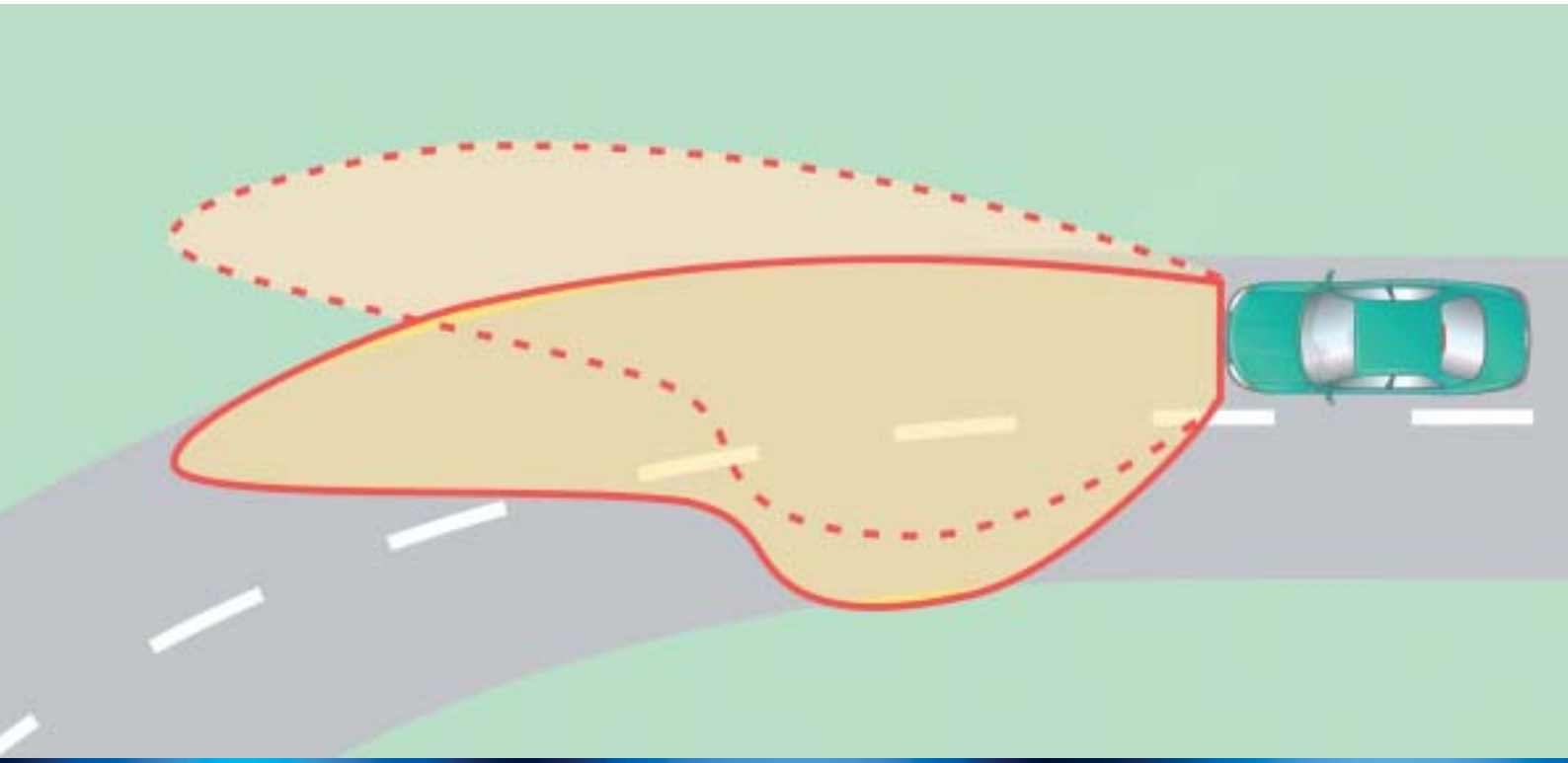
Technical Information

Electronics – Lighting Electronics



HELLA®

Ideas today for the cars of tomorrow

The product line Lighting Electronics

Lighting Electronics – Dynamic visibility, intelligent light!
The introduction of modern Xenon headlamps several years ago made an essential contribution to safer street traffic. In comparison to halogen headlamps, optimal illumination of the street is possible by doubling the luminous flux. The targeted improvement of the visibility aids the driver's orientation in the dark and is, thus, an important component for traffic safety. At the same time, glare for oncoming vehicles is greatly reduced and visual range is optimized in all driving situations through the use of headlamp leveling systems.

