High-Feature GMR Transmission Gear Tooth Sensor IC with Far Air Gap Range, Vibration Suppression, EMC Circuit, Test Pin Access

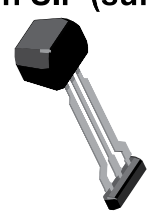
FEATURES AND BENEFITS

- GMR technology senses at near or far air gap for optimal design-in flexibility
- Integrated EMC circuit protects against harsh supply-line transients, eliminating the need for a large bypass capacitor and twisted-pair harness
- System compensation for vibration, mechanical shifts, and thermal gradients to ease controller burden and increase signal reliability
- Single in-line overmolded package reduces tolerance stack of GMR IC, EMC protection, and magnet
- Test-pin access for system characterization within application environment
- Speed output protocol or speed and direction output protocol allows single qualification to cover multiple applications
- ASIL Compliant: ASIL B SEooC developed in accordance with ISO26262, when used as specified in the safety manual

Continued on next page...

ISO 26262 ASIL Compliant

PACKAGE: 3-pin SIP (suffix ST)



Not to scale

DESCRIPTION

The ATS19581 is a giant-magnetoresistance (GMR) integrated circuit (IC) with an extensive feature set for high levels of flexibility, reliability, and performance in transmission applications, including electric vehicles (EV), where speed or speed and direction data is required using ferromagnetic gear-tooth targets.

Designed specifically for automotive transmission applications, the ATS19581 has an on-chip electromagnetic-compatible (EMC) circuit and a small bypass capacitor capable of handling the harshest automotive requirements, including wire-to-wire coupling from unintended transient disturbances.

Built on the Allegro SolidSpeed digital architecture and state-of-the-art GMR technology, the sensor IC offers robust and reliable gear-tooth sensing on a diverse set of ferromagnetic target geometries. Extensive application experience has been put into the algorithms, making the ATS19581 capable of compensating for system dynamics such as startup and running mode vibration, mechanical air-gap jumps, and thermal gradients, ensuring robust signal integrity and easing controller burden. Two available air-gap ranges maximize installation flexibility and compatibility for small, spatially constrained systems.

To ensure robust performance in each unique system, the ATS19581 has test-pin access to integral IC signals, making it possible to assess signal integrity and system-level compatibility during the development cycle, or for debug of production returns.

Continued on next page...

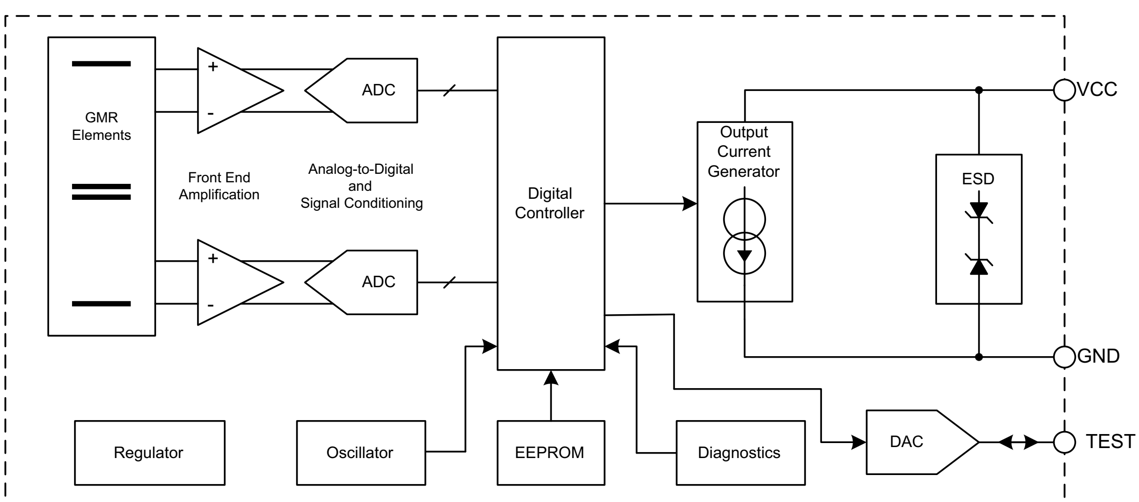


Figure 1: Functional Block Diagram

FEATURES AND BENEFITS (continued)

- IC measures differentially to reject common-mode stray magnetic fields
- Orientation compatible with Hall-effect technology for ease of drop-in replacement in existing designs
- Integrated ASIL diagnostics and certified safety design process (optional fault reporting)

DESCRIPTION (continued)

To further simplify design-in to applications that have historically used the Hall effect, the GMR-based IC is orientation-compatible with Hall-effect technology.

ATS19581 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 datasheet. Keeping safety in mind, the ATS19581 has integrated diagnostics to detect an IC failure that would impact the output protocol accuracy, providing coverage compatible with ASIL B. ASIL reporting can be enabled or disabled as a product offering, depending on the application needs. In addition, EEPROM scratch memory provides factory traceability throughout the IC product lifecycle.

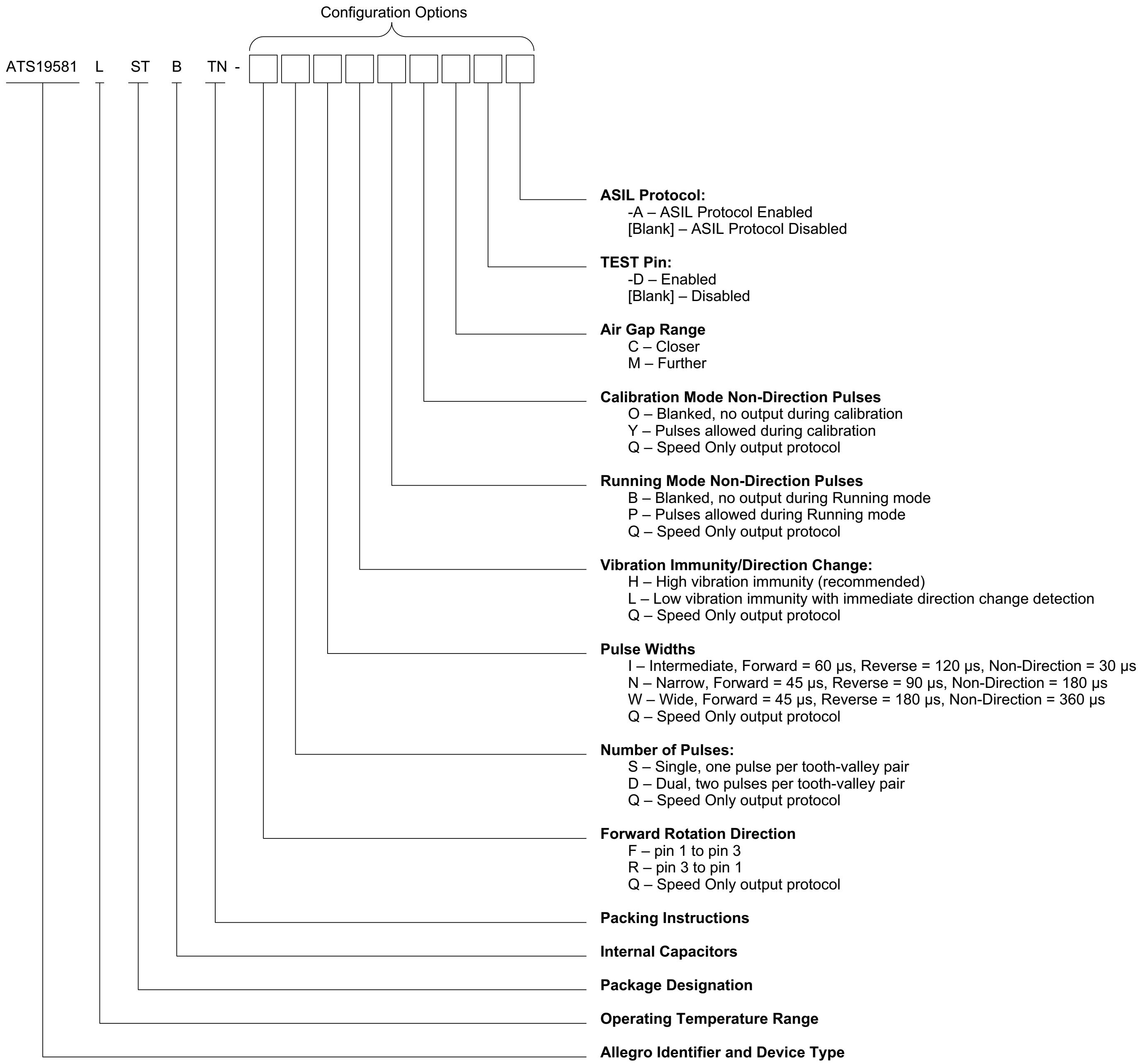
The ATS19581 is provided in a single overmolded lead (Pb) free 3-pin single in-line package (SIP; suffix -ST) with tin leadframe plating. The ST package includes a GMR IC, a magnet, and the EMC circuit, including the bypass capacitor. To maintain the sensor IC lead integrity, there is an additional molded lead-stabilizing bar for robust shipping and ease of assembly.

