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 wide range of 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.

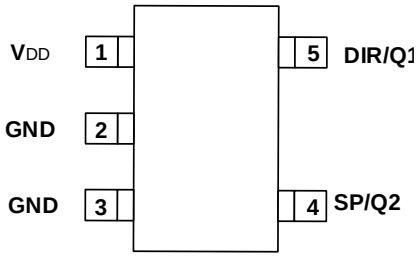
In the occasion of a supply voltage drop to minimum threshold point, undervoltage lockout protection would be triggered to freeze the device, which prevents the electrical malfunction from affecting the next magnetic measurement circuits, and the output current state updated is always based on the proper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

Pin Assignments

(Top View)



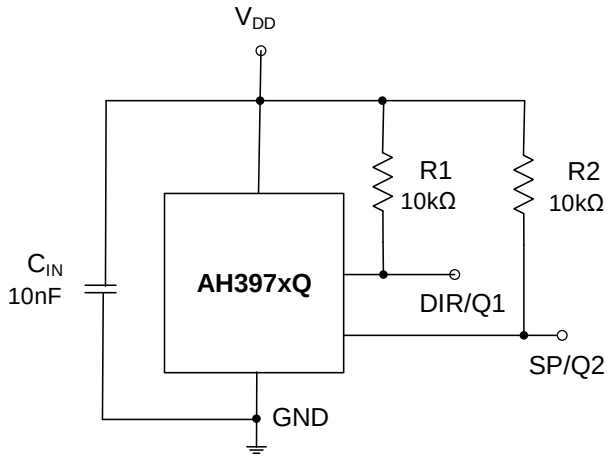
TSOT25 (Type A1)

Applications

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

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.

Typical Applications Circuit

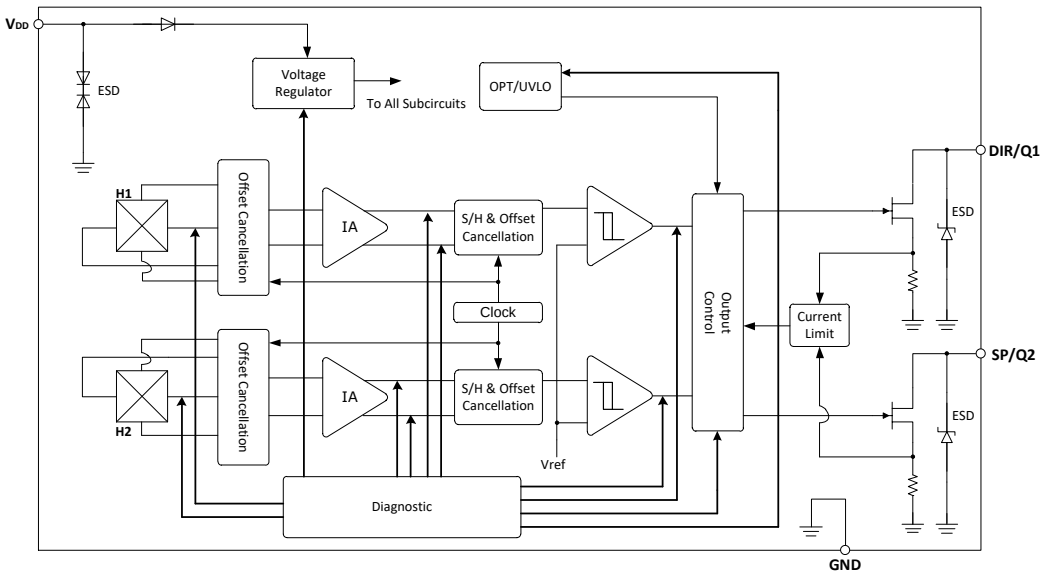


Pin Descriptions

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	V_{DD}		Supply voltage input
2	GND		Ground
3	GND		Ground

Functional Block Diagram



Absolute Maximum Ratings (Note 4) (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Rating	Unit
V_{DD} (Note 5)	Supply voltage	40	V
V_{DDR} (Note 5)	Reverse supply voltage	-18	V
I_{DD}	Supply current	50	mA
I_{DDR}	Reverse supply current	-50	mA
I_{OUT}	Output current	50	mA
I_{OUTR}	Reverse output current	-50	mA
B	Magnetic flux density	Unlimited	GS
T_A	Operation ambient temperature	-40 to +150	°C
T_J	Maximum junction temperature	+180	°C
T_S	Storage temperature	-55 to +180	°C
ESD (HBM)	ESD (Human Body Model)	5000	V
ESD (CDM)	ESD (Charged Device Model)	2000	V

Notes: 4. 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.
5. Should not be exceeding the maximum junction temperature and maximum duration of 500ms.

Recommended Operating Conditions (@T_A = -40°C to +150°C, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Max	Unit
V_{DD}	Supply voltage	Operating	2.7	27	V
T_{OP}	Operating temperature	Operating	-40	+150	°C

Electrical Characteristics (Note 6) (@T_A = -40°C to +150°C, V_{DD} = 2.7V to 27V, 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} = 2.7V to 27V	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} = -18V, T_A = -40°C to +150°C	-1.5	—	—	mA
V_{Osat}	Output saturation voltage	B > B_{OP}, I_{OUT} = 10mA	—	0.2	0.5	V
I_{LEK}	Output leakage current	V_{OUT} = 12V, V_{DD} = 12V, B < B_{RP}	—	0.1	1	µA
I_{LIM}	Output current limit	Output on	11	25	44	mA
T_{TP}	Thermal protection threshold	Junction temperature	+165	+180	—	°C
T_{TPR}	Thermal protection release threshold	Junction temperature	—	+155	—	°C
f_M	Maximum switching frequency*	B > 3 x B_{OP}, alternative square magnet field	40	60	—	kHz
f_C	Chopping frequency*	—	—	500	—	kHz
t_{PON}	Power on time (Note 7)	V_{DD} = 12V, dV_{DD}/dt > 2.7V/µs	—	13	—	µs
t_R	Output rise time*	V_{DD} = 12V, pullup resistor 1kΩ, C_L = 50pF	—	0.2	1	µs
t_F	Output fall time*	V_{DD} = 12V, pullup resistor 1kΩ, C_L = 50pF	—	0.2	1	µs
t_D	Response delay time (Note 8)	B > 3 x B_{OP}	—	13	—	µs
t_{DC}	Count signal delay (Note 6)	—	50	400	1000	ns
t_J	Output jitter (Note 6)	—	—	±5	—	μs_{RMS}
d_{HALL}	Hall plate distance	—	—	1.45	—	mm
V_Z	Zener clamp voltage	I_{DD} = 8mA, T_A = +25°C	36	—	—	V

* Guaranteed by design.

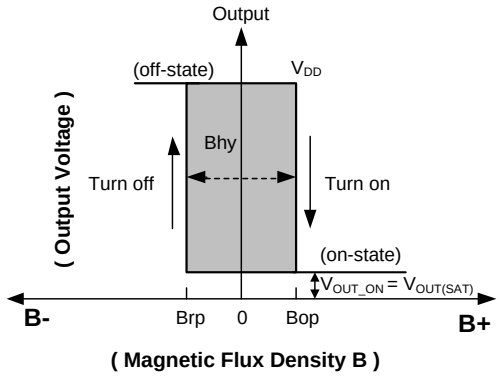
Notes:
6. Typical values are defined at T_A = +25°C, V_{DD} = 12V. Maximum and minimum values over the operating temperature range are not tested in production but guaranteed by design, process control and characterization.
7. Time from applying V_{DD} ≥ 2.7V to the sensor until the output state is valid.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

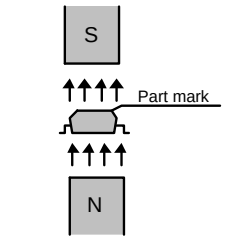
Magnetic Characteristics (Notes 6, 9) (T_A = -40°C to +150°C, V_{DD} = 2.7V to 27V, unless otherwise specified.)

