

# ZXCT1010

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## ENHANCED HIGH-SIDE CURRENT MONITOR

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### DESCRIPTION

The ZXCT1010 is a high side current sense monitor. Using this device eliminates the need to disrupt the ground plane when sensing a load current.

It is an enhanced version of the ZXCT1009 offering reduced typical output offset and improved accuracy at low sense 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 4 $\mu$ A, combined with its SOT23-5 package make suitable for portable battery equipment.

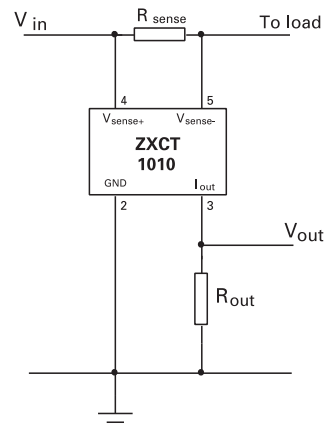
### FEATURES

- Low cost, accurate high-side current sensing
- Output voltage scaling
- Up to 2.5V sense voltage
- 2.5V – 20V supply range
- 300nA typical offset current
- 3.5 $\mu$ A quiescent current
- 1% typical accuracy
- SOT23 -5 package

### APPLICATIONS

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

### APPLICATION CIRCUIT



### ORDERING INFORMATION

| DEVICE       | REEL SIZE | TAPE WIDTH | QUANTITY PER REEL |
|--------------|-----------|------------|-------------------|
| ZXCT1010E5TA | 7"        | 8mm        | 3,000 units       |

PARTMARK 101  
PACKAGE SOT23-5

# ZXCT1010

## ABSOLUTE MAXIMUM RATINGS

|   |                                       |
|---|---------------------------------------|
| Voltage on any pin                      | -0.6V to 20V (relative to GND)        |
| Continuous output current, $I_{OUT}$    | 25mA                                  |
| Continuous sense voltage, $V_{SENSE}^2$ | -0.5V to +5V                          |
| Operating temperature, $T_A$            | -40 to 85°C                           |
| Storage temperature                     | -55 to 150°C                          |
| Package power dissipation<br>SOT23-5    | ( $T_A = 25^\circ\text{C}$ )<br>300mW |

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

Test Conditions  $T_A = 25^\circ\text{C}$ ,  $V_{in} = 5\text{V}$ ,  $R_{out} = 100\Omega$ .

| SYMBOL        | PARAMETER                                  | CONDITIONS  | LIMITS |       |       | UNIT            |
|---------------|--|---|--------|-------|-------|-----------------|
|               |  |   | Min    | Typ   | Max   |                 |
| $V_{in}$      | $V_{CC}$ Range                             |   | 2.5    |       | 20    | V               |
| $I_{out}^1$   | Output current                             | $V_{sense} = 0\text{V}$                               | 0      | 0.3   | 10    | $\mu\text{A}$   |
|               |  | $V_{sense} = 10\text{mV}$                             | 85     | 100   | 115   | $\mu\text{A}$   |
|               |  | $V_{sense} = 100\text{mV}$                            | 0.975  | 1.00  | 1.025 | mA              |
|               |  | $V_{sense} = 200\text{mV}$                            | 1.95   | 2.00  | 2.05  | mA              |
|               |  | $V_{sense} = 1\text{V}$                               | 9.7    | 10.0  | 10.3  | mA              |
| $I_q$         | Ground pin current                         | $V_{sense} = 0\text{V}$                               |        | 3.5   | 8     | $\mu\text{A}$   |
| $V_{sense}^2$ | Sense Voltage                              |   | 0      |       | 2500  | mV              |
| $I_{sense}^-$ | $V_{sense}^-$ input current                |   |        |       | 100   | nA              |
| Acc           | Accuracy                                   | $R_{sense} = 0.1\Omega$<br>$V_{sense} = 200\text{mV}$ | -2.5   |       | 2.5   | %               |
| Gm            | Transconductance,<br>$I_{out} / V_{sense}$ |   |        | 10000 |       | $\mu\text{A/V}$ |
| BW            | Bandwidth                                  | $V_{SENSE(DC)} = 10\text{mV}$ , Pin = -40dBm ‡        |        | 300   |       | kHz             |
|               |  | $V_{SENSE(DC)} = 100\text{mV}$ , Pin = -20dBm ‡       |        | 2     |       | MHz             |

<sup>1</sup> Includes input offset voltage contribution

<sup>2</sup>  $V_{SENSE}$  is defined as the differential voltage between  $V_{SENSE+}$  and  $V_{SENSE-}$ .

