

**Description**

The ZXCT1009 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. A minimum operating current of just 4μA, combined with a SOT23 package make it a unique solution for portable battery equipment. The SM8 device offers an alternative package option.

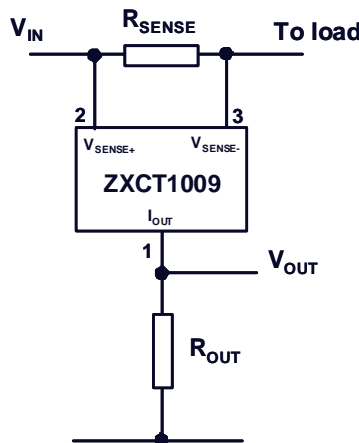
**Features**

- 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 and SM8 packages
- AEC-Q100.3 qualified; ZXCT1009FTA only

**Applications**

- Battery chargers
- Smart battery packs
- DC motor control
- Over current monitor
- Power management
- Level translating
- Programmable current source
- 

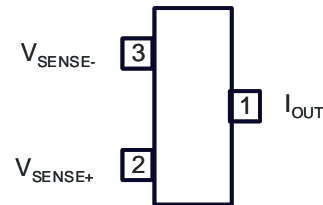
**Application Circuit**



**Pin Assignments**

**SOT23**

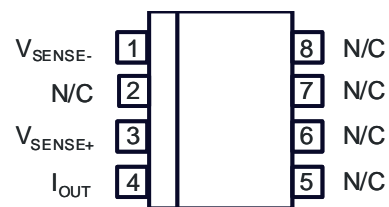
**Package Suffix - F**



**(Top View)**

**SM8**

**Package Suffix - T8**



**(Top View)**

### 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

### Absolute Maximum Ratings (T<sub>A</sub> = 25°C)

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> <sup>†</sup>	-0.5 to +5	V	
Operating temperature, T <sub>A</sub>	-40 to 85	°C	
Storage temperature	-55 to 125	°C	
Package power dissipation @ T <sub>A</sub> = 25°C (Derate to zero @ 125°C)	SOT23	450	mW
	SM8	2	W

Operation above the absolute maximum rating may cause device failure. Operation at the absolute maximum ratings for extended periods may reduce device reliability.

### Electrical Characteristics (T<sub>A</sub> = 25°C, V<sub>IN</sub> = 5V, R<sub>OUT</sub> = 100Ω)

Symbol	Parameter	Conditions	Limits			Units
			Min	Typ	Max	
V <sub>IN</sub>	V <sub>CC</sub> range		2.5		20	V
I <sub>OUT</sub> <sup>1</sup>	Output Current	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	1.002	1.025	mA
		V <sub>SENSE</sub> = 200mV	1.95	2.0	2.05	mA
		V <sub>SENSE</sub> = 1V	9.6	9.98	10.2	mA
V <sub>SENSE</sub> <sup>†</sup>	Sense Voltage		0		2500	mV
I <sub>SENSE-</sub>	V <sub>SENSE-</sub> Input Current				100	nA
ACC	Accuracy	R <sub>SENSE</sub> = 0.1Ω V <sub>SENSE</sub> = 200mV	-2.5		2.5	%
G <sub>M</sub>	Transconductance, I <sub>OUT</sub> /V <sub>SENSE</sub>			10000		μA/V
BW	Bandwidth	V <sub>SENSE(DC)</sub> = 10mV, RF P <sub>IN</sub> = -40dBm <sup>‡</sup>		300		kHz
		V <sub>SENSE(DC)</sub> = 100mV, RF P <sub>IN</sub> = -20dBm <sup>‡</sup>		2		MHz

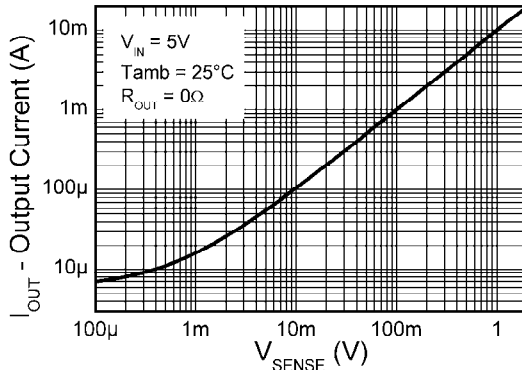
- Notes:
1. Includes input offset voltage contribution
  - †. V<sub>SENSE</sub> is defined as the differential voltage between V<sub>SENSE+</sub> and V<sub>SENSE-</sub>.  

