

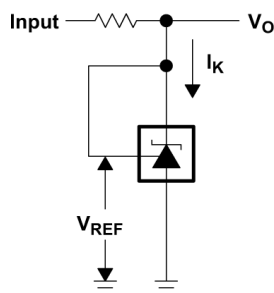
TLV431x Low-Voltage Adjustable Precision Shunt Regulator

1 Features

- Low-voltage operation, $V_{REF} = 1.24V$
- Adjustable output voltage, $V_O = V_{REF}$ to 6V
- Reference voltage tolerances at 25°C
 - 0.5% for TLV431B
 - 1% for TLV431A
 - 1.5% for TLV431
- Typical temperature drift
 - 4mV (0°C to 70°C)
 - 6mV (–40°C to 85°C)
 - 11mV (–40°C to 125°C)
- Low operational cathode current, 80µA typical
- 0.25Ω typical output impedance
- Ultra-small SC-70 package offers 40% smaller footprint than SOT-23-3
- See TLVH431 and TLVH432 for:
 - Wider V_{KA} (1.24V to 18 V) and I_K (80mA)
 - Additional SOT-89 package
 - Multiple pinouts for SOT-23-3 and SOT-89 packages
- On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. on all other products, production processing does not necessarily include testing of all parameters.

2 Applications

- [Adjustable voltage and current referencing](#)
- [Secondary side regulation in flyback SMPSs](#)
- [Zener replacement](#)
- [Voltage monitoring](#)
- [Comparator with integrated reference](#)



Simplified Schematic

3 Description

The TLV431 device is a low-voltage 3-terminal adjustable voltage reference with specified thermal stability over applicable industrial and commercial temperature ranges. Output voltage can be set to any value between V_{REF} (1.24V) and 6V with two external resistors (see the *Parameter Measurement Information* section). These devices operate from a lower voltage (1.24V) than the widely used TL431 and TL1431 shunt-regulator references.

When used with an optocoupler, the TLV431 device is an ideal voltage reference in isolated feedback circuits for 3V to 3.3V switching-mode power supplies. These devices have a typical output impedance of 0.25Ω. Active output circuitry provides a very sharp turnon characteristic, making them excellent replacements for low-voltage Zener diodes in many applications, including on-board regulation and adjustable power supplies.

Package Information

| PART NUMBER | PACKAGE ⁽¹⁾ | PACKAGE SIZE ⁽²⁾ |
|-------------|------------------------|-----------------------------|
| TLV431 | DBZ (SOT-23, 3) | 2.92mm × 2.37mm |
| | DBV (SOT-23, 5) | 2.90mm × 2.8mm |
| | LP (TO-92, 3) | 5.2mm × 3.68mm |
| | PK (SOT-89, 3) | 4.5mm × 4.095mm |
| TLV431A | DBV (SOT-23, 5) | 2.90mm × 2.8mm |
| | DBZ (SOT-23, 3) | 2.92mm × 2.37mm |
| | PK (SOT-89, 3) | 4.5mm × 4.095mm |
| | LP (TO-92, 3) | 5.2mm × 3.68mm |
| | D (SOIC, 8) | 4.9mm × 6mm |
| TLV431B | DBV (SOT-23, 5) | 2.90mm × 2.8mm |
| | DBZ (SOT-23, 3) | 2.92mm × 2.37mm |
| | PK (SOT-89, 3) | 4.5mm × 4.095mm |
| | LP (TO-92, 3) | 5.2mm × 3.68mm |
| | DCK (SOT-SC70, 6) | 2mm × 1.5mm |

- (1) For all available packages, see the orderable addendum at the end of the data sheet.
- (2) The package size (length × width) is a nominal value and includes pins, where applicable



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4 Pin Configuration and Functions

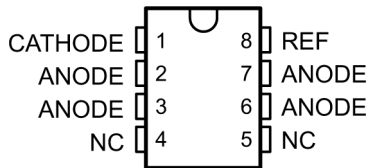
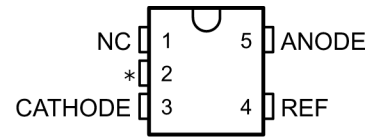


Figure 4-1. D (SOIC) Package (Top View)



NC – No internal connection

* Pin 2 is attached to Substrate and must be connected to ANODE or left open.

Figure 4-2. DBV (SOT-23-5) Package (Top View)

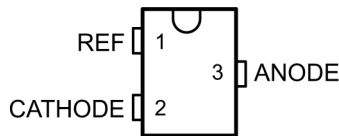


Figure 4-3. DBZ (SOT-23-3) Package (Top View)

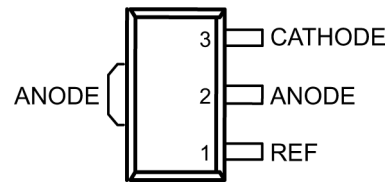
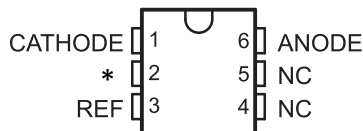


Figure 4-4. PK (SOT-89) Package (Top View)



NC – No internal connection

* - Must be connected to ANODE or left open

Figure 4-5. DCK (SC-70) Package (Top View)

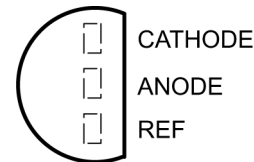


Figure 4-6. LP (TO-92/TO-226) Package (Top View)

Table 4-1. Pin Functions

| NAME | PIN | | | | | | TYPE | DESCRIPTION |
|---------|-----|-----|----|------------|----|------|------|--|
| | DBZ | DBV | PK | D | LP | DCK | | |
| CATHODE | 2 | 3 | 3 | 1 | 1 | 1 | I/O | Shunt Current/Voltage input |
| REF | 1 | 4 | 1 | 8 | 3 | 3 | I | Threshold relative to common anode |
| ANODE | 3 | 5 | 2 | 2, 3, 6, 7 | 2 | 6 | O | Common pin, normally connected to ground |
| NC | — | 1 | — | 4, 5 | — | 4, 5 | I | No Internal Connection |
| * | — | 2 | — | — | — | 2 | I | Substrate Connection. Must be connected to ANODE or left open. |

5 Specifications

5.1 Absolute Maximum Ratings

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

| | | MIN | MAX | UNIT |
|-----------|--|-------|-----|------|
| V_{KA} | Cathode voltage ⁽²⁾ | | 7 | V |
| I_K | Continuous cathode current | -20 | 20 | mA |
| I_{ref} | Reference current | -0.05 | 3 | mA |
| | Operating virtual junction temperature | | 150 | °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, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Voltage values are with respect to the anode terminal, unless otherwise noted.

5.2 ESD Ratings

| PARAMETER | DEFINITION | VALUE | UNIT |
|-----------|-------------------------|--|-------|
| $V(ESD)$ | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins ⁽¹⁾ | ±2000 |
| | | Charged device model (CDM), per JEDEC specification JESD22-C101, all pins ⁽²⁾ | ±1000 |

- (1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process.

5.3 Recommended Operating Conditions

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

| | | MIN | MAX | UNIT |
|----------|--------------------------------|-----------|-----|------|
| V_{KA} | Cathode voltage | V_{REF} | 6 | V |
| I_K | Cathode current | 0.1 | 15 | mA |
| T_A | Operating free-air temperature | TLV431_C | 0 | 70 |
| | | TLV431_I | -40 | 85 |
| | | TLV431_Q | -40 | 125 |

5.4 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | TLV431x | | | | | | UNIT |
|-------------------------------|---|---------|--------|--------|--------|--------|--------|------|
| | | DCK | D | PK | DBV | DBZ | LP | |
| | | 6 PINS | 8 PINS | 3 PINS | 5 PINS | 3 PINS | 3 PINS | |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 87 | 97 | 52 | 206 | 206 | 140 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | 259 | 39 | 9 | 131 | 76 | 55 | °C/W |

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report (SPRA953).

5.5 Electrical Characteristics for TLV431

at 25°C free-air temperature (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | TLV431 | | | UNIT | |
|---|--|-----------|-------|------|-------|------|
| | | MIN | TYP | MAX | | |
| V _{REF} Reference voltage | V _{KA} = V _{REF} , I _K = 10mA T _A = 25°C T _A = full range ⁽¹⁾ (see Figure 6-1) | TLV431C | 1.222 | 1.24 | 1.258 | V |
| | | TLV431I | 1.202 | | 1.278 | |
| | | TLV431Q | 1.194 | | 1.286 | |
| V _{REF(dev)} V _{REF} deviation over full temperature range ⁽²⁾ | V _{KA} = V _{REF} , I _K = 10mA ⁽¹⁾ (see Figure 6-1) | TLV431C | | 4 | 12 | mV |
| | | TLV431I | | 6 | 20 | |
| | | TLV431Q | | 11 | 31 | |
| $\frac{\Delta V_{REF}}{\Delta V_{KA}}$ Ratio of V _{REF} change in cathode voltage change | V _{KA} = V _{REF} to 6V, I _K = 10mA (see Figure 6-2) | | -1.5 | | -2.7 | mV/V |
| I _{ref} Reference terminal current | I _K = 10mA, R1 = 10kΩ, R2 = open (see Figure 6-2) | | 0.15 | | 0.5 | μA |
| I _{ref(dev)} I _{ref} deviation over full temperature range ⁽²⁾ | I _K = 10mA, R1 = 10kΩ, R2 = open ⁽¹⁾ (see Figure 6-2) | TLV431C | | 0.05 | 0.3 | μA |
| | | TLV431I | | 0.1 | 0.4 | |
| | | TLV431Q | | 0.15 | 0.5 | |
| I _{K(min)} Minimum cathode current for regulation | V _{KA} = V _{REF} (see Figure 6-1) | TLV431C/I | | 55 | 80 | μA |
| | | TLV431Q | | 55 | 100 | |
| I _{K(off)} Off-state cathode current | V _{REF} = 0, V _{KA} = 6V (see Figure 6-3) | | 0.001 | | 0.1 | μA |
| z _{KA} Dynamic impedance ⁽³⁾ | V _{KA} = V _{REF} , f ≤ 1kHz, I _K = 0.1mA to 15mA (see Figure 6-1) | | 0.25 | | 0.4 | Ω |

(1) Full temperature ranges are –40°C to 125°C for TLV431Q, –40°C to 85°C for TLV431I, and 0°C to 70°C for TLV431C.

(2) The deviation parameters V_{REF(dev)} and I_{ref(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, αV_{REF}, is defined as:

$$|\alpha V_{REF}| \left(\frac{\text{ppm}}{^{\circ}\text{C}} \right) = \frac{\left(\frac{V_{REF(dev)}}{V_{REF}(T_A = 25^{\circ}\text{C})} \right) \times 10^6}{\Delta T_A}$$

where ΔT_A is the rated operating free-air temperature range of the device. αV_{REF} can be positive or negative, depending on whether minimum V_{REF} or maximum V_{REF}, respectively, occurs at the lower temperature.

(3) The dynamic impedance is defined as $|z_{ka}| = \frac{\Delta V_{KA}}{\Delta I_K}$. When the device is operating with two external resistors (see Figure 6-2), the

total dynamic impedance of the circuit is defined as: $|z_{ka}|' = \frac{\Delta V}{\Delta I} \approx |z_{ka}| \times \left(1 + \frac{R1}{R2} \right)$

5.6 Electrical Characteristics for TLV431A

at 25°C free-air temperature (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | | TLV431A | | | UNIT |
|---|--|--|----------|-------|-------|------|
| | | | MIN | TYP | MAX | |
| V _{REF} Reference voltage | V _{KA} = V _{REF} , I _K = 10mA | T _A = 25°C | 1.228 | 1.24 | 1.252 | V |
| | | T _A = full range ⁽¹⁾ (see Figure 6-1) | TLV431AC | 1.221 | 1.259 | |
| | | | TLV431AI | 1.215 | 1.265 | |
| | | | TLV431AQ | 1.209 | 1.271 | |
| V _{REF(dev)} V _{REF} deviation over full temperature range ⁽²⁾ | V _{KA} = V _{REF} , I _K = 10mA ⁽¹⁾ (see Figure 6-1) | TLV431AC | | 4 | 12 | mV |
| | | TLV431AI | | 6 | 20 | |
| | | TLV431AQ | | 11 | 31 | |
| $\frac{\Delta V_{REF}}{\Delta V_{KA}}$ Ratio of V _{REF} change in cathode voltage change | V _{KA} = V _{REF} to 6V, I _K = 10mA (see Figure 6-2) | | | -1.5 | -2.7 | mV/V |
| I _{ref} Reference terminal current | I _K = 10mA, R1 = 10kΩ, R2 = open (see Figure 6-2) | | | 0.15 | 0.5 | μA |
| I _{ref(dev)} I _{ref} deviation over full temperature range ⁽²⁾ | I _K = 10mA, R1 = 10kΩ, R2 = open ⁽¹⁾ (see Figure 6-2) | TLV431AC | | 0.05 | 0.3 | μA |
| | | TLV431AI | | 0.1 | 0.4 | |
| | | TLV431AQ | | 0.15 | 0.5 | |
| I _{K(min)} Minimum cathode current for regulation | V _{KA} = V _{REF} (see Figure 6-1) | TLV431AC/AI | | 55 | 80 | μA |
| | | TLV431AQ | | 55 | 100 | |
| I _{K(off)} Off-state cathode current | V _{REF} = 0, V _{KA} = 6V (see Figure 6-3) | | | 0.001 | 0.1 | μA |
| z _{KA} Dynamic impedance ⁽³⁾ | V _{KA} = V _{REF} , f ≤ 1kHz, I _K = 0.1mA to 15mA (see Figure 6-1) | | | 0.25 | 0.4 | Ω |

(1) Full temperature ranges are –40°C to 125°C for TLV431Q, –40°C to 85°C for TLV431I, and 0°C to 70°C for TLV431C.

(2) The deviation parameters V_{REF(dev)} and I_{ref(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, αV_{REF}, is defined as:

$$|\alpha V_{REF}| \left(\frac{\text{ppm}}{^{\circ}\text{C}} \right) = \frac{\left(\frac{V_{REF(dev)}}{V_{REF}(T_A = 25^{\circ}\text{C})} \right) \times 10^6}{\Delta T_A}$$

where ΔT_A is the rated operating free-air temperature range of the device. αV_{REF} can be positive or negative, depending on whether minimum V_{REF} or maximum V_{REF}, respectively, occurs at the lower temperature.

(3) The dynamic impedance is defined as $|z_{ka}| = \frac{\Delta V_{KA}}{\Delta I_K}$. When the device is operating with two external resistors (see Figure 6-2), the

total dynamic impedance of the circuit is defined as: $|z_{ka}'| = \frac{\Delta V}{\Delta I} \approx |z_{ka}| \times \left(1 + \frac{R1}{R2} \right)$

5.7 Electrical Characteristics for TLV431B

at 25°C free-air temperature (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | | TLV431B | | | UNIT |
|---|---|---|----------|-------|-------|------|
| | | | MIN | TYP | MAX | |
| V _{REF} Reference voltage | V _K A = V _{REF} , I _K = 10mA | T _A = 25°C | 1.234 | 1.24 | 1.246 | V |
| | | T _A = full range ⁽¹⁾ (see Figure 6-1) | TLV431BC | 1.227 | 1.253 | |
| | | | TLV431BI | 1.224 | 1.259 | |
| V _{REF(dev)} V _{REF} deviation over full temperature range ⁽²⁾ | V _K A = V _{REF} , I _K = 10mA ⁽¹⁾ (see Figure 6-1) | TLV431BC | | 4 | 12 | mV |
| | | TLV431BI | | 6 | 20 | |
| | | TLV431BQ | | 11 | 31 | |
| $\frac{\Delta V_{REF}}{\Delta V_{KA}}$ Ratio of V _{REF} change in cathode voltage change | V _K A = V _{REF} to 6V, I _K = 10mA (see Figure 6-2) | | | -1.5 | -2.7 | mV/V |
| I _{ref} Reference terminal current | I _K = 10mA, R1 = 10kΩ, R2 = open (see Figure 6-2) | | | 0.1 | 0.5 | μA |
| I _{ref(dev)} I _{ref} deviation over full temperature range ⁽²⁾ | I _K = 10mA, R1 = 10kΩ, R2 = open ⁽³⁾ (see Figure 6-2) | TLV431BC | | 0.05 | 0.3 | μA |
| | | TLV431BI | | 0.1 | 0.4 | |
| | | TLV431BQ | | 0.15 | 0.5 | |
| I _{K(min)} Minimum cathode current for regulation | V _K A = V _{REF} (see Figure 6-1) | | | 55 | 100 | μA |
| I _{K(off)} Off-state cathode current | V _{REF} = 0, V _K A = 6V (see Figure 6-3) | | | 0.001 | 0.1 | μA |
| z _{KA} Dynamic impedance ⁽⁴⁾ | V _K A = V _{REF} , f ≤ 1kHz, I _K = 0.1mA to 15mA (see Figure 6-1) | | | 0.25 | 0.4 | Ω |

- (1) Full temperature ranges are –40°C to 125°C for TLV431Q, –40°C to 85°C for TLV431I, and 0°C to 70°C for TLV431C.
(2) The deviation parameters V_{REF(dev)} and I_{ref(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, αV_{REF}, is defined as:

$$|\alpha V_{REF}| \left(\frac{\text{ppm}}{^{\circ}\text{C}} \right) = \frac{\left(\frac{V_{REF(dev)}}{V_{REF}(T_A = 25^{\circ}\text{C})} \right) \times 10^6}{\Delta T_A}$$

where ΔT_A is the rated operating free-air temperature range of the device. αV_{REF} can be positive or negative, depending on whether minimum V_{REF} or maximum V_{REF}, respectively, occurs at the lower temperature.

