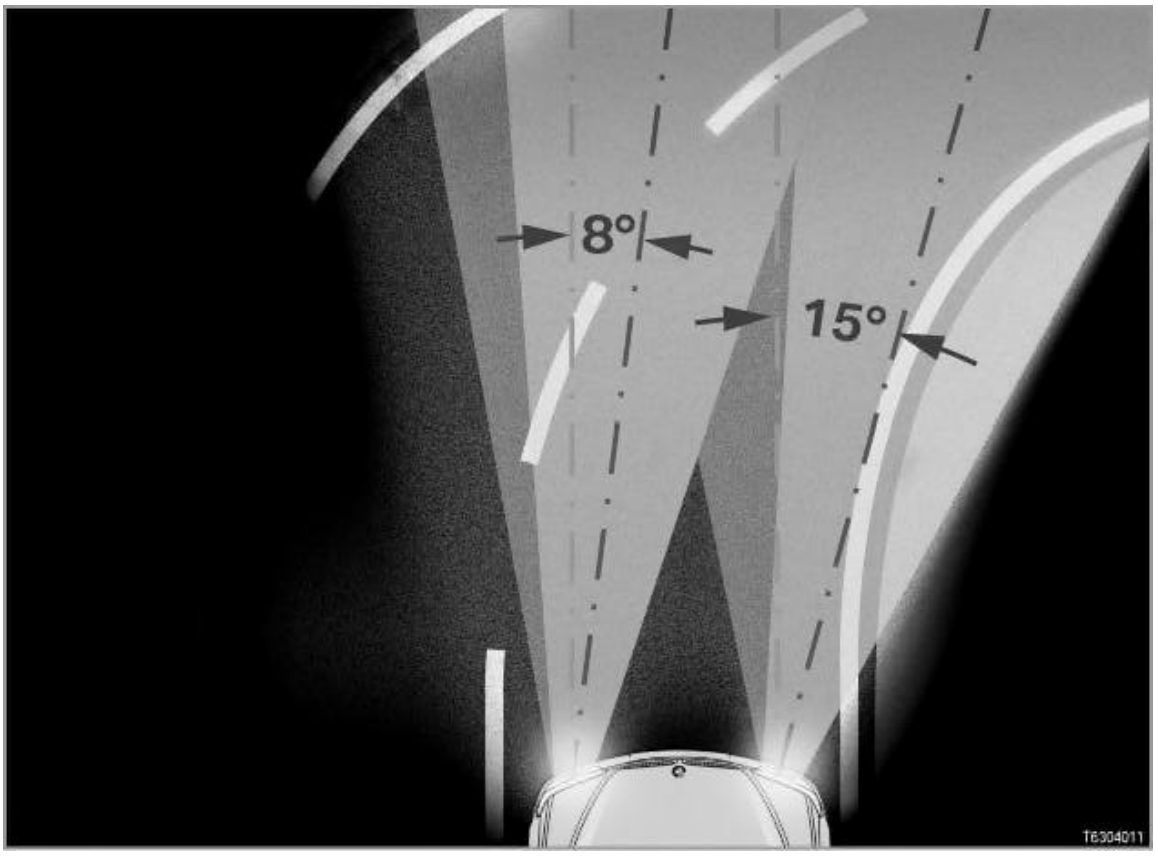
Adaptive headlights

E60 only in conjunction with option 524



Launch schedule for option 524 "Adaptive headlights":

- E46 Coupé (E46/2) and E46 Convertible (E46/C) model revision: 03/2003
- E60: 07/2003. Adaptive headlights are approved for the European market, for Great Britain and for the US release from start of series production of the E60 (07/2003).

  The same applies to Japan and Taiwan.
- E65, E63, E83: 10/2003
  - E83 US version: "Xenon lights without AHL" option 522 available from 03/2004.
  - E83 EURO: "Xenon lights without AHL" option 522 available from 09/2004.
- E53: 04/2004

Note: Option 524 is only available in conjunction with option 522.

Option 524 "Adaptive headlights" is only delivered in conjunction with option 522 "Bi-xenon main and dipped-beam headlights".

Note: EU approval for option 522 only in conjunction with option 502.

Option 522 "Bi-xenon main and dipped-beam headlights" is only delivered in conjunction with option 502 "Headlight cleaning system" (in countries with EU approval).

Note: AHL = ALC

The development code for the adaptive headlights was "ALC".
ALC stood for "Adaptive Light Control".
The marketing and sales designation for option 524 in English-language markets is "adaptive headlights", abbreviated to "AHL".
Diagnosis and technical vehicle documentation therefore use the abbreviation "AHL".
However, "ALC" is still used on some control units and in the EPC (Electronic Parts Catalogue).

Introduction

The adaptive headlights system turns the bi-xenon headlights towards the inside of a bend when cornering. This improves illumination of the curve of the road. Visibility is thus improved.
When cornering, the driver is not looking into a "black hole" - instead, the adaptive headlights allow the driver to see the curve of the road. [System overview ...]

Brief description of components

Note: Components for the AHL for the E53

- Similarities with the E46: The E53 has the same vehicle electrical system as the E46.

  The E53 uses the LSZ (light switch cluster) control unit for controlling the exterior lights (as does the E46).
- Similarities with the E60: The E53 has a position sensor (as does the E60) instead of a zero-position sensor (= E46).

Note: Components for the AHL for the E63

- Similarities with the E46: The E63 has a zero-position sensor (as does the E46).
- Similarities with the E60: The E63 has the same vehicle electrical system as the E60. The E63 uses the LM (light module) control unit for controlling the exterior lights (as does the E60).

The following components and control units provide signals for the adaptive headlight system:

- **Light switch**

  The rotary switch for the side lights and dipped-beam headlights differs depending on the vehicle equipment level (adaptive headlights, automatic driving lights control, automatic or manual headlight-range adjustment). For the adaptive headlights function to operate, the light switch must be set to position "A" ("A" = "automatic driving lights control" or "adaptive headlights"). [more ...]
- **Direction indicator/main-beam switch**

  The main-beam headlights are switched on and off with the direction indicator/main-beam switch (by pressing or pulling the switch). The adaptive headlights function operates with both dipped and main-beam headlights. [more ...]
- **Steering column switch cluster**

  The control unit in the steering column switch cluster (SZL) forwards the signals from the direction indicator/main-beam switch.
  Signal path:

  SZL -> **byteflight** -> SGM -> K-CAN -> LM

  SZL -> **byteflight** -> SGM -> PT-CAN -> AHL

  (steering column switch cluster -> **byteflight** -> safety and gateway module -> K-CAN -> light module or -> AHL control unit) [more]
- **Ride-height sensors**

  The ride-height sensors supply the input signals for the headlight-range adjustment. One ride-height sensor is located on the right-hand side of the front axle. A ride-height sensor is located on the right of the rear axle.
  The automatic headlight-range adjustment adapts the height adjustment of the headlights for different operating conditions

(e.g. when laden, when braking and when accelerating in dynamic driving situations).

If the special equipment "Adaptive headlights" is fitted, the adaptive headlights control unit evaluates the signals from the ride-height sensors (AHL control unit). This is because: The AHL control unit also controls automatic headlight-range adjustment. [more ...]

- **Brake light switch**

  If the special equipment "Adaptive headlights" is fitted, the signals from the brake light switch are read by the adaptive headlights control unit.
  In addition, the brake light switch signal is also an input signal for automatic headlight-range adjustment, see above: ride-height sensors.

- **Position sensor** (E60, E65, E53)

  The position sensor in the positioner module for the bi-xenon headlights supplies a signal indicating the aim of the headlights in the horizontal plane. [more ...]

- **Car Access System**

  The Car Access System (CAS) supplies input signals with regard to the terminal management (e.g. terminal 15 ON).
  The adaptive headlights control unit is activated when terminal 15 is switched ON.

- **EGS control unit or reversing light switch**

  When reverse gear is engaged, the headlights are moved to the straight-ahead position.

  - On vehicles with automatic transmission, the EGS control unit supplies the relevant signal to the light module (the EGS control unit is the control unit for electronic transmission control).
  - On vehicles with manual transmission, the signal is supplied by the reversing light switch.

- **Rain-light sensor for automatic driving lights control**

  The rain-light sensor measures the ambient light conditions outside the vehicle.

  - As it starts to get dark, the rain-light sensor sends the message "Twilight" to the light module. The light module informs the adaptive headlights control unit so that the automatic headlight-range adjustment of the dipped-beam headlights can be activated. The headlights are tilted up and down as required, but they are not yet swivelled towards the bend in the road.
  - In darkness, the rain-light sensor sends the message "Darkness" to the light module. The light module sends the relevant information to the adaptive headlights control unit.
    The headlights are swivelled as necessary.

  [more ...]

- **Steering angle sensor and DSC sensor**

  The steering angle sensor and DSC sensor (DSC = Dynamic Stability Control) supply signals for the adaptive headlights to the adaptive headlights control unit. These signals are evaluated as follows, depending on the vehicle's speed:

  - Vehicle speeds up to **30 km/h**:
    The adaptive headlights function is controlled on the basis of the information from the **steering angle sensor** (in the steering column switch cluster).
  - Vehicle speeds between **30 km/h and 50 km/h** :
    In the 30 to 50 km/h speed range, there is a **continuous transition** in signal evaluation: from the evaluation of signals sent by the steering angle sensor to evaluation of the signals sent by the yaw rate sensor (in the DSC sensor).
  - **In extreme dynamic driving situations**, e.g. if the vehicle starts to skid or fishtail, even at speeds less than **50 km/h** , the signals from the yaw-rate-sensor are considered.
    If the vehicle starts to skid or fishtail, the headlights will move to the straight-ahead position. The headlights are not swivelled until the vehicle has stabilised.
  - Vehicle speeds over **50 km/h**:
    At speeds upwards of 50 km/h, the signals from the **yaw rate sensor** (in the DSC sensor) form the primary basis for control of the adaptive headlights function.

    Reason: for a constant cornering radius, the steering angle required increases overproportionally with increasing speed.

In addition, the steering angle required also depends on the coefficient of friction of the road surface.
Yaw rate is directly proportional to speed. For this reason, the yaw rate is always the most suitable measure for controlling the adaptive headlights at high speeds.

Even at high speeds, however, the steering angle sensor signal is used to detect (predict) the driver's commands **in advance**. This is because: The yaw rate signal is not supplied until the vehicle has **responded** to the steering wheel movement.

The steering-angle sensor signal is disabled so that rapid, momentary steering adjustments do not affect the adaptive headlights function.

A number of control units are involved in the adaptive headlights system (see above: CAS, EGS, SZL).
In a narrower sense, the following control units are involved in the adaptive headlights function:

- **AHL control unit on E60, E63**

  The AHL control unit controls the adaptive headlights. For safety reasons, the AHL control unit is also responsible for the automatic headlight-range adjustment.

  The following fault is conceivable: After swivelling, one headlight remains in a position that is dazzling oncoming traffic. As a result, the AHL control unit attempts to tilt this headlight down (using the stepper motors for the automatic headlight-range adjustment).

  Conditions for switching off: The vehicle must be parked (vehicle must be stationary and terminal R OFF for several minutes).

  The AHL control unit is connected to the PT-CAN.

  [more ...]

- **Stepper motor controllers**

  The stepper motor controllers (SMCs) control the stepper motors in the headlights (for the automatic headlight-range adjustment and for the adaptive headlights).

  [more ...]

- **Light module**

  On the E60, the light module (LM) controls and monitors all vehicle lights. Information is transmitted and received via the K-CAN data bus.

  The light module actuates the indicator light for the adaptive headlights (on the light switch).

  [more ...]

- **Safety and gateway module**

  On the E60, the safety and gateway module (SGM) is the interface between the two data buses K-CAN and PT-CAN. Thus, all information exchanged between the light module and the AHL control unit passes through the SGM. Information from the yaw rate sensor (in the DSC sensor) is also fed through the SGM to the AHL control unit.

- **Xenon-headlight control unit**

  The xenon-headlight control unit monitors the D2-S bulbs for the bi-xenon headlights. [more ...]

The following components are controlled:

- **Stepper motors for the adaptive headlights**

  In the headlight units. [more ...]

  The stepper motors turn the positioner modules [more ...] in the bi-xenon headlights.

  The stepper motors turn the headlights vertically and horizontally (vertically = up and down for automatic headlight-range adjustment;

  horizontally = left and right for adaptive headlights).

- **Green indicator light on the light switch**

  The green indicator light (LED) next to the "A" (stands for automatic driving lights control or for adaptive headlights) has two display functions:

- The LED **lights up permanently** when the automatic driving lights control/adaptive headlights function is switched on (= light switch in position "A").
- The LED **flashes** if a fault develops in the adaptive headlight system.

  [more ...]

The green indicator light is actuated by the light module.

System functions

The adaptive headlights system adjusts the horizontal aim of the headlights (i.e. from side to side) in order to illuminate the inside of a bend when cornering.

