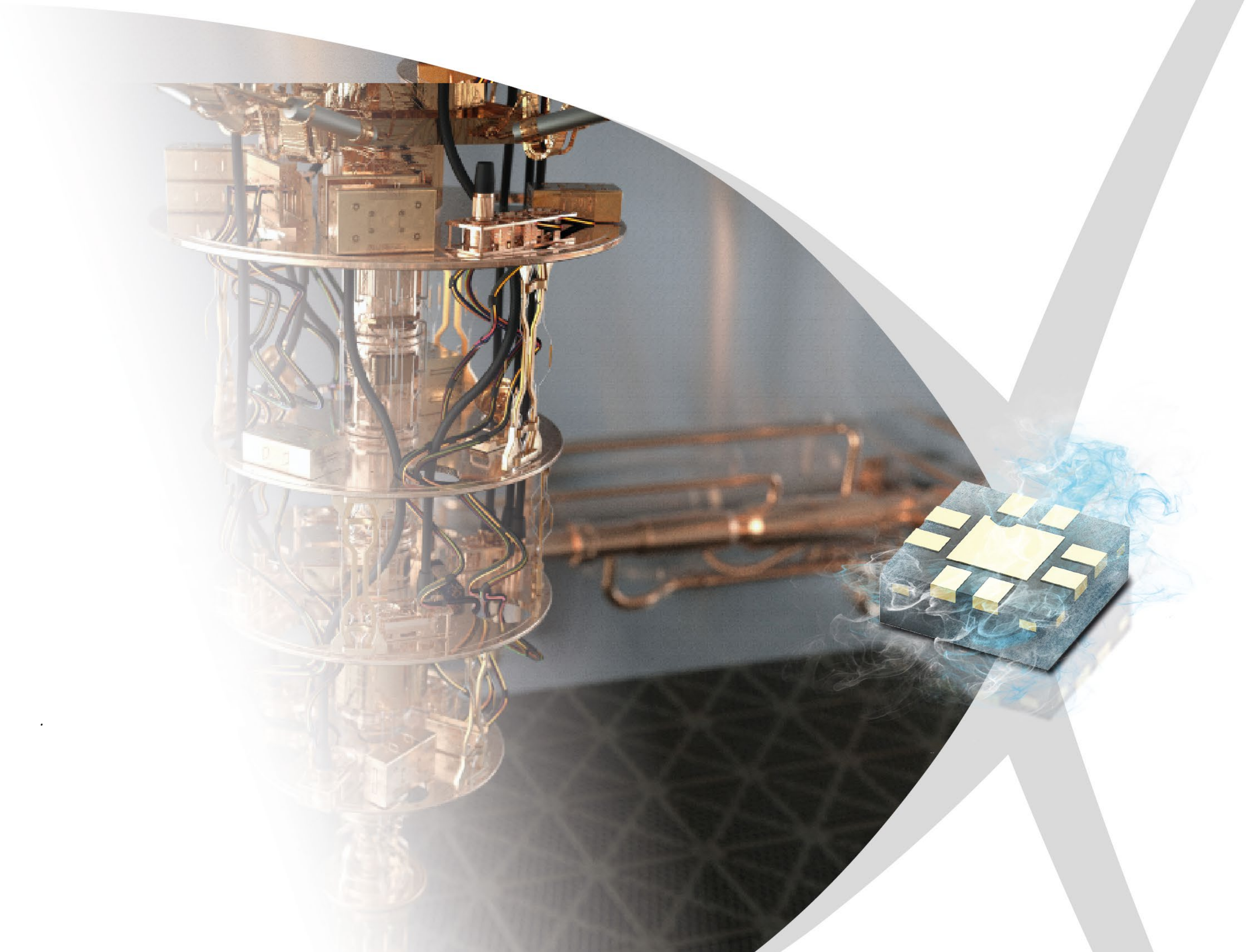
Datasheet

GHS Extreme Hall Sensor Range [Preliminary]

This datasheet contains preliminary data, which is subject to change



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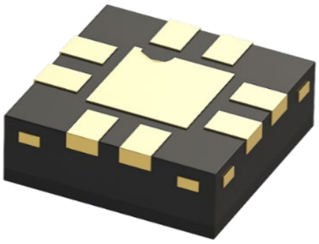
1. Features and Benefits

Paragraf is the world's first company to use graphene to mass produce electronic devices using standard semiconductor processes. Utilising the inherently high sensitivity of graphene, the GHS Extreme range of cryogenic single-axis graphene Hall sensors achieves outstanding resolution at cryogenic extremes with measurements up to 30 T in space restricted environments such as in a low temperature vacuum chamber.

