ADJUSTABLE PRECISION SHUNT REGULATION

General Description

The DIODES™ LE431 is a low voltage three terminal adjustable shunt regulator with a guaranteed thermal stability over applicable temperature ranges. The output voltage can be set to any value between 2.495V (VREF) to 36V with two external resistors (please refer application circuit). The high precise Reference voltage tolerance is available in two grades: ±0.4% and ±1.0%. This device has a typical minimum cathode current of 0.1 mA. Active output circuitry provides a very sharp turn on characteristic, making this device excellent replacement for Zener diodes in many applications.

Features

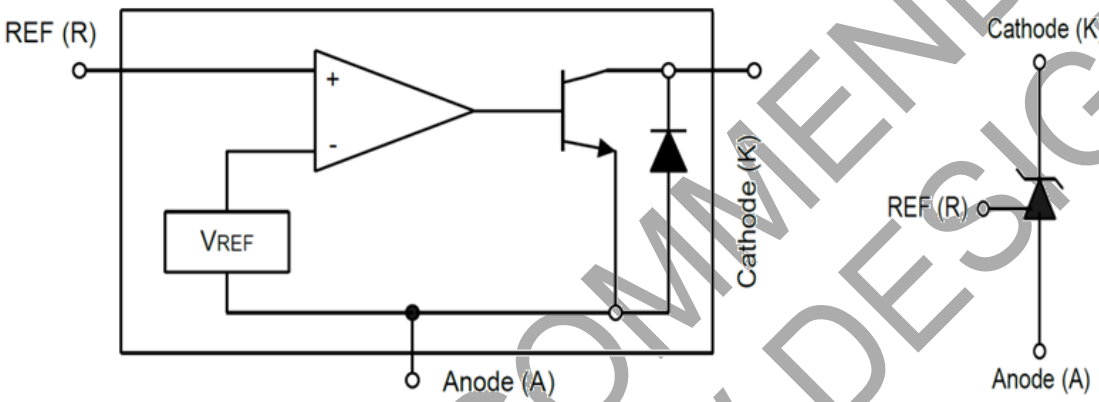
- Precision reference voltage :
  - LE431O : 2.495V±0.4%
  - LE431N : 2.495V±1.0%
- Adjustable output voltage is VREF to 36V
- Sink current capability is 120mA
- Low dynamic output impedance is 0.2Ω (typ.)
- Minimum Cathode current for regulation is 0.1mA (typ.)
- Plastic material has UL flammability classification 94V-0
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative.**
  https://www.diodes.com/quality/product-definitions/

Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

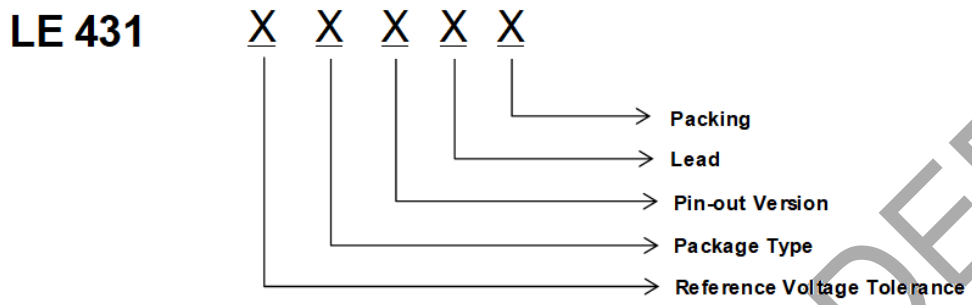
Applications

- Switching Mode Power Supply
- Voltage Reference Application

Block Diagram & Symbol



Ordering Information



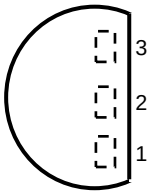
Reference Voltage Tolerance	Package	Pin-out Version	Lead	Packing
O : ±0.4% N : ±1.0%	H : TO92-3L C : SOT23-3L	Blank (TO92-3L): 1. REF 2. ANODE 3. CATHODE A (SOT23-3L): 1. CATHODE 2. REF 3. ANODE R (SOT23-3L): 1. REF 2. CATHODE 3. ANODE	P : RoHS & Halogen Free (ref. IEC 61249-2-21)	A : Tape & Reel

Product Number	Output Voltage Tolerance	Package	Lead	Packing	Status
LE431OHPA	0.4 %	TO92-3L	RoHS & Halogen Free	Taping	Inactive
LE431NHPA	1.0 %	TO92-3L	RoHS & Halogen Free	Taping	Inactive
LE431OCAPA	0.4 %	SOT23-3L	RoHS & Halogen Free	Taping & Reel	Inactive
LE431NCAPA	1.0 %	SOT23-3L	RoHS & Halogen Free	Taping & Reel	Inactive
LE431OCRPA	0.4 %	SOT23-3L	RoHS & Halogen Free	Taping & Reel	Active
LE431NCRPA	1.0 %	SOT23-3L	RoHS & Halogen Free	Taping & Reel	Inactive

