

## High-Feature Three-Wire Hall-Effect Transmission Speed and Direction Sensor IC

### FEATURES AND BENEFITS

- Integrated diagnostics and certified safety design process for ASIL B compliance
- Three-wire output pulse-width protocol supporting speed, direction, and ASIL
- Advanced algorithms supporting vibration detection and sudden air gap changes
- Ring magnet and ferrous target sensing
- Air gap independent switch points
- True zero-speed operation
- Integrated EMC capacitor in a single overmolded miniature package
- Robust test coverage capability with Scan Path and IDDQ measurement

### DESCRIPTION

The A19530 is an optimized Hall-effect integrated circuit (IC) that provides a user-friendly solution for direction detection and true zero-speed digital magnetic wheel or gear tooth sensing. The small package can be easily assembled and used in conjunction with a wide variety of magnetic wheels or back-biased with a magnet for gear tooth sensing applications.

The IC employs patented algorithms for the special operational requirements of automotive transmission applications. The speed and direction of the target are communicated through a variable pulse-width output protocol. The A19530 high vibration immunity option prevents direction pulses from occurring under angular vibration without sacrificing maximum air gap capability, whereas the no vibration immunity option allows for continuous direction pulse emission under vibration. The advanced vibration detection algorithm will systematically calibrate the sensor IC on the initial teeth of true target rotation and not on vibration, always providing an accurate signal in running mode.

More classic output options such as speed only protocol, representing target profile or fast direction change recognition with reduced vibration immunity also complete the programming panel of the A19530.

Advanced signal processing, innovative algorithms, short/open detection capability, and ASIL B compliant design make the A19530 an ideal solution for a wide range of speed and direction sensing needs with diagnostic requirements.

This device is available in a lead (Pb) free 3-pin SIP package with tin-plated leadframe.

### PACKAGE:



3-pin SIP (suffix UC)

*Not to scale*

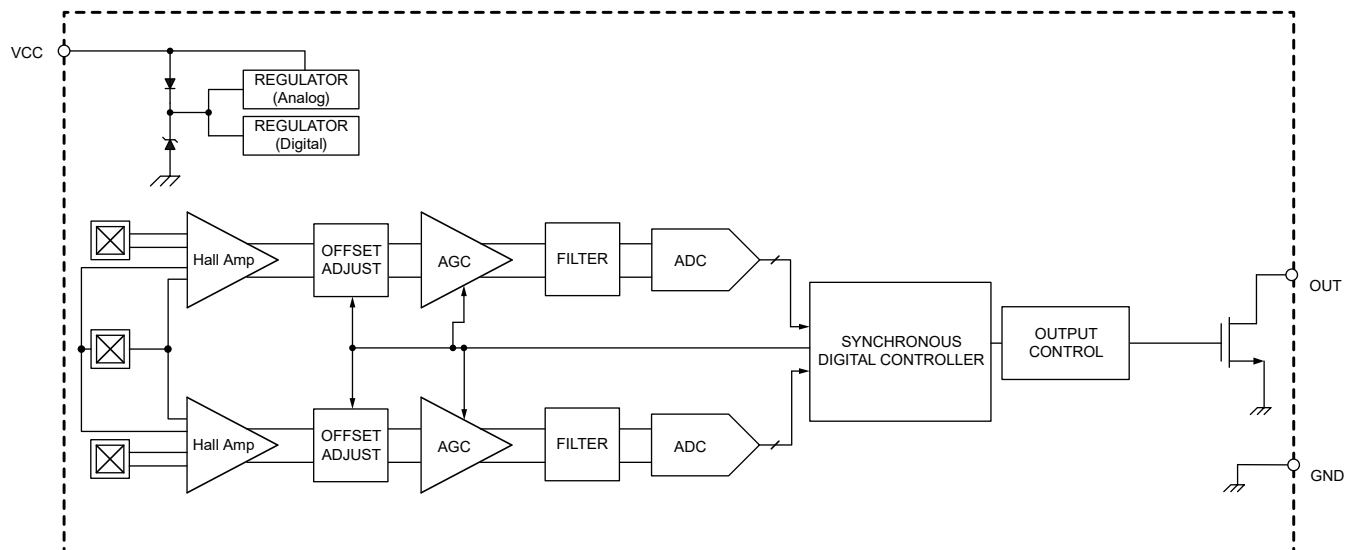


Figure 1: Functional Block Diagram

# A19530

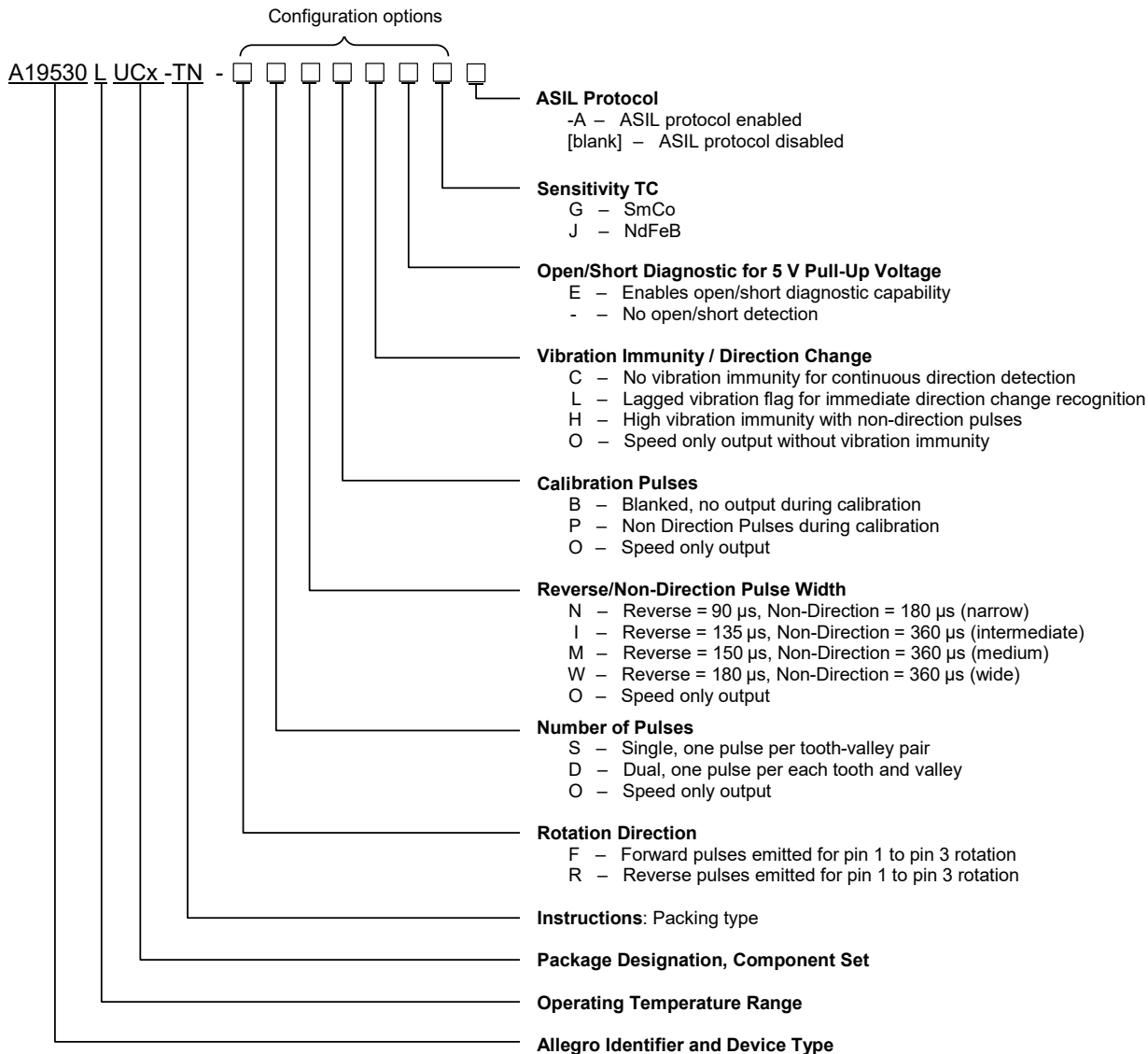
# High-Feature Three-Wire Hall-Effect Transmission Speed and Direction Sensor IC

