289

Service.

Adaptive cruise control in the Audi A8 Design and operation

Self Study Programme 289

For internal use only

Adaptive cruise control is a new system designed to assist drivers and offers a much wider range of functions than the conventional Tempomat.

Driver convenience is considerably enhanced, as fewer accelerator and brake pedal operations are required. Speed restrictions and safe distances are reliably observed and the flow of traffic thus better regulated.

Contents

The Self Study Programme contains information on design features and functions.

The Self Study Programme is not intended as a Workshop Manual. Values given are only intended to help explain the subject matter and relate to the software version applicable when the SSP was compiled.

Use should always be made of the latest technical publications when performing maintenance and repair work.

New!

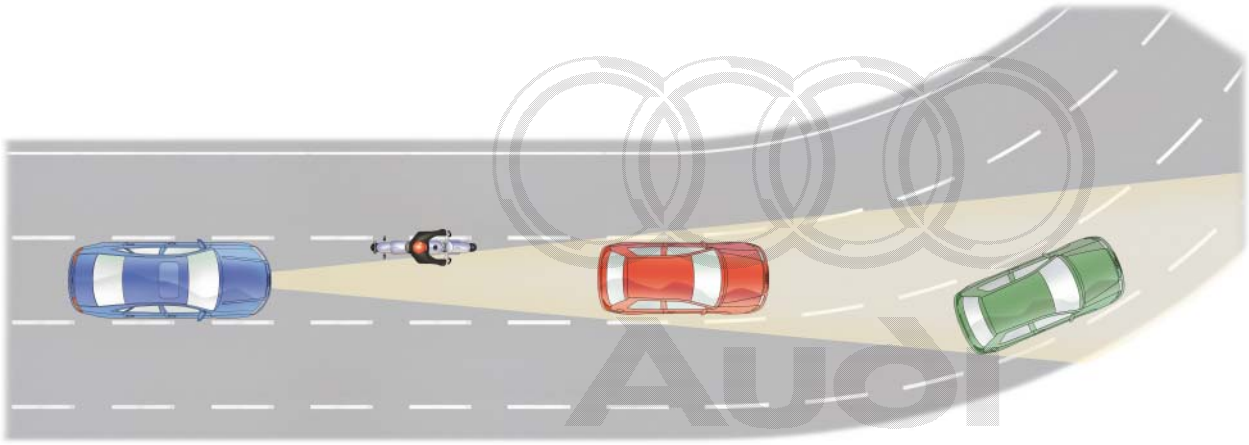
Attention! Note!

Introduction

Summary of adaptive cruise control

The basic adaptive cruise control function is to maintain a driver-selectable distance from the vehicle in front.
Adaptive cruise control thus represents the logical next step on from the original cruise control system.
The distance from and speed of the vehicle in front are determined by a radar sensor. If the distance is greater than desired, the vehicle is accelerated until the required speed input by the driver is achieved.

If the distance is less than desired, the vehicle is decelerated by reducing power, changing gear and if necessary applying the brakes. In the interests of ride comfort, maximum possible braking is restricted to approx. 25 % of the maximum deceleration potential of the brake system (full braking).
The control action is designed to assist the driver and thus indirectly contributes to greater road safety.
In certain traffic situations, active braking by the driver may still be necessary.



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Limits of adaptive cruise control system

– Adaptive cruise control is designed to assist the driver and is not a safety system. It is not a fully autonomous driving system.

– Adaptive cruise control provides regulation in a speed range of 30-200 km/h.

– Adaptive cruise control does not react to stationary objects.

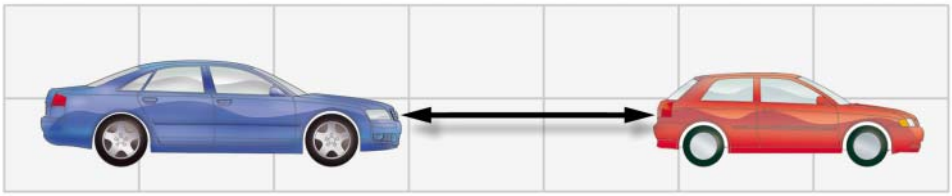
– Radar operation is impaired by rain, spray and slush.

– Tight bends may restrict operation on account of the limited radar detection range.

Requirements for adaptive cruise control operation

The following essential information is required for control purposes:

Distance from vehicle in front



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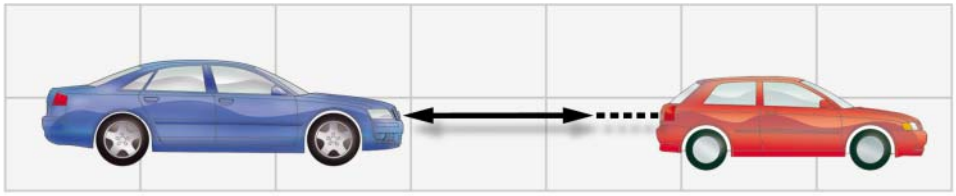
Speed of vehicle in front



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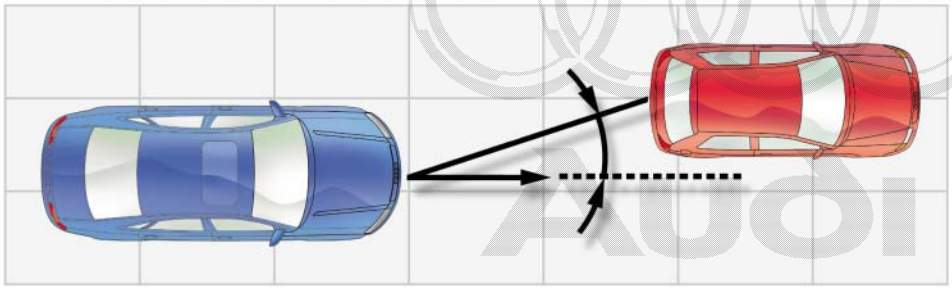
Position of vehicle in front



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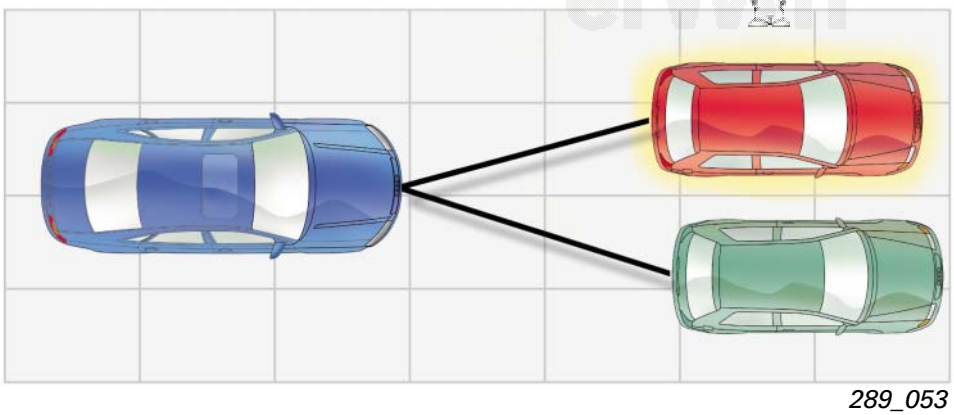
If there are several vehicles within the radar detection range at the same time, the above information is used to select the vehicle to which control is to be related.



289_053

Introduction

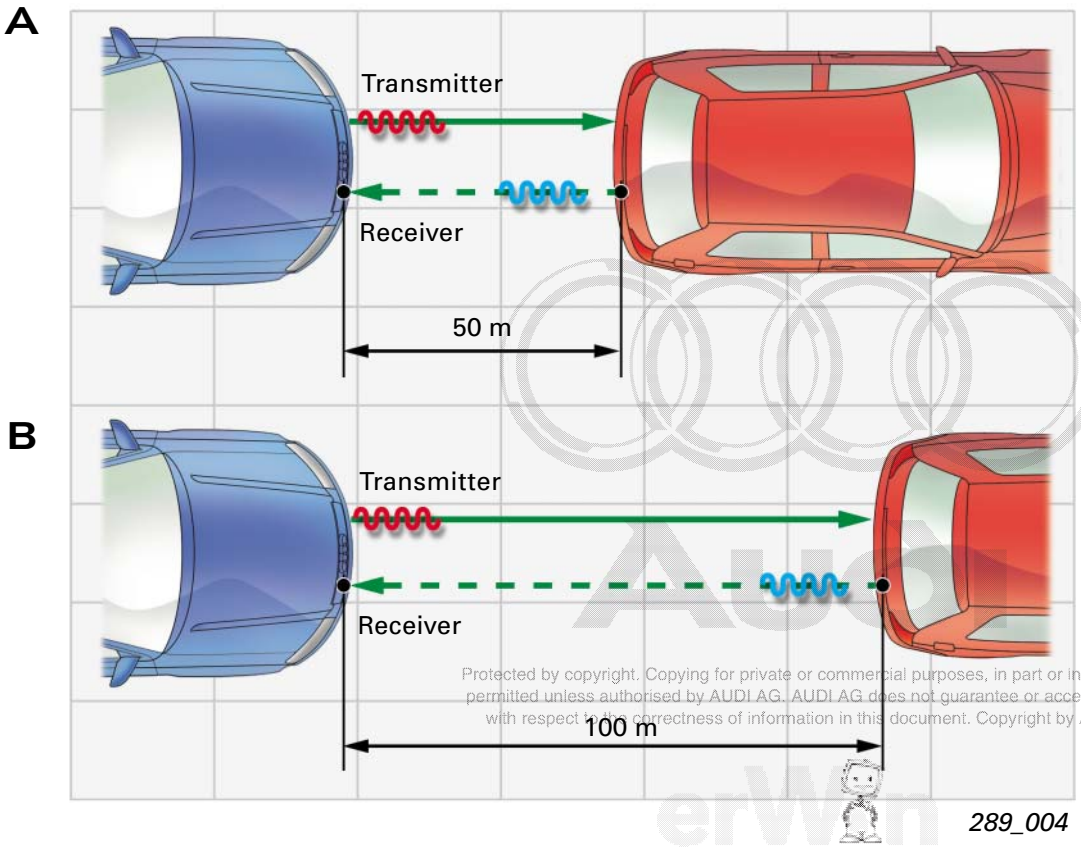
Radar basic principles

The designation **Ra**dio **d**etection **a**nd **r**anging (Radar) refers to an electronic system developed to establish the position of a given object.

It is based on a simple principle: Electromagnetic waves are reflected by the surfaces of objects.
The waves returning are detected as an "echo".

Distance measurement

The time between signal transmission and reception of the reflected signal components is governed by the distance from the object concerned.

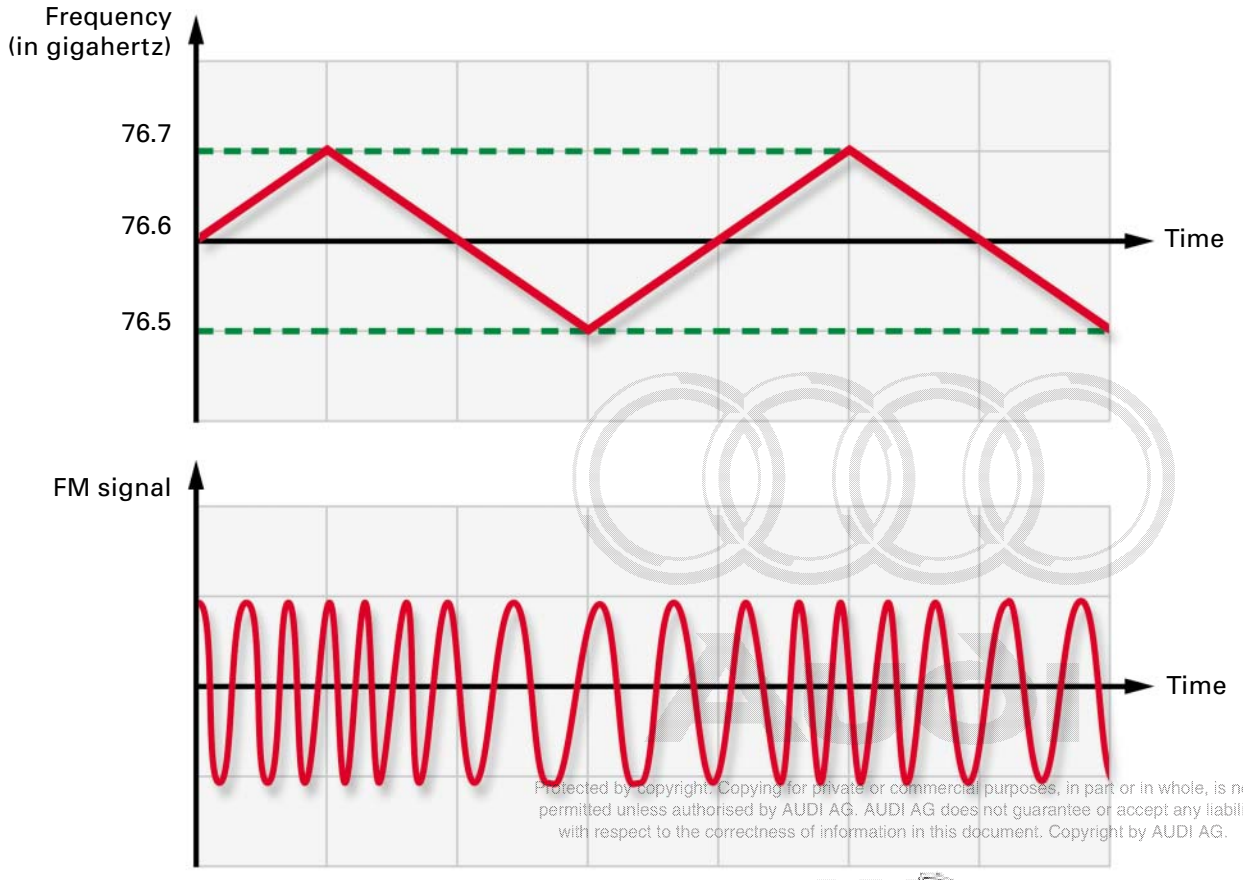


Relationship between signal propagation time and distance between transmitter/receiver and object

Example: The distance in case B is twice that of case A.
The time required for the reflected signal to reach the receiver is twice as long in case B as in case A.

