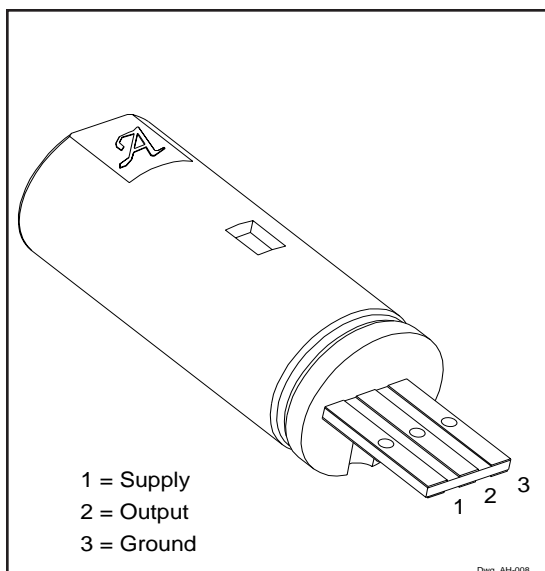


# ATS632LSC

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



**PRELIMINARY INFORMATION**  
(subject to change without notice)  
**April 8, 1998**

### **ABSOLUTE MAXIMUM RATINGS**

Supply Voltage,  $V_{CC}$  ..... **24 V**  
Reverse Supply Voltage,  
 $V_{RCC}$  (1 minute max.) ..... **-24 V**  
Output OFF Voltage,  $V_{OUT}$  ..... **24 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**

The ATS632LSC gear-tooth sensor is an optimized Hall-effect IC/magnet combination that provides tooth/valley recognition and extremely accurate tooth edge detection when used with large-pitch targets. The sensor subassembly consists of a high-temperature plastic shell that holds together a compound samarium-cobalt magnet, a single-element self-calibrating Hall-effect IC that has been optimized to the magnetic circuit, and a voltage regulator. This small package, with its non-oriented operation, can be easily assembled and used in conjunction with a number of gear configurations.

The gear sensing technology used for this sensor subassembly 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.

The sensor system is ideal for use in gathering speed, position and profile information of ferrous objects. The device is 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 ATS611LSB is recommended.

