ZXCT1051
Precision wide input range current monitor

Description
The ZXCT1051 is a wide input range current monitor, which operates over a range of input voltages from ground up to $V_{CC}-2V$. As a result the ZXCT1051 can be used on the high or low side of the load.

The very low offset voltage enables a typical accuracy of 1% for sense voltages of only 30mV, giving better tolerances for small sense resistors necessary at higher currents.

Features
- Accurate down to end current sensing
- Output voltage scaling x10
- 0 to $V_{CC}-2V$ sense input range
- 2.7 to 20V supply range
- 50 µA quiescent current
- 1% typical accuracy
- SOT23-5 package

Applications
- Power supply
- DC motor and solenoid control
- Battery management
- Over current monitor
- Power management
- Short circuit detection

Pin connections

```
VCC    VSENSE-
|      |
|      |
GND    VSENSE+
|      |
|      |
VOUT   VSENSE-
```

Typical application circuit

```
VSENSE+ RSENSE VSENSE-
VCC      ZXCT1051 GND
VSENSE+  VSENSE-
VOUT     VOUT
```

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>
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<tbody>
<tr>
<td>ZXCT1051E5TA</td>
<td>SOT23-5</td>
<td>1051</td>
<td>7</td>
<td>8</td>
<td>3,000</td>
</tr>
</tbody>
</table>
Absolute maximum ratings

$V_{CC}$ max. 20V
Voltage on $V_{SENSE^-}$ and $V_{SENSE^+}$ -0.6 to $V_{CC}$
Voltage on all other pins -0.6V and $V_{CC} +0.6V$
$V_{SENSE^+} - (V_{SENSE^-})$ 500mV
Operating temperature, $T_{amb}$ -40 to 125°C
Storage temperature -55 to 150°C
Maximum junction temperature 150°C
Package power dissipation 300mW at $T_{amb} = 25°C$ (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>$V_{SENSE^+}$</td>
<td>0</td>
<td>$V_{CC} -2$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{CC}$</td>
<td>2.7</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>$V_{SENSE}$</td>
<td>0</td>
<td>0.3</td>
<td>V</td>
</tr>
<tr>
<td>$V_{OUT}$</td>
<td>0</td>
<td>$V_{CC} -2$</td>
<td>V</td>
</tr>
<tr>
<td>$T_{amb}$</td>
<td>-40</td>
<td>125</td>
<td>°C</td>
</tr>
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</table>

Pin function table

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$V_{CC}$</td>
<td>This is the analog supply and provides power to internal circuitry</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>$V_{SENSE^+}$</td>
<td>This is the positive input of the current monitor and has an input range from 0V up to $V_{CC} - 2V$.</td>
</tr>
<tr>
<td>5</td>
<td>$V_{SENSE^-}$</td>
<td>This is the negative input of the current monitor and has an input range from 0V up to $V_{CC} - 2V$. The current through this pin varies with differential sense voltage.</td>
</tr>
</tbody>
</table>
Electrical characteristics

Test conditions $T_{amb} = 25^\circ C$, $V_{SENSE+} = 10V$, $V_{CC} = 12V$, $V_{SENSE} = 100mV$

<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>$V_{CC}$ pin current</td>
<td>$V_{SENSE} = 0V$</td>
<td>45</td>
<td>70</td>
<td></td>
<td>$\mu A$</td>
</tr>
<tr>
<td>$V_{OUT}$</td>
<td>Output voltage</td>
<td>$V_{SENSE} = 0V$</td>
<td>0</td>
<td>6</td>
<td>15</td>
<td>$mV$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$=30mV$</td>
<td>291</td>
<td>300</td>
<td>309</td>
<td>$mV$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$=100mV$</td>
<td>0.98</td>
<td>1.00</td>
<td>1.02</td>
<td>$V$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$=150mV$</td>
<td>1.45</td>
<td>1.50</td>
<td>1.55</td>
<td>$V$</td>
</tr>
<tr>
<td>$I_{SENSE+}$</td>
<td>$V_{SENSE+}$ input current</td>
<td>$V_{SENSE} = 0V$</td>
<td>10</td>
<td>150</td>
<td></td>
<td>$nA$</td>
</tr>
<tr>
<td>$I_{SENSE-}$</td>
<td>$V_{SENSE-}$ input current</td>
<td>$V_{SENSE} = 0V$</td>
<td>60</td>
<td>150</td>
<td></td>
<td>$nA$</td>
</tr>
<tr>
<td>$V_{OUT TC}$</td>
<td>$V_{OUT}$ variation with temperature</td>
<td>See note (b)</td>
<td>300</td>
<td></td>
<td></td>
<td>ppm/$^\circ C$</td>
</tr>
<tr>
<td>$R_{OUT}$</td>
<td>Output resistance</td>
<td></td>
<td>2.5</td>
<td>3.75</td>
<td>5</td>
<td>k$\Omega$</td>
</tr>
<tr>
<td>Gain</td>
<td>$V_{OUT}/V_{SENSE}$</td>
<td></td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>Total output error</td>
<td></td>
<td>-2</td>
<td>2</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>BW</td>
<td>Bandwidth</td>
<td>$V_{SENSE(AC)} = 10mV$, $V_{SENSE(DC)} = 100mV$</td>
<td>300</td>
<td></td>
<td></td>
<td>kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{SENSE(DC)} = 10mV$, $CL = 5pF$, $V_{SENSE(AC)} = 10mV_{PP}$</td>
<td>1</td>
<td></td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>PSRR</td>
<td>Power supply rejection ratio referred to output</td>
<td>$V_{CC} = 2.7V$ to $20V$, $V_{SENSE+} = 0V$</td>
<td>58</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>CMRR</td>
<td>Common mode rejection ratio referred to output</td>
<td>$V_{CC} = 20V$, $V_{SENSE+} = 0$ to $18V$</td>
<td>66</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
</tbody>
</table>

