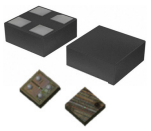
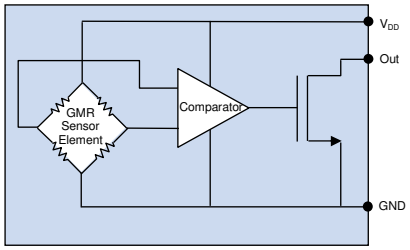
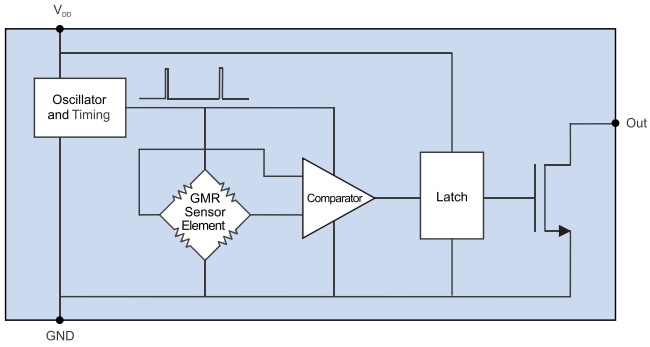
AHL-Series Low-Voltage Nanopower Digital Switches



Functional Diagrams

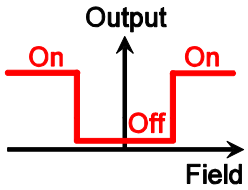


AHL9xx
(continuous duty)



AHL0xx
(duty-cycled)

Magnetic Response



Features

- 0.9 V to 2.4 V operating voltage
- Power as low as 29 nW
- Sensitive operate points as low as 0.5 mT (5 Oe)
- Precise detection of low magnetic fields
- Ultraminiature 1.1 x 1.1 mm DFN4 and 0.65 x 0.65 mm wafer-level, chip-scale packages

Applications

- Hearing aids
- Gas and water meters
- Portable instruments
- Single-cell battery or harvested power applications

Description

AHL-Series sensors are Giant Magnetoresistive (GMR) Digital Switch devices designed to run at low voltages and extremely low currents. The devices are manufactured with NVE's patented spintronic GMR technology for unmatched miniaturization, sensitivity, precision, and low power.

The output is configured as a magnetic "switch" where the output turns on when the magnetic field is applied, and turns off when the field is removed. Continuous duty versions are available, as well as internally duty cycled versions that further reduce power consumption. An integrated latch ensures the output is available continuously in duty-cycled versions.

The applied field can be of either polarity, and the operate point is extremely stable over supply voltage and temperature. The output is current-sinking, and can sink up to 100 microamps.

The product consists of an approximately 0.65 x 0.65 mm die containing a GMR sensor element, CMOS signal processing circuitry to convert the analog sensor element output to a digital output, and an oscillator and timing circuit for duty cycling.

The parts are available in an ultraminiature 1.1 x 1.1 mm DFN4 leadless packages; a 0.65 x 0.65 mm solder-bumped, wafer-level chip-scale package version is also available.

A range of magnetic operate points are available, and custom thresholds can be provided at request: sensor-apps@nve.com

Absolute Maximum Ratings

Parameter	Min.	Max.	Units
Supply voltage		5.5	Volts
Output voltage		5.5	Volts
Output current		200	µA
ESD HBM	2000		V
Storage temperature	−65	170	°C
Junction temperature		170	°C
Applied magnetic field		Unlimited	tesla

