ATS645LSH

Preliminary – Subject to Change

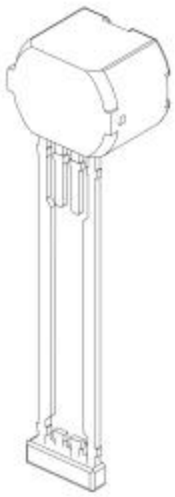
PRELIMINARY DATASHEET
(subject to change without notice)

True Zero Speed Miniature Gear Tooth Sensor

The ATS645LSH is an optimized Hall effect sensing integrated circuit and magnet combination that provides a user-friendly solution for true zero-speed digital gear-tooth sensing in two-wire applications. The sensor consists of a single-shot molded plastic package that includes a samarium cobalt magnet, a pole piece, and a Hall effect IC that has been optimized to the magnetic circuit. This small package can be easily assembled and used in conjunction with a wide variety of gear shapes and sizes.

The integrated circuit incorporates a dual element Hall effect sensor and signal processing that switches in response to differential magnetic signals created by ferrous gear teeth. The circuitry contains a sophisticated digital circuit to eliminate magnet and system offsets and to achieve true zero speed operation (ref U.S. Patent 5,917,320). A-D and D-A converters are used to adjust the device gain at power up and to allow air gap independent switching.

The regulated current output is configured for two wire applications and the sensor is ideally suited for obtaining speed and duty cycle in ABS and transmission application gear-tooth-based configurations.



Pin 1: Supply
Pin 2: No connection
Pin 3: Test pin
Pin 4: Ground

ABSOLUTE MAXIMUM RATINGS

Supply Voltage,
V_{CC} . . . . . 26.5 V*
Reverse Supply Voltage,
V_R . . . . . –18 V
Operating Temperature Range,
T_A . . . . . –40 °C to 150 °C*
Storage Temperature,
T_S . . . . . 170 °C
Package Power Rating,
ϑ_{JA} . . . . . 126 °C/W
Maximum Junction Temperature,
T_{Jmax} . . . . . 165 °C

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

FEATURES

- Fully optimized differential digital gear tooth sensor
- Single chip sensing IC for high reliability
- Internal current regulator for 2 wire operation
- Small mechanical size (8 mm dia x 5.5 mm length)
- Air gap independent switch points
- Digital output representing gear profile
- Precise duty cycle signal with temperature
- Large operating air gaps
- Automatic Gain Control (AGC)
- Automatic Offset Adjustment circuit
- True zero speed operation
- Under-voltage lockout
- Wide operating voltage range
- Defined power-on state

CHARACTERISTICS

Valid over operating temperature range and Supply Voltage within specification unless otherwise noted.

Characteristics	Symbol	Test Conditions	Limits			
			Min.	Typ.	Max.	Units
ELECTRICAL CHARACTERISTICS						
Supply Voltage	V_{CC}	Operating, T_J < 165°C	4.0		24	V
Under Voltage Lockout	$V_{CC(UV)}$	V_{CC} 0 → 5 V	-	-	<Vcc_{Min}	V
[1]Supply Zener Clamp Voltage	V_Z	I_{ZT} = 1 mA	28	32	-	V
Max Zener Pulse Current	I_Z	t=20mS Pulse Mode	-	-	50	mA
Supply Zener Resistance	R_Z		-	50	-	Ω
Supply Current ATS645LSH – I1	I_{CC}	Low Current State: Icc_{Low}	4.0	6	8.0	mA
		High Current State: Icc_{High}	12.0	14.0	16.0	mA
Supply Current ATS645LSH – I2	I_{CC}	Low Current State: Icc_{Low}	5.9	7	8.4	mA
		High Current State: Icc_{High}	11.8	14.0	16.8	mA
POWER-ON STATE CHARACTERISTICS						
Power-On State	S_{PO}	V_{CC} 0 → 5 V	-	Icc_{High}	-	-
[2]Power-On Time	t_{on}	Gear speed < 100 rpm	-	1	2	ms
OUTPUT STAGE						
Output Current Slew Rate	I_R	Icc_{High} → Icc_{Low}, Icc_{Low} → Icc_{High}, R_S = 100 Ω, C_S = 10 pF, 10 to 90%		10		mA/µs

[1] The zener is tested using a pulse method and is designed for transient protection, continuous operation may destroy the device.
[2] Power On Time is the time required to complete internal offset adjust. It does not include automatic gain control, which requires three tooth valley transitions to complete and is therefore RPM dependent.

