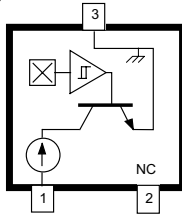


# A1140/41/42/43

## Sensitive Two-Wire Chopper-Stabilized Unipolar Hall-Effect Switches

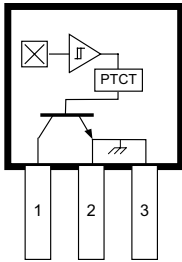
Package LH, 3-pin SOT

1. VCC
2. No connection
3. GND



Package UA, 3-pin SIP

1. VCC
2. GND
3. GND



### ABSOLUTE MAXIMUM RATINGS

Supply Voltage, $V_{CC}$ .....	28 V
Reverse-Supply Voltage, $V_{RCC}$ .....	-18 V
Magnetic Flux Density, B .....	Unlimited
Operating Temperature	
Ambient, $T_A$ , Range E .....	-40°C to 85°C
Ambient, $T_A$ , Range L .....	-40°C to 150°C
Maximum Junction, $T_{J(max)}$ .....	165°C
Storage Temperature, $T_S$ .....	-65°C to 170°C

The A1140, A1141, A1142, and A1143 devices are sensitive, two-wire, unipolar, Hall effect switches that are factory-programmed at end-of-line to optimize magnetic switchpoint accuracy. These devices are produced on the Allegro MicroSystems advanced BiCMOS wafer fabrication process, which implements a patented, high-frequency, chopper-stabilization technique that achieves magnetic stability and eliminates the offsets that are inherent in single-element devices exposed to harsh application environments. Commonly found in a number of automotive applications, the A1140-43 family of devices are utilized to sense: seat track position, seat belt buckle presence, hood/trunk latching, and shift selector position.

Two-wire unipolar switches are particularly advantageous in price-sensitive applications, because they require one less wire than the more traditional open-collector output switches. Additionally, the system designer gains inherent diagnostics because output current normally flows in either of two narrowly-specified ranges. Any output current level outside of these two ranges is a fault condition. The A1140-43 family of devices also features on-chip transient protection, and a Zener clamp to protect against overvoltage conditions on the supply line.

The output currents of the A1141 and A1143 switch HIGH in the presence of a south polarity magnetic field of sufficient strength; and switch LOW otherwise, including when there is no significant magnetic field present. The A1140 and A1142 have inverted output current levels: switching LOW in the presence of a south polarity magnetic field of sufficient strength, and HIGH otherwise. The devices also differ in their specified LOW current supply levels.

All family members are offered in two package styles: SOT-23W, a miniature low-profile package for surface-mount applications (suffix *-LH*), and TO-92, three-lead ultra-mini Single Inline Package (SIP) for through-hole mounting (suffix *-UA*).

Field-programmable versions are also available. Refer to: A1180, A1181, A1182, and A1183.

