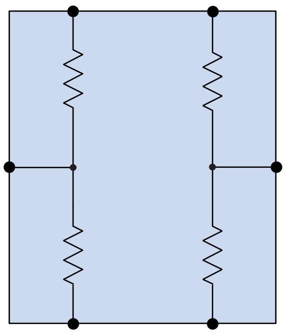
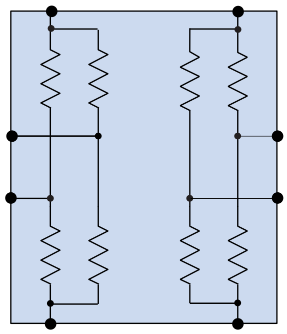
ABL/AKL-Series Gear-Tooth Sensors

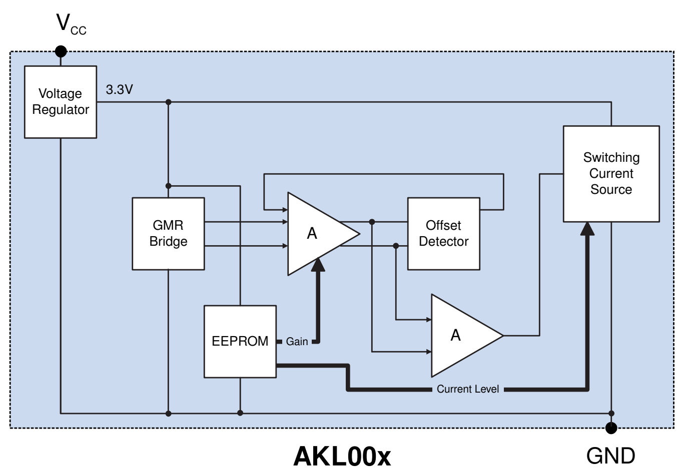
Block Diagrams



ABL00x

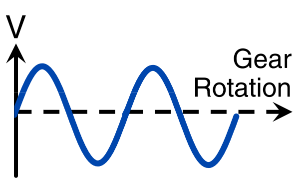


ABL01x

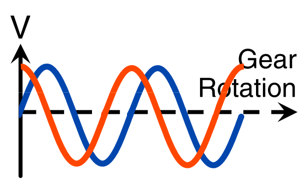


AKL00x

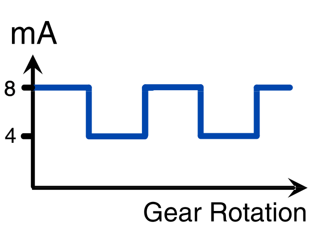
Outputs



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						
AKL001-12E		1		3.5	mm	
AKL002-12E		1		2.5		
AKL003-12E		1		2		
Operating frequency	f_{MAX}	DC		10	kHz	

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:

- 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).

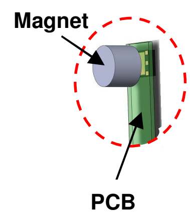

Figure 1. Biasing magnet.

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:

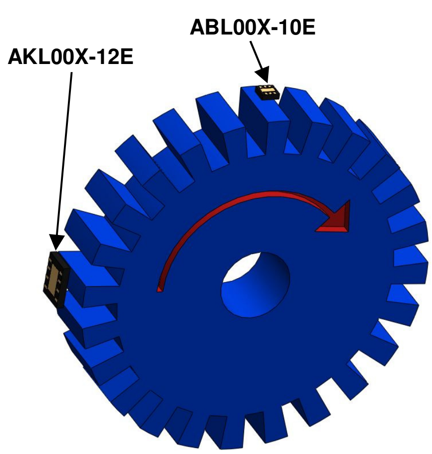

Figure 2. Sensor orientation.

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 <u>one-fourth</u> 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.

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.

