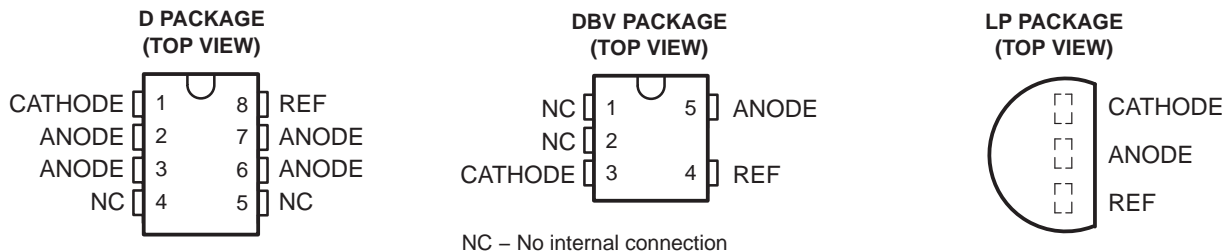


# TLV431, TLV431A

## LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

SLVS139H– JULY 1996 – REVISED FEBRUARY 2004

- 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  $\mu$ A Typ
- 0.25- $\Omega$  Typical Output Impedance



NC – No internal connection

### 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  $\Omega$ . 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.



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.



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# TLV431, TLV431A

## LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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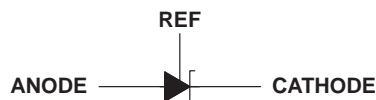
### ORDERING INFORMATION

TA	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	

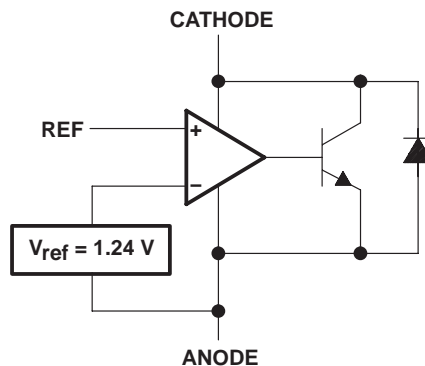
† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).

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

### logic symbol



### logic diagram (positive logic)

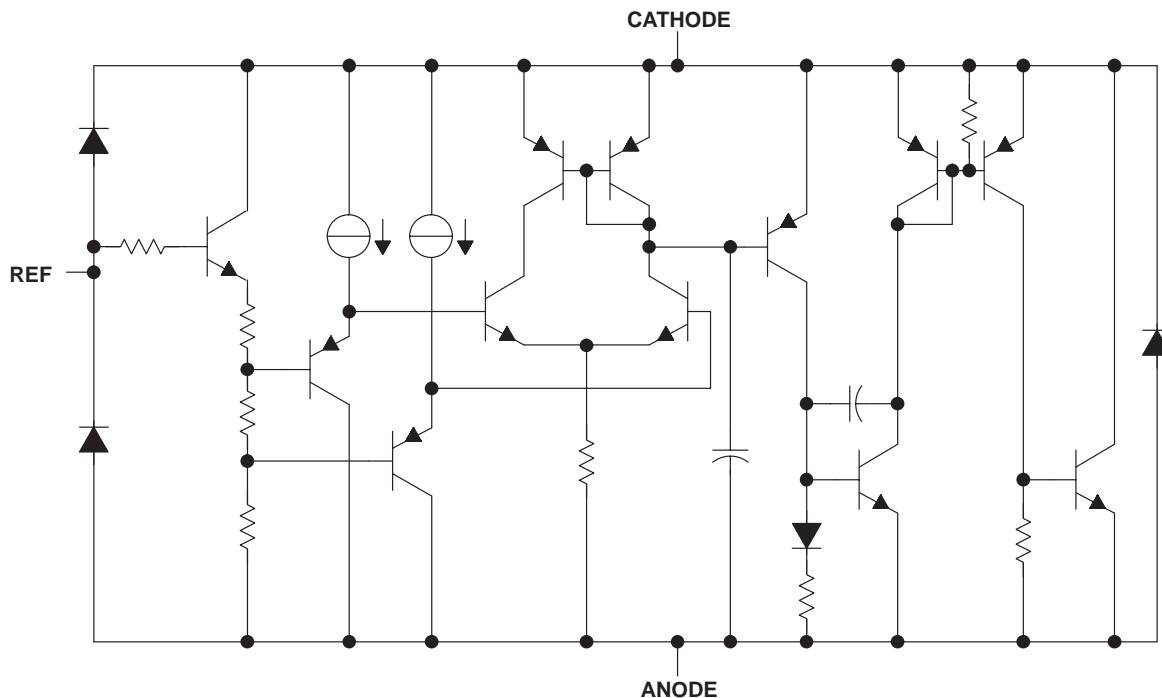


# TLV431, TLV431A

## LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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### 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	$\theta_{JC}$	$\theta_{JA}$
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  $T_J(\max)$ ,  $\theta_{JA}$ , 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.

# TLV431, TLV431A

## LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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### 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		°C
		TLV431I, TLV431AI		

### electrical characteristics, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TLV431C			TLV431I			UNIT		
		MIN	TYP	MAX	MIN	TYP	MAX			
$V_{ref}$	Reference voltage $V_{KA} = V_{ref}$ , $I_K = 10\text{ mA}$	$T_A = 25^\circ\text{C}$		1.222	1.24	1.258	1.222	1.24	1.258	V
		$T_A = \text{full range}$ (see Note 3 and Figure 1)		1.21		1.27	1.202		1.278	
$V_{ref}(\text{dev})$	$V_{ref}$ deviation over full temperature range (see Note 4)	$V_{KA} = V_{ref}$ , $I_K = 10\text{ mA}$ (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	$I_K = 10\text{ mA}$ , $V_{KA} = V_{ref}$ to 6 V (see Figure 2)			-1.5	-2.7	-1.5	-2.7	mV/V	
$I_{ref}$	Reference terminal current	$I_K = 10\text{ mA}$ , $R1 = 10\text{ k}\Omega$ , $R2 = \text{open}$ (see Figure 2)			0.15	0.5	0.15	0.5	$\mu\text{A}$	
$I_{ref}(\text{dev})$	$I_{ref}$ deviation over full temperature range (see Note 4)	$I_K = 10\text{ mA}$ , $R1 = 10\text{ k}\Omega$ , $R2 = \text{open}$ (see Note 3 and Figure 2)			0.05	0.3	0.1	0.4	$\mu\text{A}$	
$I_{K(\text{min})}$	Minimum cathode current for regulation	$V_{KA} = V_{ref}$ (see Figure 1)			55	80	55	80	$\mu\text{A}$	
$I_{K(\text{off})}$	Off-state cathode current	$V_{KA} = 6\text{ V}$ , $V_{ref} = 0$ (see Figure 3)			0.001	0.1	0.001	0.1	$\mu\text{A}$	
$ z_{KA} $	Dynamic impedance (see Note 5)	$V_{KA} = V_{ref}$ , $f \leq 1\text{ kHz}$ , $I_K = 0.1\text{ mA}$ to $15\text{ mA}$ (see Figure 1)			0.25	0.4	0.25	0.4	$\Omega$	

