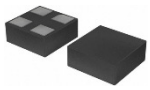
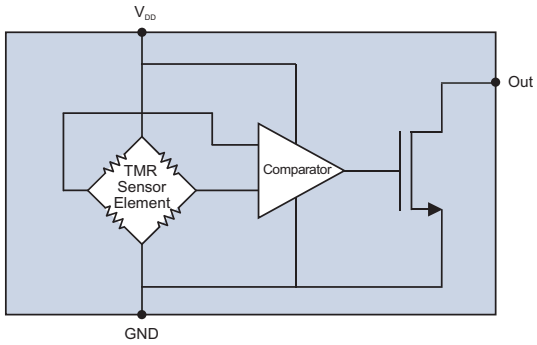
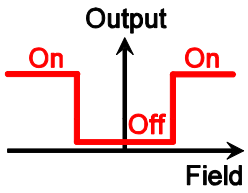
BDK991 High-Field, 3-Volt Low-Power Omni-Directional Medical Grade TMR Switch



Functional Diagram



Idealized Magnetic Response



Features

- Detection of large magnetic fields
- 320 mT operate point
- Unlimited maximum field
- 2.4 V to 4.2 V operating voltage for single-cell operation
- 2.8 µA typical quiescent current
- Continuous operation for low noise and high-speed
- 1.1 x 1.1 mm DFN or 0.65 x 0.65 mm WLCSP
- Omni-directional field sensitivity

Applications

- Primary lithium or rechargeable lithium-ion powered devices
- MRI field detection
- Portable instruments

Description

The BDK991 is a digital switch for detecting large magnetic fields. They can withstand unlimited fields up to nine tesla 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 DFN leadless package or as 0.65 x 0.65 mm wafer level chip-scale package.

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 a TMR sensor element and CMOS signal processing circuitry to convert the analog sensor element output to a digital output.

Custom magnetic operating thresholds can be provided.

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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
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	4.2	Volts	
Operating temperature	T_{MIN}; T_{MAX}	−40		85	°C	
Magnetic operate point	H_{OP}	200	320	400	mT	25°C
		200	320	470		−40°C to 85°C Fields in-plane
Operate point temperature coefficient	$\Delta H_{OP} / \Delta T$		0.4		%/°C	
Operate point angle coefficient	$\Delta H_{OP} / \Delta \angle$		1.1		%/°	
Magnetic release point	H_{REL}	100			mT	
Hysteresis	H_{DIF}	10	50		mT	
Quiescent current	I_{DDQ}		1.5		µA	V_{DD} = 2.4 V
		2	2.8	4		V_{DD} = 3.3 V
			3.3			V_{DD} = 3.6 V
			4.2			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		20		kHz	

Notes:

- ESD per Human Body Model (HBM), JESD22-A114.

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Typical Performance

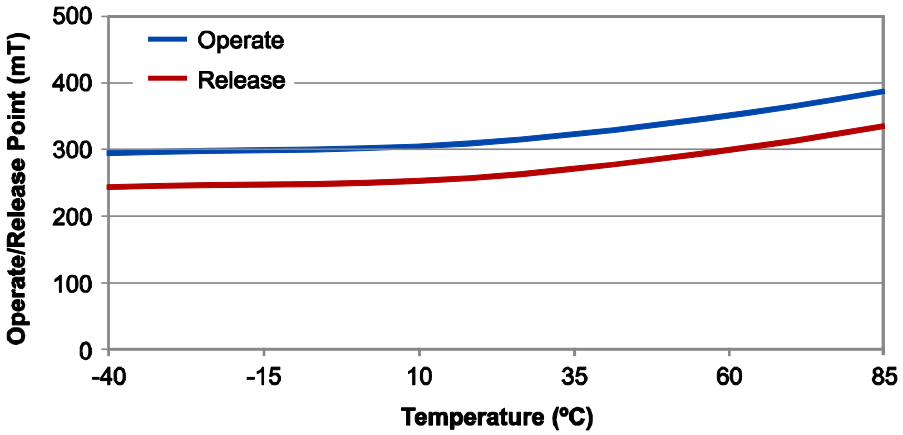

Figure 1. Magnetic operate point vs. temperature.

