ALLEGRO microsystems

A19352

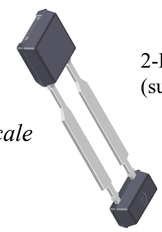
High-Accuracy GMR Wheel Speed and Direction Sensor IC with Advanced AK Protocol

FEATURES AND BENEFITS

- **GMR** elements provide highly repeatable, ultra-low jitter signal for iTPMS and ADAS applications
- **Wide Air Gap** capability eases mechanical mounting tolerance requirements to enable lower system cost
- **Advanced AK Protocol** with additional safety features
- **SolidSpeed Digital Architecture** provides robust, adaptive performance with advanced algorithms
- **ASIL Compliant:** ASIL B safety element out-of-context (SEooC) developed in accordance with ISO 26262, when used as specified in the safety manual
- **Integrated** diagnostics and certified safety design process

A2 SiL ISO 26262 ASIL Compliant — SOLIDSPEED DIGITAL ARCHITECTURE — BY ALLEGRO GMR

PACKAGE



2-Pin SIP (suffix UB)

Not to scale

DESCRIPTION

The A19352 is a giant magnetoresistance (GMR) magnetic sensor integrated circuit (IC) designed to measure ring magnets used in automotive braking systems, to provide wheel speed and direction data. The IC fully integrates sensing elements, voltage regulators, analog-to-digital converters, and a digital controller to adaptively measure the magnetic signal and provide a robust, low-jitter advanced AK protocol output across the two-wire interface.

The A19352 features Allegro's SolidSpeed Digital Architecture, the latest mixed-signal speed sensor architecture for highly adaptive performance that provides the widest dynamic range of operating air gap and compensates for temperature drift effects. Flexibility is passed to the system integrator, enabling looser mechanical constraints with a wide operating air gap.

The A19352 was developed in accordance with ISO 26262 as a hardware safety element out of context with ASIL B capability for use in automotive safety-related systems when integrated and used in the manner prescribed in the applicable safety manual and this datasheet.

The A19352 is provided in a 2-pin SIP package (suffix UB) that is lead (Pb) free, with tin leadframe plating. The UB package includes an IC and protection capacitor integrated into a single overmolded package, with an additional molded lead-stabilizing bar for robust shipping and ease of assembly.