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

SELECTION GUIDE [1]

Part Number	Packing	Fault Detection Mode	TEST Pin
ATS19581LSTBTN-FSWHPYM-A	Tape and reel, 13-in. reel, 800 pieces per reel	Enabled	Disabled
ATS19581LSTBTN-RSWHPYM	Tape and reel, 13-in. reel, 800 pieces per reel	Enabled	Disabled

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

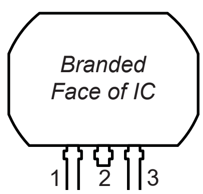


Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

ABSOLUTE MAXIMUM RATINGS

Characteristic	Symbol	Notes	Rating	Units
Supply Voltage	V_{CC}	Refer to Power Derating section	28	V
Reverse Supply Voltage	V_{RCC}		–18	V
Test Pin Voltage	V_{TEST}		7	V
Test Pin Reverse Voltage	$V_{R(TEST)}$		0	V
Operating Ambient Temperature	T_A	Range L	–40 to 150	°C
Maximum Junction Temperature	$T_{J(max)}$		165	°C
Storage Temperature	T_{stg}		–65 to 170	°C
Externally Applied Magnetic Flux Density	B	In any direction	500	G

PINOUT DIAGRAM AND TABLE



Package ST, 3-Pin SIP Pinout Diagram

Pinout Table

Number	Name	Function
1	VCC	Supply Voltage
2	TEST	Test Signals
3	GND	Ground

Internal Components

Characteristic	Symbol	Notes	Rating	Units
Nominal Capacitance	C_{SUPPLY}	Connected between VCC and GND; refer to Figure 2	10	nF

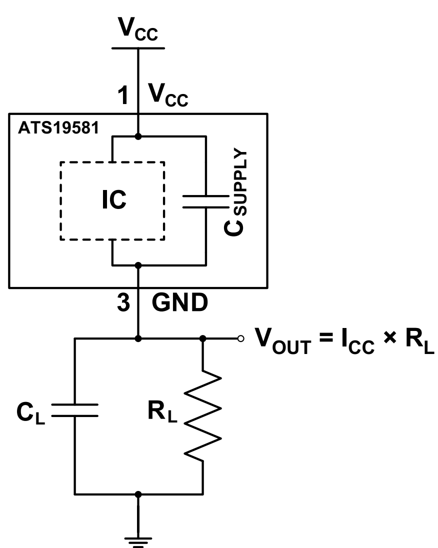


Figure 2: Typical Application Circuit

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

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

Characteristic	Symbol	Test Conditions	Min.	Typ. [1]	Max.	Unit
ELECTRICAL SUPPLY CHARACTERISTICS						
Supply Voltage [2]	V_{CC}	Voltage across pin 1 and pin 3; does not include voltage across R_L	4	–	24	V
Undervoltage Lockout	$V_{CC(UV)}$		–	–	3.99	V
Reverse Supply Current [3]	I_{RCC}	V_{CC} = –18 V	–10	–	–	mA
Supply Current	$I_{CC(LOW)}$	Non-D variants; low-current state	5.9	–	8	mA
	$I_{CC(HIGH)}$	Non-D variants; high-current state	12	–	16	mA
Supply Current Transient	$I_{CC(STEP)}$	See Functional Description	5.9	–	8.5	mA
Supply Current Ratio	$I_{CC(HIGH)}$ / $I_{CC(LOW)}$	Non-D variants; ratio of high current to low current (isothermal)	1.9	–	–	–
ASIL Safety Current	I_{FAULT}	Non-D variants	1.5	–	3.9	mA
ELECTRICAL PROTECTION CHARACTERISTICS						
Supply Zener Clamp Voltage	$V_{Zsupply}$	I_{CC} = 19 mA	28	–	–	V
Reverse Supply Zener Clamp Voltage	$V_{RZSUPPLY}$	I_{CC} = –3 mA	–	–	–18	V
POWER-ON STATE CHARACTERISTICS						
Power-On State	POS	$V_{CC} > V_{CC(min)}$		$I_{CC(LOW)}$		–
Power-On Time [4]	t_{PO}	Time from $V_{CC} > V_{CC(min)}$, until device is in calibration mode	–	–	1	ms
OUTPUT CHARACTERISTICS						
Output Rise Time	t_r	Voltage measured at pin 3 (see Figure 2), R_L = 100 Ω, C_L = 10 pF, measured between 10% and 90% of signal	0	2	4	μs
Output Fall Time	t_r	Voltage measured at pin 3 (see Figure 2), R_L = 100 Ω, C_L = 10 pF, measured between 10% and 90% of signal	0	2	4	μs
Overshoot	I_{OS}	Largest deviation of output signal from the final steady state value; rising or falling output transition; R_L = 100 Ω and C_L = 10 pF	–	10	–	%
Pulse Width, Fault	$t_{w(FAULT)}$	R_L = 100 Ω, C_L = 10 pF, pulse duration measured at threshold of $(I_{CC(LOW)} + I_{FAULT}) / 2$; A (ASIL) variant	4	–	8	ms

Continued on next page...