- (3) Full temperature ranges are –40°C to 125°C for TLV431Q, –40°C to 85°C for TLV431I, and 0°C to 70°C for TLV431C.

- (4) dynamic impedance is defined as $|z_{ka}| = \frac{\Delta V_{KA}}{\Delta I_K}$. When the device is operating with two external resistors (see Figure 6-2), the total

dynamic impedance of the circuit is defined as: $|z_{ka}|' = \frac{\Delta V}{\Delta I} \approx |z_{ka}| \times \left(1 + \frac{R1}{R2} \right)$

5.8 Typical Characteristics

Operation of the device at these or any other conditions beyond those indicated in the *Recommended Operating Conditions* table are not implied.

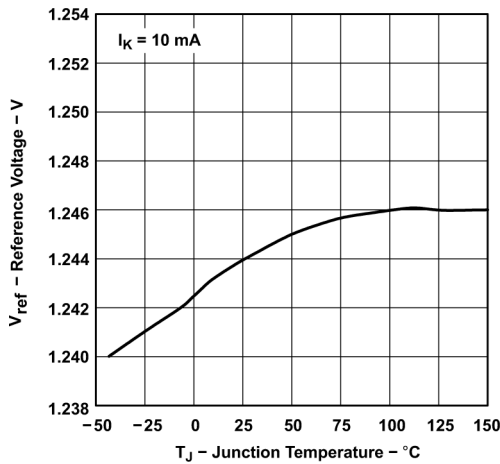


Figure 5-1. Reference Voltage vs Junction Temperature

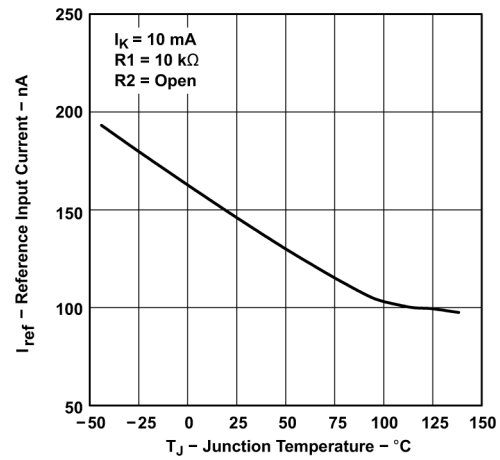


Figure 5-2. Reference Input Current vs Junction Temperature (for TLV431 and TLV431A)

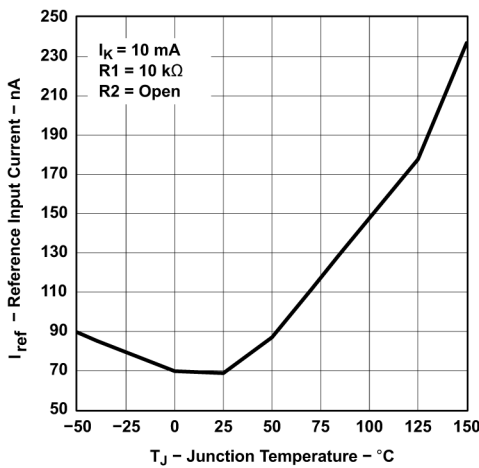


Figure 5-3. Reference Input Current vs Junction Temperature (for TLV431B)

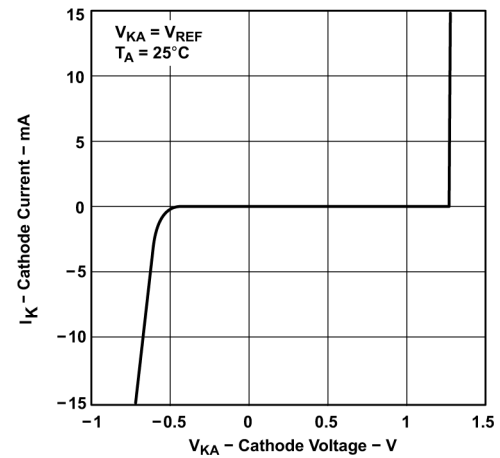


Figure 5-4. Cathode Current vs Cathode Voltage

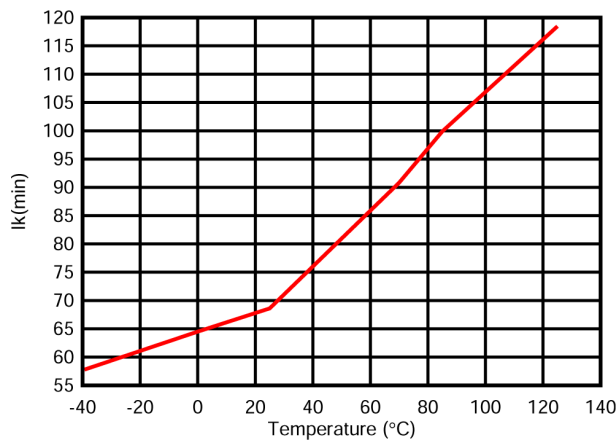


Figure 5-5. Minimum Cathode Current vs Temperature

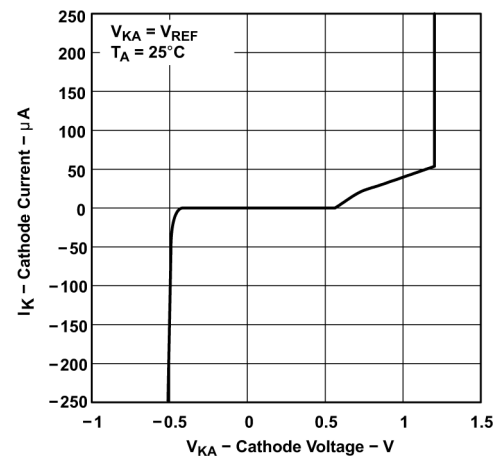


Figure 5-6. Cathode Current vs Cathode Voltage

5.8 Typical Characteristics (continued)

Operation of the device at these or any other conditions beyond those indicated in the *Recommended Operating Conditions* table are not implied.

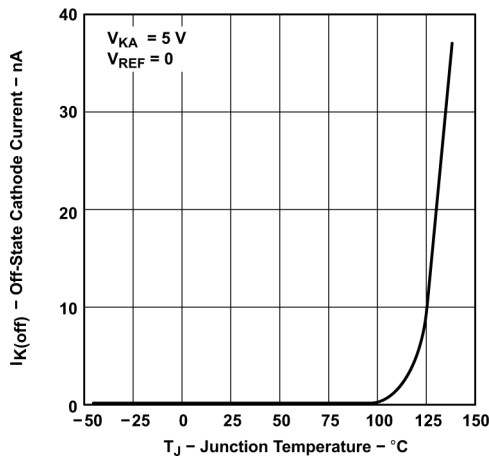


Figure 5-7. Off-State Cathode Current vs Junction Temperature (for TLV431 and TLV431A)

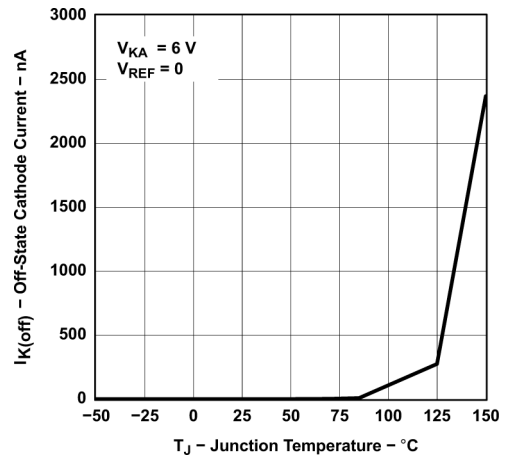


Figure 5-8. Off-State Cathode Current vs Junction Temperature (for TLV431B)

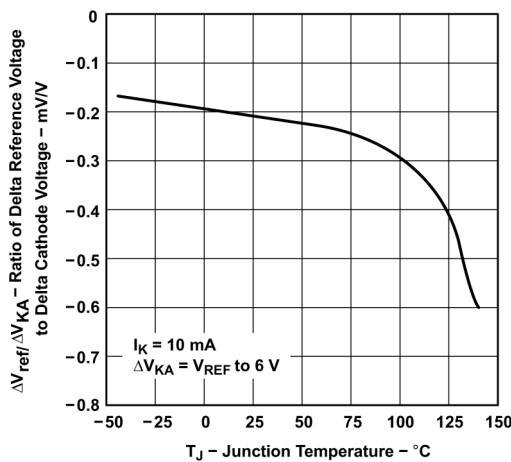


Figure 5-9. Ratio of Delta Reference Voltage to Delta Cathode Voltage vs Junction Temperature (for TLV431 and TLV431A)

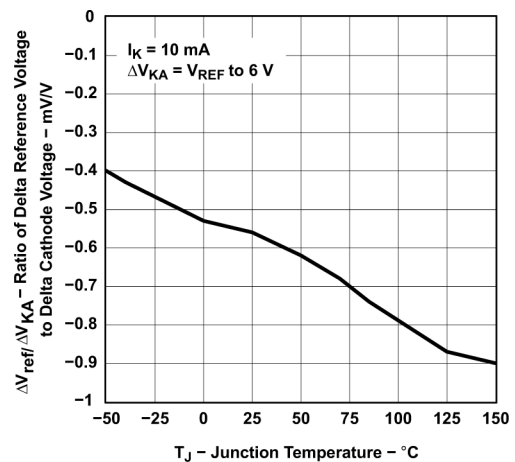


Figure 5-10. Ratio of Delta Reference Voltage to Delta Cathode Voltage vs Junction Temperature (for TLV431B)

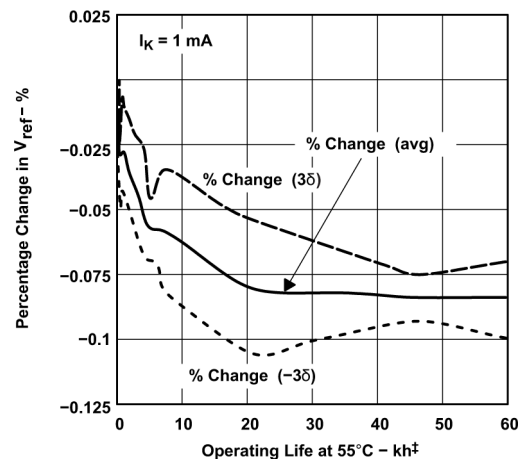
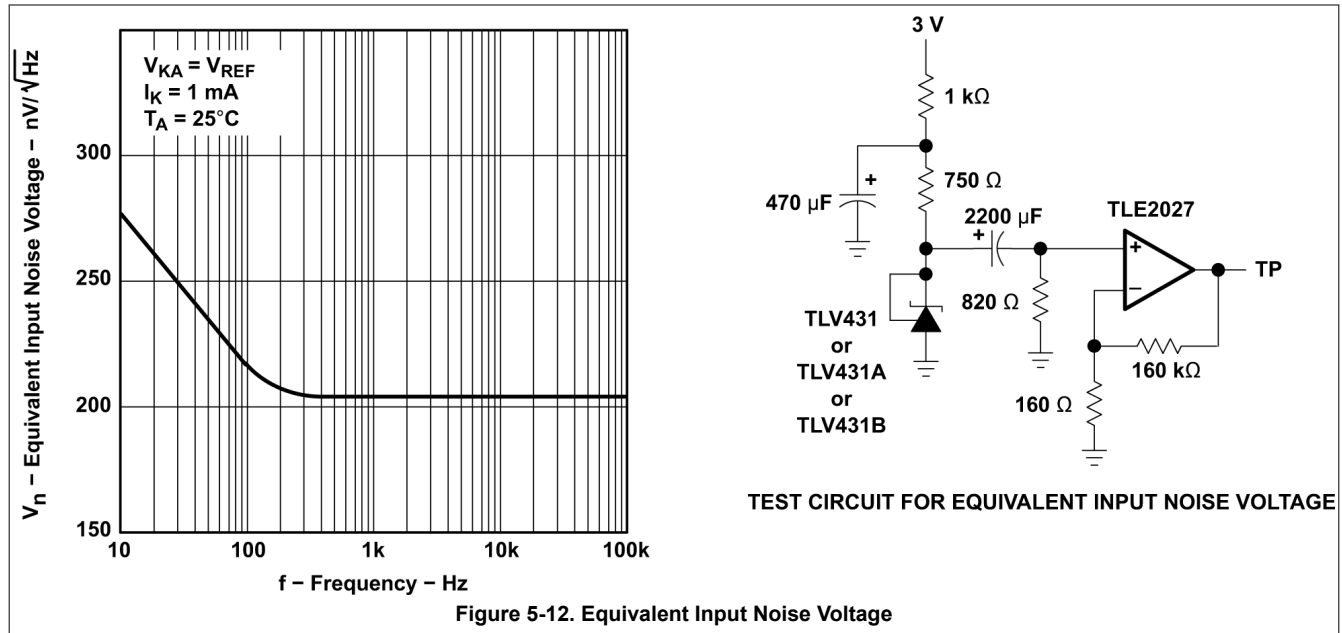


Figure 5-11. Percentage Change in V_{REF} vs Operating Life at 55°C

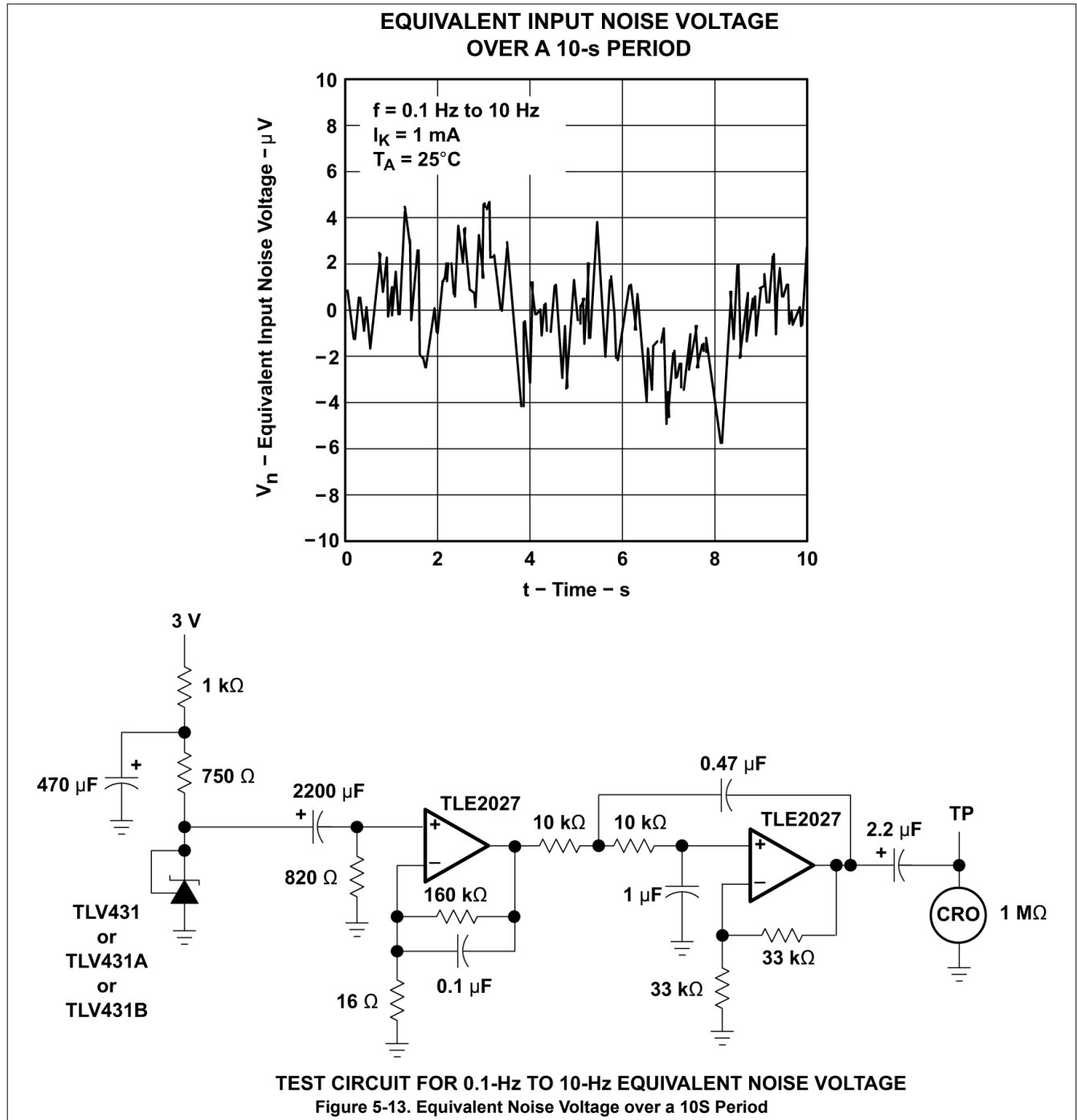
5.8 Typical Characteristics (continued)

Operation of the device at these or any other conditions beyond those indicated in the *Recommended Operating Conditions* table are not implied.



