

## Description

The AH3975Q/AH3976Q/AH3977Q/AH3978Q is an AEC-Q100 qualified high voltage dual Hall-effect sensor designed for the applications that require accurate speed and direction sensing. To support the wide range of the demanding applications, the design has been optimized to operate over the supply range of 2.7V to 27V. With chopper stabilized architecture and an internal bandgap regulator to provide temperature compensated supply for internal circuits, the AH3975Q/AH3976Q/AH3977Q provides speed and direction outputs, while AH3978Q provides two independent outputs at Q1 and Q2.

For robustness and protection, the device has a reverse blocking diode with a Zener clamp on the supply. The built-in thermal protection also shuts down the chip if temperature rises to an abnormal value, and it will automatically restart the chip once the junction temperature drops below the safe value. The device is integrated with self-diagnostics which monitor internal blocks, and it will enter safe mode when error is detected.

In the occasion of a supply voltage drop to minimum threshold point, undervoltage lockout protection would be triggered to freeze the device, which prevents the electrical malfunction from affecting the next magnetic measurement circuits, and the output current state updated is always based on the proper accurate measurement result.

## Features and Performance

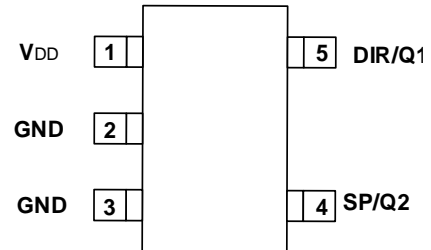
- Dual Latch Hall Operation with Dual Outputs (AH3978Q) or Speed & Direction Output (AH3975Q/AH3976Q/AH3977Q)
- Wide Supply Voltage Operation: 2.7V to 27V
- Chopper Stabilized Design Provides
  - Superior Temperature Stability
  - Minimal Switch Point Drift
  - Enhanced Immunity to Stress
- Battery Polarity Reverse Connection Protection
- Transient Spike Voltage Protection
- Overtemperature Shutdown and Auto-Restart
- UVLO Protection
- High ESD Rating: HBM = 5kV, CDM = 2kV
- AEC-Q100 Grade 0 Qualified
- Ready for ISO 26262
- Built-in Self-Diagnostics for Functional Safety Requirements
- Temperature Range: -40°C to +150°C
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **The AH3975Q/AH3976Q/AH3977Q/AH3978Q is suitable for automotive applications requiring specific change control; this part is AEC-Q100 qualified, PPAP capable, and manufactured in IATF16949 certified facilities.**

<https://www.diodes.com/quality/product-definitions/>

- Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
  2. See <https://www.diodes.com/quality/lead-free/> for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
  3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

## Pin Assignments

(Top View)

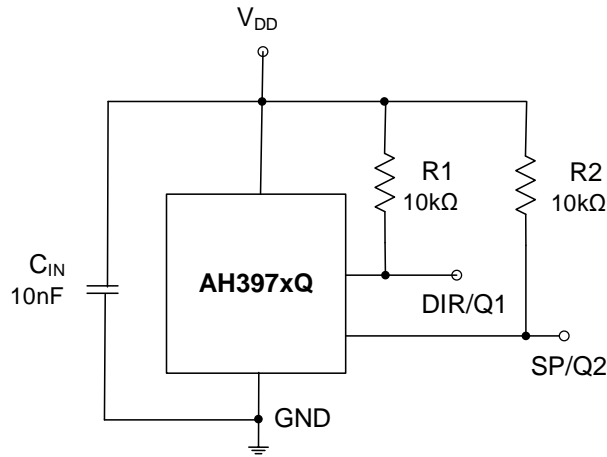


TSOT25 (Type A1)

## Applications

- Power closures with anti-pinch features
- Rotation speed & direction detection
- Linear speed & direction detection
- Angular position detection
- Knob controls

**Typical Applications Circuit**

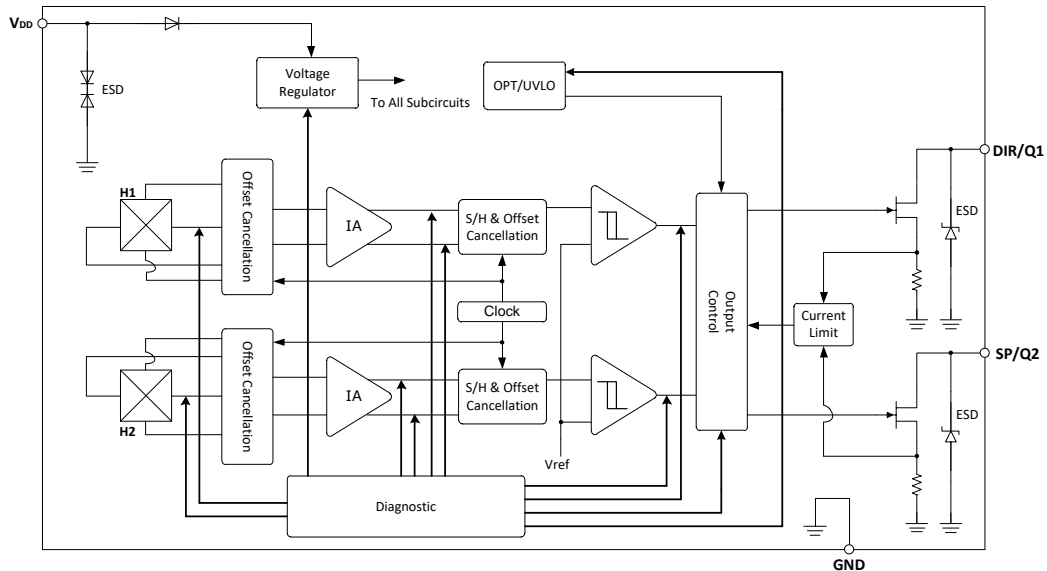


**Pin Descriptions**

Package: TSOT25 (Type A1)

Pin Number	Pin Name	Function	
4	AH3975Q/AH3976Q/AH3977Q	SP	Speed, open-drain output
	AH3978Q	Q2	Speed 2, open-drain output
5	AH3975Q/AH3976Q/AH3977Q	DIR	Direction, open-drain output
	AH3978Q	Q1	Speed 1, open-drain output
1	VDD	Supply voltage input	
2	GND	Ground	
3	GND	Ground	

**Functional Block Diagram**



### Absolute Maximum Ratings (Note 4) (@T<sub>A</sub> = +25°C, unless otherwise specified.)

Symbol	Parameter	Rating	Unit
V <sub>DD</sub> (Note 5)	Supply voltage	40	V
V <sub>DDR</sub> (Note 5)	Reverse supply voltage	-18	V
I <sub>DD</sub>	Supply current	50	mA
I <sub>DDR</sub>	Reverse supply current	-50	mA
I <sub>OUT</sub>	Output current	50	mA
I <sub>OUTR</sub>	Reverse output current	-50	mA
B	Magnetic flux density	Unlimited	GS
T <sub>A</sub>	Operation ambient temperature	-40 to +150	°C
T <sub>J</sub>	Maximum junction temperature	+180	°C
T <sub>S</sub>	Storage temperature	-55 to +180	°C
ESD (HBM)	ESD (Human Body Model)	5000	V
ESD (CDM)	ESD (Charged Device Model)	2000	V

Notes:

- Stresses greater than those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to *Absolute Maximum Ratings* for extended periods can affect device reliability.
- Should not be exceeding the maximum junction temperature and maximum duration of 500ms.

### Recommended Operating Conditions (@T<sub>A</sub> = -40°C to +150°C, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>DD</sub>	Supply voltage	Operating	2.7	27	V
T <sub>OP</sub>	Operating temperature	Operating	-40	+150	°C

**Electrical Characteristics** (Note 6) (@ $T_A = -40^\circ\text{C}$  to  $+150^\circ\text{C}$ ,  $V_{DD} = 2.7\text{V}$  to  $27\text{V}$ , unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$V_{DD}$	Supply voltage	Operating	2.7	12	27	V
$I_{DD}$	Supply current	$V_{DD} = 2.7\text{V}$ to $27\text{V}$	3.5	4.7	7	mA
$V_{UVLO}$	Undervoltage lockout threshold	$V_{DD}$ falling	2.0	2.35	2.7	V
$I_{DDR}$	Reverse supply current	$V_{DD} = -18\text{V}$ , $T_A = -40^\circ\text{C}$ to $+150^\circ\text{C}$	-1.5	—	—	mA
$V_{Osat}$	Output saturation voltage	$B > B_{OP}$ , $I_{OUT} = 10\text{mA}$	—	0.2	0.5	V
$I_{LEK}$	Output leakage current	$V_{OUT} = 12\text{V}$ , $V_{DD} = 12\text{V}$ , $B < B_{RP}$	—	0.1	1	$\mu\text{A}$
$I_{LIM}$	Output current limit	Output on	11	25	44	mA
$T_{TP}$	Thermal protection threshold	Junction temperature	+165	+180	—	$^\circ\text{C}$
$T_{TPR}$	Thermal protection release threshold	Junction temperature	—	+155	—	$^\circ\text{C}$
$f_M$	Maximum switching frequency*	$B > 3 \times B_{OP}$ , alternative square magnet field	40	60	—	kHz
$f_C$	Chopping frequency*	—	—	500	—	kHz
$t_{PON}$	Power on time (Note 7)	$V_{DD} = 12\text{V}$ , $dV_{DD}/dt > 2.7\text{V}/\mu\text{s}$	—	13	—	$\mu\text{s}$
$t_R$	Output rise time*	$V_{DD} = 12\text{V}$ , pullup resistor $1\text{k}\Omega$ , $C_L = 50\text{pF}$	—	0.2	1	$\mu\text{s}$
$t_F$	Output fall time*	$V_{DD} = 12\text{V}$ , pullup resistor $1\text{k}\Omega$ , $C_L = 50\text{pF}$	—	0.2	1	$\mu\text{s}$
$t_D$	Response delay time (Note 8)	$B > 3 \times B_{OP}$	—	13	—	$\mu\text{s}$
$t_{DC}$	Count signal delay (Note 6)	—	50	400	1000	ns
$t_{JITTER}$	Output jitter (Note 6)	—	—	$\pm 5$	—	$\mu\text{s}$
$d_{HALL}$	Hall plate distance	—	—	1.45	—	mm
$V_Z$	Zener clamp voltage	$I_{DD} = 8\text{mA}$ , $T_A = +25^\circ\text{C}$	36	—	—	V

