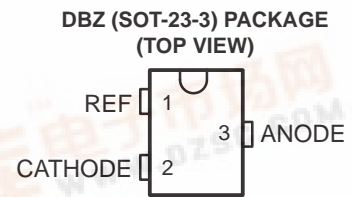
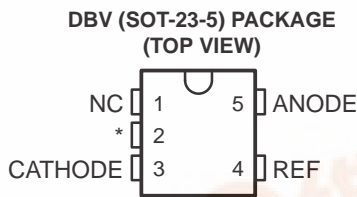
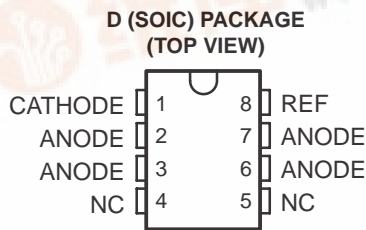


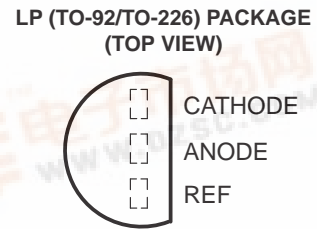
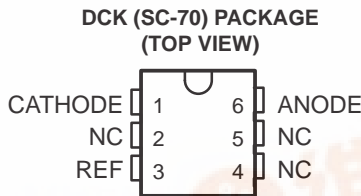
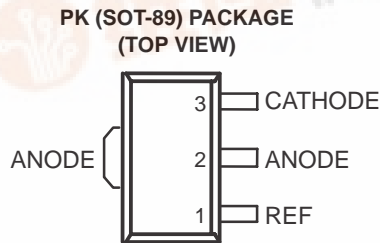
LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR

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- **Low-Voltage Operation** . . . $V_{REF} = 1.24\text{ V}$
- **Adjustable Output Voltage**, $V_O = V_{REF}$ to 6 V
- **Reference Voltage Tolerances at 25°C**
 - 0.5% for TLV431B
 - 1% for TLV431A
 - 1.5% for TLV431
- **Typical Temperature Drift**
 - 4 mV (0°C to 70°C)
 - 6 mV (–40°C to 85°C)
 - 11 mV (–40°C to 125°C)
- **Low Operational Cathode Current** . . . 80 μA Typ
- **0.25- Ω Typical Output Impedance**
- **Ultra-Small SC-70 Package Offers 40% Smaller Footprint Than SOT-23-3**
- **See TLVH431 and TLVH432 for**
 - Wider V_{KA} (1.24 V to 18 V) and I_K (80 mA)
 - Additional SOT-89 Package
 - Multiple Pinouts for SOT-23-3 and SOT-89 Packages



NC – No internal connection
 * For TLV431, TLV431A: NC – No internal connection
 * For TLV431B: Pin 2 is attached to Substrate and must be connected to ANODE or left open.



NC – No internal connection

description/ordering information

The TLV431 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} (1.24 V) and 6 V with two external resistors (see Figure 2). These devices operate from a lower voltage (1.24 V) than the widely used TL431 and TL1431 shunt-regulator references.

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

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.



TLV431, TLV431A, TLV431B

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ORDERING INFORMATION

| T _J | 25°C V _{REF} TOLERANCE | PACKAGE† | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|---------------------------------|----------------|----------------|-----------------------|------------------|
| 0°C to 70°C | 0.5% | SC-70 (DCK) | Reel of 3000 | TLV431BCDCKR | YE_ |
| | | | Reel of 250 | TLV431BCDCKT | |
| | | SOT-23-5 (DBV) | Reel of 3000 | TLV431BCDBVR | Y3GU |
| | | | Reel of 250 | TLV431BCDBVT | |
| | | SOT-23-3 (DBZ) | Reel of 3000 | TLV431BCDBZR | Y3GU |
| | | | Reel of 250 | TLV431BCDBZT | |
| | | SOT-89 (PK) | Reel of 1000 | TLV431BCPK | VE |
| | | TO-92 (LP) | Bulk of 1000 | TLV431BCLP | TV431B |
| | | | Reel of 2000 | TLV431BCLPR | |
| | | 1% | SOT-23-5 (DBV) | Reel of 3000 | TLV431ACDBVR |
| | Reel of 250 | | | TLV431ACDBVT | |
| | SOT-23-3 (DBZ) | | Reel of 3000 | TLV431ACDBZR | YAC_§ |
| | TO-92 (LP) | | Bulk of 1000 | TLV431ACL P | V431AC |
| | | | Reel of 2000 | TLV431ACLPR | |
| | 1.5% | | SOT-23-5 (DBV) | Reel of 3000 | TLV431CDBVR |
| | | Reel of 250 | | TLV431CDBVT | |
| | | SOT-23-3 (DBZ) | Reel of 3000 | TLV431CDBZR | Y3I_§ |
| | | TO-92 (LP) | Bulk of 1000 | TLV431CLP | V431C |
| Reel of 2000 | | | TLV431CLPR | | |

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

‡ Possible top-side marking on units prior to August 16, 2004

§ DBV/DBZ/DCK: The actual top-side marking has one additional character that designates the assembly/test site.

TLV431, TLV431A, TLV431B

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ORDERING INFORMATION (continued)

| T _J | 25°C V _{REF} TOLERANCE | PACKAGE† | | ORDERABLE PART NUMBER | TOP-SIDE MARKING‡ |
|----------------|------------------------------------|----------------|--------------|--------------------------|----------------------|
| –40°C to 85°C | 0.5% | SC-70 (DCK) | Reel of 3000 | TLV431BIDCKR | YF_ |
| | | | Reel of 250 | TLV431BIDCKT | |
| | | SOT-23-5 (DBV) | Reel of 3000 | TLV431BIDBVR | Y3FU |
| | | | Reel of 250 | TLV431BIDBVT | |
| | | SOT-23-3 (DBZ) | Reel of 3000 | TLV431BIDBZR | Y3FU |
| | | | Reel of 250 | TLV431BIDBZT | |
| | | TO-92 (LP) | Bulk of 1000 | TLV431BILP | TY431B |
| | | | Reel of 2000 | TLV431BILPR | |
| | 1% | SOIC (D) | Tube of 75 | TLV431AID | TY431A |
| | | | Reel of 2500 | TLV431AIDR | |
| | | SOT-23-5 (DBV) | Reel of 3000 | TLV431AIDBVR | VAH†, YAI_§ |
| | | | Reel of 250 | TLV431AIDBVT | |
| | | SOT-23-3 (DBZ) | Reel of 3000 | TLV431AIDBZR | YAI_§ |
| | | SOT-89 (PK) | Reel of 1000 | TLV431BIPK | VF |
| | | TO-92 (LP) | Bulk of 1000 | TLV431AILP | V431AI |
| | | | Ammo of 2000 | TLV431AILPM | |
| | Reel of 2000 | | TLV431AILPR | | |
| | 1.5% | SOT-23-5 (DBV) | Reel of 3000 | TLV431IDBVR | VAII†, Y3I_§ |
| Reel of 250 | | | TLV431IDBVT | | |
| SOT-23-3 (DBZ) | | Reel of 3000 | TLV431IDBZR | Y3I_§ | |
| TO-92 (LP) | | Bulk of 1000 | TLV431ILP | V431I | |
| | Reel of 2000 | TLV431ILPR | | | |
| –40°C to 125°C | 0.5% | SC-70 (DCK) | Reel of 3000 | TLV431BQDCKR | YG_ |
| | | | Reel of 250 | TLV431BQDCKT | |
| | | SOT-23-5 (DBV) | Reel of 3000 | TLV431BQDBVR | Y3HU |
| | | | Reel of 250 | TLV431BQDBVT | |
| | | SOT-23-3 (DBZ) | Reel of 3000 | TLV431BQDBZR | Y3HU |
| | | | Reel of 250 | TLV431BQDBZT | |
| | | SOT-89 (PK) | Reel of 1000 | TLV431BQPK | V6 |
| | | TO-92 (LP) | Bulk of 1000 | TLV431BQLP | TQ431B |
| | Reel of 2000 | | TLV431BQLPR | | |
| | 1% | SOT-89 (PK) | Reel of 1000 | TLV431AQPK | VA |
| | 1.5% | SOT-89 (PK) | Reel of 1000 | TLV431QPK | VB |

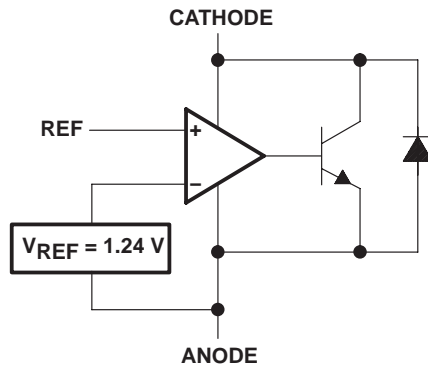
† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

‡ DBV/DBZ/DCK: The actual top-side marking has one additional character that designates the assembly/test site.

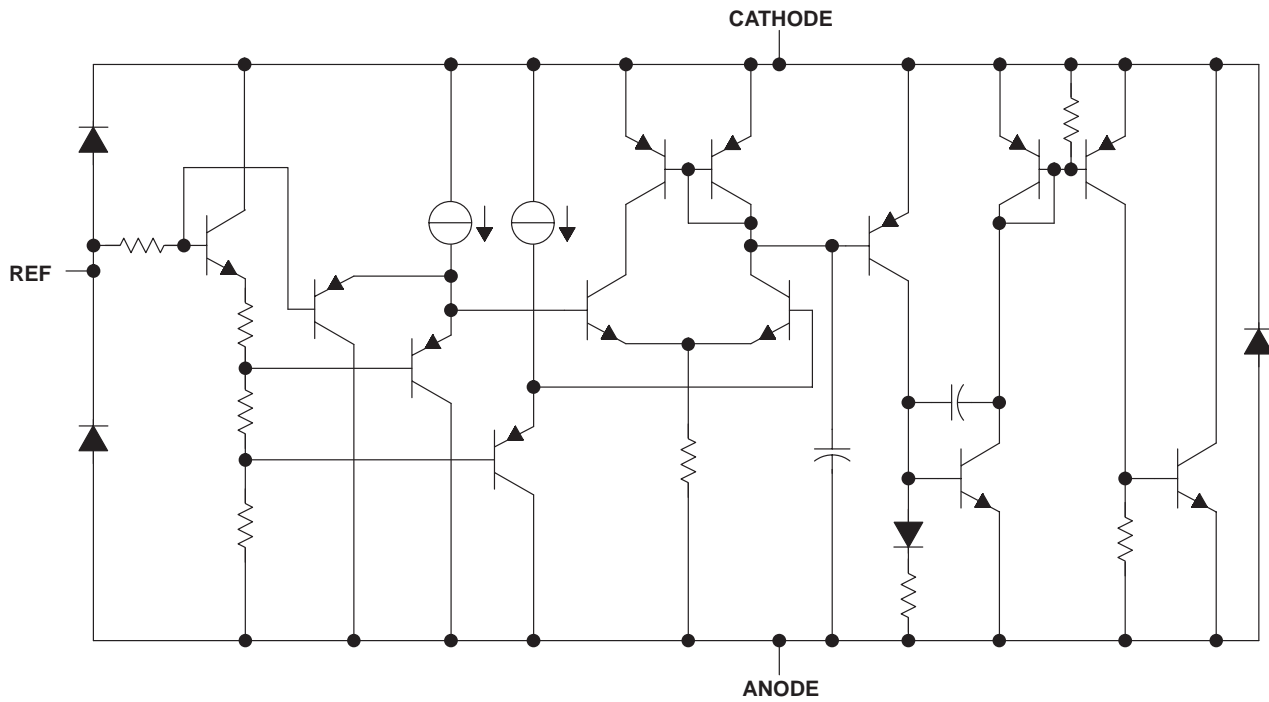
TLV431, TLV431A, TLV431B LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR

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logic block diagram



equivalent schematic



TLV431, TLV431A, TLV431B

LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR

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absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

| | |
|---|------------------|
| Cathode voltage, V_{KA} (see Note 1) | 7 V |
| Continuous cathode current range, I_K | –20 mA to 20 mA |
| Reference current range, I_{ref} | –0.05 mA to 3 mA |
| Package thermal impedance, θ_{JA} (see Notes 2 and 3): | |
| D package | 97°C/W |
| DBV package | 206°C/W |
| DBZ package | 206°C/W |
| DCK package | 252°C/W |
| LP package | 140°C/W |
| PK package | 52°C/W |
| Operating virtual junction temperature | 150°C |
| Storage temperature range, T_{stg} | –65°C to 150°C |

† 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.

