

**AUTOMOTIVE GRADE 20V HIGH-SIDE CURRENT MONITOR**

**Description**

The ZXCT1008Q is a high side current sense monitor. Using this device eliminates the need to disrupt the ground plane when sensing a load current.

It takes a high side voltage developed across a current shunt resistor and translates it into a proportional output current. A user defined output resistor scales the output current into a ground-referenced voltage.

The wide input voltage range of 20V down to as low as 2.5V make it suitable for a range of applications. The ability to withstand high voltage transients and reverse polarity connection makes this part very suitable for automotive and other transient rich environment.

The ZXCT1008Q has been qualified to AEC-Q100 Grade 1 and is Automotive Grade supporting PPAPs.

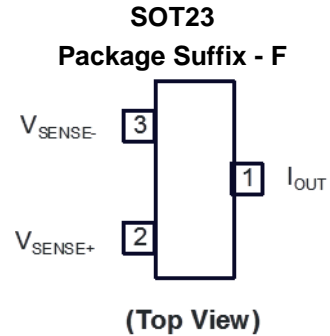
**Features**

- Low Cost, Accurate High-Side Current Sensing
- -40 to +125°C Temperature Range
- Up to 500mV Sense Voltage
- 2.5V to 20V Supply Range
- 4µA Quiescent Current
- 1% Typical Accuracy
- SOT23
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **Automotive Grade**
  - **Qualified to AEC-Q100 Standards for High Reliability**
  - **PPAP Capable (Note 4)**

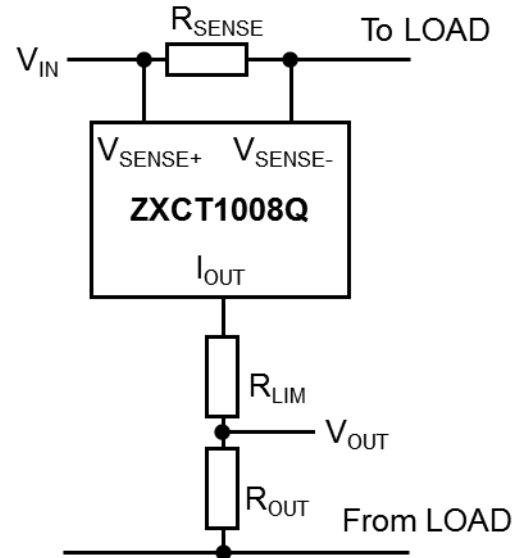
**Applications**

- Automotive Current Measurement
- Automotive DC Motor Stall Detection
- Over Current Monitor

**Pin Assignments**



**Application Circuit**

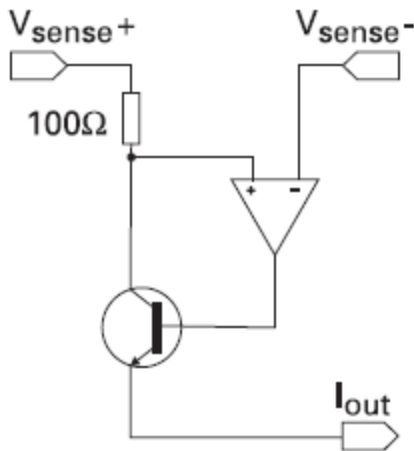


Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.  
 2. See [http://www.diodes.com/quality/lead\\_free.html](http://www.diodes.com/quality/lead_free.html) for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "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.  
 4. Automotive products are AEC-Q100 qualified and are PPAP capable. Automotive, AEC-Q100 and standard products are electrically and thermally the same, except where specified. For more information, please refer to [http://www.diodes.com/quality/product\\_compliance\\_definitions/](http://www.diodes.com/quality/product_compliance_definitions/).