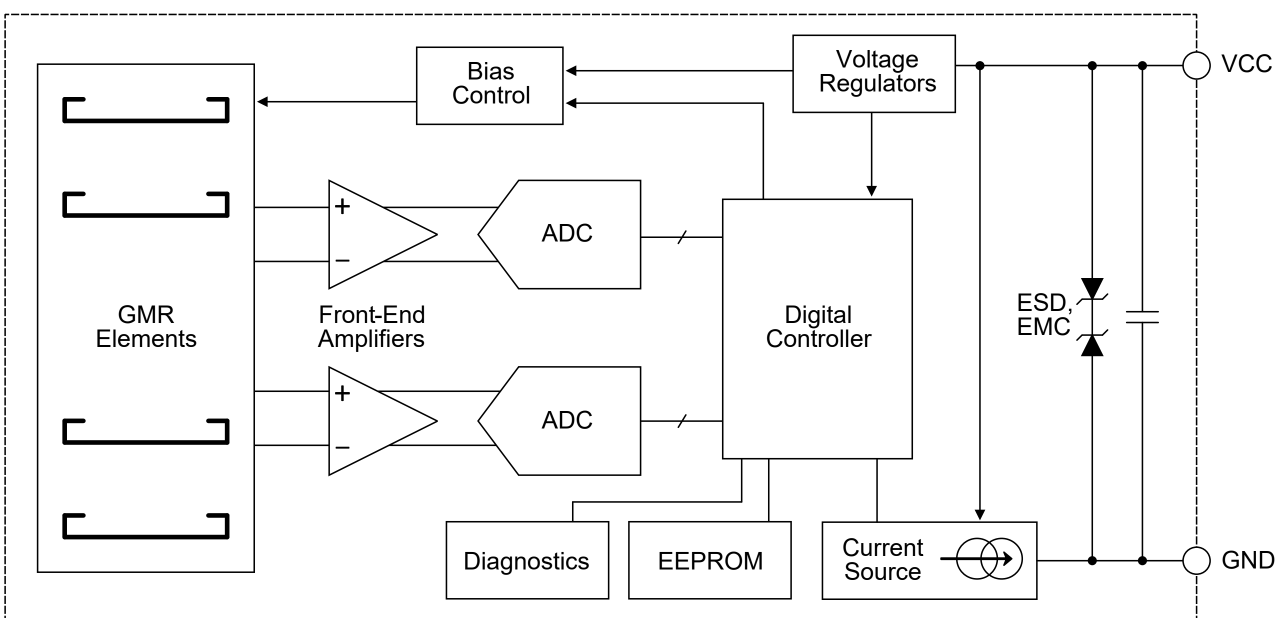


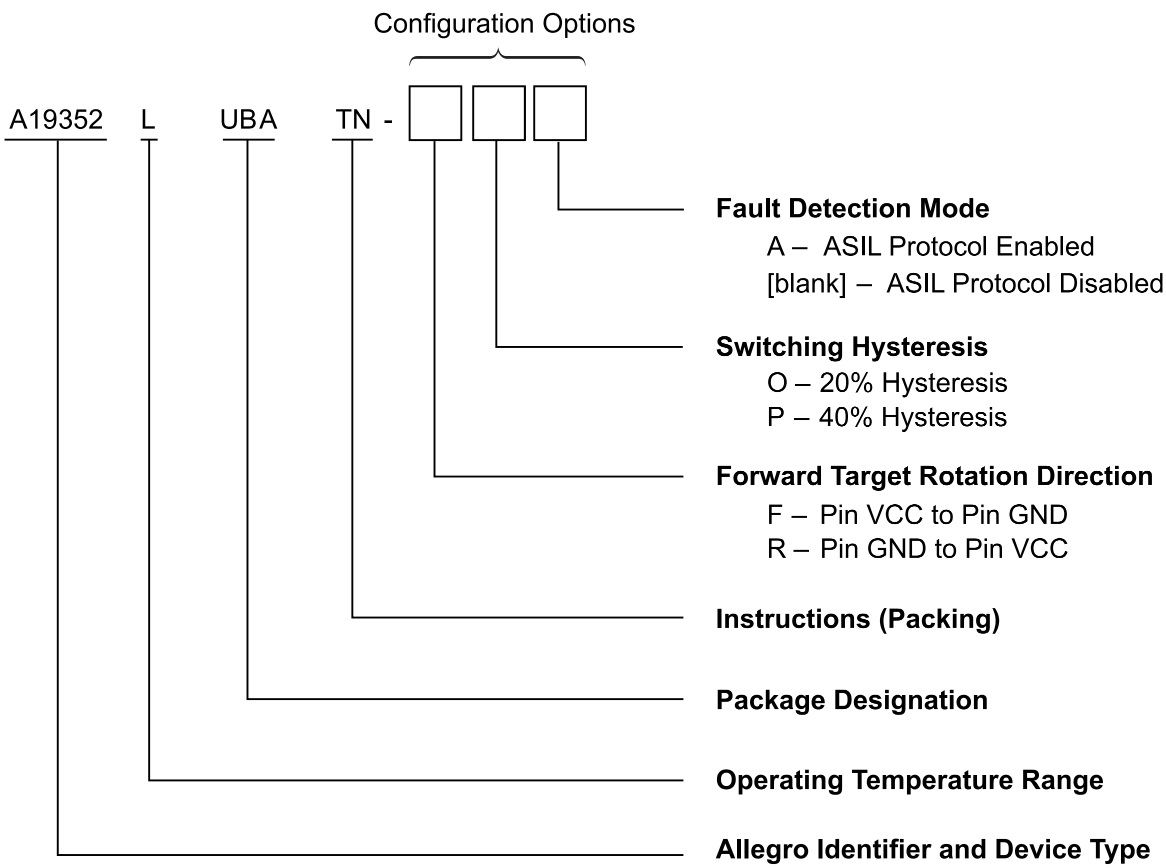
Figure 1: Functional Block Diagram

SELECTION GUIDE*

Part Number	Packing
A19352LUBATN-FO-A	Tape and Reel, 4000 pieces per reel
A19352LUBATN-RO-A	Tape and Reel, 4000 pieces per reel

* Not all combinations are available. For availability and pricing of custom programming options, contact Allegro sales.

Programming Options



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SPECIFICATIONS

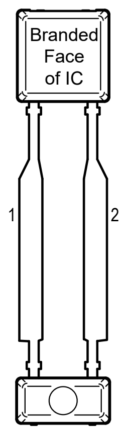
ABSOLUTE MAXIMUM RATINGS

Characteristic	Symbol	Notes	Rating	Unit
Supply Voltage	V_{CC}	Refer to Power Derating section; potential between pin 1 and pin 2	28	V
Reverse Supply Voltage	V_{RCC}		–16.5	V
Operating Ambient Temperature	T_A		–40 to 150	°C
Maximum Junction Temperature	$T_{J(MAX)}$		175	°C
Storage Temperature	T_{stg}		–65 to 170	°C
Applied Magnetic Flux Density	B	In any direction	500	G

INTERNAL DISCRETE CAPACITOR RATINGS

Characteristic	Symbol	Test Conditions	Value (typ.)	Unit
Nominal Capacitance	C_{SUPPLY}	Connected between pin 1 and pin 2 (refer to Figure 2)	2.2	nF

PINOUT DIAGRAM AND PINOUT LIST



Package UB, 2-Pin SIP Pinout Diagram

Pinout List

Pin Name	Pin Number	Function
VCC	1	Supply Voltage
GND	2	Ground

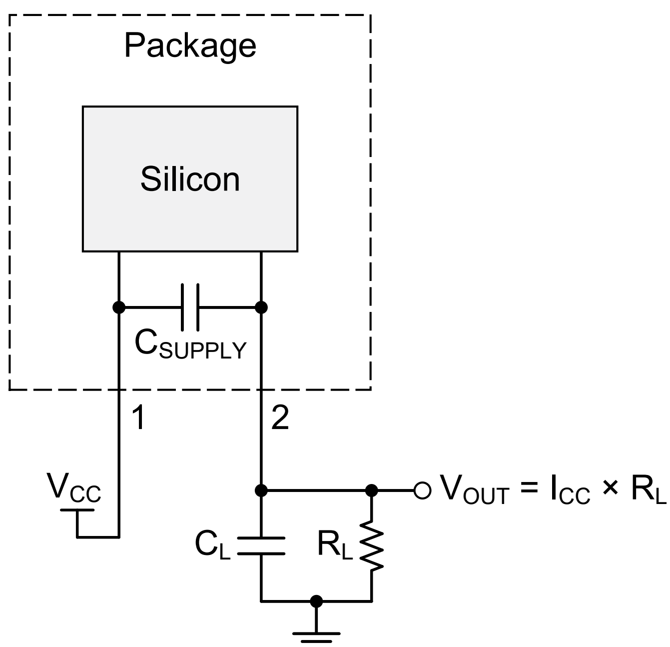


Figure 2: Typical Application Circuit

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OPERATING CHARACTERISTICS: Valid throughout full operating voltage and temperature ranges, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ. [1]	Max.	Unit
ELECTRICAL CHARACTERISTICS						
Supply Voltage [2]	V_{CC}	Potential between pin 1 and pin 2	5.5	–	24	V
Undervoltage Lockout	$V_{CC(OFF)}$	V_{CC} switch off	–	–	3.5	V
UVLO Hysteresis	V_{HYST}	R_L = 50 Ω	1.6	–	2	V
Reverse Supply Current [3]	I_{RCC}	$V_{CC} = V_{RCC(MAX)}$	–10	–	–	mA
Supply Zener Clamp Voltage	$V_{Zsupply}$	$I_{CC} = I_{CC(MAX)}$ + 3 mA, T_A = 25°C	28	–	–	V
Supply Current	$I_{CC(LOW)}$	Low-current state	5.6	7	8.4	mA
	$I_{CC(MID)}$	Mid-current state	11.76	14	16.8	mA
	$I_{CC(HIGH)}$	High-current state	23.52	28	33.6	mA
Supply Current Ratio [4]		$I_{CC(MID)} / I_{CC(LOW)}$ (isothermal)	1.9	–	–	–
		$I_{CC(HIGH)} / I_{CC(LOW)}$ (isothermal)	3.7	–	–	–
Fault Current	I_{FAULT}	Refer to Figure 14	1	–	3.8	mA
Fault Current Duration	$t_{W(FAULT)}$	Refer to Figure 14	4	–	7	ms
Output Rise, Fall Slew Rate	SR	R_L = 50 Ω, C_L = 10 pF, measured between 10% and 90% of signal	8	–	28	mA/µs
POWER-ON CHARACTERISTICS						
Power-On State	POS	$V_{CC} > V_{CC(min)}$, as connected in Figure 1		$I_{CC(LOW)}$		mA
Power-On Time [5]	t_{PO}	$V_{CC} > V_{CC(min)}$, as connected in Figure 1	–	–	1	ms
Calibration Time	T_{FP}	Rotation after t_{PO} to first output event	–	–	1.5	T_{CYCLE}
	T_{DIR}	Rotation after t_{PO} to first output event with direction information	–	–	2.75	T_{CYCLE}
PERFORMANCE						
First Direction Pulse Output Following Vibration		Period between vibration ends and valid direction output	–	–	4	T_{CYCLE}
Vibration Suppression			–	–	1	T_{CYCLE}

[1] Typical values are at T_A = 25°C and V_{CC} = 12 V. Performance may vary for individual units, within the specified maximum and minimum limits.
[2] Maximum voltage must be adjusted for power dissipation and junction temperature; see representative Power Derating section.
[3] Negative current is defined as conventional current coming out of (sourced from) the specified device terminal.
[4] Supply current ratios are taken with the mean values of $I_{CC(LOW)}$, $I_{CC(MID)}$, and $I_{CC(HIGH)}$.
[5] Time between power-on to I_{CC} stabilizing. Output transients prior to t_{PO} should be ignored.

