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Longitudinal Dynamics Systems

Subject Page

Longitudinal Dynamics Systems

Model: E60 & E61

Production: From 3/2007 Production

OBJECTIVES

After completion of this module you will be able to:

- Identify the changes made to the E60/E61 Longitudinal Dynamics Systems
- Explain the operation of the ACC Stop & Go Function
- Identify the components used in the ACC Stop & Go Function and where they are located

Introduction

Cruise Control with Braking Function

The cruise control with braking function on the E60/E61 LCI is identical in function to the system used on the E9x models. It is also referred to as "Dynamic Cruise Control" (DCC).

It relieves the burden on the driver on quiet roads by maintaining a constant speed regardless of the resistance to vehicle motion (gradient, payload).

It also offers the driver the opportunity to adjust the desired speed in small or large increments, which is then set and maintained by the system by controlling power output and braking.

Accordingly it incorporates the following features:

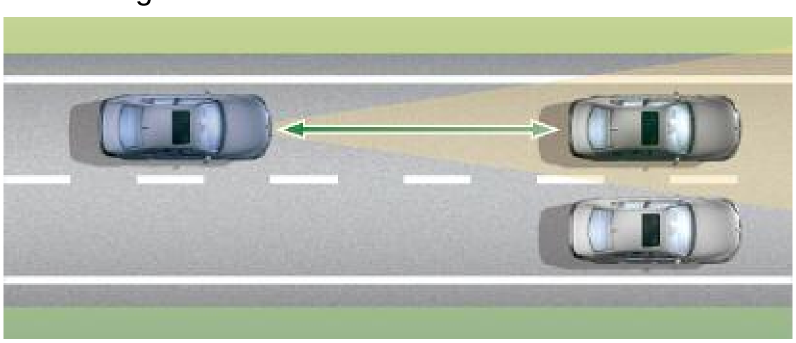
- Selection of desired speed in increments of 1 mph and 5 mph.
- Usable road-speed range of 20 mph to vehicle's maximum speed (max. 155 mph)
- Acceleration and deceleration of vehicle in two stages using the control lever
- Operation of brakes when travelling downhill and slowing down with DCC
- Modulation of longitudinal acceleration and road speed when cornering at high lateral acceleration levels.

Active Cruise Control with Stop & Go Function

Familiar ACC Function

The familiar Active Cruise Control (ACC) system keeps the car at a constant speed while there is no vehicle directly in front. It switches automatically to maintaining a safe distance as soon as its sensors detect a slower vehicle ahead in the same lane. Thus it relieves the burden on the driver not only on quiet roads but also in heavy traffic. ACC takes over the onerous task of repeated acceleration and braking in order to precisely control speed and distance from the vehicle in front. With ACC, this is only possible in moving traffic.

The driver can set the desired speed to between 15 and 110 mph. There are four possible settings for the desired distance.



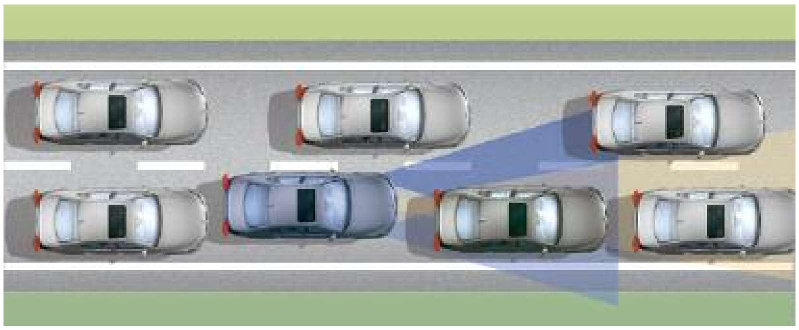
New ACC Stop & Go Function

The new Active Cruise Control with Stop & Go function (ACC Stop & Go) extends the usable range of ACC to low speeds right down to standstill. In other words, speed and distance from the vehicle in front are automatically controlled at those speeds as well.

ACC Stop & Go will automatically stop the car if necessary and then indicate to the driver as soon as it detects that it is possible to start moving again. To start moving again, the driver has to acknowledge that indication by operating the control lever or accelerator pedal.

Only if the car is stationary for a very short time does the ACC Stop & Go automatically start the car moving again.

Thus, ACC Stop & Go provides optimum assistance for the driver not only in moving traffic but also in traffic jams such as are more and more frequently encountered on highways. However, this system (in common with ACC) is not intended for use in urban areas for negotiating junctions or traffic lights.



The driver can set the desired speed to between 15 and 110 mph as with other systems. There are also four desired distance settings as with ACC.

Technically, the following challenges had to be overcome in order to implement ACC Stop & Go.

1. Detection of external environment directly in front of vehicle across full vehicle width. This is necessary in order to be able to reliably detect all road users at close proximity that are likely to be encountered at low speeds.
   Therefore, in addition to the familiar ACC sensor (long-range sensor), new sensors (close-range sensors) were developed.

2. Optimization of and development of new sensor data processing and control algorithms. At low speeds, other road users and you yourself use higher acceleration and deceleration rates.
   Accordingly, the system had to be designed so as to be able to cope with such dynamic traffic situations.

Adaptive Braking Assistance

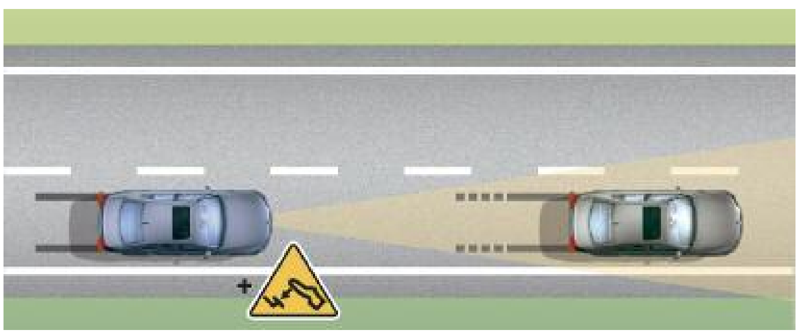
Whereas earlier driver assistance systems have only made use of information from the vehicle's external environment for convenience functions, Adaptive Braking Assistance (ABA) is the first system to utilize that information for safety functions.

On the basis of the object data supplied by the radar sensors and data relating to the vehicle's motion, an algorithm decides whether and to what degree one of the two constituent functions is to be activated:

- Priming of the braking system and
- Lowering the threshold for the Hydraulic Braking Assistance function.

Adaptive Braking Assistance works best in situations where the car is following another vehicle that suddenly performs an emergency braking operation. Its effect is to give the driver braking effect the moment the brake pedal is touched. In addition, the lowering of the threshold means that the Hydraulic Braking Assistance is triggered more easily.

The consequence is a shorter braking distance which may enable an accident to be avoided altogether or at least the impact speed to be reduced as much as possible.



System Overview

Component Locations

If a customer orders "Cruise control with braking function", no additional components are fitted on the vehicle as the function is integrated in the DSC control unit software.

Therefore, only the new sensors and control units for the option "Active Cruise Control with Stop & Go function" are presented here. They also include the essential components of the Adaptive Braking Assistance system.

Radar sensors for ACC Stop & Go, Front view

Index	Explanation
1	Long-range radar (LRR) sensor
2	Short-range radar (SRR) sensor, right
3	Short-range radar (SRR) sensor, left

The two short-range sensors are identical components that have the same part number.

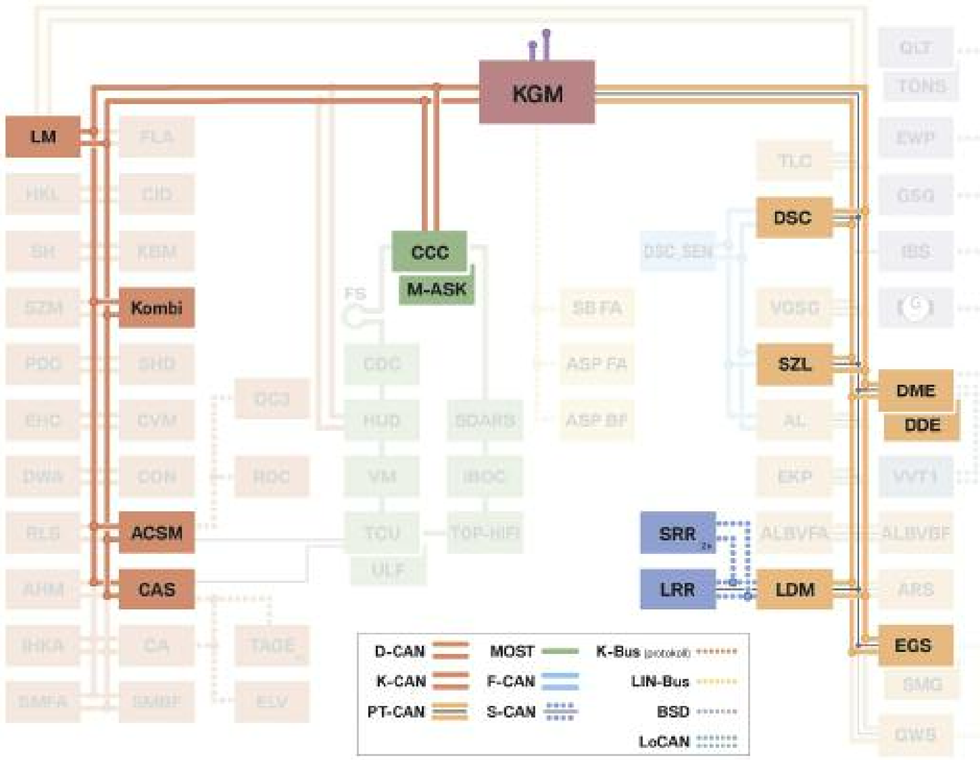
The view illustrated shows the front of the vehicle without the plastic bumper trim.

Note: The short-range sensors are fitted behind the bumper trim on the bumper crossmember. Therefore, they are only visible in this view and not with the bumper trim in place.

The location of the long-range sensor for the ACC Stop & Go is identical to that of the sensor for the familiar ACC system.

Electrical System Integration

Bus System Integration



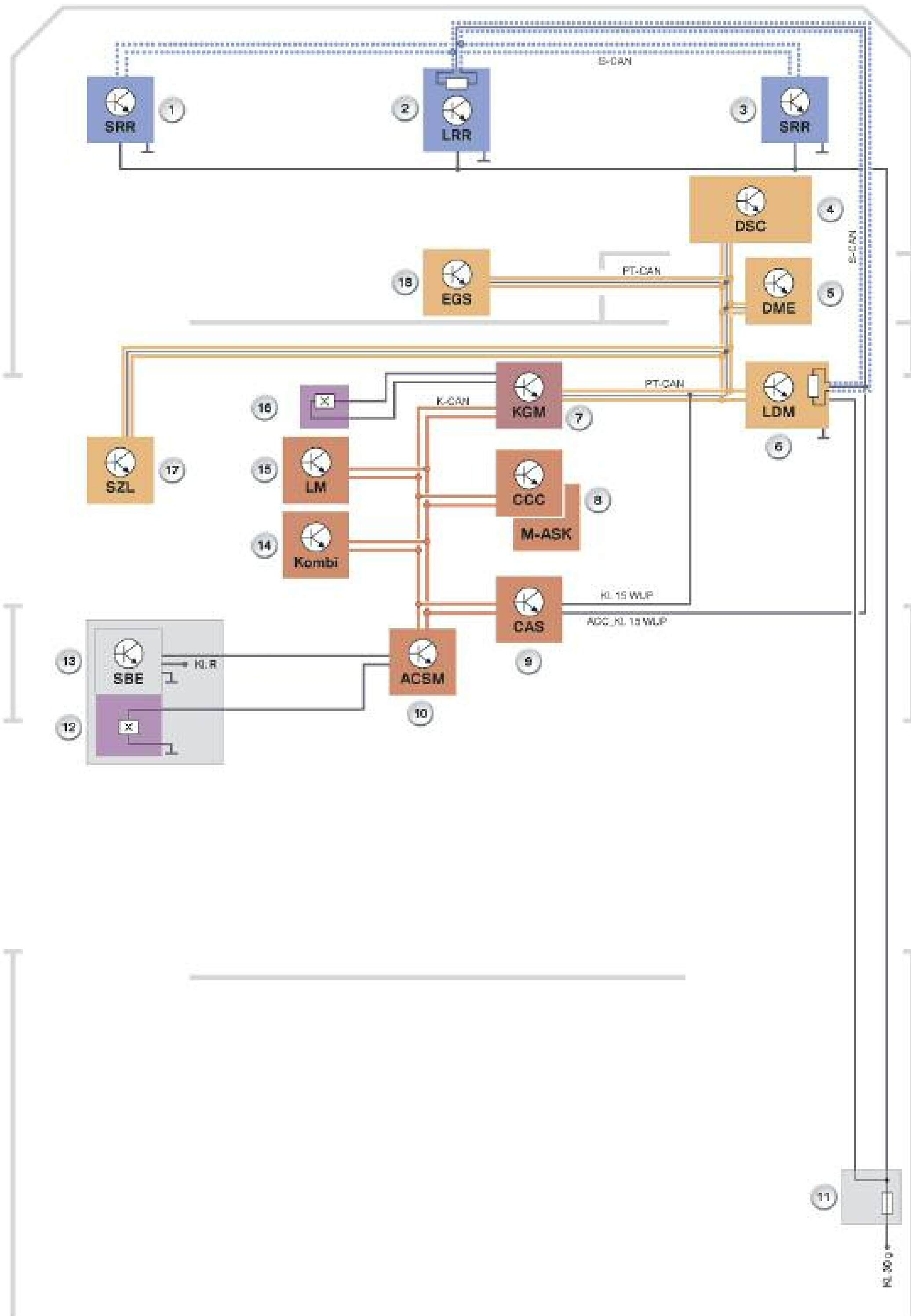
Index	Explanation	Index	Explanation
ACSM	Advanced Crash Safety Module	KOMBI	Instrument cluster
CAS	Car Access System	LDM	Longitudinal Dynamics Management
CCC	Car Communication Computer	LM	Lamp Module
DDE	Digital Diesel Electronics (ECU)	LRR	Long-range Radar Sensor
DME	Digital Engine Electronics (ECU)	M-ASK	Multi Audio System Controller
DSC	Dynamic Stability Control	SRR	Short-range Radar Sensor
EGS	Electronic Transmission Management	SZL	Steering Column Switch Cluster
KGM	Body Gateway Module		

The equipment option Active Cruise Control with Stop & Go function on the E60/E61 LCI brings with it the new Sensor CAN (abbreviated to S-CAN) bus system.

The S-CAN basically functions in the same way as the PT-CAN.

It has been introduced in order to be able to transfer the large volumes of data from the LRR and SRR radar sensors to the LDM control unit without affecting data communication between the other vehicle systems.

