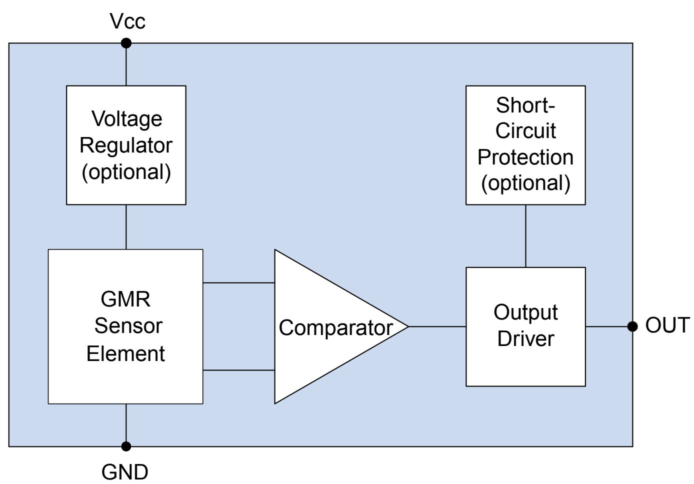
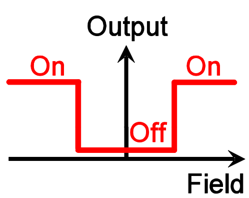
AD-Series GMR Switch™ Precision Digital Magnetic Sensors

Functional Diagram



Idealized Transfer Function



Features

- Digital outputs
- Precision magnetic operate points from 10 – 80 Oe
- 4.5 V – 30 V supply voltage
- 20 mA output drive
- Temperature and voltage stability
- Models available with short-circuit protection
- Frequency response to 100 kHz
- Ultraminiature TDFN6 and MSOP8 packages

Applications

- Motion, speed, and position control
- Pneumatic cylinder position sensing
- Speed sensing

Description

AD-Series GMR Switches are the industry standard for sensitivity and precision.

GMR Switches integrate GMR sensor elements with digital signal processing electronics. These sensors are more precise than other magnetic sensors, and magnetic field operate points are stable over voltage and temperature extremes.

AD-Series models available in a wide variety of magnetic operate points and output configurations. Versions are available with short-circuit protection circuitry and with integrated voltage regulators.

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Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Units	Test Conditions
Supply voltage	Except AD8xx/AD9xx	V_{CC}	−33	33	Volts	
	AD8xx/AD9xx		−0.5			
Output voltage			−0.5	33	Volts	
Output current (AD8xx/AD9xx only)				5	mA	
Operating temperature			−40	125	°C	
Storage temperature			−65	150	°C	
ESD				2000	Volts	Human Body Model
Applied magnetic field		H		Unlimited	Oe	

Operating Specifications

Tmin to Tmax; 4.5 V < V_{CC} < 30 V unless otherwise stated.							
Parameter		**Symbol**	**Min.**	**Typ.**	**Max.**	**Units**	**Test Conditions**
Supply voltage		V_{CC}	4.5		30	Volts	
Operating temperature		T_{MIN}; T_{MAX}	−40		125	°C	
Magnetic operate point		H_{OP}					
ADH025			8	10	12	Oe	
AD004; AD021; AD621			15	20	25	Oe	
AD024			21	28	33	Oe	
AD005; AD022			30	40	50	Oe	
AD006			60	80	100	Oe	
Operate/release differential		$H_{OP}-H_{REL}$					
ADH025			2		8	Oe	
AD004; AD021; AD621			5		14	Oe	
AD024			5		15	Oe	
AD005; AD022			5		25	Oe	
AD006			5		50	Oe	
Supply current	Except AD8xx/AD9xx	I_{CC}		2.5	4.5	mA	V_{CC} = 12V; Output Off
	AD8xx/AD9xx			1.75	3.5	mA	
Output current	Except AD8xx/AD9xx	$I_{O\text{-}ON}$	20			mA	Output On
	AD8xx/AD9xx		2			mA	
Sinking output voltage	Except AD8xx/AD9xx	V_{OL}			0.2	V	V_{CC} = 12V; I_O = 20mA
	AD8xx/AD9xx				0.4	V	I_O = 2mA
Sourcing output voltage	Except AD8xx/AD9xx	V_{OH}			V_{CC}–2.5	V	V_{CC} = 12V; I_O = 20mA
	AD8xx/AD9xx				V_{CC}–2	V	I_O = 2mA
Output leakage current		$I_{O\text{-}OFF}$			10	µA	V_{CC} = 12V; Output Off
Short-circuit voltage (AD8xx/AD9xx only)		V_{Short}	0.12		0.17	V	Output On
Regulator output	Except AD8xx/AD9xx	V_{REG}		5.8	6.2	V	V_{CC} > 6.6V; 0 < I_{REG} < 20mA
			3.5	V_{CC} – 0.9			V_{CC} < 6.6V
	AD8xx/AD9xx			5.8	6	V	V_{CC} > 6.6V; 0 < I_{REG} < 20mA
			3.5	V_{CC} – 0.9			V_{CC} < 6.6V
Regulator output current (AD4xx – AD9xx)		I_{REG}	3			mA	
Frequency response		f_{MAX}	100			kHz	
Junction–Ambient Thermal Resistance		θ_{JA}		320		°C/W	Soldered to double-sided board; free air

