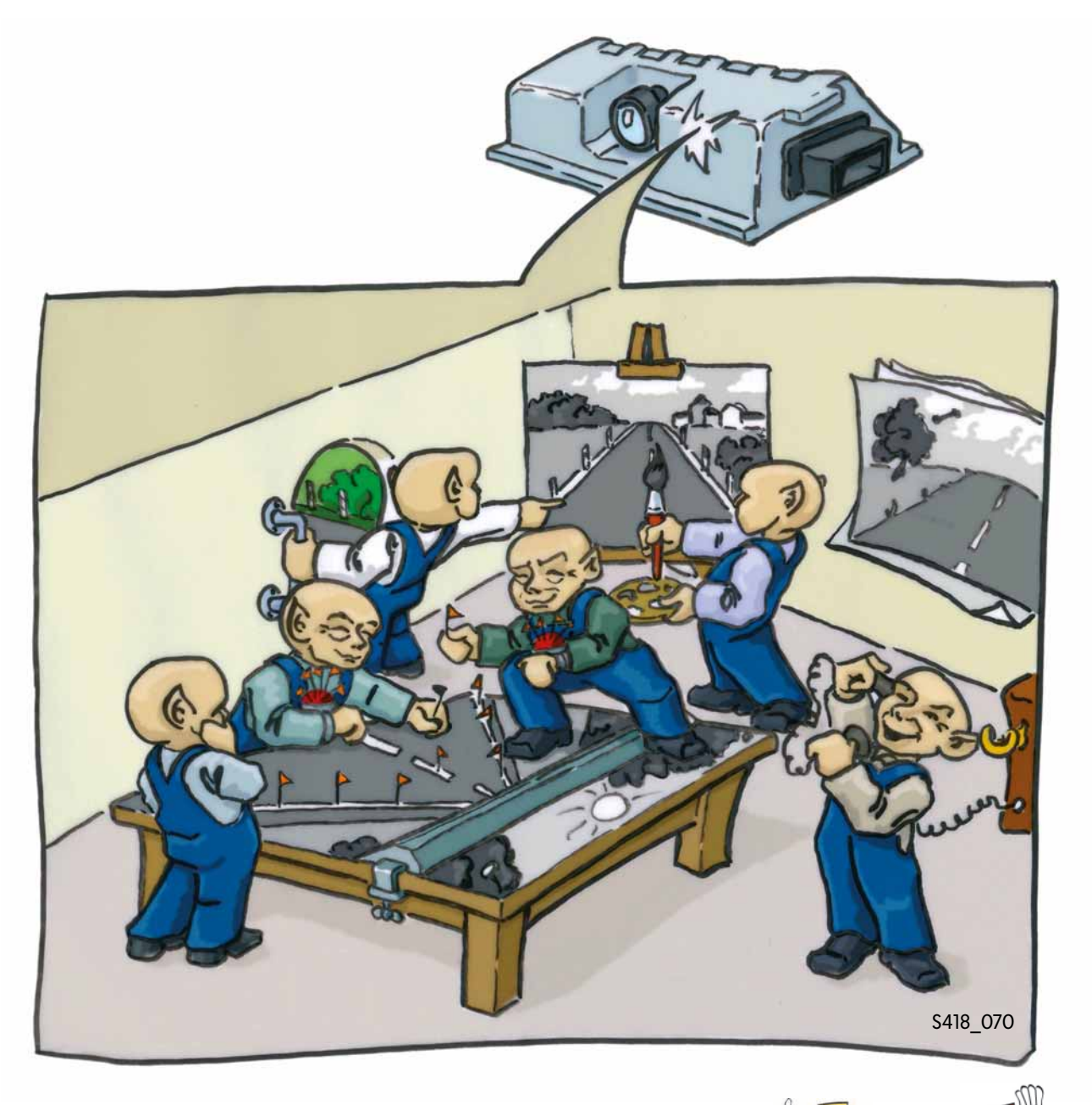
Service Training

Self-study Programme 418

The Lane Departure Warning System
Design and Function

The lane departure warning system from Volkswagen is another progressive assistance system, which is intended to provide the driver with support in controlling the vehicle in critical situations. Based on the evaluation of optical data, it recognises the course of the road and actively intervenes with the steering when the vehicle threatens to drive over the centre or outer lane markings.



The self-study programme portrays the design and function of new developments!
The contents will not be updated.

For current testing, adjustment and repair instructions, refer to the relevant service literature.

NEW

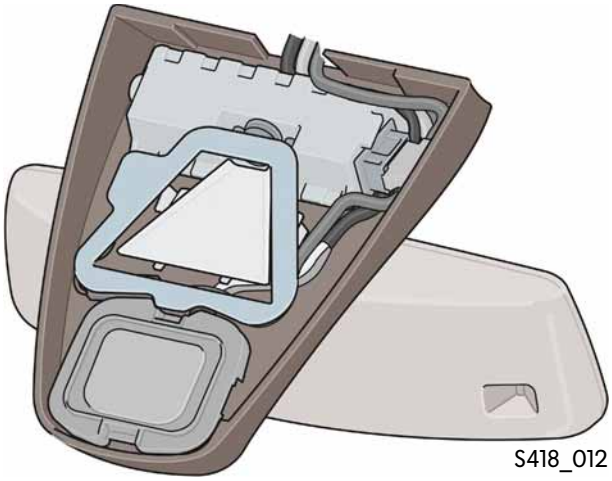
Attention Note

Contents

Overview

Driver assistance systems

Based on rapid developments in the field of computer technology, the classic brake systems such as for example the ABS system have been developed into increasingly complex and functional safety systems such as the ESP system.
The introduction of the electromechanical power steering system and the electronic throttle opened up further possibilities for directly and actively intervening with the vehicle's driving behaviour, further increasing driving safety and assisting the driver in difficult driving manoeuvres.


S418_012

As these new functions provide the driver with physical and mental support, they are now called driver assistance systems.
In addition to the lane departure warning system from Volkswagen, further systems such as

- the Park Assist system with parking function,
- the Adaptive Cruise Control system ACC or
- the Lane Change Assist system are also available.

Important note

Despite the modern technologies and the possibilities which these offer in automotive engineering, it is vital to remember that the driver of a vehicle still bears sole responsibility for their vehicle and its behaviour.
Accidents as a result of excessive and inappropriate speeds, due to alcohol, drugs or fatigue cannot be prevented or ruled out with the aid of electronic systems alone; in the final analysis, this can only be achieved by eradicating the causes.
There are no grounds whatsoever for deriving reduced culpability or even legal rights from driver assistance systems.

This must be made perfectly clear to all parties involved in sales and the core service process, and must also be communicated to the customer in order to prevent false expectations.

The lane departure warning system from Volkswagen

The lane departure warning system integrates functions into automotive technology which were previously found only in the realm of living beings or ambitious robotics research projects:

- the optical perception of a situation (seeing),
- the evaluation of this situation (thinking) and
- the reaction to this situation (acting).

Operation of the lane departure warning system is primarily intended for driving on motorways and well-developed highways, as clear lane markings and lane demarcations can be more easily recognised on these.
However, use of the system within its performance limits on rural or local roads is also basically possible.

In the following, we intend to familiarise you with the technology required for this and the system behaviour together with its possibilities and limits.

The lane departure warning system offers the following:

- Recognition of the course of the road if demarcation lines are present or the contrast between the lane and the lane demarcations is sufficiently high.

- Provision of optical information to the driver on the lane departure warning system's operating status.

- Execution of corrective or supporting steering intervention.

- Output of a perceptible warning vibration to the driver if the lane departure warning system's steering intervention is not sufficient to correct lane departure.

- Output of an optical and acoustic warning to the driver if the steering wheel is released by the driver in excess of a defined period of time (no hands recognition).

- Suppression of system functions on intentionally changing lanes, for example in the case of an overtaking manoeuvre.

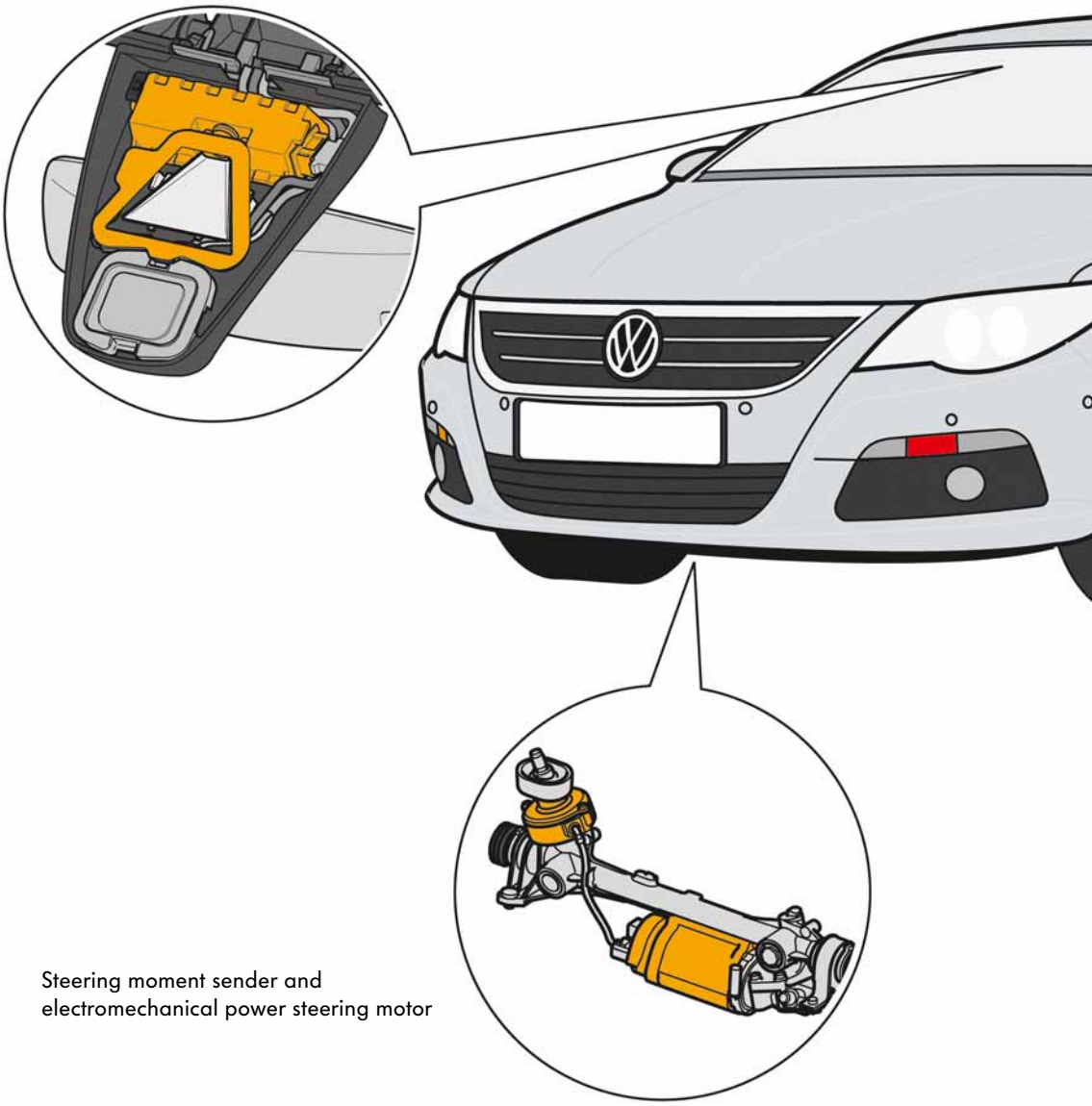
Design of the lane departure warning system

Overview of lane departure warning system components and their locations

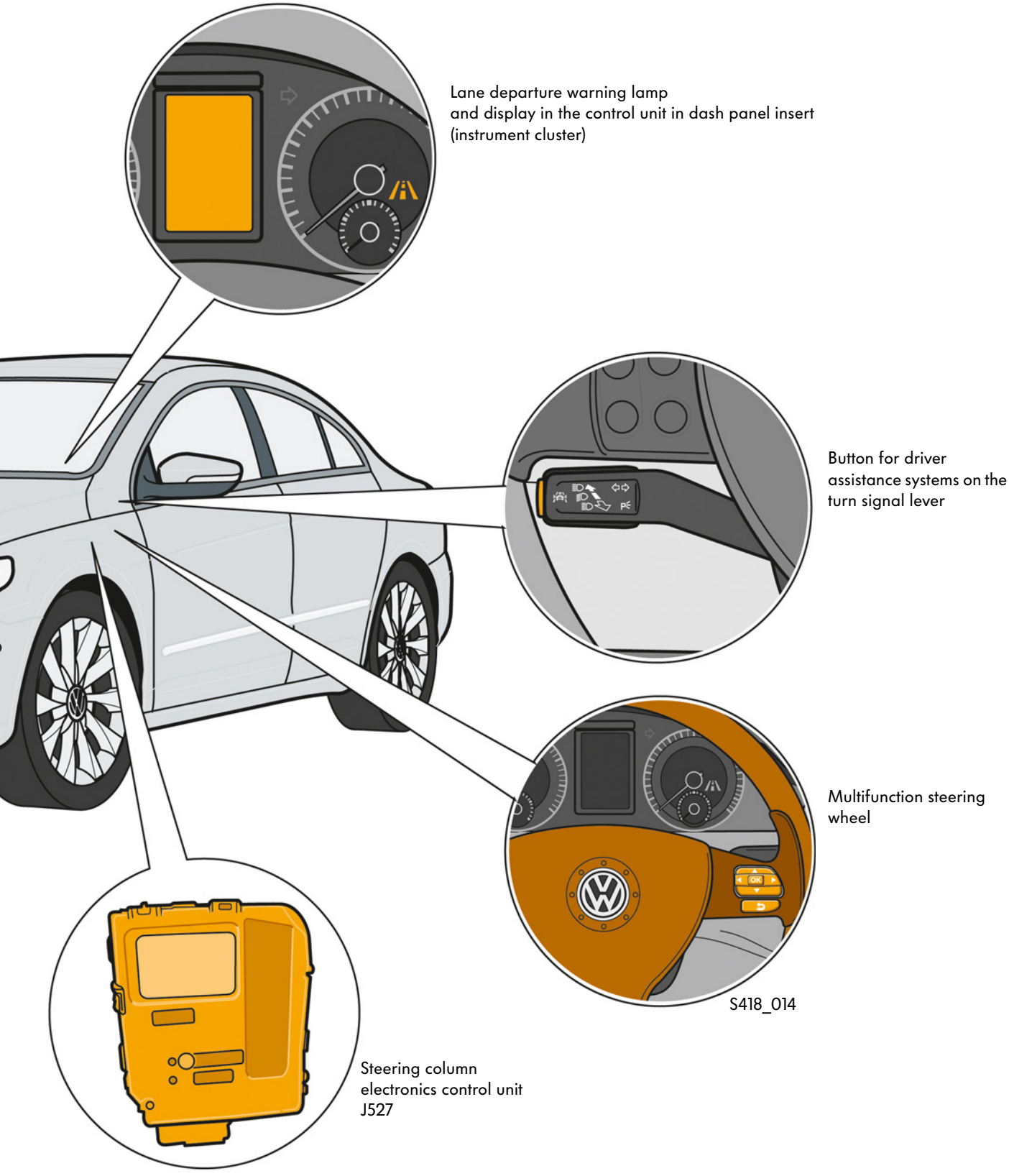
The lane departure warning system has been implemented using only a few new components, as the system makes use of numerous other vehicle systems' sensors, actuators and control units in order to carry out its functions.
The only components exclusive to the system are:

- the lane departure warning control unit J759
- the lane departure warning lamp K240
- the windscreen heater for lane departure warning Z67.

