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Passive Safety Systems

Model: F01/F02

Production: From Start of Production

OBJECTIVES

After completion of this module you will be able to:

- Describe the ACSM3 system of the F01/F02
- Describe the function of the ACSM3 system of the F01/F02
- Identify the components of the ACSM3 system of the F01/F02

Introduction

The F01/F02 passive safety system aims towards the objectives and characteristics of the E65/E66. The passive safety system fulfils all legislative requirements.

Extensive measures were taken on the body and on the occupants safety and protection systems. The passive safety system includes not only the restraint systems, but also a special body structure which offers a defined crash performance. In the event of an accident, the forces introduced are reduced in a defined manner and therefore have less on an impact on the occupants.

The restraint systems ensure that the risk of injury is further reduced.

The third generation ACSM is used as the central airbag control unit for the passive safety system on the F01/F02. It differs from the previous crash safety modules in having a sensor system placed in position.

The ACSM III provides up to 32 ignition outputs.

BMW safety concept with safety passenger cell and airbag systems in the example of an E60

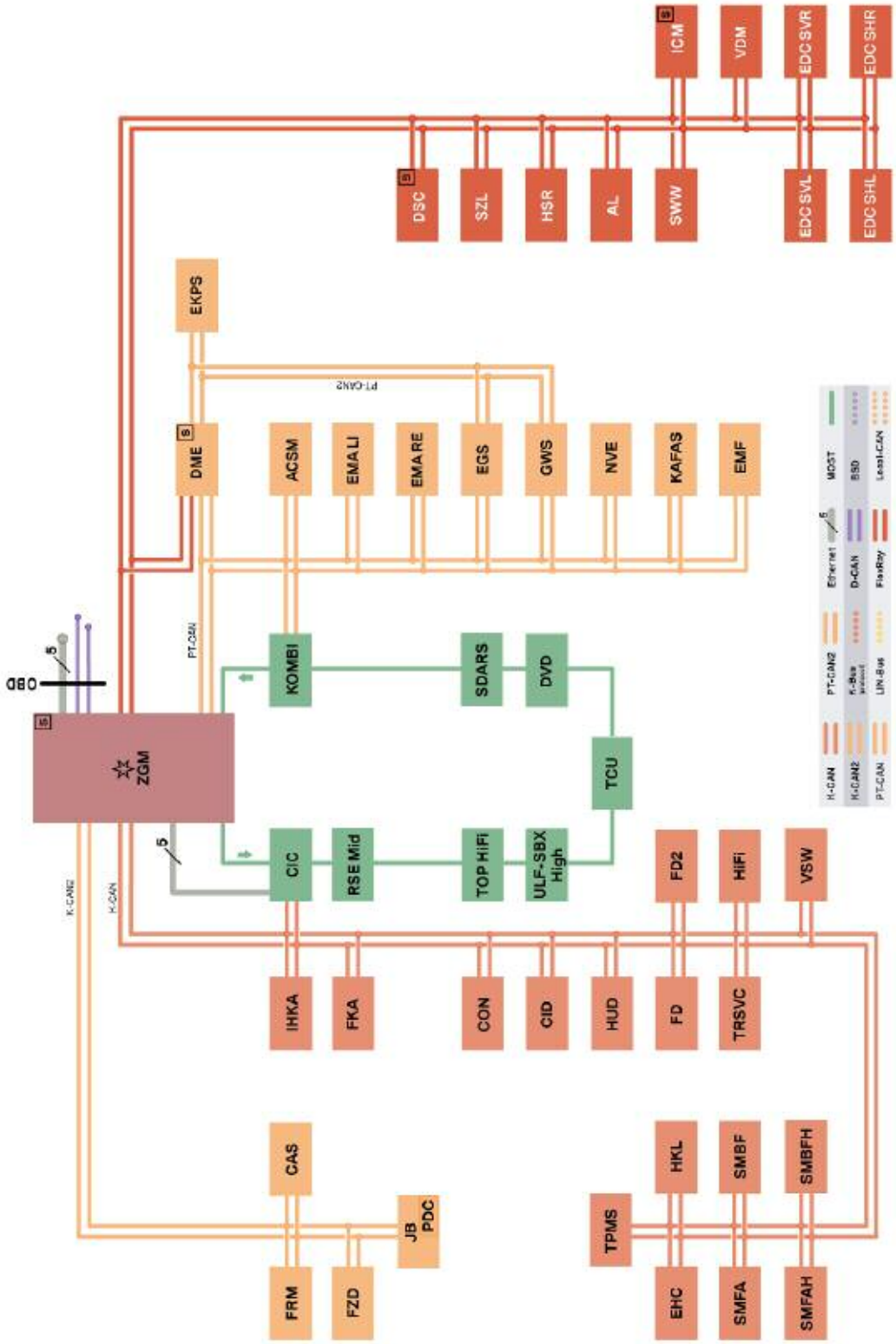
Model Overview

The passive safety system ACSM, the replacement system to the byteflight, is already used on the following models.

Model series	Model	Used as of	Variant
E60	5 Series Saloon	09/2005	ACSM 1
E61	5 Series Touring	09/2005	ACSM 1
E63	6 Series Coupé	09/2005	ACSM 1
E64	6 Series Convertible	09/2005	ACSM 1
E85	Z4 Roadster	01/2006	ACSM 1
E86	Z4 Coupé	05/2006	ACSM 1
E88	1 Series Convertible	04/2008	ACSM 2
E70	X5 SAV	11/2006	ACSM 2
E71	X6 SAC	04/2008	ACSM 2
E93	3 Series Convertible	03/2007	ACSM 2
F01	7 Series Saloon	11/2008	ACSM 3
F02	7 Series Saloon long version	11/2008	ACSM 3

System Overview

F01/F02 Bus System Overview



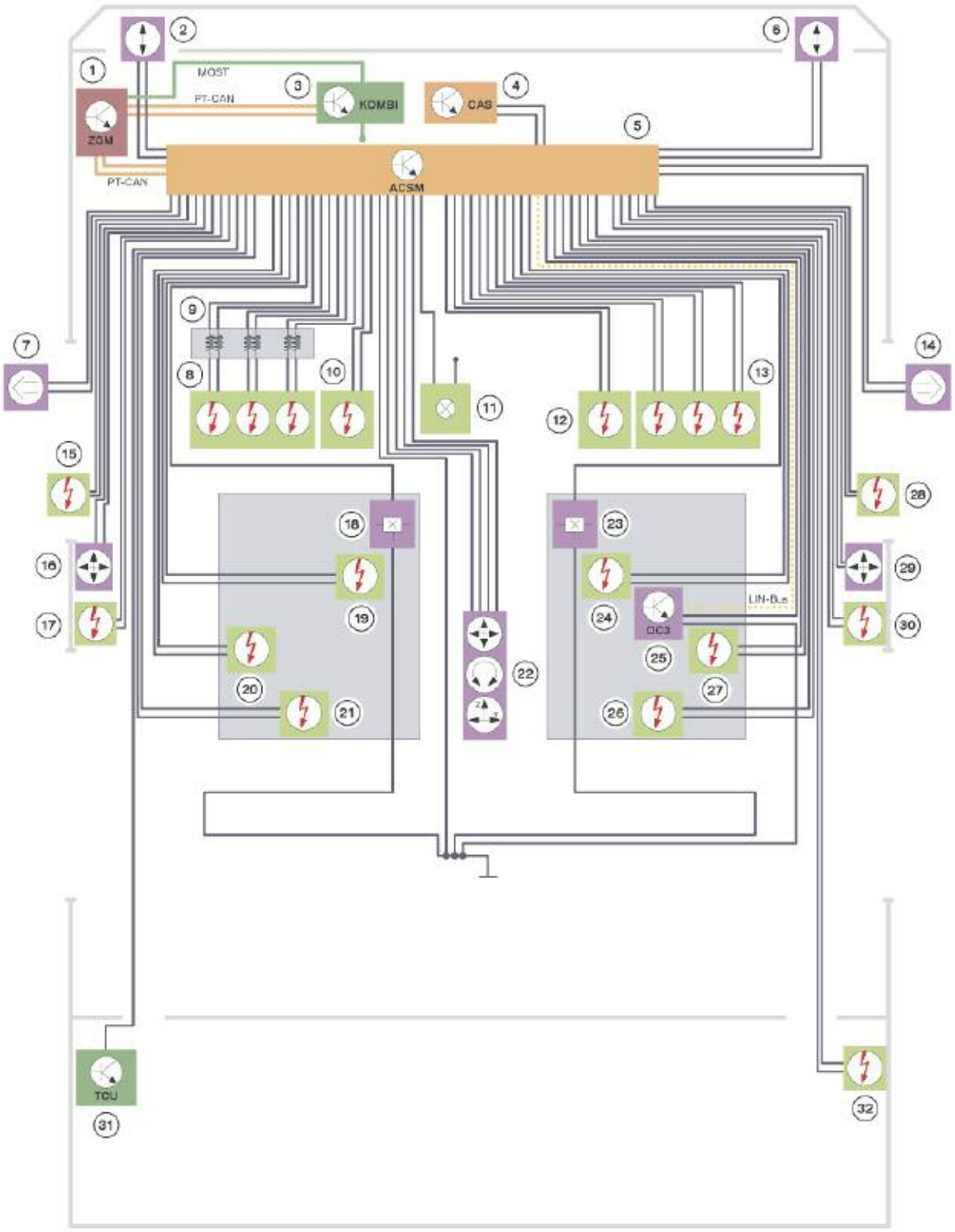
Legend for F01/F02 Bus System Overview

Index	Explanation
ACSM	Crash Safety Module (Advanced Crash Safety Module)
AL	Active steering system
CAS	Car Access System
CIC	Car Information Computer
CID	Central information display
CON	Controller
DME	Digital Motor Electronics
DSC	Dynamic Stability Control
DVD	DVD changer
EDC SHL	Electronic damper control, rear left satellite
EDC SHR	Electronic damper control, rear right satellite
EDC SVL	Electronic damper control, front left satellite
EDC SVR	Electronic damper control, front right satellite
EGS	Electronic transmission control
EHC	Electronic ride-height control
EKPS	Electrical fuel pump control
EMA LI	Electrically motorized reel, left, (seat belt)
EMA RE	Electrically motorized reel, right, (seat belt)
EMF	Electromechanical parking brake
FD	Rear compartment display
FD2	Rear display 2
FKA	Rear compartment heating/air conditioning system
FLA	High-beam assistant
FRM	Footwell module
FZD	Roof functions Center
GWS	Gear selector lever
HiFi	HiFi amplifier
HKL	Luggage compartment lid lift
HSR	Rear-axle drift angle control
HUD	Head-up display
ICM	Integrated Chassis Management
IHKA	Integrated automatic heating/air conditioning
JBE	Junction box electronics
KAFAS	Camera-based driver assistance systems
KOMBI	Instrument cluster
NVE	Night Vision electronics
PDC	Park Distance Control
TPMS	Tire Pressure Monitoring System

Legend for F01/F02 Bus System Overview (cont.)

