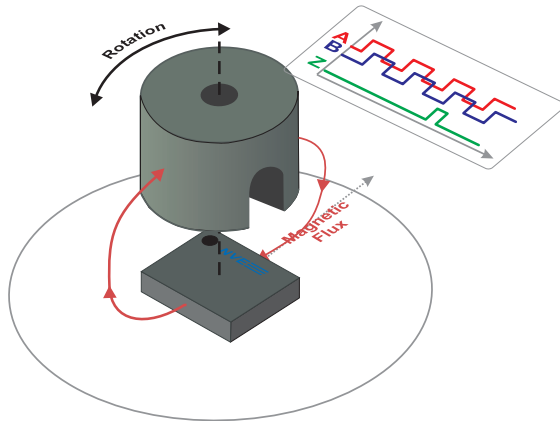
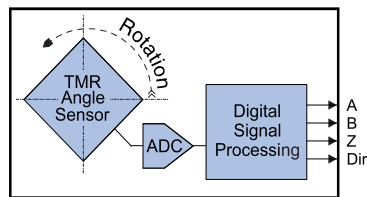


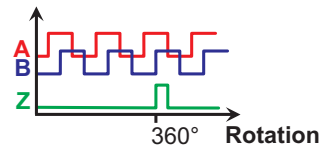
ASR022 ABZ Noncontact TMR Encoder Sensor



Block Diagram



Output



Features

- Rotational speeds to 15,000 RPM
- ABZ outputs
- Direction output
- 512 virtual lines (128 cycles) per revolution
- Robust airgap and misalignment tolerances
- Low power
- Factory calibrated
- Ultraminiature 2.5x 2.5x 0.8mm TDFN6 package

Key Specifications

- Robust 6 to 20 mT field operating range
- Flexible 2.2 to 3.6 V supply range
- Low 4 mA typical supply current
- Full -40 °C to 125 °C operating range

Applications

- Motion control
- Robotics
- Automotive applications
- Internet of Things (IoT) end nodes

Description

ASR022 noncontact TMR encoder sensors provide precise pulses indicating angular motion, and is smaller, lower power, and more accurate than other magnetic encoders.

An industry-standard ABZ interface allows the ASR022 to replace legacy optical encoders and provide noncontact operation, wide mechanical tolerance, and inherent dust and contaminant immunity.

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 an internal nonvolatile memory.

With its magnetic operation, ESD protection, and a full -40 °C to 125 °C operating temperature range, the ASR022 is ideal for harsh, contaminated environments.



ABZ Encoder Sensor

Boundary Ratings

Parameter	Min.	Max.	Units
Supply voltage	-12	4.2	Volts
Storage temperature	-55	150	°C
ESD (Human Body Model)		2000	Volts
Applied magnetic field		Unlimited	Tesla

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 $V_{DD} = 3.6$ V	
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	B	6	12	20	mT		
Accuracy and Repeatability							
Angular segments			512				
Angular hysteresis (backlash)	\square			2			
Repeatability			± 1		LSB	Fixed temperature and bias ¹	
Absolute accuracy, fixed bias ¹	ϵ			± 3			0 to 85°C
Absolute accuracy, variable bias ²				± 4			-40 to 125°C
				± 5		-40 to 125°C	
Speed							
Update rate			10		kSps		
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 factory calibration field.
2. "Variable Bias" means the magnitude of the magnetic field at the sensor can vary across the entire specification range.

ASR022 Overview

The heart of the ASR022 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 speed, accuracy, and precision in a tiny 2.5 x 2.5 mm TDFN package.

