ZXCT1012
Reduced height micro-power current monitor

Description

The ZXCT1012 is a high side current sense monitor. Using this type of device eliminates the need to disrupt the ground plane when sensing a load current.

The ZXCT1012 takes the voltage developed across a small value resistor and translates it into a proportional output current. A user defined output resistor scales the output current into a ground referenced voltage.

The ZXCT1012 has the accuracy specification of the ZXCT1010 but in TSOT23-5, and TDFN3x3-5.

A minimum operating current of just 3.5µA, combined with its TSOT23-5 package make it suitable for portable battery equipment where size and current consumption are critical.

The wide input voltage range down to as low as 2.5V make it suitable for a wide range of applications requiring direct operation from a battery.

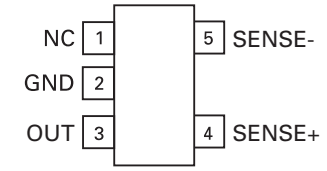
Features

- 2.5V to 20V supply range
- 3.5µA quiescent current
- Current output - user set gain
- Thin package - TSOT23-5 and TDFN3x3-5
- Temperature range -40 to 85°C

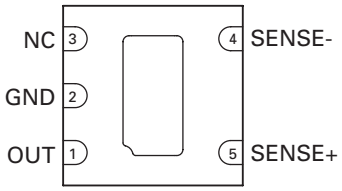
Applications

- Battery fuel gauge
- Battery chargers
- Overcurrent monitor
- Power management

Pin connections

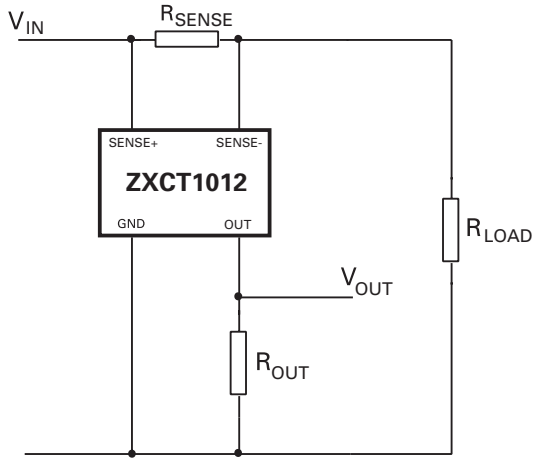


TSOT23-5
Pinout - top view



TDFN3x3-5
Pinout - bottom view

Applications circuit



Ordering information

Device	Package	Status	Device marking	Reel size (inches)	Tape width (mm)	Quantity per reel
ZXCT1012DAATA	TDFN-5 (3mm x 3mm)	Active	1012	7	8	3000
ZXCT1012ET5TA	TSOT23-5	Active	1012	7	8	3000

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Pin information

Pin		Name	Description
TDFN5	TSOT23-5		
3	1	N/C	No connection
2	2	GND	Ground connection
1	3	OUT	Output current pin. Current generated due to a difference voltage between V_{SENSE+} and V_{SENSE-} flows out of this pin. A suitable value resistor connected to ground creates an output voltage. The maximum voltage out of this pin will be V_{SENSE-} - 1.5V.
5	4	SENSE+	This pin should be connected to the rail whose current is being measured and also provides power to internal circuitry. It is the positive input of the current monitor and has an input range from 20V down to 2.5V. The current through this pin varies with differential sense voltage.
4	5	SENSE-	This is the negative input of the current monitor and has an input range from 20V down to 2.5V.

Absolute maximum ratings

V_{SENSE+} max.	20V
Voltage on any pin (relative to GND pin)	-0.6 and V_{SENSE+} +0.5V
V_{SENSE} (‡)	-0.15V to +3V
Ambient operating temperature range	-40 to 85°C
Storage temperature	-55 to 150°C
Maximimum junction temperature	150°C
Package power dissipation	300mW at T_{amb}= 25°C (De-rate to zero at 150°C)

Package	$R_{\Theta JA}$	P_{DISS} at 25°C
TSOT23-5 (*)	250°C/W	500mW
TDFN3x3 5 pin (*) (†)	232°C/W	540mW

NOTES:
(*) Mounted on 30mm x 16mm x1.1mm FR4 board with 1oz copper.

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

NOTES:
(‡) V_{SENSE} is defined as the differential voltage between the SENSE+ and SENSE- pins.

