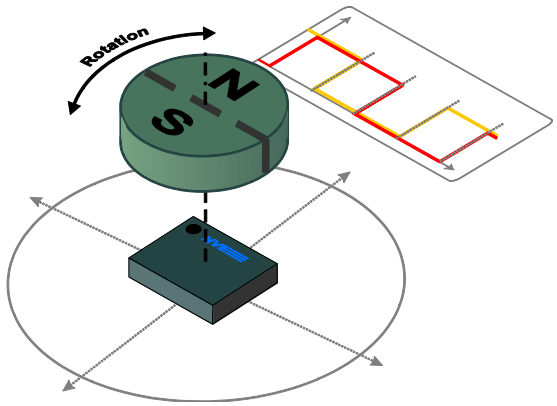
ADT501-10E Ultralow Power Rotation Sensor



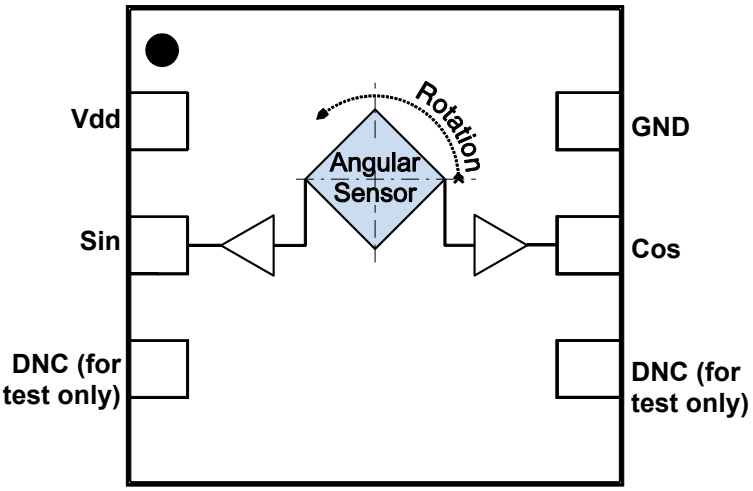
Features

- Tunneling Magnetoresistance (TMR) technology
- Extremely low power (2.8 µA typ. at 2.4 V)
- Precision digital quadrant outputs
- Wide airgap tolerance
- Operates with as little as 0.4 mT magnet field
- 2.4 V to 5.5 V supply range
- −40°C to +125°C operating range
- Ultraminiature (2.5 mm x 2.5 mm DFN6)

Applications

- Water meters
- Rotational speed sensors
- Rotational position sensors

Functional Diagram and Pinout



Description

The ADT501 rotation sensor is an ultralow power, digital-output magnetic rotation sensor. Tunneling Magnetoresistance (TMR) technology allows small size and ultra-low power, making the sensor ideal for battery operation.

The sensor has two digital, binary outputs. The two outputs are 90 degrees out of phase to provide directional information.

The parts are packaged in NVE's ultraminiature 2.5 mm x 2.5 mm x 0.8 mm DFN6 surface-mount package.

Truth Table

	Output	
Angle	Sin	Cos
0°-90°	H	H
90°-180°	H	L
180°-270°	L	L
270°-360°	L	H

Absolute Maximum Ratings

Parameter	Min.	Max.	Units
Supply Voltage	−0.5	7	Volts
Storage Temperature	−40	170	°C
ESD (Human Body Model)		2000	Volts
Applied Magnetic Field		Unlimited	tesla

Operating Specifications

T_{min} to T_{max}; 2.4 V < V_{DD} < 5.5 V unless otherwise stated.						
Parameter	**Symbol**	**Min.**	**Typ.**	**Max.**	**Units**	**Test Condition**
Operating Temperature	T_{min}; T_{max}	−40		125	°C	
Supply Voltage	V_{DD}	2.4		5.5	V	
Supply Current	I_{DDQ}		1.5	4	µA	V_{DD} = 2.4V
			2.2			V_{DD} = 3V
			2.7	6		3V < V_{DD} < 3.6V
				10		V_{DD} = 5.5V
Applied Magnetic Field Strength		0.4		40	mT	
Low-Level Output Voltage	V_{OL}	0		0.24	V	I_L = −50 µA
High-Level Output Voltage	V_{OH}	V_{DD} − 0.25		V_{DD}	V	I_L = 50 µA
Angular Precision/Repeatability				±3	deg.	
Angular Hysteresis	$\lvert\theta_H - \theta_L\rvert$	8	20	40	deg.	V_{DD} = 3.6V; 25°C
Frequency Response	f_{MAX}	2			kHz	
Power-On Time[1]	t_{on}			100	µs	

