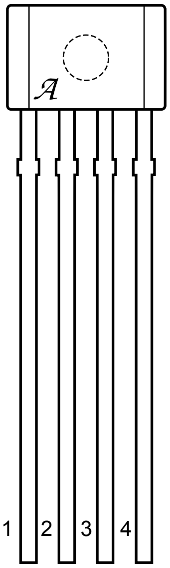
Preliminary Data Sheet
Subject to Change Without Notice
November 10, 2004

A1425

High Accuracy Analog Speed Sensor with Integrated Filter Capacitor and Dual Zero-Crossing Output Signal

Package K, 4-pin SIP



1. VCC
2. VOUT
3. Test pin, tie to GND
4. GND

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{CC}	**28 V**
Reverse-Supply Voltage, V_{RCC}	**–18 V**
Output Current, I_{OUT}	**25 mA**
Reverse-Output Current, I_{ROUT}	**–50 mA**
Reverse-Output Voltage, V_{ROUT}	**–50 mA**
Operating Temperature	
Ambient, T_A	**–40ºC to 150ºC**
Maximum Junction, $T_{J(max)}$	**165ºC**
Storage Temperature, T_S	**–65ºC to 170ºC**

The A1425 ac-coupled Hall-effect sensor is a monolithic integrated circuit that switches in response to changing differential magnetic fields created by rotating ring magnets or, when coupled with a magnet, by ferrous targets. The device is a true zero-crossing detector: the output switches precisely when the difference in magnetic field strength between the two Hall elements is zero. A unique dual-comparator scheme provides for accurate switching during zero-crossing, both when the sensed field is increasing in strength and when it is decreasing, while utilizing hysteresis to prevent false switching. The zero-crossing nature of this device provides excellent repeatability for crankshaft applications.

Changes in field strength at the device face caused by a moving target are sensed by the two integrated Hall transducers, generating signals that are differentially amplified by on-chip electronics. This differential sensing design provides immunity to radial vibration within the operating air gap range of the A1425, by rejection of the common mode signal. Steady-state magnet and system offsets are eliminated using an on-chip differential band-pass filter. This filter also provides relative immunity to interference from electromagnetic sources.

The device utilizes advanced temperature compensation for the high-pass filter, sensitivity, and the Schmitt trigger switchpoints, guaranteeing optimal operation to low frequencies over a wide range of air gaps and temperatures.

Each Hall effect digital integrated circuit includes a voltage regulator, two Hall effect sensing elements, temperature compensating circuitry, a low-level amplifier, band-pass filter, Schmitt trigger, and an output driver. The on-board regulator permits operation with supply voltages from 4.0 to 26.5 V. The output stage can easily switch 20 mA over the full frequency response range of the sensor, and is compatible with both TTL and CMOS logic circuits.

The device is packaged in a 4-pin plastic SIP (part number suffix *-K*).

Features and Benefits

- Senses motion of ring magnet targets
- Integrated filter capacitor
- Wide operating temperature range
- Operation with frequency of sensed transitions from 20 Hz to 30 kHz
- EMI-resistant
- Large working air gaps
- 4.0 to 26.5 V operating range
- Output compatible with both TTL and CMOS logic families
- Reverse battery protection

Use the following complete part number when ordering:

Part Number	Package	Ambient (ºC)
A1425LK	4-pin plastic SIP	–40 to 150

Engineering samples available on a limited basis. Contact your local sales or applications support office for additional information.

Allegro MicroSystems, Inc.
115 Northeast Cutoff, Box 15036
Worcester, Massachusetts 01615-0036 (508) 853-5000
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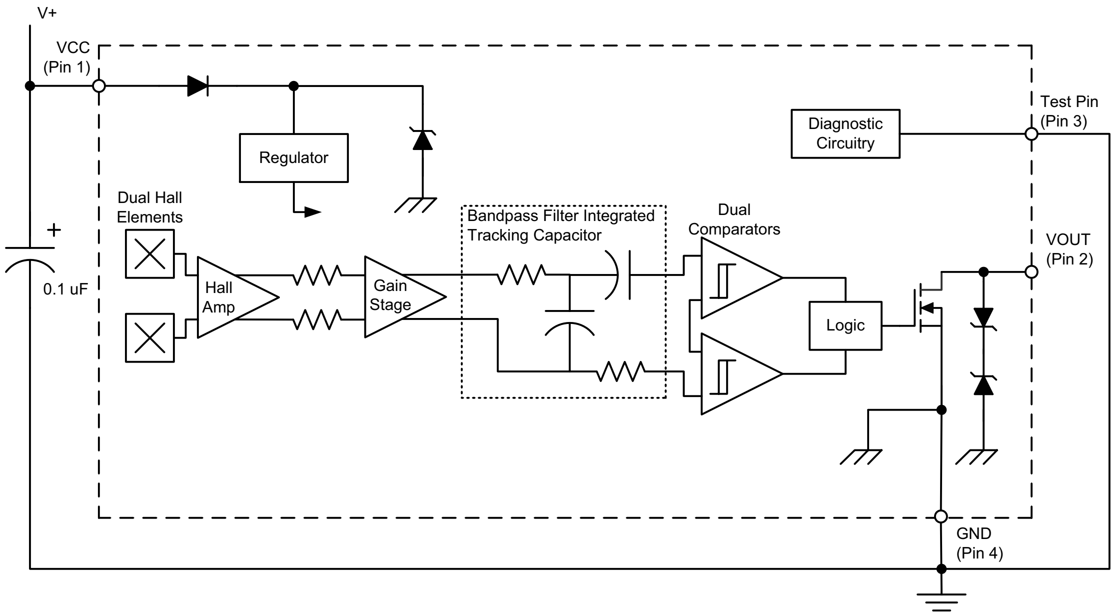
Functional Block Diagram



OPERATING CHARACTERISTICS Valid at T_A = –40°C to 150°C, $T_J \leq 165$°C; over operational air gap range and V_{CC} within operating range, unless otherwise noted. Typical operating parameters: V_{CC} = 12 V and T_A = 25°C.

