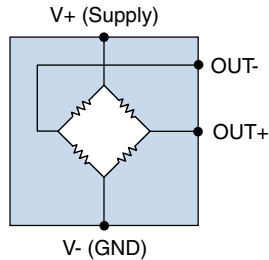


## AA/AB-Series Analog Magnetic Sensors

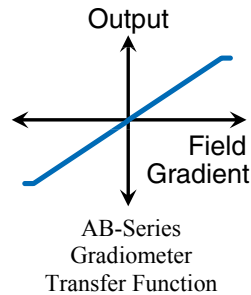
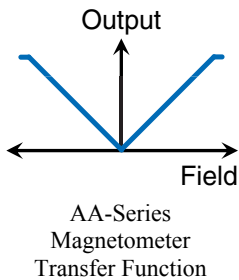
### Equivalent Circuit



### Features

- Wheatstone bridge analog outputs
- High sensitivity
- Up to 150°C operating temperature
- Operation to near-zero voltage
- Up to 1 MHz
- Magnetometer and gradiometer configurations
- Standard, ultrasensitive, and low-hysteresis versions
- TDFN6, MSOP8, and SOIC8 packages

### Idealized Transfer Functions



### Applications

- Motion, speed, and position control
- Low-field sensing
- Current sensing

### Description

NVE's analog GMR sensors have high sensitivity, excellent temperature stability, and small size. Their versatility makes them an excellent choice for a wide range of analog sensing applications including industrial and automotive position, speed, and current sensors.

The sensors are configured as inherently temperature-compensating Wheatstone bridges.

AA-Series sensors are magnetometers, which detect absolute magnetic field. AB-Series sensors are differential gradiometers. Three subtypes are available: the standard AA-Series; the ultrasensitive "H" subtype; and the low-hysteresis "L" subtype.

**Absolute Maximum Ratings**

Parameter		Symbol	Min.	Max.	Units
Supply voltage	AAxxx/ABxxx/AAL002	V <sub>CC</sub>		24	Volts
	AAHxxx/ABHxxx/AAL004			12	
Operating temperature	AAxxx/ABxxx/AALxxx		-50	125	°C
	AAHxxx/ABHxxx			150	°C
Storage temperature	AAxxx/ABxxx/AALxxx		-65	135	°C
	AAHxxx/ABHxxx		-65	150	
ESD (Human Body Model)				400	Volts
Applied magnetic field		H		Unlimited	Oe

**Operating Specifications**

Parameter		Symbol	Min.	Typ.	Max.	Units	Test Condition
Supply voltage	AAxxx/ABxxx/AAL002	V <sub>CC</sub>	<1		24	Volts	Max. limited by power dissipation
	AAHxxx/ABHxxx/AAL004				12		
Operating temperature	AAxxx/ABxxx/AALxxx	T <sub>MIN</sub>	-50		125	°C	
	AAHxxx/ABHxxx	T <sub>MAX</sub>		150			
Electrical offset	AAxxx/AALxxx/ABxxx	V <sub>O</sub>	-4		+4	mV/V	
	AAHxxx/ABHxxx		-5	+5			
Output at maximum field	AAxxx/ABxxx	V <sub>MAX</sub>		60		mV/V	
	AAHxxx/ABHxxx			40			
	AALxxx			45			
Non-linearity	AAxxx/ABxxx/AALxxx				2	%	Unipolar field sweep
	AAHxxx/ABHxxx			4			
Hysteresis	AAxxx/ABxxx				4	%	
	AAHxxx/ABHxxx			15			
	AALxxx				2		
Resistance tolerance			-20		+20	%	25°C
Resistance vs. temperature	AAxxx/ABxxx	TCR		+0.14		%/°C	No applied field
	AAHxxx/AALxxx/ABHxxx			+0.11			
Output temperature coefficient	AAxxx/ABxxx	TCOI		+0.03		%/°C	Constant-current supply
	AAHxxx/ABHxxx			+0.1			
	AALxxx	TCOV		-0.28		%/°C	Constant-voltage supply
	AAxxx/ABxxx			-0.1			
AAHxxx/ABHxxx		0					
AALxxx		-0.4					
Operating frequency	AAxxx/AAHxxx/AALxxx	f <sub>MAX</sub>	DC		100	kHz	
	ABxxx/ABHxxx				1		
Junction-Ambient thermal resistance	MSOP8 (-00 suffix)	θ <sub>JA</sub>		320		°C/W	Soldered to double-sided board; free air
	SOIC8 (-02 suffix)			240			
	TDFN6 (-10 suffix)			320			

