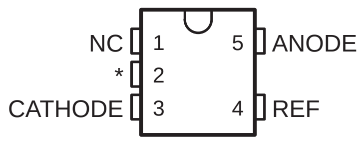
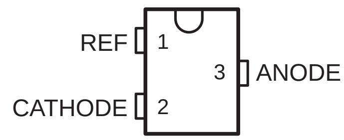
- Qualified for Automotive Applications
- Low-Voltage Operation: V_{REF} = 1.24 V
- Adjustable Output Voltage, V_O = V_{REF} to 6 V
- Reference Voltage Tolerances at 25°C
  - 0.5% for TLV431B
  - 1% for TLV431A
- Typical Temperature Drift: 11 mV
- Low Operational Cathode Current :80 µA Typ
- 0.25-Ω Typical 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

DBV (SOT-23-5) PACKAGE
(TOP VIEW)



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.

DBZ (SOT-23-3) PACKAGE
(TOP VIEW)



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.

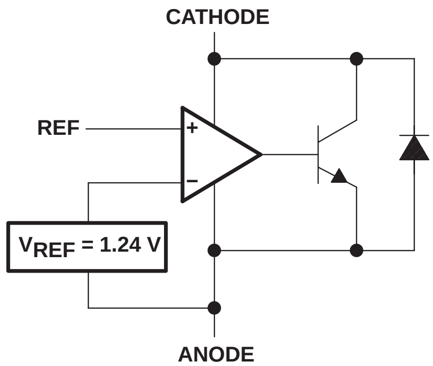
When used with an optocoupler, the TLV431 is an ideal voltage reference in isolated feedback circuits for 3-V to 3.3-V switching-mode power supplies. These devices have a typical output impedance of 0.25 Ω. Active output circuitry provides a very sharp turn-on characteristic, making them excellent replacements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

ORDERING INFORMATION

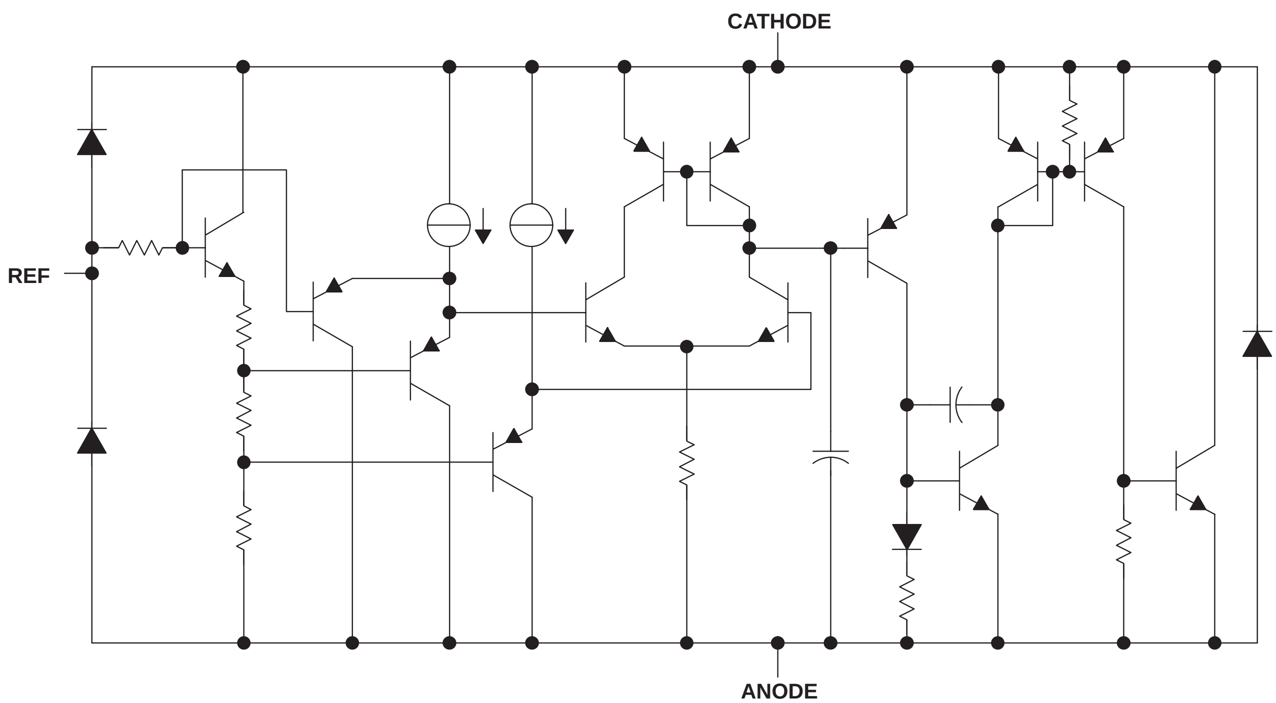
T_J	25°C V_{REF} TOLERANCE	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
−40°C to 125°C	0.5%	SOT-23-5 (DBV)	Reel of 3000	TLV431BQDBVRQ1	VOMQ
		SOT-23-3 (DBZ)	Reel of 3000	TLV431BQDBZRQ1	VOQQ
	1%	SOT-23-5 (DBV)	Reel of 3000	TLV431AQDBVRQ1	VONQ

† 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.

logic block diagram



equivalent schematic



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): 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), 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	−40	125	°C

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

PARAMETER		TEST CONDITIONS		TLV431A MIN	TLV431A TYP	TLV431A MAX	UNIT
V_{REF}	Reference voltage	$V_{KA} = V_{REF}$, I_K = 10 mA	T_A = 25°C	1.228	1.24	1.252	V
			T_A = full range† (see Figure 1)	1.209		1.271	
$V_{REF(dev)}$	V_{REF} deviation over full temperature range†‡	$V_{KA} = V_{REF}$, I_K = 10 mA (see Figure 1)			11	31	mV
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	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†	I_K = 10 mA, R1 = 10 kΩ, R2 = open (see Figure 2)			0.15	0.5	µA
$I_{K(min)}$	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
$\lvert z_{KA} \rvert$	Dynamic impedance§	$V_{KA} = V_{REF}$, f ≤ 1 kHz, I_K = 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 $V_{REF(dev)}$ 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:

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

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.

