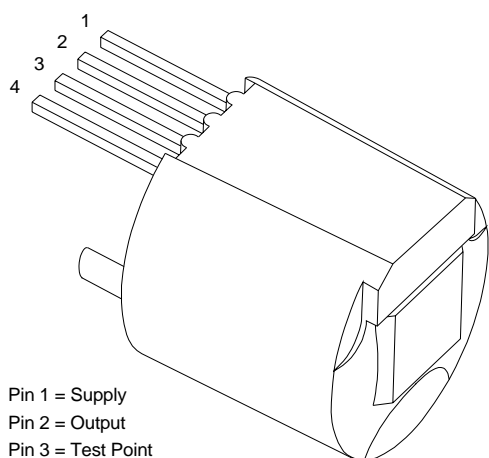


ATS632LSA

Data Sheet
27627-125

ZERO-SPEED, SELF-CALIBRATING, NON-ORIENTED, HALL-EFFECT GEAR-TOOTH SENSOR



Pin 1 = Supply
Pin 2 = Output
Pin 3 = Test Point
Pin 4 = Ground

Dwg. AH-006-2

PRELIMINARY INFORMATION
(subject to change without notice)
August 28, 2002

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{CC} **24 V***
Reverse Supply Voltage, V_{RCC} **-24 V**
Output OFF Voltage, V_{OUT} **25 V**
Output Current, I_{OUT} .. **Internally Limited**
Reverse Output Current, I_{OUT} **50 mA**
Package Power Dissipation,
 P_D **See Graph**
Operating Temperature Range,
 T_A **-40°C to +150°C**
Storage Temperature, T_S **+170°C**

* Operation at increased supply voltages with external circuitry is described in Applications Information.

The ATS632LSA gear-tooth sensor is an optimized Hall-effect IC/magnet combination that provides extremely accurate tooth edge detection when used with large-pitch targets. The sensor module consists of a high-temperature plastic shell that holds together a compound samarium-cobalt magnet and a single-element self-calibrating Hall-effect IC that has been optimized to the magnetic circuit. This small package, with its non-oriented operation, can be easily assembled on a PC board for complete protection and used in conjunction with a number of gear configurations.

The gear sensing technology used for this sensor is Hall-effect based. The sensor incorporates a single-element Hall IC that switches in response to absolute magnetic signals created by a ferrous target. The digital output is LOW over a tooth and HIGH over a valley. The sophisticated processing circuitry contains self-calibrating 6-bit A/D circuitry that adapts the thresholds to the peak-to-peak signals to minimize the effects of variation in application air gap on switch-point timing accuracy. The effects of system and device offsets are minimized by using active offset cancellation circuitry. The digital algorithm provides zero-speed detection capabilities without the associated running jitter inherent in classical digital solutions.

This sensor system is ideal for use in gathering speed, position and profile information of ferrous objects. They are particularly suited to large tooth/valley sensing applications where accurate timing accuracy is a desired feature. For applications requiring the sensing of fine-pitch gears, the ATS610LSA and ATS611LSB are recommended.