Index	Explanation
OBD	Diagnosis socket
RSE-Mid	Rear seat entertainment
SDARS	Satellite tuner
SMBF	Passenger's seat module
SMBFH	Rear passenger seat module
SMFA	Driver's seat module
SMFAH	Rear module on driver' seat side
SWW	Lane change warning
SZL	Steering column switch cluster
TCU	Telematics control unit
TOP-HIFI	Top-HiFi system
TRSVC	Control unit for rear view camera and Side View (Top Rear Side View Camera)
ULF-SBX High	Interface box - high (USB / audio interface)
VDM	Vertical dynamics management (central control unit for electronic damper control)
VSW	Video switch
ZGM	Central gateway module

ACSM3 System Circuit Diagram



Index	Explanation
1	Central gateway module
2	Up-Front sensor, left
3	Instrument cluster
4	Car Access System
5	Crash safety module
6	Up-Front sensor, right
7	Door pressure sensor, left
8	Front airbag, driver
9	Coil spring for airbag
10	Knee airbag, driver
11	Passenger Airbag OFF light
12	Knee airbag, passenger
13	Front airbag, passenger
14	Door pressure sensor, right
15	Head airbag, left
16	B-pillar sensor, left
17	Adaptive belt force limiter, driver
18	Belt contact, driver
19	Seat belt pretensioner, driver
20	Side airbag, driver's side
21	Active head restraint, driver
22	Central sensor with rollover detection
23	Belt contact, passenger
24	Seat belt pretensioner, front passenger
25	OC3 mat
26	Active head restraint, passenger
27	Side airbag, passenger side
28	Head airbag, right
29	B-pillar sensor, right
30	Adaptive belt force limiter, passenger
31	Telematics Control Unit for emergency call
32	Safety battery terminal

System Functions

The function of the ACSM is to permanently evaluate all sensor signals in order to detect a crash situation. As a result of the sensor signals and their evaluation, the Crash Safety Module identifies the direction of the crash and the severity of the impact.

Also included is information on the occupants and whether they have their seat belts fastened or not. From this information, measures are taken to selectively trigger the necessary restraint systems.

The crash safety module monitors the system itself and indicates that the system is ready for operation when the airbag warning lamp (AWL) goes out.

If a fault occurs during operation, this is stored in a fault memory, which can then be read out for diagnostic purposes.

If a crash situation is detected, this is communicated to the other users in the bus-system network by way of a bus signal. 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 flashers
- Switching on the interior lighting
- Deactivating the fuel pump
- Switching off the auxiliary heating
- Automatic emergency call.

A function of ACSM is the seat belt reminder function, which uses optical and acoustic signals to remind the driver and front passenger to fasten their seat belts.

The functions of the ACSM are divided into:

- Crash-relevant functions
- System monitoring functions
- Additional comfort functions.

Crash-relevant Functions

The Crash Safety Module must fulfill the following crash-relevant functions:

- Evaluating the sensor signals
- Crash and rollover detection
- Determining the triggering times and order
- Triggering the output stages of the firing circuits
- Output of a crash telegram for other users in the bus system network
- Crash documentation
- Emergency call functions.

Evaluating the Sensor Signals

The sensors serve to detect and verify front-end, side-on and rear-end impact as well as a rollover.

The sensor signals are transmitted straight to the crash safety module and are evaluated there.

Crash and Rollover Detection

In addition to the longitudinal acceleration sensor and lateral acceleration sensor the central sensor also incorporates rollover detection. Rollover detection consists of a rate of yaw sensor and two low-g sensors. One low-g sensor measures in the Y direction, the second sensor in the Z direction.

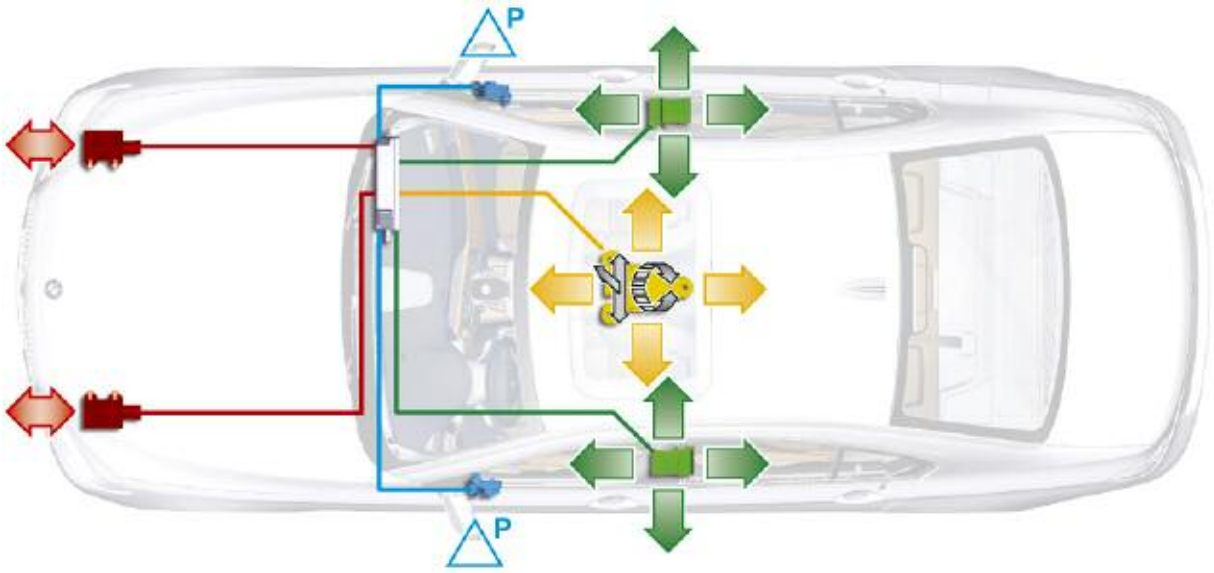
Additional airbag sensors are mounted in the B-pillars. These each consist of a longitudinal acceleration sensor and a transverse acceleration sensor.

Together with the transverse acceleration sensor in the central sensor, the transverse acceleration sensors serve to detect side-on crashes. Pressure sensors are also used in the front doors to detect side-on crashes.

Together with the longitudinal-acceleration sensor in the central sensor, the longitudinal-acceleration sensors serve to detect front-and rear-end crashes.

There are two airbag up-front sensors for front-end crash detection. They are located on the front area of the engine side members.

ACSM Sensor system



Detecting a crash and determining the triggering times and the order
The Crash Safety Module uses the values transmitted by the sensors to determine the direction and severity of the crash. The threshold values of two independent sensors must be exceeded in order to detect a crash. In the case of a front-end crash, for example, the relevant high acceleration values from the B-pillar satellite and from the longitudinal acceleration sensor must be detected in the crash safety module. Triggering the output stages of the firing circuits

Based on the acceleration values and crash severity and direction, an algorithm determines the triggering (firing) points and the order of the restraint systems to be activated.

A possible imminent rollover is also detected and the appropriate protection systems are activated.

Triggering the output stages of the firing circuits
The firing-circuit output stages are only triggered if the airbag algorithm detects that the threshold has been exceeded via different sensors, e.g. the airbag sensor in the B-pillar and the central sensor.

The crash safety module is powered by the Car Access System 4 (CAS4) using terminal 30b. At terminal 30b the crash safety module is in energy-saving mode, which means it is active at the bus and can also transmit the belt status to the EMA controller. Airbag functionality is blocked and only ready for operation at terminal 15 on completion of the system self-test.

The firing capacitors, which also serve as an energy reserve, are charged up by a switching controller. These capacitors make the firing energy available in the event of a crash. If the voltage supply is interrupted during a crash, the firing capacitors serve briefly as an energy reserve.

The output stages of the firing circuits consist of a high-side and a low-side power circuit-breaker. The high-side power circuit-breaker controls the firing voltage, while the low-side power circuit-breaker switches to ground. The output stages of the firing circuits are controlled by the microprocessor.

The high-side and low-side power circuit-breakers also serve the purpose of checking the firing circuits during the system self-test.

Output of Crash Telegram

In the event of a collision involving triggering of the restraint systems, the Crash Safety Module sends a crash telegram to the users in the bus-system network. Parallel to this, the TCU is informed via a direct single-wire line to transmit an emergency call.

As a result, the respective control units perform the following functions depending on the crash severity:

Function	Control Unit
Switch off electric fuel pump	Digital Motor Electronics DME
Switch off the auxiliary heating	Integrated automatic heating and air conditioning system IHKA (Not for US)
Release central locking	Junction box electronics JBE
Switch on hazard warning lights	Footwell module FRM
Switch on interior lights	Footwell module FRM
Transmit emergency call (only when airbag triggered)	Telematics Control Unit TCU

Crash Entries

In the event of a collision where one or more actuators are triggered, a crash entry is stored in a non-erasable memory. After three crash entries, a non-erasable fault entry is stored in the fault memory with the instruction to replace the crash safety module.

Note: The three crash entries could also be stored during the course of an accident. Each crash entry is assigned a system time.

The electronic control unit remains capable of firing 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 stored. The control unit must then be replaced.