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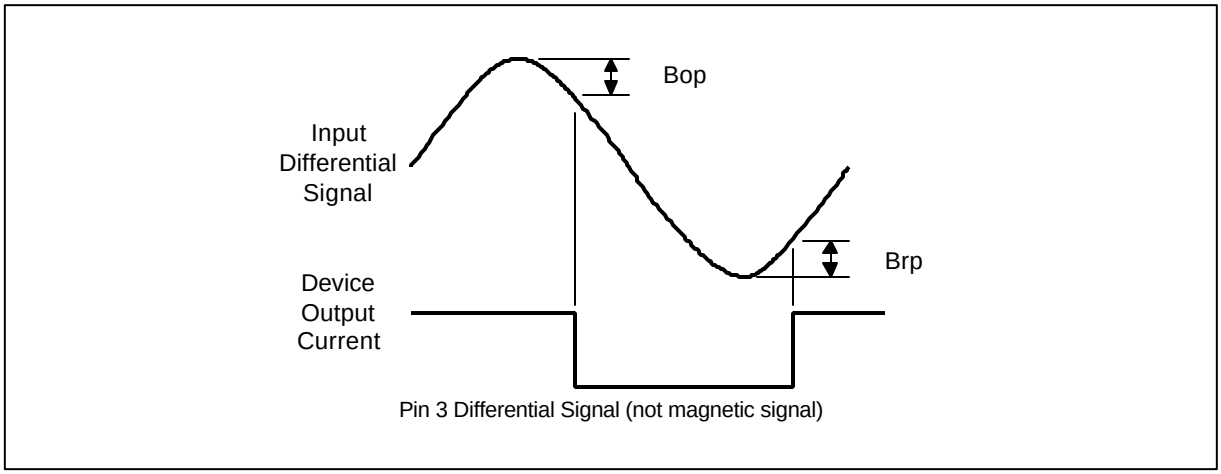
Operating Characteristics: Valid with Reference Target unless otherwise specified

Characteristics	Symbol	Test Conditions	Limits			
			Min.	Typ.	Max.	Units
SWITCH POINT CHARACTERISTICS						
Rotation Speed	S_{max}	Using Reference Target over Operating Air Gap Range	0		8K	RPM
Analog Signal Bandwidth	f-3db	-3dB Point	20	40		KHz
[1]Operate Point	Bop	$Icc_{High} \rightarrow Icc_{Low}$ Positive Peak referenced, AG < AG_{max}	-	100	150	mV
[1]Release Point	Brp	$Icc_{Low} \rightarrow Icc_{High}$ Negative Peak referenced, AG < AG_{max}	-	100	150	mV

Calibration						
Initial Calibration	C_I	Number of Rising Mechanical Edges for Accurate Edge Detection			3	Edges

DAC Characteristics						
Allowable User Induced Differential Offset		Output switching only; may not meet data sheet specifications	-60		60	G

SWITCH POINT DETAIL



[1] Bop and Brp should be adjustable with metal mask changes, limits max air gap but improves vibration immunity.

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Operating Characteristics:
Valid only if magnetic offset is within the Dynamic Offset Compensation DAC Range as specified above

Characteristics	Symbol	Test Conditions	Limits			
			Min.	Typ.	Max.	Units
OPERATING CHARACTERISTICS: Using Reference Target and Valid Over Operating Temperature Range						
[1]Operational Air Gap Range	Op_{AG}	Duty cycle within specification	0.5		2.75	mm
Switching Air Gap Range	Op_{MaxAG}	Output Switching: Duty cycle Not in Specification	3	-	-	mm
Duty Cycle Variation	DC	Wobble < 0.5mm Typical value at 1.5mm air gap Valid over operating air gap range	37	53	57	%
[2]Operating Signal Range	Sig	Duty cycle within Specification Wobble < 0.5mm	30	-	1000	G
[3]Minimum Operating Signal	Sig_{Min}	Output Switching: Duty Cycle Not in Specification	20	-	-	G

[1] Operating air gap is dependent on the available magnetic field. The available field is target geometry and materiel dependent and should be independently characterized. The field available from the reference target is given in the reference gear parameter section of the datasheet
[2] In order to remain in specification the magnetic signal must be larger than the minimum value specified, this includes the effect of target wobble.
[3] Duty cycle is not guaranteed to be in specification. Reference the Duty Cycle vs. Air Gap Over Temperature graph in the typical operating characteristics section of this document.

