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Solutions for Compact Camera Connectivity for ADAS Systems and Autonomous Driving

The use of cameras in automobiles is booming, with their application steadily increasing in numerous areas. This presents two challenges for vehicle manufacturers and suppliers: they need optics with reliable and fast data connectivity, and they must keep costs under control without compromising quality. Increasing diversity as well as disruptions in global supply chains are making it more difficult to benefit from economies of scale. "A modular system approach combined with comprehensive manufacturing and integration services can help maintain cost efficiency despite tougher global trading conditions," says Sebastian Mysyk, Director of Product Management Data Connectors at Rosenberger Hochfrequenztechnik.

Modern cars are increasingly becoming rolling computers. A growing number of driver assistance systems offer both safety benefits and additional comfort features. In many cases, cameras play a crucial role in enabling the car to comprehensively perceive its surroundings. They deliver high-resolution images with a wealth of detail, for example to recognize objects, traffic signs or road markings. The most important camera and image-based assistance systems include:

- **Front camera:** for recognizing traffic signs, lane departure warning systems and collision warnings or for an emergency brake assist system;
- **Rear view camera**: assistance when reversing and parking
- **360-degree camera systems:** provide a panoramic view when maneuvering in tight spaces and enable (partially) autonomous parking assistance;
- **Night vision cameras:** improved visibility and early pedestrian detection in poor light or weather conditions using infrared technology (IR)
- **Adaptive cruise control (ACC):** Automatic speed adjustment in flowing traffic using combined camera and radar sensors;
- **Gesture control:** the driver can control functions using specific hand movements;
- **Attention assist:** monitoring of driver behavior using an interior camera;
- **Dashcams and surveillance cameras when stationary (Sentry Mode):** These record while driving (e.g., in the event of accidents) or are used for surveillance when the vehicle is parked.

There are also special cases such as interior security monitoring, for example in taxis or cash-in-transit vehicles, or AI-based, autonomously controlled taxis and transport vehicles.
Market experts at Fortune Business Insights expect further innovations, as well as legal requirements and interest from insurance companies, to fuel the trend towards more and more cameras, with global sales of automotive cameras tripling between 2022 and 2032 to around 22.5 billion US dollars.

Division of labor in the vehicle

But it is not just the number of cameras that is growing – the technology is also changing. Image data processing is shifting away from cameras to powerful central control units, where greater computing and storage capacities are available, such as those required by AI applications. This also enables further miniaturization.

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Current vehicle cameras are therefore essentially limited to the optical components, i.e., the lens and imager chip, and a compact housing with a network interface. All other technology, such as image processing and evaluation, is outsourced.

Since image recognition is sometimes used for safety functions and information transfer is therefore time-critical, low latencies are essential. Sufficient bandwidth must also be reliably available. The connection is therefore usually established via high-speed data links that can transfer several GB/s. To achieve this, the connectors must also contribute to ensuring the connectivity of the camera. A robust and fault-resistant fit despite continuous stresses such as temperature changes, humidity, dirt and salt, as well as vibrations, is crucial for this.

Economic challenges for OEMs and Tier 1

For vehicle manufacturers (OEMs) and their suppliers (Tier 1), the additional vehicle components mean higher costs and more potential sources of error, as well as higher capital expenditure. The costs for image sensors and lens systems are even exceeded by those for other integration components such as housings, interfaces and cable harnesses. Added to this are ancillary costs for assembly, transport and storage, as well as installation in the vehicle.

Usually, attempts are made at minimizing such costs through economies of scale, i.e., by producing or processing as many identical components as possible. However, there are two obstacles to this. On the one hand, there is the model strategy of vehicle manufacturers, some of whom work with high/mid/entry versions, and on the other hand, there are vehicle variants adapted to different markets with different equipment features.

Local-to-local approach is not a contradiction

A second reason is the recent problems in global supply chains. The industry's response is, unsurprisingly, "local production for local markets." However, this does not mean that scaling effects must automatically be abandoned.

"Instead of manufacturing huge quantities of different cameras, a modular concept is recommended, which enables production entirely according to customer requirements while still keeping costs low. This is because the individual components – apart from customer-specific housings – are standardized and can therefore be produced cost-efficiently in large numbers," says Thomas Miedl, Head of Product Management Team Camera Solutions.

Flexible modular system offers advantages

The required variety of cameras is achieved by combining different parts from the "modular system." The focus is on three components:

- **Backhousing:**

Plastics or metal (aluminum) can be used here, and the size and shape can be varied according to customer requirements. Variants with 24 or 26 mm edge lengths and individually defined mounting points are in demand, for example. For cameras in vehicle interiors, such as driver monitoring, particularly slim housings are also possible. The camera can also be made waterproof in accordance with IPx7 protection class.

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The backhousing can be made entirely of metal, entirely of plastic, or in a two-part solution, with the rear cover made of aluminum and the interface housing molded from plastic.

- **Interfaces:**

There are various coaxial interfaces available for camera applications:

- FAKRA-Interface (up to 6 GHz)
- HFM®-Interface (up to 20 GHz)
- RMC®-Interface (bup to 9 GHz)

In addition, variants with optional power pins (MQS) and versions with backhousing, flange or DirectLink pigtail connections are available, including wire-to-board versions with MQS pins.

- **Tolerance compensation functions:**

The position of the PCB within the housing can be flexibly realized based on requirements, and different outlet directions for the interfaces and cables are also available. Two mounting variants are on offer as well. On the one hand, there is the "rigid" connection, which requires precise positioning during the plugging process but allows for greater tolerances when gluing or welding the camera head.

