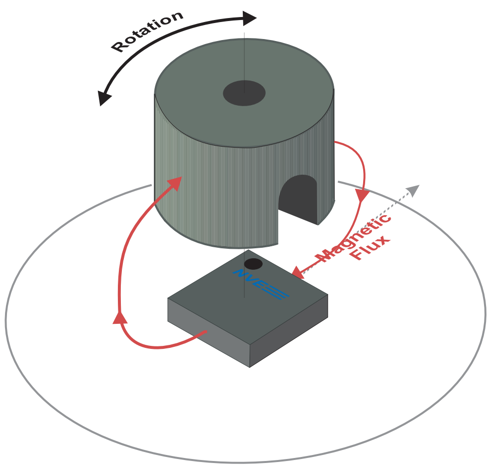
ASR002 Smart TMR Angle Sensor



Features

- Rotational speeds to 375,000 RPM
- 3.3 volt or 5 volt compatible four-wire SPI interface
- Robust airgap and misalignment tolerances
- Factory calibrated
- Ultraminiature 2.5 x 2.5 x 0.8 mm TDFN6 package

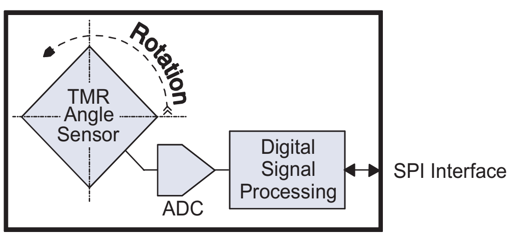
Key Specifications

- 0.1° resolution
- ±0.2° repeatability
- Robust 6 to 20 mT (60 to 200 Oe) field operating range
- Fast 12.5 kSps sample rate
- Flexible 2.2 to 3.6 V supply range
- Low 4 mA typical supply current
- Full –40 °C to 125 °C operating range

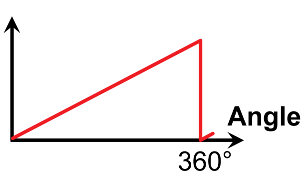
Applications

- Rotary encoders
- Robotics
- Motor control
- Automotive applications
- Internet of Things (IoT) end nodes

Block Diagram



Transfer Function



Description

ASR002 TMR Smart Angle Sensors provide a precise digital angle measurement over a wide range of speeds.

The sensor combines precise, low-power Tunneling Magnetoresistance (TMR) sensing elements with sophisticated digital signal processing.

The sensor is factory calibrated, with coefficients stored in internal memory.

A four-wire SPI interface provides angle data and allows setting device parameters.

The ASR002 is designed for harsh industrial or automotive environments with ESD protection, and full –40 °C to 125 °C operating temperature range.

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344 (952) 829-9217 www.nve.com YouTube.com/NveCorporation sensor-apps@nve.com

Boundary Ratings

Parameter	Min.	Max.	Units
Supply voltage	−12	4.2	Volts
Input and output voltages (MISO, MOSI, SS, SCLK)	−0.5	V_{CC}+2.5 up to 5.8	Volts
Input current	−100	+100	mA
Storage temperature	−55	150	°C
ESD (Human Body Model)		2000	Volts
Applied magnetic field		Unlimited	Tesla

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Operating Specifications (T_{min} to T_{max}; $2.2 < V_{DD} < 3.6$ 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}	2.2		3.6	V	
Supply current	I_{DD}		4	6	mA	Max. at V_{DD} = 3.6V
Power-on Reset supply voltage	V_{POR}		1.4		V	
Brown-out power supply voltage	V_{BOR}	0.75	1	1.36	V	
Start-up time	T_{STA}		15		ms	
Magnetics						
Applied magnetic field strength	H	20	12	20	mT	
		60	120	200	Oe	
Accuracy and Repeatability						
Angular resolution	δ		0.1			
Angular hysteresis	⎎			0.1		
Repeatability			±0.2		Angular Degrees	Fixed temperature and bias[1]
Angular accuracy, fixed bias[1]	ε			±2 ±3		0 to 85°C −40 to 125°C
Angular accuracy, variable bias[2]				±6		−40 to 125°C
Speed						
Sample rate			12.5		kSps	
SPI Bus Characteristics						
Bus voltage	V_{BUS}	2.2		5.5	V	
Low level input threshold voltage	V_{IL}	0.8			V	
High level input threshold voltage	V_{IH}			2.2	V	
Low level output current	I_{OL}	3			mA	V_{OL} = 0.4V
I/O capacitance	$C_{I/O}$			10	pF	
SPI Setup and Hold Timing						
Data transfer rate	DR			2	Mbits/s	Full duplex
SCLK Rise time	t_R				ns	
SCLK fall time	t_F				ns	
SCLK low time	t_{CL}	200			ns	
SCLK fall time	t_{CH}	200			ns	
SS to SCLK setup	t_{SE}	80			ns	
SCLK to MISO valid	t_{SDD}			170	ns	See figure 7
SS to MISO tri-state	t_{SDZ}			170	ns	
SCLK to MOSI hold time	t_{SDH}	80			ns	
MOSI to SCLK setup	t_{SDS}	80			ns	
SCLK to SS hold time	t_{SH}	80			ns	
SS to MISO valid	t_{SEZ}			170	ns	
RAM Timing						
Address setup time	t_{ADDR}	3			µs	See figure 4
Data read time	t_{READ}	10			µs	
Nonvolatile Memory Characteristics						
Address setup time	t_{ADDR}	3			µs	
Data read time	t_{READ}	10			µs	See figure 5
Data write time	t_{NVM}	20			ms	
Endurance			10000		Cycles	
Package Thermal Characteristics						
Junction-to-ambient thermal resistance	θ_{JA}		320		°C/W	
Package power dissipation			500		mW	

Specification Notes:

1. "Fixed Bias" means a fixed airgap within between the bias magnet and sensor so the magnitude of the magnetic field at the sensor is constant within the specified field range of the parts. The highest accuracy is obtained using fields closest to the 17.5 mT (175 Oe) factory calibration field.
2. "Variable Bias" means the magnitude of the magnetic field at the sensor can vary across the entire specification range.

