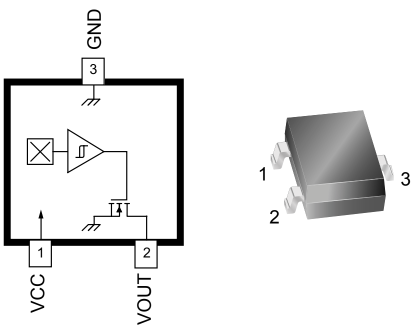
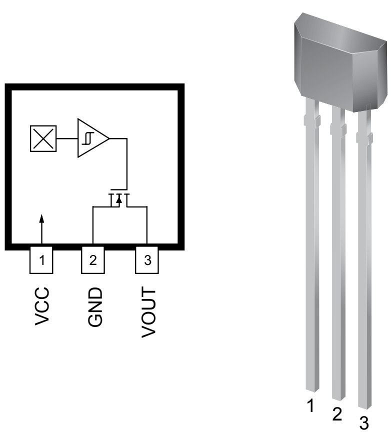
A3230

Chopper-Stabilized Hall-Effect Bipolar Switch

Package LH, 3-pin Surface Mount



Package UA, 3-pin SIP



ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{CC}	**28 V**
Reverse-Supply Voltage, V_{RCC}	**–18 V**
Output Off Voltage, V_{OUT}	**26.5 V**
Output Current, $I_{OUTSINK}$	**Internally Limited**
Reverse-Output Current, I_{ROUT}	**–10 mA**
Magnetic Flux Density, B	**Unlimited**
Operating Temperature	
Ambient, T_A, Range E	**–40ºC to 85ºC**
Ambient, T_A, Range L	**–40ºC to 150ºC**
Maximum Junction, $T_{J(MAX)}$	**165ºC**
Storage Temperature, T_S	**–65ºC to 170ºC**

The A3230 Hall-effect sensor is a temperature stable, stress-resistant bipolar switch. This sensor is the most sensitive Hall-effect device in the Allegro® bipolar switch family and is intended for ring-magnet sensing. Superior high-temperature performance is made possible through an Allegro patented dynamic offset cancellation that utilizes chopper-stabilization. This method reduces the offset voltage normally caused by device overmolding, temperature dependencies, and thermal stress.

The A3230 includes the following on a single silicon chip: a voltage regulator, Hall-voltage generator, small-signal amplifier, chopper stabilization, Schmitt trigger, and a short circuit protected open-drain output. Advanced BiCMOS wafer fabrication processing takes advantage of low-voltage requirements, component matching, very low input-offset errors, and small component geometries.

The A3230 Hall-effect bipolar switch turns on in a south polarity magnetic field of sufficient strength and switches off in a north polarity magnetic field of sufficient strength. Because the output state is not defined if the magnetic field is diminished or removed, to ensure that the device switches, Allegro recommends using magnets of both polarities and of sufficient strength in the application.

The A3230 is rated for operation between the ambient temperatures –40°C and 85°C for the E temperature range, and –40°C to 150°C for the L temperature range. Two A3230 package styles provide magnetically optimized solutions for most applications. Package LH is a SOT23W, a miniature low-profile surface-mount package, while package UA is a three-lead ultramini SIP for through-hole mounting. Each package is available in a lead (Pb) free version, with 100% matte tin plated leadframes.

Features and Benefits

- Chopper stabilization
  - Superior temperature stability
  - Extremely low switchpoint drift
  - Insensitive to physical stress
- Reverse battery protection
- Output short circuit protection
- Solid state reliability
- Small size
- Robust EMC capability
- High ESD ratings (HBM)

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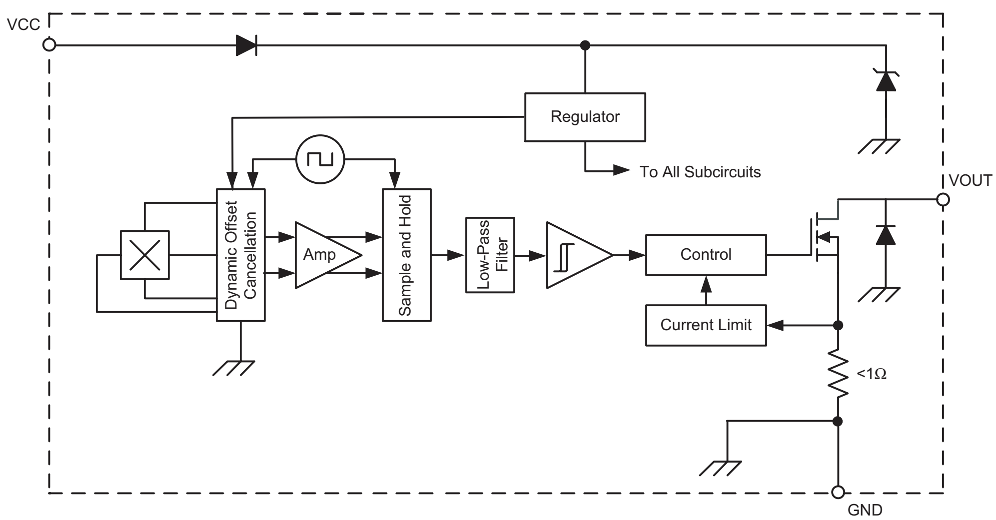
Product Selection Guide