- NOTES: 3. Full range is  $-40^\circ\text{C}$  to  $85^\circ\text{C}$  for the TLV431I and  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for the TLV431C.  
 4. The deviation parameters  $V_{ref}(\text{dev})$  and  $I_{ref}(\text{dev})$  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:

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

where:

$\Delta T_A$  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:  $|z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$

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

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



# TLV431, TLV431A

## LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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electrical characteristics,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TLV431AC			TLV431AI			UNIT	
		MIN	TYP	MAX	MIN	TYP	MAX		
$V_{\text{ref}}$ Reference voltage	$V_{\text{KA}} = V_{\text{ref}}$ , $I_{\text{K}} = 10\text{ mA}$	$T_A = 25^\circ\text{C}$	1.228	1.24	1.252	1.228	1.24	1.252	V
		$T_A = \text{full range}$ (see Note 3 and Figure 1)	1.221		1.259	1.215		1.265	
$V_{\text{ref}}(\text{dev})$ $V_{\text{ref}}$ deviation over full temperature range (see Note 4)	$V_{\text{KA}} = V_{\text{ref}}$ , $I_{\text{K}} = 10\text{ mA}$ (see Note 3 and Figure 1)		4	12		6	20	mV	
$\frac{\Delta V_{\text{ref}}}{\Delta V_{\text{KA}}}$ Ratio of $V_{\text{ref}}$ change in cathode voltage change	$I_{\text{K}} = 10\text{ mA}$ , $V_{\text{KA}} = V_{\text{ref}}$ to 6 V (see Figure 2)		-1.5	-2.7		-1.5	-2.7	mV/V	
$I_{\text{ref}}$ Reference terminal current	$I_{\text{K}} = 10\text{ mA}$ , $R1 = 10\text{ k}\Omega$ (see Figure 2)		0.15	0.5		0.15	0.5	$\mu\text{A}$	
$I_{\text{ref}}(\text{dev})$ $I_{\text{ref}}$ deviation over full temperature range (see Note 4)	$I_{\text{K}} = 10\text{ mA}$ , $R1 = 10\text{ k}\Omega$ , $R2 = \text{open}$ (see Note 3 and Figure 2)		0.05	0.3		0.1	0.4	$\mu\text{A}$	
$I_{\text{K}}(\text{min})$ Minimum cathode current for regulation	$V_{\text{KA}} = V_{\text{ref}}$ (see Figure 1)		55	80		55	80	$\mu\text{A}$	
$I_{\text{K}}(\text{off})$ Off-state cathode current	$V_{\text{KA}} = 6\text{ V}$ , $V_{\text{ref}} = 0$ (see Figure 3)		0.001	0.1		0.001	0.1	$\mu\text{A}$	
$ z_{\text{KA}} $ Dynamic impedance (see Note 5)	$V_{\text{KA}} = V_{\text{ref}}$ , $f \leq 1\text{ kHz}$ , $I_{\text{K}} = 0.1\text{ mA}$ to 15 mA (see Figure 1)		0.25	0.4		0.25	0.4	$\Omega$	

- NOTES: 3. Full range is  $-40^\circ\text{C}$  to  $85^\circ\text{C}$  for the TLV431AI and  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for the TLV431AC.  
 4. The deviation parameters  $V_{\text{ref}}(\text{dev})$  and  $I_{\text{ref}}(\text{dev})$  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,  $\alpha_{V_{\text{ref}}}$ , is defined as:

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

where:

$\Delta T_A$  is the rated operating temperature range of the device.

$\alpha_{V_{\text{ref}}}$  can be positive or negative, depending on whether minimum  $V_{\text{ref}}$  or maximum  $V_{\text{ref}}$ , respectively, occurs at the lower temperature.

5. The dynamic impedance is defined as:  $|z_{\text{KA}}| = \frac{\Delta V_{\text{KA}}}{\Delta I_{\text{KA}}}$

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

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

# TLV431, TLV431A

## LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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### PARAMETER MEASUREMENT INFORMATION

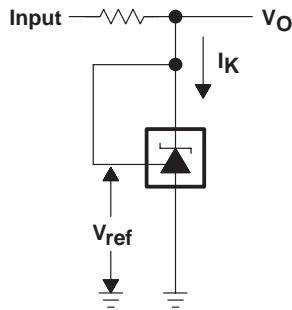


Figure 1. Test Circuit for  $V_{KA} = V_{ref}$ ,  
 $V_O = V_{KA} = V_{ref}$

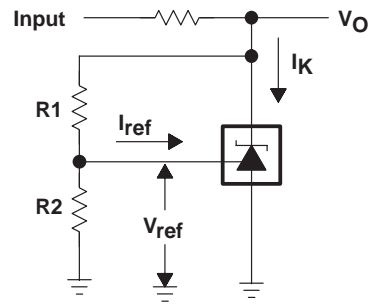


Figure 2. Test Circuit for  $V_{KA} > V_{ref}$ ,  
 $V_O = V_{KA} = V_{ref} \times (1 + R1/R2) + I_{ref} \times R1$

