## Overview Using Linear Hall Effect Sensors to Measure Angle

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Many mechanical systems have a need to measure rotational angle. This is common for simple rotating components such as motors, wheels, knobs, and valves.


Figure 1. Butterfly Valve

Angle information can also describe linear displacement. Figure 2 shows a simple construction using a hinge and lever that move in an arc.


Figure 2. Linear Displacement in an Arc
Fluid level can be measured if a float is attached, as shown in Figure 3.


Figure 3. Fluid Level Described By Angle

Some applications require measuring a true straightline linear displacement. This can be achieved with an additional joint between two rigid bars, as shown in Figure 4.


Figure 4. Linear Displacement in a Straight Line
In every case, the angle sensor measures the number of degrees the hinge is rotated. It does not require memory, and the sensor can be powered off between measurements.

## The Magnet

In order to magnetically sense the rotational angle of a hinge, a 2-pole diametrically-magnetized magnet must be attached to it, such as the one shown in Figure 5.


Figure 5. Diametrically-Magnetized Cylinder
The most commonly used magnet material is Neodymium-Iron-Boron (NdFeB), since it produces the strongest field for its size. Ceramic ferrite magnets are also used, but generate about $30 \%$ of the field of NdFeB, which means either the sensor will receive a weaker field, or a closer sensing distance must be used, or the magnet must be sized larger. For high temperature environments, Samarium-Cobalt is best suited.

## Using Linear Hall Effect Sensors

Linear Hall effect sensors like the DRV5055-Q1 measure the magnetic flux density vector component that enters the face of the package and output a linearly proportional signal. As the magnet in Figure 5 rotates, it produces a sinusoidal variation in magnetic flux density at every point in space around it, in 2 or 3 of the axes. Therefore, a linear Hall sensor that is placed nearby will produce a sine wave output as the magnet turns, as shown in Figure 6.


Figure 6. Output from One Linear Hall Sensor
When one linear Hall sensor is used, the range of unique output spans from $90^{\circ}$ to $270^{\circ}$, and the magnet must be properly aligned during component assembly. These shortcomings are eliminated when two linear Hall sensors are used with a $90^{\circ}$ phase offset to produce sine and cosine waveforms, as shown in Figure 7.


Figure 7. Output from Two Linear Hall Sensors
To create this $90^{\circ}$ phase offset, the two sensors can be placed in a $90^{\circ}$ arc across the magnet. Figure 8 shows this for each DRV5055-Q1 package option.


Figure 8. Sensor Placement Examples
For more details on how to measure angles with linear Hall effect sensors, see the Linear Hall Effect Sensor Angle Measurement Theory, Implementation, and Calibration application report. For a hands-on example, see the DRV5055 angle evaluation module.
The DRV5055-Q1 provides design flexibility in multiple package options, $3.3-\mathrm{V}$ and $5-\mathrm{V}$ support, and multiple sensitivity options. A fast $20-\mathrm{kHz}$ sensing bandwidth and low-noise output delivers a high-performance and cost-effective angle-sensing solution.

Table 1. Alternative Device Recommendations

| Device | Optimized <br> Parameters | Performance Trade-Off |
| :---: | :---: | :---: |
| DRV5055 | Non-Automotive Grade | $125^{\circ} \mathrm{C}$ Max Temperature |
| DRV5057 | $2-\mathrm{kHz}$ PWM Output <br> with Noise Immunity | Lower Sensing <br> Bandwidth |
| DRV5053, <br> DRV5053-Q1 | Higher Voltage: 2.5 V <br> to 38 V | Sensitivity $\pm 10 \%$ Over <br> Temperature |
| DRV5056, <br> DRV5056-Q1 | Higher Gain Options | Limited Angle <br> Measurement Range <br> (Unipolar) |

Table 2. Other Resources

| Resource | Description |
| :---: | :---: |
| SBOA200 | Incremental Rotary Encoder Design <br> Considerations |
| SBOA196 | Power Gating Systems with Magnetic |
| Sensors |  |\(\left|\begin{array}{cc}Linear Hall Effect Sensor Angle <br>

Measurement Theory, Implementation, <br>
and Calibration\end{array}\right|\)

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