

# TLV431, TLV431A

## LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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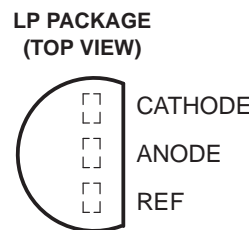
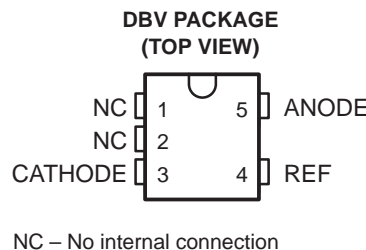
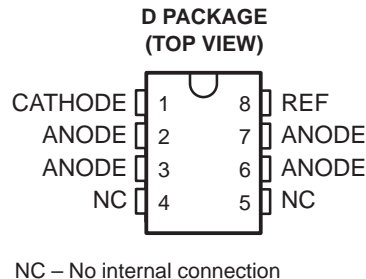
- Low-Voltage Operation . . . Down to 1.24 V
- 1% Reference-Voltage Tolerance (TLV431A)
- Adjustable Output Voltage,  $V_O = V_{ref}$  to 6 V
- Low Operational Cathode Current . . . 80  $\mu$ A Typ
- 0.25- $\Omega$  Typical Output Impedance
- Package Options Include Plastic Small-Outline (D), Small-Outline Transistor (DBV), and Cylindrical (LP) Packages

### description

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.



### AVAILABLE OPTIONS

$T_A$	PACKAGED DEVICES		
	TO-92 (LP)	SOIC (D)	5-PIN SOT-23 (DBV)
0°C to 70°C	TLV431CLP TLV431ACL	— —	TLV431CDBV TLV431ACDBV
–40°C to 85°C	TLV431ILP TLV431AILP	— TLV431AID	TLV431IDBV TLV431AIDBV

The D and LP packages are available taped and reeled. Add the suffix R to the device type (e.g., TLV431ACLPR). The DBV package is available only taped and reeled (e.g., TLV431AIDR).



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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**

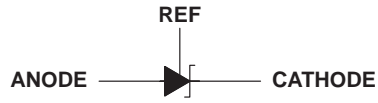
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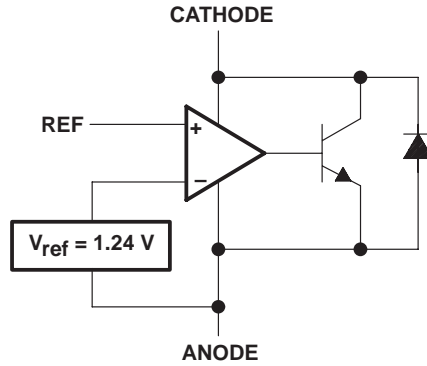
# TLV431, TLV431A LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

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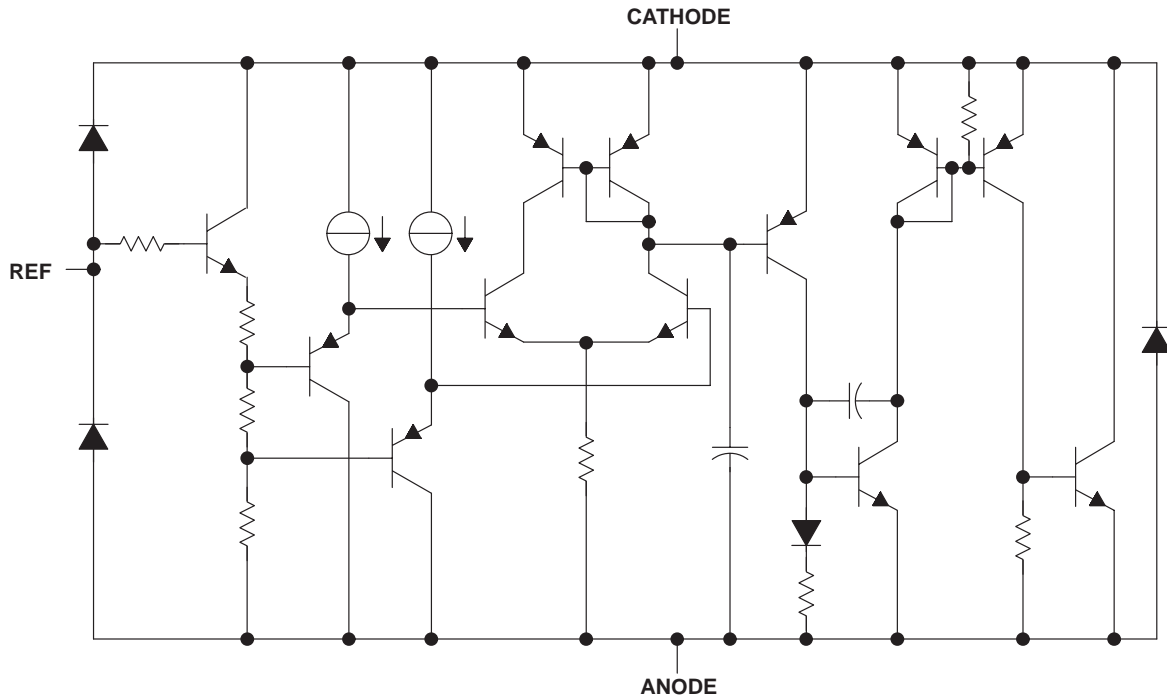
## logic symbol