$$V_{SENSE} = V_{SENSE+} - V_{SENSE-}$$

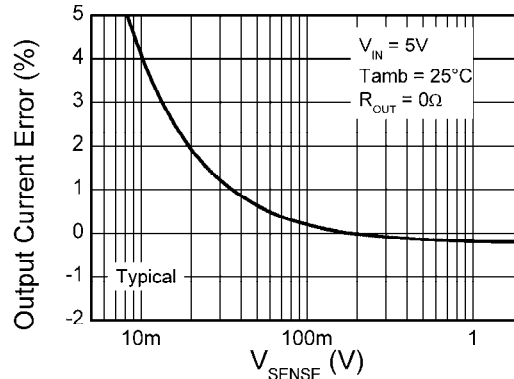
$$= V_{IN} - V_{LOAD}$$

$$= I_{LOAD} \times R_{SENSE}$$
  - ‡ -20dBm=63mVpp into 50Ω

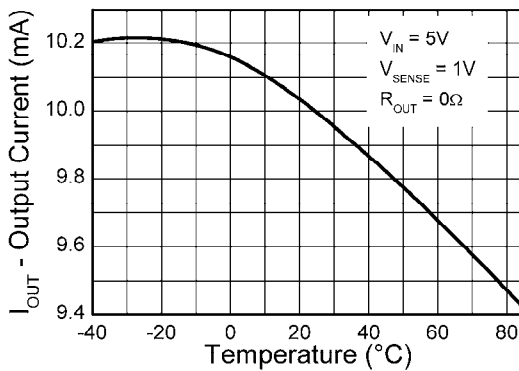
**Typical Characteristics**



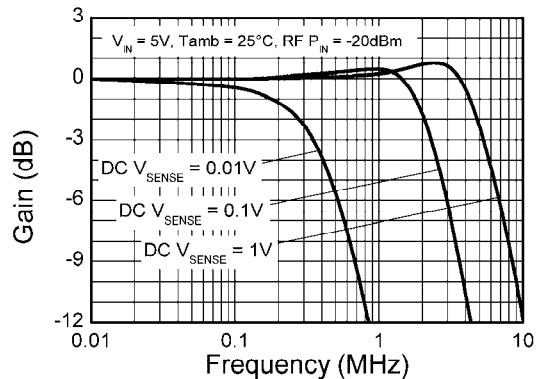
**Typical Output v Sense Voltage**



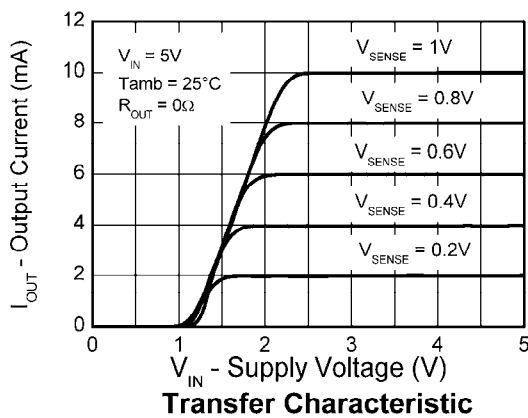
**Error v Sense Voltage**



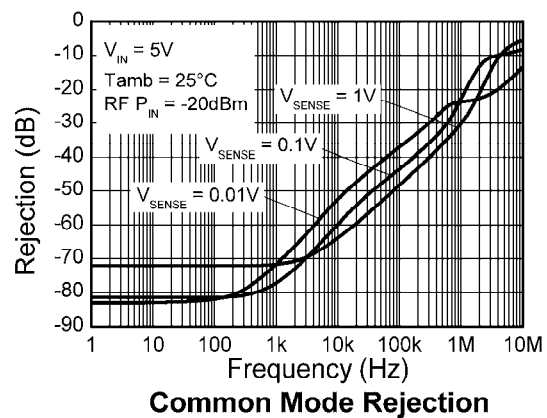
**Output Current v Temperature**



**Frequency Response**

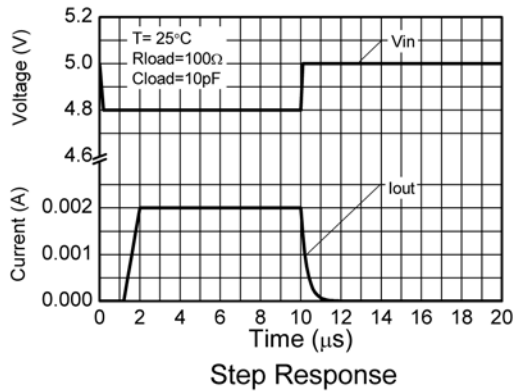


**Transfer Characteristic**



**Common Mode Rejection**

**Typical Characteristics (cont.)**



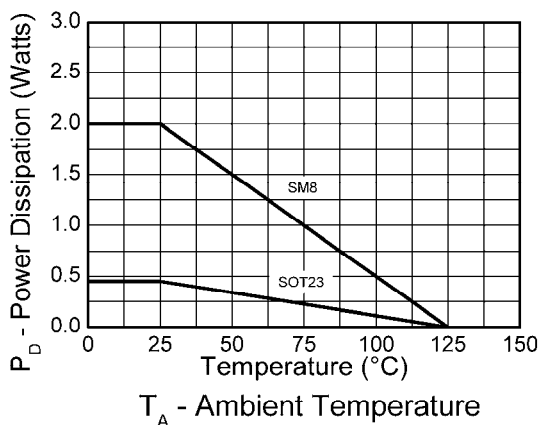
**Power Dissipation**

The maximum allowable power dissipation of the device for normal operation ( $P_{MAX}$ ), is a function of the package junction to ambient thermal resistance ( $\theta_{JA}$ ), 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:

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



**Application Information**

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

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

$$V_{OUT} = 0.01 \times V_{SENSE} \times R_{OUT}^1$$

E.g.

A 1A current is to be represented by a 100mV output voltage:

1) Choose the value of  $R_{SENSE}$  to give 50mV >

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