## SELECTION GUIDE\*

Part Number	Packing
A19530LUCCTN-FOOOEJ-A	Tape and reel, 13-in. reel, 4000 pieces per reel
A19530LUCCTN-FSIBCEJ-A	Tape and reel, 13-in. reel, 4000 pieces per reel



\* Not all combinations are available. Contact Allegro sales for availability and pricing of custom programming options

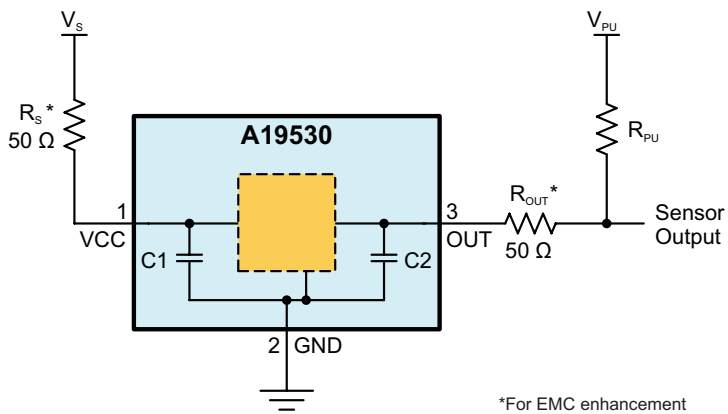


For example: A19530LUCCTN-RSNPHEJ-A

Where a configuration character is unspecified, "x" will be used. For example, -xSNPLEJ applies to both Rotation Direction configuration variants.

## ABSOLUTE MAXIMUM RATINGS

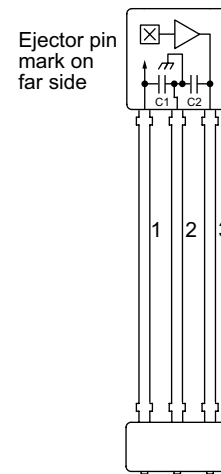
Characteristic	Symbol	Notes	Rating	Unit
Supply Voltage	$V_{CC}$	Refer to power Derating Section	27	V
Reverse Supply Voltage	$V_{RCC}$		-18	V
Reverse Supply Current	$I_{RCC}$		50	mA
Reverse Output Voltage	$V_{ROUT}$		-0.5	V
Output Sink Current	$I_{OUT}$	Open/Short detection disabled	25	mA
Operating Ambient Temperature	$T_A$		-40 to 150	°C
Maximum Junction Temperature	$T_{J(MAX)}$		165	°C
Storage Temperature	$T_{stg}$		-65 to 170	°C



**Figure 2: Typical Application Circuit**

Note: For -xxxxxEx- option (Open/Short detection Enabled), pull-up resistor value as noted in Operational Characteristics Table.

## Pinout Diagram



## INTERNAL DISCRETE COMPONENT RATINGS

Symbol	Characteristic	Rating	Unit
C1 ( $C_{SUPPLY}$ )	Nominal Capacitance	220	nF
C2 ( $C_{OUT}$ )	Nominal Capacitance	4.7	nF

## Terminal List

Number	Name	Function
1	VCC	Supply voltage
2	GND	Ground
3	OUT	Open drain output

**OPERATING CHARACTERISTICS:** Valid through full operating and temperature ranges, unless otherwise noted

Characteristics	Symbol	Test Conditions	Min.	Typ. [1]	Max.	Unit	
<b>ELECTRICAL CHARACTERISTICS</b>							
Supply Voltage [2]	$V_{CC}$	Operating; $T_J < T_{J(max)}$ , $R_{SUPPLY} = 0 \Omega$	4	–	24	V	
Undervoltage Lockout	$V_{CC(UV)}$	$V_{CC} 0 \rightarrow 5 V$ or $5 \rightarrow 0 V$ , $R_{SUPPLY} = 0 \Omega$	–	–	3.95	V	
Reverse Supply Current	$I_{RCC}$	$V_{CC} = V_{RCC(MAX)}$	–10	–	0	mA	
Supply Zener Clamp Voltage	$V_{Zsupply}$	$I_{CC} = I_{CC(MAX)} + 3 mA$ , $T_A = 25^\circ C$ , $R_{SUPPLY} = 0 \Omega$	27	–	–	V	
Supply Zener Current	$I_Z$	$T_J < T_{J(max)}$ , $V_{CC} = 27 V$	–	–	13	mA	
Supply Current	$I_{CC}$		–	8	10	mA	
<b>OUTPUT STAGE</b>							
Power-On State	POS	Connected as in Figure 2		High		–	
Low Output Voltage	$V_{diag-Low}$	4.75 V < $V_{PU}$ < 5.25 V, Output = Low, 1.45 k $\Omega$ $\leq$ $R_{PU}$ $\leq$ 3.4 k $\Omega$ at sensor output in Figure 2	-xxxxxEx- variant, $R_{OUT} = 0 \Omega$	435	875	1115	mV
			-xxxxxEx- variant, $R_{OUT} = 50 \Omega$	500	875	1250	mV
Low Output Voltage Impedance	$Z_{Sat-Low}$	$I_{SINK} = 10 mA$ , Output transistor ON, $R_{OUT} = 0 \Omega$	Open/short disabled	–	–	50	$\Omega$
High Output Voltage	$V_{diag-High}$	4.75 V < $V_{PU}$ < 5.25 V, Output = High, 1.45 k $\Omega$ $\leq$ $R_{PU}$ $\leq$ 3.4 k $\Omega$ at sensor output in Figure 2	-xxxxxEx- variant, $R_{OUT} = 0 \Omega$	3735	4125	4475	mV
			-xxxxxEx- variant, $R_{OUT} = 50 \Omega$	3750	4125	4500	mV
Output Leakage Current	$I_{OFF}$	Output transistor OFF, $V_{OUT} = 24 V$	Open/Short disabled	–	–	10	$\mu A$
Output Zener Clamp Voltage	$V_{ZOUT}$	$I_{OUT} = 3 mA$ , $T_A = 25^\circ C$	27	–	–	V	
Output Current Limit	$I_{LIM}$	$V_{OUT} = 12 V$ , $T_J < T_{J(max)}$	25	45	70	mA	
Output Rise Time	$t_{r(out-diag-ON)}$	$R_{PU} = 1.5 k\Omega$ , $V_{PU} = 5 V$ , from 10% to 90%, $R_{OUT} = 0 \Omega$	-xxxxxEx- variant	–	15	–	$\mu s$
		$R_{PU} = 3.3 k\Omega$ , $V_{PU} = 5 V$ , from 10% to 90%, $R_{OUT} = 0 \Omega$	-xxxxxEx- variant	–	35	–	$\mu s$
Output Fall Time	$t_f$	$R_{PU} = 1.5 k\Omega$ , $V_{PU} = 5 V$ , from 90% to 10%, $R_{OUT} = 0 \Omega$	-xxxxxEx- variant	1.5	–	4.5	$\mu s$
			Open/short disabled	0.5	–	2.5	$\mu s$
		$R_{PU} = 3.3 k\Omega$ , $V_{PU} = 5 V$ , from 90% to 10%, $R_{OUT} = 0 \Omega$	-xxxxxEx- variant	–	2.5	–	$\mu s$
			Open/short disabled	–	1.5	–	$\mu s$
<b>OUTPUT PULSE CHARACTERISTICS [3]</b>							
Pulse Width, Forward Rotation	$t_{w(FWD)}$			38	45	52	$\mu s$
Pulse Width, Reverse Rotation	$t_{w(REV)}$	Timing from start of falling output transition to start of rising output transition.	-xxNxxxx- variant	76	90	104	$\mu s$
			-xxLxxxx- variant	114	135	156	$\mu s$
			-xxMxxxx- variant	127	150	173	$\mu s$
Pulse Width, Non-Direction	$t_{w(ND)}$	Measured pulse width depends on circuit configuration and thresholds.	-xxWxxxx- variant	153	180	207	$\mu s$
			-xxNPxxx- variant	153	180	207	$\mu s$
			-xxIPxxx- variant, -xxMPxxx- variant, -xxWPxxx- variant	306	360	414	$\mu s$

[1] Typical values are at  $T_A = 25^\circ C$  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 Power Derating section.

[3] Only applicable to direction detection options, S (Single) and D (Dual).