Operating Specifications

T_{min} to T_{max}; 0.9 V < V_{DD} < 2.4 V unless otherwise stated.						
Parameter	**Symbol**	**Min.**	**Typ.**	**Max.**	**Units**	**Test Condition**
Supply voltage (note 1)	V_{DD}	0.9		2.4	Volts	
Operating temperature	T_{MIN}; T_{MAX}	−40		85	°C	
Magnetic operate point	B_{OP}					
AHLx25		0.7	1	1.4	mT	
AHLx21		1.5	2	2.5		
AHLx24		2.1	2.8	3.4		
AHLx23		5	6	7		
Magnetic release point	B_{REL}	0.2				
Hysteresis		0.05				
Quiescent current	I_{DDQ}					
AHL0xx			0.032	0.06	µA	V_{DD} = 0.9V
AHL9xx			15	35		
AHL0xx			0.095	0.15		V_{DD} = 1.4V
AHL9xx			35	55		
AHL0xx			0.46	0.65		V_{DD} = 2.4V
AHL9xx			75	130		
AHL0xx peak supply current	I_{DD-PK}		25	55	µA	V_{DD} = 1.4V
Output drive current	I_{OL-ON}	100			µA	
Output low voltage	V_{OL}		0.05	0.2	V	V_{DD} = 1.25V; I_{OL-ON} = 100 µA
Output leakage current	I_{OL-OFF}		0.095	0.5	µA	
Frequency response						
AHL0xx		30	40	60	Hz	V_{DD} = 0.9V
		80	110	160		V_{DD} = 1.4V
		120	260	375		V_{DD} = 2.4V
AHL9xx			100 k			

Notes:

1. Operation from −20°C to −40°C at supply voltages less than 1 V may not meet specifications.
2. Soldering profile per JEDEC J-STD-020C, MSL 1.

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Operation

Direction of Magnetic Sensitivity

As the field varies in intensity, the digital output will turn on and off. 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:

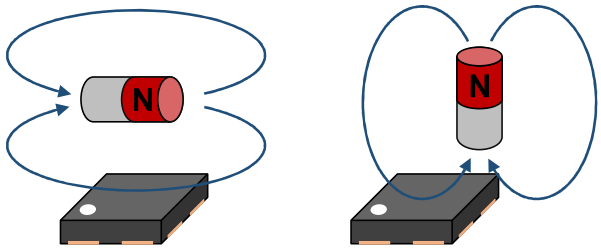


Figure 1a. AHL9xx-14E DFN4 sensor direction of magnetic sensitivity.

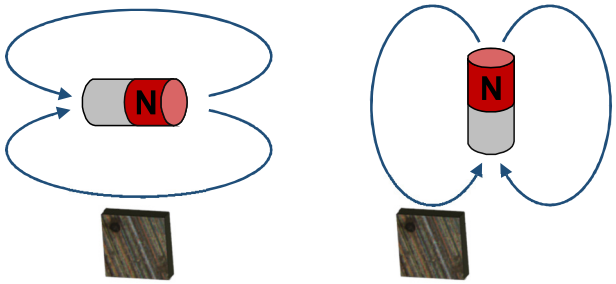


Figure 1b. AHL9xx-20E WLCSP sensor direction of magnetic sensitivity.

AHL-Series Sensors are "omnipolar," meaning the outputs turn ON when a magnetic field of either magnetic polarity is applied.

External Pull-Up Resistor – Normally-Open and Normally-Closed Sensors

The output is a logic low when the sensor is activated. The output is open-drain and should have an external pull-up resistor. For microcontroller interfaces, the microcontroller's input pull-up resistors can be activated. Typical pull-up resistors range between 24 kΩ to 1 MΩ.

