

# TL431 Series

## Adjustable Precision Shunt Regulator

### Description

The TL431 series are three-terminal adjustable regulators with guaranteed thermal stability over applicable temperature ranges. The output voltage may be set to any value between  $V_{REF}$  (approximately 2.5 volts) and 36 volts with two external resistors. These devices have a typical dynamic output impedance of  $0.2\Omega$ . Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacement for zener diodes in many applications.

### Features

- Programmable Precise Output Voltage from 2.5V to 36V
- High Stability under Capacitive Load
- Low Temperature Deviation: 4.5mV Typical
- Low Dynamic Output Resistance:  $0.1\Omega$  Typical
- Sink Current Capacity from 1mA to 100 mA
- Low Output Noise
- Wide Operating Range of  $-40$  to  $125^\circ\text{C}$
- Low Equivalent Full-range Temperature Coefficient with 20PPM/ $^\circ\text{C}$  Typical

### Absolute Maximum Ratings

(Operating temperature range applies unless otherwise specified)

Characteristics	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	$P_D$	SOT-23	370	mW
		TO-92	770	
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Operating Temperature Range (Max.)	$T_{opr}$	-40~+125		$^\circ\text{C}$
Storage Temperature Range	$T_{stg}$	-65~+150		$^\circ\text{C}$

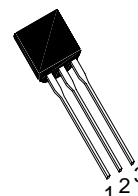
### Operating Conditions

Characteristics	Symbol	Min.	Max.	Unit
Cathode Voltage	$V_{KA}$	$V_{REF}$	36	V
Cathode Current Range (Continuous)	$I_K$	1	100	mA
Operating Ambient Temperature Range		-40	125	$^\circ\text{C}$

#### TL431 Series Pin Assignment

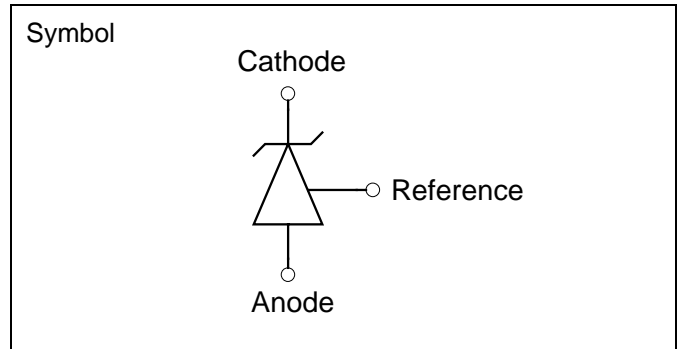
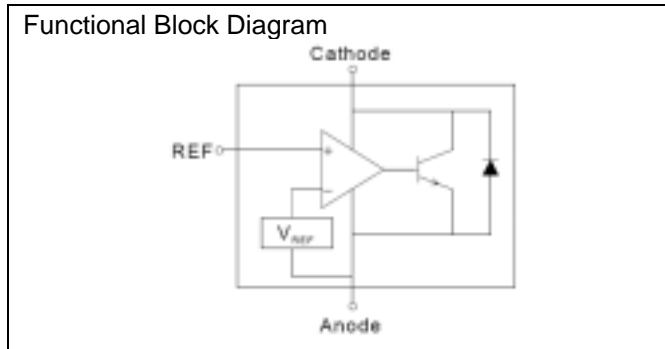


3-Lead Plastic **SOT-23**  
Package Code: N  
Pin 1: Reference  
Pin 2: Cathode  
Pin 3: Anode