Even today, numerous vehicles are equipped with bend lighting headlamps. Currently, these systems are available in combination with Xenon or halogen light sources. Through intelligent evaluation of vehicle signals, the course of the road can be determined and the light distribution can be dynamically adapted to the course of the road. This leads to a significant improvement in the illumination of bends. Especially in tight bends, serpentines, intersections, and during maneuvers, the driver needs information from the direct side area in front of his vehicle. In these situations, a cornering light is switched on in addition to the low beam, via an additional light source. Through early detection of people and obstacles and a shortened reaction-time, all road users benefit.

The intelligent Advanced Frontlighting System (AFS) by Hella is called VARILIS®. Further developments within this system were aimed at increasing driving comfort and, especially, street safety even more. Intensive studies of street geometry and night-driving situations showed that tomorrow's driving light should adapt automatically to different driving and visibility situations. The new adaptive front lighting system combines all advantages of the aforementioned systems and not only adapts to the viewing angle, but also to the visibility in various driving situations. In combination with a VARIOX® light module, up to five different light distributions (town light, country light, motorway light, high beam and adverse weather light, as well as changing from right-hand traffic to left-hand traffic) can be created with just one Xenon headlamp.

Through functional integration and extensive modularization, numerous lighting functions can be realized in the tight package space of modern frontend designs. Thus, the intelligent headlamp as a compact technology carrier is becoming increasingly more important.

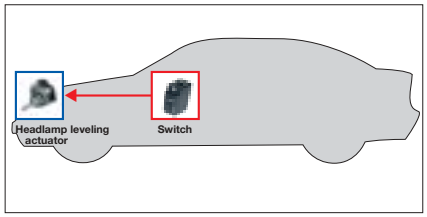
Components for headlamp leveling systems

Components for Xenon systems

Components for AFS systems

Headlamp leveling

Safe driving in the dark is only possible when the inclination angle of the headlamps is always correctly adjusted. This ensures optimal illumination of the road without glare for oncoming traffic.



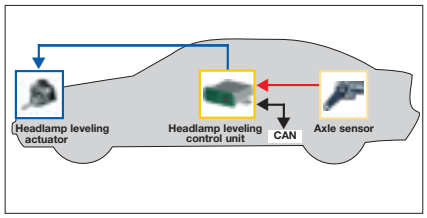
System architecture: manual headlamp leveling

Manual headlamp leveling

With today's conventional manual headlamp leveling the driver can adapt the headlamp inclination to the respective state of load using a switch on the instrument panel and a headlamp leveling actuator on the headlamp.

Automatic headlamp leveling

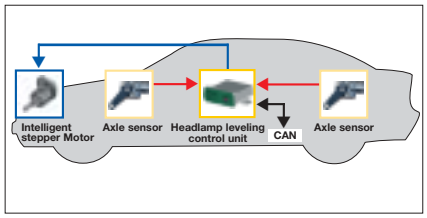
Determined by legal regulations, the installation of Xenon lighting requires automatic headlamp leveling in many countries. Automatic headlamp leveling ensures that the headlamp inclination angle is always automatically adjusted correctly independently of the state of load of the vehicle. An inductive axle sensor measures the different suspension movement of the rear axle (during loading of the vehicle) and delivers the suspension movement data to the headlamp leveling control unit. As a result, the headlamps are optimally adjusted by one headlamp leveling actuator each.



System architecture: automatic headlamp leveling

Usually, the system consists of one control unit, one vehicle level sensor (rear axle) and two headlamp leveling actuators.