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

(†) Exposed lead not connected to thermal plane

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Recommended operating conditions

Symbol	Recommended parameter	Limits		
		Min.	Max.	Units
V_{IN}	Sense+ range	2.5	20	V
T_A	Ambient temperature range differential	-40	85	°C
V_{SENSE}	Sense voltage	10	2500	mV
V_{OUT}	Output voltage swing	0	V_{SENSE-} -1.5	V

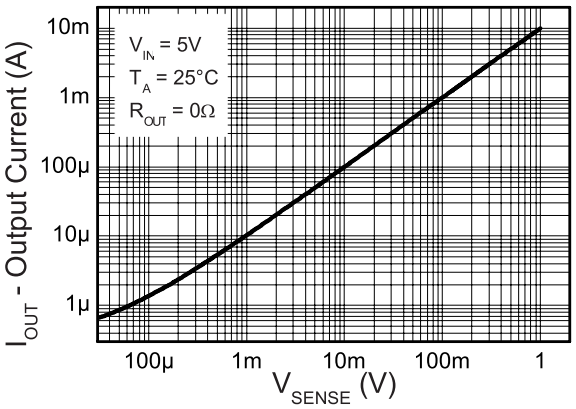
Electrical characteristics
Test conditions T_{amb} = 25°C, V_{IN} = V_{SENSE+} = 5V, unless otherwise stated

Symbol	Parameter	Conditions		Limits			Unit
				Min.	Typ.	Max.	
I_{OUT}	Output current	V_{SENSE} = 0V		0	0.3	15	µA
		V_{SENSE} = 10mV		85	100	115	µA
		V_{SENSE} = 40mV		380	400	420	µA
		V_{SENSE} = 100mV		0.975	1.00	1.025	mA
		V_{SENSE} = 200mV		1.95	2.00	2.05	mA
I_Q	Ground pin current	V_{SENSE} = 0V			3.5	8	µA
I_{SENSE-}	SENSE- pin input current					100	nA
Acc	Accuracy	R_{SENSE} = 0.1V V_{SENSE} = 200mV		-2.5		2.5	%
Gm	Transconductance, I_{OUT}/V_{SENSE} (*)				10		mA/V
Tc	Temperature coefficient	V_{SENSE} = 200mV T_{amb} = 0 to 50°C (*)			500		ppm/°C
BW	Bandwidth	C_L = 5pF, R_{OUT} = 1kΩ	V_{SENSE} = 10mV V_{SENSE} = 100mV		300 2		kHz MHz
CMRR(‡)	Common mode rejection ratio	V_{SENSE} = 100mV, R_{OUT} = 1kΩ V_{IN} = 2.5V to 20V			80		dB

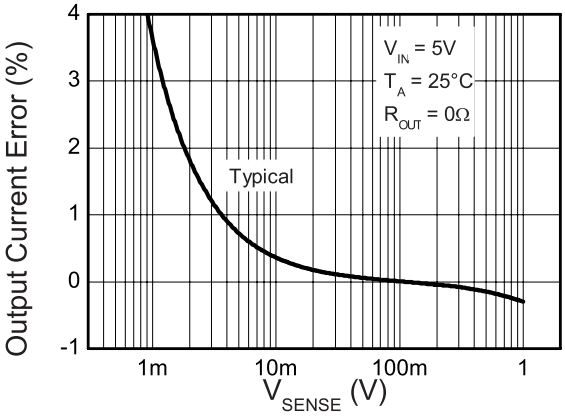
NOTES:
(*) Temperature dependent measurements are extracted from characterisation and simulation results.
(‡) With the ZXCT1012 using SENSE+ as its power supply pin, common mode rejection cannot be distinguished from power supply rejection.

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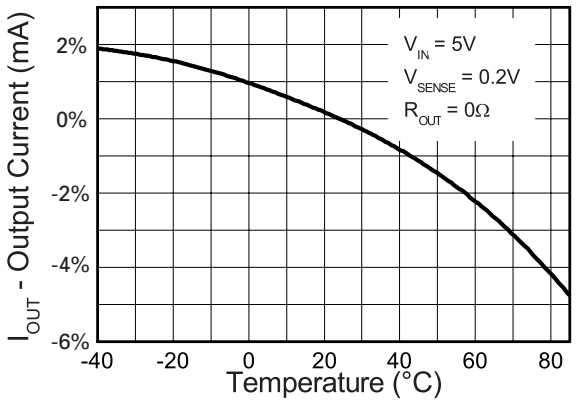
Typical characteristics



