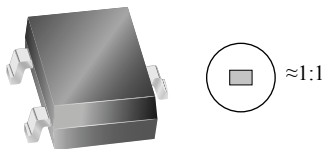


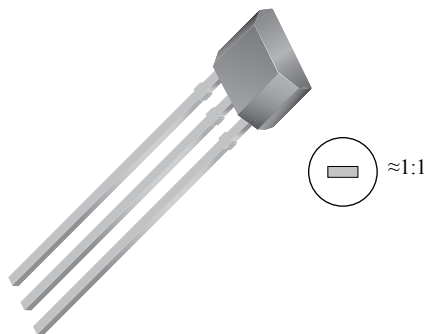
# A1140/41/42/43

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

Package LH, 3-pin SOT



Package UA, 3-pin SIP



### ABSOLUTE MAXIMUM RATINGS

Supply Voltage, $V_{CC}$ .....	28 V
Reverse-Supply Voltage, $V_{RCC}$ .....	-18 V
Magnetic Flux Density, $B$ .....	Unlimited
Power Dissipation, $P_D$ .....	Graph, p. 5
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 use a patented high frequency chopper-stabilization technique, produced using the Allegro advanced BiCMOS wafer fabrication process, to achieve magnetic stability and to eliminate offset inherent in single-element devices exposed to harsh application environments.

Commonly found in a number of automotive applications, these switches are utilized to sense seat track position, seat belt buckle presence, hood/trunk latching, and shift selector position. Two-wire unipolar switches, such as the A1140/41/42/43 family, are particularly advantageous in price-sensitive applications because they require one less wire for operation than do switches with the more traditional open-collector output. Additionally, the system designer inherently gains diagnostics because there is always output current flowing, which should be in either of two narrow ranges. Any current level not within these ranges indicates a fault condition. The A1140/41/42/43 family of switches 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, as in the presence of a weak field or a north (-) polarity field. The other two devices in the family (A1140 and A1142) have an opposite output: the currents switch LOW in the presence of a south-polarity magnetic field of sufficient strength, and switch HIGH otherwise. The other differences in the switches are their defined low current levels and magnetic switchpoints.

All versions are offered in two package styles. The LH is a SOT-23W, miniature low-profile package for surface-mount applications. The UA is a three-lead ultra-mini SIP for through-hole mounting. Each package is available in a lead (Pb) free version (suffix, -T) with 100% matte tin plated leadframe. Field-programmable versions also available: A1180, A1181, A1182, and A1183.

### Features and Benefits

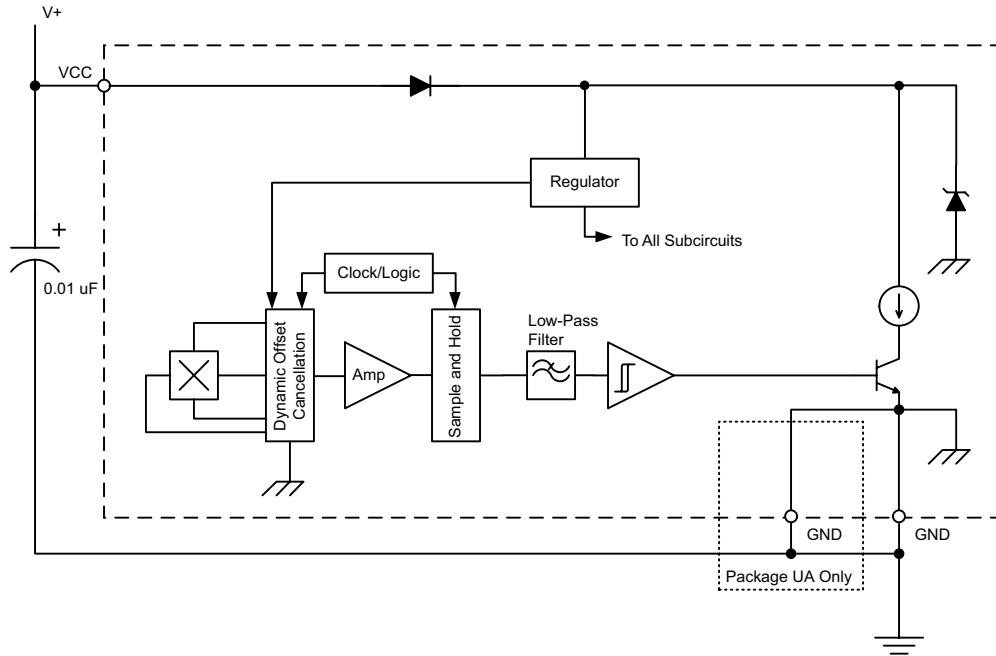
- Chopper stabilization
  - Low switchpoint drift over operating temperature range
  - Low sensitivity to stress
- On-chip protection
  - Supply transient protection
  - Reverse-battery protection
  - On-board voltage regulator
  - 3.5 to 24 V operation
- Factory programmed at end-of-line for optimized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



