Chassis Systems Control
Second generation multi purpose camera (MPC2)

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Customer benefits

▶ Realization of multiple safety and comfort functions, including pedestrian warning, forward collision warning, lane departure warning, lane keeping or lane guidance support, road sign assistant and intelligent headlight control
▶ Uniform in-house Bosch processes applied throughout the development of hardware, image processing technology and functions, ensuring that all components are optimally aligned
▶ Comprehensive portfolio of functions developed by Bosch
▶ Can be combined with other sensors, in particular with radar, to support emergency braking systems and adaptive cruise control
▶ Meets NCAP safety standards
▶ Scalable hardware concept allows components to be optimally configured to the required level of functionality
▶ CAN, FlexRay and Ethernet interfaces for easy integration in the vehicle
▶ 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
▶ Highly flexible power connector design

The second generation multi purpose camera (MPC2) allows vehicle manufacturers to integrate a wide range of driver assistance functions into their vehicles using only a single sensor — thereby enabling manufacturers to effectively and efficiently address 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 new models with at least one driver assistance system, such as automatic emergency braking, lane keeping assistance or automatic speed limit recognition. The United States and Japan are also discussing the option of including similar criteria in their own national NCAP rules.

Features and design

The Bosch MPC2 offers manufacturers a scalable, monocular camera platform for video-based driver assistance systems. All MPC2 variants are based on a scalable processor concept, allowing the system to be optimally configured to the required level of functionality. This means that the Bosch architecture is consistent across the range, with standardized interfaces and functions.

The MPC2 imager module comprises the system optics and includes a highly dynamic CMOS (complementary metal oxide semiconductor) color imager with a resolution of 1280 x 960 pixels. Thanks to its improved resolution, the new imager allows for a larger opening angle than its predecessor, and a significantly increased object detection range, now extending to over 120 meters.

The color imager allows the MPC2 to assess blue and red color information, improving the system's ability to recognize and distinguish between colored lines and specific road signs. The multi purpose camera is installed behind the windshield near the interior rear-view mirror.

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
Exposure dynamic	110 dB
Wavelength	400...750 nm
Current consumption	<5.0 W (0.35 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

The electronics system inside the camera is comprised of one scalable processing unit, which provides a programmable logic (FPGA) and a dual core microprocessor with CAN interface on a single chip. An additional processing unit can be added if necessary. 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 MPC2 is AUTOSAR-compatible and allows the vehicle manufacturer to integrate its own functional modules alongside the customer-specific functions offered by Bosch.

The MPC2 features extensive internal and external monitoring functions to detect any possible faults in the camera. It also detects if the camera lens is blocked or obscured.

Functionality
The MPC2 optics focuses incoming light onto a highly dynamic CMOS color imager. The sensor converts 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.

The system processes the image, recognizing, classifying and locating a wide range of situational factors around the vehicle with a high level of accuracy and reliability, including objects such as pedestrians, vehicles, road markings, light sources and road signs.

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

Object detection
The MPC2 detects objects based on predefined object classes that the system has been trained to recognize, distinguishing between pedestrians, cyclists, motorcycles, cars and trucks. The detected objects are assigned attributes, such as distance, speed, lateral position, angle and, if necessary, time to collision. The detection range is dependent on the size of the object, extending to over 120 meters for the detection of vehicles and approximately 60 meters for the detection of pedestrians. The functional path for pedestrian detection has been developed in accordance with ISO standard 26262 for risk class ASIL A (Automotive Safety Integrity Level A).

Lane detection
The lane detection algorithm used in the MPC2 records and classifies all common lane markings up to a distance of approximately 60 meters ahead (or up to 100 meters in excellent visibility conditions), whether the road markings are continuous, broken, white, yellow, red or blue. The camera can even detect Botts' dots (raised highway markers). The system not only detects the lateral line geometry, but also records the surface gradient in order to track upward and downward slopes in the road. If no clear markings are present, the system draws on secondary information, such as grass edges along the side of the road, to determine how the driving lane continues.

