

## ZXCT1020

### Low offset current output current monitor

#### Description

The ZXCT1020 is a precision high-side current sense monitor. Using this type of device eliminates the need to disrupt the ground plane when sensing a load current.

The ZXCT1020 uses two external resistors to set the overall voltage gain for applications where improved accuracy at small sense voltages is required. For fixed gain variants Zetex offers the ZXCT1021 ( $G=10$ ) and ZXCT1022 ( $G=100$ ).

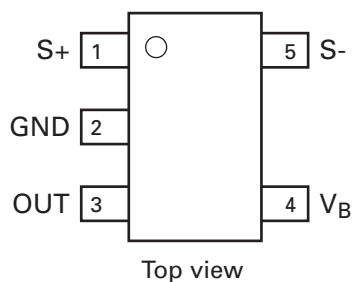
The ZXCT1020 footprint follows that of the ZXCT1021/2 with only 2 additional resistors required:

One resistor between pins 1 and 4 for setting transconductance, and the other between pins 3 and 2 for setting overall gain.

#### Features

- Accurate high-side current sensing
- Versatile current output scaling
- 2.5V - 20V operating range
- 25 $\mu$ A quiescent current
- 1% typical accuracy
- SOT23-5 package

#### Pinout information



Current output enables the user to set the gain via these external resistors. Using two external resistors to set the gain ensures optimal versatility as the transconductance can be varied to meet the output impedance requirements of the load that the ZXCT1020 has to drive.

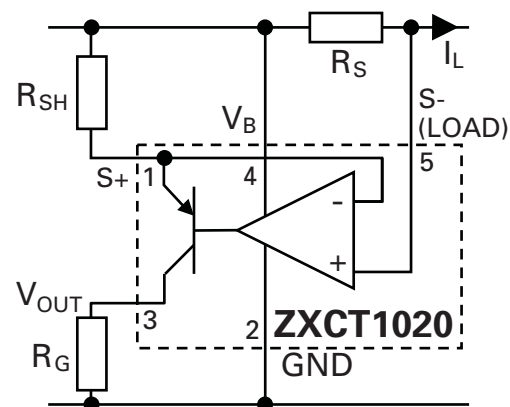
The very low offset voltage enables a typical accuracy of 3% for sense voltages of only 10mV, giving better tolerances for small sense resistors necessary at higher currents.

The wide input voltage range of 20V down to as low as 2.5V make it suitable for a range of applications. With a minimum operating current of just 25 $\mu$ A, combined with its SOT23-5 package make it suitable for portable battery equipment too.

#### Applications

- Battery chargers
- Over-current monitor
- Motherboard power supply current measurement
- Level translating
- Programmable current source

#### Typical application circuit



#### Ordering information

| Order reference | Package | Device marking | Status  | Reel size (inches) | Quantity per reel | Tape width (mm) |
|-----------------|---------|----------------|---------|--------------------|-------------------|-----------------|
| ZXCT1020E5TA    | SOT23-5 | 1020           | Preview | 7                  | 3000              | 8               |

## Absolute maximum ratings

|                                                                    |                               |
|--------------------------------------------------------------------|-------------------------------|
| Voltage on $V_B$ with respect to GND pin                           | -0.5V to 20V                  |
| Voltage on $S_+^{(a)}$ , $S_-^{(b)}$ , OUT with respect to GND pin | -0.5V to $V_B+0.5V$           |
| $V_{SENSE}^{(c)}$                                                  | -0.5V to +2.5V <sup>(d)</sup> |
| Junction temperature                                               | -40°C to 125°C                |
| Storage temperature                                                | -55°C to 150°C                |
| Package power dissipation ( $T_{amb} = 25^\circ\text{C}$ ) SOT23-5 | 300mW                         |

### NOTES:

(a) Subject to  $V_{SENSE+}$  never going 6V below  $V_B$ .

(b) Subject to absolute maximum  $V_{SENSE}$  not being exceeded.

(c)  $V_{SENSE}$  is defined as the voltage difference across the sense resistor, and is the voltage across resistor  $R_{SH}$  plus the voltage between  $S_+$  and  $S_-$ .

(d)  $V_{SENSE}$  might need to be reduced when used with smaller values of  $R_{SH}$  and at larger rails due to increased power dissipation.

## Pin out information

| Pin | Name  | Pin function                                                                                                                                                                                                                                                                                                                            |
|-----|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | $S_+$ | Positive sense input. Should be tied to positive side of sense resistor via resistance ( $R_{SH}$ ) of the order of 150Ω to 1.5kΩ.                                                                                                                                                                                                      |
| 2   | GND   | Ground and substrate connection of device.                                                                                                                                                                                                                                                                                              |
| 3   | OUT   | Current output. A gain setting resistor ( $R_G$ ) referenced to GND should be connected to this pin to set overall voltage gain of:<br>Gain = $R_G/R_{SH}$<br>The resistance, $R_G$ , placed on out will set the ZXCT1020 output impedance equal to $R_G$ . When driving low impedance loads both $R_G$ and $R_{SH}$ should be reduced. |
| 4   | $V_B$ | Input voltage pin. Provides bias to current monitor and should be tied to the rail whose current is being monitored.                                                                                                                                                                                                                    |
| 5   | $S_-$ | High impedance negative sense voltage input                                                                                                                                                                                                                                                                                             |