(1) We recommend a minimum 100 µs delay before reading SIN and COS outputs when using external power cycling. More information about applying an external duty cycle to a continuous-duty sensor can be found here: nve.com/Downloads/SB-SA-04.pdf

Operation

Overview

The ADT501 sensor uses an array of four Tunneling Magnetoresistance (TMR) sensing elements. TMR technology enables low power and miniaturization, making the sensors ideal for battery operation.

In a typical configuration, an external magnet provides a saturating magnetic field (0.4 to 40 mT) in the plane of the sensor, as illustrated below for a bar magnet and a radially-magnetized disk magnet:

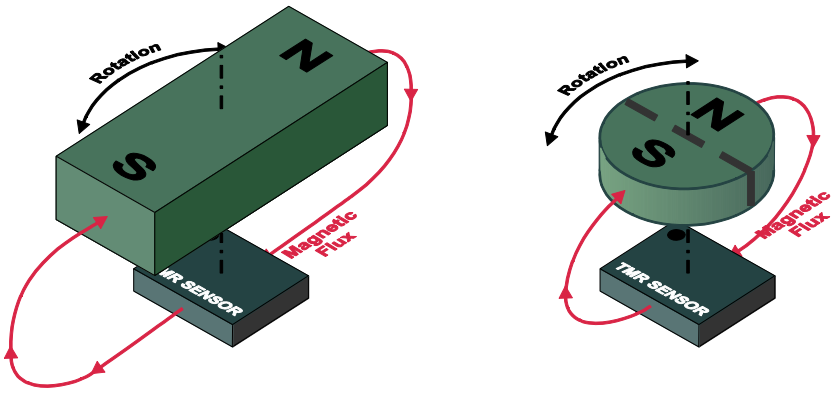


Figure 1. Sensor operation.

Simple output encoding

The rotation is encoded in two quadrature outputs, 90 degrees out of phase. Mathematically, the outputs correspond to the sign of the sine and cosine of the rotation, i.e., sgn(sinθ) and sgn(cosθ), as shown below:

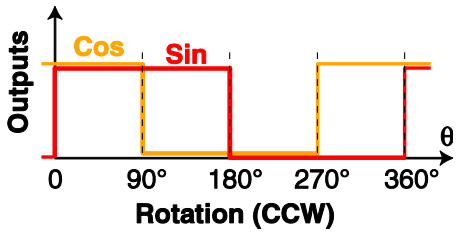


Figure 2. Sensor outputs
(counterclockwise rotation viewed from the top of the sensor).

The binary sensor SIN and COS outputs define the quadrant of rotation:

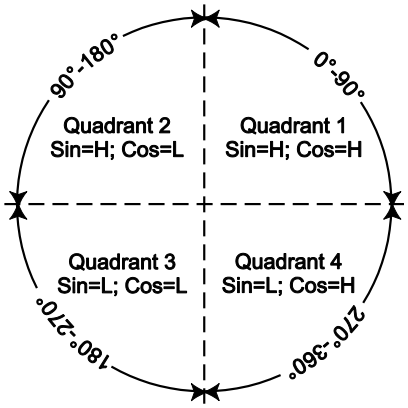


Figure 3. Sensor outputs for each rotation quadrant.

Wide range of magnets and magnet location
The sensor operates with as little as a 0.4 mT magnetic field, and is accurate up to 40 mT. This wide magnetic field range allows inexpensive magnets and operation over a wide range of magnet spacing. Larger or stronger magnets can be used at larger airgaps or at close spacing for improved tamper rejection; smaller or weaker magnets may require closer spacing. Low-cost, radially-magnetized ferrite disk magnets can be used with these sensors. Bar magnets can also be used in some configurations.

When locating the magnet in relation to the sensor, note that the rotational center of the sensor is offset slightly from the package center (see Figure 13).

