

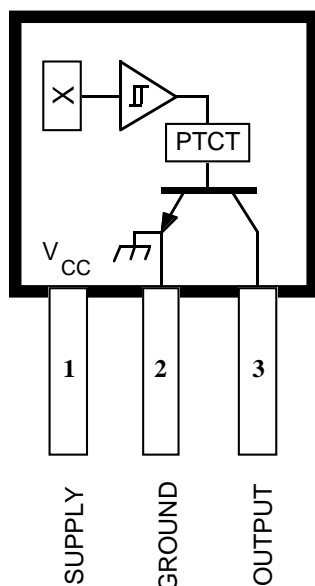
3250 AND 3251

Data Sheet
27621.41

PRELIMINARY INFORMATION
(subject to change without notice)

October 15, 2002

PROGRAMMABLE, CHOPPER- STABILIZED, HALL-EFFECT SWITCHES



Dwg. PH-003-2

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{CC}	26.5 V*
Reverse Supply Voltage, V_{RCC}	-18 V
Overvoltage Supply Current, I_{CC}	100 mA
Output Off Voltage, V_{OUT}	26.5 V
Continuous Output Current, I_{OUT}	20 mA†
Magnetic Flux Density, B	Unlimited
Package Power Dissipation, P_D ...	See Graph
Operating Temperature Range, T_A	
Suffix 'E-'	-40°C to +85°C
Suffix 'L-'	-40°C to +150°C
Junction Temperature, T_J	+165°C
Storage Temperature Range,	
T_S	-65°C to +170°C

* Fault conditions that produce supply voltage transients will be clamped by an internal Zener diode. These conditions can be tolerated but should be avoided.

† Internal current limiting is intended to protect the device from output transient short circuits.

The A3250 and A3251 are programmable Hall-effect switches for high-temperature applications. Each sensor consists of a single element, chopper-stabilized Hall-effect IC that can be programmed to the desired magnetic operate switch point (drastically reducing the effects of variations found in a production environment), while the hysteresis remains fixed. The small packages can be easily assembled and used in conjunction with a wide variety of target shapes and sizes. The A3250 output turns on in the presence of the programmed south-pole magnetic field while the A3251 turns off with the programmed south-pole magnetic field.

The first character of the part number suffix indicates the device operating temperature range. Suffix 'E-' is for the automotive and industrial temperature range of -40°C to +85°C. Suffix 'L-' is for the automotive and military temperature range of -40°C to +150°C. The second and third characters indicate the package. Suffix '-LT' is a miniature SOT89/TO-243AA transistor package for surface-mount applications; suffix '-UA' is a three-lead ultra-mini-SIP for through-hole mounting.

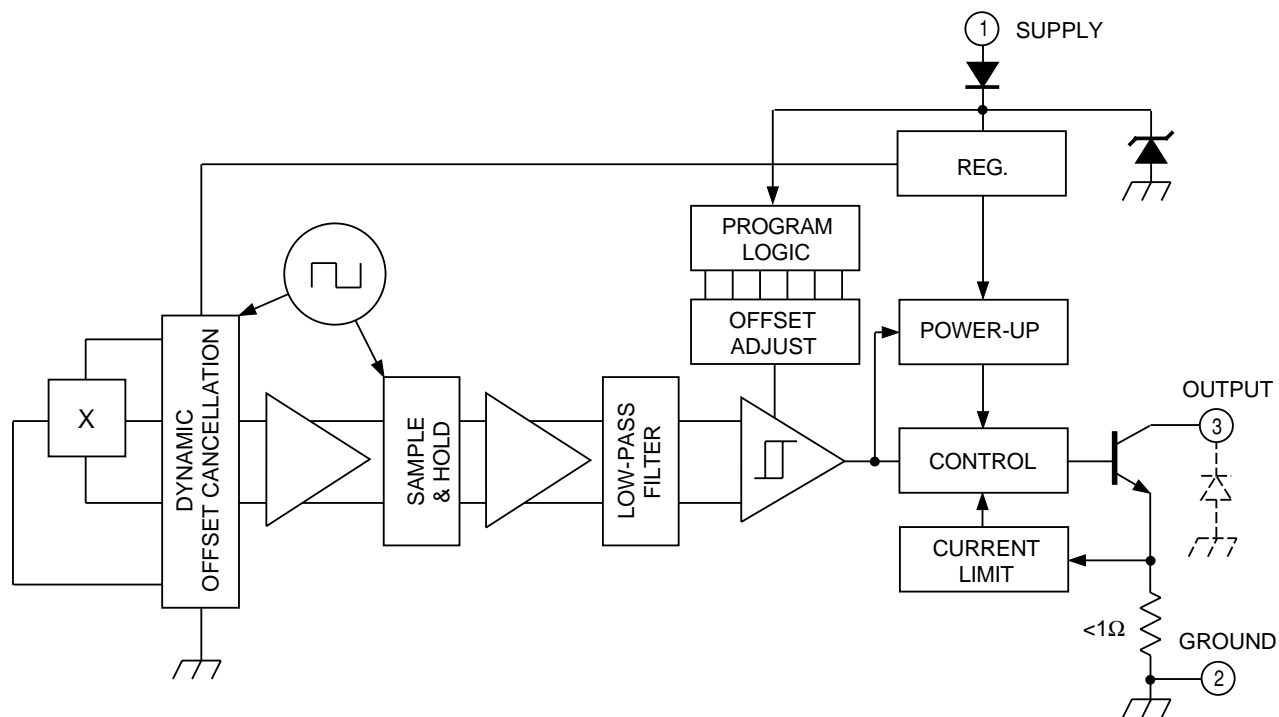
FEATURES AND BENEFITS

- Chopper Stabilized for Extremely Low Switch-Point Drift and Immunity to Mechanical Stress
- Externally Programmed Switch Point
- On-Chip Supply-Transient Protection
- Output Short-Circuit Protection
- Reverse Battery Protection
- Wide Operating Voltage Range
- Defined Power-On State