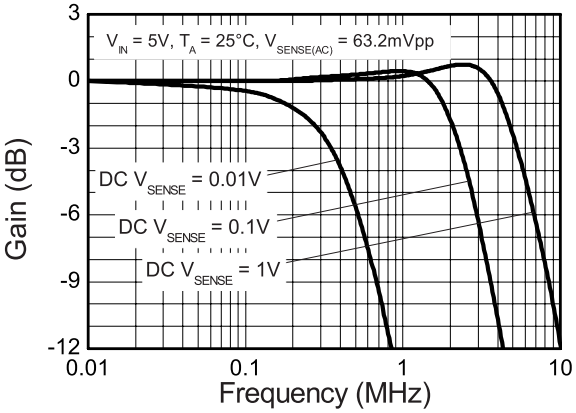
Typical Output v Sense Voltage



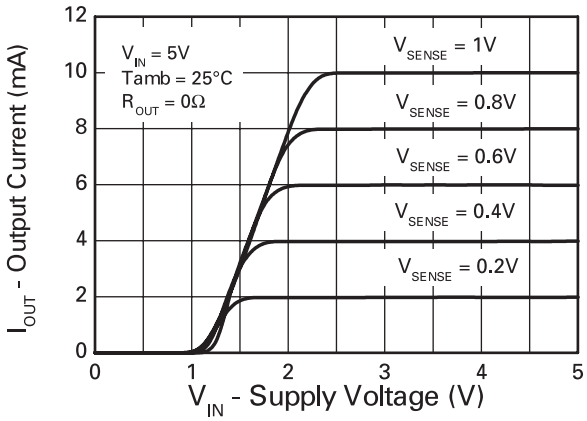
Error v Sense Voltage



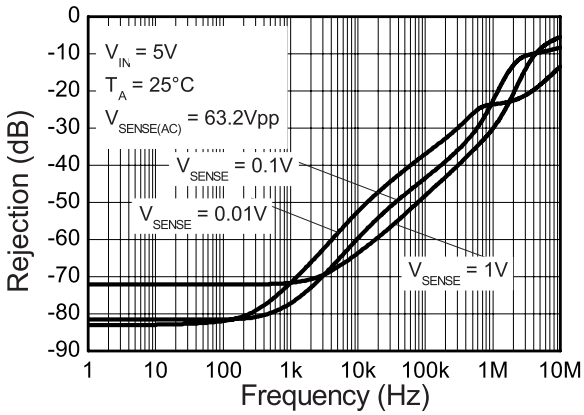
Output Current v Temperature



Frequency Response



Transfer Characteristic



Common Mode Rejection

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Applications information

The ZXCT1012 current monitor works by converting the voltage developed across a small sense resistor into a current on the out pin. In reality it is a voltage to current converter. This output current can be converted into a voltage simply by passing it through a resistor (R_{OUT}) to ground.

The current monitor has a transconductance of 10mA/V. But the overall amplifying conversion is affected by both the R_{SENSE} and R_{OUT}.

The gain equation of the ZXCT1012 is:

$$V_{OUT} = I_L \times R_{SENSE} \frac{R_{OUT}}{100}$$

For best performance R_{SENSE} should be connected as close to the SENSE+ (and SENSE-) pins; which minimizes any series resistance with R_{SENSE} and potential for interference pickup.

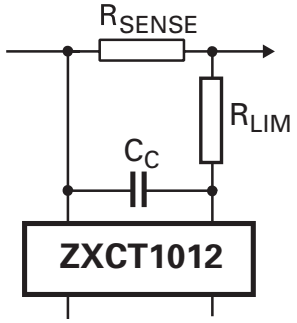
When choosing appropriate values for R_{SENSE} a compromise must be reached between in-line signal loss (including potential power dissipation effects) and small signal accuracy.

Higher values for R_{SENSE} gives better accuracy at low load currents by reducing the inaccuracies due to internal offsets. For best operation the ZXCT1012 has been designed to provide best performance with V_{SENSE} of the order of 40mV to 200mV.

Current monitors are single supply devices which means they tend to saturate at very low sense voltages. However it does mean the output can never go negative. Also the output can never change direction (monotonic). This is important if the current monitor is used in a control loop.