Part Number	Pb-free	Packing*	Mounting	Ambient, T_A (°C)	$B_{RP(MIN)}$ (G)	$B_{OP(MAX)}$ (G)
A3230ELHLT	–	7-in. reel, 3000 pieces/reel	3-pin SOT23W surface mount	–40 to 85	–25	25
A3230ELHLT-T	Yes					
A3230EUA	–	Bulk, 500 pieces/bag	3-pin SIP through hole			
A3230EUA-T	Yes					
A3230LLHLT	–	7-in. reel, 3000 pieces/reel	3-pin SOT23W surface mount	–40 to 150		
A3230LLHLT-T	Yes					
A3230LUA	–	Bulk, 500 pieces/bag	3-pin SIP through hole			
A3230LUA-T	Yes					

*Contact Allegro for additional packing options.

Functional Block Diagram



Terminal List

Name	Description	Number	
		Package LH	Package UA
VCC	Connects power supply to chip	1	1
VOUT	Output from circuit	2	3
GND	Ground	3	2

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OPERATING CHARACTERISTICS valid over full operating voltage and ambient temperature ranges, unless otherwise noted

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Electrical Characteristics						
Supply Voltage[1]	V_{CC}	Operating, T_J < 165°C	3.6	–	24	V
Output Leakage Current	I_{OUTOFF}	V_{OUT} = 24 V, B < B_{RP}	–	–	10	μA
Output On Voltage	$V_{OUT(SAT)}$	I_{OUT} = 20 mA, B > B_{OP}	–	250	500	mV
Output Current Limit	I_{OM}	B > B_{OP}	30	–	60	mA
Power-On Time	t_{PO}	V_{CC} > 3.6 V	–	8	50	μs
Chopping Frequency	f_c		–	200	–	kHz
Output Rise Time[2]	t_r	R_{LOAD} = 820 Ω, C_S = 20 pF	–	0.2	1	μs
Output Fall Time[2]	t_f	R_{LOAD} = 820 Ω, C_S = 20 pF	–	0.2	1	μs
Supply Current	I_{CCON}	B > B_{OP}	–	1.6	5	mA
	I_{CCOFF}	B < B_{RP}	–	1.6	5	mA
Reverse Battery Current	I_{RCC}	V_{RCC} = –18 V	–	–	–2	mA
Supply Zener Clamp Voltage	V_Z	I_{CC} = 8 mA; T_A = 25°C	28	–	–	V
Supply Zener Current[3]	I_Z	V_S = 28 V	–	–	8	mA
Magnetic Characteristics[4]						
Operate Point	B_{OP}	South pole adjacent to branded face of device	–10	7.5	25	G
Release Point	B_{RP}	North pole adjacent to branded face of device	–25	–7.5	10	G
Hysteresis	B_{HYS}	B_{OP} – B_{RP}	5	15	25	G

[1] Maximum voltage must be adjusted for power dissipation and junction temperature, see *Power Derating* section.
[2] C_S = oscilloscope probe capacitance.
[3] Maximum current limit is equal to the maximum $I_{CC(MAX)}$ + 3 mA.
[4] Magnetic flux density, B, is indicated as a negative value for north-polarity magnetic fields, and as a positive value for south-polarity magnetic fields. This so-called algebraic convention supports arithmetic comparison of north and south polarity values, where the relative strength of the field is indicated by the absolute value of B, and the sign indicates the polarity of the field (for example, a –100 G field and a 100 G field have equivalent strength, but opposite polarity).

DEVICE QUALIFICATION PROGRAM

Contact Allegro for information.

EMC (Electromagnetic Compatibility) REQUIREMENTS

Contact Allegro for information.

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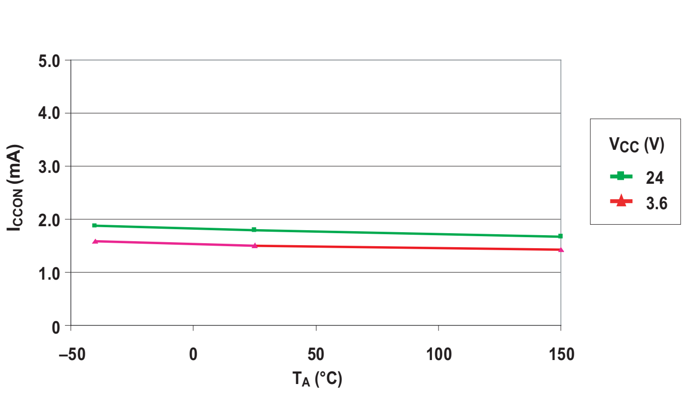
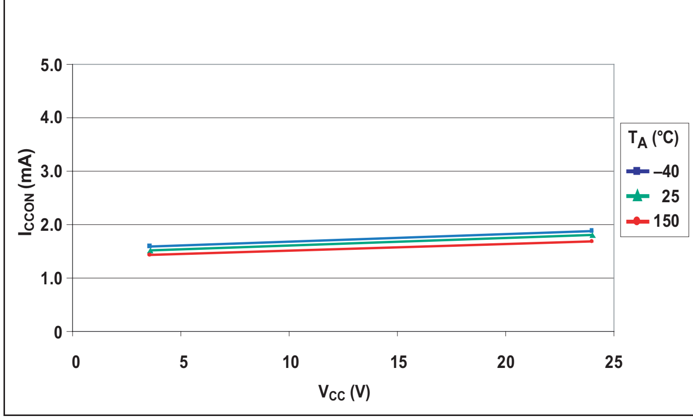
Electrical Characteristic Data