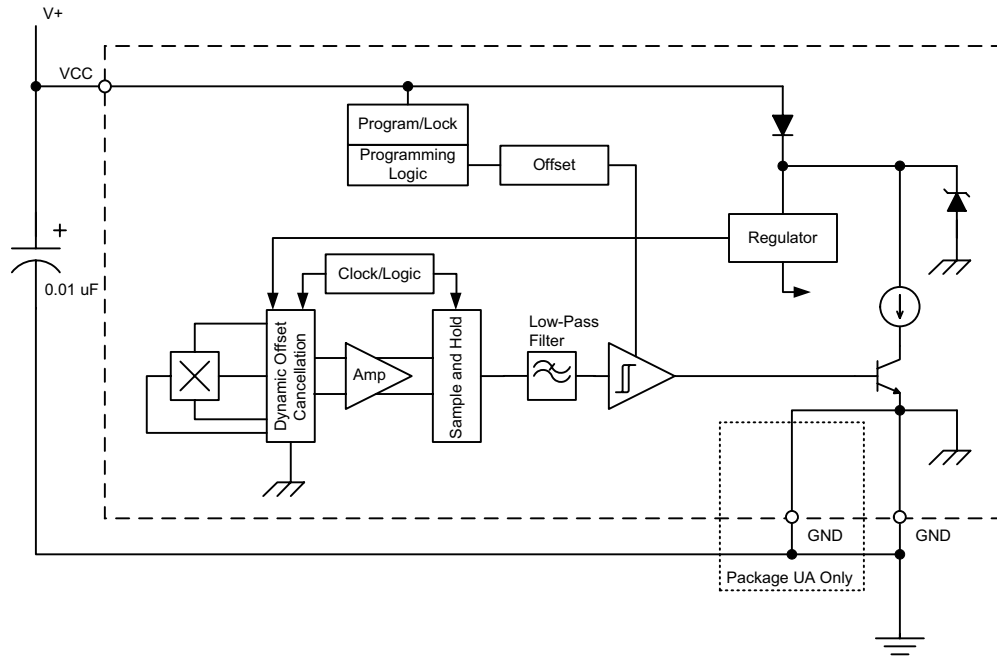
### Features and Benefits

- Chopper stabilization
- On-chip protection
- Low switchpoint drift over operating temperature range
- Supply transient protection
- Low stress sensitivity
- Reverse-battery protection
- Factory programmed at end-of-line for optimized switchpoints
- On-board voltage regulator
- 3.5 V to 24 V operation

# A1140/41/42/43

## Sensitive Two-Wire Chopper-Stabilized Unipolar Hall Effect Switches

### Functional Block Diagram



### Product Selection Guide

Use the complete part numbers when ordering

Part Number	Package	T <sub>A</sub> (°C)	Supply Current at Low Output, I <sub>CC(L)</sub> (mA)	Output	
				South (+) Field <sup>1</sup>	Other Field <sup>2</sup>
A1140ELH A1140EUA	Surface Mount SIP	-40 to 85	2 to 5	Low	High
A1140LLH A1140LUA	Surface Mount SIP	-40 to 150			
A1141ELH A1141EUA	Surface Mount SIP	-40 to 85	2 to 5	High	Low
A1141LLH A1141LUA	Surface Mount SIP	-40 to 150			
A1142ELH A1142EUA	Surface Mount SIP	-40 to 85	5 to 6.9	Low	High
A1142LLH A1142LUA	Surface Mount SIP	-40 to 150			
A1143ELH A1143EUA	Surface Mount SIP	-40 to 85	5 to 6.9	High	Low
A1143LLH A1143LUA	Surface Mount SIP	-40 to 150			

<sup>1</sup>South (+) magnetic fields must be of sufficient strength.

<sup>2</sup>Includes north (-) magnetic fields of sufficient strength, and weak fields of either polarity.

# A1140/41/42/43

## Sensitive Two-Wire Chopper-Stabilized Unipolar Hall Effect Switches

### ELECTRICAL CHARACTERISTICS over the operating voltage and temperature range, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Supply Voltage	$V_{CC}$	Device powered on	3.5	–	24	V
Supply Current <sup>1</sup>	$I_{CC(L)}$	$B > B_{OP}$ for A1140; $B < B_{RP}$ for A1141	2	–	5	mA
		$B > B_{OP}$ for A1142; $B < B_{RP}$ for A1143	5	–	6.9	mA
	$I_{CC(H)}$	$B > B_{OP}$ for A1141, A1143 $B < B_{RP}$ for A1140, A1142	12	–	17	mA
Zener Clamp Supply Voltage	$V_{Z(supply)}$	$I_{CC} = I_{CC(max)} + 3 \text{ mA}$ ; $T_A = 25^\circ\text{C}$	28	–	40	V
Zener Clamp Supply Current <sup>2</sup>	$I_{Z(supply)}$	$V_{Z(supply)} = 28 \text{ V}$	–	–	10	mA
Output Slew Rate <sup>3</sup>	di/dt	No bypass capacitor; capacitance of the oscilloscope performing the measurement = 20 pF	–	36	–	mA/ $\mu\text{s}$
Chopping Frequency	$f_C$		–	400	–	kHz
Power-On Time <sup>4</sup>	$t_{on}$	After factory programming; with and without bypass capacitor ( $C_{BYP} = 0.01 \mu\text{F}$ )	–	–	25	$\mu\text{s}$
Power-On State <sup>5</sup>	POS	$t_{on} \leq t_{on(max)}$ ; $V_{CC}$ slew rate $\geq 25 \text{ mV}/\mu\text{s}$	–	HIGH	–	–

