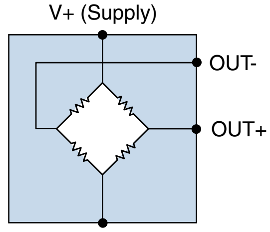
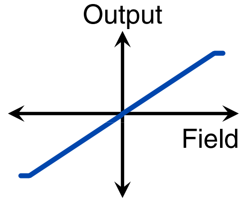
ALT025 Analog TMR Sensors

Equivalent Circuit



Idealized Transfer Functions



ALT-Series
Magnetometer
Transfer Function

Features

- Tunneling Magnetoresistive (TMR) technology
- Large signals (20 mV/V/mT typ.)
- ±10 mT (±100 Oe) linear range
- High linearity output (<1 %F.S. ±5 mT)
- Ultra-low temperature coefficient of output (±0.1 %/°C)
- Up to 300 kHz frequency bandwidth
- 20 kΩ typ. device resistance for low power
- Operation to near-zero voltage
- Up to 125 °C operating temperature
- Tiny TDFN6 package

Applications

- Motion, speed, and position control
- Non-contact current sensing
- Mechatronics and robotics

Description

The ALT025 is a Tunneling Magnetoresistance (TMR) analog bridge sensor with an extraordinary amount of signal and linear range.

The differential bridge output is bipolar, meaning it is positive for a positive field and negative for an opposite field polarity.

The Wheatstone bridge configuration allows the sensors to be pure ratiometric devices. They will operate properly at extremely low supply voltages, and the output signal will be proportional to the supply voltage.

The bridge signals are stable over a temperature range of −40 to 125 °C.

The sensor is available in a tiny TDFN6 package in tape and reel format.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Typical	Max.	Units
Supply voltage	V_{CC}			7	Volts
Operating temperature	T_{min}, T_{max}		−40	125	°C
Storage temperature			−65	150	°C
ESD (Human Body Model)[1]				2000	Volts
Applied magnetic field[2]	H			Unlimited	T
Voltage from sensor connections to center pad				63	Volts DC

Operating Specifications

Parameter	Symbol	Min.	Typical	Max.	Units
Operating temperature	T	−40		125	°C
Supply voltage	V_{cc}	0		5.5	Volts
Offset voltage	V_{offset}	−20		20	mV/V
Device resistance	R	8	20	30	kΩ
Frequency bandwidth[3]	f	DC		300	kHz
Operating field range[2]	H	−10		10	mT
Saturation field[2]	H_{sat}		30		mT
Sensitivity[2]		8	20		mV/V/mT
Hysteresis	H_c			1	% F.S.
Linearity[4] ±2mT, −40 –85°C ±5mT, −40 – 85°C ±2mT, −40 – 125°C ±5mT, −40 – 125°C	Lin		 0.1 0.2 0.2 0.5	 0.2 0.4 0.5 1	% F.S.
Output at maximum field	V_{max}			300	mV/V
Temperature coefficient of device resistance[5]	TCR		−0.08		% / °C
Temperature coefficient of output[5]	TCO	−0.1	0	0.1	% / °C
Off-axis characteristic[6]			$Cos^2(\beta)$		

Package Parameters	Symbol	Min.	Typical	Max.	Units
Junction–ambient thermal resistance[7]	θ_{JA}		320		°C/W
Power dissipation	P_D		500		mW

Notes:

1. Human Body Model (HBM) per JESD22-A114
2. 1 millitesla (mT) = 10 Gauss (G) = 10 Oersted (Oe) in air
3. Specified for amplitude reduction of −3 dB.
4. Maximum deviation from best linear fit. Excludes contributions from hysteresis.
5. TCR is the device resistance change with temperature in constant applied field. TCO is the output change with temperature using either a constant current or constant voltage source to power the sensor.
6. Beta (β) is any angle from the sensitive axis.
7. Measured per JESD51 with ground pad not connected to circuit board.

