Overview Using Linear Hall Effect Sensors to Measure Angle

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TEXAS INSTRUMENTS

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.

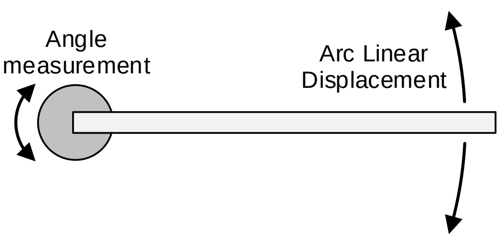

Figure 2. Linear Displacement in an Arc

Fluid level can be measured if a float is attached, as shown in Figure 3.

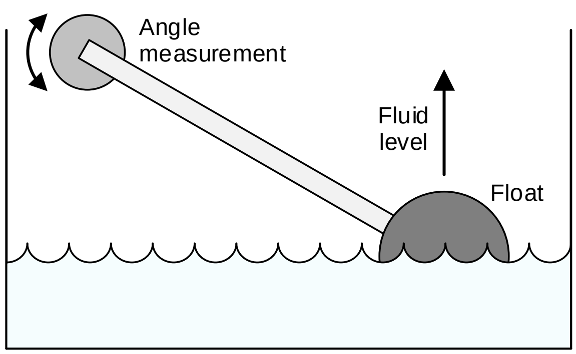

Figure 3. Fluid Level Described By Angle

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

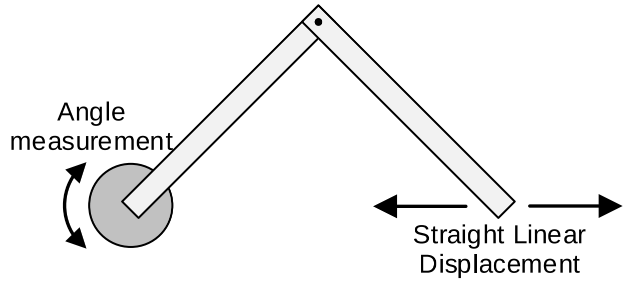

Figure 4. Linear Displacement in a Straight Line

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.

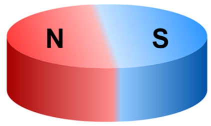

Figure 5. Diametrically-Magnetized Cylinder

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.

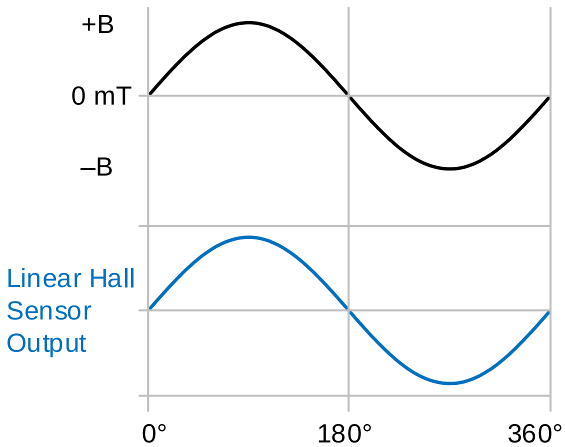

Figure 6. Output from One Linear Hall Sensor

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

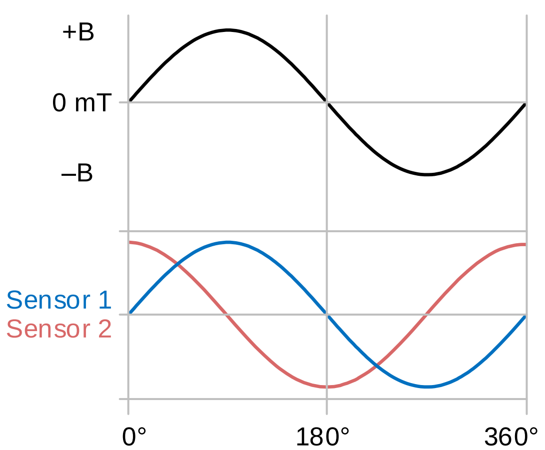

Figure 7. Output from Two Linear Hall Sensors

To create this 90° phase offset, the two sensors can be placed in a 90° arc across the magnet. Figure 8 shows this for each DRV5055-Q1 package option.

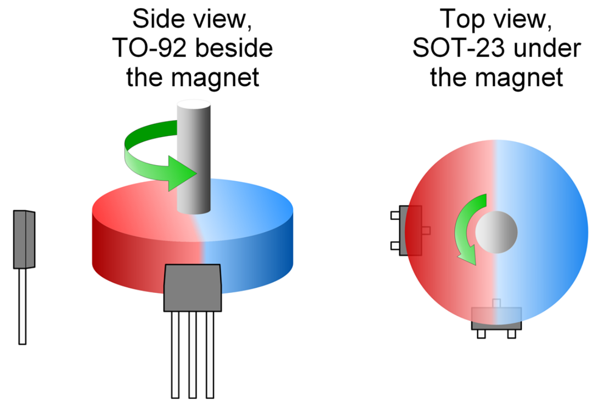

Figure 8. Sensor Placement Examples

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-V and 5-V support, and multiple sensitivity options. A fast 20-kHz sensing bandwidth and low-noise output delivers a high-performance and cost-effective angle-sensing solution.

Table 1. Alternative Device Recommendations

Device	Optimized Parameters	Performance Trade-Off
DRV5055	Non-Automotive Grade	125°C Max Temperature
DRV5057	2-kHz PWM Output with Noise Immunity	Lower Sensing Bandwidth
DRV5053, DRV5053-Q1	Higher Voltage: 2.5 V to 38 V	Sensitivity ±10% Over Temperature
DRV5056, DRV5056-Q1	Higher Gain Options	Limited Angle Measurement Range (Unipolar)

Table 2. Other Resources

Resource	Description
SBOA200	Incremental Rotary Encoder Design Considerations
SBOA196	Power Gating Systems with Magnetic Sensors
SLYA036	Linear Hall Effect Sensor Angle Measurement Theory, Implementation, and Calibration
DRV5055-ANGLE-EVM	Angle Measurement Evaluation Module Using Two DRV5055s

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