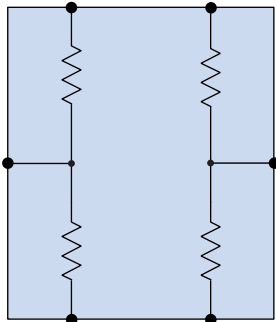
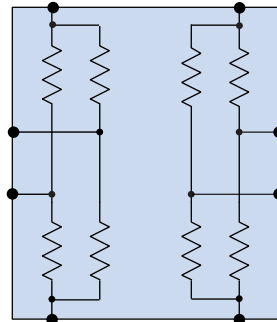


## ABL/AKL-Series Gear-Tooth Sensors

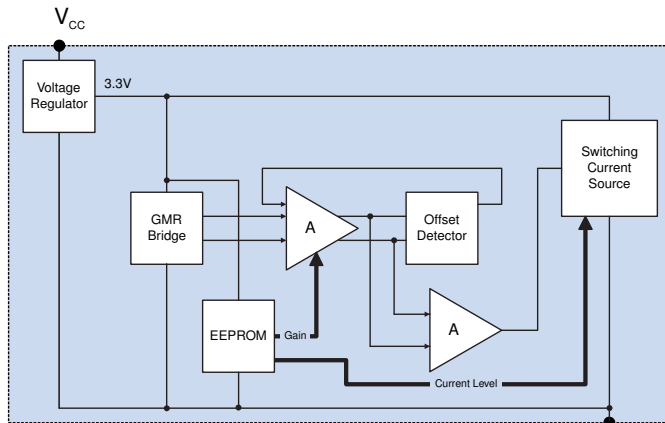
### Block Diagrams



**ABL00x**



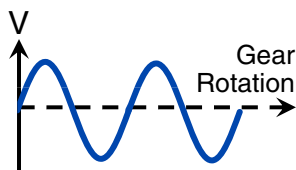
**ABL01x**



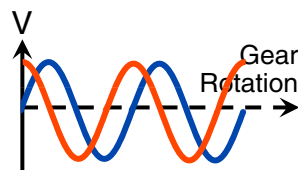
**AKL00x**

GND

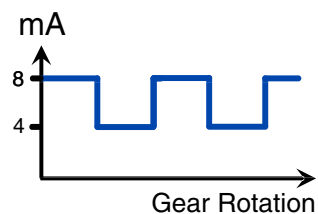
### Outputs



**ABL00x**  
Single-bridge analog sensor



**ABL01x**  
Dual-bridge analog sensor



**AKL00x** digital gear-tooth sensor

### Features

- Wide airgap
- Analog and digital versions
- Large analog peak-to-peak signal
- Single- and dual-bridge versions
- Operating frequency to 1 MHz
- 150 °C operating temperature
- Packages as small as 2.5 mm x 2.5 mm

### Applications

- Motion, speed, and position sensing
- Linear and rotational encoders
- Closed-loop servo systems
- Automotive sensors

### Description

ABL and AKL-Series Gear-Tooth Sensors are versatile, wide airgap sensors typically used with ferromagnetic gears and bias magnets.

Three standard spacings are available for use with gear pitches as small as 0.5 mm, to 6 mm or more (0.16 mm to 2 mm module).

ABL-Series analog sensors have differential sensor elements that provide sinusoidal outputs. Single- or dual-bridge configurations are available. Dual-bridge versions provide two phase-shifted outputs for A/B phase detection and absolute position interpolation.

AKL-Series sensors combine a sensor bridge with integrated signal processing to provide a 50% duty cycle digital output. Integrated signal processing includes gain and offset normalization. AKL-Series sensors are configured as two-wire devices, where the supply current indicates passing teeth.

## Absolute Maximum Ratings

ABL-Series Analog Gear-Tooth Sensors			
Parameter	Min.	Max.	Units
Supply voltage		30	Volts
Storage temperature	-65	170	°C
ESD (Human Body Model)		400	Volts
Applied magnetic field		Unlimited	Tesla

AKL-Series Digital Gear-Tooth Sensors			
Parameter	Min.	Max.	Units
Supply voltage	-60	45	Volts
Continuous output current		16	mA
Junction temperature	-40	170	°C
Storage temperature	-65	170	°C
Junction temperature	-40	170	°C
ESD (Human Body Model)		2000	Volts
Applied magnetic field		Unlimited	Tesla

## Operating Specifications

ABL-Series Analog Gear-Tooth Sensors						
Parameter	Symbol	Min.	Typ.	Max.	Units	Test Condition
Operating temperature	$T_{min}; T_{max}$	-50		150	°C	
Supply voltage	$V_{CC}$	0		30	V	
Resistance		4	5	7	k $\Omega$	At 25 °C
Offset voltage	$V_O$	-4		+4	mV/V	
Non-linearity				2	%	Unipolar field sweep through operating range
Hysteresis				2	%	
Saturation of GMR sensor elements		-18		+18	mT	
Single resistor sensitivity	$\Delta R/mT$		0.4		%/mT	
Maximum output			80		mV/V	
Resistance temperature coefficient	TCR		+0.11		%/°C	No applied field
Operating frequency	$f_{MAX}$	0	1		MHz	