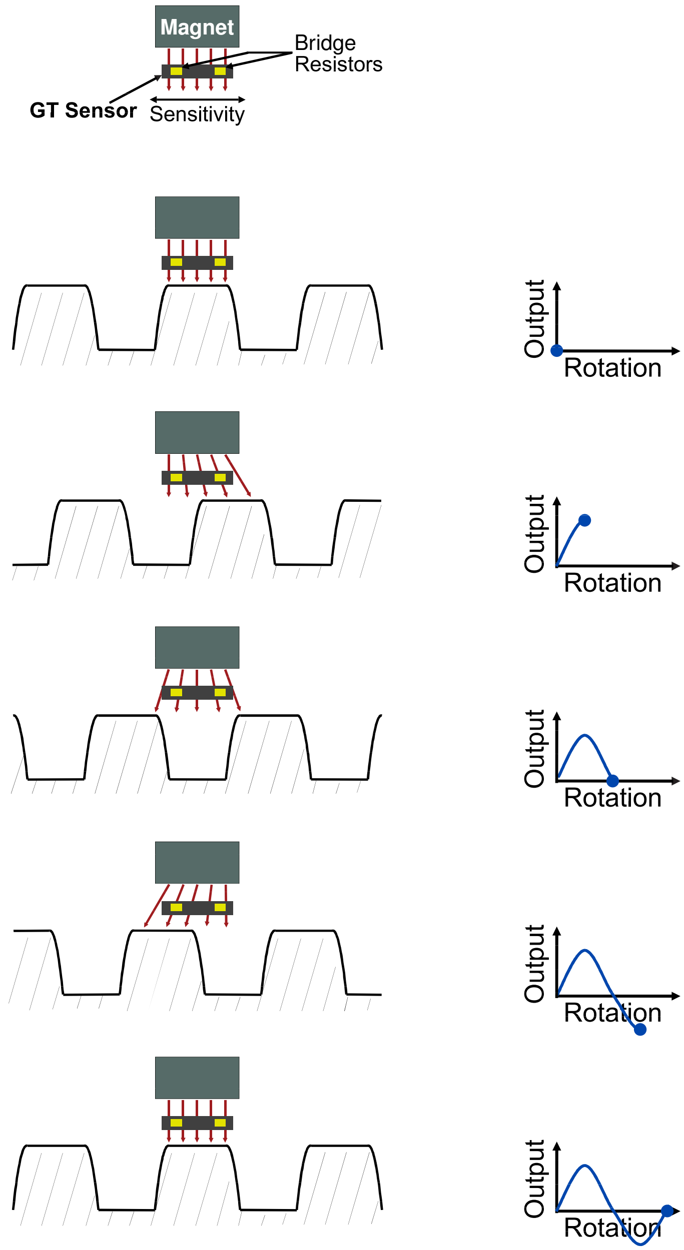

Figure 3. ABL00x output vs. gear rotation.

Typical outputs

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

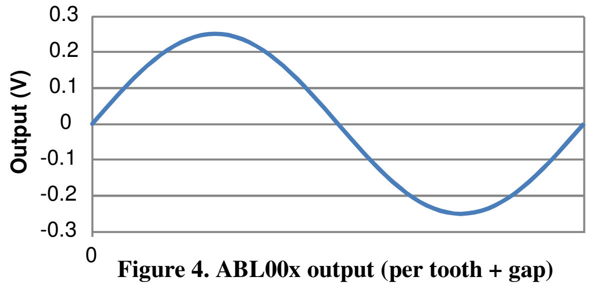

Figure 4. ABL00x output (per tooth + gap)

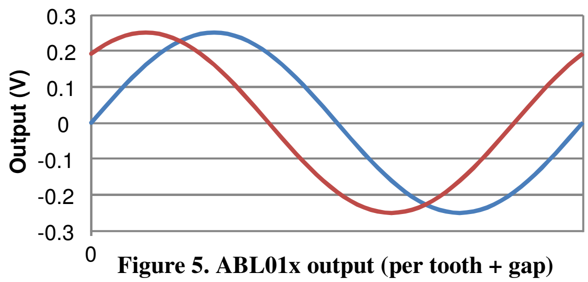

Figure 5. ABL01x output (per tooth + gap)

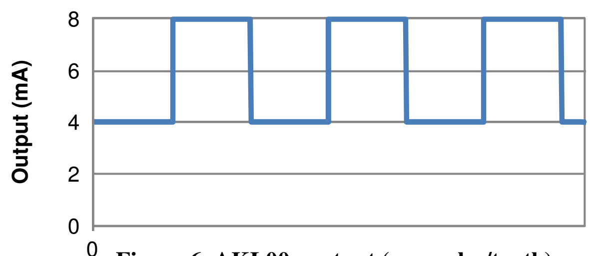

Figure 6. AKL00x output (one pulse/tooth)

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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:

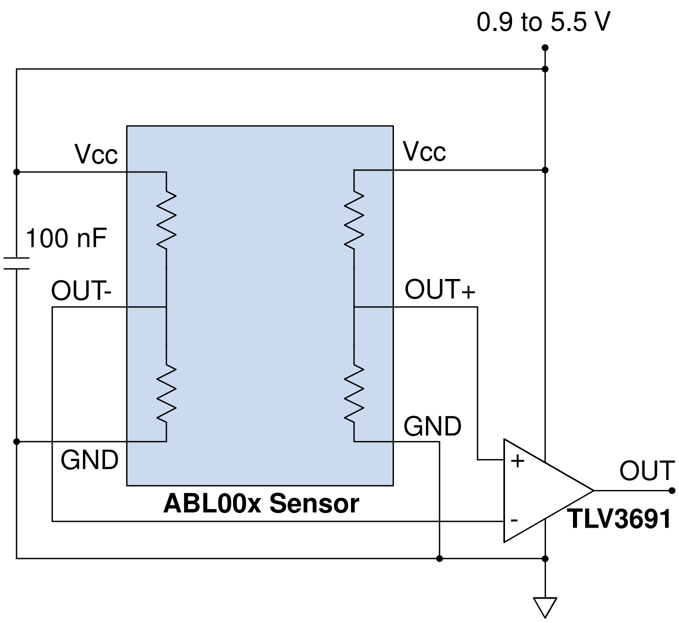

Figure 7. Digital output from an analog sensor.

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:

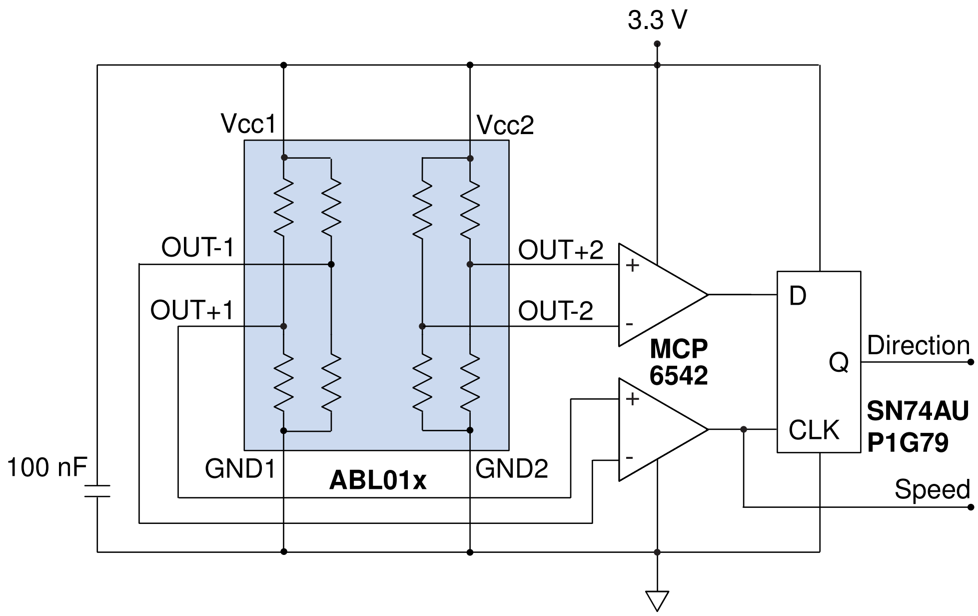

Figure 8. Digital speed and direction signals for gear-tooth sensors.

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.