Control unit and windscreen heater for lane departure warning beneath the enlarged interior rear-view mirror base designed cover



Steering moment sender and electromechanical power steering motor


Lane departure warning lamp
and display in the control unit in dash panel insert
(instrument cluster)
Button for driver
assistance systems on the
turn signal lever
Multifunction steering
wheel
S418_014
Steering column
electronics control unit
J527

Design of the lane departure warning system

System layout

The high degree of networking and the use of existing vehicle components are revealed in the lane departure warning system's layout.

Legend

Lane departure warning system

J759 Lane departure warning control unit

K240 Lane departure warning lamp

Z67 Windscreen heater for lane departure warning

a Grey scale camera in the lane departure warning control unit

Electromechanical power steering system

G269 Steering moment sender

J500 Power steering control unit

V187 Electromechanical power steering motor

Dash panel and steering column electronics

E2 Turn signal switch
E617 Button for driver assistance systems

H3 Buzzer and gong

J119 Multifunction display
J285 Control unit in dash panel insert
J527 Steering column electronics control unit

Brake system

F Brake light switch

J104 ABS control unit

b Speed sensors on the wheels
c Available traction control systems, for example ESP

Engine management

G28 Engine speed sender
G79 Accelerator position sender

J623 Engine control unit

Cruise control

G550 Sensor for automatic distance control

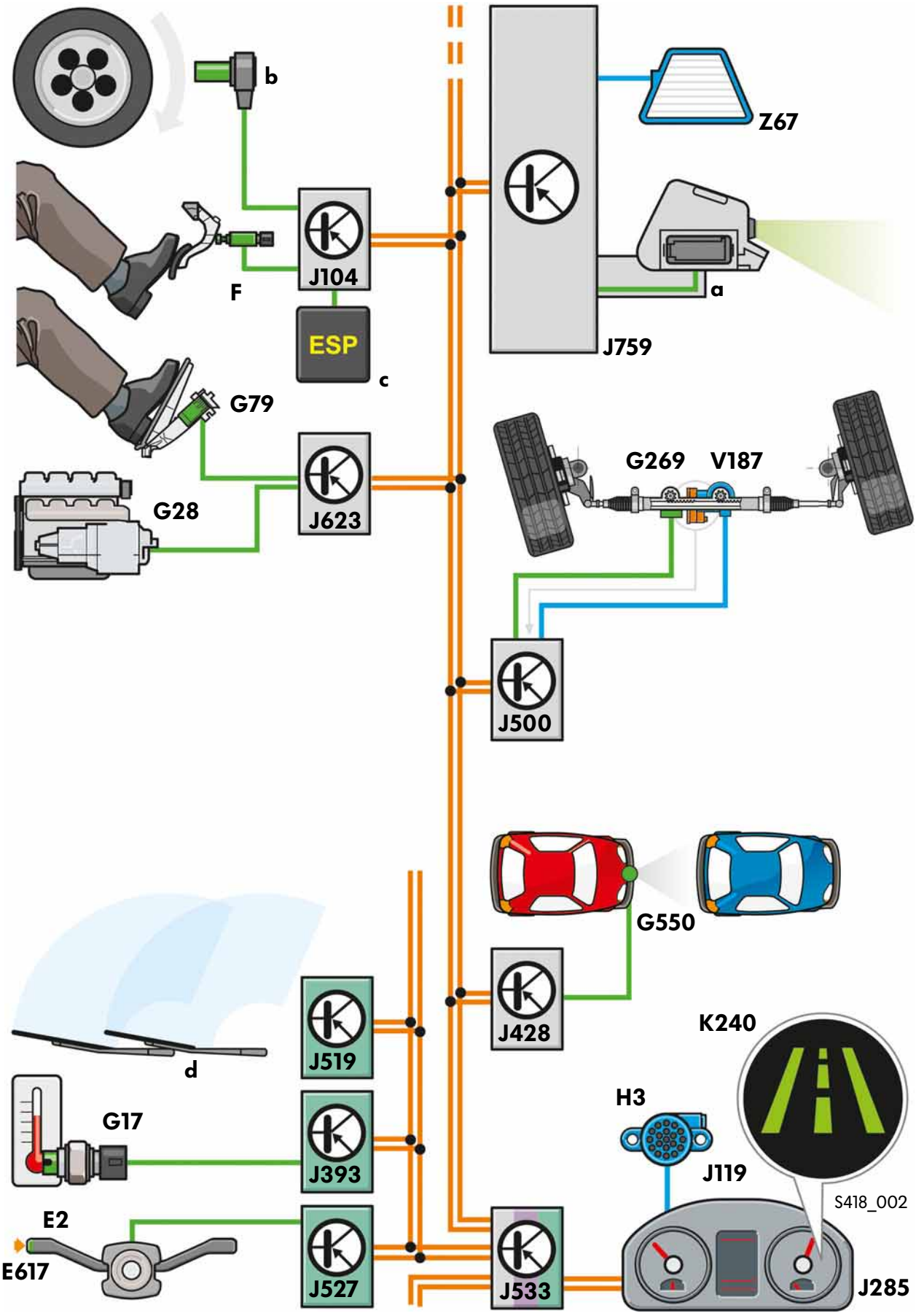
J428 Adaptive cruise control unit

Further components

G17 Ambient temperature sensor

J393 Convenience system central control unit
J519 Onboard supply control unit
J533 Data bus diagnostic interface

d Windscreen wiper functional readiness


b
Z67
J104
F
ESP
c
J759
a
G79
G269
V187
G28
J623
J500
G550
J428
K240
J519
d
H3
G17
J393
J119
S418_002
E2
E617
J527
J533
J285

Functional principle of the lane departure warning system

System behaviour

Switching on and off

The lane departure warning system is switched on and off with the button for driver assistance systems E617 on the face end of the turn signal lever.
If the button is pressed briefly, a list appears in the display in the control unit in dash panel insert.
The "Lane Assist" entry for the lane departure warning system, can be selected by navigating with the up/down buttons on the multifunction steering wheel or at the button.
Briefly clicking onto the OK button switches the lane departure warning system on or off.

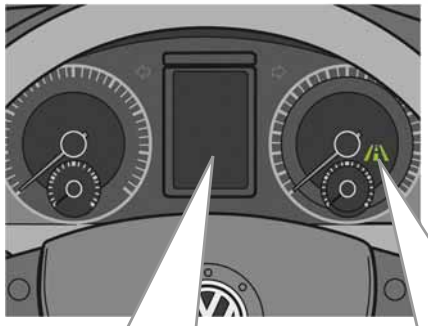
If the button is held down for more than 2 seconds, the lane departure warning system and stopping distance reduction system 2 (Front Assist) are switched on or off together. The Adaptive Cruise Control system (ACC) must be switched on/off separately.
Alternatively, the lane departure warning system can also be activated and deactivated via the settings menu.

Vehicle operation

On switching on, the lane departure warning system begins to register and evaluate the course of the road in front of the vehicle via the camera installed in the lane departure warning control unit.

In this case, the lane departure warning control unit attempts to determine the road demarcations, the centre marking and the vehicle's own position on the lane from the incoming optical data. If the system succeeds in registering this information within the system limits, the lane departure warning system remains set to active mode.
If this is not the case, the lane departure warning system switches to passive mode.
The current mode is indicated via the lane departure warning lamp.

S418_006



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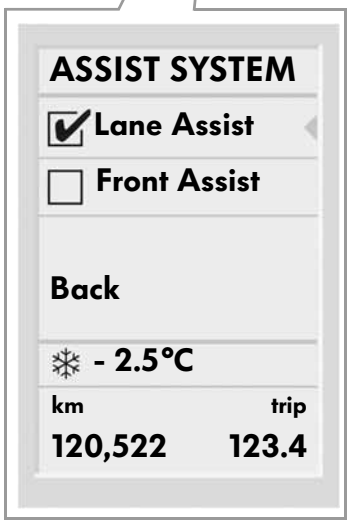

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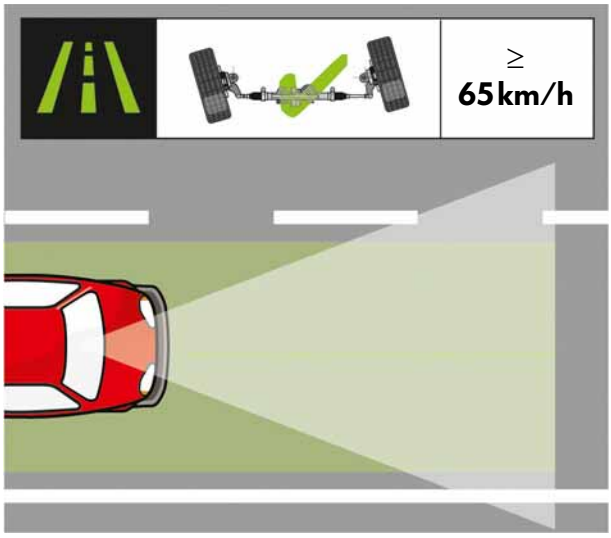
S418_009

Lane departure warning lamp

Selection menu in the dash panel display



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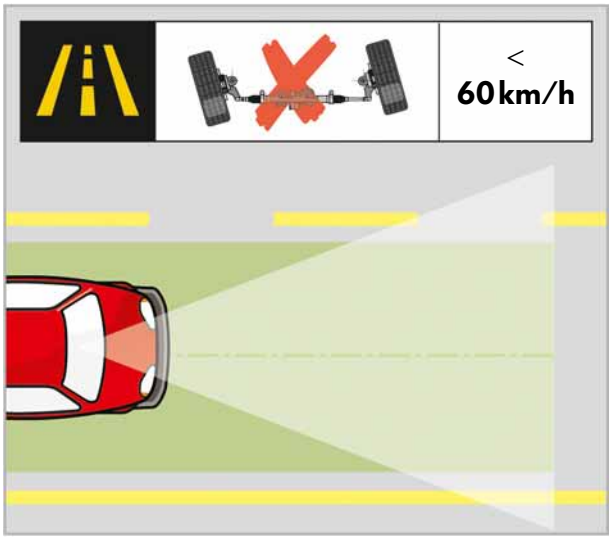


S418_016

System readiness
corrective steering torque,
steering intervention
calculated lane

As of a speed of 65 km/h, the system can be switched to active mode. At a speed of less than 60 km/h, the lane departure warning system switches to passive mode.

Lane departure warning system active mode

In active mode, the course of the road is registered and corrective steering torque is controlled via the eletromechanical power steering drive if the vehicle threatens to depart from the calculated lane.
Active mode is indicated by the green lane departure warning lamp in the dash panel insert lighting up.

Lane departure warning system passive mode

In passive mode, the road continues to be registered by the camera and evaluated by the system, in order to switch back to active mode on detection of a clear lane demarcation or when all of the necessary boundary conditions are met. The warning lamp indicates to the driver that the lane departure warning system is currently in passive mode and that no corrective steering intervention or warning take place.

If departure from the lane takes place intentionally, for example on overtaking or turning off, the lane departure warning system is temporarily switched to passive mode by actuating the turn signal. It switches back on automatically when the turn signal is switched off and a clear lane demarcation can be recognised again.

Passive mode is indicated by the yellow lane departure warning lamp in the dash panel insert lighting up.

Functional principle of the lane departure warning system

Lane departure warning function on a straight road

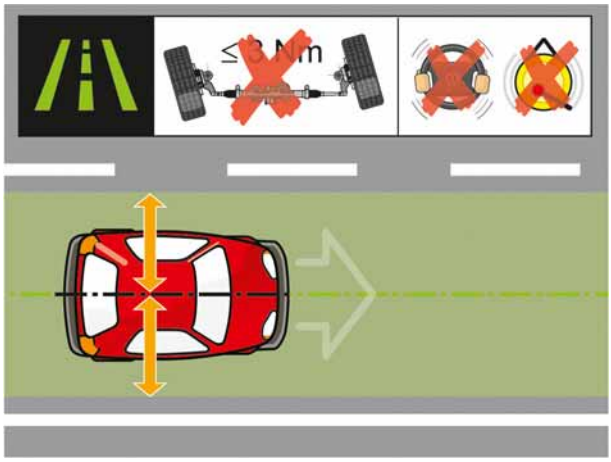
The lane departure warning system uses the detected road markings to calculate a virtual lane on which the vehicle is permitted to move. The system additionally determines the vehicle's own position in relation to the course of the virtual road.

If the vehicle threatens to depart from the virtual lane, the lane departure warning system uses a corrective steering torque, a maximum of 3Nm, which counters the vehicle's deviating movement and is implemented by the electromechanical power steering. The intensity of this corrective intervention is oriented towards the angle at which the vehicle is moving towards the recognised lane demarcation.

Steering correction lasts for a maximum of 100 seconds and is ended if the vehicle follows the course of the road again within this period of time.

This corrective intervention can be "overridden" by the driver at any time by means of an active steering process without any great effort, for example if a lane change is intended, without activating the turn signal.

If the corrective steering torque is not sufficient to remain in the lane, steering wheel vibration is generated via the electromechanical power steering motor. The driver is able to feel this as a warning on the steering wheel.



