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ZXCT1080

HIGH VOLTAGE HIGH-SIDE CURRENT MONITOR

Description

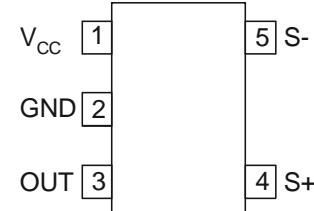
The ZXCT1080 is a high side current sense monitor with a gain of 10 and a voltage output. Using this device eliminates the need to disrupt the ground plane when sensing a load current.

The wide input voltage range of 60V down to as low as 3V make it suitable for a range of applications; including systems operating from industrial 24 to 28V rails and 48V rails.

The separate supply pin (V_{CC}) allows the device to continue functioning under short circuit conditions, giving an end stop voltage at the output.

The ZXCT1080 has an extended ambient operating temperature range of $-40^{\circ}C$ to $125^{\circ}C$ enabling it to be used in a wide range of applications including automotive.

Pin Assignments



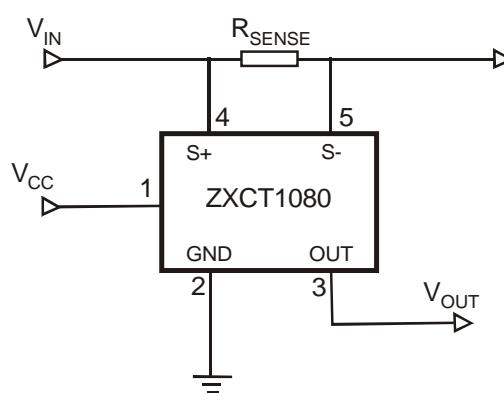
Features

- 3V to 60V continuous high side voltage
- Accurate high-side current sensing
- -40 to $125^{\circ}C$ temperature range
- AEC-Q100 Grade 1 qualified
- Output voltage scaling x10
- 4.5V to 12V V_{CC} range
- Low quiescent current:
 - 80 μ A supply pin
 - 27 μ A I_{S+}
- SOT25 package

Applications

- Industrial applications current measurement
- Battery management
- Over-current measurement
- Power management
- Automotive current measurement

Typical Application Circuit





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Pin Descriptions

Pin	Name	Description
1	V _{CC}	This is the analogue supply and provides power to internal circuitry
2	GND	Ground pin
3	OUT	Output voltage pin. NMOS source follower with 20 μ A bias to ground
4	S+	This is the positive input of the current monitor and has an input range from 60V down to 3V. The current through this pin varies with differential sense voltage
5	S-	This is the negative input of the current monitor and has an input range from 60V down to 3V

Absolute Maximum Ratings (T_A = 25°C)

Parameter	Rating	Unit
Continuous voltage on S- and S+	-0.6 and 65	V
Voltage on all other pins	-0.6 and +14	V
Differential sense voltage, V _{SENSE} (Note 1)	800	mV
Operating temperature	-40 to +125	°C
Storage Temperature	-55 to +150	°C
Maximum Junction Temperature	125	°C
Package Power Dissipation (Note 2)	300 (@ T _A = 25°C)	mW

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

Note: 1. V_{SENSE} is defined as the differential voltage between S+ and S- pins
 2. Assumes $\theta_{JA} = 420^{\circ}\text{C}/\text{W}$

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Units
V _{IN}	Common-mode Sense+ Input Range	3	60	V
V _{CC}	Supply Voltage Range	4.5	12	V
V _{SENSE}	Differential Sense Input Voltage Range	0	0.15	V
V _{OUT}	Ouput Voltage Range (Note 3)	0	1.5	V
T _A	Ambient Temperature Range	-40	125	°C

Note: 3. Based on 10x V_{SENSE}



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Electrical Characteristics

$T_A = 25^\circ\text{C}$, $V_{IN} = 12\text{V}$, $V_{CC} = 5\text{V}$, V_{SENSE} (Note 4) = 100mV (unless otherwise specified)

