

**AUTOMOTIVE DUAL HALL-EFFECT LATCH WITH SPEED & DIRECTION  
OUTPUTS INTEGRATED SELF-DIAGNOSTICS**

## 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

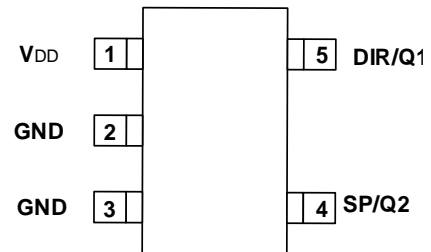
- Dual Latch Hall Operation with Dual Outputs (AH3978Q) or Speed & Direction Output (AH3975Q/AH3976Q/AH3977Q)
- Wide Supply Voltage Operation: 2.7V to 27V
- Chopper Stabilized Design Provides
  - Superior Temperature Stability
  - Minimal Switch Point Drift
  - Enhanced Immunity to Stress
- Battery Polarity 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)

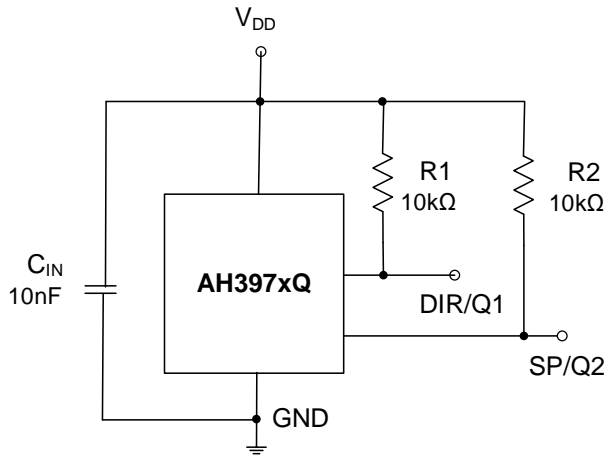


TSOT25 (Type A1)

## Applications

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

**Typical Applications Circuit**

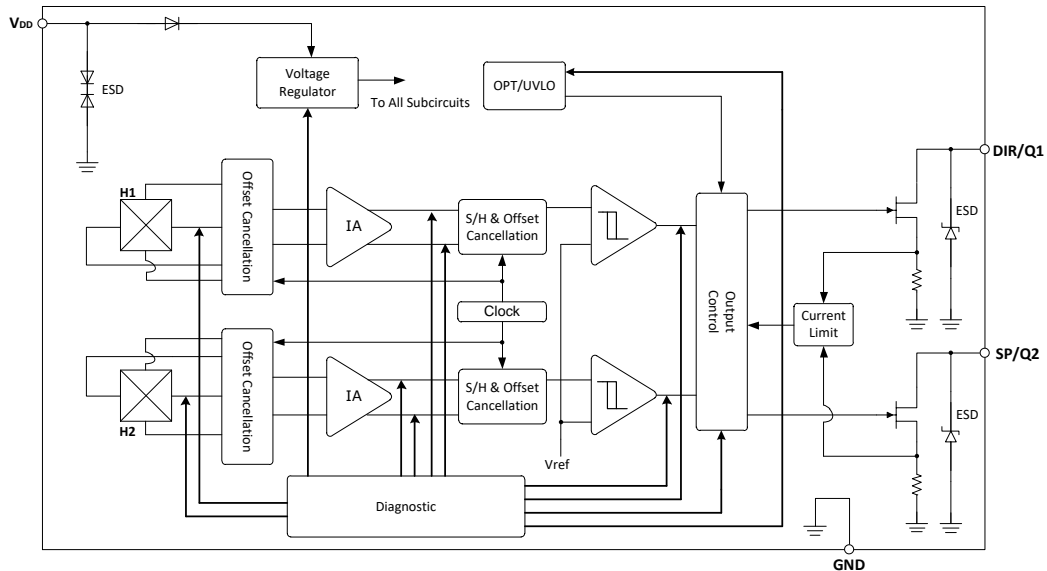


**Pin Descriptions**

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                |

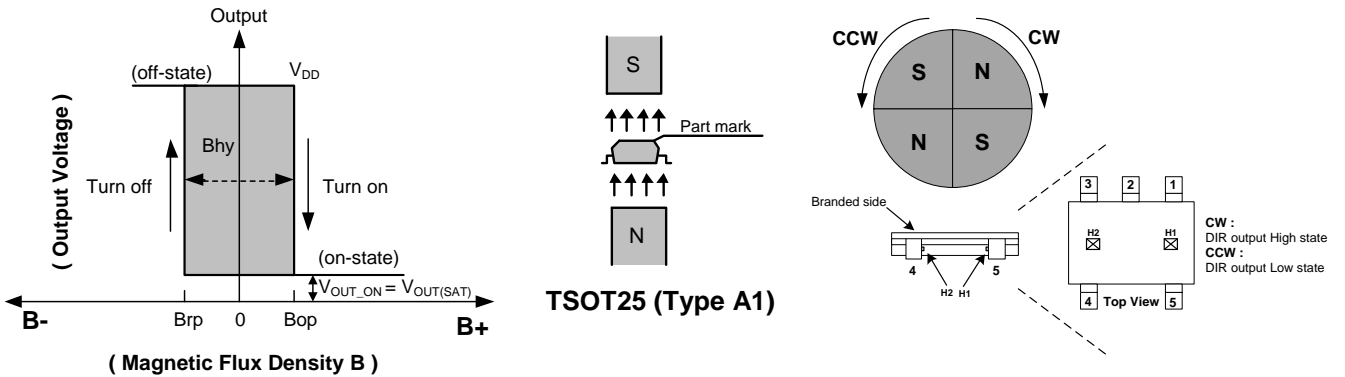
\* Guaranteed by design.

- 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.)

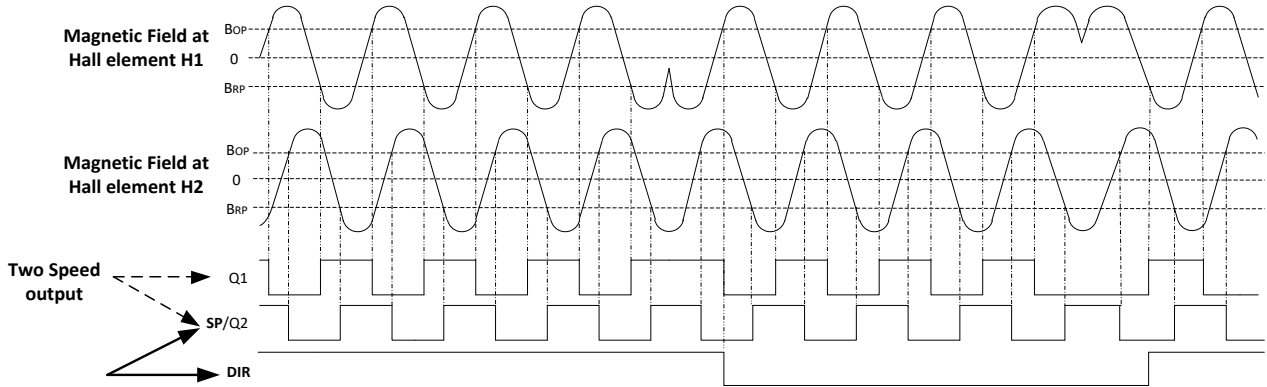
| Part Name | Operating Point BOP (Gauss) |     |     | Release Point BRP (Gauss) |     |     | Hysteresis BHYS (Gauss) |     |     | Magnetic Matching (Gauss) (Note 10) |     | Magnetic Offset (Gauss) (Note 10) |     | TC (ppm/°C) | Output |     |    |    |
|-----------|-----------------------------|-----|-----|---------------------------|-----|-----|-------------------------|-----|-----|-------------------------------------|-----|-----------------------------------|-----|-------------|--------|-----|----|----|
|           | 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  $27\text{V}$ .

