

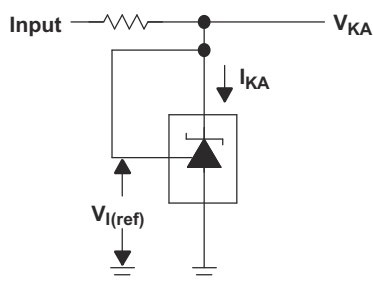
TL1431-SP クラス V、高精度プログラマブル・リファレンス

1 特長

- 100krad(Si) RHA、[5962R99620](#) に対して QMLV 認定済み
- 初期電圧の許容率: 0.4%
- 出力インピーダンス: 0.2Ω (代表値)
- 高速ターンオン: 500ns
- シンク電流容量: 1mA~100mA
- 低い基準電流 (REF)
- 可変出力電圧: $V_{I(\text{ref})} \sim 36V$

2 アプリケーション

- 調整可能な基準電圧および電流
- フライバック SMPS の 2 次側レギュレーション
- ツェナーの代替品
- 電圧監視
- 基準電圧内蔵のコンパレータ
- [コマンドとデータの処理 \(C&DH\)](#)
- [光学画像処理のペイロード](#)
- [レーダー画像処理ペイロード](#)
- [衛星用電源システム \(EPS\)](#)



簡略回路図

3 概要

TL1431 は高精度にプログラム可能な電圧リファレンスであり、該当する車載、民生、防衛用温度範囲全体にわたって熱的な安定性が規定されています。出力電圧は、2 つの外付け抵抗を使用して、 $V_{I(\text{ref})}$ (約 2.5V) と 36V の間の任意の値に設定できます。このデバイスの出力インピーダンスは 0.2Ω (代表値) です。このデバイスは、アクティブ出力回路による非常に鋭いターンオン特性を備えているため、オンボード・レギュレーション、可変電源、スイッチング電源などのアプリケーションにおいて、ツェナー・ダイオードやその他の電圧リファレンスの優れた代替品となります。

TL1431 デバイスは、防衛用温度範囲 -55°C~125°C 全体での動作が規定されています。

製品情報

部品番号 ⁽¹⁾	グレード	パッケージ
5962R9962001VPA	フライト・グレード RHA 100krad(Si)	8 ピン JG 重量: 0.87g ⁽²⁾
5962-9962001VPA	フライト・グレード・クラス V	
5962R9962001VHA	フライト・グレード RHA 100krad(Si)	10 ピン U 重量: 0.2g ⁽²⁾
TL1431U/EM	エンジニアリング・サンプル ⁽³⁾	EVM

- (1) 利用可能なパッケージについては、データシートの末尾にある注文情報を参照してください。
- (2) 重量の精度は ±10% です。
- (3) これらのユニットは、技術的な評価のみを目的としています。標準とは異なるフロー (バーンインがないなど) に従って処理されており、25°C の温度定格のみがテストされています。これらのユニットは、認定、量産、放射線テスト、航空での使用には適していません。部品は、MIL に規定されている温度範囲全体 (-55°C~125°C) にわたる性能も動作寿命全体にわたる性能も保証されていません。



Table of Contents

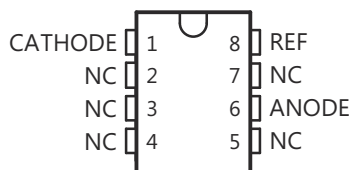
1 特長	1	8.4 Device Functional Modes.....	13
2 アプリケーション	1	9 Application and Implementation	14
3 概要	1	9.1 Application Information.....	14
4 Revision History	2	9.2 Typical Application.....	14
5 Pin Configuration and Functions	3	10 Power Supply Recommendations	20
6 Specifications	4	11 Layout	21
6.1 Absolute Maximum Ratings.....	4	11.1 Layout Guidelines.....	21
6.2 ESD Ratings.....	4	11.2 Layout Example.....	21
6.3 Recommended Operating Conditions.....	4	12 Device and Documentation Support	22
6.4 Thermal Information.....	4	12.1 Documentation Support.....	22
6.5 Electrical Characteristics.....	5	12.2 ドキュメントの更新通知を受け取る方法.....	22
6.6 Typical Characteristics.....	6	12.3 サポート・リソース.....	22
7 Parameter Measurement Information	11	12.4 Trademarks.....	22
8 Detailed Description	12	12.5 静電気放電に関する注意事項.....	22
8.1 Overview.....	12	12.6 用語集.....	22
8.2 Functional Block Diagram.....	12	13 Mechanical, Packaging, and Orderable Information	22
8.3 Feature Description.....	12		

4 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

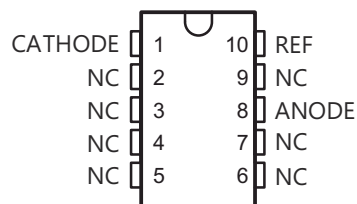
Changes from Revision B (September 2013) to Revision C (November 2020)	Page
• 「アプリケーション」セクション、「ピンの機能」表、「ESD 定格」表、「熱に関する情報」表、「詳細説明」セクション、「アプリケーションと実装」セクション、「電源に関する推奨事項」セクション、「レイアウト」セクション、「デバイスおよびドキュメントのサポート」セクション、「メカニカル、パッケージ、および注文情報」セクションを追加.....	1
• ドキュメント全体にわたって表、図、相互参照の採番方法を更新.....	1
• 「製品情報」表を更新.....	1
• Added U package pinout drawing.....	3

5 Pin Configuration and Functions



NC - No internal connection

**図 5-1. JG Package
8-Pin CDIP
Top View**



NC - No internal connection

**図 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 _{θJC}	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_{θJC}, and T_C. The maximum allowable power dissipation at any allowable case temperature is P_D = (T_{J(max)} – T_C) / R_{θJC}. 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, $I_{KA} = 10 \text{ mA}$ (unless otherwise noted)

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

(1) On products compliant to MIL-PRF-38535, this parameter is not production tested.

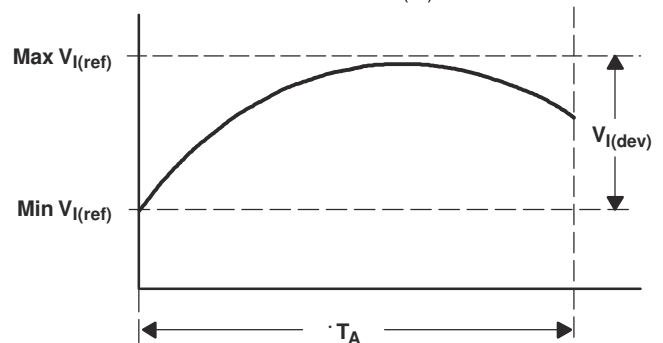
(2) Full range is -55°C to 125°C.

(3) The deviation parameters $V_{I(\text{dev})}$ and $I_{I(\text{dev})}$ 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 $\alpha_{V_{I(\text{ref})}}$ is defined as:

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

where:

ΔT_A is the rated operating temperature range of the device.



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

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

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

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

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.