## logic diagram (positive logic)



## equivalent schematic



# TLV431, TLV431A

## 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): D package .....	97°C/W
DBV package .....	206°C/W
LP package .....	156°C/W
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.

- 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.

### recommended operating conditions

		MIN	MAX	UNIT
Cathode voltage, $V_{KA}$		$V_{ref}$	6	V
Cathode current, $I_K$		0.1	15	mA
Operating free-air temperature range, $T_A$	TLV431C, TLV431AC	0	70	°C
	TLV431I, TLV431AI	–40	85	



# 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		TLV431C			TLV431I			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{\text{ref}}$ Reference voltage	$V_{\text{KA}} = V_{\text{ref}}$ , $I_{\text{K}} = 10\text{ mA}$	$T_A = 25^\circ\text{C}$	1.222	1.24	1.258	1.222	1.24	1.258	V
		$T_A = \text{full range}$ (see Note 4 and Figure 1)	1.21		1.27	1.202		1.278	
$V_{\text{ref}}(\text{dev})$ $V_{\text{ref}}$ deviation over full temperature range (see Note 5)	$V_{\text{KA}} = V_{\text{ref}}$ , $I_{\text{K}} = 10\text{ mA}$ , (see Note 4 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	$I_{\text{K}} = 10\text{ mA}$ , $R_1 = 10\text{ k}\Omega$ , $R_2 = \text{open}$ (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 5)	$I_{\text{K}} = 10\text{ mA}$ , $R_1 = 10\text{ k}\Omega$ , $R_2 = \text{open}$ (see Note 4 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 6)	$V_{\text{KA}} = V_{\text{ref}}$ , $f \leq 1\text{ kHz}$ , $I_{\text{K}} = 0.1\text{ mA}$ to $15\text{ mA}$ (see Figure 1)			0.25	0.4		0.25	0.4	$\Omega$

NOTES: 4. 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.

5. 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.

6. 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:

$$|z_{\text{KA}}| = \frac{\Delta V}{\Delta I} \approx |z_{\text{KA}}| \times \left( 1 + \frac{R_1}{R_2} \right)$$



# 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	$V_{\text{KA}} = V_{\text{ref}}, I_{\text{K}} = 10 \text{ mA},$ $T_A = 25^\circ\text{C}$ $T_A = \text{full range,}$ (see Note 4 and Figure 1)	1.228	1.24	1.252	1.228	1.24	1.252	V
		1.221		1.259	1.215		1.265	
$V_{\text{ref}}(\text{dev})$	$V_{\text{ref}}$ deviation over full temperature range (see Note 5)		4	12		6	20	mV
$\frac{\Delta V_{\text{ref}}}{\Delta V_{\text{KA}}}$	Ratio of $V_{\text{ref}}$ change in cathode voltage change		-1.5	-2.7		-1.5	-2.7	mV/V
$I_{\text{ref}}$	Reference terminal current		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 5)		0.05	0.3		0.1	0.4	$\mu\text{A}$
$I_{\text{K}}(\text{min})$	Minimum cathode current for regulation		55	80		55	80	$\mu\text{A}$
$I_{\text{K}}(\text{off})$	Off-state cathode current		0.001	0.1		0.001	0.1	$\mu\text{A}$
$ z_{\text{KA}} $	Dynamic impedance (see Note 6)		0.25	0.4		0.25	0.4	$\Omega$

- NOTES: 7. Full range is  $-40^\circ\text{C}$  to  $85^\circ\text{C}$  for the TLV4311, and  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for the TLV431C.
8. 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.

