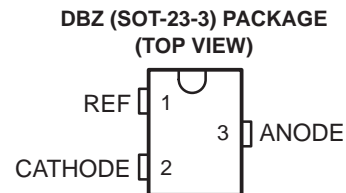
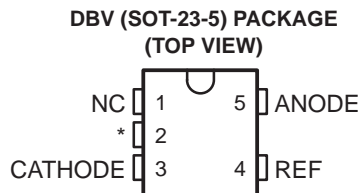


# TLV431A-Q1, TLV431B-Q1 LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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- Qualified for Automotive Applications
- 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
- Typical Temperature Drift: 11 mV
- Low Operational Cathode Current :80  $\mu\text{A}$  Typ
- 0.25- $\Omega$  Typical Output Impedance
- 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 TLV431A: NC – No internal connection

\* For TLV431B: Pin 2 is attached to Substrate and must be connected to ANODE or left open.

## 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  $\Omega$ . 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.

## ORDERING INFORMATION

$T_J$	25°C $V_{REF}$ TOLERANCE	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	0.5%	SOT-23-5 (DBV)	Reel of 3000	TLV431BQDBVRQ1	VOMQ
		SOT-23-3 (DBZ)	Reel of 3000	TLV431BQDBZRQ1	VOQQ
	1%	SOT-23-5 (DBV)	Reel of 3000	TLV431AQDBVRQ1	VONQ

† For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at <http://www.ti.com>.

‡ Package drawings, thermal data, and symbolization are available at <http://www.ti.com/packaging>.



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.

 **TEXAS  
INSTRUMENTS**

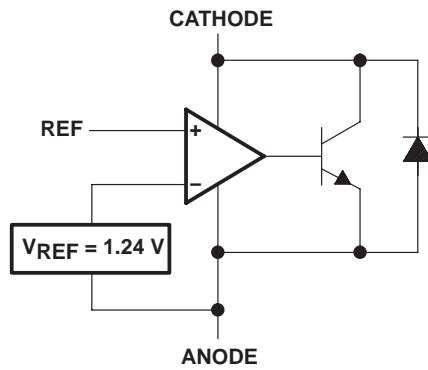
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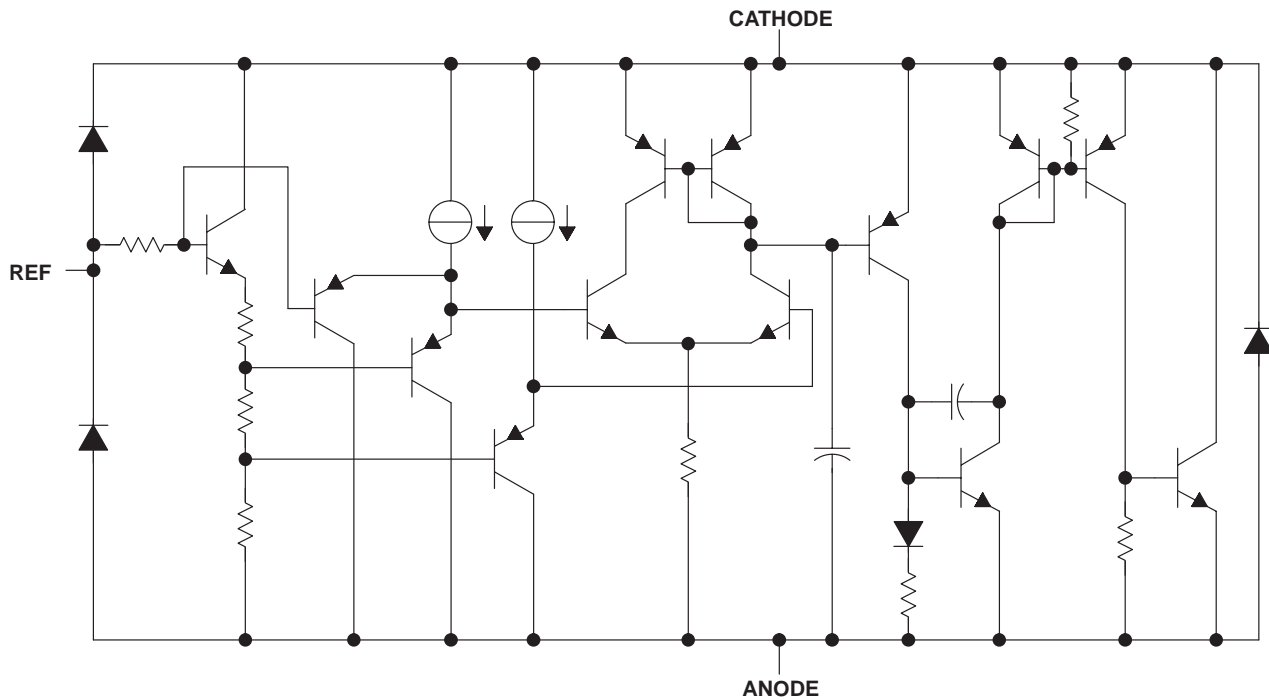
# TLV431A-Q1, TLV431B-Q1 LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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## logic block diagram



## equivalent schematic



# TLV431A-Q1, TLV431B-Q1

## LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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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, $\theta_{JA}$ (see Notes 2 and 3): DBV package .....	206°C/W
DBZ package .....	206°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  $T_J(max)$ ,  $\theta_{JA}$ , 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	–40	125	°C



# TLV431A-Q1, TLV431B-Q1

## LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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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 <sub>REF</sub> Reference voltage	V <sub>KA</sub> = V <sub>REF</sub> , I <sub>K</sub> = 10 mA, T <sub>A</sub> = 25°C	1.228	1.24	1.252	V
	T <sub>A</sub> = full range† (see Figure 1)	1.209		1.271	
V <sub>REF(dev)</sub> V <sub>REF</sub> deviation over full temperature range†‡	V <sub>KA</sub> = V <sub>REF</sub> , I <sub>K</sub> = 10 mA (see Figure 1)		11	31	mV
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$ Ratio of V <sub>REF</sub> change in cathode voltage change	V <sub>KA</sub> = V <sub>REF</sub> to 6 V, I <sub>K</sub> = 10 mA (see Figure 2)		-1.5	-2.7	mV/V
I <sub>ref</sub> Reference terminal current	I <sub>K</sub> = 10 mA, R1 = 10 kΩ, R2 = open (see Figure 2)		0.15	0.5	μA
I <sub>ref(dev)</sub> I <sub>ref</sub> deviation over full temperature range†	I <sub>K</sub> = 10 mA, R1 = 10 kΩ, R2 = open (see Figure 2)		0.15	0.5	μA
I <sub>K(min)</sub> Minimum cathode current for regulation	V <sub>KA</sub> = V <sub>REF</sub> (see Figure 1)		55	100	μA
I <sub>K(off)</sub> Off-state cathode current	V <sub>REF</sub> = 0, V <sub>KA</sub> = 6 V (see Figure 3)		0.001	0.1	μA
z <sub>KA</sub>   Dynamic impedance §	V <sub>KA</sub> = V <sub>REF</sub> , f ≤ 1 kHz, I <sub>K</sub> = 0.1 mA to 15 mA (see Figure 1)		0.25	0.4	Ω

† Full temperature range is -40°C to 125°C.

‡ The deviation parameters V<sub>REF(dev)</sub> and I<sub>ref(dev)</sub> 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<sub>REF</sub>, 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<sub>A</sub> is the rated operating free-air temperature range of the device.

αV<sub>REF</sub> can be positive or negative, depending on whether minimum V<sub>REF</sub> or maximum V<sub>REF</sub>, respectively, occurs at the lower temperature.