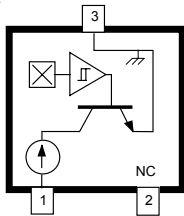
# A1140/41/42/43

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

### Functional Block Diagram

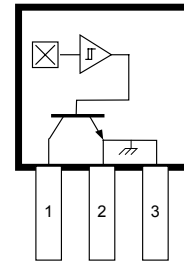


Package LH, 3-pin SOT



- 1. VCC
- 2. No connection
- 3. GND

Package UA, 3-pin SIP



- 1. VCC
- 2. GND
- 3. GND

# A1140/41/42/43

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

**ELECTRICAL CHARACTERISTICS** over the operating voltage and temperature ranges, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Supply Voltage <sup>1</sup>	$V_{CC}$		3.5	–	24	V
Supply Current <sup>2</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
Reverse Supply Current	$I_{RCC}$	$V_{RCC} = -18\text{ V}$	–	–	-1.6	mA
Supply Zener Clamp Voltage	$V_{ZSUPPLY}$	$I_{CC} = I_{CCL(max)} + 3\text{ mA}$ ; $T_A = 25^\circ\text{C}$	28	–	40	V
Supply Zener Clamp Current <sup>3</sup>	$I_{ZSUPPLY}$	$V_{ZSUPPLY} = 28\text{ V}$	–	–	10	mA
Output Slew Rate <sup>4</sup>	$di/dt$	Capacitance of the oscilloscope performing the measurement = 20 pF	–	36	–	mA/ $\mu\text{s}$
Chopping Frequency	$f_C$		–	200	–	kHz
Power-On Time <sup>5</sup>	$t_{on}$	$C_{BYPASS} = 0.01\ \mu\text{F}$	–	–	25	$\mu\text{s}$
Power-On State <sup>6,7</sup>	POS	$t < t_{on}$ ; $V_{CC}$ slew rate $> 25\text{ mV}/\mu\text{s}$	–	HIGH	–	–

<sup>1</sup> $V_{CC}$  represents the generated voltage between the VCC pin and the GND pin.

<sup>2</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>3</sup> $I_{ZSUPPLY(max)} = I_{CCL(max)} + 3\text{ mA}$ .

<sup>4</sup>Measured without bypass capacitor between VCC and GND. Use of a bypass capacitor results in slower current change.

<sup>5</sup>Measured with and without bypass capacitor of 0.01  $\mu\text{F}$ . Adding a larger bypass capacitor causes longer Power-On Time.

<sup>6</sup>POS is defined as true only with a  $V_{CC}$  slew rate of 25 mV/ $\mu\text{s}$  or greater. Operation with a  $V_{CC}$  slew rate less than 25 mV/ $\mu\text{s}$  can permanently harm device performance.

<sup>7</sup>POS is undefined for  $t > t_{on}$  or  $B_{RP} < B < B_{OP}$ .