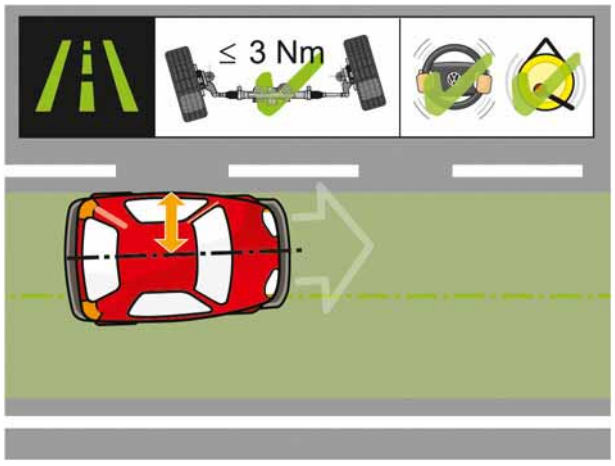
S418_018

Vehicle longitudinal axis

Lateral orientation of the vehicle longitudinal axis and the edge of the virtual lane

Virtual lane

Warning vibration and electronic warning sound

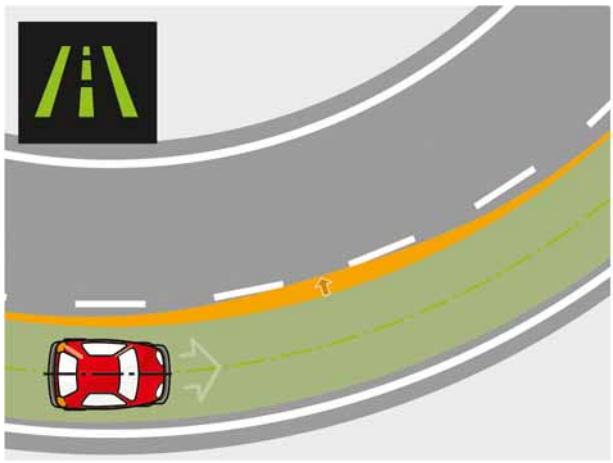


S418_020

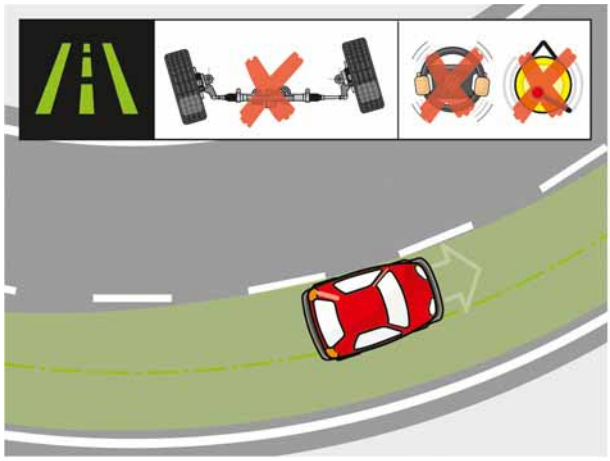
Lane departure warning system function on cornering

Even on long curves, i.e. in the case of large curve radii, the lane departure warning system is able to counter departure from the calculated lane.

In this case, this virtual lane is laid out by the lane departure warning system in such a way that the inner, virtual lane demarcation extends to the real, inner lane marking which is detected.
This enables the driver to cut the corner slightly without the lane departure warning system's intervening to correct the movement.

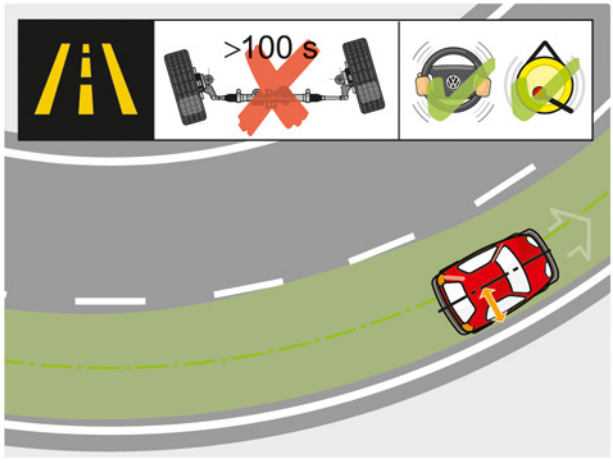


The calculated lane is extended to the inner side. S418_025



The driver is also able to cut the corner when the lane departure warning system is active. S418_026

If the maximum correction period of 100 seconds is not sufficient to keep the vehicle in the curve, the vibration alarm and the electronic warning sound are output, and a text message appears in the dash panel insert display, requesting the driver to take over the steering process.



If the maximum correction period is exceeded, the driver is warned. S418_027

Functional principle of the lane departure warning system

Lane recognition

Boundary conditions

Various internal system and ambient criteria must be met so that the lane departure warning system can switch to active mode:

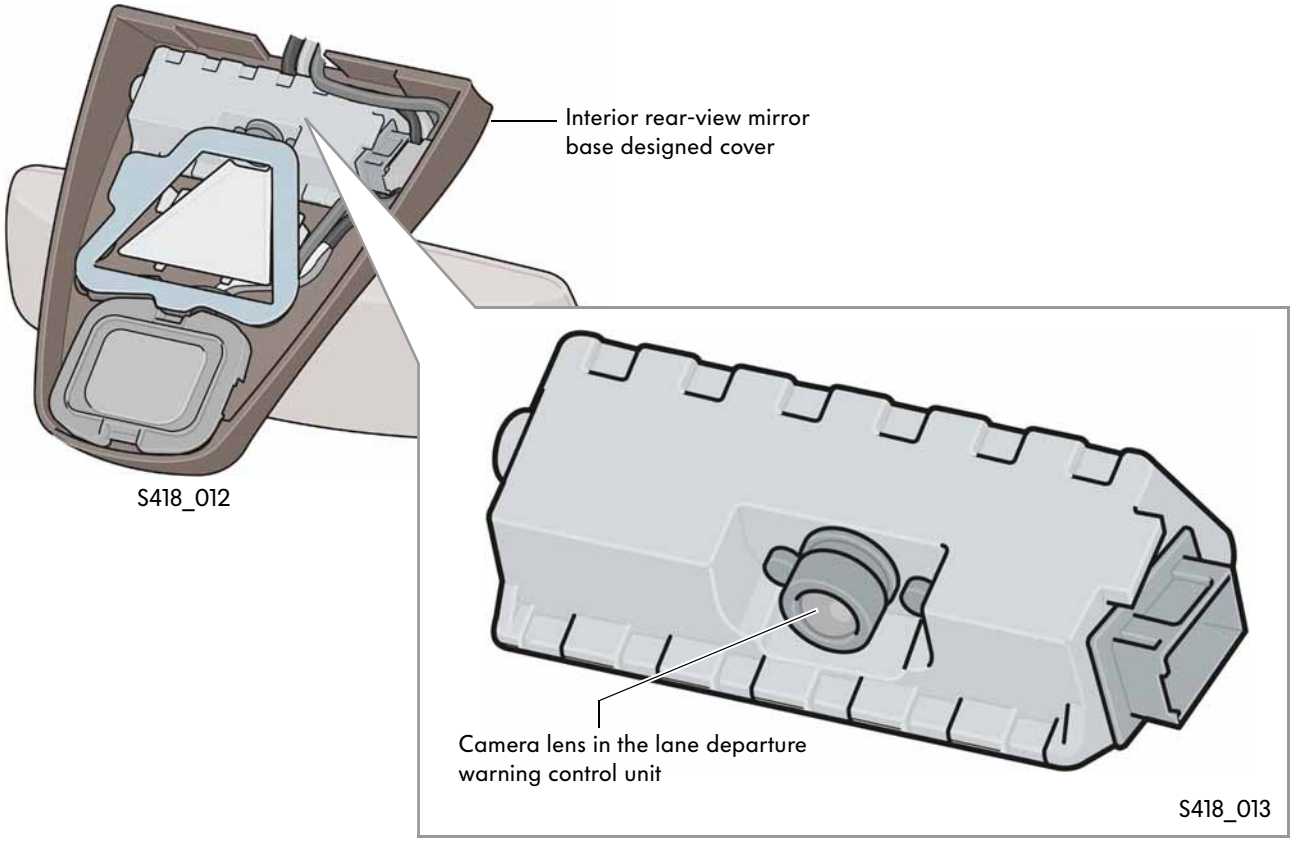
Internal system criteria

- The lane departure warning system is switched on and functional.
- The conditions for electrical operation are met (minimum voltage, unit temperature).
- Communication with the involved systems via the CAN data bus is given (for example ABS/ESP system, eletromechanical power steering, convenience system, engine management, control unit in dash panel insert, ...) and the systems are working.
- ESP must be switched on.
- The lane departure warning system camera is ready to operate.
- The windscreen heater for lane departure warning is functional.

Ambient criteria

- The recordable lane width lies between 2.45 and 4.60 metres.
- The lane markings or lane demarcations can be recognised by the lane departure warning system camera.
- The camera's lens area on the windscreen is not soiled or iced over.
- The distance between two successive lane marking stripes which are detected may be a maximum of twice the length of the marking itself.

Example:
If the system has clearly recognised a marking within a range of 5 metres, it accepts a subsequent range of 10 metres in which no marking can be recognised. Only if this tolerance range is exceeded does the lane departure warning system switch to passive mode.



Camera

In addition to the complex processing operations which the control unit has to carry out, the camera in the lane departure warning system module is an important part of the lane recognition system.
The module, consisting of the camera and control unit, plus a windscreen heater for lane departure warning, are housed beneath an enlarged designed cover, which also conceals the base of the interior rear-view mirror.

The camera is used to record and digitise the road within a range of 5.5 to 60 metres in front of the vehicle.

It is a grey scale camera with a resolution of 640 x 480 pixels. Each digital image therefore consists of 480 lines and each line of 640 picture elements. The colour gamut (COLOUR DEPTH) which can be recorded by the camera amounts to 4096 grey scales.

For comparison purposes:
The human eye can only distinguish between 100 to 120 grey scales.

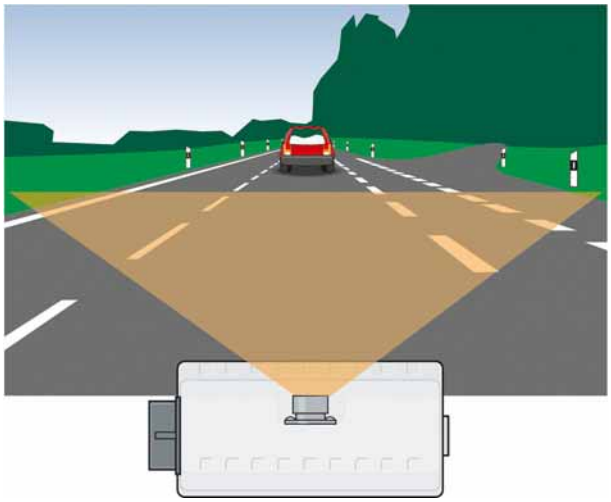
Image recording is carried out with an IMAGE RATE of 25 images per second, in order to have sufficient images available to calculate the virtual lane even at higher speeds.

For comparison purposes:
The human eye is able to perceive a maximum of 9 images per second as independent images. Over and above this, it perceives the images in distorted form or as a moving film.

Functional principle of the lane departure warning system

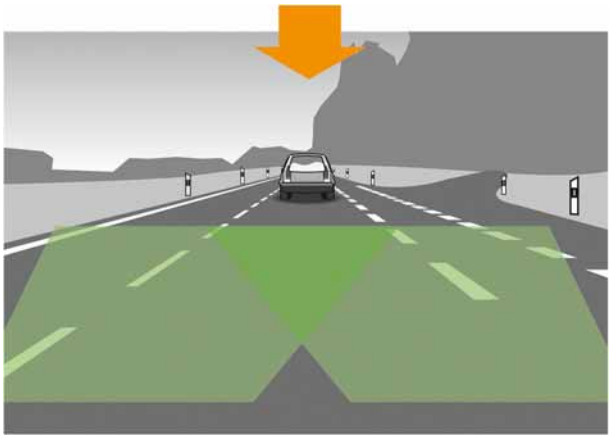
Lane recognition sequence

Each incoming digital image which the camera records is examined almost in real time by the lane departure warning system's processor for extensive leaps in the grey scale value, such as those caused by a white centre stripe on a dark asphalt covering.

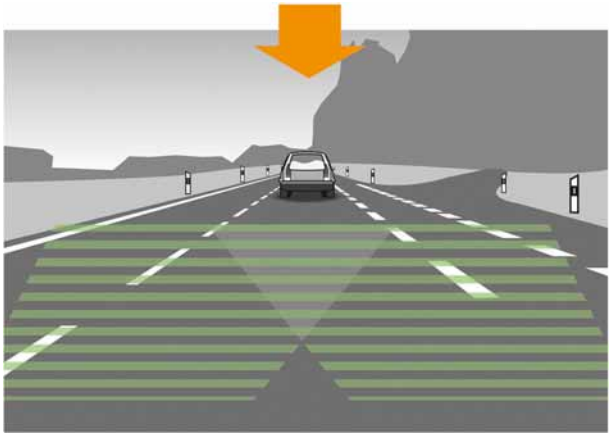


Digitisation

To reduce the processing time, the lane departure warning system restricts itself, when evaluating the images, to two trapezoidal image areas on the left and right halves of the image, in which lane markings are to be recognised. In addition, not each of the 480 image lines, but only a selection of lines within the detection range, is evaluated.
This method, together with the processor's high performance, is able to guarantee that evaluation is carried out quickly enough, even at higher speeds, to recognise the course of the road.