§ 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:

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



# TLV431A-Q1, TLV431B-Q1 LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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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 <sub>REF</sub> Reference voltage	V <sub>KA</sub> = V <sub>REF</sub> , I <sub>K</sub> = 10 mA	T <sub>A</sub> = 25°C	1.234	1.24	1.246	V
		T <sub>A</sub> = full range† (see Figure 1)	1.221		1.265	
V <sub>REF(dev)</sub> V <sub>REF</sub> deviation over full temperature range†‡	V <sub>KA</sub> = V <sub>REF</sub> , I <sub>K</sub> = 10 mA (see Figure 1)			11	31	mV
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$ Ratio of V <sub>REF</sub> change in cathode voltage change	V <sub>KA</sub> = V <sub>REF</sub> to 6 V, I <sub>K</sub> = 10 mA (see Figure 2)			-1.5	-2.7	mV/V
I <sub>ref</sub> Reference terminal current	I <sub>K</sub> = 10 mA, R1 = 10 kΩ, R2 = open (see Figure 2)			0.1	0.5	μA
I <sub>ref(dev)</sub> I <sub>ref</sub> deviation over full temperature range†‡	I <sub>K</sub> = 10 mA, R1 = 10 kΩ, R2 = open (see Figure 2)			0.15	0.5	μA
I <sub>K(min)</sub> Minimum cathode current for regulation	V <sub>KA</sub> = V <sub>REF</sub> (see Figure 1)			55	100	μA
I <sub>K(off)</sub> Off-state cathode current	V <sub>REF</sub> = 0, V <sub>KA</sub> = 6 V (see Figure 3)			0.001	0.1	μA
z <sub>KA</sub>      Dynamic impedance §	V <sub>KA</sub> = V <sub>REF</sub> , f ≤ 1 kHz, I <sub>K</sub> = 0.1 mA to 15 mA (see Figure 1)			0.25	0.4	Ω

† Full temperature range is -40°C to 125°C.

‡ The deviation parameters V<sub>REF(dev)</sub> and I<sub>ref(dev)</sub> 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<sub>REF</sub>, 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<sub>A</sub> is the rated operating free-air temperature range of the device.

αV<sub>REF</sub> can be positive or negative, depending on whether minimum V<sub>REF</sub> or maximum V<sub>REF</sub>, respectively, occurs at the lower temperature.

§ 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:

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

# TLV431A-Q1, TLV431B-Q1 LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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## PARAMETER MEASUREMENT INFORMATION

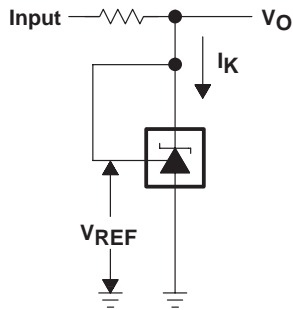


Figure 1. Test Circuit for  $V_{KA} = V_{REF}$   
 $V_O = V_{KA} = V_{REF}$

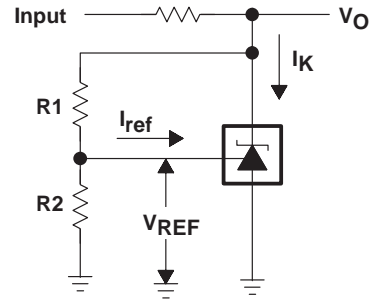


Figure 2. Test Circuit for  $V_{KA} > V_{REF}$   
 $V_O = V_{KA} = V_{REF} \times (1 + R1/R2) + I_{ref} \times R1$

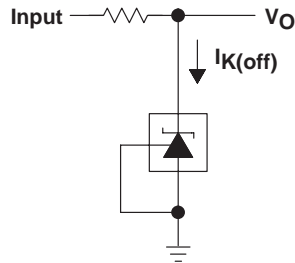


Figure 3. Test Circuit for  $I_{K(off)}$

PARAMETER MEASUREMENT INFORMATION†

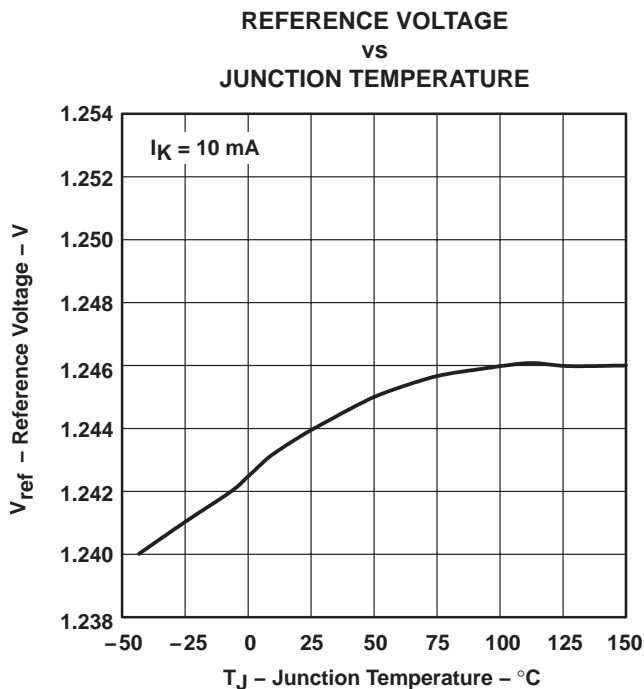


Figure 4

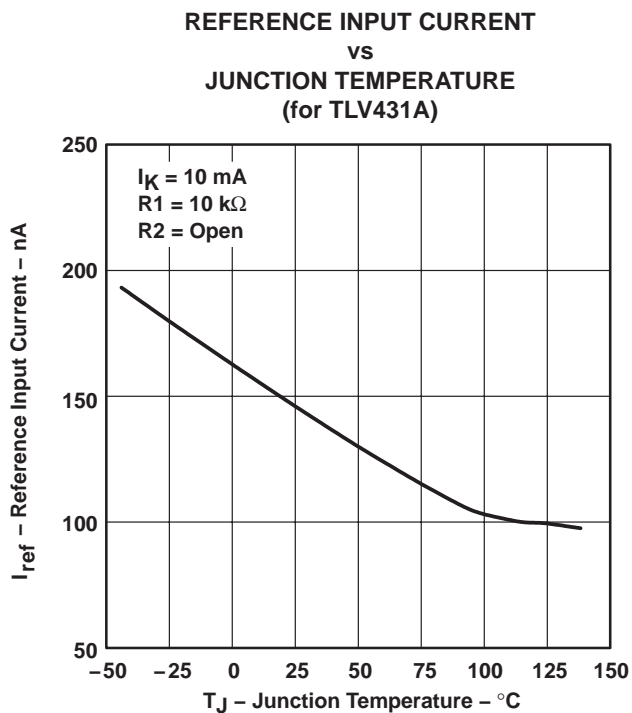


Figure 5A

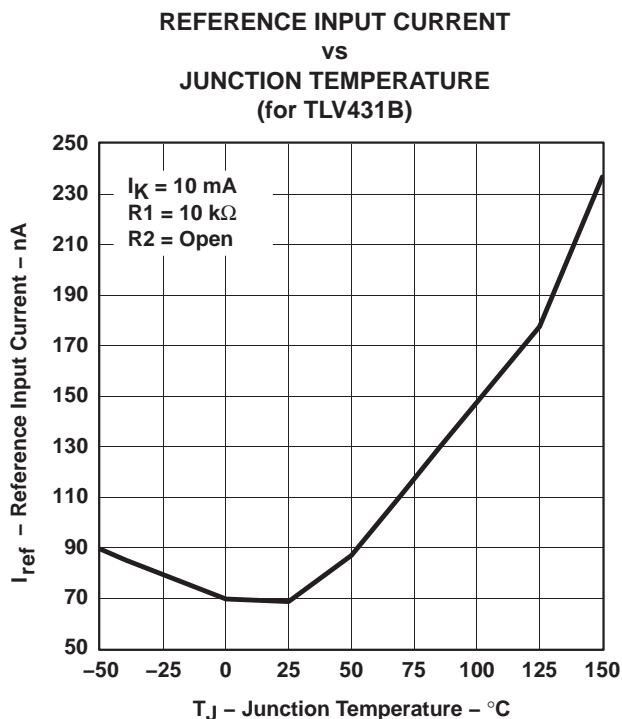


Figure 5B

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

# TLV431A-Q1, TLV431B-Q1 LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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## PARAMETER MEASUREMENT INFORMATION†

