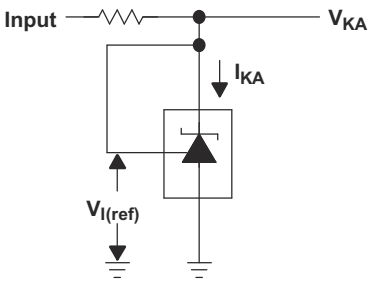
# TL1431-SP クラス V、高精度プログラマブル・リファレンス

## 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:$V_{I(ref)}$～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、$V_{I(ref)}$ (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℃～125℃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℃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℃～125℃) 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。

英語版の TI 製品についての情報を翻訳したこの資料は、製品の概要を確認する目的で便宜的に提供しているものです。該当する正式な英語版の最新情報は、www.ti.com で閲覧でき、その内容が常に優先されます。TI では翻訳の正確性および妥当性につきましては一切保証いたしません。実際の設計などの前には、必ず最新版の英語版をご参照くださいますようお願いいたします。

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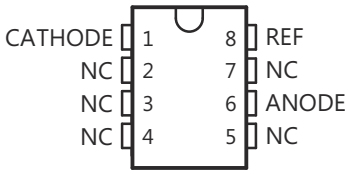
## 4 Revision History

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 |

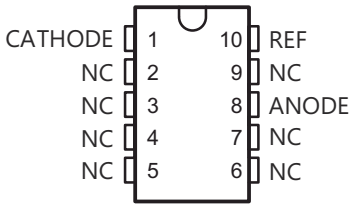

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## 5 Pin Configuration and Functions




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 |

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# 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.


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## 6.5 Electrical Characteristics

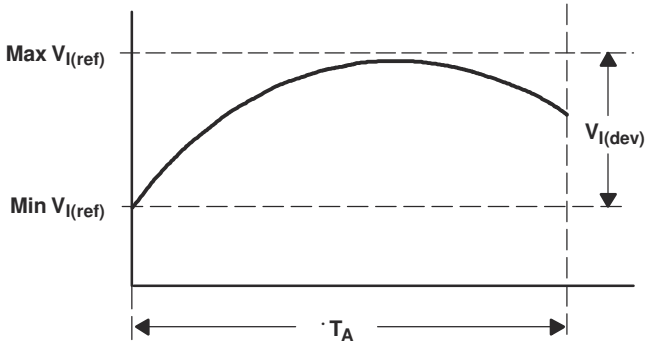
at specified free-air temperature, $I_{KA}$ = 10 mA (unless otherwise noted)

| 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 | 図 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 | 図 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 | $\Delta V_{KA}$ = 3 V to 36 V | Full range | 図 7-2 | | –1.1 | –2 | mV/V |
| $I_{I(ref)}$ | Reference input current | R1 = 10 kΩ, R2 = ∞ | 25°C | 図 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 | 図 7-2 | | 0.5 | 3(1) | μA |
| $I_{min}$ | Minimum cathode current for regulation | $V_{KA} = V_{I(ref)}$ | 25°C | 図 7-1 | | 0.45 | 1 | mA |
| $I_{off}$ | Off-state cathode current | $V_{KA}$ = 36 V, $V_{I(ref)}$ = 0 | 25°C | 図 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 | 図 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:

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

where:
$\Delta T_A$ 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 図 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.

