Magnetic Sensor
Incremental Encode Output Type
HGPRDT007A
Design Guide

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Incremental Encode Output type Magnetic Sensor HGPRDT007A

Alps Alpine high-precision magnetic sensors use Giant Magneto Resistive effect (GMR) for horizontal magnetic fields detection. Utilizing the GMR element for its high output and exceptional resistance to high temperatures and magnetic fields, our sensors achieve high output level and sensitivity compared to other GMR sensors; approximately 100 times higher than Hall element and 10 times higher than AMR element based on our research. We offer various magnetic sensors for dedicated usage such as non-contact switch applications, linear position detection and angle detection as well as rotational speed and direction sensing in response to external magnetic fields.

This document provides essential information for understanding and implementing Incremental Encode Output Type Magnetic Sensor (herein after magnetic encoder) in your design.

1. Overview

The magnetic encoder detects the rotation speed and direction of rotation of a magnet by combining a GMR magnetic sensor and an ASIC. The product can output a 2-phase signal with a phase difference of 90° by including elements that detects the 0° direction and 90° direction in a horizontal plane.

Features

- It is suitable for magnets with any magnetization pitch. Regardless of the magnetization distance, two phase signals with a phase difference of 90° are always output.
- Due to high magnetic sensitivity and small variation, the gap between the magnet and the sensor can be widens.
- Low power consumption. 2-phase signals can be used with a low current (only 1.6mA in total).
- Wide operating temperature (-40～+140°C) and voltage range (3～30V).

Principle

The magnetic encoder uses an open-collector circuit. As shown in Fig.1, the output signal of OUT1 is ON (output low) when the magnetic flux density from Pin3 to Pin1 is 0.8 mT (typ.) and the output signal of OUT1 is OFF (output high level) when its magnetic flux density is -0.8mT (typ.). The output signal of OUT2 is ON (output low level) when the magnetic flux density from Pin1 to Pin5 is 0.8mT (typ.) and the OUT2 output signal is OFF (output high) when the flux density is -0.8mT (typ.). Table1 shows magnetic flux density in operation.

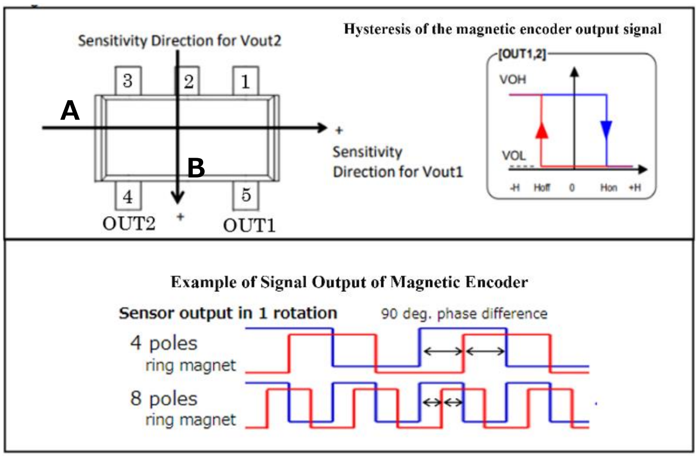


Fig.1 Sensitivity direction and output signal of magnetic encoder

Encoder output based on rotational direction of magnet

Fig.2 shows rotational direction of magnet and output signal of magnetic encoder. Both vertical and horizontal layout can be possible as Fig.3.

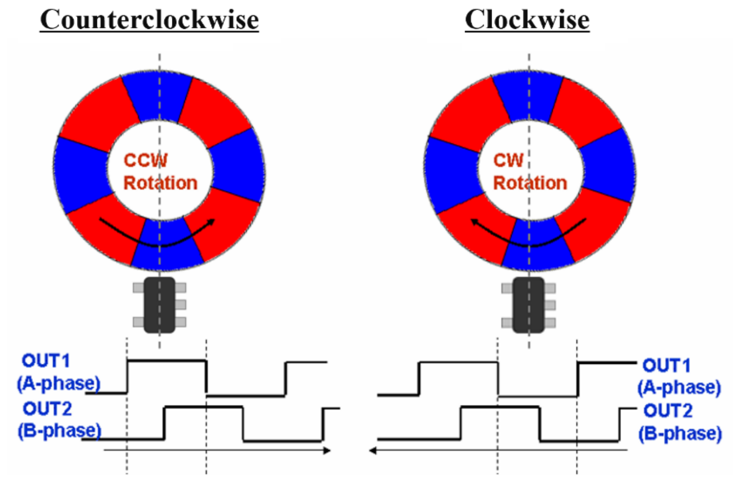


Fig.2 Encoder output to rotational direction of magnet

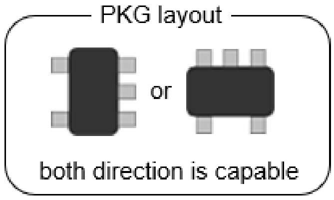


Fig.3 Package layout

2. Sensor layout

Fig.4 shows various layouts for magnetic encoder to magnet.