## Pin Descriptions

| Pin Name            | Pin Function                                     |
|---------------------|--|
| V <sub>SENSE+</sub> | Connection to Supply Voltage                     |
| V <sub>SENSE-</sub> | Connection to Load                               |
| I <sub>OUT</sub>    | Output Current, Proportional to Measured Current |

## Functional Block Diagram



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

| Description  |                      | Rating      | Unit |
|--|----------------------|-------------|------|
| Voltage on any pin (relative to I <sub>OUT</sub> )                           |                      | -0.6 to +20 | V    |
| Continuous output current, I <sub>OUT</sub>                                  |                      | 25          | mA   |
| Continuous sense voltage, V <sub>SENSE</sub> (Note 5)                        |                      | -0.5 to +5  | V    |
| Operating temperature, T <sub>A</sub>  |                      | -40 to +125 | °C   |
| Storage temperature  |                      | -55 to +125 | °C   |
| Package power dissipation @ T <sub>A</sub> = +25°C (Derate to zero @ +125°C) |                      | 450         | mW   |
| <b>ESD Susceptibility</b>  |                      |             |      |
| HBM  | Human Body Model     | 2           | kV   |
| MM   | Machine Model        | 300         | V    |
| CDM  | Charged Device Model | 1           | kV   |

Caution: Stresses greater than the 'Absolute Maximum Ratings' specified above, may 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.

Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

5. V<sub>SENSE</sub> is defined as the differential voltage between V<sub>SENSE+</sub> and V<sub>SENSE-</sub> pins.

$$\begin{aligned}
 V_{\text{SENSE}} &= V_{\text{SENSE+}} - V_{\text{SENSE-}} \\
 &= V_{\text{IN}} - V_{\text{LOAD}} \\
 &= I_{\text{LOAD}} \times R_{\text{SENSE}}
 \end{aligned}$$

**Electrical Characteristics** (@T<sub>A</sub> = +25°C, V<sub>IN</sub> = 5V, R<sub>OUT</sub> = 100Ω, unless otherwise specified.)

| Symbol              | Parameter   | Conditions<br>(Note 5)  | Limits |       |       | Units |
|---------------------|---|---|--------|-------|-------|-------|
|                     |   |   | Min    | Typ   | Max   |       |
| V <sub>IN</sub>     | V <sub>CC</sub> Range                                     | —   | 2.5    | —     | 20    | V     |
| I <sub>OUT</sub>    | Output Current<br>(Note 6)                                | V <sub>SENSE</sub> = 0V   | 1      | 4     | 15    | μA    |
|                     |   | V <sub>SENSE</sub> = 10mV   | 90     | 104   | 120   | μA    |
|                     |   | V <sub>SENSE</sub> = 100mV  | 0.975  | 1.0   | 1.025 | mA    |
|                     |   | V <sub>SENSE</sub> = 200mV  | 1.95   | 2.0   | 2.05  | mA    |
|                     |   | V <sub>SENSE</sub> = 500mV  | 4.8    | 5.0   | 5.2   | mA    |
| V <sub>SENSE</sub>  | Sense Voltage (Note 5)                                    | —   | 0      | —     | 500   | mV    |
| I <sub>SENSE-</sub> | V <sub>SENSE-</sub> Input Current                         | —   | —      | —     | 100   | nA    |
| ACC                 | Accuracy  | R <sub>SENSE</sub> = 0.1Ω<br>V <sub>SENSE</sub> = 200mV                         | -2.5   | —     | +2.5  | %     |
| G <sub>M</sub>      | Transconductance,<br>I <sub>OUT</sub> /V <sub>SENSE</sub> | —   | —      | 10000 | —     | μA/V  |
| BW                  | Bandwidth   | V <sub>SENSE(DC)</sub> = 10mv, R <sub>F</sub> P <sub>IN</sub> = -40dBm (Note 6) | —      | 300   | —     | kHz   |
|                     |   | V <sub>SENSE(DC)</sub> = 100mv, R <sub>F</sub> P <sub>IN</sub> = -20dBm         | —      | 2     | —     | MHz   |

- Notes: 5. V<sub>SENSE</sub> is defined as the differential voltage between V<sub>SENSE+</sub> and V<sub>SENSE-</sub> pins.  
 $V_{SENSE} = V_{SENSE+} - V_{SENSE-}$   
 $= V_{IN} - V_{LOAD}$   
 $= I_{LOAD} \times R_{SENSE}$
6. Includes input offset voltage contribution  
 7. -20dBm = 63mV<sub>PP</sub> into 50Ω

