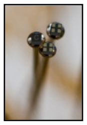
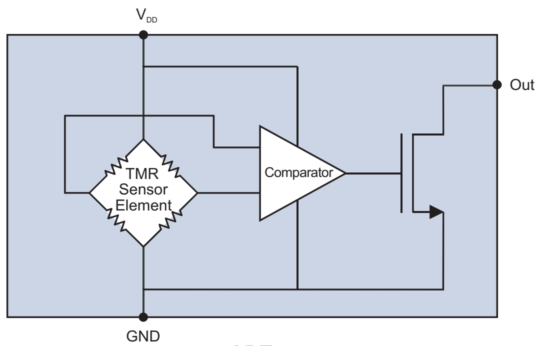


3-Volt Nanopower TMR Digital Switches

Functional Diagram



ADT92x

Features

- 2.4 to 4.2 V operation for lithium or lithium-ion batteries
- 1 µA typical quiescent current at 3 V
- Continuous operation for immediate response
- Sensitive operate points, as low as 1.5 mT
- Ultraminiature 1.1 x 1.1 mm x 0.35 mm package

Applications

- Implantable medical devices
- 3.3 volt microcontroller interfaces
- Proximity sensing
- Charging station detection
- Rechargeable sensor nodes
- Wearables
- Portable instruments

Description

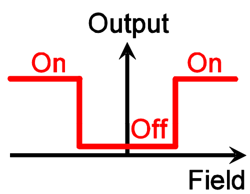
The ADT92x-14E sensors are digital switch devices based on novel magnetic tunnel junction technology that provides extremely low power consumption for 3.3 volt lithium or lithium-ion battery powered applications.

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. The applied field can be either magnetic 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 parts use NVE's ultraminiature
1.1 mm x 1.1 mm x 0.35 mm DFN leadless packages.

A wide range of magnetic operate points are available, and custom thresholds can be provided.

Magnetic Response



Absolute Maximum Ratings

Parameter	Min.	Max.	Units
Supply voltage		5.5	Volts
Output voltage		5.5	Volts
Output current		200	μA
Storage temperature	−65	135	°C
Junction temperature		135	°C
Applied magnetic field		Unlimited	

Operating Specifications

T_{min} to T_{max}; 2.4 V < V_{DD} < 4.2 V unless otherwise stated.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Condition
Supply voltage	V_{DD}	2.4	3.0	4.2	Volts	
Operating temperature	T_{MIN}; T_{MAX}	−40		85	°C	
Magnetic operate point[1]						
ADT925	H_{OP}	0.7	1.5	1.8	mT	-40°C to 85°C 2.4 V < V_{DD} < 4.2V
ADT924	H_{OP}	1.6	2.2	2.6	mT	-40°C to 85°C 2.4 V < V_{DD} < 4.2V
ADT923	H_{OP}	2.4	3.2	3.7	mT	-40°C to 85°C 2.4 V < V_{DD} < 4.2V
ADT922	H_{OP}	3.4	4.5	6.5	mT	-40°C to 85°C 2.4 V < V_{DD} < 4.2V
Magnetic release point[1]	H_{REL}	0.3			mT	
Operate release differential[1]	H_{OP}-H_{REL}		0.3	0.8	mT	
Quiescent current[2]	I_{DDQ}		0.6	1	μA	V_{DD} = 2.4 V
Quiescent current[2]	I_{DDQ}		1	1.7	μA	V_{DD} = 3 V
Quiescent current[2]	I_{DDQ}		1.2	2	μA	V_{DD} = 3.3 V
Quiescent current[2]	I_{DDQ}		1.4	2.3	μA	V_{DD} = 3.6 V
Quiescent current[2]	I_{DDQ}		1.8	3.2	μA	V_{DD} = 4.2 V
Output drive current	I_{OL-ON}	100			μA	
Output low voltage	V_{OL}		0.05	0.2	V	V_{DD} = 3.3V; I_{OL-ON} = 100 μA
Output leakage current	I_{OL-OFF}			2	nA	V_{DD} = 3.3V
Start-up time following power-up	$t_{START-UP}$		2	4	μs	
Maximum switching frequency	f		20		kHz	V_{DD} = 3.3 V; 3 dB reduction in sensitivity

