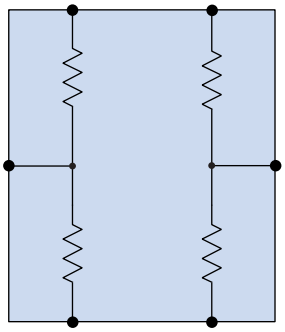
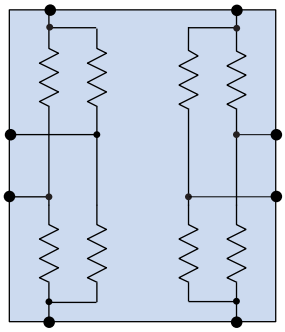
# ABL/AKL-Series Gear-Tooth Sensors

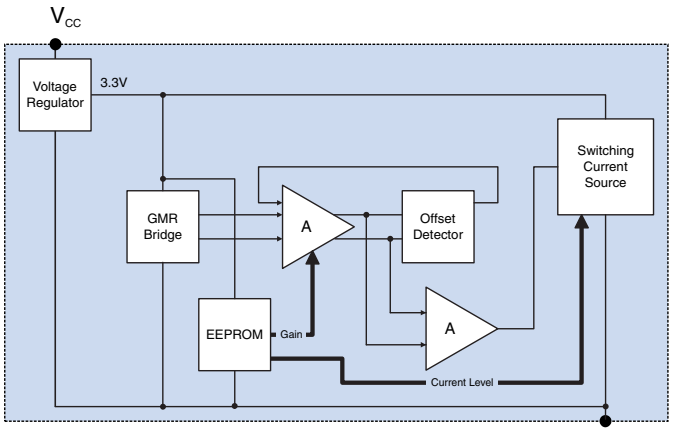
## Block Diagrams



ABL00x



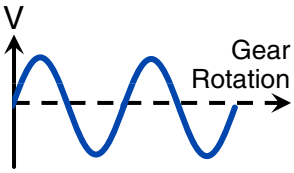
ABL01x



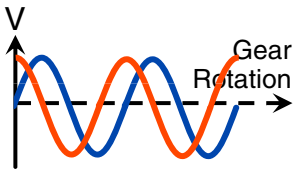

AKL00x

GND

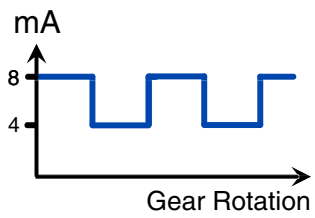
## Outputs




**ABL00x**
**Single-bridge analog sensor**




**ABL01x**
**Duak-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 0.6 mm, to 6 mm or more.

ABL-Series analog sensors have differential sensor elements that provide sinusoidal outputs. Single- or dual-bridge configurations are available. Dual-bridge versions provide sine and cosine outputs for direction information.

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.



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## 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 | Oe |

| 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 | Oe |

## 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 | kΩ | At 25°C |
| Offset voltage | $V_O$ | −4 | | +4 | mV/V | |
| Non-linearity | | | | 2 | % | Unipolar field sweep across near operating range |
| Hysteresis | | | | 2 | % | |
| Saturation of GMR sensor elements | | −180 | | +180 | Oe | |
| Single resistor sensitivity | ΔR/Oe | | 0.04 | | %/Oe | |
| 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 | $V_{CC}$ = 12V |
| On-state supply current | $I_{ON}$ | 7 | 8 | 9 | | |
| Output duty cycle | | 40 | 50 | 60 | % | |
| Airgap | | | | | | |
| AKL001-12 | | 1 | | 3.5 | mm | |
| AKL002-12 | | 1 | | 2.5 | | |
| AKL003-12 | | 1 | | 2 | | |
| Operating frequency | $f_{MAX}$ | DC | | 10 | kHz | |



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## Operation

***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:

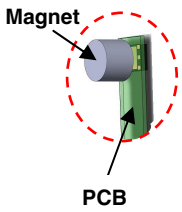


**Figure 1. Biasing magnet.**

- 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.
- Rare-earth magnets are not recommended because they tend to saturate 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 1).
- 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.
- If zero speed operation is required, zeroing the sensor output offset maximizes airgap (AKL-Series sensors have integrated zeroing).