Symbol	Parameter	Conditions	T_A	Min (Note 5)	Typ.	Max (Note 5)	Units
I_{CC}	V_{CC} Supply Current	$V_{CC} = 12\text{V}$, $V_{SENSE} = 0\text{V}$ (Note 4)	25°C	40	80	120	μA
			Full range			145	
I_{S+}	$S+$ Input Current	$V_{SENSE} = 0\text{V}$ (Note 4)	25°C	15	27	42	μA
			Full range			60	
I_{S-}	$S-$ Input Current	$V_{SENSE} = 0\text{V}$ (Note 4)	25°C	15	40	80	nA
$V_{O(0)}$	Zero V_{SENSE} error (Note 4, 6)		25°C	0		35	mV
	$V_{SENSE} = 10\text{mV}$ (Note 4)	25°C	-25		+25	mV	
$V_{O(10)}$		Output Offset Voltage (Note 7)		Full range	-55		
	$V_{SENSE} = 10\text{mV}$ to 150mV (Note 4)	25°C	9.9	10	10.1	V/V	
Gain		$\Delta V_{OUT}/\Delta V_{SENSE}$ (Note 4)		Full range	9.8		
$V_{OUT\ TC}$ (Note 8)	V_{OUT} variation with temperature				30		ppm/ $^\circ\text{C}$
A_{CC}	Total output error			-3		3	%
I_{OH}	Output Source Current	$\Delta V_{OUT} = -30\text{mV}$			1		mA
I_{OL}	Output Sink Current	$\Delta V_{OUT} = +30\text{mV}$			20		μA
PSRR	V_{CC} Supply Rejection Ratio	$V_{CC} = 4.5\text{V}$ to 12V		54	60		dB
CMRR	Common-Mode Sense Rejection Ratio	$V_{IN} = 60\text{V}$ to 3V		68	80		dB
BW	-3dB small signal bandwidth	V_{SENSE} (AC) = 10mVpp (Note 4)			500		kHz

Notes:

4. $V_{SENSE} = "V_{S+}" - "V_{S-}"$
5. All Min and Max specifications over full temperature range are guaranteed by design and characterization
6. The ZXCT1080 operates from a positive power rail and the internal voltage-current converter current flow is unidirectional; these result in the output offset voltage for $V_{SENSE} = 0\text{V}$ always being positive.
7. For $V_{SENSE} > 10\text{mV}$, the internal voltage-current converter is fully linear. This enables a true offset to be defined and used. $V_{O(10)}$ is expressed as the variance about an output voltage of 100mV
8. Temperature dependent measurements are extracted from characterization and simulation results.