Alternatively, the control unit and the vehicle level sensor can be replaced with a sensor-integrated electronic control unit, **SIECU** (**S**ensor **I**ntegrated **E**lectronic **C**ontrol **U**nit). In this case, the system consists of one SIECU and two headlamp leveling actuators.



System architecture: dynamic headlamp leveling

Dynamic headlamp leveling

Dynamic headlamp leveling also reacts to inclination changes due to brake and acceleration actions and, thus, in the case of Xenon systems, ensures a headlamp adjustment which is always correct. In contrast to automatic headlamp leveling, a vehicle level sensor is needed for both the front- and the rear-axle, in the case of dynamic headlamp leveling.

In addition to the suspension movement data from the vehicle level sensors, the central control unit uses the speed signal, to dynamically equalize brake and acceleration actions using a stepper motor on the headlamp. Through intelligent filtering a positioning rate adapted to the respective driving dynamics and, thus, a calm lighting impression is realized.

Usually, the system consists of a control unit, two vehicle level sensors (front- and rear-axle) and two intelligent stepper motors (ISM).

Headlamp leveling actuator 3i

Headlamp leveling actuator for manual and automatic headlamp leveling
In currently available systems, electric headlamp leveling actuators prevail, which are currently being built in the third generation with additional optimizations (Version 3i).

Hella offers each customer an optimal customer-specific system solution. Headlamp leveling actuators for integration into headlamps as well as headlamp leveling actuators for exterior attachment, with or without manual basic setting, are available in 12 V and 24 V versions. Fully automatic production with high-quality standards ensures production output of over 10 million actuators per year. Through the consistent expansion of international locations, we can deliver actuators to customers in Korea, India and China.

Intelligent Stepper Motor

ISM (Intelligent Stepper Motor)
The intelligent stepper motor combines the bipolar stepper motor with the power electronics (usually installed in a separate control unit) to one mechatronic unit. The core component of the ISM is an integrated circuit, realizing the complete stepper motor control, the diagnosis and the interface to the superior system via a communication module with integrated LIN bus interface.

The main functional advantages of the intelligent stepper motor are:

- Micro-stepping control (low-noise and low- resonance operation)
- Diagnosability
- Improved EMC behavior
- Partially autonomous error-handling
- Optimized wiring concept

Especially with **VARILIS**® systems, Hella focuses on ISM technology. In addition to the intelligent stepper motor for dynamic headlamp leveling, the dynamic bend lighting and the drum of the VARIOX® module are also equipped with intelligent stepper motors.

Components of dynamic headlamp leveling: Intelligent Stepper Motor (ISM), Control unit, vehicle level sensor

Control Unit for automatic and dynamic headlamp leveling
Since 1995, Hella control units have been used for automatic and dynamic headlamp leveling in vehicles with Xenon lights.

The new generation of headlamp leveling control units is characterized by an additional LIN bus output and, thus, develops into a universal standard component. The suspension movement data from the axle sensors are processed in the control unit and converted using intelligent algorithms into control variables to adjust the headlamp range. The modular design of the control units makes it possible to combine individual components, such as housing, connector, printed circuit board, or software, with regard to different customer requirements. In this way, maximum cost synergy and flexibility can be realized. Due to the CAN bus-interface, the control unit can be adapted to the specific parameters of different vehicle types at the end of the vehicle production line using coding and programming.

Vehicle level sensor

Inductive vehicle level sensor

In a number of safety and comfort-promoting vehicle features, such as active chassis, level regulation and automatic headlamp leveling, it is necessary to register the vehicle's inclination.

In the case of the inductive vehicle level sensor, several energized coils which create an electromagnetic field are housed on a circuit board. Via this circuit board, a metallic rotor is moved which is connected to the sensor's operating lever. This metallic rotor influences the electromagnetic field. Other coils on the sensor circuit-board field register changes depending on the sensor's lever position, and are evaluated by a specially developed ASIC.