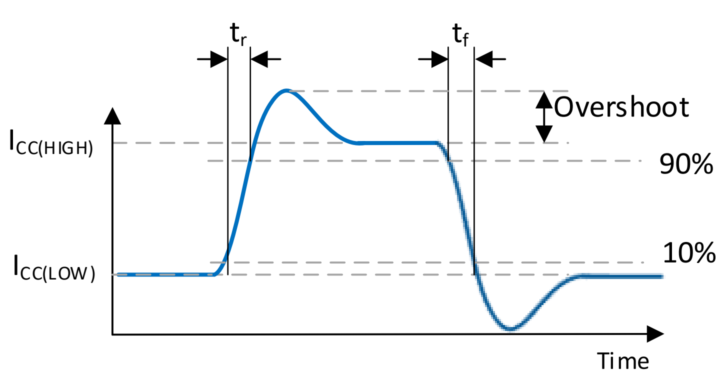


Figure 3: Definition of Rise Time, Fall Time, and Overshoot

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

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

Characteristic	Symbol	Test Conditions	Min.	Typ. [1]	Max.	Unit
NARROW PULSE WIDTH OPTION (-xSNxxxx variants) [5]						
Pulse Width, Forward Rotation	$t_{w(FWD)}$		38	45	52	μs
Pulse Width, Reverse Rotation	$t_{w(REV)}$		76	90	104	μs
Pulse Width, Nondirectional	$t_{w(ND)}$		153	180	207	μs
Operating Frequency, Forward Rotation	f_{FWD}		0	–	12	kHz
Operating Frequency, Reverse Rotation [6]	f_{REV}		0	–	7	kHz
Operating Frequency, Nondirectional Pulses [6]	f_{ND}		0	–	4	kHz
WIDE PULSE WIDTH OPTION (-xSWxxxx variants) [5]						
Pulse Width, Forward Rotation	$t_{w(FWD)}$		38	45	52	μs
Pulse Width, Reverse Rotation	$t_{w(REV)}$		153	180	207	μs
Pulse Width, Nondirectional	$t_{w(ND)}$		306	360	414	μs
Operating Frequency, Forward Rotation	f_{FWD}		0	–	12	kHz
Operating Frequency, Reverse Rotation [6]	f_{REV}		0	–	4	kHz
Operating Frequency, Nondirectional Pulses [6]	f_{ND}		0	–	2.2	kHz
INTERMEDIATE PULSE WIDTH OPTION (-xSIxxxx variants) [5][7]						
Threshold to Enter High-Speed Mode	f_{HIGH}	Increasing T_{CYCLE} frequency	0.935	1.1	1.265	kHz
Threshold to Exit High-Speed Mode	f_{LOW}	Decreasing T_{CYCLE} frequency	0.85	1	1.15	kHz
Pulse Pre-Low Length	$t_{W(PRE)}$		25	30	35	μs
Pulse Width, Forward Rotation	$t_{W(FWD)}$	T_{CYCLE} frequency < f_{LOW}	51	60	69	μs
Pulse Width, Reverse Rotation	$t_{W(REV)}$	T_{CYCLE} frequency < f_{LOW}	102	120	138	μs
Pulse Width, Nondirectional	$t_{W(ND)}$		25	30	35	μs
Pulse Width, High Speed	$t_{W(HS)}$	T_{CYCLE} frequency > f_{HIGH}	25	30	35	μs
Operating Frequency, Forward Rotation	f_{FWD}	Direction data is not available when frequency > f_{HIGH}	0	–	12	kHz
Operating Frequency, Reverse Rotation	f_{REV}	Direction data is not available when frequency > f_{HIGH}	0	–	12	kHz
Operating Frequency, Nondirectional Pulses	f_{ND}	Direction data is not available when frequency > f_{HIGH}	0	–	12	kHz

Continued on next page...

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

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

Characteristic	Symbol	Test Conditions		Min.	Typ. [1]	Max.	Unit
DIRECTION DETECTION OPTIONS (-FXXXXXX AND -RXXXXXX VARIANTS)							
Operational Air Gap Range [8]	AG	Using Allegro Reference Target 60-0, tested at 1000 rpm	-xxxxxxC variant	0.8	–	3.8	mm
			-xxxxxxM variant	1.5	–	4.5	mm
Operate Point	B_{OP}	Percentage of IC processed magnetic signals; see Figure 5		–	70	–	%
Release Point	B_{RP}	Percentage of IC processed magnetic signals; see Figure 5		–	30	–	%
PERFORMANCE CHARACTERISTICS (-FXXXXXX AND -RXXXXXX VARIANTS)							
Initial Calibration	T_{CAL}	Amount of target rotation (constant direction) after t_{PO} to first valid speed and direction output; see Figure 4		–	–	4	T_{CYCLE}
Vibration Immunity (Startup)		Refer to Functional Description section		1	–	–	T_{CYCLE}
Vibration Immunity (Running Mode)		Refer to Functional Description section		1	–	–	T_{CYCLE}
First Direction-Pulse Output Following Direction Change		High Vibration (-xxxHxxxx variant)		–	–	3	T_{CYCLE}
		Low Vibration (-xxxLxxxx variant)		–	–	1.5	T_{CYCLE}
First Direction-Pulse Output Following Running Mode Vibration				–	–	3.5	T_{CYCLE}
Switch Point Separation				See Target Design section			
Target Tooth-to-Tooth Variation		Using Allegro Reference Target 60-0 [9], correct output sequence		–	0.25	–	mm
Total Air Gap Variation During Operation		Momentary interruptions in output sequence permitted; operation within AG range		–3	–	3	mm
SPEED ONLY OUTPUT PROTOCOL OPTION (-QQQQQQX VARIANTS)							
Operational Air Gap Range [8]	AG	Using Allegro Reference Target 60-0, tested at 1000 rpm	-QQQQQQM variant	1.5	–	4.5	mm
Extended Air Gap Range	AG_{EXT}	Output duty cycle might be degraded	-QQQQQQM variant	0.5	–	–	mm
Operate Point	B_{OP}	Percentage of IC-processed magnetic signal; see Figure 5		–	70	–	%
Release Point	B_{RP}	Percentage of IC-processed magnetic signal; see Figure 5		–	30	–	%
PERFORMANCE CHARACTERISTICS (-QQQQQQX VARIANTS)							
Initial Calibration	T_{CAL}	Amount of target rotation (constant direction) following t_{PO} until first electrical output transition; see Figure 4		–	–	1.5	T_{CYCLE}
Target Tooth-to-Tooth Variation		Using Allegro Reference Target 60-0 [9], correct output sequence		–	0.25	–	mm
Total Air Gap Variation During Operation		Momentary interruptions in output sequence permitted; operation within AG range		–4	–	4	mm
Output Duty Cycle Tolerance [10]	ΔD	Using Allegro Reference Target 60-0 at any static air gap within the air gap; limits applied to maximum and minimum measurement for one full revolution of the target, around a mean value established by the average value of the IC population at the given air gap		–10	–	10	%

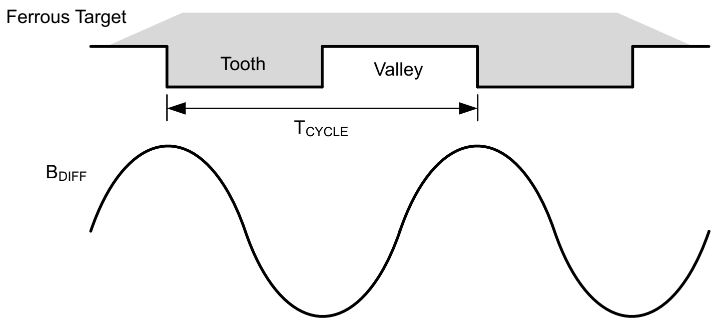
Continued on next page...