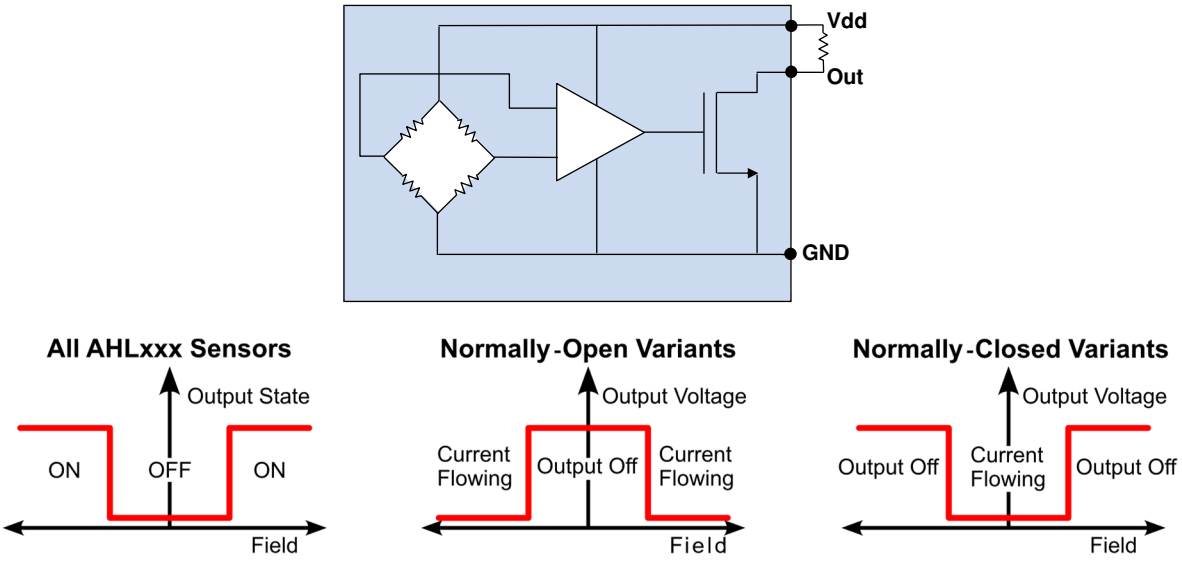


Figure 2. The difference between the switch (transistor) output state with a pull-up resistor connected for standard and NC variants.

Magnet and Sensing Distance Examples

Figure 2 shows another typical orientation for an AHL-Series sensor and magnet. The arrow on the circuit board shows the direction of magnetic sensitivity:

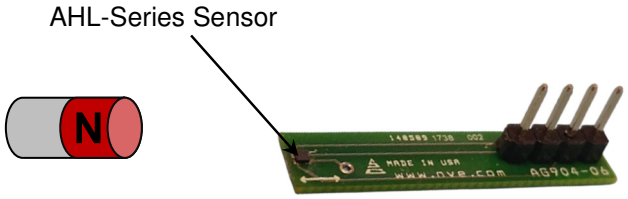


Figure 3. Typical operation; the circuit board arrow shows direction of sensitivity.

Typical magnetic operate and release distances for an inexpensive 4 mm diameter by 6 mm thick ceramic disk magnet, are illustrated in the following table:

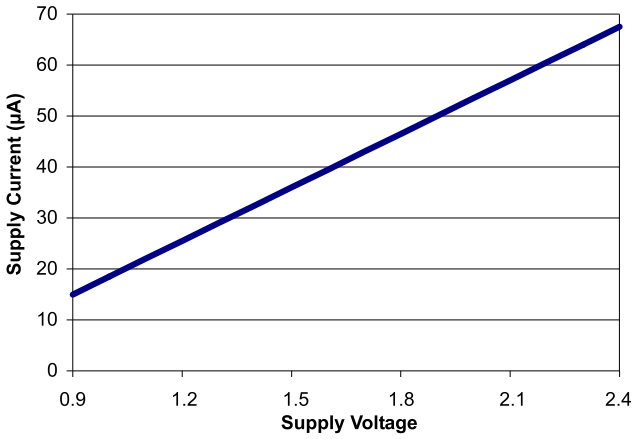
Part	Operate Point (typ.)	Operate Distance (typ.)	Release Distance (typ.)
AHLx25-xxE	1 mT	14 mm	18 mm
AHLx21-xxE	2 mT	10 mm	12 mm
AHLx24-xxE	2.8 mT	9 mm	11 mm
AHLx23-xxE	6 mT	7 mm	8 mm

Larger and stronger magnets allow farther operate and release distances. To calculate the operate point for your magnet, use our free web-calculator tool: *www.nve.com/spec/calculators#tabs-Digital-Sensor-Distance*