**MAGNETIC CHARACTERISTICS** over the operating voltage and temperature ranges, unless otherwise specified

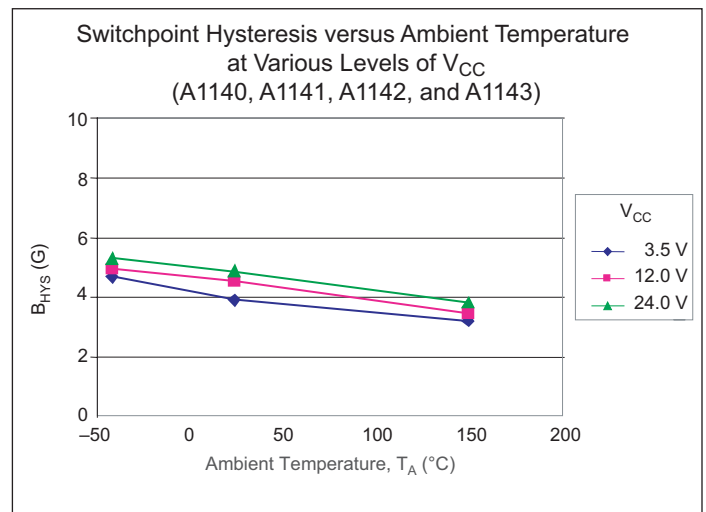
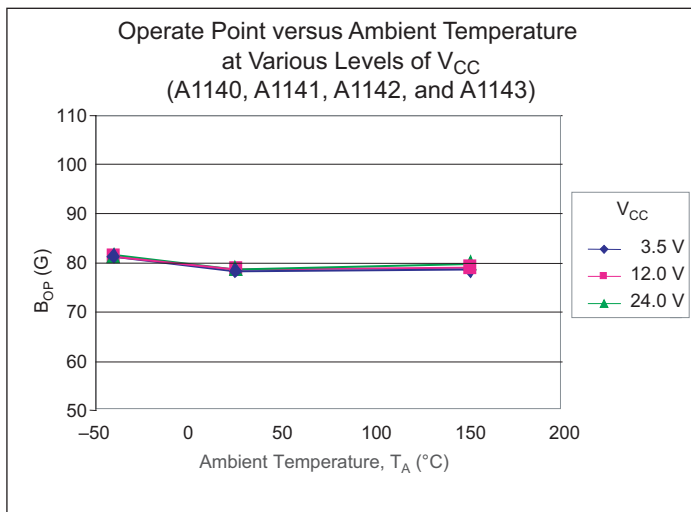
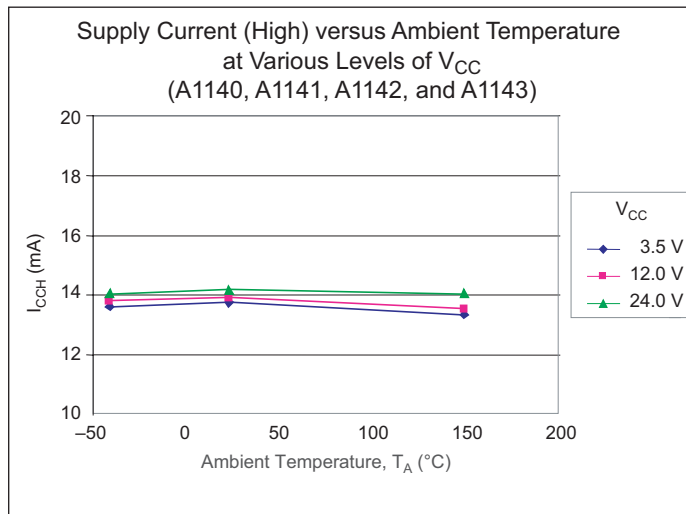
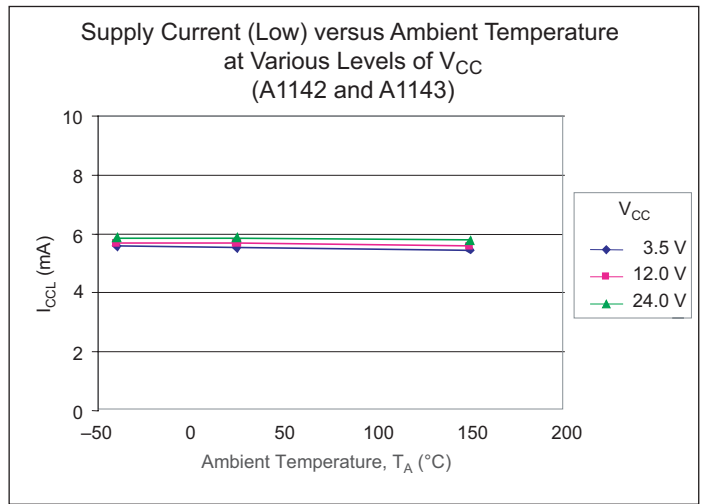
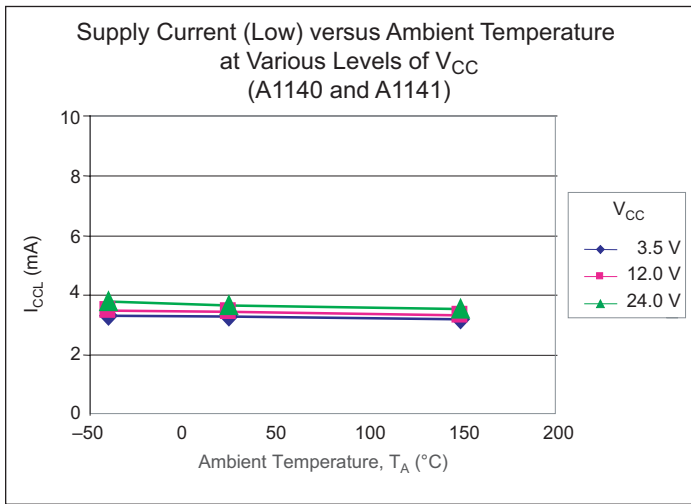
Characteristic	Symbol	Test Conditions	Min.	Typ.*	Max.	Units
Operate Point	$B_{OP}$	A1140, A1142   $I_{CC} = I_{CCL}$	50	80	115	G
		A1141, A1143   $I_{CC} = I_{CCH}$				
Release Point	$B_{RP}$	A1140, A1142   $I_{CC} = I_{CCH}$	45	65	110	G
		A1141, A1143   $I_{CC} = I_{CCL}$				
Hysteresis	$B_{HYS}$	$B_{HYS} = B_{OP} - B_{RP}$	5	15	30	G