<sup>1</sup>Relative values of B use the algebraic convention, where positive values indicate south magnetic polarity, and negative values indicate north magnetic polarity; therefore greater B values indicate a stronger south polarity field (or a weaker north polarity field, if present).

<sup>2</sup>The maximum value for  $I_{Z(supply)}$  is equal to  $I_{CC(L)MAX} + 3 \text{ mA}$ .

<sup>3</sup>The value of di is the difference between 90% of  $I_{CC(H)}$  and 10% of  $I_{CC(L)}$ , and the value of dt is time period between those two points. The value of di/dt depends on the value of the bypass capacitor, if one is used, with greater capacitances resulting in lower rates of change.

<sup>4</sup>The value of  $t_{on}$  depends on the value of the bypass capacitor, if one is used, with greater capacitances resulting in longer  $t_{on}$ .

<sup>5</sup>A  $V_{CC}$  slew rate less than 25 mV/ $\mu\text{s}$  affects device performance, both while powering-on and while running. For  $t_{on} > t_{on(max)}$ , and  $B_{RP} < B < B_{OP}$ , POS is undefined.

### MAGNETIC CHARACTERISTICS\* over the operating voltage and temperature range, unless otherwise specified

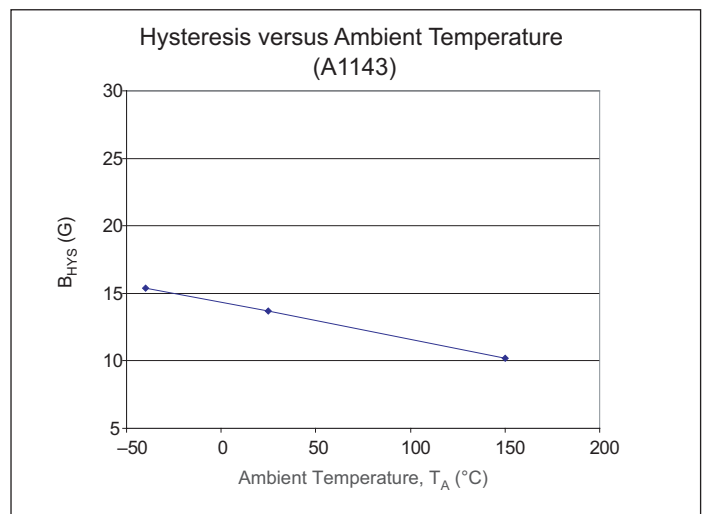