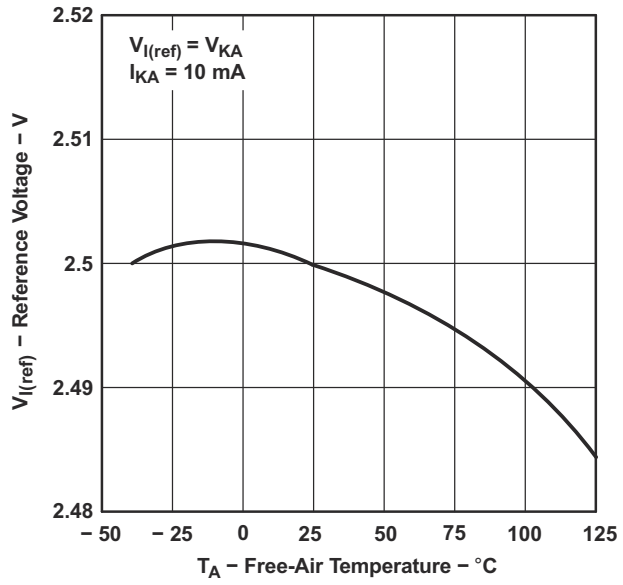



図 6-1. Reference Voltage vs Free-Air Temperature

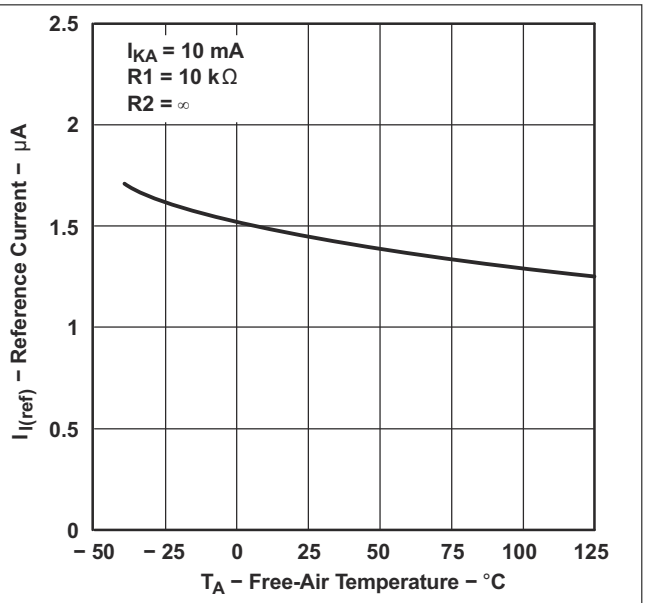



図 6-2. Reference Current vs Free-Air Temperature

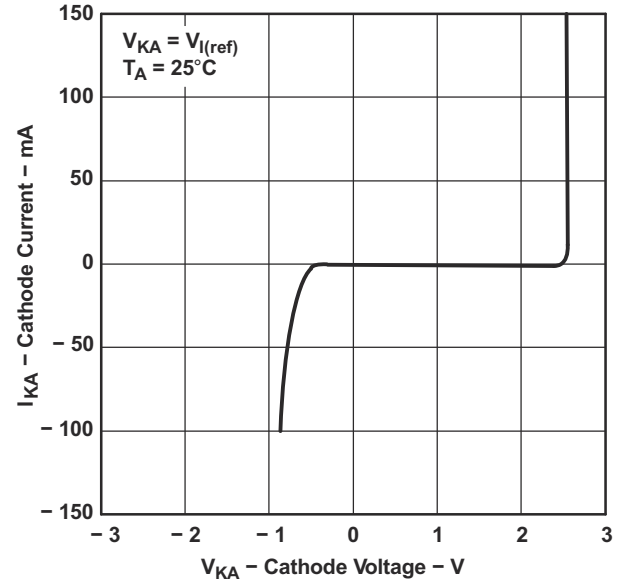



図 6-3. Cathode Current vs Cathode Voltage

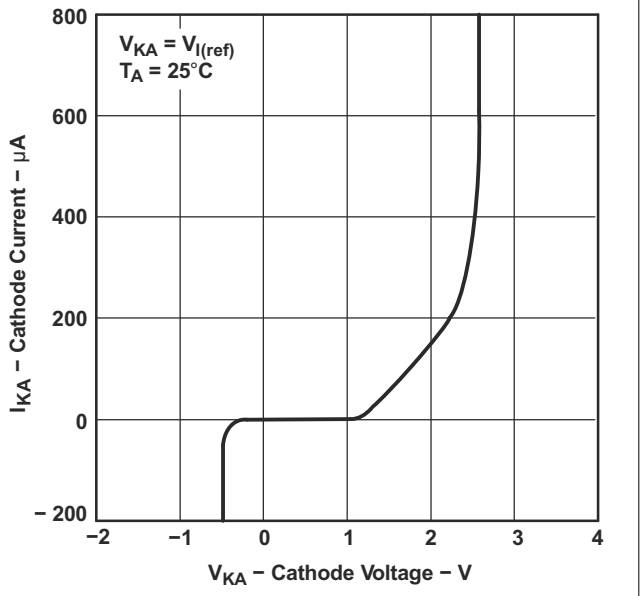



図 6-4. Cathode Current vs Cathode Voltage


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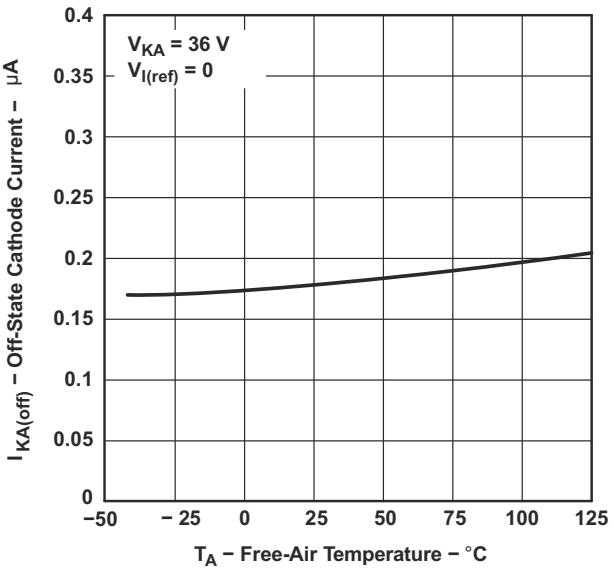