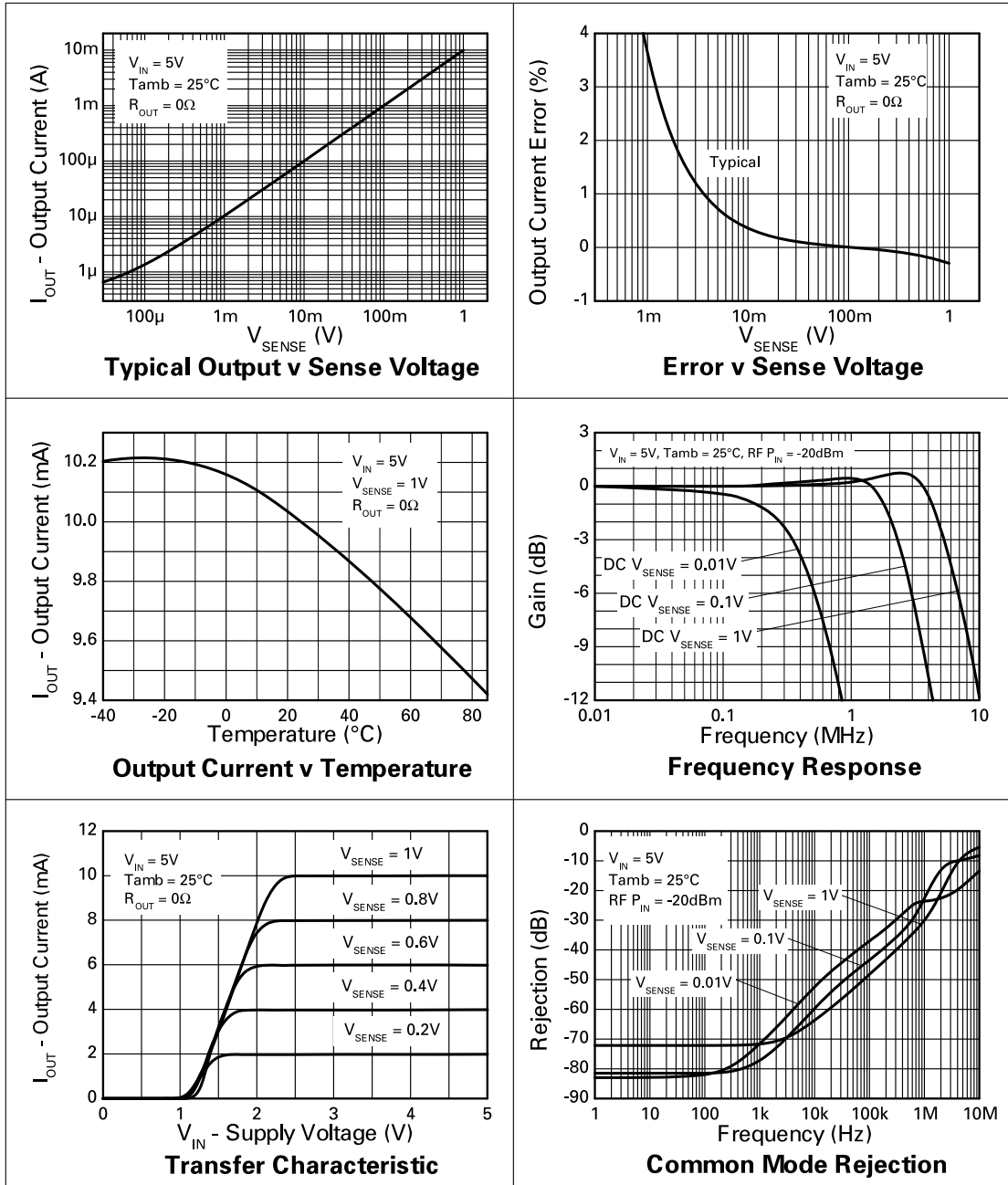
$$V_{SENSE} = V_{SENSE+} - V_{SENSE-}$$

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

$$= I_{LOAD} \times R_{SENSE}$$

<sup>3</sup> -20dBm=63mVp-p into 50 $\Omega$

## TYPICAL CHARACTERISTICS

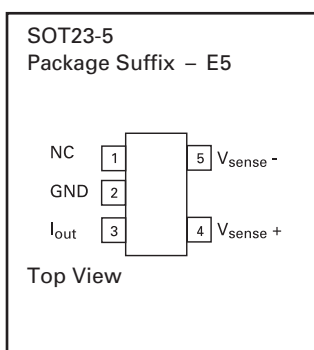


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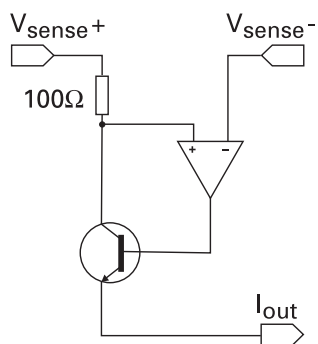
## PIN DESCRIPTION

| Pin Name            | Pin Function  |
|---------------------|---|
| $V_{\text{sense}+}$ | Supply voltage  |
| $V_{\text{sense}-}$ | Connection to load/battery  |