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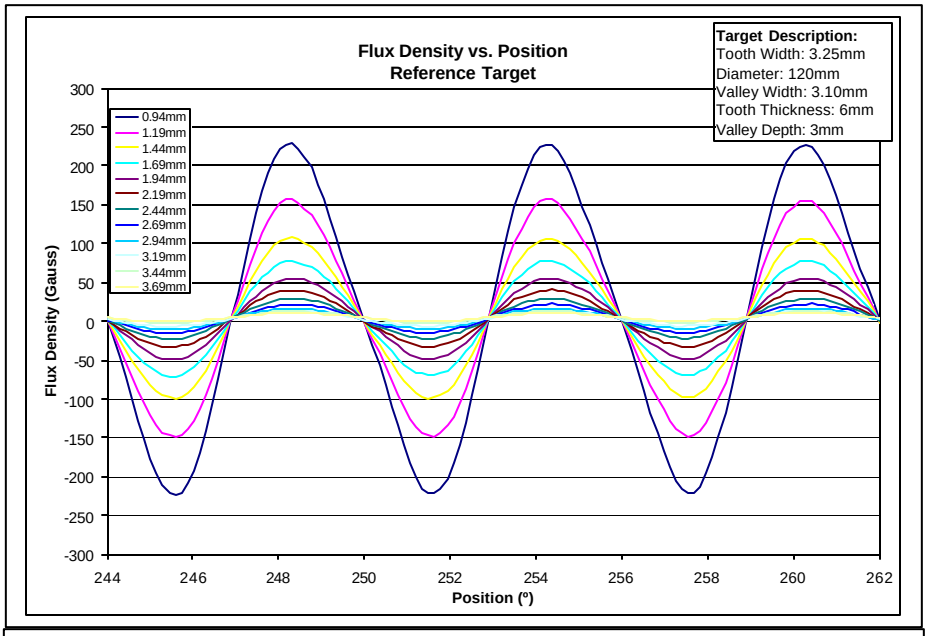
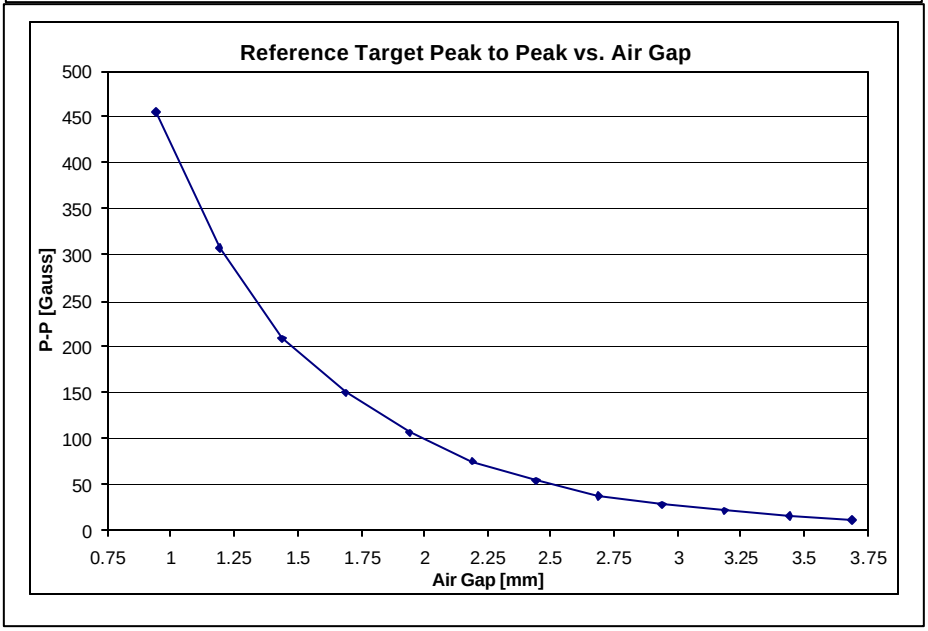
Reference Gear Parameters

REFERENCE GEAR DIMENSIONS (60-0)						
Diameter	G_d		-	120	-	mm
Thickness	G_t		-	6	-	mm
Tooth Width	T_w		-	3	-	mm
Valley Width	V_w		-	3	-	mm
Valley Depth	V_d		-	3	-	mm
Materiel		Low Carbon Steel				





