



# Bay Linear

Inspire the Linear Power

## 150mA Low Dropout Voltage Regulator

# B1121

### Description

The Bay Linear B1121 is a low power voltage regulator. This device is an excellent choice for use in battery-powered applications such as cordless telephones, radio control systems, and portable computers. The B1121 features very low quiescent current and very low dropout voltage of 0.40 volts. This includes a tight initial tolerance of  $\pm 1\%$  max, and very low output temperature coefficient, making the B1121 useful as a low-power voltage reference.

The B1121 feature low quiescent current ( 75 $\mu$ A Typ.) and low dropout of 40mV at light loads 400mV (typ.) at 150mA.

The Bay Linear B1121 is available in fixed voltages of 3.0V, 3.3V, and 5.0V in a SOT-223 and TO-92 packages.

### Features

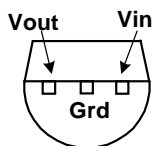
- **1% Output Accuracy @ 3.0V, 3.3V, 5.0V**
- **Very Low Quiescent Current**
- **0.40V Low Dropout Voltage**
- **Extremely Tight Load and Line Regulation**
- **Very Low Temperature Coefficient**
- **Needs only 1 $\mu$ F for Stability**
- **Current & Thermal Limiting**
- **Equivalent Replacement For LT1121**

### Applications

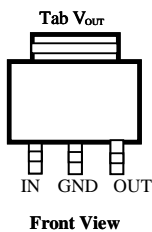
- **Battery Powered Systems**
- **Portable instrumentation**
- **Notebooks Computers**
- **Potable Consumer Equipment**
- **Automotive electronics**
- **SMPS Post-Regulator**

### Pin Connection

TO-92 (Z)



SOT-223



### Ordering Information

Package	
	1%
SOT-223	B1121-R-XX
TO-92	B1121-Z-XX

### “XX” Voltage Selection Guide

Vout	XX Code
5.0V	5
3.3V	3.3
3V	3

## Absolute Maximum Rating

Parameter	
Power Dissipation	Internally Limited
Lead Temperature ( Soldering 5 seconds )	260 °C
Storage Temperature Range	-65 °C to +150 °C
Operating Junction Temperature	-55 °C to +150 °C
Input Supply Voltage	-0.3V to +30V
Feedback Input Voltage	-1.5V to +30V
Shutdown Input Voltage	-0.3V to +30V
Error Comparator Output	-0.3V to +30V

## Electrical Characteristics

( $V_S = 15V$ ,  $T_A = 25^\circ C$ , unless otherwise specified)

