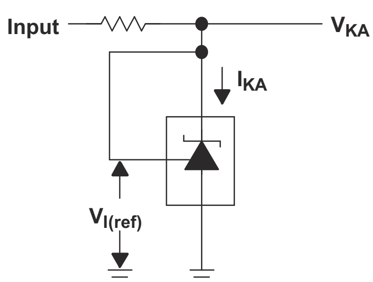
TL1431-SP V 类，精度可编程参考

1 特性

- 符合 QMLV 标准，高达 100krad (Si) RHA，5962R99620
- 0.4% 初始电压容差
- 输出阻抗典型值 0.2Ω
- 快速导通：500ns
- 灌电流能力：1mA 至 100mA
- 低基准电流 (REF)
- 可调输出电压：$V_{I(ref)}$ 至 36V

2 应用

- 可调节电压和电流基准
- 反激式开关模式电源 (SMPS) 中的次级侧调节
- 齐纳二极管替代产品
- 电压监测
- 具有集成基准的比较器
- 命令和数据处理 (C&DH)
- 光学成像有效载荷
- 雷达成像有效载荷
- 卫星电力系统 (EPS)



简化原理图

3 说明

TL1431 是一个可编程精密基准，此基准在车用、商用、和军用温度范围内具有额定的热稳定性。借助于两个外部电阻器，输出电压可在 $V_{I(ref)}$（大约 2.5V）和 36V 之间任意调节。该器件具有 0.2Ω 的输出阻抗典型值。有源输出电路提供一个非常明显的接通特性，这使得此器件成为诸如板载调节、可调电源、和开关电源应用中齐纳二极管和其它类型基准的出色替代产品。

TL1431 可在 -55°C 至 125°C 的整个军用温度范围内运行。

器件信息

器件型号(1)	等级	封装
5962R9962001VPA	飞行等级 RHA 100krad(Si)	8 引脚 JG 重量 0.87g(2)
5962-9962001VPA	飞行等级 V 级	
5962R9962001VHA	飞行等级 RHA 100krad(Si)	10 引脚 U 重量 0.2g(2)
TL1431U/EM	工程样片(3)	EVM

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。
(2) 重量误差在 ±10% 以内。
(3) 这些器件仅适用于工程评估。按非合规性流程对其进行了处理（即未进行老化等处理），并且仅在 25°C 的额定温度下进行了测试。这些器件不适用于鉴定、生产、辐射测试或飞行用途。这些零器件无法在 –55°C 至 125°C 的完整 MIL 额定温度范围内或运行寿命中保证其性能。

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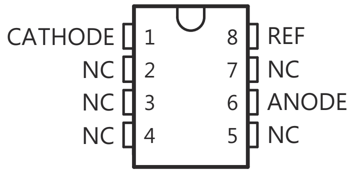
4 Revision History

注：以前版本的页码可能与当前版本的页码不同

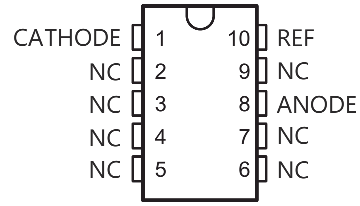
Changes from Revision B (September 2013) to Revision C (November 2020)	**Page**
• 添加了*应用* 部分、“引脚功能”表、*ESD 等级* 表、*热性能信息* 表、*详细说明* 部分、*应用和实施* 部分、*电源相关建议* 部分、*布局* 部分、*器件和文档支持* 部分，以及*机械、封装和可订购信息* 部分	1
• 更新了整个文档中的表格、图和交叉参考的编号格式	1
• 更新了“器件信息”表	1
• Added U package pinout drawing	3

5 Pin Configuration and Functions



NC - No internal connection

图 5-1. JG Package
8-Pin CDIP
Top View



NC - No internal connection

图 5-2. U Package
10-Pin CFP
Top View

表 5-1. Pin Functions

PIN			I/O	DESCRIPTION
NAME	JG	U		
ANODE	6	—	O	Common pin, normally connected to ground
CATHODE	1	—	I/O	Shunt current/voltage input
REF	8	—	I	Threshold relative to common ground
NC	2,3,4,5,7	2,3,4,5,6,7,9	—	No internal connection

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[(1)]

			MIN	MAX	UNIT
V_{KA}	Cathode voltage[(2)]			37	V
I_{KA}	Continuous cathode current		–100	150	mA
$I_{I(ref)}$	Reference input current		–0.05	10	mA
T_J	Operating virtual junction temperature			150	°C
	Lead temperature	1.6 mm (1/16 in) from case for 10 s		260	°C
T_{stg}	Storage temperature		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values are with respect to ANODE, unless otherwise noted.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[(1)]	±2000	V

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

		MIN	MAX	UNIT
V_{KA}	Cathode voltage	$V_{I(ref)}$	36	V
I_{KA}	Cathode current	1	100	mA
T_A	Operating free-air temperature	–55	125	°C

6.4 Thermal Information

THERMAL METRIC[(1)]		TL1431-SP		UNIT
		JG (CDIP)	U (CFP)	
		8 PINS	10 PINS	
$R_{\theta JC}$	Junction-to-case thermal resistance [(2)] [(3)]	14.5	19.1	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.
(2) Maximum power dissipation is a function of $T_{J(max)}$, $R_{\theta JC}$, and T_C. The maximum allowable power dissipation at any allowable case temperature is $P_D = (T_{J(max)} – T_C) / R_{\theta JC}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
(3) The package thermal impedance is calculated in accordance with MIL-STD-883.

6.5 Electrical Characteristics

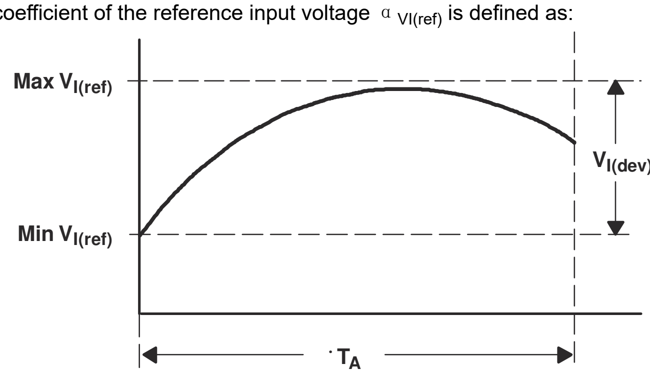
at specified free-air temperature, I_{KA} = 10 mA (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A (2)	TEST CIRCUIT	MIN	TYP	MAX	UNIT
$V_{I(ref)}$	Reference input voltage	$V_{KA} = V_{I(ref)}$	25°C	图 7-1	2475	2500	2540	mV
			Full range		2460		2550	
$V_{I(dev)}$	Deviation of reference input voltage over full temperature range(3)	$V_{KA} = V_{I(ref)}$	Full range	图 7-1		17	55(1)	mV
$\frac{\Delta V_{I(ref)}}{\Delta V_{KA}}$	Ratio of change in reference input voltage to the change in cathode voltage	ΔV_{KA} = 3 V to 36 V	Full range	图 7-2		–1.1	–2	mV/V
$I_{I(ref)}$	Reference input current	R1 = 10 kΩ, R2 = ∞	25°C	图 7-2		1.5	2.5	μA
			Full range				5	
$I_{I(dev)}$	Deviation of reference input current over full temperature range(3)	R1 = 10 kΩ, R2 = ∞	Full range	图 7-2		0.5	3(1)	μA
I_{min}	Minimum cathode current for regulation	$V_{KA} = V_{I(ref)}$	25°C	图 7-1		0.45	1	mA
I_{off}	Off-state cathode current	V_{KA} = 36 V, $V_{I(ref)}$ = 0	25°C	图 7-3		0.18	0.5	μA
			Full range				2	
$\lvert z_{KA} \rvert$	Output impedance(4)	$V_{KA} = V_{I(ref)}$, f ≤ 1 kHz, I_{KA} = 1 mA to 100 mA	25°C	图 7-1		0.2	0.4	Ω

(1) On products compliant to MIL-PRF-38535, this parameter is not production tested.
(2) Full range is –55°C to 125°C.
(3) The deviation parameters $V_{I(dev)}$ and $I_{I(dev)}$ are defined as the differences between the maximum and minimum values obtained over the rated temperature range. The average full-range temperature coefficient of the reference input voltage $\alpha_{VI(ref)}$ is defined as:

$$\left|\alpha_{VI(ref)}\right| \left(\frac{ppm}{°C}\right) = \frac{\left(\frac{V_{I(dev)}}{V_{I(ref)} \text{ at } 25°C}\right) \times 10^6}{\Delta T_A}$$

where:
ΔT_A is the rated operating temperature range of the device.



