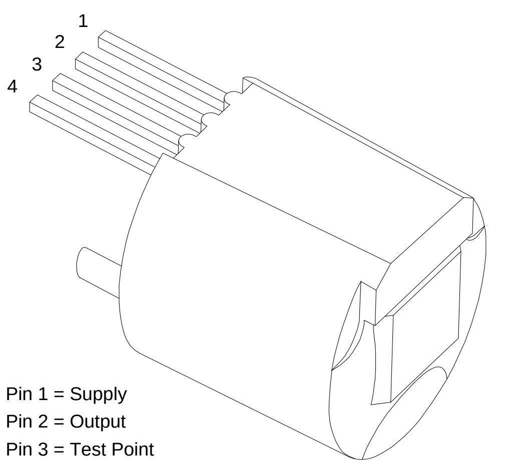
ATS630LSA AND ATS631LSA

Data Sheet 27627.120

ZERO-SPEED, SELF-CALIBRATING, HALL-EFFECT GEAR-TOOTH TRUE POWER-ON SENSORS



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

Dwg. AH-006-2

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 ATS630LSA and the ATS631LSA true power-on state (TPOS) gear-tooth sensors are optimized Hall-effect IC/magnet combinations that provide power-on tooth/valley recognition and extremely accurate tooth edge detection when used with large-pitch targets. Each sensor subassembly 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 can be easily assembled on a PC board for complete protection and used in conjunction with a number of gear configurations. The ATS630LSA and ATS631LSA are identical except for output polarity.

The gear sensing technology used for these sensor subassemblies 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 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.

These sensor systems are ideal for use in gathering speed, position and profile information of ferrous objects. These devices are particularly suited to large tooth/valley sensing applications such as those used in automotive cam-shaft sensing applications where power-on state and accurate timing accuracy are desired features. Both output polarities are provided. For applications requiring the sensing of fine-pitch gears, the ATS610LSA and ATS611LSB are recommended.

ATS630LSA: HIGH digital output state over a tooth.
ATS631LSA: LOW digital output state over a tooth.

continued next page…

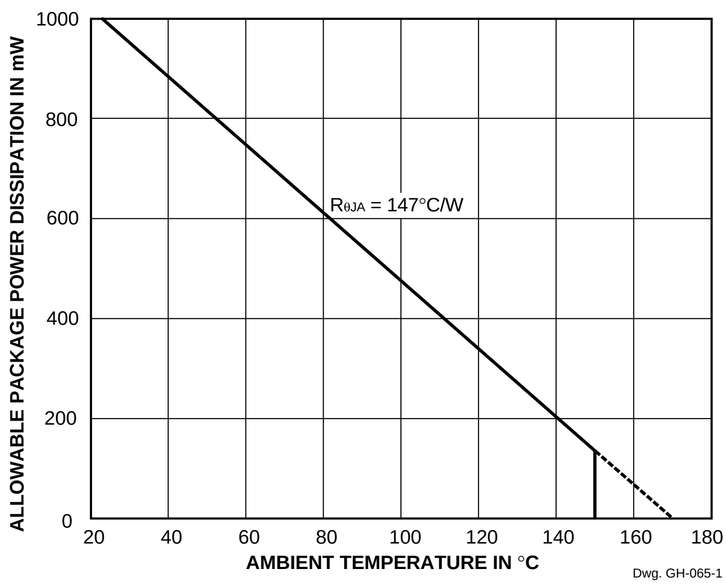
Some restrictions may apply to sales for automotive applications. Contact factory for details.

Always order by complete part number, e.g., **ATS630LSA**.