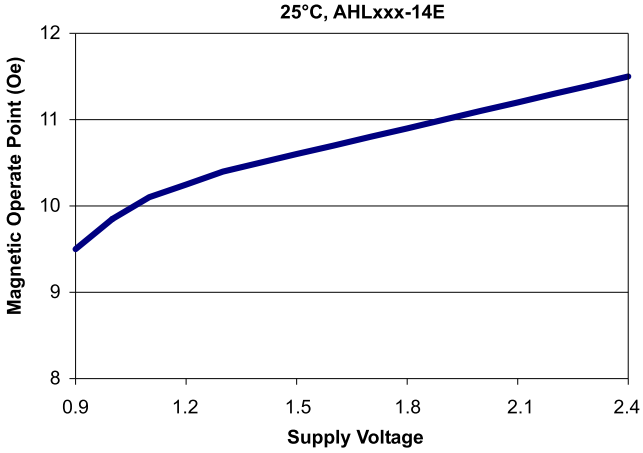
For additional simulations and assistance, contact sensor-apps@nve.com for a helpful reply within 24 hours.

Typical Performance Graphs

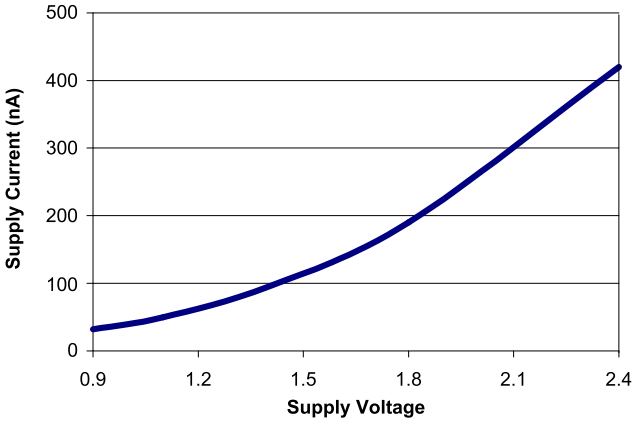
Supply Current vs. Supply Voltage, 25°C, AHL9xx



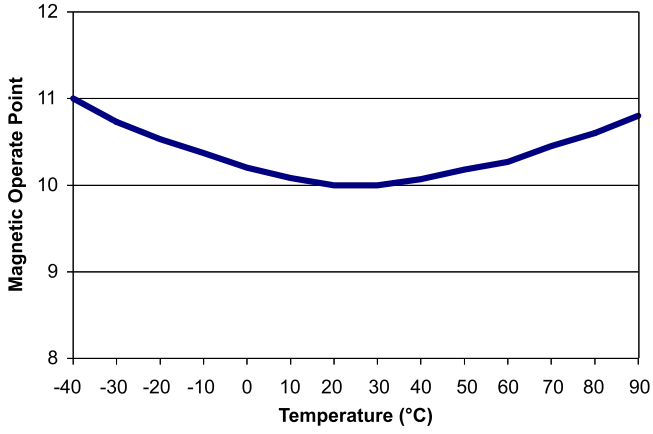
Magnetic Operate Point vs. Supply Voltage
25°C, AHLxxx-14E



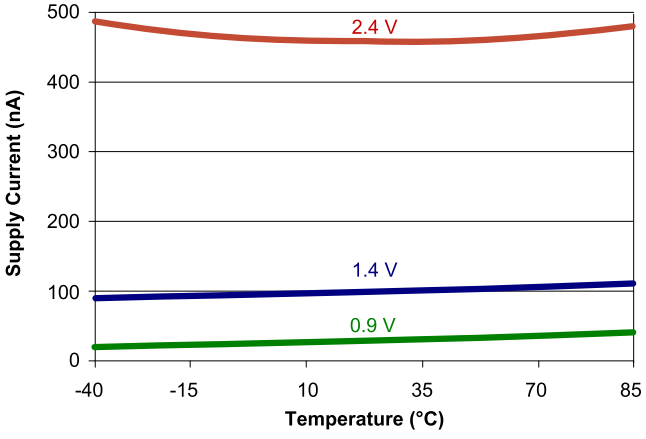
Supply Current vs. Voltage, 25°C
AHL0xx-14E