$\alpha_{VI(ref)}$ is positive or negative, depending on whether minimum $V_{I(ref)}$ or maximum $V_{I(ref)}$, respectively, occurs at the lower temperature.

(4) The output impedance is defined as: $\lvert z_{KA} \rvert = \frac{\Delta V_{KA}}{\Delta I_{KA}}$

When the device is operating with two external resistors (see 图 7-2), the total dynamic impedance of the circuit is given by: $\lvert z' \rvert = \frac{\Delta V}{\Delta I}$,

which is approximately equal to $\lvert z_{KA} \rvert \left(1 + \frac{R1}{R2}\right)$.

6.6 Typical Characteristics

Data at high and low temperatures are applicable only within the recommended operating free-air temperature ranges of the various devices.

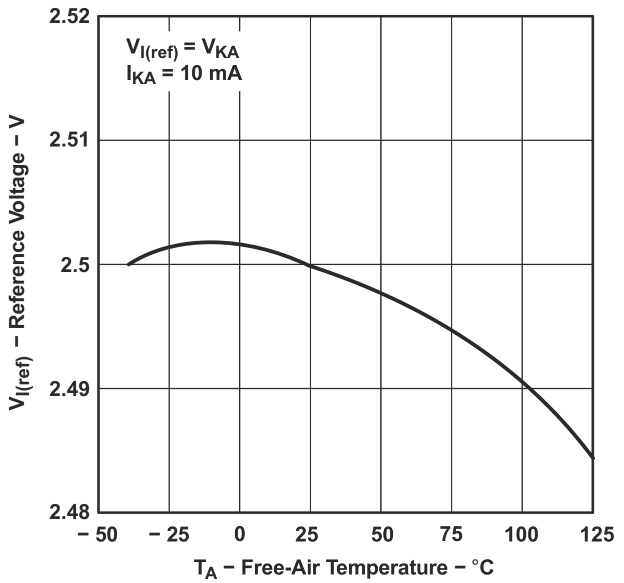


图 6-1. Reference Voltage vs Free-Air Temperature

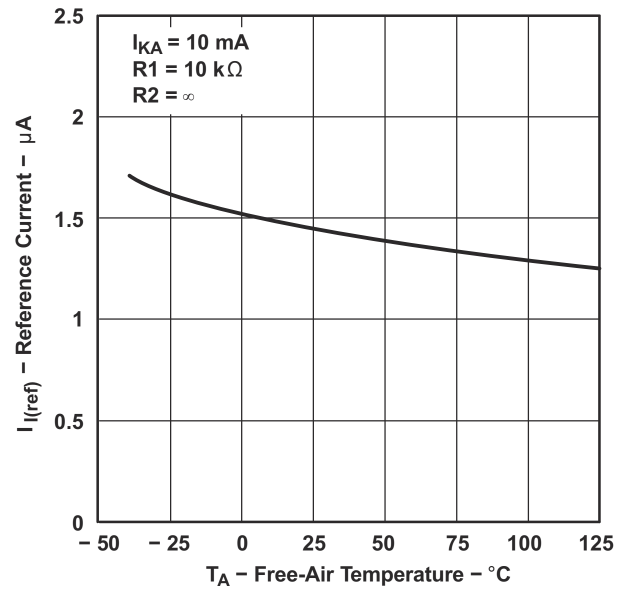


图 6-2. Reference Current vs Free-Air Temperature

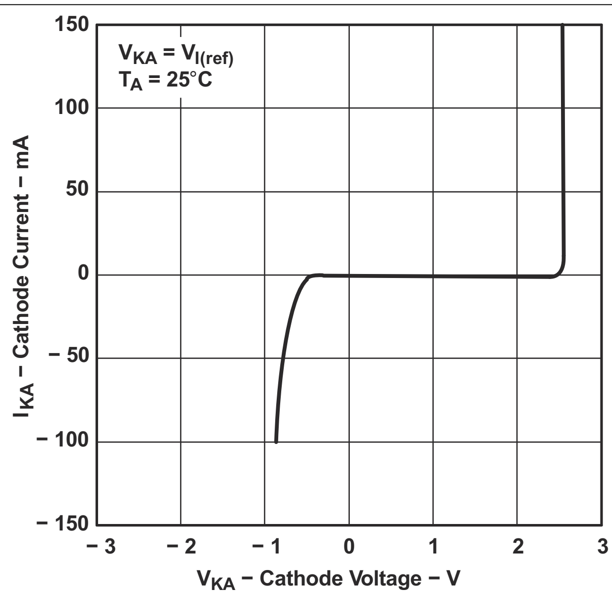


图 6-3. Cathode Current vs Cathode Voltage

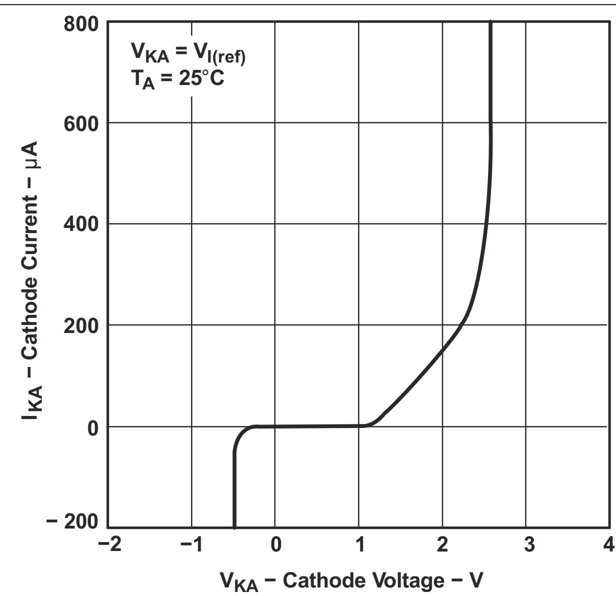


图 6-4. Cathode Current vs Cathode Voltage

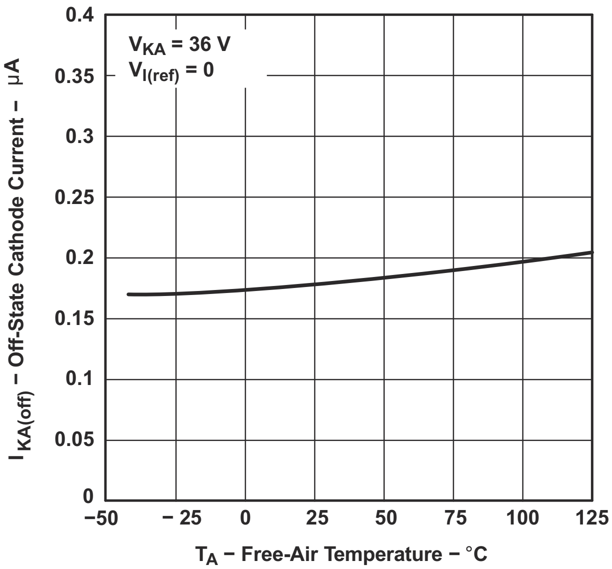


图 6-5. Off-State Cathode Current vs Free-Air Temperature

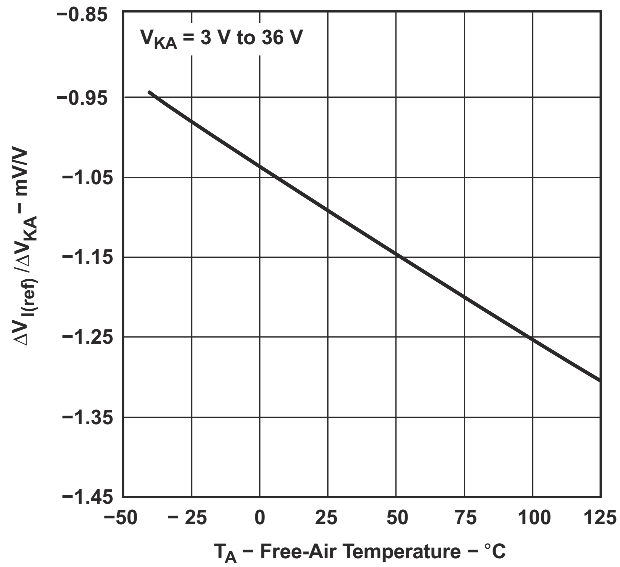


图 6-6. Ratio of Delta Reference Voltage to Delta Cathode Voltage vs Free-Air Temperature

