

ZXCT1050

Precision wide input range current monitor

Description

The ZXCT1050 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 ZXCT1050 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.

The ZXCT1050 provides variable gain by using two external resistors. The first of which sets the transconductance and the second setting the overall gain.

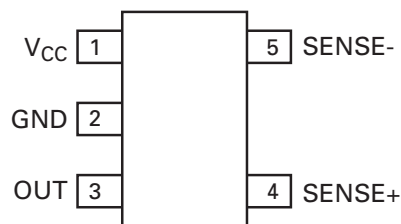
Features

- 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 μ A quiescent current
- SOT23-5 package

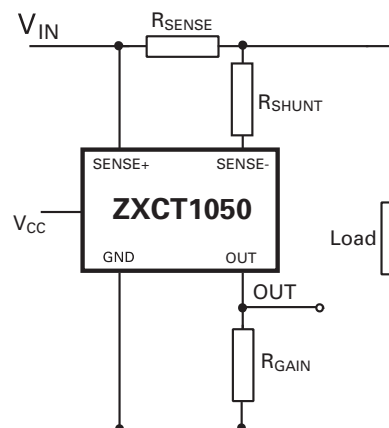
Applications

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

Pin connections



Typical application circuit



Ordering information

| Order code | Pack | Part mark | Reel size (inches) | Tape width (mm) | Quantity per reel |
|--------------|---------|-----------|--------------------|-----------------|-------------------|
| ZXCT1050E5TA | SOT23-5 | 1050 | 7 | 8 | 3000 |

Absolute maximum ratings

| | |
|--------------------------------------------|-------------------------------------------------------------------------------------|
| V_{CC} max. | 20V |
| Voltage on SENSE- and SENSE+ | -0.6 to V_{CC} |
| Voltage on all other pins | -0.6V and $V_{CC} + 0.6V$ |
| $V_{SENSE} = (V_{SENSE+}) - (V_{SENSE-})'$ | 500mV |
| Operating temperature | -40 to 125°C |
| Storage temperature | -55 to 150°C |
| Maximum junction temperature | 150°C |
| Package power dissipation | 300mW* at $T_A = 25^\circ\text{C}$ (De-rate to zero for $T_J = 150^\circ\text{C}$) |

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

| Parameter | | Min. | Max. | Units |
|--------------|----------------------------------------|------|------------|-------|
| V_{SENSE+} | Common-mode sense input range | 0 | $V_{CC}-2$ | V |
| V_{CC} | Supply voltage range | 2.7 | 20 | V |
| V_{SENSE} | Differential sense input voltage range | 10 | 300 | mV |
| V_{OUT} | Output voltage range | 0 | $V_{CC}-2$ | V |
| T_A | Ambient temperature range | -40 | 125 | °C |

Recommended resistor gain setting combinations

| Gain | R_{SH} | R_G |
|------|----------------|----------------|
| 10 | 7.5k Ω | 3.75k Ω |
| 20 | 7.5k Ω | 7.5k Ω |
| 50 | 7.5k Ω | 18.7k Ω |
| 100 | 7.5k Ω | 37.5k Ω |
| 20 | 3.75k Ω | 3.75k Ω |
| 50 | 1.5k Ω | 3.75k Ω |
| 100 | 750 Ω | 3.75k Ω |

Pin function table

| PIN | Name | Description |
|-----|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | V_{CC} | This is the analog supply and provides power to internal circuitry. |
| 2 | GND | Ground pin. |
| 3 | OUT | Output pin. A resistor, R_{GAIN} , connected from this pin pin down to ground develops an output voltage. |
| 4 | SENSE+ | This is the positive input of the current monitor and has an input range from 0V up to $V_{CC} - 2V$. |
| 5 | SENSE- | 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. A resistor, R_{SHUNT} , from this pin to the rail being sensed set the transconductance of the current monitor. |

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Electrical characteristics

Test conditions $T_A = 25^\circ\text{C}$, $V_{\text{SENSE}+} = 10\text{V}$, $V_{\text{CC}} = 12\text{V}$, $V_{\text{SENSE}} = 100\text{mV}$, $R_{\text{SH}} = 7.5\text{k}\Omega$, $R_{\text{G}} = 3.75\text{k}\Omega$.