NOTES:
(a) $V_{SENSE} = "V_{SENSE+}" - "V_{SENSE-}"$
(b) Temperature dependent measurements are extracted from characterization and simulation results.
Typical characteristics

- Supply Current vs Supply Voltage
- Supply Current vs Input Voltage
- Sense Current vs Supply Voltage
- Sense Current vs Sense Voltage
- Percentage Change of Sense Current vs Temperature
Typical characteristics

Output Voltage v Sense Voltage

Temperature Characteristic

Incremental Gain v Sense Voltage

Common Mode Characteristic

Supply Characteristic

ZXCT1051
Typical characteristics

Bandwidth

Gain (dB)

Frequency (Hz)

Gain (dB)

Supply Rejection (dB)

Frequency (Hz)

Common Mode Rejection (dB)

Frequency (Hz)

PSRR

Large Signal Pulse Response

VOUT - Output Voltage (V)

Time (μs)

VOUT - Output Voltage (V)

Time (μs)

Small Signal Pulse Response

VOUT - Output Voltage (V)

Time (μs)

Turn on/off Characteristic

VOUT - Output Voltage (V)

Time (μs)
Application information

The ZXCT1051 is Zetex’ first current monitor with a separate power supply pin. All biasing for the internal amplifiers comes from its separate V\text{CC} input and is not ‘line powered’, unlike the ZXCT1021.

This means that at very small sense voltages the ZXCT1051 draws very little current (<1µA) from the lines being sensed.

The separate V\text{CC} pin enables the ZXCT1051 to be operated at sense line voltages down to 0V, where the ZXCT1021 would switch off. This feature enables the ZXCT1051 to be used to sense the currents flowing through lines that have been shorted to ground and is Zetex’ first current monitor to do this.

Basic operation

Load current from V\text{IN} is drawn through R\text{SENSE} developing a voltage V\text{SENSE} across the ZXCT1051.

The internal amplifier forces V\text{SENSE} across internal resistance R\text{SH} causing a current to flow through transistor Q1. This current is then converted to a voltage by R\text{G}. A ratio of 10:1 between R\text{SH} and R\text{G} creates the fixed gain of 10 with an output impedance equal to R\text{G} (see electrical characteristics for output current-voltage characteristics).

The gain equation of the ZXCT1051 is:

\[ V_{\text{SENSE}} = I_L R_{\text{SENSE}} \frac{R_G}{R_{\text{SH}}} \times 1 \]

The maximum differential input voltage, V\text{SENSE}, is 150mV (I\text{L} * R\text{SENSE}); however voltages up to 500mV will not damage it. This can be increased further by the inclusion of a resistor, R\text{LIM}, between V\text{SENSE}+ pin and the load.

For best performance R\text{SENSE} should be connected as close to the V\text{SENSE}+ and V\text{SENSE}− pins thus minimizing any series resistance with R\text{SENSE}−.
The ZXCT1051 has been designed to allow it to operate from supplies (VCC) ranging from 2.7V to 20V while sensing common mode signals from 0V up to VCC -2V.

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

Higher values for RSENSE gives better accuracy at low load currents by reducing the inaccuracies due to internal offsets. For best operation the ZXCT1051 has been designed to operate with VSENSE of the order of 50mV to 150mV.

Due to the very nature of current monitors they tend to saturate at very low sense voltages. This is due to them being operated from single supply and that the basic configuration is that of a unipolar voltage to current to voltage converter. The internal amplifiers at the heart of the current monitor may well have a bipolar offset voltage but the output cannot go negative.

For this reason the ZXCT1051 has been designed to operate in a linear manner over a VSENSE range of 10mV to 150mV range, however it will still be monotonic down to VSENSE of 0V.

The device has a fixed DC voltage gain of 10; no external scaling resistors are required for the output. Output voltage is simply defined as:

\[ V_{OUT} = \text{gain} \times V_{SENSE} \ (V) \]
### Packaging details - SOT23-5

<table>
<thead>
<tr>
<th>DIM</th>
<th>Millimeters</th>
<th>Inches</th>
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<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>
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<tr>
<td>E1</td>
<td>1.30</td>
<td>1.80</td>
</tr>
<tr>
<td>e</td>
<td>0.95 REF</td>
<td></td>
</tr>
<tr>
<td>e1</td>
<td>1.90 REF</td>
<td></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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<thead>
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<th>Asia Pacific</th>
<th>Corporate Headquarters</th>
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<tbody>
<tr>
<td>Zetex GmbH</td>
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<td>Hong Kong</td>
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<td>Germany</td>
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