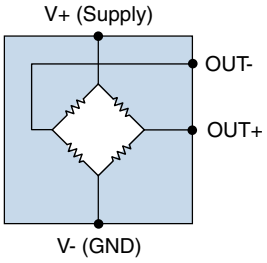
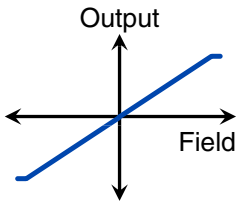
ALT-Series Analog TMR Sensors

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
- Standard (ALT005) and cross-axis (ALT025) versions

Applications

- Motion, speed, and position control
- Noncontact current sensing
- Mechatronics and robotics

Description

The ALT-series sensors are 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	Tesla
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	55	kΩ
Frequency bandwidth[3]	*f*	DC		350	kHz
Operating field range[2]	H	−10		10	mT
Saturation field[2]	H_{sat}		30		mT
Sensitivity[2]	Sen	6	20		mV/V/mT
Field Detectivity[2] 1 Hz 5 kHz	H_{min}		 30 0.7		nT/√Hz
Hysteresis[4]	H_c			1	%F.S.
Linearity[4,5] ±2 mT, −40 –85 °C ±5 mT, −40 – 85 °C ±2 mT, −40 – 125 °C ±5 mT, −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}			400	mV/V
Temperature coefficient of device resistance[6]	TCR		−0.08		%/°C
Temperature coefficient of output[6]	TCO	−0.1	0	0.1	%/°C
Off-axis characteristic[7]			$Cos^2(\beta)$		

Package Parameters	Symbol	Min.	Typical	Max.	Units
Junction–ambient thermal resistance[8]	θ_{JA}		320		°C/W
Power dissipation	P_D		500		mW

Notes:

1. Human Body Model (HBM) per JESD22-A114
2. 1 millitesla (mT) = 10^6nanotesla (nT) = 10 Gauss (G) = 10 Oersted (Oe) in air
3. Specified for amplitude reduction of −3 dB.
4. Full scale is defined as the operating field range.
5. Maximum deviation from best linear fit. Excludes contributions from hysteresis.
6. 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.
7. Beta (β) is any angle from the sensitive axis.
8. Measured per JESD51 with ground pad not connected to circuit board.

Typical Performance Graphs

Figures 1 shows the response of the ALT-Series TMR sensors.

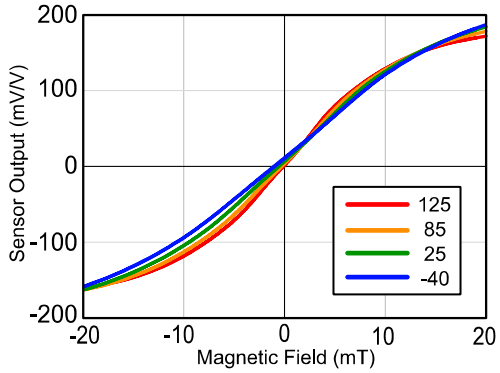


Figure 1. Typical ALT0x5 output at various temperatures.

Cross-Axis Axis Directional Sensitivity

The ALT-Series sensors have either cross-axis or standard axis sensitivity to magnetic fields. Cross-axis sensitivity corresponds to fields oriented from pad 1 to pad 6, and standard axis sensitivity corresponds to fields applied parallel to the pad 1 to pad 3 direction on the TDFN6 package. The ideal orientation for sensitivity is often determined by the orientation of the magnetic fields relative to PCB traces or system mechanical constraints.

The cross-axis configuration is useful in current sensor applications where current carrying circuit board traces oriented perpendicular to the sensitive direction avoid circuit board traces to the part and produce magnetic fields aligned the sensitive direction. The standard axis configuration is often more convenient for magnetometer applications such as magnet proximity sensing.

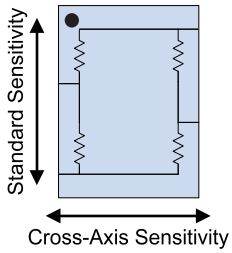


Figure 2. Standard axis and cross-axis sensitivity for ALT-Series sensors.

Bipolar

ALT-Series sensors are bipolar as shown in Figure 3. The sensor output changes sign with the magnetic field direction. This is ideal in applications such as current sensing and proximity sensing where AC waveforms are expected or the signal changes polarity. When the magnetic fields are oriented in the direction from pad 1 to pad 6 the sensor output ($V_{out+}-V_{out-}$) is positive for cross-axis sensitivity whereas the output is positive for fields oriented from pad 3 to pad 1 in the standard axis sensitivity configuration.The magnetic fields generated by the configuration in (a) and (b) produce the sensor output shown by the dot in (c).