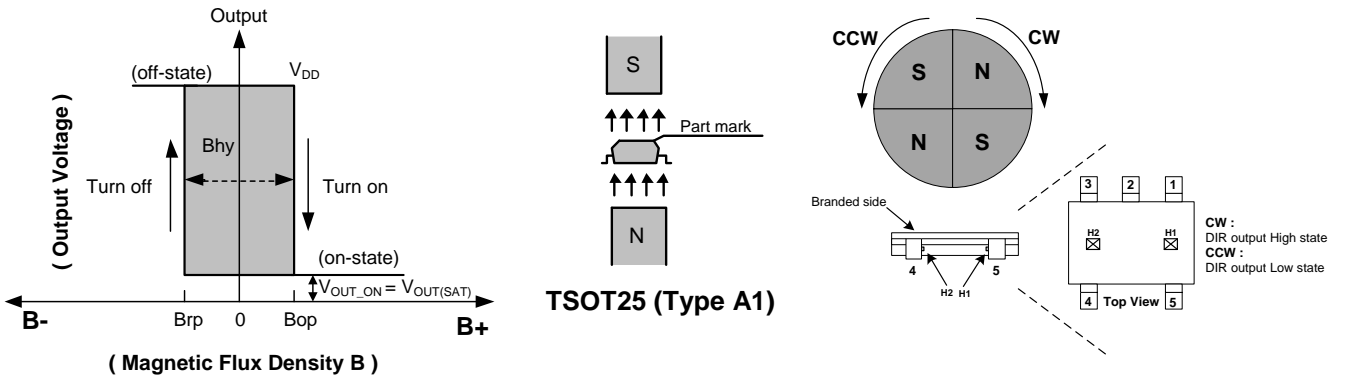
\* Guaranteed by design.

- Notes:
6. Typical values are defined at  $T_A = +25^\circ\text{C}$ ,  $V_{DD} = 12\text{V}$ . Maximum and minimum values over the operating temperature range are not tested in production but guaranteed by design, process control and characterization.
  7. Time from applying  $V_{DD} \geq 2.7\text{V}$  to the sensor until the output state is valid.
  8. Time delayed from the magnetic threshold reached to the output rise or fall.

**Magnetic Characteristics** (Notes 6, 9) ( $T_A = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{DD} = 2.7\text{V}$  to  $27\text{V}$ , unless otherwise specified.)

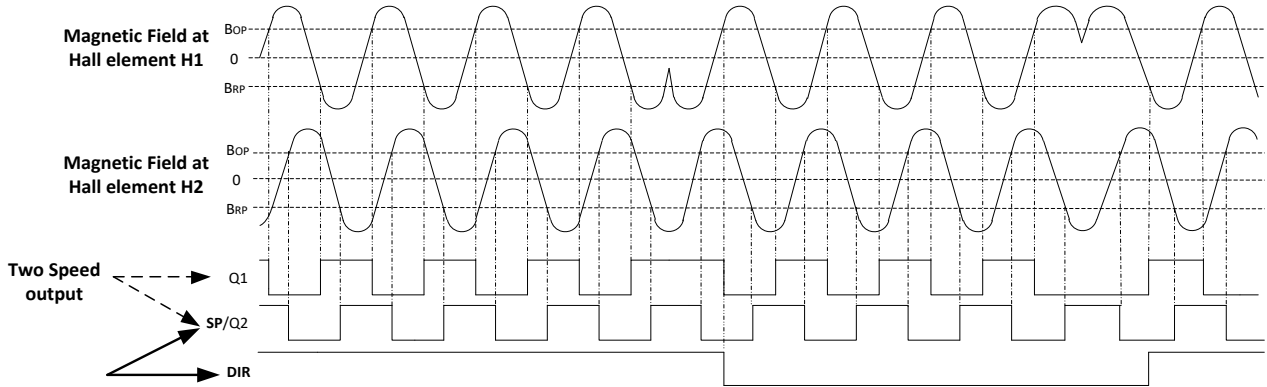
Part Name	Operating Point BOP (Gauss)			Release Point BRP (Gauss)			Hysteresis BHYS (Gauss)			Magnetic Matching (Gauss) (Note 10)		Magnetic Offset (Gauss) (Note 10)		TC (ppm/°C)	Output			
	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Max	Min	Max	Typ	SP	DIR	Q1	Q2
AH3975Q	-10	10	30	-30	-10	10	5	20	35	-25	25	-15	15	-350	V	V	—	—
AH3976Q	8	25	42	-42	-25	-8	32	50	68	-20	20	-20	20	-350	V	V	—	—
AH3977Q	50	75	100	-100	-75	-50	120	150	180	-30	30	-20	20	-350	V	V	—	—
AH3978Q	50	75	100	-100	-75	-50	120	150	180	-30	30	-20	20	-350	—	—	V	V

Notes: 9. Positive x-axis direction indicates the south pole approaching the part marking surface i.e. increasing south pole magnetic field strength to the sensor; reversing direction x-axis toward 0 means the decreasing south magnetic field strength to the sensor. Negative x-axis indicates north pole magnetic field to the part marking surface.  
 10.  $T_A = +25^{\circ}\text{C}$ ,  $V_{DD} = 2.7\text{V}$  to  $27\text{V}$ .

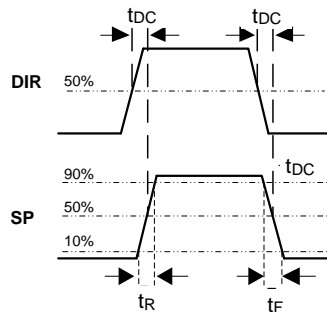


**Operating Characteristics**

**Timing Diagrams for the Speed and Direction Output SP/DIR and Two Speed Outputs Q1/Q2**

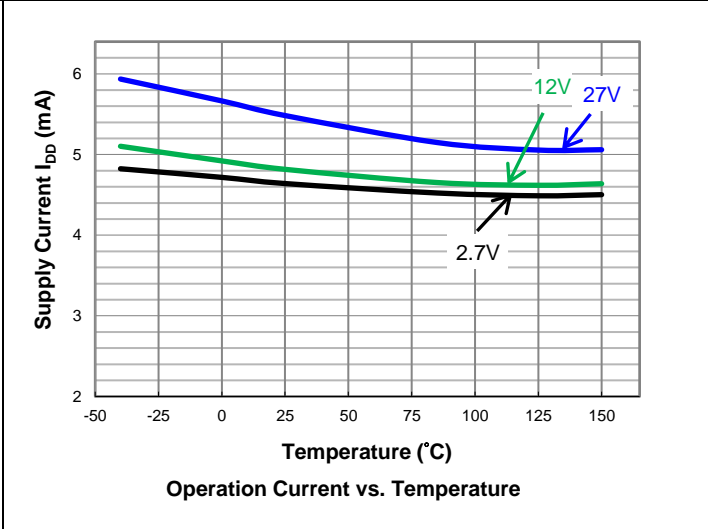
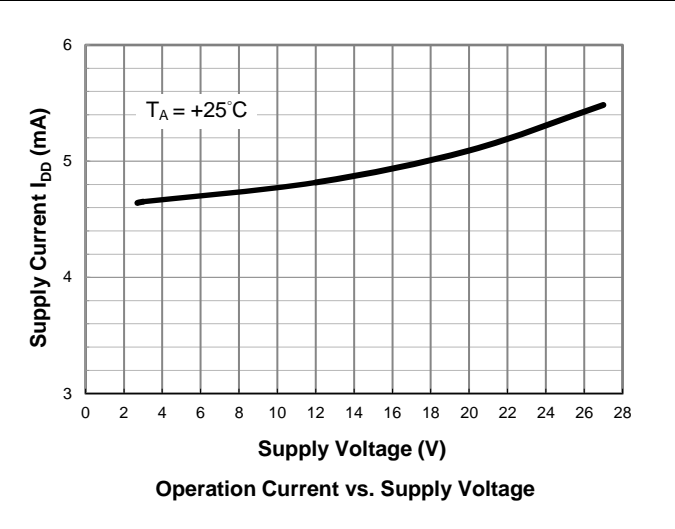