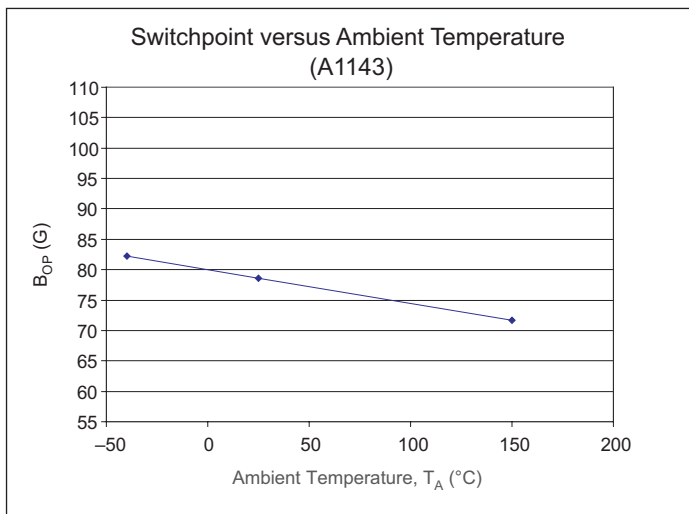
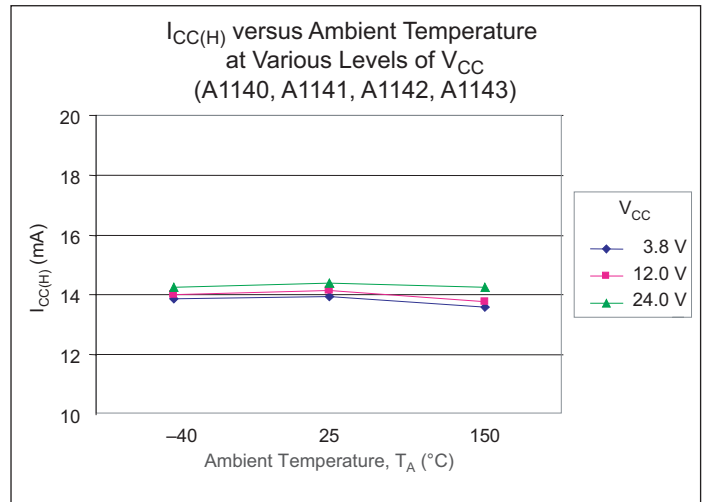
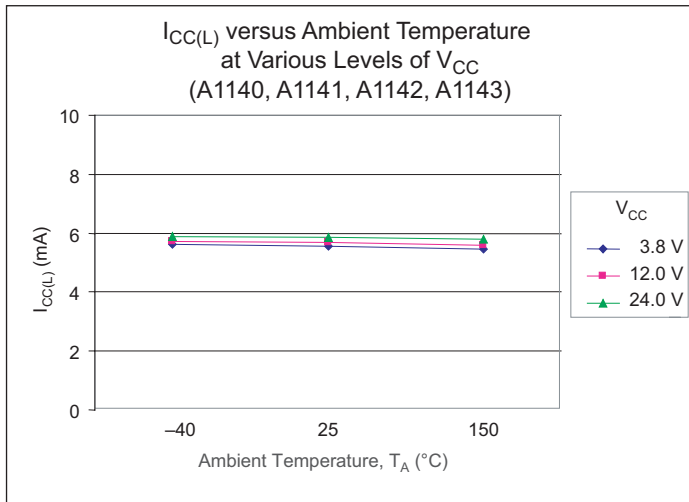
Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Operate Point	$B_{OP}$	$I_{CC(H)} \rightarrow I_{CC(L)}$ for A1140, A1142 $I_{CC(L)} \rightarrow I_{CC(H)}$ for A1141, A1143	50	85	115	G
Release Point	$B_{RP}$	$I_{CC(L)} \rightarrow I_{CC(H)}$ for A1140, A1142 $I_{CC(H)} \rightarrow I_{CC(L)}$ for A1141, A1143	45	–	110	G
Hysteresis	$B_{HYS}$	$B_{HYS} = B_{OP} - B_{RP}$	5	15	30	G

\*Relative values of B use the algebraic convention, where positive values indicate south magnetic polarity, and negative values indicate north magnetic polarity; therefore greater B values indicate a stronger south polarity field (or a weaker north polarity field, if present).

# A1140/41/42/43

## Sensitive Two-Wire Chopper-Stabilized Unipolar Hall Effect Switches

### Characteristic Data



**Device Qualification Program**  
Contact Allegro MicroSystems for information.

### EMC (Electromagnetic Compatibility) Requirements

Contact your local representative for EMC results.

