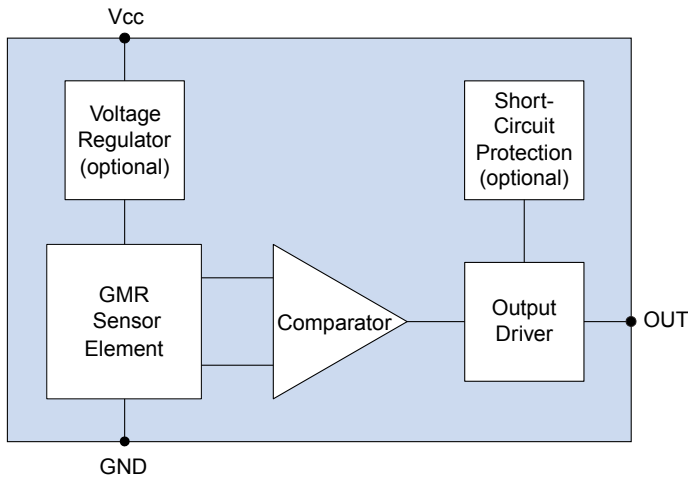


## AD-Series GMR Switch™ Precision Digital Magnetic Sensors

### Functional Diagram



### Features

- Digital outputs
- Precision magnetic operate point
- 4.5 V – 30 V supply voltage
- 20 mA output drive
- Temperature and voltage stability
- Versions with short-circuit protection circuitry
- Frequency response to 100 kHz
- Ultraminiature TDFN6 and MSOP8 packages

### Applications

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

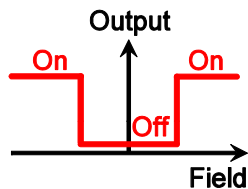
### Description

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.

### Idealized Transfer Function



## Absolute Maximum Ratings

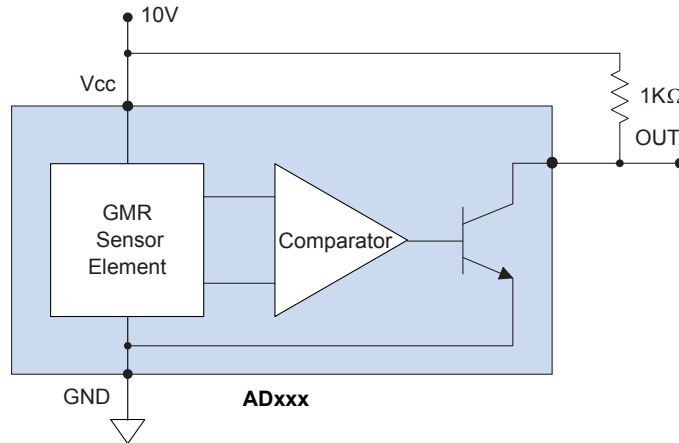
Parameter	Symbol	Min.	Max.	Units	
Supply voltage	V <sub>CC</sub>	Except AD8xx/AD9xx	-33	33	Volts
		AD8xx/AD9xx	-0.5		
Output voltage		-0.5	33	Volts	
Output current (AD8xx/AD9xx only)			5	mA	
Operating temperature		-40	125	°C	
Storage temperature		-65	150	°C	
ESD (Human Body Model)			2000	Volts	
Applied magnetic field	H		Unlimited	Oe	