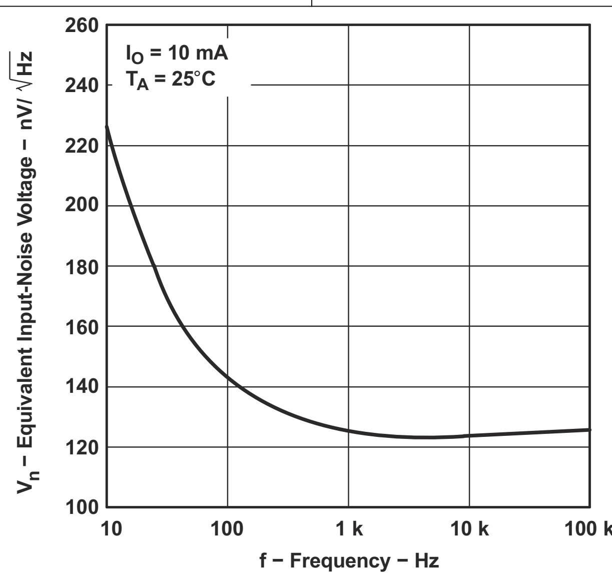


图 6-7. Equivalent Input-Noise Voltage vs Frequency

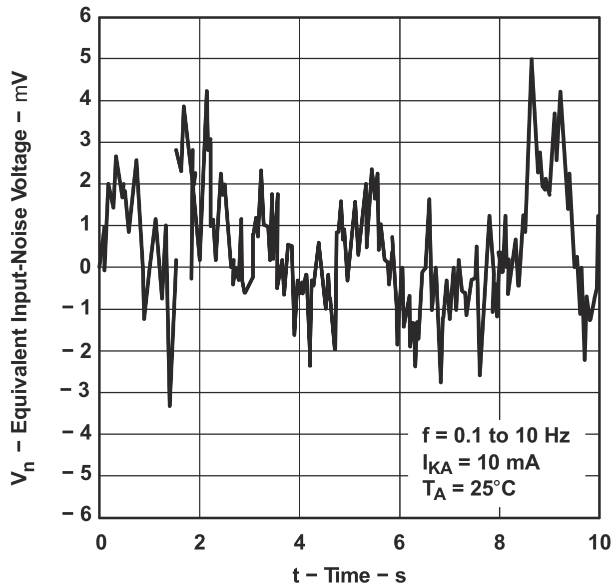


图 6-8. Equivalent Input-Noise Voltage Over a 10-s Period

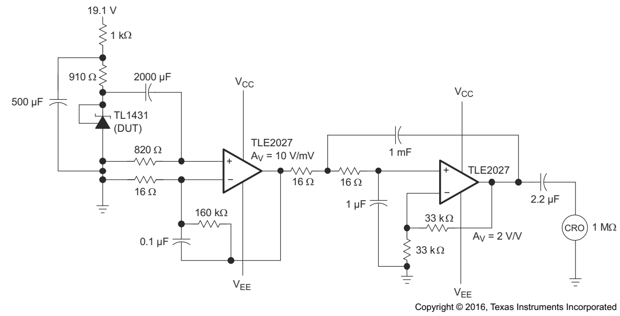


图 6-9. Test Circuit for 0.1-Hz to 10-Hz Equivalent Input-Noise Voltage

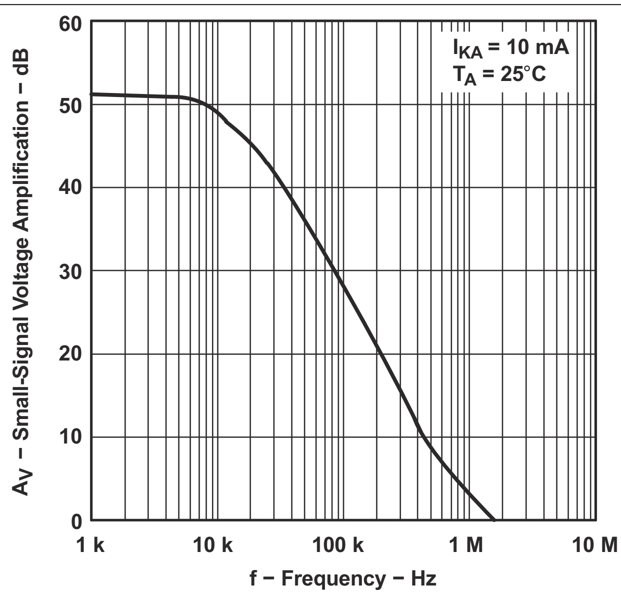


图 6-10. Small-Signal Voltage Amplification vs Frequency

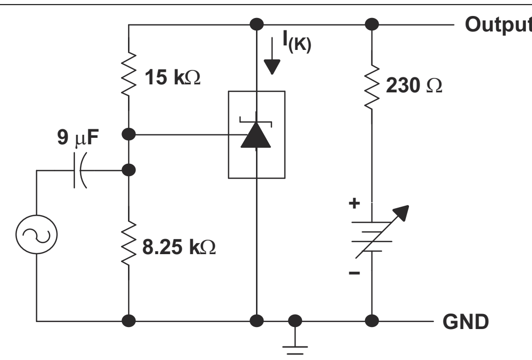


图 6-11. Test Circuit for Voltage Amplification

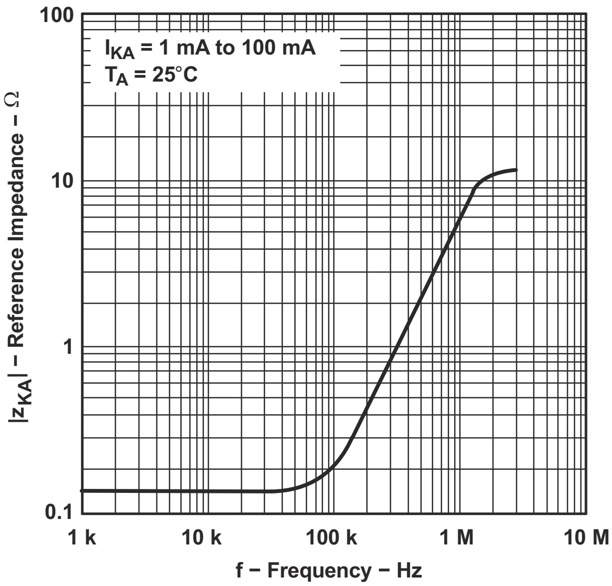


图 6-12. Reference Impedance vs Frequency

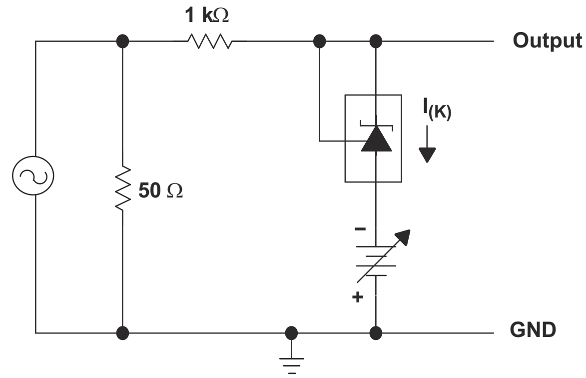


图 6-13. Test Circuit for Reference Impedance

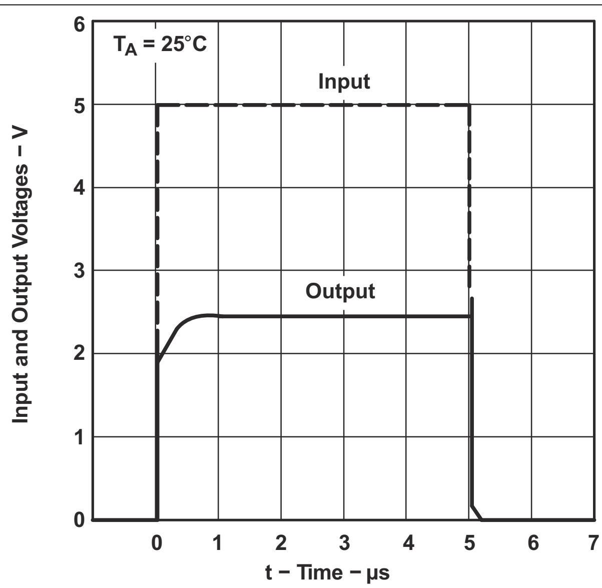


图 6-14. Pulse Response

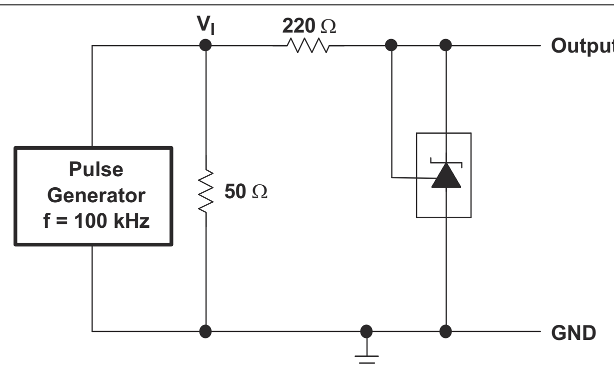
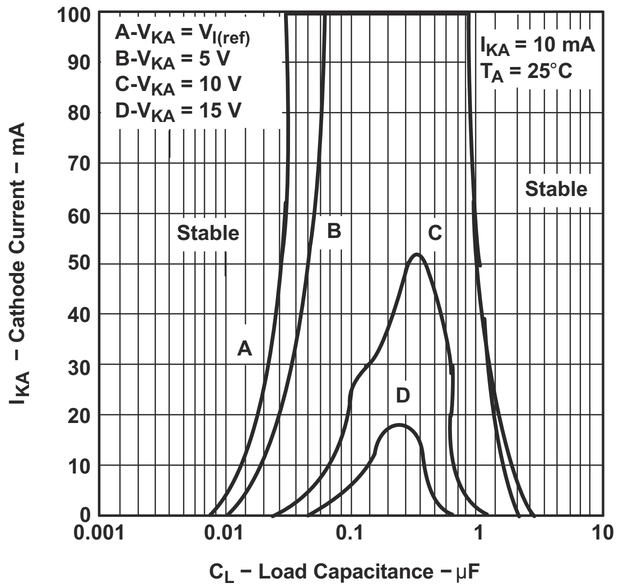


图 6-15. Test Circuit for Pulse Response



A. The areas under the curves represent conditions that may cause the device to oscillate. For curves B, C; and D, R2; and V+ are adjusted to establish the initial V_{KA} and I_{KA} conditions, with C_L = 0. V_{BATT} and C_L then are adjusted to determine the ranges of stability.

图 6-16. Stability Boundary Conditions

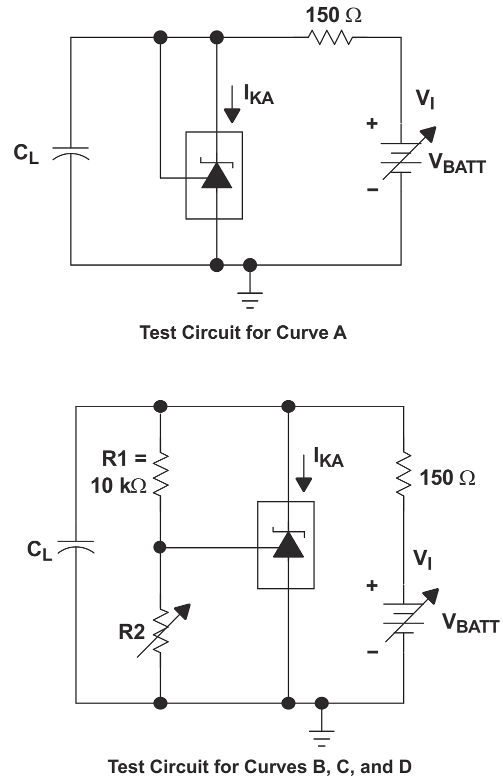


图 6-17. Test Circuits for Curves A Through D

7 Parameter Measurement Information

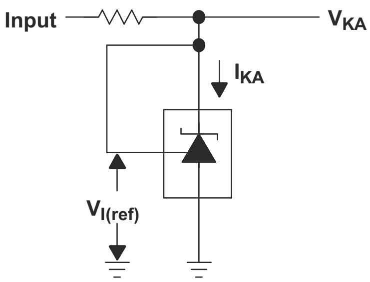
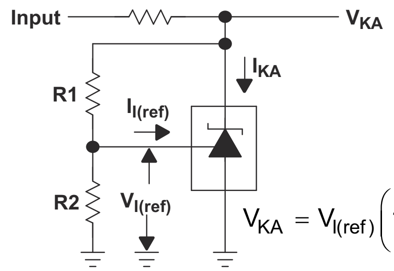


图 7-1. Test Circuit for $V_{(KA)} = V_{ref}$



$$V_{KA} = V_{I(ref)}\left(1 + \frac{R1}{R2}\right) + I_{I(ref)} \times R1$$

图 7-2. Test Circuit for $V_{(KA)} > V_{ref}$

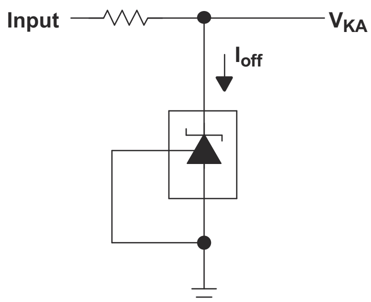


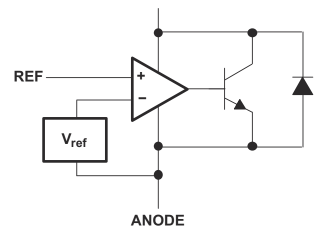
图 7-3. Test Circuit for I_{off}

8 Detailed Description

8.1 Overview

The TL1431 device has proven ubiquity and versatility across a wide range of applications, ranging from power to signal path. This is due to its key components containing an accurate voltage reference and op amp, which are very fundamental analog building blocks. TL1431 is used in conjunction with its key components to behave as a single voltage reference, error amplifier, voltage