Emergency Call Functions

The emergency call functions are country-dependent and are available to customers in countries with BMW ASSIST infrastructure. This means an appropriate service provider with a call Center must be available. Another precondition for being able to make an emergency call is the availability of a telephone network.

With BMW ASSIST, the customer has a manual and an automatic emergency call as well as other functions.

A manual and an automatic emergency call function is provided as standard. Furthermore, the driver has the option of activating a breakdown call. Irrespective of whether the customer orders a telephone or not, each vehicle is equipped with a telematics control unit TCU, a telephone antenna, an emergency antenna, a handsfree kit and a GPS antenna for determining position.

Manual emergency call

The manual emergency call is intended for customers to request help quickly if they are present when an accident occurs without being involved themselves.

The emergency-call button is located in the roof function Center. The emergency call button is connected directly to the TCU.

Pressing the emergency-call buttons establishes a voice connection with the relevant country provider. The voice connection is indicated by a flashing LED in the switch.

Automatic emergency call

The crash safety module sends a crash telegram to the TCU in the event of an accident of corresponding crash severity. The TCU places an emergency call, which at the same time contains the location of the vehicle.

Parallel to this, attempts are made to set up a voice connection with the vehicle occupants to obtain more information on the accident (severity of the accident, number of injured) so that further rescue operations can be initiated.

System Monitoring Functions

The Crash Safety Module must execute the following system monitoring functions:

- System self-test (pre-drive check)
- Indication of system operability
- Cyclic monitoring
- Fault indication and fault code storage
- Fault output (diagnosis)
- Seat belt reminder function
- Deactivation of the front passenger front airbag, the knee airbag and side airbag in via the seat-occupancy detector.

System Self-test (Pre-drive check)

ACSM performs a system self-test as from terminal 15. The airbag warning lamp is activated for approximately 5 seconds during the system self-test.

When the system self-test is concluded and no fault has been found, the airbag warning lamp goes out and the system is ready for operation.

Airbag warning lamp

Indication of System Operability

ACSM system operability is indicated by the airbag warning lamp (AWL) going out in the instrument cluster.

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. Cyclic monitoring serves the purpose of internal diagnosis of the ECU and the overall airbag system. Cyclic monitoring is carried out for as long as the system is at terminal 15.

Fault Indication and Fault Code Storage
The crash safety module has a non-volatile fault memory. The airbag warning lamp indicates any entry in the fault memory.

A distinction is made between internal and external faults when entering the fault code.

Events such as triggering of an airbag or seat belt pretensioner are also stored in the fault memory.

Note: The entry of a triggered restraint system in the fault memory does not mean that the restraint system was defective in the crash situation, rather it only means that the restrain system is not available for further triggering.

Fault Output (Diagnosis)
With the aid of the ISTA diagnostic system, the fault memory can be read out via the diagnostic interface. After rectifying the faults or after replacing the triggered components, the fault memory can be cleared with the diagnosis command “Clear fault memory”.

Note: The cleared fault code memory entries are transferred to the past events memory. A maximum of 15 faults can be stored in the past events memory. When another entry is added, the first entry is deleted. The past events memory is set up as a ring memory and can only be read out by the development department. The past events memory is not available to the Service department.

Deactivating the Front Passenger Airbag

US law requires that specified child seats tested to specifications with a child roughly one year old on the front passenger seat be automatically detected and the passenger airbags be deactivated.

In order to meet legislative requirements, the OC3 mat (Occupant Classification OC) was developed.

OC3 Mat

The OC3 mat (Occupant Classification) detects a child seat specified in accordance with NHTSA and which is occupied on the basis of the pressure per unit area and disables the passenger airbag.

The OC3 mat consists of conductors in a pressure-sensitive resistance grid, so-called FSR elements (Force Sensitive Resistance). The conductors are connected to the electronic evaluation unit.

The FSR elements are wired in such a way that they can be sampled individually. When the mechanical load on a sensor element increases electrical resistance decreases and the measurement current changes accordingly.

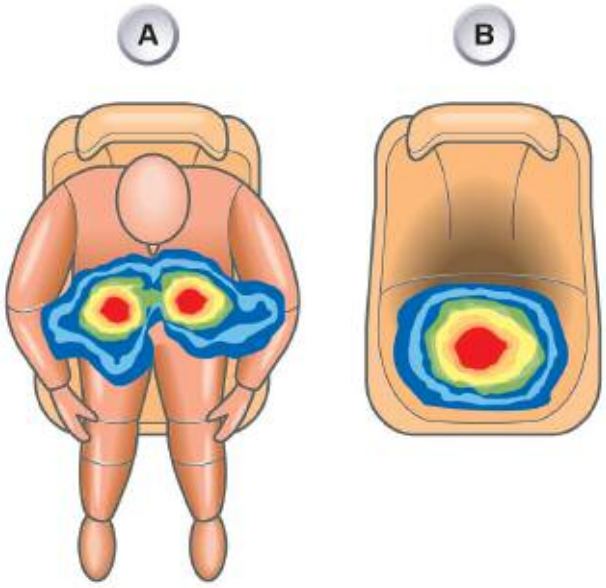
OC3 Mat

By analysing the signals from the individual sensors, the analyzer can map the occupancy of the seat surface and identify local concentrations of weight. The relationship between the areas and the load points indicates whether there is a person or a child seat holding a small child present.

The electronic evaluation unit of the OC3 mat sends a telegram via the LIN-bus to the Crash Safety Module.

The front passenger airbags (front and side airbags) are disabled when a child seat with small child is detected. The crash safety module activates the passenger airbag OFF indicator lamp in the roof function Center.

Index	Explanation
A	Surface imprint of a person
B	Surface imprint of a child seat



Example of various surface imprints

Passenger Airbag OFF light

The passenger airbag OFF light in the roof console comes on when the child restraint system has detected a small child on the front passenger's seat. Furthermore, the passenger airbag OFF lamp lights up when the seat is not occupied by a person.

The brightness of this light is controlled by automatic regulation of the display lighting.

Note: The Passenger Airbag OFF light is activated if the OC3 mat detects a child seat with a child approximately one-year old or if the front passenger seat is not occupied.

Electric Motor Driven Reel

Debuting in the F01/F02, an electric motor driven reel (EMA) is used for the seat belt. The electric motor driven reel is paired with the multifunction seat.

The electric motor driven reel reduces seat belt slack when fastening the seat belt using low retracting force as soon as the doors are closed. Removing the belt slack ensures that the seat belt fits the driver or front passenger. Thus better restraining action can be provided in the event of a crash.

Another advantage of the electric motor driven reel is the pre-tensions to the occupants before a possible accident with increased retracting force, thus also reducing the incidence of slipping out of the belt and the risk of submarining.

The dynamic driving control sensors in the ICM (Integrated Chassis Management) record data such as longitudinal acceleration and lateral acceleration, yaw rate, etc. The ICM passes on the data via the PT-CAN to the two EMA control units. The DSC also delivers information such as speed and brake pressure. The ACSM sends a message about the status of the belt contact to the two EMA control units.

From this data, the EMA control units calculate whether there is a critical driving situation, e.g. vehicle oversteer and as a result activates the electric motor, which pretensions the seat belt.

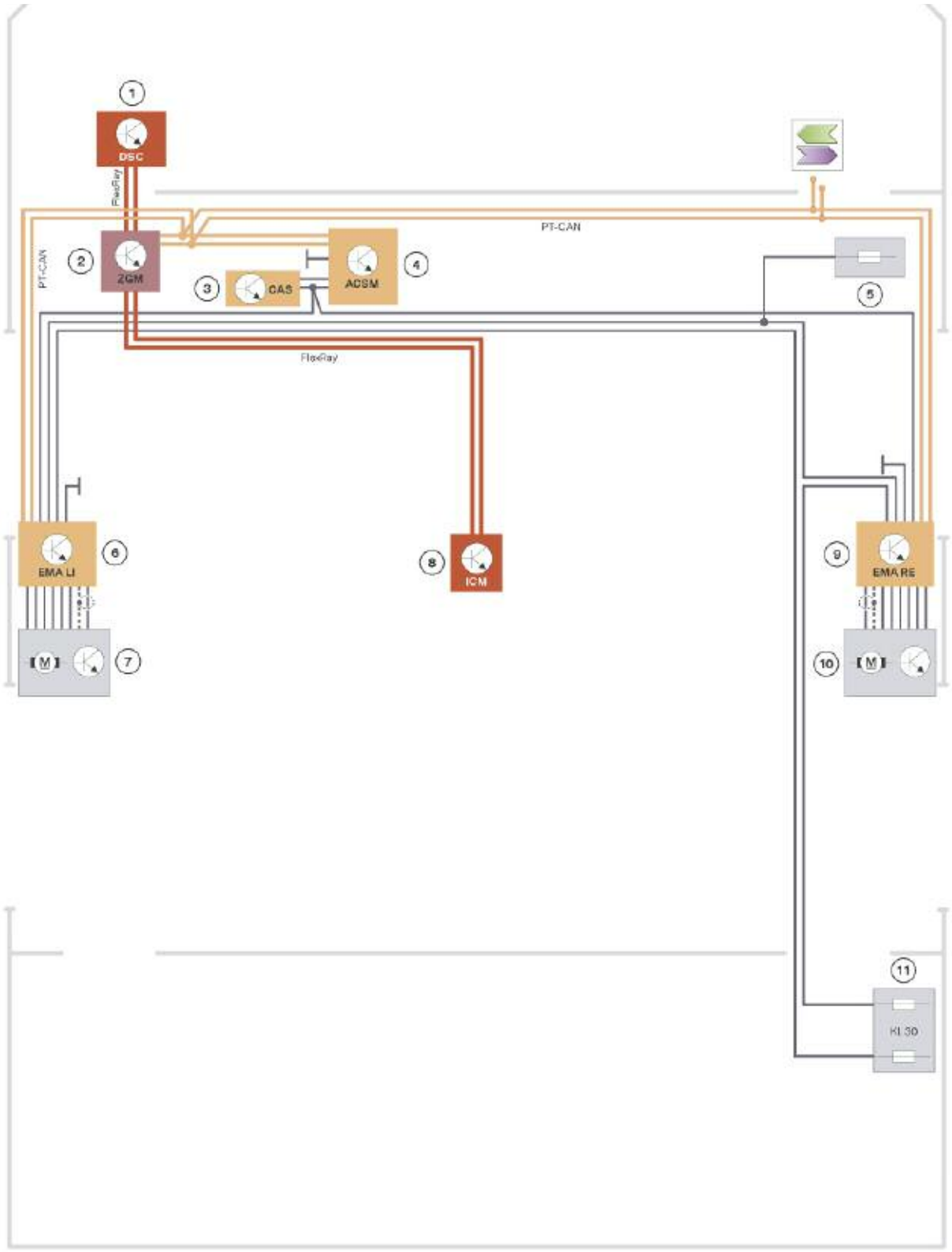
If there is now an accident with corresponding severity, the belt tensioner is also triggered and the seat belt fastened securely to the occupants.

