## Description

The DIODES™ ZXBM5408Q is a protected H-Bridge driver designed specifically for automotive manual headlight beam control and industrial servo control applications with DC-brush motor loads. The integrated full-bridge driver output stage is composed of high-current, low-$R_{DS(on)}$ H-bridge MOSFETs to maximize efficiency.

To simplify the circuit design and minimize external components, the device integrates voltage and temperature compensated internal references, amplifiers, and output H-bridge power switches with low $R_{DS(on)}$.

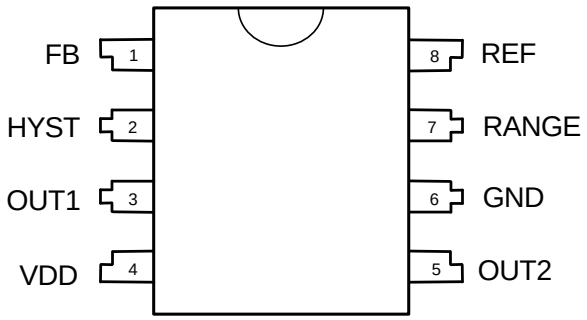
For system flexibility, the servo control forward and reverse hysteresis, deadband, and angle amplification are easily programmable by external resistors.

To help protect the motor coil, the ZXBM5408Q provides fault condition protection, such as RANGE input short to GND, short-to-supply voltage, or broken wires, by stopping the motor and disconnecting the output stage. In case of supply undervoltage and overvoltage, the device shuts down the output drive to help prevent overvoltage stress on the coil. The overcurrent protection monitors the output current and shuts down the outputs stage with periodic retry to help protect the coil from device burnout. Overtemperature shutdown provides thermal protection for the device.

The ZXBM5408Q is available in the industry standard PDIP-8 (Type A1) and SO-14 (Type A1) packages and is qualified to AEC-Q100 Grade 1 and is automotive compliant supporting PPAPs.

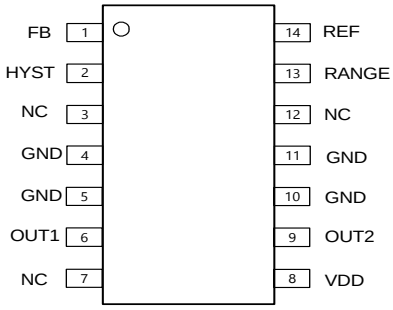
## Pin Assignments

**(Top View)**




**PDIP-8 (Type A1)**

**(Top View)**




**SO-14 (Type A1)**

## Features

- Servo DC Motor Drive
- Wide Operating Voltage Range: 8V to 18V
- Built-In H-Bridge with Low $R_{DSON}$ Resistance
- Output Drive Current capability of 0.8A (Peak Current of 1.5A)
- Fault Protection—RANGE Short to GND, Supply or Broken Wires
- Overvoltage and Undervoltage Shutdown
- Overcurrent Protection
- Thermal Protection
- Green Molding in PDIP-8 (Type A1) and SO-14 (Type A1) packages
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **The ZXBM5408Q is suitable for automotive applications requiring specific change control; this part is AEC-Q100 qualified, PPAP capable, and manufactured in IATF 16949 certified facilities. https://www.diodes.com/quality/product-definitions/**

## Applications

- Automotive Headlight Position Servo Motor
- 8V/12V/18V Servo DC Motors

## Mechanical Data

- Moisture Sensitivity: Level 1 per JSD-020
- Terminal Finish – Matte Tin Plated Leads, Solderable per JEDEC-J-STD-002.
- Weight: ZXBM5408Q-N-U 0.496 grams (Approximate)
  ZXBM5408Q-S14-13 0.150 grams (Approximate)

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.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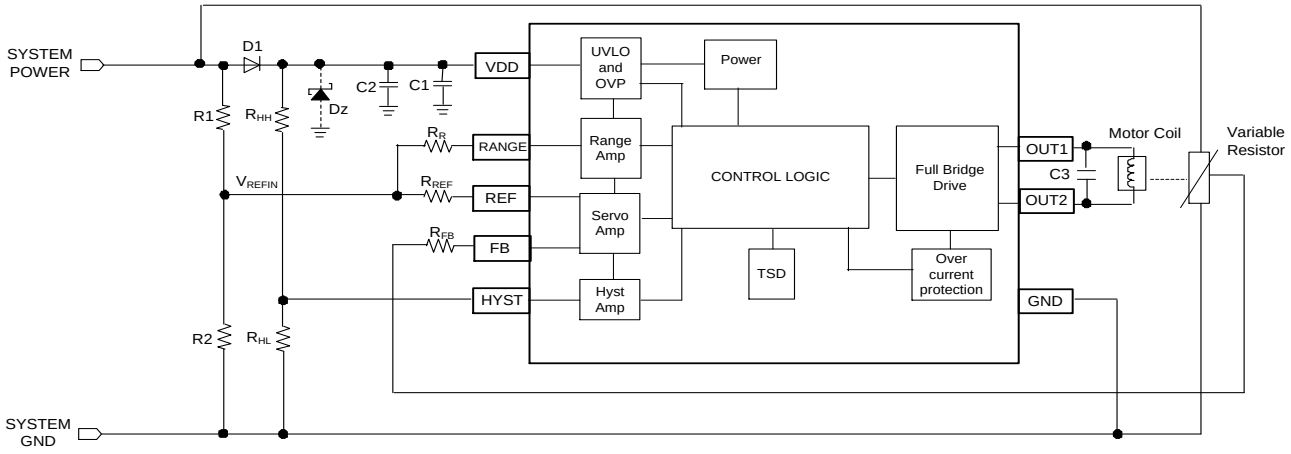
## Typical Applications Circuit (Notes 4, 5, 6, and 7)




Notes:
4. The C1 capacitor is for power stabilization and to strengthen the noise immunity, and the recommended value is 100nF. The capacitor is placed next to the VDD pin. The value of the capacitor can be optimized depending on the motor current. The value of C1 must be checked in the motor design in its operating conditions if reduced from the recommended value.
5. The C2 capacitor is for power supply filtering, and the recommended value is 47µF to 100µF. C3 is output motor noise decoupling capacitor, and the recommended value is 100nF (range of 10nF to 100nF). If strengthening OCP short function (O1 and O2 short directly), the recommended value of C2 is 10µF (range of 10µF to 20µF) for SMD type.
6. The resistor values R1 and R2 define the $V_{REFIN}$. The resistors $R_{HH}$ and $R_{HL}$ define the hysteresis window.
7. Diode D1 is for the reverse connection protection. The zener diode Dz is used to clamp the regenerative voltage spike from the motor operation to a safe level when reverse blocking diode D1 is used. If a reverse blocking diode is not used, the use of zener clamp Dz depends on the supply voltage capability to effectively sink the regenerative energy and voltage spike.

