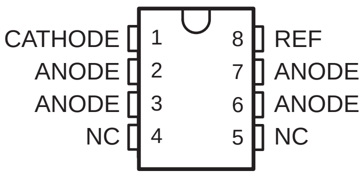
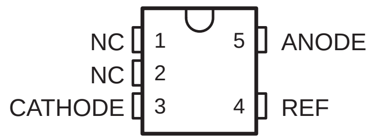
- **Low-Voltage Operation . . . Down to 1.24 V**
- **1% Reference-Voltage Tolerance (TLV431A)**
- **Adjustable Output Voltage, $V_O = V_{ref}$ to 6 V**
- **Low Operational Cathode Current . . . 80 μA Typ**
- **0.25-Ω Typical Output Impedance**

D PACKAGE (TOP VIEW)



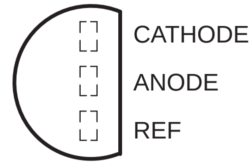
NC − No internal connection

DBV PACKAGE (TOP VIEW)



NC − No internal connection

LP PACKAGE (TOP VIEW)



description/ordering information

The TLV431 and TLV431A are low-voltage three-terminal adjustable voltage references, 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). The TLV431 and TLV431A 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 and TLV431A are ideal voltage references 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 the TLV431 and TLV431A excellent replacements for low-voltage Zener diodes in many applications, including onboard regulation and adjustable power supplies.

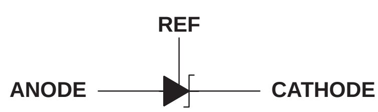
The TLV431C and TLV431AC devices are characterized for operation from 0°C to 70°C. The TLV431I and TLV431AI devices are characterized for operation from −40°C to 85°C.

ORDERING INFORMATION

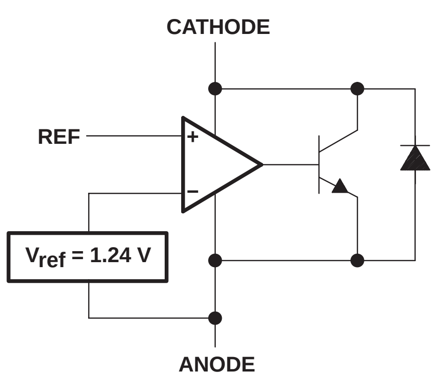
T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING‡
0°C to 70°C	SOT-23 (DBV)	Reel of 3000	TLV431CDBVR	VAIC or Y3C_
		Reel of 250	TLV431CDBVT	
		Reel of 3000	TLV431ACDBVR	VAHC or YAC_
		Reel of 250	TLV431ACDBVT	
	TO-226/TO-92 (LP)	Bulk of 1000	TLV431CLP	V431C
		Reel of 2000	TLV431CLPR	
		Bulk of 1000	TLV431ACLP	V431AC
		Reel of 2000	TLV431ACLPR	
−40°C to 85°C	SOIC (D)	Tube of 75	TLV431AID	TY431A
		Reel of 2500	TLV431AIDR	
	SOT-23 (DBV)	Reel of 3000	TLV431IDBVR	VAII or Y3I_
		Reel of 250	TLV431IDBVT	
		Reel of 3000	TLV431AIDBVR	VAHI or YAI_
		Reel of 250	TLV431AIDBVT	
	TO-226/TO-92 (LP)	Bulk of 1000	TLV431ILP	V431I
		Reel of 2000	TLV431ILPR	
		Bulk of 1000	TLV431AILP	V431AI
		Reel of 2000	TLV431AILPR	

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.
‡ DBV: The actual top-side marking has one additional character that designates the assembly/test site.

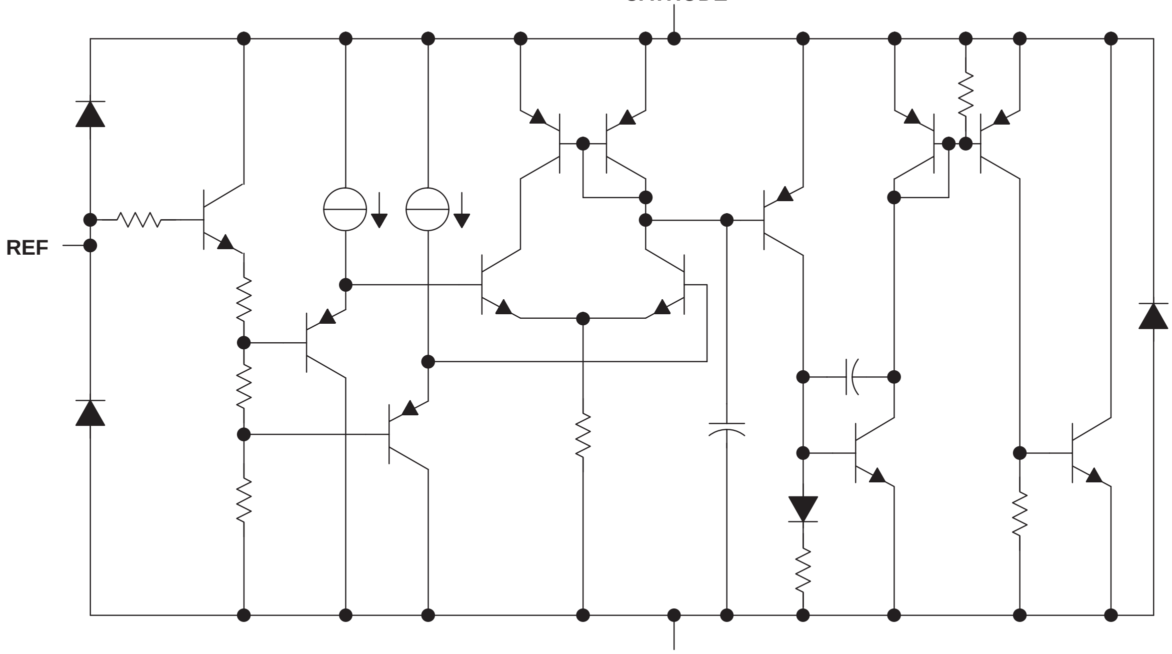
logic symbol



logic diagram (positive logic)



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
Operating virtual junction temperature, T_J . . . . 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . 260°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.

NOTE 1: Voltage values are with respect to the anode terminal unless otherwise noted.

package thermal data (see Note 2)

PACKAGE	BOARD	θ_{JC}	θ_{JA}
SOIC (D)	High K, JESD 51-7	39°C/W	97°C/W
SOT-23 (DBV)	High K, JESD 51-7	131°C/W	206°C/W
TO-92 (LP)	High K, JESD 51-7	55°C/W	140°C/W

NOTE 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.