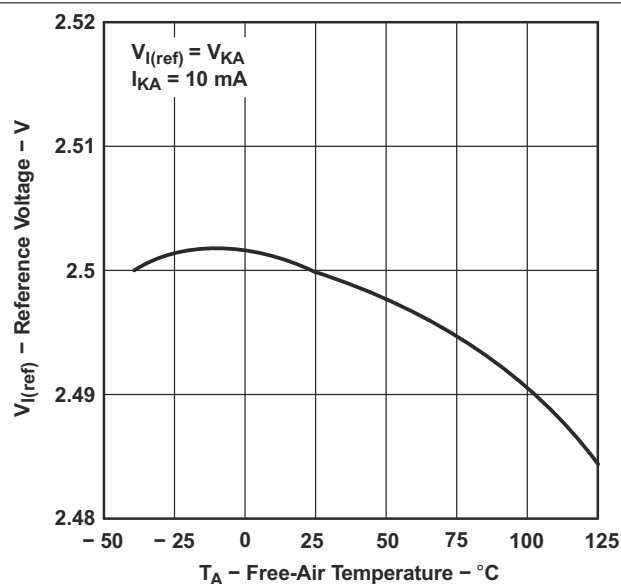


Figure 6-1. Reference Voltage vs Free-Air Temperature

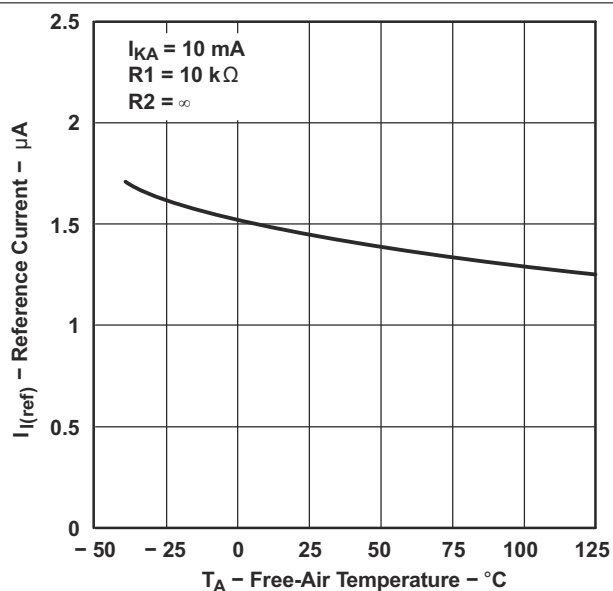


Figure 6-2. Reference Current vs Free-Air Temperature

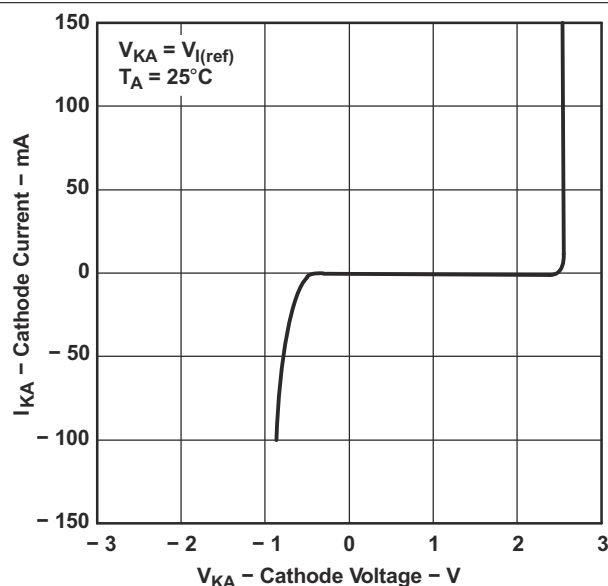


Figure 6-3. Cathode Current vs Cathode Voltage

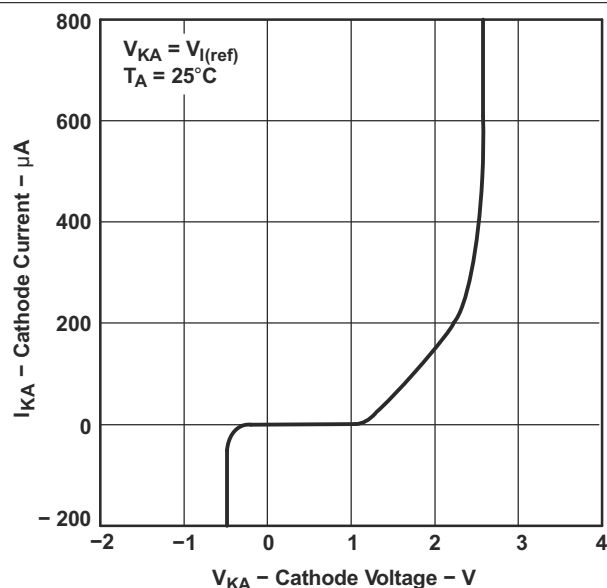
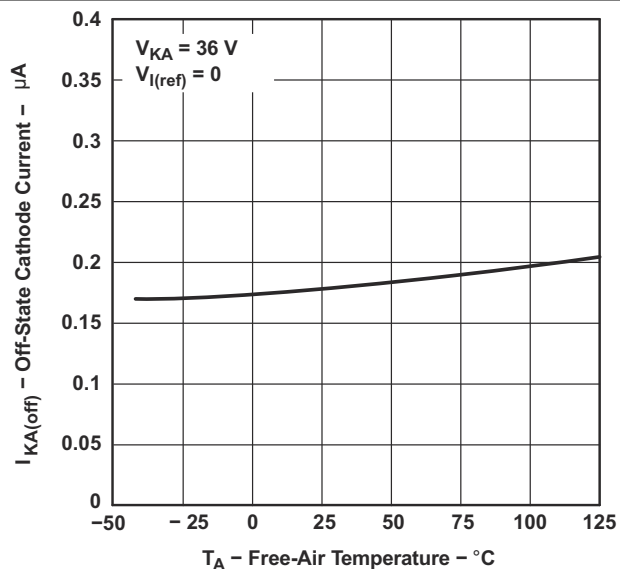
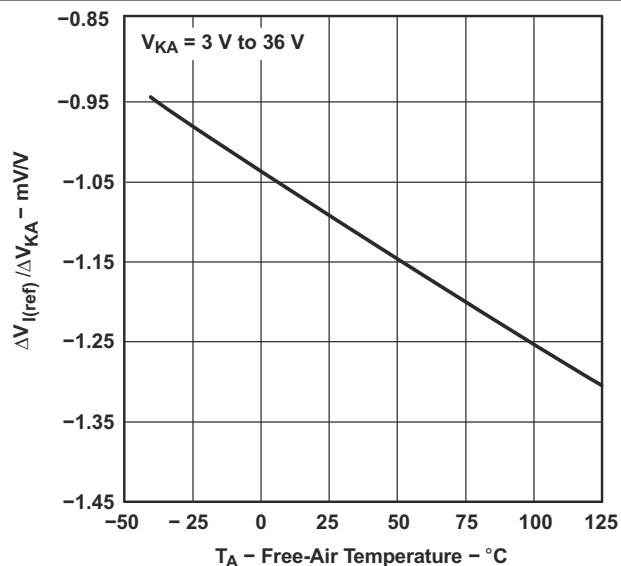


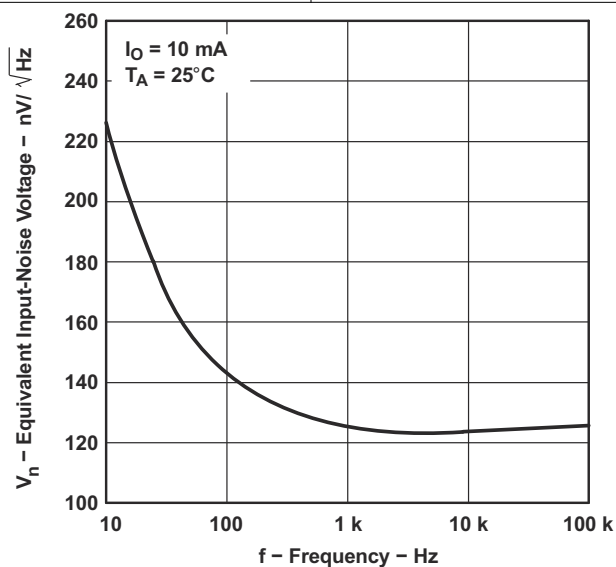
Figure 6-4. Cathode Current vs Cathode Voltage



