Application Bulletin

Magnetic Rotary Encoders

For reliable rotary encoding in harsh environments, magnetic encoders are essential and standard practice. Compared to traditional optical encoders, magnetic encoders are insensitive to dust, shock, and airgap variations. Additionally, magnetic encoders typically consume less power for comparable accuracy.

NVE sensors have high accuracy and robust airgap tolerance, making them ideal for rotary encoder applications. Besides accuracy, NVE sensors are world-renown for their low power consumption and ultraminiature size, making them cost effective for demanding applications.

Absolute Encoders for Unparalleled Reliability

Absolute encoders generate a unique output for each angle within a 0 – 360° rotation, and they retain this information even when thesystem power is cycled. NVE's ASR- and AAT-Series Angle Sensors detect the absolute angle of a rotating shaft, and they are typically used for precision absolute encoders. Figure 1 shows the standard operation of NVE's ASR- and AAT-Series sensors in three different positions relative to the shaft and magnet.

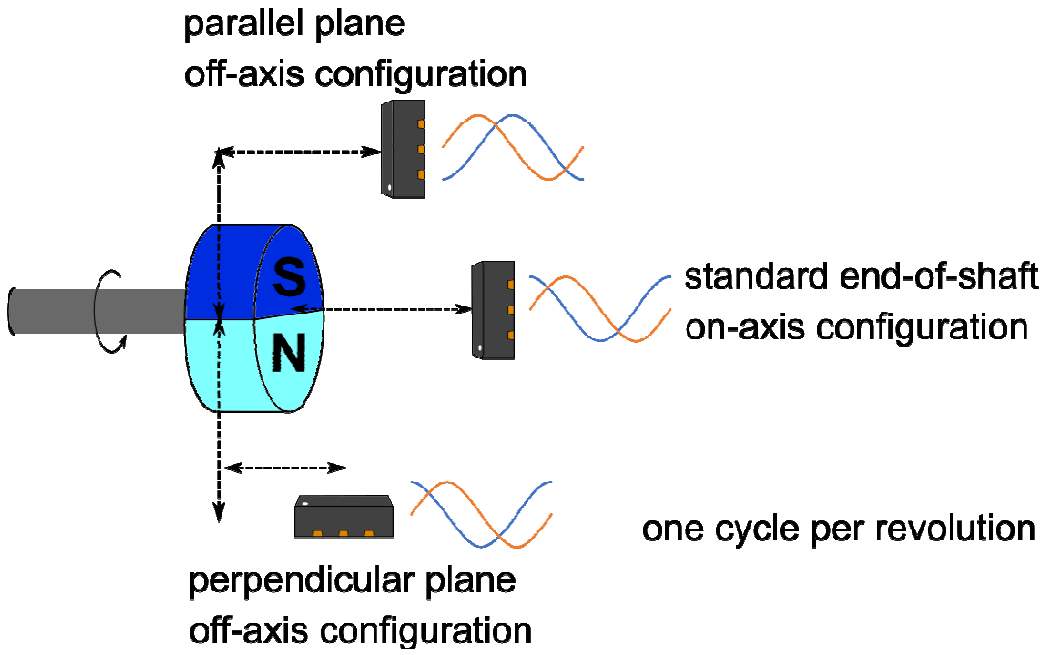

Figure 1: An NVE Angle Sensor used in an absolute encoder application. Besides the on-axis configuration, these sensors can be used in two off-axis configurations to the same accuracy: no external calibration or compensation required.

For more information about off-axis angle sensing, check out our application note, web application, and Youtube channel:

https://www.nve.com/Downloads/SB-SA-02_Off-Axis-Angle-Sensing.pdf
https://www.nve.com/spec/calculators.php#tabs-Off-Axis-Angle-Sensing
https://youtu.be/kf-rOiL-MgY
https://youtu.be/FcM1Q3N6Atw

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High-Resolution Incremental Encoders

Unlike absolute encoders, incremental encoders detect an unreferenced subdivision of a shaft rotation, typically indexed with gear teeth or repeating magnetic poles. While incremental encoders need a reference to determine absolute position and are susceptible to error after system power failures, they often offer better precision and accuracy than absolute encoders. NVE's ASR/AAT-Series Angle Sensors and ABL/AKL-Series GT Sensorsare ideal for theseapplications and function as reliable precision incremental encoders.

NVE Angle Sensors as Incremental Encoders

ASR/AAT-Series Angle Sensors read both radial and axial encoder wheels, as shown in Figure 2. Unlike Hall sensors, these angle sensors are in-plane sensitive, which makes them more usable in many instances. For example, in the case of a radially magnetized encoder wheel, the sensor can be easily mounted on a PCB concentric with the rotating shaft.