Pin Assignment

TO92-3L

(Top View)

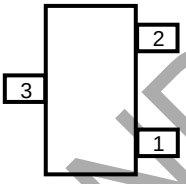


LE431OHPA
LE431NHPA

1. R
2. A
3. C

SOT23-3L

(Top View)

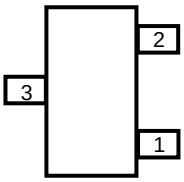


LE431OCAPA
LE431NCAPA

1. C
2. R
3. A

SOT23-3L

(Top View)



LE431OCRPA
LE431NCRPA

1. R
2. C
3. A

Pin Descriptions

Pin Name	Pin Description
R	Ref
A	Anode
C	Cathode

Absolute Maximum Ratings (@ T_A = +25°C)

Note: Operate over the "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to such conditions for extended time may still affect the reliability of the device.

Characteristics		Symbol	Rating	Unit
Cathode Voltage		V_{KA}	40	V
Continuous Cathode Current		I_{KA}	120	mA
Reference Input Current		I_{REF}	10	mA
Junction Temperature		T_J	150	°C
Storage Temperature		T_{STG}	-40~150	°C
ESD Withstand Voltage: -Human Body Model (HBM) -Machine Model (MM)		V_{ESD}	 4000 400	 V V
Thermal Resistance (Junction to Case)	SOT23-3L	θjc	110	°C/W
	TO92-3L		80	
Thermal Resistance (Junction to Ambient)	SOT23-3L	θja	350	°C/W
	TO92-3L		150	
Power dissipation	SOT23-3L	P_D	285	mW
	TO92-3L		625	
Moisture Sensitivity		MSL	Please refer the MSL label on the IC package bag/carton for detail	

Recommended Operating Conditions

Characteristics	Symbol	Min	Max	Unit
Cathode Voltage	V_{KA}	V_{REF}	36	V
Cathode Current	I_{KA}	0.3	110	mA
Operating Temperature (Operating free-air temperature)	T_A	-40	125	°C

Electrical Characteristics

(T_A=25°C, unless otherwise specified)

Characteristics	Symbol	Conditions		Min	Typ	Max	Unit
Reference Voltage	V_{REF}	V_{KA} = V_{REF}, I_{KA} = 1mA (Fig.1)	0.4 %	2.485	2.495	2.505	V
			1.0 %	2.470		2.520	
Deviation of Reference Input Voltage over full temperature Range (*Note 4)	$V_{REF(DEV)}$	V_{KA} = V_{REF}, I_{KA} = 10mA, T_A = -20~85°C (Fig.1)		—	20	30	mV
		V_{KA} = V_{REF}, I_{KA} = 10mA, T_A = -40~125°C (Fig.1)		—	25	35	
Reference Input Current	I_{REF}	R1 = 10KΩ,R2 = ∞, I_{KA}= 10mA (Fig.2)		—	1.5	3.5	uA
Deviation of Reference Input Current over Temperature (*Note 4)	$I_{REF(DEV)}$	R1 = 10KΩ,R2 = ∞, I_{KA} = 10mA T_A = -40~125°C (Fig.2)		—	0.4	1.2	uA
Ratio of the Change in Reference Voltage to the Change in Cathode Voltage	$\Delta V_{REF}/\Delta V_{KA}$	I_{KA} = 10mA (Fig.2)	V_{KA} = 10V ~V_{REF}	—	-1.2	-2.0	mV/V
			V_{KA}= 36V ~10V	—	-1	-2.0	
Minimum Cathode Current for Regulation	$I_{KA(min)}$	V_{KA} = V_{REF} (Fig.1)		—	0.1	0.3	mA
Off-state Cathode Current	$I_{KA(OFF)}$	V_{KA} = 36V, V_{REF} = 0V (Fig.3)		—	0.1	0.8	uA
Dynamic Output Impedance	Z_{KA}	V_{KA} = V_{REF} Frequency ≤ 1KHz (Fig.1)		—	0.2	0.5	Ω

Note 4 : These speicifications are guaranteed by designed and are not tested when in mass-production.

