**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.

**Features**

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

**Pin connections**

![Pin connections diagram](image)

**Ordering information**

<table>
<thead>
<tr>
<th>Order code</th>
<th>Package</th>
<th>Partmark</th>
<th>Reel size (inches)</th>
<th>Tape width (mm)</th>
<th>Quantity per reel</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZXCT1041E5TA</td>
<td>SOT23-5</td>
<td>1041</td>
<td>7</td>
<td>8</td>
<td>3000</td>
</tr>
</tbody>
</table>

**Applications**

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

**Typical application circuit**

![Typical application circuit diagram](image)
Absolute maximum ratings

Voltage on $V_{S+}$ and $V_{S-}$: -0.6 to 20V
Voltage on all other pins: -0.6V to $(V_{S+} \text{ or } V_{S-}) +0.6V$
$V_{\text{sense}} \{(V_{S+}) - (V_{S-})\}$: +/-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 $T_A = 25°C$ (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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{S\pm}$</td>
<td>2.7</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>Flag</td>
<td>0</td>
<td>$V_{S\pm}$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{\text{SENSE}}$</td>
<td>0</td>
<td>±0.8</td>
<td>V</td>
</tr>
<tr>
<td>$V_{\text{OUT}}$</td>
<td>0</td>
<td>$V_{S\pm} -1.5$</td>
<td>V</td>
</tr>
<tr>
<td>$T_A$</td>
<td>-40</td>
<td>125</td>
<td>°C</td>
</tr>
</tbody>
</table>

Pin function table

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flag</td>
<td>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 $V_S$.</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Ground pin</td>
</tr>
<tr>
<td>3</td>
<td>OUT</td>
<td>Output voltage pin</td>
</tr>
<tr>
<td>4</td>
<td>S+</td>
<td>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</td>
</tr>
<tr>
<td>5</td>
<td>S-</td>
<td>This is the negative input of the current monitor. The current through this pin varies with differential sense voltage</td>
</tr>
</tbody>
</table>
Electrical characteristics

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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_Q$</td>
<td>Ground pin current</td>
<td></td>
<td>15</td>
<td>35</td>
<td>50</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>$I_{S+}$</td>
<td>$V_{S+}$ input current</td>
<td>$V_{\text{SENSE}} = 0V$</td>
<td>10</td>
<td>17</td>
<td>24</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>$I_{S-}$</td>
<td>$V_{S-}$ input current</td>
<td>$V_{\text{SENSE}} = 0V$</td>
<td>10</td>
<td>17</td>
<td>24</td>
<td>$\mu A$</td>
</tr>
</tbody>
</table>

$V_{\text{OUT}}$ Output voltage

<table>
<thead>
<tr>
<th>Condition</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{\text{SENSE}} = +150mV$</td>
<td>1.55</td>
<td>1.5</td>
<td>1.45</td>
<td>V</td>
</tr>
<tr>
<td>$V_{\text{SENSE}} = +100mV$</td>
<td>1.02</td>
<td>1</td>
<td>0.98</td>
<td>V</td>
</tr>
<tr>
<td>$V_{\text{SENSE}} = +30mV$</td>
<td>309</td>
<td>300</td>
<td>291</td>
<td>mV</td>
</tr>
<tr>
<td>$V_{\text{SENSE}} = 0V$</td>
<td>0</td>
<td>15</td>
<td>15</td>
<td>mV</td>
</tr>
<tr>
<td>$V_{\text{SENSE}} = -30mV$</td>
<td>285</td>
<td>300</td>
<td>315</td>
<td>mV</td>
</tr>
<tr>
<td>$V_{\text{SENSE}} = -100mV$</td>
<td>0.95</td>
<td>1</td>
<td>1.05</td>
<td>V</td>
</tr>
<tr>
<td>$V_{\text{SENSE}} = -150mV$</td>
<td>1.42</td>
<td>1.50</td>
<td>1.58</td>
<td>V</td>
</tr>
</tbody>
</table>

$V_{\text{OUT}}$ TC $V_{\text{OUT}}$ variation with temperature

<table>
<thead>
<tr>
<th>Condition</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{\text{SENSE}} = \pm 100mV$</td>
<td>30</td>
<td></td>
<td></td>
<td>ppm/$^\circ C$</td>
</tr>
</tbody>
</table>

Gain $V_{\text{OUT}}/V_{\text{SENSE}}$

<table>
<thead>
<tr>
<th>Condition</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{\text{SENSE}} = 100mV$</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Accuracy Total output error (Gain + offset) $V_{\text{SENSE}} = 100mV$