Direct propagation time measurement is extremely complicated. Use is therefore made of indirect propagation time measurement in the form of an FMCW (**F**requency **M**odulated **C**ontinuous **W**ave) process, in which continuously emitted extra high frequency oscillations with time-variable frequency are employed as transmission signal. The frequency variation (modulation) rate is 200 megahertz within one millisecond.

The transfer medium for this is a carrier signal with a frequency of 76.5 gigahertz. This method makes it possible to avoid employing complicated direct propagation time measurement and instead to evaluate the differences in frequency between transmitted and received (reflected) signal, which are easier to determine.

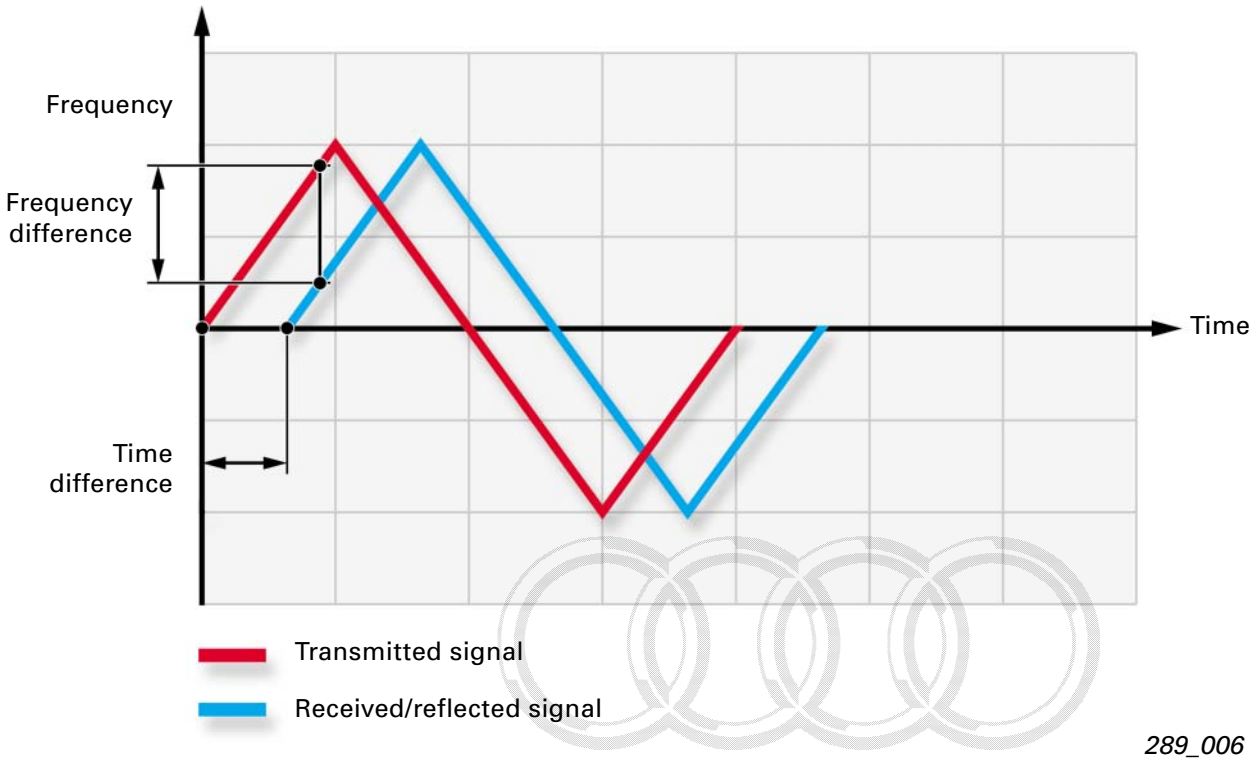


289_005

Introduction

The difference between the frequencies of the transmitted and received (reflected) signal is governed directly by the distance from the object.

The greater the distance, the longer the propagation time until the reflected signal is received again and the greater the difference between transmitted and received frequency.



289_006

Determining speed of vehicle in front

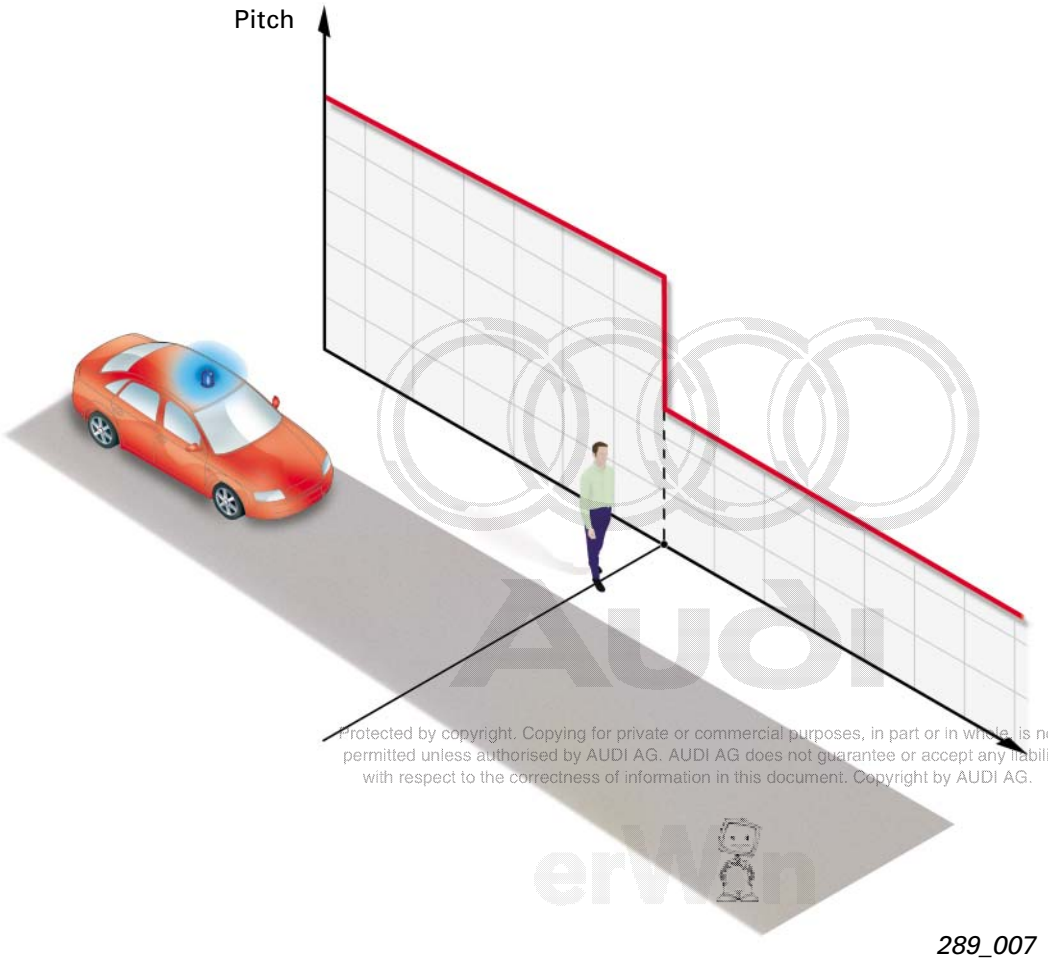
Use is made of a physical phenomenon known as the „Doppler effect“ to establish the speed of the vehicle in front.
There is a basic difference depending on whether the object reflecting the waves transmitted is stationary with respect to the transmitter or moving.

If the distance between transmitter and object decreases, the frequency of the reflected waves increases and vice versa. This change in frequency is evaluated by the electronics and supplies the speed value for the vehicle in front.

Example demonstrating the Doppler effect:

As a fire engine approaches, the siren signal sounds to be of a constantly high pitch (high frequency).

As the vehicle moves further away, the tone sounds lower (sudden frequency change – lower frequency).



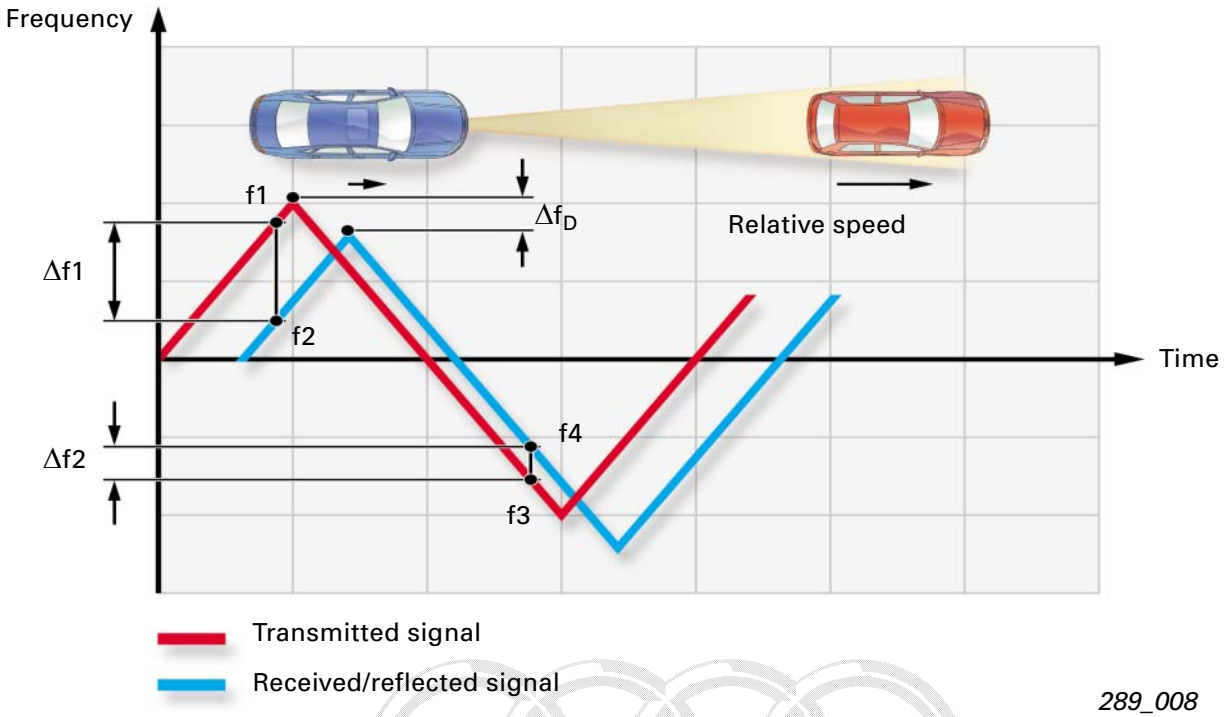
289_007

Introduction

Example showing determination of speed of vehicle in front

As the vehicle in front speeds up, the distance increases. On account of the Doppler effect, the frequency of the received (reflected) signal decreases (Δf_D).

This results in a difference in differential frequencies between leading ($\Delta f1$) and trailing edge ($\Delta f2$). This difference is evaluated by the distance control unit.



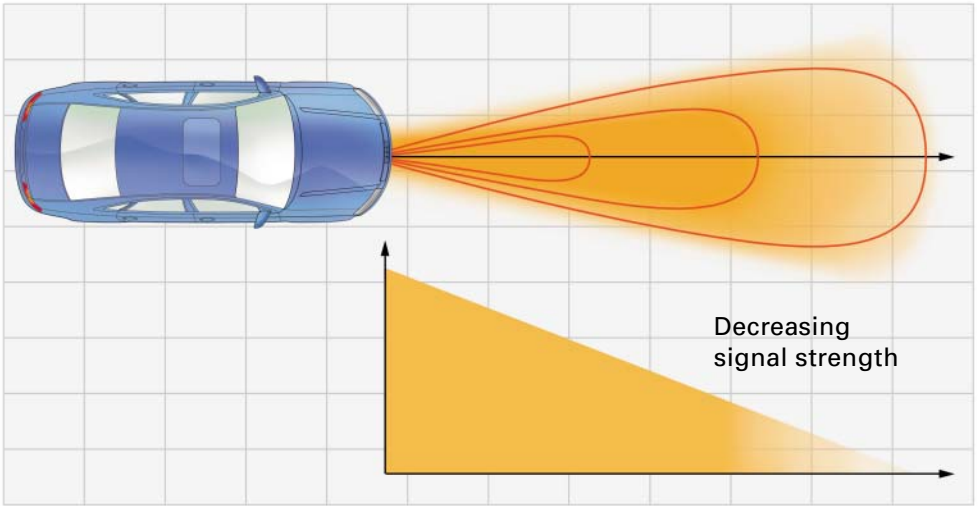
289_008

Δf: Difference between frequency f1/3 of transmitted signal and f2/4 of received signal

Determining position of vehicle in front

Radar signal propagation takes the form of a lobe pattern.

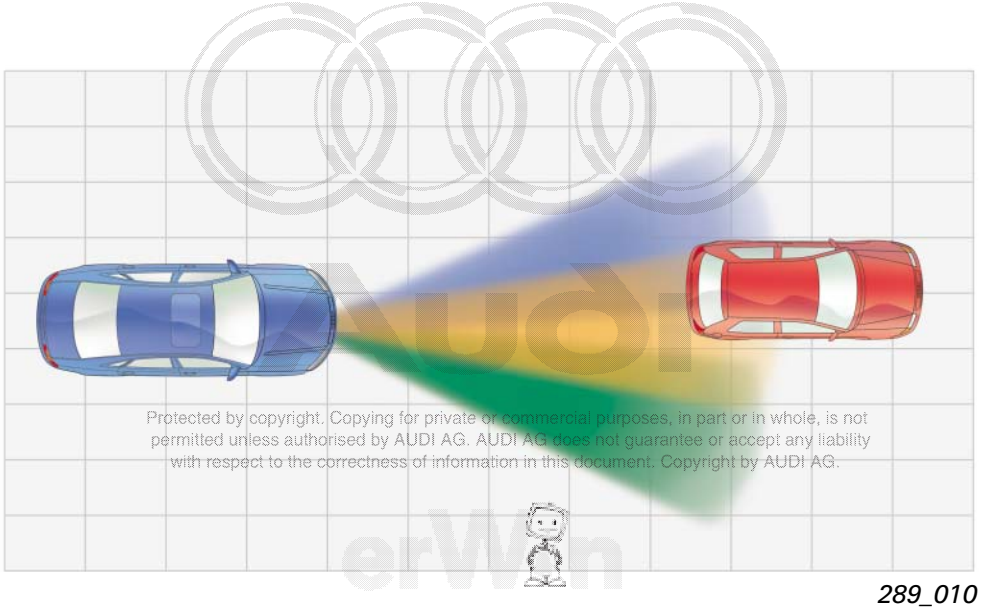
Signal strength decreases with increasing distance from the transmitter in axial and transverse vehicle direction.



