Chassis Systems Control
Stereo video camera

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Customer benefits

- Realization of multiple safety and comfort functions, such as automatic emergency braking, traffic jam assist, construction zone assist, narrow lane assist, evasive steering support, adaptive cruise control, intelligent headlight control, lane departure warning and lane keeping or lane guidance support as well as road sign assistant
- Uniform in-house Bosch processes applied throughout the development of hardware, image processing technology and functions, ensuring that all components are optimally aligned
- Can be combined with other sensors, in particular with radar and ultrasound, to support the emergency braking system, narrow lane assist, evasive steering support, parking and maneuvering assistance functions and adaptive cruise control
- Meets NCAP safety standards
- Highly scalable functionality and can be adapted to customer specifications
- CAN and Ethernet interfaces available, FlexRay interface optional
- AUTOSAR conformity enables integration of customer-specific object codes
- Housing geometry can be adapted to fit the space available
- Compact design enables installation in the crash-protected area of the interior rear-view mirror, with minimal reduction in visibility

With the stereo video camera, vehicle manufacturers can use a single sensor to integrate a wide range of driver assistance functions, which help improve safety and comfort and fulfill the ever-increasing safety standards set by legislators and consumer protection organizations. Beginning in 2014, manufacturers striving to achieve the highest rating (five stars) under the Euro NCAP (European New Car Assessment Program) must equip their new models with at least one driver assistance system, such as automatic emergency braking, lane keeping assistance or automatic speed limit recognition.

Features and design

With the stereo video camera, Bosch offers a scalable platform that combines the established functions of a mono camera with the benefits of the three-dimensional (3-D) environment detection offered by stereo technology. The different mono and stereo cameras use the same system architecture with a scalable hardware and software concept. As a result, the stereo camera's range of functions can be adapted to customer requirements on a large scale.

The stereo video camera's two CMOS (complementary metal oxide semiconductor) color imagers have a resolution of 1280 x 960 pixels. Using a powerful lens system, the camera records a horizontal range of 50 degrees and offers a 3-D measurement range of more than 50 meters. The image sensors, which feature highly sensitive and dynamic lighting technology, can process high-contrast images and cover the wavelength range that is visible to the human eye.

The control unit for image processing and function control is integrated in the housing of the stereo video camera. It comprises one scalable processing unit, which provides a programmable logic (FPGA) and a dual core microprocessor with an integrated CAN or Ethernet interface on a single chip. An additional processing unit can be added if necessary.

Technical features	
Imager size	1280 x 960 pixels
Field of view	
Horizontal	50° (nominal)
Vertical	28° (nominal)
Resolution	25 pixels/°
Frame rate	30 images/second
3-D measurement range	~55 m
Exposure dynamic	110 dB
Wavelength	400...750 nm
Current consumption	<5.8 W (0.4 A at 14 V)
Operating temperature	-40 to +85°C (+105°C for CAN communication)
Interfaces	2x CAN or CAN+Ethernet Optional: FlexRay 2x digital in/out, windscreen heating
Dimensions (L x W x H)	160 x 60 x 32 mm

This architecture uses parallel image processing in the FPGA, which allows the system to analyze complex driving situations within a very short space of time.

The software architecture of the stereo video camera is AUTOSAR-compatible and allows the vehicle manufacturer to integrate its own functional modules alongside the customer-specific functions offered by Bosch.

With a basic width of 12 centimeters – the distance between the optical axes of the lenses – the Bosch stereo video camera system is an incredibly compact solution capable of delivering high performance in automotive applications. Vehicle manufacturers can easily integrate the camera behind the windshield near the interior rear-view mirror.

Functionality

The stereo video camera optics focuses incoming light onto two highly dynamic CMOS color imagers. The sensors convert the brightness and color information into electrical image signals. These signals are then processed by a high-performance computer integrated into the camera housing – without the need for a separate controller.

By evaluating the stereoscopic disparity information (comparing the left and right-hand images), the stereo video camera can generate a precise 3-D map of the vehicle's environment. The resulting 3-D map includes a highly accurate distance estimate for all the points in the image. This approach is quick and robust; it does not require any complex two-dimensional object classification processes.

In parallel, temporal changes in the image are tracked (through optical flow). Thanks to its intelligent fusion concept, the camera is capable of determining the size, speed and distance of all objects, including vehicles, pedestrians, cyclists and motorcyclists, as well as obstacles on or near the road.