Application Circuit

Fig1: $V_{KA}=V_{REF}$

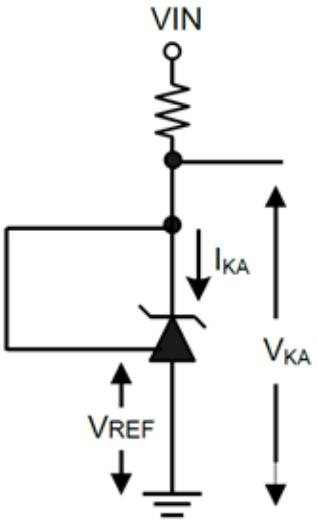
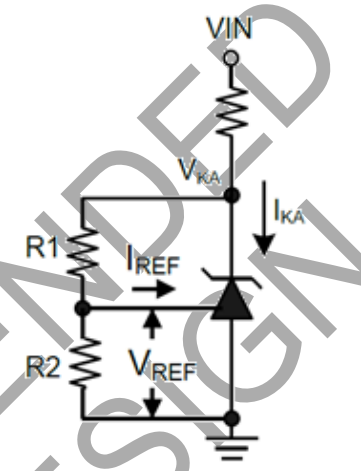
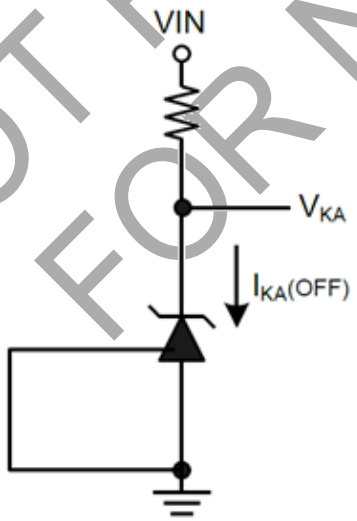


Fig2: $V_{KA}>V_{REF}$



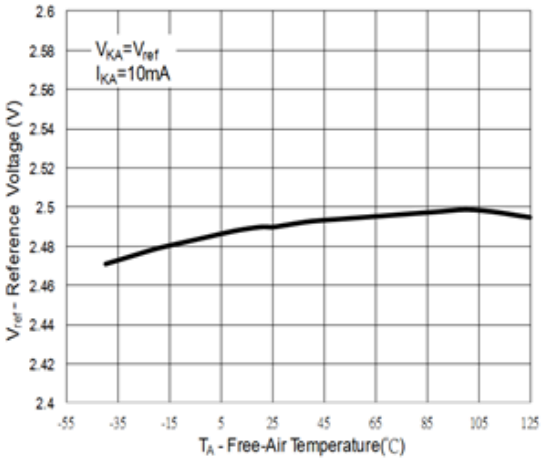
$VKA=V_{REF}(1+R1/R2)+I_{REF}*R1$

Fig3: Off state current

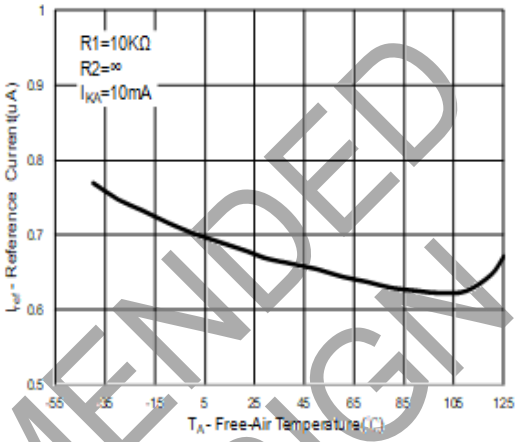


Typical Characteristics

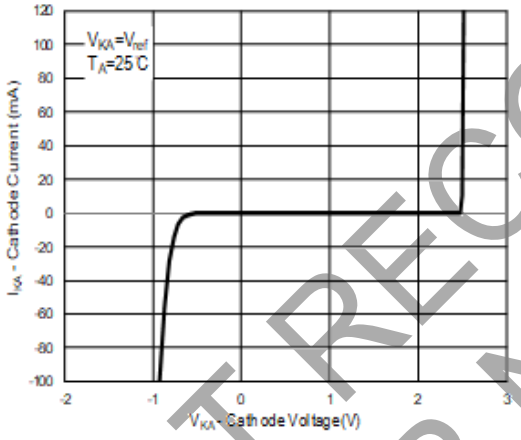
REFERENCE VOLTAGE VS. FREE-AIR TEMPERATURE



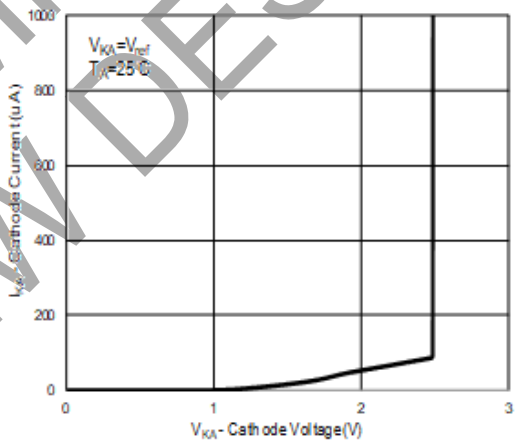
REFERENCE CURRENT VS. FREE-AIR TEMPERATURE