Operation

Typical connections with an external pull-up resistor are shown below:

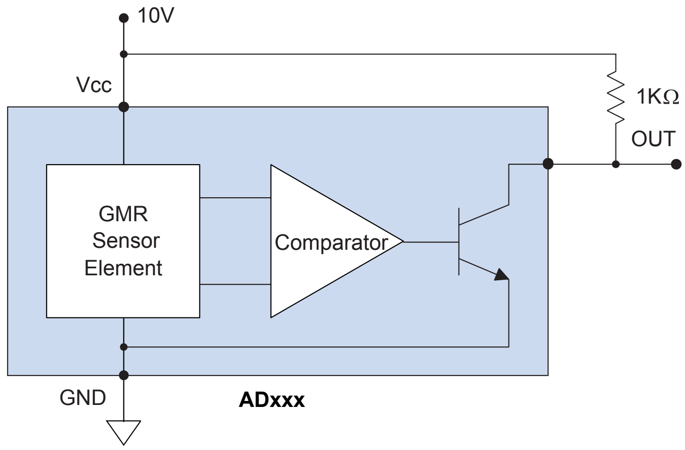

Figure 1. Typical connections.

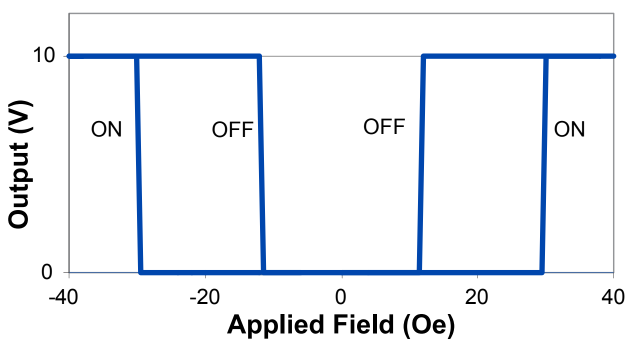

Figure 2a. Typical output vs. magnetic field
(**AD024** with a 10V supply and 1 KΩ pull-up resistor).

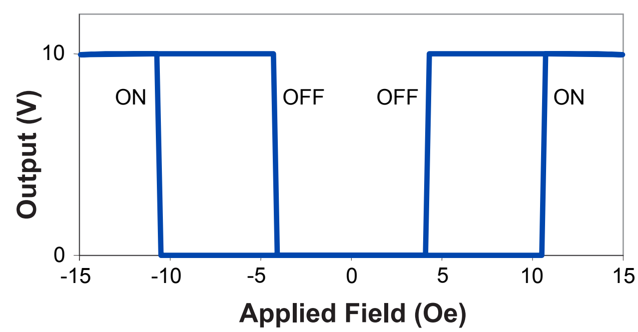

Figure 2b. Typical output vs. magnetic field
(**ADH025** with a 10V supply and 1 KΩ pull-up resistor).

ON / OFF Behavior
AD-Series sensor outputs turn ON when the field exceeds the magnetic operate point, and OFF when the field drops below the operate point minus the release differential.

External Pull-Up Resistors
Outputs are open collector, with PNP output transistors for sourcing versions and NPN transistors for sinking versions. Outputs should have external pull-up or pull-down resistors. For microcontroller interfaces, the microcontroller's input pull-up resistors can be activated.

Omnipolar
GMR Switches are "omnipolar," which means the outputs turn ON when a magnetic field of either magnetic polarity is applied.

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In-Plane Magnetic Sensitivity
As the field varies in intensity, the digital output will turn on and off. Unlike Hall-effect or other sensors, the direction of sensitivity is in the plane of the package. The diagrams below show two permanent magnet orientations that will activate the sensor in the direction of sensitivity:

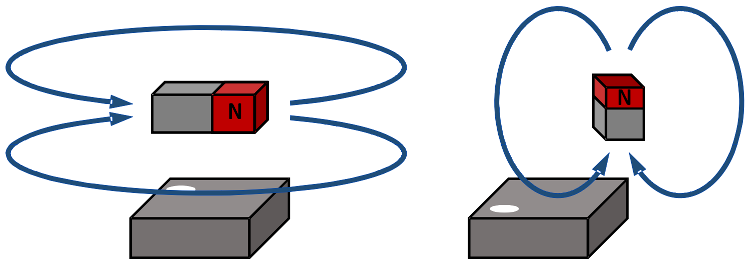

Figure 3. Planar magnetic sensitivity.

Standard and Cross-Axis Sensitivity
Standard AD-Series sensors are sensitive along the part axis as shown in Figure 4b, but a number of versions are available with cross-axis sensitivity (see Figure 4a).