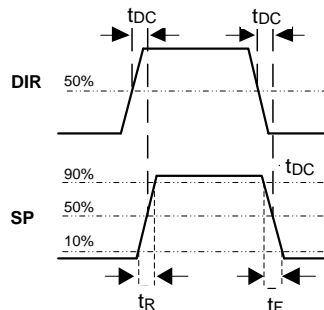


**Operating Characteristics**

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

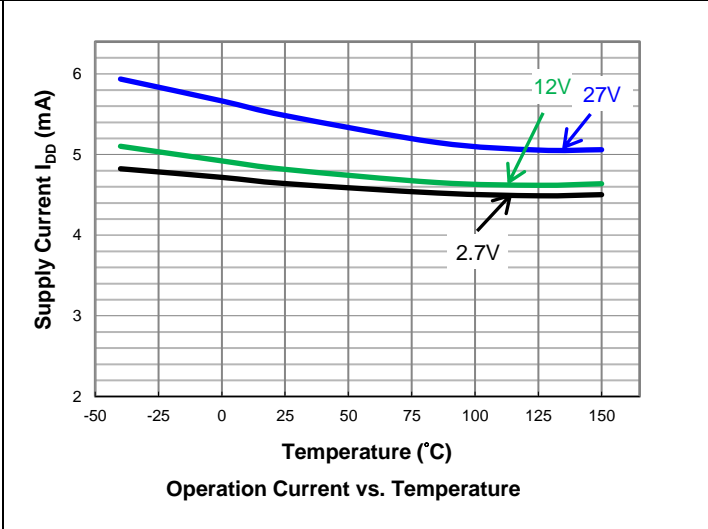
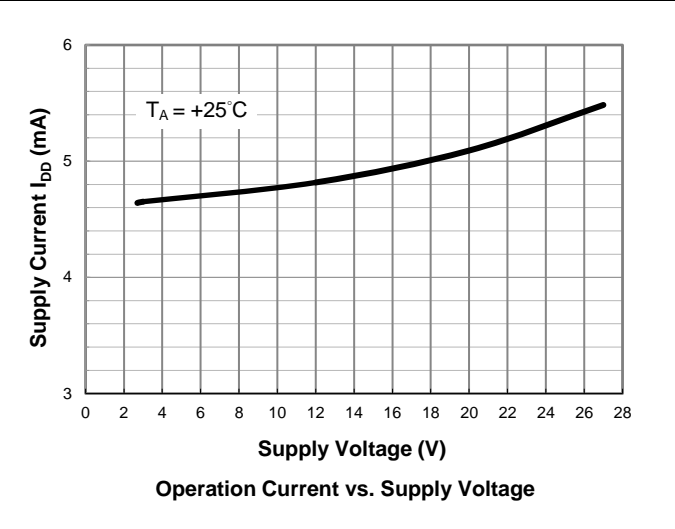


**Count Signal Delay  $t_{dc}$**

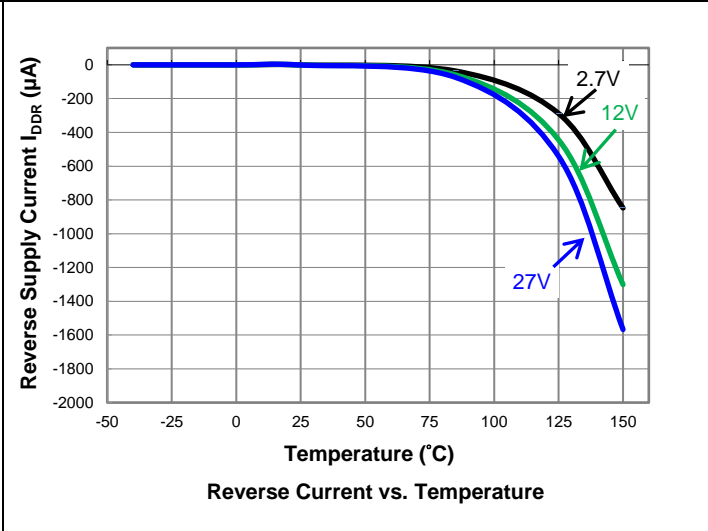
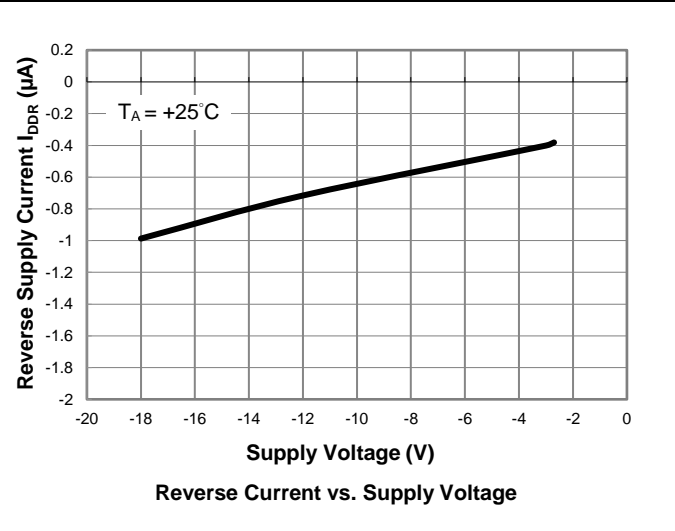


**Performance Characteristics**

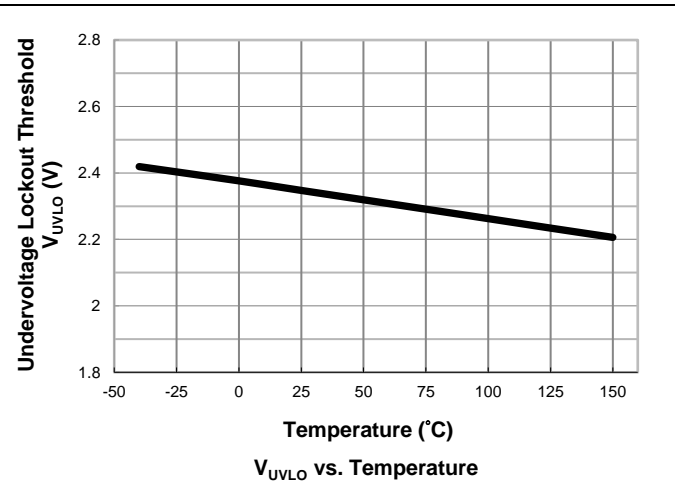
**Supply Current  $I_{DD}$**



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

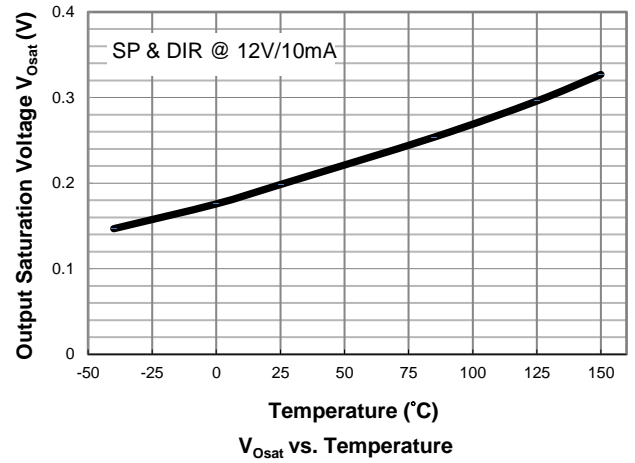
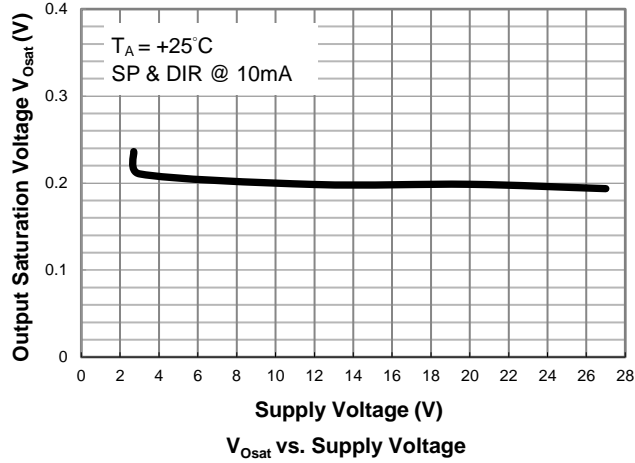