Parameter	Conditions	MIN	TYP	MAX	UNIT
<b>3.0V Version</b>					
Output Voltage	$V_{in}=3.8V$ $I_{OUT}=1mA$ $V_{IN} \leq 4.3V$ , $1mA \leq I_L \leq 150mA$	2.97 <b>2.955</b>	3.00 <b>3.00</b>	3.03 <b>3.045</b>	V
Reverse Output Current	B1121-3.0 $V_{OUT} = 3.0V$ , $V_{IN} = 0V$		16	25	$\mu A$
<b>3.3V Version</b>					
Output Voltage	$V_{in}=3.8V$ $I_{OUT}=1mA$ $V_{IN} \leq 4.3V$ , $1mA \leq I_L \leq 150mA$	3.250 <b>3.20</b>	3.30 <b>3.30</b>	3.35 <b>3.366</b>	V
Reverse Output Current	B1121-3.3 $V_{OUT} = 3.3V$ , $V_{IN} = 0V$		16	25	$\mu A$
<b>5V Version</b>					
Output Voltage	$V_{in}=3.8V$ $I_{OUT}=1mA$ $V_{IN} \leq 4.3V$ , $1mA \leq I_L \leq 150mA$	4925 <b>4.850</b>	5.00 <b>5.00</b>	5.075 <b>5.150</b>	V
Reverse Output Current	B1121-5.0 $V_{OUT} = 5.0V$ , $V_{IN} = 0V$		16	25	$\mu A$
Output Voltage	$-25^\circ C \leq T_j \leq 85^\circ C$ Full Operating Temperature	0.985 [ $V_o$ ] 0.980 [ $V_o$ ]	$V_o$	1.015 [ $V_o$ ] 1.020 [ $V_o$ ]	V
Output Voltage	$100\mu A \leq I_L \leq 150mA$ , $T_j \leq T_{jmax}$	0.976 [ $V_o$ ]	$V_o$	1.024 [ $V_o$ ]	V
Output Voltage Temperature Coefficient	(Note 1)		50	150	ppm / ° C
Line Regulation (Note 3)	$V_o + 1V \leq V_{IN} \leq 30V$ (Note 4)		0.04	0.4	%
Load Regulation (Note 5)	$100\mu A \leq I_L \leq 100mA$		0.1	0.3	%
Dropout Voltage	$I_L = 100\mu A$ $I_L = 150mA$		50 440	80 550 <b>700</b>	mV
Ground Current	$I_L = 100\mu A$ $I_L = 150mA$		75 8	120 14	$\mu A$ mA
Dropout Ground Current	$V_{IN} = V_o - 0.5V$ , $I_L = 100\mu A$		110	170	$\mu A$
Current Limit	$V_{OUT} = 0$		160	200	mA
Thermal Regulation			0.05	0.2	% / W
Output Noise, 10Hz to 100KHz	$C_L = 1\mu F$ $C_L = 200\mu F$ $C_L = 3.3\mu F$ (Bypass = 0.01 $\mu F$ pins 7 to 1 for B1121-XX)		430 160 100		$\mu V_{rms}$

**Note 1:** Output or reference voltage temperature coefficients defined as the worst case voltage change divided by the total temperature range.

**Note 2:** Unless otherwise specified all limits guaranteed for  $T_J = 25^\circ\text{C}$ ,  $V_{IN} = V_O + 1\text{V}$ ,  $I_L = 100\mu\text{A}$  and  $C_L = 1\mu\text{F}$ . Additional conditions for the 8-pin versions are feedback tied to -XX Voltage tap and output tied to output Sense pin ( $V_{OUT} = \text{XX V}$ ) and  $V_{SHUTDOWN} \leq 0.8\text{V}$

**Note 3:** Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under specification for thermal regulation.

**Note 4:** Line regulation for B1121-XX is tested at  $150^\circ\text{C}$  for  $I_L = 1\text{mA}$ . For  $I_L = 100\mu\text{A}$  and  $T_J = 125^\circ\text{C}$ , line regulation is guaranteed by design to 0.2%. See typical performance characteristics for line regulation versus temperature and load current.

**Note 5:** Dropout voltage is defined as the input to output differential at which the output voltage drops 100mV below its nominal value measured at 1V differential. At very low values of programmed output voltage, the minimum input supply voltage of 2V (2.3V over temperature) must be taken into account.

**Note 6:**  $V_{REF} \leq V_{OUT} \leq (V_{IN} - 1\text{V})$ ,  $2.3\text{V} \leq V_{IN} \leq 30\text{V}$ ,  $100\mu\text{A} \leq I_L \leq 100\text{mA}$ ,  $T_J \leq T_{JMAX}$

**Note 7:** Output or reference voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range

**Note 8:** Comparator thresholds are expressed in terms of a voltage differential at the feedback terminal below the nominal reference voltage measured at  $V_O + 1\text{V}$  input. To express these thresholds in terms of output voltage change, multiply by the error amplifier gain  $= V_{OUT} / V_{REF} = (R1 + R2)/R2$ . For example, at a programmed output voltage of 5V, the error output is guaranteed to go low when the output drops by  $95\text{mV} \times 5\text{V} / 1.235\text{V} = 384\text{mV}$ . Thresholds remain constant as a percent of  $V_{OUT}$  as  $V_{OUT}$  is varied, with the dropout warning occurring at typically 5% below nominal, 7.5% guaranteed.