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

$$R_{SENSE} = 0.1/1.0 \Rightarrow 0.1\Omega.$$

2) Choose  $R_{OUT}$  to give  $V_{OUT} = 100mV$ , when

$V_{SENSE} = 100mV$ .

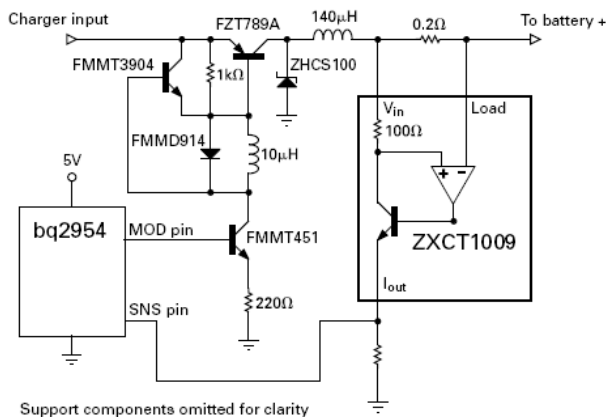
Rearranging <sup>1</sup> for  $R_{out}$  gives:

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

$$R_{OUT} = 0.1 / (0.1 \times 0.01) = 100\Omega$$

**Application Information (cont.)**

**Li-Ion Charger Circuit**



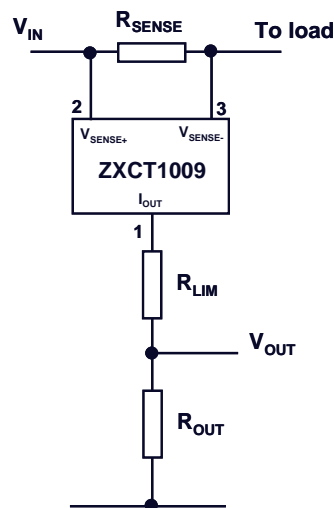
Support components omitted for clarity

The above figure shows the ZXCT1009 supporting the Benchmarq bq2954 Charge Management IC. Most of the support components for the bq2954 are omitted for clarity. This design also uses the Diodes FZT789A high current Super-β PNP as the switching transistor in the DC-DC step down converter and the FMMD451 as the drive NPN for the FZT789A. The circuit can be configured to charge up to four Li-Ion cells at a charge current of 1.25A. Charge can be terminated on maximum voltage, selectable minimum current, or maximum time out. Switching frequency of the PWM loop is approximately 120kHz.

The ZXCT1009 is intended as a direct functional replacement for the ZDS1009, which is featured in a complete design from Unirode/Texas Instruments on the Li-Ion charger circuit shown above. Reference: DVS2954S1H Li-Ion Charger Development System.