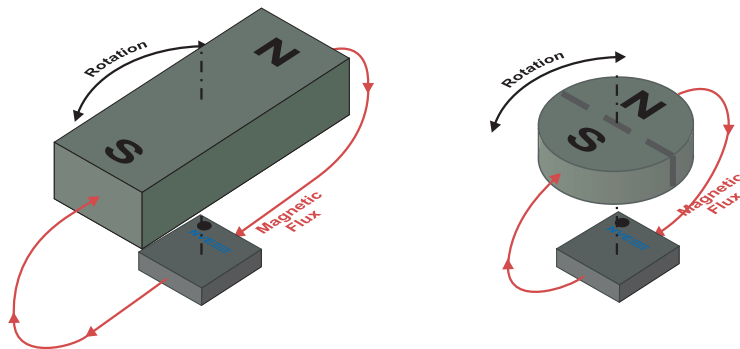


Figure 1. Magnetic operation.

ASR022 Operation

A detailed block diagram is shown below:

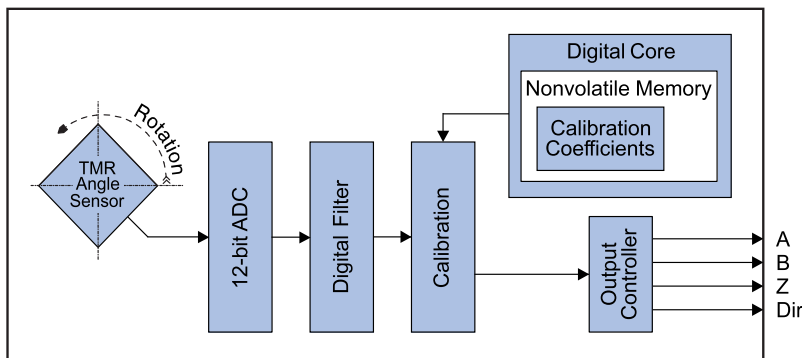


Figure 2. Detailed block diagram.

TMR Angle Sensor Element

ASR0x2 sensors use unique TMR sensor elements that are inherently high speed and low noise. The digital core calculates rotation from TMR sensor element.

ADC

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

Orientation and Direction

The zero reference is shown in the figure below. Direction is defined looking at the top of the device, so clockwise is defined as a rotating field vector through pins 1-6-4-3 and counterclockwise is through pins 1-3-4-6.

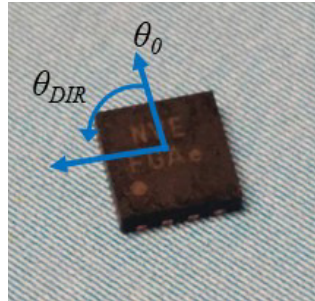


Figure 3. Zero-angle reference (θ_0) and counterclockwise rotation (θ_{DIR}). The rotational center of the sensor is the package center.

As shown in the timing diagram, below, output A leads B for clockwise magnet rotation, and B leads A for counterclockwise:

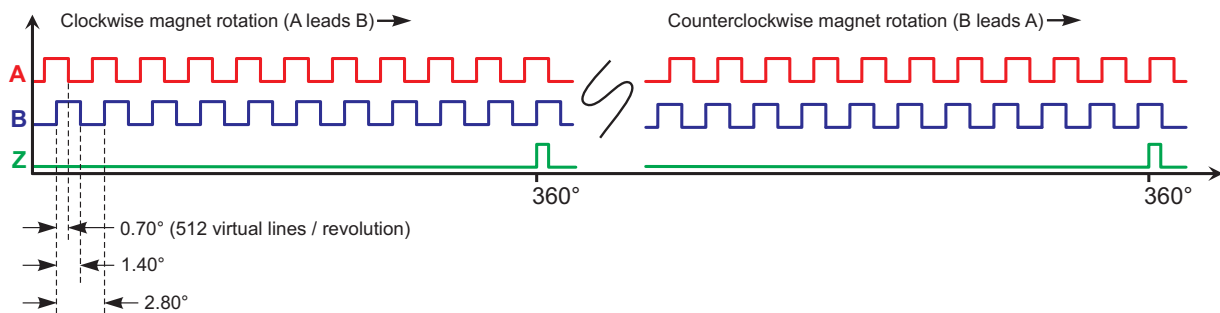


Figure 4. Timing diagram.