CATHODE CURRENT  
vs  
CATHODE VOLTAGE

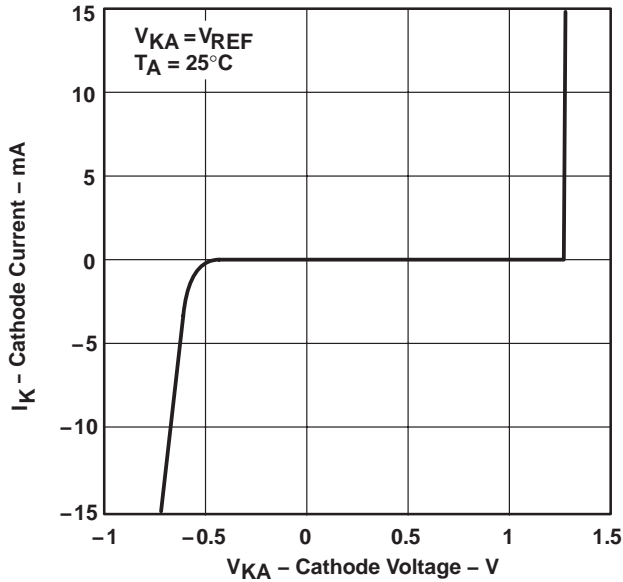


Figure 6

CATHODE CURRENT  
vs  
CATHODE VOLTAGE

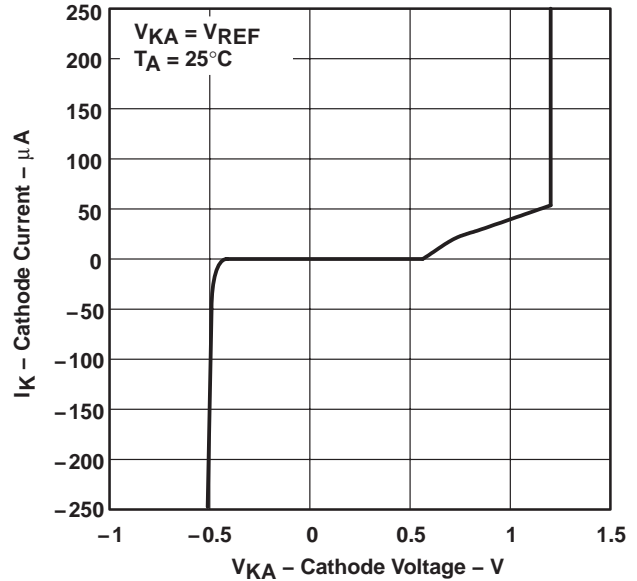


Figure 7

OFF-STATE CATHODE CURRENT  
vs  
JUNCTION TEMPERATURE  
(for TLV431A)

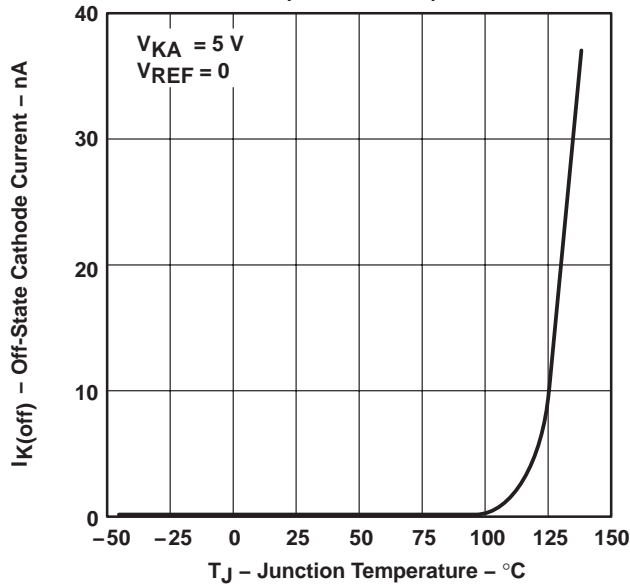


Figure 8A

OFF-STATE CATHODE CURRENT  
vs  
JUNCTION TEMPERATURE  
(for TLV431B)

