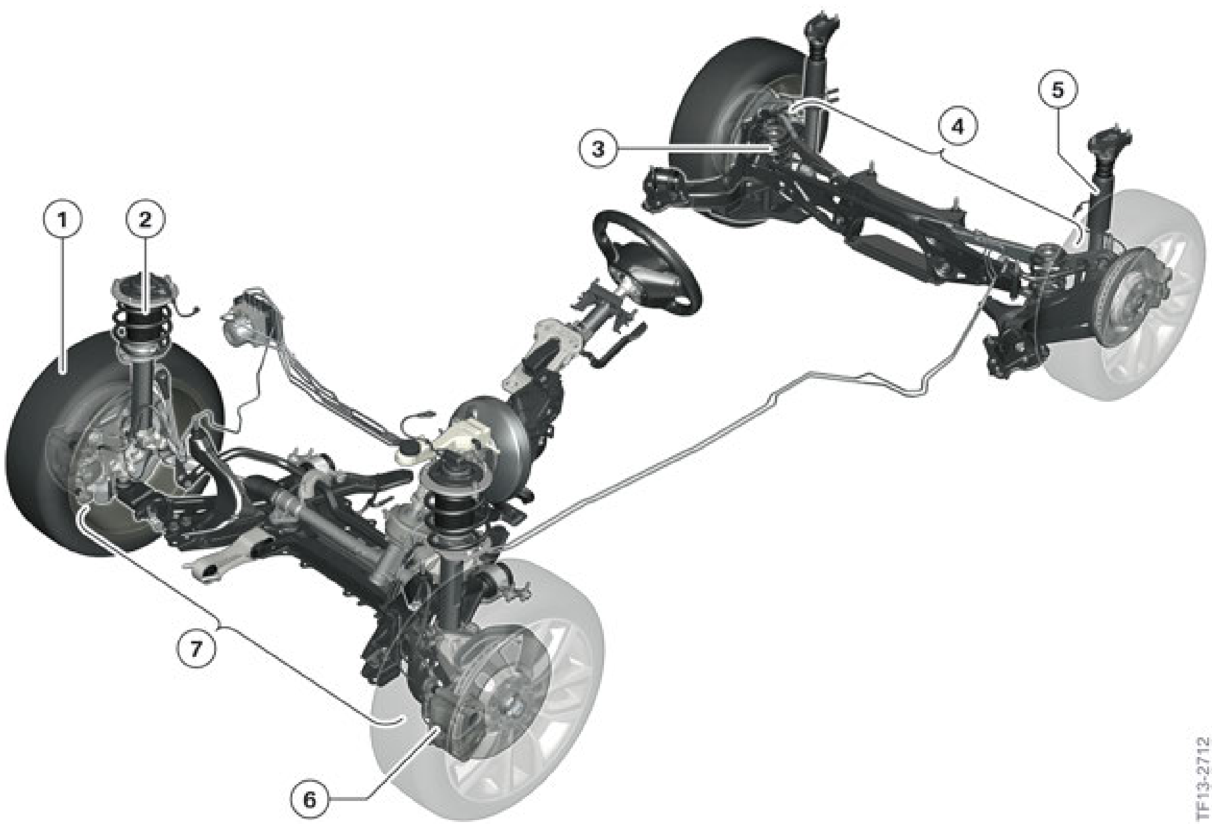
Information status: **June 2015**
Technical training.

F48 Chassis and Suspension

Contents

F48 Chassis and Suspension

1. Introduction



F48 Chassis and suspension

Index	Explanation
1	Wheels
2	Suspension/damping action
3	Suspension
4	Central link rear axle
5	Damping action
6	Brakes
7	Single-joint spring-strut-type front axle

The dynamic handling characteristics of the new BMW X1 are achieved by a completely newly developed chassis and suspension with a wide toe and complex support bearings, among other things. The spring and shock absorber setting highlight the interactive character of the F48.

F48 Chassis and Suspension

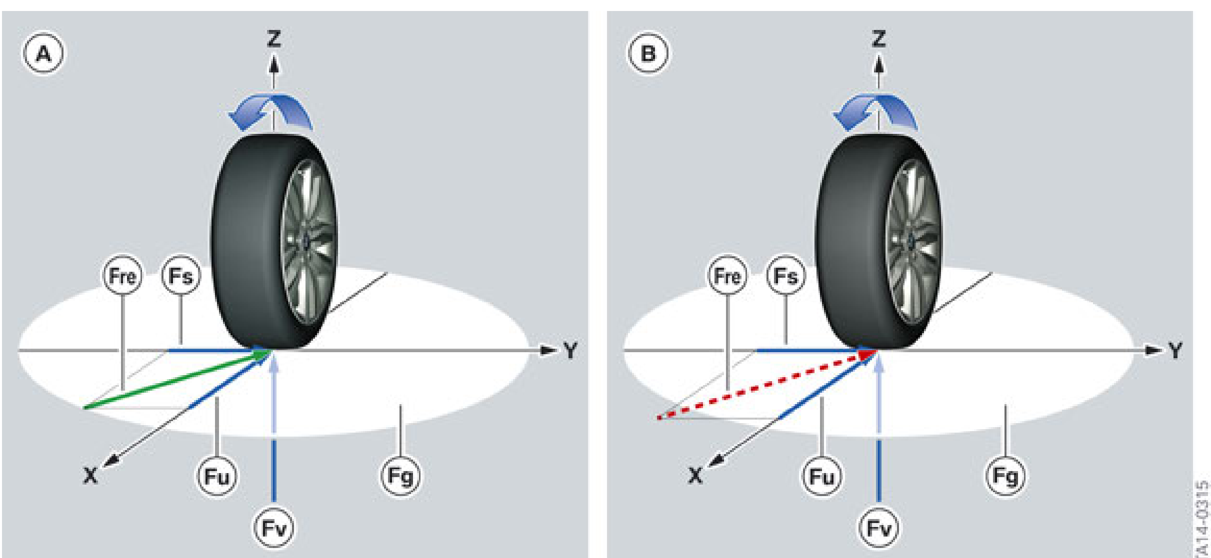
1. Introduction

Special features:

- Newly developed single-joint spring-strut-type front axle
- Negative kingpin offset.
- Newly developed central link rear axle
- Diagonal dual-circuit brake system (X-split)
- Low-friction steering system
- Optional Dynamic Damper Control (SA 223)
- Optional M sports suspension (SA 704)

1.1. Longitudinal and cornering forces at the wheel

The wheels at the vehicle must transmit longitudinal and cornering forces via the tire contact areas. The following graphic shows the connection between the driving power and the cornering force at the wheel.



Driving power and cornering force at the wheel

Index	Explanation
A	Resulting force = Maximum overall force
B	Resulting force too high
Fre	Resulting force
FS	Cornering force
Fu	Driving power
Fv	Vertical wheel force
Fg	Maximum overall force

F48 Chassis and Suspension
1. Introduction

The area shown in white corresponds to the maximum available overall force, which the wheel can transmit to the roadway. The maximum overall force is influenced by the properties of the tire, the road condition and the vertical wheel force. If, for example, the coefficient of friction between the wheel and the roadway decreases due to wet conditions, the available overall force is reduced.

The resulting force of driving power and cornering force cannot exceed the maximum overall force. If the resulting force is too high, the wheel loses adhesion and puts the vehicle in an unstable driving condition. If the driving power increases, a lower cornering force is available. The opposite is also true, meaning that the maximum driving power is only possible for straight-ahead driving.

In contrast to vehicles with a rear-wheel drive, the front wheels of X1 vehicles also have to absorb the driving powers, in addition to the steering forces. Hence why an uneven axle-load distribution, with a higher axle load at the front axle, is desired in vehicles with a front-wheel drive.
The vertical wheel force is thus increased and also the maximum available overall force.

In the new BMW X1, the axle load at the front axle is approximately 56 %.

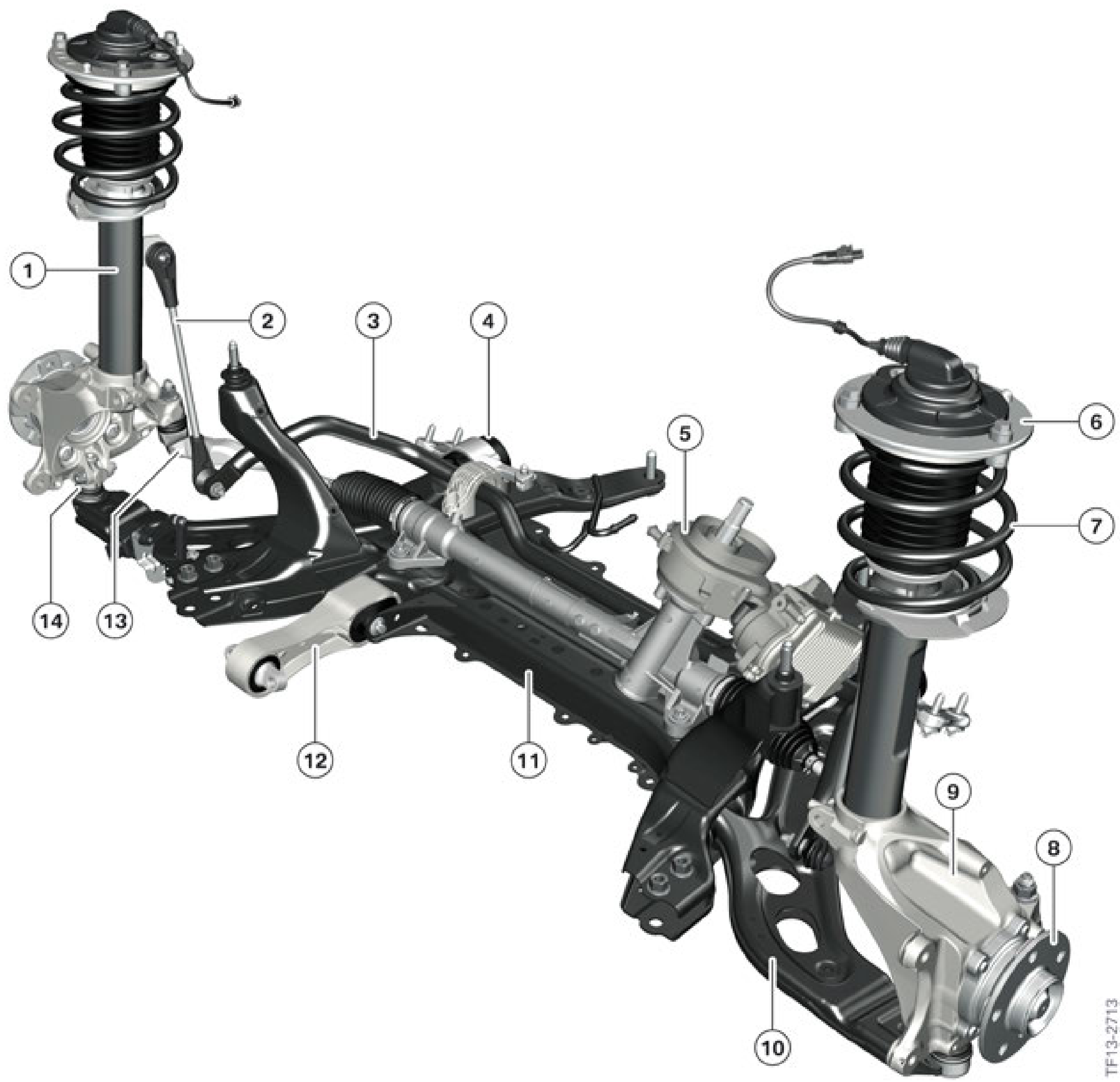
1.2. Technical data

The following table shows the technical data of the chassis and suspension of the F48.

Designation	BMW X1 28i
Wheelbase	2670
Front track width, basic wheels	1557
Rear track width, basic wheels	1562
Tires, basic wheels	205/55 R17 9 W
Basic wheel rims	7.5J x 17
Front axle	Single-joint spring-strut-type front axle
Suspension/damping action, front	Steel springs, conventional
Anti-roll bar, front	mechanical
Rear axle	Central link rear axle
Suspension/damping action, rear	Steel springs, conventional
Rear anti-roll bar	mechanical
Steering	EPS rack
Front brake	Brake disc, ventilated
Rear brakes	Brake disc, ventilated
Parking brake	Electromechanical parking brake

F48 Chassis and Suspension

2. Front Axle



F48 Single-joint spring-strut-type front axle

Index	Explanation
1	Spring strut
2	Anti-roll bar link
3	Anti-roll bar
4	Wishbone rubber mount, rear
5	Electronic Power Steering (electromechanical power steering) (EPS)
6	Support bearing
7	Coil spring
8	Wheel bearing

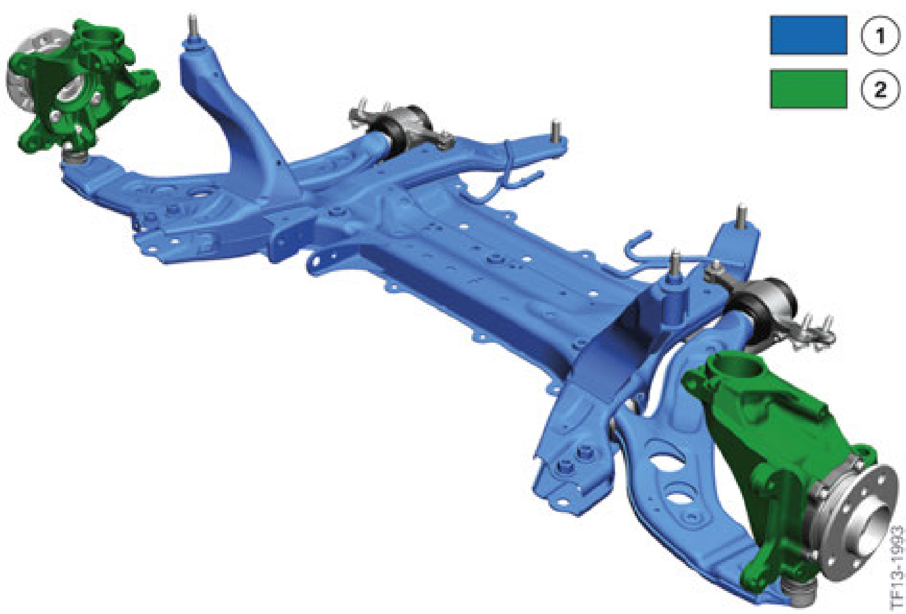
F48 Chassis and Suspension
2. Front Axle

Index	Explanation
9	Swivel bearing
10	Wishbone
11	Front axle support
12	Anti-roll bar link
13	Track rod
14	Wishbone rubber mount

All components of the single-joint spring-strut-type front axle of the F48 have been fully redeveloped. Excellent axle kinematics, as well as high rigidity, ensure agile single-joint movement and a precise steering sensation, to a large extent without engine influences.

The friction-optimized wheel bearing ensures a reduction in the fuel consumption.

Within the framework of the modular principle, the front axle in the F48 is also designed for use in vehicles with other track widths.



F48 material of front axle support, wishbone and swivel bearing

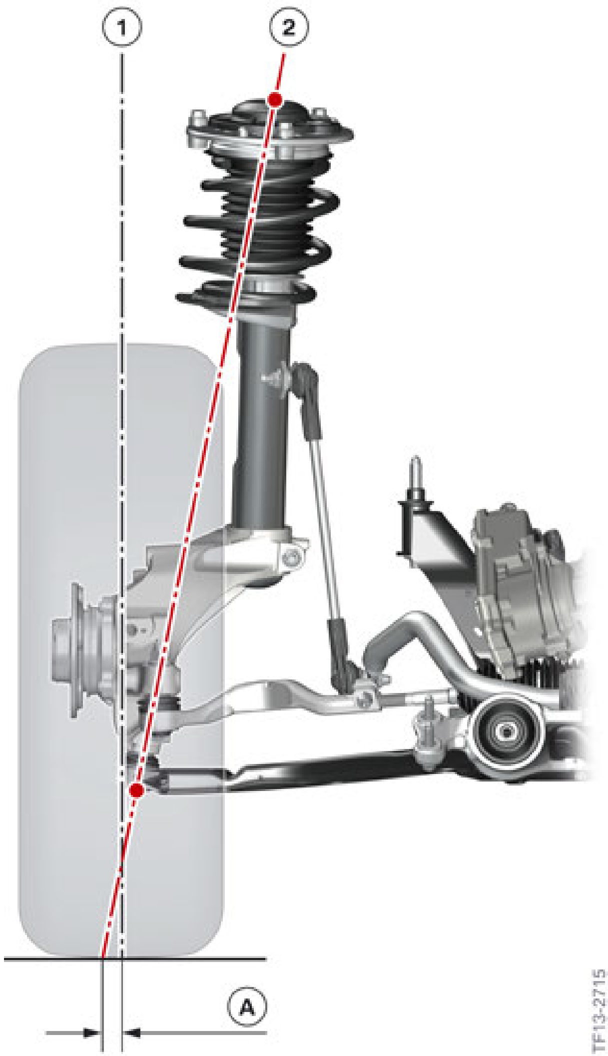
Index	Explanation
1	High-strength steel
2	Aluminium

The use of aluminium (swivel bearing) and high-strength steels (front axle support, wishbone) reduces the unsprung masses.

Engine and transmission mounts absorb the weight of the respective drive components and together with the engine anti-roll bar link support the engine torque. The rear wishbone rubber mounts are designed as hydro mounts.

2. Front Axle

2.1. Kingpin offset



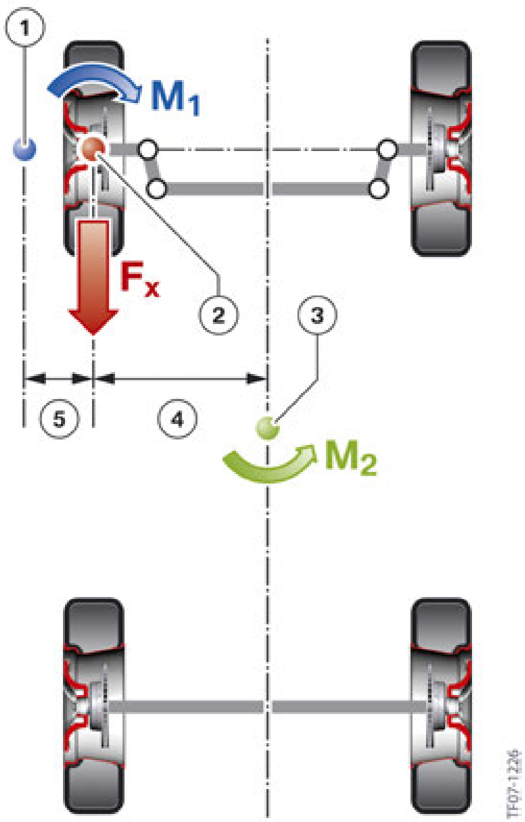
F48 Negative kingpin offset

Index	Explanation
A	Kingpin offset
1	Wheel center axis
2	Axis of movement

F48 Chassis and Suspension

2. Front Axle

The kingpin offset is the distance from the intersection point of the axis of movement with the roadway to the center of the wheel contact face. In the F48 negative kingpin offsets are used, in order to counteract the yaw moment around the vertical vehicle axis in the case of braking with only one brake circuit.



F48 effect of kingpin offset with one-sided brake force (schematic diagram)

Index	Explanation
1	Intersection point of axis of movement with roadway (exaggerated)
2	center of wheel contact face
3	center of gravity of vehicle
4	Distance from center of wheel contact face to the vehicle longitudinal axis
5	Kingpin offset
F_x	One-sided application of brake force
M_1	Torque at the wheel
M_2	Yaw moment around the vertical vehicle axis

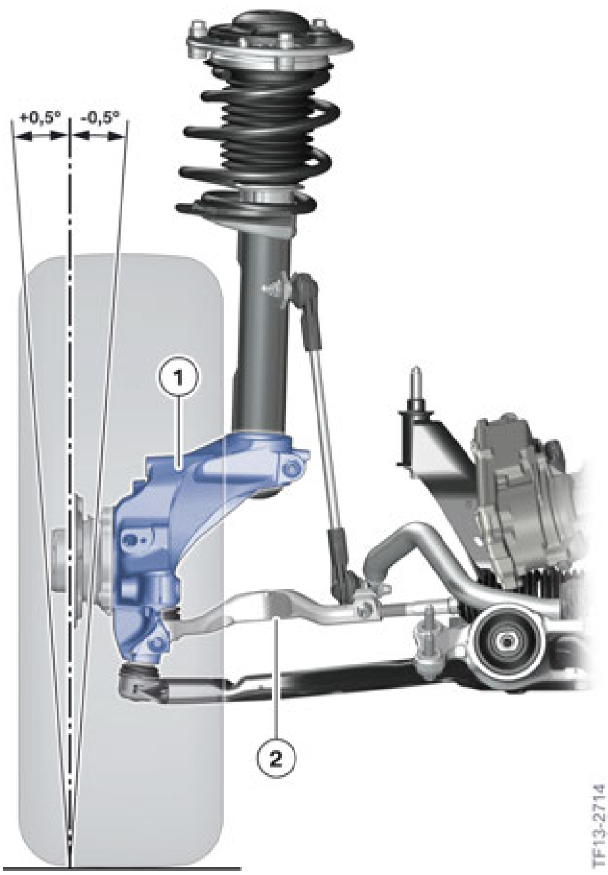
In the F48 a diagonal dual-circuit brake system (X-split) is used. One of the wheels of the front axle and one of the wheels of the rear axle, which are located diagonally opposite, are each supplied by one brake circuit. In the event of a failure of a brake circuit, the vehicle is thus decelerated at the front axle only via one wheel.

F48 Chassis and Suspension

2. Front Axle

However, a yaw moment around the vertical vehicle axis (M_2) occurs as a consequence, by the one-sided deceleration of the wheels at the front and rear axle. In order to guarantee sufficient driving stability in this case, a negative kingpin offset is used in the F48. As a result, in the event of braking with only one brake circuit a torque is generated at the wheel (M_1), which counteracts the yaw moment around the vertical vehicle axis (M_2).

2.2. Notes for Service



F48 toe and camber correction, front axle

Index	Explanation
1	Swivel bearing
2	Track rod

In the F48 a camber correction is only possible using three different swivel bearings available from spare parts service. These enable different camber adjustments, at intervals of 30 minutes (0.5°).

The toe adjustment is still possible via the track rods.

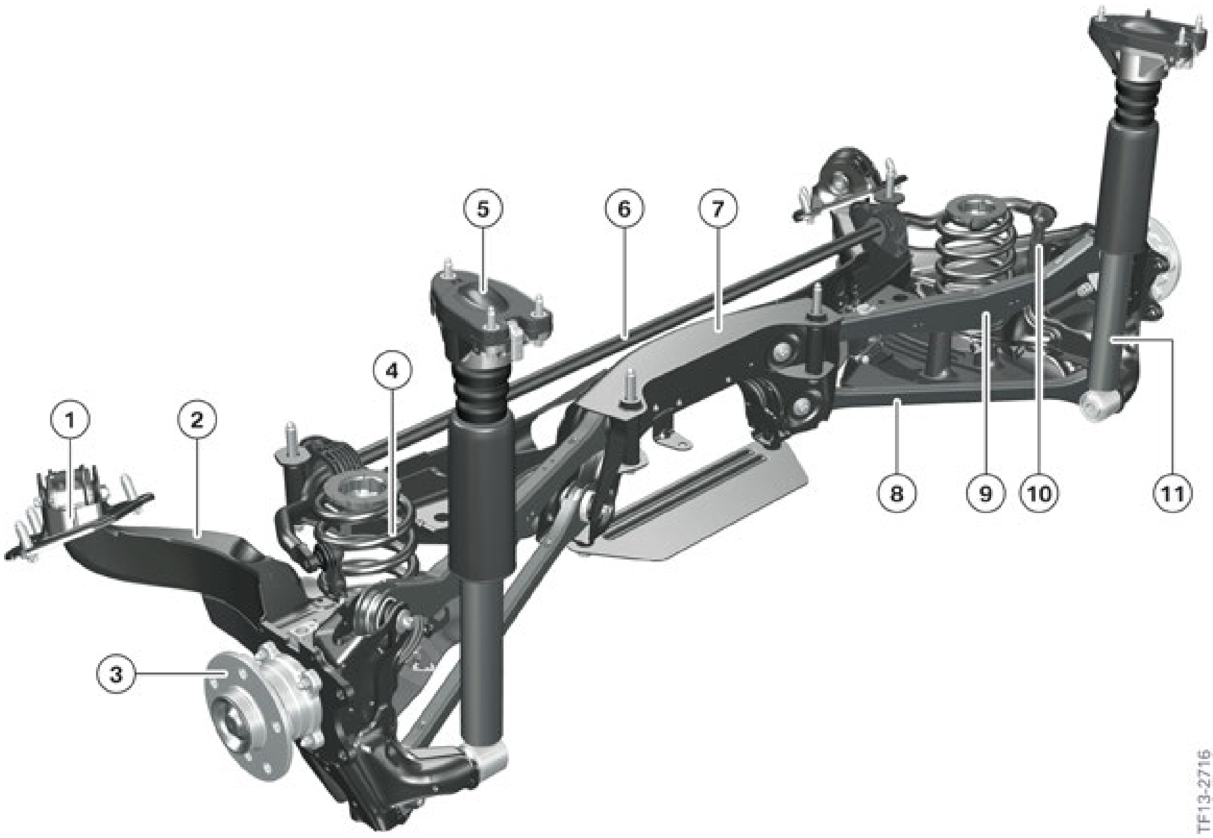
2. Front Axle

The following tables show when wheel alignment at the front axle is necessary:

Component replaced	Wheel alignment required
Front axle support	Yes
Steering gear	Yes
Wishbone	Yes
Wishbone rubber mount	Yes
Wishbone rubber mount, rear	No
Track rod	Yes
Swivel bearing	Yes
Wheel bearing	No
Spring strut	No
Coil spring	No
Support bearing	No

Screw connection unfastened	Wheel alignment required
Front axle support to body	No
Steering gear to front axle support	Yes
Wishbone to front axle support	Yes
Wishbone to swivel bearing	No
Track rod to steering gear	No
Track rod end to track rod	Yes
Track rod end to swivel bearing	No
Spring strut to swivel bearing	No
Support bearing to body	No
Bottom steering shaft to steering gear	No
Steering column to bottom steering shaft	No

3. Rear Axle



F48 central link rear axle

Index	Explanation
1	Bearing support
2	Trailing arm
3	Wheel bearing
4	Coil spring
5	Support bearing with adapter plate
6	Anti-roll bar
7	Rear axle support
8	Wishbone, bottom
9	Wishbone, top
10	Anti-roll bar link
11	Shock absorber

In the F48 a space-saving, modular central link rear axle is used. The axle principle is particularly suitable for the dynamic handling characteristics of the vehicle. It also offers very good conditions for the integration of the xDrive. All components of the rear axle were newly developed. The targeted use of high-strength steels, as well as the increased rigidity of the wheel suspension parts, form the basis for the unique driving dynamics in this class of vehicle.

F48 Chassis and Suspension

3. Rear Axle

F48 suspension/damping action, rear

Less space is required in the wheel arch thanks to the separate arrangement of shock absorbers and coil springs. This results in a generous spatial offering and a high level of entry comfort for the rear seat passengers, as well as excellent use of the luggage compartment.

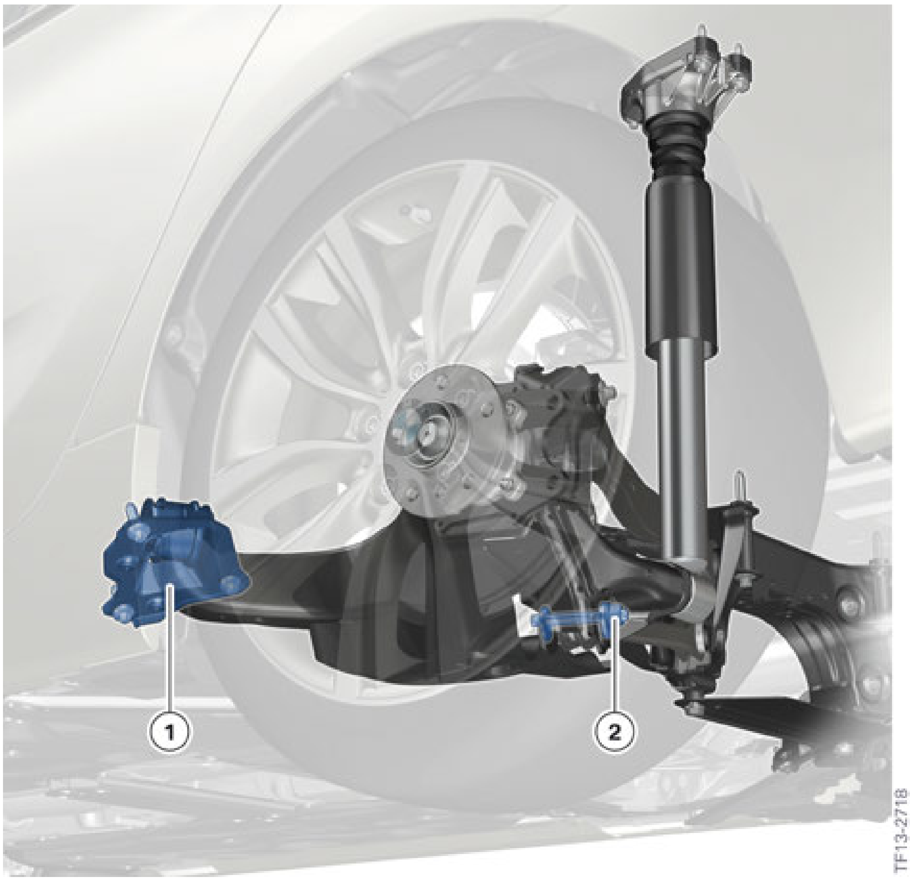
The friction-optimized wheel bearings reduce the fuel consumption.

Within the framework of the modular principle, the rear axle in the F48 is also designed for use in vehicles with other track widths.

F48 Chassis and Suspension

3. Rear Axle

3.1. Notes for Service



F48 toe and camber correction, rear axle

Index	Explanation
1	Bearing support (at trailing arm)
2	Eccentric bolt (at bottom wishbone)

The toe and camber adjustment is set via the bearing support at the trailing arm (toe), as well as via the eccentric bolt at the bottom wishbone (camber).

The following tables show when wheel alignment at the rear axle is necessary:

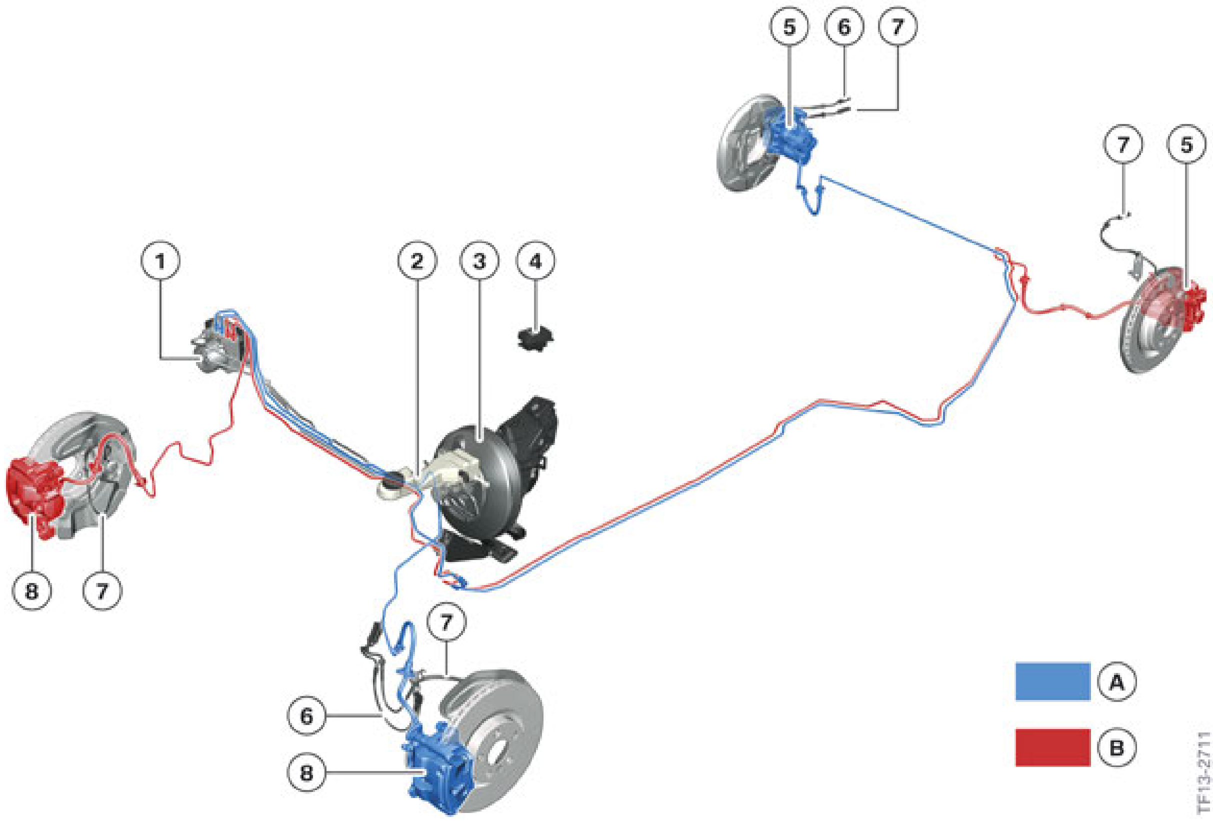
Component replaced	Wheel alignment required
Rear axle support	Yes
Wishbone, top	Yes
Wishbone, bottom	Yes
Bearing support (at trailing arm)	Yes
Wheel bearing	No
Shock absorber	No

3. Rear Axle

Component replaced	Wheel alignment required
Trailing arm	Yes
Anti-roll bar link	No
Anti-roll bar	No

Screw connection unfastened	Wheel alignment required
Rear axle support to body	No
Top wishbone to rear axle support	Yes
Bottom wishbone to rear axle support	Yes
Top wishbone to trailing arm	No
Bottom wishbone to trailing arm	Yes
Trailing arm rubber mount to trailing arm bearing support	Yes
Shock absorber to trailing arm	No
Anti-roll bar link to trailing arm	No
Wheel bearing to trailing arm	No
Anti-roll bar to rear axle support	No
Trailing arm bearing support to body	Yes

4. Brake



F48 overview of the brake system (with X-split)

Index	Explanation
A	Brake circuit 1
B	Brake circuit 2
1	Dynamic Stability Control (DSC)
2	Brake fluid expansion tank
3	Brake servo
4	Parking brake button
5	Brake caliper (with actuator for EMF)
6	Brake pad wear sensor
7	Wheel speed sensor
8	Brake caliper

In the F48 a diagonal dual-circuit brake system (X-split) is used. One of the wheels of the front axle and one of the wheels of the rear axle, which are located diagonally opposite, are supplied by one brake circuit. In the event of a failure of a brake circuit, a braked front wheel is always available.

As a result, the prescribed minimum deceleration is achieved in the event of a failure of a brake circuit despite a low rear axle load.

However, a yaw moment occurs around the vertical vehicle axis in the case of braking with only one brake circuit, because one braked front wheel transmits significantly higher brake forces than the rear wheel braked on the other side of vehicle.

In order to guarantee sufficient driving stability, a negative kingpin offset is therefore used in the F48.

4.1. Electromechanical parking brake

The activation of the EMF is also performed in the F48 via the Dynamic Stability Control (DSC).
A separate control unit could therefore be dispensed with.

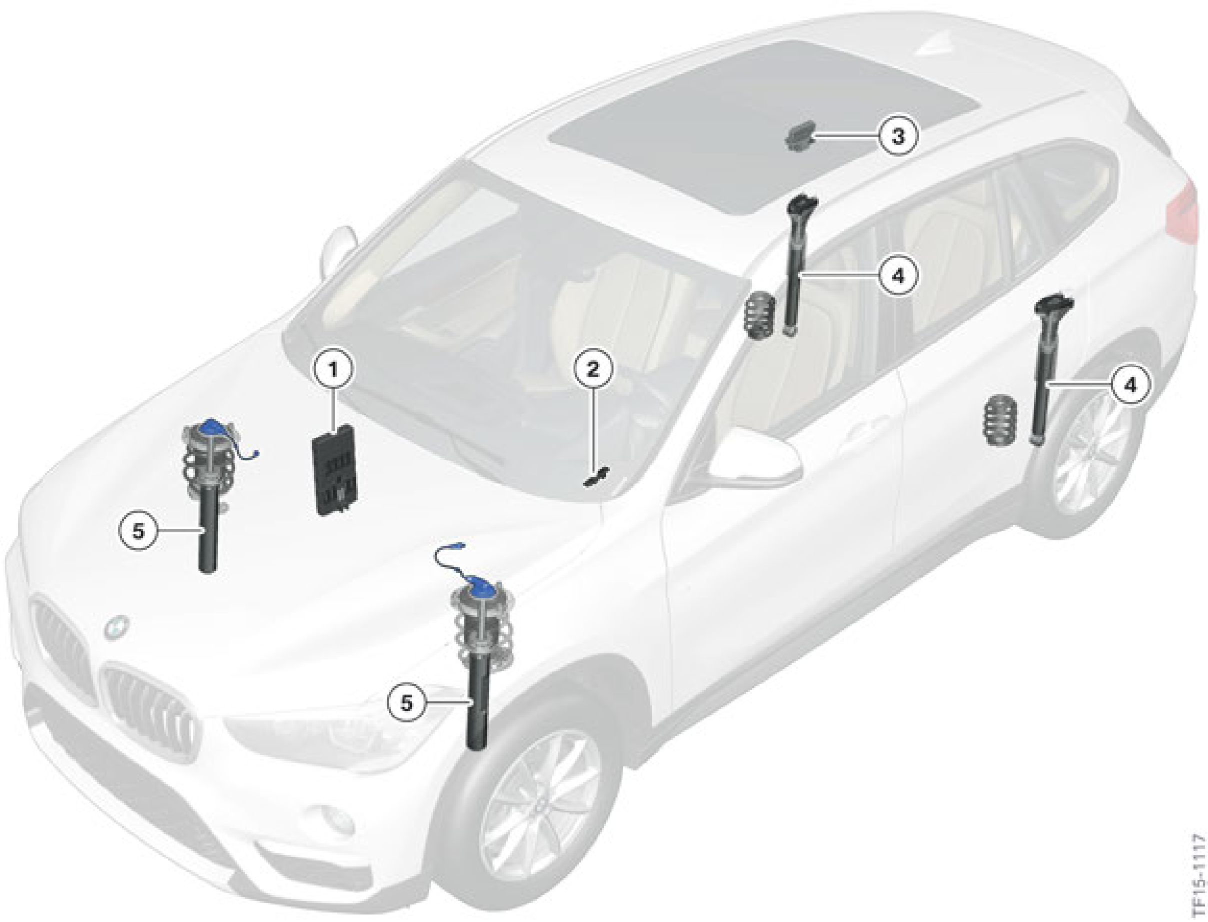
F48 Chassis and Suspension

5. Dynamic Damper Control

A Dynamic Damper Controller (SA 223) is available as optional equipment for the F48. With this system the customer can adjust the characteristics of the vehicle to a tighter, more agile setting.

The chassis and suspension is effected manually in two stages. The system manages without sensors. In addition, the different suspensions are more noticeable by the customer.

5.1. System components



F48 Dynamic Damper Control

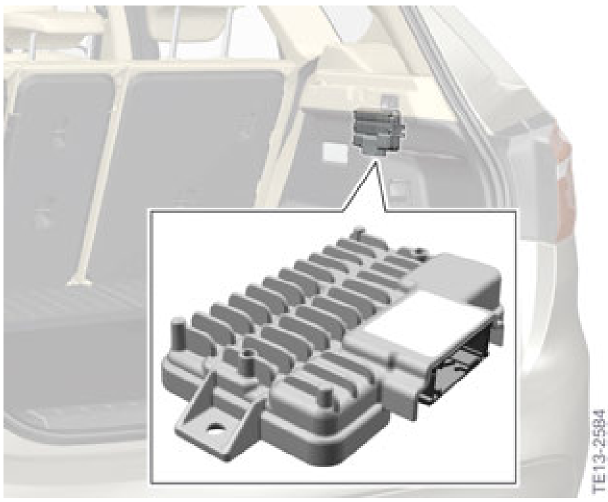
Index	Explanation
1	Body Domain Controller (BDC)
2	Operating unit, center console (with driving experience switch)
3	Optional equipment system (SAS)
4	Rear shock absorber with adapter plate and electrical line
5	Front shock absorber with protective cap and electrical line

The mounting of the shock absorbers at the support bearing is different to vehicles without dynamic damper control. The front shock absorber is secured using a self-locking 12-edge nut M14x1.5, the rear shock absorber is secured using a self-locking 6-edge nut M12x1.0 and double-cone disc.

F48 Chassis and Suspension

5. Dynamic Damper Control

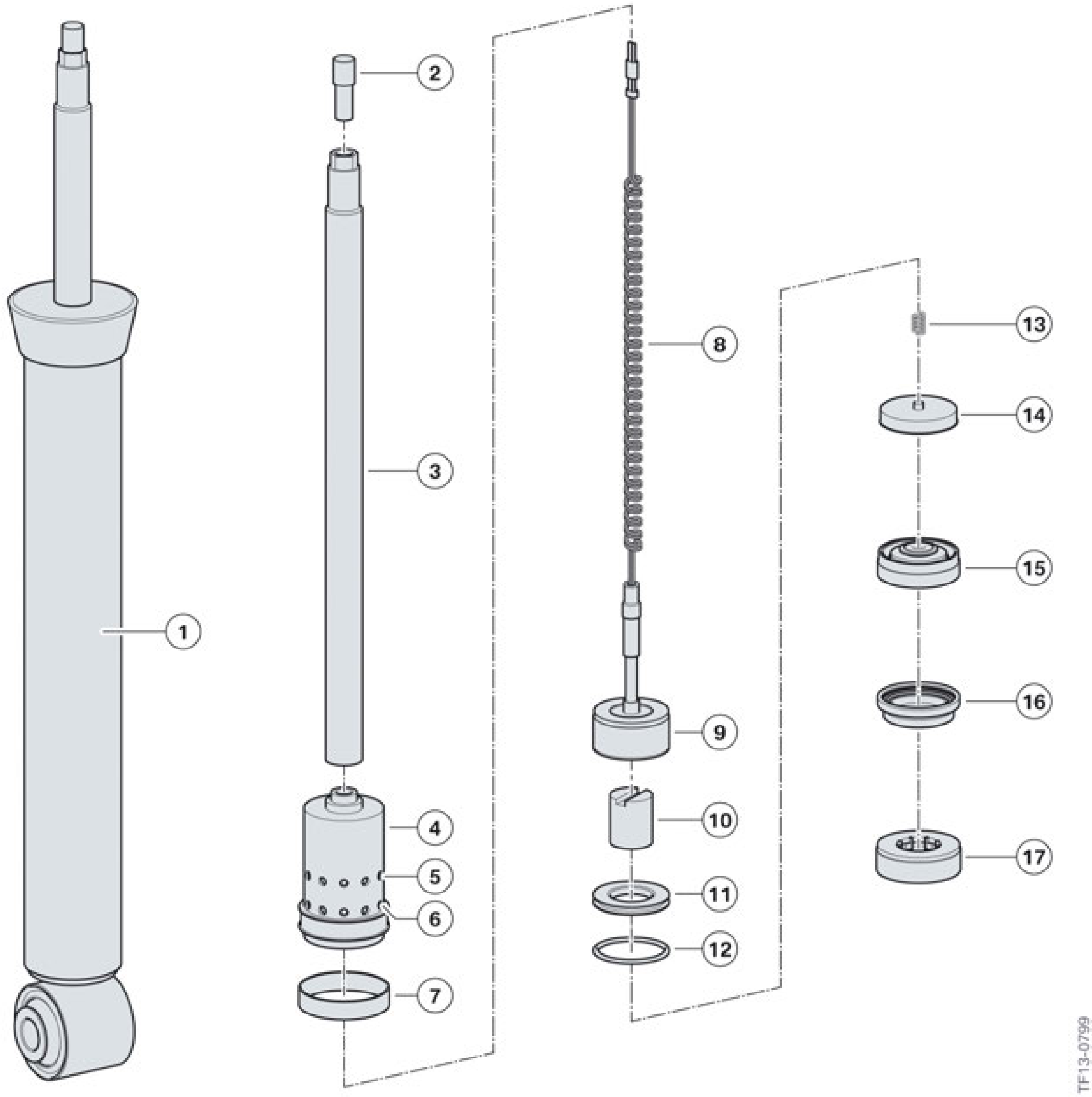
The optional equipment system (SAS) receives information about the position of the driving experience switch from the Body Domain Controller and activates the 2-stage adjustable shock absorber accordingly.



F48 Optional equipment system

The optional equipment system (SAS) is located behind the right luggage compartment trim panel.

5. Dynamic Damper Control



F48 Structure of the switchable shock absorbers

Index	Explanation
1	Shock absorber
2	Socket housing
3	Piston rod
4	Working piston
5	Piston bore hole, normal valve
6	Piston bore hole, sport valve
7	Gasket

Index	Explanation
8	Electrical line
9	Solenoid coil
10	Ferromagnetic core
11	Sealing washer
12	O-ring
13	Coil spring
14	Round slide
15	Normal valve
16	Bypass valve
17	Sport valve

5.2. Operation and function

The characteristics of the shock absorbers can be adapted in two stages using the driving experience switch:

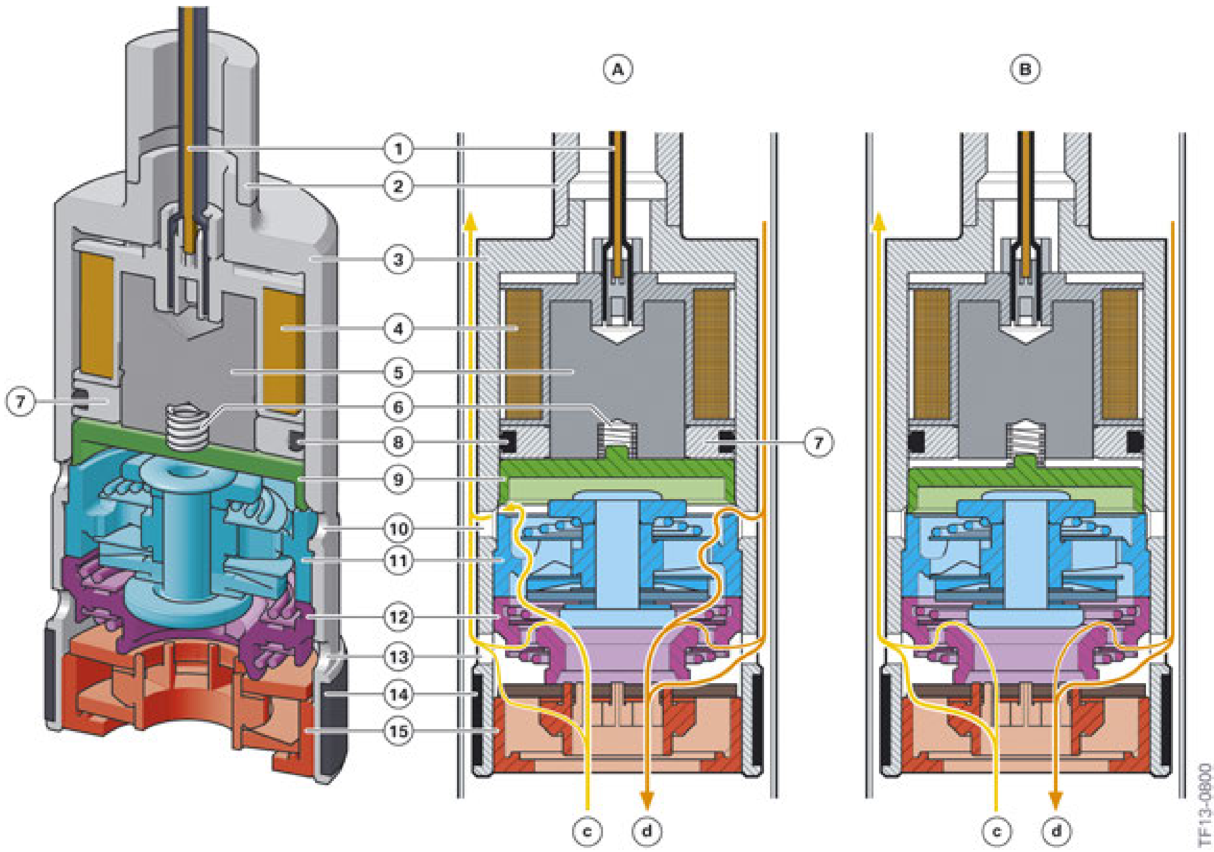
- COMFORT and ECO PRO: NORMAL suspension
- SPORT: SPORT suspension (configurable*).

* In SPORT mode there is the option to give the drive train and the chassis and suspension components a sporty dimension independent of each other.

The Body Domain Controller detects the position of the driving experience switch and transmits this information via FlexRay to the optional equipment system (SAS).

From a speed of 4 km/h the optional equipment system (SAS) checks the position of the driving experience switch and activates the shock absorbers accordingly. At vehicle standstill the shock absorbers are not activated. In the basic setting the shock absorbers are in the SPORT suspension setting. They change to NORMAL suspension setting upon activation.

5. Dynamic Damper Control



F48 working piston, Dynamic Damper Control

Index	Explanation
A	Normal suspension
B	Sport suspension
c	Compression stage
d	Rebound
1	Electrical line
2	Piston rod
3	Working piston
4	Solenoid coil
5	Ferromagnetic core
6	Coil spring
7	Sealing washer
8	O-ring
9	Round slide
10	Piston bore hole, normal valve
11	Normal valve

Index	Explanation
12	Bypass valve
13	Piston bore hole, sport valve
14	Gasket
15	Sport valve

A normal valve and sport valve are located in the working piston of the shock absorber. The flow channel through the normal valve can be enabled with a solenoid valve.

5.2.1. NORMAL suspension

In the upper area of the working piston there is a solenoid with a solenoid coil and ferromagnetic core. With the activation of the solenoid the round slider lying underneath is pulled upwards and the flow channel is enabled through the normal valve.

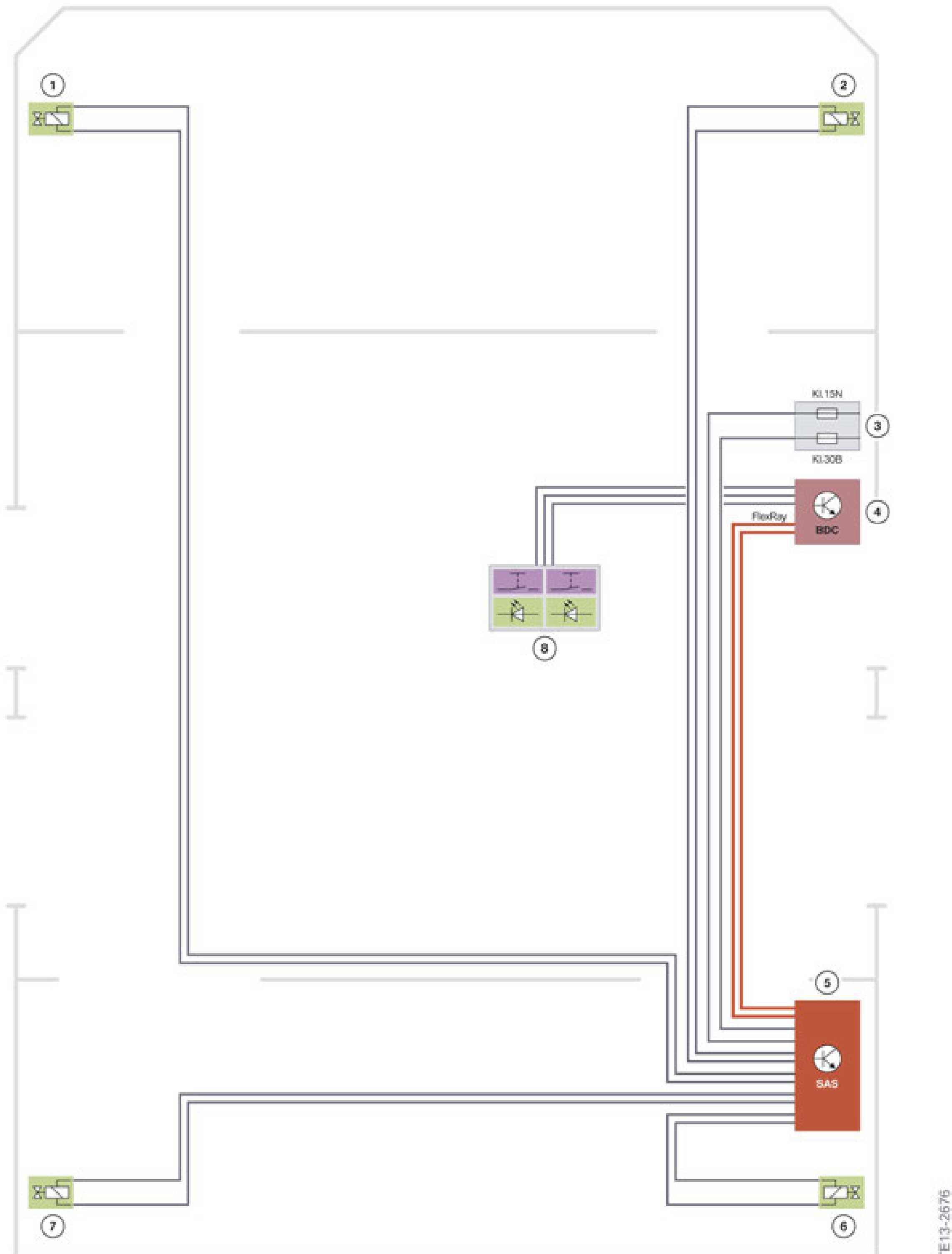
The oil flow through the working piston is directed through the sport valve and the normal valve.

5.2.2. SPORT suspension

If the solenoid is not activated, a coil spring pushes the control edge of the round slider onto the valve seat of the normal valve. The oil flow through the normal valve is thus interrupted. The oil flow through the working piston is only directed through the sport valve.

5. Dynamic Damper Control

5.3. System wiring diagram



F48 System wiring diagram for Dynamic Damper Control

5. Dynamic Damper Control

Index	Explanation
1	Solenoid valve for shock absorber, front left
2	Solenoid valve for shock absorber, front right
3	Power distribution box, passenger compartment
4	Body Domain Controller (BDC)
5	Optional equipment system (SAS)
6	Solenoid valve for shock absorber, rear right
7	Solenoid valve for shock absorber, rear left
8	Driving experience switch (in operating unit, center console)

5.4. Notes for Service

The dynamic damper control is capable of self-diagnosis and if necessary can input a fault in the fault memory.

As the suspension is always in Sport mode at vehicle standstill, the shock absorbers can also be activated with help of the diagnosis system using the "Component activation" function.

