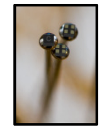
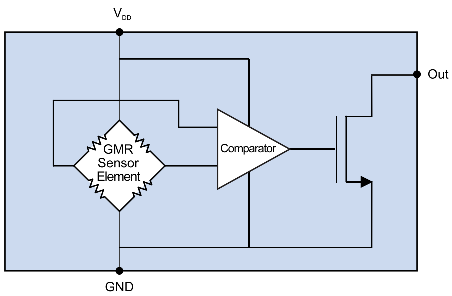
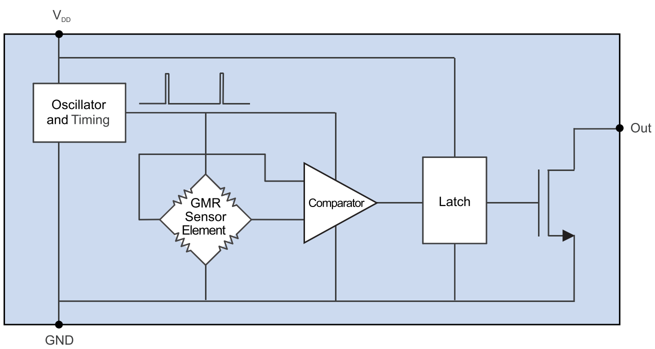
ADLxxx Nanopower Digital Switches



Functional Diagrams

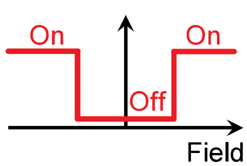


ADL9xx
(continuous duty)

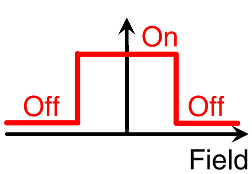


ADL0xx
(duty-cycled)

Magnetic Responses



ADL9xx-14E
(Normally Open)



ADL9xxNC-14E
(Normally Closed)

Features

- 2.4 V to 4.2 V operating voltage
- Continuously operating or duty-cycled versions
- Power as low as 84 nW (ADL1xx; V_{DD} = 2.4 V)
- Operate points as low as 1 mT (10 Oe)
- Normally-open or normally-closed outputs
- Precise detection of low magnetic fields
- Ultraminiature 1.1 x 1.1 x 0.35 mm DFN4 package

Applications

- Primary lithium or rechargeable lithium-ion powered devices
- Proximity sensing
- Wearables
- Portable instruments
- 4 – 20 mA current loops

Description

ADLxxx-Series sensors are Giant Magnetoresistive (GMR) Digital Switches designed to operate from 3.3-volt power supplies or single lithium cells with extremely supply low currents. Their 4.2 volt maximum operating voltage accommodates lithium-ion rechargeable batteries.

The devices are manufactured with NVE's patented spintronic GMR technology and low-power CMOS circuitry for unmatched miniaturization, sensitivity, precision, and low power.

Versions are available that are either continuous duty or internally duty cycled operation to further reduce power consumption. An integrated latch ensures the output is available continuously in duty-cycled versions.

The outputs are configured as magnetic switches. Normally-open versions turn on (LOW output) when the magnetic field is applied and off (OPEN output) when the field is removed. Normally-closed versions turn off when a field is applied.

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.