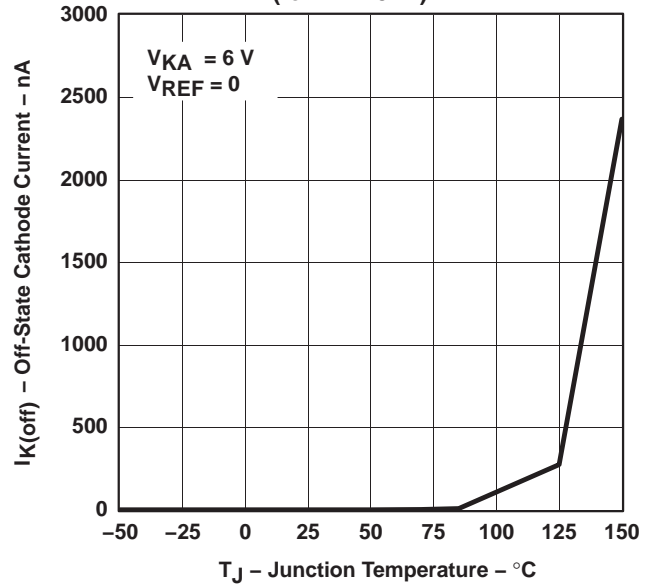


Figure 8B

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



PARAMETER MEASUREMENT INFORMATION†

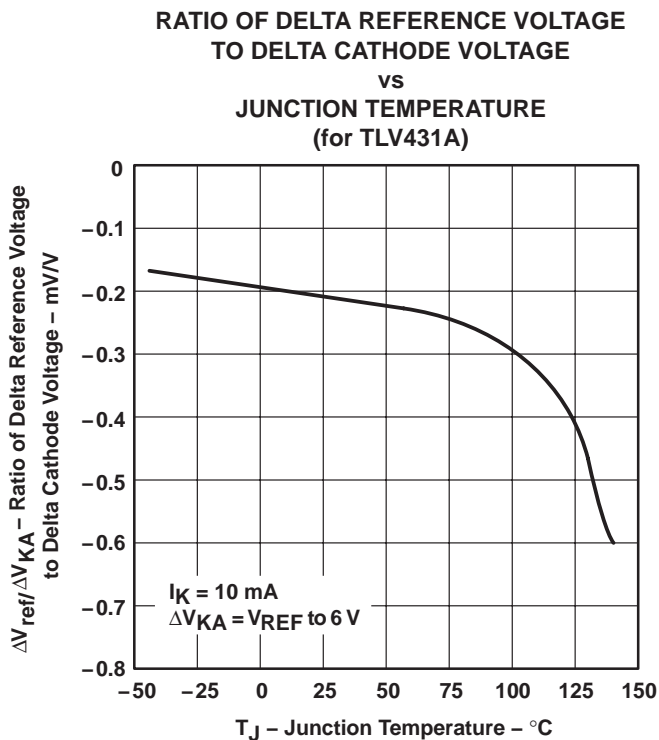


Figure 9A

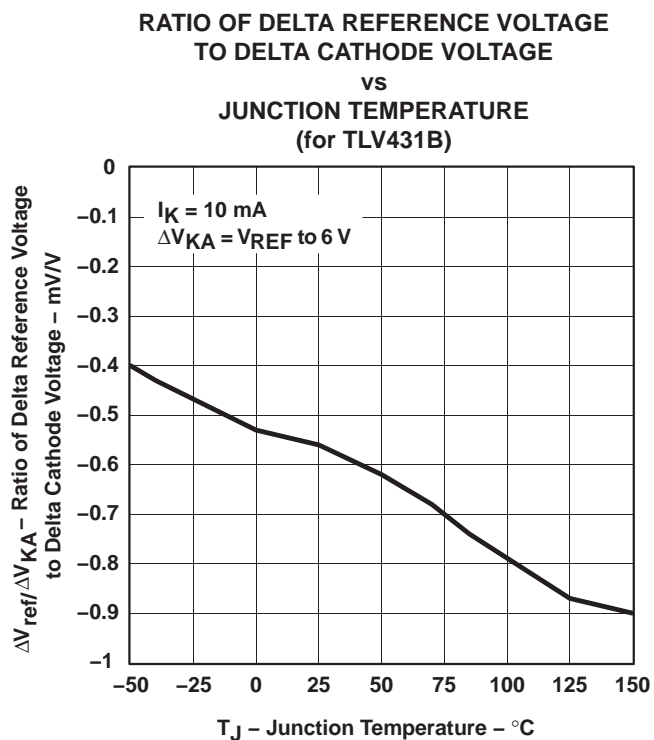
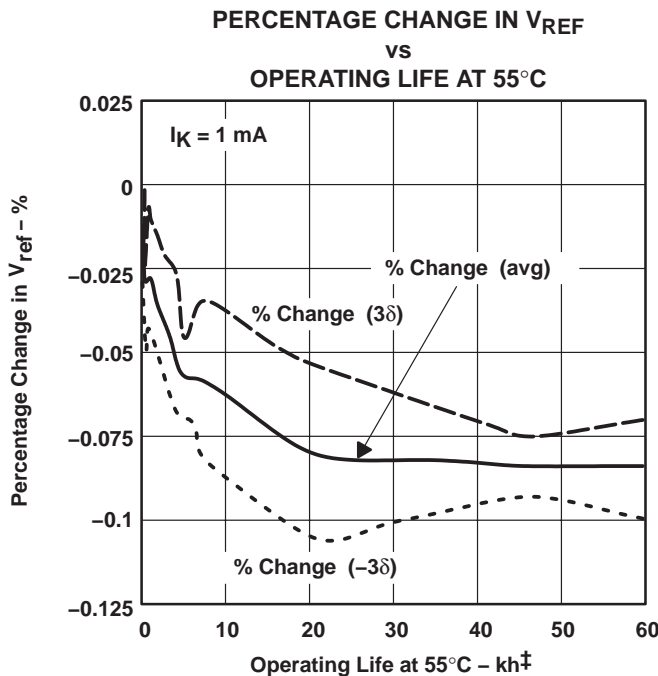


Figure 9B



‡ 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.

# TLV431A-Q1, TLV431B-Q1 LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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## PARAMETER MEASUREMENT INFORMATION

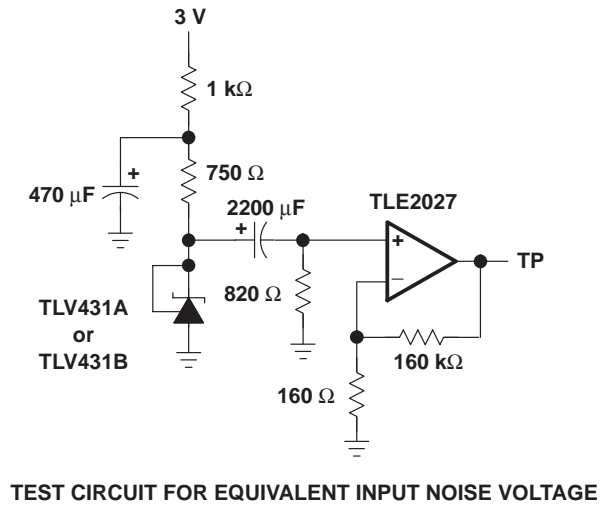
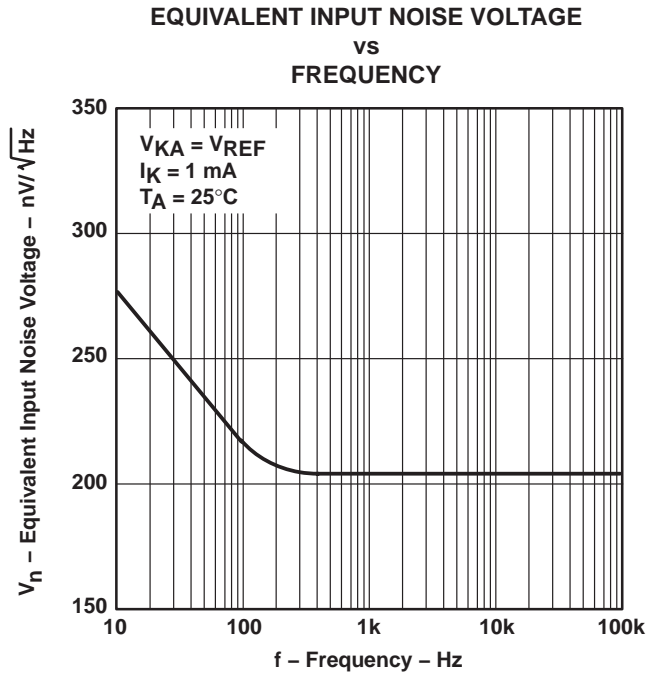
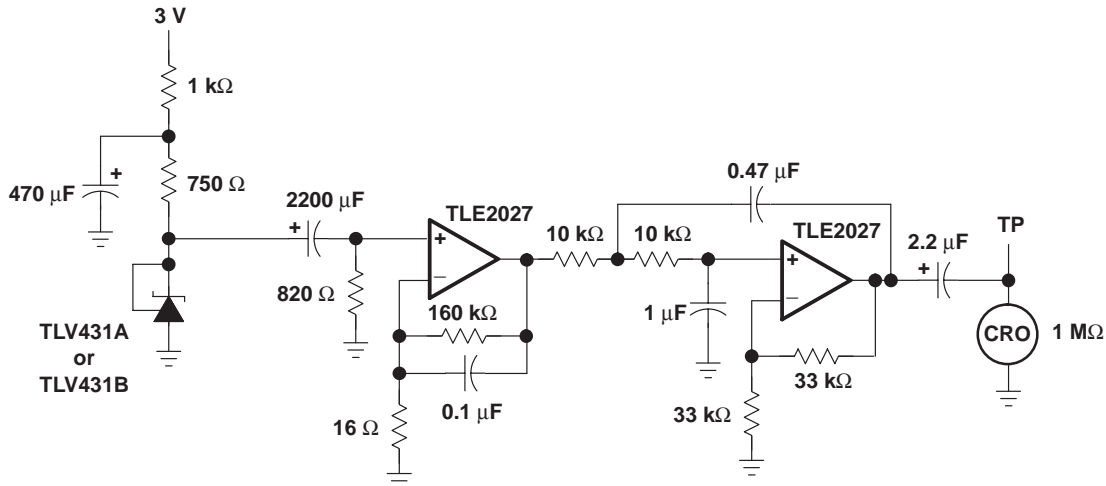
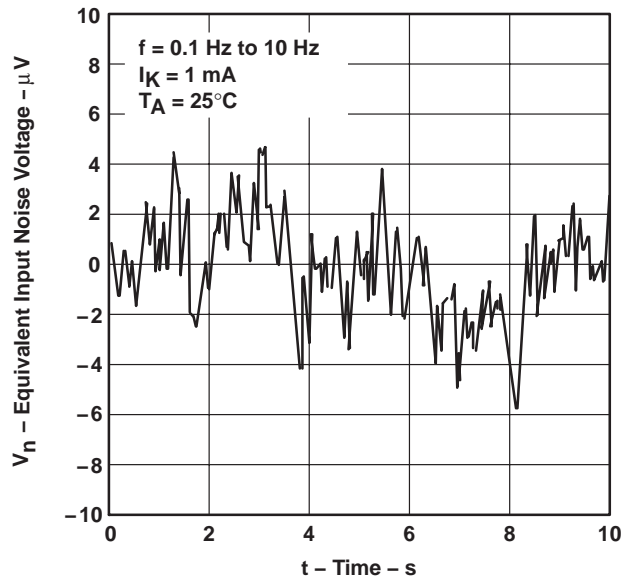