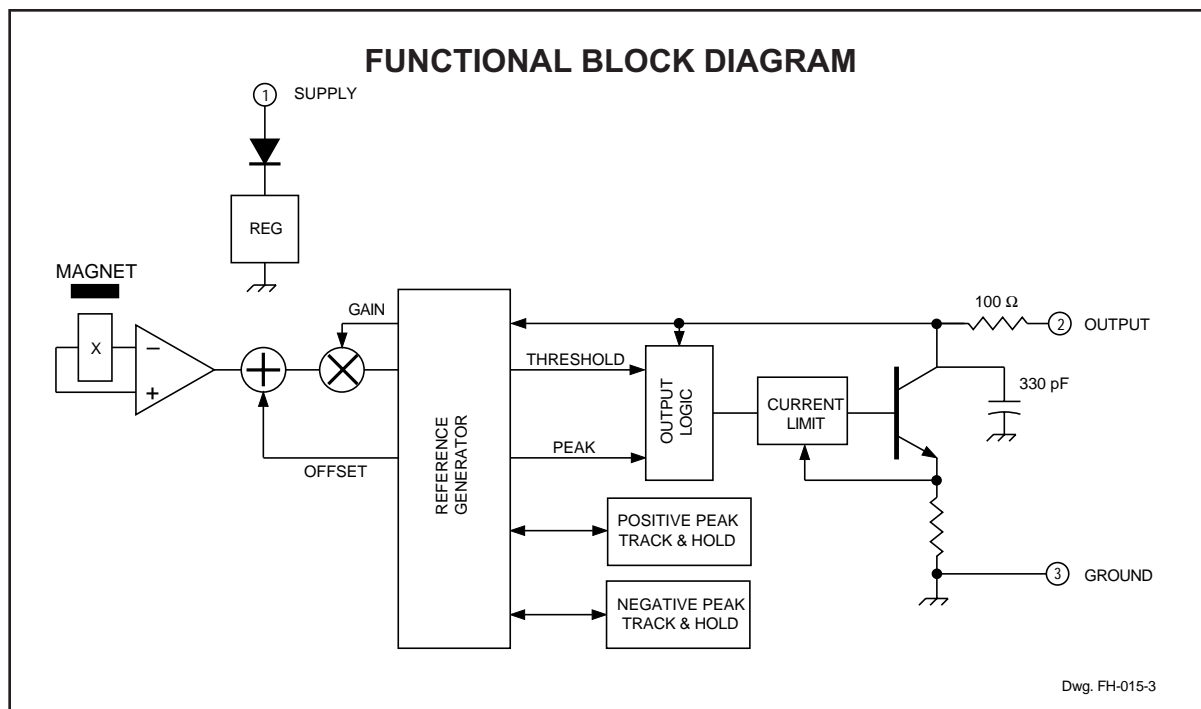
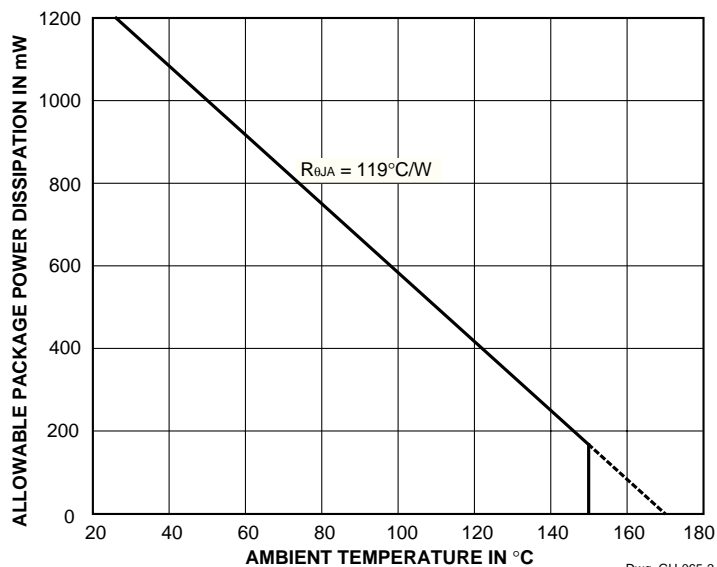
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Always order by complete part number, e.g., **ATS632LSC**.

# ATS632LSC HALL-EFFECT GEAR-TOOTH SENSOR SUBASSEMBLY

## FEATURES AND BENEFITS

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



# **ATS632LSC** **HALL-EFFECT** **GEAR-TOOTH SENSOR** **SUBASSEMBLY**

**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, $T_J < 165^{\circ}\text{C}$	6.0	12	24	V
Under-Voltage Lockout	$V_{CC(UV)}$	$I_{OUT} = 5\text{ mA}$ , $V_{CC} = 0 \rightarrow 6\text{ V}$	–	5.0	–	V
Low Output Voltage	$V_{OUT(L)}$	$I_{OUT} = 5\text{ mA}$ , Output ON	–	0.7	1.6	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	–	5.0	10	$\mu\text{A}$
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	$t_{po}$	$V_{CC} > 6\text{ V}$	–	200	500	$\mu\text{s}$
Output Rise Time	$t_r$	$R_L = 2.5\text{ k}\Omega$ , $C_L = 10\text{ pF}$	–	3.0	6.0	$\mu\text{s}$
Output Fall Time	$t_f$	$R_L = 2.5\text{ k}\Omega$ , $C_L = 10\text{ pF}$	–	1.0	3.0	$\mu\text{s}$

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

# ATS632LSC HALL-EFFECT GEAR-TOOTH SENSOR SUBASSEMBLY

**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	–	1.9	mm
Output Polarity	–	Operating, Over Tooth	Low	Low	Low	–
		Operating, Over Valley	High	High	High	–
Timing Accuracy	$t_{\theta}$	Target Speed < 3500 RPM, $0.3 \text{ mm} \leq \text{AG} \leq 1.9 \text{ mm}$	–	$\pm 0.25$	$\pm 0.50$	°

NOTE: Air Gap is defined as the distance from the face of the sensor subassembly to the target.

