

# ZXCT1041

## Bidirectional precision high-side current monitor

### Description

The ZXCT1041 is a bidirectional precision high-side current sense monitor. The output voltage is proportional to the differential input voltage. Direction of current flow is indicated by the Flag pin.

The ZXCT1041 provides a fixed gain of 10 for applications where minimal external components are required.

The very low offset voltage enables a typical accuracy of 2% for sense voltages of only 10mV, giving better tolerances for small sense resistors necessary at higher currents.

The wide input voltage range of 20V down to as low as 2.7V make it suitable for a range of applications.

A minimum operating current of just 40 $\mu$ A, combined with a SOT23-5 package makes the ZXCT1041 particularly suitable for portable battery equipment.

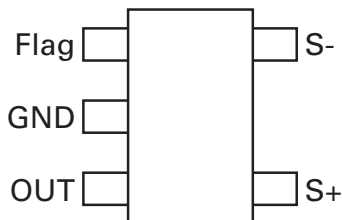
### Features

- Bidirectional high side measurement
- Output voltage scaling x10
- 2.7V to 20V high side voltage
- 35 $\mu$ A quiescent current
- 1% typical accuracy
- SOT23-5 package

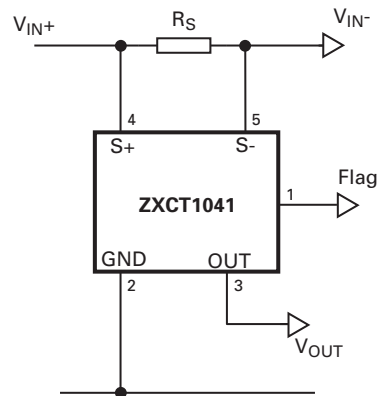
### Applications

- Battery management
- Over current monitor
- Battery gas gauging
- Motor control

### Pin connections



### Typical application circuit



### Ordering information

| Order code   | Package | Partmark | Reel size (inches) | Tape width (mm) | Quantity per reel |
|--------------|---------|----------|--------------------|-----------------|-------------------|
| ZXCT1041E5TA | SOT23-5 | 1041     | 7                  | 8               | 3000              |

## Absolute maximum ratings

|                                     |  |
|-------------------------------------|--|
| Voltage on $V_{S-}$ and $V_{S+}$    | -0.6 to 20V  |
| Voltage on all other pins           | -0.6V to ( $V_{S+}$ or $V_{S-}$ ) +0.6V                      |
| $V_{sense} [(V_{S+}) - (V_{S-})]$   | +/-6V  |
| Operating temperature, $T_A$        | -40 to 125°C   |
| Storage temperature                 | -55 to 150°C   |
| Maximum junction temperature, $T_J$ | 150°C  |
| Package power dissipation           | 300mW at $T_A = 25^\circ\text{C}$ (De-rate to zero at 150°C) |

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

## Recommended operating conditions

| Parameter   |  | Min. | Max.             | Units |
|-------------|--|------|------------------|-------|
| $V_{S\pm}$  | Common-mode sense input range          | 2.7  | 20               | V     |
| Flag        | Current direction flag output          | 0    | $V_{S\pm}$       | V     |
| $V_{SENSE}$ | Differential sense input voltage range | 0    | $\pm 0.8$        | V     |
| $V_{OUT}$   | Output voltage range                   | 0    | $V_{S\pm} - 1.5$ | V     |
| $T_A$       | Ambient temperature range              | -40  | 125              | °C    |

## Pin function table

| Pin | Name | Description   |
|-----|------|---|
| 1   | Flag | This is the current direction pin. It is open collector and allows the logic high level to be set independent of $V_{S+}$ voltage. Low indicates $V_{S+}$ is greater than $V_{S-}$ .                    |
| 2   | GND  | Ground pin  |
| 3   | OUT  | Output voltage pin  |
| 4   | S+   | This is the positive input of the current monitor. It also acts as the supply voltage pin providing current for internal circuitry. The current through this pin varies with differential sense voltage |
| 5   | S-   | This is the negative input of the current monitor. The current through this pin varies with differential sense voltage  |