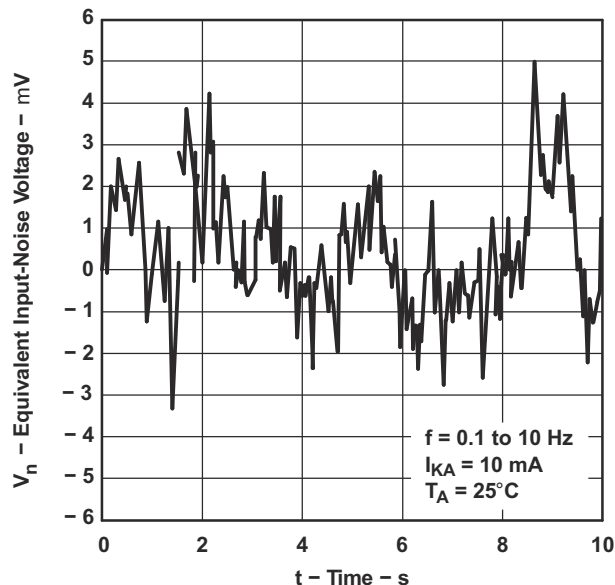
6-5. Off-State Cathode Current vs Free-Air Temperature



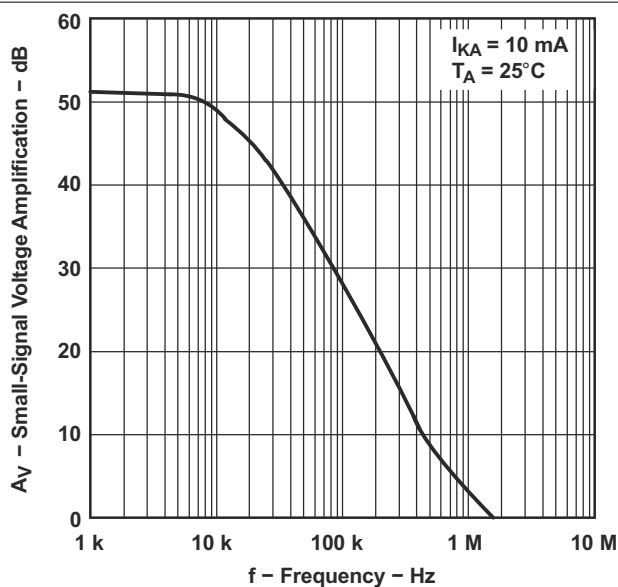
6-6. Ratio of Delta Reference Voltage to Delta Cathode Voltage vs Free-Air Temperature



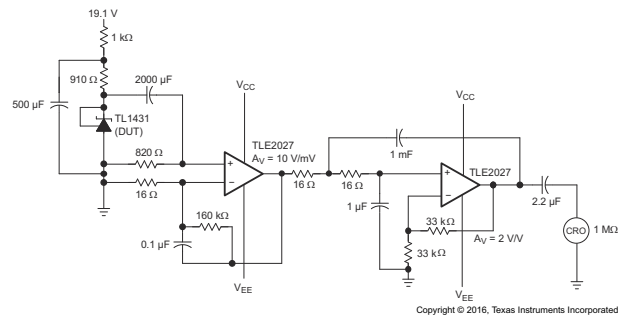
6-7. Equivalent Input-Noise Voltage vs Frequency



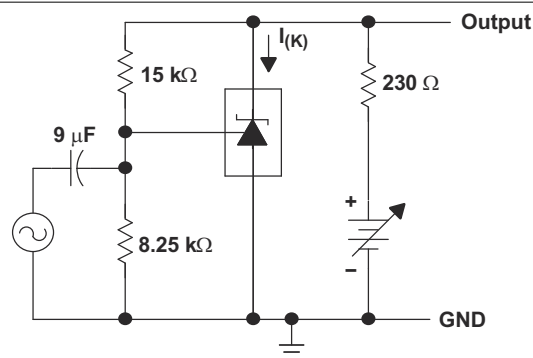
6-8. Equivalent Input-Noise Voltage Over a 10-s Period



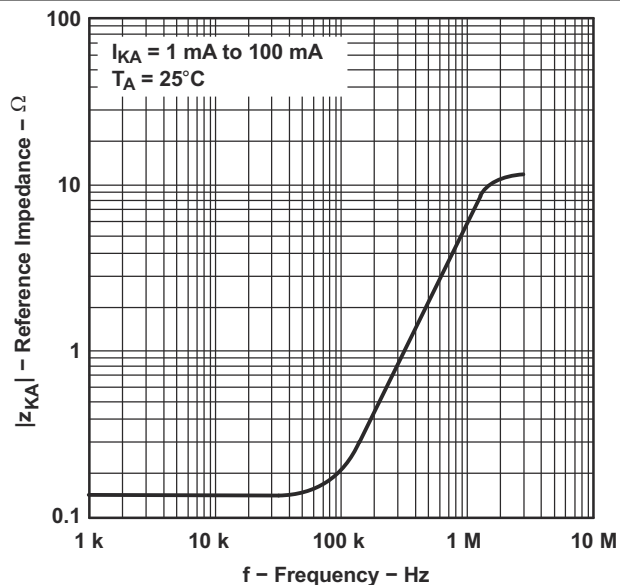
6-10. Small-Signal Voltage Amplification vs Frequency



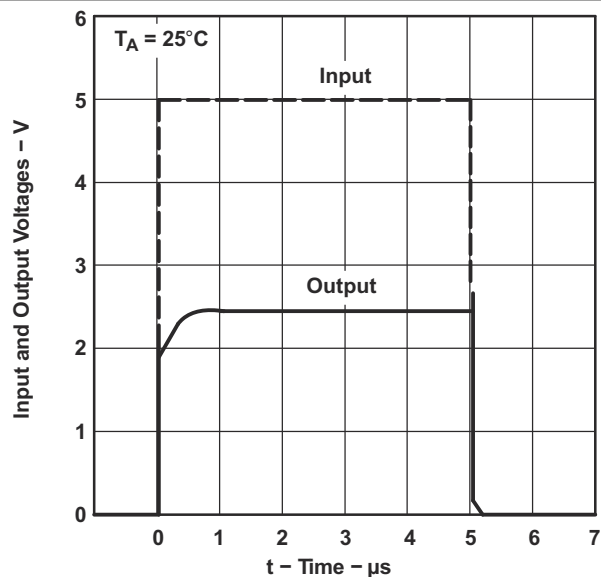
6-9. Test Circuit for 0.1-Hz to 10-Hz Equivalent Input-Noise Voltage



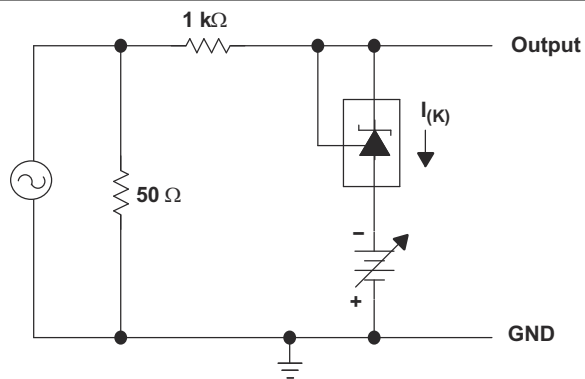
6-11. Test Circuit for Voltage Amplification