This allows for:

- More accurate characterisation of material properties at the extremes of temperature and magnetic fields.
- Measurement at the lowest possible base temperatures – the power consumption is extremely low, keeping heat load at the cold finger to a minimum.
- Measurement where space is restricted.

The lack of planar Hall effect also helps with experiments where vector fields are used or where the sample must be rotated in the field to understand material properties. Lower noise allows cleaner high resolution data.



GHS Extreme Features:

- Operation down to 1.5 K
- Field range greater than 30 T
- Low power dissipation
- Exceptionally high resolution
- Low noise measurements
- High linearity
- Negligible planar Hall effect
- 3mm wide QFN package

2. Applications

Typical applications include:

- High field superconducting magnet calibration and mapping at cryogenic temperatures for high energy physics, superconducting magnet manufacture, or magnetic confinement-based fusion systems development.
- In-situ precision magnetic field measurements in large magnetic fields and/or at cryogenic temperatures for high field materials research or remnant magnetisation measurement of research magnets.
- High precision position sensing and feedback for encoders and magnetic bearings.
- High precision positioning of sample stages with respect to magnetic field direction in research magnet applications.
- Low temperature, near-zero field measurement for cryogenic equipment manufacturing, particularly for the characterisation of magnetic shields for superconducting magnets.

3. GHS Extreme range product items and accessories

Product code	Description
Sensor only	
AGHSX01Q01	3mm Graphene Cryogenic Extreme Range/High Magnetic Field Hall Sensor
AGHSX02Q01	3mm Graphene Cryogenic Mid Range Hall Sensor
Sensor with accessories	
AGHKX01P01	Graphene High Magnetic Field Hall Sensor probe with 3mm sensor/3m cable
AGHKX02P01	Graphene Cryogenic Mid Range Hall Sensor probe with 3mm sensor/3m cable
AGHKX02P02	Graphene Cryogenic Mid Range Hall Sensor probe with 3mm sensor/PCB only
Other accessories	
AGHSA01XXX	4 Channel MiST Multi Sensor Test box

4. AGHSX01Q01 sensor specifications

4.1 Absolute maximum ratings

Parameter	Min	Max	Units
Conductor voltage	-24	+24	V
Conductor current	-5	+5	mA
Operating temperature *	1.5	323	K
Operating humidity (relative non-condensing)		75	%
Storage temperature	0.001	333	K

* The absolute maximum temperature ratings are provided for safe operation of the sensor. The user should test the products within the recommended operating conditions and assess suitability for the application.

4.2 Recommended operating conditions

Parameter	Min	Typical	Max	Units
Supply current *	0.01	200	5000	µA

* A higher current supply will give a larger voltage output for a given sensitivity and field, based on the scaling equation: Voltage output = magnetic field measured x sensitivity x current. A lower current will limit power dissipation. As per R x I^2, the power dissipation of a sensor with an internal resistance of 6.5 kΩ will be 260 µW when supplied with 200 µA or 0.65 pW when supplied with 10 nA.

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4.3 Performance characteristics

Ambient temperature = 300 K, unless otherwise specified. I_N = 200 µA.

Parameter	Test conditions/notes	Min	Typical	Max	Units
Measurable field range		±30 (300)			T (kG)
Resolution	1 T field at 1 Hz, $I = I_N$		10		ppm
Spectral noise density [1]	at 1 Hz, $I = I_N$		0.3	1	µV/√Hz
Thermal noise floor [2]	3 kHz corner frequency if $I = I_N$		0.02		µV/√Hz
Bandwidth [3]	$I = I_N$, -3dB		490		kHz
Sensitivity [4]	At ambient temperature	150 (15)	200 (20)	250 (25)	V/A.T (mV/A.G)
Linearity of Hall voltage	$I = I_N$, at 300 K at 4K		0.2 1		% of full scale
Internal resistance	Between pin 1/2 and 5/6, and between pin 3/4 and 7/8, at field B = 0 T	5	6.5	8	kΩ
Ohmic Offset [5]	B = 0 T		50		Ω
Temperature coefficient of offset	$I = I_N$		0.1		Ω/K
Temperature coefficient of sensitivity	$I = I_N$, at ambient temperature at 4K		0.01 0.22		%/K

[1] If the sensor is supplied with a current of 0.2 mA and has a sensitivity of 200 V/A.T (20 mV/A.G), a noise of 1 µV/√Hz at 1 Hz represents a noise of 25 µT/√Hz (0.25 G/√Hz).