**Operation**

**Sensor Subtypes**

There are three AA/AB-Series subtypes, as summarized in the table below. “H” subtypes are designed for very high sensitivity, and “L” types offer low hysteresis. AAH-Series parts also have a 150°C maximum temperature specification.

Parameter	AAxxx/ ABxxx	AAHxxx/ ABHxxx	AALxxx
Field Sensitivity	High	Very High	High
Operating Field Range	High	Low	Medium
Hysteresis	Medium	High	Low
Max. Temperature	High	Very High	High

**Direction of Sensitivity**

AA-Series sensors are *magnetometers*, which detect the absolute magnetic field in the plane of the IC along the part axis. These devices are “omnipolar,” meaning the output is equally sensitive to either magnetic field polarity.

AB-Series sensors are differential *gradiometers* that reject common mode magnetic fields, making them ideal for high magnetic noise environments such as near electric motors or current-carrying wires. The devices are sensitive to a field gradient along the part axis. The figure below shows a typical gradiometer response:

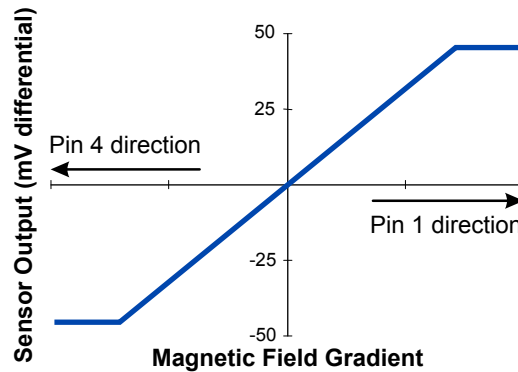
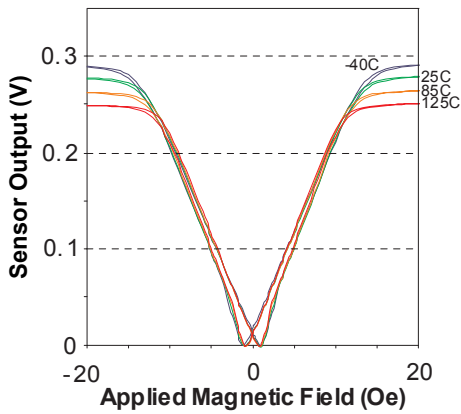
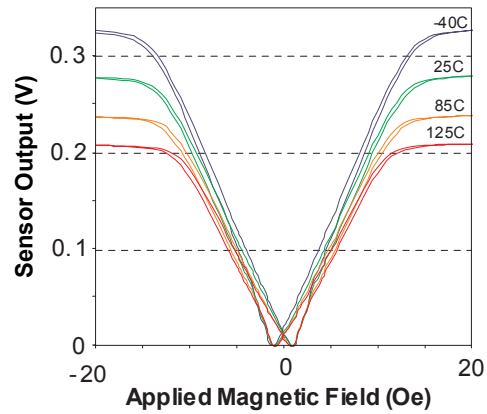


Figure 1. Typical gradiometer response.