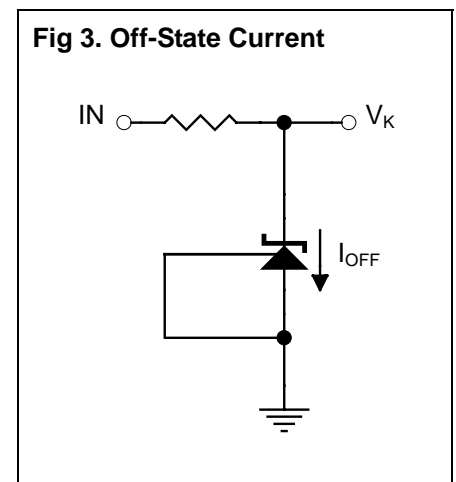
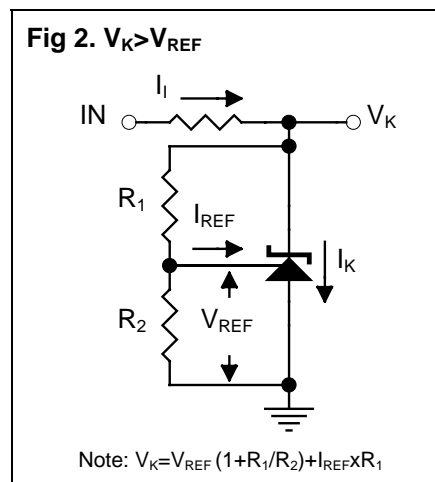
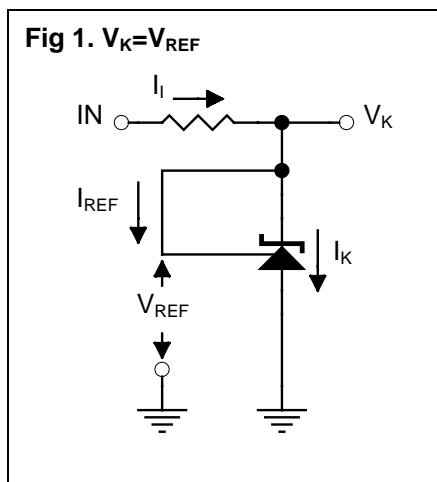


3-Lead Plastic **TO-92**  
Package Code: A  
Pin 1: Reference  
Pin 2: Anode  
Pin 3: Cathode

