

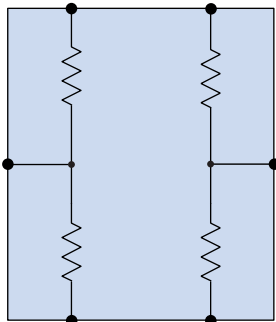


**THE DATASHEET OF
ABL006-00E**

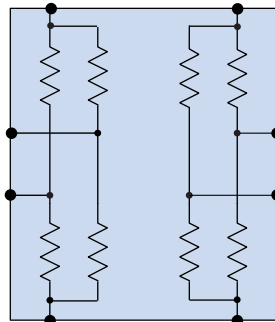


ABL/AKL-Series Gear-Tooth Sensors

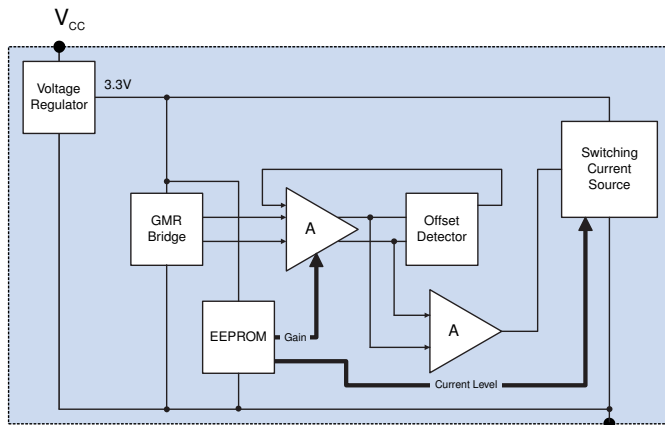
Block Diagrams



ABL00x



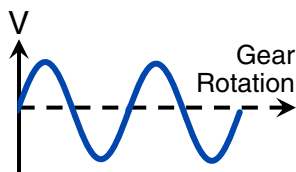
ABL01x



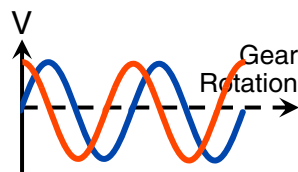
AKL00x

GND

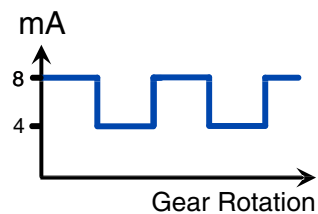
Outputs



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 Ω | 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:

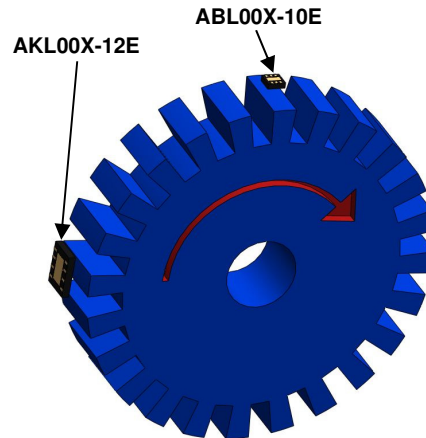


Figure 1. Sensor orientation.

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.

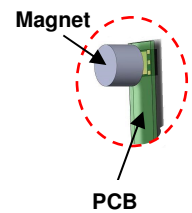


Figure 2. Biasing magnet.

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.

