P2A Low Noise Floor, High Sensitivity, Wide Dynamic Range Hall Sensor

Advanced Hall Sensors Ltd. specialise in the design, development and manufacture of highly sensitive Hall sensors using AlGaAs/InGaAs/GaAs quantum well technology.

1 Features

- Low noise floor: 20 nT Hz$^{-½}$
- High sensitivity: 160 V A^{-1} T^{-1}
- Wide (linear) dynamic range: 20 nT to 2 T
- Wide frequency operating range: DC to 5 MHz
- High linearity: 0.5 %
- Low temperature coefficient: -0.06 % °C^{-1}
- Compact size: 70 × 70 µm^2 sensor active area

2 Applications

- Magnetometry
- Magnetic imaging
- Position monitoring
- Speed monitoring / tachometry
- Electrical current measurement
- Galvanic isolation

3 Specifications

Absolute maximum ratings		
	Rating	Unit
Biasing voltage V_B	6	V
Biasing current I_B	9	mA
Power dissipation P_B	54	mW
Operating temperature T_0	-100 to +200	°C
Storage temperature T_1	-100 to +200	°C
Soldering temperature T_2	260	°C

Electrical characteristics				
	Min	Typ.	Max	Unit
Sensitivity K_H	-	160	-	V A^{-1} T^{-1}
Resistance R	620	720	780	Ω
Residual ratio θ A	-7	$\pm$5	+7	%
Temperature coefficient of Hall voltage signal α B	-0.08	-0.06	-0.05	% °C^{-1}
Temperature coefficient of resistance β C	-	0.3	0.4	% °C^{-1}
Linearity of Hall voltage signal γ D	-	0.5	1.0	%

Notes:

Testing conditions			
I_{B1} 1 mA	T_1 -100°C	B_0 0 mT	B_2 100 mT
I_{B2} 5 mA	T_2 +150°C	B_1 60 mT	B_3 500 mT

A. Residual ratio

$$\theta = \frac{V_H(B_0)}{V_H(B_2)}$$

B. Temperature coefficient of Hall voltage signal

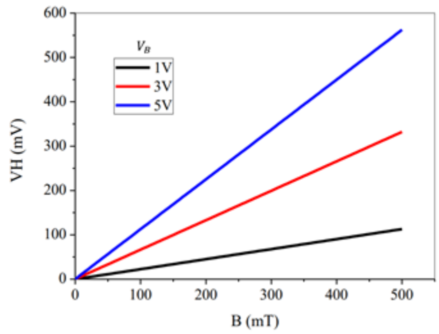
$$\alpha = \frac{1}{V_H(T_1)} \frac{V_H(T_2) - V_H(T_1)}{T_2 - T_1} \times 100$$

C. Temperature coefficient of resistance

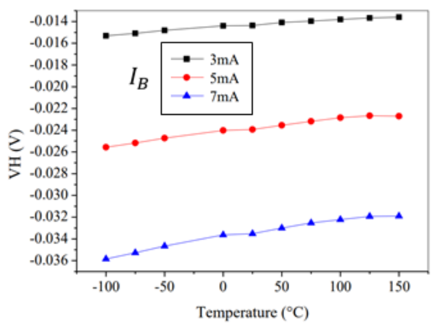
$$\beta = \frac{1}{R(T_1)} \frac{R(T_2) - R(T_1)}{T_2 - T_1} \times 100$$

D. Linearity of Hall voltage signal

$$\gamma = \frac{K_H(B_3) - K_H(B_1)}{\frac{1}{2}[K_H(B_1) + K_H(B_3)]} \times 100$$



Hall voltage signal vs. detected magnetic field



Hall voltage signal vs. temperature whilst detecting 30 mT DC magnetic field for different biasing currents

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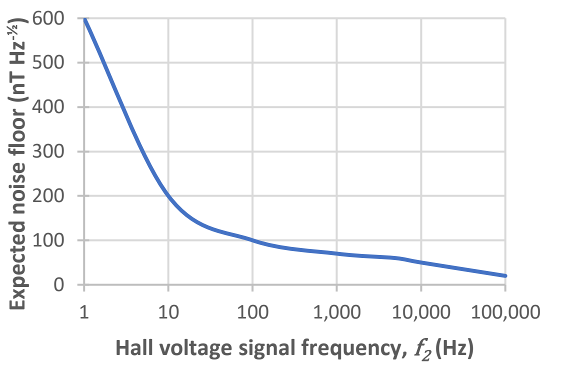
Note that the expected noise floor also includes the effects of biasing current, filtering/conditioning and ADC conversion. Please follow the recommended use guidance to achieve such performance.