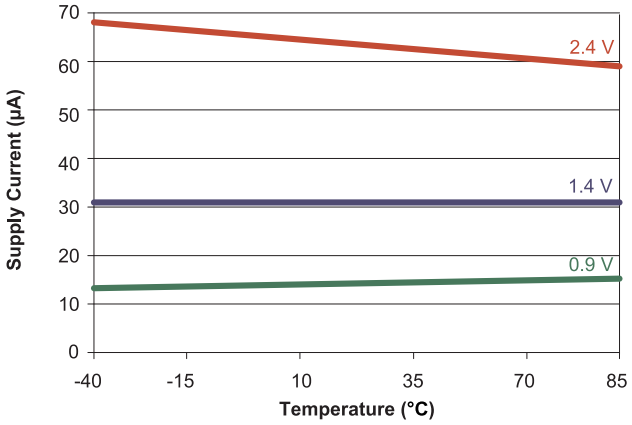
Magnetic Operate Point vs. Temperature,
1.15V, AHLxxx-14E

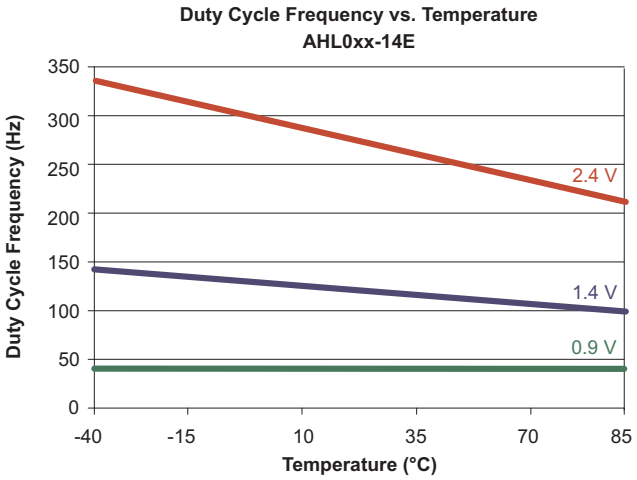


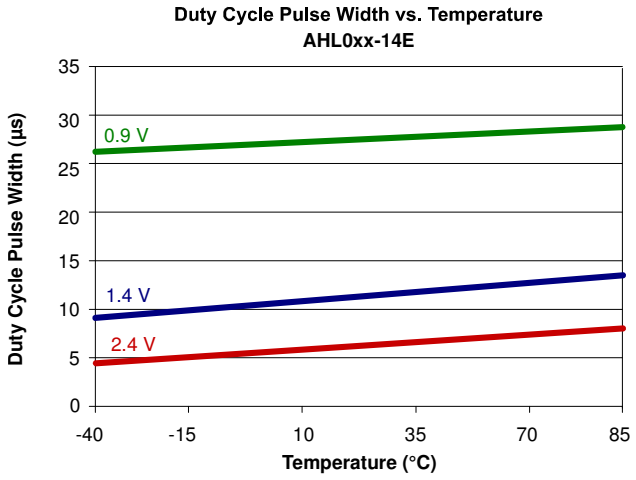
Supply Current vs. Temperature
AHL0xx-14E