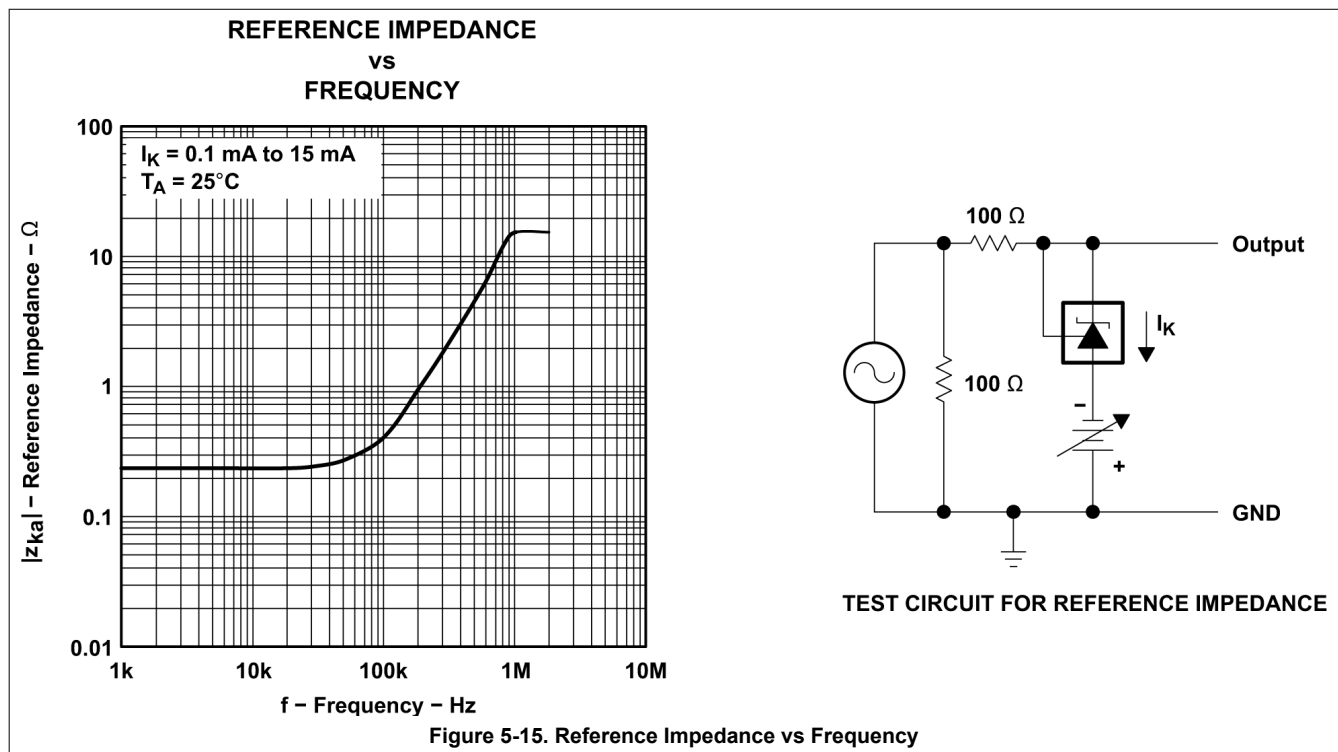
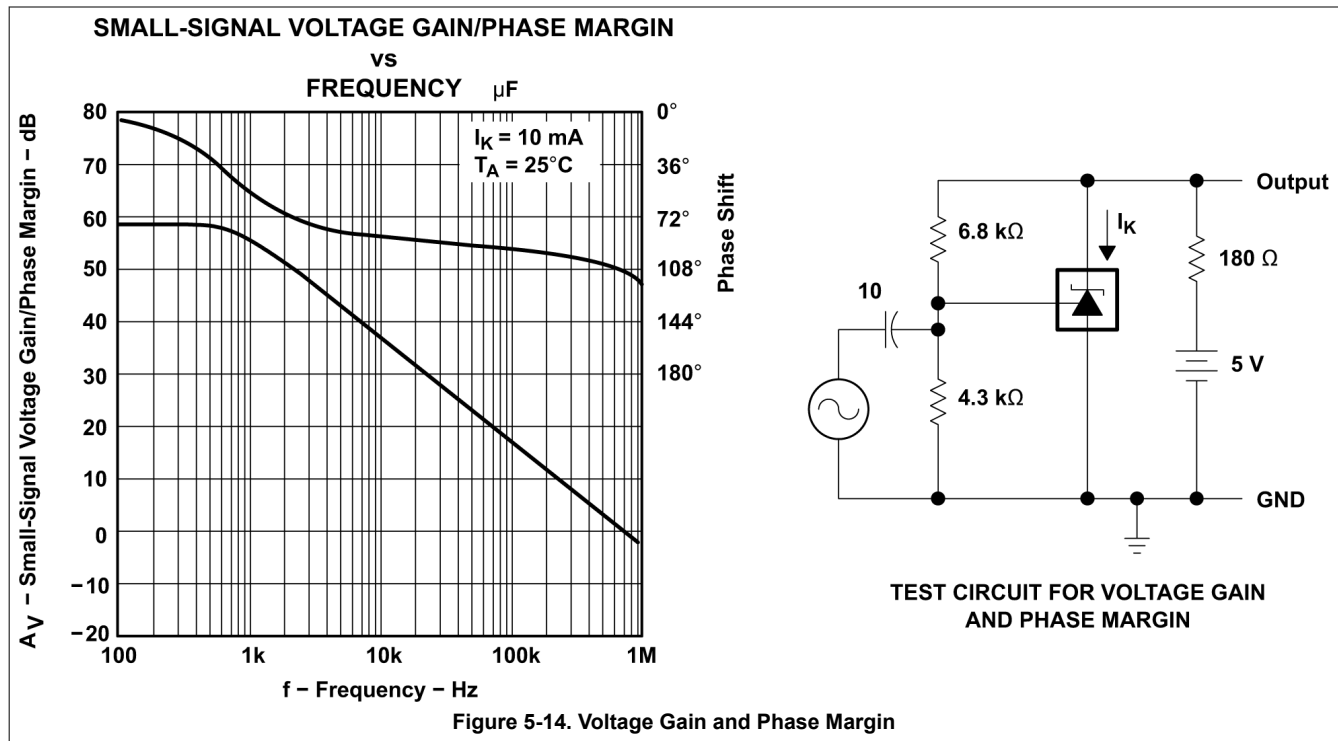
5.8 Typical Characteristics (continued)

Operation of the device at these or any other conditions beyond those indicated in the *Recommended Operating Conditions* table are not implied.



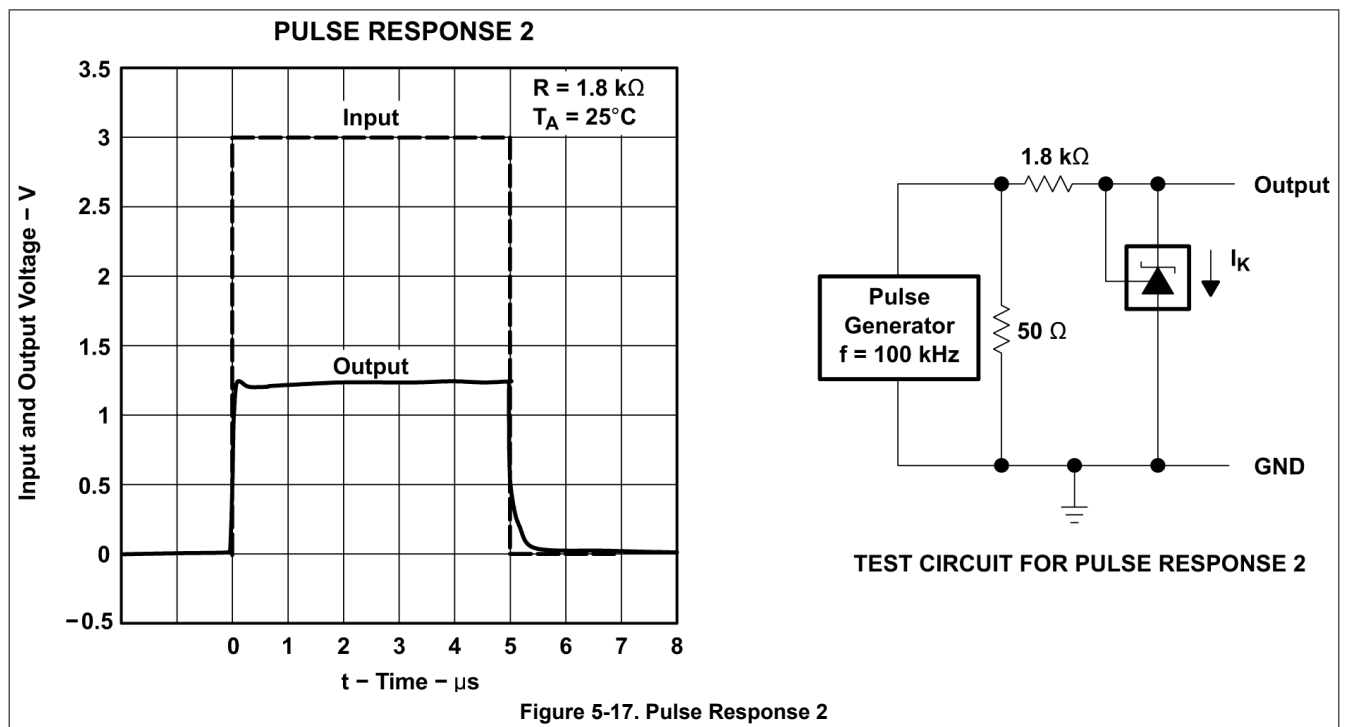
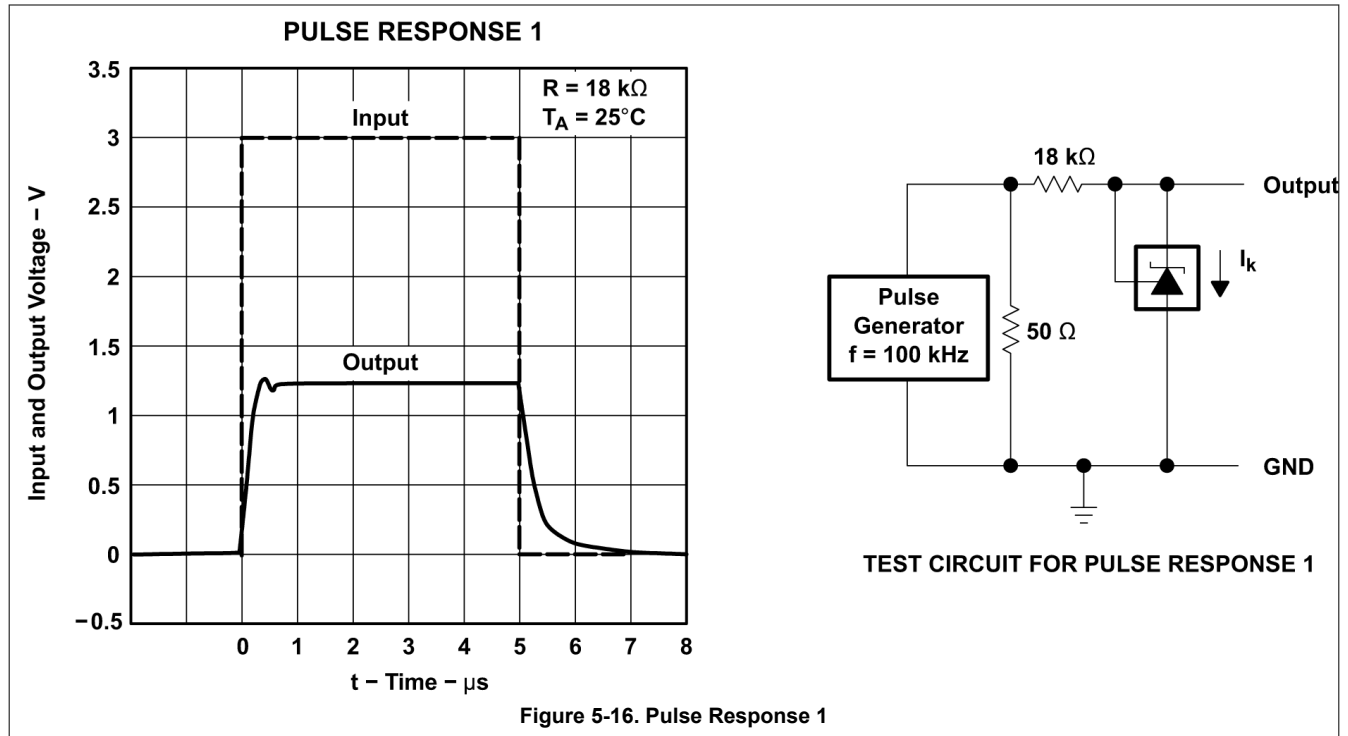
5.8 Typical Characteristics (continued)

Operation of the device at these or any other conditions beyond those indicated in the *Recommended Operating Conditions* table are not implied.



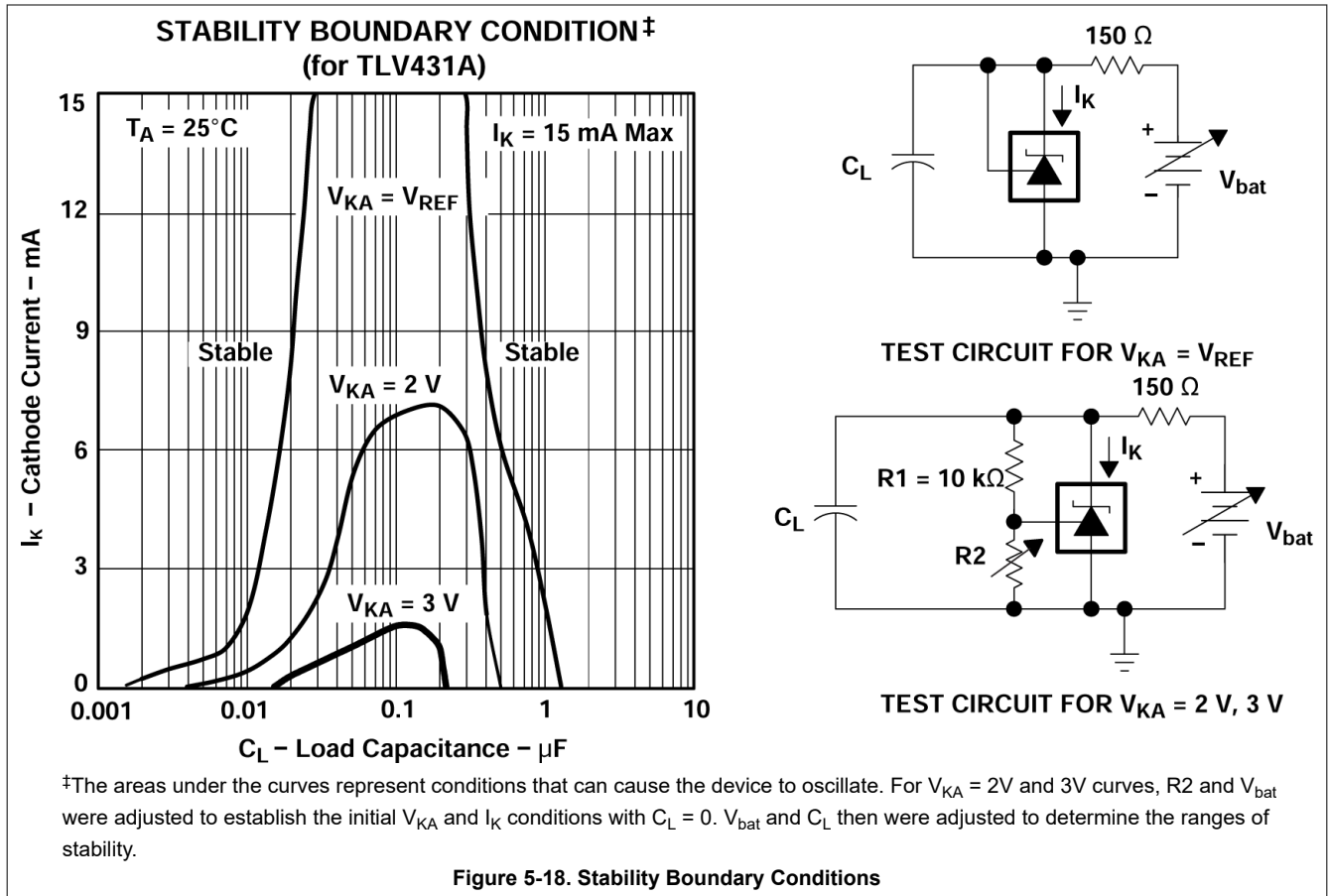
5.8 Typical Characteristics (continued)

Operation of the device at these or any other conditions beyond those indicated in the *Recommended Operating Conditions* table are not implied.



