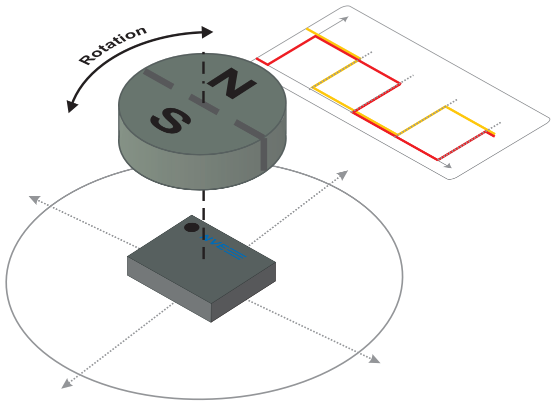
ADT002-10E Ultralow Power Rotation Quadrant Sensors



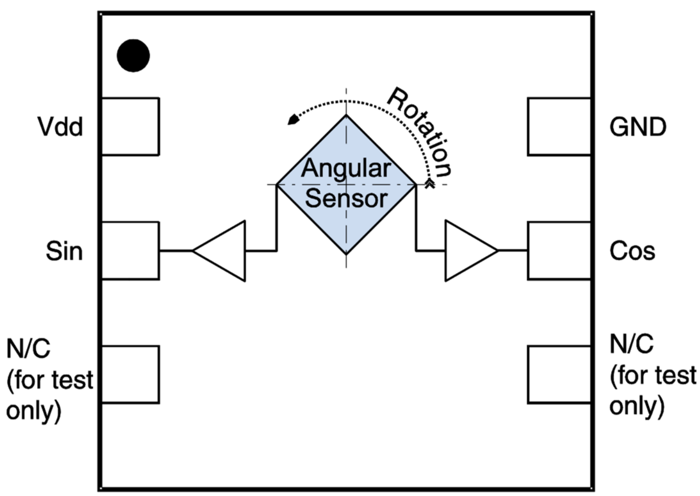
Features

- Tunneling Magnetoresistance (TMR) technology
- Extremely low power (1.8 µA typ. at 2.4 V)
- Precision digital quadrant outputs
- Wide airgap tolerance
- Operates with as little as 30 Oersteds of magnetic field
- 2.4 V to 5.5 V supply range
- −40°C to +125°C operating range
- Ultraminiature TDFN6 packages

Applications

- Water meters
- Rotational speed sensors
- Rotational position sensors

Functional Diagram and Pinout



Description

ADT002 rotation sensors are ultralow power, digital-output magnetic rotation sensors. Tunneling Magnetoresistance (TMR) technology allows small size and low power, making the sensors ideal for battery operation.

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

The ADT002 is optimized for absolute rotary position detection, with low hysteresis to provide accurate, absolute rotational quadrant information.

The parts are packaged in NVE's 2.5 mm x 2.5 mm x 0.8 mm TDFN6 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

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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	Oe

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}	0.55	1.8	3.1	µA	V_{DD} = 2.4V
			2.2			V_{DD} = 3V
		0.8	2.7	4.6		3V < V_{DD} < 3.6V
				6.95		V_{DD} = 5.5V
Applied Magnetic Field Strength		30		200	Oe	
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				±1.5	deg.	
Angular Hysteresis	$\lvert\theta_H - \theta_L\rvert$	3	4	8	deg.	V_{DD} = 3.6V; 25°C
Frequency Response	f_{MAX}	2			kHz	

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Operation

Overview

The heart of the unique sensor is an array of four Tunneling Magnetoresistance (TMR) elements, one in each quadrant. 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 (30 to 200 Oe) in the plane of the sensor, as illustrated below for a bar magnet and a radially-magnetized disk magnet:

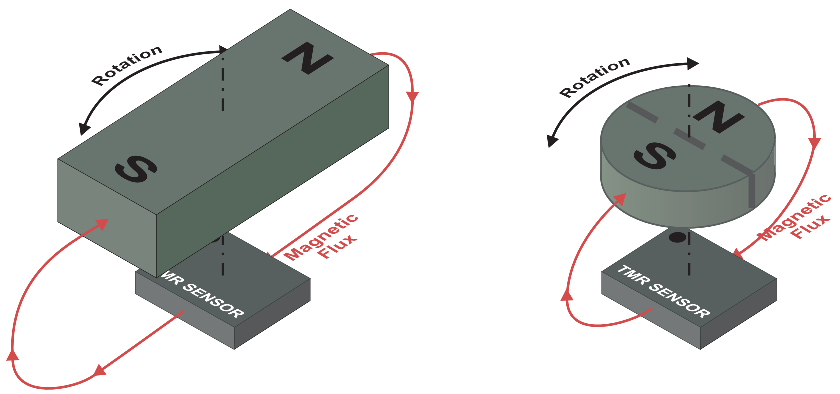

Figure 1. Sensor operation.