## Electrical characteristics

Test conditions  $T_A = 25^\circ\text{C}$ ,  $V_{S+} = 10\text{V}$ ,  $V_{\text{SENSE}} = 100\text{mV}$

| Symbol              | Parameter                                   | Conditions  | Min. | Typ. | Max.    | Units                 |
|---------------------|---|---|------|------|---------|-----------------------|
| $I_Q$               | Ground pin current                          |   | 15   | 35   | 50      | $\mu\text{A}$         |
| $I_{S+}$            | $V_{S+}$ input current                      | $V_{\text{SENSE}} = 0\text{V}$  | 10   | 17   | 24      | $\mu\text{A}$         |
| $I_{S-}$            | $V_{S-}$ input current                      | $V_{\text{SENSE}} = 0\text{V}$  | 10   | 17   | 24      | $\mu\text{A}$         |
| $V_{\text{OUT}}$    | Output voltage<br>[flag high]               | $V_{\text{SENSE}} = +150\text{mV}$  | 1.55 | 1.5  | 1.45    | V                     |
|                     |   | $V_{\text{SENSE}} = +100\text{mV}$  | 1.02 | 1    | 0.98    | V                     |
|                     |   | $V_{\text{SENSE}} = +30\text{mV}$   | 309  | 300  | 291     | mV                    |
|                     | [flag low]                                  | $V_{\text{SENSE}} = 0\text{V}$  | 0    |      | 15      | mV                    |
|                     |   | $V_{\text{SENSE}} = -30\text{mV}$   | 285  | 300  | 315     | mV                    |
|                     |   | $V_{\text{SENSE}} = -100\text{mV}$  | 0.95 | 1    | 1.05    | V                     |
|                     |   | $V_{\text{SENSE}} = -150\text{mV}$  | 1.42 | 1.50 | 1.58    | V                     |
| $V_{\text{OUT TC}}$ | $V_{\text{OUT}}$ variation with temperature | $V_{\text{SENSE}} = \pm 100\text{mV}$   |      | 30   |         | ppm/ $^\circ\text{C}$ |
| Gain                | $V_{\text{OUT}}/V_{\text{SENSE}}$           |   |      | 10   |         |                       |
| Accuracy            | Total output error (Gain + offset)          | $V_{\text{SENSE}} = 100\text{mV}$   |      |      | $\pm 2$ | %                     |
| Accuracy            | Total output error (Gain + offset)          | $V_{\text{SENSE}} = -100\text{mV}$  |      |      | $\pm 5$ | %                     |
| BW                  | Bandwidth                                   | $V_{\text{SENSE(DC)}} = 100\text{mV}$<br>$V_{\text{SENSE(AC)}} = 63\text{mV}_{\text{PP}}$ |      | 300  |         | kHz                   |
| CMRR                | $V_{S+}$ common mode rejection ratio        | $V_{\text{IN}} = 2.7$ to $20\text{V}$   |      | 60   |         | dB                    |
| Flag TP             | Flag trip point                             | Referred to $V_{\text{SENSE}}$  | -2.5 |      | +2.5    | mV                    |
| $V_{\text{FL}}$     | Flag low output voltage                     | $I_{\text{SINK}} = 100\mu\text{A}$  |      | 60   | 200     | mV                    |
| $I_{\text{FH}}$     | Flag high leakage current                   | $V_{\text{OH}} = 5\text{V}$   |      |      | 1       | $\mu\text{A}$         |

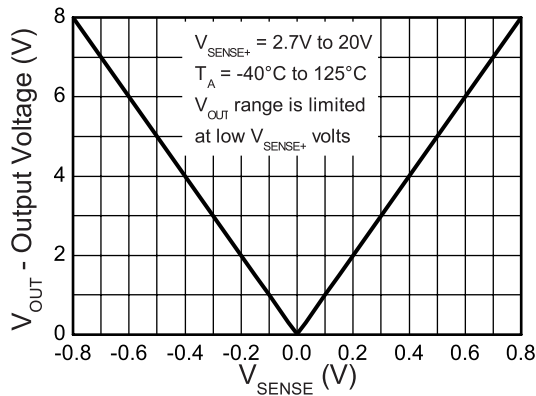
### NOTES:

(a)  $V_{\text{SENSE}} = "V_{S+}" - "V_{S-}"$

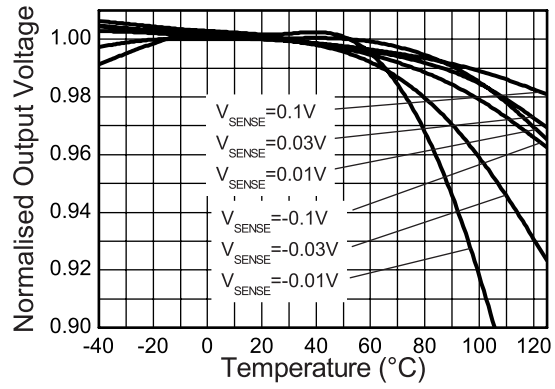
(b) Temperature dependent measurements are extracted from characterisation and simulation results.

## Typical characteristics

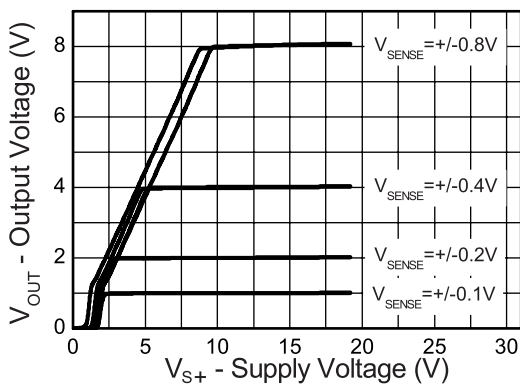
Conditions  $V_{SENSE+}=10V$ ,  $V_{SENSE}=100mV$ ,  $T_A=25^\circ C$  unless otherwise stated.