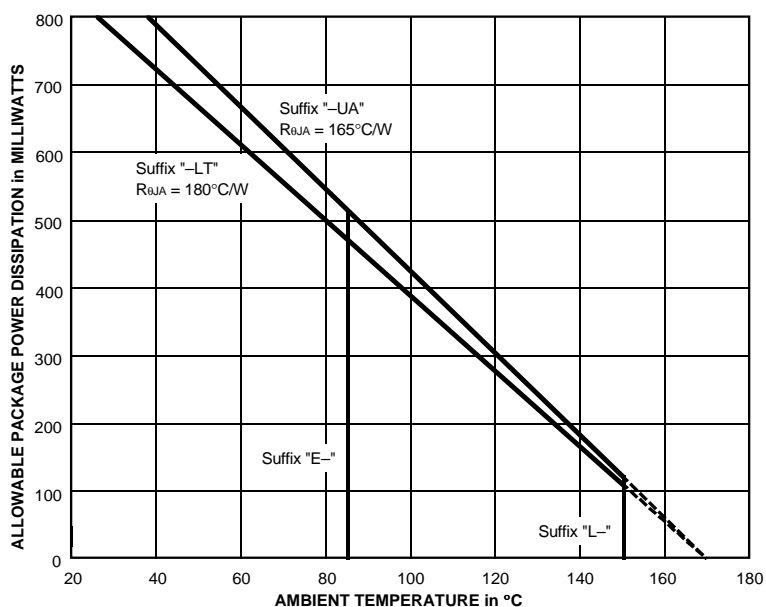
Always order by complete part number: the prefix 'A' + the basic four-digit part number + a suffix to indicate operating temperature range + a suffix to indicate package style, e.g., **A3250LUA**.

3250 AND 3251 PROGRAMMABLE, CHOPPER-STABILIZED, HALL-EFFECT SWITCHES

FUNCTIONAL BLOCK DIAGRAM



Dwg. FH-020-3



Dwg. GH-046-7

3250 AND 3251 PROGRAMMABLE, CHOPPER-STABILIZED, HALL-EFFECT SWITCHES

ELECTRICAL CHARACTERISTICS over operating voltage and junction temperature range (unless otherwise noted).

Characteristic	Symbol	Test Conditions	Limits			
			Min.	Typ.	Max.	Units
Supply Voltage	V_{CC}	Operating	4.2	–	24	V
Power-On State	POS	After programming, $V_{CC} = 0 \rightarrow 5\text{ V}$, $t > t_{on}$: A3250, $B < B_{OP}$ A3251, $B < B_{OP}$	HIGH LOW	HIGH LOW	HIGH LOW	– –
Low Output Voltage	$V_{OUT(SAT)}$	Output on, $I_{OUT} = 20\text{ mA}$	–	175	400	mV
Output Current Limit	I_{OUTM}	Pulse test, output on (note 1)	35	70	100	mA
Output Leakage Current	I_{OFF}	Output off, $V_{OUT} = 24\text{ V}$	–	–	10	μA
Supply Current	I_{CC}	Output off (High)	–	4.0	7.0	mA
		Output on (Low)	–	6.0	10	mA
Reverse Supply Current	I_{RCC}	$V_{RCC} = -18\text{ V}$	–	–	-5.0	mA
Power-On Delay	t_{on}	Output off	–	20	50	μs
Output Rise Time	t_r	$R_L = 820\ \Omega$, $C_L = 10\text{ pF}$	–	1.55	4.0	μs
Output Fall Time	t_f	$R_L = 820\ \Omega$, $C_L = 10\text{ pF}$	–	1.95	4.0	μs
Clock Frequency	f_C		–	340	–	kHz
Zener Voltage	V_Z	$I_{ZT} = 100\ \mu\text{A}$	27	32	37	V
Zener Resistance	R_Z	$I_{ZT} = 10\text{ mA}$	–	50	–	Ω

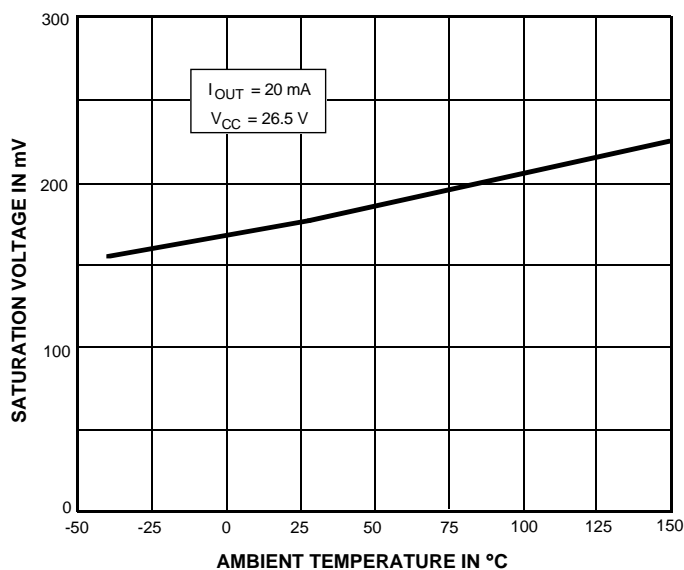
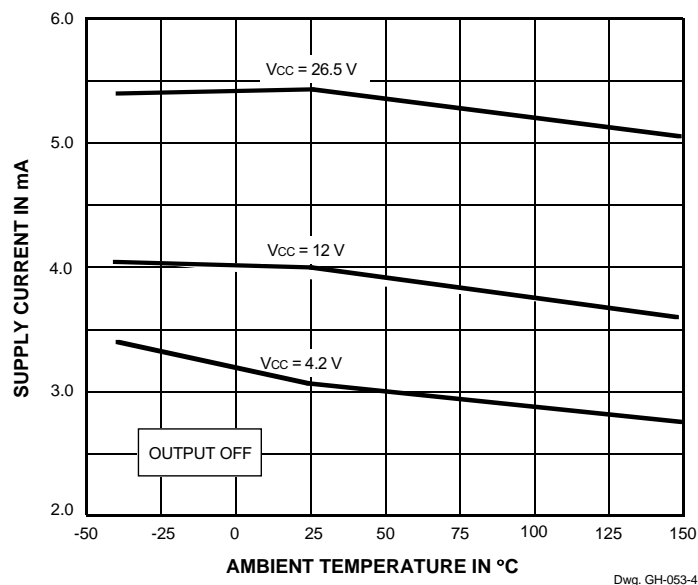
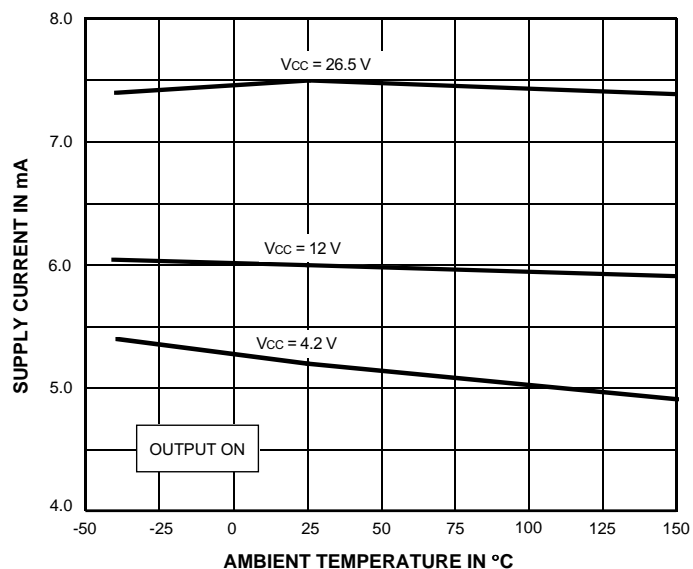
MAGNETIC CHARACTERISTICS over operating supply voltage and junction temperature range (unless otherwise noted).