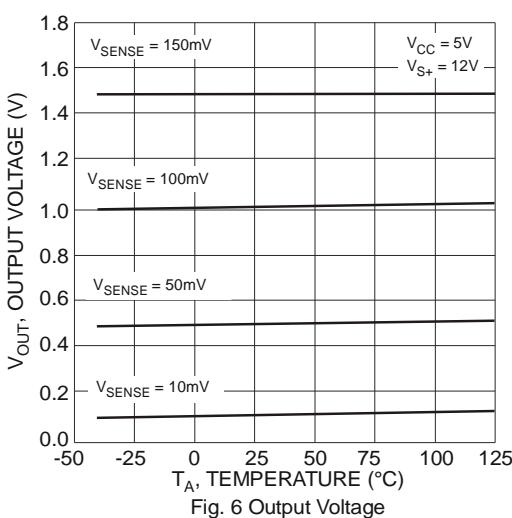
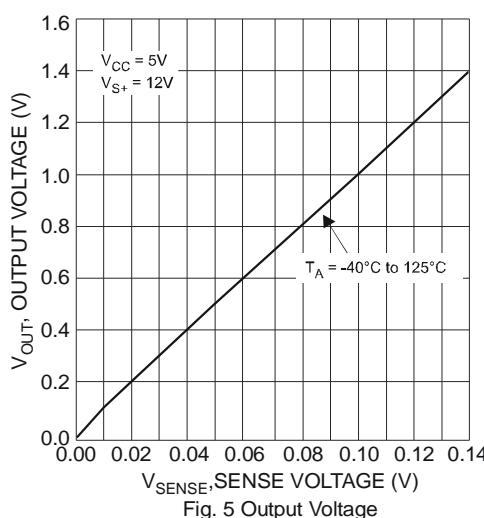
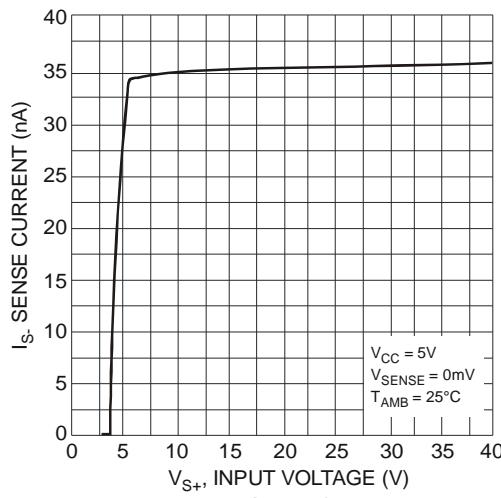
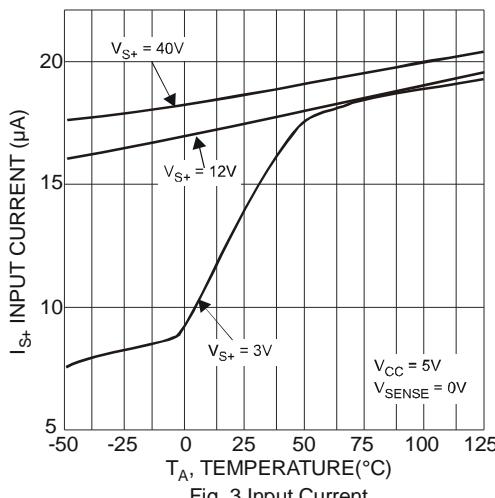
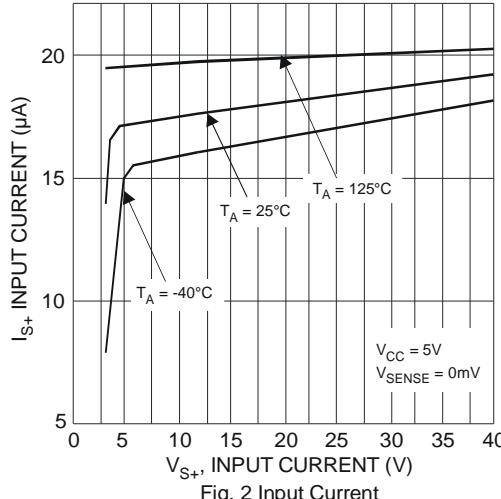
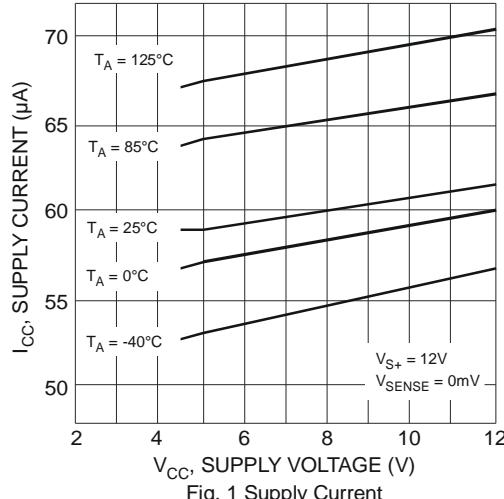


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Typical Characteristics

Test conditions unless otherwise stated: $T_A = 25^\circ\text{C}$, $V_{IN} = 12\text{V}$, $V_{CC} = 5\text{V}$, $V_{SENSE+} = 12\text{V}$, $V_{SENSE} = 100\text{mV}$





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Typical Characteristics (cont.)

Test conditions unless otherwise stated: $T_A = 25^\circ\text{C}$, $V_{IN} = 12\text{V}$, $V_{CC} = 5\text{V}$, $V_{SENSE+} = 12\text{V}$, $V_{SENSE} = 100\text{mV}$