Part Name	Operating Point B_{OP} (Gauss)			Release Point B_{RP} (Gauss)			Hysteresis B_{HYS} (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	SPD	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

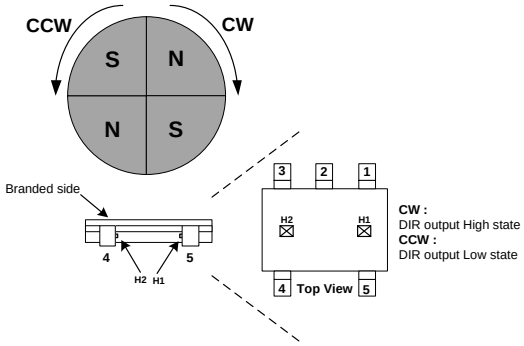
Notes: 9. Positive x-axis direction indicates the south pole approaching the part marking surface i.e. increasing south pole magnetic field strength to the sensor; reversing direction x-axis toward 0 means the decreasing south magnetic field strength to the sensor. Negative x-axis indicates north pole magnetic field to the part marking surface.

10. T_A = +25°C, V_{DD} = 2.7V to 27V.



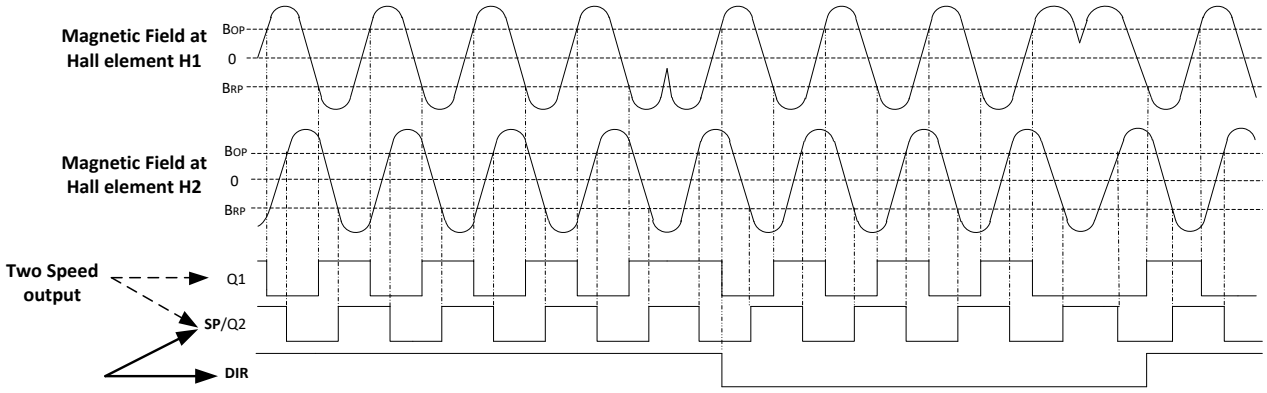


TSOT25 (Type A1)