Typical Performance Graphs

Figures 1 shows the response of the ALT025.

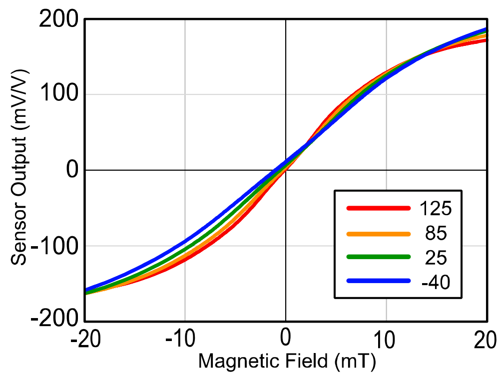


Figure 1. ALT025 performance for temperatures ranging from −40 to 125 °C.

Cross-Axis Axis Directional Sensitivity

The ALT025 has cross-axis sensitivity to magnetic fields corresponding to the pad 1 to pad 6 direction on the TDFN6 package. This configuration is useful in current sensor applications. Current carrying circuit board traces oriented beneath the part perpendicular to the sensitive direction will produce magnetic fields in the cross-axis direction for the ALT025 shown in Figure 2.

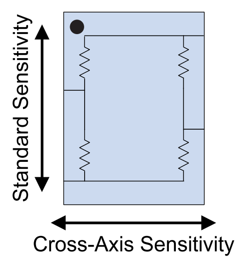


Figure 2. Cross-axis-sensitivity for ALT025 sensors.

Bipolar

ALT-Series sensors are bipolar. The sensor output changes sign with the magnetic field direction. This is ideal in applications like current sensing and proximity sensing where AC waveforms are expected or the signal changes sign. The diagram in Figure 3 shows the output polarity of the sensor referenced to the magnetic field direction. When the magnetic fields are oriented in the direction from pad 1 to pad 6 the sensor output (V_{out+}–V_{out-}) is positive. The magnetic field generated by the configuration in (a) produces the sensor output shown by the dot in (b).

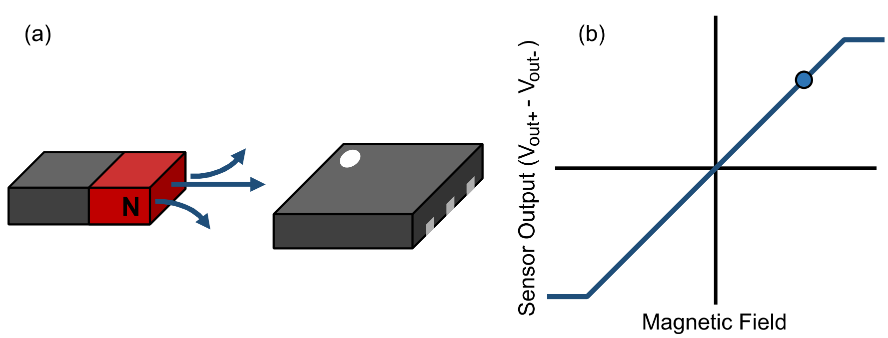


Figure 3. The bipolar response of ALT025 sensors.

Unlike Hall Effect or other sensors, the direction of sensitivity of the ALT025 TMR sensor is in the plane of the package, which is more convenient for many applications. Two alternatives to the permanent magnet orientation shown in Figure 3 are shown in Figure 4.

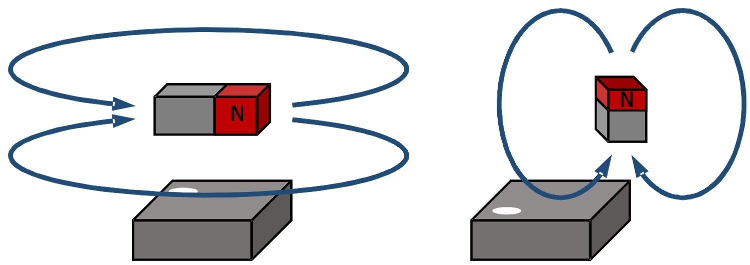


Figure 4. Planar magnetic sensitivity.

