A Product Line of
Diodes Incorporated

ZXCT1009Q

AUTOMOTIVE GRADE MICROPOWER CURRENT MONITOR

Description

The ZXCT1009Q is a micropower high side current sense monitor.

This device eliminates the need to disrupt the ground plane when sensing a load current.

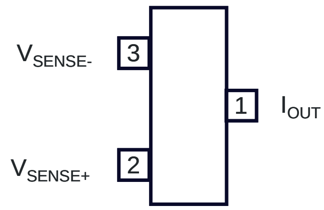
It takes a high side voltage developed across a current shunt resistor and translates it into a proportional output current. A user defined output resistor scales the output current into a ground-referenced voltage.

The wide input voltage range of 20V down to as low as 2.5V make it suitable for a range of applications. A minimum operating current of just 4µA, combined with a SOT23 package make it a unique solution for portable battery equipment.

The ZXCT1009Q has been qualified to AEC-Q100 Grade 3 and is Automotive Grade supporting PPAPs.

Pin Assignments

SOT23
Package Suffix - F



(Top View)

Features

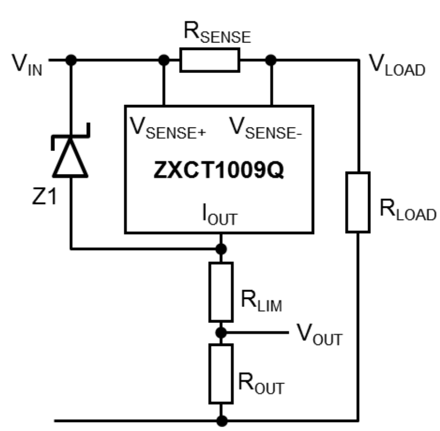
- Low cost, accurate high-side current sensing
- Output voltage scaling
- Up to 2.5V sense voltage
- 2.5V to 20V supply range
- 4µA quiescent current
- 1% typical accuracy
- SOT23
  - **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
  - **Halogen and Antimony Free. “Green” Device (Note 3)**
- 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

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 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/.

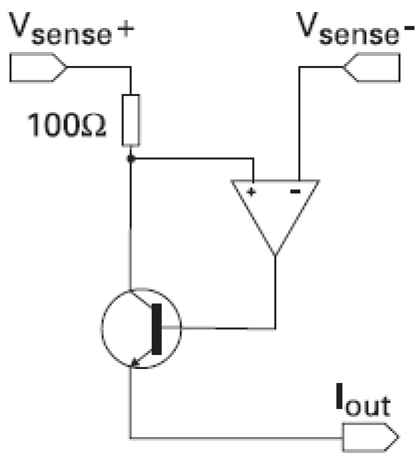
Typical Application Circuit



Pin Descriptions

Pin Name	Pin Function
V_{SENSE+}	Connection to supply voltage
V_{SENSE-}	Connection to load
I_{OUT}	Output current, proportional to measured current

Functional Block Diagram



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

Description		Rating	Unit
Voltage on any pin (relative to I_{OUT})		-0.6 to 20	V
Continous output current, I_{OUT}		25	mA
Continuous sense voltage, V_{SENSE} (Note 5)		-0.5 to +5	V
Operating temperature, T_A		-40 to +85	°C
Storage temperature		-55 to +125	°C
ESD Susceptibility			
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.

Package Thermal Data

Package	θ_{JA}	P_{DIS} T_A = +25°C, T_J = +150°C
SOT23	280°C/W	450mW

Electrical Characteristics (@T_A = +25°C, VIN = 5V, R_{OUT} = 100Ω, unless otherwise specified.)

Symbol	Parameter	Conditions	Limits			Units
			Min	Typ	Max	
V_{IN}	V_{CC} range		2.5		20	V
I_{OUT}	Output Current (Note 6)	V_{SENSE} = 0V (Note 5) V_{SENSE} = 10mV V_{SENSE} = 100mV V_{SENSE} = 200mV V_{SENSE} = 1V	1 90 0.975 1.95 9.6	4 104 1.002 2.0 9.98	15 120 1.025 2.05 10.2	µA µA mA mA mA
V_{SENSE}	Sense Voltage (Note 5)		0		2500	mV
I_{SENSE-}	V_{SENSE-} Input Current				100	nA
A_{CC}	Accuracy	R_{SENSE} = 0.1Ω V_{SENSE} = 200mV	-2.5		2.5	%
G_M	Transconductance, I_{OUT}/V_{SENSE}			10000		µA/V
BW	Bandwidth	$V_{SENSE(DC)}$ = 10mv, RF P_{IN} = -40dBm (Note 7) $V_{SENSE(DC)}$ = 100mv, RF P_{IN} = -20dBm‡		300 2		kHz MHz

Notes: 5. V_{SENSE} is defined as the differential voltage between V_{SENSE+} and V_{SENSE-} 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_{PP} into 50Ω.