## Pin Descriptions

**1. Package Type: PDIP-8 (Type A1)**

| Pin Number | Pin Name | Description |
|---|---|---|
| 1 | FB | Position Feedback Input: Voltage Input |
| 2 | HYST | Hysteresis I/O |
| 3 | OUT1 | Output1 Drive Sourcing & Sinking Pin |
| 4 | VDD | Power Supply Input Pin |
| 5 | OUT2 | Output2 Drive Sourcing & Sinking Pin |
| 6 | GND | Ground Pin |
| 7 | RANGE | Range Input |
| 8 | REF | Reference Input |

**2. Package Type: SO-14 (Type A1)**

| Pin Number | Pin Name | Description |
|---|---|---|
| 1 | FB | Position Feedback Input: Voltage Input |
| 2 | HYST | Hysteresis I/O |
| 4, 5, 10, 11 | GND | Ground pin |
| 6 | O1 | Output drive sourcing & sinking pin |
| 3, 7, 12 | NC | No Connection |
| 8 | VDD | Power supply input pin |
| 9 | OUT2 | Output2 drive sourcing & sinking pin |
| 13 | RANGE | Range Input |
| 14 | REF | Reference Input |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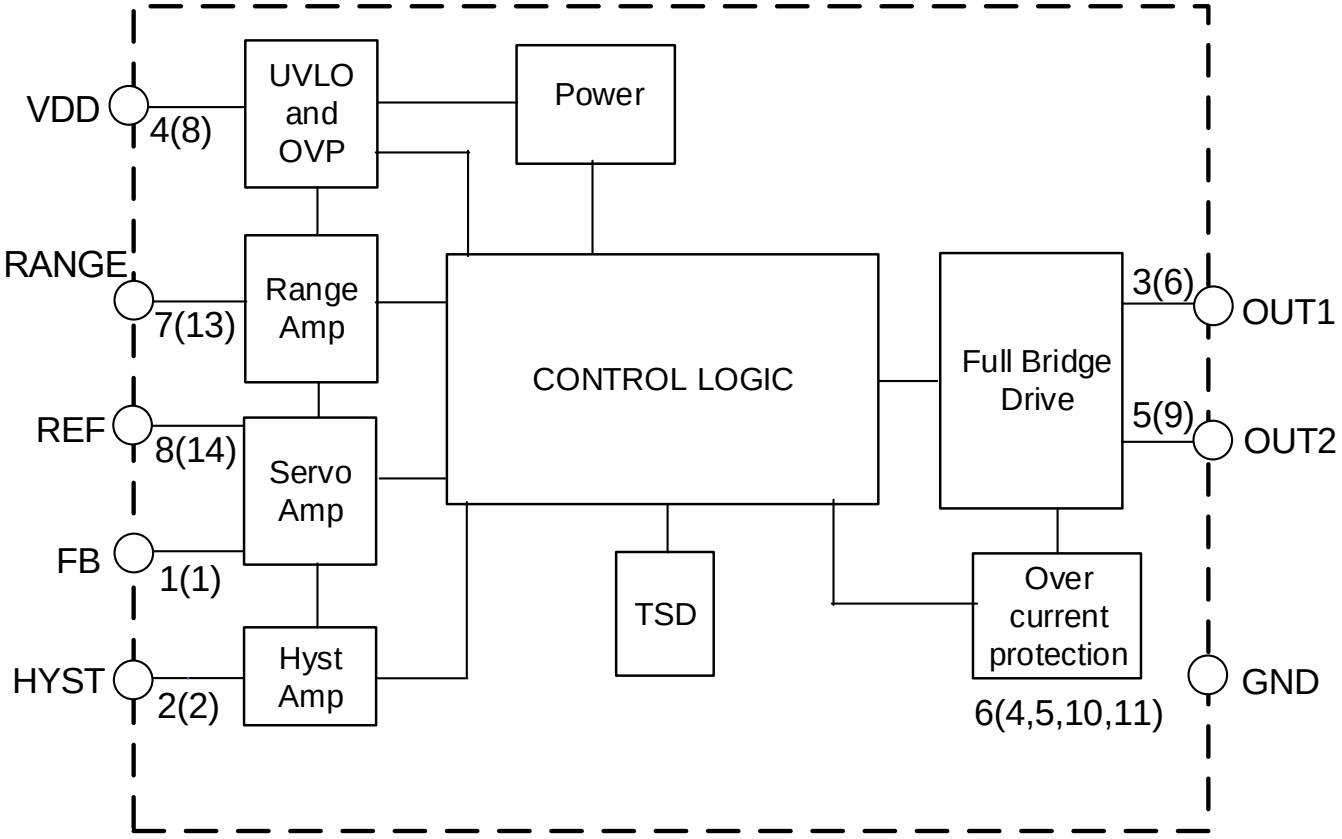
## Functional Block Diagram




A(B)
A for PDIP-8 (Type A1)
B for SO-14 (Type A1)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## Absolute Maximum Ratings (Note 8) @$T_A$ = +25°C, unless otherwise specified.

| Symbol | Characteristics | | Rating | Unit |
|---|---|---|---|---|
| $V_{DD\_MAX}$ | Maximum Supply Voltage (Note 9) | | 45 | V |
| $V_{DD\_REVERSE}$<br>$V_{REVERSE}$ | Reverse Voltage on VDD and All Pins | | -0.3 | V |
| $V_{FB\_MAX}$<br>$V_{HYST\_MAX}$<br>$V_{REF\_MAX}$ | Maximum Voltage on FB, HYST, REF Pins | | 20 | V |
| $V_{RANGE\_MAX}$ | Maximum Voltage on RANGE Pin | | 20 | V |
| $V_{FB\_REVERSE}$<br>$V_{REF\_REVERSE}$<br>$V_{HYST\_REVERSE}$<br>$V_{RANGE\_REVERSE}$ | Reverse Supply Voltage on All Pins | | -0.3 | V |
| $I_{FB\_MAX}$ | Maximum Current on FB Pin | | ±6 | mA |
| $I_{HYST\_MAX}$ | Maximum Current on HYST Pin | | ±6 | mA |
| $I_{REF\_MAX}$ | Maximum Current on REF Pin | | ±6 | mA |
| $I_{RANGE\_MAX}$ | Maximum Current on RANGE Pin | | ±6 | mA |
| $P_D$ | Power Dissipation (Note 10) | PDIP-8 (Type A1) (Note 11) | 1.61 | W |
| | | SO-14 (Type A1) (Note 12) | 1.66 | W |
| $T_{STG}$ | Storage Temperature Range | | -65 to +150 | °C |
| $T_J$ | Maximum Junction Temperature | | +150 | °C |
| ESD HBM | Human Body Model ESD Capability | PDIP-8 (Type A1) | 8 | kV |
| | | SO-14 (Type A1) | 3.5 | |
| CDM | Charged Device Model (CDM) | PDIP-8 (Type A1) | 1.5 | kV |
| | | SO-14 (Type A1) | 1.5 | |

Notes:
8. Stresses greater than the *Absolute Maximum Ratings* specified above can cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.
9. The absolute maximum $V_{DD}$ of 45V is a transient stress rating and is not meant as a functional operating condition. It is not recommended to operate the device at the absolute maximum rated conditions for any period of time.
10. For thermal de-rating curves under different PCB size and layout conditions, see *Thermal Performance* section.
11. PDIP-8 (Type A1) soldered to minimum recommended landing pads (see *Package Outline Dimensions* section) on 2" × 2" two-layer 2oz.copper FR-4 PC (1.6mm thickness) .See *Thermal Performance* section.
12. SO-14 (Type A1) soldered to minimum recommended landing pads (see Package Outline Dimension section) on 2" × 2" two-layer 2oz.copper FR4 PCB (1.6mm thickness) . See thermal performance section.