Notes:
1) 1 mT = 10 Oe in air.
2) Value at 25°C, see Figure 4 for I_{DDQ} temperature dependence

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:

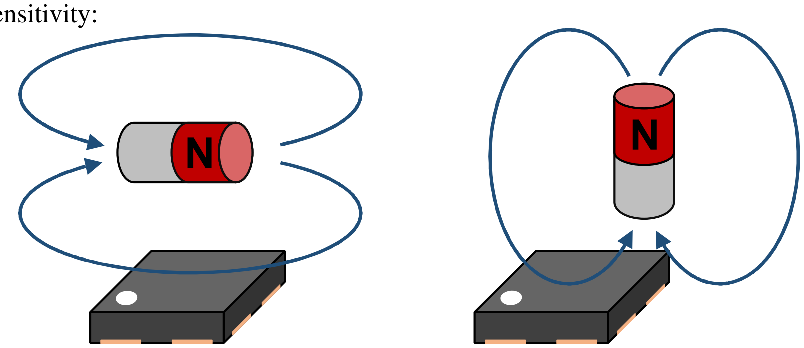


Figure 1. ADT92x sensor direction of magnetic sensitivity.

ADT92x Sensors are "omnipolar," meaning the outputs turn ON when a magnetic field of either magnetic polarity is applied.

External Pull-Up Resistor
The output is LOW when the sensor is activated. The output is open-drain should have an external pull-up resistor. For microcontroller interfaces, the microcontroller's input pull-up resistors can be activated (note that with a 3.3-volt supply, the pull-up resistor should be a minimum of 33 kΩ for compatibility with the sensor's 100 µA output current).

Typical Operation
Figure 2 shows typical ADT92x sensor orientation. The arrow on the circuit board shows the direction of magnetic sensitivity.

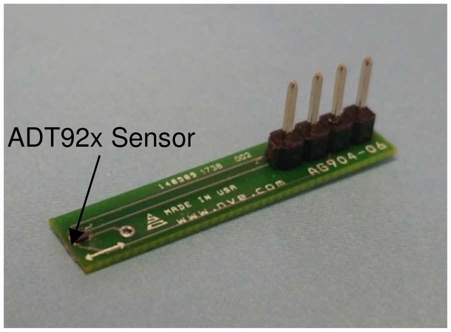


Figure 2. Typical operation; the circuit board arrow shows direction of sensitivity.

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.)
ADT925-14E	1.5 mT	9 mm	12 mm
ADT924-14E	2.2 mT	8 mm	10 mm
ADT923-14E	3.2 mT	7 mm	9 mm
ADT922-14E	4.5 mT	6 mm	8 mm

Larger and stronger magnets allow farther operate and release distances. For more calculations, use our digital sensor switching versus distance Web application at: *www.nve.com/spec/calculators.php*.

Typical Performance

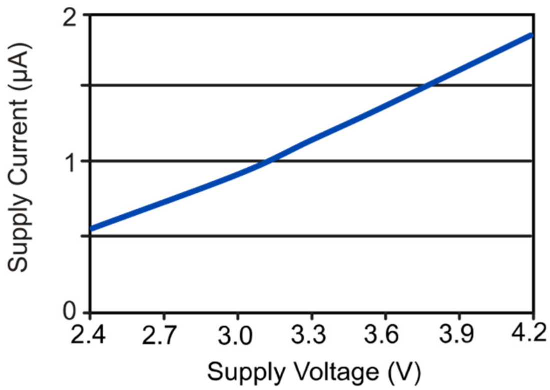


Figure 3. Typical supply current vs. supply voltage (25ºC)