The following functions of the adaptive headlights system are described below:

- System activation and calibration sequence
- Activation of stepper motor controllers (SMC)
- Speed-dependent analysis of input signals
- Horizontal swivelling of the headlights by the stepper motor controller
- Deactivation of adaptive headlight movements under extreme driving conditions
- Deactivation of adaptive headlight movements in response to system faults
- Setting headlights to parked position
- Activation of automatic headlight-range adjustment by the AHL control unit
- Adaptive headlights for automatic driving lights control

System activation and calibration sequence

When terminal 15 is switched ON, the headlights always perform a calibration sequence, even if the lights are not switched on. The AHL control unit sends the "perform calibration sequence" request to the stepper motor controllers (SMCs, control units for the headlight stepper motors). The stepper motor controllers actuate the stepper motors in the headlights. The calibration sequence is performed. During the calibration sequence, the headlights move in the following manner:

- The headlights move horizontally (= calibration sequence for the adaptive headlights).
- The headlights move vertically (= calibration sequence for the headlight-range adjustment function).
- At the end of the calibration sequence, the headlights are in the straight-ahead position.

Following the calibration sequence, the system is ready for operation.

When reverse gear is engaged, the headlights are moved to the straight-ahead position.

Note: The calibration sequence is performed only after terminal 15 has been switched OFF for at least 15 seconds.

If terminal 15 is switched on and off repeatedly (for example, for demonstration reasons), the headlights are not calibrated each time terminal 15 is switched on.
Terminal 15 must have been switched off for at least 15 seconds before it is switched on again. Only then is a calibration sequence performed when terminal 15 is switched on.

Activation of stepper motor controllers

The AHL control unit transmits the nominal values for the positioner modules (position and speed of movement of the positioner modules) to the stepper motor controllers (SMC). The AHL control unit calculates the nominal values on the basis of the following input signals:

- Vehicle road speed
- Steering angle (at speeds up to 50 km/h, depending on programming)
- Yaw rate (above 50 km/h, see "Steering-angle sensor and DSC sensor" above)

Speed-dependent analysis of input signals

The adaptive headlights are controlled by the following signals depending on the road speed: Signals from the steering angle sensor or signals from yaw rate sensor (in the DSC sensor).

The encoding (at the end of the production line) determines the priority assigned to sensor signals above which speed threshold (see above).

Horizontal swivelling of the headlights by the stepper motor controller

Horizontal range of movement of headlights

- Inwards, i.e. towards centre of vehicle: up to a maximum of 8°
  (for E60; for E46, E63 , E83: 7°)
- Outwards: up to max. 15 °

That means, for example, in a right-hand bend:
The right-hand headlight turns by up to 15° (the right-hand headlight is the "inside" headlight on a right-hand bend. It therefore swivels outwards away from the vehicle centre).
The left-hand headlight swivels through a maximum of 8° (the left-hand headlight swivels towards the vehicle centre, i.e. inwards).
The headlight on the outside of the bend reaches its end position at the same time as the headlight on the inside of the bend, ensuring that the road is evenly illuminated.

On a right-hand bend, the left-hand headlight is on the outside of the bend. The right-hand headlight is on the inside of the bend.

Deactivation of adaptive headlight movements under extreme driving conditions

If the vehicle starts to skid and fishtail, the swivelling movement of the adaptive headlights is deactivated as follows:

- The headlights are returned to the straight-ahead position. The headlights are no longer turned.
- The lights remain on.

Deactivation of adaptive headlight movements in response to system faults

If a system fault occurs, the green indicator lamp on the light switch flashes.

Dazzling of oncoming traffic must be prevented in the event of a system fault.

To this end, the swivelling movement of the adaptive headlights is deactivated as follows:

- If the stepper motors are still functional, the headlights are returned to the straight-ahead position. The headlights are no longer swivelled towards bends in the road.
- If it is no longer possible for a headlight to be moved back to the straight-ahead position, the headlight is tilted downwards (by the stepped motors for automatic headlight-range adjustment). This prevents dazzling of oncoming traffic.
- If the headlight cannot be tilted downwards, the bi-xenon bulb in this headlight is disabled as follows:

  When the vehicle is parked, the AHL control unit recognises sleep mode (standstill plus terminal R OFF for several minutes).

  The next time the vehicle is restarted, the bi-xenon light of the defective headlight is not switched on.

  The front foglights are switched on in order to ensure a minimum level of illumination.

  The dipped-beam headlights are **not** switched off while the vehicle is in motion.

Setting headlights to parked position

When terminal R is switched off, the headlights move to the parked position. The parked position is important for the headlights' next calibration sequence: from the parked position, the headlights are run through a calibration sequence in the pre-drive-check. During each calibration sequence, the AHL control unit relearns the straight-ahead position for the headlights.

When the headlights have reached the parked position, the stepper motor controllers (SMCs) inform the AHL control unit ("acknowledge").

The AHL control unit deactivates the stepper motor controllers.

The run-down period lasts approx. 10 seconds.

Activation of automatic headlight-range adjustment by the AHL control unit

If special equipment "Adaptive headlights" is fitted, the AHL control unit also controls the automatic headlight-range adjustment.

The automatic headlight-range adjustment adapts the headlight range for different operating conditions. Variations in the vehicle tilt angle are produced by vehicle loads and braking or acceleration in extreme driving situations. The automatic headlight-range adjustment tilts the headlights up and down as required.

The AHL control unit controls the automatic headlight-range adjustment as follows:

1. The ride-height sensors and the brake light switch send the input signals for the headlight-range adjustment to the AHL control unit.
2. From the input signals received, the AHL control unit calculates the vehicle tilt angle (along the longitudinal axis, relative to the road surface).
3. Using the stepper motors for moving the headlights vertically, the headlight range is adjusted automatically and dynamically.

   The headlight range is adjusted so that the actual headlight range conforms to the legally required headlight range as follows:

   - If vehicle rear is lower than front:
     The actual headlight range will be longer than the legally stipulated range. The headlight beam height is lowered to reduce the headlight range to match the legal requirement.
   - If the vehicle is horizontal:
     The actual headlight range will be the same as the legally stipulated range.
   - If vehicle front is lower than rear:
     The actual headlight range will be shorter than the legally stipulated range. The headlight beam height is raised to increase the headlight range to match the legal requirement.

Adaptive headlights for automatic driving lights control

The automatic driving lights control feature (option in conjunction with the rain-light sensor) automatically switches the side lights and dipped-beam headlights on and off.

Switch-on conditions:

- The light module must be encoded with automatic driving lights control.
- The light switch must be in position "A" ("A" for automatic driving lights control or adaptive headlights).
- The rain-light sensor must be installed and operational.

  The rain-light sensor detects the brightness of the ambient light. The rain-light sensor sends the following requests to the light module:

  - low ambient brightness (twilight, darkness, in a low-level garage or tunnel): "switch on dipped-beam headlights" request
  - sufficient ambient brightness: "switch off dipped-beam headlights" request

If only the side lights are to be switched on, the light switch must be set to side lights (switch position 1).

When the light switch is set to position "A", the AHL control unit is also activated:

- When the automatic driving lights control function switches on the dipped-beam headlights (e.g. at dawn/dusk), the adaptive headlights function is notified at the same time.

The light module sends the message "Dipped headlights on" to the AHL control unit (and the AHL control unit takes over control of automatic headlight-range adjustment).

- The light module also takes account of the signals from the rain-light sensor.

  The headlights are not turned when the vehicle is cornering until total darkness sets in.

The message "Dipped headlights on" is generated separately for each headlight unit.

If a headlight fails, the movement of the adaptive headlights is suspended.
The front foglights are switched on in order to ensure a minimum level of illumination.

Switch-on conditions

When terminal 15 is switched ON, the AHL control unit "wakes up". The swivelling of the lights is subject to the following conditions:

- Reverse gear must **not** be engaged.
- No system faults must be present. The indicator light must **not** be flashing.
- The D2-S bulbs in both headlight units must be working (the D2-S bulbs are the bulbs for the xenon headlights).
- The vehicle must not be skidding or fishtailing.
- The rain-light sensor must detect darkness.
- Additional precondition for activation: automatic driving lights control is active (light switch in position "A", see above).

Notes for service staff

Warning: Exercise caution when working on bi-xenon headlights

Whenever inspecting or working on the headlights, always observe the safety precautions and accident prevention rules. The headlight system carries dangerous high voltages.

- General notes: [more ...]
- Diagnostics: [more ...]
- Encoding/programming: [more ...]
- Car & Key Memory: ---

National versions

The equipment "Daytime driving lights" and "Manual headlight-range adjustment" are available in certain countries.
Vehicles with manual headlight-range adjustment do not have adaptive headlights This is because vehicles with manual headlight-range adjustment have halogen dipped-beam headlights. Adaptive headlights are only available with special equipment bi-xenon lights.

Activating adaptive headlights in conjunction with daytime driving lights

The special equipment "Daytime driving lights" (Northern Europe and Canada) means that

the dipped-beam headlights and the side lights are **always** on.

- light switch in position "2"
- terminal 15 ON

the automatic headlight-range adjustment function is active (controlled by the AHL control unit).

If terminal 15 is switched off, the dipped-beam headlights and the side lights are automatically switched off as well.

The light switch must be in position "A" even on vehicles with the "Daytime driving lights" option to enable the adaptive headlights control unit to operate.

System functions for "Daytime driving lights" option when the light switch is set to position "A":

- If the vehicle is encoded with the "Daytime driving lights" option (end of production line), the light switch can remain in position "A" at all times.

  When terminal R is switched on, side lights, locator lights and licence plate lights are switched on.

  When terminal 15 is switched on, dipped-beam headlights are also switched on.
- When the dipped-beam headlights are switched on, the adaptive headlights control unit is activated (for automatic headlight-range adjustment).
- The green indicator lamp on the light switch lights up, indicating that the system is functional.
- The adaptive headlights turn when the vehicle is stationary if the steering wheel is turned (to the right only).
- If darkness is detected (= signal from rain-light sensor) the headlights are turned when the vehicle is cornering.

The switch-on conditions for the adaptive headlights in conjunction with special equipment "Daytime driving lights" are as follows:

- The vehicle must be encoded with special equipment "Daytime driving lights" (end of production line)
- Light switch in must be set to position "A"
- Terminal 15 must be switched on and reverse gear must not be engaged
- The rain-light sensor must detect darkness

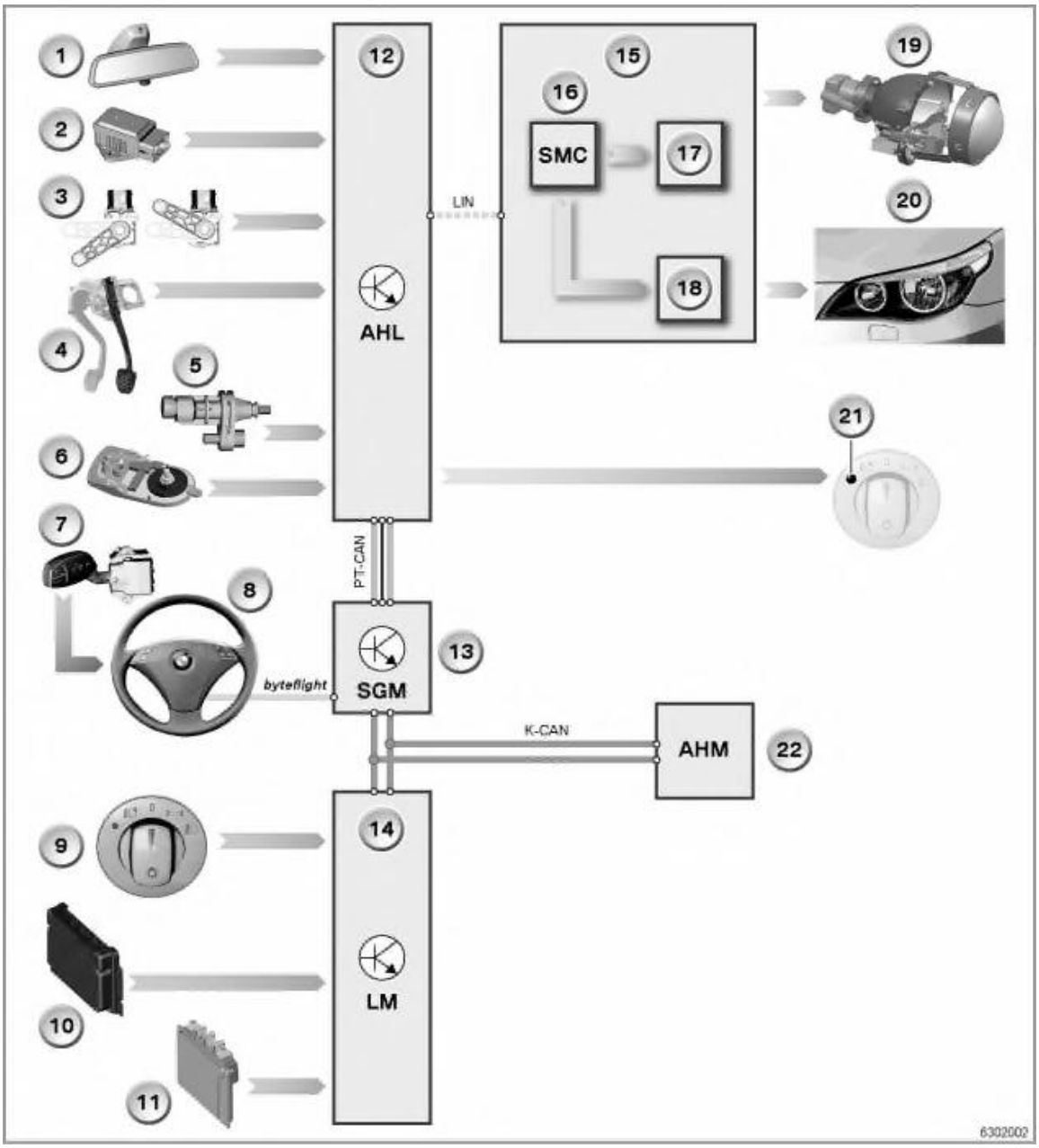
Subject to change.