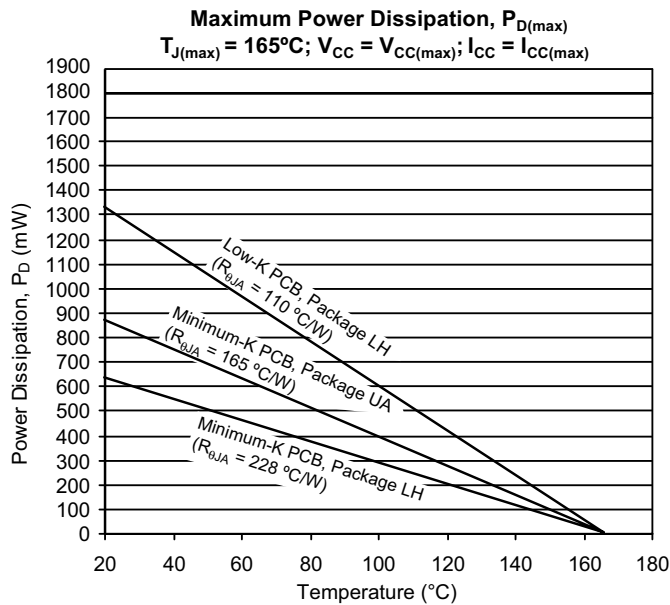
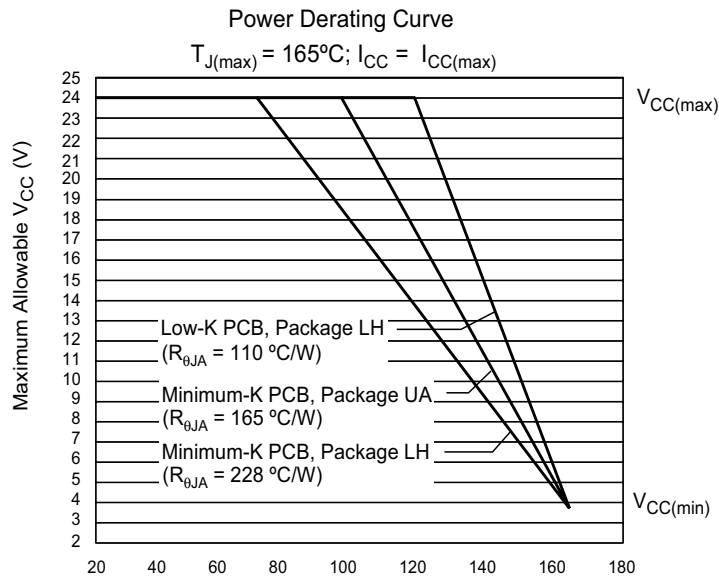
Test Name	Reference Specification
ESD – Human Body Model	AEC-Q100-002
ESD – Machine Model	AEC-Q100-003
Conducted Transients	ISO 7637-1
Direct RF Injection	ISO 11452-7
Bulk Current Injection	ISO 11452-4
TEM Cell	ISO 11452-3

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## Sensitive Two-Wire Chopper-Stabilized Unipolar Hall Effect Switches

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

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max	Units
Package Thermal Resistance	$R_{\theta JA}$	Package LH, minimum-K PCB (single-sided with copper limited to solder pads)	110	–	–	°C/W
		Package LH, low-K PCB (double-sided with 0.926 in <sup>2</sup> copper area)	228	–	–	°C/W
		Package UA, minimum-K PCB (single-sided with copper limited to solder pads)	165	–	–	°C/W



# A1140/41/42/43

## Sensitive Two-Wire Chopper-Stabilized Unipolar Hall Effect Switches

### Functional Description

#### Operation

The output,  $I_{CC}$ , of the A1140 and A1142 devices switch low after the magnetic field at the Hall sensor exceeds the operate point threshold,  $B_{OP}$ . When the magnetic field is reduced to below the release point threshold,  $B_{RP}$ , the device output goes high. The differences between the magnetic operate and release point is called the hysteresis of the device,  $B_{HYS}$ . This built-

in hysteresis allows clean switching of the output even in the presence of external mechanical vibration and electrical noise. The A1141 and A1143 devices switch with opposite polarity for similar  $B_{OP}$  and  $B_{RP}$  values, in comparison to the A1140 and A1142 (see figure 1).