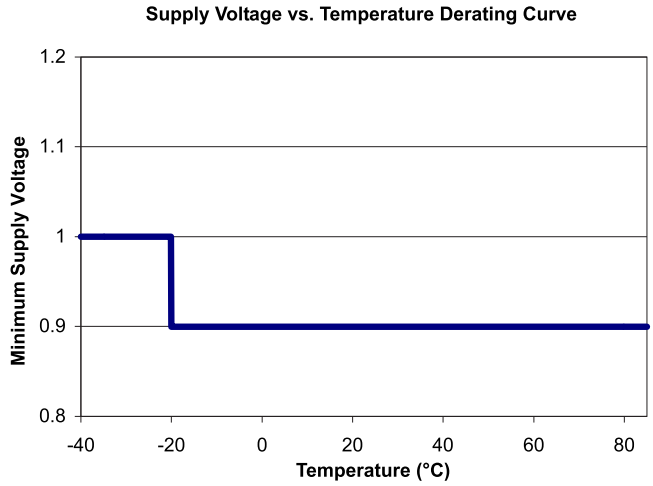


Supply Current vs. Temperature
AHL9xx-14E









Part Numbering

The following example shows the AHL-Series part-numbering system:

AHL 0 21 NC - 14E

Base Part
AHL = 0.9 V to 2.4V Nanopower digital switch

Duty Cycling
0 = 110 Hz typical
9 = Continuous duty

Typ. Magnetic Operate Point
25 = 1 mT
21 = 2 mT
24 = 2.8 mT
23 = 6 mT

Output Style
Blank = Normally Open (standard)
NC = Normally Closed

Package Type
14E = 1.1 x 1.1 x 0.45 mm DFN4 (RoHS)
20E = 0.65 x 0.65 x 0.23 mm WLCSP (RoHS)

Available Parts

Available Part	Duty Cycled?	Update Freq. (typ.)	Operate Point* (typ.)	Package	Package Marking
AHL021-14E	Y	110 Hz	2 mT	DFN4	b
AHL023-14E	Y	110 Hz	6 mT	DFN4	r
AHL024-14E	Y	110 Hz	2.8 mT	DFN4	d
AHL025-14E	Y	110 Hz	1 mT	DFN4	e
AHL921-14E	N	Continuous	2 mT	DFN4	f
AHL924-14E	N	Continuous	2.8 mT	DFN4	h
AHL925-14E	N	Continuous	1 mT	DFN4	j
AHL024-20E	Y	110 Hz	2.8 mT	WLCS	d
AHL025-20E	Y	110 Hz	1 mT	WLCS	e
AHL921-20E	N	Continuous	2 mT	WLCS	f
AHL925-20E	N	Continuous	1 mT	WLCS	j

*1 mT = 10 Oe in air.

Breakout Boards

Breakout boards are available for evaluating the most popular AHL-series chip-scale sensors:

Part numbers AHLxxx-20E-EVB01
(0.8" x 0.4" / 21 mm x 10 mm; actual size).