**Undervoltage Lockout Threshold**

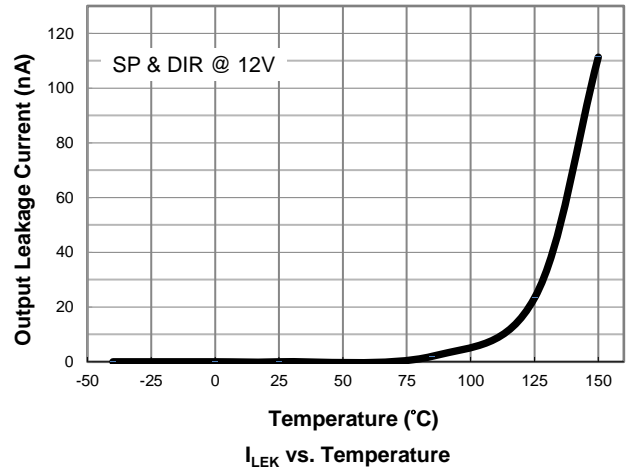
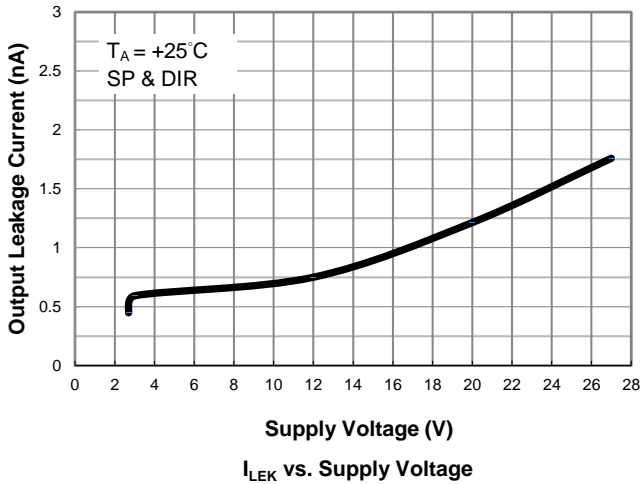


**Performance Characteristics** (continued)

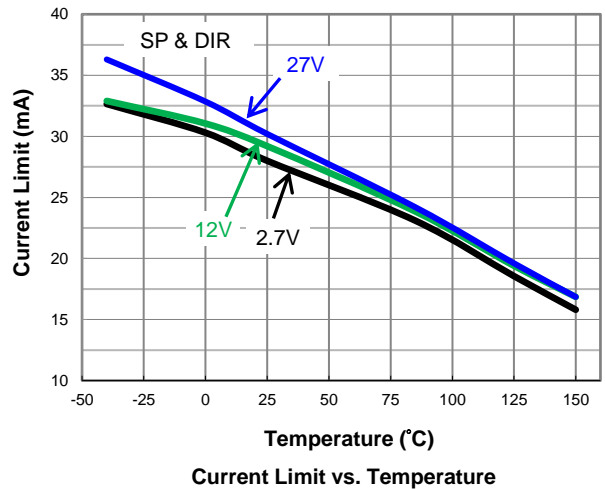
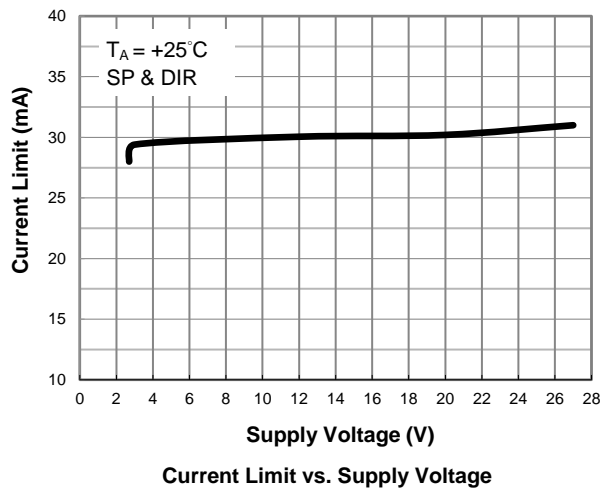
**Output Saturation Voltage  $V_{Osat}$**



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

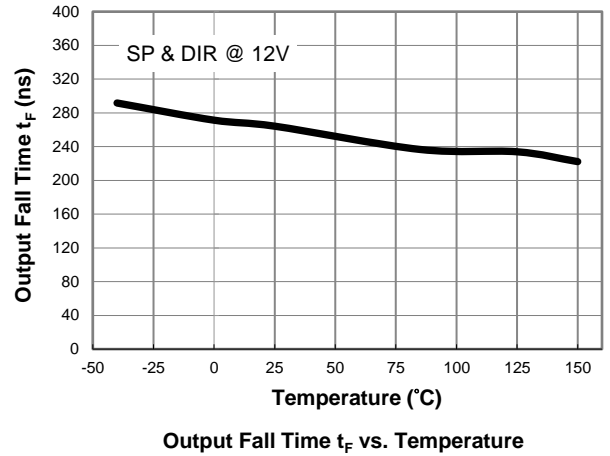
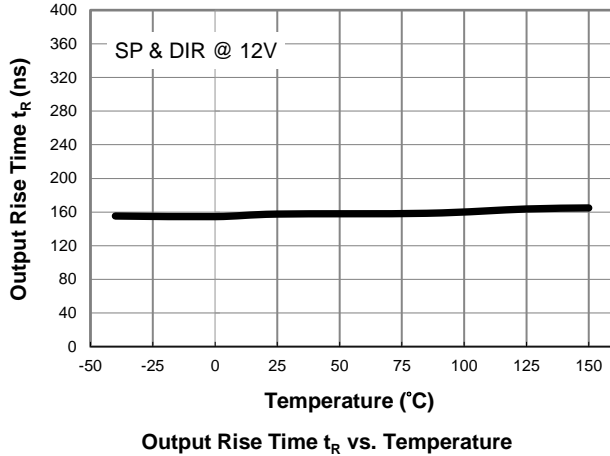


**Output Current Limit  $I_{LIM}$**

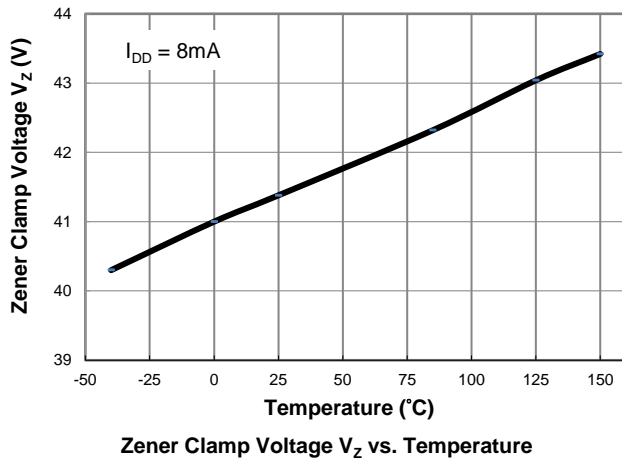


**Performance Characteristics** (continued)

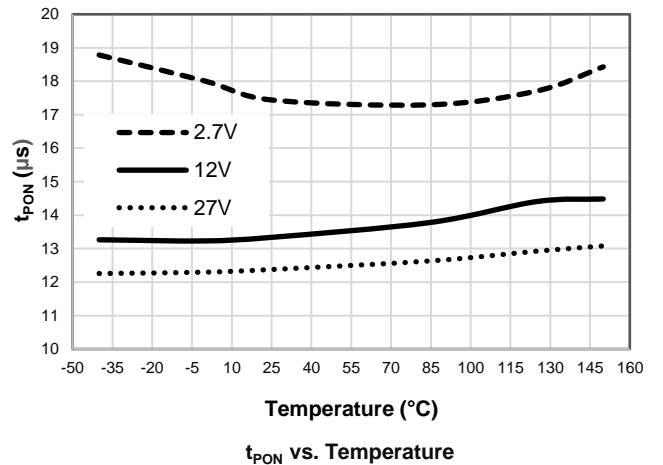
**Output Rise Time  $t_R$  & Output Fall Time  $t_F$**