**Note 9:**  $V_{SHUTDOWN} \geq 2\text{V}$ ,  $V_{IN} \leq 30\text{V}$ ,  $V_{OUT} = 0$ , Feed-back pin tied to -XX Voltage Tap.

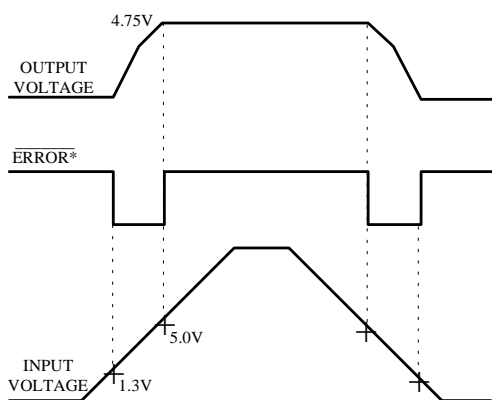
## APPLICATION HINTS

### EXTERNAL CAPACITORS

The stability of the B1121 requires a 2.2µF or greater capacitor between output and ground. Oscillation could occur without this capacitor. Most types of tantalum or aluminum electrolytic works fine here. For operations of below -25°C solid tantalum is recommended since the many aluminum types have electrolytes that freeze at about -30°C. The ESR of about 5Ω or less and resonant frequency above 500kHz are the most important parameters in the value of the capacitor. The capacitor value can be increased without limit.

At lower values of output current, less output capacitance is required for stability. For the currents below 10mA the value of the capacitor can be reduced to 0.5µF and 0.15µF for 1mA. More output capacitance needed for the 8-pin version at voltages below 5V since it runs the error amplifier at lower gain. At worst case 5µF or greater must be used for the condition of 250mA load at 1.23V output. The B1121, unlike other low dropout regulators will remain stable and in regulation with no load in addition to the internal voltage divider. This feature is especially important in application like CMOS RAM keep-alive. When setting the output voltage of the B1121, a minimum load of 10mA is recommended.

If there is more than 10 inches of wire between the input and the AC filter capacitor or if a battery is used as the input then a 0.1µF tantalum or aluminum electrolytic capacitor should be placed from the input to the ground. Instability can occur if there is stray capacitance to the B1121 feedback terminal (pin 7). This could cause more problems when using a higher value of external resistors to set the output voltage



\* See Application Info.

Figure 1. ERROR Output Timing

This problem can be fixed by adding a 100pF capacitor between output and feedback and increasing the output capacitor to at least 3.3µF.

### ERROR DETECTION COMPARATOR OUTPUT

The Comparator produces a logic low output whenever the B1121 output falls out of regulation by more than around 5%. This is around 60mV offset divided by the 1.235 reference voltage. This trip level remains 5% below normal regardless of the programmed output voltage of the regulator. Figure 1 shows the timing diagram depicting the ERROR signal and the regulator output voltage as the B1121 input is ramped up and down. The ERROR signal becomes low at around 1.3V input, and goes high around 5V input (input voltage at which Vout = 4.75). Since the B1121's dropout voltage is load dependent, the input voltage trip point (around 5V) will vary with the load current. The output voltage trip point (approx. 4.75V) does not vary with load.

The error comparator has an open-collector output, which requires an external pull-up resistor. Depending on the system requirements the resistor may be returned to 5V output or other supply voltage. In determining the value of this resistor, note that the output is rated to sink 400µA, this value adds to battery drain in a low battery condition. Suggested values range from 100k to 1MΩ. If the output is unused this resistor is not required.

### PROGRAMMING THE OUTPUT VOLTAGE OF B1121 (SO-8 Version)

The B1121 may be pin-strapped for 5V using its internal voltage divider by tying Pin 1 (output) to Pin 2 (sense) and Pin 7 (feedback) to Pin 6 (5V Tap).