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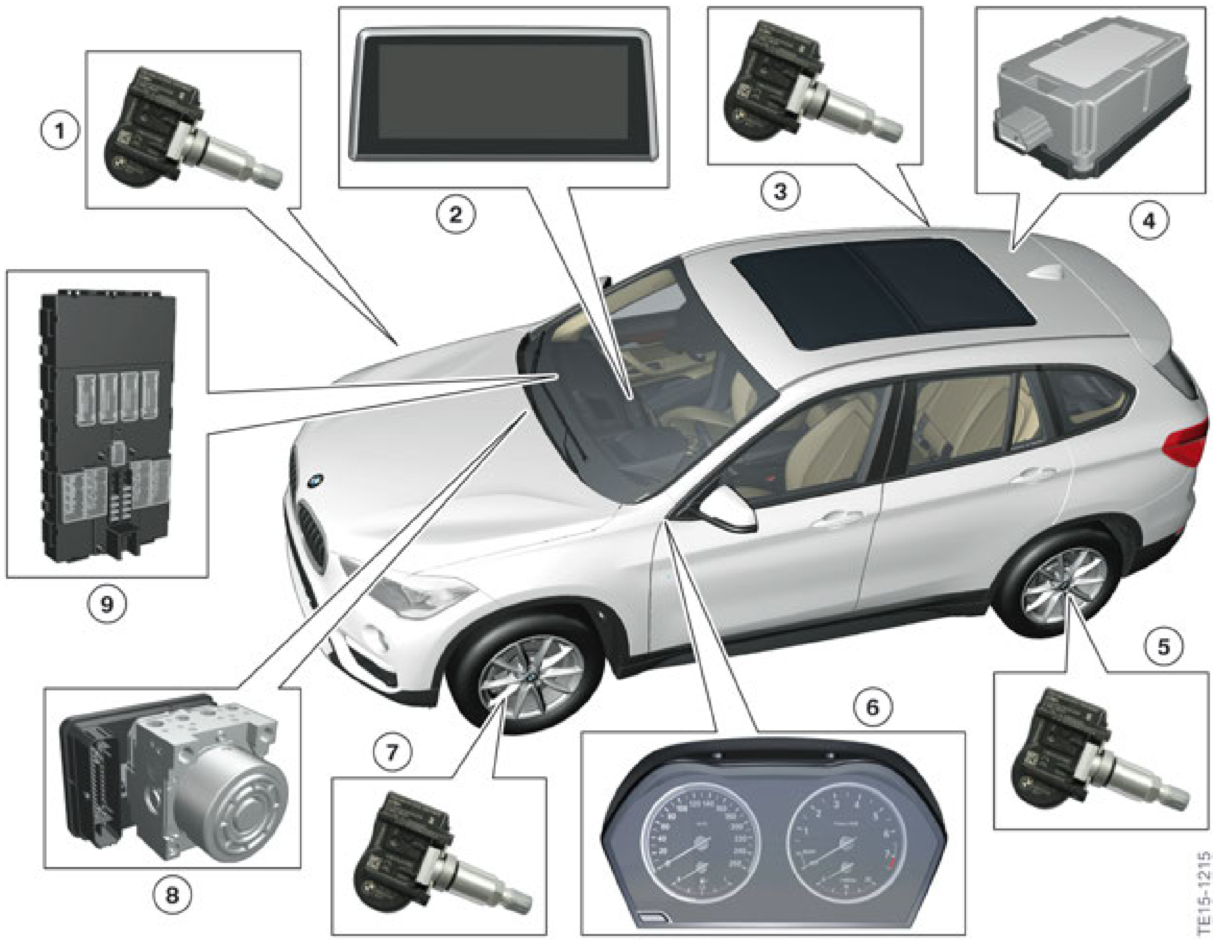
Risk of damage!

In the event of improper repair work, the shock absorbers or their plug connections may incur damage. It is imperative the current repair instructions are observed when working at the Dynamic Damper Control.

6. Tire Pressure Monitoring System



F48 Tire Pressure Monitoring System (TPMS)

Index	Explanation
1	Wheel electronics, front right
2	Central information display (CID)
3	Wheel electronics, rear right
4	Remote control receiver
5	Wheel electronics, rear left
6	Instrument cluster (KOMBI)
7	Wheel electronics, front left
8	Dynamic Stability Control (DSC)
9	Body Domain Controller (BDC)

According to an US regulation, car manufacturers have to equip their models introduced on the market since 2012 with a system for monitoring the tire pressure, which warns the driver of too little air in the tires. From 2014 all new vehicles must already have this technology.

F48 Chassis and Suspension

6. Tire Pressure Monitoring System

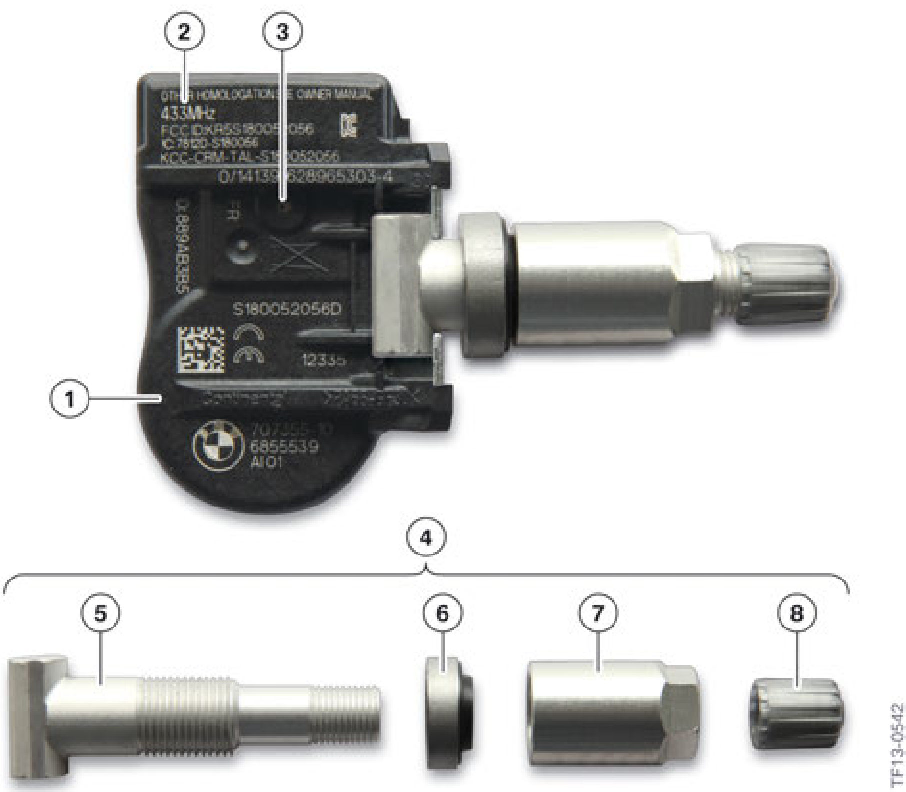
In the F48 the tire pressure monitoring is standard equipment. TPMS is a system which monitors the tire pressures. The function is integrated in the Dynamic Stability Control (DSC), whereby no separate TPMS control unit is required.

In each of the four mounted wheels there is wheel electronics, which record the tire pressure and the temperature in the tires. The wheel electronics send this information with radio signals to the remote control receiver. The remote control receiver forwards this information via the BDC to the DSC with help of the vehicle electrical system. The evaluation function of the information takes place in the DSC control unit.

The tire pressures are displayed via the central information display. Warnings due to insufficient tire pressure are output via the central information display or instrument cluster.

6.1. Notes for Service

The service life of the batteries of the wheel electronics is roughly 10 years or 300,000 km. Before each tire change the battery status of the wheel electronics should be determined using the diagnosis system, as it is not possible to check when the tires are mounted. If the remaining service life of the tires exceeds that of the battery, the wheel electronics must also be replaced.



F48 Wheel electronics with repair kit

6. Tire Pressure Monitoring System

Index	Explanation
1	Wheel electronics
2	Specification of transmission frequency
3	Pressure sensor
4	Repair kit
5	Valve unit
6	Sealing ring
7	Union nut
8	Valve cap

In the event of a leak at the valve unit a repair kit is available. Therefore, the entire wheel electronics do not have to be replaced.

7. Steering

F48 Overview of steering

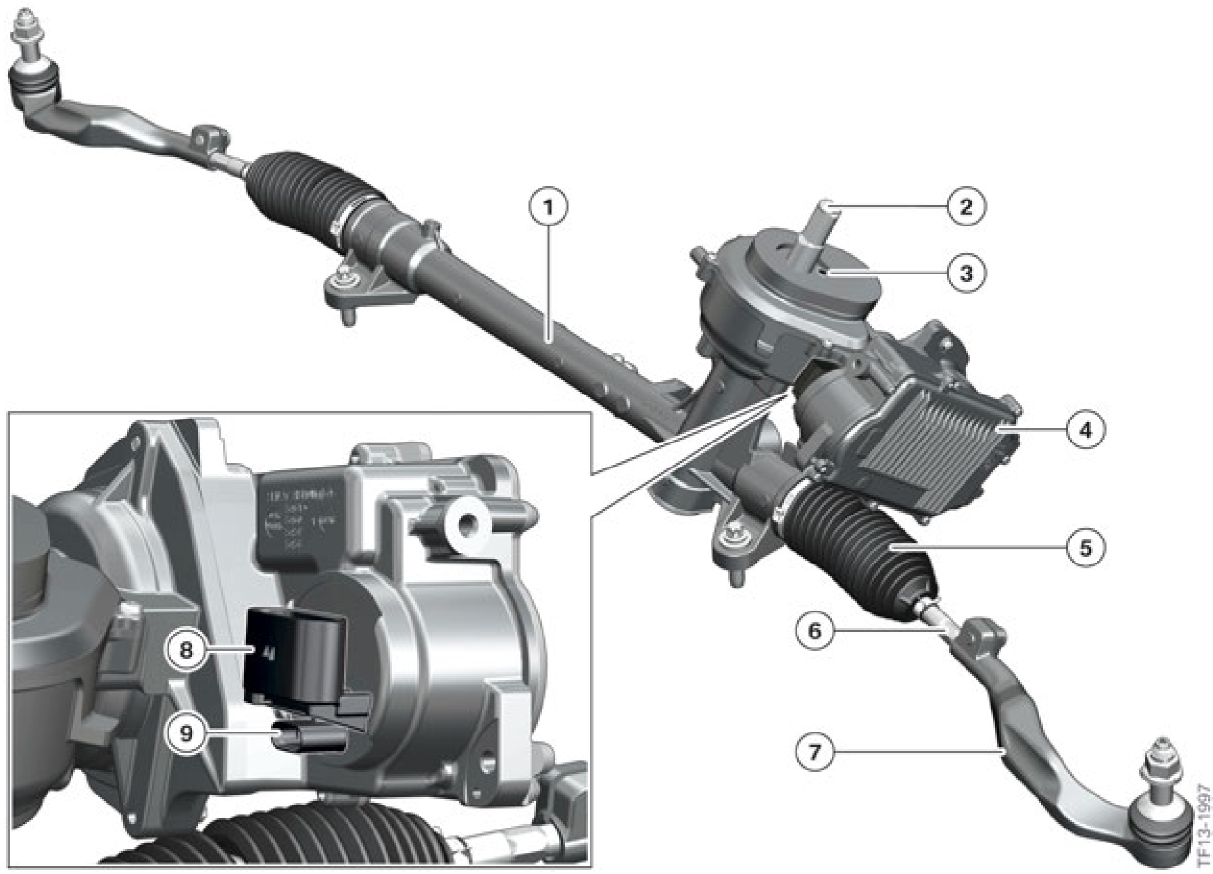
Index	Explanation
1	Steering wheel
2	Steering column adjustment
3	Top steering shaft
4	Bottom steering shaft
5	Electronic Power Steering (EPS)

The steering assistance and also the resetting forces can be freely defined with the Electronic Power Steering (EPS). This means the steering behavior and drivability can be adapted optimally to the corresponding driving situation.

F48 Chassis and Suspension

7. Steering

The lower and upper steering shafts can be telescoped together. This protects the driver against severe injuries in the event of a frontal crash. With the mechanical steering column adjustment the steering wheel position can be optimally adjusted to the seat position and body height.



F48 Electronic Power Steering (EPS)

Index	Explanation
1	Rack housing
2	Input shaft
3	Housing ventilation
4	EPS unit
5	Gaiter
6	Track rod
7	Track rod end
8	Socket, 12 V voltage supply
9	Socket, FlexRay

The 12 V steering has a maximum assistance output of 0.3 kW. The steering assistance takes place via the EPS unit parallel to the input shaft. The electric motor transmits the requested steering assistance to the pinion shaft via the worm drive. The steering system thus works with particularly low friction.

7. Steering

The EPS unit is made up of the following components:

- EPS control unit
- Three-phase electric motor
- Inverter for converting the 12 V direct current voltage to three-phase AC voltage, for the activation of the electric motor

In addition to the input shaft, there is housing ventilation. The formation of condensate is thus prevented due to alternating temperatures.

The individual components that can be replaced individually in Service at the EPS are the gaiters, the track rods and the track rod ends. It is not possible to exchange the EPS control unit or the electric motor separately.

The EPS is a prerequisite for implementation of the Parking Maneuver Assistant (PMA).

The Variable sport steering (SA 2VL) known from current BMW models is also available as an option.

7.1. Steering angle

The steering angle in the F48 is not recorded by a separate sensor at the steering wheel, but by the EPS control unit. It evaluates the signals of a rotor position sensor in the electric motor of the EPS unit.

The following values are stored in the EPS control unit for the purpose of determining the steering angle:

- Geometrical center of rack
- Straight-ahead value
- Number of rotor revolutions

7.1.1. Geometrical center of rack

The geometrical center of the rack is stored in the EPS control unit by the steering manufacturer (Nexteer) during installation and cannot be changed.

7.1.2. Straight-ahead value

Depending on the size of the production tolerance, the straight-ahead value deviates by a few degrees from the geometric center of the rack. It must be taught in again after the installation of the steering or after every removal of the steering mounting bolts. This can be effected with help of the diagnosis system via the service function "Commissioning".

Once stored, the straight-ahead value will not be deleted if the vehicle voltage is lost and can be overwritten as often as is required.

7.1.3. Number of rotor revolutions

In order to be able to calculate the position of the steering shaft, the revolutions of the rotor in the electric motor of the EPS unit must be continuously counted after the straight-ahead value is stored. In the event of a loss of the voltage supply, this value is lost and must be taught in again.

The number of rotor revolutions or the steering angle can be determined by two different teach-in routines:

- **Static**
  Turn steering wheel when ignition is switched on from the steering wheel center position to the limit position at the right, to the limit position at the left and back again to the steering wheel center position.
- **Dynamic**
  1. Rough value: The steering angle is calculated based on a short straight-ahead driving route at a driving speed of < 18 km/h with a precision of +/- 30° (approximately 2 revolutions of the rotor).
  2. Precise value: The steering angle is determined on a short straight-ahead driving route at a driving speed of < 60 km/h with a precision of +/– 7.5°.

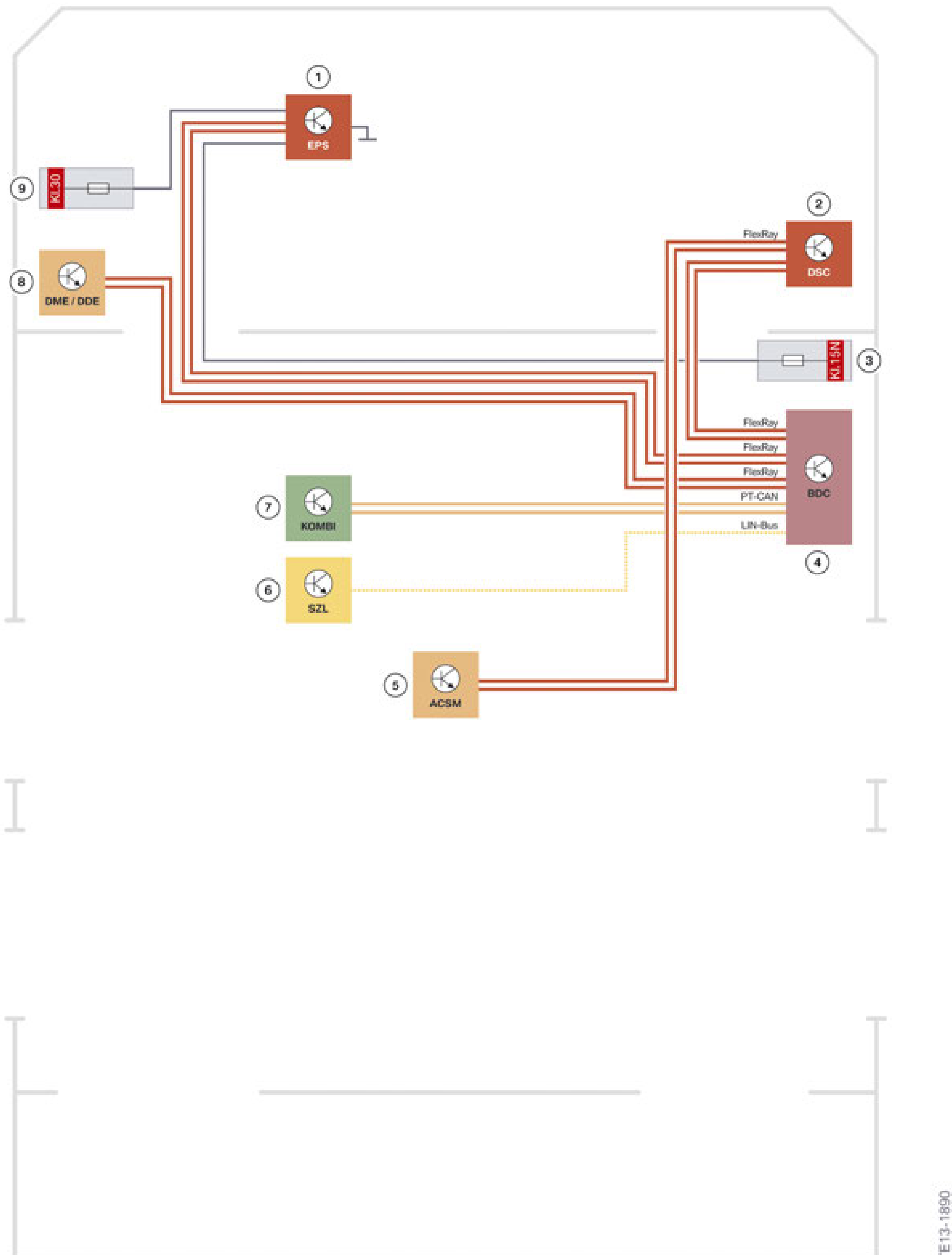
With static teaching of the steering angle, the revolutions of the rotor are counted by the EPS control unit and stored.

With dynamic teaching of the steering angle, the wheel speeds of the wheels on the rear axle, the yaw rate and the lateral acceleration are evaluated. If these values are within the stored tolerances over a short distance travelled, the steering angle is saved in the EPS control unit.

The steering angle is, however, also an important variable for calculating a wide range of DSC functions. For this reason the EPS control unit sends the steering angle information via FlexRay to the Dynamic Stability Control (DSC).

If it was not possible to determine the steering angle to the required degree of accuracy, the DSC indicator and warning light is activated if the driving speed of 12 to 37 mph is exceeded. This tells the driver that the various DSC functions are only operational to a limited extent. If the steering angle is determined dynamically during the course of the journey, the DSC functions are available again. This could, for example, occur if a customer has replaced the battery and exits the speed range of 12 to 37 mph too quickly.

7.2. System wiring diagram



F48 system wiring diagram for Electronic Power Steering (electromechanical power steering) (EPS)

Index	Explanation
1	Electronic Power Steering (EPS)
2	Dynamic Stability Control (DSC)
3	Power distribution box, passenger compartment
4	Body Domain Controller (BDC)
5	Advanced Crash Safety Module (ACSM)
6	Steering column switch cluster (SZL)
7	Instrument cluster (KOMBI)
8	Digital Motor Electronics (DME)
9	Battery power distribution box

7.3. Notes for Service

To relieve the load on the battery, the vehicle is delivered in transport mode. This means that the steering angle is not stored in the EPS control unit and must be set up again by the Service personnel with the assistance of the teach-in routine.

The EPS steering has a voltage range of between 9 V and 16 V. If a fault occurs which causes a drop in the supply voltage (up to 9 V, the current level is increased to compensate for the loss of power. To protect the system, the steering assistance is switched off if the supply voltage is less than 9 V or higher than 16 V.

System faults with the EPS are shown by the steering indicator and warning light in the instrument cluster.

Possible causes for the illumination of the indicator and warning light:

- Fault in the EPS control unit, an integrated sensor or in the electric motor
- Software error in the EPS control unit
- Over temperature threshold of EPS has been reached
- Under voltage or over voltage protection level reached
- Malfunction of external signals affecting the steering assistance
- Steering angle not taught in correctly or completely

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If the EPS has been replaced or its mounting bolts have been undone, the "Start-up" service function must be run with the assistance of the diagnosis system.

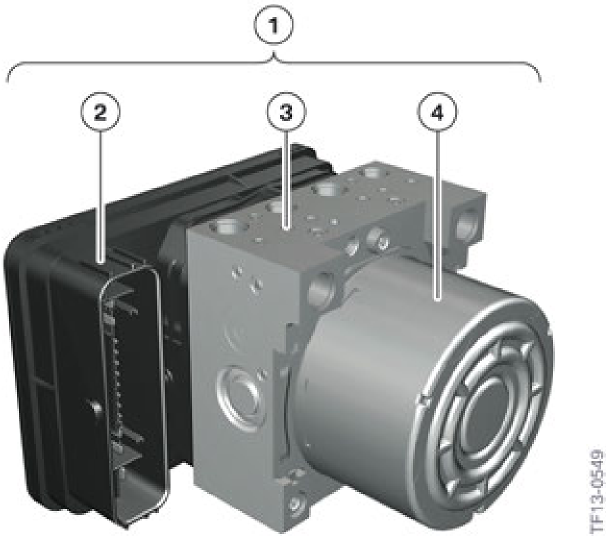
If the 12 V supply voltage to the EPS is lost, and upon deactivation of transport mode, the steering angle must be taught in statically or dynamically.

If the steering angle could not be calculated, the DSC functions are only available to a limited extent.

F48 Chassis and Suspension

8. Dynamic Stability Control

8.1. Overview



F48 DSC unit

Index	Explanation
1	DSC unit
2	DSC control unit
3	DSC hydraulic control unit
4	Electric motor

The Dynamic Stability Control (DSC) forms the core of the vehicle control systems that enhance active safety. It optimizes driving stability in all driving conditions and also traction when driving off and accelerating. Furthermore, it identifies unstable driving conditions such as understeering or oversteering and helps maintain the vehicle on a steady course.

The DSC unit is made up of the DSC control unit and the DSC hydraulic control unit with electric motor. The DSC control unit is connected to the DSC hydraulic control unit using three screws and can be replaced separately in Service.

8.2. DSC functions

Due to further developments in the meantime, the Dynamic Stability Control (DSC) functions now have many main functions and subfunctions.

Main function		Subfunction	
ABS	Antilock Brake System	EBV	Electronic brake force distribution
		CBC	Cornering Brake Control
		DBC	Dynamic Brake Control
			Dry by applying brake
			Fading Brake Support
ASC	Automatic Stability Control	MSR	Engine drag torque control
DSC	Dynamic Stability Control	GMR	Yaw moment control
			Trailer Stability Control
DTC	Dynamic Traction Control		
	Brake temperature model		
	Drive-off assistant		
LMV	Longitudinal torque distribution		
HDC	Hill Descent Control		
	Yaw moment compensation		
DCC	Dynamic Cruise Control		
RPA	Run Flat Indicator		
TPMS	Tire Pressure Monitoring System		

8.2.1. Electromechanical parking brake

Dynamic emergency braking

The law requires that there are two operating facilities for the brakes. In the F48 the second operating unit after the brake pedal is the parking brake button in the center console. If the parking brake button is pulled up while the vehicle is moving, the DSC system performs a dynamic emergency braking operation in a defined sequence. This function is intended for emergency situations in which the driver is not able to brake the vehicle using the brake pedal. Other occupants can also bring the vehicle to a standstill in this way if, for example, the driver suddenly falls unconscious.

If the parking brake button is operated during the journey above a defined driving speed, the DSC unit initiates a dynamic emergency braking operation. During dynamic emergency braking, brake pressure is generated hydraulically at all four wheel brakes. The DSC functions are fully active and the brake lights are operated. The slip of all wheels are monitored to ensure a stable braking operation until the vehicle comes to a standstill. The two actuators of the electromechanical parking brake are activated as soon as the vehicle comes to a standstill. Now only the parking brake secures the vehicle to prevent it from rolling away.

Brake test stand

The F48 has a test stand mode for checking the braking power of the electromechanical parking brake on a brake test stand. When the test stand mode is activated, the vehicle is decelerated via the actuators of the electromechanical parking brake when the parking brake button is pressed. A DSC pressure build-up in all four wheel brakes does not occur. This makes it possible to determine the brake forces of the electromechanical parking brake.

In the F48 test stand mode is automatically detected by means of a plausibility check (wheel speed comparison). The detection lasts a maximum of 5 seconds (can be recognized by slow flashing of the red parking brake indicator light).

After activation of test stand mode the system is in test stand mode. The parking brake indicator light acknowledges this status by flashing at a frequency of 1 hertz. Using the parking brake button the EMF can be applied in five stages. In this case, the braking varies between the minimum braking power in the first stage and the maximum braking power once the parking brake button has been pressed five times. If the button is operated continuously, the system increases the braking power automatically incrementally up to the maximum braking power. The flashing frequency of the parking brake indicator light changes from 1 hertz to 3 hertz when the parking brake button is pressed in test stand mode.

Automatic release

For automatic release, step on the accelerator pedal. The LED and indicator lamp go out. The parking brake is automatically released when you step on the accelerator if the following applies:

- Engine on
- Drive mode engaged
- Driver buckled in and doors closed

8.2.2. Hill Descent Control

Hill Descent Control is a downhill driving assistant that automatically controls vehicle speed on steep downhill gradients. Without applying the brakes, the vehicle moves at slightly more than walking speed. Hill Descent Control can be activated at speeds below approximately 22 mph.

When driving downhill, the vehicle reduces its speed to approximately walking speed and then keeps its speed constant. As long as there is active braking, the system is on standby. The system does not brake the vehicle during this time.

Only use HDC in low gears or in selector lever position D or R.

8. Dynamic Stability Control

Increasing or decreasing vehicle speed

Specify desired speed in the range from approximately 4 mph to approximately 15 mph using the rocker switch of the cruise control on the steering wheel. Vehicle speed can be changed by lightly accelerating.

- Press the rocker switch up to the point of resistance: the speed increases gradually.
- Press up the rocker switch past the point of resistance: the speed increases while the rocker switch is pressed.
- Press the rocker switch down to the point of resistance: the speed decreases gradually.
- Press the rocker switch down past the point of resistance: when driving forward, the speed decreases to approximately 6 mph/10 km/h; when reversing, the speed decreases to approximately 4 mph.

Vehicle speed can be changed by lightly accelerating.

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Technical training.
Product information.

F48 General Vehicle Electronics

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BMW Group University
Technical Training
ST1508 1/1/2016

BMW Service

General information

Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:

⚠

Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

Information status and national-market versions

BMW Group vehicles meet the requirements of the highest safety and quality standards. Changes in requirements for environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between the contents of this document and the vehicles available in the training course.

This document basically relates to the European version of left-hand drive vehicles. Some operating elements or components are arranged differently in right-hand drive vehicles than shown in the graphics in this document. Further differences may arise as a result of the equipment specification in specific markets or countries.

Additional sources of information

Further information on the individual topics can be found in the following:

- Owner's Handbook
- Integrated Service Technical Application.

Contact: conceptinfo@bmw.de

The information contained in this document forms an integral part of the technical training of the BMW Group and is intended for the trainer and participants in the seminar. Refer to the latest relevant information systems of the BMW Group for any changes/additions to the technical data.

Information status: **June 2015**
BV-72/Technical Training

F48 General Vehicle Electronics

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F48 General Vehicle Electronics
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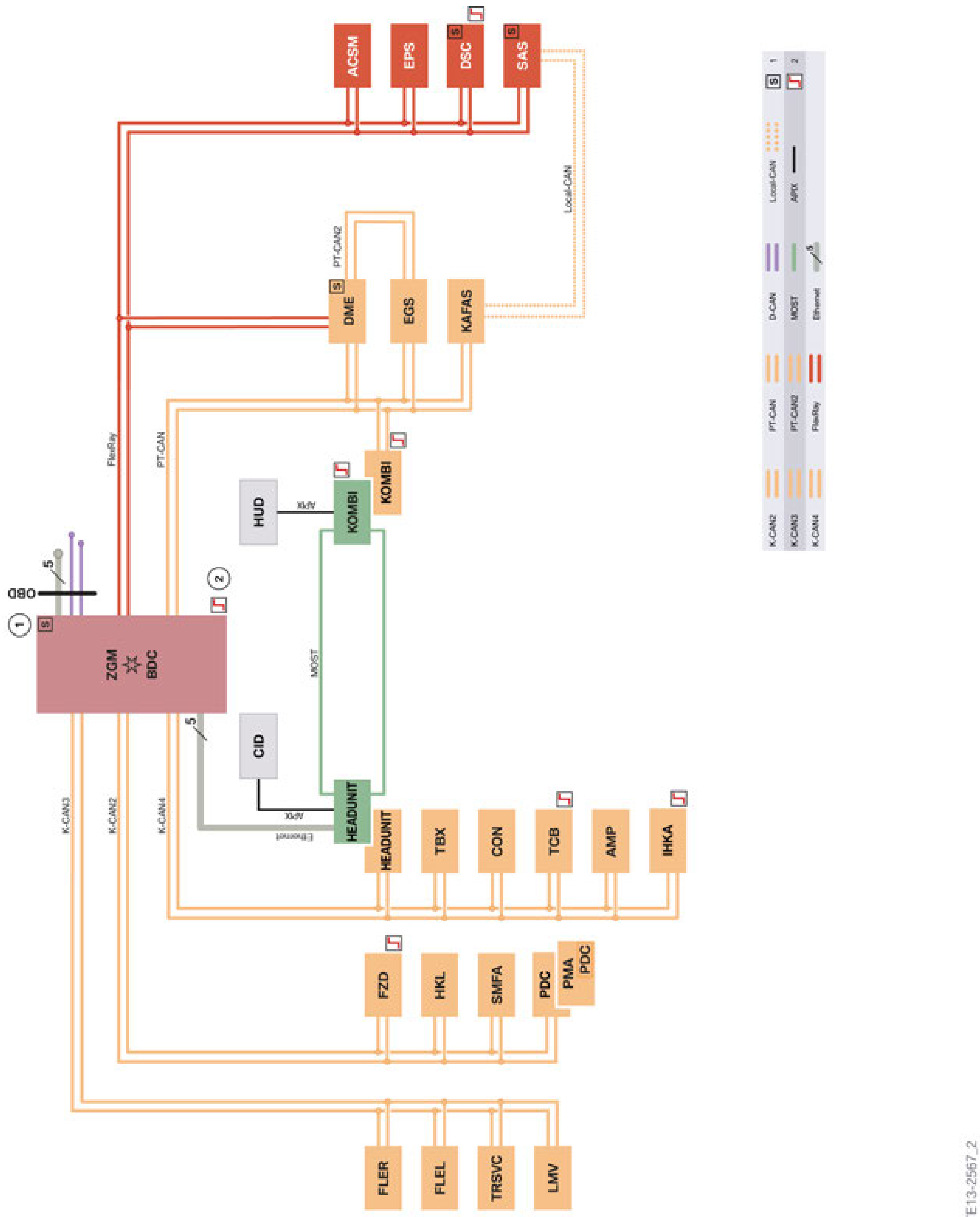
F48 General Vehicle Electronics

1. Vehicle Electrical System

1.1. Data bus overview



F48 data bus overview

F48 General Vehicle Electronics
1. Vehicle Electrical System

Index	Explanation
1	Start-up node control units for starting and synchronizing the FlexRay bus system
2	Control units with wake-up authorisation
ACSM	Advanced Crash Safety Module
AMP	Audio amplifier
BDC	Body Domain Controller
CID	Central information display
CON	Controller
DME	Digital Motor Electronics
DSC	Dynamic Stability Control
EGS	Electronic transmission control
EPS	Electronic Power Steering
FLEL	Frontal Light Electronics Left
FLER	Frontal Light Electronics Right
FZD	Roof function center
HEADUNIT	Headunit
HKL	Automatic operation of tailgate
HUD	Head-Up Display
IHKA	Integrated heating and air conditioning
KAFAS	Camera-based driver support systems
KOMBI	Instrument cluster
LMV	Longitudinal torque distribution
PDC	Park Distance Control
PMA	Parking Manoeuvring Assistant
SAS	Optional equipment system
SMFA	Driver's seat module
TBX	Touchbox
TCB	Telematic Communication Box
TRSVC	Control unit for rear view camera and Side View
ZGM	Central gateway module

1.2. Main bus systems

1.2.1. K-CAN

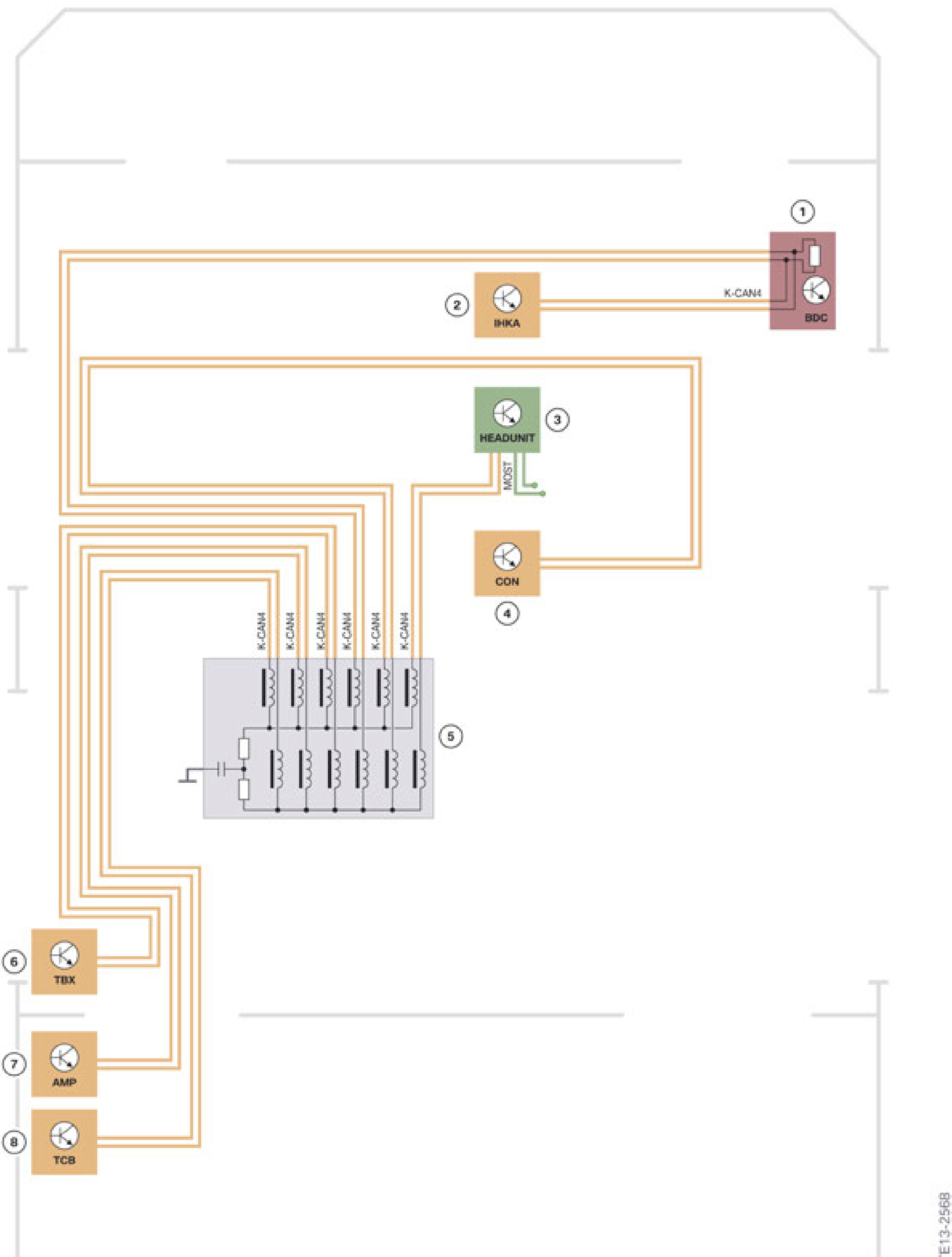
In the F48 the following K-CANs are used:

- K-CAN2
- K-CAN3
- K-CAN4

All K-CAN data buses have a data transfer rate of 500 kBit/s.

The K-CAN with 100 kBit/s is no longer used in the F48.

K-Can termination



F48 K-Can termination

Index	Explanation
1	Body Domain Controller (BDC)
2	Integrated heating and air conditioning
3	Headunit
4	Controller (CON)
5	K-CAN terminator
6	Touchbox (TBX)
7	Audio amplifier (AMP)
8	Telematic Communication Box (TCB)

The CAN buses are shown in the overview of the bus systems. The actual physical layout (topology) is shown using the example of the K-CAN2.

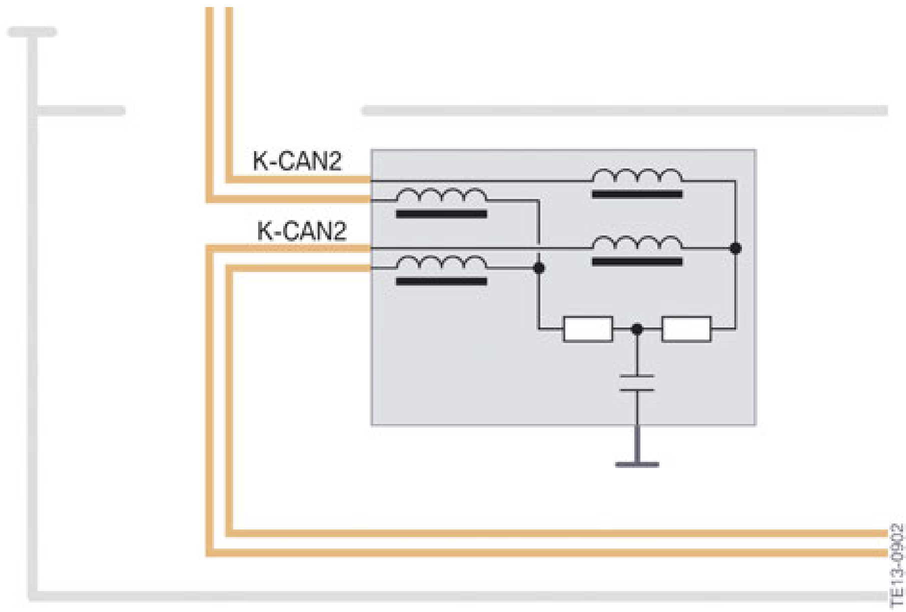
As with most bus systems, terminating resistors are also used for protection of the K-CAN to avoid residual voltages on the data lines.

The terminating resistors for the termination are located in the:

- Body Domain Controller and
- K-CAN terminators.

All other control units are connected at the K-CAN terminator without a terminating resistor.

CAN terminator



CAN terminator

Depending on the equipment package, in the CAN terminator the terminating resistor for the corresponding CAN bus is installed. The terminating resistor comprises two resistances connected in series, each 60 Ohm. A measuring tap against ground with a capacitor for the reduction of high-frequency faults is also installed. Ferrite beads are installed for all bus lines in the CAN terminator. Ferrite beads suppress high-frequency faults on the CAN data lines, thus making possible line lengths of up to 5 m in the wiring harness.

Ferrite core

A ferrite core is a component made from the ferromagnetic material iron oxide hematite (Fe203). It is characterized by low or no conductivity. The inductance or the magnetic field is increased as part of a coil (throttle or transformer). If a ferrite core is secured around a conductor, which routes signals at low frequency or direct current voltage, high-frequency faults are attenuated with its help.

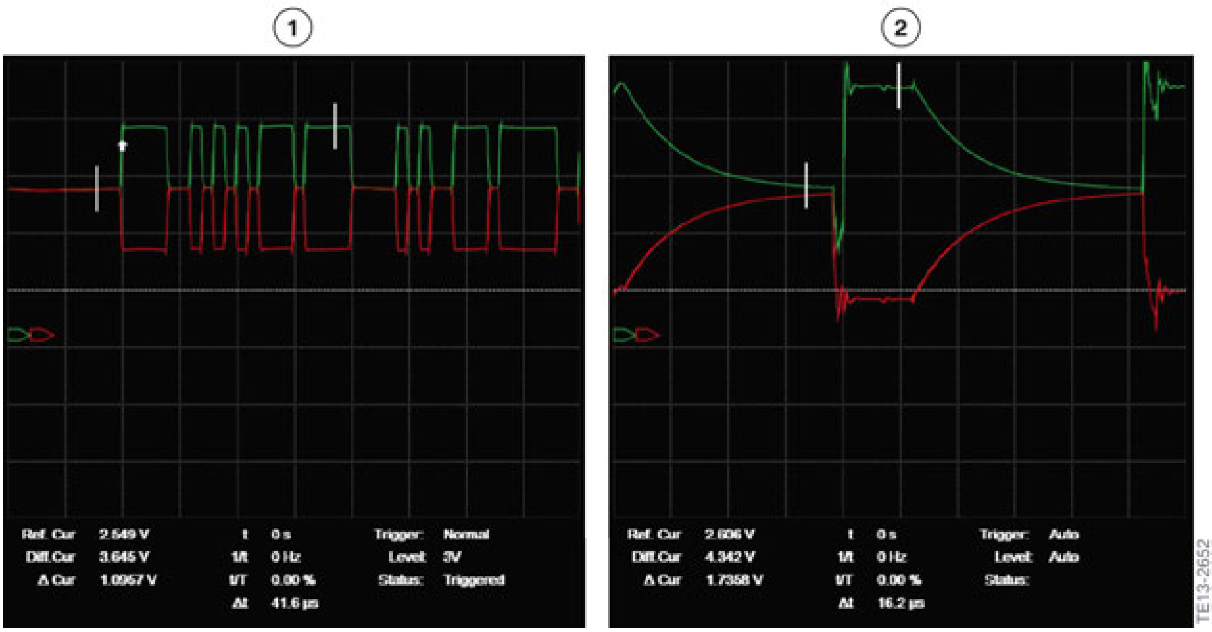
Ferrite core

Index	Explanation
1	Ferrite core using the example of a USB line

1. Vehicle Electrical System

Oscilloscope

If there are no terminating resistors in a CAN bus or they are faulty, this may lead to reflections or faults. These reflections or faults are shown in the following graphic:



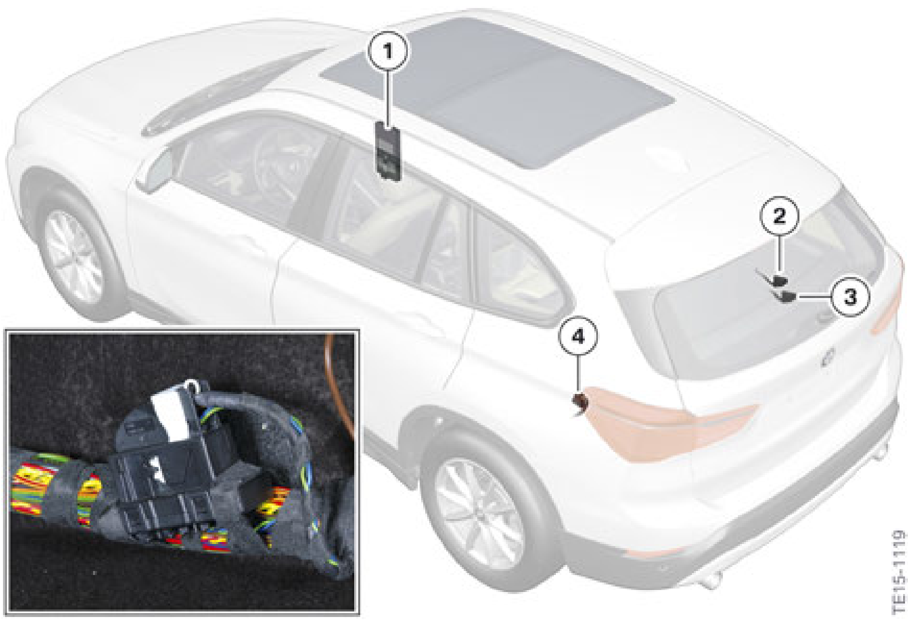
Oscilloscope holder K-CAN

Index	Explanation
1	Oscilloscope holder with active CAN terminator
2	Oscilloscope holder with disconnected or faulty CAN terminator

Installation location

Depending on the equipment package, a maximum of four CAN terminators are installed in the F48.

The installation locations are shown in the following graphic:



F48 installation location of CAN terminators

Index	Explanation
1	CAN terminator integrated in the Body Domain Controller
2	K-CAN3 terminator, rear right
3	K-CAN2 terminator, rear right
4	K-CAN4 terminator, rear left

1.2.2. PT-CAN

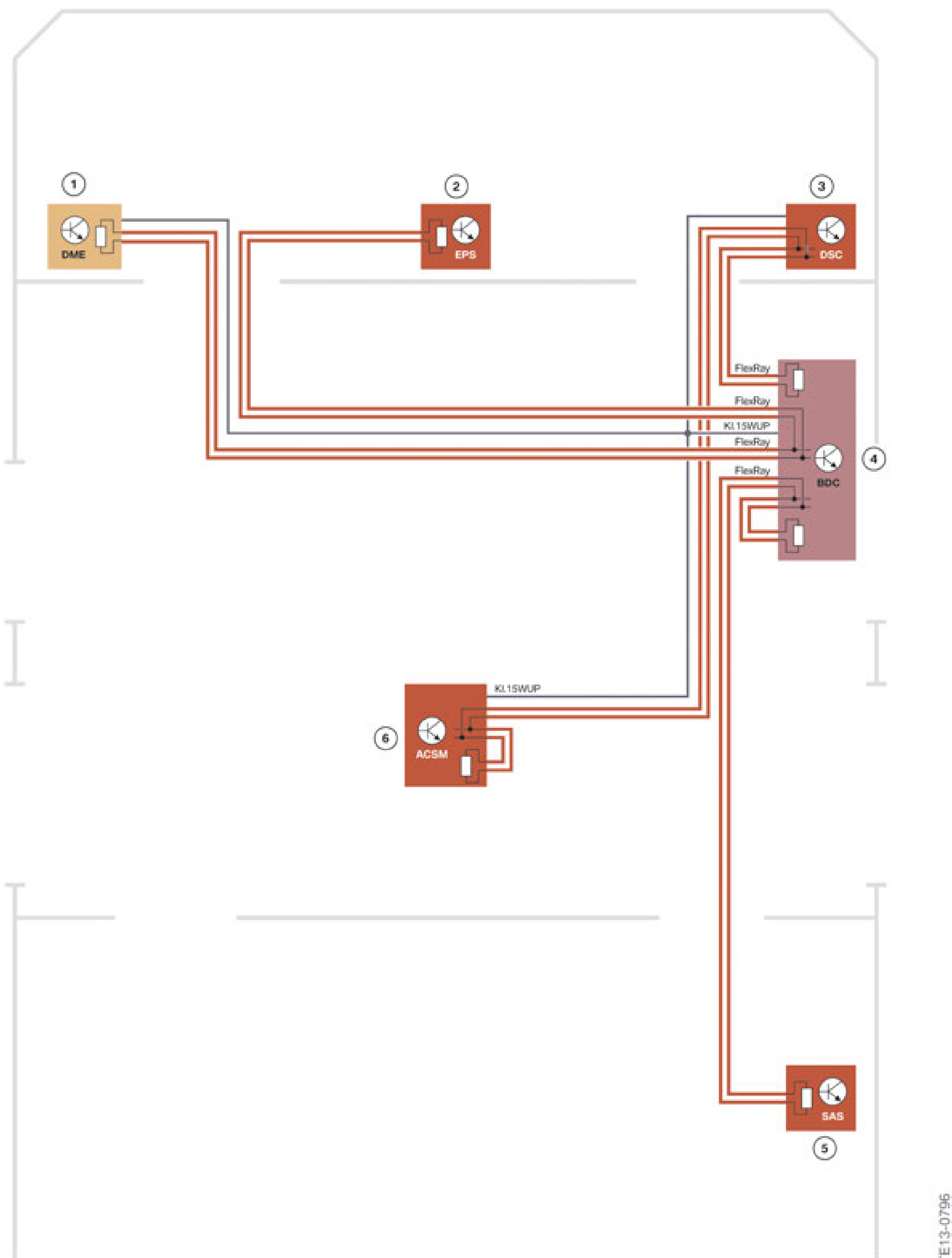
In the F48 the following PT-CANs are used:

- PT-CAN
- PT-CAN2

F48 General Vehicle Electronics

1. Vehicle Electrical System

1.2.3. FlexRay



F48 system wiring diagram for FlexRay

F48 General Vehicle Electronics
1. Vehicle Electrical System

Index	Explanation
1	Digital Motor Electronics (DME)
2	Electronic Power Steering (electromechanical power steering) (EPS)
3	Dynamic Stability Control (DSC)
4	Body Domain Controller (BDC)
5	Optional equipment system (SAS)
6	Crash Safety Module (ACSM)

FlexRay data bus topology

The FlexRay is shown in a simplified form in the data bus overview. The actual topology (star-shaped data bus topology) is shown in the graphic at the top.

The star coupler with four drivers is located in the Body Domain Controller (BDC). The FlexRay control units are connected to these bus drivers independent of their termination type.

Bus termination

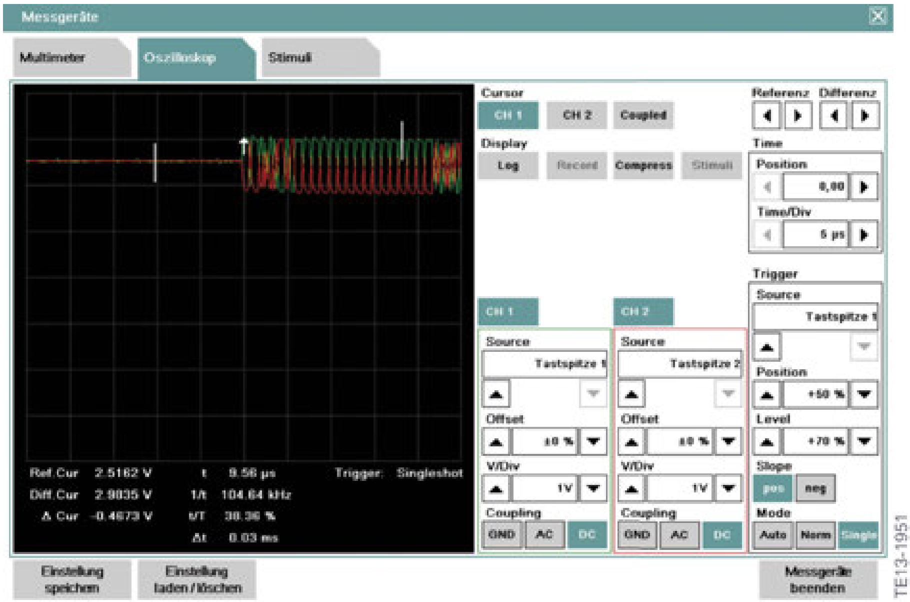
As with most bus systems, resistors are also used for termination for the FlexRay to avoid reflections on the data lines at both ends of the data lines. The value of these terminating resistors is calculated from the data transfer speed and the cable lengths. The terminating resistors are located in the control units. In the F48 the terminating resistors have a value of 90 ohm (total resistance 45 ohm).

⚠

Use the vehicle wiring diagram for measuring the (de-energized) FlexRay data bus for the determination of the line or terminating resistor.

Signal properties

Electrical faults, which arise from incorrect cable routing, contact resistances, etc. may cause faulty data transfer.



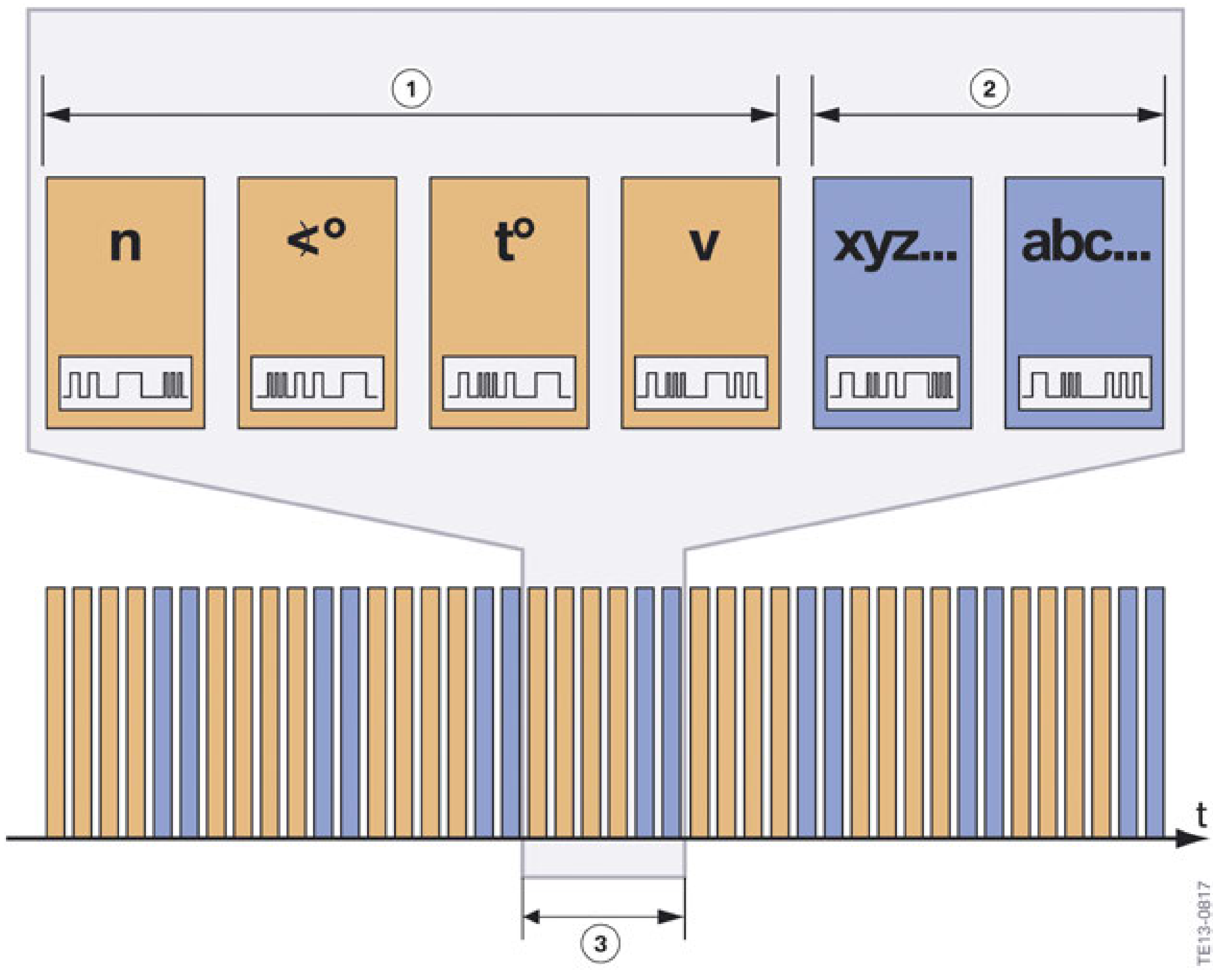
Oscilloscope presentation of FlexRay

The voltage ranges of the FlexRay bus system are:

- System ON - no bus communication 2.5 V
- High signal - 3.1 V (voltage signal increases to 600 mV and upwards)
- Low signal - 1.9 V (voltage signal decreases from 600 mV downwards)

The voltage values are measured against ground.

