

## Camera-based driver assistance systems

### Camera-based driver support systems (KAFAS)

Depending on the options fitted, various camera-based systems are available. Technical implementation realised with a camera in the mirror base and a control unit, the KAFAS control unit.

The display functions of the camera-based driver support systems are:

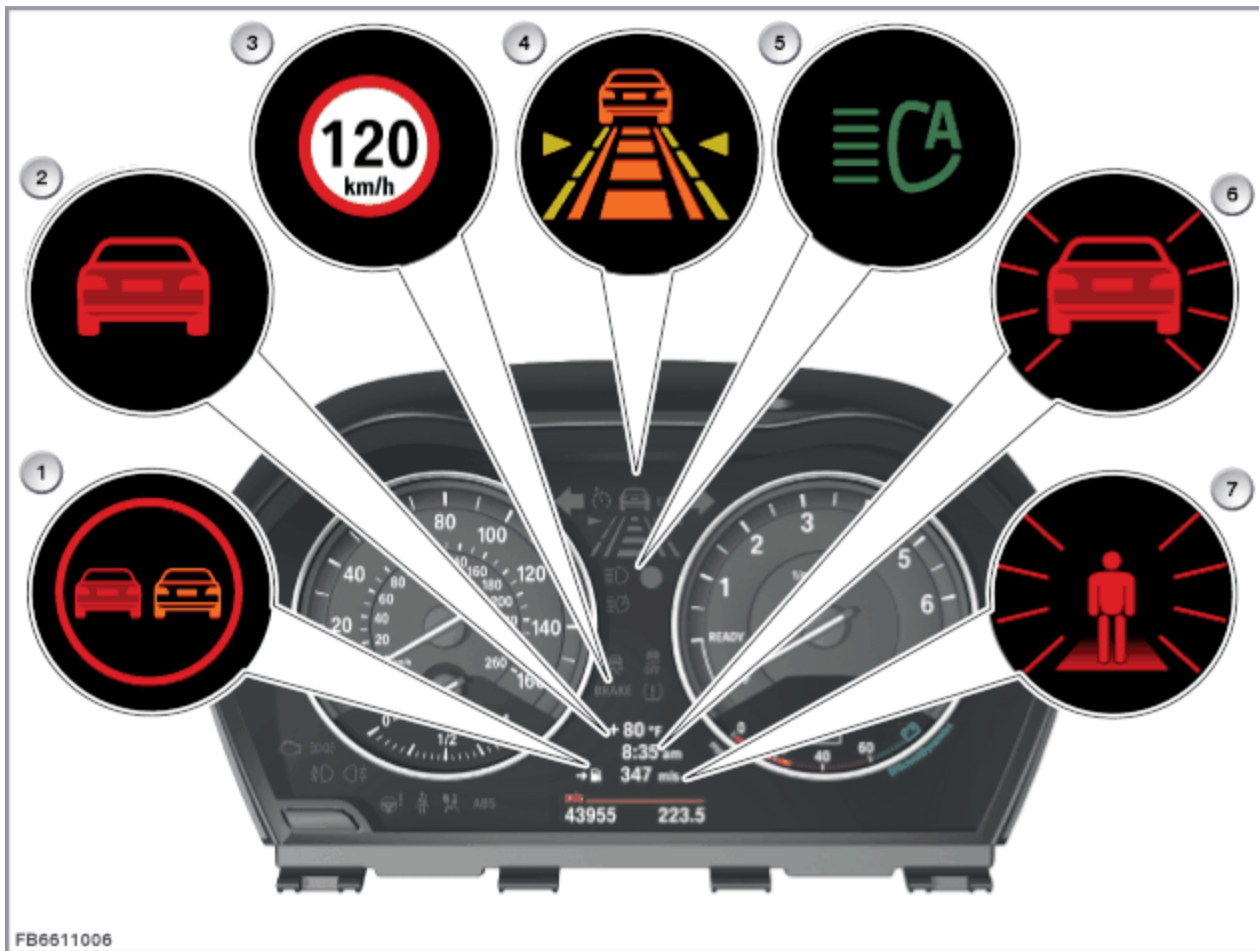
- Lane departure warning
- High-Beam Assistant (not permitted in Japan)
- Speed limit ( Speed Limit Info)
- Collision warning
- Overtaking ban
- **New:** Urban traffic accident prevention
- **New:** Preventive pedestrian protection
- **New:** Traffic jam assistant, see dedicated [functional description](#)



#### Note!

If the customer orders exclusively the high-beam assistant (5AC), the system is implemented camera and its own control unit in the inside mirror.