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	TLV431C, TLV431AC	0	70	°C
		TLV431I, TLV431AI	−40	85	

electrical characteristics, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		TLV431C			TLV431I			UNIT
				MIN	TYP	MAX	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	1.222	1.24	1.258	V
			T_A = full range (see Note 3 and Figure 1)	1.21		1.27	1.202		1.278	
$V_{ref(dev)}$	V_{ref} deviation over full temperature range (see Note 4)	$V_{KA} = V_{ref}$, I_K = 10 mA (see Note 3 and Figure 1)			4	12		6	20	mV
$\frac{\Delta V_{ref}}{\Delta V_{KA}}$	Ratio of V_{ref} change in cathode voltage change	I_K = 10 mA, $V_{KA} = V_{ref}$ to 6 V (see Figure 2)			−1.5	−2.7		−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		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)			0.05	0.3		0.1	0.4	µA
$I_{K(min)}$	Minimum cathode current for regulation	$V_{KA} = V_{ref}$ (see Figure 1)			55	80		55	80	µA
$I_{K(off)}$	Off-state cathode current	V_{KA} = 6 V, V_{ref} = 0 (see Figure 3)			0.001	0.1		0.001	0.1	µA
$\lvert z_{KA} \rvert$	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		0.25	0.4	Ω

NOTES: 3. Full range is −40°C to 85°C for the TLV431I and 0°C to 70°C for the TLV431C.

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, $\alpha_{V_{ref}}$, is defined as:

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

where:
ΔT_A is the rated operating temperature range of the device.

$\alpha_{V_{ref}}$ 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: $\left|z_{KA}\right| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$

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

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

electrical characteristics, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		TLV431AC			TLV431AI			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{ref}	Reference voltage	$V_{KA} = V_{ref}$, I_K = 10 mA	T_A = 25°C	1.228	1.24	1.252	1.228	1.24	1.252	V
			T_A = full range (see Note 3 and Figure 1)	1.221		1.259	1.215		1.265	
$V_{ref(dev)}$	V_{ref} deviation over full temperature range (see Note 4)	$V_{KA} = V_{ref}$, I_K = 10 mA (see Note 3 and Figure 1)			4	12		6	20	mV
$\frac{\Delta V_{ref}}{\Delta V_{KA}}$	Ratio of V_{ref} change in cathode voltage change	I_K = 10 mA, (see Figure 2)	$V_{KA} = V_{ref}$ to 6 V		−1.5	−2.7		−1.5	−2.7	mV/V
I_{ref}	Reference terminal current	I_K = 10 mA, (see Figure 2)	R1 = 10 kΩ		0.15	0.5		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)			0.05	0.3		0.1	0.4	µA
$I_{K(min)}$	Minimum cathode current for regulation	$V_{KA} = V_{ref}$	(see Figure 1)		55	80		55	80	µA
$I_{K(off)}$	Off-state cathode current	V_{KA} = 6 V, (see Figure 3)	V_{ref} = 0		0.001	0.1		0.001	0.1	µA
$\lvert z_{KA} \rvert$	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		0.25	0.4	Ω

NOTES: 3. Full range is −40°C to 85°C for the TLV431AI and 0°C to 70°C for the 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, $\alpha_{V_{ref}}$, is defined as:

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

where:
ΔT_A is the rated operating temperature range of the device.

$\alpha_{V_{ref}}$ 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: $\left|z_{KA}\right| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$

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

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

PARAMETER MEASUREMENT INFORMATION

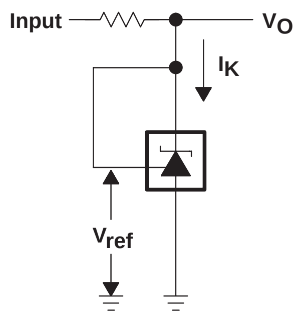


Figure 1. Test Circuit for $V_{KA} = V_{ref}$, $V_O = V_{KA} = V_{ref}$

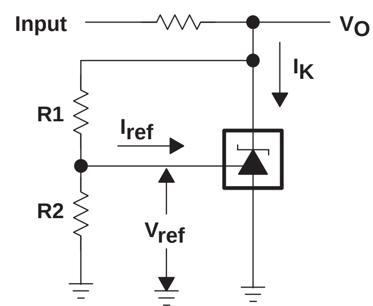


Figure 2. Test Circuit for $V_{KA} > V_{ref}$, $V_O = V_{KA} = V_{ref} \times (1 + R1/R2) + I_{ref} \times R1$