## Operating Specifications

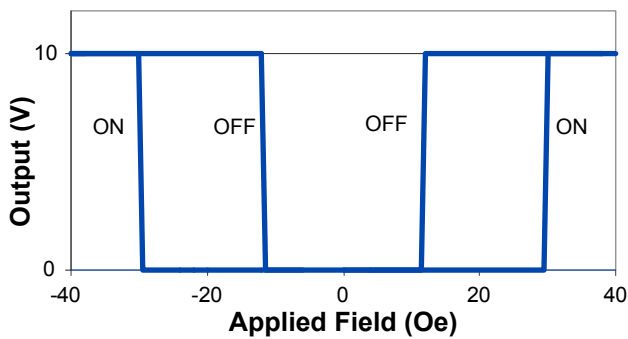
T <sub>min</sub> to T <sub>max</sub> ; 4.5 V < V <sub>CC</sub> < 30 V unless otherwise stated.							
Parameter	Symbol	Min.	Typ.	Max.	Units	Test Condition	
Supply voltage	V <sub>DD</sub>	4.5		30	Volts		
Operating temperature	T <sub>MIN</sub> ; T <sub>MAX</sub>	-40		125	°C		
Magnetic operate point ADH025 AD004; AD021; AD621 AD024 AD005; AD022	H <sub>OP</sub>		8	10	12	Oe	
			15	20	25		
			21	28	33		
			30	40	50		
Operate/release differential ADH025 AD004; AD021; AD621 AD024 AD005; AD022	H <sub>OP</sub> -H <sub>REL</sub>		2		8	Oe	
			5		14		
			5		15		
			5		25		
Supply current	I <sub>CC</sub>	Except AD8xx/AD9xx		2.5	4.5	mA	V <sub>CC</sub> = 12V; Output Off
		AD8xx/AD9xx		1.75	3.5		
Output current	I <sub>O-ON</sub>	Except AD8xx/AD9xx	20			mA	
		AD8xx/AD9xx	2				
Sinking output voltage	V <sub>OL</sub>	Except AD8xx/AD9xx			0.2	V	V <sub>CC</sub> = 12V; I <sub>O</sub> = 20mA
		AD8xx/AD9xx			0.4		I <sub>O</sub> = 2mA
Sourcing output voltage	V <sub>OH</sub>	Except AD8xx/AD9xx			V <sub>CC</sub> -2.5		V <sub>CC</sub> = 12V; I <sub>O</sub> = 20mA
		AD8xx/AD9xx			V <sub>CC</sub> -2		I <sub>O</sub> = 2mA
Output leakage current	I <sub>O-OFF</sub>			10	µA	V <sub>CC</sub> = 12V; Output Off	
Short voltage (AD8xx/AD9xx only)	V <sub>ShortH</sub> ; V <sub>ShortL</sub>	0.12		0.17	V	Output On	
Regulator output	V <sub>REG</sub>	Except AD8xx/AD9xx		5.8	6.2	V	V <sub>CC</sub> > 6.6V; 0 < I <sub>REG</sub> < 20mA
				3.5	V <sub>CC</sub> - 0.9		V <sub>CC</sub> < 6.6V
		AD8xx/AD9xx		5.8	6	V	V <sub>CC</sub> > 6.6V; 0 < I <sub>REG</sub> < 20mA
				3.5	V <sub>CC</sub> - 0.9		V <sub>CC</sub> < 6.6V
Regulator output current	I <sub>REG</sub>	3			mA		
Frequency response	f <sub>MAX</sub>	100			kHz		
Junction-Ambient Thermal Resistance	θ <sub>JA</sub>	MSOP8 (-00 suffix)		320		°C/W	Soldered to double-sided board; free air
		TDFN6 (-10 suffix)		320			

**Operation**

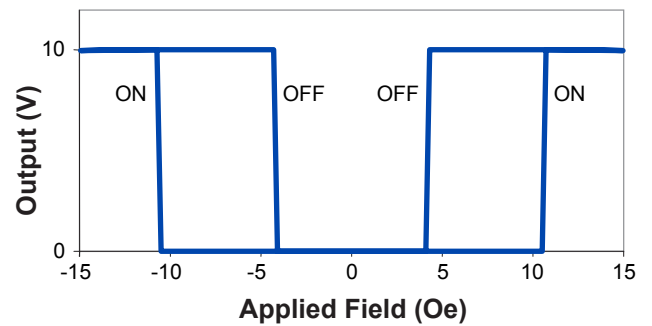
Typical operation is shown in the figures below:



**Figure 1. Typical application.**



**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**

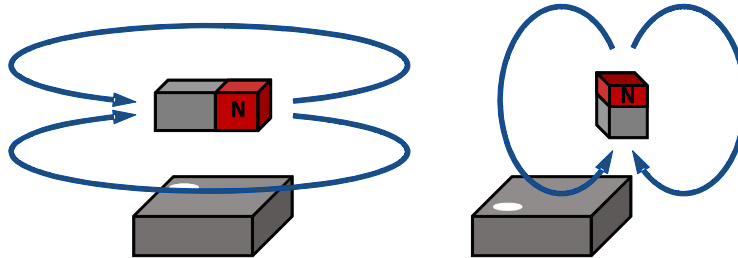
Outputs are open collector, with PNP output transistors for sourcing versions and NPN transistors for sinking versions. Outputs should have external pull-up or pull-down resistors. For microcontroller interfaces, the microcontroller’s input pull-up resistors can be activated.

**Omnipolar**

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

**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).



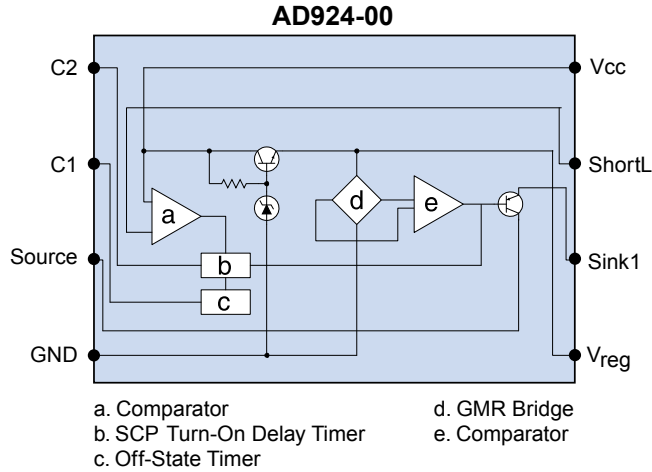
**Figure 4a.**  
Cross-axis sensitivity.