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:

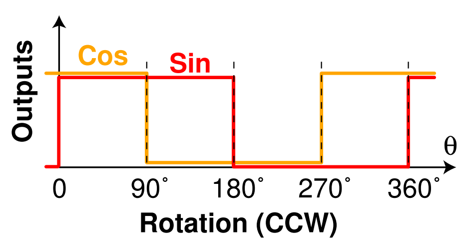

Figure 2. Sensor outputs
(counterclockwise rotation viewed from the top of the sensor).

Thus the binary sensor outputs define the quadrant of rotation:

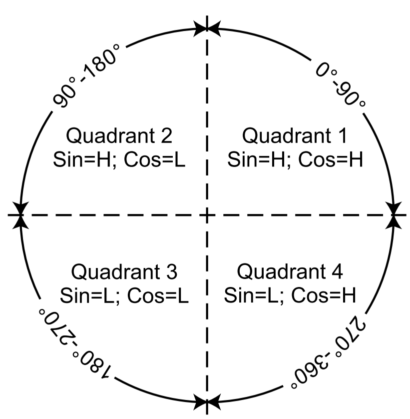

Figure 3. Sensor outputs for each rotation quadrant.

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Wide range of magnets and magnet location

The sensor operates with as little as a 30 Oe magnetic field, and is accurate up to 200 Oe. This wide magnetic field range allows inexpensive magnets and operation over a wide range of magnet spacing. Larger or stronger magnets require more distance to avoid oversaturating the sensor; 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.

Absolute position

Unlike some encoder types, ADT002 sensors detect 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

Since ADT002 sensors are duty-cycled to reduce power consumption, a bypass capacitor should be used on V_{DD} if the sensor is powered by a power supply or a battery with long connections. 10 nF ceramic capacitors are typical.

Because the sensor uses high-impedance circuitry and often operates in noisy environments, designers should consider filtering or debounce circuitry on the sensor outputs if possible, especially if the application relies on triggering or counting edges.

Integrated fault detection

An additional output indicates a fault if the magnetic field is too high for accurate measurements. This can occur if the magnet is too close to the sensor, or due to interference from adjacent magnets. The signal can also be used to align assemblies.

Typical Performance Graphs

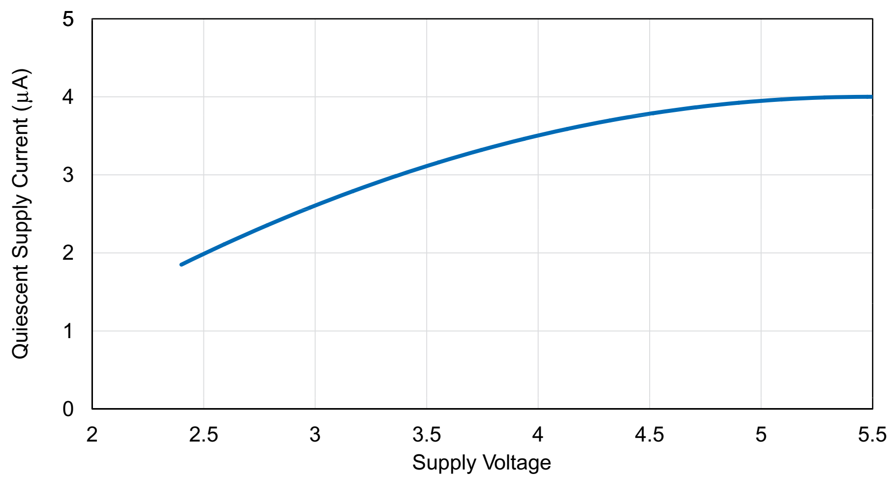

Figure 4. Typical Quiescent Supply Current (25°C).