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}< 4.2V unless otherwise stated.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Condition
Supply voltage	V_{DD}	2.4	3	4.2	Volts	
Operating temperature	T_{MIN}; T_{MAX}	−40		125	°C	
Magnetic operate point	B_{OP}				mT*	
ADLx25		0.7	1	1.4		
ADLx21		1.4	2	2.5		
ADLx24		2.1	2.8	3.4		
ADLx22		3	4	5		
Operate/release differential	B_{OP}–B_{REL}				mT*	
ADLx25		0.05		0.8		
ADLx21		0.1		1.4		
ADLx24		0.1		1.4		
ADLx22		0.1		2.5		
Quiescent current (output open)	I_{DDQ}				µA	
ADL1xx			0.035	0.07		V_{DD} = 2.4V
ADL0xx			0.05	0.1		V_{DD} = 2.4V
ADL9xx			35	50		V_{DD} = 2.4V
ADL1xx			0.08	0.16		V_{DD} = 3V
ADL0xx			0.095	0.19		V_{DD} = 3V
ADL9xx			60	100		V_{DD} = 3V
ADL1xx			0.12	0.24		V_{DD} = 3.6V
ADL0xx			0.14	0.28		V_{DD} = 3.6V
ADL9xx			85	120		V_{DD} = 3.6V
ADL1xx			0.24	0.3		V_{DD} = 4.2V
ADL0xx			0.32	0.4		V_{DD} = 4.2V
ADL9xx			140	200		V_{DD} = 4.2V
ADL0xx / ADL1xx peak supply current	I_{DD-PK}		60	100	µA	V_{DD} = 3V
Output drive current	I_{OL-ON}	100			µA	
Output low voltage	V_{OL}			0.2	V	V_{DD} = 3.6V; I_{OL-ON} = 100 µA
Output leakage current	I_{OL-OFF}			2	nA	V_{DD} = 3.6V
Update frequency					Hz	
ADL1xx		10	30			
ADL0xx		20	55			
Frequency response (ADL9xx)			100		kHz	

*1 mT = 10 Oe in air.

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:

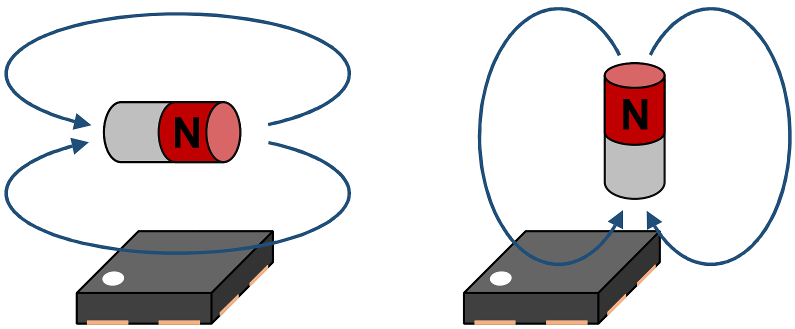


Figure 1. Direction of magnetic sensitivity.

ADL-Series sensors are “omnipolar,” meaning the outputs turn ON when a magnetic field of either magnetic polarity is applied.

External Pull-Up Resistor

Outputs are logic low when the sensor is activated. The outputs are open-drain, and 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 ADL-Series sensor orientation. The arrow on the circuit board shows the direction of magnetic sensitivity:

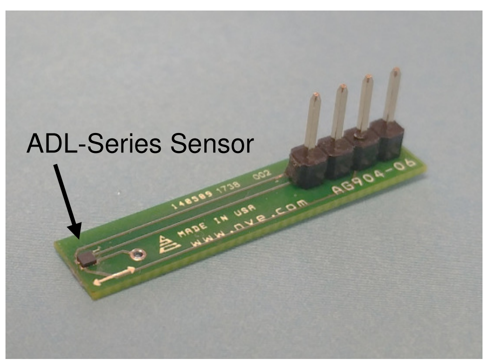


Figure 2. Typical operation; the circuit board arrow shows direction of sensitivity.

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.)
ADLx25-14E	1 mT	11 mm	13 mm
ADLx21-14E	2 mT	10 mm	12 mm
ADLx24-14E	2.8 mT	9 mm	11 mm
ADLx22-14E	4 mT	6 mm	9 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*.

Illustrative Application Circuits

Direct-Drive LED Indicator

Although ADLxxx-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:

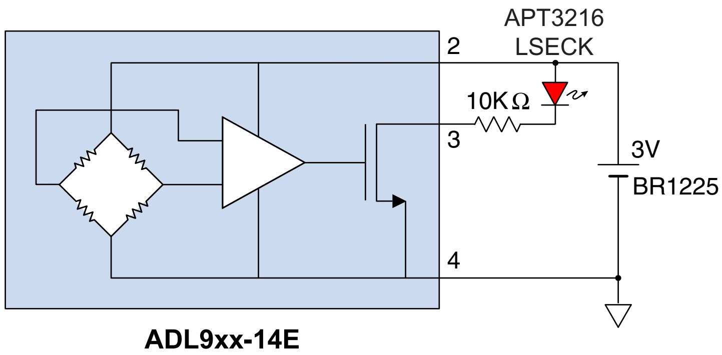


Figure 3. Typical ADLxxx-14E application.