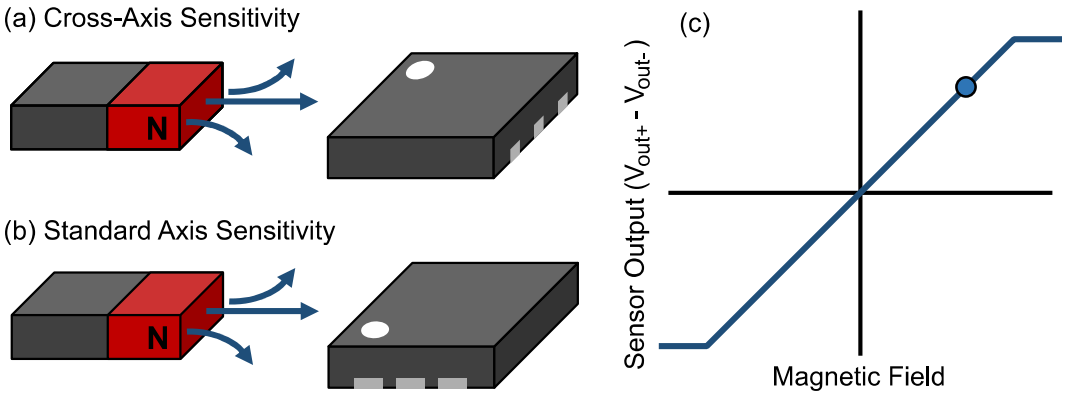


Figure 3. The ALT025 bipolar response.

The output of the sensor follows a $Cos\ (\theta)$ relationship, where Θ is the angle between the sensor's positive output sensitive direction and the applied field.

In-Plane Sensitivity

Unlike Hall Effect or other sensors, the direction of sensitivity of the ALT-Series TMR sensor is in the plane of the package, which is more convenient for many applications. Two alternative permanent magnet orientations are shown in Figure 4.

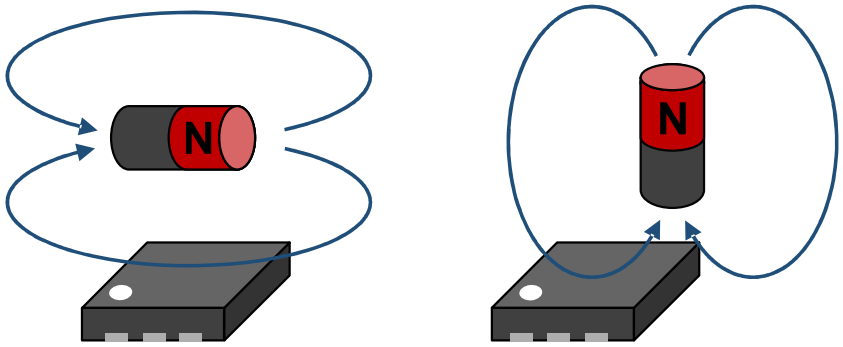


Figure 4. Planar magnetic sensitivity.

Minimum Magnetic Field Detectivity

ALT-Series TMR sensors have a remarkably high sensitivity and low noise. These parameters define the minimum detectable field for the sensor. The noise spectrum of the ALT-series sensors follow a classical 1/f noise profile at low frequency and is white noise at high frequency. So the detectivity varies with frequency. For more information, see NVE's application note on noise in TMR magnetometers, SB-00-101.

Illustrative Applications

Dual-Supply Differential Amplifier

The ALT-Series TMR sensor'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.