clamp, or comparator with integrated reference. TL1431 can be operated and adjusted to cathode voltages from 2.5 V to 36 V, making this part optimum for a wide range of end equipments in aerospace, industrial, auto, telecom, and computing. In order for this device to behave as a shunt regulator or error amplifier, > 1 mA (Imin(max)) must be supplied in to the cathode pin. Under this condition, feedback can be applied from the Cathode and Ref pins to create a replica of the internal reference voltage. The TL1431-SP devices are characterized for operation from –55°C to 125°C.

8.2 Functional Block Diagram



8.3 Feature Description

TL1431 consists of an internal reference and amplifier that outputs a sink current base on the difference between the reference pin and the virtual internal pin. The sink current is produced by the internal Darlington pair, shown in Detailed Schematic. A Darlington pair is used in order for this device to be able to sink a maximum current of 100 mA. When operated with enough voltage headroom (⩾ 2.5 V) and cathode current (IKA), TL1431 forces the reference pin to 2.5 V. However, the reference pin can not be left floating, as it needs IREF ⩾ 5 μA (see *Electrical Characteristics – TL1431-SP*). This is because the reference pin is driven into an npn, which needs base current to operate properly. When feedback is applied from the cathode and reference pins, TL1431 behaves as a Zener diode, regulating to a constant voltage dependent on current being supplied into the cathode. This is due to the internal amplifier and reference entering the proper operating regions. The same amount of current needed in the above feedback situation must be applied to this device in open loop, servo, or error amplifying implementations in order for it to be in the proper linear region giving TL1431 enough gain. Unlike many linear regulators, TL1431 is internally compensated to be stable without an output capacitor between the cathode and anode. However, if desired an output capacitor can be used as a guide to assist in choosing the correct capacitor to maintain stability.