\*Typical data taken at  $T_A = 25^\circ$

# A1140/41/42/43

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

### Characteristic Data

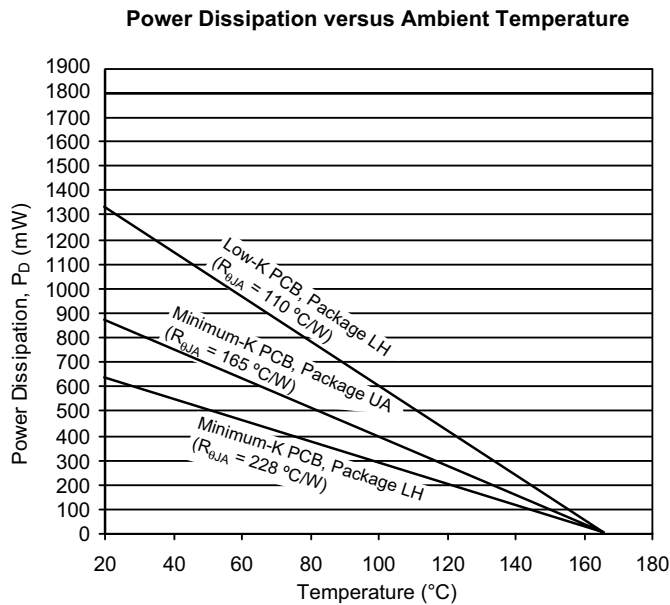
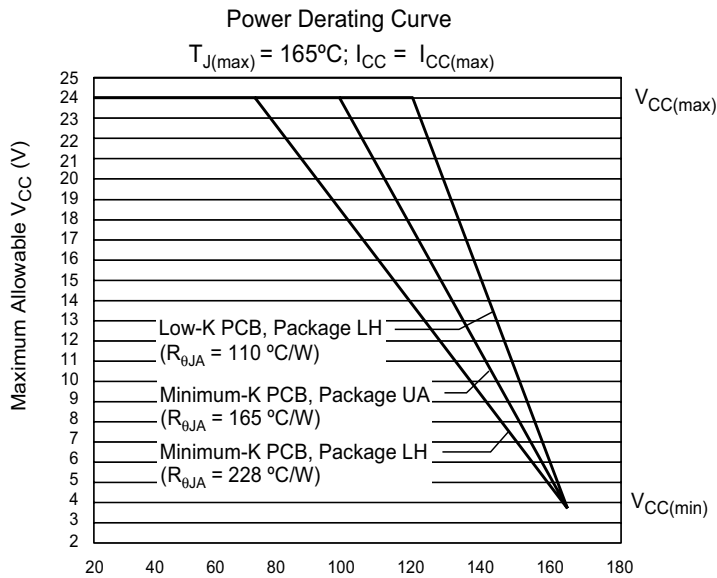


