Using Hall-effect sensors in flow meters

TI Precision Labs – Magnetic sensing

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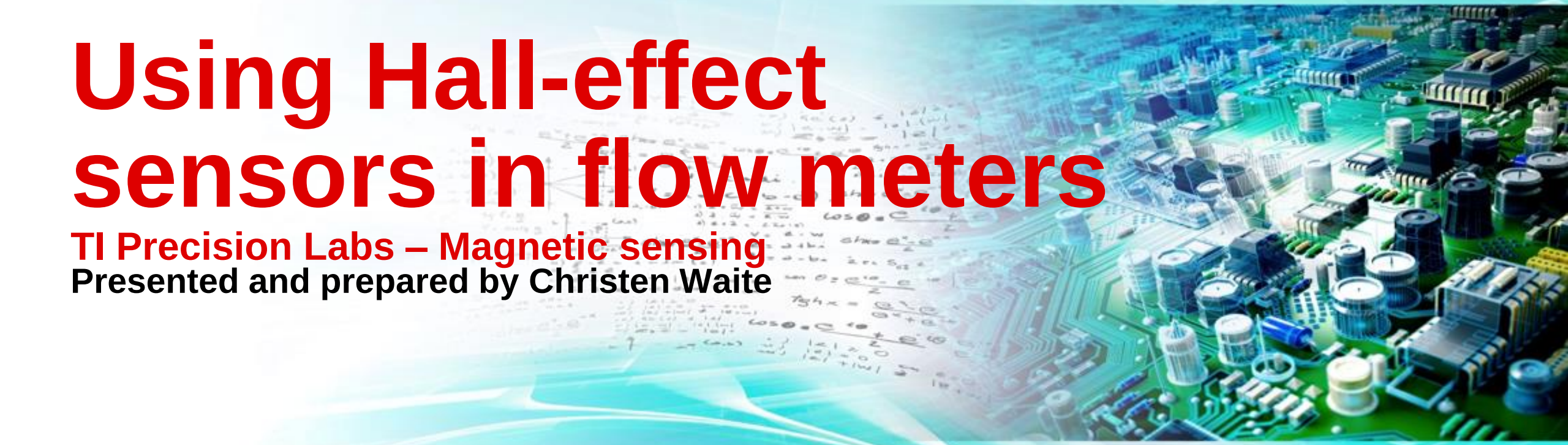
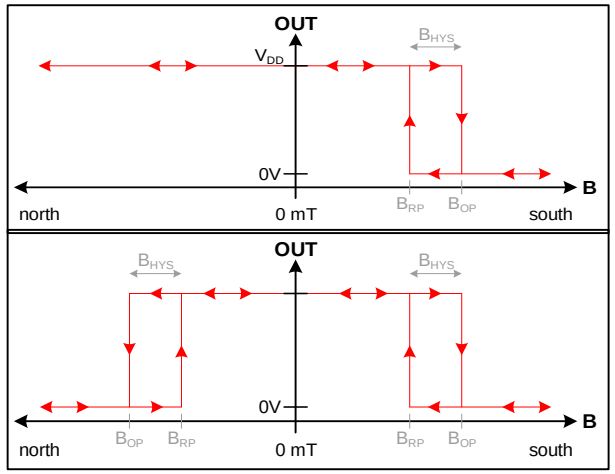


Different types of Hall-effect sensors

Hall-effect switches

Indicates the presence or absence of magnetic flux density compared to a defined threshold.

- Unipolar switch – Responds only to south magnetic poles
- Omnipolar switch – Responds to both south and north magnetic poles

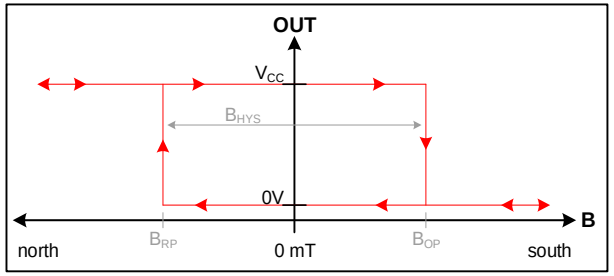


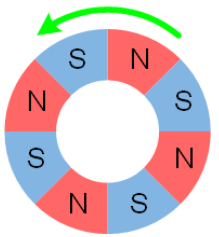
unipolar

omnipolar

Hall-effect latches

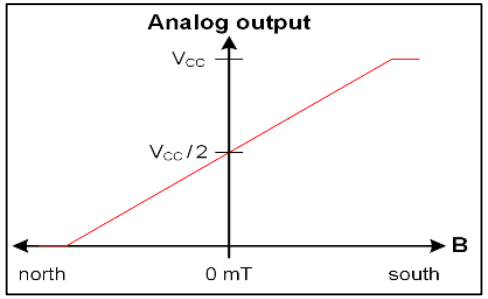
Indicates the most recently measured magnetic flux density. These are used in rotary applications, whether for BLDC motor sensors or incremental encoding.

