ATS672LSB

Self-Calibrating Gear Tooth Sensor with 9-Bit Signal Capture

Discontinued Product

These parts are no longer in production The device should not be purchased for new design applications. Samples are no longer available.

Date of status change: May 1, 2006

Recommended Substitutions:

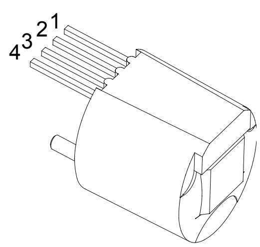
NOTE: For detailed information on purchasing options, contact your local Allegro field applications engineer or sales representative.

Allegro® MicroSystems, Inc.

ATS672LSB

Self-Calibrating Gear Tooth Sensor with 9-Bit Signal Capture

Package SB, 4-pin SIP



1. VCC
2. VOUT
3. Test pin (tie to GND)
4. GND

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{CC} .... **28 V**
Reverse-Supply Voltage, V_{RCC} .... **–18 V**
Reverse-Output Voltage, V_{ROUT} .... **??? V**
Continuous Output Current, I_{OUT} .... **20 mA**
Reverse Output Current, I_{ROUT}...................... **50 mA**
Operating Temperature
  Ambient, T_A,............................... **–40ºC to 150ºC**
  Maximum Junction, $T_{J(max)}$........................**170ºC**
  Maximum Junction ≤ 100 hr, $T_{J(max)}$ **180ºC**
Storage Temperature, T_S .... **–65ºC to 170ºC**
Package Thermal Resistance, $R_{\theta JA}$ .... **150 °C/W**

The ATS672 true zero-speed gear tooth sensors provide manufacturer-friendly solutions for digital gear tooth sensing applications, through an optimized configuration of Hall-effect IC and magnet, packaged together in a single SIP (Single In Line Package) module. The SIP consists of an overmolded enclosure, which encapsulates a samarium cobalt magnet, a pole piece, and a true zero-speed Hall-effect IC that has been optimized to the magnetic circuit. This package can be easily assembled and used in conjunction with gears of various shapes and sizes.

The ATS672 sensor incorporates a single-element Hall-effect IC that switches in response to the magnetic signal created by a ferrous target (the gear). The IC contains a sophisticated digital circuit designed to eliminate the detrimental effects of magnet and system offsets. Signal processing is used to provide zero-speed performance, independent of air gap, and also to dynamically adapt device performance to the typical operating conditions found in automotive applications, such as reducing sensitivity to vibration. High resolution (9 bit) peak-detecting DACs are used to set the adaptive switching thresholds of the device. Hysteresis in the thresholds reduces the negative effects of any anomalies in the magnetic signal (such as magnetic overshoot) associated with the targets used in many automotive applications. The ATS672 also includes a low-bandwidth filter that increases the noise immunity and the signal-to-noise ratio of the sensor. These features result in potential improvements in both the timing accuracy and the jitter performance of the device.

The ATS672LSB version is optimized for gear tooth sensing applications. The ATS672LSB-LT is optimized for cam sensing.

Features and Benefits

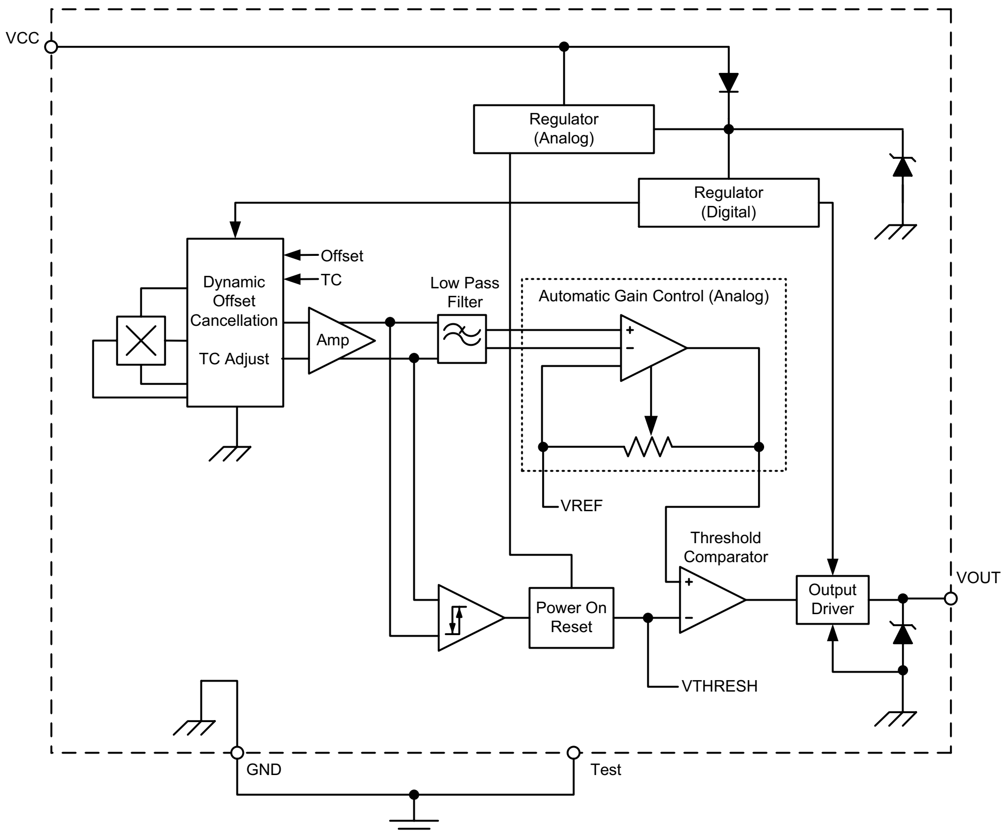
- Tight timing accuracy throughout temperature range
- True zero-speed operation
- Air gap-independent switch points
- Large operating air gaps
- Operation down to 3.3 V
- Digital output representing target profiles
- Single-chip solution for high reliability
- Small mechanical dimensions
- Optimized Hall-effect IC/magnetic systems
- AGC and reference-adjust circuits
- Undervoltage lockout

Use the following complete part numbers when ordering:

Part Number	Package	Application
ATS672LSB	4-pin plastic SIP	Gear tooth sensing
ATS672LSB-LT	4-pin plastic SIP	Cam sensing