Deterministic data transfer



Deterministic data transfer

Index	Explanation
1	Time-controlled range of cyclical data transfer
2	Event-controlled range of cyclical data transfer
3	Cycle [5 ms overall cycle duration, of which 3 ms static (= time-controlled) and 2 ms dynamic (= event-controlled)]
n	Speed of rotation
<°	Angle
t°	Temperature
v	Speed
xyz... abc...	Event-controlled information
t	Time

The CAN bus system is an event-controlled bus system. Data is transmitted when an event occurs. As these events have different priorities (e.g. ambient temperature has a lower priority than a DSC intervention, for example), the priorities are also sent in the bus message. The message with the higher priority is sent first. As the control unit still wants to send the message which has the lower priority, it frequently results in overloading in the bus systems.

The FlexRay works with so-called "time slots". With this method the messages are sent and are not controlled by events, but each control unit in the FlexRay network is assigned a fixed time slot in which it sends its message within a certain period. This time slot is synchronised with every restart of the data bus. The control units which synchronize the FlexRay are always labelled in the bus diagram with a "S" (see chapter 1.1).

The FlexRay can also be synchronised with the BMW diagnosis system in the event of a fault and corresponding fault code.

1.2.4. D-CAN

The D-CAN for the vehicle diagnosis has a data transfer rate of 500 kBit/s.

1.2.5. Ethernet

The Ethernet access is used for programming the entire vehicle.

In a F48 with navigation system the map update for the navigation can also be effected using the Ethernet interface.

1.2.6. MOST

In the F48 the Media Oriented System Transport (MOST) bus works at a data transfer rate of 22.5 MBit/s.

1.3. Sub-bus systems

1.3.1. Local interconnect network bus

Different data rates are used for the local interconnect network bus according to the information required. The data transfer rates of the local interconnect network bus in the F48 range from 19.2 kBit/s to 20.0 kBit/s.

Examples:

- 19.2 kBit/s FLEL, FLER
- 20.0 kBit/s remote control receiver

The Body Domain Controller is designed for the different data rates at the corresponding inputs.

1.3.2. Local-CAN

With corresponding optional equipment, the Local Controller Area Network connects the optional equipment system (SAS) with the control unit for the camera-based driver support systems (KAFAS).

The Local Controller Area Network has a data transfer rate of 500 kBit/s.

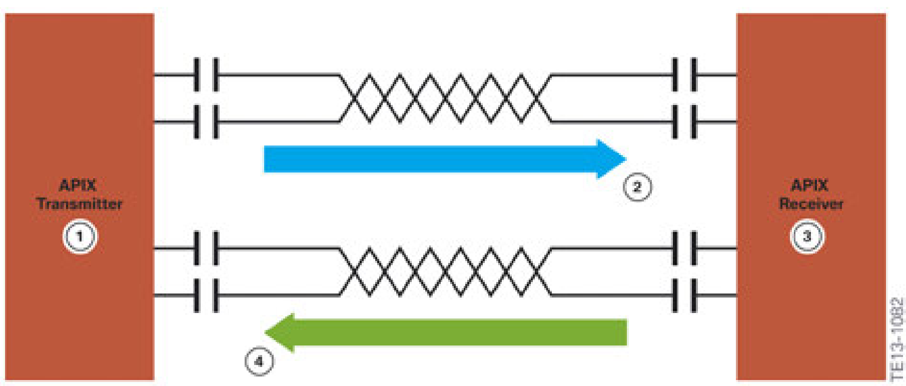
1.3.3. USB

Depending on the equipment, the following USB connections are possible:

- from the headunit to the Telematic Communication Box (TCB)
- from the headunit to the telephone base plate
- from the headunit to the USB port

1.3.4. APIX

The central information display (CID) and the Head-Up Display (HUD) in the F48 are not connected to a vehicle data bus. Both control units are connected directly to the headunit via an APIX interface or the instrument cluster (KOMBI). APIX (Automotive Pixel Link) is a bit-serial data transfer system.



APIX

Index	Explanation
1	APIX transmitter
2	Message to be sent (max. 1 Gbit/s)
3	APIX receiver
4	Confirmation message (62.5 Mbit/s)

F48 General Vehicle Electronics
1. Vehicle Electrical System

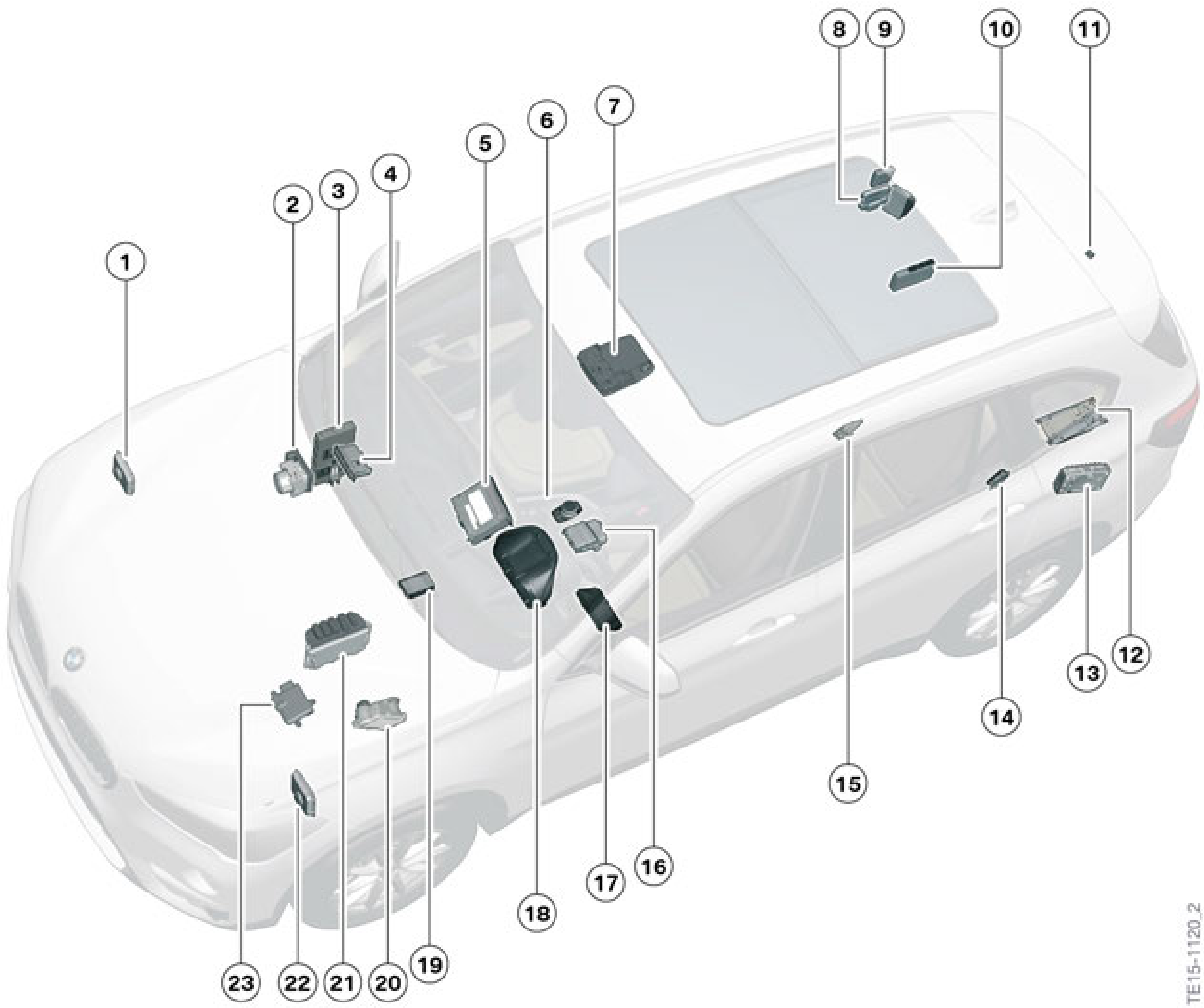
1.4. Control units

This chapter contains information on control units,

- which are used for the first time in the F48
- which have been adapted for the F48

1.4.1. Complete overview

The installation locations of all the control units are shown in the following graphic.



F48 Installation location of the control units

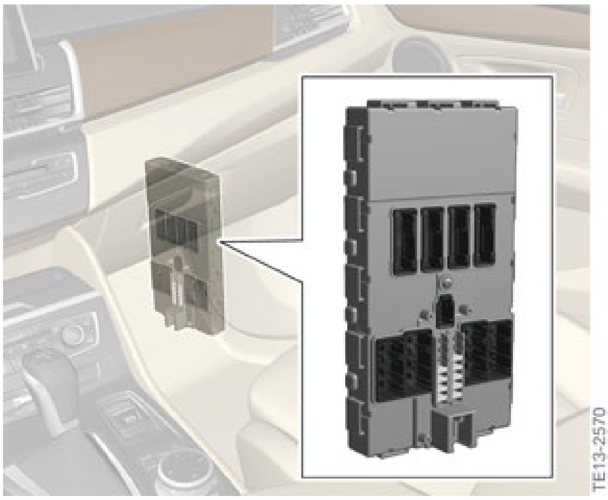
F48 General Vehicle Electronics
1. Vehicle Electrical System

Index	Explanation
1	Frontal Light Electronics Right (FLER)
2	Dynamic Stability Control (DSC)
3	Body Domain Controller (BDC)
4	Camera-based driver support systems (KAFAS)
5	Headunit
6	Controller (CON)
7	Roof function center (FZD)
8	Optional equipment system (SAS)
9	Park Distance Control (PDC)/Parking Manoeuvring Assistant (PMA)
10	Automatic operation of tailgate (HKL)
11	Rear view camera (RFK)
12	Telematic Communication Box (TCB)
13	Amplifier (AMP)
14	Touchbox (TBX)
15	Longitudinal torque distribution (LMV)
16	Crash Safety Module (ACSM)
17	Driver's seat module (SMFA)
18	Instrument cluster (KOMBI)
19	Integrated heating and air conditioning (IHKA)
20	Electronic Power Steering (EPS)
21	Digital Engine Electronics (DME)
22	Electronic transmission control (EGS)
23	Frontal Light Electronics Left (FLEL)

F48 General Vehicle Electronics

1. Vehicle Electrical System

1.4.2. Body Domain Controller



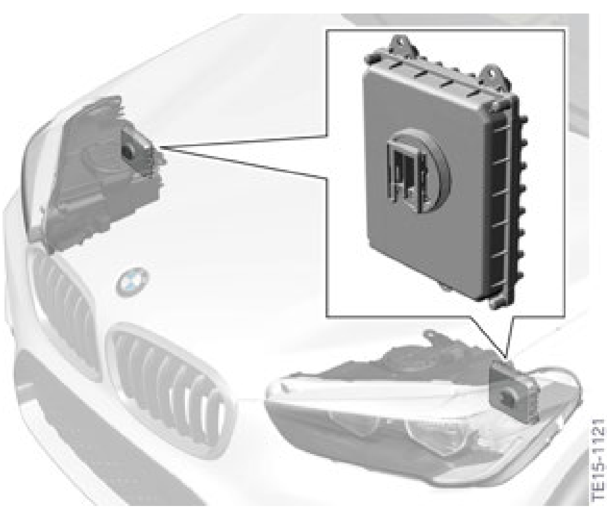
F48 Body Domain Controller (BDC)

The Body Domain Controller replaces the control units known from the F20/F30:

- Front Electronic Module (FEM)
- Rear Electronic Module (REM)

Further information on the Body Domain Controller is available in the ST1312 reference manual "F15 General Vehicle Electrical System".

1.4.3. Frontal Light Electronics



F48 Frontal Light Electronics Left and Right

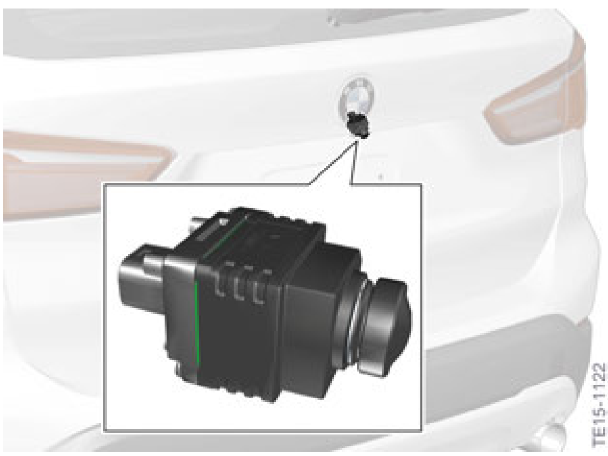
The control units for the Frontal Light Electronics Left (FLEL) and Frontal Light Electronics Right (FLER) are installed in the left and right headlight for the LED headlight equipment.

The Frontal Light Electronics includes:

- The activation of the LEDs in the corresponding headlight.
- The activation of the stepper motor for the headlight beam throw adjustment.

The control units FLEL and FLER are connected at the K-CAN3 and at the LIN.

1.4.4. TRSVC control unit



F48 TRSVC control unit

The Top Rear Side View Camera (TRSVC) control unit and the actual rear view camera are integrated in the one housing.

Only the rear view camera is offered for the F48.

The TRSVC control unit is connected at the K-CAN3. With the BMW diagnosis system the rear view camera is displayed as a TRSVC.

1.4.5. Park Distance Control/Parking Maneuver Assistant

F48 Park Distance Control

Park Distance Control (PDC) assists the driver when maneuver in and out of a parking space.
The current distance from an obstruction is indicated by acoustic signals and on a visual display.

In vehicles with Parking Maneuver Assistant (PMA), the sensors of the Park Distance Control (PDC) are evaluated by the Parking Maneuver Assistant control unit.

The customer can find the Parking Maneuver Assistant in the equipment list as Parking Maneuver Assistant (SA 5DP). The Parking Maneuver Assistant facilitates parking in gaps between cars parallel to the roadway.

The PDC/PMA control unit is connected at the K-CAN2.

⚠

In the BMW diagnosis system the PDC control unit is displayed as a PMA.

1.4.6. Crash Safety Module

F48 Crash Safety Module

The function of the Advanced Crash Safety Module (ACSM) is to permanently evaluate all sensor signals in order to identify a crash situation. The ACSM evaluates the information from the sensors then forwards corresponding measures for selective activation of the necessary restraint systems.

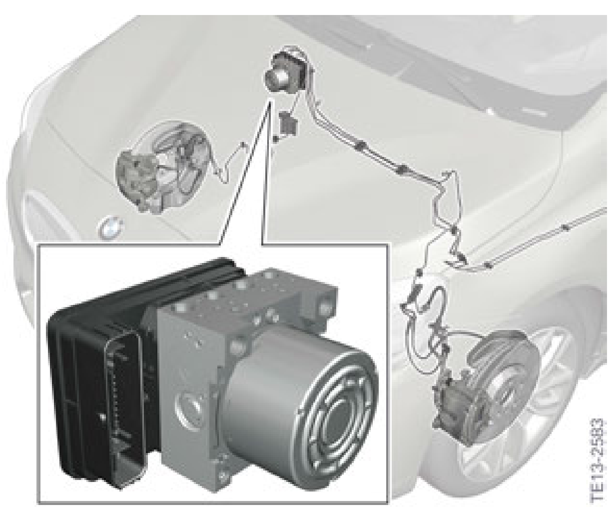
The ACSM records the yaw rate and sends this information on the FlexRay data bus.

No additional yaw sensors are required for the following systems:

- Dynamic Stability Control (DSC)
- Navigation system

The ACSM is connected to the FlexRay.

1.4.7. Dynamic Stability Control

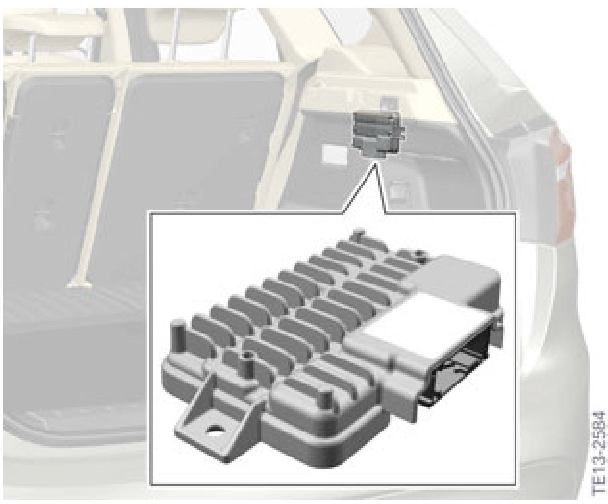


F48 Dynamic Stability Control

The Dynamic Stability Control (DSC) also includes the tire pressure control function as well as the activation of the actuators of the EMF, in addition to the familiar functions for driving stability control, in the F48. These functions are described in more detail in the section "F48 Chassis and Suspension".

The DSC is connected at the FlexRay.

1.4.8. Optional equipment system



F48 Optional equipment system

The optional equipment system SAS control unit is not an element of the standard equipment. The vehicle must have at least one of the two optional equipment packages in order for an SAS to be installed:

- Dynamic Damper Control (SA 223)
- Driving Assistant (SA 5AS)

The optional equipment system (SAS) control unit provides a variety of driver assistance functions.

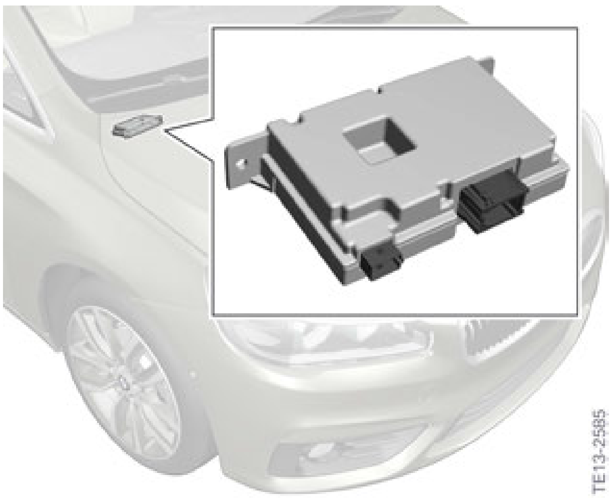
Possible functions:

- Collision warning with city braking function (SA 5AS)
- Pedestrian warning with city braking function (SA 5AS)
- Cruise control with braking function (as a sub-function of ACC Stop&Go (SA 5AS))
- Camera-based cruise control ACC Stop&Go (SA 5AT)
- Dynamic Damper Control (SA 223)

The image information required by the optional equipment system (SAS) is provided by the camera-based driver support systems (KAFAS) control unit.

The optional equipment system is connected at the FlexRay and via a Local Controller Area Network at the camera-based driver support system.

1.4.9. Camera-based driver support systems



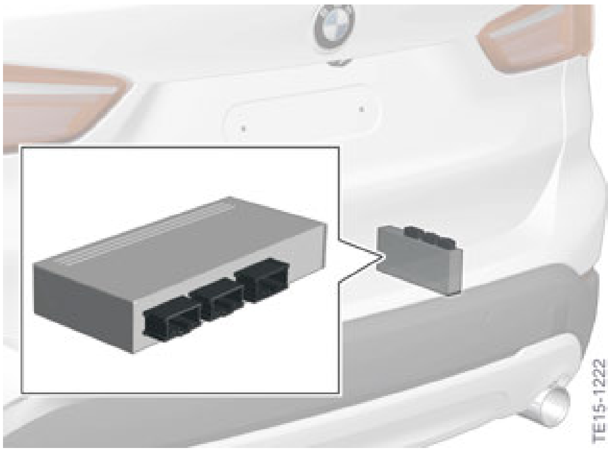
F48 Camera-based driver support systems

The control unit camera-based driver support systems (KAFAS) is required for the following optional equipment:

- Camera-based cruise control ACC Stop&Go
- Road sign recognition including no overtaking display
- Lane departure warning
- Collision warning
- Pedestrian warning with city braking function
- Collision warning with city braking function

The camera-based driver support system control unit is connected to the PT-CAN and to the optional equipment system (SAS) via a Local Controller Area Network.

1.4.10. Automatic operation of tailgate

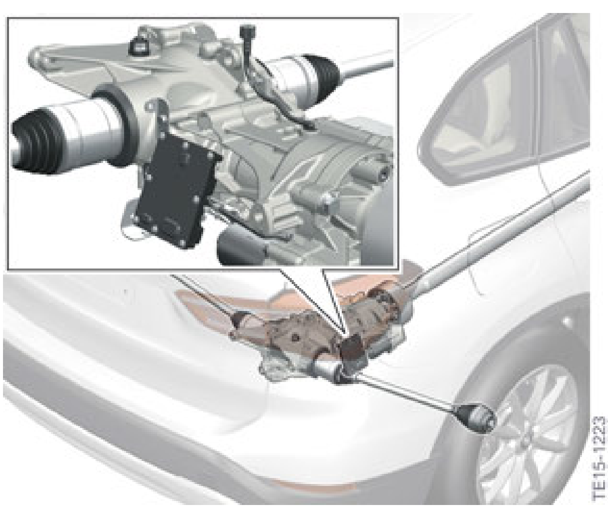


F48 control unit for automatic operation of tailgate

The automatic operation of tailgate (HKL) is responsible for the automatic tailgate opening and closing. The HKL monitors and activates the electric spindle drives for the tailgate activation.

The HKL is connected at the K-CAN2.

1.4.11. Longitudinal torque distribution



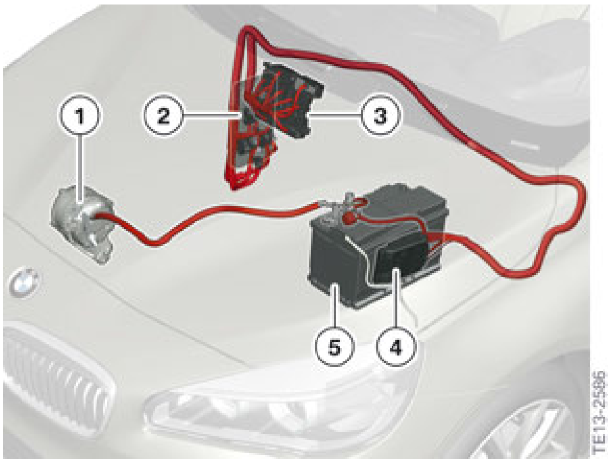
F48 control unit for longitudinal torque distribution

In the F48 with four-wheel drive, the longitudinal torque distribution distributes the drive torque variably to the front and rear axles.

The longitudinal torque distribution is connected at the K-CAN3.

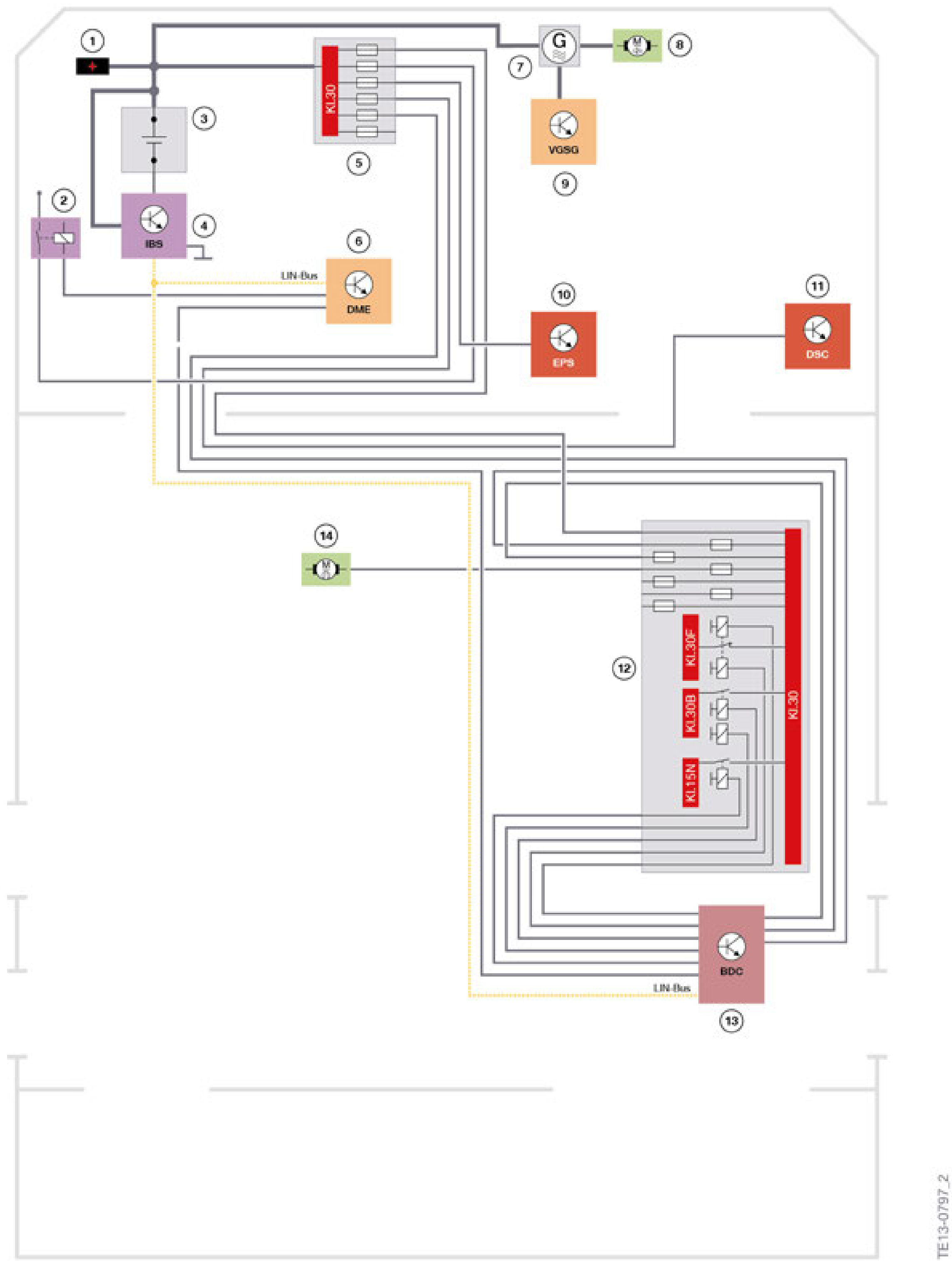
F48 General Vehicle Electronics
2. Voltage Supply

2.1. Overview



F48 Voltage supply

Index	Explanation
1	Alternator
2	Body Domain Controller (BDC)
3	Power distribution box, passenger compartment
4	Battery power distribution box
5	Battery



F48 system wiring diagram for voltage supply

Index	Explanation
1	B+ jump start terminal point
2	Electric fan relay
3	Battery
4	Intelligent battery sensor
5	Battery power distribution box
6	Digital Engine Electronics (DME)
7	Alternator
8	Starter motor
9	Preheating control unit (only for diesel-engine cars)
10	Electronic Power Steering (EPS)
11	Dynamic Stability Control (DSC)
12	Power distribution box, passenger compartment
13	Body Domain Controller (BDC)
14	Blower motor, passenger compartment

2.2. Components

The voltage supply of the F48 is comprised of the following components:

- Battery
- Intelligent Battery Sensor (IBS)
- Battery power distribution box
- Power distribution box, passenger compartment
- Alternator
- Ground connections
- Body Domain Controller (BDC)

2.2.1. Battery

AGM battery

Depending on the equipment package, either a 70 Ah AGM battery or 80 Ah AGM battery is installed in the engine compartment in the F48.

2.2.2. Intelligent battery sensor

Intelligent battery sensor

Index	Explanation
1	Negative battery terminal
2	Intelligent battery sensor (IBS)
3	Battery earth lead

The intelligent battery sensor (IBS) records the following data of the battery:

- Voltage
- Current
- Pole temperature

The IBS performs the calculation and the evaluation of the information. The results are then forwarded to the superior control units via local interconnect network bus (DME and BDC).

The IBS has the same range of functions as with the predecessor models. The data transfer via the local interconnect network bus between the IBS, DEM and BDC is new. The IBS has a wake-up function.

The IBS continuously records relevant values for the battery indicators when the vehicle is in rest state. These can be read out for the diagnosis in the DME/DDE.

⚠

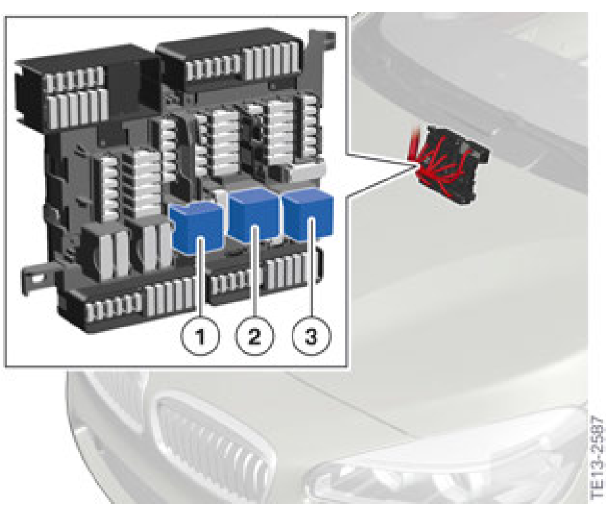
The IBS is fully functional directly after installation at the battery terminal (screw connection at negative battery terminal and connection of signal lines), i.e. the basic variables voltage, current and temperature can be called up straight away. However, the variables deduced for power management (battery condition, starting capability, etc.) must be recalculated and are therefore available with a delay.

2.2.3. Power distribution boxes

Power distribution box, passenger compartment

The power distribution box in the passenger compartment is located behind the glove box.

Some functions for which load relays are integrated in the BDC are protected directly in the BDC.



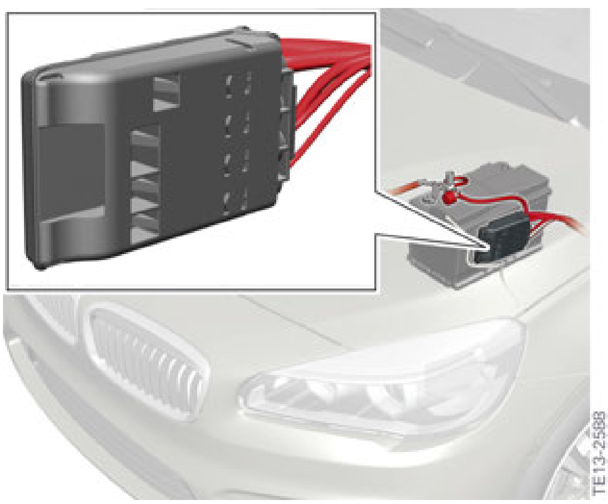
F48 Power distribution box, passenger compartment

Index	Explanation
1	Relay, terminal 15N
2	Relay, terminal 30B
3	Relay, terminal 30B

Battery power distribution box

The battery power distribution box supplies the following components with voltage:

- Power distribution box, passenger compartment
- Electric fan
- Electronic Power Steering (EPS)
- Dynamic Stability Control (DSC) (pump)
- Body Domain Controller (BDC)



F48 Battery power distribution box

Power distribution box in Body Domain Controller

The following components are protected by fuses in the BDC power distribution box:

- Steering column switch cluster (SZL)
- Intelligent Safety button
- Light switch
- Rain-light-solar-condensation sensor (RLSBS)
- OBD2 interface
- Heating and air-conditioning units
- Outside door handle electronics (TAGE)
- Telematic Communication Box (TCB)
- Hands free tailgate activation
- Power windows
- Central locking system
- Heated rear window
- Rear wiper

F48 General Vehicle Electronics

3. Exterior Lights

3.1. Headlights

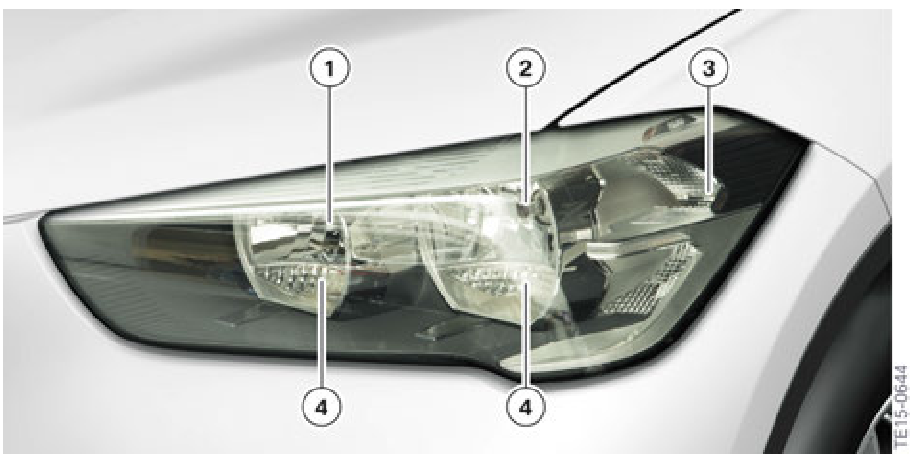
There are some new features in the area of the headlights for the F48.

The F48 receives halogen headlights in the basic equipment. LED headlights with extended scope (SA 5A4) are available as optional equipment.

Xenon headlights are not offered for the F48.

3.1.1. Halogen headlight

With the halogen headlights, the low-beam headlight, the high beam, as well as the turn indicator, are realized using bulbs. The side light and the daytime driving lights are generated via LEDs.

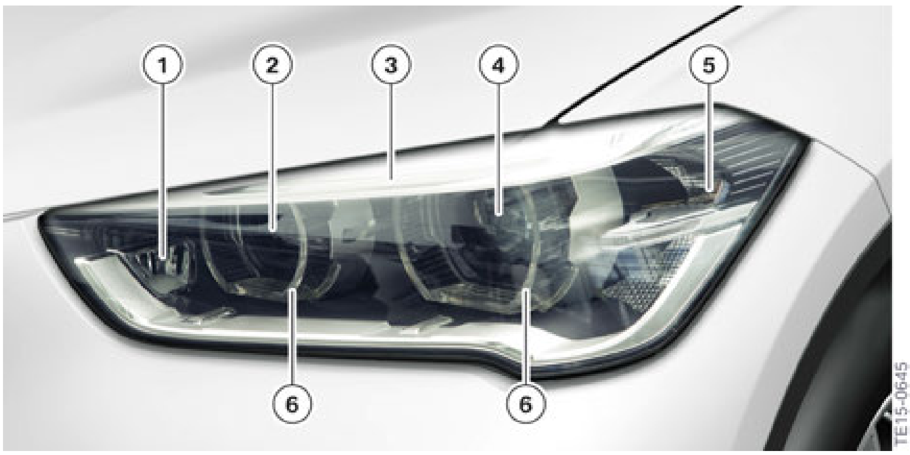


F48 Halogen headlight

Index	Explanation
1	Bulb for high beam
2	Bulb for low-beam headlight
3	Bulb for turn indicator
4	LEDs for side light/daytime driving lights

3.1.2. LED headlight with extended scope

The optional equipment LED headlight with extended scope (SA 5A4) also includes the adaptive light distribution, the cornering light and the static adaptive headlight, in addition to the functions of the LED headlight.



F48 LED headlight with extended scope

Index	Explanation
1	Cornering light
2	Design trim
3	Positioning light
4	Low-beam headlight/High-beam headlight
5	Bulb for turn indicator
6	Side lights/Daytime driving lights

Functions

The variable beam pattern offers improved adaptation of the beam pattern on the road situation. Depending on the speed driven, a distinction is made between the following beam patterns:

- Cornering light
- Adaptive headlight

Cornering light

The LED cornering light is integrated at the side in the headlight. During a slow journey (up to 45 km/h) the cornering light is either activated via the turn indicator or from a certain steering angle.

Static adaptive headlight

At speeds between 45 km/h and 70 km/h the cornering light is used as a "static Adaptive Headlight". The LEDs, which are responsible for the cornering light, are activated in order to illuminate the cornering area. This function is called a static Adaptive Headlight because the headlight is not moved.

Special features

In vehicles with LED headlights a ride height sensor for the automatic headlight beam throw adjustment is installed at the front and rear axle on the right side of vehicle.

For the F48 with LED headlight, a headlight cleaning system is **not** required. This could be waived due to compliance with all legal requirements.

The Frontal Light Electronics Left and Right (FLEL/FLER) is installed at the rear side of the LED headlight and controls the following functions:

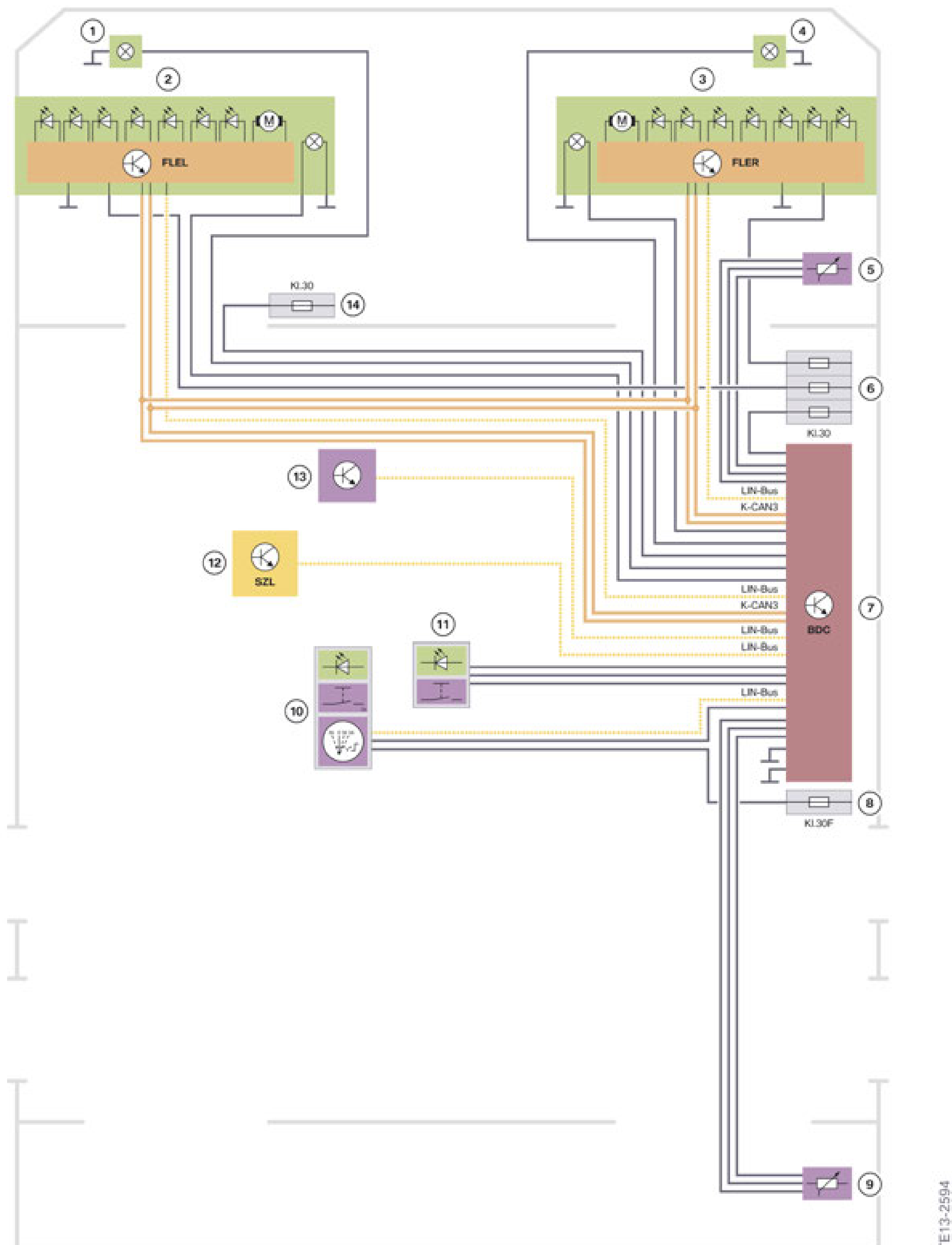
- Low-beam headlight
- High beam
- Headlight flasher
- Headlight beam angle adjustment
- Cornering lights

In addition, the FLE controls the temperature control in the LED headlight. The values of two temperature sensors at the heat sink serve as input signals. After switching off the lighting function an after-run of the fans of up to 60 seconds is possible. In the temperature control there is also a function for the de-icing of the LED headlight.

In the case of a failure of a temperature sensor the fans are switched on at full power to protect the components in the LED headlight. The data from the FLE is transferred to the Body Domain Controller (BDC) via the local interconnect network bus for the diagnosis of the fans and temperature sensors.

For legal reasons (approval of light technology), the LED headlight obtains a forced connection for the rain-light-solar-condensation sensor.

System wiring diagram



F48 system wiring diagram for the LED headlight

Index	Explanation
1	Left fog light
2	LED headlight with extended scope, left
3	LED headlight with extended scope, right
4	Right fog light
5	Ride height sensor, front right
6	Fuses in the power distribution box in the passenger compartment
7	Body Domain Controller (BDC)
8	Fuse in the Body Domain Controller
9	Ride height sensor, rear right
10	Light switch
11	Hazard warning switch/Intelligent Safety button
12	Steering column switch cluster (SZL)
13	Rain-light-solar-condensation sensor (RLSBS)
14	Fuse in the power distribution box, battery

3.1.3. fog lights

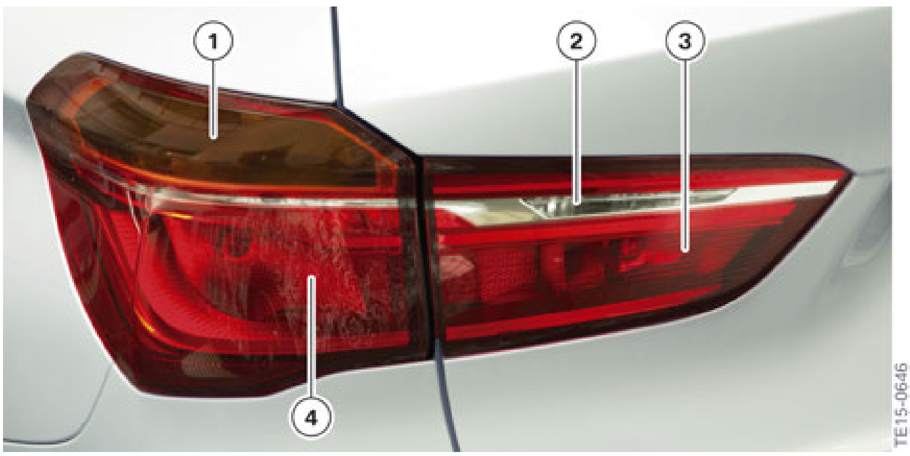
F48 fog lights

The F48 comes with fog lights as standard equipment. Halogen lights are used inside the fog lights.

3.2. Rear lights

Depending on equipment, two different versions of rear lights are used in the F48.

3.2.1. In vehicles with halogen headlights

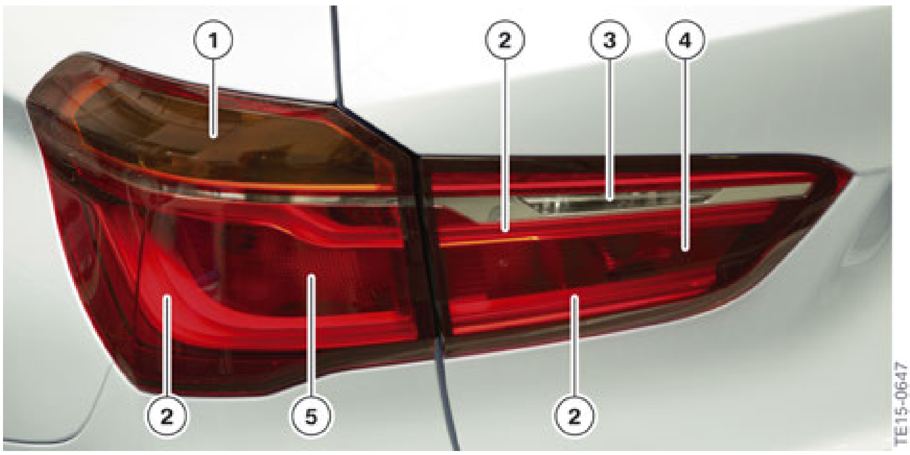


F48 with halogen headlights

Index	Explanation
1	Turn indicator
2	Reversing light
3	Tail light/fog light
4	Tail light/brake light

Only bulbs are used in the rear lights for vehicles with halogen headlights.

3.2.2. Vehicles with LED headlights



F48 with LED headlights

Index	Explanation
1	Turn indicator
2	Tail light (LED)
3	Reversing light
4	Fog light
5	Brake light

In conjunction with LED headlights (SA 5A4), the tail light function in the rear light is performed with LEDs.

F48 General Vehicle Electronics

4. Interior Lighting

The F48 is offered with two different concepts of interior lighting.

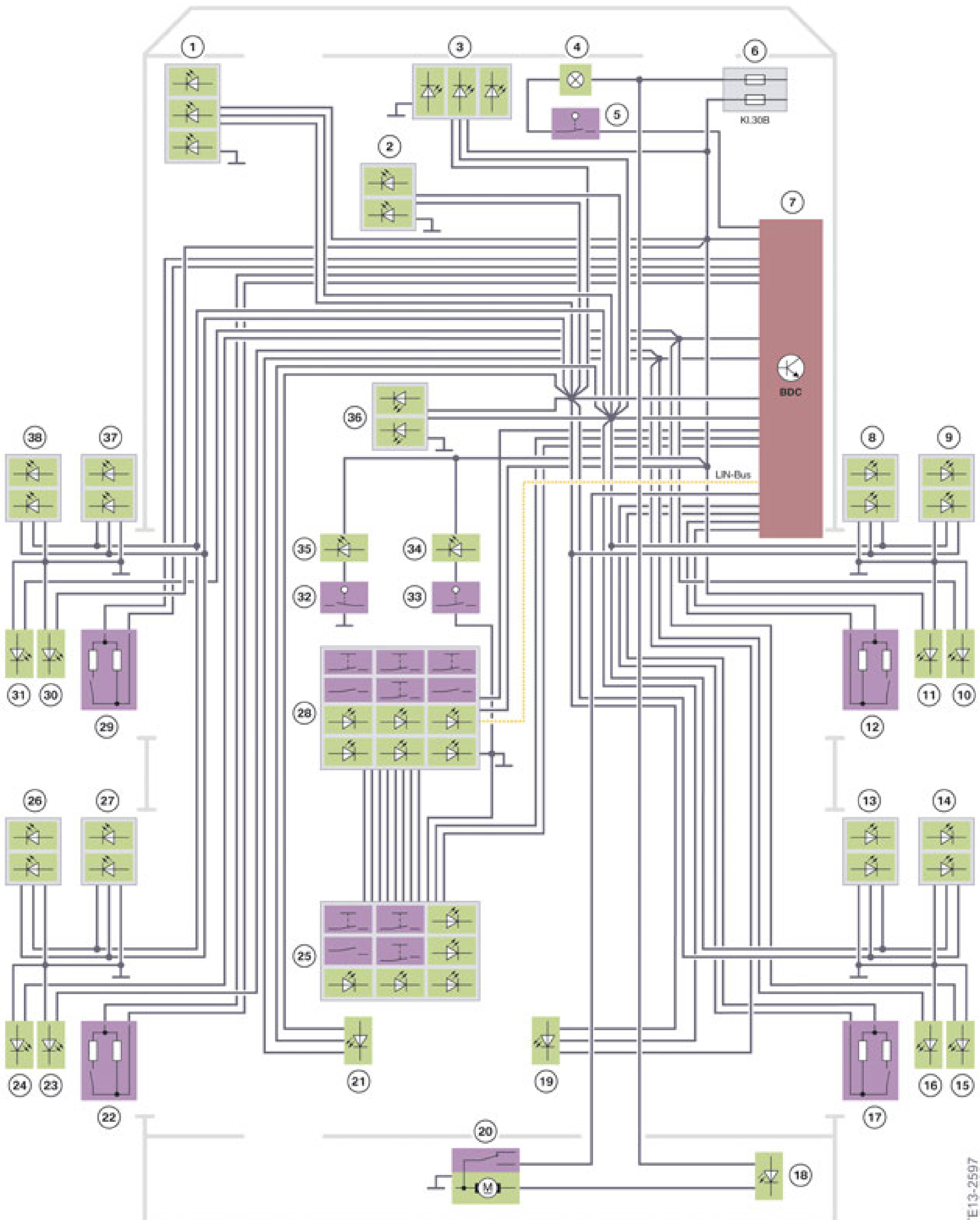
- Basic
- Lights package (SA 563)

Other contour lights can also be installed with the optional equipment Sport Line (SA 7AC) and xLine (SA 7HW).

F48 General Vehicle Electronics

4. Interior Lighting

4.1. System wiring diagram



F48 system wiring diagram for interior lighting with light package (SA 563)

F48 General Vehicle Electronics
4. Interior Lighting

Index	Explanation
1	Footwell light, front left
2	Lighting, decorative strip on passenger's side
3	Footwell light, front right
4	Glove box light
5	Glove box switch
6	Fuses in the power distribution box in the passenger compartment
7	Body Domain Controller (BDC)
8	Door pocket lighting, front right
9	Door pocket lighting, front right
10	Outside door handle light, front right
11	Door entry lighting, front right
12	Door contact, front right
13	Door pocket lighting, rear right
14	Door pocket lighting, rear right
15	Outside door handle light, rear right
16	Door entry lighting, rear right
17	Door contact, rear right
18	Luggage compartment light
19	Footwell light, rear right
20	Tailgate lock with switch
21	Footwell light, rear left
22	Door contact, rear left
23	Door entry lighting, rear left
24	Outside door handle light, rear left
25	Interior light unit, rear
26	Door pocket lighting, rear left
27	Door pocket lighting, rear left
28	Front interior light unit
29	Door contact, front left
30	Door entry lighting, front left
31	Outside door handle light, front left
32	Switch for make-up mirror light, left
33	Switch for make-up mirror light, right
34	Make-up mirror light, right

Index	Explanation
35	Make-up mirror light, left
36	Door pocket lighting, front left
37	Lighting, center stack
38	Door pocket lighting, front left

5. Heating/Air Conditioning Systems

In the F48 one variant of the heating and air conditioning systems are available for the US:

- IHKA 2/1 zones

In the zone specification the first number denotes the number of controllable temperature zones (temperature selector wheels) and the second number denotes the number of controllable airflow volume and air distribution zones (separate fan settings).

⚠

For the air-conditioning system of the F48 the refrigerant R134a is used.

Other equipment for the F48:

- Seat heating for driver and front passenger (SA 494)
- Steering wheel heating (SA 248)
- Mirror heating (standard equipment)
- Heated washer jets (standard equipment)

5.1. Components and systems

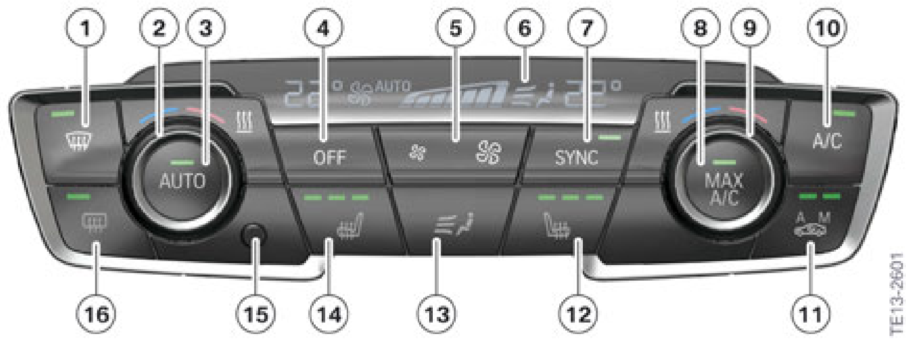
5.1.1. Integrated automatic heating and air conditioning

An automatic air-conditioning system is available for the F48 as optional equipment (SA 534).

Contents:

- Two-zone automatic air conditioning
- 5 climate controls (automatic programs) for setting the desired intensity
- Condensation sensor
- Automatic air recirculation control sensor (NOx, CO) for automatic air recirculation function
- Combination filter with activated carbon for fresh air and air recirculation function
- Personal Profiles are stored in a key-dependent way
- MAX AC function (maximum cooling in passenger compartment)
- Defrost function (quick removal of condensation)
- Fresh air vent in the rear passenger compartment

Control panel



F48 IHKA control panel

Index	Explanation
1	Defrost window glass and remove condensation
2	Temperature, left
3	Automatic program
4	Switch off system
5	Amount of air, AUTO intensity
6	Display
7	SYNC program
8	Maximum cooling
9	Temperature, right
10	Air conditioning function
11	Automatic air recirculation control/air recirculation function
12	Seat heating, right
13	Air distribution
14	Seat heating, left
15	Passenger compartment temperature sensor
16	Heated rear window

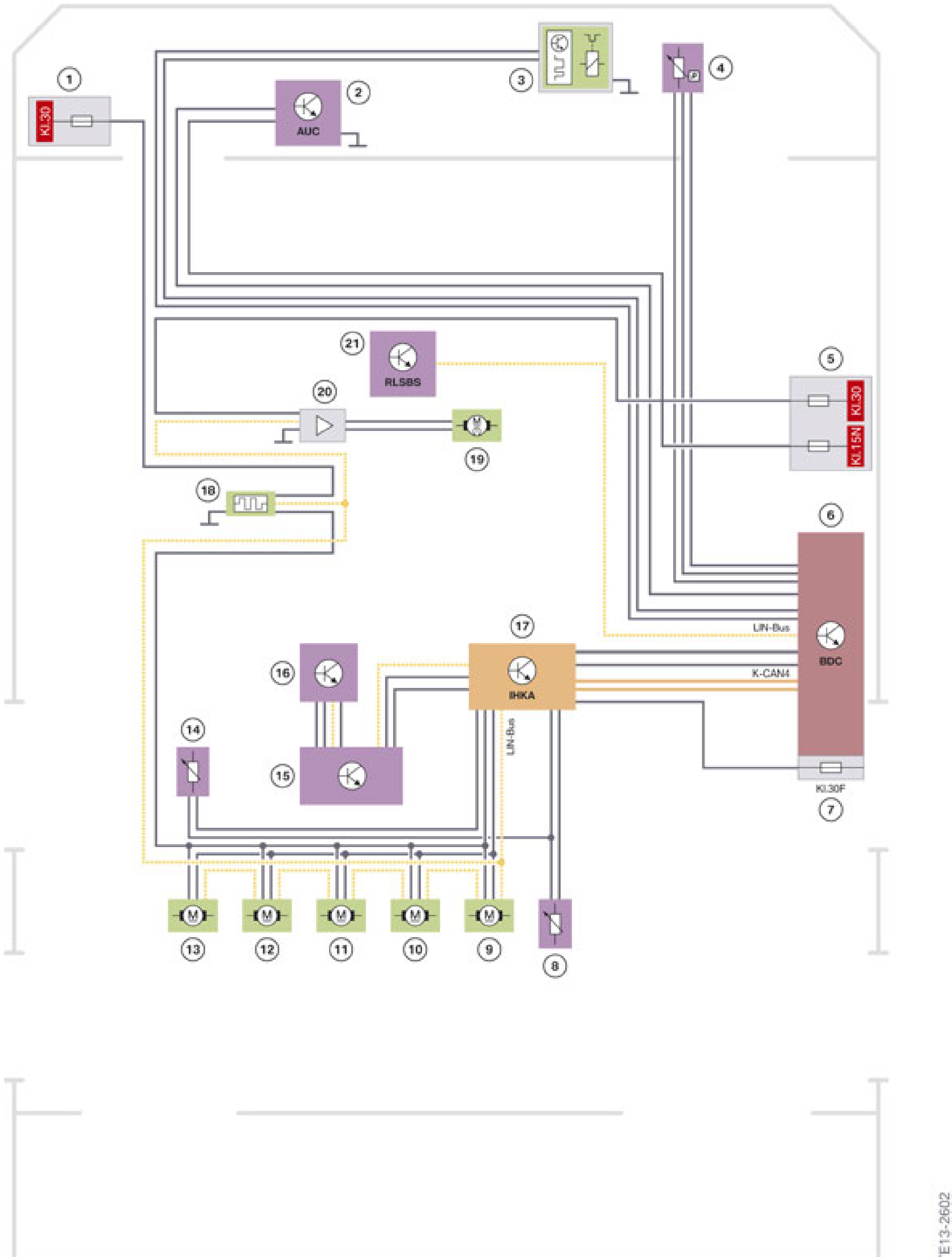
5. Heating/Air Conditioning Systems

Components

Sensors and actuators which are connected to the Body Domain Controller (BDC) control unit are involved in the function of the heating and air-conditioning system in the F48:

- Pressure sensor
  The BDC evaluates the pressure sensor signal and makes it available to the IHKA control unit via the K-CAN4.
- Blower
  The IHKA request is sent via the LIN bus to the blower.
- Air conditioning compressor
  The air conditioning compressor is controlled by the BDC by means of a pulse-width-modulated signal. The BDC can also actuate the air conditioning compressor clutch. However, the request is always made by the IHKA.
- Automatic air recirculation control sensor
  The automatic air recirculation control sensor is read by the BDC via a local interconnect network bus. The IHKA assumes the automatic air flap control, which communicates with the BDC via K-CAN4.
- Rain-light-solar-condensation sensor (RLSBS)
  The rain-light-solar-condensation sensor communicates with the BDC via a local interconnect network bus.