# A1140/41/42/43

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

**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 layer, single-sided with copper limited to solder pads)	110	$^{\circ}\text{C}/\text{W}$
		Package LH, low-K PCB (single layer, double-sided with 0.926 in <sup>2</sup> copper area)	228	$^{\circ}\text{C}/\text{W}$
		Package UA, minimum-K PCB (single layer, single-sided with copper limited to solder pads)	165	$^{\circ}\text{C}/\text{W}$



# 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).

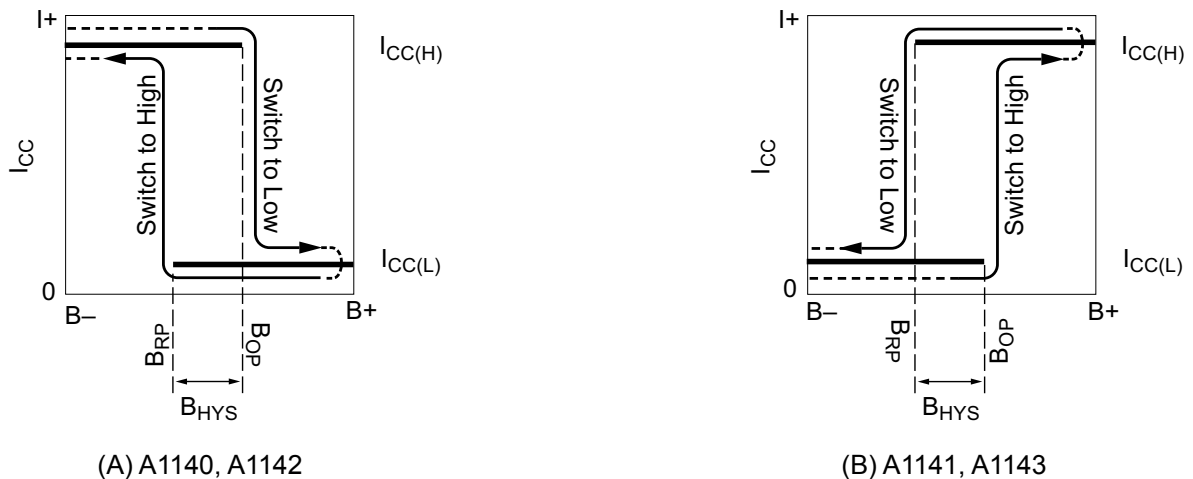


Figure 1. Alternative switching behaviors are available in the A114x device family. On the horizontal axis, the B+ direction indicates increasing south polarity magnetic field strength, and the B- direction indicates decreasing south polarity field strength (including the case of increasing north polarity).

### Chopper Stabilization Technique

When using Hall-effect technology, a limiting factor for switchpoint 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. 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.

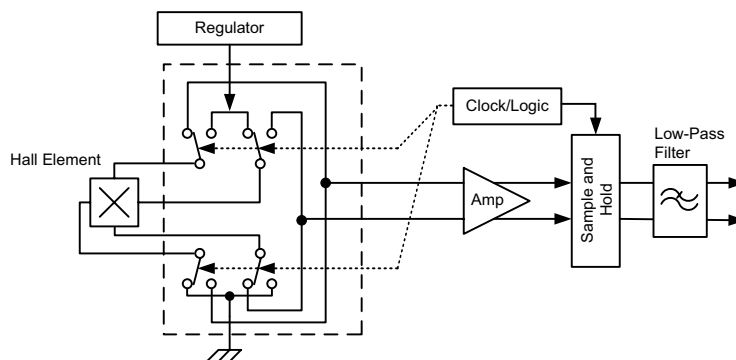


Figure 2. Chopper stabilization circuit (Dynamic Quadrature Offset Cancellation)

# A1140/41/42/43

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

### Application Information

#### 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.

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  $100 \Omega$ .