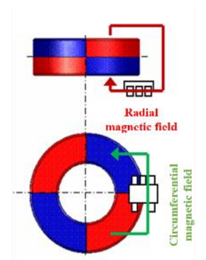
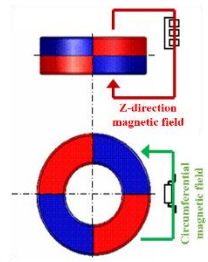
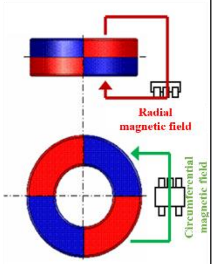
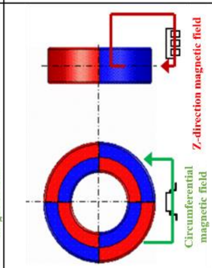
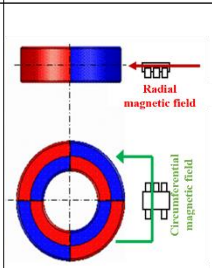
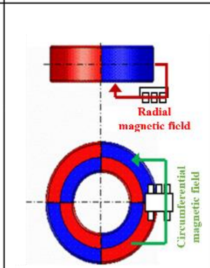
4-pole axial magnet(Chamfer magnetism)			4-pole radial magnet(Diameter magnetization)		
Layout Example(1)	Layout Example(2)	Layout Example(3)	Layout Example(4)	Layout Example(5)	Layout Example(6)
 Periphery	 Orthogonal	 Outer side	 Orthogonal	 Outer side	 Periphery

Fig.4 Magnetic encoder layout

3. Design example

Following is an example of a design in which the magnetic encoder is placed under the edge of the outer periphery of the magnet. As shown in Fig.5, the radial (A) and circumferential (B) magnetic field components are generated alternately, so that 2-phase detection with a 90-degree phase difference can be possible.

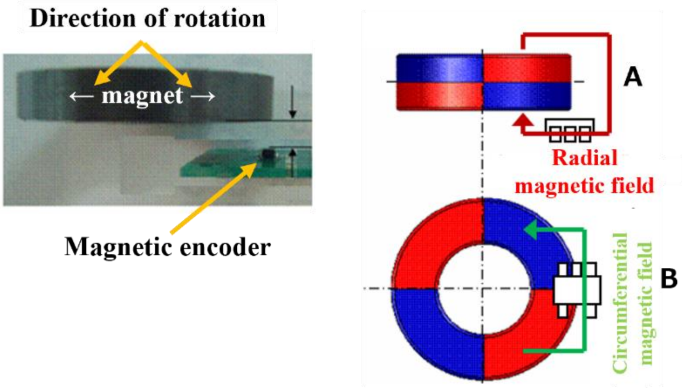


Fig.5 Layout for magnetic encoder to magnet

<u>Target value for magnetic flux density</u>

Following recommendation on the datasheet (Table 1), target magnetic flux density is assumed as 5mT.

Table3-2 Recommended Operating Conditions Parameters

Parameter	Symbol	Values			Unit	Note
		Min.	Typ.	Max.		
Supply Voltage	VDD	3	12	30	V	
Pull-up Voltage	Vpl	3	5	30	V	
Output Current	Isink	-	-	10	mA	
Pull-up Resistance	Rpl	3	3.3	30	kOhm	
Load Capacitance	CL	10	30	1000	pF	
Bypass capacitor	CDD	0.1	–	–	μF	Required
Magnetic Field	Hop	5	–	60	mT	Horizontal field