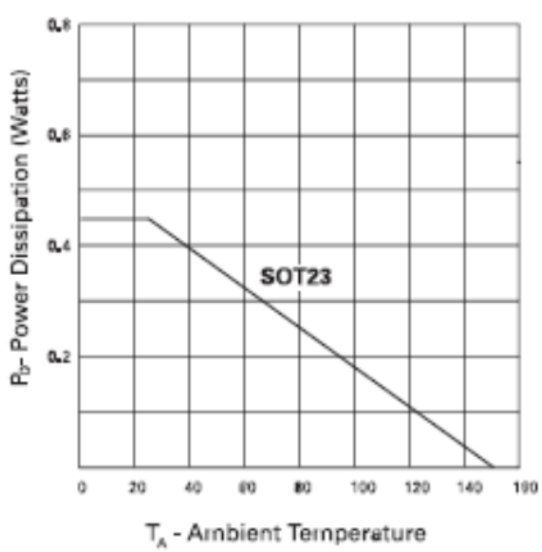
Power Dissipation

The maximum allowable power dissipation of the device for normal operation (P_{MAX}), is a function of the package junction to ambient thermal resistance (θ_{JA}), maximum junction temperature (T_{JMAX}), and ambient temperature (T_{AMB}), according to the expression:

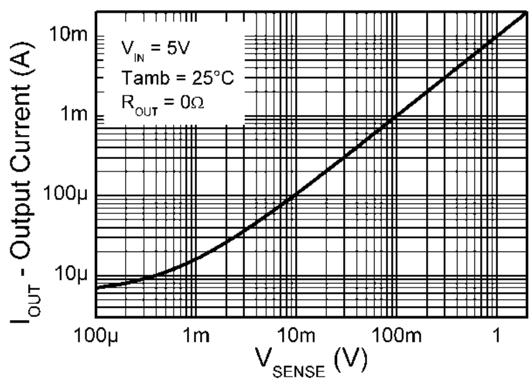
$P_{MAX} = (T_{JMAX} - T_{AMB}) / \theta_{JA}$

The device power dissipation, P_D is given by the expression:

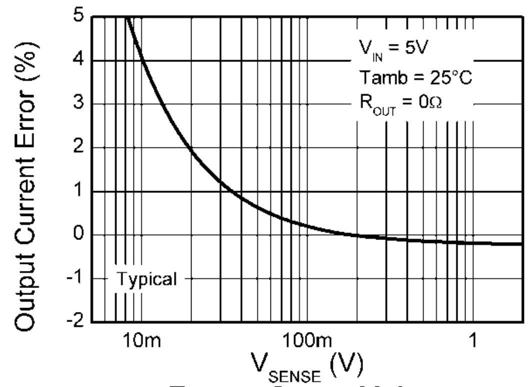
$P_D = I_{OUT} \times (V_{IN} - V_{OUT})$ W