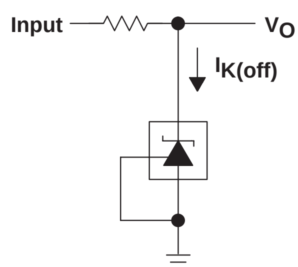


Figure 3. Test Circuit for $I_{K(off)}$

PARAMETER MEASUREMENT INFORMATION†

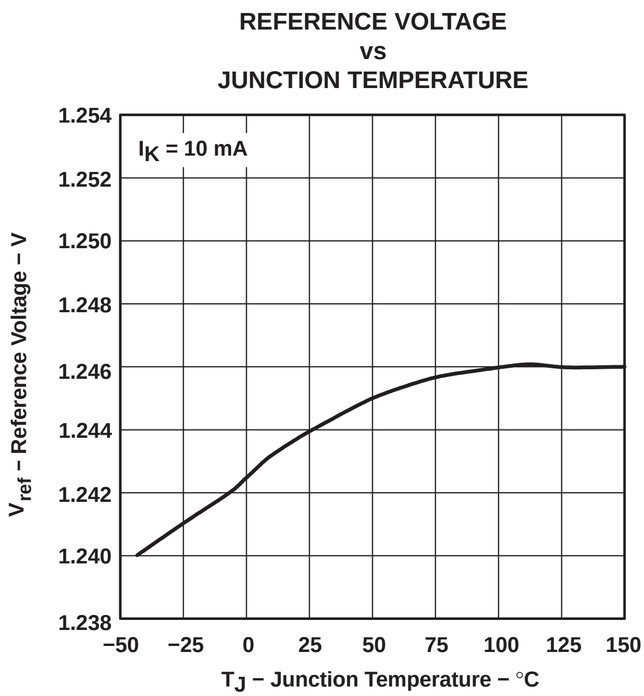


Figure 4

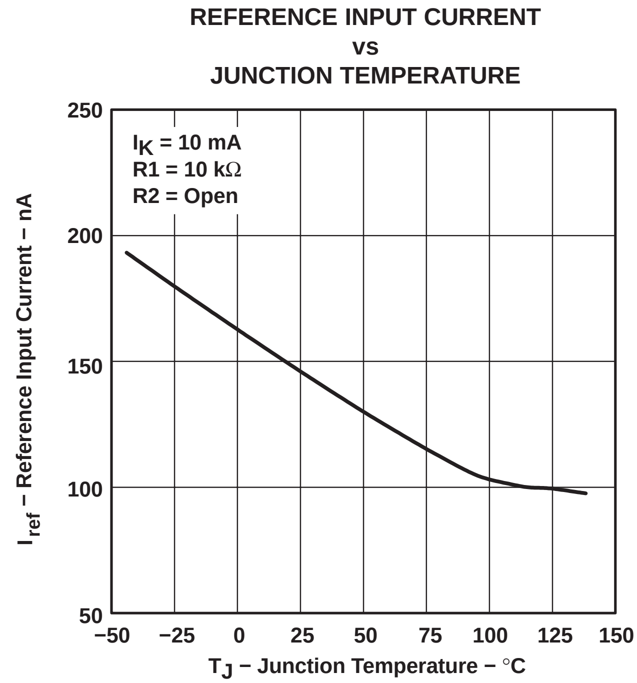


Figure 5

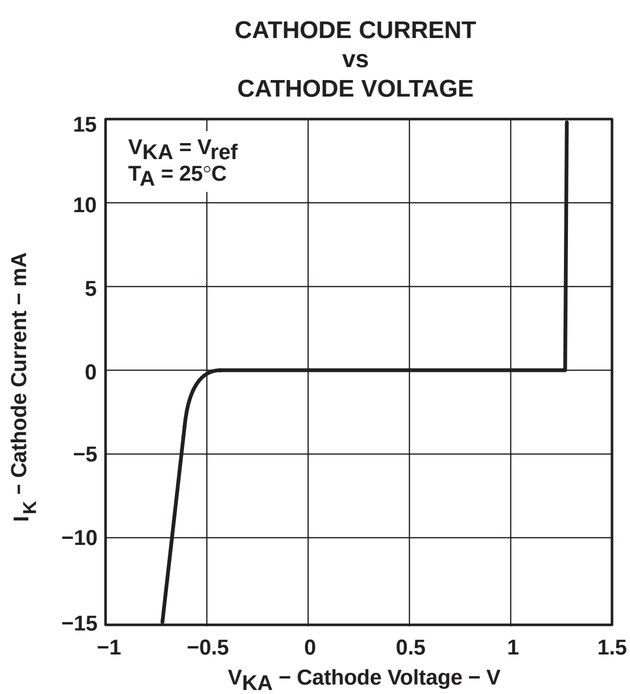


Figure 6

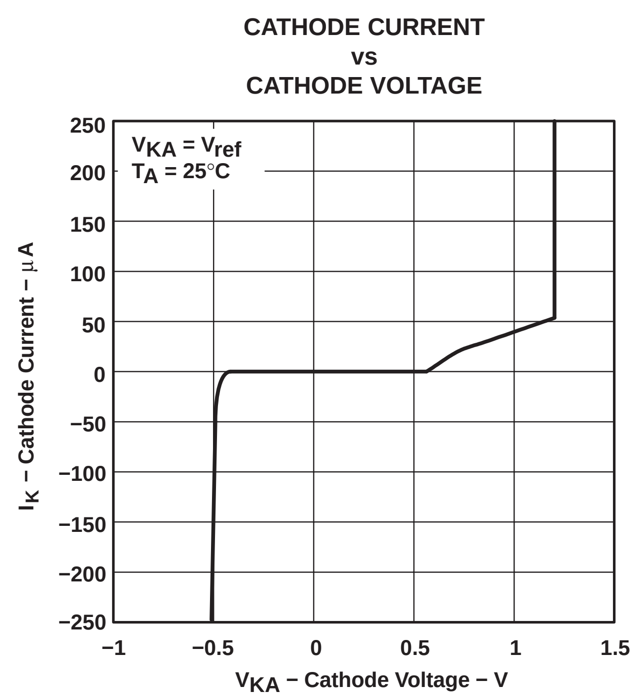


Figure 7

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

PARAMETER MEASUREMENT INFORMATION†

OFF-STATE CATHODE CURRENT vs JUNCTION TEMPERATURE

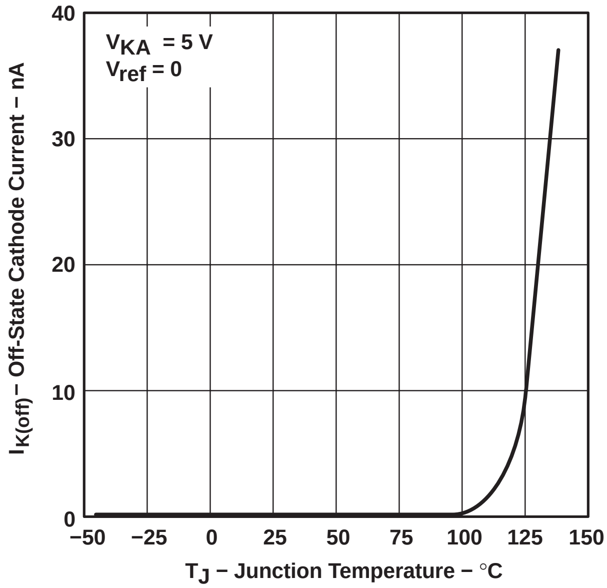


Figure 8

RATIO OF DELTA REFERENCE VOLTAGE TO DELTA CATHODE VOLTAGE vs JUNCTION TEMPERATURE

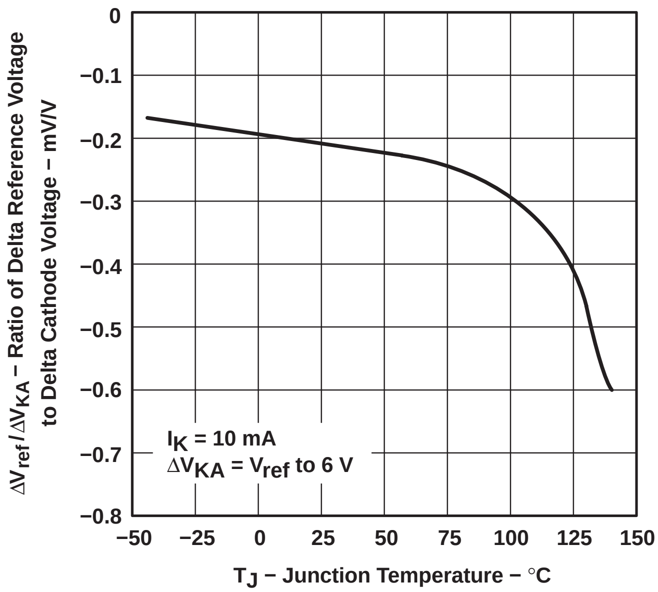
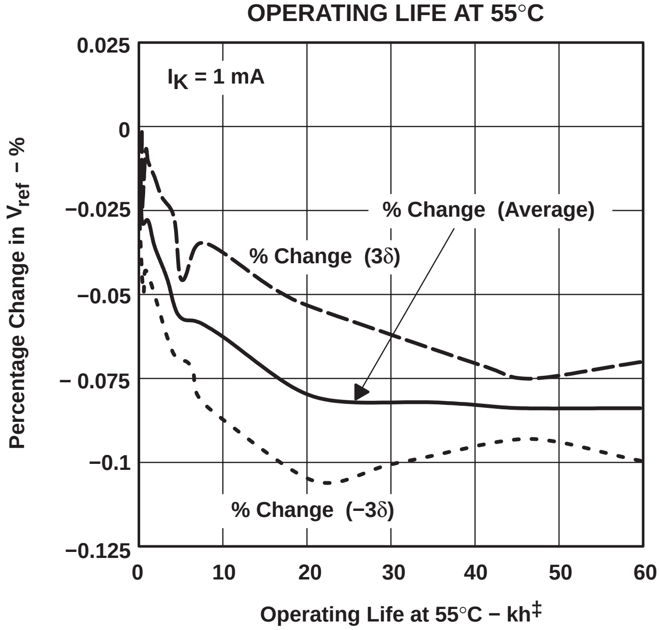