**OPERATING CHARACTERISTICS (continued):** Valid through full operating and temperature ranges, unless otherwise noted

Characteristics	Symbol	Test Conditions	Min.	Typ. [1]	Max.	Unit	
<b>PERFORMANCE CHARACTERISTICS</b>							
Operate Point	B <sub>OP</sub>	% peak to peak	–	69	–	%	
Release Point	B <sub>RP</sub>	% peak to peak	–	31	–	%	
Switch Point Separation	B <sub>DIFF(SP-SEP)</sub>	Minimum separation between channels as a percentage of signal amplitude at each switching point; refer to Figure 5	20	–	–	%	
Differential Input Signal Frequency, Forward Rotation [4]	f <sub>FWD</sub>	-xSxxxx- and -xOxxxx- variant	0	–	12	kHz	
		-xDxxxx- variant	0	–	6	kHz	
Differential Input Signal Frequency, Reverse Rotation [4]	f <sub>REV</sub>	-xSNxxxx- variant	0	–	7	kHz	
		-xDNxxxx- variant	0	–	3.5	kHz	
		-xSWxxxx- variant	0	–	4	kHz	
		-xDWxxxx- variant	0	–	2	kHz	
Differential Input Signal Frequency, Non-Direction [4]	f <sub>ND</sub>	-xSxPHxx- and -xSxPLxx- variant	0	–	2.2	kHz	
		-xDxPHxx- and -xDxPLxx- variant	0	–	1.1	kHz	
<b>TEMPERATURE COEFFICIENT</b>							
Sensitivity Temperature Coefficient (TC)	T <sub>C</sub>	-xxxxxG- variant	–	0.04	–	%/°C	
		-xxxxxJ- variant	–	0.13	–	%/°C	
<b>POWER-ON AND CALIBRATION</b>							
Power-On Time	t <sub>PO</sub>	f <sub>OP</sub> < 100 Hz	–	–	2	ms	
First Direction Output Pulse [6]		Amount of target rotation (constant direction) following power-on until first electrical output pulse of either t <sub>w(FWD)</sub> or t <sub>w(REV)</sub> ; Refer to Figure 3	-xxxxCxx- variant	–	1.5	< 2.5	T <sub>CYCLE</sub>
			-xxxxLxx- variant, -xxxxHxx- variant; B <sub>DIFF(pk-pk)</sub> > 60 G, B <sub>DIFF(pk-pk)</sub> ≤ 1500 G	–	2	< 3.1	T <sub>CYCLE</sub>
			-xxxxLxx- variant, -xxxxHxx- variant; 30 G ≤ B <sub>DIFF(pk-pk)</sub> , B <sub>DIFF(pk-pk)</sub> ≤ 60 G	–	2.5	< 4	T <sub>CYCLE</sub>
First Direction Pulse Output Following Direction Change	N <sub>CD</sub>	Amount of target rotation (constant direction) following event until first electrical output pulse of either t <sub>w(FWD)</sub> or t <sub>w(REV)</sub> ; refer to Figure 3	-xxxxCxx- variant, -xxxxLxx- variant	–	1	< 1.5	T <sub>CYCLE</sub>
			-xxxxHxx- variant	1	2	< 3	T <sub>CYCLE</sub>
First Direction Pulse Output Following Running Mode Vibration		Amount of target rotation (constant direction) following event until first electrical output pulse of either t <sub>w(FWD)</sub> or t <sub>w(REV)</sub> ; refer to Figure 3	-xxxxCxx- variant	–	1	< 2.5	T <sub>CYCLE</sub>
			-xxxxLxx- variant, -xxxxHxx- variant	1	2	< 3.5	T <sub>CYCLE</sub>

[4] Maximum operating frequency specified for output rise time t<sub>r</sub> < 17 μs. Parameter determined by satisfactory separation of output pulses t<sub>w</sub>. If end-user can resolve smaller time between pulses with faster rise time, maximum frequency may be increased up to 12 kHz.

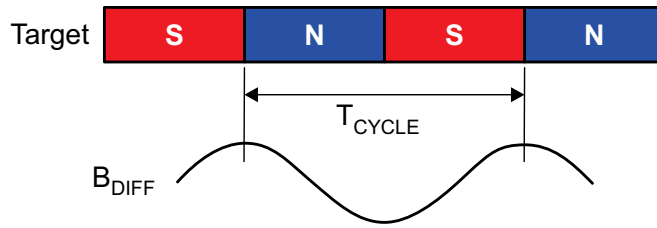
[5] Power-On Time includes the time required to complete the internal automatic offset adjust. Part is then ready for peak acquisition.

[6] Power-on frequency <200 Hz. Higher power-on frequencies may require more input magnetic cycles until directional output pulses are achieved.

**OPERATING CHARACTERISTICS (continued):** Valid through full operating and temperature ranges, unless otherwise noted

Characteristics	Symbol	Test Conditions	Min.	Typ. [1]	Max.	Unit	
<b>MAGNETIC CHARACTERISTICS</b>							
Differential Input Signal Range [7]	$B_{DIFF(pk-pk)}$	Differential magnetic signal	30	–	1500	G	
Allowable User-Induced Offset		Magnitude valid on differential magnetic channels	-xxxxCxx- variant, -xxxxLxx- variant, -xxxxHxx- variant	–200	–	200	G
			-xOOOOxx- variant	–300	–	300	G
Allowable Differential Sequential Signal Variation	$B_{SEQ(n+1)} / B_{SEQ(n)}$	Single cycle-to-cycle variation, $B_{SEQ(n+1)} / B_{SEQ(n)}$ ; no missed pulses (pulse variant), nor missed edges (-xOOOOxx- variant); refer to Figure 4	0.6	–	–	–	
Allowable Differential Sequential Signal Variation		Single cycle-to-cycle variation, $B_{SEQ(n+1)} / B_{SEQ(n)}$ ; pulses count error but device can recover (pulse variant) and possible missed edges but no flatline (-xOOOOxx- variant); refer to Figure 4	0.35	–	–	–	
<b>VIBRATION IMMUNITY</b>							
Vibration immunity (Calibration)	$Err_{Vib(SU)}$	-xxxxCxx- variant	0.5	1.0	–	$T_{CYCLE}$	
		-xxxxLxx- and -xxxxHxx variant	1	–	–	$T_{CYCLE}$	
Vibration Immunity (Running Mode)	$Err_{Vib(RM)}$	-xxxxCxx- variant	–	none	–	$T_{CYCLE}$	
		-xxxxLxx- and -xxxxHxx variant	1	–	–	$T_{CYCLE}$	
<b>ASIL OUTPUT</b>							
ASIL Output Safe State	$V_{ASIL\_safe\_low}$	Internal failure detected for $4.75\text{ V} < V_{PU} < 5.25\text{ V}$ , $R_{OUT} = 0\ \Omega$ , $1.45\text{ k}\Omega \leq R_{PU} \leq 3.4\text{ k}\Omega$ , at sensor output in Figure 2	-xxxxxEx- variant	–	–	180	mV
Time In Safe State Before Self-Reset	$t_{w(ASIL\_safe)}$	Connected as in Figure 2	-xxxxxEx- variant	–	5	–	ms

[7] Differential magnetic field is measured for Channel A (F1-F2) and Channel B (F2-F3) for pulse width variant and for Channel A' (F1-F3) for speed only variant (-xOOOOxx- variant). Magnetic field is measured orthogonally to the front of the package. Refer to Figure 7 and package drawing.