Continued on the next page…

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OPERATING CHARACTERISTICS (continued): Valid throughout full operating voltage and temperature ranges, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ. [1]	Max.	Unit
AK PROTOCOL OPTION						
Bit Width	t_p		40	50	60	μs
Standstill Period	t_{STOP}		105	150	195	ms
Air Gap Reserve Level	B_{LR}	Differential signal that engages the AK error code bit [6]	–	3.6	–	G
INPUT CHARACTERISTICS AND PERFORMANCE						
Operating Frequency [7]	f_{SIG}	Forward and reverse rotation; with AK bit truncation beginning at 1 kHz (typical)	0	–	4	kHz
Operating Differential Magnetic Input Signal [6]	$B_{DIFF(pk-pk)}$	Peak-to-peak of differential magnetic input; refer to Figure 6	2.7	–	–	G
Operating Differential Magnetic Range	B_{DIFF}		–900	–	900	G
Allowable User-Induced Differential Offset	B_{SIGEXT}	External differential signal bias (DC), operating within specification	–40	–	40	G
Operating Magnetic Input Signal Variation	$\Delta B_{DIFF(pk-pk)}$	Bounded amplitude ratio within T_{WINDOW} [8]; no missed output transitions or flat line condition; possible incorrect direction information; refer to Figure 4 and Figure 5	0.6	–	–	–
Operating Magnetic Input Signal Window	T_{WINDOW}	Rolling window where $\Delta B_{DIFF(pk-pk)}$ cannot exceed bounded ratio; refer to Figure 4 and Figure 5	4	–	–	T_{CYCLE}
Operate Point	B_{OP}	% of peak-to-peak IC-processed signal; -Oxx Option	–	60	–	%
		% of peak-to-peak IC-processed signal; -Pxx Option	–	70	–	%
Release Point	B_{RP}	% of peak-to-peak IC-processed signal; -Oxx Option	–	40	–	%
		% of peak-to-peak IC-processed signal; -Pxx Option	–	30	–	%
Repeatability [9]		Constant air gap, temperature, and target speed. $B_{DIFF(pk-pk)}$ > 20 G. Primary Pulses, percent of a T_{CYCLE} one sigma.	–	0.02	–	%
Switch Point Separation	$B_{DIFF(SP-SEP)}$	Required amount of amplitude separation between Channel A and Channel B at each B_{OP} and B_{RP} occurrence. Channels must be in phase; refer to Figure 7	20	–	–	%
THERMAL CHARACTERISTICS						
Magnetic Temperature Coefficient [10]	TC	Valid for full temperature range based on ferrite	–	0.2	–	%/°C
Package Thermal Resistance	$R_{\theta JA}$	Single-layer PCB with copper limited to solder pads	–	213	–	°C/W

[6] The differential magnetic field is measured for Channel A (E1 – E3) and Channel B (E2 – E4). The differential magnetic field of each channel is measured between two GMR elements spaced by 1.9 mm. The magnetic field is measured in the B_y direction, and the $|B_x|$ field must be less than 80 G (refer to Figure 8).
[7] Frequency is based on B_{DIFF} frequency.
[8] Symmetrical signal variation is defined as the largest amplitude ratio from B_n to $B_n + T_{WINDOW}$. Signal variation may occur continuously while B_{DIFF} remains in the operating magnetic range.
[9] Constant air gap ($B_{DIFF(pk-pk)}$ > 20 G), temperature, and target speed. Sinusoidal input signal. Repeatability (i.e., jitter) is guaranteed by design and characterization only.
[10] Ring magnet decreases in magnetic strength with rising temperature, and the device compensates. Note that $B_{DIFF(pk-pk)}$ requirement is not influenced by this.

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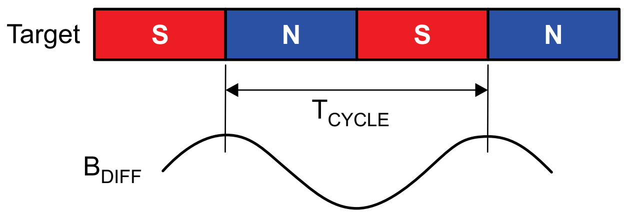

B_{DIFF} = Differential Input Signal; the differential magnetic flux sensed by the sensor

T_{CYCLE} = Target Cycle; the amount of rotation that moves one north pole and one south pole across the sensor