[2] If the sensor is supplied with a current of 5 mA and has a sensitivity of 200 V/A.T (20 mV/A.G), a thermal noise of 0.02 µV/√Hz represents a noise of 20 nT/√Hz (0.2 mG/√Hz). The corner frequency will rise if the supply current increases.

[3] Bandwidth will increase if the supply current reduces.

[4] If the sensor is supplied with a current of 5 mA and has a sensitivity of 200 V/A.T (20 mV/A.G), then a field of 50 mT (500 G) will generate an output of 50 mV.

[5] If the sensor is supplied with a current of 0.2 mA and has a sensitivity 200 V/A.T (20 mV/A.G), an offset of 50 Ohms will translate into an output voltage of 10 mV (equivalent to 250 mT (2.5 kG)).

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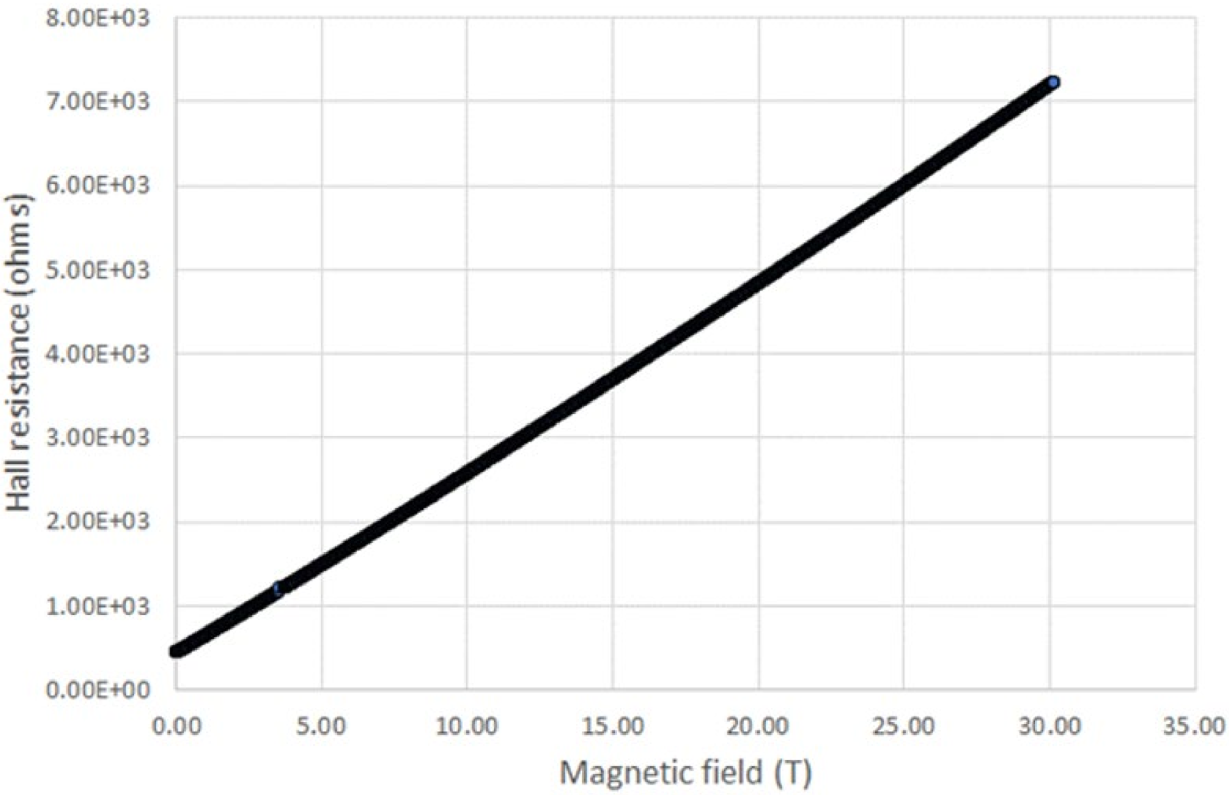
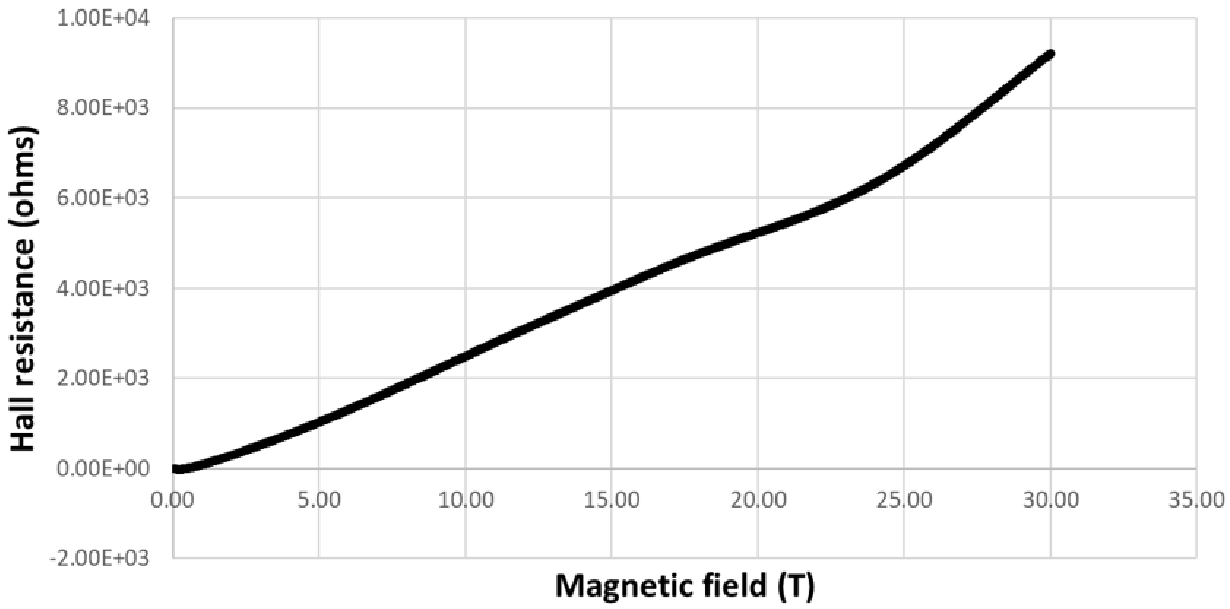
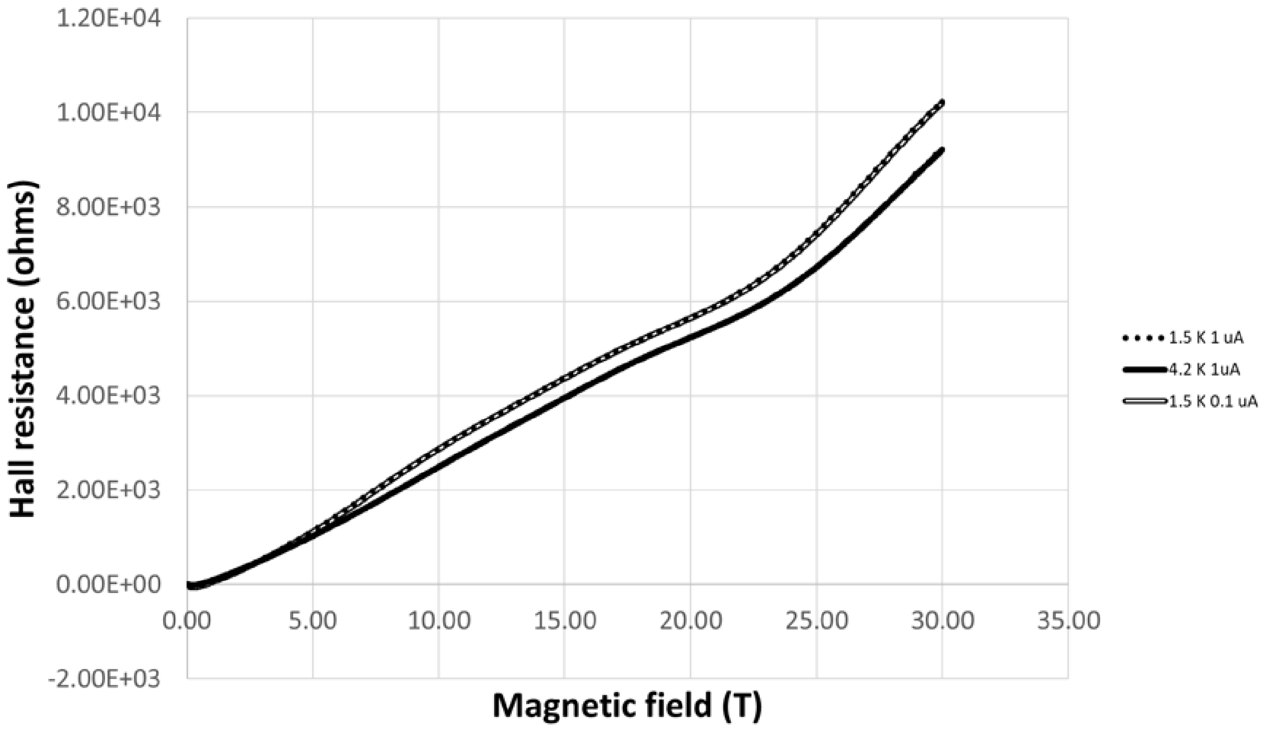
Typical Hall resistance to 30 T at 300 K