System wiring diagram

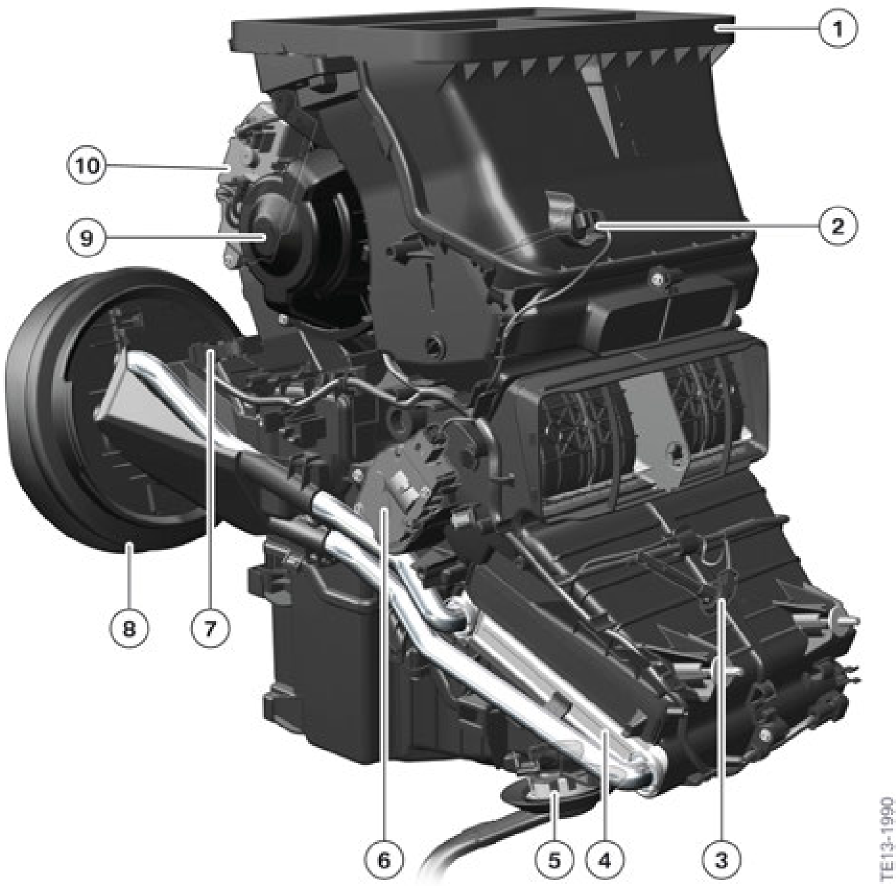


F48 system wiring diagram for IHKA

5. Heating/Air Conditioning Systems

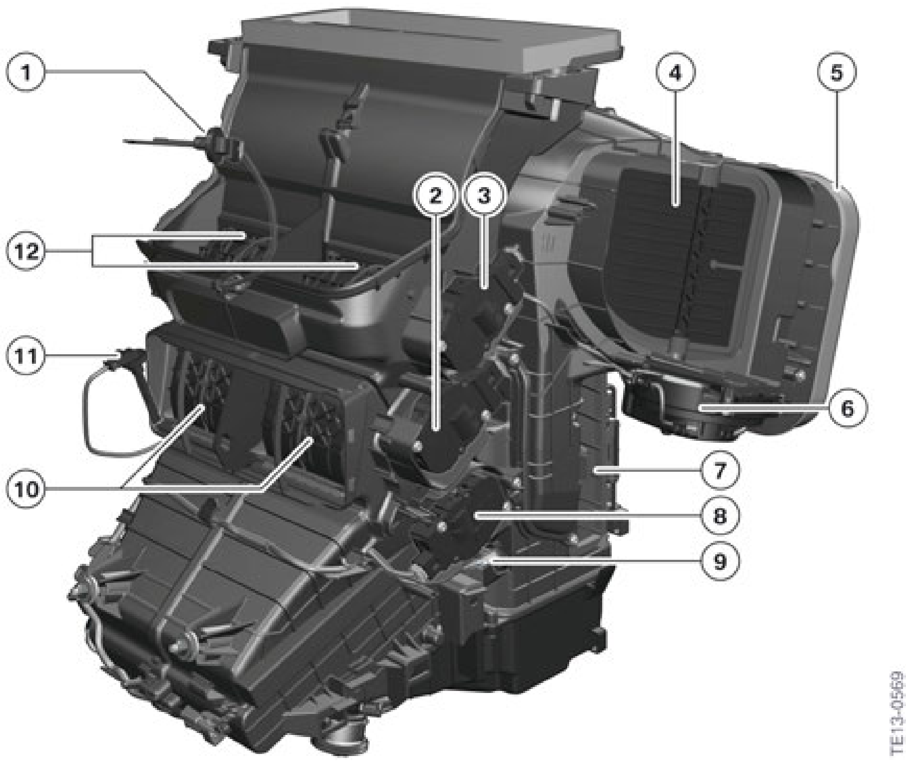
Index	Explanation
1	Battery power distribution box
2	Automatic air recirculation control sensor
3	Air conditioning compressor
4	Refrigerant pressure sensor for switching off in the event of excess pressure in the refrigerant circuit
5	Fuses in the power distribution box in the passenger compartment
6	Body Domain Controller (BDC)
7	Fuse in the power distribution box, BDC
8	Temperature sensor for evaporator
9	Stepper motor, blending flap, left
10	Stepper motor, blending flap, right
11	Stepper motor, fresh air/air recirculation function
12	Stepper motor, flaps, footwell ventilation, left and right
13	Stepper motor flaps for defrost function
14	Ventilation temperature sensor, left
15	Audio operating facility
16	Operating unit for standard heating and air conditioning
17	Integrated heating and air conditioning (IHKA)
18	Electric auxiliary heater (only for diesel engines)
19	Blower motor, passenger compartment
20	Blower output stage, local interconnect network bus control
21	Rain-light-solar-condensation sensor (RLSBS)

5.1.2. Heating and air-conditioning unit



F48 Heating and air-conditioning unit

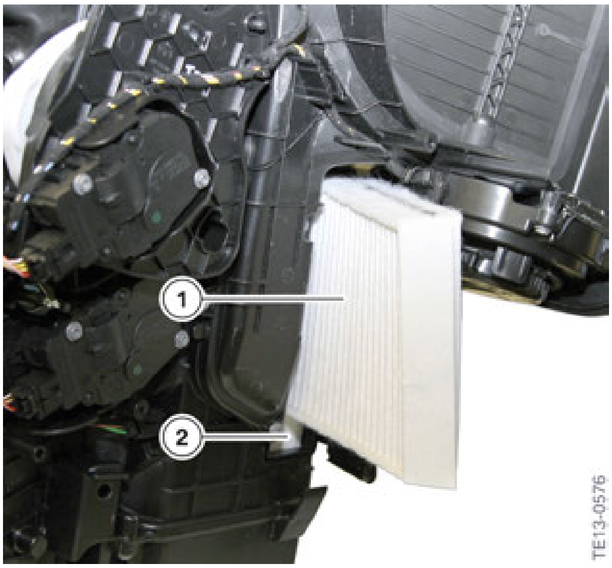
Index	Explanation
1	Air vent, top
2	Temperature sensor, center vent
3	Temperature sensor, footwell air outlet
4	Heat exchanger
5	Discharge of condensation from the heating and air-conditioning unit
6	Stepper motor for blending flap
7	Connector at the control unit for integrated heating / air-conditioning regulation/IHKA
8	Sleeve, bulkhead
9	Blower motor
10	Blower output stage



F48 Heating and air-conditioning unit

Index	Explanation
1	Temperature sensor, center vent
2	Stepper motor for footwell air outlet, left and right
3	Stepper motor for defrost function
4	Recirculated air flap
5	Ambient air intake area at the bulkhead
6	Stepper motor for recirculated air flap (with kinematics control)
7	Service flap of two microfilters
8	Stepper motor for blending flap
9	Evaporator temperature sensor
10	Ventilation flaps, air vent at feet
11	Temperature sensor, footwell air outlet
12	Air flaps, center vent

5.1.3. Microfilter



F48 heating and air-conditioning unit, replacement of microfilter

Index	Explanation
1	Upper microfilter
2	Lower microfilter

F48 heating and air-conditioning unit, replacement of microfilter

⚠

Two microfilters are installed in the F48. The BMW repair instructions must be followed for the replacement of the microfilters.

5.1.4. Air/Water separation (Venturi adapter)

F48 air/water separation (Venturi adapter)

So that no water enters the heating and air-conditioning unit, a cover (Venturi adapter) is installed before the air intake in the engine compartment.

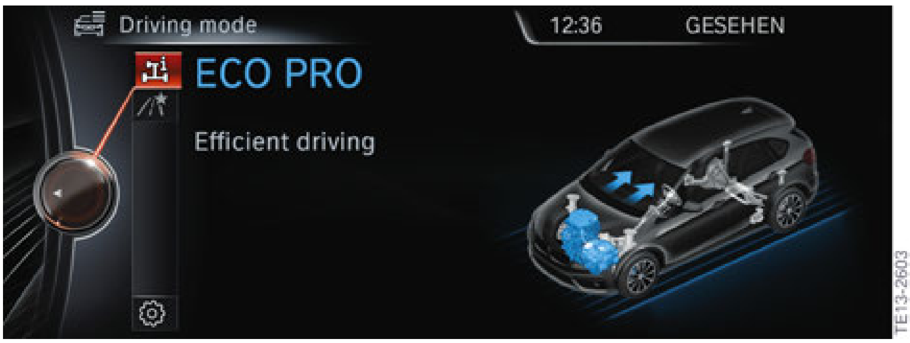
The fresh air drawn in is accelerated by the design of the Venturi adapter and redirected 90°. Through this process the water separates at the cover and then drains off downwards.

F48 function of air/water separation (Venturi adapter)

Index	Explanation
1	Cover
2	Dirt trap
3	Fresh air drawn in
4	Separated condensate

5.1.5. ECO PRO mode of heating and air conditioning program

In ECO PRO mode the heating and air conditioning functions can be configured. This also contributes to a reduction in fuel consumption thanks to the intelligent heating and air-conditioning management.



F48 ECO PRO mode

⚠

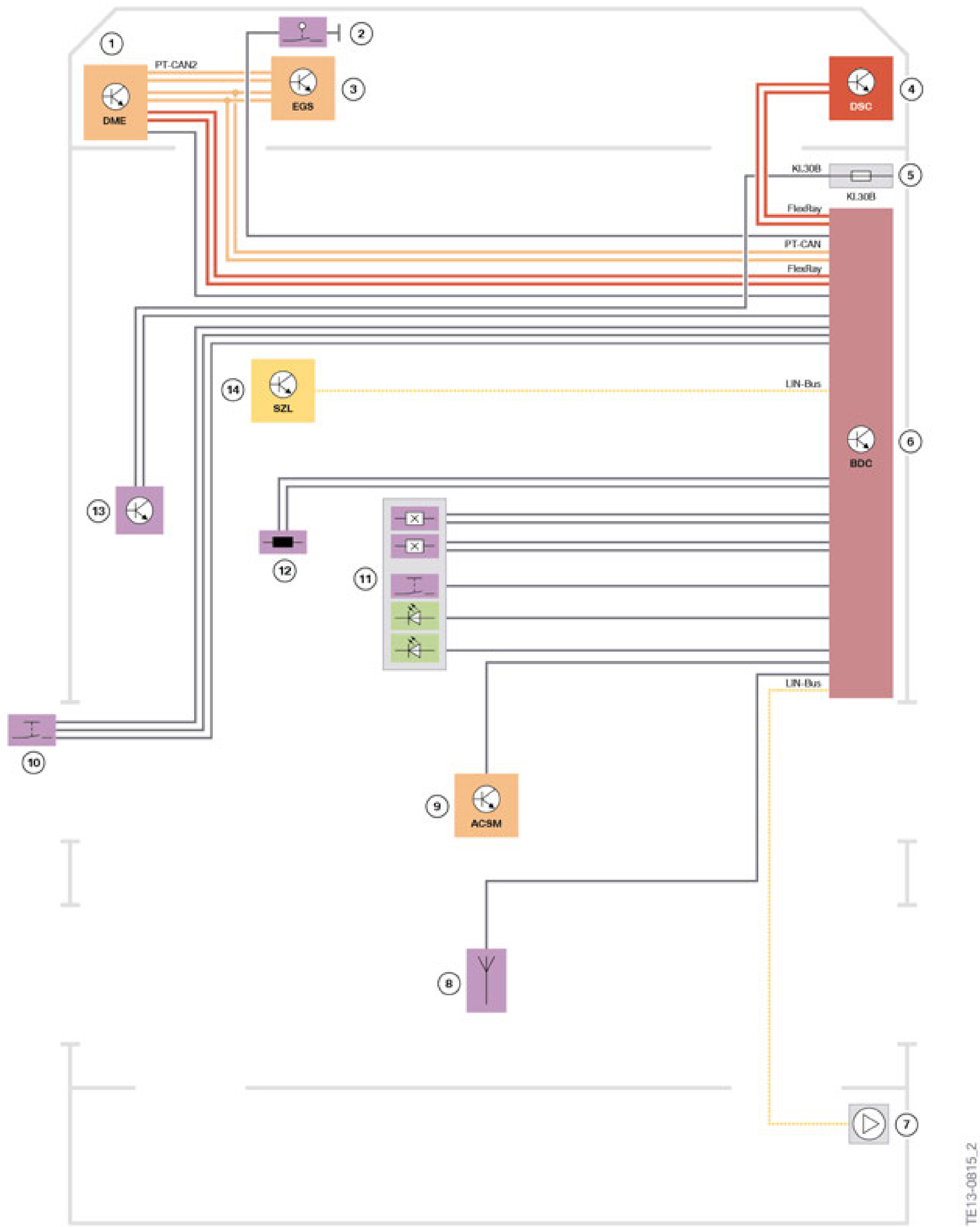
The cooling system cannot be filled or bled in ECO PRO mode. Observe the BMW repair instructions.

F48 General Vehicle Electronics
6. Locking and Security Functions

In the F48 there are two distinct systems concerned with vehicle access:

- Basic access, central locking system
- Comfort Access (SA 322)

The entire locking and security function of the F48 is integrated in the Body Domain Controller (BDC).



F48 system wiring diagram for locking and security functions

6. Locking and Security Functions

Index	Explanation
1	Digital Engine Electronics (DME)
2	Engine compartment lid contact switch
3	Electronic transmission control (EGS)
4	Dynamic Stability Control (DSC)
5	Fuse in the power distribution box in the passenger compartment
6	Body Domain Controller (BDC)
7	Remote control receiver
8	Interior antenna
9	Advanced Crash Safety Module (ACSM)
10	Central locking button, left
11	START-STOP button
12	Ring antenna (transponder coil)
13	Clutch switch (only for vehicles with manual gearbox)
14	Steering column switch cluster (SZL)

6.1. Overview of functions

The following locking and security functions are integrated in the Body Domain Controller:

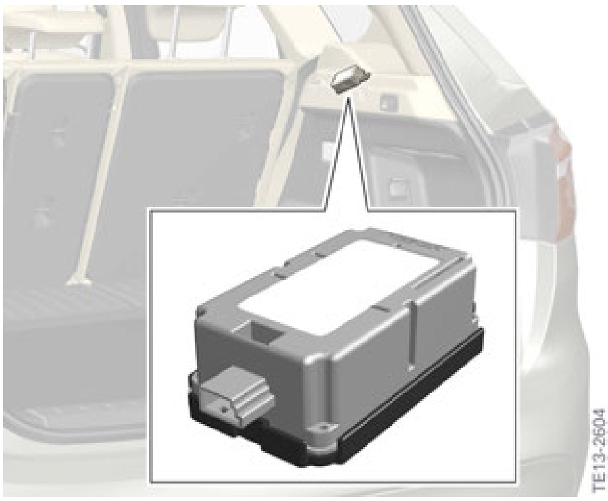
- Comfort Access
- Central locking system
- Terminal control
- Electronic immobilizer

6. Locking and Security Functions

6.1.1. Remote control receiver

The remote control receiver is installed in the luggage compartment on the right.

The radio signal received by the remote key is forwarded by the remote control receiver via a local interconnect network bus to the BDC.



F48 Installation location of the remote control receiver

6.2. Central locking system

The function of the central locking system of the F48 is based on that of current BMW models. With the introduction of the BDC, all relevant functions for the central locking system are handled by one control unit. The function is as follows:

- The radio signal from the ID transmitter is received by the remote control receiver.
- The signal causes the BDC to activate the central locking system and the interior lighting.
- The BDC evaluates the status of all door contacts. In this way, for example, the vehicle can be prevented from being locked while the driver's door is open.
- The status of the central locking system button is also evaluated by the BDC. The BDC activates the central locking system, depending on the status.
- The BDC is responsible for the status recording and activation of the central locking system in the tailgate.

6.2.1. Special functions

Automatic locking (Personal Profile)

From a speed greater than 16 km/h the vehicle is automatically locked.

Different functions of the central locking system can be individually adjusted via the central information display.

Automatic unlocking in the event of a crash

As soon as the Body Domain Controller (BDC) receives a crash message from the Advanced Crash Safety Module (ACSM), the vehicle is unlocked.

After the crash message, the central locking button and the remote control receiver are blocked for the central locking system function. Both are only reactivated after a terminal change.

Selective unlocking

The vehicle can also be selectively unlocked in the case of corresponding encoding. Initially, only the driver's door is unlocked. The rest of the vehicle is unlocked upon a subsequent request for unlocking. Depending on the operating point and the national-market version, the fuel filler flap is already unlocked after the first or second request.

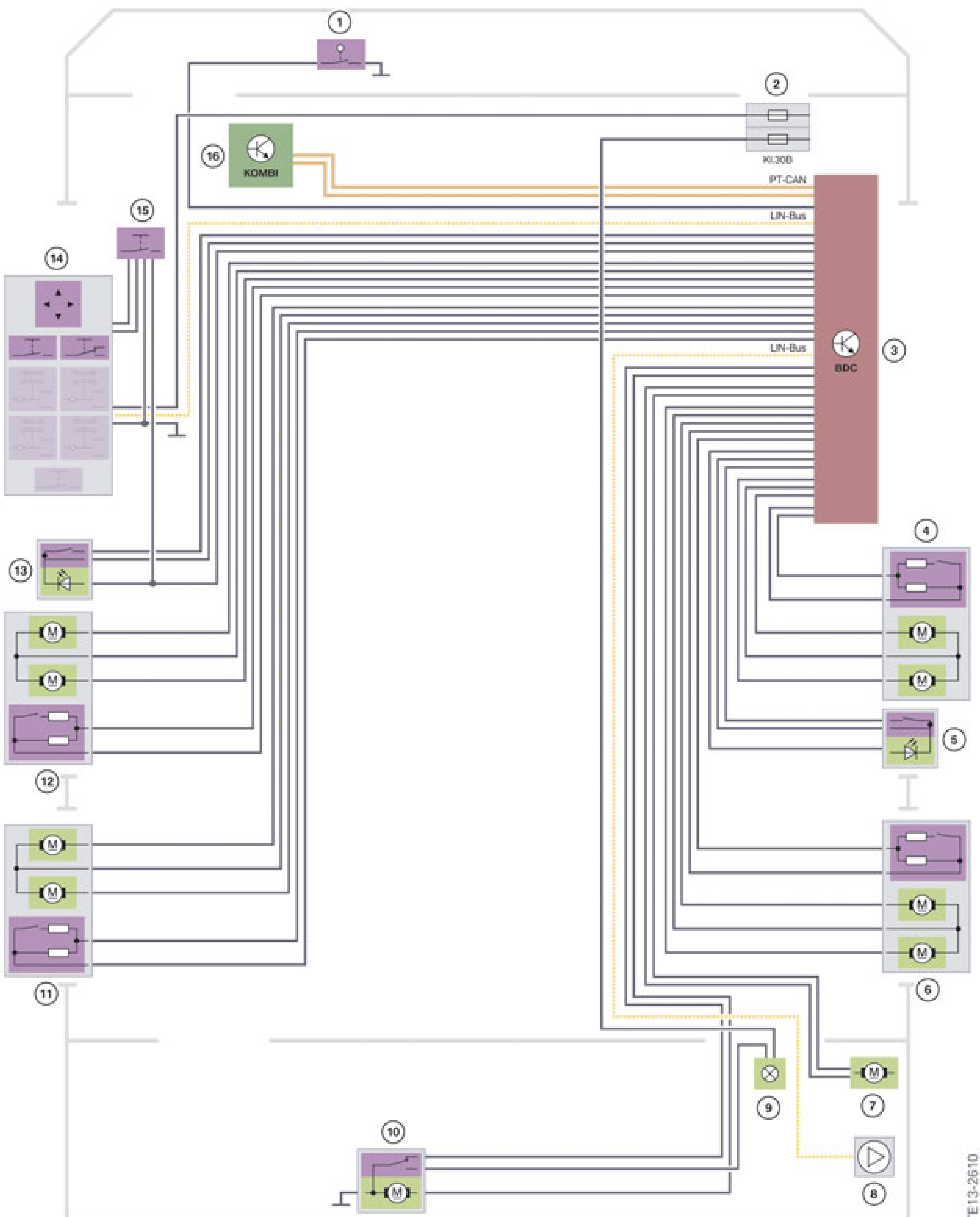
Convenient opening

By operating the remote control button "Unlock" for approximately 3 seconds the convenient opening can start. The windows and, if installed the panorama glass roof (SA 402), are opened in the process. The button on the remote key must be held down until the process is complete.

Convenient closing

If the vehicle has the optional equipment Comfort Access (SA 322), the windows and the panorama glass roof (SA 402) can be closed by pressing the grooved surface on the outer door handle.

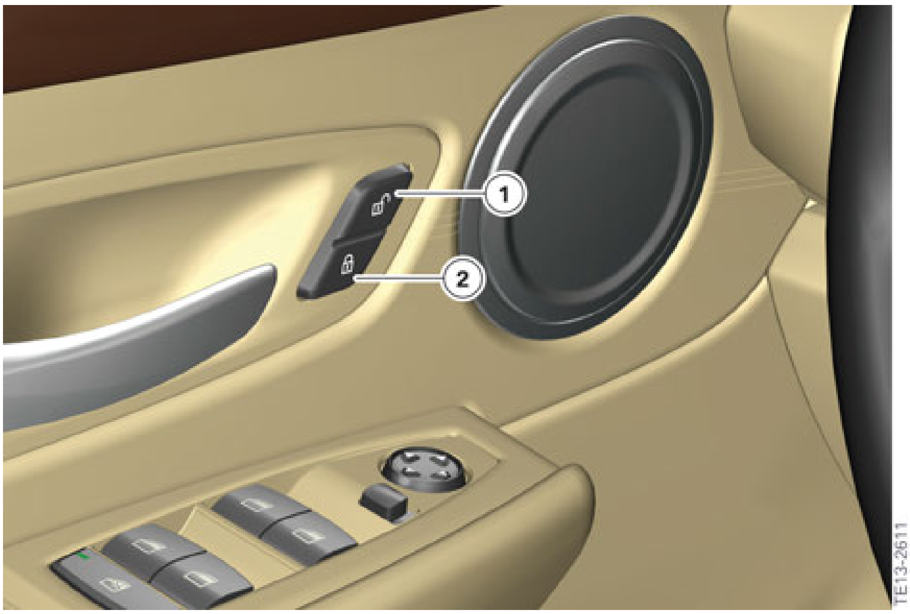
6.2.2. System wiring diagram



F48 system wiring diagram for central locking system

Index	Explanation
1	Engine compartment lid contact switch
2	Fuses in the power distribution box in the passenger compartment
3	Body Domain Controller (BDC)
4	Door lock, passenger's side, front
5	Central locking button on passenger's side
6	Door lock, passenger's side, rear
7	Servo drive for fuel filler flap
8	Remote control receiver
9	Luggage compartment light
10	Tailgate lock
11	Door lock, driver's side, rear
12	Door lock, driver's side, front
13	Central locking button, driver's side
14	Switch block for driver's side
15	Button for tailgate activation
16	Instrument cluster (KOMBI)

The central locking button is designed as a rocker switch in the F48.



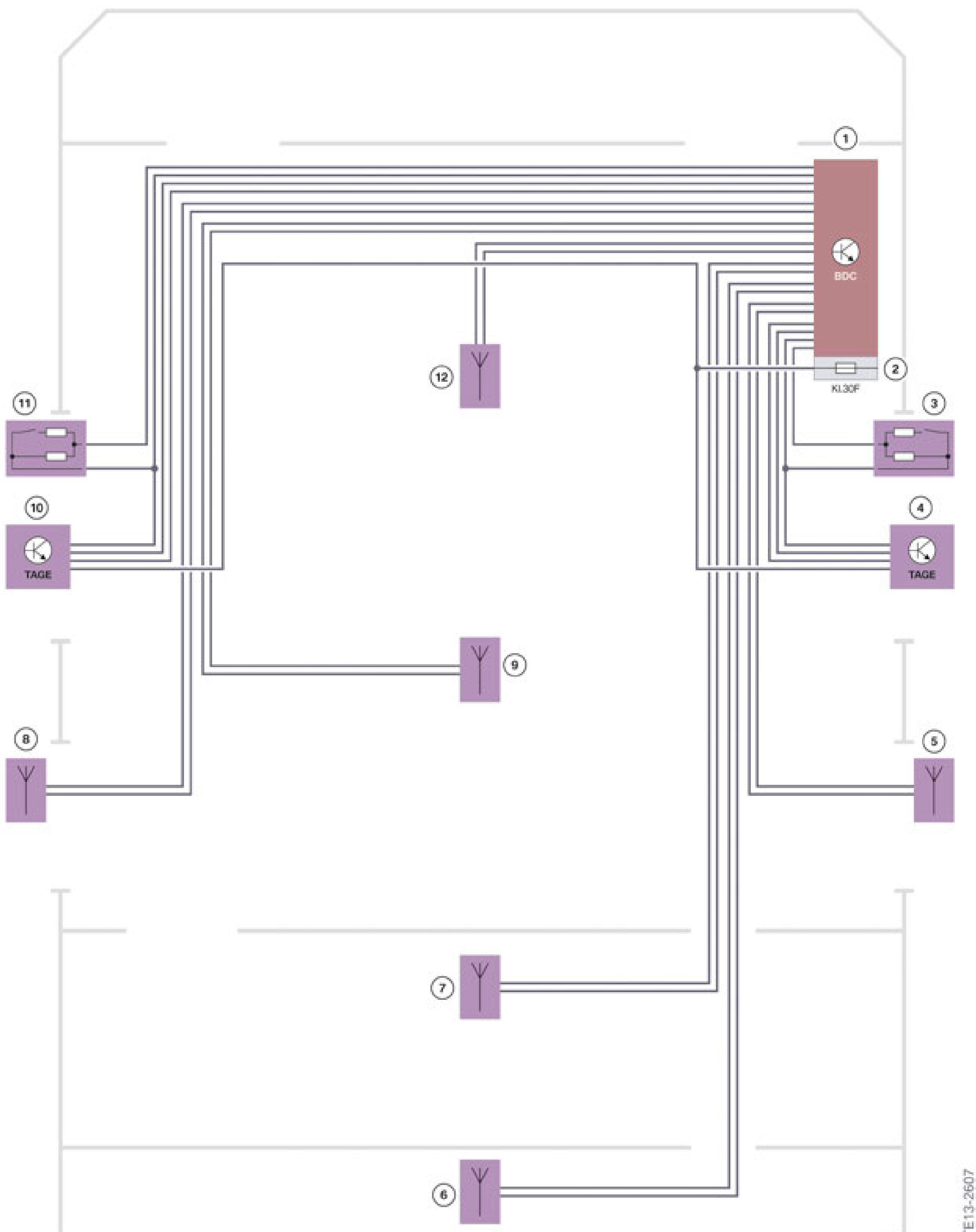
F48 central locking button

Index	Explanation
1	Unlock vehicle
2	Lock vehicle

6.3. Comfort Access

With the optional equipment Comfort Access (SA 322), the F48 obtains access to the vehicle without a key. The Comfort Access function is already known from other BMW models.

6.3.1. System wiring diagram



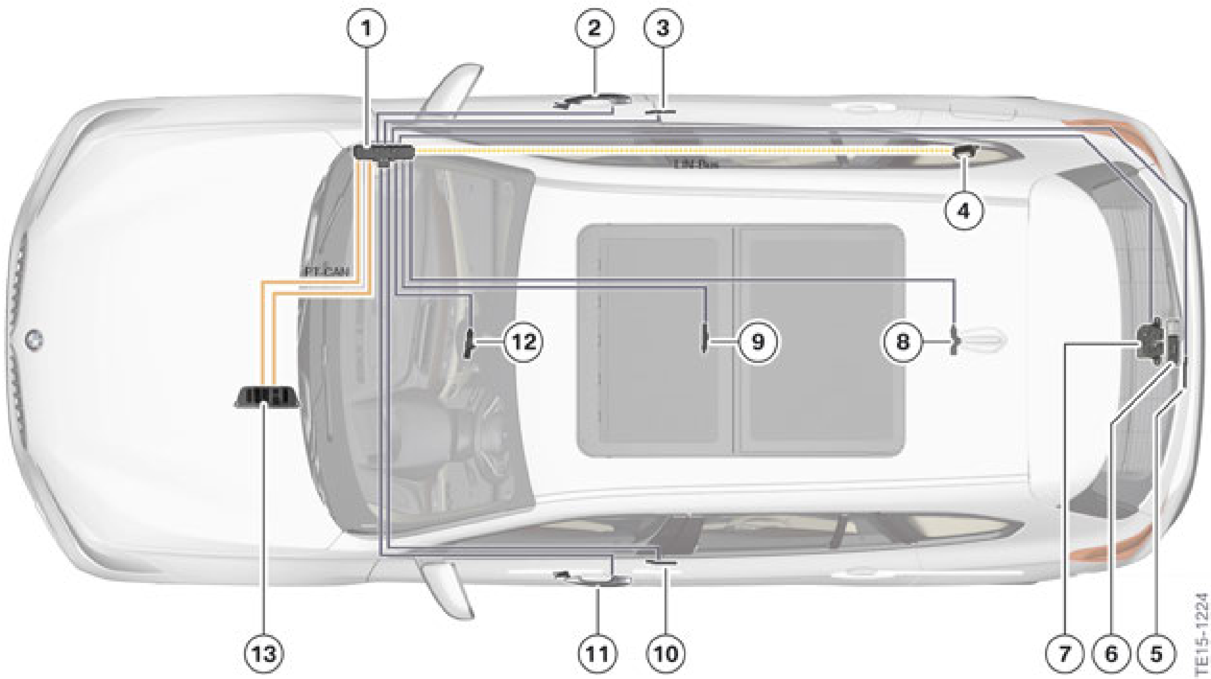
F48 system wiring diagram for Comfort Access

Index	Explanation
1	Body Domain Controller (BDC)
2	Fuse in the Body Domain Controller
3	Door contact, passenger's side
4	Outside door handle electronics, passenger's side
5	Exterior antenna, passenger's side
6	Exterior antenna, rear bumper
7	Interior antenna, luggage compartment
8	Exterior antenna, driver's side
9	Interior antenna, rear
10	Outside door handle electronics, driver's side
11	Door contact, driver's side
12	Interior antenna (front)

6.3.2. System components

For the CA function, the Body Domain Controller activates the aerials for the exterior and passenger compartment.

The outside door handle electronics TAGE are also read in by the BDC.



F48 installation location of the Comfort Access aerials

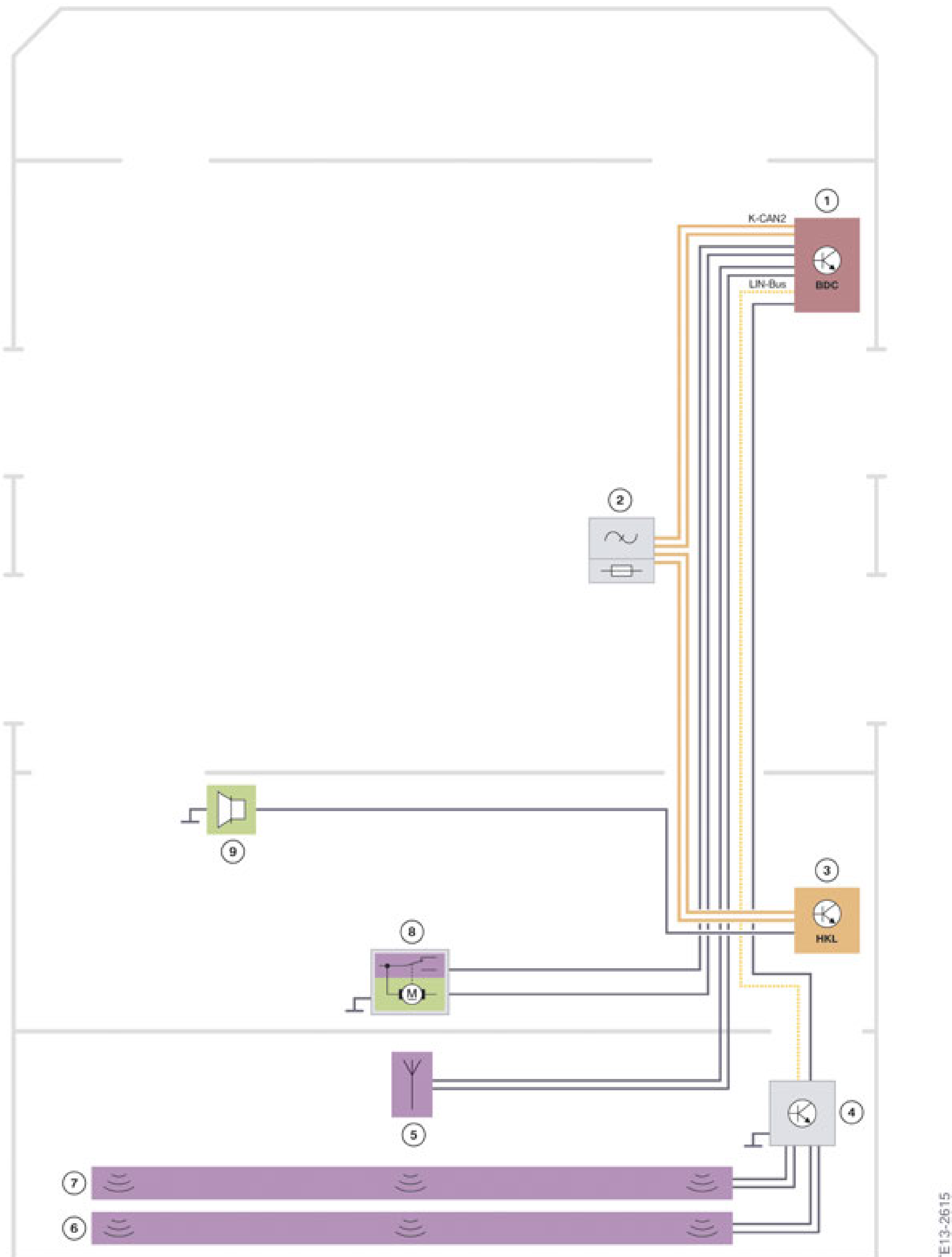
Index	Explanation
1	Body Domain Controller (BDC)
2	Outside door handle electronics, right
3	Antenna for outer area, right
4	Remote control receiver
5	Antenna for outer area in the rear bumper
6	Tailgate button
7	Tailgate lock
8	Interior antenna, luggage compartment
9	Interior antenna, rear
10	Antenna for outer area, left
11	Outside door handle electronics, left
12	Interior antenna (front)
13	Digital Motor Electronics (DME)

The function of Comfort Access is known from current BMW models.

6.4. Hands free tailgate opening

In combination with the optional equipment Comfort Access (SA 322) and automatic operation of tailgate (SA 316), the F48 has hands free tailgate opening.

6.4.1. System wiring diagram

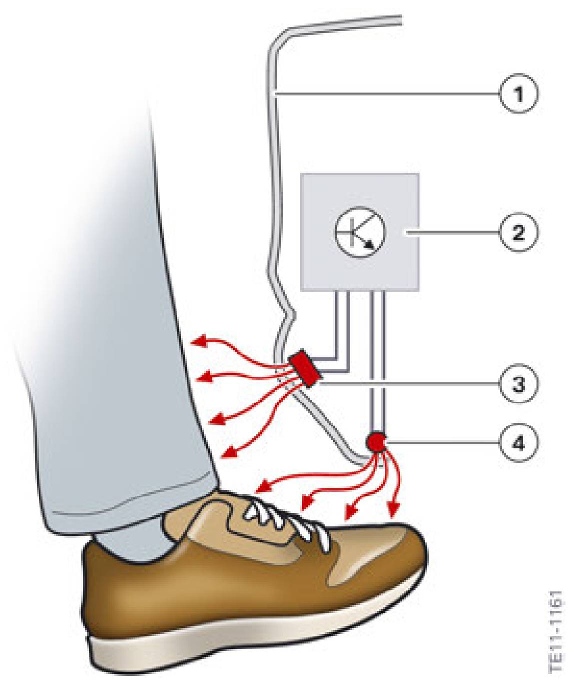


F48 system wiring diagram for non-contact tailgate opening

Index	Explanation
1	Body Domain Controller (BDC)
2	K-CAN terminator
3	Automatic operation of tailgate (HKL)
4	Control electronics for non-contact tailgate opening
5	Exterior antenna, rear bumper
6	Sensor at top for non-contact tailgate opening
7	Sensor at bottom for non-contact tailgate opening
8	Tailgate lock switch
9	Acoustic warning device

6.4.2. Functional description of tailgate opening

The operation is effected by means of targeted foot movement to and from the bumper. Two sensors detect the movement contactlessly via capacitive measurement.

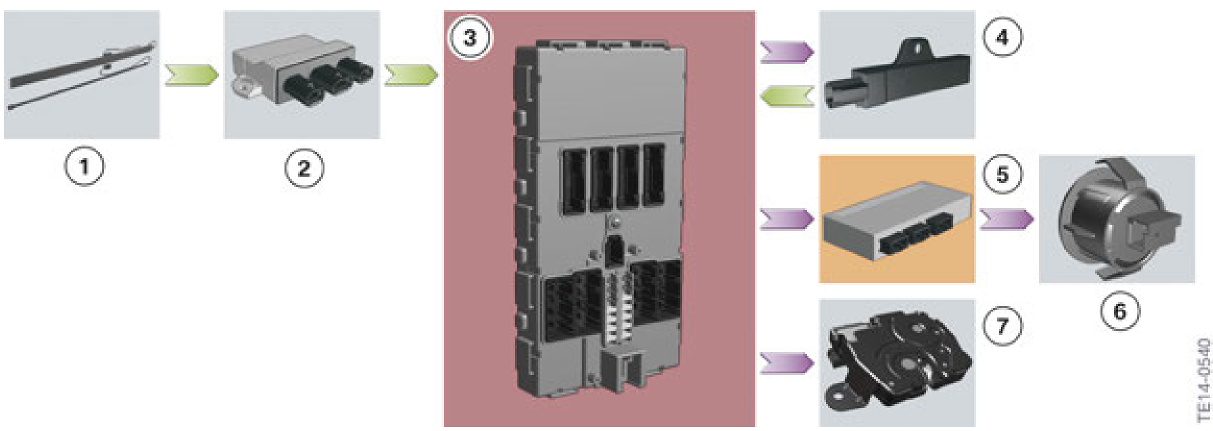


F48 non-contact tailgate opening by foot movement

Index	Explanation
1	Cross-section, rear bumper
2	Evaluation electronics for non-contact tailgate opening
3	Sensor at top for non-contact tailgate opening
4	Sensor at bottom for non-contact tailgate opening

The following components are involved in the function:

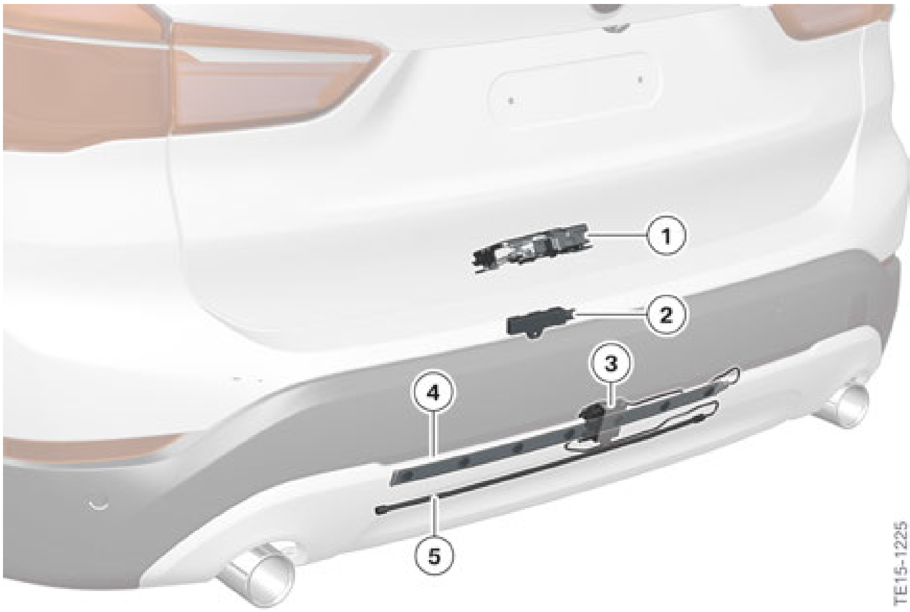
- Body Domain Controller
- Tailgate lock
- Evaluation electronics for non-contact tailgate opening
- Automatic operation of tailgate (HKL)
- Comfort Access antenna, bumper, rear
- Two capacitive sensors
- Acoustic warning device



F48 inputs/outputs for non-contact tailgate opening

Index	Explanation
1	Capacitive sensors
2	Evaluation electronics for non-contact tailgate opening
3	Body Domain Controller (BDC)
4	Exterior antenna, rear bumper
5	Automatic operation of tailgate (HKL)
6	Acoustic warning device
7	Tailgate lock

6. Locking and Security Functions



F48 sensors for non-contact tailgate opening

Index	Explanation
1	Tailgate lock
2	Comfort Access antenna, bumper, rear
3	Evaluation electronics for non-contact tailgate opening
4	Sensor at top for non-contact tailgate opening
5	Sensor at bottom for non-contact tailgate opening

The two sensors are connected to the evaluation electronics and constantly measure the capacity. A comparison of the time characteristic of the measured capacities permits the identification of a certain movement pattern.

A targeted foot movement to and from the bumper can be detected herefrom. The top sensor detects the shin, the bottom sensor the toes.

The detection range is between the rear lights.

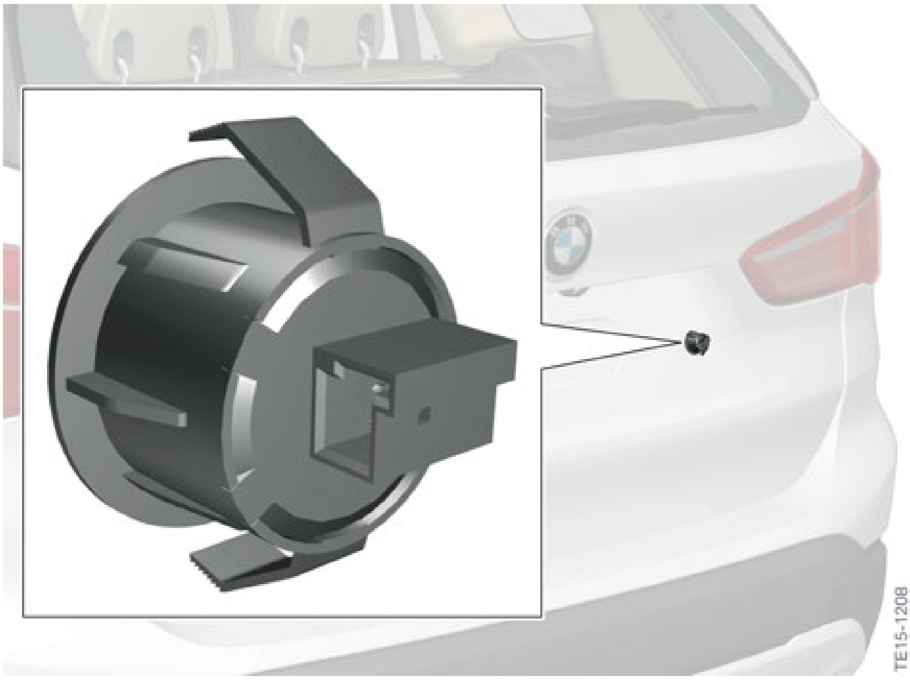
The sensors are secured in the inside of the rear bumper.

The evaluation electronics evaluate the signals from the sensors and make this information available to the BDC via the local interconnect network bus. If there is a valid ID transmitter near the Comfort Access antenna in the rear bumper, the BDC initiates an opening of the tailgate.

The tailgate opens regardless if it was locked or unlocked.

The tailgate of the F48 can also be closed again using the same foot movement as for opening.

With the closing of the tailgate via the non-contact tailgate activation, a sound is output by an acoustic warning device, which is installed in the tailgate.

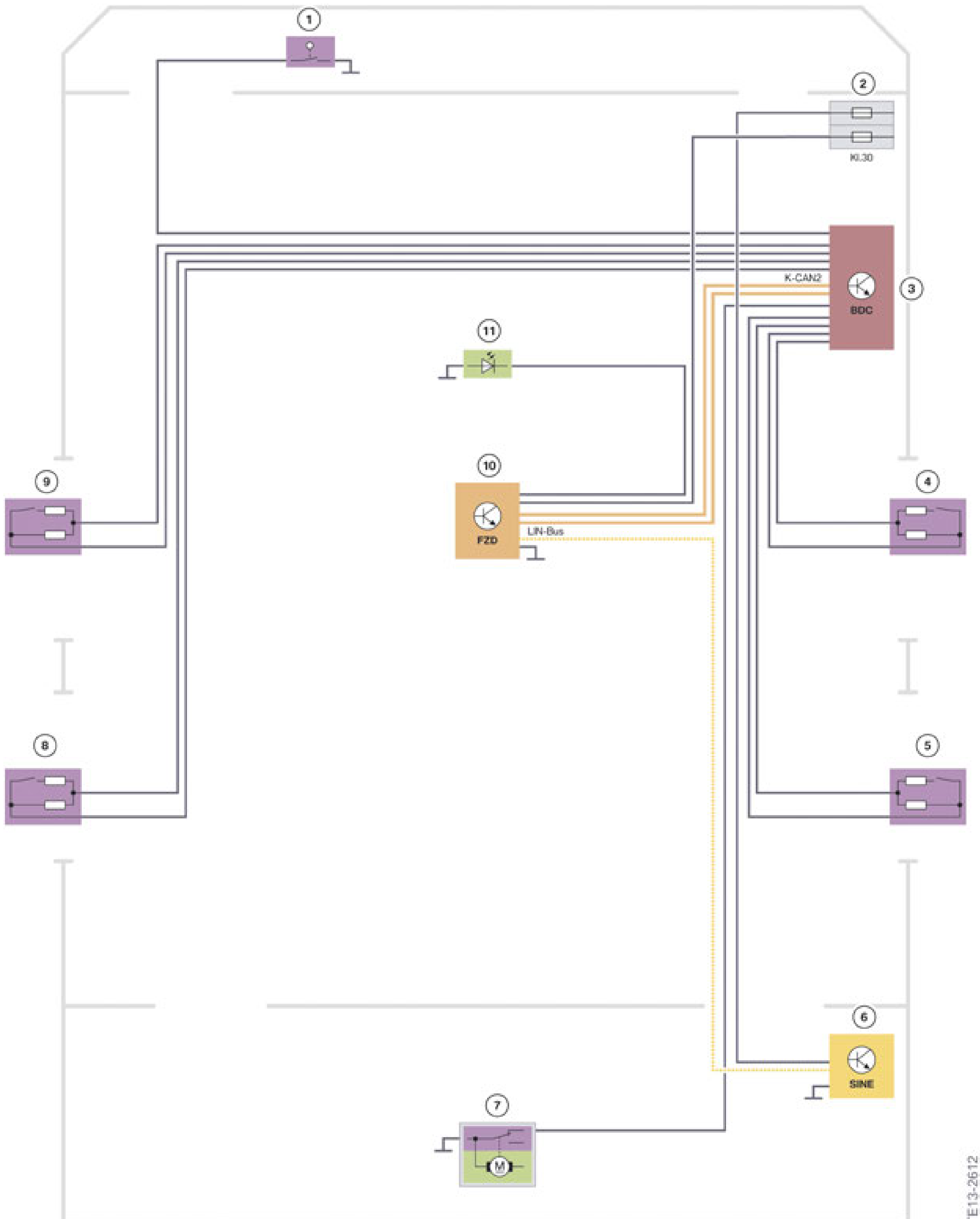


F48 acoustic warning device

F48 General Vehicle Electronics

7. Alarm System

7.1. System wiring diagram



F48 system wiring diagram for alarm system

7. Alarm System

Index	Explanation
1	Engine compartment lid contact switch
2	Fuses in the power distribution box in the passenger compartment
3	Body Domain Controller (BDC)
4	Door contact, passenger's side, front
5	Door contact on passenger's side, rear
6	Siren with tilt alarm sensor
7	Tailgate lock contact
8	Door contact, driver's side, rear
9	Door contact, driver's side, front
10	Roof function center (FZD)
11	LED in the interior mirror

The alarm system in the F48 is optional equipment (SA 302).

The alarm system in the F48 is equipped with an ultrasonic interior movement detector for monitoring the passenger compartment. The ultrasonic interior movement detector (USIS) is fully integrated in the roof function center (FZD).

The door contacts, engine compartment lid switch and the opening of the tailgate are monitored by the Body Domain Controller. As soon as a status changes, the ultrasonic interior movement detector receives this information via the K-CAN2. In the event of an activated alarm system a siren with tilt alarm sensor is activated by the control unit in the event of a break-in.

The SINE is connected to the roof function center via a local interconnect network bus.

⚠

By operating the central locking button on the remote key twice, the tilt sensor and the interior movement detector are deactivated up to the next unlocking process.

The status of the alarm system is displayed via the LED at the interior mirror.

F48 General Vehicle Electronics

8. Wash/Wipe System

8.1. Introduction

The following wipe/wash functions are possible in the F48:

- Intermittent wipes
- Continuous wipe in interval stage 1
- Continuous wipe in interval stage 2
- Flick wipes

Other equipment for the F48:

- Washer jet heating (standard equipment)
- Automatic mode via rain-light-solar-condensation sensor (SA 521)

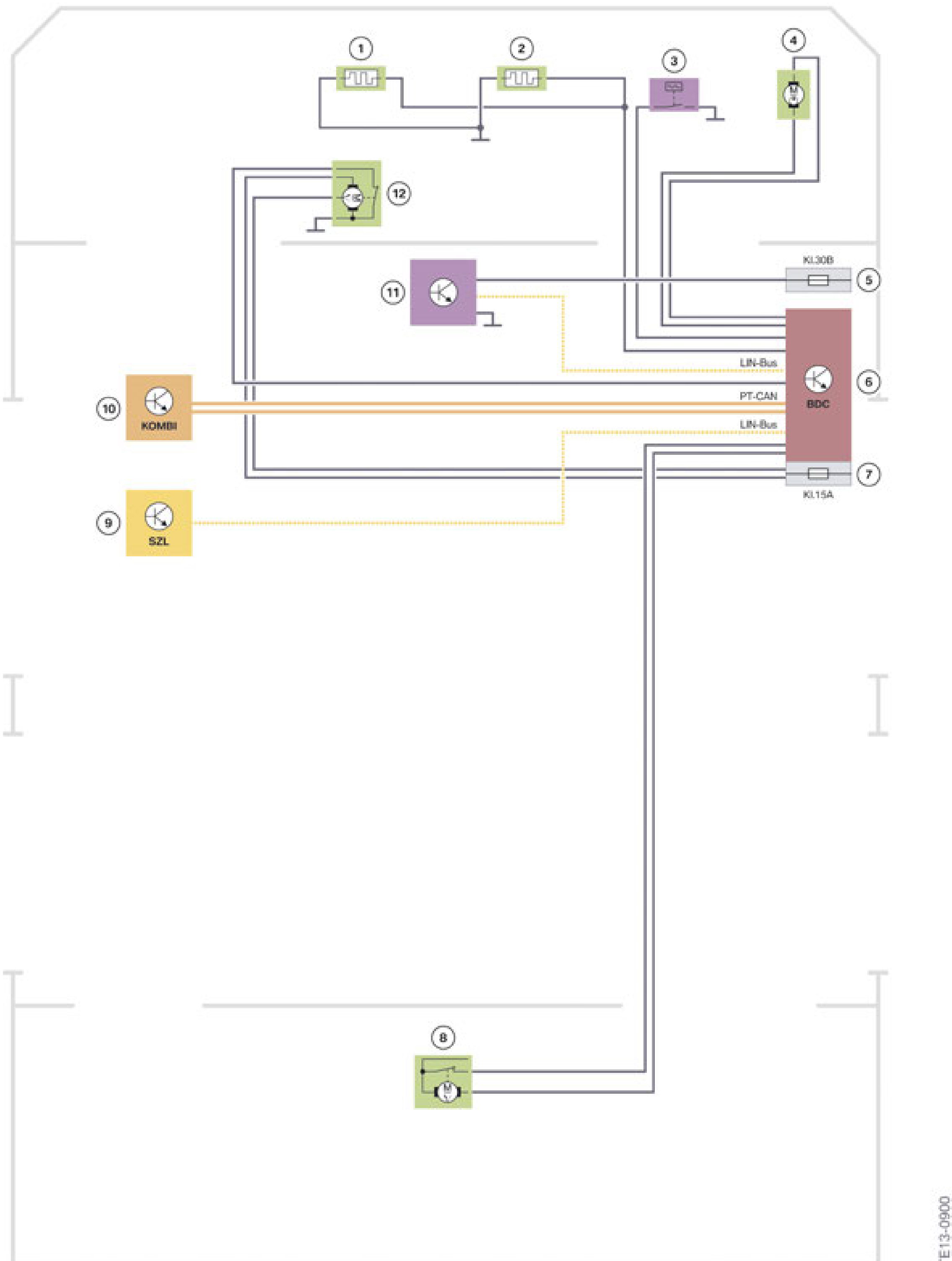
8.2. Operation

The F48 has a newly designed wiper lever. The rear wiper is no longer activated by pressing the complete wiper lever, but using a rotary switch.