Typical Operating Characteristics: Duty Cycle vs. Air Gap Over Temperature

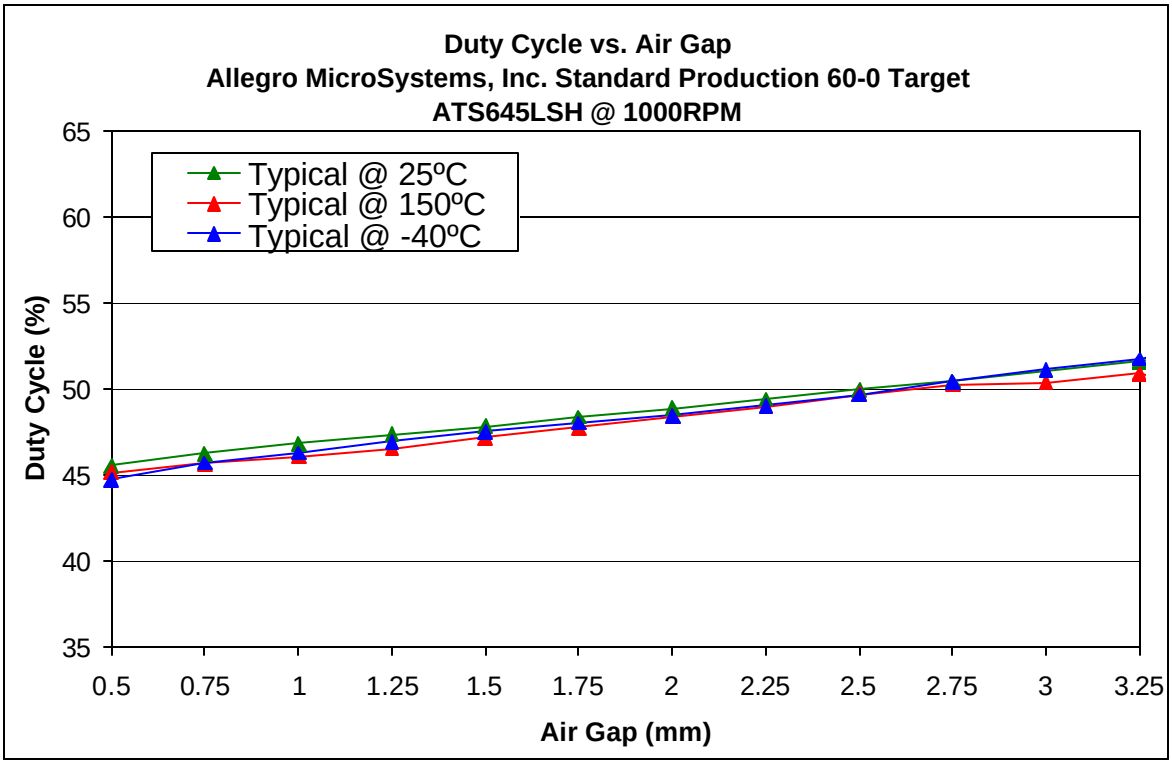


Figure #1: Duty Cycle vs. Air Gap Over Temperature with Reference Target and Orientation Given in Figure #2

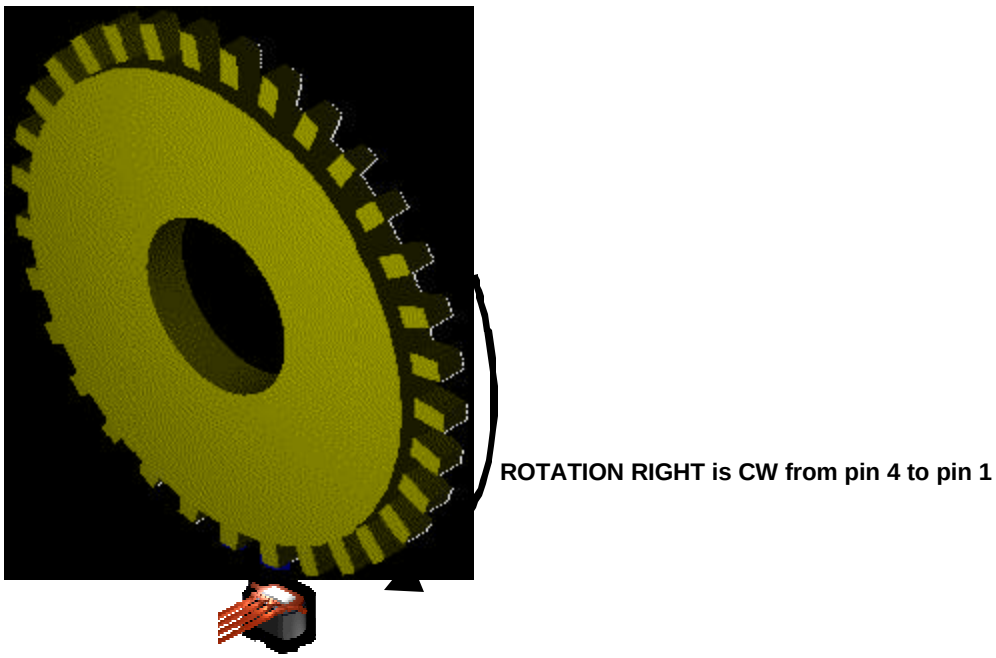


Figure #2: Sensor Orientation and Direction of Rotation of Reference Target for Duty Cycle Graph in Figure #1

