# 360-DEGREE ROTARY POSITION SENSOR HAVING A MAGNETORESISTIVE SENSOR AND A HALL SENSOR

## FIELD

The present invention relates generally to position sensors, and more particularly, relates to a 360-degree rotary position sensor.

## BACKGROUND

Magnetic sensing devices have many applications, including navigation, position sensing, current sensing, vehicle detection, and rotational displacement. There are many types of magnetic sensors, but essentially they all provide at least one output signal that represents the magnetic field sensed by the device. The Earth, magnets, and electrical currents can all generate magnetic fields. The sensor may be able to detect the presence, the strength, and/or the direction of the magnetic field. The strength of the magnetic field may be represented by a magnitude and a polarity (positive or negative). The direction of the magnetic field may be described by its angular position with respect to the sensor. One of the benefits of using magnetic sensors is that the output of the sensor is generated without the use of contacts. This is a benefit because over time contacts can degrade and cause system failures.

A Hall sensor is a type of magnetic sensor that uses the Hall effect to detect a magnetic field. The Hall effect occurs when a current-carrying conductor is placed into a magnetic field. A voltage is generated perpendicular to both the current and the field. The voltage is proportional to the strength of the magnetic field to which it is exposed. The current-carrying conductor is called a Hall element and it is typically composed of a semiconductor material. While Hall sensors are very reliable and have many useful applications, they are not as sensitive as magnetoresistive (MR) sensors. Hall sensors may also be more limited to the type of magnet used than an MR sensor.

MR sensors are a type of magnetic sensor that uses the magnetoresistive effect to detect a magnetic field. Ferromagnetic metals, such as the nickel-iron alloy commonly known as Permalloy, alter their resistivity in the presence of a magnetic field. When a current is passed through a thin ferromagnetic film in the presence of a magnetic field, the voltage will change. This change in voltage represents the strength or direction of the magnetic field. By designing an MR sensor in a Wheatstone bridge configuration, either the strength or direction of the magnetic field can be measured. MR sensors provide a high-sensitivity and high-accurate output.

Position sensors that are capable of sensing 360-degrees of rotation would be desirable for many rotary applications, such as for control of an automobile steering wheel. Typical position sensors that can sense 360-degrees of rotation contain potentiometers, which require contacts. As previously mentioned, contacts can degrade over time causing reliability issues.

Hall sensors or Giant Magneto-Resistive (GMR) sensors have also been used as 360-degree position sensors. While these sensors provide a contactless solution, they do not provide enough accuracy for many applications. In addition, these sensors cannot function in applications that require large tolerances for either the strength of the magnet or the distance between the magnet and the sensor.

Optical sensors have also been used as a contactless 360-degree rotary sensor; however, optical sensors are incremental sensors and must be calibrated every time they are powered, which limits their applicability.



Therefore, it would be desirable to have a 360-degree rotary position sensor that is highly accurate, can be used with simple magnet designs, and operates without contacts.

## SUMMARY

A 360-degree rotary position sensor is comprised of a Hall sensor and a magnetoresistive (MR) sensor. Either a magnet or the 360-degree rotary position sensor is mounted on a rotating shaft. The 360-degree rotary position sensor is located substantially close to the magnet, so that the 360-degree rotary position sensor is capable of detecting a magnetic field produced by the magnet. The Hall sensor detects a polarity of the magnetic field. The MR sensor detects an angular position of the magnetic field up to 180-degrees. A combination of an output from the Hall sensor and an output from the MR sensor provides sensing of the angular position of the magnetic field up to 360-degrees.

## BRIEF DESCRIPTION OF THE DRAWINGS

Presently preferred embodiments are described below in conjunction with the appended drawing figures, wherein like reference numerals refer to like elements in the various figures, and wherein:

FIG. **1** is an illustration of an exemplary embodiment of a 360-degree rotary position sensor;

FIG. **2** is a simplified block diagram of a 360-degree rotary position sensor, according to an exemplary embodiment;

FIG. **3** is a graphical representation of an output of an MR sensor, according to an exemplary embodiment; and

FIG. **4** is a graphical representation of an output of a Hall sensor, according to an exemplary embodiment.

## DETAILED DESCRIPTION

FIG. **1** shows an exemplary embodiment of a 360-degree rotary position sensor **100**. FIG. **1** is not drawn to scale and is an approximation of the position sensor **100**. The position sensor **100** includes a Hall sensor **102** and a magnetoresistive (MR) sensor **104**. The position sensor **100** may be located substantially close to a magnet **106**, such that the position sensor **100** may be capable of detecting a magnetic field produced by the magnet **106**. The magnet **106** may be substantially located on an end of a rotating shaft **108**. The rotating shaft **108** may be any object that rotates. For example, the rotating shaft **108** may be an automobile steering wheel column.

In an exemplary embodiment, the Hall sensor **102** may be a SS495 sensor from Honeywell; however, other Hall sensors that are capable of detecting a polarity of the magnetic field may be used. The Hall sensor **102** may include at least one Hall element, which may be composed of a semiconductor material. When the Hall sensor **102** detects the magnetic field produced by the magnet **106**, the current distribution in the at least one Hall element is disturbed, which results in a voltage change that is proportional to the magnetic field. The magnetic field may be either positive or negative. This quality may be described as the polarity of the magnetic field. An output of the Hall sensor **102** may include the polarity of the magnetic field.

In an exemplary embodiment, the MR sensor **104** may be an HMC1512 sensor from Honeywell; however, other MR sensors that are capable of detecting an angular position of