| $I_{\text{out}}$    | Output current, proportional to $V_{\text{in}} - V_{\text{load}}$ |
| GND                 | Ground  |

## CONNECTION DIAGRAM



## SCHEMATIC DIAGRAM



# ZXCT1010

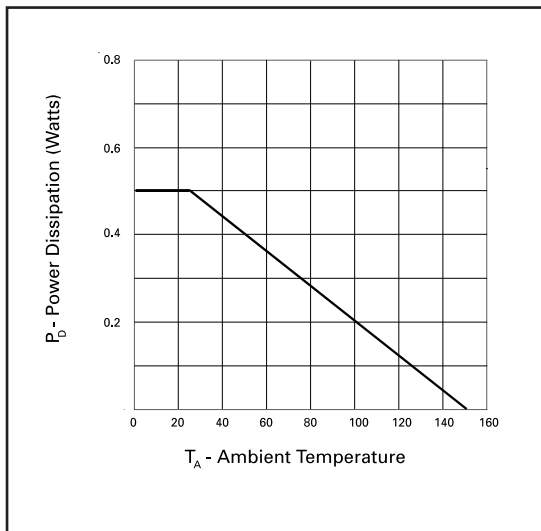
## POWER DISSIPATION

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:

$$P_D = I_{out} \cdot (V_{in} - V_{out}) \text{ Watts}$$



## APPLICATIONS INFORMATION

The following lines describe 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.  $R_{sense} = 0.1/1.0 \Rightarrow 0.1 \text{ ohms}$ .

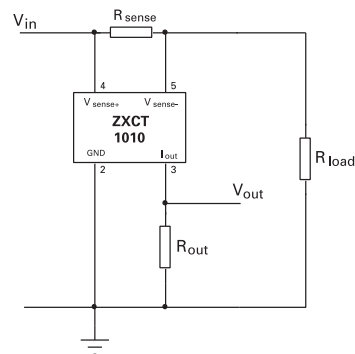
2) Choose  $R_{out}$  to give  $V_{out} = 100mV$ , when  $V_{sense} = 100mV$ .