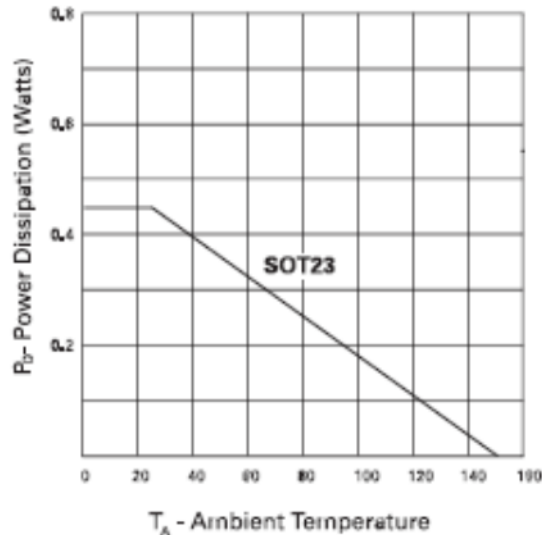
**Power Dissipation**

The maximum allowable power dissipation of the device for normal operation (P<sub>MAX</sub>), is a function of the package junction to ambient thermal resistance (θ<sub>JA</sub>), maximum junction temperature (T<sub>JMAX</sub>), and ambient temperature (T<sub>AMB</sub>), according to the expression:

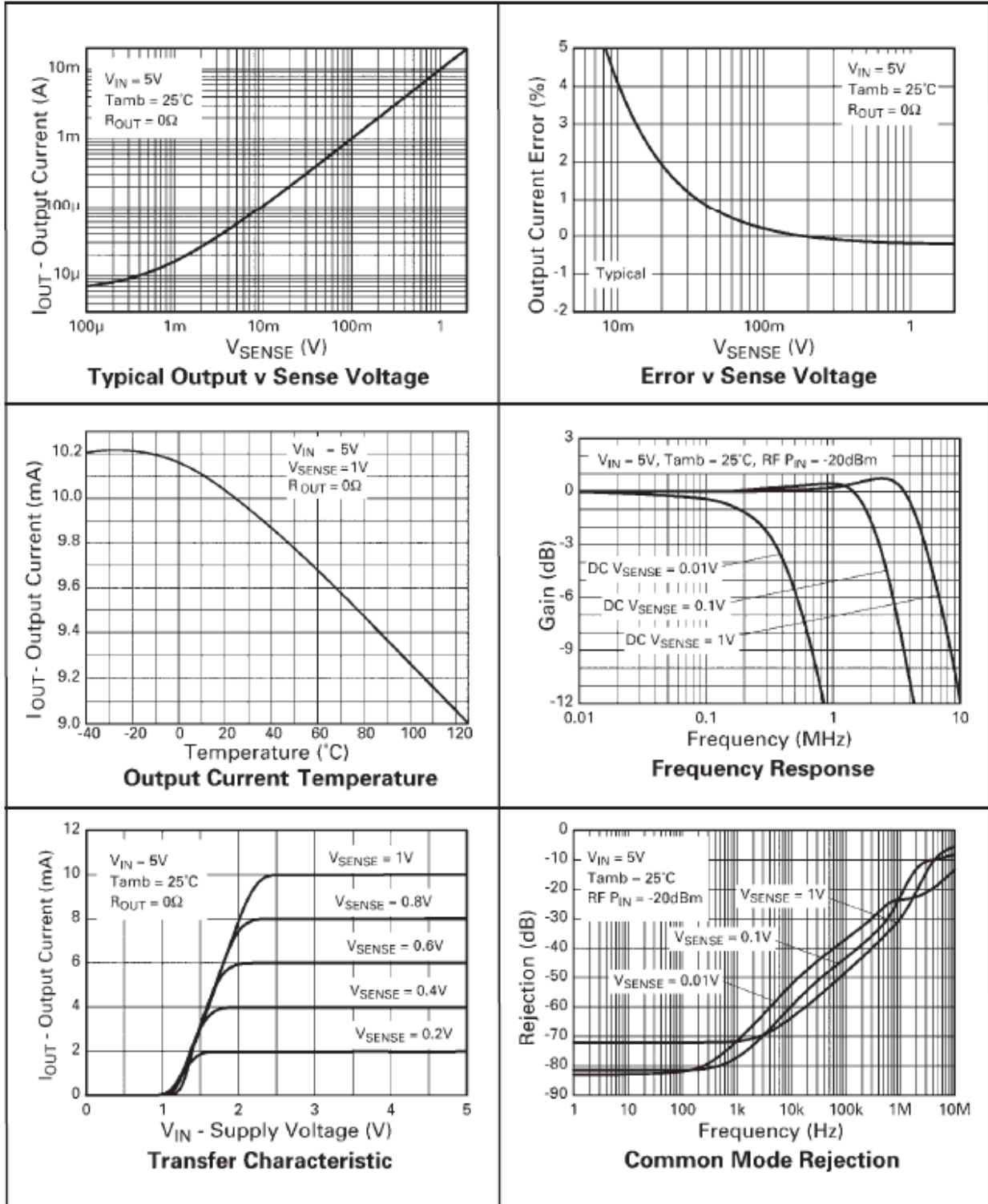
$$P_{MAX} = (T_{JMAX} - T_{AMB}) / \theta_{JA}$$