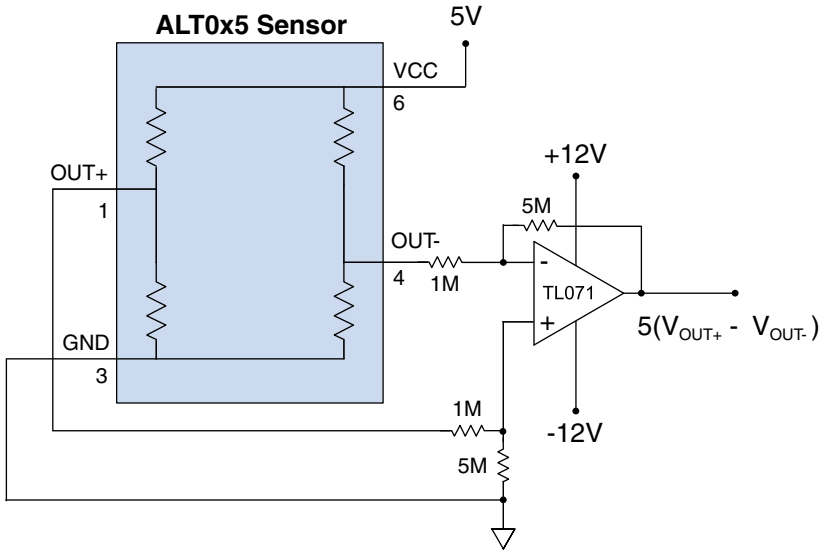


Figure 5. Dual-supply differential amplifier.

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.

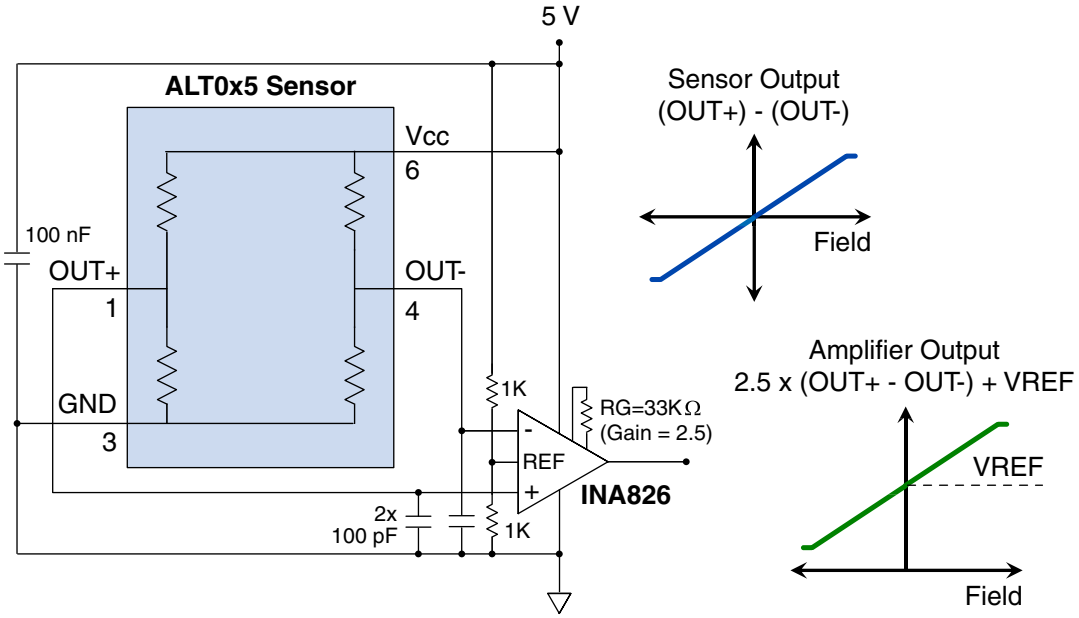


Figure 6. Single-ended analog sensor instrumentation amplifier.

Simple Direct Microcontroller Interfaces

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

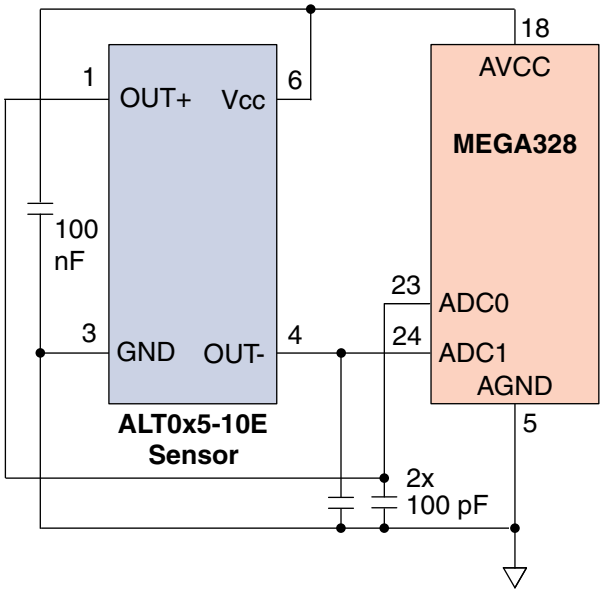


Figure 7. Typical direct microcontroller interface.