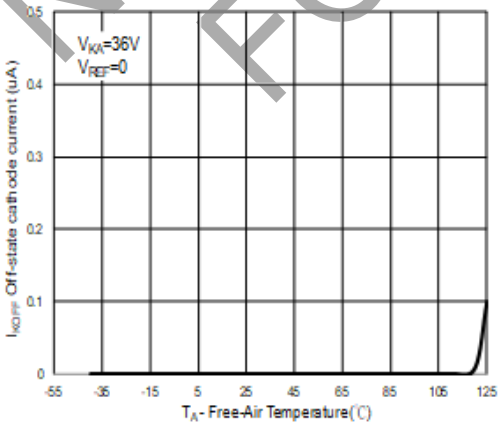
CATHODE CURRENT VS. CATHODE VOLTAGE



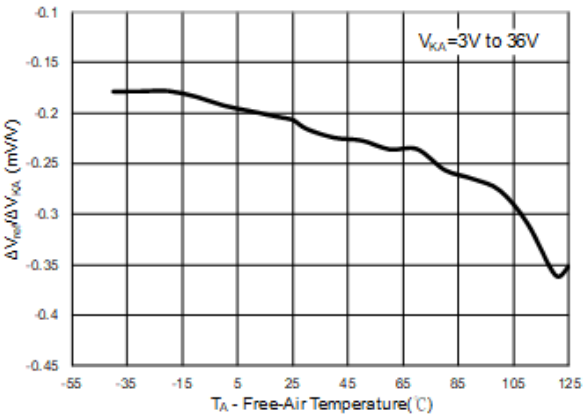
CATHODE CURRENT VS. CATHODE VOLTAG



OFF-STATE CATHODE CURRENT VS. FREE-AIR TEMPERATURE

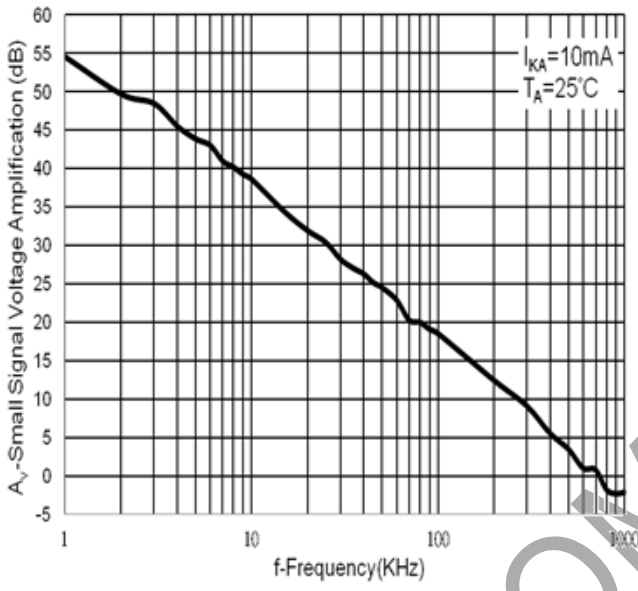


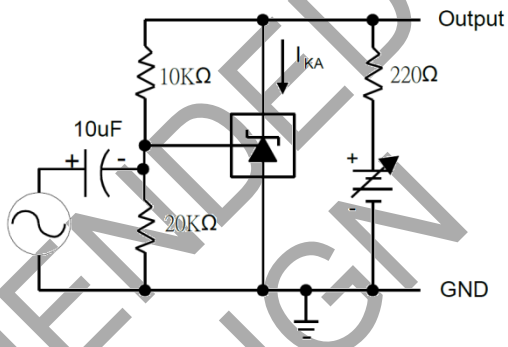
RATIO OF DELTA REFERENCE VOLTAGE TO DELTA CATHODE VOLTAGE VS. FREE-AIR TEMPERATURE



Typical Characteristics (Continued)

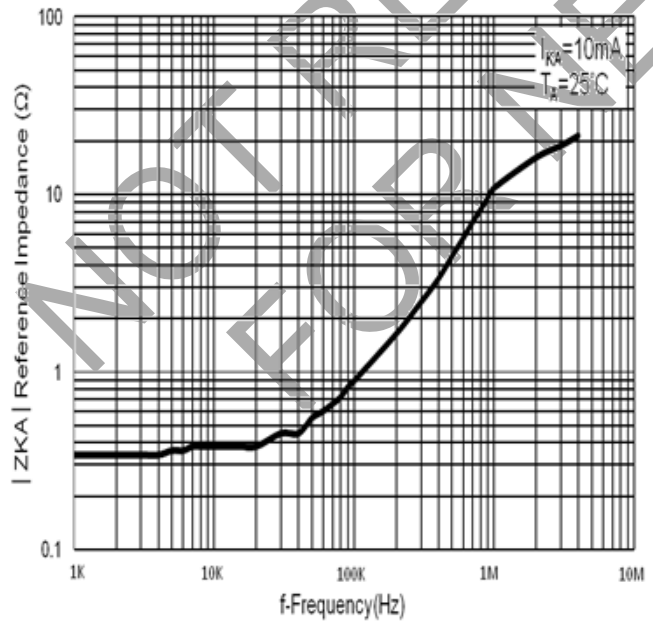
(1) Small Signal Voltage Amplification Vs Frequency