E60 - System overview of adaptive headlights

This system overview includes the following overviews of the adaptive headlights for the E60:

- Inputs/outputs
- System circuit diagram
- Overview of the signal paths for the adaptive headlights

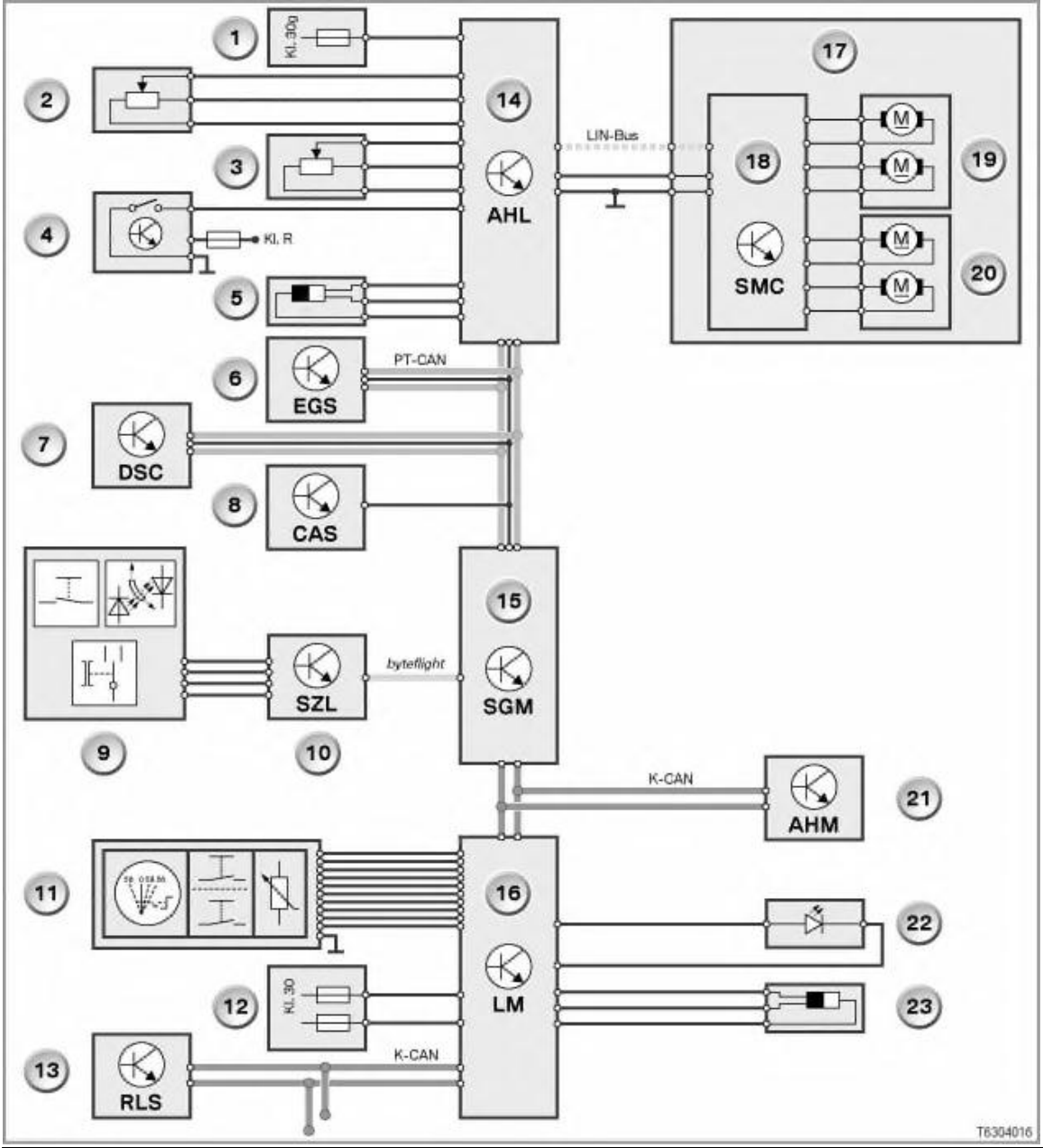
- Inputs/outputs



Key	Explanation	Key	Explanation
1	Rain-light sensor	2	Yaw rate sensor in DSC sensor
3	Ride-height sensors (one each on front axle, right and rear axle, right)	4	Brake-light switch (brake pedal highlighted in black)
5	Wheel speed sensor (4 wheel speed sensors on each vehicle)	6	Position sensor
7	Direction indicator/main-beam switch	8	

			Steering column switch cluster (SZL) with steering angle sensor
9	Light switch	10	Car Access System (CAS)
11	Electronic transmission control (EGS)	12	AHL control unit for adaptive headlights
13	Safety and gateway module (SGM)	14	Light module (LM)
15	Positioner module with SMC (stepper motor controller, control unit for adaptive headlights stepper motors); 2 positioner modules with stepper motors on each vehicle	16	Stepper motor controller (SMC) Control unit for adaptive headlight stepper motors and for automatic headlight-range adjustment stepper motors
17	Stepper motor for adaptive headlights	18	Stepper motor for automatic headlight-range adjustment
19	Xenon control unit with D2-S bulb Mechanical screen in bi-xenon headlights for switching D2-S bulb to main beam	20	Headlight
21	Green indicator light (LED) for automatic driving lights control and for adaptive headlights (on lights switch)	22	Trailer module (AHM), if fitted
LIN	Local bus between AHL and SMC (Local Interconnect Network)	K-CAN	Body CAN
PT-CAN	Powertrain CAN		

- System circuit diagram



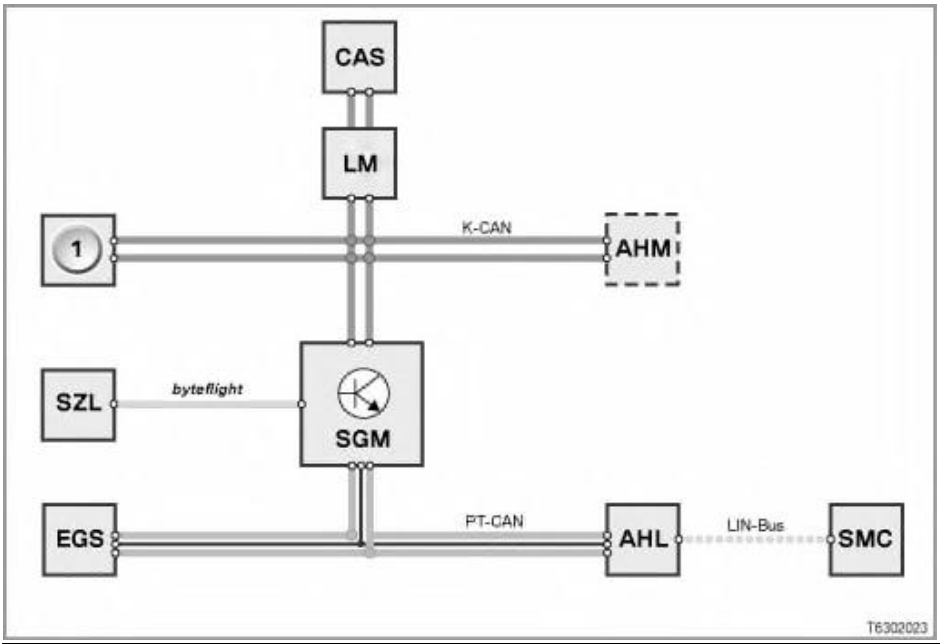
Key	Explanation	Key	Explanation
1	Power supply for terminal 30g from rear power supply	2	Ride-height sensor, front right
3	Ride-height sensor, rear right	4	Brake light switch
5	Position sensor	6	Electronic transmission control (EGS)
7	Dynamic Stability Control (DSC)	8	Car Access System (CAS) with wake-up wire to PT-CAN
9	Direction indicator/main-beam switch	10	Steering column switch cluster (SZL)
11	Light switch	12	Power supply for terminal 30g from front power supply
13	Rain-light sensor	14	AHL control unit (adaptive headlights)
15	Safety and gateway module (SGM)	16	Light module (LM)
17	Positioner module	18	Stepper motor controller (SMC)

19

	Stepper motor for automatic headlight-range adjustment	20	Stepper motor for adaptive headlights
19	Xenon control unit with D2-S bulb Mechanical screen in bi-xenon headlights for switching D2-S bulb to main beam	20	Headlight
21	Trailer module (AHM), if fitted	22	Green indicator light (LED) for automatic driving lights control and for adaptive headlights (on lights switch)
23	Xenon-headlight control unit	**Byteflight**	Fibre optics
LIN Bus	Local bus between AHL and SMC (Local Interconnect Network)	K-CAN	Body CAN
PT-CAN	Powertrain CAN		

- Overview of signal paths for adaptive headlights on E60

The signal paths between the individual control units can be seen on the following illustration:



Key	Explanation	Key	Explanation
1	Rain-light sensor		
AHL	Adaptive headlights	AHM	Trailer module (if fitted)
CAS	Car access system	EGS	Electronic transmission control
LM	Light module	SGM	Safety and gateway module
SMC	Stepper motor controllers	SZL	Steering column switch cluster
byteflight	Fibre optics	LIN	Local Interconnect Network, local bus
K-CAN	Body CAN	PT-CAN	Powertrain CAN

The safety and gateway module (SGM) is the gateway (i.e. data interface) between the K-CAN, PT-CAN and **byteflight** data buses. The signal paths from the light module to the adaptive headlights always lead through the safety and gateway module.

- **Signal path for "Switch on dipped-beam headlights" on the E60**

on when the switch is in position 2; signal path:

SZL -> **byteflight** -> SGM -> K-CAN -> LM and AHM
(steering column switch cluster -> **byteflight** -> Safety and gateway module -> K-CAN -> light module and AHL control unit)

- **Signal path for "Activate adaptive headlights" on the E60**

  When terminal 15 is switched ON (signal from CAS via K-CAN to the light module) and the light switch is in position "A", the adaptive headlights control unit is activated. Signal path:

  LM -> K-CAN -> SGM -> PT-CAN -> AHL

- **Signal path for "Turn headlights" for adaptive headlights on the E60**

  1. Switch-on condition "Light switch in position A" present. Signal path:

     LM -> K-CAN -> SGM -> PT-CAN -> AHL

     and

  2. Switch-on condition "terminal 15 ON" present; Signal path:

     CAS -> K-CAN -> LM -> SGM -> PT-CAN -> AHL
     and

  3. Switch-on condition "dark" present; Signal path:

     RLS -> K-CAN -> SGM -> PT-CAN -> AHL

     and

  4. Switch-on condition "cornering" present; Signal path:

     Steering-angle sensor in SZL -> **byteflight** -> SGM -> AHL

     or yaw rate sensor in DSC sensor -> Suspension CAN -> DSC -> PT-CAN -> AHL

     and

  5. Switch-on condition "reverse gear not engaged" present; Signal path:

     EGS -> PT-CAN -> AHL

- **Signal path for adaptive headlights calibration sequence on the E60**

  The calibration sequence is always performed when terminal 15 is switched on.
  (light switch in position "0" or "2" (dipped-beam headlights) or in position "A", for example).

  Signal path:

  CAS -> K-CAN -> LM -> SGM -> PT-CAN -> AHL -> LIN -> SMC
  (digital engine electronics (DME) or digital diesel electronics (DDE) -> PT-CAN -> Adaptive headlights -> Local bus -> Stepper motor controller)

Note: Calibration sequence is performed only after terminal 15 has been switched OFF for at least 15 seconds.

If terminal 15 is switched on and off repeatedly (for example, for demonstration reasons), the headlights are not calibrated each time terminal 15 is switched on.
Terminal 15 must have been switched off for at least 15 seconds before it is switched on. Only then is a calibration sequence performed when terminal 15 is switched on again.

For reasons of safety, there are 2 serial wire connections for linking to the bus:

- from the SZL to the LM (light module)
- from the SZL to the AL control unit: if option 217 "Active steering" is fitted, the 2nd serial wire goes from the SZL to the AL (active steering) control unit:
  This makes sure that the signal from the steering-angle sensor also reaches the AL control unit in the event of a bus error.

Note: AHL = ALC

The development designation for adaptive headlights was "ALC",
which stood for "Adaptive Light Control".

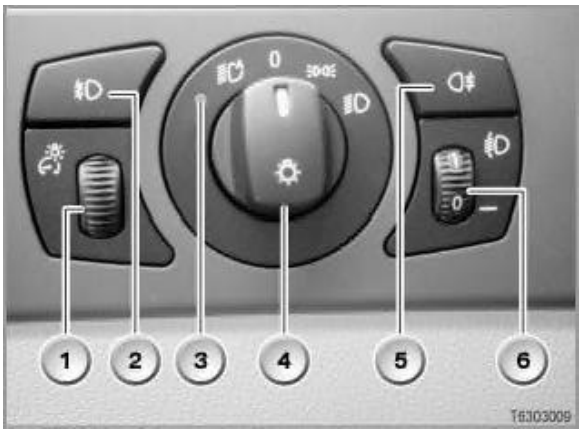
The marketing and sales designation of option 524 in English-speaking countries is "adaptive headlights", abbreviated to "AHL".