The device power dissipation, P<sub>D</sub> is given by the expression:

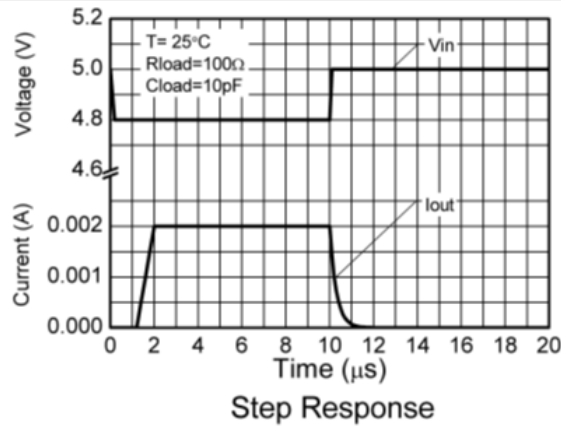
$$P_D = I_{OUT} \times (V_{IN} - V_{OUT}) W$$



**Typical Characteristics**



## Typical Characteristics (cont.)



## Application Information

The following text describes how to scale a load current to an output voltage.

$$\begin{aligned} V_{SENSE} &= V_{IN} - V_{LOAD} \\ &= R_{SENSE} \times I_{LOAD} \end{aligned} \quad (1)$$

$$I_{OUT} = V_{SENSE} \times 10\text{mA/V} \quad (2)$$

$$V_{OUT} = I_{OUT} \times R_{OUT} \quad (3)$$

Combining (2) and (3)  $V_{OUT}$  can be determined to be:

$$V_{OUT} = 0.01 \times V_{SENSE} \times R_{OUT} \quad (4)$$

Example:

A 1A current is to be represented by a 1V output voltage:

- 1) Choose the value of  $R_{SENSE}$  to give  $50\text{mV} > V_{SENSE} > 500\text{mV}$  at full load.

For example set  $V_{SENSE} = 100\text{mV}$  at 1.0A.

Rearranging (1) gives:

$$\begin{aligned} R_{SENSE} &= \frac{V_{SENSE}}{I_{LOAD}} \\ &= 0.1/1.0 = 0.1\Omega. \end{aligned}$$

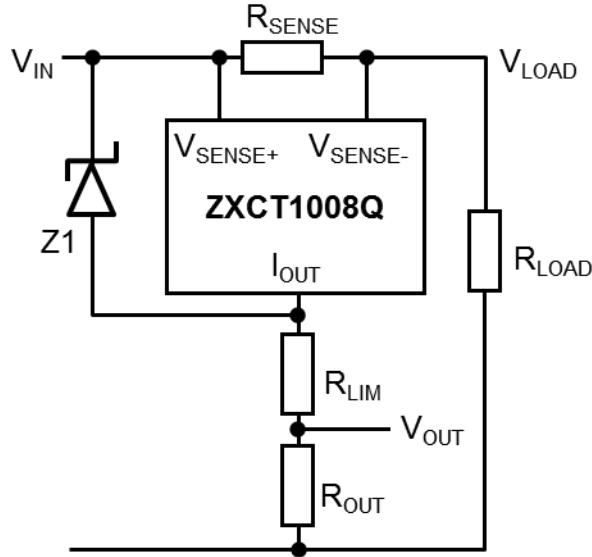
- 2) Choose  $R_{OUT}$  to give  $V_{OUT} = 1\text{V}$ , when  $V_{SENSE} = 100\text{mV}$ .