## Recommended operating conditions

| Parameter                                          | Min. | Max.             | Units |
|----------------------------------------------------|------|------------------|-------|
| $V_{SENSE+}$ Common-mode sense input range         | 2.5  | 20               | V     |
| $V_B$ Bias pin input voltage range (*)             | 2.5  | 20               | V     |
| $V_{SENSE}$ Differential sense Input voltage range | 0    | 1.5              | V     |
| $V_{OUT}$ Output voltage range                     | 0    | $V_{SENSE-} - 1$ | V     |
| $R_{SH}$ Shunt resistor value                      | 120  | 2000             | Ω     |
| $T_A$ Ambient temperature range                    | -40  | 85               | °C    |

### NOTES:

(\*) For best performance  $V_B$  and  $V_{SENSE+}$  should be referred to the rail whose current is being measured.

## Recommended resistor gain setting combinations

| Gain | $R_{SHUNT}$ | $R_{GAIN}$ |
|------|-------------|------------|
| 10   | 1.5kΩ       | 15kΩ       |
| 20   | 750Ω        | 15kΩ       |
| 50   | 300Ω        | 15kΩ       |
| 100  | 150Ω        | 15kΩ       |

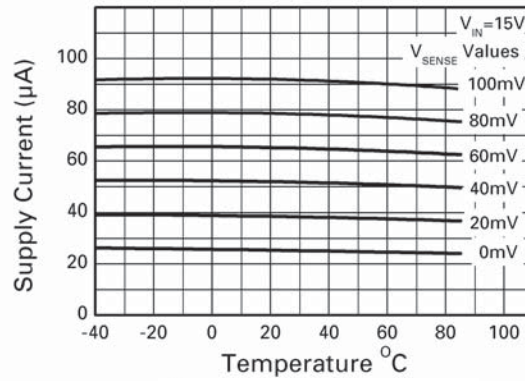
**Electrical characteristics**

$T_{amb} = 25^{\circ}\text{C}$ ,  $V_{SENSE+} = V_B = 15\text{V}$ ,  $V_{SENSE} = 100\text{mV}$ ,  $R_G = 15\text{k}\Omega$ ,  $R_{SH} = 1.5\text{k}\Omega$  unless otherwise stated.

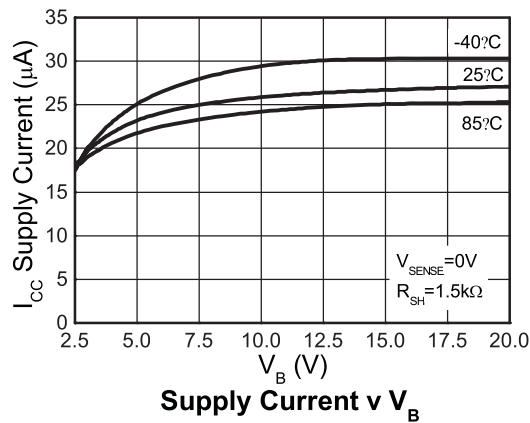
| Symbol           | Parameter                              | Conditions                                        | Limits |      |      | Unit |
|------------------|----------------------------------------|---------------------------------------------------|--------|------|------|------|
|                  |                                        |                                                   | Min.   | Typ. | Max. |      |
| V <sub>OUT</sub> | Output voltage                         | V <sub>SENSE</sub> = 0mV                          |        | 3    | 15   | mV   |
|                  |                                        | V <sub>SENSE</sub> = 30mV                         | 291    | 300  | 309  | mV   |
|                  |                                        | V <sub>SENSE</sub> = 100mV                        | 0.98   | 1    | 1.02 | V    |
|                  |                                        | V <sub>SENSE</sub> = 150mV                        | 1.47   | 1.5  | 1.53 | V    |
| TC[1]            | Output voltage temperature coefficient |                                                   |        | 50   | 300  | ppm  |
| I <sub>Q</sub>   | Ground pin current                     | V <sub>SENSE</sub> = 0V                           |        | 25   | 35   | μA   |
| I <sub>S-</sub>  | S- input current                       | V <sub>SENSE</sub> = 0V                           |        | 20   | 100  | nA   |
| I <sub>S+</sub>  | S+ input current                       | V <sub>SENSE</sub> = 0V                           |        | 100  |      | nA   |
| Acc              | Accuracy                               | V <sub>SENSE</sub> = 100mV                        | -2     |      | 2    | %    |
| Gain             | V <sub>OUT</sub> / V <sub>SENSE</sub>  | V <sub>SENSE</sub> = 100mV                        |        | 10   |      | V/V  |
| R <sub>OUT</sub> | Output resistance                      | R <sub>G</sub> not connected                      |        | 370  |      | MΩ   |
| BW               | Bandwidth                              | V <sub>SENSE</sub> (DC) = 10mV                    |        | 300  |      | kHz  |
|                  |                                        | V <sub>SENSE</sub> (DC) = 100mV                   |        | 2    |      | MHz  |
| PSRR             | Power supply rejection ratio           | V <sub>SENSE+</sub> = V <sub>B</sub> = 2.5 to 20V | 70     | 80   |      | dB   |