Absolute position
Unlike some encoder types, the ADT501 sensor detects absolute position and maintain position information when the power is removed. The sensor immediately powers up indicating the correct position.

Power supply decoupling and noise filtering
A 10 nF ceramic bypass capacitor can be used on V_{DD} if the sensor is powered by a power supply or a battery with long connections.

Magnetic Field Application

In-Plane Sensitivity
Unlike Hall Effect or other sensors, the ADT501 is sensitive in the plane of the sensor package in both X- and Y-axis directions. The ADT501 does not respond to Z-axis magnetic field perpendicular to the plane of the sensor package. Magnetic fields applied at an angle θ out of plane towards the Z-axis will be by reduced by $Cos\ (\theta)$.

Rotation Counting with Dipole Magnets
The principal application of ADT501-10E is an ultrasensitive rotation counter. The sensor can detect rotating magnetic fields as small as 0.4 mT. The sensor can also be overdriven with large magnetic field up to 40 mT, making it highly robust against misalignment, vibration, and external magnetic field interference. The most common magnet configurations are *two-pole, axial-pole,* and *radial-pole magnets*. ADT501-10E can also be used with *linear magnetic scale tape*.

Periodicity with Multipole Magnets
ADT501-10E completes one sine and cosine pulse cycle for each pair of north-south magnetic poles. For example:

- A two-pole magnet will produce one cycle per rotation
- A four-pole magnet will produce two cycles per rotation
- An eight-pole magnet will produce four cycles per rotation
- A 12-pole magnet will produce six cycles per rotation

Off-Axis Rotational and Angle Sensing
ADT501-10E are ideal for off-axis rotation sensing because of their high-sensitivity and wide dynamic range. They can be used in multipole magnet configurations with minimal zero-field zone (small regions where one of the X or Y field components drops to zero). More traditional end-of-shaft, on-axis rotational sensing is also possible.

Two-Pole Magnet Sensing

With a two-pole magnet (sometimes called "split-pole" or diametrically magnetized), the ADT501-10E will produce one full sine and cosine pulse cycle per rotation. The sensitivity zones are identified in green shaded area. Zero-field zones are marked with "x" and arrows. As you can see, the zero-field zone is very small; this is due to the ADT501-10E's very high sensitivity.

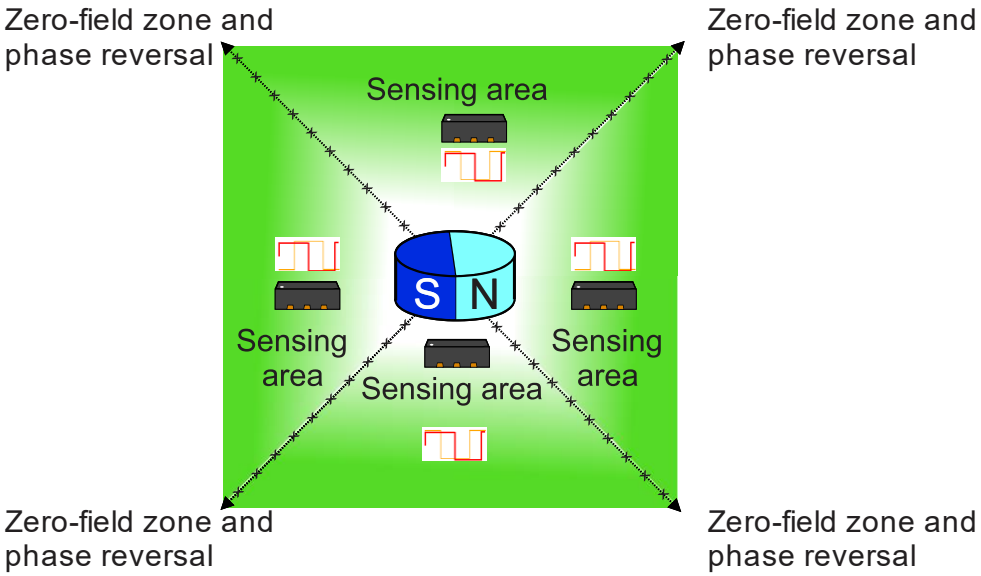


Figure 4. Two-pole magnet detection in the *Parallel Plane* configuration.