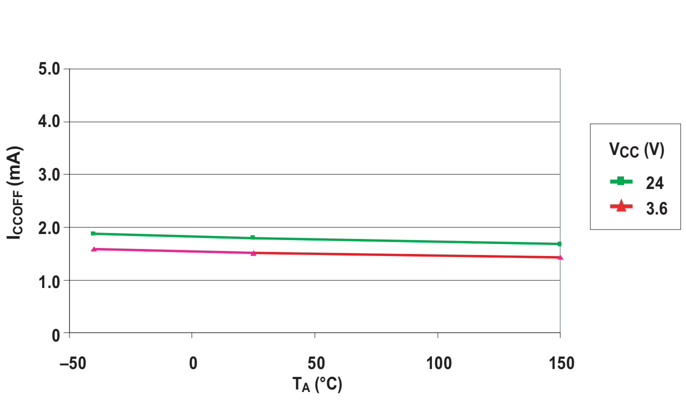
Supply Current (On) versus Ambient Temperature



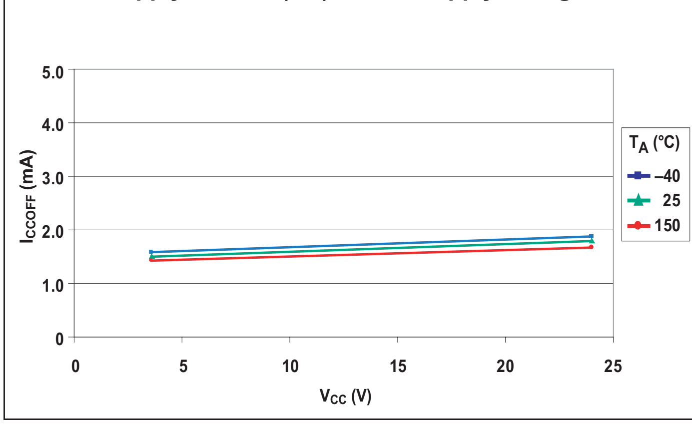
Supply Current (On) versus Supply Voltage



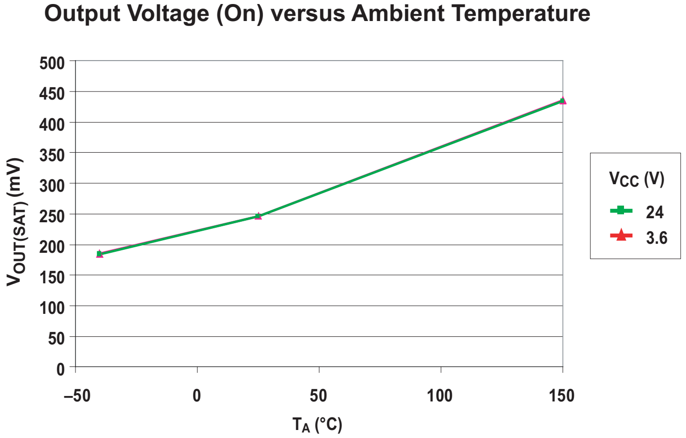
Supply Current (Off) versus Ambient Temperature



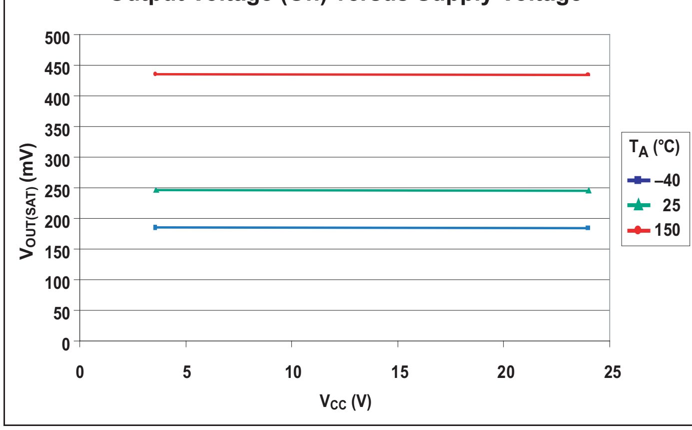
Supply Current (Off) versus Supply Voltage