## Typical characteristics

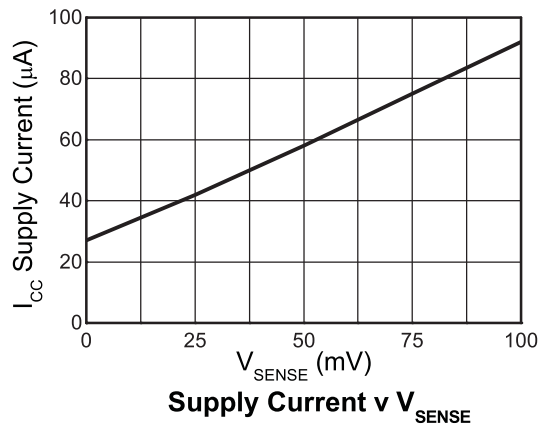
Test conditions unless otherwise stated:  $T_A = 25^\circ\text{C}$ ,  $V_B = V_{\text{SENSE}+}$  (via  $R_{\text{SH}}$ ) = 15V,  $V_{\text{SENSE}} = 100\text{mV}$ ,  $R_{\text{SH}} = 1.5\text{k}\Omega$ ,  $R_G = 15\text{k}\Omega$ .



Supply current v Temperature



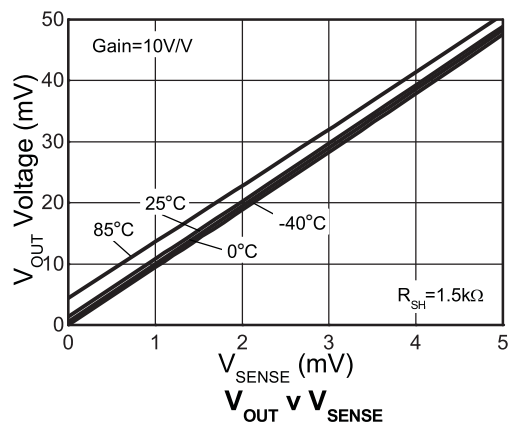
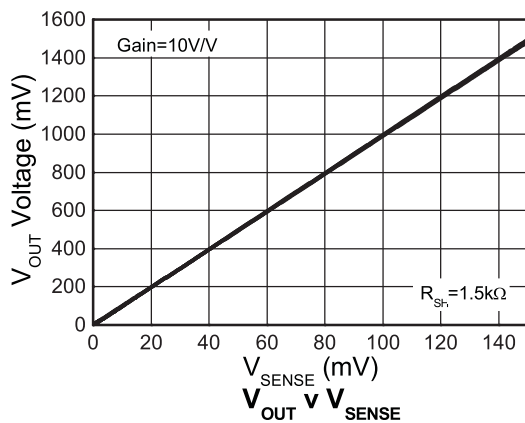
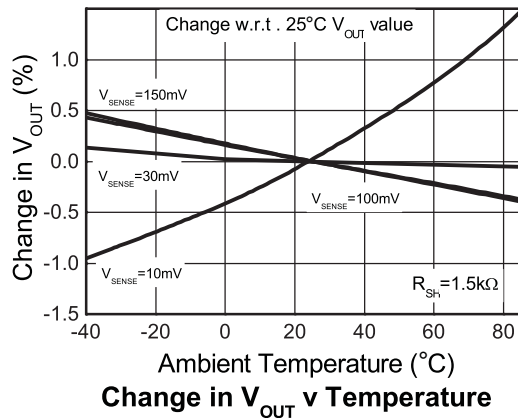
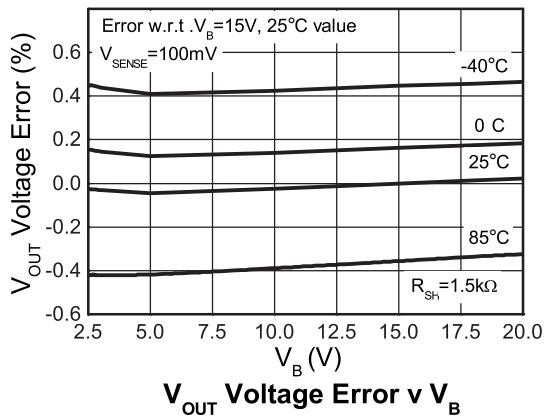
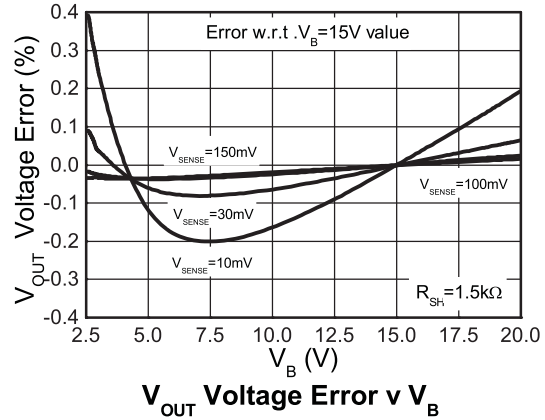
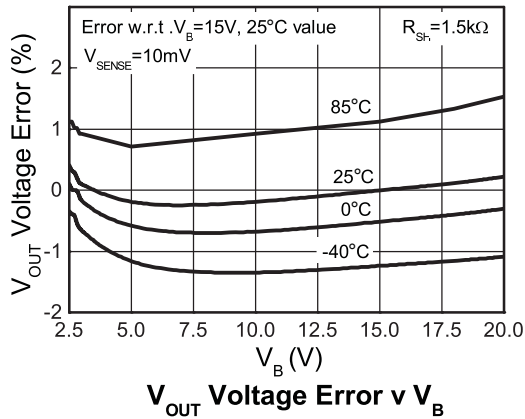
Supply Current v  $V_B$