As the sense voltage is reduced the output will tend to saturate as the input offset voltage starts to have greater effect. It is recommended to have a minimum sense voltage of 10mV to minimize linearity errors. Zetex has specified the output voltage at V_{SENSE} of 10mV, 40mV, 100mV and 200mV; which is the recommended sense voltage range.

The maximum differential input voltage, V_{SENSE}, is 2.5V; however this will cause large output currents to flow increasing power dissipation in the chip. The sense voltage can be increased further, without damaging the ZXCT1012, by the inclusion of a resistor, R_{LIM}, between SENSE- pin and the load. Typical values around 10kΩ. See figure below.



If large reverse currents are expected then the resistor, R_{LIM}, will provide protection from exceeding absolute maximum ratings.

A suitable value for R_{LIM} can be determined from:

$$R_{LIM} \gg \frac{V_{SENSE(REF)}}{5mA}$$

Where $V_{SENSE(REV)}$ is the maximum expected reverse sense voltage generated.

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The following lines describe how to scale a load current to an output voltage.

V_{SENSE} = R_{SENSE} * I_{LOAD} equation (1)

I_{OUT} = 10mA/V x V_{SENSE} equation (2)

V_{OUT} = I_{OUT} x R_{OUT} equation (3)

Design example

In the circuit below a 1A current is to be represented by a 100mV output voltage (V_{OUT}):

A) To be within recommended values choose the value of R_{SENSE} to give:

50mV > V_{SENSE} > 200mV at full load.

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

From equation (1)

R_{SENSE} = 0.1V/1.0A = 0.1Ω

B) Now choose R_{OUT} to give:

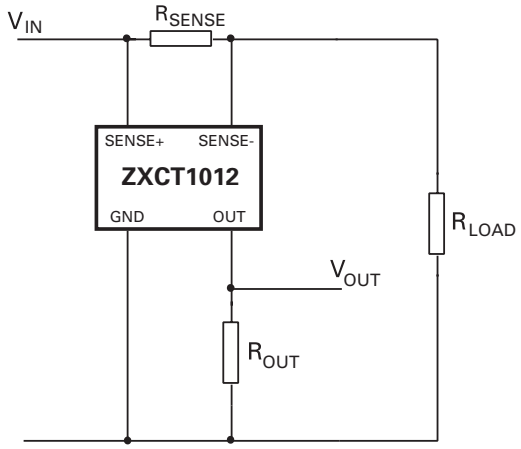
V_{OUT} = 100mV, when V_{SENSE} = 100mV.

From equation (2)

I_{OUT} = 10mA/V x 0.1 = 1mA

Rearranging equation (3) for R_{OUT} gives:

R_{OUT} = V_{OUT}/I_{OUT} = 0.1/0.001 = 100Ω



= 0.1 / (0.1 x 0.01) = 100Ω

Typical circuit application

Where R_{LOAD} represents any load including DC motors, a charging battery or further circuitry that requires monitoring, Rsense can be selected on specific requirements of accuracy, size and power rating.

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Power dissipation

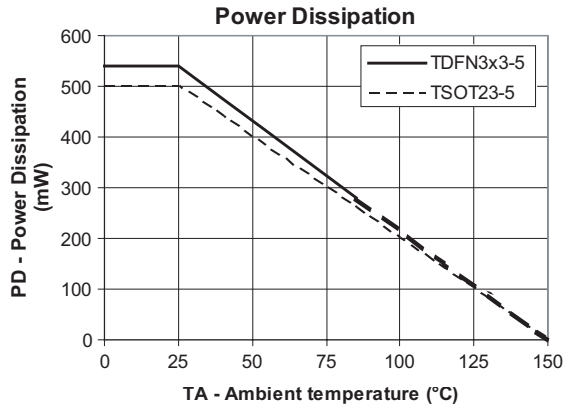
The maximum allowable power dissipation of the device for normal operation (P_{MAX}), is a function of the package junction to ambient thermal resistance (Θ_{JA}), maximum junction temperature (T_{JMAX}), and ambient temperature (T_{amb}), according to the expression:

$$P_{MAX} = (T_{JMAX} - T_{amb}) / \Theta_{JA}$$

The device power dissipation, P_D is given by the expression:

$$P_D = I_{OUT}.(V_{IN}-V_{OUT}) \text{ watts}$$

Care must be taken when using this device at large input voltages and large sense voltages to prevent too much power dissipation.