AKL-Series Digital Gear-Tooth Sensors ( $T_{min}$ to $T_{max}$ ; 4.5 V < $V_{CC}$ < 36 V unless otherwise stated)						
Parameter	Symbol	Min.	Typ.	Max.	Units	Test Condition
Operating temperature	$T_{min}; T_{max}$	-40		150	°C	
Supply voltage	$V_{CC}$	4.5		36	V	
Off-state supply current	$I_{OFF}$	3.4	4	4.8	mA	$V_{CC} = 12 V$
On-state supply current	$I_{ON}$	7	8	9		
Output duty cycle		40	50	60	%	
Airgap					mm	
AKL001-12E		1		3.5		
AKL002-12E		1		2.5		
AKL003-12E		1		2		
Operating frequency	$f_{MAX}$	DC		10	kHz	

## Operation

### Sensor orientation

To align with the axis of sensitivity, sensors should be oriented with the gear teeth perpendicular to the length of the sensor as shown in Figure 1:

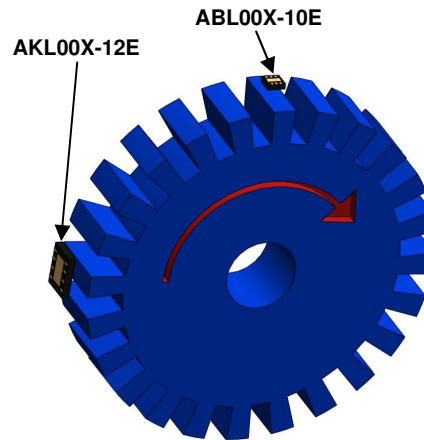


Figure 1. Sensor orientation.

### Biasing

To detect gear teeth, a permanent magnet is required to generate a magnetic bias field. The sensor can then detect magnetic field variations as the gear tooth passes by.

Here are some tips for biasing:

- Because of GT Sensors' high sensitivity, small, inexpensive Ceramic 8 ferrite magnets can be used for most applications. Small sensors and magnets allow small circuit boards.
- Alnico 8 magnets can be used in high temperature applications.
- When using rare-earth magnets, care should be taken to avoid saturating the sensors.
- Magnets and sensors can be placed on opposite sides of a 1.5 mm thick (0.062 inch) circuit board, which provides a convenient spacing for many applications (see Figure 2).
- The magnet can be glued to the circuit board using high-temperature epoxy adhesive.
- For more precise positioning, a pocket to hold the magnet can be machined into a thicker circuit board.
- If zero speed operation is not required, AC coupling the sensor removes the electrical offset induced by magnetic imperfections.

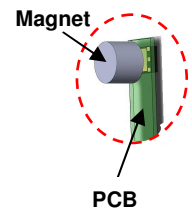


Figure 2. Biasing magnet.

### Recommended sensor element spacing vs. gear pitch

For ABL00x and AKL00x sensors, the best design margin is when the sensor element spacing is equal to approximately one-half the gear pitch. For example, this means the one-millimeter pitch ABL004 is ideal for two-millimeter pitch (0.65 mm module) gears.

For ABL01x sensors, the relative phase of the A/B outputs is determined by the ratio of the bridge phase difference and the gear pitch:

$$\text{Phase Shift} = (\text{bridge phase shift} / \text{gear pitch}) \cdot 360^\circ$$

As an example, the A/B phase difference for an ABL015 detecting a 1.2 mm gear pitch is equal to  $(0.25 / 1.2) \cdot 360^\circ = 75^\circ$ .

### Design Support

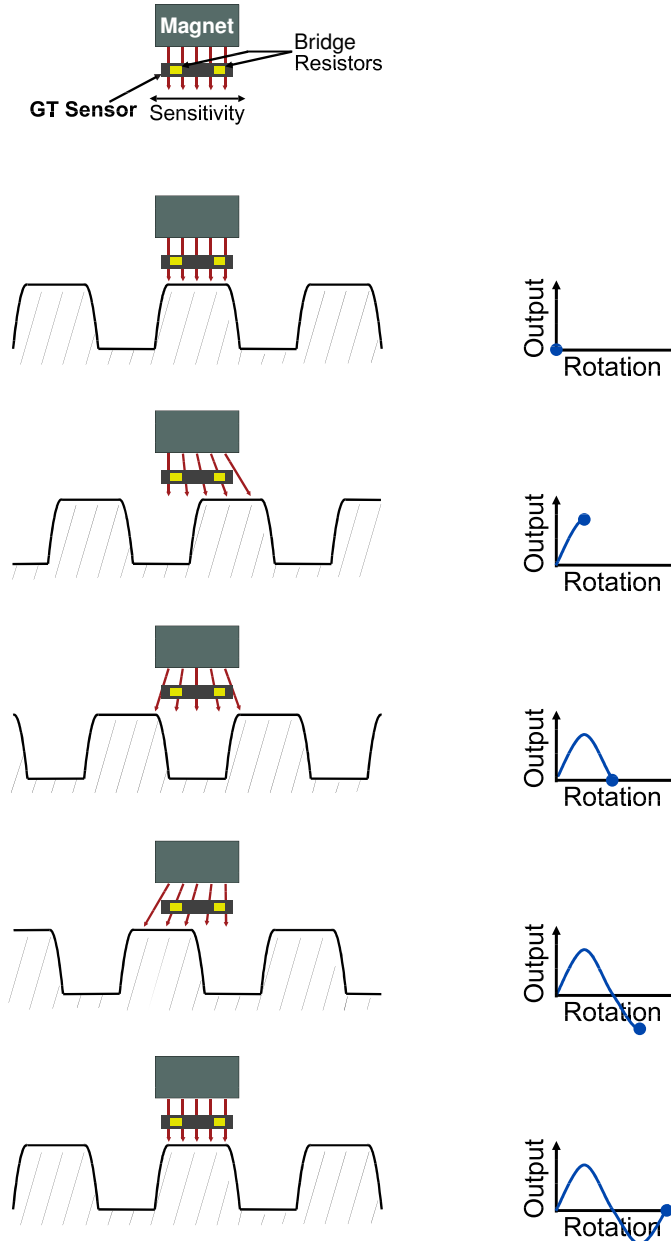
Check out our free Web application for GT sensor design support:

<https://www.nve.com/spec/calculators.php#tabs-GT-Sensor-Output>

**Sinusoidal output with rotation**

As shown in Figure 3 below, a biasing magnet provides a field, and the magnetic flux lines are deflected into the direction of sensitivity by passing metal gear teeth. Sensors are placed between the magnet and gear teeth. Thus the sensor produces a sinusoidal output with one cycle per tooth.

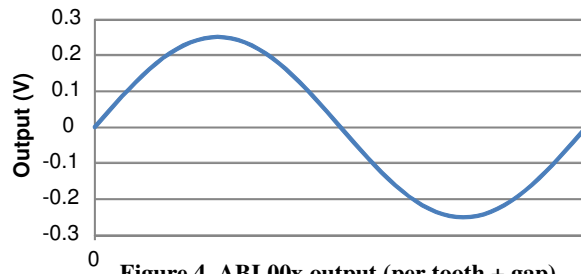
Dual-bridge sensors provide a second bridge output that is out-of-phase with the first sensor.



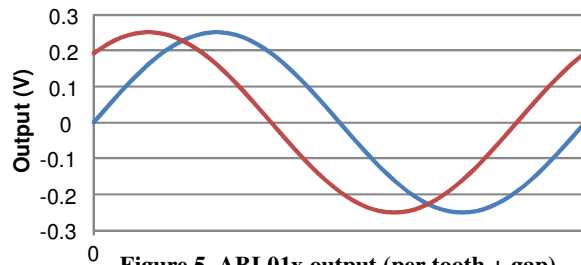
**Figure 3. ABL00x output vs. gear rotation.**

**Typical outputs**

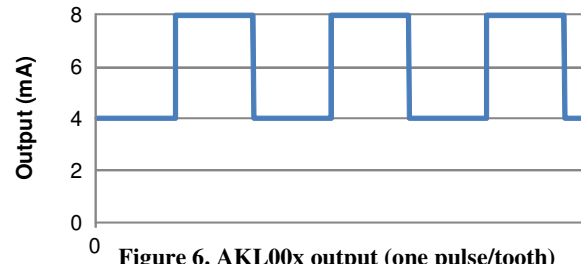
Figures 4 to 6 show typical outputs from each of the three GT Sensor types:



**Figure 4. ABL00x output (per tooth + gap)**



**Figure 5. ABL01x output (per tooth + gap)**

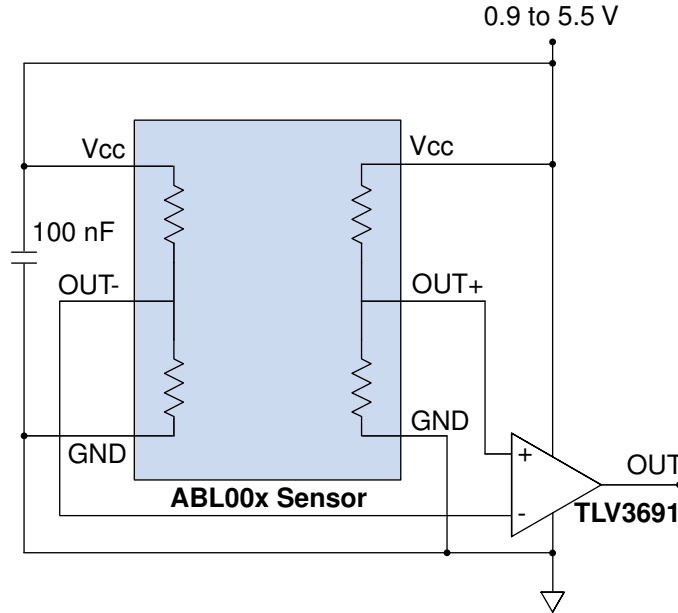


**Figure 6. AKL00x output (one pulse/tooth)**

**Illustrative Application Circuits**

**Digital output from analog gear-tooth sensors**

A comparator can be used to provide a digital signal corresponding to each gear passing:

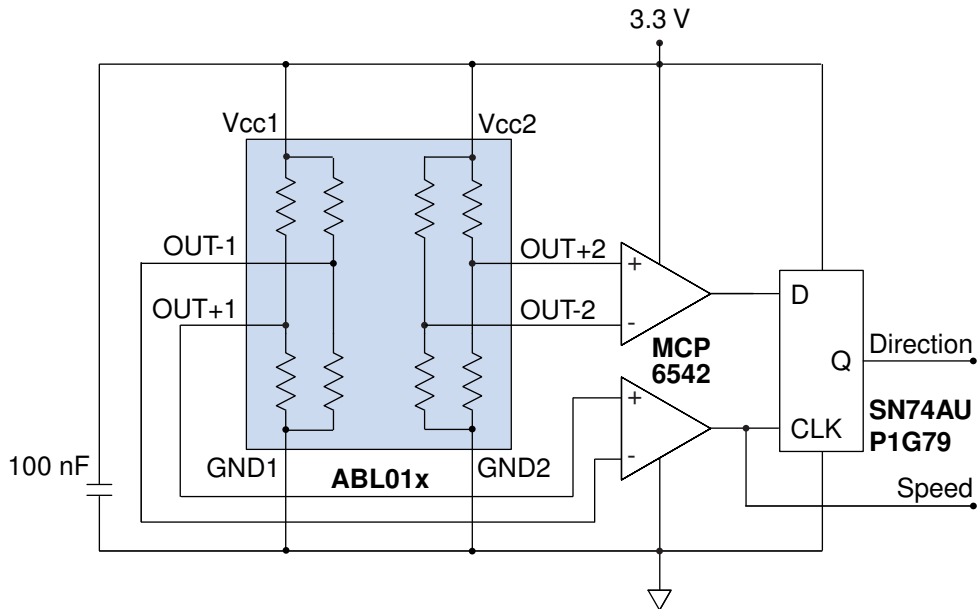


**Figure 7. Digital output from an analog sensor.**

If zero speed operation is not required, AC coupling the sensor remove offset induced by magnetic imperfections.

**Digital Speed and Direction Signals**

ABL01x dual-element sensors provide two outputs that can indicate direction of rotation. A dual comparator and flip-flop can provide direction and speed outputs. Direction is determined by detecting the phasing between the two outputs. The “Speed” output is one cycle per tooth:



**Figure 8. Digital speed and direction signals for gear-tooth sensors.**

**AKL sensor typical operation**

A single resistor in series with the sensor can detect the digital output. A 100Ω resistor provides a 400 mV peak-to-peak signal.

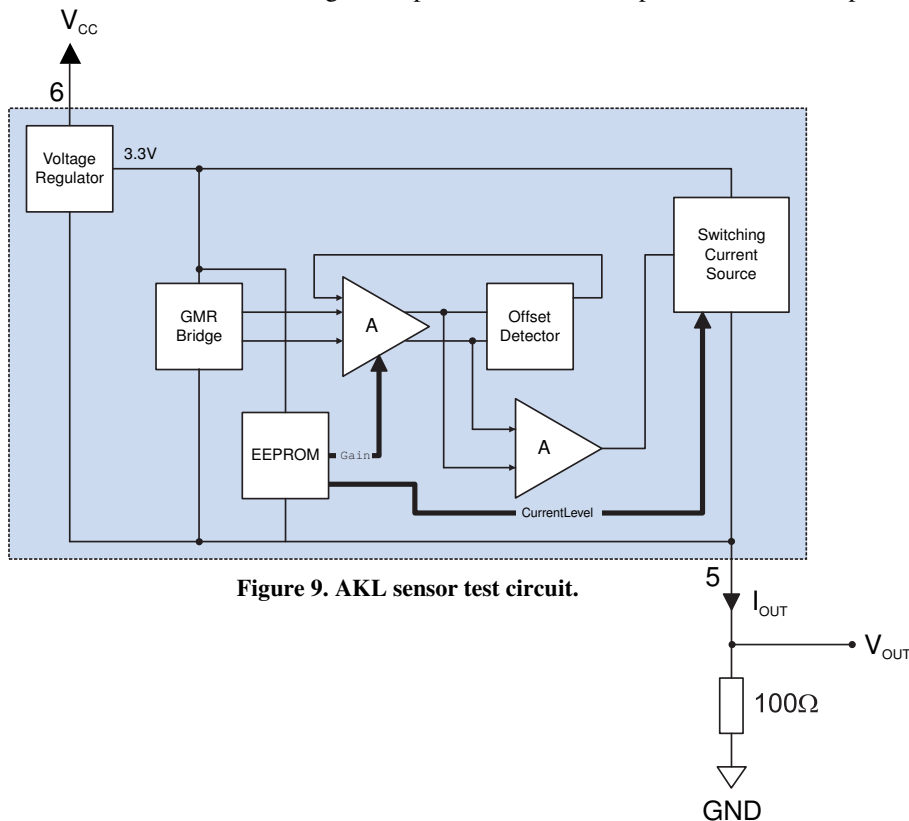


Figure 9. AKL sensor test circuit.