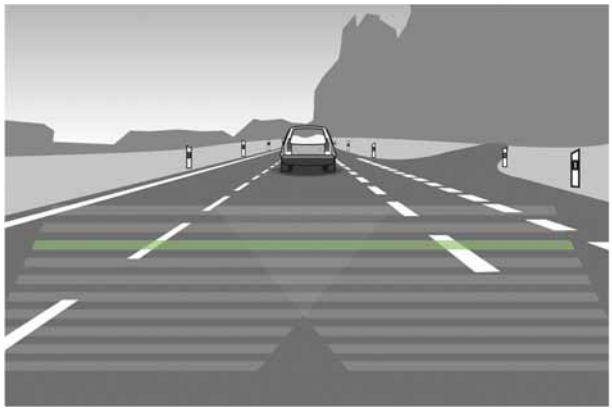


Selection of the trapezoidal detection ranges



Selection of defined lines in the trapezoidal detection range

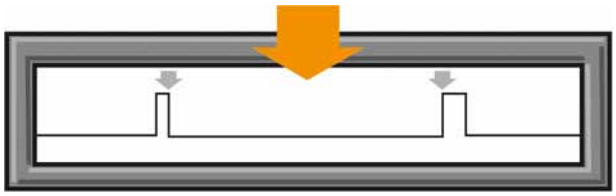
S418_028, _029, _030, _030a



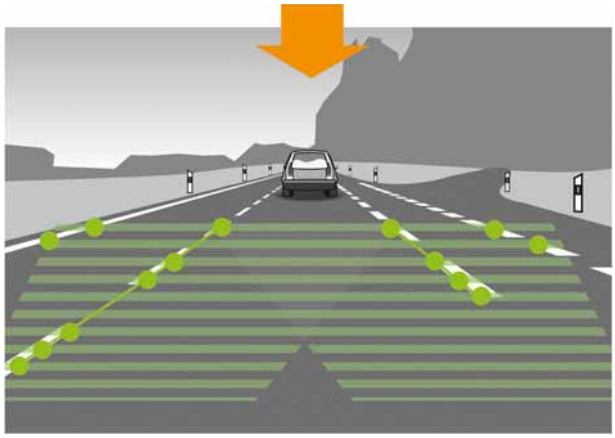
Evaluation of individual image lines

If the evaluation programme finds one or more extensive grey scale values increase in the selected lines, the system sets a detection or marking point at each of these locations.
Several marking points may therefore occur in one line.

However, the inner points are only used to calculate the vehicle's own lane if these can be enhanced from line to line to form a continuous, virtual line corresponding to the real lane marking or lane demarcation.



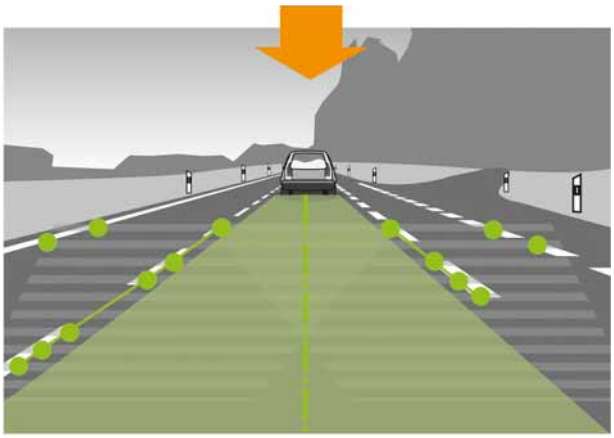
Detection of grey scale value leaps



Definition of marking points
for the true course of the road

If sufficient marking points, which can be enhanced to form a continuous line, can be set, the lane departure warning system uses the marking points which have been found to calculate the true course of the road.

The lane departure warning system uses the detected course of the road, integrating its internally defined functional and safety limits, to form the virtual lane.



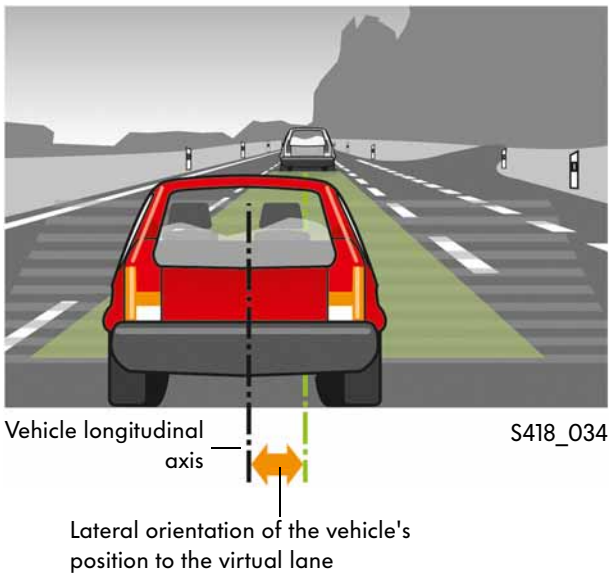
Definition of a virtual
lane from the marking points

S418_031, _031a,
_032, _033

Functional principle of the lane departure warning system

Using the image data which has been determined, the lane departure warning system now calculates the vehicle's lateral orientation to the virtual lane.
If the vehicle approaches or crosses this virtual lane, steering correction is implemented by the lane departure warning system.

If the grey scale value differences in the digital image are too slight or there are not enough marking points, from which the system can determine the course of the road, can be set, the lane departure warning system switches to passive mode, in which no warning or steering correction occurs. However, it continues to evaluate the incoming images in order to immediately reactivate itself when a lane demarcation can be clearly recognised.

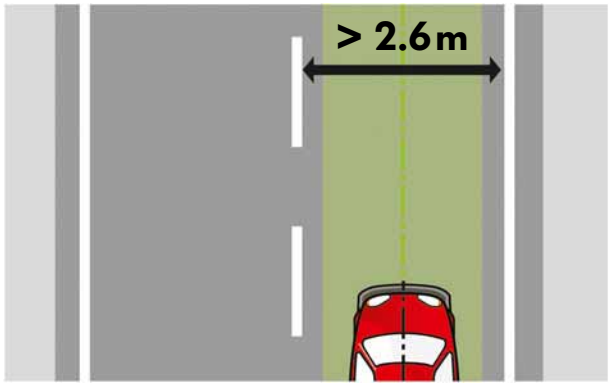


S418_034

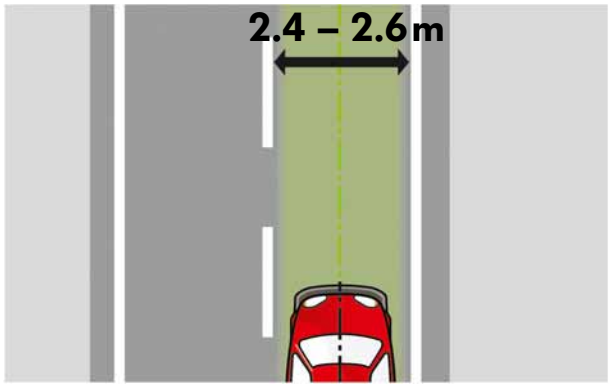
Calculation of the virtual lane

The boundary conditions for calculating the virtual lane are flexible and are oriented towards the width of the road.

If, for example, the system detects a road width of at least 2.6 metres, a safety margin area of forty centimetres is deducted from the real road demarcation which has been detected. If the detected road is narrower than 2.6 metres, the safety margin area to be deducted is continuously reduced as the width of the road decreases. If the width of the road falls below 2.4 metres, the lane departure warning system switches to passive mode.

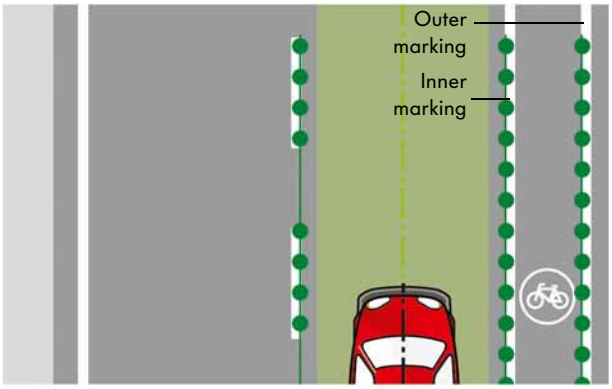


Calculation of the virtual lane on wide roads; safety margin area is deducted.



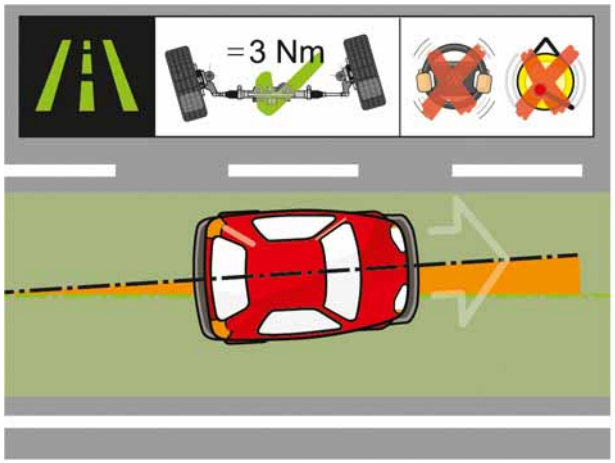
Calculation of the virtual lane on narrow roads; safety margin area is continuously reduced.

S418_035, _036



Use of the detected inner markings to calculate the virtual lane

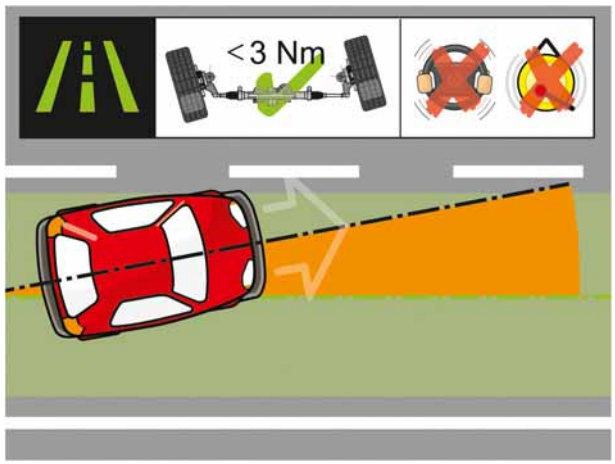
If several parallel markings are found on the road, for example in construction work areas or in the case of cycle paths at the sides, the system uses the inner marking which has been detected if it can be used to calculate a sufficiently wide virtual lane. If this is not the case, the lane departure warning system uses the next outer marking.



Slowly approaching the virtual lane's demarcation corresponds to a flat angle.

Calculation of the necessary corrective torque of max. 3Nm is also dynamic and is oriented towards the angle at which the vehicle is moving towards the recognised, virtual lane demarcation.
The lane departure warning system uses the vehicle's own longitudinal axis and the centre of the virtual lane to calculate this angle.

If the vehicle moves towards the lane's demarcations at a flat angle, the maximum torque of 3Nm is applied to correct the course. If, however, the driver wishes to depart from the lane and therefore cross the lane's demarcation, a countersteering torque is sufficient to override the corrective steering intervention.



Rapidly approaching the virtual lane's demarcation corresponds to a sharp angle.

If the vehicle moves towards the lane's demarcations at a sharp angle, the system concludes for example that the driver consciously wishes to depart from the lane without setting the turn signal. In this case, slight steering torque is sufficient to override the corrective torque.

S418_037, _038, _039

Functional principle of the lane departure warning system

No hands recognition

In addition to monitoring the vehicle's lane behaviour, the lane departure warning system also monitors whether the driver has released the steering wheel for a defined period of time and is not therefore ready to steer, for example in the case of fatigue or distracting, additional activities.

To achieve this, the lane departure warning system uses the electromechanical power steering's sensors, as explained in the following two examples:

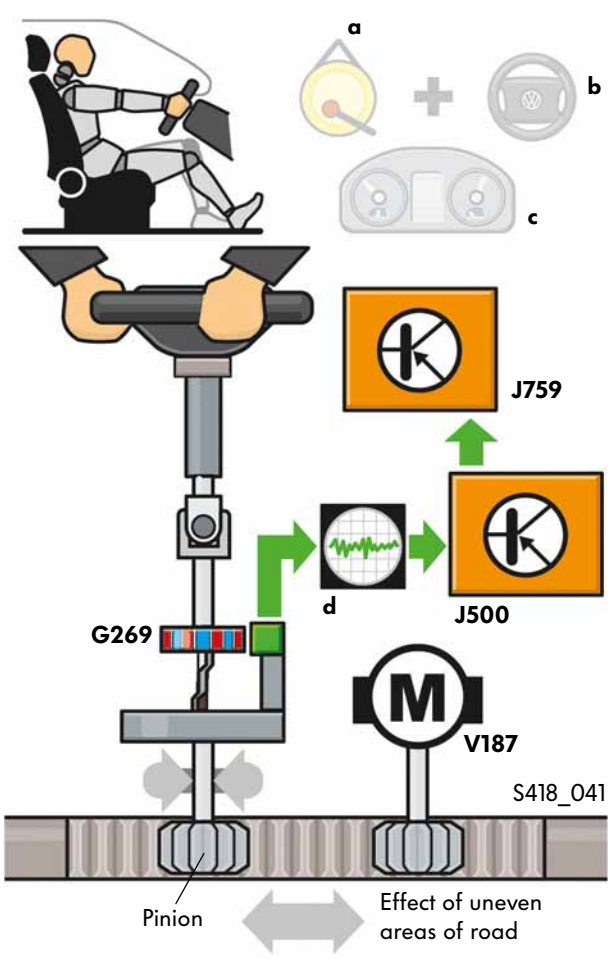
In a moving vehicle, uneven areas of road cause forces to act on the front axle; these are absorbed by the steering mechanism.

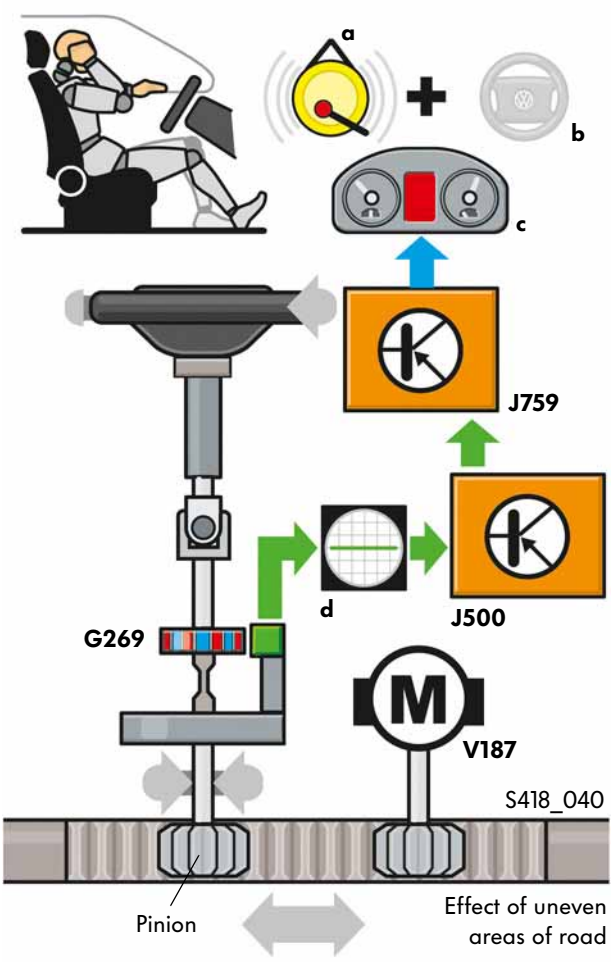
Example 1
The driver is ready to steer and has gripped the steering wheel with at least one hand.