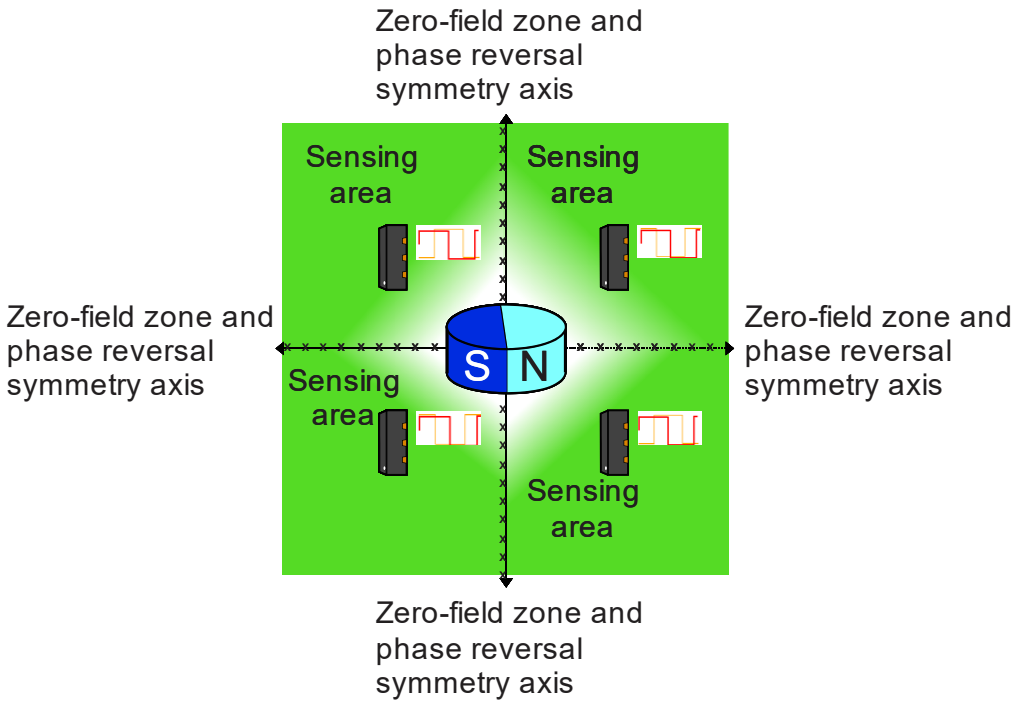


Figure 5. Two-pole magnet detection in the *Perpendicular Plane* configuration.

Axial-Pole Magnet Sensing

A 12-pole magnet is used for illustration in the figures below. In this case, the ADT501-10E will produce six full sine and cosine pulse cycles per rotation. The sensitivity zones are identified in green shaded area. Zero-field zones are marked with "x" and arrows. As you can see, the zero-field zone is very small; this is due to the ADT501-10E's very high sensitivity.

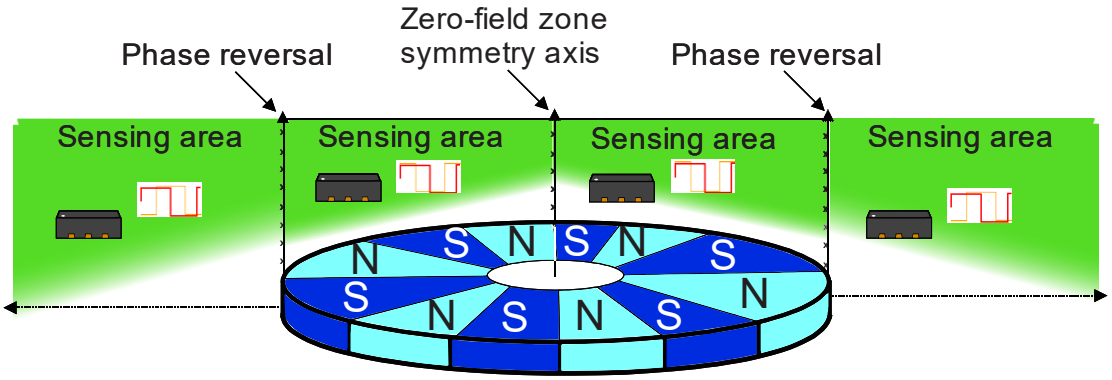


Figure 6. Axial-pole magnet detection in the *Parallel Plane* configuration.