Characteristic	Symbol	Test Conditions	Limits			
			Min.	Typ.	Max.	Units
Operate Point (A3250 output turns on) (A3251 output turns off)	B_{OP}	Initial (before programming)	–	5.0	50	G
		Resolution	–	7.0	–	G
		Maximum programmable	350	–	–	G
	ΔB_{OP}	Reference B_{OP} at $+25^\circ\text{C}$, $B_{OP} \leq 350\text{ G}$	–	± 5.0	± 35	G
Hysteresis	B_{hys}	$B_{OP} - B_{RP}$	5.0	18	35	G

- NOTES: 1. Do not exceed absolute maximum allowable junction temperature.
2. Typical data is at $V_{CC} = 12\text{ V}$ and $T_A = +25^\circ\text{C}$ and is for design information only.
3. 1 gauss (G) is exactly equal to 0.1 millitesla (mT).

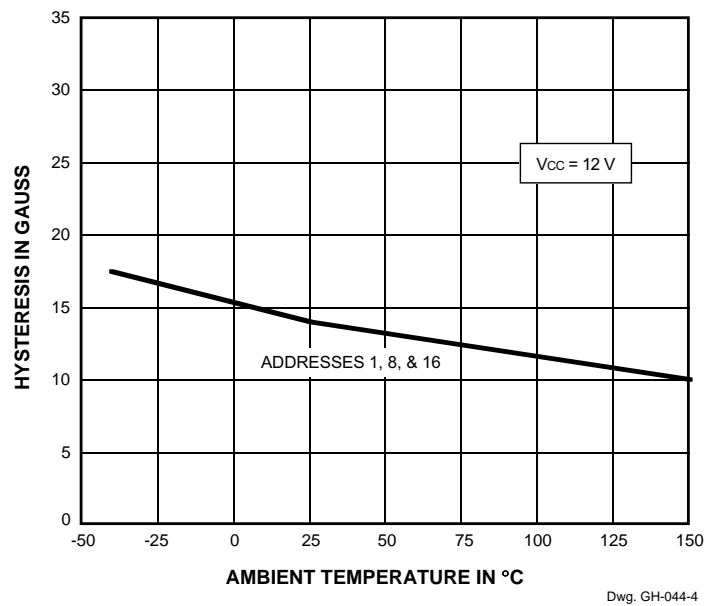
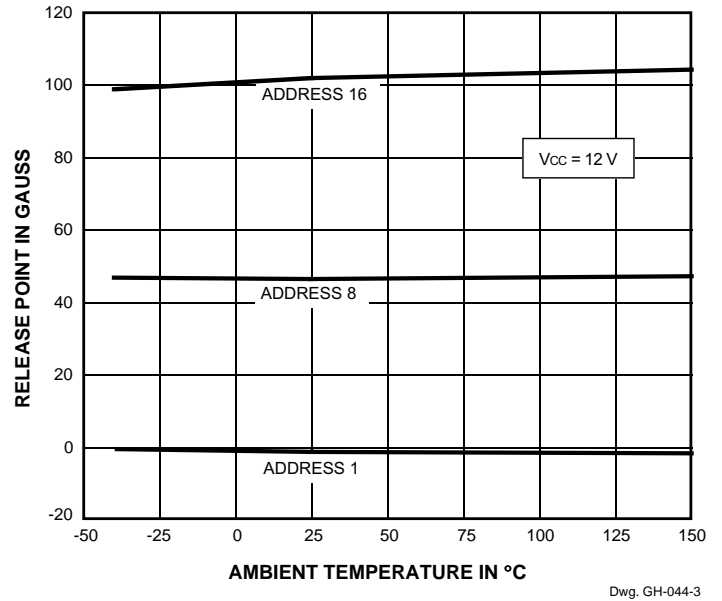
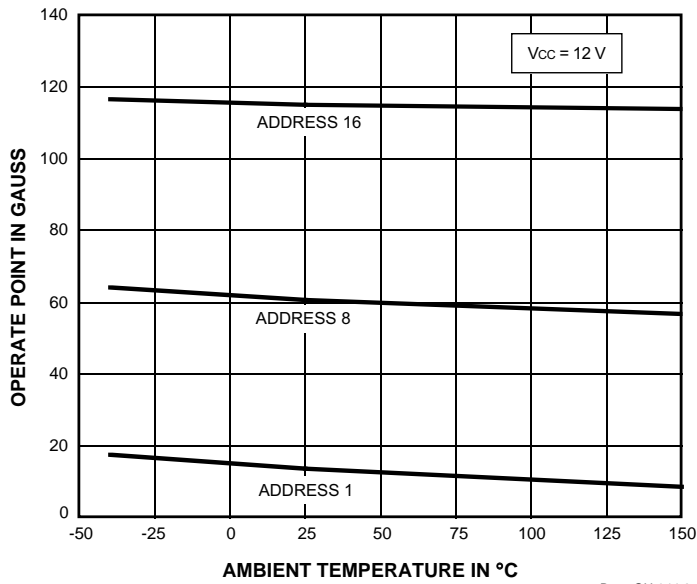
3250 AND 3251 PROGRAMMABLE, CHOPPER-STABILIZED, HALL-EFFECT SWITCHES