**図 6-5. Off-State Cathode Current vs Free-Air Temperature**

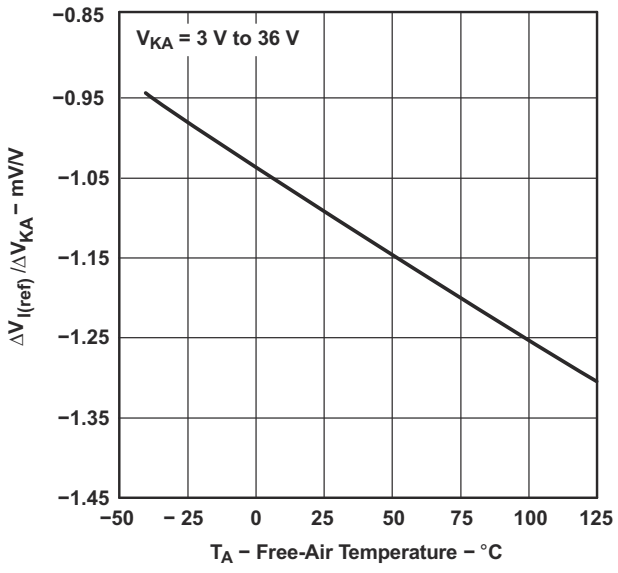



**図 6-6. Ratio of Delta Reference Voltage to Delta Cathode Voltage vs Free-Air Temperature**

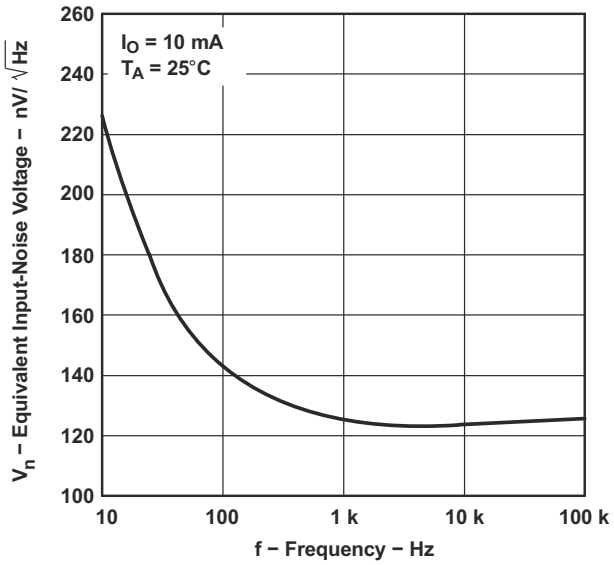



**図 6-7. Equivalent Input-Noise Voltage vs Frequency**

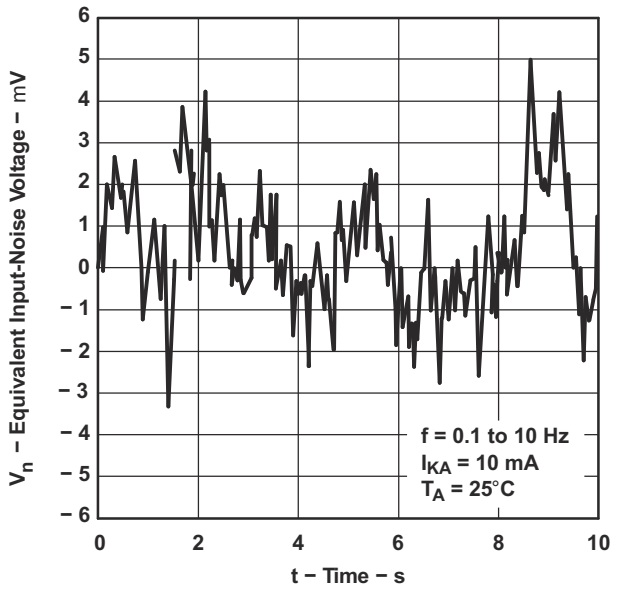



**図 6-8. Equivalent Input-Noise Voltage Over a 10-s Period**

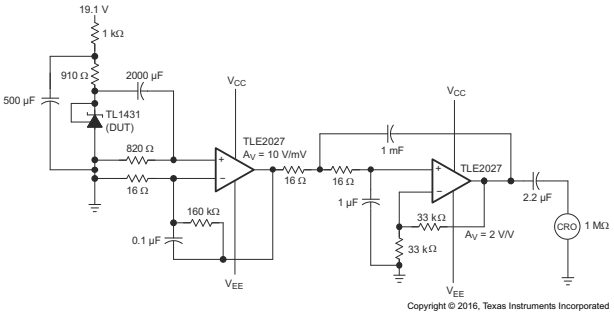



**図 6-9. Test Circuit for 0.1-Hz to 10-Hz Equivalent Input-Noise Voltage**

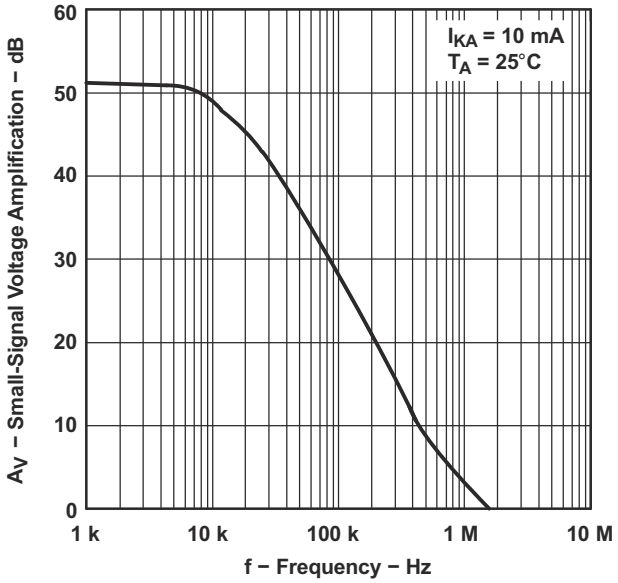



**図 6-10. Small-Signal Voltage Amplification vs Frequency**

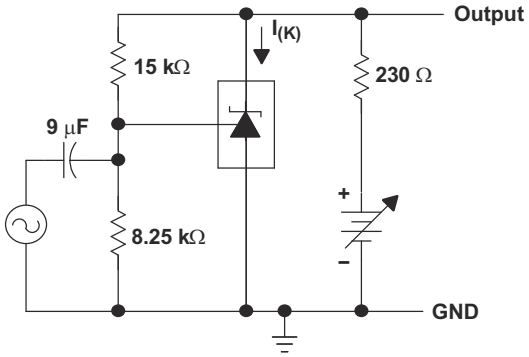



**図 6-11. Test Circuit for Voltage Amplification**


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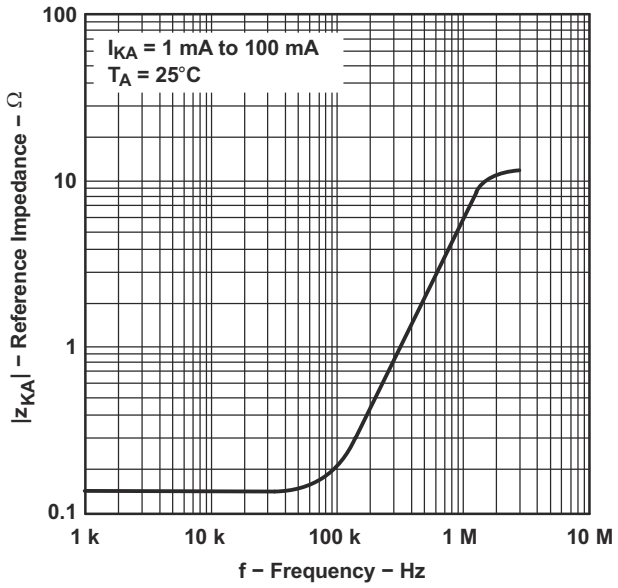