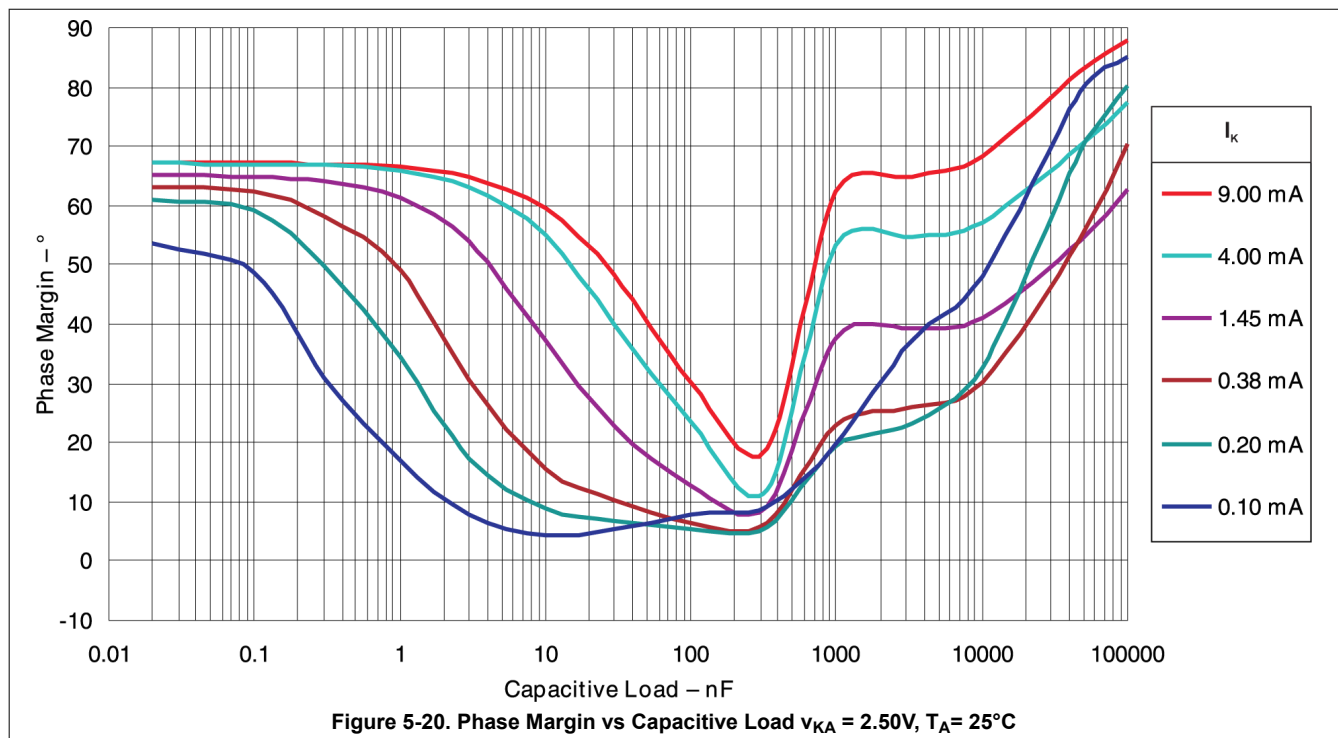
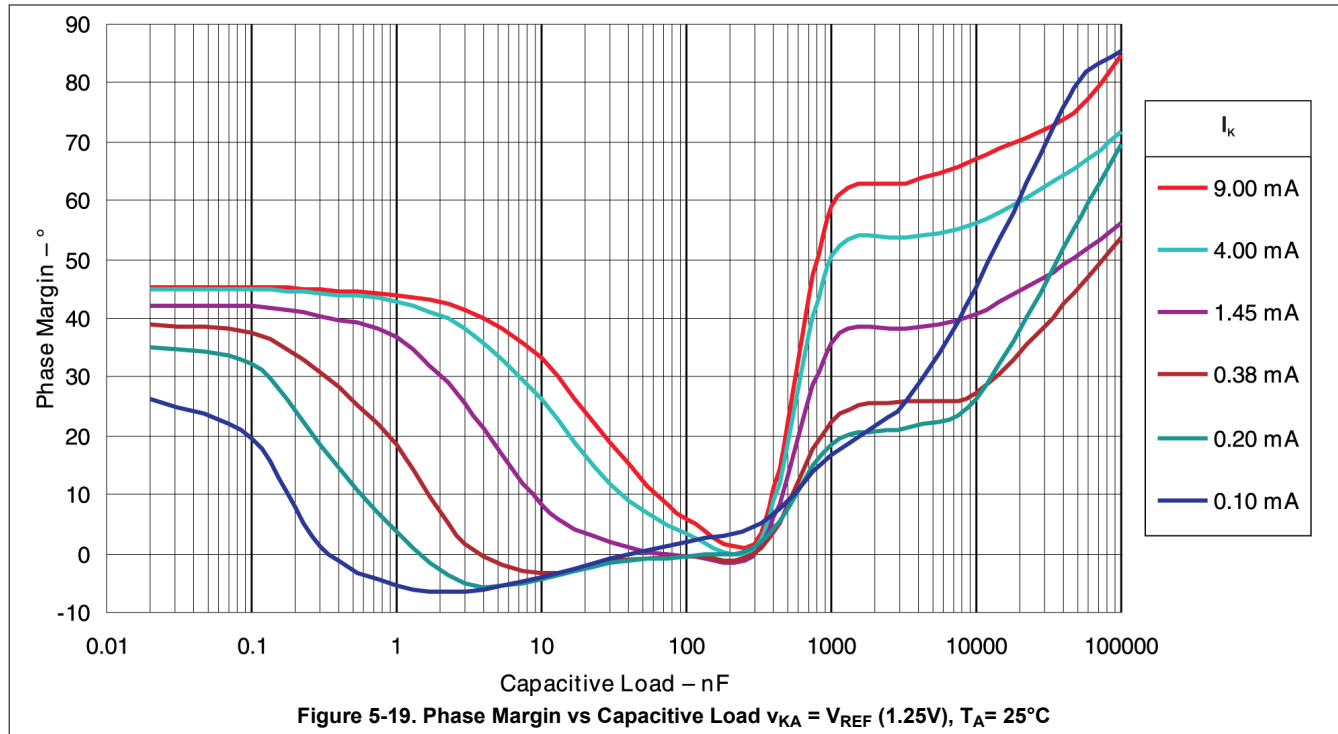
5.8 Typical Characteristics (continued)

Operation of the device at these or any other conditions beyond those indicated in the *Recommended Operating Conditions* table are not implied.



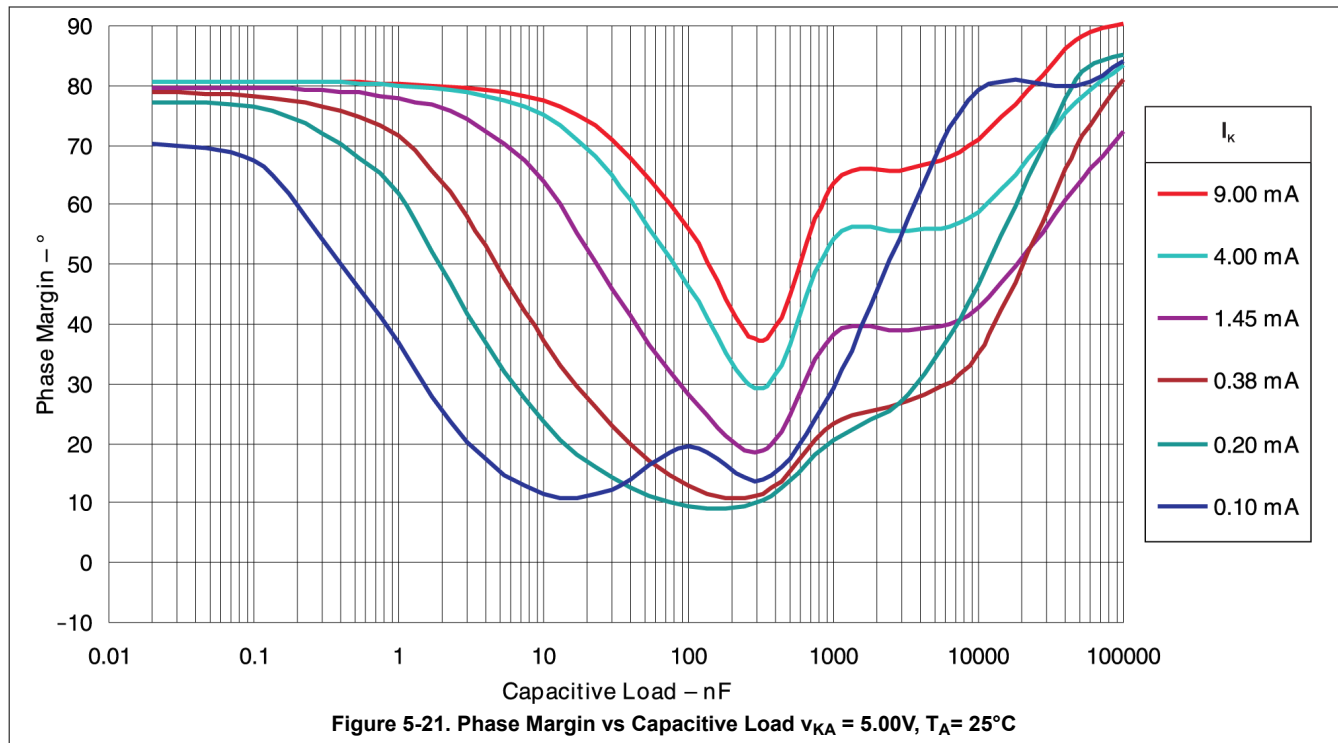
5.8 Typical Characteristics (continued)

Operation of the device at these or any other conditions beyond those indicated in the *Recommended Operating Conditions* table are not implied.



5.8 Typical Characteristics (continued)

Operation of the device at these or any other conditions beyond those indicated in the *Recommended Operating Conditions* table are not implied.



6 Parameter Measurement Information

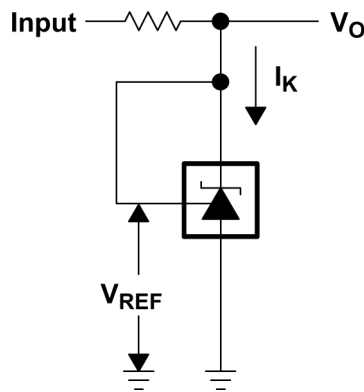


Figure 6-1. Test Circuit for $v_{KA} = V_{REF}$, $V_O = V_{KA} = V_{REF}$

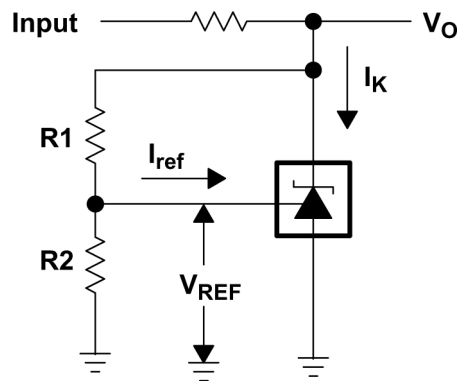


Figure 6-2. Test Circuit for $v_{KA} > V_{REF}$, $V_O = V_{KA} = V_{REF} \times (1 + R1/R2) + I_{ref} \times R1$

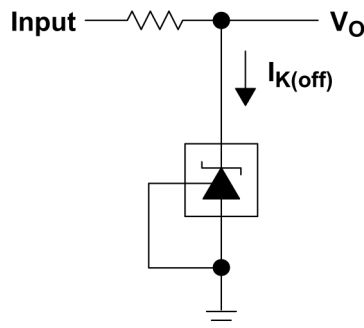


Figure 6-3. Test Circuit for $I_{K(off)}$

7 Detailed Description

7.1 Overview

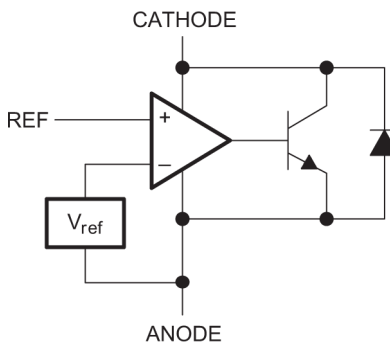
TLV431 is a low power counterpart to TL431, having lower reference voltage (1.24V vs 2.5 V) for lower voltage adjustability and lower minimum cathode current ($I_{k(\min)} = 100\mu\text{A}$ vs 1mA). Like TL431, TLV431 is used in conjunction with its key components to behave as a single voltage reference, error amplifier, voltage clamp, or comparator with integrated reference.

TLV431 can be operated and adjusted to cathode voltages from 1.24V to 6V, making this part optimum for a wide range of end equipments in industrial, auto, telecom, and computing. For this device to behave as a shunt regulator or error amplifier, $> 100\mu\text{A}$ ($I_{\min(\max)}$) 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.

Various reference voltage options can be purchased with initial tolerances (at 25°C) of 0.5%, 1%, and 1.5%. These reference options are denoted by B (0.5%), A (1.0%), and blank (1.5%) after the TLV431.

The TLV431xC devices are characterized for operation from 0°C to 70°C, the TLV431xI devices are characterized for operation from -40°C to 85°C, and the TLV431xQ devices are characterized for operation from -40°C to 125°C.

7.2 Functional Block Diagram



7.3 Feature Description

TLV431 consists of an internal reference and amplifier that outputs a sink current based on the difference between the reference pin and the virtual internal pin. The sink current is produced by an internal darlington pair.

When operated with enough voltage headroom ($\geq 1.24\text{V}$) and cathode current (I_{ka}), TLV431 forces the reference pin to 1.24V. However, the reference pin can not be left floating, as it requires $I_{ref} \geq 0.5\mu\text{A}$ (see the *Functional Block Diagram*). This is because the reference pin is driven into an NPN, which requires a base current to operate properly.

When feedback is applied from the Cathode and Reference pins, TLV431 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 required in the above feedback situation must be applied to this device in open-loop, servo, or error-amplifying implementations for it to be in the proper linear region giving TLV431 enough gain.

Unlike many linear regulators, TLV431 is internally compensated to be stable without an output capacitor between the cathode and anode. However, if it is desired to use an output capacitor [Figure 5-19](#) can be used as a guide to assist in choosing the correct capacitor to maintain stability.

7.4 Device Functional Modes

7.4.1 Open Loop (Comparator)

When the cathode/output voltage or current of TLV431 is not being fed back to the reference/input pin in any form, this device is operating in open loop. With proper cathode current (I_{ka}) applied to this device, TLV431 will have the characteristics shown in [Figure 5-6](#). With such high gain in this configuration, TLV431 is typically used as a comparator. With the reference integrated makes TLV431 the preferred choice when users are trying to monitor a certain level of a single signal.

7.4.2 Closed Loop

When the cathode/output voltage or current of TLV431 is being fed back to the reference/input pin in any form, this device is operating in closed loop. The majority of applications involving TLV431 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.

8 Applications and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

Figure 8-1 shows the TLV431, TLV431A, or TLV431B used in a 3.3V isolated flyback supply. Output voltage V_O can be as low as reference voltage V_{REF} ($1.24V \pm 1\%$). The output of the regulator, plus the forward voltage drop of the optocoupler LED ($1.24 + 1.4 = 2.64V$), determine the minimum voltage that can be regulated in an isolated supply configuration. Regulated voltage as low as 2.7 Vdc is possible in the topology shown in Figure 8-1.

The 431 family of devices are prevalent in these applications, being designers go to choice for secondary side regulation. Due to this prevalence, this section will further go on to explain operation and design in both states of TLV431 that this application will see, open loop (Comparator + Vref) and closed loop (Shunt Regulator).

Further information about system stability and using a TLV431 device for compensation can be found in the application note *Compensation Design With TL431 for UCC28600* (SLUA671).

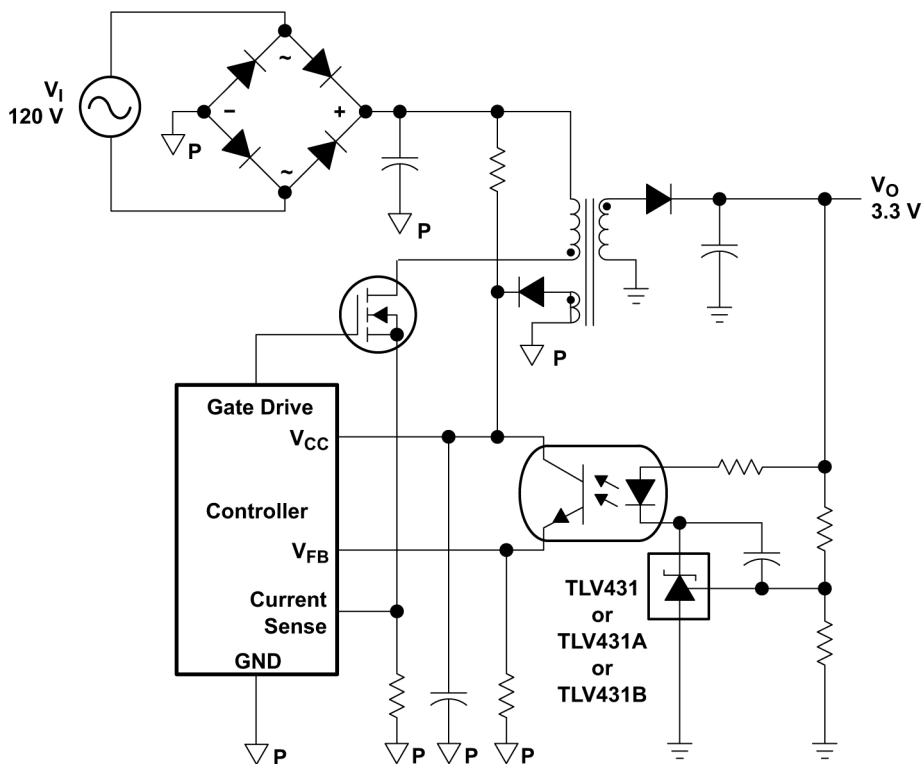


Figure 8-1. Flyback with Isolation Using TLV431, TLV431A, or TLV431B as Voltage Reference and Error Amplifier

8.2 Typical Applications

8.2.1 Comparator with Integrated Reference (Open Loop)

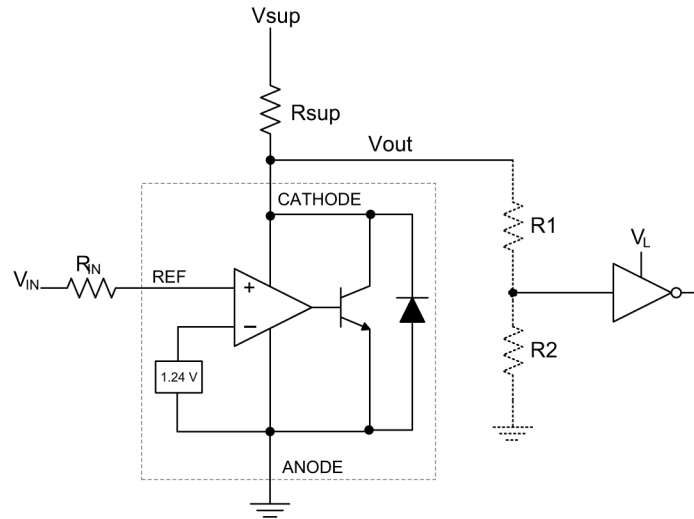


Figure 8-2. Comparator Application Schematic

8.2.1.1 Design Requirements

For this design example, use the parameters listed in [Table 8-1](#) as the input parameters.