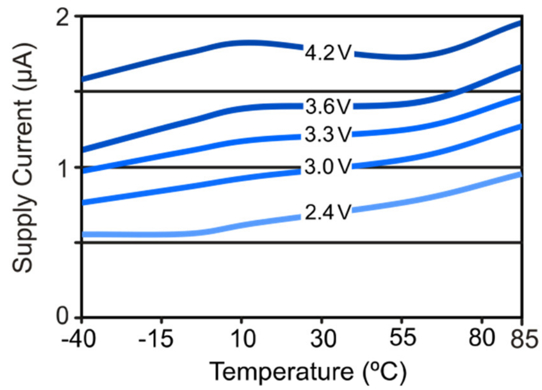


Figure 4. Supply Current versus temperature for VDD between 2.4 V and 4.2 V

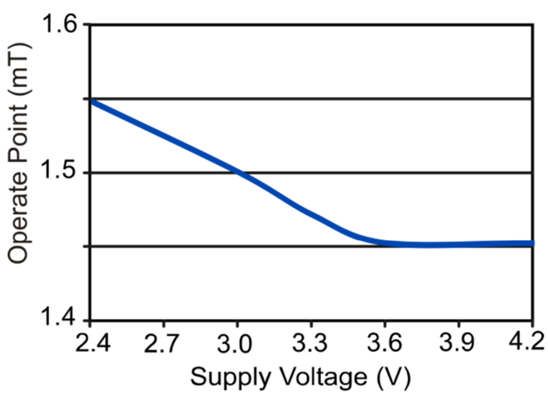


Figure 5. Typical magnetic operate point vs. supply voltage (ADT925, 25ºC)

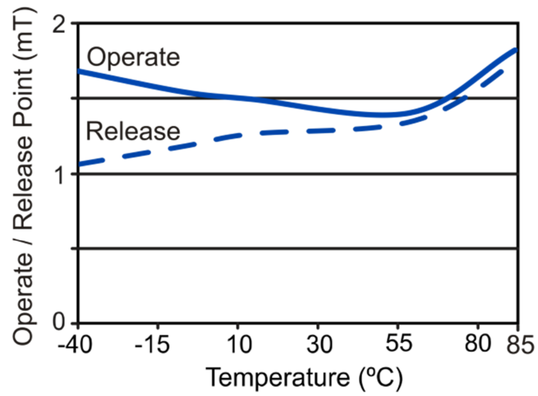


Figure 6. Magnetic operate and release point vs. temperature (ADT925, VDD = 3.3 V)

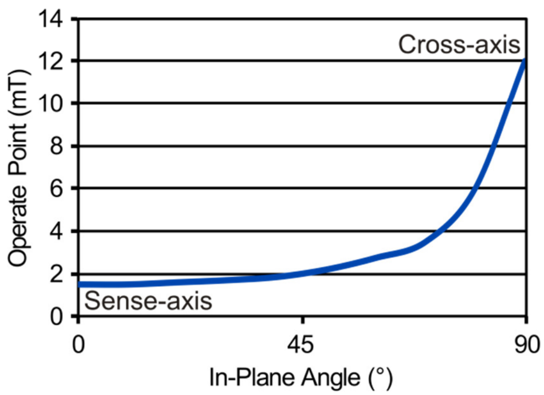


Figure 7. Typical magnetic operate point vs. in-plane applied field angle (ADT925, 25°C)

Illustrative Application Circuits

Direct-Drive LED Indicator

Although ADTxxx-14E series sensors are not capable of directly driving legacy LEDs, high-efficiency LEDs such as the APT3216LSECK are visible with the 100µA drive current provided by the sensors without an external driver.