**Three-Wire Digital Gear-Tooth Sensor**

The two-wire AKL-Series can be easily converted to a three-wire interface:

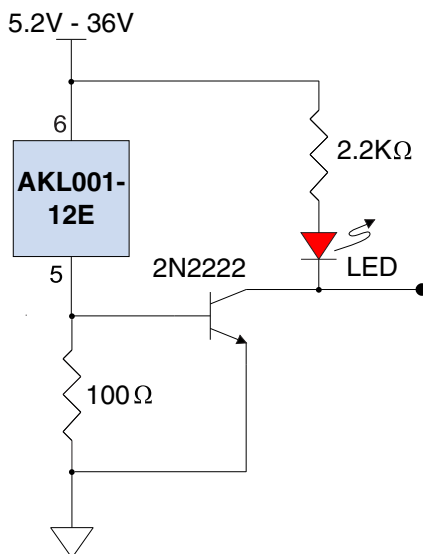
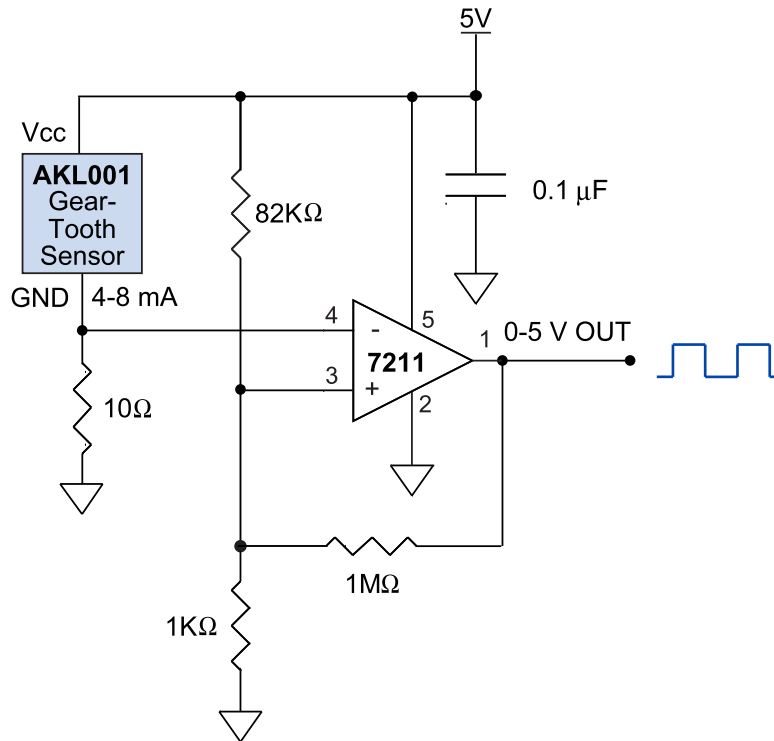


Figure 10. Simple three-wire interface.

When the current is 4 mA, the voltage across the 100Ω resistor is 0.4 V, which is not enough to turn on the transistor. With 8 mA, the transistor turns on. Note that the supply voltage must be at least 5.2 V to provide the sensor's 4.5 V minimum Vcc. The LED is optional.

**TTL Output Gear-Tooth Sensor**

The circuit below uses a simple comparator (7211 or similar) to convert the 4 to 8 mA AKL supply current to a rail-to-rail digital output.

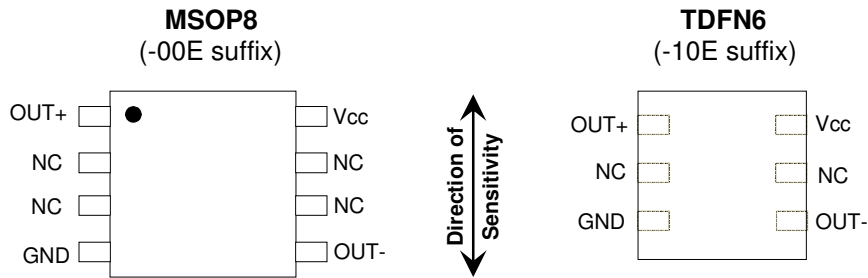


**Figure 11. TTL output gear-tooth sensor.**

The 10Ω series resistor is small enough to ensure the sensor Vcc voltage is above its 4.5 V minimum with a 4.75 to 5.25 V supply. The 1 KΩ and 82 KΩ resistors set a comparator threshold between 4 and 8 mA, and the 1 MΩ resistor provides hysteresis to enhance noise immunity.

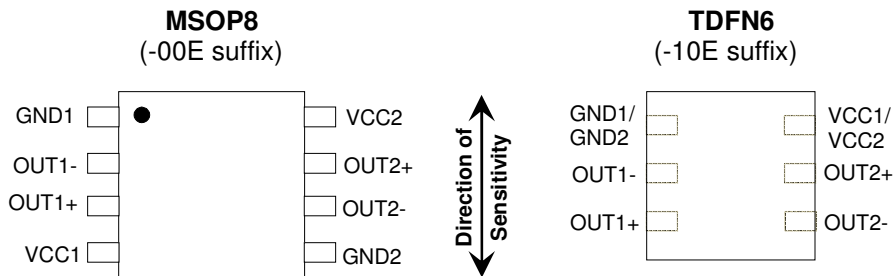


**ABL00X-XXE (single bridge) pinouts**



Pin		Symbol	Description
MSOP8	TDFN6		
8	6	V <sub>CC</sub>	Power supply
4	3	GND	Ground
1	1	OUT+	Bridge differential output
5	4	OUT-	
2, 3, 6, 7	2, 5	NC	No internal connection