Figure 9

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



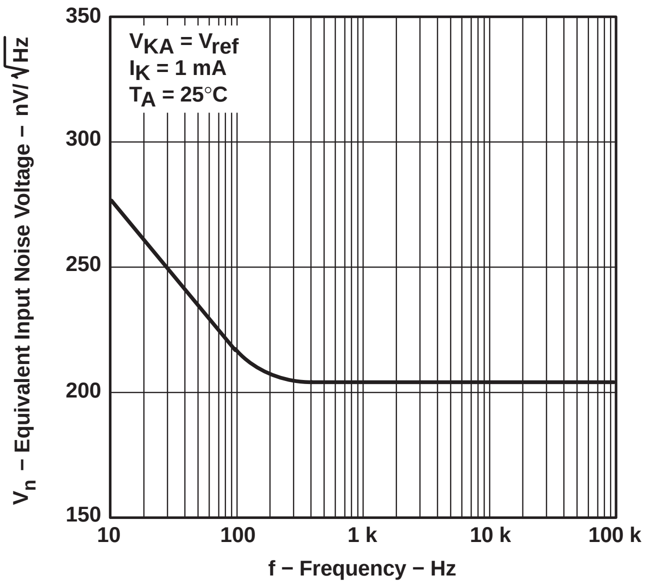
‡ Extrapolated from life-test data taken at 125°C; the activation energy assumed is 0.7 eV.

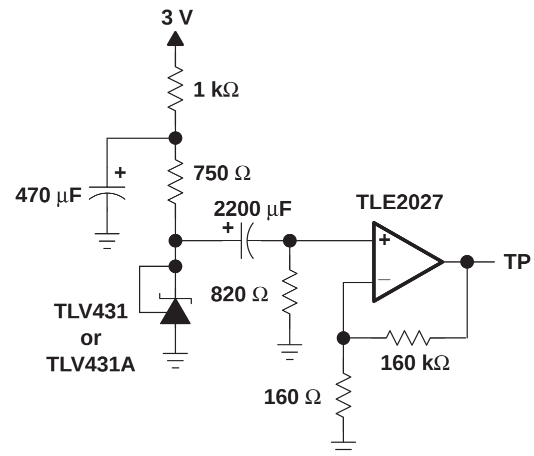
Figure 10

† 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



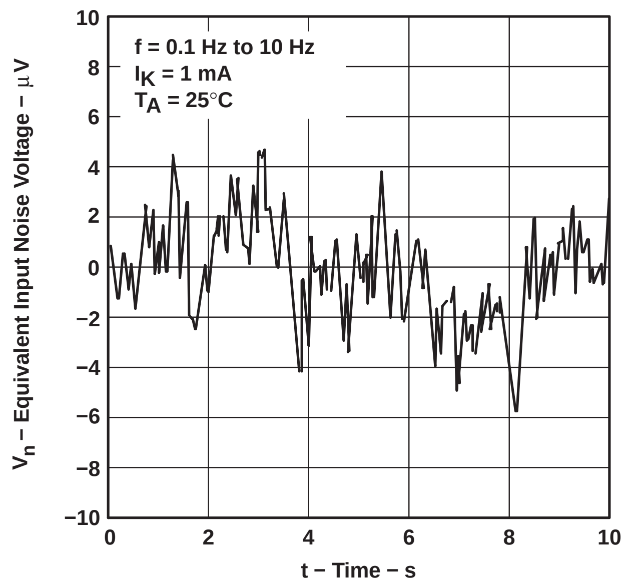


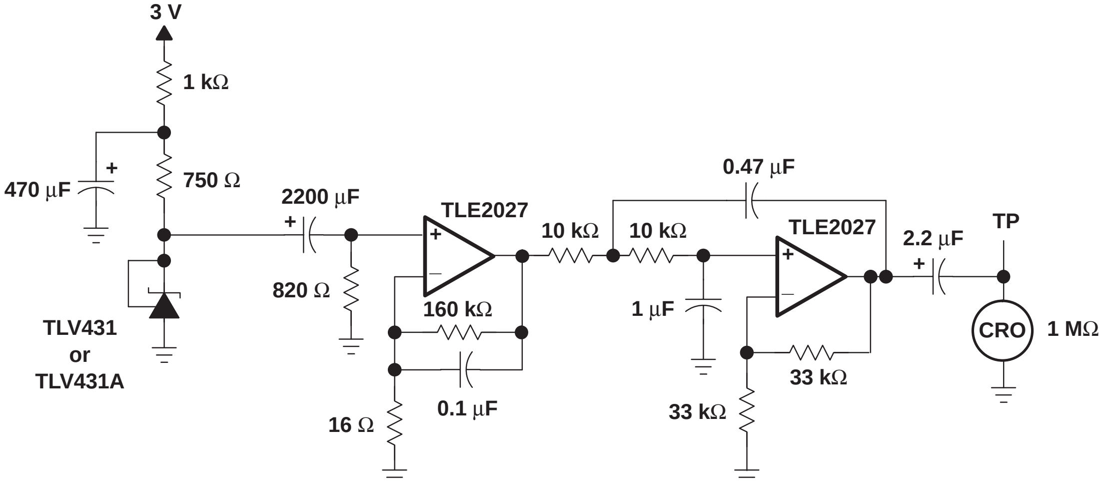
TEST CIRCUIT FOR EQUIVALENT NOISE VOLTAGE