## 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	–	–	$\pm 0.25$	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

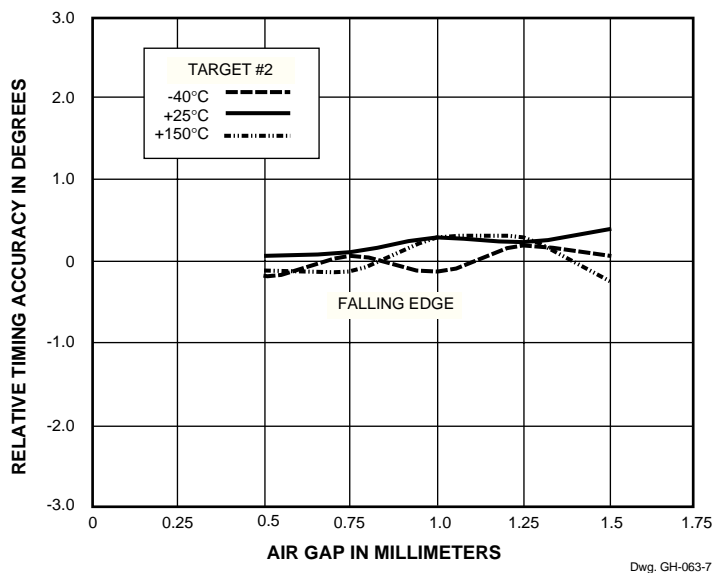
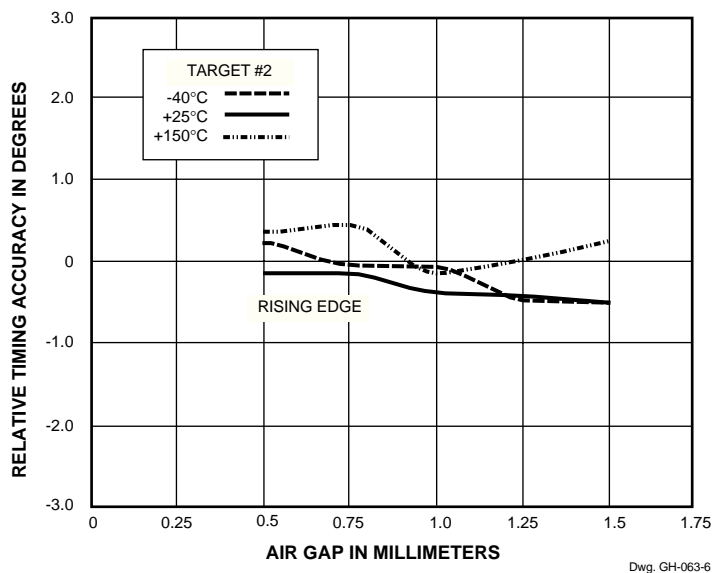
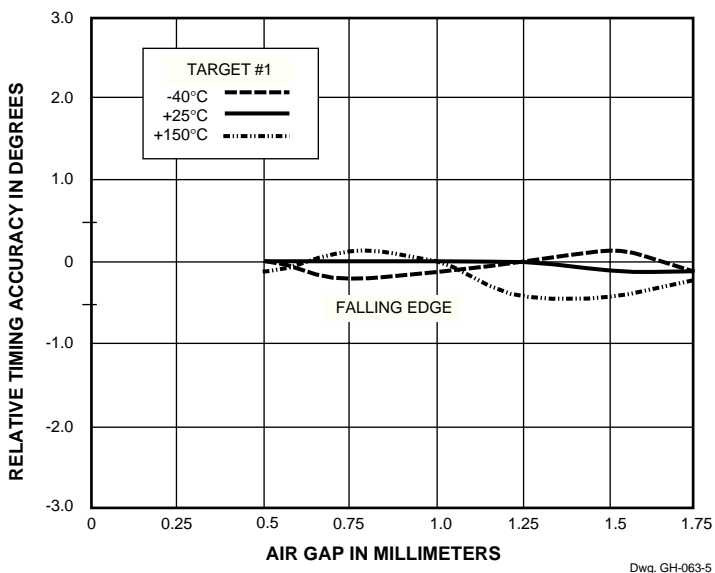
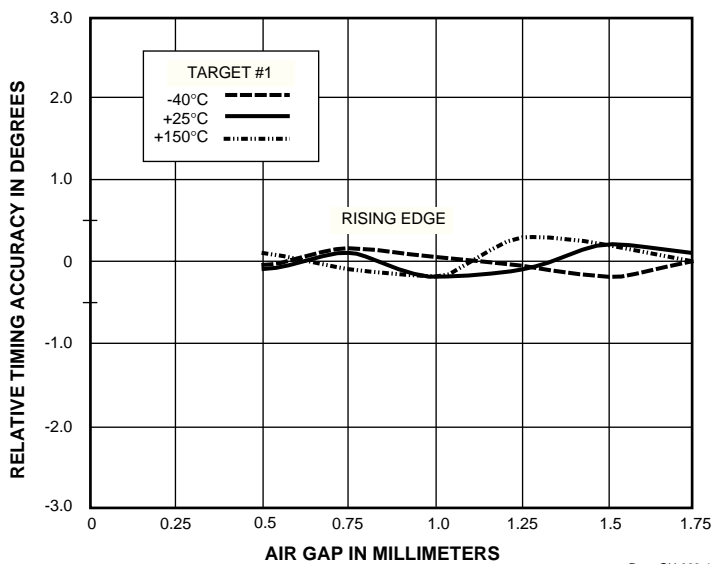
NOTE: Timing accuracy data is taken by recalibrating the unit at each air gap.