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
ELECTRICAL CHARACTERISTICS						
Supply Voltage	V_{CC}	Operating; $T_J < T_{J(max)}$	4.0	–	26.5	V
Supply Current	I_{CC}		–	4.2	7.0	mA
Output Saturation Voltage	$V_{OUT(SAT)}$	I_{SINK} = 20 mA	–	140	400	mV
Output Leakage Current	I_{OFF}	V_{OUT} = 24 V, B_{diff} = 0	–	–	5	μA
PROTECTION COMPONENT CHARACTERISTICS						
Reverse Supply Current	I_{RCC}	V_{CC} = –18 V	–	–	–1	mA
Supply Zener Current	I_{ZCC}	V_{CC} = 28 V	–	–	10	mA
Supply Zener Clamp Voltage	V_{ZCC}	I_{CC} = 10 mA[1], T_A = 25°C	28	33	37	V
Output Zener Current	I_{ZOUT}	V_{OUT} = 28 V	–	–	3	mA
Output Zener Clamp Voltage	V_{ZOUT}	I_{OUT} = 3 mA, T_A = 25°C	28	–	–	V
Output Short Circuit Current Limit	$I_{OUT(lim)}$		–	–	50	mA
RESPONSE CHARACTERISTICS						
Power-On Time[2,6]	t_{PO}	$V_{CC} > V_{CC(min)}$	–	4.5	9	ms
Settling Time[3,6]	t_S	$f_{Bdiff} \geq 100$ Hz	0	–	50	ms
Response Time[6]	t_R	Equal to $t_{PO} + t_S$; $f_{Bdiff} \geq 100$ Hz	4.5	–	59	ms
Upper Corner Frequency	f_{cu}	–3 dB, single pole	30	–	–	kHz
Lower Corner Frequency	f_{cl}	–3 dB, single pole	–	–	20	Hz
OUTPUT CHARACTERISTICS						
Output Rise Time[4]	t_r	R_{PU} = 1 kΩ, C = 10 pF	–	–	200	ns
Output Fall Time	t_f	R_{PU} = 1 kΩ, I_{SINK} = 20 mA, C = 10 pF	–	–	200	ns
MAGNETIC CHARACTERISTICS						
Output Off Switchpoint[5,6]	B_{OP}	B_{diff} increasing, f_{Bdiff} = 200 Hz, B_{diff} = 50 Gp-p; digital output signal switches low to high	–11	0	11	G
Output On Switchpoint[5,6]	B_{RP}	B_{diff} decreasing, f_{Bdiff} = 200 Hz, B_{diff} = 50 Gp-p; digital output signal switches high to low	–11	0	11	G
Applied Magnetic Field[6,7]	B_{diff}	Differential p-p magnetic field	50	–	1250	G

[1] Equivalent to $I_{CC(max)}$ + 3 mA.

[2] Time required to initialize device.

[3] Time required for the output switchpoints to be within specification.

[4] Output Rise Time will be dominated by the RC time constant.

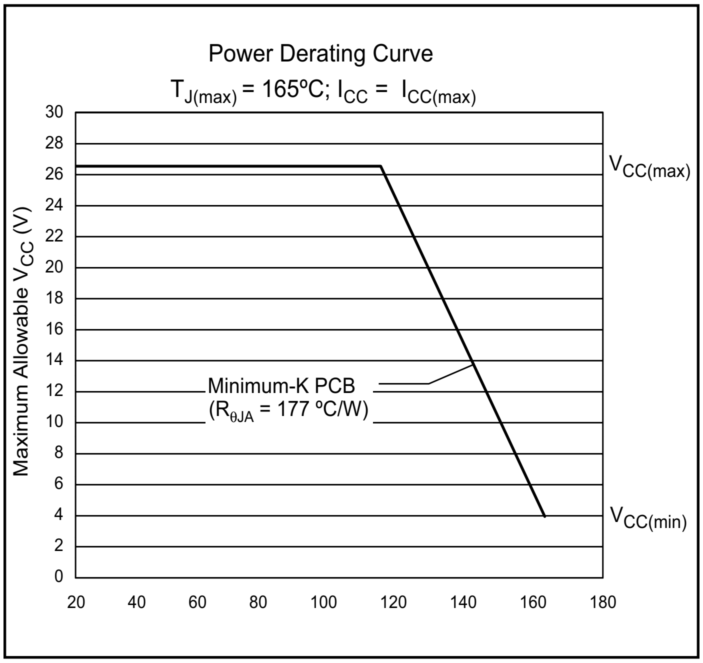
[5] For other sinusoidal signal frequencies and magnetic fields, $-B_{OP} = B_{RP} = \sin\alpha(B_{diff}/2) \pm 25\%$, where α is the phase shift shown in the Characteristic Data section.