Minimizing Noise

Several steps can be taken to minimize noise:

- A 10 μ F bypass capacitor is recommended as close as possible to the V_{DD} and GND pins. A 0.080 x 0.050 inch or smaller capacitor is recommended to minimize magnetic interference with the sensor.
- Use a circuit board ground plane.
- Grounding the sensor's center pad allows the leadframe to act 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:

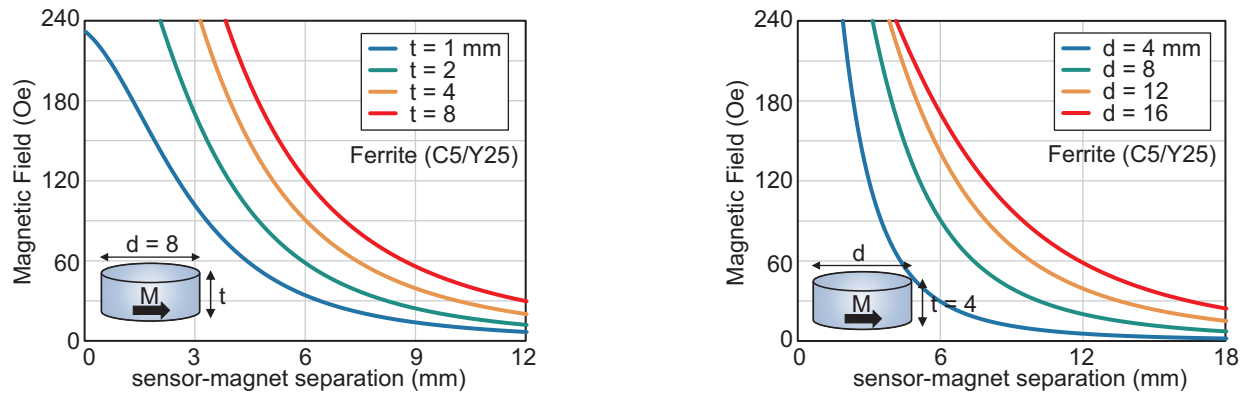


Figure 5. Magnetic fields for various geometries of C5/Y25 ferrite magnets plotted for the distance between the magnet and sensor. Eight-millimeter diameter magnets of various thicknesses are shown at left, and four-millimeter thick magnets of various diameters are shown at right.

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:

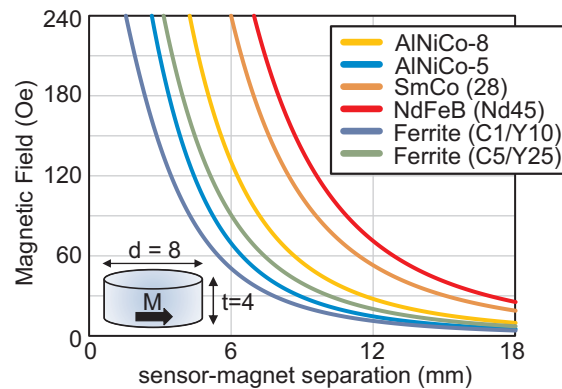


Figure 6. Magnetic fields from an 8 millimeter diameter, 4 millimeter thick magnet for increasing magnet-sensor separation. NdFeB materials produce the largest magnetic fields and separations. SmCo and AlNiCo materials offer the highest operating temperatures. Ferrite magnets are the most cost-effective.

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

Isolated Microcontroller Interface

Double isolation from human interface to line-voltage driven electrical circuitry is required in some safety intensive applications such as medical instruments. The mechanical gap between the magnet and the sensor can provide one level of isolation. Galvanic isolation from the sensor to the microcontroller provides a second isolation barrier. The IL715 isolator in the circuit above is rated at 2.5 kV isolation, is UL/VDE-compliant, and is available in an ultra-miniature QSOP package. The isolator can also level-shift between the 3.3-volt sensor and a five-volt microcontroller:

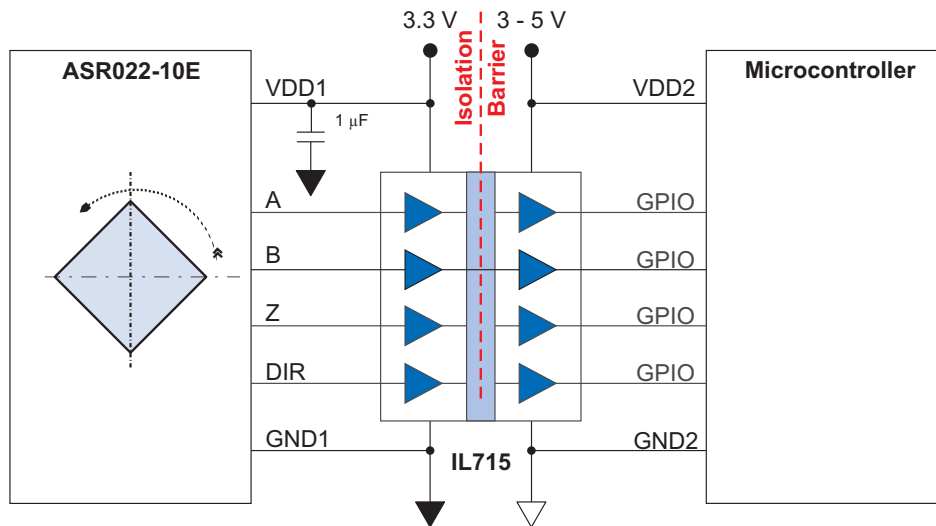


Figure 7. Isolated microcontroller interface.

Evaluation Support

Breakout Board

The AG957-07E breakout board provides easy connections to an ASR022-10E angle sensor with a six pin connector. It also has a recommended 10 μ F bypass capacitor:

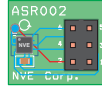


Figure 8. ASR0x2 breakout board (actual size)
0.5" x 0.6" (12 mm x 15 mm)

Smart Angle Sensor Evaluation Kit

This simple board includes a diametrically-magnetized cylindrical horseshoe magnet and fixturing. LEDs indicate the ASR022-10E outputs, and there is a three-digit rotation indicator:

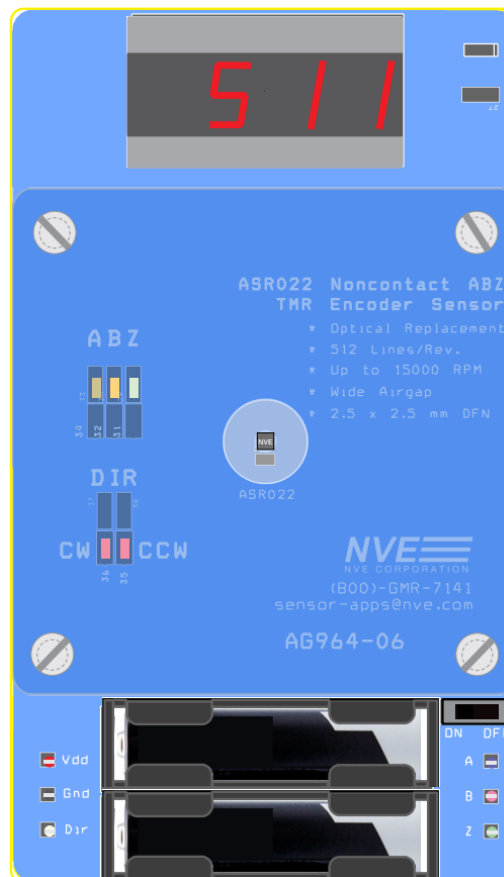


Figure 9. ASR022 TMR Encoder Sensor Evaluation Kit (AG964-07; actual size).
3" x 5.25" (76 mm x 133 mm)

Socket Board

The AG954-07E provides a TDFN6 socket for easy interface to sensors such as the ASR022-10E without soldering:

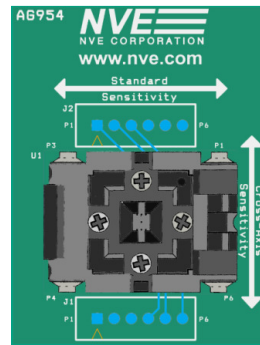


Figure 10. AG954-07E: TDFN socket board
1.5" x 2" (38 mm x 50 mm)(actual size)

Magnets

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

NVE Part Number	Compatible Magnet Holder	Diameter (mm)	Length (mm)	Typ. sensor distance (mm; 12 mT 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 Evaluation Kit for this encoder sensor.

