Ansprechpartner für Presse:
Sabine Peiler
Tel. 0711/4489-186
peiler@novotechnik.de

novotechnik
Siedle Gruppe

Novotechnik
Messwertaufnehmer OHG

Postfach 4220
73745 Ostfildern (Ruit)
Horbstraße 12
73760 Ostfildern (Ruit)
Telefon +49 711 4489-0

Advancing New Technologies:

Position and Angle Measuring Technology for the Automotive Industry

Summary:

The automotive industry is looking to achieve a high level of traffic safety, economy, driving convenience and freedom of design from the new technologies that will have impact on motor vehicles of the future. Typical examples include steer-by-wire or e-gas systems, which completely eliminate a mechanical backup system. This results in the most demanding requirements with regard to reliability, availability, ease of maintenance and safety. The sensor technology used must also fulfil these high demands. For position and angular measurement, the market trend is leaning towards the use of contactless sensor priciples. With the INDRES principle, Novotechnik has succeeded in developing inductive-resistive sensors, which combine the advantages of the conductive plastic potentiometer, which has been well proven in the automotive sector, with a contactless mode of operation and high dynamics. The sensors currently operate with resolutions of over 14 bits with linearity values of better than 0.1 %. Even without compensation, temperature and humidity coefficients of less than 30ppm/K or 1 ppm/% relative humidity are achieved. The sensor shape and redundancy level can be adapted to many applications. Rotary and linear sensors are realisable. Examples of applications using this principle include the detection of the steering and wheel angle in steer-by-wire systems and the detection of the throttle pedal and throttle valve position in electronic gas systems.

Todays automotive industry expects a high level of traffic safety, economy, driving convenience and an attractive design from modern cars. In the last 20 years modern electronics have made a major contribution to fulfilling these requirements. Some examples would be, electronic braking aids (ABS), stability control systems (DSC), which have achieved a permanent place in automotive technology. The trend, however, is moving away from these electromechanical solutions. Sensing systems of the future will be characterised without mechanical backup systems. Typical examples include steer-by-wire or e-gas systems. These systems are a major technical challenge for the future of the automotive industry, and therefore for the *manufacturers of all components used in them. As a result, the most demanding requirements with regard to reliability, availability, ease of maintenance and safety must be met.*

The traditional potentiometer comprised of conductive plastic material, has achieved a permanent place in automotive technology as position transducers and angle sensors. With its still unbeatable price-performance ratio, the potentiometer had been the ideal sensor solution. However, with the increased requirements of the automotive technology of the future, the principle-dependent wearing of the potentiometer technology is for the first time, showing some negative characteristics. As a result contactless processes, which meet higher requirements for service life, are in demand.

To avoid the principle-dependent disadvantages of traditional potentiometers without having to go without their advantages, Novotechnik has developed a contactless sensor principle based on an inductive-resistive principle that makes it ideal for use in automotive technologies that have demanding dynamics requirements. The “INDRES” sensor signals produced are analogue and therefore require no computing time which results in a position lag that is considerably smaller. Both rotary and linear sensors can be developed using this sensor principle.

INDRES: Position and angular measurement according to the inductive-resistive principle

The fundamentals of the contactless, and virtually wear-free operation of the INDRES sensors, is simple: A primary and a secondary coil are mounted on a carrier material and both are surrounded by a moving ferrite with a maintained air gap. Faraday's law states that a voltage is induced in the secondary winding if an alternating voltage is connected to the primary coil. As the field flow concentrates in the air gap of the ferrite yoke, this potential signal front follows the yoke of the ferrite during movement. A resistance layer in the secondary coil, in this case, the measuring element, now detects this change in location. As a result, the output voltage changes with the position of the ferrite core and evaluation electronics generates an analogue or digital signal from this.