Two-Wire Sensor Interface Using a Voltage Regulator

ADL-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:

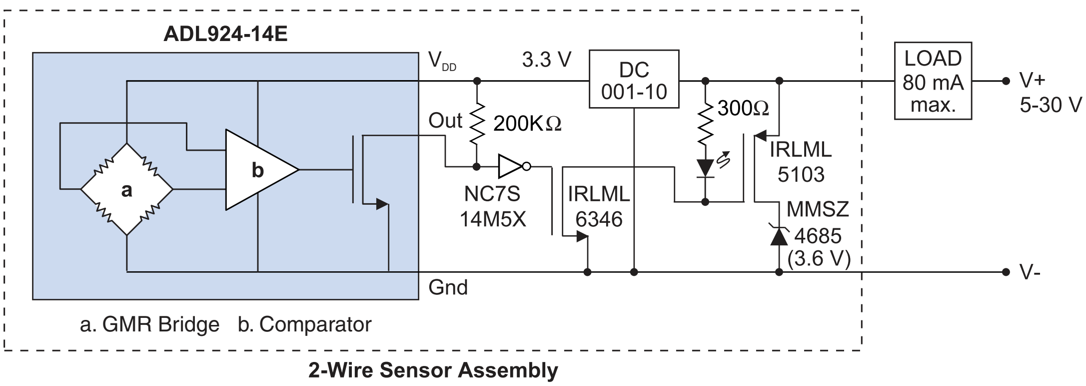


Figure 4. Typical two-wire circuit.

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

ADL-Series continuous-duty sensors can be eternally duty-cycled. 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:

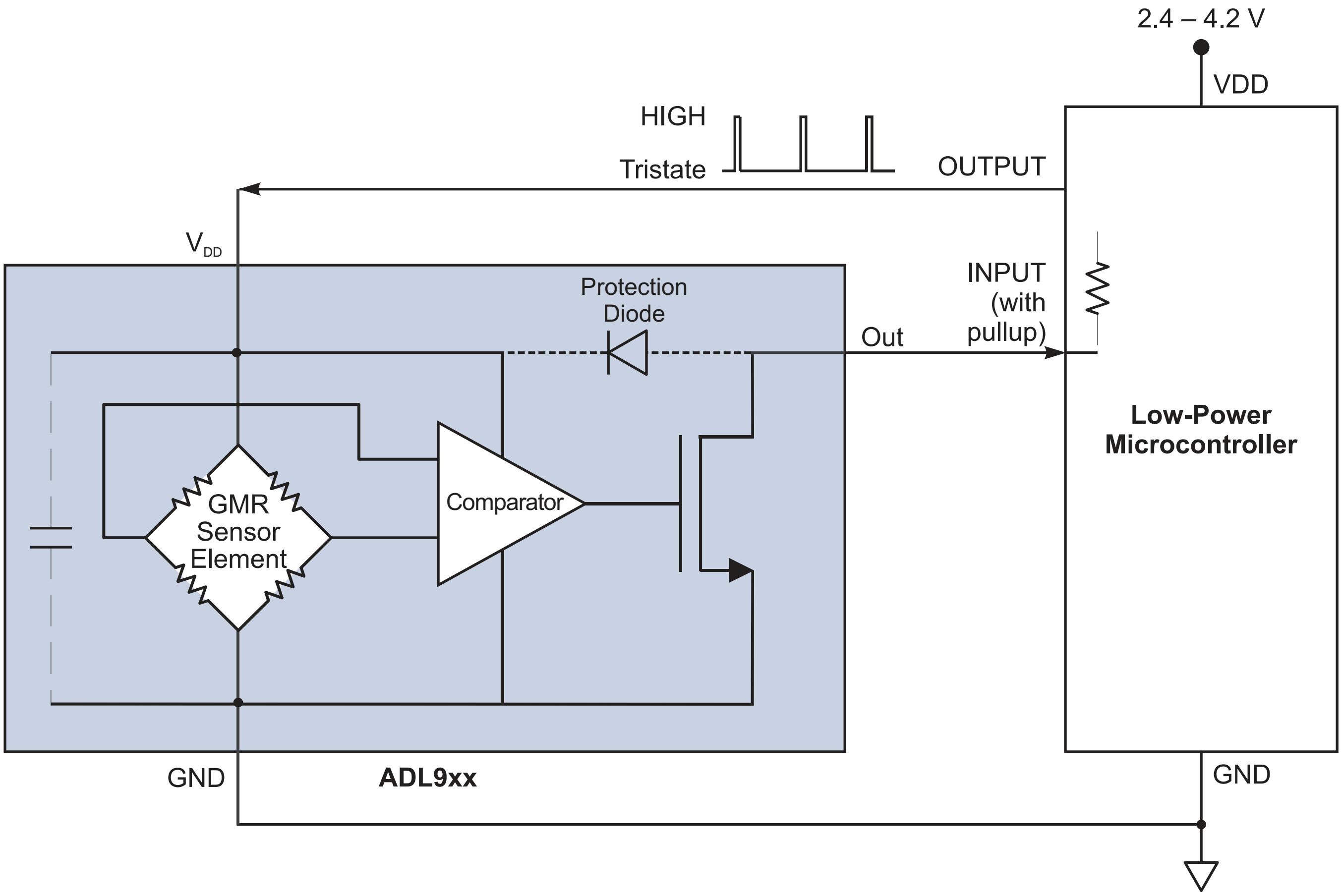


Figure 5. External duty cycling using a microcontroller.

Note that there is a protection diode from the output to V_{DD}, so that if V_{DD} is grounded the sensor output will be low (approximately 0.6 volts), and the pullup resistor will draw current. Therefore the most efficient way to duty cycle the sensor is to have an output driving V_{DD} to activate the part, and tri-state (rather than grounding) to deactivate the part.

Typical Performance Graphs

Average current increases with supply voltage but remains extremely low. The magnetic operate and release points are stable over temperature and supply voltage. Update frequency increases slightly with supply voltage.

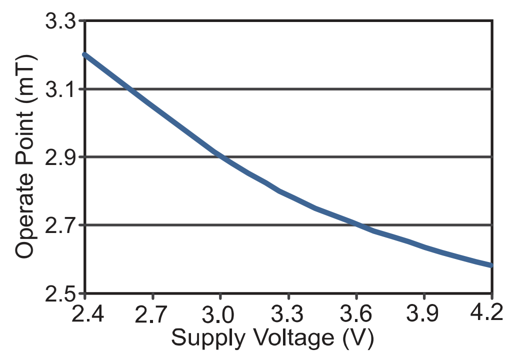


Figure 6. Typical magnetic operate versus supply voltage (ADLx24; 25 °C).

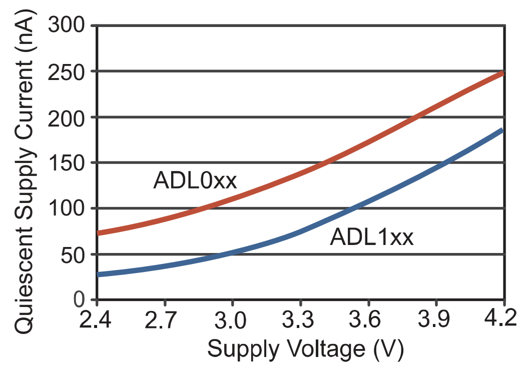


Figure 7. Typical Supply current versus supply voltage (ADL0xx and ADL1xx; 25 °C).

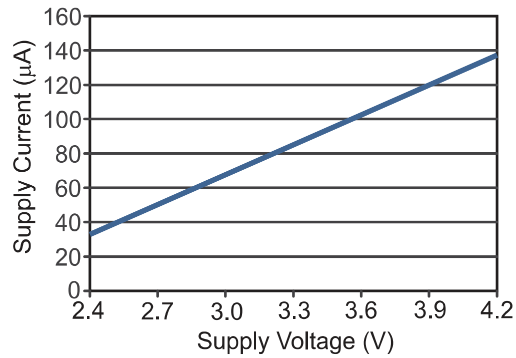


Figure 8. Typical Supply current versus supply voltage (ADL9xx; 25 °C).