ASR002 Overview

The ASR002 is a non-contact angle sensor designed for high speed applications where size is limited. The heart of the ASR002 is a tunneling magnetoresistive (TMR) sensor. In a typical configuration, an external magnet provides a magnetic field of 6 to 20 mT (60 to 200 Oe) in the plane of the sensor, as illustrated below for a bar magnet and a diametrically-magnetized disk magnet. Factory-programmed signal conditioning is combined with a temperature sensor and digital linearization to produce high speed, accuracy, and precision in a tiny 2.5 x 2.5 mm TDFN package.

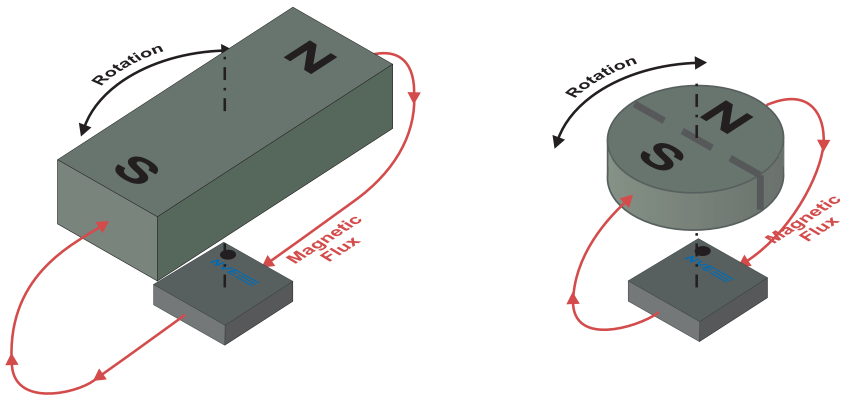


Figure 1. Sensor operation.

ASR002 Operation

A detailed block diagram is shown below:

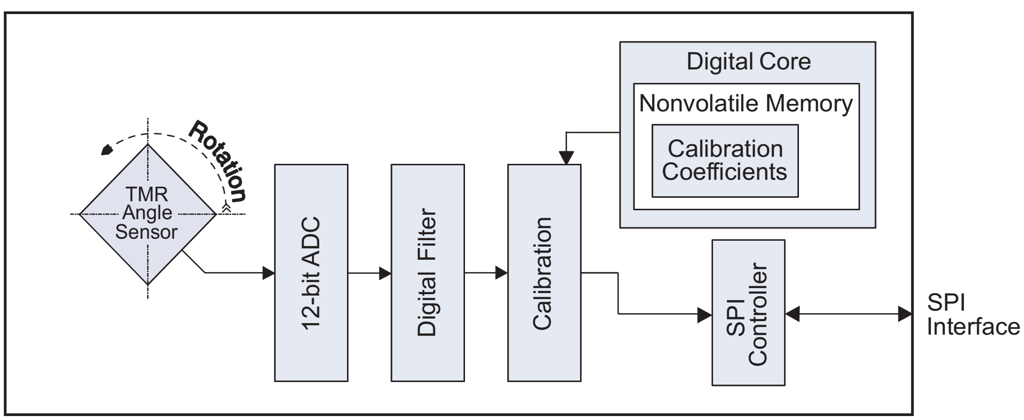


Figure 2. Detailed block diagram.

TMR Angle Sensor Element

ASR002 sensors use unique TMR sensor elements that are inherently high speed and low noise. The digital core calculates the angle from sensor element Sine and Cosine vectors, and the raw sensor data are available from separate memory locations.

ADC

The sensor output is digitized with a 12-bit ADC. The extra bits ensure precision and computational accuracy.

Digital Filter

A first-order Infinite Impulse Response (IIR) digital filter with a programmable cutoff frequency can be used for ultralow noise if high-frequency operation is required. The factory default is the filter turned off.

Rotation Direction

The ASR002 can provide increasing angle values for either clockwise or counterclockwise field rotations. Counterclockwise is defined as a rotating field vector through pins 1-3-4-6, and clockwise through pins 1-6-4-3. The rotation direction can be programmed using the θ_{DIR} parameter.

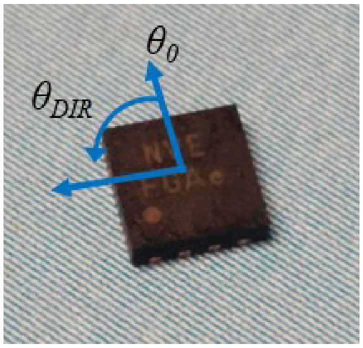


Figure 3. Zero-angle reference (θ_0) and rotation direction (θ_{DIR}).The rotational center of the sensor is the package center.

Zero-Angle Reference Point

A programmable parameter θ_0 sets the zero-degree reference or angular offset. This is the angle of "discontinuity," that is, where the angle output changes from 360° to 0°. The default θ_0 value is zero for magnetic fields pointing from pin 1 to pin 6.

Direction and Hysteresis

The Direction output indicates direction of rotation. A hysteresis setting can be changed to prevent small changes from causing the Direction output to "chatter," especially at low speed.

Digital Filter

The digital filter is an Infinite impulse response (IIR) weighted running average filter, which can reduce mechanical and electrical noise depending on the required speed.

The filtered output is calculated as follows:

$$\theta_n = \theta/m + [(m-1)/m]\theta_{n-1}$$

Where θ = is the measured angle; θ_n = the filtered angle; θ_{n-1} is the previous value of the filtered angle; and *m* is a constant that determines the cutoff frequency as follows:

$$f_{CUTOFF} = f_{SAMPLE}/(2\pi\ m)$$

Where f_{CUTOFF} is the filter cutoff frequency and f_{SAMPLE} is the sensor ADC sampling rate (approximately 12500/s). So for example, if *m* = 10, the cutoff frequency is approximately 200 Hz.

m = 1 disables filter so the output is simply updated with each sample.