System Circuit Diagram fro ACC Stop & Go



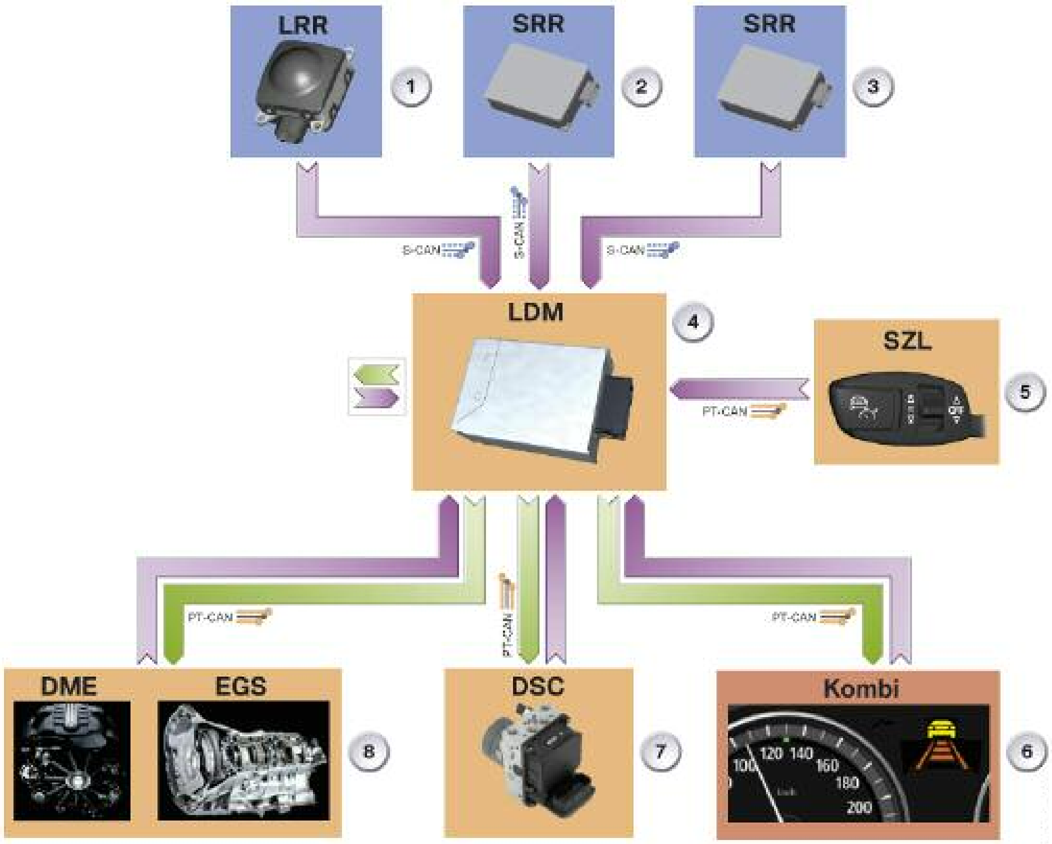
Index	Explanation	Index	Explanation
1	SRR, left	10	ACSM control unit
2	LRR	11	Fuse in boot (power supply for LDM and radar sensors)
3	SRR, right	12	Belt buckle switch, driver's seat
4	DSC control unit	13	Seat occupancy detector, driver's seat
5	DME control unit	14	Instrument cluster
6	LDM control unit	15	Light module
7	KGM control unit	16	Door switch, driver's door
8	CCC/M-ASK control unit (navigation system)	17	Steering column switch cluster
9	CAS control unit	18	EGS control unit

The new architecture for ACC Stop & Go illustrated here includes the LDM control unit, Sensor CAN and the short-range radar sensors as new components. It is being used for the first time on the E60/E61 LCI.

The characteristic feature of the previous architecture was that the ACC sensor was connected to the PT-CAN. That architecture remains in use for the cruise control on the E63/E64 for the time being.

For the purposes of comparison, the previous ACC architecture is illustrated below in the system circuit diagram.

Functional Integration



ACC Stop & Go is capable of performing gap modulation at speeds down to standstill (car is stopped). The car starts moving again on acknowledgement from the driver or automatically if only stationary for a very short period.

The control functions are integrated in the LDM control unit. The radar sensors provide information about the objects in front of the vehicle. Adaptive Braking Assistance uses information from the long-range radar sensor to detect emergency braking situations when following another vehicle. It makes it easier for the driver to obtain optimum braking effect by intervening in DSC functions.

Index	Component	Functions
1	Long Range Radar Sensor	• Detecting objects at long range, pre-processing object data, broadcasting list of objects on S-CAN (for ACC Stop & Go) • Detecting objects, pre-processing object data, calculating activation criteria and broadcasting request signals on S-CAN (for Adaptive Braking Assistance)
2	Short Range Sensor, Left	• Detecting objects at short range, pre-processing object data, broadcasting list of objects on S-CAN (for ACC Stop & Go)
3	Short Range Sensor, Right	• As short-range radar sensor, left
4	LDM control unit	• Analysis of objects and selection of relevant object (for ACC Stop & Go) • Interpretation of driver control signals and generation of display signals (for ACC Stop & Go) • Cruise control, gap modulation, and cornering speed modulation (for ACC Stop & Go) • Control of power transmission and brake actuators by output of required settings on PT-CAN (for ACC Stop & Go) • Gateway between S-CAN and PT-CAN (for diagnosis and flash-programming of long-range radar sensor) • Gateway between S-CAN and PT-CAN (for Adaptive Braking Assistance)
5	DCC/ACC control lever	• Generation of driver control signals (for DCC/ACC Stop & Go)
6	Instrument cluster	• Display of indications requested by LDM (for ACC Stop & Go) • Supply of signal for displayed speed (for ACC Stop & Go)
7	Brakes (DSC)	• Execution of braking levels specified by LDM when car is in motion and stationary (for ACC Stop & Go) • Execution of Adaptive Braking Assistance functions on instruction from LDM (priming of braking system and lowering of threshold for Hydraulic Braking Assistance) • Supply of signals relating to motion status of the car and brake pressure
8	Power transmission system consisting of engine and gearbox (DME and EGS)	• Execution of power output levels specified by LDM when car is in motion and stationary (for ACC Stop & Go) • Supply of signals indicating power transmission forces (for ACC Stop & Go)

In addition to the most important constituent parts of the system complex for ACC Stop & Go and Adaptive Braking Assistance as listed above, there are other functional groupings that are summarized below.

Other Signals to/from LDM (PT-CAN)			
In/Out	Information	Source/Recipient	Function
In	Road type, stretch of road	CCC > KGM > LDM	Adaptation of LDM control parameters according to navigation data
In	GPS location	CCC/M-ASK > KGM > LDM	Shutdown of short-range radar sensors in the vicinity of astronomical radio telescopes
In	Terminal status, engine running	CAS > KGM > LDM, DME > LDM	Activation condition for ACC/DCC
In	Automatic transmission selector position	EGS > LDM	Activation condition for ACC/DCC
In	Steering angle	SZL > LDM	Extrapolation of vehicle lane course (when stationary)
In	Driver's door open/closed	Door switch > KGM > LDM	Warning if driver is about to get out
In	Driver's seatbelt fastened/unfastened	Belt buckle switch > ACSM > KGM > LDM	Warning if driver is about to get out
In	Driver's seat occupied/unoccupied	Seat occupancy detector > ACSM > KGM > LDM	Warning if driver is about to get out
Out	Request for hazard warning flashers	LDM > KGM > LM	Warning if driver is about to get out
Out	Request for horn	LDM > SZL	Warning if driver is about to get out

Note: ACC Stop & Go and Adaptive Braking Assistance are highly integrated functions.

In the event of customer complaints, reports of failure or initially unexplained function behavior, the fault memories of the LDM and long-range radar sensor should be checked first and the programmed testing sequences followed if necessary.

If that does not identify the problem, all control units and sensors involved in the system complex must be manually checked.
A precise examination of the PT-CAN, S-CAN and K-CAN bus systems is particularly advisable in the event of signal or communication faults.

Cruise Control with Braking Function (DCC)

As this function was already familiar from the E9x models before being adopted on the E60/E61 LCI, only the most important details and new features are presented here.

Functions

Cruise Control

The cruise control calculates a required acceleration rate on the basis of the desired speed set by the driver and the vehicle's current actual speed. That acceleration rate may be positive, if the desired speed is greater than the actual speed, or negative if the reverse is the case.

Accelerating and Decelerating Using the Control Lever

The control lever allows the driver to do more than just set the desired speed. It also provides the "Easy Dynamics" function. If the control lever is pressed and held forwards or backwards, that is interpreted as a direct acceleration or deceleration command. The rate of acceleration or deceleration is dependent on whether the driver pushes the lever to the first or second position.

This mode takes precedence over cruise control.

Cornering Speed Modulation

Also known as "Lateral acceleration control", this function has the purpose of preventing the lateral acceleration rate when cornering from exceeding a comfortable level when cruise control is active.

The actual lateral acceleration is calculated from the road speed and the yaw rate. That figure is then compared to a threshold level, which is speed-dependent, with the purpose of achieving the following apparently contradictory aims:

- Avoiding irritating, over-restrictive intervention in situations where the driver would corner at higher lateral acceleration rates.
  Examples: at low speeds such as when on a mountain road or at high speeds on a highway.
  In those situations a higher threshold is applied.
- Intervening effectively and accordingly bringing about a clearly perceptible reduction in dynamic forces at typical trunk road speeds. That is when most drivers perceive too high lateral acceleration as unpleasant, which is why a lower threshold is applied for such situations.

The output variable from this function is also a required level for longitudinal acceleration.

Prioritizing Required Settings

From the required longitudinal acceleration rates calculated by the above control functions, the required setting that has the highest priority is selected according to the situation. When doing so, abrupt jumps when switching from one required setting to another are avoided by signal filtering.

Estimating Contributory Forces

In order to be able to put the prioritized longitudinal acceleration rate into effect by means of the actuators, an acceleration or deceleration rate must be calculated.

Example: when driving uphill, the engine power required to bring about a specific longitudinal acceleration rate is greater than would be required on the flat. If it is necessary to decelerate when going uphill, less braking force is required than on the flat.

In order to be able to correctly calculate the necessary forces, the precise figures would be required not only for the gradient but also for the mass of the vehicle, the rolling resistance, the wind resistance and a number of other accelerating or retarding forces.

Since there are no sensor systems for any of those contributory forces, an estimated figure is calculated by comparing the two following variables:

- the vehicle's actual motion variables and
- the vehicle's expected motion variables based on the power transmission and braking forces currently in effect.

The figure for the contributory force thus determined is included as an added quantity in the calculation of the required longitudinal acceleration rate.

Control of Actuators

In order to bring about the longitudinal acceleration calculated by the control functions and compensate for the contributory forces that are in effect, power transmission and/or braking forces must be initiated.

Accelerating the vehicle generally only involves specifying a required setting for the power transmission system consisting of engine and gearbox. (In the exceptional case of a steep descent, it may also be necessary to operate the brake to bring about a specific positive acceleration rate.)

If the vehicle is to be slowed down, the system first of all ascertains how great the possible retarding effect of the power transmission system (braking effect of engine and gearbox) is and signals it to the drivetrain control units (DME and EGS).

Only the remaining retarding force required is signalled as the required deceleration rate to the braking system control unit (DSC).

Note: If the brakes are noticeably applied in order to achieve the desired vehicle deceleration rate, the vehicle's brake lights are also switched on (legal requirement).

Operation and Display

Activation and Deactivation

The preconditions for operation for the DCC function must be satisfied before operation of the control lever by the driver can be acted upon as a request for activation.

Those preconditions for operation are:

- Vehicle's road speed must be within the permitted range (above 20 mph)
- Brake pedal must not be depressed
- A forward gear (manual gearbox) or Drive (automatic transmission) must be engaged
- Parking brake must not be on
- DSC must be switched on and no control intervention currently in progress
- There must be no system fault present

If any of those conditions is not met, activation is prevented despite any attempts by the driver to activate the function.

Conversely, if the function is active when any of those conditions ceases to be met, the function is deactivated.

Changing the Desired Speed

If the cruise control is already active, the driver can change the desired speed in increments of two different sizes by operating (pressing and immediately releasing) the control lever.

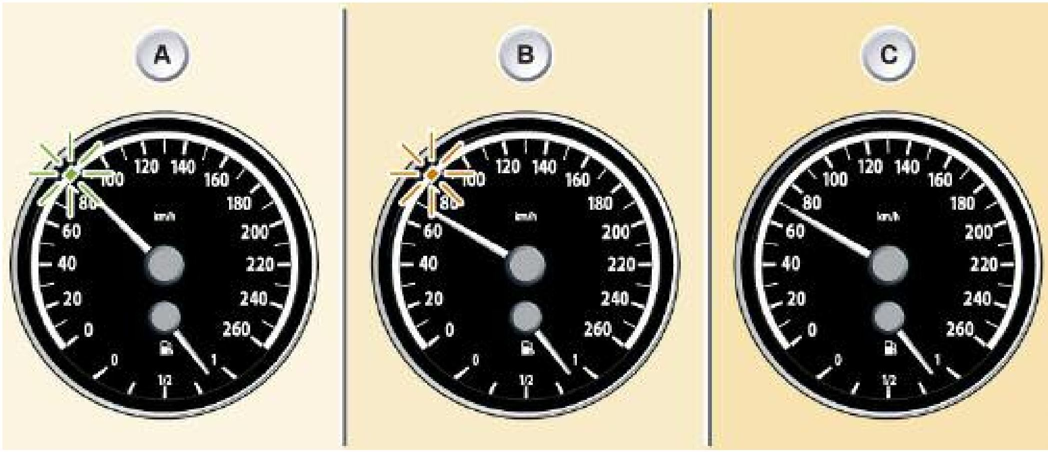
- Pressing the lever to the first position increases or decreases the desired speed by 1 mph.
- Pressing the lever to the second position increases or decreases the desired speed by 5 mph.

Pressing and holding the control lever sends a direct instruction for one of the two acceleration or deceleration rates (see the section "Control functions").

While the lever is held, the vehicle's actual speed changes due to the acceleration or deceleration rate applied. After operating the lever, the driver generally wants to continue at the resulting speed. Therefore, while the vehicle is accelerating or decelerating, the desired speed changes to match the actual speed.

The range of adjustment for the desired speed is between 20 and 155 mph for the DCC function.

The desired speed selected is permanently indicated by means of an illuminated mark on the perimeter of the speedometer.



Indication of Desired Speed on Speedometer Perimeter

Index	Explanation
A	The mark is colored green when the system is active. It then indicates the desired speed to which the system is working.
B	The mark shows orange when the system is inactive. It then indicates the desired speed last selected, which can be reactivated by the driver.
C	The mark is not visible if the system is inactive and has not been used since the engine was last started. In those circumstances, there is no stored desired speed that the driver could reactivate.