Figure 11

PARAMETER MEASUREMENT INFORMATION

EQUIVALENT INPUT NOISE VOLTAGE  
 OVER A 10-s PERIOD



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

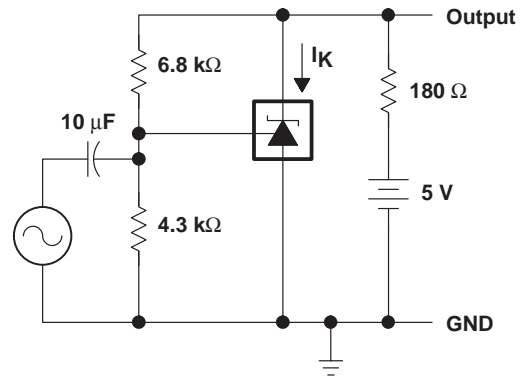
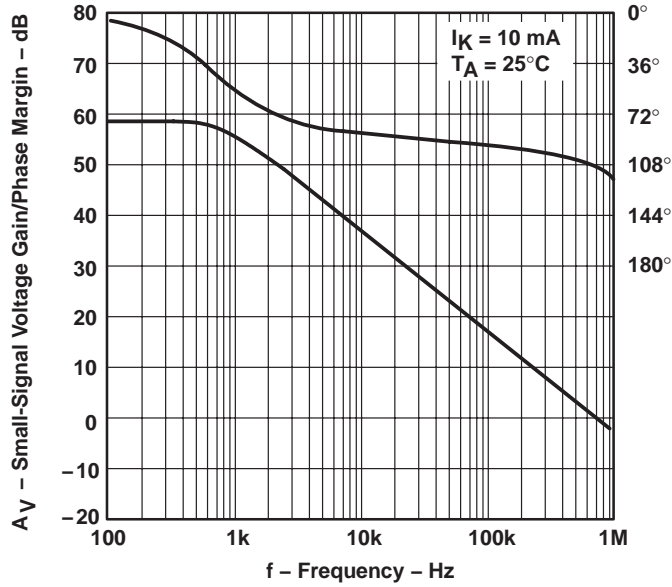
Figure 12

# TLV431A-Q1, TLV431B-Q1 LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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## PARAMETER MEASUREMENT INFORMATION

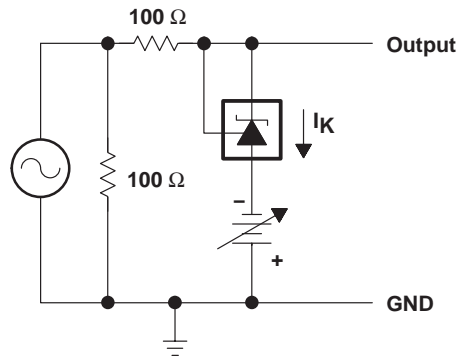
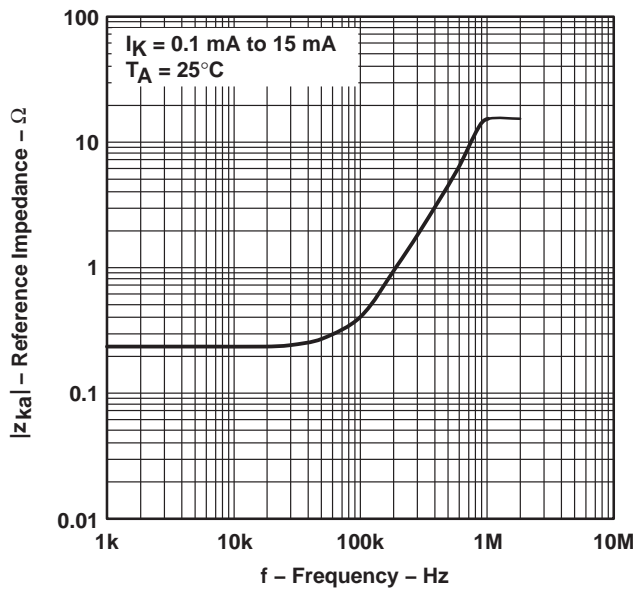
### SMALL-SIGNAL VOLTAGE GAIN/PHASE MARGIN vs FREQUENCY