Figure 4a.
Cross-axis sensitivity.

Figure 4b.
Standard sensitivity.

Typical Operation
A typical proximity sensor using an AD022 cross-axis sensor and magnet is shown in the figures below. This sensor has a 40 Oe typical operate point, and actuates with the magnet approximately 0.375 inches (9 mm) from the center of the sensor. Because the sensor is omnipolar, it will operate with either a north or south magnet face.

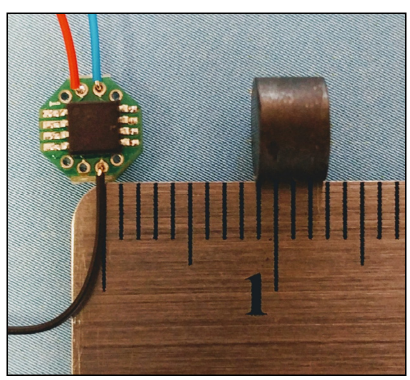

Figure 5. An AD022 sensor (pin 1 is upper left; the sensor has cross-axis sensitivity), on an AG015 circuit board with a 12031 8 mm dia. x 3 mm thick ferrite magnet. Sensor activates at approx. 9 mm distance. Red wire = V_{CC}; Blk = GND; Blue = OUT (Sink).

More sensitive sensors with lower magnetic operate points (such as the 10 Oe ADH025-00E) operate with the magnet farther away. Stronger or larger magnets will also increase the operate distance. Our most sensitive digital sensor (the AFL006; see AFL-Series sensor datasheet) has been demonstrated to operate with a rare-earth magnet at an air gap of two inches (50 mm) or more.

We have a free, Web-based application that provides fields and operate distances for various sensor and magnet types:

www.nve.com/spec/calculators.php

Illustrative Application Circuits

Integrated Short-Circuit Protection

AD8xx and AD9xx models include integrated Short Circuit Protection ("SCP") circuitry. A detailed block diagram of such a device is shown below:

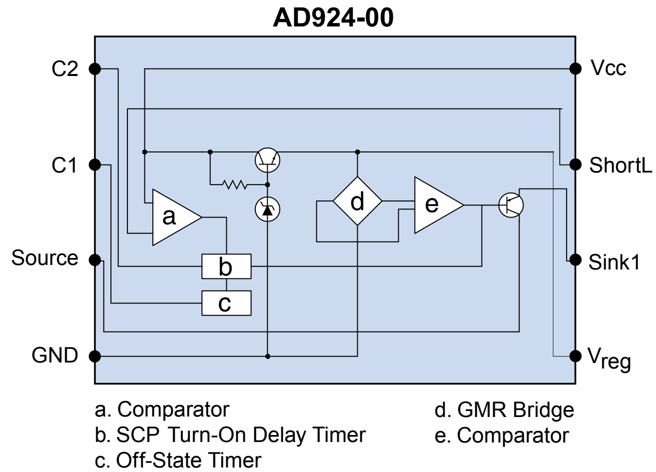

Figure 5. Detailed block-diagram of the AD924 sensor with short-circuit protection circuitry.

Typical SCP external circuitry for sourcing and sinking SCP versions are shown in the following schematics:

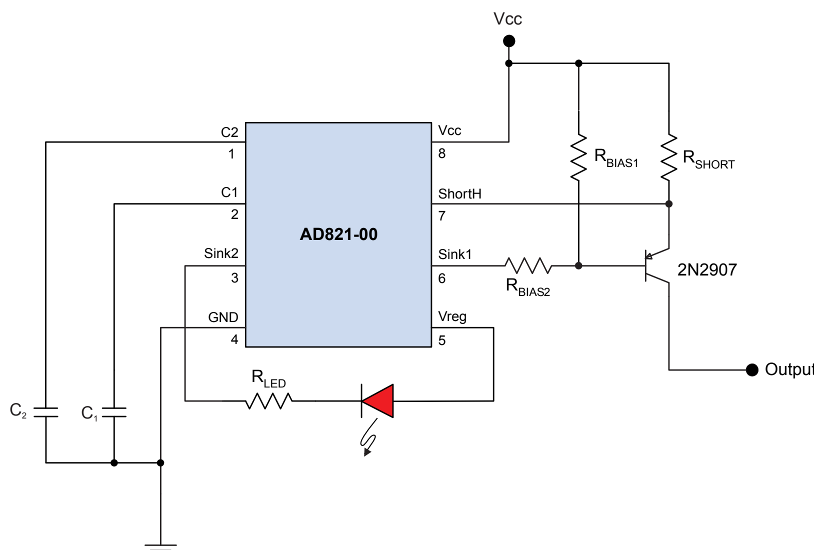

Figure 6. Short-circuit protection circuitry (sourcing output).