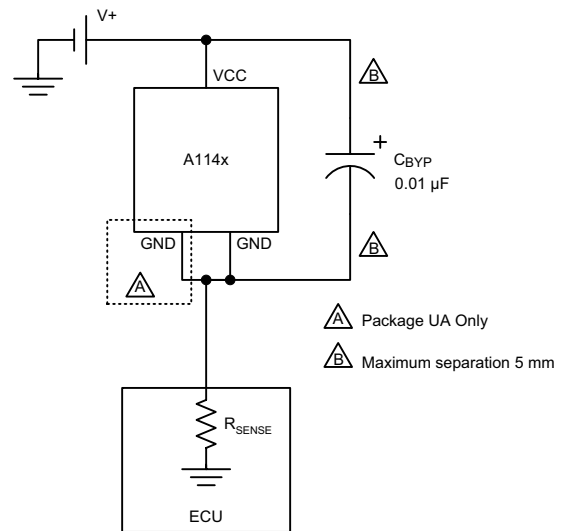


Figure 3. Typical application circuit

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



## 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

### Device Qualification Program

Contact Allegro 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

# A1140/41/42/43

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

### Product Selection Guide

Use the complete part numbers when ordering

Part Number	Pb-Free	Packing <sup>a</sup>	Package	Operating Ambient Temperature, T <sub>A</sub> (°C)	Output Level in South (+) Field <sup>b</sup>	Supply Current at Low Output, I <sub>CC(L)</sub> (mA)	
A1140ELHLT	–	Tape and Reel, 3000 pieces/reel	Surface Mount	–40 to 85	Low	2 to 5	
A1140ELHLT-T	Yes						
A1140EUA	–	Bulk Bag, 500 pieces/bag	Through Hole				
A1140EUA-T	Yes						
A1140EUATI	–	Tape and Reel, 2000 pieces/reel					
A1140EUATI-T	Yes						
A1140LLHLT	–	Tape and Reel, 3000 pieces/reel	Surface Mount				–40 to 150
A1140LLHLT-T	Yes						
A1140LUA	–	Bulk Bag, 500 pieces/bag	Through Hole				
A1140LUA-T	Yes						
A1140LUATI	–	Tape and Reel, 2000 pieces/reel					
A1140LUATI-T	Yes						
A1141ELHLT	–	Tape and Reel, 3000 pieces/reel	Surface Mount	–40 to 85	High		
A1141ELHLT-T	Yes						
A1141EUA	–	Bulk Bag, 500 pieces/bag	Through Hole				
A1141EUA-T	Yes						
A1141EUATI	–	Tape and Reel, 2000 pieces/reel					
A1141EUATI-T	Yes						
A1141LLHLT	–	Tape and Reel, 3000 pieces/reel	Surface Mount			–40 to 150	
A1141LLHLT-T	Yes						
A1141LUA	–	Bulk Bag, 500 pieces/bag	Through Hole				
A1141LUA-T	Yes						
A1141LUATI	–	Tape and Reel, 2000 pieces/reel					
A1141LUATI-T	Yes						

Continued on the next page...

# A1140/41/42/43

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

Continued from the previous page....

Part Number	Pb-Free	Packing <sup>a</sup>	Package	Operating Ambient Temperature, T <sub>A</sub> (°C)	Output Level in South (+) Field <sup>b</sup>	Supply Current at Low Output, I <sub>CC(L)</sub> (mA)
A1142ELHLT	–	Tape and Reel, 3000 pieces/reel	Surface Mount	–40 to 85	Low	5 to 6.9
A1142ELHLT-T	Yes					
A1142EUA	–	Bulk Bag, 500 pieces/bag	Through Hole			
A1142EUA-T	Yes					
A1142EUATI	–	Tape and Reel, 2000 pieces/reel				
A1142EUATI-T	Yes					
A1142LLHLT	–	Tape and Reel, 3000 pieces/reel		Surface Mount	–40 to 150	
A1142LLHLT-T	Yes					
A1142LUA	–	Bulk Bag, 500 pieces/bag	Through Hole			
A1142LUA-T	Yes					
A1142LUATI	–	Tape and Reel, 2000 pieces/reel				
A1142LUATI-T	Yes					
A1143ELHLT	–	Tape and Reel, 3000 pieces/reel		Surface Mount	–40 to 85	High
A1143ELHLT-T	Yes					
A1143EUA	–	Bulk Bag, 500 pieces/bag	Through Hole			
A1143EUA-T	Yes					
A1143EUATI	–	Tape and Reel, 2000 pieces/reel				
A1143EUATI-T	Yes					
A1143LLHLT	–	Tape and Reel, 3000 pieces/reel		Surface Mount	–40 to 150	
A1143LLHLT-T	Yes					
A1143LUA	–	Bulk Bag, 500 pieces/bag	Through Hole			
A1143LUA-T	Yes					
A1143LUATI	–	Tape and Reel, 2000 pieces/reel				
A1143LUATI-T	Yes					