A Simple SPI Interface

The SPI interface is an industry standard four-wire, full-duplex 2 megabit per second connection with the sensor as the slave to an external master such as a microcontroller. SPI data (MOSI and MISO) and the Clock (SCLK) are 2.2 volt to five-volt compliant. The digital angle is the default two byte response.

The ASR002 uses an industry-standard "Mode 0" interface (data is sampled at the leading rising edge of the clock; CPOL=0 and CPHA=0). In accordance with industry standards, slave select (SS) is active-low, and bit order and byte order are from MSB to LSB.

Details are shown in the following timing diagrams:

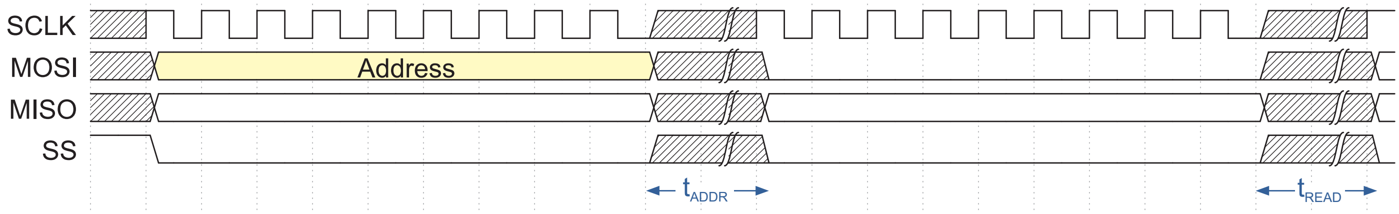


Figure 4a. Sending the address for a read.

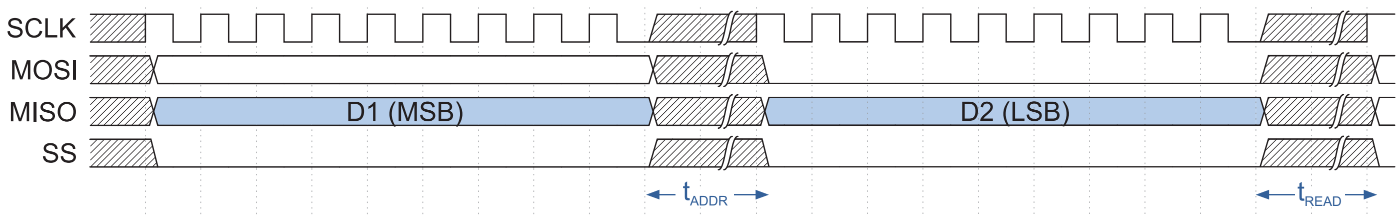


Figure 4b. Reading data.

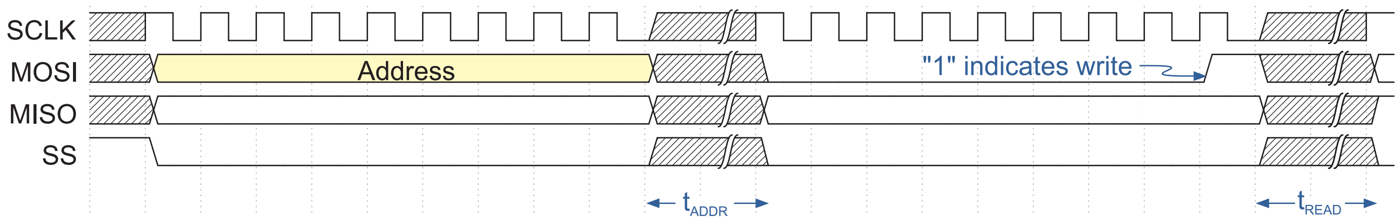


Figure 5a. Sending the address for a write.

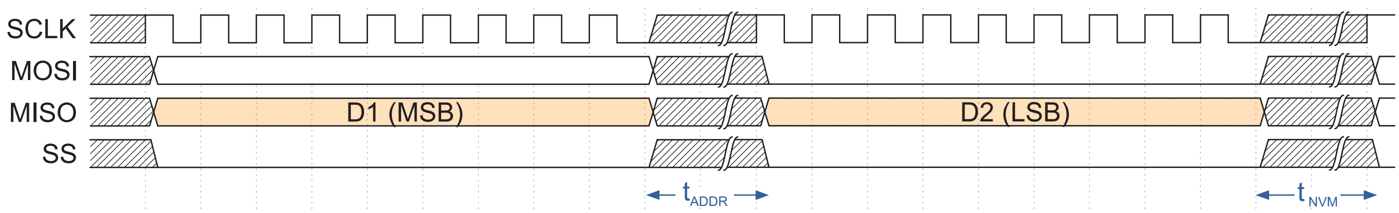


Figure 5b. Writing data.

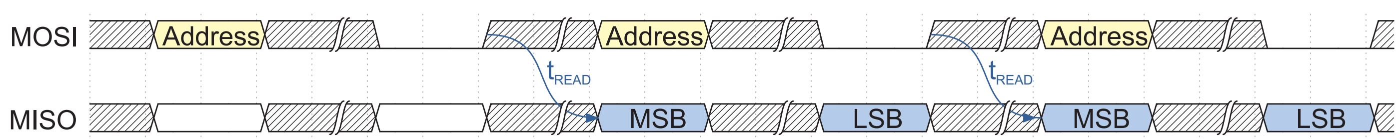


Figure 6. Continuous read.