Figure 11

PARAMETER MEASUREMENT INFORMATION

EQUIVALENT INPUT NOISE VOLTAGE
OVER A 10-SECOND PERIOD

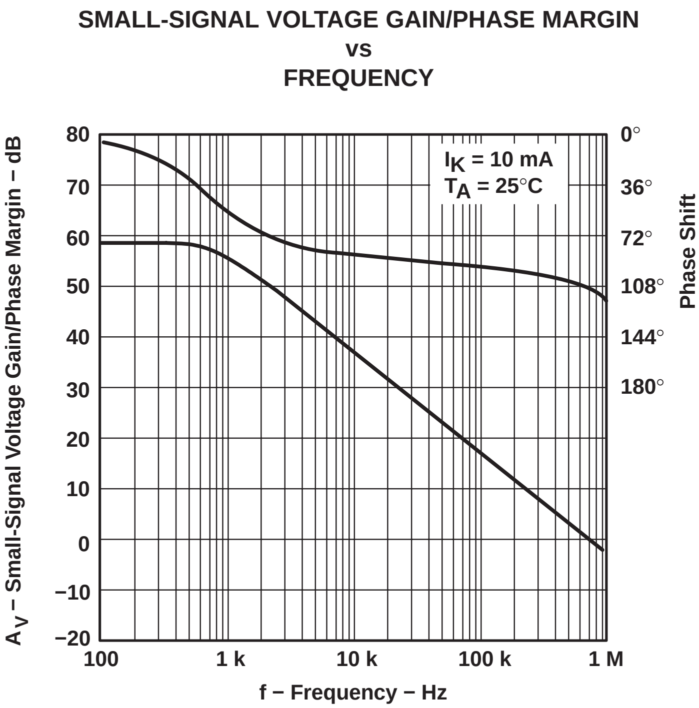


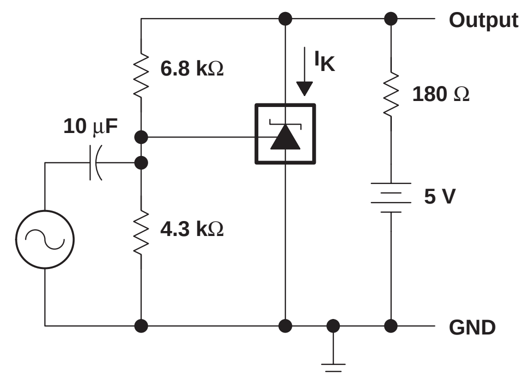


TEST CIRCUIT FOR 0.1-Hz TO 10-Hz EQUIVALENT NOISE VOLTAGE

Figure 12

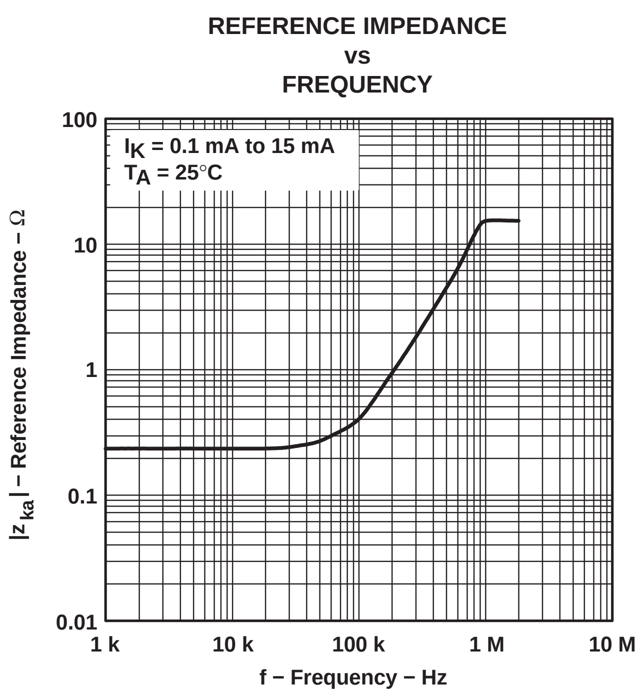
PARAMETER MEASUREMENT INFORMATION

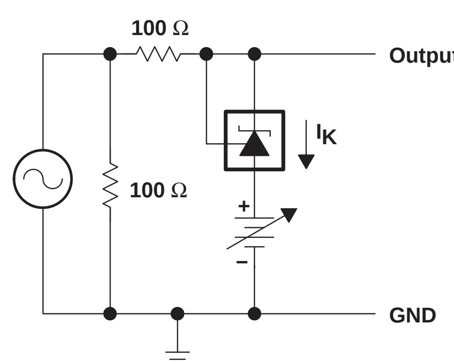




TEST CIRCUIT FOR VOLTAGE GAIN AND PHASE MARGIN

Figure 13

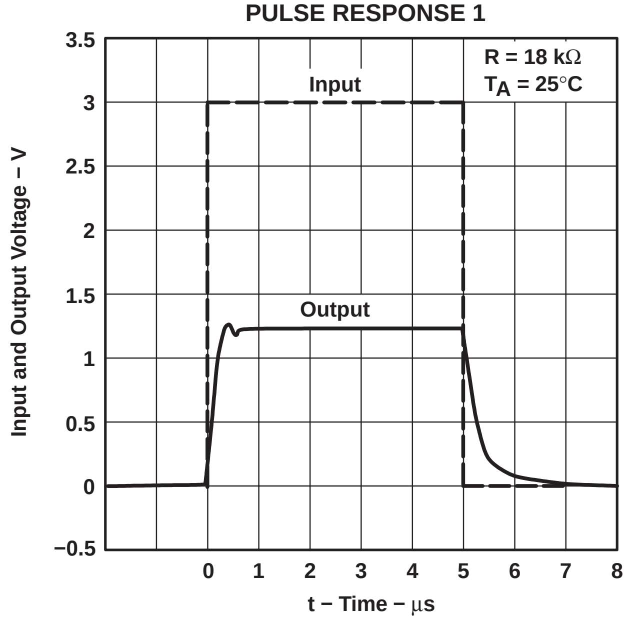


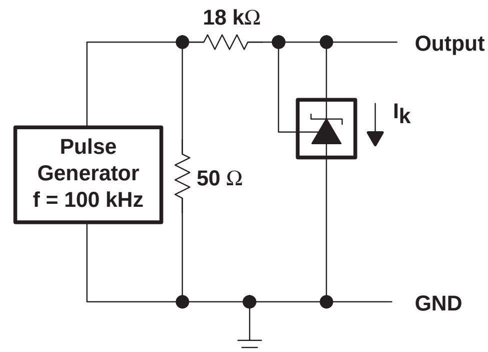


TEST CIRCUIT FOR REFERENCE IMPEDANCE

Figure 14

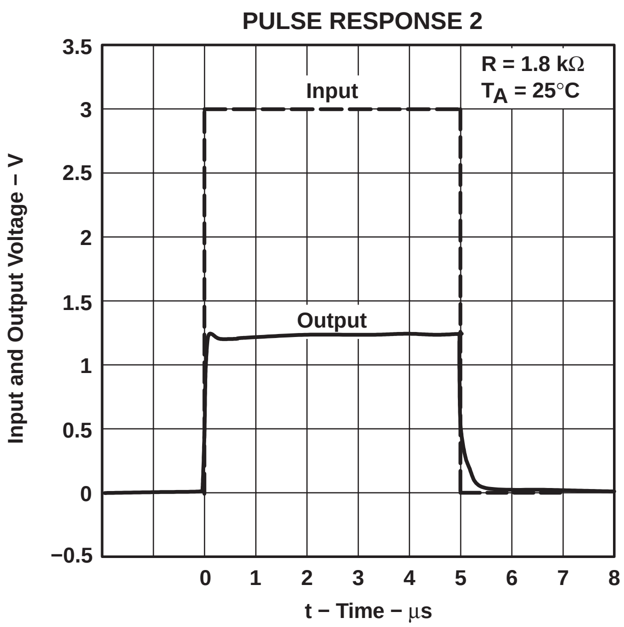
PARAMETER MEASUREMENT INFORMATION

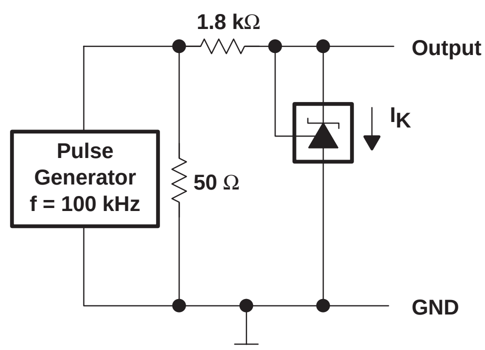