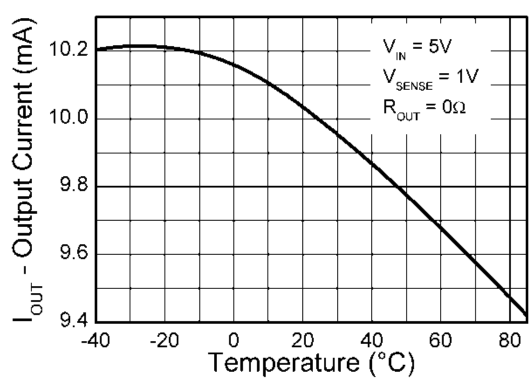
Typical Characteristics



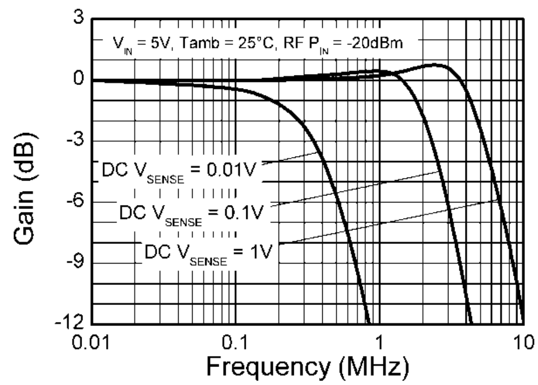
Typical Output v Sense Voltage



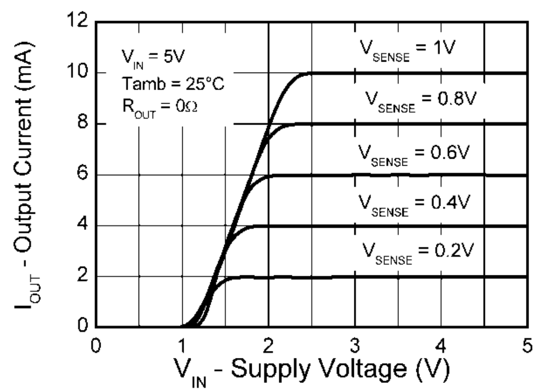
Error v Sense Voltage



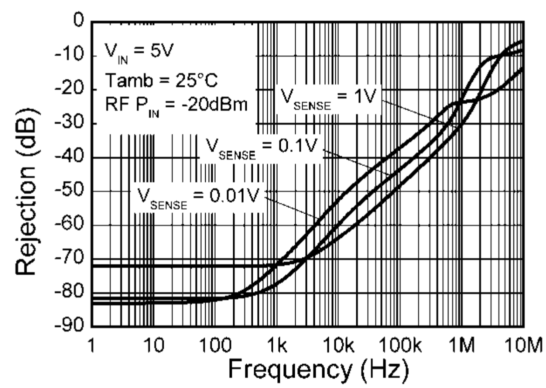
Output Current v Temperature



Frequency Response

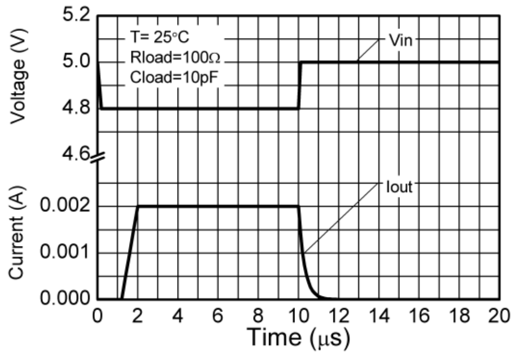


Transfer Characteristic



Common Mode Rejection

Typical Characteristics (cont.)



Step Response

Application Information

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

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

Referring to Figure 1.

$$V_{SENSE} = V_{IN} - V_{LOAD}$$

$$= R_{SENSE} \times I_{LOAD} \quad (1)$$

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

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

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 50mV > V_{SENSE} > 500mV at full load.

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

   Rearranging (1) gives:

$$R_{SENSE} = \frac{V_{SENSE}}{I_{LOAD}}$$

$$= 0.1/1.0 = 0.1\Omega.$$

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

   Rearranging (4) for R_{OUT} gives:

$$R_{OUT} = \frac{V_{OUT}}{V_{SENSE} \times 0.001}$$

$$= \frac{1}{0.1 \times 0.01} = 1k\Omega$$

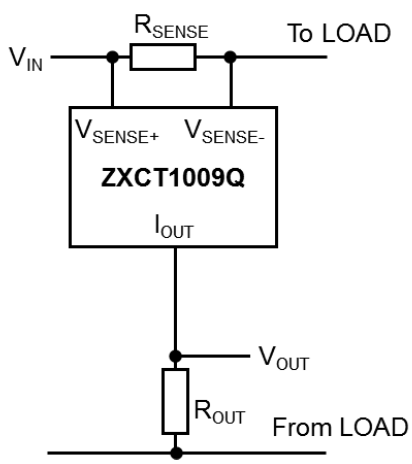


Figure 1: ZXCT1009Q typical circuit

Application Information (cont.)

Transient Protection

An additional resistor, R_{LIM} can be added in series with R_{OUT} (Figure 2), to limit the current from I_{OUT}. Any circuit connected to V_{OUT} will be protected from input voltage transients.

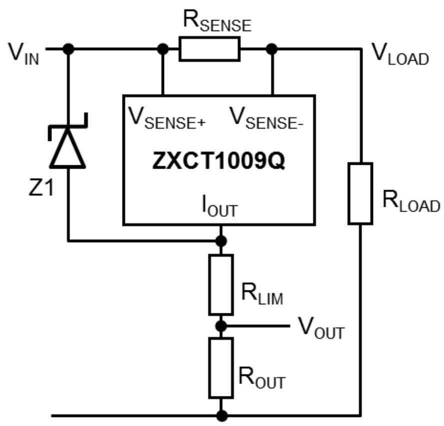


Figure 2 ZXCT1009Q with Additional Current Limiting Resistor R_{LIM} and Zener Z1.