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

$T_{CYCLE}$  = Target Cycle; the amount of rotation that moves one tooth (or north pole) and one valley (or south pole) across the sensor

Figure 3: Definition of  $T_{CYCLE}$

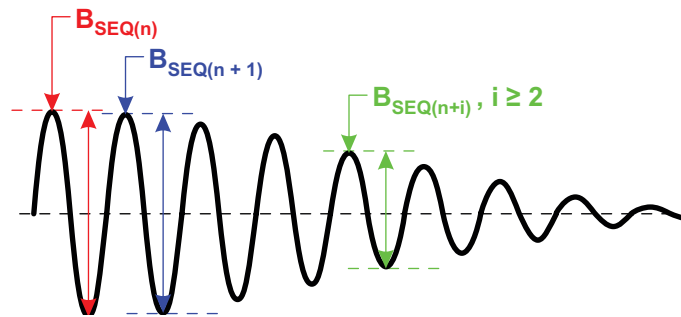


Figure 4: Differential Signal Variation

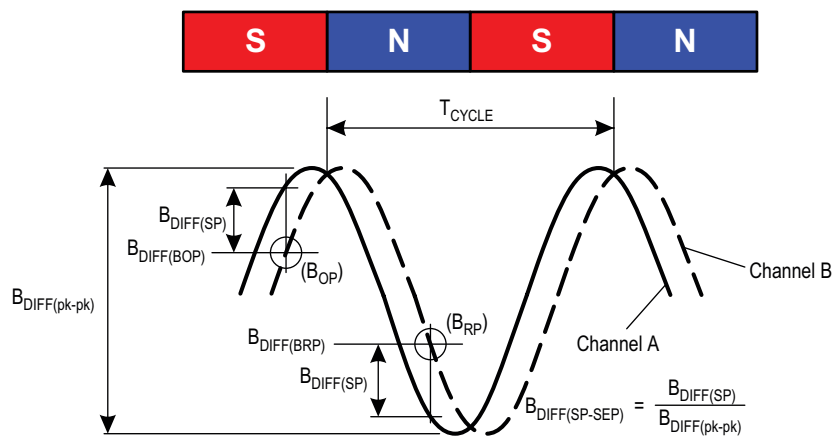


Figure 5: Definition of Switch Point Separation

## FUNCTIONAL DESCRIPTION

### Sensing Technology

The sensor IC contains a single-chip Hall-effect circuit that supports a trio of Hall elements. These are used in differential pairs to provide electrical signals containing information regarding edge position and direction of target rotation. The A19530 is intended for use with magnetic trigger wheels or ferromagnetic targets if back-biased with a magnet.

After proper power is applied to the sensor IC, it is capable of providing digital information that is representative of the magnetic features of a rotating target. The waveform diagrams in Figure 7 present the automatic translation of the target profiles, through their induced magnetic profiles, to the digital output signal of the sensor IC.

### Direction Detection

The sensor IC compares the relative phase of its two differential channels to determine which direction the target is moving. The relative switching order is used to determine the direction, which is communicated through the output protocol.

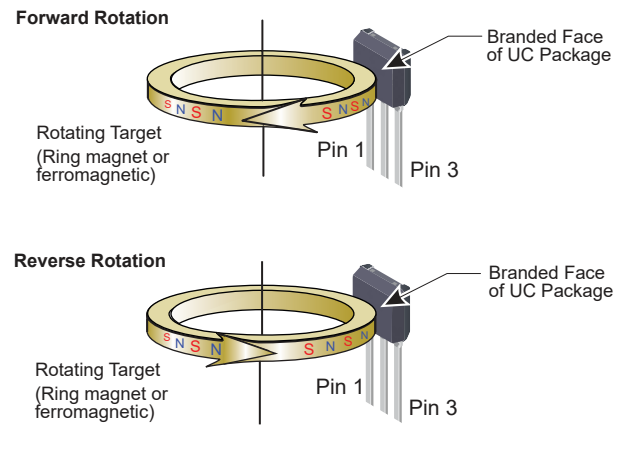
### Data Protocol Description

When a target passes in front of the device (opposite the branded face of the package case), the A19530 generates an output pulse for each pole pair of the target (-xSxxxxx variant). Speed information is provided by the output pulse rate, while direction of target rotation is provided by the duration of the output pulses. The sensor IC can sense target movement in both the forward and reverse directions.

**Forward Rotation** (see top panel in Figure 6): When the target is rotating such that a tooth near the sensor IC (of -Fxxxxxx variant) passes from pin 1 to pin 3, this is referred to as forward rotation. This direction is opposite for the -Rxxxxxx variant. Forward rotation is indicated by output pulse widths of  $t_{w(FWD)}$  (45  $\mu$ s typical).

**Reverse Rotation** (see bottom Figure 6): When the target is rotating such that a tooth passes from pin 3 to pin 1, it is referred to as reverse rotation for the -Fxxxxxx variant. Reverse rotation is indicated by output pulse widths of  $t_{w(REV)}$  (90  $\mu$ s typical for -xxNxxxx variant, or 180  $\mu$ s typical for -xxWxxxx variant).

**Speed Only Protocol:** When the A19530 is configured with the -xO000xx- variant, the device directly outputs the digital representation of the target from the master differential Channel (Channel A' in Figure 7). Changing magnetic polarity (north versus south) will invert the output polarity in same way as using a -FO000xx- variant instead of a -RO000xx- would invert it.



**Figure 6: Target Rotation for -Fxxxxxx variant; Rxxxxxx variant inverts detected direction of rotation**



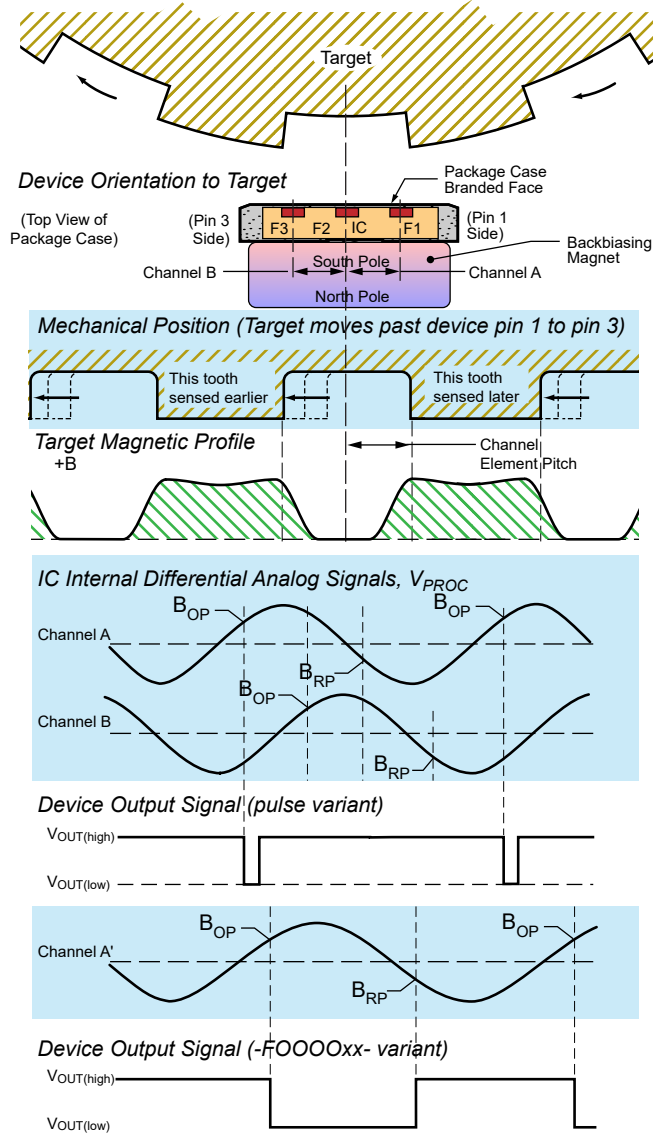
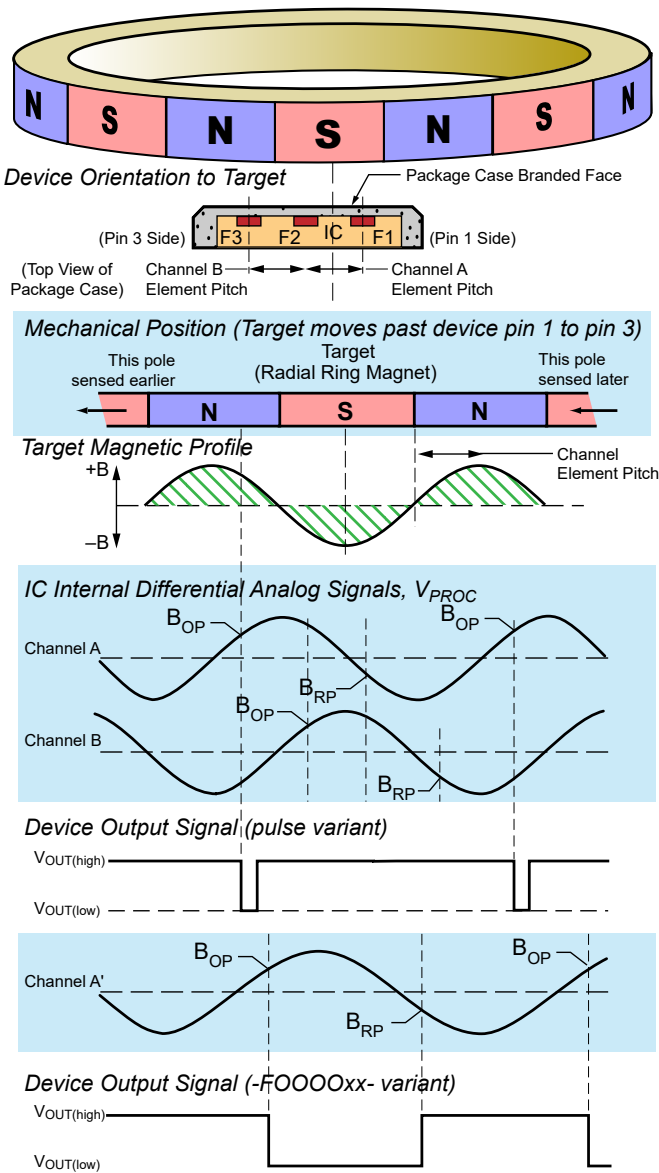


Figure 7: The magnetic profile reflects the features of the target, allowing the sensor IC to present an accurate digital output

## Timing

In speed only mode with forward direction (-FOOOOxx option), the rising electrical edge occurs slightly before the sensed magnetic edge traverses the package branded face (Figure 8).