Supply Current v  $V_{\text{SENSE}}$

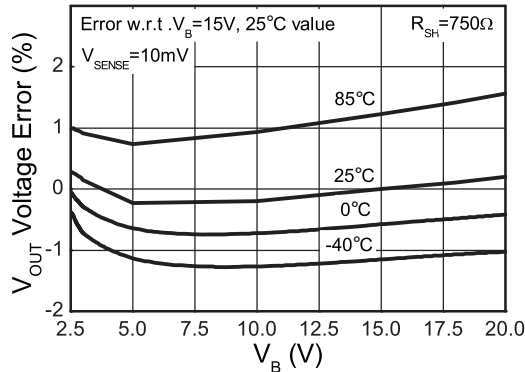
# ZXCT1020

Test conditions unless otherwise stated:  $T_A = 25^\circ\text{C}$ ,  $V_B = V_{\text{SENSE}+}$  (via  $R_{\text{SH}} = 15\text{V}$ ,  $V_{\text{SENSE}} = 100\text{mV}$   
Gain = 10,  $R_G = 15\text{k}\Omega$ .

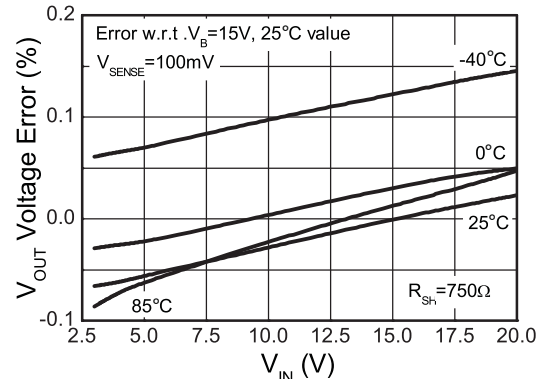


# ZXCT1020

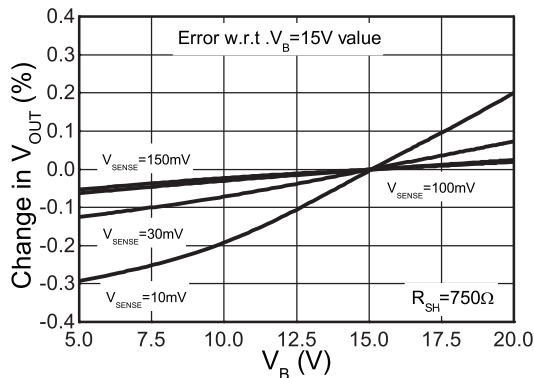
Test conditions unless otherwise stated:  $T_A = 25^\circ\text{C}$ ,  $V_B = V_{\text{SENSE}+}$  (via  $R_{\text{SH}} = 15\text{V}$ ,  $V_{\text{SENSE}} = 100\text{mV}$   
Gain = 20,  $R_G = 15\text{k}\Omega$ .



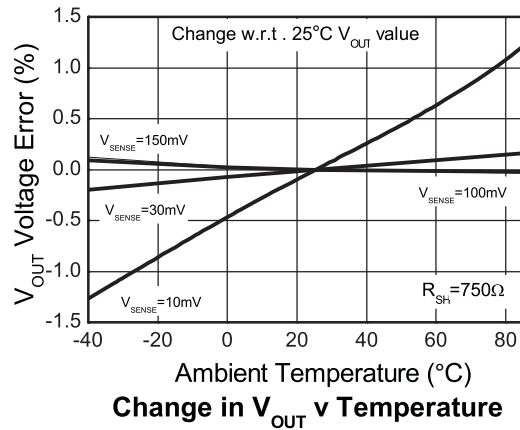
$V_{\text{OUT}}$  Voltage Error v  $V_B$