TEST CIRCUIT FOR VOLTAGE GAIN  
AND PHASE MARGIN

Figure 13

### REFERENCE IMPEDANCE vs FREQUENCY



TEST CIRCUIT FOR REFERENCE IMPEDANCE

Figure 14

PARAMETER MEASUREMENT INFORMATION

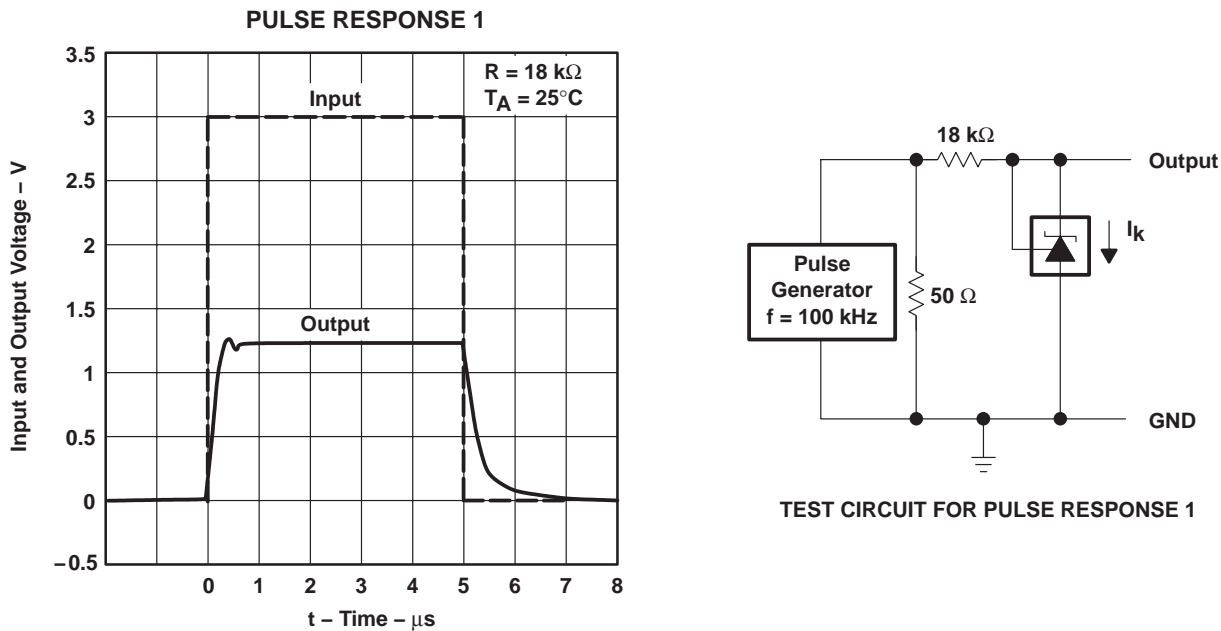


Figure 15

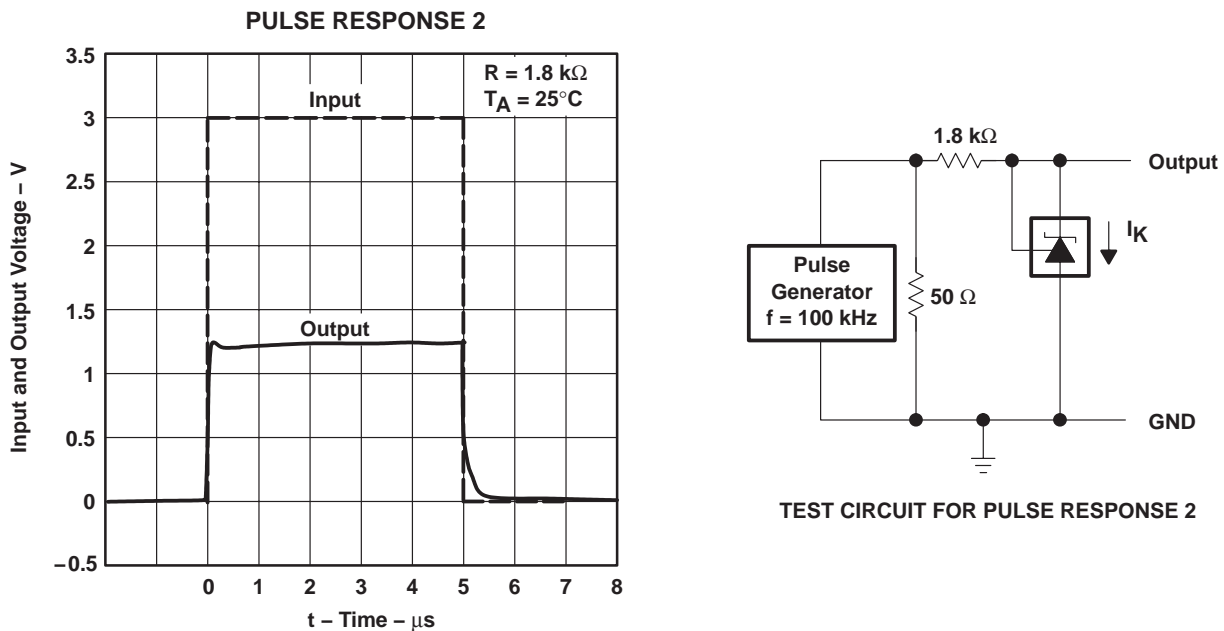
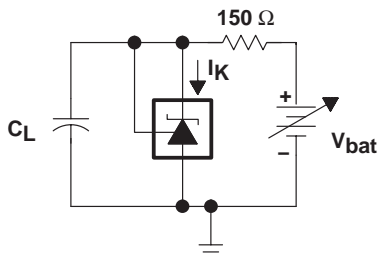
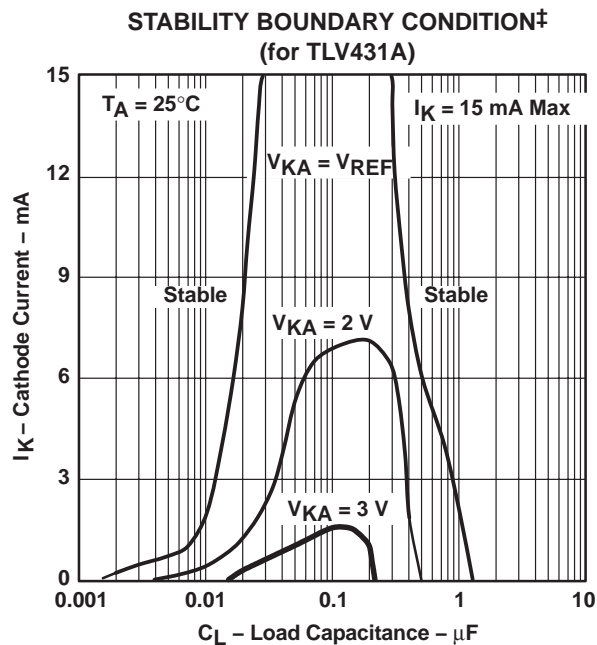


Figure 16

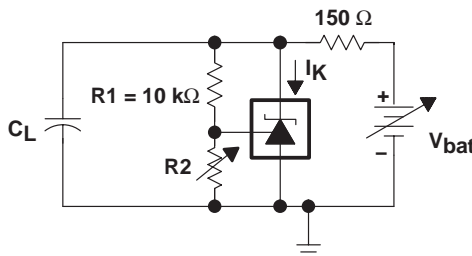
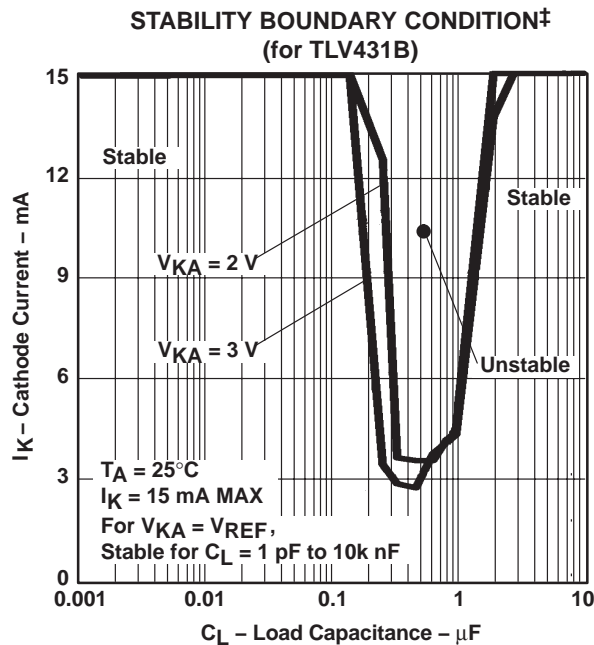
# TLV431A-Q1, TLV431B-Q1 LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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## PARAMETER MEASUREMENT INFORMATION†



TEST CIRCUIT FOR  $V_{KA} = V_{REF}$



TEST CIRCUIT FOR  $V_{KA} = 2\text{ V}, 3\text{ V}$

‡ The areas under the curves represent conditions that may cause the device to oscillate. For  $V_{KA} = 2\text{-V}$  and  $3\text{-V}$  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.