In fault-diagnostics contexts and in technical documentation, the system is referred to as "adaptive headlights" and the abbreviation "AHL" used for the control unit.

However, some control units are still marked "ALC".

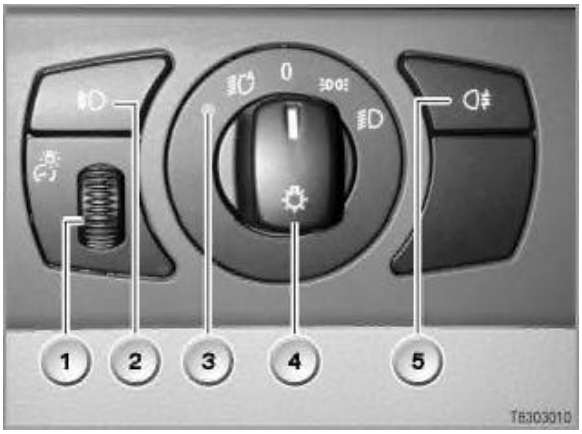
E60 - Light switch

The switch for side lights and dipped-beam headlights differs according to equipment level (adaptive headlights, automatic driving lights control or manual headlight-range adjustment).



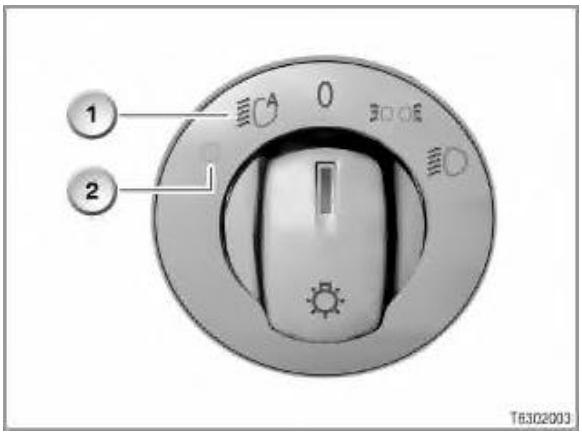
Light switch for vehicles with halogen headlights and manual headlight-range adjustment

1. Thumbwheel for instrument illumination
2. Button for the foglights
3. Green indicator lamp
4. Rotary switch for side lights and dipped-beam headlights (see below for detailed illustration)
5. Button for rear foglights
6. Thumbwheel for manual headlight-range adjustment



Light switch for vehicles with bi-xenon headlights, automatic headlight-range adjustment and adaptive headlights

1. Thumbwheel for instrument illumination
2. Button for the foglights
3. Green indicator lamp
4. Rotary switch for side lights and dipped-beam headlights (see below for detailed illustration)
5. Button for rear foglights



Rotary switch for side lights and dipped-beam headlights

The following are important for the adaptive headlights:

1. Switch position "A" for adaptive headlights and automatic driving lights control
2. Green indicator light (LED) for adaptive headlights and automatic driving lights control

Installation location

The light switch is located on the extreme left of the dashboard.

Construction

The rotary switch switches on the following:

- Side lights (switch position 1)
- Dipped-beam headlights (switch position 2)
- "A" for special equipment "Automatic driving lights control" and for special equipment "Adaptive headlights"

The following variations are possible depending on the vehicle equipment level and the national version:

- Green indicator light and switch position "A" on rotary switch for side lights and dipped-beam headlights: the rotary switch

has an additional "A" position and a green indicator lamp (LED) for the automatic driving lights control or the adaptive headlights.

- Light switch **without** thumbwheel: vehicles with bi-xenon and automatic headlight-range adjustment do not need a thumbwheel for the headlight-range adjustment.
- Light switch **with** thumbwheel: vehicles with halogen headlights and manual headlight-range adjustment have a thumbwheel for manual headlight-range adjustment.

How it works

The switch is fed a supply voltage of 5 volts from the light module.

If the power supply is faulty, the lights will remain switched on so long as terminal 15 is ON (i.e. the lights are switched on when terminal 15 is switched on).

The lights are automatically switched on if the wiring to and from the light switch develops the following faults:

- Open circuit, or
- Short circuit to earth, or
- Short circuit to positive

For reasons of safety, the light switch can only be switched off if a voltage of 5 volts is applied to the two switch outputs of the light module. The lights **cannot** be switched off in the event of a short circuit causing a voltage of 5 volts at one of the switch outputs and 12 volts at the other. Dipped-beam headlights and automatic driving lights control/adaptive headlights remain on until terminal 15 is switched off.

E60 - Direction indicator/main-beam switch

Installation location

The direction indicator/main-beam switch is on the left of the steering wheel (the upper steering-column stalk).

1	To switch main-beam headlights on and off	2	Headlight flasher
3	Turn indicator		

Construction

The direction indicator/main-beam switch comprises a steering-column stalk with 2 axial one-touch buttons for the on-board computer and Check-Control messages.

How it works

Dual transmission of turn signal

The turn signal is autonomously transmitted (twice):

- A message is transmitted through the data buses to the light module.
  Signal path: SZL (steering column switch cluster) -> **byteflight** data bus -> SGM (safety and gateway module) -> K-CAN data bus -> LM (light module);
- The turn signal is transmitted a second time directly from the steering-column stalk to the light module via a dedicated wire.

This makes the turn signal independent of the data buses.

Function limitations in the event of a failure of one or both data buses:

- Main-beam headlights and the headlight flasher only work if the steering-column stalk is held.
- The turn signals only work if the steering-column stalk is held.
- No hazard warning lights in the event of an accident or when the anti-theft alarm system is primed.

Operation

Moving the steering-column stalk to the front (in direction of travel) or to the rear switches the main-beam headlights on and off.

The steering-column stalk no longer engages in the switch positions.

Moving the steering-column stalk has the following functions:

- Turn signals: the turn signals work as follows when terminal R is ON:
  - To signal briefly, move the steering-column stalk briefly up for a right signal or down for a left signal;
  - For a continuous signal, press the steering-column stalk beyond the pressure point.
- Main-beam headlights and headlight flasher or dipped-beam headlights: Move the switch to the front or to the rear.
- Parking lights, left or right: When terminal R is OFF, move the steering-column stalk beyond the pressure point as for a continuous turn signal (up for right and down for left).

E60 - Steering column switch cluster

The SZL (steering column switch cluster) processes all data from the multi-function steering wheel. The SZL transmits the data (via the **byteflight** data bus) to the safety and gateway module (SGM).

The safety and gateway module (SGM) connects the multi-function steering wheel with the other systems in the vehicle. The SGM transmits the data from the multi-function steering wheel, e.g. to the following control units: wiper module, rain-light sensor, EGS, DME, KOMBI and LM.

For reasons of safety, there are 2 serial wire connections for linking to the bus:

- from the SZL to the LM (light module)
- from the SZL to the AL control unit: if option 217 "Active steering" is fitted, the 2nd serial interface goes from the SZL to the AL (active steering) control unit:
  This makes sure that the signal from the steering-angle sensor also reaches the AL control unit in the event of a bus error.

Installation location

The SZL is located on the steering column.

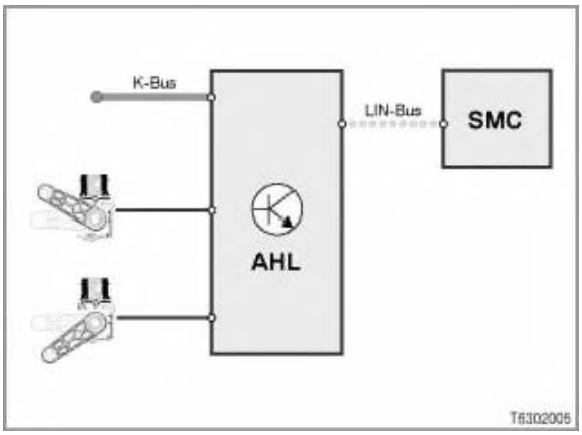
How it works

The range of functions of the SZL can be divided into 3 main blocks:

- SZL as control unit for the passive safety system (ASE Advanced Safety Electronics) with connection to the **byteflight** data bus
- SZL as switch cluster for the control functions of the steering column
  - Multi-function buttons in the multi-function steering wheel
  - Fully electronic steering column fore-and-aft and height adjustment via buttons on left-hand side of steering column
  - Steering wheel heating via button on left-hand side of steering column
- SZL as switch cluster for the 3 steering-column stalks for
  - Wipers
  - Turn indicator
  - Cruise control system
- SZL as steering-angle sensor

E60 - Ride-height sensors

The ride-height sensors on the front and rear axles supply the input signals for the automatic headlight-range adjustment.
The automatic headlight-range adjustment adjusts the vertical setting of the headlights in order to compensate for variations in the vehicle tilt angle, e.g. due to payload, braking or acceleration in dynamic driving situations).



The AHL control unit controls the automatic headlight-range adjustment as follows:

The AHL control unit evaluates the signals from the ride-height sensors. The ride-height sensors are connected by a direct wire to the AHL control unit.
The signals from the ride-height sensors are **not** transmitted via the K-bus.

The AHL control unit transmits the nominal values for the stepper motors to the stepper motor controllers (SMCs) via the LIN bus.

The stepper motor controllers control the stepper motors for the automatic headlight-range adjustment feature.

Installation location

The ride-height sensors are installed on the front and rear axles as follows:

- Front axle: 1 ride-height sensor on the transverse link, front right
- Rear axle: 1 ride-height sensor on the pendulum support, rear right

The ride-height sensors for the headlight-range adjustment are always built into **one** side of the vehicle (for example, front right and rear right). If the ride-height sensors were installed diagonally (e.g. front right and rear left), transverse movements of the vehicle would have an effect on the headlight range.

Vehicles with electronic height control (EHC) have 3 ride-height sensors:

- Front right
- Rear right
- Rear left

The rear right ride-height sensor is a double sensor (only on vehicles with EHC).

Construction

The ride-height sensors are Hall-type sensors.

On vehicles with electronic height control (EHC), a double sensor is installed on the right of the rear axle. The double sensor comprises the following components:

- 1 ring magnet
- 2 Hall sensors
- 2 independent electronic evaluation units

The signals from one of the electronic evaluation units are evaluated by the AHL control unit; the signals from the other electronic evaluation unit are evaluated by the EHC control unit.

How it works

The ride-height sensors for automatic headlight-range adjustment send voltage signals to the AHL control unit as follows:
As the springs are compressed, the output voltage of the ride-height sensors changes linearly.

Voltage change on E60:

- Front axle: As the springs are compressed, the output voltage of the ride-height sensor drops.
  As the springs extend, the output voltage of the ride-height sensor increases.
- Rear axle: As the springs are compressed, the output voltage of the ride-height sensor increases.
  As the springs extend, the output voltage of the ride-height sensor drops.

On vehicles with electronic height control (EHC), the signal of the double sensor at the rear right is evaluated for the automatic headlight-range adjustment.

Note: Analogue sensors cannot be evaluated by several control units.

For this reason, a double sensor has to be installed at the rear right on vehicles with EHC.

Reason: Hall sensors transmit an analogue voltage signal. This voltage signal is measured against a resistance in the control unit.

If 2 control units were to receive the voltage signal, the result would be a parallel connection of the resistances and thus a change in the measured value.
The earth offset between the front end and the rear of the vehicle (front and rear have different earths) will also affect the measured value if the control units are installed far apart from one another.
An unambiguously evaluable signal would therefore not be possible.

For this reason, sensors whose signals are important for several control units (e.g. the steering angle sensor) are manufactured as digital sensors with CAN connection.

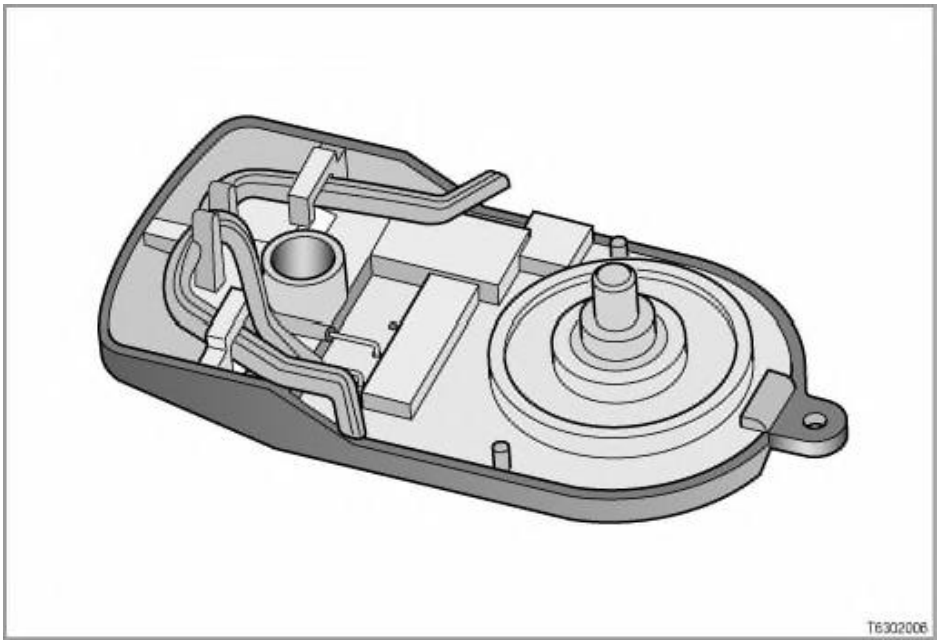
E60 - Position sensor

The position of the swivel modules for the adaptive headlights is detected by the following sensors depending on the vehicle model:

- Position sensor (Hella headlights) in E60, E65, E63 vehicles
- Zero-position sensor (Automotive Light, previously Bosch, headlights) in E46, E63 and E83 vehicles

Position sensor

The position sensor supplies information about the position of the adaptive headlights' positioner modules.