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

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

Characteristic	Symbol	Test Conditions	Min.	Typ. [1]	Max.	Unit
THERMAL CHARACTERISTICS						
Package Thermal Resistance [11]	$R_{\theta JA}$	Single-layer PCB with copper limited to solder pads	–	150	–	°C/W

[1] Typical values are at V_{CC} = 5 V and T_A = 25°C, unless otherwise specified. Performance might vary for individual units, within the maximum and minimum limits.
[2] Maximum voltage must be adjusted for power dissipation and junction temperature; see Power Derating section.
[3] Negative current is defined as conventional current coming out of (sourced from) the specified device terminal.
[4] Output transients prior to t_{PO} should be ignored.
[5] R_L = 100 Ω and C_L = 10 pF. Pulse duration measured at threshold of ($I_{CC(HIGH)}$ + $I_{CC(LOW)}$) / 2.
[6] Maximum operating frequency is determined by satisfactory separation of output pulses. If shorter low-state durations can be resolved, the maximum f_{REV} and f_{ND} might be higher.
[7] For the intermediate-pulse-width variant, direction data is not available in high-speed mode.
[8] Operating air gap is dependent on the available magnetic field. The available field is dependent on target geometry and material, and it should be independently characterized.
[9] To determine IC tolerance to air-gap variations on other targets, the complete magnetic system must be analyzed. Due to the nature of the GMR system, contact Allegro for assistance in assessing other targets for use with ATS19581.
[10] Limit applied pertains to full-scale of 0 to 100%, not as a percentage of measured duty cycle.
[11] Additional thermal information is available on the Allegro website.



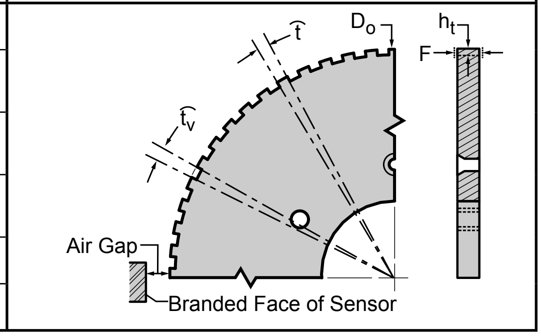
T_{CYCLE} = Target Cycle; the amount of rotation that moves one tooth and valley across the sensor.

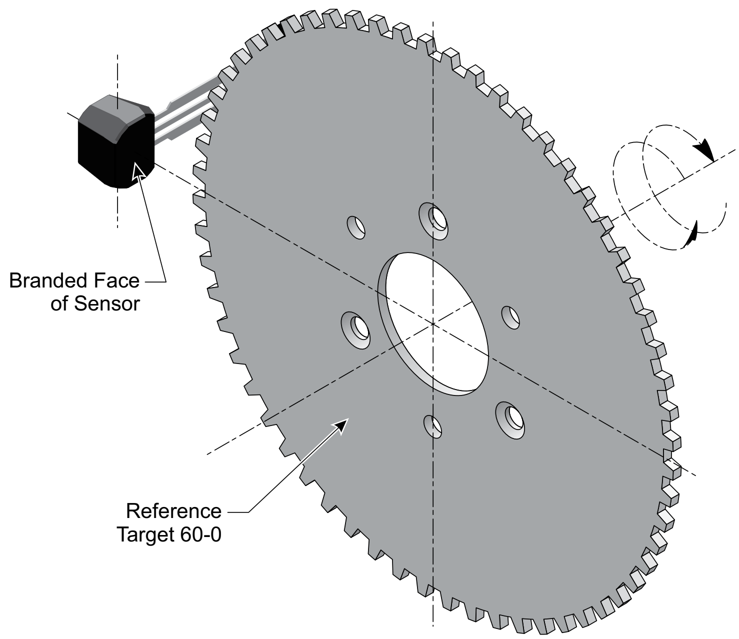
B_{DIFF} = The differential magnetic flux density sensed by the sensor.

Figure 4: Definition of T_{CYCLE}

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

ALLEGRO REFERENCE TARGET 60-0 (60-TOOTH TARGET)

Characteristics	Symbol	Test Conditions	Typ.	Units	Symbol Key
Outside Diameter	D_o	Outside diameter of target	120	mm	
Face Width	F	Breadth of tooth, with respect to branded face	6	mm	
Circular Tooth Length	t	Length of tooth, with respect to branded face	3	degrees	
Circular Valley Width	t_v	Length of valley, with respect to branded face	3	degrees	
Tooth Whole Depth	h_t		3	mm	
Material		Low-carbon steel	–	–	



FUNCTIONAL DESCRIPTION

Sensing Technology

The sensor IC contains on-chip GMR elements that are used to detect magnetic signals created by an adjacent target. These transducers provide electrical signals that contain data regarding the edge position and direction of target rotation. The ATS19581 is intended for use with ferromagnetic targets.

After proper power is applied to the sensor IC, it is capable of providing digital data that is representative of the features of a rotating target. The waveform diagrams in Figure 5 present the automatic translation of the target profiles, through their induced magnetic profiles, to the digital output signal of the sensor IC.

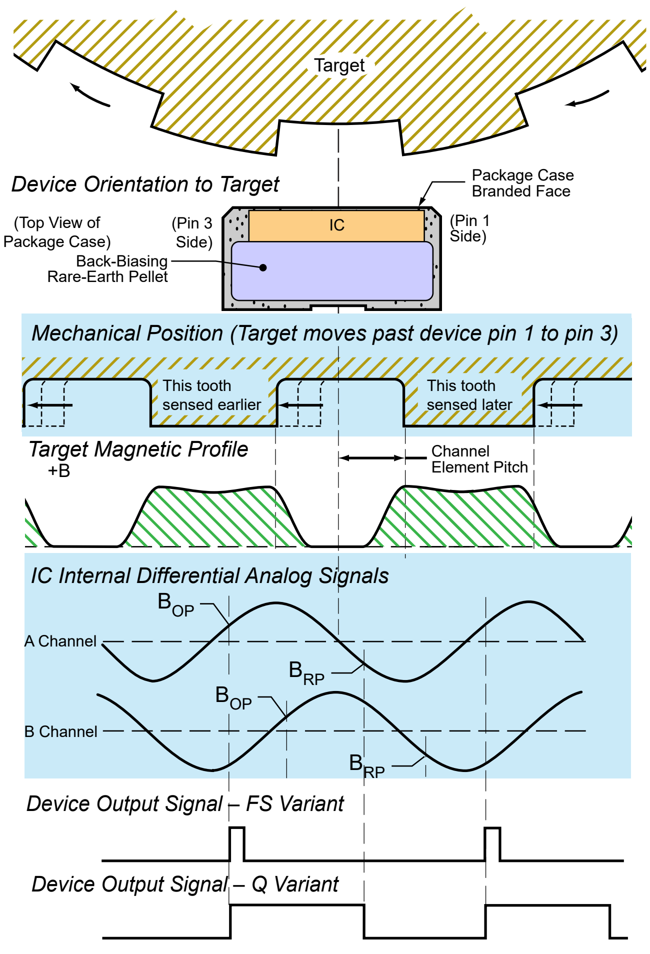


Figure 5: Magnetic Profile

Data Protocol – Speed Only

When a target passes in front of the device (opposite the branded face of the package case), the ATS19581 Q variant generates one electrical output edge per target mechanical edge.

Data Protocol – Direction Detection

When a target passes in front of the device (opposite the branded face of the package case), the ATS19581 FS and RS variants generate an output pulse for each tooth-valley pair of the target. Speed data is provided by the output pulse rate, while direction of target rotation data is provided by the duration of the output pulse. The sensor IC can sense target movement in both the forward and reverse directions.

VARIANTS

Forward and reverse rotation for the F variant of the sensor IC is shown in Figure 6, where forward is defined as target motion from pin 1 to 3. The sensor IC can also be factory-programmed for the opposite definition (R variant), where forward is defined as target motion from pin 3 to 1.

The D variant provides an output pulse for each tooth and each valley of the target.

NOTE: To achieve constant periods between each pulse, target design is a critical factor.