**Zener Clamp Voltage  $V_Z$**



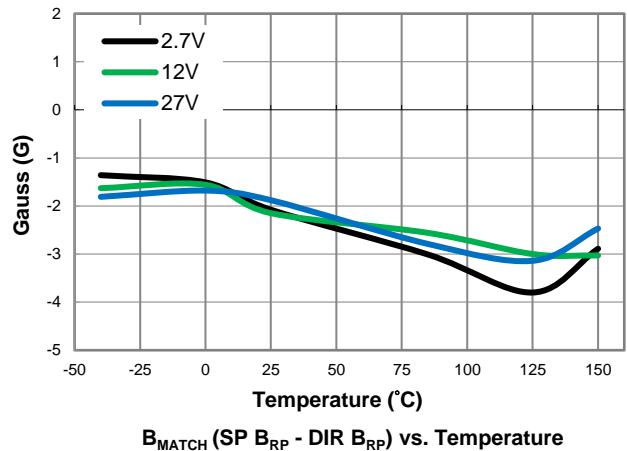
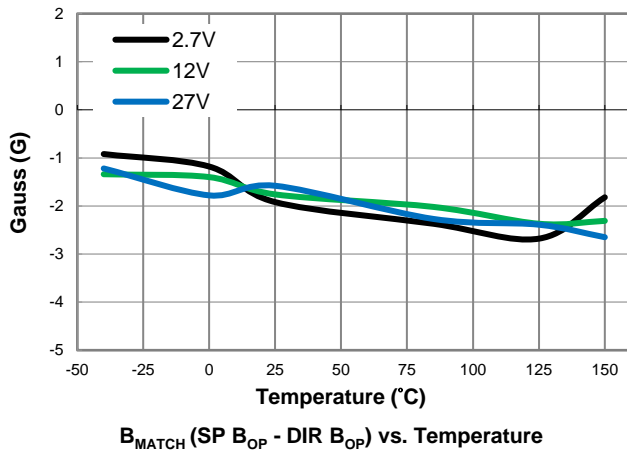
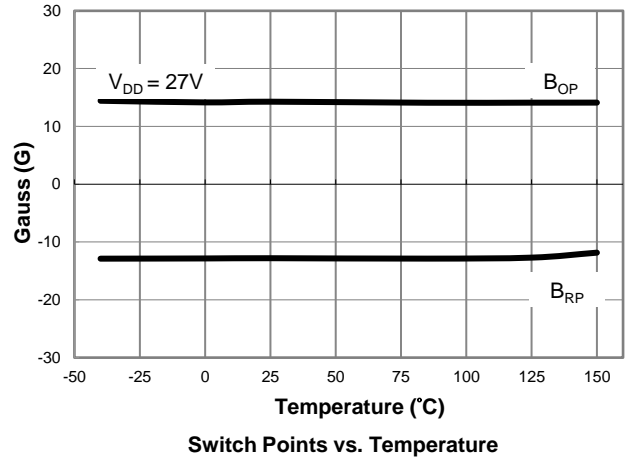
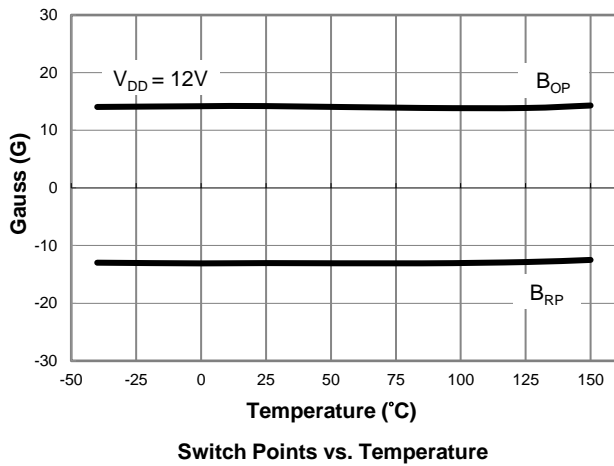
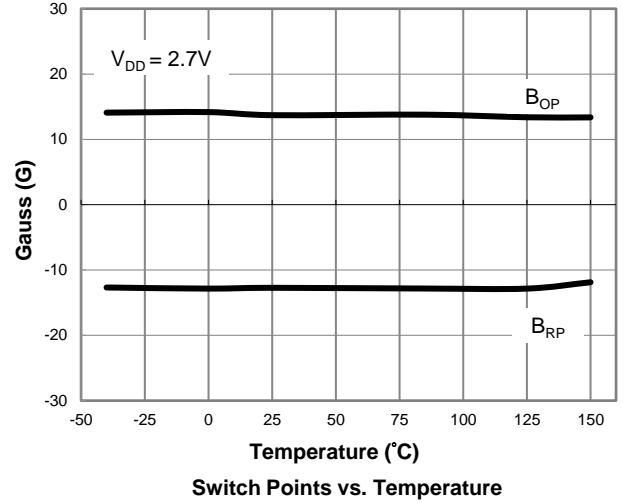
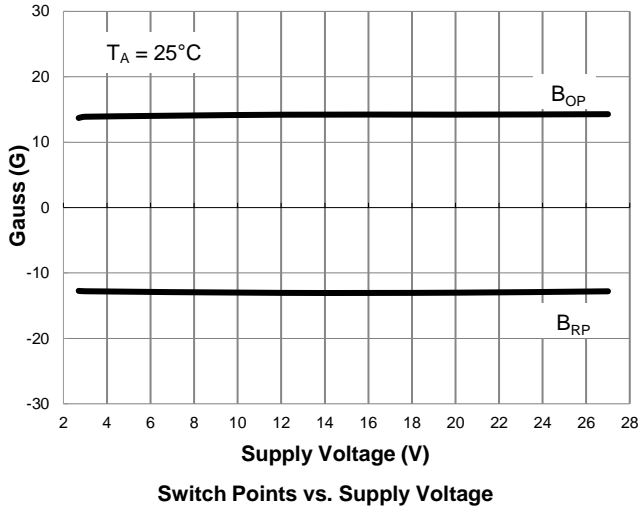
**Power On Time  $t_{PON}$**





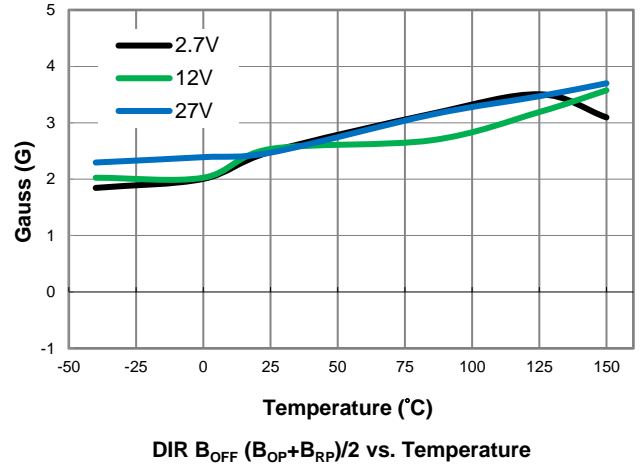
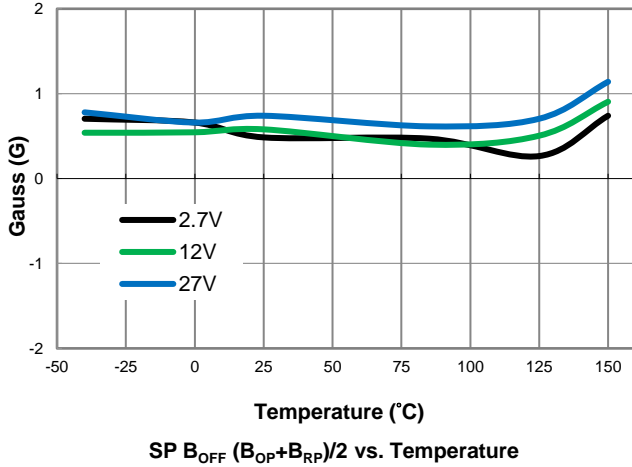
**Performance Characteristics** (continued)