The pre-tensions of the seat belt can reduce the force on the occupants in the event of an accident.

Index	Explanation
1	EMA control unit
2	Electric motor
3	Automatic reel
4	EMA drive unit

Seat belt with electric motor driven reel

System Circuit Diagram for Electric Motor Driven Reel



Index	Explanation
1	Dynamic stability control DSC
2	Central gateway module (ZGM)
3	Car Access System (CAS)
4	Crash safety module (ACSM)
5	Junction Box
6	Control unit, electric motor driven reel, left
7	Electric motor driven reel, left
8	Integrated Chassis Management
9	Control unit, electric motor driven reel, right
10	Electric motor driven reel, right
11	Luggage compartment junction box

Bus signals

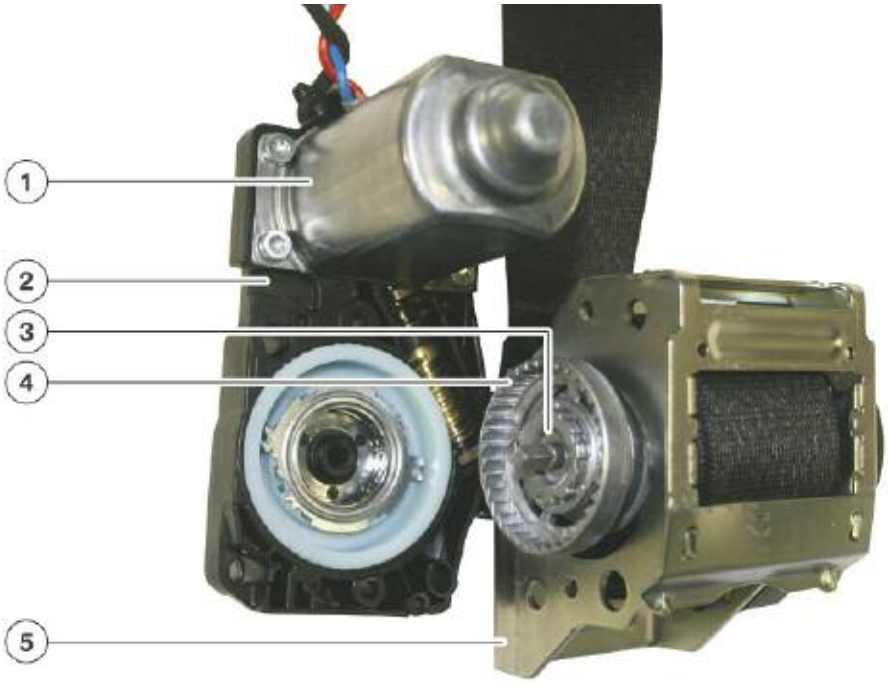
In/out	Information	Source/sink	Function
In	Terminal control	CAS > EMA LE/ EMA RI	Status terminal 30b
In	Vehicle speed	DSC > EMA LE/ EMA RI	Vehicle speed
In	Braking torque	DSC > EMA LE/ EMA RI	Emergency braking detection
In	Yaw speed	ICM > EMA LE/ EMA RI	Detection of skidding tilt
In	Steering angle effective at the front axle	ICM > EMA LE/ EMA RI	Steering effort
In	Longitudinal acceleration	ICM > EMA LE/ EMA RI	Acceleration
In	Lateral acceleration	ICM > EMA LE/ EMA RI	Lateral acceleration
In	Accelerator pedal angle	DME > EMA LI/ EMA RE	Driver power request
In	Belt contact status	ACSM > EMA LE/ EMA RI	Information whether the seat belt is fastened
In	Door contact	FRM > EMA LE/ EMA RI	Information whether the doors are closed

Design and Function of the Electric Motor Driven Reel

The electric motor driven reel is an extension of the functions of the existing automatic reel. The F01/F02 front automatic seat belt reels are also equipped with a pyrotechnic devices that operate the adaptive force limiters, as on E65/E66. The adaptive force limiters work independently from the (EMA) electric motor driven reels.

The electric motor driven reel essentially consists of an electric motor, a drive unit and a coupling, which establishes the connection to the automatic reel.

Components of the electric motor driven reel



Index	Explanation	Index	Explanation
1	Electric motor	4	Ring gear
2	Drive unit	5	Automatic reel
3	Belt shaft		

Electric motor driven reel, not working

The following image shows the design of the drive unit in detail (A). The locking pawls are retracted.

Image (B) shows the drive unit with ring gear. The ring gear and the belt shaft can rotate freely. The seat belt can be pulled out or rolled up.

Drive unit with separate components (A) and freely rotatable ring gear (B)

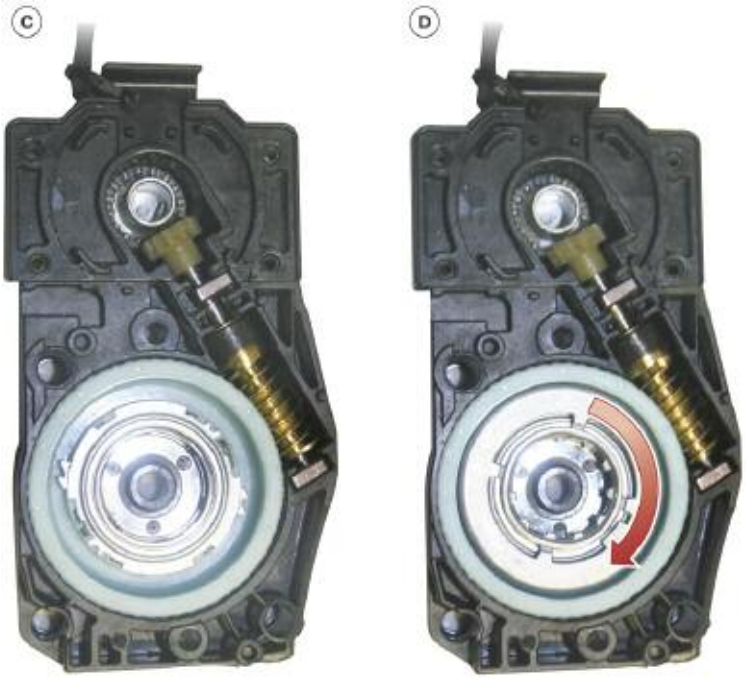
Index	Explanation	Index	Explanation
1	Drive gear for the electric motor	3	Worm gear
2	Drive gear for the drive shaft	4	Drive wheel with coupling

Electric motor driven reel in operation

When the driver or front passenger fastens their seat belt or there is a critical driving situation in terms of driving dynamics, the electric motor is activated and moves the drive shaft using the worm gear.

The worm gear turns the drive wheel with the coupling. The locking pawls move out and engage in the ring gear (C).

The ring gear, which is located on the belt shaft, drives the belt shaft (D). The seat belt is rolled up on the belt shaft and thereby shortened. This tensions the seat belt to the occupants.



Locking pawls move out (C) and the ring gear turns the belt shaft (D).

System Components

Driver Airbag

In conjunction with the seat belt, the driver's front airbag is designed to reduce the risk of serious injury to the driver's head or thorax during a head-on collision. The front airbag for the driver's side is located in the hub cushion of the steering wheel. The driver front airbag is equipped with a gas generator.

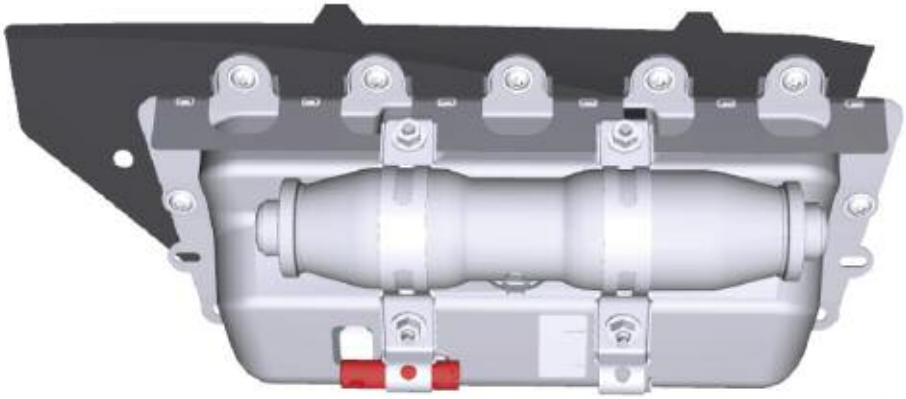
The airbag is triggered depending on the severity of the crash.

Driver airbag

Front Passenger Airbag

In conjunction with the seat belt, the front passenger front airbag, just as the driver front airbag, is designed to reduce the risk of serious injury to the passenger's head or thorax during a head-on collision. The front passenger front airbag is located under the dashboard.

Inflation of the front passenger airbag breaks the dashboard at defined points and opens two flaps, which are connected to the dashboard by means of fabric tapes. The passenger airbag opens in the direction of the windshield. The passenger airbag emerges in an upward direction and is supported on the windshield and on the instrument panel.



Front passenger airbag with pyrotechnically activated vent valve

Note: The F01/F02 uses driver and passenger airbags with pyrotechnically activated vent valves which are explained under the "Actuators" section of this training material.