F48 wash/wipe switch

Index	Explanation
1	Windscreen wiper, wiper stages
2	Interval setting or for rain sensor (SA 521) sensibility setting
3	Rotary switch for rear window wiper function
4	Automatic button, for rain sensor (SA 521)

8.3. System wiring diagram



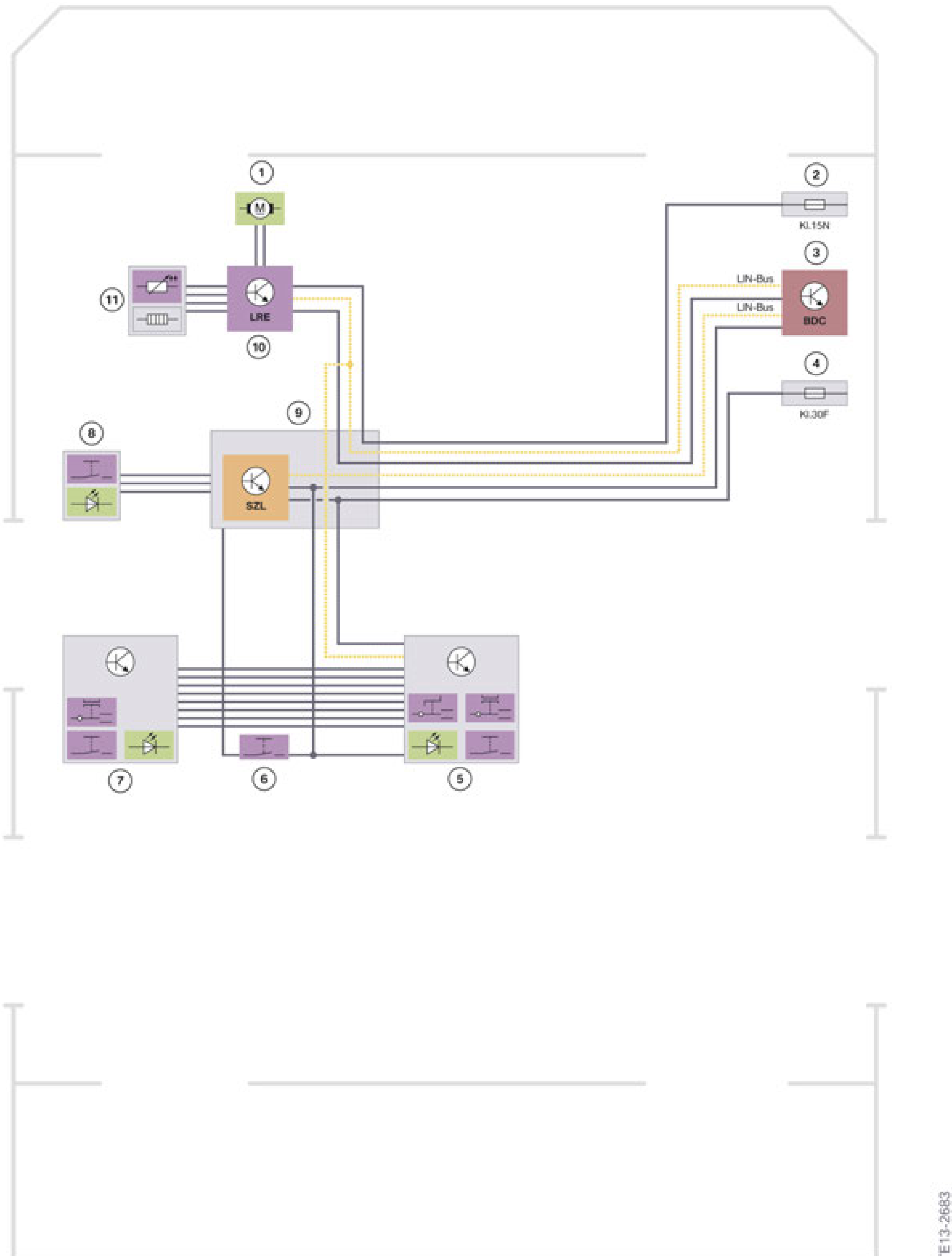
F48 system wiring diagram for wash/wipe system

8. Wash/Wipe System

Index	Explanation
1	Heated washer jet, left (SA 313)
2	Heated washer jet, right (SA 313)
3	Washer fluid level switch
4	Electric motor, windscreen washer pump
5	Fuse in the power distribution box in the passenger compartment
6	Body Domain Controller (BDC)
7	Fuse in the power distribution box Body Domain Controller
8	Wiper motor, rear
9	Steering column switch cluster (SZL)
10	Instrument cluster (KOMBI)
11	Rain-light-solar-condensation sensor (RLSBS)
12	Wiper motor, front

9. Steering Wheel Heating

9.1. System wiring diagram



F48 system wiring diagram for steering wheel heating

9. Steering Wheel Heating

Index	Explanation
1	Vibration actuator
2	Fuse in the power distribution box in the passenger compartment
3	Body Domain Controller (BDC)
4	Fuse in the Body Domain Controller
5	Multifunction steering wheel buttons, right
6	Horn switch
7	Multifunction steering wheel buttons, left
8	Button, steering wheel heating
9	Steering column switch cluster (SZL)
10	Steering wheel module
11	Heating element for the steering wheel heating

The F48 receives a steering wheel heating (SA 248) as optional equipment. The steering wheel heating is only available in conjunction with the leather sports steering wheel (SA 255).

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Technical training.
Product information.

F48 Driver Assistance Systems

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General information

Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:

⚠

Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

Information status and national-market versions

BMW Group vehicles meet the requirements of the highest safety and quality standards. Changes in requirements for environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between the contents of this document and the vehicles available in the training course.

This document basically relates to the European version of left-hand drive vehicles. Some operating elements or components are arranged differently in right-hand drive vehicles than shown in the graphics in this document. Further differences may arise as a result of the equipment specification in specific markets or countries.

Additional sources of information

Further information on the individual topics can be found in the following:

- Owner's Handbook
- Integrated Service Technical Application.

Contact: conceptinfo@bmw.de

The information contained in this document forms an integral part of the technical training of the BMW Group and is intended for the trainer and participants in the seminar. Refer to the latest relevant information systems of the BMW Group for any changes/additions to the technical data.

Information status: **June 2015**
BV-72/Technical Training

F48 Driver Assistance Systems
Contents

F48 Driver Assistance Systems
Contents

F48 Driver Assistance Systems

1. Introduction

The assistance systems facilitate driving of the vehicle by:

- providing the driver with information
- giving the driver suggestions or
- automatically intervening in the driving process.

This product information bulletin provides an overview of the assistance systems which are new or whose function has been modified:

- Collision warning with city braking function
- Pedestrian warning with city braking function
- Road sign recognition including no overtaking display
- Park Distance Control
- Parking Maneuver Assistant
- Rear view camera
- Cruise control

In the F48, a lot of the optional equipment known from other BMW models is still only available in conjunction with optional equipment packages Driving Assistant (SA 5AS) or Driving Assistant Plus (SA 5AT). The following table shows which systems are included in the different optional equipment packages:

System	Driving Assistant (SA 5AS)	Driving Assistant Plus (SA 5AT)	Standard equipment
High-beam assistant	X	X	
Lane departure warning	X	X	
Road sign recognition	X	X	
Collision warning with city braking function	X	X	X
Pedestrian warning with city braking function	X	X	
Active Cruise Control		X	

The optional equipment package Driving Assistant (SA 5AS) is an element of the optional equipment package Driving Assistant Plus (SA 5AT).

F48 Driver Assistance Systems

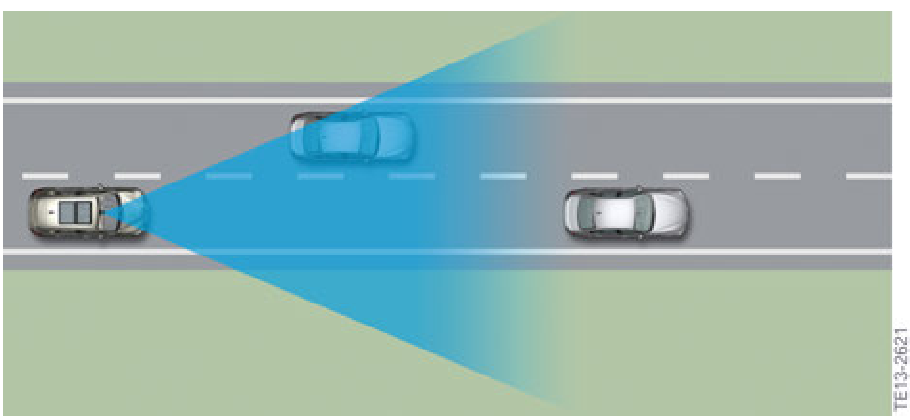
2. KAFAS

The recognition of road users driving ahead and the detection of pedestrians are among the most important functions to be satisfied by assistance systems. This function must be satisfied at both long distance and close range. The functions in the F48 have been implemented in optionally available combinations as camera-based systems using a shared camera and shared control unit.

The KAFAS camera and KAFAS control unit therefore constitute the central element of the following assistance systems:

- Collision warning with city braking function
- Pedestrian warning with city braking function
- Road sign recognition
- Lane departure warning
- Camera-based cruise control

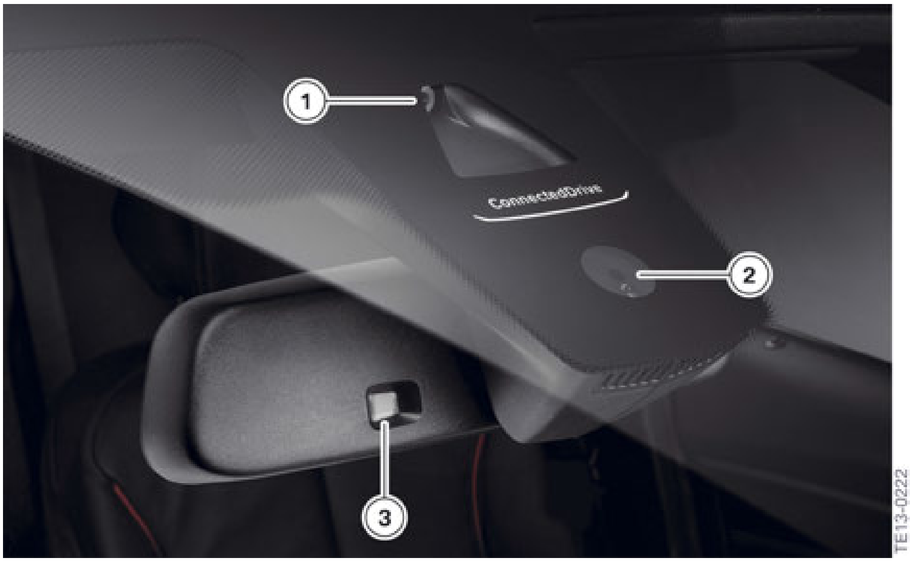
2.1. Person recognition



F48 Detection range of KAFAS camera

The person recognition in the F48 only takes place with the help of the camera-based driver support system. A radar sensor is not offered in the F48, unlike in other BMW models.

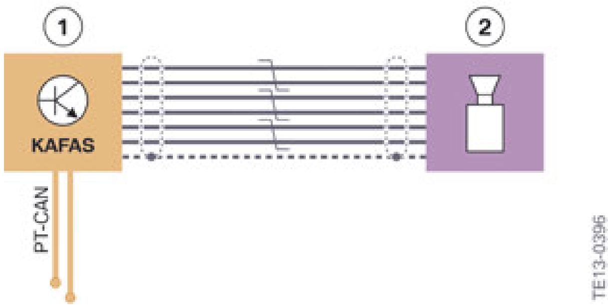
F48 Driver Assistance Systems
2. KAFAS



F48 KAFAS camera

Index	Explanation
1	KAFAS camera
2	Rain-light-solar-condensation sensor
3	Photosensor for electrochromic interior mirror

F48 KAFAS control unit



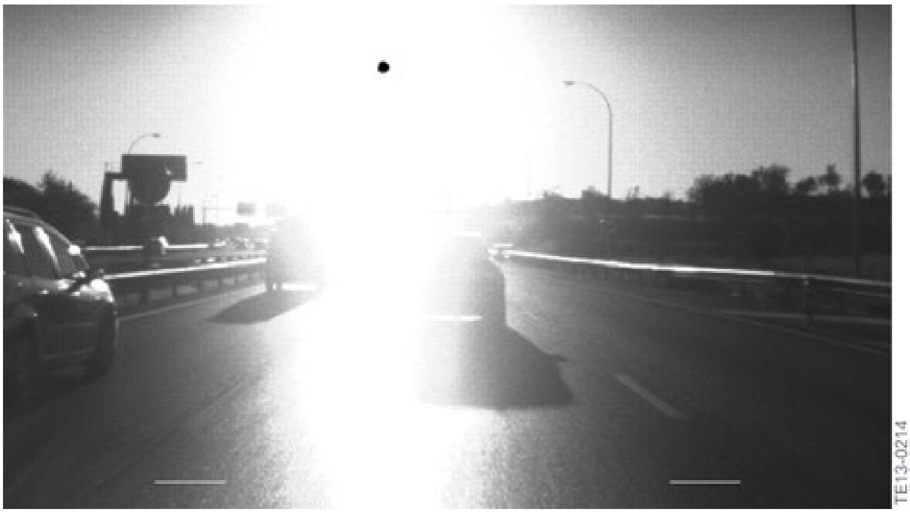
F48 Image transmission via LVDS data line

Index	Explanation
1	KAFAS control unit
2	KAFAS camera

The KAFAS camera captures the scene in front of the vehicle and detects entire rear views of moving and stationary vehicles in the field of view using machine vision. The KAFAS camera also ensures that driving lane information, vehicle positions and movements are determined at the same time.
With the aid of the image data from the KAFAS camera, objects can be clearly identified as vehicles and corresponding transverse movements as lane changes.

F48 Driver Assistance Systems
2. KAFAS

2.2. Functional limitations

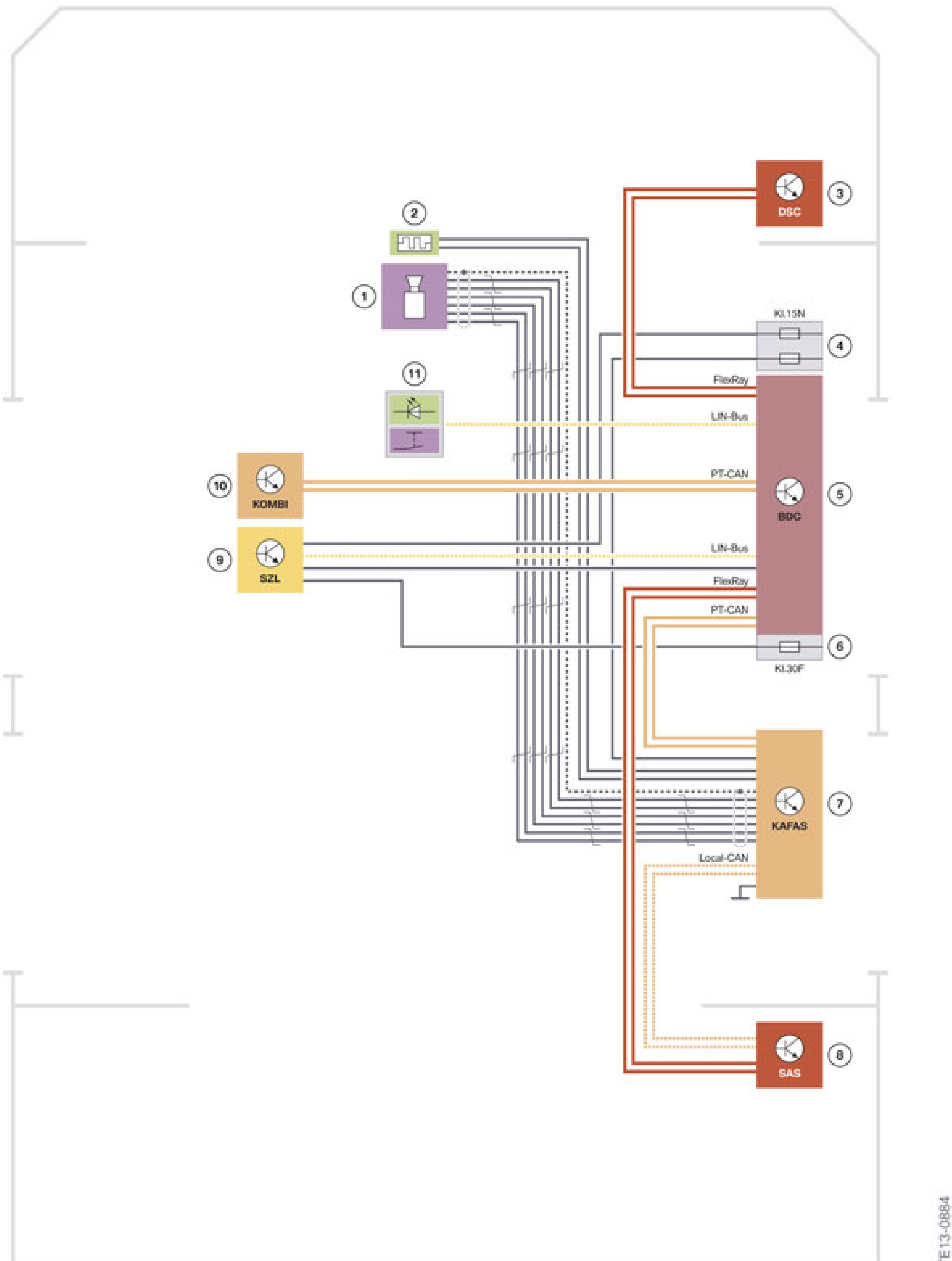


Example of functional limitation by backlight

The function of the KAFAS camera and thus also the function of the corresponding assistance systems may be impaired in the following situations, for example:

- heavy fog, rain, rain spray or snow
- strong backlight
- if the field of view of the KAFAS camera or the windscreen is dirty or covered
- at sharp bends
- up to 10 seconds after the engine start via the START-STOP button
- during the calibration process for the KAFAS camera immediately after vehicle delivery or a camera change

2.3. System wiring diagram



F48 system wiring diagram for KAFAS

F48 Driver Assistance Systems
2. KAFAS

Index	Explanation
1	KAFAS camera
2	Heating, KAFAS camera
3	Dynamic Stability Control (DSC)
4	Fuse in the power distribution box in the passenger compartment
5	Body Domain Controller (BDC)
6	Fuse in the Body Domain Controller
7	Camera-based driver support systems (KAFAS)
8	Optional equipment system (SAS)
9	Steering column switch cluster (SZL)
10	Instrument cluster (KOMBI)
11	Intelligent Safety button

F48 Driver Assistance Systems

3. Road Sign Recognition

With the road sign recognition function, current top speed limitations can be displayed in the instrument cluster and, if applicable, also in the Head-Up Display, in order to avoid possible excess speed.

The road sign recognition is an element of the optional equipment Driving Assistant (SA 5AS).

Depending on the equipment, the function of the road sign recognition may vary:

- Road sign recognition with navigation system
- Road sign recognition without navigation system

⚠

The responsibility for the vehicle and the speed driven lies solely with the driver.

3.1. Operation

The road sign recognition can be switched on and off using a controller. For this purpose, select the following:

1 Settings
2 Instrument cluster
3 Road sign recognition

If the road sign recognition is switched on, the information recorded is shown in the instrument cluster. If a speed limitation symbol with three horizontal lines is displayed in the instrument cluster instead of the max. permissible speed, then the road sign recognition is not available (e.g. in non-mapped areas such as underground car parks and car parks).

3.2. Function

In the F48, the road sign recognition can be ordered from BMW by the customer for the first time **without** the connection to a navigation system. This also makes it possible to offer the function in countries which had to waive this function due to missing navigation data.

3.2.1. Road sign recognition with navigation system

The control unit for the road sign recognition function is the KAFAS control unit.

In addition, the detected top speed limitation is compared using data from the navigation system, in order to avoid incorrect displays and to display a top speed limitation on unmarked roads.

If data on the top speed limitations relating to the current road is stored in the navigation system, this is used by the KAFAS control unit and forms the basis of a possible display for the driver.

Traffic signs containing supplementary information, e.g. "In wet conditions", or symbols are also detected and synchronised with internal vehicle data, e.g. the rain sensor, and displayed depending on the situation. The system also takes the applicable time restrictions which have been identified, e.g. "between 10:00 pm and 6:00 am" into account. Here the current time of the on-board clock and the time from the navigation map are used.

At the same time, the video data from the centrally arranged KAFAS camera which points forward is also evaluated in the KAFAS control unit.

The image data is read by the KAFAS control unit and evaluated for traffic signs relating to speed limitations and withdrawal of speed limitations.

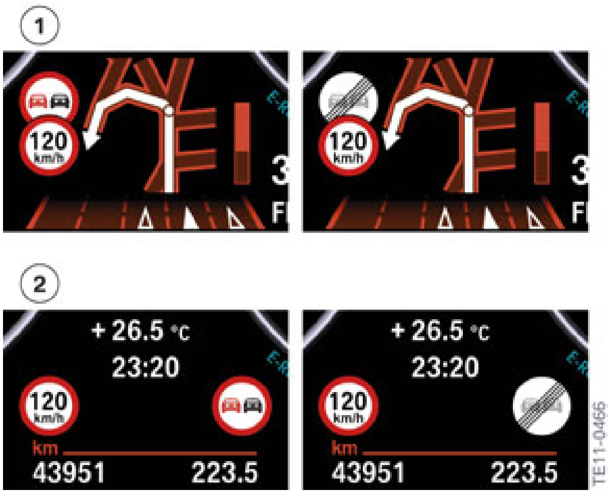
In the case of concealed and non-recognizable signs on the withdrawal of top speed limitations, the displays are cancelled according to the specified time and distance parameters.

In addition to image data, other information from the vehicle electrical system is also used in the evaluation and calculation for the display:

- Time display (for temporal additional conditions)
- Status of wiper (for additional sign "In wet conditions")
- Turn indicator signal (special speed limit, e.g. on motorway exits)
- Status of outside temperature sensor in "Frost/Snow"

The basis of this diverse information leads to relatively high precision of this function in the evaluation.

3. Road Sign Recognition



F48 display of road sign recognition in the instrument cluster

Index	Explanation
1	Displays of road sign recognition during an active navigation display
2	Displays in standard view

Traffic signs for speed limits and for no overtaking, which do not correspond to the legal standard, in particular those without a circular frame, are not always recognized. The same also applies for traffic signs which are fully or partially covered by labels, dirt or vegetation.

Long distances to the road sign, high driving speeds and poor weather conditions, particularly at night, make it more difficult for the system to recognise road signs reliably.

The data from the navigation map must be up-to-date for the correct display of the current speed limit and no overtaking sign. If the current location for the navigation is not yet taken into consideration, for example when driving in development areas, on new roads or on roads with modified road layout, a recognized traffic sign for speed limits or for no overtaking can only be displayed for roughly the next 500 m.

3.3. Limits of the system

Traffic signs on parallel, forking or emerging roads

Parallel roads are not recognized with the KAFAS camera or using the navigation map. Signs on these roads can be recognized and displayed as speed limits or no overtaking for the current road. Speed limits and no passing signs for forking or emerging roads are generally also assumed and displayed for the current road.

Traffic signs at exits

Speed limits for exits off highway with or without an arrow as an additional character are generally evaluated correctly and suppressed in the display if driven past. This is only the case if the data on the navigation map is up-to-date.

In the case of sign gantries on the highway with different, lane-dependent speed limits, the speed limit which is closest to the lane of the vehicle is displayed. There is no adaptation of the display after a later lane change.

Information signs in the road sign surroundings

Information signs with speed limits or no overtaking, such as at border crossing points with information on the different legal speed limits for national roads and highway, may be incorrectly recognized as currently valid and displayed. The same applies to information signs with different color configurations, e.g. for minimum or recommended speeds.

Stickers on vehicles

Labels with a speed limit on vehicles ahead or overtaken, such as trucks, buses, trailers or construction machinery, etc., may be incorrectly recognized as a currently valid speed limit and displayed.

Town/city limits

If the sign for the entrance to a village/town is not clearly recognized (detection is only possible in Germany) and the data from the navigation map is not up-to-date, the speed limit at the entrances to and exits from villages/towns may be displayed incorrectly.

Legal changes

If legally prescribed maximum speeds change, then these are only available after a map data update. Up until the update the original, but no longer valid speed limits are displayed.

General no passing signs

No overtaking signs are only displayed if these are also signs posted. General no overtaking, which applies for example at level crossings or is marked by a white line on the roadway, is not displayed without an additional sign.

F48 Driver Assistance Systems

4. Camera-based Collision Warning

The collision warning warns the driver of a possible risk of collision and is recognized in the F48 using the KAFAS system. The camera-based collision warning includes the following functions:

- Collision warning with city braking function
- Pedestrian warning with city braking function

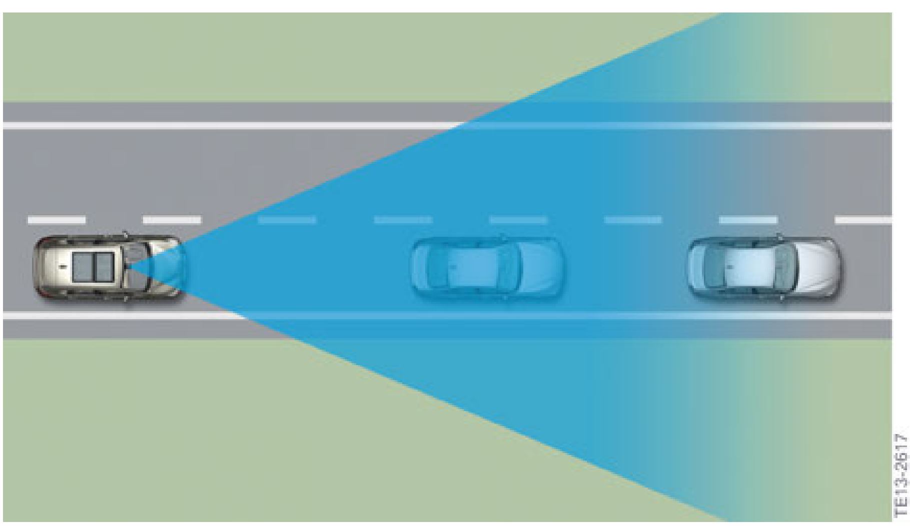
The collision warning with city braking function is already included in the standard equipment of the F48. The pedestrian warning with city braking function is an element of the optional equipment Driving Assistant (SA 5AS).

The system can warn the driver in situations where a collision is imminent. The **early warning**, a visual signal, is issued first to draw the driver's attention to the situation. If the situation becomes more critical, an **acute warning** in the form of a visual and acoustic signal is issued. The nature of the warning is such that the driver can still prevent a collision providing he acts quickly. If there is no reaction from the driver after an acute warning, the driver is supported with automatic braking of the vehicle (5-85 km/h).

4.1. Collision warning with city braking function

4.1.1. Functional principle

The corresponding warning stages "early warning" and "acute warning" are output in critical situations on the basis of the calculated positions, distances and relative speeds of other vehicles. For the early warning and acute warning, the brakes of the vehicle are prepared for emergency braking, depending on the actual speed, and the activation thresholds of the brake assistant are reduced.



F48 Detection range of collision warning by KAFAS camera

4. Camera-based Collision Warning

4.1.2. Early warning

The early warning works from a speed of approximately 15 km/h.

The early warning is issued, for example, if there is a danger of collision because the vehicle driving ahead is being driven at a much slower speed and/or if the distance to a vehicle ahead is extremely short.

The early warning is indicated by a vehicle symbol which lights up red in the instrument cluster.

The early warning can be configured using the controller ("early", "middle" or "late"). The "late" setting corresponds to a deactivated early warning, for this reason, only the acute warning is active for an immediate risk of collision due to a high differential speed.

⚠

The collision warning is dependent on the vehicle's own driving speed. The distance measured for the collision warning is significantly lower than the legally required minimum distance. It is therefore the responsibility of the driver to adhere to the legal minimum distance.

4.1.3. Acute warning

The acute warning works from a speed of approximately 15 km/h and is issued by the system as late as possible and only if there is an imminent danger of a collision when the vehicle is approaching the vehicle driving ahead at a relatively high differential speed or if there is an imminent danger of a collision with a pedestrian. The time of the acute warning is measured so that a collision can only be avoided by immediate emergency braking or by swerving. The acute warning can therefore not be introduced or controlled intentionally.

If the vehicle is, for example, approaching the vehicle driving ahead at very low speed, or is approaching a person, an acute warning is not issued even when the distance is very small. This intentional driving situation only triggers the early warning. This way there are fewer meaningless and annoying acute warnings issued by the system.

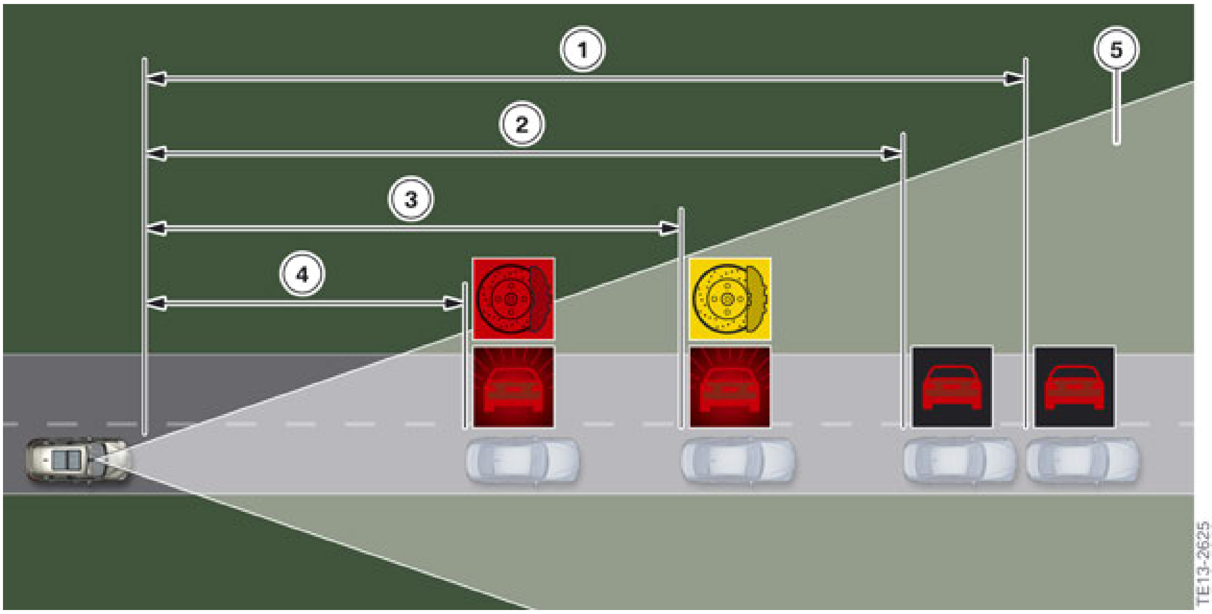
The acute warning cannot be deactivated. The time for the acute warning also cannot be adjusted. If the acute warning is not to be issued, the "collision warning" front protective function must be deactivated.

The acute warning issues a prompt for intervention and is supported if there is a danger of collision by a two-stage intervention. Brake preconditioning is only effected after the driver warning.

⚠

The acute warning does not relieve the driver of his responsibility to adapt the speed and driving style to the traffic conditions and adhere to the prescribed safety distance.

F48 Driver Assistance Systems
4. Camera-based Collision Warning



F48 Time plan for the camera-based collision warning

Index	Explanation
1	Collision warning ("early")
2	Collision warning ("medium")
3	Acute warning (acoustic warning signal, brake system is prepared and brake assistant is adapted)
4	Braking at approximately 4 m/s² is introduced (city braking function only in the range between 5 and 85 km/h)
5	Detection range of KAFAS camera

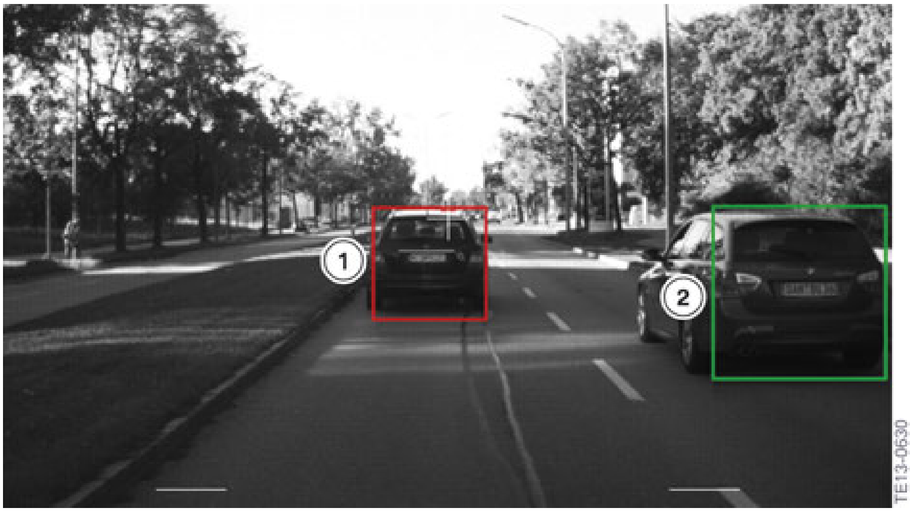
4.1.4. Braking function

The collision warning with city braking function is active from 5-85 km/h. This way the severity of collisions should be reduced through automatic brake intervention up to 85 km/h. With the braking function an accident up to approximately 20 km/h differential speed can be prevented. In the case of a greater differential speed the accident severity can be reduced.

If there is still no response from the driver in this speed range (approximately 5 – 85 km/h) after an acute warning, the vehicle is decelerated at approximately 4 m/s².

The brake intervention is restricted to approximately 1.5 seconds. Additional dangers for the traffic behind are therefore avoided.

The brake intervention is only effected when the Dynamic Stability Control is switched on.



Example of vehicle identification by KAFAS camera

Index	Explanation
1	Vehicle in same lane
2	Vehicle in different lane

4.2. Pedestrian warning with city braking function

The system warns the driver of possible collisions with pedestrians in the 10 and 60 km/h range and can thus reduce the results of an accident or prevent accidents. In addition, braking is automatically introduced.

The pedestrian warning with city braking function is based on the collision warning with braking function. It detects critical situations in which pedestrians cross the path of the vehicle. In the warning stage (acute warning), a pedestrian symbol is displayed in the instrument cluster and an acoustic warning is also issued. The warning stage can be switched on or off using the Intelligent Safety button. The function is always available upon an engine start.

The KAFAS camera captures the scene in front of the vehicle and detects pedestrians in the field of view using machine vision. Based on the calculated positions, distances and the movement of the detected pedestrians, an acute warning is issued in critical situations and the vehicle is decelerated at approximately 4 m/s².

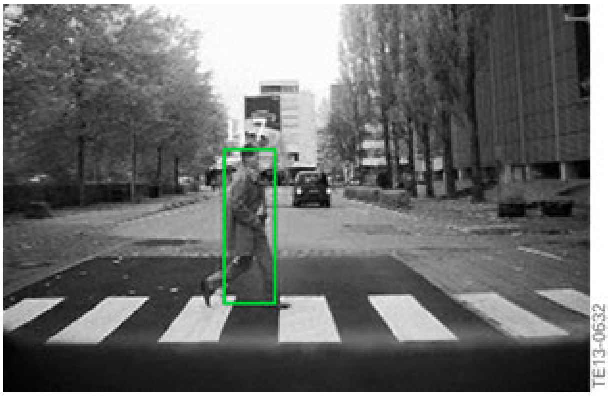
The brake intervention is restricted to approximately 1.5 seconds. Additional dangers for the traffic behind are therefore avoided.

An early warning is not available for the pedestrian warning with city braking function.

The brake intervention is only performed when the Dynamic Stability Control is switched on.

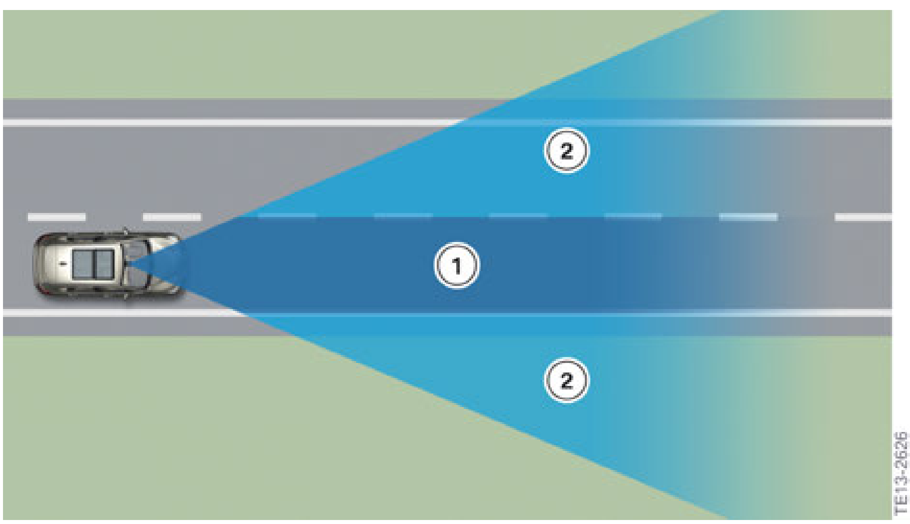
F48 Driver Assistance Systems

4. Camera-based Collision Warning



Example of person recognition by KAFAS camera

The warning zone for person recognition in front of the vehicle is subdivided into two areas. The central area (ahead of the vehicle) and the additional area (to the left and right in front of the vehicle).



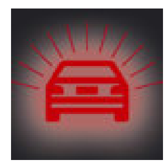
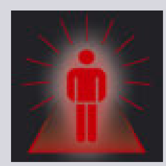
F48 Warning zone, person recognition

Index	Explanation
1	Central area
2	Extended area

A collision is imminent if people are located in the central area. A warning is only issued for people located in the extended area if they are moving in the direction of the central area.

4.3. Warnings in the instrument cluster

The warning function is divided into two stages. If there is a danger of collision, a warning symbol is displayed in the instrument cluster.

System	Speed range	Early warning	Acute warning	Active brake intervention
Collision warning with city braking function	> 85 km/h	 Early warning from approximately 15 km/h		No. The brake system is prefilled and the activation thresholds of the brake assistant are reduced.
Collision warning with city braking function	5-85 km/h	—		4 m/s² for maximum 1.5 seconds
Pedestrian warning with city braking function	10-60 km/h	—		4 m/s² for maximum 1.5 seconds

⚠

The system sensitivity is reduced for intentional tailgating of a vehicle in order to avoid unfounded and therefore annoying warnings.

⚠

The collision warning with city braking function and the pedestrian warning with brake activation function via the KAFAS camera. For this reason, the same functional limitations apply for both systems, like for all KAFAS systems.

4.4. Operation

The collision warning and pedestrian warning functions are switched on automatically after each engine start via the start/stop button.

Switching on/off

The collision warning and pedestrian warning with city braking function, as well as the lane departure warning, are switched on and off via the Intelligent Safety button.

4. Camera-based Collision Warning

TE13-2627

F48 Intelligent Safety button

Index	Explanation
1	Intelligent Safety button

Press button:

- A board on the Central Information Display (CID) is displayed on which the settings can be performed. The individual settings are stored for the ID transmitter currently used.

Press button briefly:

- Intelligent Safety systems are switched off individually depending on the Personal Profile.
- The LED in the Intelligent Safety button lights up orange or goes out, depending on the Personal Profile.

Press button again:

- All Intelligent Safety systems are switched on.
- The LED in the Intelligent Safety button lights up green.

Press and hold button:

- All Intelligent Safety systems are switched off.
- The LED in the Intelligent Safety button goes out.

Adjusting the warning time:

The driver can set the time for the warning in three stages when the collision warning is active. The "late" setting corresponds to the point of the acute warning.

F48 Driver Assistance Systems

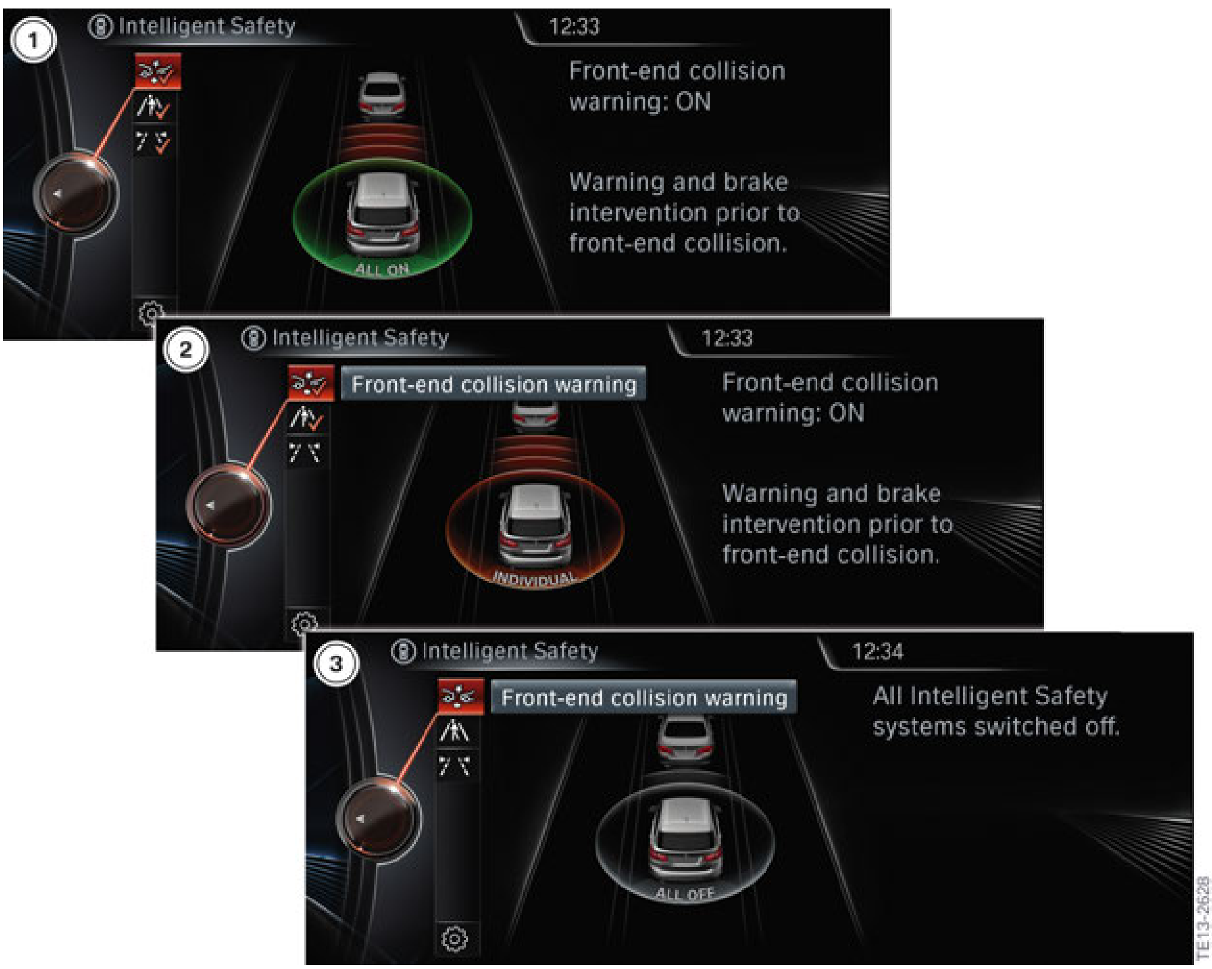
4. Camera-based Collision Warning

The setting is made via the controller:

- "Settings"
- "Collision warning"
- Set the required warning time using the controller at the Central Information Display (CID).

The setting for the time of the early warning is saved for the current driver profile or for the ID transmitter currently used.

4.5. Displays



F48 Intelligent Safety displays

Index	Explanation
1	All systems active
2	Systems are individually adjusted
3	All systems deactivated

4.6. Limits of the system

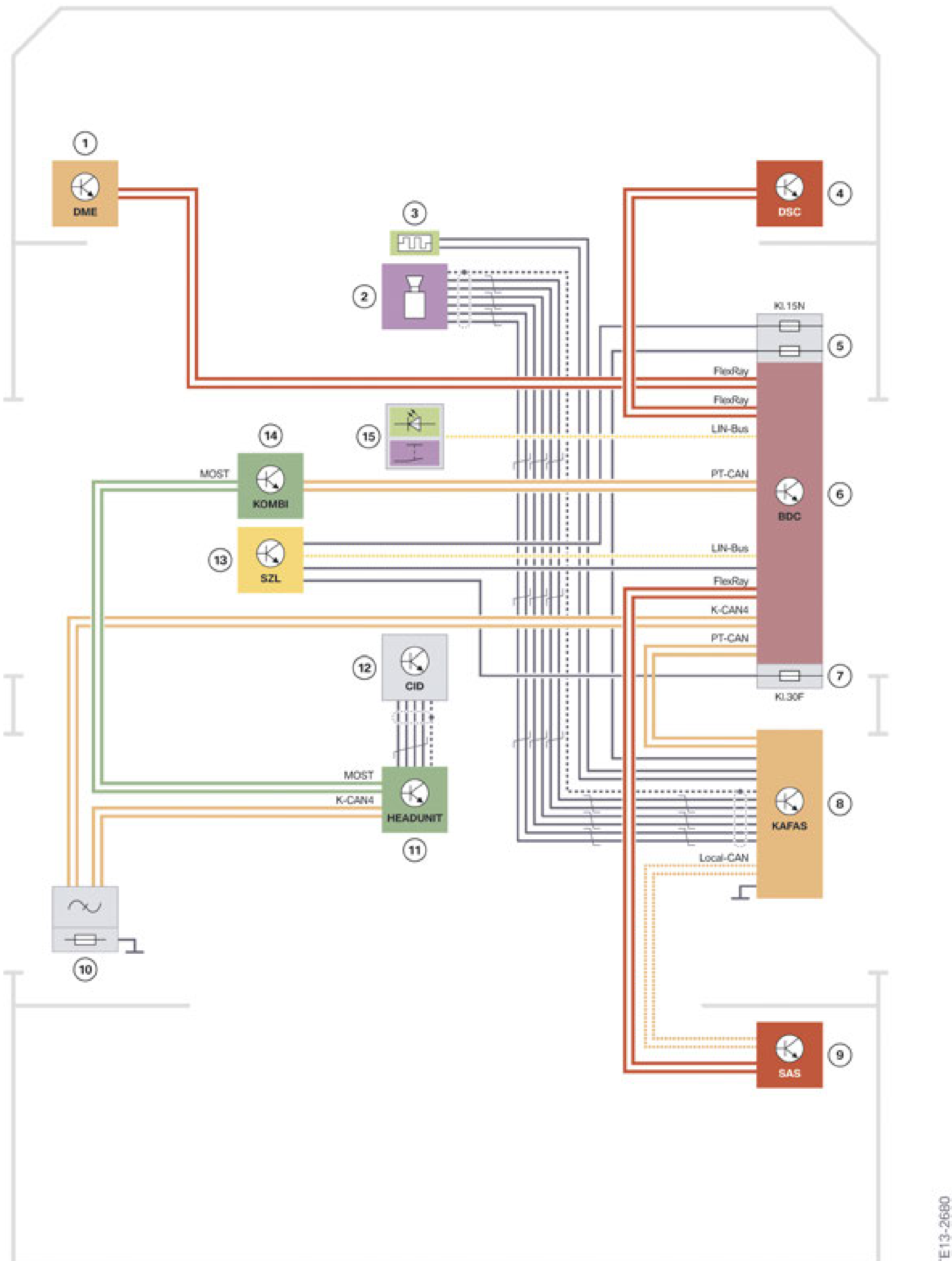
⚠

The collision warning has a limited capacity for detection. As a result, incorrect or delayed warnings may occur.

It is possible the following vehicles are not detected:

- a slower vehicle when driving off at high speed
- sudden swerving or heavy decelerating vehicles
- vehicles with an unusual rear view or with insufficiently visible rear lights
- partially covered vehicles
- bicycles ahead.

4.7. System wiring diagram



F48 system wiring diagram for camera-based collision warning

F48 Driver Assistance Systems
4. Camera-based Collision Warning

Index	Explanation
1	Digital Motor Electronics (DME)
2	KAFAS camera
3	Heating, KAFAS camera
4	Dynamic Stability Control (DSC)
5	Fuses in the power distribution box in the passenger compartment
6	Body Domain Controller (BDC)
7	Fuse in the Body Domain Controller
8	Camera-based driver support systems (KAFAS)
9	Optional equipment system (SAS)
10	K-CAN terminator
11	Headunit
12	Central information display (CID)
13	Steering column switch cluster (SZL)
14	Instrument cluster (KOMBI)
15	Intelligent Safety button

F48 Driver Assistance Systems

5. Park Distance Control

The optional equipment Park Distance Control is available in two versions. In the following table you see where and how many ultrasonic sensors are installed with the respective optional equipment:

Optional equipment	sensors
Park Distance Control (SA 507)	4 sensors in the rear bumper
Park Distance Control (SA 508)	4 sensors in the rear bumper and 4 sensors in the front bumper

Vehicles not equipped with a Parking Maneuver Assistant have their own PDC control unit. The control unit is used instead of the PDC control unit in vehicles with the optional equipment Parking Maneuver Assistant. The PMA control unit then assumes the function of the PDC.

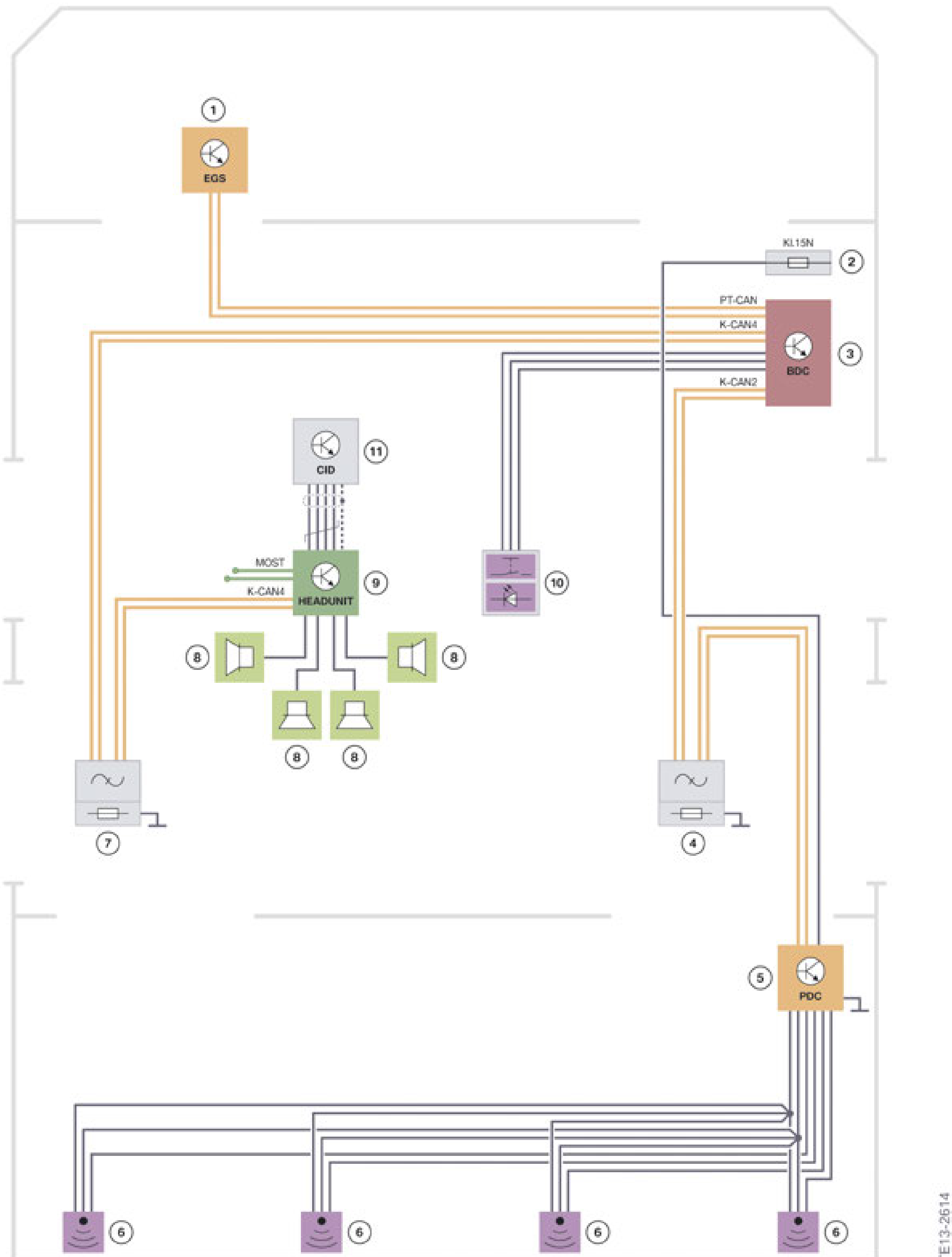
⚠

During the vehicle diagnosis the PDC control unit is always displayed as a PMA control unit.

F48 Driver Assistance Systems

5. Park Distance Control

5.1. System wiring diagram



F48 system wiring diagram for Park Distance Control

F48 Driver Assistance Systems
5. Park Distance Control

Index	Explanation
1	Electronic transmission control (EGS)
2	Fuse in the power distribution box in the passenger compartment
3	Body Domain Controller (BDC)
4	K-CAN terminator
5	Park Distance Control (PDC)
6	Ultrasonic sensors for Park Distance Control, rear
7	K-CAN terminator
8	Speaker
9	Headunit
10	Park Distance Control button
11	Central information display (CID)

5.2. Operation

PDC is automatically switched on in the following situations:

- If when the engine is running the selector lever position R is engaged.
- If with corresponding equipment obstacles are detected at the rear or front of the vehicles by the ultrasonic sensors and the speed is less than 4 km/h (Auto PDC must be active).