**Count Signal Delay  $t_{dc}$**

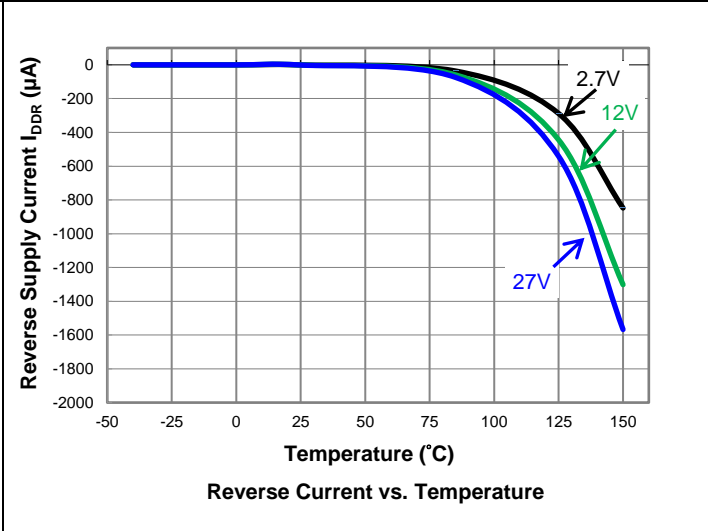
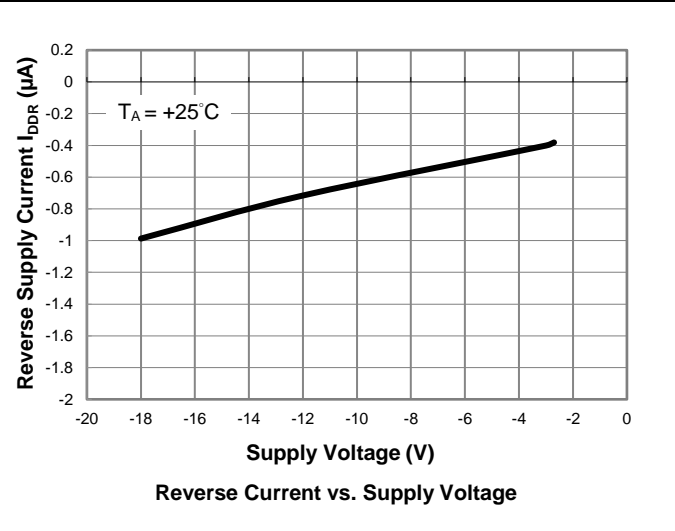


**Performance Characteristics**

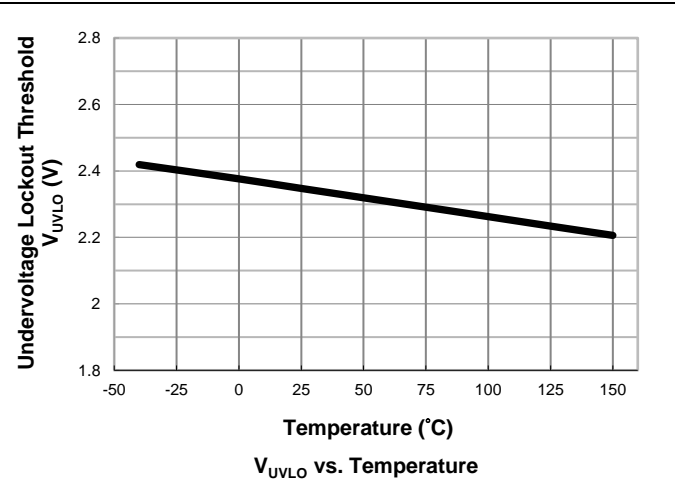
**Supply Current  $I_{DD}$**



**Reverse Supply Current  $I_{DDR}$**

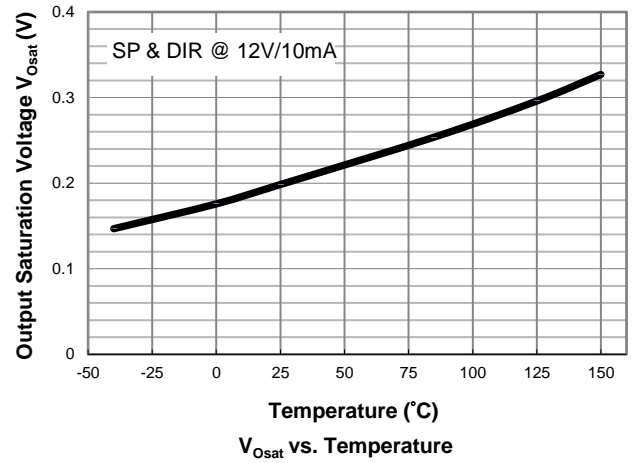
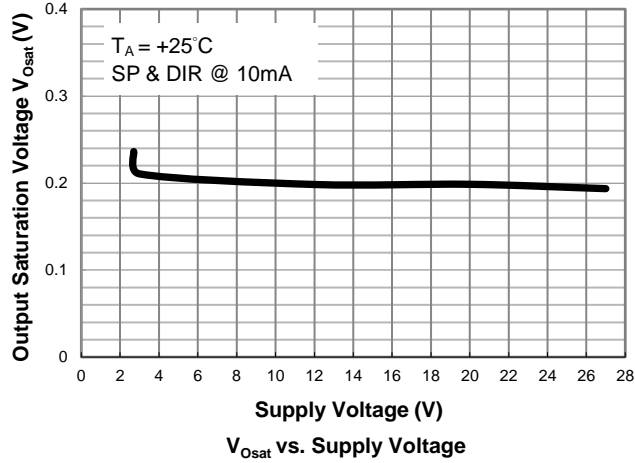


**Undervoltage Lockout Threshold**

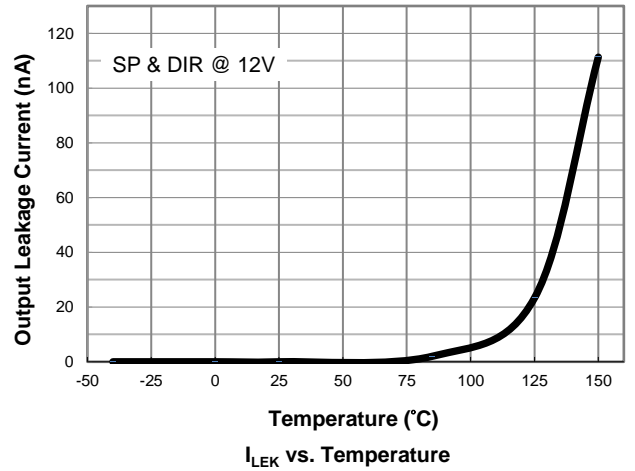
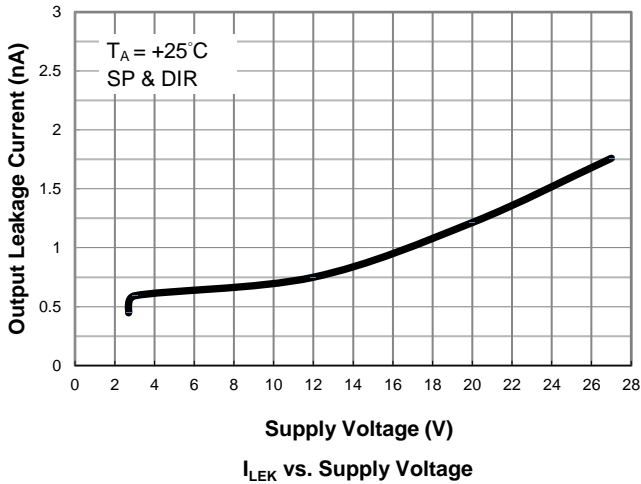


**Performance Characteristics** (continued)

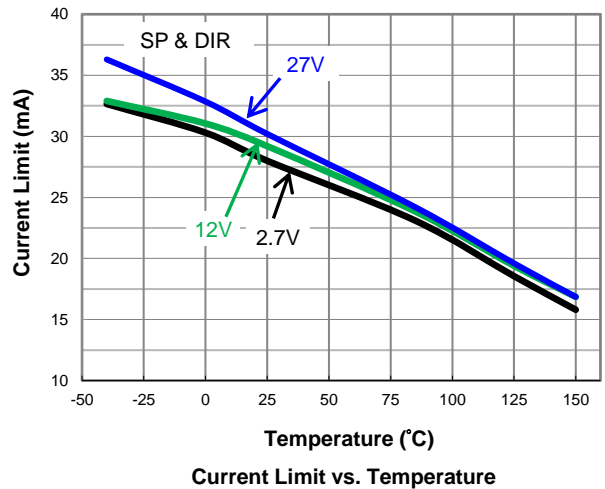
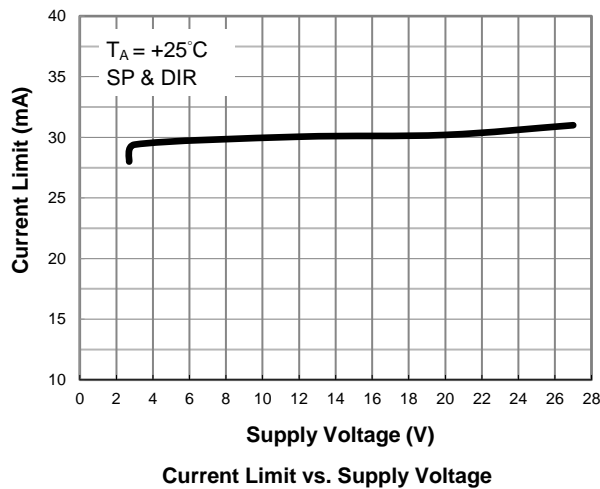
**Output Saturation Voltage  $V_{Osat}$**