Also, it may be programmed for any output voltage between its 1.235V reference and its 30V maximum rating. As seen in Figure 2, an external pair of resistors is required.

Refer to the below equation for the programming of the output voltage::

$$V_{OUT} = V_{REF} \times (1 + R_1 \setminus R_2) + I_{FB}R_1$$

The  $V_{REF}$  is 1.235 and  $I_{FB}$  is the feedback bias current, nominally -20nA. The minimum recommended load current of 1 µA forces an upper limit of 1.2 MΩ on value of  $R_2$ . If no load is presented the  $I_{FB}$  produces an error of typically 2% in  $V_{OUT}$ , which may be eliminated at room temperature by trimming  $R_1$ . To improve the accuracy choose the value of  $R_2 = 100k$  this reduces the error by 0.17% and increases the resistor program current by 12µA. Since the B1121 typically draws 60 µA at no load with Pin 2 open-circuited this is a small price to pay

## REDUCING OUTPUT NOISE

It may be an advantage to reduce the AC noise present at the output. One way is to reduce the regulator bandwidth by increasing the size of the output capacitor. This is the only way that noise can be reduced on the 3 lead B1121 but is relatively inefficient, as increasing the capacitor from 1 $\mu$ F to 220 $\mu$ F only decreases the noise from 430 $\mu$ V to 160 $\mu$ V Vrms for a 100kHz bandwidth at 5V output.

Noise could also be reduced fourfold by a bypass capacitor across R<sub>1</sub>, since it reduces the high frequency gain from 4 to unity. Pick

$$C_{\text{BYPASS}} \cong 1 / 2\pi R_1 \times 200 \text{ Hz}$$

or choose 0.01 $\mu$ F. When doing this, the output capacitor must be increased to 3.3 $\mu$ F to maintain stability. These changes reduce the output noise from 430 $\mu$ V to 100 $\mu$ V Vrms for a 100kHz bandwidth at 5V output. With the bypass capacitor added, noise no longer scales with output voltage so that improvements are more dramatic at higher output voltages.

## HEAT SINK REQUIREMENTS

Depending on the maximum ambient temperature and maximum power dissipation a heat sink may be required with the B1121. The junction temperature range has to be within the range specified under Absolute Maximum Ratings under all possible operating conditions. To find out if a heat sink is required, the maximum power dissipation of the device needs to be calculated. This is the maximum specific AC voltage that must be taken into consideration at input. Figure 3 shows the condition and power dissipation which should be calculated with the following formula:

$$P_{\text{TOTAL}} = (V_{\text{IN}} - 5) I_L + (V_{\text{IN}}) I_G$$

Next step is to calculate the temperature rise T<sub>R</sub> (max). T<sub>J</sub> (max) maximum allowable junction temperature, T<sub>A</sub> (max) maximum ambient temperature :

$$T_R (\text{max}) = T_J (\text{max}) - T_A (\text{max})$$

Junction to ambient thermal resistance  $\theta_{(J-A)}$  can be calculated after determining of P<sub>TOTAL</sub> & T<sub>R</sub> (max):

$$\theta_{(J-A)} = T_R (\text{max}) / P_{(\text{max})}$$

If the  $\theta_{(J-A)}$  is 60°C/W or higher, the device could be operated without a heat sink. If the value is below 60°C/W then the heat sink is required and the thermal resistance of the heat sink can be calculated by the following formula,  $\theta_{(J-C)}$  junction to case,  $\theta_{(C-H)}$  case to heat sink,  $\theta_{(H-A)}$  heat sink to ambient:

$$\theta_{(J-A)} = \theta_{(J-C)} + \theta_{(C-H)} + \theta_{(H-A)}$$

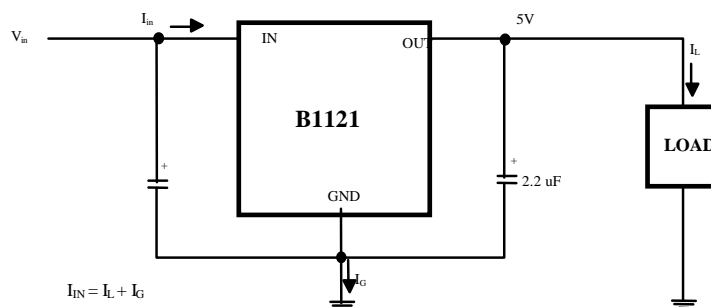
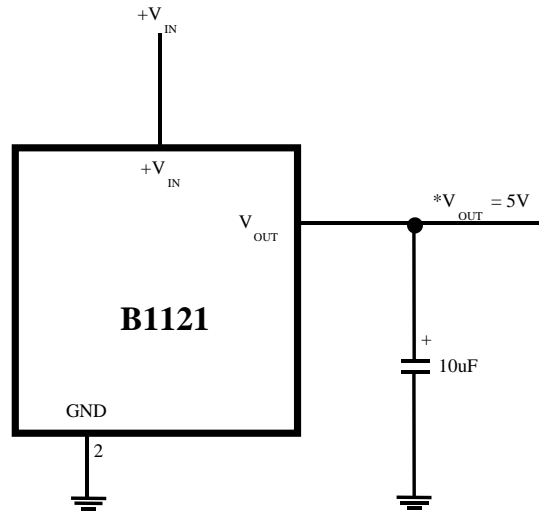
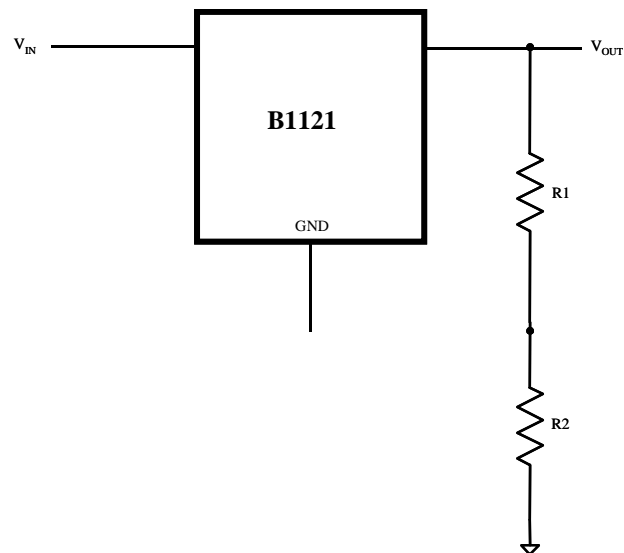
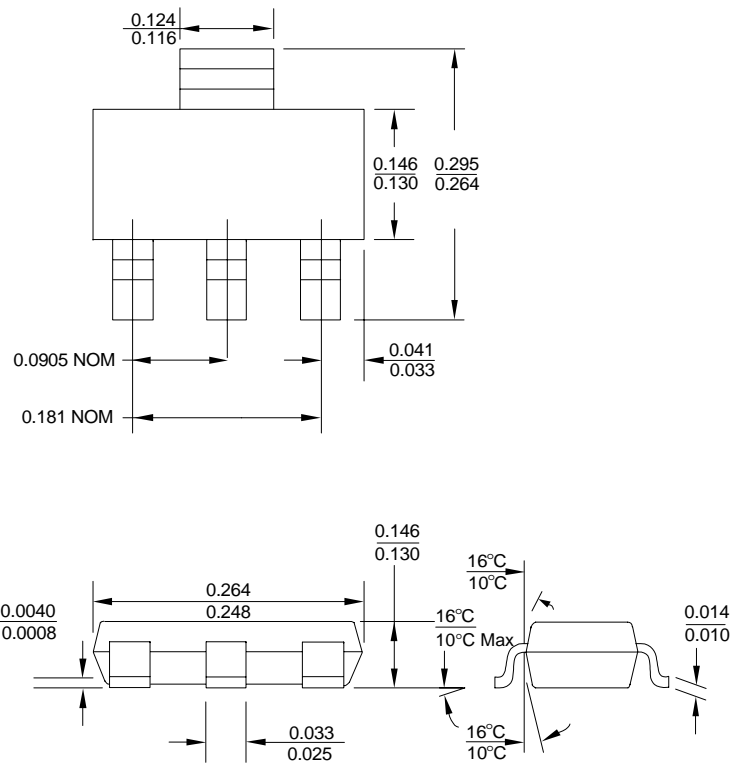