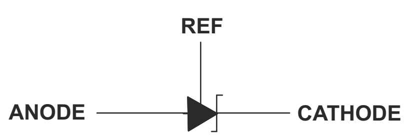


图 8-1. Symbol

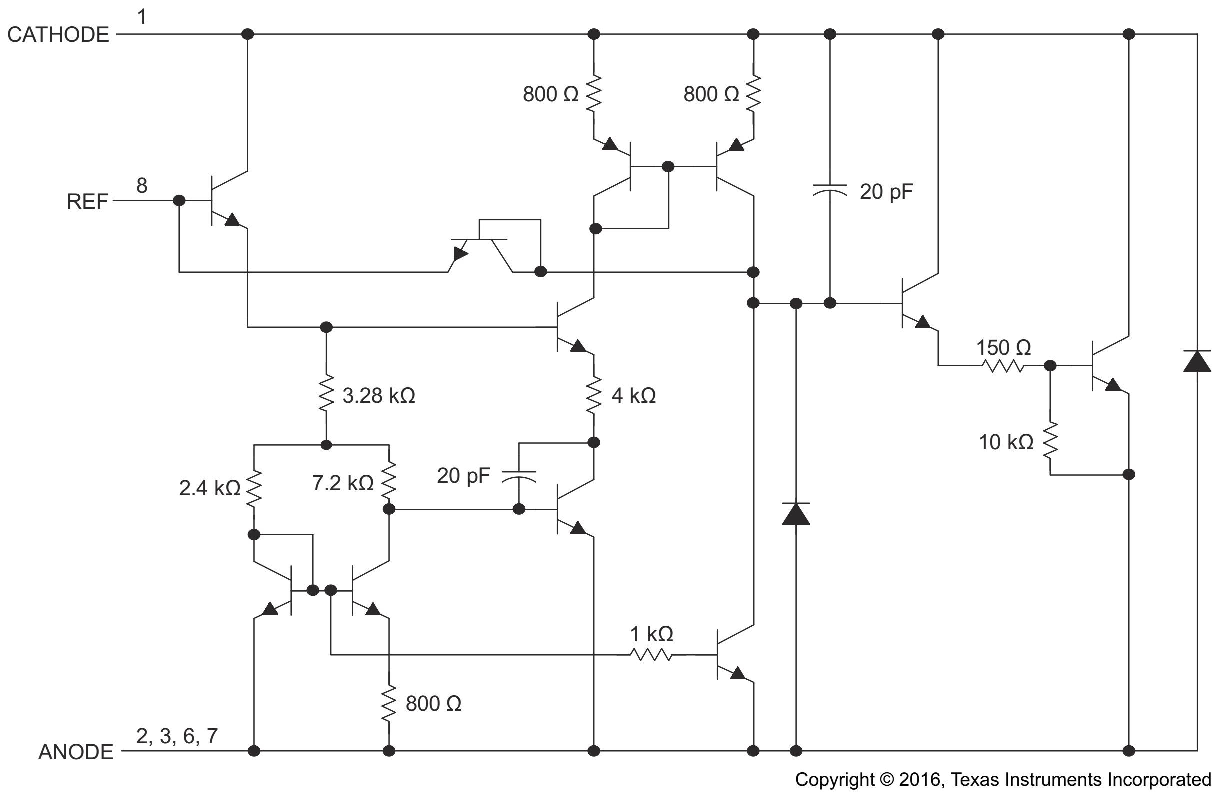


图 8-2. Equivalent Schematic

8.4 Device Functional Modes

8.4.1 Open Loop (Comparator)

When the cathode or output voltage or current of TL1431 is not being fed back to the reference or input pin in any form, this device is operating in open loop. With proper cathode current (I_{KA}) applied to this device, TL1431 has the characteristics shown in 图 9-1. With such high gain in this configuration, TL1431 is typically used as a comparator. With the reference integrated makes TL1431 the preferred choice when users are trying to monitor a certain level of a single signal.

8.4.2 Closed Loop

When the cathode or output voltage or current of TL1431 is being fed back to the reference or input pin in any form, this device is operating in closed loop. The majority of applications involving TL1431 use it in this manner to regulate a fixed voltage or current. The feedback enables this device to behave as an error amplifier, computing a portion of the output voltage and adjusting it to maintain the desired regulation. This is done by relating the output voltage back to the reference pin in a manner to make it equal to the internal reference voltage, which can be accomplished through resistive or direct feedback.

9 Application and Implementation

备注

以下应用部分的信息不属于 TI 组件规范，TI 不担保其准确性和完整性。客户应负责确定 TI 组件是否适用于其应用。客户应验证并测试其设计，以确保系统功能。

9.1 Application Information

As the TL1431 device has many applications and setups, there are many situations that this datasheet cannot characterize in detail. The linked application notes help the designer make the best choices when using this part. *Understanding Stability Boundary Conditions Charts in TL431, TL432 Data Sheet* (SLVA482) provides a deeper understanding of this devices stability characteristics and aid the user in making the right choices when choosing a load capacitor. *Setting the Shunt Voltage on an Adjustable Shunt Regulator* (SLVA445) assists designers in setting the shunt voltage to achieve optimum accuracy for this device.

9.2 Typical Application

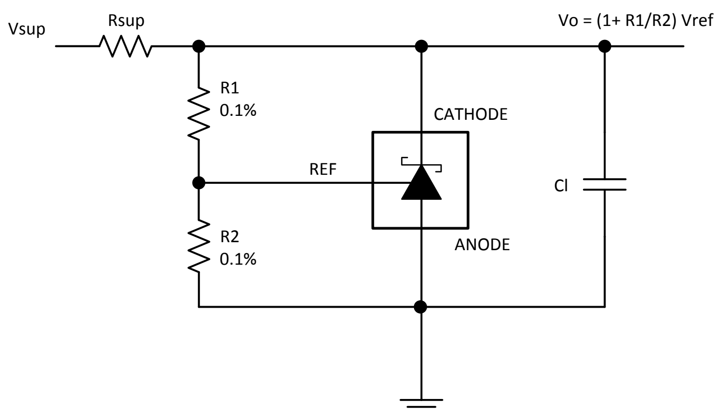


图 9-1. Comparator Application Schematic

9.2.1 Design Requirements

For this design example, use the parameters listed in 表 9-1 as the input parameters.

表 9-1. Design Parameters

PARAMETER	VALUE
Reference initial accuracy	0.4%
Supply voltage	48 V
Cathode current (I_K)	50 µA
Output voltage level	2.5 V to 36 V
Load capacitance	1 nF
Feedback resistor values and accuracy (R1 and R2)	10 kΩ

9.2.2 Detailed Design Procedure

When using TL1431 as a shunt regulator, determine the following:

- Input voltage range
- Temperature range
- Total accuracy
- Cathode current

- Reference initial accuracy
- Output capacitance

9.2.3 Programming Output/Cathode Voltage

To program the cathode voltage to a regulated voltage a resistive bridge must be shunted between the cathode and anode pins with the mid point tied to the reference pin. This can be seen in 图 9-1, with R1 and R2 being the resistive bridge. The cathode/output voltage in the shunt regulator configuration can be approximated by the equation shown in 图 9-1. The cathode voltage can be more accurately determined by taking in to account the cathode current with 方程式 1.

$$Vo = (1 + R1 / R2) \times V_{REF} - I_{REF} \times R1 \quad (1)$$

For this equation to be valid, TL1431 must be fully biased so that it has enough open loop gain to mitigate any gain error. This can be done by meeting the Imin specification denoted in 节 6.5.

9.2.4 Total Accuracy

When programming the output above unity gain (V_{KA}=V_{REF}), TL1431 is susceptible to other errors that may effect the overall accuracy beyond V_{REF}. These errors include:

- R1 and R2 accuracies
- $V_{I(dev)}$ – Change in reference voltage over temperature
- ΔV_{REF} / ΔV_{KA} – Change in reference voltage to the change in cathode voltage
- $|z_{KA}|$ – Dynamic impedance, causing a change in cathode voltage with cathode current

Worst case cathode voltage can be determined taking all of the variables in to account.

9.2.5 Stability

Though TL1431 is stable with no capacitive load, the device that receives the shunt regulator's output voltage could present a capacitive load that is within the TL1431 region of stability, shown in 图 6-16. Also, designers may use capacitive loads to improve the transient response or for power supply decoupling. When using additional capacitance between Cathode and Anode, refer to 图 6-16.

9.2.6 Start-up Time

As shown in 图 9-2, TL1431 has a fast response up to approximately 2 V and then slowly charges to its programmed value. This is due to the compensation capacitance the TL1431 has to meet its stability criteria. Despite the secondary delay, TL1431 still has a fast response suitable for many clamp applications.

9.2.7 Application Curve

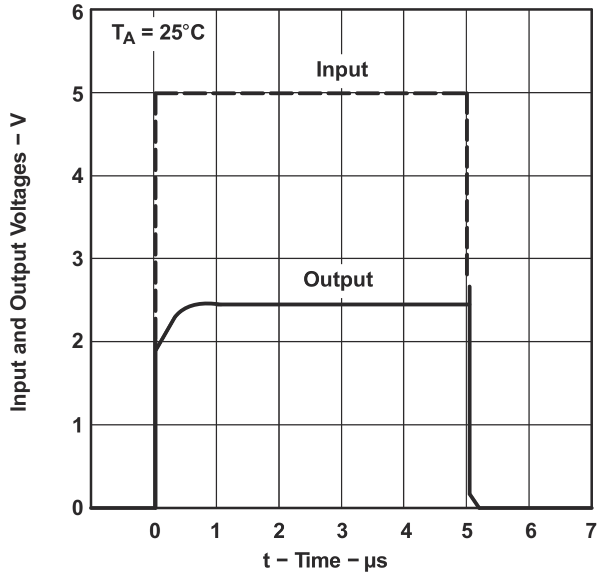


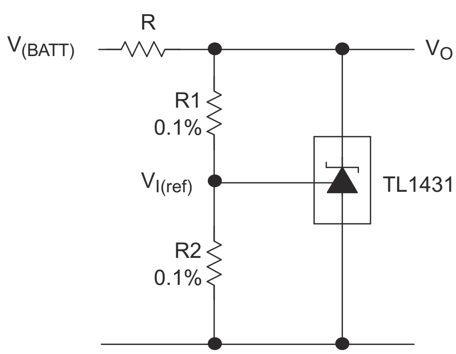
图 9-2. TL1431 Start-up Response

9.2.8 System Examples

表 9-2 lists example circuits of the TL1431.