Crash Safety Module

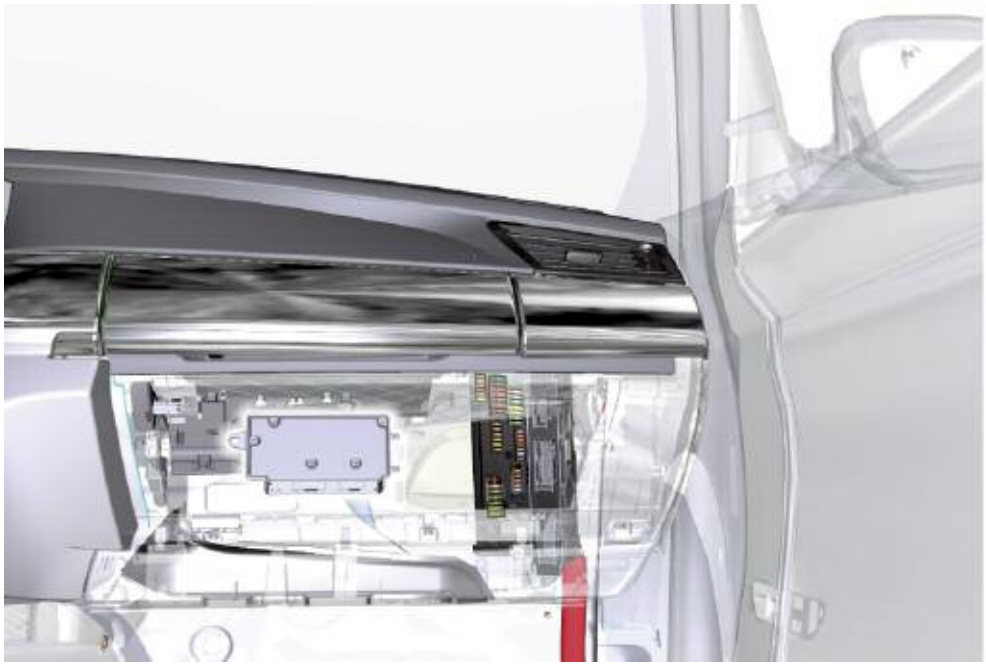
The crash safety module in US vehicles is identical to vehicles for the rest of the world. It is adapted to the law and country-specific requirements by programming and coding.

With ACSM3 Crash Safety Module is now integrated into the PT-CAN.

There are no sensors located in the crash safety module.

Crash safety module

The crash safety module has a new installation location for the F01/F02 is behind the glove compartment.



Crash safety module installation location

Sensors and Switches

All of the following sensors and switches were used on the previous ACSM systems with the exception of the Central Sensor, its functions where integrated inside the crash safety module:

- Central sensor
- Up-front sensor
- OC3 mat
- B-pillar sensor
- Door pressure sensor
- Seat belt buckle switches
- Emergency call button

Central Sensor

The central sensor is located centrally in the vehicle on the transmission tunnel.

In addition to the longitudinal acceleration sensor and lateral acceleration sensor, the central sensor has also been extended to incorporate rollover detection.

The longitudinal and lateral acceleration sensors detect positive and negative vehicle acceleration in a measuring range of 0-100 g. The longitudinal and lateral acceleration sensors detect acceleration in the event of a head-on, side or rear-end collision.

Rollover Detection

Rollover detection is provided by a rate of yaw sensor and two additional low-g sensors. The low-g sensors act in Y and Z directions.

There are different factors which can cause a car to overturn or roll over.

The most common causes are:

- The car hits a ramp (e.g. a crash barrier) on one side or the vehicle tilts due to the terrain. The car rotates about its longitudinal axis as a result of the high angular velocity.
- The car skids sideways off the road surface and its wheels become buried in soft soil. The kinetic energy could be sufficient to upend and overturn the car.
- The car skids sideways off the road into the kerb and is upended.

The crucial factors which determine whether the car overturns are not just the angle of rotation but also the angular velocity or angular acceleration at which the car is set into the roll. All these vehicle movements can also occur after a front-end, side-on or rear-end crash.

The two Low-g sensors have a small measuring range of 0-2 g and can therefore detect small accelerations and decelerations with great accuracy.

For example, when the vehicle skids sideways off the road surface and buries itself with its wheels in soft ground.

The sensors provide a voltage as measured variable. This voltage is a measure for the acceleration and is converted directly into digital signals in the sensor. The digital values are sent to the crash safety module for evaluation. The crash safety module evaluates the signals from the two Low-g sensors and the rate of yaw sensor. The results are compared with the stored algorithm. If the processor detects that a rollover situation is imminent, the seat belt pretensioners and the head airbags are triggered.

The sensor cluster is connected via a four-wire lead. A current interface which transfers a special report is used so that for the five sensors, this saves on six leads. This interface is also used for the other airbag sensors, so that, here too, savings can be made on leads and thereby weight.

Digital data transmission by means of current interface

The recorded acceleration values of the micro-mechanical acceleration sensors are converted in an ASIC (Application Specific Integrated Circuit) into digital signals. With the aid of a data telegram, the digital signals are transmitted unidirectionally to the Crash Safety Module.

The signals are transmitted via a current interface, which supplies the electronic circuitry with voltage.

The electronic circuitry receives a voltage level of approximately 5-10 mA via the current interface. The level rises at a step of 20 mA when a data telegram is transmitted so that only two lines per measurement channel are required.

The transmitted data is evaluated in the crash safety module.

Up-Front sensor

The airbag up-front sensors in the front area of the side member on the left and right sides serve to detect a head-on collision. They deliver additional information on the progress and severity of the collision to the crash safety module.

Each airbag up-front sensor consists of an acceleration sensor for recording the deceleration, a signal conditioner and an ASIC for data transmission.

The measured values are sent in the form of a data telegram to the crash safety module and are used in the calculation of the algorithm.

OC3 Mat

US legislation stipulates that the use of a child restraint system tested by NHTSA and holding a small child on the front passenger seat must be detected automatically and the front passenger airbag disabled.

The OC3 mat can detect an occupied child seat tested in accordance with the regulation (NHTSA FMVSS 208) on the basis of the pressure per unit area and disable the passenger airbag (front and side airbag). The passenger airbag OFF light comes on when a child restraint system tested in accordance with NHTSA and holding a small child was detected on the front passenger's seat.

Note: NHTSA FMVSS 208 stands for National Highway Traffic Safety Administration Federal Motor Vehicle Safety Standard 208

B-Pillar Sensor

The B-pillar airbag sensor consists of a longitudinal acceleration sensor and a transverse 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 the definitive factor in determining the direction of the impact.

The B-pillar airbag sensors serve the purpose of detecting head-on, side and rear-end collisions.

The B-pillar airbag sensors on the left and right are of identical design and are allocated by way of mechanical coding during installation.

Door Pressure Sensor

The airbag sensors in the front doors serve the purpose of verifying the plausibility of the acceleration signals from the B-pillar airbag sensors and the central sensor during side crash detection.

The airbag sensors are situated in the inner panels of the front doors and measure the increase in pressure in the event of a side-on impact.

In the event of a side-on impact with the door, the outer door panel is pressed inward, thus reducing the inner door space and increasing the pressure. This change in pressure is measured by the airbag sensors.

The airbag sensor also includes an electronic module, in addition to the pressure sensor, which digitizes the pressure values and transmits them cyclically to the Crash Safety Module. The data is transmitted in the same way as the B-pillar airbag sensors.

The pressure values are evaluated in the crash safety module.

Seat Belt Buckle Switches

The seat-belt buckle switches signal whether the seat belts are fastened or not. The signals from the seat belt buckle switches are transmitted to the Crash Safety Module and are used for triggering the required restraint systems and for the seat belt reminder function.

The seat belt buckle switch is located in the seat belt buckles of the driver's and front passenger's seat.

The seat-belt buckle switch is designed as a two-wire Hall-effect switch. The crash safety module powers the Hall switch via a current interface. The current intake of the switch varies depending on whether the seat belt is fastened or not. The seat belt buckle switch is permanently monitored as from terminal R "ON".

Actuators

The crash safety module is used in to control the following actuators:

- Adaptive driver airbag
- Adaptive front passenger airbag
- Driver/front-passenger side knee airbag
- Curtain (head) airbags, left and right
- Side airbag, integrated in the left and right front seats
- Front seat belt pre-tensioner, front left and right
- Automatic seat belt tensioner with adaptive force limiter
- Active head restraint, front left and right
- Safety battery terminal

The following warning lamps are additionally activated:

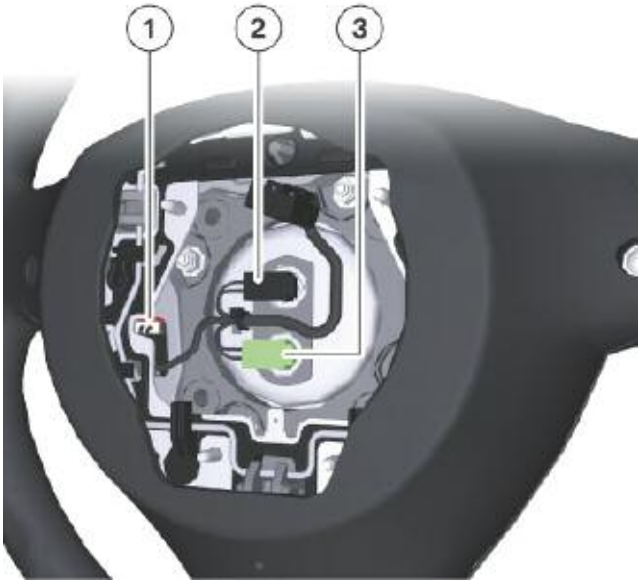
- Airbag warning lamp AWL
- Seat belt mannikin
- Passenger Airbag OFF light (POL)

Adaptive Driver Airbag, with Active Vent

Index	Explanation
1	Gas generator with exhaust vents
2	Actuator for vent valve

Driver airbag without airbag

Driver airbag, rear, without retaining plate



Index	Explanation
1	Connection of the squib for The active vent valve
2	Connection of the squib for the first stage
3	Connection of the squib for the second stage

Vent Valve

Airbags with pyrotechnically activated vent valve are used for the first time in a BMW vehicle on the F01/F02.