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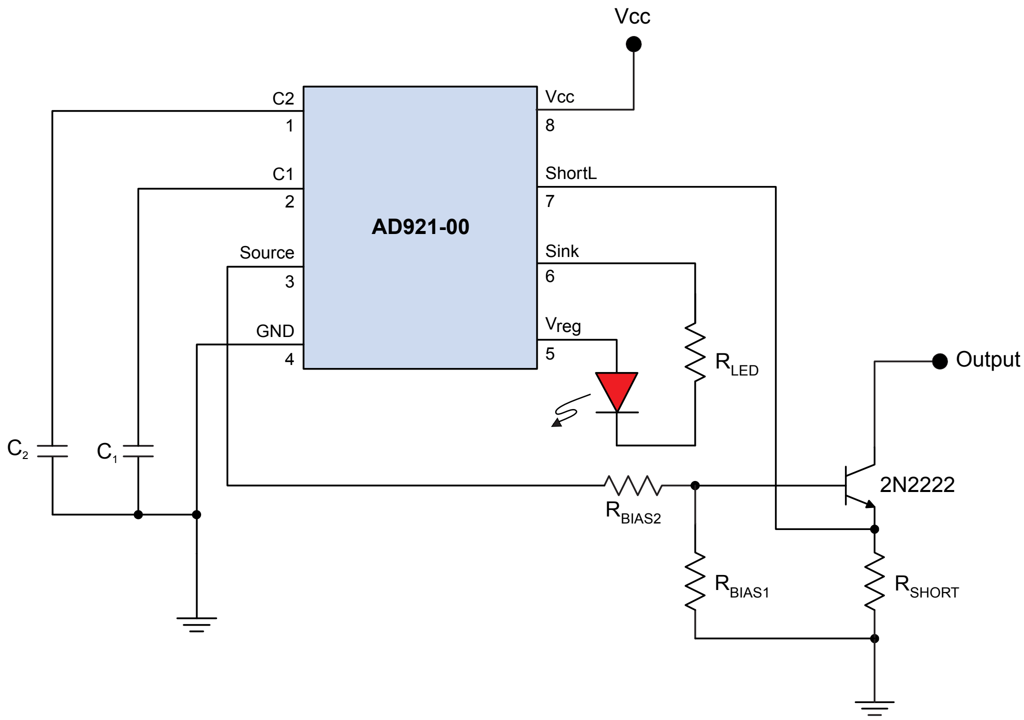

Figure 7. Short-circuit protection circuitry (sinking output).

If the voltage across R_{SHORT} exceeds 145 mV (typical), the SCP circuitry is activated. An R_{SHORT} of 0.47Ω then results in a protection threshold of approximately 300 mA.

Capacitor C_2 delays the shutdown so normal startup transients do not trigger the circuitry; a 0.001 µF capacitor can be used for a typical 35 µs delay (t_1). C_1 sets the SCP "OFF" time (t_2), which is typically 0.01 µF for 15 ms OFF time.

The short-circuit output current using these typical component values is shown below:

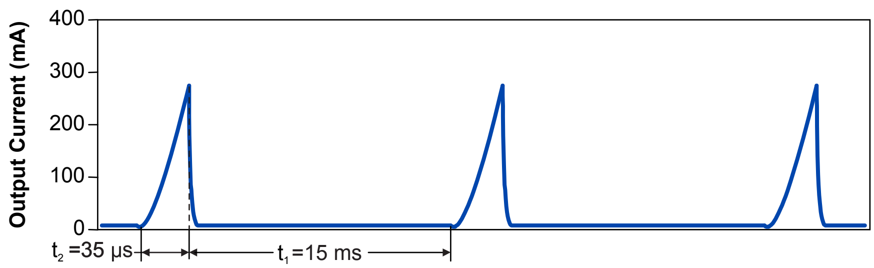

Figure 8. AD821 / AD921 output current with typical SCP components and output shorted (see Figures 5 and 6 for circuits).

R_{BIAS1} and R_{BIAS2} bias the output transistor. Typical values for are 16 KΩ for R_{BIAS1} and 3 KΩ for R_{BIAS2}, which provides 1 mA of transistor base current. R_{LED} sets the LED current up to a maximum of 3 mA.

External Short-Circuit Protection

NVE offers a separate Power Switch IC, the DB001-00, for sensor Short Circuit Protection of sensors that do not have SCP support. The DB001 also provides a high-current output, reverse battery protection, and transient protection.

A typical circuit is as follows:

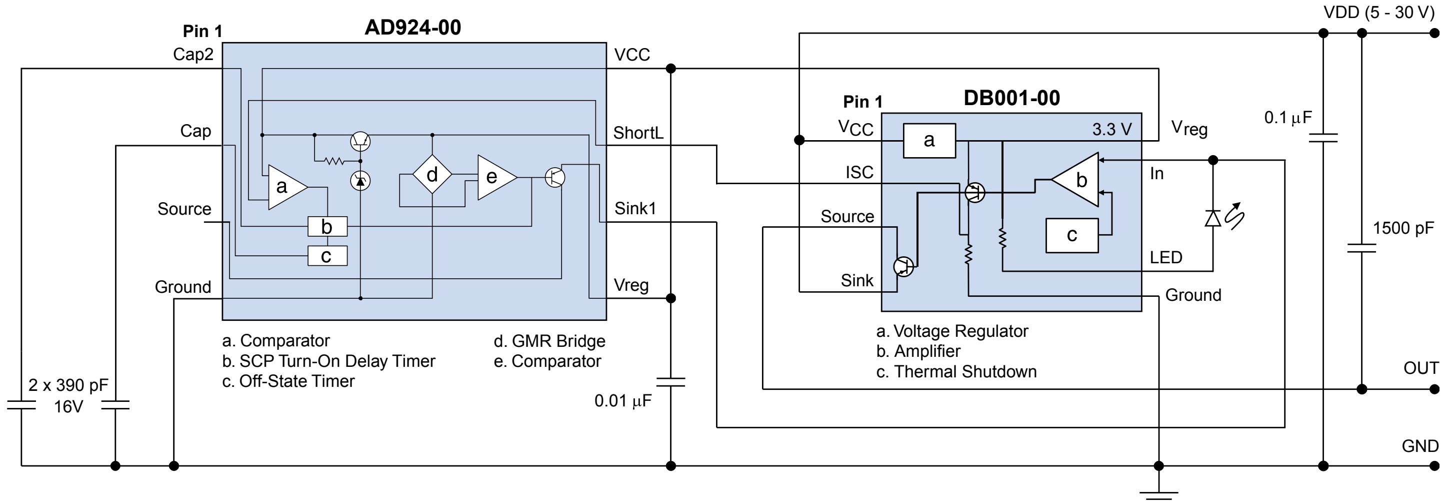

Figure 9. A GMR Switch with an external power switch IC for a high-power output, bullet-proof system.

Typical Performance Graphs

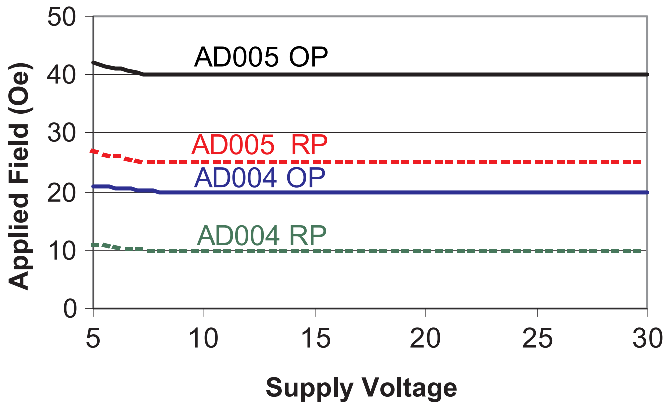

Figure 10. Typical Operate Points (OP) and Release Points (RP) vs. supply voltage (25°C).

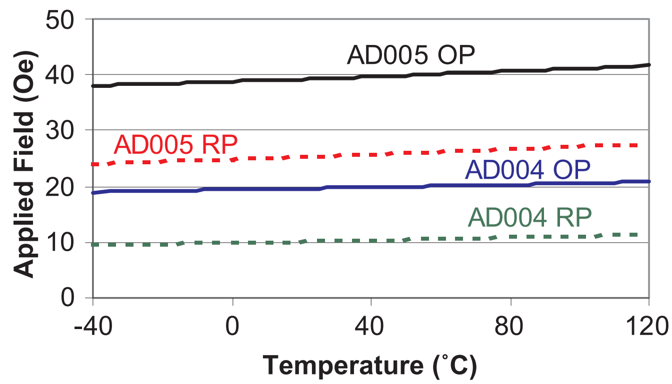

Figure 11. Typical Operate Points (OP) and Release Points (RP) vs. temperature.

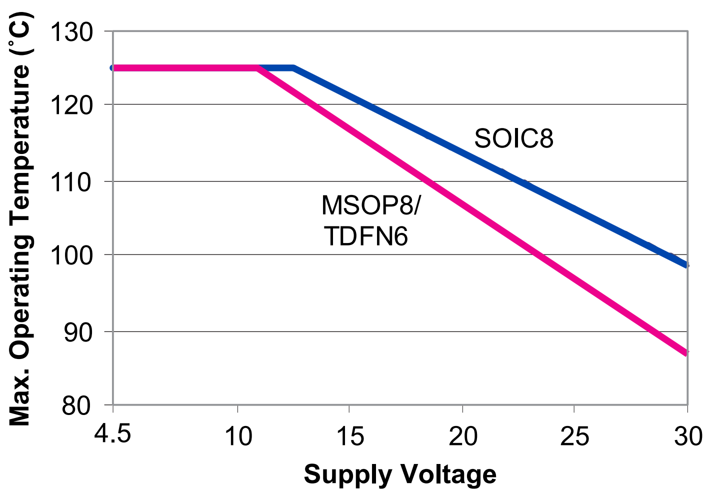

Figure 12. Operating temperature derating (free air).

