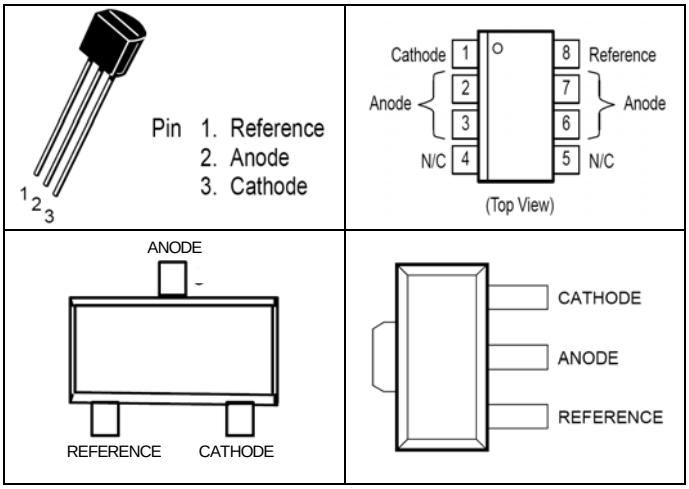
Programmable Precision Reference

TL431

FEATURES

- Programmable Output Voltage to 40V
- Low Dynamic Output Impedance 0.2Ω
- Sink Current Capability of 0.1 mA to 100 mA
- Equivalent Full-Range Temperature Coefficient of 50 ppm/°C
- Temperature Compensated for Operation over Full Rated Operating Temperature Range
- Low Output Noise Voltage
- Fast Turn on Response
- TO-92, SOP- 8, SOT-23, SOT-89 packages

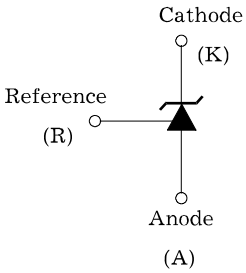
PIN CONNECTIONS



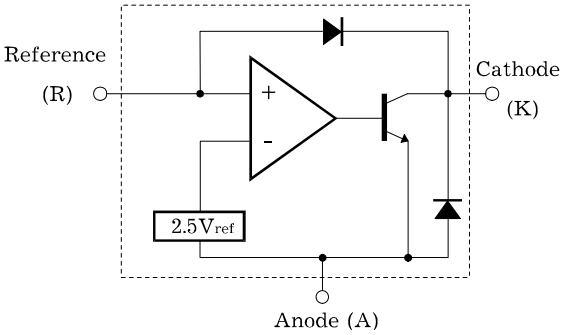
DESCRIPTION

The TL431 is a three-terminal adjustable regulator series with a guaranteed thermal stability over applicable temperature ranges. The output voltage may be set to any value between Vref (approximately 2.5 volts) and 40 volts with two external resistors. These devices have a typical dynamic output impedance of 0.2Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacement for zener diodes in many applications.
The TL431 is characterized for operation from -25°C to +85°C.

SYMBOL



FUNCTIONAL BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

(Operating temperature range applies unless otherwise specified)

Characteristic	Symbol	Value	Unit
Cathode Voltage	V_{KA}	40	V
Cathode Current Range (Continuous)	I_K	-100 ~ 150	mA
Reference Input Current Range	I_{REF}	0.05 ~ 10	mA
Power Dissipation at 25°C: SOP, TO – 92 Package ($R_{\theta JA}$ = 178°C/W) SOT Package ($R_{\theta JA}$ = 625°C/W)	P_D	 0.7 0.2	 W W
Junction Temperature Range	T_J	-40 ~ 150	°C
Operating Temperature Range	T_g	-40 ~ +85	°C
Storage Temperature Range	T_{stg}	-65 ~ +150	°C

RECOMMENDED OPERATING CONDITIONS

Characteristic	Symbol	Test Condition	Min	Typ	Max	Unit
Cathode Voltage	V_{KA}		V_{REF}		40	V
Cathode Current	I_K		0.5		100	mA

ELECTRICAL CHARACTERISTICS

(T_a = 25°C, $V_{KA} = V_{REF}$, I_K = 10mA unless otherwise specified)