**Output Leakage Current  $I_{LEK}$**

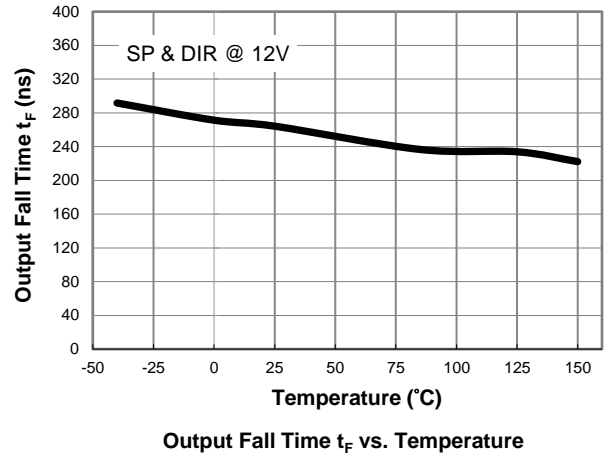
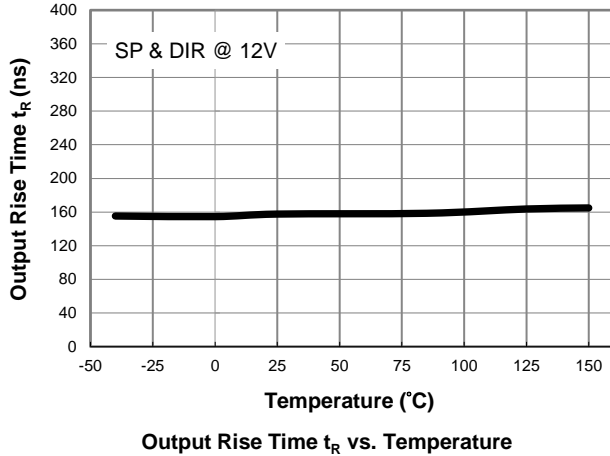


**Output Current Limit  $I_{LIM}$**

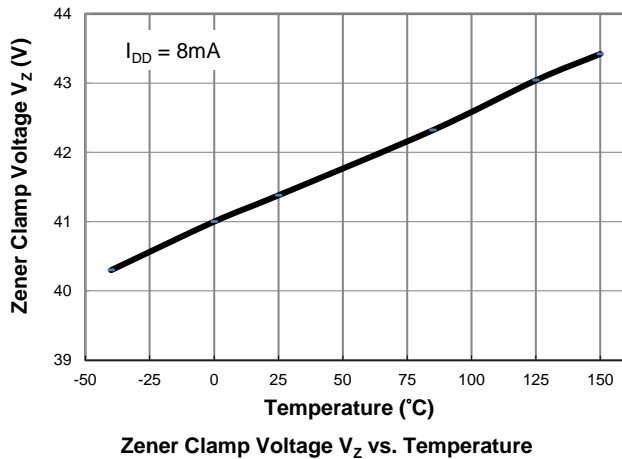


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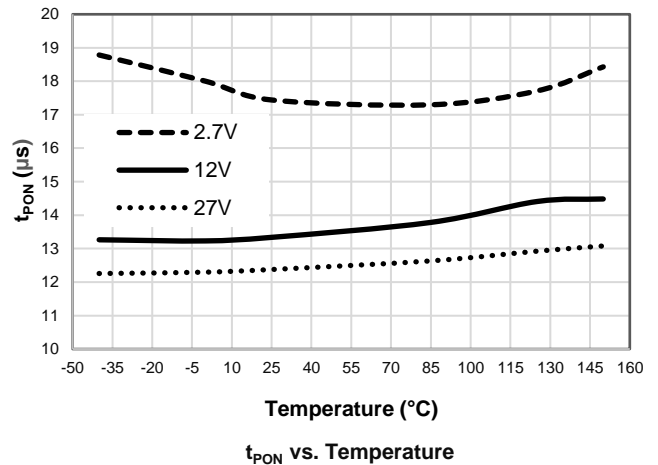
**Output Rise Time  $t_R$  & Output Fall Time  $t_F$**



**Zener Clamp Voltage  $V_Z$**



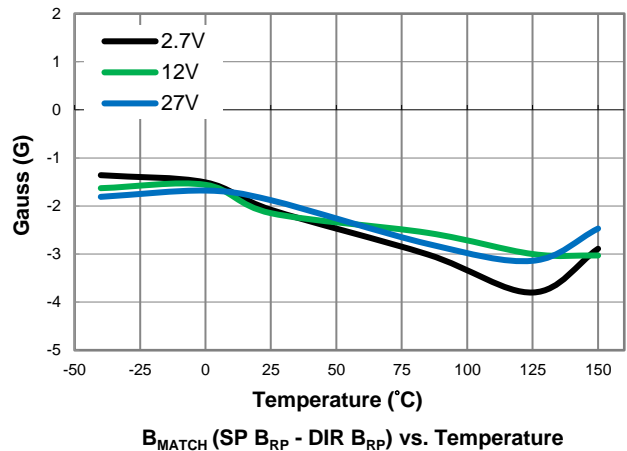
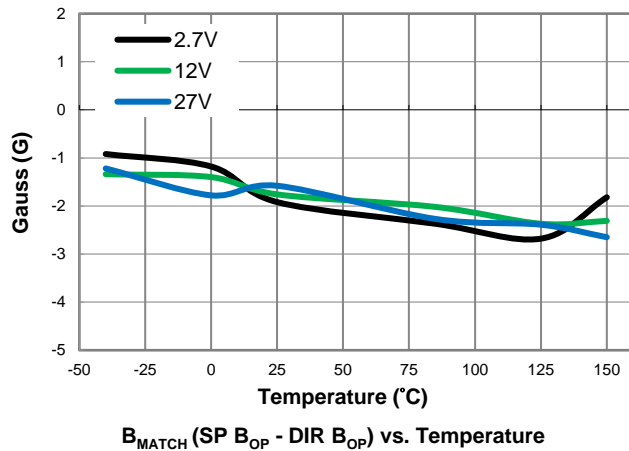
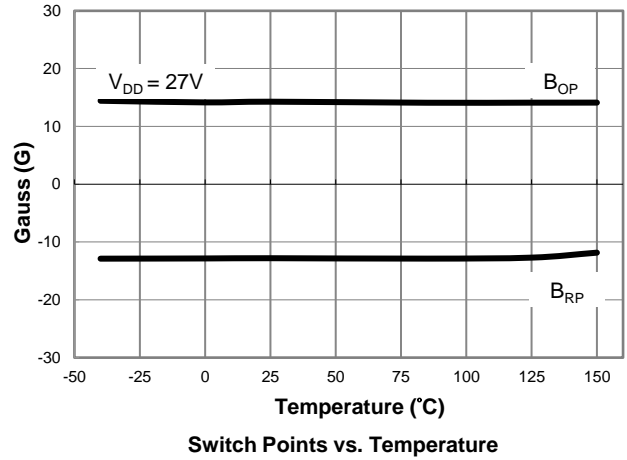
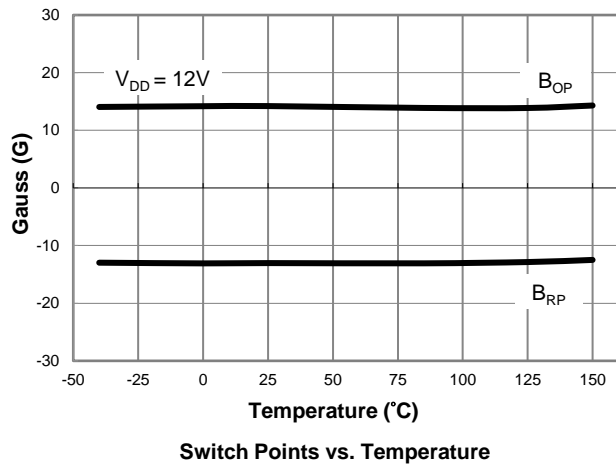
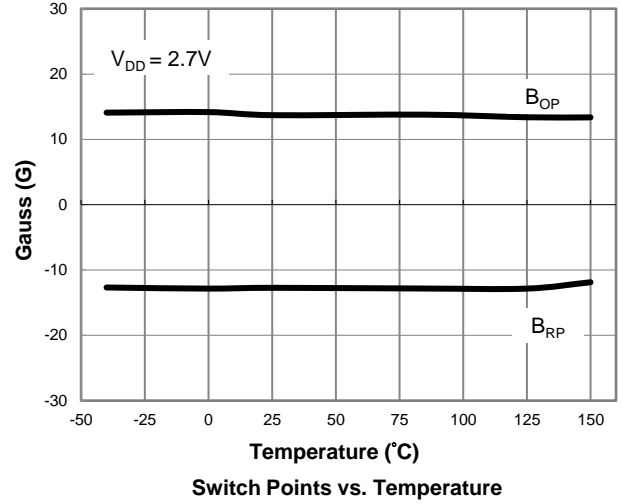
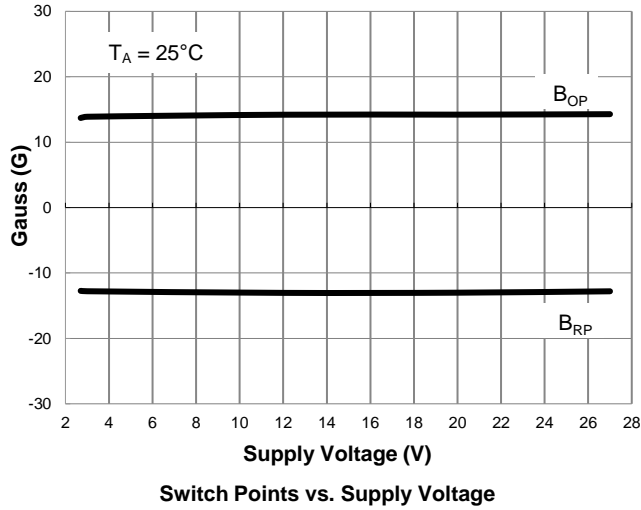
**Power On Time  $t_{PON}$**