289_009

A further variable required for determining position is the angle at which the vehicle in front is moving with respect to the vehicle in which the system is fitted.
This information is obtained by the use of a three-beam radar.

The ratio of the amplitudes (= signal strengths) of the received (reflected) signals of the individual radar lobes supplies the angle information.



289_010

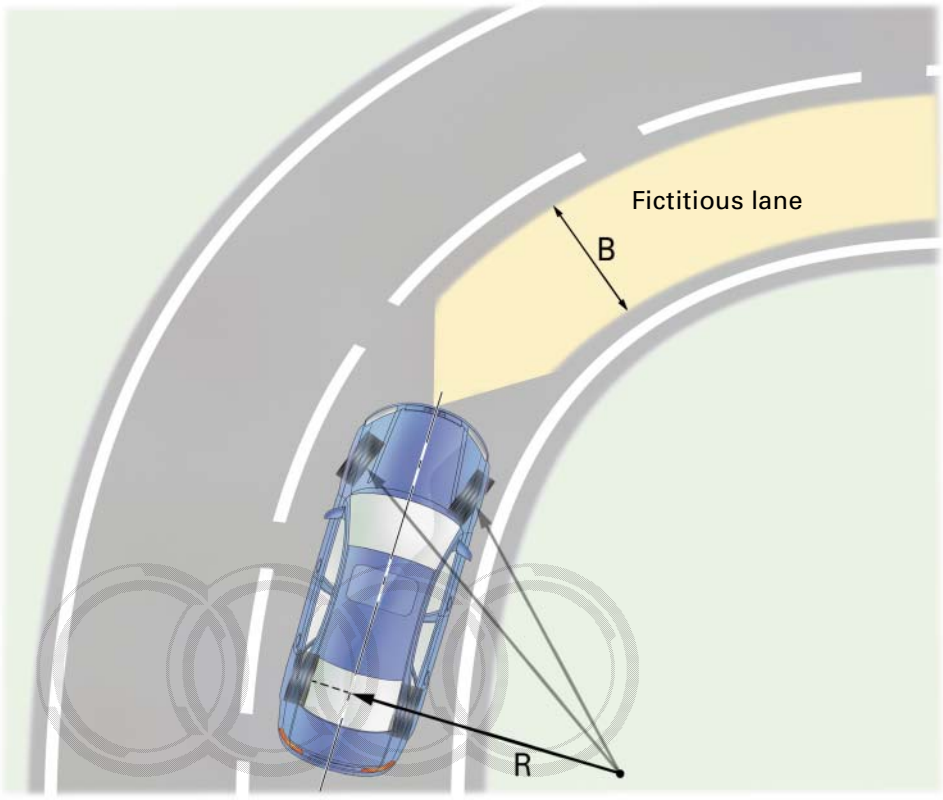
Determining vehicle to which control is to be related

In real traffic situations (e.g. on motorways and multi-lane roads or when cornering), there are generally several vehicles within the radar detection range at the same time.

In this case it is essential to detect which vehicle is travelling in the same lane (or from which vehicle the selected distance is to be maintained).

This requires lane determination by the distance control unit. Such a process is relatively complex and demands extra information (additional input signals).

Of primary importance are the signals of the turn angle sensor, wheel speed sensors and steering angle sender. Evaluation of these signals provides information on bends in the road.



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B = Average lane width

R = Cornering radius

This "fictitious" lane is derived from the current cornering radius of the adaptive cruise control vehicle and a specified average lane width.

The closest object located in this lane picked up by the radar sensor is then taken as the relevant object for control purposes.

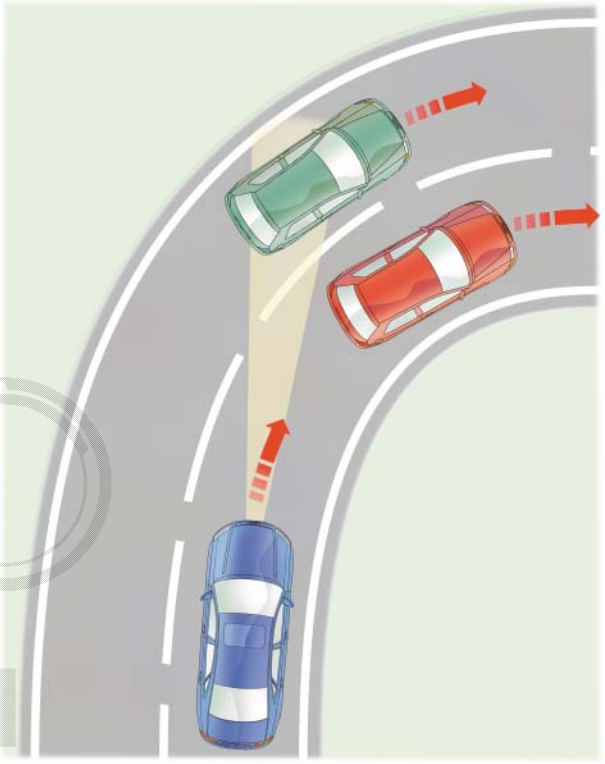
On alternating bends or on entering or leaving a bend, a vehicle may briefly be "lost" or a vehicle in the adjacent lane may be "picked up".

This may lead to brief implausible acceleration or deceleration of the vehicle with adaptive cruise control.

Such behaviour is system-related and does not represent a fault.

Example

The blue vehicle is following the red vehicle at a controlled distance. On negotiating the 90 degree bend, the red vehicle leaves the radar transmission/reception range. A vehicle travelling in the adjacent lane briefly enters the radar range. Although the distance control unit calculates the bend in the road, control action caused by the other vehicle may occur temporarily.



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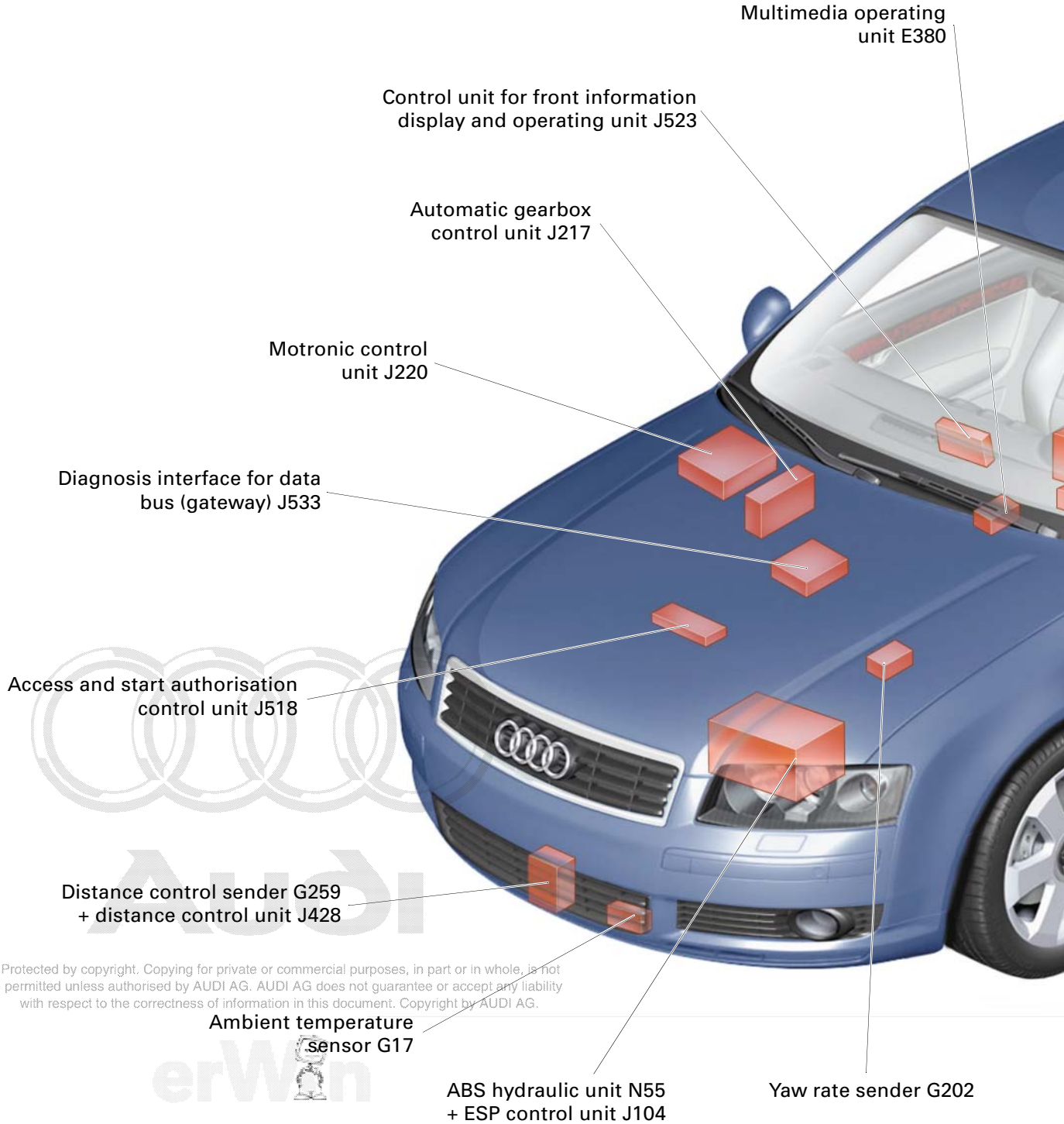
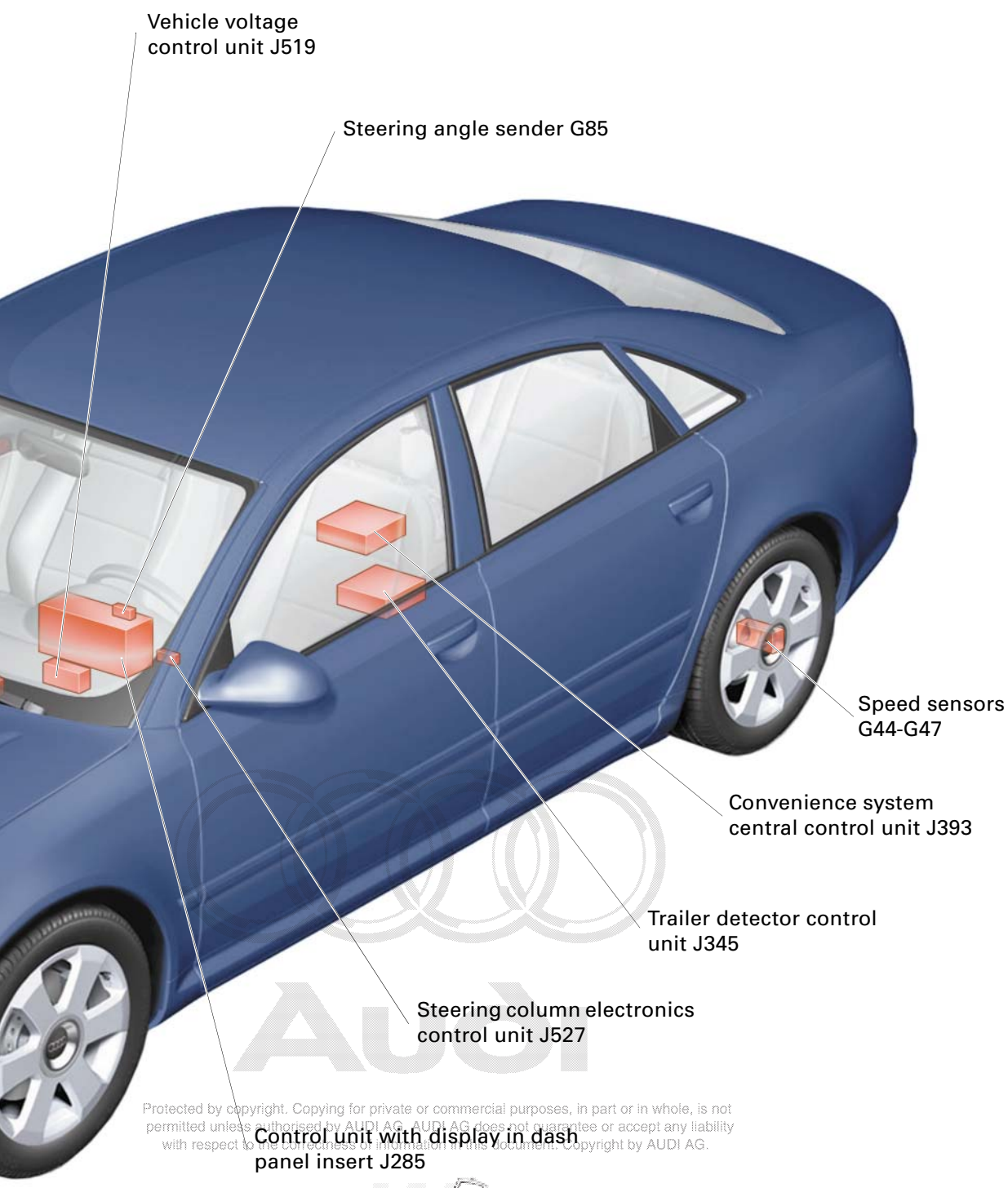
System components