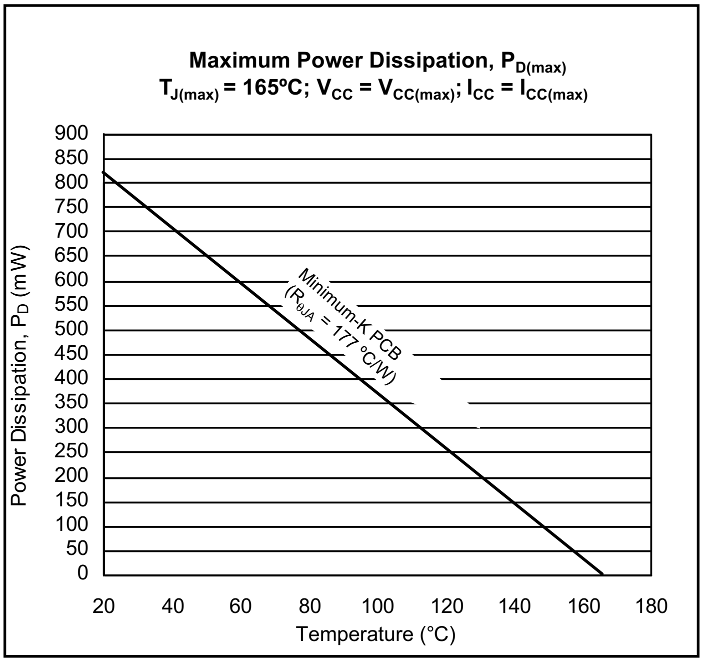
[6] See Definitions of Terms section.

[7] Exceeding the maximum magnetic field may result in compromised absolute accuracy.

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

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max	Units
Package Thermal Resistance	$R_{\theta JA}$	Minimum-K PCB (single-sided with copper limited to solder pads)	177	–	–	ºC/W





Definitions of Terms

The following provide additional information about some of the parameters cited in the Operating Characteristics table. For additional information, visit the Allegro Web site at *www.allegromicro.com*.

Applied Magnetic Field, B_{diff} – The differential magnetic flux density which is calculated as the arithmetic difference of the flux densities observed by each of the two Hall elements.

Output Off Switchpoint (Operate Point), B_{OP} – The value of increasing differential magnetic flux density at which the device output switches from low to high. This value may be greater than or less than 0 G.

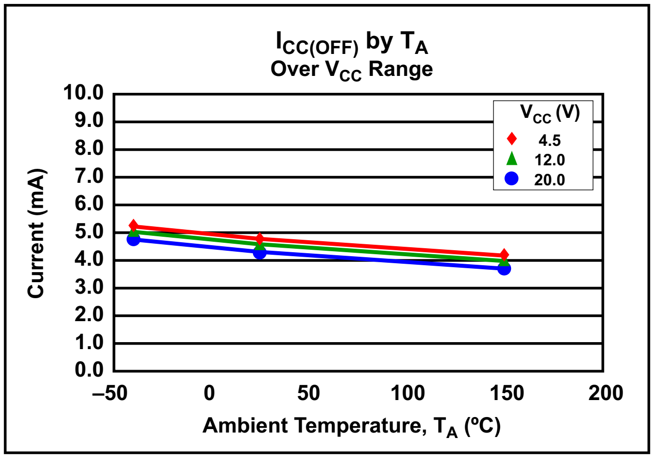
Output On Switchpoint (Release Point), B_{RP} – The value of decreasing differential magnetic flux density at which the device output switches from high to low. This value may be greater than or less than 0 G.

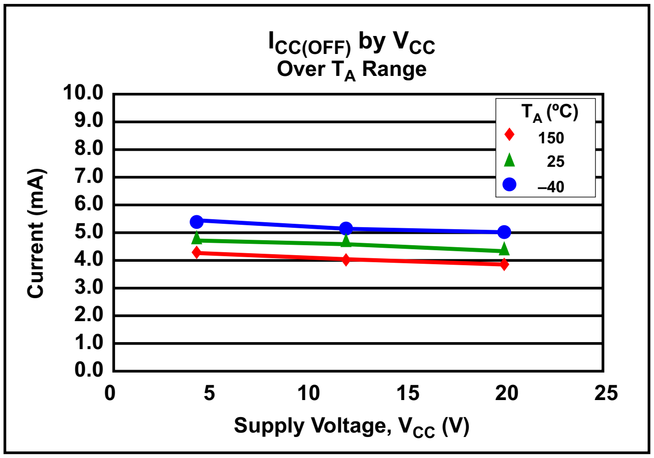
Power-On Time, t_{PO} – The time needed by the device, after power is applied, to initialize all circuitry necessary for proper operation.

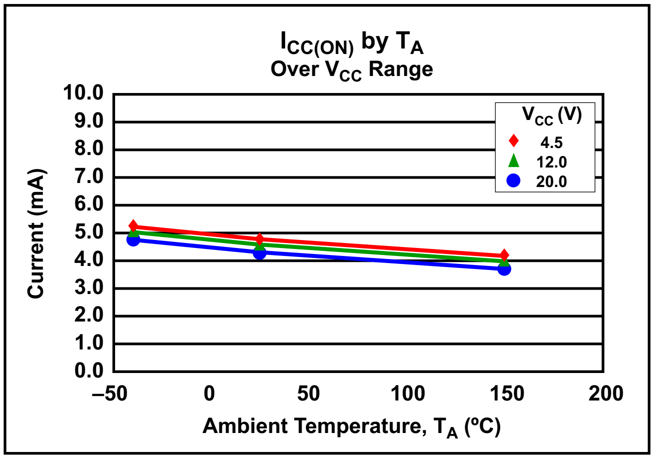
Settling Time, t_S – The time required by the device, after t_{PO}, and after a valid magnetic signal has been applied, to provide proper output transitions. Settling time is a function of magnetic offset, offset polarity, signal phase, signal frequency, and signal amplitude.