**AH3975Q Magnetic Characteristics**

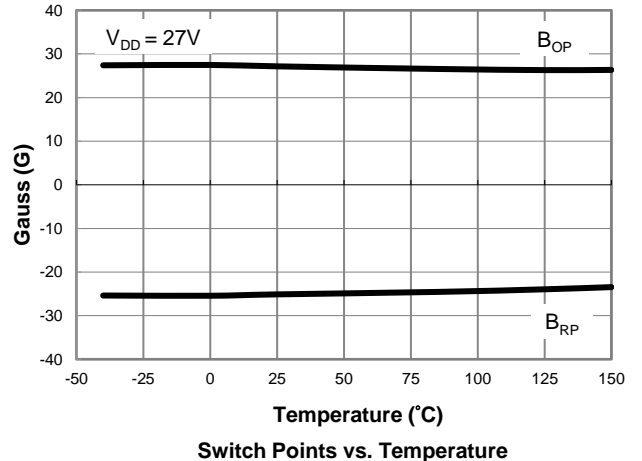
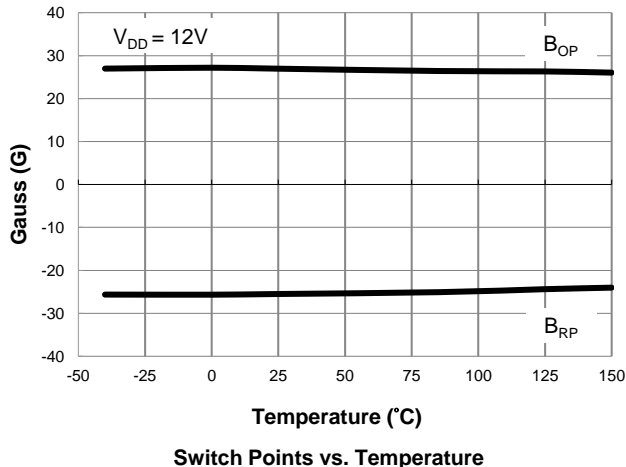
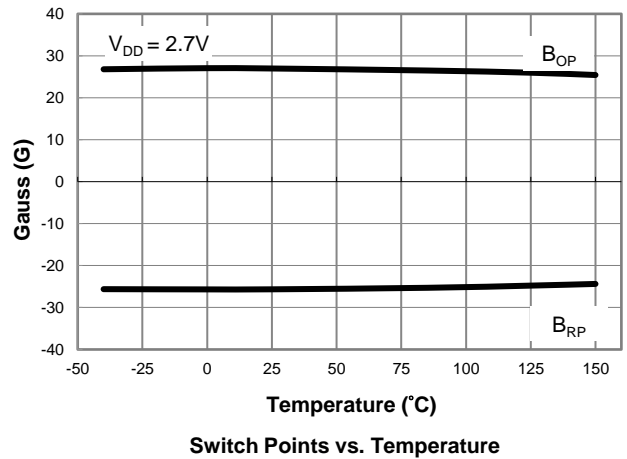
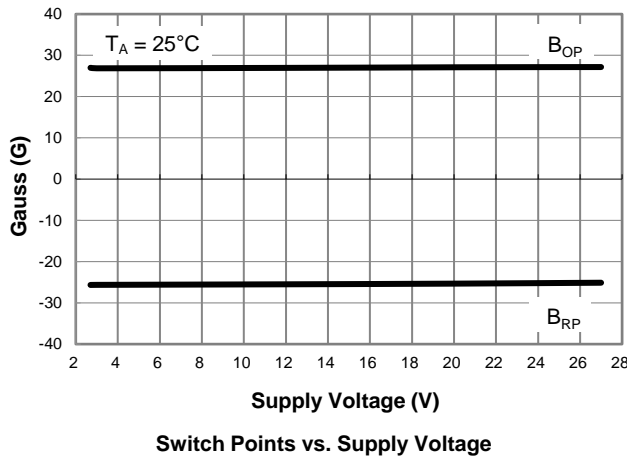


**Performance Characteristics** (continued)

**AH3975Q Magnetic Characteristics** (continued)

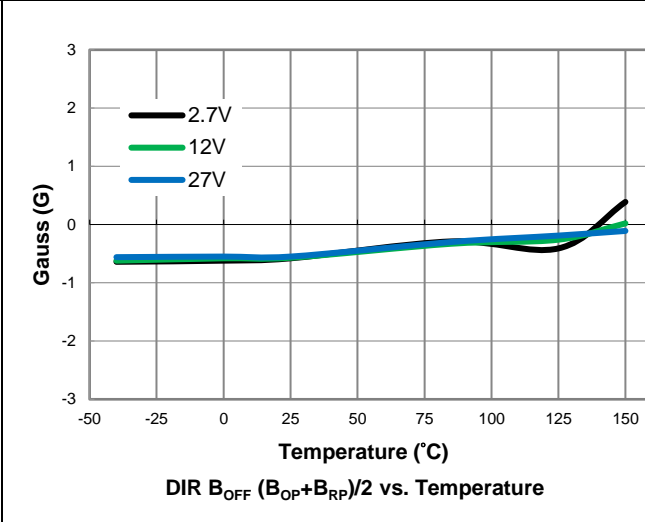
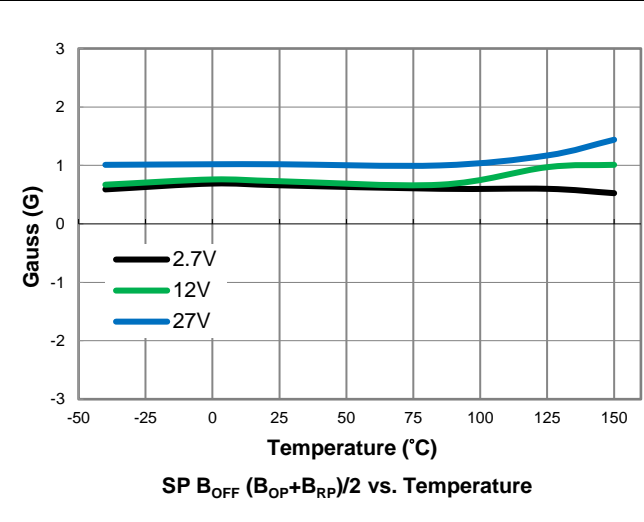
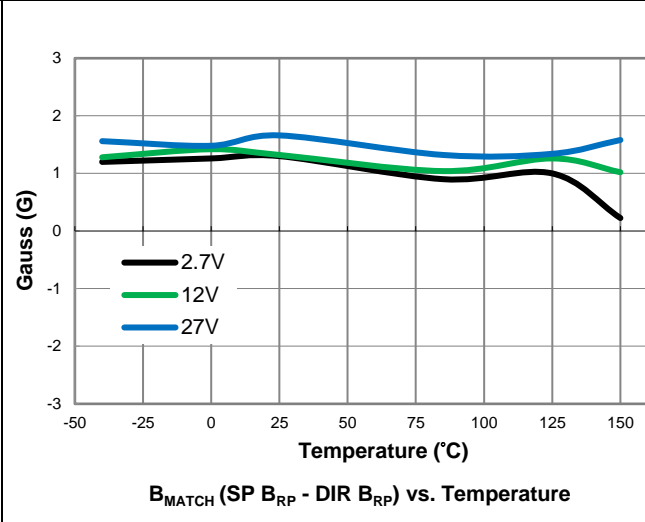
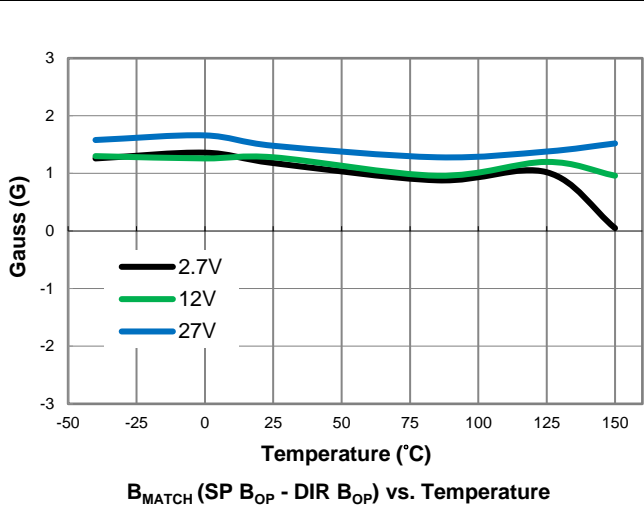