## Functional Block Diagram & Symbol



## Test Circuits

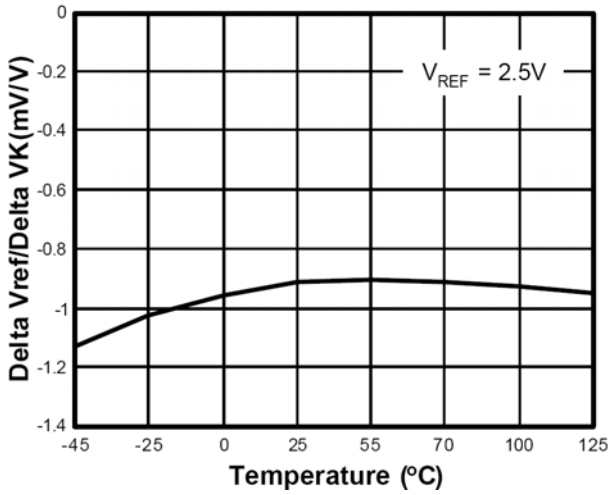


## Electrical Characteristics ( $T_A = 25^\circ\text{C}$ unless otherwise specified)

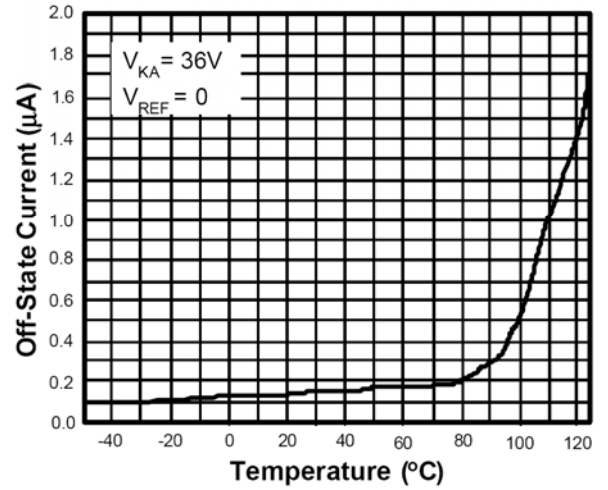
Characteristics	Symbol	Test Conditions	Min	Typ	Max	Unit	
Reference Input Voltage (Fig1)	$V_{REF}$	$V_K = V_{REF}$ , $I_K = 10\text{mA}$	0.4%	2.49	2.50	2.51	V
			0.8%	2.48	2.50	2.52	
Deviation of Reference Input Voltage Over-Temperature (Fig1)	$V_{REF(\text{dev})}$	$V_K = V_{REF}$ , $I_K = 10\text{mA}$ $T_{\text{min}} \leq T_a \leq T_{\text{max}} (-40 \sim +125^\circ\text{C})$	-	4.5	16	mV	
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage (Fig2)	$\Delta V_{REF} / \Delta V_K$	$I_K = 10\text{mA}$ , $\Delta V_K = 10\text{V}$ to $V_{REF}$	-	1.0	2.7	mV/V	
		$I_K = 10\text{mA}$ , $\Delta V_K = 36\text{V}$ to $10\text{V}$	-	0.4	2.0	mV/V	
Reference Input Current (Fig2)	$I_{REF}$	$I_K = 10\text{mA}$ , $R_1 = 10\text{k}\Omega$ , $R_2 = \infty$	-	0.5	1.2	$\mu\text{A}$	
Deviation of Reference Input Current Over Full Temperature Range (Fig2)	$I_{REF(\text{dev})}$	$I_K = 10\text{mA}$ , $R_1 = 10\text{k}\Omega$ , $R_2 = \infty$ , $T_a = -40 \sim +125^\circ\text{C}$	-	0.4	1.2	$\mu\text{A}$	
Minimum Cathode Current for Regulation (Fig1)	$I_{K(\text{min})}$	$V_K = V_{REF}$	-	0.1	0.3	mA	
Off-State Cathode Current (Fig3)	$I_{K(\text{off})}$	$V_K = 36\text{V}$ , $V_{REF} = 0$	-	0.01	0.8	$\mu\text{A}$	
Dynamic Output Impedance (Fig1)	$Z_K$	$V_K = V_{REF}$ , $f \leq 1\text{kHz}$ $I_K = 1$ to $100\text{mA}$	-	0.10	0.4	$\Omega$	