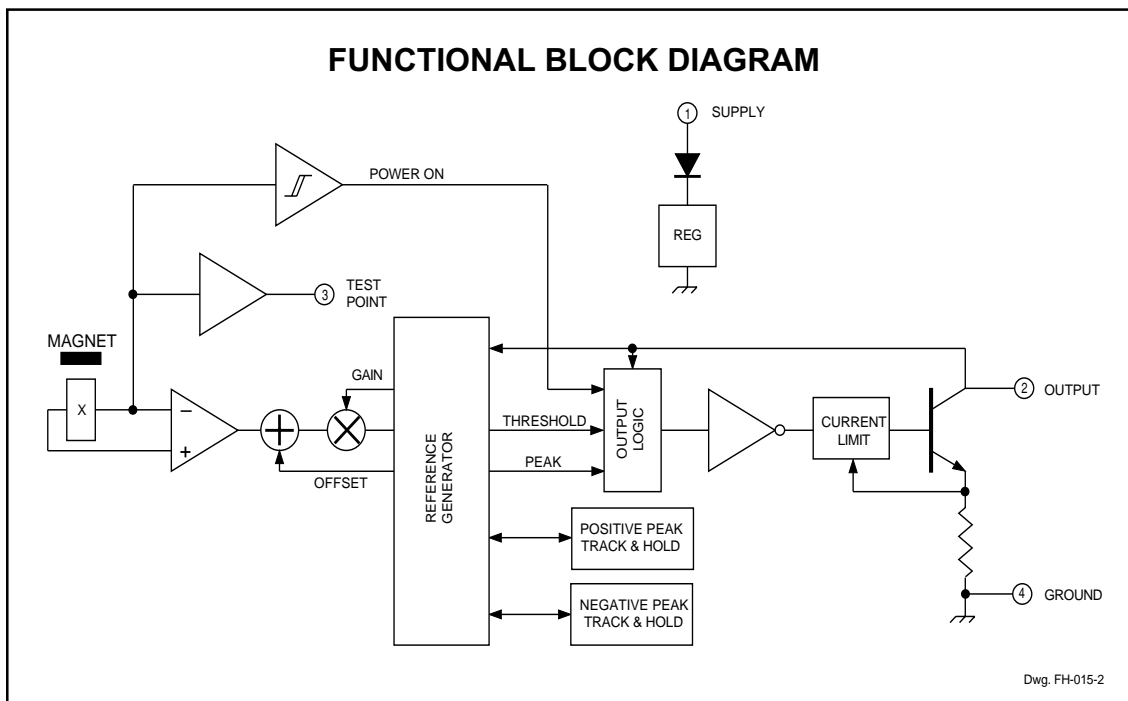
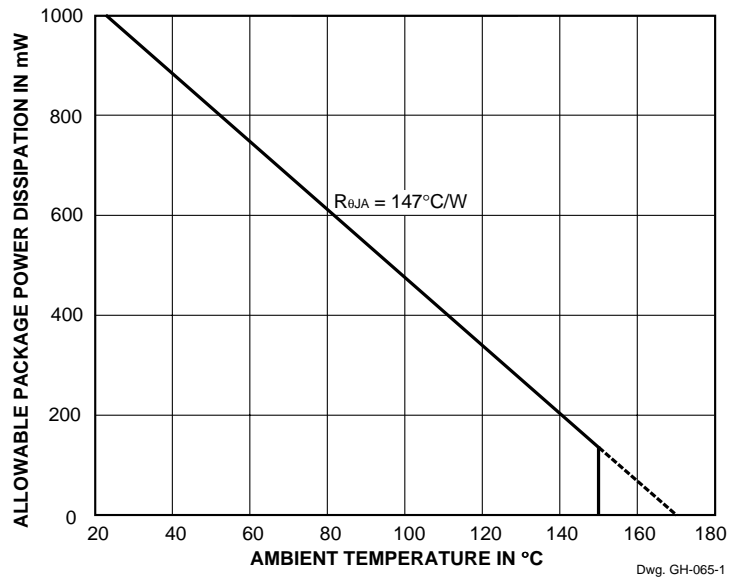
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Always order by complete part number, e.g., **ATS632LSA**.

ATS632LSA HALL-EFFECT GEAR-TOOTH SENSOR

FEATURES AND BENEFITS

- Non-Oriented Installation
- Fully Optimized Gear-Tooth Sensors
- Zero-Speed Digital Output Representing Target Profile
- Large Operating Air Gaps
- Extremely Low Timing Accuracy Drift with Temperature
- Correct First-Edge Detection
- Self-Calibrating Circuitry with Integrated Offset Cancellation
- 6-bit A/D Converters to Capture Peaks
- Thresholds Proportional to Peak-to-Peak Signals
- Optimized Magnetic Circuit
- Single-Chip Sensing IC for High Reliability



ATS632LSA
HALL-EFFECT
GEAR-TOOTH SENSOR

ELECTRICAL CHARACTERISTICS over operating voltage and temperature range (unless otherwise specified).

| Characteristic | Symbol | Test Conditions | Limits | | | |
|------------------------|--------------|---|--------|------|------|---------------|
| | | | Min. | Typ. | Max. | Units |
| Supply Voltage | V_{CC} | Operating, $T_J < 165^{\circ}\text{C}$ | 4.5 | – | 24 | V |
| Under-Voltage Lockout | $V_{CC(UV)}$ | $I_{OUT} = 20\text{ mA}$, $V_{CC} = 0 \rightarrow 5\text{ V}$ | – | 4.0 | – | V |
| Low Output Voltage | $V_{OUT(L)}$ | $I_{OUT} = 20\text{ mA}$, Output ON | – | 0.2 | 0.4 | V |
| Output Current Limit | I_{OUTM} | $V_{OUT} = 12\text{ V}$ | 25 | 45 | 55 | mA |
| Output Leakage Current | I_{OFF} | $V_{OUT} = 24\text{ V}$, Output OFF | – | 0.2 | 5.0 | μA |
| Supply Current | I_{CC} | Output OFF, Target Speed = 0 RPM | – | 9.0 | 15 | mA |
| Calibration Count | n_{cal} | Output falling mechanical edges after power on for startup calibration to be complete | 16 | 16 | 16 | Pulses |
| Calibration Update | n_{up} | Output falling mechanical edges for the threshold calibration to be complete | 64 | 64 | 64 | Pulses |
| Power-On Time | t_{po} | $V_{CC} > 4.5\text{ V}$ | – | 80 | 500 | μs |
| Output Rise Time | t_r | $R_L = 500\ \Omega$, $C_L = 10\text{ pF}$ | – | 0.2 | 5.0 | μs |
| Output Fall Time | t_f | $R_L = 500\ \Omega$, $C_L = 10\text{ pF}$ | – | 0.2 | 5.0 | μs |

NOTE: Typical data is at $V_{CC} = 12\text{ V}$ and $T_A = +25^{\circ}\text{C}$ and is for design information only.