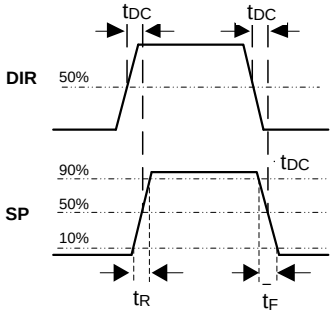


Operating Characteristics

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

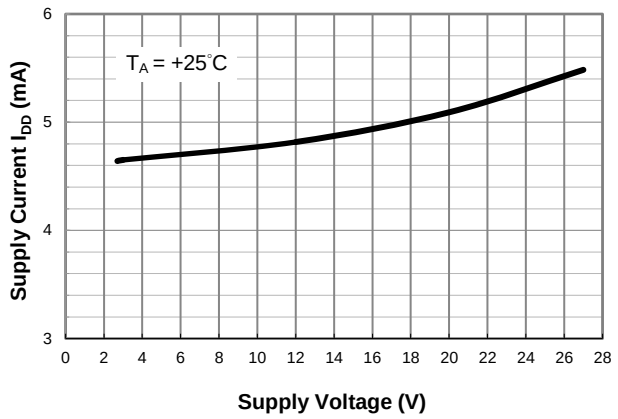


Count Signal Delay t_{DC}

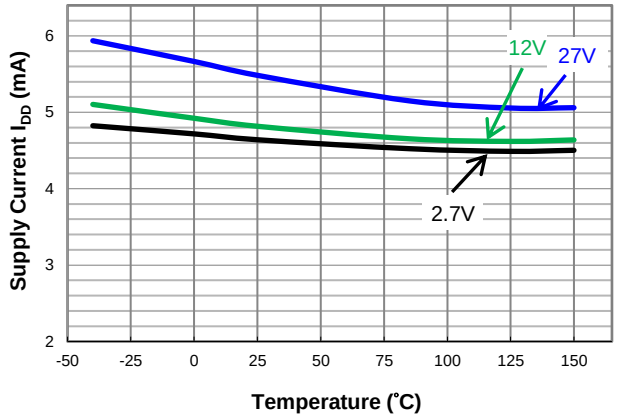


Performance Characteristics

Supply Current I_{DD}

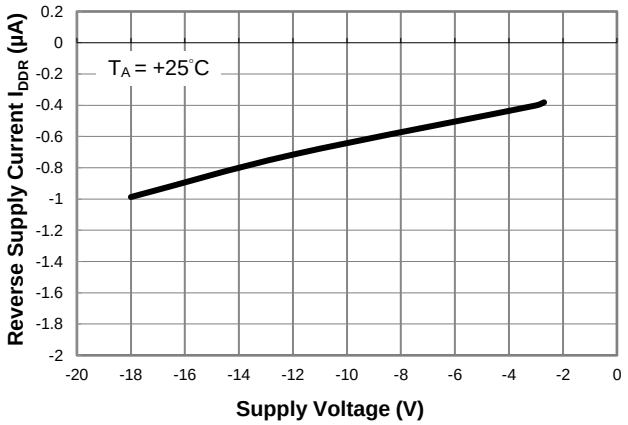


Operation Current vs. Supply Voltage

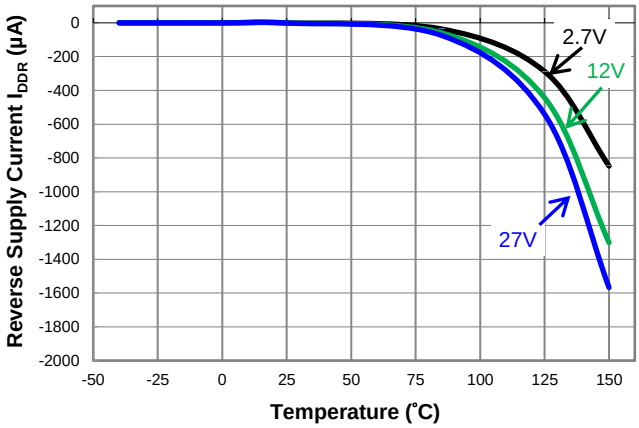


Operation Current vs. Temperature

Reverse Supply Current I_{DDR}

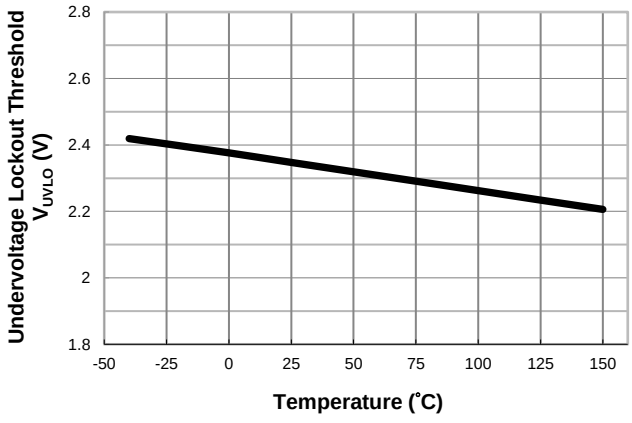


Reverse Current vs. Supply Voltage



Reverse Current vs. Temperature

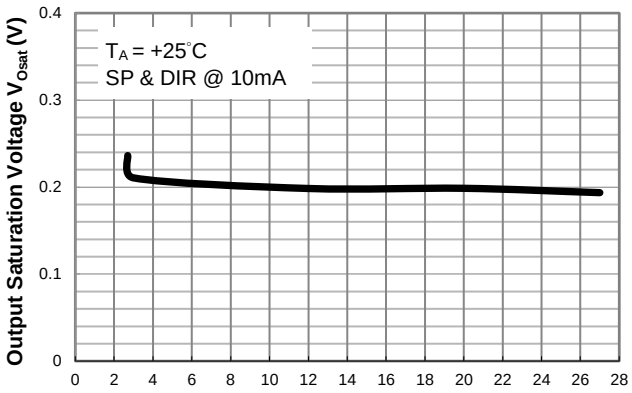
Undervoltage Lockout Threshold



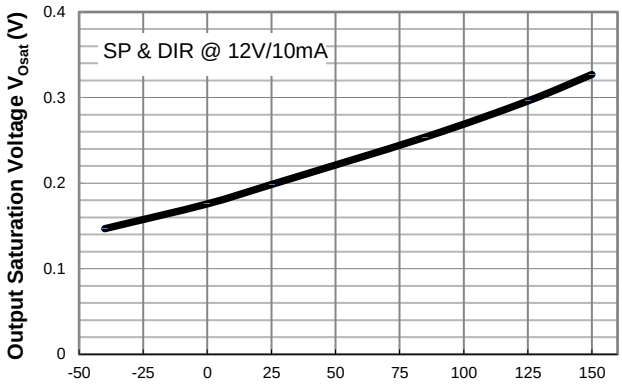
V_{UVLO} vs. Temperature

Performance Characteristics (continued)

Output Saturation Voltage V_{Osat}

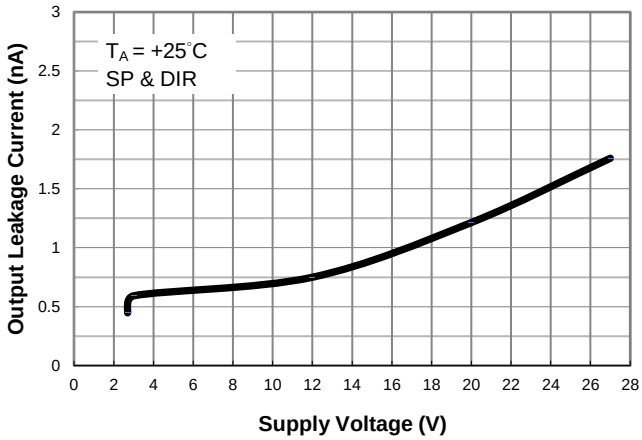


V_{Osat} vs. Supply Voltage

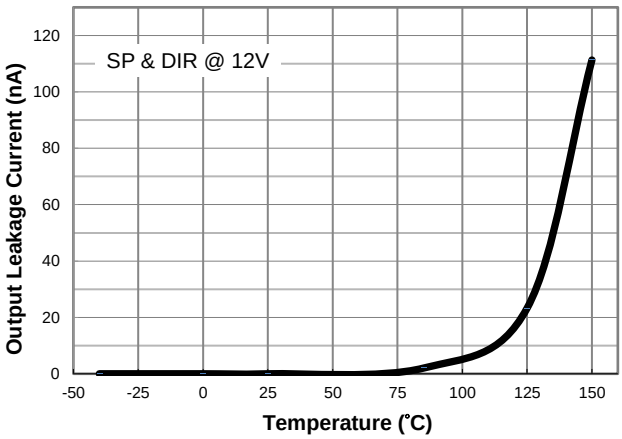


V_{Osat} vs. Temperature

Output Leakage Current I_{LEK}

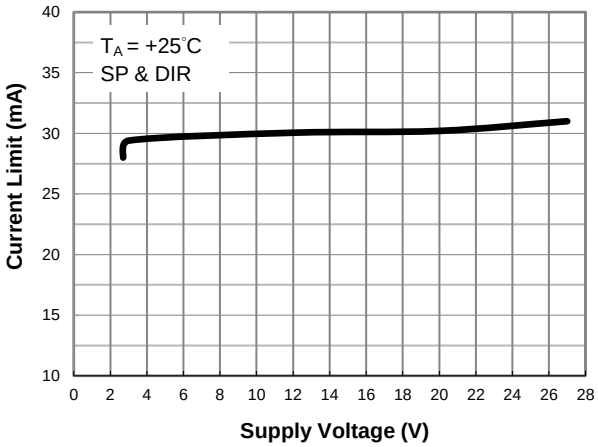


I_{LEK} vs. Supply Voltage

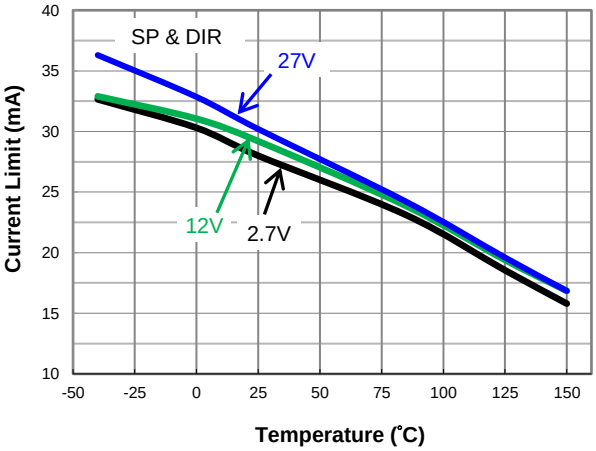


I_{LEK} vs. Temperature

Output Current Limit I_{LIM}



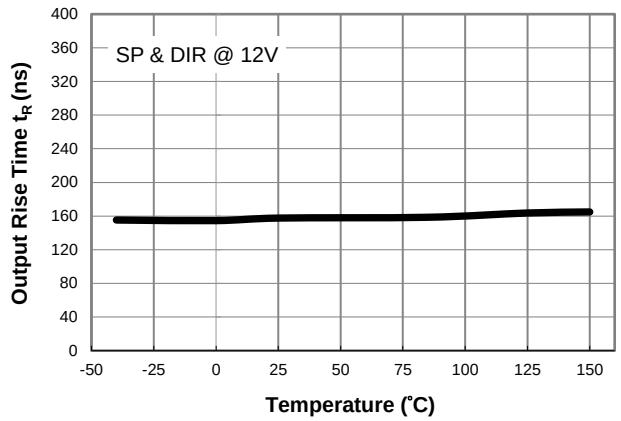
Current Limit vs. Supply Voltage



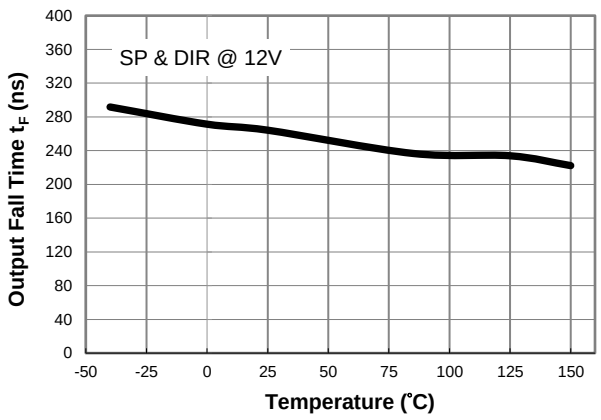
Current Limit vs. Temperature

Performance Characteristics (continued)