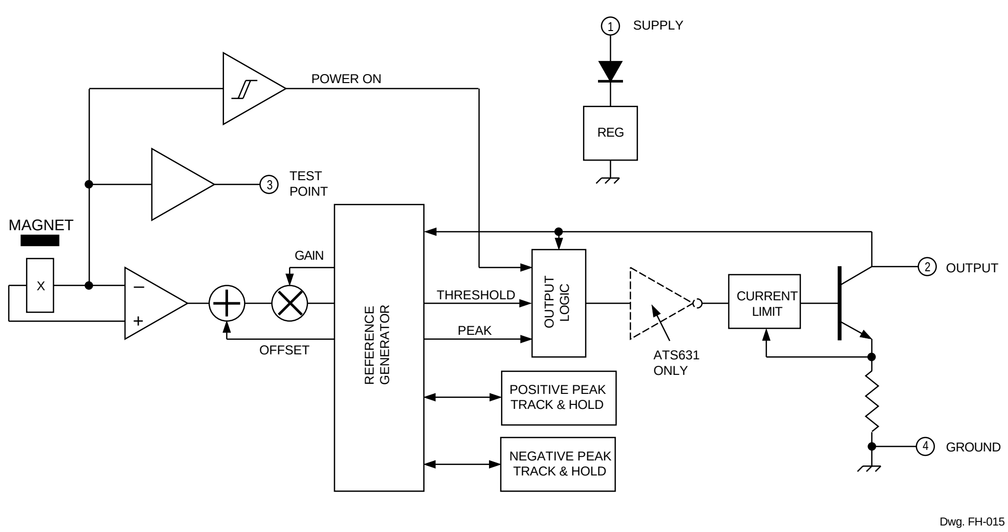
ATS630LSA AND ATS631LSA
ZERO-SPEED, SELF-CALIBRATING, HALL-EFFECT GEAR-TOOTH TRUE POWER-ON SENSORS

FEATURES AND BENEFITS

- Fully Optimized True Power-On State 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 True Power-On State (TPOS)
- 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



FUNCTIONAL BLOCK DIAGRAM



Allegro MicroSystems, Inc.
115 Northeast Cutoff, Box 15036
Worcester, Massachusetts 01615-0036 (508) 853-5000

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°C	4.5	–	24	V
Power-On State (ATS630LSA)	POS	V_{CC} = 0 → 5 V, Over Tooth	HIGH	HIGH	HIGH	–
		V_{CC} = 0 → 5 V, Over Valley	LOW	LOW	LOW	–
Power-On State (ATS631LSA)	POS	V_{CC} = 0 → 5 V, Over Tooth	LOW	LOW	LOW	–
		V_{CC} = 0 → 5 V, Over Valley	HIGH	HIGH	HIGH	–
Under-Voltage Lockout	$V_{CC(UV)}$	I_{OUT} = 20 mA, V_{CC} = 0 → 5 V	–	4.0	–	V
Low Output Voltage	$V_{OUT(L)}$	I_{OUT} = 20 mA, Output ON	–	0.2	0.4	V
Output Current Limit	I_{OUTM}	V_{OUT} = 12 V	25	45	55	mA
Output Leakage Current	I_{OFF}	V_{OUT} = 24 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 V	–	80	500	µs
Output Rise Time	t_r	R_L = 500 Ω, C_L = 10 pF	–	0.2	5.0	µs
Output Fall Time	t_f	R_L = 500 Ω, C_L = 10 pF	–	0.2	5.0	µs

NOTE: Typical data is at V_{CC} = 12 V and T_A = +25°C and is for design information only.

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
Minimum TPOS Air Gap	AG_{min}		–	–	0.25	mm
Maximum TPOS Air Gap	AG_{max}		2.0	3.0	–	mm
Timing Accuracy	t_θ	Target Speed < 3500 RPM, 0.3 mm ≤ AG ≤ 2.0 mm	–	±0.25	±0.50	°

TARGET DESIGN CRITERIA

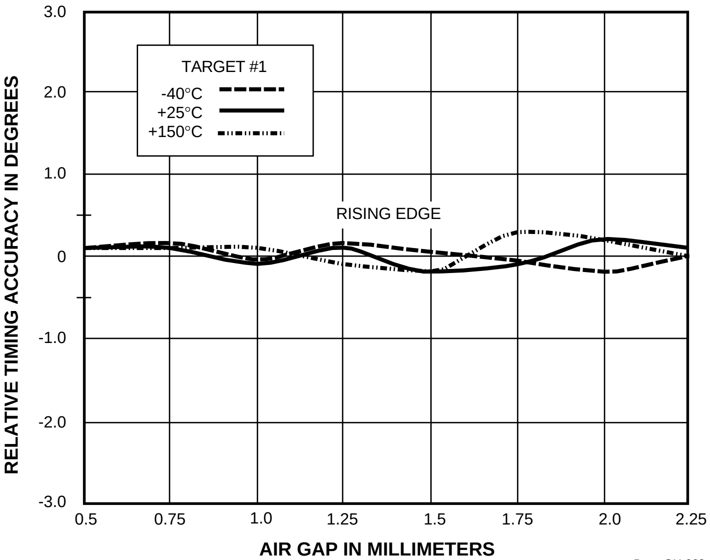
Characteristic	Symbol	Description	Limits			
			Min.	Typ.	Max.	Units
Valley Depth	h_t	For correct Power-On state	5.0	–	–	mm
Valley Width	$(P_C - T)$	For correct Power-On state	13	–	–	mm
Tooth Width	T	For correct Power-On state	7.0	–	–	mm
Thickness	F		7.0	–	–	mm
Eccentricity	–	Timing accuracy may change	–	–	±0.25	mm