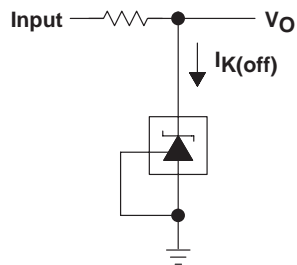


Figure 3. Test Circuit for  $I_{K(off)}$

# TLV431, TLV431A

## LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

SLVS139H– JULY 1996 – REVISED FEBRUARY 2004

### PARAMETER MEASUREMENT INFORMATION†

**REFERENCE VOLTAGE  
vs  
JUNCTION TEMPERATURE**

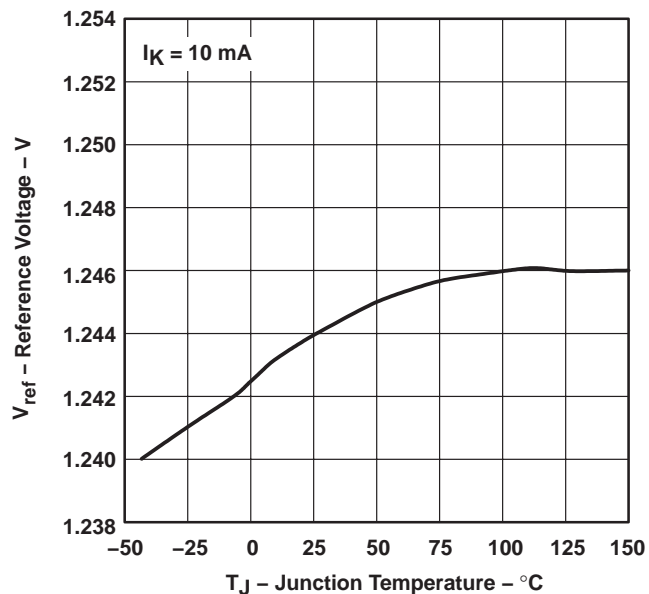


Figure 4

**REFERENCE INPUT CURRENT  
vs  
JUNCTION TEMPERATURE**

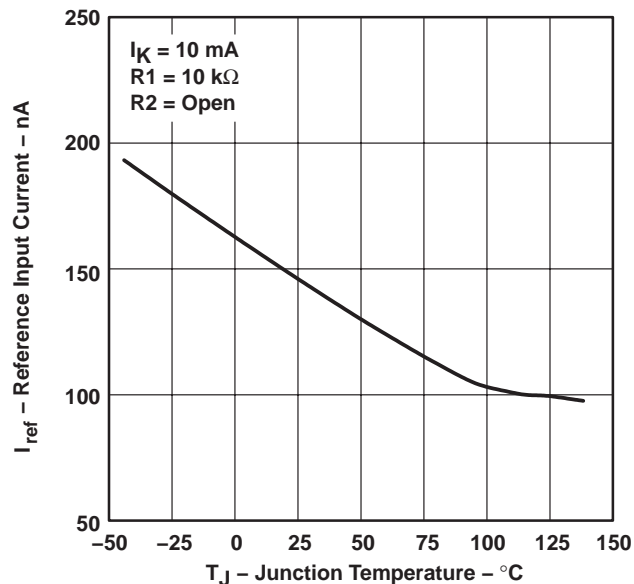


Figure 5

**CATHODE CURRENT  
vs  
CATHODE VOLTAGE**

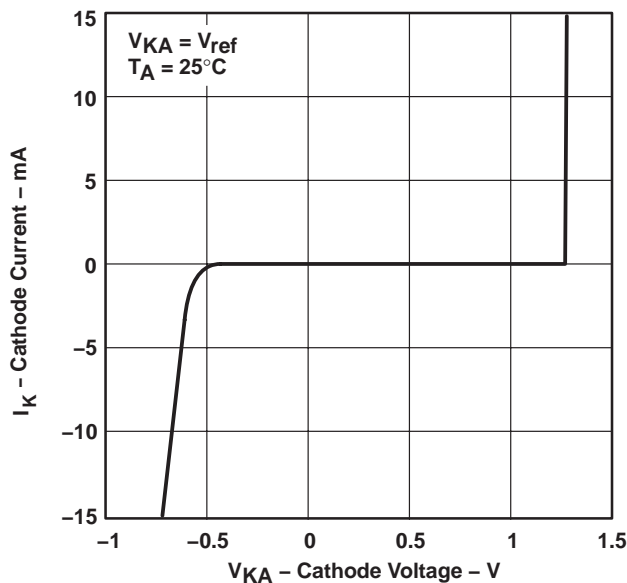


Figure 6

**CATHODE CURRENT  
vs  
CATHODE VOLTAGE**

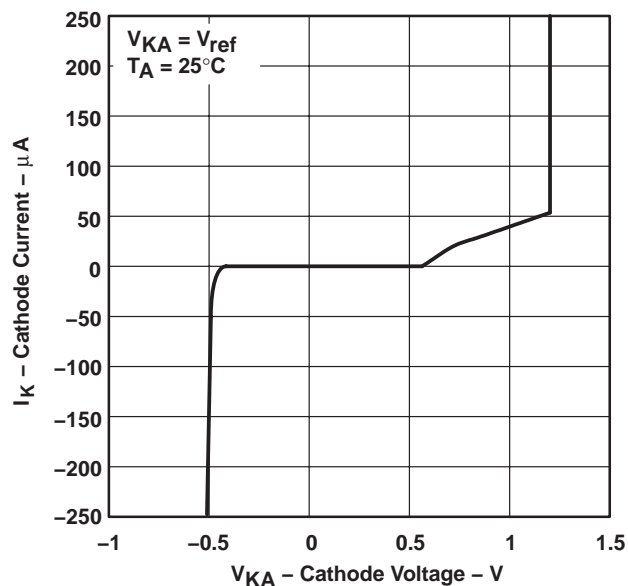


Figure 7

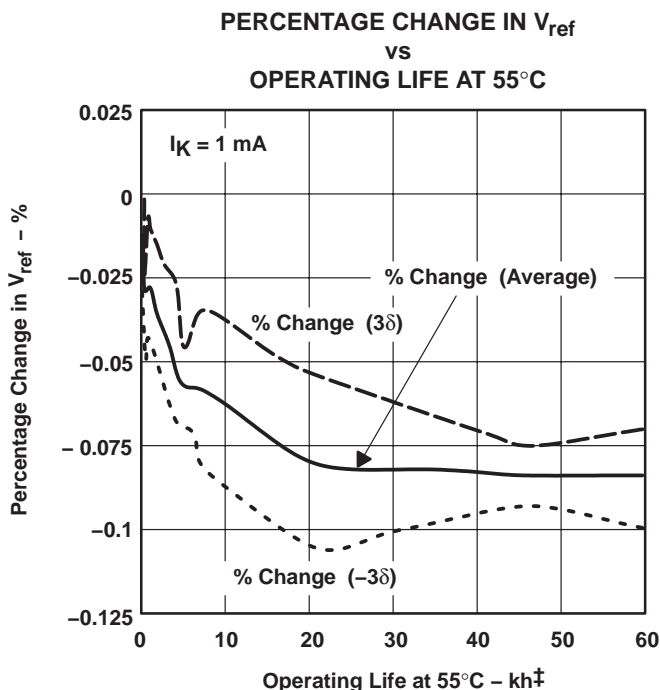
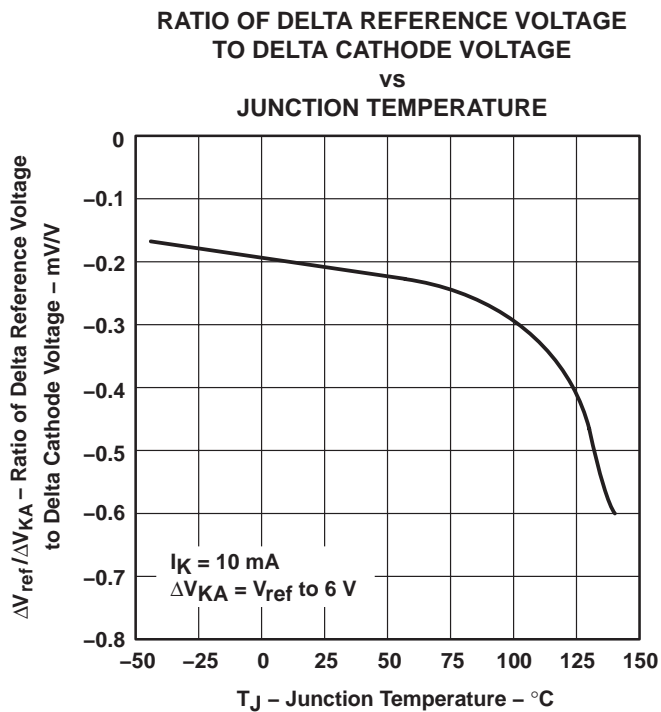
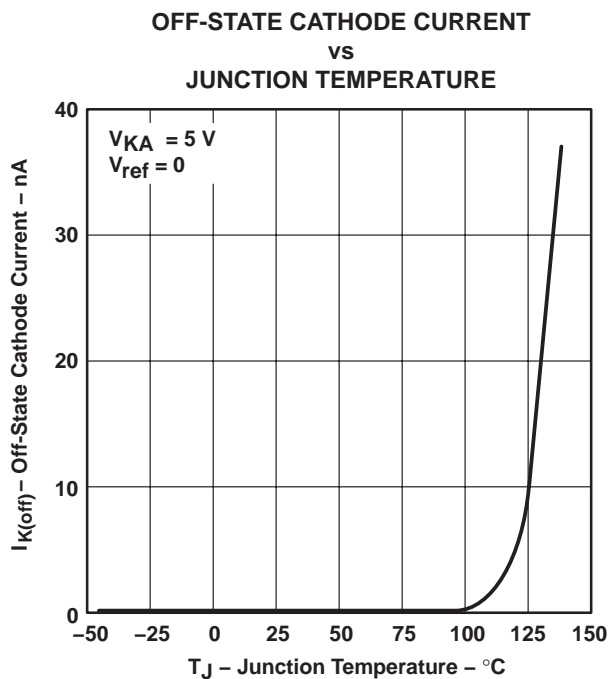
† Operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied.