- NOTES:
1. Voltage values are with respect to the anode terminal, unless otherwise noted.
 2. Maximum power dissipation is a function of $T_J(\max)$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(\max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
 3. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions

| | | 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 range | TLV431_C | 0 | 70 |
| | | TLV431_I | –40 | 85 |
| | | TLV431_Q | –40 | 125 |

TLV431, TLV431A, TLV431B

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TLV431 electrical characteristics 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 = 10 mA | T _A = 25°C | | 1.222 | 1.24 | 1.258 | V |
| | | T _A = full range (see Note 4 and Figure 1) | TLV431C | 1.21 | 1.27 | | |
| | | | TLV431I | 1.202 | 1.278 | | |
| | | | TLV431Q | 1.194 | 1.286 | | |
| V _{REF(dev)} V _{REF} deviation over full temperature range (see Note 4) | V _{KA} = V _{REF} , I _K = 10 mA (see Note 4 and Figure 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 6 V, I _K = 10 mA (see Figure 2) | | -1.5 | -2.7 | mV/V | |
| I _{ref} | Reference terminal current | I _K = 10 mA, R1 = 10 kΩ, R2 = open (see Figure 2) | | 0.15 | 0.5 | μA | |
| I _{ref(dev)} I _{ref} deviation over full temperature range (see Note 4) | I _K = 10 mA, R1 = 10 kΩ, R2 = open (see Note 4 and Figure 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 1) | TLV431C/I | 55 | 80 | μA | | |
| | | TLV431Q | 55 | 100 | | | |
| I _{K(off)} | Off-state cathode current | V _{REF} = 0, V _{KA} = 6 V (see Figure 3) | | 0.001 | 0.1 | μA | |
| z _{KA} | Dynamic impedance (see Note 5) | V _{KA} = V _{REF} , f ≤ 1 kHz, I _K = 0.1 mA to 15 mA (see Figure 1) | | 0.25 | 0.4 | Ω | |

NOTES: 4. 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.

5. 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.

6. 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 2), the total dynamic impedance of the circuit is defined as:

$$|z_{ka}'| = \frac{\Delta V}{\Delta I} \approx |z_{ka}| \times \left(1 + \frac{R1}{R2} \right)$$

TLV431, TLV431A, TLV431B

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TLV431A electrical characteristics at 25°C free-air temperature (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | | TLV431A | | | UNIT |
|---|---|---|----------|-------|-------|------|
| | | | MIN | TYP | MAX | |
| V _{REF} Reference voltage | V _{K_A} = V _{REF} , I _K = 10 mA | T _A = 25°C | 1.228 | 1.24 | 1.252 | V |
| | | T _A = full range (see Note 3 and Figure 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 (see Note 4) | V _{K_A} = V _{REF} , I _K = 10 mA (see Note 3 and Figure 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 _{K_A} = V _{REF} to 6 V, I _K = 10 mA (see Figure 2) | | | -1.5 | -2.7 | mV/V |
| I _{ref} Reference terminal current | I _K = 10 mA, R1 = 10 kΩ, R2 = open (see Figure 2) | | | 0.15 | 0.5 | μA |
| I _{ref(dev)} I _{ref} deviation over full temperature range (see Note 4) | I _K = 10 mA, R1 = 10 kΩ, R2 = open (see Note 3 and Figure 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 _{K_A} = V _{REF} (see Figure 1) | TLV431AC/AI | | 55 | 80 | μA |
| | | TLV431AQ | | 55 | 100 | |
| I _{K(off)} Off-state cathode current | V _{REF} = 0, V _{K_A} = 6 V (see Figure 3) | | | 0.001 | 0.1 | μA |
| z _{KA} Dynamic impedance (see Note 5) | V _{K_A} = V _{REF} , f ≤ 1 kHz, I _K = 0.1 mA to 15 mA (see Figure 1) | | | 0.25 | 0.4 | Ω |

- NOTES: 3. Full temperature ranges are -40°C to 125°C for TLV431AQ, -40°C to 85°C for TLV431AI, and 0°C to 70°C for TLV431AC.
 4. 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.

5. 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 2), the total dynamic impedance of the circuit is defined as:

$$|z_{ka}'| = \frac{\Delta V}{\Delta I} \approx |z_{ka}| \times \left(1 + \frac{R1}{R2} \right)$$

TLV431, TLV431A, TLV431B

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TLV431B electrical characteristics at 25°C free-air temperature (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | | TLV431B | | | UNIT |
|---|---|---|----------|-------|-------|------|
| | | | MIN | TYP | MAX | |
| V _{REF} Reference voltage | V _{KA} = V _{REF} , I _K = 10 mA | T _A = 25°C | 1.234 | 1.24 | 1.246 | V |
| | | T _A = full range (see Note 3 and Figure 1) | TLV431BC | 1.227 | 1.253 | |
| | | | TLV431BI | 1.224 | 1.259 | |
| V _{REF(dev)} V _{REF} deviation over full temperature range (see Note 4) | V _{KA} = V _{REF} , I _K = 10 mA (see Note 3 and Figure 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 _{KA} = V _{REF} to 6 V, I _K = 10 mA (see Figure 2) | | | -1.5 | -2.7 | mV/V |
| I _{ref} Reference terminal current | I _K = 10 mA, R1 = 10 kΩ, R2 = open (see Figure 2) | | | 0.1 | 0.5 | μA |
| I _{ref(dev)} I _{ref} deviation over full temperature range (see Note 4) | I _K = 10 mA, R1 = 10 kΩ, R2 = open (see Note 3 and Figure 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 _{KA} = V _{REF} (see Figure 1) | | | 55 | 100 | μA |
| I _{K(off)} Off-state cathode current | V _{REF} = 0, V _{KA} = 6 V (see Figure 3) | | | 0.001 | 0.1 | μA |
| z _{KA} Dynamic impedance (see Note 5) | V _{KA} = V _{REF} , f ≤ 1 kHz, I _K = 0.1 mA to 15 mA (see Figure 1) | | | 0.25 | 0.4 | Ω |

- NOTES: 3. Full temperature ranges are -40°C to 125°C for TLV431BQ, -40°C to 85°C for TLV431BI, and 0°C to 70°C for TLV431BC.
 4. 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, α_{VREF}, 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.

α_{VREF} can be positive or negative, depending on whether minimum V_{REF} or maximum V_{REF}, respectively, occurs at the lower temperature.

5. 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 2), the total dynamic impedance of the circuit is defined as:

$$|z_{ka}'| = \frac{\Delta V}{\Delta I} \approx |z_{ka}| \times \left(1 + \frac{R1}{R2} \right)$$

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PARAMETER MEASUREMENT INFORMATION

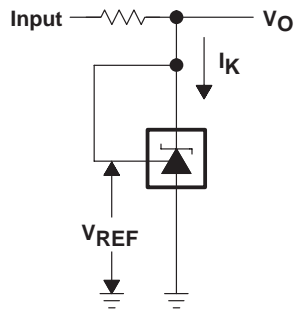


Figure 1. Test Circuit for $V_{KA} = V_{REF}$,
 $V_O = V_{KA} = V_{REF}$

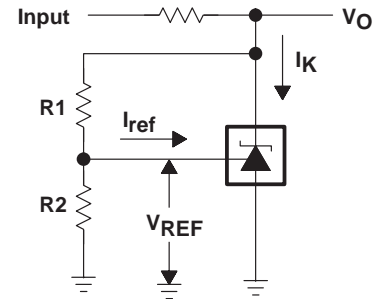


Figure 2. Test Circuit for $V_{KA} > V_{REF}$,
 $V_O = V_{KA} = V_{REF} \times (1 + R1/R2) + I_{ref} \times R1$

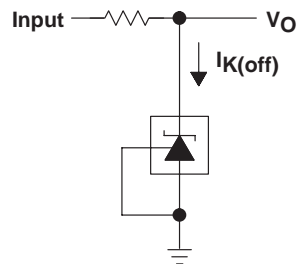
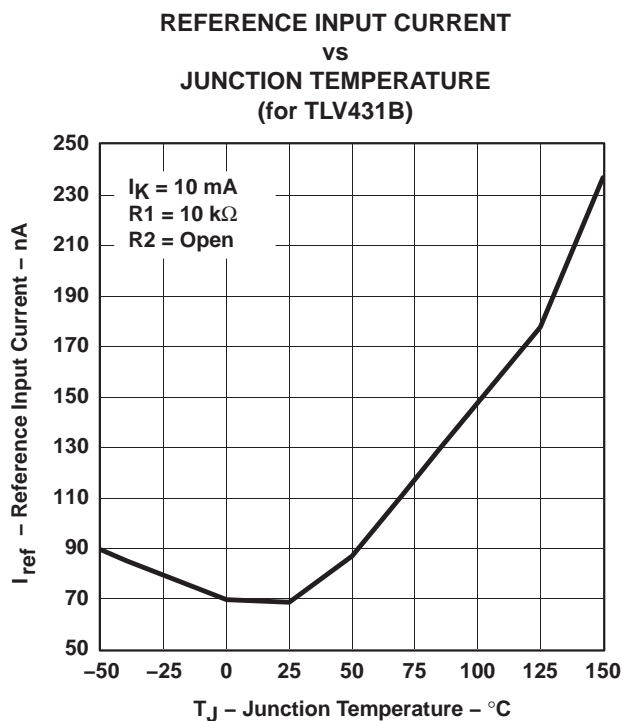
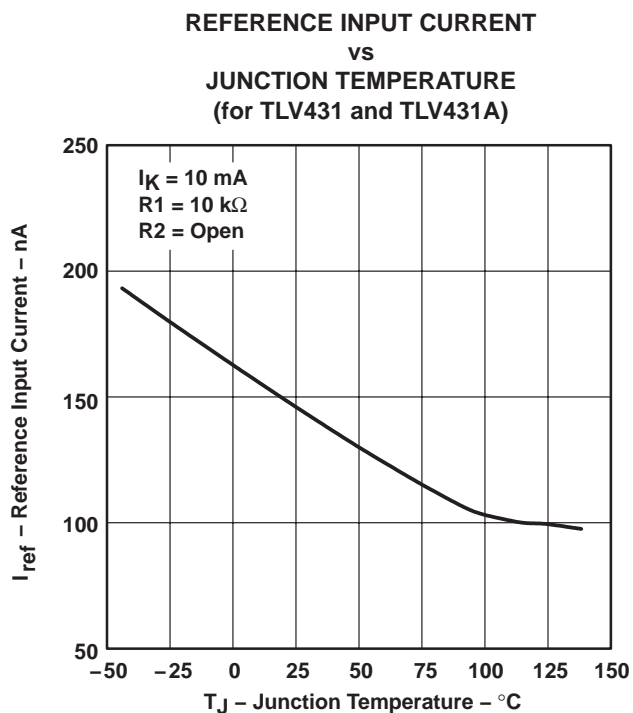
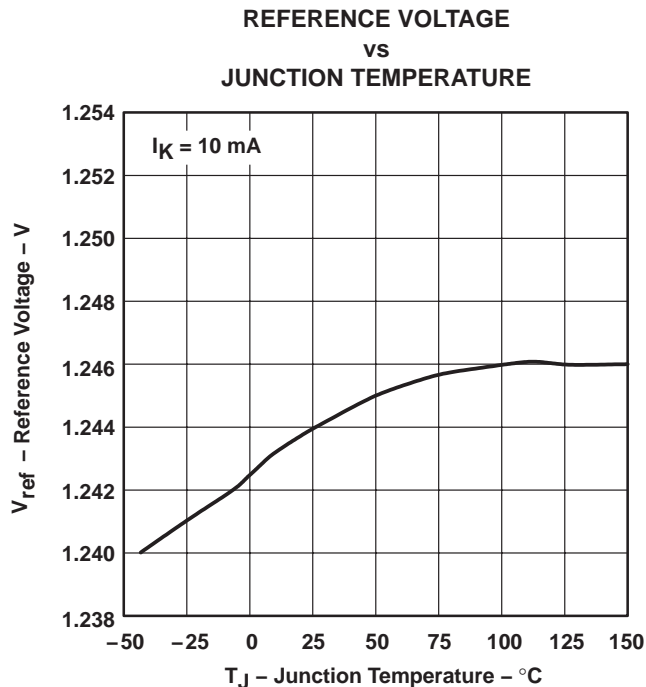