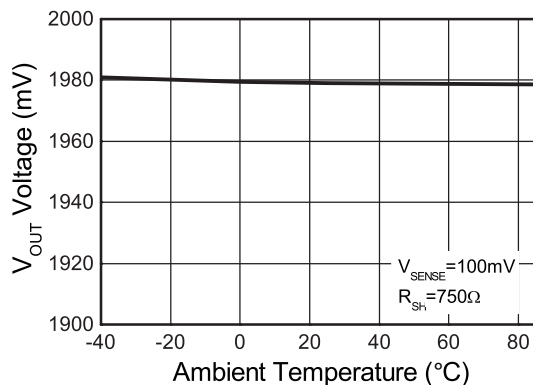
$V_{\text{OUT}}$  Voltage Error v  $V_{\text{IN}}$



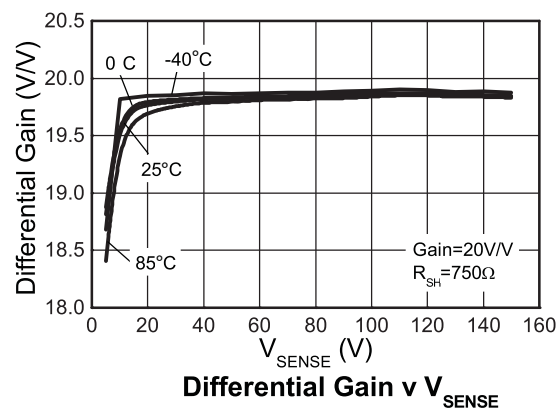
$V_{\text{OUT}}$  Voltage Error v  $V_B$



Change in  $V_{\text{OUT}}$  v Temperature



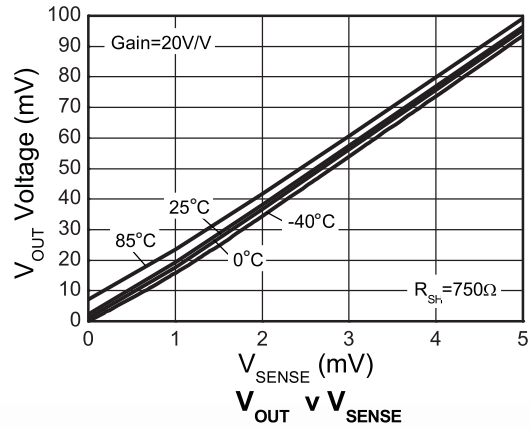
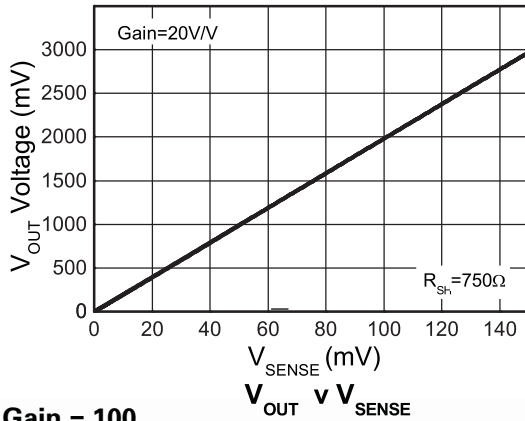
$V_{\text{OUT}}$  v Ambient Temperature



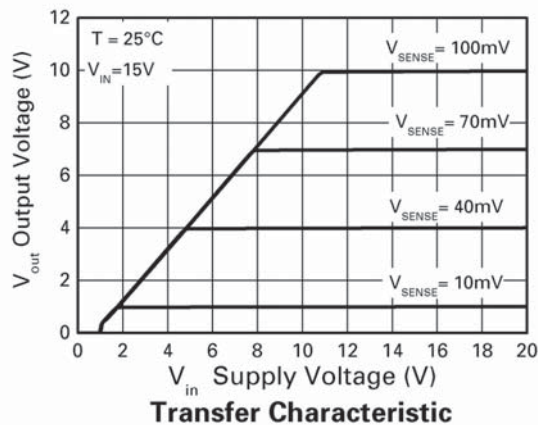
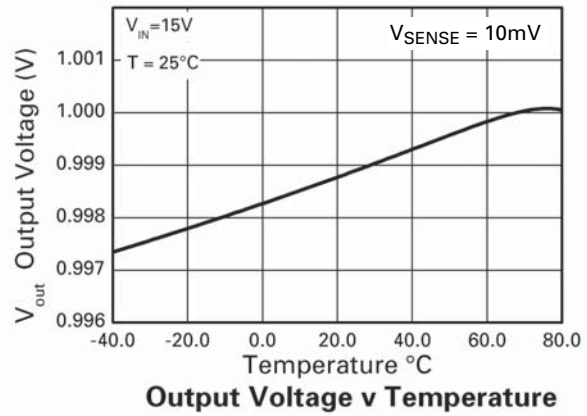
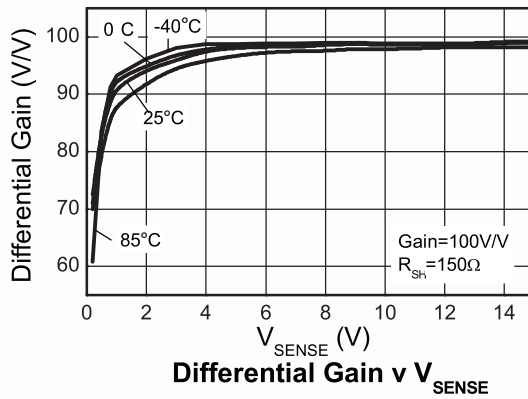
Differential Gain v  $V_{\text{SENSE}}$