# TLV431, TLV431A

## LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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### PARAMETER MEASUREMENT INFORMATION†



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

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





**PARAMETER MEASUREMENT INFORMATION**

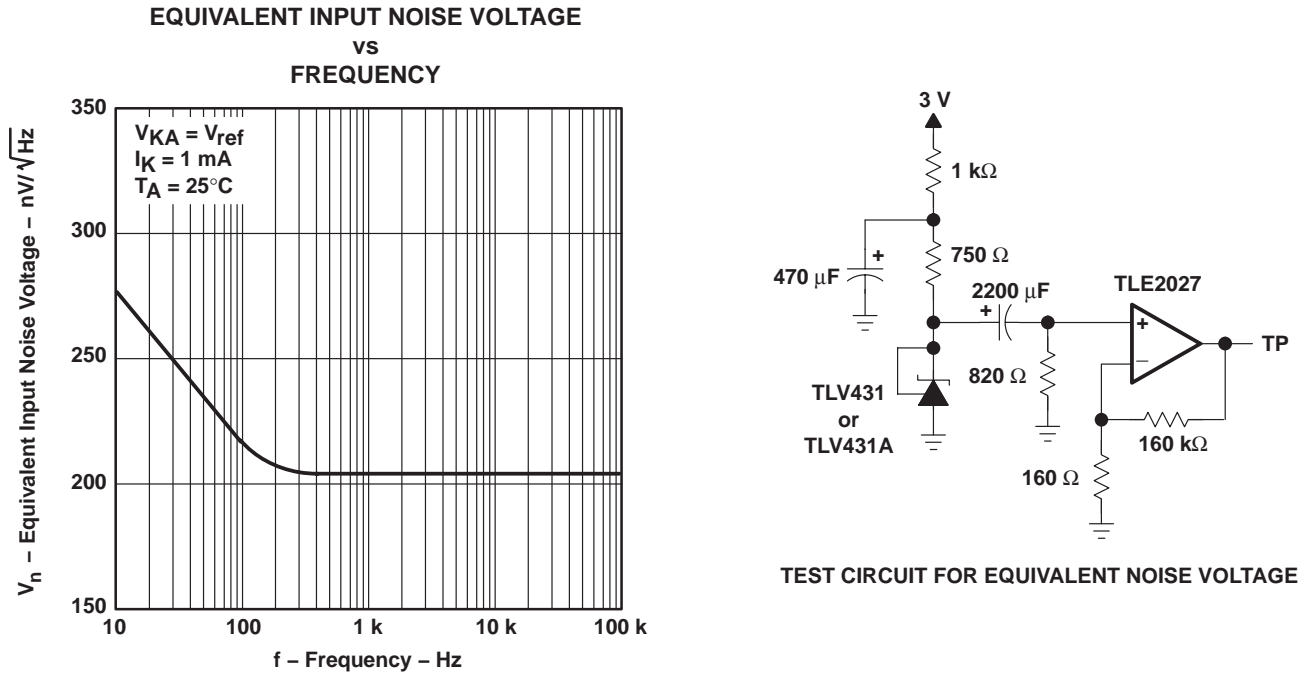


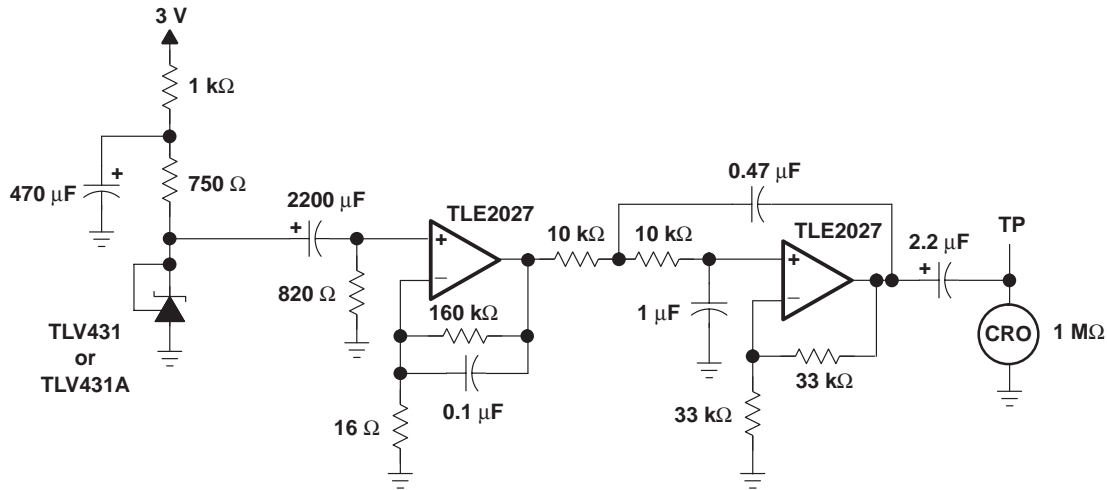
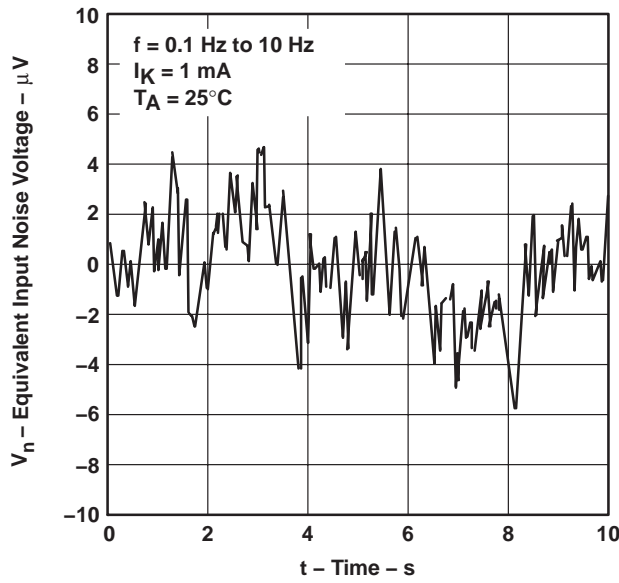
Figure 11