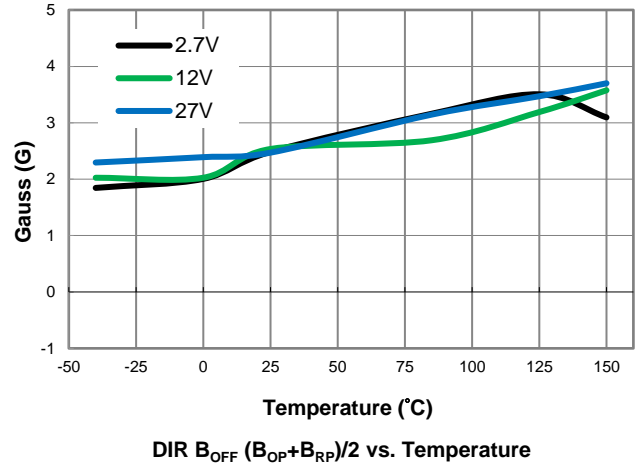
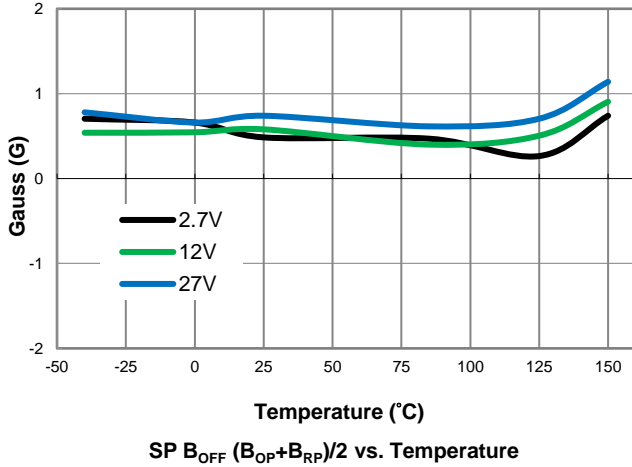
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**AH3975Q Magnetic Characteristics**

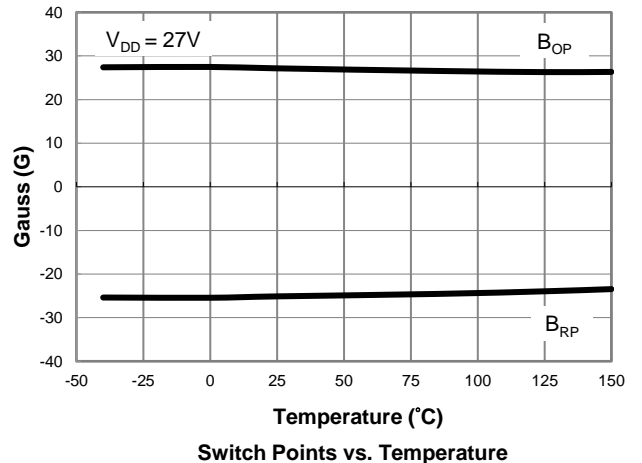
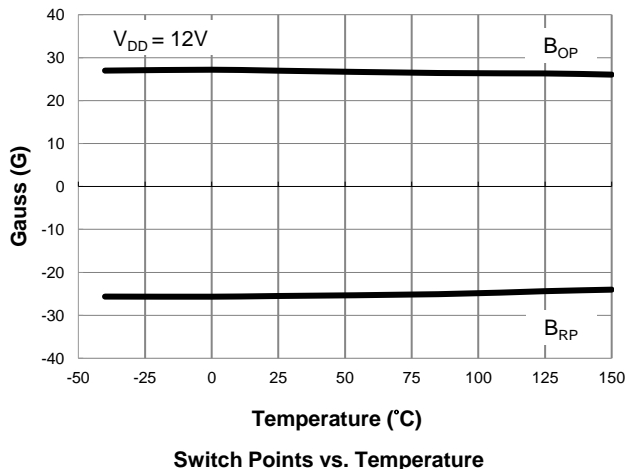
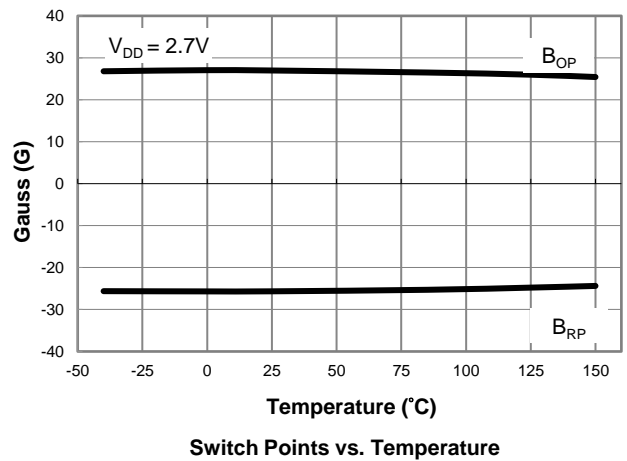
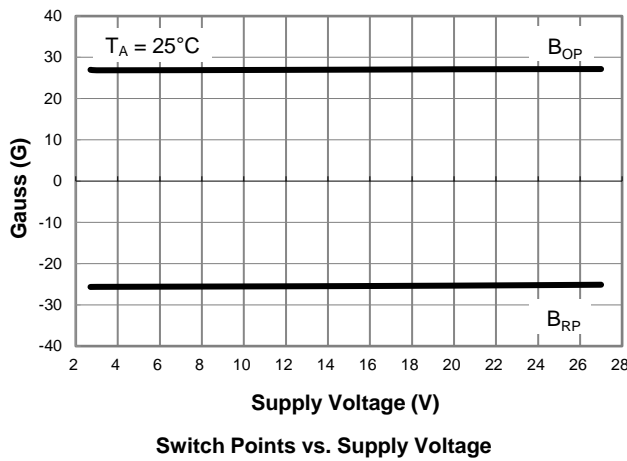