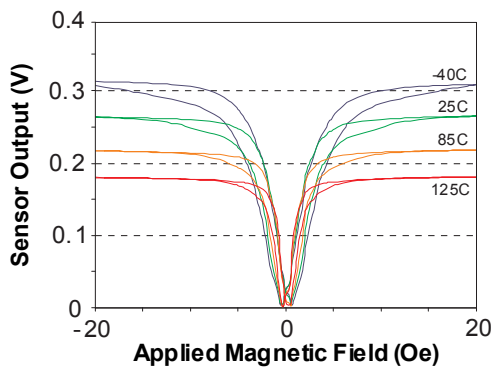
**Typical Performance Graphs**



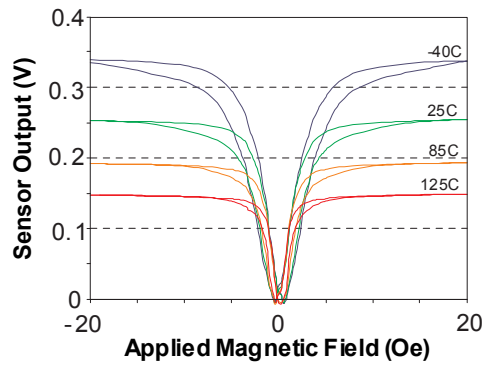
**Figure 2a. Typical AA002 output with 1 mA constant-current drive.**



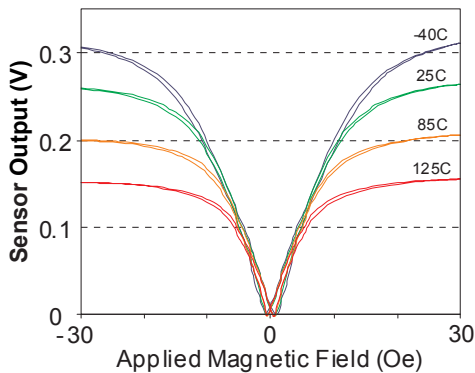
**Figure 2b. Typical AA002 output with a 5V supply.**



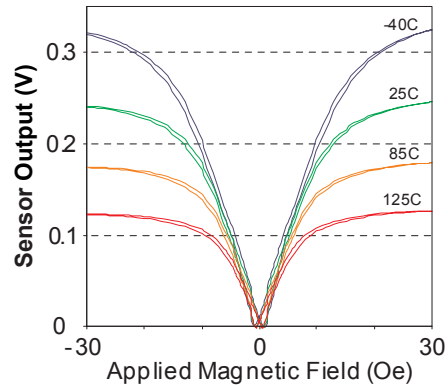
**Figure 3a. Typical AAH002 output with 2.28 mA constant-current drive.**



**Figure 3b. Typical AAH002 output with a 5V supply.**



**Figure 4a. Typical AAL002 output with 1 mA constant-current drive.**

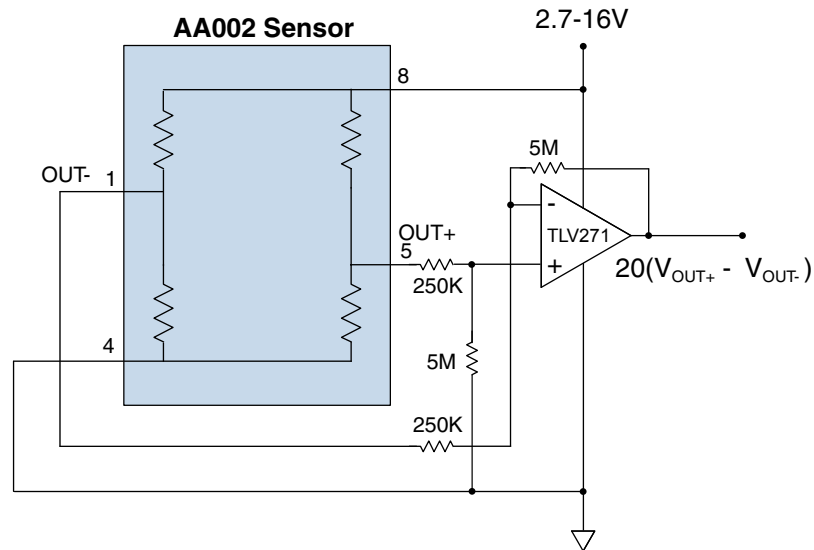


**Figure 4b. Typical AAL002 output with a 5V supply.**

**Illustrative Application Circuits**

**Traditional Differential Amplifier**

Traditional differential amplifiers use low-cost op-amps to provide a single-ended analog output. The circuit below has a gain of 20, which provides a full-scale output at slightly less than the sensor's saturation. A low-cost, low bias current op amp allows large resistors to avoid loading the sensor bridge. The 250 KΩ input resistors are 100 times the 2.5 KΩ sensor output impedance to avoid loading.