Table 8-1. Design Parameters

| DESIGN PARAMETER | EXAMPLE VALUE |
|--|---------------------|
| Input Voltage Range | 0V to 5V |
| Input Resistance | 10k Ω |
| Supply Voltage | 5V |
| Cathode Current (I_k) | 500 μ A |
| Output Voltage Level | $\sim 1V - V_{sup}$ |
| Logic Input Thresholds V_{IH}/V_{IL} | VL |

8.2.1.2 Detailed Design Procedure

When using TLV431 as a comparator with reference, determine the following:

- Input voltage range
- Reference voltage accuracy
- Output logic input high and low level thresholds
- Current source resistance

8.2.1.2.1 Basic Operation

In the configuration shown in [Figure 8-2](#) TLV431 will behave as a comparator, comparing the V_{ref} pin voltage to the internal virtual reference voltage. When provided a proper cathode current (I_k), TLV431 will have enough open-loop gain to provide a quick response. With the TLV431's maximum operating current ($I_{min(max)}$) being 100 μ A and up to 150 μ A over temperature, operation below that could result in low gain, leading to a slow response.

8.2.1.2.2 Overdrive

Slow or inaccurate responses can also occur when the reference pin is not provided enough overdrive voltage. This is the amount of voltage that is higher than the internal virtual reference. The internal virtual reference voltage will be within the range of 1.24V \pm (0.5%, 1.0%, or 1.5%) depending on which version is being used.

The more overdrive voltage provided, the faster the TLV431 will respond. This can be seen in [Figure 8-3](#) and [Figure 8-4](#) where it displays the output responses to various input voltages.

For applications where TLV431 is being used as a comparator, it is best to set the trip point to greater than the positive expected error (that is, +1.0% for the A version). For fast response, setting the trip point to > 10% of the internal V_{ref} should suffice.

For minimal voltage drop or difference from V_{in} to the ref pin, TI recommends using an input resistor < 10k Ω to provide I_{ref} .

8.2.1.2.3 Output Voltage and Logic Input Level

For the TLV431 to properly be used as a comparator, the logic output must be readable by the receiving logic device. This is accomplished by knowing the input high and low level threshold voltage levels, typically denoted by V_{IH} and V_{IL} .

As seen in [Figure 8-3](#), TLV431's output low level voltage in open-loop/comparator mode is approximately 1V, which is sufficient for some 3.3V supplied logic. However, this does not work for 2.5V or 1.8V supplied logic. To accommodate this a resistive divider can be tied to the output to attenuate the output voltage to a voltage legible to the receiving low voltage logic device.

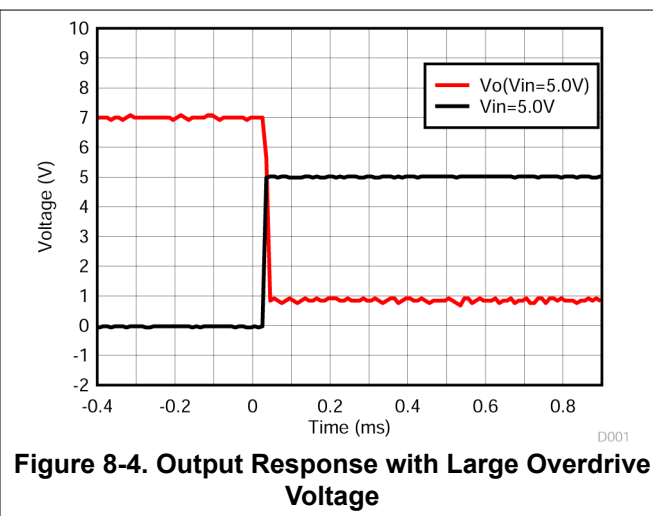
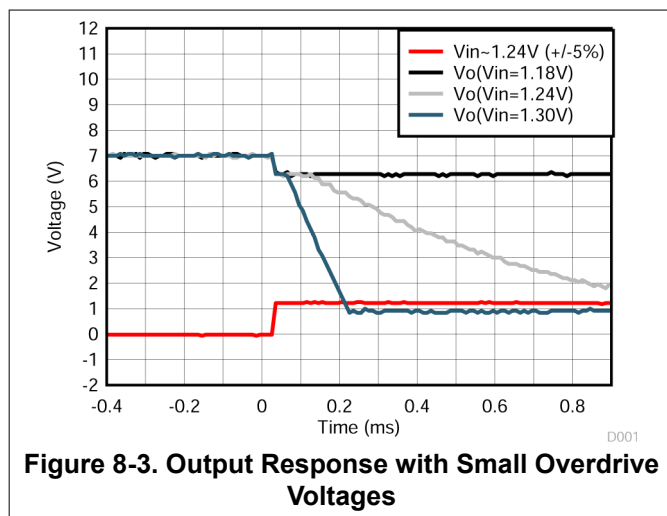
TLV431's output high voltage is approximately V_{sup} due to TLV431 being open-collector. If V_{sup} is much higher than the receiving logic's maximum input voltage tolerance, the output must be attenuated to accommodate the outgoing logic's reliability.

When using a resistive divider on the output, be sure to make the sum of the resistive divider (R_1 and R_2 in [Figure 8-2](#)) is much greater than R_{sup} to not interfere with TLV431's ability to pull close to V_{sup} when turning off.

8.2.1.2.3.1 Input Resistance

TLV431 requires an input resistance in this application to source the reference current (I_{ref}) needed from this device to be in the proper operating regions while turning on. The actual voltage seen at the ref pin will be $V_{ref} = V_{in} - I_{ref} \times R_{in}$. Because the I_{ref} can be as high as 0.5 μ A, TI recommends using a resistance small enough that will mitigate the error that I_{ref} creates from V_{in} .

8.2.1.3 Application Curves



8.2.2 Shunt Regulator/Reference

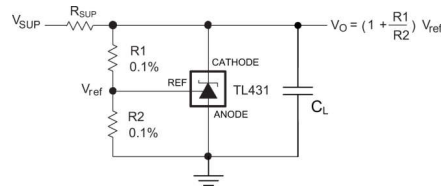


Figure 8-5. Shunt Regulator Schematic

8.2.2.1 Design Requirements

For this design example, use the parameters listed in [Table 8-2](#) as the input parameters.

Table 8-2. Design Parameters

| DESIGN PARAMETER | EXAMPLE VALUE |
|---|---------------|
| Reference Initial Accuracy | 1.0% |
| Supply Voltage | 6V |
| Cathode Current (I _k) | 1mA |
| Output Voltage Level | 1.24V - 6V |
| Load Capacitance | 100pF |
| Feedback Resistor Values and Accuracy (R1 and R2) | 10kΩ |

8.2.2.2 Detailed Design Procedure

When using TLV431 as a Shunt Regulator, determine the following:

- Input voltage range
- Temperature range
- Total accuracy
- Cathode current
- Reference initial accuracy
- Output capacitance

8.2.2.2.1 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 [Figure 8-5](#), 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 [Figure 8-5](#). The cathode voltage can be more accurately determined by taking the cathode current in to account

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

For [Equation 1](#) to be valid, TLV431 must be fully biased so that it has enough open-loop gain to mitigate any gain error. This can be done by meeting the I_{min} spec denoted in *Recommended Operating Conditions* table.

8.2.2.2.2 Total Accuracy

When programming the output above unity gain (V_{ka} = V_{ref}), TLV431 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. Application note [Setting the Shunt Voltage on an Adjustable Shunt Regulator \(SLVA445\)](#) assists designers in setting the shunt voltage to achieve optimum accuracy for this device.

8.2.2.2.3 Stability

Though TLV431 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 TLV431 region of stability, shown in Figure 5-18. Also, designers may use capacitive loads to improve the transient response or for power supply decoupling.

8.2.2.3 Application Curve

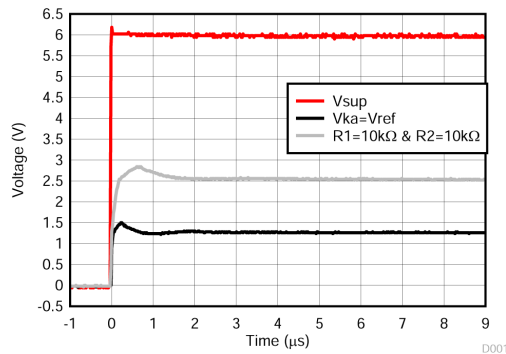


Figure 8-6. TLV431 Start-Up Response

8.3 Power Supply Recommendations

When using TLV431 as a Linear Regulator to supply a load, designers will 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 5-18.

To not exceed the maximum cathode current, be sure that the supply voltage is current limited. Also, be sure to limit the current being driven into the Ref pin, as not to exceed the 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.

8.4 Layout

8.4.1 Layout Guidelines

Place decoupling capacitors as close to the device as possible. Use appropriate widths for traces when shunting high currents to avoid excessive voltage drops.

8.4.2 Layout Example

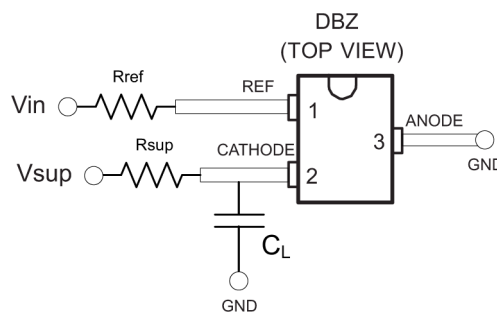


Figure 8-7. DBZ Layout Example

9 Device and Documentation Support

9.1 Documentation Support

9.1.1 Related Documentation

For related documentation, see the following:

- [Compensation Design With TL431 for UCC28600](#) (SLUA671)
- [Setting the Shunt Voltage on an Adjustable Shunt Regulator](#) (SLVA445)

9.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

9.3 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

9.4 Trademarks

E2E is a trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

9.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

9.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

10 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Revision Y (March 2024) to Revision Z (June 2024) | Page |
|---|-------------|
| • Updated pinout diagrams..... | 3 |

| Changes from Revision X (May 2018) to Revision Y (March 2024) | Page |
|---|-------------|
| • Updated the numbering format for tables, figures, and cross-references throughout the document..... | 1 |
| • Moved <i>Simplified Schematic</i> from <i>Description</i> to <i>Applications</i> | 1 |
| • Updated pinout diagrams..... | 3 |
| • Updated <i>Typical Applications Design Requiements</i> | 23 |

| Changes from Revision W (March 2018) to Revision X (May 2018) | Page |
|--|-------------|
| • Changed Figure 5-18 | 8 |

11 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) |
|---------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|--|
| TLV431ACDBVR | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | (YAC6, YACC, YACI, YACN) (YACG, YA CL, YACS) |
| TLV431ACDBVR.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | (YAC6, YACC, YACI, YACN) (YACG, YA CL, YACS) |
| TLV431ACDBVR1G4 | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | (YAC6, YACC, YACI) (YACG, YA CL, YACS) |
| TLV431ACDBVR1G4.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | (YAC6, YACC, YACI) (YACG, YA CL, YACS) |
| TLV431ACDBVRG4 | Obsolete | Production | SOT-23 (DBV) 5 | - | - | Call TI | Call TI | 0 to 70 | YACI |
| TLV431ACDBVT | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | (YAC6, YACC, YACI) (YACG, YA CL, YACS) |
| TLV431ACDBVT.A | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | (YAC6, YACC, YACI) (YACG, YA CL, YACS) |
| TLV431ACDBZR | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU SN NIPDAUAG | Level-1-260C-UNLIM | 0 to 70 | (YAC6, YAC8, YACB, YACS) (YAC3, YACS, YACU) |
| TLV431ACDBZR.A | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | (YAC6, YAC8, YACB, YACS) (YAC3, YACS, YACU) |
| TLV431ACDBZRG4 | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU NIPDAUAG | Level-1-260C-UNLIM | 0 to 70 | YAC6 YACS |

| 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) |
|---------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---|
| TLV431ACDBZRG4.A | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | YAC6 YACS |
| TLV431ACLP | Active | Production | TO-92 (LP) 3 | 1000 BULK | Yes | SN | N/A for Pkg Type | 0 to 70 | V431AC |
| TLV431ACLP.A | Active | Production | TO-92 (LP) 3 | 1000 BULK | Yes | SN | N/A for Pkg Type | 0 to 70 | V431AC |
| TLV431ACLPR | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | 0 to 70 | V431AC |
| TLV431ACLPR.A | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | 0 to 70 | V431AC |
| TLV431AID | Obsolete | Production | SOIC (D) 8 | - | - | Call TI | Call TI | -40 to 85 | TY431A |
| TLV431AIDBVR | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | (YAI6, YAIC, YAI1, YAIN) (YAIG, YAIL, YAIS) |
| TLV431AIDBVR.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (YAI6, YAIC, YAI1, YAIN) (YAIG, YAIL, YAIS) |
| TLV431AIDBVR1G4 | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (YAI6, YAIC) (YAIL, YAIS) |
| TLV431AIDBVR1G4.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (YAI6, YAIC) (YAIL, YAIS) |
| TLV431AIDBVRG4 | Obsolete | Production | SOT-23 (DBV) 5 | - | - | Call TI | Call TI | -40 to 85 | YAI1 |
| TLV431AIDBVT | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | (YAI6, YAIC, YAI1) (YAIG, YAIL, YAIS) |
| TLV431AIDBVT.A | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | (YAI6, YAIC, YAI1) (YAIG, YAIL, YAIS) |
| TLV431AIDBZR | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU SN NIPDAUAG | Level-1-260C-UNLIM | -40 to 85 | (YAI6, YAI8, YAIB, YAIS) (YAI3, YAIS, YAIU) |
| TLV431AIDBZR.A | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (YAI6, YAI8, YAIB, YAIS) (YAI3, YAIS, YAIU) |

| 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) |
|--------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| TLV431AIDBZRG4 | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU NIPDAUAG | Level-1-260C-UNLIM | -40 to 85 | YAI6 YAIS |
| TLV431AIDBZRG4.A | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | YAI6 YAIS |
| TLV431AIDE4 | NRND | Production | SOIC (D) 8 | 75 TUBE | - | Call TI | Call TI | -40 to 85 | |
| TLV431AIDR | NRND | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | TY431A |
| TLV431AIDR.A | NRND | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | TY431A |
| TLV431AIDRE4 | NRND | Production | SOIC (D) 8 | 2500 LARGE T&R | - | Call TI | Call TI | -40 to 85 | |
| TLV431AILP | Obsolete | Production | TO-92 (LP) 3 | - | - | Call TI | Call TI | -40 to 85 | V431AI |
| TLV431AILPM | Active | Production | TO-92 (LP) 3 | 2000 AMMO | Yes | SN | N/A for Pkg Type | -40 to 85 | V431AI |
| TLV431AILPM.A | Active | Production | TO-92 (LP) 3 | 2000 AMMO | Yes | SN | N/A for Pkg Type | -40 to 85 | V431AI |
| TLV431AILPR | NRND | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -40 to 85 | V431AI |
| TLV431AILPR.A | NRND | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -40 to 85 | V431AI |
| TLV431AQPK | Active | Production | SOT-89 (PK) 3 | 1000 LARGE T&R | Yes | SN | Level-2-260C-1 YEAR | -40 to 125 | VA |
| TLV431AQPK.A | Active | Production | SOT-89 (PK) 3 | 1000 LARGE T&R | Yes | SN | Level-2-260C-1 YEAR | -40 to 125 | VA |
| TLV431BCDBVR | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | 0 to 70 | (Y3GG, Y3GJ, Y3GU) |
| TLV431BCDBVR.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | 0 to 70 | (Y3GG, Y3GJ, Y3GU) |
| TLV431BCDBVT | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | 0 to 70 | (Y3GG, Y3GJ, Y3GU) |
| TLV431BCDBVT.A | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | 0 to 70 | (Y3GG, Y3GJ, Y3GU) |
| TLV431BCDBZR | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU SN NIPDAUAG | Level-1-260C-UNLIM | 0 to 70 | (Y3G3, Y3GS, Y3GU) |
| TLV431BCDBZR.A | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | (Y3G3, Y3GS, Y3GU) |
| TLV431BCDBZT | Active | Production | SOT-23 (DBZ) 3 | 250 SMALL T&R | Yes | NIPDAU SN NIPDAUAG | Level-1-260C-UNLIM | 0 to 70 | (Y3GS, Y3GU) |
| TLV431BCDBZT.A | Active | Production | SOT-23 (DBZ) 3 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | (Y3GS, Y3GU) |
| TLV431BCDBZTG4 | Active | Production | SOT-23 (DBZ) 3 | 250 SMALL T&R | Yes | NIPDAU NIPDAUAG | Level-1-260C-UNLIM | 0 to 70 | Y3GS |
| TLV431BCDBZTG4.A | Active | Production | SOT-23 (DBZ) 3 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | Y3GS |
| TLV431BCDCKR | Active | Production | SC70 (DCK) 6 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | 0 to 70 | YEU |