**Performance Characteristics** (continued)

**AH3975Q Magnetic Characteristics** (continued)

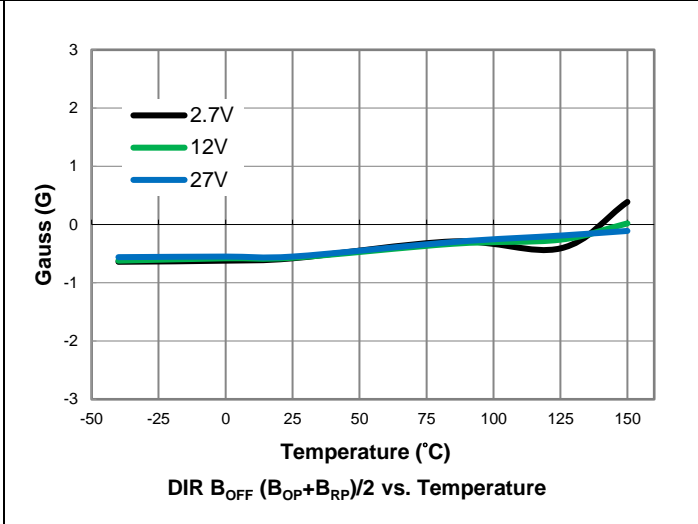
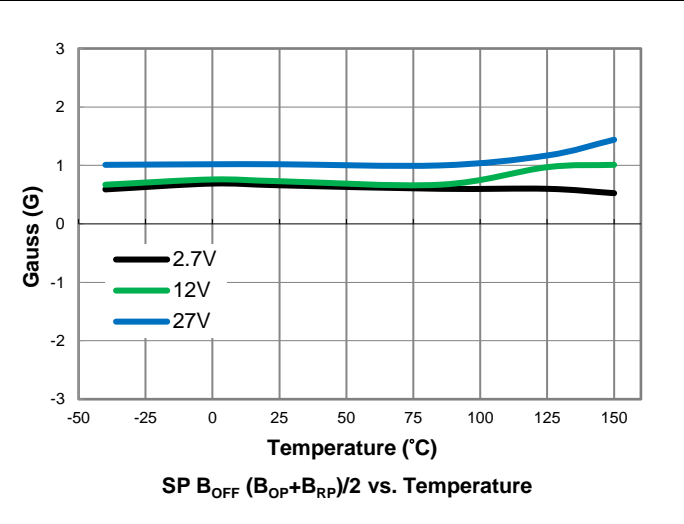
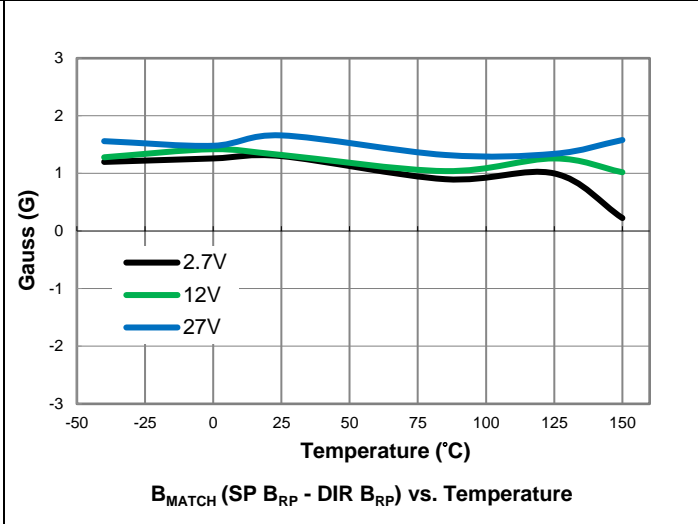
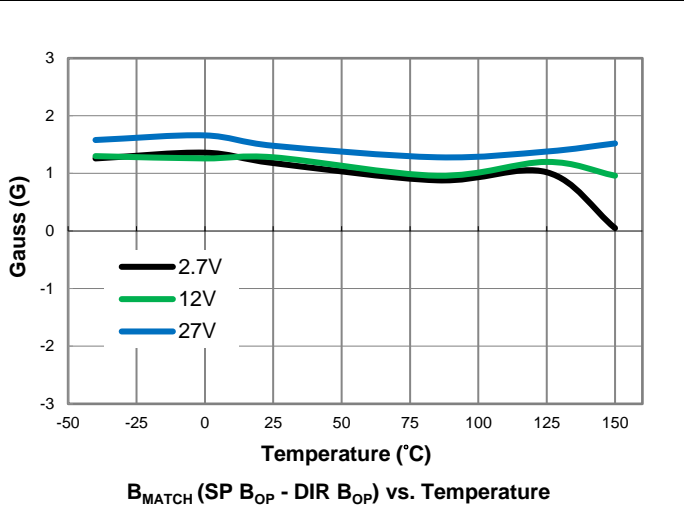


**AH3976Q Magnetic Characteristics**

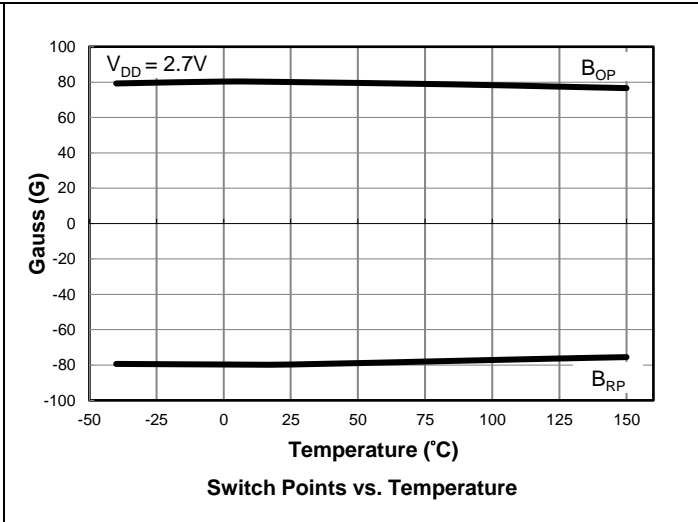
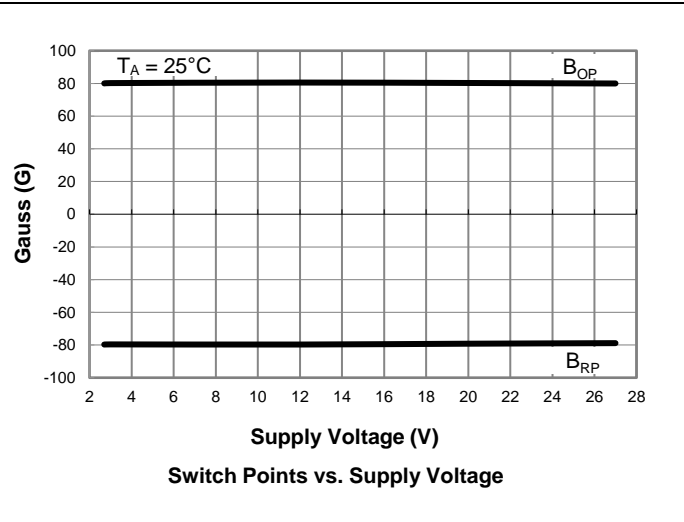


**Performance Characteristics** (continued)

**AH3976Q Magnetic Characteristics** (continued)

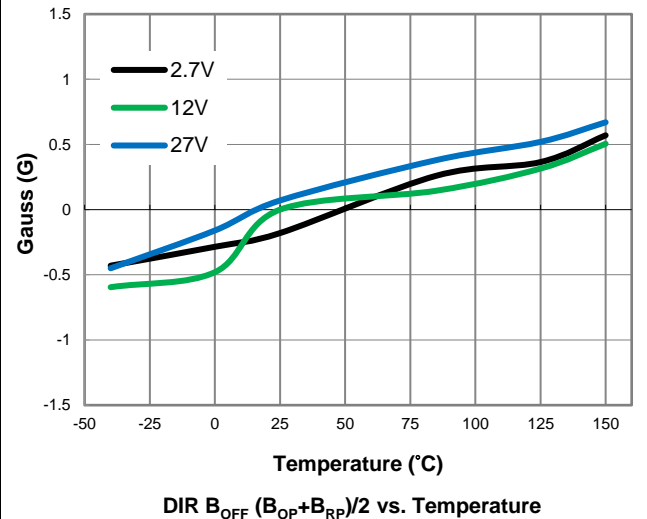
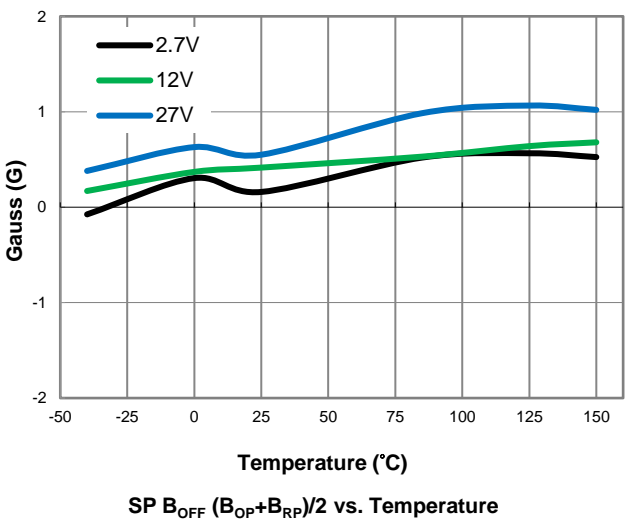
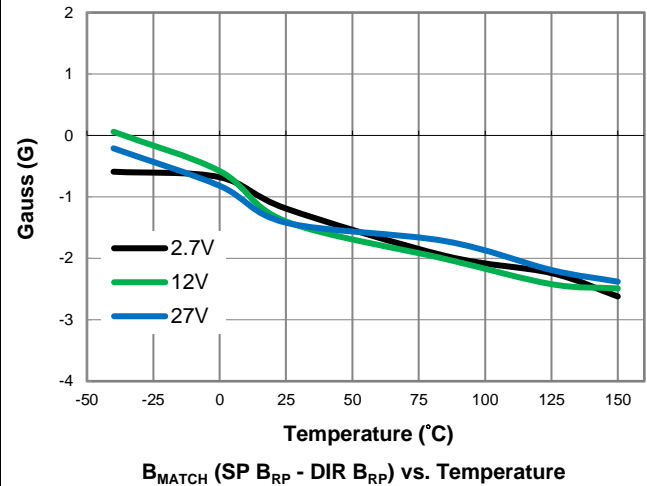
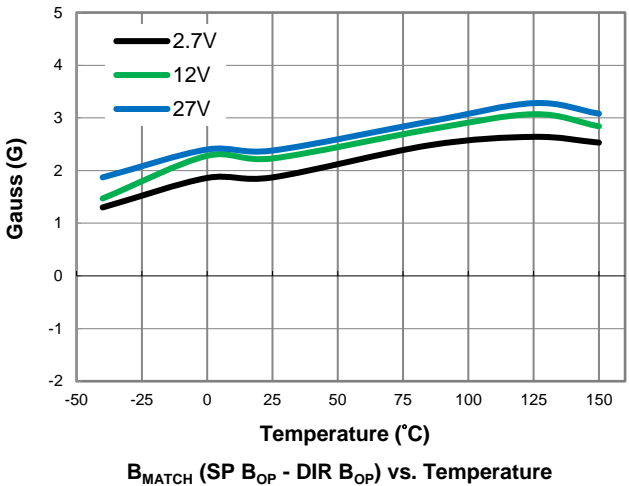
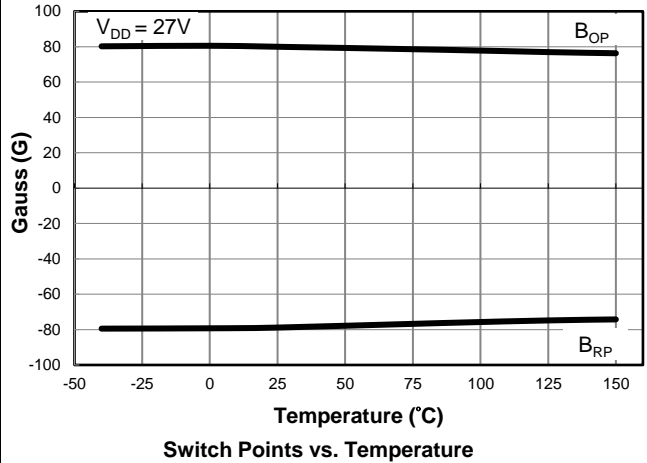
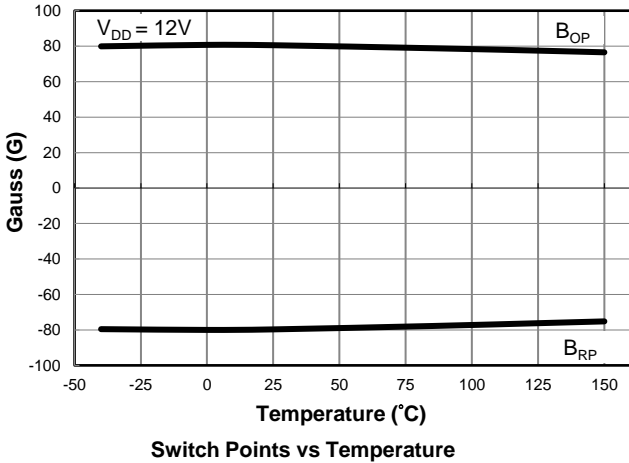