The above described forces lead to the fact that constantly changing torques act on the lower end of the torsion bar via the steering column's pinion, thereby attempting to misadjust the steering column by a small degree.

As the driver is gripping the steering wheel, the upper end of the torsion bar is fixed. As a result of this, the torsion bar is constantly turned slightly to the left and right due to the alternating torques.
These continuous torsion bar rotational angle changes are measured by the steering moment sender and lead, on evaluation of the signals in the power steering control unit, to a constant signal sequence which continues as long as the driver holds the steering wheel and does not consciously move the steering.

The presence of this signal sequence therefore tells the lane departure warning system that the driver has his hands on the steering wheel.





Example 2
The no hands recognition function registers that the steering wheel is not being gripped and warns the driver acoustically and optically.

Legend for examples 1 and 2

G269	-	Steering moment sender
J759	-	Lane departure warning control unit
J500	-	Power steering control unit
V187	-	Electromechanical power steering motor
a	-	Electronic warning sound
b	-	Warning vibration
c	-	Warning message in the dash panel insert display
d	-	Sensor signal

Example 2
The driver does not have his hands on the steering wheel.

If the driver releases the steering wheel, the upper end of the torsion bar is no longer a fixed point. The steering is able to rotate freely up to the steering wheel. In contrast to the first example, the torques caused by the uneven areas of road now no longer lead to constantly alternating rotation of the torsion bar, with the result that the steering moment sender does not register any difference in rotational angle. The signal sequence is absent during signal evaluation.

If the lane departure warning system ascertains that this condition lasts for longer than 8 seconds, an electronic warning sound is output to draw the driver's attention to the risk which may occur by his releasing the steering wheel. In the dash panel insert display, a text message additionally instructs the driver to take over the steering process.

Functional principle of the lane departure warning system

Functional limits

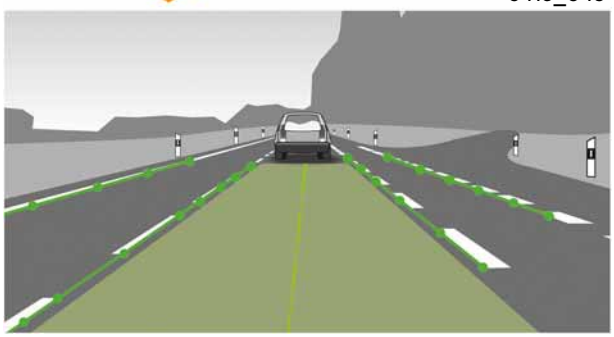
The light and weather conditions and the visibility of the road may lead to situations in which the lane departure warning system is unable to detect a clear road and calculate a virtual lane or in which misinterpretations on the part of the lane departure warning system may occur. In these cases, the lane departure warning system usually switches automatically to passive mode.

The active operating status is only implemented when the system receives clear information, from which the virtual lane can be calculated within the system limits.
Familiarity with these functional limits is necessary to be able to answer customers' questions properly and appropriately.

Influence of the optical condition of the road.

As long as high-contrast delimitation markings are present on the asphalt and the road is not so severely soiled that the markings are difficult to see, the lane departure warning system is usually able to detect a clear road marking and therefore calculate a virtual lane.

S418_043



Road delimitations are detected.

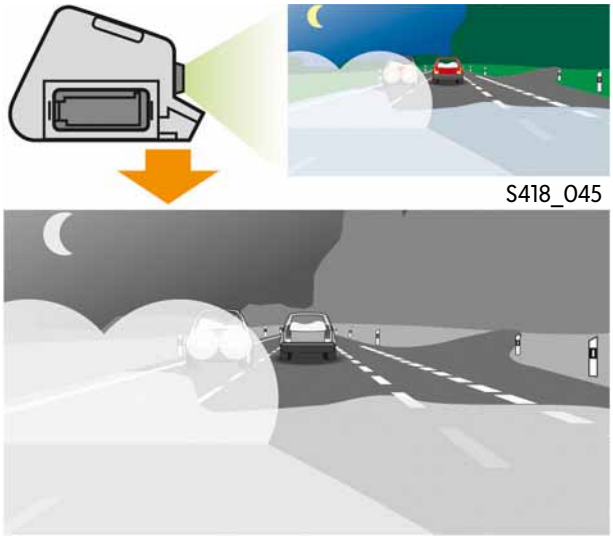
Particularly in mortorway construction, however, concrete is used to surface the road. This then results in a very bright road colour on which the white or even yellow demarcation lines do not stand out extensively.
In this case, the grey scale value difference between the covering and the marking may not be sufficient, particularly under unfavourable light conditions, to enable the marking points to be set clearly.

Border lines between different road surface materials, for example different types of asphalt, may also lead to misinterpretations.

S418_044

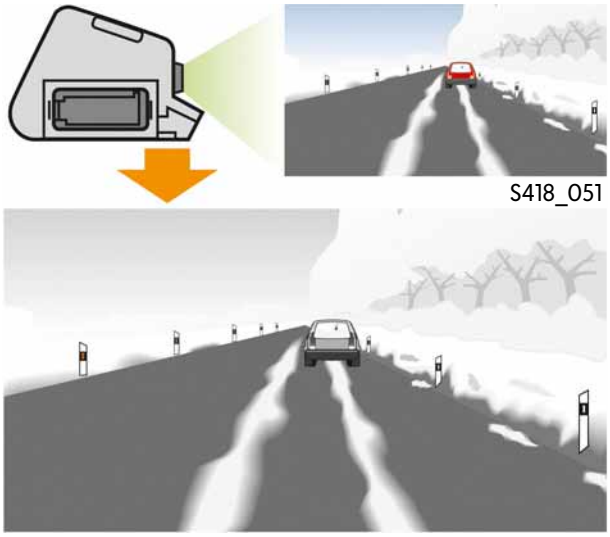
Road delimitations are not detected.

Weather and light conditions



Reflections and dazzling effects prevent detection of the road demarcations and the centre marking.

Particularly on wet road surfaces, light reflections or oncoming vehicles may lead to dazzling effects, in which the brightness value of the marking stripes is blanketed by the dazzling light. Clear determination of the road markings or the road demarcation may also be hampered in this case.
Bitumen joints in the road may also be interpreted as road markings in unfavourable light conditions, leading the system to believe that the road is wider than in reality.



This also applies when the road markings or the sides of the road are covered with dirt or severely covered with snow or ice.

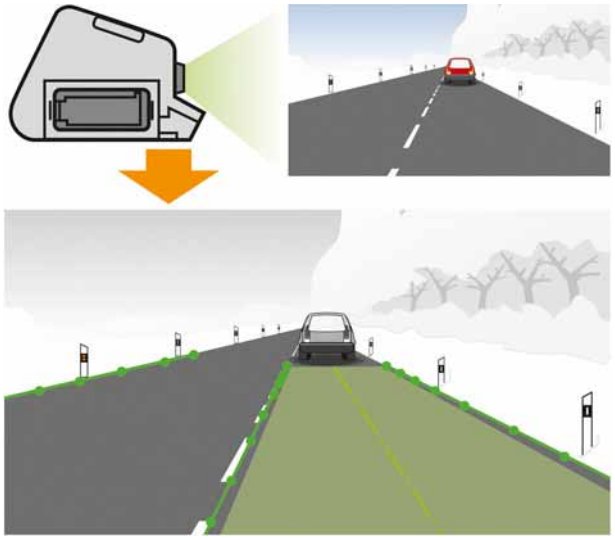
Please note:
The examples portrayed here are borderline situations in which, under the most unfavourable ambient conditions, the above described limitations in the calculation of the virtual lane may occur. However, this is not necessarily the case. If the results obtained from calculation of the virtual lane are implausible to the system, the lane departure warning system switches to passive mode.
However, the examples show very clearly that assessment and reaction on the part of the driver is still an indispensible part of vehicle operation at the current point in time of technical development.

Functional principle of the lane departure warning system

Edge of the road

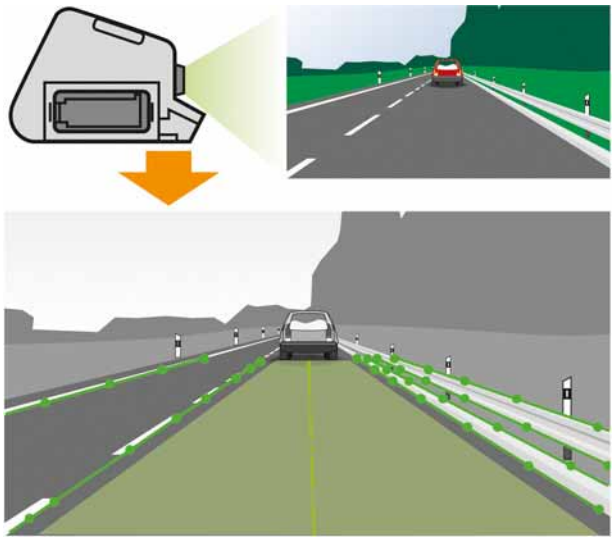
The edge of the road may also influence the lane departure warning system's operating status.

If no outer road markings have been applied, the lane departure warning system may still be able, under certain circumstances, to detect the edge of the road if the difference in brightness between the road covering and the side stripe (for example grass, paving or snow) is clearly distinguishable.

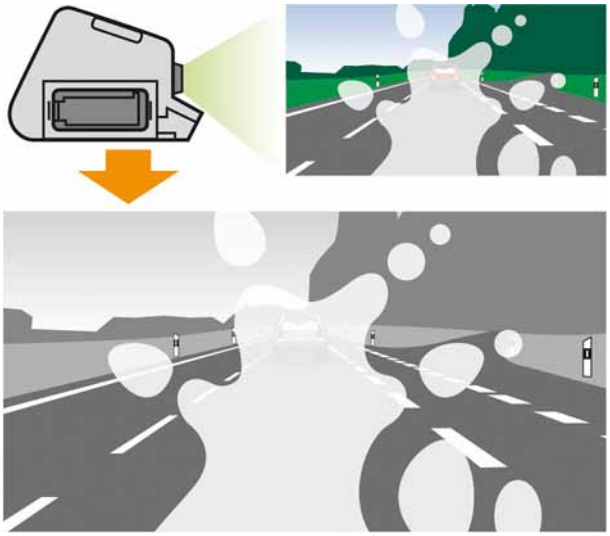


Extensive differences in brightness facilitate detection of the road. S418_046

Curbs or crash barriers can also be recognised as demarcation lines by the lane departure warning system provided that the difference in brightness versus the road covering or the surrounding area is sufficiently high.



S418_052

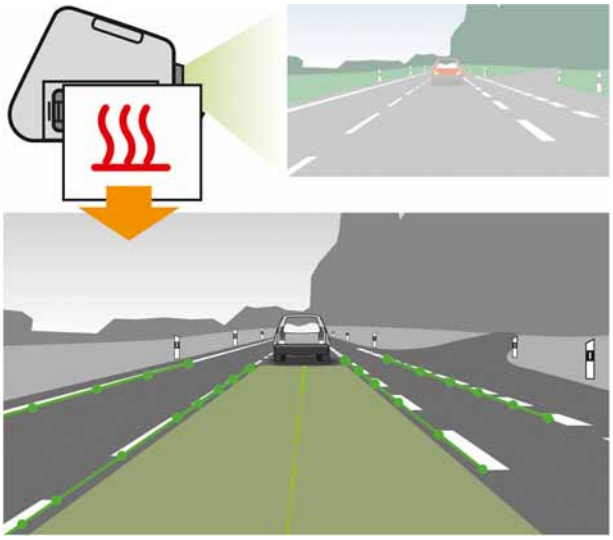


S418_072

Soiled windscreen

If the windscreen is so severely soiled in the camera's visual area that image data recording is permanently limited, the lane departure warning system switches to passive mode with the system message "Lane Assist – no sensor visibility at present!".

However, detection of such a soiled windscreen occurs with a time lag versus the occurrence of the soiling, as the lane departure warning system initially has to determine the reduced range of vision caused by the soiling by comparing the incoming image data.



S418_048

Fogged windscreen

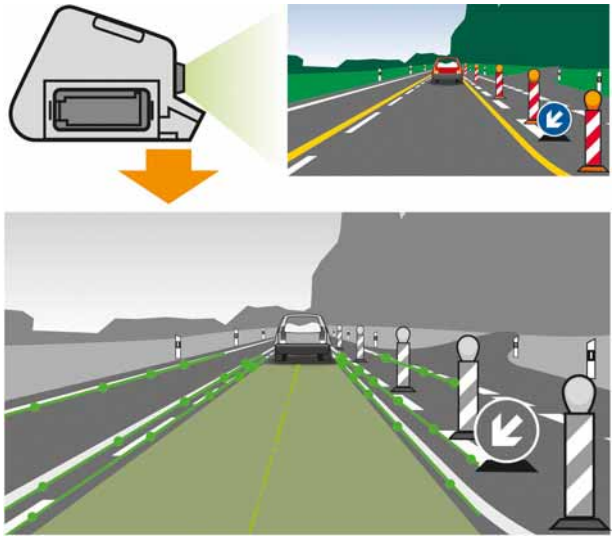
A fogged windscreen may lead to the lane departure warning system's switching to passive mode if the camera is unable to see clearly through the windscreen due to the water droplets condensing on the glass.
A small windscreen heater, which only covers the camera's area of vision, helps to prevent this area from fogging.
It is automatically switched on by the system when the camera determines fogging based on a decline in the quality of the image data.