When the system is switched on or the desired speed changed, an additional indication is displayed: the new setting for the desired speed is shown in figures on the variable display panel of the instrument cluster.

This method of indication is also used if activation is not possible because the preconditions for operation are not satisfied. In that case, three lines are shown instead of the figures.

Monitoring Functions

All monitoring functions serve the two purposes of preventing the function from operating with incorrect input signals or parameters and also preventing critical dynamic handling conditions arising from system faults.

For those reasons, all input signals, the operational status of the associated systems involved and the system's own control unit hardware are monitored. If a fault is detected, the control function is shut down or its activation prevented. In addition, an indication is given on the instrument cluster by means of a check control message.

Symbol displayed on fault related failure of cruise control with braking function

The failure message referred to above should not be confused with the message the driver receives when the system is deactivated due to the preconditions for operation ceasing to be met.

Symbol displayed on deactivation of cruise control with braking function due to operation reconditions ceasing to be met

Active Cruise Control with Stop & Go Function

Even with its distinctly wider operating range, Active Cruise Control with Stop & Go function (ACC Stop & Go) remains a system intended to relieve the burden on but not replace the driver. The driver is and remains responsible for employing the system sensibly. The fact that the driver must continue to pay careful attention to the road traffic conditions is self-evident and is merely made easier by the system. Only in that way can the driver intervene promptly and in a controlled manner when ACC Stop & Go reaches its limits.

Information from the Vehicle's External Environment

Detecting Objects

Detecting other road users in front of the vehicle represents one of the most important functions of Active Cruise Control. With the introduction of the Stop & Go function, the system has to be capable of doing so not only at long range but also at short range right down to the area directly in front of the vehicle.

This is necessary because at low speeds, shorter gaps of only a few meters can be maintained (see the section "Gap modulation").

Consequently, that task cannot be performed by one radar sensor on its own. The familiar ACC sensor, now referred to as the long-range radar sensor, is supplemented by two additional short-range sensors.

In addition to the simple detection of objects, those sensors ascertain the position of objects on the x and y axes and their relative velocities in relation to the vehicle. From the relative speed, the sensors also compute the relative acceleration of the objects in relation to the vehicle. That figure is required for gap modulation.

Pre-processing Object Data

Initial processing of the object data (position and motion variables) is performed by the radar sensors themselves. They collate and track individual undefined objects over time in order to bridge detection gaps. They also pre-filter the object data.

The second processing stage takes place in the LDM control unit. The position data is first of all standardized and adjusted by the offset of the radar sensors from the vehicle's center axis (x axis).

The object data received from the different radar sensors then has to be merged because parts of the sensors' detection zones overlap.

That overlap occurs in the close-range zone in particular where objects are frequently detected by more than one sensor.

A further filtering process is then performed on the merged object data to take account of the special requirements of gap modulation.

Assessing Objects

In order to decide which object should used as the basis for gap modulation, an assessment rating is calculated for each object. The following two essential criteria are taken account of by the calculation:

1. The position and speed of the object relative to the vehicle.
   The closer the object is to the vehicle and/or the faster it is approaching the vehicle, the higher is its assessment rating.

2. Position of the object in the vehicle's lane.
   The radar sensors cannot identify the actual lane or the lane markings on the road. And the data from the camera based system that is used for the "lane departure warning" system is not available to the ACC at this stage. For that reason, the ACC Stop & Go, like the familiar ACC system, calculates a probable lane course ahead of the vehicle.

   While the vehicle is moving, it is based on variables that define the motion of the vehicle itself and the position of detected stationary objects.

   When the vehicle is stationary, the calculation is based primarily on analysis of the signal from the steering angle sensor. That means that steering wheel movements while the vehicle is stationary change the lane course calculated by the ACC Stop & Go and, consequently, the assessment of the objects detected.

The object with the highest assessment rating ultimately forms the basis on which gap modulation is performed.

In this processing phase, objects are also classified on the basis of their motion status. A distinction is made between moving and stationary objects. Special treatment is given to objects classified as stationary (since they were first detected).

Control Functions

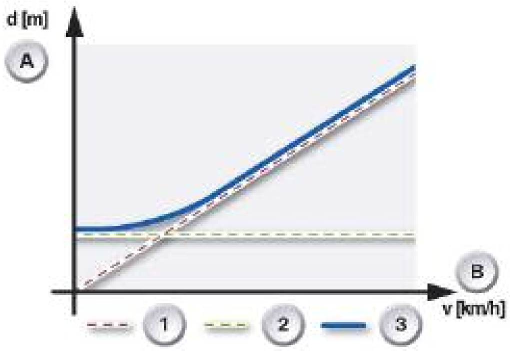
Cruise Control

The cruise control function on the ACC system basically operates in precisely the same way as on the DCC system.

Distance Control

Gap modulation is the core function of any ACC system. On the ACC Stop & Go system it is integrated in the LDM control unit. (As distinct from ACC on the E9x on which gap modulation is integrated in the ACC control unit.)

The driver can set the desired gap to one of four choices by means of a rocker on the control lever. On the basis of that desired gap setting, the ACC Stop & Go calculates the required distance from the vehicle in front.



Calculation of required gap for gap modulation by ACC Stop & Go

Index	Explanation
A	Required gap d in meters
B	Road speed v in kph
1	Required gap, in-motion component, proportional to road speed
2	Required gap, stationary component, constant
3	Resulting required gap from in-motion and stationary components

As with the familiar ACC system, the required gap when the vehicle is moving is proportional to the road speed (1).

At low speeds and when stationary, a second component is given greater weight by the ACC Stop & Go. This is a fixed quantity in meters (2). If this component were not taken into account, the required gap when stationary would be zero meters. Instead, this second component is used to set the desired gap when stationary (approx. 5 m).

The resulting required gap is calculated from the two components. They are differently weighted according to the vehicle's road speed.

The input data for the gap modulation function is the pre-processed object data relating to the object with the highest assessment rating.

In comparison with the previous ACC system, the new system had to meet additional requirements:

1. The maximum acceleration and deceleration rates for the ACC Stop & Go system have been increased compared with the ACC. The change was introduced for the low-speed range (below approximately 50 kph) as drivers uses greater rates themselves at those speeds but still perceive them as comfortable.

   Depending on the situation, the ACC Stop & Go accelerates at up to approximately 2 m/s^2 and decelerates at up to approximately 4 m/s^2.

   The increase was technically justifiable as, firstly, the additional short-range sensors have increased the reliability with which vehicles in front can be identified.
   And secondly, the projection of the lane course is also more reliable in the lower speed range, which is also why selection of the object on which control is based has also improved.

2. Traffic queue stability. In very heavy traffic moving at very slow speeds it is all the more important that following vehicles do not make successively greater changes to longitudinal dynamics (longitudinal acceleration) than the vehicle in front in each case. If that were to happen, at some point further along the queue a vehicle would be forced to make an emergency stop even though the first vehicle in the queue had only braked very slightly.

The ACC Stop & Go gap modulation function is designed in such a way that it reacts as soon as possible but not any more severely than the vehicle in front.

Cornering Speed Modulation

The cornering speed modulation function on the ACC Stop & Go is based on that of the DCC.

It has been extended to take account of the lateral limits of the radar sensor detection zones. If the bend being negotiated is so tight that objects can no longer be detected, it intervenes and prevents the vehicle accelerating.

Prioritizing Required Settings

Prioritization of the required settings on the ACC Stop & Go system is basically the same as on a DCC system. There is merely an additional specified control setting generated by the gap modulation function.

Estimating Contributory Forces

The estimation of contributory forces by the ACC Stop & Go is also based on the DCC system. Nevertheless, the fine detail required numerous optimizations because at slow speeds (under 20 mph) inaccuracies in the estimation of contributory forces are much more noticeable than at high speeds.

Greater accuracy of estimation combined with simultaneously quicker adaptation to changes in the contributory forces present was therefore necessary.

Control of Actuators

Apart from the situation when stationary, for which the data interface between the LDM and DSC has been extended, the control of actuators by the ACC Stop & Go is effected in the same way as by the DCC or ACC on the E9x.

Note: The brake lights are also switched on when the ACC Stop & Go brings the car to a stop.

Operation and Display

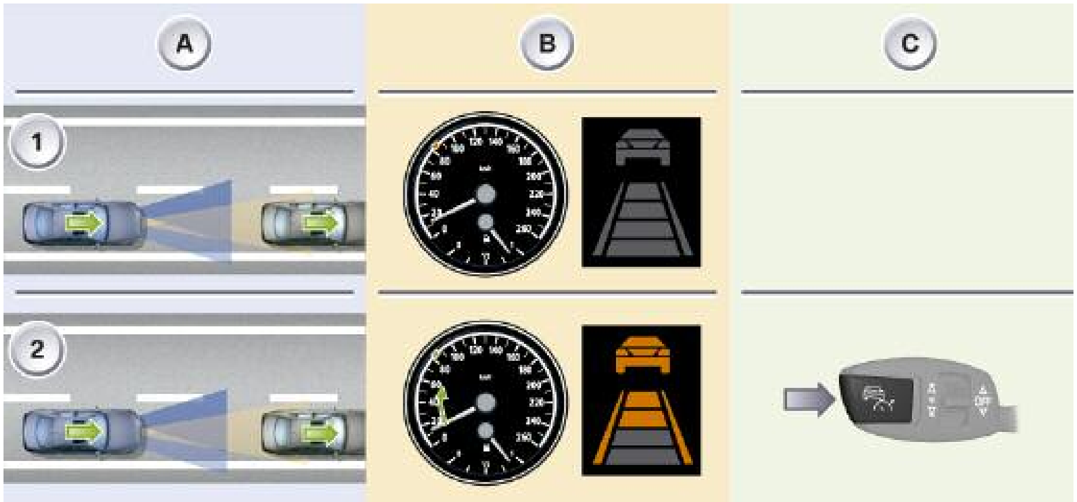
Activation and Deactivation

When the car is moving, the same conditions have to be met for the ACC Stop & Go system to be activated as for the familiar Active Cruise Control:

- Brake pedal must not be depressed
- Automatic transmission must be in Drive
- Parking brake must not be on
- DSC must be switched on and no control intervention currently in progress
- Radar sensors must be operational and not dirty
- There must be no system fault present

Activation when Moving

In contrast with the previous ACC system, ACC Stop & Go can be activated at speeds below 20 mph if a vehicle is detected ahead.



Activation of ACC Stop & Go when Moving

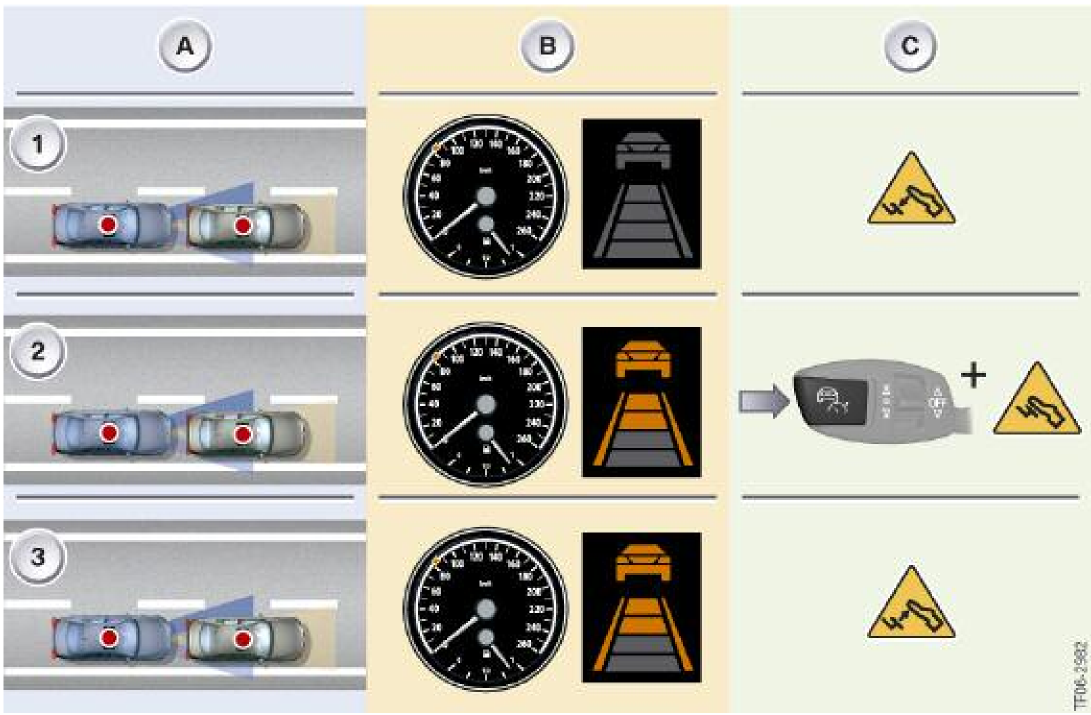
Index	Explanation
A	Road traffic situation
B	ACC indications on the instrument cluster
C	Control operations by driver
1	ACC Stop & Go is inactive. A desired speed has been stored from a previous activation (orange mark). Object and gap indications are off.
2	ACC Stop & Go is switched on by means of the Resume button. The desired speed mark changes color to green. The vehicle accelerates so as to either reach the desired speed or adjust the distance from the vehicle in front to the desired gap setting.

Activation when Stationary

If the driver wants to activate ACC Stop & Go when stationary, the same basic conditions must be met as when the vehicle is moving.

The following additional conditions must also be satisfied:

- The driver must be pressing the brake pedal to keep the vehicle stationary.
- There must be another stationary vehicle in front of the car.
- The driver's door must be closed and the driver must have the seat belt on.