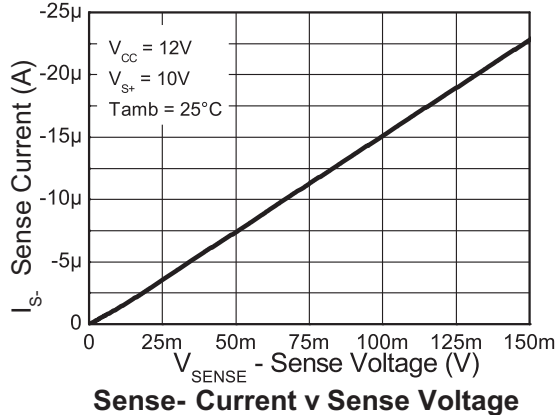
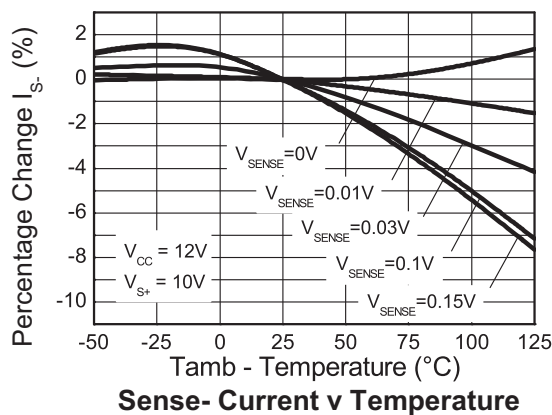
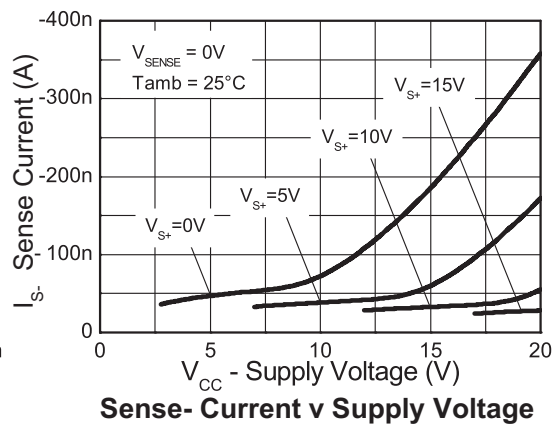
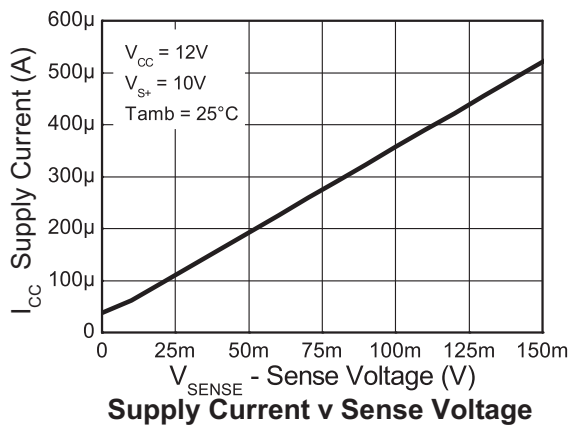
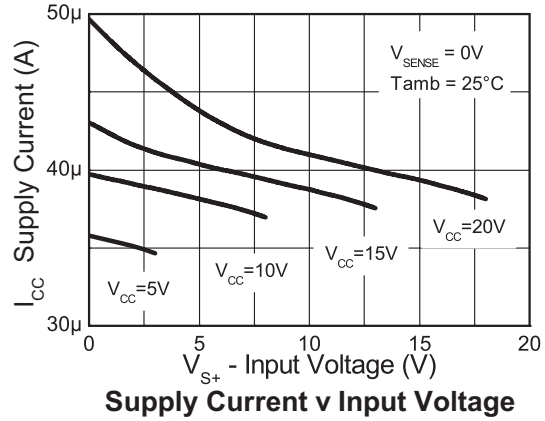
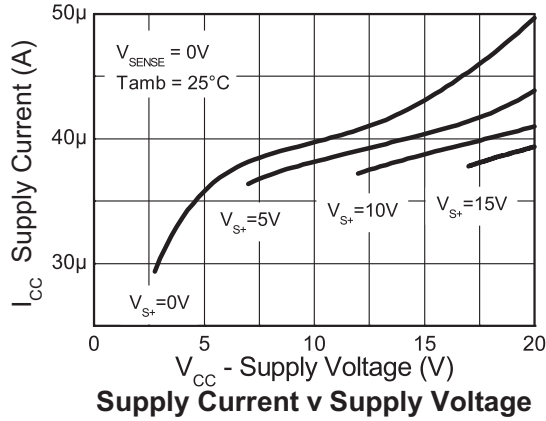
| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Units | |
|---------------------|---------------------------------------------|-------------------------------------------------------------------------------------------|----------------------------------------------------------------------|--------------------------|---------------------------|-----------------------|-----|
| I_{Q} | V_{CC} pin current | $V_{\text{SENSE}} = 0\text{V}$ | | 45 | 70 | μA | |
| V_{OUT} | Output voltage | $V_{\text{SENSE}} = 0\text{V}$ $= 30\text{mV}$ $= 100\text{mV}$ $= 150\text{mV}$ | 0 285 0.97 1.45 | 3 300 1.00 1.50 | 15 315 1.03 1.55 | mV mV V V | |