The speed limit and overtake warning functions are **only** available with the Professional navigation sy



Example schematic diagram

Item	Explanation	Item	Explanation
1	Overtaking ban display, road sign recognition	2	Display: collision warning
3	Speed limit display	4	Lane departure warning display
5	High-beam assistant display	6	Urban traffic accident prevention
7	Preventive pedestrian protection		

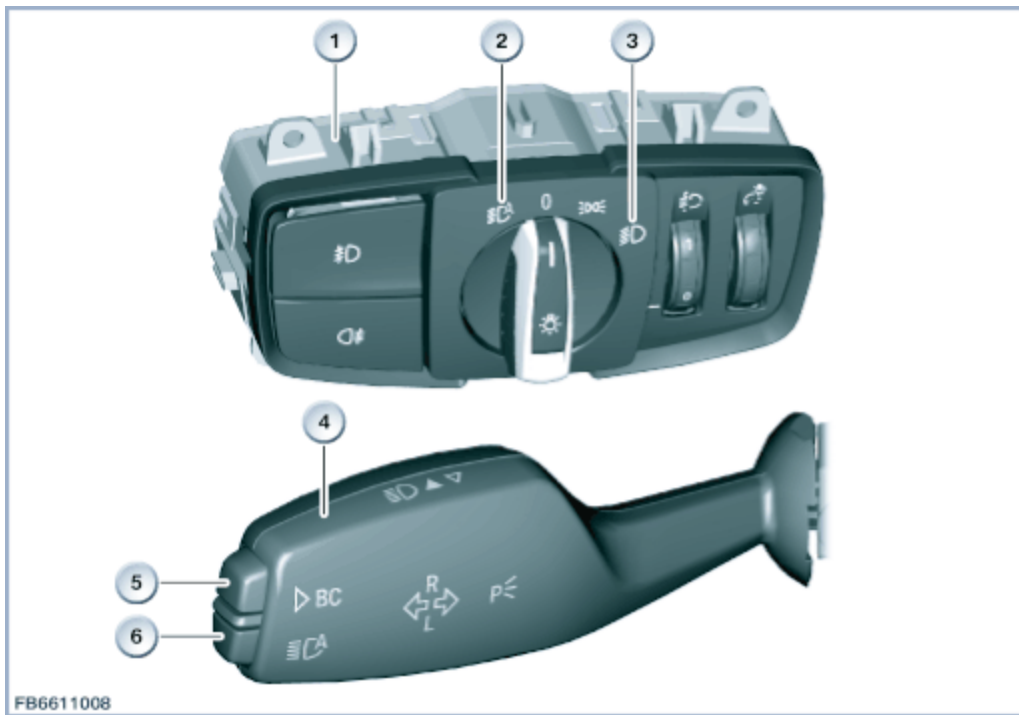
### Brief component description

The following components for the camera-based driver support systems (KAFAS) are described:

#### operating facility for light, turn signal/high beam switch as well as the operating facilities for assist systems

The high-beam assistant is switched on and off at the turn signal/high beam switch. To do this, the light must be in the automatic driving lights control (Position A) or low-beam headlight position. An additional prerequisite is that the low-beam headlights are switched on due to sufficient darkness.

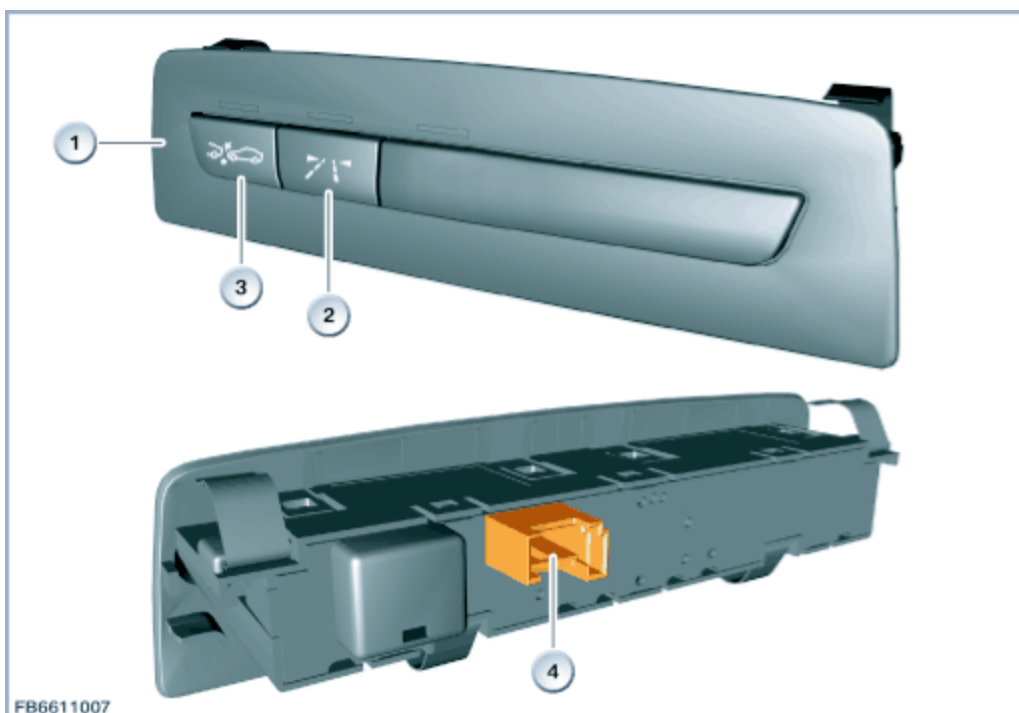
For vehicles without automatic driving lights control, the high-beam assistant can also be activated for brightness. The high-beam assistant switches on the low-beam headlights based on the ambient brightness.