<table>
<thead>
<tr>
<th>Condition</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{\text{SENSE}} = -100mV$</td>
<td>300</td>
<td></td>
<td></td>
<td>kHz</td>
</tr>
</tbody>
</table>

CMRR $V_{S+}$ common mode rejection ratio

<table>
<thead>
<tr>
<th>Condition</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{\text{IN}} = 2.7$ to $20V$</td>
<td>60</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
</tbody>
</table>

Flag TP Flag trip point Referred to $V_{\text{SENSE}}$

<table>
<thead>
<tr>
<th>Condition</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{\text{FL}}$ Flag low output voltage $I_{\text{SINK}} = 100\mu A$</td>
<td>60</td>
<td>200</td>
<td>$\mu V$</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

(a) $V_{\text{SENSE}} = "V_{S+}\" - "V_{S-}\"$
(b) Temperature dependent measurements are extracted from characterisation and simulation results.
Typical characteristics

Conditions $V_{\text{SENSE}+}=10\text{V}$, $V_{\text{SENSE}}=100\text{mV}$, $T_A=25\degree\text{C}$ unless otherwise stated.
Typical characteristics

Conditions $V_{\text{SENSE}+}=10\text{V}$, $V_{\text{SENSE}}=100\text{mV}$, $T_A=25\text{°C}$ unless otherwise stated.
Typical characteristics

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

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

![Graphs of Large Sig Zero Crossing Response and Small Sig Zero Crossing Response](image)
Typical characteristics

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

![Forward CMRR graph](image1)

![Reverse CMRR graph](image2)

![Forward Frequency Response graph](image3)

![Reverse Frequency Response graph](image4)
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 1.5kΩ thereby setting the internal transconductance to 0.67mA/V of VSENSE-. The outputs of both current monitors (current) are summed into an internal common gain-setting resistor of 15kΩ. 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.
When choosing appropriate values for $R_{\text{SENSE}}$ a compromise must be reached between in-line signal loss (including potential power dissipation effects) and small signal accuracy.

Higher values for $R_{\text{SENSE}}$ 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 $V_{\text{SENSE}}$ of the order of 50mV to 150mV.
### Package outline - SOT23-5

![Diagram of SOT23-5 package outline]

<table>
<thead>
<tr>
<th>DIM</th>
<th>Millimeters</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>A</td>
<td>0.90</td>
<td>1.45</td>
</tr>
<tr>
<td>A1</td>
<td>0.00</td>
<td>0.15</td>
</tr>
<tr>
<td>A2</td>
<td>0.90</td>
<td>1.30</td>
</tr>
<tr>
<td>b</td>
<td>0.20</td>
<td>0.50</td>
</tr>
<tr>
<td>C</td>
<td>0.09</td>
<td>0.26</td>
</tr>
<tr>
<td>D</td>
<td>2.70</td>
<td>3.10</td>
</tr>
<tr>
<td>E</td>
<td>2.20</td>
<td>3.20</td>
</tr>
<tr>
<td>E1</td>
<td>1.30</td>
<td>1.80</td>
</tr>
<tr>
<td>e</td>
<td>0.95</td>
<td>REF</td>
</tr>
<tr>
<td>e1</td>
<td>1.90</td>
<td>REF</td>
</tr>
<tr>
<td>L</td>
<td>0.10</td>
<td>0.60</td>
</tr>
<tr>
<td>a°</td>
<td>0°</td>
<td>30°</td>
</tr>
</tbody>
</table>

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

Europe
Zetex GmbH
Kustermann-park
Balanstraße 59
D-81541 München
Germany
Telephone: (49) 89 45 49 49 0
Fax: (49) 89 45 49 49 49

Americas
Zetex Inc
700 Veterans Memorial Highway
Hauppauge, NY 11788
USA
Telephone: (1) 631 360 2222
Fax: (1) 631 360 8222

Corporate Headquarters
Zetex Semiconductors plc
Zetex Technology Park, Chadderton
Oldham, OL9 9LL
United Kingdom
Telephone: (44) 161 622 4444
Fax: (44) 161 622 4446
hq@zetex.com

Asia Pacific
Zetex (Asia Ltd)
3701-04 MetroPlaza Tower 1
Hing Fong Road, Kwai Fong
Hong Kong
Telephone: (852) 26100 611
Fax: (852) 24250 494
asia.sales@zetex.com

Americas
Zetex Semiconductors sales office
USA
Telephone: (1) 631 360 2222
Fax: (1) 631 360 8222
usa.sales@zetex.com

Corporate Headquarters
Zetex Semiconductors plc
Zetex Technology Park, Chadderton
Oldham, OL9 9LL
United Kingdom
Telephone: (44) 161 622 4444
Fax: (44) 161 622 4446
hq@zetex.com

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