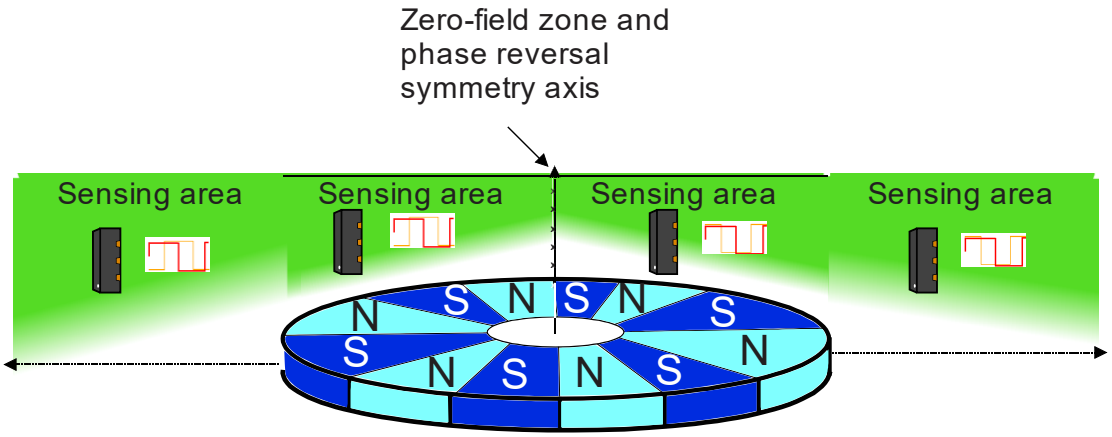


Figure 7. Axial-pole magnet detection in the *Perpendicular Plane* configuration.

Radial-Pole Magnet and Linear Magnetic Scale Sensing

A 12-pole magnet is used for illustration in the figures below. In this case, the ADT501-10E will produce six full sine and cosine pulse cycles per rotation. The sensitivity zones are identified in green shaded area. Zero-field zones are marked with "x" and arrows. As you can see, the zero-field zone is very small; this is due to the ADT501-10E's very high sensitivity.

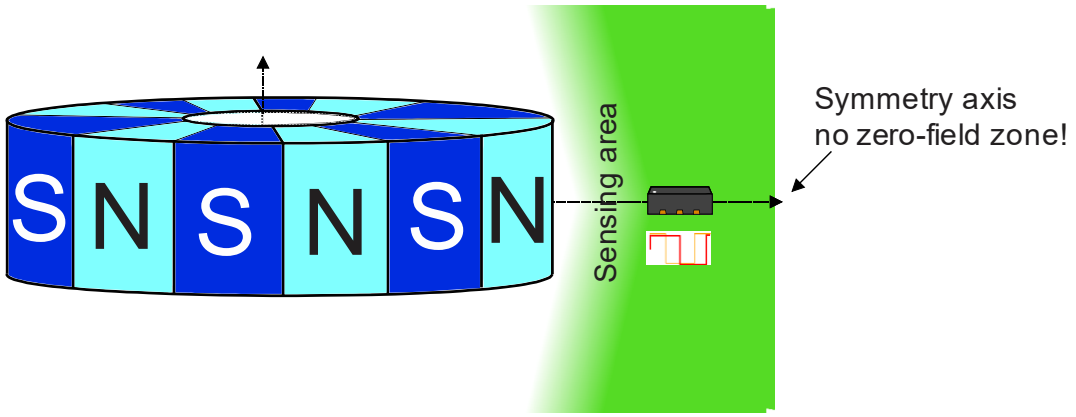


Figure 8. Radial-pole magnet detection in the *Parallel Plane* configuration.