The volume of the PDC signal can be adjusted via the central information display.

F48 Park Distance Control volume balancing

5. Park Distance Control

5.2.1. Deactivation criteria

The deactivation criteria are dependent on which optional equipment the F48 has. The following table points out the deactivation criteria of the individual systems:

System	Distance travelled	Speed
Park Distance Control	approximately 50 m	approximately 15 km/h
Parking Maneuver Assistant	—	approximately 35 km/h
Rear view camera	approximately 10 m	approximately 15 km/h

To ensure the ultrasonic sensors remain fully operational, they must be kept clean and free of ice. When cleaning the sensors using a high pressure cleaner, avoid direct and sustained contact with a high-pressure water jet. Furthermore, when using high pressure cleaners, a distance of at least 30 cm from the sensors must be maintained.

5.3. Auto PDC

PDC is automatically activated with the Auto PDC function:

- if there is an object closer than 60 cm to the front of the vehicle when driving forwards.
- if there is an object closer than 1.5 m to the rear of the vehicle when reversing.
- if the speed driven does not exceed 4 km/h.

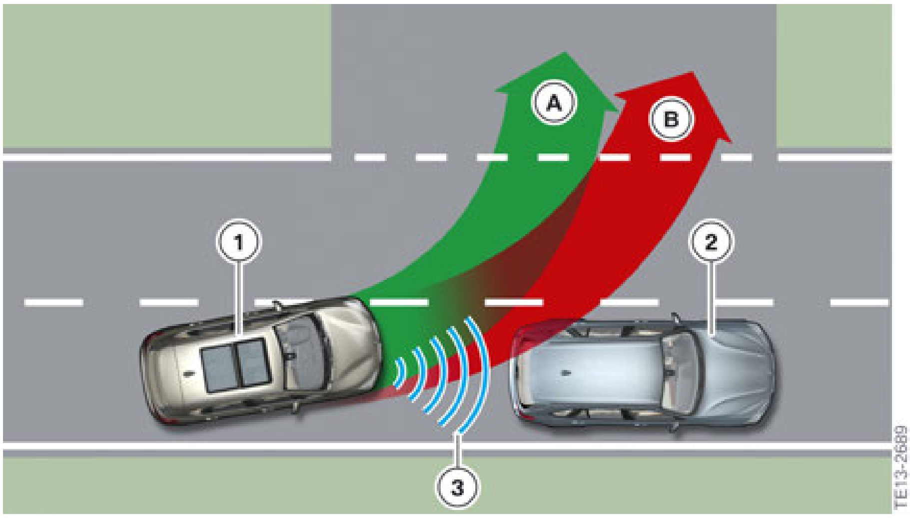
The automatic switching-on upon the identification of obstructions can be switched on and off in the "Settings" menu using a controller. The settings are stored for the ID transmitter currently used.

TE13-0866

F48 Auto PDC

A sound is only output if the detected object (in front of or behind the vehicle) is directly in the lane (risk of collision). If the detected object is not directly in the lane, the acknowledgement is only done visually in the CID.

5. Park Distance Control



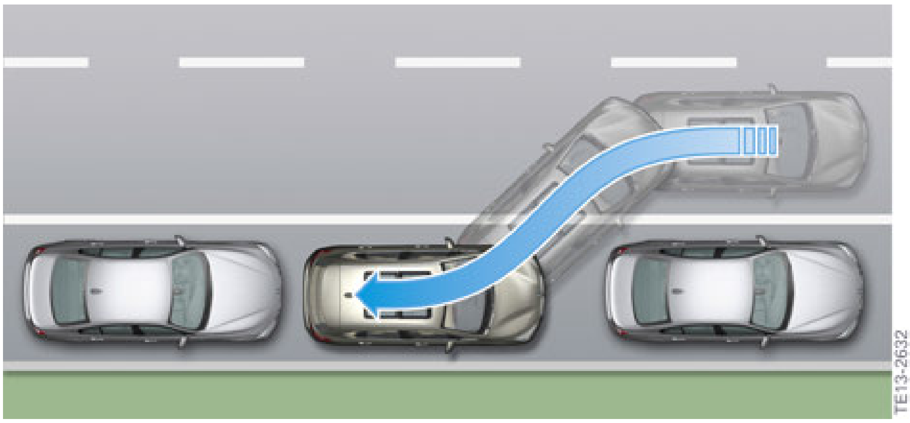
F48 Person recognition

Index	Explanation
A	Lane without object contact (visual acknowledgement in the CID)
B	Lane with object contact (visual and acoustic acknowledgement)
1	Turning vehicle
2	Detected object
3	Detection of obstacle by the PDC sensors

F48 Driver Assistance Systems

6. Parking Maneuver Assistant

6.1. Introduction



F48 Principle of Parking maneuver Assistant

The optional equipment Parking Assistance Package comprises the following elements:

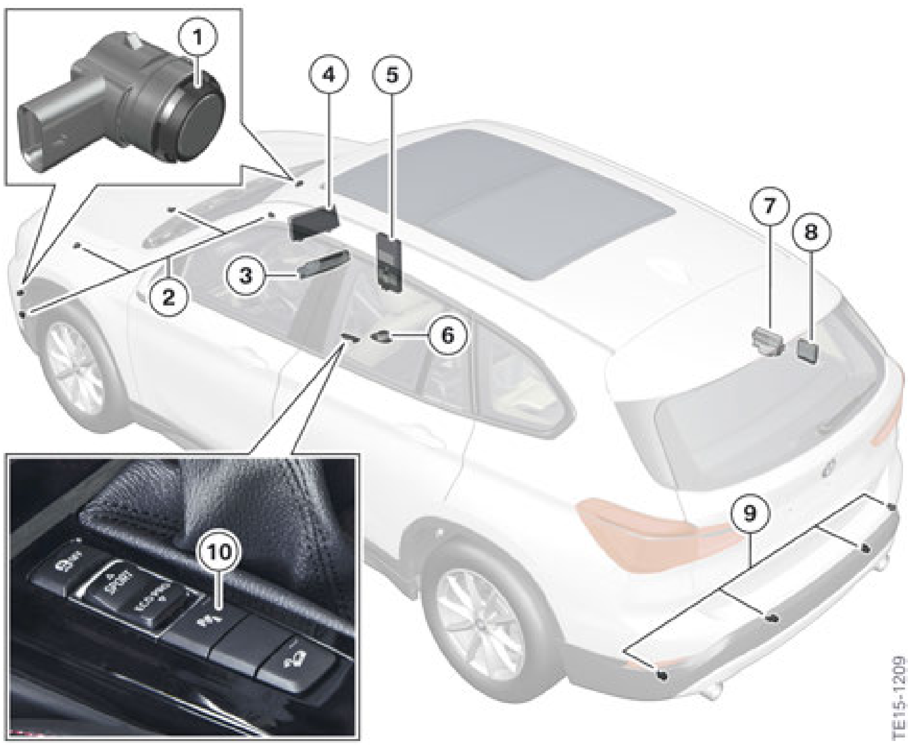
- Park Distance Control, rear (4 sensors) (SA 507)
- Park Distance Control, front (4 sensors) (SA 508)
- Parking Maneuver Assistant with 2 additional sensors in the wheel arch panel

The Parking Maneuver Assistant only facilitates parking in gaps between cars parallel to the roadway.

F48 Driver Assistance Systems
6. Parking Maneuver Assistant

6.2. System components

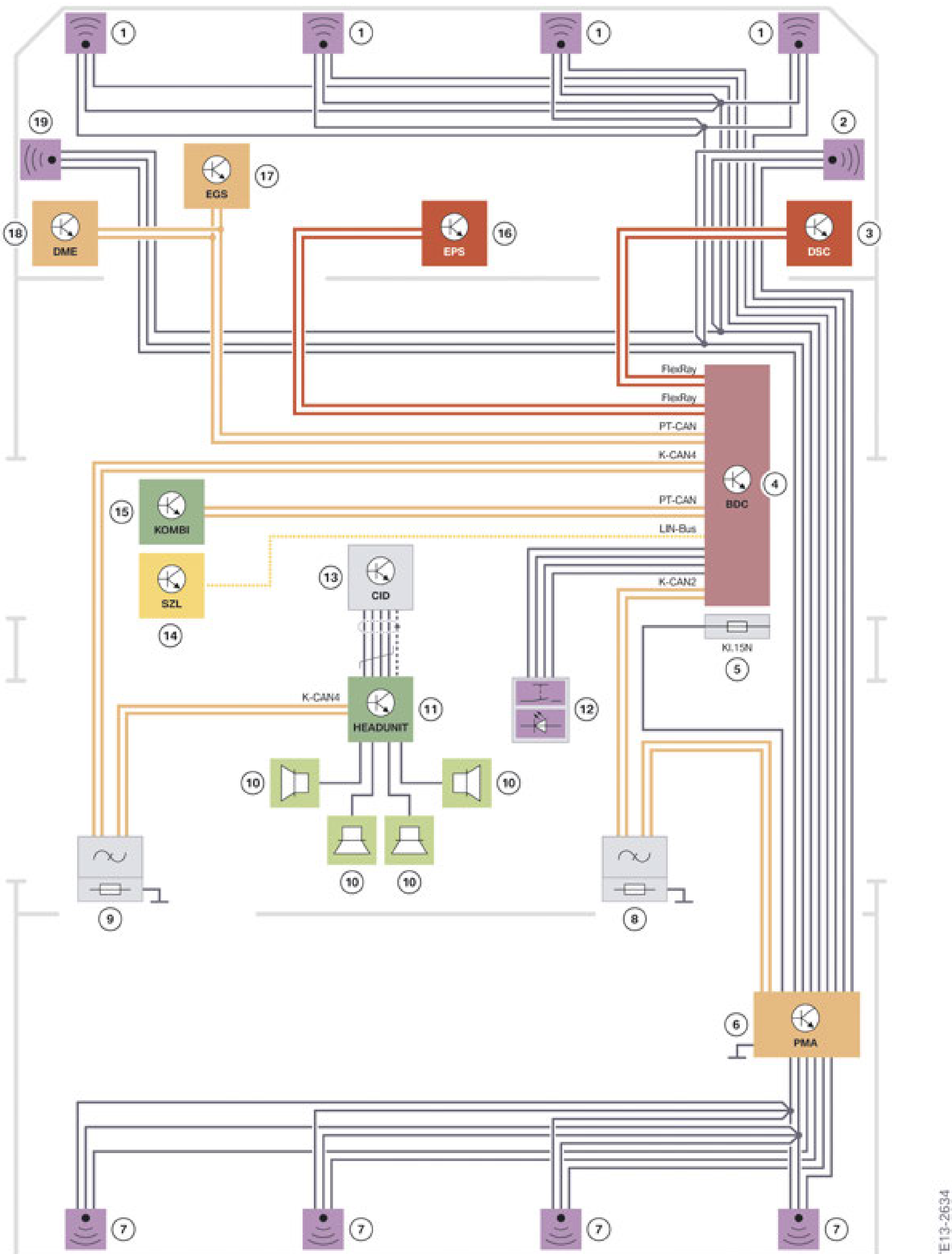
Vehicles with the optional equipment Parking Assistant Package (SA 5DU) also obtain four additional ultrasonic sensors in the front bumper, as well as the rear ultrasonic sensors known from the PDC. For the detection of the parking space, the Parking Maneuver Assistant requires two additional ultrasonic sensors at the side, which can detect the parking space on the left or right of the vehicle when driving by. The ultrasonic sensors of the Parking Maneuver Assistant are installed in the wheel arch panels at the front left and right.



F48 System components of Parking maneuver Assistant

Index	Explanation
1	Ultrasonic sensors at the side (for Parking maneuver Assistant)
2	Ultrasonic sensors, front
3	Headunit
4	Central information display (CID)
5	Body Domain Controller (BDC)
6	Controller (CON)
7	Optional equipment system (SAS)
8	Parking maneuver Assistant (PMA)
9	Ultrasonic sensors, rear
10	Park Distance Control button

6.3. System wiring diagram



F48 system wiring diagram for Parking maneuver Assistant

6. Parking Maneuver Assistant

Index	Explanation
1	Ultrasonic sensors, front
2	Ultrasonic sensor, right (for Parking Maneuver Assistant)
3	Dynamic Stability Control (DSC)
4	Body Domain Controller (BDC)
5	Fuse in the power distribution box in the passenger compartment
6	Parking Maneuver Assistant (PMA)
7	Ultrasonic sensors, rear
8	K-CAN terminator
9	K-CAN terminator
10	Speaker
11	Headunit
12	Park Distance Control button (Parking Maneuver Assistant)
13	Central information display (CID)
14	Steering column switch cluster (SZL)
15	Instrument cluster (KOMBI)
16	Electronic Power Steering (EPS)
17	Electronic transmission control (EGS)
18	Digital Motor Electronics (DME)
19	Ultrasonic sensor, left (for Parking maneuver Assistant)

6. Parking Maneuver Assistant

6.4. Control unit

F48 Parking maneuver Assistant control unit

The Parking Maneuver Assistant control unit evaluates the signals of the ultrasonic sensors and calculates the length of a parking space based on the distance information from the DSC. It also calculates the optimum path into a parking space and monitors the parking procedure.

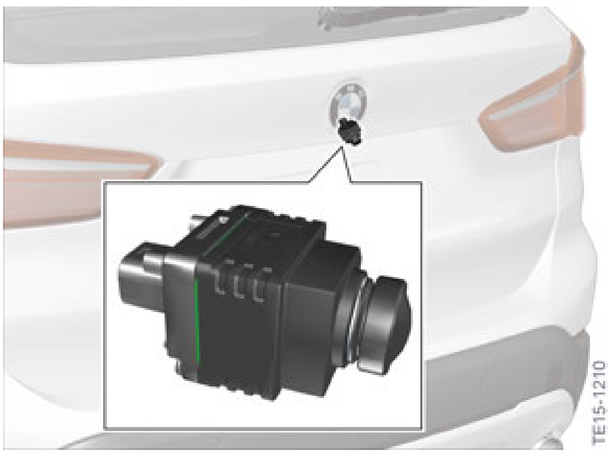
F48 Driver Assistance Systems

7. Rear View Camera

The main function of the rear view camera system is the optical detection of a wide-angled view of the rear area of the vehicle in order to offer the driver additional support during the parking process or maneuver. The image is forwarded from the rear view camera via a CVBS line to the headunit.

The image from the rear view camera is displayed with additional auxiliary lines in the CID.

7.1. System components



F48 Control unit for the rear view camera

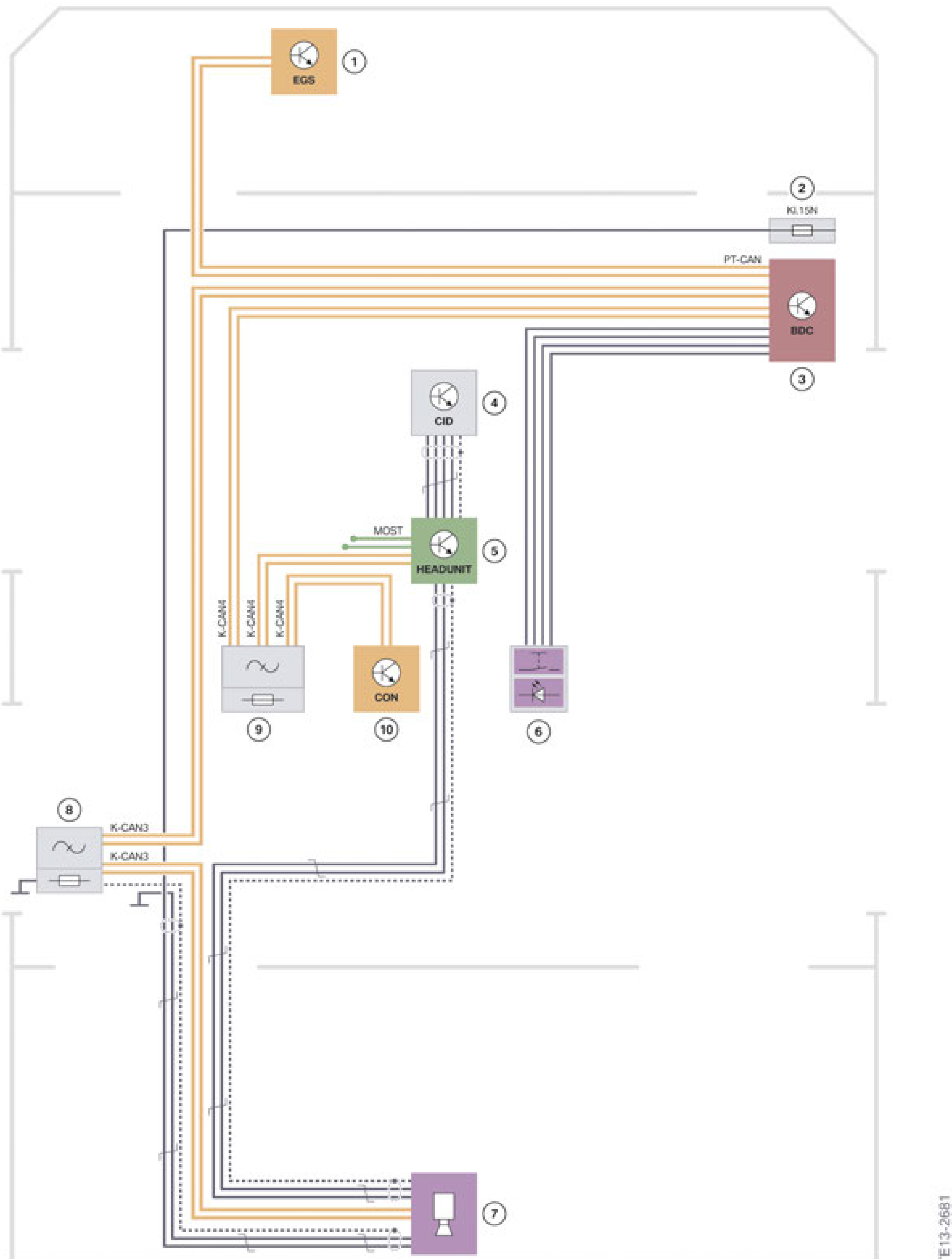
The lens of the rear view camera is located in the handle strip of the tailgate.

The top rear side view camera control unit is integrated in the housing of the rear view camera.

The new camera must be taught in after the rear view camera is replaced. The rear view camera of the F48 does not need to be calibrated after teaching-in, as it is self-calibrating. The calibration is effected during the journey by the TRSVC control unit by means of a steering angle sensor and known road markings. Calibration compensates for installation tolerances by shifting and rotating the image.
The maximum time required for a full calibration is five hours. A Check Control message is displayed in the CID if the rear view camera could not be successfully calibrated. Reasons for failed calibration may be incorrect installation, dirt contamination or a defect with the rear view camera. The rear view camera is also constantly readjusted after a full calibration in order to ensure an optimum image.

7. Rear View Camera

7.2. System wiring diagram



F48 System wiring diagram for rear view camera

F48 Driver Assistance Systems

7. Rear View Camera

Index	Explanation
1	Electronic transmission control (EGS) (for vehicles with automatic transmission)
2	Fuse in the power distribution box in the passenger compartment
3	Body Domain Controller (BDC)
4	Central information display (CID)
5	Headunit
6	Park Distance Control button
7	Rear view camera (RFK)
8	K-CAN terminator
9	K-CAN terminator
10	Controller (CON)

8. Cruise Control

8.1. Introduction

Two cruise controls are offered for the F48. The customer can choose between the optional equipment DCC cruise control with braking function and the optional equipment ACC active cruise control.

The DCC is an element of the optional equipment Driving Assistant Plus (SA 5AT), or can be ordered as separate optional equipment (SA 544).

The ACC Stop & Go function was extended with the traffic jam assistant function. The traffic jam assistant is described in more detail in chapter 9 "Traffic jam assistant".

⚠

The speed control systems support the driver with adapting his speed, distance and driving style to the traffic conditions but do not relieve him of this responsibility. The driver may need to actively intervene, e.g. by braking, steering or taking evasive action, as otherwise there is a risk of an accident.

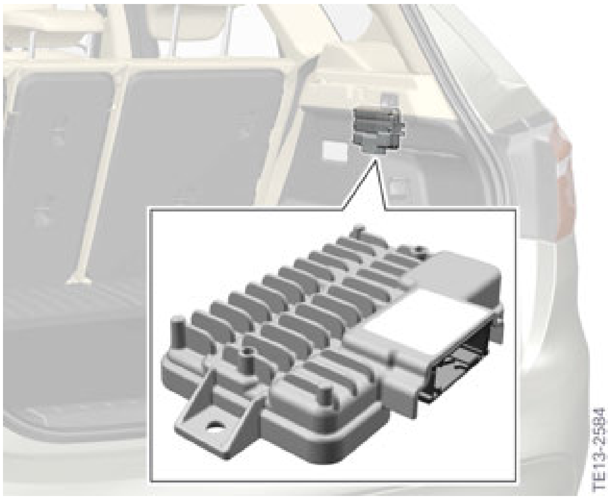
8.2. Cruise control with braking function

The cruise control with braking function (SA 544) is used in the F48 as optional equipment.
The system is also referred to as "Dynamic Cruise Control". Dynamic Cruise Control supports the driver on roads with less traffic by keeping the speed constant irrespective of the rolling resistances (incline, vehicle load). In spite of the support, the driver remains responsible for control of the vehicle. It is possible to override the DCC function at any time by braking or accelerating the vehicle.

When ECO PRO mode is activated, the cruise control is also adjusted to a consumption-friendly driving style.

Depending on equipment, the calculation is effected in different control units:

- The calculations are performed by the DSC control unit.
- In vehicles that are equipped with an optional equipment system (SAS) due to other optional equipment packages, the calculations are performed in the SAS control unit.

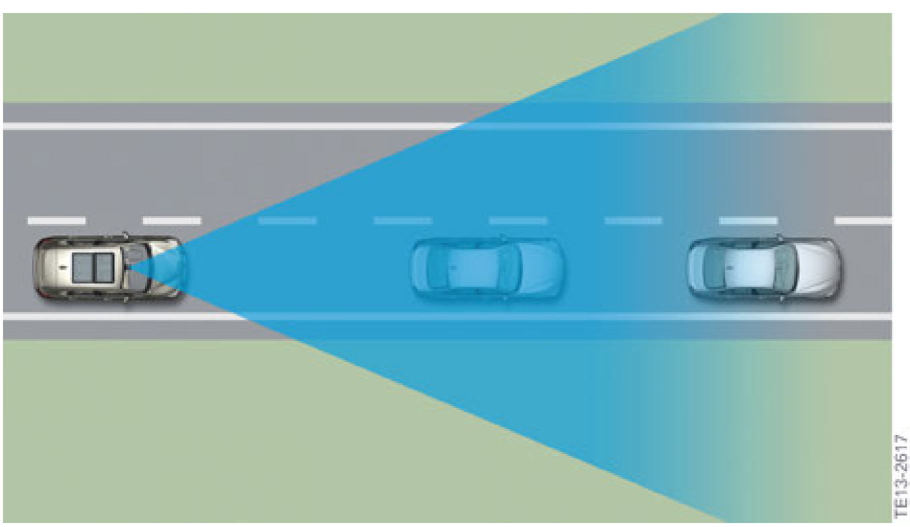


F48 Installation location of optional equipment system

8.3. Camera-based cruise control with Stop&Go function

The active cruise control (ACC) Stop&Go function is an element of the optional equipment Driving Assistant Plus (SA 5AT).

With the ACC Stop&Go function in the F48, there are **no** radar sensors installed for the detection of vehicles ahead. The detection is effected solely via the KAFAS system.



F48 Active Cruise Control detection by KAFAS camera

ACC Stop&Go adjusts a driver-specified desired speed and, if required by the traffic situation, also the preselected trailing distance automatically to the vehicle driving ahead. Passenger cars, trucks and motorbikes are detected as vehicles. The application range of ACC Stop&Go ranges from higher speeds down to a standstill. The distance and the speed are automatically adjusted in this range.

Depending on the stationary time, driving off from a standstill is performed automatically or in response to a prompt by the driver.

ACC Stop&Go detects not only slowly stopping, but also stationary vehicles, and can react to these. The response to transverse movements has been improved and the system can now respond more quickly to vehicles swerving in and out and turning off.

The application range is extended by incorporating the KAFAS camera and the image data is evaluated by the KAFAS control unit. The KAFAS control unit detects vehicles clearly when their rear is identified by the video camera. In addition, the KAFAS control unit ensures that the driving lane information, vehicle positions and movements are determined.

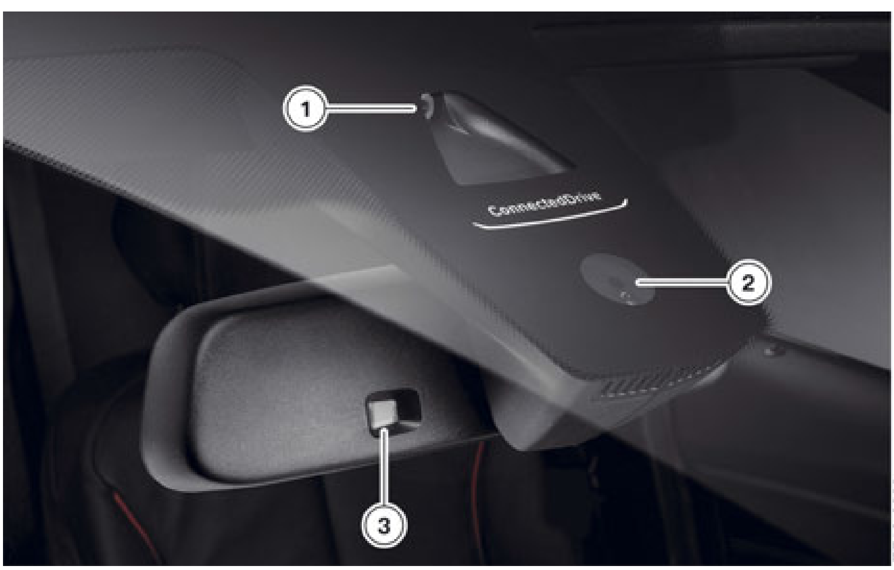
As the ACC Stop&Go in the F48 is a pure camera system without radar sensors, the adjustment range for the set speed was restricted to 140 km/h.

The acceleration behavior of ACC Stop&Go is adapted for ECO PRO mode. In ECO PRO mode, ACC Stop&Go accelerates the vehicle in a fuel-efficient manner.

⚠

If the vehicle ahead drives off again after a standstill, the driver is informed thereof with a note. To drive off again, the driver must acknowledge this information. The acknowledgement is effected by operating the RES button or by briefly touching the accelerator pedal. Only if the duration of the standstill is very short (approximately 3 seconds), is the starting process effected automatically.

8.3.1. KAFAS camera

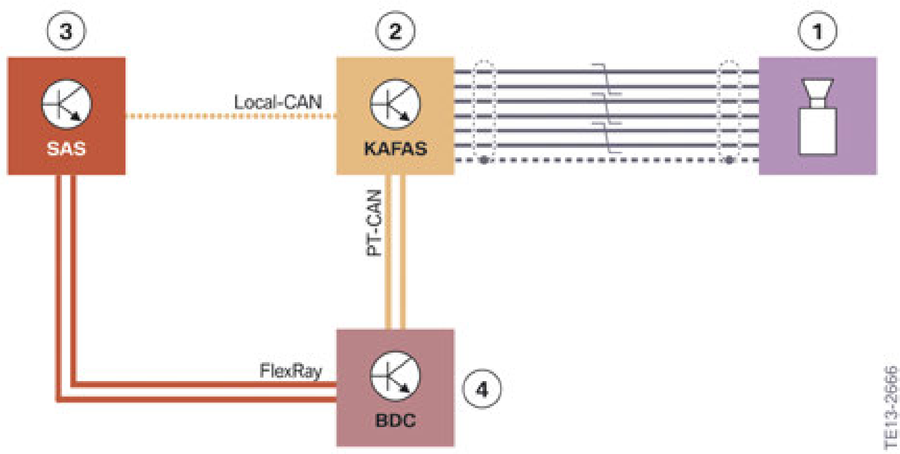


TE13-0222

F48 KAFAS camera

Index	Explanation
1	KAFAS camera
2	Rain-light-solar-condensation sensor
3	Photosensor for electrochromic interior mirror

Connection for KAFAS camera



F48 ACC Stop&Go detection, KAFAS camera

Index	Explanation
1	KAFAS camera
2	Camera-based driver support systems (KAFAS)
3	Optional equipment system (SAS)
4	Body Domain Controller (BDC)

The front camera can detect vehicles ahead at a distance of up to 90 m. Stationary vehicles and vehicles weaving in and out of traffic are also detected early.

As with the front camera it is an optical sensor, the quality of the person recognition and signal accuracy are dependent on the existing weather conditions.

8.3.2. Control function

Vehicles with ACC Stop&Go; element of optional equipment Driving Assistant Plus (SA 5AT):

- The calculations are performed in the optional equipment system (SAS).

Cruise control

In principle, the cruise control in the ACC Stop&Go system works in exactly the same way as the Dynamic Cruise Control (DCC) system.

Distance control (ranging)

The distance control is the core function of the ACC Stop&Go system. The driver can select a desired distance in four stages using a button on the multifunction steering wheel. The optional equipment system calculates the set point distance of the control from this preselection.

The set point distance during the journey is proportional to the driving speed. At a lower driving speed the proportional distance to the driving speed is no longer used for the ACC Stop&Go, but instead a fixed value in metres. The distance control uses the prepared object data with the highest diagnostic statistic as input variables.

Acceleration and deceleration

Depending on the situation, the ACC Stop&Go accelerates the vehicle by a maximum of approximately 2 m/s^2 and decelerates the vehicle by a maximum of approximately 4 m/s^2.

Cruise control on bends

The cruise control of the ACC Stop&Go on bends is based on the control characteristics of the Dynamic Cruise Control (DCC). If an object is lost on bends, the system waits to see whether the object reappears (transition curve). The vehicle only accelerates if it does not reappear or the KAFAS camera no longer detects an object. Depending on the actual lateral acceleration, the speed is reduced in a longitudinal direction during controlled cornering as necessary. When coming out of the bend the speed is adjusted until it once again reaches the desired level.

8.3.3. Display

The set speed is shown in the instrument cluster with digital speed reading. During active control this display is illuminated in green. If the active cruise control is in a "Deactivated" state this display is illuminated in orange. The resume speed is displayed.

Vehicles driving ahead to which a safe trailing distance is observed are displayed in orange in the round instrument as soon as they have been detected and are at a distance relevant for the control. If the system can no longer adjust a safe distance, for example due to very high differential speeds, then the driver is requested to assume the guidance of the vehicle entirely by a flashing red vehicle symbol and an acoustic signal. With active control the messages are also displayed in the optional equipment Head-Up Display HUD (SA 610).

8.3.4. Operation

ACC Stop&Go cannot only be activated by the driver during the journey, but also when the vehicle is at a standstill, if the system detected another vehicle before its own vehicle. To activate ACC Stop&Go at standstill, the driver must press the brake pedal and at the same time press the SET or RES button.

When the system is active the set speed can be adjusted in 1 or 10 km/h increments.

The driver has the option at any time to override the ACC system request and thus accelerate stronger by pressing the accelerator pedal. The system is not activated as a result. The overriding is shown in the instrument cluster by the suppression of the distance bar.

F48 Driver Assistance Systems
8. Cruise Control

The following conditions must also be satisfied for activation:

- Seat belt fastened and door closed
- Drive position D is engaged
- Engine running
- Parking brake not activated
- No system faults detected

The system does not decelerate for:

- pedestrians, cyclists or similar slow road users
- red lights
- cross traffic
- oncoming traffic
- unlit vehicles or vehicles with defective lighting at night

Detection

Many vehicles are not detected or are detected at a late stage. The reason for this may be:

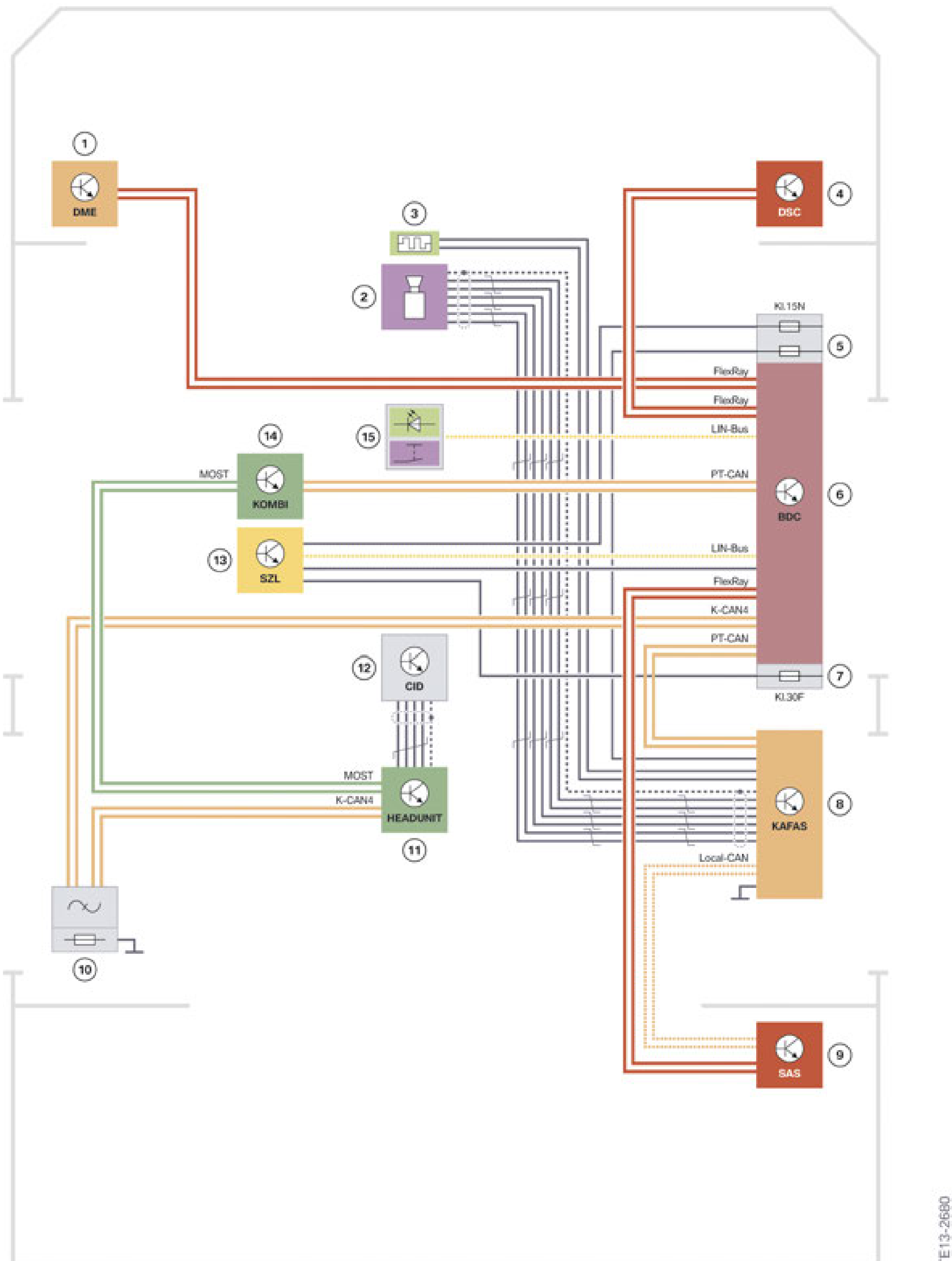
- Vehicles swinging out
  A vehicle ahead is only detected when it is completely in its own lane.
- Cornering
  In narrow bends there may be situations where a vehicle ahead is no longer detected or detected at a significantly later stage due to the restricted detection range of the system.

Malfunction

If the system has a malfunction, the driver is made aware of such with a Check Control message. The reasons for malfunctions may be:

- heavy fog, rain, rain spray or snow
- if the camera field of view or the windscreen is dirty or concealed
- strong back light
- up to 20 seconds after engine starting via the START-STOP button
- when calibrating the camera immediately after vehicle delivery

8.3.5. System wiring diagram



F48 system wiring diagram for active cruise control (ACC) Stop&Go

8. Cruise Control

Index	Explanation
1	Digital Motor Electronics (DME)
2	KAFAS camera
3	Heating, KAFAS camera
4	Dynamic Stability Control (DSC)
5	Fuses in the power distribution box in the passenger compartment
6	Body Domain Controller (BDC)
7	Fuse in the Body Domain Controller
8	Camera-based driver support systems (KAFAS)
9	Optional equipment system (SAS)
10	K-CAN terminator
11	Headunit
12	Central information display (CID)
13	Steering column switch cluster (SZL)
14	Instrument cluster (KOMBI)
15	Intelligent Safety button

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Technical training.
Product information.

F48 Displays and Controls

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BMW Group University
Technical Training
ST1508 8/1/2015

BMW Service

General information

Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:

⚠

Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

Information status and national-market versions

BMW Group vehicles meet the requirements of the highest safety and quality standards. Changes in requirements for environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between the contents of this document and the vehicles available in the training course.

This document basically relates to the European version of left-hand drive vehicles. Some operating elements or components are arranged differently in right-hand drive vehicles than shown in the graphics in this document. Further differences may arise as a result of the equipment specification in specific markets or countries.

Additional sources of information

Further information on the individual topics can be found in the following:

- Owner's Handbook
- Integrated Service Technical Application.

Contact: conceptinfo@bmw.de

The information contained in this document forms an integral part of the technical training of the BMW Group and is intended for the trainer and participants in the seminar. Refer to the latest relevant information systems of the BMW Group for any changes/additions to the technical data.

Information status: **June 2015**
BV-72/Technical Training

F48 Displays and Controls
Contents

F48 Displays and Controls

1. System Overview

Similar to other BMW models, the operating concept of the F48 is designed for clear and optimal structuring of the cockpit. This is achieved primarily through the simplified and logical operation, as well as the clear arrangement of the display and operating elements.

Overview of cockpit of F48

Index	Explanation
1	Instrument cluster (KOMBI)
2	Head-Up Display (HUD)
3	Central information display (CID)
4	Control panel, audio system with favorit buttons
5	Heating/Air-conditioning control panel
6	Dynamic Stability Control button
7	Driving experience switch
8	Park Distance Control button
9	Hill Descent Control button
10	Controller (CON)
11	Parking brake button

F48 Displays and Controls

2. Instrument Cluster

F48 versions of instrument clusters

Index	Instrument cluster	Display	Equipment
1	High version	5.7" TFT display	• Navigation Plus (SA 6UP) and/or • Driving Assistant (SA 5AS) and/or • Head-Up Display (SA 610).

The F48 has two instrument clusters, which are known from other BMW models:

- High version of instrument cluster.

F48 Displays and Controls

3. Head-Up Display

The Head-Up Display (SA 610) projects a virtual image into the driver's field of view. The driver thus always has important information such as the driving speed and Check Control messages directly in his field of view.

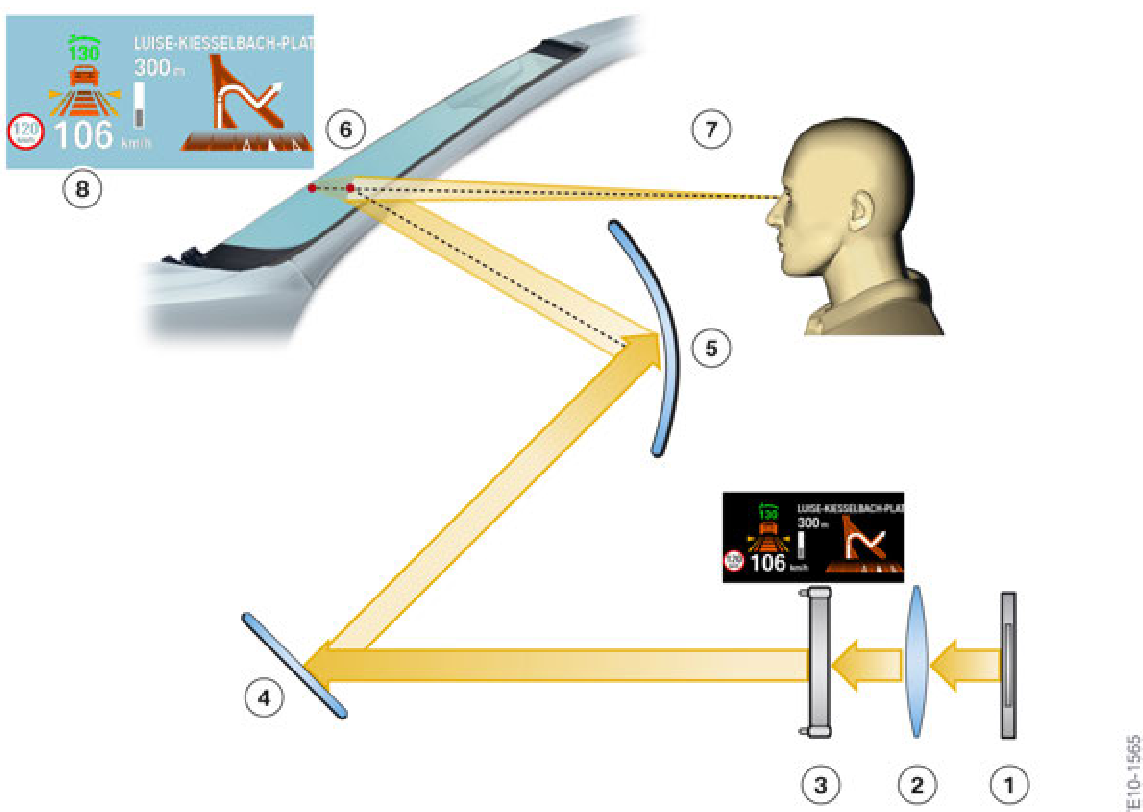
The HUD in the F48 can project the colors red, green and blue. Contents can be displayed in all colors of the RGB color spectrum, as is the case with an LCD monitor, by mixing the three colors.

The Head-Up Display (HUD) for the F48 is not connected to a CAN bus, but is connected directly to the instrument cluster via an Automotive Pixel Link interface. Fault code entries are entered in the instrument cluster.

3.1. Functional principle

The HUD is similar to a projector. A light source is required to project the HUD information. Two white LEDs serve as the light source. The light is directed through a lens onto a TFT projection display where the screen contents are displayed. The TFT projection display can be compared to a filter which admits or blocks light.

An optical imaging element determines the shape, distance and size of the HUD images.



Principle of Head-Up Display

F48 Displays and Controls
3. Head-Up Display

Index	Explanation
1	Light source
2	Lens
3	TFT projection display
4	Plane mirror
5	Curved mirror
6	Windshield
7	Observer's point of vision
8	Projected image

The image appears to float freely over the roadway, projected on the windshield.

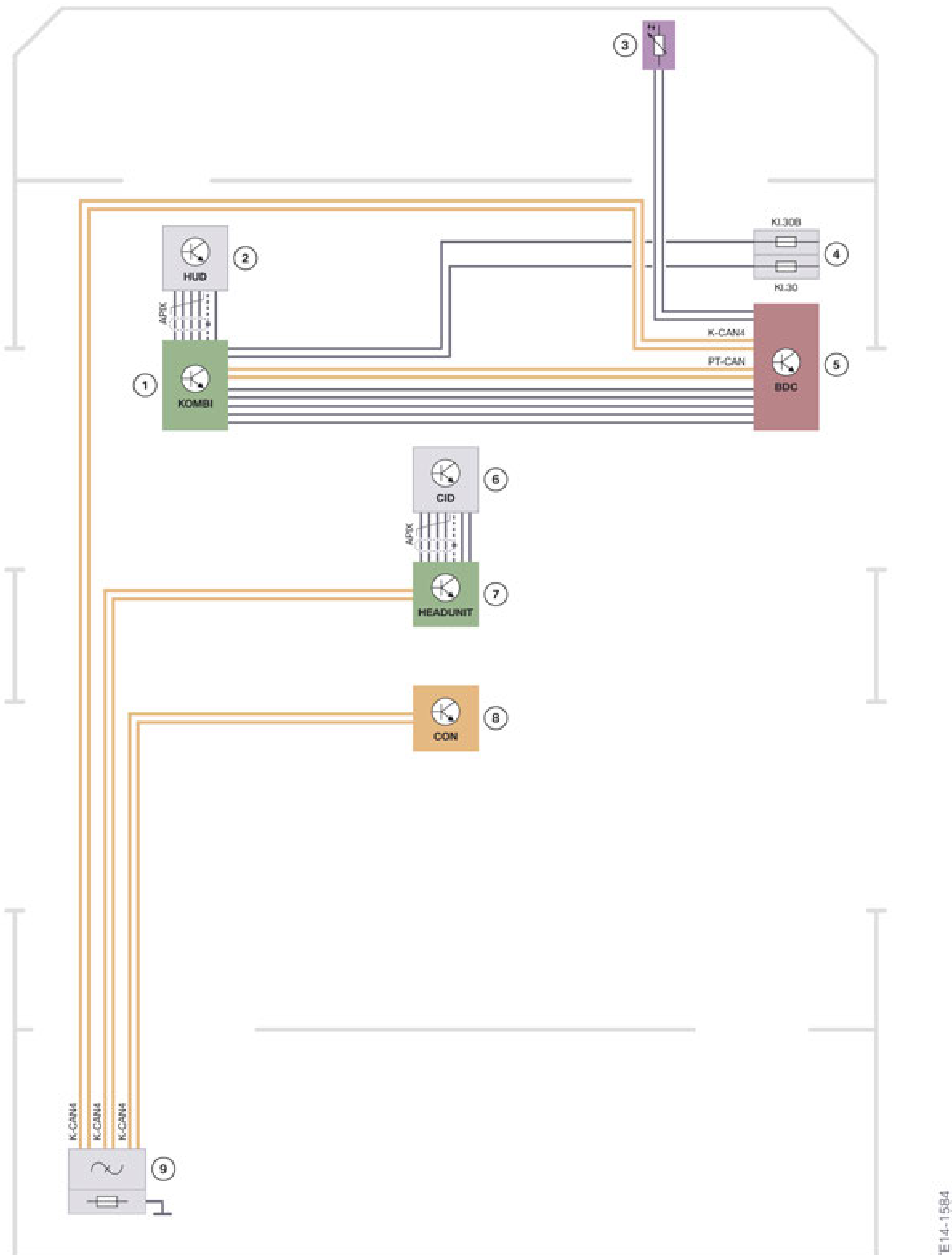
The windshield is a "special pane" and important element in the projection of the displays.
The outer and inner glass panes are bonded to a plastic film, just like in the standard windshield.
However, unlike in the standard windshield, this plastic film is not parallel but is tapered over the entire area of the windshield.

The head-up display is fitted above the steering column, immediately behind the instrument cluster.
It is secured to the bulkhead supporting structure using three screws.

F48 Displays and Controls

3. Head-Up Display

3.2. System wiring diagram



F48 system wiring diagram of Head-Up Display

Index	Description
1	Instrument cluster (KOMBI)
2	Head-Up Display (HUD)
3	Ambient temperature sensor
4	Power distribution box, front
5	Body Domain Controller (BDC)
6	Central Information Display (CID)
7	Headunit
8	Controller (CON)
9	K-CAN-Terminator

3.3. Displays

Depending on the vehicle equipment, the displays of the Head-Up Display contain information relevant to the driver, such as:

- Speed
- Set speed regulation by the cruise control with braking function (DCC)
- Navigation system
- Check Control messages
- Speed limit information
- Lane departure warning
- Night Vision with person recognition

F48 Displays and Controls

4. Central Information Display

Depending on the equipment installed, two different versions of a central information display are installed in the F48.

The CID in the F48 is directly connected to the headunit via an Automotive Pixel Link interface. Fault code entries are stored in the headunit.

4.1. Overview

F48 Overview of central information display

Index	Explanation
1	Central information display with 8.8" screen diagonal; resolution 1280 x 480 pixels
2	Central information display with 6.5" screen diagonal; resolution 800 x 480 pixels

4. Central Information Display

4.2. 6.5" screen diagonal

A CID with 6.5" screen diagonal is installed with the installation of a Headunit Basis with the equipment **Media System** or **Navigation (SA 6UN)**.

4.3. 8.8" screen diagonal

A CID with 8.8" screen diagonal is installed in conjunction with the Headunit Basis and the optional equipment **Navigation Plus (SA 6UP)**. The 8.8" CID also has an anti-reflective glass cover.

F48 Displays and Controls

5. Controller

5.1. Overview

Depending on equipment, the F48 has two different controllers with direct access keys:

- 7-button
- Touch controller

The controller variants based on the different optional equipment can be found in the following table:

Equipment	Headunit	Controller	Central information display
Navigation (SA 6UN)	Headunit Basis **with** navigation		6.5”
Navigation Plus (SA 6UP)	Headunit High **with** navigation		8.8”

F48 Displays and Controls

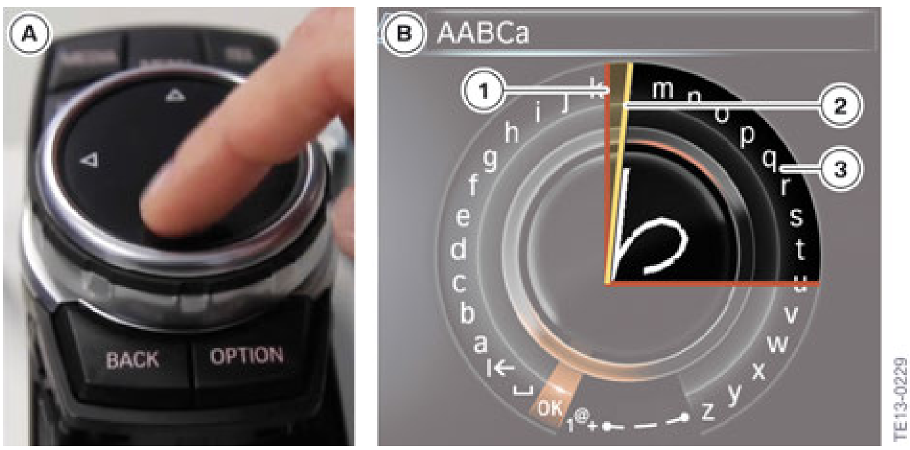
5. Controller

5.2. Touch Controller

Vehicles with the optional equipment Navigation Plus (SA 6UP) have a controller with touch control panel.

In the Touch Controller the customer can input location information for the navigation system or telephone numbers and contact details. In the interactive map, the map section, for example, can be moved and enlarged or reduced by finger movement.

The input of characters with the wordmatch principle is detected at an angle of 45°.



Input area, Touch Controller

Index	Explanation
A	Input using Touch Controller
B	Displays in central information display (CID)
1	Edge of angular range for input
2	"Angle" of input
3	Angular range for input

F48 Displays and Controls

5. Controller

For the evaluation of inputs an additional control unit "Touchbox" is used in separate country versions.

F48 Touchbox control unit

The Touchbox control unit is required for interpreting the contact sensors of the Touch Controller for the Headunit High user interface. The Touchbox is connected to the Touch Controller and headunit via the K-CAN4.

F48 Displays and Controls

6. Driving Experience Switch

F48 Driving experience switch

Index	Explanation
1	Driving experience switch

6.1. Modes

The following program can be selected for the F48:

- SPORT
- COMFORT
- ECO PRO

6.1.1. SPORT mode

In SPORT mode the accelerator pedal characteristic curve in the throttle and the shifting points in vehicles with an automatic transmission have a sporty design. If the vehicle has the optional equipment Dynamic Damper Control (SA 223), the corresponding chassis components also have a sporty design.

6.1.2. COMFORT mode

COMFORT mode is the "normal" mode of the vehicle. COMFORT mode is active upon every engine start, regardless of the mode in which the parked vehicle was previously.

6.1.3. ECO PRO mode

The ECO PRO mode supports the driver in adopting an optimized-consumption driving style and reduces fuel consumption through intelligent control of energy and A/C management. The number and length of the automatic engine start/stop function phases are maximized in ECO PRO mode.

F48 Displays and Controls
7. Intelligent Safety Button

Using the Intelligent Safety button, certain assistance systems of the F48 can be activated, deactivated and individualized.

In the F48, the Intelligent Safety button is only installed with the optional equipment Driving Assistant (SA 5AS). A description of the optional equipment Driving Assistant (SA 5AS) can be found in the section "F48 Driver Assistance Systems".

The Intelligent Safety button together with the hazard warning switch is located below the central information display (CID).

F48 Intelligent Safety button

Index	Explanation
1	Intelligent Safety button

Press button:

- A board on the central information display (CID) is displayed on which the settings can be performed. The individual settings are stored for the ID transmitter currently used.

Press button briefly:

- Intelligent Safety systems are switched off individually depending on the Personal Profile.
- The LED in the Intelligent Safety button lights up orange or goes out, depending on the Personal Profile.

Press button again:

- All Intelligent Safety systems are switched on.
- The LED in the Intelligent Safety button lights up green.

Press and hold button:

- All Intelligent Safety systems are switched off.
- The LED in the Intelligent Safety button goes out.

F48 Displays and Controls

8. Service

8.1. Activation of the Service menu

The activation of the Service menu for a Headunit Basis is identical to the activation of the Service menu of a Headunit High.

The following steps explain how you can activate the Service menu:

- Call up main menu
- Move controller **to the front for longer than 10 seconds**
- **Turn** controller **to the right 3 steps**
- **Turn** controller **to the left 3 steps**
- **Turn** controller **to the right 1 step**
- **Turn** controller **to the left 1 step**
- **Turn** controller **to the right 1 step**
- Press controller **once**

The Service menu is then added as an additional submenu in the "Settings" menu.

8.2. Showroom mode for Head-Up Display

There is a Showroom mode for the Head-Up Display (HUD), with which the various displays of the Head-Up Display can be shown.

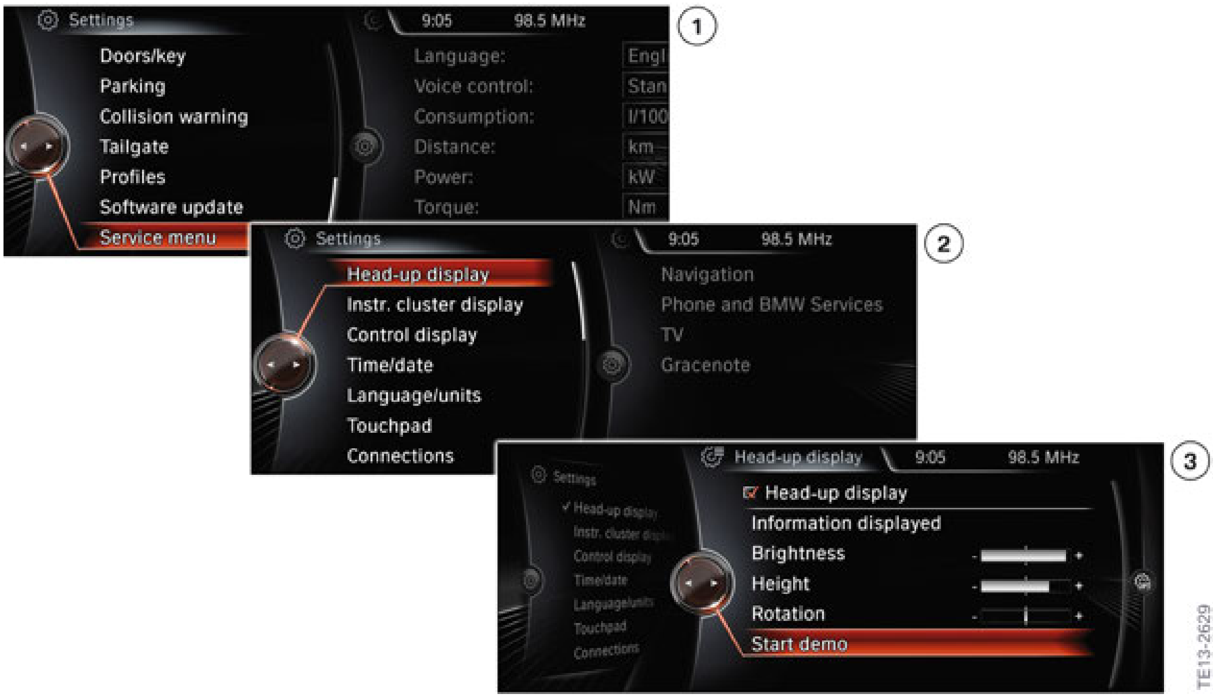
The following steps must be observed for the activation:

- Head-Up Display must be active
- Call up "Head-Up Display" menu
- Switch Head-Up Display on/off 3 times

Alternatively, Showroom mode can also be activated using the diagnosis system.