| $I_{\text{SENSE}+}$ | $V_{\text{SENSE}+}$ input current | $V_{\text{SENSE}} = 0\text{V}$ | | 60 | 150 | nA | |
| $I_{\text{SENSE}-}$ | $V_{\text{SENSE}-}$ input current | $V_{\text{SENSE}} = 0\text{V}$ | | 15 | 150 | nA | |
| $V_{\text{OUT TC}}$ | V_{OUT} variation with temperature | See note (*) | | | 300 | ppm/ $^\circ\text{C}$ | |
| Gain | $V_{\text{OUT}}/V_{\text{SENSE}}$ | | | 10 | | | |
| Accuracy | Total output error | | -3 | | 3 | % | |
| BW | Bandwidth | $V_{\text{SENSE}(\text{DC})} = 10\text{mV}$ | $V_{\text{SENSE}(\text{AC})} = 10\text{mV}_{\text{PP}}$ CL = 5pF, | | 300 | | kHz |
| | | $V_{\text{SENSE}(\text{DC})} = 100\text{mV}$ | | | 0.8 | | MHz |
| PSRR | Power supply rejection ratio | $V_{\text{CC}} = 2.7\text{V to } 20\text{V}$ $V_{\text{SENSE}+} = 0.7\text{V}$ | | 60 | | dB | |
| CMRR | Common mode rejection ratio | $V_{\text{CC}} = 20\text{V}$ $V_{\text{SENSE}+} = 0 \text{ to } 18\text{V}$ | | 70 | | dB | |