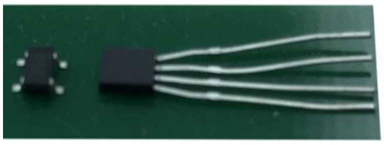


Expected noise floor vs. Hall voltage signal frequency

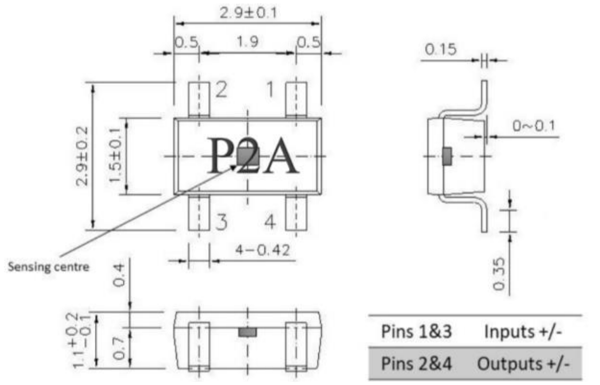
4 Pin configuration and layout

The sensor is available in two packages:

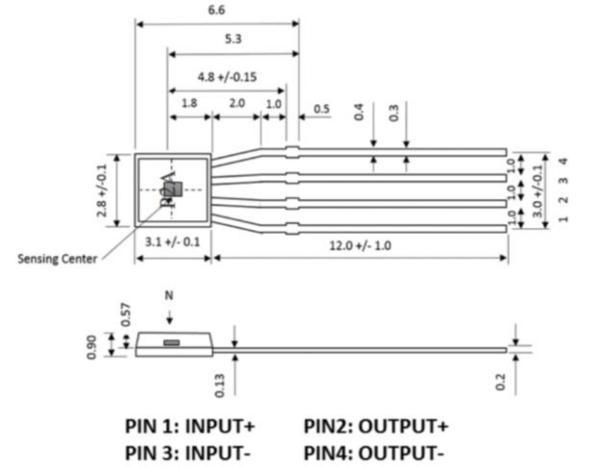
	Package	Package size (mm^2)
Surface mount	SOT-143	2.9 × 2.9
Through hole	4 pin	3.1 × 2.8



P2A surface mount and through hole



SOT-143 surface mount footprint – dimensions in mm



4 pin through hole footprint – dimensions in mm

5 Sensor description

The P2A is a high-performance Hall sensor with a low noise floor, high sensitivity and wide dynamic and operating range. Using AlGaAs/InGaAs/GaAs technology, the P2A contains a quantum well which confines the electrons of the biasing current within a 2-Dimensional Electron Gas. From this, the electrons experience the Hall effect via a detected magnetic field in a more controlled manner with less scattering, allowing for greater measurement sensitivity and significantly reduced noise floor compared to generic Hall sensors.

The detected magnetic field can be easily reconstructed using the equation:

$$B_z = \frac{V_H}{K_H \cdot I_B} = \frac{V_H \cdot R}{K_H \cdot V_B}$$

B_z is the magnetic flux density detected tangential to the sensor plane (T), V_H is the Hall voltage signal (V), K_H is the P2A sensitivity (160 V A^{-1} T^{-1}), I_B is the biasing current used (A), R is the P2A resistance (Ω) and V_B is the biasing voltage used (V).

Users have full control over the biasing current (frequency and magnitude) which is externally provided to pins 1 and 3, or 2 and 4. This direct control enables greater versatility of the sensor, with users able to control the dynamic range and suitability of the output signal to ensure compatibility to downstream amplification, filtering and Analogue-Digital Conversion as required.

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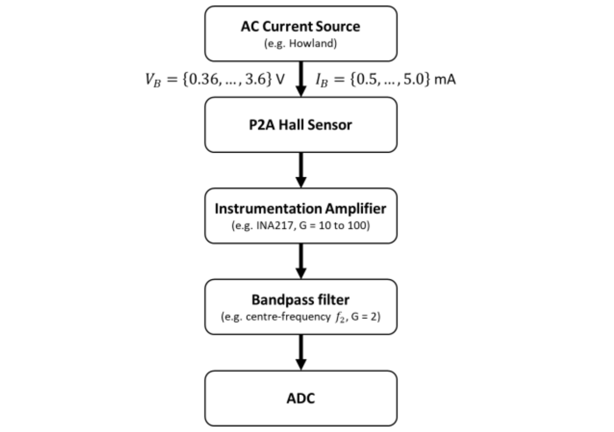
6 Recommended use

For low noise wide dynamic range applications, it is recommended to bias the P2A Hall sensor using a low noise AC biasing current, such as that provided by a Howland current source within the range of 0.5 to 5.0 mA. It is also recommended to amplify the output Hall voltage signal using a suitable low noise, low distortion instrumentation amplifier, such as the INA217. A secondary amplification and bandpass filter stage will also help to reduce the bandwidth of the circuit and further reduce noise.