図 6-12. Reference Impedance vs Frequency

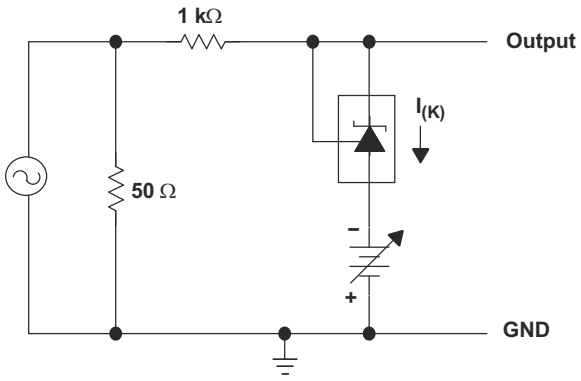



図 6-13. Test Circuit for Reference Impedance

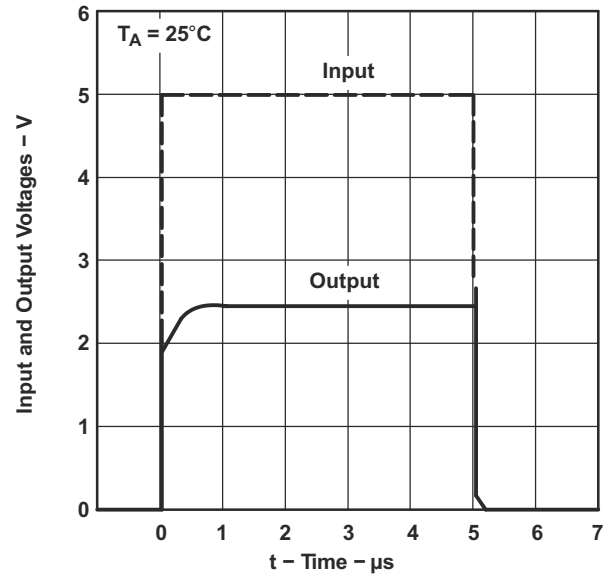



図 6-14. Pulse Response

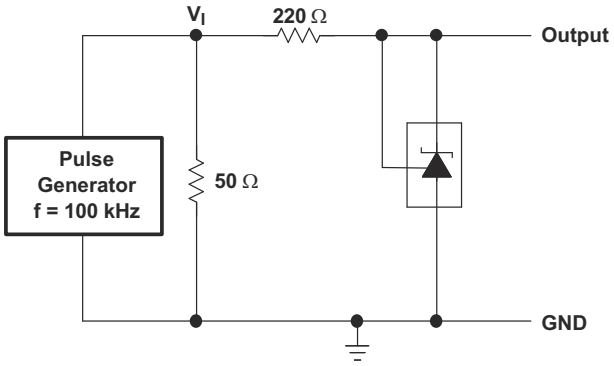
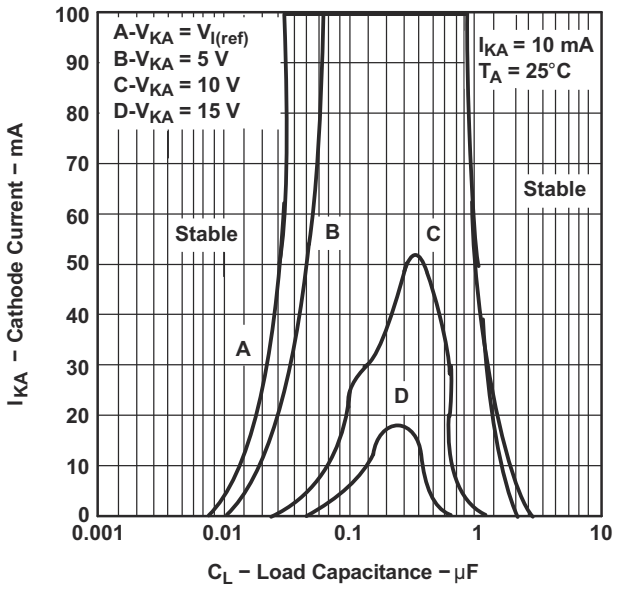



図 6-15. Test Circuit for Pulse Response




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.

**図 6-16. Stability Boundary Conditions**

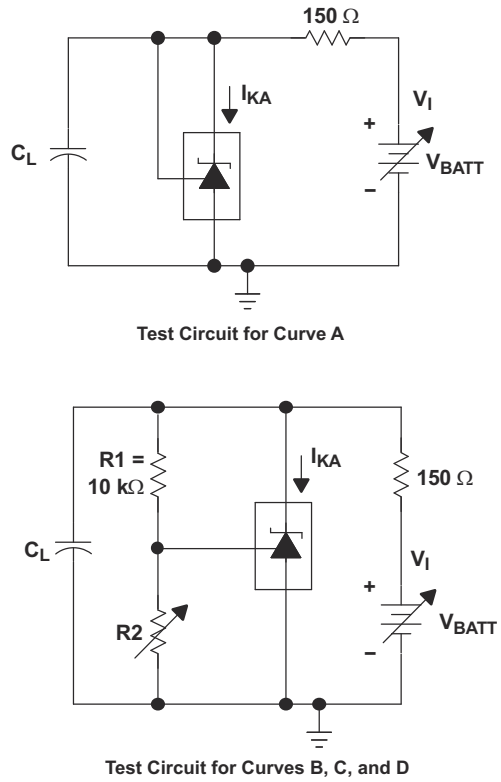



**図 6-17. Test Circuits for Curves A Through D**


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# 7 Parameter Measurement Information

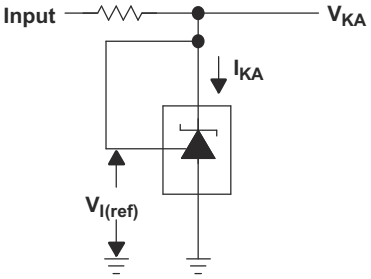



図 7-1. Test Circuit for $V_{(KA)} = V_{ref}$

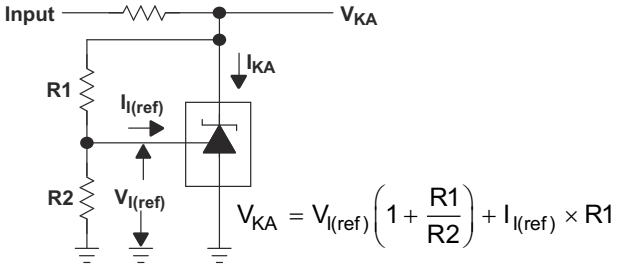



図 7-2. Test Circuit for $V_{(KA)} > V_{ref}$

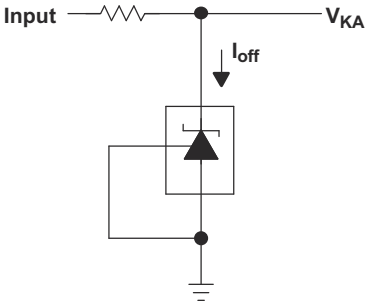


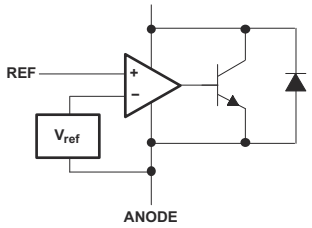

図 7-3. Test Circuit for $I_{off}$

# 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.

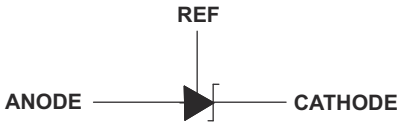



**図 8-1. Symbol**


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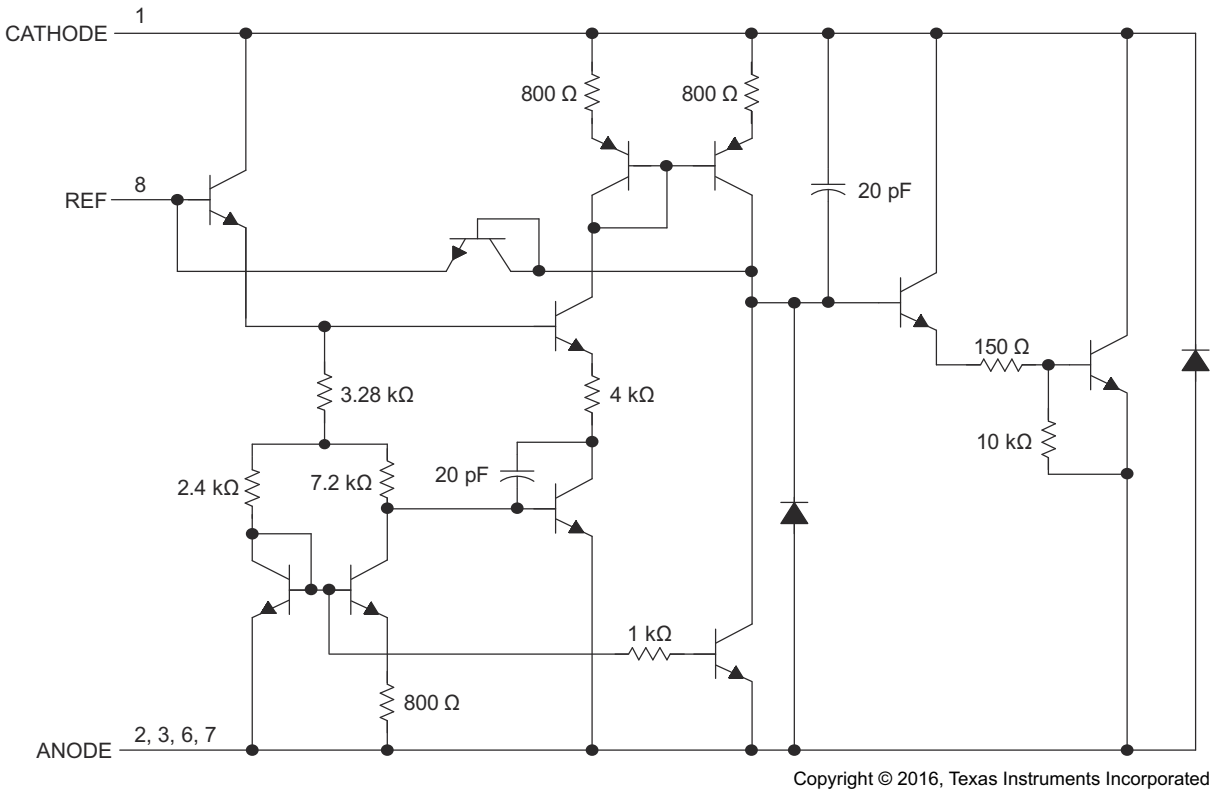