Installation location

The position sensor is located on the axis of rotation of the positioner module.

Construction

The position sensor is an inductive sensor (an analogue sensor).

The position sensor consists of 2 parts in longitudinal section (the illustration shows one of the two parts of the position sensor, magnified approx. 3 fold). The two parts are installed as follows:

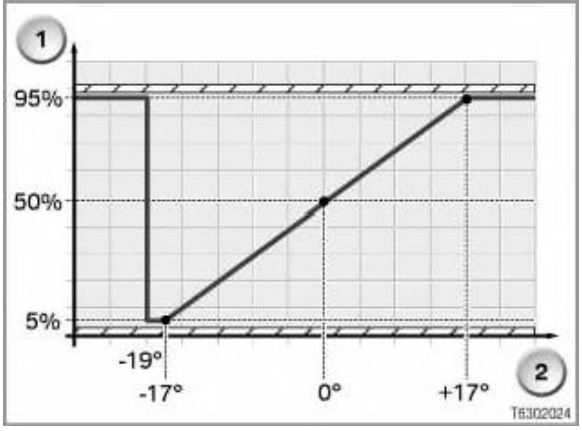
- The first part (see illustration) is fixed to the frame in the headlight housing.
- The other part is connected to the positioner module and moves with the positioner module as follows:

  When the positioner module is moved, the position sensor also moves. The moving part of the position sensor is thus turned relative to the fixed part.

  The pulse width of the PWM signal is derived from the turning movement.

How it works

The position sensor records the mechanical angle on the rotor of the positioner module.
This angle is converted to a pulse-modulated signal.



The (Hella) position sensor output signal is a pulse-modulated signal.

In the straight-ahead position, the cycle ratio is 50:50.

The position sensor is highly accurate: The resolution of the position sensor at reference point 50:50 is less than 0.2 °.

Key	Explanation	Key	Explanation
1	Cycle ratio of PWM signal in %	2	Measuring range of position sensor

The position sensor works as follows:

Power supply from the stepper motor controller (SMC)

5 volts (± 10 %).

Overvoltage protection

The overvoltage protection of the position sensor is in the stepper motor controller.

Calibration

The position sensor is calibrated for the respective positioner module by a test at the end of the assembly line (performed by the headlight manufacturer). The adaptation parameters for the positioner module are programmed in the position sensor.

Defined position in relation to the straight-ahead position

The position sensor has a defined position in relation to the headlights' straight-ahead position. This defined position is stored in the encoding data. The position may vary, depending on the type of headlight.

Measuring range

The measuring range of the position sensor is from -17° to + 17°.

This measuring range is not used to the full by the positioner modules.

Position sensor map

The position sensor map is a pulse-modulated signal.

Measuring accuracy

For reasons of precision, the cycle ratio is recorded in the range between 5 % and 95 %.

Default value for the position sensor

If the position sensor should fail, the headlights will be reset relative to a mechanical reference point (tolerance ± 1 °).

E60 - Rain-light sensor

The rain-light sensor detects water on the windscreen and the ambient brightness. The signals of the rain-light sensor control the wiper function, the automatic driving lights control and the adaptive headlights control unit.

1) Rain-light sensor in base of interior rear-view mirror

Installation location

The rain-light sensor is located on the windscreen in the base of the interior rear-view mirror.

Construction

The rain-light sensor is an optical system consisting of the rain sensor, the driving lights sensor and an electronic evaluation unit.

The rain sensor comprises

- Optical element: the optical element is affixed to the windscreen.
- Electronics unit: the electronics unit houses 4 optical transmitter and 4 receiver diodes in addition to the evaluation electronics.
- Heating: an integrated heating system prevents the optical element and the diodes from misting over.

The driving light sensor consists of 2 photodiodes and an electronic evaluation unit.

How it works

How the rain sensor and the driving light sensor work is described separately below:

Rain sensor

The rain sensor is activated as follows:

- Terminal R ON (ignition key position 1)
- Wiper lever set to intermittent
- Briefly rotate the thumbwheel (on the wiper lever) or clean the windscreen (pull the wiper lever).

When the rain sensor is activated, the green LED on the wiper lever lights up.

On the E60, the rain sensor works as follows:

- A single wipe cycle is performed to provide a visual indication that the rain sensor has been activated.
- The transmitter diodes emit an infrared light. The infrared light is carried to the windscreen by the optical element.
- When the windscreen is completely dry and clean, the infrared light will be completely reflected to the receiver diodes.
- If the part of the windscreen near the optical element is wet or covered (water, snow, dirt), the infrared beam can no longer be fully reflected.

  Only a certain fraction of the beam will be able to penetrate the windscreen. Only a portion of the light then reaches the

receiver diodes.

- The electronic evaluation unit then detects the degree of wetness of the windscreen based on the fraction of beam received. The electronic evaluation unit transmits a signal through the K-CAN data bus to the body general module. The body general module actuates a wipe cycle.

The sensitivity of the rain sensor can be adjusted to one of 4 sensitivity settings using the thumbwheel on the wiper lever. Each time the thumbwheel is moved to "Increase sensitivity" (thumbwheel turned up), a wipe cycle is performed. Sensitivity is automatically reduced when the vehicle is stationary. The wiper usually works in intermittent mode. Only in very heavy rain will intermittent wipe mode switch to continuous wipe mode.

If the rain sensor should fail, the windscreen wiper will continue with a fixed wipe interval.

For reasons of safety, the rain sensor is deactivated if terminal R is switched off.

Preconditions for fault-free operation of the rain sensor are:

- No smears on the windscreen
- Wiper blades not damaged
- Windscreen free of faults in area of rain sensor
- Optical element is affixed to the windscreen free of bubbles.

Initialisation of rain sensor: conditioned by the optical process, the rain sensor must be calibrated to the windscreen. The rain sensor is calibrated to the windscreen during initialisation.

Driving light sensor

The driving light sensor works as follows:

- The two photodiodes record the light incidence from the front (frontal light intensity) and from above (surrounding brightness).
  The photodiodes work when terminal R is ON, regardless of whether or not the automatic driving lights control is switched on.
- If lighting conditions change, the driving light sensor transmits a signal through the K-CAN data bus to the light module.
- The light module switches the driving lights on or off To do this, the automatic driving lights control must be activated (light switch in switch position "A").
- The adaptive headlights are also activated when the rain-light sensor detects darkness. The headlights are swivelled in bends. The threshold values from which the rain-light sensor detects "darkness" are stored in the rain-light sensor.

The driving lights sensor is encoded with the encoding data for the series during the encoding procedure.

The sensitivity of the driving light sensor can be set to one of 2 settings with the Car & Key Memory.

Important: Used rain-light sensors must be encoded.

If a used rain-light sensor from a different vehicle has been installed, it will be necessary to encode this rain-light sensor prior to initialisation.

E60 - AHL control unit for adaptive headlights

The AHL control unit is the identical component on all vehicle models with option 524:
The AHL control unit is encoded for the model concerned at end of the assembly line. The AHL control unit is encoded by the manufacturer for the E60.

The AHL control unit is the master control unit for the vertical and horizontal adjustment of the headlights. The AHL control unit sends the preset values for the position and the speed of the swivelling motion to the stepper motor controllers (in the headlight housing). The stepper motor controllers then control the stepper motors for the headlights accordingly.

Installation location

The AHL control unit is installed in the carrier behind the glove compartment.

Construction

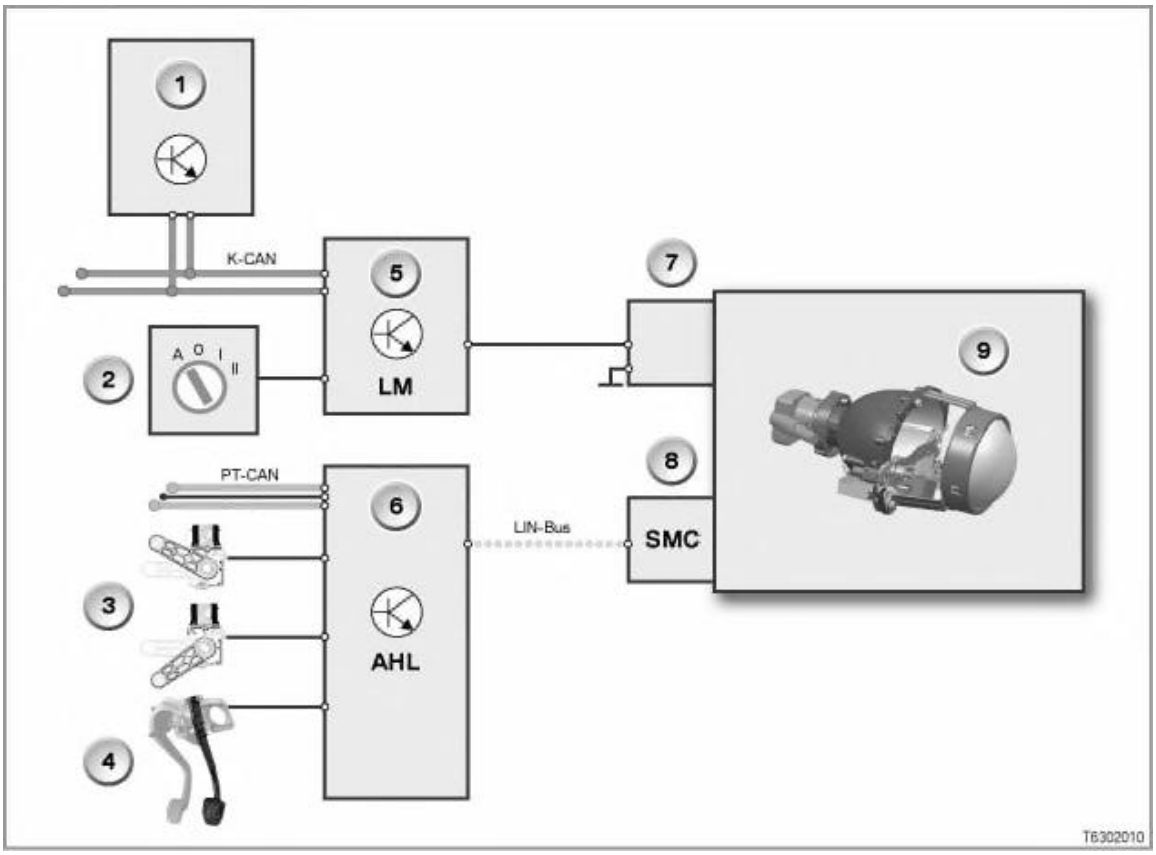
The illustration shows the AHL control unit with the conventional components for the adaptive headlights system:

- Adaptive headlights block diagram
- Pin assignment

- Adaptive headlights block diagram

The block diagram shows the following relationships for the E60:

- Headlight components that are actuated by the light module and by the AHL control unit
- Components supplying the input signals necessary for this
- Buses and direct wire connections



Key	Explanation	Key	Explanation
1	Rain-light sensor	2	Light switch

3	Ride-height sensors (one each on front axle, right and rear axle, right)	4	Brake-light switch (brake pedal highlighted in black)
5	Light module (LM)	6	AHL control unit for adaptive headlights
7	Xenon control unit and electronic ballast for D2-S bulbs, actuated by the light module	8	Stepper motor controller (SMC), actuated by AHL control unit
9	Positioner module	LIN	Local bus (Local Interconnect Network)
K-CAN	Body CAN	PT-CAN	Powertrain CAN

- Pin assignment for X10513, 18-pin multi-pin connector

Pin	Type	Description
1	V	AHL control unit supply voltage
2	A	Supply voltage switched for the left stepper motor controller (SMC)
3	A	Supply voltage switched for SMC, right
4	M	Earth
5	M	Earth for automatic headlight-range adjustment, front right ride-height sensor
6	M	Earth for automatic headlight-range adjustment, rear right ride-height sensor
7	E	Terminal 15 wake-up wire
8	E	Input from automatic headlight-range adjustment, rear right ride-height sensor
9	E	Input from automatic headlight-range adjustment, front right ride-height sensor
10	E	Input from brake-light switch
11	---	---
12	---	Diagnosis wire (only for E46, E53, E83; not assigned for E60)
13	E/A	PT-CAN High
14	E/A	PT-CAN Low
15	A	Supply voltage for automatic headlight-range adjustment, front right ride-height sensor
16	A	Supply voltage for automatic headlight-range adjustment, rear right ride-height sensor
17	E/A	LIN bus to stepper motor controller (SMC) in left-hand headlight
18	E/A	LIN bus to SMC in right-hand headlight
	A = Output E = Input E/A = Input/output M = Earth V = Supply voltage For details of current pin assignment, please refer to BMW diagnosis system	

How it works

The AHL control unit uses dynamic driving data to calculate the movements of the adaptive headlights and the automatic headlight-range adjustment.