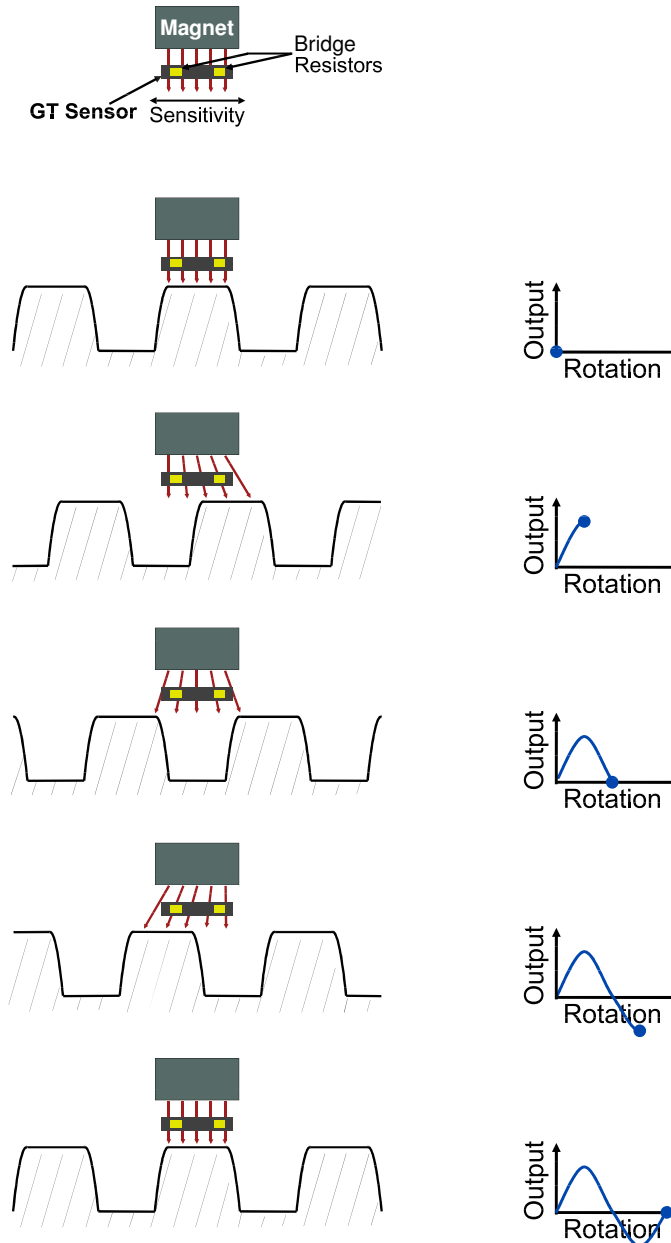


Figure 3. ABL00x output vs. gear rotation.

Typical outputs

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

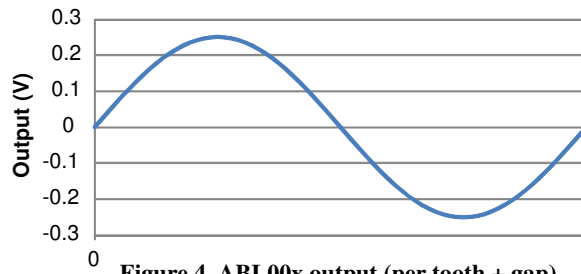


Figure 4. ABL00x output (per tooth + gap)

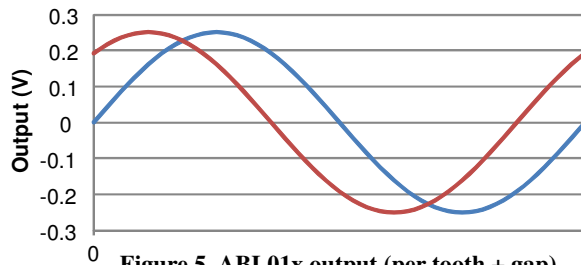


Figure 5. ABL01x output (per tooth + gap)

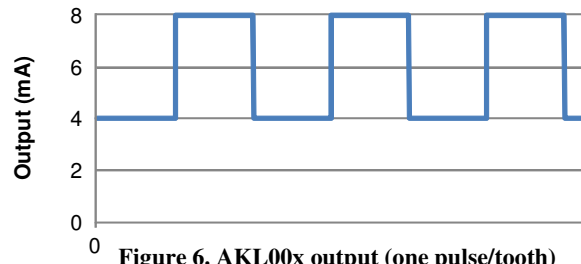


Figure 6. AKL00x output (one pulse/tooth)

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:

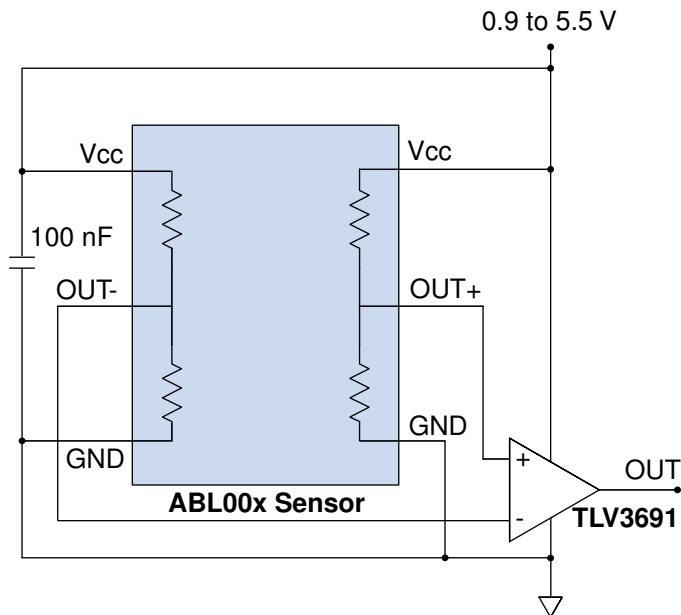


Figure 7. Digital output from an analog sensor.

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:

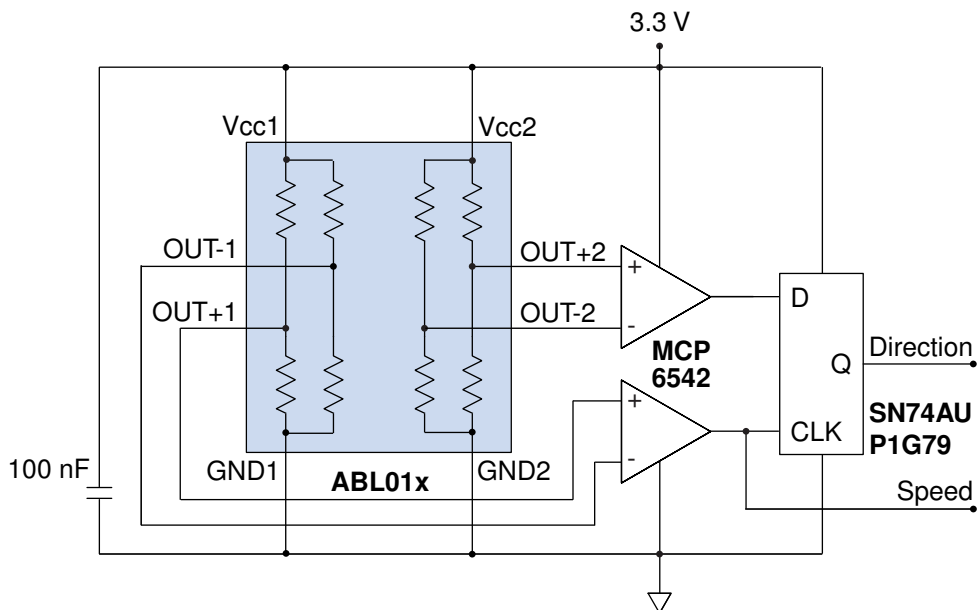


Figure 8. Digital speed and direction signals for gear-tooth sensors.

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.