## Typical Performance Characteristics

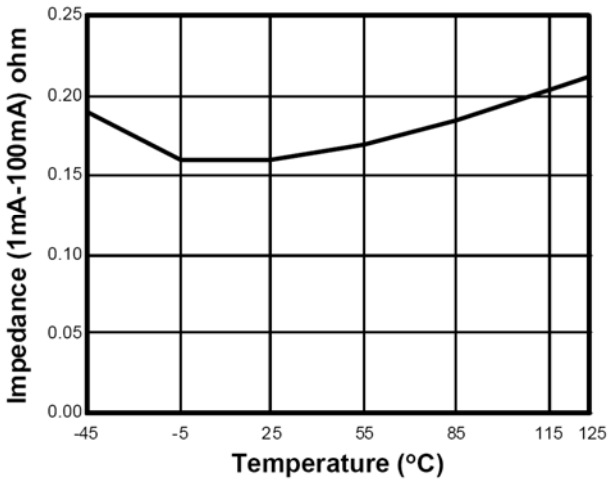
Delta Reference Voltage vs. Temperature



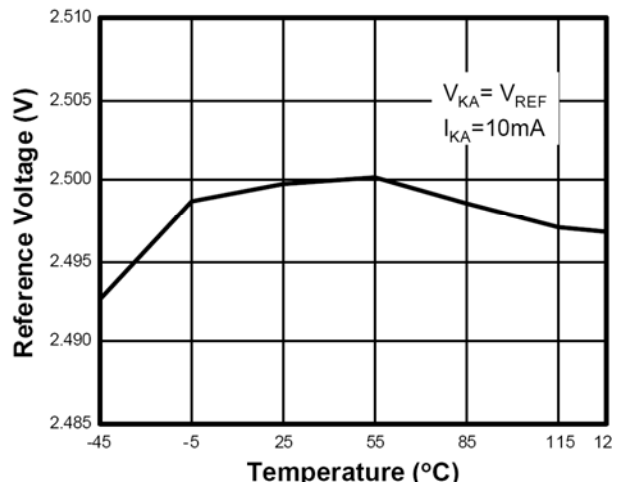
Off-State Current vs. Temperature



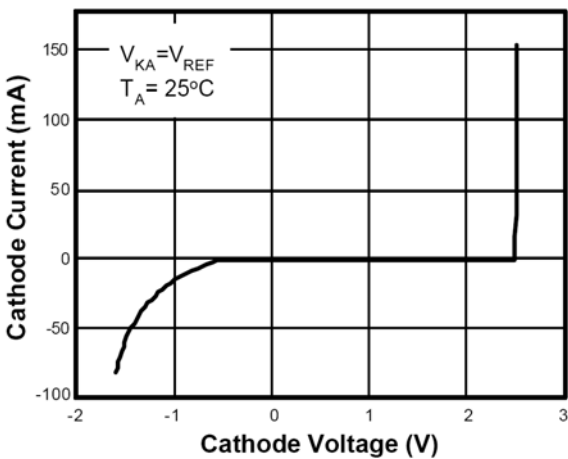
Impedance vs. Temperature



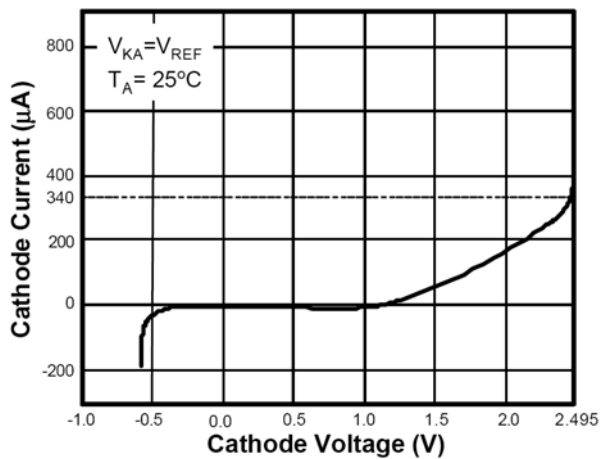
Reference Voltage vs. Temperature



Cathode Current vs. Cathode Voltage