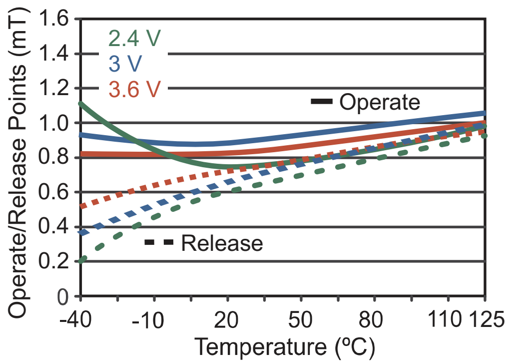


Figure 9. Typical magnetic operate point versus temperature (ADLx25).

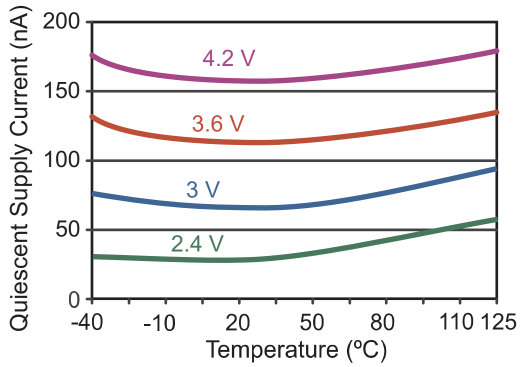


Figure 10. Typical supply current versus temperature (ADL1xx).

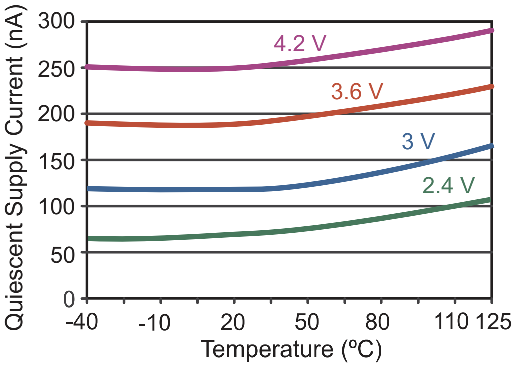


Figure 11. Typical supply current versus temperature (ADL0xx).

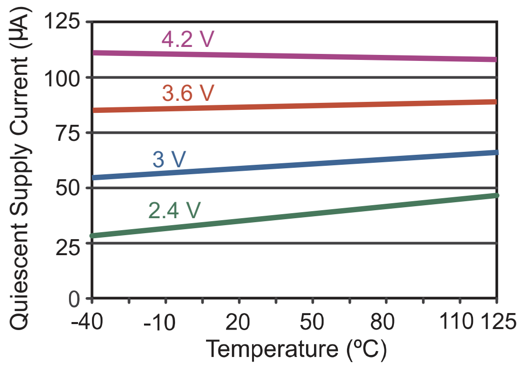


Figure 12. Typical supply current versus temperature (ADL9xx).

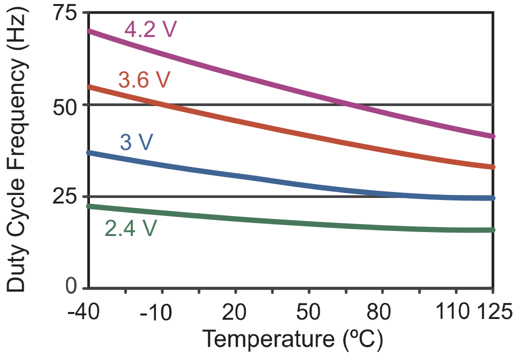


Figure 13. Typical update frequency versus temperature (ADL1xx).

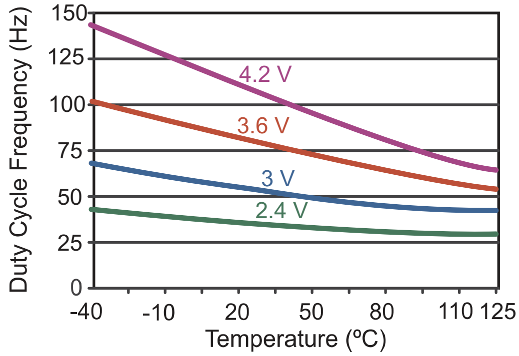


Figure 14. Typical update frequency versus temperature (ADL0xx).