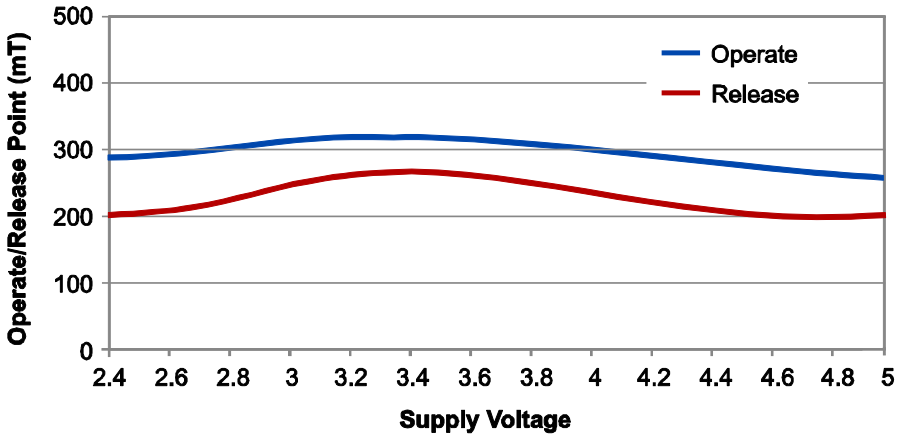

Figure 2. Magnetic operate point vs. supply voltage.

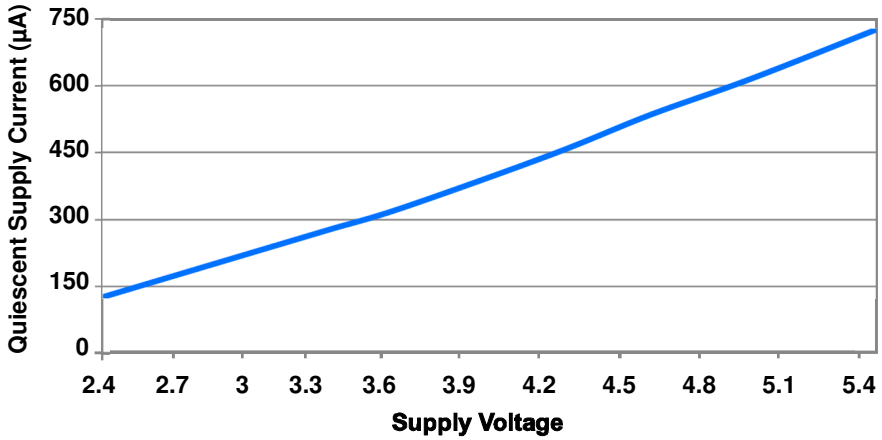

Figure 3. Quiescent supply current vs. supply voltage.

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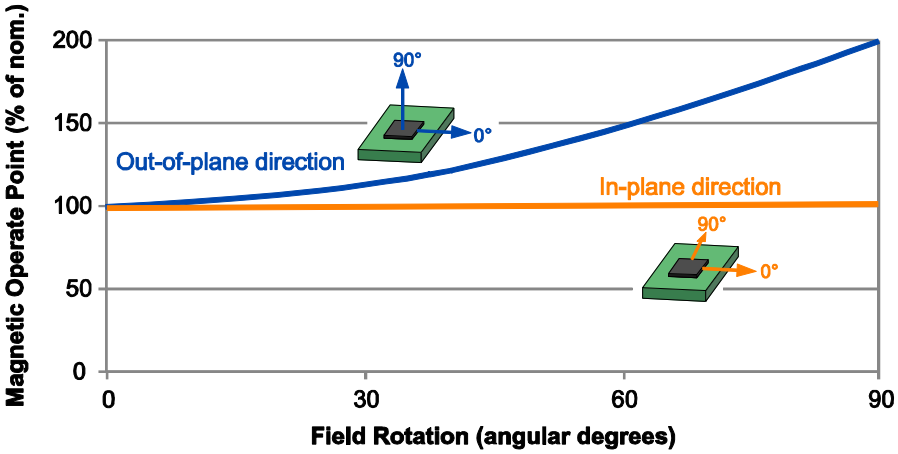