# TLV431, TLV431A LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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## 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

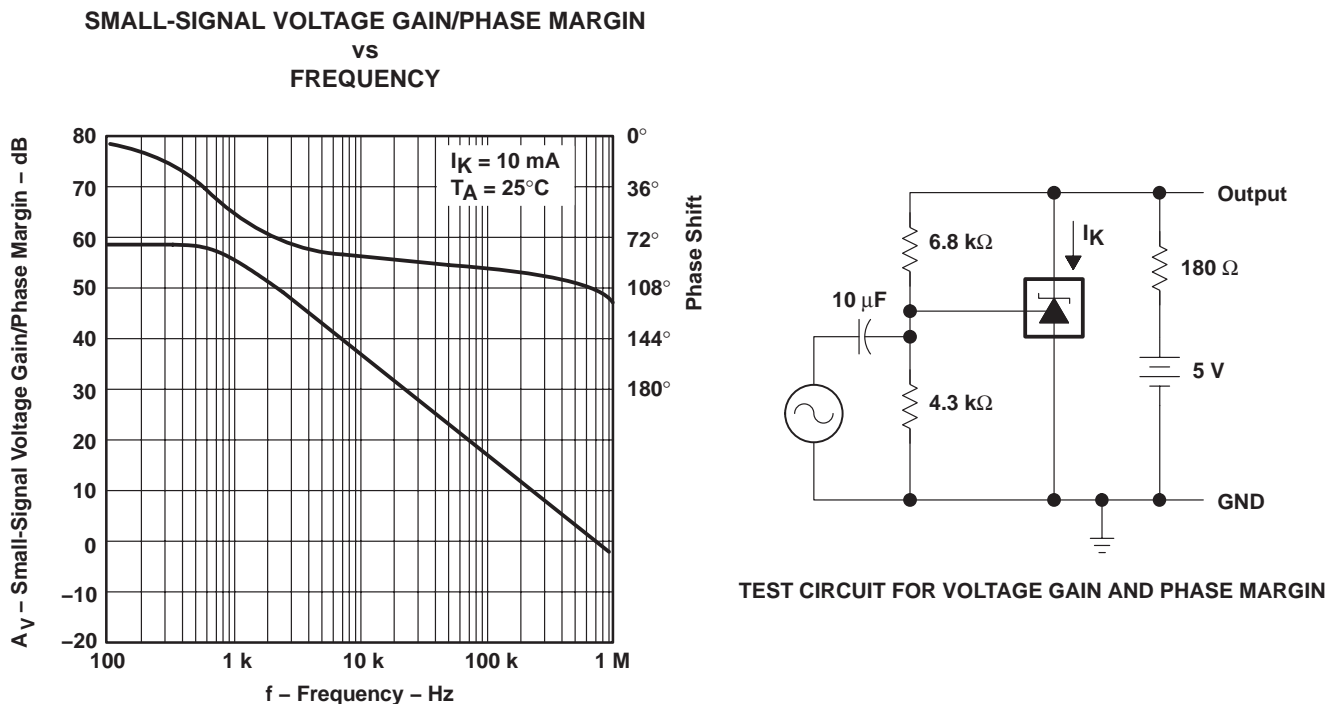


Figure 13

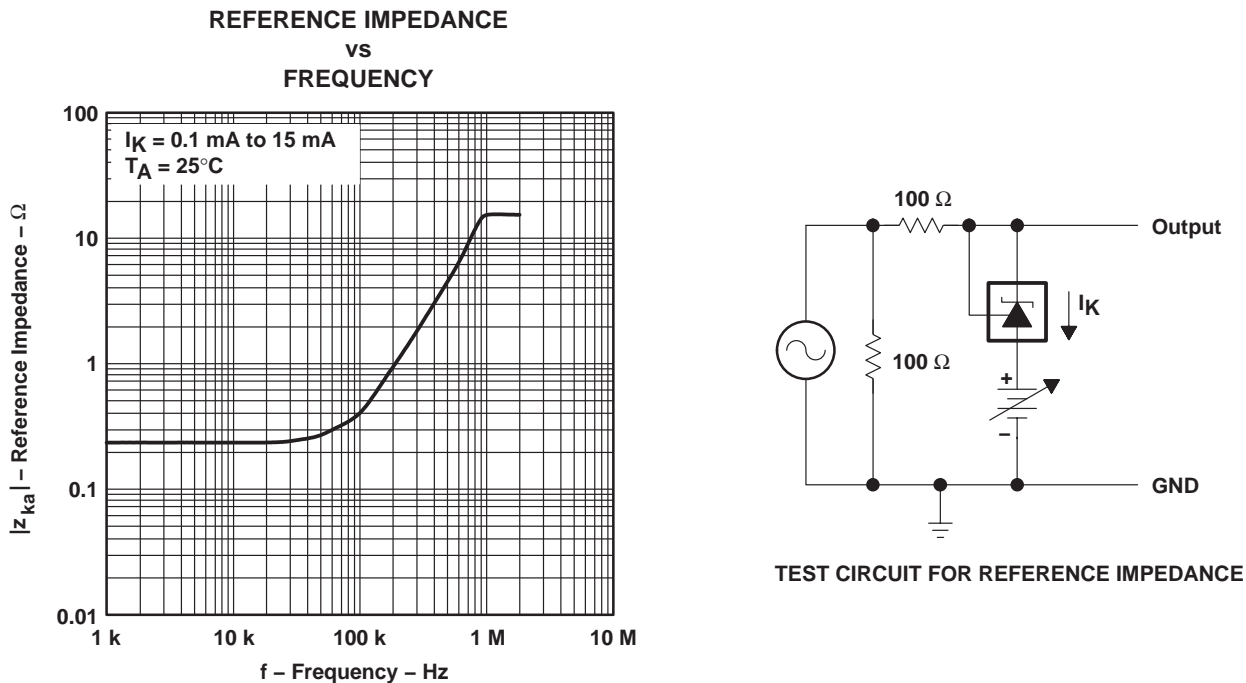


Figure 14

# TLV431, TLV431A

## LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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### PARAMETER MEASUREMENT INFORMATION

