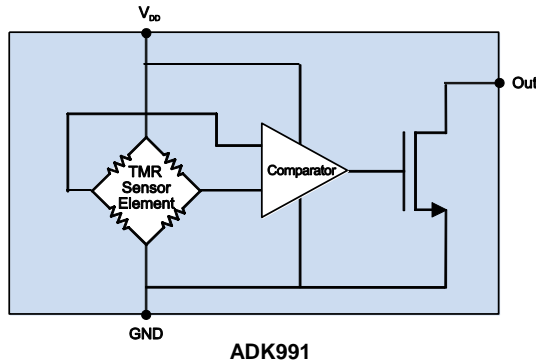


ADK991 High-Field, Low-Power TMR Switch

Functional Diagram



Features

- Detection of large magnetic fields
- 350 mT operate point
- Unlimited maximum field
- 2.4 V to 4.2 V operating voltage for single-cell operation
- 1 μ A typical quiescent current
- Continuous operation for low noise and high-speed
- Ultraminiature 1.1 x 1.1 mm package
- Omni-directional field sensitivity

Applications

- Primary lithium or rechargeable lithium-ion powered devices
- Tamper detection
- Limit switches
- Portable Instruments
- MRI field detection

Description

The ADK991 is a digital switch for detecting large magnetic fields. They can withstand unlimited fields without being damaged or turning off.

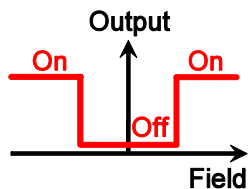
The part uses novel tunneling magnetoresistance (TMR) technology to provide both the lowest quiescent current available in a continuous-duty solid state magnetic switch and large field detection. The sensor also provides unmatched miniaturization. The parts are available in NVE's ultraminiature 1.1 mm x 1.1 mm ULLGA leadless package or as bare die.

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 of either magnetic polarity and in any direction, 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 0.6 mm x 0.6 mm die containing a TMR sensor element, CMOS signal processing circuitry to convert the analog sensor element output to a digital output.

Custom magnetic operating thresholds can be provided.

Idealized 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 | 150 | °C |
| Junction temperature | | 150 | °C |
| ESD | 500 | | V |
| Applied magnetic field | | Unlimited | |

Operating Specifications

| T _{min} to T _{max} ; 0.9 V < V _{DD} < 1.8 V 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 | | 85 | °C | |
| Magnetic operate point | H _{OP} | 250 | 350 | 400 | mT | 25 °C |
| | | 250 | 350 | 470 | | |
| Operate point temperature coefficient | ΔH _{OP} / ΔT | | 0.4 | | %/°C | -40 °C to 85 °C Fields in-plane |
| Operate point angle coefficient | ΔH _{OP} / Δζ | | 1.1 | | %/° | |
| Magnetic release point | H _{REL} | 200 | | | mT | |
| Hysteresis | | 1 | | 50 | mT | |
| Quiescent current | I _{DDQ} | | 0.3 | 0.6 | μA | V _{DD} = 2.4 V |
| | | | 0.9 | 1.3 | | V _{DD} = 3 V |
| | | | 1.71 | 2.5 | | V _{DD} = 3.6 V |
| | | | 4.0 | 7.0 | | V _{DD} = 4.2 V |
| Output drive current | I _{OL-ON} | 100 | | | μA | |
| Output low voltage | V _{OL} | | | 0.3 | V | V _{DD} = 3V; I _{OL-ON} = 100 μA |
| Output leakage current | I _{OL-OFF} | | 0.095 | 0.5 | μA | |
| Maximum switching frequency | f | | 3000 | | Hz | |

Notes:

- 1 millitesla (mT) = 10 gauss (G) = 10 oersted (Oe) in air
ESD per Human Body Model (HBM), JESD22-A114

Operation

Omni-directional Sensitivity

As the magnetic field intensity varies, the ADK001's digital output will turn on and off. Unlike single-axis switches like Hall effect or other sensors, the ADK991 sensor is sensitive to magnetic fields in any direction, so multiple sensors are not needed for orthogonal or unknown directions of applied fields. The magnetic operate and release points are virtually unaffected by the angle of magnetic field in the plane of the sensor, and increase slightly for magnetic fields out of the plane of the sensor. The diagrams below show three permanent magnet orientations that will activate the sensor:

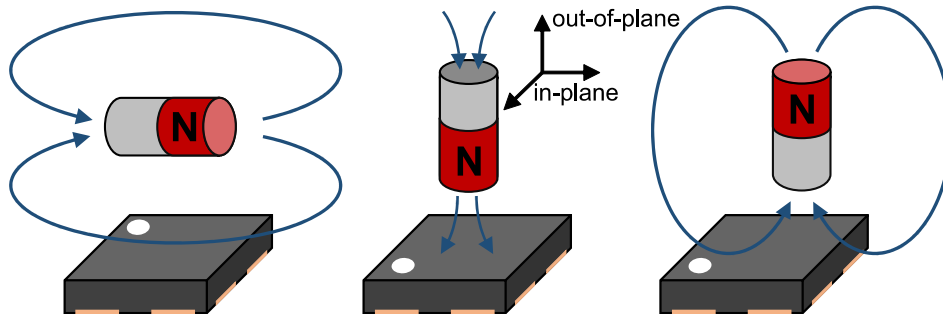


Figure 1. ADK991 sensor direction of magnetic sensitivity.

The omni-directional nature of the sensor also makes the sensitivity omnipolar. Either polarity applied fields activate the sensor.

External Pull-Up Resistor

The output is a logic 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.

Typical Operation

Figure 2 shows an ADK991 sensor mounted to an available demonstration board:

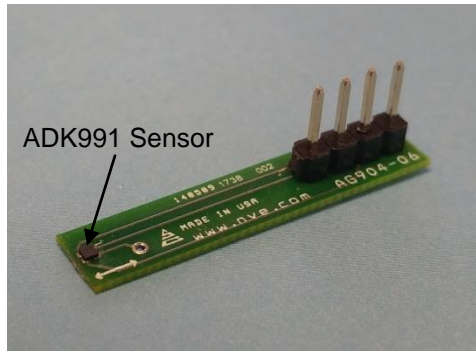


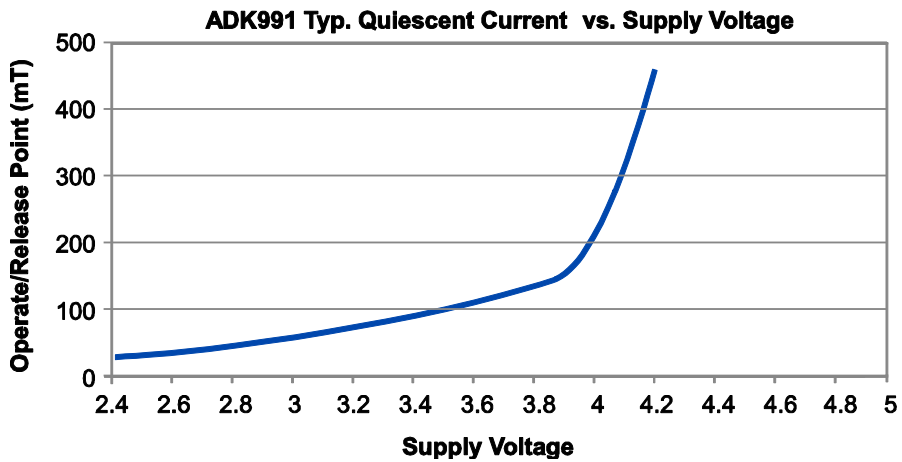
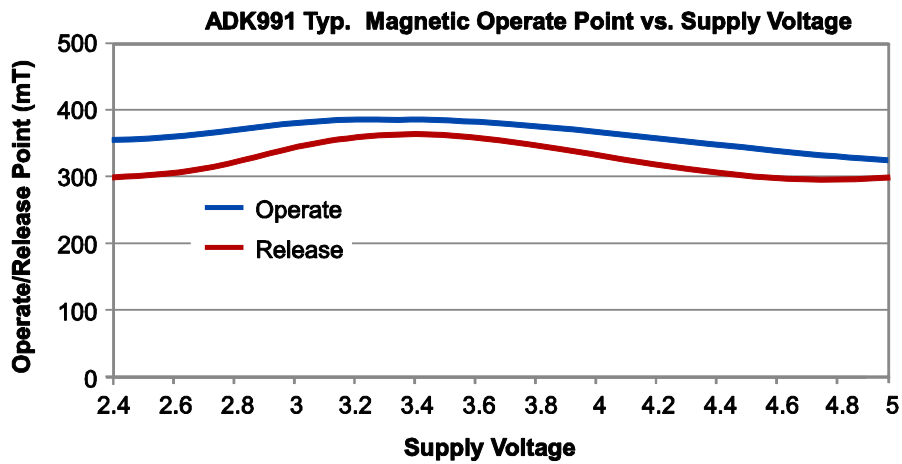
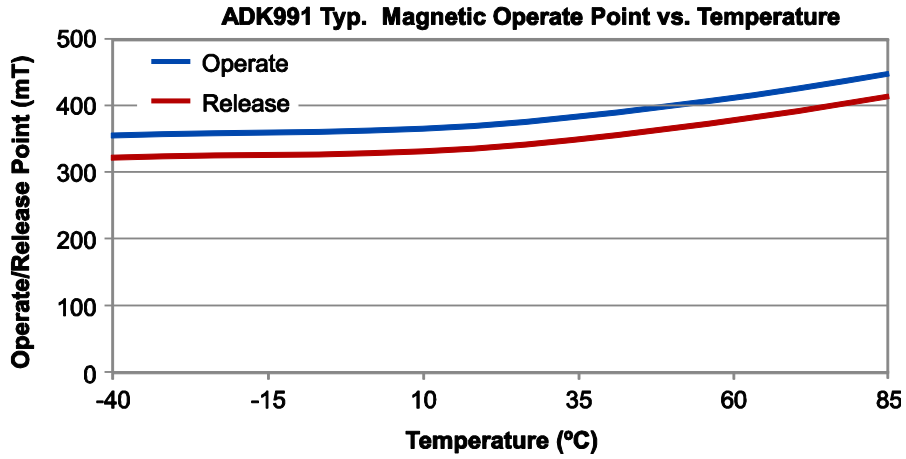
Figure 2. ADK991 on a circuit board.

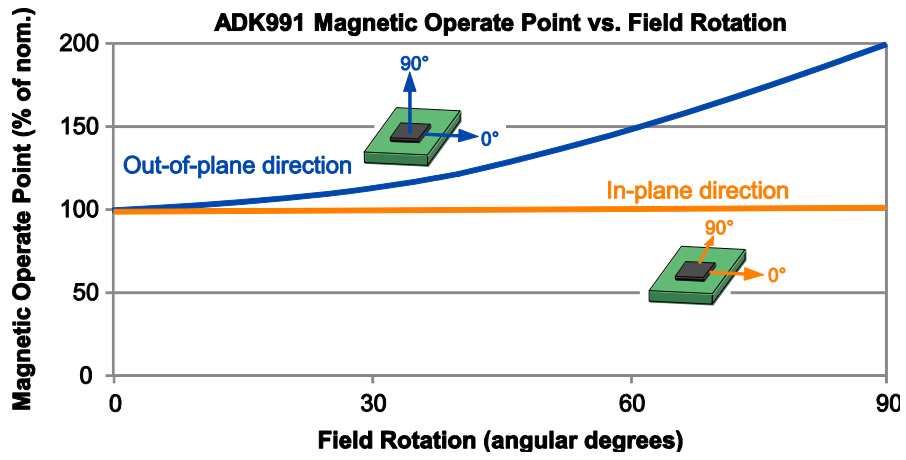
Typical switching distances from the face of the magnet to the center of the sensor for common rare-earth magnets are illustrated in the following table:

| Magnet | Typical Operate Distance |
|----------------------------------|--------------------------|
| 6 mm dia. x 4 mm thick N45 | 1.1 mm |
| 6 mm dia. x 25.4 mm long N45 | 1.6 mm |
| 12.7 mm dia. x 12.7 mm thick N48 | 2.5 mm |

For more calculations, use our digital sensor switching versus distance Web application at: www.nve.com/spec/calculators.php.