Output Rise Time t_R & Output Fall Time t_F

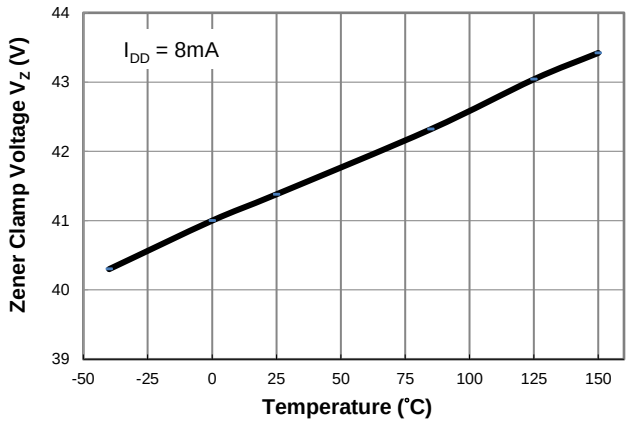


Output Rise Time t_R vs. Temperature



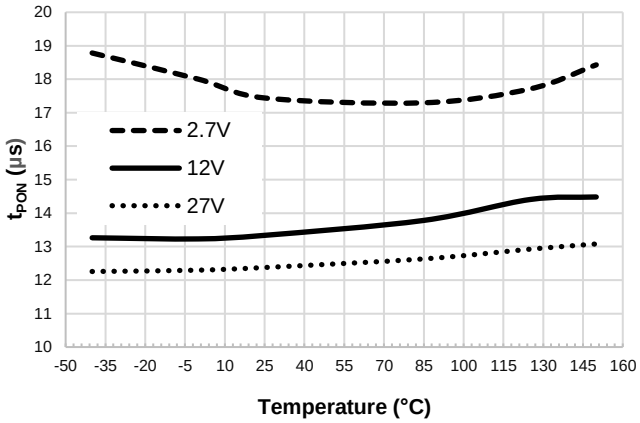
Output Fall Time t_F vs. Temperature

Zener Clamp Voltage V_Z



Zener Clamp Voltage V_Z vs. Temperature

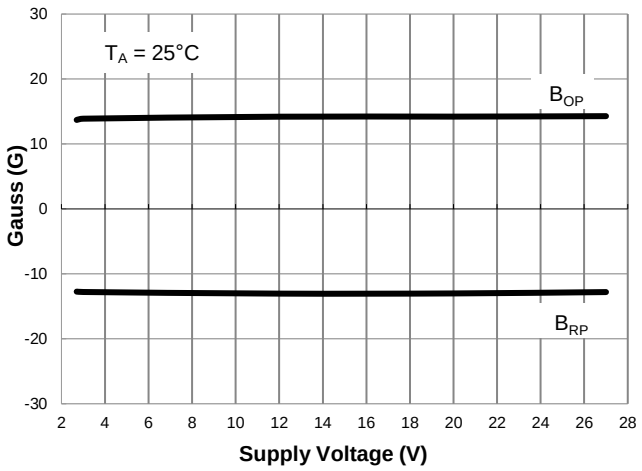
Power On Time t_{PON}



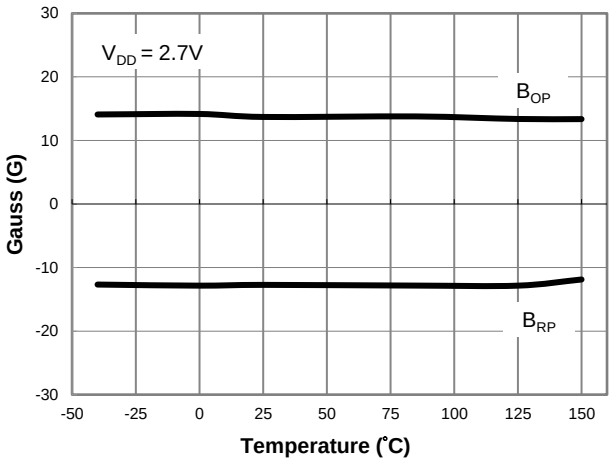
t_{PON} vs. Temperature

Performance Characteristics (continued)

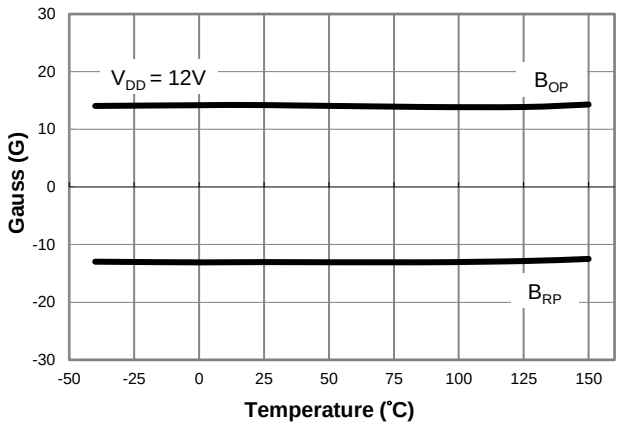
AH3975Q Magnetic Characteristics



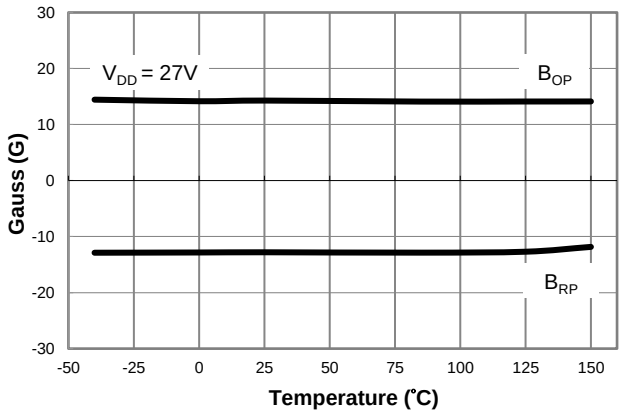
Switch Points vs. Supply Voltage



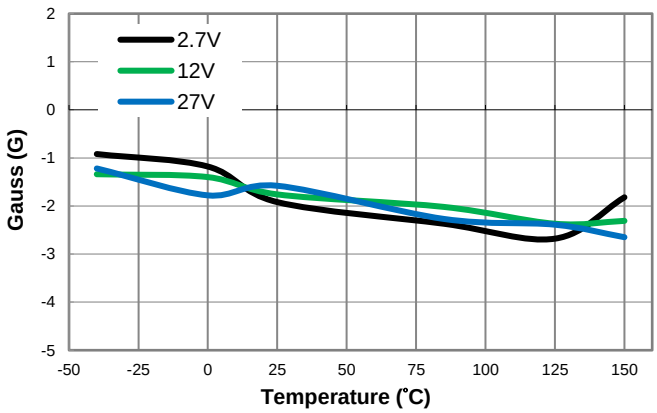
Switch Points vs. Temperature



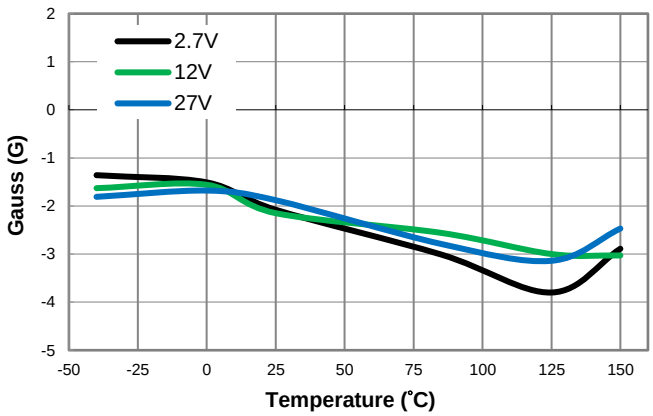
Switch Points vs. Temperature



Switch Points vs. Temperature



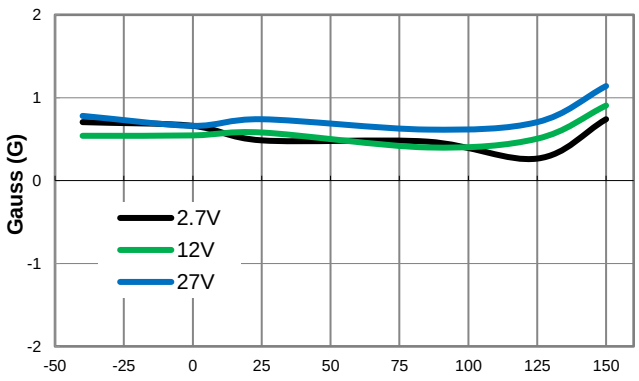
B_{MATCH} (SP B_{OP} - DIR B_{OP}) vs. Temperature