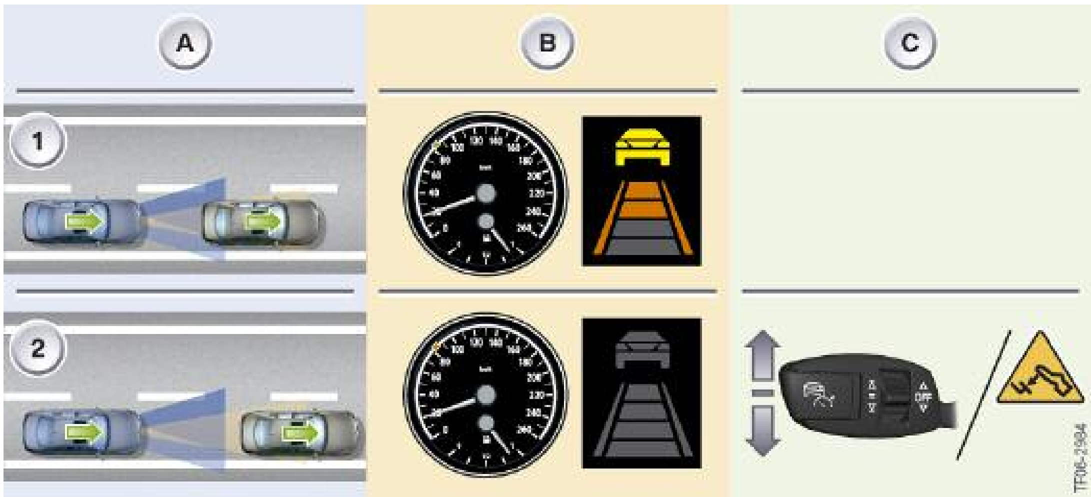


Activation of ACC Stop & Go when Stationary

Index	Explanation
A	Road traffic situation
B	ACC indications on the instrument cluster
C	Control operations by driver
1	ACC Stop & Go is inactive. A desired speed has been stored from a previous activation (orange mark). The object and gap indications are off. The driver is pressing the brake pedal to keep the vehicle stationary.
2	The driver continues to press the brake pedal while also pressing the resume button. This switches on the ACC Stop & Go. Object and gap indications are also switched on. The desired speed mark stays orange.
3	The driver releases the brake pedal. The active ACC Stop & Go system continues to keep the vehicle stationary by operating the brake. The desired speed mark stays orange to indicate that the ACC Stop & Go will not automatically move the car off (see the section "Stopping and moving off").

Deactivation when Moving

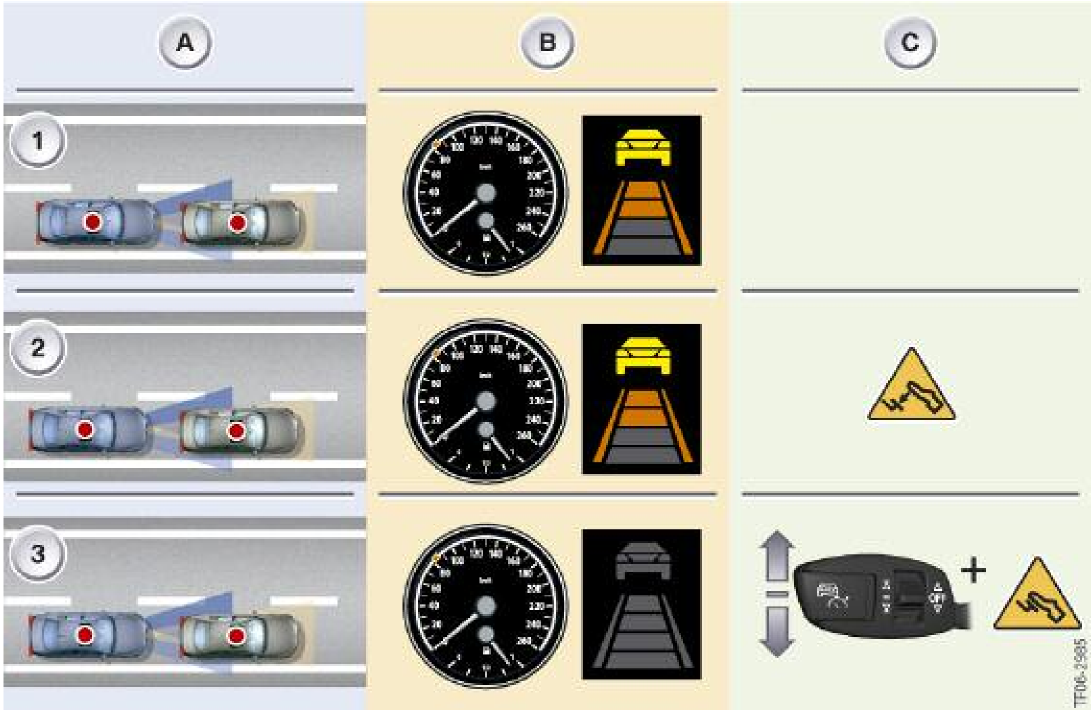
Deactivation of the ACC Stop & Go is effected by driver control operations that are more or less the reverse of those for activation.



Activation of ACC Stop & Go when Stationary

Index	Explanation
A	Road traffic situation
B	ACC indications on the instrument cluster
C	Control operations by driver
1	ACC Stop & Go is active. Object and gap indications are on. The desired speed mark is showing green.
2	The driver pushes the control lever up or down or presses the brake pedal to switch off the ACC Stop & Go. The object and gap indications are switched off. The desired speed mark changes color to orange thereby indicating that the last desired speed setting can be resumed.

Deactivation when Stationary



Deactivation of ACC Stop & Go when Stationary

Index	Explanation
A	Road traffic situation
B	ACC indications on the instrument cluster
C	Control operations by driver
1	ACC Stop & Go is active and holding the car stationary behind another stationary vehicle. Object and gap indications are on. The desired speed mark is showing orange.
2	The driver operates the brake pedal. ACC Stop & Go remains active, waiting for further control operations by the driver. If the driver were next to release the brake pedal, the ACC Stop & Go would remain active and keep the car stationary by operating the brakes. The indications would not change as a result of the brakes being operated.
3	As well as operating the brake pedal, the driver pushes the control lever up or down to switch off the ACC Stop & Go. The object and gap indications are switched off. The desired speed mark shows orange thereby indicating that the last desired speed setting can be resumed.

Changing the Desired Speed

The driver can change the desired speed for the ACC Stop & Go when the system is switched on in the same way as with the DCC.

The adjustment range for the desired speed setting is from 15 to 110 mph, as with the familiar ACC system.

Changing the Desired Gap

As with the familiar ACC system, the desired gap can be changed when the system is switched on by pressing and releasing the rocker on the control lever. The usual choice of four gap settings is offered and the selected setting is indicated by the bars below the object indication on the instrument cluster.

Changing the desired gap when the vehicle is moving produces an immediate perceptible vehicle response. It accelerates or slows down slightly to adjust the gap to the new setting.

Note: When the vehicle is stationary, changing the desired setting will not cause the vehicle to move off - it will neither move forwards to reduce the gap nor backwards to increase the gap.

Stopping and Moving Off

Although the "gap modulation" function basically operates at speeds down to zero (standstill), there are additional software functions that control the stopping and moving off sequences.

Their job is to operate the power transmission system and the brakes in such a way that the perception of the vehicle's Behavior by the driver and passengers is as comfortable as possible. In addition, the vehicle must not be allowed to roll backwards in the course of those operations.

Maximum driver assistance and relief would be offered by a Stop & Go function that automatically performed all operations from stopping to moving off again.

The function actually technically achieved is one that automatically stops the car but only automatically moves it off again if the car is only briefly stationary.

If the stationary period lasts longer than a few seconds, the ACC Stop & Go does not automatically move the vehicle off again.

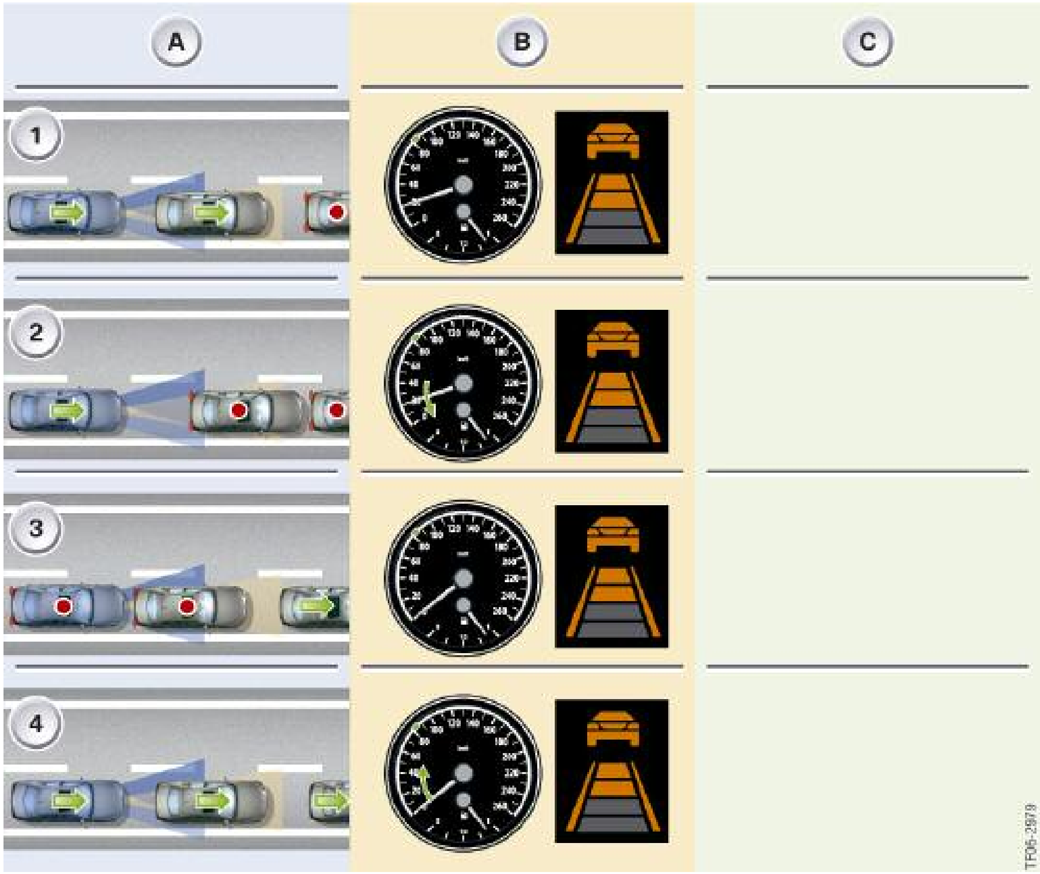
Instead, the ACC Stop & Go signals to the driver on the instrument cluster that it has detected a situation in which the vehicle can move forwards and only moves the vehicle off when the driver acknowledges that signal by a control operation.

Note: Requiring acknowledgement ensures that the driver is paying attention to the traffic situation again after an extended stationary period. Because even though the Active Cruise Control has been extended by the Stop & Go function, the driver remains responsible for driving the vehicle and making appropriate use of the assistance functions available.

For extended standstill phases, the ACC Stop & Go makes use of a Dynamic Stability Control function known as standstill management.

That function firstly ensures that the braking force necessary to stop the vehicle moving is increased as circumstances demand if the vehicle starts rolling when it shouldn't (longitudinal motion detection). In addition, standstill management observes whether there are interventions from the ABS system during the stopping sequence. If that is the case, skid detection, which reduces the braking force at each of the wheels in turn, is activated when the vehicle is "stationary". If any of the wheels starts rotating, the standstill management identifies that the vehicle is skidding. As a consequence, the ACC Stop & Go is switched off, the brakes are released on all wheels and the driver is informed by a check control message. Releasing the brakes makes the skidding vehicle steerable again. Of course, the driver still has the option of stopping the car again by operating the brakes if the road conditions allow.

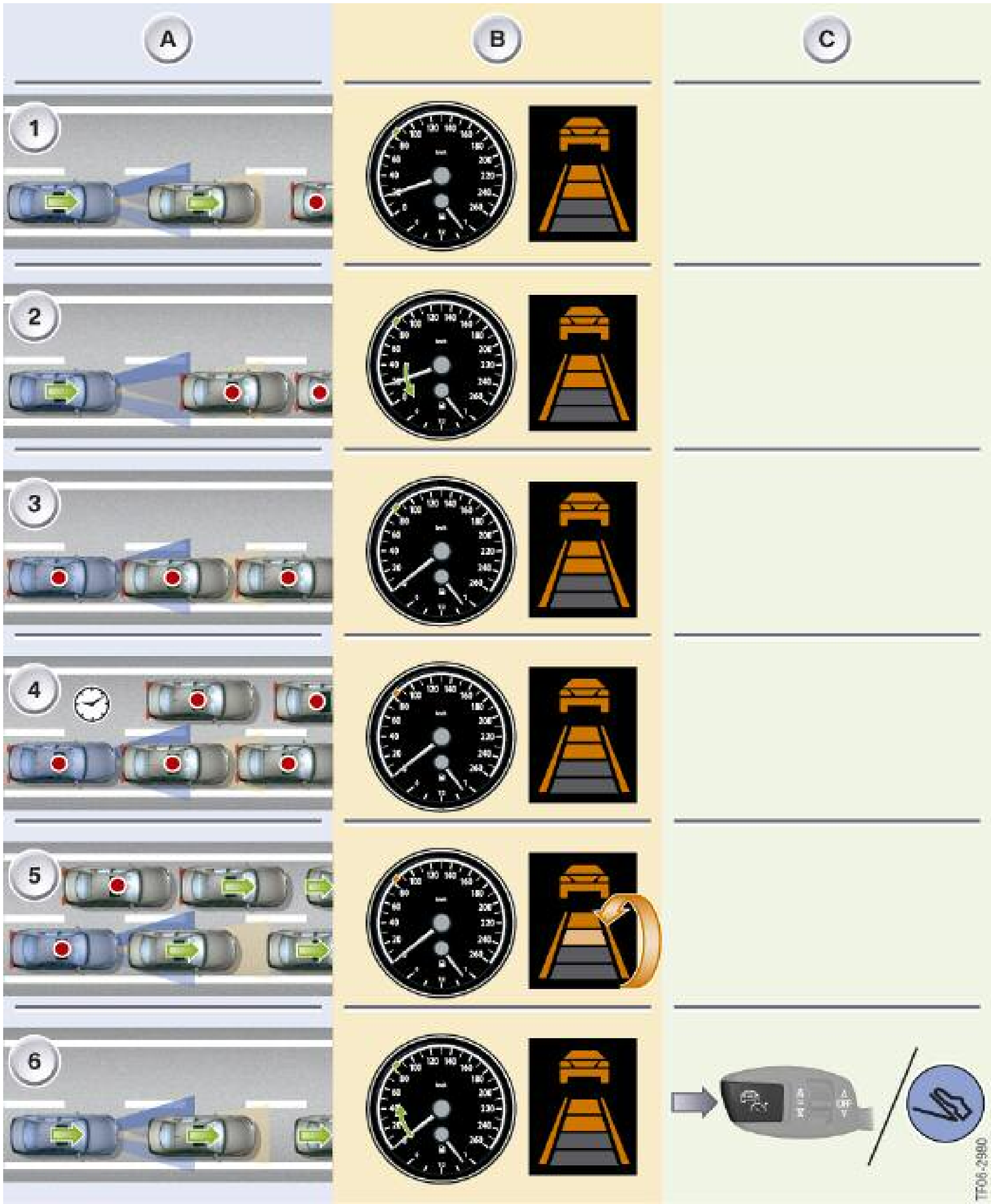
Automatic Moving-off Sequence



Stopping and Moving off Automatically with ACC Stop & Go

Index	Explanation
A	Road traffic situation
B	ACC indications on the instrument cluster
C	Control operations by driver (no control operations are required in this situation)
1	The vehicle with ACC Stop & Go is following another vehicle at a slow speed. Due to the short-range radar sensors, reliable detection remains possible at the resulting short distance between the vehicles.
2	The vehicle in front stops. The ACC Stop & Go vehicle automatically slows down by carefully controlled application of the brakes.
3	The ACC Stop & Go vehicle automatically comes to a halt. Once the vehicle is stationary, the brakes are applied in such a way that there is a certain amount of surplus braking force so as to ensure there is no undesirable movement of the vehicle. In the situation illustrated, the period of standstill is very short. The first vehicle in the queue has already started moving again.
4	The ACC Stop & Go detects that the vehicle in front has started moving again after a very short time and automatically starts the moving-off sequence. To do so, it gradually releases the brakes at the same time as increasing the transmission of power. As a result, the ACC Stop & Go smoothly starts the vehicle moving.