Figure 3: Definition of T_{CYCLE}

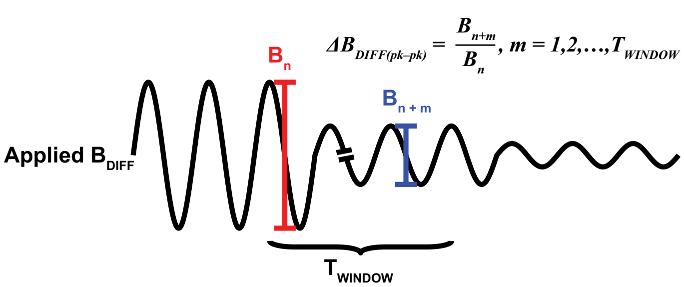

Figure 4: Single Period-to-Period Variation

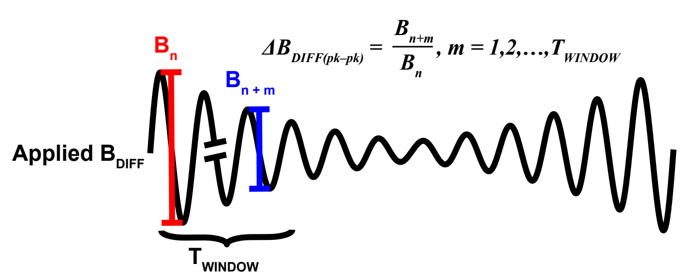

Figure 5: Repeated Period-to-Period Variation

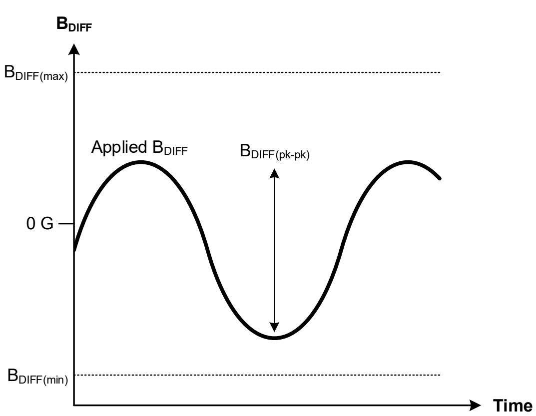

Figure 6: Input Signal Definition

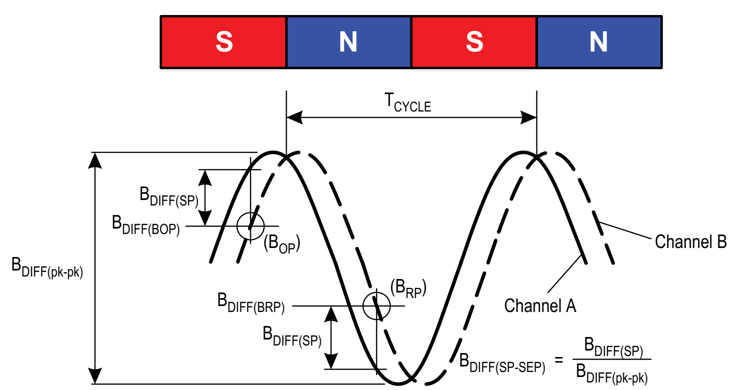

Figure 7: Definition of Switch Point Separation

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FUNCTIONAL DESCRIPTION

The A19352 sensor IC contains a single-chip GMR circuit that uses spaced elements. These elements are used in differential pairs to provide electrical signals containing data regarding edge position and direction of rotation. The A19352 is intended for use with ring magnet targets as shown in Figure 9 and Figure 10. The IC detects the peaks of the magnetic signals and sets dynamic thresholds based on these detected signals.

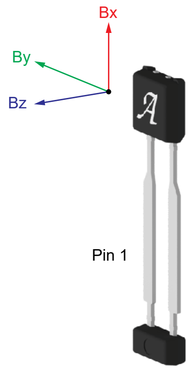

Figure 8: Package Orientation

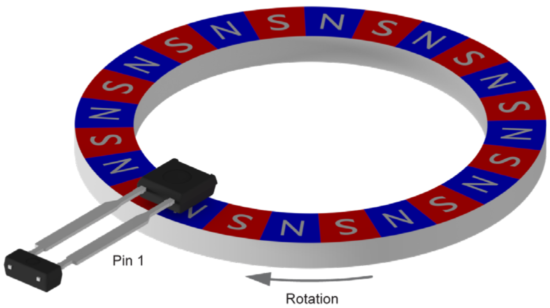

Figure 9: Target Orientation Relative to Device (Parallel)

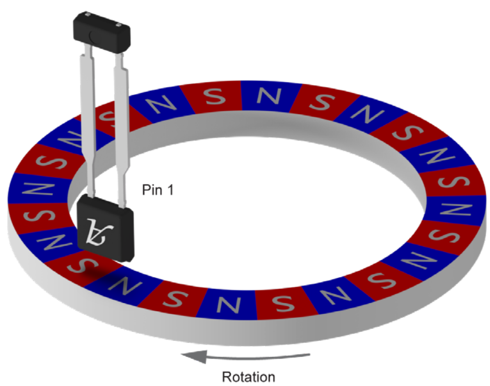

Figure 10: Target Orientation Relative to Device (Perpendicular)

Forward Rotation

For the -F variant, when the target is rotating such that a target feature passes from pin 1 to pin 2, this is referred to as forward rotation. For the -R variant, forward direction is indicated for target rotation from pin 2 to 1.

Reverse Rotation

For the -F variant, when the target is rotating such that a target feature passes from pin 2 to pin 1, this is referred to as reverse rotation. For the -R variant, reverse direction is indicated for target rotation from pin 1 to 2.

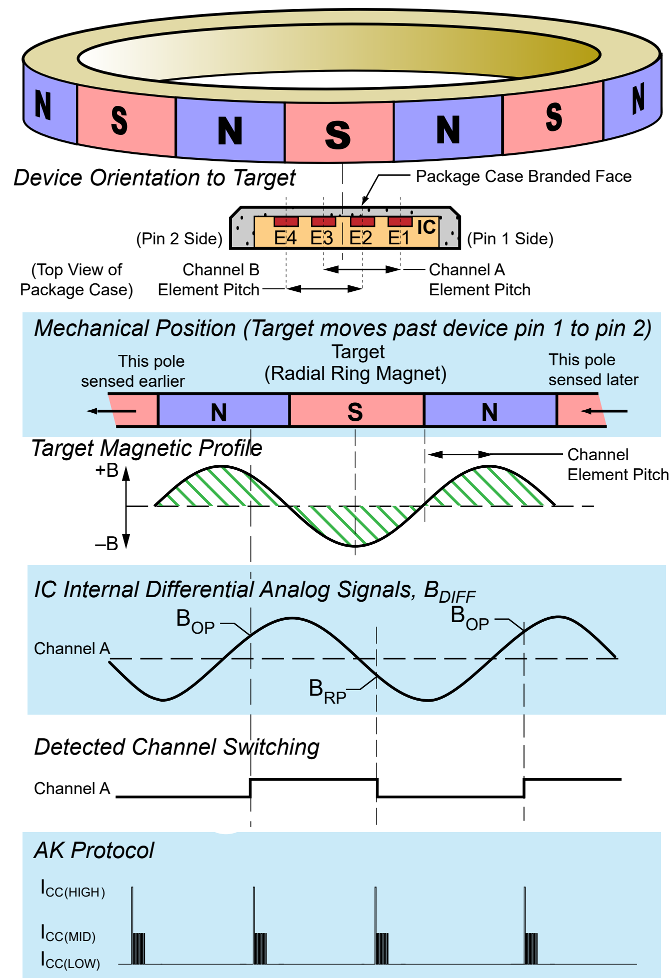

Figure 11: Basic Operation

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Switch Points and Hysteresis

Switch points B_{OP} and B_{RP} are established dynamically as a percentage of the tracked peaks and valleys of the magnetic input signal. Two switching-hysteresis options are available for order.

Advanced AK Protocol Description

When a target passes in front of the device (opposite the branded face of the package case), the A19352 generates two output words for each magnetic pole-pair of the target. Speed data is provided by the speed pulse rate, and other data is directly communicated via the AK bits, as described next.

Output words are triggered by B_{DIFF} transitions through two equidistant switch points. On a crossing, the speed pulse and relevant data are generated and transmitted. The IC is always capable of properly detecting input signals up to the defined operating frequency. At frequencies beyond the operational frequency, the speed pulses will be present until the ASIL over-frequency limit asserts.