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

Functional Block Diagram



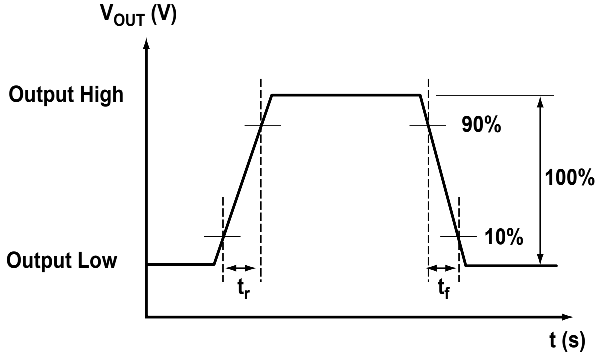
Allegro MicroSystems, Inc.
115 Northeast Cutoff, Box 15036
Worcester, Massachusetts 01615-0036 (508) 853-5000
www.allegromicro.com

OPERATING CHARACTERISTICS Valid at T_a = –40ºC to 150ºC, and V_{CC} within specification, unless otherwise noted

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Electrical Characteristics						
Supply Voltage	V_{CC}	Operating; $T_J < T_{J(max)}$	3.3	–	26.5	V
Reverse Supply Voltage	V_{RCC}	I_{RCC} = –5 mA, maximum	–	–	–18	V
Supply Zener Clamp Voltage	$V_{ZSupply}$	I_{CC} = 14 mA (≈$I_{CC(max)}$ + 3 mA); T_A = 25°C	28	–	–	V
Output Zener Clamp Voltage	$V_{ZOutput}$	I_{OUT} = 3 mA; T_A = 25°C	30	–	–	V
Supply Zener Current	$I_{ZSupply}$	Test conditions only; V_{CC} = 28 V	–	–	$I_{CC(max)}$ + 3	mA
Output Zener Current	$I_{ZOutput}$	V_{OUT} = 30 V	–	–	3	mA
Supply Current	I_{CC}	Output = OFF	3	6.5	11	mA
		Output = ON	3	6.5	11	mA
Power-On State Characteristics						
Power-On Time	t_{PO}	Gear Speed < 100 RPM; V_{CC} > 3.3 V	–	–	500	μs
Undervoltage Lockout	V_{UV}		–	–	< $V_{CC(min)}$	V
Output Stage						
Low Output Voltage	V_{LOUT}	I_{SINK} = 15 mA, Output = ON	–	0.2	0.45	V
Output Current Limit	I_{lim}	Output = ON; $T_J < T_{J(max)}$	25	45	70	mA
Output Leakage Current	I_{OFF}	Output = OFF; $V_{OUT} = V_{CC(max)}$	–	–	10	μA
Output Rise Time	t_r	R_{LOAD} = 500 Ω; C_{LOAD} = 10 pF; T_A = 25°C	–	0.9	5	μs
Output Fall Time	t_f	R_{LOAD} = 500 Ω; C_{LOAD} = 10 pF; T_A = 25°C	–	0.5	5	μs
Switch Point Characteristics						
Tooth Speed	S_{max}		0	–	8	kHz
Bandwidth	f – 3 dB		–	40	–	kHz
Operate Point	B_{OP}	% of peak-to-peak, referenced to tooth sensing signal; AG < AG_{Max}	–	30	–	%
Release Point	B_{RP}	% of peak-to-peak, referenced to tooth sensing signal; AG < AG_{Max}	–	40	–	%
Output Polarity	V_{OUT}	Valley opposite the sensor	–	HIGH	–	
		Tooth opposite the sensor	–	LOW	–	
Calibration						
Initial Calibration	C_I	Number of rising mechanical edges on the target that are required for accurate edge detection	–	2	3	
AGC Disable	C_f	Number of rising mechanical edges on the target that are required to complete the AGC calibration	–	–	3	

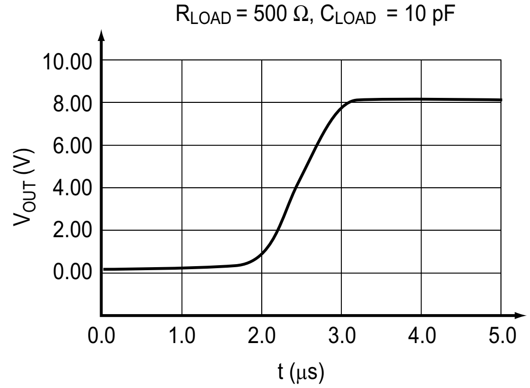
Allegro MicroSystems, Inc.
115 Northeast Cutoff, Box 15036
Worcester, Massachusetts 01615-0036 (508) 853-5000
www.allegromicro.com

Output Rise Time (t_r) and Fall Time (t_f)



