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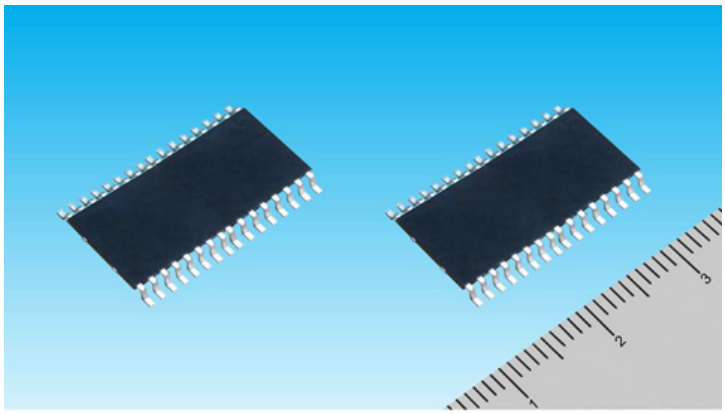
Panasonic Develops a Vehicular High-precision Angle Sensor



High-precision Angle Sensor "A³MR" (Developed product)

(March 2017, Panasonic)

Panasonic's new vehicular high-precision angle sensor is small and light and is capable of detecting rotation angles with high precision. It allows accurate reading of the movements of vehicular motors, giving precise control.

Osaka, Japan - Panasonic Corporation announced today that it has developed an angle sensor called "A³MR" [1] that precisely detects the rotation angle of vehicular motors. This is a small and highly accurate sensor with built-in AMR thin films [2] and Hall elements [3]. The AMR thin films respond to a wide range of strong magnetic fields and the Hall elements are able to detect angles of up to 360˚. The sensor meets the requirements of ISO 26262 (functional safety requirements) [4] for sensors incorporated into vehicles.

This newly-developed sensor reads the angle of rotation (rotational angle) of the rotor in the motor to a high degree of precision. This enables accurate detection of the motor's movement, allowing efficient control of the motor's rotational speed and driving amount to achieve more efficient control. The sensor is small and light and is capable of precise detection even in irregular magnetic fields. This characteristic allows side shaft detection [5], which greatly increases the options for sensor attachment. In an Advanced Driver Assistance System (ADAS) [6], for example, the rotation of the power steering or operation of the gearshift exerts control over the behavior of the vehicle through changes in the rotational angle of the motor. Controlling the motor in such a highly precise manner causes the vehicle to travel with precision and puts the driving motor included in an ISG hybrid system [7] under close control. This prevents the motor from running erratically, thus achieving lower fuel consumption by improving its efficiency.

Panasonic's new sensor has the following features:

1. It is small and light and is capable of precisely detecting angles of up to 360˚ (angle detection precision < ± 0.1˚ at 25˚C).
2. High degree of freedom in positioning the sensor facilitates design (allows side shaft detection).
3. Responds to a wide range of high magnetic field strengths (20 mT to 200 mT) and has high resistance to noise.

This sensor has been developed by making use of the following element techniques:

1. A technique for forming AMR thin films that detect the direction of a magnetic field, even if irregular, with high precision.
2. A technique for constructing a control circuit that allows precise detection of angles of up to 360˚.

A resolver [8], which is the type of rotation angle sensor currently in widest use, is capable of highly precise detection. It is, however, large and heavy and therefore poses a problem in that redundant design [9], which is required by ISO 26262, is difficult to achieve. Magnetic sensors like GMRs [10] are also in use today. They are relatively compact, but are inferior to the resolver in precision of angle detection. GMRs have another drawback in that they lose their angle detection precision in environments influenced by strong magnetic fields. This has led to market demand for a small and high-precision sensor to replace resolvers and which can be used in a wide range of magnetic field strengths.

Suitable applications:

Detecting the rotating angle of a vehicular motor (for power steering, ISG hybrid systems, shift-by-wire transmissions [11], etc.)

Sample availability:

Samples are scheduled to be shipped out in May 2017. Receipt of product orders will be started in September 2019.

[Product Features]

1. It is small and light and is capable of precisely detecting angles of up to 360˚ (angle detection precision < ± 0.1˚ at 25˚C).

The resolver type, which is capable of high-precision detection, uses bulky coils, posing a problem in that it is large and heavy. AMR thin films can detect the direction of a magnetic field precisely but cannot determine its polarity (positive or negative direction). It therefore detects rotation angles of up to 180˚, which is why AMR thin film is not adopted in vehicular motors that require detection of angles of up to 360˚. We have now developed a new control circuit by combining AMR thin films with Hall elements, which are capable of determining polarity. We have thus created a sensor that is small and light (1/2 or less in weight of the resolver type) and which detects rotation angles of up to 360˚ with high precision, paving the way for the use of this type of sensor in vehicular motors.

2. High degree of freedom in positioning the sensor facilitates design work (allows side shaft detection).

A magnetic sensor works most effectively in a uniform magnetic field. The sensor, therefore, must be positioned in the small area on the rotating shaft of the motor where the magnetic field is stable. This configuration is, however, not easy because of numerous restrictions created by the design specifications of the motor shaft. The AMR thin film in the developed sensor can detect the direction of a magnetic field precisely, even if its strength is high, eliminating the need to locate the sensor on the motor's rotating shaft. This allows high-precision angle detection at a distance from the motor shaft, where the magnetic field is not uniform, thus increasing the options for system design.