The resolution is theoretically infinite, and typical values currently in the range of over 14 bits for linearity values of better than 0.1%. In contrast to potentiometers that are subject to wear, the linearity in this sensor principle is retained over the entire life of the sensor. Figure 3 shows a schematic of the signal processing structure. This figure indicates that this is a ratiometric principle which compensates for fluctuations in the input voltage with signal processing.

Like a potentiometer, the INDRES sensor operates as a voltage divider. As a result, with less than 30ppm/K or 1 ppm/% relative humidity, the temperature and humidity coefficients are very small compared to other magnetic systems (e.g. magnetostrictive or Hall probes). This fact is especially interesting for automotive applications. There are hardly any restrictions with regard to the design or the geometric arrangement in these applications and the measuring element can be attached to the carrier material individually in any custom designs. The sensor geometry follows the application, and not vice versa. A typical application for the INDRES sensors is steer-by-wire systems.

Steer-by-wire: Separation of steering wheel and wheel-angle adjustment unit

In this kind of "all-electronic" system, the steering is no longer mechanically connected via the steering column, but instead electrically with the tie rod or the wheel-angle adjustment unit. The driver's request is picked up with the steering angle sensor and passed on to the control unit. This specifies the signal for the actuator, which converts the request to a steering action in accordance with the respective driving condition. In practice, a wide range of advantages are seen compared to the traditional mechanical method, due to the elimination of the steering shaft. These advantages include a reduction in space and weight, more design freedom and, last but not least, also safety advantages, such as forced feedback to limit influences of the driver in extreme conditions.

Demanding requirements for sensor technology

At least two position and angular measuring systems are required for a steer-by-wire system, i.e. one sensor for detecting the steering angle and one that detects the actual value of the wheel position. For the steering angle sensor, a rotary system that operates over a full 360° is necessary. Depending on the actuator used, the wheel position can be detected with either a rotary or a linear position sensor. The sensors must operate with a resolution of 12 to 14 bits, and the required accuracy is in the range of 0.5°. These are values that the INDRES sensors can easily achieve.

Safety requires redundancy

To ensure the greatest possible fault tolerance, the systems used in this kind of steer-by-wire system must be redundant so as to not result in a steering failure. One way to achieve this goal is with the redundancy of the components, i.e. including the position and angle sensors. That is why two identical sensors are used for the steering angle detection and for the detection of the wheel position. They are installed in the same installation space and have the same measuring task. This means both the steering angle and wheel positions are detected with one redundant measuring system each consisting of two sensors. If one of the sensors fails, the full reliability is retained by the other, and at the same time a fault message is generated.

In addition, each individual INDRES sensor can also be designed with different levels of redundancy depending on the requirements of the application: Fully redundant solutions with two mechanically coupled ferrites, two inductively decoupled primary and two separate secondary circuits are required, for example in brake systems. However, this kind of high and comparatively complex safety reserve is unnecessary for many other applications. Primarily redundant solutions without a double ferrite, but with a double primary circuit or secondarily redundant solutions in which only the secondary circuit has a double design then offer a better cost-benefit ratio. In addition to the analogue output signal, the sensor also supplies a pulse width modulated output signal so that transmission errors are reliably detected in systems with transmission redundancy.

Electronic throttle pedal and throttle valve control

Another example of use for the INDRES sensors is in electronic gas systems. Here again there is no need for mechanical links. The throttle pedal module determines the current throttle pedal position with its sensors and transmits a corresponding signal to the engine control unit, which converts the driver's request to an engine torque. It actuates the throttle valve drive to open the throttle valve wider or to close it more. With this kind of actuation, other engine torque requirements can also be taken into account, including torque limitation. The position of the throttle valve is determined by a rotary sensor and reported back to the engine control unit.

Here again, the system requires two sensors: one for detecting the throttle pedal position and one sensor for the throttle valve position. For the same reasons as described in the steer-by-wire system, redundant sensors are also used here. Potentiometers are still frequently used today for this purpose. Here the quantities are manufactured in the millions. In the future, the contactless INDRES sensors will also replace potentiometer technology for this application.