Characteristic	Symbol	Test Condition	Min	Typ	Max	Unit
Reference Input Voltage	V_{REF}	$V_{KA} = V_{REF}$, I_K = 10mA				
		TL431 (2%)	2.440	2.495	2.550	V
		TL431-A (1%)	2.470	2.495	2.520	
		TL431-C (0.5%)	2.482	2.495	2.508	
Deviation of Reference Input Voltage Over Full Temperature Range	$V_{REF(dev)}$	$T_{min} \le Ta \le T_{max}$		3	17	MV
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	ΔV_{KA} = 10V-V_{REF}		-1.4	-2.7	mV/V
		ΔV_{KA} = 36V- 10V		-1.0	-2.0	
Reference Input Current	I_{REF}	R_1 = 10KΩ, R_2 = ∞		1.8	4	μA
Deviation of Reference Input Current Over Full Temperature Range	$I_{REF(dev)}$	R_1 = 10KΩ, R_2 = ∞		0.4	1.2	μA
Minimum Cathode Current for Regulation	$I_{K(min)}$			0.25	0.5	mA
Off-State Cathode Current	$I_{K(off)}$	V_{KA} = 40 V, V_{REF} = 0		0.26	0.9	μA
Dynamic Impedance	Z_{KA}	I_K = 10mA to 100 mA , f ≤ 1.0KHz		0.22	0.5	Ω

TEST CIRCUITS

Figure 1. Test Circuit for $V_{KA} = V_{REF}$

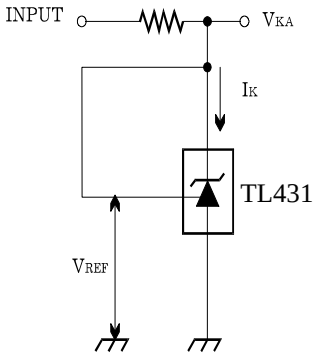


Figure 2. Test Circuit for $V_{KA} \ge V_{REF}$

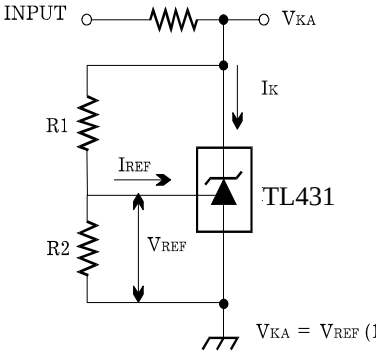
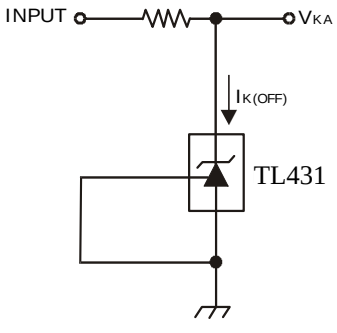
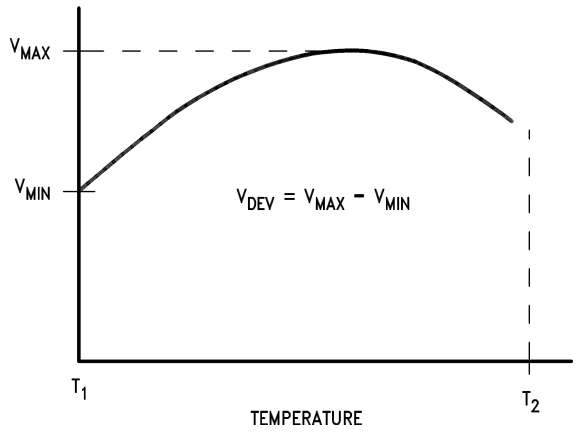


Figure 3. Test Circuit for I_{off}



Electrical Characteristics (Continued)



The average temperature coefficient of the reference input voltage, $\propto V_{REF}$, is defined as:

$$\propto V_{REF} \frac{ppm}{°C} = \frac{\pm\left[\frac{V_{Max} - V_{Min}}{V_{REF}\ (at\ 25°C)}\right]10^6}{T_2 - T_1} = \frac{\pm\left[\frac{V_{DEV}}{V_{REF}\ (at\ 25°C)}\right]10^6}{T_2 - T_1}$$

Where:

$T_2 - T_1$ = full temperature change (0-70˚C).

$\propto V_{REF}$ can be positive or negative depending on whether the slope is positive or negative.

Example: V_{DEV} = 8.0 mV, V_{REF} = 2495 mV, $T_2 - T_1$ = 70˚C, slope is positive.

$$\propto V_{REF} = \frac{\left[\frac{8.0\ mV}{2495\ mV}\right]10^6}{70°C} = +46\ ppm/°C$$