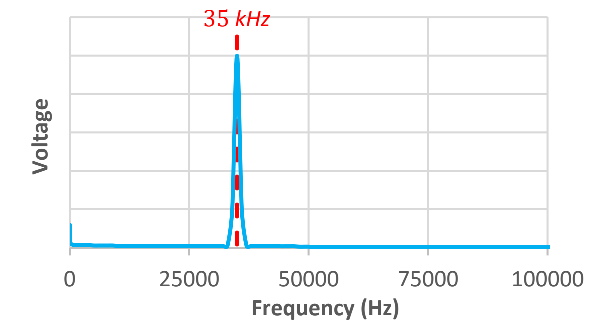
Recommended sensor use / circuit design

Note that the frequency and phase of the output Hall voltage is a modulated combination of both the biasing current and the detected magnetic field:

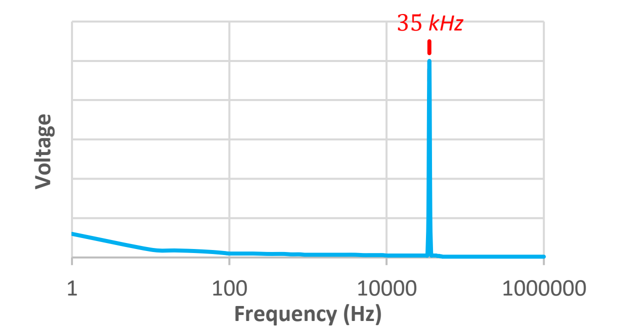
$$f_2 = \max(f_0, f_1) \pm \min(f_0, f_1)$$

f_2 is the frequency of the Hall voltage signal (Hz), f_1 is the frequency of the biasing current (Hz), f_0 is the frequency of the detected magnetic field (Hz).

e.g. Using a biasing current frequency of 35 kHz and detecting a static (DC) magnetic field: $f_0 = 0$, $f_1 =$ 35 kHz and $f_2 =$ 35 kHz.

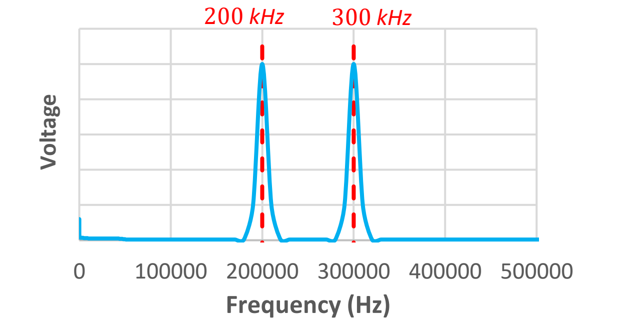


Expected frequency spectrum of signal voltage

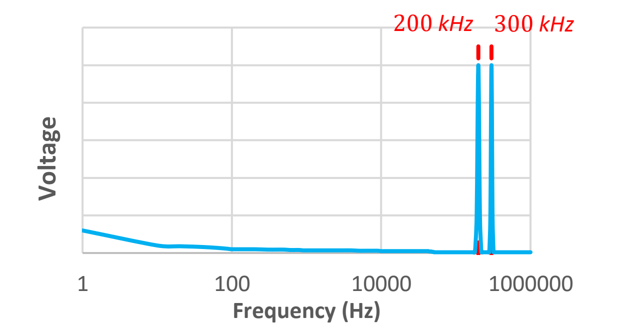


Expected frequency spectrum of signal voltage (log scale)

e.g. Using a biasing current frequency of 50 kHz and detecting a magnetic field of 250 kHz: $f_0 =$ 50 kHz, $f_1 =$ 250 kHz; $f_2 =$ 200 kHz and 300 kHz.



Expected frequency spectrum of signal voltage



Expected frequency spectrum of signal voltage (log scale)