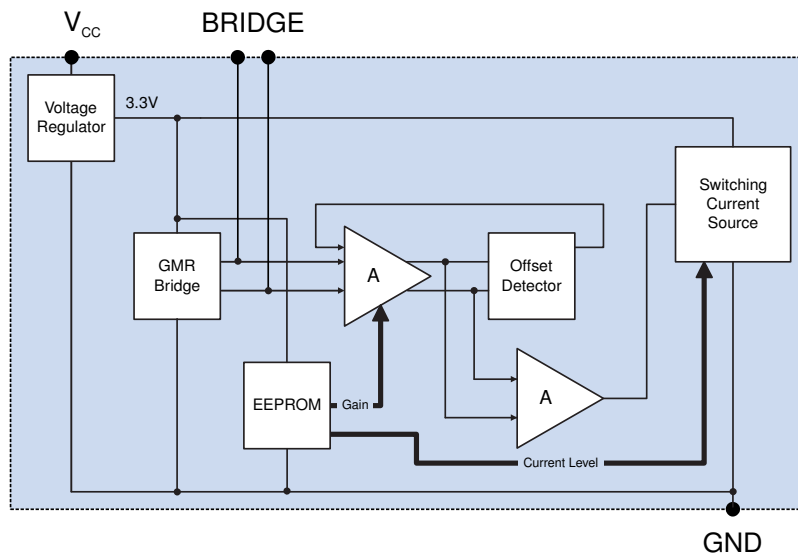
**ABL01X-XXE (dual bridge) pinouts**



Pin		Symbol	Description
MSOP8	TDFN6		
4	6	V <sub>CC1</sub>	Bridge 1 power supply
8		V <sub>CC2</sub>	Bridge 2 power supply
1	1	GND1	Bridge 1 ground
5		GND2	Bridge 2 ground
2	2	OUT1-	Bridge 1 differential output
3	3	OUT1+	
6	4	OUT2-	Bridge 2 differential output
7	5	OUT2+	

OUT1 and OUT2 are A/B phase shifted outputs.

**AKL-Series Pinout**



TDFN8 Pin	Symbol	Description
6	V <sub>CC</sub>	Supply voltage
5	GND	Ground
4	BRIDGE+	Bridge outputs (leave floating for normal operation)
7	BRIDGE-	
1, 2, 3, 8	Test	No connections should be made for normal operation

## Available Parts

ABL-Series Analog Gear-Tooth Sensors							
Part No.	Single or Dual Bridge	Element Spacing	Phase Shift Between Bridges	Recommended Gear Pitch	Recommended Gear Module	Package	Package Marking Code
ABL004-00E	Single	1 mm	NA	1.7 – 6 mm	0.5 – 2 mm	MSOP8	FDB
ABL005-00E	Single	0.5 mm	NA	0.8 – 1.7 mm	0.25 – 0.5 mm	MSOP8	FDC
ABL006-00E	Single	0.3 mm	NA	0.5 – 0.8 mm	0.16 – 0.25 mm	MSOP8	FDL
ABL014-00E	Dual	1 mm	0.5 mm	1.7 – 6 mm	0.5 – 2 mm	MSOP8	FDD
ABL015-00E	Dual	0.5 mm	0.25 mm	0.8 – 1.7 mm	0.25 – 0.5 mm	MSOP8	FDF
ABL016-00E	Dual	0.3 mm	0.15 mm	0.5 – 0.8 mm	0.16 – 0.25 mm	MSOP8	FDM
ABL004-10E	Single	1 mm	NA	1.7 – 6 mm	0.5 – 2 mm	TDFN6	FDG
ABL005-10E	Single	0.5 mm	NA	0.8 – 1.7 mm	0.25 – 0.5 mm	TDFN6	FDH
ABL006-10E	Single	0.3 mm	NA	0.5 – 0.8 mm	0.16 – 0.25 mm	TDFN6	FDN
ABL014-10E	Dual	1 mm	0.5 mm	1.7 – 6 mm	0.5 – 2 mm	TDFN6	FDJ
ABL015-10E	Dual	0.5 mm	0.25 mm	0.8 – 1.7 mm	0.25 – 0.5 mm	TDFN6	FDK
ABL016-10E	Dual	0.3 mm	0.15 mm	0.5 – 0.8 mm	0.16 – 0.25 mm	TDFN6	FDP

AKL-Series Digital Gear-Tooth Sensors				
Part No.	Element Spacing	Recommended Gear Pitch	Recommended Gear Module	Package
AKL001-12E	1 mm	1.7 – 6 mm	0.5 – 2 mm	TDFN8
AKL002-12E	0.5 mm	0.8 – 1.7 mm	0.25 – 0.5 mm	TDFN8
AKL003-12E	0.3 mm	0.5 – 0.8 mm	0.16 – 0.25 mm	TDFN8

## Customer Support

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### *Evaluation and Demonstration Boards*

Inexpensive evaluation boards are available for the ABL- and AKL-Series GT sensors.



#### **AG920-07—GT Sensor Evaluation Kit**

Evaluate gear tooth sensors for measuring rotational speed with a variety of analog and digital GT Sensors, plus the DD001-12 stand-alone signal processing IC. A variety of PCB configurations are provided so the parts can be tested in different housing and barrel sizes, including the M8 housing. Biasing magnets are also included.



#### **AG921-07—AKL002 Gear-Tooth Sensor Demonstrator**

NVE's AG921-07 evaluation kit is a self-contained demonstrator for NVE's unique AKL digital gear tooth sensor. The battery-powered demonstrator (battery included) uses an AKL002 sensor to detect passing gear teeth. The demonstrator also includes a circuit board with an LED and driver, a biasing magnet, and a gear that can be turned by hand. No assembly required. Dimensions 3" x 3" x 1.5" (75 mm x 75 mm x 38 mm).