LED Field-Strength Indicator

The ALT-Series sensor'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:

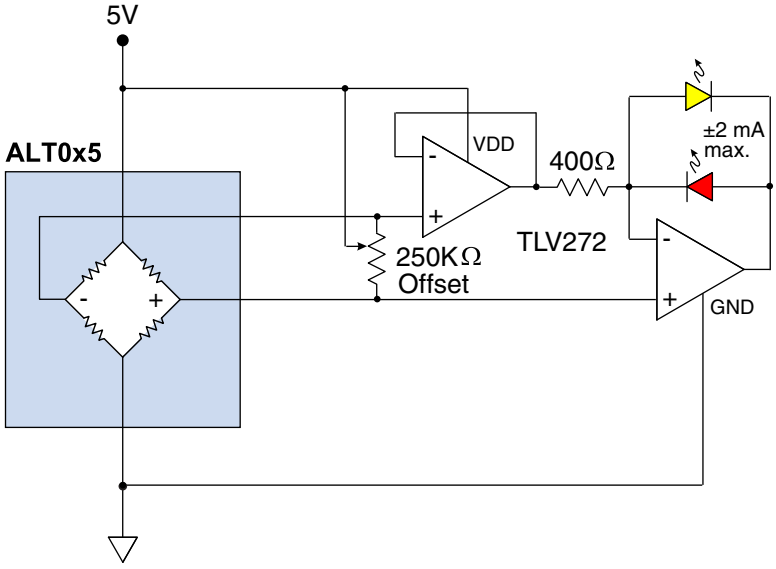


Figure 8. LED brightness indicates the magnetic field and color indicates polarity.

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 ALT025 is 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.

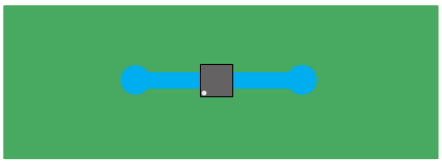


Figure 9a. 0.05" (1.3 mm) trace for currents 0 – 5 A.

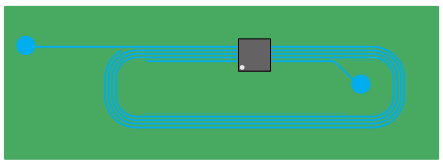


Figure 9b. Five turns of 0.0055" (0.14 mm) trace for currents 0 – 1 A.

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.

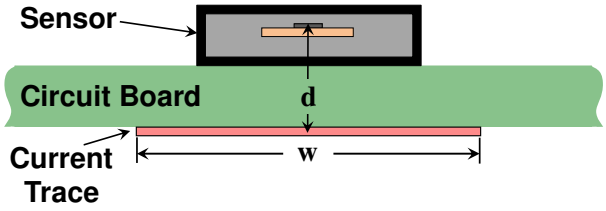


Figure 10. The geometry of current-sensing over a circuit board trace.
Depending on the trace's width and thickness, currents up to 250 A can safely be measured.

$$H = \frac{4I}{w} \cdot arcTan\left[\frac{w}{2d}\right]$$ ["H" in oersteds, "I" in amps, "d" in millimeters includes half of the package thickness, and "w" in millimeters.]