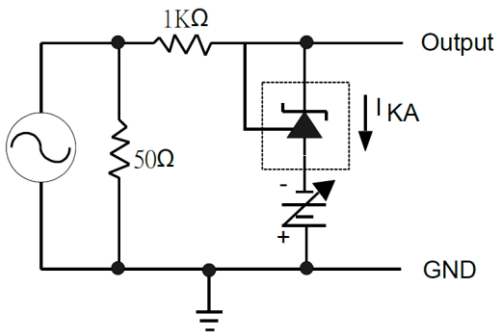




Test Circuit For Voltage Amplification

(2) Reference Impedance VS Frequency

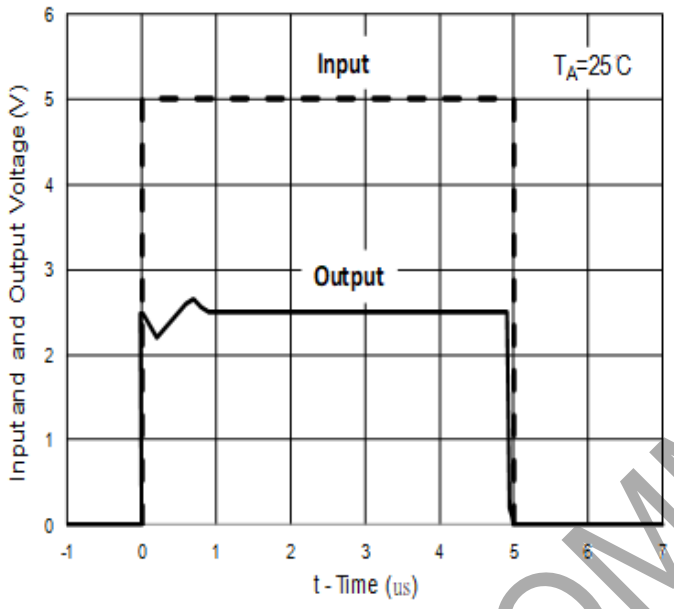


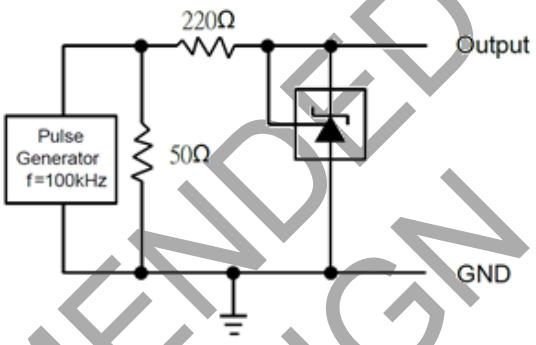


Test Circuit For Reference Impedance

Typical Characteristics (Continued)