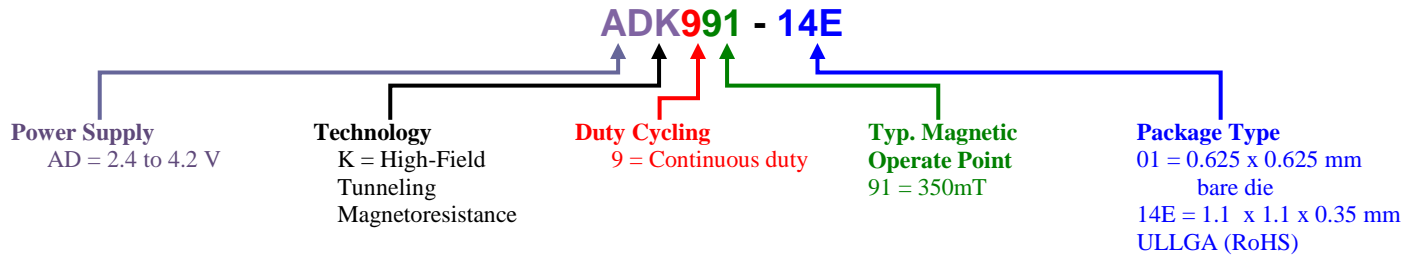
Typical Performance





Part Numbering

This shows the ADK991 part number meaning:



Bare Circuit Boards

NVE offers two bare circuit boards designed for easy connections to ULLGA 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 General-Purpose PCB

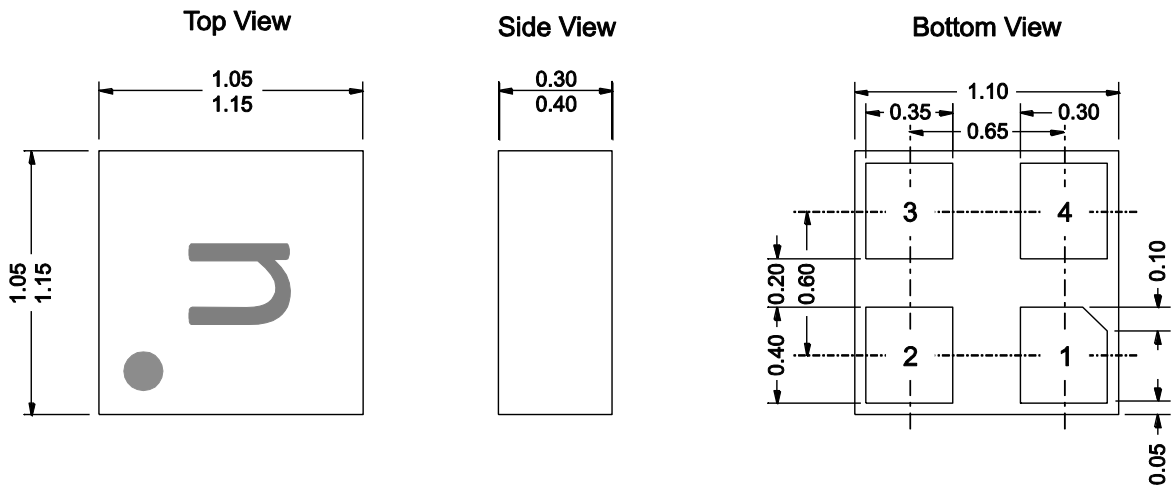
A 30 x 6 mm (1.2 x 0.25 inch) PCB for demonstrating 1.1 x 1.1 mm ULLGA4 sensors (-14E sensor suffix).



AG039-06: ULLGA Digital Sensor Demonstration Bare Board

A 40 x 6 mm (1.57 x 0.25 inch) PCB for demonstrating ADK991 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 Package (-14E suffix)



Dimensions in mm; ± 0.05 mm unless otherwise noted.



| | |
|-------|------------|
| Pad 1 | No Connect |
| Pad 2 | V_{DD} |
| Pad 3 | Out |
| Pad 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-00-135A

November6, 2020

Change

- Initial release.

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