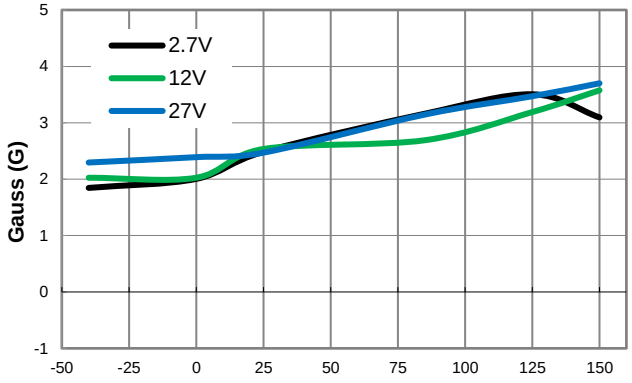
B_{MATCH} (SP B_{RP} - DIR B_{RP}) vs. Temperature

Performance Characteristics (continued)

AH3975Q Magnetic Characteristics (continued)

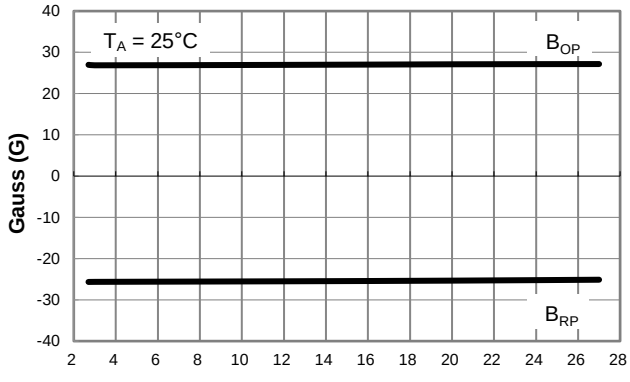


SP B_{OFF} (B_{OP}+B_{RP})/2 vs. Temperature

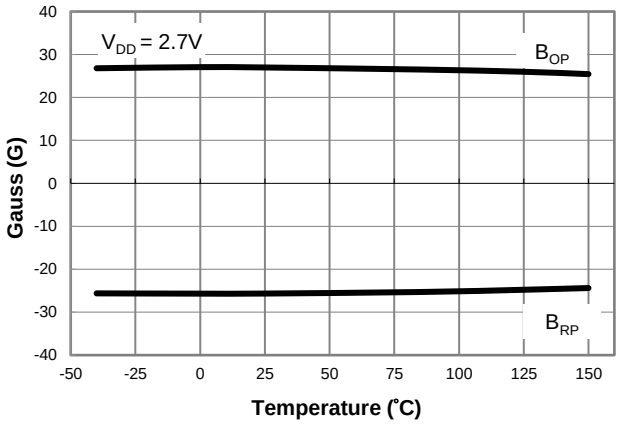


DIR B_{OFF} (B_{OP}+B_{RP})/2 vs. Temperature

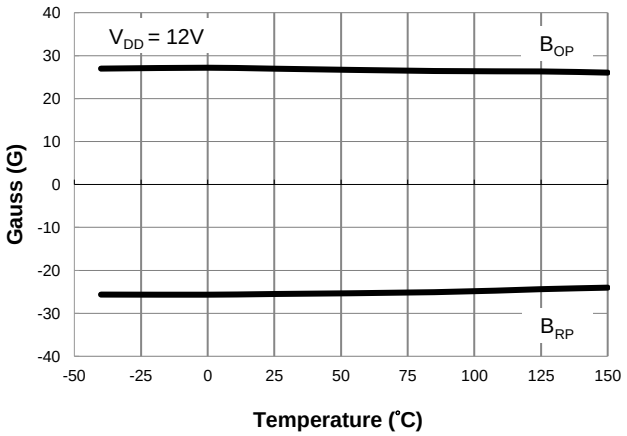
AH3976Q Magnetic Characteristics



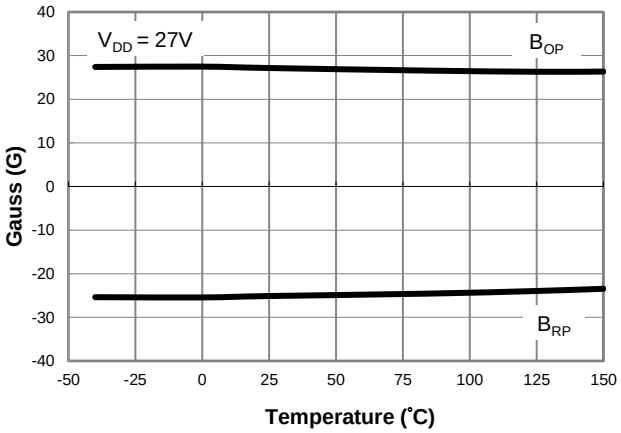
Switch Points vs. Supply Voltage



Switch Points vs. Temperature



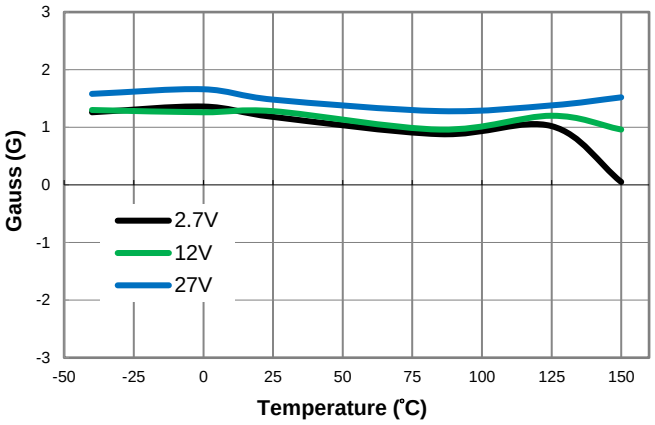
Switch Points vs. Temperature



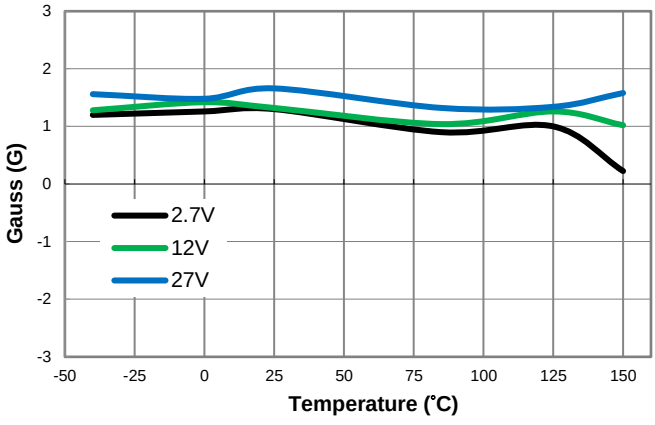
Switch Points vs. Temperature

Performance Characteristics (continued)