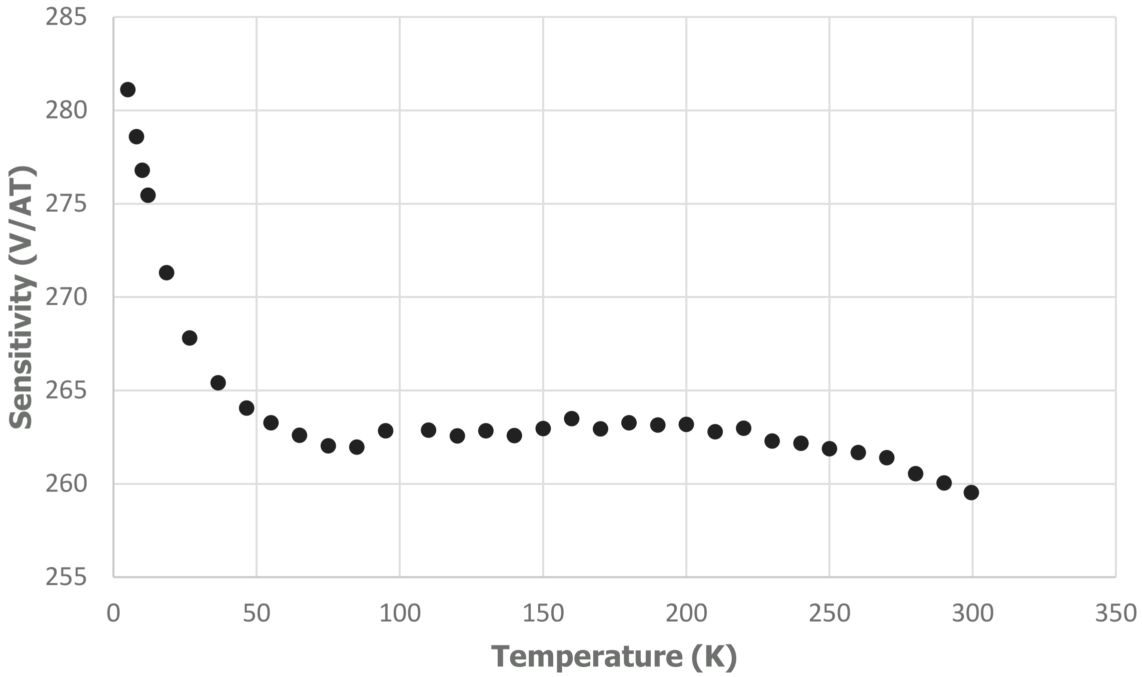
Typical Hall resistance to 30 T at 4 K



Typical Hall resistance to 30 T at 4 K vs at 1.5 K



Typical sensitivity to 300 K



5. AGHSX02Q01 sensor specifications

5.1 Absolute maximum ratings

Parameter	Min	Max	Units
Conductor voltage	-24	+24	V
Conductor current	-5	+5	mA
Operating temperature *	4	323	K
Operating humidity (relative non-condensing)		75	%
Storage temperature	4	333	K

* Temperature ratings are provided for safe operation of the sensor. The user should test the products within the recommended operating conditions and assess suitability for the application. The minimum operating temperature is limited by material properties.