***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 2:

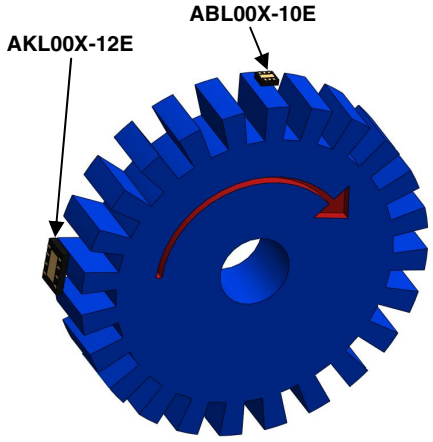


**Figure 2. Sensor orientation.**

***Recommended sensor element spacing vs. gear pitch***

Optimal sensor element spacing depends on a number of factors, including gear pitch, magnet, and sensor spacing. A rule of thumb is to select a sensor with an element spacing of approximately one-fourth the gear pitch. For example, for a gear pitch of 1 mm, the optimal element spacing would be 0.25 mm. Therefore a sensor with s 0.3 mm spacing, the closest available, would be selected.



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***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 out-of-phase with the first sensor.

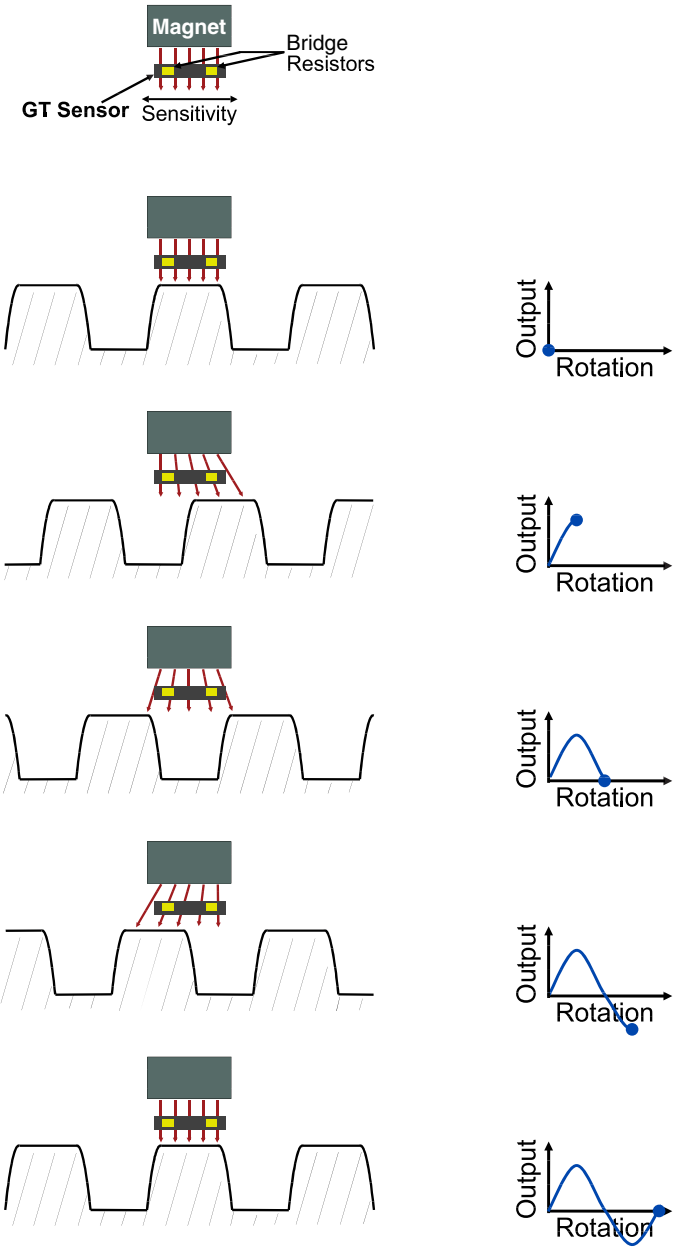


**Figure 3. ABL00x output vs. gear rotation.**



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***Typical outputs***

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

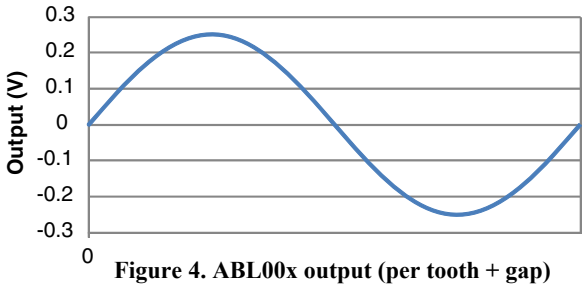


**Figure 4. ABL00x output (per tooth + gap)**

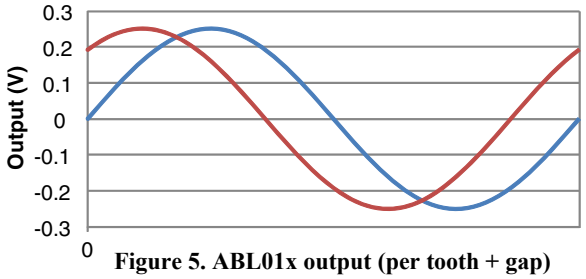


**Figure 5. ABL01x output (per tooth + gap)**

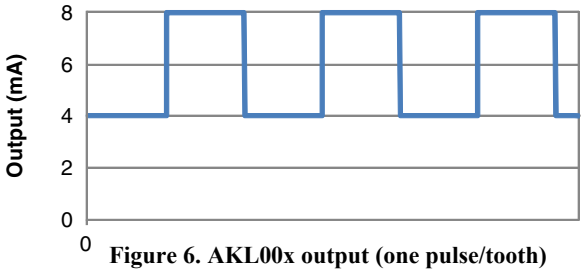


**Figure 6. AKL00x output (one pulse/tooth)**



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## 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:

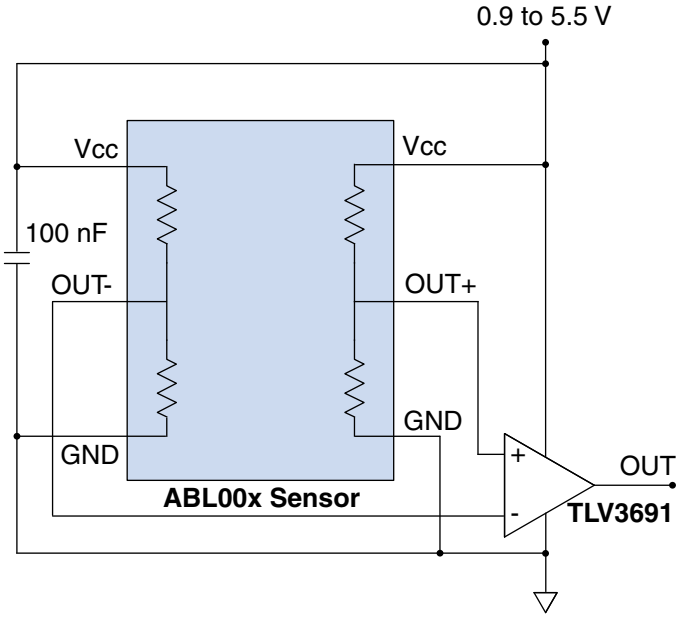


**Figure 7. Digital output from an analog sensor.**

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:

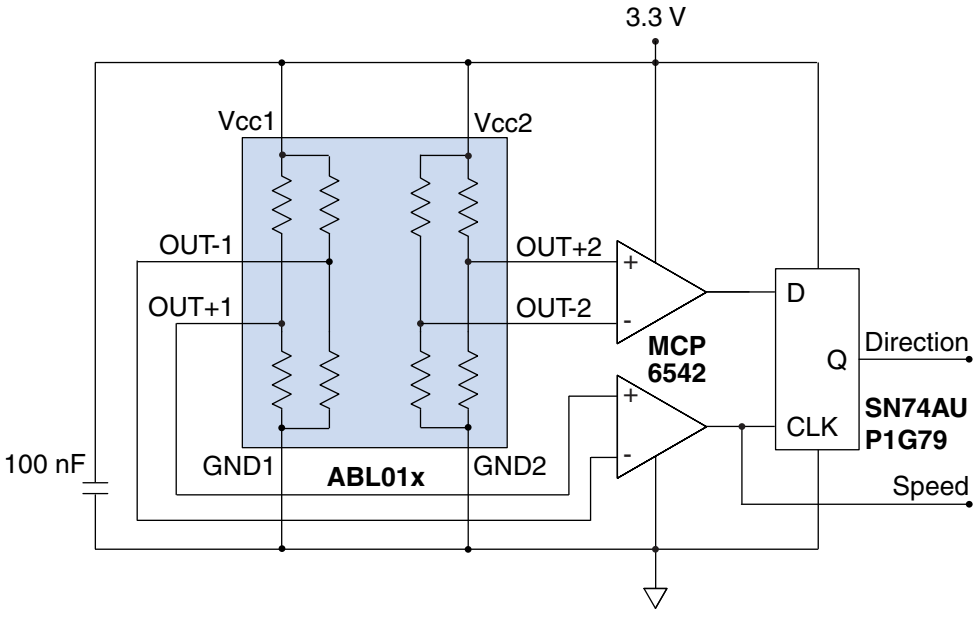


**Figure 8. Digital speed and direction signals for gear-tooth sensors.**



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***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.