Table 2. Popular encoder sensing magnets.

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:

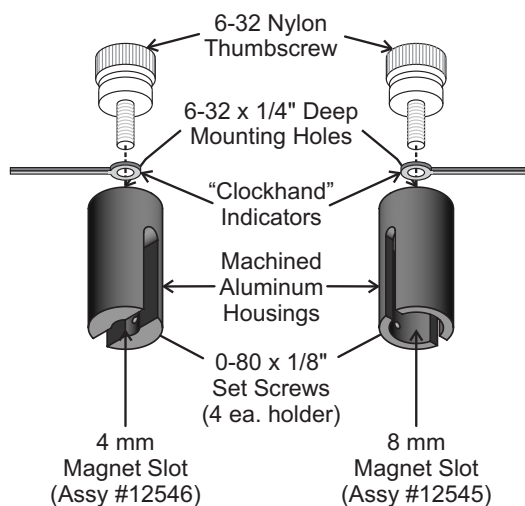


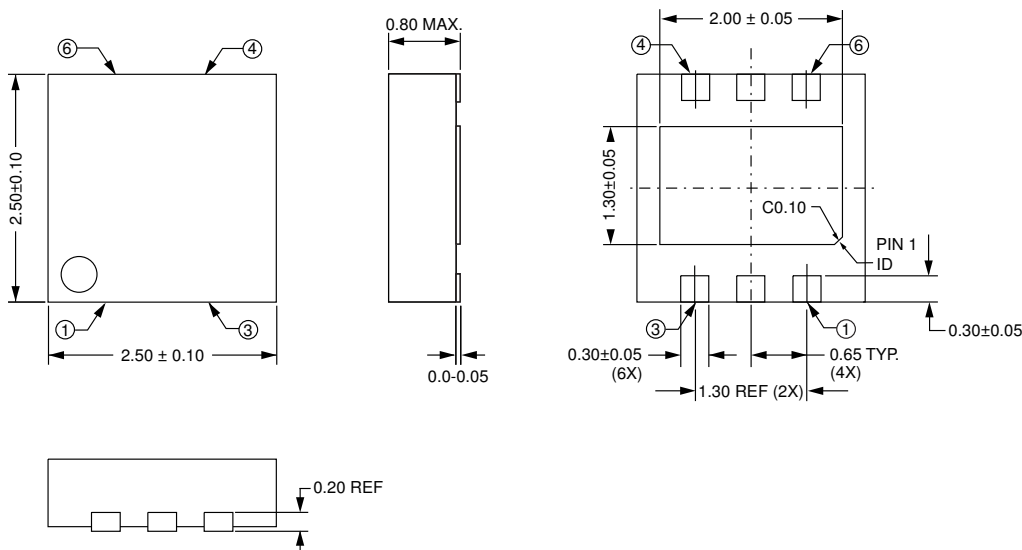
Figure 11. Four millimeter magnet holder (part #12546; left) and 8 mm magnet holder (part #12545; right). 0.44" dia. x 0.88" tall (11 mm x 22 mm) outside dimensions; actual size).

The holders are compatible with several popular diametrically-magnetized disk magnets and can be used with the Evaluation Kits:

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	A	A Output
3	B	B Output
4	VDD	Power Supply (2.2 – 3.6 V; bypass with a 10 μ F capacitor)
5	Z	Index output. HIGH indicates zero to 1 degree.
6	DIR	Direction output. Low is clockwise and HIGH is counterclockwise.
Center pad		Internal leadframe connection; connect to GND to minimize noise.