TARGET DIMENSIONS

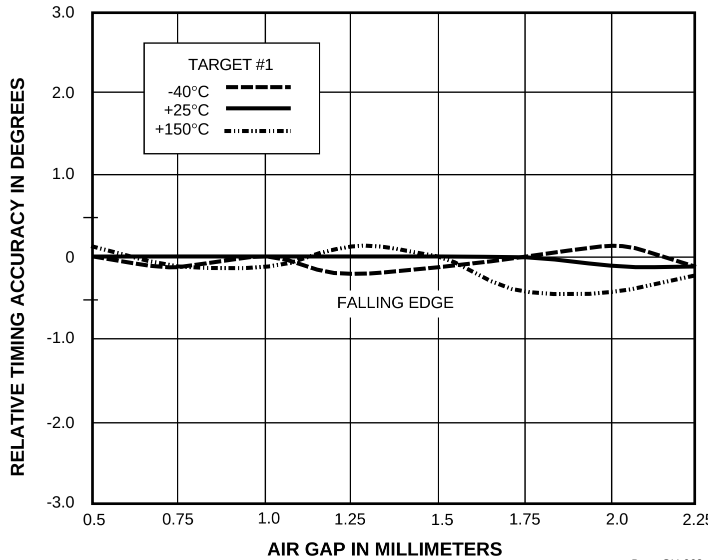
Type	Diameter (D_o)	Thickness (F)	Tooth Width (T)	Valley Width (P_C - T)	Valley Depth (h_t)
Reference Target	84 mm	16 mm	9 mm	13 mm	5 mm
Characterization Target #1	84 mm	16 mm	1 tooth, 180°		5 mm
Characterization Target #2	35 mm	7 mm	1 tooth, 180°		6 mm