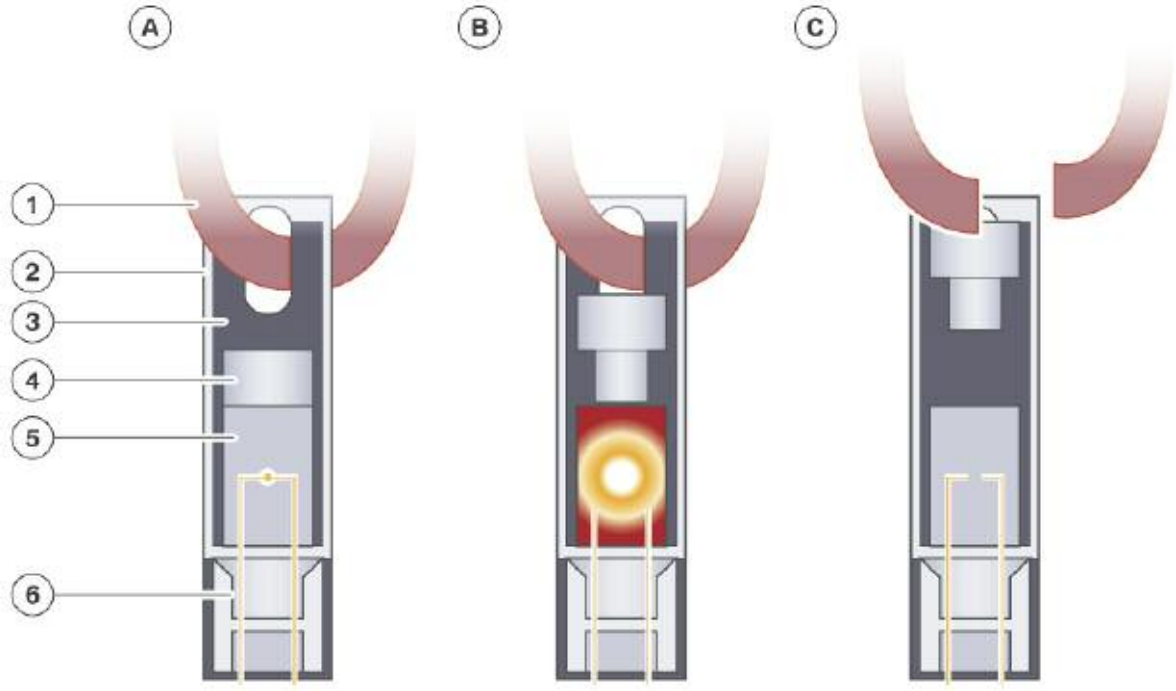
This measure serves to adapt the hardness of the airbag in possible accident scenarios with small persons or persons sitting close to the steering wheel.

On the basis of the crash severity, belt status and seat position information, the crash safety module decides whether the vent valve is activated or not.

The vent valve is an exhaust vent incorporated into the airbag, which is closed by an arrester band. The arrester band ends in a cylinder, in which there is a blade. In the event of triggering, the blade is pushed in the cylinder by the pyrotechnical actuator and the arrester band is cut through.

Due to the airbag inner pressure, the exhaust vent opens outwards and the hardness of the airbag is controlled by the gas venting.

Activation of the active vent valve



Index	Explanation	Index	Explanation
A	Vent valve is closed by arrester band	3	Cylinder
B	Squib triggered, blade is deployed	4	Piston with blade
C	Blade cuts through retaining strap and vent valve opens	5	Squib
1	Retaining strap	6	Squib connection
2	Housing		

The active vent valve is normally activated for smaller, lighter occupants.

If the system, (due to the seat position) detects a heavy occupant, a reduction of the airbag pressure is not desirable.

In this case, the active vent valve remains closed and is activated at a later stage for disposal firing, when the occupant is no longer in contact with the airbag.

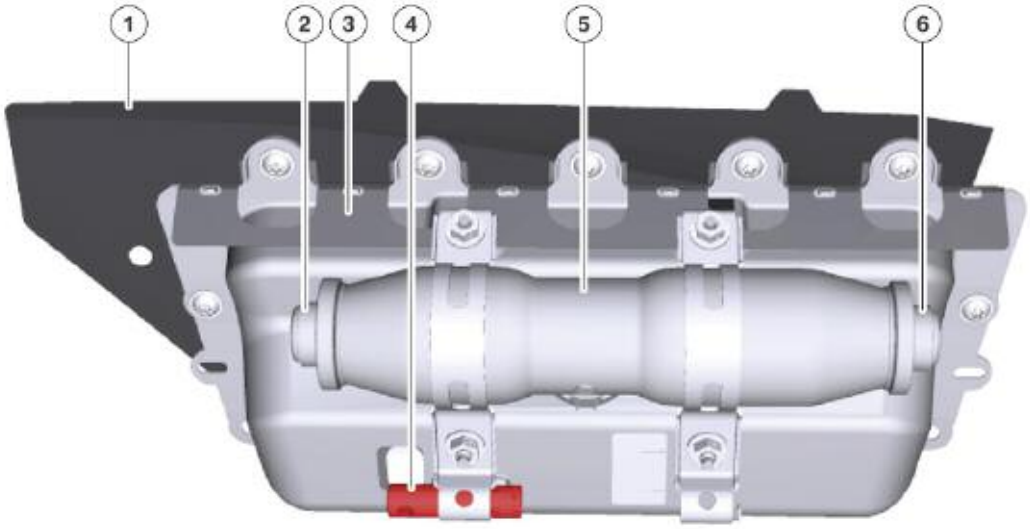
Vent valve remains closed

Normally heavy occupant

Vent valve is opened

Small, light occupant

Adaptive front passenger airbag with active vent valve



Front passenger airbag, two-stage with vent valve

Index	Explanation	Index	Explanation
1	Cover for airbag	4	Actuator for active vent valve
2	First stage squib	5	Inflator assembly
3	Airbag housing	6	Second stage squib

Knee Airbags

The knee airbags on the driver's side and front-passenger side are designed to control the forward movement of the occupant in the event of a head-on impact.

In the event of a collision in which the driver or front passenger are not wearing seat belts, the knee airbag provides support to protect the knees. This initiates a controlled forward displacement of the upper body, which is cushioned by the deployment on the corresponding airbag.

A knee airbag on the driver and front passenger side are standard equipment for the F01/F02.

The knee airbag is designed as a single-stage airbag with inflator assembly. The volume is approximately 20 liters/ 5.2 Gallons.

The gas generator is triggered in the event of a crash of sufficient severity and the resulting gas fills the airbag.

When occupant's knees make contact with the airbag, the load is distributed over the area of the airbag, thus supporting the occupant.

The knee support results in a controlled forward displacement of the upper body that is taken up and absorbed by the airbag.

The knee airbag on the driver's side is located below the steering column in the footwell trim while the knee airbag on the passenger side is located in the footwell trim.

Knee airbag in operation

F01/F02 driver's side knee airbag,

Note: The driver and front passenger knee airbags are also triggered by occupants wearing seat belts, though at a higher crash severity than if the seat belts are not fastened.

F01/F02 passengers side knee airbag

Curtain/Head Airbag

On the F01/F02, the curtain airbag for the driver and front passenger side is used as head airbag.

The head airbag extends from the A-pillar to the C-pillar and covers the entire side section at the level of the side windows.

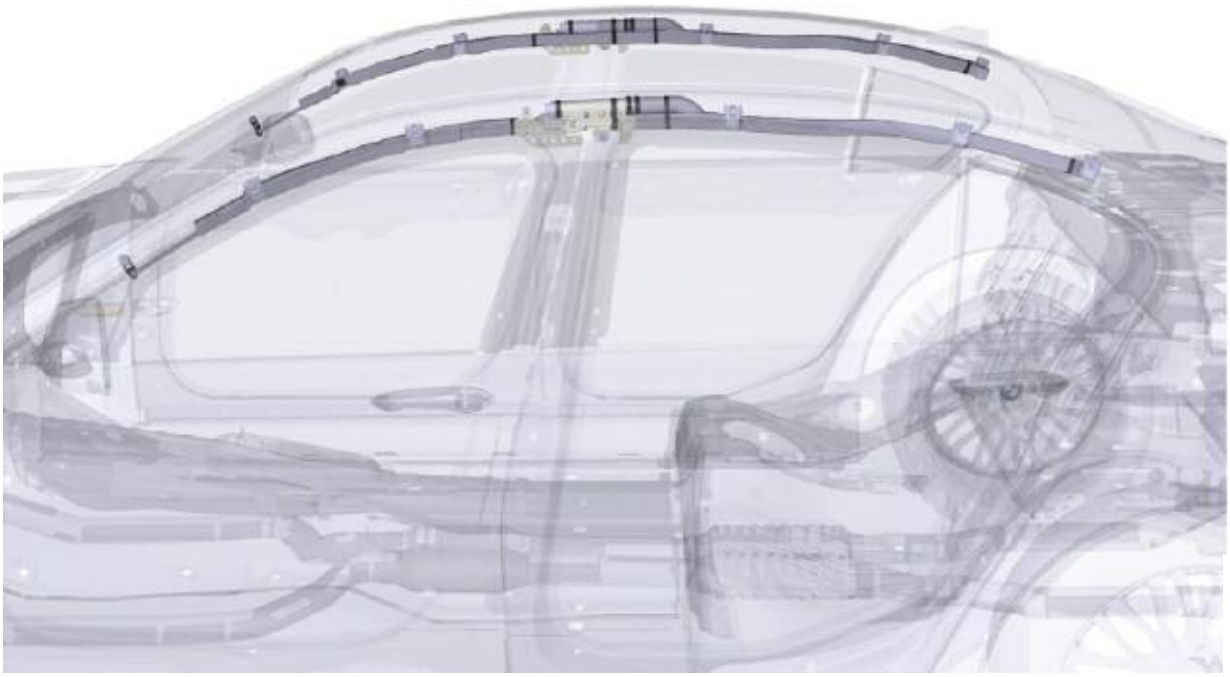
It deploys between the occupants, windows and pillar trim panels.

