Technical Information
Electronics – Contactless Sensors for X-By-Wire Systems
Introduction

Sensors, which detect driver wishes and monitor system status are essential components of mechatronics in vehicles today. In all moving systems, position sensors automatically assume particular importance.

For measuring displacement and angles, potentiometer solutions have become firmly established in many automotive applications thanks to their simple structure, the decades of know-how already built up in this sector, and last but not least thanks to their low price. The application limits of potentiometers caused by their working principle are mainly due to possible wear and contamination under unfavourable environmental conditions such as high temperatures and vibration. In addition, the working principle of potentiometers only allows them to process small signal currents. For these reasons, contactless sensor solutions are being used increasingly to improve the reliability and availability of mechatronics.

Hella developed a measuring method on an inductive basis following intensive analysis of the most well known measuring principles on the market at the time (MR, Hall, capacitive). Thus Hella has core competence in its own contactless measuring method as well as potentiometer know-how. The measuring principle went into series production in 1999 and has since proven itself millions of times over in automobile technology.

Hella inductive sensor applications:

- Accelerator pedal sensor (suspended)
- Steering angle sensor
- End of shaft sensor
- Actuator for turbocharger control
- Accelerator pedal sensor (floor mounted)
- Steering torque sensor
- Vehicle level sensor
- Throttle valve sensor
The general structure is very easy to implement: The stator element comprises excitation coils and receiver coils using planar technology along with evaluation electronics and consists of a standard PCB and an ASIC. The rotor consists of one or more conductive loops in a specific geometry and can be made from a punched part, an MID component or another PCB element. A linear sensor can be designed in a similar way. In this case the ASIC’s can be taken over without changes being necessary.

Alternating current passes through the excitation coils, creating an electromagnetic field. The electromagnetic field influences the conductive loops of the rotor and the receiver coils. Voltages dependent on the position of the rotor are induced in the receiver coils and evaluated by the electronics.

The ratiometric measuring principle is independent of temperature and insensitive to mechanical tolerances. The sensor can be integrated quite easily thanks to its simple structure. Thus the principle can be used universally for tasks of travel and angle measurement as a favorably priced solution.

**Throttle valve sensors**

The advantages of the inductive measuring principle are most obvious in the engine compartment, e. g. with throttle valves. High temperatures and vibration due to installation in the engine compartment make a non-sensitive measuring method imperative here. For safety reasons, the throttle valve sensor has been designed redundant. Redundancy is achieved in a space-saving design, with the inductive principle, by integrating a second sensor structure in the same PCB. With an additional ASIC two independent signals are available.
In connection with the drive train and chassis, the trend toward more and more mechatronic components in vehicles is linked with the term X-By-Wire. The first X-By-Wire systems to go into production are the E-gas systems, which are also known as Power-By-Wire or Accelerate-By-Wire systems. In addition to the electronic throttle valve and the accelerator pedal, the system also includes the accelerator pedal sensor, which combines the recording of the electronic pedal position and generates the resistance to the driver’s foot. Thus electronic accelerator pedals represent an important interface to the driver.

Hella is the first manufacturer to have developed integrated electronic accelerator pedals for Diesel and gasoline engines for passenger cars and electric vehicles using Power-By-Wire. To provide individual adaptation to meet a wide range of customer preferences, Hella’s accelerator pedal sensor has been designed to accommodate the accelerator pedal, the generation of pedal force, and the position sensors in one modular structural unit.

This technology makes Hella the market leader in Europe. Following the introduction of the first Hella pedal sensors in the year 1996, the 10 million threshold barrier was already exceeded in the year 2002. The production of pedals continues increasing steadily.

The most important features of the Hella accelerator pedal sensor are its compact modular design, low weight, economical concept, and above all its adaptability. The flexibility and adaptability of both the electronic interfaces (analogue or PWM signals, characteristic signal curves, redundancies) and the mechanical parameters, such as the characteristic force curve, hysteresis or pedal geometry allows Hella to accommodate a broad range of customer specifications.
The force important for driver feedback is implemented through two cylindrical pressure springs and a friction element dependent on the return force. The springs guarantee a safe return to the idle position while the friction element (hysteresis) provides a high degree of driver comfort. The activation characteristics of conventional vehicles are successfully simulated by matching the individual components to one another. The kick-down function required for automatic transmissions is implemented with a plug-in element while otherwise keeping the design identical.