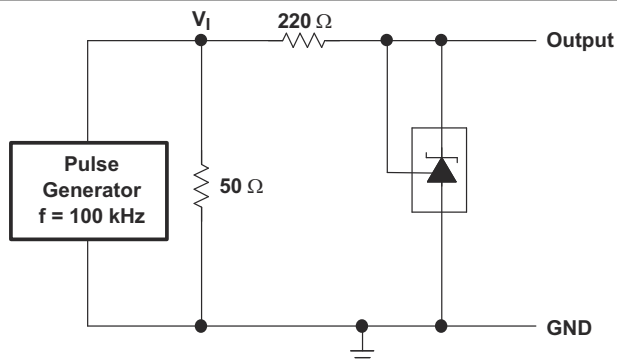
6-12. Reference Impedance vs Frequency



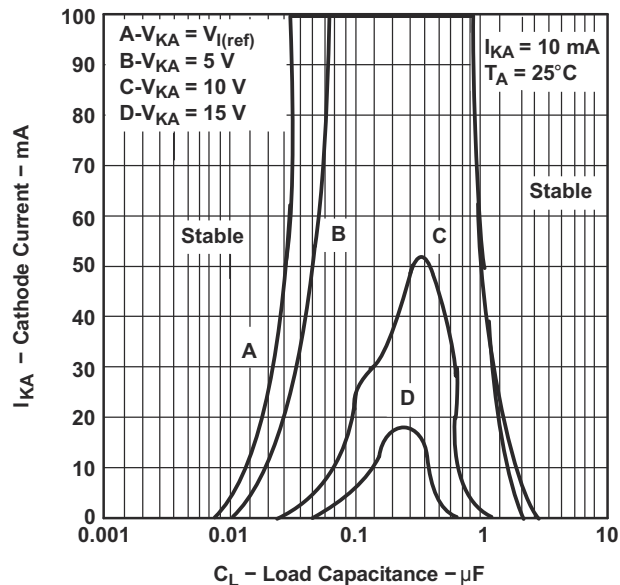
6-14. Pulse Response



6-13. Test Circuit for Reference Impedance

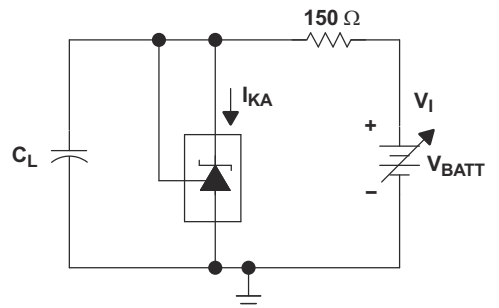


6-15. Test Circuit for Pulse Response

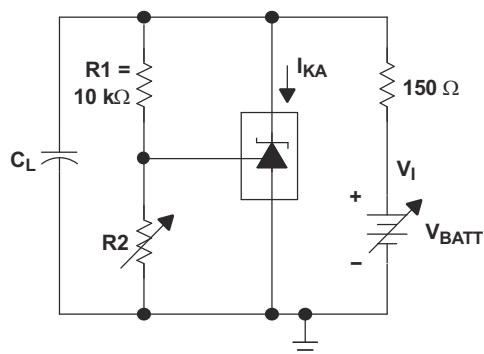


- A. The areas under the curves represent conditions that may cause the device to oscillate. For curves B, C, and D, R_2 and V_+ are adjusted to establish the initial V_{KA} and I_{KA} conditions, with $C_L = 0$. V_{BATT} and C_L then are adjusted to determine the ranges of stability.

FIG 6-16. Stability Boundary Conditions



Test Circuit for Curve A



Test Circuit for Curves B, C, and D

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

7 Parameter Measurement Information

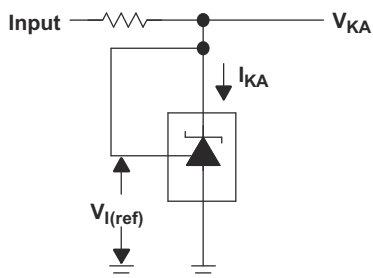


图 7-1. Test Circuit for $V_{(KA)} = V_{ref}$

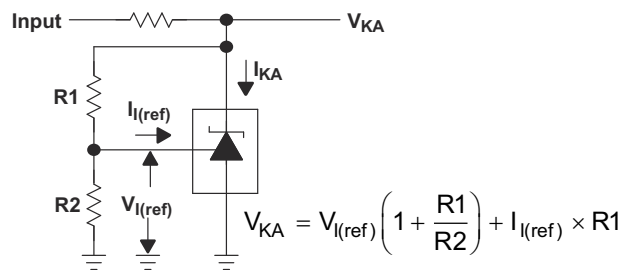


图 7-2. Test Circuit for $V_{(KA)} > V_{ref}$

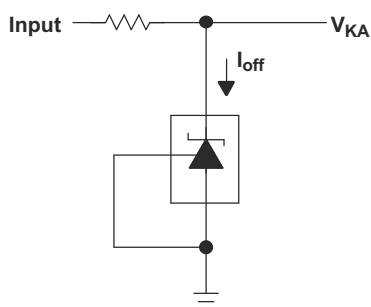


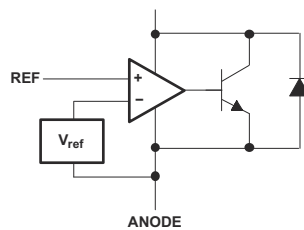
图 7-3. Test Circuit for I_{off}

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, $> 1 \text{ mA}$ ($I_{\text{min(max)}}$) 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 ($\geq 2.5 \text{ V}$) and cathode current (I_{KA}), TL1431 forces the reference pin to 2.5 V. However, the reference pin can not be left floating, as it needs $I_{\text{REF}} \geq 5 \mu\text{A}$ (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.

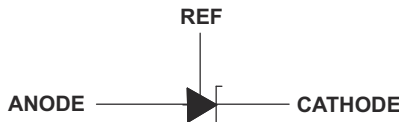
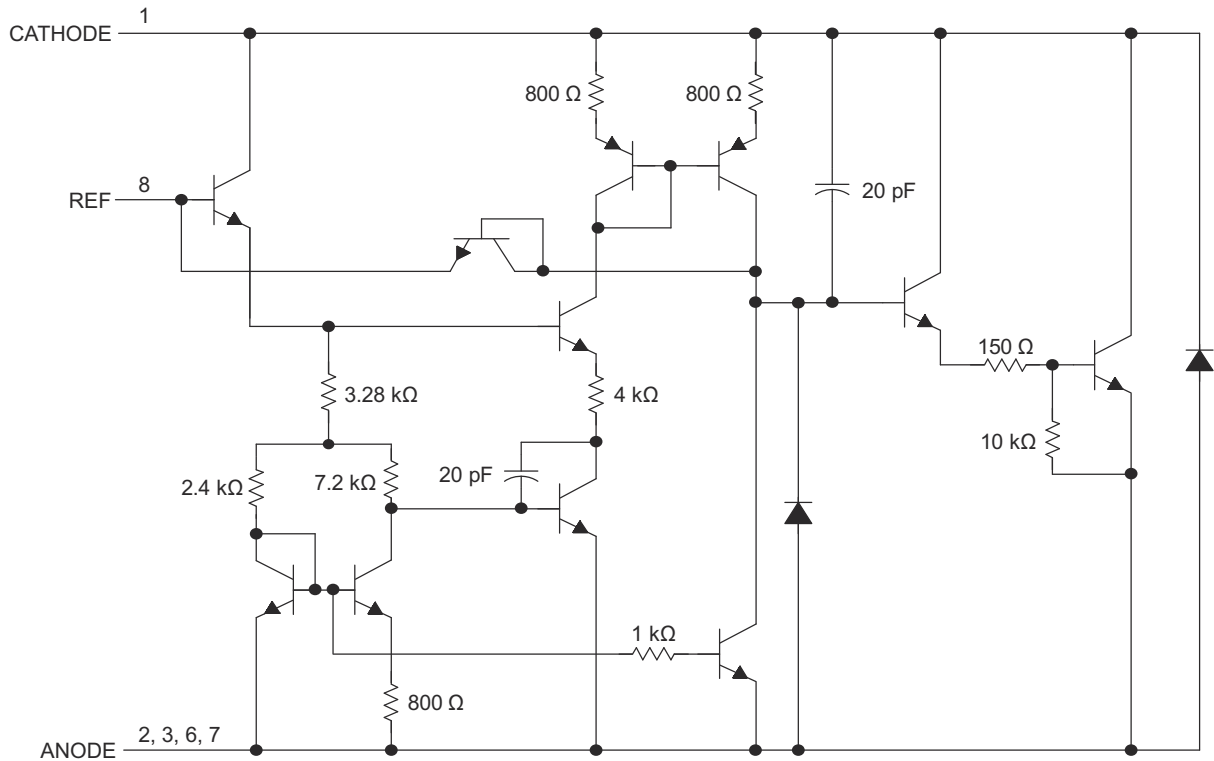