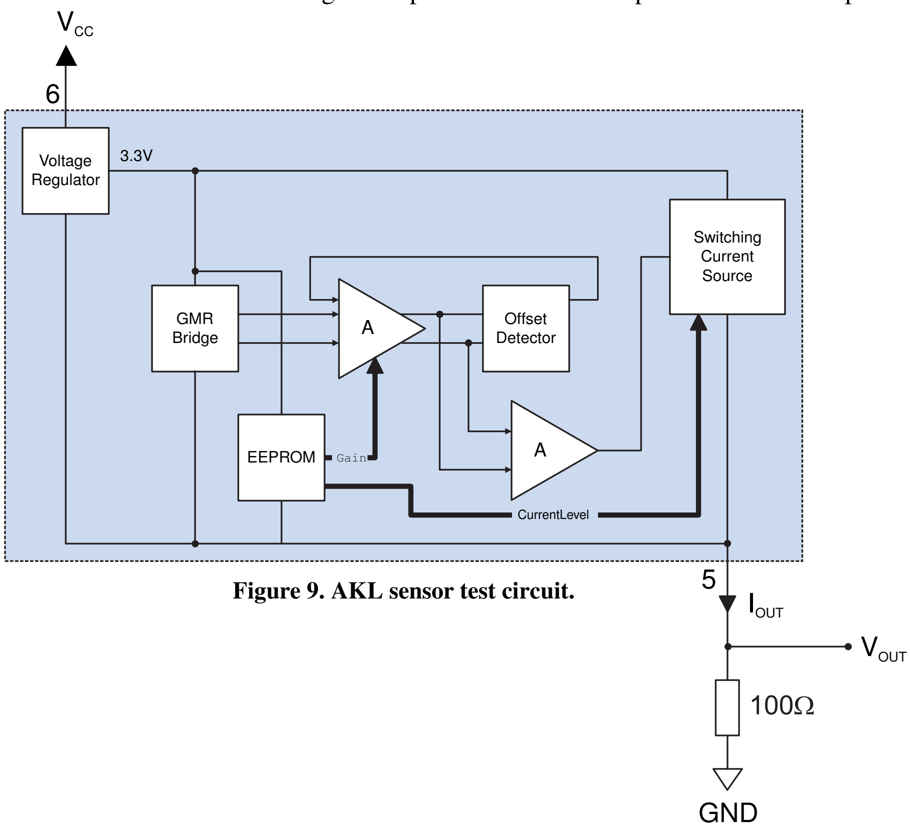

Figure 9. AKL sensor test circuit.

Three-Wire Digital Gear-Tooth Sensor

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

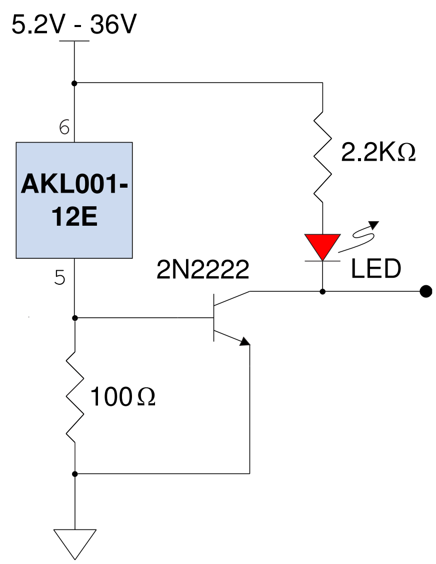

Figure 10. Simple three-wire interface.

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.

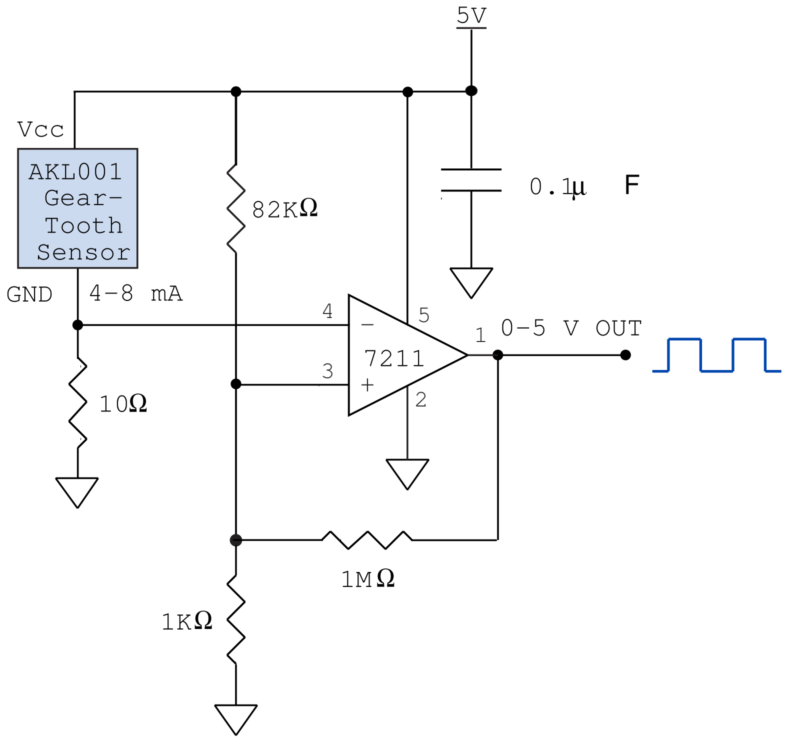
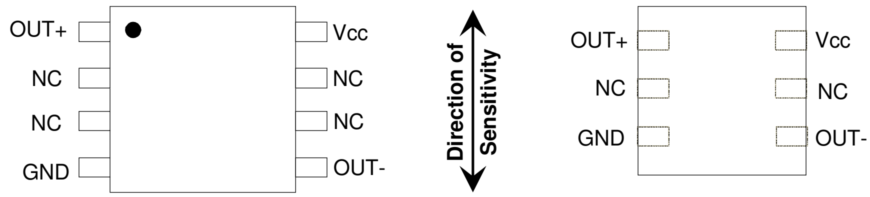