FIGURE 3. 5V Regulator Circuit

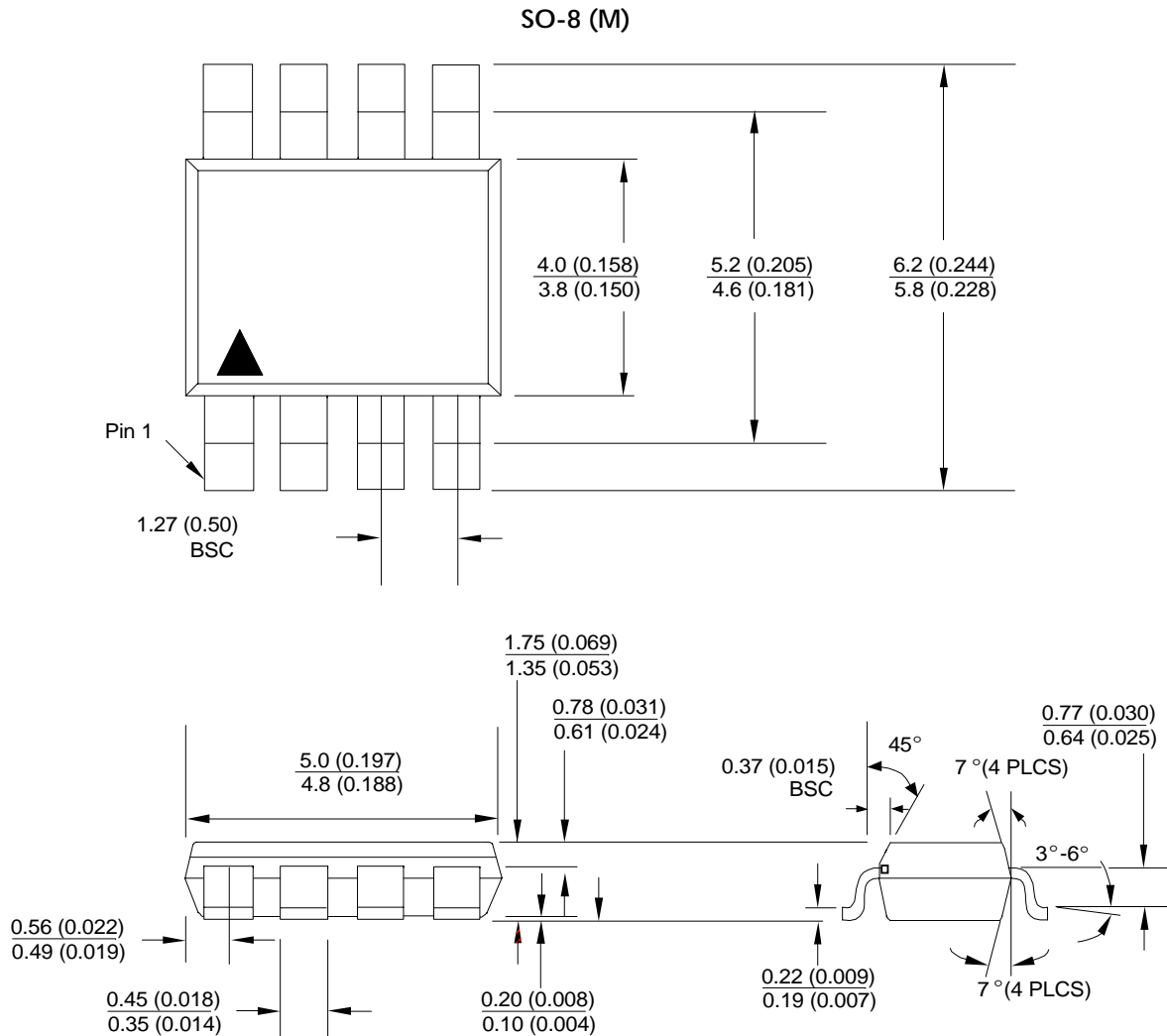
**TYPICAL APPLICATIONS****B1121 FIXED +5V REGULATOR****B1121 ADJUSTABLE REGULATOR**