While a mono camera must undergo a lengthy process of training to enable the detection and classification of different objects – for example, pedestrians and vehicles in the image – the stereo video camera automatically measures all objects. In addition, the stereo video camera provides all mono-based classification algorithms, allowing it to detect lane markings, road signs and light sources as well.

Image processing algorithms

At the heart of all advanced driver assistance functions are the intelligent and powerful image processing algorithms that Bosch has developed independently for application in the automotive industry. In order to ensure multi-functional operation in its systems, Bosch has optimized these image processing algorithms to deliver the best possible performance while minimizing the memory, runtime and optical path requirements.

Applications and use

The stereo video camera allows the integration of a wide range of functions to make driving safer and more comfortable. The complete three-dimensional recording of the vehicle's surroundings also provides the basis for the automated driving functions of the future.

Automatic emergency braking for vehicles and vulnerable road users

The stereo video camera is an excellent tool for improving safety in both urban and highway traffic, ensuring that the NCAP safety requirements are met in full. At speeds of up to 80 km/h (49 mph), the camera data can be used to trigger automatic emergency braking in response to any stationary or moving objects that the vehicle cannot drive over, which significantly reduces the risk and the severity of collisions. At speeds of up to 50 km/h (31 mph), the system can even help to prevent such collisions altogether. Restraint systems are prepared for the potential impact so that airbags and seat belt pretensioners can be triggered optimally in the event of a collision.

The stereo video camera has been developed for risk class ASIL B (Automotive Safety Integrity Level B), in accordance with the functional requirements for emergency braking systems as set out in ISO standard 26262.

Adaptive cruise control (ACC) with stop & go function
The stereo video camera allows a video-based distance and speed control system to be integrated into the vehicle. ACC can draw on the data provided by the stereo video camera at speeds of up to 130 km/h (80 mph), with comfortable brake interventions of up to 3.5 m/s^2. When approaching a slow-moving vehicle at high speed, the driver is alerted to the need to take control, allowing enough time for the driver to slow the vehicle down beyond the system interventions. If a critical situation does occur in spite of these features, the driver is supported by the brake assist systems. Thanks to its 3-D detection system, the stereo-based ACC function performs particularly well in dense urban traffic and where vehicles are pulling in and out tightly on highways. The speed range can be extended up to 250 km/h (155 mph) by combining the camera with a radar sensor.

Traffic jam assist
The traffic jam assist function can be integrated into a vehicle by combining the stereo video camera with ultrasonic sensors that monitor the areas around the sides of the vehicle. This function helps the driver to arrive at his destination relaxed, even after traveling through slow-moving or congested traffic. Traffic jam assist is a partially-automated driver comfort function that is capable of controlling the longitudinal and lateral movements of the vehicle. At speeds of up to 30 km/h (18 mph), the system can automatically initiate forward movement, accelerate and brake, and, subject to certain conditions, can also steer the vehicle independently to keep it on course and in its lane. The driver retains full responsibility for controlling the vehicle and must monitor the system and ensure that he or she is in a position to take over control at any time.

Integrated cruise assist
This partially-automated function supports the driver in monotonous highway driving situations by combining ACC-based longitudinal control with the lateral guidance provided by lane keeping support. Integrated cruise assist can be supplemented with an automatic lane change function, which requires the driver only to signal his intention to change lanes using the direction indicator – the system then performs the maneuver as soon as it is safe to move into the adjacent lane. This technology requires additional radar sensors to monitor the traffic to the rear and side of the vehicle. Integrated cruise assist provides the driver with extended, partially-automated system support, even at higher speeds, for secondary activities that are unrelated to actual driving; however, the driver retains full responsibility for the vehicle and must be able to take control at any time.

Lane departure warning
The lane departure warning function compares the road markings to the vehicle's position in its lane. If the system detects that the driver is at risk of leaving the driving lane unintentionally at vehicles speeds of 60 km/h (37 mph) and above, it issues a visual, audible and/or haptic signal, for example a steering wheel vibration. These warnings alert the driver to the fact that the vehicle is drifting off course, allowing him/her to countersteer accordingly with sufficient time to avoid any danger. When the driver activates the turn signal to intentionally change lanes or turn, the function does not issue a warning.

Lane keeping and lane guidance support
If the system detects that the vehicle is traveling too close to the lane boundary at a speed of around 60 km/h (37 mph) and above, the system gently, but noticeably, countersteers to keep the vehicle on course. The driver can individually set the point at which the steering intervention takes place and the strength at which it is applied – with options ranging from very early but gentle intervention, up to a later but stronger countersteering effect. The system can intervene directly via electrical steering, or indirectly by applying the brakes on one side of the vehicle. Drivers can override the function at any time, allowing them to remain in control of the vehicle. When the driver activates the turn signal to intentionally change lanes or turn, the function does not intervene.

