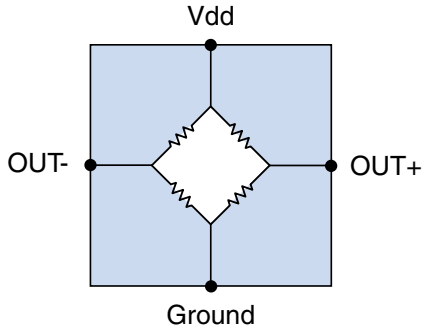


AAK001-14E High-Field Magnetic Sensor

Schematic Diagram



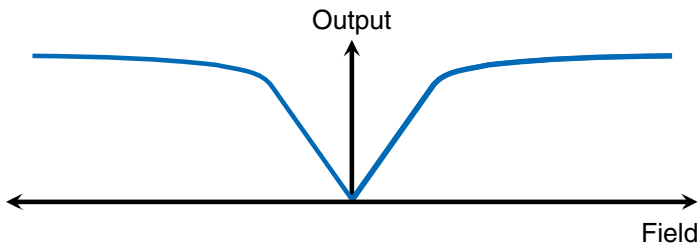
Features

- Precise sensing of magnetic fields up to 4 kOe (400 mT)
- Sensitive to fields of any direction in the IC plane
- Ratiometric Wheatstone bridge outputs
- Any operating supply voltage up to 12V
- Ultraminiature 1.1 x 1.1 mm package

Applications

- Brushless DC motors
- Motor commutator sensors
- Noncontact high-current measurement
- Harsh industrial applications

Magnetic Response



Description

The AAK001-14E is a high-field magnetometer sensor that provides precise sensing of magnetic fields up to 4 kOe (400 mT). NVE's proprietary Giant Magnetoresistive (GMR) technology provides precision over a wide field range without the complications of shielding.

The sensors respond from zero field to 4 kOe (400 mT), and are highly linear from 400 Oe (40 mT) to 2.5 kOe (250 mT).

The sensor is configured as a Wheatstone bridge with two element types—one to sense the field and the other for temperature compensation.

The sensor element is not directionally sensitive in the IC plane, so output from the sensor element is the same regardless of the direction of the applied magnetic field. As the direction of the applied field moves out of the plane of the IC, the sensor output is roughly proportional to the cosine of the angle between the applied field and the IC.

Absolute Maximum Ratings

Parameter	Min.	Max.	Units
Supply voltage		30	Volts
Storage temperature	-65	135	°C
Junction temperature	-65	135	°C
Applied magnetic field		Unlimited	

Operating Specifications

Specifications valid overall operating voltage and temperature ranges unless otherwise noted.						
Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Supply voltage	V_{DD}	<1		12.6	Volts	
Operating temperature	$T_{MIN}; T_{MAX}$	-40		85	°C	
Saturation field	H_{SAT}		4000		Oe	
Linear range	H_{LIN}	400		2500	Oe	
Sensitivity	$\Delta V_{OUT}/\Delta H$		3.3		$\mu V/V/Oe$	
Device resistance	R_{DEVICE}	2.8	3.5	4.2	k Ω	$T_A = 25^\circ C$
Electrical offset	V_O	-4		4	mV/V	
Maximum output	$V_{OUT-MAX}$	19	25		mV/V	$T_A = 25^\circ C$
Operating frequency	$f_{MIN}; f_{MAX}$	DC		50	kHz	
Nonlinearity				2	%	Unipolar field sweep
Hysteresis				4		
Resistance vs. temperature	TC_R		+0.1		%/°C	
Output temperature coefficient	TC_{O-I}		-0.13			Constant current supply
	TC_{O-V}		-0.3			Constant voltage supply
Saturation field temperature coefficient	TC_{HSAT}		-0.19			

Thermal Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Junction–Ambient Thermal Resistance	θ_{JA}		500		°C/W	Soldered to double-sided board
Power Dissipation	P_D			100	mW	

Operation

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:

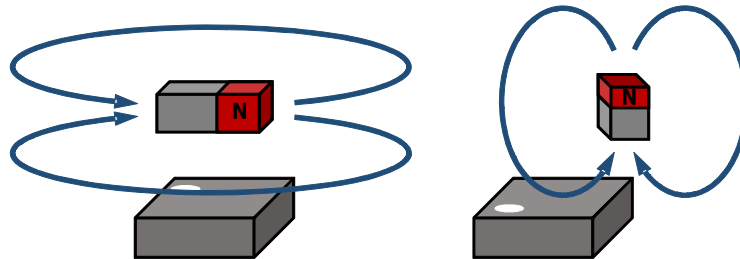


Figure 1. Planar magnetic sensitivity.

The sensor element is not directionally sensitive in the IC plane, so output from the sensor element is the same regardless of the direction of the applied magnetic field. Out of the IC plane, the output is roughly proportional to the cosine of the angle between the applied field and the IC.

Typical Performance

As shown in Figure 2, the AAK001 respond from zero field to 4 kOe, and are highly linear from 400 Oe to 2.5 kOe. The saturation field is dependant on temperature, but sensitivity is quite stable with temperature.

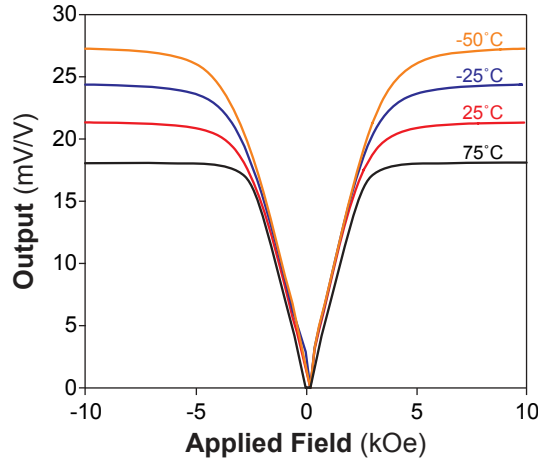


Figure 2. Output versus temperature.

Typical Applications

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 30, 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 200 KΩ input resistors are more than 100 times the 1.75 KΩ typical sensor output impedance to avoid loading.

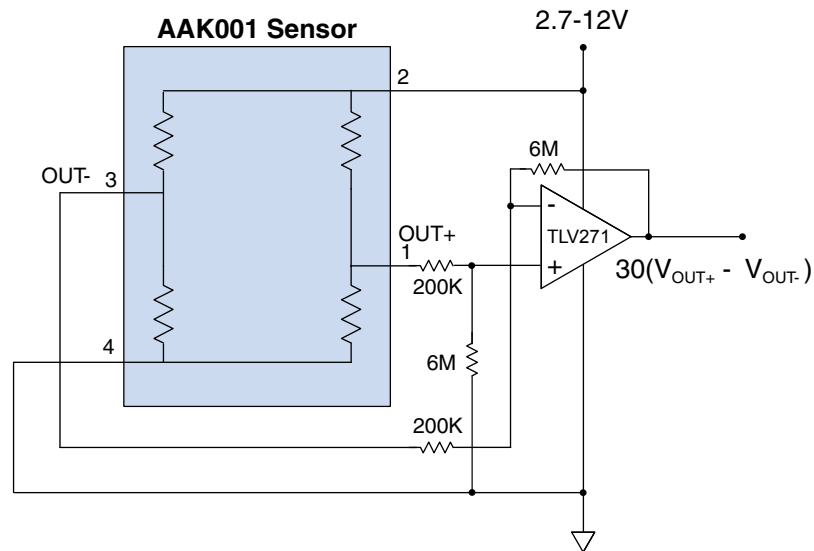


Figure 3. Traditional op-amp differential amplifier.