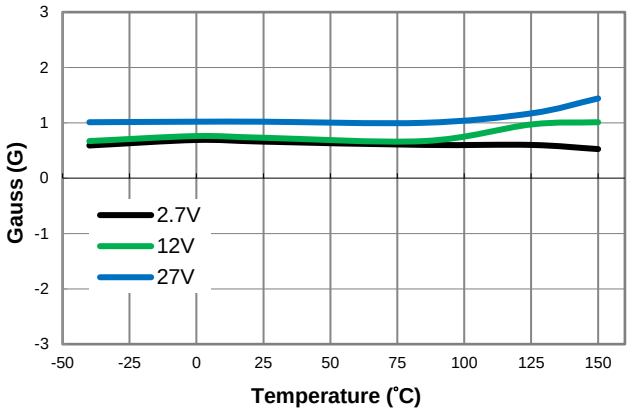
AH3976Q Magnetic Characteristics (continued)



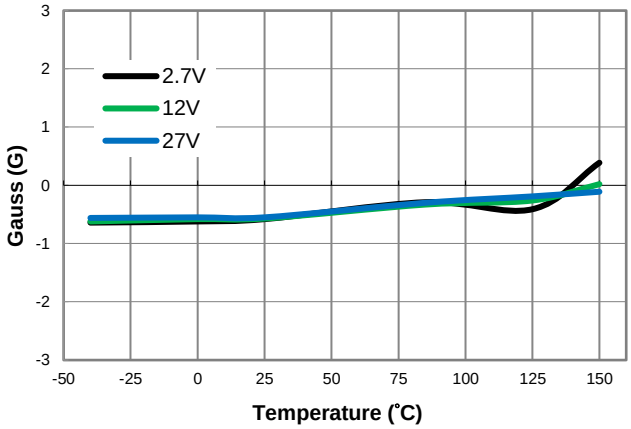
B_{MATCH} (SP B_{OP} - DIR B_{OP}) vs. Temperature



B_{MATCH} (SP B_{RP} - DIR B_{RP}) vs. Temperature

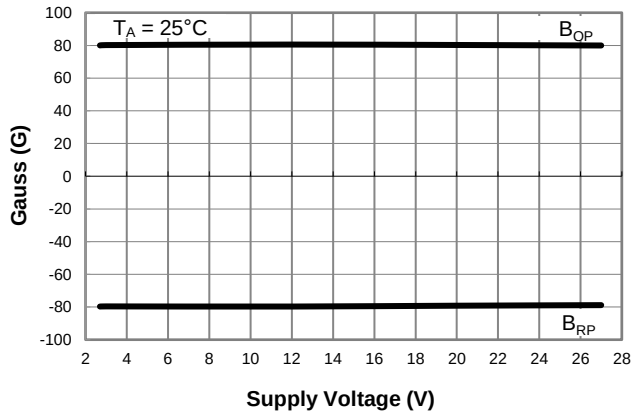


SP B_{OFF} (B_{OP}+B_{RP})/2 vs. Temperature

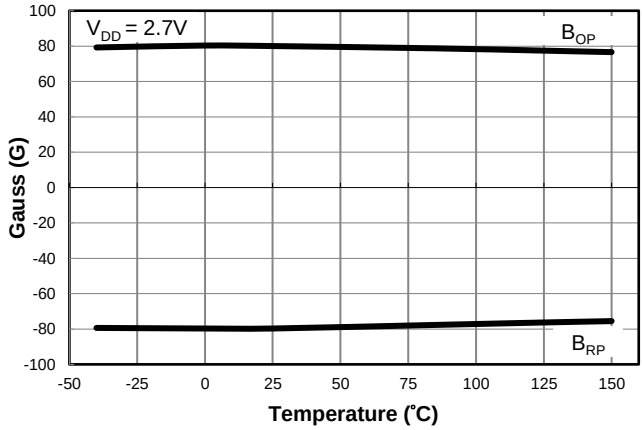


DIR B_{OFF} (B_{OP}+B_{RP})/2 vs. Temperature

AH3977Q Magnetic Characteristics



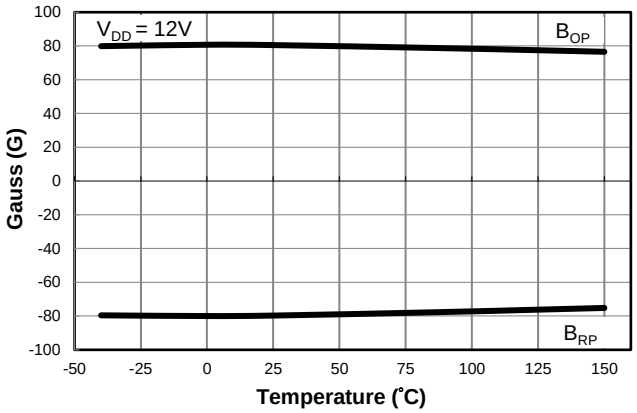
Switch Points vs. Supply Voltage



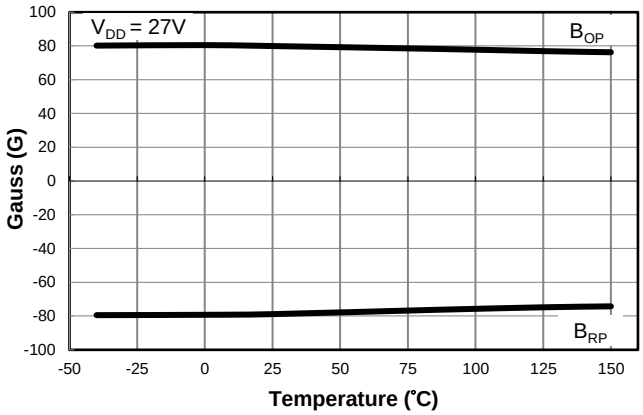
Switch Points vs. Temperature

Performance Characteristics (continued)

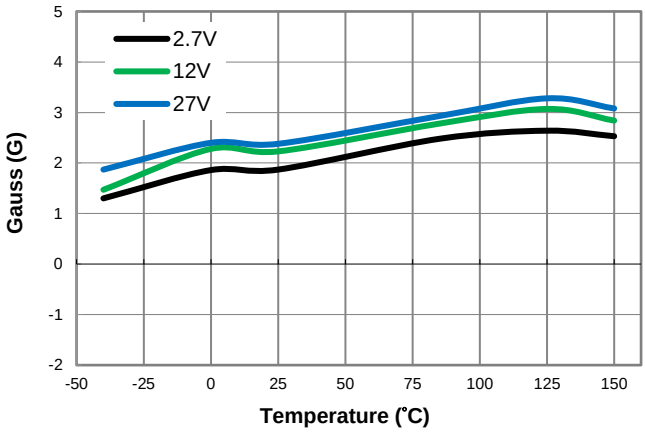
AH3977Q Magnetic Characteristics (continued)



