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THE NERVOUS SYSTEM OF THE CONNECTED VEHICLE

How an automotive ethernet and 5G will power autonomous driving

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Human beings are complex creatures: Our brains transmit signals via our nervous systems to our muscles. At the same time, impulses that we perceive through our sensory organs are transmitted by our nerves to our brains. This enables us to communicate, act and react in and with our environment. Autonomous driving works in much the same manner: The car must react to outside influences while simultaneously communicating with its environment.
The key requirements needed by such a vehicle are a brain, in the form of powerful computers installed throughout the vehicle, tactile sense in the form of sensors, an automotive ethernet and high-performance 5G communication systems. The automotive ethernet will form the nervous system and the antenna(e) the ears and the mouth, so to speak. In the process, they will help turn the future of autonomous driving into a reality.

SAFETY IN THE CONNECTED CAR WILL COME FROM WITHIN

Like humans, an autonomous vehicle must produce safety from within and function on its own. Fully and highly automated vehicles must be able to independently manage safety issues with their own sensory and actuating systems. And they must do so without relying on data produced by other vehicles on the road or the infrastructure. For this reason, the vehicle needs data from sensors and an agile nervous system that will pass on the data to all computing units installed throughout the vehicle. This is where the automotive ethernet comes into play. The ethernet can serve as the nervous system for car manufacturers because the technologies that have arisen from IT have already proven themselves there. They meet the needs of the automotive industry in terms of transmission speeds, fault tolerance and, above all, safety. Furthermore, the ethernet is considered to be future-proof, a feature that is vital to autonomous driving.

HIGH DATA RATES AND RELIABILITY AS KEY CRITERIA

The automotive ethernet will make it possible to achieve high data speeds within the car. At the moment, automobile data networks have speeds of up to 10 Gbps. Initial solutions were showcased at this year's CES in Las Vegas. The high bandwidth and fast signal processing are essential to autonomous driving. In addition, the ethernet must be fail-safe and reliable. To make this happen, cars will be equipped with redundant wiring harnesses that can make up for a partial failure and facilitate the continued operation of the entire system. Another way to boost ethernet reliability is to use a ring-shape arrangement of cables. With this system, individual components can continue to communicate with one another if a complete failure occurs at one point in the ring.

One critically important job that the ethernet will have to perform is to quickly and reliably supply the safety-related data produced by vehicle sensors to the computing units. This will enable the vehicle to autonomously operate in urban traffic. Other data will be needed for autonomous driving, in particular to increase riding comfort. They will be produced by the car's antenna. It will also have to meet certain requirements in order to quickly feed external data to the vehicle's computer.

5G COMMUNICATION SYSTEMS FOR INCREASED COMFORT IN AUTONOMOUS VEHICLES

Antennas are already a key component of connected driving. They are used to supply signals received from other vehicles or the infrastructure via the ethernet and a connectivity platform to the car's computing brains. This so-called preprocessing sensor system is something like the voice of the connected vehicle, with which the vehicle communicates with its environment and can send and receive signals. The received signals are designed to increase comfort. One such scenario would occur when the vehicle applies the brakes earlier than expected and, thus, more gently because the vehicle ahead of it has wirelessly reported a braking maneuver. Or an ambulance would announce its presence wirelessly to vehicles ahead so that they could form a corridor in time.

Today, sensor data are transmitted in a heavily preprocessed state because of the lack of bandwidth. The currently available bandwidth per vehicle amounts to just a few hundred kilobits. This will do for right now, but it is not enough for autonomous driving. Vehicles will have to be able to receive more sensor data, some of which is unprocessed. Such requirements make bigger bandwidth unavoidable. The ideal vision is that vehicles would be able to receive [raw] sensor data in an amount equal to its own already available data. Every OEM will implement its own, brand-shaping algorithms, something that can function only if it can access raw sensor data – both its own and those of the environment. This will require significantly higher data streams – extending all the way to the gigabit level. Other scenarios in which tremendous amounts of data are transferred are also important to autonomous driving. This includes the downloading of current, high-resolution maps that show current construction sites and obstacles to which the vehicle will have to react.