Example shown: F30

Item	Explanation	Item	Explanation
1	Operating facility for light	2	Automatic driving lights control p
3	Low-beam headlight position	4	Turn signal/high beam switch
5	On-board computer button	6	High beam assistant button

The lane departure warning and collision warning are switched on and off using the button in the drive assistance system operating facility.



Item	Explanation	Item	Explanation
1	Assist systems operating facility	2	Lane departure warning button
3	Button collision warning	4	4-pin plug connection

- Vehicles with front electronic module(FEM):

The operating facility for driver assist systems is connected to the Front Electronic Module (FEM) LIN bus. A bus signal from the Front Electronic Module to the KAFAS control unit indicates the button has been pressed. The ICM control unit only allows the lane departure warning to be switched on if the system is operating trouble-free. Only then is there positive confirmation by means of a bus signal to the Front Electronic Module to activate the function indicator light of the button. If there is a fault in the system, the function indicator light remains switched off despite keystroke. This allows the driver to see that the lane departure warning is not available.

- Vehicles with junction box electronics (JBE):

The operating facility for assist systems is connected via LIN bus to the footwell module (FRM). A bus signal from the footwell module to the KAFAS control unit indicates the button has been pressed. The ICM control unit only allows the lane departure warning to be switched on if the system is operating trouble-free. Only then is there positive confirmation by means of a bus signal to the footwell module to activate the function indicator light of the button. If there is a fault in the system, the function indicator light remains switched off despite keystroke. This allows the driver to see that the lane departure warning is not available.

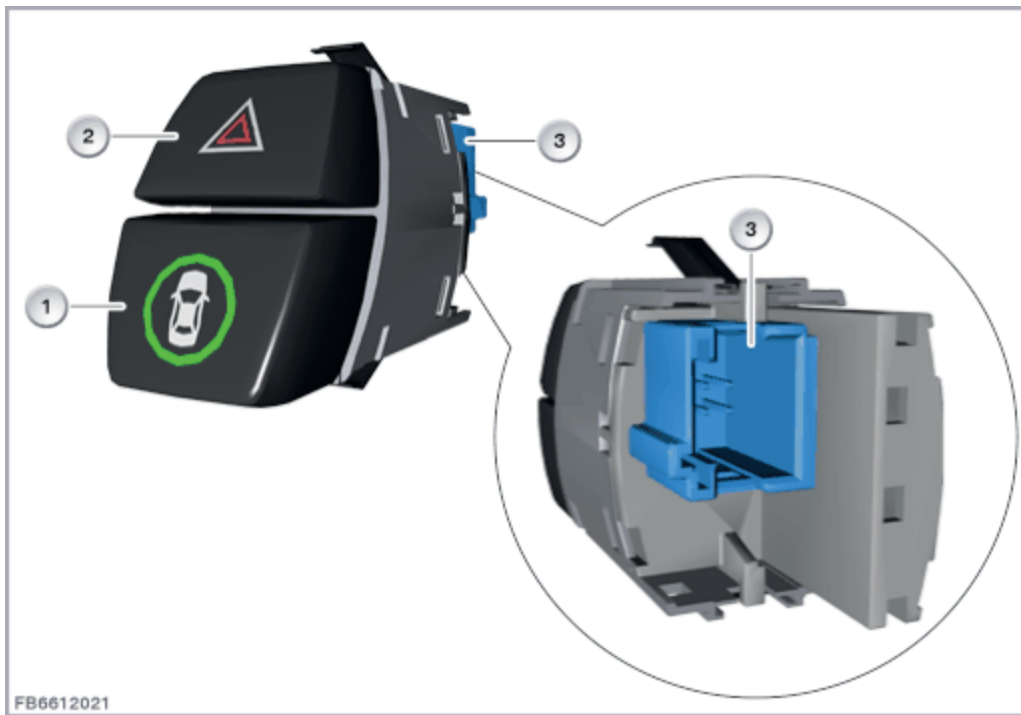
- From F15: Vehicles with Body Domain Controller (BDC):

The driver assistance system operating facility is connected to the Body Domain Controller (BDC) local interconnect network bus. A bus signal from the Body Domain Controller to the KAFAS control unit informs it that the button has been pressed. The ICM control unit only allows the lane departure warning to be switched on if the system is operating trouble-free. Only then is there positive confirmation by means of a bus signal to the Body Domain Controller to activate the button function indicator light. If there is a fault in the system, the function indicator light remains switched off despite keystroke. This allows the driver to see that the lane departure warning is not available.