ATS632LSA HALL-EFFECT GEAR-TOOTH SENSOR

OPERATION over operating voltage and temperature range with reference target (unless otherwise specified).

| Characteristic | Symbol | Test Conditions | Limits | | | |
|-------------------------|--------------|---|--------|------------|------------|-------|
| | | | Min. | Typ. | Max. | Units |
| Operating Air Gap Range | AG | Operating, Target Speed > 20 RPM | 0.3 | – | 2.5 | mm |
| Output Polarity | – | Operating, Over Tooth | Low | Low | Low | – |
| | | Operating, Over Valley | High | High | High | – |
| Timing Accuracy | t_{θ} | Target Speed < 3500 RPM, $0.3 \text{ mm} \leq \text{AG} \leq 2.0 \text{ mm}$ | – | ± 0.25 | ± 0.50 | ° |

TARGET DESIGN CRITERIA

| Characteristic | Symbol | Description | Limits | | | |
|----------------|-------------|----------------------------|--------|------|------------|-------|
| | | | Min. | Typ. | Max. | Units |
| Valley Depth | h_t | | – | 5.0 | – | mm |
| Valley Width | $(P_C - T)$ | | – | 5.0 | – | mm |
| Tooth Width | T | | – | 5.0 | – | mm |
| Thickness | F | | – | 5.0 | – | mm |
| Eccentricity | – | Timing accuracy may change | – | – | ± 0.25 | mm |

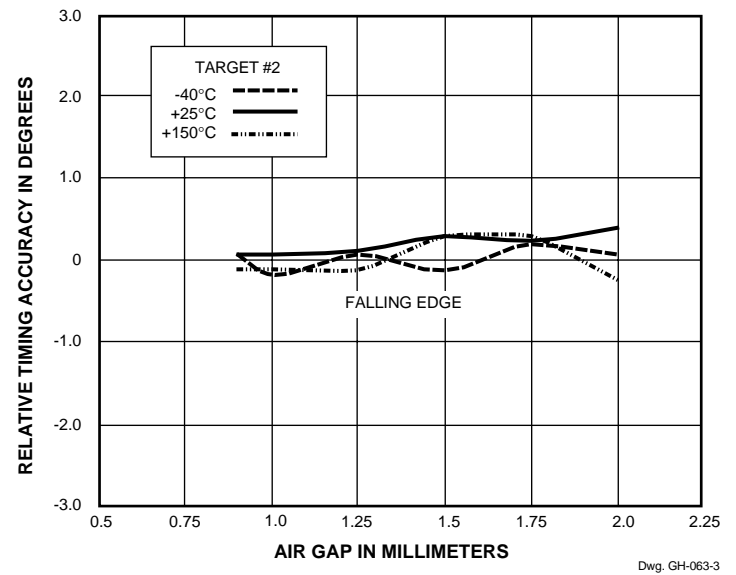
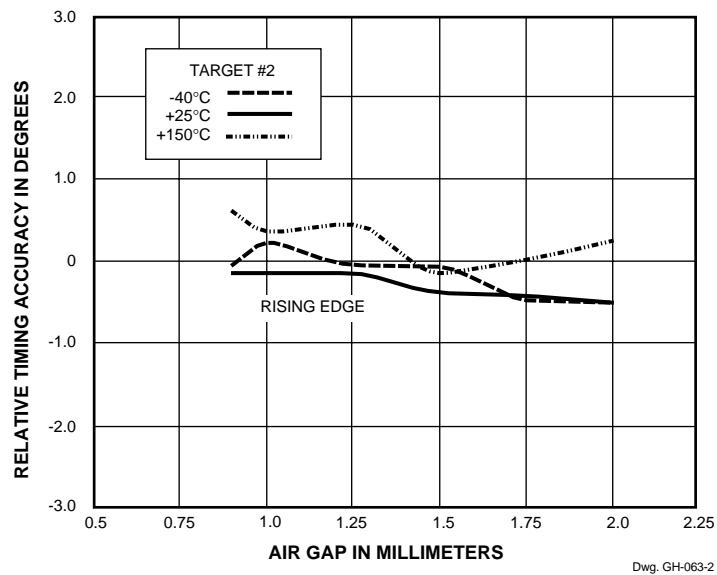
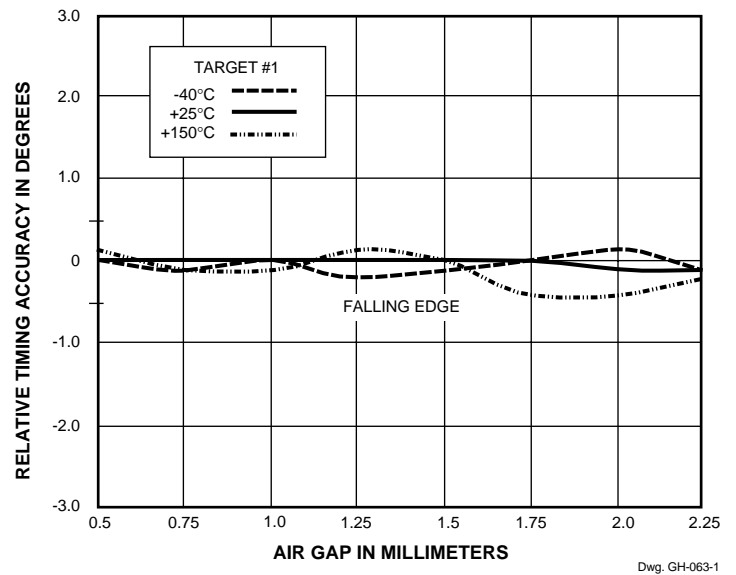
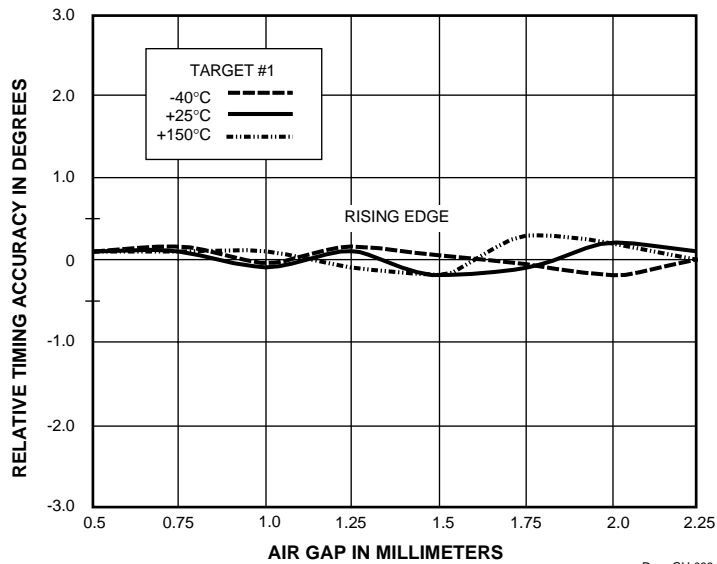
TARGET DIMENSIONS