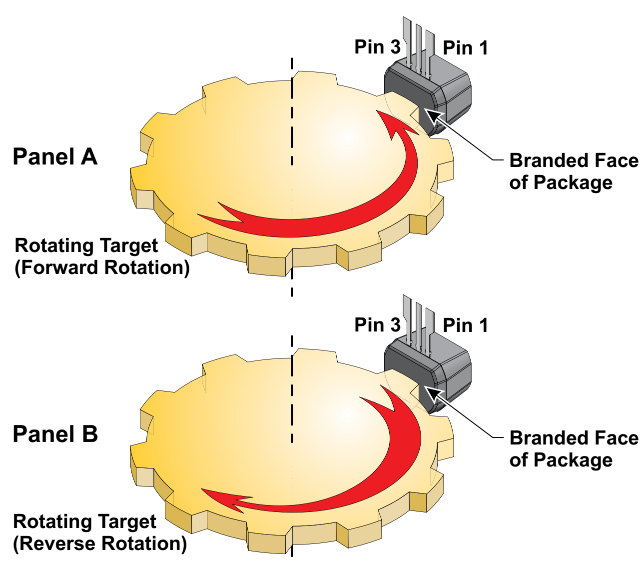


Figure 6: Target Rotation (F Variant Shown)

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

Power-On (Calibration)

After power is applied to the sensor IC, the IC internally detects the magnetic profile of the target. Operation begins with a calibration period. With direction variants (F or R suffix), the sensor IC does not provide direction data until constant direction of rotation is determined. With the Y variant, nondirectional pulses ($t_{W(ND)}$) are present during calibrtion.

With the speed-only protocol, the sensor IC provides output edges during calibration. Full edge accuracy might not be achieved until calibration is complete.

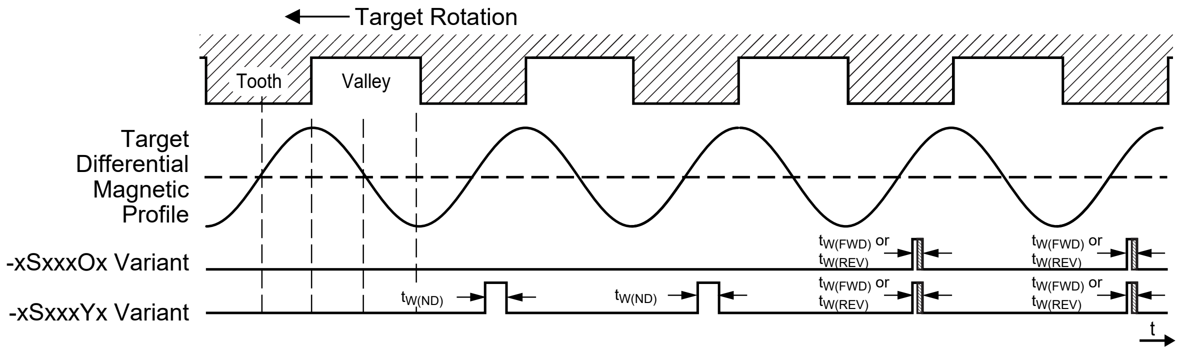


Figure 7: Output Options After Power-On (FS or RS)

Vibration

The IC has vibration detection ability, where vibration is defined as multiple changes in target direction within the vibration immunity specification. Two vibration output protocols are available, where the first change in direction is either provided to the output or suppressed. Options are also available such that nondirectional pulses can be provided during the vibration event until constant target rotation is validated. If the nondirectional option is selected, output pulses of $t_{w(ND)}$ might or might not occur, depending on the amplitude and phase of the vibration.

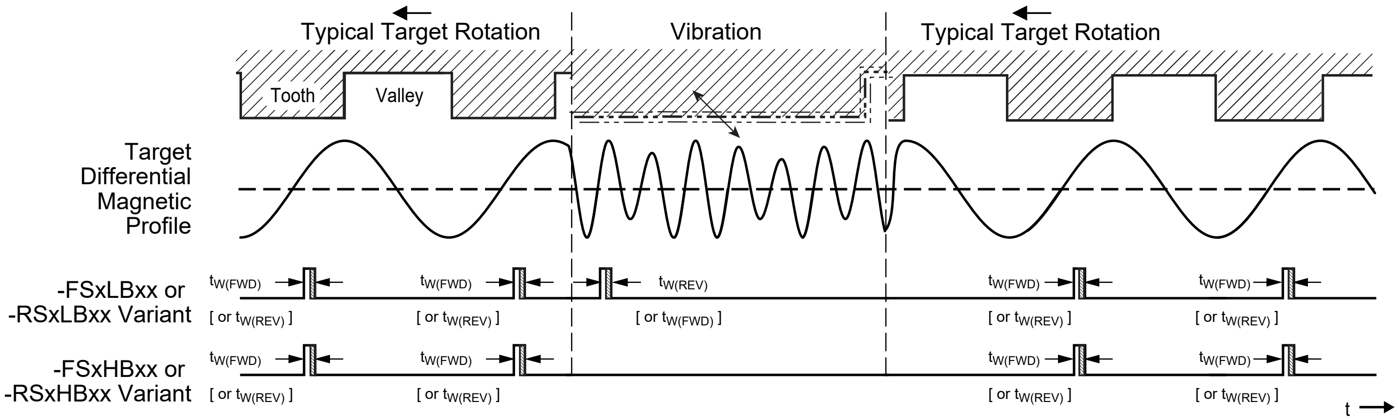


Figure 8: Output Functionality in the Presence of Running-Mode Target Vibration

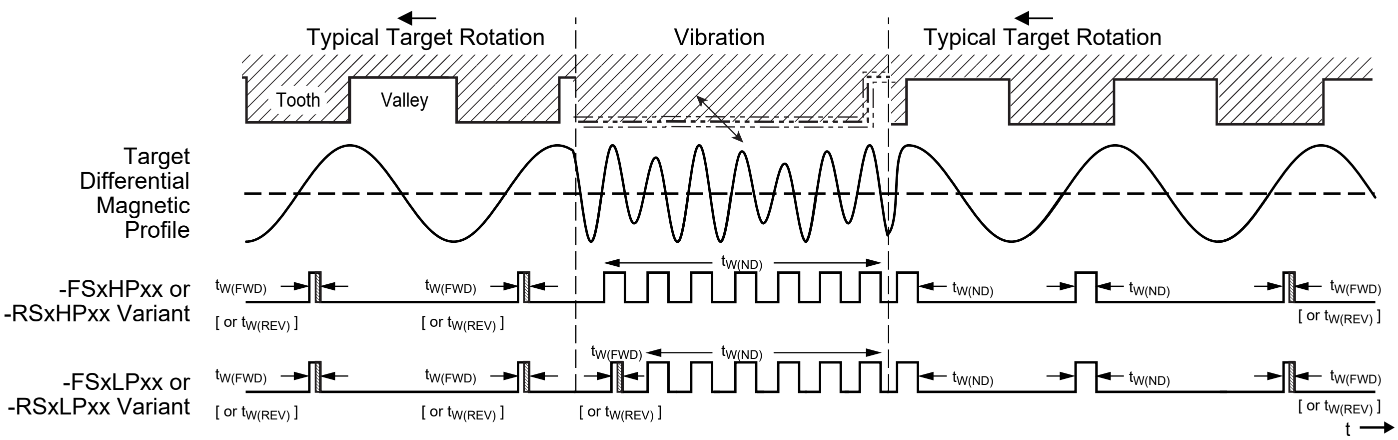


Figure 9: Output Functionality in the Presence of Running-Mode Target Vibration with Nondirectional Pulses

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

ASIL Safe State

The ATS19581 sensor IC contains diagnostic circuitry that continuously monitors occurrences of failure defects within the IC. For the output protocol of the ASIL safe state, refer to Figure 10. For additional details, refer to the ATS19581 Safety Manual.