### Note!

If the vehicle is equipped with the latest generation of DSC (MK100), parts of the function logic previously calculated in the Integrated Chassis Management (ICM) are integrated in the DSC unit. As a result, it was possible to omit the ICM control unit, among other items.



F15 shown

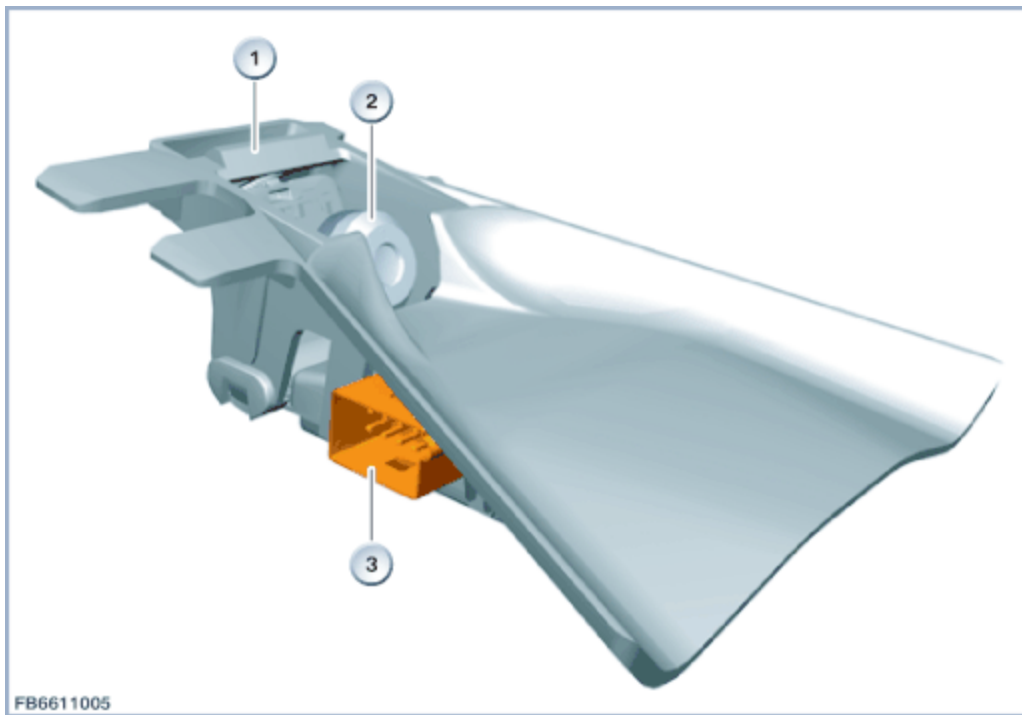
Item	Explanation	Item	Explanation
1	Assist systems operating facility	2	Hazard warning switch
3	six-pin plug connection		

The driver assistance system operating facility is located in the centre console by the hazard warning driver assistance system operating facility is connected through a six-pin plug connection.

### Camera-based driver support systems camera

The video camera for the lane departure warning installed in the mirror base of the inside mirror monitor near field of the vehicle. The video camera records the roadway up to approx. 40 metres in front of the vehicle and up to approx. 5 metres to the right and left at the sides of the vehicle. Image data are routed over a data line to the KAFAS control unit and evaluated. The control unit uses image processing to search the imagery recorded by the video camera for possible existing lane and road markings.

The camera is connected to the KAFAS control unit by means of a 10-pin plug connection and shielded



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Item	Explanation	Item	Explanation
1	Holder	2	Camera-based driver support system camera
3	Plug connection 10-pin, LVDS data line		

The KAFAS camera heating is located on the edge of the KAFAS camera's field of view. The heating is used to prevent the windscreen in front of the KAFAS camera from fogging over and freezing. This increases the availability of the camera-based driver support systems camera during cold weather.