**Figure 4b.**  
Standard sensitivity.

**Illustrative Application Circuits**

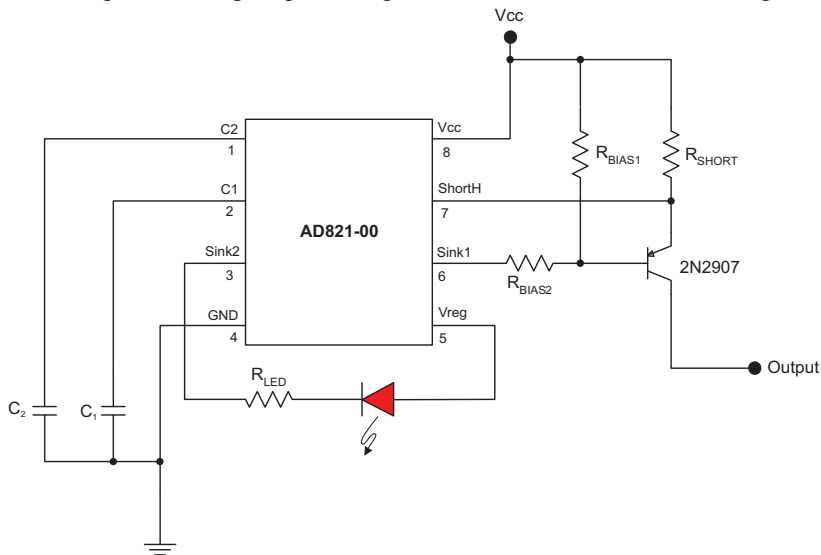
**Integrated Short-Circuit Protection**

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

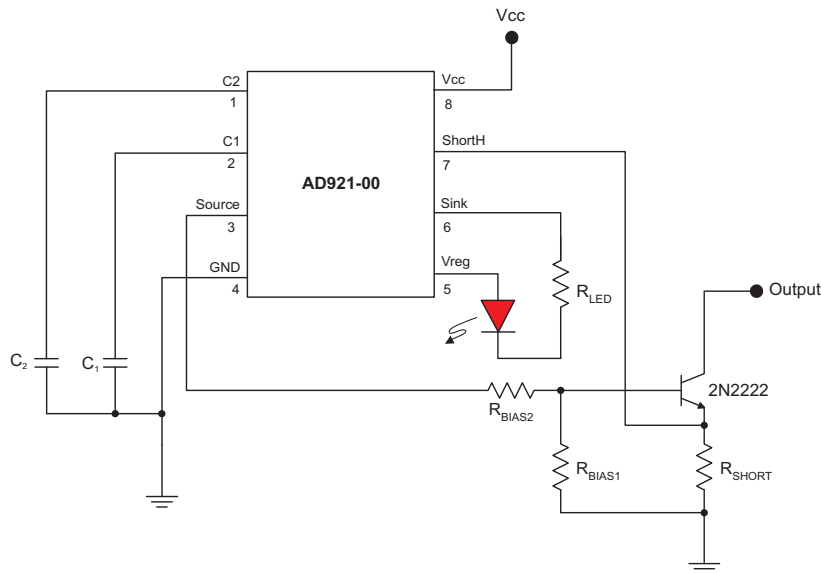


**Figure 5. Detailed block-diagram of the AD924 sensor with short-circuit protection circuitry.**

Typical external circuitry for sourcing and sinking output configurations are shown in the following schematics:



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

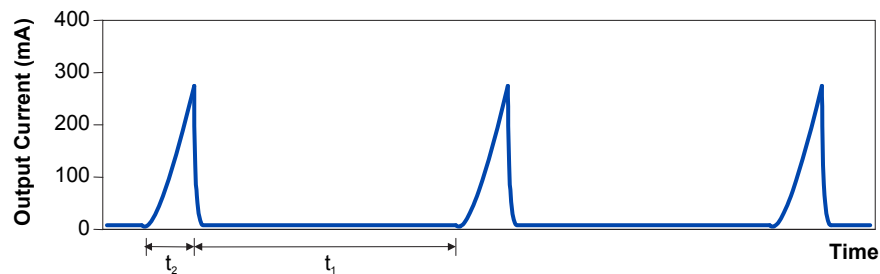


**Figure 7. Short-circuit protection circuitry (sinking output).**

If the voltage across  $R_{SHORT}$  exceeds 145 mV (typical), the SCP circuitry is activated. A typical  $R_{SHORT}$  of  $0.47\Omega$  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  $0.001\ \mu\text{F}$  capacitor can be used for a typical 35  $\mu\text{s}$  delay.  $C_1$  is used to set the SCP “OFF” time; typically  $0.01\ \mu\text{F}$  for a 15 ms OFF time.

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



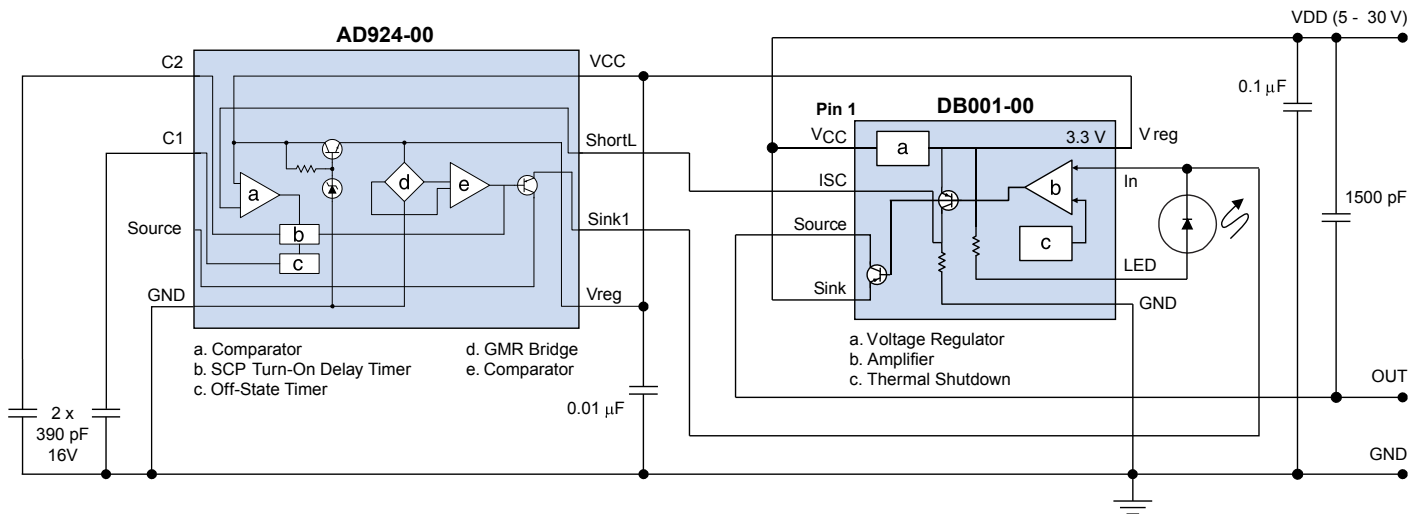
**Figure 8. AD821 / AD921 output current with SCP and output shorted (see Figures 5 and 6 for circuits).**