**図 8-2. Equivalent Schematic**

## 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 図 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.

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# 9 Application and Implementation

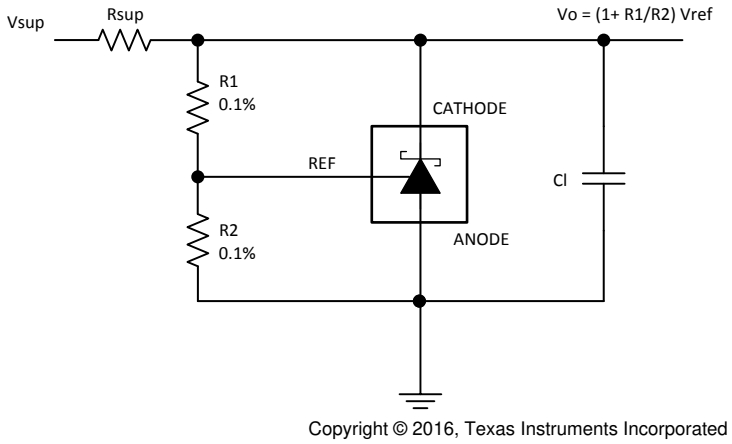
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## 9.1 Application Information

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




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**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 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


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- 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.

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

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 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.

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### 9.2.7 Application Curve

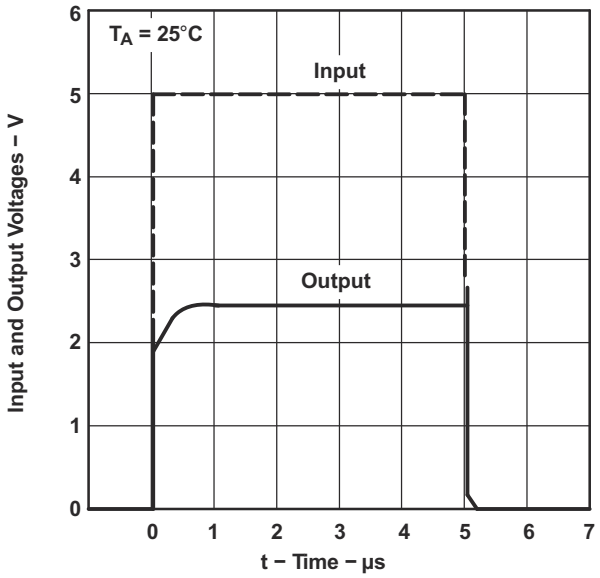



図 9-2. TL1431 Start-up Response

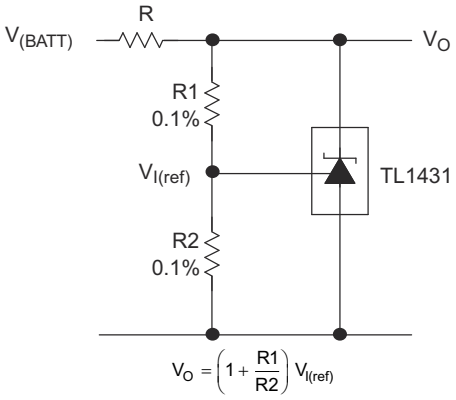

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### 9.2.8 System Examples

表 9-2 lists example circuits of the TL1431.

**表 9-2. Table of Example Circuits**

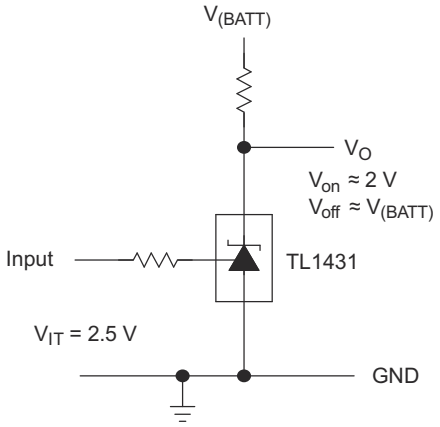
| APPLICATION | FIGURE |
|---|---|
| Shunt regulator | 図 9-3 |
| Single-supply comparator with temperature-compensated threshold | 図 9-4 |
| Precision high-current series regulator | 図 9-5 |
| Output control of a three-terminal fixed regulator | 図 9-6 |
| Higher-current shunt regulator | 図 9-7 |
| Crowbar | 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 |




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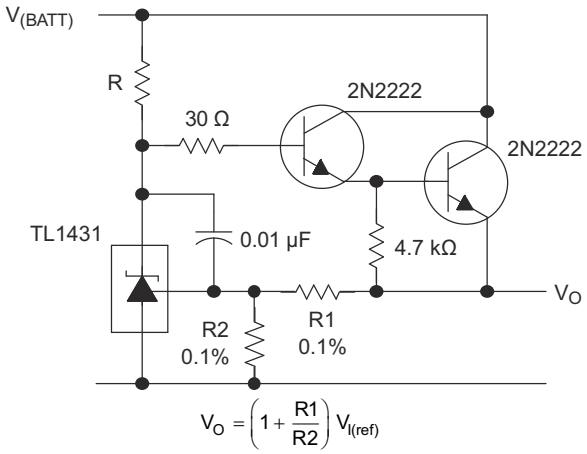
R must provide cathode current ≥1 mA to the TL1431 at minimum $V_{(BATT)}$.