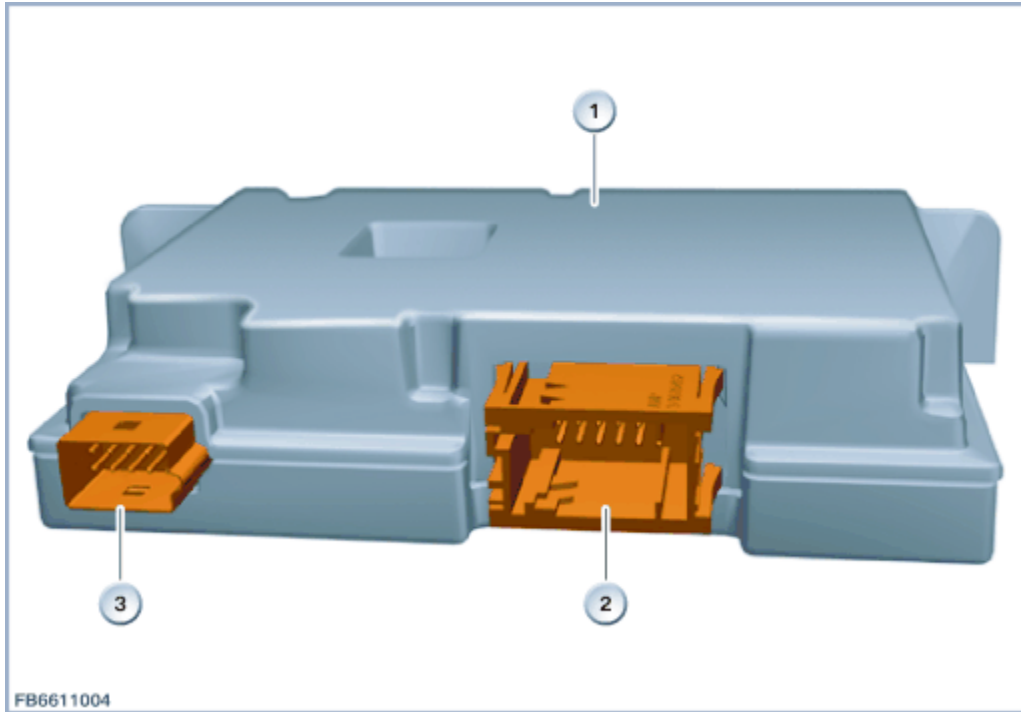
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Item	Explanation
1	Camera-based driver support systems camera heating

## KAFAS: Control unit for camera-based driver support systems

The light points, light colours and light intensities picked up by the video camera are evaluated by the control unit. The evaluation by the KAFAS control unit results in a switch-on or switch-off recommendation. The video camera is connected to the KAFAS control unit by means of a 12-pin line. The KAFAS control unit is connected to the PT-CAN.

The KAFAS control unit is supplied via terminal 15N by the front power distribution box.



Item	Explanation	Item	Explanation
1	Camera-based driver support systems camera control unit	2	12-pin plug connection
3	10-pin plug connection		

## Vibration actuator in the steering wheel

The vibration actuator is fitted in the spoke of the steering wheel. The vibration actuator has the task to make the steering wheel vibrate. The driver assistance systems 'lane departure warning' and 'lane change assist' use this vibration to warn the driver regarding dangerous situations.

The steering wheel module also housed inside the steering wheel activates the vibration actuator. The request for activation of the vibration actuator is sent by the Integrated Chassis Management (ICM) or the Dynamic Stability Control (DSC) as a bus signal to the bus users.

- Vehicles with Body Domain Controller

The Body Domain Controller (BDC) forwards this request across the LIN bus to the steering wheel module in the steering column switch cluster.



- Vehicles with Front Electronic Module:

The Front Electronic Module (FEM) forwards this request via LIN bus to the steering wheel elect the steering-column switch cluster.

- Vehicles with junction box electronics:

The junction box electronics (JBE) forward this request via the LIN bus to the steering wheel ele the steering-column switch cluster.

The steering column switch cluster is not a control unit.



Item	Explanation	Item	Explanation
1	Electronic steering wheel module	2	Vibration actuator

## System functions

The following system functions are described:

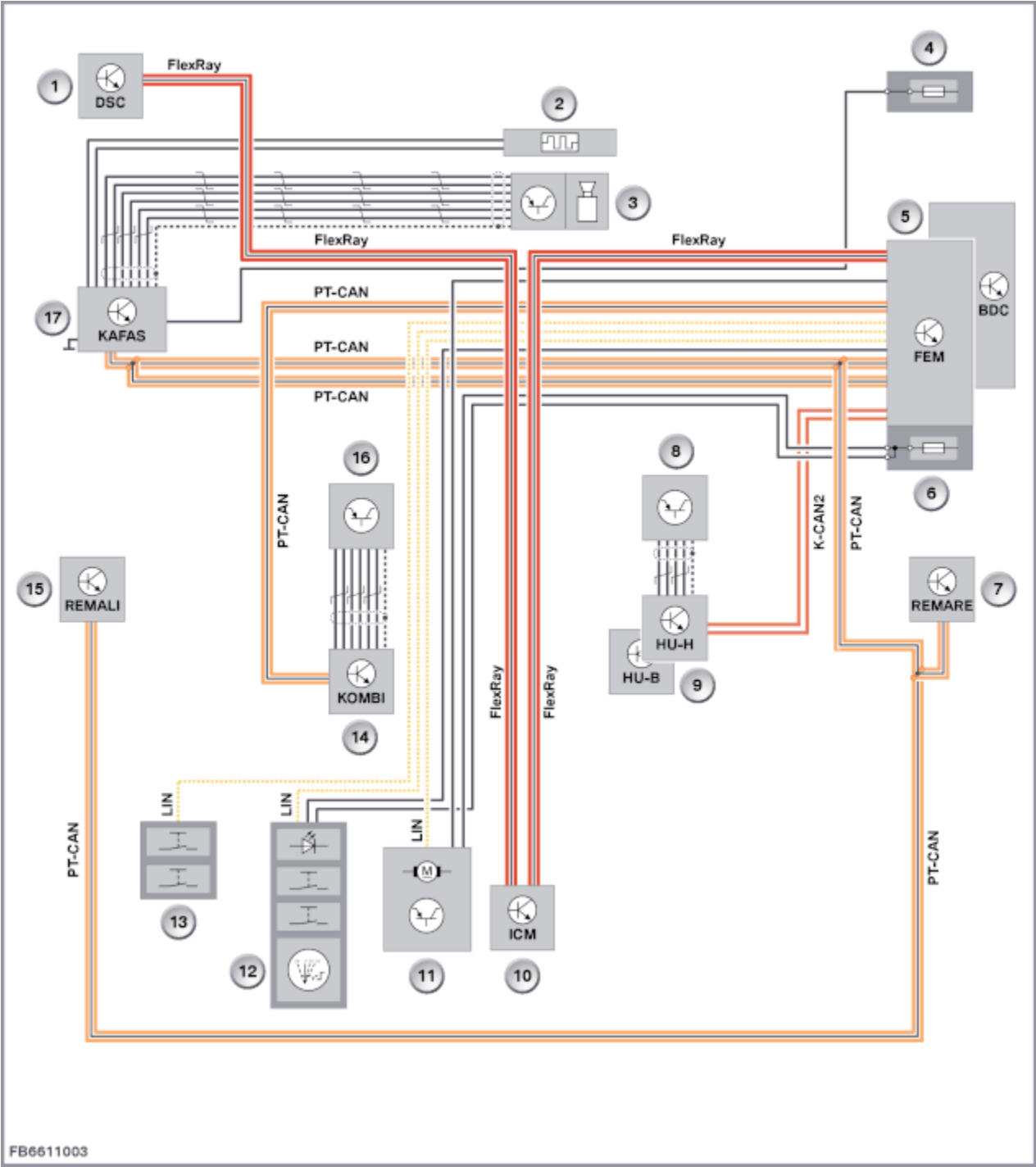
- Functional networking
- Urban traffic accident prevention
- Preventive pedestrian protection
- Lane departure warning
- High-beam assistant
- Road sign recognition
- Collision warning
- Automatic braking for the recognition of stationary vehicles
- Overtaking ban
- System limits



## Functional networking

A complex system network with distributed functions in other control units is necessary for implementing lane departure warning as well as the high-beam assistant.

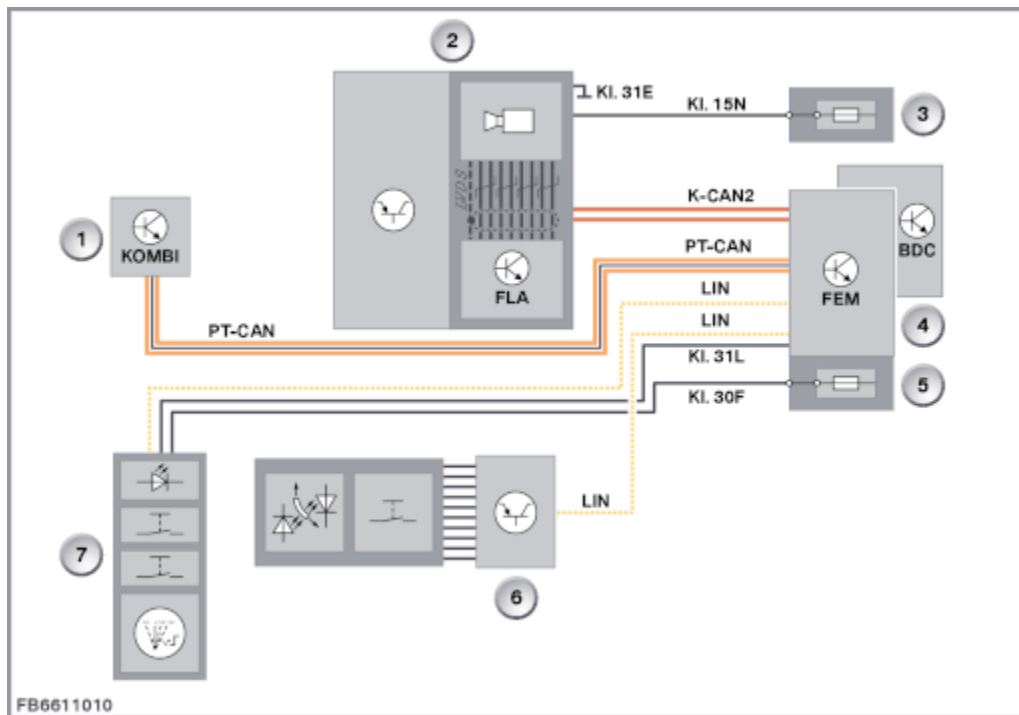
The following graphic shows the system network of the lane departure warning and the high-beam assistant using the example of the F2x, F3x, F15.