5.2 Recommended operating conditions

Parameter	Min	Typical	Max	Units
Supply current *	0.01	200	5000	µA

* A higher current supply will give a larger voltage output for a given sensitivity and field, based on the scaling equation: Voltage output = magnetic field measured x sensitivity x current. A lower current will limit power dissipation. As per $R \times I^2$, the power dissipation of a sensor with an internal resistance of 6.5 kΩ will be 260 µW when supplied with 200 µA or 0.65 pW when supplied with 10 nA.

5.3 Performance characteristics

Ambient temperature = 300 K, unless otherwise specified. I_N = 200 µA.

Parameter	Test conditions/notes	Min	Typical	Max	Units
Measurable field range		±7 (70)			T (kG)
Resolution	1 T field, $I = I_N$		10		ppm
Spectral noise density [1]	at 1 Hz, $I = I_N$		0.3	1	µV/√Hz
Thermal noise floor [2]	3 kHz corner frequency if $I = I_N$		0.02		µV/√Hz
Bandwidth [3]	$I = I_N$, -3dB		490		kHz
Sensitivity [4]	At ambient temperature	250 (25)	290 (29)	400 (40)	V/A.T (mV/A.G)
Linearity of Hall voltage from -1 T to 1 T	$I = I_N$, at 300 K at 4K		0.2 1		% of full scale
Linearity of Hall voltage from 0 T to 7 T	$I = I_N$, at 300 K at 4K		0.25 1.5		% of full scale
Internal resistance	Between pin 1/2 and 5/6, and between pin 3/4 and 7/8, at field B = 0 T	5	6.5	8	kΩ
Ohmic Offset [5]	B = 0 T		50		Ω
Temperature coefficient of offset	$I = I_N$		0.1		Ω/K
Temperature coefficient of sensitivity	$I = I_N$ at ambient temperature at 4K		0.01 0.22		%/K

[1] If the sensor is supplied with a current of 0.2 mA has a sensitivity of 300 V/A.T (30 mV/A.G), a noise of 1µV/√Hz at 1 Hz represents a noise of 17 µT/√Hz (0.17 G/√Hz).

[2] If the sensor is supplied with a current of 5 mA and has a sensitivity of 300 V/A.T (30 mV/A.G), a thermal noise of 0.02µV/√Hz represents a noise of 13nT/√Hz (0.13 mG/√Hz). The corner frequency will rise if the supply current increases.

[3] Bandwidth will increase if the supply current decreases.

[4] If the sensor is supplied with a current of 5 mA and has a sensitivity of 300 V/A.T (30 mV/A.G), then a field of 50 mT (500 G) will generate an output of 75 mV.

[5] If the sensor is supplied with a current of 0.2 mA and has a sensitivity 300 V/A.T (30 mV/A.G), an offset of 50 Ohms will translate into an output voltage of 10 mV (equivalent to 167 mT (1.67 kG)).