| Type | Diameter (D_o) | Thickness (F) | Tooth Width (T) | Valley Width ($P_C - T$) | Valley Depth (h_t) |
|----------------------------|-----------------------|------------------|--------------------|-------------------------------|---------------------------|
| Reference Target | 84 mm | 16 mm | 9 mm | 13 mm | 5 mm |
| Characterization Target #1 | 84 mm | 16 mm | 1 tooth, 180° | | 5 mm |
| Characterization Target #2 | 35 mm | 7 mm | 1 tooth, 180° | | 6 mm |

NOTE: Timing accuracy data is taken by recalibrating the unit at each air gap.

ATS632LSA HALL-EFFECT GEAR-TOOTH SENSOR

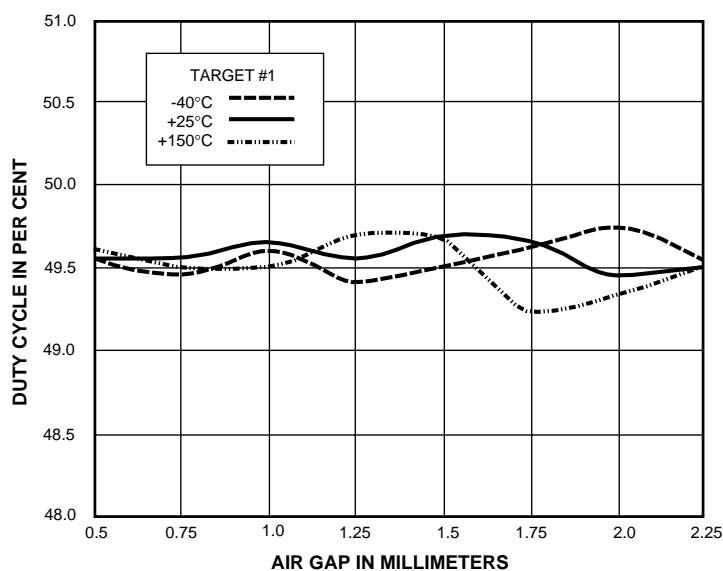
TYPICAL OPERATING CHARACTERISTICS



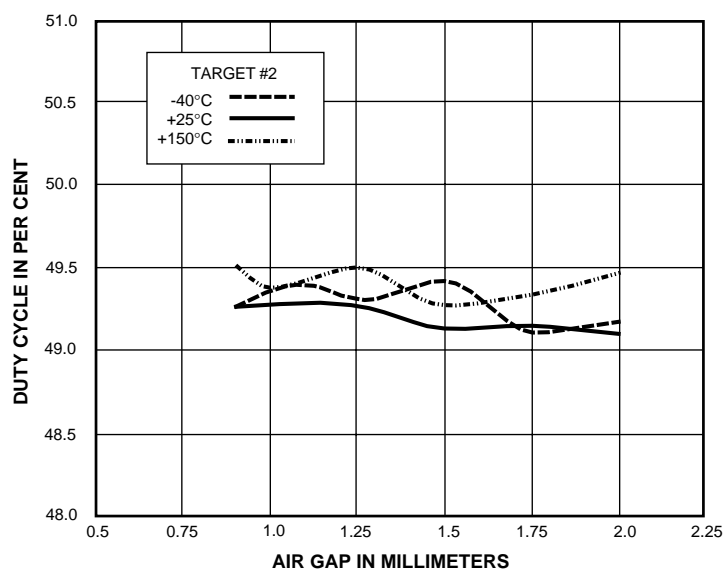
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ATS632LSA HALL-EFFECT GEAR-TOOTH SENSOR

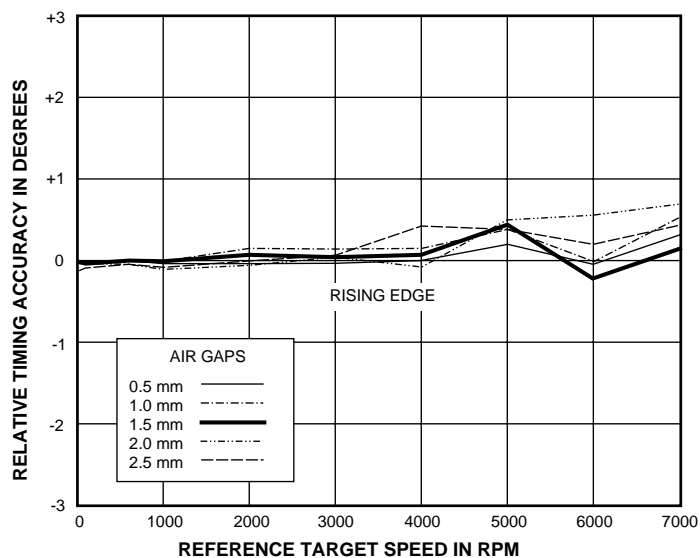
TYPICAL OPERATING CHARACTERISTICS — Continued



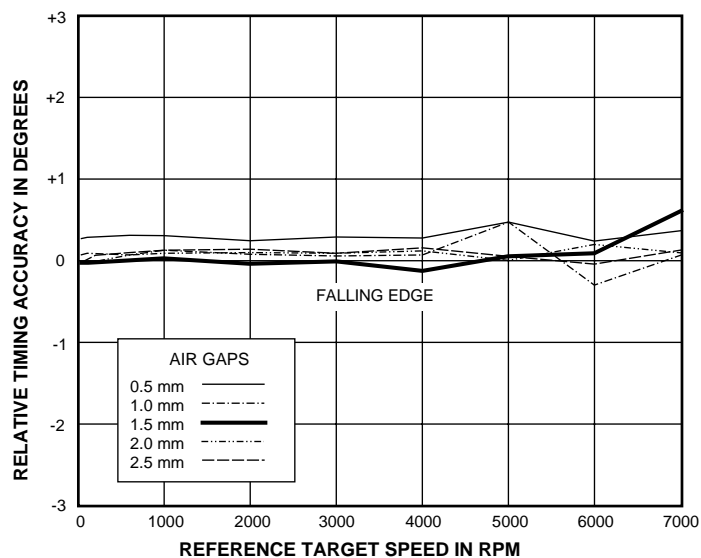
Dwg. GH-008-3



Dwg. GH-008-4



Dwg. GH-064-1



Dwg. GH-064-2

ATS632LSA HALL-EFFECT GEAR-TOOTH SENSOR

CRITERIA FOR DEVICE QUALIFICATION