This circuit illustrates a sensor powered by a single lithium button cell with a surface-mount indicator LED:

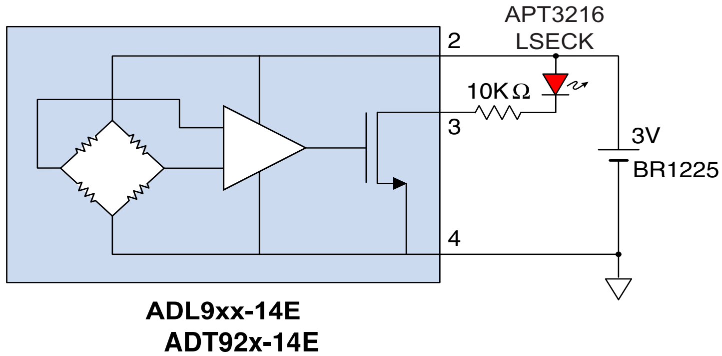


Figure 8. Driving an LED.

Higher-Current Drive

ADT92x-Series sensors have a maximum output current of 100 µA with a drop of up to 200 mV in the output transistor. These limitations are easily overcome with an external transistor. The following circuit can be used to power circuitry when the sensor is activated, such as charging station detection application:

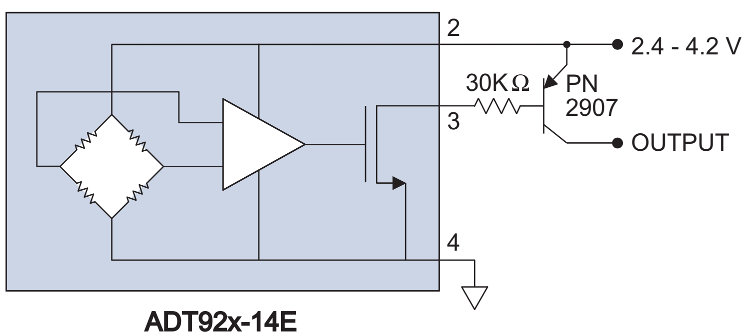


Figure 9. High-current drive.

The PN2907 transistor in this circuit can drive at least 8 mA with a typical $V_{CE(sat)}$ of 50 mV. A high-gain transistor such as a ZTX788B can drive at least 40 mA without exceeding the ADT9xx's maximum output current.

Higher-Current Inverting Drive

An external MOSFET can be used to invert the output (the output is ON, or LOW when the sensor is not exposed to a magnetic field):

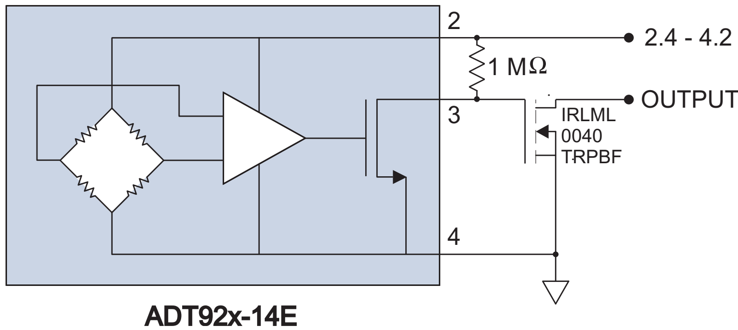


Figure 10. Inverting high-current drive.

The MOSFET can provide an output current as high as several amps and has negligible on-resistance.

Two-Wire Sensor Interface Using a Voltage Regulator

ADT-Series sensors are perfect for two-wire applications, because their low supply voltage and low quiescent current provide plenty of design margin. Two-wire interfaces need to operate over a wide power supply range. With the sensor off, the circuit must draw a minimal residual current, typically less than 1.5 milliamps. With the sensor on, the circuit must provide enough current to drive a significant load such as a motor or solenoid:

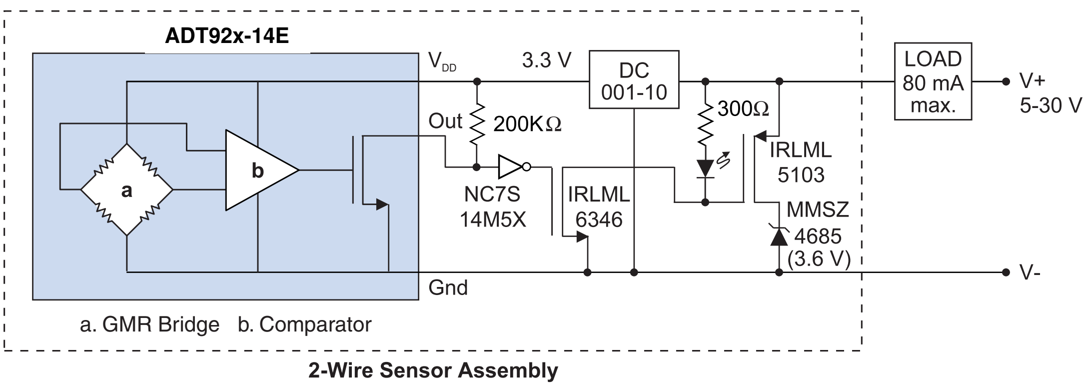


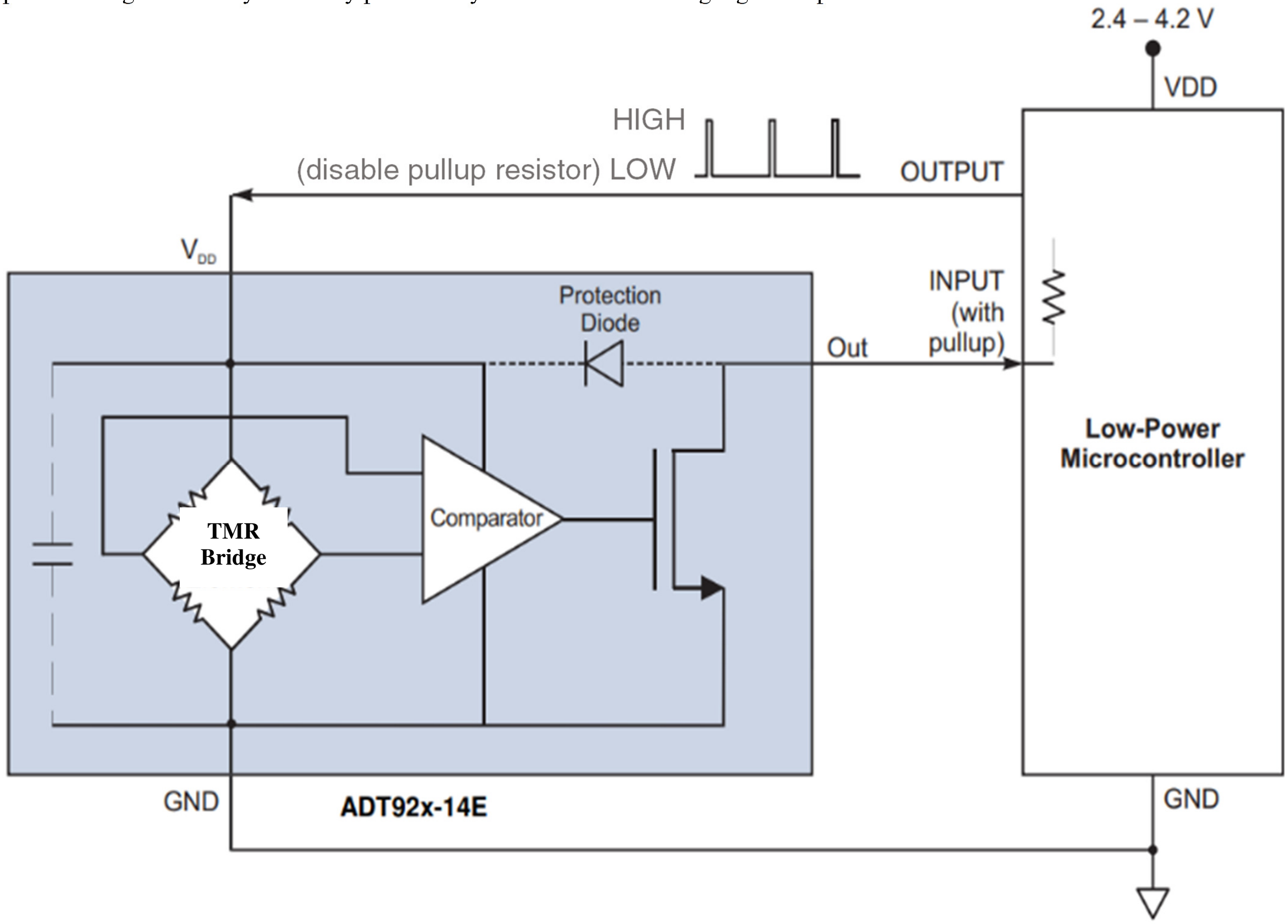
Figure 11. Typical two-wire circuit.