## Recommended Operating Conditions

| Symbol | Characteristic | Conditions | Min | Max | Unit |
|---|---|---|---|---|---|
| $V_{DD}$ | Supply Voltage | Operating | 8 | 18 | V |
| $T_A$ | Operating Ambient Temperature Range | Operating | -40 | +125 | °C |
| $T_J$ | Operating Junction Temperature Range | Operating | -40 | +150 | °C |


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## Electrical Characteristics (Note 13) (@$T_A$ = -40°C to +125°C, $V_{DD}$ = 8V to 18V, unless otherwise specified.)

| Symbol | Characteristics | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{DD}$ | Supply Current (Excluding Load Current) | No Load | — | 1.45 | 2.5 | mA |
| $V_{UVLO\_ON}$ | Under Voltage Protection Release Threshold | Voltage Increasing | — | 7.4 | 8 | V |
| $V_{UVLO\_OFF}$ | Under Voltage Protection Threshold for Shutdown to Standby Mode | Voltage Decreasing | 6.3 | 6.9 | — | V |
| $V_{OVP\_ON}$ | Over Voltage Protection Threshold for Shutdown to Standby Mode | Voltage Increasing | 18.5 | 20.5 | 23 | V |
| $V_{OVP\_OFF}$ | Over Voltage Release Threshold | Voltage Decreasing | 17.5 | 20 | 22 | V |
| $V_{OH}$ | Output Voltage High | $I_{OUT}$ = 800mA | $V_{DD}$ - 1.66 | $V_{DD}$ - 0.86 | — | V |
| | | $I_{OUT}$ = 500mA | $V_{DD}$ – 1.05 | $V_{DD}$ - 0.54 | — | V |
| $V_{OL}$ | Output Voltage Low | $I_{OUT}$ = 800mA | — | 0.56 | 1.12 | V |
| | | $I_{OUT}$ = 500mA | — | 0.35 | 0.7 | V |
| $R_{ON\_TOTAL}$ | Combined NMOS and PMOS $R_{DSON}$ Including Bond Wire Resistance | $I_{OUT}$ = 800mA | — | 1.8 | 3.46 | Ω |
| | | $I_{OUT}$ = 500mA | — | 1.8 | 3.46 | Ω |
| $V_{REFQ}$ | REF Quiescent Voltage | $I_{REF}$ = 0 | 185 | 200 | 215 | mV |
| $R_{REF\_IN}$ | REF Pin Input Resistance | 0 < $V_{REF}$ < 0.5V | 4.5 | 6 | 7.5 | kΩ |
| $V_{FBQ}$ | FB Quiescent Voltage | $I_{FB}$ = 0 | 185 | 200 | 215 | mV |
| $R_{FB\_IN}$ | REF Pin Input Resistance | 0 < $V_{FB}$ < 0.5V | 4.5 | 6 | 7.5 | kΩ |
| $I_{HYST\_IO\_250}$ | Current Offset | $I_{REF}$ = $I_{FB}$ = 250µA, $V_{HYST}$ = $V_{DD}$/2 | -2 | 0.35 | 3 | µA |
| $I_{HYST\_IO\_40}$ | | $I_{REF}$ = $I_{FB}$ = 40µA, $V_{HYST}$ = $V_{DD}$/2 | -1.3 | 0 | 1.3 | µA |
| $V_{HYST\_H}/V_S$ | Threshold Voltage High | — | — | 52 | — | % |
| $V_{DB\_H}/V_S$ | Deadband Voltage High | — | — | 50.4 | — | % |
| $V_{DBL}/V_S$ | Deadband Voltage Low | — | — | 49.6 | — | % |
| $V_{HYST\_L}/V_S$ | Threshold Voltage Low | — | — | 48 | — | % |
| $V_{HYST\_W}/V_S$ | Hysteresis Window | ($V_{HYH}$ – $V_{HYL}$) / $V_{DD}$ | 3 | 4 | 5 | % |
| $V_{DB\_W}/V_S$ | Deadband Window | ($V_{DBH}$ – $V_{DBL}$) / $V_{DD}$ | 0.4 | 0.8 | 1.2 | % |
| $I_{RANGE}$ | Range Pin Input Current | 0V < $V_{RANGE}$ <$V_{DD}$ | -1 | — | 1 | µA |
| $V_{OFFH}$ | Range Pin Input Voltage Monitor Switch-Off Voltage High | Referred to $V_{DD}$ | -100 | 0 | 150 | mV |
| $V_{OFFL}$ | Range Pin Input Voltage Monitor Switch-Off Voltage Low | Referred to GND | 300 | 400 | 500 | mV |
| $I_{OCP}$ | Overcurrent protection | — | 1.5 | — | — | A |
| $T_{J\_SDN\_TH}$ | IC Junction Temperature Thermal Shutdown Threshold | — | 150 | +170 | 190 | °C |
| $T_{J\_SDN\_HYST}$ | IC Junction Temperature Thermal Shutdown Hysteresis | — | — | +30 | — | °C |

Note: 13. Typical data is measured at $T_A$ = +25°C, $V_{DD}$ = 12V. The maximum and minimum parameters values over operating temperature range are not tested in production, and they are guaranteed by design, characterization, and process control.


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## Operating Characteristics