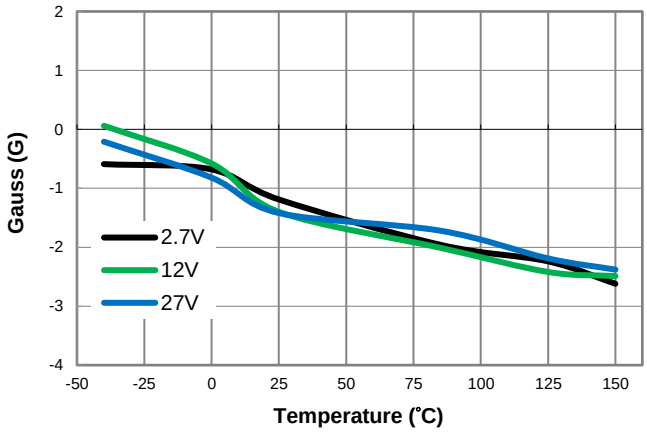
Switch Points vs Temperature



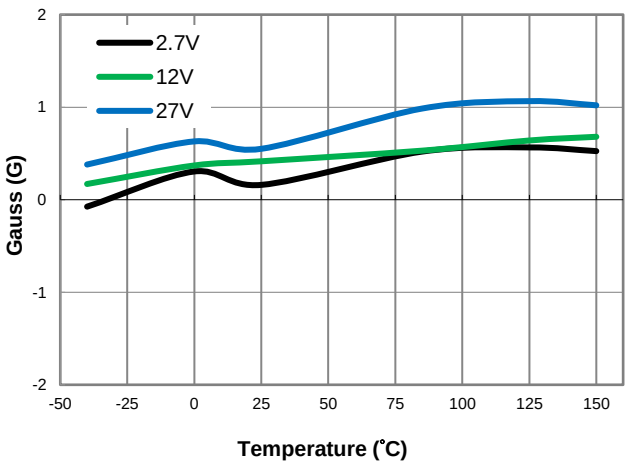
Switch Points vs. Temperature



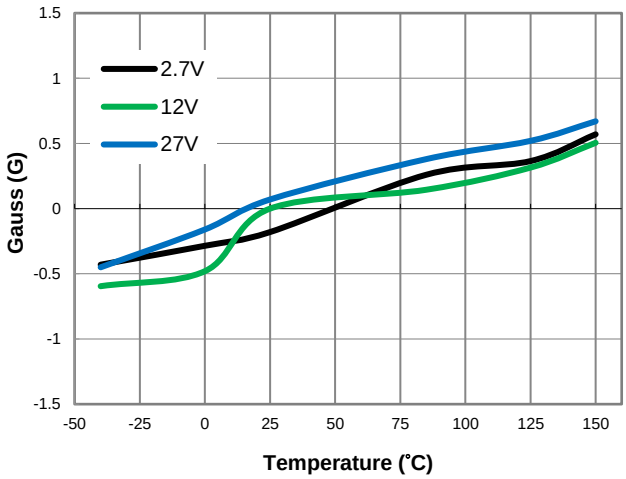
B_{MATCH} (SP B_{OP} - DIR B_{OP}) vs. Temperature



B_{MATCH} (SP B_{RP} - DIR B_{RP}) vs. Temperature



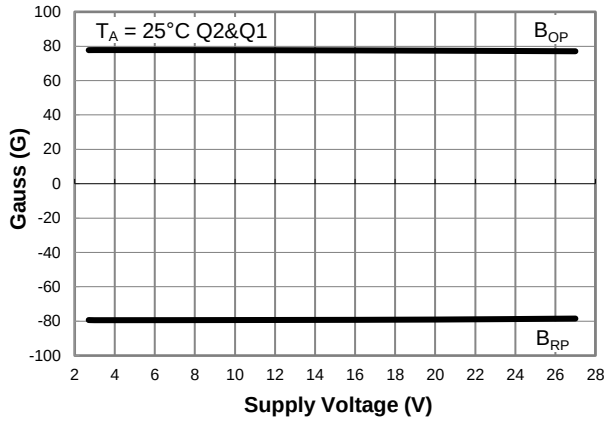
SP B_{OFF} (B_{OP}+B_{RP})/2 vs. Temperature



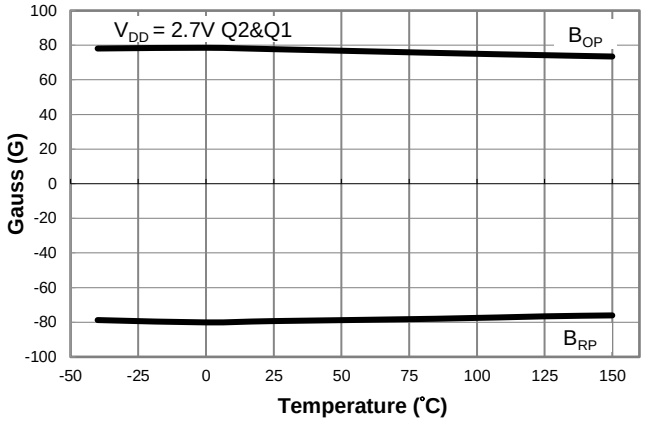
DIR B_{OFF} (B_{OP}+B_{RP})/2 vs. Temperature

Performance Characteristics (continued)

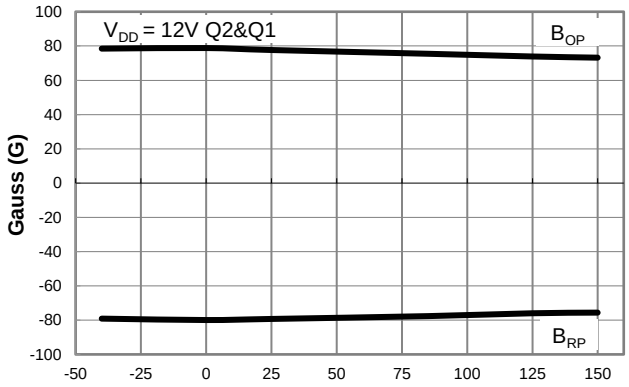
AH3978Q Magnetic Characteristics



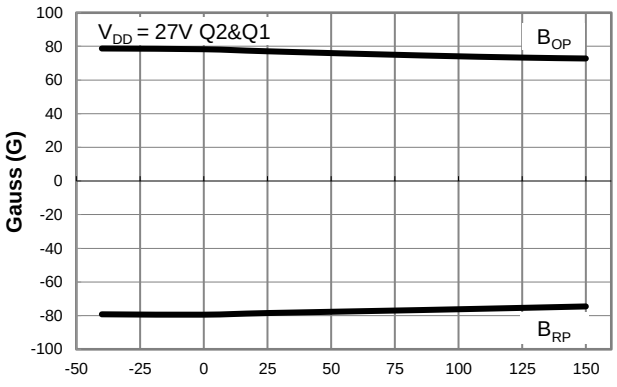
Switch Points vs. Supply Voltage



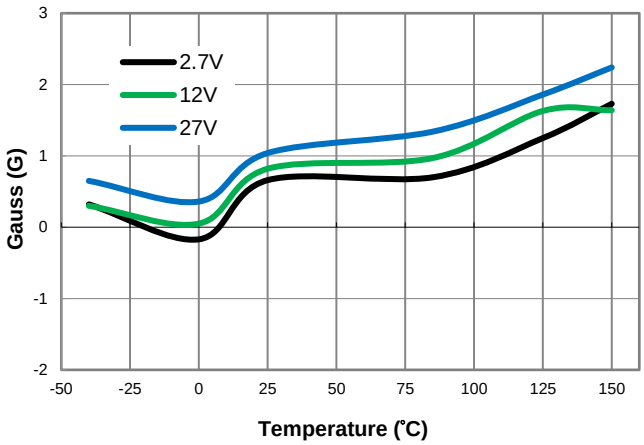
Switch Points vs. Temperature



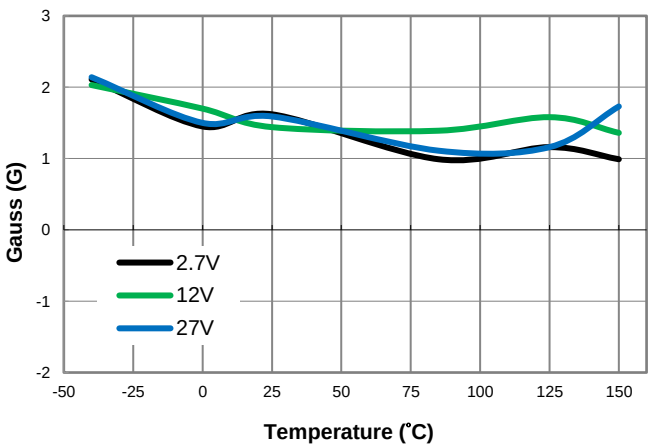
Switch Points vs. Temperature



Switch Points vs. Temperature



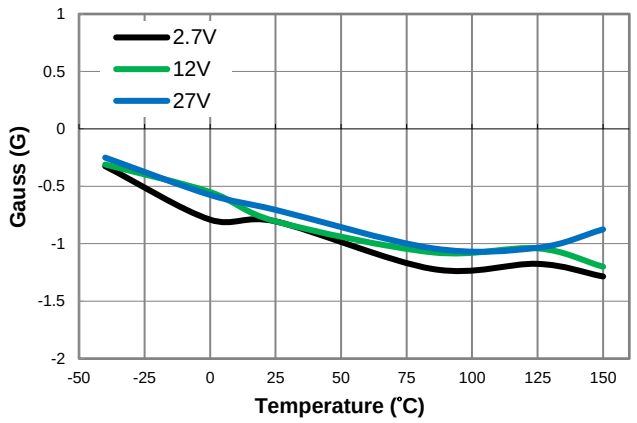
B_{MATCH} (B_{OP} Q2 - B_{OP} Q1) vs. Temperature