General view of vehicle





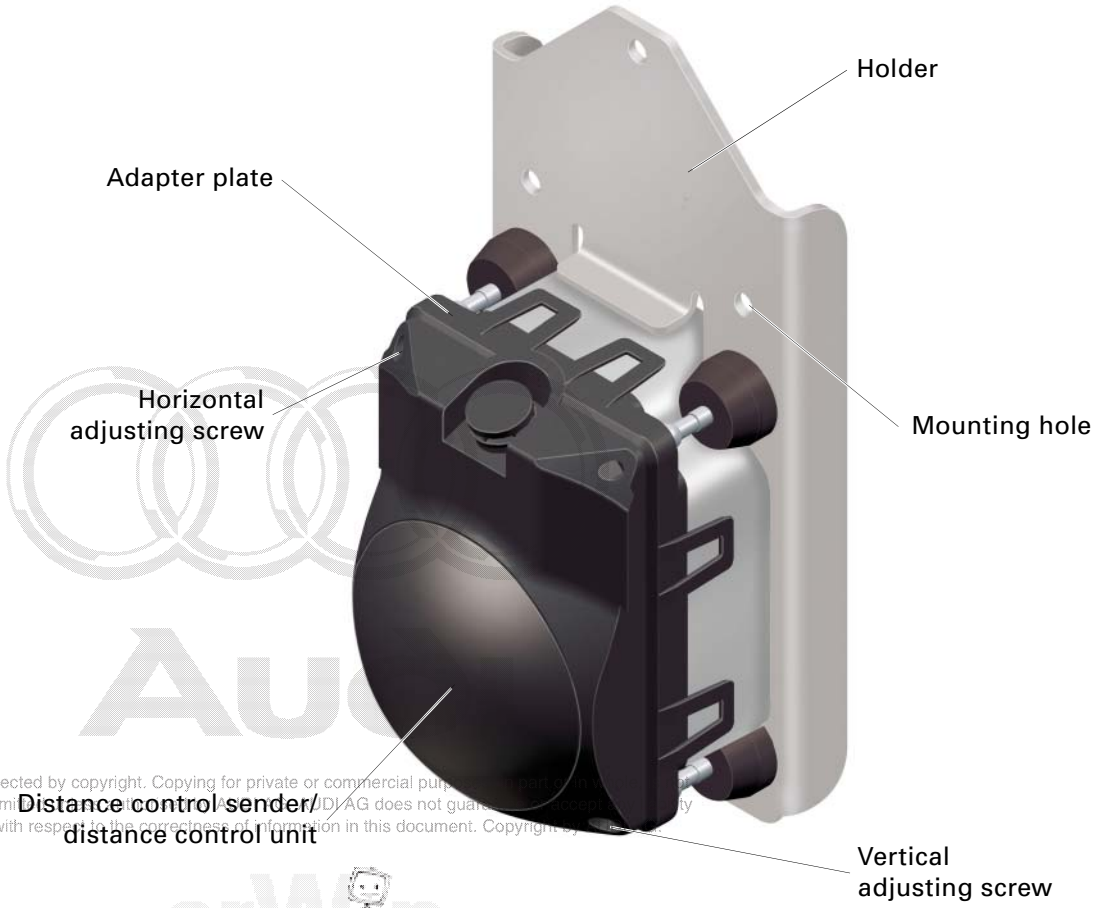
289_011

Distance control sender G259 and distance control unit J428

Design:

Sender and control unit are fitted in one housing. The entire unit must be replaced in the event of a sender/control unit fault.

An adapter plate permits fitting and adjustment at a holder bolted to the centre of the bumper bracket.
For detailed information, refer to relevant Workshop Manual.



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Operation:

The speed control sender G259 transmits the frequency-modulated signal and receives the reflected signal. The control unit processes the radar signals and other additional input signals. These signals are used to determine the relevant vehicle in front for control purposes from all the objects in the radar detection range.

The position and speed of the vehicle, as well as the current distance, are established. The necessary control action is derived from this data and the appropriate information transmitted to the Motronic control unit J220, automatic gearbox control unit J217 and ESP control unit J104.
The data are transferred by way of the distance control CAN and diagnosis interface for data bus (gateway) J533 to the drive system CAN.

Cover for distance control sender

The cover of the speed control sender in the bumper trim panel is made of radar-permeable material.

The cover can be heated to prevent possible malfunctioning due to snow and ice.

Any surface changes, such as subsequent painting or the attachment of stickers or other items may lead to malfunctions.

Operation and driver information concept

Operating and display concept

Operation is by way of the adaptive cruise control stalk on the left side of the steering column.

289_018

The display concept includes three display blocks:

All important information is always centrally displayed in the speedometer.

289_019

Important information of relevance to the system which does not have to be displayed permanently on account of its infrequent occurrence appears on the info line in the centre display of the dash panel insert.

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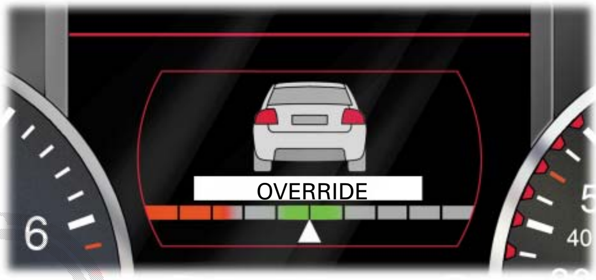
Additional information giving details of system functions can be called up by the driver in an extra display. This involves pressing the RESET button on the underside of the wiper stalk.



289_042

A distinction is made between 4 system statuses (modes):

ACC OFF
The system is deactivated and system operation is not possible.

ACC READY
This mode represents a standby status. The system remains switched on but no active control takes place. If adaptive cruise control had previously been active, the desired speed is present in the memory.

ACC ACTIVE
The adaptive cruise control implements the set speed (on an open road) or regulates the distance from the vehicle in front.

ACC OVERRIDE
The driver exceeds the set speed by pressing the accelerator.

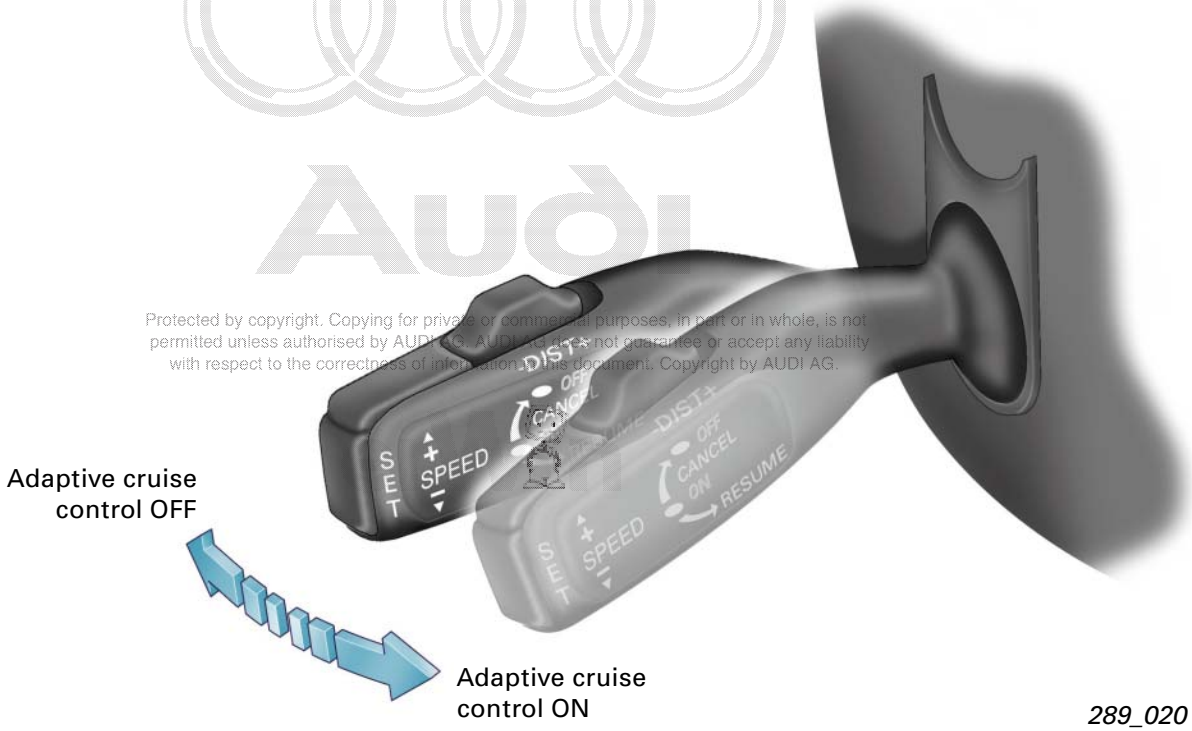
System functions

Operation and driver information

System activation/deactivation

The stalk has 2 latching positions. Basic system activation involves moving the stalk towards the driver into the latching adaptive cruise control ON position.
The system is deactivated by moving the stalk into the latching adaptive cruise control OFF position.

After starting the engine, the adaptive cruise control is set either to READY mode (stalk position ON) or OFF mode (stalk position OFF) depending on stalk position.
Following activation, the system is set to READY mode.
As yet there is no display in the speedometer.
The adaptive cruise control is not switched to ACTIVE mode until the SET button is pressed.



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Setting desired speed

The desired speed is the maximum speed to be regulated by the adaptive cruise control on an open road (corresponds to cruise control system function). Pressing the SET button stores the current speed as desired speed.

SET

289_023

The set speed is displayed by a bright red LED in the speedometer rim and the adaptive cruise control active symbol appears in the speedometer.
The adaptive cruise control active status is indicated by faint red illumination of all LEDs in the range between 30 and 200 km/h.

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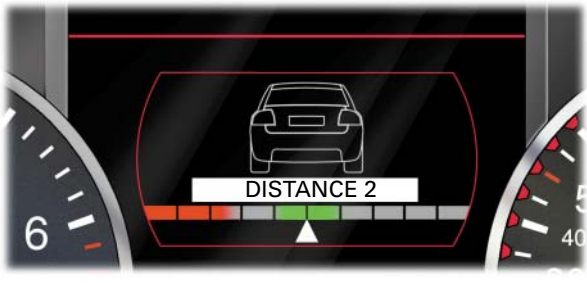
If the extra display has been activated by the driver, a message also appears in the centre display.
On switching off the ignition, the desired speed stored is erased for safety reasons.



289_025

System functions

Detection of a vehicle in front

Detection of a vehicle travelling in front results in a display in the speedometer.

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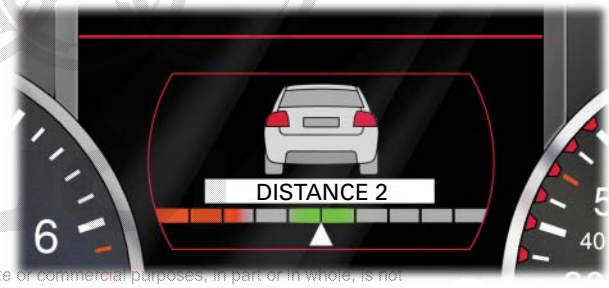
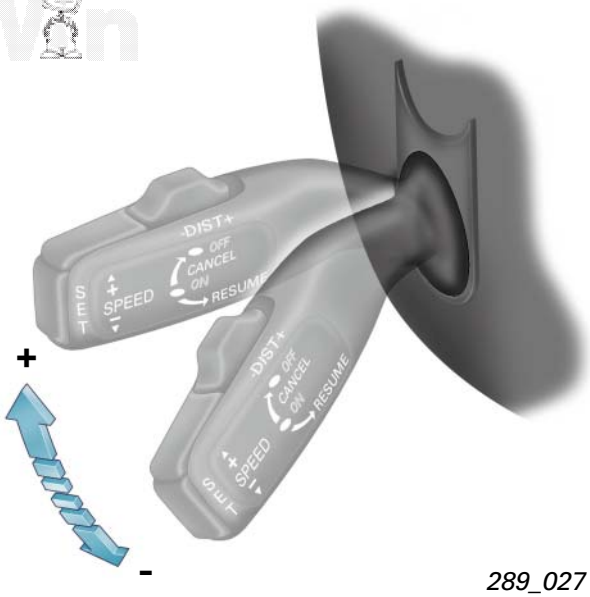
If the extra display is active, a message also appears in the centre display.



289_042

During operation, the desired speed set can be altered by the driver in the speed range between 30 and 200 km/h by pressing the stalk up (to increase speed) or down (to reduce speed).
The modified desired speed is indicated by the appropriate LED in the speedometer rim. Actuation in + or - direction alters the desired speed by one scale division each time.



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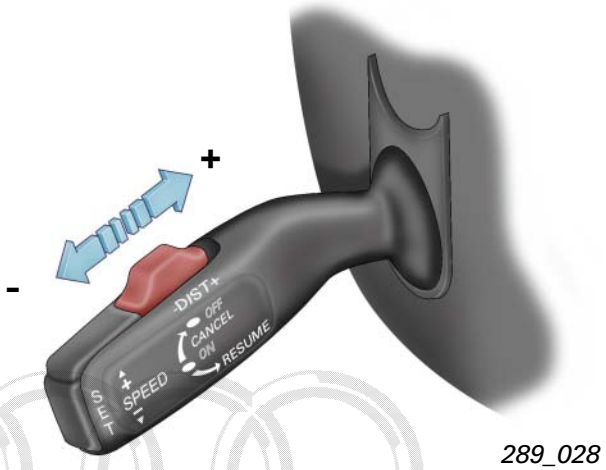
Setting desired distance

The desired distance from the vehicle in front can be set by the driver in four stages. The distance set by the adaptive cruise control is governed by the respective vehicle speed.

The distance increases with increasing speed. The minimum setting ensures compliance with the legally prescribed safety distance when travelling at a constant speed in traffic.

The desired distance from the vehicle in front is set by means of the sliding switch on the stalk. Actuation of the switch increases or reduces the distance by one stage each time. The desired distance selected determines the vehicle acceleration dynamics.



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The chosen distance is briefly indicated on the info line in the dash panel centre display. The centre display is activated the first time the button is pressed.

The number of bars between the vehicles displayed corresponds to the distance stage selected in each case.
Basic setting of the distance stage after starting the engine can be set for each driver (refer to adaptive cruise control system settings).

DISTANCE 1	DISTANCE 2	DISTANCE 3	DISTANCE 4
Time interval 1.0 s	Time interval 1.3 s	Time interval 1.8 s "Half km/h"	Time interval 2.3 s
Dynamics: Sporty	Dynamics: Standard	Dynamics: Standard	Dynamics: Comfort
Ideally suited to: Slow moving line of traffic Brisk driving	Ideally suited to: Free-flowing line of traffic Relaxed moving with the flow	Ideally suited to: Free-flowing line of traffic Relaxed moving with the flow	Ideally suited to: Country roads Vehicle with trailer

289_060

Driver intervention prompt

If the system recognises that the braking operation initiated is not sufficient to achieve the specified distance, an acoustic signal (gong) sounds.
The driver is additionally requested to perform active braking by a display flashing at a frequency of 0.5 hertz on a red background in the speedometer.