TEST CIRCUIT FOR PULSE RESPONSE 1

Figure 15



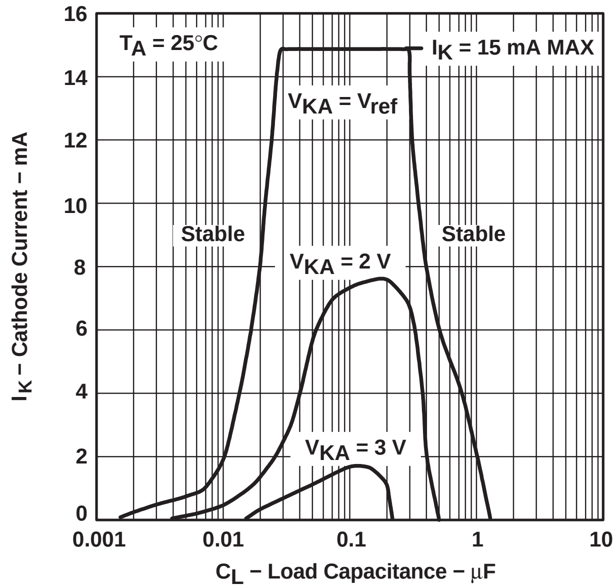


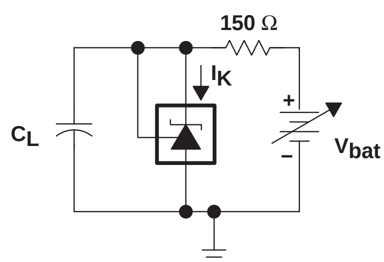
TEST CIRCUIT FOR PULSE RESPONSE 2

Figure 16

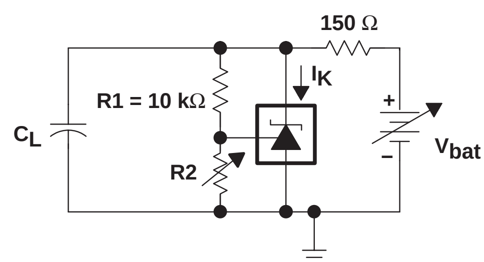
PARAMETER MEASUREMENT INFORMATION†

STABILITY BOUNDARY CONDITION‡





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. For best results, use low-ESR tantalum or aluminum electrolytic capacitors.

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 shows the TLV431 or TLV431A 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 using the circuit in Figure 18.

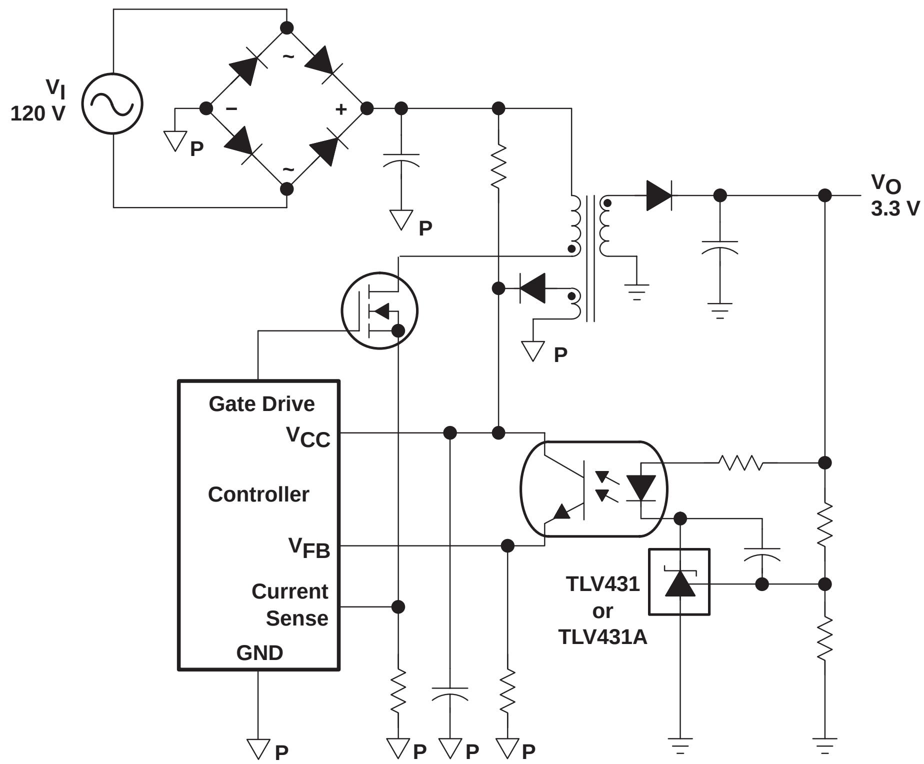
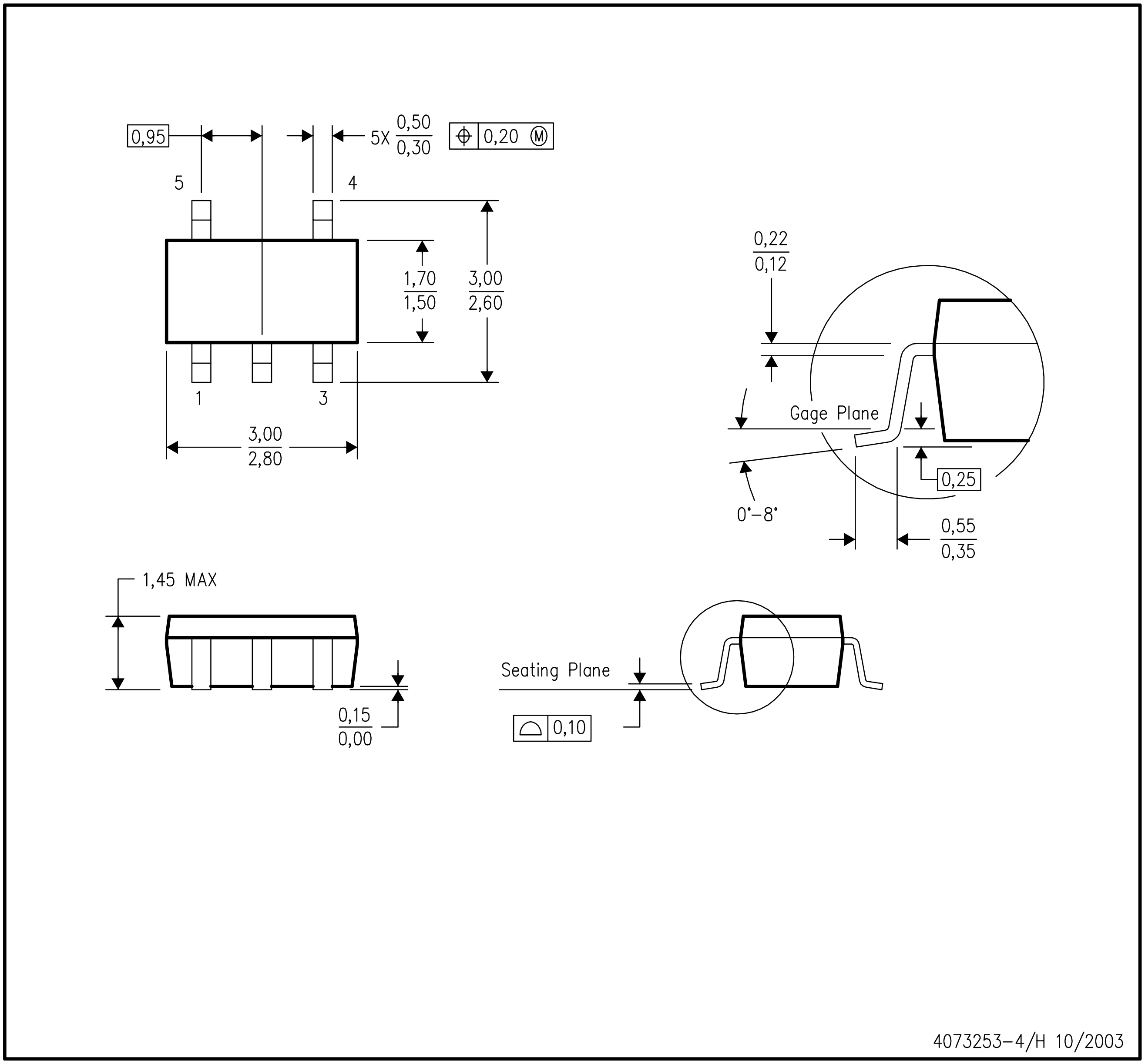


