The ATS632LSC gear-tooth sensor IC is an optimized Hall-effect IC that provides tooth/valley recognition and extremely accurate tooth edge detection when used with large-pitch targets. This sensor subassembly consists of a high-temperature plastic shell that holds together a compound samarium-cobalt pellet, 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 circuit 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 device 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.

ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage, $V_{CC}$</td>
<td>24 V</td>
</tr>
<tr>
<td>Reverse Supply Voltage, $V_{RCC}$</td>
<td>-24 V</td>
</tr>
<tr>
<td>Output OFF Voltage, $V_{OUT}$</td>
<td>24 V</td>
</tr>
<tr>
<td>Output Current, $I_{OUT}$</td>
<td>50 mA</td>
</tr>
<tr>
<td>Reverse Output Current, $I_{OUT}$</td>
<td>Internally Limited</td>
</tr>
<tr>
<td>Package Power Dissipation, $P_D$</td>
<td>See Graph</td>
</tr>
<tr>
<td>Operating Temperature Range, $T_A$</td>
<td>-40°C to +150°C</td>
</tr>
<tr>
<td>Storage Temperature, $T_S$</td>
<td>+170°C</td>
</tr>
</tbody>
</table>

Always order by complete part number, e.g., ATS632LSC.
FEATURES AND BENEFITS

- Non-Oriented Installation
- Fully Optimized Gear-Tooth Sensor IC
- 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
ELECTRICAL CHARACTERISTICS over operating voltage and temperature range (unless otherwise specified).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>$V_{CC}$</td>
<td>Operating, $T_J &lt; 165^\circ C$</td>
<td>Min.</td>
</tr>
<tr>
<td>Under-Voltage Lockout</td>
<td>$V_{CC(UV)}$</td>
<td>$I_{OUT} = 5 , mA$, $V_{CC} = 0 \rightarrow 6 , V$</td>
<td>–</td>
</tr>
<tr>
<td>Low Output Voltage</td>
<td>$V_{OUT(L)}$</td>
<td>$I_{OUT} = 5 , mA$, Output ON</td>
<td>–</td>
</tr>
<tr>
<td>Output Current Limit</td>
<td>$I_{OUTM}$</td>
<td>$V_{OUT} = 12 , V$</td>
<td>25</td>
</tr>
<tr>
<td>Output Leakage Current</td>
<td>$I_{OFF}$</td>
<td>$V_{OUT} = 24 , V$, Output OFF</td>
<td>–</td>
</tr>
<tr>
<td>Supply Current</td>
<td>$I_{CC}$</td>
<td>Output OFF, Target Speed = 0 RPM</td>
<td>–</td>
</tr>
<tr>
<td>Calibration Count</td>
<td>$n_{cal}$</td>
<td>Output falling mechanical edges after power on for startup calibration to be complete</td>
<td>16</td>
</tr>
<tr>
<td>Calibration Update</td>
<td>$n_{up}$</td>
<td>Output falling mechanical edges for the threshold calibration to be complete</td>
<td>64</td>
</tr>
<tr>
<td>Power-On Time</td>
<td>$t_{po}$</td>
<td>$V_{CC} &gt; 6 , V$</td>
<td>–</td>
</tr>
<tr>
<td>Output Rise Time</td>
<td>$t_r$</td>
<td>$R_L = 2.5 , k\Omega$, $C_L = 10 , pF$</td>
<td>–</td>
</tr>
<tr>
<td>Output Fall Time</td>
<td>$t_f$</td>
<td>$R_L = 2.5 , k\Omega$, $C_L = 10 , pF$</td>
<td>–</td>
</tr>
</tbody>
</table>

NOTE: Typical data is at $V_{CC} = 12 \, V$ and $T_A = +25^\circ C$ and is for design information only.
**ATS632LSC**

**HALL-EFFECT**

**GEAR-TOOTH SENSOR IC**

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

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Limits</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Air Gap Range</td>
<td>AG</td>
<td>Operating, Target Speed &gt; 20 RPM</td>
<td>0.3 – 1.9</td>
<td>mm</td>
</tr>
<tr>
<td>Output Polarity</td>
<td>–</td>
<td>Operating, Over Tooth</td>
<td>Low – Low Low –</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operating, Over Valley</td>
<td>High High High –</td>
<td>–</td>
</tr>
<tr>
<td>Timing Accuracy</td>
<td>t₀</td>
<td>Target Speed &lt; 3500 RPM, 0.3 mm ≤ AG ≤ 1.9 mm</td>
<td>– ±0.25 ±0.50</td>
<td>°</td>
</tr>
</tbody>
</table>

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

**TARGET DESIGN CRITERIA**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Description</th>
<th>Limits</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valley Depth</td>
<td>h₀</td>
<td></td>
<td>– 5.0 –</td>
<td>mm</td>
</tr>
<tr>
<td>Valley Width</td>
<td>(P₀ - T)</td>
<td></td>
<td>– 5.0 –</td>
<td>mm</td>
</tr>
<tr>
<td>Tooth Width</td>
<td>T</td>
<td></td>
<td>– 5.0 –</td>
<td>mm</td>
</tr>
<tr>
<td>Thickness</td>
<td>F</td>
<td></td>
<td>– 5.0 –</td>
<td>mm</td>
</tr>
<tr>
<td>Eccentricity</td>
<td>–</td>
<td>Timing accuracy may change</td>
<td>– – ±0.25</td>
<td>mm</td>
</tr>
</tbody>
</table>

**TARGET DIMENSIONS**

<table>
<thead>
<tr>
<th>Type</th>
<th>Diameter (D₀)</th>
<th>Thickness (F)</th>
<th>Tooth Width (T)</th>
<th>Valley Width (P₀ - T)</th>
<th>Valley Depth (h₀)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Target</td>
<td>84 mm</td>
<td>16 mm</td>
<td>9 mm</td>
<td>13 mm</td>
<td>5 mm</td>
</tr>
<tr>
<td>Characterization Target #1</td>
<td>84 mm</td>
<td>16 mm</td>
<td>1 tooth, 180°</td>
<td>5 mm</td>
<td></td>
</tr>
<tr>
<td>Characterization Target #2</td>
<td>35 mm</td>
<td>7 mm</td>
<td>1 tooth, 180°</td>
<td>6 mm</td>
<td></td>
</tr>
</tbody>
</table>

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

- AIR GAP IN MILLIMETERS
- RELATIVE TIMING ACCURACY IN DEGREES

TARGET #1

RISING EDGE

TARGET #2

FALLING EDGE

continued next page...
CRITERIA FOR DEVICE QUALIFICATION

All Allegro devices 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.

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

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.
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 device 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.

**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 IC 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.

**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.

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

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

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

Element Location (in millimeters)
(element location relative to package center is the design objective)

Dwg. MH-021 mm
DIMENSIONS IN MILLIMETERS

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