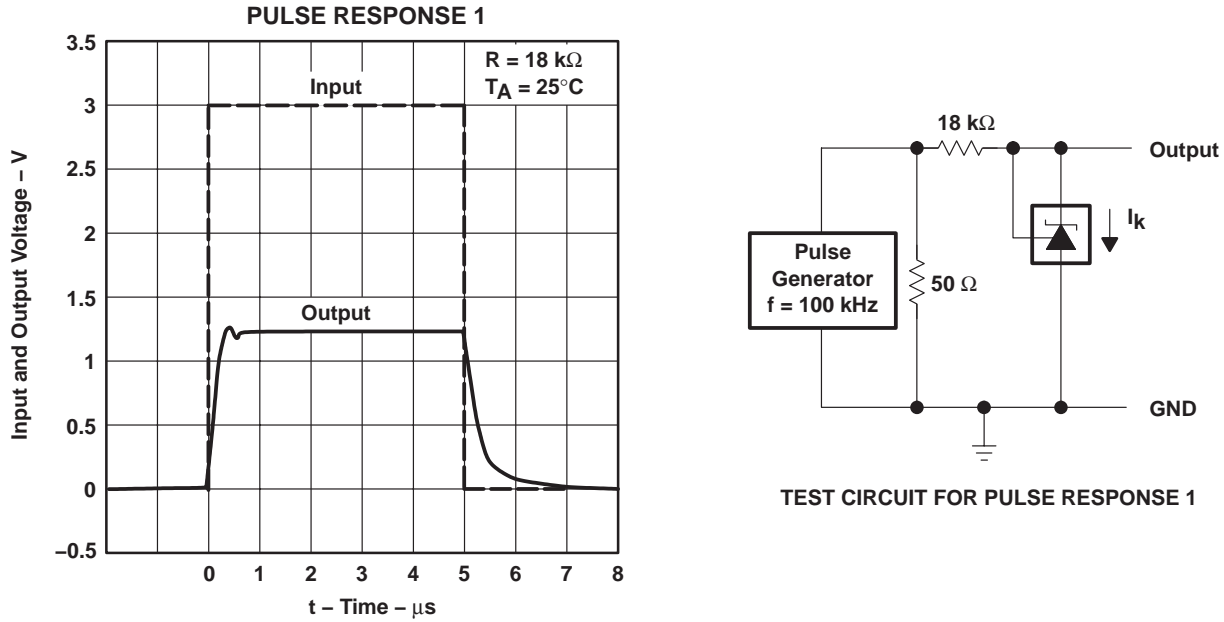


Figure 15

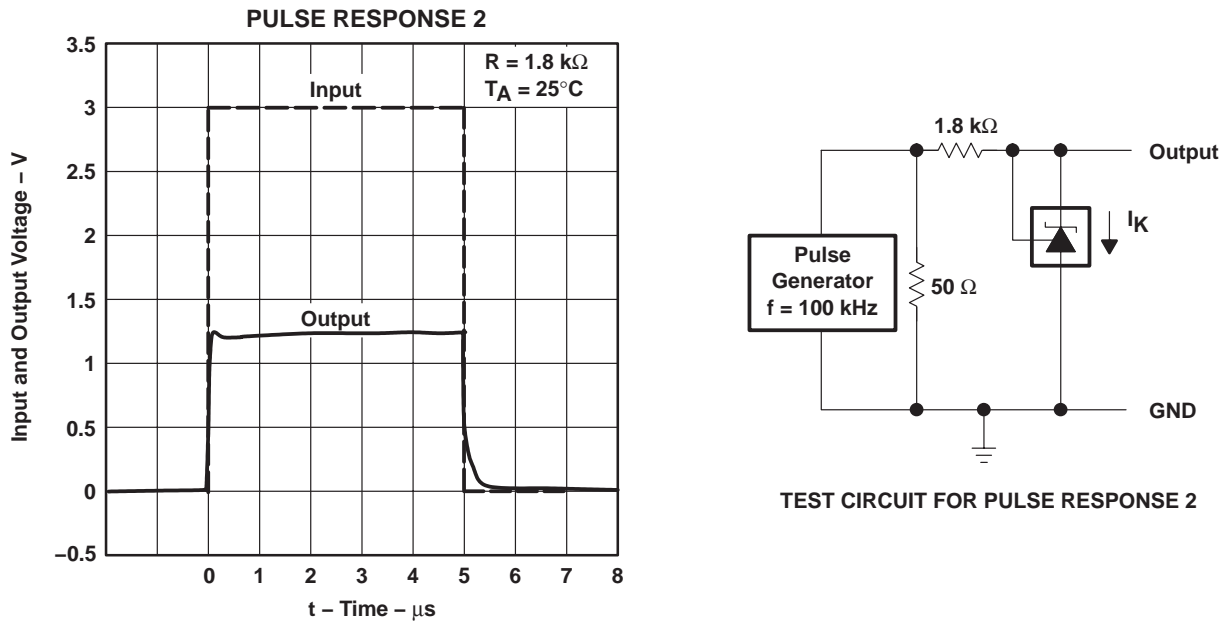
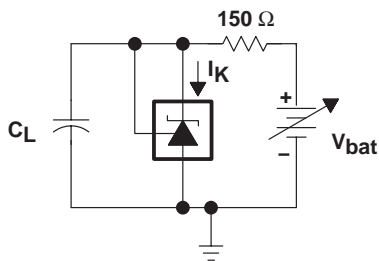
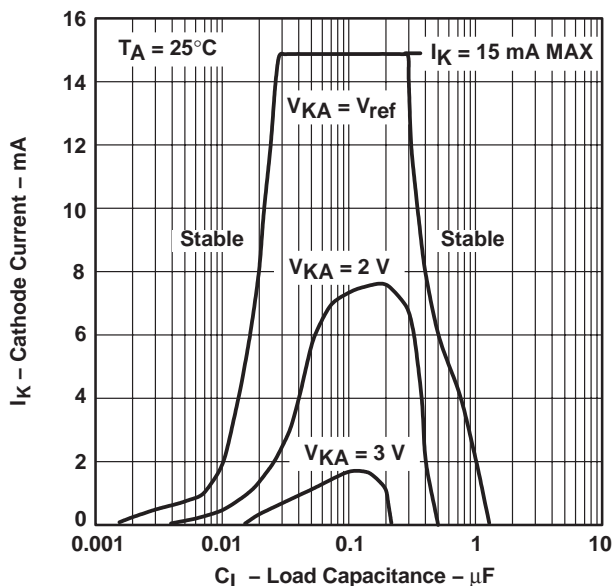


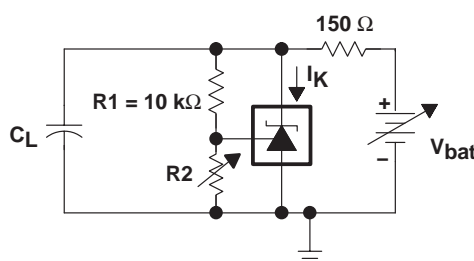
Figure 16

PARAMETER MEASUREMENT INFORMATION†

STABILITY BOUNDARY CONDITION‡



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. 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.

# TLV431, TLV431A

## LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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### 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  $V_{ref}$  ( $1.24\text{ V} \pm 1\%$ ). 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 using the circuit in Figure 18.