TYPICAL ELECTRICAL CHARACTERISTICS



3250 AND 3251 PROGRAMMABLE, CHOPPER-STABILIZED, HALL-EFFECT SWITCHES

TYPICAL MAGNETIC CHARACTERISTICS



3250 AND 3251 PROGRAMMABLE, CHOPPER-STABILIZED, HALL-EFFECT SWITCHES

FUNCTIONAL DESCRIPTION

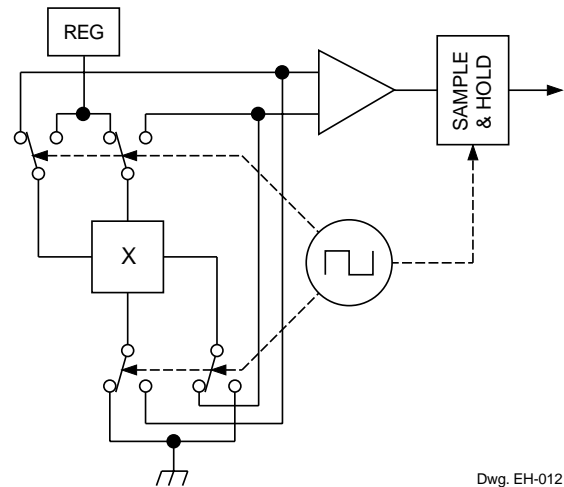
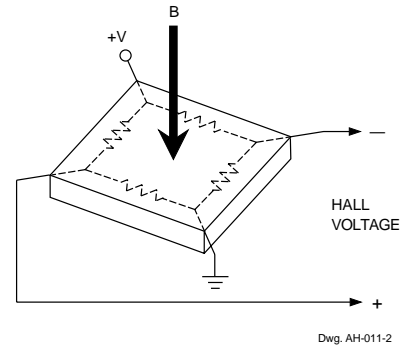
The basic Hall sensor is a small sheet of semiconductor material in which a constant current will flow when a regulated voltage is applied. The output will take the form of a voltage measured across the width of the sheet and will have negligible value in the absence of a magnetic field. When a magnetic field with flux lines at right angles to the current flow is applied, a small voltage directly proportional to the strength of the magnetic field and the current will occur at the output terminals.

The small signal voltage is proportionally small relative to the offset produced by the semiconductor chip. This makes it very difficult to process the signal and maintain an accurate, reliable output over the operating temperature range.

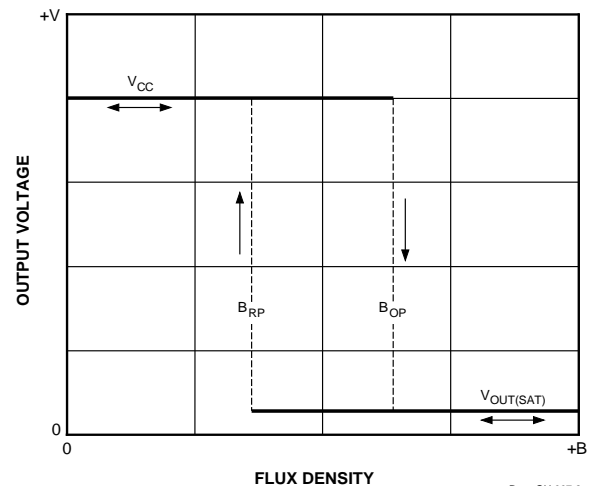
Chopper-Stabilized Technique. These devices use a proprietary dynamic offset cancellation technique, with an internal high-frequency clock to reduce the residual offset voltage of the Hall element that is normally caused by device overmolding, temperature dependencies, and thermal stress. This technique produces devices that have an extremely stable quiescent Hall output voltage, are immune to thermal stress, and have precise recoverability after temperature cycling. This technique will also slightly degrade the device output repeatability.

The Hall element can be considered as a resistor array similar to a Wheatstone bridge. A large portion of the offset is a result of the mismatching of these resistors. The chopper-stabilizing technique cancels the mismatching of the resistors by changing the direction of the current flowing through the Hall plate and Hall voltage measurement taps, while maintaining the Hall-voltage signal that is induced by the external magnetic flux. The signal is, then, captured by a sample-and-hold circuit.

Operation. The output of the A3250 switches low (turns on) when a magnetic field (south pole) perpendicular to the Hall sensor exceeds the operate point threshold (B_{OP}). After turn-on, the output is capable of sinking 20 mA and the output voltage is $V_{OUT(SAT)}$. The A3250 operate point is programmable (see next section). When the magnetic field is reduced below the release point (B_{RP}), the device output goes high (turns off).



A3250 Output characteristic



3250 AND 3251 PROGRAMMABLE, CHOPPER-STABILIZED, HALL-EFFECT SWITCHES

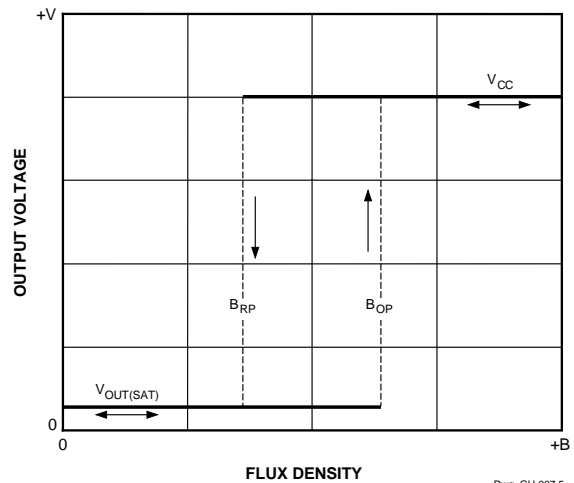
FUNCTIONAL DESCRIPTION (cont'd)

The output of the A3251 switches high (turns off) when a magnetic field (south pole) perpendicular to the Hall sensor exceeds the operate point threshold (B_{OP}). The A3251 operate point is programmable (see next section). When the magnetic field is reduced below the release point (B_{RP}), the device output goes low (turns on). After turn-on, the output is capable of sinking 20 mA and the output voltage is $V_{OUT(SAT)}$.

The difference in the magnetic operate and release points is the hysteresis (B_{hys}) of the device. The hysteresis of both devices is identical and independent of the programmed operate point. This built-in hysteresis allows clean switching of the output even in the presence of external mechanical vibration and electrical noise.

Output Overloads. Current through the output transistor is sensed with a low-value on-chip aluminum resistor. The voltage drop across this resistor is fed back to control the base drive of the output stage. This feedback prevents the output transistor from exceeding its maximum current density rating by limiting the output current. Under short-circuit conditions, the device will dissipate an increased amount of power ($P_D = V_{OUT} \times I_{OUTM}$) and the output transistor will be thermally stressed.