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

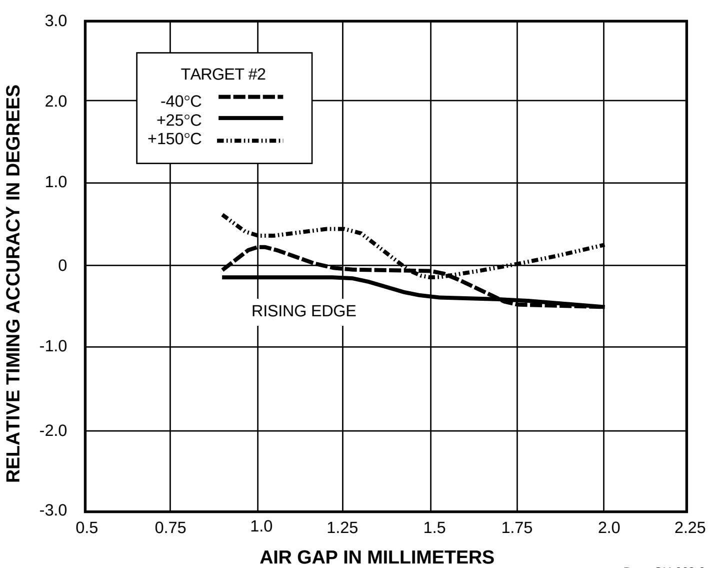
TYPICAL OPERATING CHARACTERISTICS



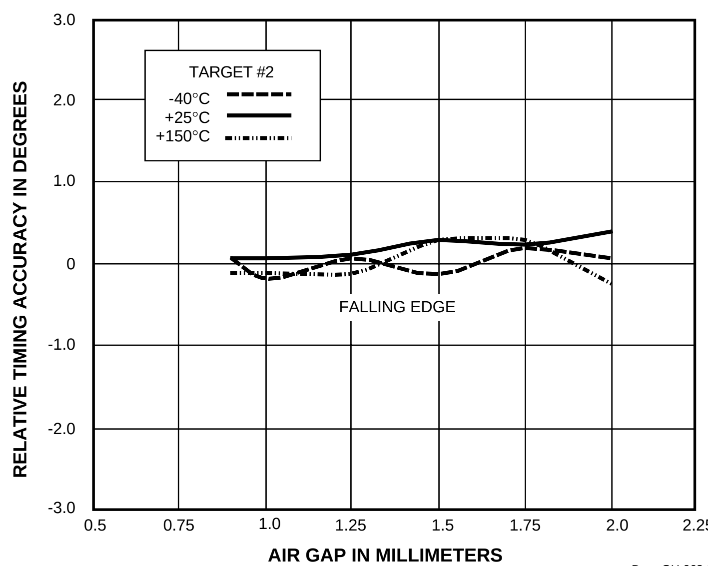
Dwg. GH-063



Dwg. GH-063-1



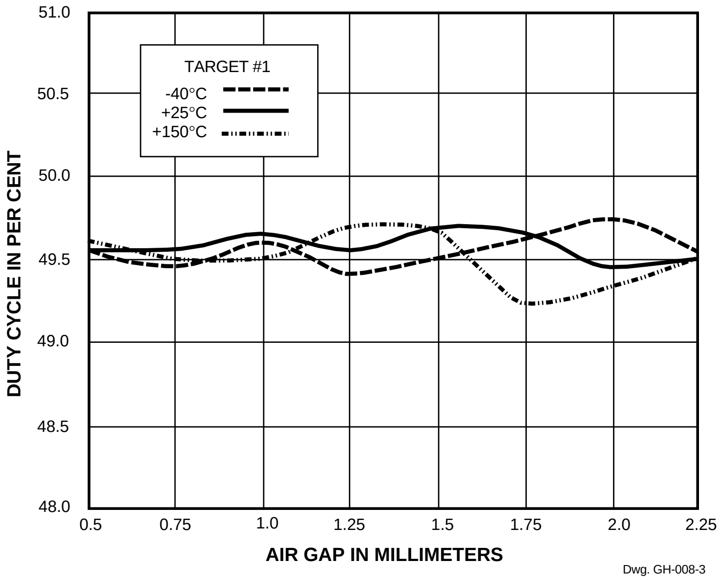
Dwg. GH-063-2

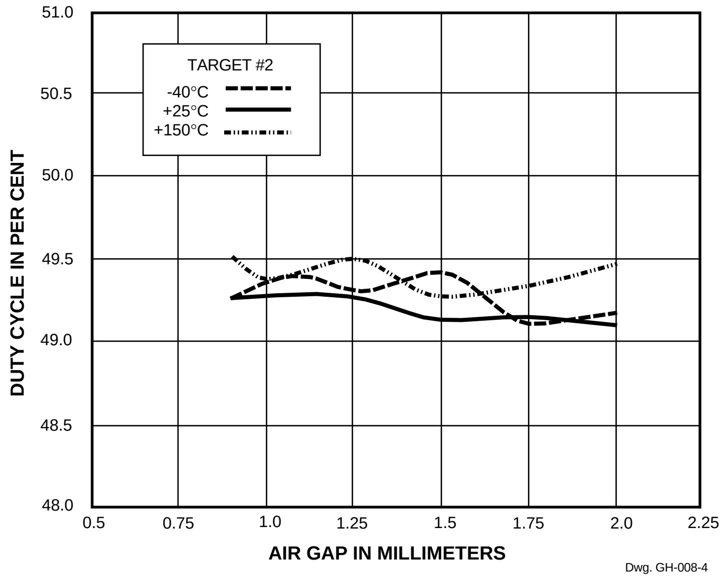


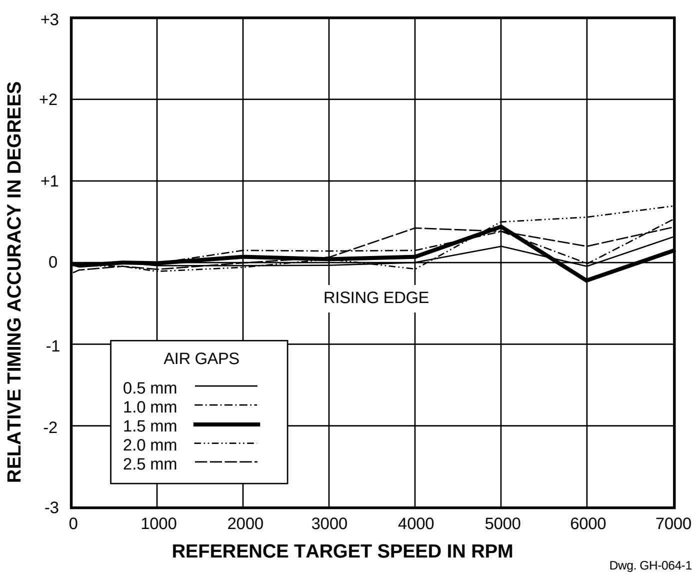
Dwg. GH-063-3

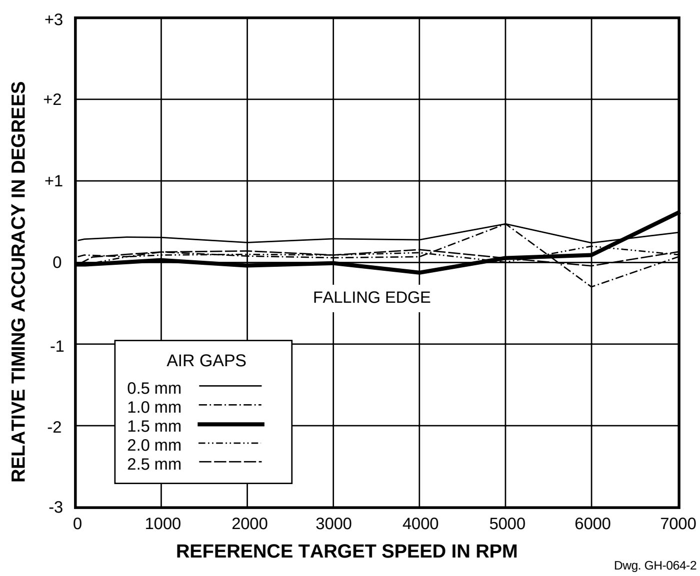
continued next page…

TYPICAL OPERATING CHARACTERISTICS — Continued









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°C, RH = 85%	1000 hrs	48	Device biased for minimum power
Bias Life	JESD22-A108, T_A = 150°C, T_J = 165°C	1000 hrs	48	
(Surge Operating Life)	JESD22-A108, T_A = 175°C, T_J = 190°C	168 hrs	48	
Autoclave, Unbiased	JESD22-A102, T_A = 121°C, 15 psig	96 hrs	48	
High-Temperature (Bake) Storage Life	JESD22-A103, T_A = 170°C	1000 hrs	48	
Temperature Cycle	JESD22-A104	1000 cycles	48	-55°C to +150°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 ATS630LSA and ATS631LSA requires that a special evaluation technique be used to measure their 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.

True Power-On Function. These sensors are designed to provide TRUE tooth/valley information at power on. The ATS630LSA is designed to provide a HIGH output state when positioned over a tooth and a LOW output state when position over a valley/slot over the specified air gap range. The ATS631LSA has an output state that is inverted from the ATS630LSA. The POS function should be tested using the following procedure.

1. Set the air gap to the minimum value required. Position the subassembly over a valley/slot of the target. Apply power to the subassembly and check for correct output state. In the case of a narrow or insufficiently deep valley, an incorrect state may be detected.
2. Set the air gap to the maximum value required. Position the subassembly over a valley/slot of the target. Apply power to the subassembly and check output state.
3. Set the air gap to the minimum value required. Position the subassembly over a tooth of the target. Apply power to the subassembly and check output state.
4. Set the air gap to the maximum value required. Position the subassembly over a tooth of the target. Apply power to the subassembly and check output

APPLICATIONS INFORMATION — Continued

state. If an incorrect state is detected, then the maximum air gap requirement is too large for this sensor.