9. 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

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### PARAMETER MEASUREMENT INFORMATION

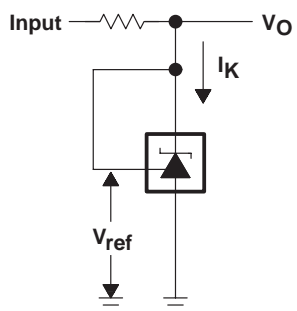


Figure 1. Test Circuit for  $V_{KA} = V_{ref}$ ,  
 $V_O = V_{KA} = V_{ref}$

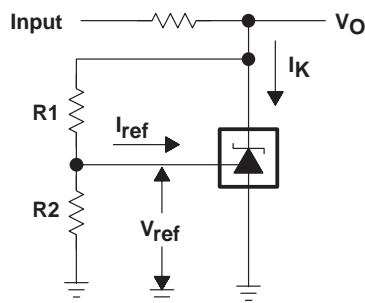


Figure 2. Test Circuit for  $V_{KA} > V_{ref}$ ,  
 $V_O = V_{KA} = V_{ref} \times (1 + R1/R2) + I_{ref} \times R1$

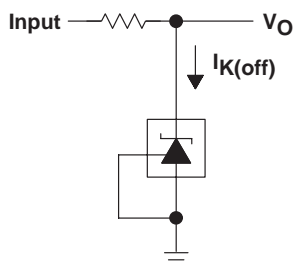


Figure 3. Test Circuit for  $I_{K(off)}$

PARAMETER MEASUREMENT INFORMATION†