During typical operation, the A19352 fulfills the requirements according to the AK protocol specification "Requirement Specification for Standardized Interface for Wheel Speed Sensors with Additional Information 'AK-Protokoll,'" version 4.0, with some modifications. The A19352 also features an advanced AK protocol when the digital controller detects an internal failure. The advanced AK error codes give specific data about the internal failure. The following sections give additional details about interpreting the AK data bits.

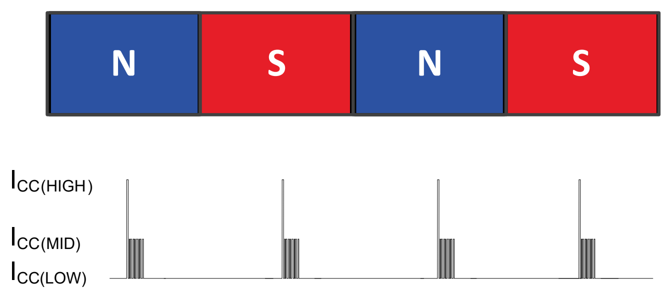

Figure 12: Output Protocol Timing Example

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AK Bit Definitions

The AK word consists of 10 pulses: a single speed pulse, 8 data bits, and a single parity bit. The speed pulse and data bit definitions during typical operation are described Table 1. When the sensor detects an internal failure, the data bit definitions change as described in Table 3.

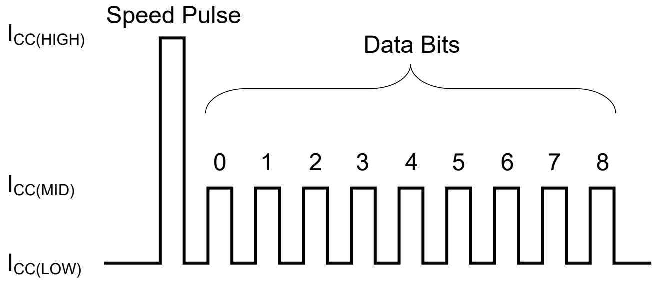

Figure 13: AK Protocol Message Format

Table 1: Standard AK Mode—Speed Pulse and Data Bit Definitions

Bit Number	Field	Abbreviation	Coding	Post-Power-On Default Value
–	Speed Pulse	SP	$I_{CC(HIGH)}$ if speed pulse, $I_{CC(MID)}$ if standstill pulse	–
0	Error Flag	ERR	1 if the sensor detects an internal failure, 0 otherwise	0
1	Status Mode	M	1 if not in running mode, 0 otherwise	1
2	Unused	X	1 always	1
3	Direction Validity	GDR	1 if direction is valid, 0 otherwise	0
4	Direction	DR	1 if rotation direction is FWD, 0 if direction REV	0
5	Air Gap Indication (LSB)	LM0	LM LSB	0
6	Air Gap Indication	LM1	LM	0
7	Air Gap Indication (MSB)	LM2	LM MSB	0
8	Parity	P	Even Parity	0

Table 2: LM Air Gap

Data bits [5:7] report the air gap indication. These bits give eight air gap ranges with respect to the measured peak-to-peak magnetic field, BDIFF(pk-pk)

LM2	LM1	LM0	$B_{DIF(pk-pk)}$ Range (Typ.)
0	0	0	–
0	0	1	≤ 1.72 G
0	1	0	1.72 to 3.46 G
0	1	1	3.46 to 6.91 G
1	0	0	6.91 to 13.8 G
1	0	1	13.8 to 27.6 G
1	1	0	27.6 to 41.5 G
1	1	1	> 41.5

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Table 3: Advanced AK Mode—Speed Pulse and Data Bit Definitions

Bit Number	Field	Abbreviation	Coding
–	Speed Pulse	SP	$I_{CC(HIGH)}$ if speed pulse, $I_{CC(MID)}$ if standstill pulse
0	Error Flag	ERR	1 if the sensor detects an internal failure
1	Error Code	E0	Refer to Table 4
2	Error Code	E1	Refer to Table 4
3	Direction Validity	GDR	1 if direction is valid, 0 otherwise
4	Direction	DR	1 if rotation direction is FWD, 0 if direction REV
5	Error Code	E2	Refer to Table 4
6	Error Code	E3	Refer to Table 4
7	Error Code	E4	Refer to Table 4
8	Parity	P	Even parity

Table 4: Advanced AK Mode—Definition of Error Codes

Error Condition	Description	ERR	E0	E1	E2	E3	E4
NO_P_W	Number of pulses wrong	1	1	0	0	0	0
NO_P_H	Number of pulses high	1	1	1	0	0	0
NO_P_L	Number of pulses low	1	1	1	1	0	0
DR_W	Direction recognition wrong	1	0	1	0	0	0
FE_ERR	ADC conversion error	1	0	1	0	0	1
AIR_LIM	Air gap reserve reached	1	0	1	0	1	0
OFFSET_MISMATCH	Offset deviation between the two channels	1	0	1	0	1	1
OFFSET_RANGE	Offset out of range	1	0	1	1	0	0
ADC_CLIP	ADC clipping	1	0	1	1	0	1
VDDA_RANGE	Analog regulator out of range	1	0	0	0	0	0
VDDD_RANGE	Digital regulator out of range	1	0	0	0	0	1
T_HIGH_T1	Temperature monitor out of range	1	0	0	1	0	1

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Output Protocol in Fault Condition

The A19352 sensor IC contains diagnostic circuitry that continuously monitors the occurrence of failure defects within the IC. Failures can be reported either by an error code in the advanced AK protocol, or by the output transitioning to the I_{FAULT} level. For the output protocol after a fault has been detected, refer to Figure 14.

NOTE: If a fault exists continuously, the device output remains at the I_{FAULT} level. For additional details, refer to the A19352 Safety Manual.