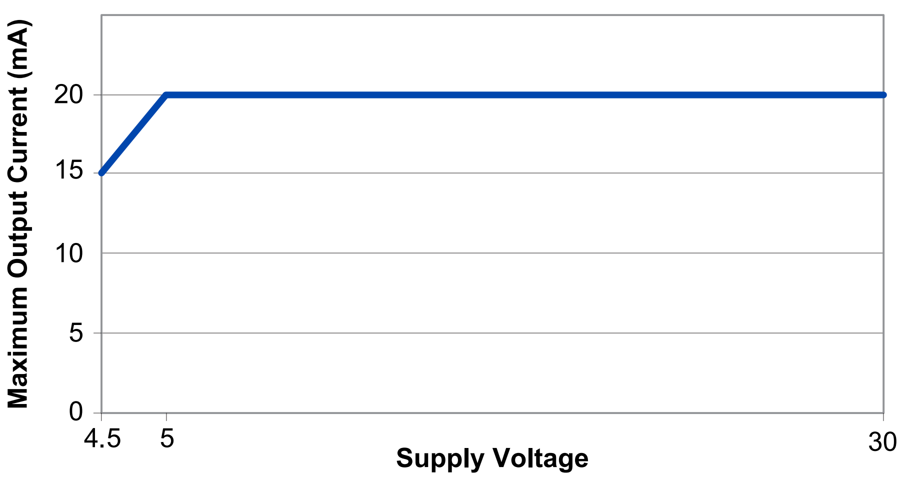

Figure 13. Output current vs. supply voltage.

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Part Numbering

AD 0 21 - 00E

Base Part
AD = Standard digital switches

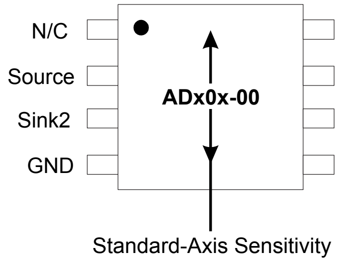
Outputs
- 0 = Sink1
- 1 = Source
- 2 = Sink1 + Source
- 3 = Sink1 + Sink2
- 4 = Sink + Regulated Output
- 5 = Source + Regulated Output
- 6 = Sink + Source + Regulated Output
- 7 = Two Sinks + Regulated Output
- 8 = Two Sinks + Regulated Output + Short-Circuit Protection
- 9 = Sink + Source + Regulated Output + Short-Circuit Protection

Operating Field
- 04 = 20 Oe; Standard Direction
- 05 = 40 Oe; Standard Direction
- 06 = 80 Oe; Standard Direction
- 20 = 28 Oe; Standard Direction
- 21 = 20 Oe; Cross-Axis Sensitivity
- 22 = 40 Oe; Cross-Axis Sensitivity
- 24 = 28 Oe; Cross-Axis Sensitivity
- 25 = 10 Oe; Cross-Axis Sensitivity

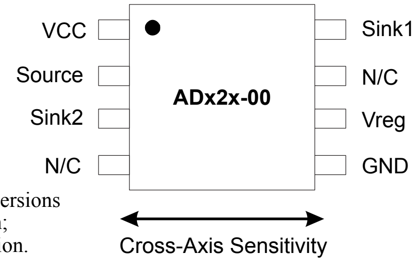
Package Type
- 00 = MSOP8
- 10 = TDFN6
- E = RoHS

Pinouts

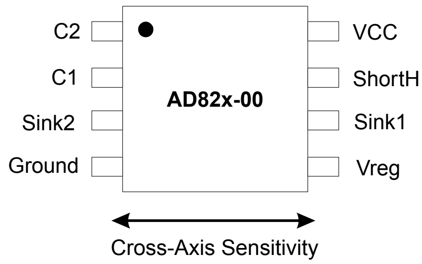
MSOP GMR Switches Without Short-Circuit Protection (AD0xx-00 – AD7xx-00; ADH0xx-00):

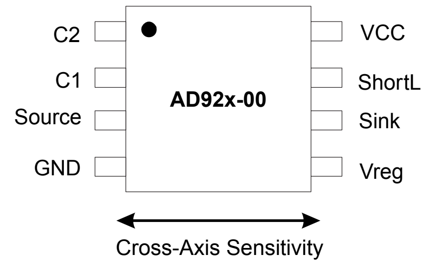


*Sink1 on pin 7 for versions without Vreg option; pin 5 with Vreg option.