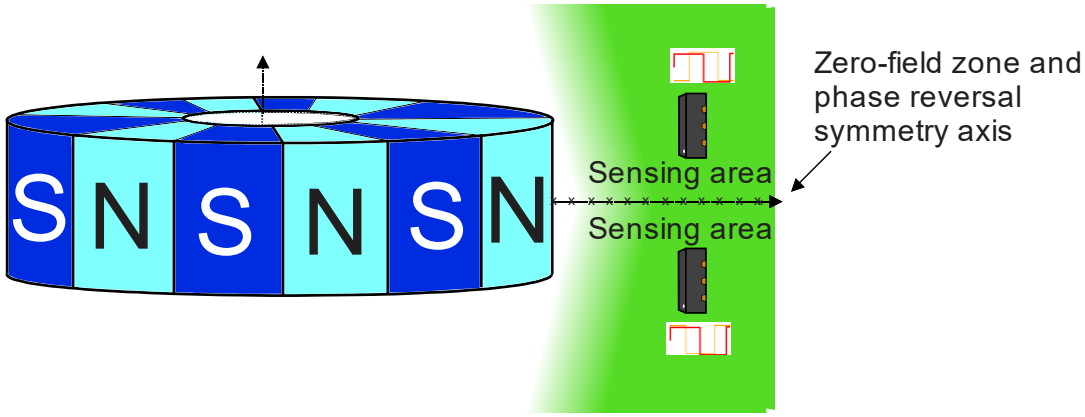


Figure 9. Radial-pole magnet detection in the *Perpendicular Plane* configuration.

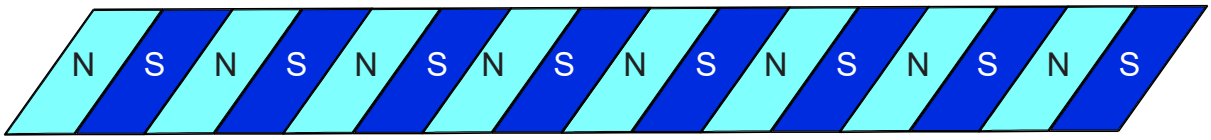


Figure 10. For linear encoders, *linear magnetic scale tape* can be used in similar configuration to radial-pole magnets.

Typical Performance

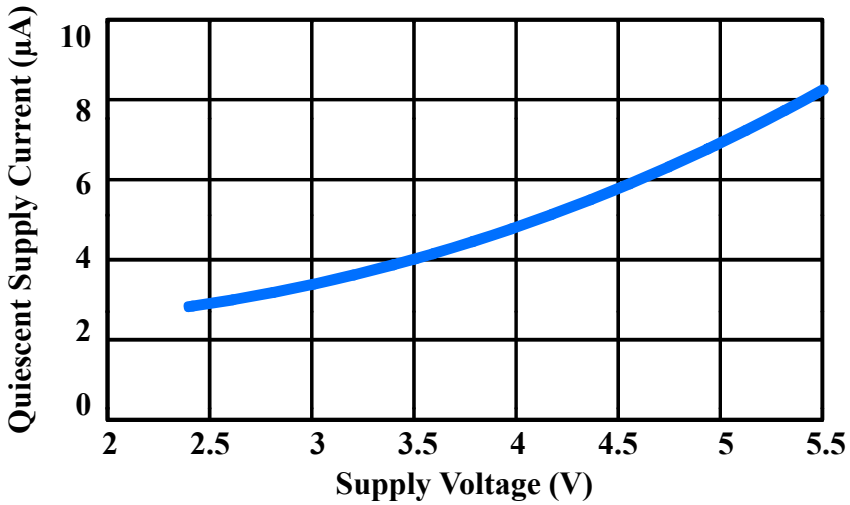


Figure 11. Typical Quiescent Supply Current (25°C).