On the other hand, there is the "floating" variant: thanks to tolerance compensation within the plug-in system, the plug is automatically centered and ideally positioned during the camera assembly process. This effectively prevents the components from becoming distorted, which could exert pressure on the connector or cause the circuit board to bend. This ensures long-term reliable operation, as the RF path is always exactly the same. As a result, fewer tolerances are permitted during bonding or welding.

Of particular interest to OEMs and Tier 1 suppliers: both variants are footprint-compatible. This means that if, for example, the customer uses one variant in its US plant and the other in its EU plant, only the PCB connector needs to be changed. All other components – including the camera head's characteristic values – remain the same.

- **„DirectLink pigtails or wire-to-board solutions**

DirectLink pigtails or wire-to-board solutions demonstrate their advantages particularly in driver monitoring systems, which are often installed in confined spaces, such as behind rear-view mirrors or in the headliner. Their compact designs enable space-saving integration without compromising signal quality or electromagnetic compatibility. Even in complex interior camera systems for analyzing eye behavior or detecting fatigue, the interfaces can be implemented seamlessly and with high transmission reliability.

All elements of this "modular system" are available to customers worldwide. The use of standardized components enables automated production in line with the best-cost approach. This means that production can be carried out cost-efficiently in different markets according to the "local-to-local" principle. At the same time, customers enjoy full flexibility with minimal effort. For example, they can

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offer a FAKRA variant in one market and a HFM® variant in another, with the only difference being the interface, while all other components are standardized.

Phy2Phy strategy

Instead of simply supplying components, the focus is increasingly shifting to a holistic system approach in which technical responsibility covers the entire signal path – from capture by the image sensor to further processing in the central control unit ("from Phy to Phy").

On the one hand, this means that the reliability of the data connection with high bandwidths, low latencies and no interruptions in data transmission is paramount. All components for the camera head are optimized for this purpose, right down to optimized EMC compatibility.

On the other hand, we also see ourselves as a system partner on an equal footing, who keeps an eye on the customer's processes and contributes to cost-efficient production.

Conclusion

No new vehicle can do without a camera system anymore. In fact, the number of cameras in vehicles is increasing, and manufacturers and suppliers are challenged to manage this growth in vehicle equipment in a cost-efficient manner. Model variance on the one hand and multi-source approaches and risks in supply chains on the other require new strategic responses that go beyond the scaling effects of mass production.

A modular approach provides these answers – on several levels. It offers flexibility in the choice of standardized components such as the interface, combines this with individuality in housing shapes and sizes, and also takes into account the different production processes of the customers. Technical expertise in the field of high-frequency data transmission on the part of an IT service provider is essential to ensure the quality of the data signal across all segments of the data link, from the image sensor to the processing CPU.

Further information: https://www.rosenberger.com/de/produkt/kameraloesungen-fuer-automobile-anwendungen/

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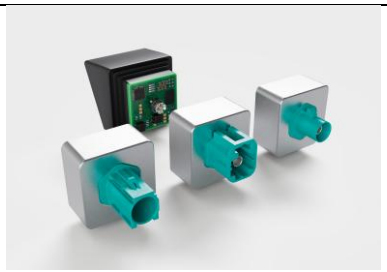
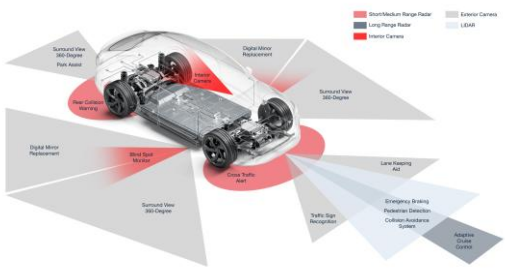
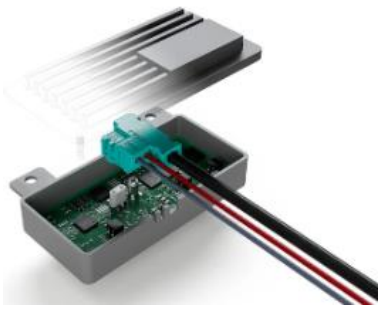
	Modular camera connectors in three coaxial interfaces: RMC®, HFM® and FAKRA
	This all-in-one solution, which includes a connector, housing, and PCB connector/bullet, is suitable for all camera applications in vehicles
	Various material options for camera and interface housings, such as metal and plastic, are robust, cost-optimized and offers excellent EMC shielding
	Overview of the various automotive camera applications incl. LiDAR, radar and interior and exterior camera systems, including surround view, front, rear and mirror cameras
	“DirectLink” pigtail connectors in a compact size, enable flexible installation in highly constrained environments

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About Rosenberger

Rosenberger, a globally renowned manufacturer of electronic components and systems, stands for cutting-edge technologies, development expertise and uncompromising quality. Headquartered in Germany, the Rosenberger Group has sales and production sites around the world and offers a wide range of standardized and customized connection solutions in high-frequency, high-voltage and fibre optic technologies.

Rosenberger ensures the reliable transmission of signals, data and energy in the most demanding applications. Leading high-tech companies in the fields of mobile communications and telecommunications, industrial measurement technology, automotive electronics, medical and industrial electronics, data centers and aerospace rely on Rosenberger products, which are characterized by precision and maximum reliability. The CNC machining division manufactures precision parts for various industries, including the automotive and commercial vehicle industry, shipbuilding and traditional mechanical and plant engineering.

Rosenberger has been family-owned since its foundation in 1958 and employs around 15,000 people worldwide (m/f/d), who stand for commitment, innovation and quality awareness in the tradition of a family-owned company. Further information can be found at www.rosenberger.com

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