Illustrative Application Circuits

Quadrant detection

A 2-to-4 Line Decoder can provide digital signals indicating the quadrant of rotation:

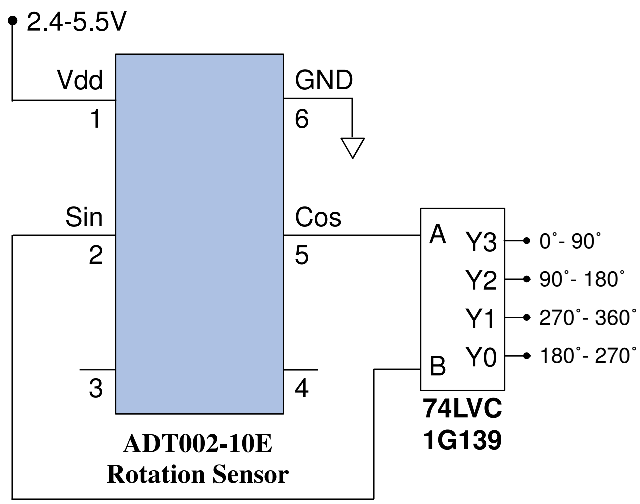

Figure 5. Quadrant detection.

A two-cycle/revolution signal

An Exclusive-OR gate can be used to provide a digital signal with two cycles per revolution and transitions every 90 degrees:

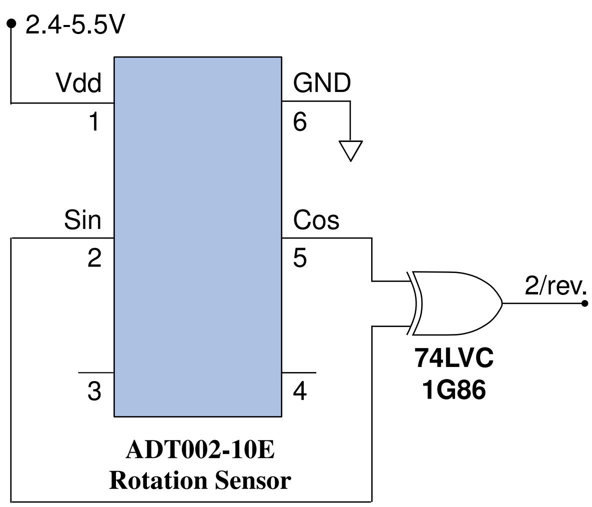

Figure 6. Two-cycle per revolution signal.

Ultralow power external circuitry

Any of the application circuits described in this section can use 74AUP-series logic instead of 74LVC circuitry if lower power is required and five-volt operation is not needed.

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Pinout

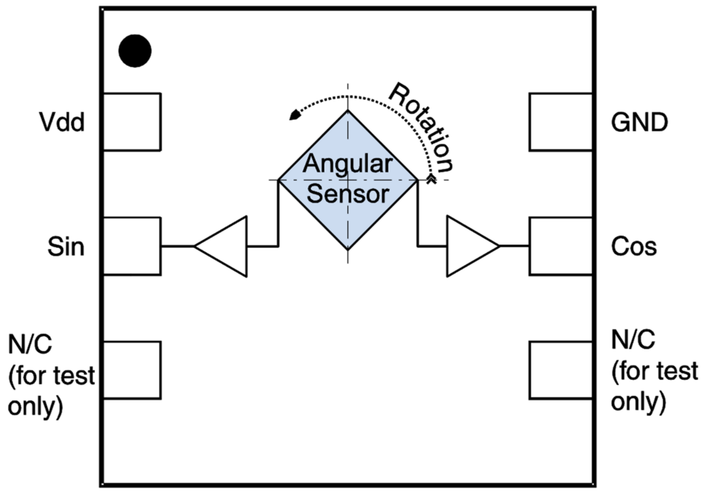


Figure 7. ADT002-10E pinout and center of rotation.

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 – 180°).
3	DNC	Do not connect, leave floating (for test only).
4	DNC	Do not connect, leave floating (for test only).
5	Cos	HIGH CMOS output when the cosine of the rotation angle is positive (0 – 90° or 270° – 360°).
6	GND	Ground.