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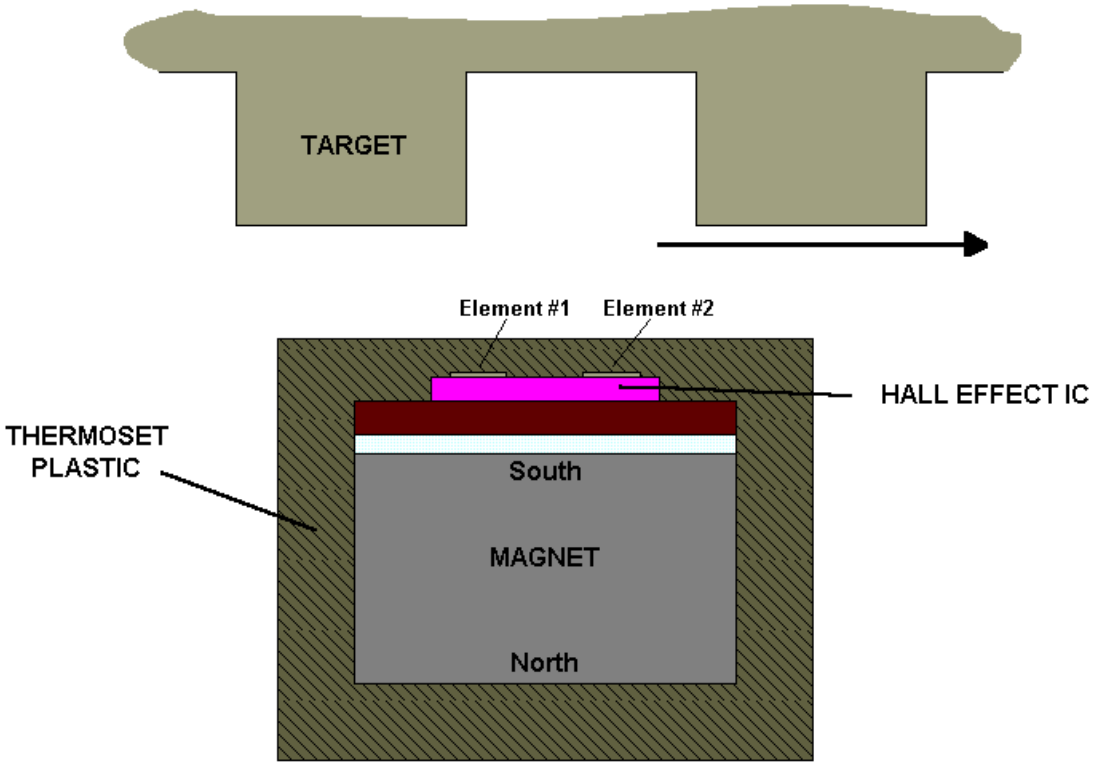
SENSOR DESCRIPTION

Assembly Description:
The ATS645LSH true zero speed gear tooth sensor is a Hall IC/magnet configuration that is fully optimized to provide digital detection of gear tooth edges. This sensor 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.

Sensing Technology:
The gear tooth sensor sub-assembly contains a single-chip differential Hall effect sensor IC, a Samarium Cobalt magnet, and a flat ferrous pole piece. The Hall IC consists of 2 Hall elements spaced 1.5 mm apart that measure the magnetic gradient created by the passing of a ferrous object. The two elements measure the magnetic gradient and convert it to an analog voltage that is then processed to provide a digital output signal.



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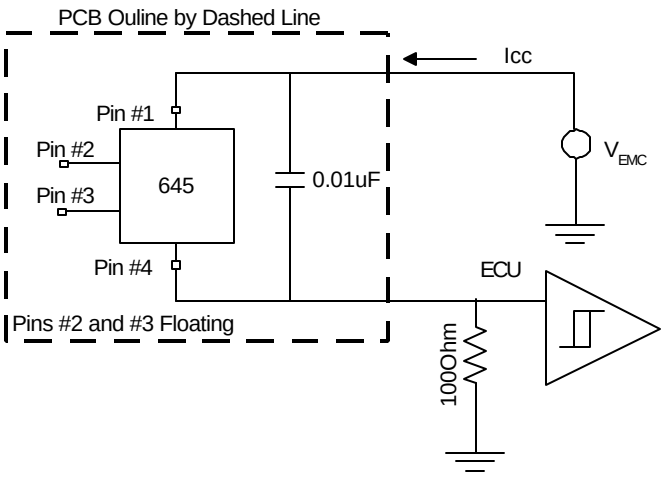
Transient Performance per ISO 7637-1

at T_A = 23 ±5°C
(Tested at Allegro test facility – for engineering reference only)

Pulse No.	Test	Performance Class at Test Level I	II	III	IV
1	Inductive turn off (negative)	-	-	-	C
2	Inductive turn off (positive)	-	-	-	A
3a	Capacitive/inductive coupling (neg)	-	-	-	A
3b	Capacitive/inductive coupling (pos)	-	-	-	A
4	Reverse battery	-	-	-	A
5	Load dumb	A	C	C	E
6	Ignition coil disconnect	-	-	C	E
7	Field decay (negative)	-	-	-	C

U_A = 13.5V for pulses 1, 2, 3a, 3b, 5, 6, 7 and 12V for pulse 4.