| 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) |
|--------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| TLV431BCDCKR.A | Active | Production | SC70 (DCK) 6 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | 0 to 70 | YEU |
| TLV431BCDCKT | Active | Production | SC70 (DCK) 6 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | 0 to 70 | YEU |
| TLV431BCDCKT.A | Active | Production | SC70 (DCK) 6 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | 0 to 70 | YEU |
| TLV431BCLP | Obsolete | Production | TO-92 (LP) 3 | - | - | Call TI | Call TI | 0 to 70 | TV431B |
| TLV431BCLPR | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | 0 to 70 | TV431B |
| TLV431BCLPR.A | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | 0 to 70 | TV431B |
| TLV431BCPK | Active | Production | SOT-89 (PK) 3 | 1000 LARGE T&R | Yes | SN | Level-2-260C-1 YEAR | 0 to 70 | VE |
| TLV431BCPK.A | Active | Production | SOT-89 (PK) 3 | 1000 LARGE T&R | Yes | SN | Level-2-260C-1 YEAR | 0 to 70 | VE |
| TLV431BIDBVR | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | (Y3FJ, Y3FU) |
| TLV431BIDBVR.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | (Y3FJ, Y3FU) |
| TLV431BIDBVT | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | (Y3FJ, Y3FU) |
| TLV431BIDBVT.A | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | (Y3FJ, Y3FU) |
| TLV431BIDBZR | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU SN NIPDAUAG | Level-1-260C-UNLIM | -40 to 85 | (Y3F3, Y3FS, Y3FU) |
| TLV431BIDBZR.A | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (Y3F3, Y3FS, Y3FU) |
| TLV431BIDBZRG4 | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU NIPDAUAG | Level-1-260C-UNLIM | -40 to 85 | (Y3F3, Y3FS) |
| TLV431BIDBZRG4.A | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (Y3F3, Y3FS) |
| TLV431BIDBZT | Active | Production | SOT-23 (DBZ) 3 | 250 SMALL T&R | Yes | NIPDAU SN NIPDAUAG | Level-1-260C-UNLIM | -40 to 85 | (Y3FS, Y3FU) |
| TLV431BIDBZT.A | Active | Production | SOT-23 (DBZ) 3 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (Y3FS, Y3FU) |
| TLV431BIDBZTG4.A | Active | Production | SOT-23 (DBZ) 3 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | Y3FS |
| TLV431BIDCKR | Active | Production | SC70 (DCK) 6 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | YFU |
| TLV431BIDCKR.A | Active | Production | SC70 (DCK) 6 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | YFU |
| TLV431BIDCKRG4 | Active | Production | SC70 (DCK) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | YFU |
| TLV431BIDCKRG4.A | Active | Production | SC70 (DCK) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | YFU |
| TLV431BIDCKT | Active | Production | SC70 (DCK) 6 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | YFU |
| TLV431BIDCKT.A | Active | Production | SC70 (DCK) 6 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | YFU |
| TLV431BILP | Obsolete | Production | TO-92 (LP) 3 | - | - | Call TI | Call TI | -40 to 85 | TY431B |
| TLV431BILPR | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -40 to 85 | TY431B |
| TLV431BILPR.A | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -40 to 85 | TY431B |

| 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) |
|--------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|------------------------------|
| TLV431BIPK | Active | Production | SOT-89 (PK) 3 | 1000 LARGE T&R | Yes | SN | Level-2-260C-1 YEAR | -40 to 85 | VF |
| TLV431BIPK.A | Active | Production | SOT-89 (PK) 3 | 1000 LARGE T&R | Yes | SN | Level-2-260C-1 YEAR | -40 to 85 | VF |
| TLV431BQDBVR | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 125 | (Y3HJ, Y3HU) |
| TLV431BQDBVR.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | (Y3HJ, Y3HU) |
| TLV431BQDBVRE4 | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | - | Call TI | Call TI | -40 to 125 | |
| TLV431BQDBVRG4 | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | Y3HU |
| TLV431BQDBVRG4.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | Y3HU |
| TLV431BQDBVT | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 125 | (Y3HJ, Y3HU) |
| TLV431BQDBVT.A | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | (Y3HJ, Y3HU) |
| TLV431BQDBZR | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU SN NIPDAUAG | Level-1-260C-UNLIM | -40 to 125 | (Y3H3, Y3HS, Y3HU) |
| TLV431BQDBZR.A | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | (Y3H3, Y3HS, Y3HU) |
| TLV431BQDBZRG4 | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU NIPDAUAG | Level-1-260C-UNLIM | -40 to 125 | Y3HS |
| TLV431BQDBZRG4.A | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | Y3HS |
| TLV431BQDBZT | Active | Production | SOT-23 (DBZ) 3 | 250 SMALL T&R | Yes | NIPDAU SN NIPDAUAG | Level-1-260C-UNLIM | -40 to 125 | (Y3HS, Y3HU) |
| TLV431BQDBZT.A | Active | Production | SOT-23 (DBZ) 3 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | (Y3HS, Y3HU) |
| TLV431BQDCKR | Active | Production | SC70 (DCK) 6 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 125 | YGU |
| TLV431BQDCKR.A | Active | Production | SC70 (DCK) 6 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | YGU |
| TLV431BQDCKT | Active | Production | SC70 (DCK) 6 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 125 | YGU |
| TLV431BQDCKT.A | Active | Production | SC70 (DCK) 6 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | YGU |
| TLV431BQLP | Obsolete | Production | TO-92 (LP) 3 | - | - | Call TI | Call TI | -40 to 125 | TQ431B |
| TLV431BQLPR | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -40 to 125 | TQ431B |
| TLV431BQLPR.A | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -40 to 125 | TQ431B |
| TLV431BQPK | Active | Production | SOT-89 (PK) 3 | 1000 LARGE T&R | Yes | SN | Level-2-260C-1 YEAR | -40 to 125 | V6 |
| TLV431BQPK.A | Active | Production | SOT-89 (PK) 3 | 1000 LARGE T&R | Yes | SN | Level-2-260C-1 YEAR | -40 to 125 | V6 |
| TLV431CDBVR | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | 0 to 70 | (Y3C6, Y3CI) (Y3CG, Y3CS) |
| TLV431CDBVR.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | 0 to 70 | (Y3C6, Y3CI) (Y3CG, Y3CS) |
| TLV431CDBVRG4 | Obsolete | Production | SOT-23 (DBV) 5 | - | - | Call TI | Call TI | 0 to 70 | Y3CI |

| 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) |
|--------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---|
| TLV431CDBVT | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | 0 to 70 | (Y3C6, Y3CI) (Y3CG, Y3CS) |
| TLV431CDBVT.A | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | 0 to 70 | (Y3C6, Y3CI) (Y3CG, Y3CS) |
| TLV431CDBZR | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU SN NIPDAUAG | Level-1-260C-UNLIM | 0 to 70 | (Y3C6, Y3C8, Y3CB, Y3CS) (Y3C3, Y3CS, Y3CU) |
| TLV431CDBZR.A | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | (Y3C6, Y3C8, Y3CB, Y3CS) (Y3C3, Y3CS, Y3CU) |
| TLV431CLP | Obsolete | Production | TO-92 (LP) 3 | - | - | Call TI | Call TI | 0 to 70 | V431C |
| TLV431CLPR | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | 0 to 70 | V431C |
| TLV431CLPR.A | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | 0 to 70 | V431C |
| TLV431IDBVR | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | (Y3I6, Y3II) (Y3IG, Y3IS) |
| TLV431IDBVR.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | (Y3I6, Y3II) (Y3IG, Y3IS) |
| TLV431IDBVR1G4 | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | Y3I6 Y3IS |
| TLV431IDBVR1G4.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | Y3I6 Y3IS |
| TLV431IDBVRG4 | Obsolete | Production | SOT-23 (DBV) 5 | - | - | Call TI | Call TI | -40 to 85 | Y3II |
| TLV431IDBVT | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | (Y3I6, Y3II) (Y3IG, Y3IS) |
| TLV431IDBVT.A | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | (Y3I6, Y3II) (Y3IG, Y3IS) |
| TLV431IDBZR | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU SN NIPDAUAG | Level-1-260C-UNLIM | -40 to 85 | (Y3I6, Y3IB, Y3IS) (Y3IU, Y3IU) |
| TLV431IDBZR.A | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (Y3I6, Y3IB, Y3IS) (Y3IU, Y3IU) |
| TLV431IDBZRG4 | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU NIPDAUAG | Level-1-260C-UNLIM | -40 to 85 | Y3I6 Y3IS |

| 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) |
|----------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| TLV431IDBZRG4.A | Active | Production | SOT-23 (DBZ) 3 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | Y3I6 Y3IS |
| TLV431ILP | Obsolete | Production | TO-92 (LP) 3 | - | - | Call TI | Call TI | -40 to 85 | V4311 |
| TLV431ILPR | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -40 to 85 | V4311 |
| TLV431ILPR.A | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -40 to 85 | V4311 |
| TLV431QPK | Active | Production | SOT-89 (PK) 3 | 1000 LARGE T&R | Yes | SN | Level-2-260C-1 YEAR | -40 to 125 | VB |
| TLV431QPK.A | Active | Production | SOT-89 (PK) 3 | 1000 LARGE T&R | Yes | SN | Level-2-260C-1 YEAR | -40 to 125 | VB |

(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 TLV431A, TLV431B :

- Automotive : [TLV431A-Q1](#), [TLV431B-Q1](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TLV431ACDBVR | SOT-23 | DBV | 5 | 3000 | 178.0 | 9.0 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| TLV431ACDBVR1G4 | SOT-23 | DBV | 5 | 3000 | 178.0 | 9.0 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| TLV431ACDBVR1G4 | SOT-23 | DBV | 5 | 3000 | 180.0 | 8.4 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| TLV431ACDBVT | SOT-23 | DBV | 5 | 250 | 178.0 | 9.0 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| TLV431ACDBZR | SOT-23 | DBZ | 3 | 3000 | 178.0 | 9.0 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431ACDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431ACDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 2.9 | 3.35 | 1.35 | 4.0 | 8.0 | Q3 |
| TLV431AIDBVR | SOT-23 | DBV | 5 | 3000 | 178.0 | 9.0 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| TLV431AIDBVR1G4 | SOT-23 | DBV | 5 | 3000 | 180.0 | 8.4 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| TLV431AIDBVT | SOT-23 | DBV | 5 | 250 | 178.0 | 9.0 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| TLV431AIDBZR | SOT-23 | DBZ | 3 | 3000 | 178.0 | 9.0 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431AIDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 2.9 | 3.35 | 1.35 | 4.0 | 8.0 | Q3 |
| TLV431AIDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431AIDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLV431AQPK | SOT-89 | PK | 3 | 1000 | 180.0 | 12.4 | 4.91 | 4.52 | 1.9 | 8.0 | 12.0 | Q3 |
| TLV431AQPK | SOT-89 | PK | 3 | 1000 | 180.0 | 12.4 | 4.91 | 4.52 | 1.9 | 8.0 | 12.0 | Q3 |

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TLV431BCDBVR | SOT-23 | DBV | 5 | 3000 | 178.0 | 9.0 | 3.3 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV431BCDBVT | SOT-23 | DBV | 5 | 250 | 178.0 | 9.0 | 3.3 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV431BCDBZR | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 2.9 | 3.35 | 1.35 | 4.0 | 8.0 | Q3 |
| TLV431BCDBZR | SOT-23 | DBZ | 3 | 3000 | 178.0 | 9.0 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431BCDBZT | SOT-23 | DBZ | 3 | 250 | 178.0 | 9.0 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431BCDBZTG4 | SOT-23 | DBZ | 3 | 250 | 180.0 | 8.4 | 2.9 | 3.35 | 1.35 | 4.0 | 8.0 | Q3 |
| TLV431BCDBZTG4 | SOT-23 | DBZ | 3 | 250 | 180.0 | 8.4 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431BCDCKR | SC70 | DCK | 6 | 3000 | 179.0 | 8.4 | 2.2 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| TLV431BCDCKT | SC70 | DCK | 6 | 250 | 179.0 | 8.4 | 2.2 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| TLV431BCPK | SOT-89 | PK | 3 | 1000 | 180.0 | 12.4 | 4.91 | 4.52 | 1.9 | 8.0 | 12.0 | Q3 |
| TLV431BCPK | SOT-89 | PK | 3 | 1000 | 180.0 | 12.4 | 4.91 | 4.52 | 1.9 | 8.0 | 12.0 | Q3 |
| TLV431BIDBVR | SOT-23 | DBV | 5 | 3000 | 178.0 | 9.0 | 3.3 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV431BIDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV431BIDBVT | SOT-23 | DBV | 5 | 250 | 178.0 | 9.0 | 3.3 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV431BIDBZR | SOT-23 | DBZ | 3 | 3000 | 178.0 | 9.0 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431BIDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431BIDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 2.9 | 3.35 | 1.35 | 4.0 | 8.0 | Q3 |
| TLV431BIDBZT | SOT-23 | DBZ | 3 | 250 | 178.0 | 9.0 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431BIDCKR | SC70 | DCK | 6 | 3000 | 179.0 | 8.4 | 2.2 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| TLV431BIDCKRG4 | SC70 | DCK | 6 | 3000 | 179.0 | 8.4 | 2.2 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| TLV431BIDCKT | SC70 | DCK | 6 | 250 | 179.0 | 8.4 | 2.2 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| TLV431BIPK | SOT-89 | PK | 3 | 1000 | 180.0 | 12.4 | 4.91 | 4.52 | 1.9 | 8.0 | 12.0 | Q3 |
| TLV431BIPK | SOT-89 | PK | 3 | 1000 | 180.0 | 12.4 | 4.91 | 4.52 | 1.9 | 8.0 | 12.0 | Q3 |
| TLV431BQDBVR | SOT-23 | DBV | 5 | 3000 | 178.0 | 9.0 | 3.3 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV431BQDBVRG4 | SOT-23 | DBV | 5 | 3000 | 179.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV431BQDBVT | SOT-23 | DBV | 5 | 250 | 178.0 | 9.0 | 3.3 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV431BQDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV431BQDBZR | SOT-23 | DBZ | 3 | 3000 | 178.0 | 9.0 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431BQDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 2.9 | 3.35 | 1.35 | 4.0 | 8.0 | Q3 |
| TLV431BQDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431BQDBZT | SOT-23 | DBZ | 3 | 250 | 178.0 | 9.0 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431BQDCKR | SC70 | DCK | 6 | 3000 | 179.0 | 8.4 | 2.2 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| TLV431BQDCKR | SC70 | DCK | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| TLV431BQDCKT | SC70 | DCK | 6 | 250 | 179.0 | 8.4 | 2.2 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| TLV431BQDCKT | SC70 | DCK | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| TLV431BQPK | SOT-89 | PK | 3 | 1000 | 180.0 | 12.4 | 4.91 | 4.52 | 1.9 | 8.0 | 12.0 | Q3 |
| TLV431BQPK | SOT-89 | PK | 3 | 1000 | 180.0 | 12.4 | 4.91 | 4.52 | 1.9 | 8.0 | 12.0 | Q3 |
| TLV431CDBVR | SOT-23 | DBV | 5 | 3000 | 178.0 | 9.0 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| TLV431CDBVT | SOT-23 | DBV | 5 | 250 | 178.0 | 9.0 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| TLV431CDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 8.4 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| TLV431CDBZR | SOT-23 | DBZ | 3 | 3000 | 178.0 | 9.0 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TLV431IDBVR | SOT-23 | DBV | 5 | 3000 | 178.0 | 9.0 | 3.3 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV431IDBVR1G4 | SOT-23 | DBV | 5 | 3000 | 180.0 | 8.4 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| TLV431IDBVT | SOT-23 | DBV | 5 | 250 | 178.0 | 9.0 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| TLV431IDBZR | SOT-23 | DBZ | 3 | 3000 | 178.0 | 9.0 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431IDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 2.9 | 3.35 | 1.35 | 4.0 | 8.0 | Q3 |
| TLV431IDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TLV431QPK | SOT-89 | PK | 3 | 1000 | 180.0 | 12.4 | 4.91 | 4.52 | 1.9 | 8.0 | 12.0 | Q3 |
| TLV431QPK | SOT-89 | PK | 3 | 1000 | 180.0 | 12.4 | 4.91 | 4.52 | 1.9 | 8.0 | 12.0 | Q3 |