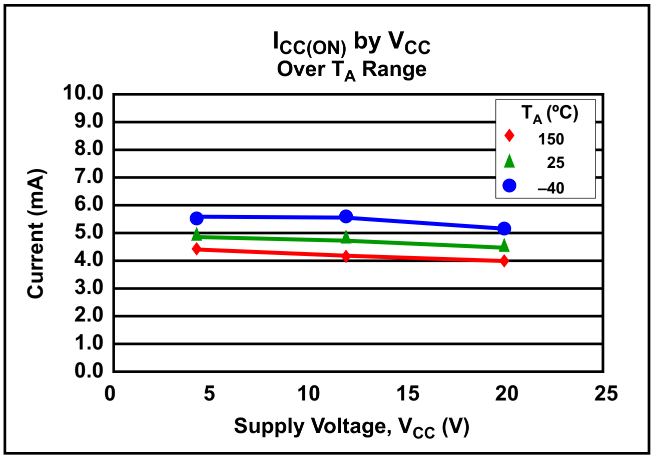
Response Time – The total time required for generating zero-crossing output transitions after power-up (the sum of power-on time and settling time).

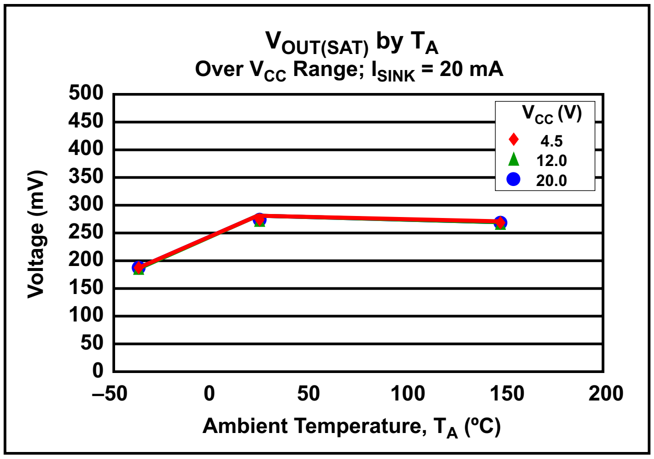
Empirical Results

