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Magnetoresistive Sensors

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All magnetic sensors convert a magnetic signal into an electrical signal. For example the sensor can detect the angle of an applied magnetic field and delivers an analog or digital output which corresponds to the field angle. This general property is used to detect and control linear or rotational movements of magnets. Typically the magnet is mounted on a body which moves, e.g. a shaft or a valve or a bearing. Measuring the magnetic field immediately tells the movement of the body which holds the magnet. Based on this straight forward principle, the wheelspeed sensor [1] in vehicles is realized or many other linear or rotational sensors.

The two main magnetic sensor technologies are magnetoresistive sensors and Hall sensors [2,3]. The volume production of magnetic sensors is dominated by Hall sensors, because they offer the sensing element and the conditioning circuit in a monolithically integrated chip. Hall sensors are mainly used in consumer electronics such as compass application and for diverse automotive applications. Magnetoresistive sensors dominate the field of high precision measurements. They are also more temperature stable and can be used at higher temperatures, too. In this paper, only magnetoresistive sensors are discussed.

All magnetoresistive sensors are based on materials which change their electrical resistance depending on the strength and/or the angle of an external magnetic field. Because the resistance changes strongly with temperature, too, wheatstone bridge designs are required with four magnetoresistive elements. Here each of the four elements follow the same temperature dependence such the temperature dependence of the bridge voltage is zeroed. By proper design the bridge voltage only reflects the response to the external magnetic field.

Today, three different technologies are used in MR-based sensors. This is the anisotrope magnetoresistive effect or AMR effect, the giant magnetoresistive effect of GMR effect, and the tunneling magnetoresistive effect or TMR effect [4]. In the talk these basic MR effects are introduced and discussed. For deeper understanding angle sensors and linear motion sensors are discussed for AMR and TMR. The relevance of key parameters like bridge offset, amplitude and phase will be explained. Special focus will be given on robustness and stress tests of sensors. Also quality control in mass production of spintronic devices will be discussed. Finally some highly fascinating applications can be shown.

[1] http://www.ntn-snr.com/autoaftermarket/fr/en-en/index.cfm?page=/autoaftermarket/home/produits/roue/technologie_asb

[2] http://www.sensitec.de/english/

[3] http://www.infineon.com/cms/de/product/sensor-ics/magnetic-sensors/channel.html?channel=ff80808112ab681d0112ab68f47200a6

[4] http://en.wikipedia.org/wiki/Magnetoresistance