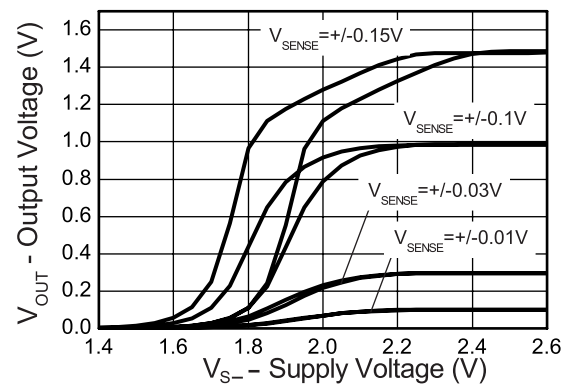
Output Voltage v Sense Voltage



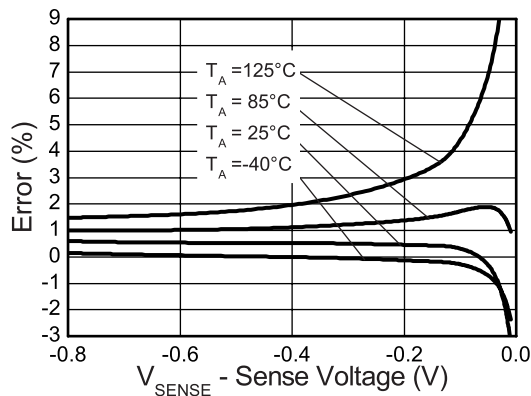
Output v Temperature



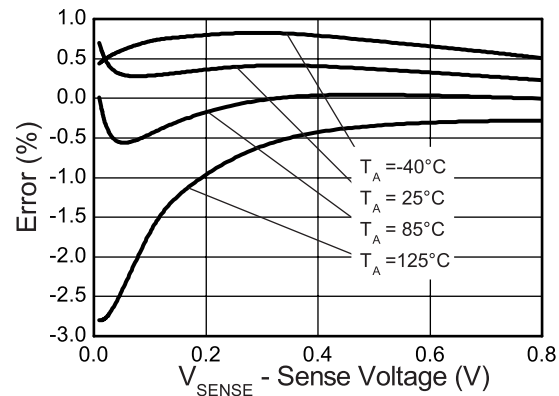
Output v Supply Voltage



Output v Supply Voltage



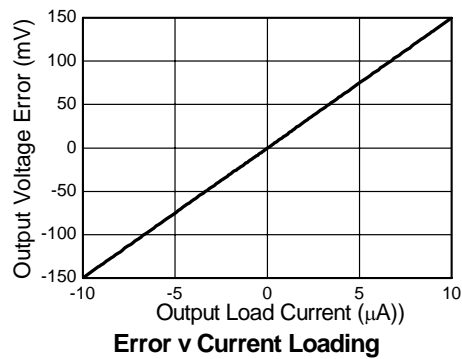
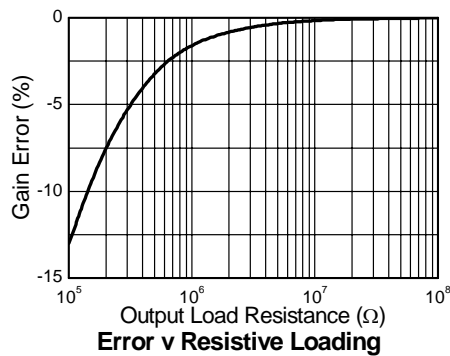
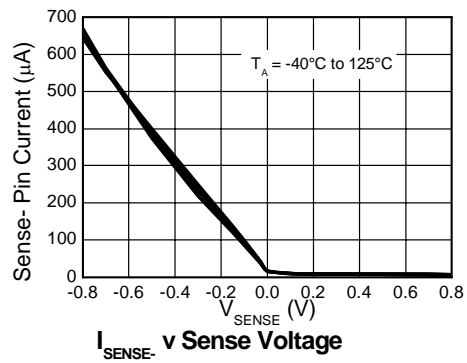