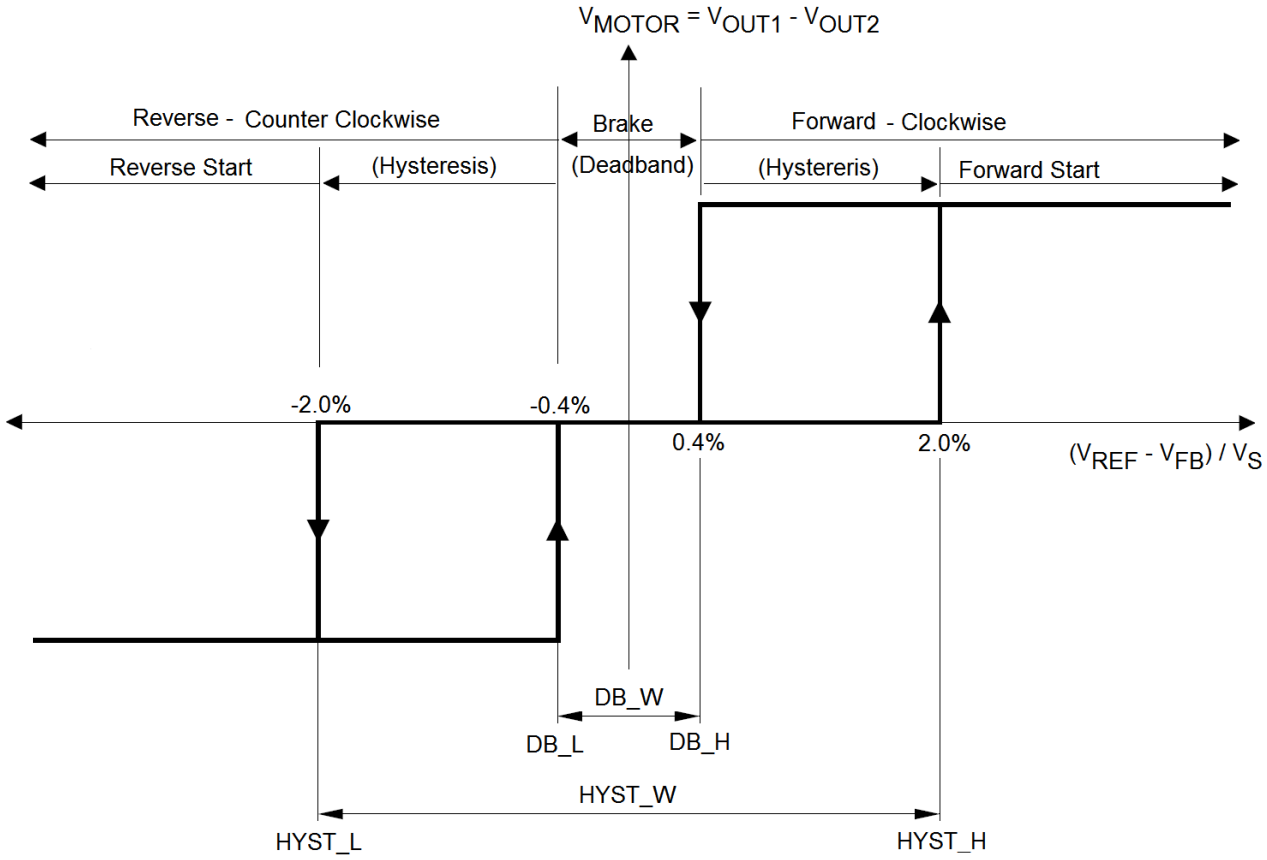


**Figure 1.** Hysteresis, Deadband, and Rotation Directions


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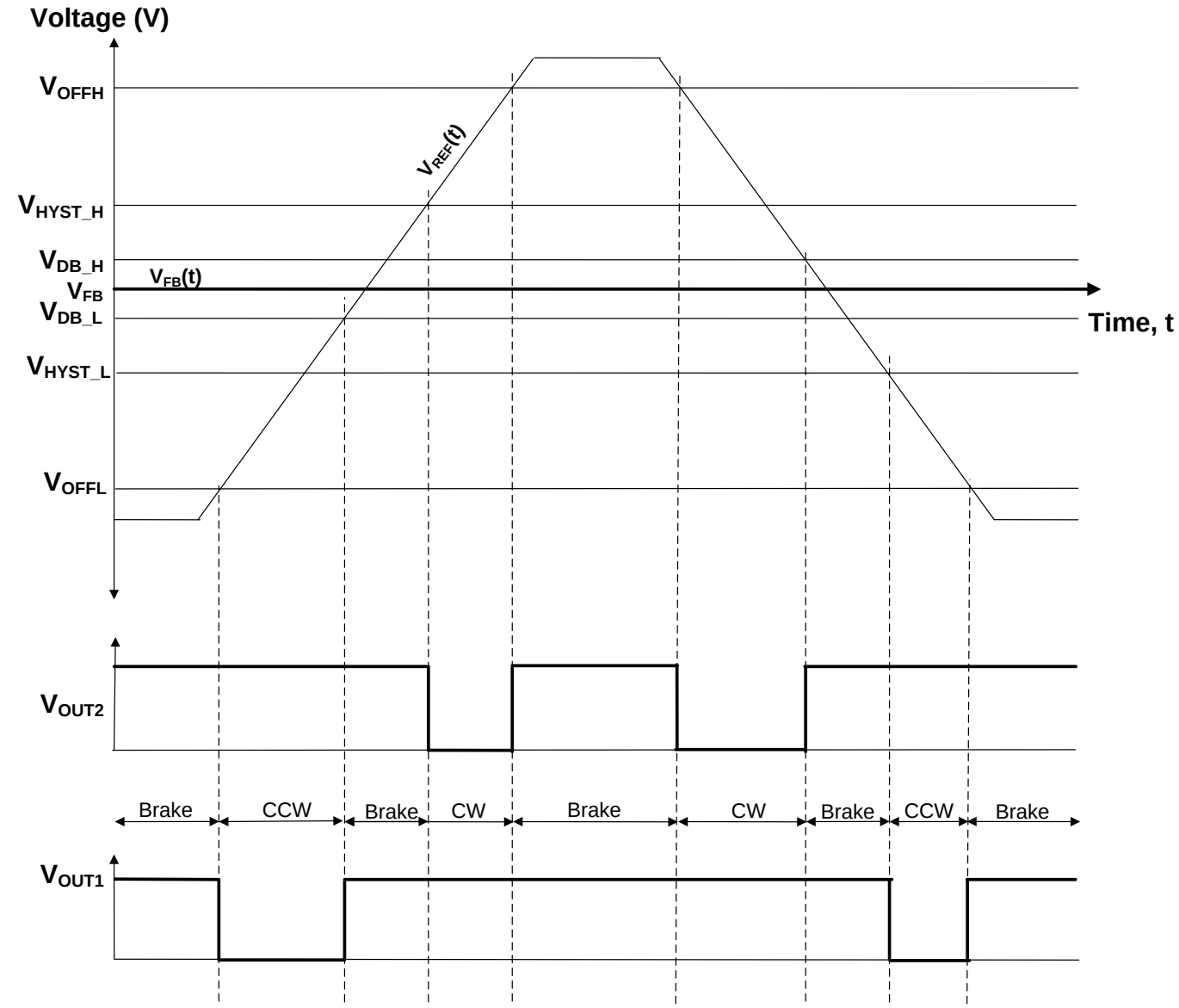
## Operating Characteristics (continued)




CW: Clockwise
CCW: Counter Clockwise

**Figure 2.** Rotation Directions with Respect to $V_{REF}$, $V_{FB}$, Hysteresis, and Deadband Settings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## Application Note

**REF and FB Pin**

The REF and FB pins are servo AMP input, and the voltage difference between REF/FB terminals are based on the OUT1 and OUT2 operating status (like CW/CCW or Brake status on page 6 and 7). For normal operating, the voltage applied to REF/FB terminals does not exceed 1.5V (= 6k × 250μA; refer to *Electrical Characteristics* section). The two pins both have a series resistor with same value to degrade applied voltage. 1.5V is the maximum voltage at REF/FB pin, so $R_{REF}/R_{FB}$ resistor is calculated as below:

Assuming $V_{DD}$ = 12V and 1.5V maximum on FB/REF pin, the minimum $R_{REF}/R_{FB}$ is equal to 1.5V= {6K / (6K + $R_{REF}$)} × 12V; $R_{REF}$ = 42kΩ.