In pulse output protocol with forward direction (-FSxxLxx and -FSxxHxx variants), the pulse appears at the output slightly before the sensed magnetic edge traverses the package branded face. This is true in both forward and reverse target rotation direction, but it must be noticed that the magnetic edge is opposite in reverse direction (Figure 9).

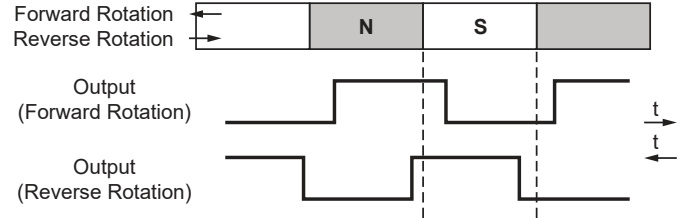
With the -xxxxCxx variant, the sensed mechanical edge that stimulates output pulses is kept the same for both forward and reverse rotation, resulting in having the pulse on same pole in forward and reverse rotation (Figure 10). It must also be noticed that in this mode, the pulse location may be different depending on the power-up cycle conditions.

## Direction Validation

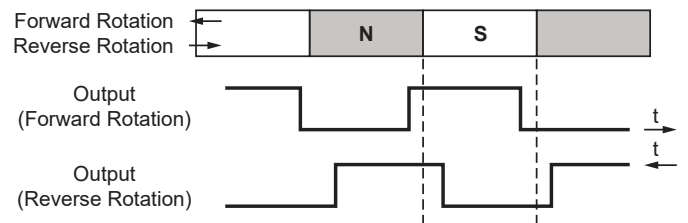
For the -xxxxLxx and -xxxxCxx variants, following a direction change in running mode, direction changes are immediately transmitted to the output (Figure 11 and Figure 12).

For the -xxxxHxx variant, following a direction change in running mode, output pulses have a width of  $t_{w(ND)}$  until direction information is validated (Figure 13).

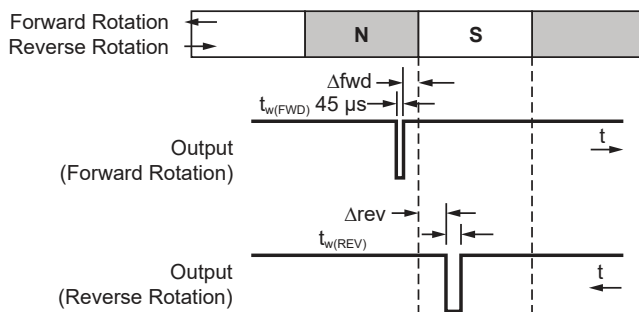
For the -xOOOOxx option, output transitions are emitted directly after direction change event.



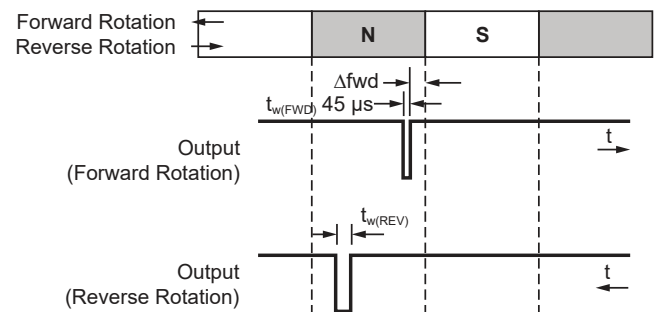
**Figure 8a: Output Protocol  
(-FOOOxx- variant)**



**Figure 8b: Output Protocol  
(-ROOOxx- variant)**



**Figure 9: Output Protocol  
(-FSxxLxx & -FSxxHxx variants)**



**Figure 10: Output Protocol (-FSxxCxx variant)**

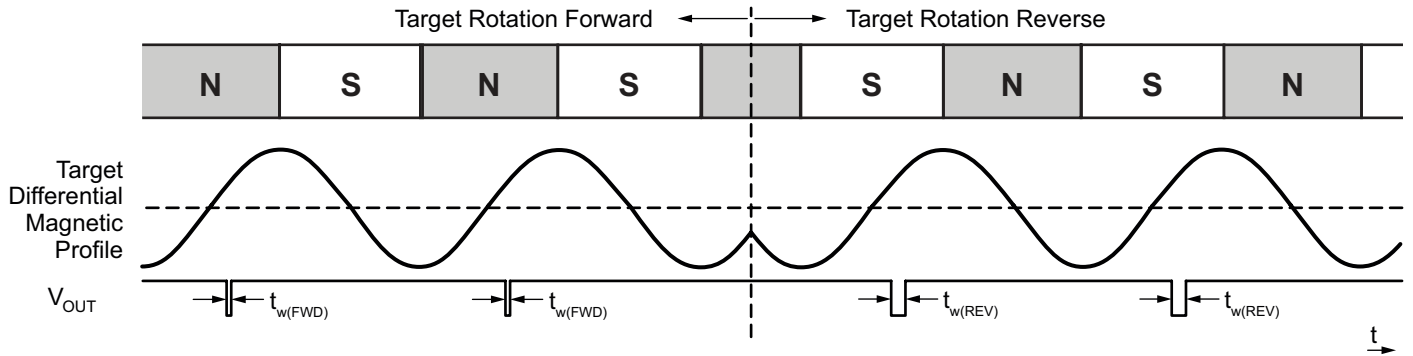


Figure 11: Example of running mode direction change (-FSxxLxx variant)

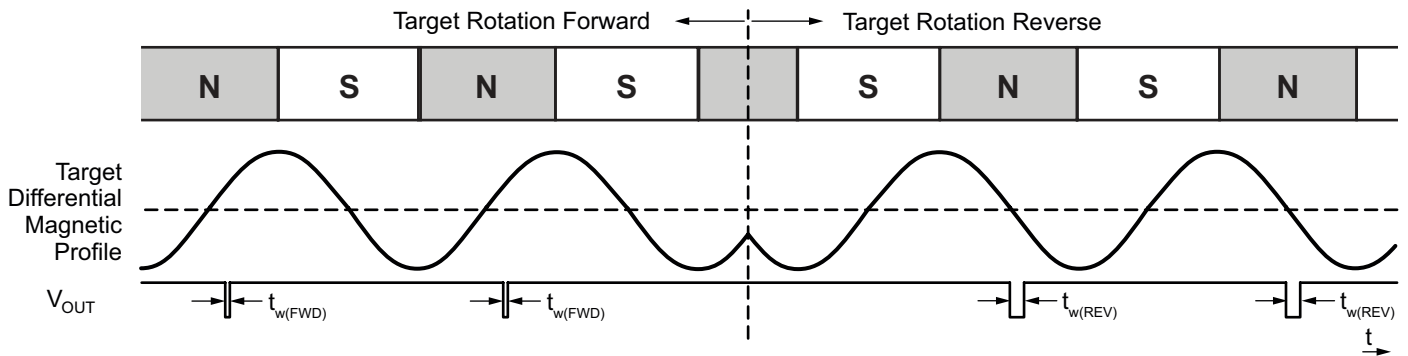


Figure 12: Example of running mode direction change (-FSxxCxx variant)