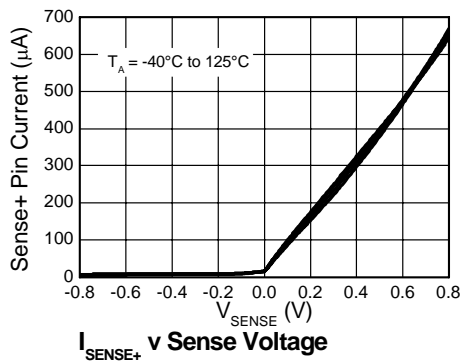
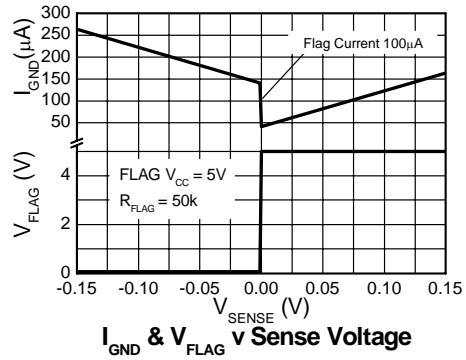
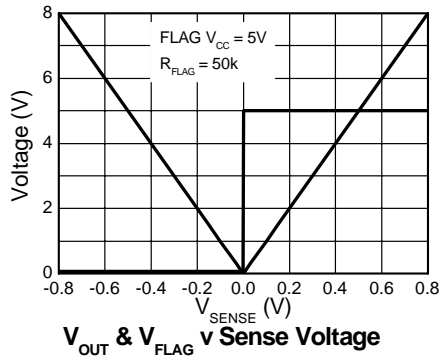
Error v Reverse Sense Voltage



Error v Forward Sense Voltage

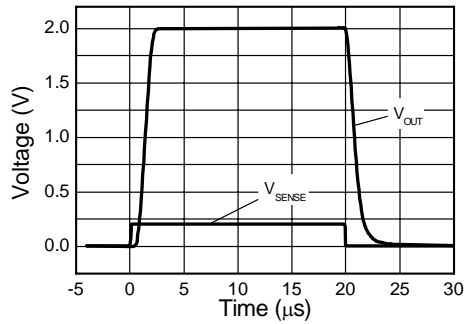
## Typical characteristics

Conditions  $V_{SENSE+}=10V$ ,  $V_{SENSE}=100mV$ ,  $T_A=25^\circ C$  unless otherwise stated.