3. It responds to a wide range of strong magnetic fields (20 mT to 200 mT) and has high resistance to noise.

All electric motors generate magnetic fields. A motor sensor needs to work in a strong magnetic field. Conventional sensors, however, tend not to function reliably in strong magnetic fields exceeding 100 mT. The developed sensor maintains its high-precision detection capability in strong magnetic fields of up to 200 mT, and offers superior noise resistance.

[Panasonic Technology]

1. A technique for forming an AMR thin film that detects the direction of a magnetic field, even if it is an irregular one, with high precision

It is essential for precise detection of a rotation angle to form a magnetic thin film on which magnetic domains [12] are aligned with the magnetic field generated by the rotating motor. We have developed an AMR thin film whose magnetic domains are readily aligned, through processing and thin-film deposition techniques originally developed by our company. The AMR thin film prevents its magnetic domains from becoming scrambled, enabling very precise detection of the direction of the magnetic field.

2. A technique for constructing a control circuit that allows precise detection of angles of 0 - 360˚

The developed sensor includes a control circuit original to our company, which is composed of the AMR element capable of precisely detecting angles of up to 180˚ plus Hall elements capable of determining polarity, and is therefore able to detect rotation angles of up to 360˚. Making good use of the knowledge accumulated during the AMR element development process, we have also achieved a self-diagnostic function, which identifies any state in which the AMR element is likely to fail and immediately warns the electronic control unit of signs of failure. The product has been developed in conformity to ISO 26262 and is compatible with systems that have a hazard category of ASIL-D [13].

[Basic Specifications]

Item	Details
Angle detection precision	< ± 0.5˚ over the whole temperature range
	< ± 0.1˚ at 25˚C after calibration
Detected magnetic field area	> 20 mT
Applied voltage	4.0 - 5.5 V
Current consumption	< 15 mA
Output interface	SPI,SENT

[Term Descriptions]

[1] The angle sensor "A³MR"
This is a sensor that detects the rotational angle of a vehicular motor. It reads the change in magnetic resistance caused by a change in the magnetic field generated by the rotating motor shaft, and uses this information to measure the rotational angle. A³MR (A-Cube-MR) is the name of the sensor we have developed. A³ or the cube of A signifies "Anisotropic (AMR element)," "Absolute (absolute angle measurement)," and "Accurate (accurate detection)."
[2] AMR thin film
This is an element used in the magnetic sensor. AMR stands for anisotropic magneto resistance.
[3] Hall element
This is an element used in the magnetic sensor. A Hall element is a magnetic sensor that employs the Hall effect, in which a magnetic field perpendicular to the direction of an electric current generates an electromotive force that is perpendicular to both the electric current and the magnetic field.
[4] ISO 26262 (functional safety requirements)
ISO 26262 is the international standard for the functional safety of electric/electronic equipment in automobiles. These standards define the requirements that must be met to ensure the safety of a system if any of its functions or components fails.
[5] Side shaft detection
Side shaft detection refers to a method of positioning a magnetic sensor, in which it is installed not on the end of the rotating shaft of the motor, but on its periphery.

[6] Advanced Driver Assistance System (ADAS)
ADAS stands for advanced driver assistance system - a system that detects the risk of an accident in advance so as to avert it.
[7] ISG hybrid system
This is a hybrid system featuring a motor that combines both starter and generator functions. ISG hybrid system stands for integrated starter generator hybrid system.
[8] Resolver
A resolver type angle detector is constructed by attaching several coils to the rotating shaft of the motor. It detects the angle of rotation using electromagnetic induction.
[9] Redundant design
This is a specific design method by which auxiliary functions are provided as backups to compensate for failing elements so as to keep the regular functions working. Placing a large component to serve an auxiliary function in a limited space is problematic. For this reason, redundant design using an ordinary resolver type is regarded as challenging.
[10] GMR
GMR stands for giant magnetoresistance - an element used in a magnetic sensor.
[11] Shift-by-wire
Shift-by-wire refers to a transmission control system that controls gear shifting not by mechanical means, such as a shaft, but by electric signals.
[12] Magnetic domain
A magnetic domain is an area where vectors representing the magnetic strength of a magnet (size of magnetic force) and the direction of the magnetic strength are all facing in the same direction.
[13] ASIL-D
ISO 26262 defines four hazard levels ranging from "A" to "D" according to ASIL (Automotive Safety Integrity Level) classification, based on an analysis of risks posed by a defective system. ASIL-D requires the highest level of safety measures.

About Panasonic

Panasonic Corporation is a worldwide leader in the development of diverse electronics technologies and solutions for customers in the consumer electronics, housing, automotive, enterprise solutions and device industries. Since its founding in 1918, the company has expanded globally and now operates 474 subsidiaries and 94 associated companies worldwide, recording consolidated net sales of 7.553 trillion yen for the year ended March 31, 2016. Committed to pursuing new value through innovation across divisional lines, the company uses its technologies to create a better life and a better world for its customers. To learn more about Panasonic:
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