This sensor allows the realization of different angle ranges with constantly high linearity. The inductive axle sensor delivers an analog as well as a PWM signal. The sensor works with high precision, fully independently of the temperature. The sensor's zero position can be individually varied.

The new inductive sensor is a further development of this sensor, which, on the scope, delivers an always-recurrent PWM signal compressed to 75 percent. This enables the sensor to be used as an identical component across platforms. Different installation positions and mounting tolerances are balanced through electronic adjustment in the evaluating control unit.

The next development goal is to further optimize the package space and to improve the output signal for chassis applications (2nd generation vehicle level sensor).

Sensor-integrated headlamp leveling control unit (SIECU)

Sensor-integrated headlamp leveling control unit

For automatic headlamp leveling in compact vehicles, the separate control unit was integrated into the axle sensor in another development step: Sensor Integrated Electronic Control Unit (SIECU).

The basis for the sensor-integrated headlamp leveling control unit is the inductive vehicle level sensor. The mechanical interfaces, such as fixing and sensor lever correspond to those of the axle sensors.

As a sensor-integrated control unit on the rear-axle, this solution for automatic headlamp leveling is not only suitable for vehicles with Xenon headlamps, but also, as a replacement for manual headlamp leveling adjustment in the case of vehicles with halogen headlamps, leads to a considerable gain in comfort and safety.

Xenon ballast electronics
With over 11,000,000 ballasts produced, Hella is the European market leader for Xenon lighting systems. The Xenon system consists of an electronic ballast, and an ignition unit for the Xenon HID lamp, as well as the lamp itself. The ballast takes over the regulation of the light start-up and the constant power output.

The ignition of the Xenon lamp can require high-voltage of more than 20 kV for a short amount of time. The Hella systems, therefore, have a conclusive safety concept.

The further development of the Xenon systems focuses on the further optimization of devices at a high level of quality with regard to costs and package space. The goal is to equip all vehicle classes with Xenon light.

Determined by legal regulations, the installation of Xenon lights in many countries requires additional components, such as a headlamp power wash system and automatic headlamp leveling. Since all components are part of the Hella product suite, powerful complete systems can be realized.

A special focus is on the optimization of the components' integrability into the headlamp. The comprehensive lighting electronics competence makes it possible to offer complete systems to the customer.

Since the beginning of 2001, 4th generation Xenon ballasts have been available in numerous vehicles worldwide.

Xenon electronics

Xenon 4.1 ballast electronics with D1 lamp

Xenon 4.1 ballast

The Xenon 4.1 system is a consistent further development of the Xenon 4 system and has been produced in series since the beginning of 2005. It operates a Xenon HID lamp with integrated igniter (D1 lamp).

The Xenon 4.1 ballast has the following system features:

- Increased temperature resistance through setup of the SMD components on a ceramics substrate with heat-sink technology
- Possibility for self-diagnosis in combination with intelligent lighting-control module
- Additional volume and weight reduction
- Improved EMC behavior through a fully shielded system
- Optimized integrability in the headlamp system

Xenon 5 electronic ballast/AFS control unit with D1 lamp

Xenon 5 electronic ballast/AFS control unit

With the Xenon 5 control unit, Hella combines the control electronics for VARILIS® functions and the ballast electronics for the operation of Xenon HID lamps. The entire electronics is installed in a compact package-space-optimized housing mounted directly onto the headlamp housing. Thus, intelligent lighting functions are achieved with a minimum number of control units.

Xenon 5 receives signals from the vehicle via a CAN bus connection, which denote the current driving situation and are necessary for the calculation of the control signals using complex algorithms. The control signals are transferred via a LIN bus to the intelligent stepper motors in the headlamp for adjustment of the headlamp leveling, the swiveling of the light module, and the adjustment of the drum of a VARIOX® module. The control unit has a power driver, driving additional halogen bulbs with up to 55 W bulb power for the realization of static bend lighting or a cornering light. The concept of the XENON 5 control unit contains a driving situation-dependent power increase of the Xenon HID lamp for increased luminous flux, e. g. in the case of motorway trips.