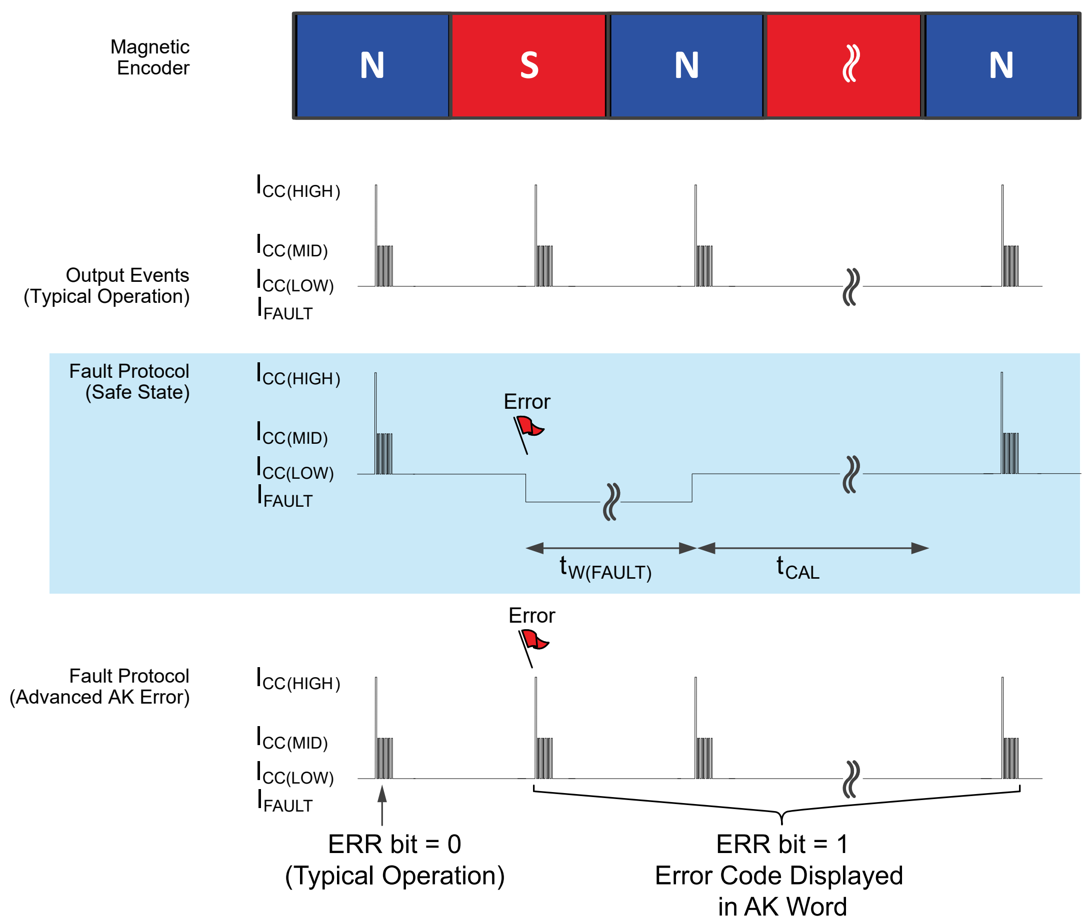

Figure 14: Output Protocols in Fault Condition

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Calibration and Direction Validation

When power is applied to the A19352, the built-in algorithm performs an initialization routine. For a short period after power-on, the device calibrates itself and determines the direction of target rotation. The output does not transmit any output words during calibration. Once the calibration routine is complete, the A19352 transmits accurate speed and direction data via AK protocol.

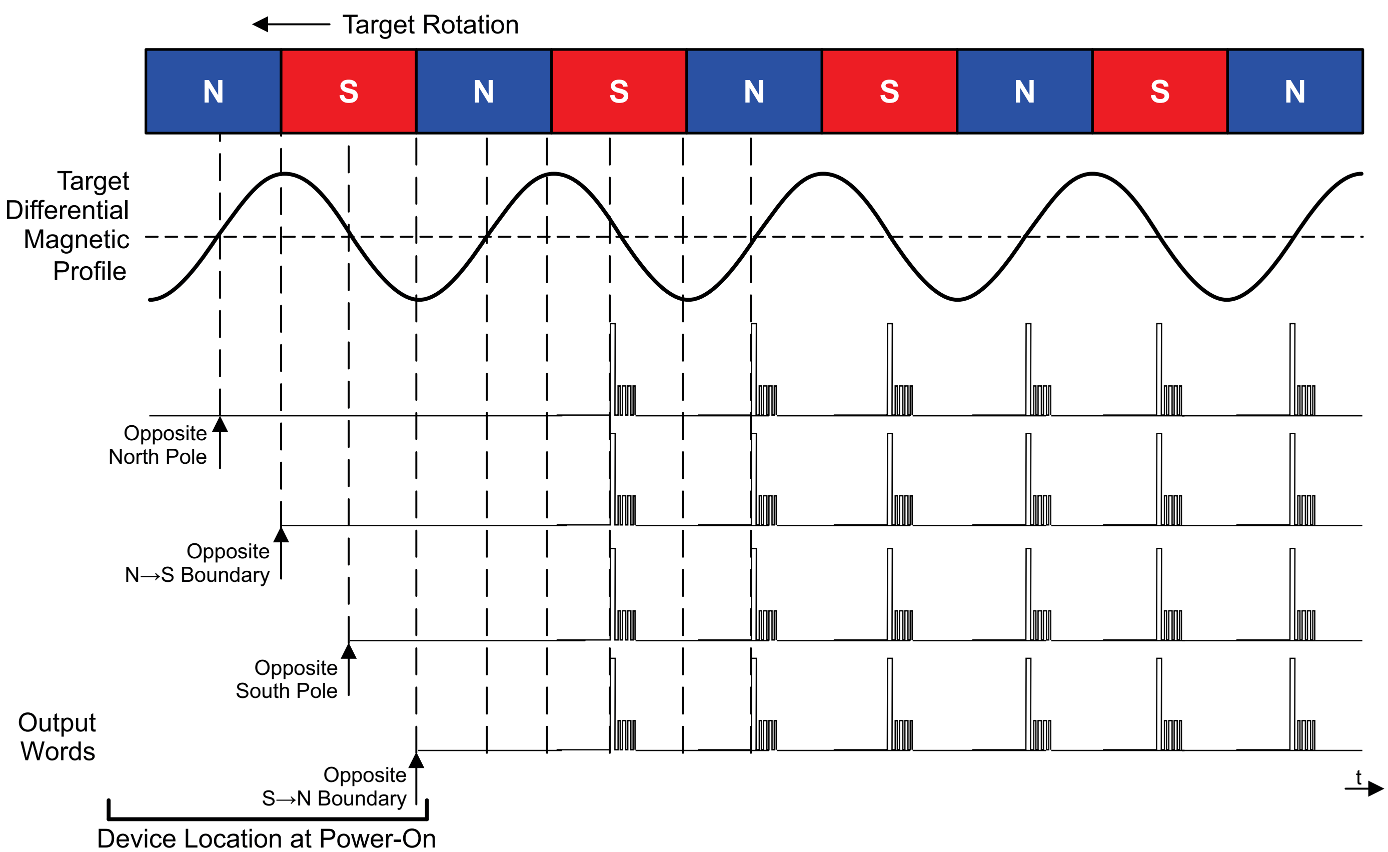

Figure 15: Calibration Behavior

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Direction Changes, Vibrations, and Anomalous Events

During typical operation, the A19352 is exposed to changes in the direction of target rotation (Figure 16), vibrations of the target (Figure 17), and anomalous events such as sudden air gap changes. The A19352 does not transmit any pulses during vibrations.