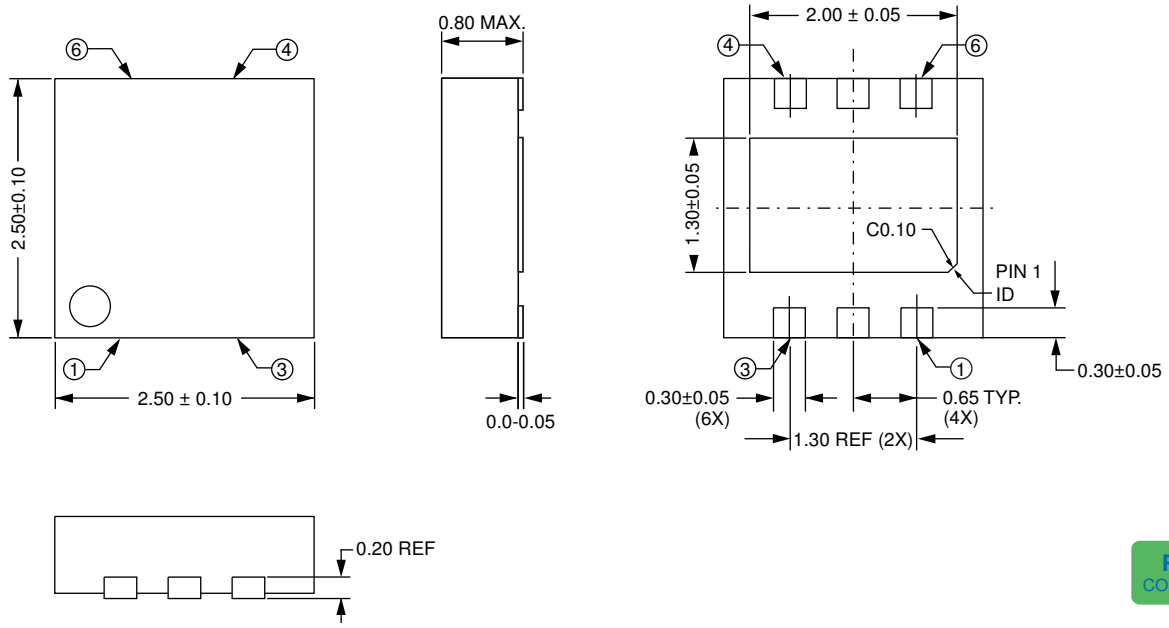
To simplify these calculations, we have a free, Web-based application with these formulas to calculate magnetic fields and sensor outputs in this application:

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)

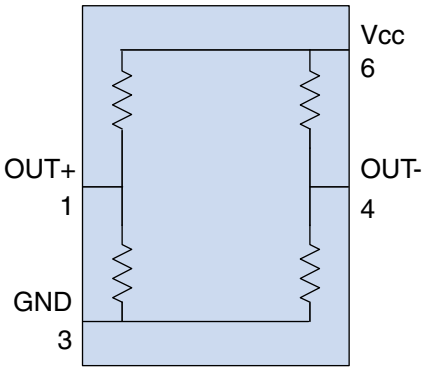


RoHS COMPLIANT

Notes:

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

ALT-Series Sensors Functional Diagram and 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	Sensitivity Direction	Sensitivity Code	Package Type
ALT = Analog TMR Magnetometer Sensors	00 = Standard Axis 02 = Cross-Axis	5 = 10 mT Linear Range	10 = TDFN6 E = RoHS

Available Parts

Part Number	Marking
ALT005-10E	FHB
ALT025-10E	FHC

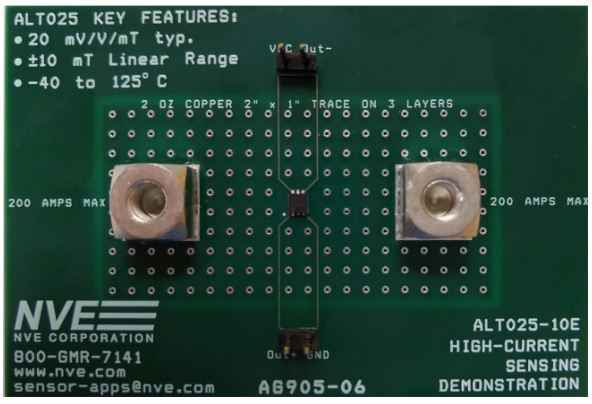
Bare Circuit Board

NVE offers a bare circuit board designed for easy connections to TDFN6 sensors such as ALT-Series sensors:

AG035-06:TDFN6 connection board
(1.57" x 0.25" /40 mm x 6 mm; actual size).

Current Sensor Evaluation Board

This demonstration board shows the ALT025's remarkable linear range and accuracy for up to ±200 A noncontact current measurement:



AG905-07E: ALT025-10E High-Current Demonstration Board
(3" x 2.065" / 76 mm x 52 mm; actual size).

Revision History

SB-00-102 – Rev. E April 2020	**Change** • Increased maximum resistance rating for lower power.
SB-00-102 – Rev. D November 2019	**Change** • Added ALT005 part for standard-axis sensitivity. • Updates and clarifications for standard axis and cross-axis sensitivities.
SB-00-102 – Rev. C August 2019	**Change** • Revised Fig. 4 (p. 4). • Added AG905-07E current sensing demonstration board (p. 9). • Minor typographical changes.
SB-00-102 – Rev. B June 2019	**Change** • Added part marking. • Added minimum sensor detectivity. • Clarified definition of full scale and 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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