REFERENCE VOLTAGE  
 vs  
 JUNCTION TEMPERATURE

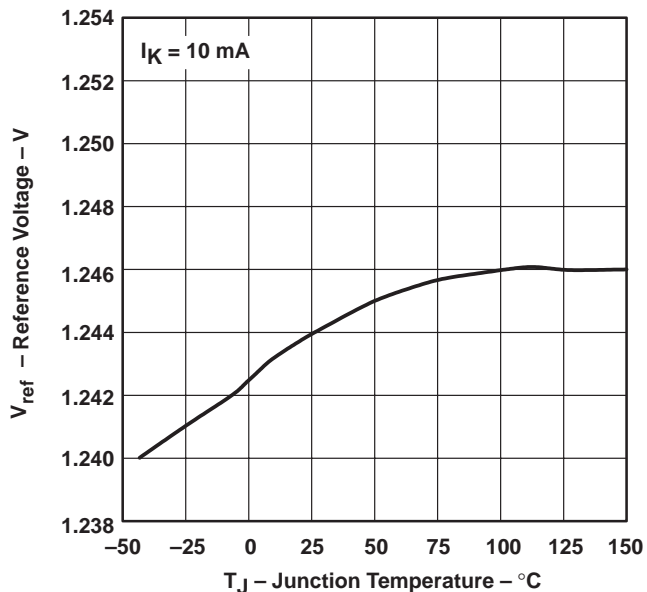


Figure 4

REFERENCE INPUT CURRENT  
 vs  
 JUNCTION TEMPERATURE

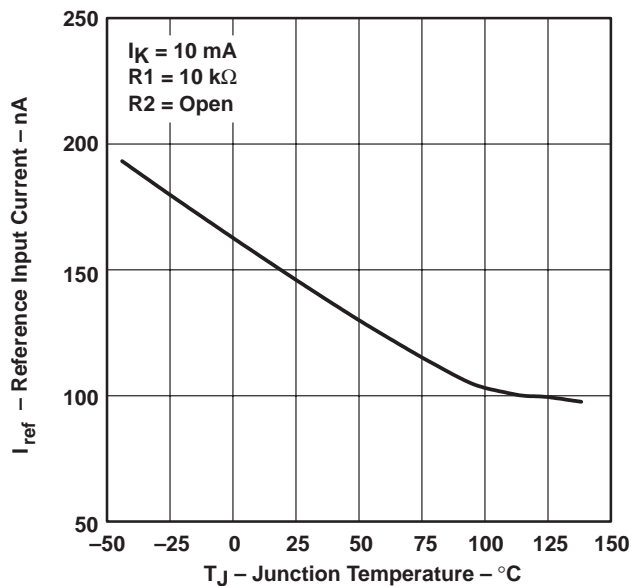


Figure 5

CATHODE CURRENT  
 vs  
 CATHODE VOLTAGE

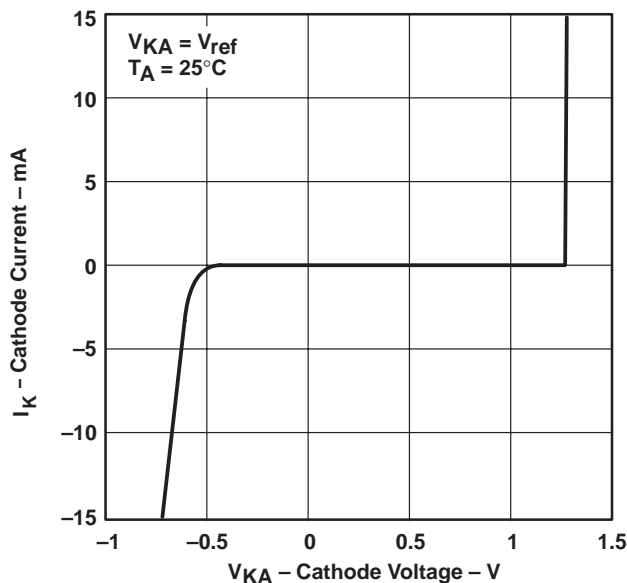


Figure 6

CATHODE CURRENT  
 vs  
 CATHODE VOLTAGE

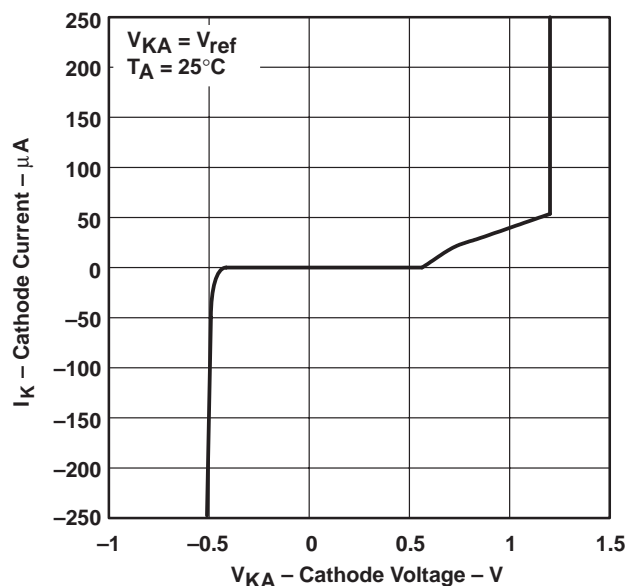


Figure 7

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

# TLV431, TLV431A

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### PARAMETER MEASUREMENT INFORMATION†