A3251 Output characteristic



3250 AND 3251 PROGRAMMABLE, CHOPPER-STABILIZED, HALL-EFFECT SWITCHES

PROGRAMMING PROTOCOL

The A3250 and A3251 operate points are programmed by serially addressing the device through the supply terminal (1). After the correct operate point is determined (see application note *Programming A Back-Biased Switch For Proximity Sensing*), the device programming bits are selected and blown, then a “lock” bit is selected and blown to prevent any further (accidental) programming.

Programming voltages (V_{PL} , V_{PH} , and V_{PP}) are applied to terminal 1 of the device. A minimum capacitance of 0.1 μF must be connected between terminal 1 and ground to provide the necessary peak current to blow the internal fuse.

Program Enable. To program the device, a sequence of pulses (as shown in figure 1) is used to activate/enable the programming mode. This sequence of a V_{PP} pulse, at least seven V_{PH} pulses, and a V_{PP} pulse with no supply interruptions, is designed to prevent the device from being programmed accidentally (for example, as a result of noise on the supply line).

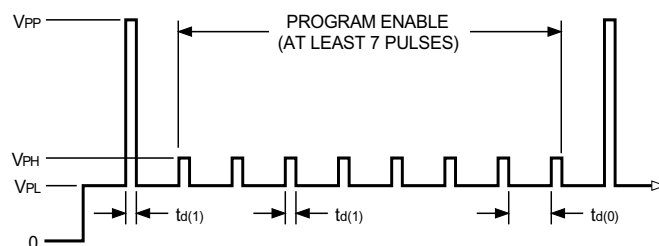


Figure 1 — Program enable

Dwg. WH-013

PROGRAMMING PROTOCOL over operating temperature range.

Characteristic	Symbol	Description	Limits			
			Min.	Typ.	Max.	Units
Programming Voltage	V_{PL}	Low voltage during programming	4.5	5.0	5.5	V
	V_{PH}	High voltage during programming	8.5	—	15	V
	V_{PP}	Programming enable & bit-blow voltage	25	—	27	V
Programming Current	I_{PP}	Max. supply current during programming	—	500	—	mA
Pulse Width	$t_{d(0)}$	Off time between bits	20	—	—	μs
	$t_{d(1)}$	Enable, address, program, or lock bit on time	20	—	—	μs
	t_{dP}	Program pulse on time	100	300	—	μs
Pulse Rise Time	t_r	V_{PL} to V_{PH} or V_{PP}	—	—	11	μs
Pulse Fall Time	t_f	V_{PH} or V_{PP} to V_{PL}	—	—	5.0	μs

NOTE: Typical data is at $T_A = +25^\circ\text{C}$ and is for design information only.

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PROGRAMMING PROTOCOL (cont'd)

Addressing. The magnetic operate point is adjustable in 63 increments (64 addresses including the unprogrammed address 0). With the appropriate target* in position, up to 63 switch points are sequentially selected (figure 2) until the required operate point is reached. Note that the difference between the operate point and the release point (hysteresis) is a constant for all addresses.

Code Programming. After the desired switch-point address is determined (0 through 63), each bit of the equivalent 6-bit binary code is programmed individually (not at the same time). For example, as illustrated in figure 3, to program switch-point address 5 (binary code 000101), bits 3 and 1 need to be programmed. Each bit is programmed (blown) during the wide V_{PP} pulse and is not reversible.

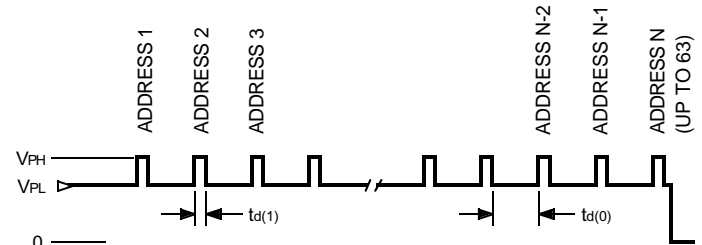


Figure 2 — Code determination

Dwg. WH-014A

Lock-Bit Programming. After the desired binary code is programmed, the lock bit (address 65) is then programmed (blown) (figure 4) to prevent further programming of the device.

Each device should then be tested by turning it off and then on again to ensure that proper programming has been accomplished (verifying proper switch points).

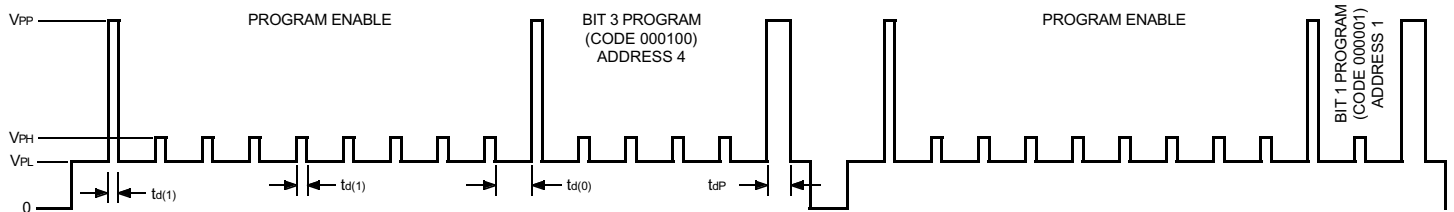


Figure 3 — Switch-point programming example

Dwg. WH-015A

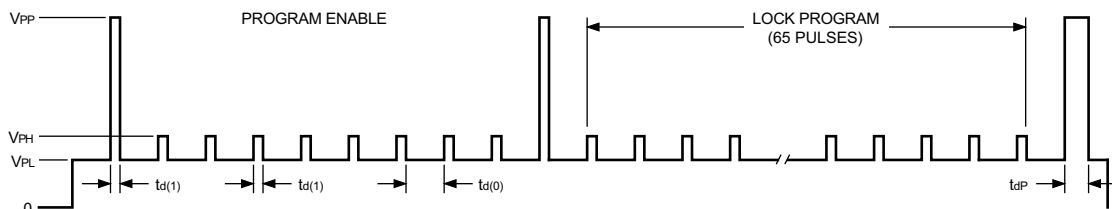


Figure 4 — Lock programming

Dwg. WH-016

* In application, the terms “gear” and “target” are often interchanged. However, “gear” is preferred when motion is transferred.

3250 AND 3251 PROGRAMMABLE, CHOPPER-STABILIZED, HALL-EFFECT SWITCHES

APPLICATIONS INFORMATION

External Components. It is strongly recommended that an external bypass capacitor be connected (less than 5 mm from the Hall sensor) between the supply and ground of the device to reduce both external noise and noise generated by the chopper-stabilization technique.