Figure 3. Test Circuit for $I_{K(off)}$

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PARAMETER MEASUREMENT INFORMATION†



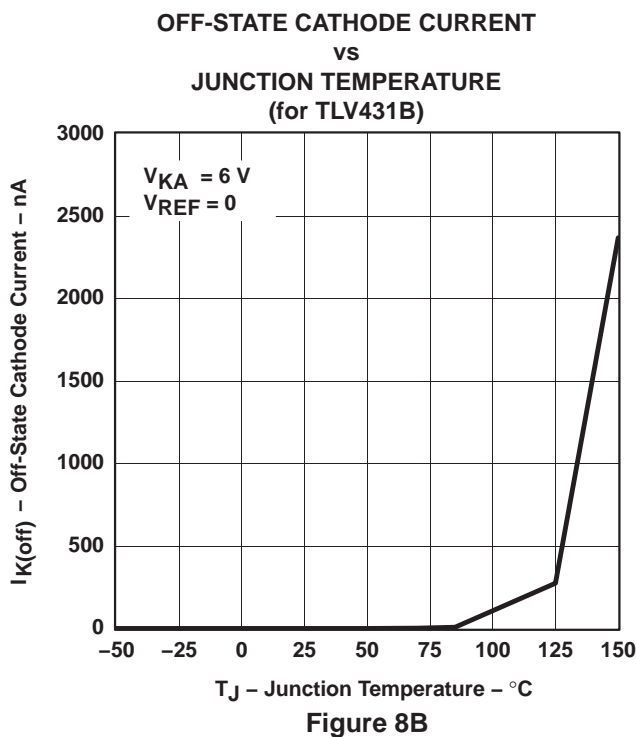
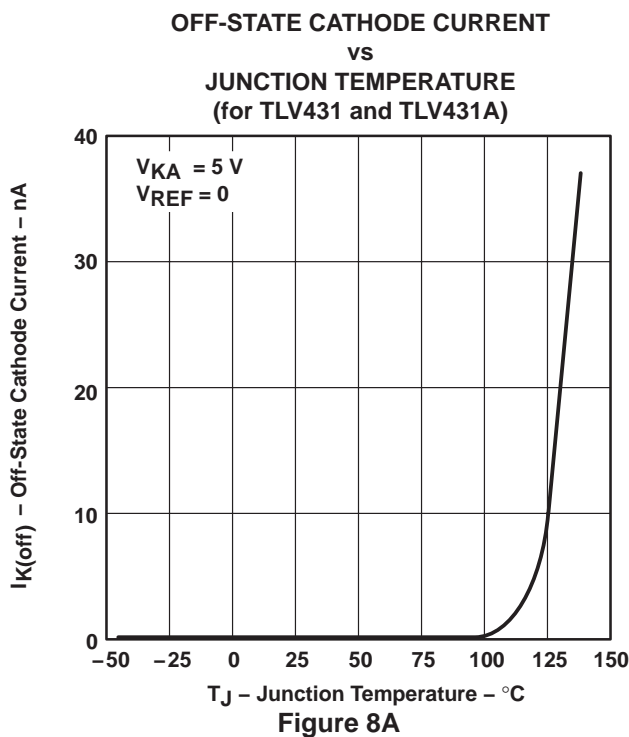
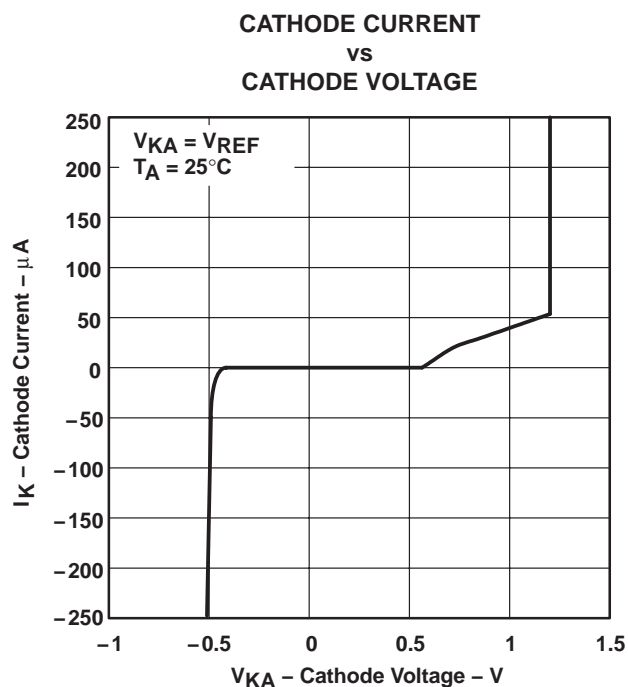
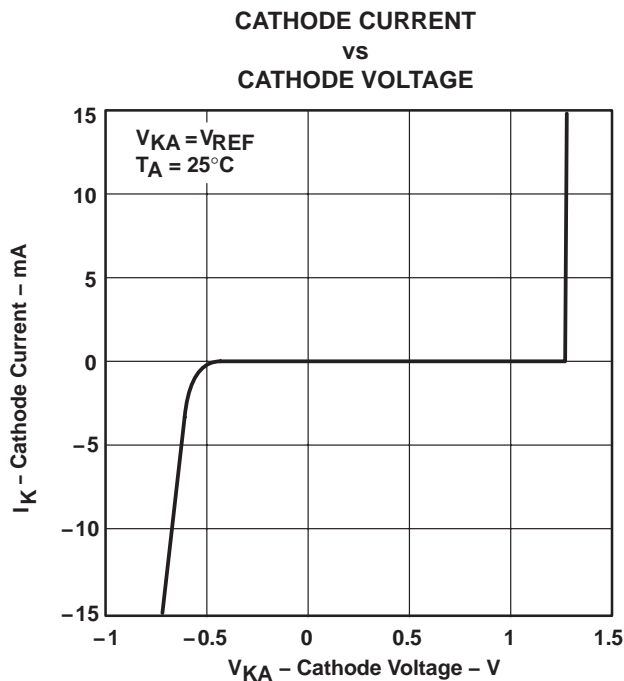
† Operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied.

TLV431, TLV431A, TLV431B

LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR

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PARAMETER MEASUREMENT INFORMATION†



† Operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied.

TLV431, TLV431A, TLV431B LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR

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PARAMETER MEASUREMENT INFORMATION†

RATIO OF DELTA REFERENCE VOLTAGE
TO DELTA CATHODE VOLTAGE
vs
JUNCTION TEMPERATURE
(for TLV431 and TLV431A)

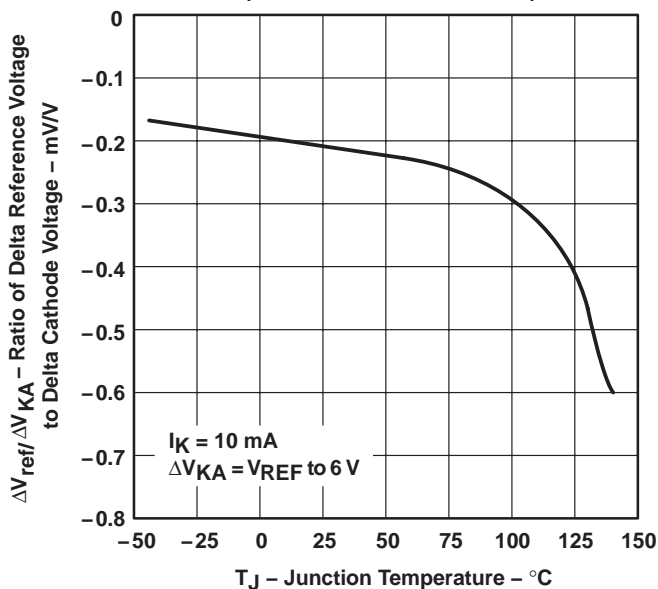


Figure 9A

RATIO OF DELTA REFERENCE VOLTAGE
TO DELTA CATHODE VOLTAGE
vs
JUNCTION TEMPERATURE
(for TLV431B)

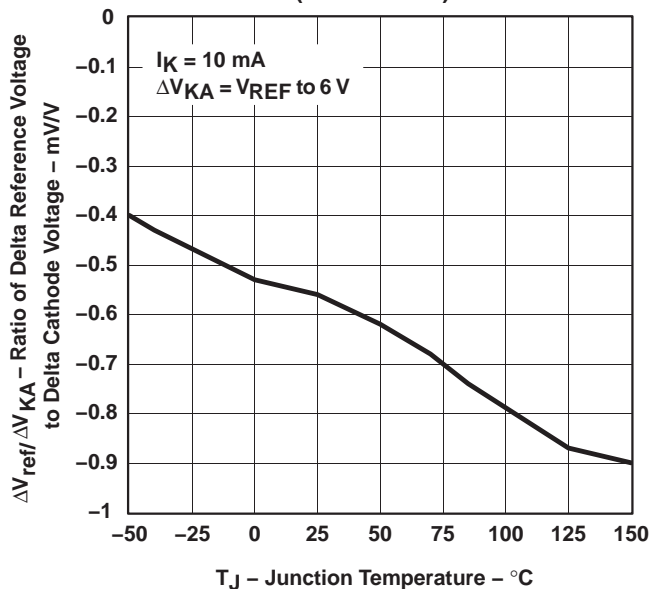
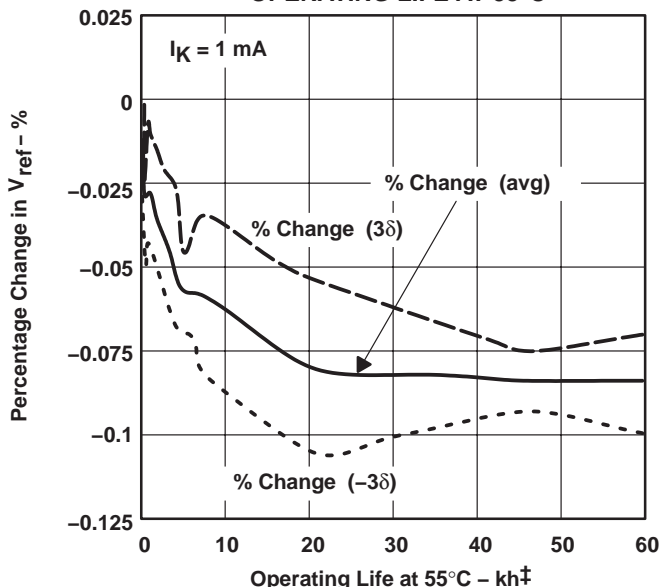


Figure 9B

PERCENTAGE CHANGE IN V_{REF}
vs
OPERATING LIFE AT 55°C



‡ Extrapolated from life-test data taken at 125°C; the activation energy assumed is 0.7 eV.

Figure 10

† Operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied.