OFF-STATE CATHODE CURRENT  
vs  
JUNCTION TEMPERATURE

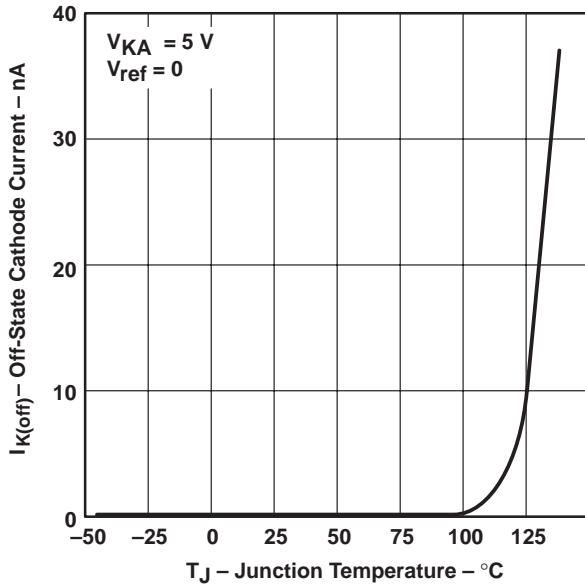


Figure 8

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

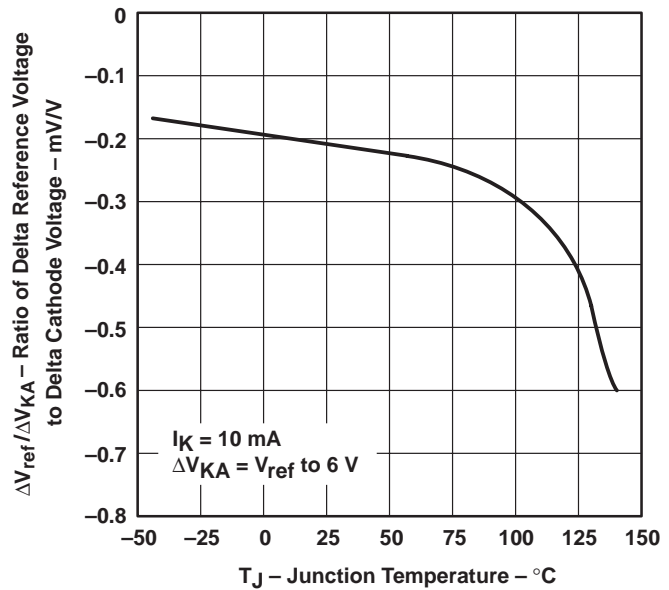


Figure 9

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

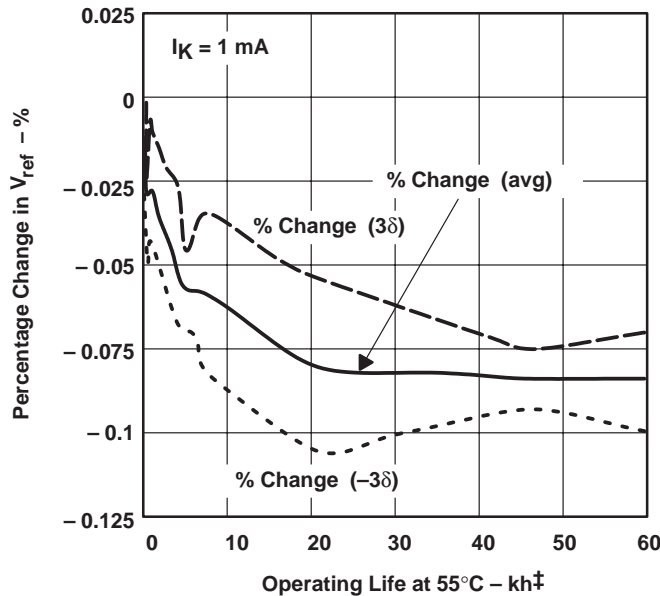


Figure 10

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

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PARAMETER MEASUREMENT INFORMATION