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# ATS632LSC HALL-EFFECT GEAR-TOOTH SENSOR SUBASSEMBLY

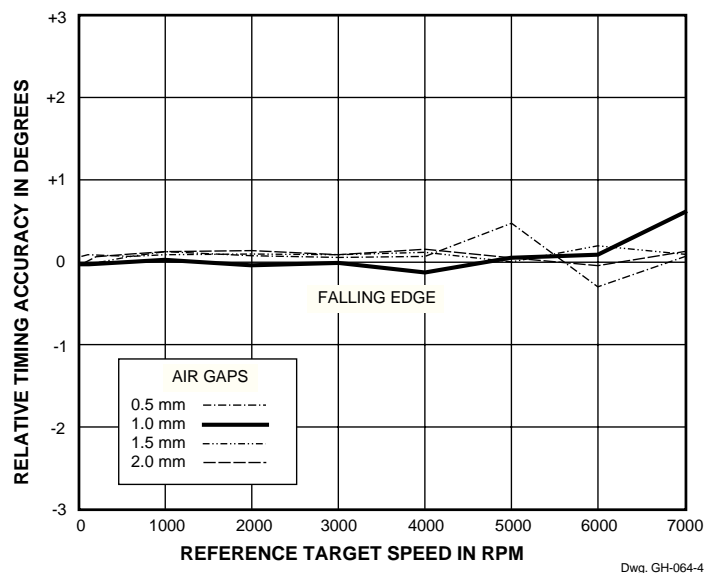
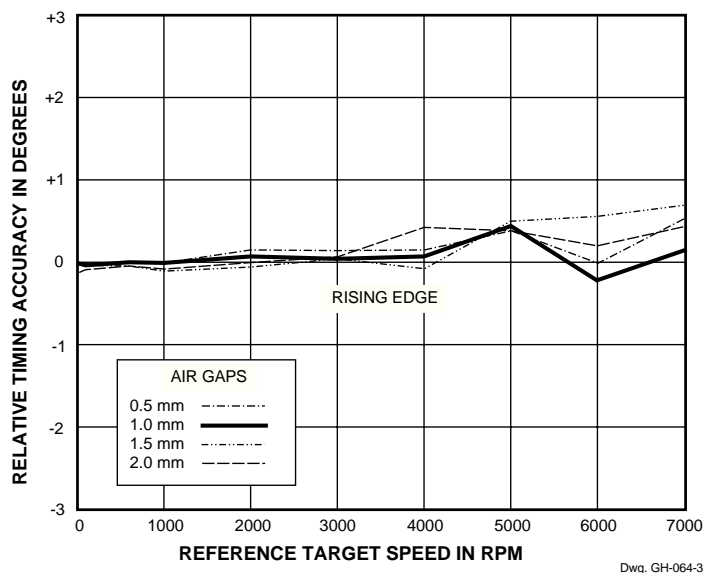
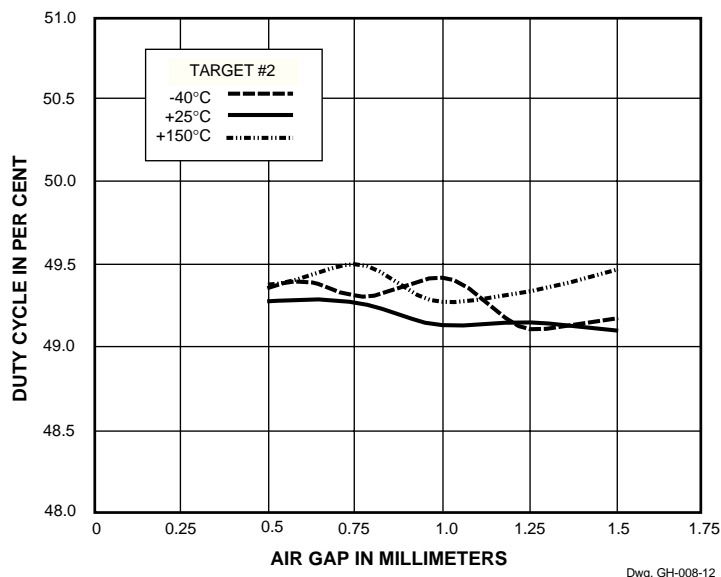
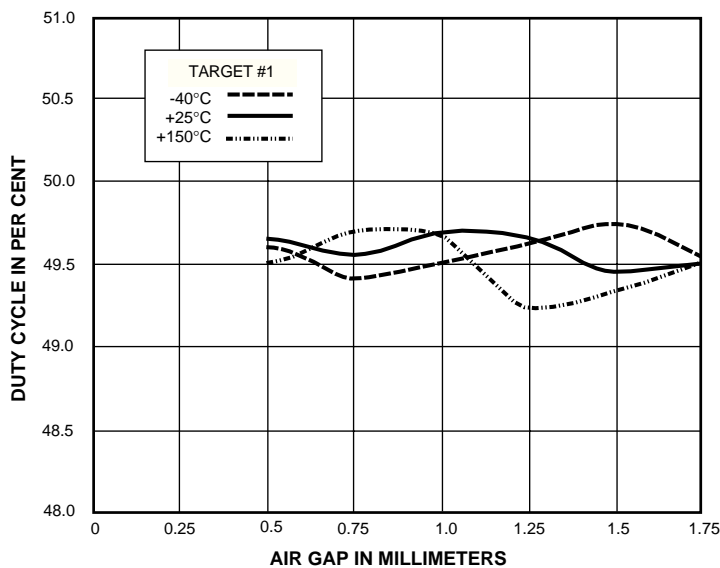
## TYPICAL OPERATING CHARACTERISTICS



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# ATS632LSC HALL-EFFECT GEAR-TOOTH SENSOR SUBASSEMBLY

## TYPICAL OPERATING CHARACTERISTICS — Continued



**ATS632LSC  
HALL-EFFECT  
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SUBASSEMBLY**

**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	$-55^{\circ}\text{C}$ to $+150^{\circ}\text{C}$
ESD, Human Body Model	CDF-AEC-Q100-002	Pre/Post Reading	3 per test	Test to failure All leads > 8 kV

**APPLICATIONS INFORMATION**

**Recommended Evaluation Technique.** The self-calibrating feature of the ATS632LSC 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.** This subassembly is designed to minimize performance variation caused by the large air gap variations resulting from installation by self-calibrating at power-on. It is 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.