TLV431, TLV431A, TLV431B LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR

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PARAMETER MEASUREMENT INFORMATION

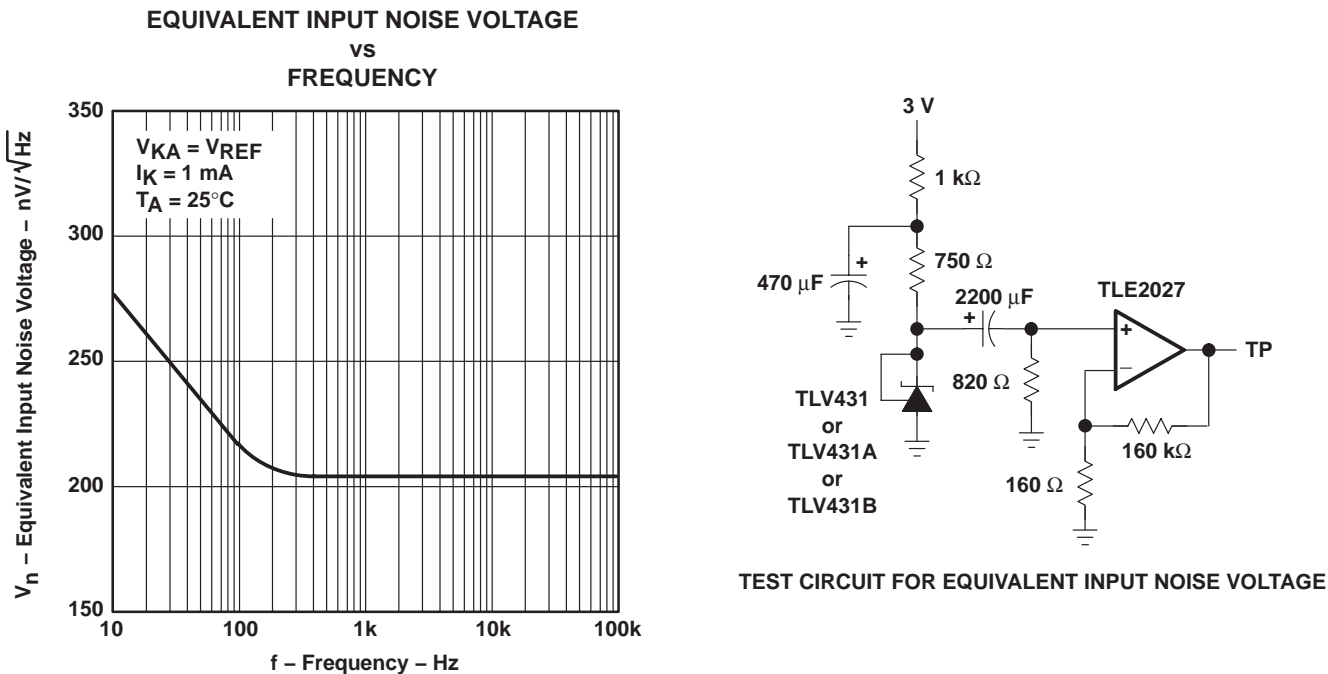


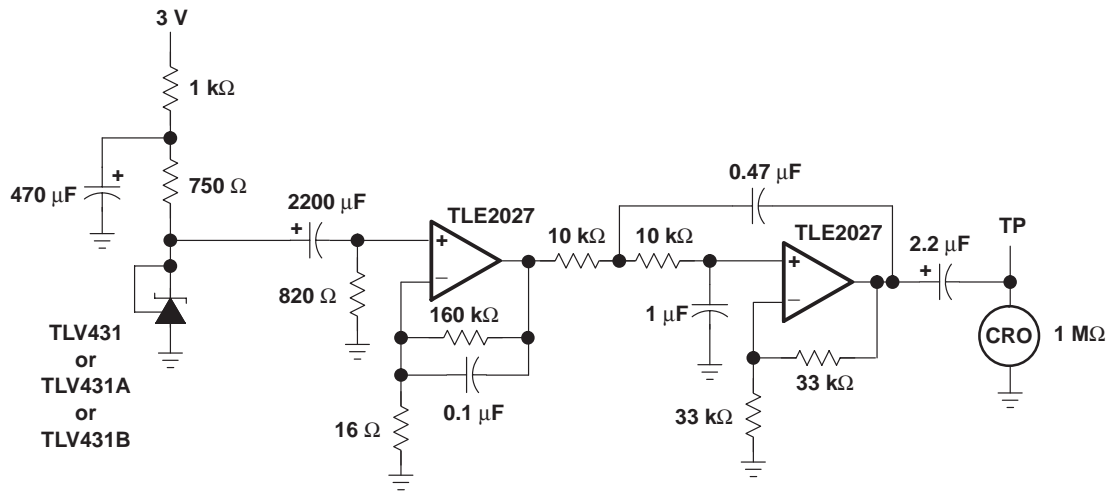
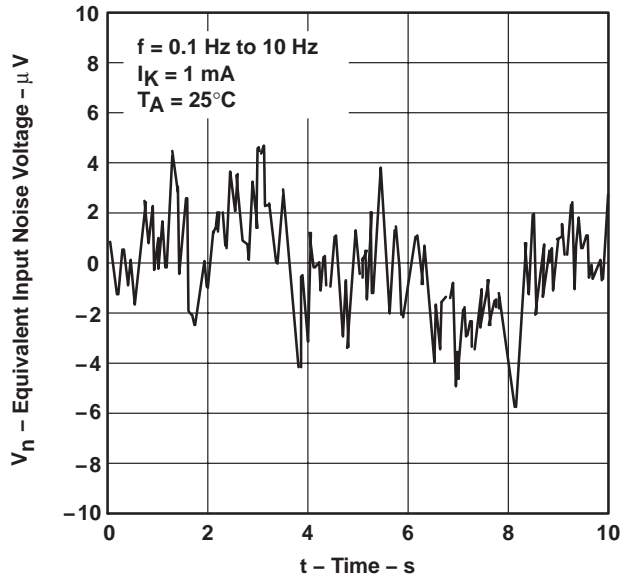
Figure 11

TLV431, TLV431A, TLV431B LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR

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PARAMETER MEASUREMENT INFORMATION

EQUIVALENT INPUT NOISE VOLTAGE
OVER A 10-s PERIOD



TEST CIRCUIT FOR 0.1-Hz TO 10-Hz EQUIVALENT NOISE VOLTAGE

Figure 12

TLV431, TLV431A, TLV431B

LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR

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PARAMETER MEASUREMENT INFORMATION

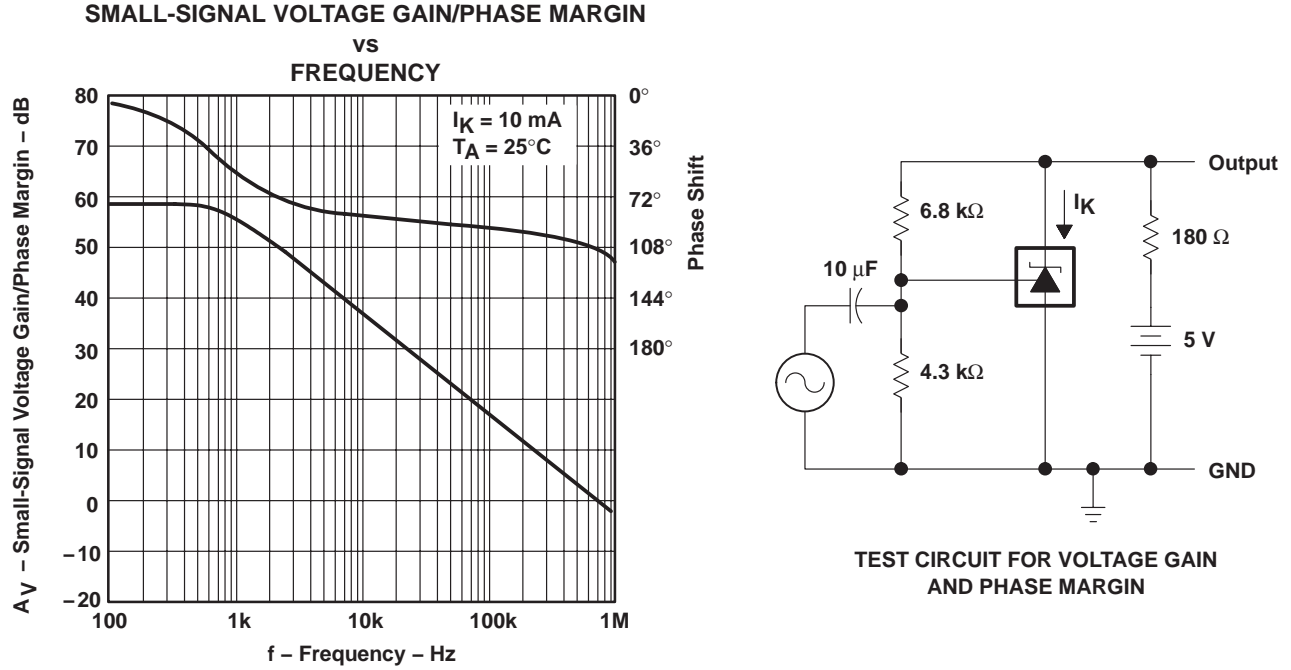


Figure 13

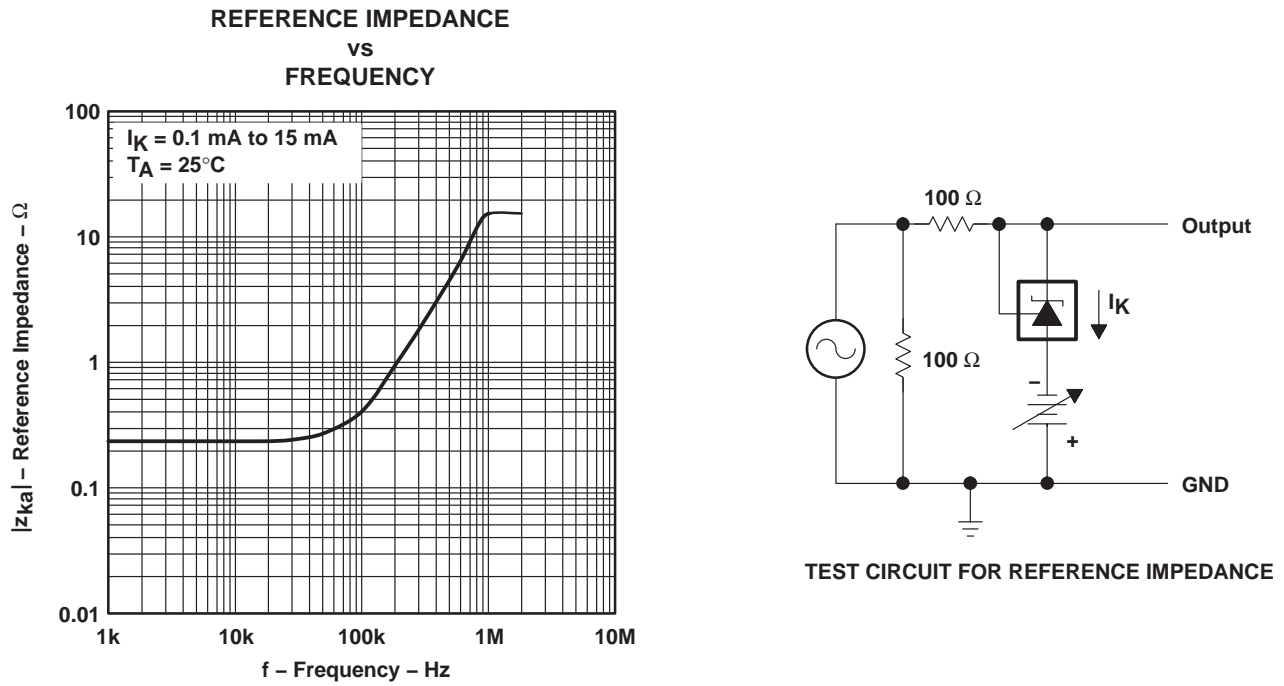
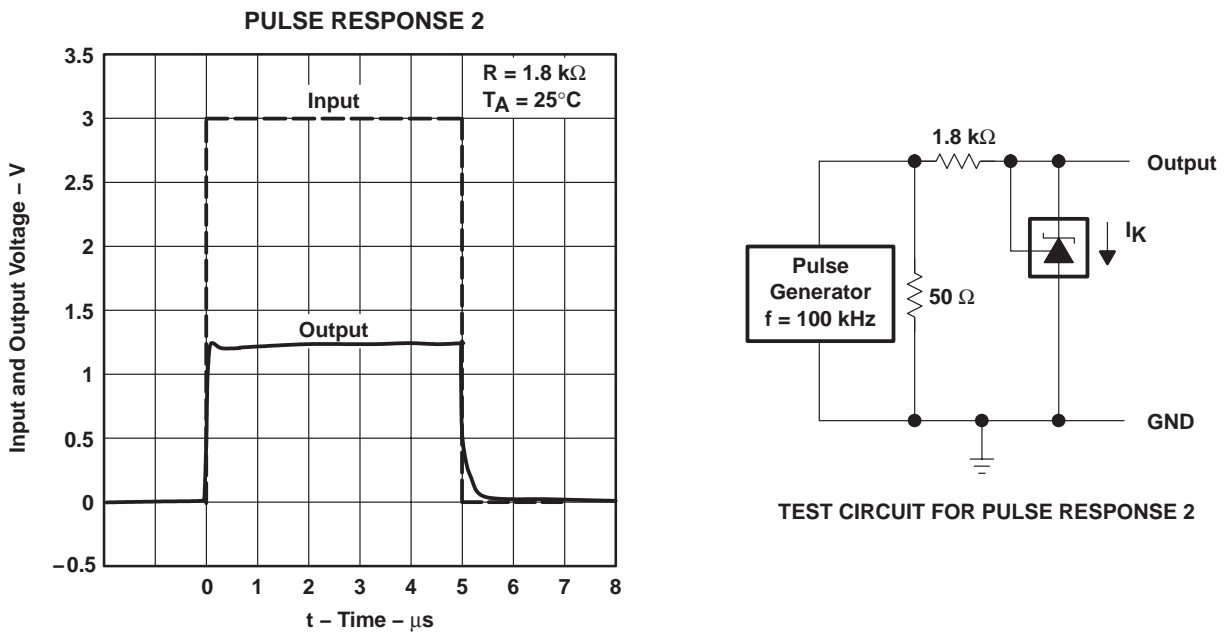
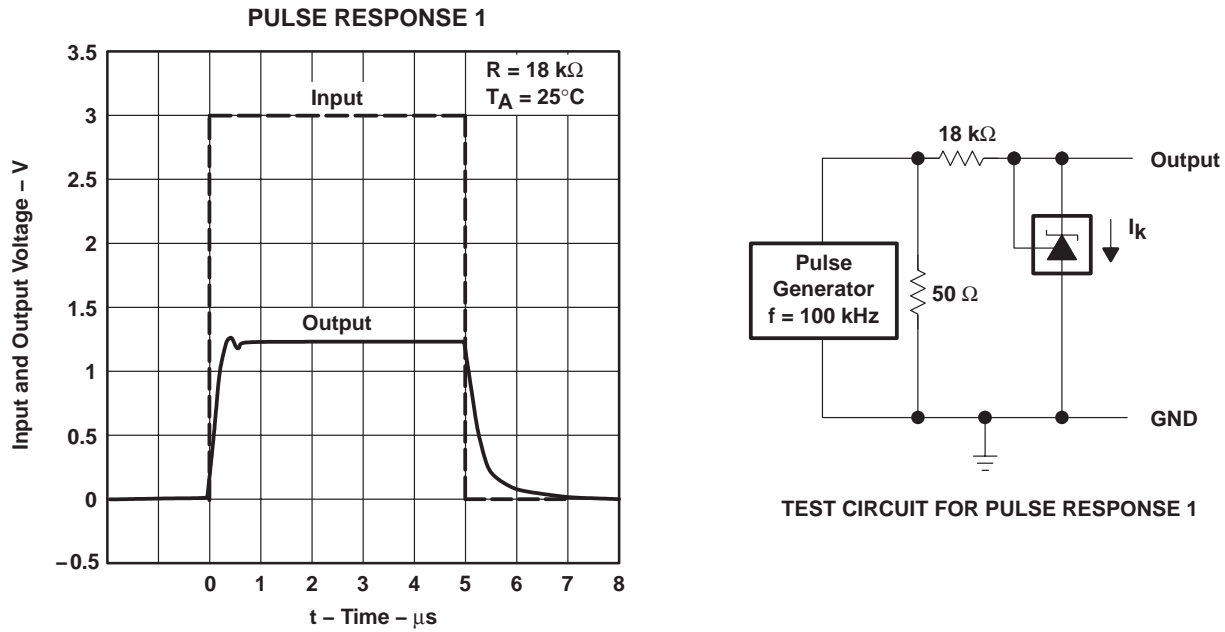