Output Voltage (On) versus Ambient Temperature



Output Voltage (On) versus Supply Voltage



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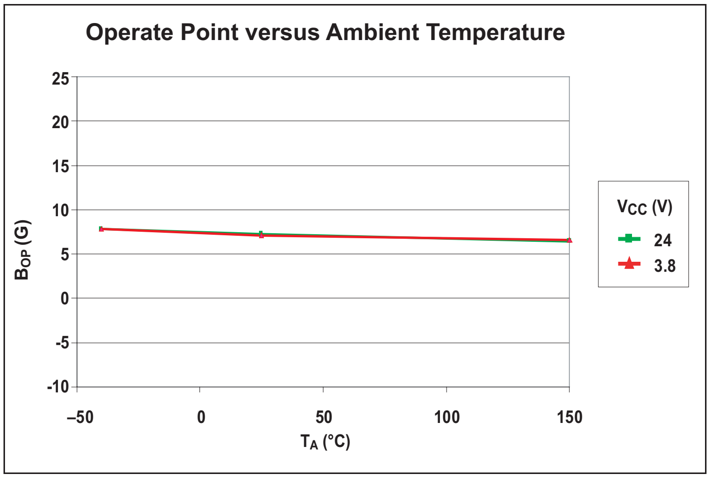
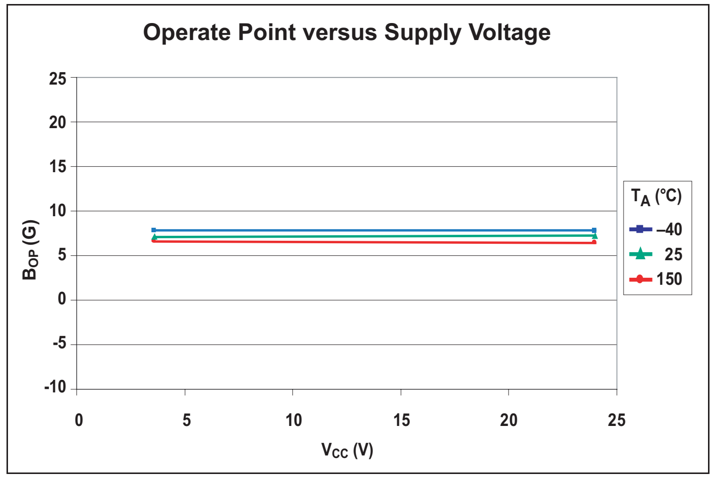
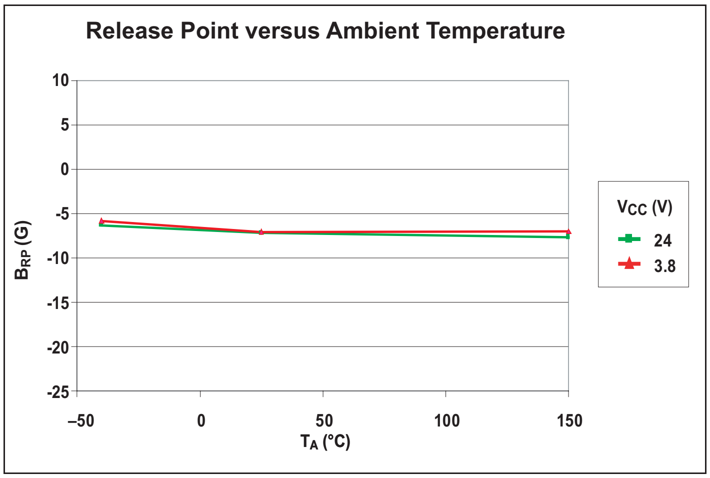
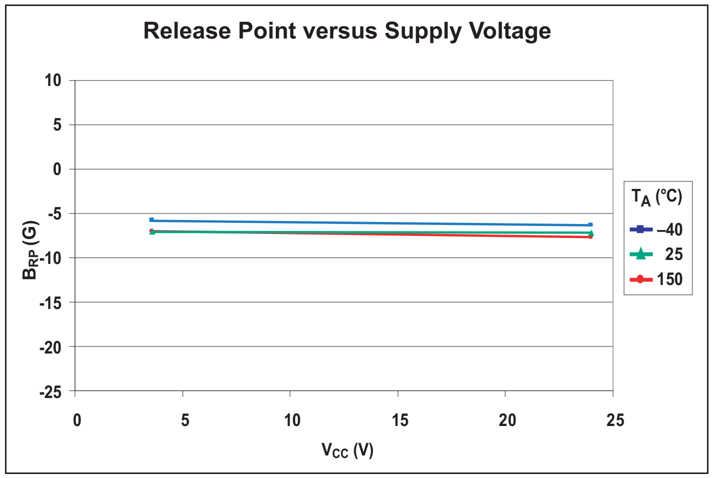
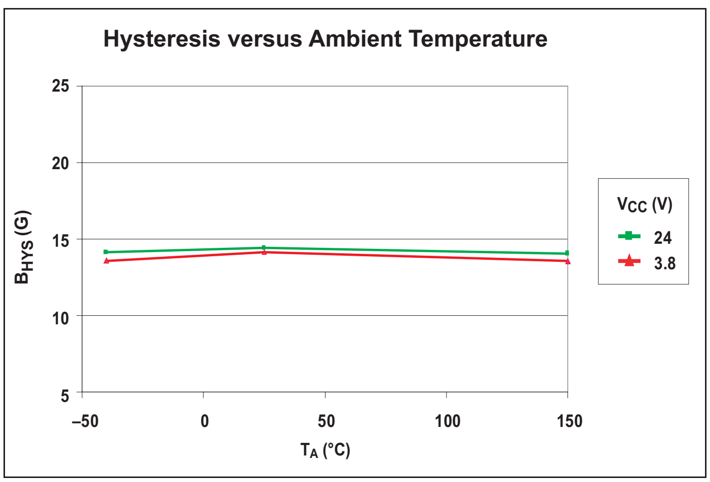
Magnetic Characteristic Data