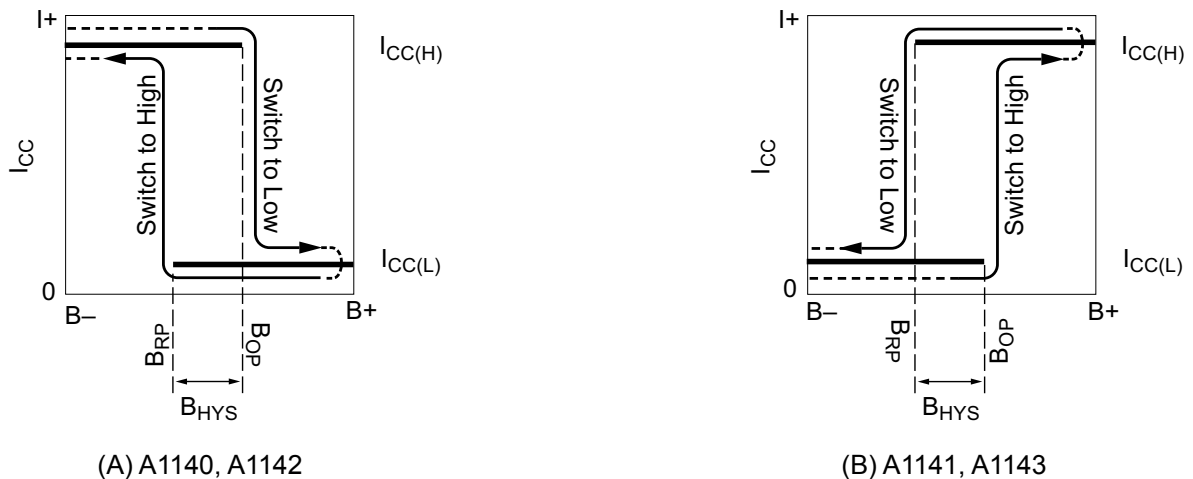


Figure 1. Alternative switching behaviors are available in the A114x device family. On the horizontal axis, the B+ direction indicates increasing south polarity magnetic field strength, and the B- direction indicates decreasing south polarity field strength (including the case of increasing north polarity).

### Chopper Stabilization Technique

When using Hall-effect technology, a limiting factor for switch-point accuracy is the small signal voltage developed across the Hall element. This voltage is disproportionately 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-sourced signal then can pass through a low-pass filter, while the modulated dc offset is suppressed.

The chopper stabilization technique uses a 200 kHz high frequency clock. The chopping occurs on each clock edge, result-

ing in a 400 kHz chop frequency. 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. This process is illustrated in figure 2.

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.

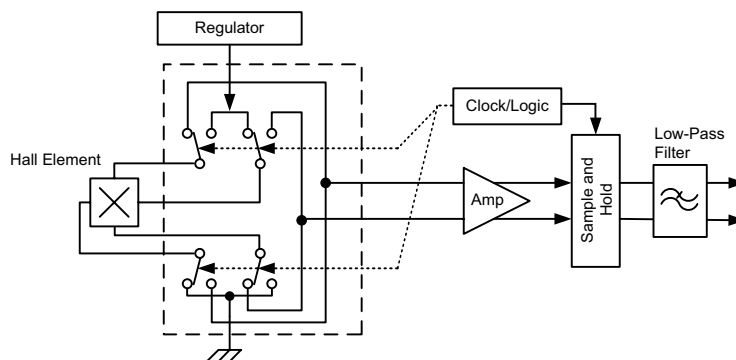


Figure 2. Chopper stabilization circuit (dynamic quadrature offset cancellation)

# A1140/41/42/43

## Sensitive Two-Wire Chopper-Stabilized Unipolar Hall Effect Switches

### Application Information

For additional general application information, visit the Allegro MicroSystems Web site at [www.allegromicro.com](http://www.allegromicro.com).

#### Typical Application Circuit

The A114x family of devices must be protected by an external bypass capacitor,  $C_{BYP}$ , connected between the supply,  $V_{CC}$ , and the ground,  $GND$ , of the device.  $C_{BYP}$  reduces both external noise and the noise generated by the chopper-stabilization function. As shown in figure 3, a 0.01  $\mu F$  capacitor is typical.