Package Drawing

SOT-223



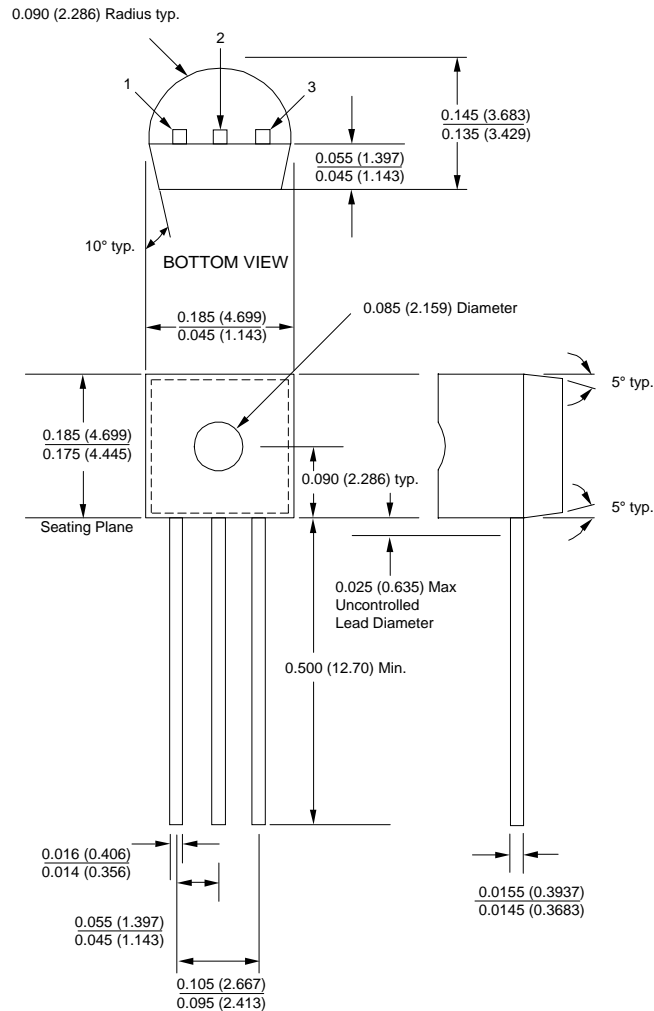
Package Drawing





PACKAGE DRAWING

TO-92(Z)



**Advance Information-** These data sheets contain descriptions of products that are in development. The specifications are based on the engineering calculations, computer simulations and/ or initial prototype evaluation.

**Preliminary Information-** These data sheets contain minimum and maximum specifications that are based on the initial device characterizations. These limits are subject to change upon the completion of the full characterization over the specified temperature and supply voltage ranges.

The application circuit examples are only to explain the representative applications of the devices and are not intended to guarantee any circuit design or permit any industrial property right to other rights to execute. Bay Linear takes no responsibility for any problems related to any industrial property right resulting from the use of the contents shown in the data book. Typical parameters can and do vary in different applications. Customer's technical experts must validate all operating parameters including "Typical" for each customer application.

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