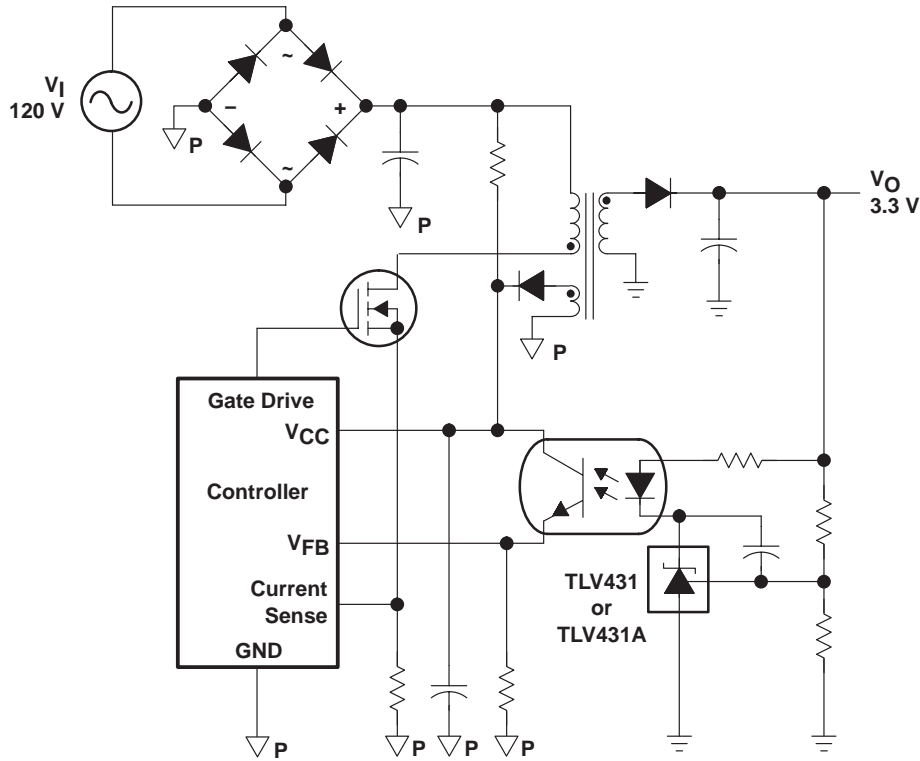


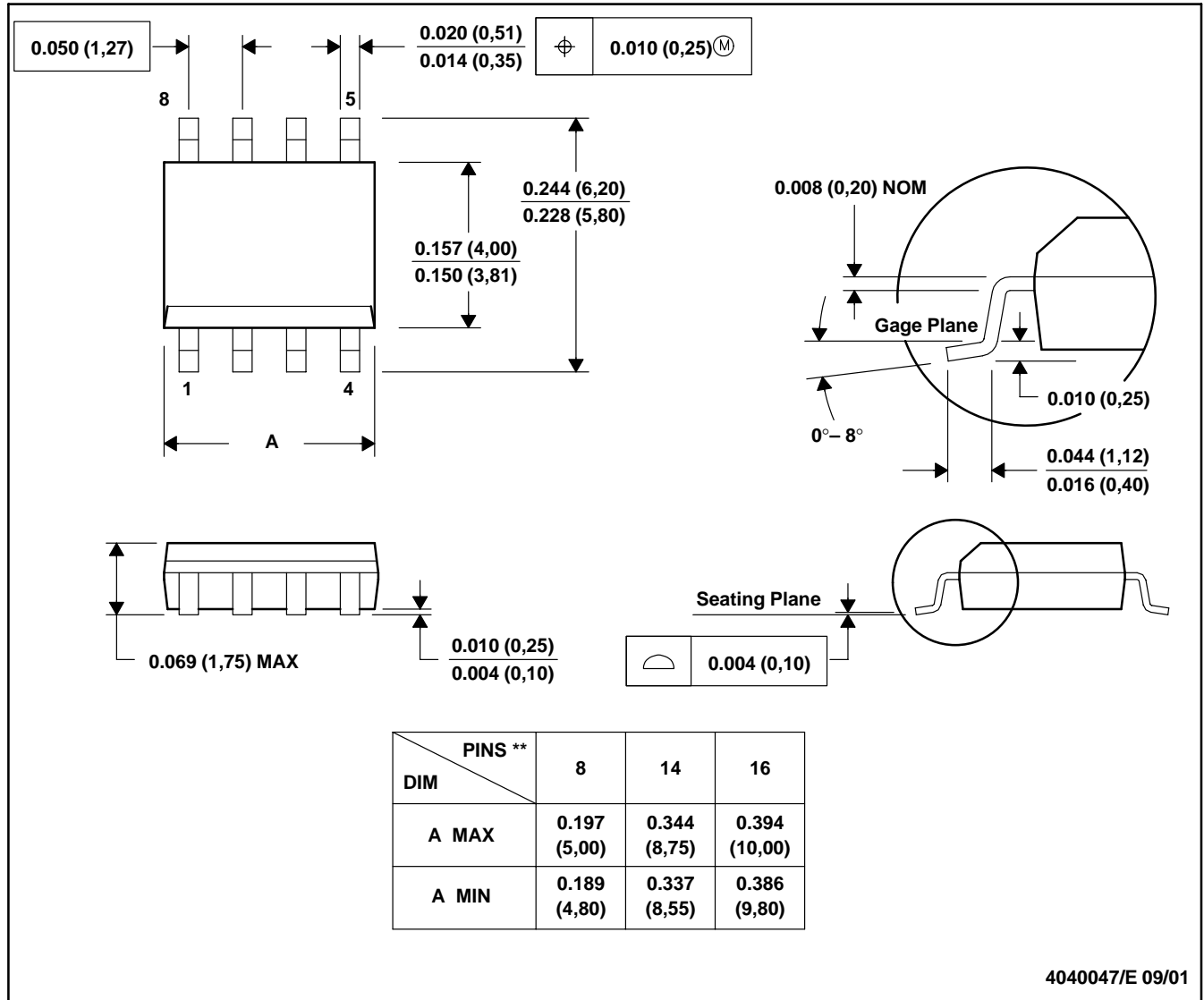
Figure 18. Flyback With Isolation Using TLV431 or TLV431A as Voltage Reference and Error Amplifier