**AH3977Q Magnetic Characteristics**



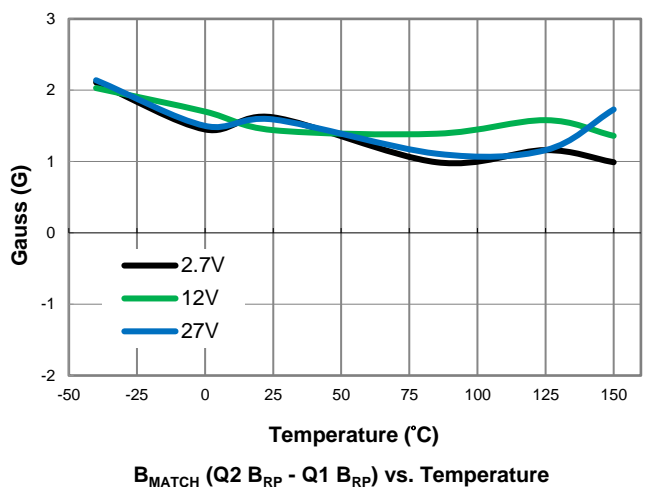
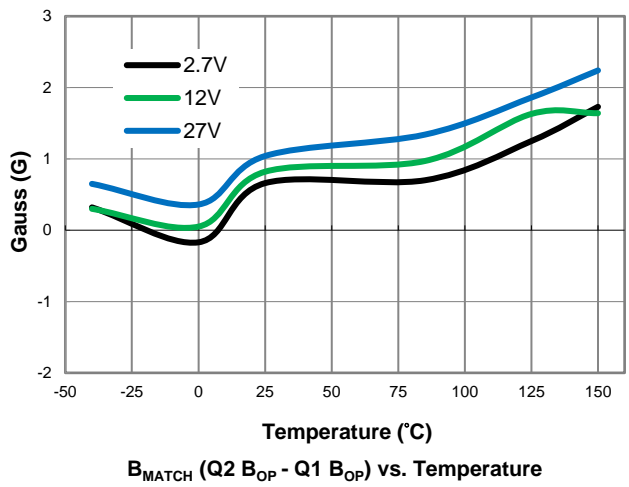
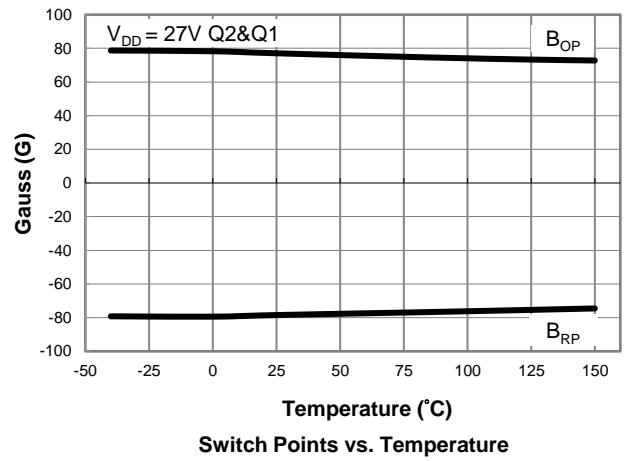
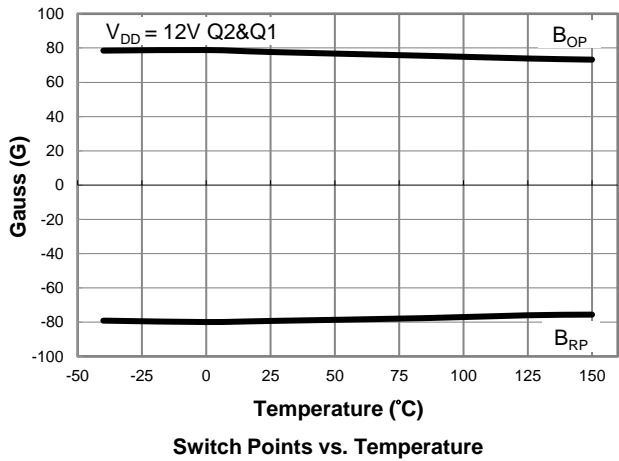
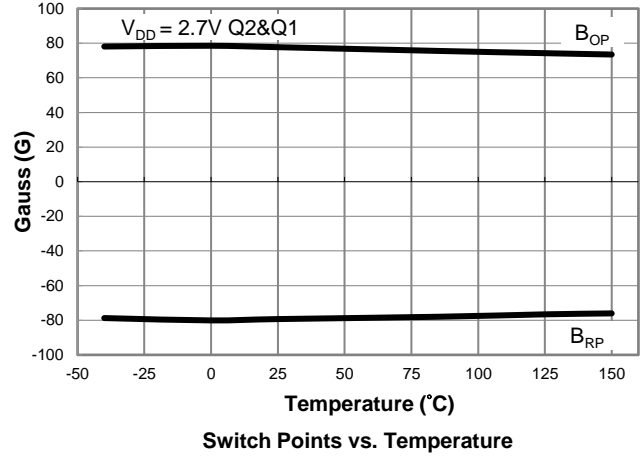
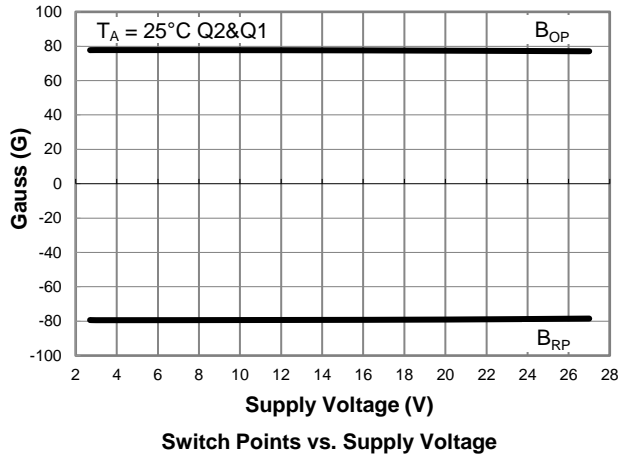
**Performance Characteristics** (continued)