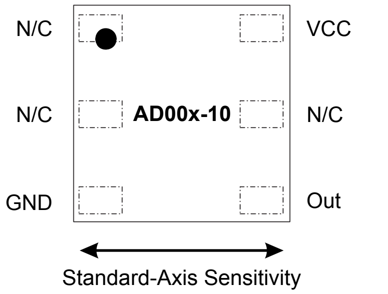


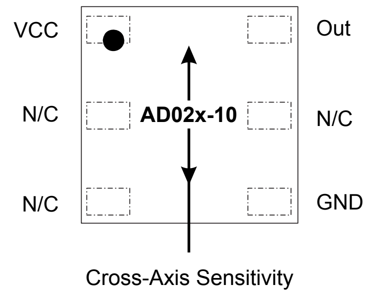
MSOP GMR Switches With Short-Circuit Protection (AD8xx-00 – AD9xx-00):



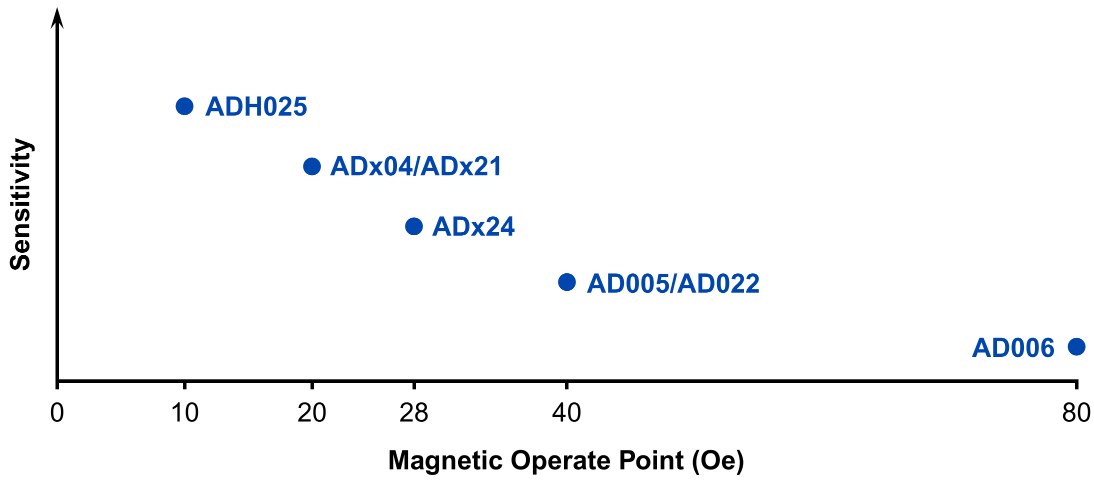


TDFN GMR Switches (AD0xx-10):





Operating Point Chart



Stock Parts

Available Part	**Operate Point** (typ.)	**Release Point** (typ.)	**Output Configuration**	**Max. Operating Temperature**	**Package**
AD004-00E	20 Oe	10 Oe	Sink	125°C	MSOP8
AD005-00E	40 Oe	25 Oe	Sink	125°C	MSOP8
AD006-00E	80 Oe	50 Oe	Sink	125°C	MSOP8
AD021-00E	20 Oe	10 Oe	Sink	125°C	MSOP8
AD022-00E	40 Oe	25 Oe	Sink	125°C	MSOP8
AD024-00E	28 Oe	14 Oe	Sink	125°C	MSOP8
AD024-10E	28 Oe	14 Oe	Sink	125°C	TDFN6
AD621-00E	20 Oe	10 Oe	Sink+Source	125°C	MSOP8
AD824-00E	28 Oe	14 Oe	2 Sinks + Short-Circuit Protection	150°C	MSOP8
ADH025-00E	10 Oe	5 Oe	Sink	150°C	MSOP8

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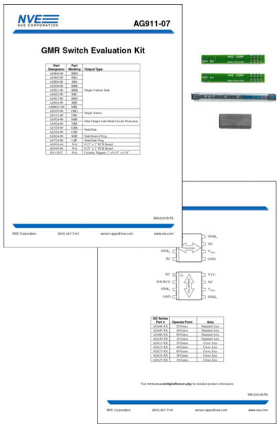
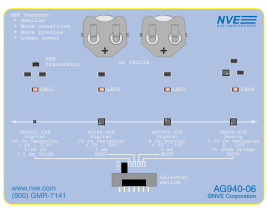
Evaluation Kits

Two inexpensive evaluation kits including AD-Series GMR switches are available:



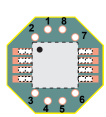
AG910-07/AG911-07—GMR Switch Evaluation Kits
Several GMR Switches with different magnetic operate points and different output options such as current sink and current source. Magnets and circuit boards for mounting the parts are also included. The AG910-07 kit also includes a zero insertion force (ZIF) socket for easy testing of the MSOP-packaged sensors.



AG940-07E: Digital/Analog/Omnipolar/Bipolar Sensor Demo Board
The kit includes a demo board with our most popular digital, analog, omnipolar, and bipolar sensors, including an AD004-00 digital sensor. Each sensor drives an indicator LED. A bar magnet is included so you can see for yourself how the sensors work. The evaluation boards are 3.75 by 5 inches (95 mm by 127 mm), and are powered by two coin cells (included).