Functional principle of the lane departure warning system

Roadworks

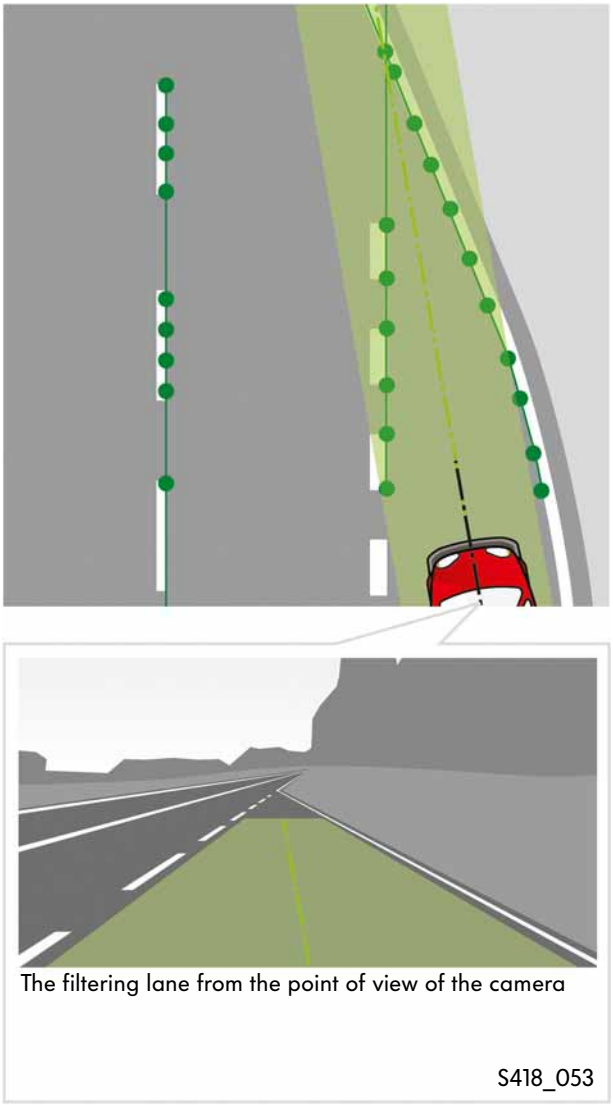
Particularly on motorways, temporary yellow road markings are frequently applied onto the road in the area of roadworks in order to guide traffic past the area of construction, for example via the hard shoulder. Drivers know that the yellow markings take priority over the white markings.
Instead of the yellow lines, however, the lane departure warning system only "sees" light grey lines.

This may therefore lead to misinterpretations if white and yellow lines occur together. If in doubt, the lane departure warning system always uses the inner line which has been detected, with the result that it may possibly calculate a narrower virtual lane. If it falls below the system limit for the required road width, the next outer marking, which is invalid in this case, may be used. As a rule, however, the lane departure warning system switches to passive mode if no clear or plausible lane demarcation can be recognised.



S418_042

If the higher-priority, yellow marking cannot be recognised and the vehicle continues to follow the white line, the driver must briefly override steering correction. As a result of this, the lane departure warning system is switched to passive mode, and only switches back to active mode automatically when a clear road marking is detected.



The filtering lane from the point of view of the camera

S418_053

Optical illusions

As the lane departure warning system acquires the virtual lane from optical data, it is subject to the same visual illusion images as humans.

From the camera's point of view, two lines moving together or intersecting at a flat angle, which can be clearly recognised as such from a bird's eye perspective, create the impression that the road runs straight ahead to the horizon.

In the case of long filtering lanes or roadworks, it may therefore occur that the lane departure warning system calculates a virtual lane running to the intersection point of the detected markings, as the situation appears to the system as if the vehicle were driving along a straight road.

If the vehicle continues moving along this supposed road towards the lines' intersection point, the lane departure warning system detects a narrower road with each image which is evaluated.
If the calculated width falls below the threshold value, the system switches to passive mode.

Functional principle of the lane departure warning system

System messages

The lane departure warning system outputs operating and system status messages with the aid of the lane departure warning lamp and the display in the control unit in dash panel insert. These display options are supported by an electronic warning sound and the warning vibration, which are intended to draw the driver's attention to a displayed message.

Lane departure warning system operating status display and messages

Situation/case example	**Display**	**Reaction**	**Display text in the dash panel insert**
Lane departure warning system is off.		Lane departure warning lamp is off.	No text display provided.
Lane departure warning system is switched on and in active mode.		Lane departure warning lamp lights up green.	No text display provided.
Lane departure warning system is on and in passive mode.		Lane departure warning lamp lights up yellow.	No text display provided.

Driving situation and system reaction display and messages

Situation/case example	**Display**	**Reaction**	**Display text in the dash panel insert**
Speed is less than 60 km/h. From the incoming optical data, the lane departure warning system calculates that the lane is narrower than 2.45 metres or wider than 4.60 metres. The ratio of the detected demarcation to the undetectable marking is greater than 1:2. No road marking or road demarcation can be detected.		Lane departure warning lamp lights up yellow. Lane departure warning system is in passive mode. No acoustic warning signal provided.	No text display provided.

S418_060, _061, _062

Driving situation and system reaction display and messages (continued)

Situation/case example	**Display**	**Reaction**	**Display text in the dash panel insert**
The driver carries out an overtaking manoeuvre without actuating the turn signal for example whilst the lane departure warning system is active. In doing so, he "overrides" the lane departure warning system's corrective steering torque. No clear road demarcation is detected. On cornering, the curve radius is less than 250 metres, with the result that the camera is no longer able to reliably detect the lane due to the road's curvature.		Lane departure warning lamp lights up yellow. No acoustic warning signal provided.	No text display provided.
The windscreen is soiled in the area of the camera.	 	Lane departure warning lamp lights up yellow. Lane departure warning system is in passive mode. Acoustic warning signal sounds.	Lane Assist: Lane departure warning system not available. No sensor visibility at present.
The vehicle threatens to depart from the lane. Steering intervention is carried out by the lane departure warning system. However, the maximum steering correction time of 100 seconds is not sufficient.	  	Lane departure warning lamp lights up yellow. Lane departure warning system switches to passive mode. Acoustic warning signal sounds. Warning vibration is output.	Lane Assist: Please take over steering!

S418_062, _063, _064

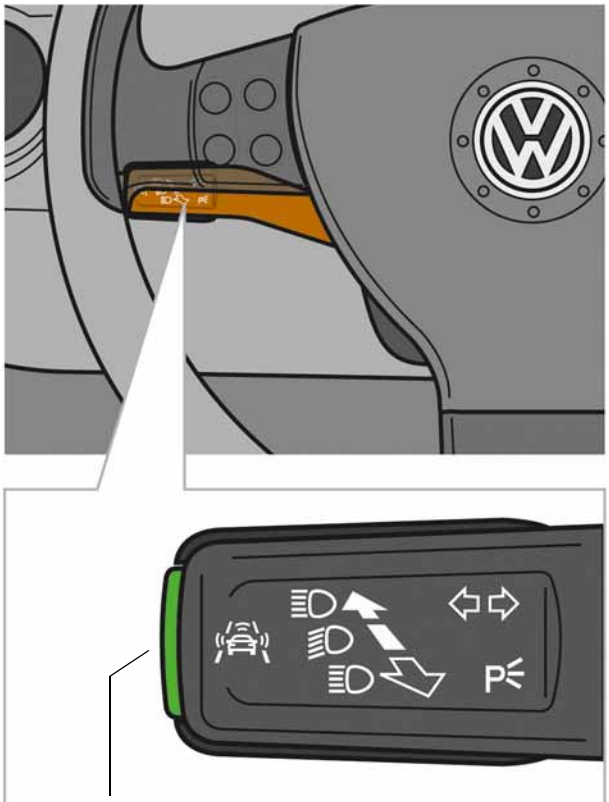
Functional principle of the lane departure warning system

Examples of system error and malfunction display and messages

Situation/case example	Display	Reaction / message	Display text in the dash panel insert
The vehicle threatens to depart from the lane. Steering intervention is carried out by the lane departure warning system. The maximum corrective torque of 3Nm is reached but is insufficient to keep the vehicle within the virtual lane.		Lane departure warning lamp lights up yellow. Warning vibration is output. Lane departure warning system switches to passive mode.	Lane Assist: Please take over steering!
Lane departure warning control unit is not coded. Camera is not calibrated. (No, or incorrect, basic setting on the lane departure warning control unit). The lane departure warning control unit receives for example no data from the power steering control unit (no CAN communication).		Lane departure warning lamp is switched off. Acoustic warning signal sounds.	Lane Assist: System error.
Excessively high temperature in the lane departure warning control unit. Excessively low operating voltage at the lane departure warning control unit.		Lane departure warning lamp lights up yellow. Acoustic warning signal sounds.	Lane Assist: Lane departure warning system not available at present.

S418_063, _073, _074

The faults listed here are merely examples, and do not necessarily reflect the current number of possible faults.
For complete fault and diagnostic descriptions, please refer to the current diagnosis and repair instructions.



Button for driver assistance systems E617

S418_005

Sensors

Button for driver assistance systems E617

Installation location

The button for driver assistance systems is located in the end of the turn signal lever on the steering column.

It is used to switch the driver assistance systems available in the vehicle, for example the lane departure warning system, on and off via the driver assistance system menu in the dash panel insert display.

Signal use

The signal regarding actuation of the button is transmitted via the CAN data bus to the control units for the relevant driver assistance systems in order to switch the assistance function on and off.

Effect in the event of failure

In the event of a defective driver assistance system button, the driver assistance systems which are actuated or configured via the button are no longer available.

Electrical components

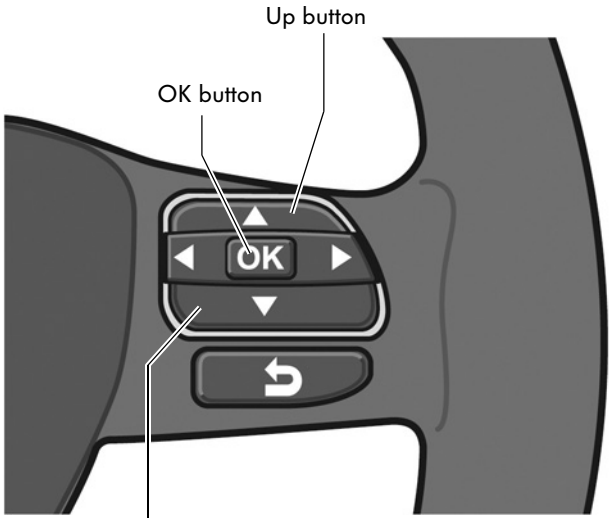
Button activation and deactivation behaviour

The vehicle's equipment with the available driver assistance systems may result in various handling options for activating the lane departure warning system and the available driver assistance systems via the button for driver assistance systems and the up/down and OK buttons on the multifunction steering wheel.

The following switching options are merely examples, and refer to a vehicle which is equipped with the lane departure warning system.

1st option:
Briefly pressing the button for driver assistance systems opens up the selection menu for the assistance systems installed in the vehicle in the dash panel insert display. Clicking onto the down button selects the lane departure warning system. Pressing the OK button confirms the selection and switches the lane departure warning system on.

If this process is carried out again, the lane departure warning system is switched off. Individual driver assistance systems can therefore be specifically switched on and off in this way.

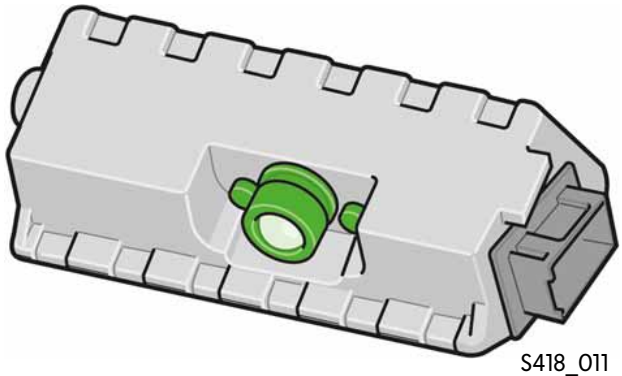


S418_071

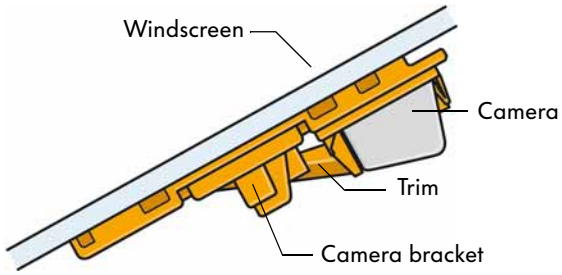
2nd option:
Press the button for driver assistance systems for a longer period of time.
If one or more assistance systems were already switched on before pressing the button, all assistance systems are now switched off.

If all assistance systems were switched off before pressing the button, the driver assistance systems displayed as activated in the display menu prior to switching off are now switched on again.

The Adaptive Cruise Control system (ACC) is not subject to this switching scheme, but must be switched on and off separately.



S418_011



S418_055

Effect in the event of failure

The assistance function is not possible without the digital image information from the camera.
If the camera is defective, the entire control unit has to be renewed. If the camera bracket is defective, the entire windscreen has to be renewed at present.

Camera in the lane departure warning control unit J759

As the camera is comprised, together with the lane departure warning control unit, in a single housing to form a module, it has no separate designation in the workshop manuals.

Installation location

The camera/control unit module is installed in a special camera bracket, which is bonded firmly to the windscreen.
The camera's lens is positioned and oriented in such a way that it lies within the windscreen wiper's wiping range.
As a result of this, the lane departure warning system's function cannot be impeded by windscreen soiling.

Signal use

The camera supplies the lane departure warning control unit with digitised images of the road in front of the vehicle. The digital images are evaluated in the control unit's processors, not in the camera itself.