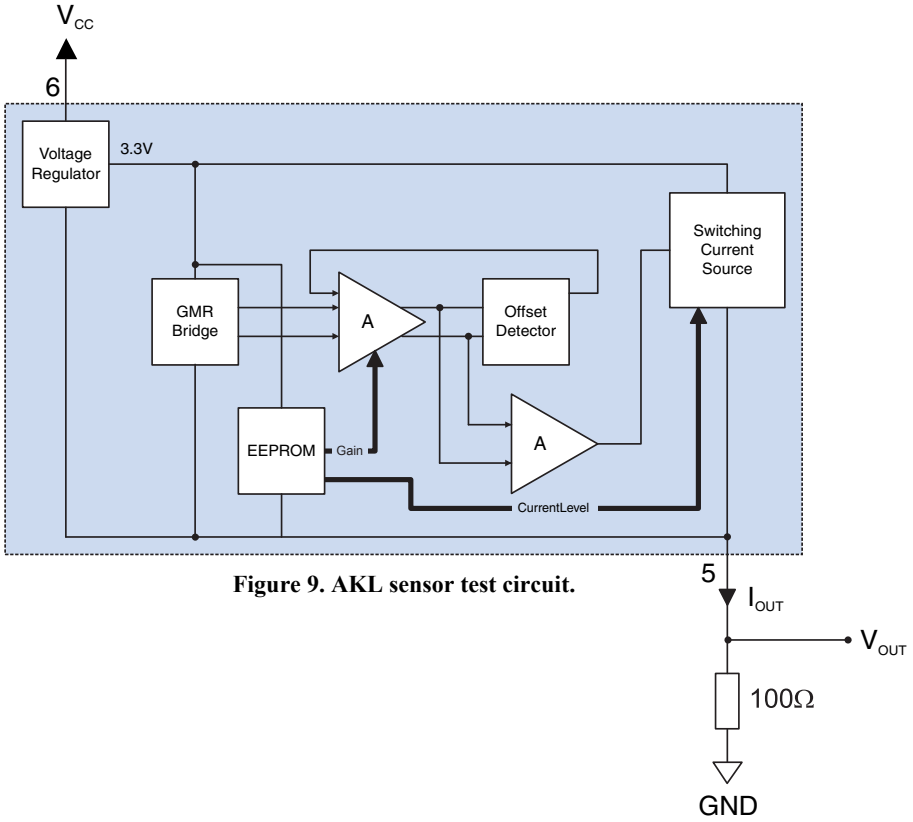


**Figure 9. AKL sensor test circuit.**

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

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

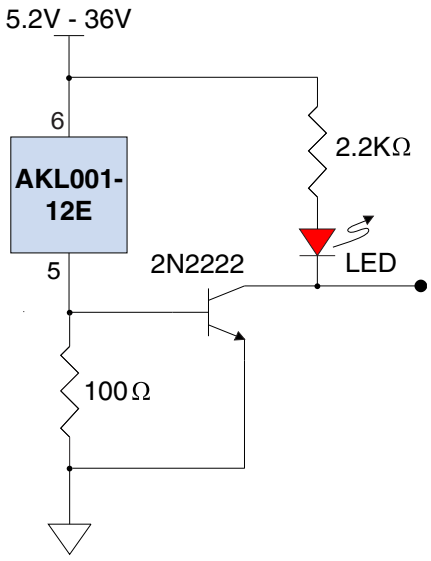


**Figure 10. Simple three-wire interface.**

When the current is 4 mA, the voltage across the 100Ω resistor is 0.4 V, 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.



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***TTL Output Gear-Tooth Sensor***

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

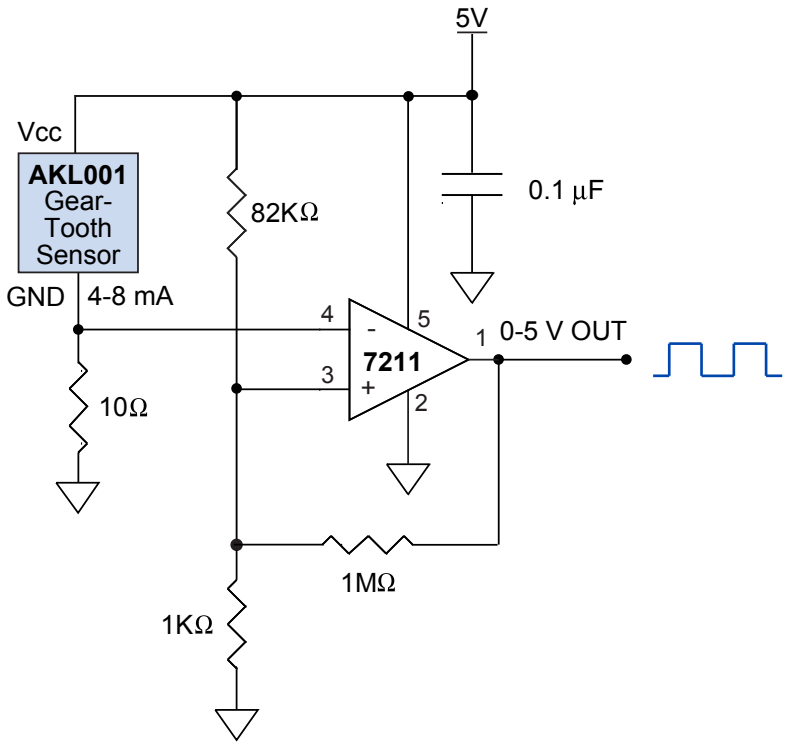


**Figure 11. TTL output gear-tooth sensor.**

The 10Ω series resistor is small enough to ensure the sensor Vcc voltage is above its 4.5 V minimum with a 4.75 − 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.



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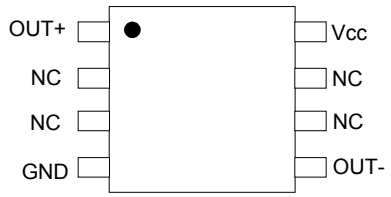
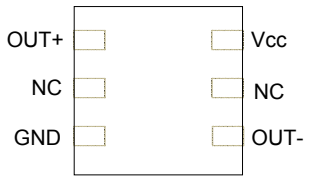
## ABL00X-XX (single bridge) pinouts

**MSOP8**
(-00 suffix)





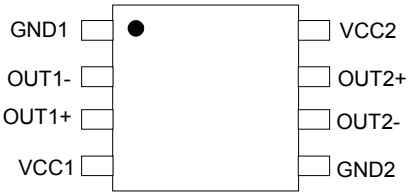
**TDFN6**
(-10 suffix)