Moving-off Sequence with Driver Acknowledgement

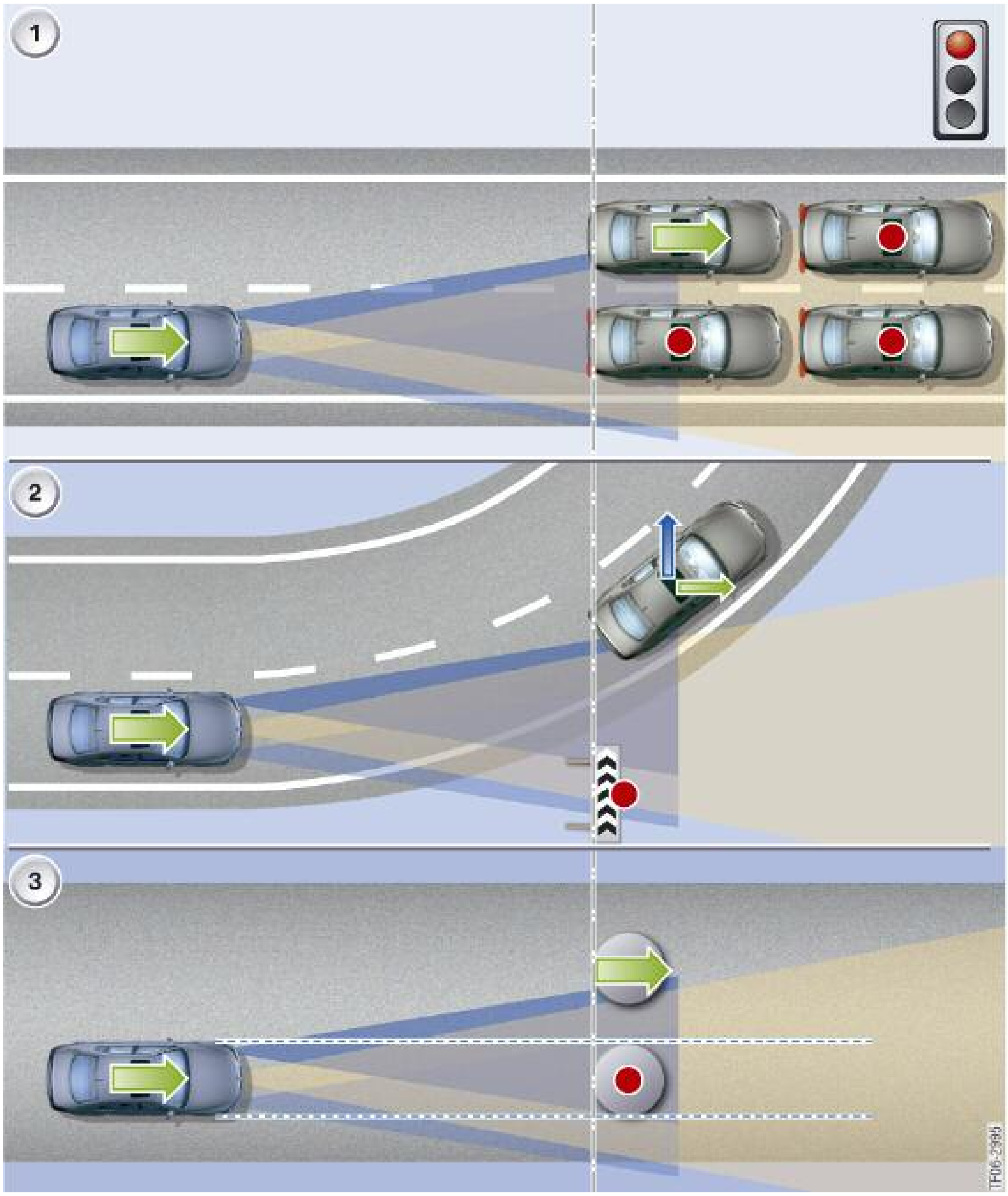


Stopping and Moving-off with Driver Acknowledgement

Index	Explanation
A	Road traffic situation
B	ACC indications on the instrument cluster
C	Control operations by driver
1	The vehicle with ACC Stop & Go is following another vehicle at a slow speed. Due to the short-range radar sensors, reliable detection remains possible at the resulting short distance between the vehicles.
2	The vehicle in front stops. The ACC Stop & Go vehicle automatically slows down by carefully controlled application of the brakes.
3	The ACC Stop & Go vehicle automatically comes to a halt. Once the vehicle is stationary, the brakes are applied in such a way that there is a certain amount of surplus braking force so as to ensure there is no undesirable movement of the vehicle.
4	In the situation illustrated, the traffic congestion increases and the standstill period is longer. The ACC Stop & Go and the DSC standstill management function make sure that the vehicle continues to be kept stationary. To signal to the driver that ACC Stop & Go will not automatically start the car moving, the desired speed mark changes color from green to orange. Object and gap indications remain on.
5	The traffic starts moving and the vehicles directly in front move off again. The ACC Stop & Go signals to the driver by means of rolling gap bars that it has detected a situation in which the vehicle can move off. But as long as the driver does not acknowledge the signal, the ACC Stop & Go continues to keep the vehicle stationary.
6	The driver acknowledges the moving-off signal from the ACC Stop & Go either by pressing the Resume button on the control lever or pressing the accelerator. The ACC Stop & Go then resumes the control function and follows the vehicle in front.

Response to Stationary Objects

Special treatment is given to stationary objects that have not been detected as moving (velocity equal to zero) since they were first identified.



Road Traffic Scenarios Involving Stationary Objects

Index	Explanation
1	Real road traffic scenario The vehicle with ACC Stop & Go approaches a stationary vehicle that has not been identified as moving at any point up to then. In this scenario, the driver wants the ACC Stop & Go to slow the car to a stop in response to the stationary object in front.
2	Real road traffic scenario From a straight section of road, the vehicle with ACC Stop & Go approaches a bend at the beginning of which there is a warning sign. That warning sign is similarly identified by the ACC Stop & Go as a stationary object. In this scenario, the driver does not expect the ACC Stop & Go to slow the car down in response to the stationary warning sign.
3	Road traffic scenario as seen by ACC Stop & Go The real road traffic scenarios (1) and (2) are indistinguishable to the ACC Stop & Go as the radar sensors merely provide information about the position and motion status of the objects detected. They do not provide any details of the type of object, which is why in both cases the ACC Stop & Go responds as in scenario (3).

A distinction can only be made between actual road users and other objects such as road signs or buildings if we assume that a road user must have been moving at some time.

That is precisely the assumption that cannot be made of stationary objects so that no reliable conclusion about their significance with regard to ACC response can be drawn either.

Note: To prevent the car slowing down inappropriately, for instance for road signs, ACC and ACC Stop & Go never respond to stationary objects. In other words, it does not even slow the vehicle down if it is approaching the end of a stationary queue of traffic at high speed.

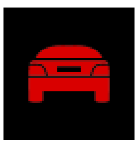
However, the driver can activate the ACC Stop & Go function when the vehicle is stationary behind another stationary object. In that situation it is assumed that the driver would only activate the function when stationary behind another road user.

Instruction to Take Over Control

As with the familiar ACC, the ACC Stop & Go also has procedures for instructing the driver to take over control. A new algorithm has been developed to take account of the substantially more diverse and dynamic situations in the lower speed range and shorter distance zone. Development of a new algorithm also made it possible to improve the instruction to take over control in the higher speed range.

Now, rather than the ACC Stop & Go not informing the driver until it has reached the self-imposed limit for maximum deceleration when it can, therefore, no longer control the situation, the instruction to take over control is initiated if the motion data from the system's own vehicle and the vehicle in front demand a quick response from the driver (before the ACC Stop & Go has achieved the maximum deceleration). Reduction of the gap to below a minimum distance for an extended period has also been integrated as a third trigger criterion.

A feature that remains the same compared with the previous ACC is that the instruction to take over control is only issued when the ACC is switched on. The method of indication is also unchanged. It consists of a visual signal in the form of the red flashing object symbol and a two-tone audible beep signal.



Red flashing object symbol as instruction to take over control

Warning if Driver is About to Get Out

ACC Stop & Go uses the DSC hydraulics to reliably slow the vehicle to a halt and keep it stationary. However, the following general parameters and differences from other systems must be made clear:

- When the vehicle comes to a standstill in the course of ACC Stop & Go operation, this constitutes a transitional phase before the vehicle moves off again. ACC Stop & Go is, therefore, by no means a system for permanently parking the vehicle.
- Without a supply of electricity, the DSC hydraulics are unable to indefinitely maintain the braking force necessary to keep the vehicle stationary. The valves require a constant supply of electricity and the hydraulic pump also has to be brought into action if the pressure in a brake circuit threatens to drop. Under extreme circumstances, the DSC hydraulics may even become overheated. In such conditions, the standstill function has to be cancelled in order to protect the components from permanent damage.
- The only technical device on the vehicle designed to secure it against rolling away is the parking brake. Some BMW vehicles now have an electromechanical parking brake. It can be electronically operated if needed so as to automatically secure the vehicle against rolling away.

The E60/E61 LCI, however, continues to be fitted with a conventional hand operated parking brake.

Note: The driver is responsible for securing the vehicle against rolling away and remains so even with ACC Stop & Go fitted on the E60/E61 LCI.

This can be done by engaging Park on the automatic transmission but the parking brake should be applied as well.

As the use of the ACC Stop & Go driver assistance function may result in drivers becoming unaware of that responsibility, a multi-stage warning concept has been developed. It is designed to prevent sudden and unexpected cessation of the standstill function on the one hand while also insistently reminding the driver to carry out that responsibility.

Typical Warning Sequence if Driver is About to Get Out

Index	Explanation
A	Actions by driver that trigger warning stages
B	ACC indications on the instrument cluster
C	Road traffic situation or perceptible response of vehicle with ACC Stop & Go
0	No warning stage active ACC Stop & Go is switched on and automatically holding the car stationary behind another vehicle. That vehicle moves away after an extended standstill period.
1	Warning stage one is active The driver undoes the seatbelt or opens the driver's door. The belt buckle switch and the door switch generate signals when that happens. The driver may be intending to get out of the car. ACC Stop & Go remains active and continues to keep the vehicle stationary. The yellow warning symbol on the instrument cluster is accompanied by a single audible signal. In addition, a check control message warning that the vehicle could roll away is displayed. If the driver fastens the seat belt again and closes the driver's door, the warning is cancelled and the ACC Stop & Go continues to hold the vehicle stationary as before.
2	Warning stage two is active The driver has undone the seatbelt and opened the driver's door. The driver's intention to get out of the car is more definite. ACC Stop & Go switches itself off and releases the brakes. The vehicle starts to move. This alone raises the barrier to the driver getting out of the vehicle completely. The red warning symbol on the instrument cluster is accompanied by a repetitive audible signal. The check control message that is also displayed insistently informs the driver that the vehicle is now moving and it must be secured against rolling away. Even if the driver fastens the seat belt again and closes the driver's door, the ACC Stop & Go remains switched off. It can subsequently be reactivated by the driver.
3	Warning stage three is active As well as having undone the seat belt and opened the driver's door, the driver gets out. This is detected by the fact that the driver's seat is no longer occupied. The vehicle continues to move. In addition to the alerts inside the vehicle, the light module switches on the hazard warning flashers and the SZL sounds the horn repeatedly. Those alerts perceptible from outside the vehicle are intended to persuade the driver to get back in the car and secure it against rolling away.

In addition to the typical sequence described above, there are a number of other possible combinations of events that can trigger the individual warning stages.

Example: the driver undoes the seat belt and raises himself/herself from the seat. The driver's door is still closed.

Warning stage 2 is triggered. In this case too the vehicle will start to move because the ACC Stop & Go switches itself off!

Monitoring Functions

As is familiar from the Active Cruise Control on the E9x models, the LDM monitors the system complex to check that all constituent systems are operational, all input signals required for the function are present and correct and the control unit's own hardware is functioning properly.

That same concept has basically been adopted for the ACC Stop & Go system.

The new constituent systems have been incorporated into the monitoring concept.

Note: When troubleshooting it is important to include not only individual components but all systems involved in the extended system complex.

If a fault occurs, the function is completely shut down as with previous ACC systems. In addition, the driver is informed of the failure by an indication on the instrument cluster and a check control message. Reactivation is not possible until the fault has been eliminated.

Symbol displayed on fault related failure of Active Cruise Control with Stop & Go function

The failure message referred to above should not be confused with the message the driver receives when the system is deactivated due to the preconditions for operation ceasing to be met. Reactivation is possible once the preconditions for operation are satisfied again.

Symbol displayed on deactivation of ACC Stop & Go due to preconditions for operation ceasing to be met

In order to be able to offer the driver as wide a range of functions as possible for as long as possible, the following cases are given special treatment. Appropriate symbols and information in the check control message explain the circumstances to the driver in each case.

- If only the short-range radar sensors are sporadically non-operational, the ACC function is not shut down until the vehicle's speed drops below a threshold of approximately 20 mph. It is only at speeds below that threshold that the short-range radar sensors are indispensable for overall system function with the result that shutdown can be delayed until that point.
- If one or more radar sensors are sporadically unavailable, the ACC function is shut down but the driver can still switch to DCC mode so as to at least benefit from the assistance of that function.

This is option is particularly useful if the radar sensors are dirty or the vehicle is close to an astronomical radio telescope. This option is also possible if the radar sensors temporarily signal a fault status.

Adaptive Braking Assistance (ABA)

Adaptive Braking Assistance offers the greatest benefit in situations where the vehicle is following another vehicle. If the vehicle in front brakes hard, it is detected by the long-range radar sensor. The two sub-functions of:

- priming the braking system and
- lowering the threshold for the Hydraulic Braking Assistance function

assist the driver to perform the braking operation to best effect and thus in the best case to avoid a rear-end collision with the vehicle in front.

However, the Adaptive Braking Assistance technology also has limits and cannot react fast enough in situations such as other road users cutting in right in front of the vehicle.

Driving with care and anticipation remains the fundamental imperative even with Adaptive Braking Assistance!