**図 9-3. Shunt Regulator**




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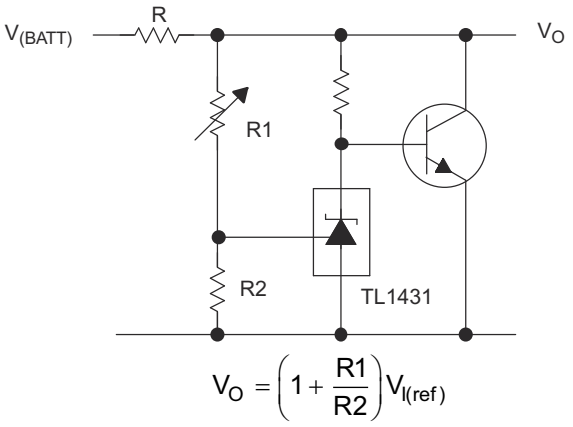
**図 9-4. Single-Supply Comparator With Temperature-Compensated Threshold**




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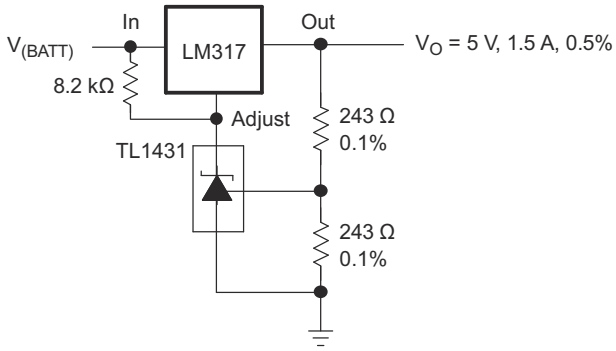
R must provide cathode current ≥1 mA to the TL1431 at minimum $V_{(BATT)}$.

**図 9-5. Precision High-Current Series Regulator**



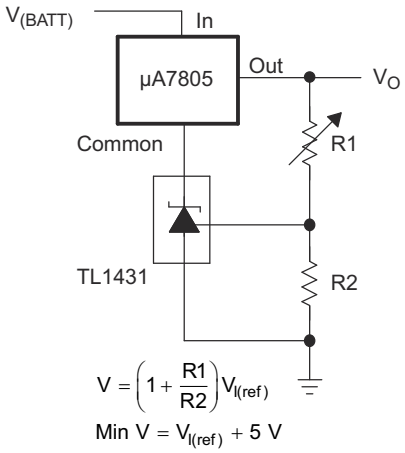

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**図 9-7. Higher-Current Shunt Regulator**



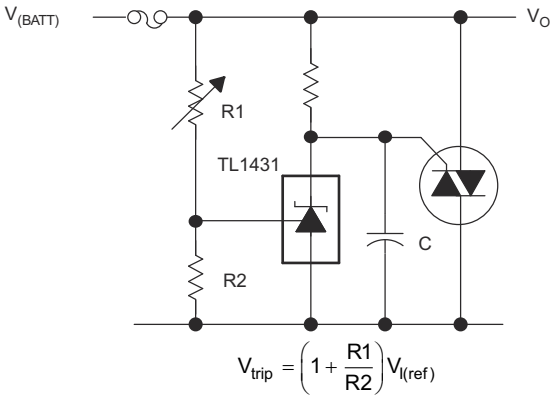

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**図 9-9. Precision 5-V, 1.5-A, 0.5% Regulator**




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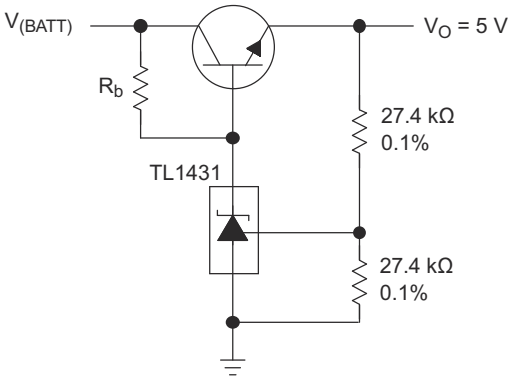
**図 9-6. Output Control of a Three-Terminal Fixed Regulator**




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

**図 9-8. Crowbar**

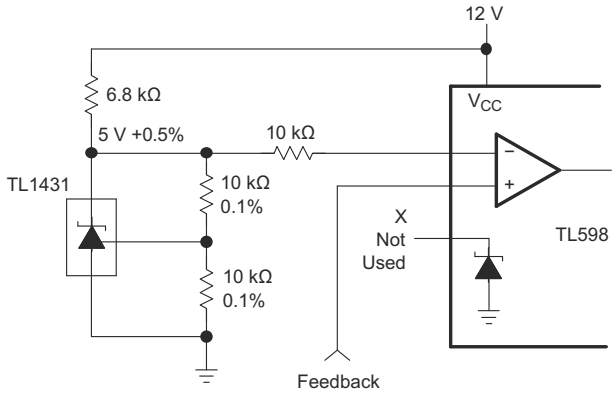



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$R_b$ must provide cathode current ≥1 mA to the TL1431.

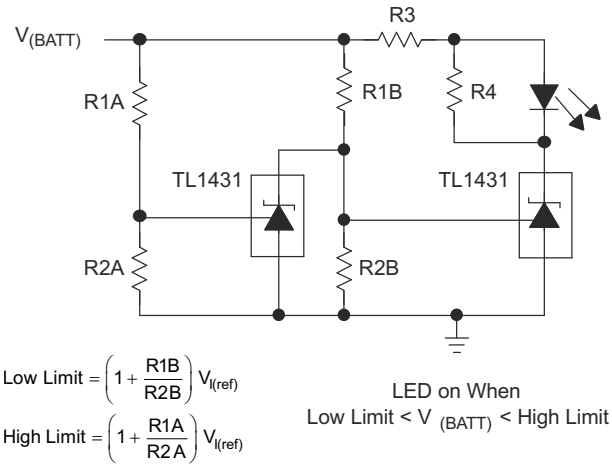
**図 9-10. 5-V Precision Regulator**


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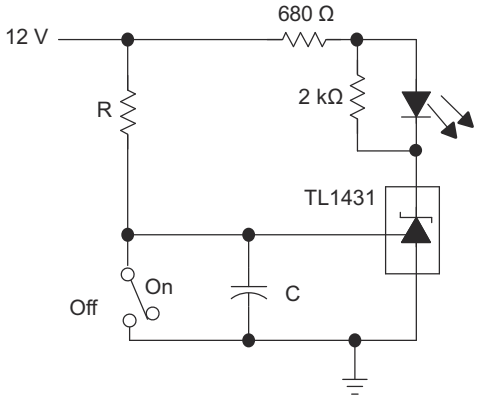
**図 9-11. PWM Converter With 0.5% Reference**




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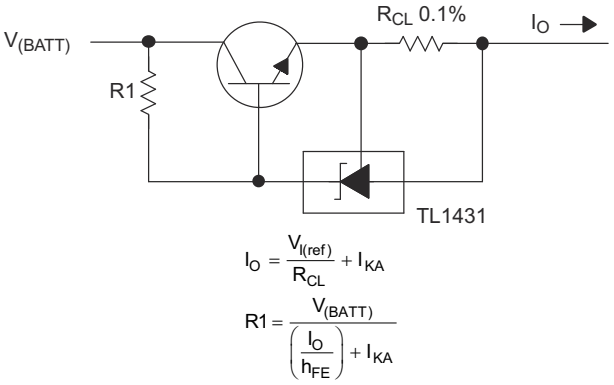
Select R3 and R4 to provide the desired LED intensity and cathode current ≥1 mA to the TL1431.