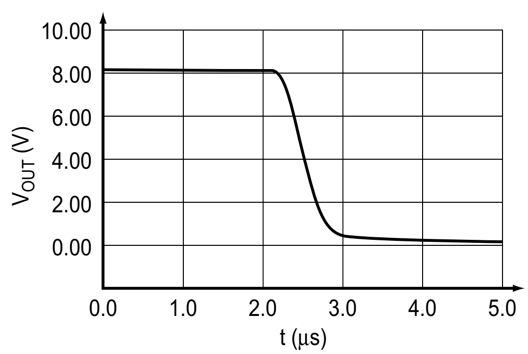
Output Voltage Rise Duration

R_{LOAD} = 500 Ω, C_{LOAD} = 10 pF



Output Voltage Fall Duration

R_{LOAD} = 500 Ω, C_{LOAD} = 10 pF

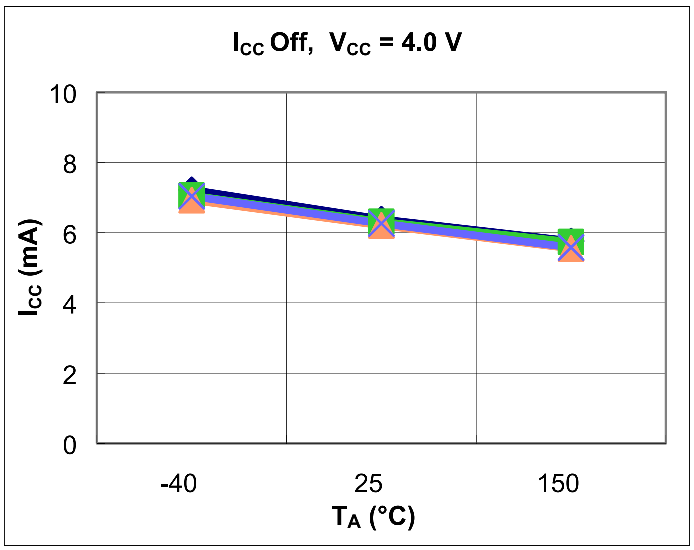


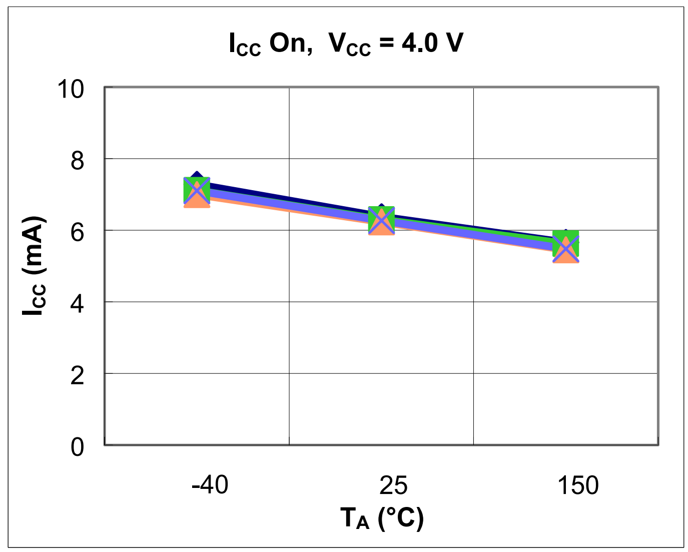
Allegro MicroSystems, Inc.
115 Northeast Cutoff, Box 15036
Worcester, Massachusetts 01615-0036 (508) 853-5000
www.allegromicro.com

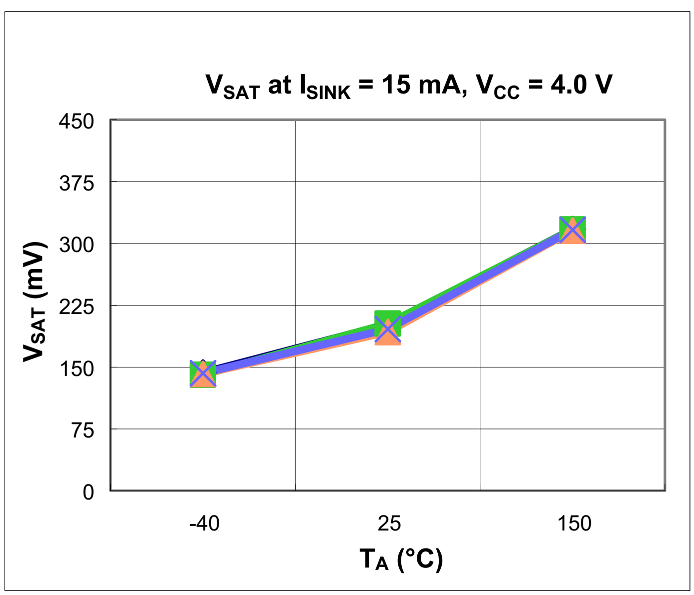
OPERATING CHARACTERISTICS using reference target 8X and test circuit #1; air gap within AG range, and over rated ambient temperature range, unless otherwise noted

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Relative Timing Accuracy*	T_{ICRel}	During initial calibration; rising and falling mechanical edges; RPM = 1000; gear eccentricity < 0.1 mm	–	3	6	deg.
	T_{Rel}	After initial calibration; rising mechanical edge; RPM = 1000; gear eccentricity < 0.1 mm	–	0.3	0.6	deg.
		After initial calibration; falling mechanical edge; RPM = 1000; gear eccentricity < 0.1 mm	–	0.5	0.8	deg.
Operational Air Gap Range	AG	Output switching: Running mode only	–	0.5	2.5	mm

*Relative Timing Accuracy range is the change in edge position over the AG range and the device operating temperature range.







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

Functional Description

POR. (Power-On Reset) Allows complete reset to the original power-on state, when initial calibration occured, regardless of the state of the device immediately prior to POR.

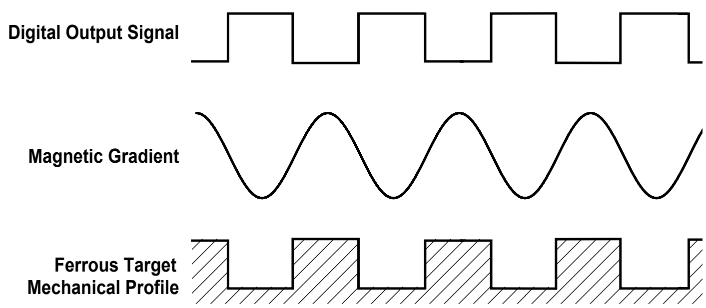
TC. (Temperature Coefficient) This supports fine tuning of the ATS672 for flat parametric performance over the full rated operating temperature range.