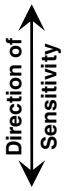



| Pin | | Symbol | Description |
|---|---|---|---|
| MSOP8 | TDFN6 | | |
| 8 | 6 | $V_{CC}$ | Power supply |
| 4 | 3 | GND | Ground |
| 1 | 1 | OUT+ | Bridge differential output |
| 5 | 4 | OUT- | |
| 2, 3, 6, 7 | 2, 5 | NC | No internal connection |

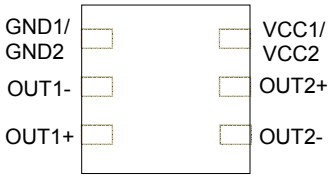
## ABL01X-XX (dual bridge) pinouts

**MSOP8**
(-00 suffix)




**TDFN6**
(-10 suffix)




| 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+ | |



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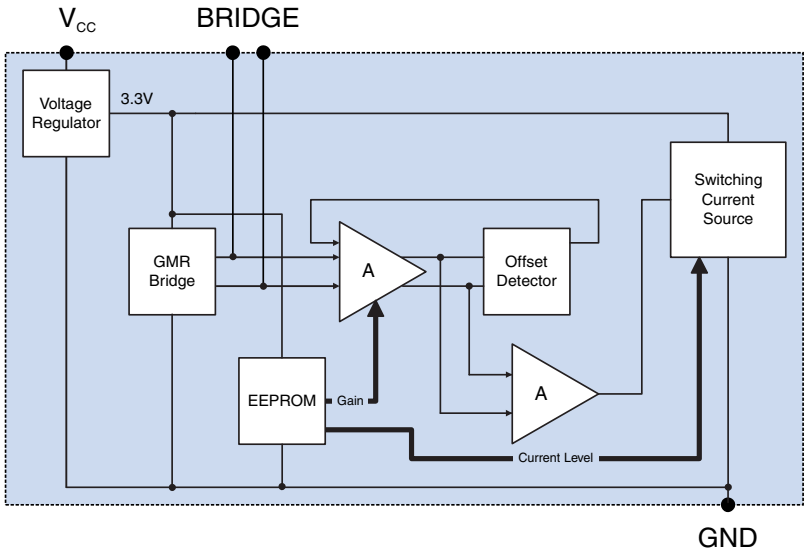
## AKL-Series Pinout




| 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** | **Package** | **Package Marking Code** |
| ABL004-00 | Single | 1 mm | NA | 2.5 − 6 mm | MSOP8 | FDB |
| ABL005-00 | Single | 0.5 mm | NA | 1.5 − 2.5 mm | MSOP8 | FDC |
| ABL006-00 | Single | 0.3 mm | NA | 0.6 − 1.5 mm | MSOP8 | FDL |
| ABL014-00 | Dual | 1 mm | 0.5 mm | 2.5 − 6 mm | MSOP8 | FDD |
| ABL015-00 | Dual | 0.5 mm | 0.25 mm | 1.5 − 2.5 mm | MSOP8 | FDF |
| ABL016-00 | Dual | 0.3 mm | 0.15 mm | 0.6 − 1.5 mm | MSOP8 | FDM |
| ABL004-10 | Single | 1 mm | NA | 2.5 − 6 mm | TDFN6 | FDG |
| ABL005-10 | Single | 0.5 mm | NA | 1.5 − 2.5 mm | TDFN6 | FDH |
| ABL006-10 | Single | 0.3 mm | NA | 0.6 − 1.5 mm | TDFN6 | FDN |
| ABL014-10 | Dual | 1 mm | 0.5 mm | 2.5 − 6 mm | TDFN6 | FDJ |
| ABL015-10 | Dual | 0.5 mm | 0.25 mm | 1.5 − 2.5 mm | TDFN6 | FDK |
| ABL016-10 | Dual | 0.3 mm | 0.15 mm | 0.6 − 1.5 mm | TDFN6 | FDP |

| AKL-Series Digital Gear-Tooth Sensors | | | |
|---|---|---|---|
| **Part No.** | **Element Spacing** | **Recommended Gear Pitch** | **Package** |
| AKL001-12 | 1 mm | 2.5 − 6 mm | TDFN8 |
| AKL002-12 | 0.5 mm | 1.5 − 2.5 mm | TDFN8 |
| AKL003-12 | 0.3 mm | 0.6 − 1.5 mm | TDFN8 |