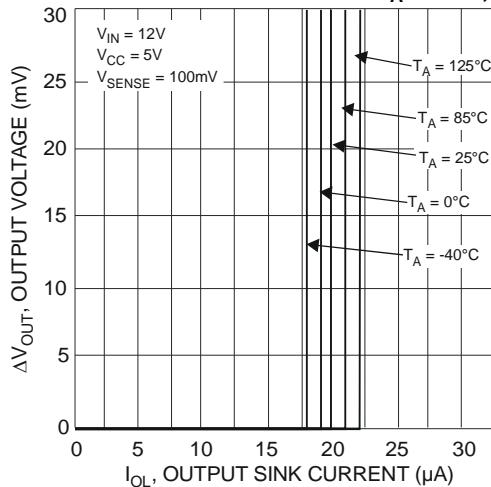


Fig. 7 Output Current Sink

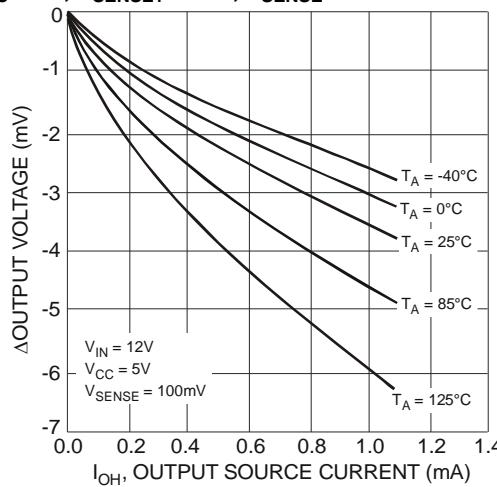


Fig. 8 Output Current Source

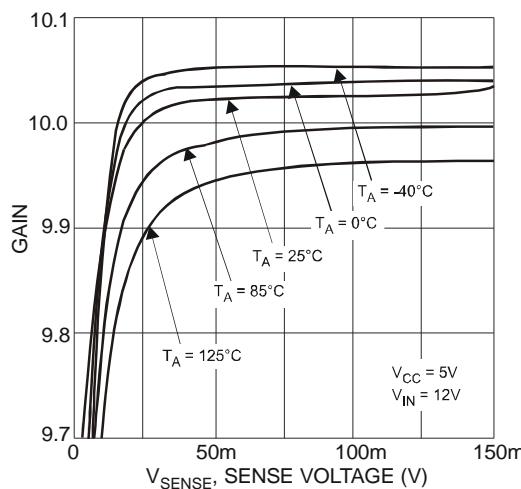


Fig. 9 Differential gain

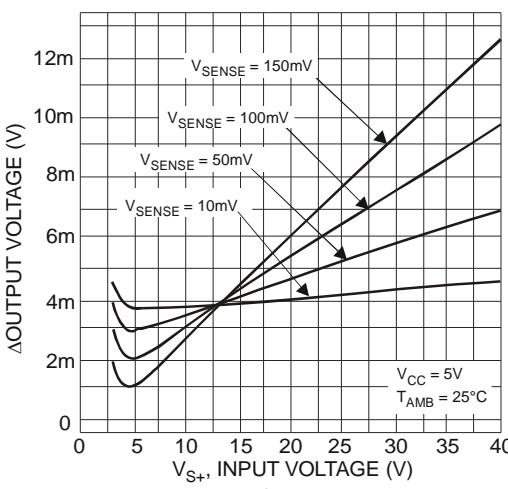


Fig. 10 Output Voltage

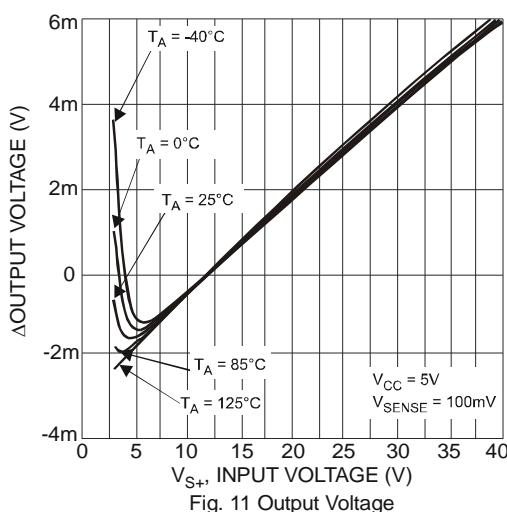


Fig. 11 Output Voltage



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Typical Characteristics (cont.)