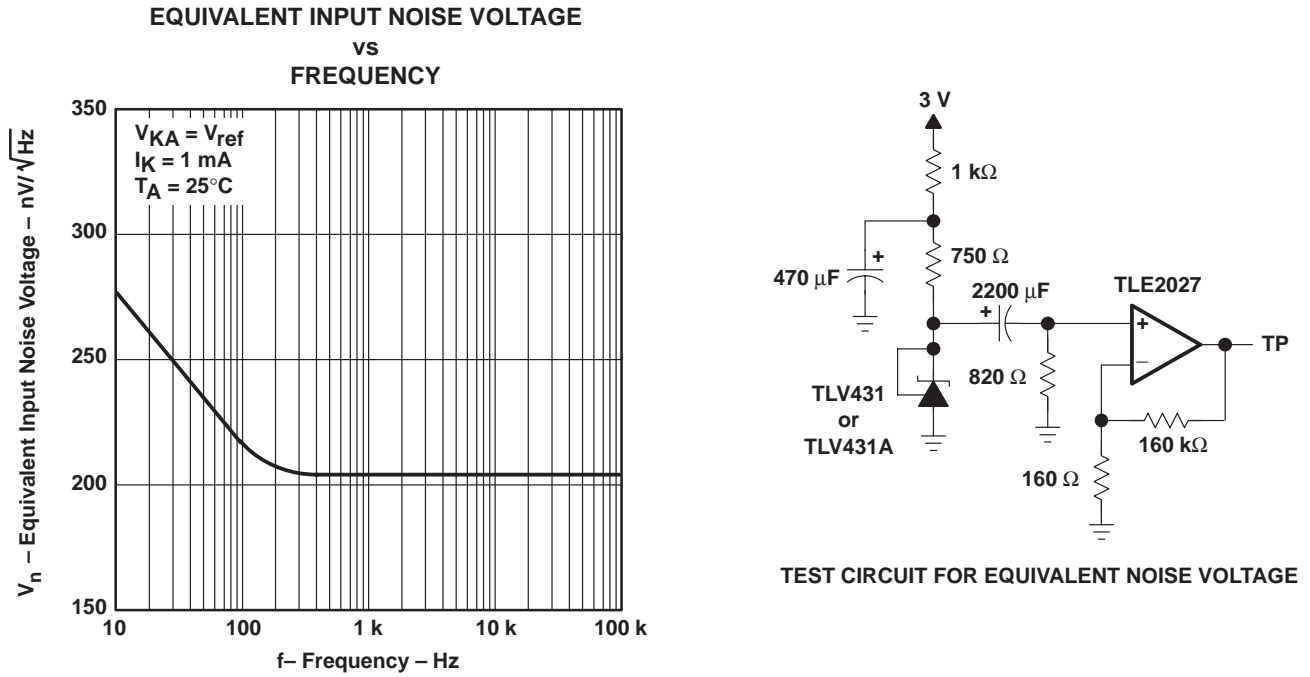


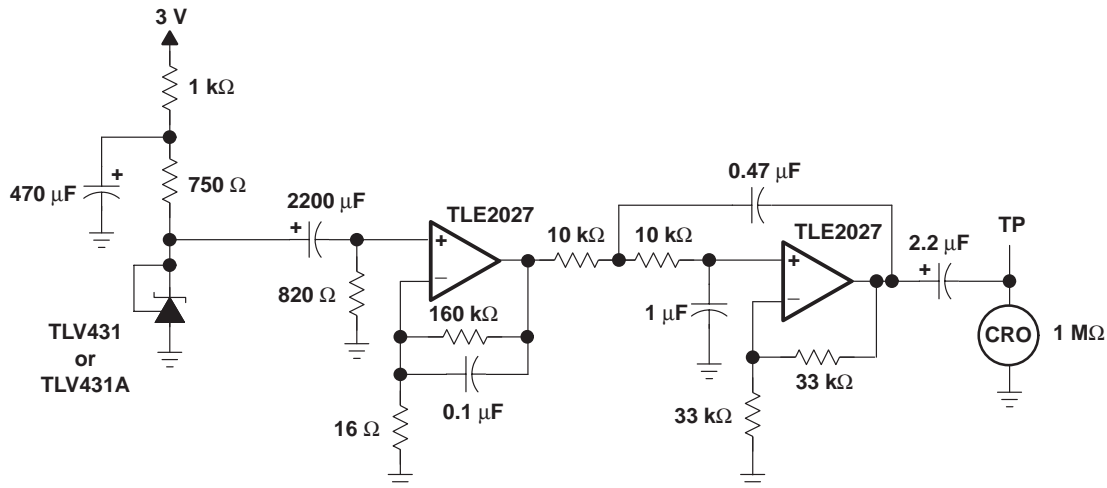
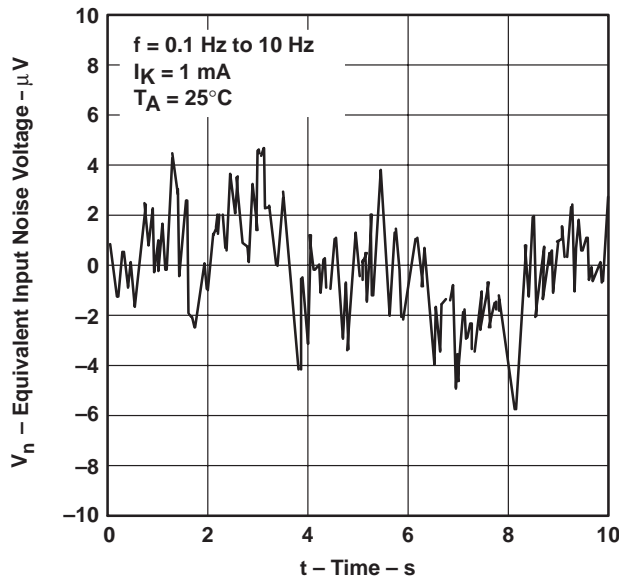
Figure 11