**HYST Pin**

The hysteresis window can be set via input at HYST pin. If the two resistances $R_{HYH}$ and $R_{HYL}$ are equal, the hysteresis window is located symmetrically at 50 ± 2% relative to the supply voltage. The position of the window can be adjusted by varying the ratio of $R_{HYH}$ to $R_{HYL}$. The size of the window tolerance can be adjusted by changing the ratio of the hysteresis resistances to the resistances $R_{REF}$ and $R_{FB}$ on the other. For example, if the resistances $R_{HYH}$ and $R_{HYL}$ are both halved in comparison to $R_{REF}$ and $R_{FB}$, the window tolerance doubles in size (i.e. to 50 ± 4%).

**RANGE Pin**

If the potentiometer or the connecting leads reference input to $V_{REF}$ are shorted or open connected, uncontrolled movements of the servo motor must not occur. For this reason, two additional switch-off thresholds $V_{OFFL}$ and $V_{OFFH}$ are provided. The corresponding window comparator for these thresholds behind the RANGE input has a typical low threshold of 0.4V and a typical high threshold of $V_{DD}$. If the voltage $V_{REFIN}$ falls below 0.4V typical, which will be the case if the reference potentiometer input is shorted to ground, the motor will be switched off. Similarly, if the voltage $V_{REFIN}$ rises above $V_{DD}$ typical, which will be the case if the reference potentiometer input is open circuited, the motor will be switched off.

**Undervoltage Lockout**

To make sure the minimum voltage required to operate the driver is supplied, the ZXBM5408Q has an undervoltage lockout. At start up the device only starts if the supply voltage is typically over $V_{UVLO\_RLTH}$. During normal operation, the device will switch off all the output switches and power down if the supply voltage drops below $V_{UVLO\_TH}$ typical.

When the supply voltage drops below undervoltage lockout threshold, $V_{UVLO\_TH\_R}$, the ZXBM5408Q shuts down all the output drive switches and enters standby mode to help prevent overvoltage stress on the coil.

**Overvoltage Shutdown of Output Drive**

When the supply voltage exceeds the overvoltage shutdown threshold, $V_{OV\_TH}$, the ZXBM5408Q shuts down all the output drive switches and enters standby mode to help prevent overvoltage stress on the coil. The driver returns to normal condition if the supply voltage drops below $V_{OV\_RLTH}$ provided no other fault condition or signals are preventing it to enter normal operation.

**Overcurrent Protection**

The internal overcurrent protection (OCP) threshold is 1.5A minimum at 12V supply +25°C.

When the motor current exceeds the OCP threshold for longer than 4μs typical on any of the H-Bridge switches, the device switches off all the output switches and remains off for 260μs typical. The IC returns to normal operation after the 260μs if overcurrent condition has gone away. If the motor current is still higher than the OCP threshold, the device enters another 260μs standby mode.

**Thermal Shutdown Protection**

The device has an internal thermal shutdown to prevent a thermal runaway scenario. The thermal shutdown is triggered when the junction temperature of the device reaches +170°C. It will remain in standby mode until the junction temperature falls by +30°C.


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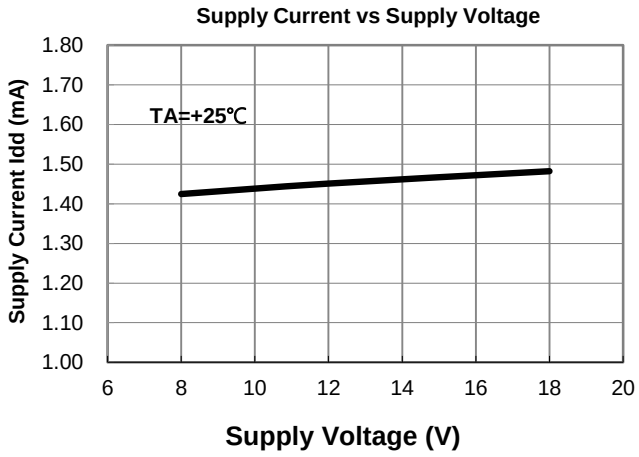
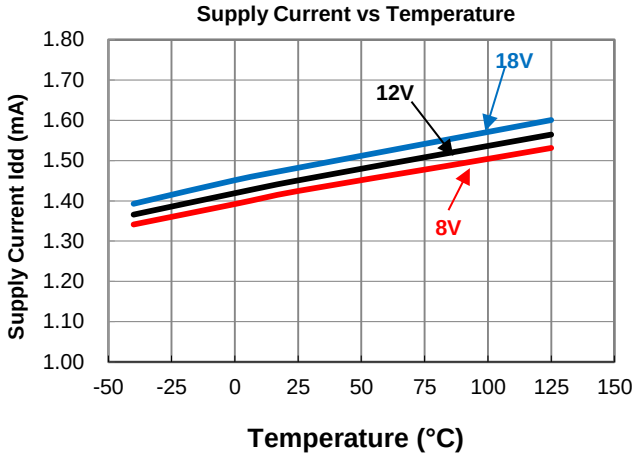
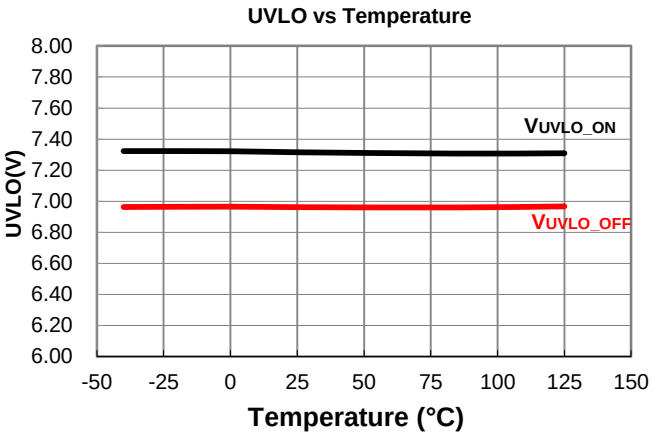
## Typical Operating Characteristics