Illustrative Applications

Dual-Supply Differential Amplifier

The ALT025's bipolar output is ideal for applications requiring positive and negative output voltages. The circuit below has a gain of five. A low-cost, low bias current op amp allows large resistors to avoid loading the sensor bridge. The 1 MΩ input resistors are 100 times the 10 KΩ sensor output impedance to avoid loading.

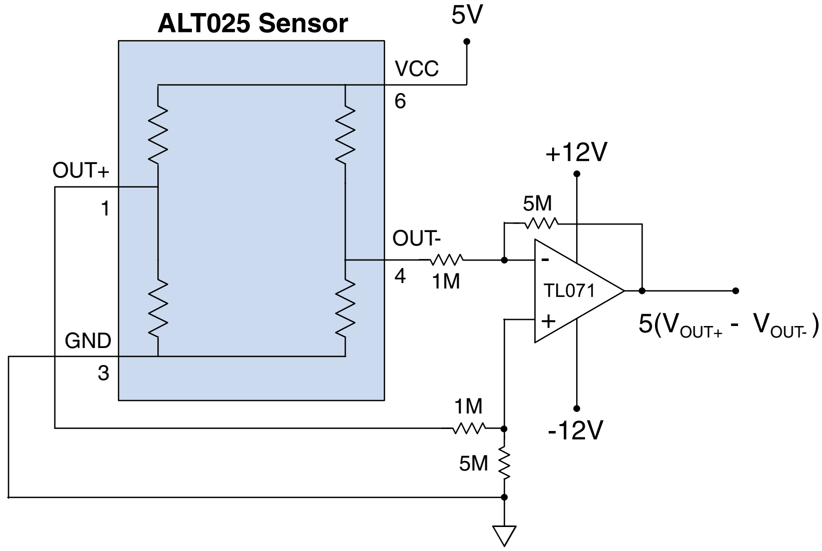


Figure 5. Dual-supply differential amplifier.

Single-Ended Instrumentation Amplifier

TMR sensors have high output signals, but if amplification or a single-ended output is required, a circuit like the one below can be used. A gain of 2.5 amplifies the sensor's typical maximum output of ±160 mV/V to 80% of rail-to-rail (one volt/volt), providing more usable signal without risk of saturating the amplifier for a sensor at the high end of the output signal range. A voltage divider provides a 2.5 V reference voltage to center the amplifier output with zero field.