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

$$R_{out} = V_{out} / (V_{sense} \times 0.01)$$

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

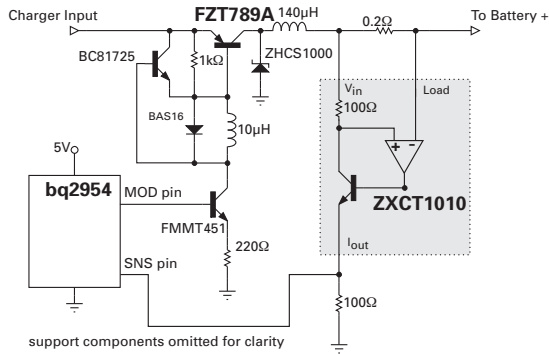
## TYPICAL CIRCUIT APPLICATION



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.

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## APPLICATIONS INFORMATION (Continued)

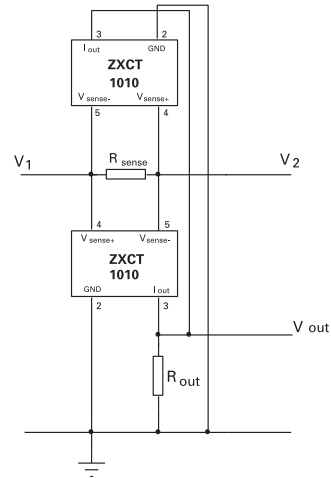


### Li-Ion Charger Circuit

The above figure shows the ZXCT1010 supporting the Benchmarq bq2954 Charge Management IC. Most of the support components for the bq2954 are omitted for clarity. This design also uses the Zetex FZT789A high current Super- $\beta$  PNP as the switching transistor in the DC-DC step down converter and the FMNT451 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.

### Bi-Directional Current Sensing

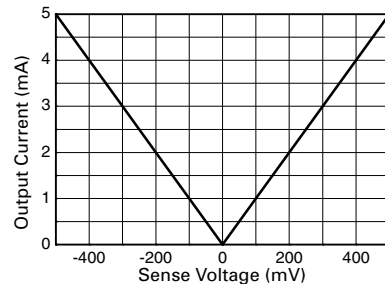
The ZXCT1010 can be used to measure current bi-directionally, if two devices are connected as shown below.



If the voltage  $V_1$  is positive with respect to the voltage  $V_2$  the lower device will be active, delivering a proportional output current to  $R_{out}$ . Due to the polarity of the voltage across  $R_{sense}$ , the upper device will be inactive and will not contribute to the current delivered to  $R_{out}$ . When  $V_2$  is more positive than  $V_1$ , current will be flowing in the opposite direction, causing the upper device to be active instead.

Non-linearity will be apparent at small values of  $V_{sense}$  due to offset current contribution. Devices can use separate output resistors if the current direction is to be monitored independently.

### Bi-directional Transfer Function



Output Current v Sense Voltage

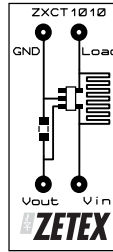
# ZXCT1010

## APPLICATIONS INFORMATION (Continued)

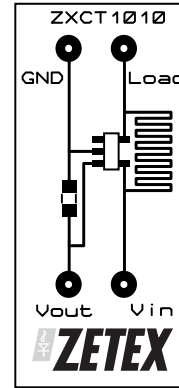
### PCB trace shunt resistor for low cost solution

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.

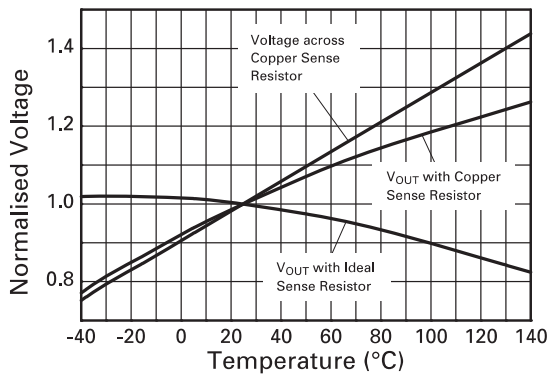
The figure opposite shows a PCB layout suggestion. The resistor section is 25mm x 0.25mm giving approximately 150mΩ using 1oz copper. The data for the normalised graph was obtained using a 1A load current and a 100Ω output resistor. An electronic version of the PCB layout is available at [www.zetex.com/isense](http://www.zetex.com/isense)