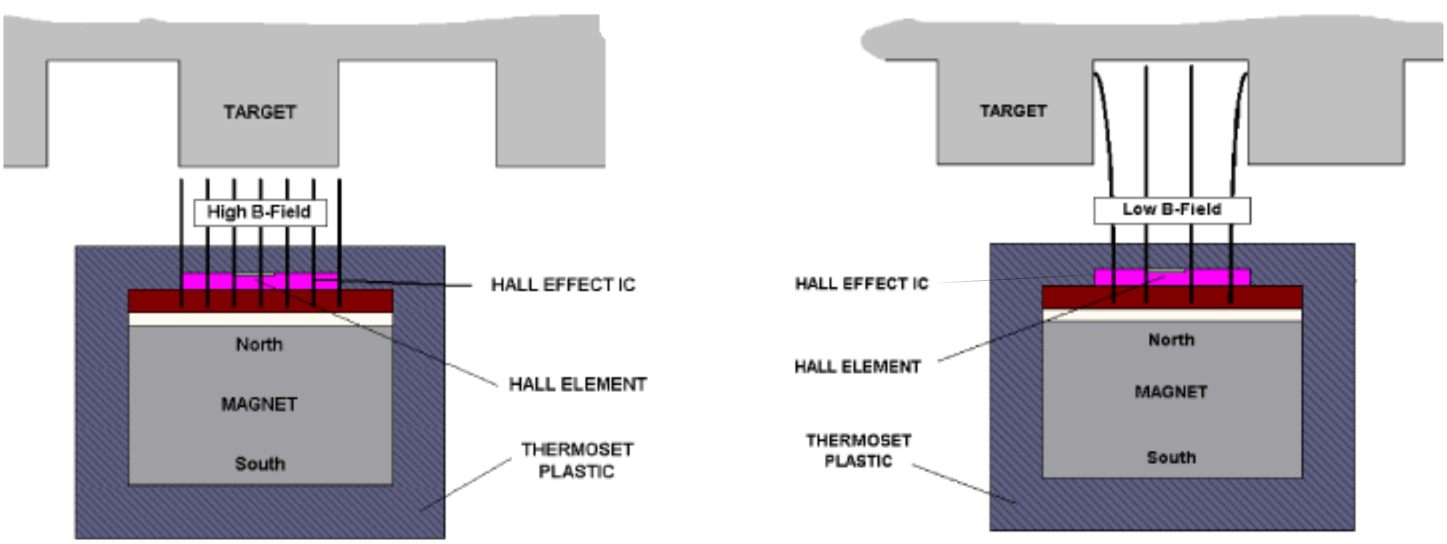
Sensor Integration. The ATS672 contains a self-calibrating Hall-effect IC that possesses temperature compensated amplifier circuitry and a voltage regulator that provides supply noise rejection over the operating voltage range. The Hall transducer and the electronics are integrated on the same silicon substrate using a proprietary BiCMOS process. Changes in temperature do not greatly affect this device due to the stable amplifier design and the offset rejection circuitry.

Assembly Description. The ATS672 is integrally molded into a plastic body that has been optimized for size, ease of assembly, and manufacturability. High operating temperature materials are used in all aspects of construction.

Operation. When proper power is applied to the sensor, it is capable of providing digital information that is representative of the profile of a rotating gear. No additional optimization is needed and minimal processing circuitry is required. This ease of use should reduce design time and incremental assembly costs for most applications.

Sensing Technology. The sensor contains a single-chip Hall-effect sensor IC, a 4-pin leadframe, and a specially-designed rare earth magnet. The Hall IC possesses a Hall element that measures the magnetic gradient created by the passing of a ferrous object. The difference in the magnetic gradients created by a tooth and valley allow the generation of the digital output signal. The following output diagram corresponds to a sensor with the standard polarity.





Sensing technology. As the target moves by the sensor, there is a change in the magnetic flux density, B, which is measured in gauss (G). The left panel shows the effect of a tooth opposite the sensor, a higher B. The right panel shows the effect of a valley, a lower B.

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

Start-Up Detection. The ATS672 generates a digital output transition when the first rising or falling mechanical edge is detected after being powered-on, indicating when the first significant motion in the target is detected.

Undervoltage Lockout. When the supply voltage falls below the minimum operating voltage, V_{CCUV}, the device turns off. It then stays off, regardless of the state of the magnetic field, until an operating range V_{CC} is restored. It then turns on again. This lockout feature prevents false signals, caused by undervoltage conditions, from propagating to the output of the sensor.

Power Supply Protection. The device contains an on-chip regulator and can operate over a wide V_{CC} range. For devices that need to operate from an unregulated power supply, transient protection must be added externally. For applications using a regulated line, EMI/RFI protection may still be required.Contact Allegro Microsystems for information on the circuitry needed for compliance with various EMC specifications.

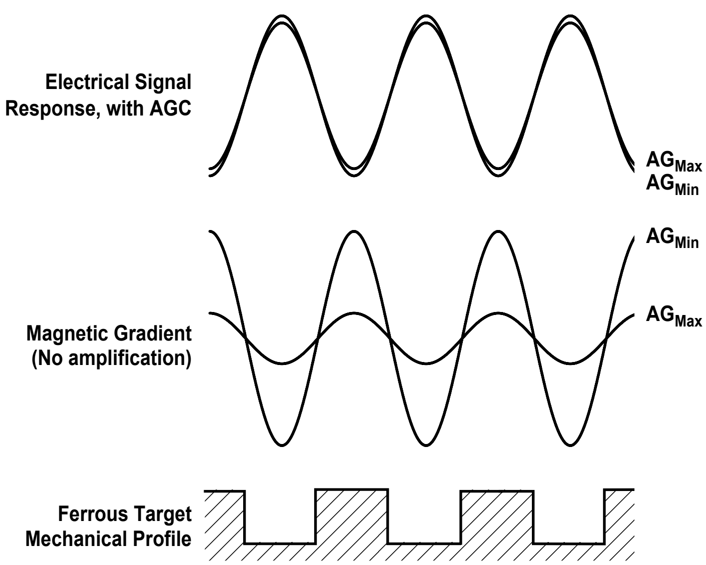
Automatic Gain Control (AGC). The patented self-calibrating circuitry is unique. Each time the device is powered-on, the device starts measuring the peak-to-peak magnetic gradient. The gain of the sensor is automatically adjusted, keeping the internal electrical signal amplitude constant over the air gap range, AG, of the device. This feature provides consistent operational characteristics independent of variances in the air gap.

Switch Points. Switch points are the levels of magnetic flux density, B, which trigger switch turn-on and turn-off. When B exceeds a certain limit, referred to as the Operate point (B_{op}), the trigger provides a clean transition from off to on. When the magnetic field falls below B_{op} by a certain limit, referred to as the Release point, B_{rp}, the trigger provides a clean transition from on to off.