# ZXCT1020

Test conditions unless otherwise stated:  $T_A = 25^\circ\text{C}$ ,  $V_B = V_{\text{SENSE}+}$  (via  $R_{\text{SH}} = 15\text{V}$ ,  $V_{\text{SENSE}} = 100\text{mV}$ ,  $R_G = 15\text{k}\Omega$ .



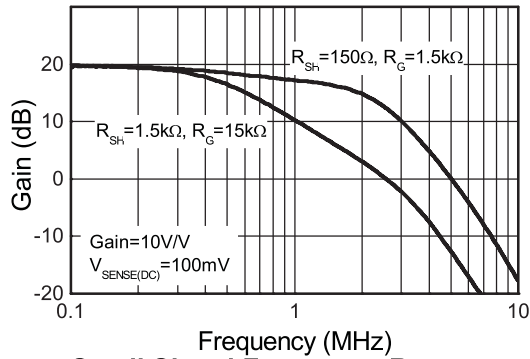
Gain = 100



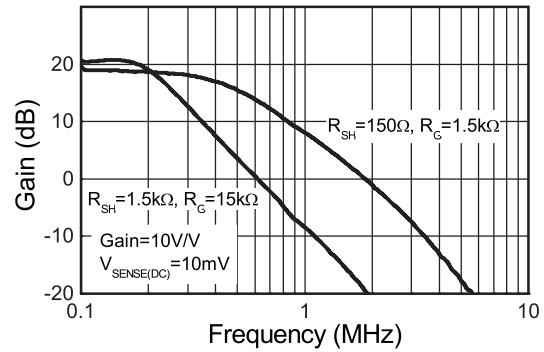
## Typical AC characteristics

Test conditions unless otherwise stated:  $T_A = 25^\circ\text{C}$ ,  $V_B = V_{\text{SENSE}+}$  (via  $R_{\text{SH}}$ ) = 15V,  $V_{\text{SENSE}} = 100\text{mV}$ ,  $R_G = 15\text{k}\Omega$ .

### Gain = 10

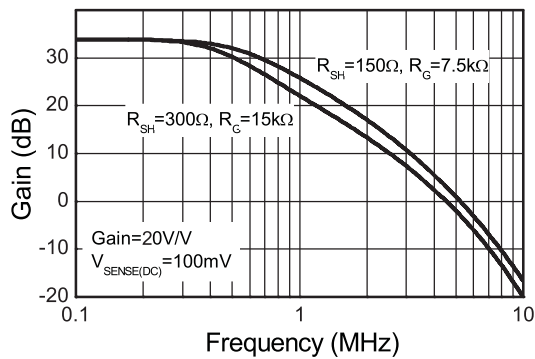


Small Signal Frequency Response

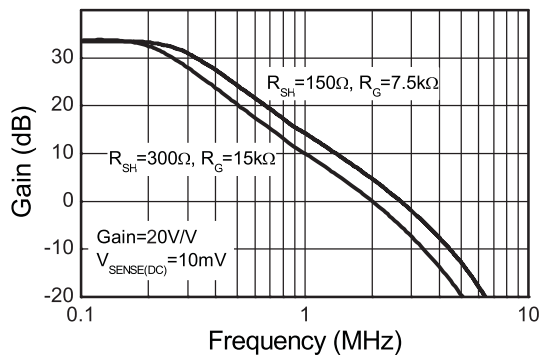


Small Signal Frequency Response

### Gain = 50



Large Signal Frequency Response

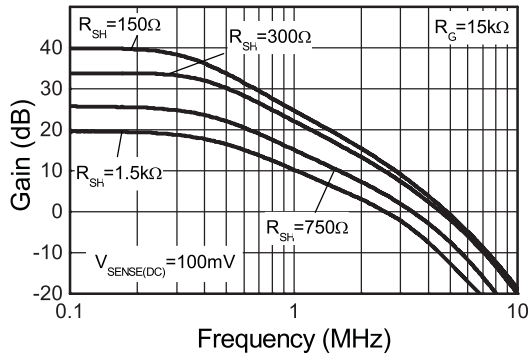


Small Signal Frequency Response

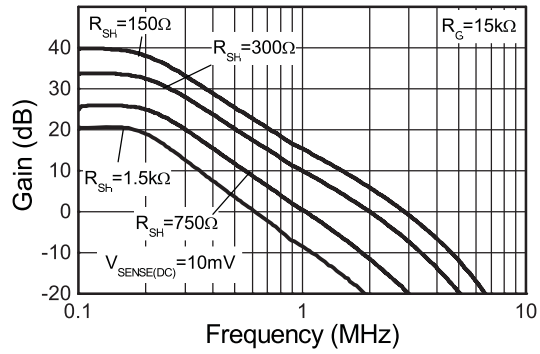


Test conditions unless otherwise stated:  $T_A = 25^\circ\text{C}$ ,  $R_G = 15\text{k}\Omega$ ,  $V_B = V_{\text{SENSE}+}$  (via  $R_{\text{SH}}$ ) = 15V,  $V_{\text{SENSE}} = 100\text{mV}$  unless otherwise stated.