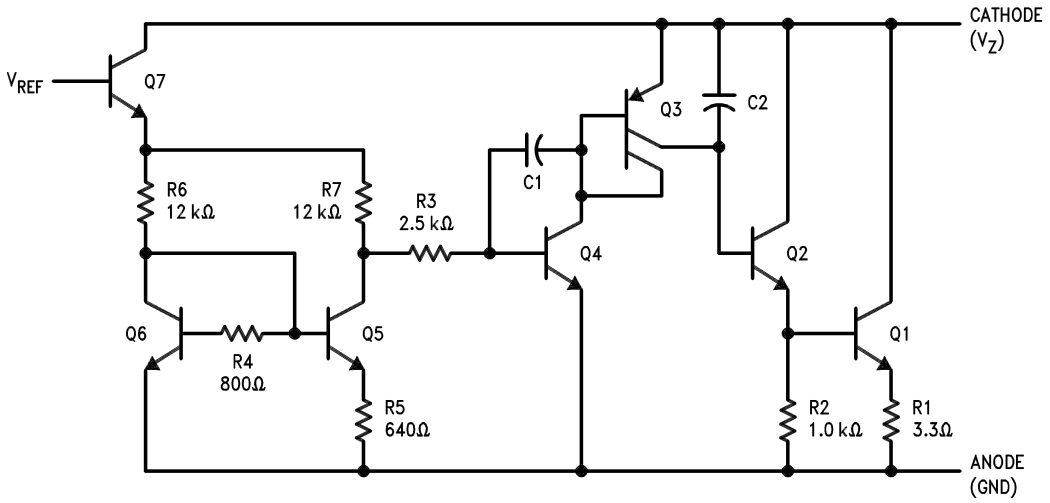
Note 6: The dynamic output impedance, r_Z, is defined as:

$$r_Z = \frac{\Delta V_Z}{\Delta I_Z}$$

When the device is programmed with two external resistors, R1 and R2, (see *Figure 2*), the dynamic output impedance of the overall circuit, r_Z, is defined as:

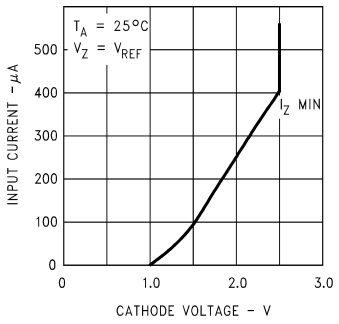
$$r_Z = \frac{\Delta V_Z}{\Delta I_Z} \cong \left[r_Z\left(1 + \frac{R1}{R2}\right)\right]$$

Equivalent Circuit

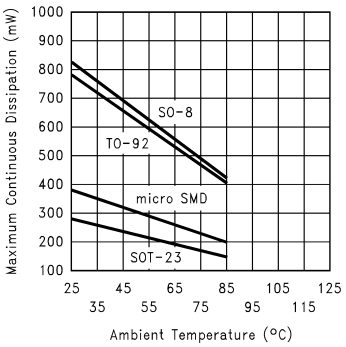


Typical Performance Characteristics

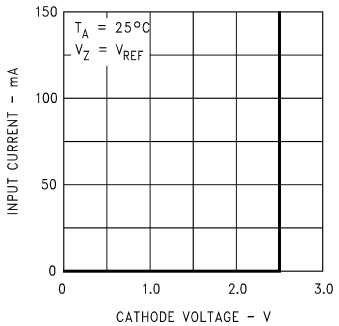
Input Current vs V_Z



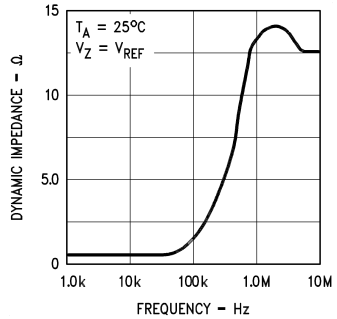
Thermal Information



Input Current vs V_Z

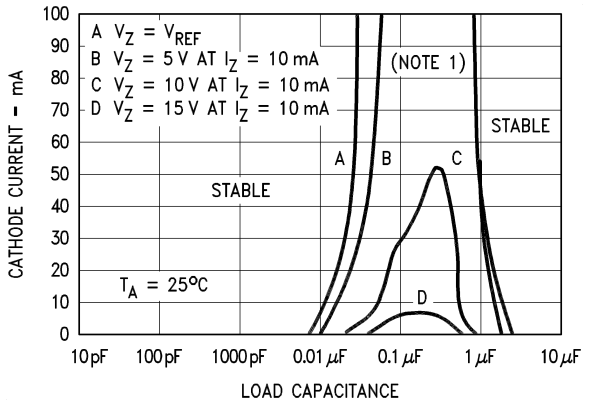


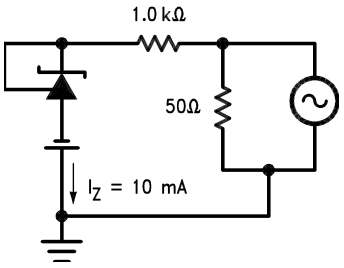
Dynamic Impedance vs Frequency



Typical Performance Characteristics (Continued)