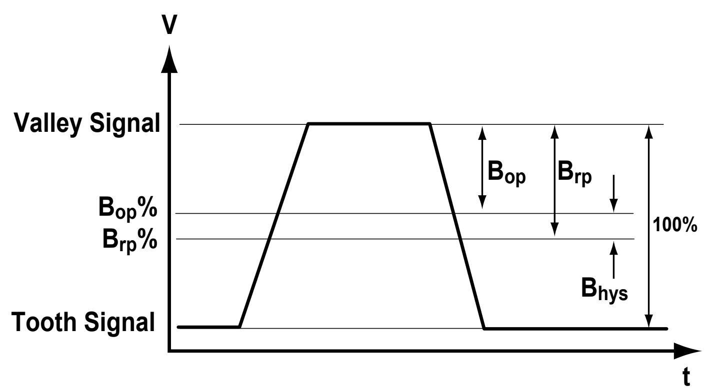
In the ATS672, switch points are established dynamically as a percentage of the amplitude of the normalized magnetic signal. Two DACs track the peaks of the normalized magnetic signal, and the switching thresholds are established at fixed percentages of the two DAC values. The values of the thresholds have been carefully selected to provide the most accurate and consistent switching where the signal is steepest and least affected by air gap variation.

The figure below graphically demonstrates the establishment of the switching threshold levels.

The low hysteresis of 10% provides high performance over the full AG, and immunity to false switching due to noise, vibration, backlash, or other transient events.



Automatic Gain Control (AGC). The AGC function corrects for variances in the air gap. Differences in the air gap affect the magnetic gradient, but AGC prevents that from affecting device performance.



Switch Points. The ATS672 design minimizes hysteresis, B_{hys}.

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

Application Information

For additional general application information, visit the Allegro MicroSystems Web site at www. allegromicro.com.

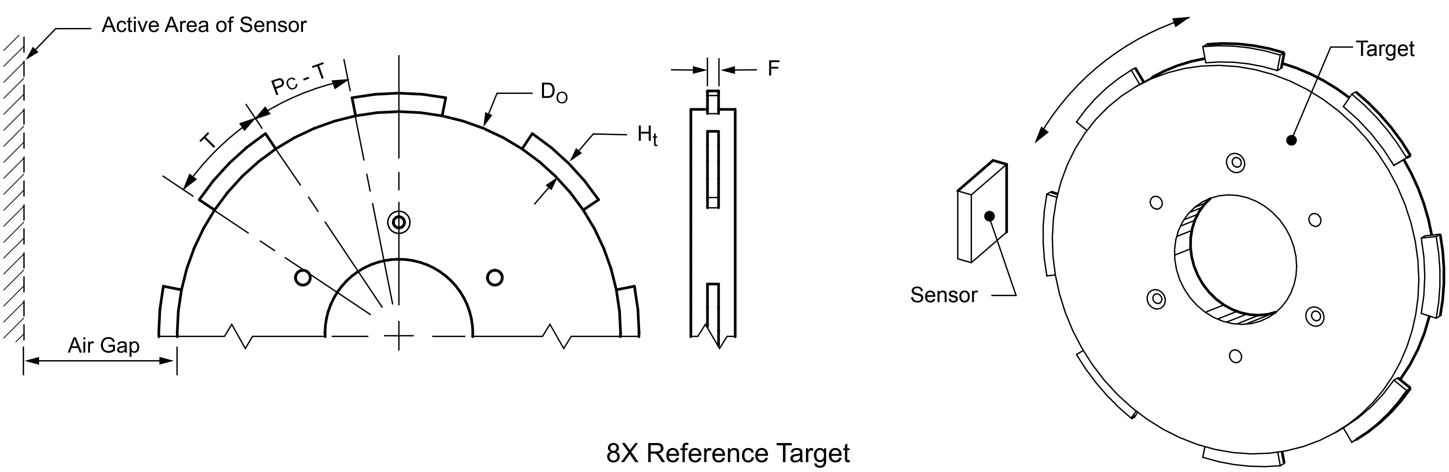
Target Design

The Hall-effect sensor can detect variations in magnetic flux density generated by features of a target. To distinguish between two features of a target, such as between a tooth and a valley of a spur gear, there must be a minimum differential of 120 G in the magnetic flux densities corresponding to the features, as measured at the sensor.

The target must be mounted with an air gap in the range AG, the distance between the target object and the plane of the Hall-effect sensor as installed. In general, the nearer a target feature is to the active area of the sensor, the greater the magnetic flux density at the sensor.

The following figures and table specify a design that can be used to construct a reference target. The target represents a ferrous spur gear, with uniform tooth and valley widths. The target would be mounted so that its axis of rotation is parallel to the plane of the Hall-effect sensor element, and centered on the element. When the target is produced to the specifications listed in the Reference Target column of the table, the required differential (tooth peak to valley) in magnetic flux densities is generated.

Also in the table, the Minimum Required for TPOS column provides specifications for a similar application. These values are the minimum required for the TPOS function to operate accurately, as defined in the Operating Characteristics table.



8X Reference Target

Reference Target Characteristics

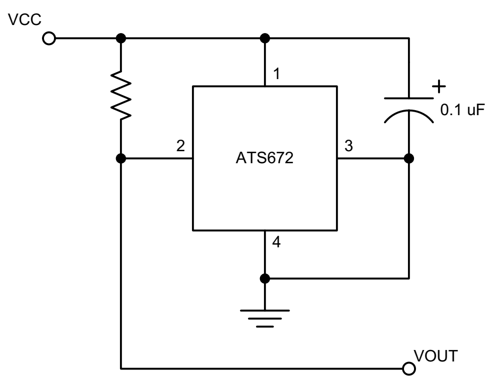
Characteristic	Symbol	Description	Reference Target 8X Only	Minimum Required for TPOS	Units
Material		Target has uniform composition	CRS1018	–	–
Diameter	D_O	Diameter of target, to valley	120	–	mm
Tooth Thickness	F	Breadth of tooth, with respect to sensor	6	5	mm
Tooth Height	H_t	Height of tooth, measured from the valley (D_O)	5	5	mm
Tooth Width	T	Width of tooth	22.5*	5	deg.
Valley Width	$P_C – T$	Width of valley, with P_C = pitch of teeth	22.5*	13	deg.

*Resulting arc measures 23.6 mm in length at D_O

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

Typical Circuit Design

The following circuit is the most basic configuration required for proper device operation. A pull-up resistor is used.