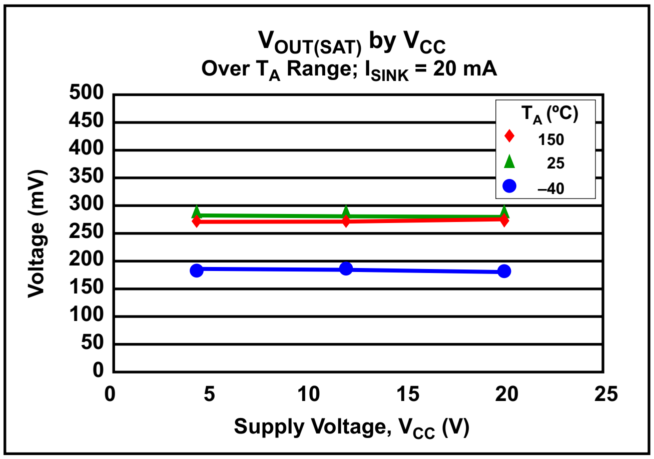












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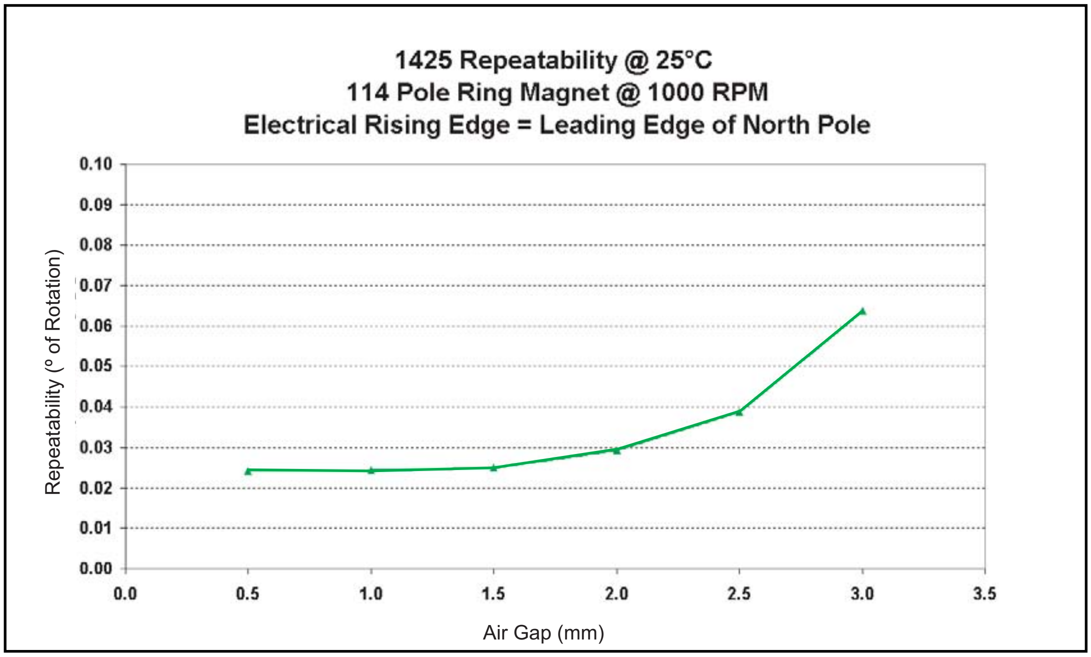
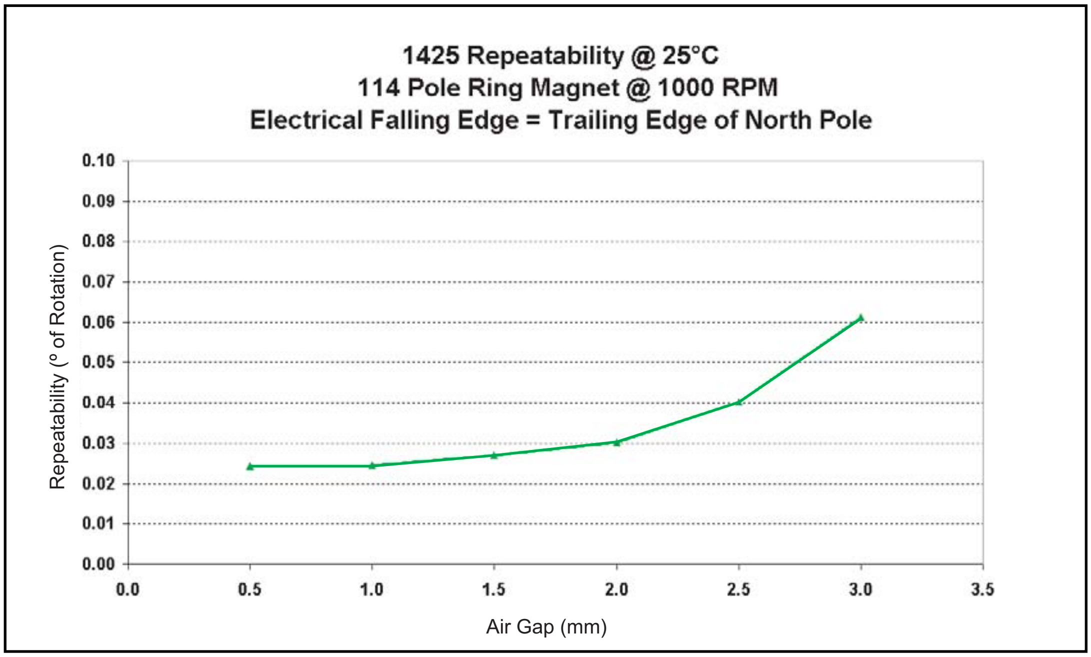
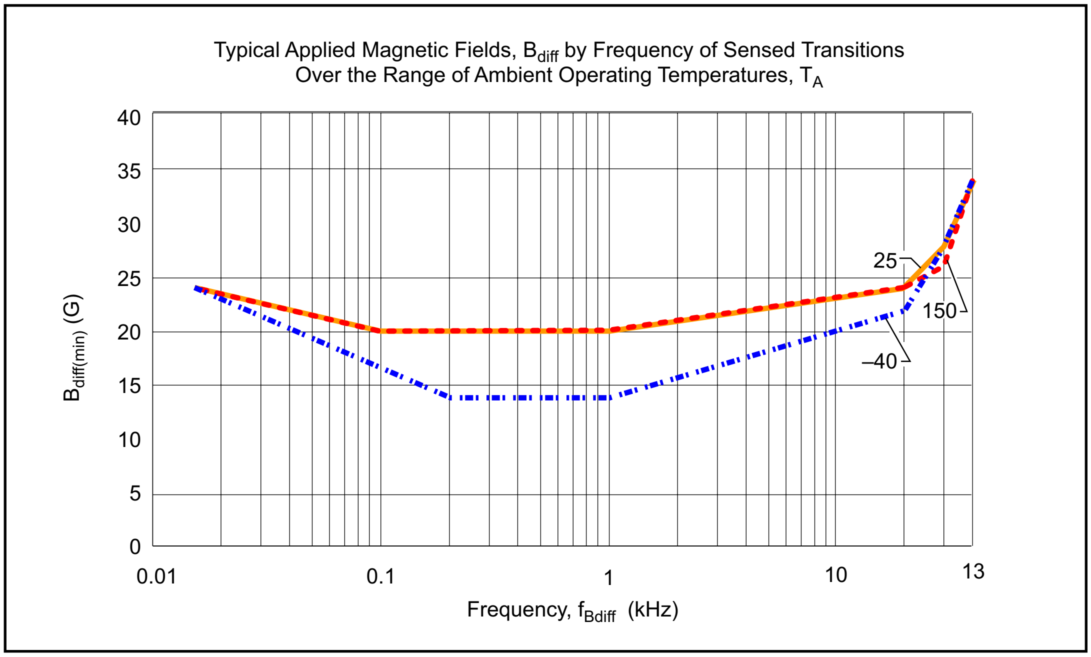
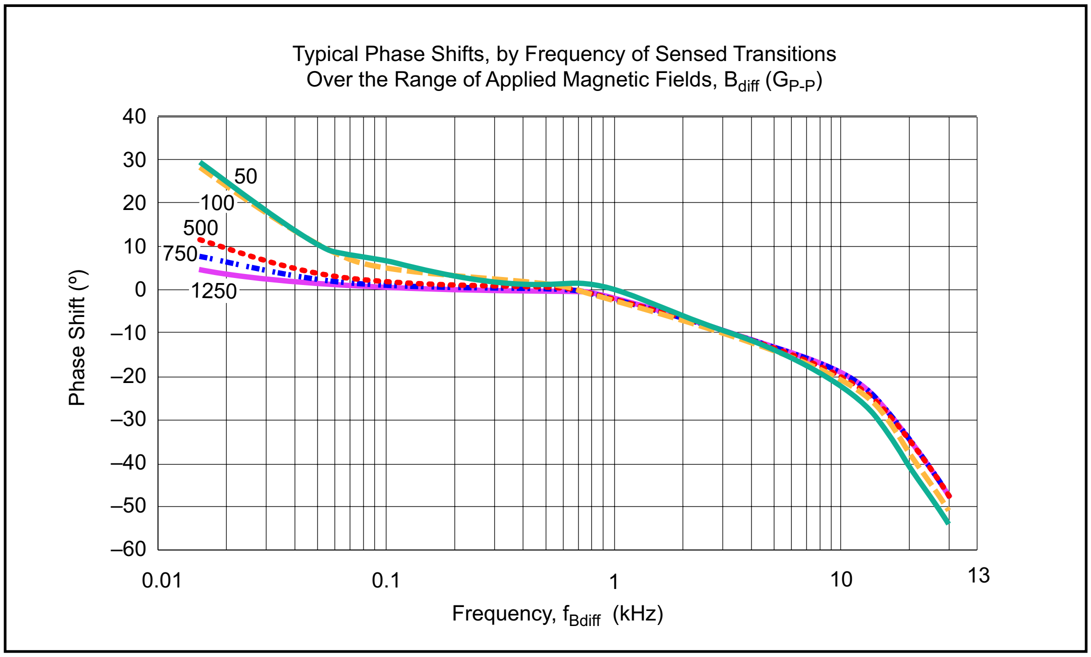
Empirical Results, continued