F48 Displays and Controls

8. Service



F48 Head-Up Display, Showroom mode

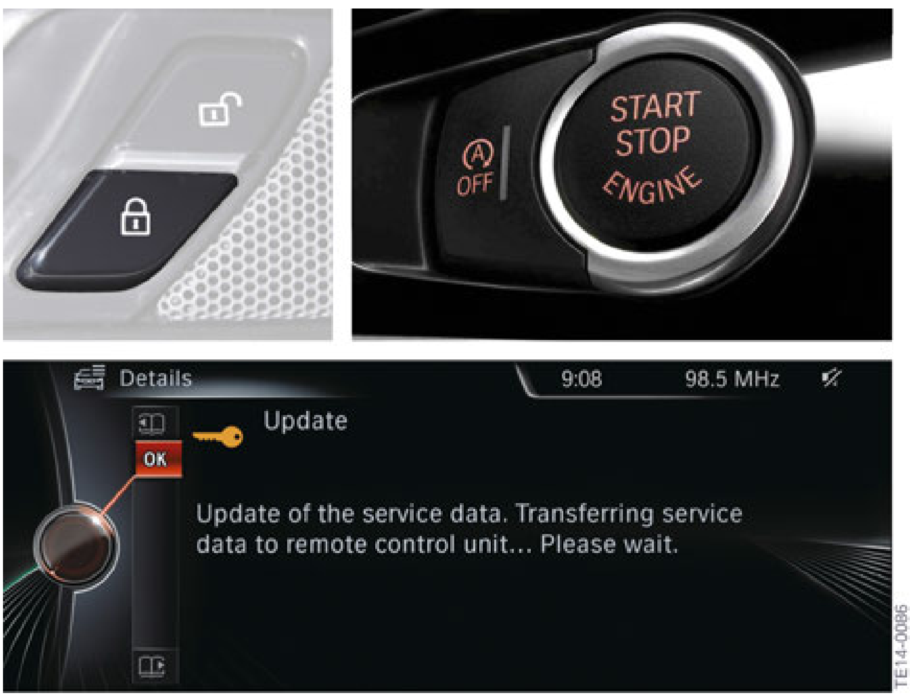
Index	Explanation
1	Service menu
2	"Settings" menu
3	Showroom mode for Head-Up Display in the "Head-Up Display" menu

8.3. Updating Service key data

The service data are adjusted at regular intervals using the ID transmitter. If the data of the ID transmitter is not up-to-date, there is the option for Service to manually initiate the transfer.

Proceed as follows to transfer current service data to the ID transmitter during Service:

- Keep the central locking button in the driver's door pressed down and then press the start/stop button (terminal 15 ON), then release both buttons.
- Hold the ID transmitter within 10 seconds at the key symbol on the right side of the steering column shroud.



F48 Updating Service key data

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Technical training.
Product information.

F48 Information and Communication

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BMW Service

General information

Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:

⚠

Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

Information status and national-market versions

BMW Group vehicles meet the requirements of the highest safety and quality standards. Changes in requirements for environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between the contents of this document and the vehicles available in the training course.

This document basically relates to the European version of left-hand drive vehicles. Some operating elements or components are arranged differently in right-hand drive vehicles than shown in the graphics in this document. Further differences may arise as a result of the equipment specification in specific markets or countries.

Additional sources of information

Further information on the individual topics can be found in the following:

- Owner's Handbook
- Integrated Service Technical Application.

Contact: conceptinfo@bmw.de

The information contained in this document forms an integral part of the technical training of the BMW Group and is intended for the trainer and participants in the seminar. Refer to the latest relevant information systems of the BMW Group for any changes/additions to the technical data.

Information status: **June 2015**
Technical Training

F48 Information and Communication
Contents

F48 Information and Communication

1. Introduction

This section is intended to provide an overview of the information and communication systems used in the F48.

With the new Headunit, the F48 reaches another milestone in the area of multimedia technology.

F48 Information and Communication

2. Headunits

2.1. Overview of headunits

The equipment of the different headunits can be found in the following table:

Optional equipment	Headunit	CID	Controller	Navigation
Media system (standard equipment)	Headunit	6.5"	5-button	No
Navigation Business (SA 6UN)	Headunit with navigation	6.5"	7-button	Yes
Navigation Plus (SA 6UP)	Headunit with navigation	8.8"	7-buttons with touch pad	Yes

The F48 does not have a DVD changer. The USB interface is already included in the basic equipment independent of the headunit.

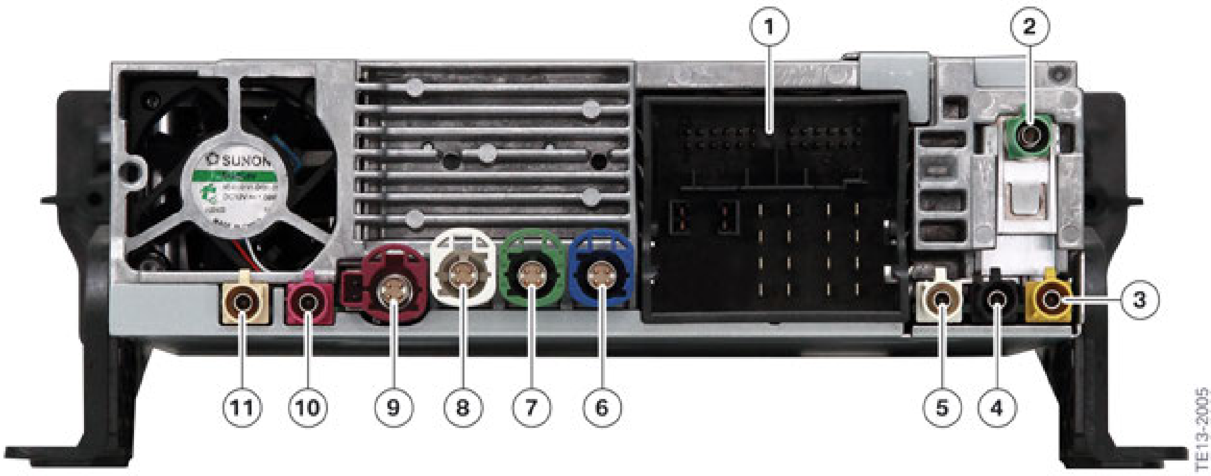
2.2. Media System

The F48 receives a completely redeveloped headunit. The manufacturer of this headunit is Magneti-Marelli.

The Media System receives a CD drive as standard equipment (SA 650).

2.2.1. Media system

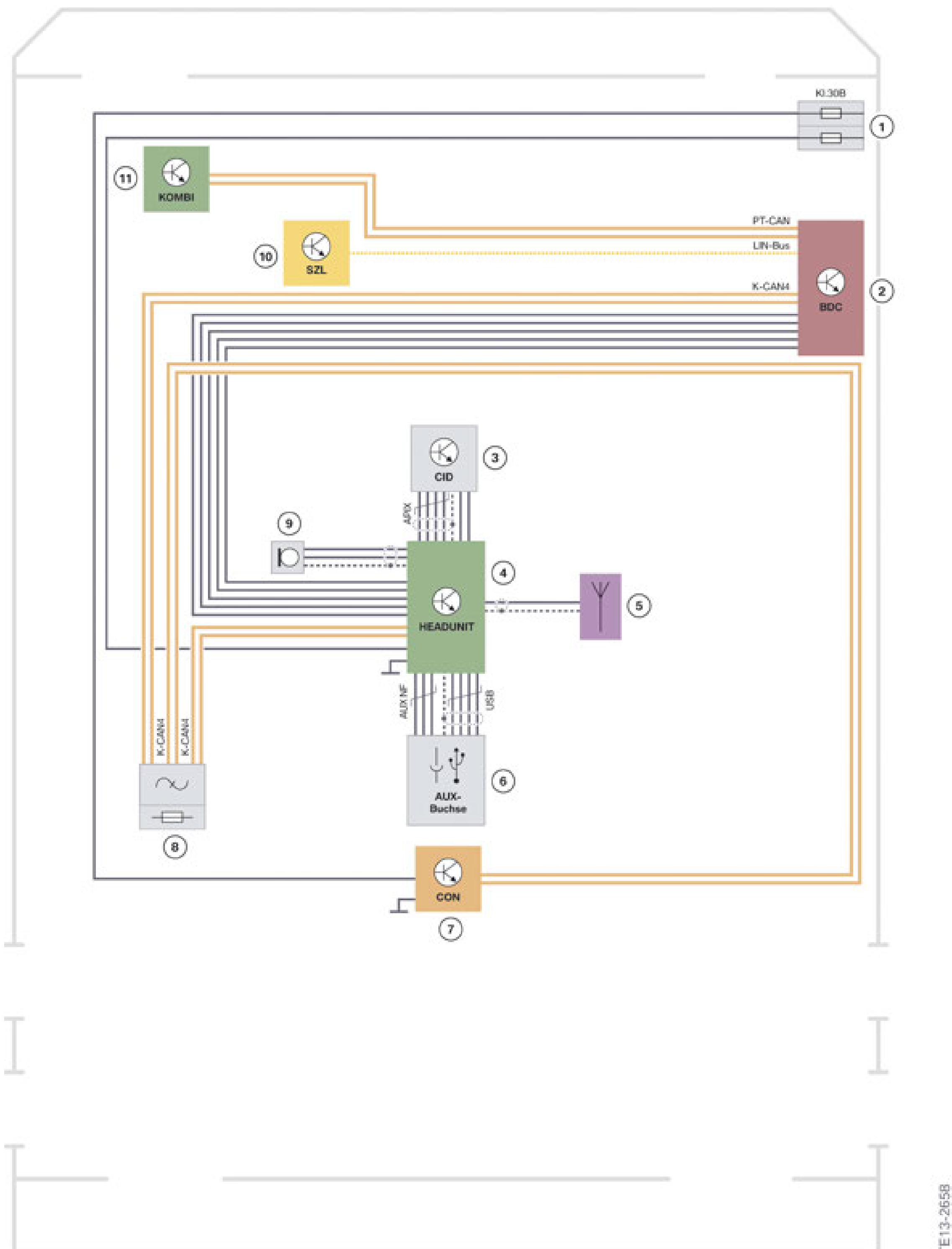
With the Media System, the F48 receives a controller with five function keys and a 6.5" central information display, in addition to a radio.



Rear view of Headunit without navigation

Index	Explanation
1	Main connector
2	Not for US
3	SDARS Antenna
4	AM/FM1 antenna
5	FM2 antenna
6	USB2 connection; connection for customer smartphone via the telephone base plate
7	USB3 connection; connection for Telematic Communication Box (TCB)
8	USB1 connection; customer access at the Aux-IN USB port (also for data import/export)
9	Automotive Pixel Link connection and voltage supply of central information display
10	Preparation of WLAN antenna
11	Connection for Bluetooth antenna

System wiring diagram



F48 system wiring diagram for media system

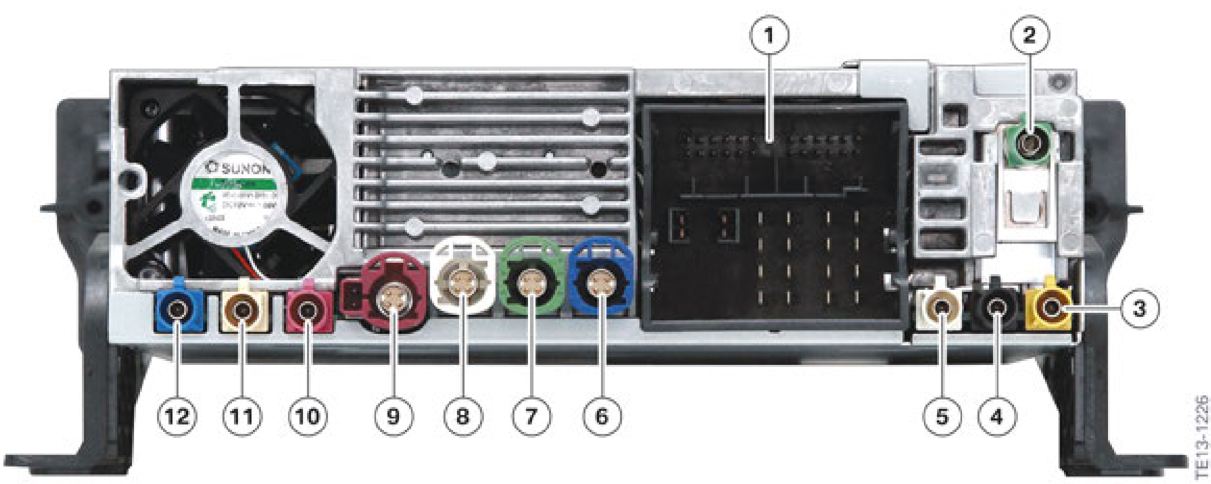
F48 Information and Communication

2. Headunits

Index	Explanation
1	Fuses in the power distribution box in the passenger compartment
2	Body Domain Controller (BDC)
3	Central information display (CID)
4	Headunit
5	Bluetooth antenna
6	USB audio interface
7	Controller (CON)
8	K-CAN terminator
9	Microphone, driver's side
10	Steering column switch cluster (SZL)
11	Instrument cluster (KOMBI)

2.2.2. Navigation systems

The customer has the option of ordering two navigation systems. The optional equipment Navigation (SA 6UN) and the optional equipment Navigation Plus (SA 6UP). The headunit is identical for the two equipment specifications. With the optional equipment Navigation Plus (SA 6UP), the F48 receives additional equipment, for example a touch controller and 8.8" central information display, as well as a Head-Up Display.



Rear view, Headunit with navigation

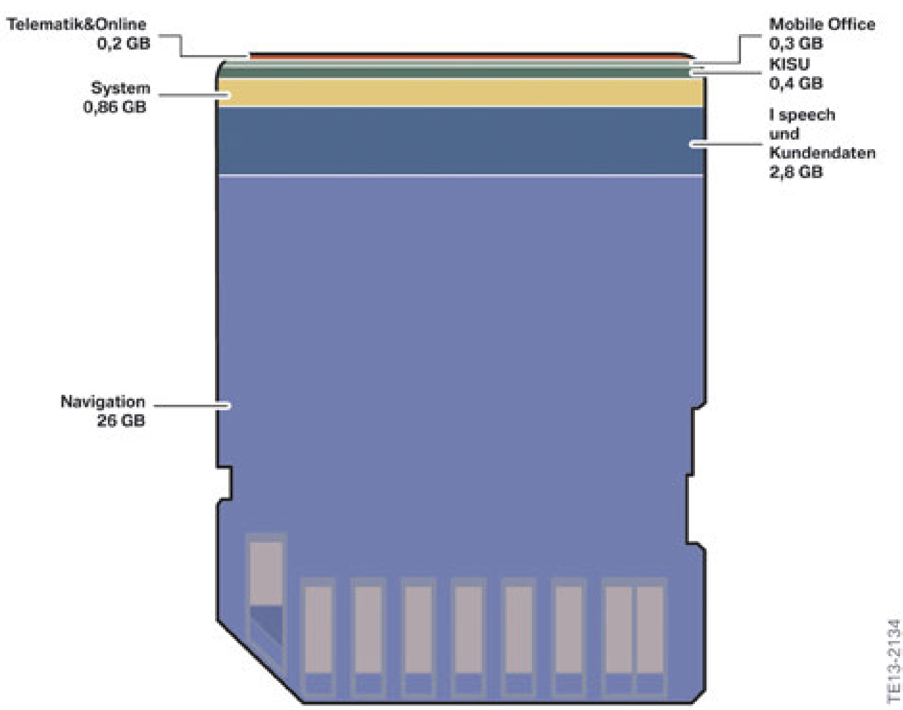
Index	Explanation
1	Main connector
2	Not for US
3	SDARS Antenna
4	AM/FM1 antenna
5	FM2 antenna

2. Headunits

Index	Explanation
6	USB2 connection; connection for customer smartphone via the telephone base plate
7	USB3 connection; connection for Telematic Communication Box (TCB)
8	USB1 connection; customer access at the Aux-IN USB port (also for data import/export)
9	Automotive Pixel Link connection and voltage supply of central information display
10	Preparation of WLAN antenna
11	Connection for Bluetooth antenna
12	GPS antenna

The basic structure of the hardware of both Headunit devices is the same. In contrast to the media system, the navigation systems are equipped with an antenna connection for the navigation antenna. All components for navigation are also located therein. With the exception of the yaw sensor, which in the F48 is housed in the Advanced Crash Safety Module (ACSM) and transfers the data to the headunit via a bus signal.

A larger flash memory with 32 GB, instead of the 4 GB with the media system, is installed for the navigation systems. The permanent storage of the map data is a reason for this.



Schematic diagram with symbols for the flash memory in the Headunit with navigation

2.2.3. Comparison

In the following table you see the different features of the optional equipment Navigation (SA 6UN) and the optional equipment Navigation Plus (SA 6UP):

Function	Navigation (SA 6UN)	Navigation Plus (SA 6UP)
Satellite map	No	No
Weather on map (in conjunction with BMW Online)	Yes	Yes
Elevation models with "perspective" map	No	No
3D models	Only attractions	Only attractions
Assistance window (split screen)	No	Yes
Arrow on map	Yes	No
Map preview for destination input	No	Yes
Different map view in main window and split screen	No	No
Favorite special destinations	Yes	Yes
Quick Access menus (list selection for the customer in the different menus)	Yes	Yes
Journey with stage finishes	Yes	Yes
Route overview after start of route guidance	Yes	Yes
Lane guiding (exit recommendation)	No	No
Import of routes	No	No

Map view of Different Navigation Systems

Index	Explanation
1	Assistance window with the 8.8" screen version of the central information display
2	"Arrow on map" schematic diagram with 6.5" screen version of the central information display

F48 Information and Communication

3. Speaker Systems

3.1. Overview

The speaker systems in the F48 are available in three specification levels:

- Hi-fi system (SA 676)
- Harman Kardon® hi-fi system (SA 674)

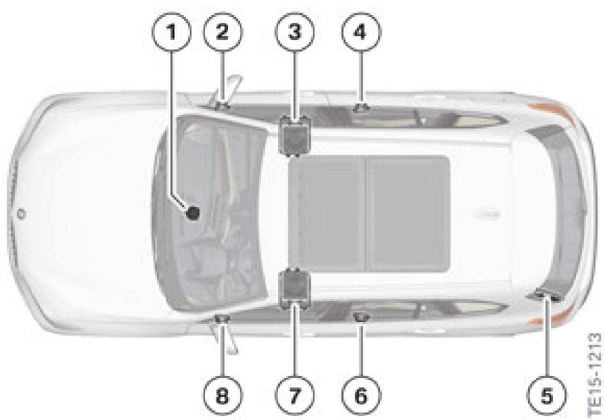
3.2. Components

3.2.1. Hi-fi system

The hi-fi system in the F48 is standard equipment (SA 676). The hi-fi system comprises 7 speakers, with an overall power of 205 Watt.

The amplifier of the hi-fi system is not connected to any bus system.

Components

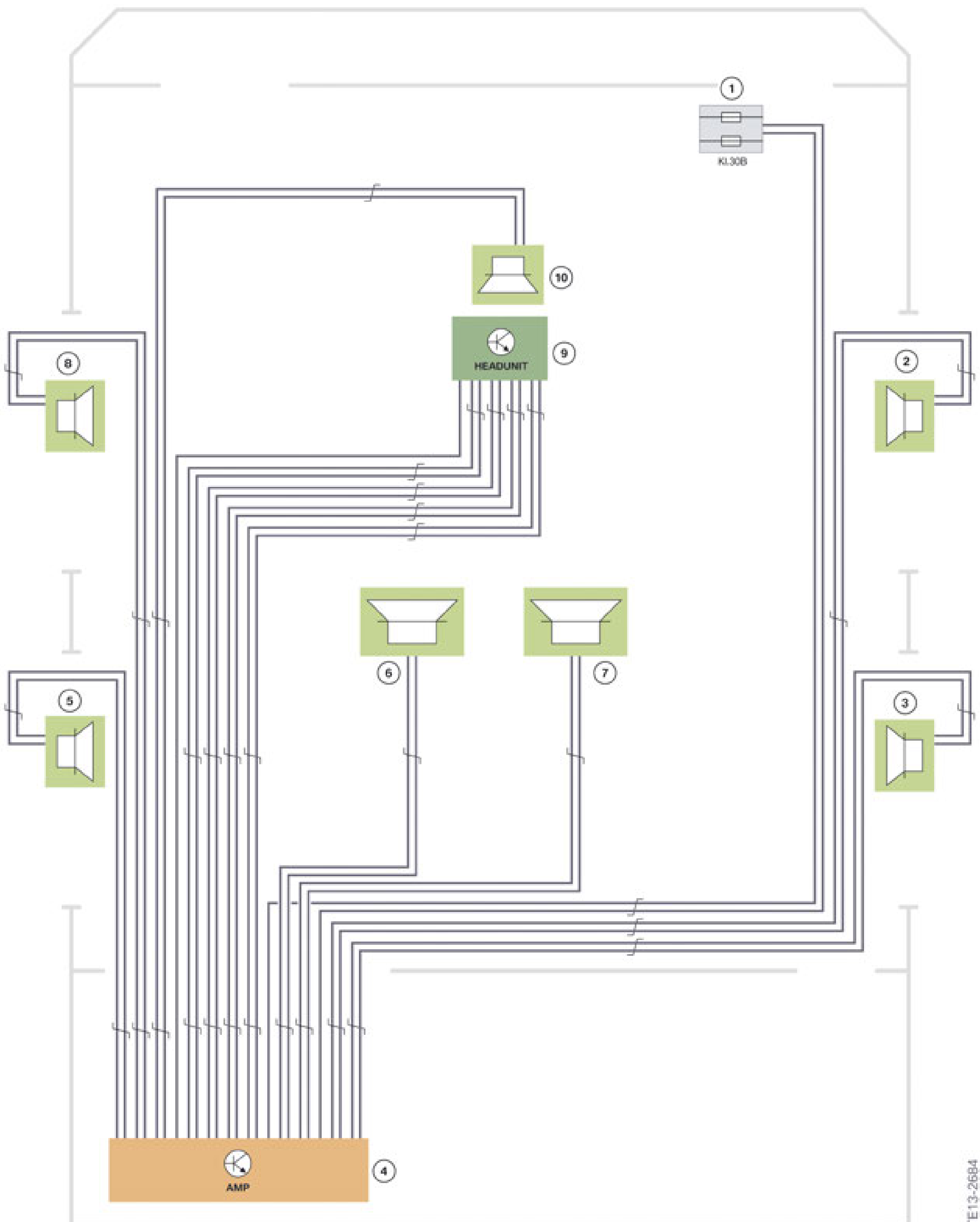


F48 system components of hi-fi system

Index	Explanation
1	Mid-range speaker, front center
2	Mid-range speaker, front right
3	Bass speaker, right
4	Mid-range speaker, rear right
5	Amplifier (AMP)
6	Mid-range speaker, rear left
7	Bass speaker, left
8	Mid-range speaker, front left

3. Speaker Systems

System wiring diagram



F48 system wiring diagram of hi-fi system

Index	Explanation
1	Fuses in the power distribution box in the passenger compartment
2	Mid-range speaker, front right
3	Mid-range speaker, rear right
4	Amplifier (AMP)
5	Mid-range speaker, rear left
6	Bass speaker, left
7	Bass speaker, right
8	Mid-range speaker, front left
9	Headunit
10	Mid-range speaker, front center

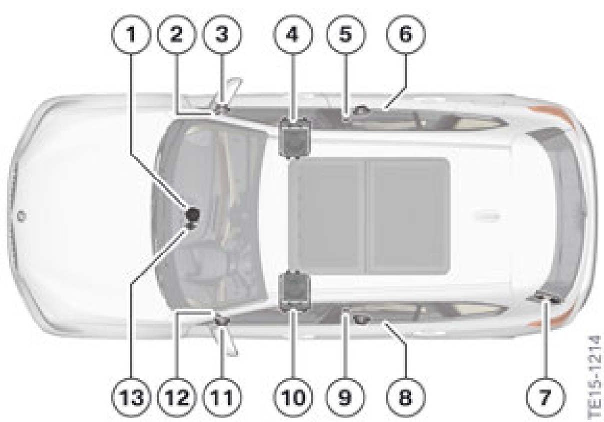
3.2.2. Hi-fi system Harman Kardon®

The Harman Kardon® hi-fi system (SA 674) consists of twelve speakers. Separate speakers are installed in the Harman Kardon® hi-fi system for the tweeter and mid-tone ranges. A seven-channel amplifier with a digital equalizer is integrated in the Harman Kardon® hi-fi system. The amplifier is a bus slave in the K-CAN4.

The mid-range speakers and tweeters of the Harman Kardon® hi-fi system have high-quality aluminium membranes for a clearly differentiated sound pattern. Thanks to the additional use of hexagonally structured metal covers, the damping and resonances of the covers are minimized.

The speakers and the amplifier of the Harman Kardon® hi-fi system are illustrated in the following graphic. The speakers have an overall power of 360 Watt.

Components



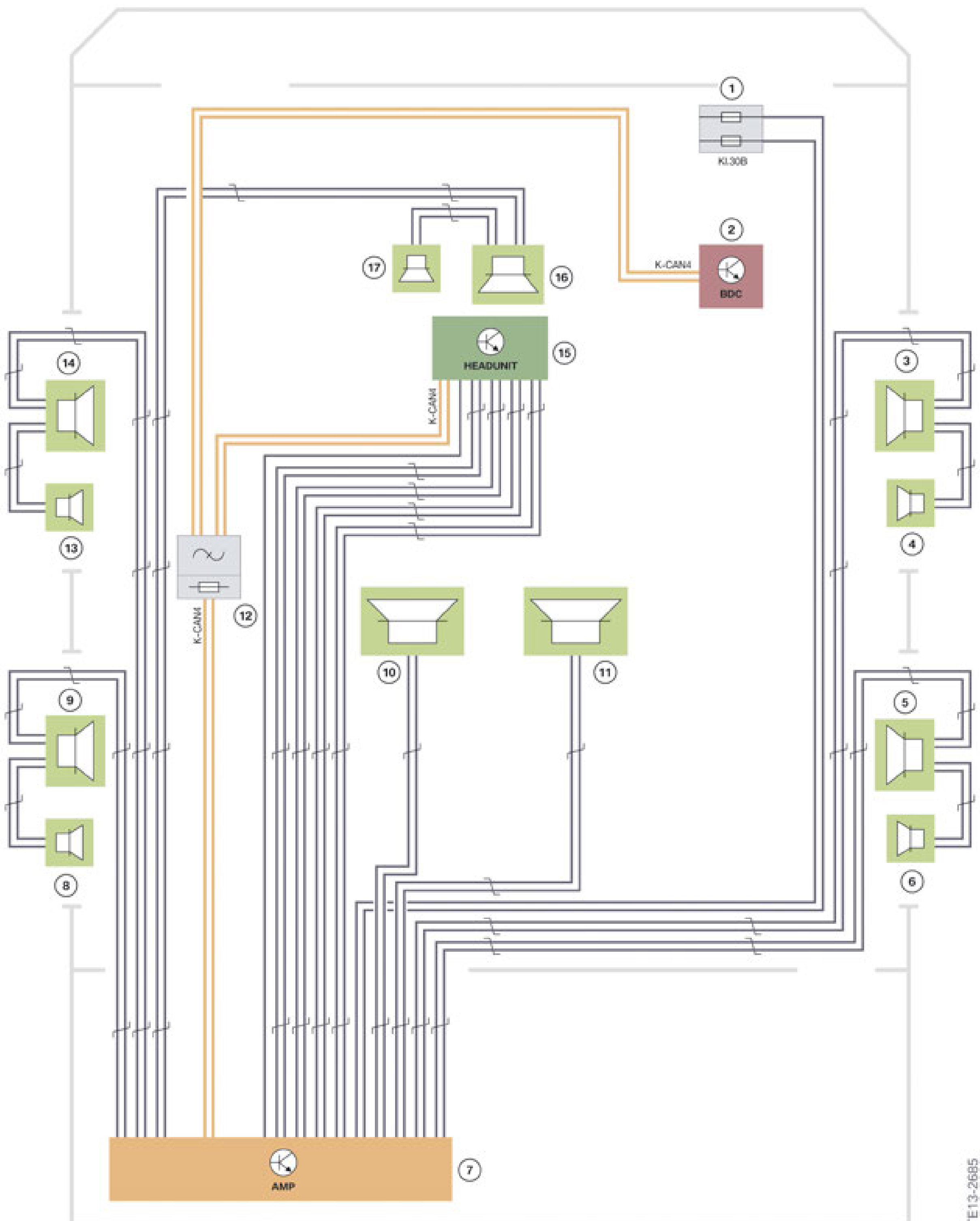
F48 system components of Harman Kardon® hi-fi system

3. Speaker Systems

Index	Explanation
1	Mid-range speaker, front center
2	Tweeter, front right
3	Mid-range speaker, front right
4	Bass speaker, right
5	Tweeter, rear right
6	Mid-range speaker, rear right
7	Amplifier (AMP), Harman Kardon®
8	Mid-range speaker, rear left
9	Tweeter, rear left
10	Bass speaker, left
11	Mid-range speaker, front left
12	Tweeter, front left
13	Tweeter, front center

3. Speaker Systems

System wiring diagram



F48 system wiring diagram for Harman Kardon® hi-fi system

F48 Information and Communication

3. Speaker Systems

Index	Explanation
1	Fuses in the power distribution box in the passenger compartment
2	Body Domain Controller (BDC)
3	Mid-range speaker, front right
4	Tweeter, front right
5	Mid-range speaker, rear right
6	Tweeter, rear right
7	Amplifier (AMP), Harman Kardon®
8	Tweeter, rear left
9	Mid-range speaker, rear left
10	Bass speaker, left
11	Bass speaker, right
12	K-CAN terminator
13	Tweeter, front left
14	Mid-range speaker, front left
15	Headunit
16	Mid-range speaker, front center
17	Tweeter, front center

F48 Information and Communication

4. Telephone Systems

4.1. Overview

Two different items of optional equipment are available for the F48 telephone systems:

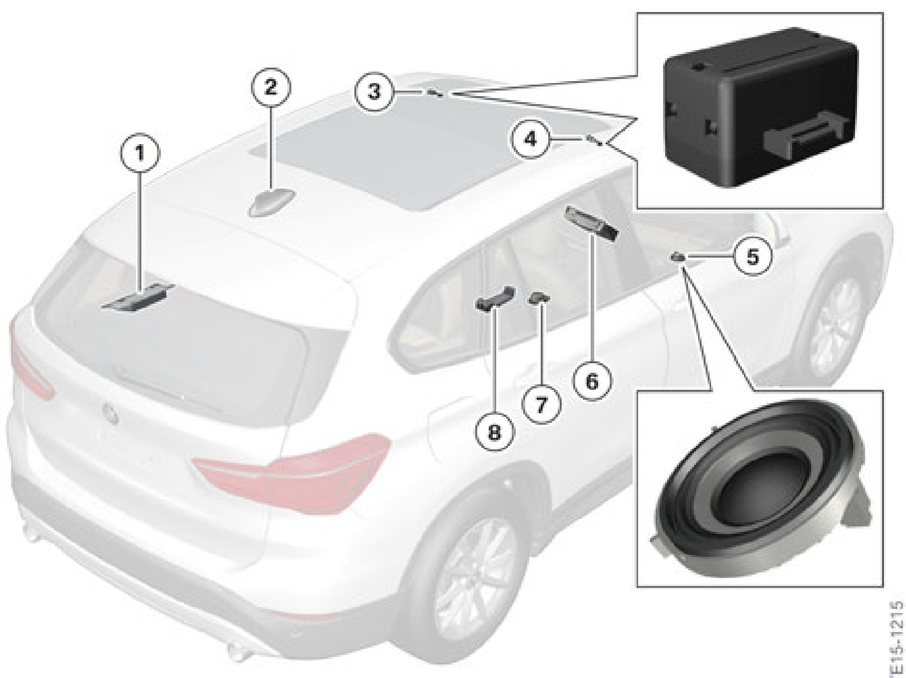
- Hands-free system (already included in the standard equipment)
- Convenient telephone system with extended smartphone connection (SA 6NS)

These two equipment specifications are fully supported by the headunit, i.e. the Bluetooth module is already integrated in the headunit. In the F48, a Combox is no longer required as an interface box.

A Telematic Communication Box (TCB) is installed for the emergency call or the ConnectedDrive services. Further information on the ConnectedDrive services can be found in the product information bulletin "Information and Communication System News I/2014".

⚠

The specified range of functions is only available with BMW-recommended Bluetooth-capable mobile phones. For details, please visit: www.bmw.com/bluetooth



F48 Components of telephone system

Index	Explanation
1	Telematic Communication Box (TCB)
2	Roof antenna
3	Microphone, driver's side
4	Microphone, passenger's side (SA 6NS)

4. Telephone Systems

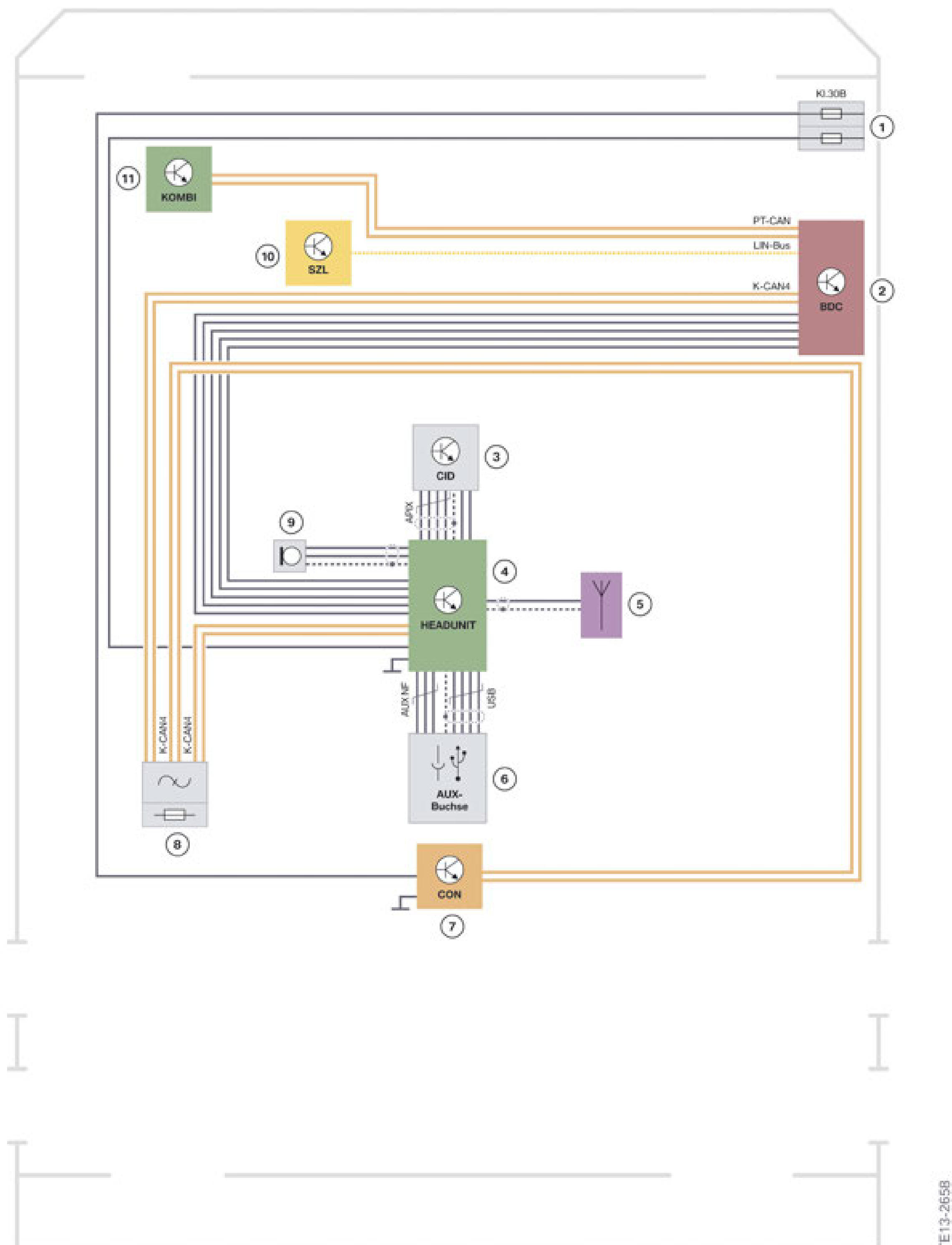
Index	Explanation
5	Emergency loudspeaker (only with installation of Telematic Communication Box)
6	Headunit
7	Controller (CON)
8	Base plate (SA 6NS)

4.2. Hands-free system

The headunit-supported hands-free system, including the Bluetooth audio streaming function, is already included in the standard equipment.

In the standard equipment "hands-free system", the vehicle does **not** have a base plate, i.e. the mobile phone does not have a connection for the vehicle telephone antenna and cannot be charged via a snap-in adapter.

4.2.1. System wiring diagram



F48 system wiring diagram for hands-free system

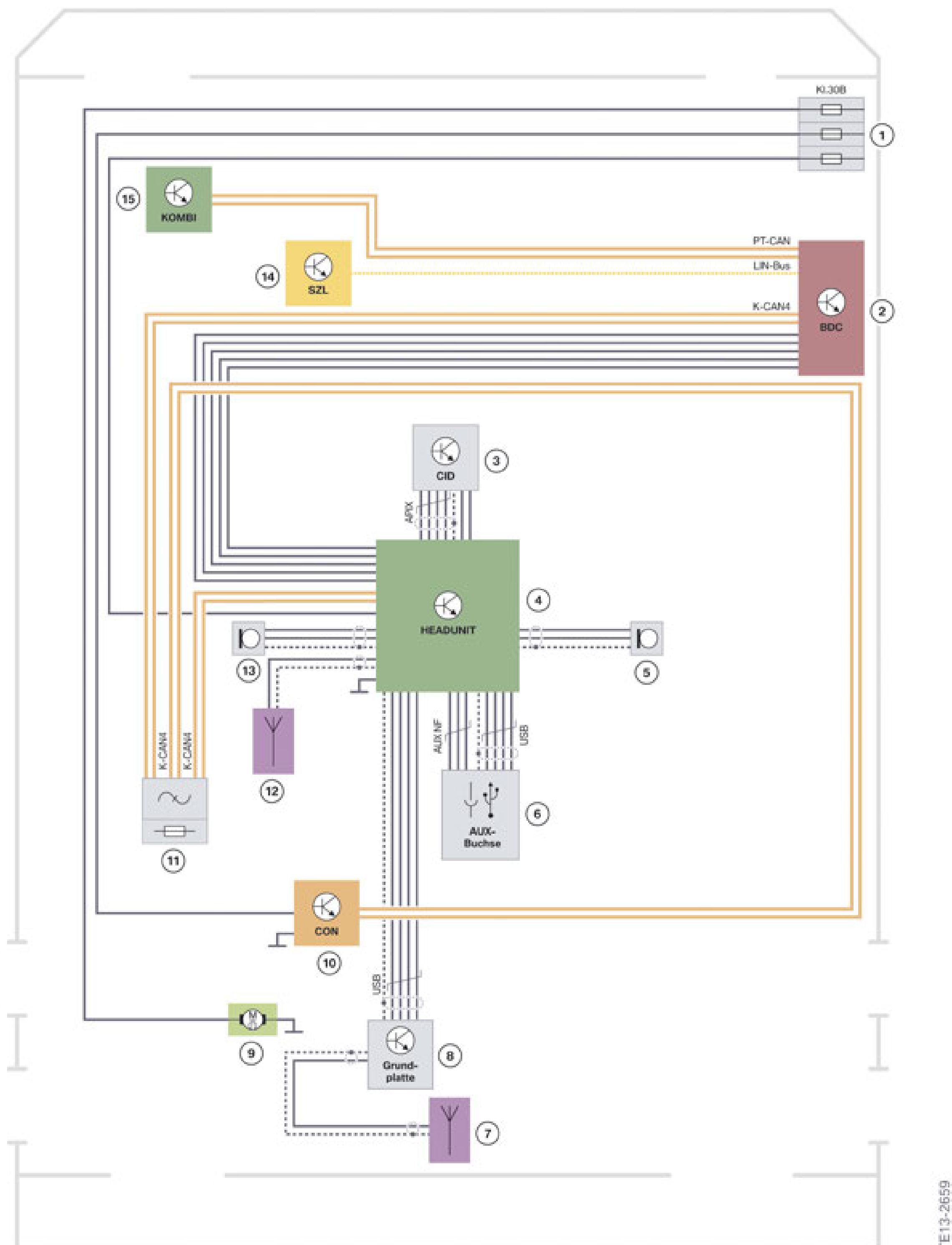
Index	Explanation
1	Fuses in the power distribution box in the passenger compartment
2	Body Domain Controller (BDC)
3	Central information display (CID)
4	Headunit
5	Bluetooth antenna
6	USB audio interface
7	Controller (CON)
8	K-CAN terminator
9	Microphone, driver's side
10	Steering column switch cluster (SZL)
11	Instrument cluster (KOMBI)

4.3. Enhanced USB and Bluetooth with Smartphone Integration

With the variant hands-free system, Enhanced USB and Bluetooth with Smartphone Integration (SA 6NS) can be added afterwards upon customer request. The customer receives all functions and interfaces of the CBX-MEDIA, the hands-free mode via Bluetooth, the smartphone connection via the base plate and snap-in adapter and all additional functions such as Office, Cover Art and voice input. The features "Bluetooth audio streaming" and customer-initiated software update (KISU) are already available from the Bluetooth hands-free system.

4. Telephone Systems

4.3.1. System wiring diagram

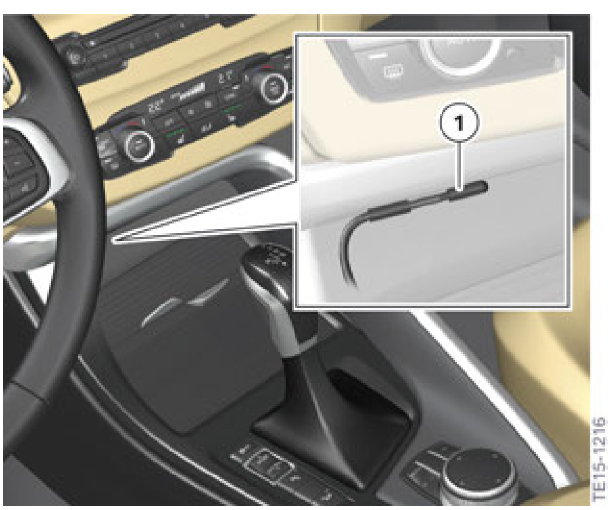


F48 System wiring diagram for convenient telephony with extended smartphone connection

Index	Explanation
1	Fuses in the power distribution box in the passenger compartment
2	Body Domain Controller (BDC)
3	Central information display (CID)
4	Headunit
5	Microphone, right
6	USB audio interface
7	Telephone antenna, roof
8	Base plate
9	Fan in the center armrest
10	Controller (CON)
11	K-CAN terminator
12	Bluetooth antenna
13	Microphone, left
14	Steering column switch cluster (SZL)
15	Instrument cluster (KOMBI)

4.4. Bluetooth antenna

The Bluetooth antenna is designed as a simple cable antenna. The installation location is near the headunit.



F48 installation location of Bluetooth antenna

Index	Explanation
1	Bluetooth antenna

5. Antenna Systems

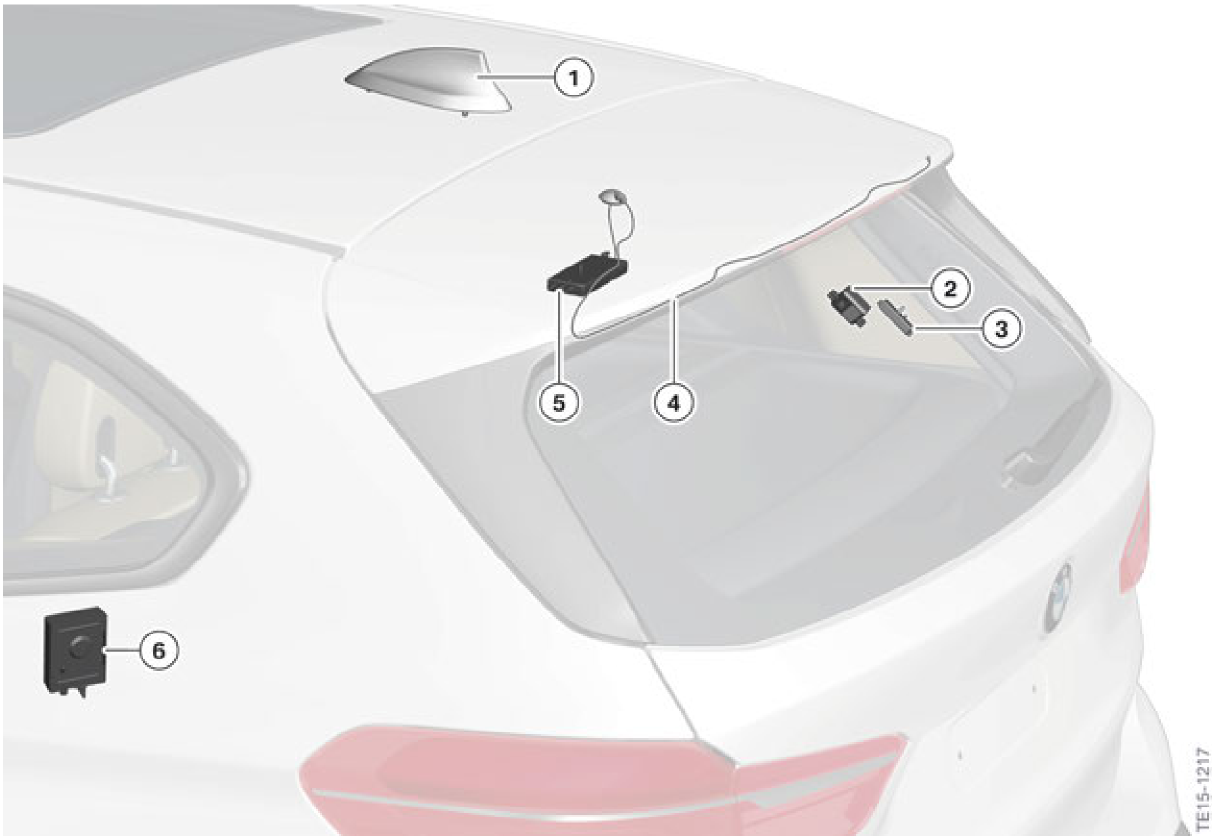
5.1. Overview

The F48 has different antenna systems, depending on the national-market version and optional equipment used:

Antenna	System	Installation location
FM antenna	Radio	FM1 and FM2 in the rear window
AM antenna	Radio	AM antenna sensor in the roof spoiler
SDARS antenna	Radio	Roof antenna
GPS antenna	Navigation system	Roof antenna
Remote control services antenna	Body Domain Controller (remote control service)	Luggage compartment, right
Telephone antenna	Telephone	Roof antenna
Bluetooth antenna	Telephone	Integrated in the wiring harness
Emergency call antenna (back-up antenna)	Telematics services	In the luggage compartment, left

5. Antenna Systems

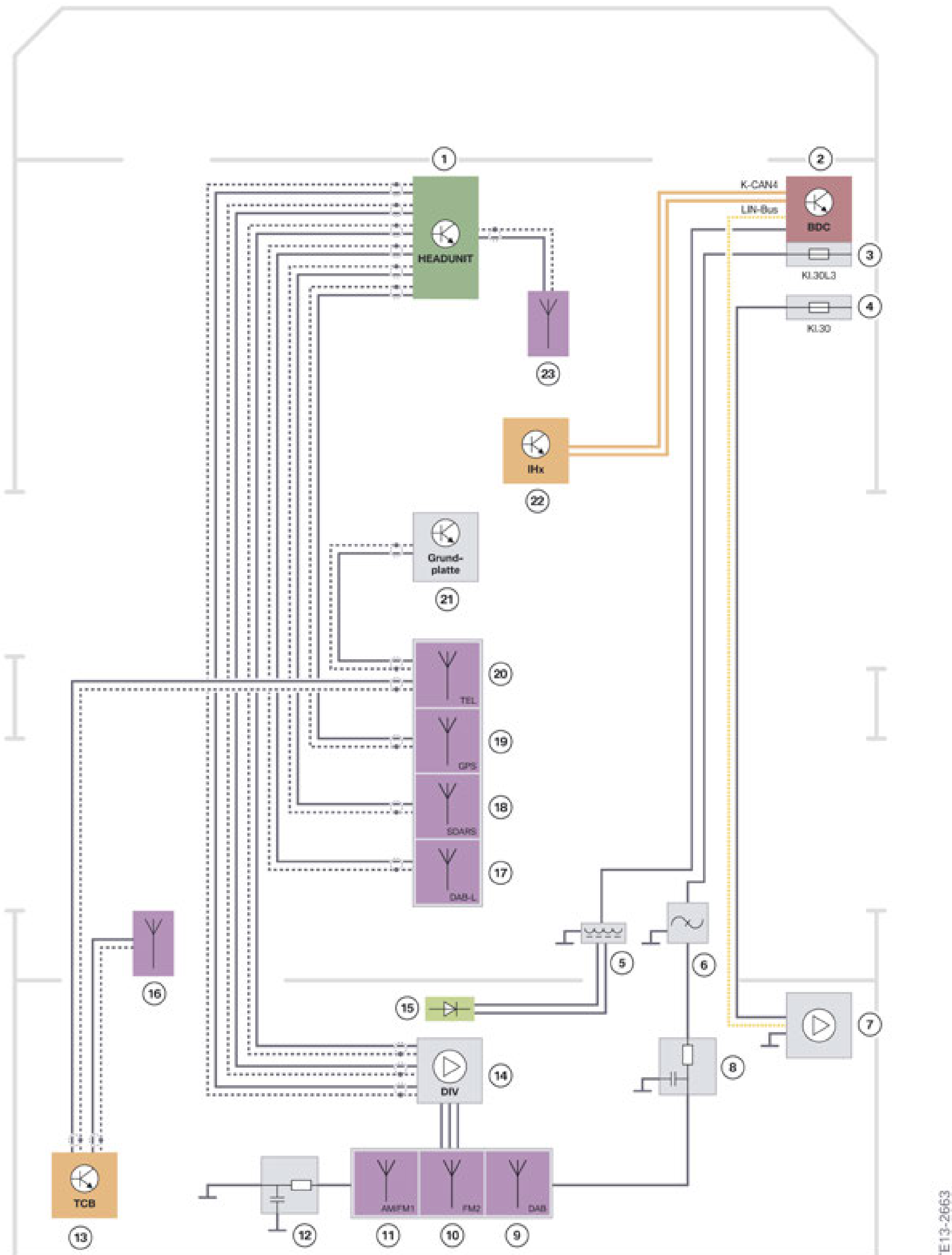
5.2. Components



F48 components of the antenna system

Index	Explanation
1	Roof antenna
2	Wave trap
3	Interference suppression filter
4	AM antenna sensor
5	Antenna amplifier
6	Emergency call antenna

5.3. System wiring diagram



F48 system wiring diagram for aerials

5. Antenna Systems

Index	Explanation
1	Headunit
2	Body Domain Controller (BDC)
3	Fuse in the power distribution box (BDC)
4	Fuse in the power distribution box in the passenger compartment
5	Interference suppression filter
6	Wave trap
7	Remote control receiver
8	Wave trap
9	Not for US
10	FM2 antenna
11	AM/FM1 antenna
12	Wave trap
13	Telematic Communication Box (TCB)
14	Antenna diversity module
15	Additional brake light
16	Emergency call antenna
17	Not for US
18	SDARS antenna (US version)
19	GPS antenna
20	Telephone antenna
21	Base plate
22	Standard heating and air conditioning (IHx)
23	Bluetooth antenna

F48 Information and Communication

6. Android Devices

6.1. Introduction

Customers with Android smartphones and the Android operating system "Jelly Bean" 4.2.x. can download the BMW Connected app free of charge in the Google Play Store, depending on their mobile phone manufacturer.

Android operating system "Jelly Bean" 4.2.2

At present, not all Android smartphones are supported.

Compatible smartphones can be found here: www.bmw.com/bluetooth.

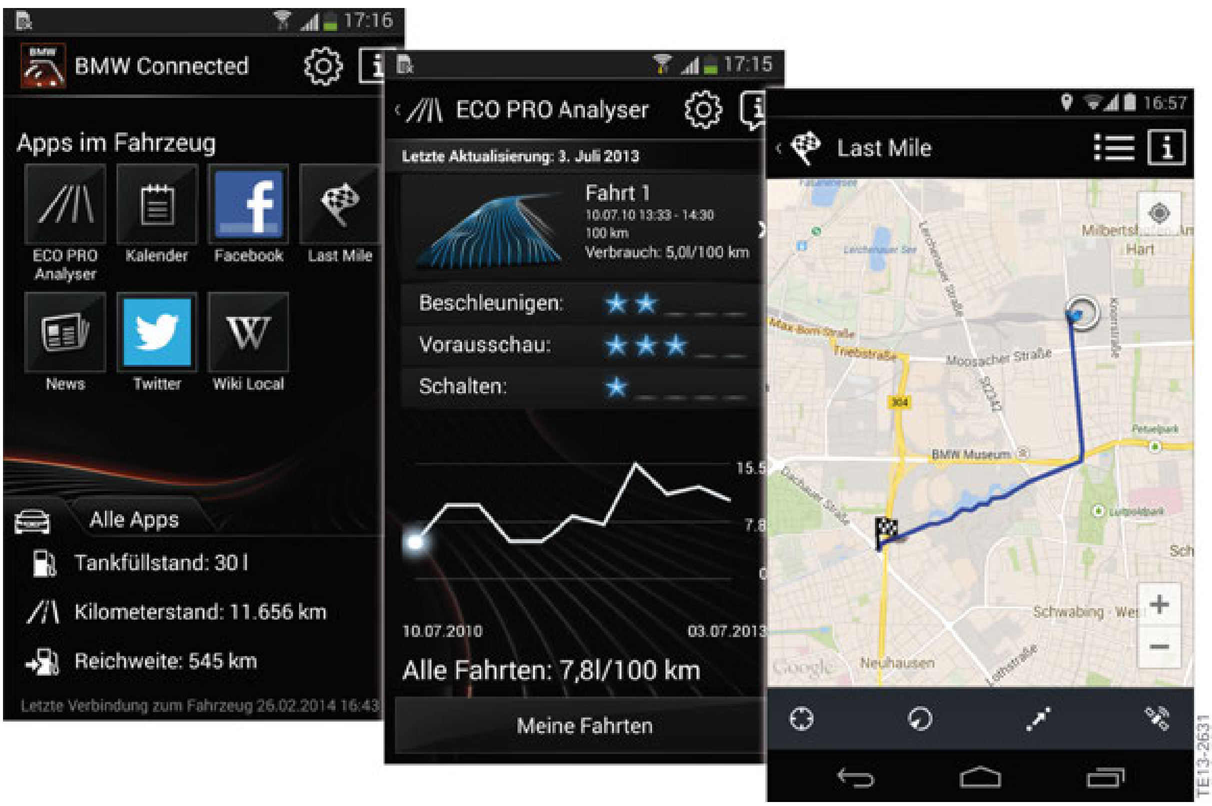
For Android telephones the selection of apps is not as extensive as for Apple telephones. The number of available apps is being increased continuously. With the software updates of the BMW Connected app, the customer receives new functions.