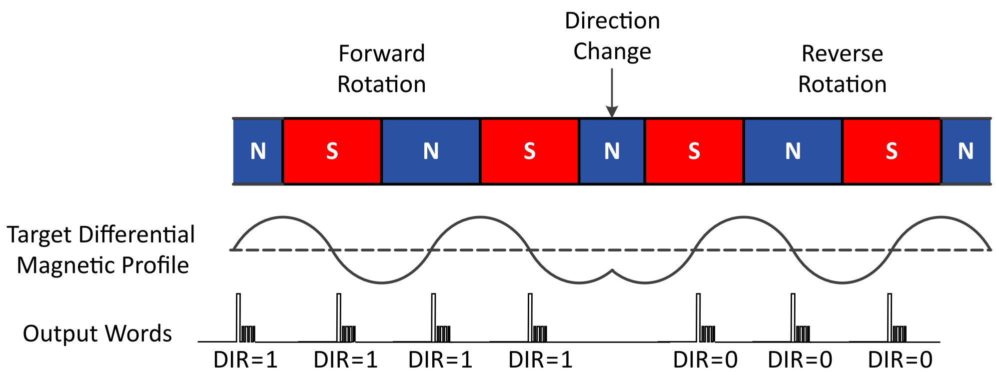

Figure 16: Direction Change Behavior

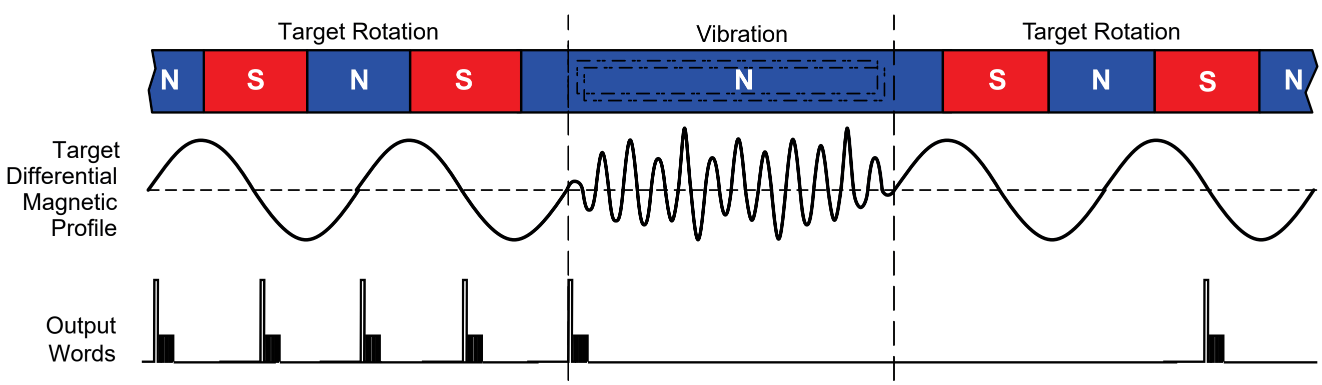

Figure 17: Vibration Behavior

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POWER DERATING

The device must be operated below the maximum junction temperature of the device, $T_{J(max)}$. Under certain combinations of peak conditions, reliable operation may require derating the supplied power or improving the heat dissipation properties of the application. This section presents a procedure for correlating factors affecting operating T_J. (Thermal data is also available on the Allegro MicroSystems website.)

The package thermal resistance, $R_{\theta JA}$, is a figure of merit summarizing the ability of the application and the device to dissipate heat from the junction (die), through all paths to the ambient air. Its primary component is the effective thermal conductivity, K, of the printed circuit board, including adjacent devices and traces. Radiation from the die through the device case, $R_{\theta JC}$, is a relatively small component of $R_{\theta JA}$. Ambient air temperature, T_A, and air motion are significant external factors, damped by overmolding.

The effect of varying power levels (power dissipation, P_D) can be estimated. The following formulas represent the fundamental relationships used to estimate T_J at P_D:

$$P_D = V_{IN} \times I_{IN} \quad (1)$$

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

$$T_J = T_A + \Delta T \quad (3)$$

For example, given common conditions such as:

T_A= 25°C, V_{CC} = 12 V, I_{CC} = 7.15 mA, and $R_{\theta JA}$ = 213°C/W,

then:

$$P_D = V_{CC} \times I_{CC} = 12\ V \times 7.15\ mA = 85.8\ mW$$

$$\Delta T = P_D \times R_{\theta JA} = 85.8\ mW \times 213°C/W = 18.3°C$$

$$T_J = T_A + \Delta T = 25°C + 18.3°C = 43.3°C$$

A worst-case estimate, $P_{D(max)}$, represents the maximum allowable power level ($V_{CC(max)}$, $I_{CC(max)}$), without exceeding $T_{J(max)}$, at a selected $R_{\theta JA}$ and T_A.

Example: Reliability for V_{CC} at T_A = 150°C, package UB, using minimum-K PCB.

Observe the worst-case ratings for the device, specifically:

$R_{\theta JA}$ = 213°C/W (subject to change), $T_{J(max)}$ = 175°C, $V_{CC(max)}$ = 24 V, and $I_{CC(AVG)}$ = 18.5 mA. $I_{CC(AVG)}$ is computed using $I_{CC(HIGH)(max)}$, $I_{CC(MID)(max)}$, $I_{CC(LOW)(max)}$, and maximum operational frequency of 4 kHz.

To calculate the maximum allowable power level, $P_{D(max)}$, first rearrange Equation 3:

$$\Delta T_{max} = T_{J(max)} - T_A = 175°C - 150°C = 25°C$$

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

$$P_{D(max)} = \Delta T_{max} \div R_{\theta JA} = 25°C \div 213°C/W = 117.4\ mW$$

Finally, solve Equation 1 with respect to voltage:

$$V_{CC(est)} = P_{D(max)} \div I_{CC(avg)} = 117.4\ mW \div 18.5\ mA = 6.3\ V$$

The result indicates that, at T_A , the application and device can dissipate adequate amounts of heat at voltages ≤ $V_{CC(est)}$.

Compare $V_{CC(est)}$ to $V_{CC(max)}$. If $V_{CC(est)}$ ≤ $V_{CC(max)}$, reliable operation between $V_{CC(est)}$ and $V_{CC(max)}$ requires enhanced $R_{\theta JA}$. If $V_{CC(est)}$ ≥ $V_{CC(max)}$, operation between $V_{CC(est)}$ and $V_{CC(max)}$ is reliable under these conditions.