§ The dynamic impedance is defined as $\left|z_{ka}\right| = \frac{\Delta V_{KA}}{\Delta I_K}$

When the device is operating with two external resistors (see Figure 2), the total dynamic impedance of the circuit is defined as:

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

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

PARAMETER		TEST CONDITIONS		TLV431B MIN	TLV431B TYP	TLV431B MAX	UNIT
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 Figure 1)	1.221		1.265	
$V_{REF(dev)}$	V_{REF} deviation over full temperature range†‡	$V_{KA} = V_{REF}$, I_K = 10 mA (see Figure 1)			11	31	mV
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	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†‡	I_K = 10 mA, R1 = 10 kΩ, R2 = open (see Figure 2)			0.15	0.5	µA
$I_{K(min)}$	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
$\lvert z_{KA}\rvert$	Dynamic impedance§	$V_{KA} = V_{REF}$, f ≤ 1 kHz, I_K = 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 $V_{REF(dev)}$ 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:

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

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.

§ The dynamic impedance is defined as $\left|z_{ka}\right| = \frac{\Delta V_{KA}}{\Delta I_K}$

When the device is operating with two external resistors (see Figure 2), the total dynamic impedance of the circuit is defined as:

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

PARAMETER MEASUREMENT INFORMATION

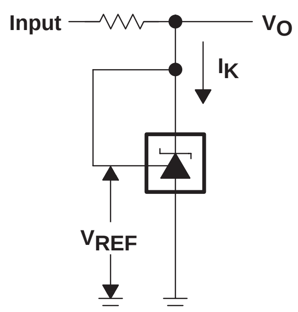


Figure 1. Test Circuit for $V_{KA} = V_{REF}$,
$V_O = V_{KA} = V_{REF}$

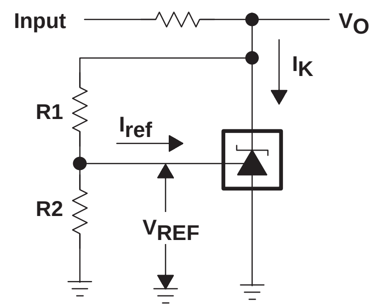


Figure 2. Test Circuit for $V_{KA} > V_{REF}$,
$V_O = V_{KA} = V_{REF} \times (1 + R1/R2) + I_{ref} \times R1$