Item	Explanation	Item	Explanation
1	Dynamic stability control (DSC)	2	Heating for KAFAS camera

3	KAFAS camera in the inside mirror	4	Front power distribution box, front passenger
5	Front Electronic Module (FEM) or Body Domain Controller (BDC)	6	Power distribution box
7	Reversible motorised automatic reel, right (REMABF), model-specific	8	Central information display
9	Headunit (HU-H, HU-B)	10	Integrated Chassis Management (ICM). Omitted if the vehicle is equipped with the latest generation DSC (MK100).
11	Steering column switch cluster with vibration actuator	12	Operating facility for light
13	Assist systems operating facility	14	Instrument panel (KOMBI)
15	Reversible motorised automatic reel, left (REMAFA), model-specific	16	Head-Up Display, model-specific
17	Camera-based driver support systems camera control unit		

If only a high-beam assistant (5AC) is present, the system network is as follows for the example of F2 F15:



Item	Explanation	Item	Explanation
1	Instrument panel (KOMBI)	2	Inside mirror with camera and control unit high-beam assistant (FLA)
3	Front fuse and relay module	4	Front Electronic Module (FEM) or Body Domain Controller (BDC)
5	Front fuse and relay module	6	Steering column switch cluster

7	Operating facility for light		
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## Urban traffic accident prevention

The camera monitors the area in front of the vehicle. The camera uses image processing to detect ev (passenger cars, trucks, motorbikes) within visual range, including stationary vehicles. Based on the p distances and relative speeds calculated, the warning is output or braking is triggered.

This function warns the driver of critical collision situations and thus prevents rear-end collisions. The also applied automatically at speeds between 3 and 60 km/h, which reduces the consequences of an Accidents can be avoided up to a speed differential of approx. 18 km/h. The function is available durir and night.

The collision warning is emitted in two stages. The first stage (pre-warning) shows the warning symbc instrument cluster (KOMBI). The symbol flashes in the 2nd stage (acute warning). Additionally there is acoustic warning.

Both stages can be switched on or off using the assist system operating facility. The function is always when the vehicle is started. The pre-warning can be set on the central information display (early, med Shortly before a collision the brakes are applied automatically with a medium brake force in order to r severity of the impact.

When an acute warning is output, the brakes are prepared to deliver emergency braking as quickly as

## Preventive pedestrian protection

The camera monitors the area in front of the vehicle. The camera uses image processing to detect pe Based on the positions, distances and relative speeds calculated, the warning is output or braking is t

This function warns the driver of possible collisions between 10 and 60 km/h. The brakes are also ap automatically. This will reduce the consequences of an accident or even avoid it completely. The func available during the day.

The collision warning is emitted in two stages. The first stage (pre-warning) shows the warning symbc instrument cluster (KOMBI). The symbol flashes in the 2nd stage (acute warning). Additionally there is acoustic warning.

Both stages can be switched on or off using the assist system operating facility. The function is always when the vehicle is started. Shortly before a collision the brakes are applied automatically with a medi force in order to reduce the severity of the impact.

When an acute warning is output, the brakes are prepared to deliver emergency braking as quickly as

## Lane departure warning

The prerequisites for a lane departure warning are an identified lane and a specific driving speed. The the system fundamentally ready to give a warning. When crossing over a lane is imminent, the system driver through a vibrating steering wheel. The system firstly uses one or two identified lanes to calcula vehicle position relative to these lanes. Using the yaw rate and the driving speed, the remaining time f over a lane is calculated. A warning is output in good time before crossing over the marking.

A warning is only output once when approaching a road marking. The warning lasts for a maximum of 2.5 seconds. No further warning is output if the vehicle remains on the lane marking. A renewed warn possible after steering back into the lane or a lane change. A lane change intended by the driver: no v output when the turn indicator is operated as an input signal.