**AH3976Q Magnetic Characteristics**

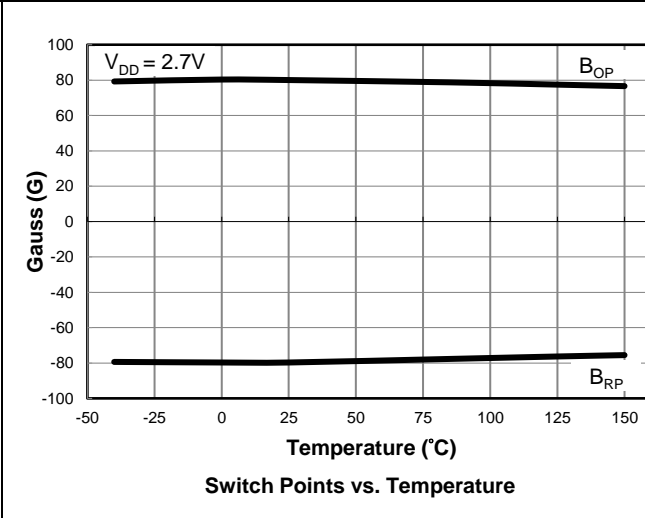
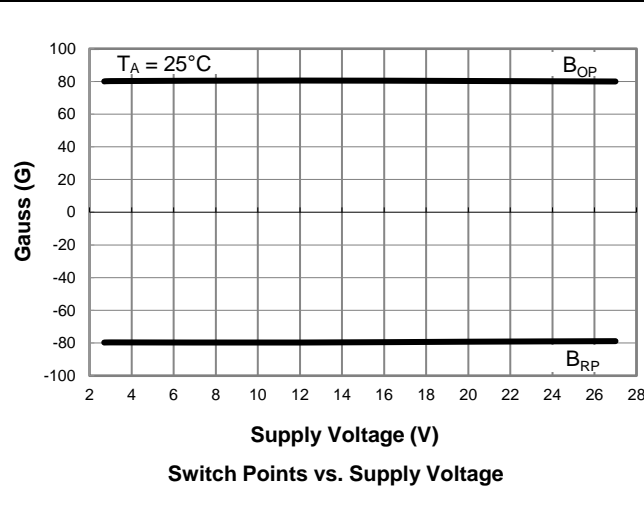


**Performance Characteristics** (continued)

**AH3976Q Magnetic Characteristics** (continued)

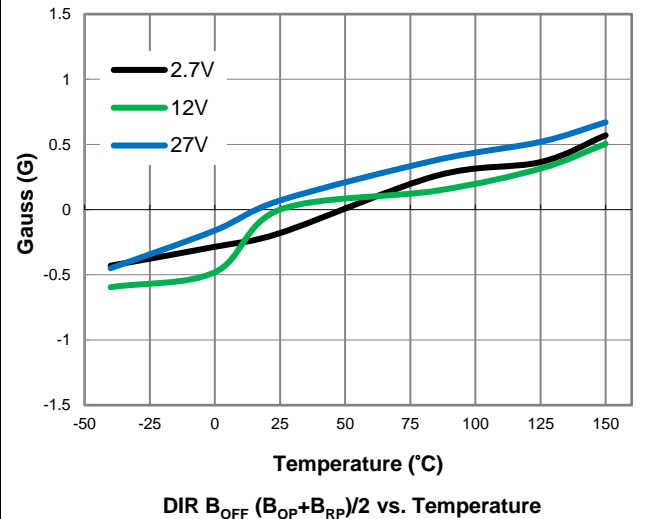
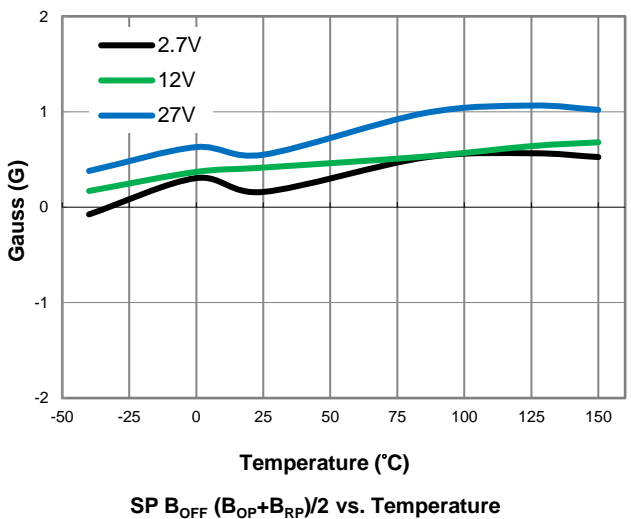
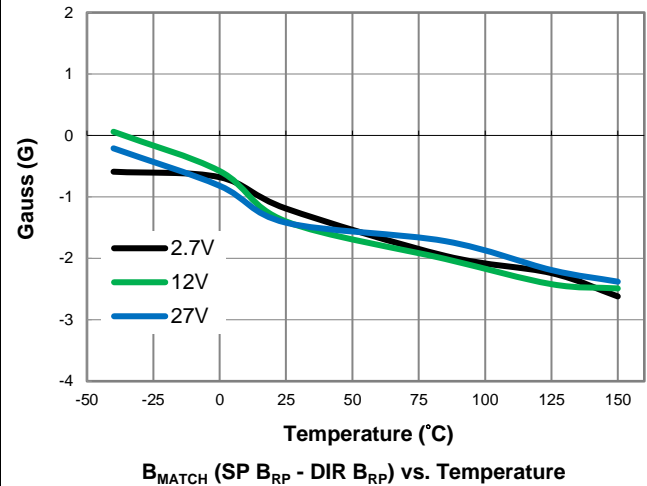
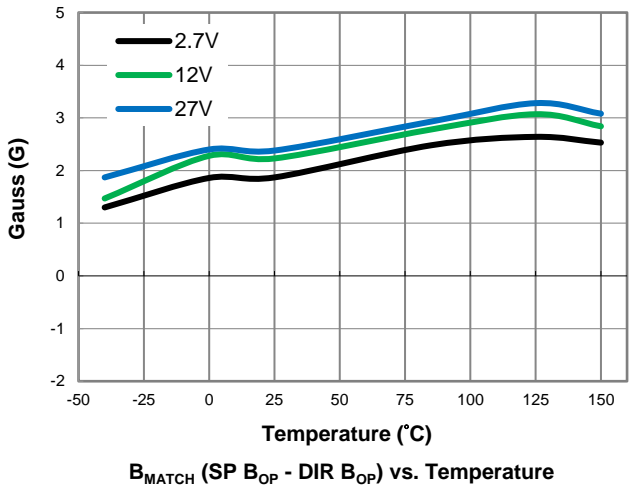
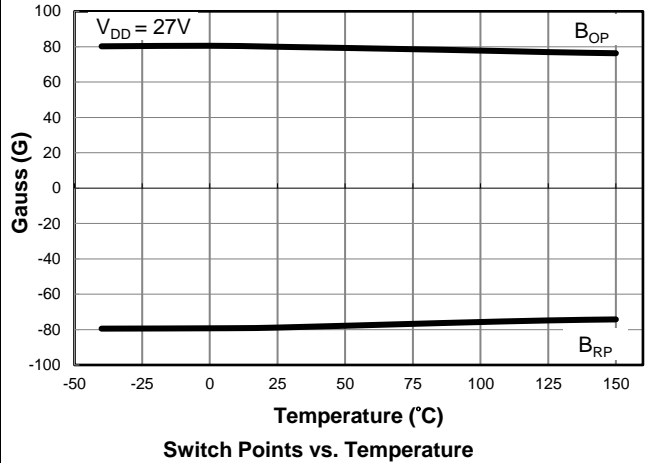
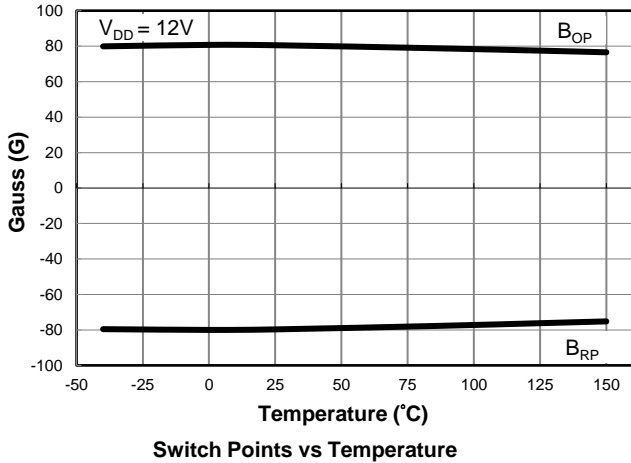