Test conditions unless otherwise stated: $T_A = 25^\circ\text{C}$, $V_{IN} = 12\text{V}$, $V_{CC} = 5\text{V}$, $V_{SENSE+} = 12\text{V}$, $V_{SENSE} = 100\text{mV}$

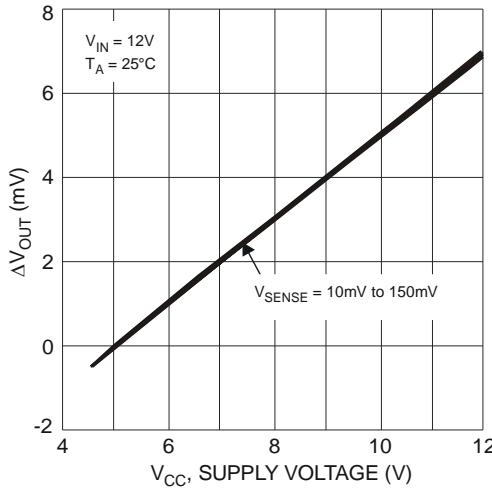


Fig. 12 Normalized Output Voltage

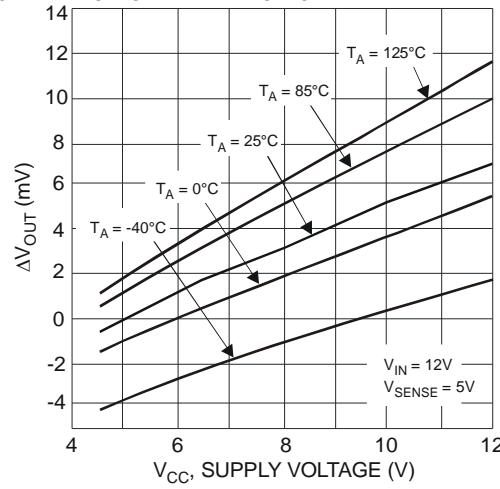


Fig. 13 Normalized Output Voltage

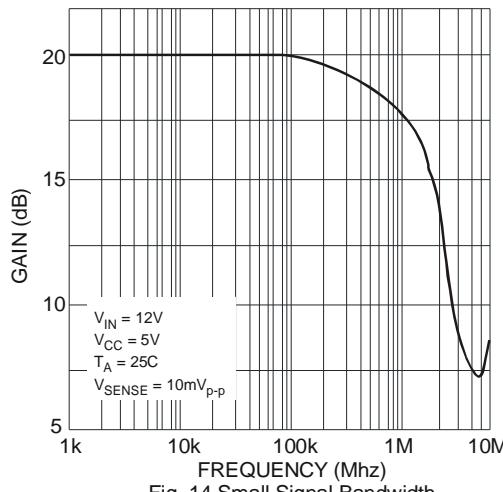


Fig. 14 Small Signal Bandwidth

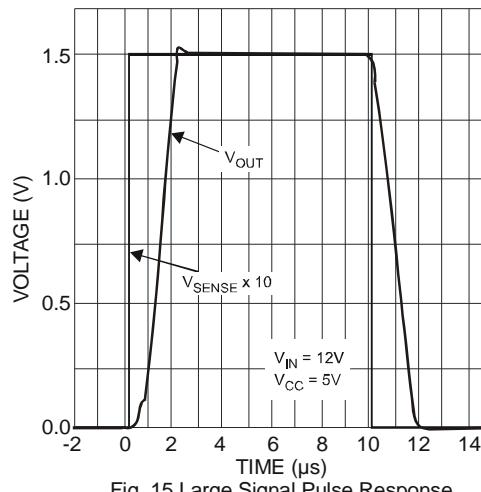


Fig. 15 Large Signal Pulse Response

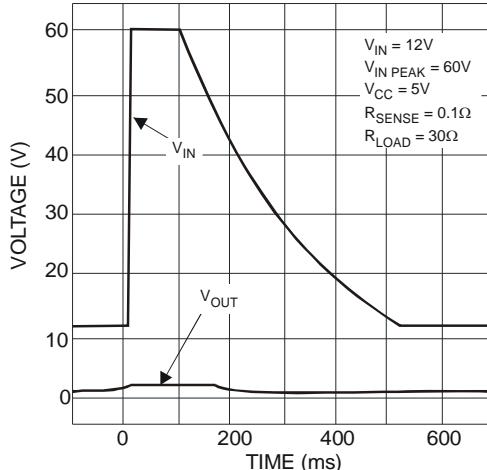


Fig. 16 Load Dump Waveform

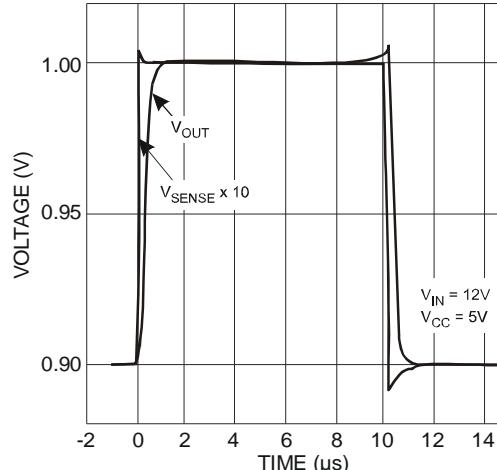


Fig. 17 Small Signal Pulse Response



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Typical Characteristics (cont.)