This can be of particular use in automotive applications where load dump and other common transients need to be considered.
Adding a Zener diode Z1 provides additional protection for local dump, reverse battery and high voltage transient incidents.

Assuming the worst case condition of V_{OUT} = 0V; providing a low impedance to a transient, the minimum value of R_{LIM} is given by:

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

Where:

V_{PK} = Peak transient voltage to be withstood
V_{MAX} = Maximum working voltage = 20V
I_{PK} = Peak output current = 40mA

The maximum value of R_{LIM} is set by $V_{IN(MIN)}$, $V_{OUT(MAX)}$ and the dropout voltage (see transfer characteristic on page 3) of the ZXCT1009Q:

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

Where:

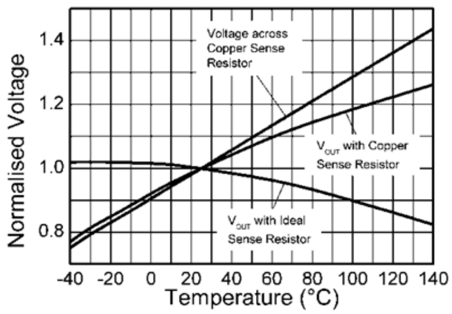
$V_{IN(MIN)}$ = Minimum Supply Operating Voltage
V_{DP} = Dropout Voltage
$V_{OUT(MAX)}$ = Maximum Operating Output Voltage

PCB Trace Shunt Resistor for Low Cost Solution

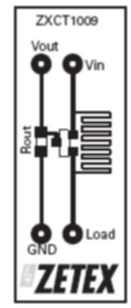
The figure below shows output characteristics of the device when using a PCB resistive trace for a low cost solution in replacement for a conventional shunt resistor. The graph shows the linear rise in voltage across the resistor due to the PTC of the material and demonstrates how this rise in resistance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

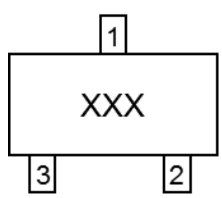
ZXCT1009Q X XX

Qualification	Package	Packing
Q : Automotive Grade	F : SOT23	TA : 7" Tape & Reel

Device	Packaging (Note 8)	Package Code	Identification Code	Packing: 7" Tape and Reel			Qualification Grade (Note 9)
				Quantity	Tape Width	Part Number Suffix	
ZXCT1009QFTA	SOT23	F	109	3000 Units	8mm	7"	Grade 3

Note: 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. ZXCT1009Q has been qualified to AEC-Q100 grade 3 and is classified as "Automotive Grade" which supports PPAP documentation. See ZXCT1009 datasheet for commercial qualified version.

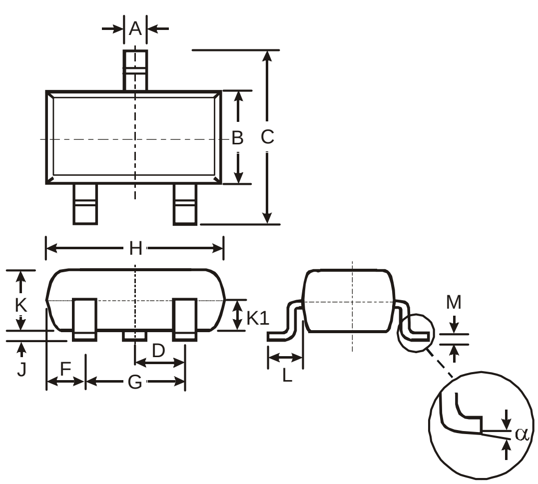
Marking Information



XXX : Identification code : 109

Package Outline Dimensions (All Dimensions in mm)

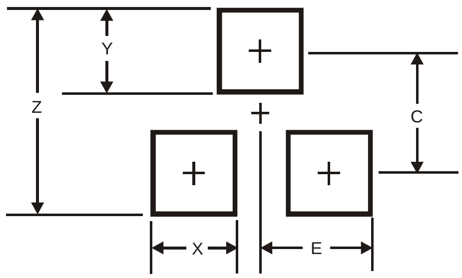
Please see AP02001 at http://www.diodes.com/datasheets/ap02002.pdf for latest version



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	0.903	1.10	1.00
K1	-	-	0.400
L	0.45	0.61	0.55
M	0.085	0.18	0.11
α	0°	8°	-
All Dimensions in mm			

Suggested Pad Layout

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



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