表 9-2. Table of Example Circuits

APPLICATION	FIGURE
Shunt regulator	图 9-3
Single-supply comparator with temperature-compensated threshold	图 9-4
Precision high-current series regulator	图 9-5
Output control of a three-terminal fixed regulator	图 9-6
Higher-current shunt regulator	图 9-7
Crowbar	图 9-8
Precision 5-V, 1.5-A, 0.5% regulator	图 9-9
5-V precision regulator	图 9-10
PWM converter with 0.5% reference	图 9-11
Voltage monitor	图 9-12
Delay timer	图 9-13
Precision current limiter	图 9-14
Precision constant-current sink	图 9-15



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

R must provide cathode current ≥1 mA to the TL1431 at minimum $V_{(BATT)}$.

图 9-3. Shunt Regulator

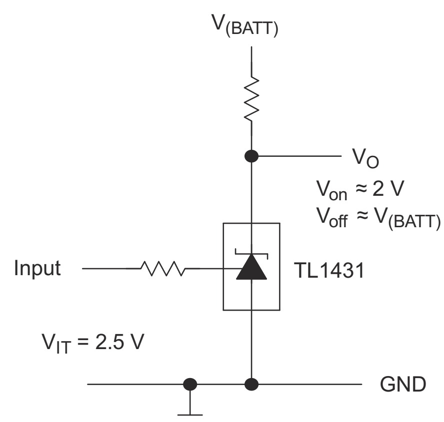
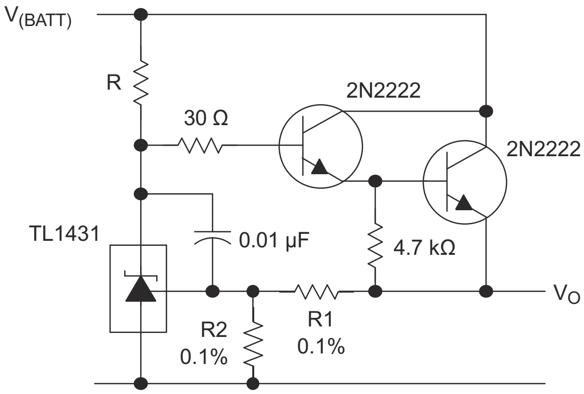


图 9-4. Single-Supply Comparator With Temperature-Compensated Threshold



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

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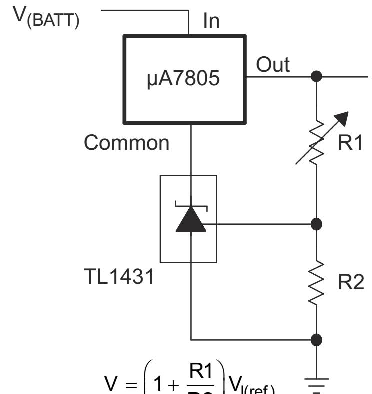
R must provide cathode current ≥1 mA to the TL1431 at minimum $V_{(BATT)}$.

图 9-5. Precision High-Current Series Regulator



$$V = \left(1 + \frac{R1}{R2}\right) V_{I(ref)}$$

$$\text{Min } V = V_{I(ref)} + 5\text{ V}$$

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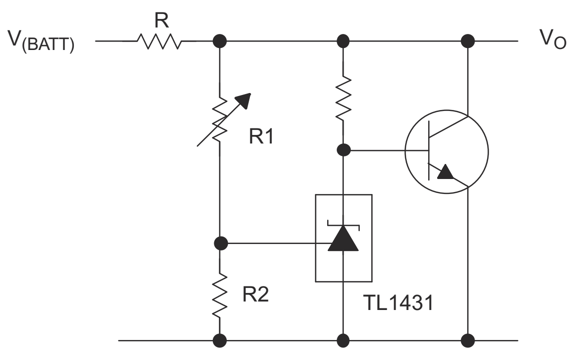
图 9-6. Output Control of a Three-Terminal Fixed Regulator



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

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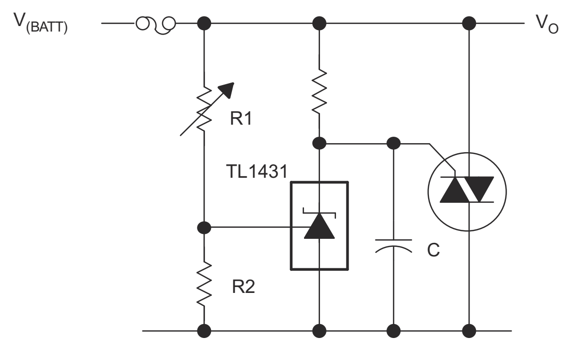
图 9-7. Higher-Current Shunt Regulator



$$V_{trip} = \left(1 + \frac{R1}{R2}\right) V_{I(ref)}$$

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See the stability boundary conditions in 图 6-16 to determine allowable values for C.

图 9-8. Crowbar

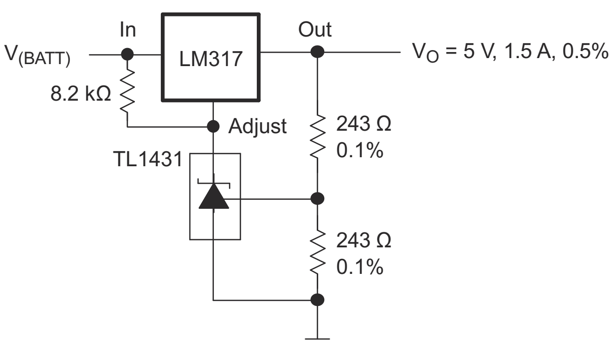

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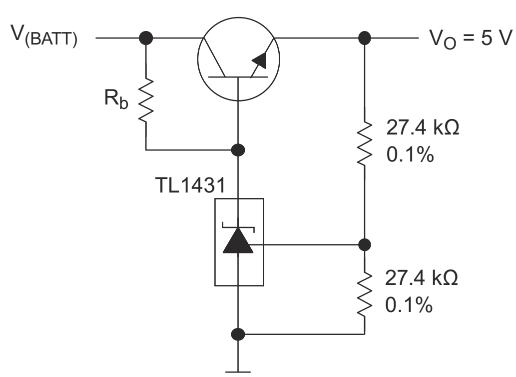
图 9-9. Precision 5-V, 1.5-A, 0.5% Regulator



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R_b must provide cathode current ≥1 mA to the TL1431.

图 9-10. 5-V Precision Regulator

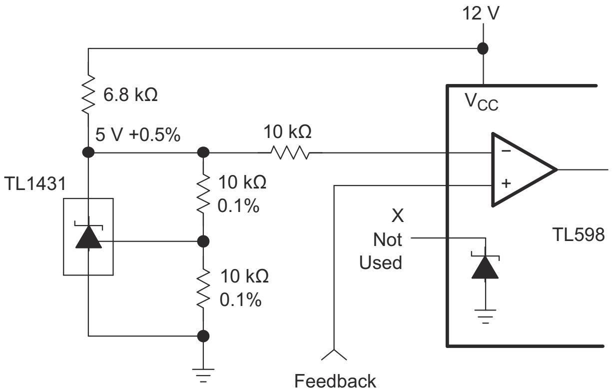
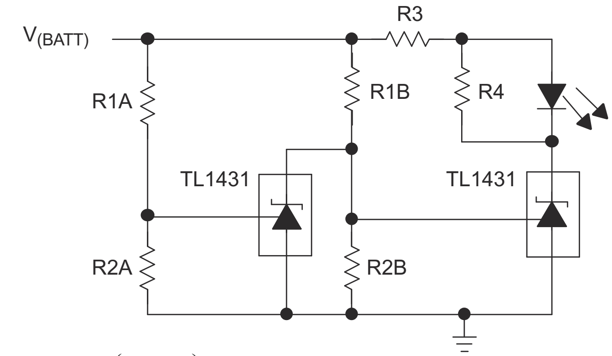