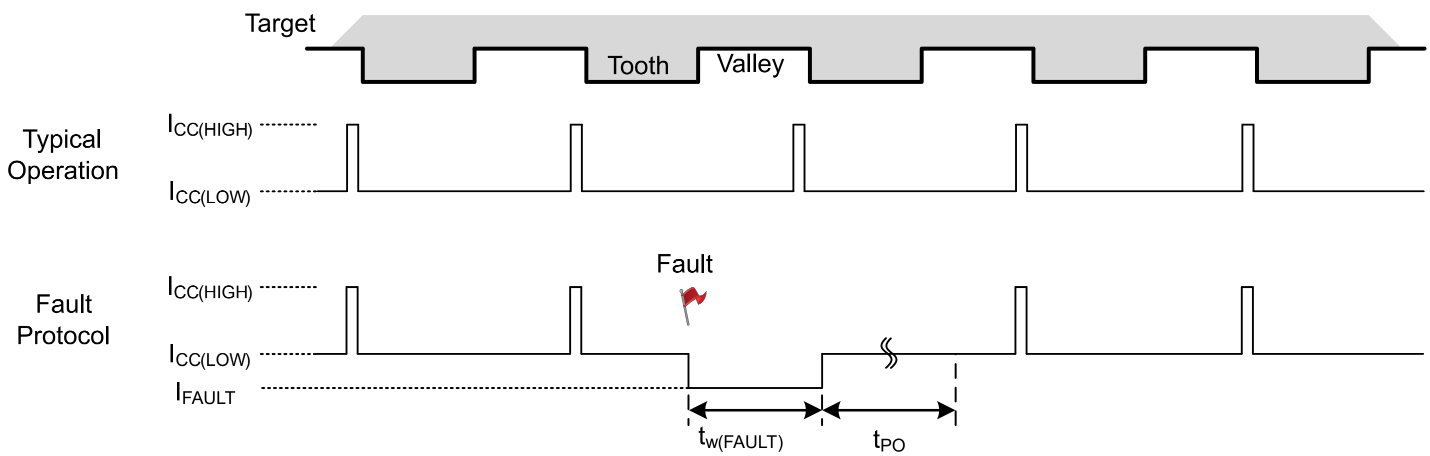


Figure 10: Output Protocol (ASIL Safe State)

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

Target Design

The ATS19581 is designed to work with a variety of target shapes and sizes, in addition to the Allegro Reference Target 60-0 design presented in this datasheet. To determine the operating air-gap range for each target, as well as the suitability for proper direction and vibration detection, the magnetic profile of each must be analyzed. The signals available on the TEST pin of the D variant can aid in the system-compatibility analysis.

TEST Pin Signals

Multiple signals are available, one at a time, via the TEST pin on the D variant. These analog signals can be used to judge the robustness of the sensor operation within the system, or to perform real-time diagnosis or characterization of system behaviors. The dedicated TEST pin allows the sensor to continue to operate uninterrupted during these investigations, with the sensor IC sending output signals to the control unit while simultaneously providing diagnostic signals.

The TEST pin signal list includes two detected magnetic channels (A Channel and B Channel; see Figure 5). Example analog output signals from the TEST pin are shown in Figure 11; note that output and A Channel were collected simultaneously; B Channel was recorded and synchronized to the A Channel using a reference encoder signal (not shown).

Also available on the TEST pin are several signals for assessing the quality of magnetic signals by querying the IC algorithm itself. An example is shown in Figure 12: At left, the target assessment signal exceeds the assigned threshold, thus showing magnetic input signals are good; while, at right, the target assessment signal is reduced to less than the threshold, indicating insufficient signal margin to operate correctly, as shown by missing output pulses.

With the D variant, signals are commanded via a sequence of voltages applied to the TEST pin. This allows the user to select which signal is active; it also allows the user to change offset and gain scaling on some analog signals. For more information regarding the use of the TEST pin, contact your local technical support.

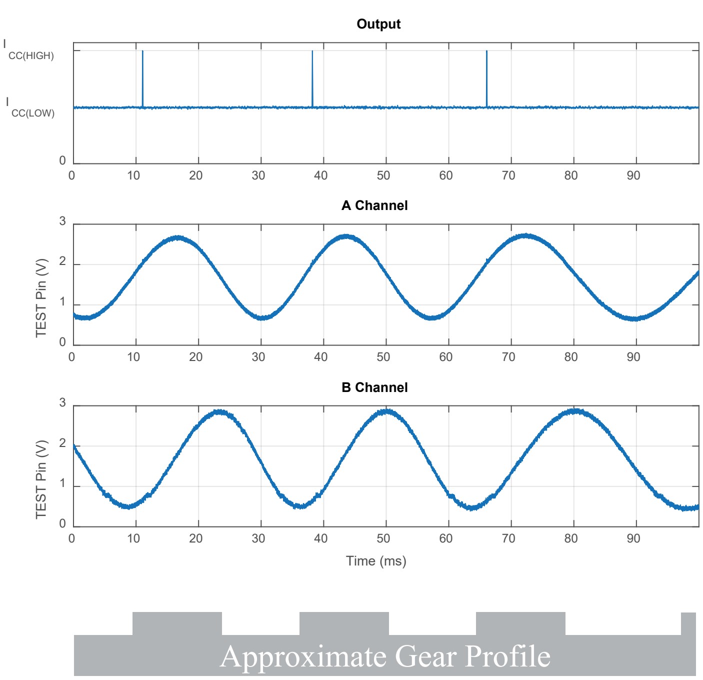


Figure 11: Example of TEST Pin Signals

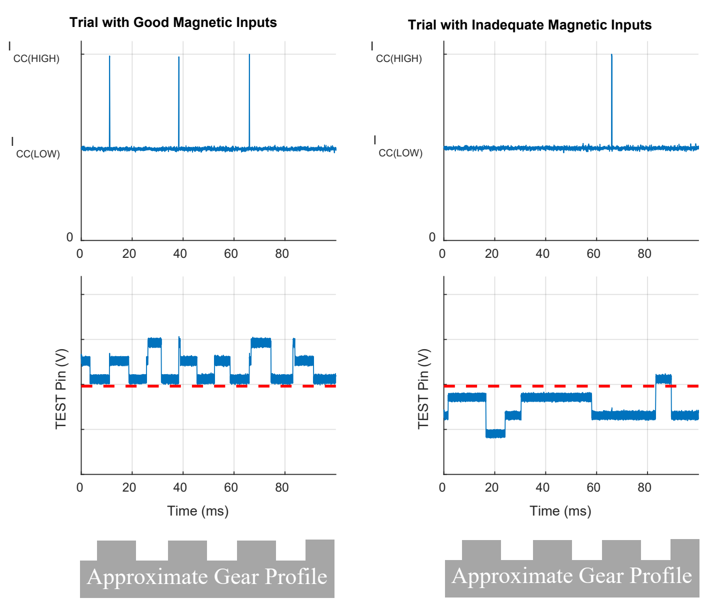


Figure 12: Example of Target Assessment Signal Showing Signals That Are Greater Than (left) and Less Than (right) the Threshold of Goodness.

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

Supply-Line Interruptions

The integrated EMC capabilities of the ATS19581 in the -ST package enables improved performance to momentary supply-voltage interruptions.

An example of the IC in continued operation in the presence of a supply interruption event is shown in Figure 13. Note that the output sequence of pulses continues after the supply disruption, indicating operation of the IC is uninterrupted.