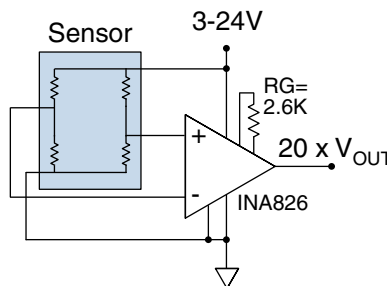
**Figure 5. Traditional op-amp differential amplifier.**

**Sensor Instrumentation Amplifier**

Instrumentation amplifiers such as the INA826 are popular bridge sensor preamplifiers because they have a low component count and have excellent common-mode rejection ratios without needing to match resistors. These amplifiers can run on single or dual supplies. AC coupling can be used for small, dynamic signals.

The circuit below has a gain of 20. The general equation for the output voltage is:

$$V_{OUT} = (1 + 49.4K / R_G)V_{IN} + V_{REF}; V_{IN} = V_{OUT+} - V_{OUT-}$$



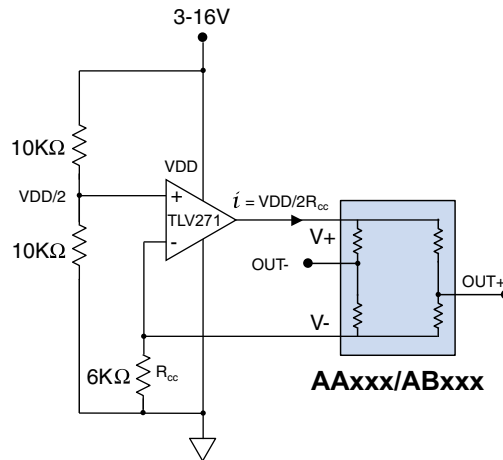
**Figure 6. Single-ended analog sensor instrumentation amplifier.**

Note that the instrumentation amplifier has a minimum output of 0.1V, so to detect very low fields on a single supply, an offset can be provided by using a non-zero  $V_{REF}$ .

**Constant-Current Sensor Drive**

Using a constant current rather than conventional constant voltage sensor supply can significantly improve temperature stability of AAxxx/ABxxx sensors. AA00x sensors have an output temperature coefficient (TCOI) of 0.03%/°C with constant current, versus -0.1%/°C with constant voltage (TCOV).

A simple constant-current supply is illustrated below:

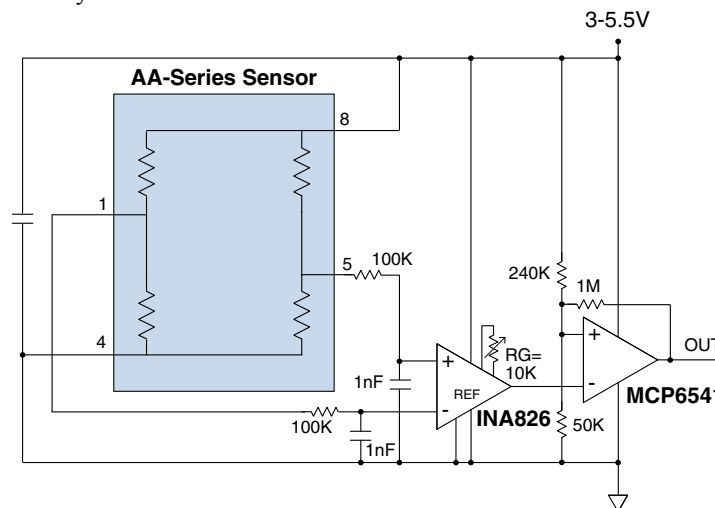


**Figure 7. Constant-current supply.**

The supply current for the circuit above is  $V_{cc}/2R_{cc}$ .  $R_{cc}$  can be set to the maximum sensor bridge resistance (e.g., 6 KΩ for many sensors) to provide the highest possible output without saturating the op-amp. The sensor will be driven with 1 mA for a 12 V supply in the circuit above. Similar op-amp or instrumentation amplifiers can be used for constant-current or constant-voltage supplies.