The warning is ended in the following conditions:

- Driver steers back into the lane
- Lane change is carried out
- Vehicle is on the line for longer than 2.5 seconds
- Turn indicator for lane change is operated
- Brake is operated firmly (depending on brake pressure).

The speed for activation of a warning is country-dependent.

- Europe: 70 km/h
- United States: 40 mph
- Japan: 50 km/h

The displays for system and warning readiness are shown on the instrument cluster as well as (vehicle dependent) in the Head-Up Display.

## **High-beam assistant**

The video camera monitors the near field of the vehicle for light sources. Traffic driving in front or approaching is identified at a distance of approx. 400 meters. The detection range of the video cameras is approx. 100 m. The video camera field of view has a horizontal side angle of approx. 15° to the left and right. The video camera field of view has a vertical elevation angle of approx. 5° up and down. The video camera records position when it is in operation. Distinction can be drawn between different parameters such as light colour and intensity.

The recorded light points, light colours and light intensities picked are evaluated by the KAFAS control unit. In the evaluation the control unit gives a recommendation to switch on or off. The KAFAS or FLA control unit sends the recommendation to the FLA control unit. The recommendation to switch on or off also incorporates driving speed. For speeds under 30 km/h, the high-beam headlights are switched off. For a speed higher than 30 km an hour, the high-beam headlights are switched on in dependence on all additional parameters. The high-beam headlight is not switched on when the vehicle is in an environment with sufficient lighting. The KAFAS control unit (or FLA control unit) sends a switch-off recommendation.

## **Road sign recognition**

Marketing designation: Speed Limit Information

Road sign recognition displays current speed limits on the instrument cluster as well as the Head-Up Display. Road sign recognition therefore provides the driver with an aid to prevent excessive speeds. Responsibility for the vehicle and driven speed lies exclusively with the driver. The display of speed limits is based upon the following evaluations:

- Data from navigation system
- Image data from the video camera

Provided data on speed limits for the current road are stored in the navigation data, these are used as a basis by the KAFAS control unit. In parallel to this, the video data from the video camera are also evaluated by the KAFAS control unit. The image data are read in by the KAFAS control unit and evaluated for speed limit signs of speed limit traffic signs. If the video camera identifies signed, local, temporary speed limits, these are displayed with priority over the navigation data. In the case of covered or non-identifiable signs for enforcement of speed limitations, the speed limit displays are cancelled in accordance with a specified time and route parameters.

## **Collision warning**

In contrast to the collision warning, with Active Cruise Control (ACC = Radar), a camera-based technique is applied. Beyond a speed threshold of 15 km/h, the collision warning can issue warnings to rear views.

The collision warning has the following subfunctions:

- Initial warning

Warning, e.g. for signs of collision risk or for very small distances to a vehicle ahead.

Warning through red vehicle symbol in the instrument cluster, alternative Head-Up Display.

- Static prewarning for small distance
- Dynamic prewarning for approaching

- Acute warning

Warning for immediate risk of collision, if the vehicle approaches another object with relatively high differential speed.

Flashing red vehicle symbol in the instrument cluster, alternative Head-Up Display and acoustic signal

- Pre-filling of the brake
- Adaptation of the thresholds for the Dynamic Brake Control

A Check Control message is also issued.

The time of the warning can be dependent on different values. For example:

- Classification of the current driving situation
- Possibly wet roadway
- Estimation of the attention of the driver via pedal movements and steering wheel movements

**Observe functional limitations in the Owner's Handbook!**

## **Automatic braking for the recognition of stationary vehicles**

If the vehicle has the optional equipment 5AT, stationary and moving vehicles are also identified. Emergency braking can take place for stationary vehicles in danger areas.

## **Overtaking ban**

This function displays with the corresponding icons in the instrument cluster (alternative Head-Up Display) detected overtaking bans. The images recorded by the camera-based driver support systems camera are consolidated with the navigation data. The cancellation of overtaking bans is also displayed.

Additional traffic signs (e.g. truck, trailer) are detected and analysed for plausibility.

## **System limits**

The system function is restricted for some road and ambient conditions: for instance a snow-covered road, fog, rain, counter-light and dazzling due to the physical limits of the optical system.

## **Notes for Service department**

## General notes

In the event of replacement of the windscreen, calibration of the lane departure warning is required, as in cases where the position of the camera could have changed. If the control unit is replaced, no calibration is required. In this case, the calibration data stored in the camera are transferred to the control unit and stored there.

## Diagnosis instructions

### **Note! Follow the instructions for service functions!**

The diagnosis system provides the following service functions for the lane departure warning:

- Adjustment of lane departure warning actuator
- Calibration of lane departure warning

Path: **Service functions > Driver assist > Camera-based driver support systems**

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