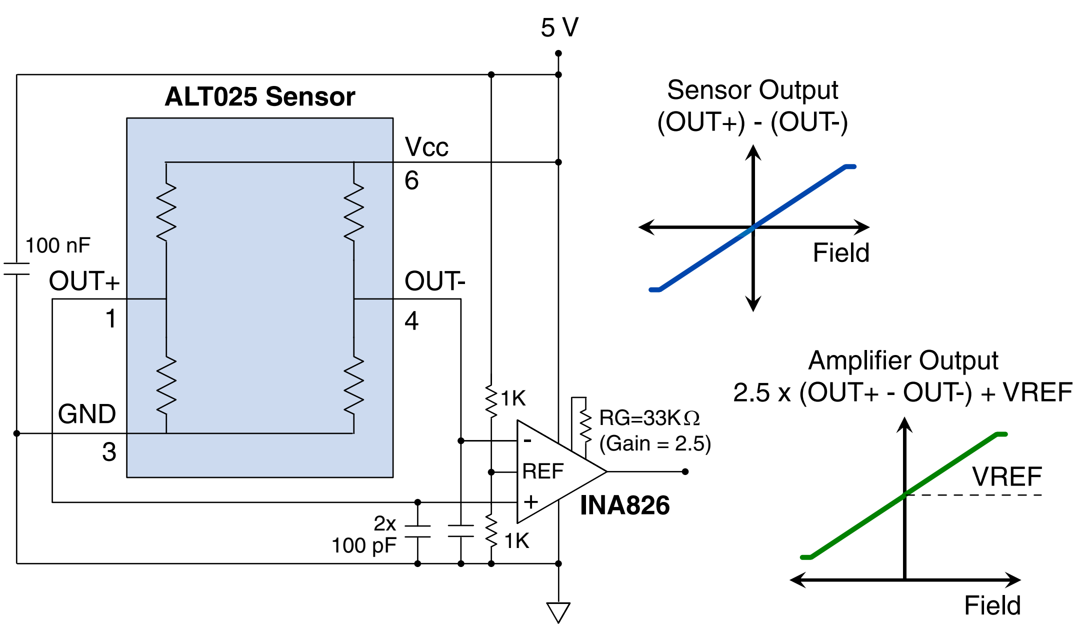


Figure 6. Single-ended analog sensor instrumentation amplifier.

Simple Direct Microcontroller Interfaces
With their large output signals, ALT025 sensors can often interface directly to microcontrollers, even the 10-bit ADCs built into inexpensive microcontrollers such as an Atmel AVR®. Such microcontrollers are common in Arduino and other sensor interface boards. The ALT025's 20 kΩ typical device resistance provides 10 kΩ output impedances, ideal for direct interface to many microcontrollers:

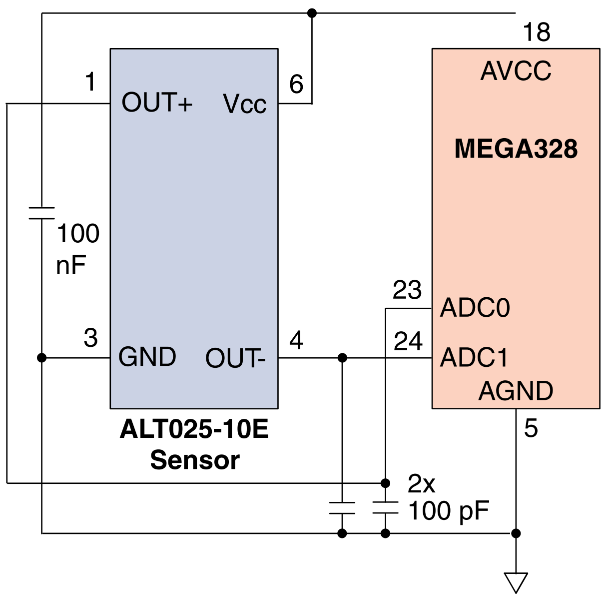


Figure 7. Typical direct microcontroller interface.

LED Field-Strength Indicator
The ALT025's true bipolar output allows detection of field polarity. The op-amp circuit in the figure below can be used to detect the polarity of the magnetic field, and change brightness to indicate field strength at a glance:

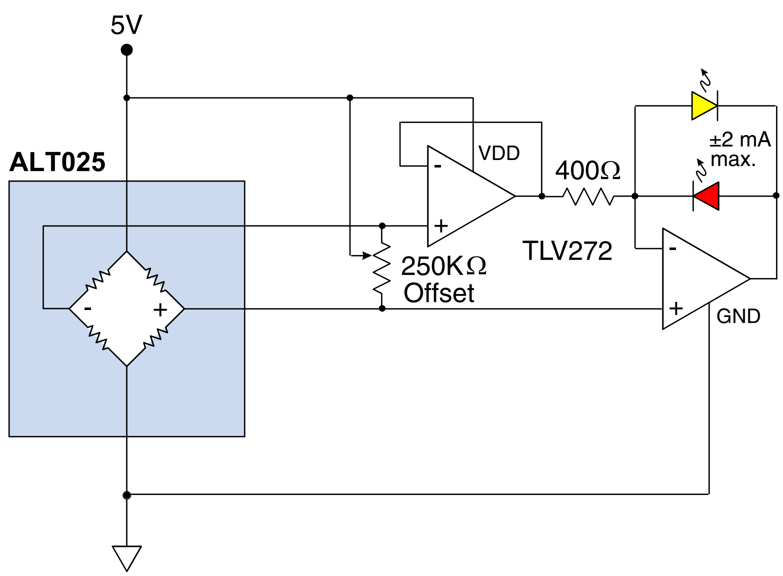


Figure 8. LED brightness indicates the magnetic field and color indicates polarity.