The system features:

- Extended coverage for front and rear windows.
- Reduction of the risk of glass splinters and objects entering the vehicle.
- Optimized coverage even for different sizes of occupant.

The curtain airbag is housed folded up in the roof frame. It consists of the inflator assembly and the curtain.

In the event of a side impact or of a rollover, the inflator assembly is triggered and a valve to the pressure tank is opened. The stored gas flows through the gas lance into the curtain.



Installation location of the curtain airbags on the F01/F02

The head airbag is set in the correct position by its mounting on the A-pillar and on the C-pillar. In addition, the curtain deploys between the side windows, pillar trim panels and the occupants.

The structural strength and stability is preserved for several seconds by the closed system.

In connection with the side airbag in the front seat, it provides optimum protection for the occupants in the event of side impact.

The head airbag reduces the movement of the head and other occupant extremities towards the outside during a side impact. This results in lower neck shear forces as well as bending moments in the cervical vertebrae. It additionally prevents direct contact with the side structure or the obstacle thus reducing the risk of head injuries.

Seat-integrated Side Airbag

The seat-integrated side airbags are mounted on the F01/F02 for the purpose of achieving optimum interior functionality, an appealing design while satisfying high safety requirements.

The side airbags are folded, together with the inflator assembly (gas generator) in a plastic housing. The airbag module is secured into the backrest and concealed by the rear panel.

The side airbag is triggered in response to a sufficiently strong impact from the side. The side airbag emerges between the seat backrest and the rear panel and inflates between the door and occupant.

The air cushion between the door and occupant provides controlled impact damping and therefore reduces the load on the occupant.

Side airbag (1) integrated in the seat

Note: It is important that no additional seat covers are fitted as they would greatly impair or even immobilize the airbag function.

Seat Belt Pretensioner

The task of the pyrotechnical seat belt tensioner is to minimize the seat belt slack in the pelvis and shoulder areas in the event of a crash, thereby improving the restraining action.

The seat belt catch pretensioners are located on the driver's and front passenger seats. The seat belt catch tensioners are triggered in the event of a head-on or rear-end crash and on vehicles with rollover sensor in the event of a rollover.

In the event of a crash of sufficient severity, the squibs in the seat belt catch tensioner are triggered by the crash safety module. The seat belt buckle is connected by means of a steel cable to the piston in the tensioning tube. If the squib is triggered, gas pressure is created, which moves the piston in the tensioning tube. At this, the seat belt buckle is pulled down by the cable and the seat belt is tensioned.

Seat belt pretensioner

Index	Explanation
1	Seat belt buckle switch
2	Connection for the squib
3	Tensioning tube with piston

Automatic seat belt tensioner with adaptive force limiter

The belt force limiter on the F01/F02 works according to the same principle as on the one used on the E65/E66.

For the driver and front passenger, an automatic reel with adaptive force limitation is mounted. With the aid of a gas generator, there is a changeover from a high to a low power level during the impact, in order to reduce the restraining forces.

With optimally tuning in connection with the airbag, the kinetic energy of the occupant is more uniformly reduced over the duration of the impact. Thus lower occupant stress values are achieved.

F01/F02 adaptive belt force limiter

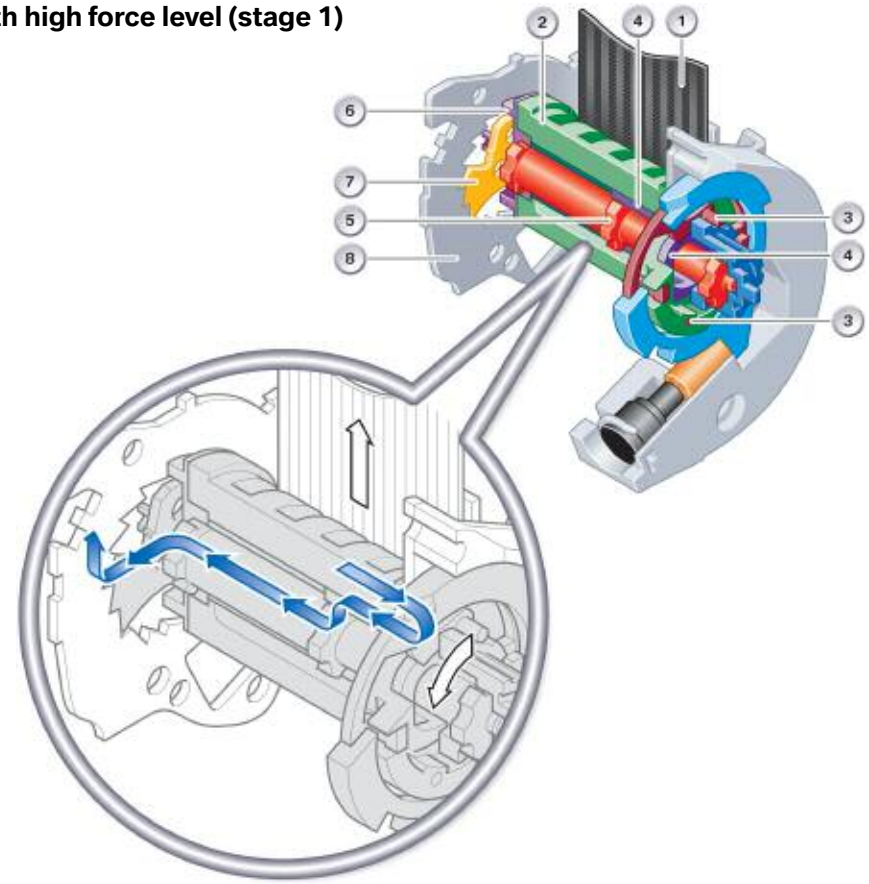
The adaptive force limitation is based on a two-step torsion bar (step shaft). The torsion bar consists of the two head ends at left and right, the step and the central head.

The belt force is transmitted through the seat belt webbing to the belt reel. The belt roller is joined to a sleeve, in which the torque bar is fitted. There is a shaft ring with locking pawls on the sleeve. The locking pawls transmit the torque to the torsion bar.

In the first stage, the belt force is transmitted from the seat belt strap on the belt roller via the locking pawls to the central head of the torsion bar. If the belt roller is rotated relative to the fixed torsion bar, the force is transmitted to the thicker part of the torsion bar. The high force level is thus set.

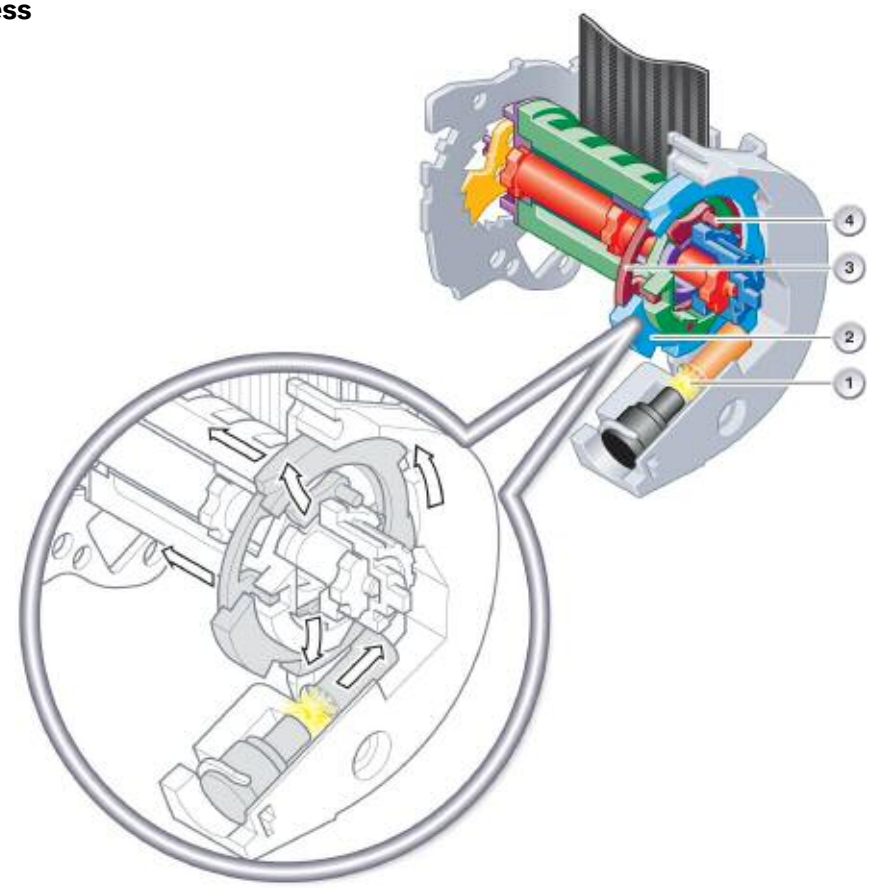
In the event of an impact with corresponding severity, the gas generator is ignited and a piston driven out which rotates the ratchet ring, thus moving the shaft ring axially.