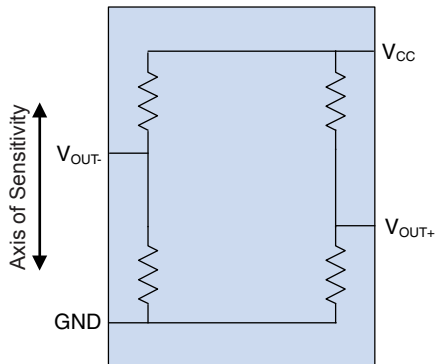
**Variable Threshold Magnetic Switch**

NVE offers AD-Series factory-set GMR Switches, but AA-Series analog sensors can be used for special thresholds or hysteresis, or for variable thresholds. In this circuit, the threshold is varied by changing  $R_G$ , which sets the gain of the differential amplifier. The 1 MΩ resistor sets the threshold hysteresis:



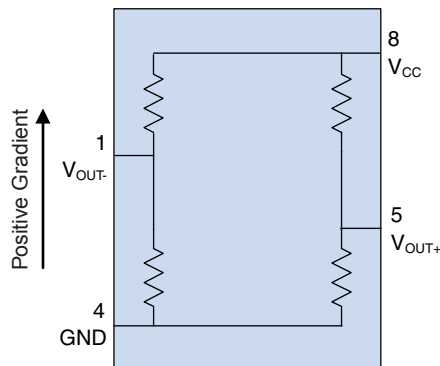
**Figure 8. Variable threshold magnetic switch.**

**AA-Series Pinout**



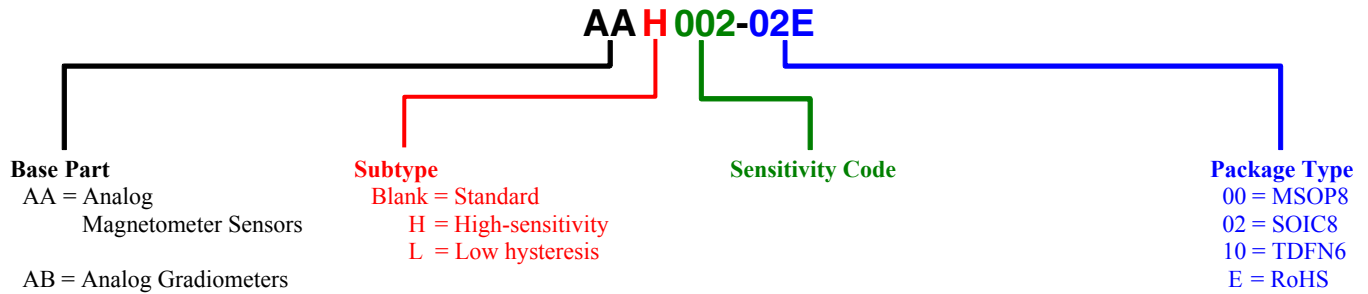
Pin		Symbol	Description
MSOP8/ SOIC8	TDFN6		
1	1	$V_{OUT-}$	Negative bridge output (decreases with increasing field).
2	2	NC	No internal connection.
3			
4	3	$V-/GND$	Negative supply or ground.
5	4	$V_{OUT+}$	Positive bridge output (increases with field).
6	5	NC	No internal connection.
7			
8	6	$V+$	Positive supply voltage.

**AB-Series Pinout**



Pin	Symbol	Description
1	$V_{OUT-}$	Negative bridge output (decreases with gradient).
2	NC	No internal connection.
3		
4	$V-/GND$	Negative supply or ground.
5	$V_{OUT+}$	Positive bridge output (increases with gradient).
6	NC	No internal connection.
7		
8	$V+$	Positive supply.