Test Circuit #1



Transient & EMC test circuit

Power supply voltage transients, or device output short circuits, may be caused by faulty connectors, crimped wiring harnesses, or service errors. The prevent catastrophic failure, internal protection against over-voltage, reverse voltage, and output overloads have been incorporated to meet the automotive 12 volt system protection requirements of ISO DP7637/1. A series-blocking diode or current-limiting resistor is required in order to survive pulse number six.

Performance Class Definitions

(for transient performance and EMC performance)

A – All functions of a device perform as designed during and after the exposure.

B – All functions of a device perform as designed during exposure; however, one or more of them may go beyond the specified limit tolerance. All functions return automatically to within normal limits after exposure is removed. Memory must remain Class A.

C – One or more functions of the device do not perform as designed during exposure but return automatically to normal operation after exposure is removed.

D – One or more functions of the device do not perform as designed during exposure and do not return to normal operation until exposure is removed and the device is reset by simple " operator" action.

E – One or more functions of the device do not perform as designed during and after the exposure and cannot be returned to proper operation without repairing or replacing the device.

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ELECTROMAGNETIC COMPATIBILITY (EMC) PERFORMANCE

at T_A = 23 ±5°C
(Tested at Allegro test facility – for engineering reference only)

TEM Cell Performance per ISO 11452-3

Test severity level
I = 50 V/m
II = 100 V/m
III = 150 V/m
IV = 200 V/m

Frequency Band (MHz)	Performance Class at Test Level I	II	III	IV
F1 (0.01 to 10)	–	–	–	A
F2 (0 to 30)	–	–	–	A
F3 (30 to 80)	–	–	–	A
F4 (80 to 200)	–	A	B	B

BCI per ISO 11452-4

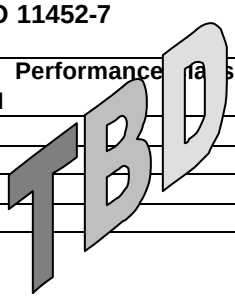
Test severity level
I = 25 mA
II = 50 mA
III = 75 mA
IV = 100 mA

Frequency Band (MHz)	Performance Class at Test Level I	II	III	IV
F1 (1 to 10)	–	–	–	A
F2 (10 to 30)	–	–	–	A
F3 (30 to 80)	–	–	–	A
F4 (80 to 200)	–	–	–	A
F5 (200 to 400)	–	–	–	A

Direct RF per ISO 11452-7

Test severity level
I = 100 mW
II = 200 mW
III = 300 mW
IV = 400 mW
V = 500 mW

Frequency Band (MHz)	Performance Class at Test Level I	II	IV	V
F1 (1 to 10)				
F2 (10 to 30)				
F3 (30 to 80)				
F4 (80 to 200)				
F5 (200 to 400)				



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MECHANICAL INFORMATION

Component	Material	Function	Value
Sensor Package Material	Thermoset Epoxy	Max. Temperature	170°C[1]
Leads	Copper, 0.016” dia, 0.050” spacing		
Lead Coating	Solder, Tin / Lead 90/10[2]		

[1] Temperature excursions of up to 225°C for 2 minutes or less are permitted.
[2] Industry accepted soldering techniques are acceptable for this sub-assembly as long as the indicated maximum temperatures for each component are not exceeded.

DEVICE QUALIFICATION PROGRAM

Test Name	Test Conditions	Test Length	# of Lots	Sample / lot	Comments
High Temperature Operating Life	AEC-Q100 #2 (JA108) Ta = 150°C, Tj = 165°C	408 hrs	1	77	
High Temperature Bake	AEC-Q100 #3 (JA103) Ta = 170°C	1000 hrs	1	77	
Temperature Humidity Bias	AEC-Q100 #5 (JA101) 85°C/85%RH	1008 hrs	1	77	
Autoclave	AEC-Q100 #6 (JA102)	96 hrs	1	77	
Temperature Cycling	AEC-Q100 #7(JA104)	500 cycles	1	77	-65°C to +160°C, 30 sec. transition, 30 minute dwell
ESD	AEC-Q100 #20 (AEC-Q100-002, AEC-Q100-003)	-	1	3/model/step	Passes ±6kV all pin combinations: Human Body Model
Early Life Failure Rate	AEC-Q100 #25 (AEC-Q100-008)	150°C/24 hrs	1	800	