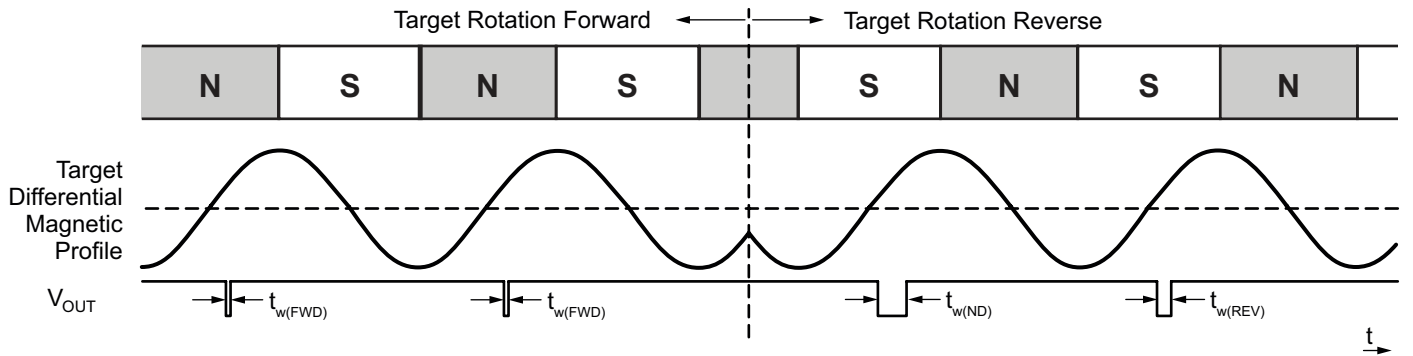


Figure 13: Example of running mode direction change (-FSxxHxx variant)

## Start-Up Detection / Calibration

When power is applied to the A19530, the sensor IC internally detects the profile of the target. The gain and offset of the detected signals are adjusted during the calibration period, normalizing the internal signal amplitude for the air gap range of the device.

The Automatic Gain Control (AGC) feature ensures that operational characteristics are isolated from the effects of installation air gap variation.

Automatic Offset Adjustment (AOA) is circuitry that compensates for the effects of chip, magnet, and installation offsets. This

circuitry works with the AGC during calibration to adjust signal to the A-to-D input range and allow for acquisition of signal peaks. AOA and AGC function separately on the two differential signal channels.

Direction information is available after calibration is complete.

For the -xxxBxxx- variant, the output becomes active at the end of calibration. For the -xxxPxxx- variant, output pulses of  $t_w(ND)$  are supplied during calibration.

Figure 14 through Figure 16 show where the first output edge may occur for various starting target phases.

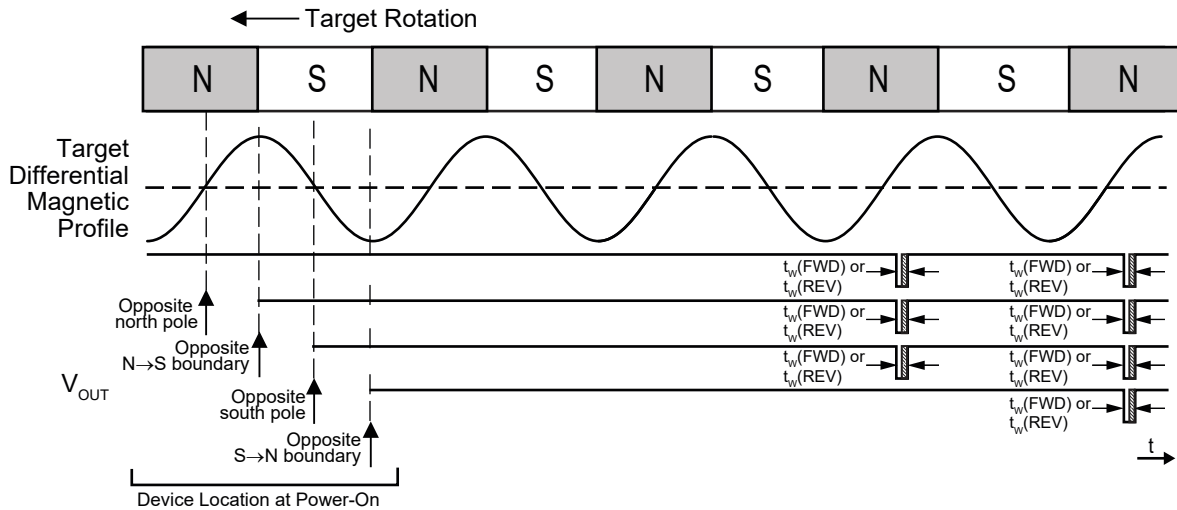


Figure 14: Start-up position effect on first device output switching (-xxxBHxx or -xxxBLxx variants)

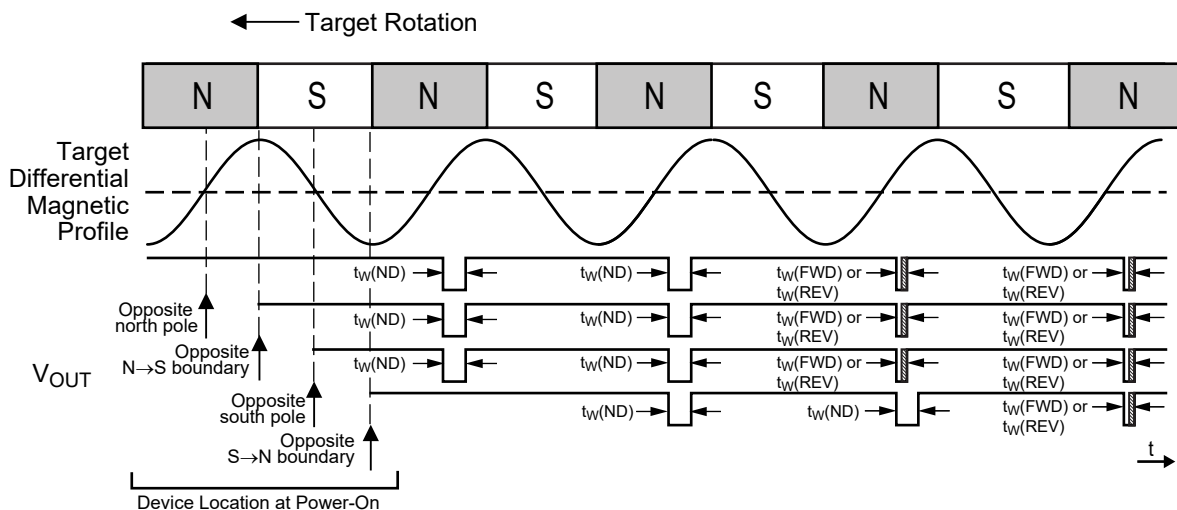


Figure 15: Start-up position effect on first device output switching (-xxxPHxx or -xxxPLxx variants)

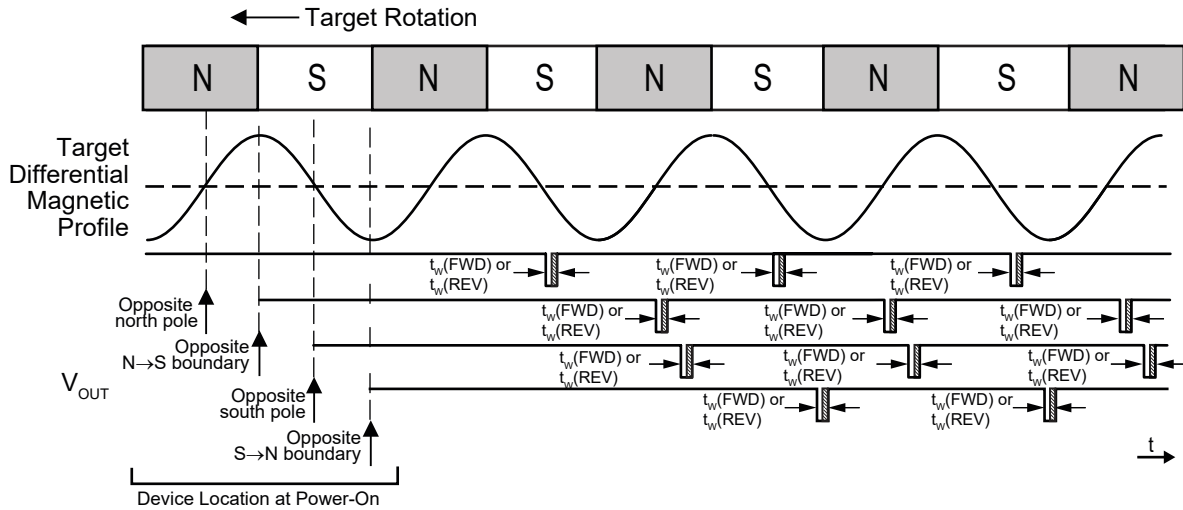


Figure 16: Start-up position effect on first device output switching (-xxxBCxx variant)

## Vibration Detection

Algorithms embedded in the IC’s digital controller detect the presence of target vibration through analysis of the two magnetic input channels.