APPLICATION INFORMATION

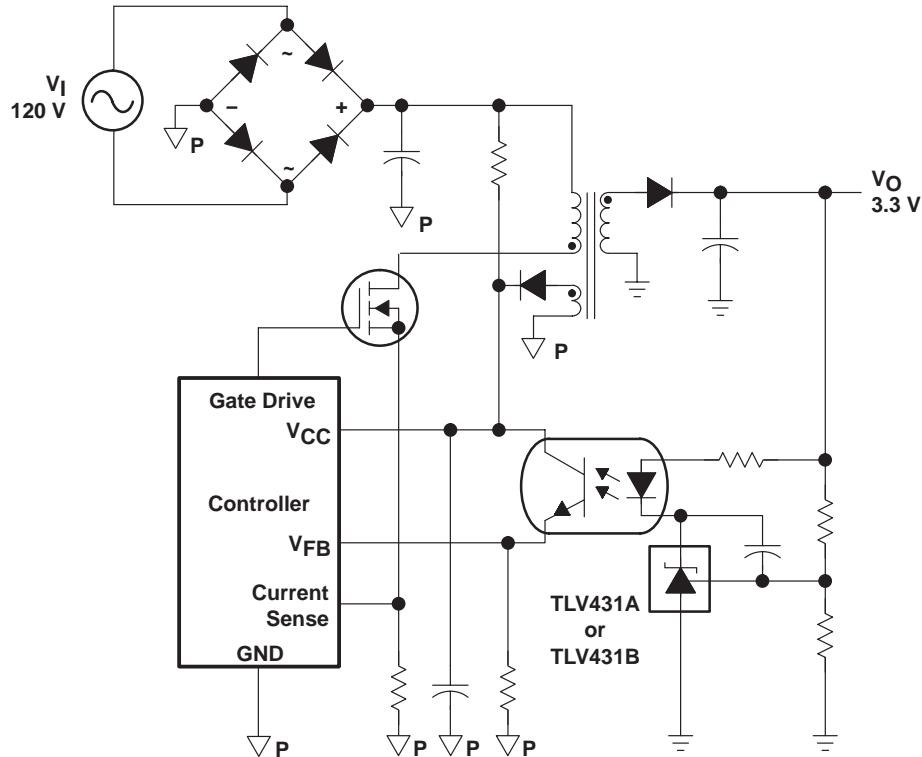


Figure 18. Flyback With Isolation Using TLV431, TLV431A, or TLV431B as Voltage Reference and Error Amplifier

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)	Op Temp (°C)	Top-Side Markings (4)	Samples
TLV431AQDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VONQ	<a href="#">Samples</a>
TLV431BQDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VOMQ	<a href="#">Samples</a>
TLV431BQDBZRQ1	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VOQQ	<a href="#">Samples</a>

(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.

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

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**OTHER QUALIFIED VERSIONS OF TLV431A-Q1, TLV431B-Q1 :**

- Catalog: [TLV431A](#), [TLV431B](#)

## NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

**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
TLV431AQDBVRQ1	SOT-23	DBV	5	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TLV431BQDBVRQ1	SOT-23	DBV	5	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TLV431BQDBZRQ1	SOT-23	DBZ	3	3000	179.0	8.4	3.15	2.95	1.22	4.0	8.0	Q3

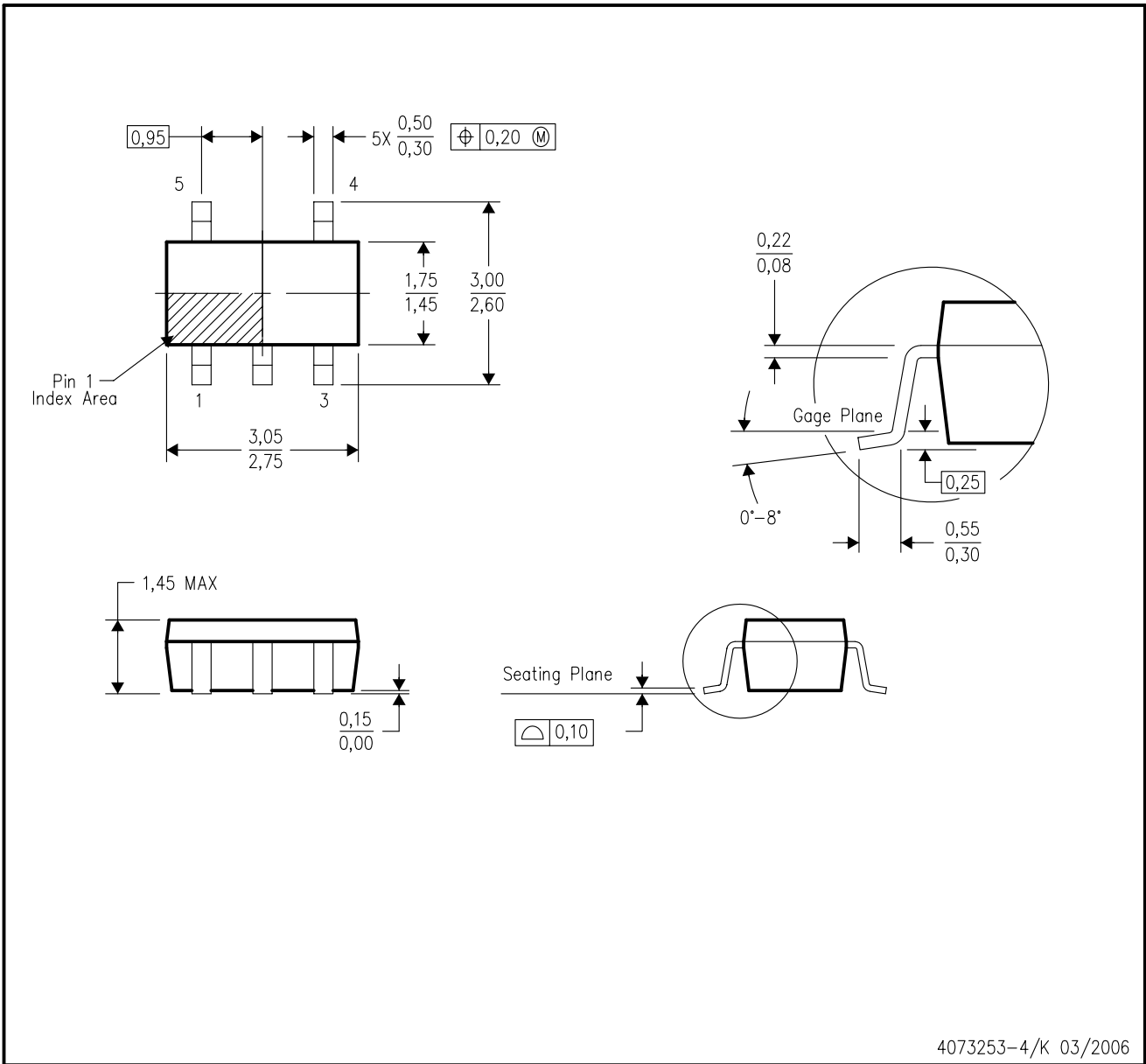
**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLV431AQDBVRQ1	SOT-23	DBV	5	3000	203.0	203.0	35.0
TLV431BQDBVRQ1	SOT-23	DBV	5	3000	203.0	203.0	35.0
TLV431BQDBZRQ1	SOT-23	DBZ	3	3000	203.0	203.0	35.0

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



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

DBV (R-PDSO-G5)