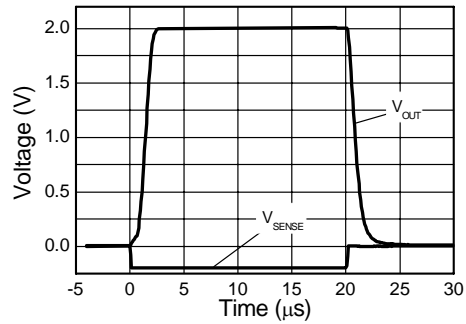


## Typical characteristics

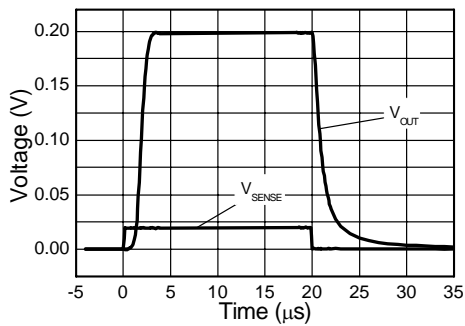
Conditions  $V_{SENSE+}=10V$ ,  $V_{SENSE}=100mV$ ,  $T_A=25^{\circ}C$  unless otherwise stated.



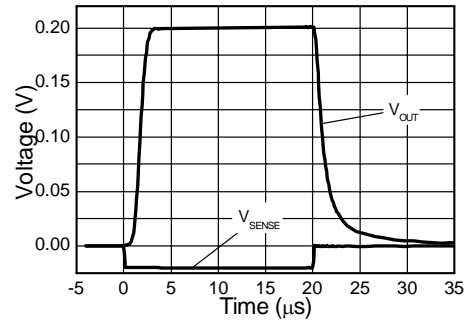
**Forward Large Signal Step Response**



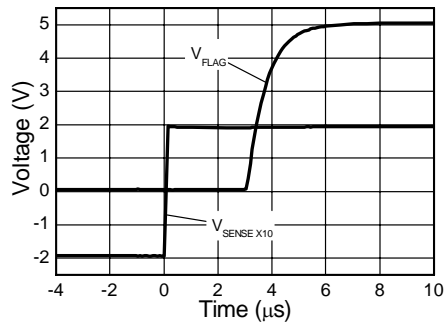
**Reverse Large Signal Step Response**



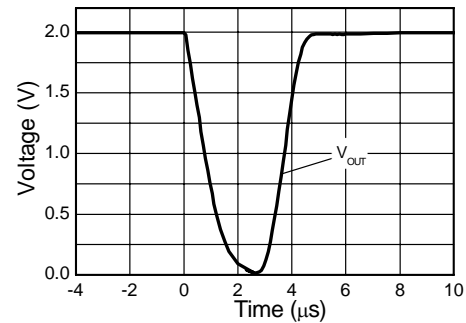
**Forward Small Signal Step Response**



**Reverse Small Signal Step Response**



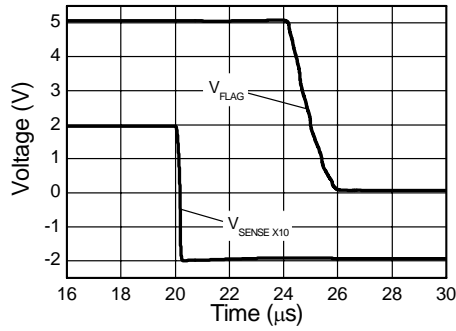
**Large Sig Zero Crossing Response**



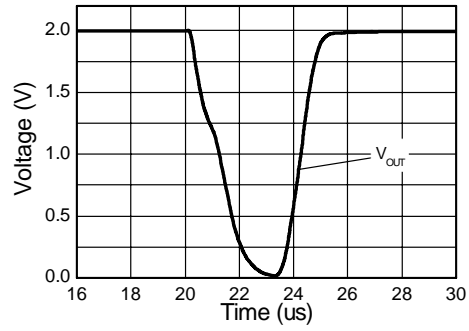
**Large Sig Zero Crossing Response**

## Typical characteristics

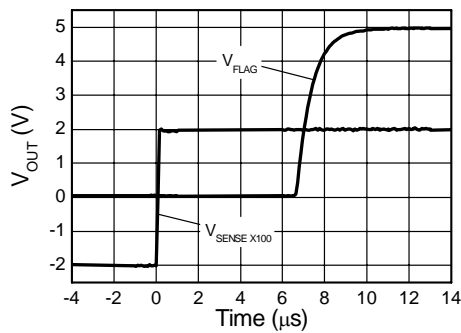
Conditions  $V_{SENSE+}=10V$ ,  $V_{SENSE}=100mV$ ,  $T_A=25^{\circ}C$  unless otherwise stated.