The AHL control unit must be encoded with the vehicle-specific data.
Vehicle-specific data are, for example:

- Wheelbase
- Height of headlights
- Maps for headlight-range adjustment

Data specific to the headlights is encoded in the stepper motor controller (SMC).

E60 - Stepper motor controller

The stepper motor controllers (SMC) control the movement of the swivel modules in the bi-xenon headlights as follows:

- Vertically for the automatic headlight-range adjustment (stepper motor for automatic headlight-range adjustment)
- Horizontally for the adaptive headlights (stepper motor for adaptive headlights)

Installation location

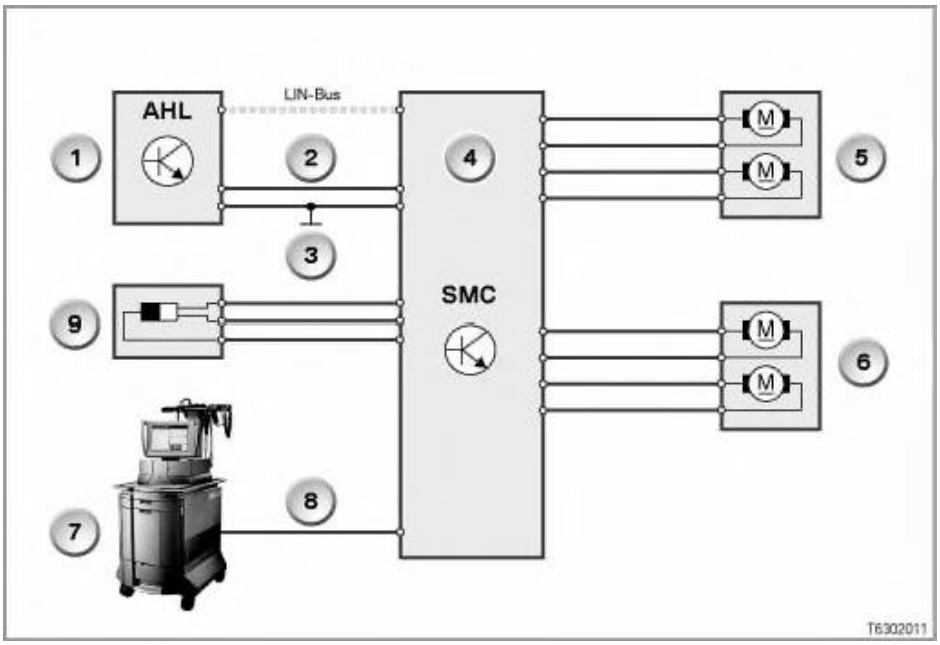
The stepper motor controllers are affixed to the headlight housing.

Construction

The left-hand stepper motor controller is identical to the right-hand stepper motor controller.

To differentiate between the two headlights (left and right), pin 12 of the stepper motor controller for the **left-hand** headlight must be connected to earth. The SMC must be encoded accordingly (either by the headlight manufacturer at the end of the production line or in the workshop after replacement).

The following block diagrams show the stepper motor controller with its connections.



Key	Explanation	Key	Explanation
1	AHL control unit (adaptive headlights)	2	Power supply
3	Earth	4	Stepper motor controller (SMC)
5	Stepper motor for automatic headlight-range adjustment	6	Stepper motor for adaptive headlights
7	BMW diagnostic system with DISplus	8	Encoding pin for right or left
9	Position sensor	LIN Bus	Local Interconnect Network, local bus between AHL control unit and stepper motor controller (SMC)

Pin assignment for the stepper motor controller

Pin	Type	Description

1	A	Output to stepper motor for adaptive headlights
2	E	Input from position sensor
3	A	Power supply for position sensor
4	E	Power supply for stepper motor controller
5	M	Earth for stepper motor controller
6	A	Output to stepper motor for adaptive headlights
7	A	Output to stepper motor for adaptive headlights
8	M	Earth for position sensor
9	---	---
10	A	Output to stepper motor for adaptive headlights
11	E/A	LIN bus (local bus, Local Interconnect Network)
12	E	Encoding pin for right or left
13	E	Left/right differentiation
14	---	---
15	A	Output to automatic headlight-range adjustment (LWR) motor
16	A	Output to automatic headlight-range adjustment (LWR) motor
17	E	Encoding pin for various encoding data
18	---	---
19	A	Output to automatic headlight-range adjustment (LWR) motor
20	A	Output to automatic headlight-range adjustment (LWR) motor
	A Output E Input M Earth V Power supply For details of current pin assignment, please refer to BMW diagnosis system	

How it works

Precondition for the stepper motor controller to work is correct encoding and correct pin assignment as follows:

- Encoding: headlight-specific data for the adaptive headlights are encoded in the stepper motor controllers.
- Pin assignment: to differentiate between the installation locations, pin 12 of the stepper motor controller (SMC) for the left-hand headlight must be connected to earth (plausibility when calibrating).

The stepper motor controller calculates the swivelling motion of the headlights for the adaptive headlights based on defined positions as follows:

- The stepper motor controller receives from the AHL control unit the position to which the headlight is to move (nominal value).
- The stepper motor controller recognises the current position of "its" headlight, i.e. the one to which it is assigned (actual value).
- The stepper motor controller calculates the distance that the headlight must be moved (in steps). The stepper motor controller allows the stepper motor to turn as many steps as required until the headlight is in the correct position.

The position sensor recognises each position of the positioner module.

Straight-ahead position

The headlights are aligned to the vehicle longitudinal axis and shine straight ahead.
This position is assigned to the 0° angle.

Straight-ahead position is recognised in 2 ways:

- The position sensor records the straight-ahead position. The position sensor recognises each position of the positioner module. The straight-ahead position is recognised with a high degree of precision at 50:50 %. On each movement, the respective position of the positioner module is recognised and corrected as necessary.
- In addition, the straight-ahead position is defined as an angle to a mechanical reference point.

  If the position sensor fails, the headlight is moved to the straight-ahead position from the mechanical stop (using encoded replacement values).

When terminal 15 is switched ON, the headlights always move to the straight-ahead position during the calibration sequence.

Parked position

The parked position is also defined as an angle to the straight-ahead position.

The parked position is important for the headlights' next calibration sequence:

From the parked position, the headlights are run through a calibration sequence.

Here, the AHL control unit "learns" the straight-ahead position of the headlights.

The calibration sequence is executed in the pre-drive check when terminal 15 is switched ON.

Ranges of movement

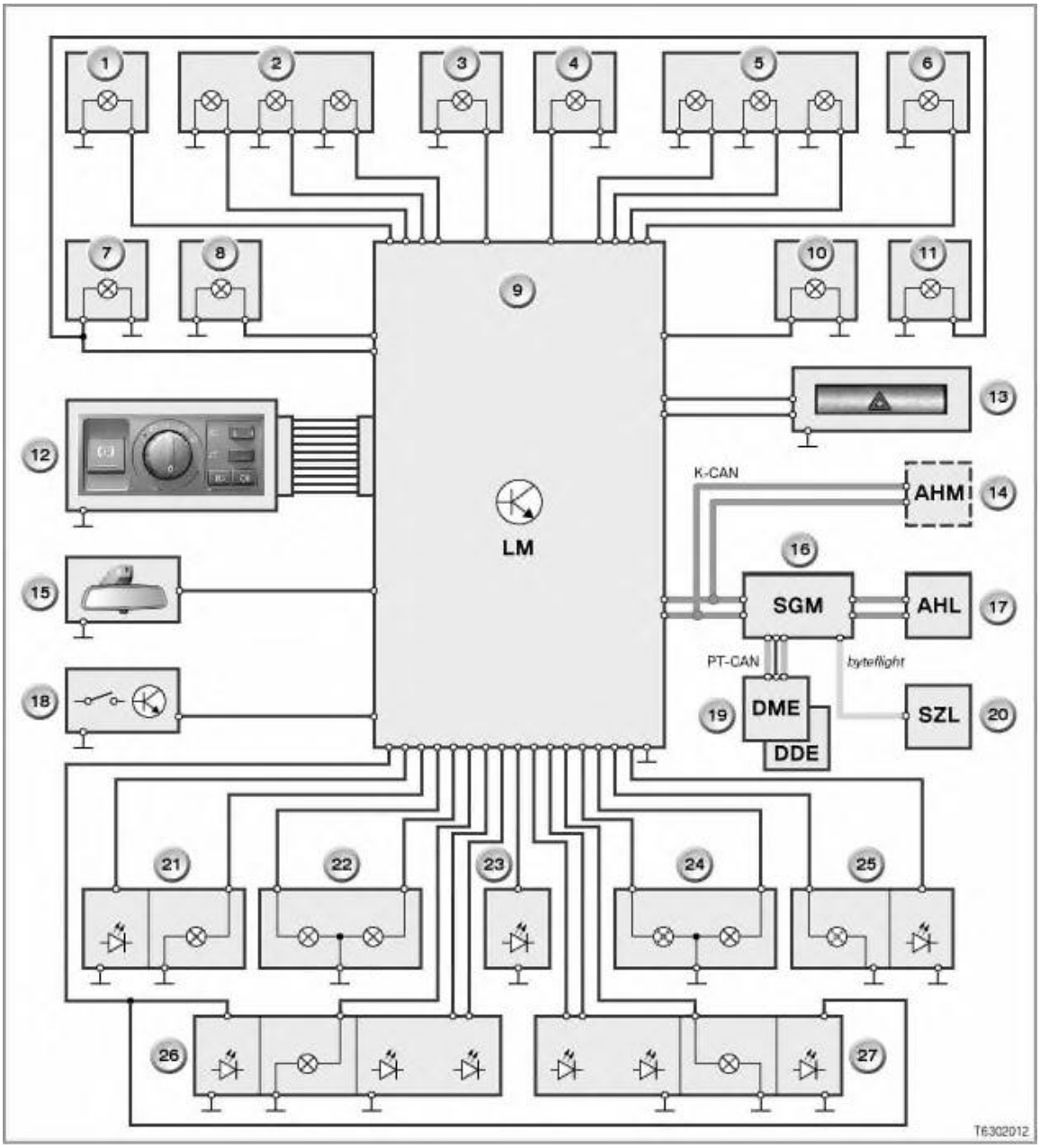
The swivel motors are controlled in a forwards and reverse direction from the straight-ahead position as follows:

For example, the right-hand headlight has the following ranges of movement:

- To the right as far as the encoded end stop of the swivelling range:
  Swivelling angle 15° (based on straight-ahead position)
- To the left as far as the encoded end stop of the swivelling range:

  8° (based on straight-ahead position)

The stepper motor controller (SMC) sends the encoded end stop of the swivelling range to the AHL control unit. The AHL control unit only outputs values that correspond to the encoded end stop of the swivelling range.



Key	Explanation	Key	Explanation
1	Turn signal (front left)	2	Front left: main-beam headlights, dipped-beam headlights, side lights
3	Front foglight (left)	4	Front foglight (right)
5	Front right: main-beam headlights, dipped-beam headlights, side lights	6	Turn signal (front right)
7	Auxiliary turn signal (left)	8	Side-marker lamp (front left)
9	Light module (LM)	10	Side-marker lamp (front right)
11	Auxiliary turn signal (right)	12	Light switch
13	Hazard-warning lights switch	14	Trailer module (if fitted)
15	Rain-light sensor	16	Safety and gateway module (SGM)
17	AHL control unit for adaptive headlights	18	Brake light switch

19	Digital engine electronics (DME) or digital diesel electronics (DDE)	20	Steering column switch cluster (SZL)
21	Rear light (left), rear foglight (left)	22	Reversing light (left), license-plate light (left)
23	Additional brake light (middle)	24	Reversing light (right), license-plate light (right)
25	Rear light (right), rear foglight (right)	26	Rear left: side-marker lamp, turn signal, side lights and brake light
27	Rear right: side-marker lamp, turn signal, side lights and brake light		

Installation location

The light module is installed in the dashboard, directly behind the light switch.

How it works

The range of functions of the light module includes the following tasks:

- Control and monitoring of the headlights and lamps on the exterior of the vehicle
- Control and monitoring of the turn signals and hazard warning lights function
- Dimmer for the instrument and locating lighting (terminal 58g) and the function and locating lighting for the hazard-warning lights switch
- Evaluation of messages from the rain-light sensor for the automatic driving lights control and for the adaptive headlights
- Communication with the trailer module, if fitted
- Actuation of the green indicator lamp for the adaptive headlights (on light switch)
- Data exchange via the K-CAN (see below for detailed description)
- Data management for diagnostics and monitoring (see below for detailed description)
- With option 522 "Bi-xenon dipped/main-beam headlights", the light module evaluates faults in the bi-xenon headlights.
- Emergency-running characteristics (see below for detailed description)

Control and monitoring of lighting

All lighting loads are actuated and individually diagnosed via the light module.

- Output limitation: if the on-board supply voltage exceeds an encoded value, the lights are dimmed to increase the service life of the bulbs.

  Each bulb type (rear light, brake light etc.) has its own encoded value.
  The values are encoded during production at the end of the assembly line.
- Reduced ON current: the light module switches on the individual lights one at a time to prevent the vehicle electrical system from being overloaded unnecessarily by voltage peaks and high currents produced when the lights are switched on.
- Prevents light intensity fluctuations: Valvetronic creates short load peaks resulting in voltage dips in the vehicle electrical system. These voltage dips can cause fluctuations in the intensity of the vehicle lighting. Corresponding parameters are stored in the light module to prevent visible light intensity fluctuations as much as possible.
- Cold monitoring: for cold monitoring, the lights are switched on briefly without the bulbs glowing (thermal inertia of bulb elements).
  Exception: LEDs and D2-S bulbs (= xenon lights) are **not** cold monitored (LEDs react too quickly; D2-S bulbs are on principle not to be actuated with voltage pulses).