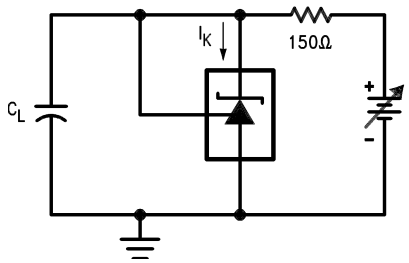
Stability Boundary Conditions



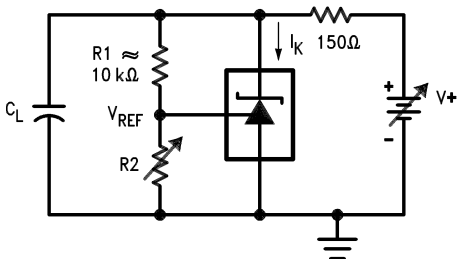


Note: The areas under the curves represent conditions that may cause the device to oscillate. For curves B, C, and D, R2 and V^+ were adjusted to establish the initial V_Z and I_Z conditions with C_L = 0. V^+ and C_L were then adjusted to determine the ranges of stability.

Test Circuit for Curve A Above

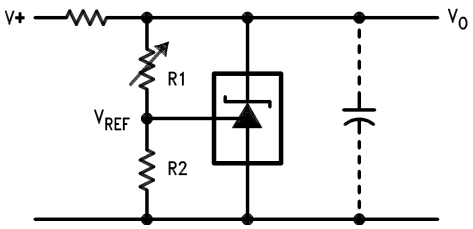


Test Circuit for Curves B, C and D Above



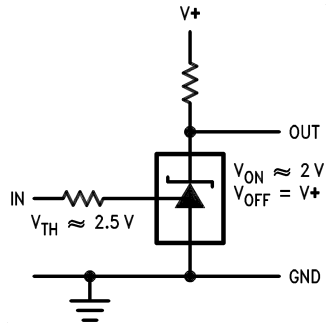
Typical Applications

Shunt Regulator



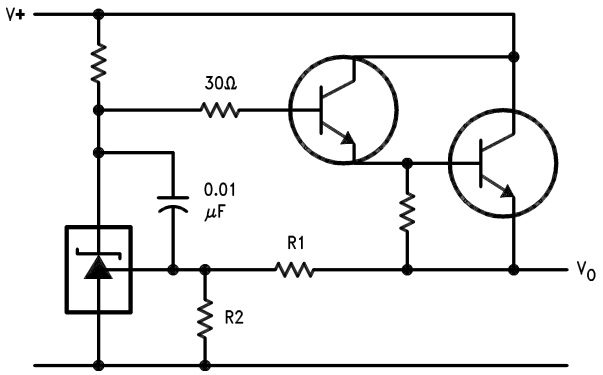
$$V_O \approx \left(1 + \frac{R1}{R2}\right) V_{REF}$$

Single Supply Comparator with Temperature Compensated Threshold



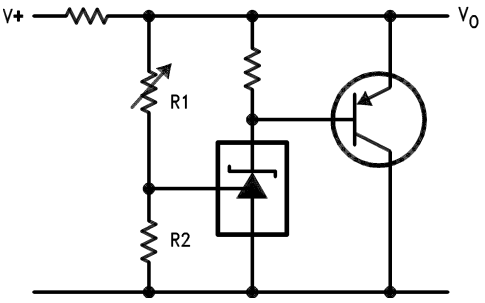
Typical Applications (Continued)

Series Regulator



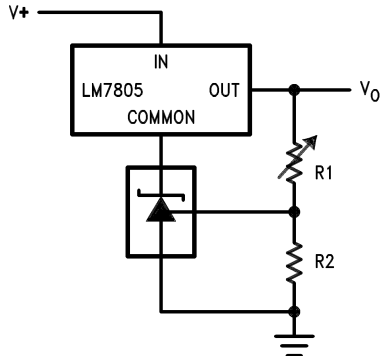
$$V_O \approx \left(1 + \frac{R1}{R2}\right) V_{REF}$$

Higher Current Shunt Regulator



$$V_O \approx \left(1 + \frac{R1}{R2}\right) V_{REF}$$

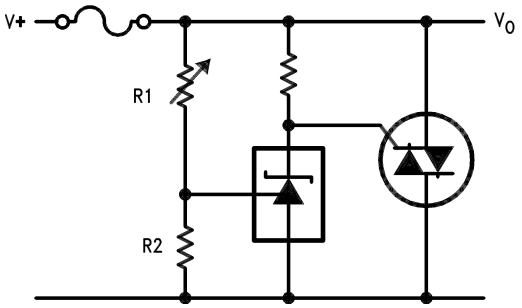
Output Control of a Three Terminal Fixed Regulator