Figure 11. TTL output gear-tooth sensor.

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.

ABL00X-XXE (single bridge) pinouts

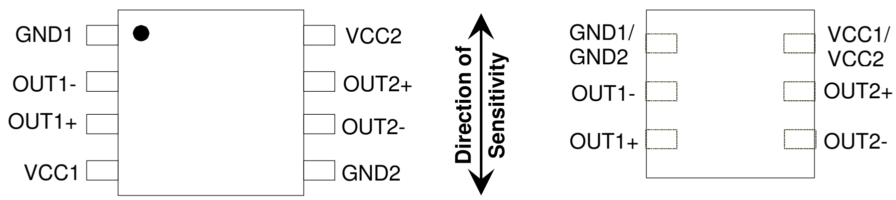
MSOP8 (-00E suffix) **TDFN6** (-10E suffix)



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-XXE (dual bridge) pinouts

MSOP8 (-00E suffix) **TDFN6** (-10E 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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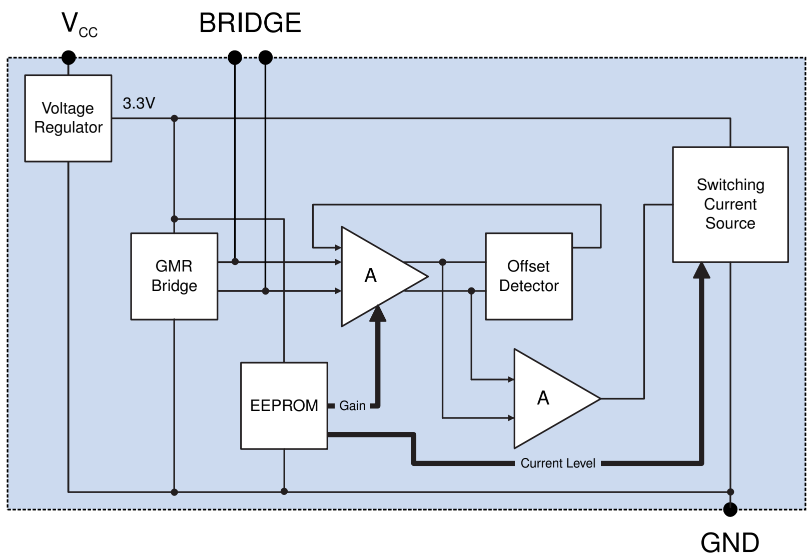
AKL-Series Pinout



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

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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
ABL004-00E	Single	1 mm	NA	2.5 – 6 mm	MSOP8	FDB
ABL005-00E	Single	0.5 mm	NA	1.5 – 2.5 mm	MSOP8	FDC
ABL006-00E	Single	0.3 mm	NA	0.6 – 1.5 mm	MSOP8	FDL
ABL014-00E	Dual	1 mm	0.5 mm	2.5 – 6 mm	MSOP8	FDD
ABL015-00E	Dual	0.5 mm	0.25 mm	1.5 – 2.5 mm	MSOP8	FDF
ABL016-00E	Dual	0.3 mm	0.15 mm	0.6 – 1.5 mm	MSOP8	FDM
ABL004-10E	Single	1 mm	NA	2.5 – 6 mm	TDFN6	FDG
ABL005-10E	Single	0.5 mm	NA	1.5 – 2.5 mm	TDFN6	FDH
ABL006-10E	Single	0.3 mm	NA	0.6 – 1.5 mm	TDFN6	FDN
ABL014-10E	Dual	1 mm	0.5 mm	2.5 – 6 mm	TDFN6	FDJ
ABL015-10E	Dual	0.5 mm	0.25 mm	1.5 – 2.5 mm	TDFN6	FDK
ABL016-10E	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
AKL001-12E	1 mm	2.5 – 6 mm	TDFN8
AKL002-12E	0.5 mm	1.5 – 2.5 mm	TDFN8
AKL003-12E	0.3 mm	0.6 – 1.5 mm	TDFN8