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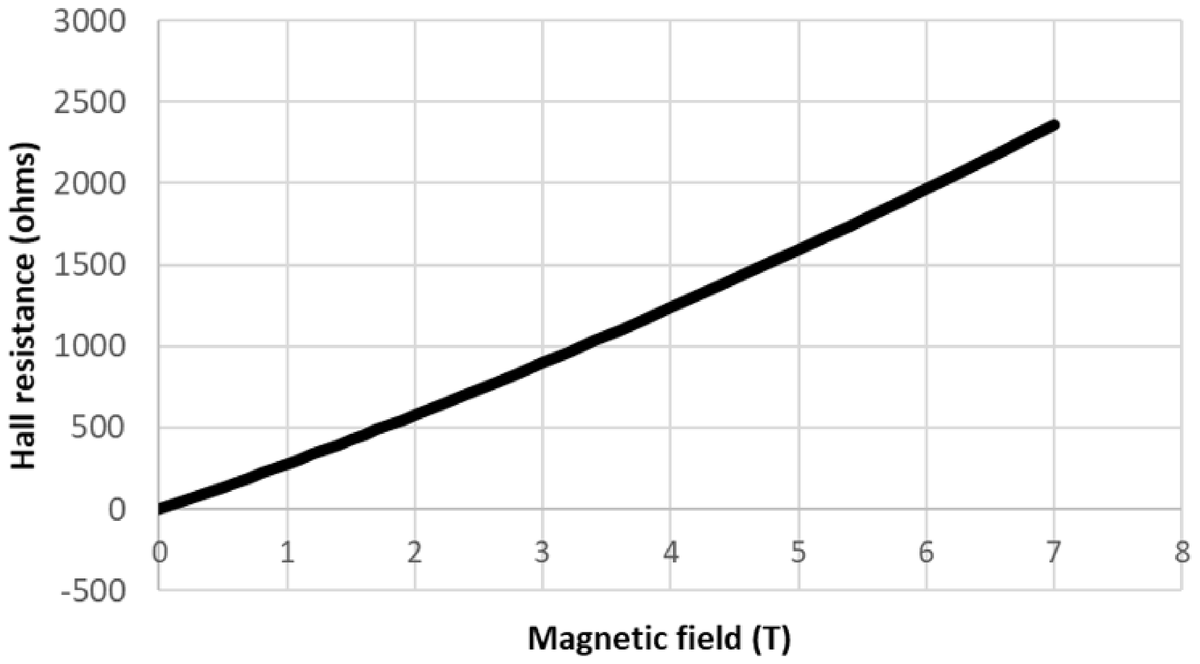
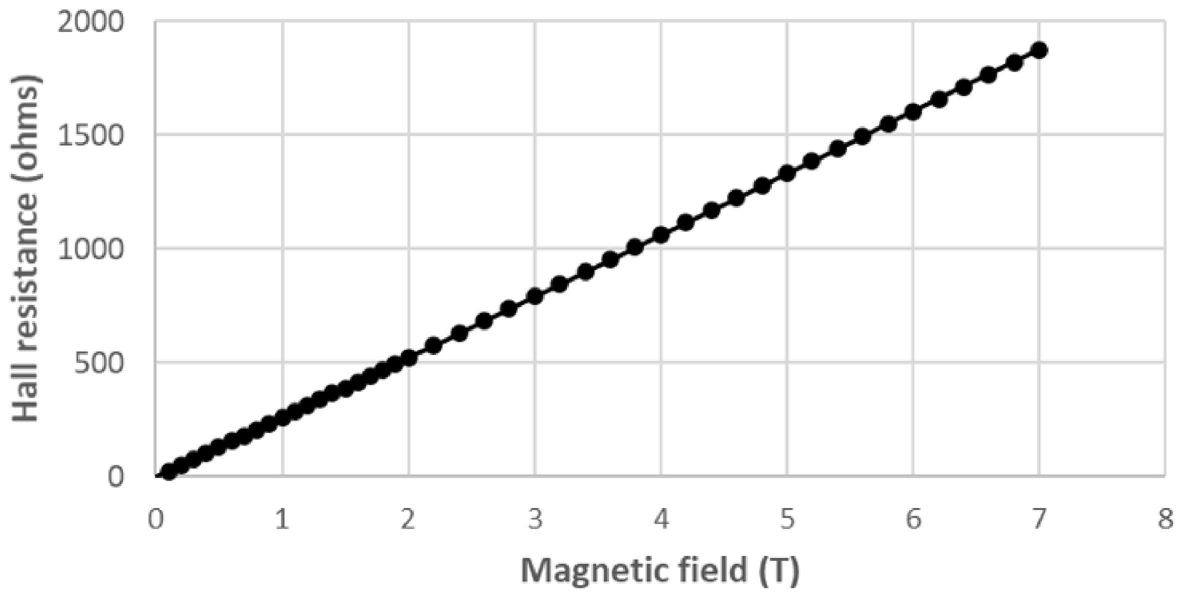
Typical Hall resistance to 7 T at 4 K