**Transient Protection**

An additional resistor, R<sub>LIM</sub> can be added in series with R<sub>OUT</sub> (as below), 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.



ZXCT1009 with additional current limiting Resistor R<sub>LIM</sub>.

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 ZXCT1009 :-

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

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

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

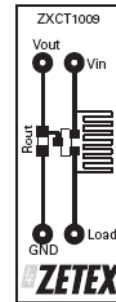
V<sub>OUT(MAX)</sub> = Maximum Operating Output Voltage

**Application Information (cont.)**

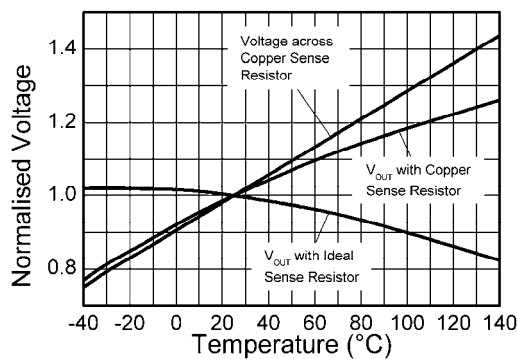
**PCB trace shunt resistor for low cost solution**

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 normalised 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.



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



Effect of Sense Resistor Material on Temperature Performance

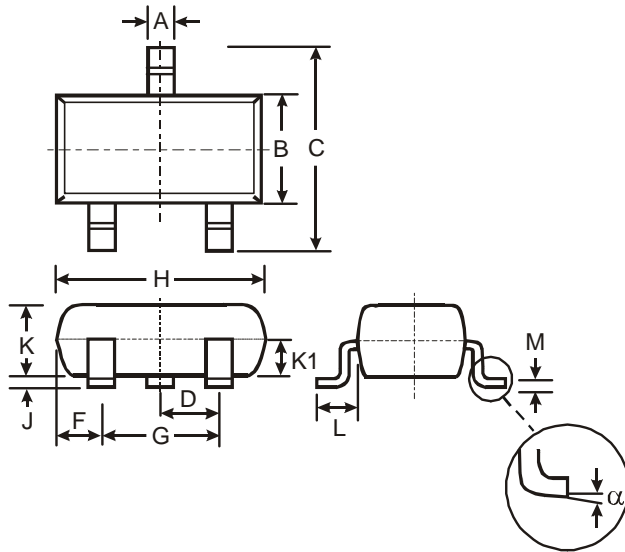
**Effect of Sense Resistor Material on Temperature Performance**

**Ordering Information**

Device	AEC-Q100 level	Reel Size	Tape Width	Quantity per Reel	Part Marking	Package
ZXCT1009FTA	Grade 3	7"	8mm	3000 Units	109	SOT23
ZXCT1009F-7	None	7"	8mm	3000 Units	109	SOT23
ZXCT1009T8TA	None	7"	12mm	1000 Units	ZXCT1009	SM8

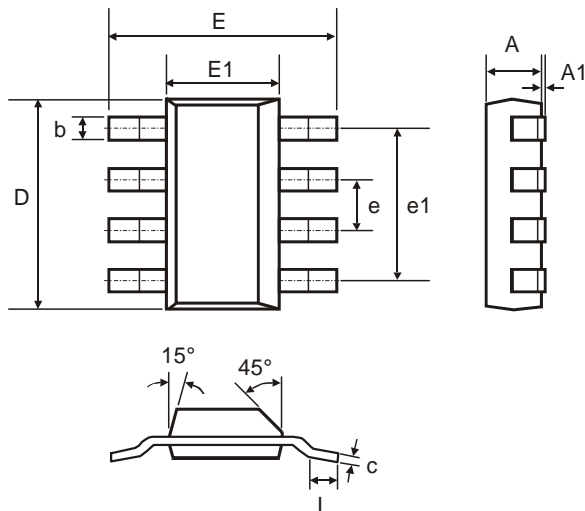
**Package Outline Dimensions (All Dimensions in mm)**

**1) SOT23**



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			

**2) SM8**



SM-8			
Dim	Min	Max	Typ
A	-	1.7	-
A1	0.02	0.1	-
b	-	0.7	-
c	0.24	0.32	-
D	6.3	6.7	-
e	-	-	1.53
e1	-	-	4.59
E	6.7	7.3	-
E1	3.3	3.7	-
L	0.9	-	-
All Dimensions in mm			

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