Simulation Results





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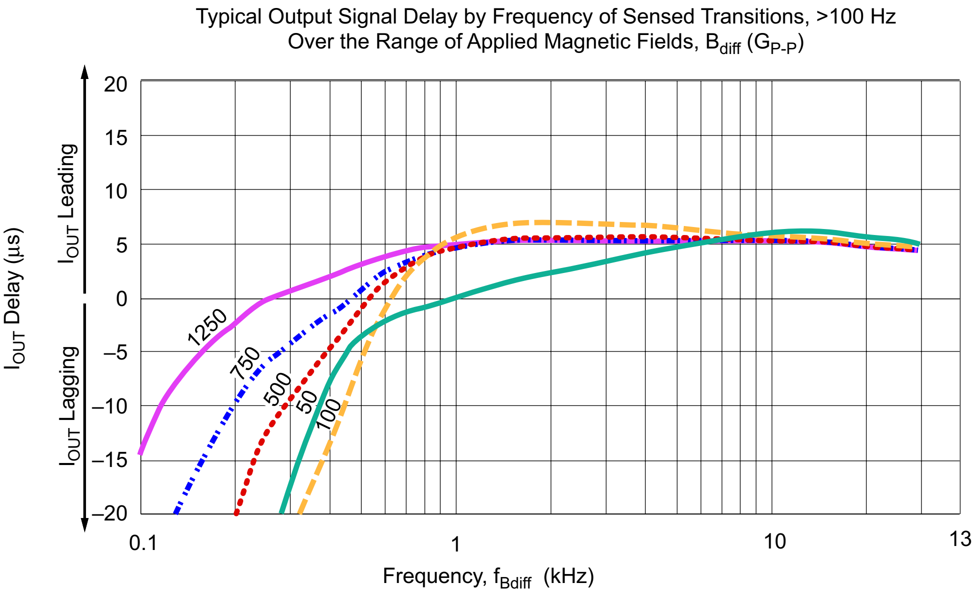
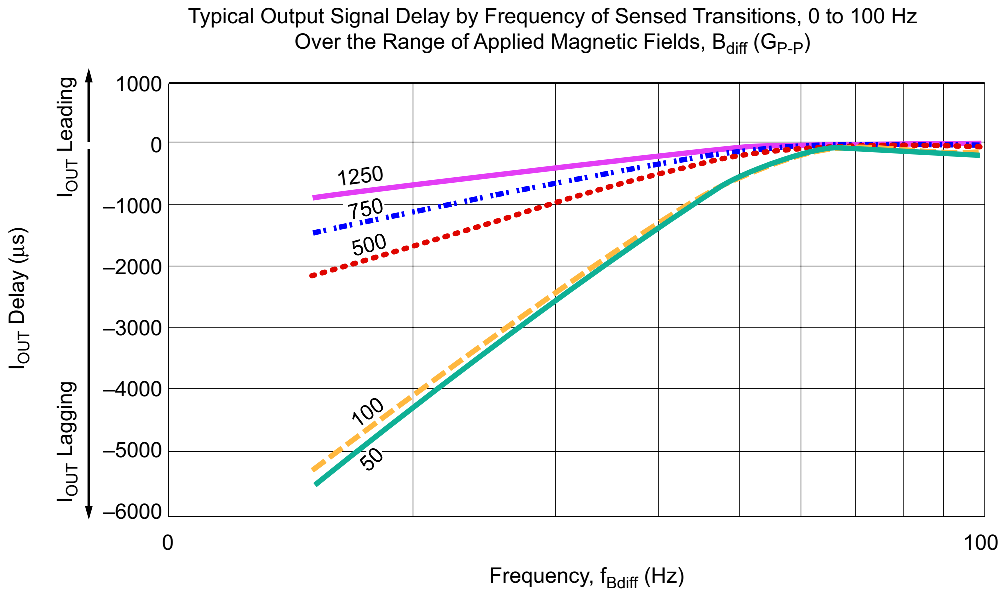
Simulation Results, continued