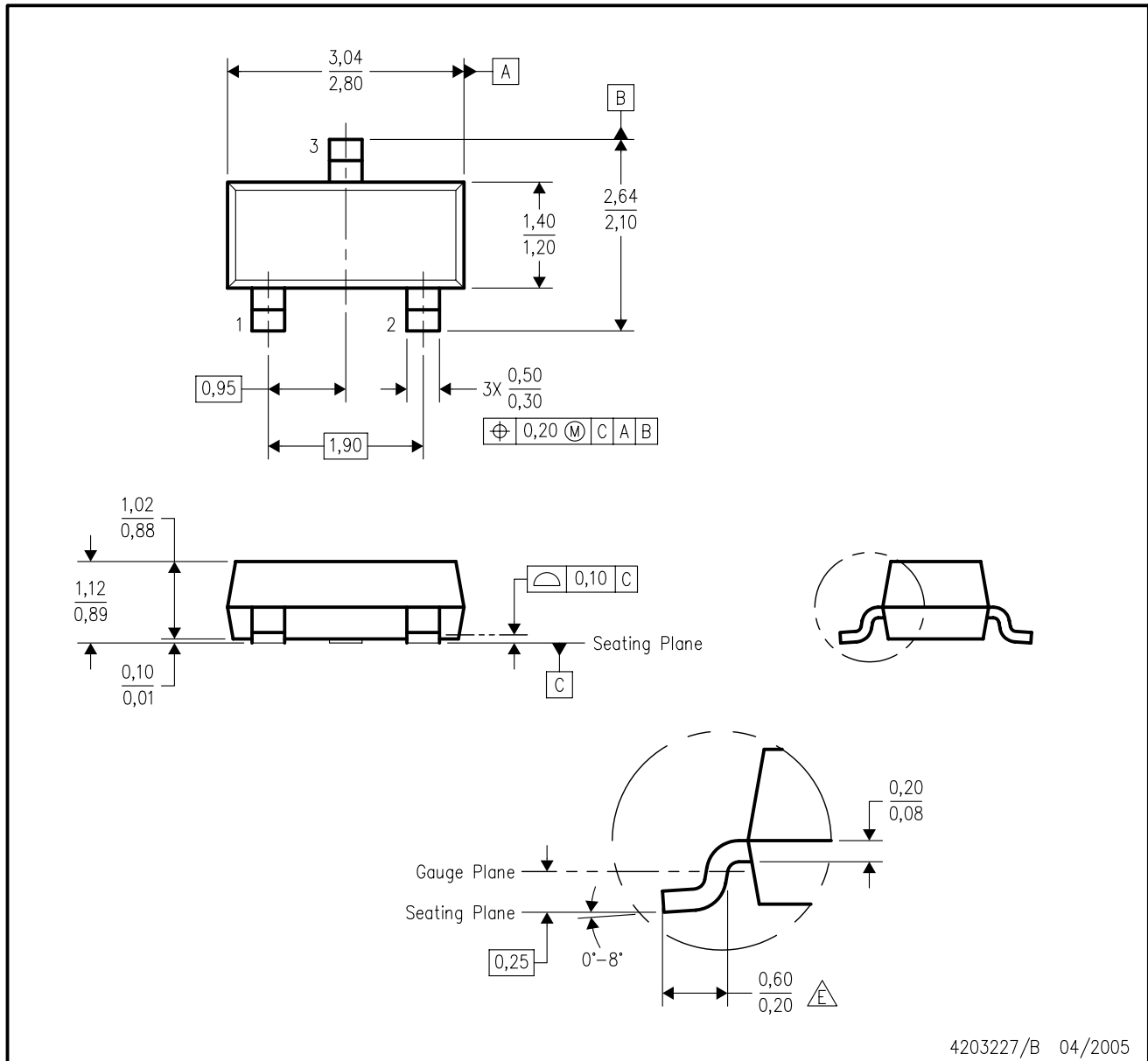
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - D. Publication IPC-7351 is recommended for alternate designs.
  - E. 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. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

DBZ (R-PDSO-G3)

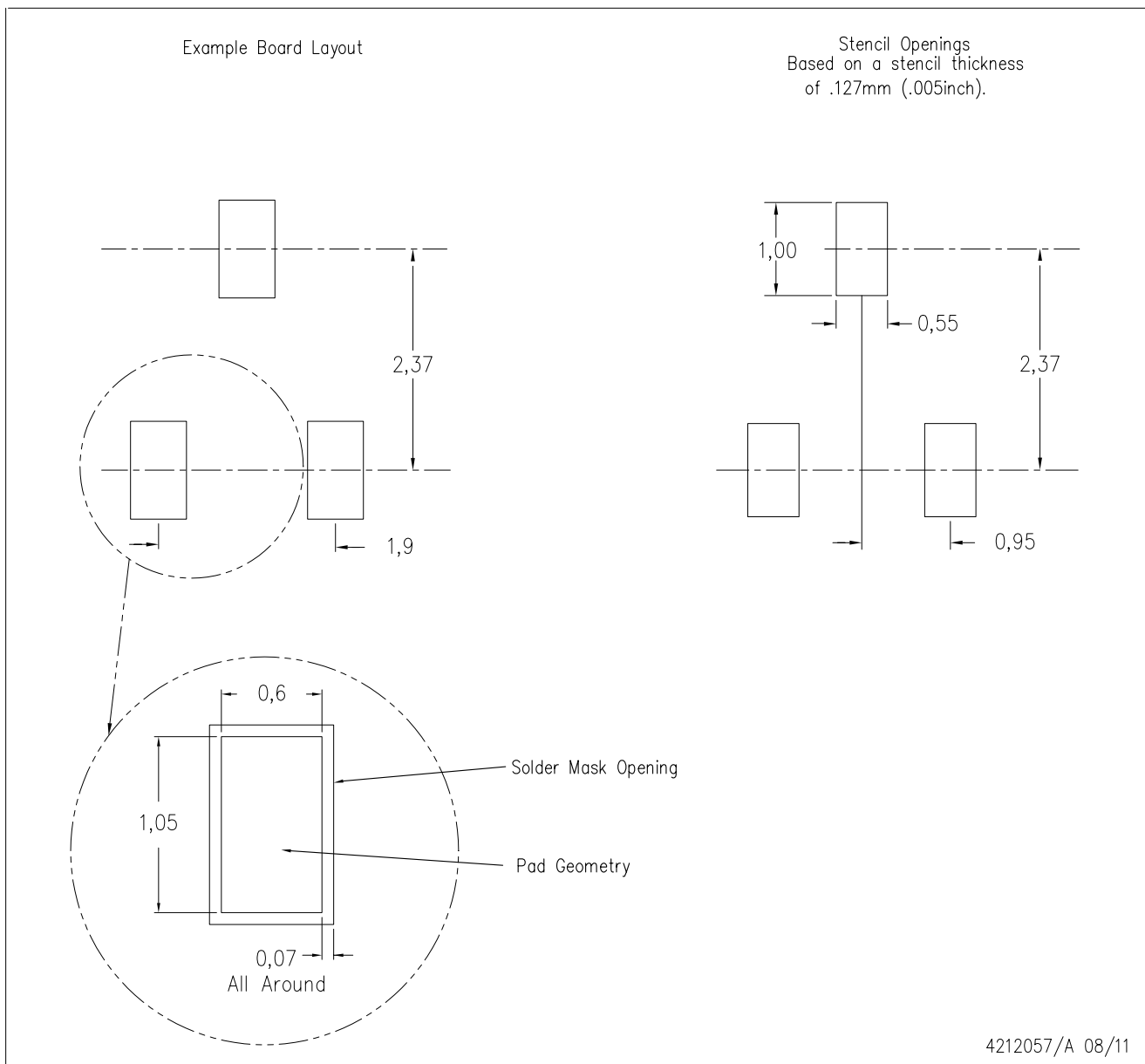
PLASTIC SMALL-OUTLINE



- 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.

DBZ (R-PDSO-G3)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - D. Publication IPC-7351 is recommended for alternate designs.
  - E. 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. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

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