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From Single-Turn to Multiturn:

Non-Contact Rotary Sensor Technology Moving into High-Volume Applications

Operating principles used frequently in today's non-contact angle detection include magnetic systems. They operate non-contacting, i.e. without mechanical wear and provide absolute measurement values. Non-contacting magnetic principles are reliable even under harsh environmental conditions and, due to their low cost compared to other measurement principles, are an excellent choice for high-volume applications. The typical markets include countless applications in mechanical and process plant engineering, but also mobile applications, e.g. in vehicle engineering or on naval vessels and pleasure boats. Thanks to their form fit compatibility, they can often replace conventional potentiometer technology, which tends to be susceptible to wear in high vibration environments.

The necessity for measuring angles has long played a major part in technology.

Angle measurement has long played a major part in technology. A basic distinction can be made between the measurement of up to a full rotation or multiple rotations. Basically, one can distinguish between the single-turn sensors with measurements of up to a full rotation and multi-turn sensor with the ability to detect multiple rotations. In both cases non-contacting principles provide potential users with excellent pricing.

Magnetic angle sensors for 360°

There are various methods for mechanical angular measurement, however the basic design initially appears to be almost identical. A magnet is attached to a rotating axis. The different shape of the field lines dependent on the angle of rotation is detected by a sensor element. The selection of

this sensor element is decisive for the detection range of the angle sensor. With the optimization of Hall sensor elements (see text in box 1) and evaluation electronics matched to them, Novotechnik has succeeded in developing extremely rugged, reliable and high-precision sensors in this area.

A magnet is also attached to the rotating axis with the NOVO Hall sensors. Depending on the angle of rotation the orientation of the magnetic field and the signal voltage of the sensor element changes. The element consists of two Hall elements arranged vertically to each other. This enable a clear assignment of each angular position over a full rotation. The respective voltage change is converted into an analogue signal proportional to the angle of rotation within the sensor IC. The sensors operate internally with a resolution of 14 bits and an independent linearity of typically ± 0.3 %. They are insensitive to contamination or moisture (IP54 or IP65) and are designed so that play-free connection is easily possible. Oblong holes on the housing simplify adjustment.

There are suitable versions for both industrial and mobile applications. The RFC 4800, for example, complies with all EMC specifications required for mobile applications, meets the requirements for ingression protection up to IP69 and, with various mechanisms and plug modules, can easily be integrated in various applications. Different interfaces are also available for the miniature version RFC 4000. With an overall height of 7 mm, this sensor is extremely flat and can easily be integrated even under tight installation conditions.

New-generation contactless rotation counters

Many applications require angle measurements beyond a full rotation. Depending on the application, today’s common multi-turn sensors have functional limitations. For example, the typical low-cost 10-turn potentiometers frequently do not meet the requirements for resolution and reliability. Some optical encoder solutions are too expensive for many applications. A new

patented rotation counter principle based on Giant Magnetoresistance solves the problem (see text in box 2).

The new sensor system supplies absolute position values and is well-suited, for example, for use in true-power-on systems, as it requires no reference signals of any kind. The maintenance-free and cost efficient design opens up new possibilities in the automotive sector, for example in electronic steering systems. The ability to magnetically detect up to 16 rotations is also of interest for industrial applications.

The design principle of the magnetic rotation counter is easy to understand and is described in detail in the technical article "Rotation counter uses GMR effect" on Page $$. In addition to the angle of rotation signal, the magnetic multiturn sensor can also count and permanently store up to 16 rotations in the powerless state without a buffer battery and without a gear unit. Concepts for higher rotation counts (up to 12 bits, which is equivalent to 4,096 rotations) are already available and will be realized in the next two to three years. The advantages of the new multiturn technology can already be used in a large number of industrial and automotive applications today.

The multi turn technology was implemented first in the RSM2800 series, which uses the extremely compact 28mm diameter design of the familiar RSC 2800 single-turn potentiometer.

The angular range of the series can be selected by the customer, covers between 2 and 16 rotations and maps the measured angle as a constant, analogue characteristic curve. Various supply voltage and output voltage ranges are being currently realized.

Text in box 1

The Hall effect for single-turns

The Hall effect was discovered in 1879 by the physicist Edwin Hall. A magnetic field arranged vertically to a conductor with current flowing through the conductor deflects the current. Electric motors, for example, operate according to this principle. Within the conductor, there is an analogous feature. The current lines are displaced to one side. The displacement effect results in a displacement voltage laterally to the current flow. This effect is especially pronounced in the Hall Generators. However, as the signal change in the sensor elements based on the Hall effect which function according to this principle is not linear to the angle of rotation, only restricted detection of angles was possible in the past. By optimising the sensor elements and the evaluation electronics, sensors are available on the market today which are suitable for detecting measurement angles of up to a full 360°.

Text in box 2

The GMR effect for multiturns

The GMR (Giant Magnetoresistance) effect is a phenomenon in quantum mechanics that is observed in thin film structures of ferromagnetic and non-ferromagnetic layers. In a heterogeneous structure consisting of two magnetic layers (sensor layer and reference layer), which are separated by a non-magnetic only a few atom layers thick, the magnetic torques of the two layers take up a position relative to each other as soon as they are subjected to an external magnetic field. The reference layer orientation is held in place by an artificial antiferromagnet (AAF). As a result, the sensor layer aligns either parallel or anti-parallel to it. The electrical resistance changes dramatically when the magnetic torques fold over in this "sandwich". The resistance drops to a minimal value, when they are positioned parallel to each other, with an anti-parallel alignment it reaches its maximum. The magnetization state of this kind of structure can easily be determined with a resistive measurement.