Test conditions unless otherwise stated: $T_A = 25^\circ\text{C}$, $V_{IN} = 12\text{V}$, $V_{CC} = 5\text{V}$, $V_{SENSE+} = 12\text{V}$, $V_{SENSE} = 100\text{mV}$

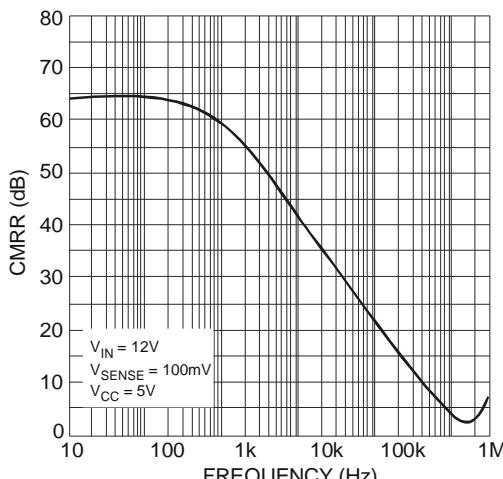


Fig. 18 Common Mode Rejection

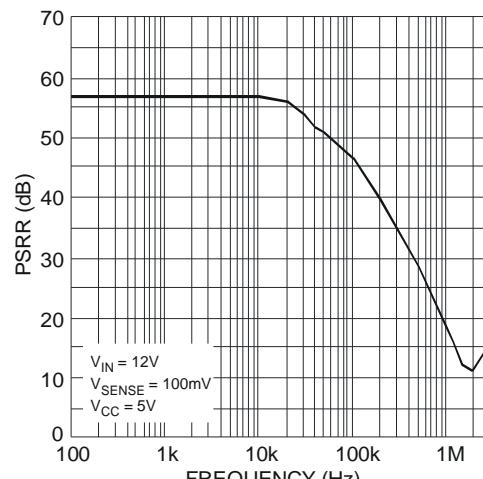


Fig. 19 Supply Rejection



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Application Information

The ZXCT1080 has been designed to allow it to operate with 5V supply rails while sensing common mode signals up to 60V. This makes it well suited to a wide range of industrial and power supply monitoring applications that require the interface to 5V systems while sensing much higher voltages.

To allow this its V_{CC} pin can be used independently of $S+$.

Figure 1 shows the basic configuration of the ZXCT1080.

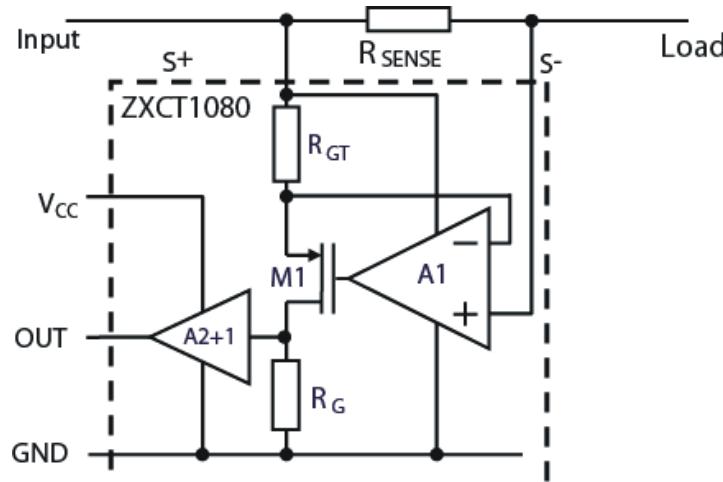


Fig. 20 Typical Configuration of ZXCT1080

Load current from the input is drawn through R_{SENSE} developing a voltage V_{SENSE} across the inputs of the ZXCT1080.