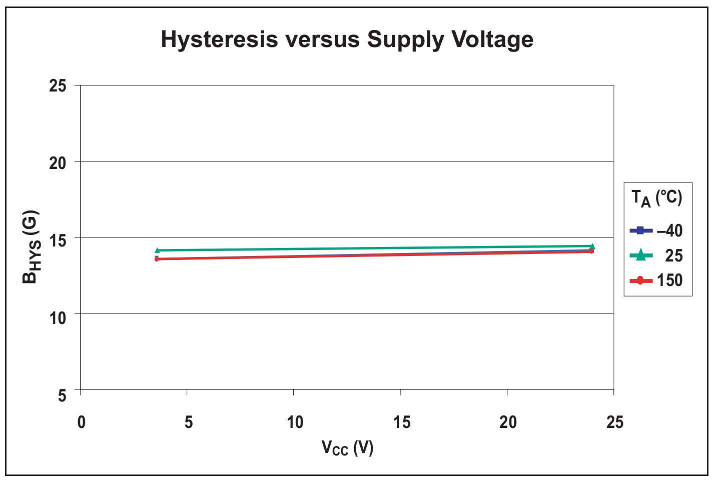












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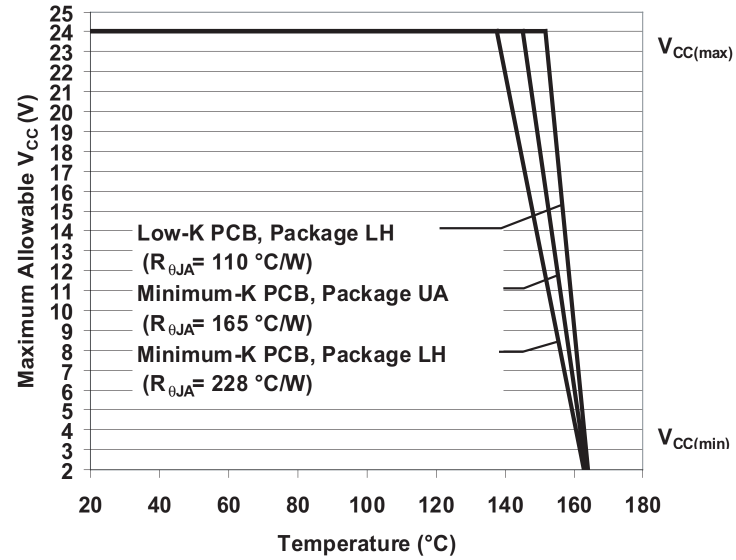
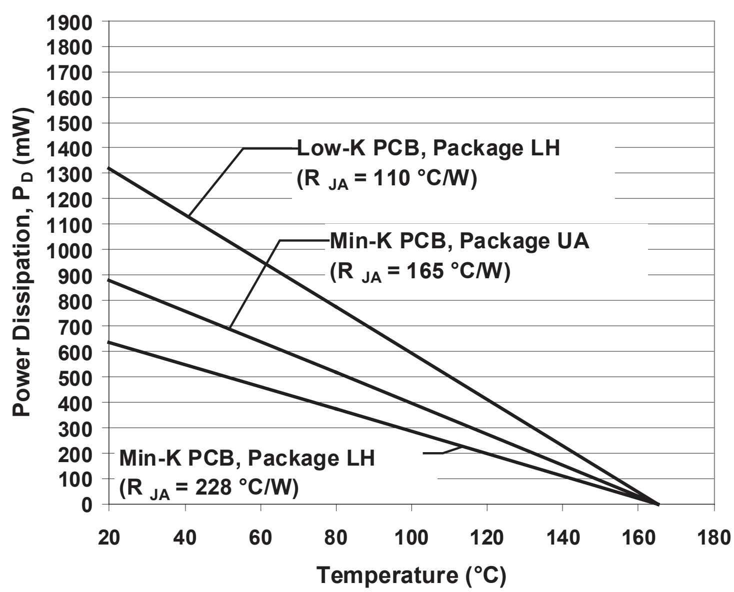
THERMAL CHARACTERISTICS may require derating at maximum conditions, see application information

Characteristic	Symbol	Test Conditions	Value	Units
Package Thermal Resistance	$R_{\theta JA}$	Package LH, minimum-K PCB (single-sided with copper limited to solder pads)	110	ºC/W
		Package LH, low-K PCB (double-sided with 0.926 in^2 copper area)	228	ºC/W
		Package UA, minimum-K PCB (single-sided with copper limited to solder pads)	165	ºC/W