$$V_O = \left(1 + \frac{R1}{R2}\right) V_{REF}$$

$$V_{O\ MIN} = V_{REF} + 5V$$

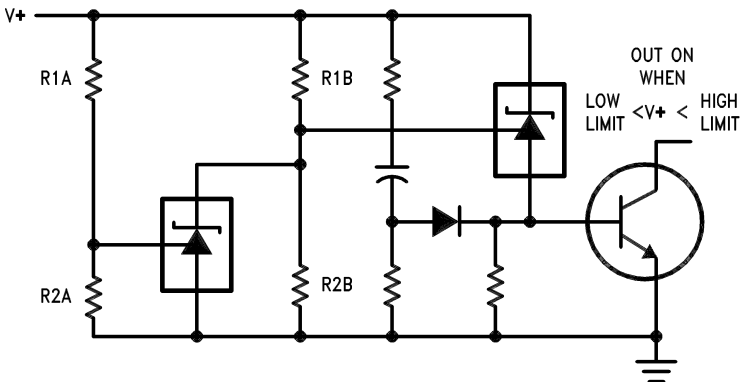
Crow Bar



$$V_{LIMIT} \approx \left(1 + \frac{R1}{R2}\right) V_{REF}$$

Typical Applications (Continued)

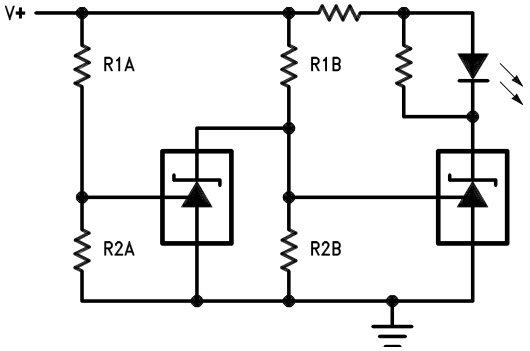
Over Voltage/Under Voltage Protection Circuit



$$\text{LOW LIMIT} \approx V_{REF}\left(1+\frac{R1B}{R2B}\right)+V_{BE}$$

$$\text{HIGH LIMIT} \approx V_{REF}\left(1+\frac{R1A}{R2A}\right)$$

Voltage Monitor



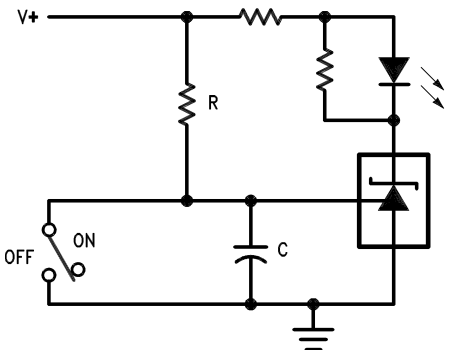
$$\text{LOW LIMIT} \approx V_{REF}\left(1+\frac{R1B}{R2B}\right)$$

$$\text{HIGH LIMIT} \approx V_{REF}\left(1+\frac{R1A}{R2A}\right)$$

LED ON WHEN
LOW LIMIT $< V^{+} <$ HIGH LIMIT

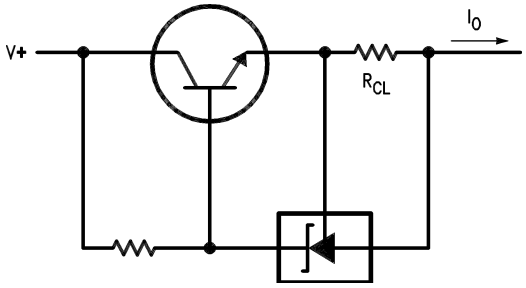
Typical Applications (Continued)

Delay Timer



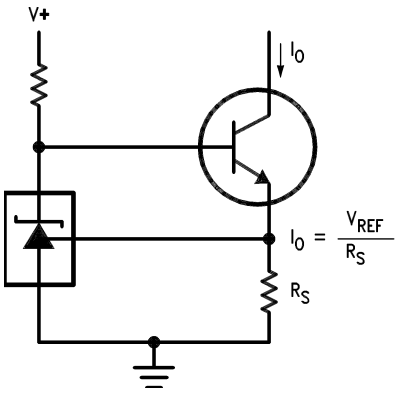
$$\text{DELAY} = R \bullet C \bullet \ell n \frac{V+}{(V^+) - V_{REF}}$$