Rearranging (4) for  $R_{OUT}$  gives:

$$\begin{aligned} R_{OUT} &= \frac{V_{OUT}}{V_{SENSE} \times 0.001} \\ &= \frac{1}{0.1 \times 0.01} = 1\text{k}\Omega \end{aligned}$$

**Application Information** (cont.)

Referring to Figure 1, where R<sub>LOAD</sub> represents any load including DC motors, a charging battery or further circuitry that requires monitoring, R<sub>SENSE</sub> can be selected on specific requirements of accuracy, size and power rating.



**Figure 1 ZXCT1008Q with Additional Current Limiting Resistor R<sub>LIM</sub> and Zener Z1.**

An additional resistor, R<sub>LIM</sub> can be added in series with R<sub>OUT</sub> (Figure 1), to limit the current from I<sub>OUT</sub>. Any circuit connected to V<sub>OUT</sub> will be protected from input voltage transients. This can be of particular use in automotive applications where load dump and other common transients need to be considered. The Zener Z1 provides additional protection for local dump, reverse battery and high voltage transient incidents.

Assuming the worst case condition of V<sub>OUT</sub> = 0V; providing a low impedance to a transient, the minimum value of R<sub>LIM</sub> is given by:

$$R_{LIM(min)} = (V_{PK} - V_{MAX}) / I_{PK}$$

V<sub>PK</sub> = Peak transient voltage to be withstood

V<sub>MAX</sub> = Maximum working voltage = 20V

I<sub>PK</sub> = Peak output current = 40mA

The maximum value of R<sub>LIM</sub> is set by V<sub>IN(MIN)</sub>, V<sub>OUT(MAX)</sub> and the dropout voltage (see transfer characteristic on page 3) of the ZXCT1008Q:

$$R_{LIM(MAX)} = \frac{R_{OUT} \times [V_{IN(MIN)} - \{V_{DP} + V_{OUT(MAX)}\}]}{V_{OUT(MAX)}}$$

Where:

V<sub>IN(MIN)</sub> = Minimum Supply Operating Voltage

V<sub>DP</sub> = Dropout Voltage

V<sub>OUT(MAX)</sub> = Maximum Operating Output Voltage

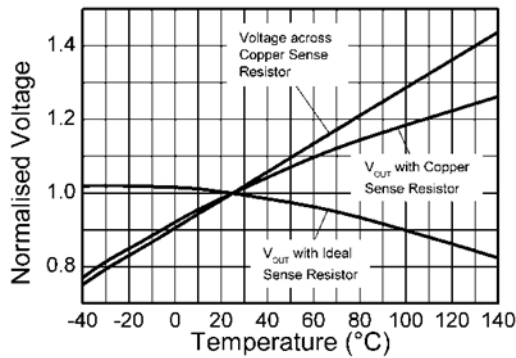
**Application Information** (cont.)

**PCB Trace Shunt Resistor for Low Cost Solution**

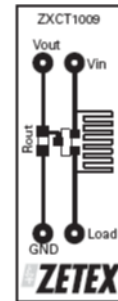
The figure below shows output characteristics of the device when using a PCB resistive trace for a low cost solution in replacement for a conventional shunt resistor. The graph shows the linear rise in voltage across the resistor due to the PTC of the material and demonstrates how this rise in resistance value over temperature compensates for the NTC of the device.

The figure opposite shows a PCB layout suggestion. The resistor section is 25mm x 0.25mm giving approximately 150mΩ using 1oz copper.

The data for the normalized graph was obtained using a 1A load current and a 100Ω output resistor. An electronic version of the PCB layout is available through Diodes applications group.