All Allegro sensors are subjected to stringent qualification requirements prior to being released to production. To become qualified, except for the destructive ESD tests, no failures are permitted.

| Qualification Test | Test Method and Test Conditions | Test Length | Samples Per Lot | Comments |
|--------------------------------------|---|------------------|-----------------|---|
| Temperature Humidity Bias Life | JESD22-A101, $T_A = 85^{\circ}\text{C}$, RH = 85% | 1000 hrs | 48 | Device biased for minimum power |
| Bias Life | JESD22-A108, $T_A = 150^{\circ}\text{C}$, $T_J = 165^{\circ}\text{C}$ | 1000 hrs | 48 | |
| (Surge Operating Life) | JESD22-A108, $T_A = 175^{\circ}\text{C}$, $T_J = 190^{\circ}\text{C}$ | 168 hrs | 48 | |
| Autoclave, Unbiased | JESD22-A102, $T_A = 121^{\circ}\text{C}$, 15 psig | 96 hrs | 48 | |
| High-Temperature (Bake) Storage Life | JESD22-A103, $T_A = 170^{\circ}\text{C}$ | 1000 hrs | 48 | |
| Temperature Cycle | JESD22-A104 | 1000 cycles | 48 | -55°C to $+150^{\circ}\text{C}$ |
| ESD, Human Body Model | CDF-AEC-Q100-002 | Pre/Post Reading | 3 per test | Test to failure Pin 3 > 1.5 kV All leads > 8 kV |