V_{IN} = 20V V_{SENSE} = 2.5V

R_{OUT} = 100Ω

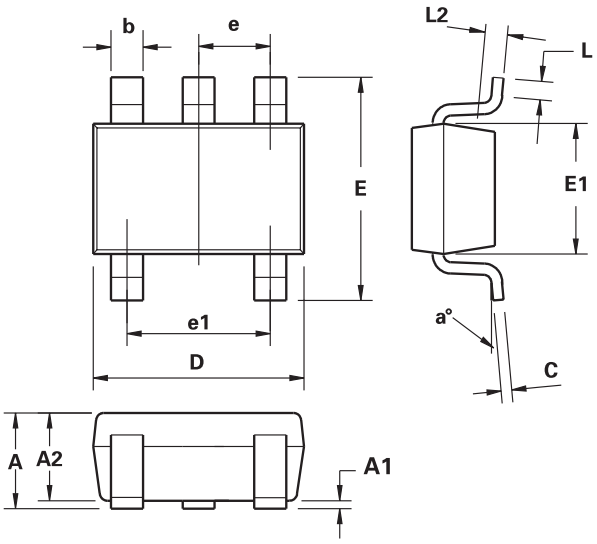
I_{OUT} = 2.5 x 0.01
= 25mA

V_{OUT} = I_{OUT} x R_{OUT}
= 25mA x 100Ω
= 2.5V

$\therefore P_D$ = 25mA (20 - 2.5)V
= 438mW

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Package outline - TSOT23-5

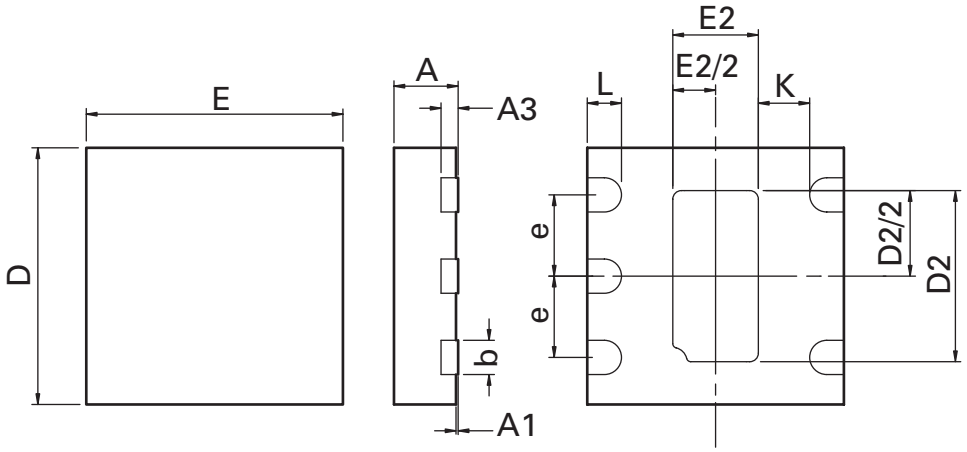


DIM	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	-	1.00	-	0.0393
A1	0.01	0.10	0.0003	0.0039
A2	0.84	0.90	0.0330	0.0354
b	0.30	0.45	0.0118	0.0177
c	0.12	0.20	0.0047	0.0078
D	2.90 BSC		0.114 BSC	
E	2.80 BSC		0.110 BSC	
E1	1.60 BSC		0.062 BSC	
e	0.95 BSC		0.0374 BSC	
e1	1.90 BSC		0.0748 BSC	
L	0.30	0.50	0.0118	0.0196
L2	0.25 BSC		0.010 BSC	
a°	4°	12°	4°	12°

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

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DAA package outline - TDFN3x3-5



Dim.	Millimeters		Inches		Dim.	Millimeters		Inches	
	Min.	Max.	Min.	Max.		Min.	Max.	Max.	Max.
A	0.70	0.80	0.0276	0.0315	e	0.95REF		0.0374REF	
A1	0.00	0.05	0.00	0.002	E	3.00BSC		0.1181BSC	
A3	0.20REF		0.0079REF		E2	0.85	1.10	0.0335	0.0433
b	0.30	0.45	0.0118	0.0177	L	0.30	0.50	0.0118	0.0197
D	3.00BSC		0.1181BSC		K	0.20	-	0.0079	-
D2	1.85	2.10	0.0728	0.0827	-	-	-	-	-

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