In this circuit, when a magnetic field is applied to the sensor, the MOSFETs turn on, turning on the LED and powering the load. This circuit uses an NVE DC001-10E regulator, which provides better regulation and operating latitude over the input voltage range than a Zener diode.

With no magnetic field and the sensor off, the residual current of the circuit is dominated by the DC001 regulator's quiescent current, which is less than one milliamp and relatively constant over input voltage. The Zener diode provides enough voltage to power the circuitry when the load is powered.

External Duty Cycling

ADT-Series continuous-duty sensors can be eternally duty-cycled to reduce power consumption even more. Since they are low power to begin with they are easily powered by microcontroller or logic gate outputs:



External duty cycling using a microcontroller.

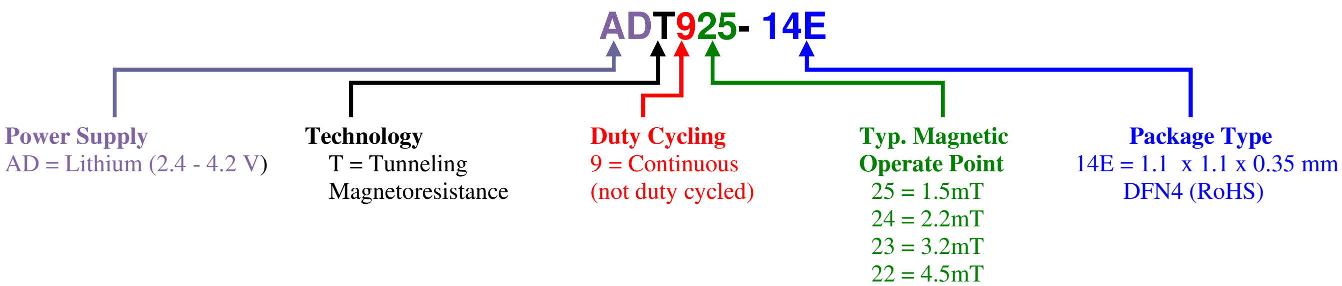
Unlike other types of sensors, the switching hysteresis is provided by the magnet sensor element, not a comparator, so the proper hysteresis state is retained when the part is duty-cycled.

After applying power to the sensor, the microcontroller should allow for the sensor's maximum *turn-on time* before sampling the sensor's output. The sensor does not have an internal latch circuit, so the microcontroller must read the sensor output when power is applied.

The sensors have an internal protection diode from the output to V_{dd}, so the microcontroller's pullup resistor should be disabled before driving V_{dd} LOW. This is the most efficient method of duty-cycling the sensors.