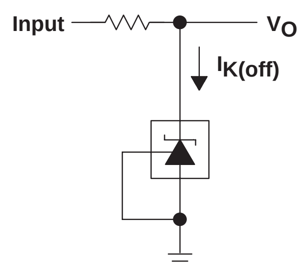


Figure 3. Test Circuit for $I_{K(off)}$

PARAMETER MEASUREMENT INFORMATION†

**REFERENCE VOLTAGE
vs
JUNCTION TEMPERATURE**

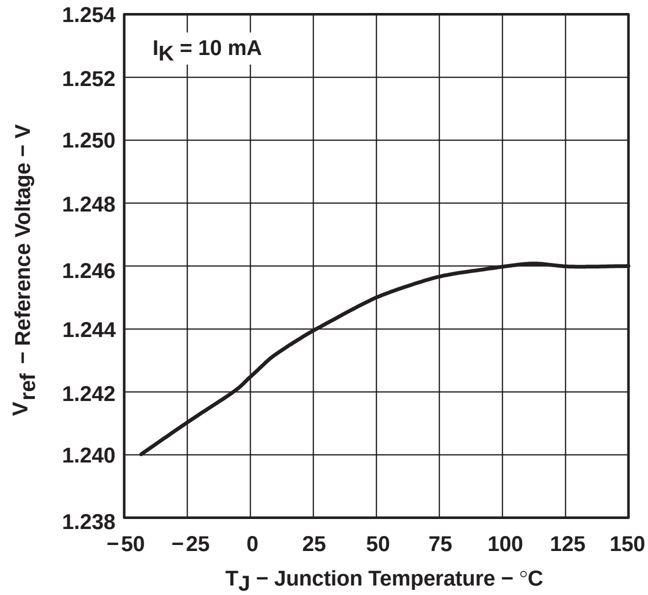


Figure 4

**REFERENCE INPUT CURRENT
vs
JUNCTION TEMPERATURE
(for TLV431A)**

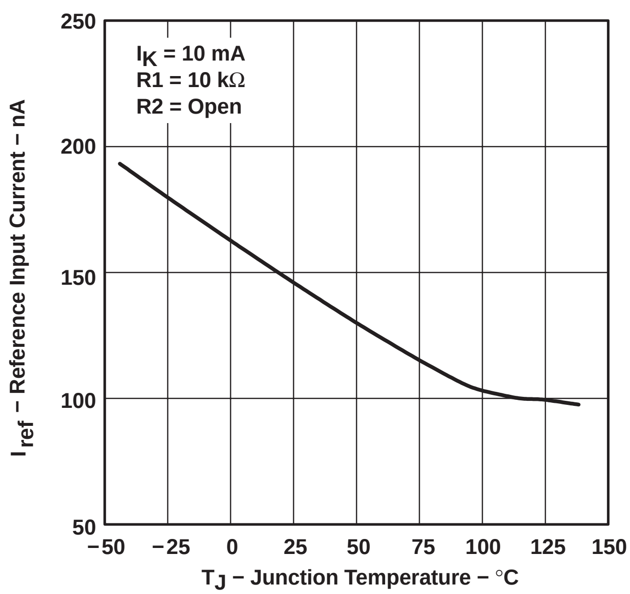


Figure 5A

**REFERENCE INPUT CURRENT
vs
JUNCTION TEMPERATURE
(for TLV431B)**

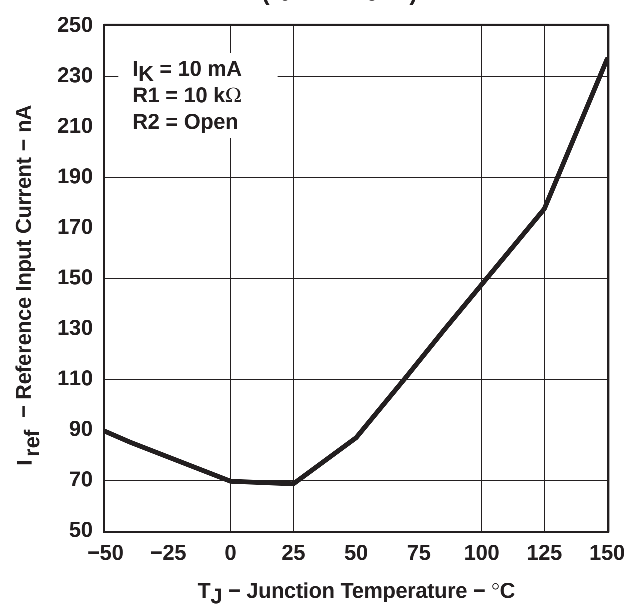


Figure 5B

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

PARAMETER MEASUREMENT INFORMATION†

CATHODE CURRENT
vs
CATHODE VOLTAGE

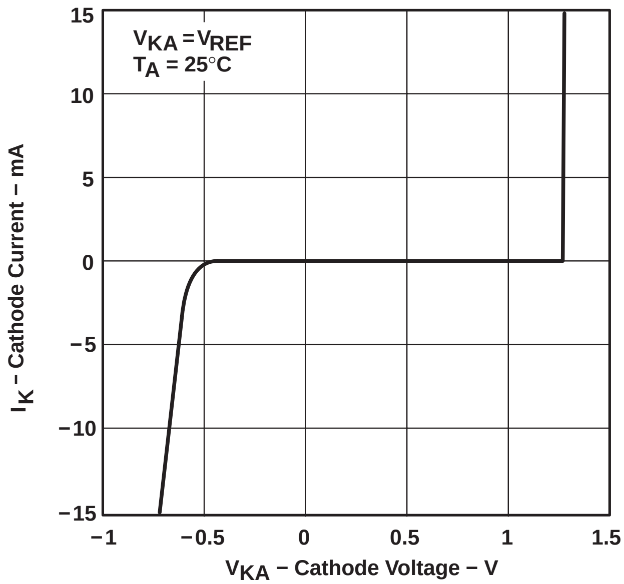


Figure 6

CATHODE CURRENT
vs
CATHODE VOLTAGE

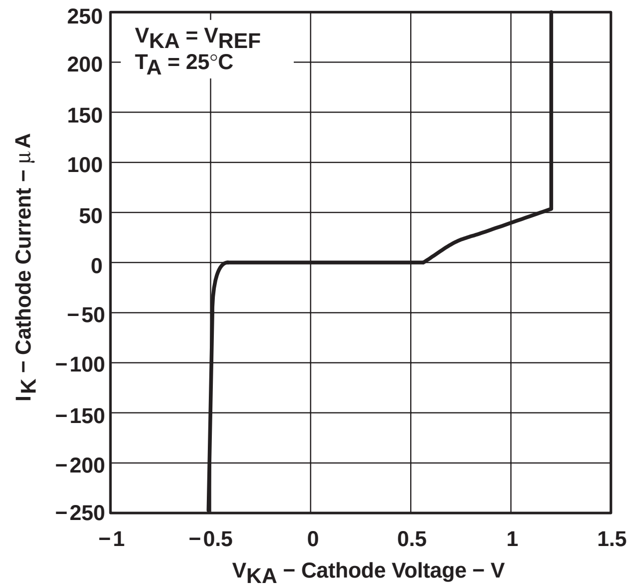


Figure 7