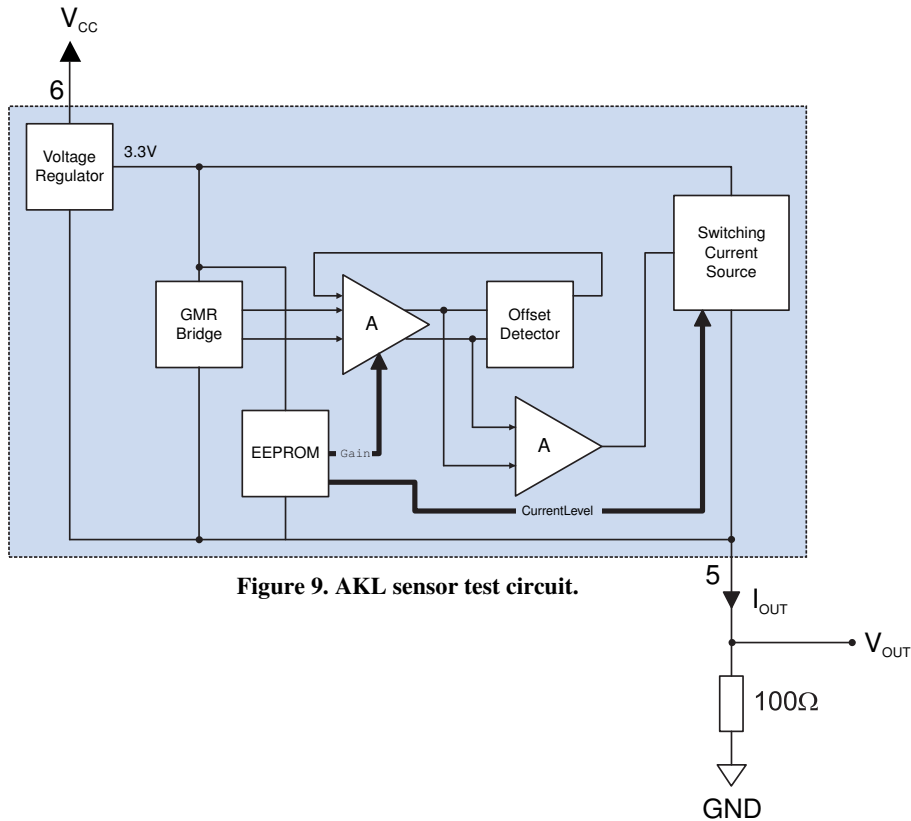


Figure 9. AKL sensor test circuit.

Three-Wire Digital Gear-Tooth Sensor

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

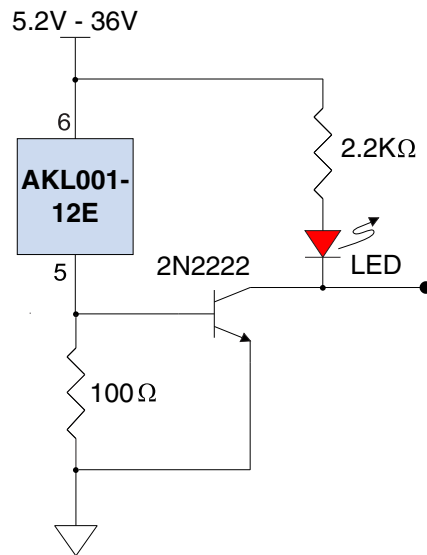


Figure 10. Simple three-wire interface.

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.

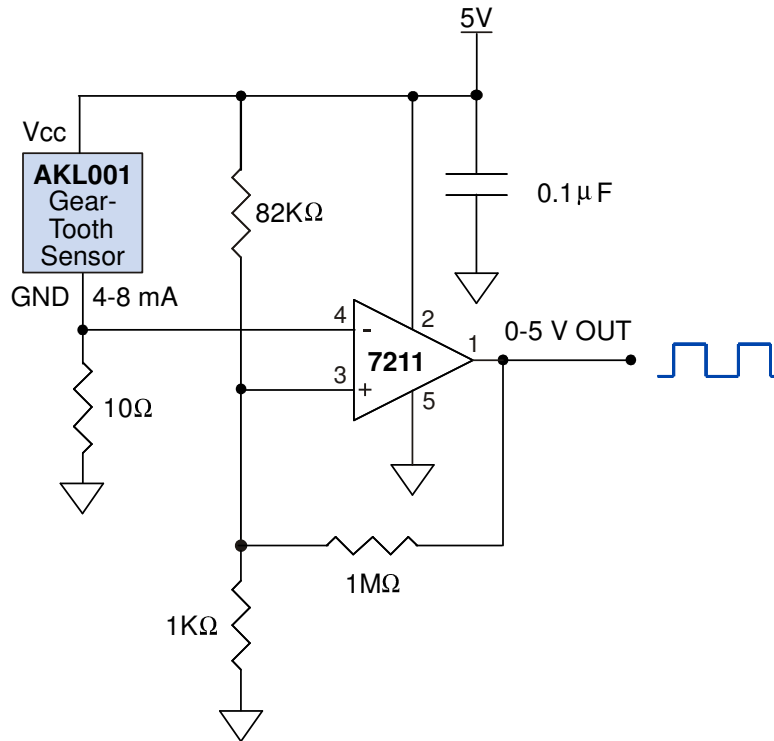
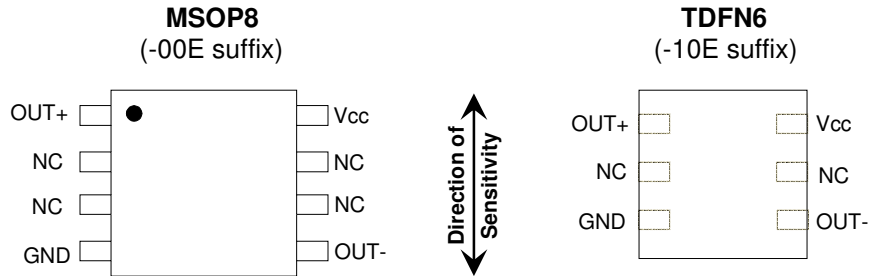