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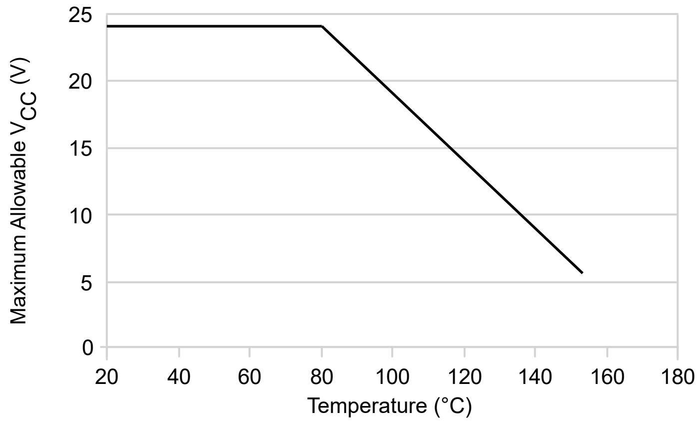
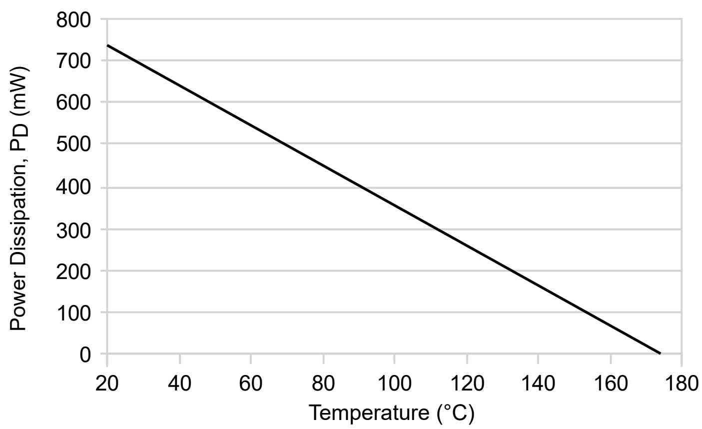
Power Derating Curve



Power Dissipation versus Ambient Temperature



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PACKAGE OUTLINE DRAWING

For Reference Only – Not for Tooling Use

(Reference DWG-0000408, Rev. 4)
Dimensions in millimeters – NOT TO SCALE
Exact case and lead configuration at supplier discretion within limits shown

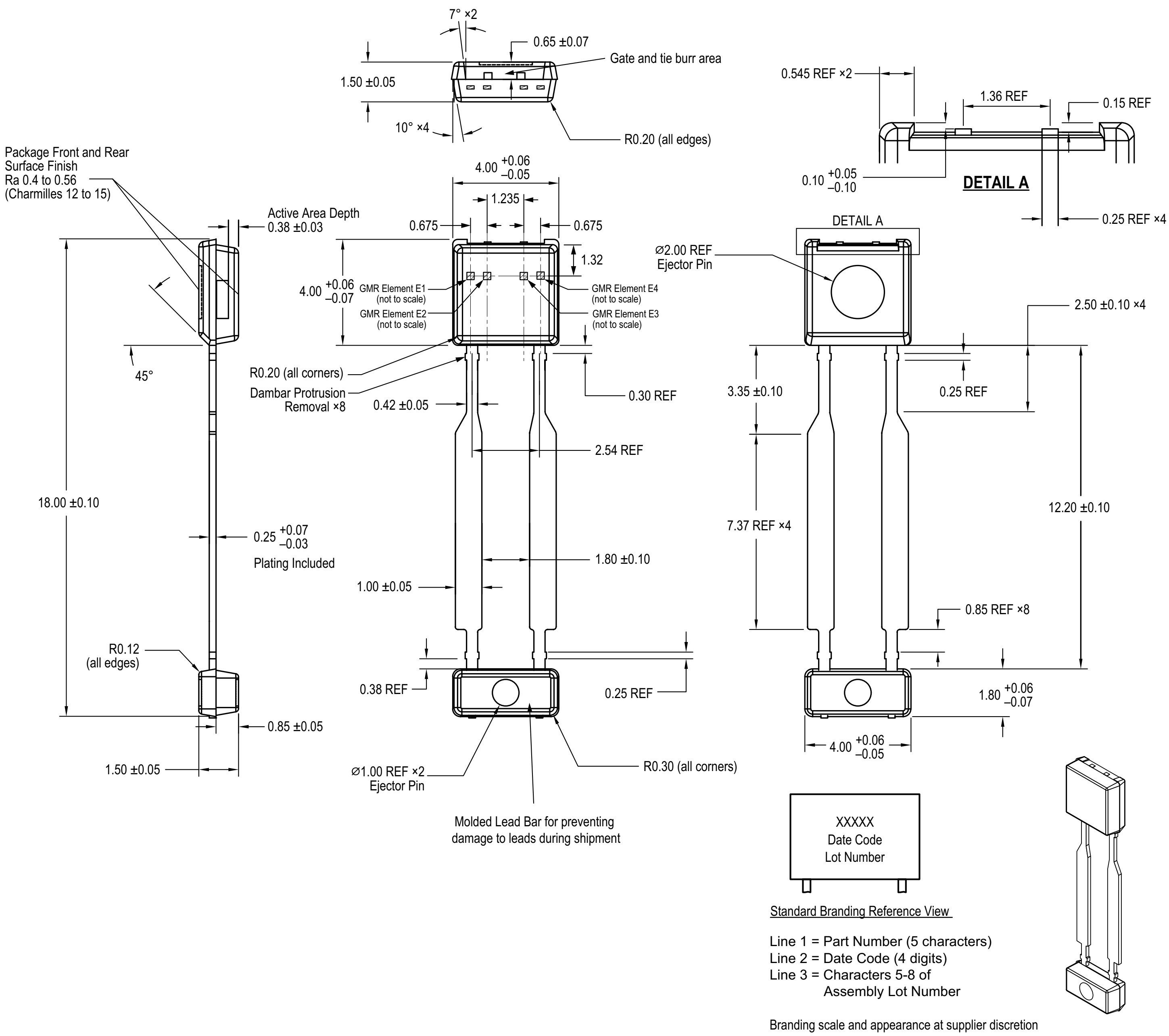

Figure 18: Package UB, 2-Pin SIP

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Revision History

Number	Date	Description
–	October 31, 2023	Initial release
1	December 5, 2023	Editorial corrections (pages 2 and 10)
2	January 2, 2024	Corrected illustration of programming options (page 2)
3	April 25, 2024	Updated package drawing (page 16)
4	August 12, 2024	Updated ISO 26262 status and description, both in Features and Benefits as well as Description (page 1); updated selection guide (page 2); updated Absolute Maximum Ratings table supply voltage (page 3)
5	October 16, 2024	Updated orientation illustrations (page 7, figures 9 and 10)
6	October 14, 2025	Updated ASIL branding and text (page 1) and made minor formatting modifications throughout

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