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

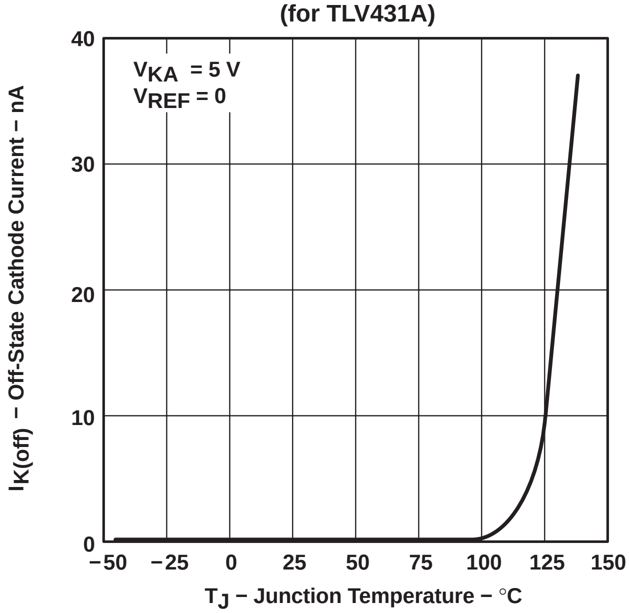


Figure 8A

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

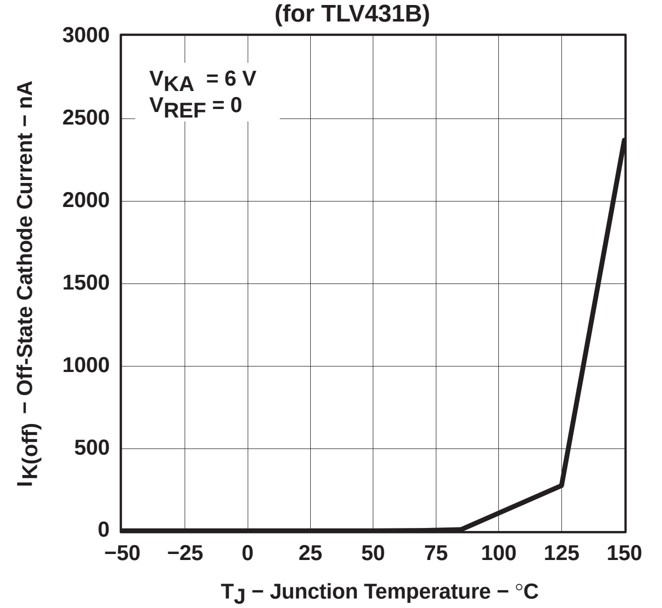


Figure 8B

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

PARAMETER MEASUREMENT INFORMATION†

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

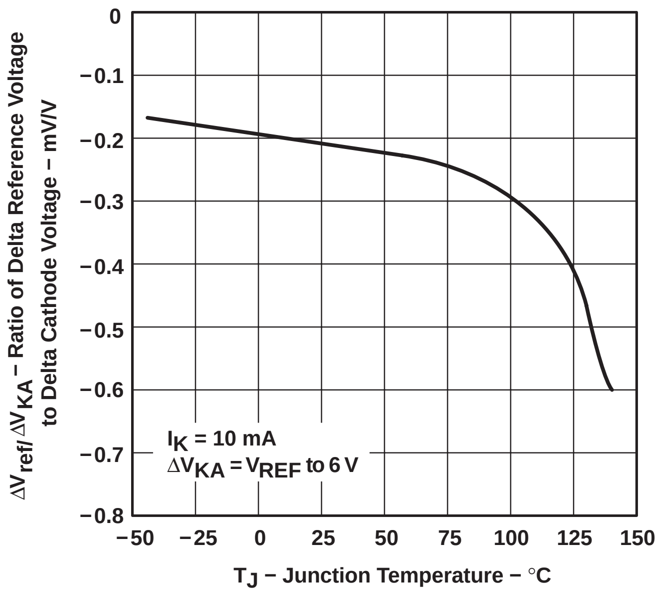


Figure 9A

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

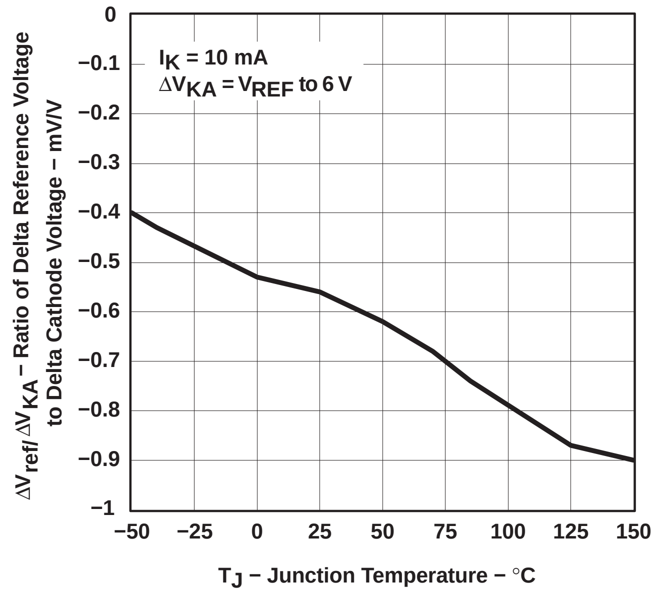
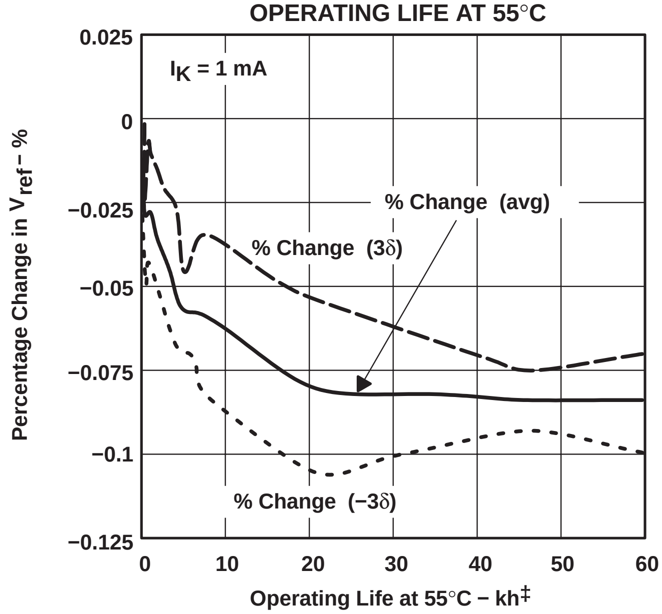


Figure 9B

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



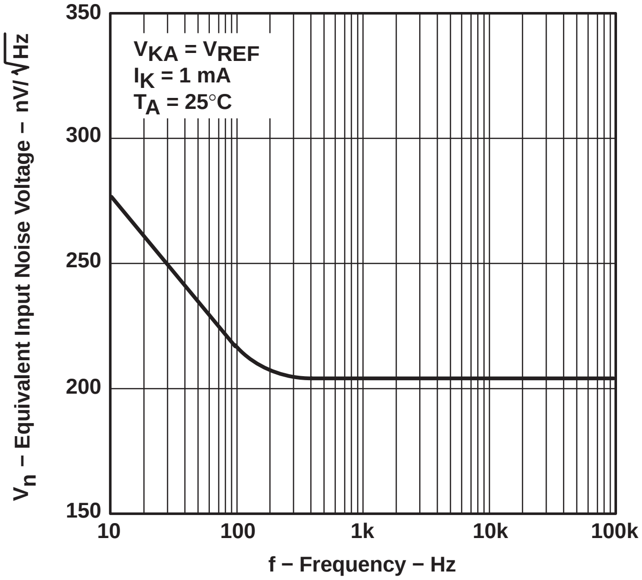
‡ Extrapolated from life-test data taken at 125°C; the activation energy assumed is 0.7 eV.