APPLICATIONS INFORMATION

Recommended Evaluation Technique. The self-calibrating feature of the ATS632LSA requires that a special evaluation technique be used to measure its high-accuracy performance capabilities. Installation inaccuracies are calibrated out at power on; hence, it is extremely important that the device be re-powered at each air gap when gathering timing accuracy data.

Self-Calibrating Functions. These sensors are designed to minimize performance variation caused by the large air gap variations resulting from installation by self-calibrating at power-on. They are also designed to minimize performance variation caused by the smaller, slower air gap changes resulting from temperature change and gear run-out during continuous operation by

updating the self-calibration periodically (after every 64 output pulses) if necessary. These two functions should be tested using the following procedure.

1. Set the air gap to the desired value.
2. Power down and then power on the device.
3. Rotate the target at the desired speed.
4. Wait for calibration to complete (16 output pulses to occur).
5. Monitor output for correct switching and measure accuracy.
6. Repeat the above for multiple air gaps within the operating range of the device.
7. This can be repeated over the entire temperature range.

ATS632LSA HALL-EFFECT GEAR-TOOTH SENSOR

APPLICATIONS INFORMATION — Continued

Measurement of the effect of changing air gap after power on:

1. Set the air gap to the desired value (nominal, for example). Rotate the target at the desired speed. Apply power to the module. Wait for 16 output pulses to occur. Monitor output for correct switching and measure accuracy.
2. Change the air gap by ± 0.25 mm. Do not re-power module. Wait for 64 output pulses to occur. Monitor the output for correct switching and measure accuracy.

Device Switch Points. The device switch points are referenced to the peak-to-peak values of the gain-adjusted signal. The comparator thresholds have been chosen to provide timing accuracy, as well as limited immunity from mis-detection caused by short valley conditions or by gear run-out.

Gear Design Criteria.* The system was designed to work correctly with minimum valley depths of 5 mm and minimum valley widths of 13 mm. As the valley depth decreases, the valley field rises above the open-circuit value of the magnetic circuit when the sensor is at minimum air gap. The same is true when the valley width decreases. In both cases, the metal mass from the valley bottom or side walls provides an interference at minimum air gap and will provide a signal that may be interpreted as a tooth upon power on. It is important to note that this anomaly will normally only affect the power-on state of the device and the self-calibration circuitry will null this baseline shift when the device is in running mode.

* In application, the terms “gear” and “target” are often interchanged. However, “gear” is preferred when motion is transferred.

Signal-Timing Accuracy. Timing accuracy is improved with larger gear diameters. The magnetic field profile has a defined spread that narrows in degrees as the target diameter increases. The slope of this magnetic profile also changes with air gap. For highest accuracy, targets greater than 100 mm diameter should be used.

Operation with Fine-Pitch Gears. The self-calibration routines allow the detection of fine-pitch gears once the target is rotating. The major issue in these applications is the impact of gear run-out on the baseline of the magnetic field. Excessive run-out may result in tooth edges not being detected.

Signal Duty Cycle. For regular tooth geometries, precise duty cycle is maintained over the operating air gap and temperature range due to the good symmetry of the magnetic switch points of the device.

Output. The output of the sensor is a short-circuit-protected open-collector stage capable of sinking 20 mA. An external pull-up (resistor) to a supply voltage of not more than 24 V must be supplied.

Output Polarity. The switching of the output is independent of the direction of gear rotation.

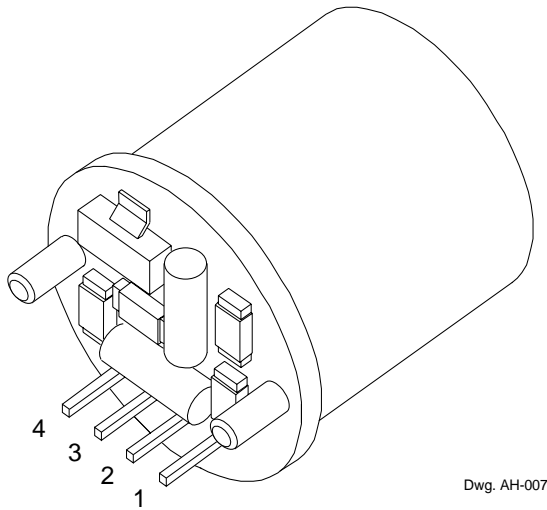
Power Supply Protection. The device contains an on-chip regulator and can operate over a wide supply voltage range (4.5 V to 24 V). For devices that need to operate from an unregulated power supply, transient protection must be added externally. For applications being run off a regulated line, EMI/RFI protection is still required. Incorrect protection can result in unexplained pulses on the output line, providing inaccurate sensing information to the user.