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 provides a single-ended, amplified output with offset correction:

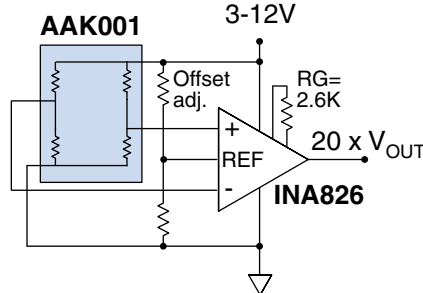


Figure 4. Single-ended analog sensor instrumentation amplifier.

The circuit has a gain of 20, which will provide full-scale output of half the power supply with the typical maximum sensor output of 20 mV/V. The general equation for the output voltage is:

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

Constant-Current Sensor Drive

Using a constant current rather than conventional constant voltage sensor supply can significantly improve temperature stability of the sensor. AAK001 sensors have an output temperature coefficient (TC_{O-I}) of 0.13%/°C with constant current, versus -0.3%/°C with constant voltage (TCOV).

A simple constant-current supply is illustrated below:

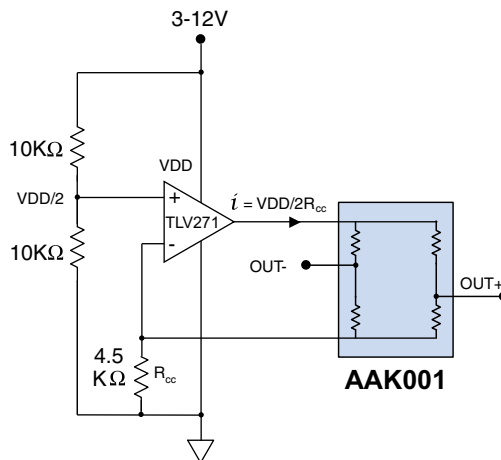


Figure 5. Constant-current supply.

The supply current for the circuit above is $V_{cc}/2R_{cc}$. R_{cc} can be set slightly more than the 4.2 KΩ maximum sensor bridge resistance to provide the highest possible output without saturating the op-amp. The circuit above will drive the sensor with 1.33 mA for a 12-volt supply.

Constant-current drive circuitry can be combined with amplifier circuitry such as that in Figure 3 or Figure 4.

Variable Threshold Magnetic Switch

AAK001 sensors can be used as high-field magnetic switches, allowing thresholds as high as 4 kOe and variable hysteresis, using a circuit such as this:

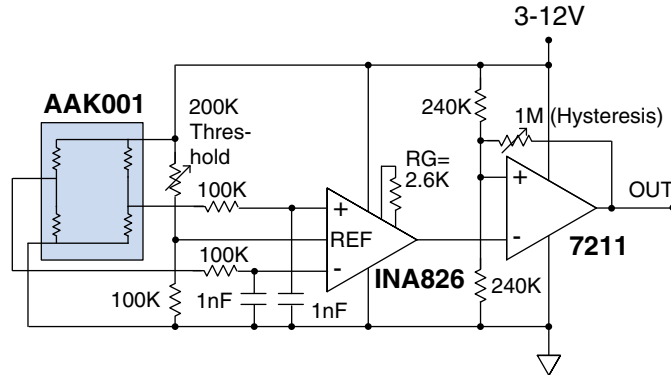


Figure 6. Variable threshold magnetic switch.

LED Field-Strength Indicator

The op-amp circuit in Figure 7 can be used to change the brightness of an LED to indicate magnetic field strength:

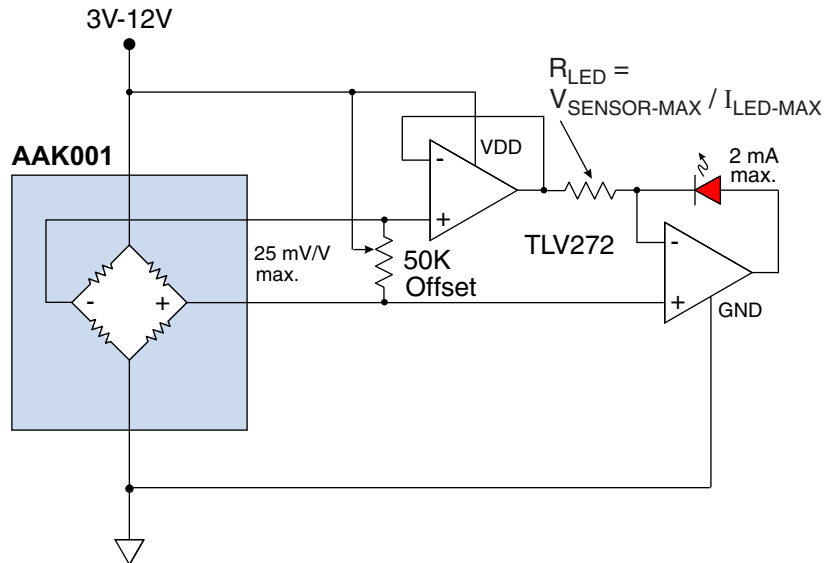


Figure 7. LED brightness changes with magnetic field.

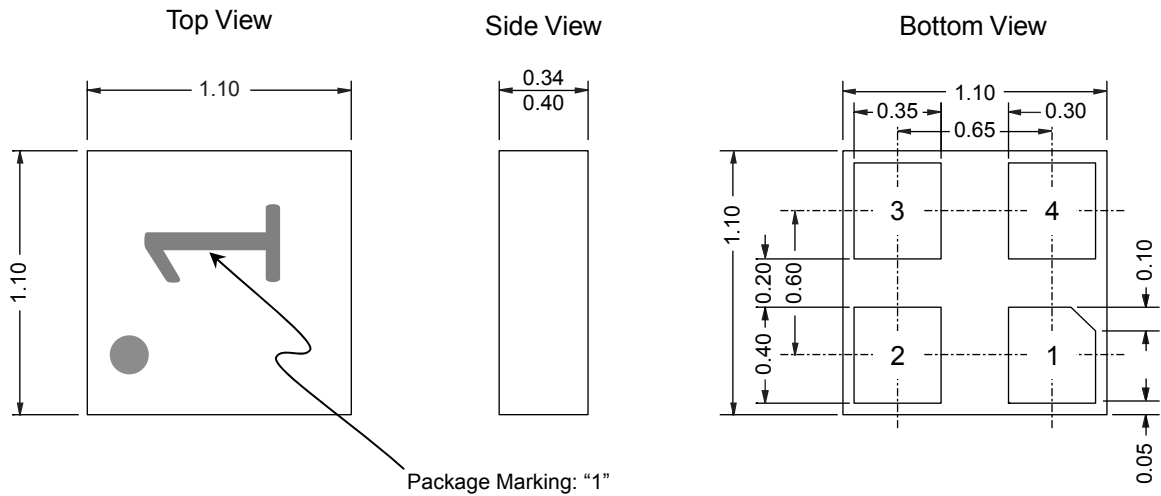
The LED current is proportional to the sensor output:

$$I_{LED} = (V_{OUT+} - V_{OUT-}) / R_{LED}$$

The maximum LED current can be set to the maximum sensor output. For example, the typical maximum sensor output is 25 mV/V, so for a 3 volt supply the maximum is approximately 75 mV. For a high-efficiency LED, the maximum LED current is 2 mA, so $R_{LED} = 75 \text{ mV} / 2 \text{ mA} = \underline{38\Omega}$.

The 50 K Ω potentiometer can be used to correct for sensor offset or to set the minimum field to turn on the LED.

1.1 x 1.1 x 0.37 mm ULLGA Package (-14E suffix)



Package Marking: "1"

Dimensions in mm; ± 0.10 mm unless otherwise noted.



Pin	Function
1	Out+
2	V _{DD}
3	Out-
4	Ground

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

This product has been tested for electrostatic sensitivity to the limits stated in the specifications. However, NVE recommends that all integrated circuits be handled with appropriate care to avoid damage. Damage caused by inappropriate handling or storage could range from performance degradation to complete failure.



Revision History

SB-00-068
August 2017

Change
• Initial Release

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