Part Numbering



Available Parts

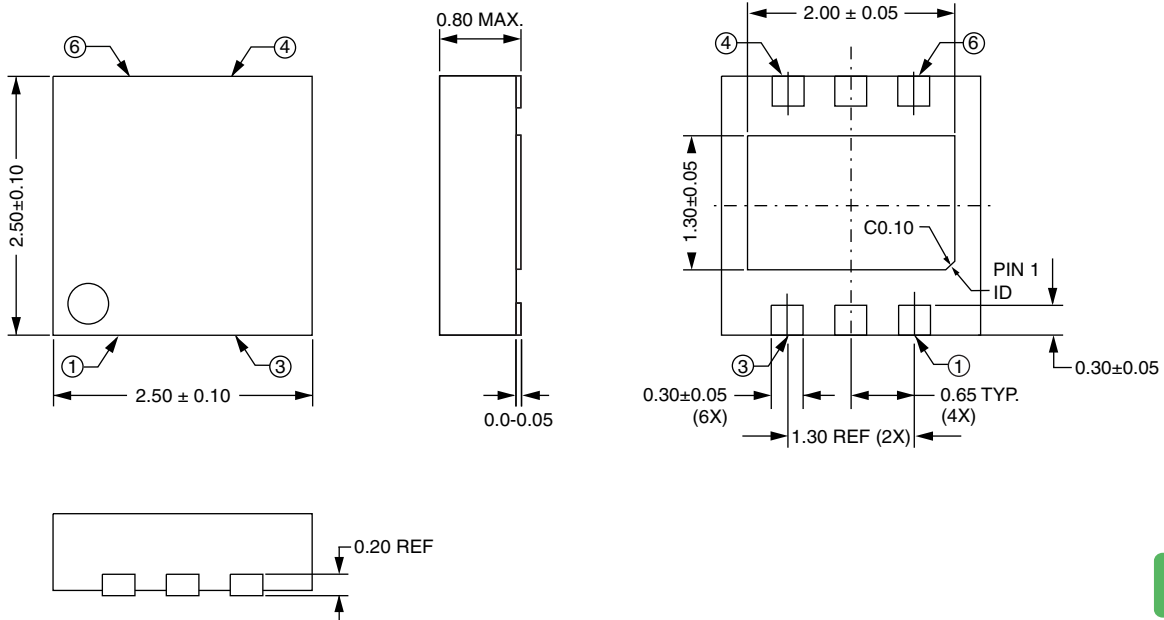
Magnetometers (AA-Series)										
Available Part	Linear Range ( Oe)		Saturation ( Oe)	Sensitivity (mV/V-Oe)		Max. Non-linearity (% Uni.)	Max. Hysteresis (% Uni.)	Max. Operating Temp.	Typ. Resistance	Package
	Min.	Max.		Min.	Max.					
AA002-02	1.5	10.5	15	3	4.2	2%	4%	125°C	5 kΩ	SOIC8
AA003-02	2	14	20	2	3.2	2%	4%	125°C	5 kΩ	SOIC8
AA004-00	5	35	50	0.9	1.3	2%	4%	125°C	5 kΩ	MSOP8
AA004-02	5	35	50	0.9	1.3	2%	4%	125°C	5 kΩ	SOIC8
AA005-02	10	70	100	0.45	0.65	2%	4%	125°C	5 kΩ	SOIC8
AA006-00	5	35	50	0.9	1.3	2%	4%	125°C	30 kΩ	MSOP8
AA006-02	5	35	50	0.9	1.3	2%	4%	125°C	30 kΩ	SOIC8
AAH002-02	0.6	3	6	11	18	4%	15%	150°C	2 kΩ	SOIC8
AAH004-00	1.5	7.5	15	3.2	4.8	4%	15%	150°C	2 kΩ	MSOP8
AAL002-02	1.5	10.5	15	3	4.2	2%	2%	125°C	5.5 kΩ	SOIC8
AAL004-10	1.5	10.5	15	3	4.2	2%	2%	125°C	2.2 kΩ	TDFN6

Gradiometers (AB-Series)										
Available Part	Linear Range ( Oe)		Saturation ( Oe)	Sensitivity (%R/Oe)		Max. Non-linearity (% Uni.)	Max. Hysteresis (% Uni.)	Max. Operating Temp.	Typ. Resistance	Package
	Min.	Max.		Min.	Max.					
AB001-02	10	175	250	0.02	0.03	2%	4%	125°C	2.5 kΩ	SOIC8
AB001-00	10	175	250	0.02	0.03	2%	4%	125°C	2.5 kΩ	MSOP8
ABH001-00	5	40	70	0.06	0.12	4%	15%	150°C	1.2 kΩ	MSOP8