**AH3977Q Magnetic Characteristics**



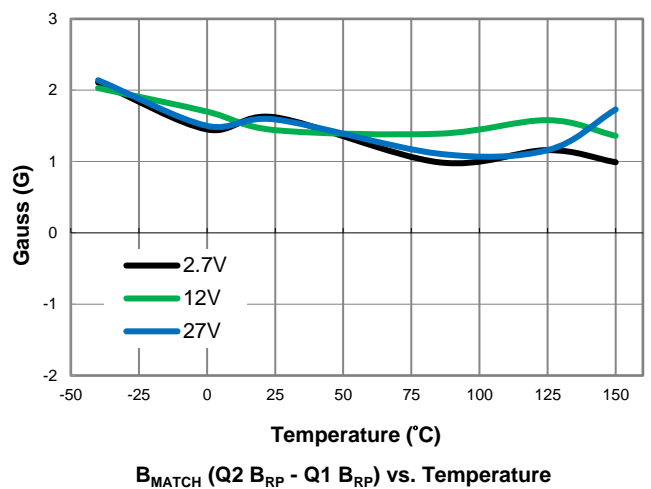
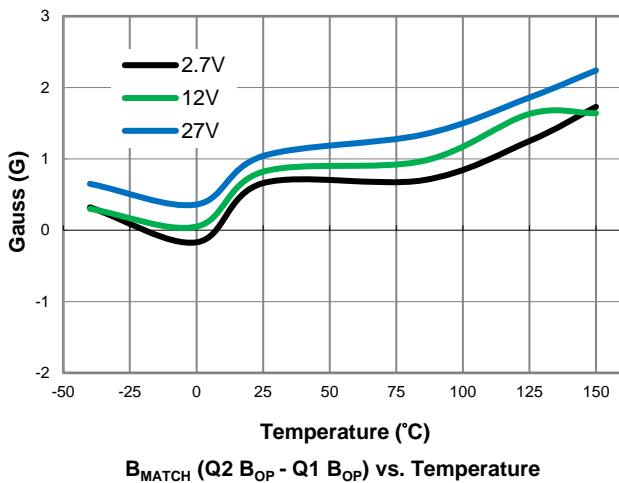
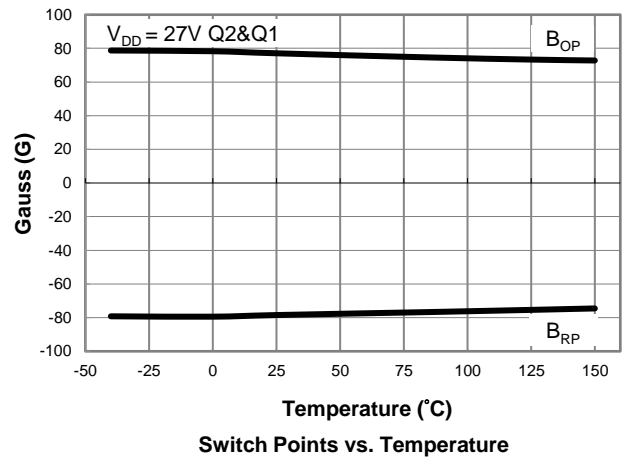
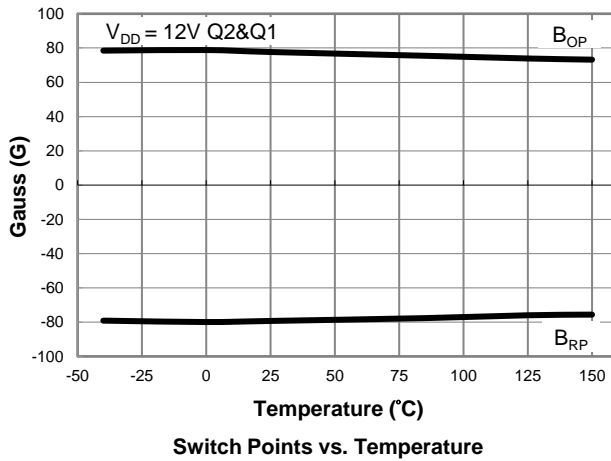
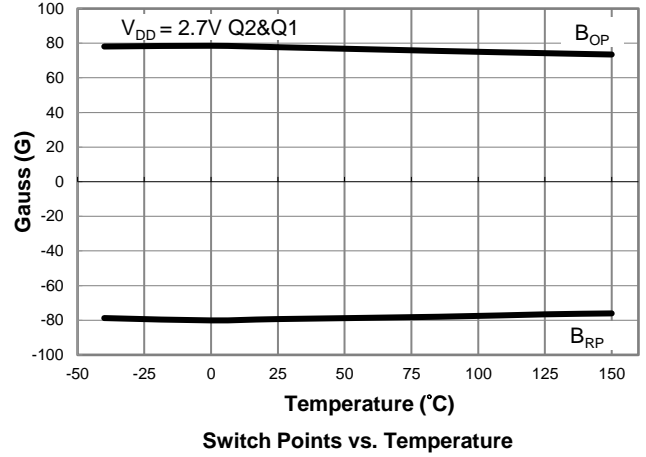
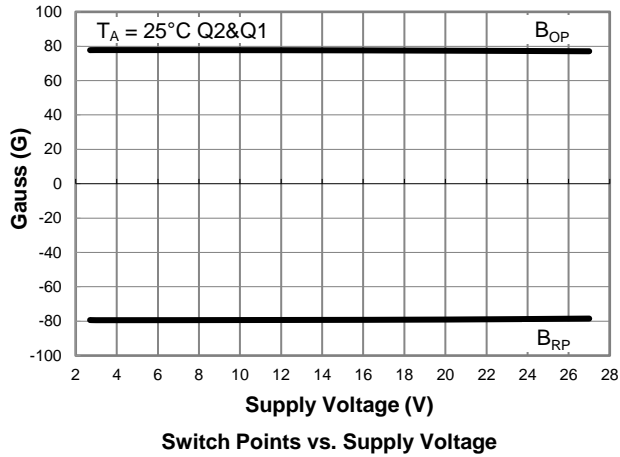
**Performance Characteristics** (continued)