F48 Information and Communication

6. Android Devices

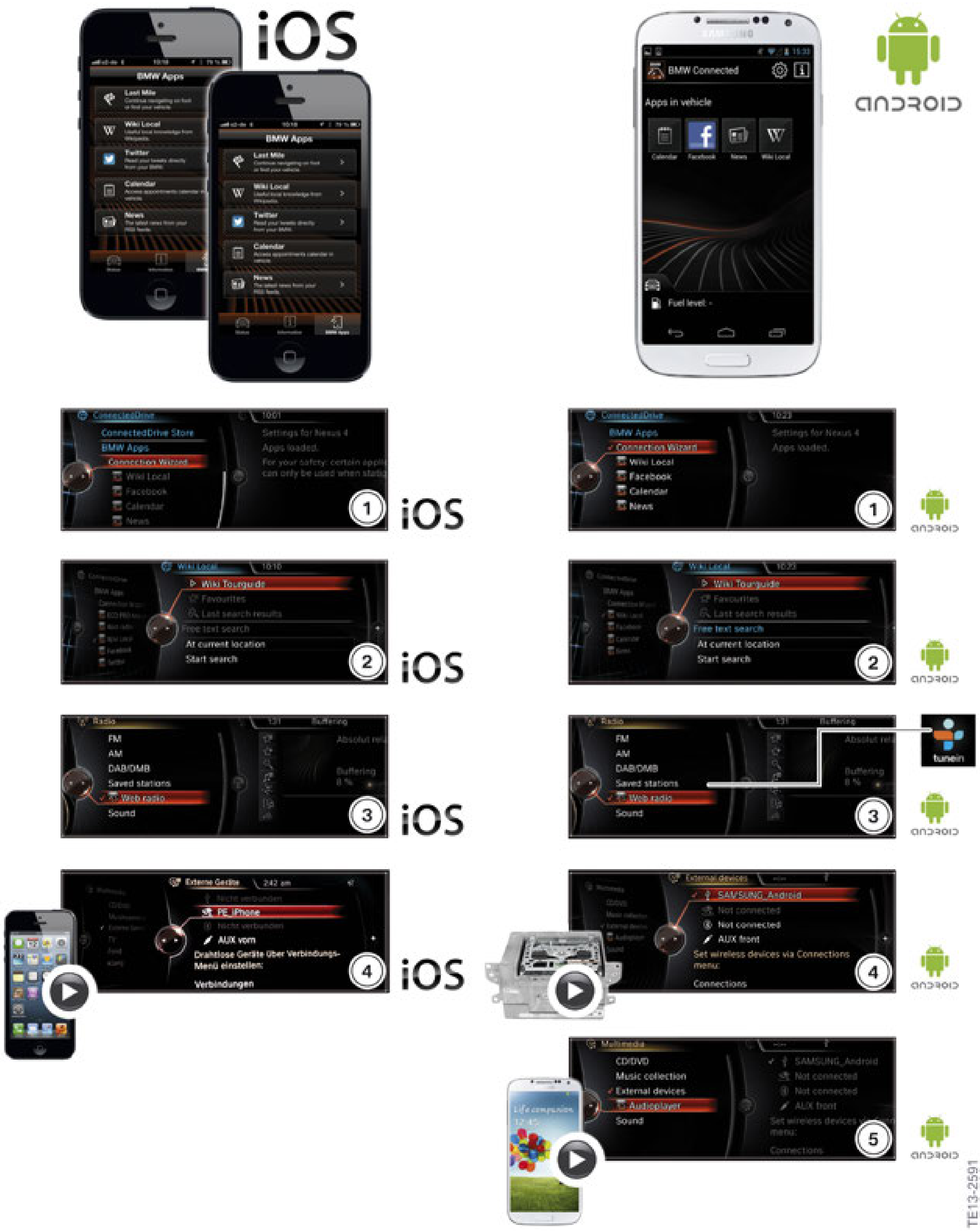
The following functions are possible at the moment:

- Facebook
- Twitter
- Wiki Local
- News
- ECO PRO Analyzer
- Last Mile Navigation



BMW Connected app for Android

6.2. Comparison of Android and iOS



iOS vs. Android

Index	Explanation
1	Connection manager
2	Wiki Local
3	Web radio
4	Audio player in USB mode
5	Android smartphone as audio player in Accessory mode

6.3. Function

With an Android telephone there are two different options to play media in the vehicle:

- USB mode
- Accessory mode

6.3.1. USB mode

USB mode is comparable to the function of a mass storage device. If the Android smartphone is connected to the vehicle with a USB cable, then one can find the telephone under the "Multimedia" main menu under "External devices", similar to the connection of a mass storage device. A search can be performed for artists or genres. The headunit is the audio player in USB mode. The end device only supplies the audio data to the headunit.

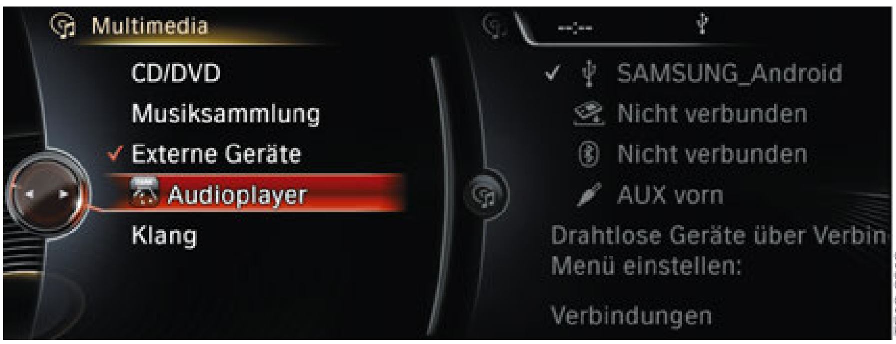
In the following table you see the most frequent transmission types of the various end devices.

End device	Transmission
USB mass storage device	MSC (Mass Storage Class)
Mobile phones	MTP (Media Transfer Protocol)

Music search in USB mode

6.3.2. Accessory mode

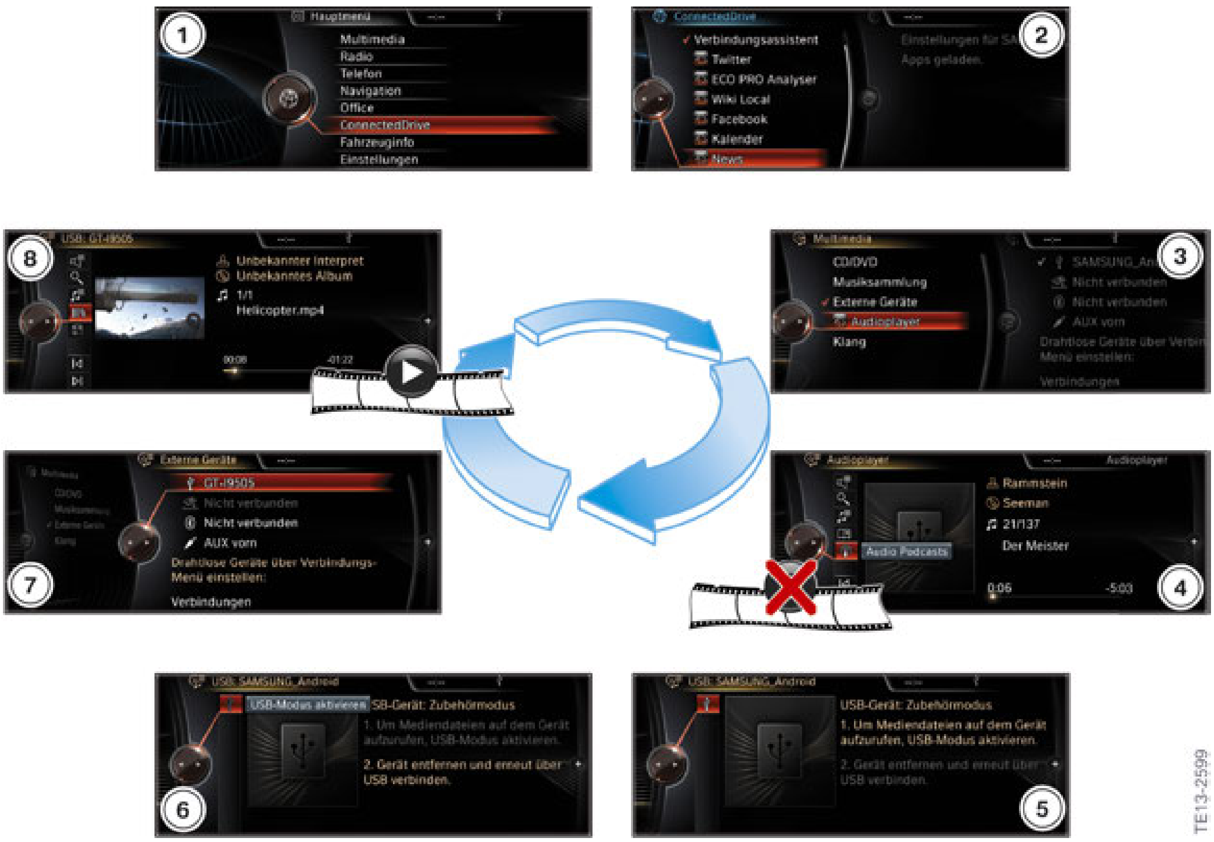
If Accessory mode is activated, the mobile phone now becomes the source of audio.
The BMW Connected app also has an audio player, in addition to apps such as Facebook, News, etc. This is visible in Accessory mode under CD/Multimedia and can play music data stored on the mobile phone (not music data stored on the additional memory card). The mobile phone of the customer is now the audio player, in contrast to the headunit (USB mode). This is necessary so that the customer does not always have to change to USB mode when he is working with the apps in order to listen to music on his smartphone.



TE13-0518

Audio player Accessory mode

6.3.3. Accessory mode activation



Accessory mode

Index	Explanation
1	"Start" main menu (USB mode)
2	Connection assistant in the ConnectedDrive menu after connection
3	"Audio player" Accessory mode
4	Accessory mode (not possible to play videos)
5	Change from Accessory mode to USB mode
6	Activate USB mode
7	USB mode
8	Not for US

Android smartphones are either connected to the vehicle via the snap-in adapter or a USB cable.

A new snap-in adapter is available for many Android smartphones. The "Snap-in Adapter Connected Universal" is suitable for different mobile phones. The antenna is connected inductively via a coupling antenna without any contact. Further information on the snap-in adapter can be found in the product information bulletin "Information and Communication System News I/2014".

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Technical training.
Product information.

F48 Passive Safety Systems

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BMW Group University
Technical Training
ST1508 9/1/2016

BMW Service

General information

Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:

⚠

Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

Information status and national-market versions

BMW Group vehicles meet the requirements of the highest safety and quality standards. Changes in requirements for environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between the contents of this document and the vehicles available in the training course.

This document basically relates to the European version of left-hand drive vehicles. Some operating elements or components are arranged differently in right-hand drive vehicles than shown in the graphics in this document. Further differences may arise as a result of the equipment specification in specific markets or countries.

Additional sources of information

Further information on the individual topics can be found in the following:

- Owner's Handbook
- Integrated Service Technical Application.

Contact: conceptinfo@bmw.de

The information contained in this document forms an integral part of the technical training of the BMW Group and is intended for the trainer and participants in the seminar. Refer to the latest relevant information systems of the BMW Group for any changes/additions to the technical data.

Information status: **June 2015**
Technical Training

F48 Passive Safety Systems

Contents

F48 Passive Safety Systems

Contents

F48 Passive Safety Systems

1. Introduction

1.1. The hidden protector

The passive safety system of the F48 is based on the objectives and characteristics of current BMW models. The passive safety system fulfils all legislative requirements worldwide.

The restraint systems ensure that the risk of injury is reduced.

The 4th generation Advanced Crash Safety Module (ACSM) is used as the central airbag control unit for the passive safety system in the F48. In comparison to other current series, with the passive safety system of the F48 the central sensor system is integrated in the ACSM control unit and not in the Integrated Chassis Management (ICM). This is possible with the F48 as the ACSM is located in the center of vehicle.

The ACSM4 of the F48 is connected to the FlexRay instead of previously in the PT-CAN. The sensor data of the central sensor system, which was previously provided by the ICM, can be transmitted directly by the ACSM via FlexRay to the DSC. The DSC processes the sensor data and makes it available to other bus users.

F48 Passive Safety Systems

2. System Overview

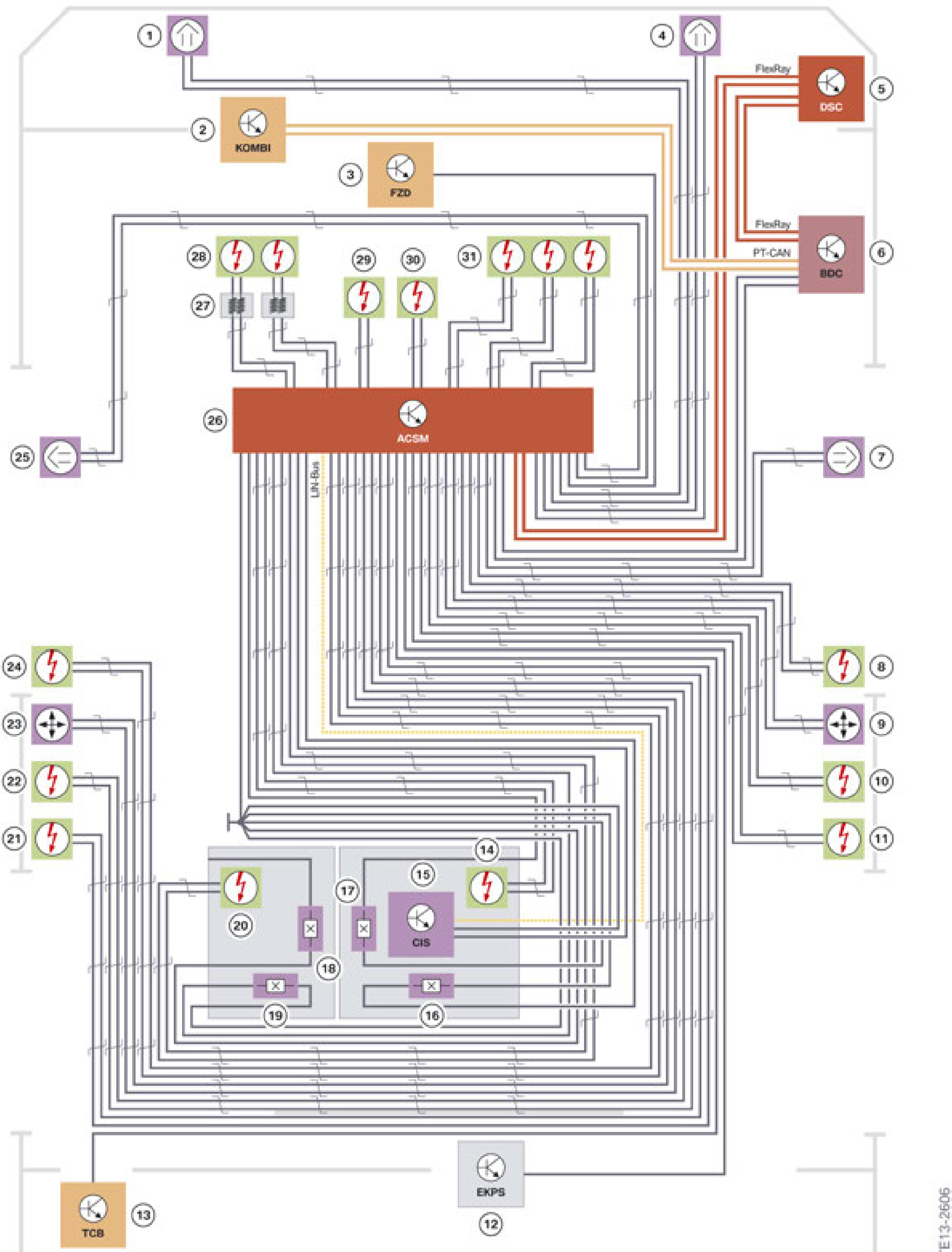
2.1. System wiring diagrams

The following bus overview shows an overview of the vehicle circuit structure of the F48 and incorporation of the ACSM in the Flexray.

F48 Passive Safety Systems

2. System Overview

2.1.1. System wiring diagram for US version

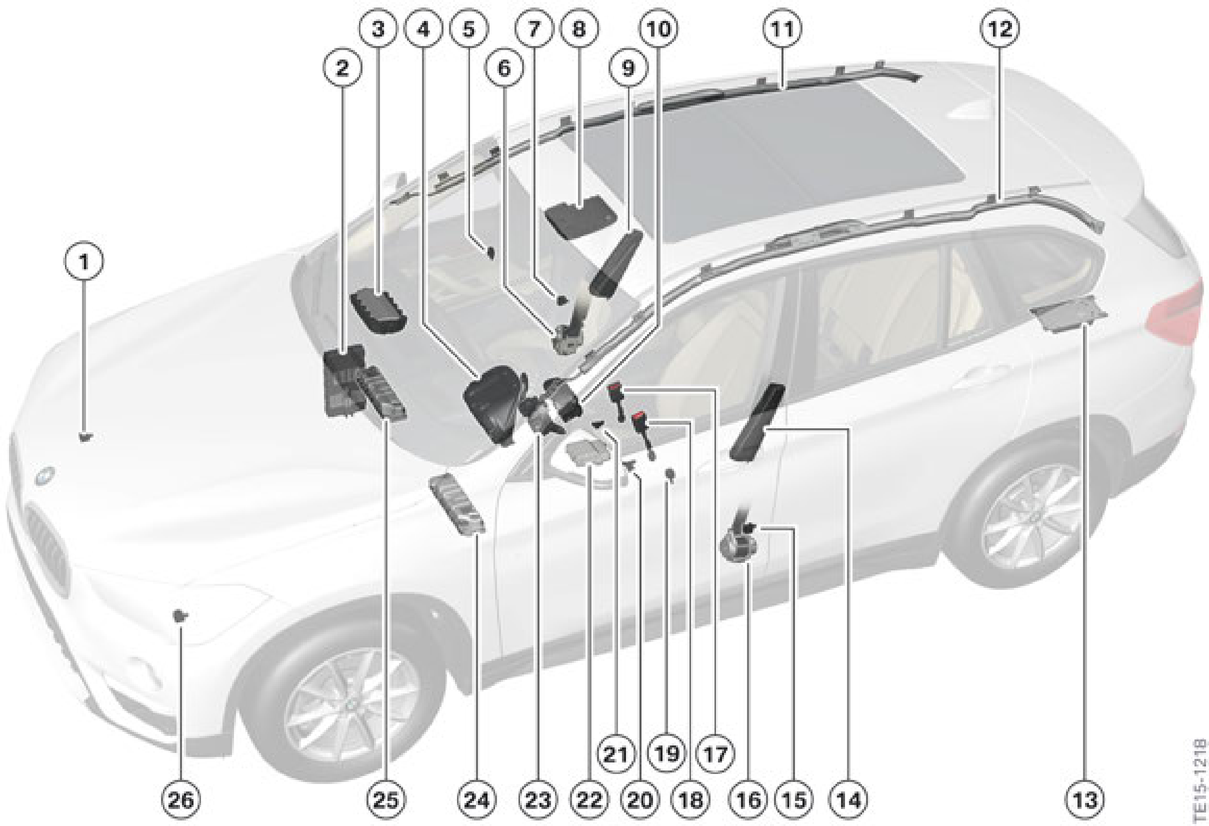


F48 system wiring diagram for passive safety in US-version vehicles

F48 Passive Safety Systems
2. System Overview

Index	Explanation
1	Airbag front sensor, left
2	Instrument cluster (KOMBI)
3	Indicator lamp for front passenger airbag deactivation in roof function center
4	Airbag front sensor, right
5	Dynamic Stability Control (DSC)
6	Body Domain Controller (BDC)
7	Airbag sensor, door, right (pressure)
8	Head airbag, passenger's side
9	Acceleration sensor, B-pillar, right
10	Adaptive belt force limiter, passenger's side
11	Side airbag, passenger's side
12	Electronic fuel pump control (EKPS)
13	Telematic Communication Box (TCB)
14	Belt tensioner, passenger 's side
15	CIS mat
16	Seat-position sensor, passenger's side
17	Seat belt buckle contact, passenger's side
18	Seat belt buckle contact, driver's side
19	Seat-position sensor, driver's side
20	Belt tensioner, driver's side
21	Side airbag, driver's side
22	Adaptive belt force limiter, driver's side
23	Acceleration sensor, B-pillar, left
24	Head airbag, driver's side
25	Airbag sensor, door, left (pressure)
26	Advanced Crash Safety Module (ACSM)
27	Steering Column Switch Cluster
28	Driver's airbag, two-stage
29	Knee airbag, driver's side
30	Knee airbag, passenger's side
31	Front passenger airbag, two-stage with active vent valve

2.2. System overview of US version



F48 System overview for US-version vehicles

Index	Explanation
1	Airbag front sensor, right
2	Body Domain Controller (BDC)
3	Front passenger airbag, two-stage with active vent valve
4	Instrument cluster (KOMBI)
5	Airbag sensor, door, right (pressure)
6	Belt tensioner and adaptive belt force limiter, passenger's side
7	Acceleration sensor, B-pillar, right
8	Indicator lamp for front passenger airbag deactivation in roof function center
9	Side airbag, passenger's side
10	Driver's airbag, two-stage
11	Head airbag, passenger's side
12	Head airbag, driver's side
13	Telematic Communication Box (TCB)
14	Side airbag, driver's side

F48 Passive Safety Systems
2. System Overview

Index	Explanation
15	Acceleration sensor, B-pillar, left
16	Belt tensioner and adaptive belt force limiter, driver's side
17	Seat belt buckle contact, passenger's side
18	Seat belt buckle contact, driver's side
19	Airbag sensor, door, left (pressure)
20	Seat-position sensor, driver's side
21	Seat-position sensor, passenger's side
22	Advanced Crash Safety Module (ACSM)
23	Steering Column Switch Cluster in the steering column switch cluster
24	Knee airbag, driver's side
25	Knee airbag, passenger's side
26	Airbag front sensor, left

F48 Passive Safety Systems

3. Functions

3.1. Functions of Advanced Crash Safety Module

The function of the Advanced Crash Safety Module is to permanently evaluate all sensor signals in order to identify a crash situation. As a result of the sensor signals and their evaluation, the Advanced Crash Safety Module identifies the direction and the severity of the crash.

The ACSM evaluates the information from the sensors and then forwards corresponding measures for selective activation of the necessary restraint systems.

The Advanced Crash Safety Module monitors the system itself and indicates when it is ready for operation by switching off the airbag indicator light.

If an error occurs during operation this is stored in a fault memory and can be read out for diagnosis purposes.

If a crash situation is detected, a crash message is sent to the other bus users in the data bus network as notification. The relevant control units respond to this signal by executing their own activities according to the severity of the crash.

The activities include:

- Opening the central locking system
- Activating the hazard warning light
- Switching on the interior light
- Making an emergency call

An additional function of the Advanced Crash Safety Module is the acoustic seat belt warning that reminds the driver and front passenger using visual and acoustic signals to fasten their seat belts. Seat belt buckle switches are used to identify whether the driver and/or the front passenger have their seat belts fastened. Information on occupancy of the front passenger seat is also included for the acoustic seat belt warning. Furthermore, for vehicles in the US version the position of the driver and the front passenger seat is monitored.

The functions of the Advanced Crash Safety Module generally belong to one of the following areas:

- Crash-relevant functions
- System monitoring functions
- Additional convenience functions

3.2. Crash-relevant functions

The Advanced Crash Safety Module must fulfil the following crash-relevant functions:

- Evaluating the sensor signals
- Impact detection
- Determining actuators to be activated
- Specifying the trigger time and trigger sequence
- Activation of the ignition circuit output stages
- Sending the crash message to all bus users
- Crash documentation
- Emergency call function

3.2.1. Evaluating the sensor signals

The sensors serve to identify and verify front-end, side-on and rear-end crashes and also as roll-over detection.

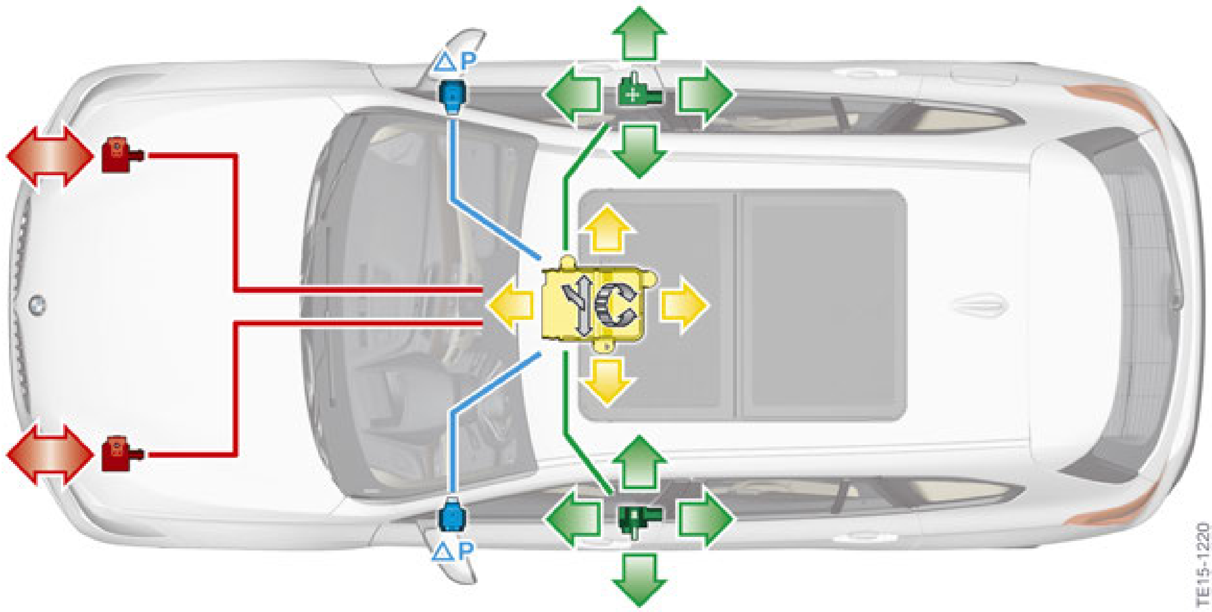
The sensors are located in the ACSM or are directly connected to the Advanced Crash Safety Module where their signals are evaluated and processed.

3.2.2. Impact detection for US version of vehicles

The US version of the vehicles is equipped with the following sensors:

- one lateral and one longitudinal acceleration sensor in the B-pillars (green)
- one airbag sensor to monitor the pressure in each of the front doors (blue)
- one lateral and one longitudinal acceleration sensor in the ACSM (yellow)
- one yaw rate sensor in the ACSM (yellow)
- one vertical acceleration sensor in the ACSM (yellow)
- one airbag front sensor beside the headlights (red)

The airbag front sensors assist with the identification of a head-on crash and its corresponding severity.



F48 Sensors in US version of vehicles

3.2.3. Trigger time and trigger sequence

The Advanced Crash Safety Module uses the values transmitted by the sensors to determine the direction and severity of the crash.

In the case of a head-on crash, for example, corresponding high acceleration values from the longitudinal acceleration sensors in the rear doors and ACSM respectively must be detected. An algorithm determines the severity and direction of the crash based on the accelerations. This information is used to assist calculation of the trigger times and sequence in which the restraint systems are activated.

A possible imminent rollover is also detected and the appropriate protection systems are activated.

3.2.4. Activation of the ignition circuit output stages

The Advanced Crash Safety Module is supplied in the BDC with terminal 30B. The Advanced Crash Safety Module is in offline mode with terminal 30B. This means that it is active on the data bus and can perform all diagnostic functions. Activation of the ignition circuits is blocked and is only enabled as of terminal 15 once the system self-test is complete. The Advanced Crash Safety Module is also ready for ignition, even with the logical terminal R.

The ignition capacitors are recharged via a switching controller. These ignition capacitors make the firing energy available in the event of a crash. If the voltage supply is interrupted during a crash, the ignition capacitors serve briefly as an energy storage device.

The ignition circuit output stages consist of a high-side and a low-side power switch. The high-side power switch connects the ignition voltage, while the low-side power switch connects to the ground. The ignition circuit output stages are controlled by a microcontroller.

The high-side and low-side power switches also serve to check the ignition circuits during the system self-test.

3. Functions

3.2.5. Sending the crash message

In the event of a collision involving activation of the restraint systems, the Advanced Crash Safety Module sends a crash message to the bus users in the data bus network.

The activation of the Telematic Communication Box is connected via a direct single-wire connection.

As a result, the respective control units perform the following functions depending on the crash severity:

Function	Control unit
Switch off electric fuel pump	Via direct line to the electronic fuel pump control (EKPS)
Release central locking system	Via FlexRay signal to the Body Domain Controller (BDC)
Switch on hazard warning lights	Via FlexRay signal to the Body Domain Controller (BDC)
Switch on interior light	Via FlexRay signal to the Body Domain Controller (BDC)
Make emergency call	Via direct line to the Telematic Communication Box (TCB)

3.2.6. Crash documentation

In the event of a collision where one or more actuators are activated, a crash entry is stored in a non-erasable memory. After three crash entries, a non-erasable fault entry is stored together with the information that the three crash messages have been saved. The airbag indicator light also lights up continuously.

⚠

The three crash entries could also be stored during the course of an accident. Each crash entry is assigned a system time. The control unit remains ignitable even after three crash entries. The crash entries cannot be erased and serve the purpose of subsequent device diagnosis. A maximum of three crash entries can be saved. The control unit must then be replaced.

3.2.7. Emergency call function

The emergency call functions are country-specific and are available to customers in countries with ConnectedDrive Services infrastructure. A prerequisite for an emergency call is an active SIM card in the Telematic Communication Box and the availability of a mobile phone network.

The emergency call button is connected directly to the Telematic Communication Box.

The manual emergency call allows the driver to request assistance in the event of a medical emergency.

3. Functions

The functions of the emergency call have been modified with the realignment of the ConnectedDrive Services. The next chapters provide detailed information on which functions the F48 receives with Intelligent eCall (SA 6AC).

3.2.8. Vehicles with Intelligent eCall

The Intelligent eCall (SA 6AC) always includes the option of a manual or automatic emergency call (voice call and data transmission). A voice contact is initiated and data, such as the current position, is transmitted. The emergency call is made to a BMW Call Center or an emergency coordination center, depending on the national-market version.

The Advanced Crash Safety Module sends a message to the Telematic Communication Box in the event of an accident with corresponding crash severity. The Telematic Communication Box makes an emergency call.

With this automatic emergency call, the presumed number of people in the vehicle and sensor data, among other things, are transmitted to the BMW Call Center, in order to identify the severity of the crash.

The information about the accident available at the call center can be forwarded to the emergency coordination center. The emergency coordination center can then initiate appropriate measures.

Attempts are made at the same time to establish a voice contact with the occupants of the vehicle in order to obtain more detailed verbal information about the accident (e.g. condition of occupants).

The following tables provides information on which functions are available in the case of an emergency call with Intelligent eCall :

Equipment	Manual emergency call	Automatic emergency call
Intelligent eCall (SA 6AC)	• Voice call (BMW Call Center) • Data transfer (location).	• Voice call (BMW Call Center) • Data transfer (location) • Sensor data transmission.

If, for various reasons, a connection to the BMW Call Center cannot be established, the emergency call is automatically forwarded to the emergency coordination center.

3.3. System monitoring functions

The Advanced Crash Safety Module has the following system monitoring functions:

- System self-test (pre-drive check)
- Display of system operability
- Cyclic monitoring
- Fault display and fault storage

- Output of faults (diagnosis)
- Acoustic and visual seat belt warning
- Deactivation of the front passenger airbag, side airbag and knee airbag on the passenger's side in the US version of the vehicles.

3.3.1. System self test

The Advanced Crash Safety Module performs a system self test from terminal 15. The airbag indicator light is activated for roughly five seconds during the system self test.

Once the system self test is complete and no faults have been identified, the airbag indicator light goes out and the system is ready to operate.

3.3.2. Display of system operability

The airbag indicator light in the instrument cluster goes out to indicate that the Advanced Crash Safety Module (ACSM) is ready for operation.

3.3.3. Cyclic monitoring

Once the system self-test has been successfully concluded and the system is ready for operation, a cyclic monitoring procedure is performed for fault monitoring purposes. This cyclical monitoring serves the internal diagnosis of the control unit and overall airbag system. Cyclical monitoring takes place continuously from terminal 15. It is also continued when the logical terminal R is reached.

3.3.4. Fault display and fault storage

The Advanced Crash Safety Module has a non-volatile fault memory. The airbag indicator light illuminates to indicate a fault entry.

Events, such as the activation of an airbag or belt tensioner, are stored in the fault memory.

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If the fault memory contains the entry that the restraint system has been activated, this only means the ignited restraint system is not available for further activation and not that it malfunctioned during the crash.

3.3.5. Output of faults (diagnosis)

The fault memory can be read out via the diagnostic interface with the assistance of the Integrated Service Technical Application (ISTA) in the BMW diagnosis system. After rectifying the faults or after renewing activated components, the fault memory can be cleared with the diagnosis command "Clear fault memory".

3.3.6. Acoustic and visual seat belt warning

An acoustic and visual seat belt warning is a standard feature of all vehicles equipped with the Advanced Crash Safety Module. The Advanced Crash Safety Module records whether or not the driver or front passenger have fastened their seat belts. If they have not, an acoustic and visual warning is output to remind them to fasten their seatbelts. Both seat belt buckle switches are monitored separately.

3.3.7. Deactivating the airbag

Provision is made in US versions of the vehicles for the airbag to be deactivated automatically in order to satisfy the regulations of the National Highway Traffic Safety Administration (NHTSA). When the child seats listed in the regulation are occupied by a child this must lead to deactivation of the airbag.

To do so, a seat occupancy mat is used on the front passenger seat for the purpose of occupancy detection and classification of occupants in the front passenger seat. In the F48 a capacitive interior sensing floor mat (CIS floor mat) is used.

The CIS mat is made up of two elements: A sensor wire, which runs parallel to the seat heating in the seat cushion, and an evaluation unit. The CIS mat measures the capacity and ohmic resistance between the sensor wire (anode) and the vehicle ground (cathode) at a frequency of 120 kHz.
The CIS mat determines from the change in capacity and resistance whether the front passenger seat is occupied by an adult or a child in a child seat.

The deactivation of the front passenger airbag, the side airbag and knee airbag on the passenger's side is signalled by the indicator lamp for front passenger airbag deactivation.

The indicator lamp for front passenger airbag deactivation in the roof function center illuminates if a child seat with child, that has been tested in accordance with the NHTSA regulations, was detected on the front passenger seat or if the front passenger seat is unoccupied.

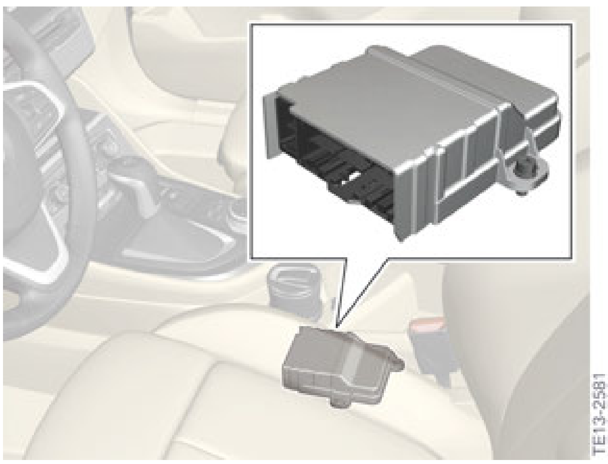
F48 Passive Safety Systems

4. System Components

4.1. Advanced Crash Safety Module

The Advanced Crash Safety Module is accommodated in a housing with two sockets.

The wiring harness is connected via one of the sockets. An additional socket is provided for the cockpit wiring harness.



F48 Advanced Crash Safety Module

The ACSM in the F48 is located centrally in the vehicle under the center console between the two front seats.

The central sensor system was able to be integrated in the ACSM thanks to the central position of the ACSM.

4.2. Sensors and switches

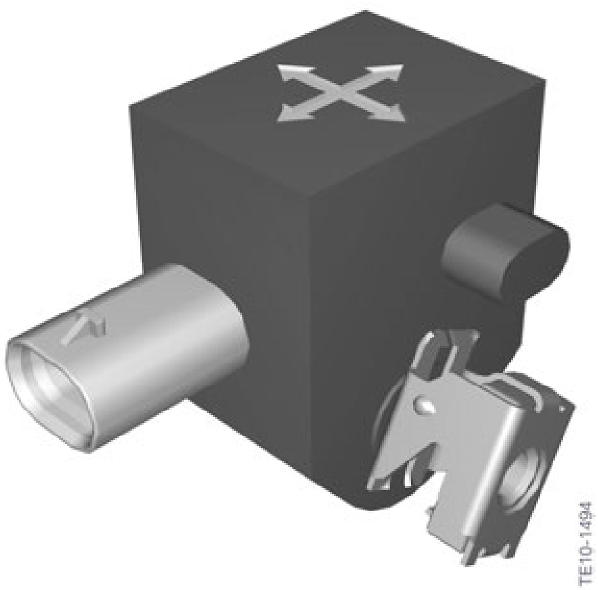
The following sensors and switches are installed:

- Lateral and longitudinal acceleration sensors in ACSM
- Yaw rate sensor in the ACSM
- Vertical acceleration sensor in the ACSM
- Lateral and longitudinal acceleration sensors in the B-pillars
- One airbag sensor in each of the front doors for pressure
- One airbag front sensor beside the headlights
- CIS mat with occupant classification
- Seat belt buckle switch
- Seat-position sensor, driver's side
- Seat-position sensor, passenger's side
- Emergency call button

4.2.1. Lateral and longitudinal acceleration sensor, B-pillar

The lateral and longitudinal acceleration sensors in the B-pillars assist with the identification of front-end crashes, side-on crashes and rear-end crashes.

The B-pillar airbag sensor consists of a longitudinal acceleration sensor and a lateral acceleration sensor. The acceleration sensors measure both the acceleration and the deceleration in the X and Y directions. The resultant from the X and Y signals is decisive in identifying the direction of the crash.

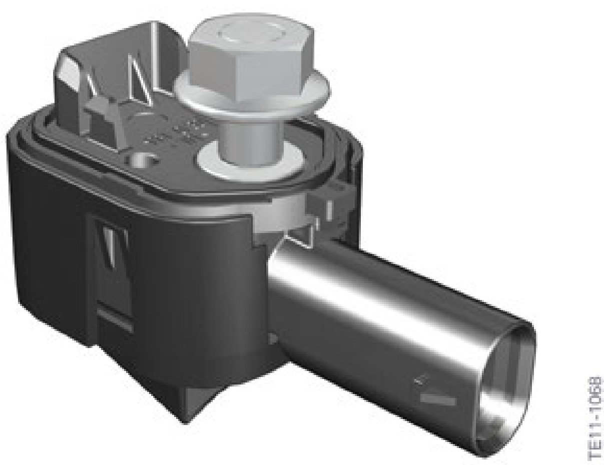


F48 lateral and longitudinal acceleration sensor in the B-pillar

4.2.2. Door airbag sensor (pressure)

For vehicles in US version, pressure sensors are installed in the driver and front passenger doors. Side-on crashes are identified with the assistance of the airbag sensors. In addition to the lateral acceleration values that are present, the pressure in the door cavity also increases in the event of a side-on crash.

The airbag sensors in the doors serve to verify the plausibility of the acceleration signals from the B-pillar airbag sensors and the ACSM when a side-on crash is detected. The airbag sensors are situated in the inner panel of the doors and measure the pressure increase in the event of a side-on collision. In the event of a side collision with the door, the outer skin is pressed inward, thus reducing the door interior and increasing the inner pressure. This pressure change is measured by the airbag sensors. The airbag sensor also includes electronics, in addition to the pressure sensor, that digitise the pressure readings and transmit them cyclically to the Advanced Crash Safety Module (ACSM). The pressure readings are evaluated in the ACSM.



F48 Door airbag sensor (pressure)

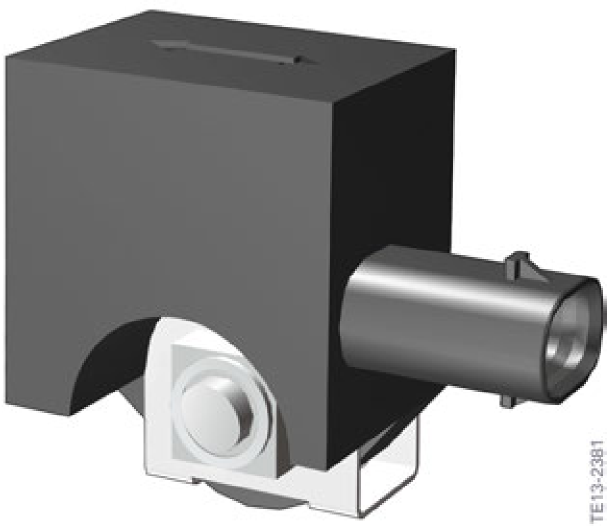
F48 Passive Safety Systems
4. System Components

4.2.3. Airbag front sensor

Two airbag front sensors are installed beside the headlights. The measured values are forwarded to the Advanced Crash Safety Module (ACSM) where they are evaluated.

The airbag front sensors on the left and right assist with the identification of a head-on crash.

They deliver additional information to the Advanced Crash Safety Module on the characteristics and severity of the collision. Each sensor contains an acceleration sensor for recording the deceleration, signal processing technology and electronics for data transfer. The measured values are sent in the form of a message to the Advanced Crash Safety Module (ACSM) and are used in the calculation of the algorithm.

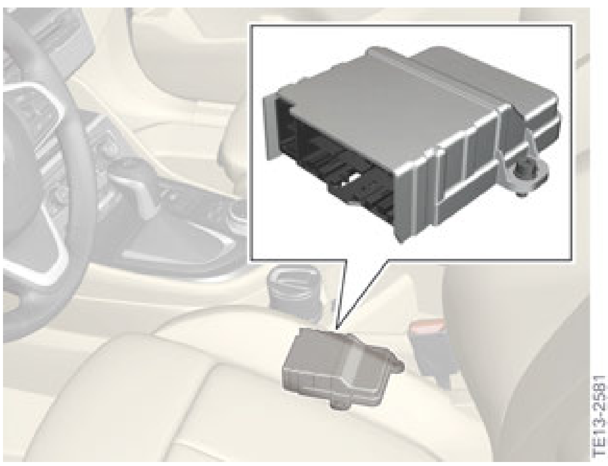


F48 airbag front sensor

4.2.4. Sensors in the ACSM

In the F48, the central sensor system is integrated into the ACSM control unit. The ACSM contains a longitudinal and lateral acceleration sensor, a vertical acceleration sensor and a yaw rate sensor (only US-version vehicles). The ACSM also includes a longitudinal and lateral acceleration sensor and a yaw sensor for the driving dynamics control.

The sensor data for impact detection are evaluated in the ACSM and help identify side-on, rear-end or head-on crashes and assists with roll-over detection. The sensor data not yet evaluated for the driving dynamics control is sent to the DSC control unit via FlexRay, where it is processed.



F48 Advanced Crash Safety Module

4.2.5. CIS mat

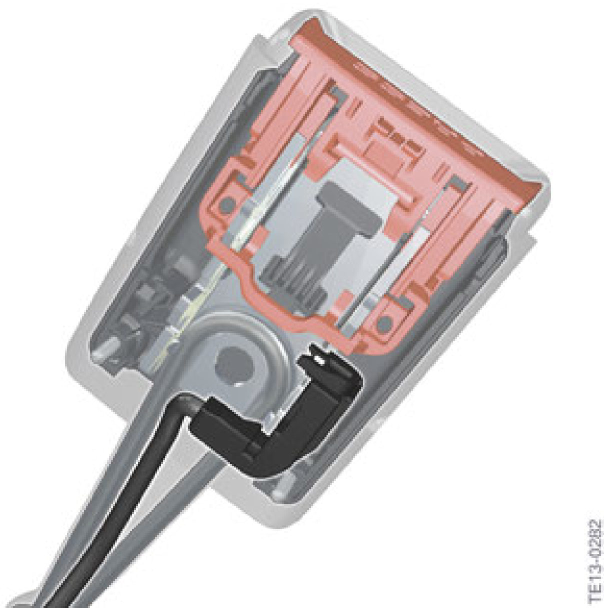
In the US version of vehicles, the capacitive interior sensing mat (CIS mat) is fitted in the front passenger seat instead of the seat occupancy mat. The CIS mat can detect whether the front passenger seat is occupied by an adult or a child in a child seat. The deactivation of the front passenger airbag and side airbag and knee airbag on the passenger's side is signalled by the indicator lamp for front passenger airbag deactivation.

4.2.6. Seat belt buckle switch

The seat belt buckle switches are located in the seat belt buckles of the driver and front passenger seat.

The seat belt buckle switch detects whether the seat belt buckle tongue is in the seat belt buckle. The Advanced Crash Safety Module supplies power to the sensors and performs the evaluation.

From terminal 15, the seat belt buckle switch is permanently monitored and used for the visual and acoustic seat belt warning and also to determine which restraint systems are triggered.



F48 Seat belt buckle switch

4.2.7. Emergency call button

The emergency call button is located in the roof function center.

F48 roof function center with emergency call button in European version

4. System Components

4.2.8. Seat-position sensors

In accordance with the US legal requirement (FMVSS208), a height identification for the person in the driver and front passenger seat must be assessed. This height identification is performed via the adjustment travel of the forward/back seat adjustment. In US-version vehicles, the exact position is identified using the seat-position sensors for the driver and front passenger seats.

The job of the seat-position detector is to distinguish between a relatively small person and a person of normal height within the lengthways adjustment range of the seat. This detection is another technical feature aimed at increasing the safety of the occupants. The deployment of the three airbag stages is then adjusted to the driver's/front passenger's seat position.

The seat-position detector takes the form of a 2-wire hall effect sensor and is supplied with power via the ACSM control unit. The current level of the seat-position sensor changes depending on the seat position.

4.3. Actuators

4.3.1. Overview

The following actuators are installed in the F48:

- Two-stage driver's airbag
- Two-stage passenger's airbag with active vent valve
- Knee airbag on front left and right
- Head airbag on left and right
- Side airbag on front left and right
- Belt tensioner with adaptive force limiter

In addition, the following indicator lights inform the vehicle occupants about the condition of the safety systems:

- Airbag indicator light
- Seat belt warning light
- Indicator lamp for front passenger airbag deactivation

The familiar three-point seat belts are used as the seat belt systems for all seats in the F48.

F48 Passive Safety Systems
4. System Components

4.3.2. Driver's airbag

The purpose of the driver's airbag is to reduce the risk of injury to the driver in combination with the seat belt when a front-end crash occurs. The driver's airbag is located in the steering wheel impact plate. The driver's airbag is equipped with a gas generator.

A two-stage gas generator is installed in the US-version of vehicles, which can be used to activate the stages at short or long time differences, depending on the severity of the crash detected and taking into consideration the seat position.

F48 Driver's airbag in US version of vehicles

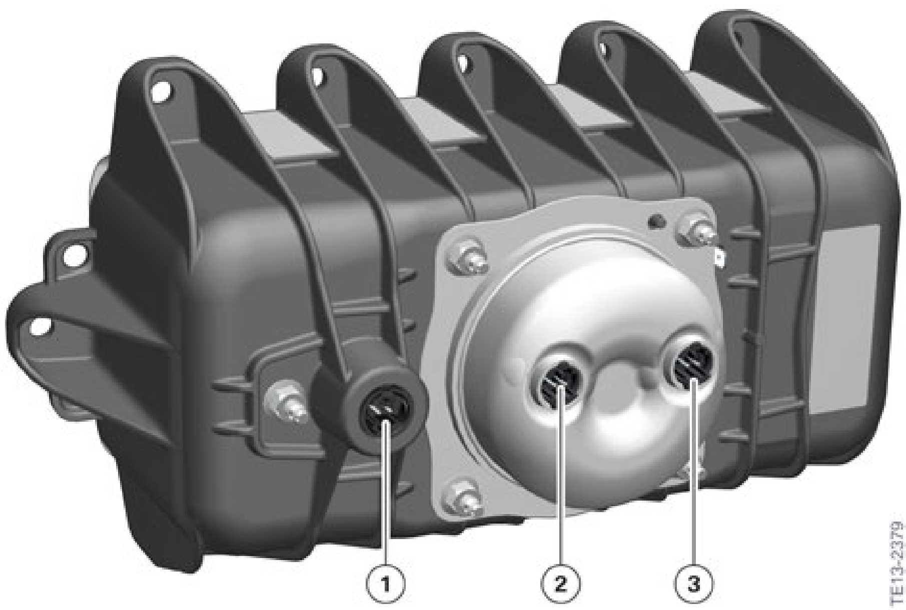
Index	Explanation
1	Ignition squib, stage 1
2	Ignition squib, stage 2

4.3.3. Front passenger airbag

The purpose of the front passenger airbag is to reduce the risk of injury to the front passenger in the event of a front-end crash. The front passenger airbag is located in the instrument panel. When the front passenger airbag expands, the instrument panel tears open at defined points.

A two-stage gas generator is installed in the US-version of vehicles, which can be used to activate the stages at short or long time differences, depending on the severity of the crash detected and taking into consideration the seat position.

Furthermore, the front passenger airbag in the US version of the vehicles features an active vent valve.



F48 Front passenger airbag in US version of vehicles

Index	Explanation
1	Ignition squib for active vent valve
2	Ignition squib, level 1
3	Ignition squib, level 2

4.3.4. Knee airbag

The US standards (laws) contain requirements on the passive restraint of occupants (without seatbelt). This is why in the US version of the vehicles a knee airbag is also required on the driver's side and passenger's side to control the forwards displacement of the occupant(s) in the event of a head-on crash.

F48 Knee airbag in US version of vehicles

4.3.5. Head airbag

Head airbags are installed in the F48 to protect the occupants' heads in the event of a side collision.

The head airbag extends from the A-pillar to the C-pillar and covers the entire area of the side windows. It expands between the occupants and side structure.

System features:

- Extended covered area across all front and rear side windows.
- Protection of occupants from glass splinters.
- Covered area for different-sized occupants optimized.

F48 Head airbag

4.3.6. Side airbag

As with all current BMW models, the side airbag at the front ignites out of the front seat backrest.

The side airbags and gas generators are located in a plastic housing.

This is installed in the front seat backrest and is concealed by the seat cover.

If activated, the side airbag emerges outwards from the backrest frame and spreads between the side structure and occupant.

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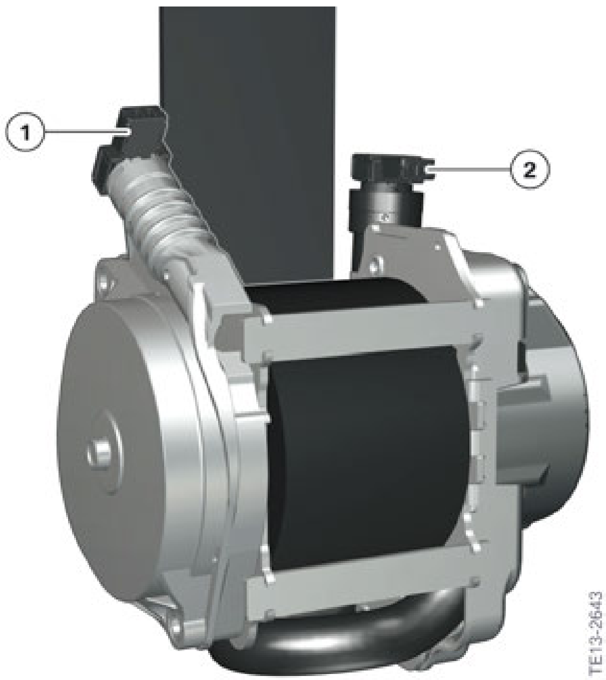
It is important to ensure that no additional seat covers are fitted as they would greatly impair the function of the side airbag, or even immobilise it altogether.

F48 Seat with side airbag

Index	Explanation
1	Side airbag

4.3.7. Belt tensioner with adaptive force limiter



F48 Belt tensioner with adaptive force limiter

Index	Explanation
1	Connection of ignition squib, belt tensioner
2	Connection of ignition squib, adaptive force limiter

A belt tensioner with adaptive force limiter for the driver and front passenger is built into the US version of the vehicles. The gas generator-assisted belt tensioner ensures that the seat belt strap is reeled in to reduce belt slack prior to forwards displacement of the occupants.

The adaptive force limiter switches from a high level force to a low level force depending on the position of the seat with the assistance of a gas generator in order to reduce the retaining force of the seat belt during the crash depending on the size of the occupant. The further forward the seat is, the earlier the changeover takes place.

When optimally harmonised with the airbag, it ensures the kinetic energy acting on the occupants is more evenly dissipated for the duration of the head-on collision. Thus lower occupant stress values are achieved.

4.3.8. Airbag indicator light

The airbag indicator light is located on the instrument cluster. The airbag indicator light lights up then goes out during the pre-drive check to signal readiness of the Advanced Crash Safety Module and passive safety systems. The airbag indicator light is controlled via a message on the FlexRay from the Advanced Crash Safety Module via the Body Domain Controller (BDC) to the instrument cluster.
The instrument cluster receives a message cyclically. If the message remains off, the airbag indicator light is activated.

F48 Airbag indicator light

4.3.9. Seat belt warning light

A visual and audible warning is issued if the seat belt is not fastened or is unbuckled during the journey.

F48 Seat belt warning light

The status of the seat belt contacts in the seat belt is visible for a short period in the instrument cluster TFT display during starting
or if a contact is changed.

4.3.10. Indicator lamp for front passenger airbag deactivation

The indicator light for the front passenger airbag deactivation is located in the roof function center. It is automatically activated if the CIS seat mat detects a small child in a child seat or if the front passenger seat is not occupied.

The brightness of the indicator lamp for front passenger airbag deactivation is controlled via the automatic brightness control of the display illumination.

F48 roof function center with indicator lamp for front passenger airbag deactivation in US version

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