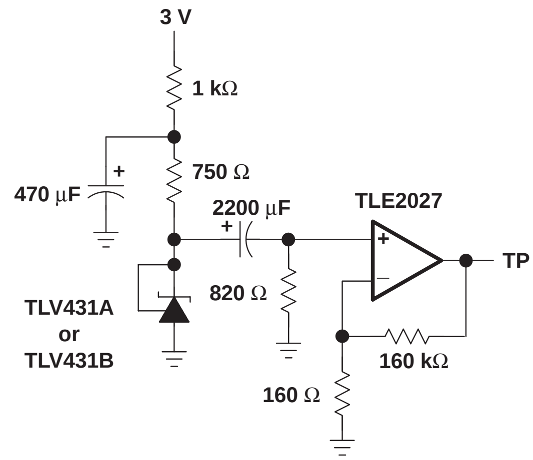
Figure 10

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

PARAMETER MEASUREMENT INFORMATION

EQUIVALENT INPUT NOISE VOLTAGE
vs
FREQUENCY



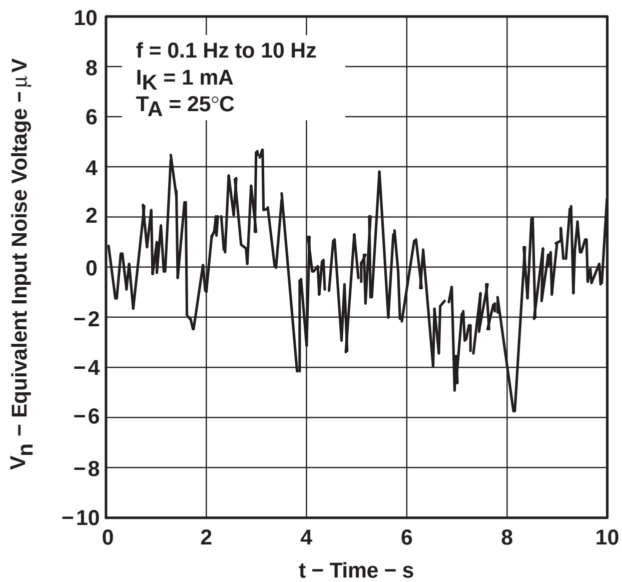


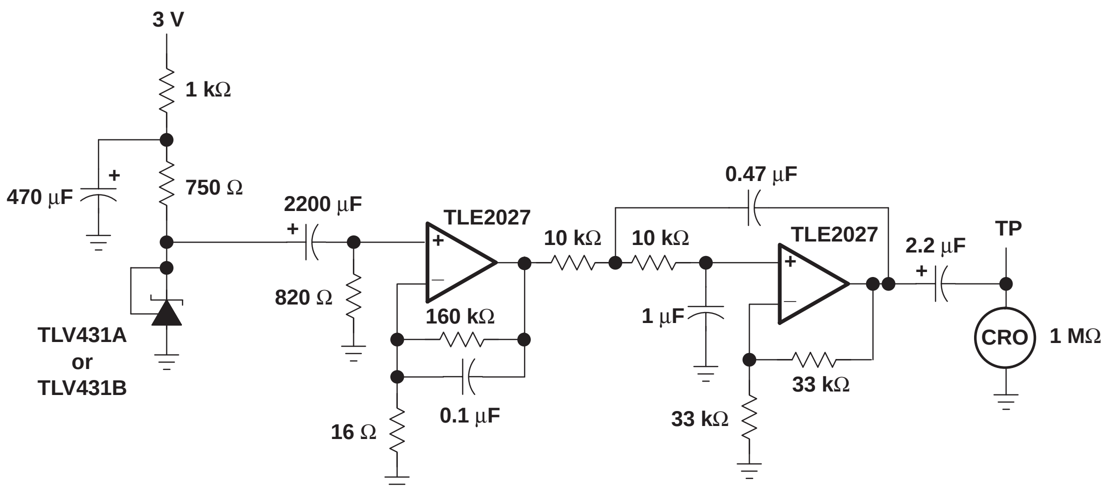
TEST CIRCUIT FOR EQUIVALENT INPUT NOISE VOLTAGE