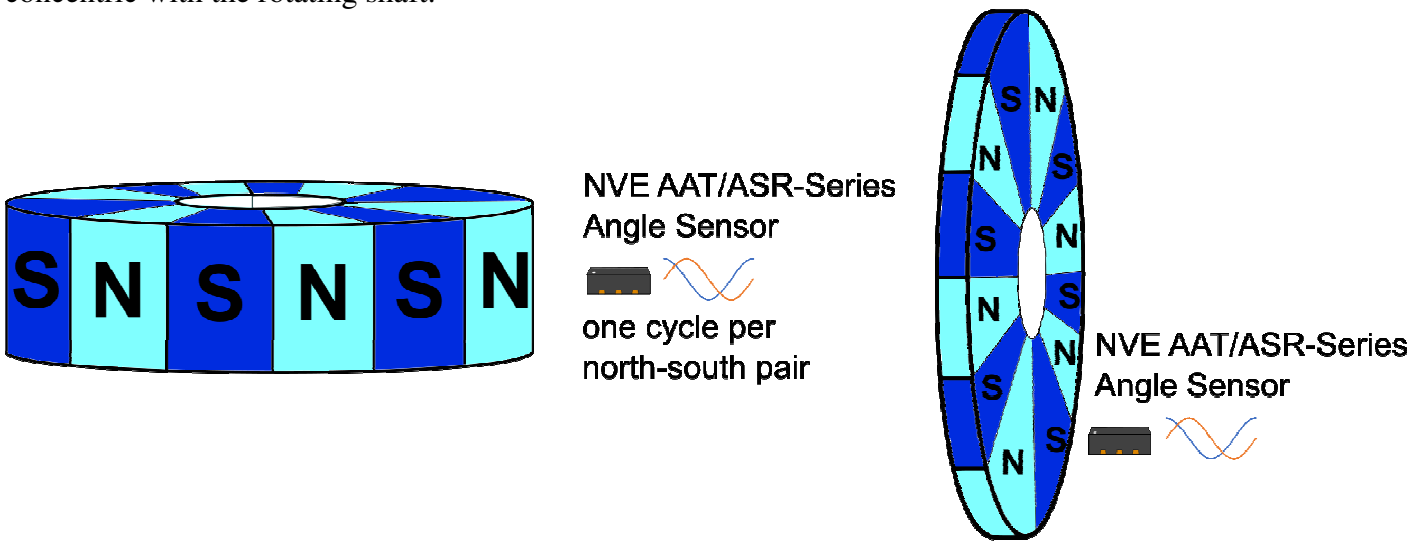

Figure 2: An NVE Angle Sensor detecting radial (left) and axial (right) encoder wheel magnets. AAT-Series Angle Sensors produce sine and cosine outputs with airgap-independent amplitude, and ASR-Series Angle Sensors output a 0 – 360° angle cycle with each north-south pair.

Because of the magnetic field distribution of these multipole magnets, NVE angle sensors will produce sine and cosine signals independent of the magnet pole pitch. For best results, the sensor should be centered with respect to the magnet poles, as shown in Figure 2.

For systems requiring a digital output, NVE's ADT-Series has integrated comparators with factory-trimmed hysteresis to provide precision without any output jitter.

Key features of these configurations include:

- Pitch free 90° quadrature outputs
- Airgap independent amplitude
- Convenient placement orientation
- One cycle per north-south pole pair

For more information about AAT/ASR-Series Angle Sensors and ADT-Series Rotation Sensors:
https://www.nve.com/angleSensors.php

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NVE GT Sensors as Incremental Encoders

NVE's ABL-Series GT sensors are designed to detect passing gear teeth, typically using a bias magnet and a ferromagnetic gear, as shown in Figure 3.

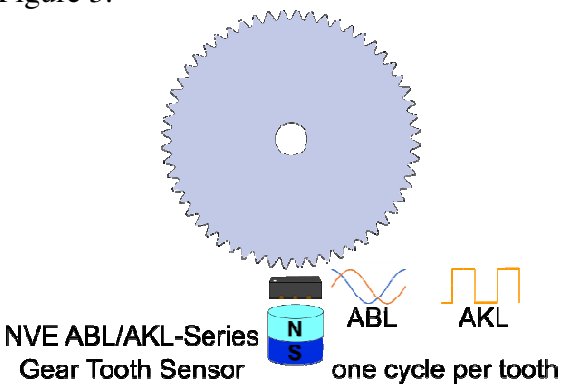

Figure 3: Typical GT Sensor operation.

ABL-Series GT Sensors output low distortion sine waves with one cycle per tooth. The single-channel ABL00x are ideal for tachometer applications, while the dual-channel ABL01x outputs are phase shifted, allowing for A/B phase detection or absolute position interpolation. The phase shift of the ABL01x outputs is determined by the ratio of the gear pitch to the sensor's mechanical element standoff:

$$\text{Phase Shift} = (\text{ bridge phase shift / gear pitch}) \cdot 360°$$

AKL00x GT Sensors are single channel and configured as two-wire devices, with the supply current modulating for each passing tooth.

NVE GT Sensors are also capable of reading encoder wheels, and they provide double the resolution of typical Hall encoders; NVE's state-of-the-art GMR sensor elementsgenerate two cycles per north-south pair. The sensor configuration and typical application circuit are shown in Figures 4 and 5. ABL-Series GT sensors need an externalcomparator to function correctly when used to detect encoder wheel magnets, while AKL-Series GT sensors need no external circuitry.