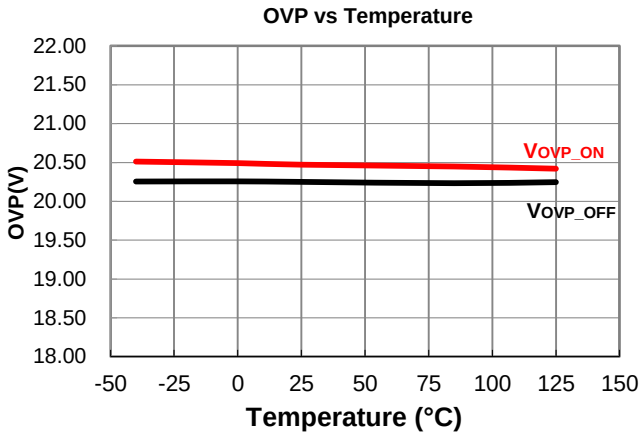
### Supply Current




### UVLO and OVP Threshold





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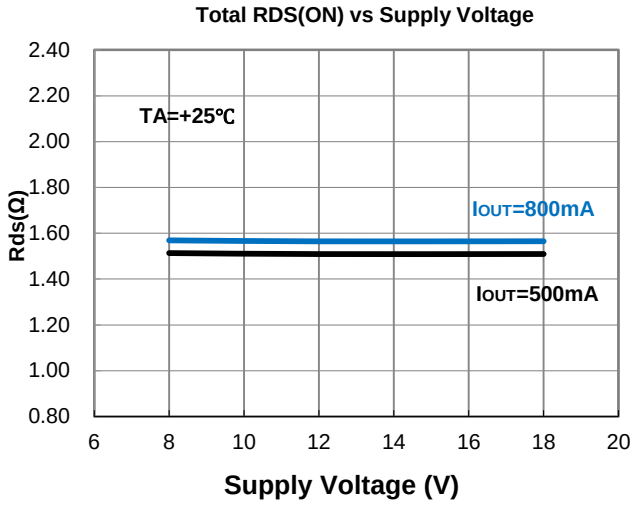
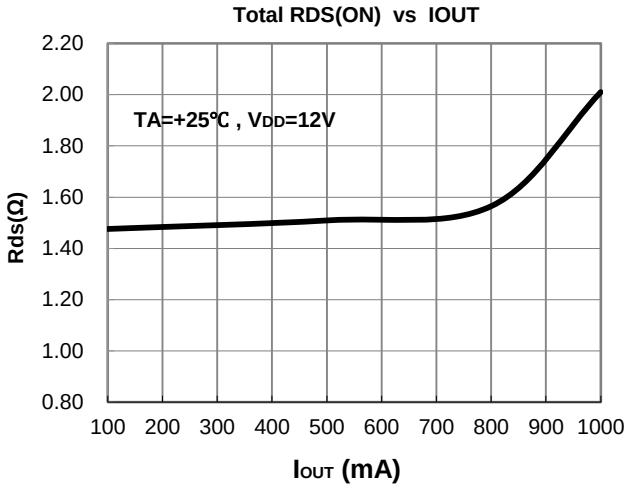
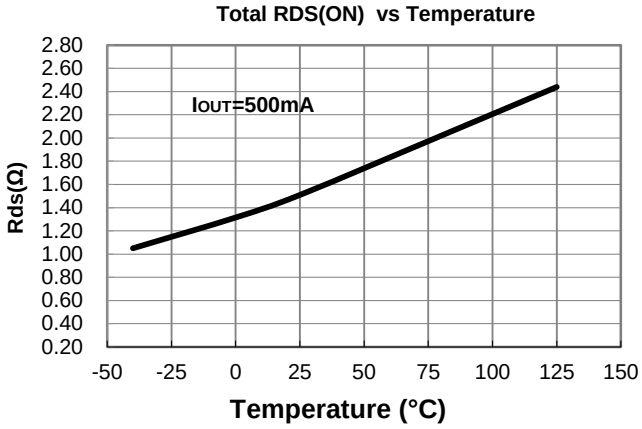
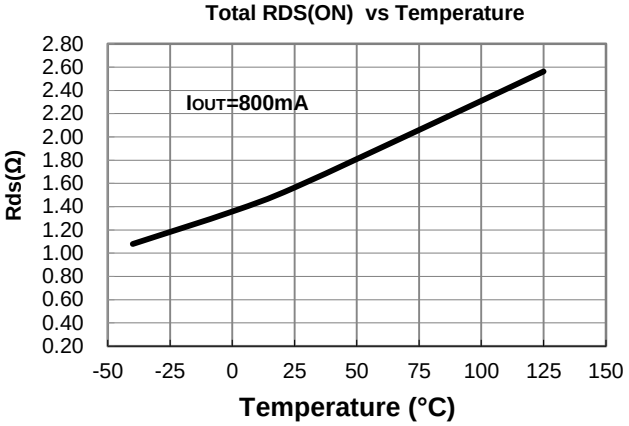
## Typical Operating Characteristics (continued)

### Total H-Bridge Path Resistance – Total RDS(ON) of High-Side and Low-Side Switches





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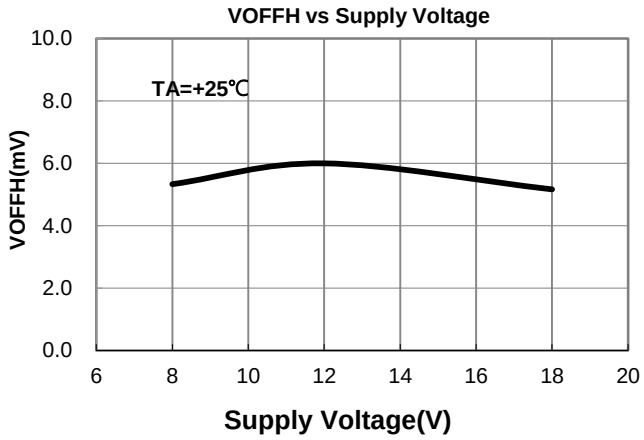
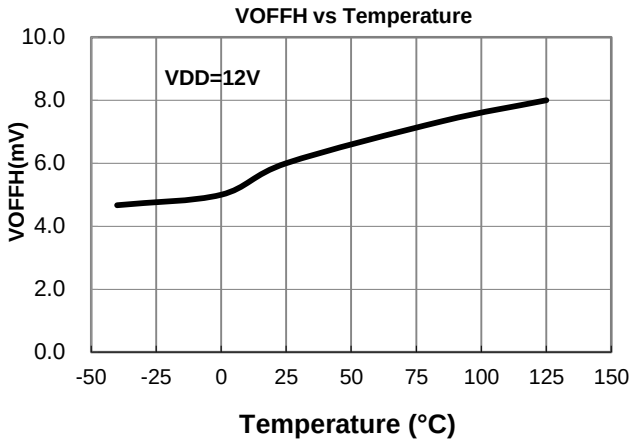
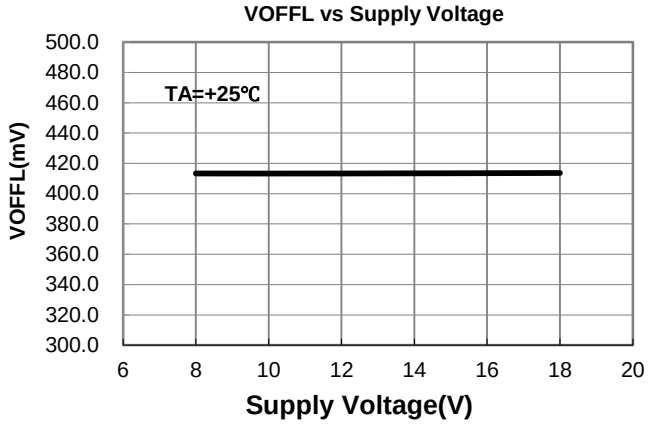
## Typical Operating Characteristics (continued)

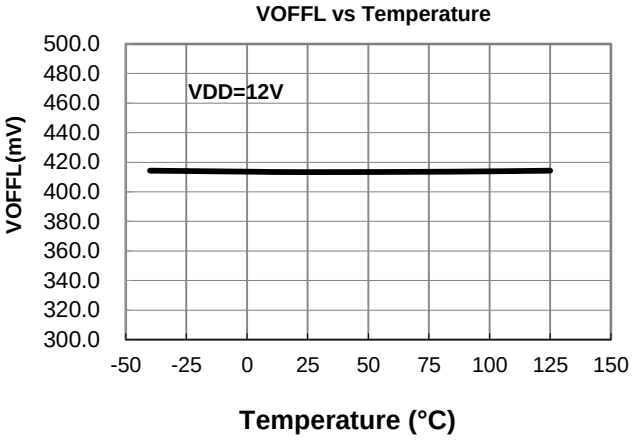
### VOFFH : Range pin input voltage referred to VDD