$R_{BIAS1}$  and  $R_{BIAS2}$  bias the output transistor. Typical values for are  $16\ \text{K}\Omega$  for  $R_{BIAS1}$  and  $3\ \text{K}\Omega$  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. Using an external power switch IC for a high-power output, bullet-proof system.**

**Typical Performance Graphs**

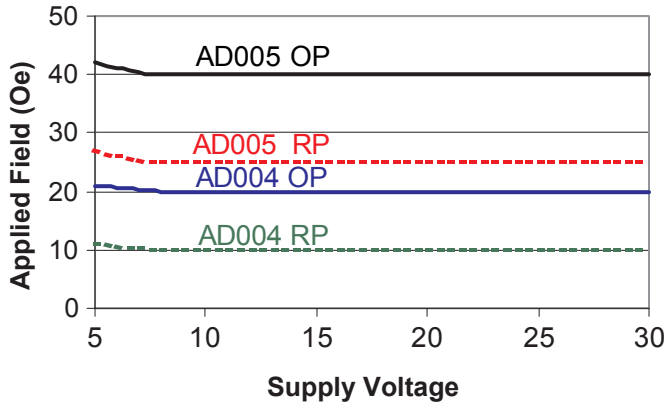


Figure 10. Typical Operate Points (OP) and Release Points (RP) vs. supply voltage (at 25°C).

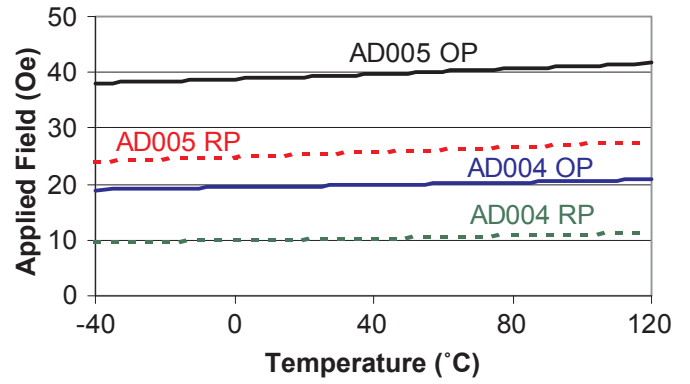


Figure 11. Typical Operate Points (OP) and Release Points (RP) vs. temperature.

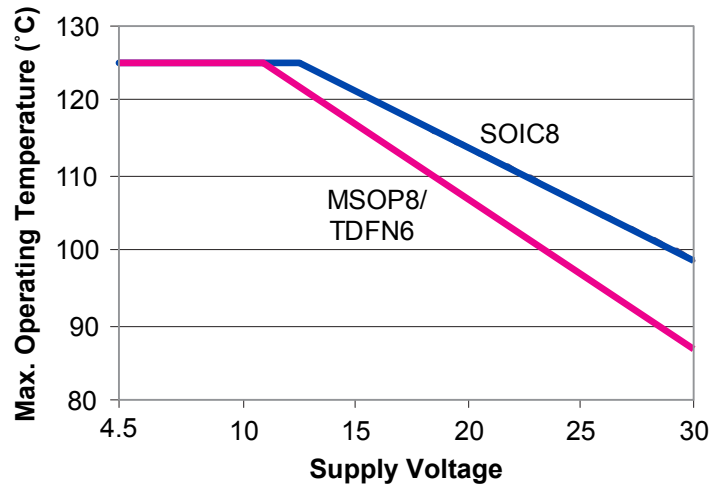


Figure 12. Operating temperature derating (free air).