Power Derating Curve
$T_{J(max)}$ = 165°C; I_{CC} = $I_{CC(max)}$



Power Dissipation versus Ambient Temperature



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Functional Description

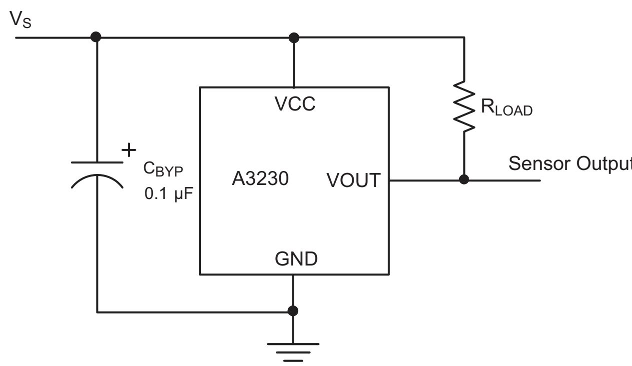
Operation

The output of these devices switches low (turns on) when a magnetic field perpendicular to the Hall sensor exceeds the operate point threshold, B_{OP}. After turn-on, the output voltage is $V_{OUT(SAT)}$. The output transistor is capable of sinking current up to the short circuit current limit, I_{OM}, which is a minimum of 30 mA. When the magnetic field is reduced below the release point, B_{RP}, the device output goes high (turns off). The difference in the magnetic operate and release points is the hysteresis, B_{HYS}, of the device. This built-in hysteresis allows clean switching of the output even in the presence of external mechanical vibration and electrical noise.

There are three switching modes for bipolar devices, referred to as *latch*, *unipolar switch*, and *negative switch*. Mode is determined by the switchpoint characteristics of the individual device. Note that, as shown in figure 1, these switchpoints can lie in either north or south polarity ranges. The values of the magnetic parameters for the A3230 are specified in the Magnetic Characteristics table, on page 3.

Bipolar devices typically behave as latches (although these devices are not guaranteed to do so). In this mode, magnetic fields of opposite polarity and equivalent strengths are needed to switch the output. When the magnetic fields are removed ($B \rightarrow 0$) the device remains in the same state until a magnetic field of the opposite polarity and of sufficient strength causes it to switch. The hysteresis of latch mode behavior is shown in panel A of figure 1.

In contrast to latching, when a device exhibits unipolar switching, it only responds to a south magnetic field. The field must be of sufficient strength, $> B_{OP}$, for the device to operate. When the field is reduced beyond the B_{RP} level, the device switches back to the high state, as shown in panel B of figure 1. Devices



(D)

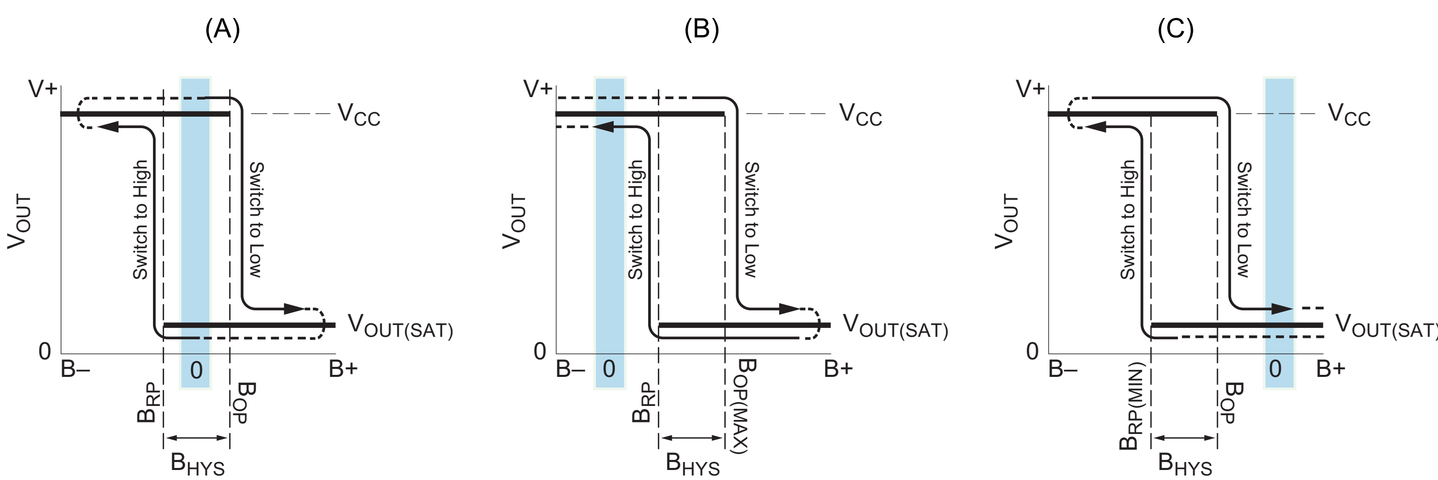


Figure 1. Bipolar Device Output Switching Modes. These behaviors can be exhibited when using a circuit such as that shown in panel D. Panel A displays the hysteresis when a device exhibits latch mode (note that the B_{HYS} band incorporates B= 0), panel B shows unipolar switch behavior (the B_{HYS} band is more positive than B = 0), and panel C shows negative switch behavior (the B_{HYS} band is more negative than B = 0). Bipolar devices, such as the A3230, can operate in any of the three modes.

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exhibiting negative switch behavior operate in a similar but opposite manner. A north polarity field of sufficient strength, > B_{RP}, (more north than B_{RP}) is required for operation, although the result is that V_{OUT} switches high, as shown in panel C. When the field is reduced beyond the B_{OP} level, the device switches back to the low state.

The A3230 is designed to attain a small hysteresis, and thereby provide more sensitive switching. Although this means that true latching behavior cannot be guaranteed in all cases, proper switching can be ensured by use of both south and north magnetic fields, as in a ring magnet.