A component-related diagnosis and an intelligent fail-safe strategy ensure that legal requirements are fulfilled in error-situations as well. With the Xenon 5 control unit, an optimized EMC behavior is obtained through full shielding.

Mechatronics for AFS (Adaptive Frontlighting System)

VARILIS® architecture for Xenon technology with AFS1 control unit

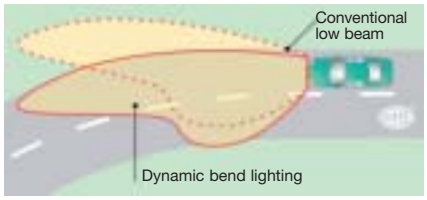
Experience light with VARILIS®

The intelligent Advanced Frontlighting System (AFS) by Hella is called VARILIS® (Variable Intelligent Lighting System) and offers fully automatic lighting control through an innovative combination of electronics and lighting technology. In addition to the already established bend lighting, which adapts the light distribution to the course of the road, a completely new light function is created through the combination with a VARIOX® projection module. The automatic change-over of the free-form drum, which is rotatable on bearings, as a shield in the VARIOX® module makes it possible to adapt the light distribution also to the driving situation (country, motorway, town) for left-hand and right-hand and traffic.

	Halogen light	Xenon light
Cornering light	■	■
Bend lighting	■	■
Adaptive light distributions (VARIOX®)	—	■

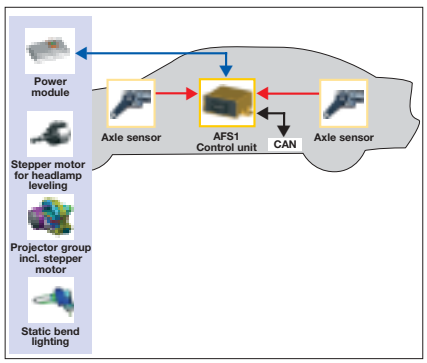
AFS functions for halogen and Xenon light

Static bend lighting (from 2002)



Dynamic bend lighting (from 2003)

Through the many possibilities realized through Hella software, the system parameters can be adapted to customer requirements so that a customer-specific light appearance image can be shown. The vehicle manufacturer receives an additional feature to distinguish itself from the competitors in each vehicle segment or to distinguish its vehicles within a platform.



VARILIS® architecture for Xenon technology with AFS1 control unit

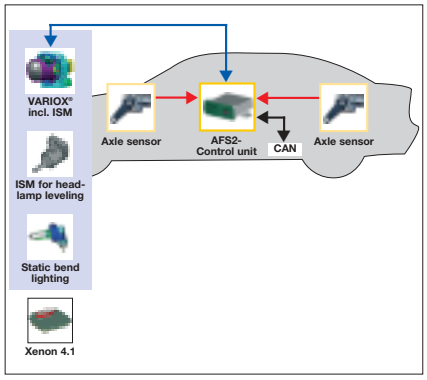
VARILIS® for Xenon technology

For the control of intelligent light functions in headlamps using Xenon HID lamps as a light source for low beam and high beam, Hella has several different control systems. The flexible system architectures can be optimally adapted to the vehicle architecture and the customer requirements.

Bend lighting with AFS1 control unit and power module

Today's available Xenon bend lighting systems by Hella are based on the AFS1 control unit. This evaluates the information for the calculation of the current driving situation received via the CAN bus and sends control commands to the power modules (LEIMO) via a communication link attached to the headlamp housing.

The power modules convert the control signals into corresponding voltages to control the stepper motor for dynamic bend lighting and dynamic headlamp leveling. Additionally, the power modules can switch halogen light sources for static bend lighting or cornering light. The operation of the Xenon HID lamp is controlled through a Xenon 4.1 electronic ballast.



VARILIS® architecture for Xenon technology with AFS2 control unit

Bend lighting and adaptive light distributions with AFS2 control unit and ISM

In order to realize VARILIS® functions such as adaptive light distributions, the 2nd generation AFS control unit was developed. Through combination with intelligent stepper motors, the new systems no longer have power modules and the number of control units is reduced.