**図 9-12. Voltage Monitor**



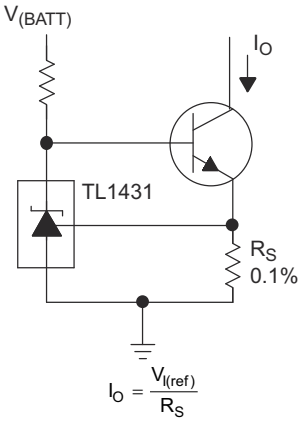

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**図 9-13. Delay Timer**




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**図 9-14. Precision Current Limiter**




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**図 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 図 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.


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# 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

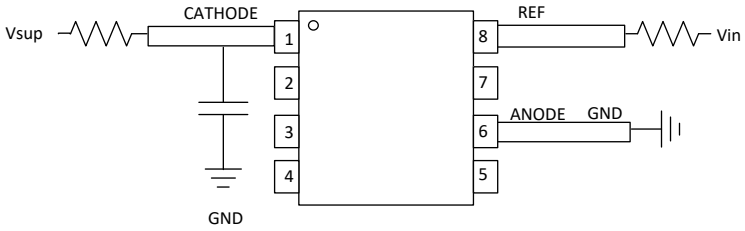



**図 11-1. 8-Pin JG Layout Example**

# 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

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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.


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## 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.

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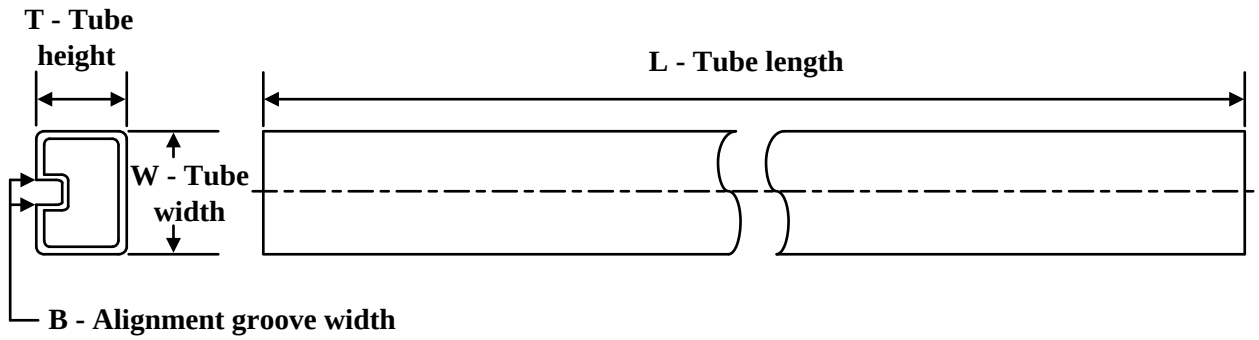
**OTHER QUALIFIED VERSIONS OF TL1431-SP :**

- 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

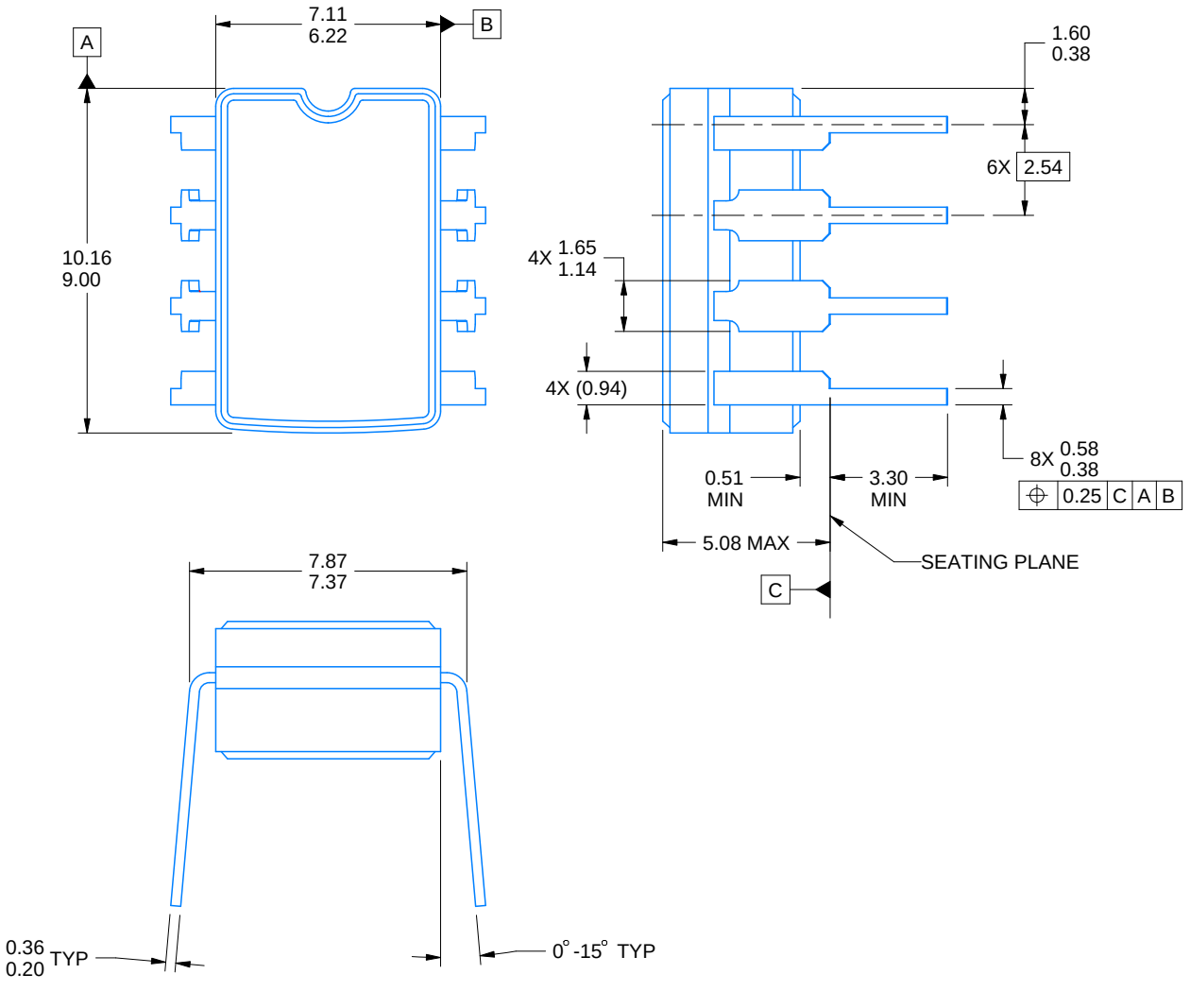
| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|---|---|---|---|---|---|---|---|---|
| 5962R9962001VHA | U | CFP | 10 | 25 | 506.98 | 26.16 | 6220 | NA |
| 5962R9962001VHA.A | U | CFP | 10 | 25 | 506.98 | 26.16 | 6220 | NA |
| 5962R9962001VPA | JG | CDIP | 8 | 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 |