Bare Circuit Boards for Sensors

NVE offers several bare circuit boards specially designed for easy connections to surface-mount sensors. Popular PCBs are shown below (images are **two times** actual size):



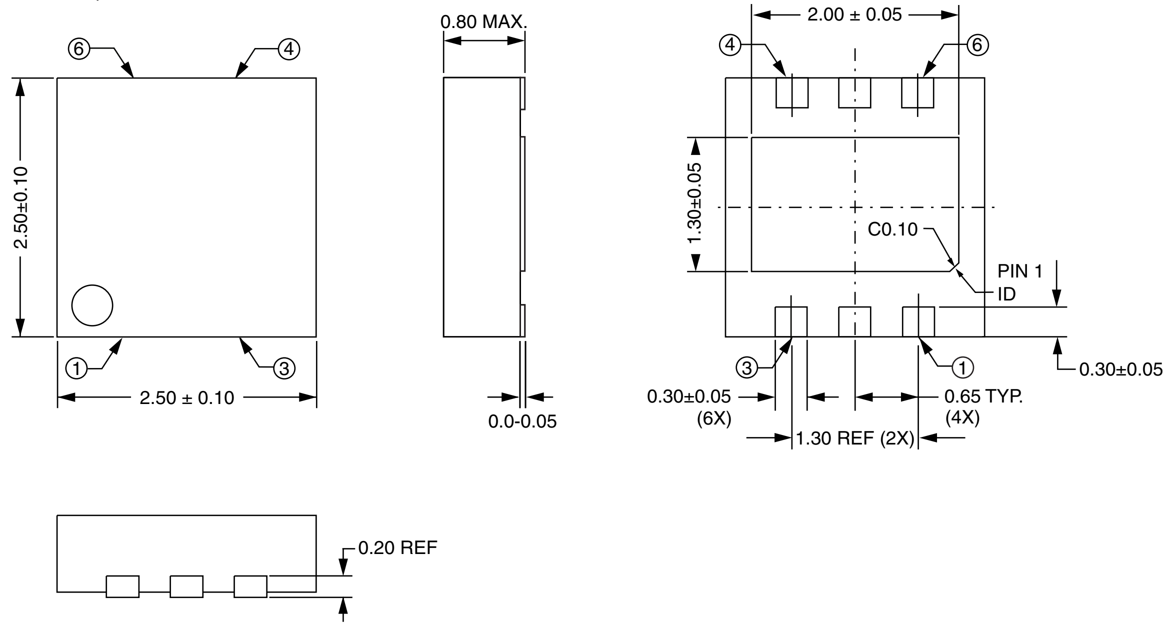
AG915-06:
0.25" (6 mm) octagonal
MSOP8

AG918-06 (standard) / **AG919-06** (cross-axis):
2" x 0.25" (50 mm x 6 mm) MSOP8

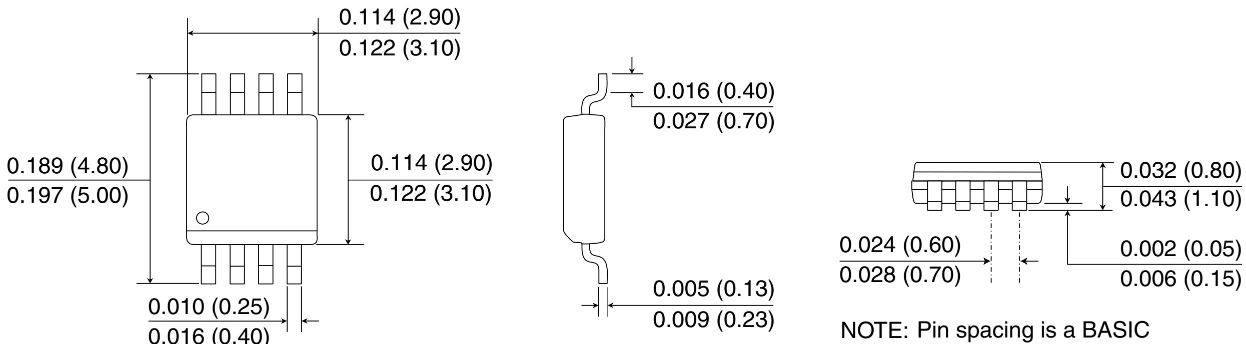
AG035-06:
1.57" x 0.25" (40 mm x 6 mm) TDFN6

Package Drawings

TDFN6 (-10 suffix)



MSOP8 (-00 suffix)



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

Soldering profiles per JEDEC J-STD-020C, MSL1

RoHS COMPLIANT

Revision History

SB-00-060-D
October 2017

Change
- Added description and image for “Typical Operation” (p. 4).
- Changed pin 5 of AD00x-10 drawing to “NC” instead of “Test” (p. 9).
- Added Operating Point Chart (p. 10).
- Added Evaluation Kits and bare circuit boards (p. 11).

SB-00-060-C
September 2017

Change
- Added AD006 (80 Oe GMR Switch).
- Misc. cosmetic changes.

SB-00-060-B
August 2017

Change
- Eliminated SOIC package option.
- Misc. cosmetic changes.

SB-00-060-A
March 2017

Change
- Initial datasheet release superseding catalog.

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October 2017