NOTES:

(*) Temperature dependent measurements are extracted from characterisation and simulation results.

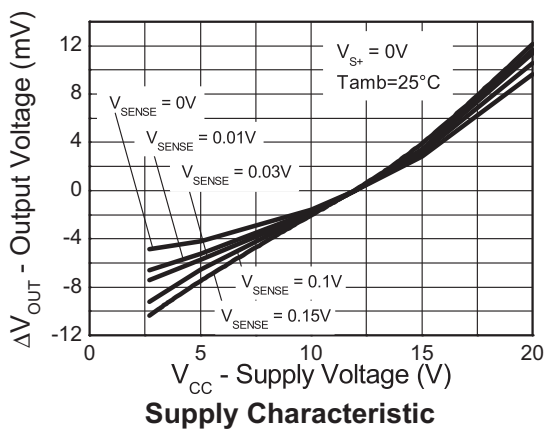
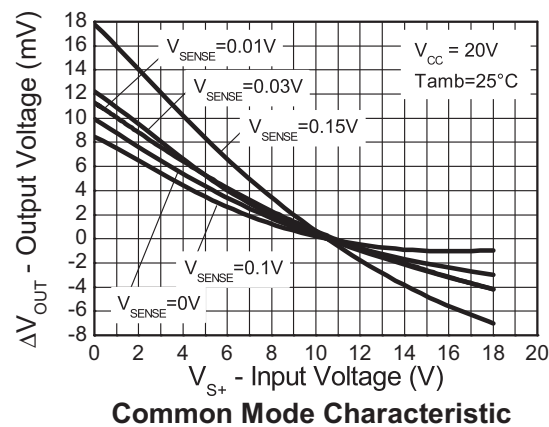
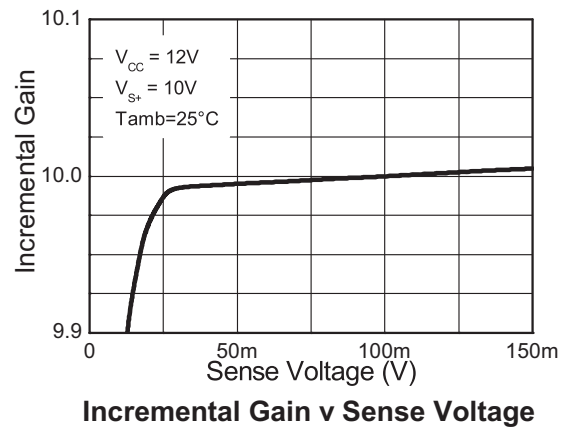
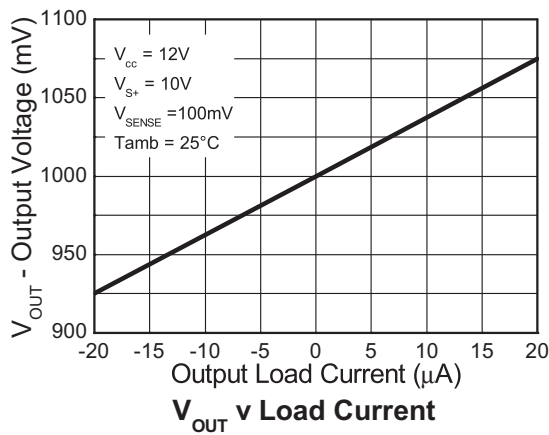
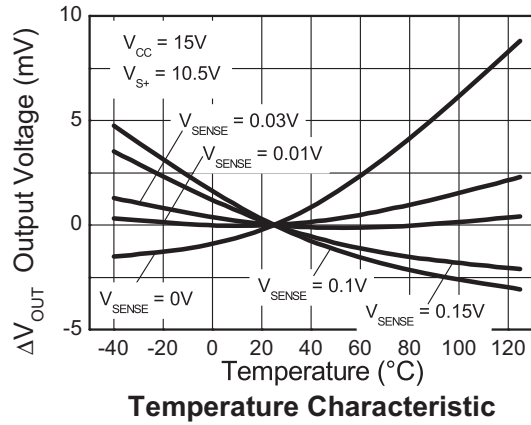
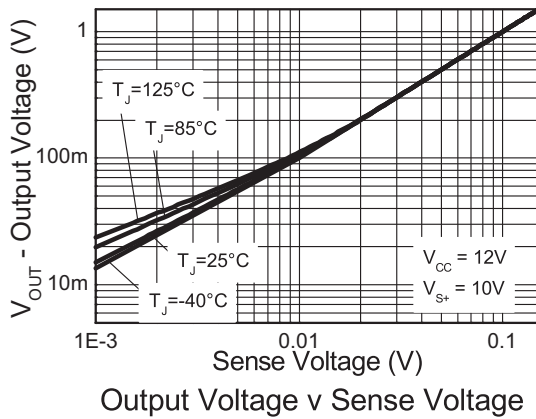
Typical characteristics

$R_G = 3.75k\Omega$, $R_{SH} = 7.5k\Omega$ unless otherwise stated.