# PACKAGE OUTLINE

## JG0008A

## CDIP - 5.08 mm max height

CERAMIC DUAL IN-LINE PACKAGE




4230036/A 09/2023

NOTES:

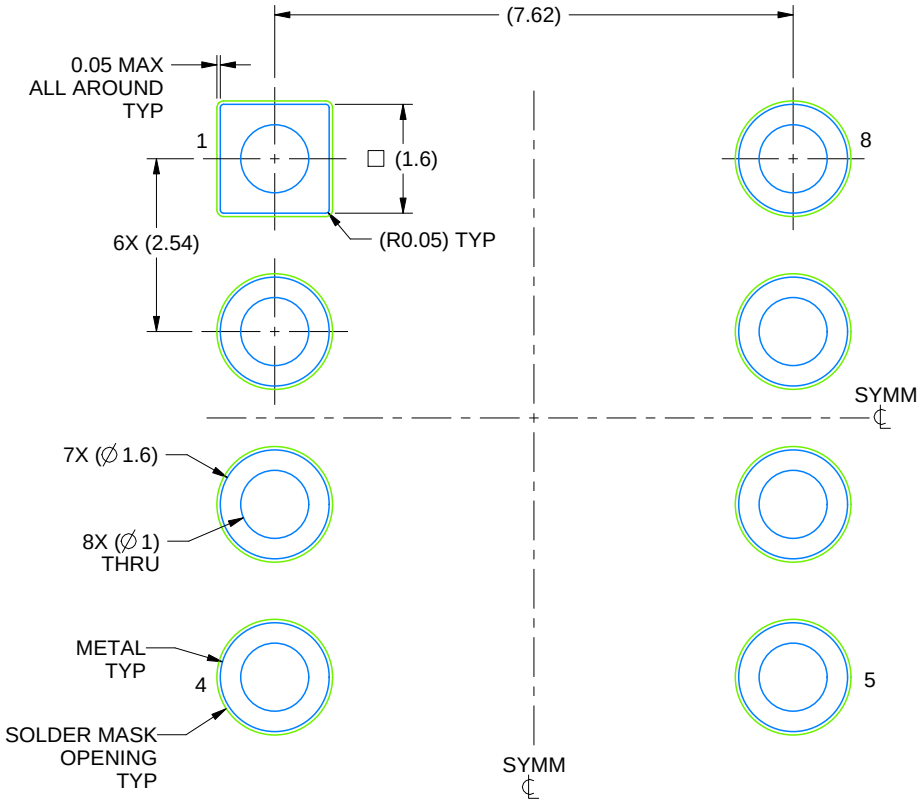
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package can be hermetically sealed with a ceramic lid using glass frit.
4. Index point is provided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

# EXAMPLE BOARD LAYOUT

## JG0008A

## CDIP - 5.08 mm max height

CERAMIC DUAL IN-LINE PACKAGE




LAND PATTERN EXAMPLE
NON SOLDER MASK DEFINED
SCALE: 9X

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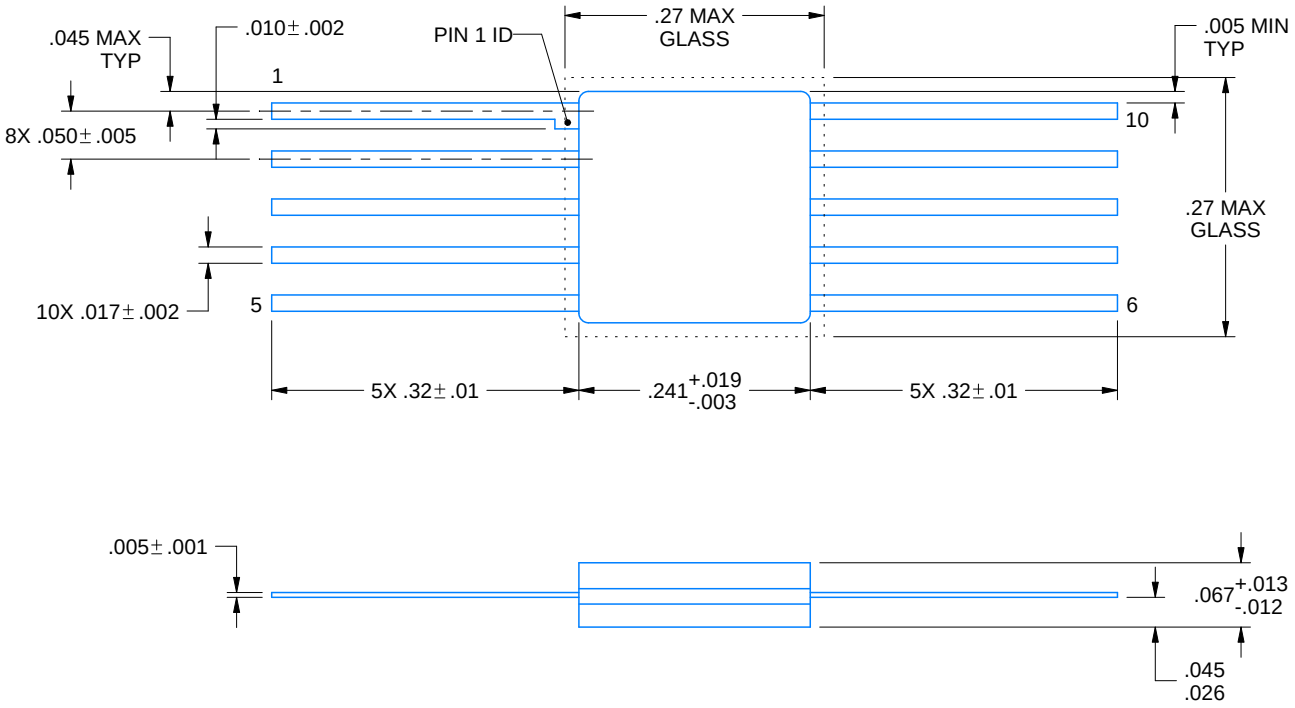
# U0010A



# 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.

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