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ATS632LSA HALL-EFFECT GEAR-TOOTH SENSOR

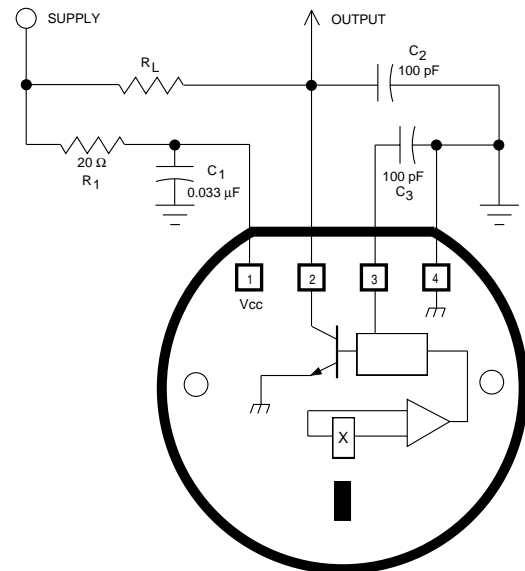
APPLICATIONS INFORMATION — Continued

The protection circuitry can easily be added to a PC board for use with this device. Provisions have been made for easy mounting of a PC board on the back of the unit. PC board installation parallel to the device axis is also possible.



Dwg. AH-007

Operation From a Regulated Power Supply. These devices require minimal protection circuitry during operation from a low-voltage regulated line. The on-chip voltage regulator provides immunity to power supply variations between 4.5 V and 24 V. However, even while operating from a regulated line, some supply and output filtering is required to provide immunity to coupled and injected noise on the supply line. A basic RC low-pass filter circuit (R_1C_1) on the supply line and an optional output capacitor (C_2) is recommended for operation in noisy environments. In extremely noisy environments, a filter capacitor at pin 3 may also be required. Because the device has an open collector output, an output pull-up resistor must be added either at the sensor module or at the controller.



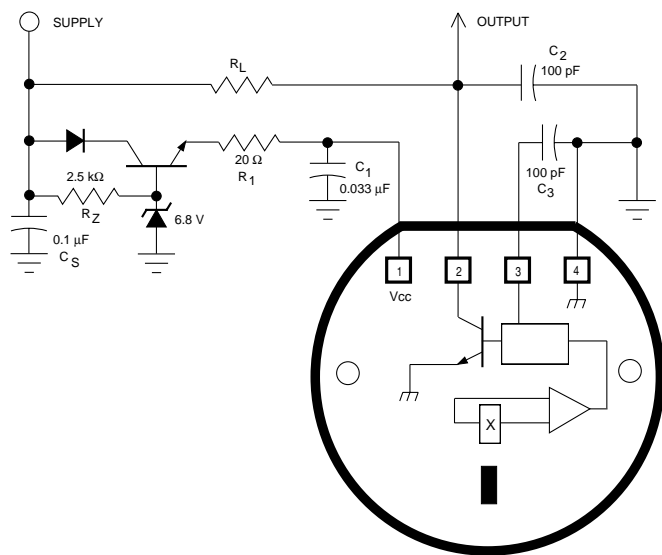
Dwg. EH-008-3A

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ATS632LSA HALL-EFFECT GEAR-TOOTH SENSOR

APPLICATIONS INFORMATION — Continued

Operation from an Unregulated Power Supply. In applications where the device gets its power from an unregulated supply such as an automotive battery, full protection is generally required. In addition to supply regulation, such applications require the device to withstand various supply side transients. Specifications for such transients vary between car manufacturers and protection circuit design should be optimized for each application. In the circuit shown below, a simple Zener-controlled regulator is constructed using discrete components. The RC low-pass filter on the supply line (R_1C_1) and a low-value supply bypass capacitor (C_S) can be included, if necessary, so as to minimize the susceptibility to EMI/RFI. The NPN should be chosen with sufficiently high forward breakdown voltage so as to hold off supply-side transients. The series diode should be chosen with sufficiently high reverse breakdown capabilities so as to withstand the most negative transient. The current-limiting resistor (R_Z) and the Zener diode should be sized for power dissipation requirements.



Additional applications Information on gear-tooth and other Hall-effect sensors is provided in the *Allegro Integrated and Discrete Semiconductors Data Book* or *Application Note 27701*.