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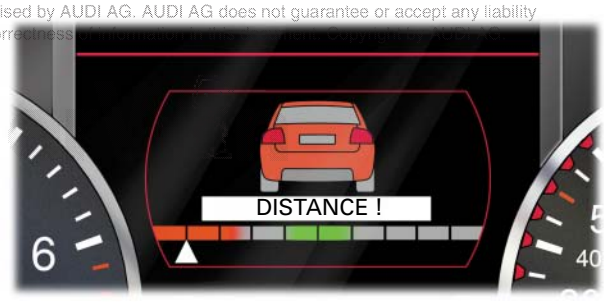
If the extra display has been activated by the driver, the warning also appears in the centre display.

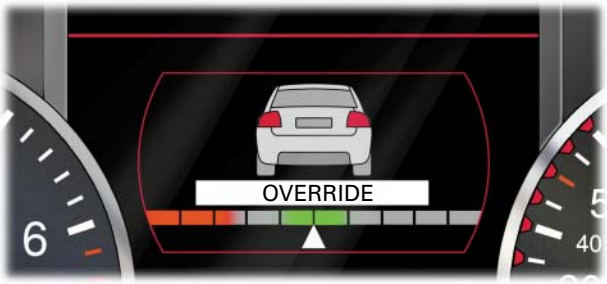
The volume of the gong can be set for each driver
(refer to adaptive cruise control system settings).



289_045

Increasing speed above desired speed (OVERRIDE)

If the driver accelerates more than the adaptive cruise control system, the symbol in the speedometer goes out.
If the extra display has been activated by the driver, this status will appear in it.



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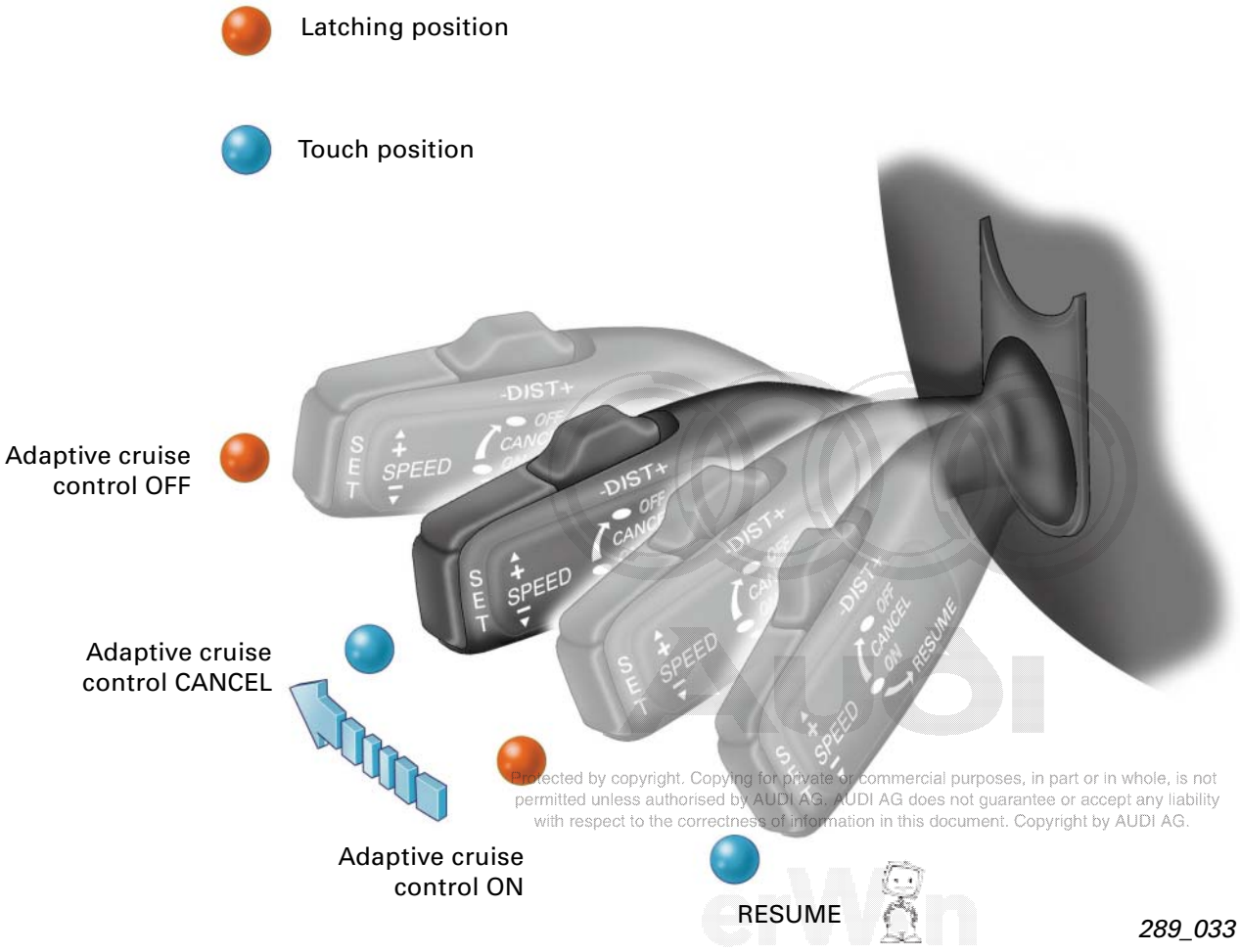
System functions

Deactivating adaptive cruise control (READY mode)

(Refer to "System statuses" under "System functions")

Touching the stalk in direction of travel deactivates the adaptive cruise control. This results in a change of mode from ACTIVE/OVERRIDE to READY.

The LED for displaying the desired speed remains active.
On release, the stalk returns automatically to the latching ON position.

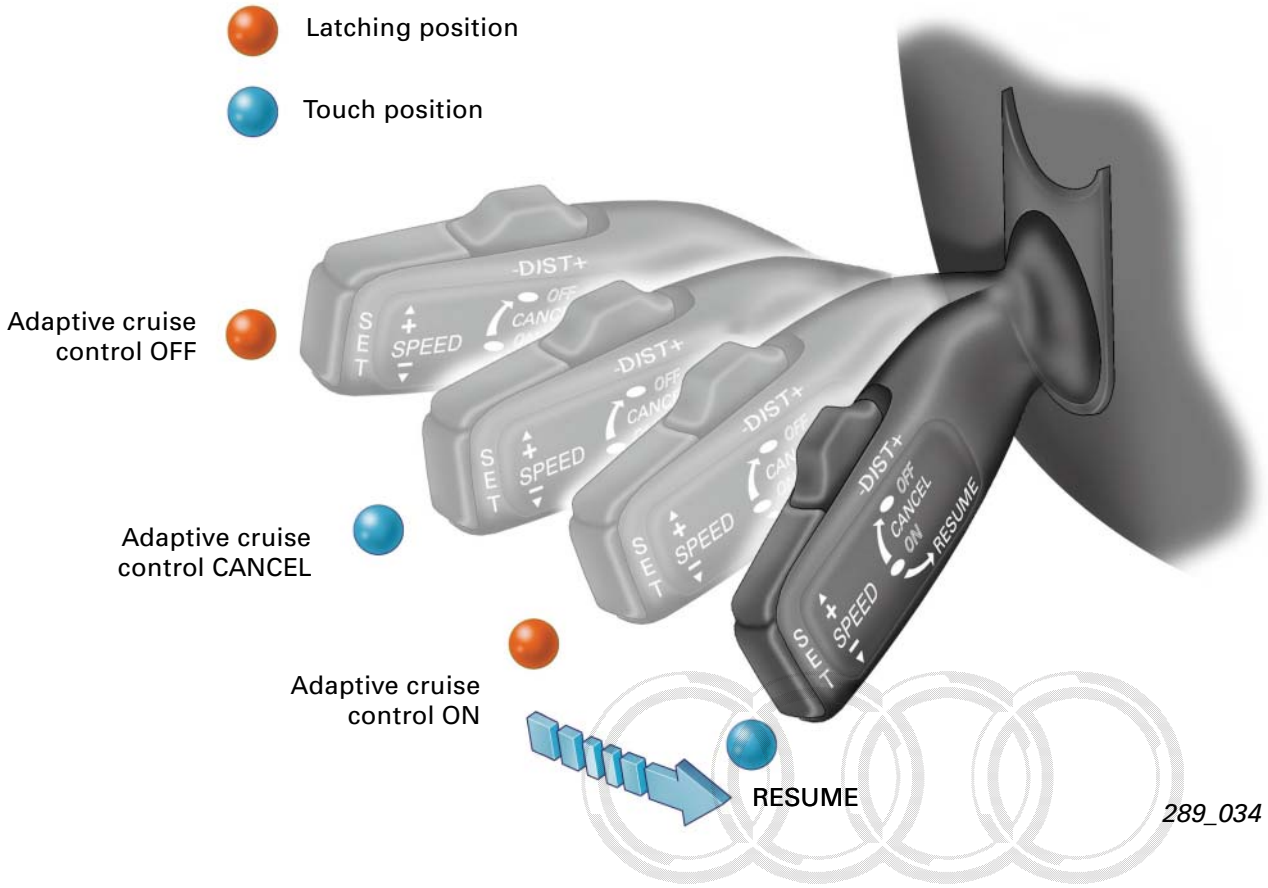


Adaptive cruise control is also deactivated on pressing the brake pedal (system switches to READY mode).

Activating adaptive cruise control (resume)

If adaptive cruise control has been deactivated and is set to READY mode, it can be activated by pulling the stalk towards the driver.

Prerequisite: Desired speed still set



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System settings

The following system settings can be made in the MMI:

Basic setting of DISTANCE (1, 2, 3, 4):
DISTANCE 3 is preset at the factory on activation of adaptive cruise control. The term system setting means that this setting remains valid on activation until the driver enters a different desired distance.

Setting of gong volume (off, low, medium, high):
The factory presetting is "high".

System settings can be made for four different people (by way of key encoding or one-touch memory).
(Refer to relevant owner's manual for details).

Fault displays/deactivation

Whether or not the adaptive cruise control is functioning properly can easily be checked while the vehicle is still stationary:
If the adaptive cruise control stalk is switched from OFF to ON position with the engine running, the faintly red illuminated LED rim (30-200 km/h) must light for 3 seconds.
Faults are indicated on the info line of the centre display.
Deactivation is additionally indicated by a gong signal.

Serious fault:
Serious fault in system or periphery, adaptive cruise control is deactivated, entry in fault memory e.g. failure of distance control unit.

289_054

Fault:
Fault in periphery, limited adaptive cruise control operation, no entry in fault memory, e.g. adaptive cruise control not available on account of excessive brake temperature.

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Active braking by driver:
Driver braking has priority; even a slight touch of the brake pedal can result in deactivation.

ESP/ABS/TCS/MSR control:
Even brief control action not perceived by the driver can lead to deactivation

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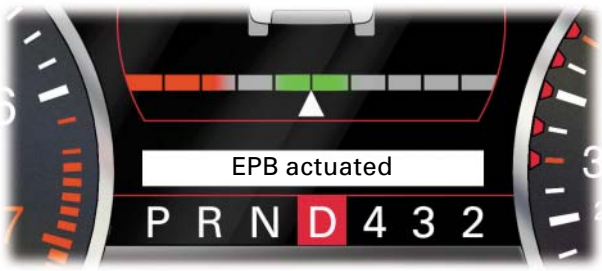
Electromechanical parking brake active:
Even briefly pulling parking brake switch will result in deactivation



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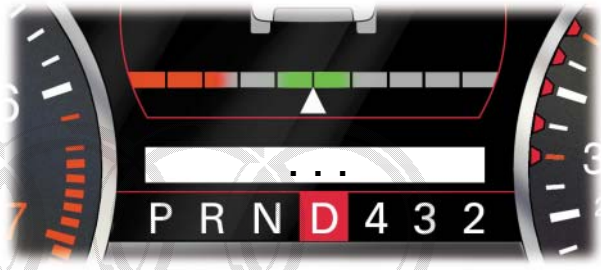
Invalid operation:
For example, activation of resume function with no desired speed set or tip up/ tip down outside valid vehicle speed range



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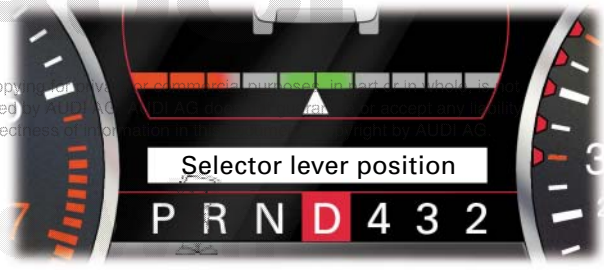
Selector lever position invalid:
For example, selector lever set to "N" whilst driving



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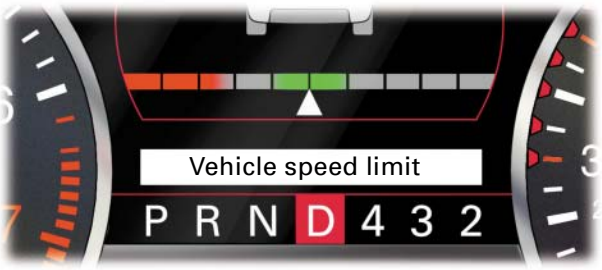
System functions

Departure from vehicle speed range:
On leaving speed range between 25 and 220 km/h or on pressing SET button at less than 30 km/h



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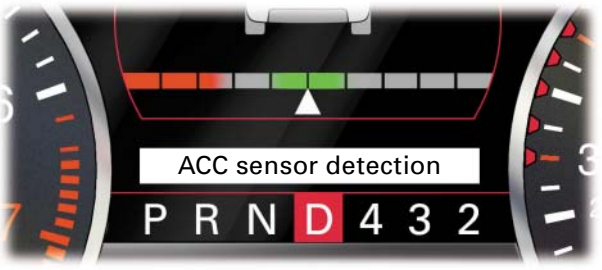
No distance control sender detection:
Object detection problems in target range, e.g. in the case of "faint" targets such as motorcyclists or in certain areas with wide open spaces and few stationary objects in the target range (e.g. in Arizona)

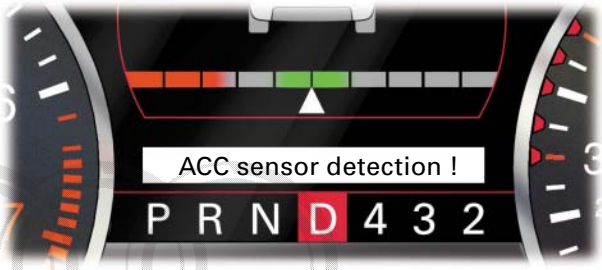
There are basically two different cases:

1. On open road (with no vehicle in front): Immediate deactivation in the event of detection problems at ambient temperatures between –5 and 5°C or if windscreen wipers are activated
2. In traffic (with vehicle in front): Preliminary warning does not result in immediate deactivation; adaptive cruise control is switched off after 10 s, leading to fault display with exclamation mark

Not all instances of inadequate object detection give rise to display and deactivation.