D (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

8 PINS SHOWN

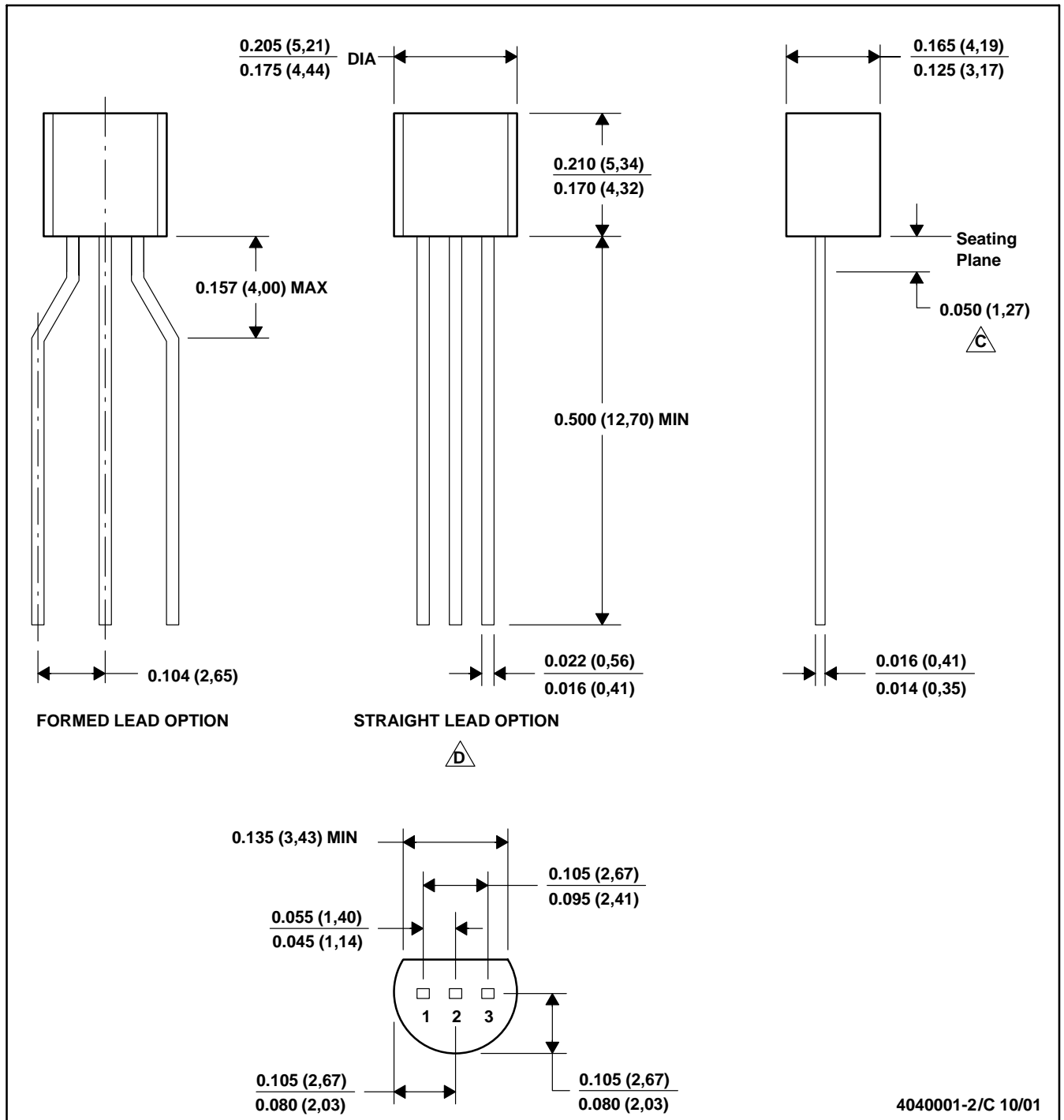


- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).  
 D. Falls within JEDEC MS-012



LP (O-PBCY-W3)

PLASTIC CYLINDRICAL PACKAGE



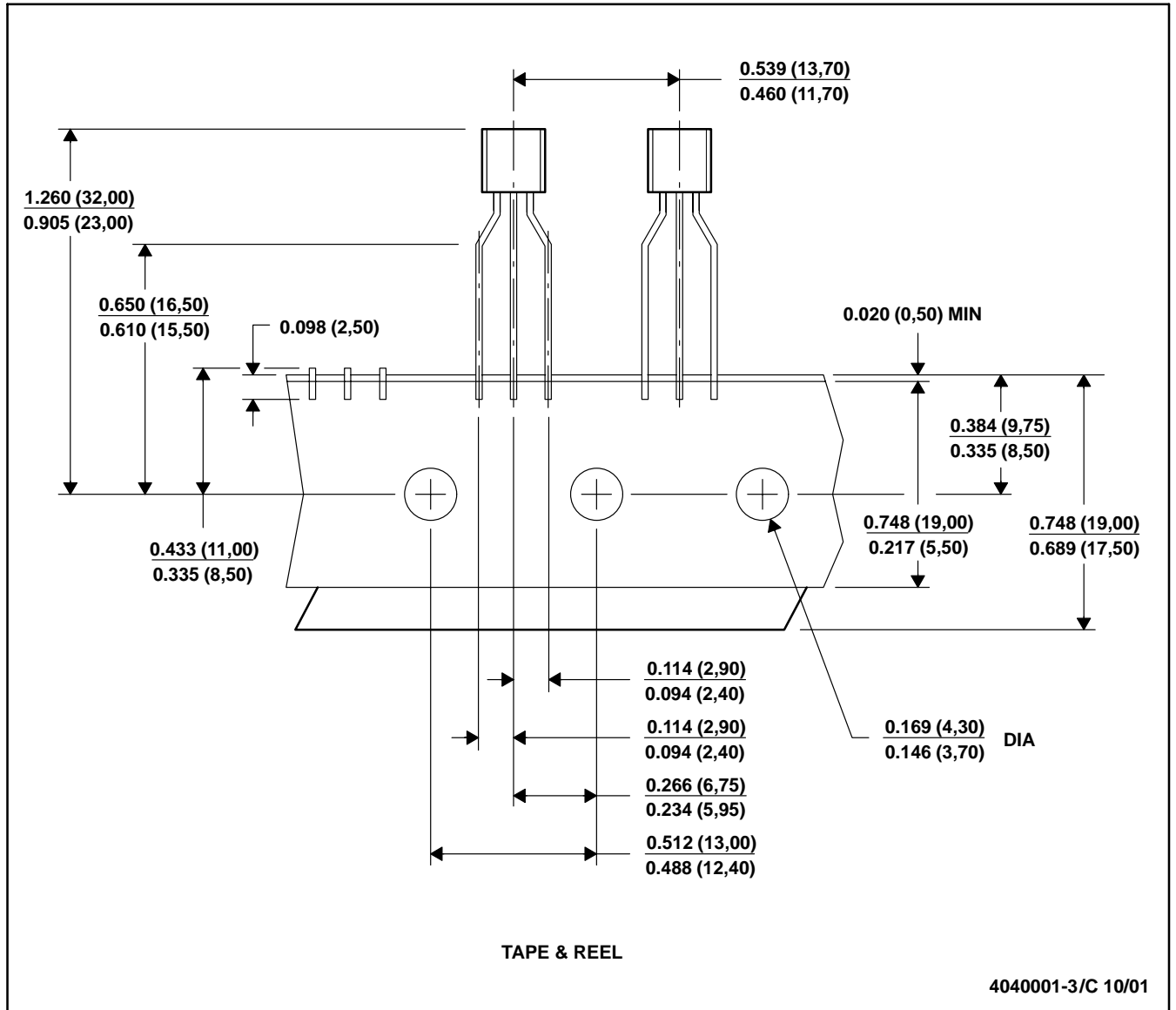
- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Lead dimensions are not controlled within this area  
 D. Falls within JEDEC TO -226 Variation AA (TO-226 replaces TO-92)  
 E. Shipping Method:  
 Straight lead option available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

# 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.

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