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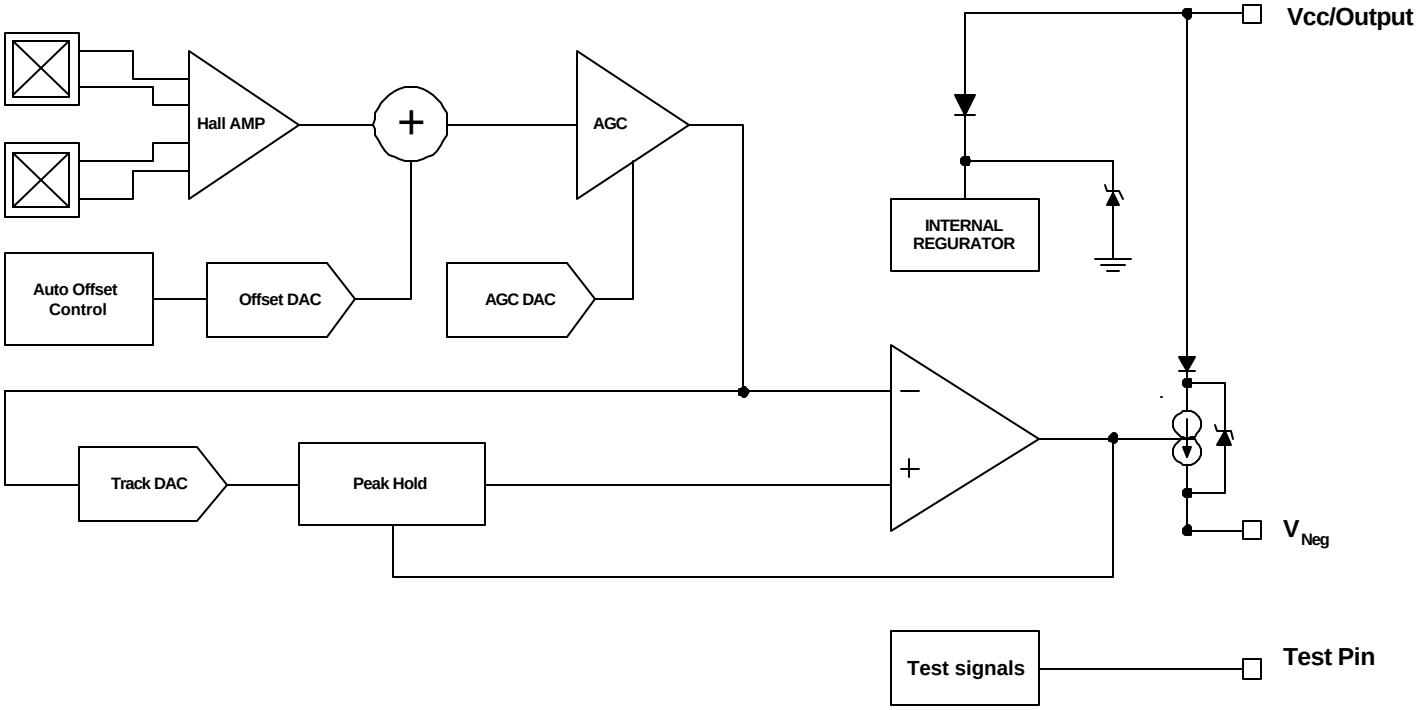
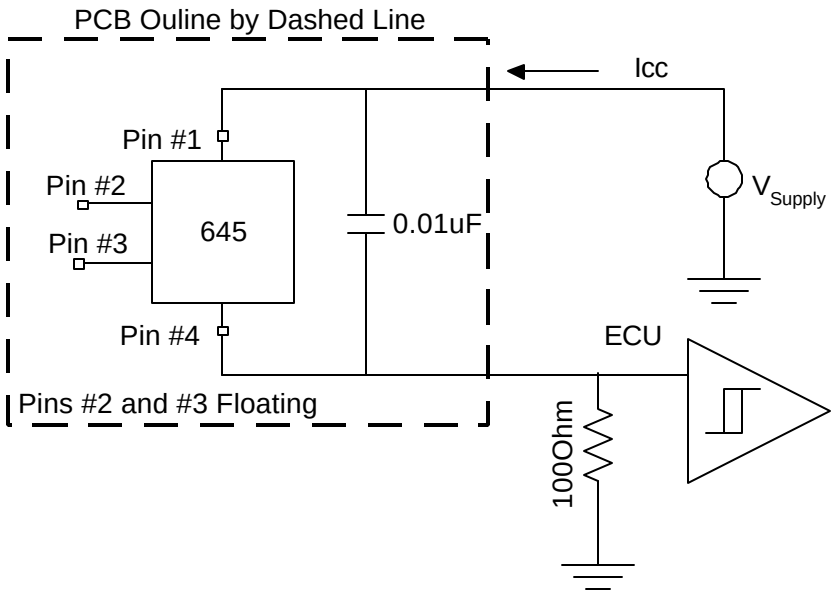
Functional block diagram