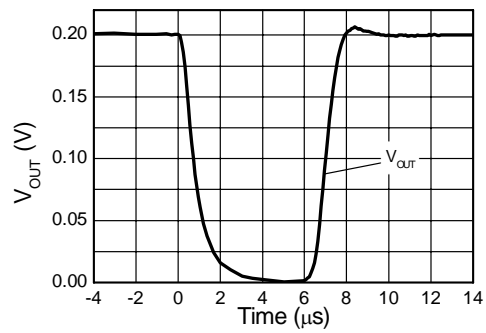
**Large Sig Zero Crossing Response**



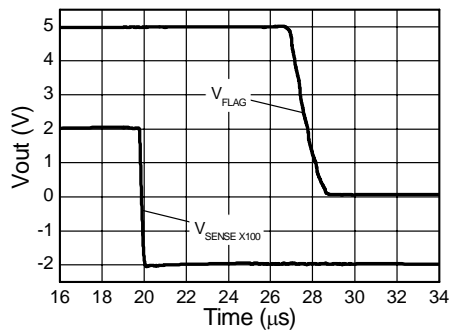
**Large Sig Zero Crossing Response**



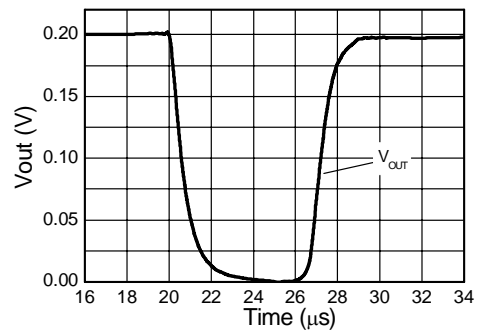
**Small Sig Zero Crossing Response**



**Small Sig Zero Crossing Response**



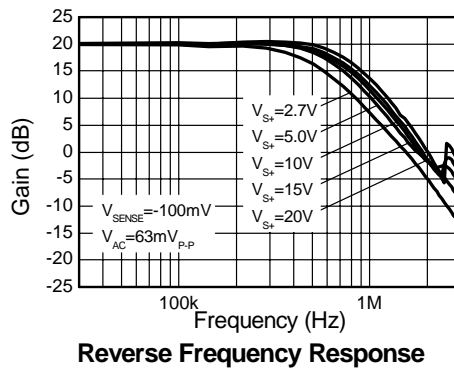
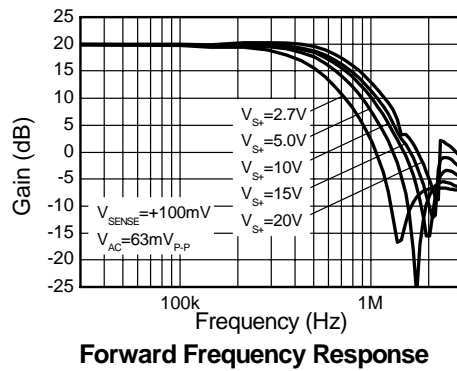
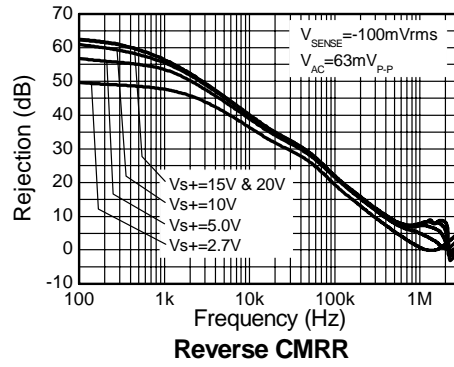
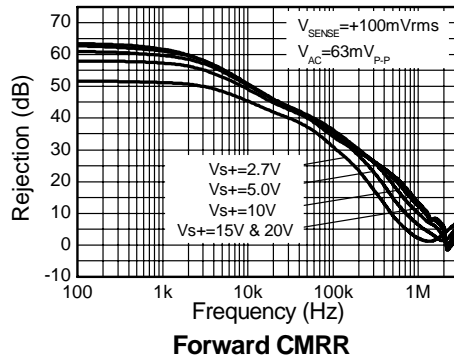
**Small Sig Zero Crossing Response**



**Small Sig Zero Crossing Response**

## Typical characteristics

Conditions  $V_{SENSE+}=10V$ ,  $V_{SENSE}=100mV$ ,  $T_A=25^{\circ}C$  unless otherwise stated.





# ZXCT1041

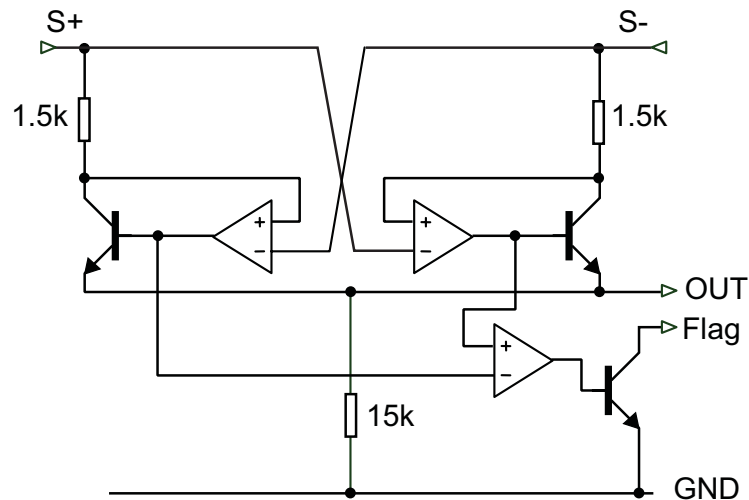
## Application information

The ZXCT1041 uses two current monitors in anti-parallel to provide bidirectional current measurement. The integrated resistors while having a broad actual value variance provide very good matching to one another; this provides very tight gain matching from forward current measurement to reverse current management and removes the need to trim the resistor values.

The internal transconductance setting resistors have a nominal value of  $1.5k\Omega$  thereby setting the internal transconductance to  $0.67mA/V$  of  $V_{SENSE}$ . The outputs of both current monitors (current) are summed into an internal common gain-setting resistor of  $15k\Omega$ . This sets the overall gain to 10 which has a very small variance due to the very good matching of internal transistors.