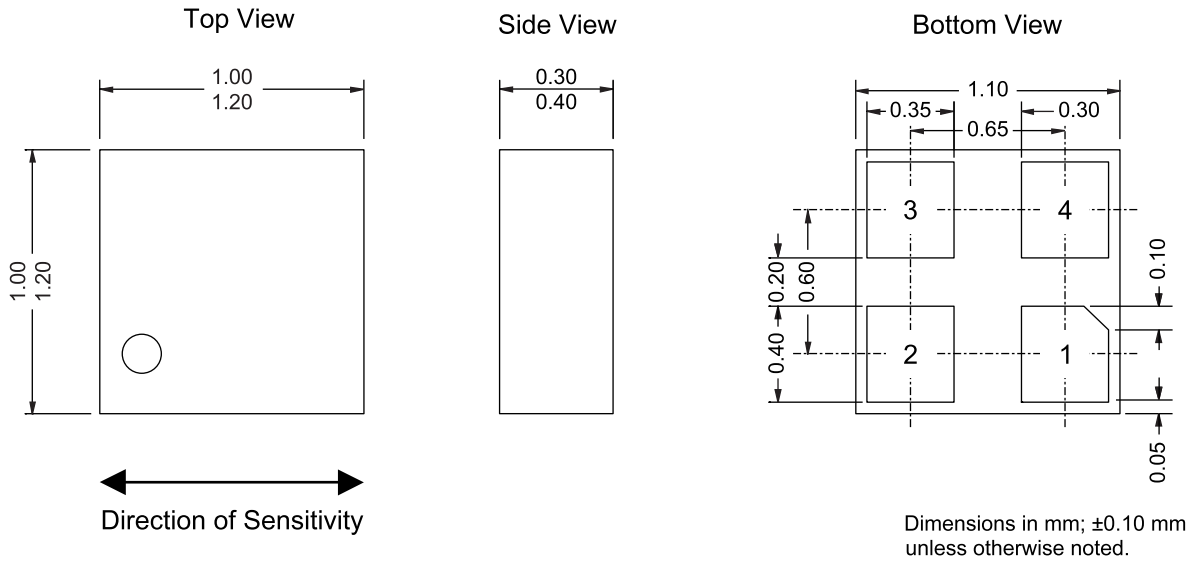
Bare Circuit Boards

NVE offers bare circuit boards for easy connections to ULLGA DFN4 sensors. Note that since these boards use very small sensors, they require reflow or hot-air soldering techniques. Images are actual size:

Part Number AG904-06: DFN4 General-purpose Board
(1.2" x 0.25" / 30 x 6 mm; actual size).

Part Number AG039-06: DFN4 Digital Sensor Board with locations for 0402-size pull-up resistors and bypass capacitors
(1.57" x 0.25" / 40 x 6 mm, actual size).

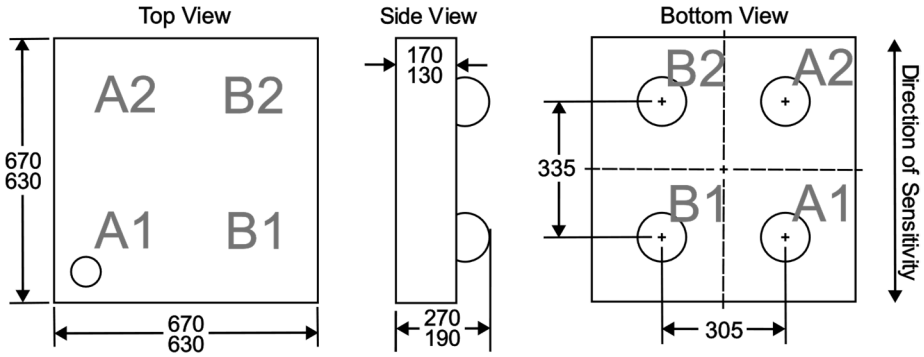
1.1 mm x 1.1 mm ULLGA DFN4 Package (-14E suffix)



RoHS COMPLIANT

Dimensions in mm; ±0.10 mm unless otherwise noted.

0.65 mm x 0.65 mm WLCSP (-20E suffix)



RoHS COMPLIANT

Pinout

Symbol	Pad Designation	
	AHLxxx-14E (DFN4)	AHLxxx-20E (WLCSP)
No Connect	Pin 1	B1
V_{DD}	Pin 2	A1
Out	Pin 3	B2
Ground	Pin 4	A2

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

These products have 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-00-027
November 2024

Change
- Added wafer level chip-scale products.
- Added 2 kV HBM ESD rating.
- Added explanation of output state with pull-up resistor.

SB-00-027
March 2020

Change
- Changed AHL9xx I_{DDQ} at 2.4 V max. specification from 110 µA to 130 µA (p. 2).
- Added performance graphs (pp. 4 - 5).
- Changed magnetic units from Oe to mT.

SB-00-027
November 2017

Change
- Added “Typical Operation” section and image (p. 3).
- Added bare boards (p. 5).

SB-00-027
October 2017

Change
- Revised package outline dimensions.

SB-00-027
July 2017

Change
- Deleted AHL927 (replaced with AFL006).

SB-00-027
April 2017

Changes
- Added AHL927 part type.
- Added package marking codes.
- Specified minimum ULLGA package thickness.
- Cosmetic changes.

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