Current Limiter or Current Source



$$I_O = \frac{V_{REF}}{R_{CL}}$$

Constant Current Sink

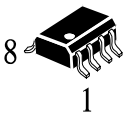


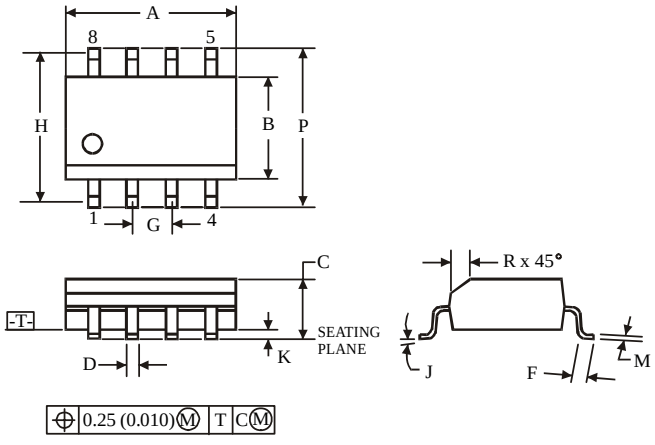
Ordering Information

Product Number	Reference Input Voltage	Package
TL431CLF TL431CLS	0.5%	TO-92
TL431CD		8-SOP
TL431CS		SOT-23
TL431CP		SOT-89
TL431ALF TL431ALS	1%	TO-92
TL431AD		8-SOP
TL431AS		SOT-23
TL431AP		SOT-89
TL431LF TL431LS	2%	TO-92
TL431D		8-SOP
TL431S		SOT-23
TL431P		SOT-89

Package Dimensions

D SUFFIX SOIC
(MS - 012AA)