图 9-11. PWM Converter With 0.5% Reference



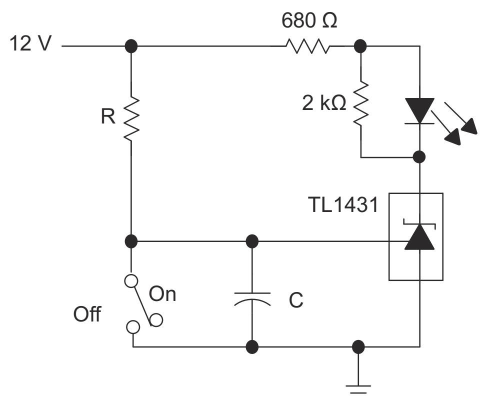
$$\text{Low Limit} = \left(1 + \frac{R1B}{R2B}\right) V_{I(ref)}$$

$$\text{High Limit} = \left(1 + \frac{R1A}{R2A}\right) V_{I(ref)}$$

LED on When
Low Limit < $V_{(BATT)}$ < High Limit

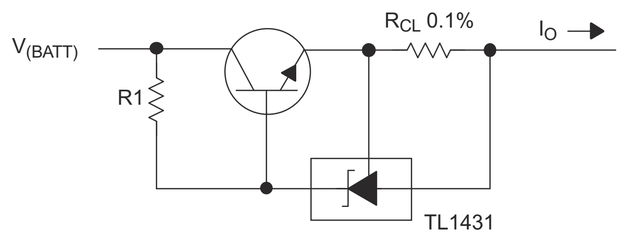
Select R3 and R4 to provide the desired LED intensity and cathode current ≥1 mA to the TL1431.

图 9-12. Voltage Monitor



$$\text{Delay} = R \times C \times I_I \frac{12\ \text{V}}{(12\ \text{V}) - V_{I(ref)}}$$

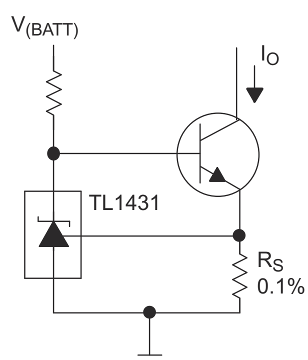
图 9-13. Delay Timer



$$I_O = \frac{V_{I(ref)}}{R_{CL}} + I_{KA}$$

$$R1 = \frac{V_{(BATT)}}{\left(\frac{I_O}{h_{FE}}\right) + I_{KA}}$$

图 9-14. Precision Current Limiter



$$I_O = \frac{V_{I(ref)}}{R_S}$$

图 9-15. Precision Constant-Current Sink

10 Power Supply Recommendations

When using TL1431 as a linear regulator to supply a load, designers typically use a bypass capacitor on the output/cathode pin. When doing this, be sure that the capacitance is within the stability criteria shown in 图 6-16. To not exceed the maximum cathode current, ensure the supply voltage is current limited. Also, be sure to limit the current being driven into the Ref pin, as not to exceed it's absolute maximum rating. For applications shunting high currents, pay attention to the cathode and anode trace lengths, adjusting the width of the traces to have the proper current density.

11 Layout

11.1 Layout Guidelines

Bypass capacitors must be placed as close to the part as possible. Current-carrying traces need to have widths appropriate for the amount of current they are carrying; in the case of the TL1431, these currents are low.

11.2 Layout Example

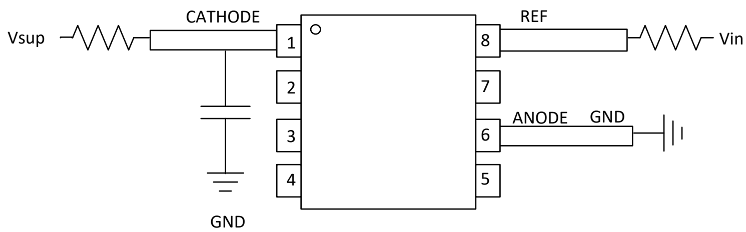


图 11-1. 8-Pin JG Layout Example

12 Device and Documentation Support

12.1 Documentation Support

12.1.1 Related Documentation

For related documentation see the following:

- Texas Instruments, *Understanding Stability Boundary Conditions Charts in TL431, TL432 Data Sheet* application report
- Texas Instruments, *Setting the Shunt Voltage on an Adjustable Shunt Regulator* application report

12.2 接收文档更新通知

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12.6 术语表

TI 术语表　　本术语表列出并解释了术语、首字母缩略词和定义。

13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
5962-9962001VPA	ACTIVE	CDIP	JG	8	50	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	9962001VPA TL1431M	Samples
5962R9962001VHA	ACTIVE	CFP	U	10	25	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	R9962001VHA TL1431M	Samples
5962R9962001VPA	ACTIVE	CDIP	JG	8	50	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	R9962001VPA TL1431M	Samples
TL1431U/EM	ACTIVE	CFP	U	10	25	Non-RoHS & Green	SNPB	N / A for Pkg Type	25 to 25	TL1431U/EM EVAL ONLY	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

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RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
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(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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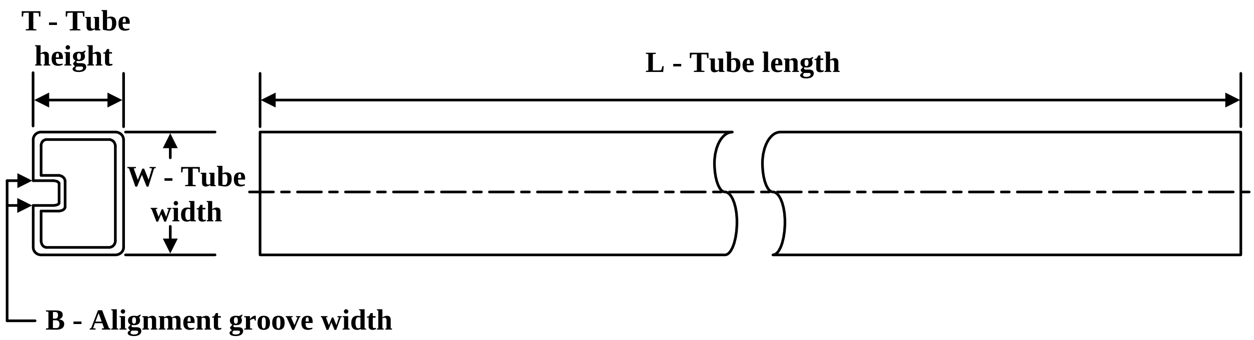
OTHER QUALIFIED VERSIONS OF TL1431-SP :

- Catalog : TL1431
- Automotive : TL1431-Q1
- Enhanced Product : TL1431-EP
- Military : TL1431M

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Enhanced Product - Supports Defense, Aerospace and Medical Applications
- Military - QML certified for Military and Defense Applications