Technical data

Resolution	-	640 x 480 pixels (VGA)
Colour depth	-	12-bit, corresponding to 2^{12} i.e. 4096 grey scales
Image refresh rate	-	25 images per second
Focal depth	-	6.1 mm (corresponds to approx. 42 mm with a miniature camera)
Aperture angle	-	horizontal 45° vertical 16°
Lower detection limit	-	5.5 meters in front of the vehicle
Forward scanning range	-	20 to 60 metres

Actuators

Lane departure warning lamp K240

Installation location

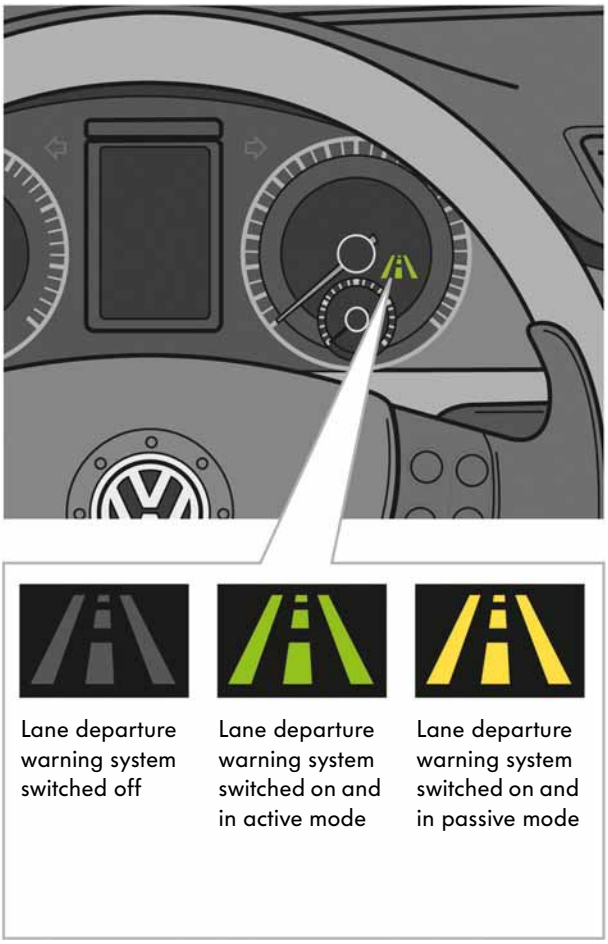
The lane departure warning lamp is integrated for example in the Passat CC into the right-hand dash panel insert display field.

Task and function

It indicates the lane departure warning system's operating status to the driver.

Effect in the event of failure

If the lane departure warning lamp fails, this assistance function is no longer available, as the current operating status cannot be clearly displayed to the driver.

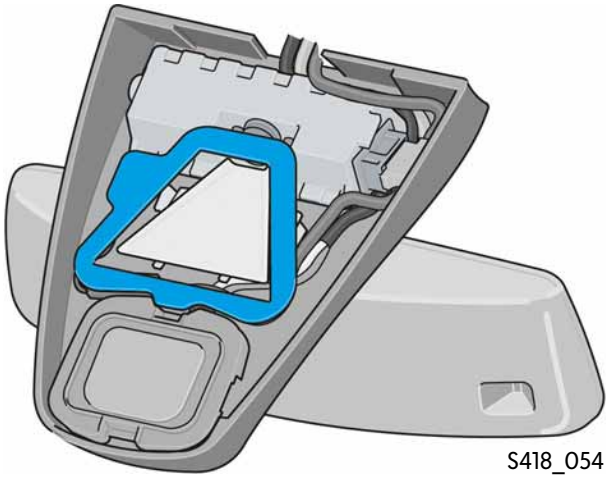


S418_003

Windscreen heater for lane departure warning Z67

Installation location

This small heating element is bonded to the windscreen from the inside and is located beneath the enlarged interior rear-view mirror base designed cover.



S418_054

Task and function

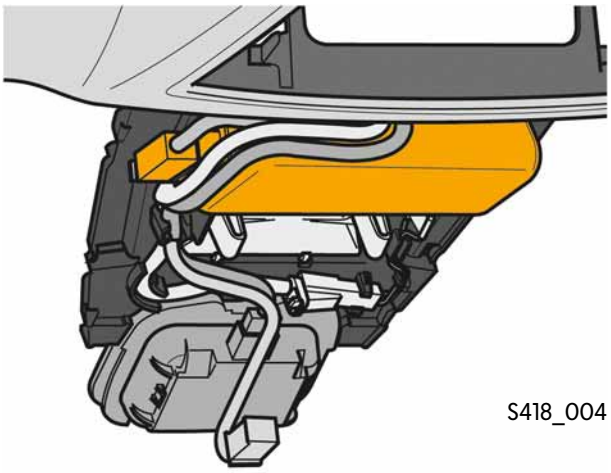
The windscreen heater for lane departure warning ensures that the windscreen in the camera's visual range does not freeze over or become coated with condensation. This guarantees that the camera is able to register the area of road in front of it without hindrance.

Effect in the event of failure

The functional capability of the heating element is one of the system's internal activation conditions. If only one of these conditions is not met, the lane departure warning system cannot be switched on again.

If the failure occurs during operation, with the result that recognition of the road is impeded, the lane departure warning system switches off.

Lane departure warning control unit J759



S418_004

Effect in the event of failure

If the control unit is defective, this assistance function is no longer available, and the control unit must be renewed.

Installation location

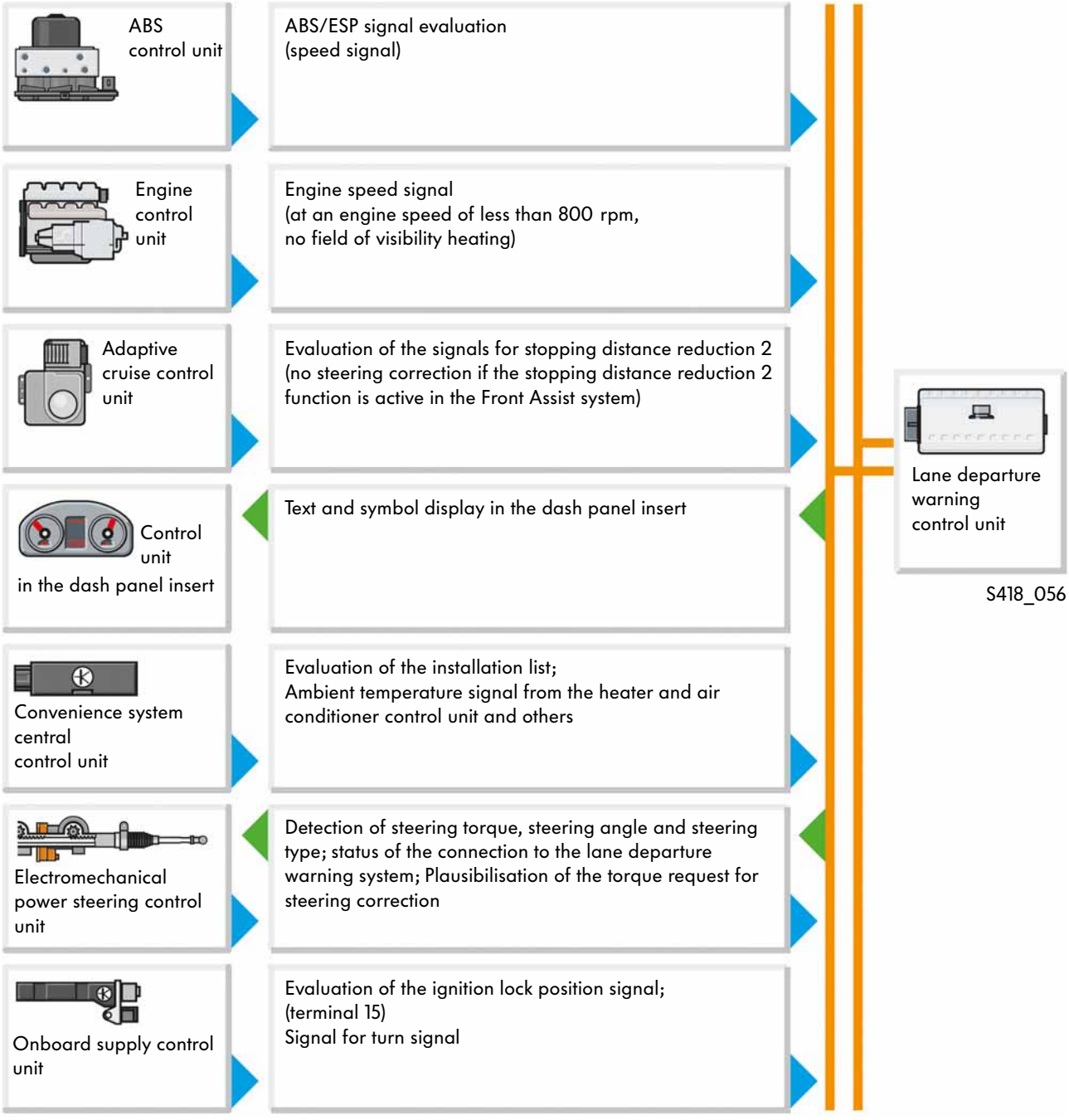
The lane departure warning control unit is located behind the mirror base designed cover together with the windscreen heater for lane departure warning and the rain sensor.

Task and function

The control unit with the integrated camera uses the optical data to calculate the virtual road and decides whether, and the length of time for which, steering correction has to be carried out within the specified system limits.

Data bus communication

The following graphic is intended to visualise the various messages which are required for the lane departure warning system function.



Further actuators

The following actuators belong to other vehicle systems, for example the electromechanical power steering. However, their function is vital to enable the lane departure warning system's correction intervention to be carried out.

S418_057

Effect in the event of failure

If the electromechanical power steering motor fails, all other vehicle systems, in addition to the power steering, which actively influence the vehicle's behaviour via the steering, also fail.
As this also includes the lane departure warning system, it cannot be switched on again if the motor is defective. If the motor fails during lane departure warning system operation, the system switches off.

Electromechanical power steering motor V187

Installation location

The electromechanical power steering motor is mounted parallel to the rack in the steering gear housing. It applies the steering assistance force.

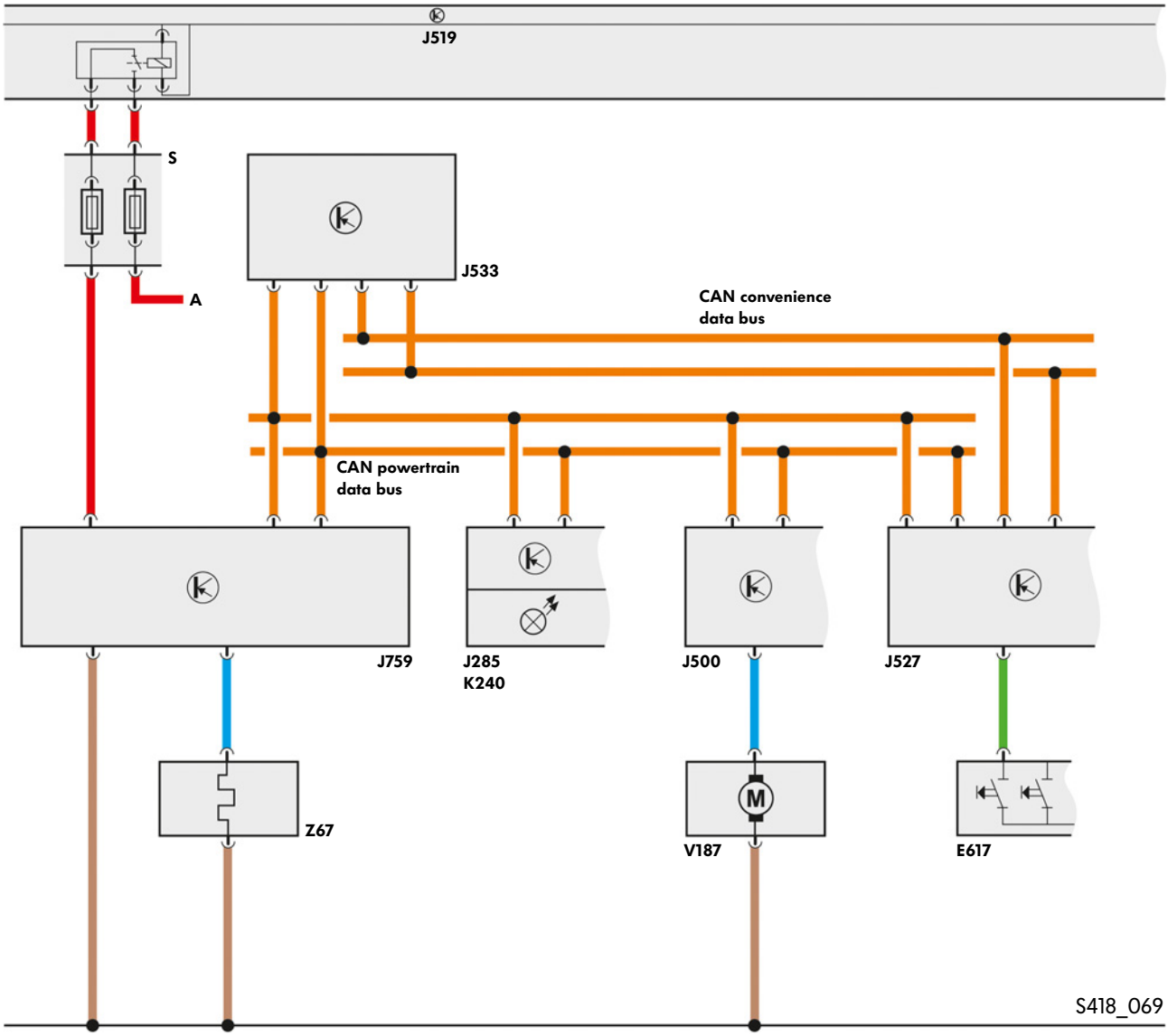
Task and function

If the power steering control unit determines a directional command by the driver, it actuates the motor and thereby supports the driver's steering movement with an appropriate torque.

Within the lane departure warning function, the motor has the task of carrying out the steering correction and of generating the warning vibration, which is felt on the steering wheel. To do this, the lane departure warning control unit instructs the power steering control unit to actuate the motor accordingly.

Detailed information on the electromechanical power steering can be found in self-study programmes:
SSP 225 "The electro-mechanical power steering system",
SSP 317 "The Electromechanical Power-Assisted Steering with Double Pinion" and
SSP 399 "The electromechanical steering with parallel-axis drive".

Functional diagram



A Battery

E617 Button for driver assistance systems

J285 Control unit with display in dash panel insert
J500 Power steering control unit
J519 Onboard supply control unit
J527 Steering column electronics control unit
J533 Data bus diagnostic interface
J759 Lane departure warning control unit

K240 Lane departure warning lamp

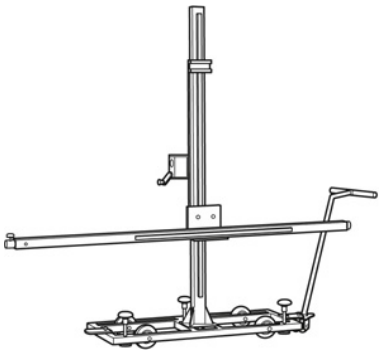
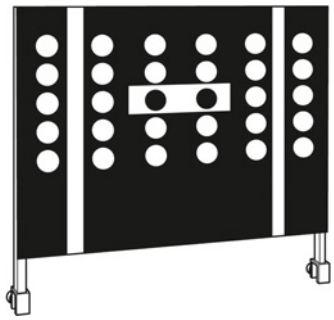
S Fuse

V187 Electromechanical power steering motor

Z67 Windscreen heater for lane departure warning

Special tools

The setting device VAS 6430 is required to calibrate the lane departure warning system's camera.
The setting device consists of various components and is also required for example to set the ACC system.