The algorithm is capable of determining the lateral position and the angle of the vehicle in the lane to an exceptional degree of accuracy, which is crucial for functions such as lane departure warning or lane keeping/lane guidance support. Even if road markings are temporarily removed or are not present on a particular stretch, the lane assistance functions that use the lane detection algorithm remain fully functional and ready to assist at any time.

Light source detection

In addition to object detection, the MPC2 also recognizes and classifies individual, paired and clustered light sources, at dawn or dusk and in darkness. The algorithm measures the horizontal and vertical angular position and the distance to the light sources, differentiating between headlights and tail lights in order to distinguish between oncoming vehicles or vehicles traveling ahead. It is also capable of detecting and classifying elements of the road infrastructure, such as street lights and delineators. Using this data, in conjunction with information regarding the ambient light conditions, the algorithm assesses whether the vehicle is traveling in an urban environment — deciding whether or not the high beam headlights can be switched on.

The headlights of oncoming vehicles are detected and classified at a distance of up to 800 meters, and tail lights of vehicles ahead can be detected from approximately 400 meters away. Capable of providing a wide range of intelligent lighting functions, the MPC2 meets all demands placed on modern headlight technology, including systems such as high beam control, adaptive high beam control and continuous high beam control.

Road sign recognition

The MPC2 detects and classifies round, triangular and rectangular road signs, including the start and end points of stretches where speed limits are in force, or where passing is prohibited. It also recognizes "no entry", "stop", "right of way" and "road works" signs. Road sign recognition also classifies relevant supplementary signs, such as time limits, signs applicable only to specific vehicle types and turn arrows. The system reliably detects road signs whether they are sited on actual signs, variable message systems or gantries, offering a high level of international coverage for a wide range of different sign types.

Applications and use

The variants of the multi purpose camera allow manufacturers to integrate a wide range of functions that make driving safer and more comfortable.

Pedestrian warning

The system continually analyzes the area in front of the vehicle in order to detect impending collisions with pedestrians who are in the vehicle's path or moving toward it in a way that is likely to present a risk. If the system recognizes any impending dangerous situation for pedestrians at vehicle speeds of up to 60 km/h (37 mph), it can warn the driver and, working in conjunction with a radar sensor, also trigger emergency braking.

Forward collision warning

As part of a strategy to focus on accident prevention technologies, one of the functions recommended by US-NCAP is forward collision warning. If the system detects an impending rear-end collision with a vehicle traveling ahead, it warns the driver via a visual, audible and/or haptic signal. The function does not intervene independently, but prompts the driver to brake.

Lane departure warning

The lane departure warning system 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 marking at vehicle speeds 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. A driver can override the function at any time, allowing him or her 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.

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

Light source detection opens up a variety of lighting functions that significantly improve visibility at dusk, dawn and in darkness — making driving safer and more comfortable.

High beam control 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. It activates the high beams when it detects that no other vehicles are in the vicinity, and if a vehicle is detected, it switches the high beam off again.

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.

Sensor data fusion

Data fusion combines the benefits of different sensors and measuring principles in the most effective way possible, providing data that individual sensors working in isolation cannot generate. By fusing multiple sensors, the measurement range, reliability and accuracy is increased.

The multi purpose camera is an integral part of a surround sensor network, and can be used in conjunction with other surround sensors, such as radar and ultrasonic sensors.

For automatic emergency braking — which independently applies the brakes if the driver fails to react to an impending collision — Bosch fuses a radar sensor and the multi purpose camera or alternatively uses a stereo video camera. Where fusion is applied, automatic full deceleration is only triggered if both sensor systems detect the critical object.

Sensor data fusion can be used to significantly improve the performance of comfort functions too. Thanks to the lateral measurement accuracy of the MPC2, the ACC function is able, for example, to detect vehicles pulling in or out at an earlier stage, and therefore respond more dynamically. The system also ensures that vehicles in front are assigned to the correct lanes, which further enhances ACC functionality, especially when driving on a curve.