SPI setup and hold timing constraints are shown in Figure 7:

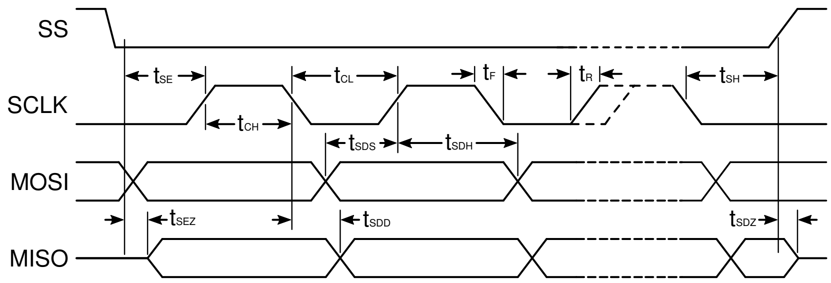


Figure 7. SPI setup and hold timing.

A schematic of a typical interface to a 3.3-volt or five-volt microcontroller is show in Figure 10.

Straightforward Reading and Writing

The sensor is reset on a falling edge of SS. All reads and writes are initiated by the master pulling SS "LOW" and sending an eight-bit address to the ASR002 plus a second byte. The least significant bit of the second address byte indicates whether the address request is for a read or a write ("0" is a read; "1" is a write). The slave responds with two bytes of data.

As shown in figures 4 and 5, and the specification table, a 3 µs delay (t_{ADDR}) is needed between address bytes; 10 µs (t_{READ}) should be allowed before data can be read, and 20 ms (t_{NVM}) should be allowed for writing parameters to the nonvolatile memory.

Reading the angle

To read the angle, the master simply writes two zero bytes for the "0" angle address, then reads the two-byte angle, which is expressed in tenths of degrees. These two-byte reads can be repeated to continuously read the angle as shown in the Figure 6 timing diagram and the code on p. 14.

Reading and writing parameters

Reading and writing parameters are simple four-byte sequences. The master writes two bytes for the parameter address, then reads or writes two bytes for the parameter value. Illustrative code to zero the sensor by writing the offset parameter is shown on p. 15.

The number of bits in different parameters varies. Unused bits are sent as zeros by the sensor. Similarly, unused bits should be written as zeros to the sensor to avoid an out-of-range parameter that could be ignored.

Memory Map

The ASR002 memory provides access to angle data and user-programmable parameters. The memory is accessed via SPI as described in the SPI interface section.

Parameter	Symbol	Default	Read/ Write	Range	Address	Description
Data						
Angle	θ	N/A	R	0 – 3600	0x00	In tenths of a degree
Raw Sin Vector	Sinθ			Approx. 1500 – 2500	0x01	Raw outputs centered at approx. 2048 with peak-peak amplitudes of approx. 1000.
Raw Cos Vector	Cosθ				0x02	
Direction	Dir			0 – 1	0x03	0 = decreasing angle 1 = increasing angle
User-Programmable Parameters						
Rotation Direction	θ_{DIR}	0	R/W	0 – 1	0x40 [bit 0]	0 ➔ increasing CCW; 1 ➔ increasing CW (see Fig. 3)
Angular Offset	θ_0	0		0 – 3600	0x41 [bits 13:0]	Point at which angle is zero (see Fig. 3)
Digital Filter Constant	m	1		1 – 255	0x42	$f_{CUTOFF} = f_{SAMPLE}/(2\pi\ m)$; f_{SAMPLE} = approx. 12.5 kSps m = 1 disables filter
Direction Hysteresis	δ_{DIR}	25		0 – 255 (0 – 25.5°)	0x43	Hysteresis of the “Dir” output; in tenths of a degree
Read-Only Memory						
Lot code	YY	N/A	R	N/A (ASCII)	0x80–x81	ASCII date code in the form YYWWXX, where: YY = year; WW = work week; XX = internal code. The left-most character is in address 0x80 and the right-most in 0x85.
	WW				0x82–x83	
	XX				0x84–x85	

Table 1. ASR002 Memory Locations.

Power-Up and Initialization

Absolute position

Unlike some encoder types, ASR002 sensors detect absolute position and maintain position information when the power is removed. The sensor powers up indicating the correct position.

Nonvolatile parameters

All parameters are nonvolatile so they can be set once (via SPI), and remain for the life of the product if desired.

Minimizing Magnetic Interference

Several precautions can be taken for applications requiring the best accuracy to avoid distorting the magnetic field at the sensor:

- Components such as resistors and capacitors are generally slightly magnetic, and should be located at least several millimeters from the sensor.
- If components must be located near the sensor, ultrasmall components such as 0201 (0603 metric) contain less ferromagnetic material than larger components.
- Nonmagnetic resistors and capacitors can be used for extremely sensitive applications. A nonmagnetic 0.1 µF bypass capacitor can be used close the sensor, with a conventional 10 µF ceramic capacitor at least several millimeters away.

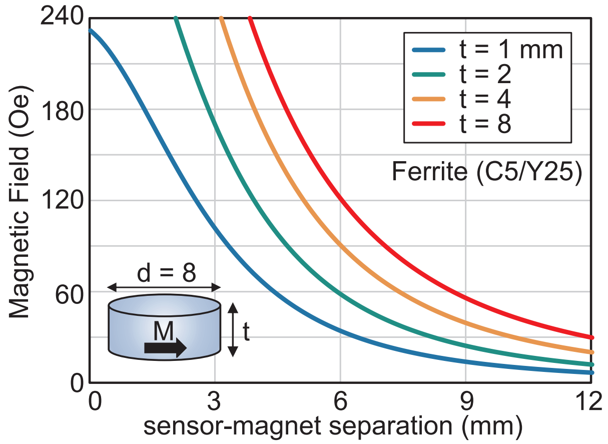
Minimizing Noise

Several steps minimize noise:

- Inadequate bypassing can cause noise or anomalous device behavior. 10 µF total bypass capacitance is recommended. To minimize magnetic field disruption, a small (e.g., 0201 / 0603 metric) 0.1 µF ceramic capacitor can be placed as close as possible to the V_{DD} and GND pins with a 10 µF ceramic capacitor a few millimeters away. The small capacitors contain very little ferromagnetic material.
- Use a circuit board ground plane.
- If the sensor is not being used for current over trace sensing, ground the sensor's center pad so the leadframe acts as a shield.