For the -xxxxCxx variant, vibration detection algorithms are activated in calibration only. Once the device exits calibration, vibration detection algorithms are deactivated, and any direction change or vibration events are transmitted through the output with continuous direction information.

For the -xxxxLxx variant, any direction change post calibration is immediately transmitted to the output, and if any subsequent

vibration occurs, the output is blanked, and no output pulses are emitted for vibrations less than the specified vibration immunity. Output pulses containing the proper direction information will resume when direction information is validated on constant target rotation.

For the -xxxxHxx variant, in the presence of vibration, output pulses of  $t_{w(ND)}$  may occur or no pulses may occur, depending on the amplitude and phase of the vibration. Output pulses have a width of  $t_{w(ND)}$  until direction information is validated on constant target rotation.

For the -xOOOOxx variant, in the presence of vibration, output transitions representing target vibration profile may occur.

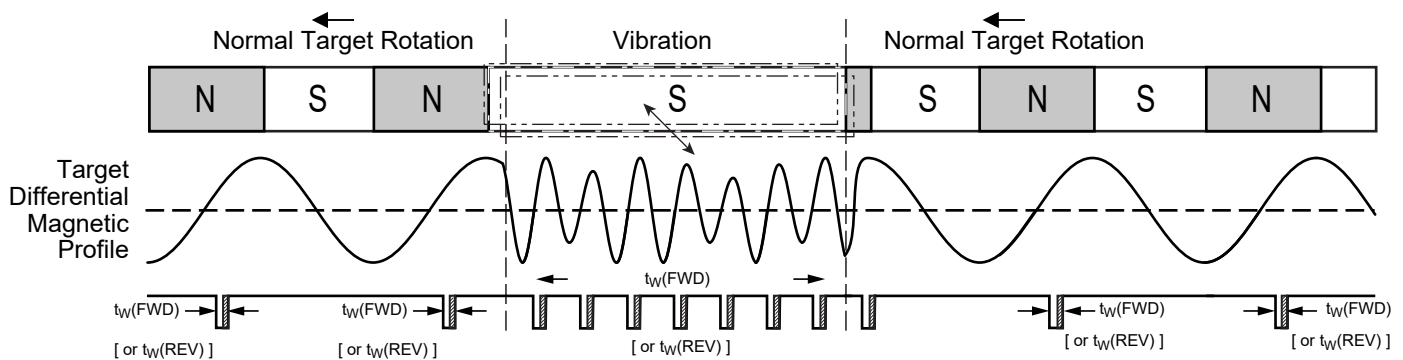


Figure 17: Output Functionality in the presence of Running Mode Target Vibration (-xxxBCxx variant)

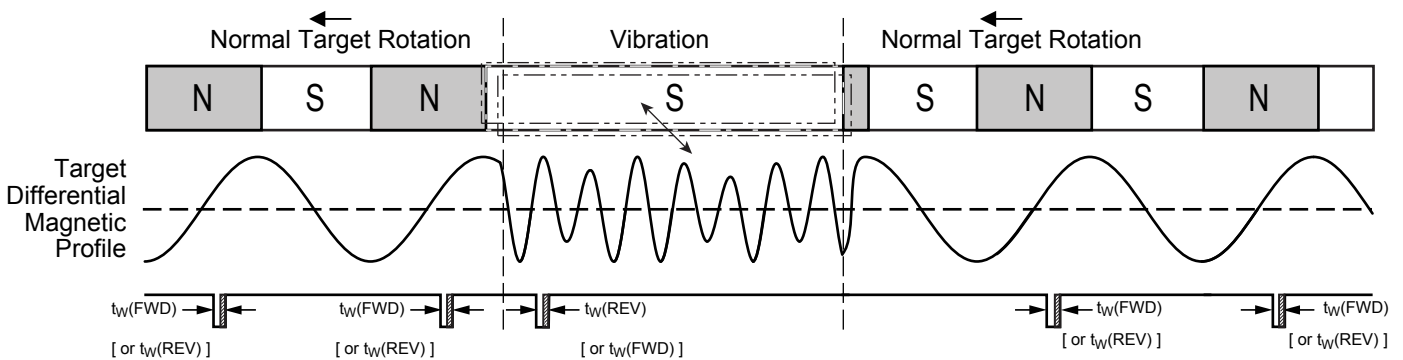
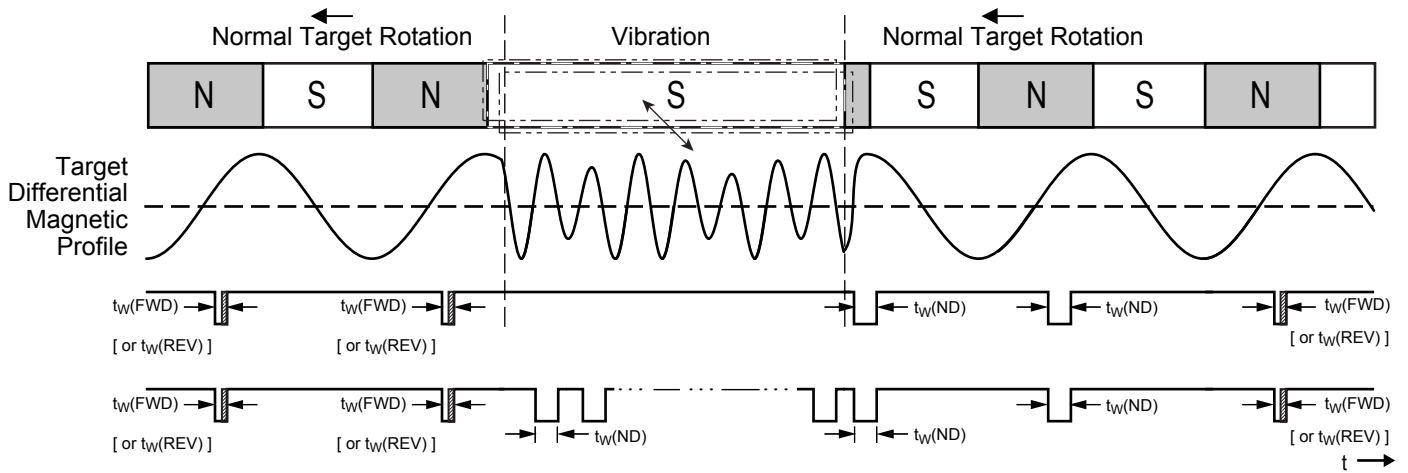


Figure 18: Output Functionality in the presence of Running Mode Target Vibration (-xxxBLxx variant)



**Figure 19: Output Functionality in the presence of Running Mode Target Vibration (-xxxPHxx variant)**

## Diagnostic Capability

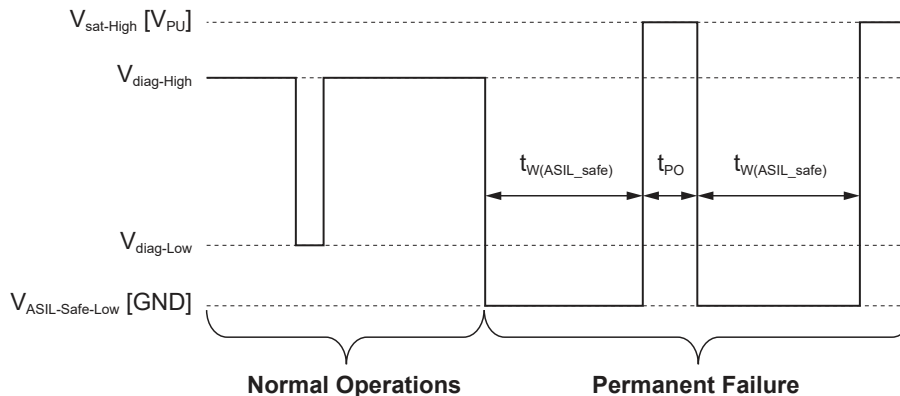
When diagnostic functionality is activated, the device continuously monitors itself, from the signal chain to output levels and reports a fault by driving the output to the safe state (low level) for a period of time defined by  $t_{w(ASIL\_safe)}$ . After this period of time, the device will attempt to recover by self-reset. In case of permanent detectable failure, the sequence is repeated indefinitely (see Figure 20).