Construction zone assist
Construction zone assist is an extension of lane keeping support, which is also intended for narrow highway construction sites. The system operates at speeds of up to 100 km/h (62 mph) and supports the driver while traveling in narrow lanes by helping to maintain a lateral safety distance between vehicles in the adjacent lane and the crash barriers. The system can also prevent the driver from driving into a space that is too narrow by either warning the driver or automatically braking the vehicle. For this purpose, the stereo video camera is supplemented with ultrasonic sensors to monitor the lateral distance between the vehicle and surrounding objects.

Narrow lane assist
The narrow lane assist function supports the driver while driving in narrow lanes at speeds of up to 50 km/h (31 mph). The 3-D information provided by the stereo video camera is supplemented by data regarding frontal and lateral distances as measured by the ultrasonic sensors. Initially, the function will only inform and warn the driver; however, over the coming years, the function can be gradually extended to provide automatic lateral guidance for the vehicle when traveling in narrow lanes.

Evasive steering support

Emergency braking is not always sufficient, and may not be the most appropriate way to prevent an accident. For example, the laws of physics dictate that rear-end collisions at high approach speeds can only be prevented through evasive maneuvers once the vehicles have passed a certain distance threshold. In urban traffic, evasive steering support can automatically initiate an evasive maneuver, for example, if a car door opens suddenly in the driving path of the vehicle, or if a pedestrian steps out into the road from behind an obstacle. The vehicle does not move beyond the boundaries of its own lane to perform the evasive maneuver. In later stages of development, evasive steering support will be combined with a radar sensor in the front of the vehicle to detect fast-moving oncoming traffic, as well as radar sensors in the rear of the vehicle to detect approaching or passing vehicles; this combination will allow the system to automatically steer the vehicle into the adjacent lane to prevent an impending rear-end collision. In both cases, the system calculates a suitable evasion path and if necessary, independently initiates an evasive maneuver.

Parking and maneuver assistance systems

With accurate 3-D data covering the entire area in front of the vehicle, in combination with ultrasonic sensors, the stereo video camera forms the ideal basis for a wide range of parking and maneuver functions. These functions support the driver at speeds of up to approximately 20 km/h (12 mph), for example, when identifying appropriate parking spaces, when maneuvering into and out of parking bays and when driving through narrow spaces. In addition, the vehicle can also drive into and out of a selected parking space independently. As an option, the driver can control the parking process from outside the vehicle, using a button on the ignition key or a smartphone.

Road sign assistant

The road sign assistant evaluates road sign recognition data and displays the information that is relevant for the driver in the instrument cluster. The road sign display can be used to provide a range of warning functions, including warning the driver before the speed limit is exceeded, warning against passing on a stretch where such maneuvers are prohibited, or letting the driver know when a "stop" sign or "no entry" sign has been overlooked. Detected speed limits can also be used by the ACC system, which can automatically adjust its set speed to the speed limit in force on the road. To increase reliability and supplement the data used with information that cannot typically be detected by a camera, the system can also draw on data from the navigation system, for example, to distinguish between urban and rural roadways or interpret text-based supplementary signs, such as the validity period of speed limits.

Intelligent headlight control

Using monocular detection, the stereo video camera can detect oncoming vehicle headlights at a distance of up to 800 meters, and is capable of distinguishing these from stationary light sources. The system can detect tail lamps of vehicles ahead at a maximum distance of 400 meters, and then use this information to switch high beam on and off automatically. High beam control, therefore, allows the driver to utilize high beam lighting wherever possible to improve visibility when driving at night, without having to constantly switch it on and off manually.

In future generations of LED headlights, it will be possible to control the entire light distribution range in separate segments. This new technology means that the vehicle high beam is permanently activated for driving at night, which significantly improves visibility without blinding oncoming traffic.

Adaptive high beam control not only controls the range or segmentation of the light, but also adapts the width of the illumination beam to the traffic conditions. As a result, bends can be illuminated in advance of the vehicle's approach, and a wider light cone can be used to more effectively illuminate the edges of the road in urban areas, helping the driver to spot any potentially vulnerable pedestrians.

The improved level of illumination provided by modern headlight systems with intelligent lighting control helps drivers to recognize dangers faster and improve safety when driving at night. It also improves the performance of video-based systems for the detection of obstacles and dangers.

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