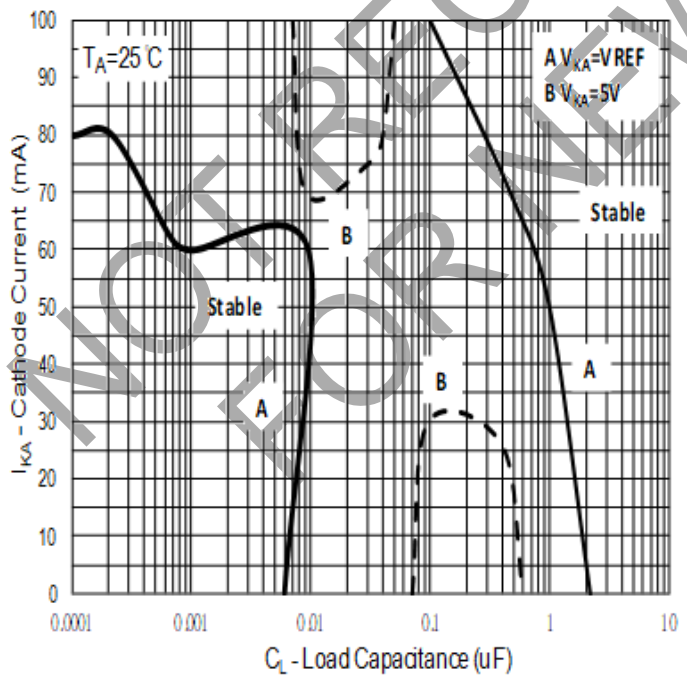
(3) Pulse Response

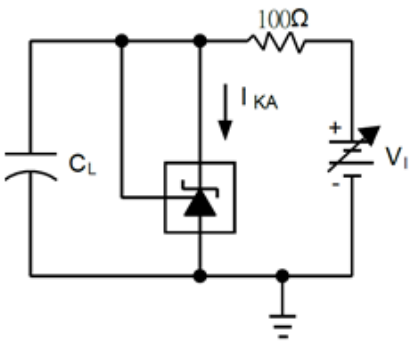




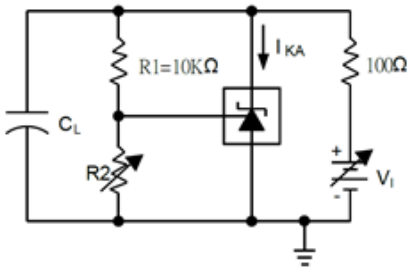
Test Circuit For Pulse Response

(4) Stability boundary conditions





Test Circuit For Curve A

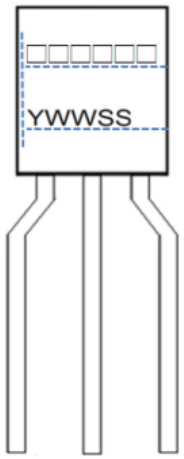


Test Circuit For Curve B

Marking Information (NEW)

Effective Date: 2015/11/1

(1) TO92-3L



1) YWWSS = Date Code,

Y: Year

WW: Week

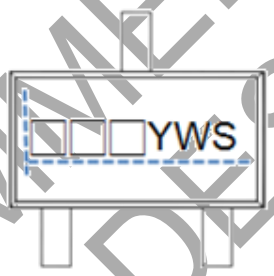
SS: Internal control code

2) □□□□□□ = Marking Number

LE431NHPA: E431NH

LE431OHPA: E431OH

(2) SOT23-3L



1) YWS = Date Code,

Y: Year

W: Week

S: Internal control code

2) □□□ = Marking Number

LE431NCAPA: AB1

LE431OCAPA: AB2

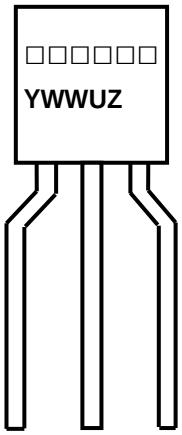
LE431NCRPA : AB3

LE431OCRPA : AB4

Marking Information (OLD)

Before 2015/10/31 (included) production, the marking code of parts were used as below.