Bipolar devices adopt an indeterminate output state when powered-on in the absence of a magnetic field or in a field that lies within the hysteresis band of the device. The correct state is attained after the first excursion beyond B_{OP} or B_{RP}.

For more information on Bipolar switches, refer to Application Note 27705, *Understanding Bipolar Hall Effect Sensors*.

Applications

It is strongly recommended that an external bypass capacitor be connected (in close proximity to the Hall sensor) between the supply and ground of the device to reduce both external noise and noise generated by the chopper stabilization technique. As is shown in Panel B of figure 1, a 0.1µF capacitor is typical.

Extensive applications information on magnets and Hall-effect sensors is available in:

- *Hall-Effect IC Applications Guide*, AN27701,
- *Hall-Effect Devices: Gluing, Potting, Encapsulating, Lead Welding and Lead Forming*, AN27703.1
- *Soldering Methods for Allegro's Products – SMT and Through-Hole*, AN26009

All are provided in *Allegro Electronic Data Book*, AMS-702 and the Allegro Web site: www.allegromicro.com

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Chopper Stabilization Technique

When using Hall-effect technology, a limiting factor for switchpoint accuracy is the small signal voltage developed across the Hall element. This voltage is disproportionally small relative to the offset that can be produced at the output of the Hall sensor. This makes it difficult to process the signal while maintaining an accurate, reliable output over the specified operating temperature and voltage ranges.

Chopper stabilization is a unique approach used to minimize Hall offset on the chip. The patented Allegro technique, namely Dynamic Quadrature Offset Cancellation, removes key sources of the output drift induced by thermal and mechanical stresses. This offset reduction technique is based on a signal modulation-demodulation process. The undesired offset signal is separated from the magnetic-field-induced signal in the frequency domain, through modulation. The subsequent demodulation acts as a modulation process for the offset, causing the magnetic-field-induced signal to recover its original spectrum at baseband, while the dc offset becomes a high-frequency signal. The magnetic-field-induced signal then can pass through a low-pass filter, while the modulated dc offset is suppressed. This configuration is illustrated in figure 2.

The chopper stabilization technique uses a 200 kHz high-frequency clock. For demodulation process, a sample and hold technique is used, where the sampling is performed at twice the chopper frequency (400 kHz). This high-frequency operation allows a greater sampling rate, which results in higher accuracy and faster signal-processing capability. This approach desensitizes the chip to the effects of thermal and mechanical stresses, and produces devices that have extremely stable quiescent Hall output voltages and precise recoverability after temperature cycling. This technique is made possible through the use of a BiCMOS process, which allows the use of low-offset, low-noise amplifiers in combination with high-density logic integration and sample-and-hold circuits.

The repeatability of magnetic-field-induced switching is affected slightly by a chopper technique. However, the Allegro high-frequency chopping approach minimizes the affect of jitter and makes it imperceptible in most applications. Applications that are more likely to be sensitive to such degradation are those requiring precise sensing of alternating magnetic fields; for example, speed sensing of ring-magnet targets. For such applications, Allegro recommends its digital sensor families with lower sensitivity to jitter. For more information on those devices, contact your Allegro sales representative.

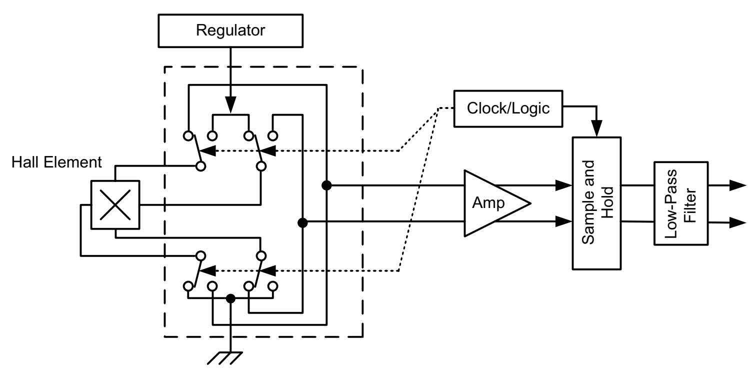

Figure 2. Chopper Stabilization Circuit (Dynamic Quadrature Offset Cancellation)

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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 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 Web site.)

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 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.

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

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

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

For example, given common conditions such as: T_A= 25°C, V_{CC} = 12 V, I_{CC} = 1.5 mA, and $R_{\theta JA}$ = 165 °C/W, then:

$$P_D = V_{CC} \times I_{CC} = 12\text{ V} \times 1.5\text{ mA} = 18\text{ mW}$$

$$\Delta T = P_D \times R_{\theta JA} = 18\text{ mW} \times 165\text{ °C/W} = 3\text{°C}$$

$$T_J = T_A + \Delta T = 25\text{°C} + 3\text{°C} = 28\text{°C}$$

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°C, package LH, using a low-K PCB.

Observe the worst-case ratings for the device, specifically: $R_{\theta JA}$=228 °C/W, $T_{J(max)}$=165°C, $V_{CC(max)}$= 24 V, and $I_{CC(max)}$ = 5 mA.