<u>Example of magnet selection and encoder layout</u>

Type: Ring 4-pole Axial magnet

Size: OD:30mm, ID:12mm, Tickness:5mm

Distance: about 8mm from encoder

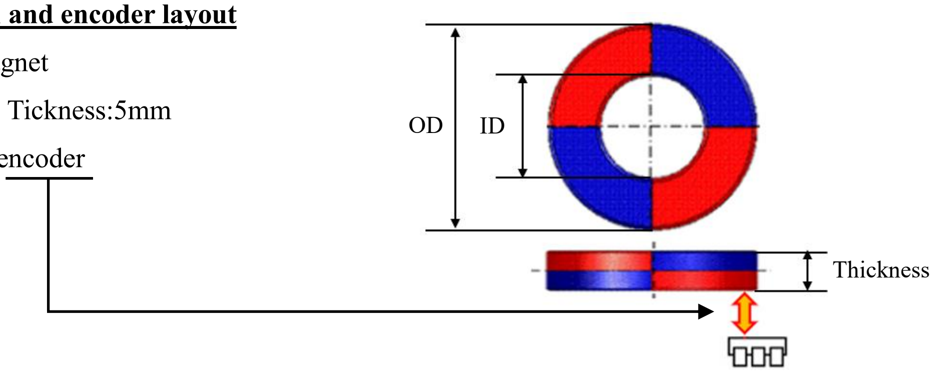


Fig.6 Design example

4. Circuit design

Fig.7 shows reference circuit for magnetic encoder.

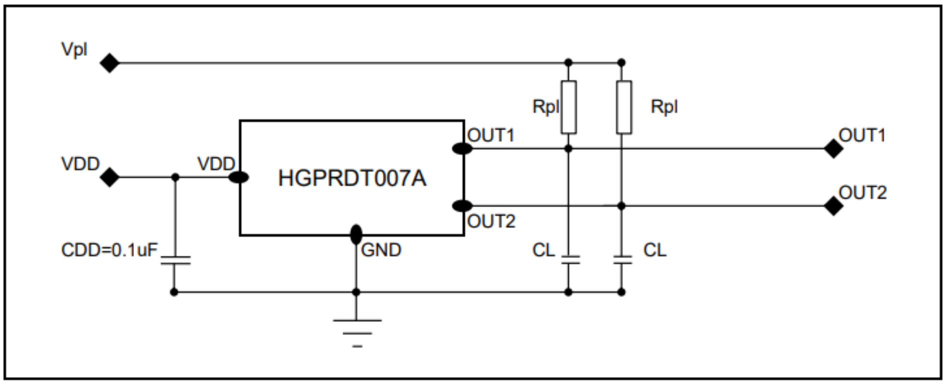


Fig.7 Reference circuit for magnetic encoder

Parameters

Supply voltage	VDD=3.3V
Pull-up voltage	Vpl=3.3V
Pull-up resistor	Rpl=3.3kΩ
Input current (OUT1)	Isink＝Vpl / Rpl < 10mA
Input current (OUT2)	Isink＝Vpl / Rpl < 10mA
Bypass capacitor (VDD)	CDD=0.1uF
Load capacitor (OUT1/2)	CL＝30pF

HGPRDT series accept high voltage. The supply voltage (VDD) and pull-up voltage (Vpl) of the magnetic switches can be up to 30 V. However, the pull-up voltage (Vpl) should be compliant with the maximum input voltage of the MCU. The pull-up resistor (Rpl) should be defined to control the maximum current of Isink up to 10mA. The capacitor CL should be selected to ensure the overall capacity of the circuit (1000pF or less). For detail, refer to the "HGPRDT007A Datasheet”.

5. General precautions

The following are general precautions for using magnetic sensors and magnets.

Selecting the appropriate magnet

Select the type and strength of the magnet in accordance with the specification of the magnetic sensor and the requirements of the application scenario. Excessive strength of the magnet may cause the sensor to malfunction.

Thermal environment

Magnets are sensitive to temperature and the strength of the magnetic field varies with temperature. When the magnetic sensor and magnet are heated, the stability of the magnetic field may be affected. Therefore it is necessary to investigate appropriate thermal countermeasures.

Influence of Magnet Configuration and Surrounding Magnetic Materials

Magnetic sensors are affected by surrounding magnetic materials (e.g. magnets, iron). Check whether the interference of the magnetic field affects the operating performance of the magnetic sensor and take care to adjust the magnet, the surrounding magnetic material and the sensor to the appropriate positional relationship.

Static electricity

Magnetic sensors are semiconductor devices. They can be damaged by static electricity that exceeds the capacity of the specified electrostatic protection circuit. Take adequate measures to protect against static electricity during use.

EMC

Magnetic sensors may be damaged or malfunction due to over-voltage of the power supply in an automobile environment, exposure to radio waves, and so on. Implement protection measures (Zener diodes, capacitors, resistors, inductors, etc.) as necessary.

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Revision history

Date	Version	Change
Apr. 18 2024	1.0	Layout Release (English version)