Figure 11. TTL output gear-tooth sensor.

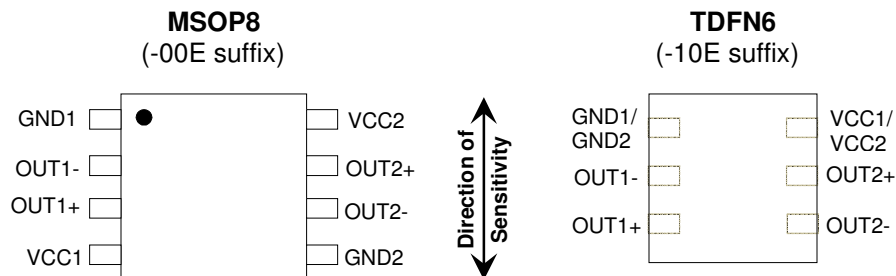
The 10Ω series resistor is small enough to ensure the sensor Vcc voltage is above its 4.5 V minimum with a 4.75 to 5.25 V supply. The 1 KΩ and 82 KΩ resistors set a comparator threshold between 4 and 8 mA, and the 1 MΩ resistor provides hysteresis to enhance noise immunity.

ABL00X-XXE (single bridge) pinouts



| Pin | | Symbol | Description |
|------------|-------|-----------------|----------------------------|
| MSOP8 | TDFN6 | | |
| 8 | 6 | V _{CC} | 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 |

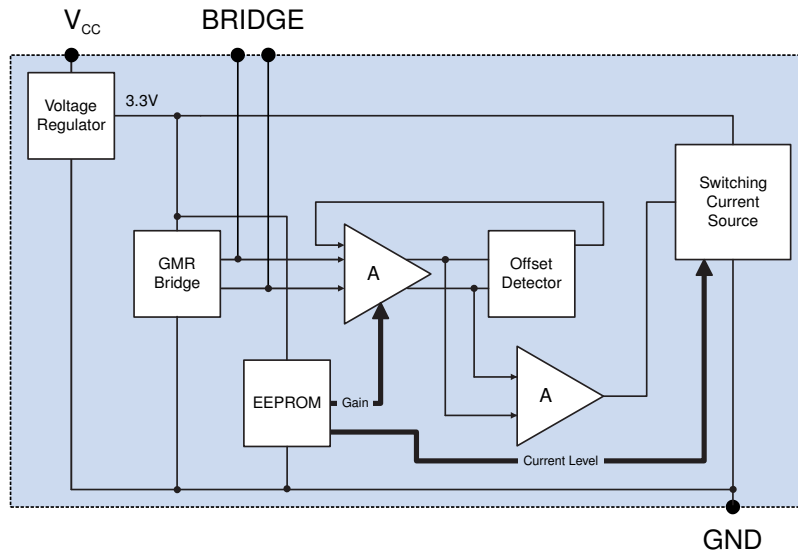
ABL01X-XXE (dual bridge) pinouts



| Pin | | Symbol | Description |
|-------|-------|------------------|------------------------------|
| MSOP8 | TDFN6 | | |
| 4 | 6 | V _{CC1} | Bridge 1 power supply |
| 8 | | V _{CC2} | 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 _{CC} | 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

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

Detecting tiny gear teeth with the ultraprecise ABL006:

youtu.be/brDLly1L6aE

ABL/AKL-Series GT Sensor oscilloscope demonstration:

youtu.be/7R3qPD51W2w

Handheld AKL002 demonstration:

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

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



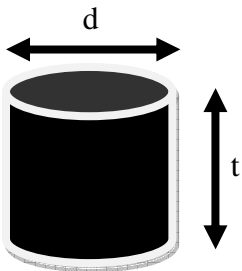
AG918-06 (standard) / **AG919-06** (cross-axis):
2" x 0.25" (50 mm x 6 mm) MSOP8



AG035-06:
1.57" x 0.25" (40 mm x 6 mm) TDFN6

Magnets

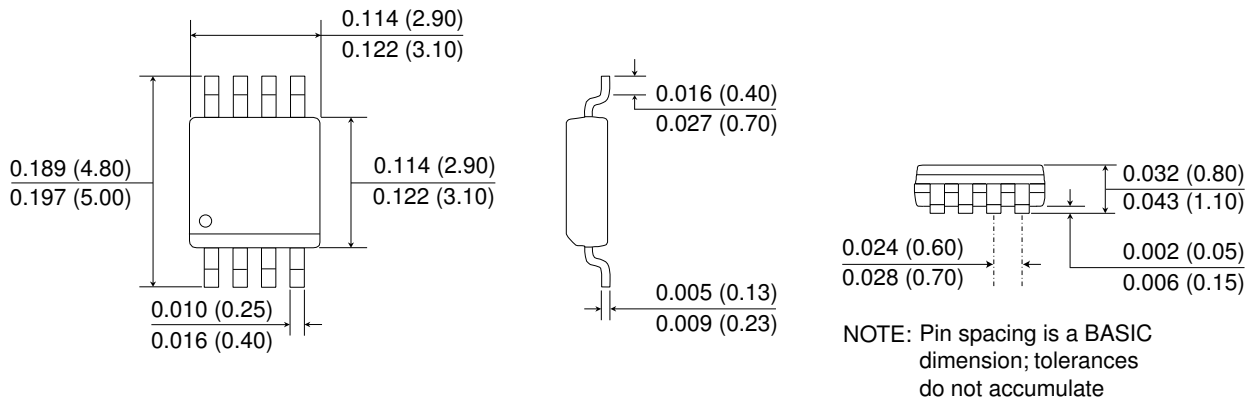
NVE offers three standard ferrite disk magnets for use with GT Sensors:



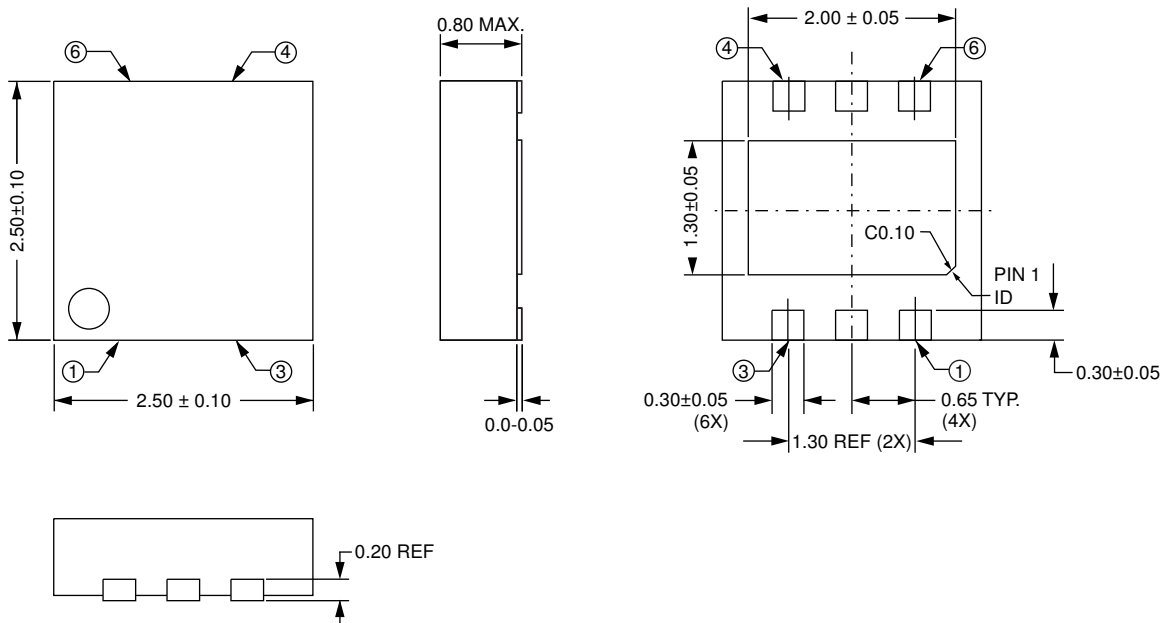
| NVE Part # | Material | Diameter (d) | Thickness (t) |
|------------|----------|--------------|---------------|
| 12031 | C5/Y25 | 8 mm | 3.2 mm |
| 12216 | C5/Y25 | 6 mm | 4 mm |
| 12217 | C5/Y25 | 3.5 mm | 4 mm |