Potentiometers have established themselves as the standard solution for accelerator pedal sensors and will retain their respective share of the accelerator pedal market in the future. However, due to the disadvantages of potentiometers such as wear and tear, contactless technology is becoming more and more important. Therefore, Hella offers an inductive solution, which went into series production as early as 2001.

In 2003, a contactless linear sensor for pedals went into production with the floor-mounted version of the accelerator pedal sensor. The linear contactless sensor works according to the same measuring principle as the rotary position sensor. The floor mounted accelerator pedal complements the portfolio of Hella pedals with an additional ergonomic solution.

The next generation of accelerator pedals is further improving the integration of contactless inductive sensors. The continuous reduction of the design space produces less weight, more compact, and cost-optimised solutions.

Hella already has development and production facilities for accelerator pedal sensors worldwide and is steadily expanding its international competence, primarily in the NAFTA region and in Asia. Continual product innovations and international competence places Hella in an excellent position to face the challenges of the future pedal market.
Steering sensors

Sensors for steering systems support different vehicle functions. They detect the steering intention of the driver for electrically and electro-hydraulically supported steering, on the other hand, they are part of complex dynamic vehicle systems such as ESP.

A distinction must be made between steering angle and steering torque sensors. While the steering angle sensor measures the angle or the speed of turning of the steering wheel, the steering torque sensor measures the effort required for the steering action.

Hella has already produced millions of steering angle sensors as standard parts. Steering torque sensors or combination sensors for future steering systems such as overlay steering or steer-by-wire are currently under development.

The steering angle sensors are multi-turn capable if required. Hella uses the differential angle method to measure the steering torque on the torsion rod of the steering.

Hella solutions are based on the inductive measuring principle and stand out thanks to their extremely flexible application possibilities. The installation location is not restricted to the inside of the vehicle. This sensor principle is also resistant to temperature and mechanical tolerances and can thus be used without limitations even in the engine compartment.

Steering systems are subject to particularly stringent safety requirements. Along with the reliability of the measuring principle itself, a redundant arrangement of sensors is necessary for safety reasons. The Hella inductive sensor has proven itself in different applications during the past several years and provides all values of redundancy. It thus represents a comprehensive sensor solution for steering systems.
End of shaft sensors

Position sensors, as end of shaft sensors, are the obvious solution wherever integration in a system is not possible or not economically feasible. In some applications, the space available does not permit the sensors to be used where they are physically required. In other cases, the direct environment is unfavourable, e.g. due to high temperatures or aggressive media. In this case integration would not be possible or only be possible with a disproportionate effort. For such applications, travel or angle measurement must be implemented via auxiliary shafts or levers.

Hella has developed end of shaft sensors for all applications that combine the advantages of contactless inductive sensors with simple and flexible attachments. The sensor is suitable for universal use and can be used in both the passenger and engine compartments. There are optimised solutions available for different angle measurement ranges. The sensor is also suitable as a replacement for a potentiometer. Analog or PWM are available.

One special advantage of the end of shaft sensor is the fact that it can be stacked. Thanks to the geometry of the sensor and its housing, two position sensors can be combined with one another. In gear applications for example, it is thus possible to stack one hollow and one solid end of shaft sensor. This will allow two different angle ranges to be measured.

This combination of two sensors used with a solid shaft will provide the possibility for redundancy. If one of the sensors is defective, the higher-order control unit receives two different sensor signals and can thus trigger an emergency routine before the system fails. This significantly increases system safety.

Vehicle level sensor

One application example of the inductive sensor principle at the end of a shaft is the vehicle level sensor. For a whole range of vehicle features, which increase safety and comfort, such as active chassis, level control, and automatic headlamp leveling, it is necessary to record the tilting angle of the vehicle. Thanks to its robust contactless measuring principle Hella’s vehicle level sensor provides all advantages mentioned above.

The ASIC used here and in other applications makes an end-of-line test of mechanical and electrical tolerances possible as well as adjustment of the sensor zero position.