**AH3977Q Magnetic Characteristics** (continued)

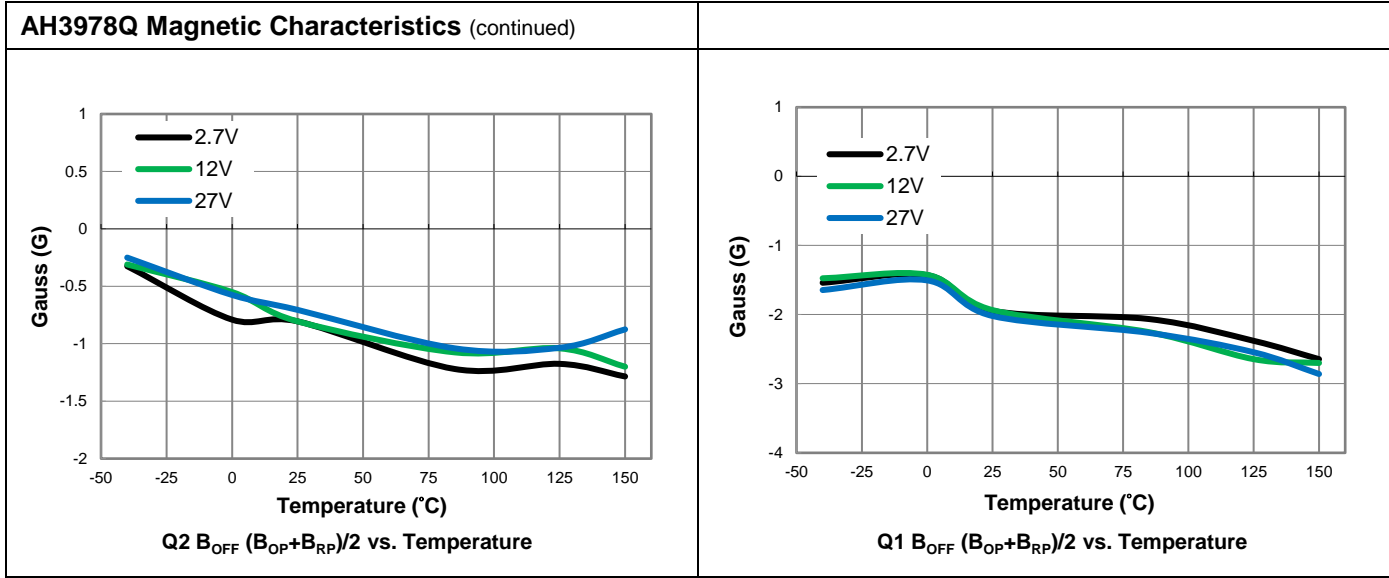


**Performance Characteristics** (continued)

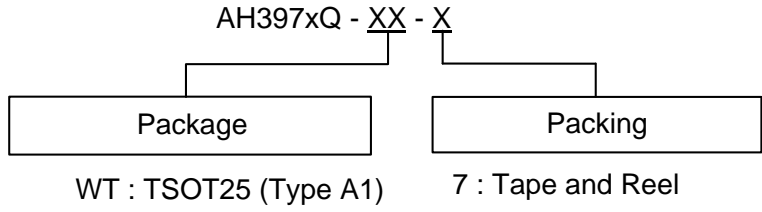
**AH3978Q Magnetic Characteristics**



**Performance Characteristics** (continued)



### Ordering Information

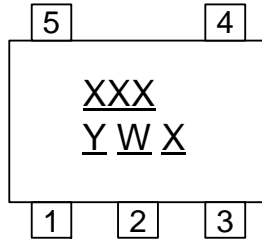


| Part Number  | Part Number Suffix | Package Code | Package          | Packing |                  |
|--------------|--------------------|--------------|------------------|---------|------------------|
|              |                    |              |                  | Qty.    | Carrier          |
| 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)



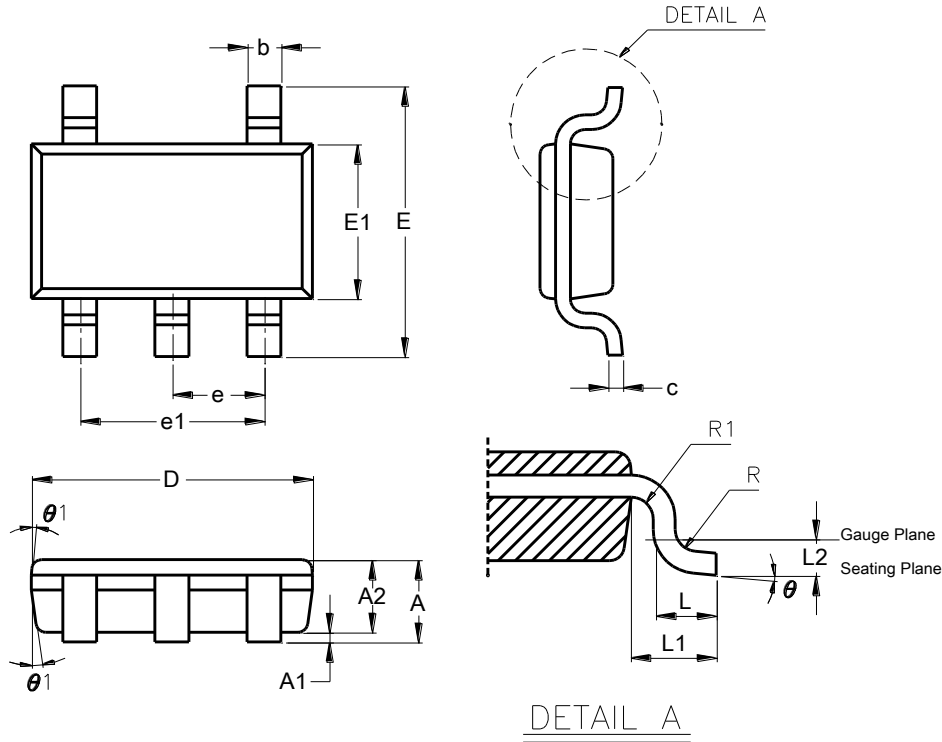
- XXX : Identification Code
- Y : Year 0 to 9 (ex: 3 = 2023)
- W : Week : A to Z : week 1 to 26;  
a to z : week 27 to 52; z represents week 52 and 53
- X : Internal Code

| 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                 |

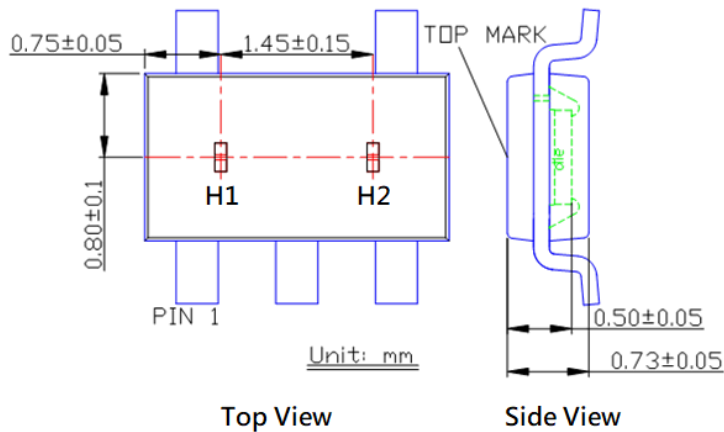
**Package Outline Dimensions**

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°   |
| All Dimensions in mm |           |       |       |



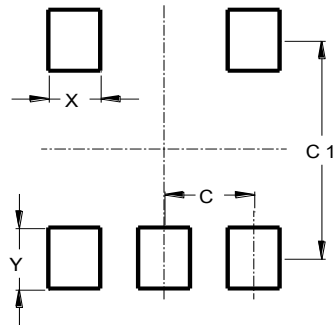
**Sensor Location**



**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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