**AH3977Q Magnetic Characteristics** (continued)

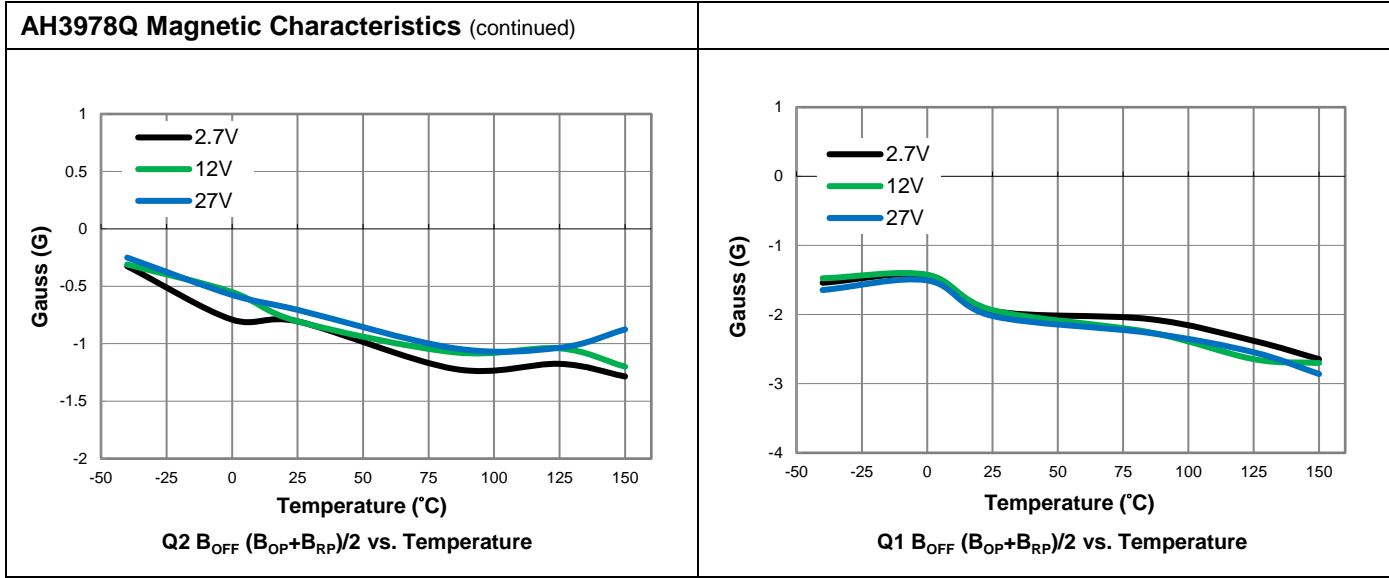


**Performance Characteristics** (continued)

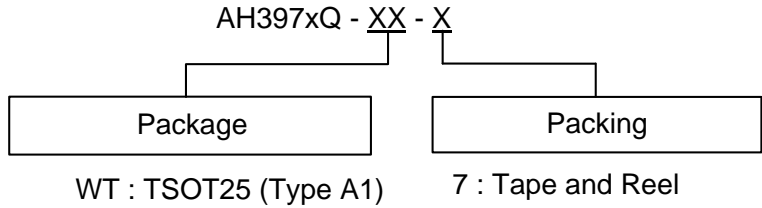
**AH3978Q Magnetic Characteristics**



**Performance Characteristics** (continued)



## Ordering Information

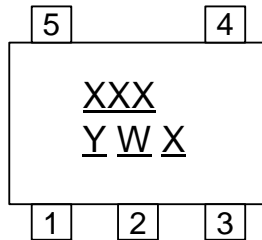


Part Number	Part Number Suffix	Package Code	Package	Packing	
				Qty.	Carrier
AH3975Q-WT-7	-7	WT	TSOT25 (Type A1)	3000	7" Tape and Reel
AH3976Q-WT-7	-7	WT	TSOT25 (Type A1)	3000	7" Tape and Reel
AH3977Q-WT-7	-7	WT	TSOT25 (Type A1)	3000	7" Tape and Reel
AH3978Q-WT-7	-7	WT	TSOT25 (Type A1)	3000	7" Tape and Reel

## Marking Information

Package Type: TSOT25 (Type A1)

(Top View)



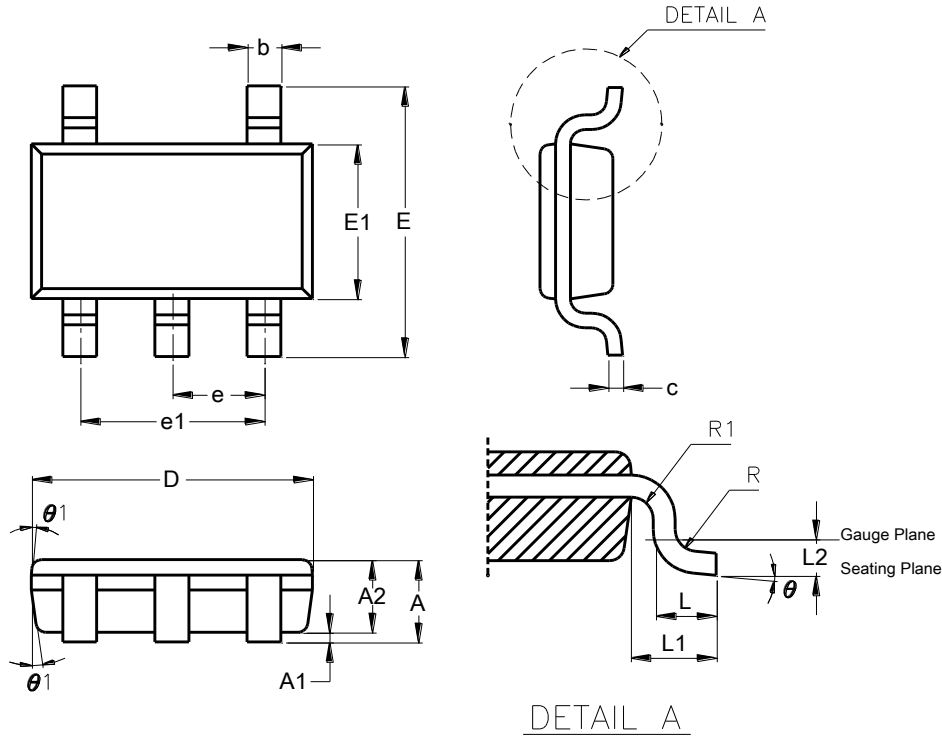
- XXX : Identification Code
- Y : Year 0 to 9 (ex: 3 = 2023)
- W : Week : A to Z : week 1 to 26;  
a to z : week 27 to 52; z represents week 52 and 53
- X : Internal Code

Part Number	Package	Identification Code
AH3975Q-WT-7	TSOT25 (Type A1)	M6Q
AH3976Q-WT-7	TSOT25 (Type A1)	M7Q
AH3977Q-WT-7	TSOT25 (Type A1)	M8Q
AH3978Q-WT-7	TSOT25 (Type A1)	M9Q

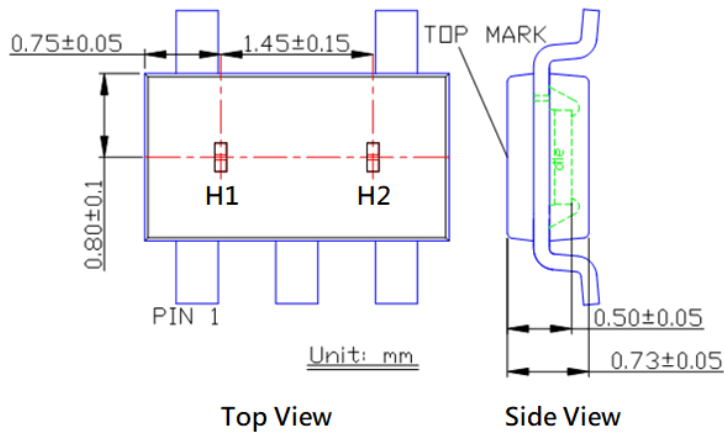
**Package Outline Dimensions**

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

**TSOT25 (Type A1)**



TSOT25 (Type A1)			
Dim	Min	Max	Typ
A	0.750	0.800	--
A1	0.00	0.050	--
A2	0.700	0.775	0.750
b	0.350	0.500	--
c	0.100	0.200	--
D	2.800	3.000	2.900
E	2.600	3.000	2.800
E1	1.500	1.700	1.600
e	0.950 BSC		
e1	1.900 BSC		
L	0.370	0.600	0.450
L1	0.600 REF		
L2	0.250 BSC		
R	0.100	--	--
R1	0.100	--	--
theta	0°	8°	4°
theta1	4°	12°	10°
<b>All Dimensions in mm</b>			



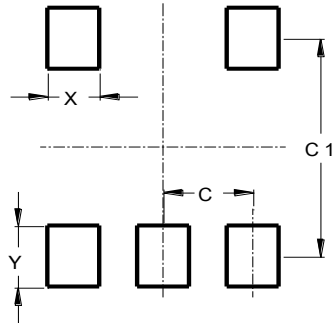
**Sensor Location**



## Suggested Pad Layout

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

TSOT25 (Type A1)



Dimensions	Value (in mm)
C	0.95
C1	2.50
X	0.55
Y	0.70

## Mechanical Data

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish – Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 (E3)
- Weight: 0.016 grams (Approximate)

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