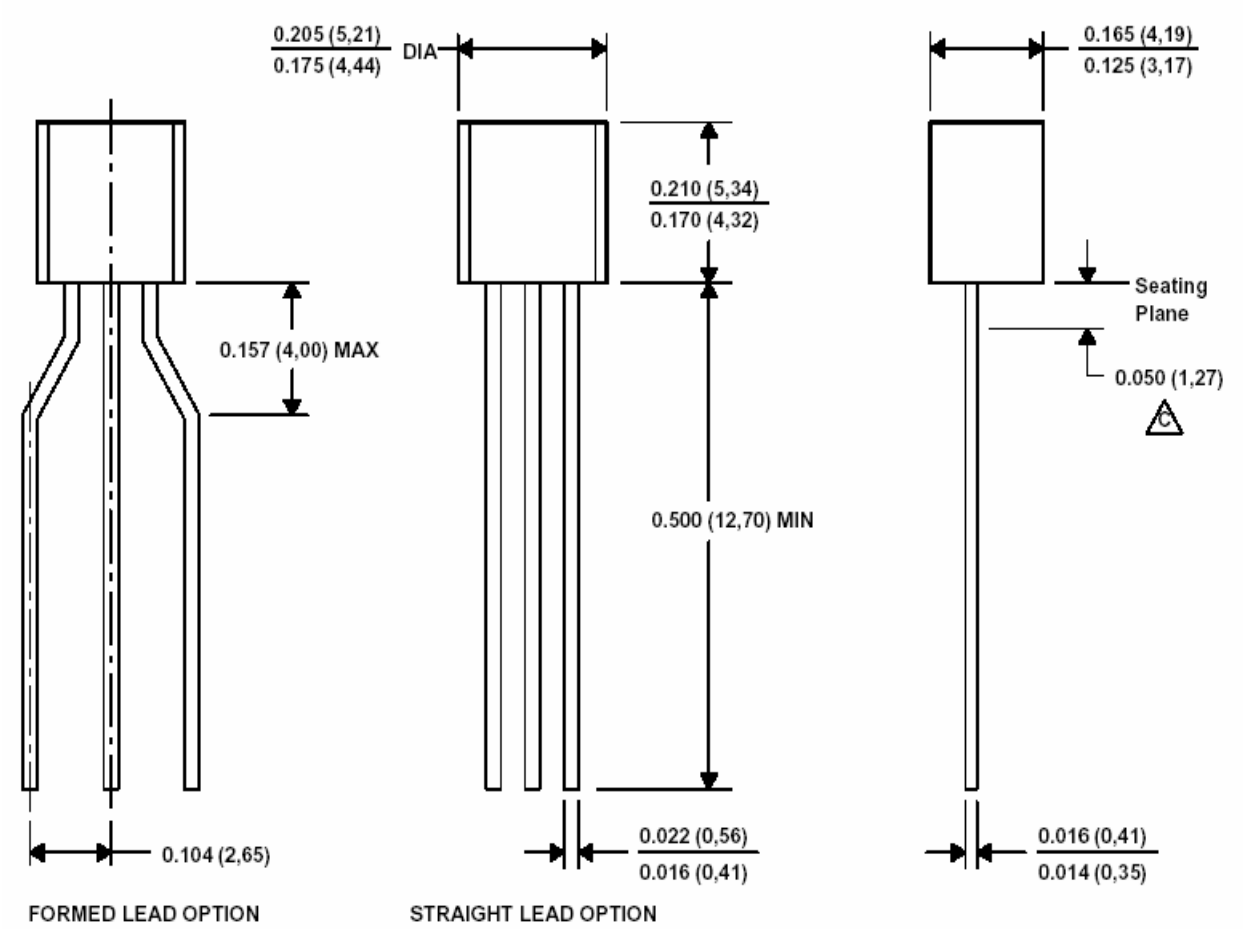


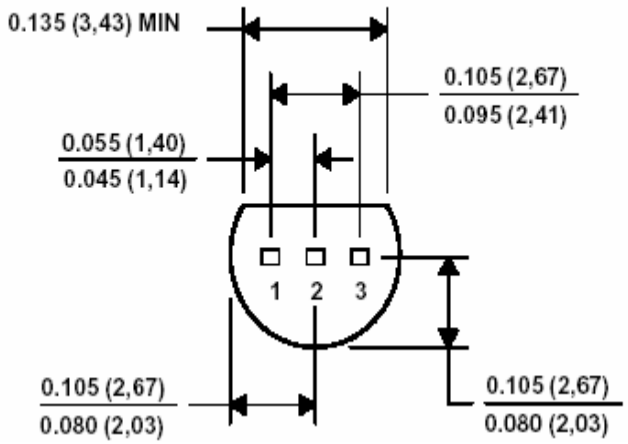
	Dimension, mm	
Symbol	**MIN**	**MAX**
A	4.80	5.00
B	3.80	4.00
C	1.35	1.75
D	0.33	0.51
F	0.40	1.27
G	1.27	
H	5.72	
J	0°	8°
K	0.10	0.25
M	0.19	0.25
P	5.80	6.20
R	0.25	0.50

NOTES:

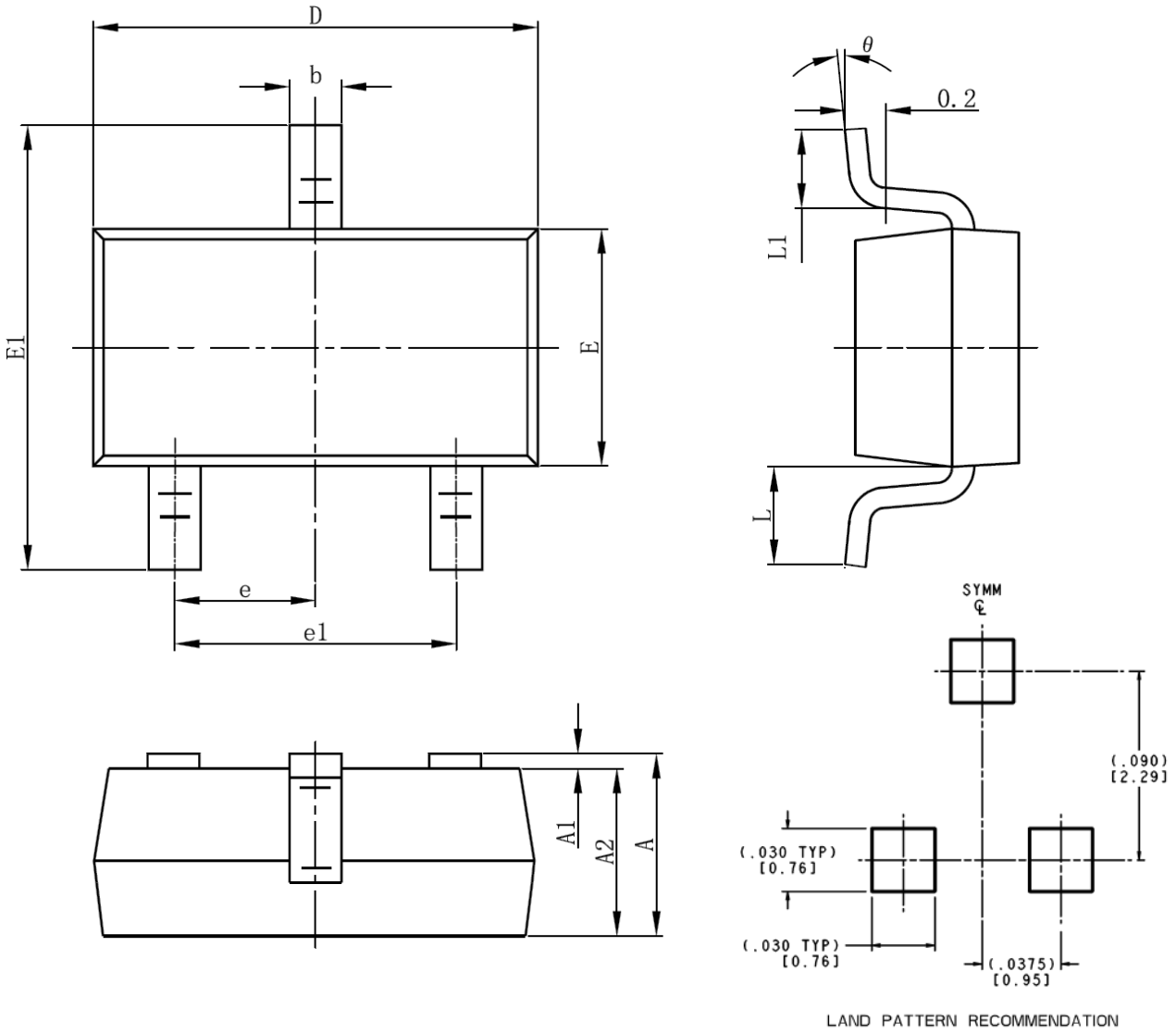
1. Dimensions A and B do not include mold flash or protrusion.
2. Maximum mold flash or protrusion 0.15 mm (0.006) per side for A; for B - 0.25 mm (0.010) per side.