All sensor-related and processing functions of Adaptive Braking Assistance are computed in the long-range radar sensor. However, the computed output variables have to be transmitted to the DSC control unit because that is where they are put into action.

Therefore, the LDM control unit acts as a gateway for that purpose from the S-CAN to the PT-CAN.

Note: Adaptive Braking Assistance is always active and does not have to be switched on separately by the driver.

Information from the Vehicle's External Environment

Detecting Objects

Adaptive Braking Assistance only takes account of objects detected by the long-range radar sensor. The short-range sensors would only increase the usable number of relevant objects by a very small margin. The reason for that is that Adaptive Braking Assistance is an anticipatory function that must be followed by a response on the part of the driver. The time thus required necessitates detection of an emergency braking situation as early as possible and, therefore, focussing primarily on objects that are relatively distant.

Pre-processing Object Data

The long-range radar sensor pre-processes the position and motion data of the objects detected more or less as it does for the ACC Stop & Go function. However, different parameters are used for filtering, for instance, in order to take account of the more dynamic nature of emergency braking situations.

Assessing Objects

Different assessment criteria are applied to the objects for the two constituent functions:

- For brake-system priming, only objects in the same lane as the vehicle are treated as relevant.
- For lowering the Hydraulic Braking Assistance threshold, objects in the same lane as the vehicle are treated as highly relevant but objects in adjacent lanes are also taken into account. Ultimately that means that the system is able to react more quickly if an object switches lanes from an adjacent lane to the same lane as the vehicle and in so doing precipitates an emergency braking situation.

In comparison with the ACC, there is a slightly longer confirmation period for the object situation with Adaptive Braking Assistance functions. The purpose of that is to reduce inappropriate reactions to detection errors.

Identifying and Reacting to Emergency Braking Situations

Criteria for an Emergency Braking Situation

Based on the motion data of the vehicle itself and the objects detected in the vehicle's external environment, a deceleration rate is calculated at which the driver would have to brake to avoid a collision (avoidance deceleration). That deceleration rate is compared with threshold levels that are stored in the memory of the long-range radar sensor, e.g. 3 m/s^2, 6m/s^2 and 8 m/s^2. If the computed deceleration rate is greater than one of those threshold levels, an output signal is sent to the Dynamic Stability Control to prime the braking system and/or lower the Hydraulic Braking Assistance response threshold.

Priming the Braking System

When the braking system is not primed, there is a small gap between the brake pads and the disc. This is intended and useful in uncritical situations for preventing noise and friction.

However, that gap means that when the brakes are applied, the pads have to complete a certain amount of free travel before they come onto contact with the discs. Only at the point where they come into contact with the discs does any retarding force come into play.

While that response characteristic is acceptable for normal braking operations, in an emergency braking situation it means losing valuable time/braking distance.

Note: When the braking system is primed, the brake pads are already in direct contact with the discs. Thus any degree of brake application results in an immediate braking effect.

DSC also attempts to detect situations in which brake priming is helpful. If the driver backs off the accelerator very abruptly, the DSC automatically activates the brake priming function.

However, this does have the disadvantage that no information about the road traffic situation in the vehicle's immediate environment goes into the decision to activate the function.

By incorporating the data supplied by the long-range radar sensor about the objects in front of the vehicle, brake system priming can be adapted much more effectively to the actual traffic situation. The result is that it can be activated much earlier on the basis of the radar sensor data, i.e. regardless of when and how quickly the driver takes his/her foot off the accelerator.

Brake system priming can only be switched on or off by the long-range radar sensor; other parameters (e.g. relating to the degree of priming) are controlled by the Dynamic Stability Control itself.

Priming is only maintained for a limited period from the point of activation. If the driver does not apply the brakes in that period, it is assumed the danger has passed and the braking system does not need to remain primed.

Even if brake priming were to be erroneously activated, there is no inconvenience to the driver whatsoever because the function does not produce any perceptible degree of deceleration.

Although the long-range radar sensor may request brake system priming by the DSC, it is the DSC that ultimately decides whether to implement the action.

Lowering the Threshold for the Hydraulic Braking Assistance Function

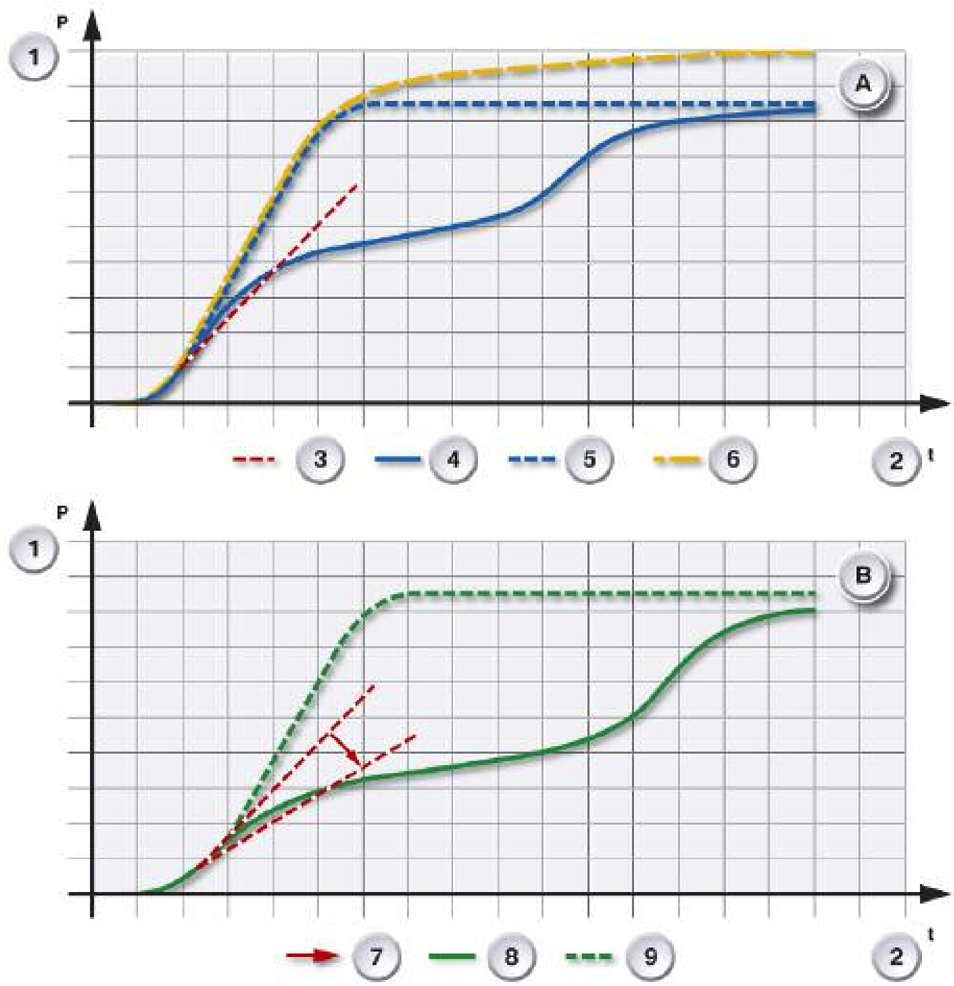
The Hydraulic Braking Assistance (HBA) function integrated in the DSC operates according to two basic response criteria. The driver must apply the brakes in such a way as to produce:

- a minimum brake system pressure and
- a minimum rate of brake system pressure increase.

The parameters are chosen so that, on the one hand, the HBA responds reliably in genuine emergency braking situations, but on the other, that inappropriate response is avoided.

Note: The new threshold lowering function only affects the second response criterion, the minimum rate of increase of brake system pressure.

If an emergency braking situation is detected, the response threshold is lowered in stages according to the calculated avoidance deceleration rate. The result is that the driver can trigger the HBA more easily, i.e. with a lower rate of brake system pressure increase.



Comparison of Response Thresholds for Hydraulic Braking Assistance (HBA)

Index	Explanation
A	Brake system pressure curves without threshold lowering
B	Brake system pressure curves with threshold lowering
1	Brake system pressure
2	Time
3	Standard threshold level (rate of increase of brake system pressure) above which the HBA is activated
4	Brake system pressure curve for a normal driver without HBA who brakes soon enough but not hard enough
5	Brake system pressure curve for a normal driver with HBA. Based on the rate of brake system pressure increase, the HBA detects that the driver intends to perform an emergency stop and with the aid of the DSC hydraulic pump increases the brake system pressure to a level that produces maximum braking effect
6	Brake system pressure curve for an experienced driver who brakes soon enough and hard enough in an emergency braking situation
7	Lowered threshold level (rate of increase of brake system pressure) above which the HBA is activated
8	Brake system pressure curve for a hesitantly braking driver who does not exceed the standard threshold for HBA activation. The HBA therefore does not respond even though the situation might be such that there is a risk of a collision. Thus valuable braking distance is lost because neither is the reaction fast enough nor is sufficient braking force developed.
9	Brake system pressure curve for a hesitantly braking driver. Even though the rate of brake system pressure increase is below the standard threshold, the HBA is still activated. The threshold level has been lowered because a potential collision situation has been detected on the basis of the data from the long-range radar sensor. As a result, even a hesitantly braking driver can trigger the HBA in an appropriate situation.

Whereas hesitantly braking drivers could not previously trigger the HBA, this function gives them the possibility of avoiding or at least reducing the severity of an accident in a potential collision situation with the aid of the HBA.

As threshold lowering only takes place if the long-range radar sensor actually detects a potential collision situation and, at the same time, the threshold for the minimum brake system pressure remains unchanged, inappropriate activation is avoided. If a driver should nevertheless inadvertently activate the HBA, the braking severity can be reduced by means of the familiar graduated response function. To do so, the driver merely has to reduce the amount of brake pedal travel.

HBA threshold lowering can not only be switched on or off by the long-range radar sensor, it can also be activated in degrees. Threshold lowering is only maintained for a certain period from the point of activation. If the driver does not apply the brakes in that period, it is assumed the danger has passed and the threshold can revert to normal.

Even though the long-range radar sensor may request threshold lowering, the DSC retains ultimate control over the decision to trigger the HBA.

Monitoring Functions

The monitoring concept for Adaptive Braking Assistance is shared between the following three areas.

1. Fault statuses in object detection and on the long-range sensor hardware are monitored by the sensor itself.
2. Communication faults on the S-CAN or PT-CAN are primarily monitored by the LDM control unit.
3. Faults on the DSC hydraulics or DSC electronic circuitry are monitored by the DSC itself.

Regardless of where a fault status is detected, the brake system priming and threshold lowering functions are not then carried out.

The fault status is recorded in the fault memory of the control unit that detects it.

Note: A message to the driver indicating failure of Adaptive Braking Assistance is not issued. The next time the car is taken for a service, the fault can be diagnosed and rectified by reading the fault memory.

Some faults result not only in the Adaptive Braking Assistance functions being unavailable but also the ACC Stop & Go function, for instance. A typical example of such a case is an electronic fault on the long-range radar sensor or the LDM control unit. In such circumstances the driver would be informed indirectly of the fault status by way of the ACC Stop & Go failure message.

System Components

Only the components that are either entirely new or the design and function of which has changed since previous applications are described at this point.

Those system components are:

- Long-range radar sensor
- Short-range radar sensors
- LDM control unit
- Sensor-CAN
- DSC control unit and hydraulic unit
- Sensor systems for detecting if the driver is about to get out of the car

Of course there are also changes to other system components such as the drivetrain or the instrument cluster in order to be able to implement the new longitudinal dynamics systems. However, they are not dealt with in this document.

Long-range Radar Sensor

Physical Differences

The long-range radar (LRR) sensor is outwardly identical with the familiar ACC II device supplied by Bosch. The ACC II device used previously on the E60 and other vehicles can be distinguished from the new ACC Stop & Go unit by means of the part number.

Index	Explanation
1	Position of screw for vertical adjustment
2	Position of fixed mounting
3	Position of screw for horizontal adjustment

Compared with the sensor previously used on the E60/E61, the positions of the adjusting screws and the fixed mounting screw have changed, see illustration.

Note: The adjustment procedure for the long-range radar sensor is unchanged. The diagnosis system takes account of the fact that the positions of the screws have changed and gives the correct instructions.

As the fixed mounting screw remains inaccessible from the outside as with the previous unit, the possibility of adjustment errors can be virtually excluded.

Electrical Differences

The long-range radar sensor on the E60/E61 LCI is no longer connected to the PT-CAN. Instead it is now connected to the new Sensor-CAN. Nevertheless, it can still be accessed via the diagnosis system as before because the LDM control unit relays diagnosis communication to and from the long-range radar sensor.

The power supply and connection to the wake-up lead are unchanged from the familiar arrangement.

Note: A terminal resistor for the S-CAN is accommodated in the long-range radar sensor.
LRR sensor and LDM control unit are supplied by the CAS control unit using a separate wake-up lead that is electrically isolated from the normal wake-up lead. This arrangement was chosen because the long-range radar sensor is fitted in an accident prone area (front end of vehicle).

If the wake-up lead of the LRR sensor were damaged in an accident (e.g. causing a short to earth), this arrangement limits the consequences for other control units.

See also system circuit diagram in the System overview section.

An additional wiring harness which carries the power supply and the Sensor-CAN both the to the long-range radar sensor and the short-range radar sensors has been added between the vehicle wiring harness and the long-range radar sensor.

If no short-range radar sensors are fitted (e.g. in Japan due to lack of radio transmissions approval), the additional wiring harness is missing and the long-range radar sensor is connected directly to the vehicle wiring harness. Even where in such cases the Stop & Go function is not available and the familiar Active Cruise Control is used instead, the architecture using long-range radar sensor and LDM control unit remains the same.

Modified Range of Functions

The ACC II units used up to now on BMW vehicles perform both sensor and control functions. In the ACC Stop & Go system complex by contrast, the long-range radar sensor now primarily performs only sensor functions, i.e. it detects vehicles ahead, measures their distance and motion variables and pre-processes that data. Subsequent processing and control functions are performed by the LDM control unit.

Accordingly, the data interface between the long-range radar sensor and the LDM control unit consists of a list of the objects detected and the associated data relating to their position and motion status.

New functions that have been added are the assessment of objects and computation of the activation criteria for the Adaptive Braking Assistance functions. The long-range radar sensor issues request signals to the LDM control unit. They are transmitted via the SCAN and indicate whether brake system priming and/or HBA threshold lowering are to be activated.

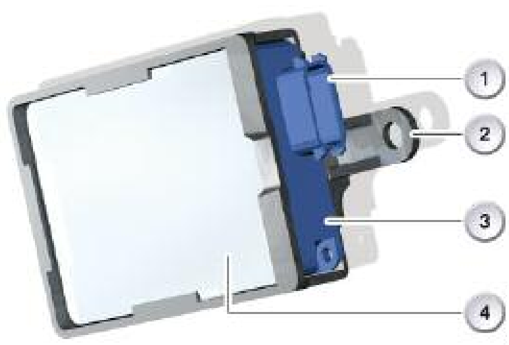
The algorithm integrated in the long-range radar sensor for detecting maladjustment has been optimized to the extent that it continues to be computed even if the maladjustment cut-off threshold has been exceeded. Thus if the algorithm has at any time erroneously initiated a shutdown (e.g. due to the lens being partially obscured), it can still "relearn" the correct setting afterwards.