Actual Size



Layout shows area of shunt resistor compared to SOT23-5 package. Not actual size



Effect of Sense Resistor Material on Temperature Performance

# ZXCT1010

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"Preview"Future device intended for production at some point. Samples may be available

"Active"Product status recommended for new designs

"Last time buy (LTB)"Device will be discontinued and last time buy period and delivery is in effect

"Not recommended for new designs"Device is still in production to support existing designs and production

"Obsolete"Production has been discontinued

Datasheet status key:

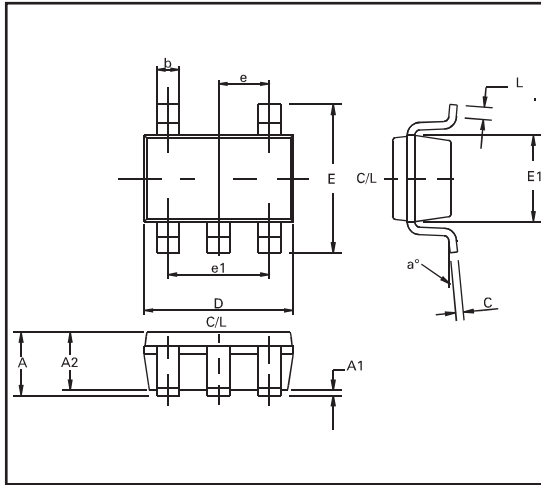
"Draft version" This term denotes a very early datasheet version and contains highly provisional information, which may change in any manner without notice.

"Provisional version" This term denotes a pre-release datasheet. It provides a clear indication of anticipated performance. However, changes to

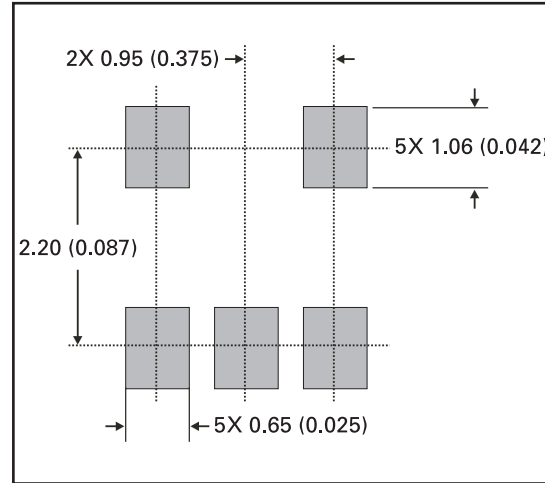


# ZXCT1010

## PACKAGE DIMENSIONS



## PAD LAYOUT DETAILS



Controlling dimensions are in millimeters. Approximate conversions are given in inches

## PACKAGE DIMENSIONS

| DIM | Millimeters |      | Inches |       | DIM | Millimeters |      | Inches    |       |
|-----|-------------|------|--------|-------|-----|-------------|------|-----------|-------|
|     | MIN         | MAX  | MIN    | MAX   |     | MIN         | MAX  | MIN       | MAX   |
| A   | 0.90        | 1.45 | 0.035  | 0.057 | E   | 2.60        | 3.00 | 0.102     | 0.118 |
| A1  | 0.00        | 0.15 | 0.00   | 0.006 | E1  | 1.50        | 1.75 | 0.059     | 0.069 |
| A2  | 0.90        | 1.3  | 0.035  | 0.051 | e   | 0.95 REF    |      | 0.037 REF |       |
| b   | 0.35        | 0.50 | 0.014  | 0.020 | e1  | 1.90 REF    |      | 0.075 REF |       |
| C   | 0.09        | 0.20 | 0.0035 | 0.008 | L   | 0.10        | 0.60 | 0.004     | 0.024 |
| D   | 2.80        | 3.00 | 0.110  | 0.118 | a°  | 0           | 10   | 0         | 10    |

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