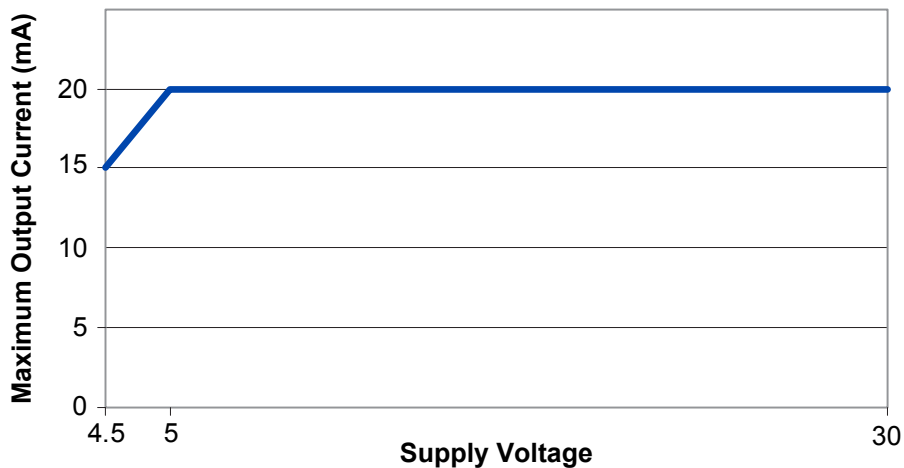
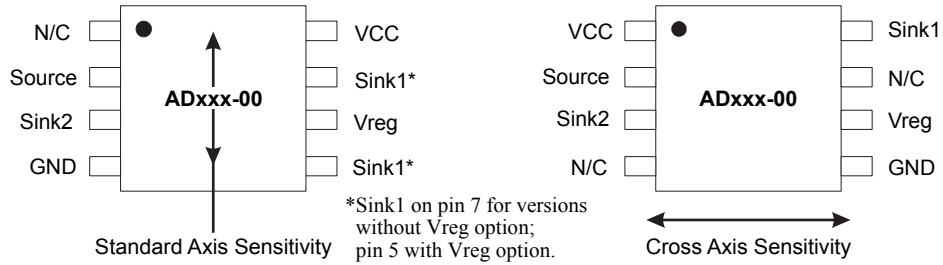


Figure 132. Output current vs. supply voltage.