(1) TO92-3L



1) □□□□□□ = Marking Name

E431NH= LE431NHPA

E431OH= LE431OHPA

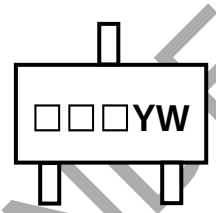
2) YWWUZ = Date Code & Internal Code

Y = Years

WW = Weeks

U Z =Internal Code

(2) SOT23-3L



1) □□□ = Marking Name

AB1= LE431NCAPA

AB2= LE431OCAPA

AB3= LE431NCRPA

AB4= LE431OCRPA

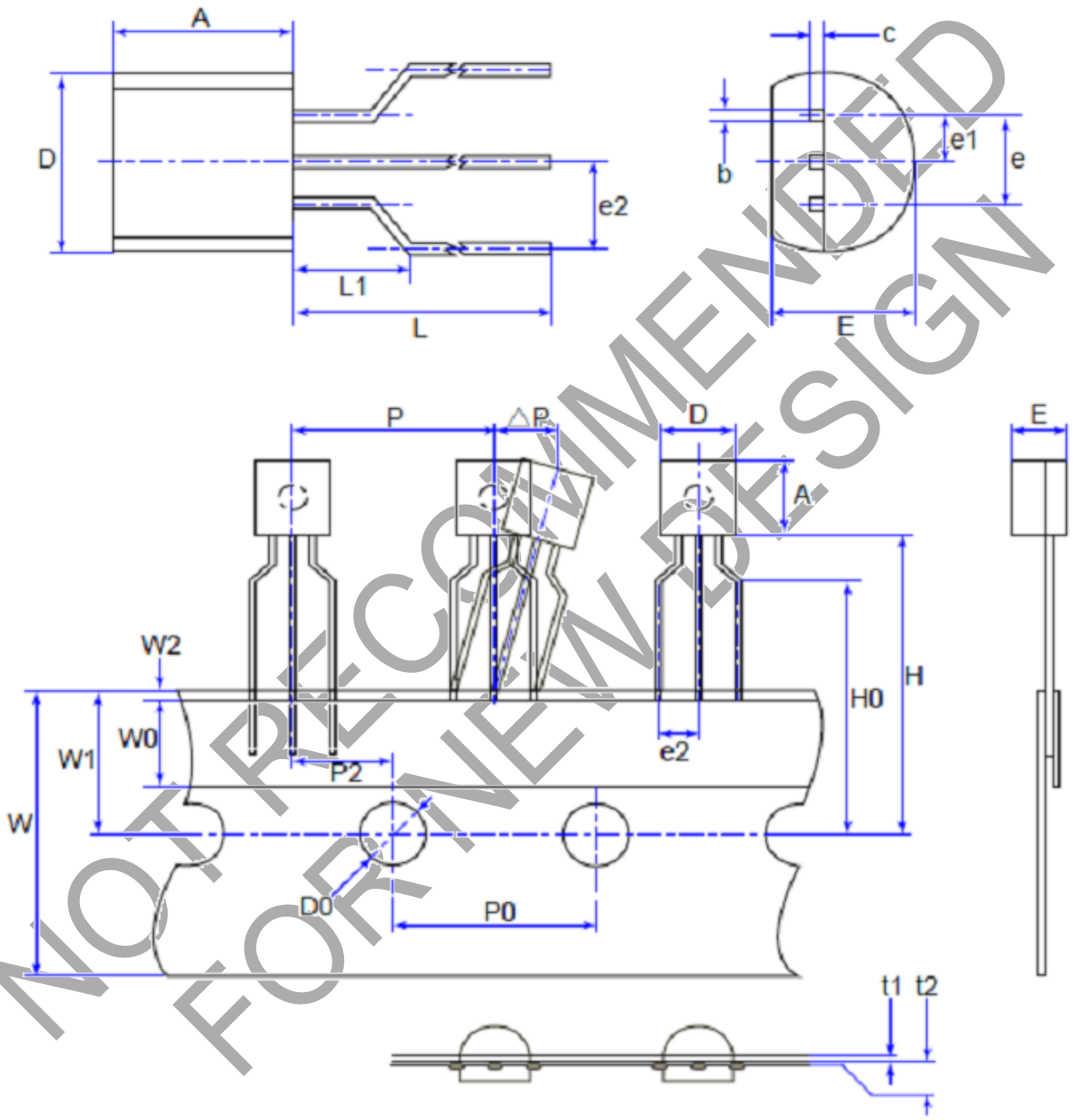
2) YW = Date Code

Y = Years

W = Weeks

Mechanical Information

(1) Package type: TO92-3L

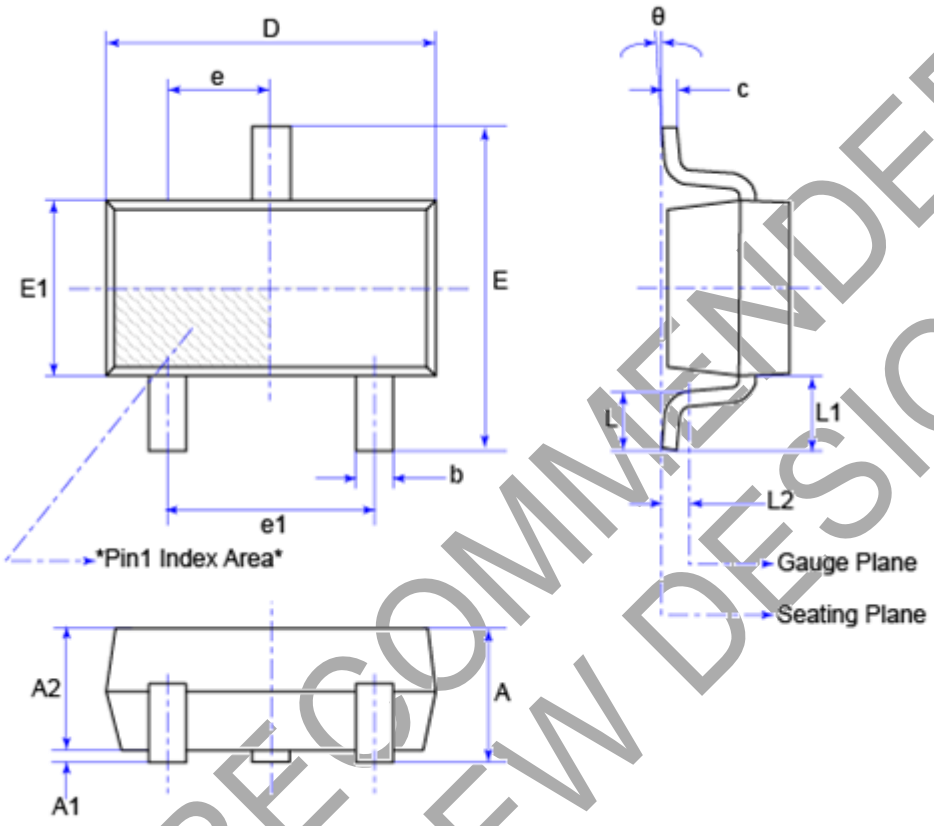


Symbol	Min	Max
A	4.30	4.70
b	0.38	0.55
c	0.36	0.51
D	4.30	4.70
D0	3.80	4.20
E	3.30	3.70
e	2.44	2.64
e1	1.27 TYP	
e2	2.20	2.96
H	18.00	21.00
H0	15.50	16.50
L	12.70	-
L1	2.50	4.50
P	12.40	13.00
P0	12.50	12.90
P2	6.05	6.65
t1	0.35	0.45
t2	0.15	0.25
W	17.50	19.00
W0	5.50	6.50
W1	8.50	9.50
W2	-	1.00
▵P	-	1.00

Unit: mm

Mechanical Information (Continued)

(2) Package type: SOT23-3L



Unit: mm

Variations / Symbol	SOT23 (A)	
	Min	Max
A	0.900	1.150
A1	-	0.100
A2	0.890	1.100
b	0.300	0.500
c	0.070	0.202
D	2.800	3.040
E	2.100	2.640
E1	1.200	1.400
e	0.950 REF	
e1	1.800	2.000
L	0.300	0.500
L1	0.550 REF	
L2	0.250 BSC	
θ	0°	8°

MSL (Moisture Sensitive Level) Information

IPC/JEDEC J-STD-020D.1 Moisture Sensitivity Levels Table

LEVEL	FLOOR LIFE		SOAK REQUIREMENTS				
			Standard		Accelerated Equivalent [1]		
					eV 0.40-0.48	eV 0.30-0.39	CONDITION
	TIME	CONDITION	TIME (hours)	CONDITION	TIME (hours)	TIME (hours)	
1	Unlimited	≤30 °C /85% RH	168 +5/-0	85 °C /85% RH	NA	NA	NA
2	1 year	≤30 °C /60% RH	168 +5/-0	85 °C /60% RH	NA	NA	NA
2a	4 weeks	≤30 °C /60% RH	696[2] +5/-0	30 °C /60% RH	120 -1/+0	168 -1/+0	60 °C/ 60% RH
3	168 hours	≤30 °C /60% RH	192[2] +5/-0	30 °C /60% RH	40 -1/+0	52 -1/+0	60 °C/ 60% RH
4	72 hours	≤30 °C /60% RH	96[2] +2/-0	30 °C /60% RH	20 +0.5/-0	24 +0.5/-0	60 °C/ 60% RH
5	48 hours	≤30 °C /60% RH	72[2] +2/-0	30 °C /60% RH	15 +0.5/-0	20 +0.5/-0	60 °C/ 60% RH
a	24 hours	≤30 °C /60% RH	48[2] +2/-0	30 °C /60% RH	10 +0.5/-0	13 +0.5/-0	60 °C/ 60% RH