Figure 18. Flyback With Isolation Using TLV431 or TLV431A as Voltage Reference and Error Amplifier

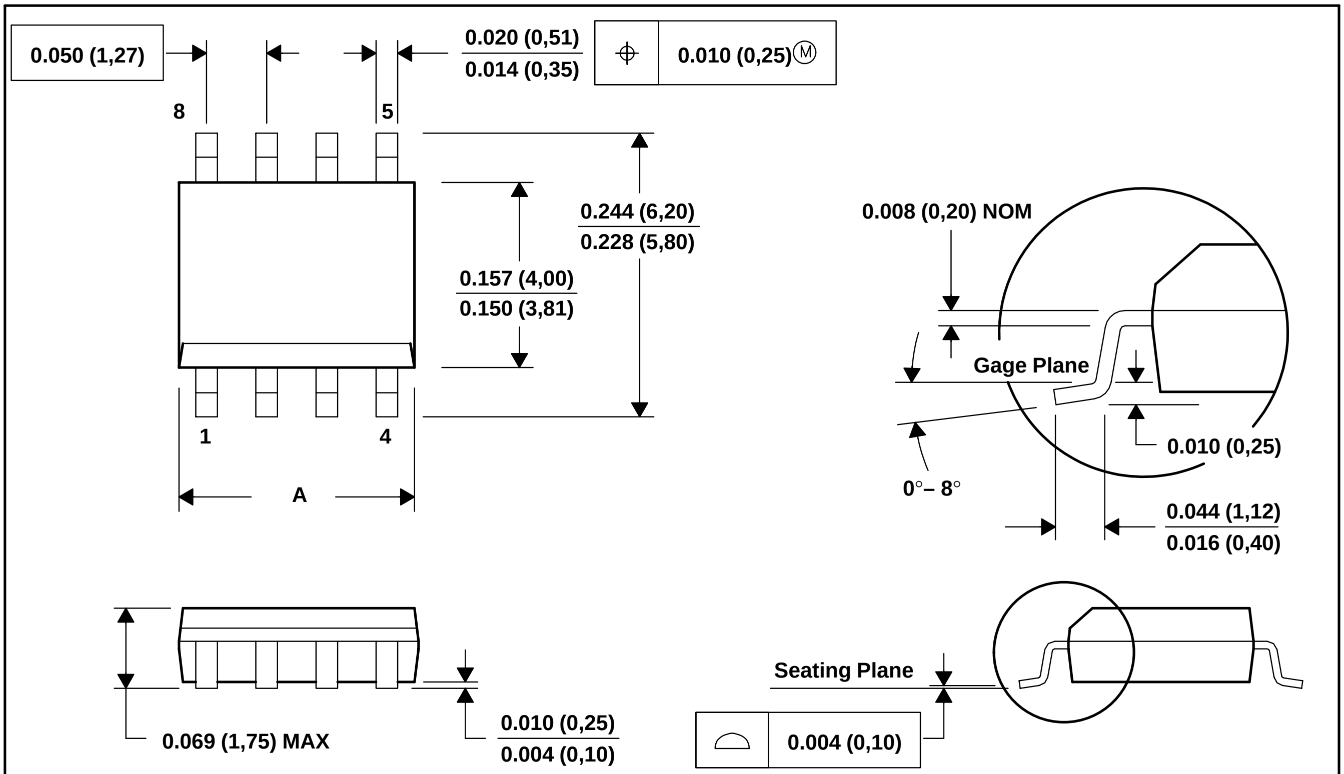
DBV (R-PDSO-G5) PLASTIC SMALL-OUTLINE PACKAGE



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.
D. Falls within JEDEC MO-178 Variation AA.