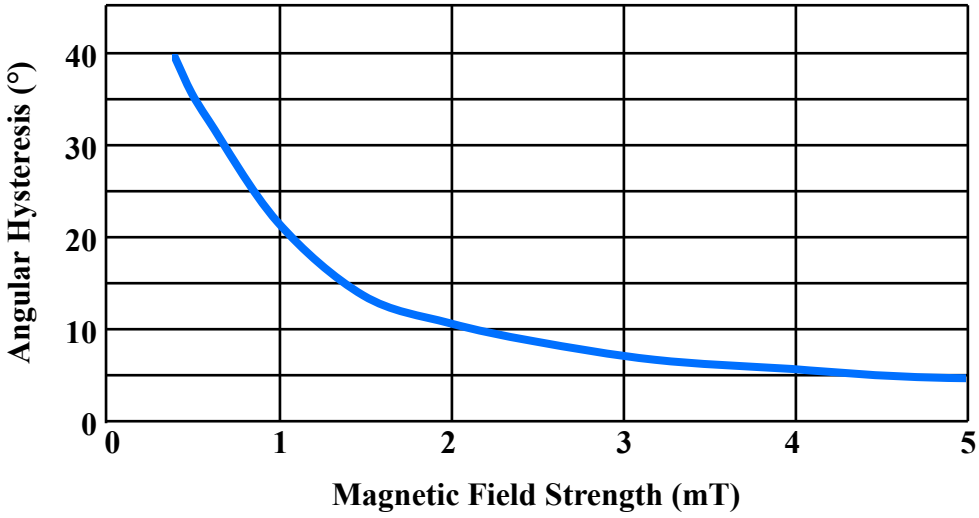


Figure 12. Typical Angular Hysteresis (25°C). Typical hysteresis remains at 3-5° from 5 to 40 mT

Pinout and Part Marking

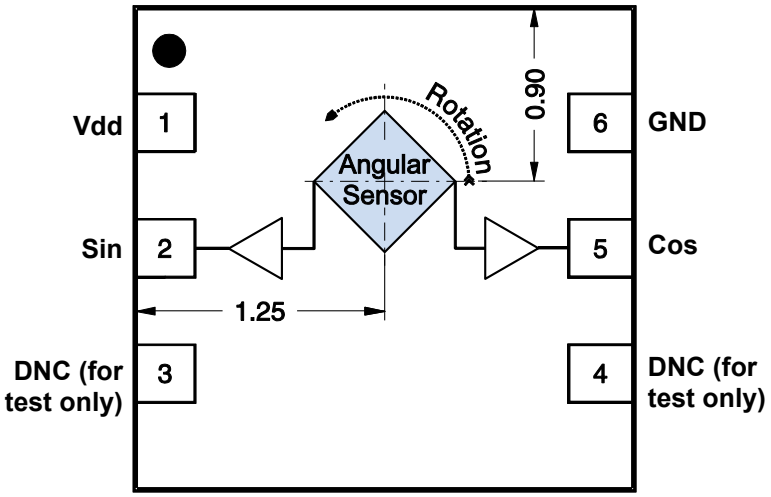


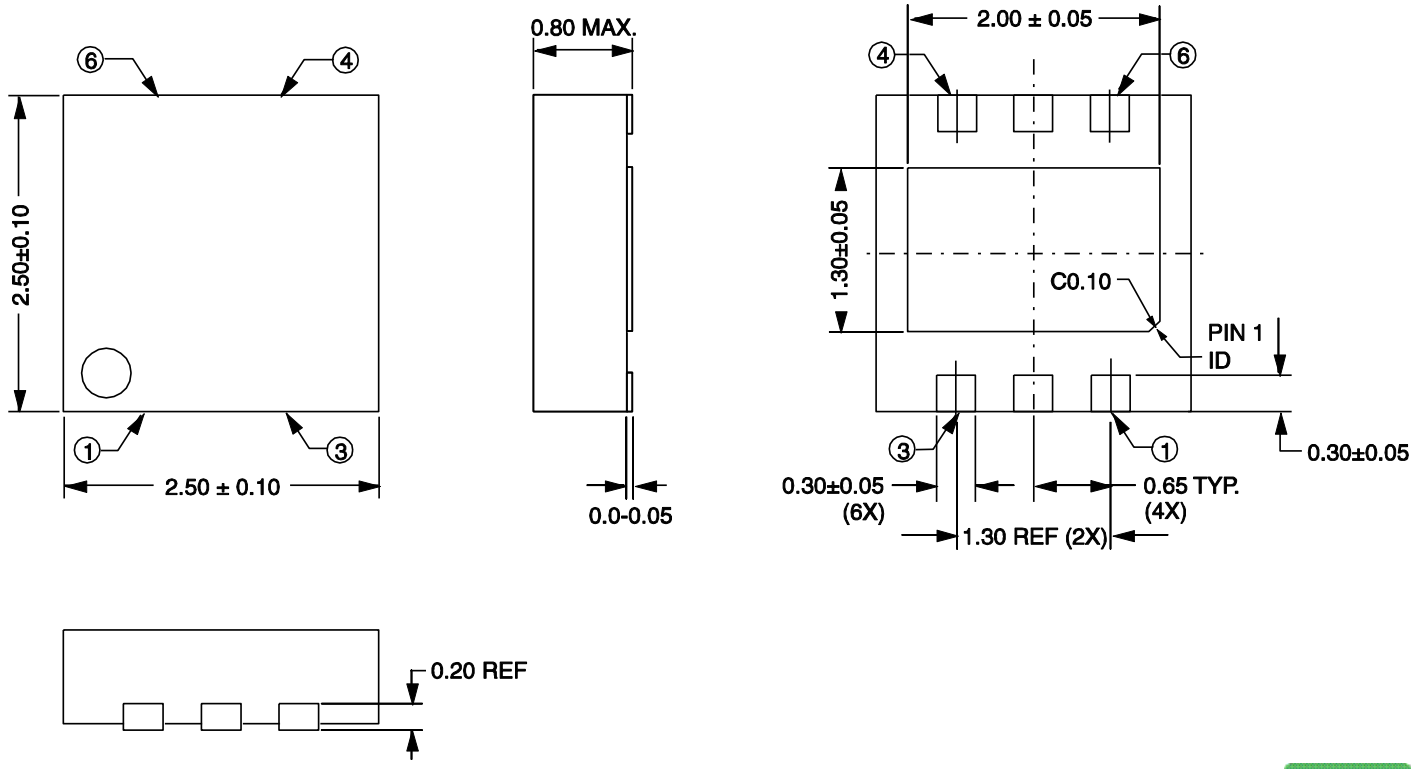
Figure 13. ADT501-10E pinout and center of rotation.