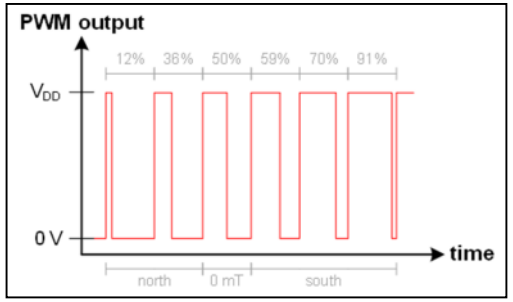




Linear Hall-effect sensor

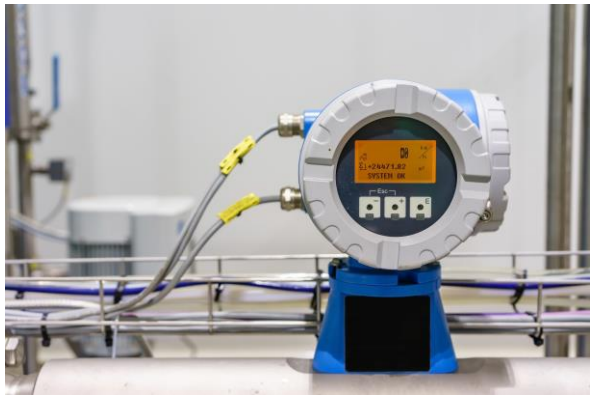
Outputs a signal that's proportional to magnetic flux density to measure precise movement.

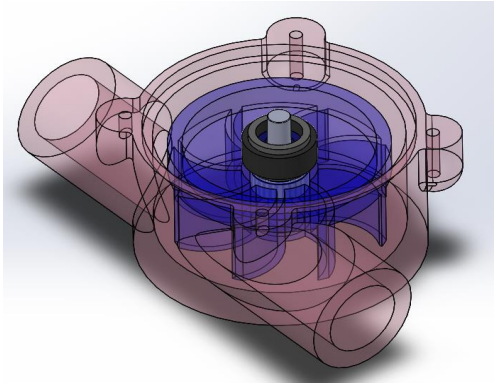


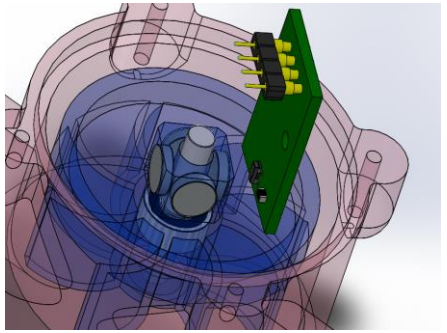


What is a flow meter?

- Flow meters are typically used in gas or water meters to measure the rate of consumption of these resources.
- Mechanical flow meters monitor the rotational speed of an impeller to calculate the rate of fluid or gas movement.
- A ring magnet or multiple dipole magnets are attached to the shaft of the impeller and are not exposed to the liquid or gas.
- Hall-effect sensors or reed switches are typically used to sense the change in the magnetic field.