Short-range Radar Sensors

Principle of Operation

The fundamental measurement method of the short-range radar sensors is significantly different from that of the long-range radar sensor, as the table below illustrates.

Characteristic	Long-range Radar Sensor	Short-range Radar Sensors
Modulation method	FMCW - (frequency modulated continuous wave)	PD - (pulse doubler)
Mid-range transmission frequency	76.5 GHz	24 GHz
Distance measurement	Based on frequency deviation	Based on pulse propagation time
Measurement of relative speed	Based on frequency shift - (Doppler effect)	Based on phase difference measurement (Doppler effect)
Angle measurement	Ratio calculation based on ampli-tudes of the radar lobes	Ratio calculation based on two measured variables (sum and differential signals)
Transmission power	< 5 mW (average) 10 mW - (maximum)	approximately 0.08 mW (average) approximately 100 mW (single pulse)



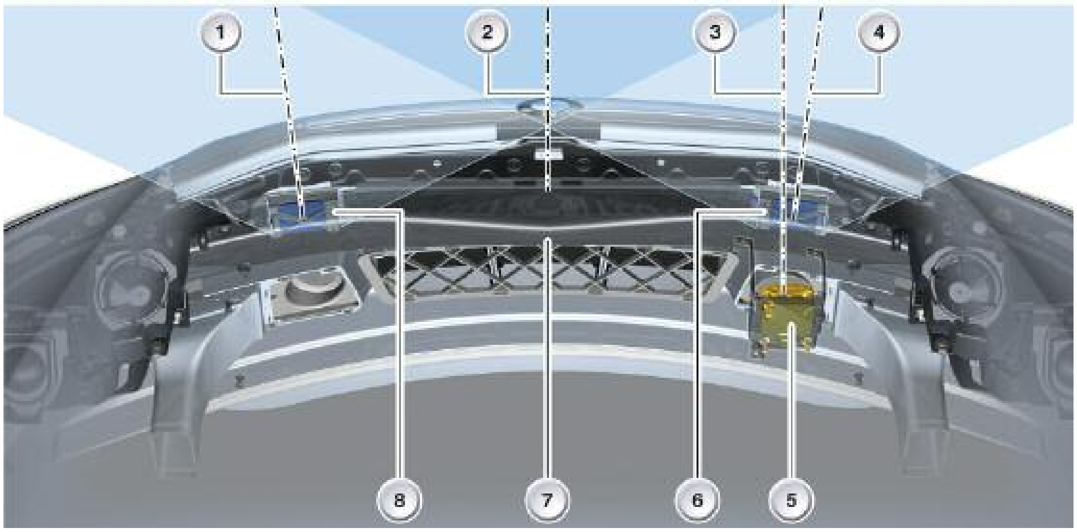
Index	Explanation
1	Connector
2	Plastic bracket
3	Plastic sensor casing
4	Aerial cover

Short-range Radar Sensor for ACC Stop & Go

Note: If short-range radar sensors are replaced, it is important to ensure that the connector faces towards the vehicle.

Fitting of Short-range Radar Sensors

Two identical short-range radar sensors are fitted for the ACC Stop & Go function. They are mounted on the front bumper crossmember by means of an additional plastic bracket.



Fitted Location of Radar Sensors for ACC Stop & Go, Rear Overhead View

Index	Explanation
1	Center axis of left short-range radar sensor
2	Vehicle x-axis
3	Center axis of long-range radar sensor
4	Center axis of right short-range radar sensor
5	Long-range radar sensor and bracket
6	Right short-range radar sensor with bracket
7	Bumper cross-member
8	Left short-range radar sensor with bracket

The center axes of the short-range radar sensors (1 and 4) are angled outwards relative to the vehicle's x-axis (2).

Two different versions of the front bumper trim are fitted depending on whether or not the vehicle has the M aerodynamics package. This affects the fitting location of the short-range radar sensors and the angle at which their center axis points outwards.

That means that a vehicle cannot simply converted to the M aerodynamics package (or vice versa) without additional adjustments.

The following additional operations are required and are described in detail in the Repair Instructions:

- Replacement of black impact absorbers, which have a special cut-out for the short-range radar sensors (to match new bumper trim)
- Replacement of brackets for short-range radar sensors (different fitting location requires different bracket design)
- Coding the vehicle, and specifically the LDM control unit, to take account of the new equipment configuration with/without M aerodynamics package
- Commissioning the LDM control unit and short-range radar sensors using the diagnosis system. In the process, the new fitted position is recorded in the memory.

In contrast with the long-range radar sensor, the aerials and lenses of the short-range radar sensors are flat.

Functions of the Short-range Radar Sensors in the System Complex

Like the long-range radar sensor, the primary function of the short-range radar sensors is to detect objects in front of the vehicle and compute their position and motion data.

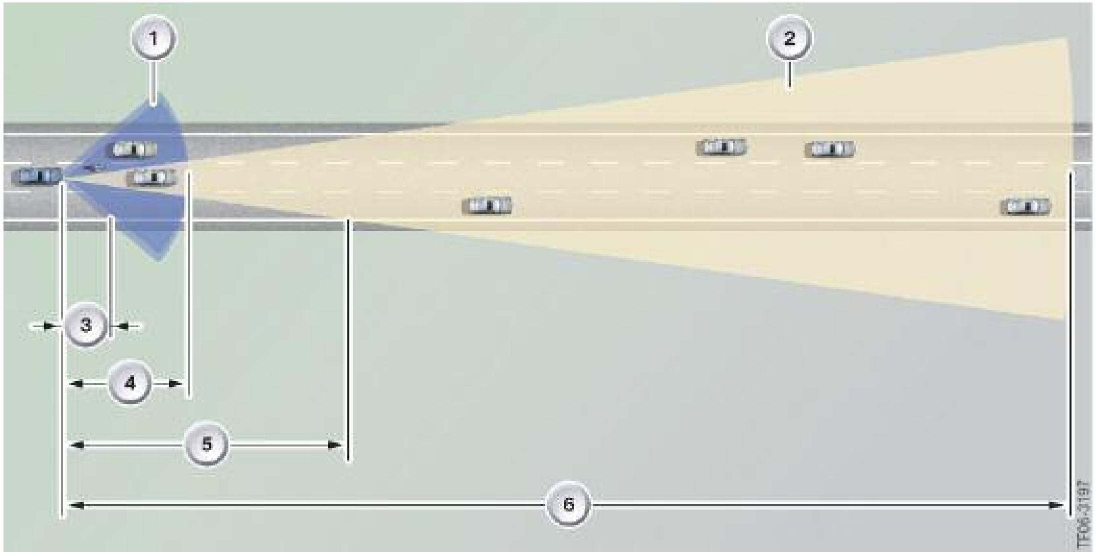
The object data from the short-range radar sensors is used only for the ACC Stop & Go function and not for the Adaptive Braking Assistance functions.

The short-range radar sensors have a significantly different detection range than the long-range radar sensor.

Characteristic	Explanation	Short Range Radar
Range	At least 120 m, up to 150 m	At least 10 m, up to 20 m
Horizontal angular width of beam	+/-8°	+/-40°
Vertical angular width of beam	Approximately 4°	Approximately 20°

The figures quoted for range vary according to the type of object being detected. A pedestrian, for instance, can not be detected as far away as a car. They reflect the radar beam to differing degrees.

The illustration below shows clearly why the large horizontal beam width is required by the short-range radar sensors. In the area directly in front of the vehicle, the detection range of the long-range radar sensor is a long way short of covering the width of the car let alone the width of the lane. However, precisely that is what is required in order to be able to stop reliably behind cars driving off-center or motorcycles.



Scale drawing of detection ranges of the radar sensors used for ACC Stop & Go

Index	Explanation
1	Detection range of short-range radar sensors
2	Detection range of long-range radar sensor
3	Distance from which short-range radar sensors detect objects across full width of three lanes (approximately 4.5 m)
4	Range of short-range radar sensors (here assumed to be 15 m)
5	Distance from which long-range radar sensor detects objects across full width of three lanes (approximately 40 m)
6	Range of long-range radar sensor (here assumed to be 120 m)

Electrical Integration in the Vehicle

The short-range radar sensors are supplied with power from Terminal 30g. They are not connected to the wake-up line. Instead, they are woken by the LDM control unit by means of appropriate messages on the S-CAN. The two short-range radar sensors also use the S-CAN to each supply a list of object data to the LDM control unit.

In the wiring loom, pin no. 5 is applied to earth for the left sensor and pin no. 6 for the right sensor. The other pin in each case is left unconnected. In that way the identical right and left sensors can identify which side of the vehicle they are fitted on and take it into account when computing the object data.

Note: The short-range radar sensors are intelligent sensors which monitor their own operational capability. They record any fault statuses that may arise, although they cannot be accessed directly by the diagnosis system for diagnosis/programming. Instead, the LDM control unit copies the details of faults reported by the short-range radar sensors to its own fault memory.

Self-diagnosis and Types of Fault

In the cases listed below, short-range radar sensor monitoring functions respond because reliable function is no longer possible. This results in shutdown of the ACC Stop & Go function.

As the problems in such cases are not always genuine faults that necessitate repair action, they are described briefly at this point.

Dirty Short-range Radar Sensors

The short-range radar sensors cannot reliably detect objects if there is a layer of snow, slush or ice over their aerials. Neither their aerial covers nor the bumper trim are heated.

Therefore, there are situations in which the heated lens of the long-range radar sensor is clear but the areas around the short-range radar sensors are covered in snow.

Index	Explanation
1	Area of bumper trim in front of the short-range radar sensors completely covered in snow
2	Lens of long-range radar sensor only partially snow-covered due to heating

In order to maintain the greatest possible availability of the ACC Stop & Go function, detection of dirt on the short-range radar sensors does not necessarily immediately result in shutdown. Only if the vehicle is travelling at a low speed (slower than approximately 30 kph) at that point is shutdown immediate.

At substantially higher road speeds, the function is maintained on the basis of the data from the long-range radar sensor.

Shutdown due to dirty short-range radar sensors is indicated to the driver by a notification in the check control message issued at the same time.

Note: No fault memory entry is recorded for dirty short-range radar sensors.

External Interference Affecting Radar Signal Analysis

Other automobile manufacturers also use radar sensors for driver assistance functions.

The radar signals emitted by those sensors can interfere with the signal analysis by the short-range radar sensors.

If such a problem is detected, the ACC Stop & Go is deactivated. It can be switched on again by the driver as soon as the vehicle is far enough away from the vehicle causing the interference.

Note: Such instances of interference are recorded in the fault memory that can be read from the LDM control unit by the diagnosis system. However, there is no repair action that can be taken. Instead, the customer should be informed of the cause of the fault (external interference).

Temporary Faults

The following events can cause temporary faults on the short-range radar sensors that are summarized under a single fault memory entry:

- Communication fault on S-CAN
- Power supply voltage too high or too low
- Temperature of short-range radar sensors too high

The procedure according to the diagnosis system testing sequence should be followed.

When doing so, the connectors on the short-range radar sensors and the wiring loom should be checked in particular.

Control Unit Faults

If there is a control unit fault on one of the short-range radar sensors, it can be rectified by replacing the defective sensor.

After fitting the new short-range radar sensor, the commissioning sequence as specified by the diagnosis system must be completed.

This resets some adapted settings in the LDM control unit memory that apply to the sensor that has been replaced.

Sensor Out of Adjustment

As with the long-range radar sensor, the short-range radar sensors in conjunction with the LDM control unit can detect maladjustment resulting from an accident. If the calculated degree of maladjustment exceeds a certain limit, the ACC Stop & Go function is shut down.

An entry in the fault memory indicates the cause of the fault. To rectify the fault, the procedure described in the next section must be followed.

Adjustment and Repair

Adjustment of the short-range radar sensors during production or in the course of servicing is not provided for. It can be dispensed with for the following reasons:

- The horizontal fitting tolerance for the short-range radar sensors is considerably greater than for the long-range radar sensor. It is +/-2° (compared with 0.25° for the long-range radar sensor).
- The accuracy of fit of the bumper crossmember is sufficient for the sensors to be within the required fitting tolerance.
- The short-range radar sensors and LDM control unit have a correction algorithm that detects maladjustment of the sensors and compensates appropriately. Due to the wide horizontal detection range of the short-range radar sensors, there is a greater possible degree of compensation for imprecise adjustment than with the long-range radar sensor.

Accident

If a vehicle with ACC Stop & Go suffers accident damage to the front end, it is entirely possible that the permissible fitting tolerance will be exceeded. The scenarios and associated repair actions set out below should be distinguished.

1. Scenario: there is no visible damage, the customer makes no mention of an accident.
   Possible cause is that on the production line or in the course of previous repairs, the commissioning sequence was not correctly carried out.

   Action: carry out the commissioning sequence for the short-range radar sensors again using the diagnosis system. In the process, the correct fitted position is recorded in the memory and the maladjustment figure reset.

2. Scenario: bumper trim is scratched and/or marginally misshapen (visible dent).

   Action: The area of the trim in front of the short-range radar sensors must not be painted more than twice.
   Nor must dents be repaired by applying additional plastic material in that area. Instead, the trim must be removed and the short-range radar sensors behind it checked for damage.
   If the dent is directly in front of the short-range radar sensor, impairment of function must be expected. If the customer complains of problems, the bumper trim should be replaced.

3. Scenario: bumper trim or entire vehicle front end is clearly out of shape.

   Action: the bumper trim must be removed and replaced if there is visible damage directly in front of the short-range radar sensors.
   In addition, the bumper cross-member should be checked for damage. If it is more than approx. 5 mm out of position, the bumper cross-member must also be replaced. In that case, it is advisable to check the engine sub-frame members for damage as well. Repair of the engine sub-frame may then also be necessary. Only in that way can the correct position of the bumper cross-member and, therefore, of the short-range radar sensors be reinstated.

The repair measures have only been briefly summarized at this point and are described in detail in the Repair Instructions.

After any of the work described here that may involve the alignment of the short-range radar sensors, the commissioning sequence must be carried out using the diagnosis system.

Note: Care must be taken in the course of any repair work that the bumper trim is refitted correctly. No force should be applied as otherwise the intended design clearance between trim and short-range radar sensor casings will not be guaranteed.

If the vehicle concerned is fitted with PDC, the electrical wiring to the ultrasonic sensors must be refitted correctly. On no account must the wires be left hanging loose in front of the aerial cover of a short-range radar sensor because otherwise the sensor function could be severely impaired.