6	Time on Label (TOL)	≤30 °C /60% RH	TOL	30 °C /60% RH	NA	NA	NA

Note 1: CAUTION - To use the ‘‘accelerated equivalent’’ soak conditions, correlation of damage response (including electrical, after soak and reflow), should be established with the ‘‘standard’’ soak conditions. Alternatively, if the known activation energy for moisture diffusion of the package materials is in the range of 0.40 - 0.48 eV or 0.30 - 0.39 eV, the ‘‘accelerated equivalent’’ may be used. Accelerated soak times may vary due to material properties (e.g .mold compound, encapsulant, etc.). JEDEC document JESD22-A120 provides a method for determining the diffusion coefficient.

Note 2: The standard soak time includes a default value of 24 hours for semiconductor manufacturer’s exposure time (MET) between bake and bag and includes the maximum time allowed out of the bag at the distributor’s facility. If the actual MET is less than 24 hours the soak time may be reduced. For soak conditions of 30 °C/60% RH, the soak time is reduced by 1 hour for each hour the MET is less than 24 hours. For soak conditions of 60 °C/60% RH, the soak time is reduced by 1 hour for each 5 hours the MET is less than 24 hours. If the actual MET is greater than 24 hours the soak time must be increased. If soak conditions are 30 °C/60% RH, the soak time is increased 1 hour for each hour that the actual MET exceeds 24 hours. If soak conditions are 60 °C/60% RH, the soak time is increased 1 hour for each 5 hours that the actual MET exceeds 24 hours.

Mechanical Data

- Moisture Sensitivity: SOT23-3L Level 3 per J-STD-020
- Terminals: SOT23-3L Finish – Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 e3

  TO92-3L Finish – Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 e3
- Weight: SOT23-3L 0.009 grams (Approximate)

  TO92-3L 0.211 grams (Approximate)

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