The internal amplifier forces V_{SENSE} across internal resistance R_{GT} causing a current to flow through MOSFET M1. This current is then converted to a voltage by R_G . A ratio of 10:1 between R_G and R_{GT} creates the fixed gain of 10. The output is then buffered by the unity gain buffer.

The gain equation of the ZXCT1080 is:

$$V_{OUT} = I_L R_{SENSE} \frac{R_G}{R_{GT}} \times 1 = I_L \times R_{SENSE} \times 10$$

The maximum recommended differential input voltage, V_{SENSE} , is 150mV; it will however withstand voltages up to 800mV. This can be increased further by the inclusion of a resistor, R_{LIM} , between $S-$ pin and the load; typical value is of the order of 10k.



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Application Information (cont.)

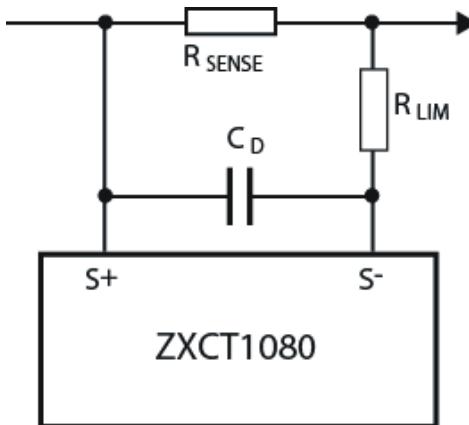


Fig. 21 Protection/Error Sources for ZXCT1080

Capacitor C_D provides high frequency transient decoupling when used with R_{LIM} ; typical values are of the order 10pF.

For best performance R_{SENSE} should be connected as close to the S+ (and SENSE) pins; minimizing any series resistance with R_{SENSE} .

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 ZXCT1080 has been designed to operate with V_{SENSE} of the order of 50mV to 150mV.

Current monitors' basic configuration is that of a unipolar voltage to current to voltage converter powered from a single supply rail. The internal amplifier at the heart of the current monitor may well have a bipolar offset voltage but the output cannot go negative; this results in current monitors saturating at very low sense voltages.

As a result of this phenomenon the ZXCT1080 has been specified to operate in a linear manner over a V_{SENSE} range of 10mV to 150mV range, however it will still be monotonic down to V_{SENSE} of 0V.

It is for this very reason that Diodes has specified an input offset voltage ($V_{O(10)}$) at 10mV. The output voltage for any V_{SENSE} voltage from 10mV to 150mV can be calculated as follows:

$$V_{OUT} = (V_{SENSE}) \times G + V_{(10)}$$

Alternatively the load current can be expressed as:

$$I_L = \frac{(V_{OUT} - V_{O(10)})}{G \times R_{SENSE}}$$



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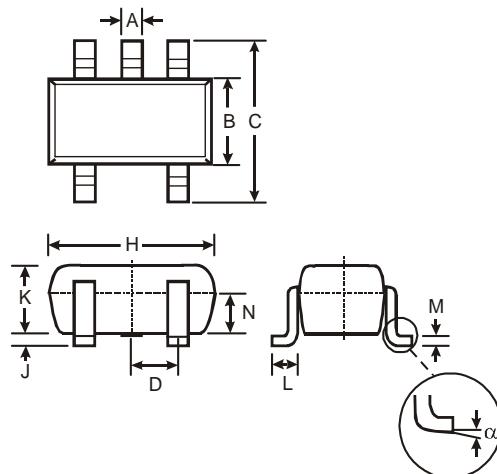
HIGH VOLTAGE HIGH-SIDE CURRENT MONITOR

Ordering Information

Device	AEC-Q100	Package	Part Mark	Reel Size	Tape Width (mm)	Quantity per Reel
ZXCT1080E5TA	Grade 1	SOT25	1080	7	8	3000

Package Outline Dimensions (All Dimensions in mm)

SOT25



SOT25			
Dim	Min	Max	Typ
A	0.35	0.50	0.38
B	1.50	1.70	1.60
C	2.70	3.00	2.80
D	—	—	0.95
H	2.90	3.10	3.00
J	0.013	0.10	0.05
K	1.00	1.30	1.10
L	0.35	0.55	0.40
M	0.10	0.20	0.15
N	0.70	0.80	0.75
α	0°	8°	—

All Dimensions in mm



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