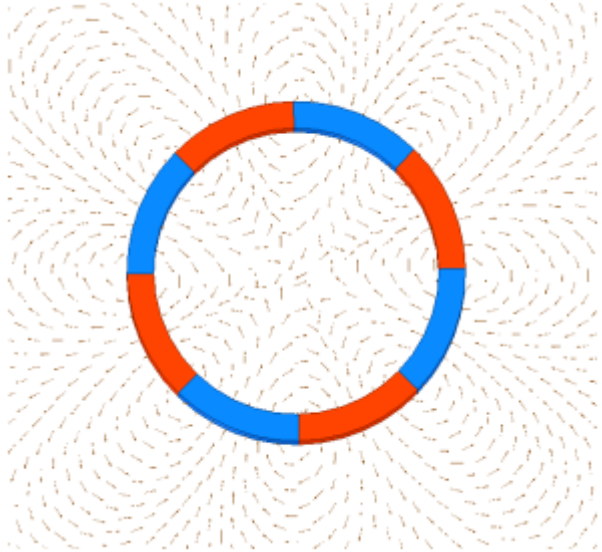


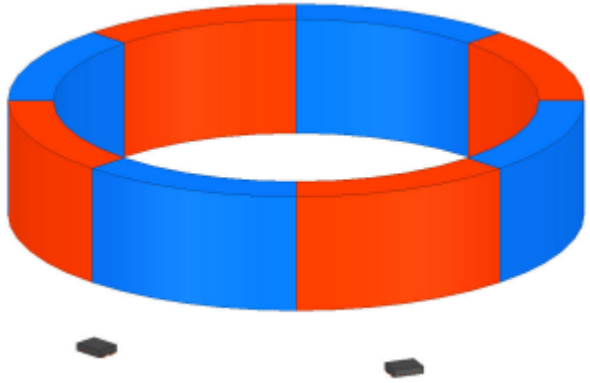




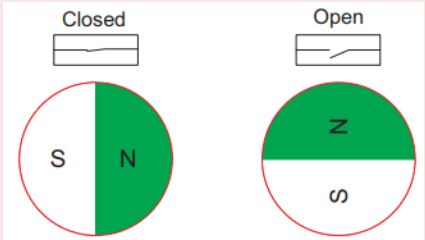
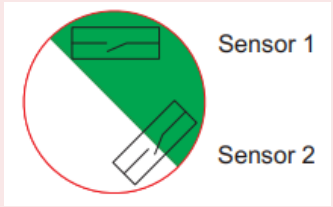
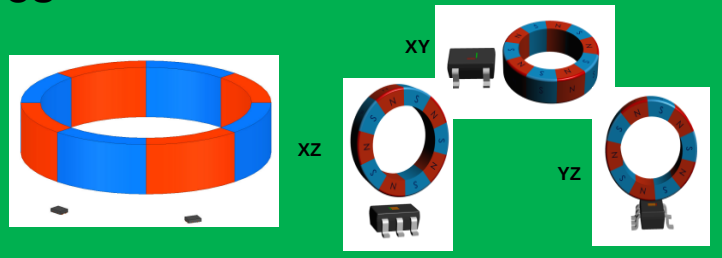
Rotary encoding using magnetic sensors

- Magnetic sensors are used to determine the change in polarity of a rotating magnet.
- Using the output of the sensors, the speed and direction of the rotating magnet can be determined.
- For flow meters, this information can be used to determine the rate of fluid or gas movement.



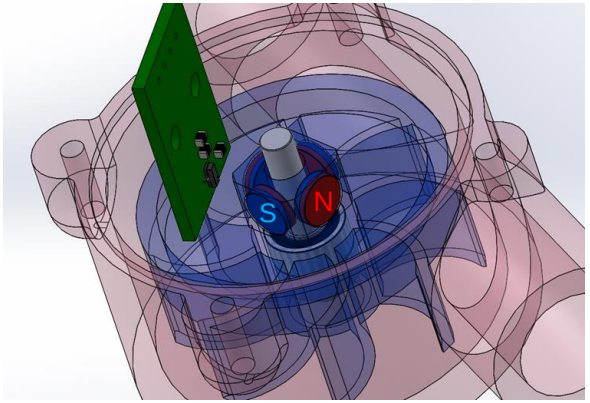


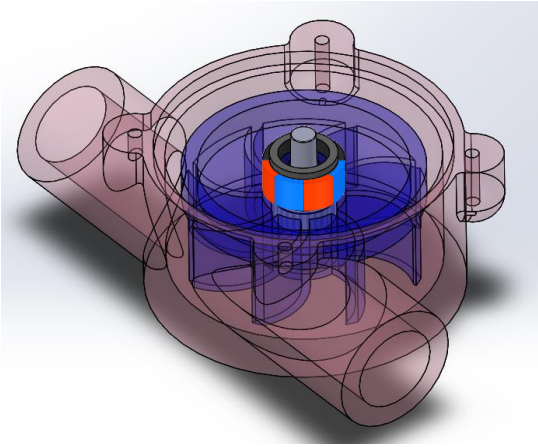
Magnetic sensing technologies

	Reed switch	Hall-effect latches
Size	5 mm x 1.8 mm (through hole)	2.9 mm x 1.6 mm (SOT-23)
Different sensitivity options	Yes	Yes
Multiple axis of sensitivity options	No	Yes
Immune to wear, shock and vibrations	No	Yes
Moving components	Yes	No
Current consumption	Only when switch is closed	Constant
Flexibility in sensor placement	No  	Yes 

Flow meter magnet configurations

- Multiple disk magnets can be installed on the impeller by gluing or pressing them in.
- When using disk magnets, it is important to ensure they are installed with alternating polarity
- A ring magnet can be mounted on the shaft of the impeller for simpler installation because they have built in alternating poles.