Notes:

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





ABZ Encoder Sensor

Ordering Information

ASR012- 10E TR13

Product Family

ASR = Smart Angular Sensors

I/O Interface

00 = SPI

01 = I²C

02 = ABZ

Sensor Element

2 = 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

Available Product Variants

Part Number	Evaluation Kit	Repeat-ability	Resolution	Speed	Outputs
ASR022-10E	AG964-07	0.2°	0.1°	12500 Sps	ABZ; Dir
ASR002-10E	AG956-07		512 virtual lines (128 cycles) / rev.		SPI
ASR012-10E	AG963-07		I ² C; PWM		



ABZ Encoder Sensor

Revision History

SB-00-119-A
April 2020

Changes

- Added demonstration board.
- Revised some graphics.
- Initial release.

SB-00-119-PRELIM
March 2020

Change

- Preliminary release.

Datasheet Limitations

The information and data provided in datasheets shall define the specification of the product as agreed between NVE and its customer, unless NVE and customer have explicitly agreed otherwise in writing. All specifications are based on NVE test protocols. In no event however, shall an agreement be valid in which the NVE product is deemed to offer functions and qualities beyond those described in the datasheet.

Limited Warranty and Liability

Information in this document is believed to be accurate and reliable. However, NVE does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information.

In no event shall NVE be liable for any indirect, incidental, punitive, special or consequential damages (including, without limitation, lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Right to Make Changes

NVE reserves the right to make changes to information published in this document including, without limitation, specifications and product descriptions at any time and without notice. This document supersedes and replaces all information supplied prior to its publication.

Use in Life-Critical or Safety-Critical Applications

Unless NVE and a customer explicitly agree otherwise in writing, NVE products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical devices or equipment. NVE accepts no liability for inclusion or use of NVE products in such applications and such inclusion or use is at the customer's own risk. Should the customer use NVE products for such application whether authorized by NVE or not, the customer shall indemnify and hold NVE harmless against all claims and damages.

Applications

Applications described in this datasheet are illustrative only. NVE makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NVE products, and NVE accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NVE product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customers. Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NVE does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customers. The customer is responsible for all necessary testing for the customer's applications and products using NVE products in order to avoid a default of the applications and the products or of the application or use by customer's third party customers. NVE accepts no liability in this respect.

Limiting Values

Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and operation of the device at these or any other conditions above those given in the recommended operating conditions of the datasheet is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

Terms and Conditions of Sale

In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NVE hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NVE products by customer.

No Offer to Sell or License

Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

Export Control

This document as well as the items described herein may be subject to export control regulations. Export might require a prior authorization from national authorities.

Automotive Qualified Products

Unless the datasheet expressly states that a specific NVE product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NVE accepts no liability for inclusion or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NVE's warranty of the product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NVE's specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NVE for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NVE's standard warranty and NVE's product specifications.



ABZ Encoder Sensor

An ISO 9001 Certified Company

NVE Corporation
11409 Valley View Road
Eden Prairie, MN 55344-3617 USA
Telephone: (952) 829-9217
www.nve.com
e-mail: sensor-info@nve.com

©NVE Corporation
All rights are reserved. Reproduction in whole or in part is prohibited without the prior written consent of the copyright owner.

SB-00-119_ASR022-10_RevA

April 2020

We are here for you. Addresses and Contacts.

Headquarter Switzerland:

Angst+Pfister Sensors and Power AG
Thurgauerstrasse 66
CH-8050 Zurich
Phone +41 44 877 35 00
sensorsandpower@angst-pfister.com

Office Germany:

Angst+Pfister Sensors and Power Deutschland GmbH
Edisonstraße 16
D-85716 Unterschleißheim
Phone +49 89 374 288 87 00
sensorsandpower.de@angst-pfister.com

Scan here and get an overview of personal contacts!



sensorsandpower.angst-pfister.com