In this circuit, a positive field turns on the red LED, and a negative field turns on the yellow LED. The 250 KΩ potentiometer is optional to correct for sensor offset.

Noncontact Current Sensing
With low hysteresis, high linearity at low fields, and high speed, the ALT025is ideal for noncontact current measurement. Due to its convenient in-plane sensitivity, it can be mounted directly over PCB traces. The sensor measures the current by detecting the magnetic field generated by the current through the trace.

The ALT025 features cross-axis sensitivity, so it is able to detect current traces directly beneath the part for maximum accuracy. These sensors have a wide linear range, so they are solutions for a wide variety of current requirements. By tailoring the PCB trace to the application, the ALT025 can detect currents from 0.1 mA to 250 A.

Two typical high-resolution current sensing configurations are shown below. The current trace runs directly under the ALT025 on a single side of the PCB.

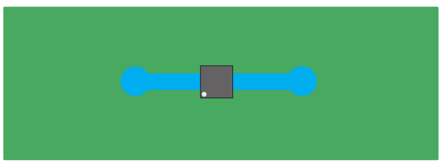


Figure 9a. 0.05" (1.3 mm) trace for currents 0 – 5 A.

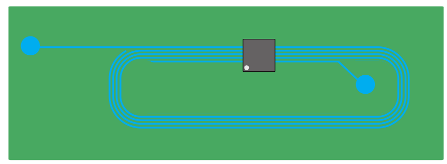


Figure 9b. Five turns of 0.0055" (0.14 mm) trace for currents 0 – 1 A.

For these configurations, the generated magnetic field is easy to calculate with Ampere's Law:

$$H = 5nI$$ ["H" in oersteds and "I" in amps. "n" is the number of turns.]

For high current sensing, larger traces are required. The sensor is typically mounted opposite a high current trace on a standard PCB, as shown in Figure 10. In this case, the width of the trace is significant, and a formula can be obtained by breaking the trace into a finite element array of thin traces, and calculating the field from each array element.

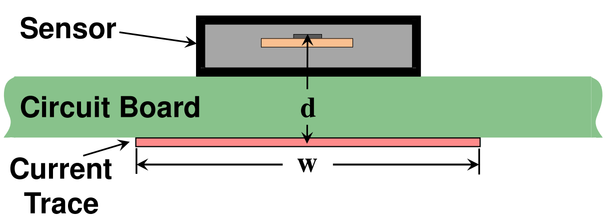


Figure 10. The geometry of current-sensing over a circuit board trace.
Depending on the trace's width and thickness, currents up to 250 A can safely be measured.

$$H = \frac{4I}{w} \cdot arctan\left[\frac{w}{2z}\right]$$ ["H" in oersteds, "I" in amps, "d" in millimeters, and "w" in millimeters.]