图 8-1. Symbol



Copyright © 2016, Texas Instruments Incorporated

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

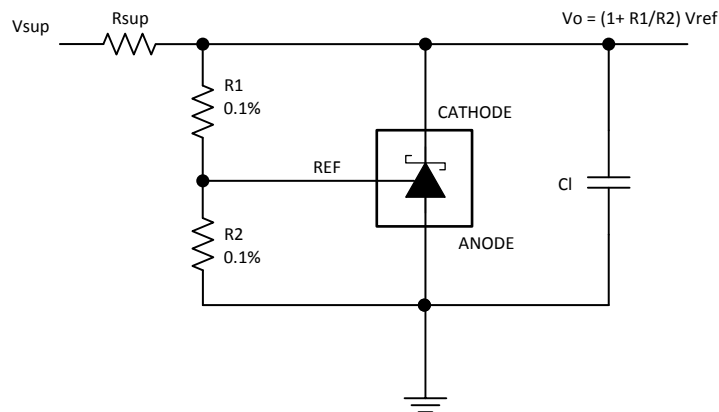
注

以下のアプリケーション情報は、TI の製品仕様に含まれるものではなく、TI ではその正確性または完全性を保証いたしません。個々の目的に対する製品の適合性については、お客様の責任で判断していただくことになります。お客様は自身の設計実装を検証しテストすることで、システムの機能を確認する必要があります。

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



Copyright © 2016, Texas Instruments Incorporated

図 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 μ A
Output voltage level	2.5 V to 36 V
Load capacitance	1 nF
Feedback resistor values and accuracy (R1 and R2)	10 k Ω

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 [図 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 [図 9-1](#). The cathode voltage can be more accurately determined by taking in to account the cathode current with [式 1](#).

$$V_o = (1 + R_1 / R_2) \times V_{REF} - I_{REF} \times R_1 \quad (1)$$

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 [セクション 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
- $\Delta V_{REF} / \Delta V_{KA}$ – 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.

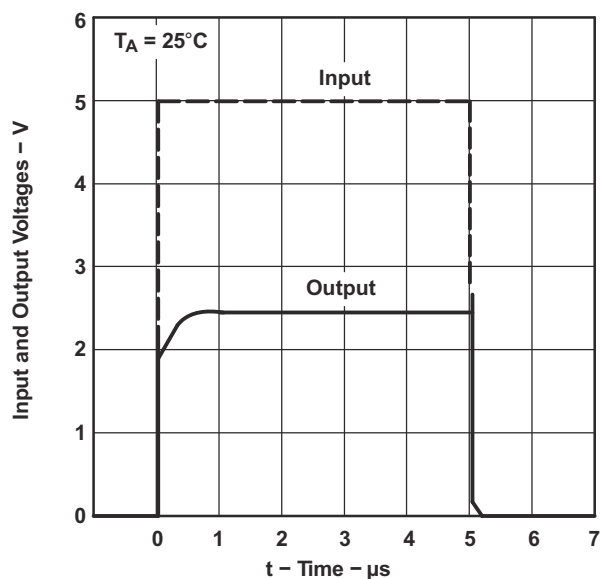
9.2.5 Stability

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 [図 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 [図 6-16](#).

9.2.6 Start-up Time

As shown in [図 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



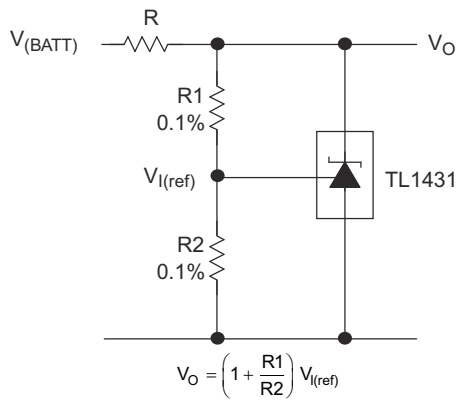
9-2. TL1431 Start-up Response

9.2.8 System Examples

表 9-2 lists example circuits of the TL1431.

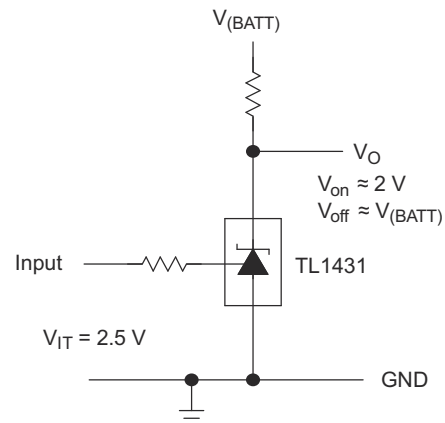
表 9-2. Table of Example Circuits

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



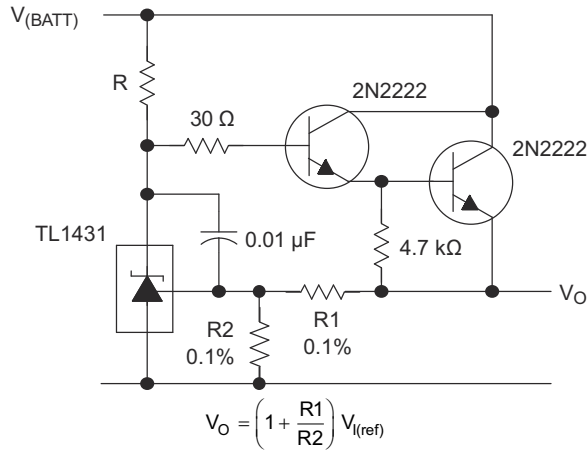
Copyright © 2016, Texas Instruments Incorporated
R must provide cathode current ≥ 1 mA to the TL1431 at minimum $V_{(BATT)}$.

図 9-3. Shunt Regulator



Copyright © 2016, Texas Instruments Incorporated

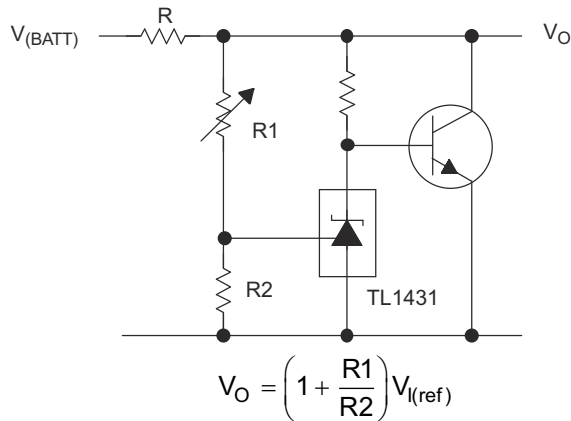
図 9-4. Single-Supply Comparator With Temperature-Compensated Threshold



Copyright © 2016, Texas Instruments Incorporated

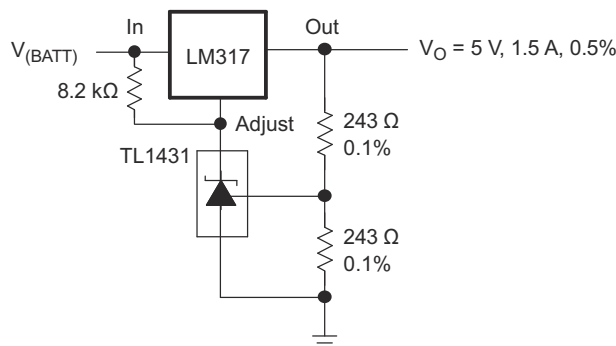
R must provide cathode current ≥ 1 mA to the TL1431 at minimum $V_{(BATT)}$.