D (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

8 PINS SHOWN

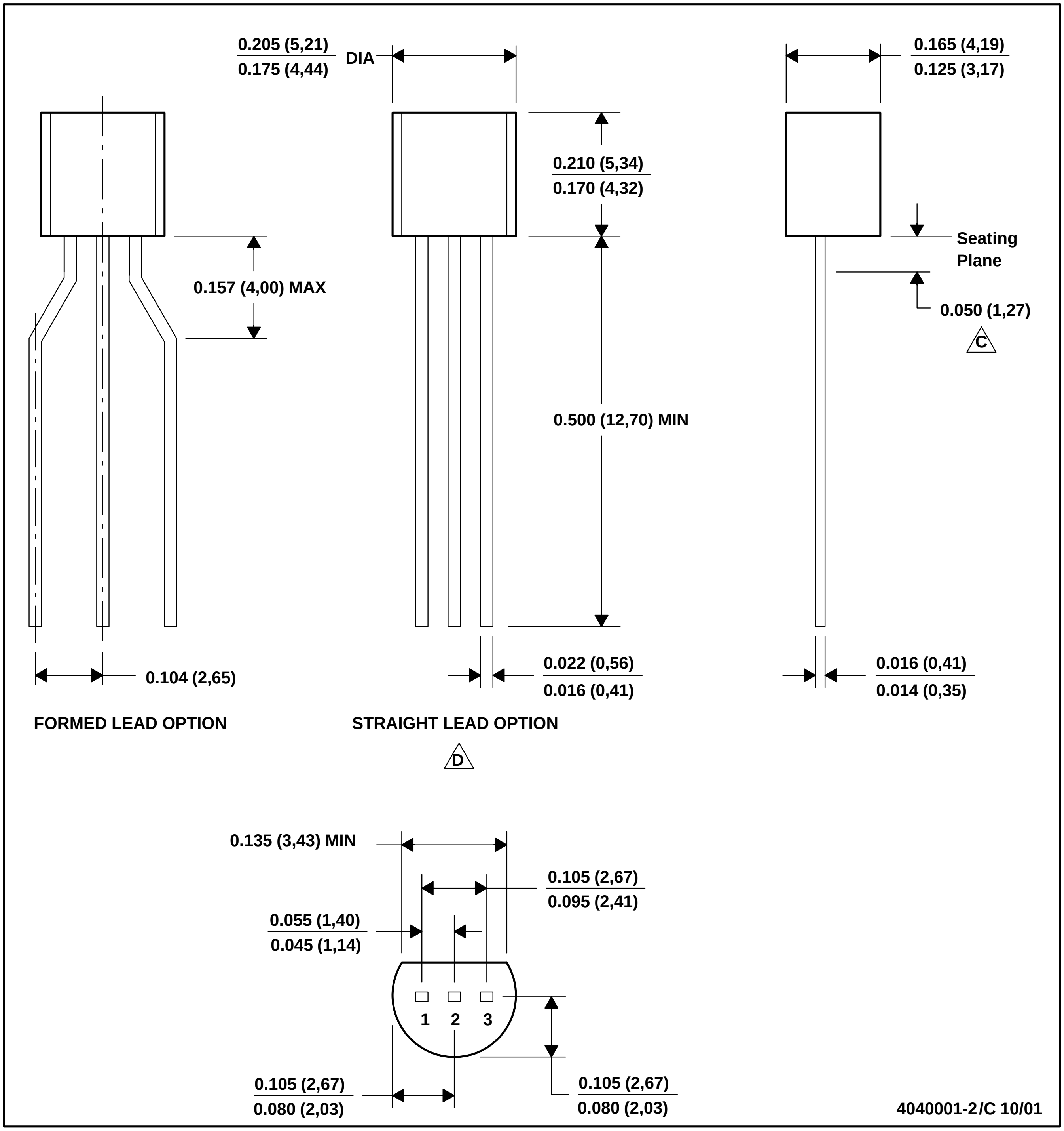


PINS ** / DIM	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

4040047/E 09/01

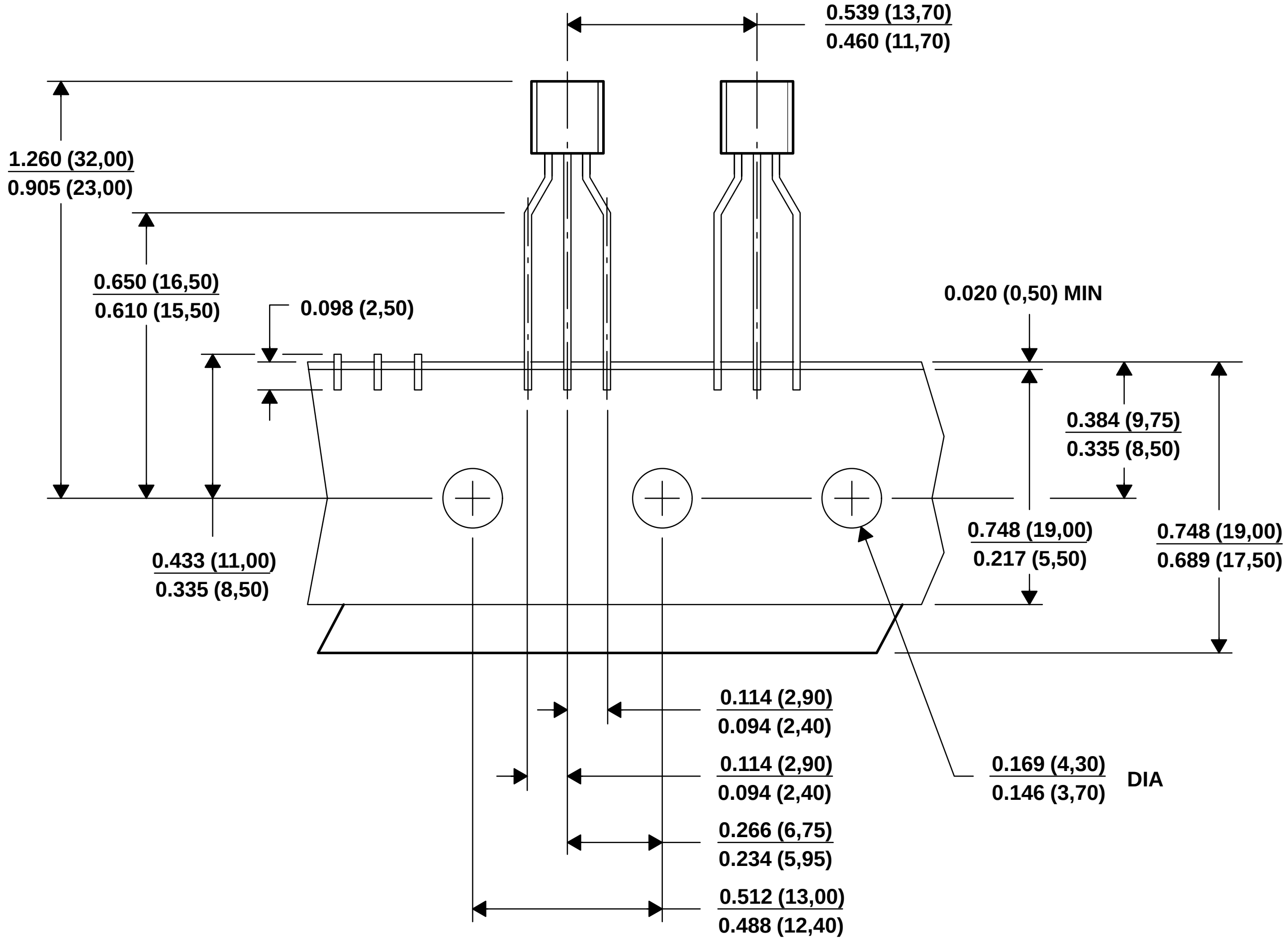
NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
D. Falls within JEDEC MS-012

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. 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.

LP (O-PBCY-W3) **PLASTIC CYLINDRICAL PACKAGE**



TAPE & REEL

4040001-3/C 10/01

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.

IMPORTANT NOTICE

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
		Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

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