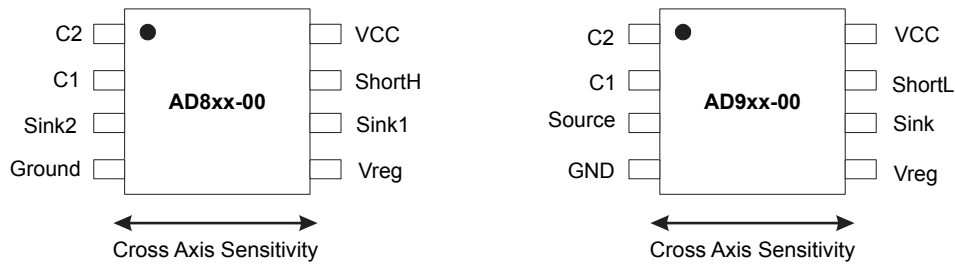


**Pinouts**

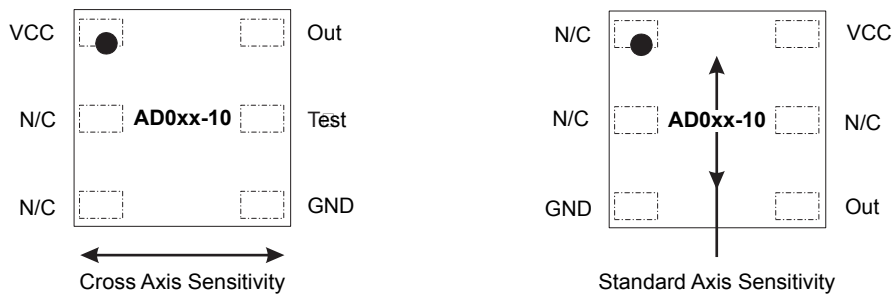
**MSOP GMR Switches Without Short-Circuit Protection (AD0xx-00– AD7xx-xx; ADH0xx-00):**



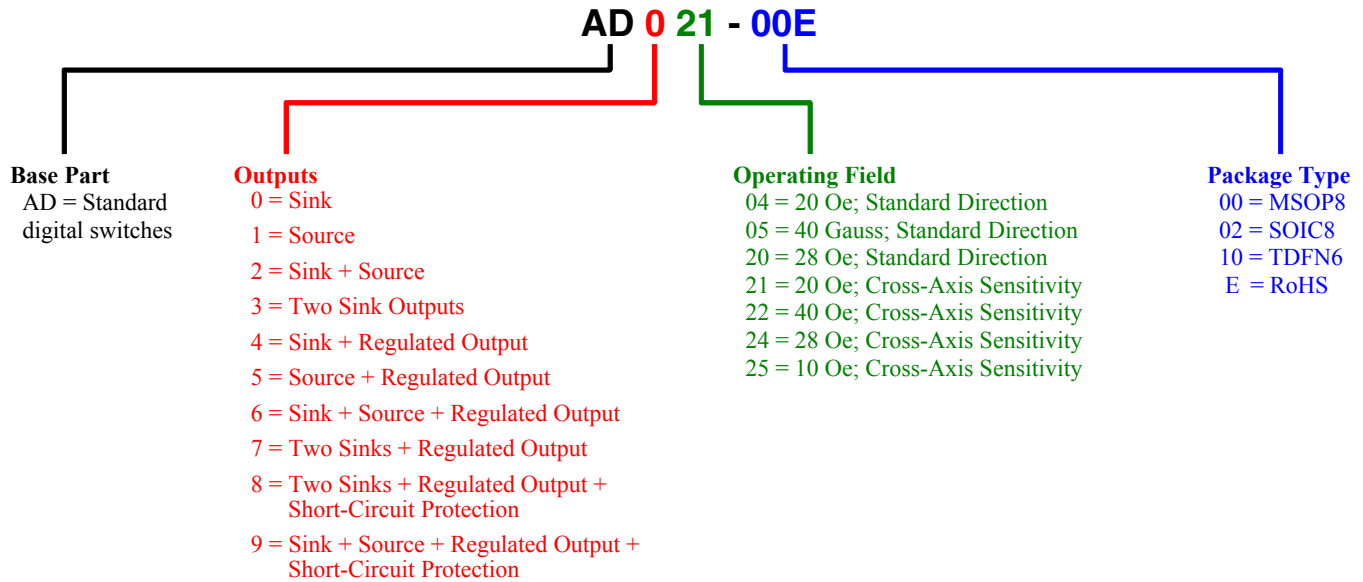
**MSOP GMR Switches With Short-Circuit Protection (AD8xx-00– AD9xx-00):**