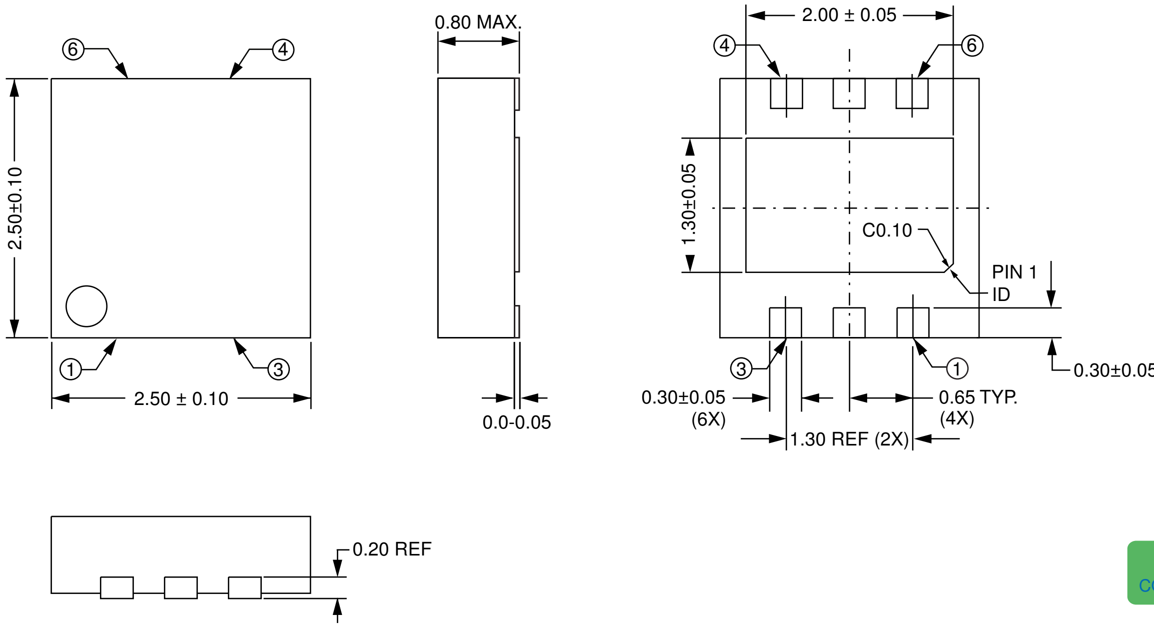
To simplify these calculations, we have a free, Web-based application with these formulas to calculate magnetic fields and sensor outputs in this application:

www.nve.com/spec/calculators.php#tabs-Current-Sensing

To help with the design of high current traces for current sensing applications, see our application note, which provides a comprehensive guide.

www.nve.com/Downloads/SB-00-083_Precision_High_Current_Sensing_Over_PCB_Traces.pdf

TDFN6 Package (-10 suffix)

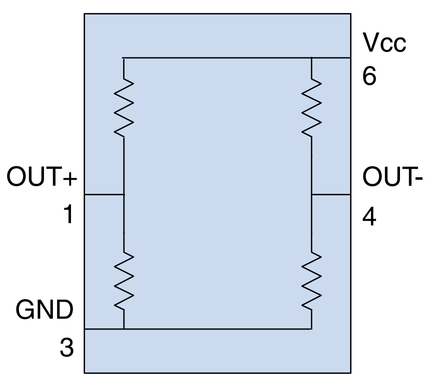


RoHS COMPLIANT

Notes:

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

ALT025-10E Pinout and Functional Diagram:



ALT025-10E Pinout		
Pin	Symbol	Description
1	V_{out+}	Positive bridge output (increases with field).
2	NC	No internal connection.
3	GND	Negative bridge supply or ground.
4	V_{out-}	Negative bridge output (decreases with field).
5	NC	No internal connection.
6	V_{cc}	Positive bridge supply.
Center Pad		Internally connected to leadframe

Part Numbering

ALT025-10E

Base Part
ALT = Analog TMR Magnetometer Sensors

Sensitivity Direction
02 = Cross-Axis

Sensitivity Code
5 = 10 mT Linear Range

Package Type
10 = TDFN6
E = RoHS

Bare Circuit Boards for Sensors

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

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

Revision History

SB-00-102 – Rev. B June 2019	**Change** • Corrected offset specification
SB-00-102 – Rev. A June 2019	**Change** • Clarified connections on application circuits • Increased typical sensitivity consistent with test data
SB-00-102 – Prelim June 2019	**Change** • Preliminary Release

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