289_054



289_054

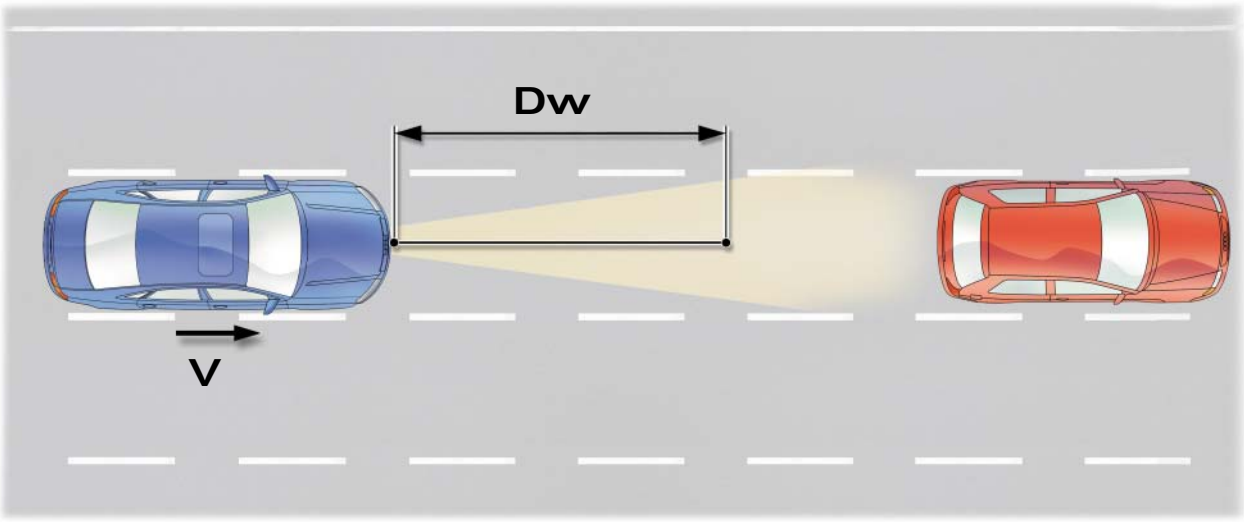
As soon as the reason for deactivation is no longer applicable, adaptive cruise control can be reactivated by way of RESUME or SET stalk.
This does not apply to serious faults.

Notes

General mode of operation of adaptive cruise control

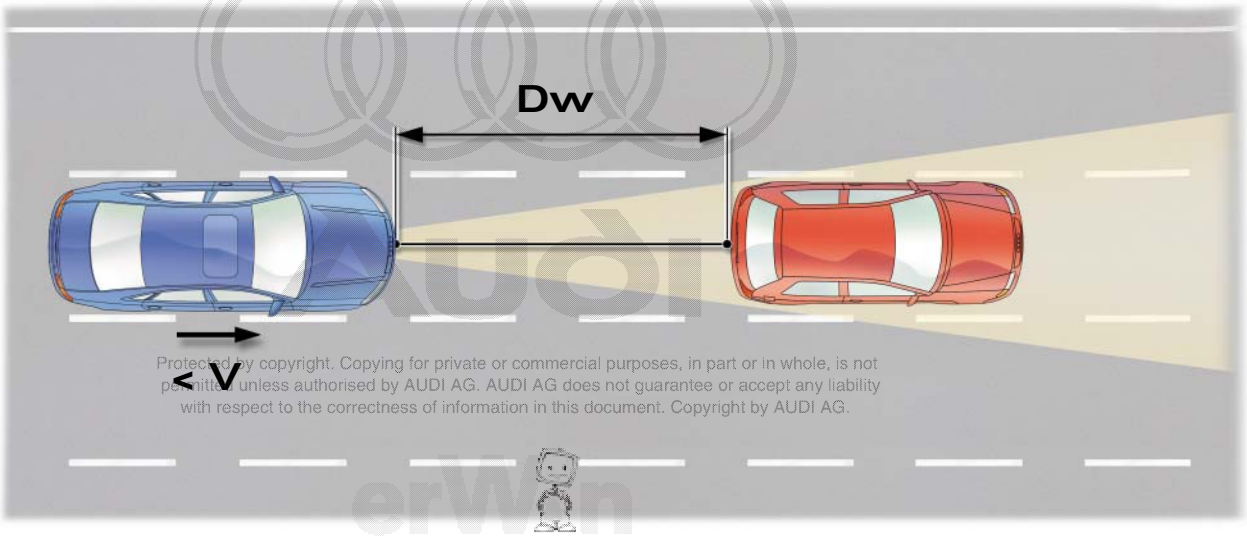
The mode of operation is outlined below on the basis of typical control action:

The driver of the blue vehicle activates the control system, selects desired speed V and desired distance Dw. The vehicle is accelerated to the desired speed specified.



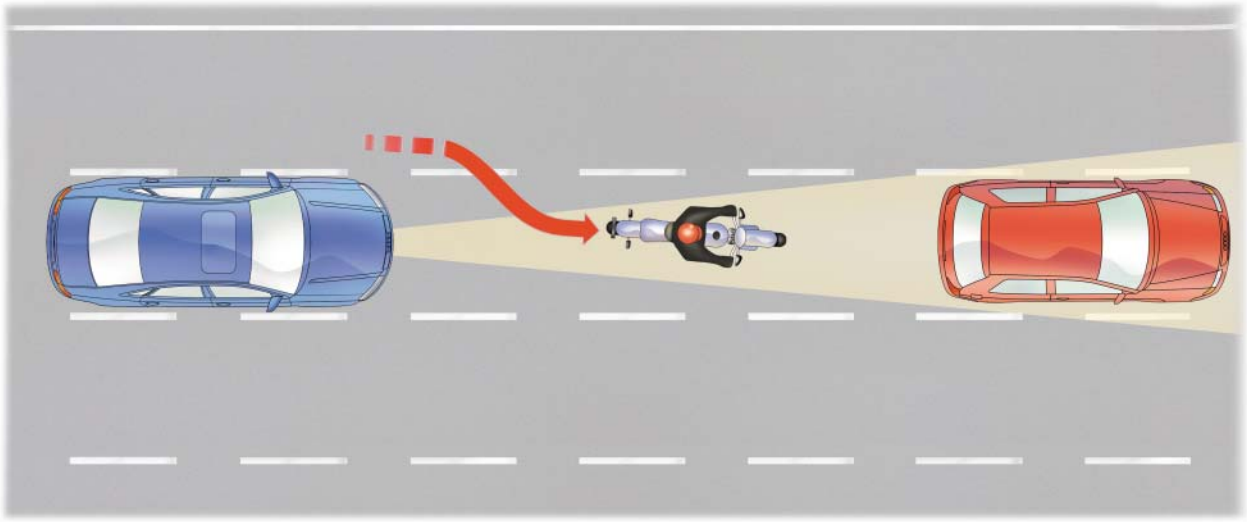
289_014

A vehicle travelling in front (red) in the same lane is detected. By decelerating and, if necessary, applying the brakes the speed of the blue vehicle is reduced until the desired distance is attained.



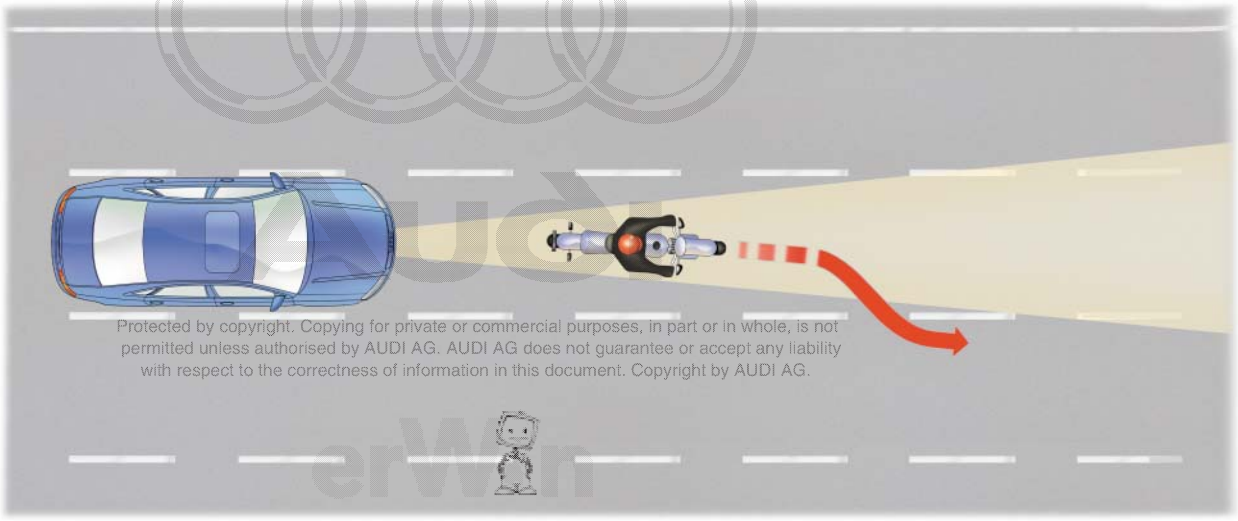
289_015

A second vehicle (motorcycle) cuts into the gap between the two vehicles.
The deceleration implemented by the adaptive cruise control system is not sufficient to achieve the desired distance from the motorcycle. Visual and acoustic warnings prompt the driver to take active braking action.



289_017

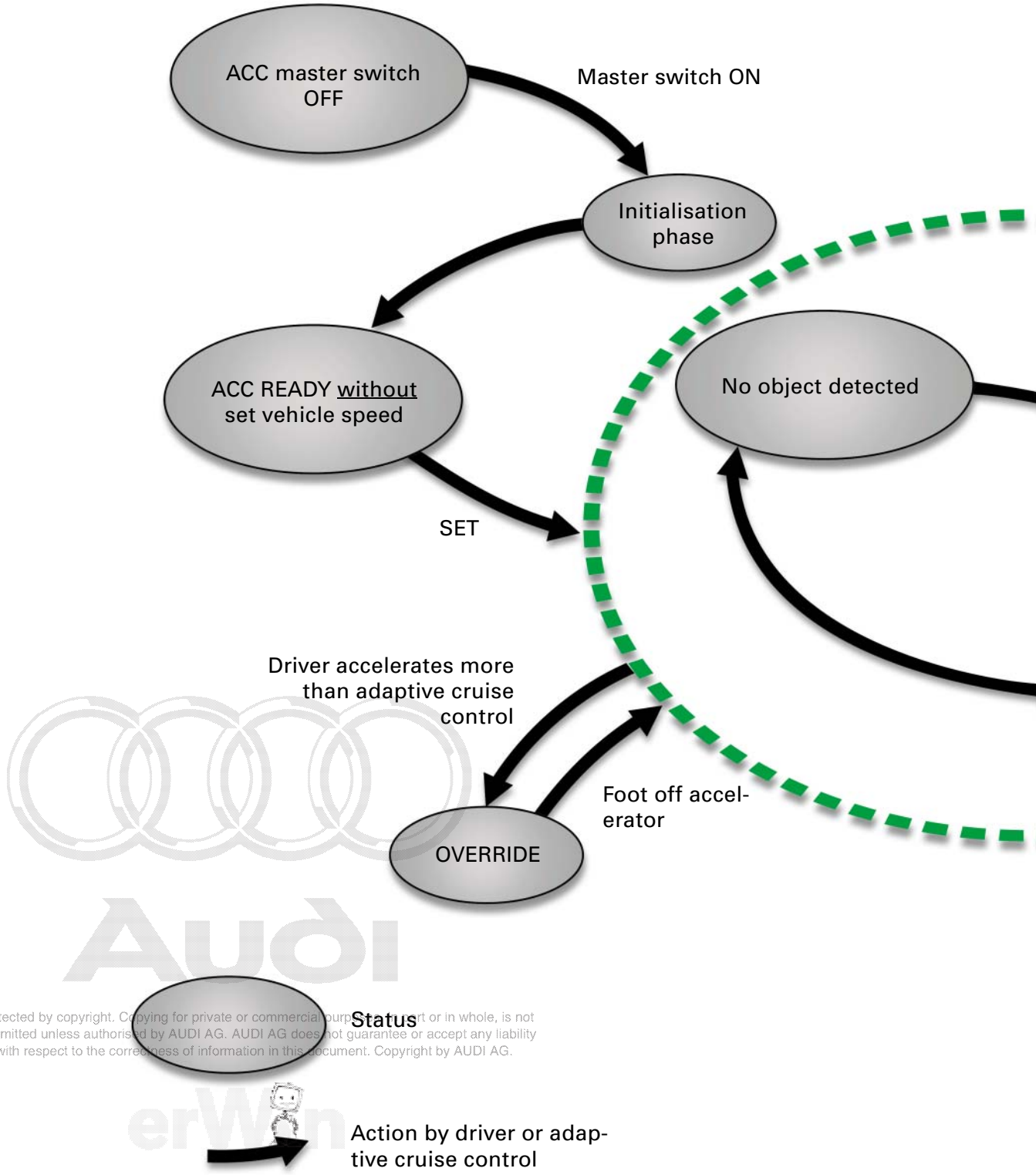
The vehicle in front moves out of the lane. This is detected by the radar sensor. The blue vehicle is accelerated again to the desired speed specified.