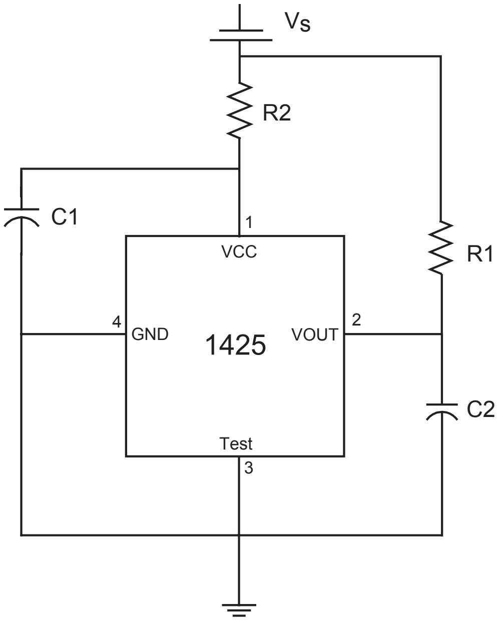


Sensor Evaluation: EMC Characterization

Please contact Allegro MicroSystems for EMC performance information.
(EMC test results are available after review of first silicon.)

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

*ESD test is done with no external components.



Component	Value	Units
R1*	1.2	kΩ
R2	100	Ω
C1	0.1	µF
C2	0.1	ηF

*Pull-up resistor not required for protection but for normal operation.

Recommended EMC test circuit. Test circuit recommended configuration may change after evaluation of first silicon.

Applications Information

The A1425 is a versatile high-precision differential sensing device that can be used in a wide range of applications. Proper choice of the target material and shape, and assembly techniques enables large working air gaps and high switchpoint accuracy over the device operating temperature range.

Sensor Operation

The A1425 sensor IC contains two integrated Hall transducers that are used to differentially sense a magnetic field across the surface of the IC. Referring to figure 1, the trigger switches the output off (output high) when the differential magnetic field crosses zero while increasing in strength (referred to a the positive direction), and switches the output on (output low) when the differential magnetic field crosses zero while decreasing (the negative direction).

The operation is achieved through the use of two separate comparators. Both comparators use the same reference point, 0 G, to provide high accuracy, but one comparator has a positive hysteresis, B_{HYS1}, and the other a negative hysteresis, B_{HYS2}. Therefore, one comparator switches at the zero crossing on an increasing differential signal and the other switches at the zero crossing on a decreasing differential signal. The hysteresis on each comparator precludes false switching on noise or target jitter.

Start-up

During power-on time, t_{PO}, the output signal, V_{OUT}, is high. Beyond this time, if the applied magnetic field, B_{diff}, is absent or less than 50 G peak-to-peak, the switching state and V_{OUT} polarity are indeterminate. V_{OUT} will be valid for $B_{diff} > 50$ Gp-p, after the additional settling time, t_S, has also elapsed.

Also during t_{PO}, a circuit in the A1425 is briefly enabled that charges the on-chip capacitor. This feature reduces t_{PO}, relative to the long RC time constant of a high-pass filter.

Delay

The on-chip band-pass filter induces delay in the output signal, V_{OUT}, relative to the applied magnetic field, B_{diff}. Simulation data shown in the Characteristic Data section quantify the effect of the input signal amplitude on the phase shift of the output.