Figure 14

TLV431, TLV431A, TLV431B LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR

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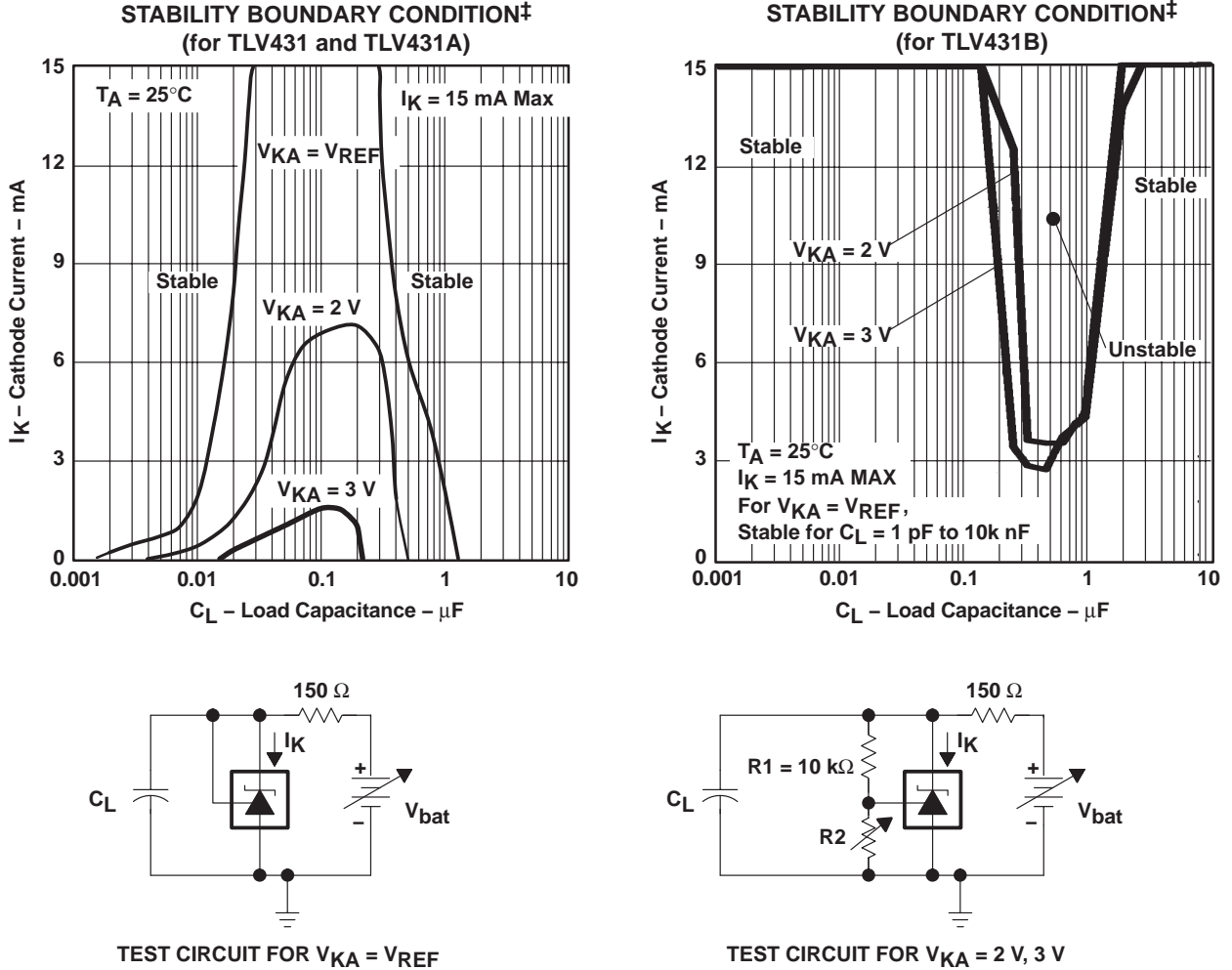
PARAMETER MEASUREMENT INFORMATION



TLV431, TLV431A, TLV431B LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR

SLVS139S – JULY 1996 – REVISED JANUARY 2006

PARAMETER MEASUREMENT INFORMATION†



‡ The areas under the curves represent conditions that may cause the device to oscillate. For $V_{KA} = 2\text{-V}$ and 3-V curves, R_2 and V_{bat} were adjusted to establish the initial V_{KA} and I_K conditions with $C_L = 0$. V_{bat} and C_L then were adjusted to determine the ranges of stability.

Figure 17

† Operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied.

TLV431, TLV431A, TLV431B LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR

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APPLICATION INFORMATION

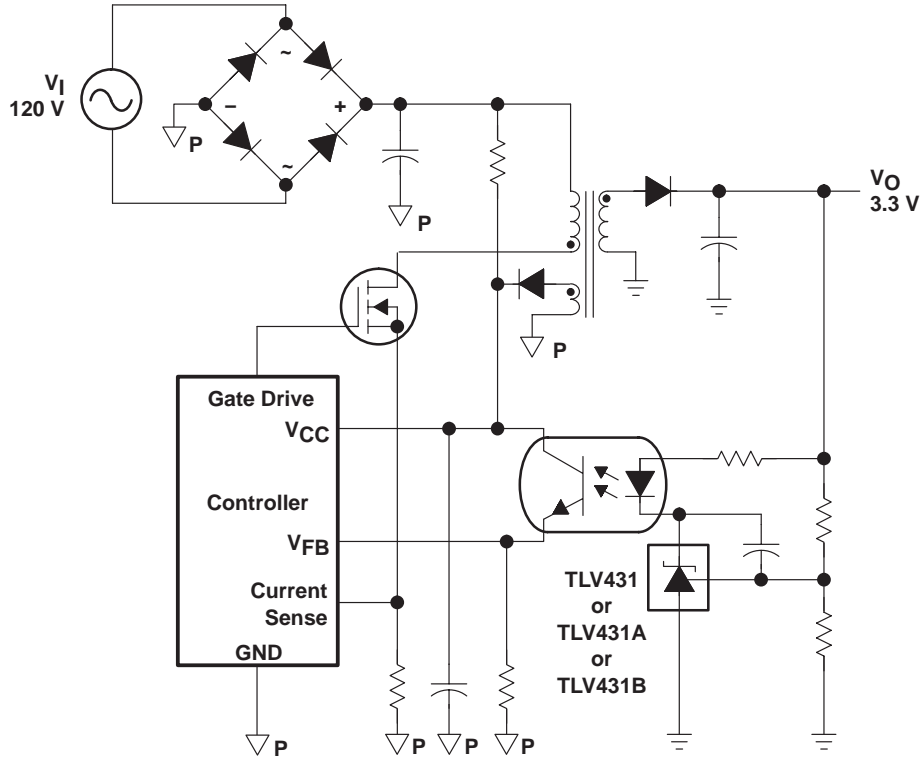


Figure 18. Flyback With Isolation Using TLV431, TLV431A, or TLV431B as Voltage Reference and Error Amplifier

Figure 18 shows the TLV431, TLV431A, or TLV431B used in a 3.3-V isolated flyback supply. Output voltage V_O can be as low as reference voltage V_{REF} ($1.24\text{ V} \pm 1\%$). The output of the regulator, plus the forward voltage drop of the optocoupler LED ($1.24 + 1.4 = 2.64\text{ V}$), 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 18.