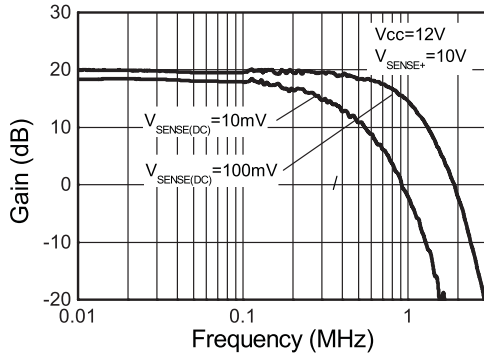
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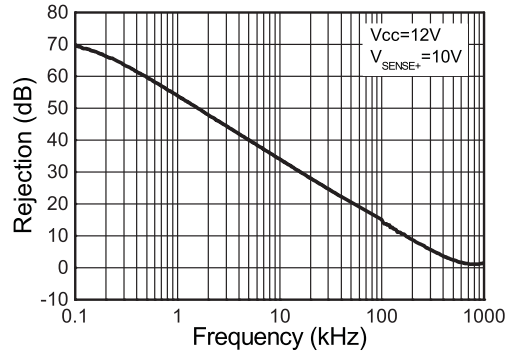


Typical characteristics

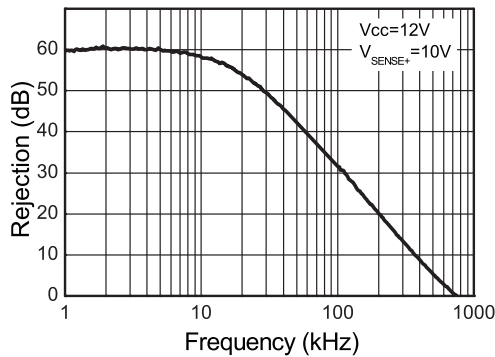
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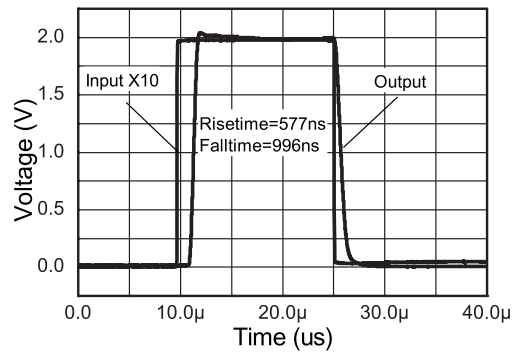
Small Signal Frequency Response