LDM Control Unit

Design and Electrical Characteristics

Like the radar sensors, the LDM control unit is only fitted on the vehicle if it is ordered with the option Active Cruise Control with Stop & Go function.

An LDM control unit was previously introduced on E9x models. The same basic concept has been adopted for the ACC Stop & Go function. As before, it contains two micro-processors with different primary tasks:

- functional tasks
- safety monitoring functions.

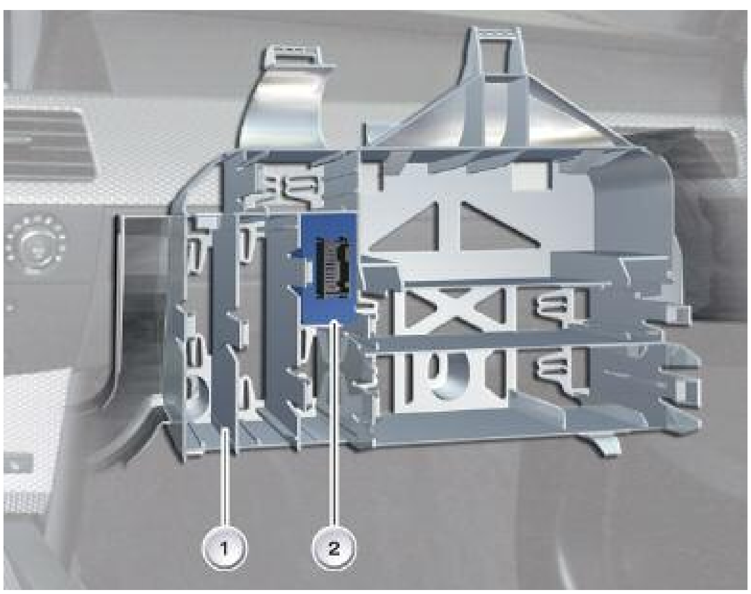
The processing and memory capacity of the processors has been increased in order to be able to implement the more extensive functionality.

As on E9x models, the new LDM control unit for the E60/E61 LCI contains only control electronics and no sensors or power electronics. All input signals from sensors are received via the PT-CAN and S-CAN bus systems. The LDM controls all actuators via the PT-CAN.

Note: The LDM control unit contains one of the terminal resistors for the S-CAN.

Location

The LDM control unit is on the equipment mounting bracket near to the glove box.



Index	Explanation
1	Glove box equipment mounting bracket
2	LDM control unit

Location of LDM Control Unit on E60/E61 LCI

Functions within System Complex

The LDM control unit represents the central processing unit for the ACC Stop & Go function and performs the following constituent functions:

- Merging of object data supplied by the radar sensors
- Assessment of objects detected and selection of the relevant object for gap modulation
- Analysis of driver control signals and generation of display signals
- Control of speed and distance from the vehicle in front
- Generation and output of the required settings to the power transmission and braking system actuators via the PT-CAN
- Monitoring of all input signals, its own control unit hardware and vehicle behavior for faults or implausible conditions

For the Adaptive Braking Assistance functions, the LDM control unit acts primarily as a gateway.

- The signals from the long-range radar sensor are transferred from the S-CAN to the PT-CAN. Those are the signals that the long-range radar sensor produces in order to activate the brake system priming and HBA threshold lowering functions.
- The DSC indicates by means of signals on the PT-CAN that it is operational and supplies signals that describe the motion status of the vehicle. The LDM control unit transfers those signals from the PT-CAN to the S-CAN so that they can be received from there by the long-range radar sensor.

Note: The gateway function on the part of the LDM control unit is also required to be able to access the long-range radar sensor using the diagnosis system.

Behavior in the Event of Faults

The LDM control unit responds differently according to the type of monitoring function triggered by the fault. This also has consequences in terms of the fault memory entries and troubleshooting, which is why a brief description is given here.

- Short-range radar sensor faults are recorded in the LDM control unit memory because the short-range radar sensors are not accessible by the diagnosis system.
- Long-range radar sensor faults are stored in the sensor's own fault memory. The LDM control unit records a fault that refers to the long-range radar sensor.
- The LDM always records fault memory entries referring to other control units if the LDM itself is not the cause of the fault. An implausible input signal or another control unit not being operational are possible causes of that type of fault memory entry.
  In such cases, the testing sequences applicable to the fault memory entries on the control units to which the LDM refers should be followed.
  Replacing the LDM control unit will by no means cure a fault of this type.
- Most monitoring functions on the LDM operate in such a way that the function and system complex are shut down normally in the event of a fault. The associated fault cause is then also recorded in the LDM control unit's fault memory.
- There is an exceptional case in which normal shutdown can not be carried out: if the microprocessor that performs the safety monitoring functions has to disconnect the LDM control unit from the PT-CAN. This only happens if no other shutdown action is effective and at the same time an irregular LDM output is detected on the PT-CAN. In that case, all of the LDM's associated control units (e.g. DME, DSC and instrument cluster) register a communication fault with the LDM.

Troubleshooting should always proceed according to the diagnosis-system testing sequences. If the LDM control unit has to be replaced, the replacement unit fitted must be:

- coded
- commissioned

This allows for such tasks as entering the fitted positions of the short-range radar sensors in the memory and resetting the adaptation settings to their initial values.

Sensor-CAN

The new Sensor-CAN (S-CAN for short) connects:

- the LDM control unit
- the long-range radar sensor
- and the short-range radar sensors.

The introduction of this new bus system was necessary in order to be able to transmit the large volumes of data from the radar sensors to the LDM control unit. The volume of data is so great because the radar sensors send extensive lists of data about the objects detected to the LDM control unit. That amount of data would have exceeded the available capacity on the existing bus systems.

The electrical characteristics are largely the same as the PT-CAN and feature:

- Data transmission rate of 500 kBit/s
- Two-core cable
- Two terminal resistors of 120 Ω each (in long-range radar sensor and LDM control unit)
- Separate wake-up line for long-range radar sensor and LDM control unit (electrically isolated from wake-up line used for the other control units).

DSC Control Unit and Hydraulic Unit

On vehicles with ACC Stop &Go, the DSC unit performs the function of:

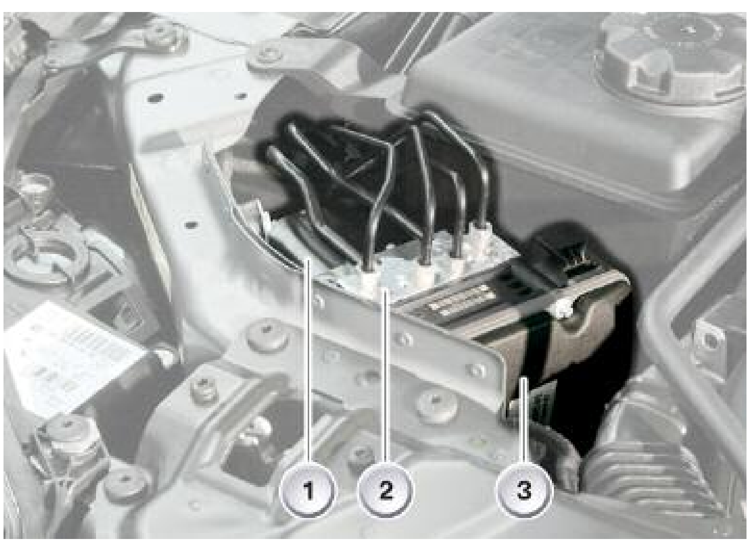
- an actuator (execution of braking requests from LDM and Adaptive Braking Assistance) and
- a signal supplier (supplying information about the motion status of the vehicle).

On vehicles with DCC, the DSC control unit also performs the task of computing the DCC control algorithms.

On the E60/E61 LCI, the DSC unit technology has been taken over from the E70. That technology was the fundamental prerequisite for the ability to implement the ACC Stop & Go function at all. It is only with that technology that it is possible to:

- very sensitively,
- dynamically and
- quietly increase brake system pressure as is required for ACC Stop & Go.

The DSC unit is located in the engine compartment on the right at the front between the right headlight and the coolant expansion tank - see illustration below.



Index	Explanation
1	Electrically operated hydraulic pump
2	Valve block
3	DSC control unit

DSC unit on E60/E61 LCI

Driver’s Seat Status Sensor

In order that ACC Stop & Go can issue a warning if the driver is about to get out of the car, the following sensor signals are used:

- Door switch, driver's door
- Belt buckle switch, driver's seat
- Seat occupancy detector, driver's seat

They are made available to the LDM control unit on the PT-CAN. The transmitting control units are:

- Body Gateway Module (KGM) for the door switch signal
- Crash Safety Module (ACSM) for the belt buckle switch and seat occupancy detector signals. These signals have to be transferred from the K-CAN to the PT-CAN by the KGM.

The door-switch and belt-buckle switch signals were already available on the vehicle before the introduction of ACC Stop & Go.

The seat occupancy detector in the driver's seat was introduced on the E60/E61 LCI for ACC Stop & Go.

These three signals have thus been used firstly to be able to warn the driver as soon as possible, and secondly to increase the reliability of the warning. None of the signals on their own would have been able to provide the reliability demanded.

Service Information

Important!!! Points for Servicing and Repairs

Cruise Control with Braking Function

- Vehicles with the option "Cruise control with braking function" do not have an LDM control unit. The function is integrated entirely in the DSC control unit.

Active Cruise Control with Stop & Go Function

- ACC Stop & Go and Adaptive Braking Assistance are highly integrated functions. In the event of customer complaints, reports of failure or initially unexplained function Behavior, the fault memories of the LDM and long-range radar sensor should be checked first and the programmed testing sequences followed if necessary.

  If that does not identify the problem, all control units and sensors involved in the system complex must be manually checked. A precise examination of the PT-CAN, S-CAN and K-CAN bus systems is particularly advisable in the event of signal or communication faults.
- If the brakes are noticeably applied in order to achieve the desired vehicle deceleration rate, the vehicle's brake lights are also switched on (legal requirement). The brake lights are also switched on when the ACC Stop & Go brings the car to a stop.
- The driver can also set the desired speed and desired gap while the vehicle is being held stationary by the ACC Stop & Go. However, the new settings do not take effect until the vehicle is moving.
- In order that stopping and moving off are performed smoothly and without the vehicle rolling backwards, the power and brakes are applied gradually and simultaneously. Such system Behavior is intended absolutely comparable with that of the driver when performing a hill start using the hand brake and the accelerator.
- Requiring acknowledgement ensures that the driver is paying attention to the traffic situation again after an extended stationary period. Because even though the Active Cruise Control has been extended by the Stop & Go function, the driver remains responsible for driving the vehicle and making appropriate use of the assistance functions available.
- To prevent the car slowing down inappropriately, for instance for road signs, ACC and ACC Stop & Go never respond to stationary objects. In other words, it does not even slow the vehicle down if it is approaching the end of a stationary queue of traffic at high speed.
- When the ACC Stop & Go is operating in DCC mode there is no gap modulation function whatsoever and no instruction to take over control is issued!

- ACC Stop & Go is not a system for permanently stopping or parking the car. The driver is responsible for securing the vehicle against rolling away before leaving it. The parking brake and the automatic transmission Park setting are the means provided for that purpose.

Adaptive Braking Assistance

- Adaptive Braking Assistance is always active and does not have to be switched on separately by the driver.
- Adaptive Braking Assistance never initiates an emergency stop of its own accord. With the aid of information from the long-range radar sensor it detects situations in which emergency braking is necessary. In such cases, it then assists the driver when he/she applies the brakes.
- A message to the driver indicating failure of Adaptive Braking Assistance is not issued.

  The next time the car is taken for a service, the fault can be diagnosed and rectified by reading the fault memory.

Long-range Radar Sensor

- The location of the long-range sensor for the ACC Stop & Go is identical to that of the sensor for the familiar ACC system.
- A terminal resistor for the S-CAN is accommodated in the long-range radar sensor.
- The adjustment procedure for the long-range radar sensor is unchanged. The diagnosis system takes account of the fact that the positions of the screws have changed and gives the correct instructions.

Short-range Radar Sensor

- The short-range sensors are fitted behind the front bumper trim on the bumper crossmember. Therefore, they are not visible from the outside unless the bumper trim is removed.
- If short-range radar sensors are replaced, it is important to ensure that the connector faces towards the vehicle.
- The short-range radar sensors are intelligent sensors which monitor their own operational capability. They record any fault statuses that may arise, although they cannot be accessed directly by the diagnosis system. Instead, the LDM control unit copies the details of faults reported by the short-range radar sensors to its own fault memory.
- The short-range radar sensors cannot be programmed either.
- No fault memory entry is recorded for dirty short-range radar sensors.

- Interference from radar sensors on other cars affecting the short-range radar sensors is recorded as a fault in the fault memory.

  However, there is no repair action that can be taken. Instead, the customer should be informed of the cause of the fault (external interference).

- If a vehicle with ACC Stop & Go suffers accident damage to the front end, it is entirely possible that the permissible fitting tolerance will be exceeded. The scenarios and associated repair actions set out below should be distinguished.

  - Scenario: there is no visible damage, the customer makes no mention of an accident. Possible cause is that on the production line or in the course of previous repairs, the commissioning sequence was not correctly carried out.
    Action: carry out the commissioning sequence for the short-range radar sensors again using the diagnosis system. In the process, the correct fitted position is recorded in the memory and the maladjustment figure reset.

  - Scenario: bumper trim is scratched and/or marginally misshapen (visible dent).
    Action: The area of the trim in front of the short-range radar sensors must not be painted more than twice. Nor must dents be repaired by applying additional plastic material in that area. Instead, the trim must be removed and the short-range radar sensors behind it checked for damage.
    If the dent is directly in front of the short-range radar sensor, impairment of function must be expected. If the customer complains of problems, the bumper trim should be replaced.

  - Scenario: bumper trim or entire vehicle front end is clearly out of shape.
    Action: the bumper trim must be removed and replaced if there is visible damage directly in front of the short-range radar sensors. In addition, the bumper cross-member should be checked for damage. If it is more than approx. 5 mm out of position, the bumper cross-member must also be replaced. In that case, it is advisable to check the engine sub-frame members for damage as well. Repair of the engine sub-frame may then also be necessary. Only in that way can the correct position of the bumper cross-member and, therefore, of the short-range radar sensors be reinstated.

- Care must be taken in the course of any repair work that the bumper trim is refitted correctly. No force should be applied as otherwise the intended design clearance between trim and short-range radar sensor casings will not be guaranteed.

- If the vehicle concerned is fitted with PDC, the electrical wiring to the ultrasonic sensors must be refitted correctly. On no account must the wires be left hanging loose in front of the aerial cover of a short-range radar sensor because otherwise the sensor function could be severely impaired.

LDM Control Unit

The LDM control unit contains one of the terminal resistors for the S-CAN.

The gateway function on the part of the LDM control unit is also required to be able to access the long-range radar sensor using the diagnosis system.