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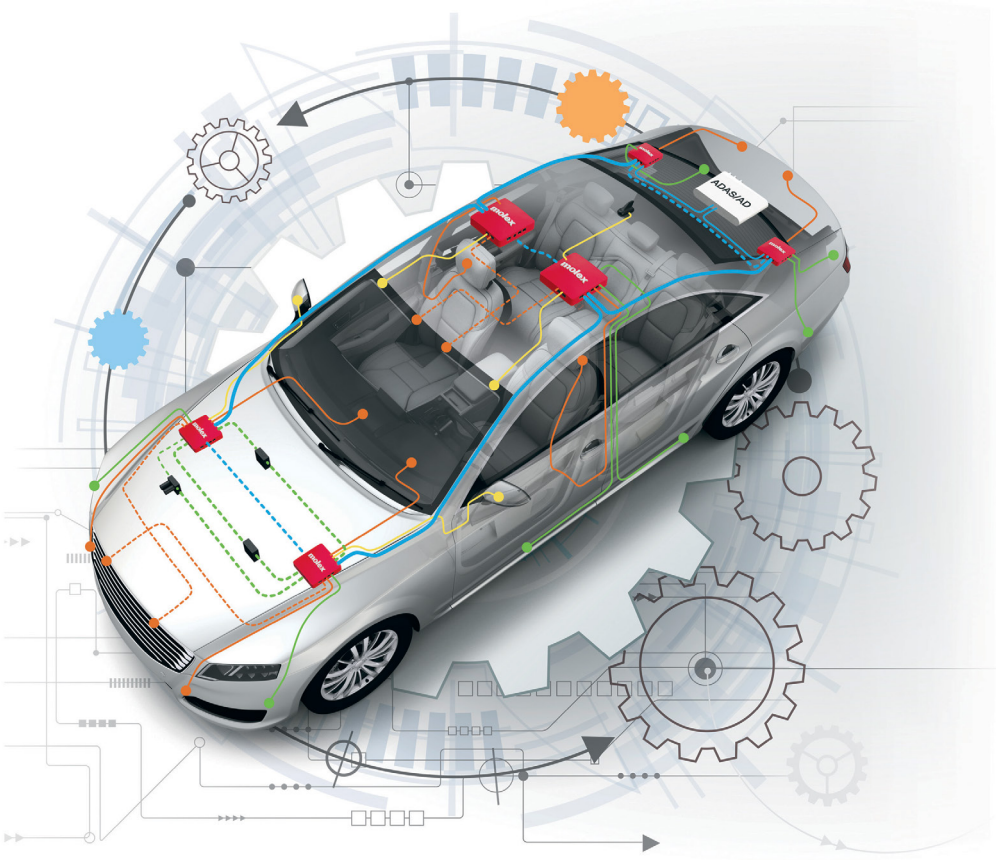
FREQUENCY RANGE MUST BE EXPANDED

To be able to offer this bandwidth, antennae will have to cover a larger frequency range. This will require a new standard, something that a number of groups are currently developing. This new standard — 5G V2X — should facilitate several 100 MBits, ideally several gigabit/s, of bandwidth. As a result, vehicles would be able to receive and send the relevant data quantities for increased comfort. Because standardization groups are currently meeting and are defining application cases, experts forecast that the first products will appear on the market at the beginning of the next decade and will support fully and highly autonomous driving beginning about 2025. An important question that still must be answered involves the frequency range that should be used for 5G V2X. After all, there is no available and gratis frequency range below 60 GHz around the world that could carry this amount of data. There is also a physical problem in the area of 60 GHz, an issue that involves the resonant frequency of the oxygen molecule. If this molecule begins to oscillate, it will withdraw energy from radio waves and restrict their range to just a few meters. Applications such as communications among vehicles and the infrastructure would be impossible as a result.

Antenna technology offers a way to solve this problem: Instead of using an omni-directional antenna that sends out radio waves in a ring-shaped form, several directed antennae would be used. These antennae could continuously beam their waves in one direction and increase the range during the trip in the process. They will be needed to receive the signals of other vehicles on the road and to send their own signals as well. They will also have to be connected to one another as well as with the vehicle's computers. This, in turn, will require the automotive ethernet to quickly transmit the data.

THE FUTURE BEGINS NOW

Car manufacturers are already testing automated cars in field trials. Daimler, for example, recently obtained authorization to test autonomous cars on urban streets in Beijing. Volvo, meanwhile, is already testing self-driving cars on Swedish roads. Initial results show that drivers accept the autonomous cars and are willing to turn over control to them. The autonomous car acts like a human being: Sensors receive a signal, transmit it via the nervous system and communication systems to the brain and communicate over (directed) antennae with other vehicles on the road.



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