# ATS632LSC HALL-EFFECT GEAR-TOOTH SENSOR SUBASSEMBLY

## 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 subassembly. Wait for 16 output pulses to occur. Monitor output for correct switching and measure accuracy.
2. Change the air gap by  $\pm 0.25$  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.** 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 either at the sensor module or at the controller.

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

**Power Supply Protection.** These devices require minimal protection circuitry during operation from a low-voltage line. The internal voltage regulator provides immunity to power supply variations between 6 V and 24 V. EMI/RFI protection is provided as part of the internal regulator. In extremely noisy environments, additional (external) components may be required.

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*.





**ATS632LSC**  
**HALL-EFFECT**  
**GEAR-TOOTH SENSOR**  
**SUBASSEMBLY**

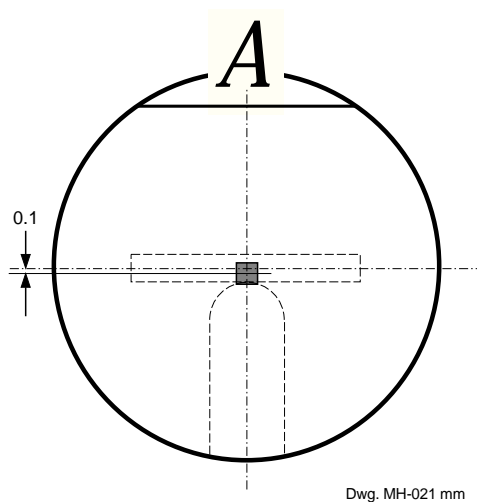
**MECHANICAL INFORMATION**

Component	Material	Function	Units
Package	Polyamide 6/12, 33% glass filled	264 psi deflection temp. (DTUL) Approximate melting temperature	200°C 219°C
Circuit Board	High-temperature FR-4	Glass transition temperature	170°C
Terminals	1 oz Copper	—	—
Terminal Finish	63/37 tin/lead solder plate	—	†
Flame Class Rating	—	—	UL94V-0