A series resistor (R_S) in combination with the bypass capacitor prevents external EMC pulses from affecting the sensor. The voltage drop across this resistor subtracts from the supply voltage and must be considered.

$$V_{\text{SUPPLY}} \geq V_{\text{CC(min)}} + (I_{\text{CC}} \times R_S)$$

where V_{SUPPLY} is the minimum supply value (including transients), $V_{\text{CC(min)}}$ is the specified minimum supply voltage, I_{CC} is the specified maximum supply current and R_S is the maximum series-resistor value (including tolerances). A low operating supply voltage requires a low-value resistor, but noise and other considerations suggest a high-value resistor. Therefore, specify the highest value resistor that will still allow meeting the minimum operating supply voltage requirement. This will also help to minimize package power dissipation (especially under over-voltage conditions).

If not included as part of the load, the output pullup resistor should be chosen to limit the current through the output transistor. Do not exceed the absolute maximum rated output current. Internal current limiting is only intended to protect the device from output short circuits.

Power Derating. Due to the internal device power dissipation, the junction temperature (T_J) will be higher than the ambient temperature (T_A). To ensure that the absolute maximum junction temperature is not exceeded, the following equations should be applied:

$$T_J = T_A + (P_D \times R_{\theta JA})$$

where P_D is the sum of the supply power

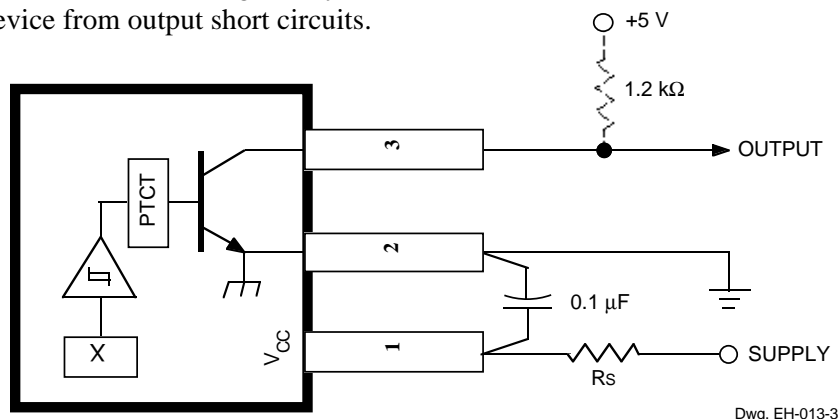
$$I_{\text{CC}} \times V_{\text{CC}}$$

and the output power

$$I_{\text{OUT}} \times V_{\text{OUT(SAT)}}$$

and $R_{\theta JA}$ is the package thermal resistance. The specified limits for I_{CC} and $V_{\text{OUT(SAT)}}$ should be used to ensure a margin of safety. Note that if an over-voltage condition occurs, I_{CC} will increase, limited only by the Zener voltage and the external R_S , and the device will likely be thermally stressed.

Magnets. The simplest form of magnet that will operate these devices is a button magnet. Other methods of operation, such as linear magnets, are possible.



Dwg. EH-013-3

Typical application

3250 AND 3251 PROGRAMMABLE, CHOPPER-STABILIZED, HALL-EFFECT SWITCHES

CRITERIA FOR DEVICE QUALIFICATION

All Allegro sensors are subjected to stringent qualification requirements prior to being released to production. To become qualified, except for the destructive ESD tests, no failures are permitted.

Qualification Test	Test Method and Test Conditions	Test Length	Samples	Comments
Biased Humidity (HAST)	JESD22-A101, $T_A = 85^{\circ}\text{C}$, RH = 85%	1000 hrs	77	$V_{CC} = V_{OUT} = 4.2\text{ V}$
High-Temperature Operating Life (HTOL)	JESD22-A108, $T_A = 150^{\circ}\text{C}$, $T_J = 165^{\circ}\text{C}$	1000 hrs	77	
Accelerated HTOL	JESD22-A108, $T_A = 170^{\circ}\text{C}$, $T_J = 180^{\circ}\text{C}$	168 hrs	77	
Autoclave, Unbiased	JESD22-A102, Condition C, $T_A = 121^{\circ}\text{C}$, 15 psig	96 hrs	77	
High-Temperature (Bake) Storage Life	MIL-STD-883, Method 1008, $T_A = 170^{\circ}\text{C}$	1000 hrs	77	
Temperature Cycle	MIL-STD-883, Method 1010, -55°C to $+150^{\circ}\text{C}$	1000 cycles	77	
ESD, Human Body Model	CDF-AEC-Q100-002	Pre/Post Reading	3 per test	Test to failure, All leads > 1 kV
ESD, Machine Model	JESD22-A115	Pre/Post Reading	3 per test	Test to failure, All leads > 200 V
Electrical Distributions	Per Specification	—	30	

APPLICATIONS INFORMATION (cont'd)

Extensive applications information for Hall-effect sensors is available in:

- *Hall-Effect IC Applications Guide*, Application Note 27701;
- *Hall-Effect Devices: Soldering, Gluing, Potting, Encapsulating, and Lead Forming*, Application Note 27703.1;
- *Soldering of Through-Hole Hall-Sensor Devices*, Application Note 27703; and
- *Soldering of Surface-Mount Hall-Sensor Devices*, Application Note 27703.2.

More detailed descriptions of the chopper-stabilized circuit operation can be found in:

- *Monolithic Magnetic Hall Sensor Using Dynamic Quadrature Offset Cancellation*, Technical Paper STP 97-10; and
- *Chopper-Stabilized Amplifiers With A Track-and-Hold Signal Demodulator*, Technical Paper STP 99-1.