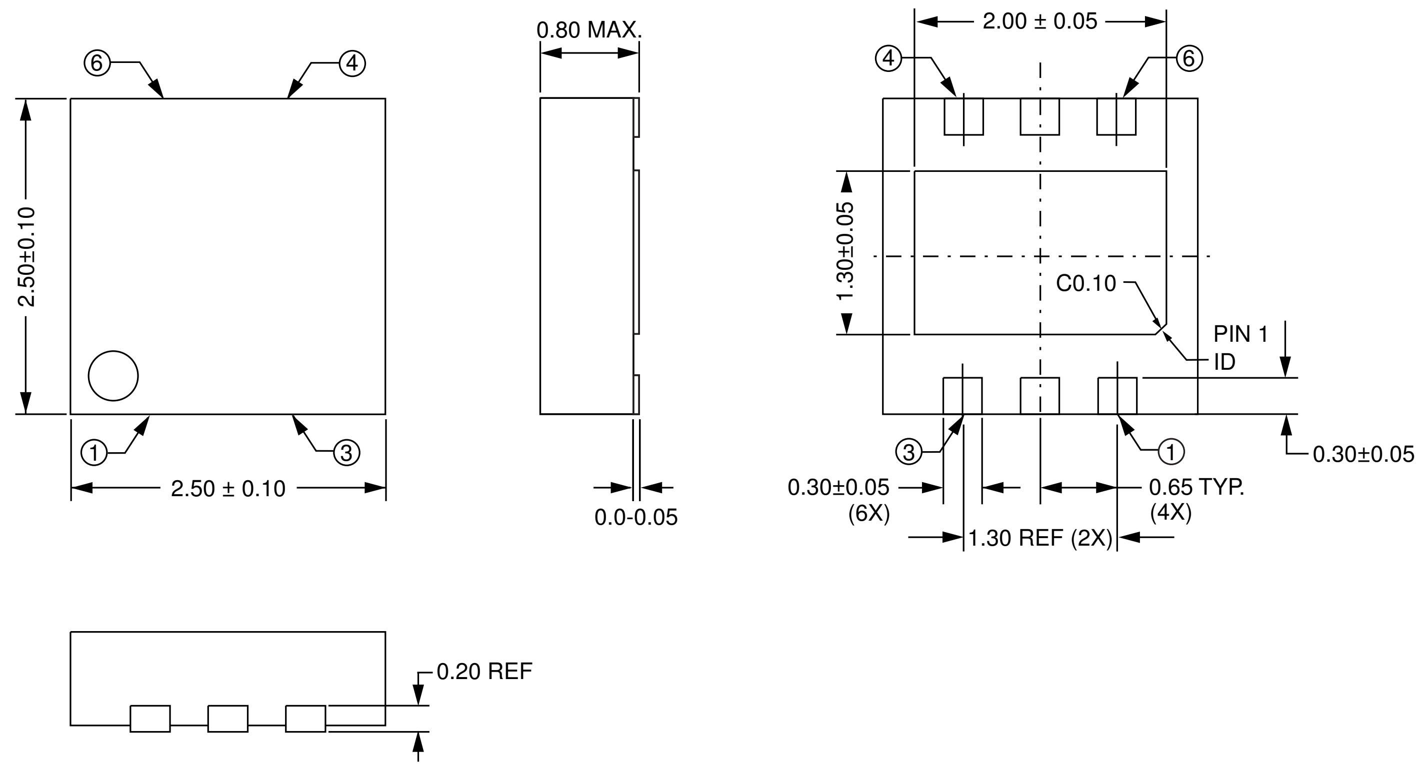
Notes:

- 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.

Available Parts

Part No.	Package	Marking	Description
ADT002-10E	TDFN6	FDYe	Low hysteresis, ultralow-power rotation sensor

2.5 mm x 2.5 mm TDFN6 Package



RoHS
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Notes:

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

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Revision History

SB-00-048-C
July 2022

Change

- Removed ADT001 to for a standalone datasheet. See SB-00-155-A for ADT001 standalone datasheet.
- Removed FAULT sensor functionality.
- Max. Agular Hysteresis specification increased from 6° to 8°.

SB-00-048-B
April 2017

Change

- Tightened supply current spec. based on more test data.
- Clarified repeatability vs. accuracy (p. 2).
- Added performance graphs of angular hysteresis vs. temperature and supply voltage.

SB-00-048-A
Sept. 2016

Change

- Initial release.

SB-00-048-PRELIM
May 2016

Change

- Preliminary release.

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