Magnet Selection

The sensor's wide operating field range of 6 to 20 mT (60 to 200 Oe) allows inexpensive magnets and operation over a wide range of magnet spacing. The figures below show the magnetic field for various magnet geometries and distances for inexpensive C5/Y25 grade ferrite magnets:



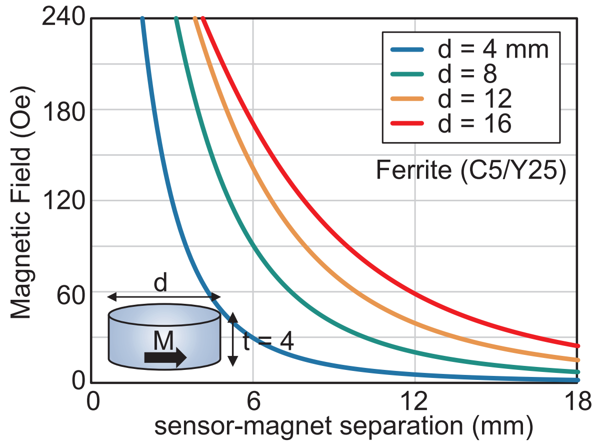


Figure 8. Magnetic fields for various geometries of C5/Y25 ferrite magnets plotted for the distance between the magnet and sensor. Eight-millimeter diameter magnets of various thicknesses are shown at left, and four-millimeter thick magnets of various diameters are shown at right.

Field varies less with distance for larger magnets, so maximizing magnet size within the mechanical constraints of the system maximizes accuracy.

Higher-grade magnets can be used for high-temperature applications or large magnet-sensor separations. The graph below shows field strengths with various materials:

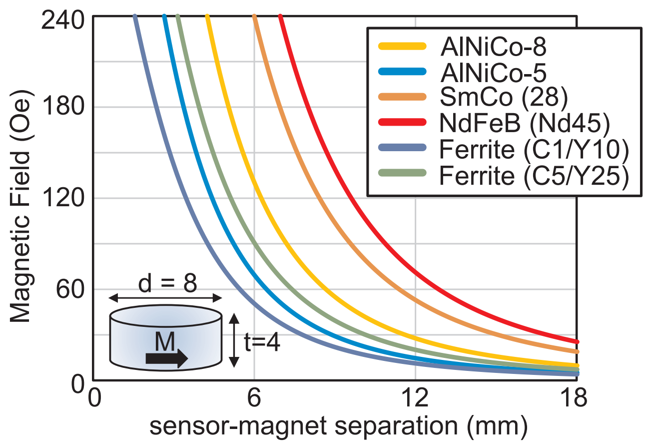


Figure 9. Magnetic fields from an 8 millimeter diameter, 4 millimeter thick magnet for increasing magnet-sensor separation. NdFeB materials produce the largest magnetic fields and separations. SmCo and AlNiCo materials offer the highest operating temperatures. Ferrite magnets are the most cost-effective.

Our free Web app can be used to determine optimum separations for various magnet sizes and materials:
https://www.nve.com/spec/calculators.php.

NVE's Online Store stocks popular magnets.

Application Circuits

Typical Microcontrollers Interface
A typical microcontroller interface is shown below:

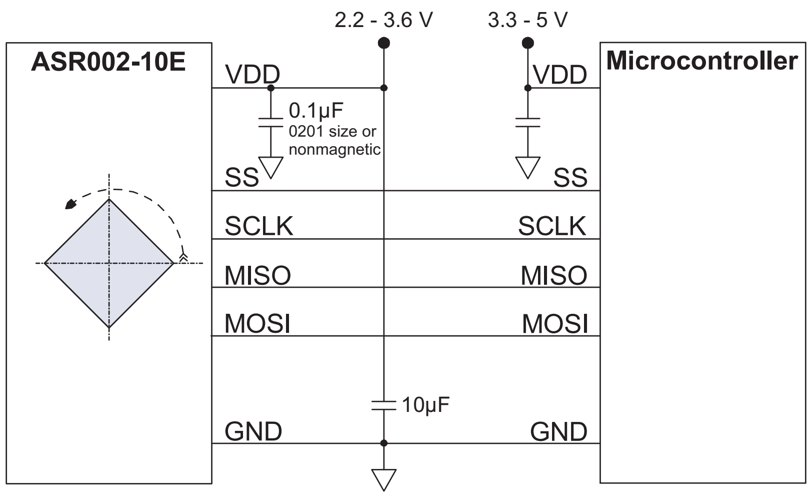


Figure 10. Typical microcontroller interface.

The ASR002 is configured as a Slave and the microcontroller should be configured as the Master. The ASR002 SPI interface is compatible with 3.3 or five-volt microcontrollers.

Typical Read and Write Communications Pseudocode

```
//SPI clock set elsewhere (2 MHz max.)
//SPSR = SPI Status Register; SPIF = SPI Status Register Interrupt flag
//SS set low (active) elsewhere
      {
      case COMM_GET_MEM:          //Routine to READ memory
SPDR=buffer[1];                   //Sends the address to read from
while(! (SPSR & (1<<SPIF)));      //Waits for transmission
_delay_us(3);                     //Allow 3 microseconds between address bytes

SPDR=0x00;                        //'0' for second address byte (indicates read)
while(! (SPSR & (1<<SPIF)));      //Waits for transmission
_delay_us(10);                    //Allows 10 microseconds for the address to be sent

SPDR=0x00;
while(! (SPSR & (1<<SPIF)));      //Waits for transmission to complete
_delay_us(10);                    //Allows 10 microseconds for data to be sent
MSB=SPDR;                         //Reads the first byte of data (MSB)

SPDR=0x00;
while(!(SPSR & (1<<SPIF)));
_delay_us(10);                    //Allows 10 microseconds for data to be sent
LSB=SPDR;                         //Reads the second byte of data (LSB)

buffer[0]=MSB;                    //Stores data in the buffer
buffer[1]=LSB;

*output_len=2;                    //Number of bytes to transmit
break;

      case COMM_SET_MEM:          //WRITE memory routine (to set sensor parameters)
SPDR=buffer[1];                   //Puts the address to read from in the buffer
while(! (SPSR & (1<<SPIF)));      //Wait for transmission to be complete
_delay_us(3);                     //Allow address byte to be sent

SPDR=0x01;                        //'1' for second address byte (write bit)
while(! (SPSR & (1<<SPIF)));      //Wait for transmission to complete
_delay_us(10);                    //Allows time for data to be sent

SPDR=buffer[2];                   //Read first data byte(MSB)
while(! (SPSR & (1<<SPIF)));
_delay_us(10);                    //Allows time for the data to be sent

SPDR=buffer[3];                   //Read second data byte(LSB)
while(! (SPSR & (1<<SPIF)));
_delay_ms(20);                    //Allows 20 MILLIseconds to write to nonvolatile memory

break;
      }
```