Pin	Symbol	Description
1	V_{DD}	Supply voltage (2.4 V to 5.5 V).
2	Sin	HIGH CMOS output when the sine of the rotation angle is positive (0 to 180°).
3	DNC	Do not connect (for test only).
4	DNC	Do not connect (for test only).
5	Cos	HIGH CMOS output when the cosine of the rotation angle is positive (0 to 90° or 270° to 360°).
6	GND	Ground.

Notes:

- The package center pad may be left floating or connected to ground.
- This product has been tested for electrostatic sensitivity to the limits stated in the specifications. However, NVE recommends that all integrated circuits be handled with appropriate care to avoid damage. Damage caused by inappropriate handling or storage could range from performance degradation to complete failure.
- Part marking: **FECe**

2.5 mm x 2.5 mm DFN6 Package



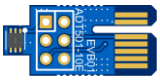
RoHS COMPLIANT

Notes:

- Dimensions in millimeters.
- Soldering profile per JEDEC J-STD-020C, MSL 1.

Breakout Boards

Breakout boards are available for the ADT501-10E:



Part number ADT501-10E-EVB01
(0.8" x 0.4" / 21 mm x 10 mm; actual size).

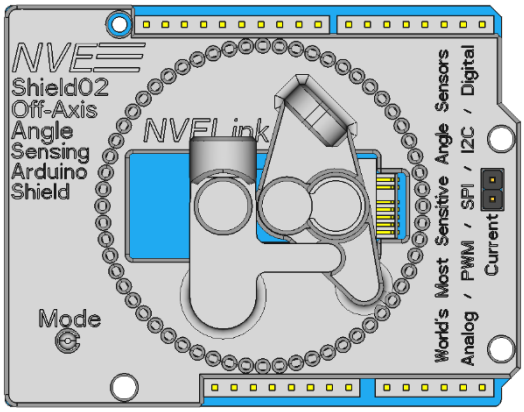
Bare Circuit Boards

NVE offers bare circuit boards for easy connections to DFN6 sensors such as the ADT501-10E:

AG035-06: DFN6 connection board for -10E suffix sensors
(1.57" x 0.25" / 40 mm x 6 mm; actual size).

Off-Axis Rotation Sensor Evaluation Board

This evaluation board allows you to try NVE's unique off-axis angle and rotational sensors, including the ADT501:



SHIELD02: Off-Axis Angle Sensor Evaluation Board.
(2.7" x 2.1" / 69 mm x 53 mm; actual size).

Revision History

SB-00-175-RevA July 2025	**Change** • Initial release.

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