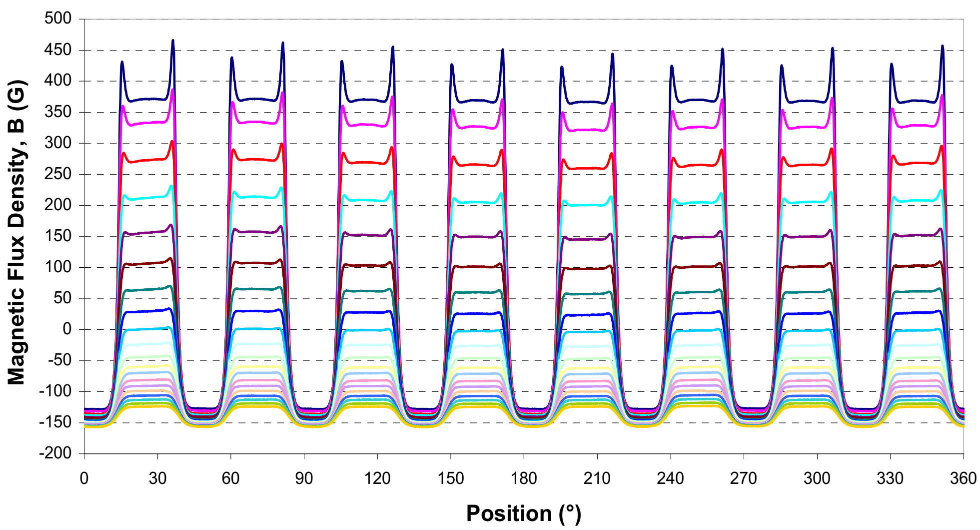


Sensor/Target Evaluation

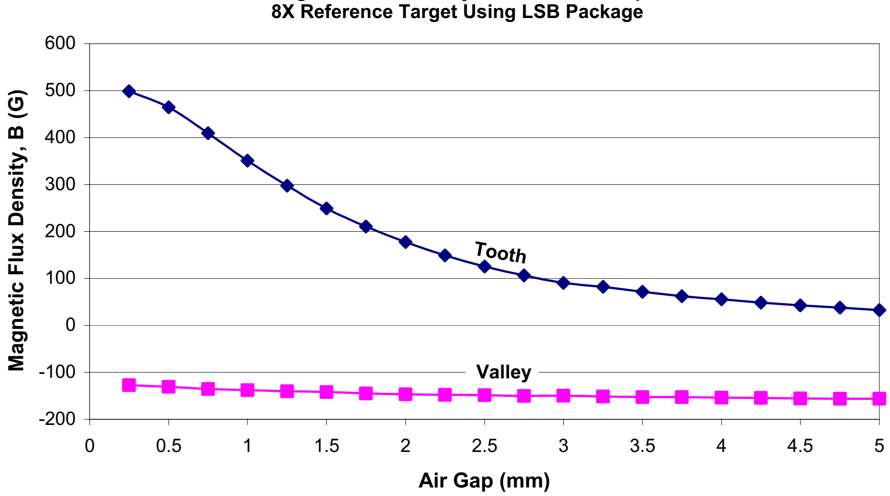
In order to establish the proper operating specification for a particular sensor/target configuration, a systematic evaluation of the magnetic circuit should be performed. The first step is the generation of a magnetic map of the target. By using a calibrated device, a magnetic signature of the system is made. A magnetic map of the 8X reference target, created using the LSB sensor package, is shown below.

From this map data, a pair of curves can be derived that describe the tooth and valley magnetic fields versus air gap. Knowing the minimum amount of magnetic flux density that guarantees operation of the sensor, one can determine the maximum operational air gap of the sensor/target system.

Magnetic Map, 8X Reference Target, Using LSB Package



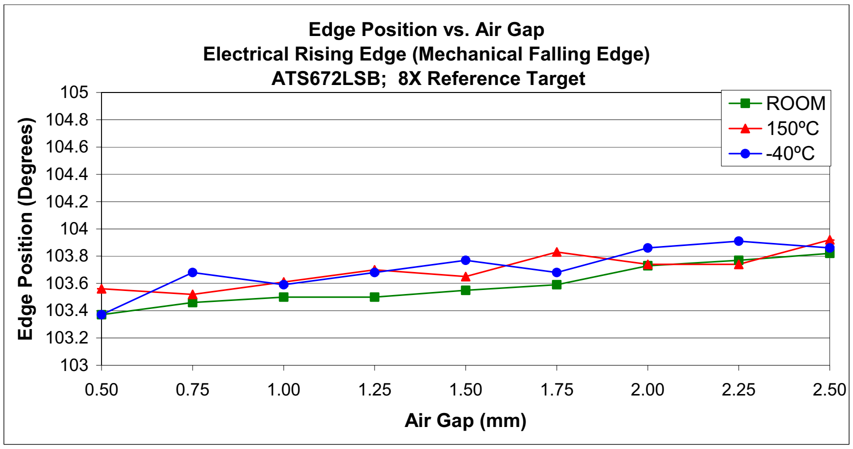
Magnetic Flux Density, B, Versus Air Gap
8X Reference Target Using LSB Package