ATS632LSA **HALL-EFFECT** **GEAR-TOOTH SENSOR**

MECHANICAL INFORMATION

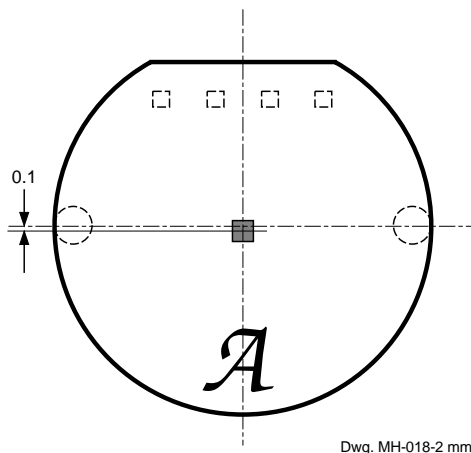
| Component | Material | Function | Units |
|--------------------|---|---------------------------------|---------|
| Sensor Face | Thermoset epoxy | Maximum temperature | 170°C* |
| Plastic Housing | Polyamide, 33% glass filled (Nylon 6, 6) | 264 psi deflection temp. (DTUL) | 225°C |
| | | Approximate melting temperature | 260°C |
| Leads | Copper | — | — |
| Lead Pull | — | — | 8 N |
| Lead Finish | 90/10 tin/lead solder plate | — | † |
| Flame Class Rating | — | — | UL94V-0 |

*Temperature excursions to 225 °C for 2 minutes or less are permitted.

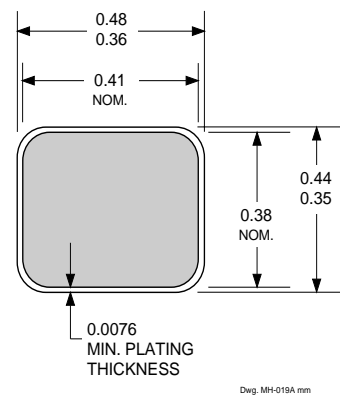
†All industry-accepted soldering techniques are permitted for these modules provided the indicated maximum temperature for each component (e.g., sensor face, plastic housing) is not exceeded. Reasonable dwell times, which do not cause melting of the plastic housing, should be used.

Sensor Location (in millimeters)

(sensor location relative to package center is the design objective)



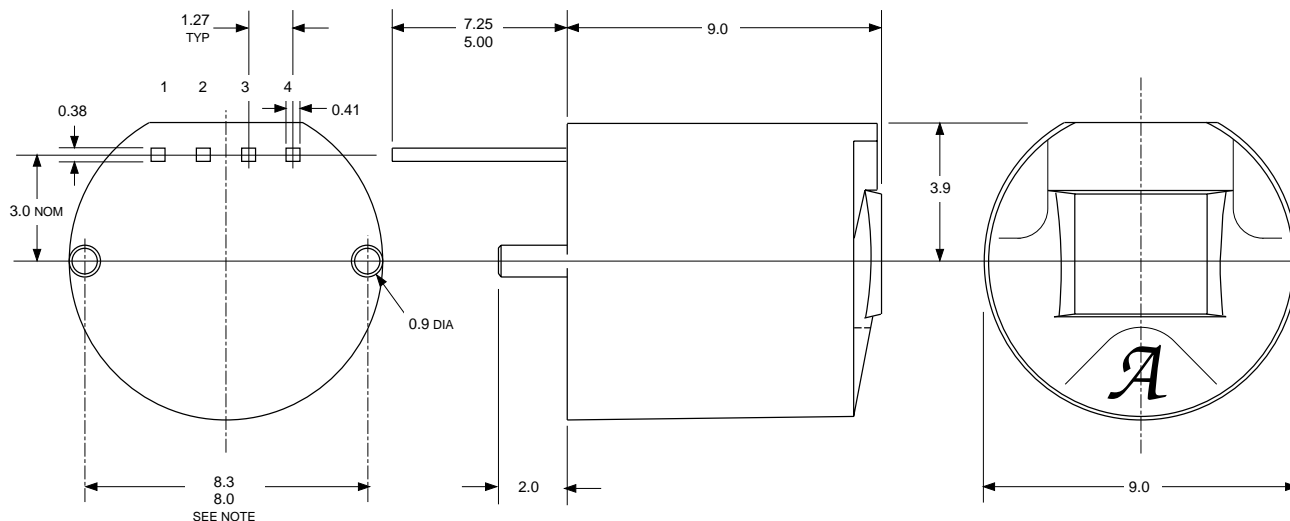
Lead Cross-Section (in millimeters)



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ATS632LSA HALL-EFFECT GEAR-TOOTH SENSOR

DIMENSIONS IN MILLIMETERS



Dwg. MH-017A mm

Tolerances unless otherwise specified: 1 place ± 0.1 mm, 2 places ± 0.05 mm.

NOTE — Nominal dimension and tolerances dependent on package material. Contact factory.

The products described herein are manufactured under one or more of the following U.S. patents: 5,045,920; 5,264,783; 5,442,283; 5,389,889; 5,581,179; 5,517,112; 5,619,137; 5,621,319; 5,650,719; 5,686,894; 5,694,038; 5,729,130; 5,917,320; and other patents pending.

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