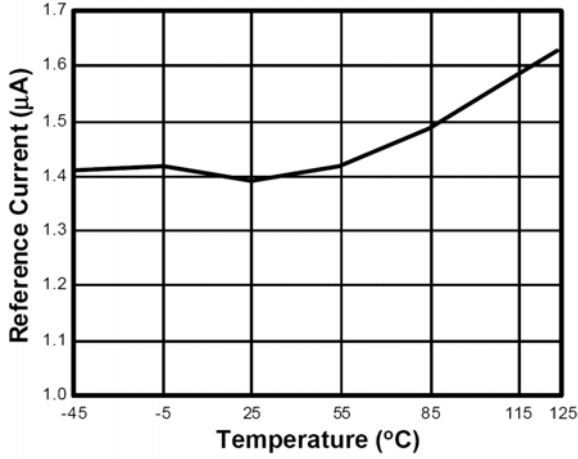


Current vs. Cathode Voltage

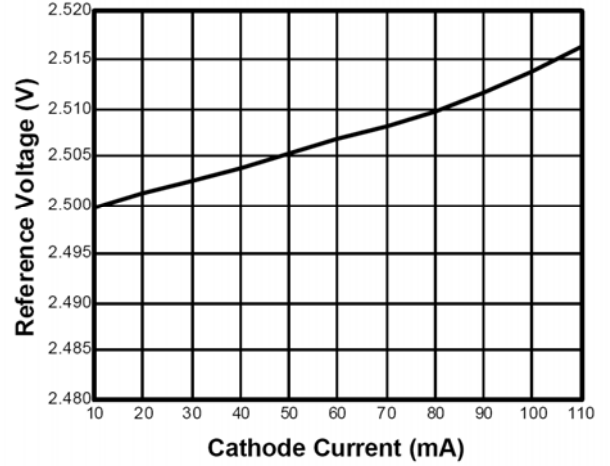


## Typical Performance Characteristics (Continued)

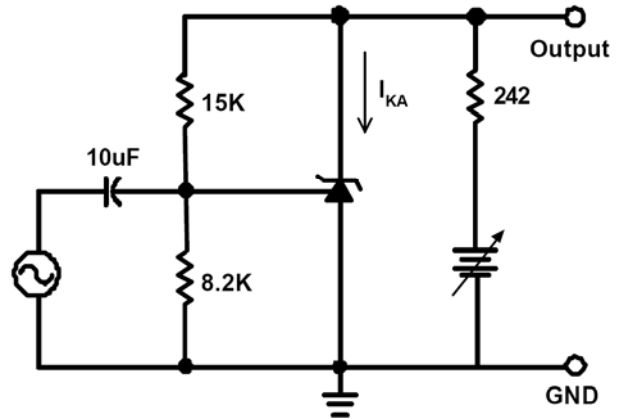
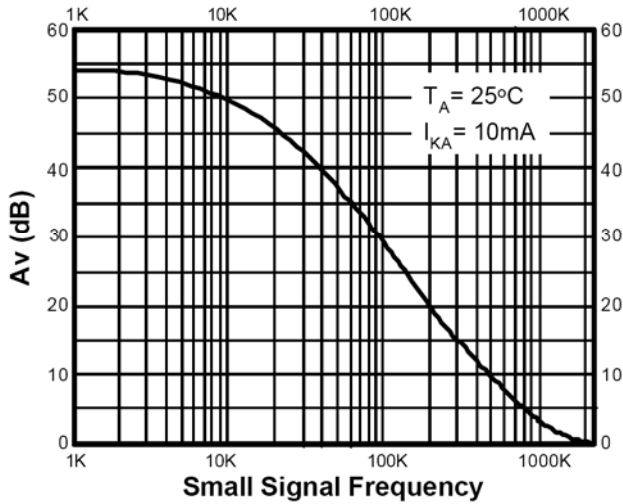
Reference Current vs. Temperature



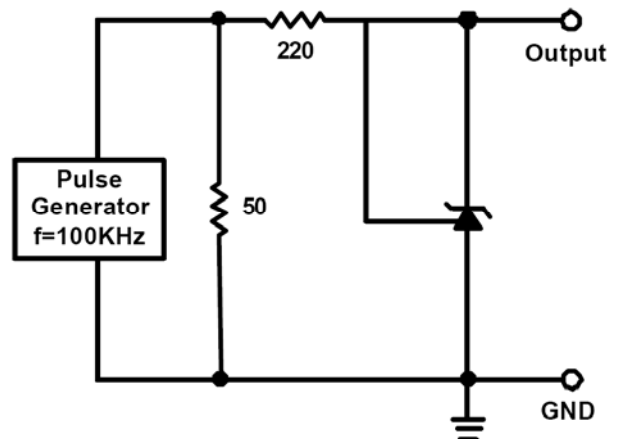
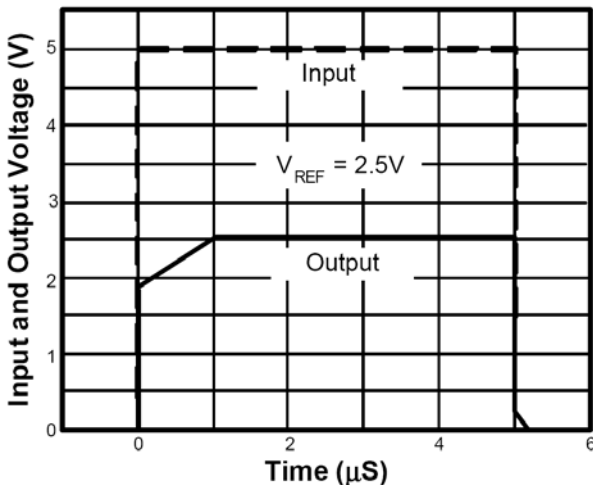
Reference Voltage vs. Cathode Current