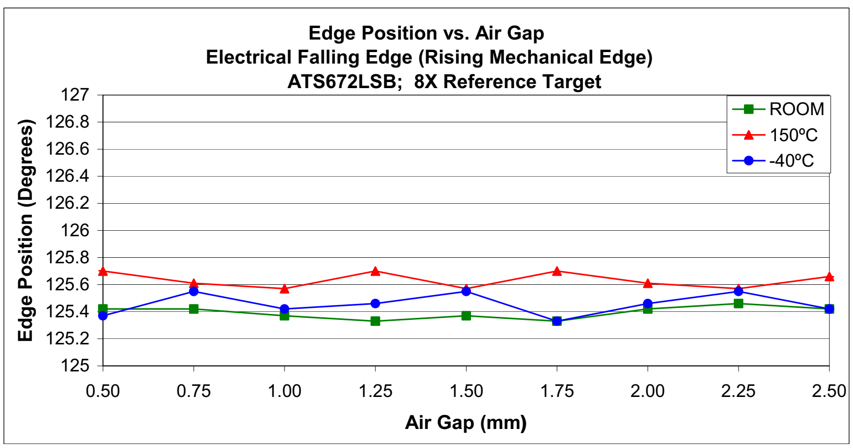


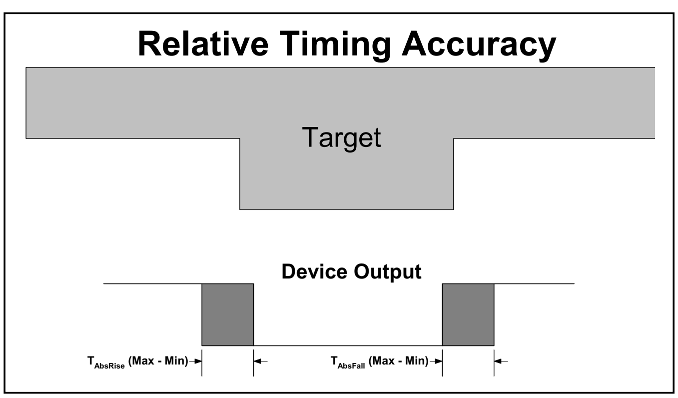
Allegro MicroSystems, Inc.
115 Northeast Cutoff, Box 15036
Worcester, Massachusetts 01615-0036 (508) 853-5000
www.allegromicro.com

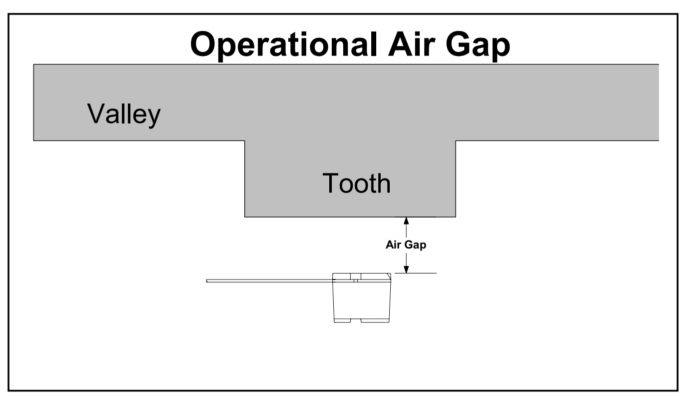
SENSOR EVALUATION: ACCURACY

The self-calibration algorithm allows the sensor to adapt to system changes such as air gap increase. However, major changes in air gap can adversely affect switching performance. When characterizing sensor performance over a significant air gap range, be sure to power-off and then power-on the device at each air gap. This ensures that self-calibration occurs for each installation condition. See the Operating Charactersitics table for information on timing accuracy performance.









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

Temperature Compensation

The device should be operated at or below the maximum junction temperature of the device, $T_{J(max)}$ (see the Absolute Maximum Ratings section, on page 1). The actual operating T_J of the device is affected by several factors. Under certain combinations of peak conditions (corresponding to the gray area of the Power De-Rating Curve chart), operation may require power de-rating or heat sinking.

The relevent factors are characteristic of the device and package, as well as the application, including the effect of adjacent external sources of heat. The Package Thermal Resistance, $R_{\theta JA}$, indicates the resitance to heat transfer from the heat-generating portions of the die (the "junction") through all paths to the ambient air. This includes heat sinking through the PCB, as well as direct radiation from the die through the package, $R_{\theta CA}$. Thermal information on packages is available on the Allegro Web site.

The Allowable Power Dissipation, P_D, represents the amount of power that can be applied to the device at a given $R_{\theta CA}$ and ambient temperature, T_A, without causing the temperature of the die to exceed , $T_{J(max)}$. This section presents a procedure for correlating these factors with operating voltage, V_{CC}, and operating current, I_{CC}, to estimate their effect on T_J.

If the estimated operating T_J exceeds $T_{J(max)}$, then power levels can be reduced or external heat sinking can be applied. Typically, V_{CC} is the factor reduced, to accommodate the required T_A. A power de-rating curve can be constructed, representing the maximum allowable V_{CC} per T_A.

If the calculated V_{CC} exceeds the power de-rating curve at the required T_A, and heat sinking is not preferred, estimate the amount to reduce V_{CC}. This can be estimated through calculating $P_{D(max)}$, the maximum allowable P_D for the given device and package. $P_{D(max)}$ is related to $R_{\theta JA}$ and T_A. The following formulas represent the fundamental relationships used to calculate the V_{CC} adjustment, based on the temperature effect, ΔT.

$$T_J = T_A + \Delta T \qquad (1)$$

where ΔT denotes the increase in T_J due to power dissipation within the device.

$$\Delta T = P_D \times R_{\theta JA} \qquad (2)$$

$$P_D = V_{CC} \times I_{CC} \qquad (3)$$

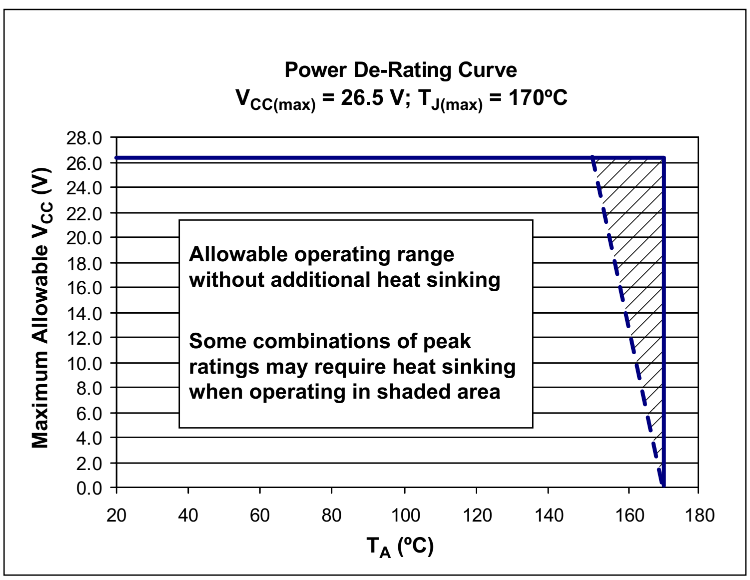
Examples for estimating V_{CC} are provided on the next page.