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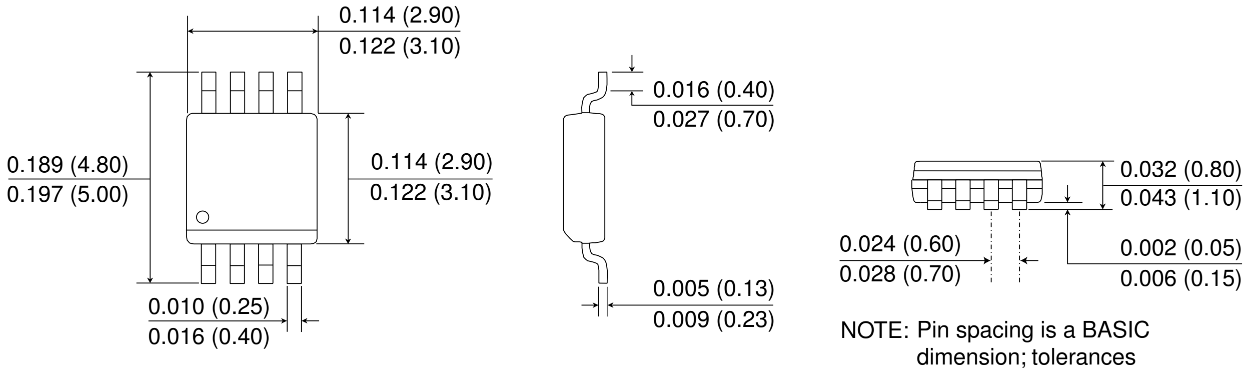
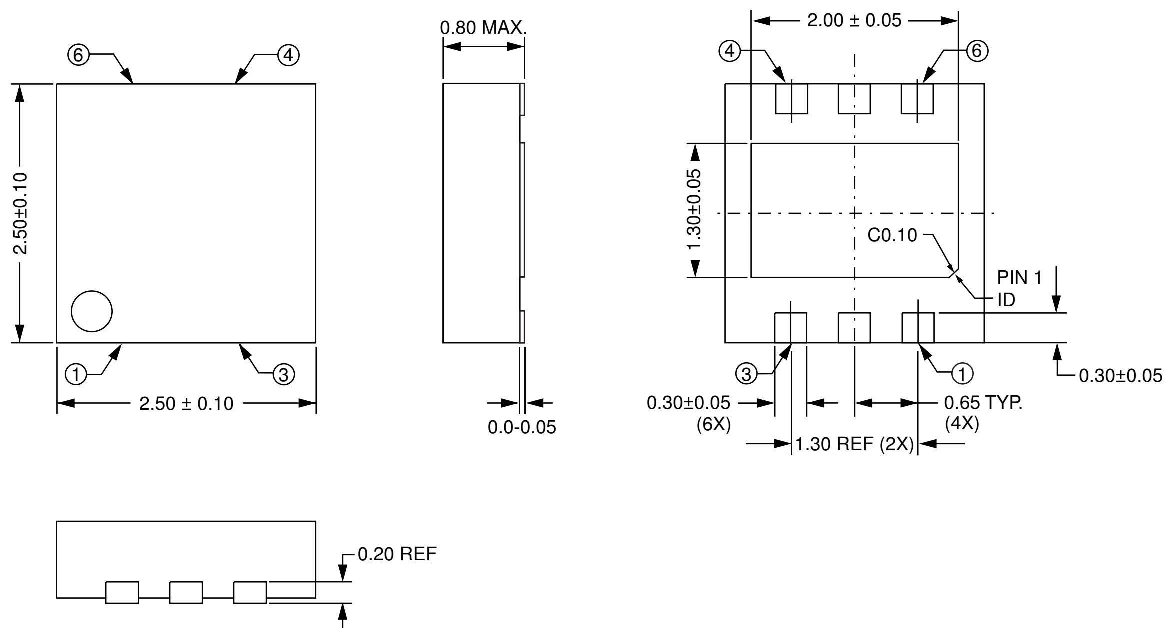
Package Drawings