  Cold monitoring starts when terminal 15 is switched ON. This pre-drive-check indicates the condition of the lights

before the start of a journey (Check Control car symbol).
Cold monitoring detects either "light available" or "open circuit".
The cold current is a multiple of the rated current.

- Hot monitoring: the rated current of bulb when it is switched on is monitored via the status output of the lamp driver. A defective bulb can be detected within 2 seconds.

  Frequency counters count how often a recognised defect occurs. The fault is reported once a certain number has been reached. When the ignition is switched off, all frequency counters are reset to zero to prevent a bulb that has already been replaced from being indicated as still defective.

Data exchange via the K-CAN

The light module receives the following messages via the K-CAN:

- Terminal R, signals from the Car Access System (CAS or ignition starter switch)
- Two-stage brake lights
- Parking lights
- Dipped-beam headlights
- Front foglights
- Rear foglight
- Ride-height sensors
  If option 524 "Adaptive headlights" is fitted, the signals from the ride-height sensors are fed directly to the AHL control unit.

Data management for diagnostics and monitoring

The light module stores data relevant to diagnosis:

- Stored fault encodes
- Bi-xenon diagnostics:

  In the event of a fault developing, the xenon control unit will issue a fault signal: residual current of approx. 20 mA, superimposed on a square-wave signal.

  If the light module receives the prompt through the K-CAN to initiate bi-xenon diagnosis, the light module will switch over its internal driver output.

  A fault is only accepted as valid after being repeated 3 times.

Emergency-running characteristics

The light module has the following emergency-running characteristics:

- **Power supply failure:** The light module has two terminal 30 power supplies.

  If one terminal 30 supply should fail, the following are actuated

  - Front lighting: Dipped-beam headlights and parking lights (one side each)
  - Rear lighting: The position lights and outer brake lights are actuated on one side (parking lights). On the other side, the inner rear lights are actuated.
    The vehicle thus remains lit on both sides. It is thus impossible to confuse the vehicle with a single-track vehicle (motorbike).
  - Brake lights: The brake lights on one side are actuated with normal output (encoding variant for European models). This allows "single-track braking", as if, for example, a single brake light had failed.

- **Processor failure:** If the processor fails, the system will switch to emergency operating mode. Emergency operating mode is a hardware feature and thus completely independent of the light module.

  Emergency-running characteristics if the processor fails:

- Vehicle lighting: The following are switched on when terminal 15 is switched ON: at the front the dipped-beam headlights, and at the rear the position lights and the left and right outer brake lights (side lights).
  The position lights and the left and right outer brake lights are not dimmed to 10% brightness, as is usually the case, but rather operated at full power.
  Vehicle lighting is thus assured, regardless of the position of the light switch.
- Brake lights: When terminal 15 is switched ON, the left and right brake lights are switched on when the brake is applied (via a hard wire direct from the brake-light switch to the lamp drivers).

Malfunctions in the event of processor failure:

- No turn signal, no hazard warning lights
- No main beam, no headlight flasher
- No front or rear foglights
- No additional centre brake light
- No communication via the K-CAN
- No communication with the trailer module

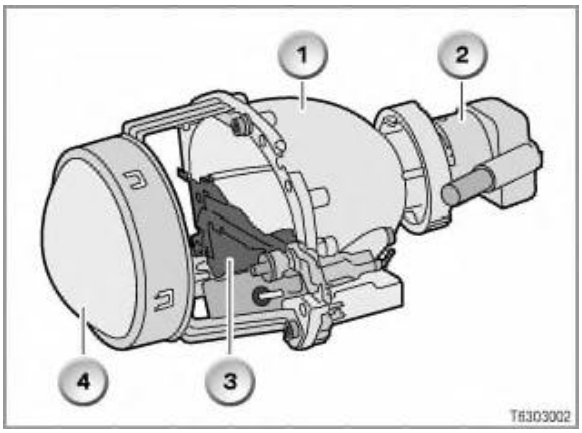
E60 - Bi-xenon headlights

The bi-xenon headlights are a further development of the xenon headlights. With bi-xenon headlights, the xenon light can be directed up for the main-beam headlights.

Construction

The bi-xenon headlights include the following components:

- The xenon-headlight control unit with
- Ignitor and D2-S bulb
- Mechanical screen in front of the D2-S bulb for redirecting the dipped-beam headlights when the main-beam headlights are switched on (with a lifting solenoid).
- Return spring for mechanical screen



1. Reflector
2. Ignition device
3. Mechanical screen in front of the D2-S bulb for redirecting the dipped beam when the main-beam headlights are switched on
4. Lens

The following bulb designations are available for bi-xenon headlights:

- D2-S bulb: bulb and ignitor are two components
- D2-R bulb (for MINI and Rover L30): bulb and ignitor are two components
- D1-S bulb: bulb and ignitor form a single component (from E87)
- D1-R bulb: not used at present

How it works

When the dipped-beam headlights are switched on, the mechanical screen is positioned vertically in front of the D2-S bulb (as illustrated). The beam of the xenon headlight is thus dipped.

When main beam is switched on, the mechanical screen in front of the D2-S bulb is folded forward in the direction of travel. The screen is then horizontal.
This redirects the beam of the xenon headlight to main-beam headlights. The rays of lights are able to shine uninterrupted to the front and to make use of the complete area of the reflector and the lens.

The mechanical screen in front of the D2-S bulb is controlled by the light module as follows: The light module actuates the solenoid. The solenoid moves the screen to the horizontal. If the light module is not able to actuate the solenoid for the mechanical screen, the screen is pulled back to the vertical position by the return spring.

E60 - Positioner module

The positioner modules of option 524 "Adaptive headlights" turn the dipped and main-beam headlights.
The positioner modules used on E60, E65 and E53 vehicles are manufactured by Hella.

Installation location

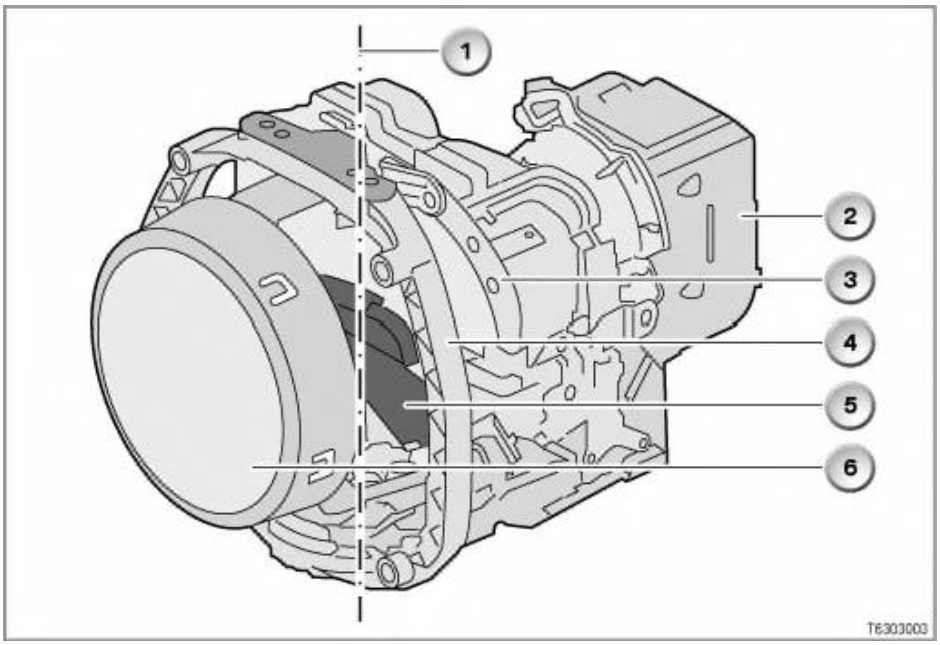
The positioner modules are installed in the headlights. The swivel modules do not distinguish between right and left. The swivel modules can therefore be installed in both the left and right-hand headlights.

Installation locations of components associated with the positioner modules:

- Stepper motor controller (SMC): on the outside headlight housing
- Stepper motor for adaptive headlights on positioner module
- Stepper motor for headlight-range adjustment next to the stepper motor for adaptive headlights, but on headlight housing
- Xenon-headlight control unit on headlight housing

Construction

The positioner modules in the left and right-hand headlights are identical in design.



Key	Explanation	Key	Explanation
1	Axis of movement	2	Ignition device
3	Reflector	4	Positioning frame
5	Mechanical screen in front of the D2-S bulb for redirecting the dipped beam when the main-beam headlights are switched on	6	Lens

How it works

The positioner modules move the headlights around the axis of movement as follows:

- The range of movement of the headlight on the inside of the bend is less than or equal to 15 degrees.

  On a right-hand bend, the right-hand headlight is on the inside of the bend.

  On a left-hand bend, the left-hand headlight is on the inside of the bend.

- Speed: The rate of swivel is approx. 25 degrees per second.

  That means the headlights can be moved over the entire range of movement in approximately 1 second.

E60 - Adaptive headlights (AHL), diagnosis

Please note the following when performing diagnostics on the adaptive headlights:

- Switch-on conditions for the indicator lamp
- Customer complaint: "Large sweep and then nothing".
- Customer complaint: "No adaptive headlights at (e.g.) 80 km/h"
- AHL control unit diagnostic mode
- List of malfunctions for adaptive headlights
- Diagnostics on bi-xenon lights

Indicator lamp flashes

The indicator lamp on the left of the light switch always flashes if a fault is detected in the system.

The indicator lamp also flashes if the bi-xenon headlights are defective and the adaptive headlights are deactivated for this reason.
The light module sends the message "Dipped-beam headlights on" to the AHL control unit.
The message "Dipped-beam headlights on" is generated separately for each bi-xenon headlight unit.
If one of the D2-S bulbs fails, the turning movement of the adaptive headlight function is deactivated.

Customer complaint: "Large sweep and then nothing".

If terminal 15 is switched ON and the headlights move through a large sweep and then remain in the straight-ahead position, the signal from the position sensor is not being received.

If the position sensor fails, the position of the headlights can be measured via a mechanical reference point as follows: The positioner module moves as far as the permitted mechanical end stop (= "large sweep") and then into the straight-ahead position. The turning movement of the adaptive headlights is then deactivated (= "and then nothing").

Customer complaint: "No adaptive headlights at (e.g.) 80 km/h"

If the adaptive headlights fail at speeds over 50 km/h, the signal from the yaw rate sensor is not being received. A fault memory entry must be present in the DSC control unit.
The indicator lamp does **not** flash.

The indicator light only flashes if faults in the adaptive headlight system are present; the yaw rate sensor "belongs" to the DSC. This means that the indicator lamp will not indicate a fault in the yaw rate sensor.

AHL control unit diagnostic mode

For the following diagnosis orders, the AHL control unit must be set to diagnostic mode:

- Reading off relevant bus signals at standstill shows whether or not the following signals are present:
  - Vehicle road speed
  - Yaw rate
  - Steering angle
- Check whether messages are received by the AHL control unit:
  - Check control unit inputs
  - Check whether the control unit is receiving any valid signals via the K-CAN
- Check whether switch-on conditions for the adaptive headlights are satisfied:
  - Rain-light sensor status
  - Light switch status

Faults are stored as follows:

- Faults in the stepper motors etc. are fed to the AHL control unit by the stepper motor controllers (SMCs) and stored in the AHL control unit.
- The AHL control unit reports these faults in response to the status request (e.g. "communication with left-hand headlight failed").
- Missing bus signals and missing signals from components are stored in the AHL control unit.

List of malfunctions for adaptive headlights

Faults	Description
1	Stepping error within specified tolerance range: The positioner module aligns itself.
2	Stepping error outside specified tolerance range: Range of movement is mechanically restricted. The AHL control unit and the stepper motor controller react as follows: - At first, an attempt is made to "compensate" for the difference between actual and nominal values by generating a number of turning movements. Each turning movement compensates for "lost" steps. - If an adjustment is not possible because the positioner module is "sticking", an attempt is made to move the headlight to the straight-ahead position. - The turning movement of the adaptive headlights is deactivated. Automatic headlight-range adjustment (LWR) remains active.
3	If the LIN bus (local bus, Local Interconnect Network) should fail, the AHL control unit and the stepper motor controller react as follows: - Stepper motor controller (SMC): emergency program. If the stepper motor controller (SMC) is still responding, the positioner module is moved to the straight-ahead position. - Fault message to the indicator lamp on the light switch Automatic headlight-range adjustment (LWR) remains active.
4	Missing earth connection or earth fault in stepper motor controller (SMC): - The stepper motor controller (SMC) is inoperable. There is no backup provision. - The stepper motors cannot be actuated. The AHL control unit reacts as follows: - Fault message to the indicator lamp on the light switch. - If the headlight's last position could dazzle oncoming traffic, the bi-xenon light is switched off the next time the system is started. Conditions required for switch-off: The vehicle is parked. Sleep mode is activated. Terminal 15 is switched on again.
5	Position sensor defective or headlight motor defective or headlight mechanics defective: No difference can be made between a defect in the position sensor and a mechanical defect in the headlight motor. If no change in PWM signal from the position sensor can be detected within the specified tolerance range, the AHL control unit will initiate the following function limitations:

	- Stepper motor controller (SMC): Emergency deactivation of the swivel movement - Safety: Dazzle is prevented by lowering the automatic headlight-range adjustment **or** - Bi-xenon headlights are switched off on the side affected (only when the vehicle is parked and after sleep mode has been reactivated) - Message to light module - Switches on substitute function (foglights)
6	Electrical fault in headlight motor (short or open circuit): No difference between electric motor failure and a defective wire. The stepper motor controller (SMC) reacts as follows: - Emergency deactivation of the swivel movement - In the event that it can be assumed that oncoming traffic will be dazzled (position sensor signal evaluation), the headlight will be lowered. The headlight is lowered by the automatic headlight-range adjustment motor. If the headlight cannot be moved down, the bi-xenon light of that headlight is switched off. Conditions for switching off: the vehicle must be parked (terminal R OFF for several seconds, see above).
7	Electric defect in automatic headlight-range adjustment motor (short or open circuit): automatic headlight-range adjustment is deactivated.