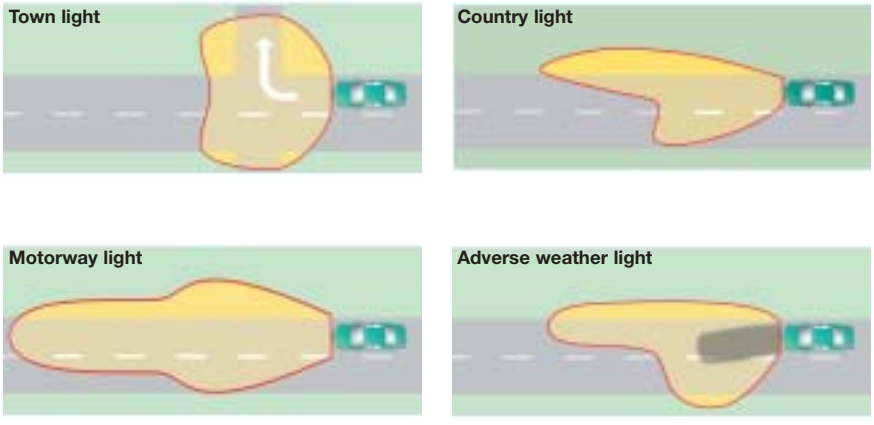
As a central control unit, the AFS2 control unit has a CAN bus connection by means of which vehicle electric system information such as speed, steering angle and yaw rate are read in. Moreover, signals from vehicle level sensors or from the headlamp leveling switch can be read in. The micro-controller calculates the necessary control variable from these data to adjust the driving situation-dependent light distributions. The control variables are transferred to the intelligent stepper motors in the headlamps via a LIN bus and used for the adjustment of the headlamp leveling (dynamic headlamp leveling), the swiveling angle, and the position of the VARIOX® drum. Furthermore, the DC actuators can be controlled for the purpose of manual or automatic headlamp leveling. The AFS2 control unit also has a power driver to dim the halogen light sources for the static bend lighting/cornering light.

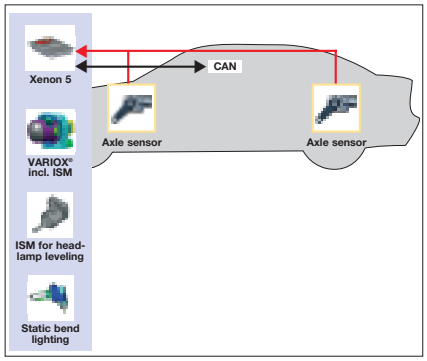
Through the use of intelligent stepper motors, networked via a LIN bus with the control unit, a modular system is achieved. This concept makes the use of the same control unit for headlamps with different equipment variants possible.

The key features of this system are:

- Control of the intelligent stepper motor (ISM) for dynamic headlamp leveling,
- Operation of the Xenon HID lamp using a Hella Xenon 4.1 ballast
- Control of static bend lighting
- Component-related diagnosis (VARILIS®)
- Closed fail-safe concept
- Mounting of the control unit in the engine compartment or in the vehicle interior
- Use of the AFS2 control unit in connection with halogen headlamps is possible

Possible adaptive light distribution as a basis for customer-specific light appearance image.





VARILIS® Architecture for Xenon technology with Xenon 5 electronic ballast/AFS control unit

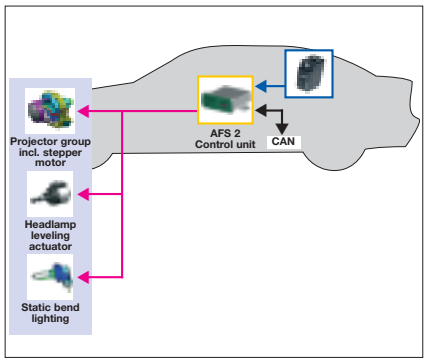
Bend lighting and Adaptive Light Distributions with Xenon 5 Electronic Ballast/AFS Control Unit and ISM

With Xenon 5, further goals with regard to optimization of current intelligent lighting systems were realized. In each control unit on the headlamps, the control electronics for all VARILIS® functions and the ballast electronics for the operation of Xenon HID lamps are combined. The concept of the XENON 5 control unit comprises a situation-dependent power increase of the Xenon HID lamp for increased luminous flux, e. g. in the case of motorway trips.