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

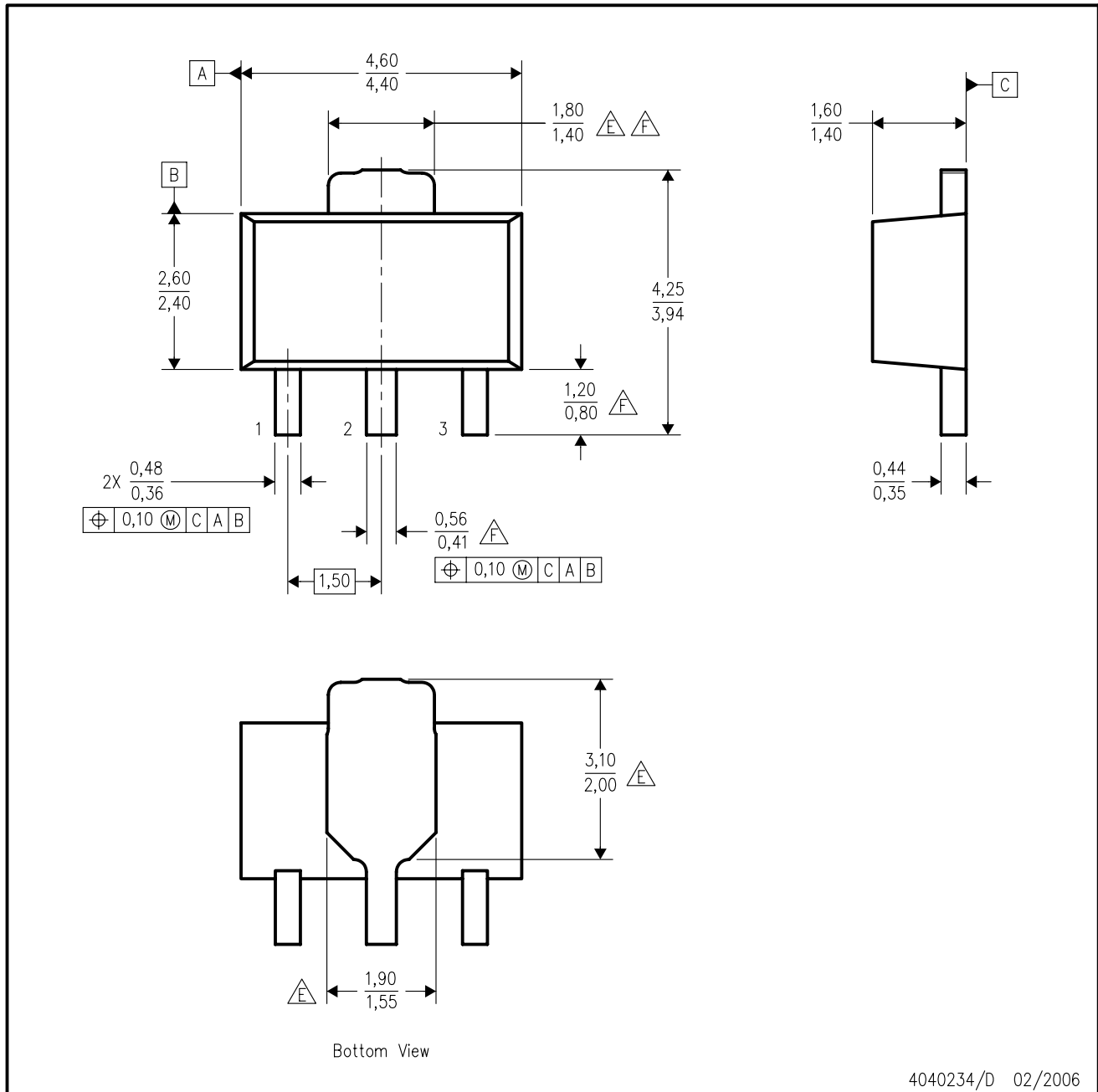
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|-----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TLV431ACDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431ACDBVR1G4 | SOT-23 | DBV | 5 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431ACDBVR1G4 | SOT-23 | DBV | 5 | 3000 | 183.0 | 183.0 | 20.0 |
| TLV431ACDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 180.0 | 18.0 |
| TLV431ACDBZR | SOT-23 | DBZ | 3 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431ACDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 183.0 | 183.0 | 20.0 |
| TLV431ACDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 210.0 | 185.0 | 35.0 |
| TLV431AIDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431AIDBVR1G4 | SOT-23 | DBV | 5 | 3000 | 183.0 | 183.0 | 20.0 |
| TLV431AIDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 180.0 | 18.0 |
| TLV431AIDBZR | SOT-23 | DBZ | 3 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431AIDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 210.0 | 185.0 | 35.0 |
| TLV431AIDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 183.0 | 183.0 | 20.0 |
| TLV431AIDR | SOIC | D | 8 | 2500 | 353.0 | 353.0 | 32.0 |
| TLV431AQPK | SOT-89 | PK | 3 | 1000 | 190.0 | 190.0 | 30.0 |
| TLV431AQPK | SOT-89 | PK | 3 | 1000 | 340.0 | 340.0 | 38.0 |
| TLV431BCDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431BCDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 180.0 | 18.0 |

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TLV431BCDBZR | SOT-23 | DBZ | 3 | 3000 | 210.0 | 185.0 | 35.0 |
| TLV431BCDBZR | SOT-23 | DBZ | 3 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431BCDBZT | SOT-23 | DBZ | 3 | 250 | 180.0 | 180.0 | 18.0 |
| TLV431BCDBZTG4 | SOT-23 | DBZ | 3 | 250 | 210.0 | 185.0 | 35.0 |
| TLV431BCDBZTG4 | SOT-23 | DBZ | 3 | 250 | 183.0 | 183.0 | 20.0 |
| TLV431BCDCKR | SC70 | DCK | 6 | 3000 | 203.0 | 203.0 | 35.0 |
| TLV431BCDCKT | SC70 | DCK | 6 | 250 | 203.0 | 203.0 | 35.0 |
| TLV431BCPK | SOT-89 | PK | 3 | 1000 | 340.0 | 340.0 | 38.0 |
| TLV431BCPK | SOT-89 | PK | 3 | 1000 | 190.0 | 190.0 | 30.0 |
| TLV431BIDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431BIDBVT | SOT-23 | DBV | 5 | 250 | 203.0 | 203.0 | 35.0 |
| TLV431BIDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 180.0 | 18.0 |
| TLV431BIDBZR | SOT-23 | DBZ | 3 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431BIDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 183.0 | 183.0 | 20.0 |
| TLV431BIDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 210.0 | 185.0 | 35.0 |
| TLV431BIDBZT | SOT-23 | DBZ | 3 | 250 | 180.0 | 180.0 | 18.0 |
| TLV431BIDCKR | SC70 | DCK | 6 | 3000 | 203.0 | 203.0 | 35.0 |
| TLV431BIDCKRG4 | SC70 | DCK | 6 | 3000 | 203.0 | 203.0 | 35.0 |
| TLV431BIDCKT | SC70 | DCK | 6 | 250 | 203.0 | 203.0 | 35.0 |
| TLV431BIPK | SOT-89 | PK | 3 | 1000 | 190.0 | 190.0 | 30.0 |
| TLV431BIPK | SOT-89 | PK | 3 | 1000 | 340.0 | 340.0 | 38.0 |
| TLV431BQDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431BQDBVRG4 | SOT-23 | DBV | 5 | 3000 | 200.0 | 183.0 | 25.0 |
| TLV431BQDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 180.0 | 18.0 |
| TLV431BQDBVT | SOT-23 | DBV | 5 | 250 | 203.0 | 203.0 | 35.0 |
| TLV431BQDBZR | SOT-23 | DBZ | 3 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431BQDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 210.0 | 185.0 | 35.0 |
| TLV431BQDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 183.0 | 183.0 | 20.0 |
| TLV431BQDBZT | SOT-23 | DBZ | 3 | 250 | 180.0 | 180.0 | 18.0 |
| TLV431BQDCKR | SC70 | DCK | 6 | 3000 | 200.0 | 183.0 | 25.0 |
| TLV431BQDCKR | SC70 | DCK | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| TLV431BQDCKT | SC70 | DCK | 6 | 250 | 200.0 | 183.0 | 25.0 |
| TLV431BQDCKT | SC70 | DCK | 6 | 250 | 210.0 | 185.0 | 35.0 |
| TLV431BQPK | SOT-89 | PK | 3 | 1000 | 340.0 | 340.0 | 38.0 |
| TLV431BQPK | SOT-89 | PK | 3 | 1000 | 190.0 | 190.0 | 30.0 |
| TLV431CDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431CDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 180.0 | 18.0 |
| TLV431CDBVT | SOT-23 | DBV | 5 | 250 | 183.0 | 183.0 | 20.0 |
| TLV431CDBZR | SOT-23 | DBZ | 3 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431IDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 180.0 | 18.0 |
| TLV431IDBVR1G4 | SOT-23 | DBV | 5 | 3000 | 183.0 | 183.0 | 20.0 |
| TLV431IDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 180.0 | 18.0 |
| TLV431IDBZR | SOT-23 | DBZ | 3 | 3000 | 180.0 | 180.0 | 18.0 |

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TLV431IDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 210.0 | 185.0 | 35.0 |
| TLV431IDBZRG4 | SOT-23 | DBZ | 3 | 3000 | 183.0 | 183.0 | 20.0 |
| TLV431QPK | SOT-89 | PK | 3 | 1000 | 340.0 | 340.0 | 38.0 |
| TLV431QPK | SOT-89 | PK | 3 | 1000 | 190.0 | 190.0 | 30.0 |

PK (R-PSS0-F3)

PLASTIC SINGLE-IN-LINE PACKAGE



4040234/D 02/2006

- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. The center lead is in electrical contact with the tab.
 - D. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion not to exceed 0.15 per side.
 - $\triangle E$ Thermal pad contour optional within these dimensions.
 - $\triangle F$ Falls within JEDEC TO-243 variation AA, except minimum lead length, pin 2 minimum lead width, minimum tab width.

PK (R-PDSO-G3)



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525.
 - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.



D0008A

PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

NOTES:

- Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
- This drawing is subject to change without notice.
- This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed $.006$ [0.15] per side.
- This dimension does not include interlead flash.
- Reference JEDEC registration MS-012, variation AA.

EXAMPLE BOARD LAYOUT

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
 EXPOSED METAL SHOWN
 SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

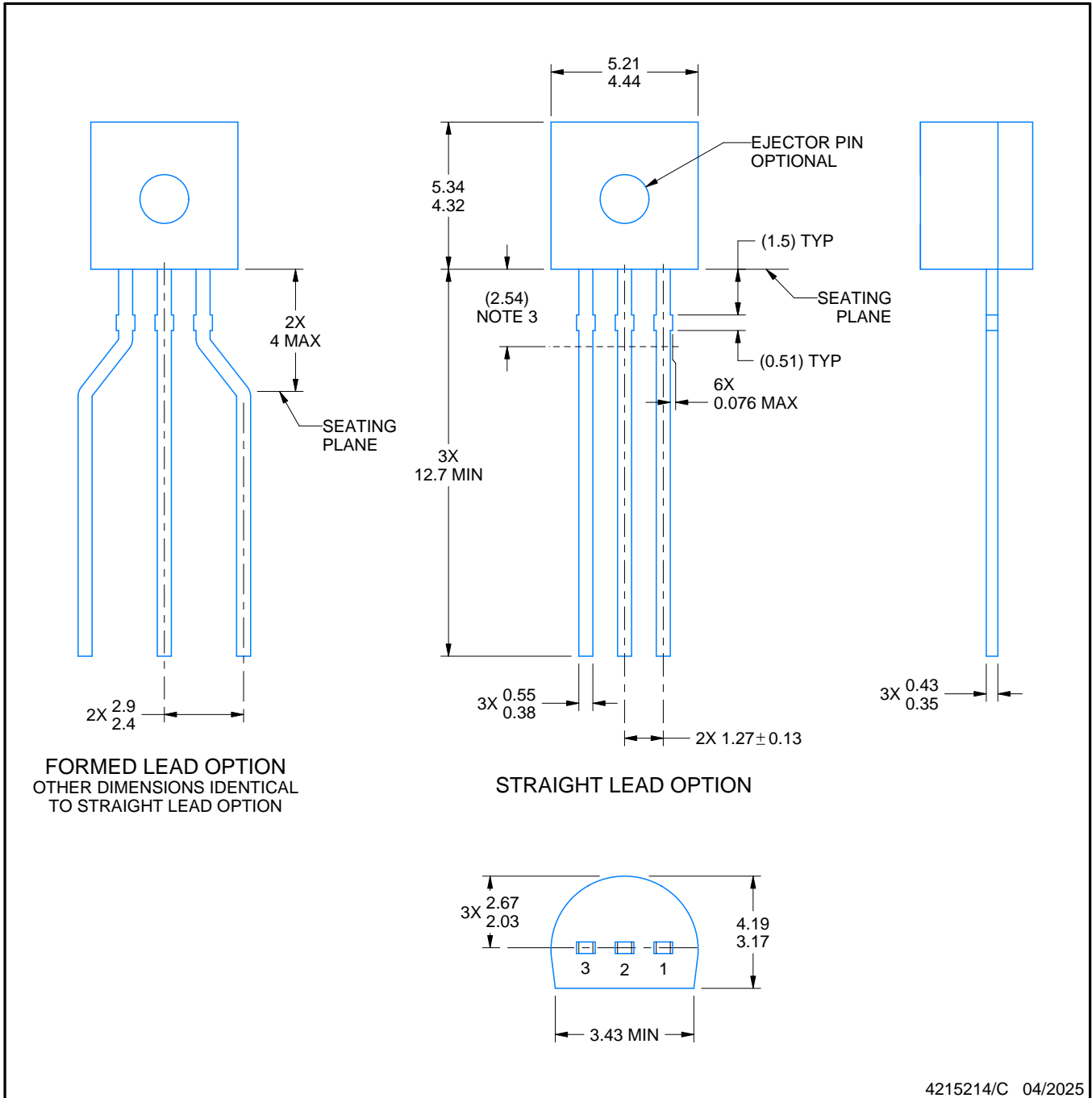
LP0003A



PACKAGE OUTLINE

TO-92 - 5.34 mm max height

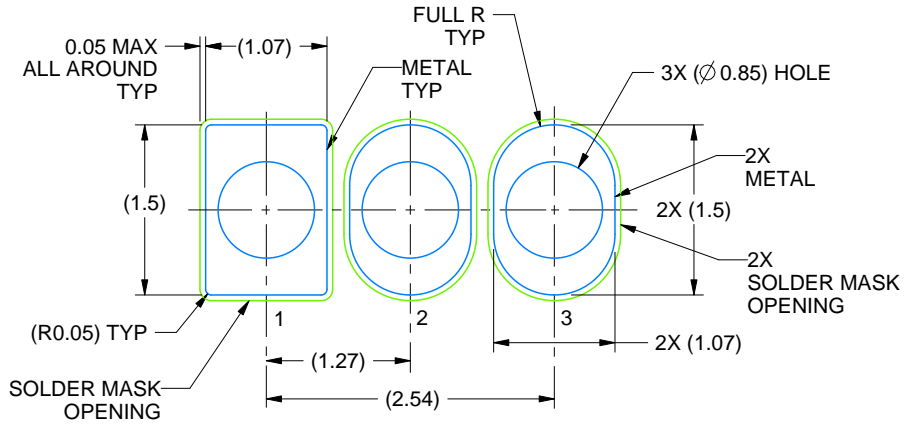
TO-92



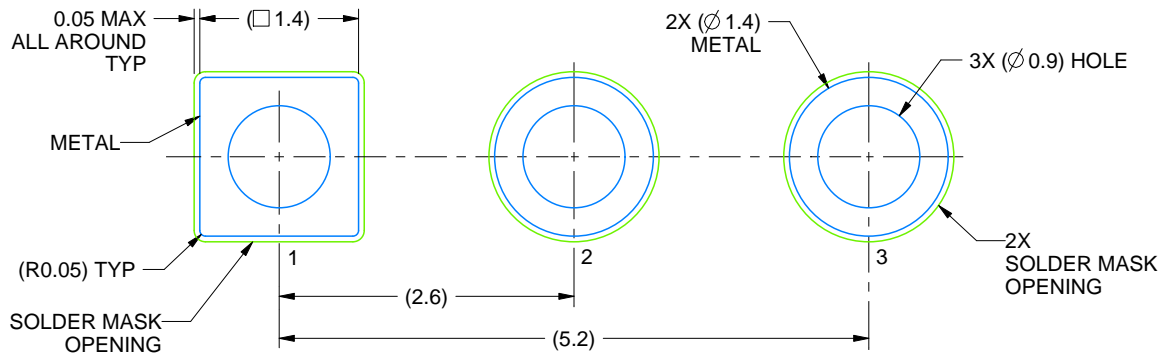
4215214/C 04/2025

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. Lead dimensions are not controlled within this area.
4. Reference JEDEC TO-226, variation AA.
5. Shipping method:
 - a. Straight lead option available in bulk pack only.
 - b. Formed lead option available in tape and reel or ammo pack.
 - c. Specific products can be offered in limited combinations of shipping medium and lead options.
 - d. Consult product folder for more information on available options.