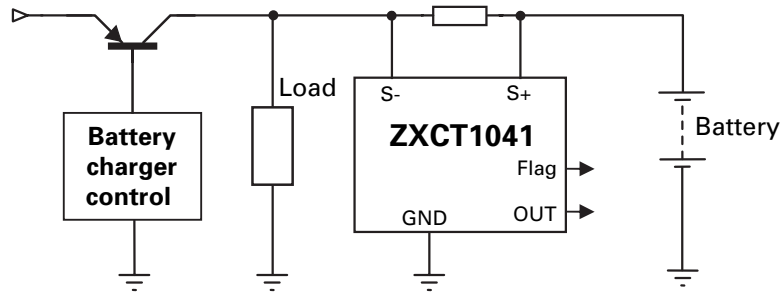
To improve accuracy the offset of amplifier 1 is trimmed.

The direction of measured current flow is determined by comparing the voltages applied to the bases of transconductance transistors (Q1 and Q2). For maximum versatility the flag output uses an open collector; this allows the ZXCT1041 to monitor rails at a much higher potential than what the flag output is interfacing to.



A common application for micro-power current monitors is measuring the discharge current of a rechargeable lithium ion/polymer battery. The ZXCT1041 enables measuring both the charge and discharge current into the battery and with its wide operating voltage of 2.5 to 20V enables it to measure the currents in to/ out of up to 4 cells connected in series.

# ZXCT1041

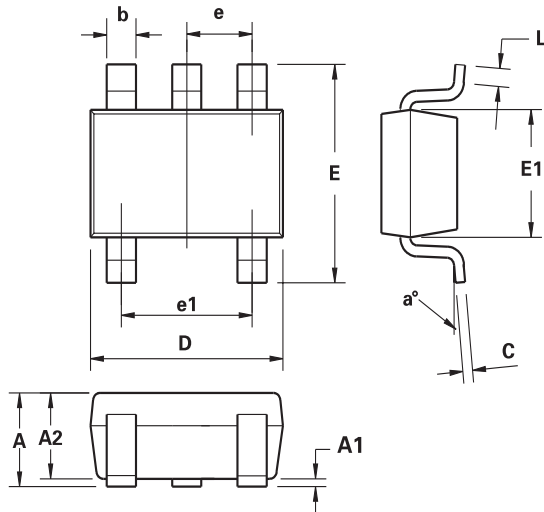


When choosing appropriate values for  $R_{SENSE}$  a compromise must be reached between in-line signal loss (including potential power dissipation effects) and small signal accuracy.

Higher values for  $R_{SENSE}$  gives better accuracy at low load currents by reducing the inaccuracies due to internal offsets. For best operation the ZXCT1041 has been designed to operate with  $V_{SENSE}$  of the order of 50mV to 150mV.

# ZXCT1041

## Package outline - SOT23-5



| DIM | Millimeters |      | Inches     |        |
|-----|-------------|------|------------|--------|
|     | Min.        | Max. | Min.       | Max.   |
| A   | 0.90        | 1.45 | 0.0354     | 0.0570 |
| A1  | 0.00        | 0.15 | 0.00       | 0.0059 |
| A2  | 0.90        | 1.30 | 0.0354     | 0.0511 |
| b   | 0.20        | 0.50 | 0.0078     | 0.0196 |
| C   | 0.09        | 0.26 | 0.0035     | 0.0102 |
| D   | 2.70        | 3.10 | 0.1062     | 0.1220 |
| E   | 2.20        | 3.20 | 0.0866     | 0.1181 |
| E1  | 1.30        | 1.80 | 0.0511     | 0.0708 |
| e   | 0.95 REF    |      | 0.0374 REF |        |
| e1  | 1.90 REF    |      | 0.0748 REF |        |
| L   | 0.10        | 0.60 | 0.0039     | 0.0236 |
| a°  | 0°          | 30°  | 0°         | 30°    |

**Note:** Controlling dimensions are in millimeters. Approximate dimensions are provided in inches

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1. are intended to implant into the body

or

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### Product status key:

|                                   |  |
|-----------------------------------|--|
| "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 the test conditions and specifications may occur, at any time and without notice. |
| "Issue"               | This term denotes an issued datasheet containing finalized specifications. However, changes to specifications may occur, at any time and without notice.  |

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