Illustrative Arduino Code for Continuous Read

```
/******************************************************************************
Continuously read the angle from an NVE ASR002 Smart Angle Sensor
Arduino Uno connections: pin 10=SS; pin 11=MOSI; pin 12=MISO; pin 13=SCLK
******************************************************************************/

#include <SPI.h>
int angle;

void setup() {
pinMode(10, OUTPUT); //Pin 10 = Sensor SS
SPI.begin ();

//Set clock rate at 2 Mbits/s; MSB first; Mode 0
SPI.beginTransaction(SPISettings(2000000, MSBFIRST, SPI_MODE0));
digitalWrite(CS, HIGH); //Disable to reset the sensor
digitalWrite(10, LOW); //Re-enable sensor
}

void loop() {
angle = (SPI.transfer (0))<<8; //Send 0 for address angle; receive angle MSB
delayMicroseconds (3); //Allow 3 us between address bytes
angle |= SPI.transfer (0); //2nd address byte (0 for read); receive angle LSB
delayMicroseconds (10); //Allow 10 us for next data
}
```

Illustrative Arduino Code to Zero the Sensor

```
/*************************************************************************************
Zeros an ASR002 at its current location to establish a "home position."
Arduino Uno connections: pin 11=MOSI; pin 12=MISO; pin 13=SCLK; pins 9 & 10=SS
Includes a simple procedure to read the angle.
*************************************************************************************/
#include <SPI.h>
int angle;

void setup() {
pinMode(10, OUTPUT); //Pin 10 = Sensor SS
SPI.begin ();

//Set clock rate to 2 Mbits/s; MSB first; Mode 0
SPI.beginTransaction(SPISettings(2000000, MSBFIRST, SPI_MODE0));
digitalWrite(10, HIGH); //Disable to reset the sensor
digitalWrite(10, LOW); //Re-enable sensor

//Read starting angle
SPI.transfer (0); //Send 0 for address angle to read starting angle
delayMicroseconds (3); //Allow 3 us between address bytes
angle = (SPI.transfer (0x41))<<8; Read starting angle MSB and point to offset address
delayMicroseconds (3); //Allow 3 us between address bytes
angle |= SPI.transfer (1); //Read angle LSB; 2nd address byte = 1 for write
delayMicroseconds (10); //Allow 10 us for next data

//Reset offset
SPI.transfer (0); //Write offset MSB
delayMicroseconds (3); //Allow time between bytes
SPI.transfer (0); //Write offset LSB
delay (20); //20 ms NVM delay

//Write measured angle to offset parameter to zero the sensor
angle=getAngle(); //Read angle now that offset has been set to zero
SPI.transfer (0x41); //Point to offset address
delayMicroseconds (3); //Allow time between address bytes
SPI.transfer (1); //2nd address byte = 1 for write
delayMicroseconds (10);
SPI.transfer (0x41); //Write to offset parameter to zero the sensor
delayMicroseconds (3);
SPI.transfer (angle & 0xFF); //Write LSB
delay (20); //20 ms NVM delay
}

void loop() {}

//Procedure to read the angle
int getAngle(){
int angle;
angle = (SPI.transfer (0))<<8; //Send 0 for address angle; receive angle MSB
delayMicroseconds (3); //Allow 3 us between address bytes
angle |= SPI.transfer (0); //2nd address byte (0 for read); receive angle LSB
delayMicroseconds (10); //Allow 10 us for next data
return angle;
}
```

In Case of Difficulty

Random data, or measured angles outside the allowable 0 to 3600 range.
- The SPI clock may be too fast (the ASR002 maximum clock rate is specified as 2 Mbits/s).
- Ensure the Master is operating in the correct mode (Mode 0).

Random data, or measured angles outside the allowable 0 to 3600 range on the first readings after the sensor is selected.
- The sensor is reset on a falling edge of SS. Toggling SS HIGH, then LOW will ensure the sensor is reset.

MSB/LSB bytes are reversed.
- The MSB should be read first. SPI devices use different byte orders, but the ASR002 follows the most common convention of MSB first.

Angle data is shifted by one or more bits.
- This is usually because the sensor has not completed internal shifting of bits into the correct positions. Ensure there is enough settling time between writing the address and reading the data (10 µs minimum).

Garbled data on first startup of Master.
- Data can be left in the sensor if the Master microcontroller is reset and the sensor is not. This can be corrected by doing a "dummy read" as part of the microcontroller startup sequence, or toggling SS HIGH then LOW to reset the sensor.

Parameters do not appear to be written correctly.
- Ensure that the Write bit is set in the second (LSB), i.e., the second address byte is a "1."

- Ensure there is adequate settling time before reading or using a written parameter (10 milliseconds minimum). Parameters are stored in nonvolatile memory, not RAM, and writing to nonvolatile memory is much slower.