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

PARAMETER MEASUREMENT INFORMATION

SMALL-SIGNAL VOLTAGE GAIN/PHASE MARGIN
vs
FREQUENCY

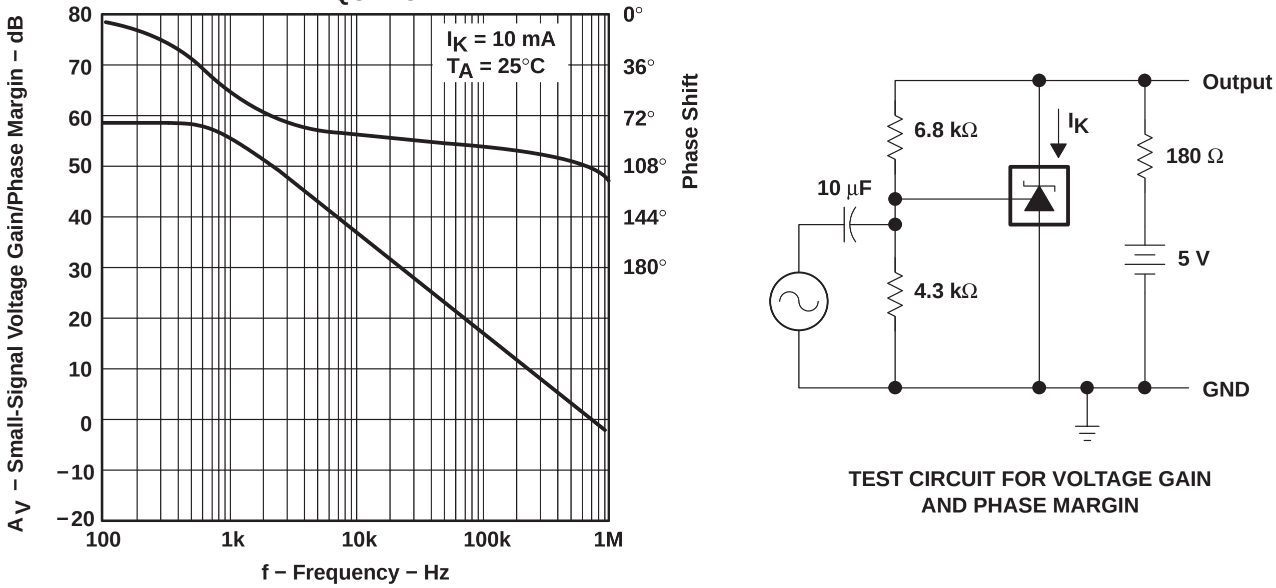


Figure 13

REFERENCE IMPEDANCE
vs
FREQUENCY

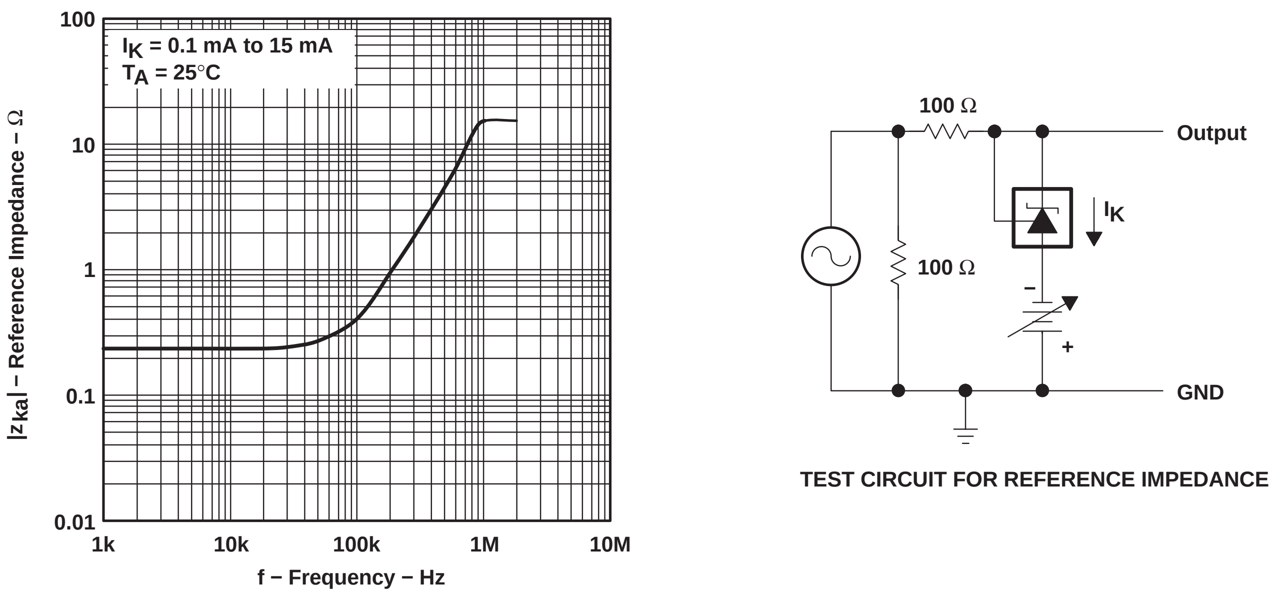
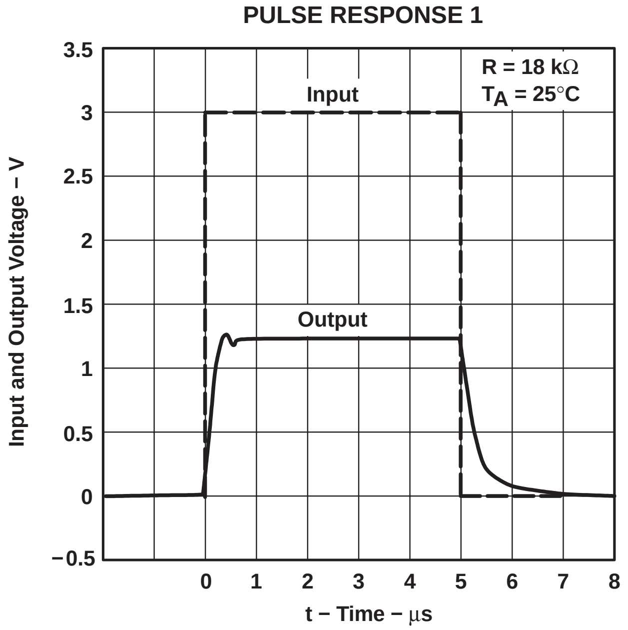
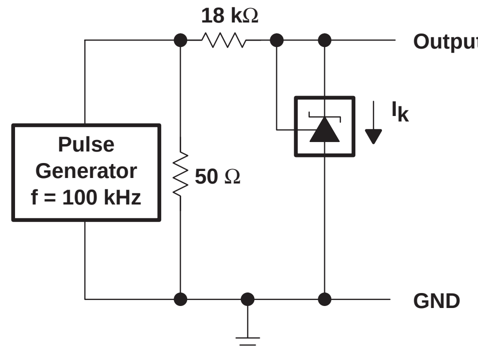