TUBE



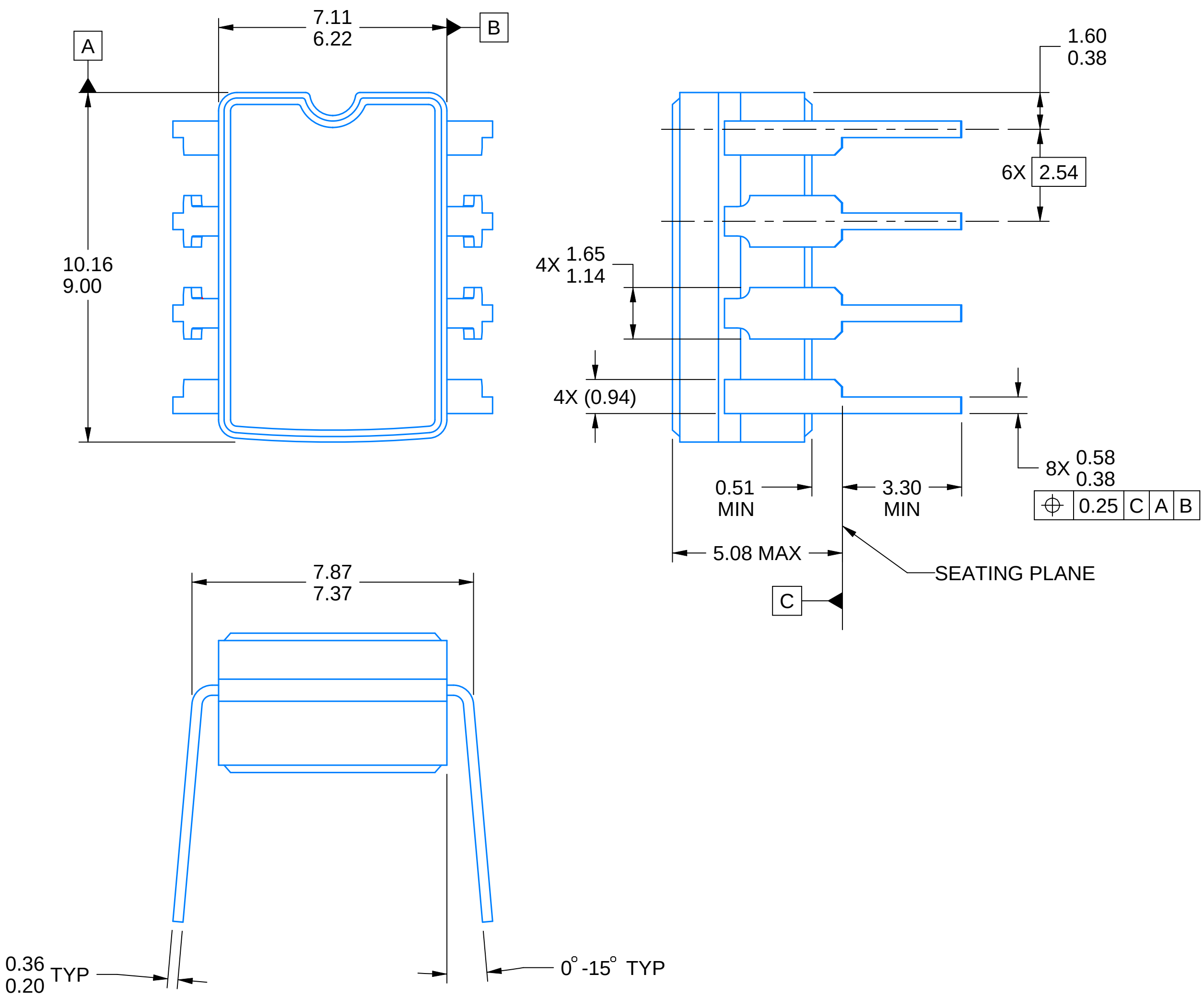
*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
5962R9962001VHA	U	CFP	10	25	506.98	26.16	6220	NA
5962R9962001VPA	JG	CDIP	8	50	506.98	15.24	13440	NA
TL1431U/EM	U	CFP	10	25	506.98	26.16	6220	NA

JG0008A

CDIP - 5.08 mm max height

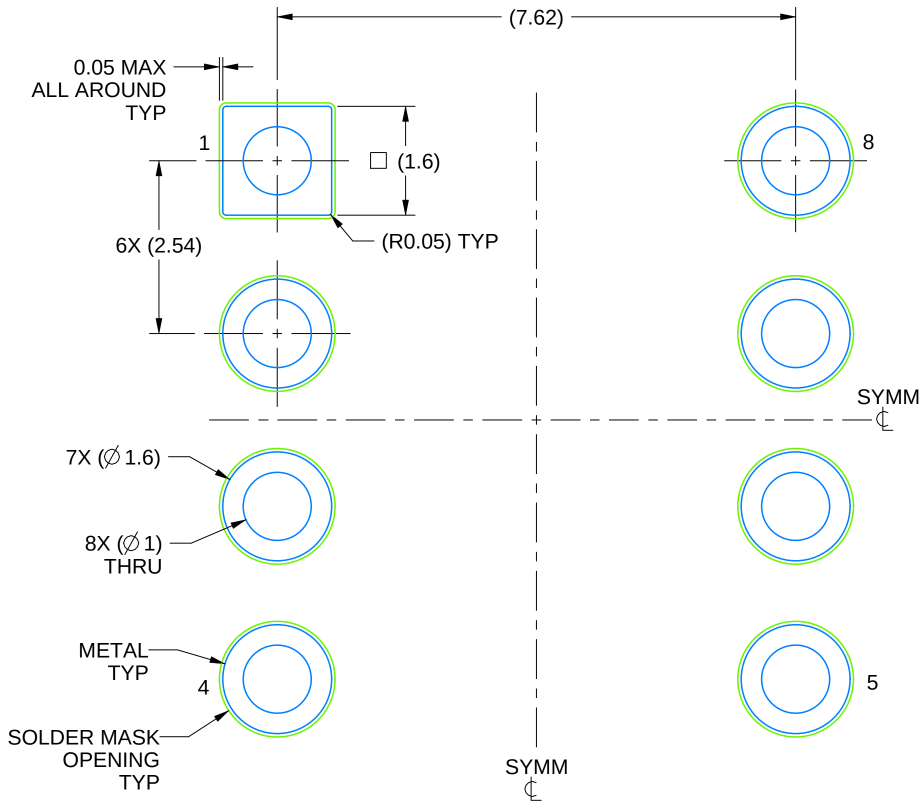
CERAMIC DUAL IN-LINE PACKAGE



4230036/A 09/2023

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package can be hermetically sealed with a ceramic lid using glass frit.
4. Index point is provided on cap for terminal identification.
5. Falls within MIL STD 1835 GDIP1-T8



LAND PATTERN EXAMPLE
NON SOLDER MASK DEFINED
SCALE: 9X

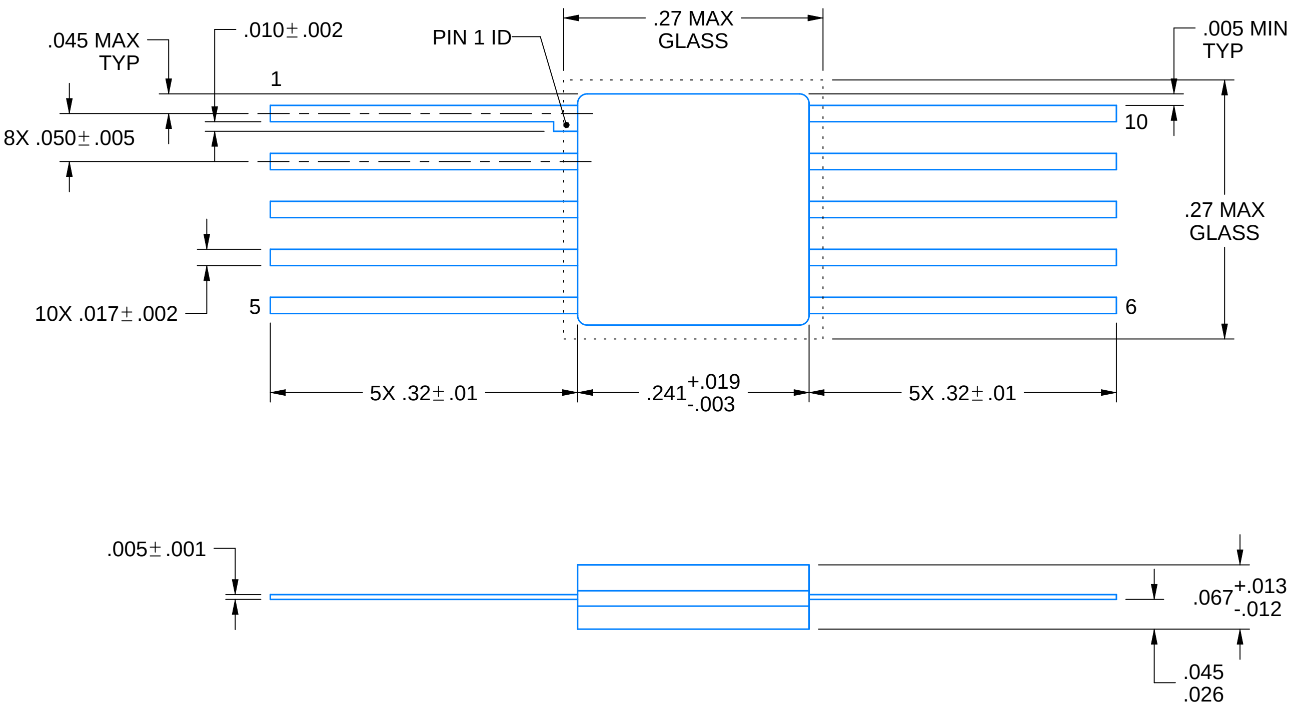
4230036/A 09/2023

PACKAGE OUTLINE

U0010A

CFP - 2.03 mm max height

CERAMIC FLATPACK



4225582/A 01/2020

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