Bench characterization shows uninterrupted operation for supply cuts of 55 µs for T_A = 150°C, and in excess of 90 µs at T_A = –40°C. Values are expected to be altered with different voltage and resistor values. For more information regarding micro-cut performance, contact your local technical support.

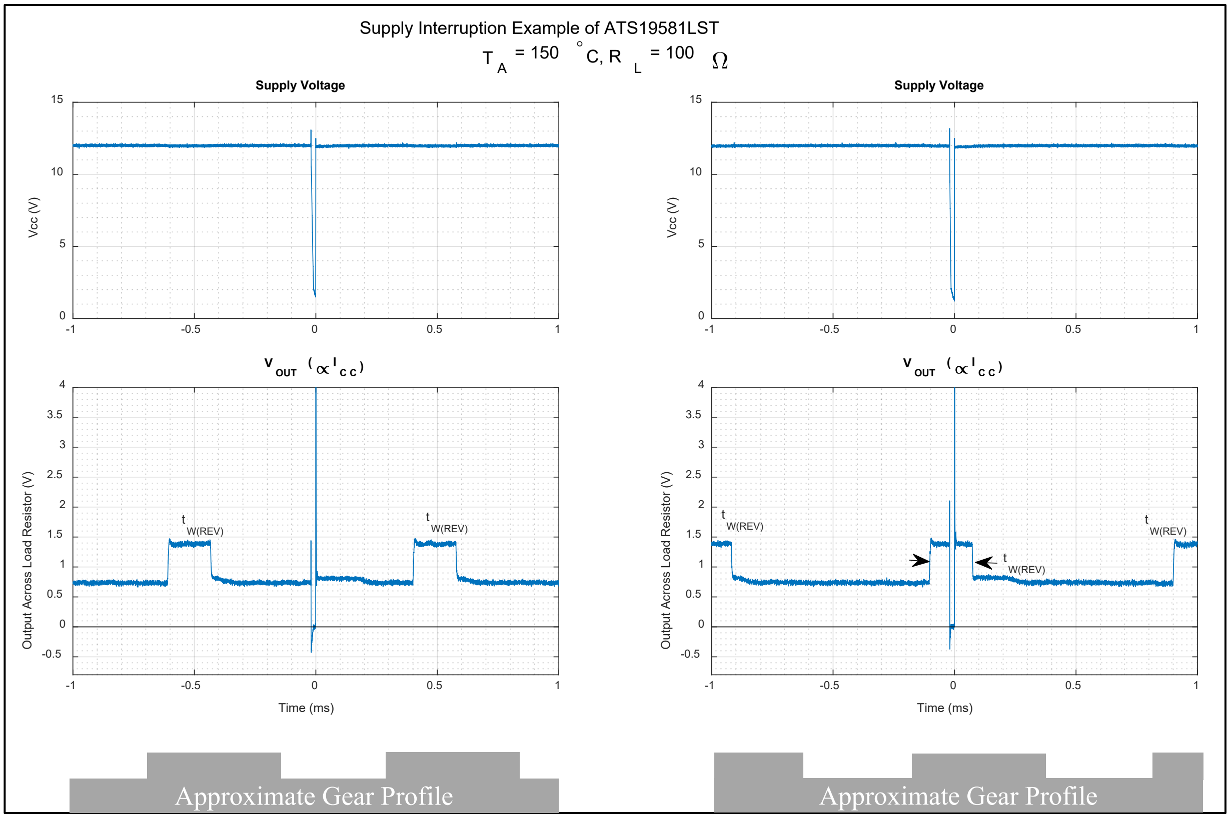


Figure 13: Example of Continued Operation in Presence of 20 µs Supply-Voltage Interruption
Left: Supply Interruption with Output in $I_{CC(LOW)}$
Right: Supply Interruption with Output in $I_{CC(HIGH)}$

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

Supply Current Transient

In response to abrupt increases in supply voltage, the IC consumes a small additional current, for a short duration. In a typical application with a low-side sense resistor (see Figure 2), a small voltage transient occurs on each output pulse. Because the specification $I_{CC(STEP)}$ is intended for all voltage transients within the allowable V_{CC} range, $I_{CC(STEP)}$ magnitudes expected in application are closer to the $I_{CC(LOW)}$ range. Characteristic output profiles are shown in Figure 14 and Figure 15, for R_L = 100 and 250 Ω and V_{SUPPLY} = 9 V.

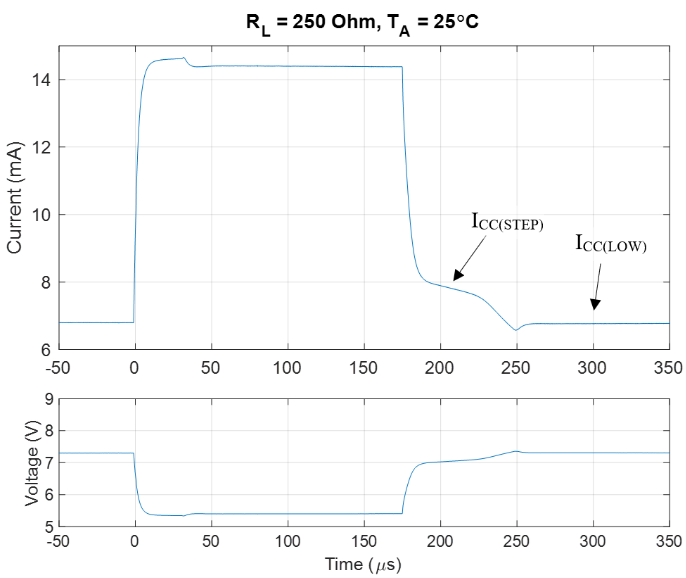


Figure 14: Characteristic Output Profile (R_L = 250 Ω and V_{SUPPLY} = 9 V)

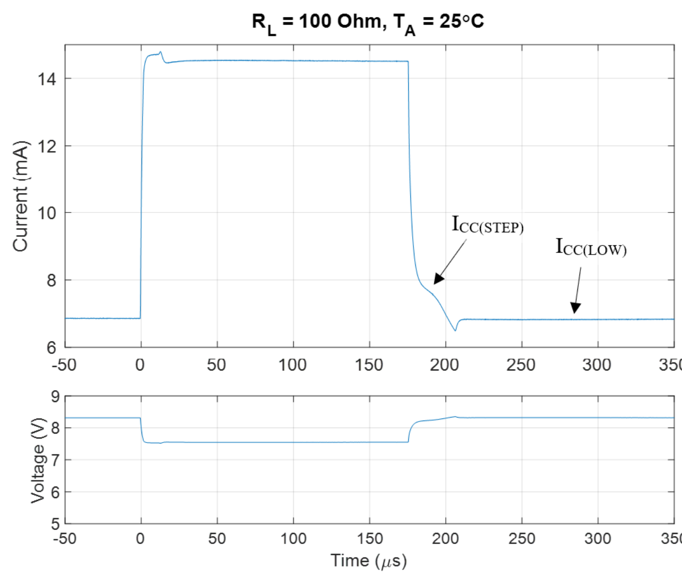


Figure 15: Characteristic Output Profile (R_L = 100 Ω and V_{SUPPLY} = 9 V)

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

POWER DERATING

The device must be operated at less than the maximum junction temperature of the device ($T_{J(max)}$). Under certain combinations of peak conditions, reliable operation might require derating 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 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.