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| TLV431ACDBVR | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431ACDBVRE4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431ACDBVRG4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431ACDBVT | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431ACDBVTE4 | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431ACDBZR | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431ACDBZRG4 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431ACLP | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431ACLPE3 | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431ACLPR | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431ACLPRE3 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431AID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431AIDBVR | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431AIDBVRE4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431AIDBVT | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431AIDBVTE4 | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431AIDBZR | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431AIDBZRG4 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431AIDE4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431AIDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431AIDRE4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431AILP | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431AILPE3 | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431AILPM | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431AILPME3 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| TLV431AILPR | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431AILPRE3 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431AQPK | ACTIVE | SOT-89 | PK | 3 | 1000 | Green (RoHS & no Sb/Br) | CU SN | Level-2-260C-1YEAR |
| TLV431AQPKG3 | ACTIVE | SOT-89 | PK | 3 | 1000 | Green (RoHS & no Sb/Br) | CU SN | Level-2-260C-1YEAR |
| TLV431BCDBVR | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BCDBVRE4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BCDBVRG4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BCDBVT | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BCDBVTE4 | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BCDBZR | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BCDBZRG4 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BCDBZT | ACTIVE | SOT-23 | DBZ | 3 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BCDBZTG4 | ACTIVE | SOT-23 | DBZ | 3 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BCDCKR | ACTIVE | SC70 | DCK | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BCDCKRE4 | ACTIVE | SC70 | DCK | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BCDCKT | ACTIVE | SC70 | DCK | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BCDCKTE4 | ACTIVE | SC70 | DCK | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BCLP | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431BCLPE3 | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431BCLPR | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431BCLPRE3 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431BCPK | ACTIVE | SOT-89 | PK | 3 | 1000 | Green (RoHS & no Sb/Br) | CU SN | Level-2-260C-1YEAR |
| TLV431BCPKG3 | ACTIVE | SOT-89 | PK | 3 | 1000 | Green (RoHS & no Sb/Br) | CU SN | Level-2-260C-1YEAR |
| TLV431BIDBVR | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BIDBVRE4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BIDBVT | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| TLV431BIDBVTE4 | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BIDBZR | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BIDBZRG4 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BIDBZT | ACTIVE | SOT-23 | DBZ | 3 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BIDBZTG4 | ACTIVE | SOT-23 | DBZ | 3 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BIDCKR | ACTIVE | SC70 | DCK | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BIDCKRE4 | ACTIVE | SC70 | DCK | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BIDCKT | ACTIVE | SC70 | DCK | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BIDCKTE4 | ACTIVE | SC70 | DCK | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BILP | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431BILPE3 | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431BILPR | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431BILPRE3 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431BIPK | ACTIVE | SOT-89 | PK | 3 | 1000 | Green (RoHS & no Sb/Br) | CU SN | Level-2-260C-1YEAR |
| TLV431BIPKG3 | ACTIVE | SOT-89 | PK | 3 | 1000 | Green (RoHS & no Sb/Br) | CU SN | Level-2-260C-1YEAR |
| TLV431BQDBVR | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BQDBVRE4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BQDBVT | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BQDBVTE4 | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BQDBZR | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BQDBZRG4 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BQDBZT | ACTIVE | SOT-23 | DBZ | 3 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BQDBZTG4 | ACTIVE | SOT-23 | DBZ | 3 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BQDCKR | ACTIVE | SC70 | DCK | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BQDCKRE4 | ACTIVE | SC70 | DCK | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BQDCKT | ACTIVE | SC70 | DCK | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| TLV431BQDCKTE4 | ACTIVE | SC70 | DCK | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431BQLP | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431BQLPE3 | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431BQLPR | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431BQLPRE3 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431BQPK | ACTIVE | SOT-89 | PK | 3 | 1000 | Green (RoHS & no Sb/Br) | CU SN | Level-2-260C-1YEAR |
| TLV431BQPKG3 | ACTIVE | SOT-89 | PK | 3 | 1000 | Green (RoHS & no Sb/Br) | CU SN | Level-2-260C-1YEAR |
| TLV431CDBV | OBSOLETE | SOT-23 | DBV | 5 | | TBD | Call TI | Call TI |
| TLV431CDBVR | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431CDBVRE4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431CDBVT | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431CDBVTE4 | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431CDBZR | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431CDBZRG4 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431CLP | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431CLPE3 | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431CLPM | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431CLPME3 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431CLPR | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431CLPRE3 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431IDBV | OBSOLETE | SOT-23 | DBV | 5 | | TBD | Call TI | Call TI |
| TLV431IDBVR | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431IDBVRE4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431IDBVRG4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431IDBVT | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431IDBVTE4 | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431IDBZR | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| | | | | | | no Sb/Br | | |
| TLV431IDBZRG4 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLV431ILP | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431ILPE3 | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431ILPR | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431ILPRE3 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| TLV431QPK | ACTIVE | SOT-89 | PK | 3 | 1000 | Green (RoHS & no Sb/Br) | CU SN | Level-2-260C-1YEAR |
| TLV431QPKG3 | ACTIVE | SOT-89 | PK | 3 | 1000 | Green (RoHS & no Sb/Br) | CU SN | Level-2-260C-1YEAR |

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBsolete: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

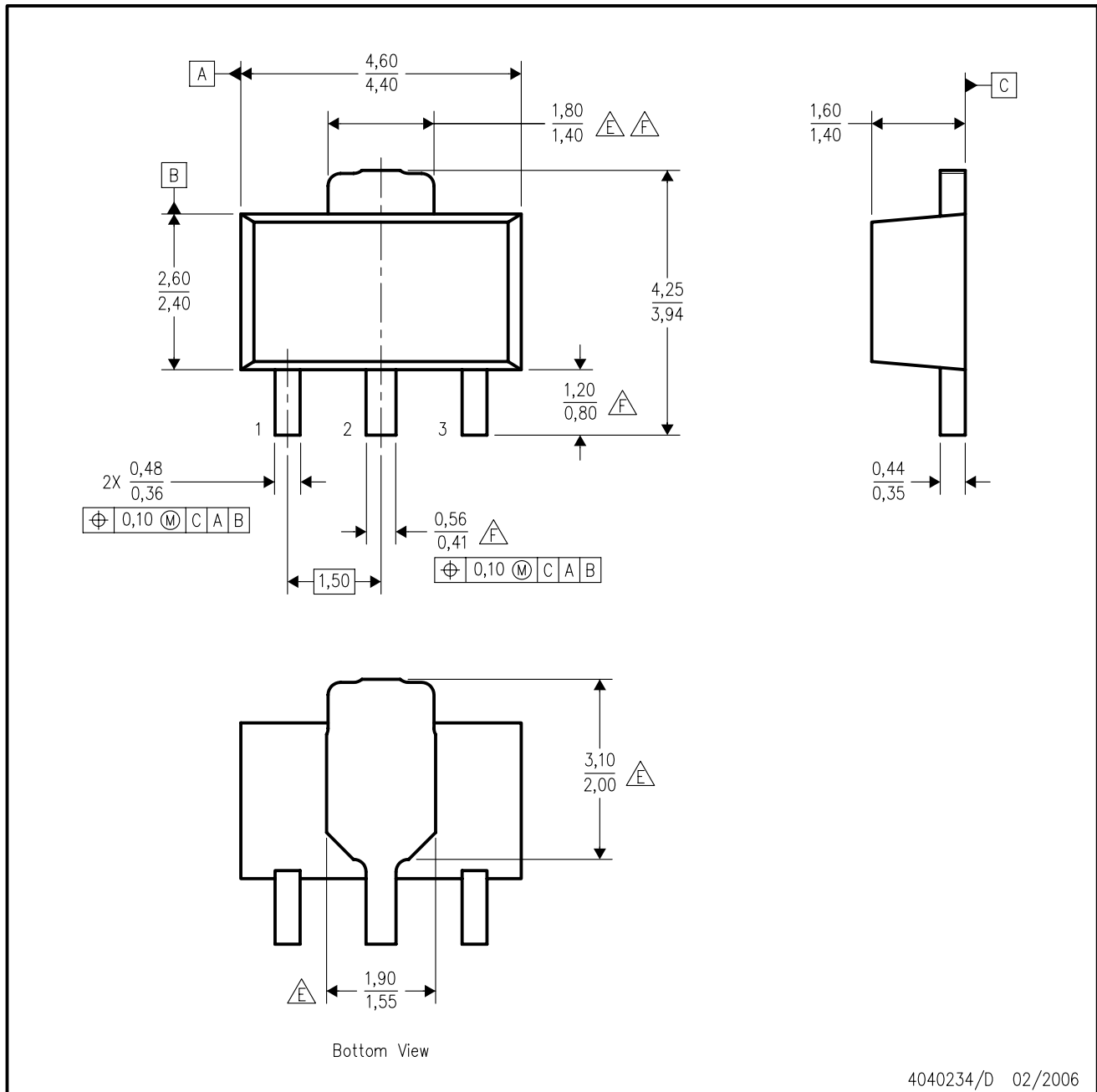
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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

MECHANICAL DATA

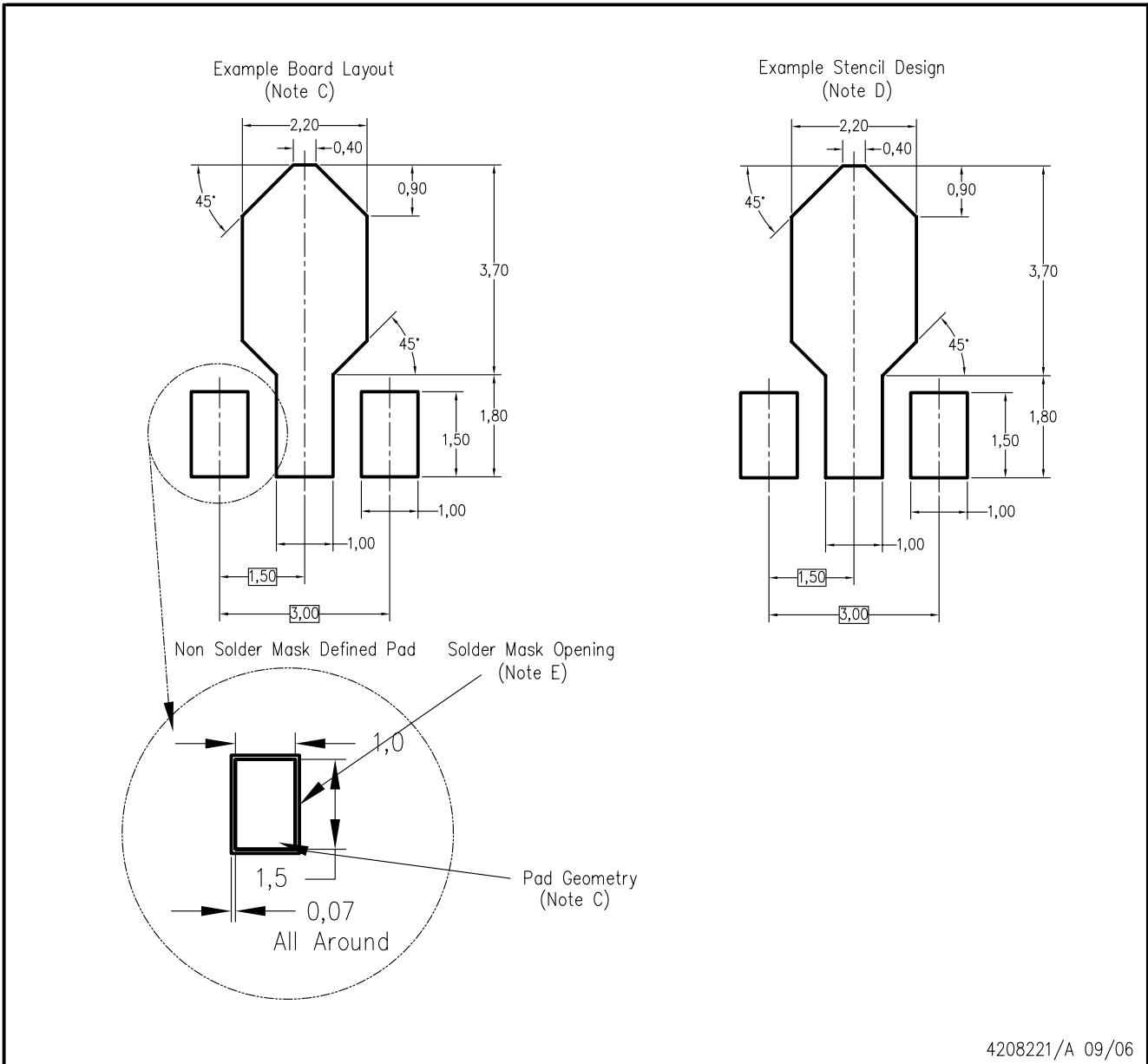
PK (R-PSS0-F3)

PLASTIC SINGLE-IN-LINE PACKAGE



- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - This drawing is subject to change without notice.
 - The center lead is in electrical contact with the tab.
 - 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)