Magnetic output response

Given:

$B_{max} > B_{OP}$

$B_{min} < B_{RP}$

Speed within bandwidth specification

$$\frac{2\ poles}{1\ rotation} \times \frac{1\ pulse}{2\ poles} = 1 \text{ pulse per rotation}$$

$$\frac{\#\ poles}{1\ rotations} \times \frac{1\ pulses}{2\ poles} \times \frac{\#\ rotations}{minute} \times \frac{1\ minute}{60\ s} = \frac{\#\ pulses}{s} = frequency$$

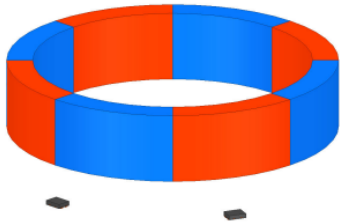
$$\frac{1}{Frequency} = Period$$

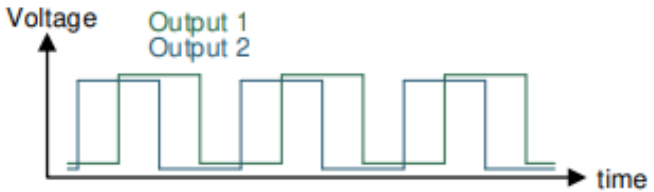
$$\frac{1\ rotations}{\#\ poles} \times \frac{2\ poles}{1\ pulse} \times frequency\left(\frac{pulse}{s}\right) \times \frac{60\ s}{1\ minute} = \text{RPM}$$

Choosing a Hall-effect sensor

1D latch:

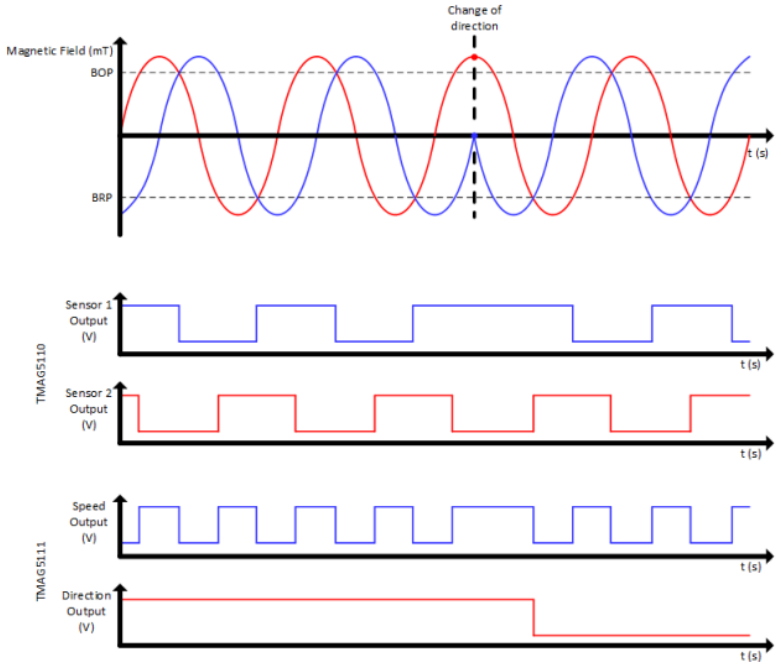
- Two devices must be placed 90° out of phase for quadrature of the rotating magnet

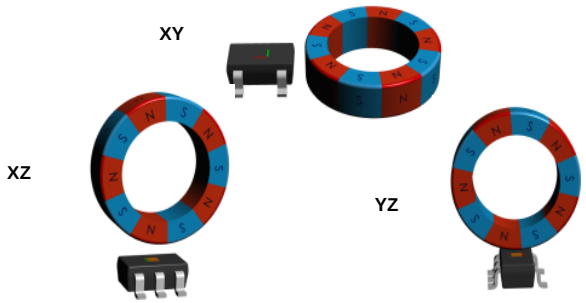




2D latch:

- Flexibility in sensor placement
- a single device can be used to measure the quadrature of the rotating magnet





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