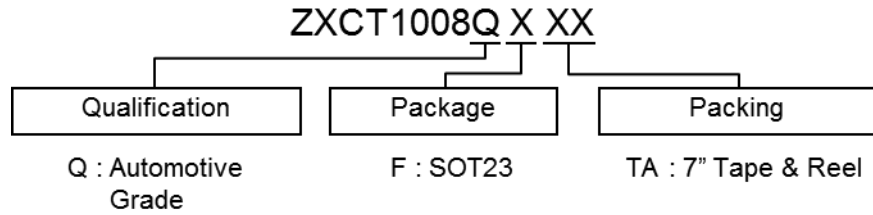


**Effect of Sense Resistor Material on Temperature Performance**



Layout shows area of shunt resistor compared to SOT23 package. Not actual size.

**Ordering Information**

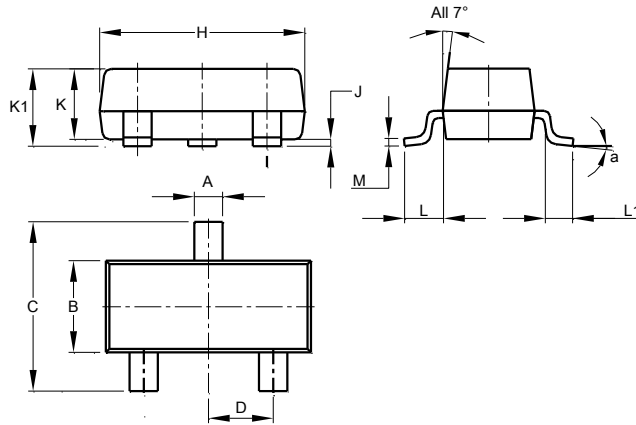


| Device       | Packaging (Note 8) | Package Code | Identification Code | Packing: 7" Tape and Reel |            |                    | Qualification Grade (Note 9) |
|--------------|--------------------|--------------|---------------------|---------------------------|------------|--------------------|------------------------------|
|              |                    |              |                     | Quantity                  | Tape Width | Part Number Suffix |                              |
| ZXCT1008QFTA | SOT23              | F            | 108                 | 3000 Units                | 8mm        | 7"                 | Grade 1                      |

- Notes: 8. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at <http://www.diodes.com/datasheets/ap02001.pdf>
9. ZXCT1008Q has been qualified to AEC-Q100 grade 1 and is classified as "Automotive Grade" which supports PPAP documentation. See ZXCT1008 datasheet for commercial qualified version.

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

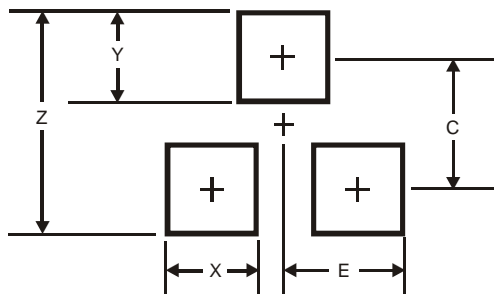
Please see AP02002 at <http://www.diodes.com/datasheets/ap02002.pdf> for latest version.



| SOT23                |       |       |       |
|----------------------|-------|-------|-------|
| Dim                  | Min   | Max   | Typ   |
| A                    | 0.37  | 0.51  | 0.40  |
| B                    | 1.20  | 1.40  | 1.30  |
| C                    | 2.30  | 2.50  | 2.40  |
| D                    | 0.89  | 1.03  | 0.915 |
| F                    | 0.45  | 0.60  | 0.535 |
| G                    | 1.78  | 2.05  | 1.83  |
| H                    | 2.80  | 3.00  | 2.90  |
| J                    | 0.013 | 0.10  | 0.05  |
| K                    | 0.890 | 1.00  | 0.975 |
| K1                   | 0.903 | 1.10  | 1.025 |
| L                    | 0.45  | 0.61  | 0.55  |
| L1                   | 0.25  | 0.55  | 0.40  |
| M                    | 0.085 | 0.150 | 0.110 |
| a                    | 8°    |       |       |
| All Dimensions in mm |       |       |       |

**Suggested Pad Layout**

Please see AP02001 at <http://www.diodes.com/datasheets/ap02001.pdf> for the latest version.



| Dimensions | Value (in mm) |
|------------|---------------|
| Z          | 2.9           |
| X          | 0.8           |
| Y          | 0.9           |
| C          | 2.0           |
| E          | 1.35          |



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