Small Signal Voltage Gain vs. Frequency

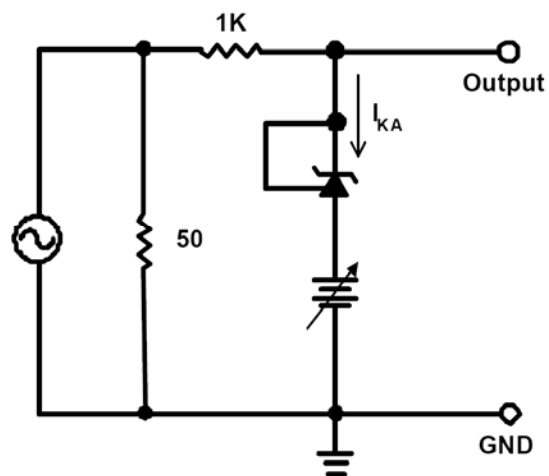
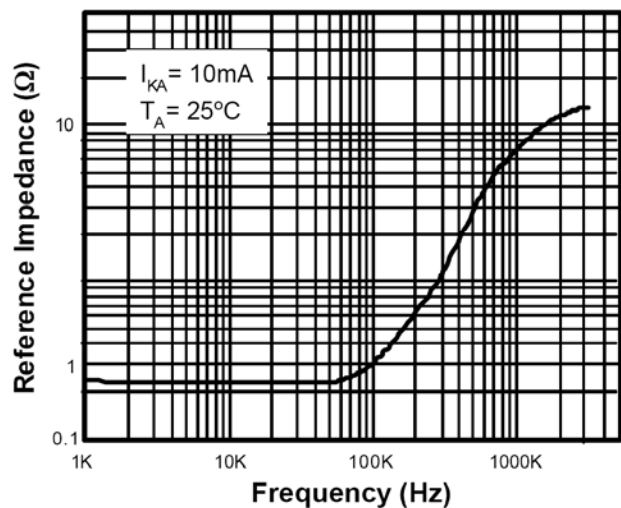