Part Numbering

The following example shows ADT92x part numbering:

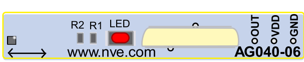


Available Parts

Part Number	Operate Point (typ.)	Package	Marking
ADT925-14E	1.5mT	1.1 x 1.1 mm DFN4	7
ADT924-14E	2.2 mT		
ADT923-14E	3.2 mT		
ADT922-14E	4.5mT		

Demonstration Board

The AG040T Demonstration Board is powered by a three-volt lithium coin cell (included). It has an ADT923-14E magnetic switch and an LED to show the sensor output. The sensor's low quiescent power allows the battery to last at least several years with occasional LED use. A miniature bar magnet is included so you can see for yourself how these remarkable sensors work.
The board is just 1.57 by 0.25 inches (40 x 6 mm).The image is actual size:



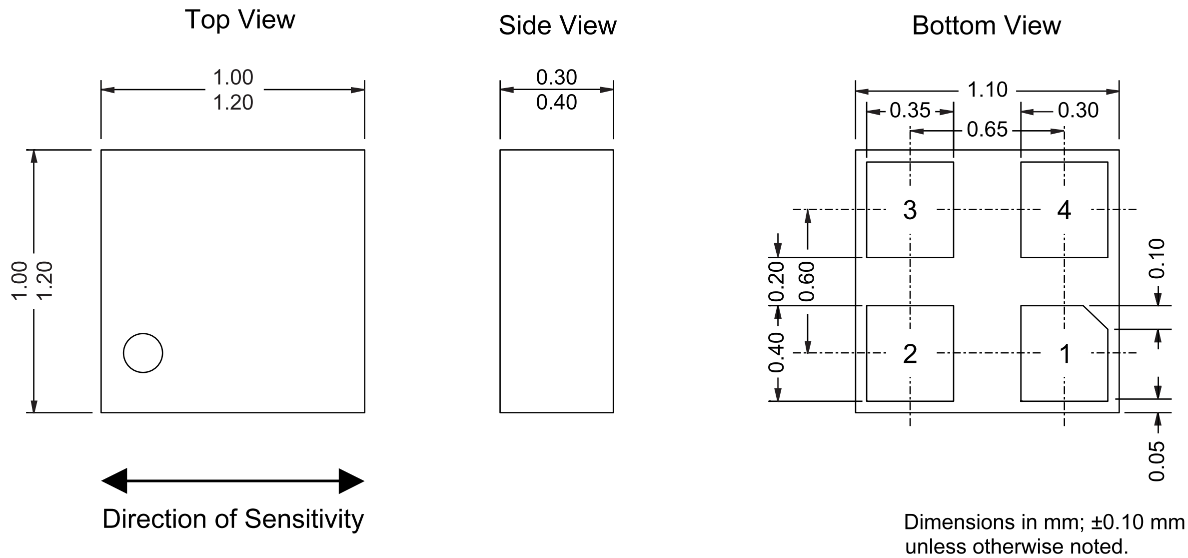
Bare Circuit Boards

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

AG904-06: ULLGA DFN4 General-Purpose PCB
1.2 x 0.25 inch (30 x 6 mm) PCB for connecting to 1.1 x 1.1 mm "ULLGA" DFN4 sensors (-14E sensor suffix).

AG039-06: ULLGA DFN4 Digital Sensor Demonstration Bare Board
A 1.57 x 0.25 inch PCB for demonstrating ADT92x or similar sensors (sensors sold separately). In addition to space for the sensor, the boards have locations for 0402-size pull-up resistors and bypass capacitors.

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



RoHS COMPLIANT

Pin 1	No Connect
Pin 2	V_{DD}
Pin 3	Out
Pin 4	Ground

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-00-109F
February 2023

Changes

- Updated recommendations for external duty cycling
- Clarified release point specification

SB-00-109E
May 2021

- Added specification for start-up time following power-up (p. 2).
- Added application circuits (pp. 5 – 7).
- Changed package description from "ULLGA" to the more standard "DFN."

SB-00-109D
February 2021

Change

- Updates for reduced operating point variations over temperature.

SB-00-109C
May 2020

Change

- Widened quiescent current specifications.

SB-00-109B
November 2019

Change

- Updates for new part types.

SB-00-109A
September 2019

Change

- Initial release.

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