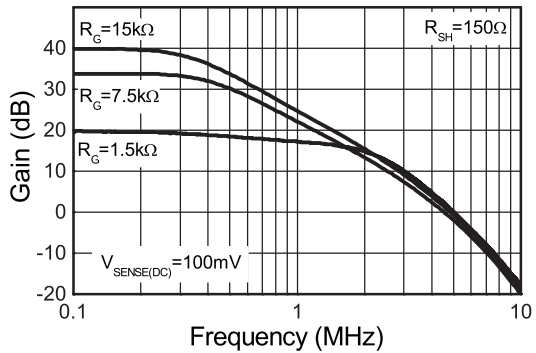
## Various gains with constant $R_G$



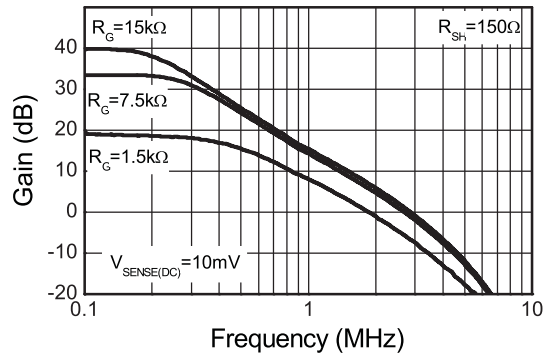
Frequency Response with constant  $R_G$



Frequency Response with constant  $R_G$



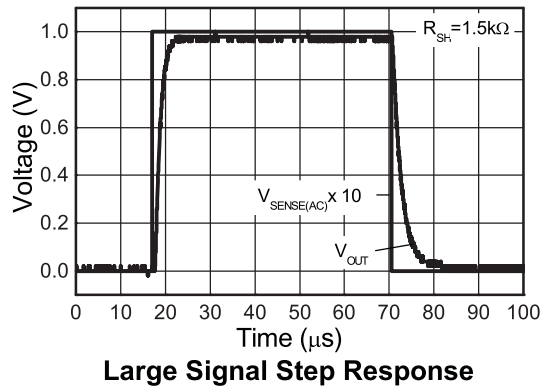
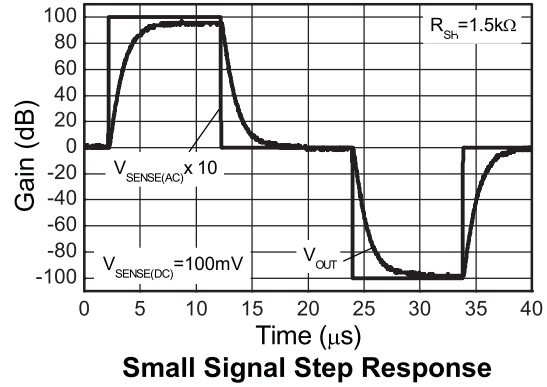
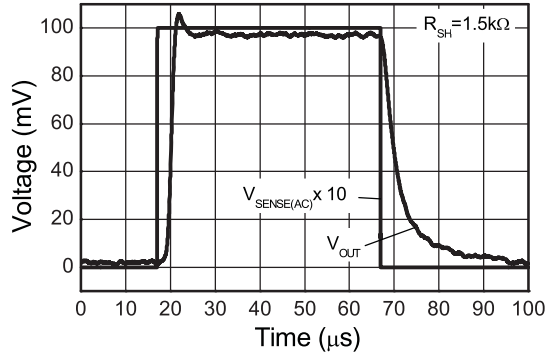
Frequency Response with constant  $R_{\text{SH}}$