TO-92


0.205 (5,21)
0.175 (4,44)
DIA
0.165 (4,19)
0.125 (3,17)
0.210 (5,34)
0.170 (4,32)
Seating
Plane
0.157 (4,00) MAX
0.050 (1,27)
0.500 (12,70) MIN
0.104 (2,65)
0.022 (0,56)
0.016 (0,41)
0.016 (0,41)
0.014 (0,35)
FORMED LEAD OPTION
STRAIGHT LEAD OPTION


0.135 (3,43) MIN
0.105 (2,67)
0.095 (2,41)
0.055 (1,40)
0.045 (1,14)
1
2
3
0.105 (2,67)
0.080 (2,03)
0.105 (2,67)
0.080 (2,03)

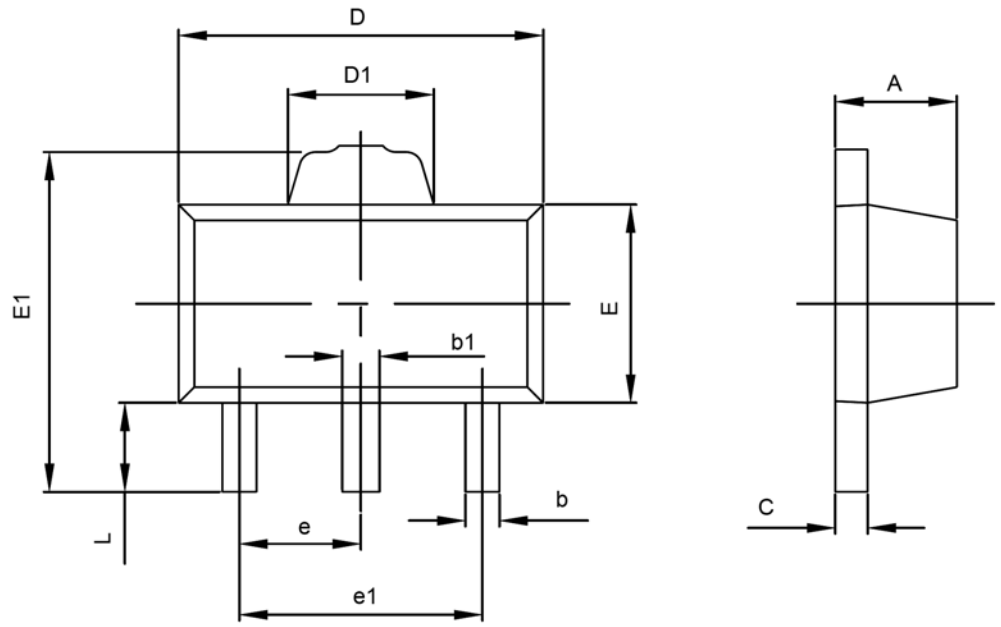
SOT-23-3L PACKAGE OUTLINE DIMENSIONS



LAND PATTERN RECOMMENDATION

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

SOT-89-3L PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.400	1.600	0.055	0.063
b	0.320	0.520	0.013	0.020
b1	0.360	0.560	0.014	0.022
c	0.350	0.440	0.014	0.017
D	4.400	4.600	0.173	0.181
D1	1.400	1.800	0.055	0.071
E	2.300	2.600	0.091	0.102
E1	3.940	4.250	0.155	0.167
e	1.500TYP		0.060TYP	
e1	2.900	3.100	0.114	0.122
L	0.900	1.100	0.035	0.043