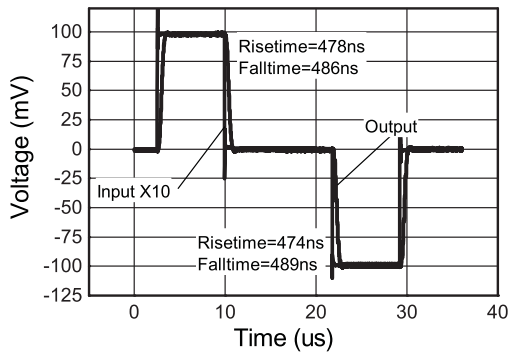
CMRR



PSRR



Large Signal Step Response



Small Signal Step Response

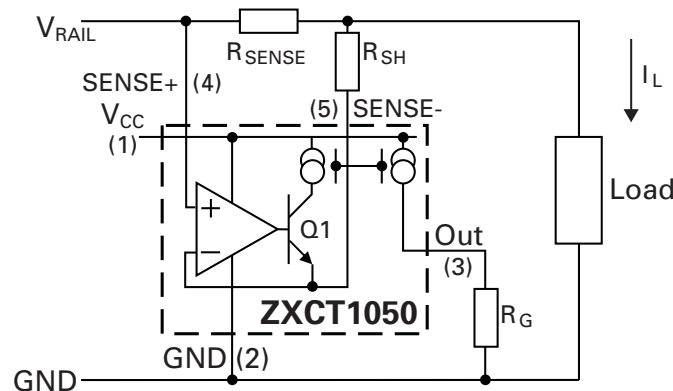
Referred to 1V

Applications information

The ZXCT1050 is a current output version of the ZXCT1051 and as such uses a separate power supply pin. All biasing for the internal amplifiers comes from its separate V_{CC} input and is not 'line powered', unlike the ZXCT1021.

This means that at very small sense voltages the ZXCT1050 draws very little current ($<1\mu\text{A}$) from the lines being sensed.

The separate V_{CC} pin enables the ZXCT1050 to be operated at sense line voltages down to 0V, where the ZXCT1021 would switch off. This feature enables the ZXCT1050 to be used to sense the currents flowing through lines that have been shorted to ground.



Basic operation

Load current, I_L , from V_{RAIL} is drawn through R_{SENSE} developing a voltage V_{SENSE} across the sense inputs of the ZXCT1050.

The internal amplifier forces V_{SENSE} across external resistance R_{SH} (internal on the ZXCT1051) causing a current to flow through transistor Q1 and out of the output pin, OUT. This current is then converted to a voltage by a resistor, R_G , between OUT and GND.

The overall gain of the ZXCT1050 is determined by the following expression:

$$\text{GAIN} = 20 \times \frac{R_G}{R_{SH}}$$

A ratio of 1:2 between R_{SH} and R_G creates the fixed gain of 10 with an output impedance equal to R_G (see electrical characteristics for output current-voltage characteristics).

The ZXCT1050 has both R_G and R_{SH} external. This allows R_G and R_{SH} to be varied so that the required gain can be achieved at the required output impedance.

For low power applications both R_G and R_{SH} can be increased whereas for driving low impedance R_G and R_{SH} can be decreased.

The maximum recommended value for R_G is 40k Ω and the maximum recommended value for R_{SH} is 10k Ω . Large values of R_{SH} start increasing the effective input offset error, while large values of R_G can create load errors and reduce bandwidths.

The maximum differential input voltage, V_{SENSE} , is 150mV ($I_L \cdot R_{SENSE}$); however voltages up to 500mV will not damage it. This can be increased further by the inclusion of a resistor, R_{LIM} , between the SENSE+ pin and the rail being sensed, V_{RAIL} .

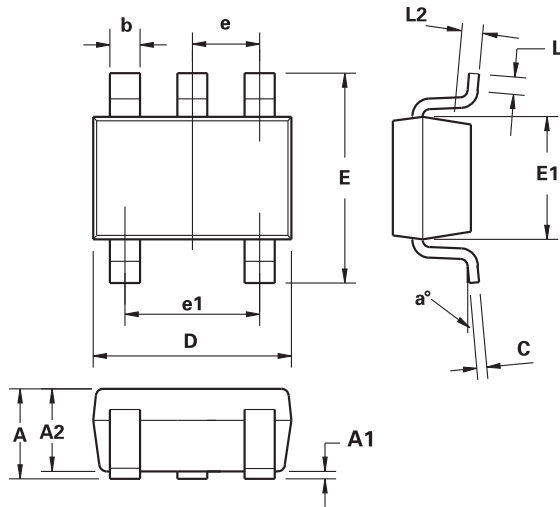
For best performance R_{SENSE} should be connected as close to the SENSE+ and SENSE- pins thus minimizing any series resistance with R_{SENSE} .

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ZXCT1050

Package outline - SOT23-5



| 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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| | |
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| | |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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