These formulas and results can also be used to estimate T_J. For example, given common conditions such as: T_A= 25°C, V_{CC} = 5 V, $I_{CC(on)}$ = 6.5 mA, and $R_{\theta JA}$ = 150 °C/W then:

$$P_D = V_{CC} \times I_{CC(on)} = 5\text{ V} \times 6.5\text{ mA} = 32.5\text{ mW}$$

$$\Delta T = P_D \times R_{\theta JA} = 32.5\text{ mW} \times 150\text{ °C/W} = 4.9\text{°C}$$

$$T_J = T_A + \Delta T = 25\text{°C} + 4.9\text{°C} = 29.9\text{°C}$$



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

Example: V_{CC} Adjustment, Package SE

Observe the absolute maximum ratings for the package, specifically:

$R_{\theta JA}$ = 150 °C/W
$T_{J(max)}$ = 170°C

Also observe the characteristic operating maximums:

$V_{CC(max)}$ = 26.5 V
$I_{CC(max)}$ = 11 mA

For a given T_A (e.g., 150°C), first calculate the Maximum Allowable Power Dissipation, $P_{D(max)}$. Invert equation 1:

$$\Delta T_{max} = T_{J(max)} - T_A = 170°C - 150°C = 20°C$$

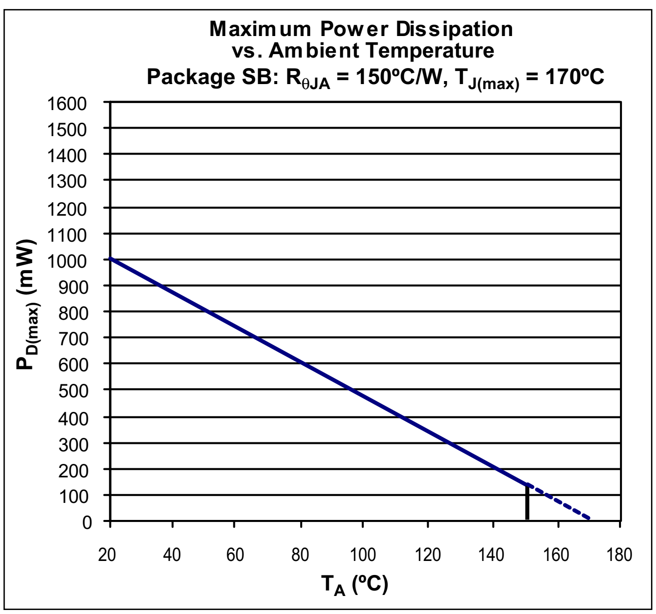
This provides the allowable increase to T_J resulting from internal power dissipation. Then, invert equation 2:

$$P_{D(max)} = \Delta T_{max} \div R_{\theta JA} = 20°C \div 150\ °C/W = 133\ mW$$

This provides the corresponding allowable increase in power level. Finally, invert equation 3 to determine the corresponding supply voltage V_{CC}:

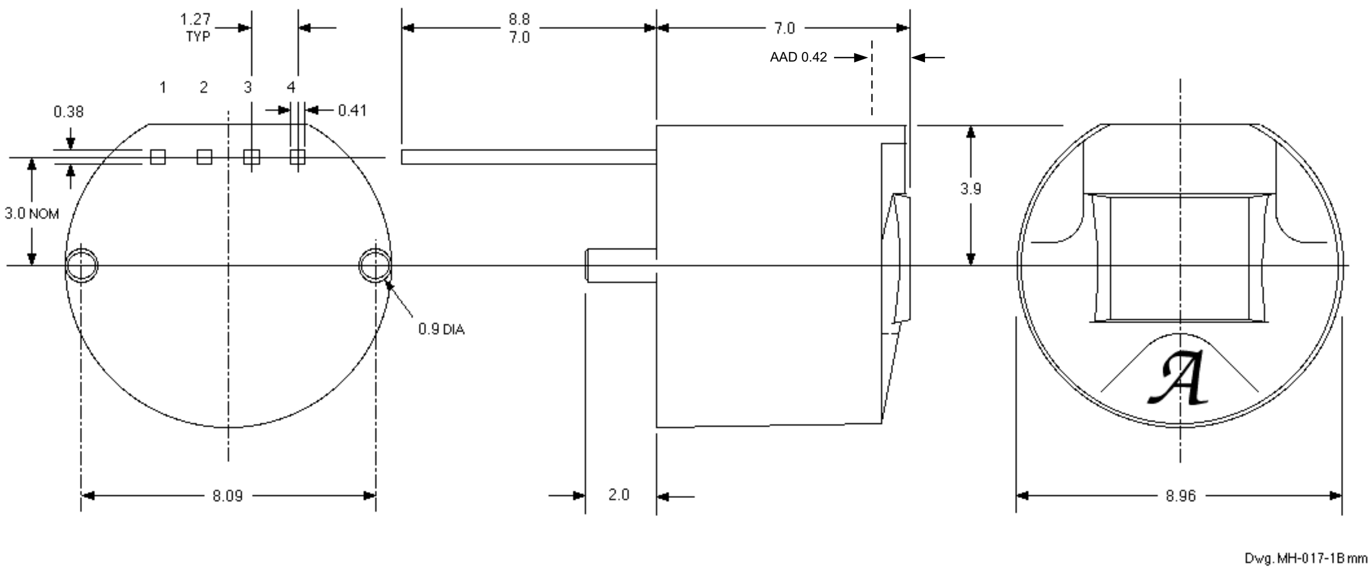
$$V_{CC} = P_{D(max)} \div I_{CC(max)} = 133\ mW \div 11\ mA = 12\ V$$

The result indicates that the device and package can dissipate adequate amounts of heat at voltages up to 12 V, at T_A = 150ºC. Because $V_{CC(max)}$ is more than the calculated V_{CC}, however, the device requires additional heat sinking for operation between the calculated V_{CC} and $V_{CC(max)}$, under these conditions. If the calculated V_{CC} were greater than or equal to $V_{CC(max)}$, then operation up to $V_{CC(max)}$ would not require additional heat sinking.



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

Package SB, 4-pin SIP



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

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.

Allegro MicroSystems, Inc. reserves the right to make, from time to time, such departures from the detail specifications as may be required to permit improvements in the performance, reliability, or manufacturability of its products. Before placing an order, the user is cautioned to verify that the information being relied upon is current.

Allegro products are not authorized for use as critical components in life-support devices or systems without express written approval.

The information included herein is believed to be accurate and reliable. However, Allegro MicroSystems, Inc. assumes no responsibility for its use; nor for any infringement of patents or other rights of third parties which may result from its use.