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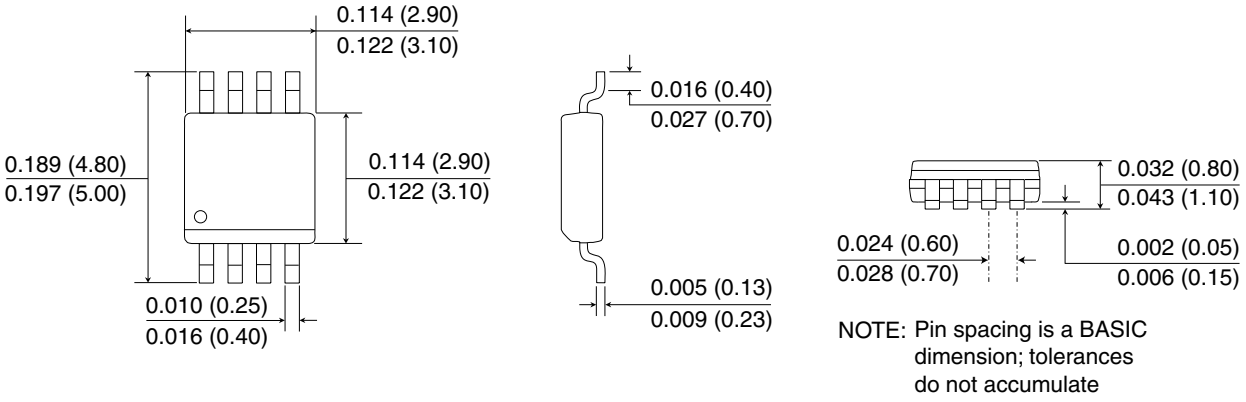
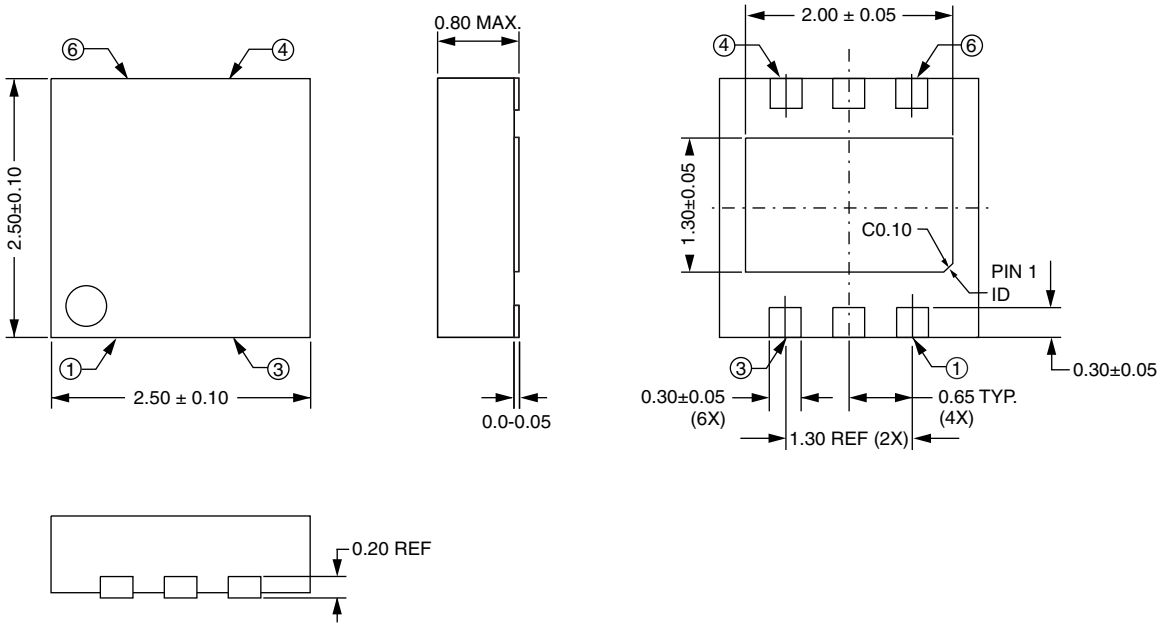
## Package Drawings