### *Demonstration Videos*

NVE uploads regular new product and application demonstrations to *Youtube*; check out our channel:

[www.YouTube.com/NveCorporation](http://www.YouTube.com/NveCorporation)

Detecting tiny gear teeth with the ultraprecise ABL006:

[youtu.be/brDLly1L6aE](http://youtu.be/brDLly1L6aE)

ABL/AKL-Series GT Sensor oscilloscope demonstration:

[youtu.be/7R3qPD51W2w](http://youtu.be/7R3qPD51W2w)

Handheld AKL002 demonstration:

[youtu.be/sAA3ILHs7h4](http://youtu.be/sAA3ILHs7h4)

### *Application Note*

Best practices and design support for NVE GT Sensors:

[https://www.nve.com/Downloads/SB-00-103\\_GT-Sensor-App-Note.pdf](https://www.nve.com/Downloads/SB-00-103_GT-Sensor-App-Note.pdf)

### *Design Assistance Web-Application*

We have a free web-based application to provide design support for ABL Series GT Sensors, including bias magnet selection. Enter your gear's dimensions, then choose your sensor, bias magnet, and PCB thickness and view approximate sensor outputs for your system:

<https://www.nve.com/spec/calculators.php#tabs-GT-Sensor-Output>

## Bare Circuit Boards and Magnets for Sensors

### PCBs

NVE offers several bare circuit boards specially designed for easy connections to GT Sensors. Popular PCBs are shown below (images are actual size):



**AG915-06:**

0.25" (6 mm) octagonal  
MSOP8



**AG918-06** (standard) / **AG919-06** (cross-axis):  
2" x 0.25" (50 mm x 6 mm) MSOP8

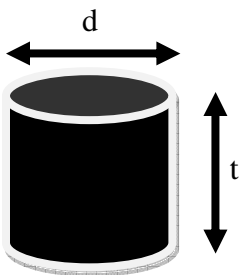


**AG035-06:**

1.57" x 0.25" (40 mm x 6 mm) TDFN6

### Magnets

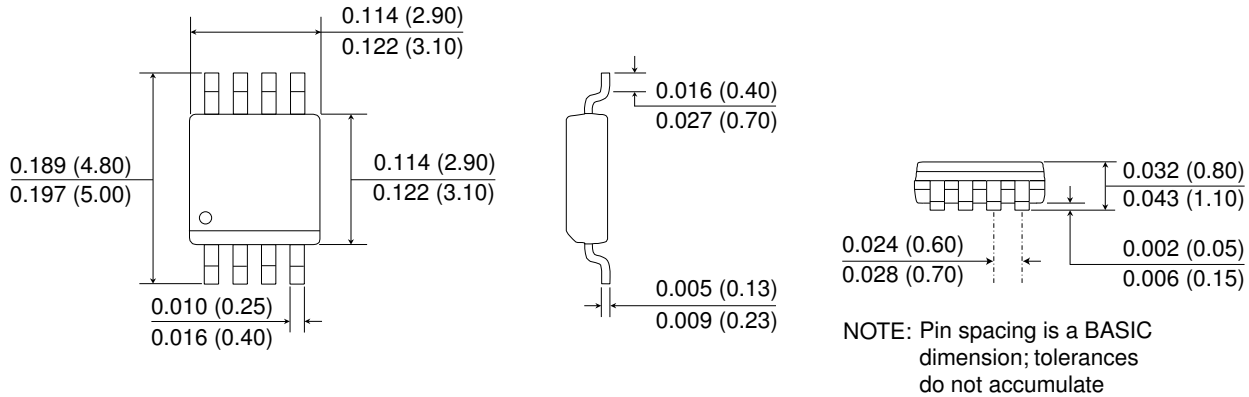
NVE offers three standard ferrite disk magnets for use with GT Sensors:



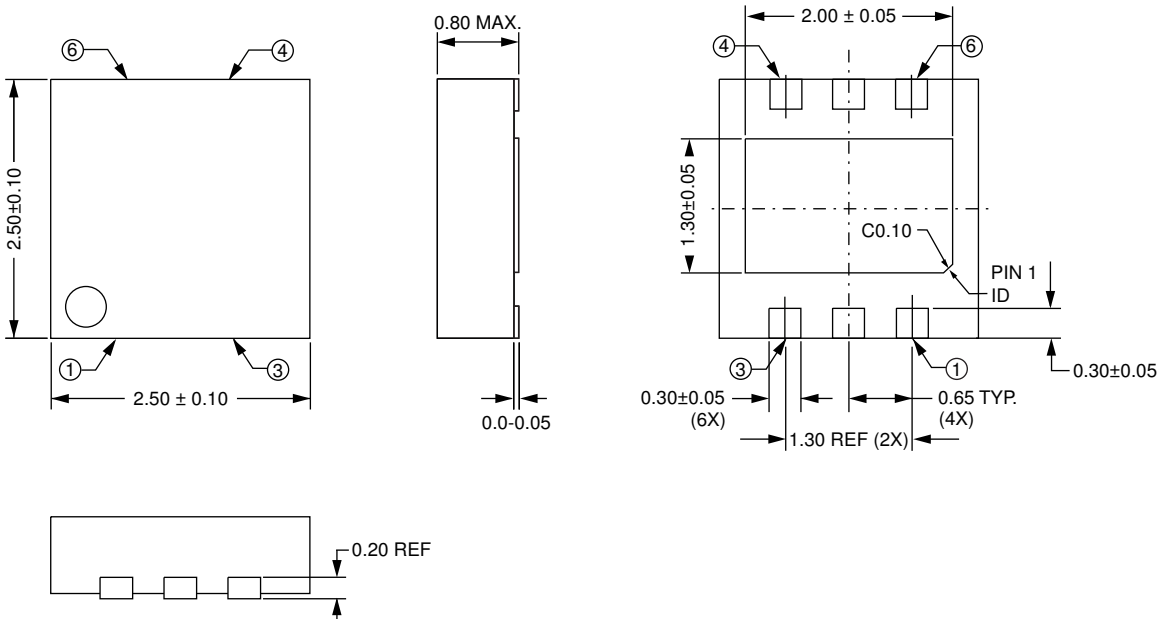
NVE Part #	Material	Diameter (d)	Thickness (t)
12031	C5/Y25	8 mm	3.2 mm
12216	C5/Y25	6 mm	4 mm
12217	C5/Y25	3.5 mm	4 mm

**Package Drawings**

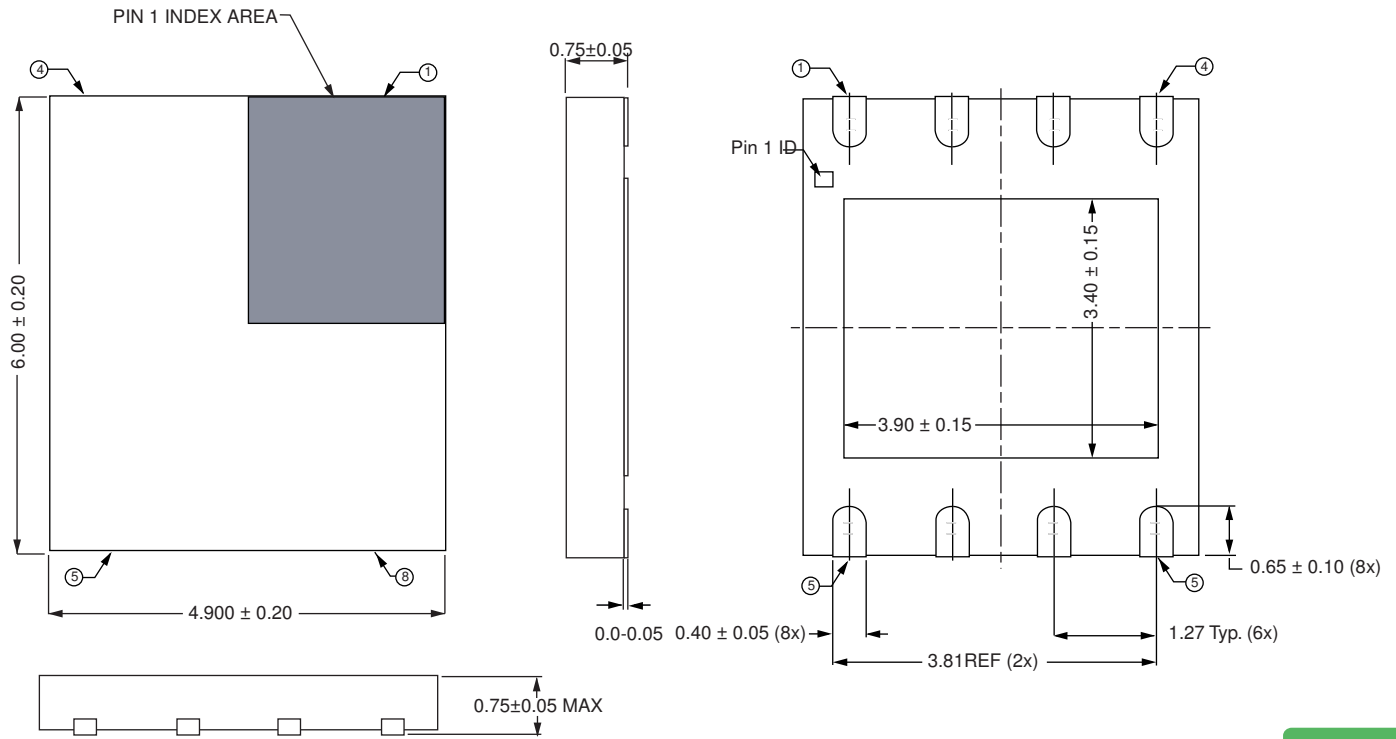
**MSOP8 (-00E suffix)**



**TDFN6 (-10E suffix)**



**TDFN8 (-11E suffix)**



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

## Revision History

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**SB-00-061-C**

November 2019

**Change**

- Clarified operating recommendations, updated customer support section.
- Added a “Recommended Gear Module” column to the “Available Parts” tables on p. 11.

**SB-00-061-B**

July 2018

**Change**

- Added E suffix to all part numbers in available parts table.

**SB-00-061-A**

March 2017

**Change**

- Initial datasheet release superseding catalog.



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*November 2019*