Frequency Response with constant  $R_{\text{SH}}$

# ZXCT1020

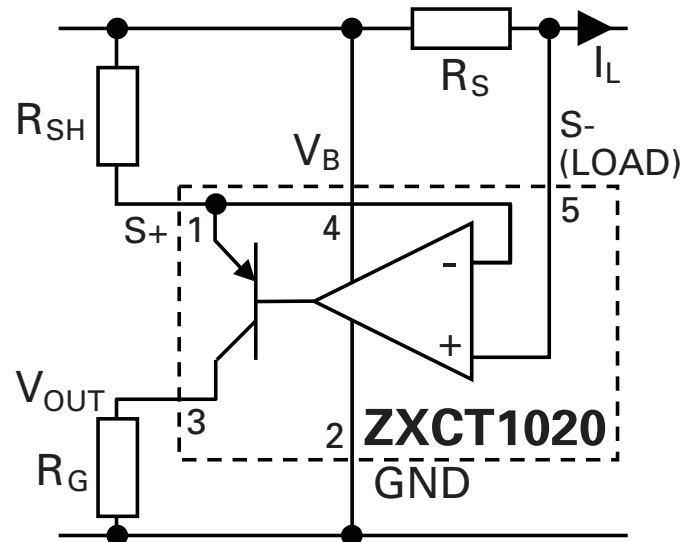
Test conditions unless otherwise stated:  $T_A = 25^\circ\text{C}$ ,  $G=100$ ,  $R_G = 15\text{k}$ ,  $V_B = V_{\text{SENSE}+}$  (via  $R_{\text{SH}}$ ),  $V_{\text{SENSE}} = 100\text{mV}$ .



## Application information

The ZXCT1020 has a  $V_B$  pin that is used to provide power to the current monitor. The maximum voltage applied to the ZXCT1020 must be applied to this pin. The S+ and S- pins are used to measure the current flowing to the load through the sense resistor. In normal use, the S+ is tied to  $V_B$  via a shunt resistor,  $R_{SH}$  making the ZXCT1020 essentially line powered.

The ZXCT1020 has a programmable gain set by the ratio of two external resistors  $R_G$  and  $R_{SH}$ .



$R_{SH}$  sets the transconductance whereas  $R_G$  set the gain and results in an output voltage defined as:

$$V_{OUT} = \frac{R_G}{R_{SH}} \times V_{SENSE}$$

$$\text{Where } V_{SENSE} = R_{SENSE} \times I_L$$

The ZXCT1020 has been tested to the same conditions as the ZXCT1021 giving an overall voltage gain of 10. The gain of the ZXCT1020 can be adjusted simply by varying  $R_G$ . So to achieve a gain of 50  $R_G$  is increased from 15k $\Omega$  to 75k $\Omega$ . An alternative is to decrease  $R_{SH}$  from 1.5k $\Omega$  to 300 $\Omega$ .

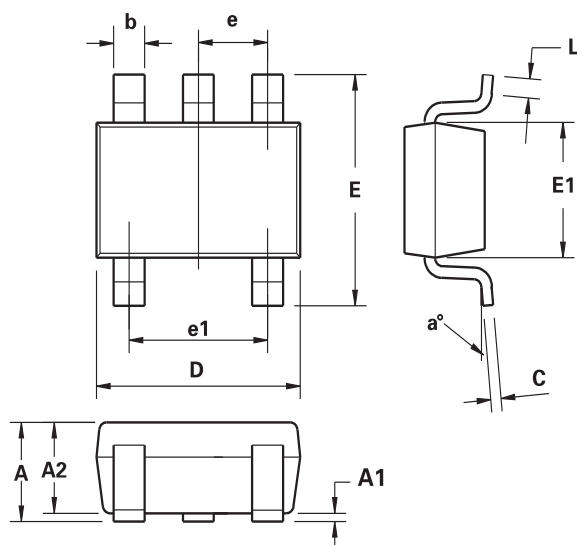
Decreasing  $R_{SH}$  increases the transconductance and, if for any given gain, reducing the  $R_{SH}$  will reduce the overall output impedance.

To achieve a gain of 100, for example, the following resistor values could be used:

$$R_{SH} = 150 \quad R_G = 15k$$

Intentionally left blank

## 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

## Definitions

### Product change

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1. are intended to implant into the body

or

2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labelling can be reasonably expected to result in significant injury to the user.

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Semiconductor devices are susceptible to damage by ESD. Suitable precautions should be taken when handling and transporting devices. The possible damage to devices depends on the circumstances of the handling and transporting, and the nature of the device. The extent of damage can vary from immediate functional or parametric malfunction to degradation of function or performance in use over time. Devices suspected of being affected should be replaced.

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All Zetex components are compliant with the RoHS directive, and through this it is supporting its customers in their compliance with WEEE and ELV directives.

### 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.                                                    |

### Zetex sales offices

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| Zetex GmbH<br>Kustermannpark<br>Balanstraße 59<br>D-81541 München<br>Germany<br>Telefon: (49) 89 45 49 49 0<br>Fax: (49) 89 45 49 49 49<br>europe.sales@zetex.com | Zetex Inc<br>700 Veterans Memorial Highway<br>Hauppauge, NY 11788<br>USA<br>Telephone: (1) 631 360 2222<br>Fax: (1) 631 360 8222<br>usa.sales@zetex.com | Zetex (Asia Ltd)<br>3701-04 Metroplaza Tower 1<br>Hing Fong Road, Kwai Fong<br>Hong Kong<br>Telephone: (852) 26100 611<br>Fax: (852) 24250 494<br>asia.sales@zetex.com | Zetex Semiconductors plc<br>Zetex Technology Park, Chadderton<br>Oldham, OL9 9LL<br>United Kingdom<br>Telephone: (44) 161 622 4444<br>Fax: (44) 161 622 4446<br>hq@zetex.com |

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