# 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

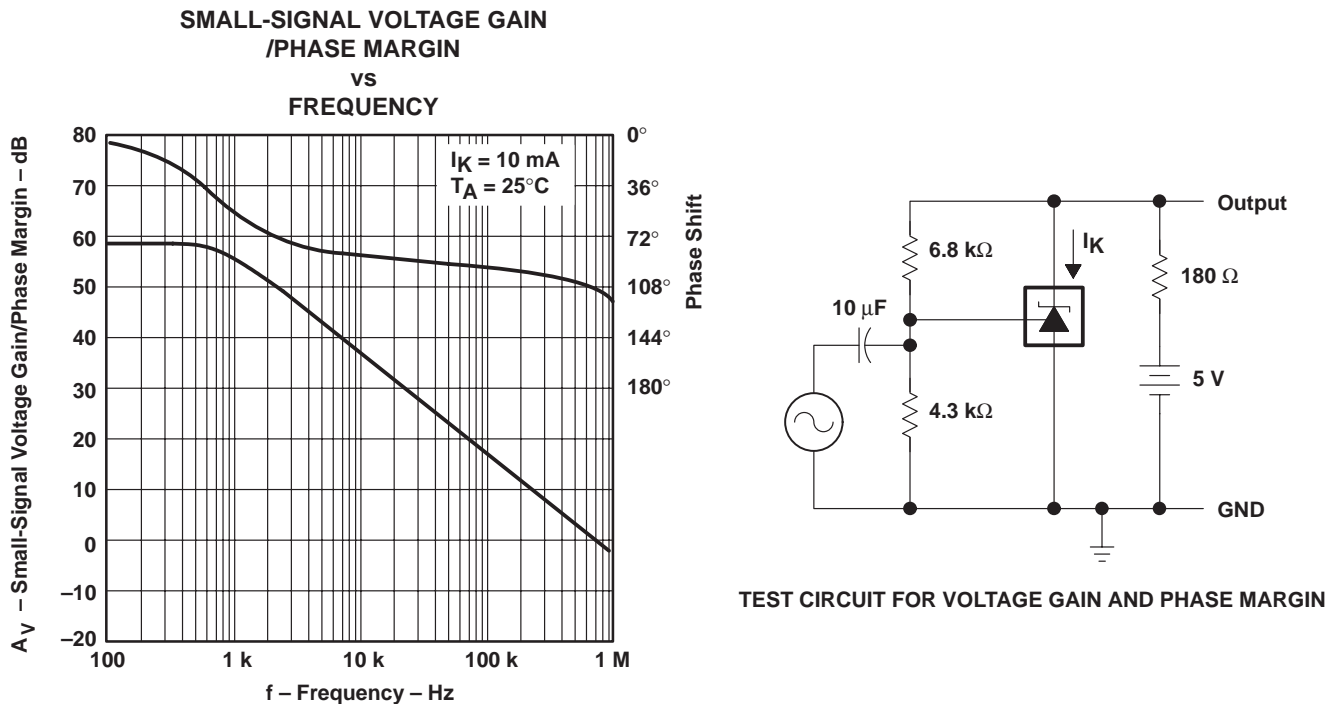


Figure 13

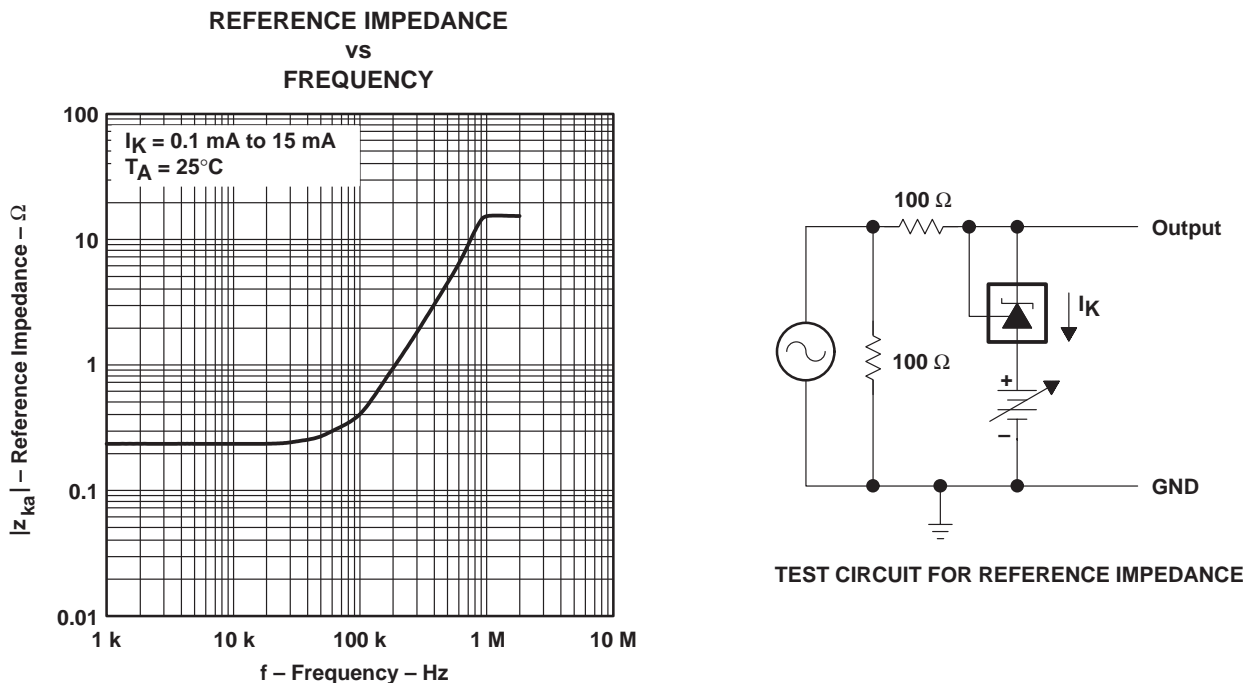


Figure 14

# TLV431, TLV431A

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### PARAMETER MEASUREMENT INFORMATION