Typical Application Circuit



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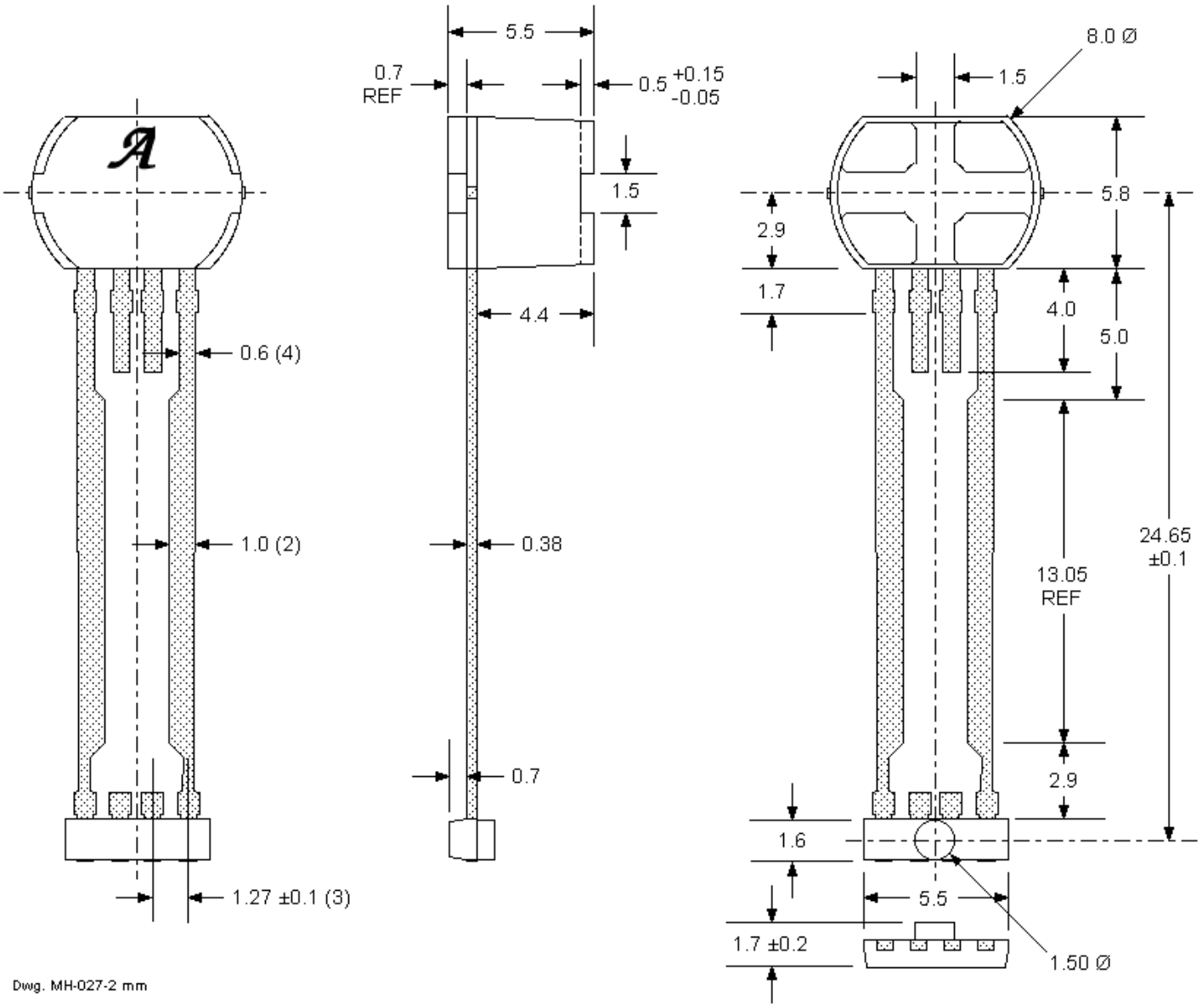
SENSOR PACKAGE

LSH PACKAGE
REFERENCE DIMENSIONS ONLY



Dwg. MH-027-2 mm

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