Small Signal Voltage Gain vs. Frequency

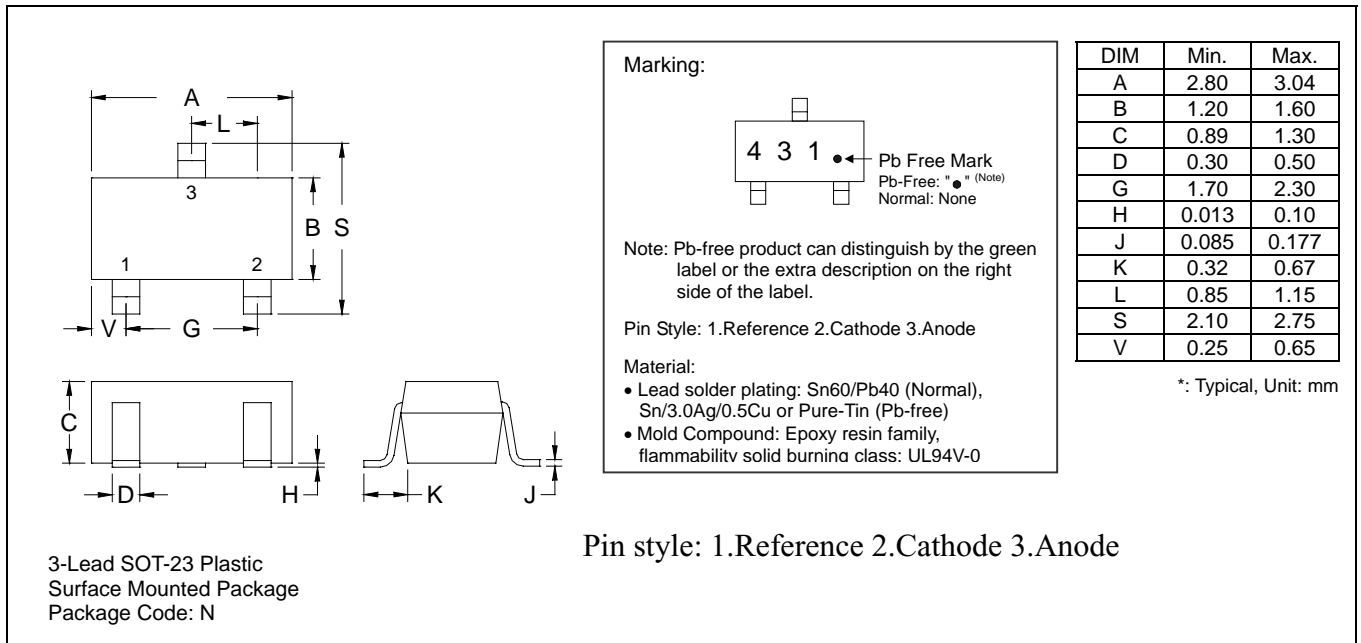


Typical Performance Characteristics (Continued)