Self-Calibrating Functions. These subassemblies 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.

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 subassembly. 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 subassembly. 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. While the TPOS function may not work correctly at power on, 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 subassembly 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.

continued next page…

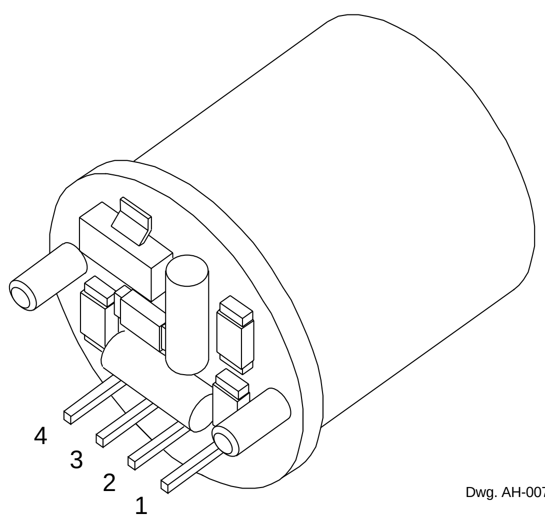
APPLICATIONS INFORMATION — Continued

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

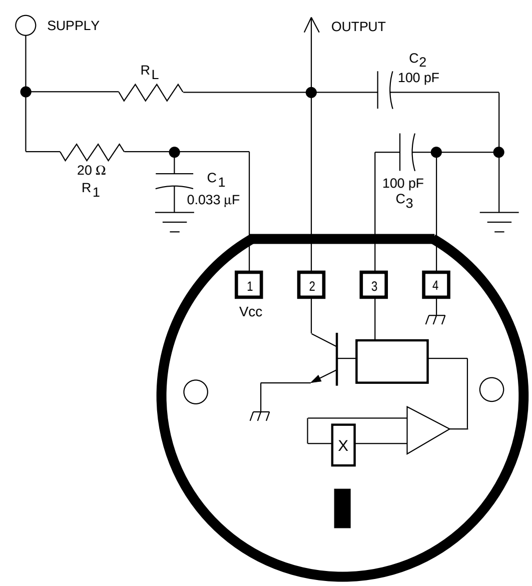
Power Supply Protection. The device contains an on-chip regulator and can operate over a wide supply voltage range (4.5 V to 24 V). For devices that need to operate from an unregulated power supply, transient protection must be added externally. For applications being run off a regulated line, EMI/RFI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

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.

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. AH-007

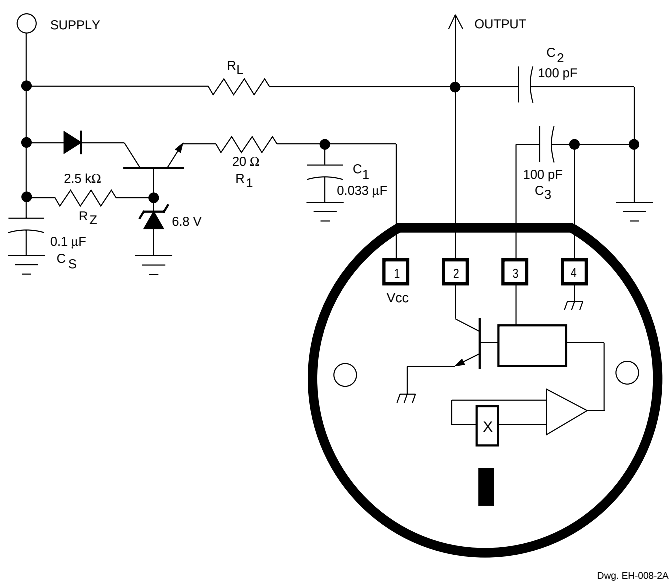


Dwg. EH-008-3A

continued next page…

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.



Dwg. EH-008-2A

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.