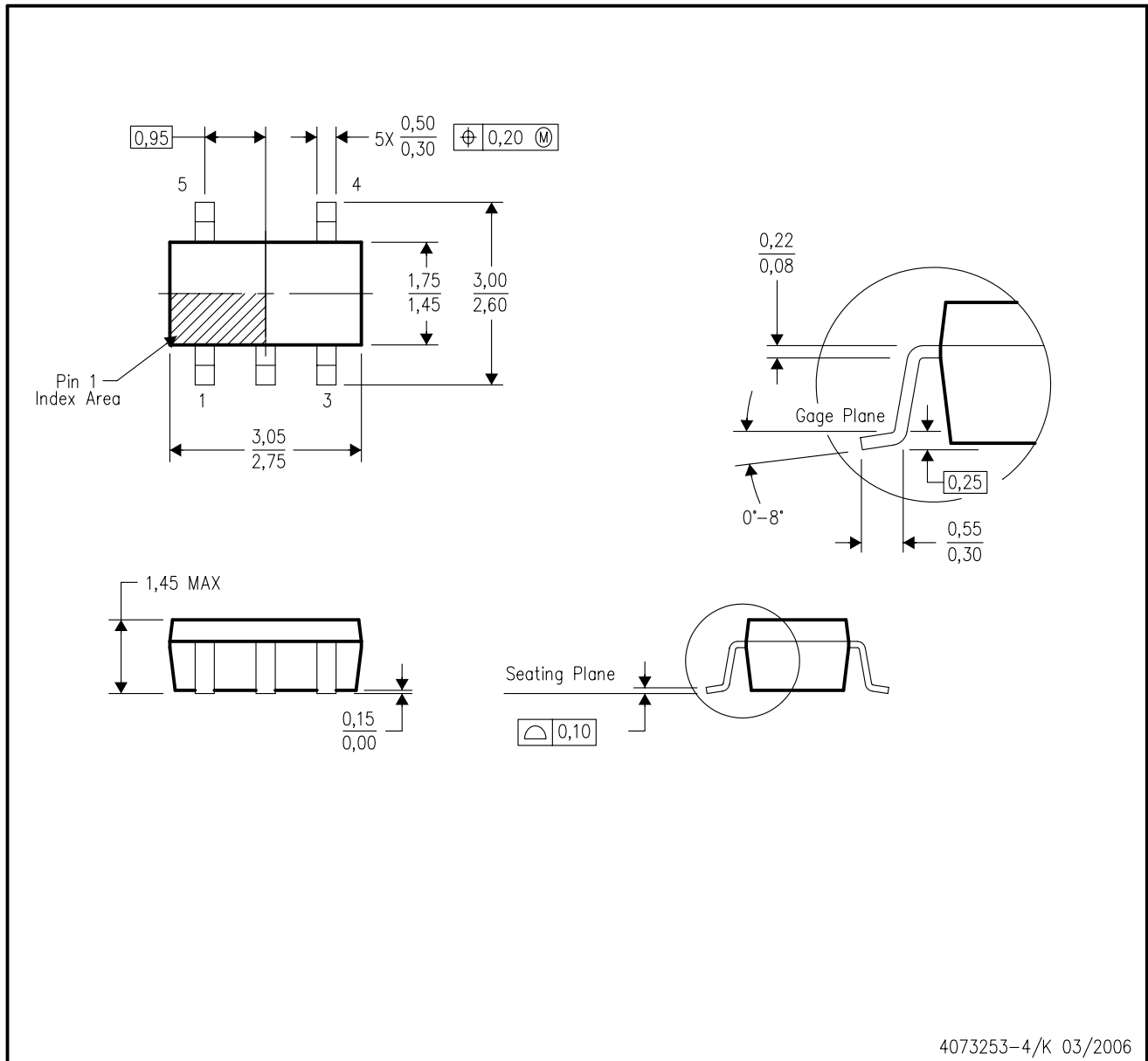
4208221/A 09/06

- 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.

MECHANICAL DATA

DBV (R-PDSO-G5)

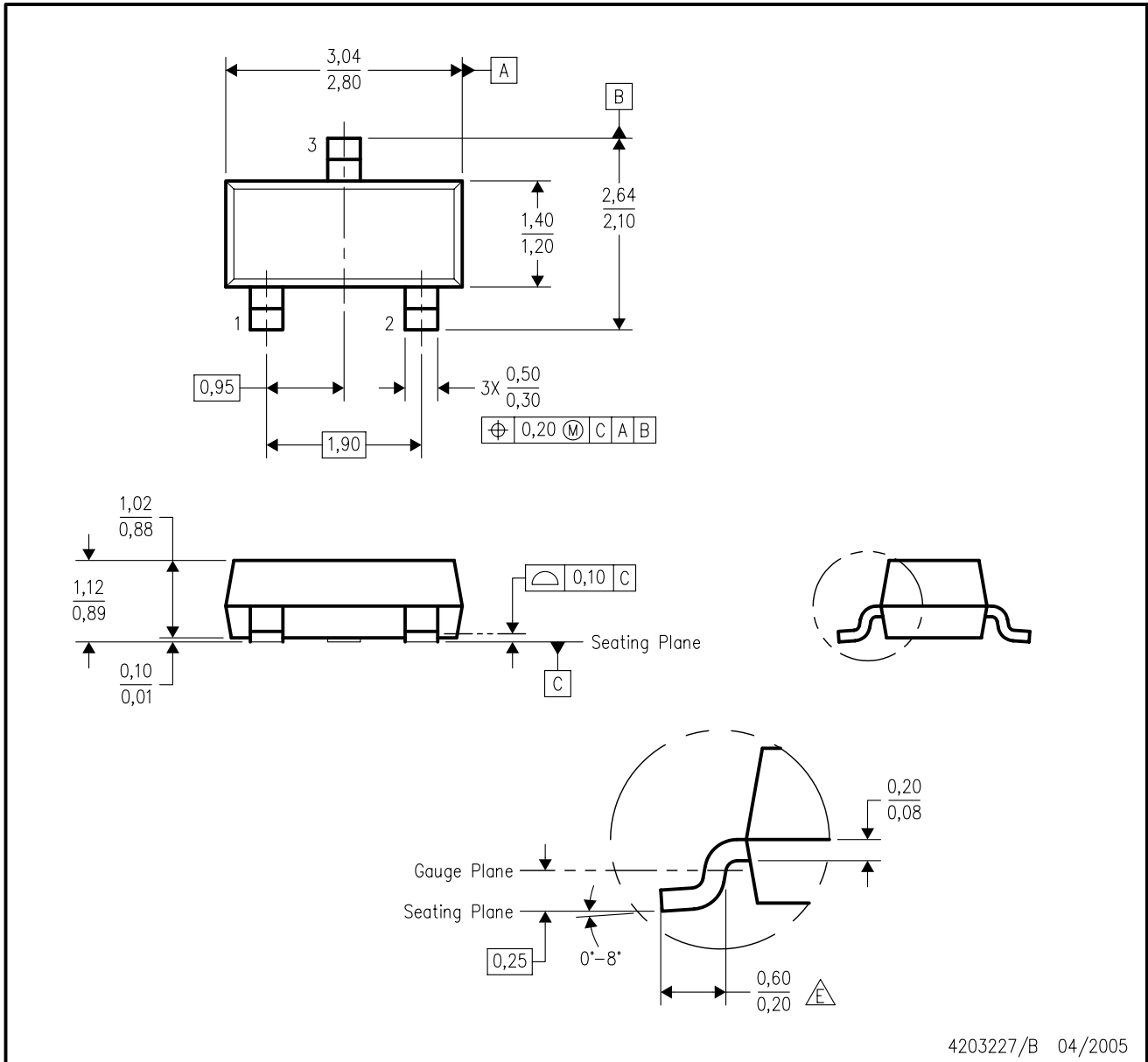
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
 - Falls within JEDEC MO-178 Variation AA.

DBZ (R-PDSO-G3)

PLASTIC SMALL-OUTLINE

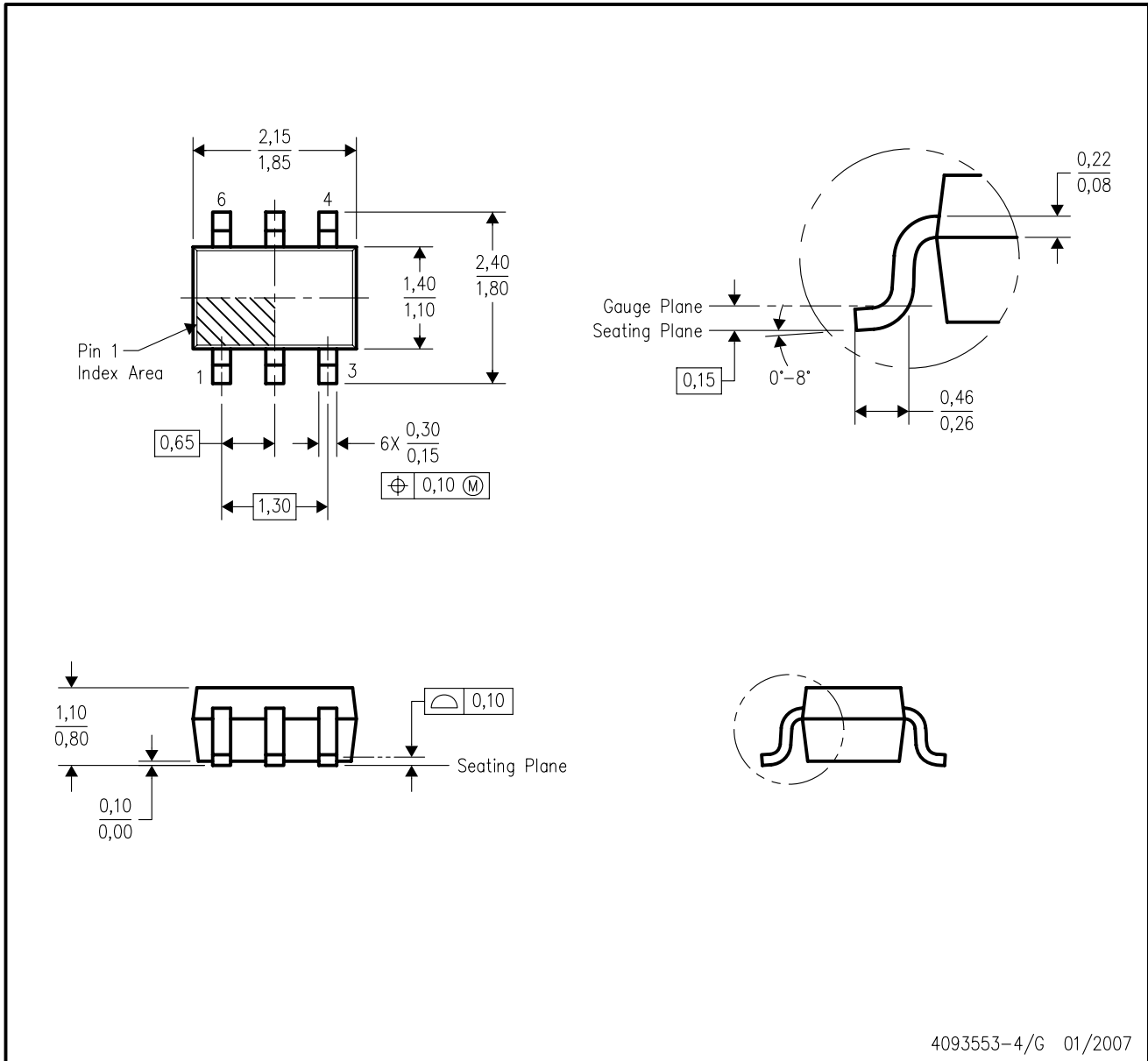


- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. Lead dimensions are inclusive of plating.
 - D. Body dimensions are exclusive of mold flash and protrusion. Mold flash and protrusion not to exceed 0.25 per side.
 - $\triangle E$ Falls within JEDEC TO-236 variation AB, except minimum foot length.