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

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

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

$$P_{D(max)} = \Delta T_{max} \div R_{\theta JA} = 15\text{°C} \div 228\text{ °C/W} = 66\text{ mW}$$

Finally, invert equation 1 with respect to voltage:

$$V_{CC(est)} = P_{D(max)} \div I_{CC(max)} = 66\text{ mW} \div 5\text{ mA} = 13\text{ V}$$

The result indicates that, at T_A, the application and device can dissipate adequate amounts of heat at 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.

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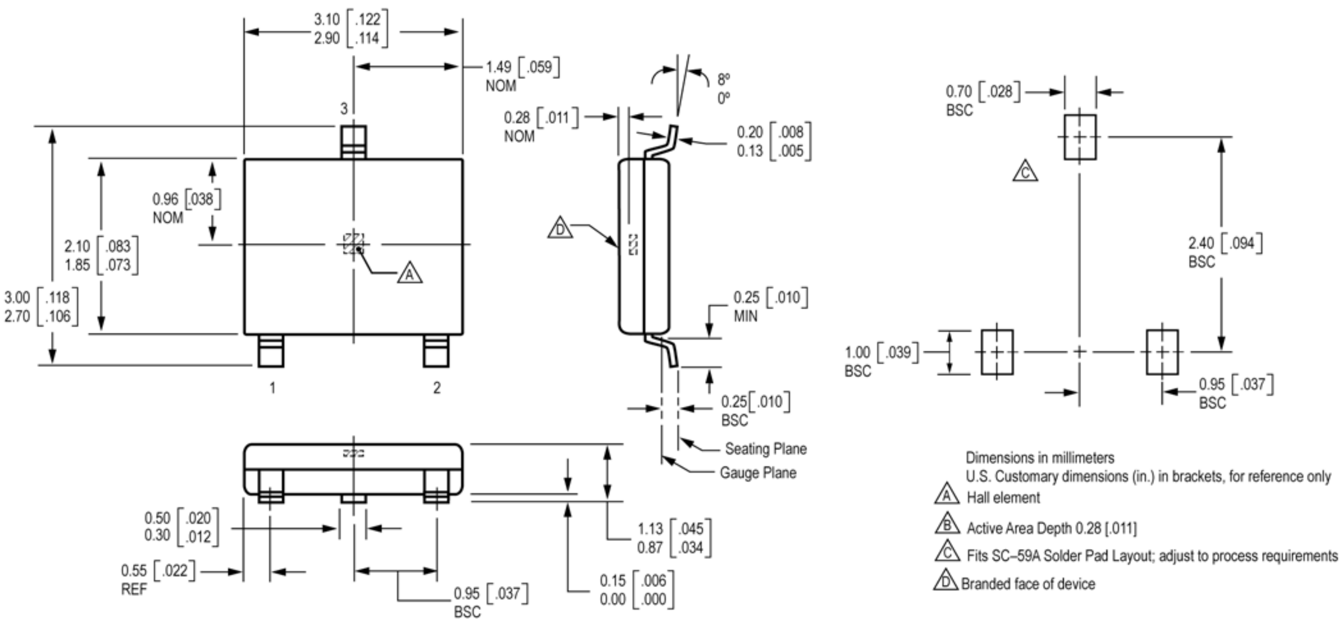
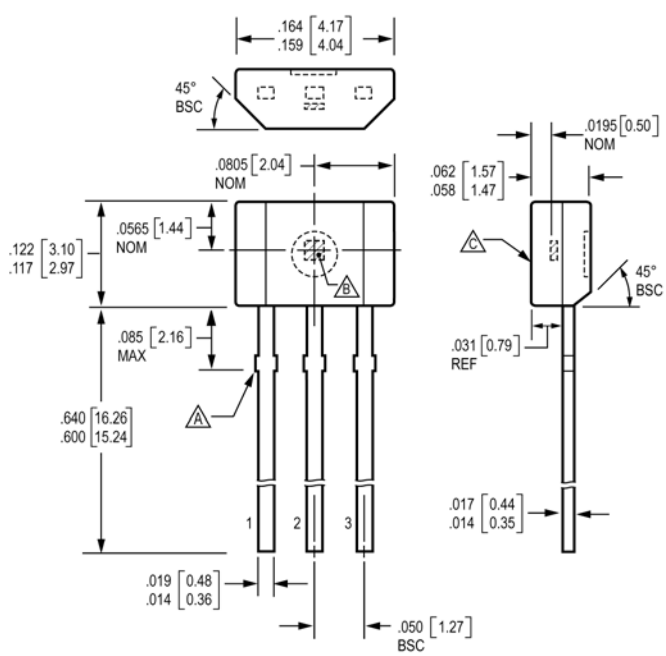
Package LH, 3-Pin (SOT-23W)



Dimensions in millimeters
U.S. Customary dimensions (in.) in brackets, for reference only

A Hall element
B Active Area Depth 0.28 [.011]
C Fits SC–59A Solder Pad Layout; adjust to process requirements
D Branded face of device

Package UA, 3-Pin



Dimensions in inches
Metric dimensions (mm) in brackets, for reference only

A Dambar removal protrusion
B Hall element
C Branded face of device

The products described herein are manufactured under one or more of the following U.S. patents: 5,045,920; 5,264,783; 5,442,283; 5,389,889; 5,581,179; 5,517,112; 5,619,137; 5,621,319; 5,650,719; 5,686,894; 5,694,038; 5,729,130; 5,917,320; and other patents pending.

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