† 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)**

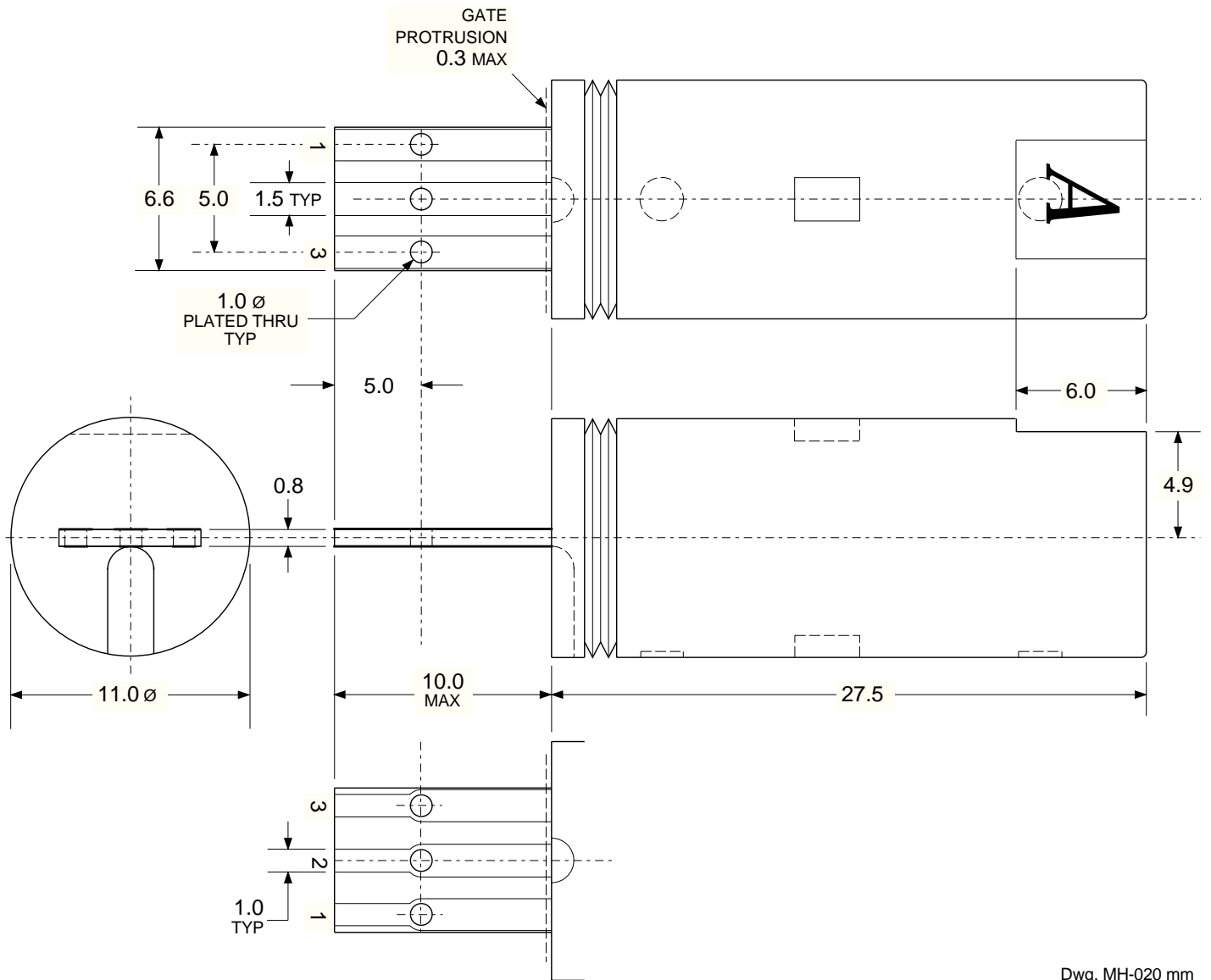
(sensor location relative to package center is the design objective)



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**ATS632LSC  
HALL-EFFECT  
GEAR-TOOTH SENSOR  
SUBASSEMBLY**

**DIMENSIONS IN MILLIMETERS**



Dwg. MH-020 mm

Tolerances unless otherwise specified: 1 place  $\pm 0.1$  mm, 2 places  $\pm 0.05$  mm.

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***HALL-EFFECT***  
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***ADAPTIVE THRESHOLD SENSORS  
SELECTION GUIDE***

<b>Part Number</b>	<b>Application</b>
ATS535CSB	Programmable, TPOS, large-tooth gear-position or proximity sensing (commercial temp. range)
ATS535JSB	Programmable, TPOS, large-tooth gear-position or proximity sensing (industrial/auto. temp. range)
ATS610LSA	Large-tooth, gear-position sensing – crank angle, cam angle
ATS610LSC	Large-tooth, gear-position sensing with internal voltage regulator – crank angle, cam angle
ATS611LSB	Fine-pitch, large air gap, gear speed sensing – transmission speed, ABS
ATS612JSB	Large/small-tooth gear-position sensing – crank angle, transmission speed, cam angle
ATS632LSA	Large-tooth, gear-position sensing (LOW digital output state over a tooth), cam angle
ATS632LSC	Large-tooth, gear-position sensing (LOW digital output state over a tooth), with internal voltage regulator – cam angle
ATS640JSB	TPOS, gear-position sensing for two-wire applications

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