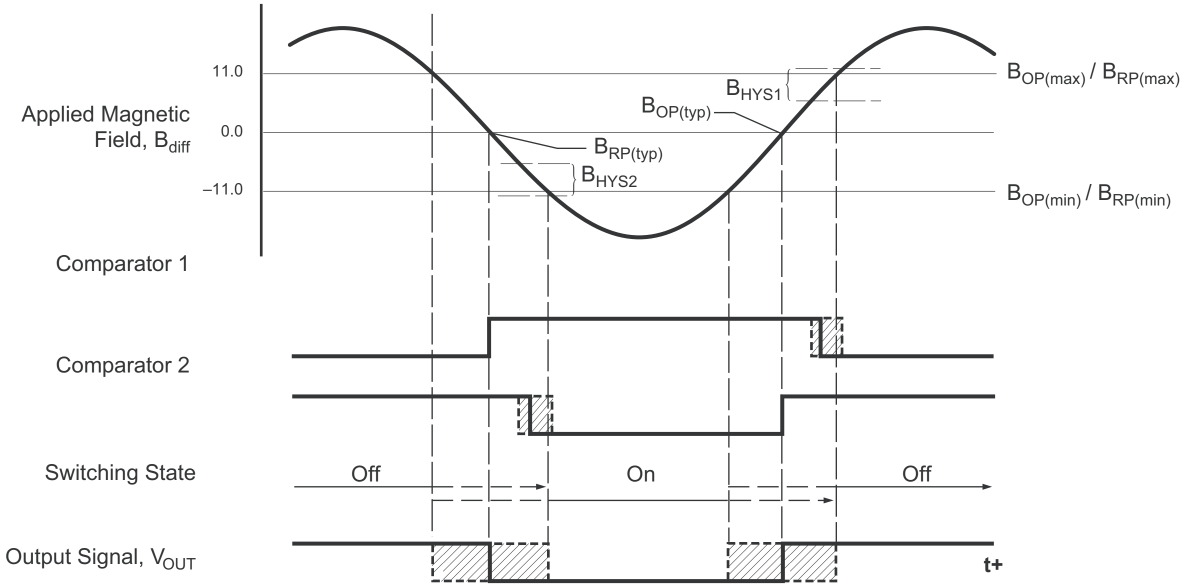


Figure 1. Typical output characteristics with dual comparator operation. Characteristics shown without delay, see characteristic data charts for delay and phase shift contributions.

AC-Coupled Operation

Steady-state magnet and system offsets are eliminated using an on-chip differential band-pass filter. The low and high frequency poles of this band-pass filter are set using internal integrated capacitors and resistors. The differential structure of this filter improves the ability of the IC to reject single-ended noise on the ground (GND pin) or supply line (VCC pin) and, as a result, makes it more resistant to electromagnetic interference typically seen in hostile remote-sensing environments.

Power Supply Protection

The A1425 contains an on-chip voltage regulator and can operate over a wide supply voltage range. In applications that operate the device from an unregulated power supply, transient protection must be added externally. For applications using a regulated line, EMI/RFI protection may still be required. The circuit shown in figure 2 is the most basic configuration required for proper device operation.

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.

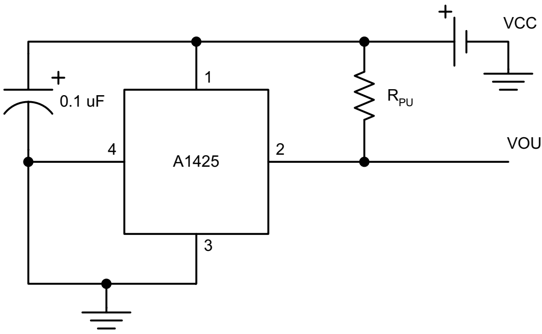


Figure 2. Basic application circuit. A pull-up resistor is required with the output driver.

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} = 4.2 mA, and $R_{\theta JA}$ = 177 °C/W, then:

$$P_D = V_{CC} \times I_{CC} = 12\text{ V} \times 4.2\text{ mA} = 50\text{ mW}$$

$$\Delta T = P_D \times R_{\theta JA} = 50\text{ mW} \times 177\ °\text{C/W} = 9°\text{C}$$

$$T_J = T_A + \Delta T = 25°\text{C} + 9°\text{C} = 34°\text{C}$$

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 L-I1, using minimum-K PCB

Observe the worst-case ratings for the device, specifically: $R_{\theta JA}$=177°C/W, $T_{J(max)}$ =165°C, $V_{CC(max)}$=26.5 V, and $I_{CC(max)}$ = 7.0 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:

$$P_{D(max)} = \Delta T_{max} \div R_{\theta JA} = 15°\text{C} \div 177\ °\text{C/W} = 91\text{ mW}$$

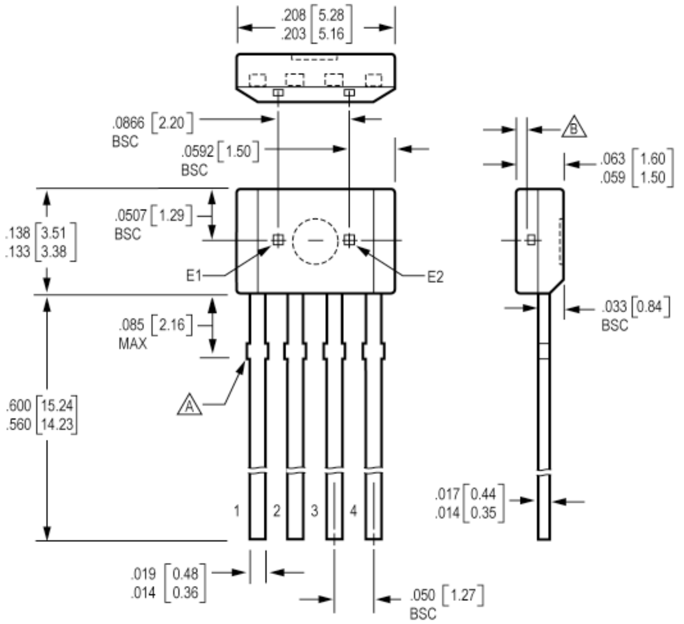
Finally, invert equation 1 with respect to voltage:

$$V_{CC(est)} = P_{D(max)} \div I_{CC(max)} = 91\text{ mW} \div 7.0\text{ mA} = 13\text{ V}$$

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.

Package K, 4-pin SIP



Dimensions in inches (in.)
Millimeters (mm) in brackets, for reference only

△A Dambar removal protrusion

△B Active Area Depth .0165 [0.42] BSC

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.