Installation of  $C_{BYP}$  must ensure that the traces that connect it to the A114x pins are no greater than 5 mm in length.

All high-frequency interferences conducted along the supply lines are passed directly to the load through  $C_{BYP}$ , and it serves only to protect the A114x internal circuitry. As a result, the load ECU (electronic control unit) must have sufficient protection, other than  $C_{BYP}$ , installed in parallel with the A114x.

A series resistor on the supply side,  $R_S$  (not shown), in combination with  $C_{BYP}$ , creates a filter for EMI pulses. (Additional information on EMC is provided on the Allegro MicroSystems Web site.)

When determining the minimum  $V_{CC}$  requirement of the A114x device, the voltage drops across  $R_S$  and the ECU sense resistor,  $R_{SENSE}$ , must be taken into consideration. The typical value for  $R_{SENSE}$  is approximately 100  $\Omega$ .

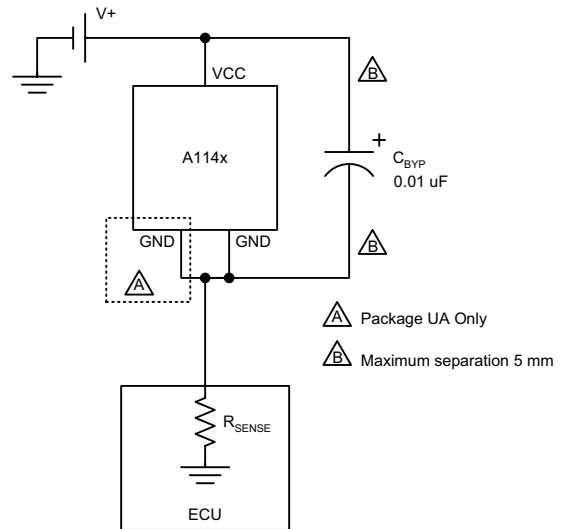


Figure 3. Typical application circuit



## 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  $P_D$ .

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

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

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

For example, given common conditions such as:  $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 12\text{ V}$ ,  $I_{CC} = 4\text{ mA}$ , and  $R_{\theta JA} = 140\text{ }^\circ\text{C/W}$ , then:

$$P_D = V_{CC} \times I_{CC} = 12\text{ V} \times 4\text{ mA} = 48\text{ mW}$$

$$\Delta T = P_D \times R_{\theta JA} = 48\text{ mW} \times 140\text{ }^\circ\text{C/W} = 7^\circ\text{C}$$

$$T_J = T_A + \Delta T = 25^\circ\text{C} + 7^\circ\text{C} = 32^\circ\text{C}$$

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  $T_A = 150^\circ\text{C}$ , package UA, using minimum-K PCB.

Observe the worst-case ratings for the device, specifically:  $R_{\theta JA} = 165^\circ\text{C/W}$ ,  $T_{J(max)} = 165^\circ\text{C}$ ,  $V_{CC(max)} = 24\text{ V}$ , and  $I_{CC(max)} = 17\text{ mA}$ .

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:

$$P_{D(max)} = \Delta T_{max} \div R_{\theta JA} = 15^\circ\text{C} \div 165\text{ }^\circ\text{C/W} = 91\text{ mW}$$

Finally, invert equation 1 with respect to voltage:

$$V_{CC(est)} = P_{D(max)} \div I_{CC(max)} = 91\text{ mW} \div 17\text{ mA} = 5\text{ V}$$