MSOP8 (-00E suffix)



NOTE: Pin spacing is a BASIC dimension; tolerances do not accumulate

TDFN6 (-10E suffix)



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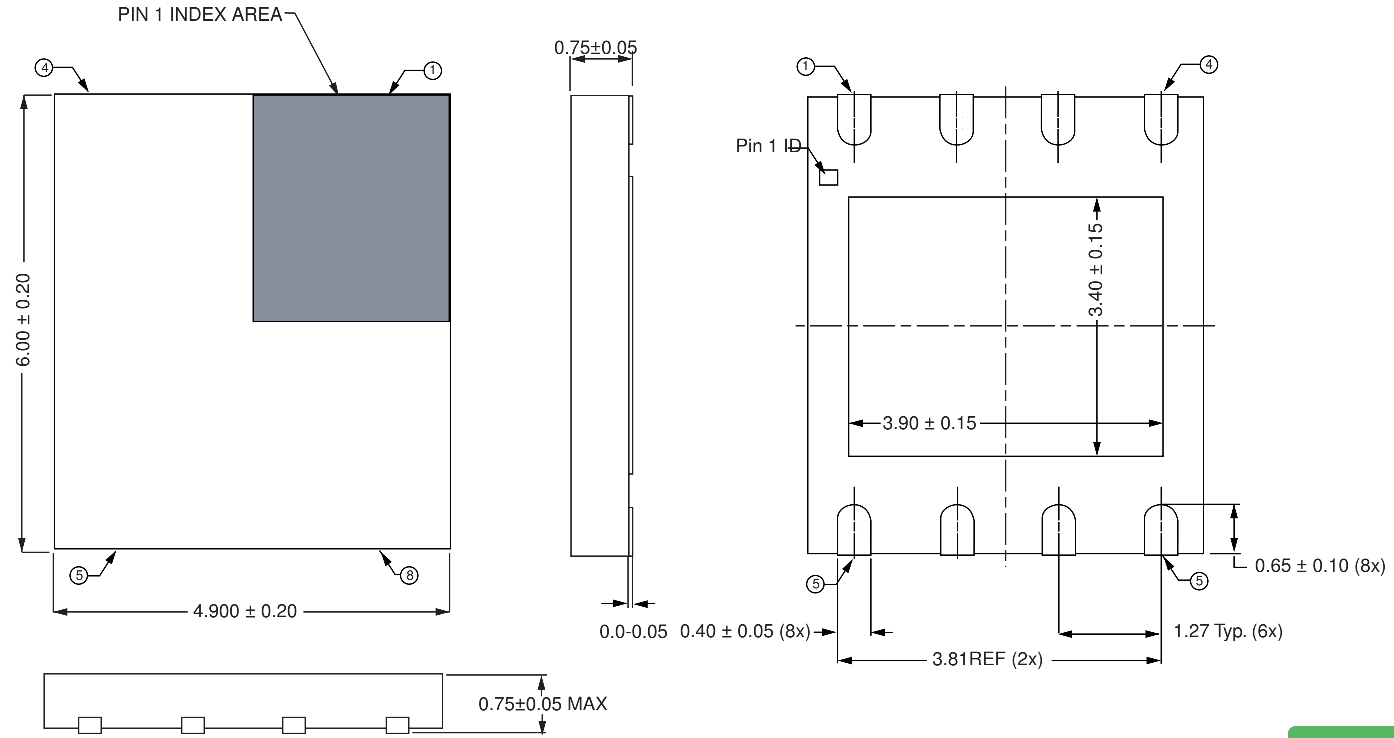
TDFN8 (-11E suffix)



RoHS COMPLIANT

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

Revision History

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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NVE Corporation
11409 Valley View Road
Eden Prairie, MN 55344-3617 USA
Telephone: (952) 829-9217
Fax: (952) 829-9189
www.nve.com
e-mail: sensor-info@nve.com

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