**TDFN GMR Switches (AD0xx-10):**



## Part Numbering

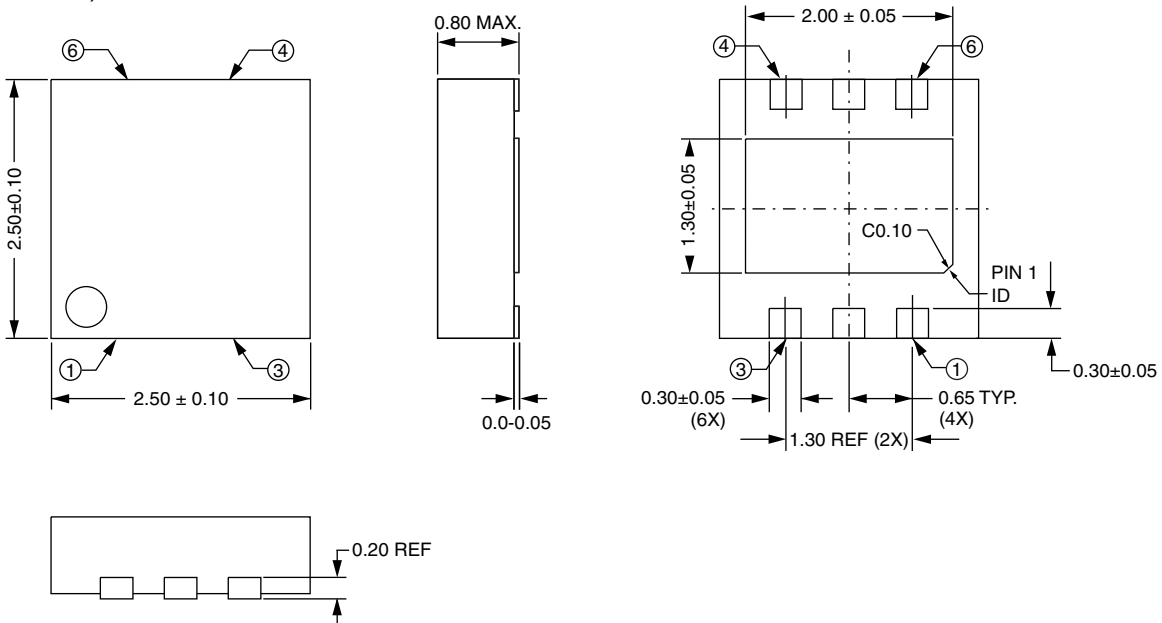


## Stock Parts

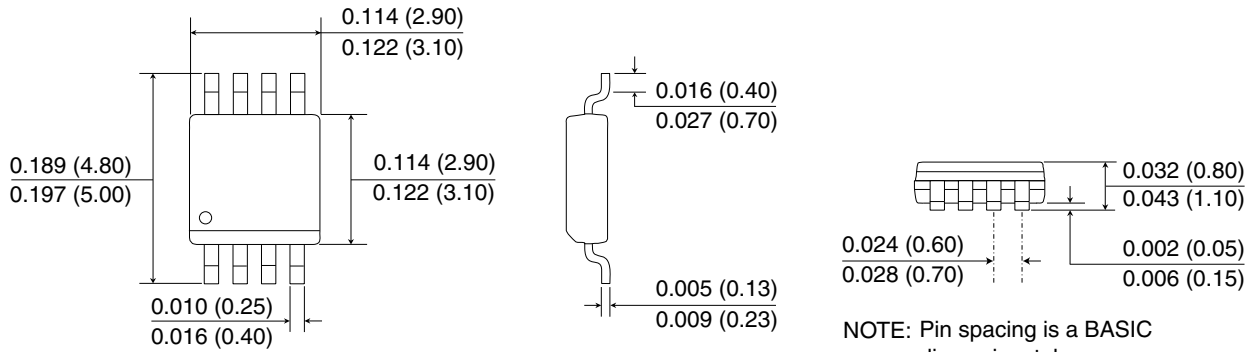
Available Part	Operate Point (typ.)	Release Point (typ.)	Output Type	Max. Operating Temperature	Package
AD004-00	20 Oe	10 Oe	Sink	125°C	MSOP8
AD005-00	40 Oe	25 Oe	Sink	125°C	MSOP8
AD021-00	20 Oe	10 Oe	Sink	125°C	MSOP8
AD022-00	40 Oe	25 Oe	Sink	125°C	MSOP8
AD024-00	28 Oe	14 Oe	Sink	125°C	MSOP8
AD024-10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

**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



**Revision History**

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**SB-00-060-A**  
March 2017

**Change**

- Initial datasheet release superseding catalog.

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*March 2017*