LAND PATTERN EXAMPLE
STRAIGHT LEAD OPTION
NON-SOLDER MASK DEFINED
SCALE:15X



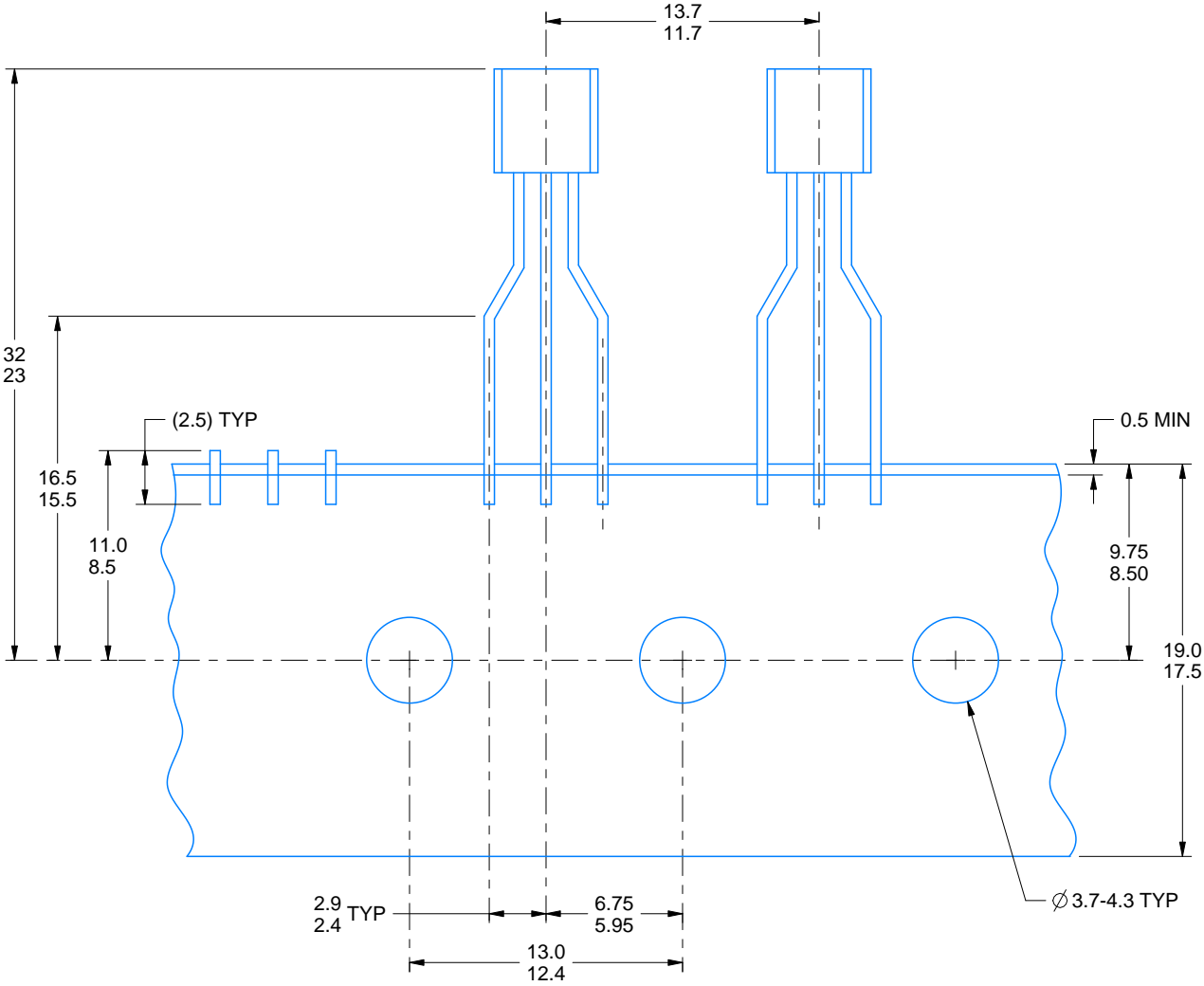
LAND PATTERN EXAMPLE
FORMED LEAD OPTION
NON-SOLDER MASK DEFINED
SCALE:15X

TAPE SPECIFICATIONS

LP0003A

TO-92 - 5.34 mm max height

TO-92



FOR FORMED LEAD OPTION PACKAGE

4215214/C 04/2025

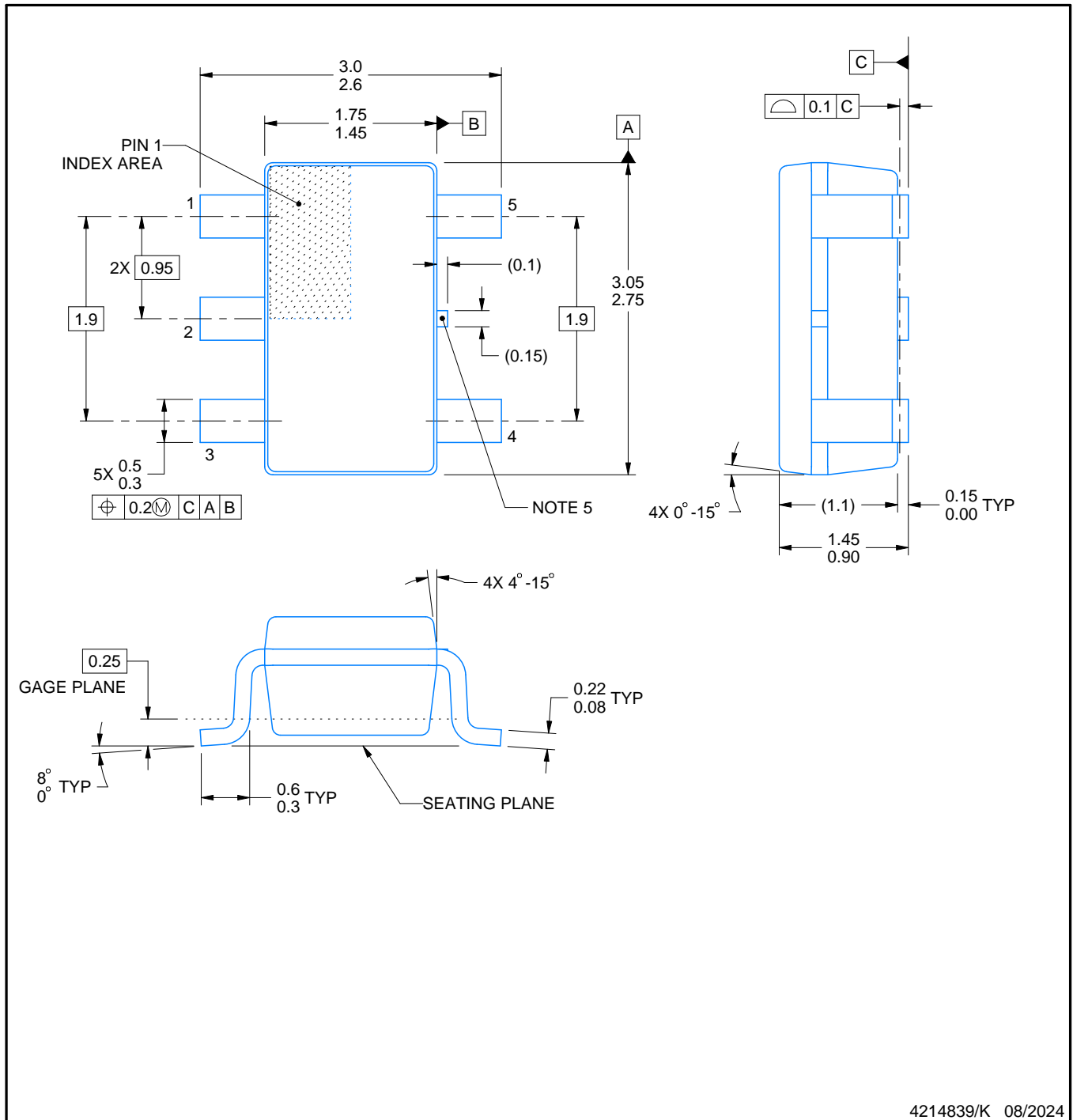
DBV0005A



PACKAGE OUTLINE

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



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. Reference JEDEC MO-178.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25 mm per side.
5. Support pin may differ or may not be present.

EXAMPLE BOARD LAYOUT

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



SOLDER MASK DETAILS

4214839/K 08/2024

NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

4214839/K 08/2024

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

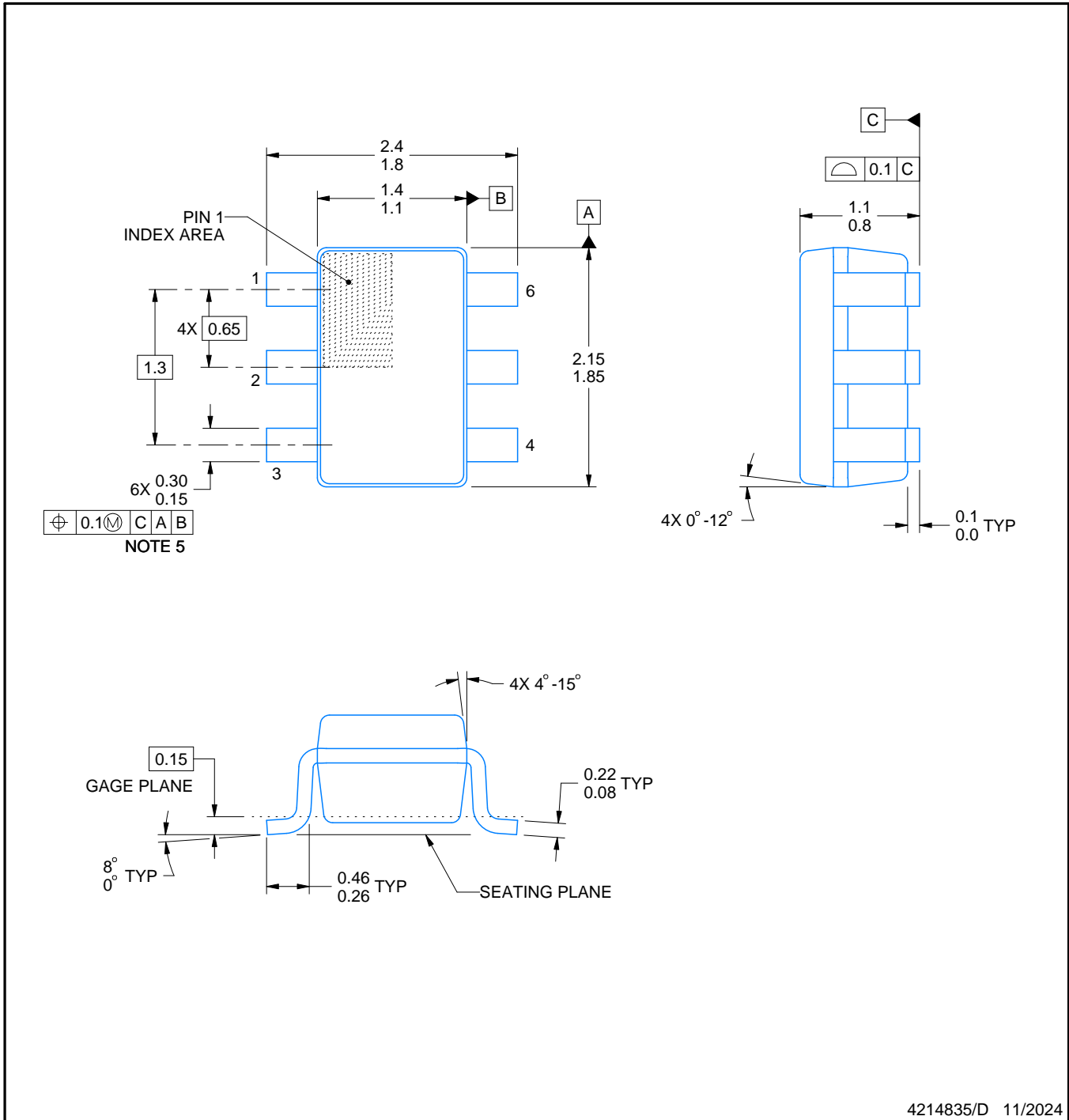
DCK0006A



PACKAGE OUTLINE

SOT - 1.1 max height

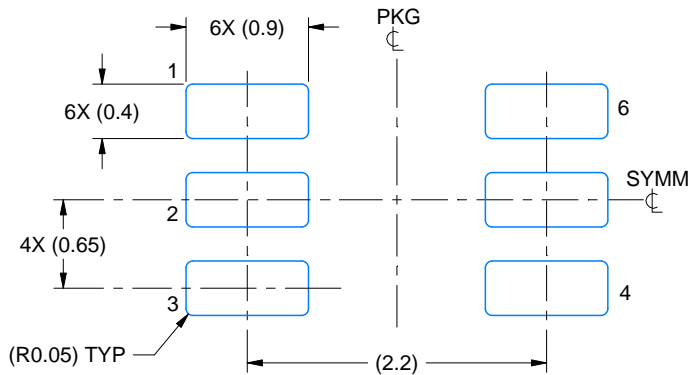
SMALL OUTLINE TRANSISTOR



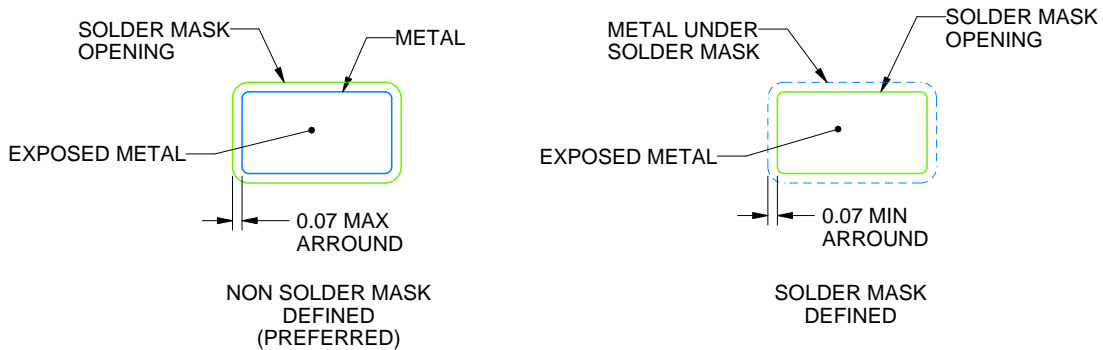
4214835/D 11/2024

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. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
4. Falls within JEDEC MO-203 variation AB.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:18X



SOLDER MASK DETAILS

4214835/D 11/2024

NOTES: (continued)

- 5. Publication IPC-7351 may have alternate designs.
- 6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 THICK STENCIL
SCALE:18X

4214835/D 11/2024

NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

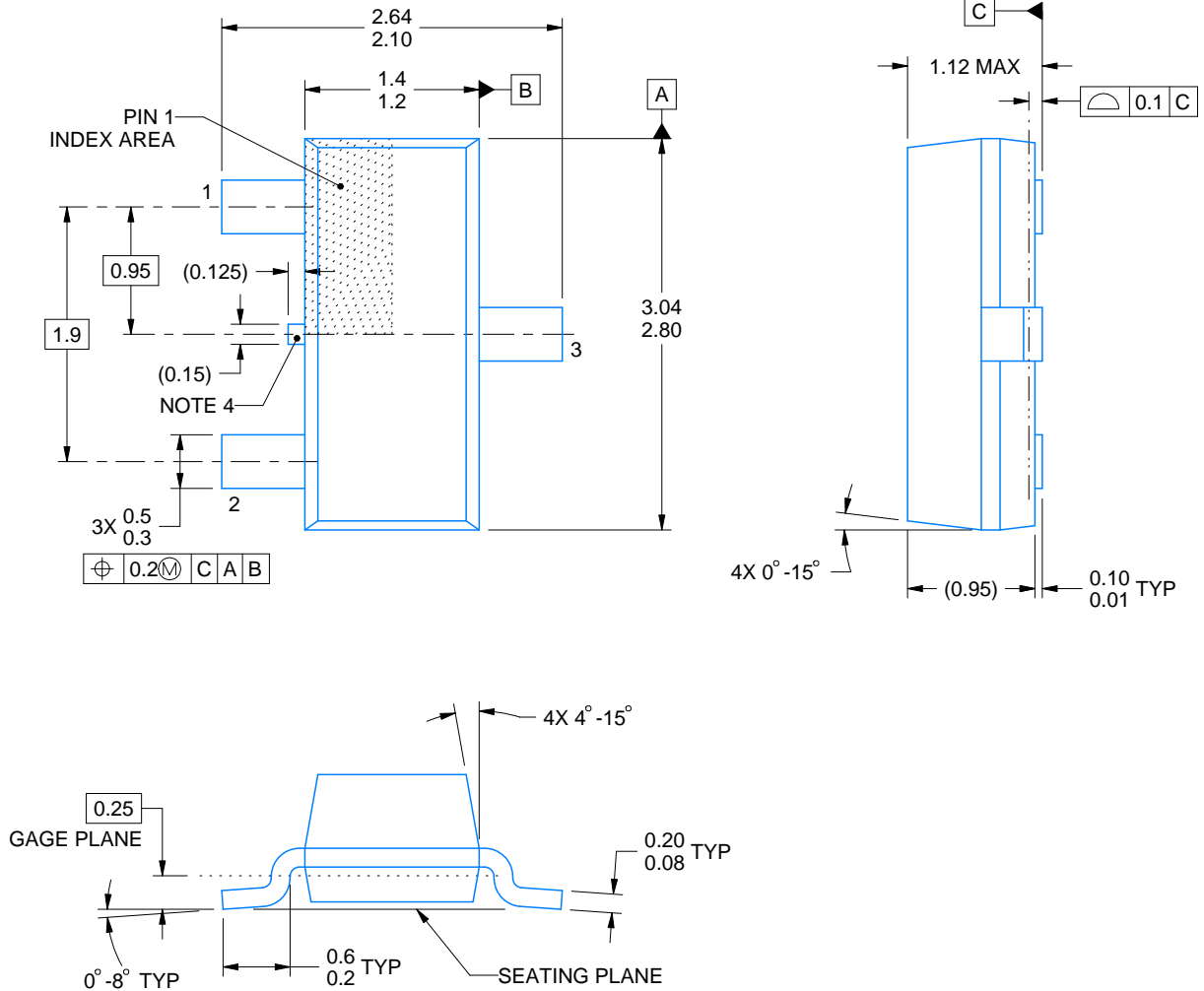
DBZ0003A



PACKAGE OUTLINE

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



4214838/F 08/2024

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. Reference JEDEC registration TO-236, except minimum foot length.
4. Support pin may differ or may not be present.
5. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25mm per side

EXAMPLE BOARD LAYOUT

DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
SCALE:15X



SOLDER MASK DETAILS

4214838/F 08/2024

NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE
BASED ON 0.125 THICK STENCIL
SCALE:15X

4214838/F 08/2024

NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

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