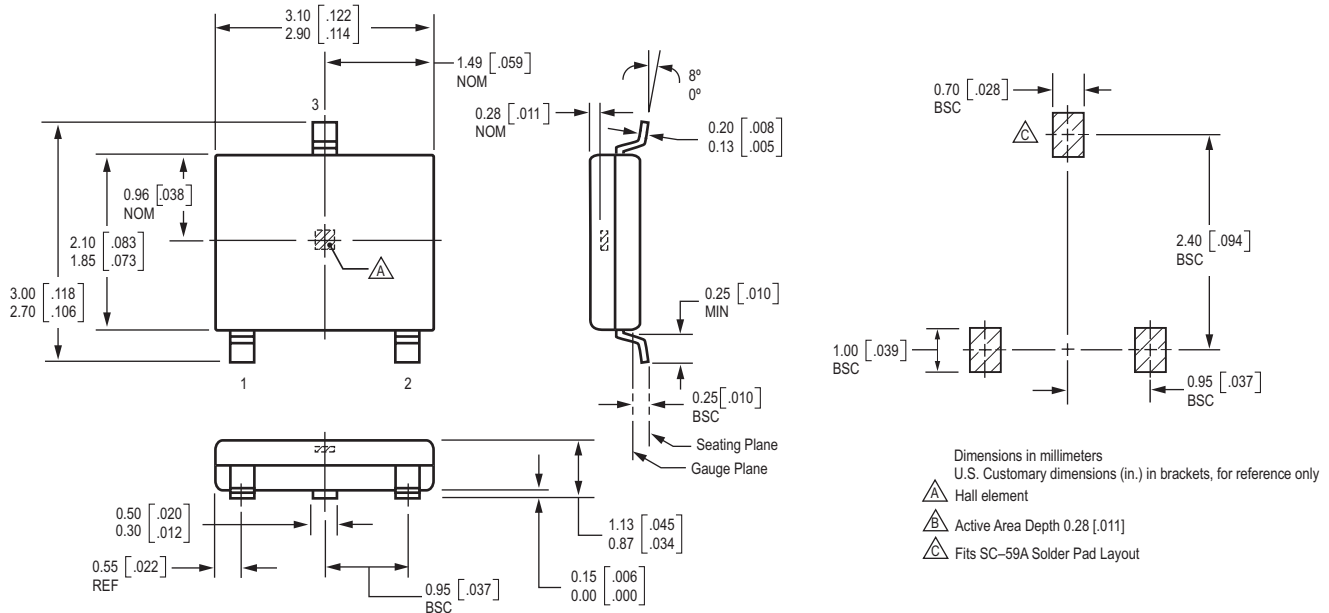
The result indicates that, at  $T_A$ , the application and device can dissipate adequate amounts of heat at voltages  $\leq V_{CC(est)}$ .

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.

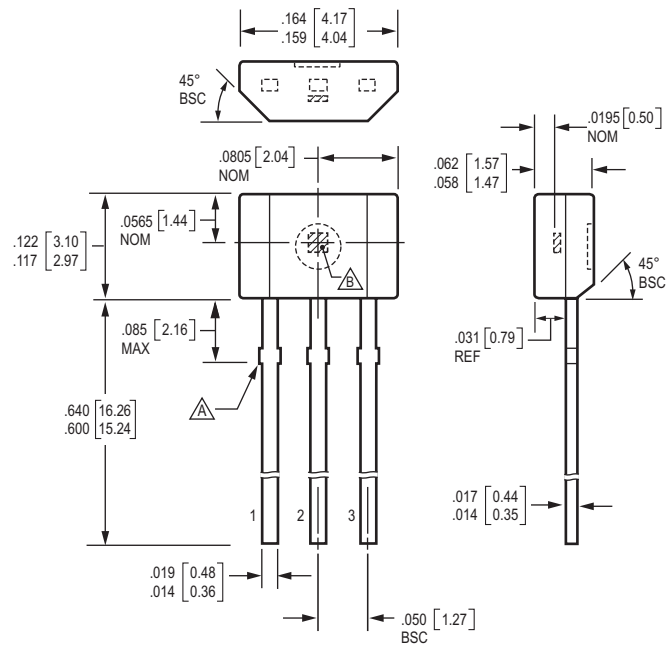
# A1140/41/42/43

## Sensitive Two-Wire Chopper-Stabilized Unipolar Hall Effect Switches

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



### Package UA, 3-Pin; (TO-92)



*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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