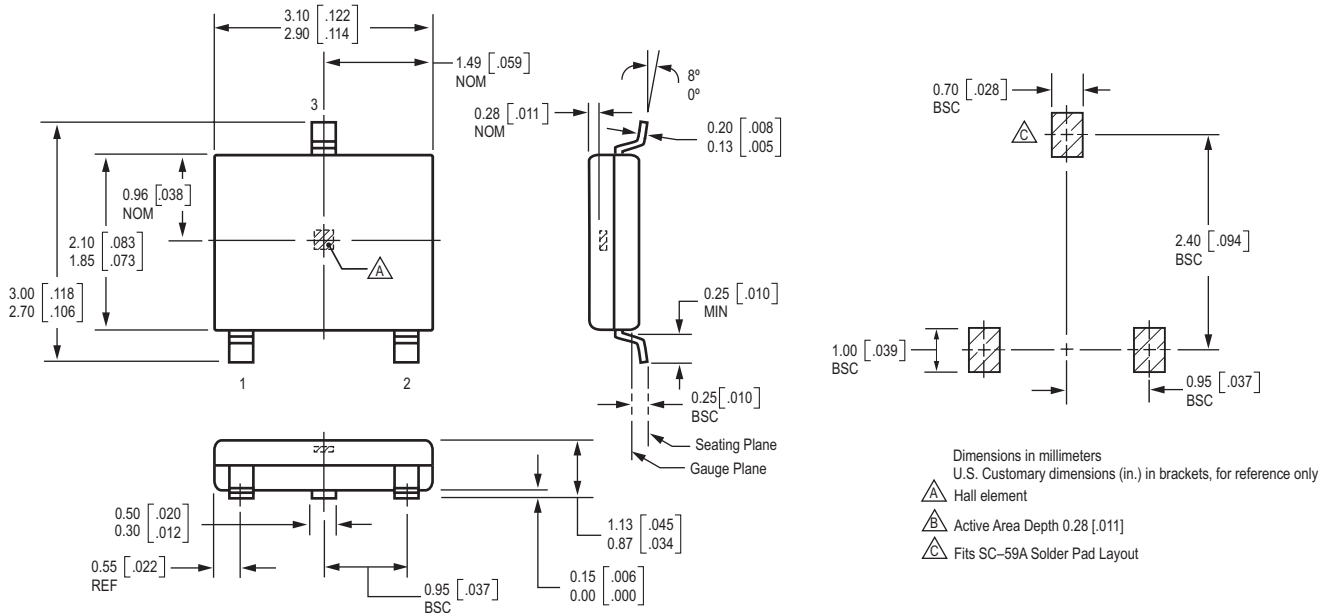
<sup>a</sup>Contact Allegro for additional packing options.

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

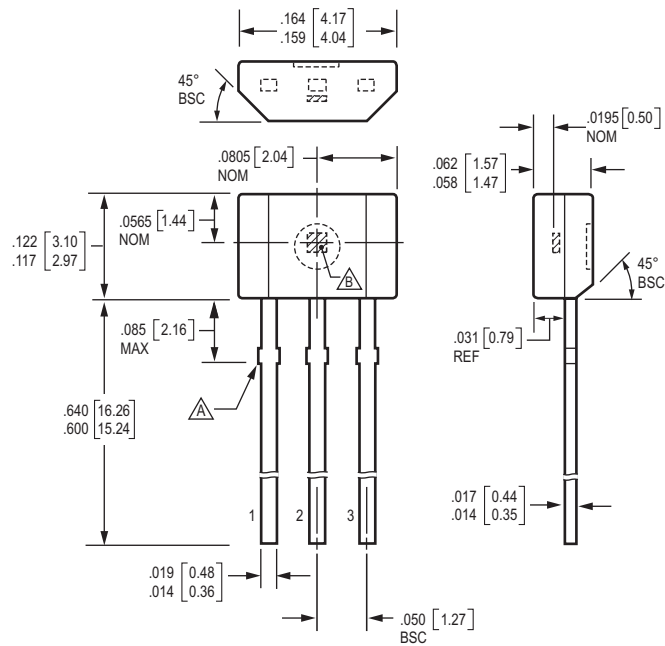
# A1140/41/42/43

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

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



### Package UA, 3-Pin SIP



*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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