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Evaluation Support

Breakout Board

The AG957-07E breakout board provides easy connections to an ASR002-10E angle sensor with a six pin connector. It also has a recommended 1 µF bypass capacitor:

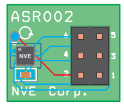


Figure 11. AG957-07E breakout board (actual size)
0.5" x 0.6" (12 mm x 15 mm)

Smart Angle Sensor Evaluation Kit

This simple board includes an ASR002-10E Smart Angle Sensor, a microcontroller that interfaces to the Sensor via SPI, and to a PC via USB. The kit includes a diametrically-magnetized cylindrical horseshoe magnet and fixturing. A PC-based user interface provides two-way communication with the sensor to display the sensor outputs and change the sensor’s parameters.

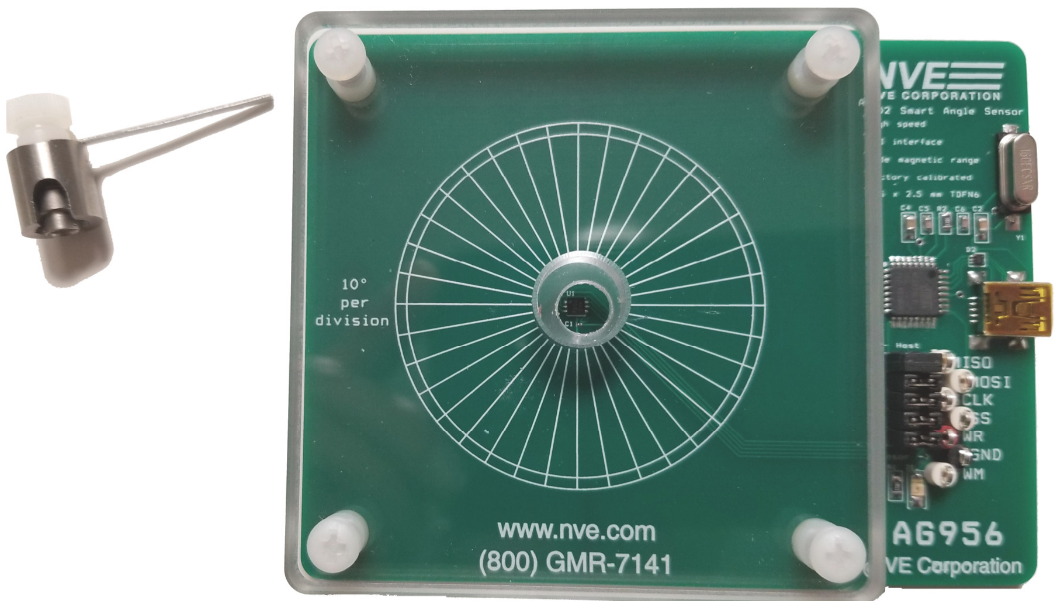


Figure 12. AG956-07E: Smart Angle Sensor Evaluation Kit.

Socket Board

The AG954-07E provides a TDFN6 socket for easy interface to sensors such as the ASR002-10E without soldering:

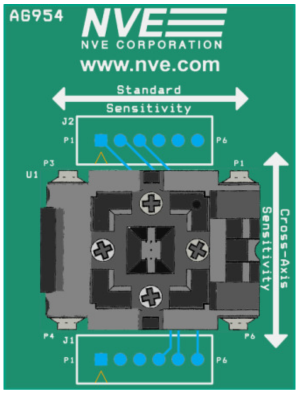


Figure 13. AG954-07E: TDFN socket board
1.5" x 2" (38 mm x 50 mm)(actual size)

Magnets
NVE stocks five popular magnets for use with its angle sensors:

NVE Part Number	**Compatible Magnet Holder**	**Diameter** (mm)	**Length** (mm)	**Typ. sensor distance** (mm; 12 mT/120 Oe nom. field)	**Material and Configuration**
12526	4 mm	4	4	3	C5/Y25 ferrite disk magnets
12249	N/A	12.5	3.5	4	
12527	8 mm	8	4	5	
12528	8 mm	8	8	6	
12426*	N/A	11	11	8	Alnico-5 round horseshoe magnet with mounting hole

*Included in the AG956-07E Smart Angle Sensor Evaluation Kit.

Table 2. Popular magnets for angle sensing.

Magnet Holders
NVE offers two magnet holders for evaluation and prototyping. The holders are machined aluminum. Set screws secure the magnets in the holders and allow magnet position adjustments. There are threaded mounting holes for a thumbscrew to turn the magnet, or the hole can be used to attach the holder to a rotating shaft. A “clockhand” indicator helps track magnet rotation:

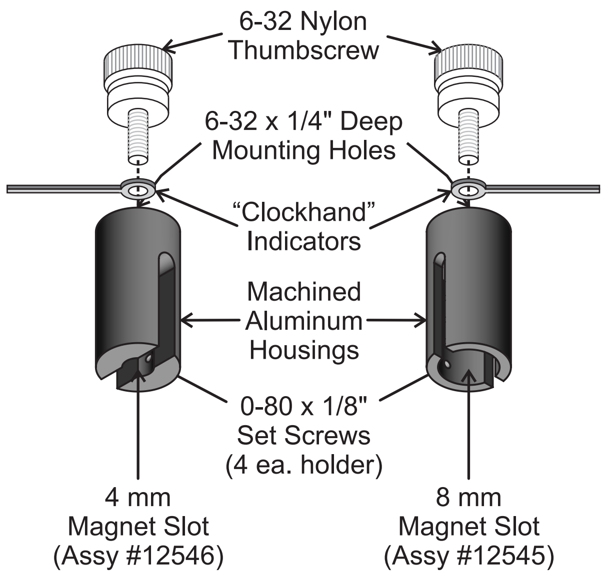


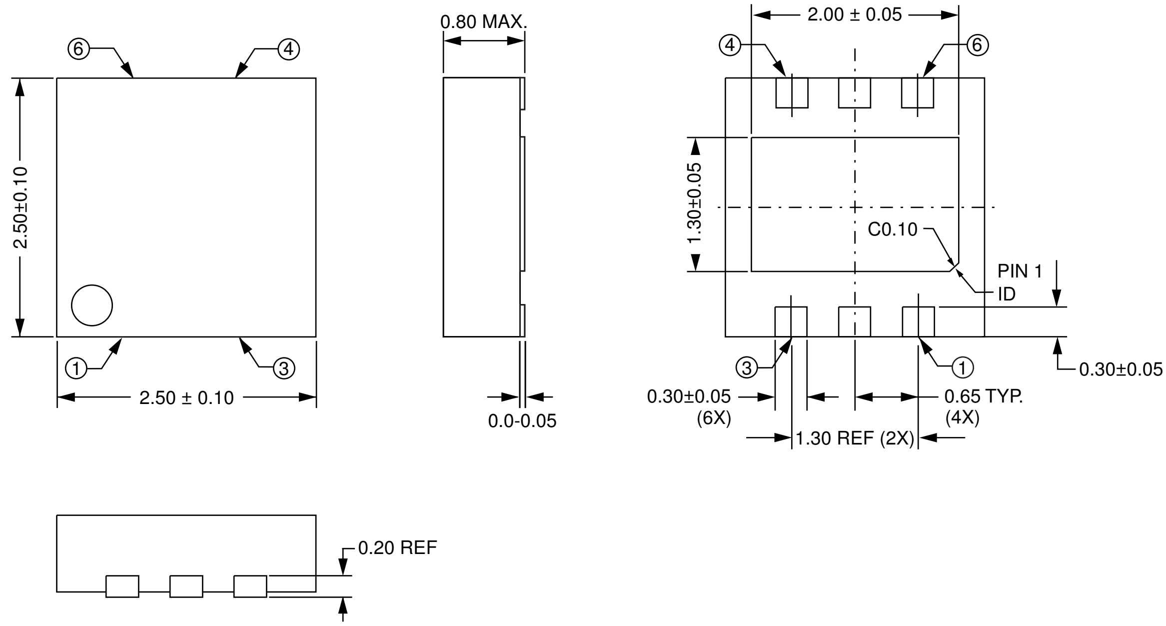
Figure 14. 4 mm magnet holder (part #12546; left) and 8 mm magnet holder (part #12545; right).
0.44" dia. x 0.88" tall (11 mm x 22 mm) outside dimensions; actual size).

The holders are compatible with several popular diametrically-magnetized disk magnets and can be used in the AG956-07E Evaluation Kit:

Holder Part Number	**Outside Dimensions**	**Compatible Magnets** (NVE part #s)	**Magnet Diameter** (mm)	**Max. Magnet Length** (mm)
12546	11 mm dia. x 22 mm tall	12526	4	4
12545		12527; 12528	8	8

Table 3. Magnet holders.

2.5 x 2.5 mm TDFN6 Package



Pad	Symbol	Description
1	GND	Ground/V_{SS}
2	SCLK	SPI Clock Input
3	MISO	Sensor SPI Data Output
4	VDD	Power Supply (bypass with a 1µF capacitor)
5	MOSI	Sensor SPI Data Input
6	SS	Sensor Select Input (low to select)
Center pad		Internal leadframe connection; connect to GND to minimize noise.

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

RoHS
COMPLIANT

Ordering Information

ASR002 - 10E TR13

Product Family
ASR = Smart Angle Sensors

Base Part Number
002 = High speed, medium accuracy

Field Range Identifier
Blank = General Purpose (6 to 20 mT / 60 to 200 Oe)

Part Package
10E = RoHS-Compliant 2.5 x 2.5 mm TDFN6 Package

Bulk Packaging
TR13 = 13" Tape and Reel Package

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Revision History

SB-00-081-K September 2019	**Change** • More specifics on bypass capacitors (p. 10). • Added bypass capacitor details to microcontroller application circuit. (p. 12). • Added second bypass capacitor to breakout board (p. 17).
SB-00-081-J August 2019	**Change** • Added Absolute Maximum output current specification (p. 2). • Offering a breakout board instead of a bare board (p. 17).
SB-00-081-I July 2019	**Change** • Clarified lot code formatting and corrected its memory address range (p. 9).
SB-00-081-H June 2019	**Change** • Noted 17.5 mT (175 Oe) factory calibration field (p. 4, Note 1). • Clarified two-byte and four-byte SPI read and write sequences (p. 8). • Corrected default filter memory setting (p. 9).
SB-00-081-G June 2019	**Change** • Added SI units (tesla) in addition to CGS (oersteds). • Changed Operating Specification "RAM Timing" from maximums to minimums.
SB-00-081-F April 2019	**Change** • Recommend 1 µF bypass capacitor.
SB-00-081-E Feb. 2019	**Change** • Improved "Magnet Selection" section. • Added magnet and magnet holder information (p. 18).
SB-00-081-D Feb. 2019	**Change** • Added details on center pad and grounding recommendation to minimize noise.
SB-00-081-C Jan. 2019	**Change** • Faster RAM timing. • Reduced data transfer rate from 2.5 to 2 Mbits/s for more design margin. • Corrected number of bits in angular offset. • Added Arduino code to zero the Sensor. • Added "In Case of Difficulty" section. • Dropped daisy-chained SPI application diagram (not supported). • Added AG954-07E socket board. • Typographic and cosmetic changes.
SB-00-081-B Jan. 2019	**Change** • Added typical communications pseudocode.
SB-00-081-A Jan. 2019	**Change** • Expanded and updated SPI timing specifications. • Added detailed SPI timing diagrams. • Tightened typ. supply current specification to 4 mA. • Revised minimum operating field to 60 Oe. • Added sensor direction output and hysteresis parameter. • Added raw Sin and Cos vector outputs. • Added illustrative microcontroller code. • Finalized pinout. • Added evaluation kit and board. • Dropped customer calibration capability (unnecessary). • Various typographic corrections.
SB-00-081-PRELIM	**Change** • Preliminary release.

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