Figure 14

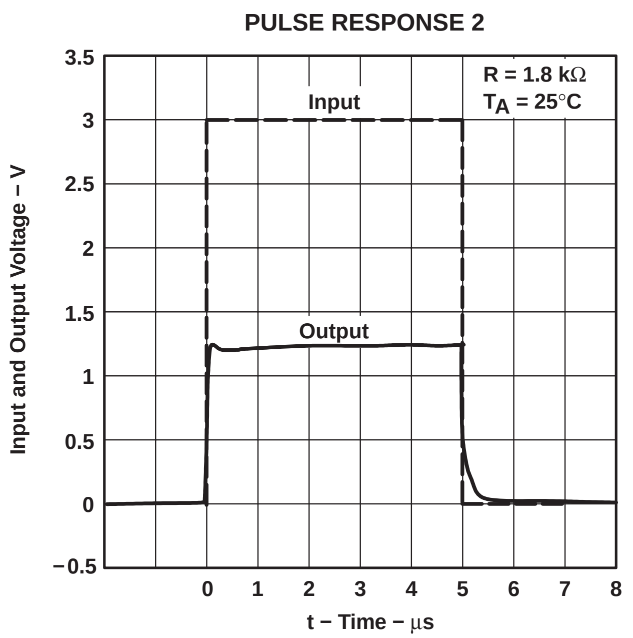
PARAMETER MEASUREMENT INFORMATION

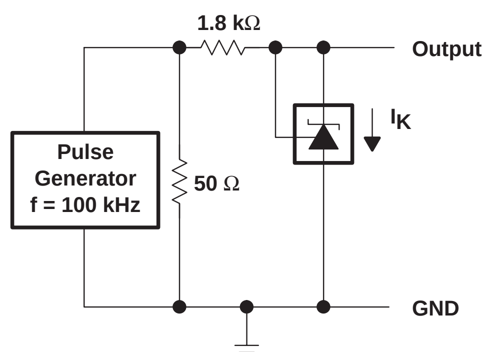




TEST CIRCUIT FOR PULSE RESPONSE 1

Figure 15



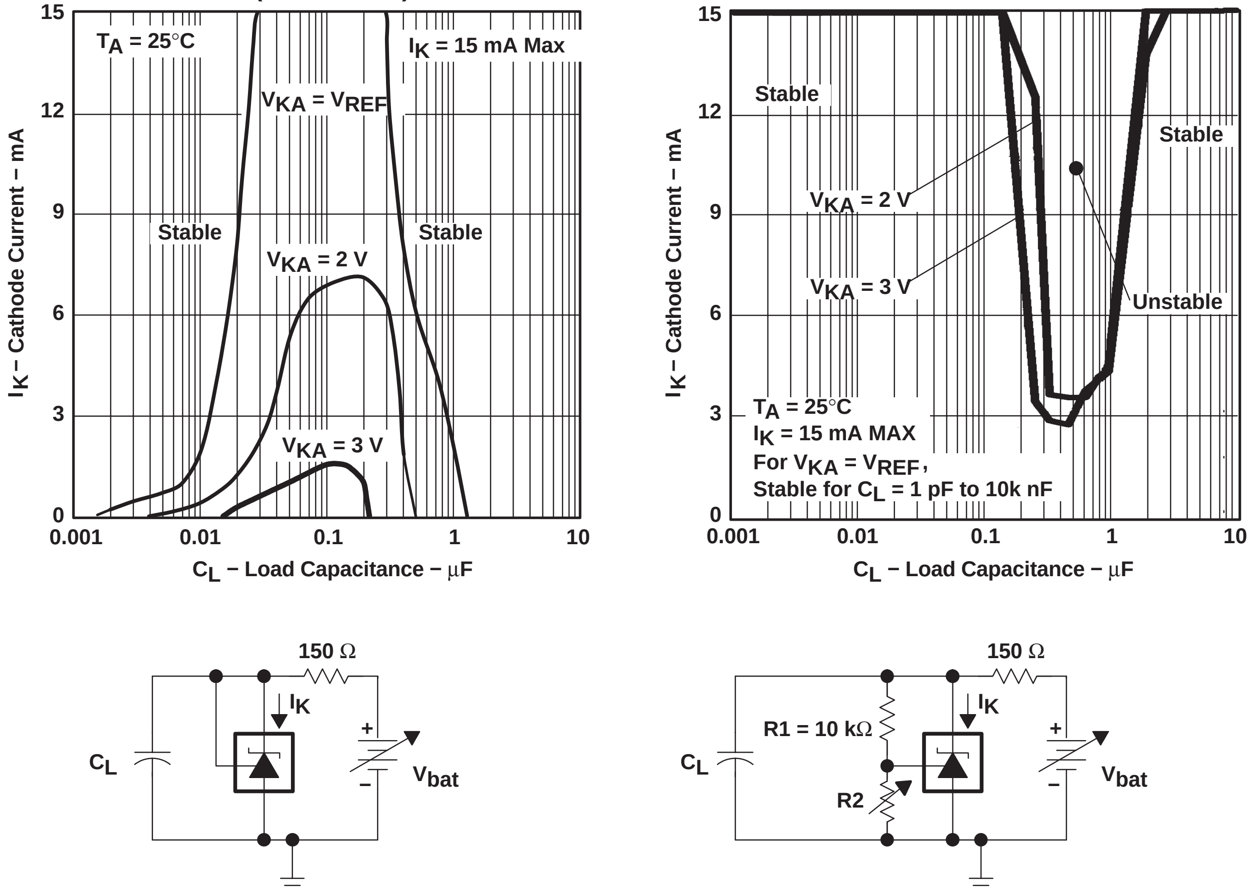


TEST CIRCUIT FOR PULSE RESPONSE 2

Figure 16

PARAMETER MEASUREMENT INFORMATION†

STABILITY BOUNDARY CONDITION‡ (for TLV431A) | STABILITY BOUNDARY CONDITION‡ (for TLV431B)



TEST CIRCUIT FOR $V_{KA} = V_{REF}$ | TEST CIRCUIT FOR V_{KA} = 2 V, 3 V

‡ The areas under the curves represent conditions that may cause the device to oscillate. For V_{KA} = 2-V and 3-V curves, R2 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

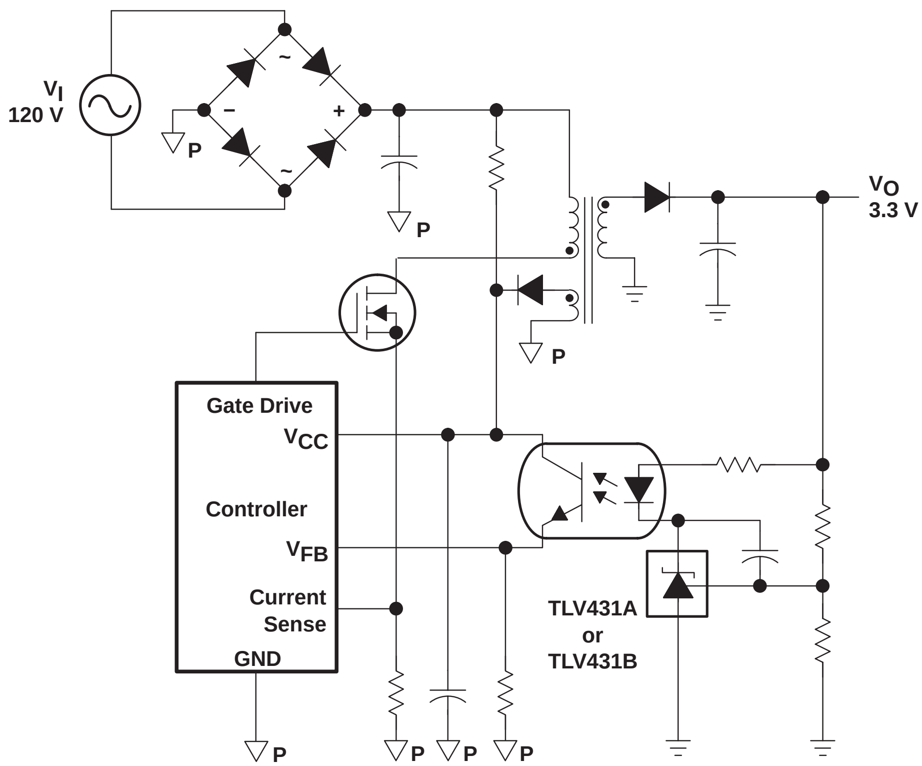


Figure 18. Flyback With Isolation Using TLV431, TLV431A, or TLV431B as Voltage Reference and Error Amplifier

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 V ± 1%). The output of the regulator, plus the forward voltage drop of the optocoupler LED (1.24 + 1.4 = 2.64 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]
TLV431AQDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV431BQDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV431BQDBZRQ1	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