All are provided in *Allegro Electronic Data Book*, AMS-702 or at

www.allegromicro.com

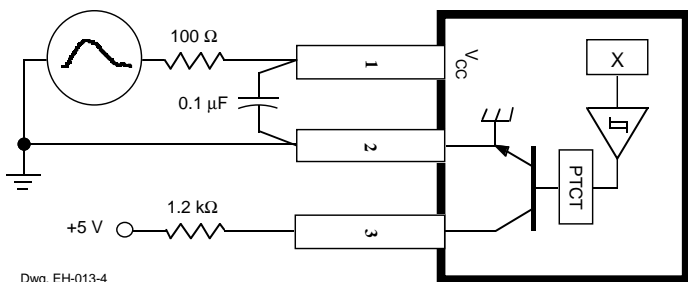
3250 AND 3251 PROGRAMMABLE, CHOPPER-STABILIZED, HALL-EFFECT SWITCHES

Transient Performance per ISO 7637-1

at $T_A = 23 \pm 5^\circ\text{C}$

(Tested at Allegro test facility — for engineering reference only)

Pulse No.	Test	Performance Class at Test Level			
		I	II	III	IV
1	Inductive turn off (negative)	—	—	—	C
2	Inductive turn off (positive)	—	—	—	C
3a	Capacitive/inductive coupling (neg)	—	—	—	A
3b	Capacitive/inductive coupling (pos)	—	—	—	A
4	Reverse battery	—	—	—	A
5	Load dump:	A	C	C	E
6	Ignition coil disconnect	—	—	C	E
7	Field decay (negative)	—	—	—	C



Transient & EMC test circuit

Power supply voltage transients, or device output short circuits, may be caused by faulty connectors, crimped wiring harnesses, or service errors. To prevent catastrophic failure, internal protection against overvoltage, reverse voltage, and output overloads have been incorporated to meet the automotive 12 volt system protection requirements of ISO DP7637/1. A series-blocking diode or current-limiting resistor is required in order to survive pulse number six.

Performance Class Definitions

(for transient performance and EMC performance)

A — All functions of a device perform as designed during and after the exposure.

B — All functions of a device perform as designed during exposure; however, one or more of them may go beyond the specified limit tolerance. All functions return automatically to within normal limits after exposure is removed. Memory must remain Class A.

C — One or more functions of the device do not perform as designed during exposure but return automatically to normal operation after exposure is removed.

D — One or more functions of the device do not perform as designed during exposure and do not return to normal operation until exposure is removed and the device is reset by simple “operator” action.

E — One or more functions of the device do not perform as designed during and after the exposure and cannot be returned to proper operation without repairing or replacing the device.

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PROGRAMMABLE,
CHOPPER-STABILIZED,
HALL-EFFECT SWITCHES

ELECTROMAGNETIC COMPATIBILITY (EMC) PERFORMANCE

at $T_A = 23 \pm 5^\circ\text{C}$

(Tested at Allegro test facility — for engineering reference only)

Transverse Electro-Magnetic (TEM) Radiation Performance per ISO 11452-3

Test severity level	Frequency band (MHz)	Performance Class at Test Level			
		I	II	III	IV
I = 50 V/m	F1 (0.01 to 10)	—	—	—	A
II = 100 V/m	F2 (0 to 30)	—	—	—	A
III = 150 V/m	F3 (30 to 80)	—	—	—	A
IV = 200 V/m	F4 (80 to 200)	—	A	C	C

Bulk Current Injection (BCI) per ISO 11452-4

Test severity level	Frequency band (MHz)	Performance Class at Test Level			
		I	II	III	IV
I = 25 mA	F1 (1 to 10)	—	—	—	A
II = 50 mA	F2 (10 to 30)	—	—	—	A
III = 75 mA	F3 (30 to 80)	—	—	—	A
IV = 100 mA	F4 (80 to 200)	—	—	—	A
	F5 (200 to 400)	—	—	—	A

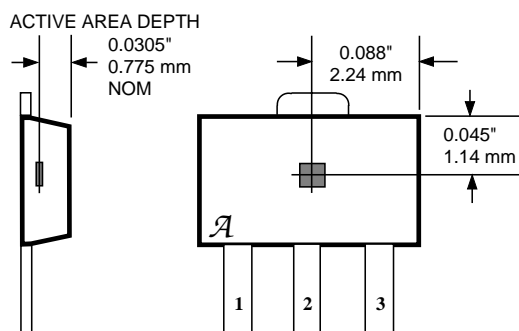
Direct RF per ISO 11452-7

Test severity level	Frequency band (MHz)	Performance Class at Test Level				
		I	II	III	IV	V
I = 100 mW	F1 (0.25 to 10)	—	—	—	—	—
II = 200 mW	F2 (10 to 30)	—	—	—	—	—
III = 300 mW	F3 (30 to 80)	—	—	—	—	—
IV = 400 mW	F4 (80 to 200)	—	—	—	—	—
V = 500 mW	F5 (200 to 400)	—	—	—	—	—

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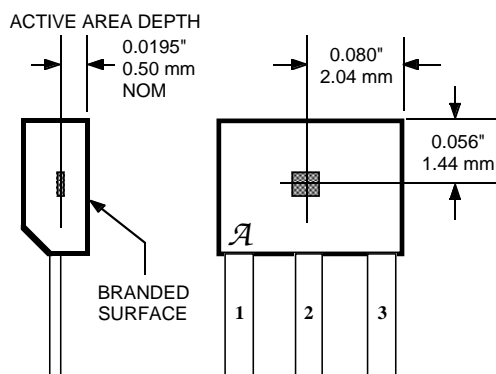
Sensor locations
(± 0.005 " [0.13 mm] die placement)

Package designator 'LT'



Dwg. MH-008-8A

Package designator 'UA'



Dwg. MH-011-9B

Although sensor location is accurate to three sigma for a particular design, product improvements may result in small changes to sensor location.

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.

Allegro MicroSystems, Inc. reserves the right to make, from time to time, such departures from the detail specifications as may be required to permit improvements in the performance, reliability, or manufacturability of its products. Before placing an order, the user is cautioned to verify that the information being relied upon is current.

Allegro products are not authorized for use as critical components in life-support appliances, devices, or systems without express written approval.

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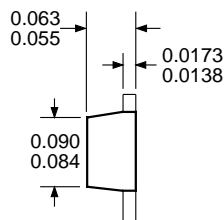
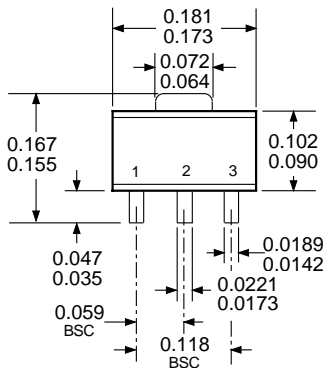
3250 AND 3251 PROGRAMMABLE, CHOPPER-STABILIZED, HALL-EFFECT SWITCHES

MECHANICAL DIMENSIONS

Package designator 'LT'

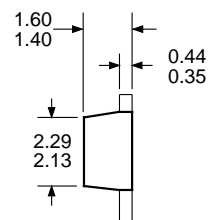
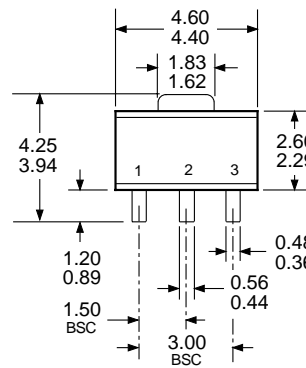
(SOT89/TO-243AA)