MECHANICAL DATA

DCK (R-PDSO-G6)

PLASTIC SMALL-OUTLINE PACKAGE

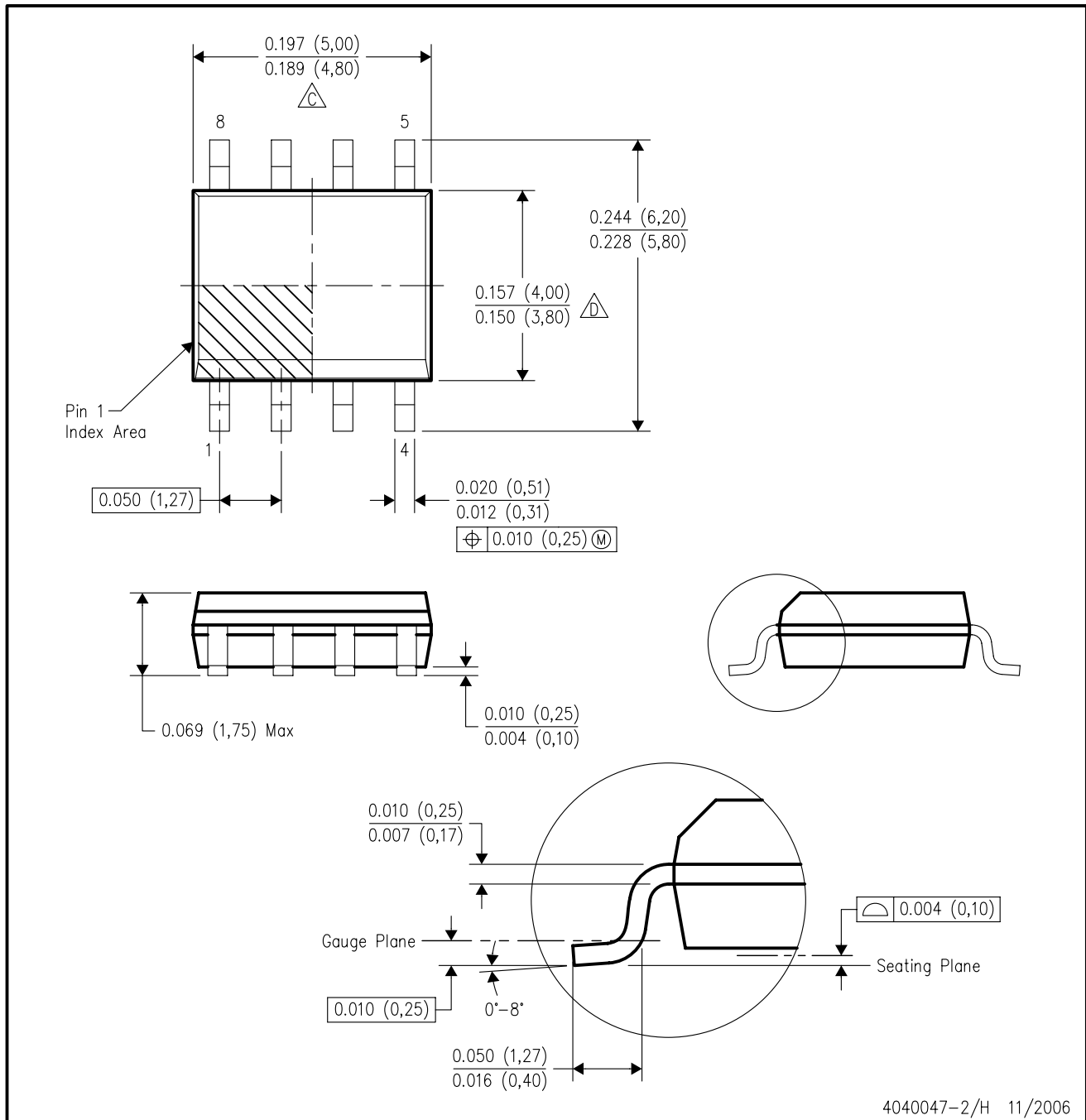


- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
 - Falls within JEDEC MO-203 variation AB.

MECHANICAL DATA

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



4040047-2/H 11/2006

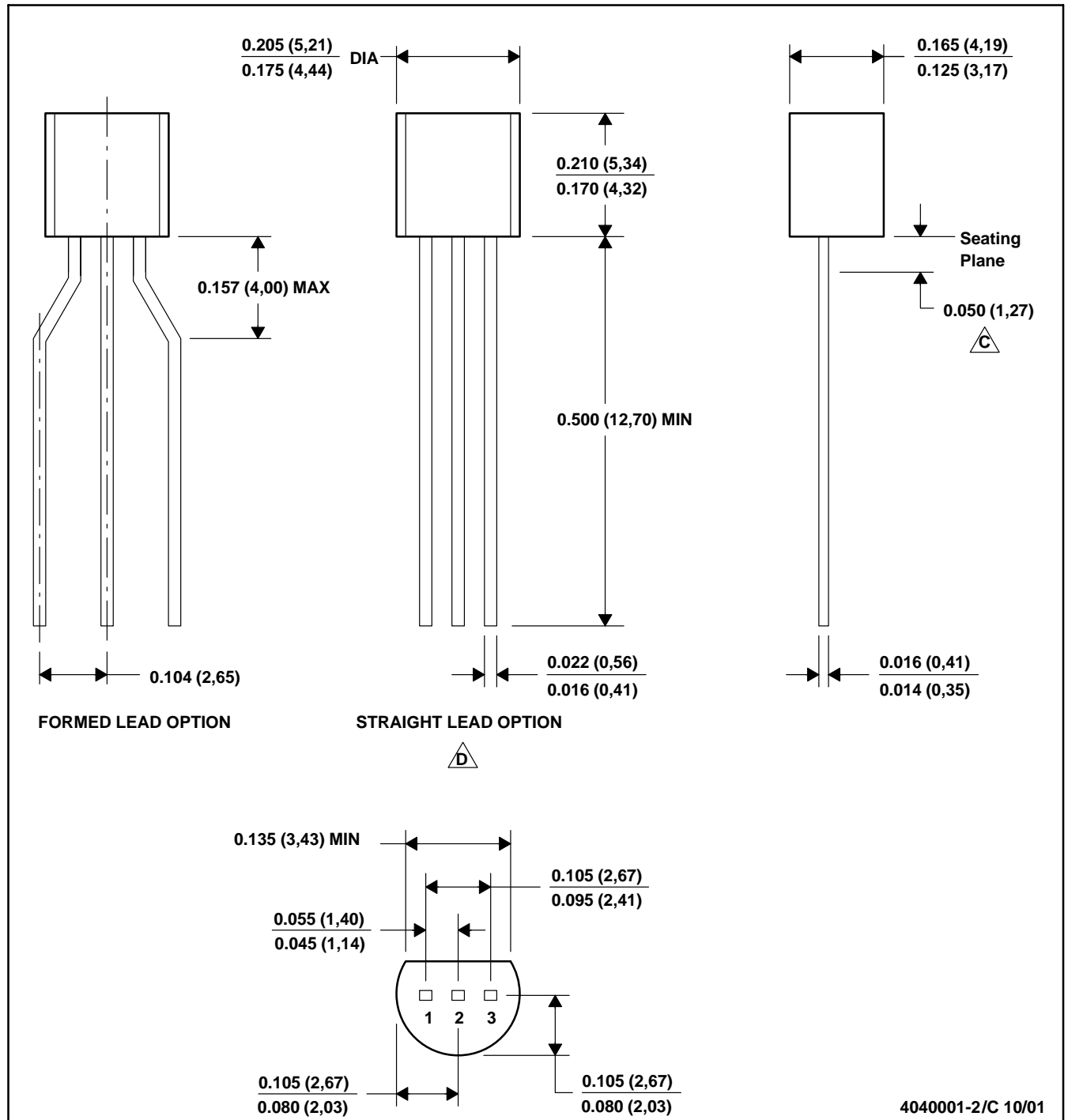
- NOTES:
- All linear dimensions are in inches (millimeters).
 - This drawing is subject to change without notice.
 - Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
 - Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
 - Reference JEDEC MS-012 variation AA.

MECHANICAL DATA

MSOT002A – OCTOBER 1994 – REVISED NOVEMBER 2001

LP (O-PBCY-W3)

PLASTIC CYLINDRICAL PACKAGE



4040001-2/C 10/01

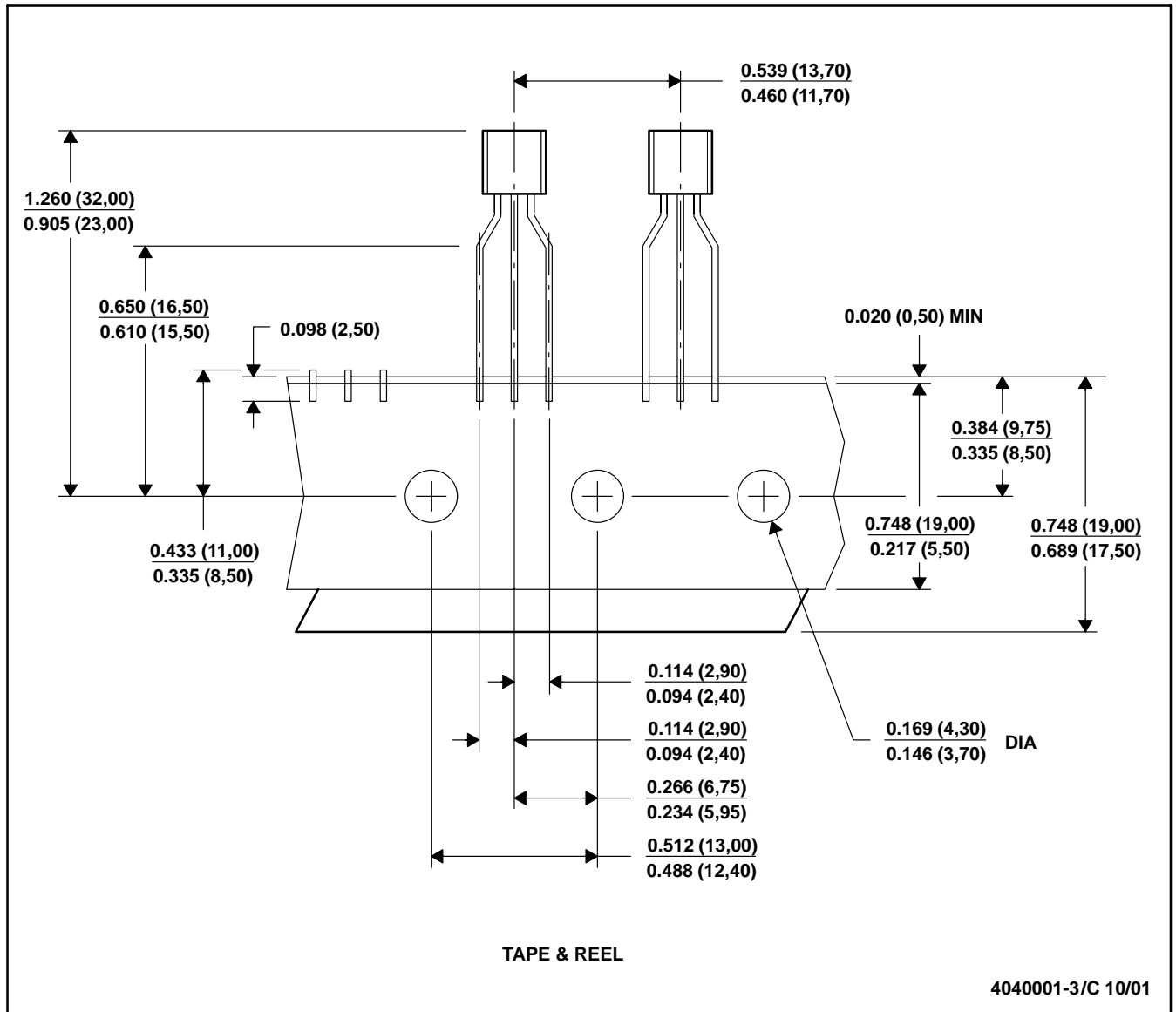
- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Lead dimensions are not controlled within this area
 D. Falls within JEDEC TO -226 Variation AA (TO-226 replaces TO-92)
 E. Shipping Method:
 Straight lead option available in bulk pack only.
 Formed lead option available in tape & reel or ammo pack.

MECHANICAL DATA

MSOT002A – OCTOBER 1994 – REVISED NOVEMBER 2001

LP (O-PBCY-W3)

PLASTIC CYLINDRICAL PACKAGE



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Tape and Reel information for the Format Lead Option package.