Package Drawings

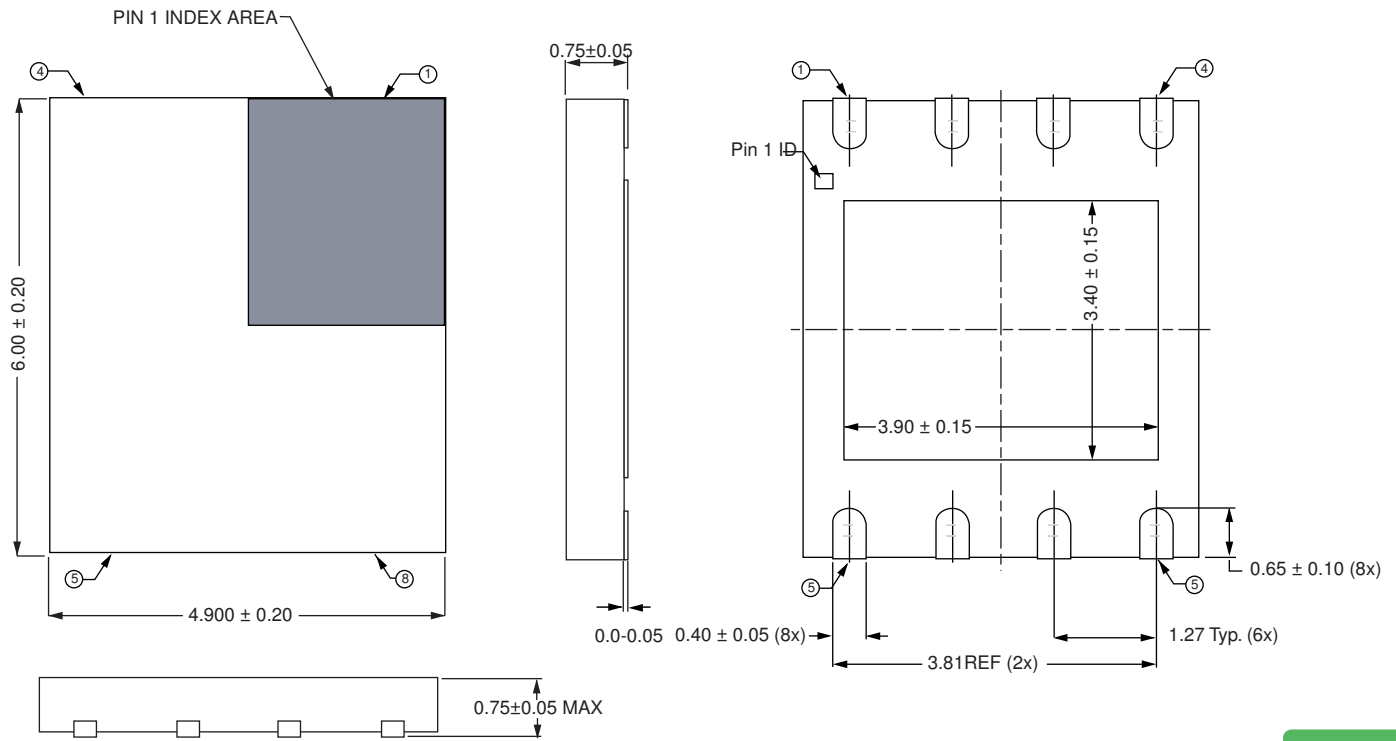
MSOP8 (-00E suffix)



TDFN6 (-10E suffix)



TDFN8 (-11E suffix)



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

Revision History

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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An ISO 9001 Certified Company

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September 2023

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