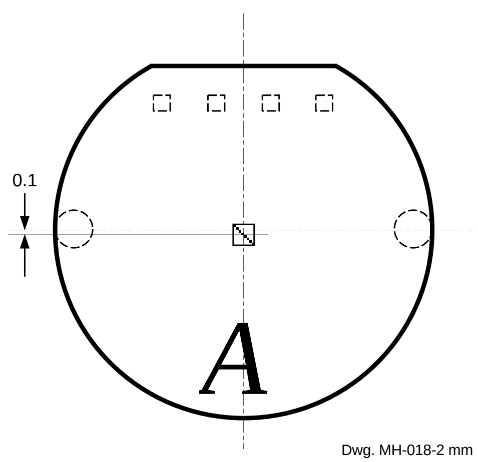
Allegro® MicroSystems, Inc.
115 Northeast Cutoff, Box 15036
Worcester, Massachusetts 01615-0036 (508) 853-5000

MECHANICAL INFORMATION

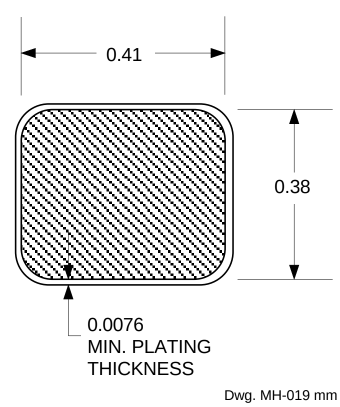
Component	Material	Function	Units
Sensor Face	Thermoset epoxy	Maximum temperature	170°C*
Plastic Housing	Polyamide, 33% glass (Nylon 6, 6)	264 psi deflection temp. (DTUL)	225°C
		Approximate melting temperature	260°C
Leads	Copper	–	–
Lead Pull	–	–	8 N
Lead Finish	90/10 tin/lead solder plate	–	†
Flame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

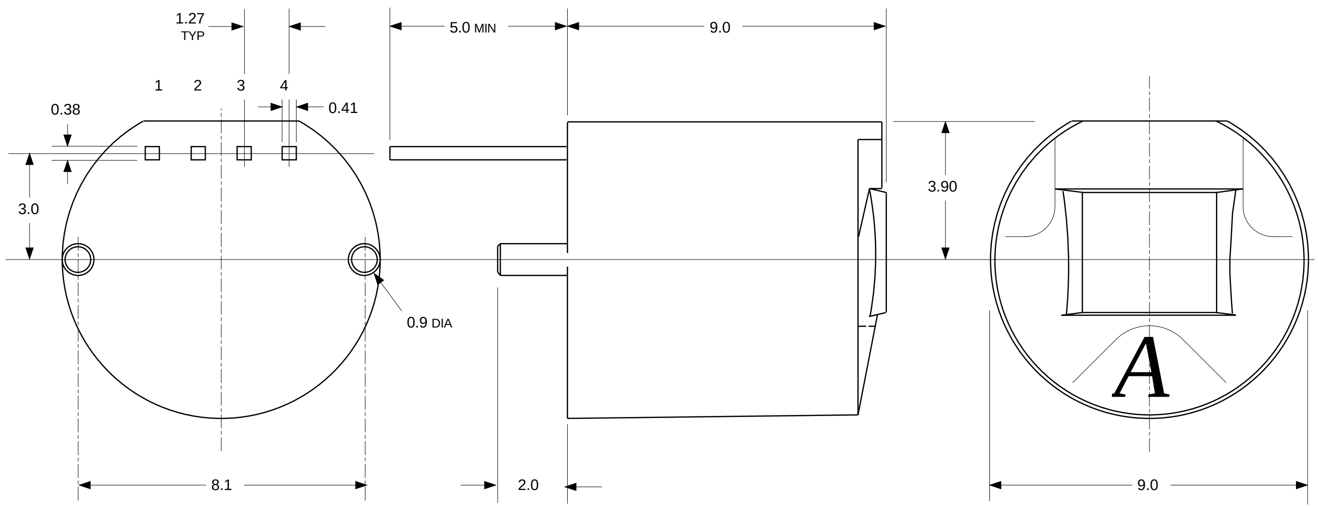


Lead Cross-Section (in millimeters)



continued next page…

ATS630LSA & ATS631LSA DIMENSIONS IN MILLIMETERS



Dwg. MH-017 mm

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

Allegro MicroSystems, Inc.
115 Northeast Cutoff, Box 15036
Worcester, Massachusetts 01615-0036 (508) 853-5000