Figure 9-5. Precision High-Current Series Regulator



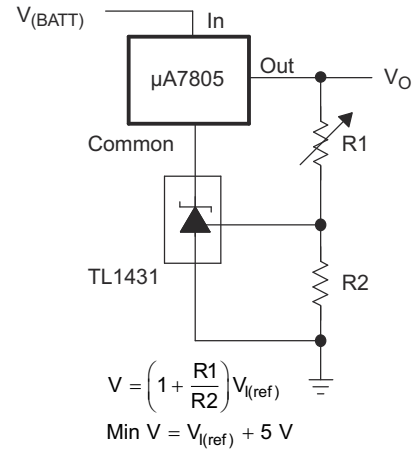
Copyright © 2016, Texas Instruments Incorporated

Figure 9-7. Higher-Current Shunt Regulator



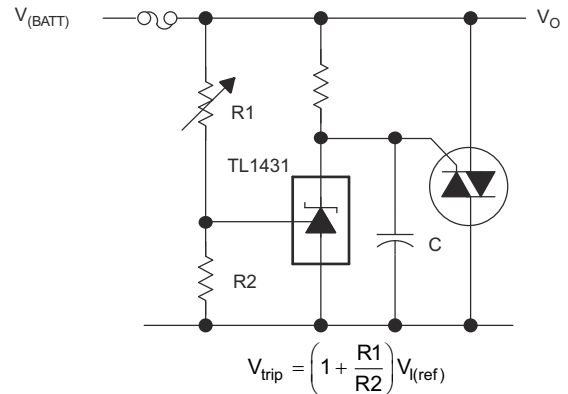
Copyright © 2016, Texas Instruments Incorporated

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



Copyright © 2016, Texas Instruments Incorporated

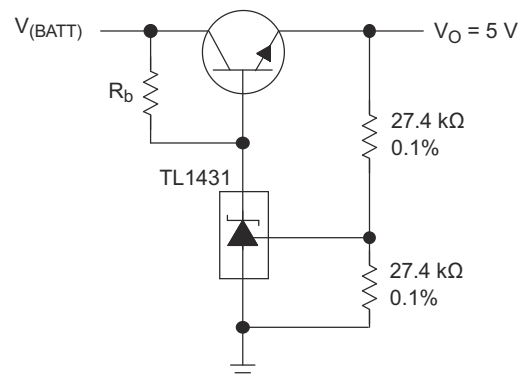
Figure 9-6. Output Control of a Three-Terminal Fixed Regulator



Copyright © 2016, Texas Instruments Incorporated

See the stability boundary conditions in [Figure 6-16](#) to determine allowable values for C.

Figure 9-8. Crowbar



Copyright © 2016, Texas Instruments Incorporated

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

Figure 9-10. 5-V Precision Regulator

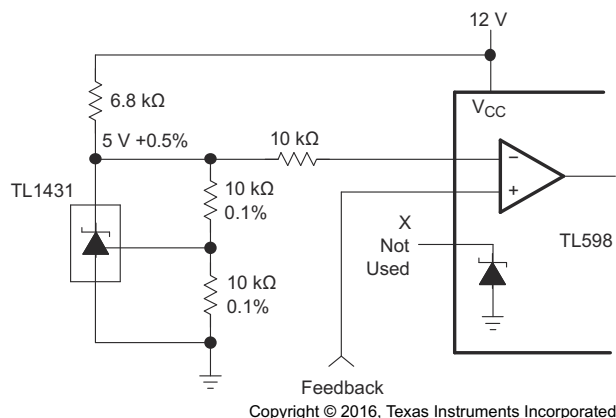
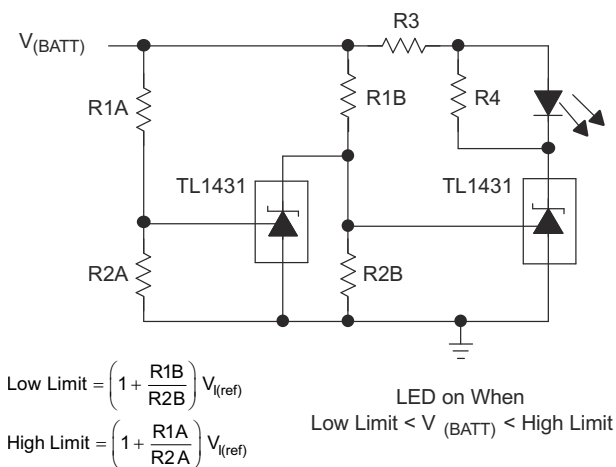
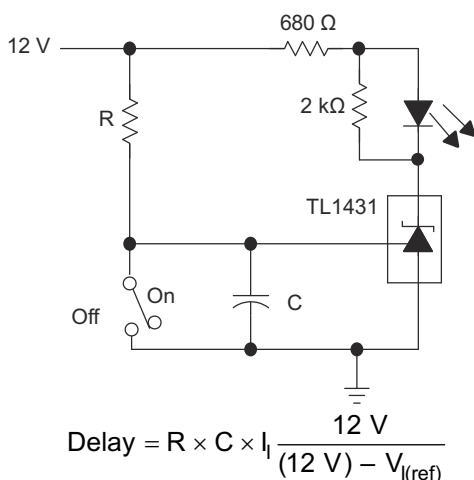


Figure 9-11. PWM Converter With 0.5% Reference



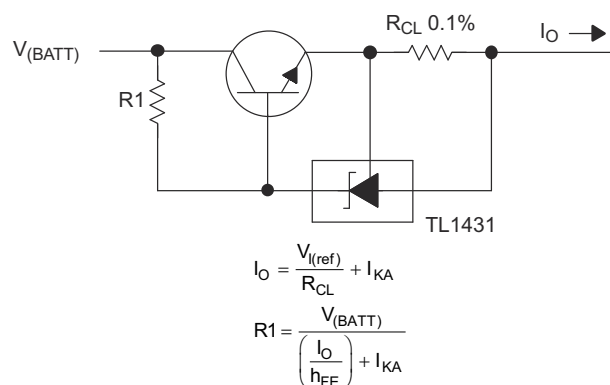
Select R3 and R4 to provide the desired LED intensity and cathode current ≥ 1 mA to the TL1431.

Figure 9-12. Voltage Monitor



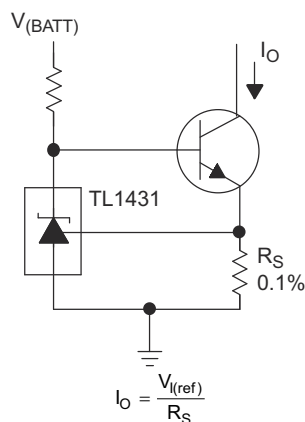
Copyright © 2016, Texas Instruments Incorporated

Figure 9-13. Delay Timer



Copyright © 2016, Texas Instruments Incorporated

Figure 9-14. Precision Current Limiter



Copyright © 2016, Texas Instruments Incorporated

Figure 9-15. Precision Constant-Current Sink

10 Power Supply Recommendations

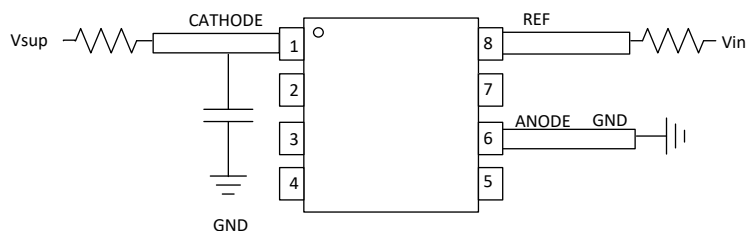
When using TL1431 as a linear regulator to supply a load, designers typically use a bypass capacitor on the output/cathode pin. When doing this, be sure that the capacitance is within the stability criteria shown in [Figure 6-16](#). To not exceed the maximum cathode current, ensure the supply voltage is current limited. Also, be sure to limit the current being driven into the Ref pin, as not to exceed its 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