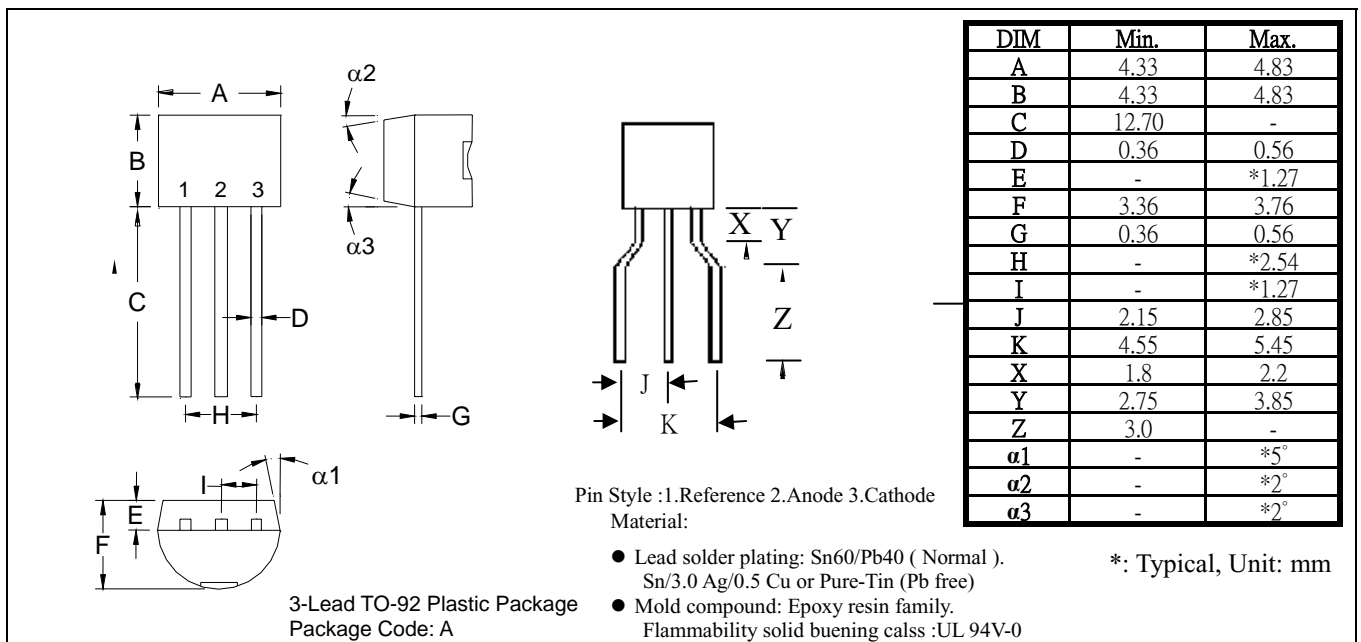
Reference Impedance vs. Frequency



## SOT-23 Dimension



## TO-92 Dimension

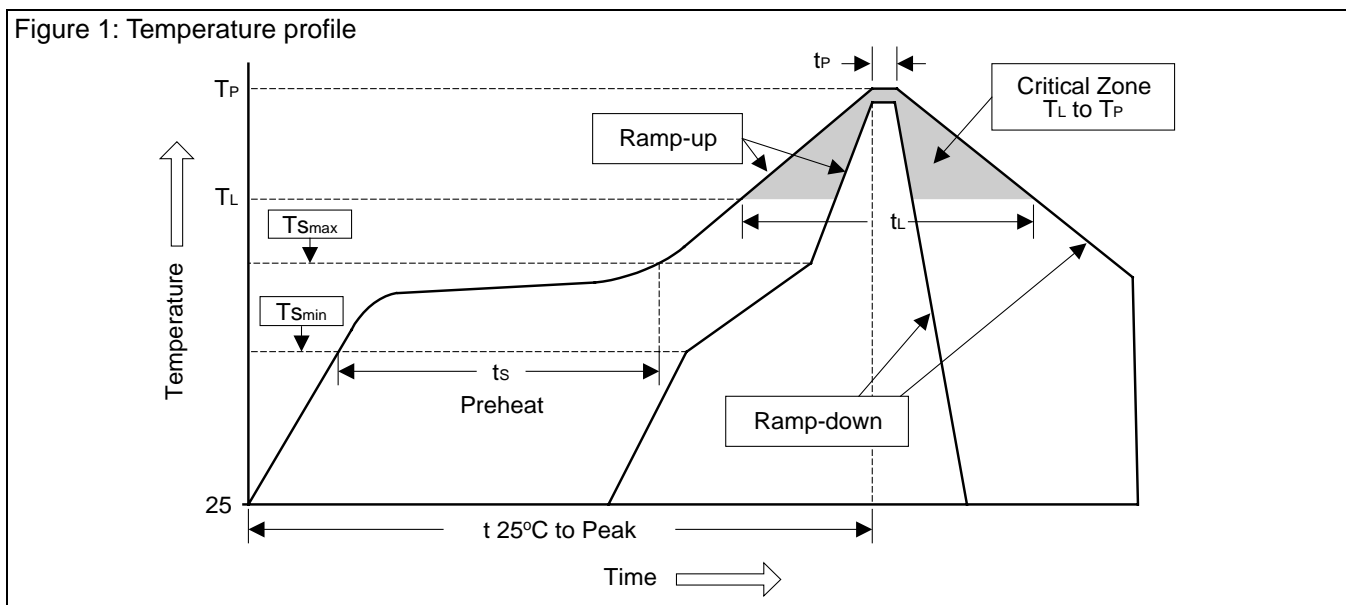


## Ordering Information

Package	V <sub>REF</sub> : 2.5±0.8%	V <sub>REF</sub> : 2.5±0.4%
SOT-23	TL431BN	TL431CN
TO-92	TL431BA	TL431CA

## Soldering Methods for CTC Products

1. Storage environment: Temperature=10°C~35°C Humidity=65%±15%
2. Reflow soldering of surface-mount devices



Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Average ramp-up rate ( $T_L$ to $T_P$ )	<3°C/sec	<3°C/sec
Preheat		
- Temperature Min ( $T_{Smin}$ )	100°C	150°C
- Temperature Max ( $T_{Smax}$ )	150°C	200°C
- Time (min to max) ( $t_s$ )	60~120 sec	60~180 sec
$T_{Smax}$ to $T_L$		
- Ramp-up Rate	<3°C/sec	<3°C/sec
Time maintained above:		
- Temperature ( $T_L$ )	183°C	217°C
- Time ( $t_L$ )	60~150 sec	60~150 sec
Peak Temperature ( $T_P$ )	240°C +0/-5°C	260°C +0/-5°C
Time within 5°C of actual Peak Temperature ( $t_p$ )	10~30 sec	20~40 sec
Ramp-down Rate	<6°C/sec	<6°C/sec
Time 25°C to Peak Temperature	<6 minutes	<8 minutes

3. Flow (wave) soldering (solder dipping)

Products	Peak temperature	Dipping time
Pb devices.	245°C ±5°C	5sec ±1sec
Pb-Free devices.	260°C +0/-5°C	5sec ±1sec