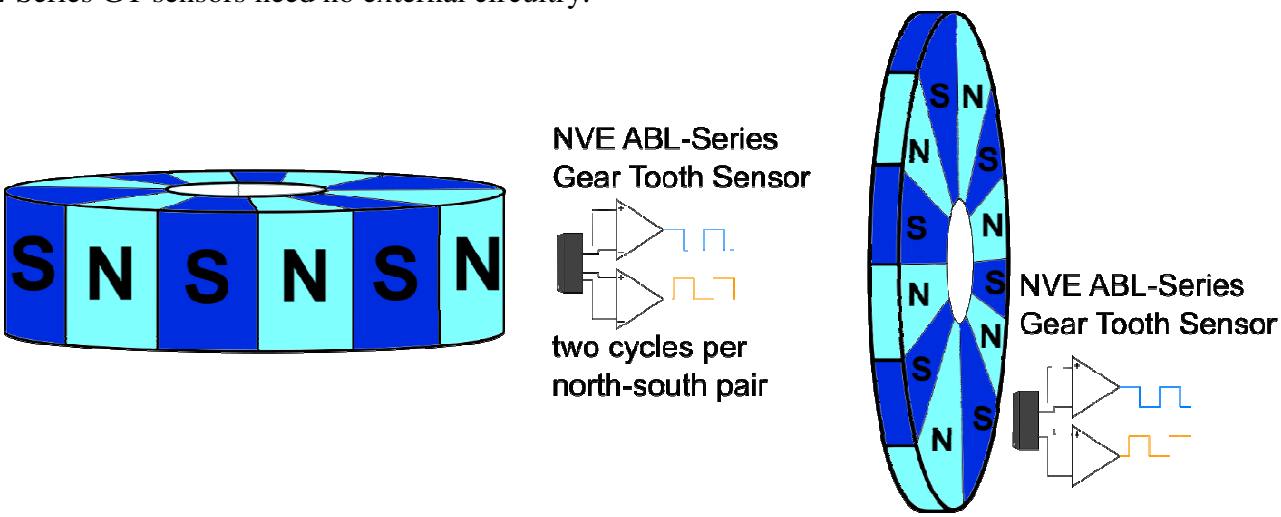

Figure4: ABL-Series GT Sensors detecting radial and axial encoder magnets. A dual bridge ABL01X is shown, with a dual comparator generating A/B phase pulses.

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The phase shift of the ABL01x A/B outputsis determined by the ratio of the magnet pole pitch to the phase shift of the sensor elements.

$$\text{Phase Shift} = \frac{N \cdot p}{\pi \cdot d} \cdot 360°$$

d is the magnet diameter, *N* is the number of poles, *p* is the sensor's phase shift.

Key features of these configurations include:

- Digital A/B quadrature outputs
- Wide airgap tolerance
- High speed, up to 1 MHz
- One cycle per pole

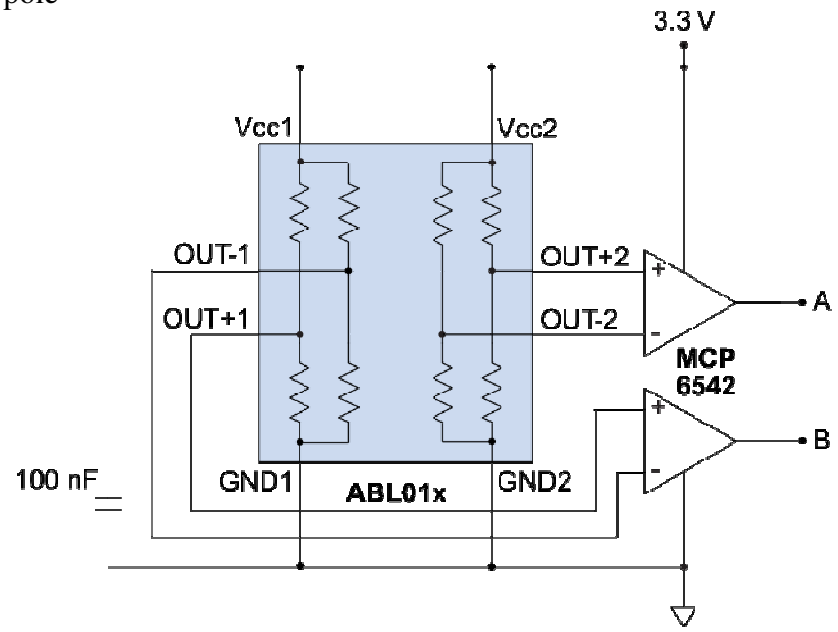

Figure 5: Adding a low cost (dual) comparator allows ABL-Series GT Sensors to detect encoder wheels with remarkably stable airgap performance.

For more information about ABL/AKL-Series GT Sensors:
https://www.nve.com/gtSensors.php

Contact Us

NVE engineers are experts in rotation sensing and eager to help. Please contact sensor-apps@nve.com for solutions to the most demanding rotary encoder designs.

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