Designation	Tool	Application
VAS 6430/1 Setting device, basic set		The setting device, basic set VAS 6430/1 serves as a conversion kit for the existing ADC setting device VAS 6041 and ACC setting device VAS 6190. This conversion kit enables the calibration board for lane guard system VAS 6430/4 to be adapted. At the same time, the setting device serves as a basic set for calibrating VW vehicles with an ACC laser unit. The basic set consists of the base frame with A-frame, the carrier pillar with line unit, the setting bar with precision guide rail and the assembly and operating instructions.
VAS 6430/4 Calibration board for lane guard system		Accessory for the setting device, basic set VAS 6430/1. The calibration board is required as an extension for the basic set for calibrating the camera in the lane departure warning control unit J759. The set contains the calibration board incl. frame and precision slats plus a gap measuring unit with tape measure tape and pins.
VAS 6190/2		Setting tool recommended as an accessory

S418_066, _067

System calibration

Under certain circumstances, the lane departure warning system must check whether the alignment of the camera's lens still "matches" the vehicle's geometry. This is necessary to guarantee fault-free evaluation and interpretation of the digital image data.
The system offers three types of calibration:

- Calibration in the factory (static initial calibration)
- Online calibration exclusive to the system (dynamic calibration) and
- Workshop-aided system calibration (static calibration).

Causes of necessary system calibration

The lane departure warning system has to be calibrated if the following situations or faults have arisen:

- The fault "no, or incorrect, basic setting" is entered in the lane departure warning control unit's fault memory.
- The lane departure warning control unit has been renewed.
- The windscreen has been removed or renewed.
- The rear axle track has been adjusted.
- Work which has changed the vehicle body level has been carried out on the vehicle's running gear.

Online calibration

The term online calibration describes a self-test, which the lane departure warning system carries out during vehicle operation.
It is necessary when the vehicle's level changes, for example due to loading the luggage compartment. In this case, the camera's "angle of vision", which is now no longer correct, is electronically compensated as soon as a clear road marking is detected.
This function is also referred to as dynamic calibration, and does not replace workshop calibration.
During this self-test, the lane departure warning system checks whether the YAW and PITCH ANGLE determined when calibration was last carried out have changed. Due to technical reasons, the ROLL ANGLE determined during static calibration is not integrated into dynamic calibration.

If the lane departure warning control unit determines a deviation in these two angles, the changes are stored under the memory addresses "yaw angle offset" and "pitch angle offset" and are taken into consideration by the system during image evaluation. Both values can be read out from a measured value block. They are reset to the value "zero" again when static calibration is next carried out.

Workshop calibration

The workshop sequence described here is merely a rough overview to provide an insight into the calibration process.
Please refer to the current workshop manuals for the precise procedure.

At least one diagnostic tester VAS 5052 or VAS 5051B, an approved wheel alignment computer with the wheel alignment lifting platform and special tools VAS 6430/1 and VAS6430/4 are required.

During CALIBRATION with the setting device, the height of the camera above the road and the YAW, PITCH AND ROLL ANGLES of the camera are checked to guarantee an optimal camera detection range with reference to the vehicle geometry. This is necessary to enable correct digital evaluation of the image material.
Workshop calibration is also referred to as static CALIBRATION.
The following operations, amongst others, are carried out according to the current repair instructions, for example.

- Start of calibration with the VAS tester.
- The "lane departure warning system CALIBRATION" programme is started in the wheel alignment computer.
- Quick-action clamps are mounted on all four wheels, etc.
- Transducers for laser alignment are mounted on the two rear wheels.
- The setting device VAS 6430 is positioned in front of the vehicle in several stages, which are specified by the wheel alignment computer.
- The CALIBRATION programme is started in the diagnostic tester under the "Guided Fault Finding" function.
- The body height is measured at the edges of all four wheel housings and entered into the calibration programme on the VAS tester, and CALIBRATION is initialised in the control unit.

Measured value blocks for calibration

The lane departure warning control unit can be addressed by the diagnostic tester with the address word "5C" in order to access the measured value blocks regarding the system status.
The following values can be called up in the measured value blocks for CALIBRATION:

- The camera's YAW, PITCH AND ROLL ANGLES
- CAMERA HEIGHT (derived from the vehicle height)
- Reason for failed CALIBRATION
- YAW and PITCH ANGLE offset according to dynamic CALIBRATION (online calibration)
- Further information on dynamic CALIBRATION

Diagnosis

Measured value blocks for the lane departure warning system function

Via the address word "5C", the measured value blocks for the lane departure warning control unit J759 output values for the following variables:

- Status of the lane departure warning system
  (switched on and in passive mode, switched on and in active mode, switched off)
- Data on the currently calculated virtual lane (road width, curve radius)
- Supply voltage at the lane departure warning control unit
- Interior temperature of the control unit
- System status of the button for driver assistance systems E617
- System status of the turn signal switch E2
- Operating status and status of the windscreen heater for lane departure warning Z67
- System message regarding the reason for activation and deactivation of the windscreen heater Z67
- Status message regarding CAN communication between the control units involved in the lane departure warning system

System reset

To reset the system to delivery status, the control electronics are equipped with so-called adaptation channels, in which the default values are stored and which are not overwritten by static CALIBRATION.

Control unit coding

Control unit coding must be carried out completely so that the lane departure warning system can be activated. On coding, the following information is stored in the lane departure warning control unit:

- Vehicle model
- Market identification (Japan, USA, United Kingdom, RoW)
- Vehicle equipment with/without Adaptive Cruise Control ACC
- Vehicle equipment with/without MOBILITY AID
- Vehicle equipment with/without the "stopping distance reduction" function
- Vehicle operation with/without trailer

Basic setting

The basic setting corresponds to static system calibration and is independently carried out by the diagnostic tester after setting up the setting and wheel alignment devices.

Glossary

STOPPING DISTANCE REDUCTION 2
Additional ABS system function which gently applies the brake pads onto the brake disks to shorten the driver's reaction phase in a braking situation. It also outputs a brake pulse and an acoustic signal as a warning if the driver does not react in good time when the Adaptive Cruise Control system (ACC) is switched off or he fails to depress the brake or fails to do so sufficiently during the driving situation.

IMAGE RATE
Number of images per second which can be recorded by a camera or played by a projection device.

COLOUR DEPTH
Number of different colour values which can be portrayed in a digital image. The colour depth is usually defined as a bit specification, i.e. as a power of two.
Example:
8-bit colour depth = 2^8 colours = 256 colours

YAW ANGLE
Angle around which the vertical axis of the camera is rotated versus the vertical axis of the vehicle as the reference system.

CALIBRATION
To bring to a precise dimension, to calibrate.
In the case of the lane departure warning system, an automated process in which the orientation of the spatial axes of the camera are brought into accord with the orientation of the vehicle's spatial axes as the reference system by means of numerical adaptation. This means that no mechanical adjustment of the camera takes place.

CAMERA HEIGHT
Value which specifies the distance of the camera's optical system above the ground. This is dependent on the vehicle's height and any air suspension systems, which influence the vehicle's height.

MOBILITY AID
Assistance function for physically disabled drivers, in which the execution of selection processes is facilitated with the aid of control elements.

PITCH ANGLE
Angle around which the camera's lateral axis is rotated versus the lateral axis of the vehicle as the reference system.

ROLL ANGLE
Angle around which the camera's longitudinal axis is rotated versus the longitudinal axis of the vehicle as the reference system.

Which answers are correct?

One or several of the given answers may be correct.

1. What is the meaning of the Lane Assist menu option shown in the dash panel insert display?

☐ a) Lane Assist is the English term for the Park Assist system.

☐ b) Lane Assist is the English term for the lane departure warning system.

☐ c) Lane Assist is the English term for the lane change assist system.

2. What is the purpose of the lane departure warning system?

☐ a) It supports fatigued drivers by keeping the vehicle within the detected lane by means of independent, active steering intervention with the aid of the electromechanical power steering's full steering torque.

☐ b) It supports the driver in keeping the vehicle within the lane. If the vehicle threatens to depart from the calculated virtual lane, the lane departure warning system applies limited, corrective steering torque. If this measure is not sufficient, an acoustic and optical warning and a vibration alarm are output.

☐ c) It takes over the steering when the driver removes his hands from the steering wheel, and drives the vehicle along the centre of the calculated virtual lane.

3. Which components belong exclusively to the lane departure warning system?

☐ a) Lane departure warning control unit

☐ b) Lane departure warning system motor

☐ c) Button for driver assistance systems

☐ d) Steering moment sender

☐ e) Lane departure warning lamp

☐ f) Steering wheel contact sender

Test yourself

4. What does it mean when the lane departure warning system is in passive mode?

☐ a) The lane departure warning system is unable to detect any road demarcations or calculate any virtual lane. It therefore switches itself off. The warning lamp alternatingly flashes yellow/red.

☐ b) The lane departure warning system is switched on and warns the driver by means of a vibration alarm via the electromechanical power steering on departure from the detected lane. However, the system does not actively correct the steering, as the driver has his hands on the steering wheel (no hands recognition). In passive mode, the warning lamp flashes yellow.

☐ c) With the aid of the camera, the lane departure warning system continues to monitor the road in front of the vehicle and evaluates the digital images. If all conditions for detecting the lane are met, the lane departure warning system automatically switches to active mode. In passive mode, no steering correction takes place and no vibration warning is output. In passive mode, the warning lamp continuously lights up yellow.

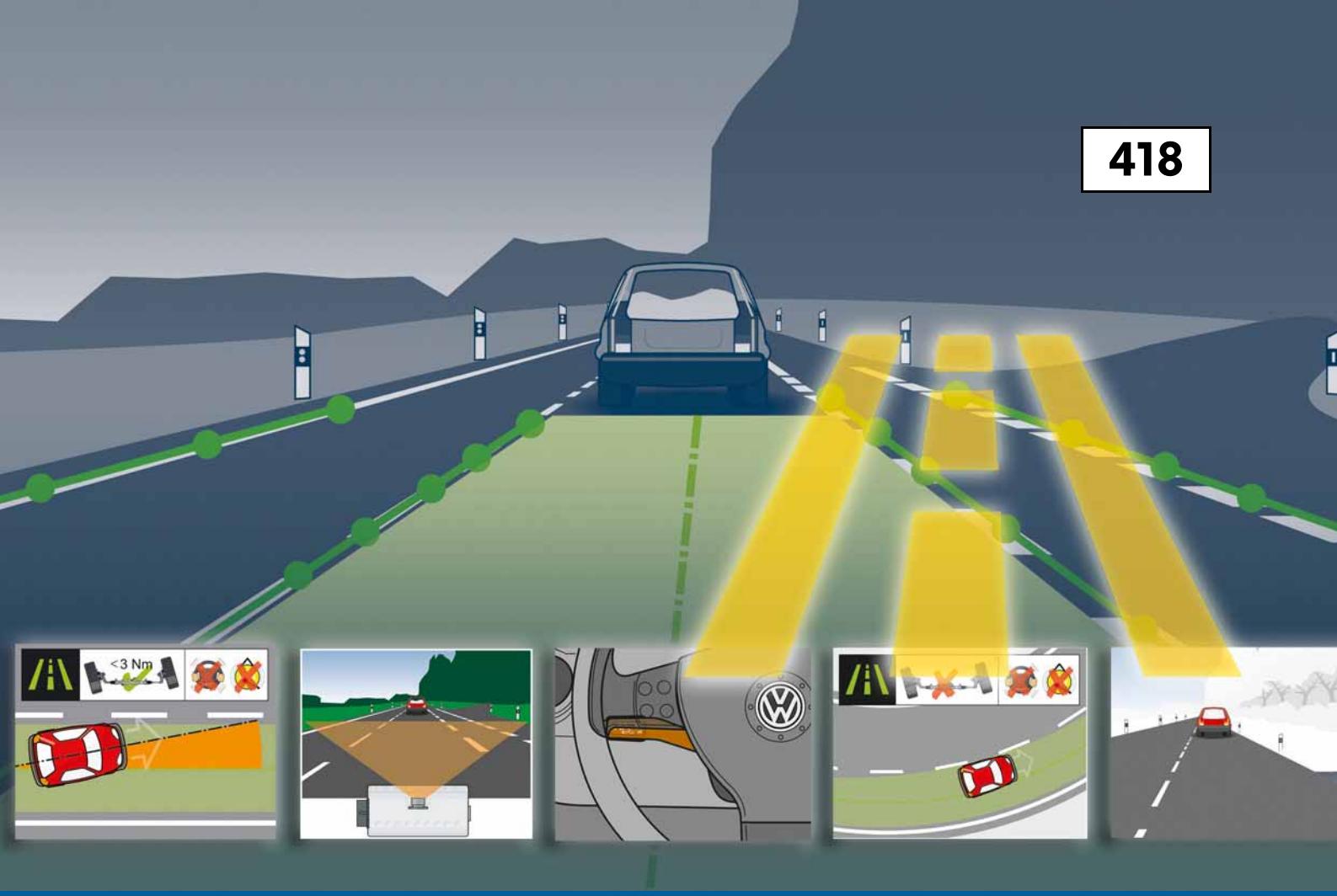
5. How is digital image evaluation carried out in the lane departure warning control unit?

☐ a) Within two trapezoidal selection areas, a specified number of image lines is checked for grey scale value leaps. The system sets marking points at the grey scale value leaps which are detected. If sufficient marking points can be set, and these can be enhanced to form a line, the system uses these to calculate the virtual lane.

☐ b) Within the trapezoidal selection area, every second image line is checked for white points, which stem from the road markings. The area between the two inner points which are detected is registered as a stripe. The system uses the sequence of the detected stripes to calculate a virtual lane.

☐ c) The lane departure warning system uses the incoming pixels of the entire colour image to calculate a trapezoidal, virtual lane. It aligns the vehicle with the centre axis of this by means of corrective steering intervention.

Answers:
1. b); 2. b); 3. a), e); 4. c); 5. a)



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