Dimensions in Inches
(for reference only)

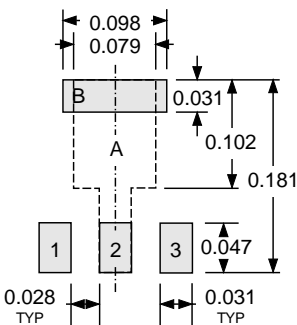


Dwg. MA-009-3A in

Dimensions in Millimeters
(controlling dimensions)

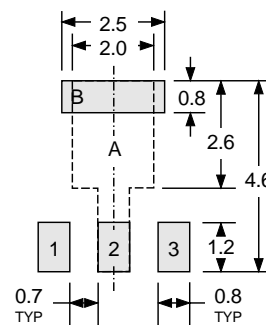


Dwg. MA-009-3A mm



Pads 1, 2, 3, and A — Standard SOT89 Layout
Pads 1, 2, 3, and B — Low-Stress Version
Pads 1, 2, and 3 only — Lowest Stress, But Not Self Aligning

Dwg. MA-012-3 in



Pads 1, 2, 3, and A — Standard SOT89 Layout
Pads 1, 2, 3, and B — Low-Stress Version
Pads 1, 2, and 3 only — Lowest Stress, But Not Self Aligning

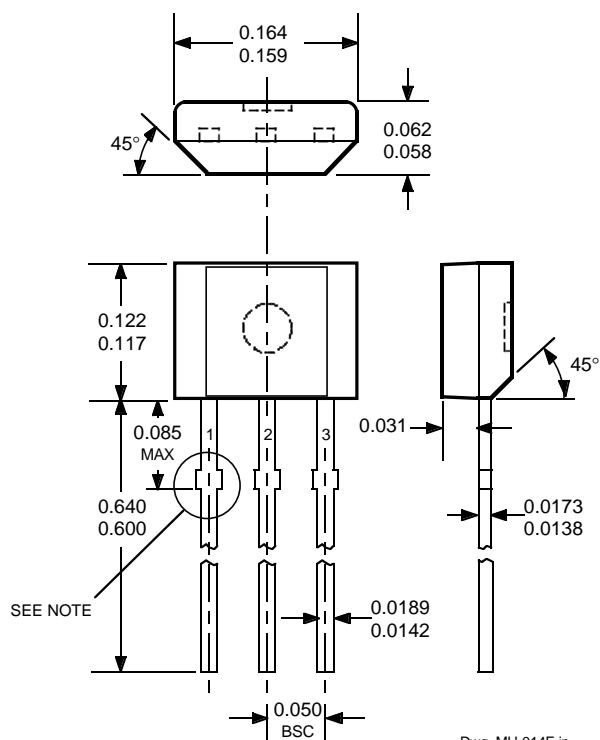
Dwg. MA-012-3 mm

- NOTES:
- Exact body and lead configuration at vendor's option within limits shown.
 - Supplied in bulk pack (500 pieces per bag) or add "TR" to part number for tape and reel.
 - Only low-temperature ($\leq 240^{\circ}\text{C}$) reflow-soldering techniques are recommended for SOT89 devices.

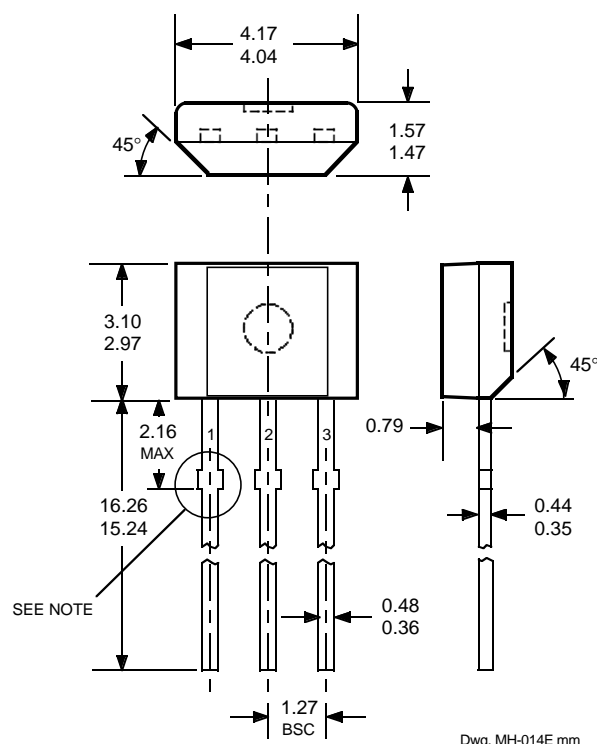
3250 AND 3251 PROGRAMMABLE, CHOPPER-STABILIZED, HALL-EFFECT SWITCHES

Package designator 'UA'

Dimensions in Inches
(controlling dimensions)

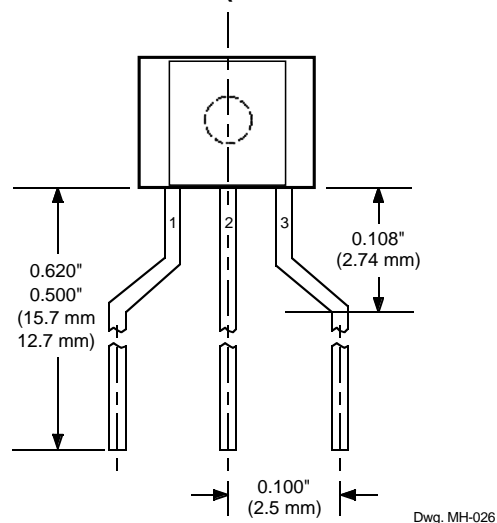


Dimensions in Millimeters
(for reference only)



- NOTES:
1. Tolerances on package height and width represent allowable mold offsets. Dimensions given are measured at the widest point (parting line).
 2. Exact body and lead configuration at vendor's option within limits shown.
 3. Height does not include mold gate flash.
 4. Recommended minimum PWB hole diameter to clear transition area is 0.035" (0.89 mm).
 5. Where no tolerance is specified, dimension is nominal.
 6. Supplied in bulk pack (500 pieces per bag).

Radial Lead Form (order A325xxUA-LC)



NOTE: Lead-form dimensions are the nominals produced on the forming equipment. No dimensional tolerance is implied or guaranteed for bulk packaging (500 pieces per bag).