Typical Hall resistance to 7 T at 300 K

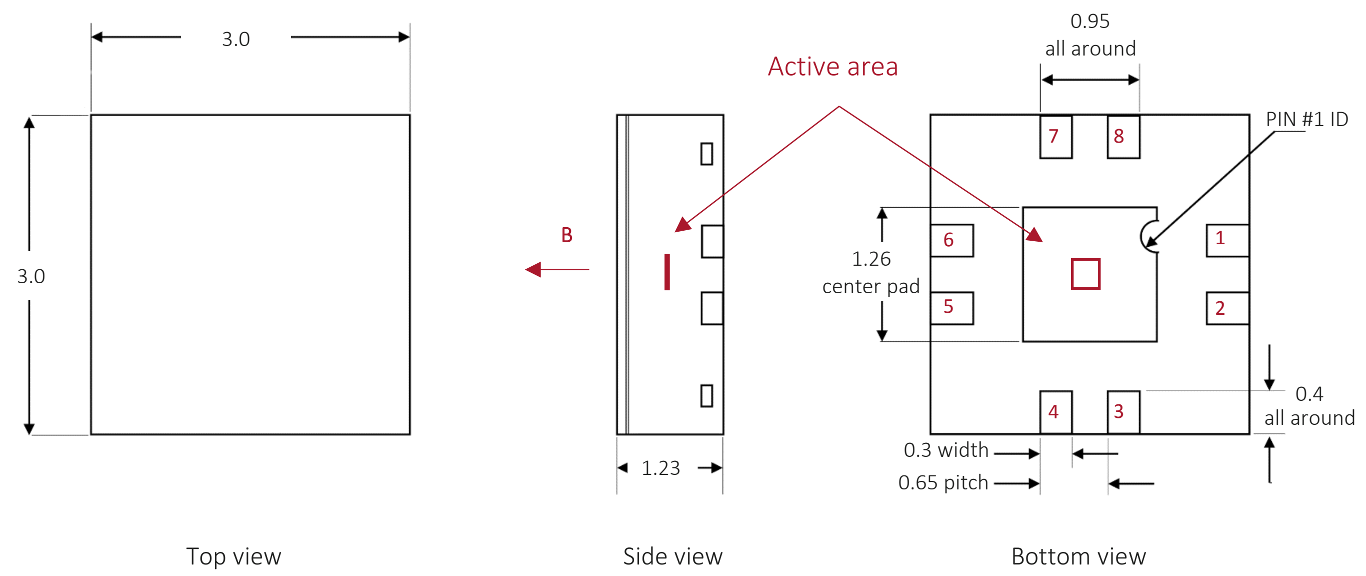


6. Packaging information

Package type: 8-pin QFN, ceramic, Ni-free, surface mount.

Recommended soldering method: reflow soldering with maximum peak temperature of 150-170°C and 40-80s maximum for temperature >138°C.

Active area: 35 µm x 35 µm located at the centre of the package and 550 µm from the top of the package.



All dimensions are in mm

Pin	Signal
1/2 or 5/6	V_{IN}+
5/6 or 1/2	V_{IN}-
3/4 or 7/8	V_H+
7/8 or 3/4	V_H-

Note 1: Pin 1 and 2, pin 3 and 4, 5 and 6, 7 and 8 are connected to each other within the package.

Note 2: Input voltage can be supplied with either polarity. Hall voltage polarity will depend on V_{IN} polarity and field polarity. For instance, if the magnetic field passes from the base of the device, through the active area to the lid of the sensor as per the drawing above then:

- If V_{IN}+ is connected to Pin 1/2, V_H due to B will be positive if V_H+ is connected to Pin 3/4.
- If V_{IN}+ is connected to Pin 5/6, V_H due to B will be positive if V_H+ is connected to Pin 7/8.

7. Safety information

WARNING!	
	To prevent injury, do not use Paragraf products if they appear to be damaged in any way. In the case of damaged goods, contact Paragraf immediately.

CAUTION!	
	Paragraf products should only be used in accordance with the specification limits described in the associated datasheets. Using the product outside of these limits can result in damage to the product and risk injury to the user.

ESD CAUTION!	
	The GHS sensors should be treated as ESD (Electrostatic Discharge) sensitive devices. Proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

8. Disclaimers

Unless otherwise stated by Paragraf in its order acknowledgement, GHS Extreme is provided by Paragraf Limited under Paragraf's Standard Terms and Conditions of Sale, in effect at the time of order acknowledgement. A copy of Paragraf's Standard Terms and Conditions of Sale can be viewed at www.paragraf.com.

This notice and all associated technical datasheets contain important safety information about temperatures and voltages.

Please note that this is a preliminary datasheet.

9. Copyright and trademark

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For further information:

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