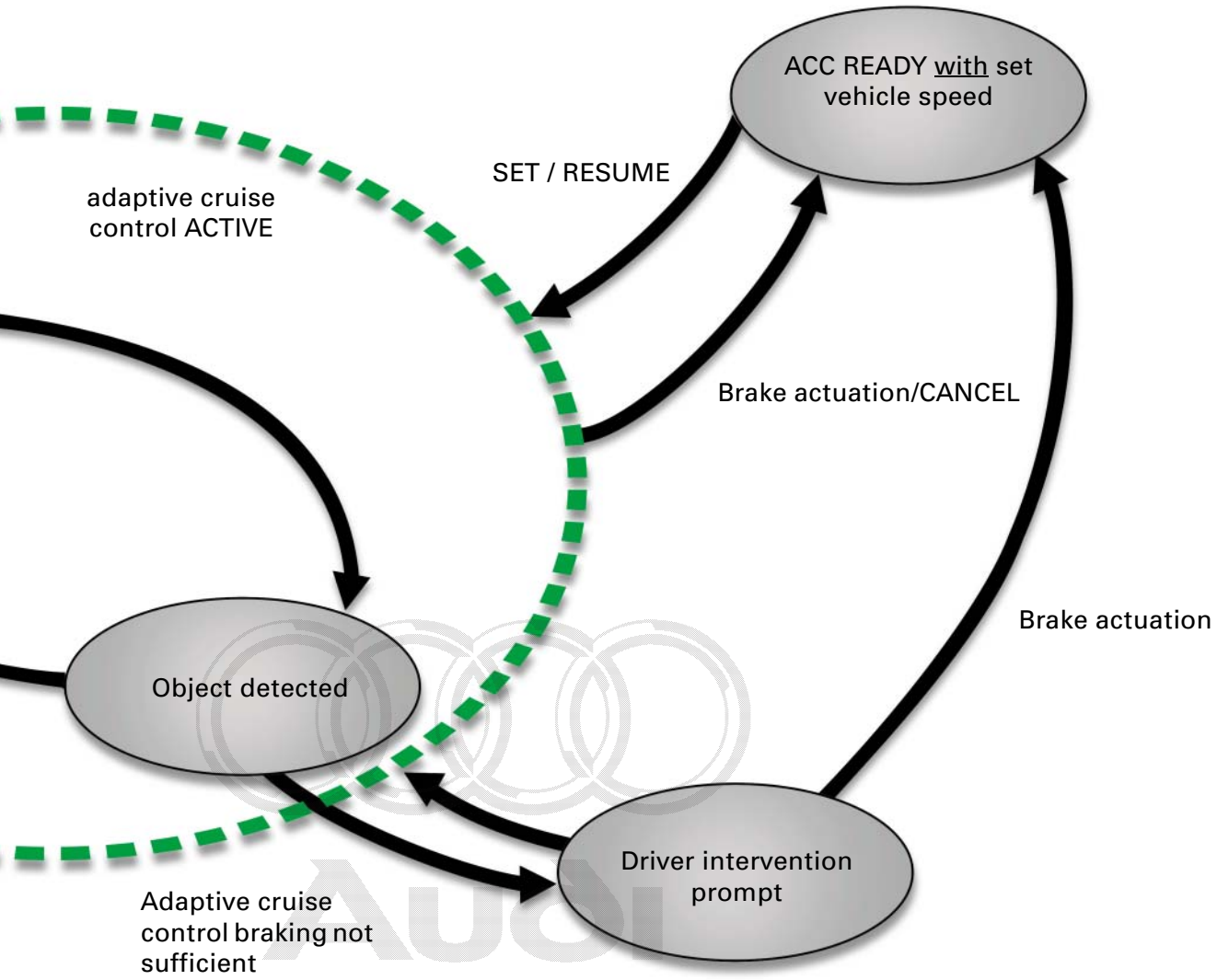


289_016

Mode of operation

Status diagram

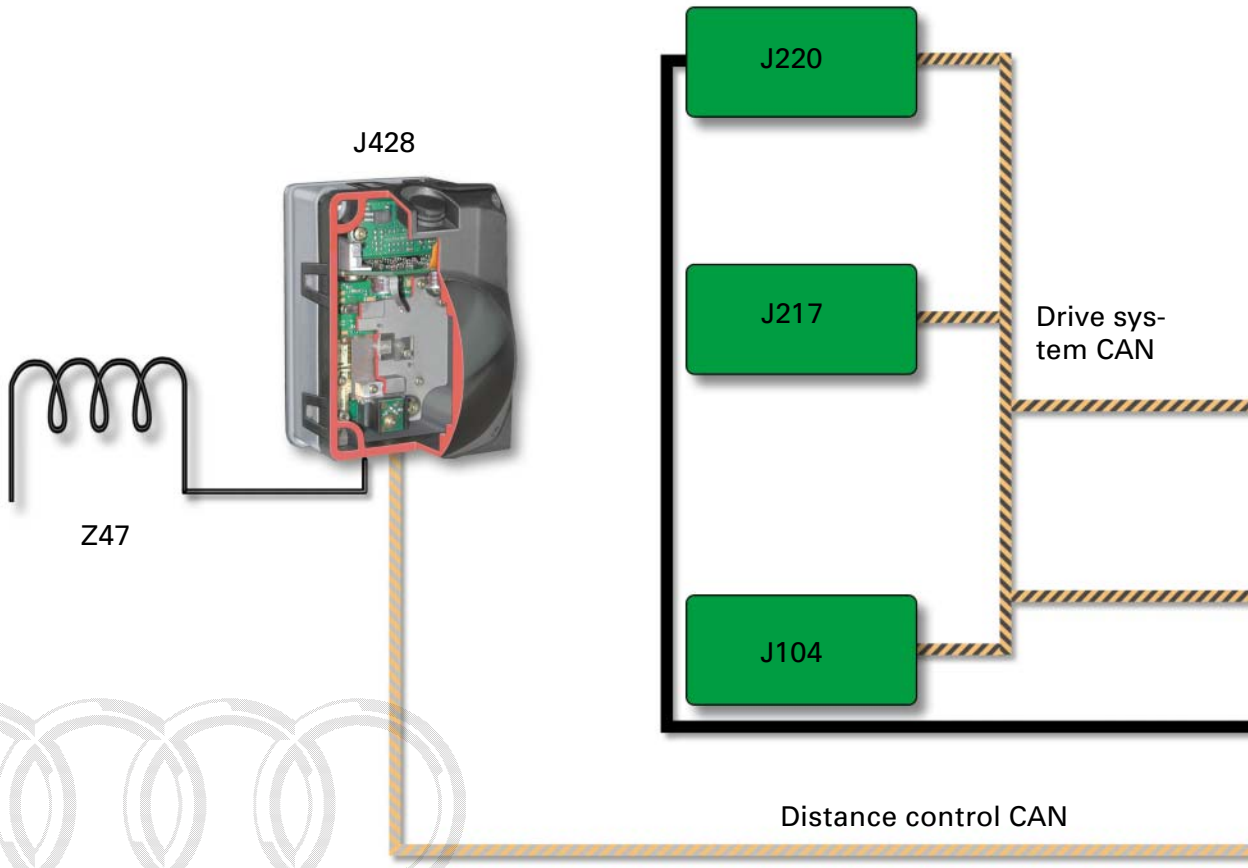




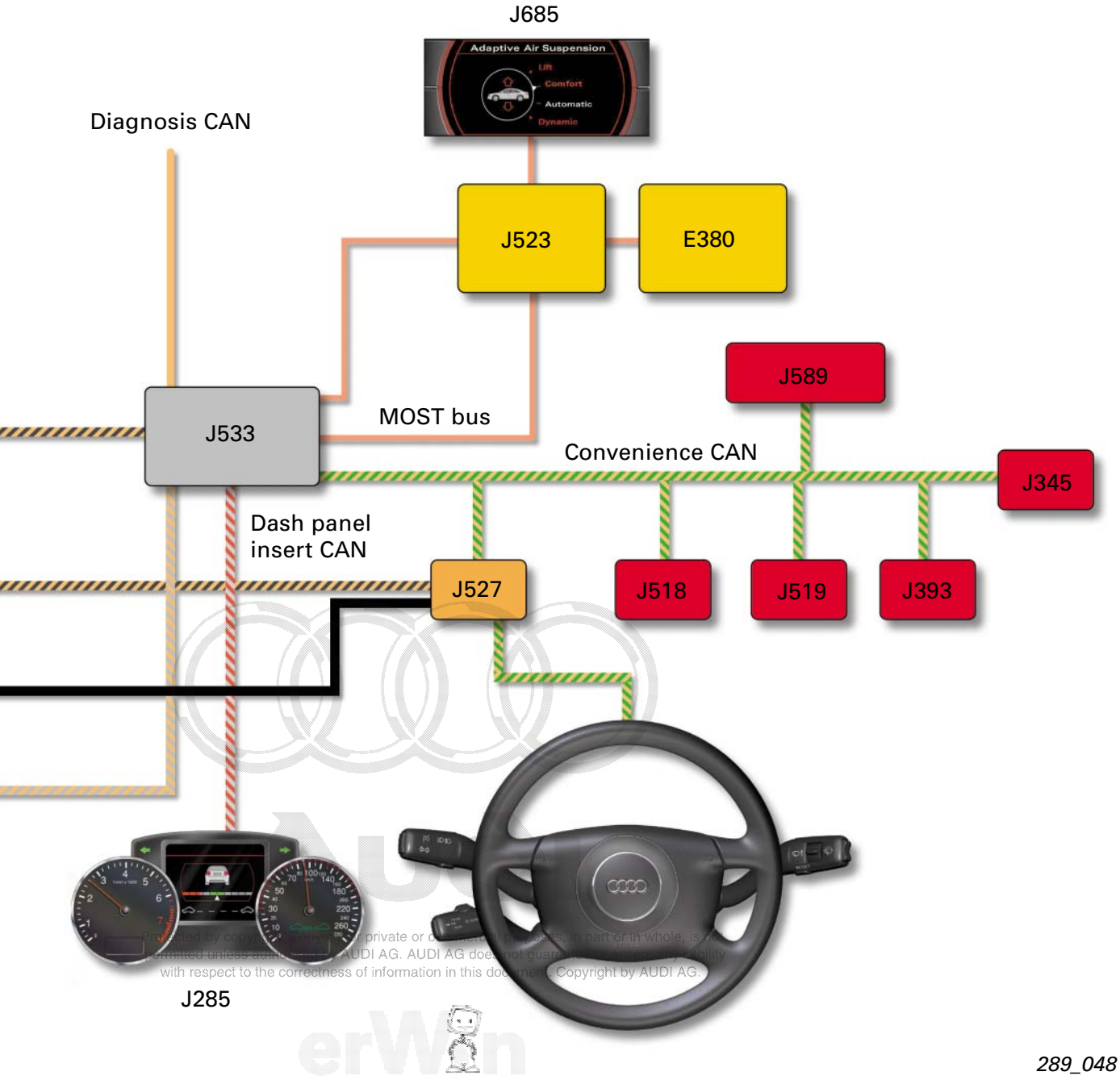
289_047

Data flow

System layout



J428 Distance control unit
J220 Motronic control unit
J217 Automatic gearbox control unit
J104 ESP control unit
J533 Diagnosis interface for data bus (gateway)
J285 Control unit with display in dash panel insert
J527 Steering column electronics control unit / G85 Steering angle sender
J523 Control unit for front information display and operating unit

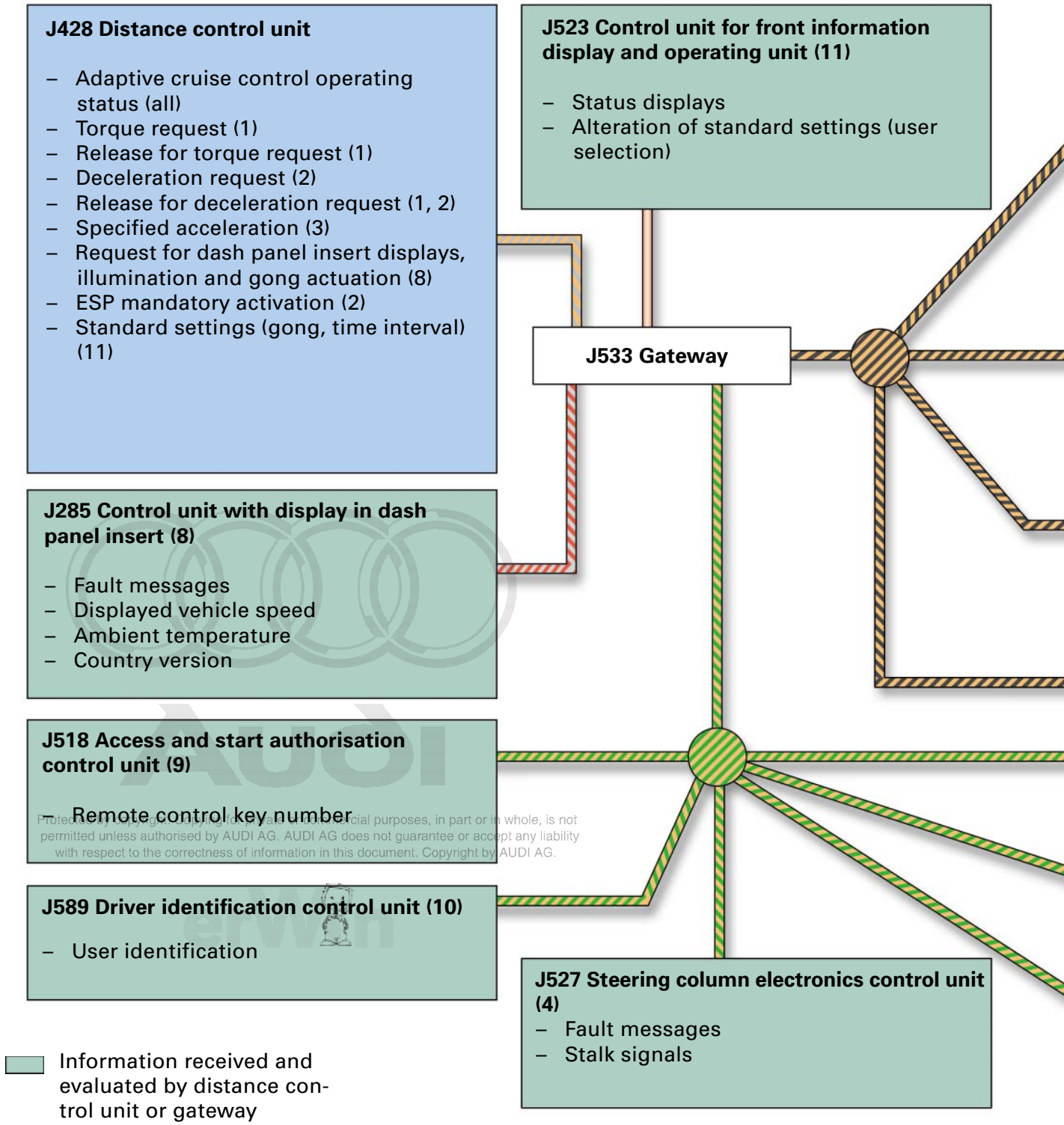


289_048

Z47	Distance control sender heater
E380	Multimedia operating unit
J685	Front information display unit
J589	Driver identification control unit
J518	Access and start authorisation control unit
J519	Vehicle voltage control unit
J393	Convenience system central control unit
J345	Trailer detector control unit