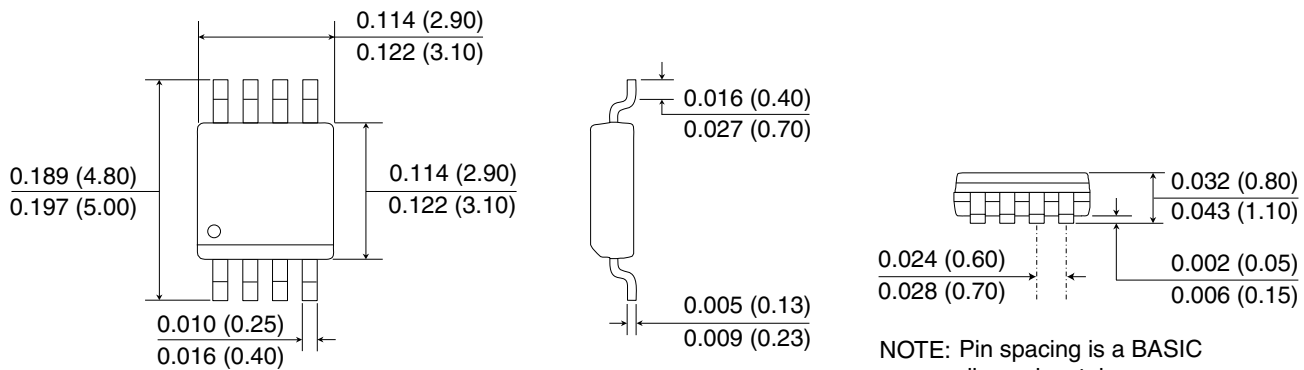
**Package Drawings**

**TDFN6 (-10 suffix)**



RoHS  
COMPLIANT

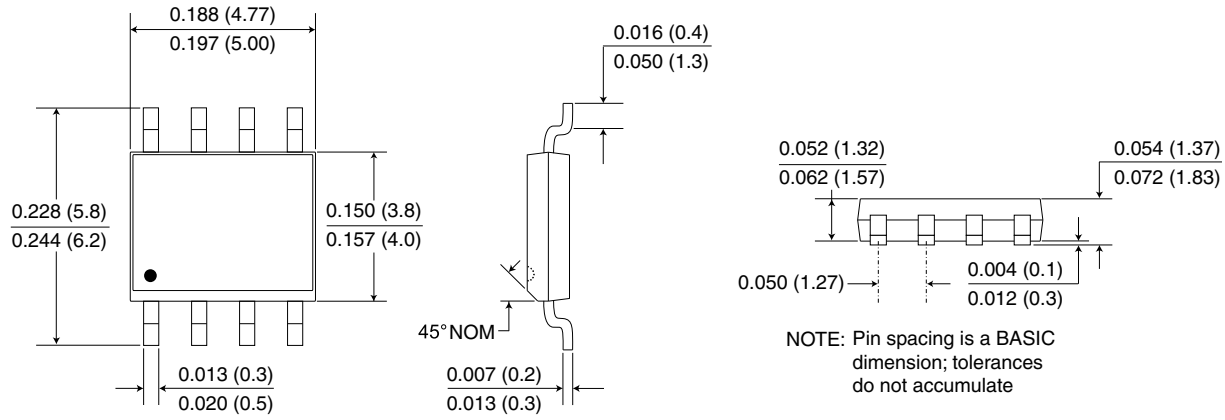
**MSOP8 (-00 suffix)**



NOTE: Pin spacing is a BASIC dimension; tolerances do not accumulate

RoHS  
COMPLIANT

**SOIC8 (-02 suffix)**



Soldering profiles per JEDEC J-STD-020C, MSL 1.



**Revision History**

---

**SB-00-059-A**

April 2017

**Change**

- Initial datasheet release superseding catalog.

### 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.

An ISO 9001 Certified Company

NVE Corporation  
11409 Valley View Road  
Eden Prairie, MN 55344-3617 USA  
Telephone: (952) 829-9217  
Fax: (952) 829-9189  
[www.nve.com](http://www.nve.com)  
e-mail: [sensor-info@nve.com](mailto: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-00-059\_RevA

*April 2017*