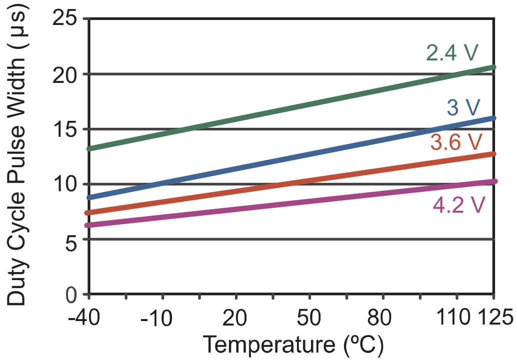
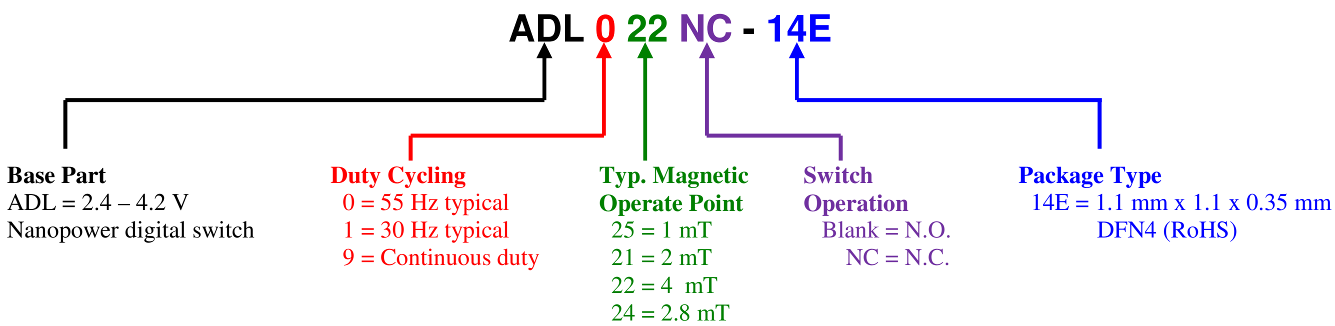


Figure 15. Typical update frequency versus temperature (ADL0xx and ADL1xx).

Part Numbering

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

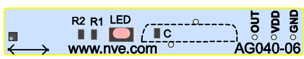


Available Parts

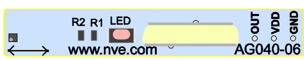
Available Part	**Duty Cycled?**	**Update Freq.** (typ.)	**Operate Point** (typ.)	**Switch Operation**	**Package**	**Package Marking**
ADL021-14E	Y	55 Hz	2 mT	Normally Open	DFN4	V
ADL024-14E	Y	55 Hz	2.8 mT		DFN4	C
ADL025-14E	Y	55 Hz	1 mT		DFN4	J
ADL121-14E	Y	30 Hz	2 mT		DFN4	B
ADL124-14E	Y	30 Hz	2.8 mT		DFN4	D
ADL125-14E	Y	30 Hz	1 mT		DFN4	F
ADL921-14E	N	Continuous	2 mT		DFN4	M
ADL922-14E	N	Continuous	4 mT		DFN4	W
ADL922NC-14E	N	Continuous	4 mT	Normally Closed	DFN4	Q
ADL924-14E	N	Continuous	2.8 mT	Normally Open	DFN4	N
ADL925-14E	N	Continuous	1 mT		DFN4	P

Evaluation Kits

NVE offers two ADL-Series Demonstration Boards, one with a battery and one without. These inexpensive evaluation kits include demo boards with the ultraminiature, ultralow-power ADL021 magnetic switch included. An LED shows the sensor output. A miniature bar magnet is included so you can see for yourself how these remarkable sensors work. These miniature evaluation boards are just 40 x 6 mm (1.57 by 0.25 inches). Images are actual size:



AG040C: ADL021 Externally-Powered Evaluation Board
This board has a digital output, and can be powered from a 3.3-volt nominal supply. An LED shows the output.



AG040B: ADL021 Battery-Powered Demonstration Board
This board is powered by a three-volt lithium coin cell (included), and the sensor quiescent power consumption is so low that the battery will last indefinitely.