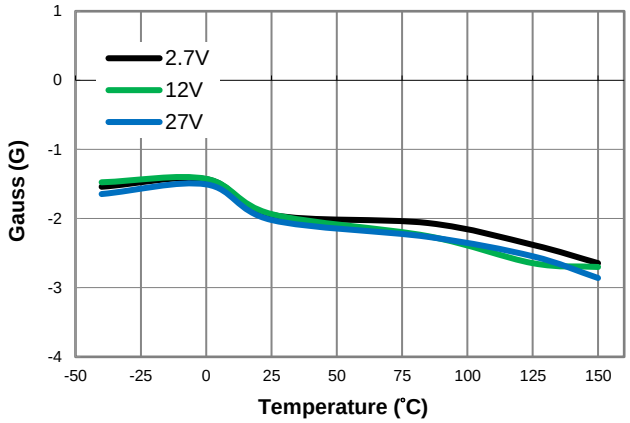
B_{MATCH} (B_{RP} Q2 - B_{RP} Q1) vs. Temperature

Performance Characteristics (continued)

AH3978Q Magnetic Characteristics (continued)

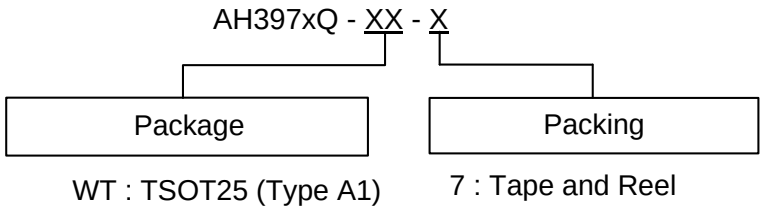


Q2 B_{OFF} (B_{OP}+B_{RP})/2 vs. Temperature



Q1 B_{OFF} (B_{OP}+B_{RP})/2 vs. Temperature

Ordering Information

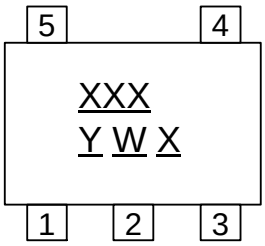


Part Number	Part Number Suffix	Package Code	Package	Packing	
				Qty.	Carrier
AH3975Q-WT-7	-7	WT	TSOT25 (Type A1)	3000	7” Tape and Reel
AH3976Q-WT-7	-7	WT	TSOT25 (Type A1)	3000	7” Tape and Reel
AH3977Q-WT-7	-7	WT	TSOT25 (Type A1)	3000	7” Tape and Reel
AH3978Q-WT-7	-7	WT	TSOT25 (Type A1)	3000	7” Tape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

Marking Information

Package Type: TSOT25 (Type A1)

(Top View)



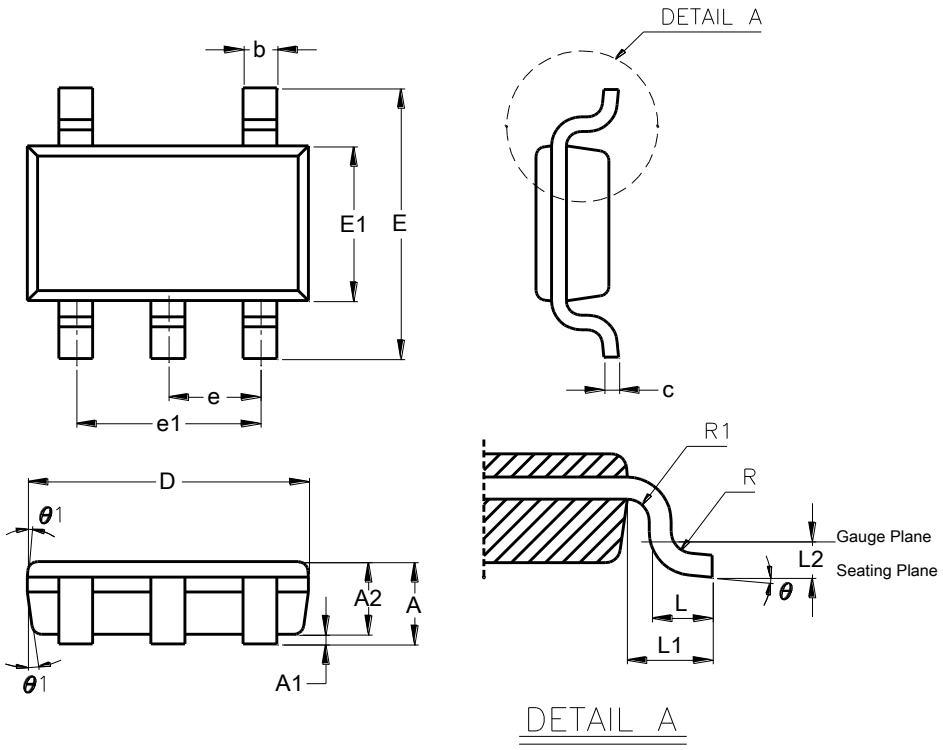
XXX : Identification Code
Y : Year 0 to 9 (ex: 3 = 2023)
W : Week : A to Z : week 1 to 26;
a to z : week 27 to 52; z represents week 52 and 53
X : Internal Code

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

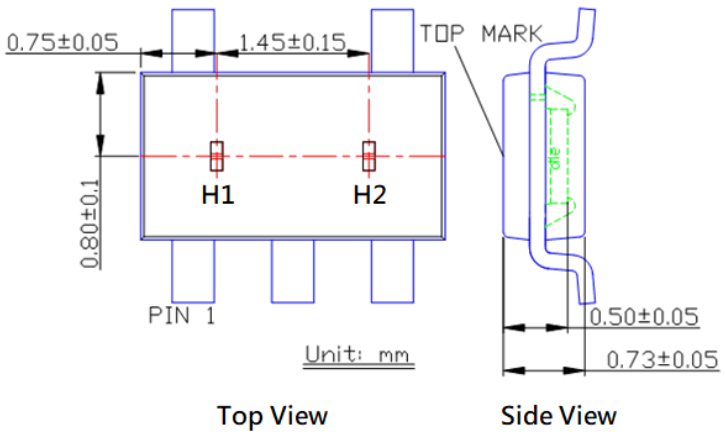
Package Outline Dimensions

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	--	--
θ	0°	8°	4°
θ1	4°	12°	10°
All Dimensions in mm			

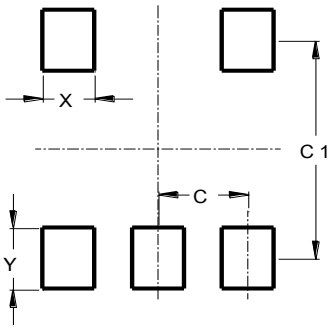


Sensor Location

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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