Force flow with high force level (stage 1)



Index	Explanation	Index	Explanation
1	Seat belt webbing	5	Torsion bar (central head)
2	Belt roller	6	Sleeve
3	Locking pawls	7	Locking pawl
4	Sleeve	8	Housing

Ignition process

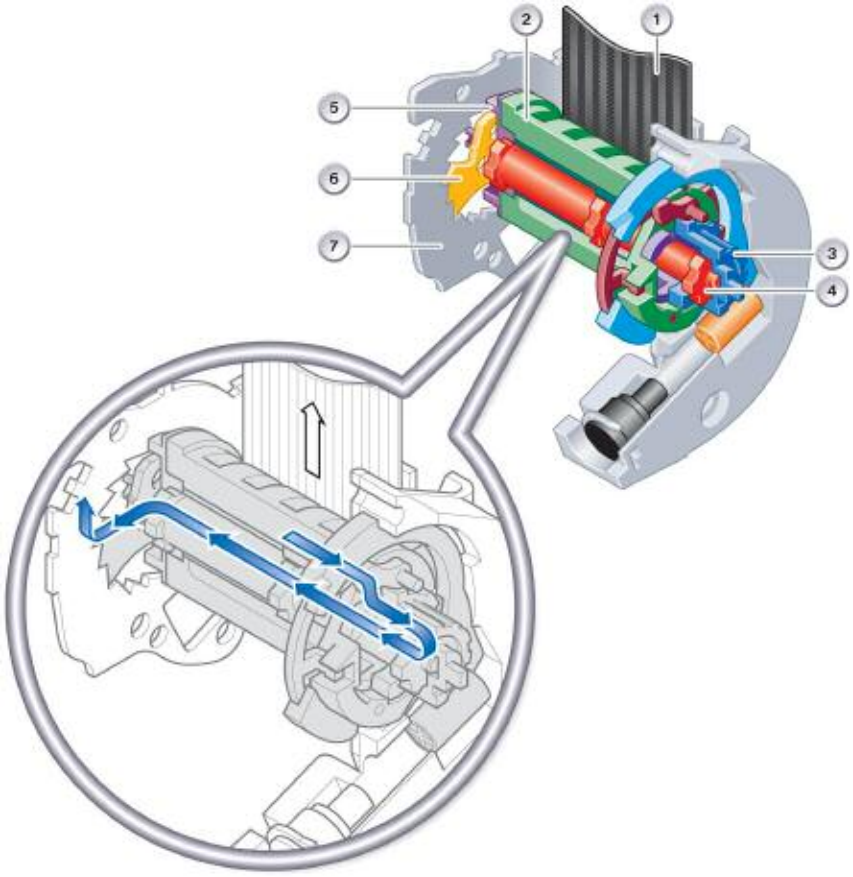


Index	Explanation	Index	Explanation
1	Ignition	3	Shaft ring
2	Ratchet ring	4	Locking pawls

The locking pawls are now no longer held by the sleeve. Therefore no more torque acts on the center head of the torsion bar.

The belt force is now introduced into the step shaft via the right-hand head end, and thus passes through the complete torsion bar. Because of the smaller diameter of the right-hand side, the torsion bar is rotated further, and thus the force is degraded to a lower level.

Force flow with lower force level (stage 2)



Index	Explanation	Index	Explanation
1	Seat belt webbing	5	Sleeve
2	Belt roller	6	Locking pawls
3	Connecting sleeve	7	Housing
4	Torsion bar		

Active Head Restraint

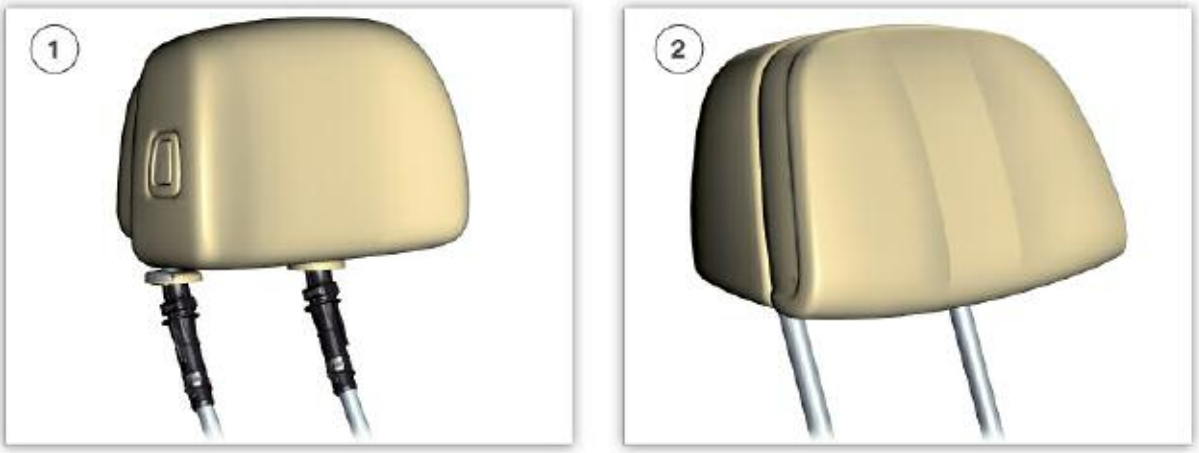
Used on previous BMW vehicles since 09/2007, Active head restraint are now installed on the F01/F02.

This is the version with pyrotechnical actuator and spring elements for adjustment.

There are two versions of active head restraints, depending on the seat option installed.

The memory seat (1) is designed for manual headrest adjustment.

In order to offer as much convenience as possible, the front section of the head restraint can be pulled forward or pushed backward approximately 30 mm. It is a two-stage adjustment. This allows for three different positions for the head restraint depth adjustment.



(1): Manually adjustable head restraint on the memory seat.
(2): Fixed head restraint on the multifunction seat

On the multi-function seat, (2) the headrest is adjusted by means of the headrest adjustment.

The active head restraint reduces the load on the cervical vertebrae in the event of a rear-end collision by reducing the distance between the head and the head restraint before the occupant moves backwards. This reduces the risk of injury to the cervical vertebrae.

In the event of a rear-end impact, the front section of the head restraint, driven by a spring, is moved towards the front by up to 60 mm within a very short space of time. Even before the head is jerked backwards due to the rear-end impact, the active head restraint reduces the distance to the head. The reduced distance contributes to increasing the stabilizing and securing function of the head restraints.

Triggering in the event of a rear-end collision

The crash safety module detects via sensors whether a rear-end collision has occurred.

If there is an appropriately severe crash, the active head restraints are triggered. This can even occur in the case of a slight rear-end collision.

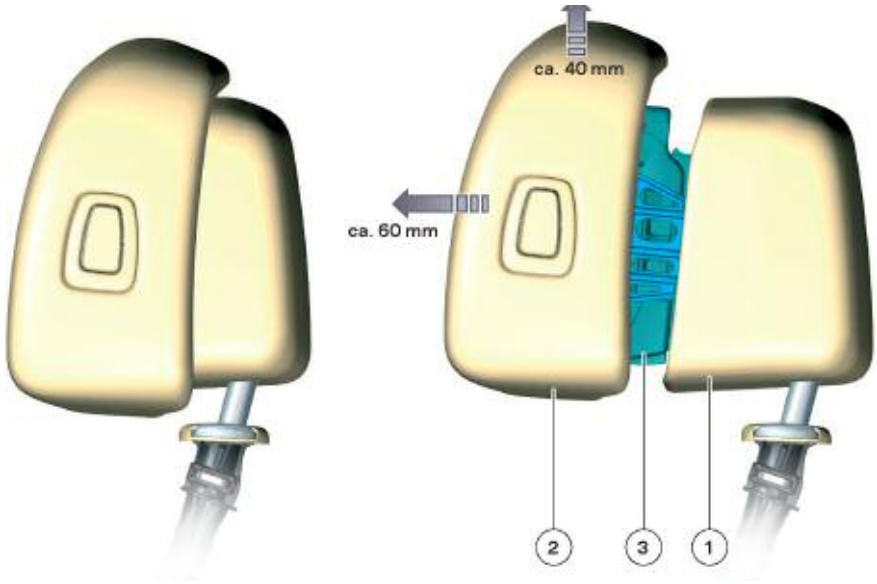
If the crash safety module detects a massive rear-end collision, other safety components, such as e.g. the belt tensioner and the safety battery terminal are also activated.

The crash safety module deploys the active head restraint, by igniting the head restraint actuator squib. The actuator releases the head restraint spring force by activating the release plate. This enables the front section of the head restraint to be moved towards the front by means of a spring.

The head restraint drive springs are only locked again once the pyro-actuator has been replaced.

Note: If the active head restraints have been triggered, the pyro-actuators must be replaced in the workshop. For more information please refer to the repair instructions available in ISTA and TIS.

Active head restraint, left, normal position, Active head restraint, right, after triggering

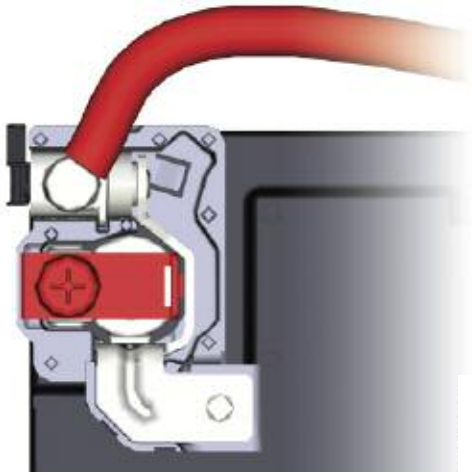


Index	Explanation	Index	Explanation
1	Head restraint support	3	Head restraint drive
2	Front section of the head restraint		

Safety Battery Terminal

The safety battery terminal is triggered at different thresholds when the Crash Safety Module detects a front-end, side-on or rear-end crash of sufficient severity. The connection between battery and starter/ alternator cable is then separated by pyrotechnical teams. The safety battery terminal is located directly at the positive terminal of the battery.

Despite the safety battery terminal being pressed off, it is guaranteed that all consumers relevant to safety such as hazard warning lights, interior lighting and telephone will continue to be supplied with voltage.



Safety battery terminal

Airbag Warning Lamp

The airbag warning lamp (AWL) is located in the instrument cluster. ACSM system operability is indicated by the AWL lighting up and then going out in during the predrive check. The AWL is controlled by means of a signal from the ACSM to the instrument cluster on the PT-CAN. The instrument cluster receives a signal on a cyclical basis. If the signal fails to materialize, the AWL is activated.

Airbag warning lamp

Passenger Airbag OFF light

In the F01/F02, the passenger airbag OFF lamp is located at the front of the roof function center FZD next to the interior lights.

The Passenger Airbag OFF light is activated if the OC3 mat detects a child seat with a child approximately one-year old or if the front passenger seat is not occupied.

The brightness of the Passenger Airbag OFF light is regulated by the automatic display lighting.

Roof function center with passenger airbag OFF light