**MSOP8** (-00 suffix)



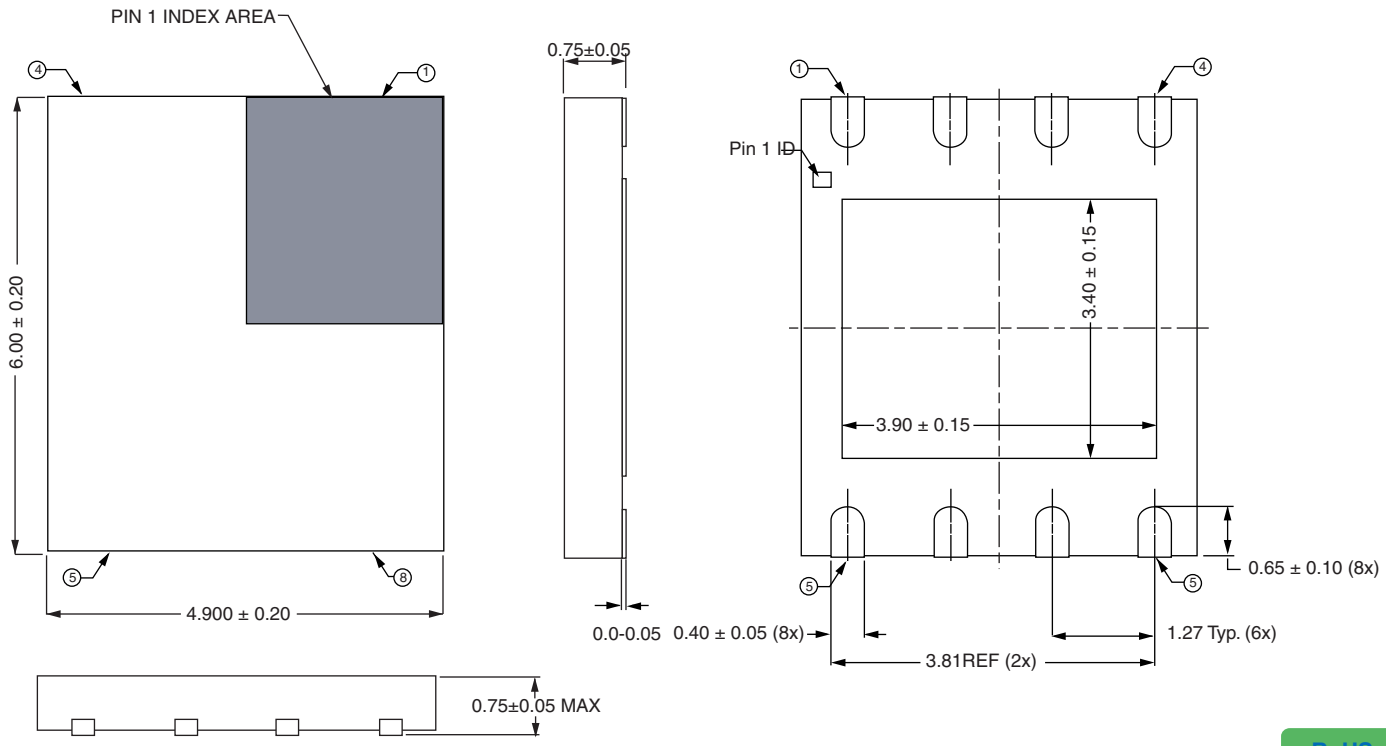

**TDFN6** (-10 suffix)





**TDFN8** (-11 suffix)




RoHS COMPLIANT

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



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## Revision History

| | |
|---|---|
| **SB-00-061-A**<br>March 2017 | **Change**<br>• Initial datasheet release superseding catalog. |



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