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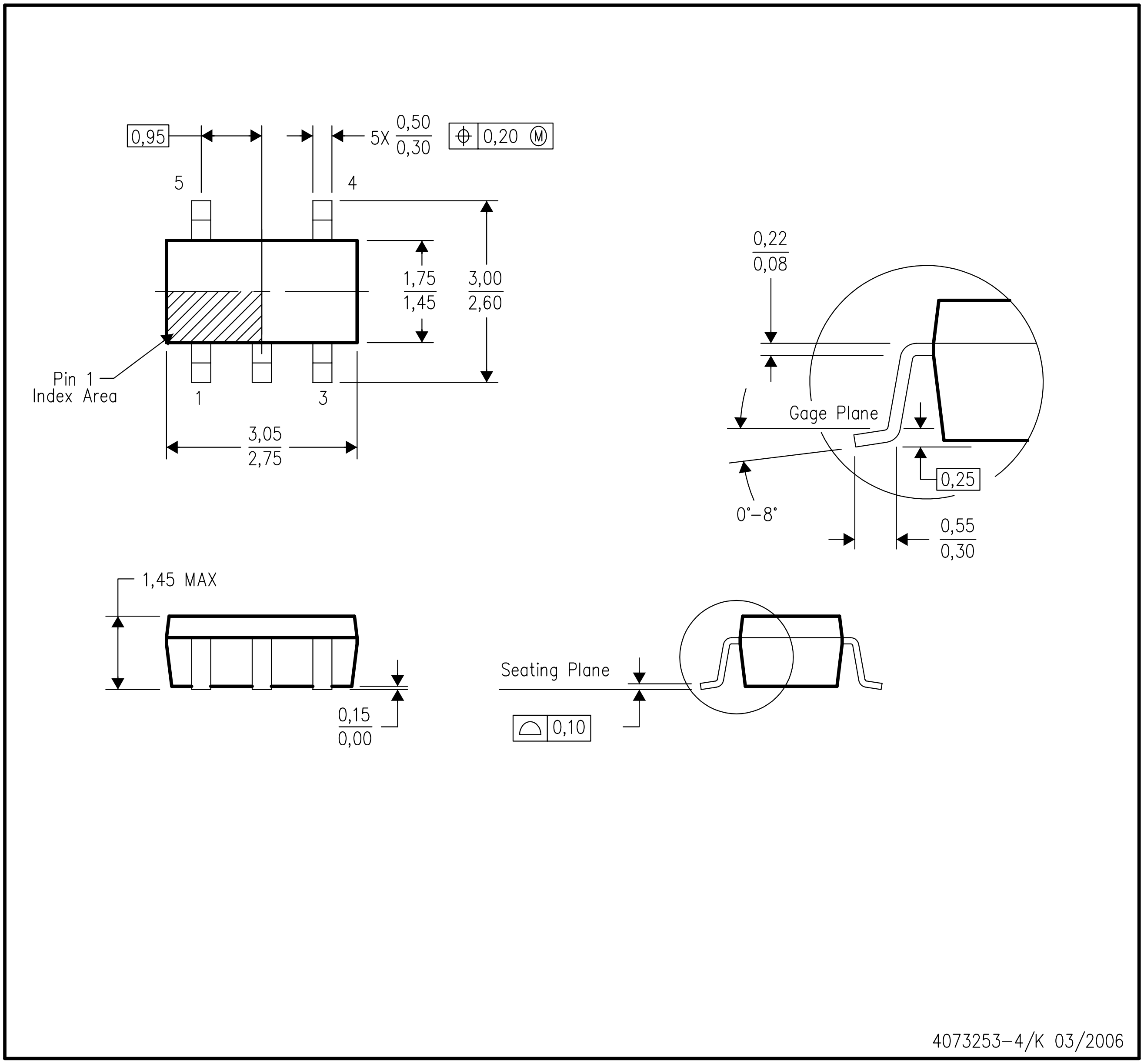
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

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

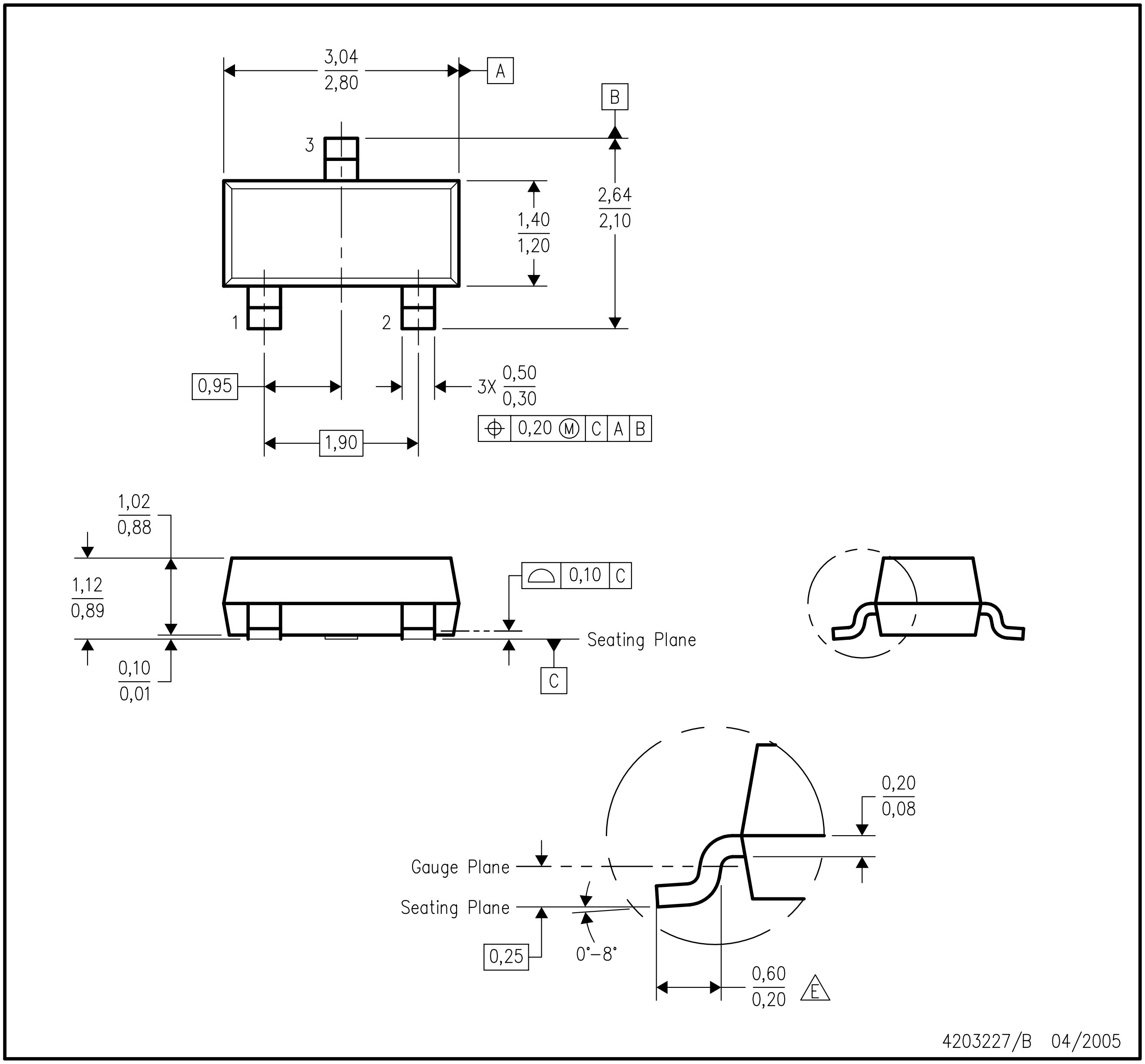
NOTE: Qualified Version Definitions:
- Catalog - TI's standard catalog product

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.

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.
E. Falls within JEDEC TO–236 variation AB, except minimum foot length.

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