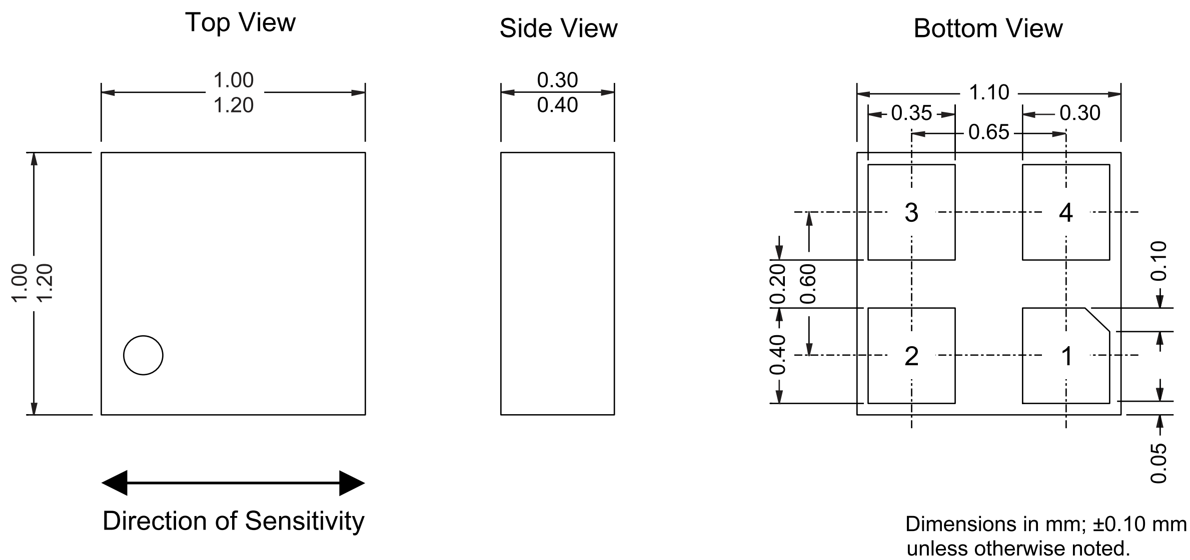
Bare Circuit Boards

NVE offers two bare circuit boards designed 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:

AG904-06: DFN4 General-Purpose PCB
A 30 x 6 mm (1.2 x 0.25 inch) PCB for demonstrating 1.1 x 1.1 mm DFN4 sensors (-14E part number suffix).

AG039-06: DFN4 Digital Sensor Demonstration Bare Board
A 40 x 6 mm (1.57 x 0.25 inch) PCB for demonstrating ADL-Series 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 ULLGA DFN4 Package (-14E suffix)



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

Soldering profile 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-00-017
March 2020

Change
- Added ADLx25 (1 mT typ. magnetic operate point), ADL922 (4 mT typ.), and ADL922NC (4 mT typ.; normally closed).
- Added multiple supply voltages to magnetic operate point versus temperature graph.
- Added graphs of supply current, duty cycle frequency, and pulse width vs. temperature.
- Added external duty-cycling application circuit (p. 5).
- Changed most magnetic units from Oe to mT.

SB-00-017
July 2019

Change
- Added Iq supply specs for 4.2 V operation (p. 2).
- Updated typical performance vs. supply at 4.2 V (p. 5; Figs. 4, 6-8).

SB-00-017
September 2018

Change
- Tighter ADL0xx and ADL1xx quiescent supply current specifications (p. 2).
- Updated graph of typical supply current vs. supply (p. 5; Fig. 5).
- Added quiescent supply current specifications at 3-volt supply (p. 2).
- More detailed output leakage current specification (p. 2).

SB-00-017
November 2017

Change
- Added “Typical Operation” section and image (p. 3).
- Added Evaluation Kits and bare boards (p. 7).

SB-00-017
October 2017

Change
- Revised package outline dimensions.

SB-00-017
May 2017

Changes
- Added application circuit.
- Revised quiescent current specifications.
- Added selector guide.
- Obsoleted ADLx22 versions/
- Cosmetic changes.

SB-00-017
December 2008

Change
- Initial Release.

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