✎ 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 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、ti.com のデバイス製品フォルダを開いてください。「更新の通知を受け取る」をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取れます。変更の詳細については、修正されたドキュメントに含まれている改訂履歴をご覧ください。

12.3 サポート・リソース

TI E2E™ サポート・フォーラムは、エンジニアが検証済みの回答と設計に関するヒントをエキスパートから迅速かつ直接得ることができる場所です。既存の回答を検索したり、独自の質問をしたりすることで、設計に必要な支援を迅速に得ることができます。

リンクされているコンテンツは、該当する貢献者により、現状のまま提供されるものです。これらは TI の仕様を構成するものではなく、必ずしも TI の見解を反映したものではありません。TI の[使用条件](#)を参照してください。

12.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.

すべての商標は、それぞれの所有者に帰属します。

12.5 静電気放電に関する注意事項



この IC は、ESD によって破損する可能性があります。テキサス・インスツルメンツは、IC を取り扱う際には常に適切な注意を払うことを推奨します。正しい ESD 対策をとらないと、デバイスを破損するおそれがあります。

ESD による破損は、わずかな性能低下からデバイスの完全な故障まで多岐にわたります。精密な IC の場合、パラメータがわずかに変化するだけで公表されている仕様から外れる可能性があるため、破損が発生しやすくなっています。

12.6 用語集

TI 用語集 この用語集には、用語や略語の一覧および定義が記載されています。

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 part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
5962-9962001VPA	Active	Production	CDIP (JG) 8	50 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	9962001VPA TL1431M
5962-9962001VPA.A	Active	Production	CDIP (JG) 8	50 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	9962001VPA TL1431M
5962R9962001VHA	Active	Production	CFP (U) 10	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	R9962001VHA TL1431M
5962R9962001VHA.A	Active	Production	CFP (U) 10	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	R9962001VHA TL1431M
5962R9962001VPA	Active	Production	CDIP (JG) 8	50 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	R9962001VPA TL1431M
5962R9962001VPA.A	Active	Production	CDIP (JG) 8	50 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	R9962001VPA TL1431M
TL1431U/EM	Active	Production	CFP (U) 10	25 TUBE	No	SNPB	N/A for Pkg Type	25 to 25	TL1431U/EM EVAL ONLY
TL1431U/EM.A	Active	Production	CFP (U) 10	25 TUBE	No	SNPB	N/A for Pkg Type	25 to 25	TL1431U/EM EVAL ONLY

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts 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.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

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

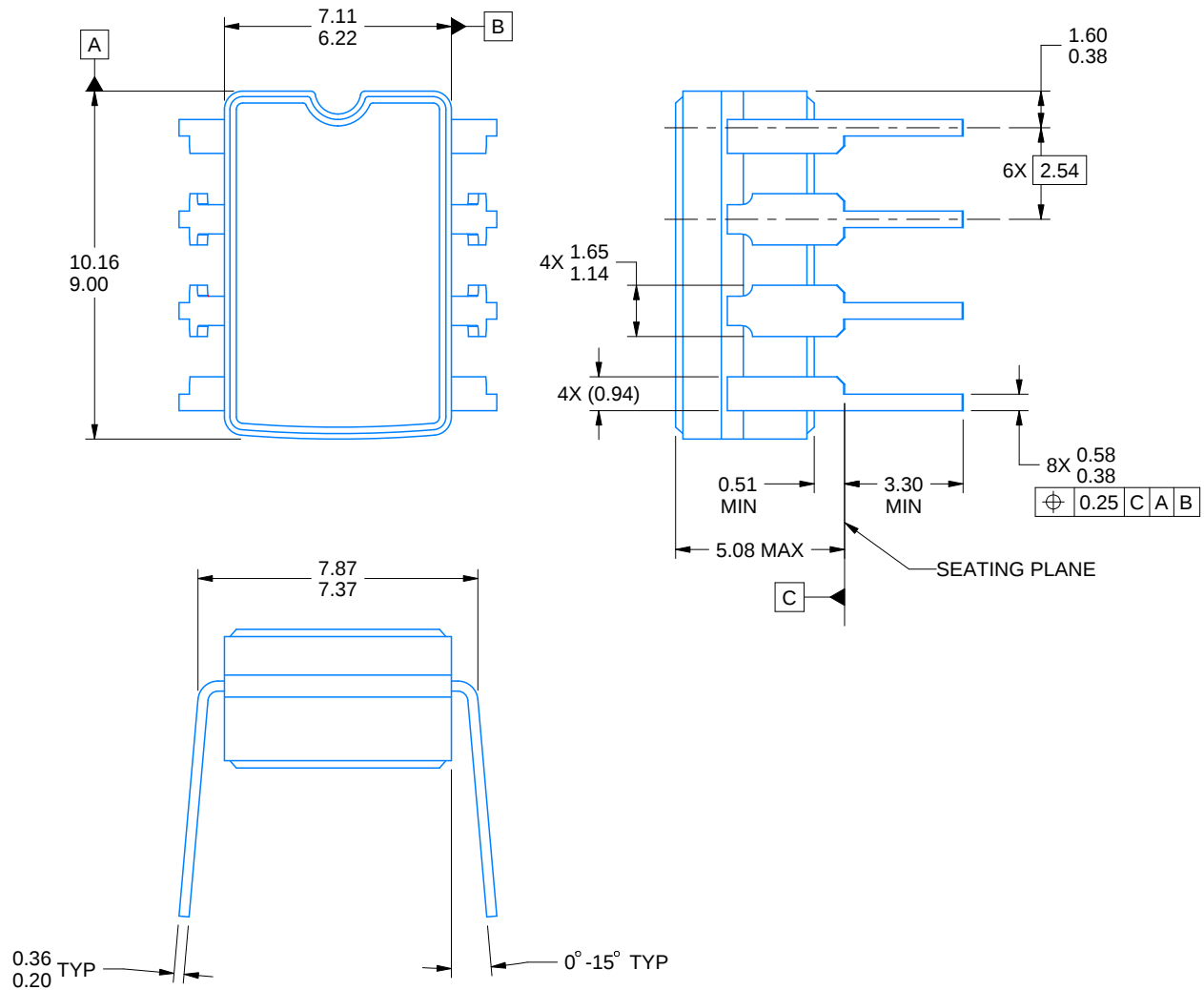
TUBE


*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
5962R9962001VHA.A	U	CFP	10	25	506.98	26.16	6220	NA
5962R9962001VPA	JG	CDIP	8	50	506.98	15.24	13440	NA
5962R9962001VPA.A	JG	CDIP	8	50	506.98	15.24	13440	NA
TL1431U/EM	U	CFP	10	25	506.98	26.16	6220	NA
TL1431U/EM.A	U	CFP	10	25	506.98	26.16	6220	NA

JG0008A**PACKAGE OUTLINE****CDIP - 5.08 mm max height**

CERAMIC DUAL IN-LINE PACKAGE



4230036/A 09/2023

NOTES:

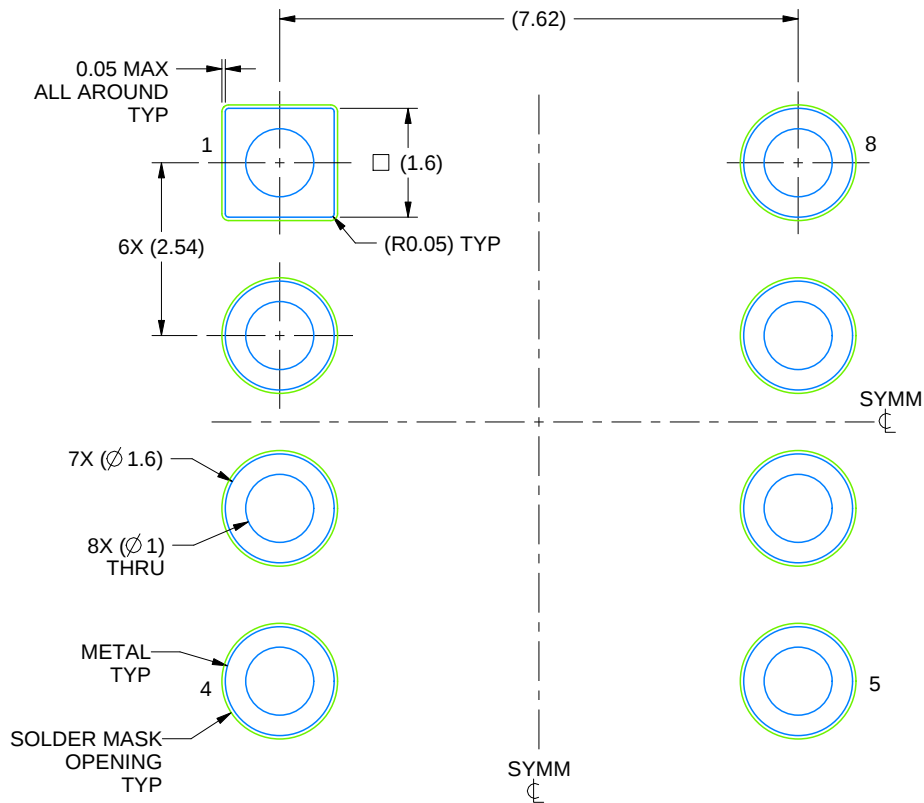
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package can be hermetically sealed with a ceramic lid using glass frit.
4. Index point is provided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

EXAMPLE BOARD LAYOUT

JG0008A

CDIP - 5.08 mm max height

CERAMIC DUAL IN-LINE PACKAGE



LAND PATTERN EXAMPLE
NON SOLDER MASK DEFINED
SCALE: 9X

4230036/A 09/2023

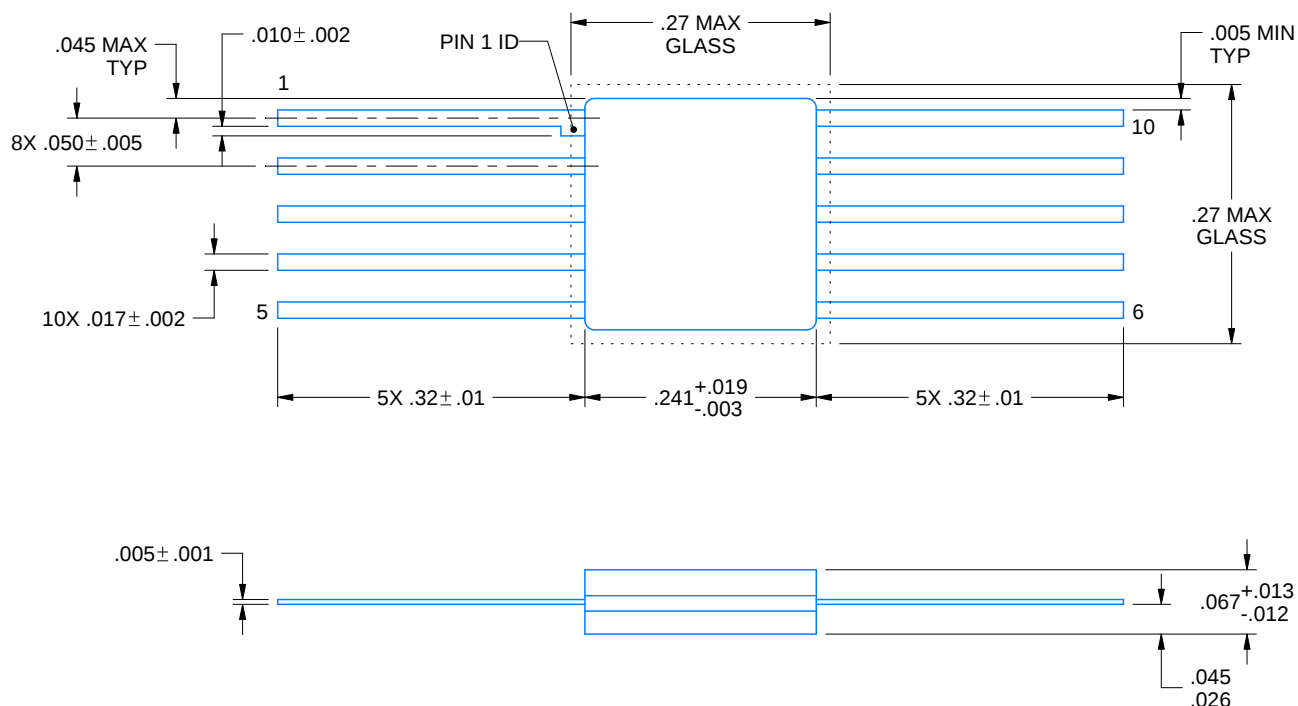
U0010A



PACKAGE OUTLINE

CFP - 2.03 mm max height

CERAMIC FLATPACK



4225582/A 01/2020

NOTES:

1. All linear dimensions are in inches. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

重要なお知らせと免責事項

TI は、技術データと信頼性データ (データシートを含みます)、設計リソース (リファレンス デザインを含みます)、アプリケーションや設計に関する各種アドバイス、Web ツール、安全性情報、その他のリソースを、欠陥が存在する可能性のある「現状のまま」提供しており、商品性および特定目的に対する適合性の黙示保証、第三者の知的財産権の非侵害保証を含みいかなる保証も、明示的または黙示的にかかわらず拒否します。

これらのリソースは、TI 製品を使用する設計の経験を積んだ開発者への提供を意図したものです。(1) お客様のアプリケーションに適した TI 製品の選定、(2) お客様のアプリケーションの設計、検証、試験、(3) お客様のアプリケーションに該当する各種規格や、その他のあらゆる安全性、セキュリティ、規制、または他の要件への確実な適合に関する責任を、お客様のみが単独で負うものとし、TI は一切の責任を拒否します。

上記の各種リソースは、予告なく変更される可能性があります。これらのリソースは、リソースで説明されている TI 製品を使用するアプリケーションの開発の目的でのみ、TI はその使用をお客様に許諾します。これらのリソースに関して、他の目的で複製することや掲載することは禁止されています。TI や第三者の知的財産権のライセンスが付与されている訳ではありません。お客様は、これらのリソースを自身で使用した結果発生するあらゆる申し立て、損害、費用、損失、責任について、TI およびその代理人を完全に補償するものとし、TI は一切の責任を拒否します。

TI の製品は、[TI の販売条件](#)、[TI の総合的な品質ガイドライン](#)、[ti.com](#) または TI 製品などに関連して提供される他の適用条件に従い提供されます。TI がこれらのリソースを提供することは、適用される TI の保証または他の保証の放棄の拡大や変更を意味するものではありません。TI がカスタム、またはカスタマー仕様として明示的に指定していない限り、TI の製品は標準的なカタログに掲載される汎用機器です。

お客様がいかなる追加条項または代替条項を提案する場合も、TI はそれらに異議を唱え、拒否します。

Copyright © 2026, Texas Instruments Incorporated

最終更新日：2025 年 10 月