Data flow

CAN data exchange



J220 Motronic control unit (1)

- Engine speed
- Engine torque
- Driver input torque
- Brake light switch setting
- Brake test switch setting
- Engine control unit operating status
- Accelerator pedal signal
- Altitude info
- Limiting torque

J104 ESP control unit (2)

- TCS/MSR/ESP control
- ESP switched to passive
- Wheel speeds
- Yaw velocity/direction of rotation
- Vehicle stationary
- Brake status feedback following adaptive cruise control request
- Deceleration by electric parking brake activated
- Brake overheated
- Brake pressure
- Fault messages
- Switching of vehicle speed formation between FWD/Quattro drive

J217 Automatic gearbox control unit (3)

- Gearshift status (active/inactive)
- Selector lever position
- Transmission function (transmission ratio)
- Gearbox emergency operation
- Gearbox info

G85 Steering angle sender (12)

- Steering wheel angle

J519 Vehicle voltage control unit (5)

- Wiper function status
- Turn signal indicator actuation status

J345 Trailer detector control unit (7)

- Brake light actuation status

J393 Convenience system central control unit (6)

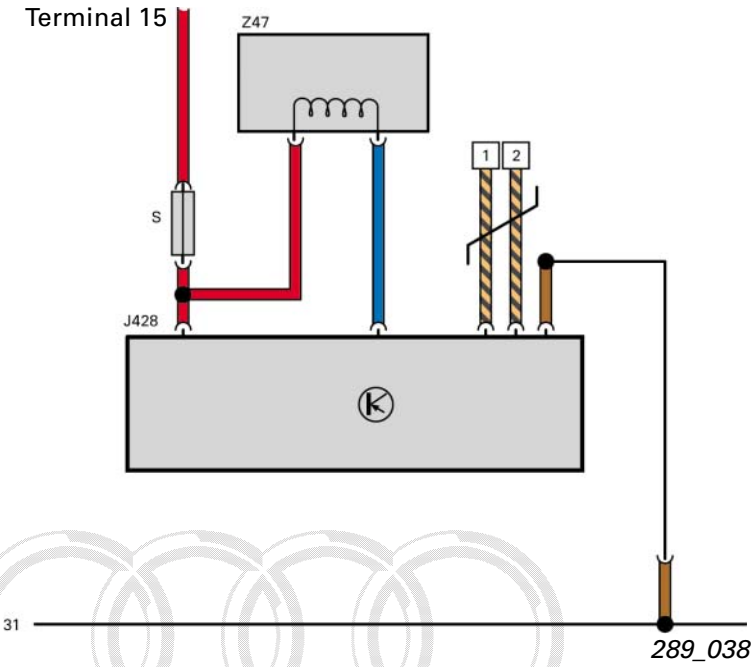
- Brake light actuation status

289_063

The numbers in brackets after the distance control unit messages indicate which control units process the information concerned. For example: "Torque request" message is processed by control unit no. 1, J220.

Data flow

Block diagram



Components

J428 Distance control unit
Z47 Distance control sender heater
S Fuse

Additional signals

(1) Drive system CAN Low
(2) Drive system CAN High

Colour code

= Positive

= Earth

= Output signal (heating actuation)

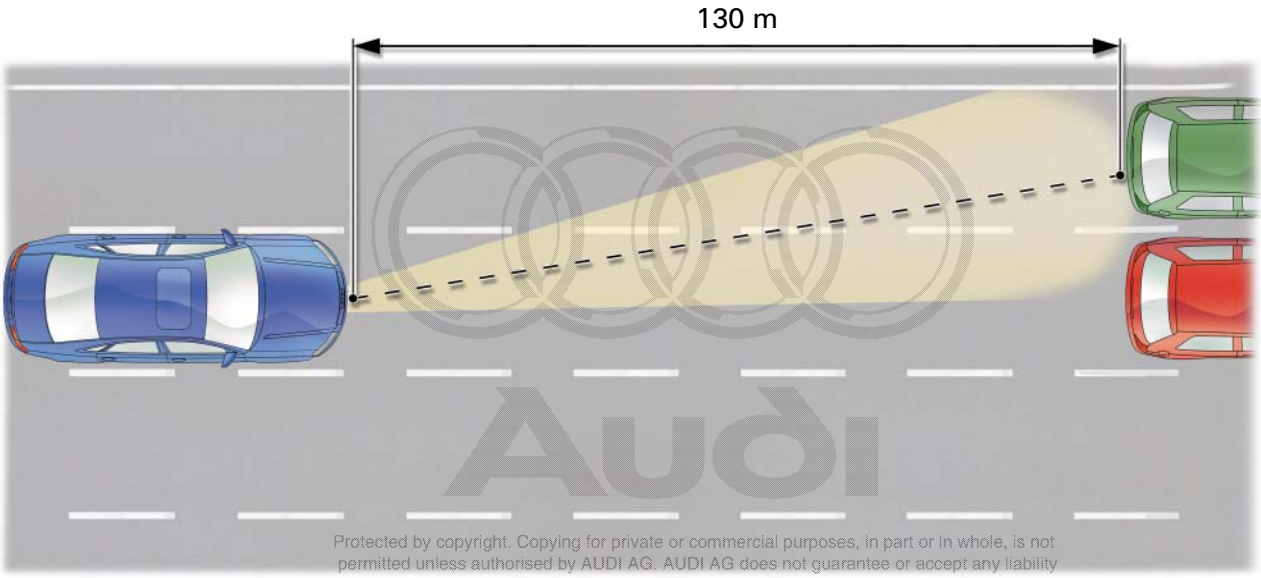
= Drive system CAN

Notes

Setting of distance control sender

The following example illustrates the need for precise sender setting.
The radar signal range for detection of a vehicle travelling in front is approx. 130 m.

A horizontal deviation of only 1 degree from the correct sender installation position already results in a deviation of approx. 2.1 m at a distance of 130 m. In extreme cases this would lead to regulation of the distance from the vehicle in front in the adjacent lane.



289_039

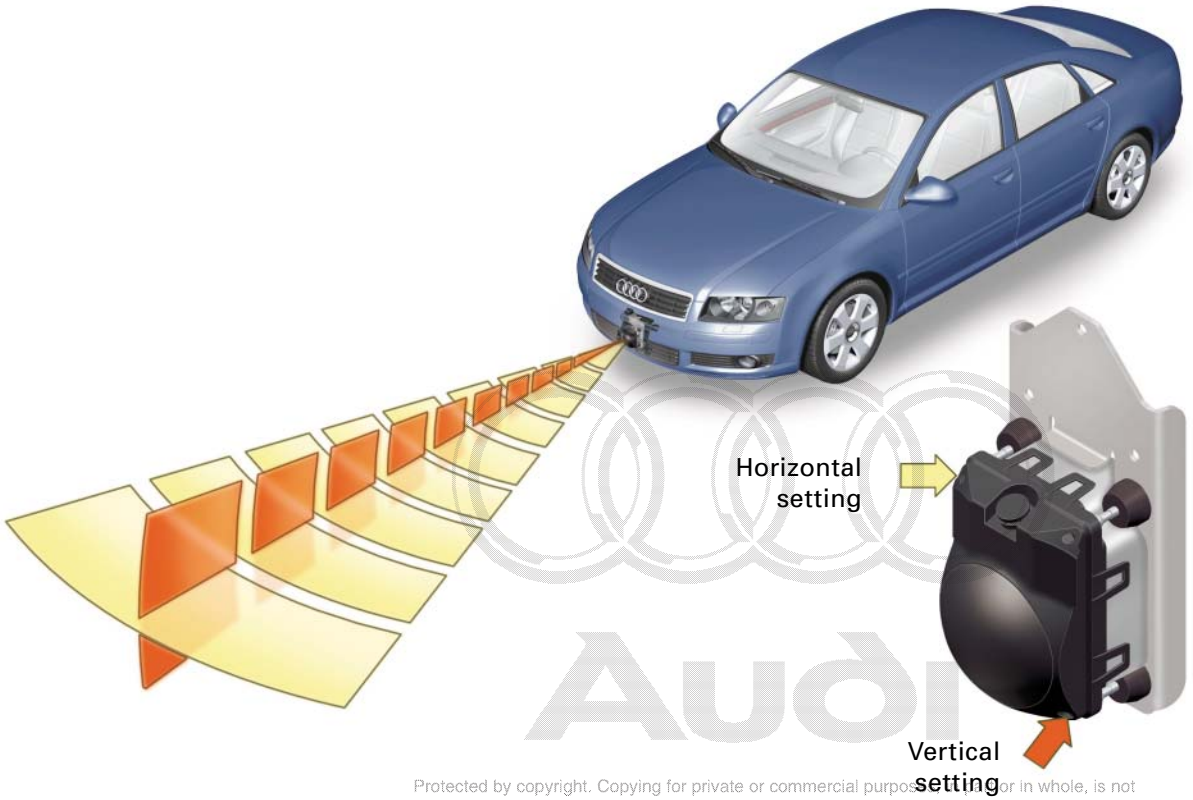
Mechanical setting of the distance control sender is absolutely essential following:

- Changes to running gear setting at rear axle
- Replacement of sender, sender holder, bumper cross member and front end
- Damage (e.g. after collision)

For detailed information on setting procedure, refer to relevant Workshop Manual.

Setting procedure:

Setting is performed on wheel alignment equipment.
Refer to Workshop Manual for details.



289_049

Diagnosis

Operation of all adaptive cruise control system components is constantly monitored. Any faults occurring are stored in the fault memory.

The fault memory can be read out and assisted fault-finding performed using the tester VAS 5051. Detailed information can be found in the relevant Workshop Manual.

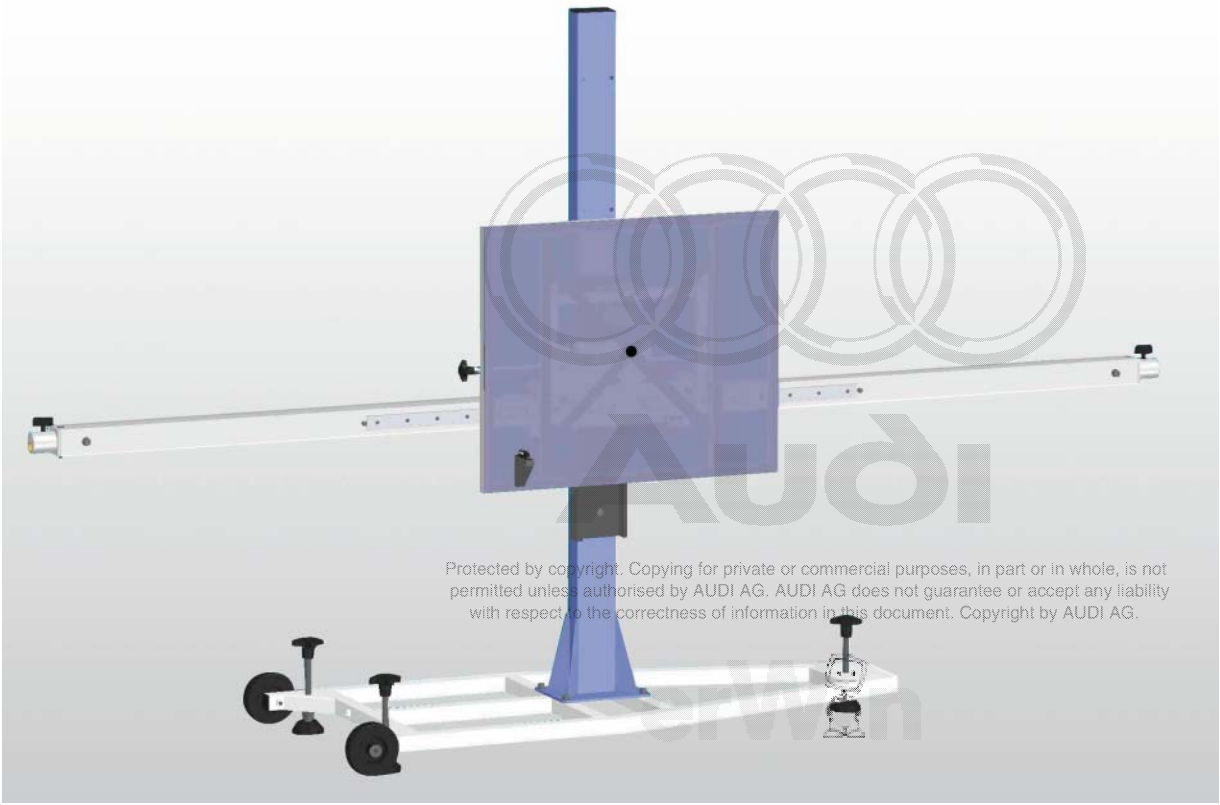
Special tools

Two new special tools are available for setting the distance control sender.

Gauge VAS 6190/1 is used for rough setting.

Precision setting is made with setting tool VAS 6190 (see Fig.).

Refer to Workshop Manual for details.



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