### VOFFL : Range Pin input voltage referred to GND





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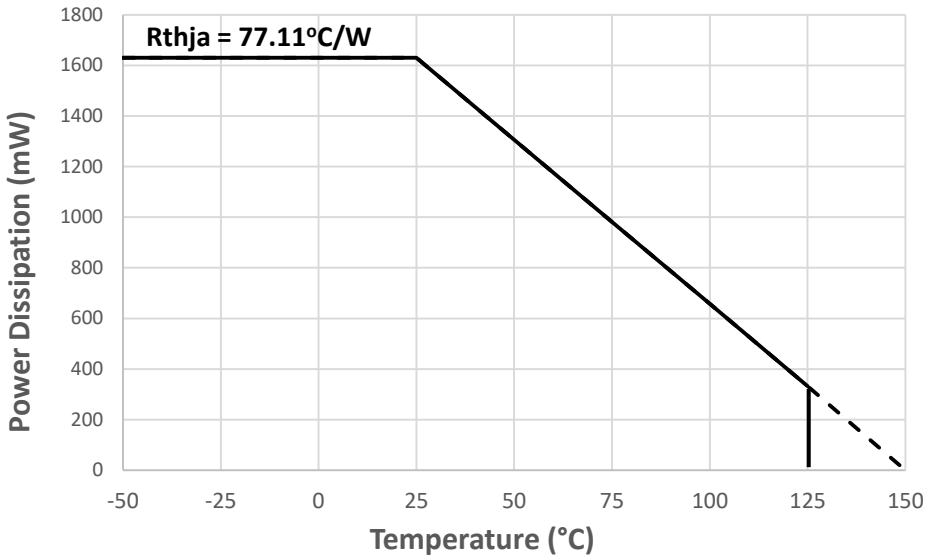
## Thermal Performance

**(1) Package Type: PDIP-8 (Type A1)**

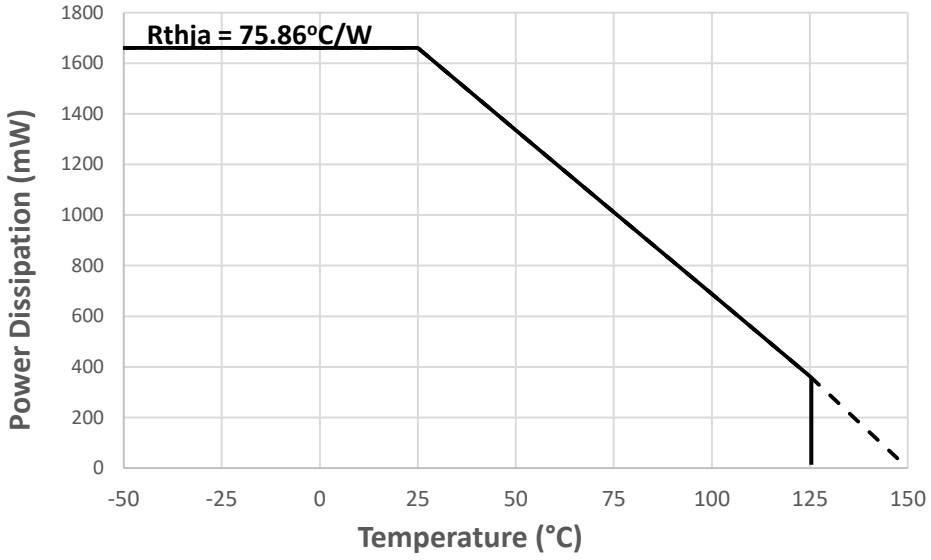
**PDIP-8 (Type A1) Power Dissipation De-rating Curve 1** (Note 14)




Note: 14. PDIP-8 (Type A1) soldered to minimum recommended landing pads on 2" × 2" two-layer 2oz.copper FR-4 PCB (1.6mm thickness).

**(2) Package Type: SO-14 (Type A1)**

**SO-14 Power Dissipation De-rating Curve 1** (Note 15)




Note: 15. The SO-14 pad is soldered to the minimum recommended landing pads (see Package Outline Dimension section) on a 2" x 2" 2oz. copper FR4 PCB (1.6mm thickness) with no copper flood connecting to the landing pattern or on the bottom layer.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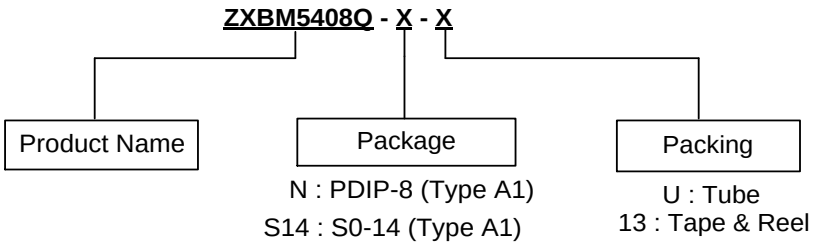
## Ordering Information (Note 16)

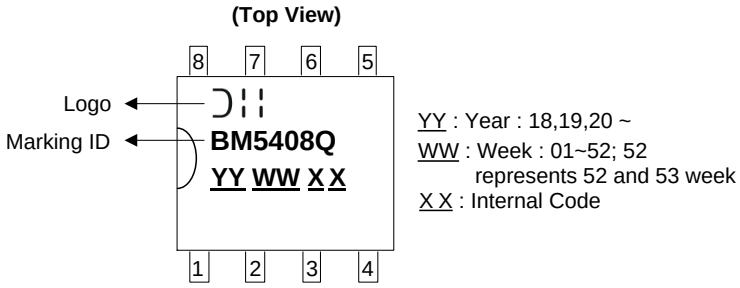



| Part Number | Package Code | Packaging (Note 17) | Tube(Note 19) | | 13" Tape and Reel | | Compliance (Note 18) |
|---|---|---|---|---|---|---|---|
| | | | Quantity | Part Number Suffix | Quantity | Part Number Suffix | |
| ZXBM5408Q -N-U | N | PDIP-8 (Type A1) | 60 | -U | NA | NA | Automotive Grade Compliant |
| ZXBM5408Q -S14-13 | S14 | SO-14 (Type A1) | NA | NA | 2,500/Tape & Reel | -13 | Automotive Grade Compliant |

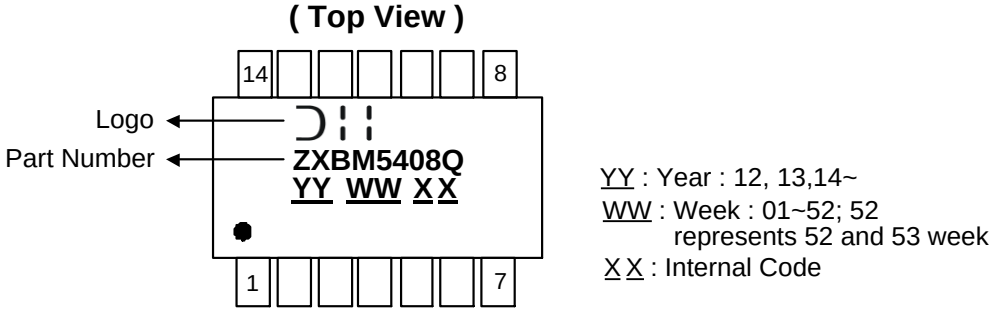
Notes:
16. For packaging details, go to our website at https://www.diodes.com/design/support/packaging/diodes-packaging/.
17. Pad layout as shown on Diodes Incorporated's Suggested pad layout can be found at https://www.diodes.com/design/support/packaging.
18. ZXBM5408Q -N-U is classified as "Automotive Compliant" and supports PPAP documentation.
19 There are 60 tubes in a box and the standard order quantity is 3600 pcs.