Equation 1: $P_D = V_{IN} \times I_{IN}$

Equation 2: $\Delta T = P_D \times R_{\theta JA}$

Equation 3: $T_J = T_A + \Delta T$

For example, given common conditions such as: T_A= 25°C, V_{CC} = 12 V, I_{CC} = 7 mA, and $R_{\theta JA}$ = 150°C/W, then:

$$P_D = V_{CC} \times I_{CC} = 12\ V \times 7.0\ mA = 84\ mW$$

$$\Delta T = P_D \times R_{\theta JA} = 84\ mW \times 150°C/W = 12.6°C$$

$$T_J = T_A + \Delta T = 25°C + 12.6°C = 37.6°C$$

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 SN, using a single-layer PCB.

Observe the worst-case ratings for the device, specifically: $R_{\theta JA}$ =150°C/W, $T_{J(max)}$ =165°C, $V_{CC(max)}$ = 24 V, and $I_{CC(avg)}$ = 16 mA (using the Q variant).

Calculate the maximum allowable power level, $P_{D(max)}$. First, invert Equation 3:

$$\Delta T_{max} = T_{J(max)} - T_A = 165°C - 150°C = 15°C$$

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

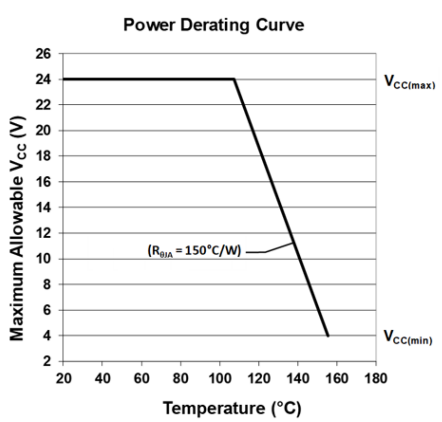
$$P_{D(max)} = \Delta T_{max} \div R_{\theta JA} = 15°C \div 150°C/W = 100\ mW$$

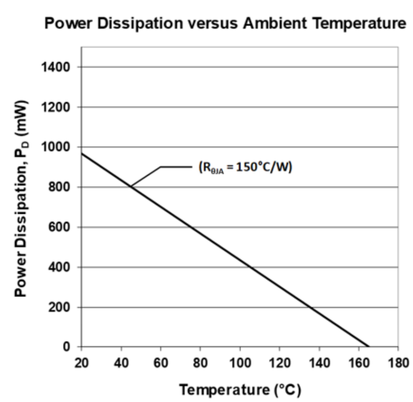
Finally, invert Equation 1 with respect to voltage:

$$V_{CC(est)} = P_{D(max)} \div I_{CC(avg)} = 100\ mW \div 16\ mA = 6.3\ V$$

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

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

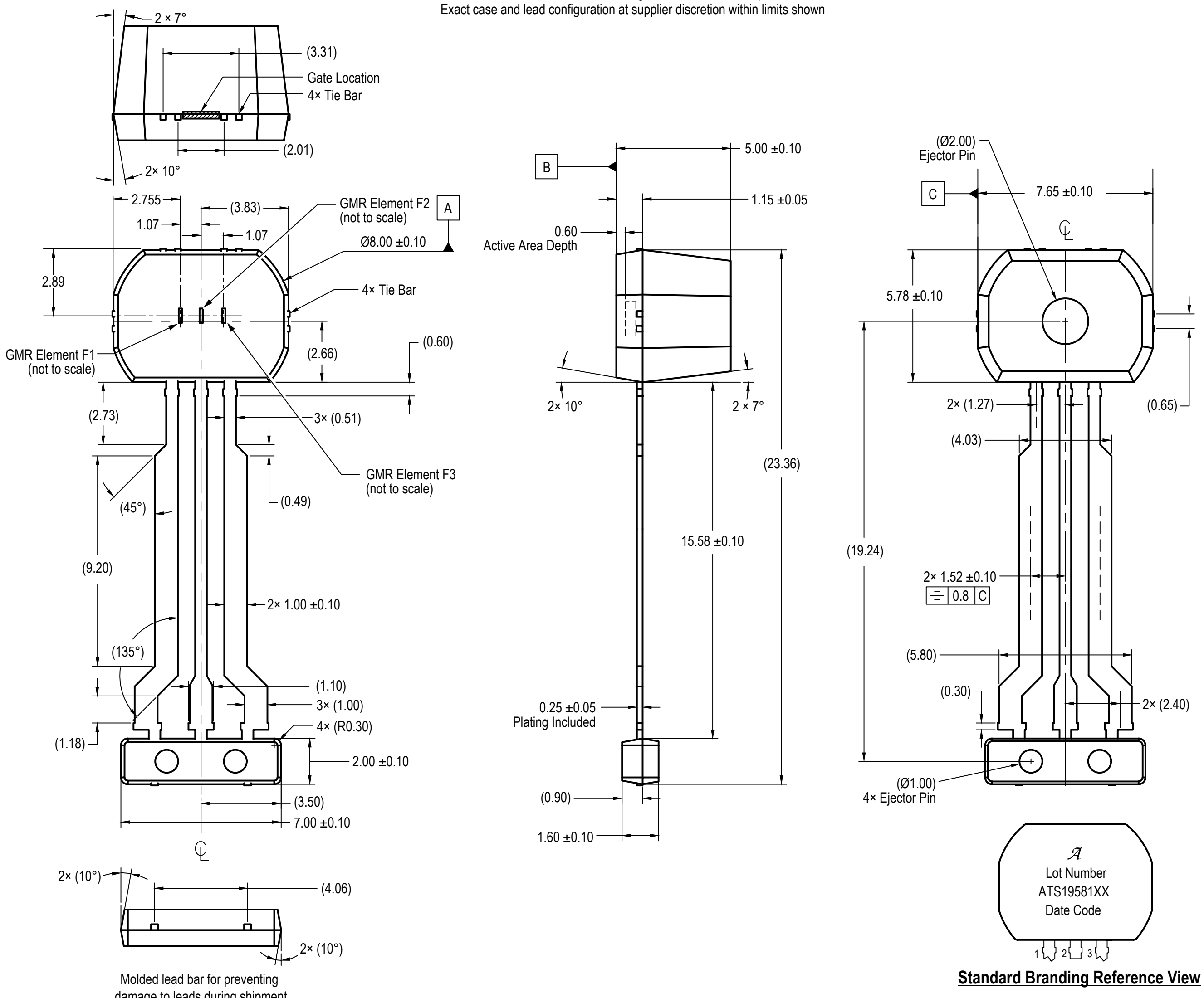




Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

PACKAGE OUTLINE DRAWING

For Reference Only – Not for Tooling Use
(Reference Allegro DWG-0000934)
Dimensions in millimeters – NOT TO SCALE
Dimensions exclusive of mold flash, gate burs, and dambar protrusions
Exact case and lead configuration at supplier discretion within limits shown



Standard Branding Reference View

Lines 1, 2, 3, 4: Up to 10 characters, centered

Line 1: Logo A
Line 2: Characters 5, 6, 7, 8, 9, 10, 11 of Assembly Lot Number
Line 3: Part Number:
3 character prefix (ATS),
5 digit part number (19581),
0-2 character part variant (XX).
Example: ATS19581B
Line 4: 4 digit Date Code

Branding scale and appearance at supplier discretion

Figure 16: Package ST, 3-Pin SIP

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

Revision History

Number	Date	Description
–	March 24, 2023	Initial release
1	July 23, 2024	Updated ASIL compatibility (page 2)
2	September 4, 2025	Modified Features and Benefits (page 1), added first direction-pulse output characteristic (page 7), modified Power-On Calibration section (page 11), modified Vibration section (page 12), and made minor editorial modifications throughout (all pages)

For the latest version of this document, visit our website:
www.allegromicro.com

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com