Figure 4. Magnetic operate point vs. field orientation.

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Application Information

Rigorous Testing
All parts are 100% tested for electrical and magnetic parameters. To ensure quality and reliability in medical applications, BDxxx parts are preconditioned and tested as follows:

- 100% of the parts receive a 24-hour bake at 150°C prior to final test.
- 100% visual inspection of the parts in the tape after final test.
- Lot qualification test where 200 parts that have passed final test from each production lot are exposed to two thermal cycles using a standard solder reflow profile, then re-tested for correct operation. All parts must pass for the parts to be accepted into inventory.

Omni-Directional Sensitivity
As the magnetic field intensity varies, the BDK991's digital output will turn on and off. Unlike single-axis switches like Hall effect or other sensors, the BDK991 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 but remain sensitive for magnetic fields out of the plane of the sensor. The diagrams below show three permanent magnet orientations that will activate the sensor:

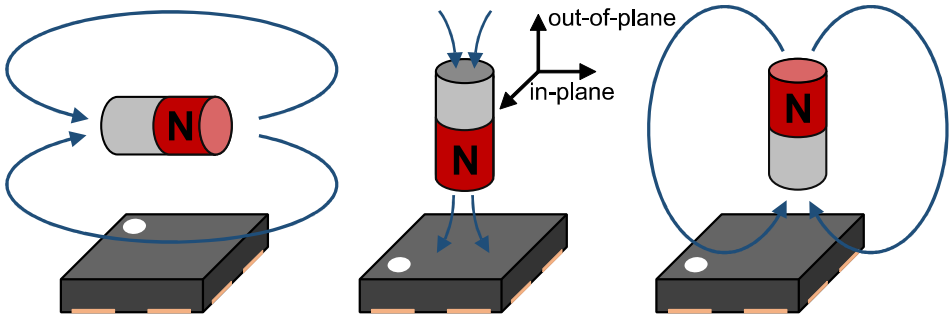

Figure 5. The BDK991's omni-directional sensitivity.

The omni-directional nature of the sensor also makes the sensitivity omnipolar. Either magnetic polarity activates 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.

External Duty Cycling
The BDK991 can be externally 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:

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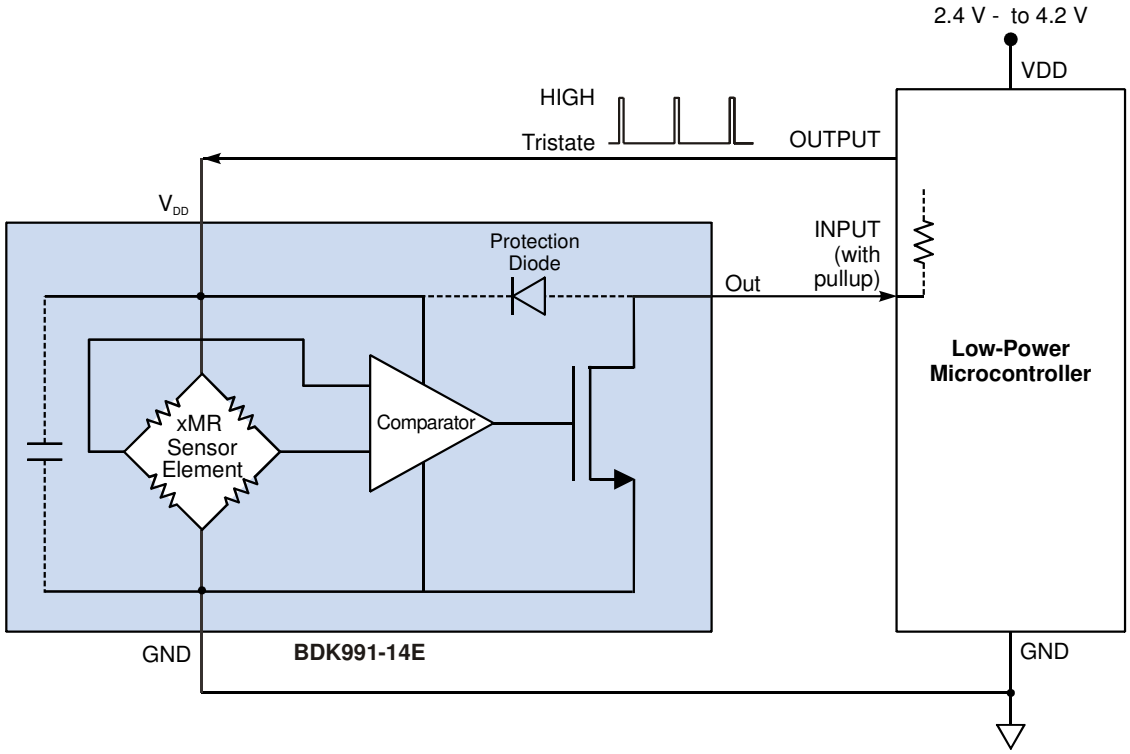

Figure 6. External duty cycling using a microcontroller.

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.

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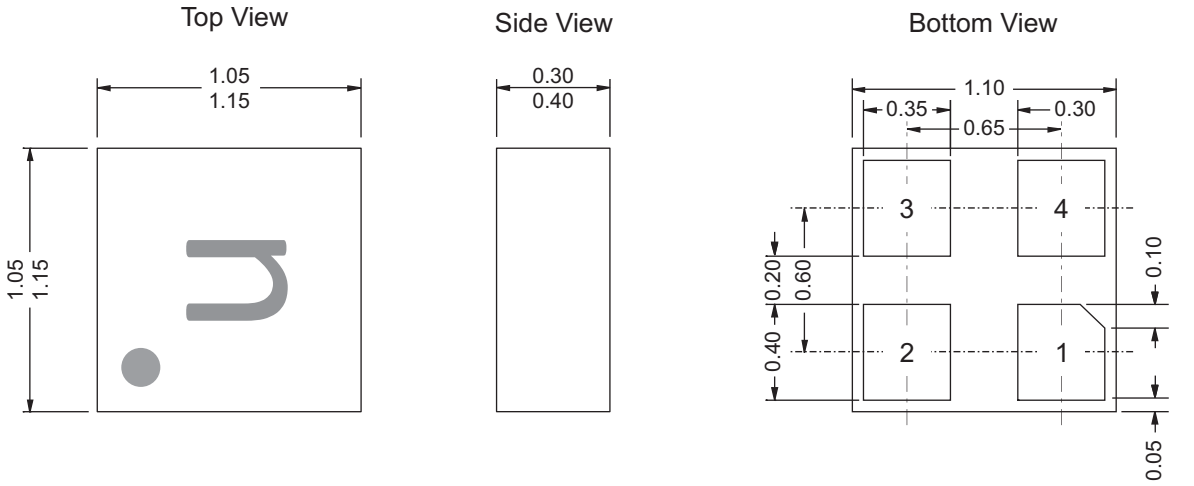
1.1 mm x 1.1 mm DFN4 Package (-14E suffix)



Dimensions in mm; ±0.05 mm unless otherwise noted.

RoHS COMPLIANT

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-00-179 December 2025	Change
	• Initial release.

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