## Marking Information

**1. Package Type: PDIP-8 (Type A1)**




**2. Package Type: SO-14 (Type A1)**





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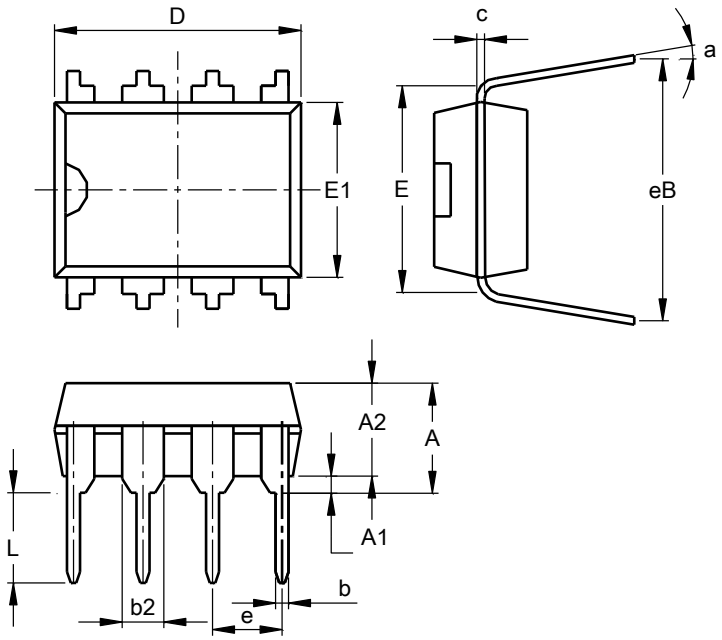
## Package Outline Dimensions (All dimensions in mm.)

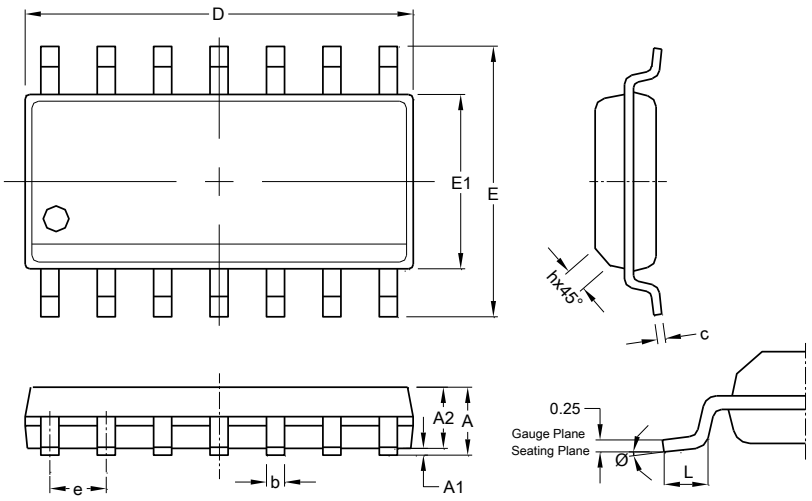
Please see https://www.diodes.com/design/support/packaging/ for the latest version.

**1. Package Type: PDIP-8 (Type A1)**




| PDIP-8 (Type A1) | | | | | | |
|---|---|---|---|---|---|---|
| Dim | Inches | | | Millimeters | | |
| | Min | Max | Typ | Min | Max | Typ |
| A | -- | 0.210 | -- | -- | 5.334 | -- |
| A1 | 0.015 | -- | -- | 0.381 | -- | -- |
| A2 | 0.125 | 0.135 | 0.130 | 3.175 | 3.429 | 3.302 |
| b | -- | -- | 0.018 | -- | -- | 0.457 |
| b2 | -- | -- | 0.060 | -- | -- | 1.524 |
| c | 0.008 | 0.014 | 0.010 | 0.203 | 0.356 | 0.254 |
| D | 0.355 | 0.400 | 0.365 | 9.017 | 10.160 | 9.271 |
| E | 0.300 BSC | | | 7.62 BSC | | |
| E1 | 0.245 | 0.255 | 0.250 | 6.223 | 6.477 | 6.350 |
| eB | 0.335 | 0.375 | 0.355 | 8.509 | 9.525 | 9.017 |
| e | -- | -- | 0.100 | -- | -- | 2.540 |
| L | 0.115 | 0.150 | 0.130 | 2.921 | 3.810 | 3.302 |
| a | 0° | 15° | 7° | 0° | 15° | 7° |
| Controlling dimensions are in inches | | | | | | |

**2. Package Type: SO-14 (Type A1)**




| SO-14 (Type A1) | | | |
|---|---|---|---|
| Dim | Min | Max | Typ |
| A | -- | 1.75 | -- |
| A1 | 0.10 | 0.25 | -- |
| A2 | 1.25 | -- | -- |
| b | 0.31 | 0.51 | -- |
| c | 0.10 | 0.25 | -- |
| D | 8.65 BSC | | |
| E | 6.00 BSC | | |
| E1 | 3.90 BSC | | |
| e | 1.27 BSC | | |
| h | 0.25 | 0.50 | -- |
| L | 0.40 | 1.27 | -- |
| θ | 0° | 8° | -- |
| All Dimensions in mm | | | |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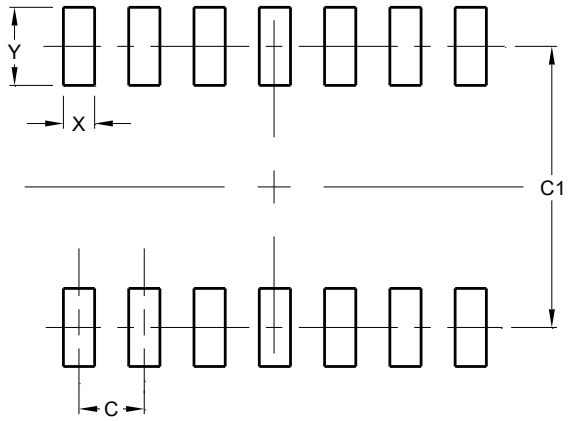
## Suggested Pad Layout

Please see https://www.diodes.com/design/support/packaging/ for the latest version.

**SO-14 (Type A1)**




| Dimensions | Value (in mm) |
|---|---|
| **C** | 1.27 |
| **C1** | 5.40 |
| **X** | 0.60 |
| **Y** | 1.50 |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