Diagnostic option of A19530 allows for system failure detection such as short circuit or open wire. In such case, output goes above or below normal operating voltage range ( $V_{diag-Low}$  or  $V_{diag-High}$ ) depending on the failure mode.

Table 1 summarizes the possible output states corresponding to each of short or open wire events.

**Table 1: Output Open Short Diagnostic**

External Event Type	Output Level
Hard short between VCC and GND	$V_{PU}$
Hard short between VCC and OUT	$V_{CC}$
Hard short between OUT and GND	GND
Open VCC	$V_{PU}$
Open OUT	$V_{PU}$
Open GND	$V_{PU}$



**Figure 20: ASIL Output behavior (-xxxxEx- variant)**

## 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 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:  $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 12\text{ V}$ ,  $I_{CC} = 8\text{ mA}$ , and  $R_{\theta JA} = 270^\circ\text{C/W}$ , then:

$$P_D = V_{CC} \times I_{CC} = 12\text{ V} \times 8\text{ mA} = 96\text{ mW}$$

$$\Delta T = P_D \times R_{\theta JA} = 96\text{ mW} \times 270^\circ\text{C/W} = 25.9^\circ\text{C}$$

$$T_J = T_A + \Delta T = 25^\circ\text{C} + 25.9^\circ\text{C} = 50.9^\circ\text{C}$$

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  $T_A = 150^\circ\text{C}$ , estimated values based on package UC, using single layer PCB.

Observe the worst-case ratings for the device, specifically:  $R_{\theta JA} = 270^\circ\text{C/W}$ ,  $T_J(\max) = 165^\circ\text{C}$ ,  $V_{CC(\max)} = 24\text{ V}$ , and  $I_{CC} = 10\text{ mA}$ .

Calculate the maximum allowable power level,  $P_D(\max)$ . First, invert equation 3:

$$\Delta T(\max) = T_J(\max) - T_A = 165^\circ\text{C} - 150^\circ\text{C} = 15^\circ\text{C}$$

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

$$P_D(\max) = \Delta T(\max) \div R_{\theta JA} = 15^\circ\text{C} \div 270^\circ\text{C/W} = 55.5\text{ mW}$$

Finally, invert equation 1 with respect to voltage:

$$V_{CC(\text{est})} = P_D(\max) \div I_{CC} = 55.5\text{ mW} \div 10\text{ mA} = 5.55\text{ V}$$

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

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

## THERMAL CHARACTERISTICS: May require derating at maximum conditions

Characteristic	Symbol	Test Conditions*	Value	Unit
Package Thermal Resistance	$R_{\theta JA}$	1-layer PCB with copper limited to solder pads	270	$^\circ\text{C/W}$

\*Additional thermal information available on the Allegro website.



PACKAGE OUTLINE DRAWING

For Reference Only – Not for Tooling Use

(Reference DWG-0000409, Rev. 3)  
Dimensions in millimeters – NOT TO SCALE  
Dimensions exclusive of mold flash, gate burrs, and dambar protrusions  
Exact case and lead configuration at supplier discretion within limits shown

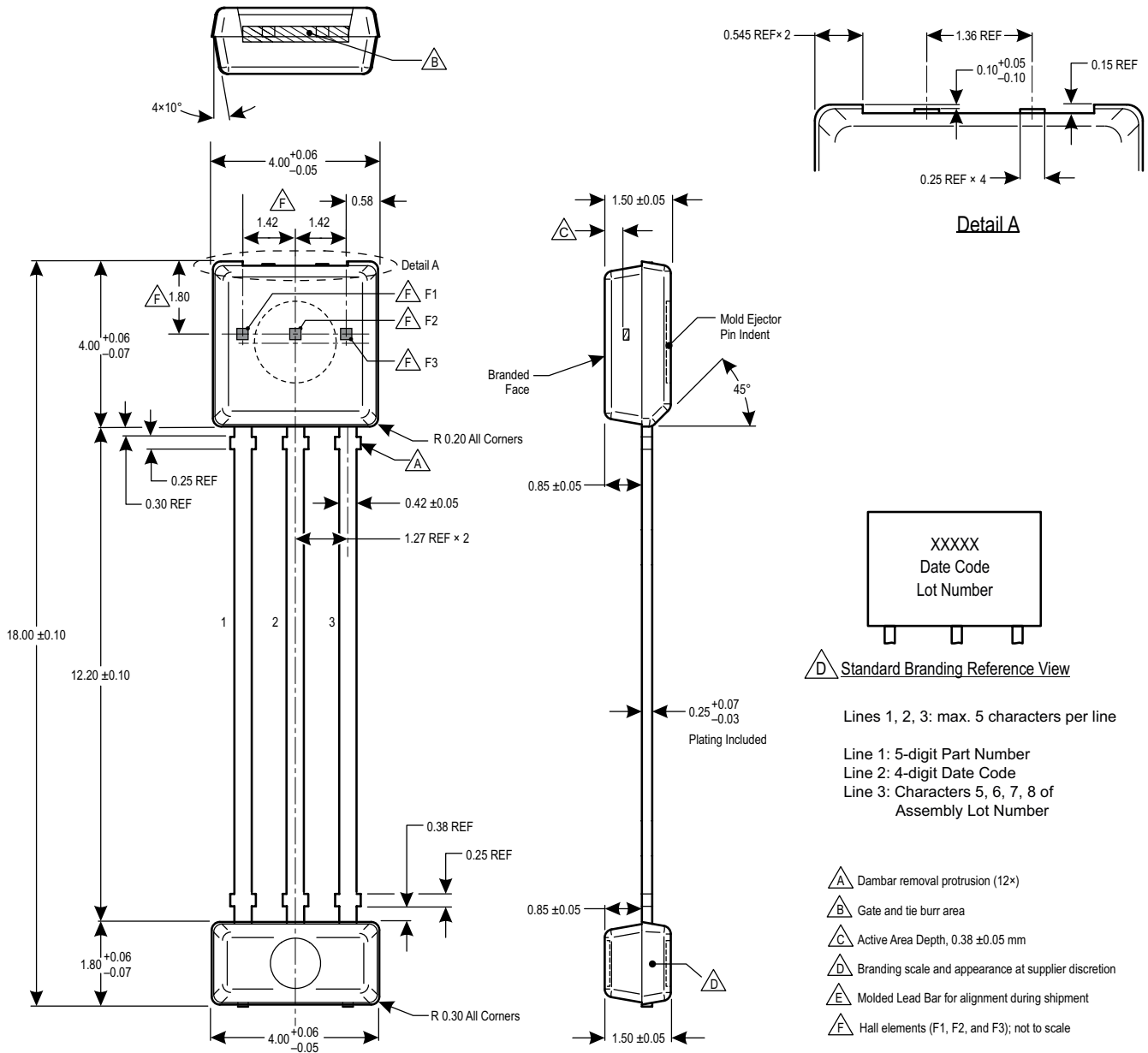
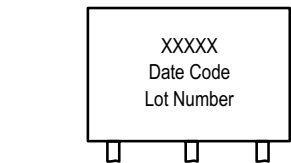


Figure 21: Package UC, 3-pin SIP



**D** Standard Branding Reference View

Lines 1, 2, 3: max. 5 characters per line

Line 1: 5-digit Part Number  
Line 2: 4-digit Date Code  
Line 3: Characters 5, 6, 7, 8 of Assembly Lot Number

- A** Dambar removal protrusion (12x)
- B** Gate and tie burr area
- C** Active Area Depth, 0.38 ±0.05 mm
- D** Branding scale and appearance at supplier discretion
- E** Molded Lead Bar for alignment during shipment
- F** Hall elements (F1, F2, and F3); not to scale

## Revision History

Number	Date	Description
–	September 13, 2018	Initial release
1	October 7, 2019	Added “Detail A” to package outline drawing (page 17), and other minor editorial updates
2	May 18, 2021	Updated Speed Only Protocol section (page 8), inverted output polarity of -FOOOOxx- variant (page 9), updated Figure 8 (page 10).

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