Through the use of intelligent stepper motors networked via a LIN bus with the control unit, a modular system is realized. This concept makes the use of the same control unit for headlamps different equipment variants possible. The interface to the vehicle electric system remains the same for all headlamp variants.

The key features of this system are:

- Integration of AFS control unit and Xenon ballast in one housing
- Control of the intelligent stepper motor (ISM) for dynamic headlamp leveling, dynamic bend lighting and VARIOX® drum via a LIN bus
- Control of static bend lighting
- Driving situation-dependent Xenon power regulation
- Component-related diagnosis (VARILIS®, Xenon)
- Closed fail-safe concept
- Improved EMC behavior
- Compact design, minimal wiring expenditure in the headlamp
- Installation on the headlamp



VARILIS® Architecture for halogen

VARILIS® for halogen technology

The advantages of dynamic bend lighting can be experienced as a cost-effective solution also in combination with halogen headlamps.

For this, the AFS2 control unit developed by Hella is used. This control unit receives signal data available on the CAN bus, such as vehicle speed and steering angle, which denote the current driving situation. These data are processed in the control unit and converted into control signals through intelligent algorithms. The control signals are transferred via a LIN bus to the intelligent stepper motors (ISM) in the headlamps, in order to swivel the light modules according to the course of the road. Furthermore, the halogen light sources for static bend lighting can be controlled via a PWM signal. In order to balance the states of load of the vehicle, the AFS2 control unit can likewise control the headlamp leveling actuators in the headlamps.

Into the future with Lighting Electronics

In the case of the development of future systems, the use of information of forward-looking driver assistance systems for lighting electronics will play an increasingly important role. While today's intelligent light systems are based on sensors receiving their information from vehicle measurement variables (steering angle, speed ...), in the future information regarding the vehicle's surroundings can be considered as well. Forward-looking driver assistance systems such as navigation systems and ACC (Adaptive Cruise Control) will deliver information regarding the further course of the lane as well as the presence of other road users close up to the vehicle. This information can be used to automatically adapt the variable light distributions, the bend lighting and the headlamp leveling of an intelligent headlamp system to the respective traffic situation optimally in a forward-looking manner.

Further developments concern the calculation of driving-dynamics models in AFS control units. For this, state variables regarding driving dynamics are calculated using measurement variables (steering angle, speed ...) and parameters describing the vehicle (wheelbase, mass ...) which cannot be registered through measurements. The consideration of these state variables makes an optimal situation-adapted illumination of the road possible even with a dynamic driving style. In addition to optimized AFS control, there is the possibility to substitute sensors. An example is the front vehicle level sensor of dynamic headlamp leveling, which can be substituted by a driving dynamics pitching model (single-axle headlamp leveling).

For environmental purposes the automobile industry aims at eliminating mercury in vehicles. Mercury is a technically essential component in current Xenon bulbs, considerably influencing the operational behavior of the bulb. The substitution of mercury in Xenon bulbs requires a new generation of Xenon ballasts in order to fulfill the technical requirements. Hella has faced the challenge and has developed ballast concepts for this environmentally friendly technology. The ballast itself is designed as lead-free technology in order not only to reduce mercury, but also the heavy metal lead.

Hella uses existing systems from lighting and light-electronics know-how to develop complete system solutions based on standard components. The modular design of control electronics, as well as the scalability of software algorithms, offer additional potential for cost-efficient system performance. Additionally, the networking of the fields of competence "Body Electronics" and "Lighting Electronics" makes flexible adaptation to customer-specific vehicle electric system structures possible.

Altogether, Hella offers an innovative mechatronic concept for the realization of tomorrow's driver assistance in relation to lighting.

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