Diagnostics on bi-xenon headlights

The light module (LM) checks whether or not current flows to the D2-S bulb of the bi-xenon headlights when dipped-beam headlights are switched on. If no current flows, the light module will recognise a fault and store a fault message.

E60 - Adaptive headlights, general information for service staff

The following general information is provided for servicing the lighting:

- Initialising the rain-light sensor
- Distinguishing between left/right stepper motor controllers
- Repairing the adaptive headlights
- Replacing the AHL control unit
- Replacing the stepper motor controllers (SMC)
- Replacing the bi-xenon headlights
- Retrofitting adaptive headlights on vehicles with halogen headlights
- Retrofitting adaptive headlights on vehicles with option 522 "Bi-xenon dipped/main-beam headlights"
- Retrofitting adaptive headlights on vehicles with electronic height control (EHC)
- Final operations for all vehicles

Initialising the rain-light sensor

The rain-light sensor must be initialised in the following situations:

- When the windscreen has been replaced
- When a used rain-light sensor has been installed

Important: Used rain-light sensors must be encoded.

A used rain-light sensor must be encoded before it can be initialised. The used rain-light sensor can only be initialised (= calibrated to the new windscreen) after it has been encoded.

Important: Initialise the rain-light sensor after replacing the windscreen.

Conditioned by the optical process, the rain-light sensor must be calibrated to the windscreen. During initialisation, the rain sensor in the rain-light sensor is calibrated to the windscreen concerned.

Important: Clean the windscreen before initialising the rain-light sensor.

Precondition for fault-free initialisation is the windscreen being dry, clean and free of faults in the area of the rain-light sensor.

The rain-light sensor is initialised using the "Initialise rain sensor" service function in the BMW diagnostic system. The adaptation values stored in the rain sensor are deleted in the service function. The sensor is then calibrated to the windscreen using the following process:

1. Switch off the rain-light sensor.
2. Switch off terminal 15 and terminal R.
3. Switch on terminal R and terminal 15 and wait 10 seconds.

   In the 10 seconds waiting period, the new adaptation values are determined and stored.

Distinguishing between left/right stepper motor controllers

The stepper motor controllers can be used in both the left and right-hand headlights.
In production, the two stepper motor controllers (SMC) are "primed" at the end of the production line. "Priming" means:

- The vehicle identification number is stored in each SMC.
- Whether or not pin 12 is connected to earth is stored in both SMCs. On the positioner module installed on the left-hand side, pin 12 (encoding pin) must be connected to earth.
- Which type pin is connected is stored in each SMC

The type pin provides information as to which type of headlight is installed.

The SMC now "knows" whether it is installed on the left or the right.
If the stepper motor controllers are interchanged in the workshop, they will "recognise" that they are installed in a different headlight, and will not function. These SMCs must be recoded.

Important: Distinction between left/right-hand stepper motor controllers during encoding

The stepper motor controllers can be installed in both the left and right-hand headlights. To differentiate between the installation location, pin 12 of the stepper motor controller (SMC) for the left-hand headlight must be connected to earth. The SMC must be encoded accordingly.

If an attempt is made to encode an SMC as the right-hand SMC when pin 12 (= coding pin) is earthed, the SMC does **not** respond to the encoding.

Repairing the adaptive headlights

Repairs could result in components with different status being installed. The following combinations are possible:

- New components are added to an existing system.
- Used parts are fitted in the existing system.

Important: Encode parts after performing repairs.

Replaced parts must always be calibrated to the system installed in the vehicle.

Encoding is necessary after the following repairs to the adaptive headlights:

- If the AHL control unit is replaced, the control unit must be encoded.
- If SMCs are replaced, the SMCs must be encoded.
- If SMCs are replaced, the SMCs must be encoded.

Replacing the AHL control unit

The following calibrations must be performed after the AHL control unit has been replaced:

- Vehicle identification number stored in AHL control unit (with the BMW diagnosis system).
- AHL control unit encoded according to vehicle data.

Important: The AHL control unit must be encoded.

If the AHL control unit is not calibrated to the vehicle data, the adaptive headlights will not work.

Replacing the stepper motor controllers

The following calibrations must be performed after a stepper motor controller has been replaced:

- Vehicle identification number encoded in the stepper motor controller (with the BMW diagnosis system).
- Encode the stepper motor controller to match the headlight.

Important: The stepper motor controllers must be encoded.

If the stepper motor controller is not calibrated to the vehicle data, the adaptive headlights will not work.

Important: Make sure the headlight housing does not leak.

When exchanging a stepper motor controller, make sure that the headlight housing is sealed correctly.

Replacing the bi-xenon headlights

Warning: Exercise caution when working on bi-xenon headlights

Whenever inspecting or working on the headlights, always observe the safety precautions and accident prevention rules.

The headlight system carries dangerous high voltages.

Important: Encode the SMC after replacing a headlight!

After a bi-xenon headlight has been replaced, the stepper motor controller (SMC) must be recoded according to the headlight data.
This is because the range of movement of the headlight and the installation location of the position sensor may vary from vehicle to vehicle. The new bi-xenon headlight may have a different hardware number to that of the old one.

The headlight type pin must correspond with the SMC encoding. This calibration is performed during encoding.

The adaptive headlights will not work if the stepper motor controller is not recoded.

Retrofitting adaptive headlights on vehicles with halogen headlights

The adaptive headlights system only works with AHL headlights (with bi-xenon headlights).
Vehicles with halogen headlights must be "upgraded" to AHL headlights.

When retrofitting adaptive headlights on vehicles with halogen headlights, the following components must be replaced or installed:

- Light switch with position "A" for "Adaptive headlights"
- AHL control unit
- AHL headlights with D2-S bulbs and integrated stepper motor controllers (SMC)
- Rain-light sensor
- Ride-height sensors on front and rear axles;

  With EHC: replace ride-height sensor on rear axle (see below)
- Wiring harness conversion (ride-height sensors, rain-light sensor and light module / light switch for AHL control unit)
- Headlight cleaning system

Retrofitting adaptive headlights on vehicles with option 522 "Bi-xenon dipped/main-beam headlights"

The following components must be replaced or installed:

- AHL control unit
- AHL headlights with D2-S bulbs and integrated stepper motor controllers (SMC)
- Rain-light sensor
- Ride-height sensors connected to AHL control unit
- Wiring harness conversion (see above)

Retrofitting adaptive headlights on vehicles with electronic height control (EHC)

Different actions are required, depending on whether bi-xenon lights are already installed or halogen dipped-beam headlights are fitted.
Precondition: Bi-xenon lights already fitted.

Retrofitting AHL on basis of halogen headlights and EHC

Ride-height sensors must be retrofitted at the front and rear.

- One ride-height sensor must be retrofitted on the front axle.
  To do this, the bolt connection of the transverse link to the front axle carrier must be unscrewed.
  For this reason, the wheels should be aligned after the ride-height sensor has been installed.
- On the rear axle, a double sensor must be installed in place of the EHC ride-height sensor. The double sensor supplies signals for both the AHL control unit and the EHC control unit.

Retrofitting AHL on the basis of bi-xenon headlights and EHC

- A ride-height sensor (for the automatic headlight-range adjustment) is already fitted on the front axle (bi-xenon headlights

are only available with automatic headlight-range adjustment).

- On the rear axle, a double sensor must be installed in place of the EHC ride-height sensor. The double sensor supplies signals for both the AHL control unit and the EHC control unit.

Final operations for all vehicles

Important: Encode control units after working on the lighting system.

The following work must always be performed after performing repairs or retrofits:

- Encoding the light module
- Encoding the AHL control unit
- Encoding the stepper motor controllers (SMC)

Important: Only perform function check of AHL with rain-light sensor covered.

If the adaptive headlights are checked in daylight, the rain-light sensor must be covered.
The adaptive headlights are only activated when the rain-light sensor detects darkness.

Important: Encode the headlights after working on the lighting system.

The correct basic setting for the headlights is a precondition for the adaptive headlights working correctly.

E60 - Adaptive headlights (AHL), encoding/programming

Encoding

Encoding the adaptive headlights includes the following functions:

- Variant encoding (country-specific functions)
- Retrofitting adaptive headlights on vehicles that already have "Bi-xenon dipped/main-beam headlights" option 522
- Converting halogen dipped-beam headlights to option 522 "Bi-xenon dipped/main-beam headlights" and retrofitting adaptive headlights
- "Right-hand drive" encoding variant: headlights turn to the right only when the vehicle is stationary (see below for detailed description)
- "European models" encoding variant: dipped-beam headlights switched off if adaptive headlights fail (see below for detailed description)
- Encoding US models
- No transport mode for adaptive headlights (see below for detailed description)

Important: Distinction between left/right stepper motor controllers during encoding

The stepper motor controllers can be installed in both the left and right-hand headlights. To differentiate between the installation location, pin 12 of the stepper motor controller (SMC) for the left-hand headlight must be connected to earth. The SMC must be encoded accordingly.

If an attempt is made to encode an SMC as the right-hand SMC when pin 12 (= coding pin) is earthed, the SMC does not respond to the encoding.

Important: Encode control units after working on the lighting system!

The following work must always be performed after performing repairs or retrofits:

- Encoding the light module
- Encoding the AHL control unit
- Encoding the stepper motor controllers (SMC)
- Adjusting headlights

"Right-hand drive" encoding variant: headlights swivel to the right only when the vehicle is stationary

Depending on the country concerned, the adaptive headlights are encoded for right or left-hand traffic at the end of the production line.

For right-hand traffic, this encoding means: when the vehicle is stationary, the headlights only turn to the right (not to the left) when the steering wheel is turned. On vehicles for left-hand traffic, the headlights only turn to the left (not to the right) when the vehicle is stationary.

"European models" encoding variant:
Switch off dipped-beam headlights if adaptive headlights fail

Oncoming traffic may be dazzled if the adaptive headlights do not work properly. The headlights remain in a position that could cause dazzling.

Vehicle occupants must be informed of the malfunction: the indicator lamp for the adaptive headlights (on the light switch) flashes.

The AHL control unit attempts to move the dazzling headlight down (with the actuator motor for the automatic headlight-range adjustment) so that this headlight causes as little dazzle as possible to oncoming traffic.

If the headlight cannot be moved down, the bi-xenon light of that headlight is switched off. Conditions for switching off: The vehicle must be parked (vehicle stationary and terminal R OFF for several minutes).

The lights or the headlight affected must not be switched off so long as the journey is continued. For this reason, the following

conditions must be satisfied before the headlight(s) is (are) switched off:

- Terminal 15 OFF
- Terminal R OFF
- Speed = 0 km/h
- Sleep mode (idle state) for at least approximately 2 minutes

If the second headlight should fail, the dazzling headlight is switched on again to ensure that the vehicle still has at least **one** dipped-beam headlight.

This fail safe feature is only activated on vehicles with the "European model" encoding variant.

Fault messages and their effects:

- Fault code 0001: Adaptive headlights not OK (= "adaptive headlights not OK": minor fault, no dazzling):
  The headlights can be switched on. Adaptive headlights are **not** set to standby mode.
  The indicator lamp for adaptive headlights (on the light switch) flashes.
- Fault code 0010 or 0011: Possible dazzle from left or right-hand headlight:
  The left or right-hand headlight is no longer switched on after the vehicle has been parked.
  The indicator lamp for the adaptive headlights flashes.
  The light module sends a message to the instrument cluster. The headlight affected is indicated as being defective (Check Control car symbol).
  Both front foglights are switched on.
  If the headlights that are still on should fail, the headlights that are switched off will be switched back on again as a substitute.
- Fault code 0100: Possible dazzle from both headlights:
  After the vehicle has been parked, both headlights are no longer switched on.
  The indicator light for the adaptive headlights flashes.
  Both headlights are indicated as being defective (Check Control car symbol). In addition, a Check-Control message is emitted.
  Both foglights are switched on. Fault entry in light module.
- Fault code 1111: No "alive" signal from AHL control unit:
  The headlights are switched on. The indicator light for the adaptive headlights flashes.

Encoding US models

Whenever a fault occurs, the adaptive headlights indicator light will flash (as on the Europe version).
However, both dipped-beam headlights remain on (no fail safe feature).
There is no fail safe feature installed (see above: "European models encoding variant").

No transport mode

The adaptive headlights are not currently set to "transport mode" at the factory.
The adaptive headlights remain enabled even during transport.