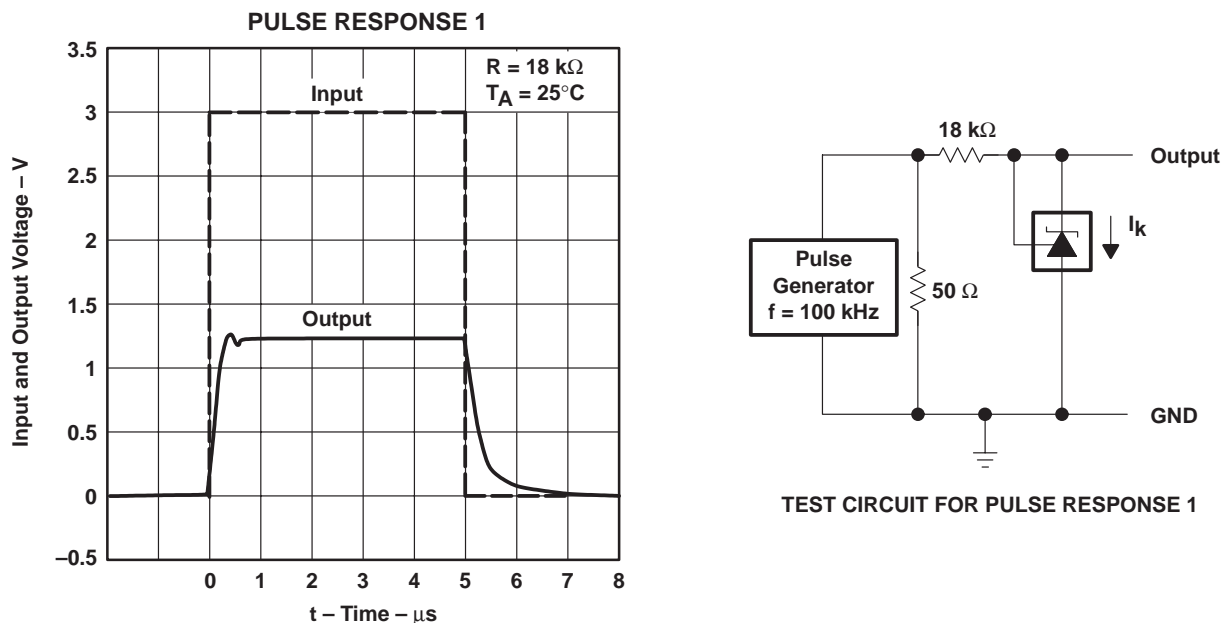


Figure 15

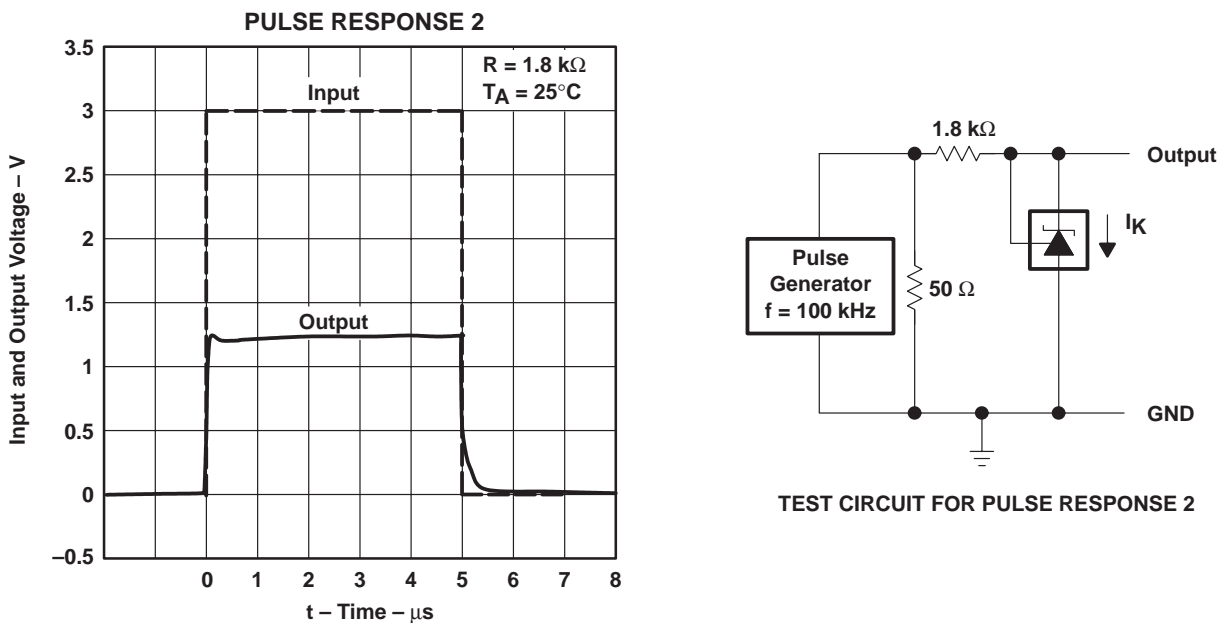
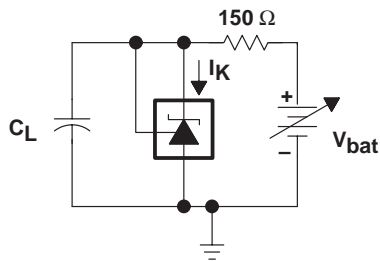
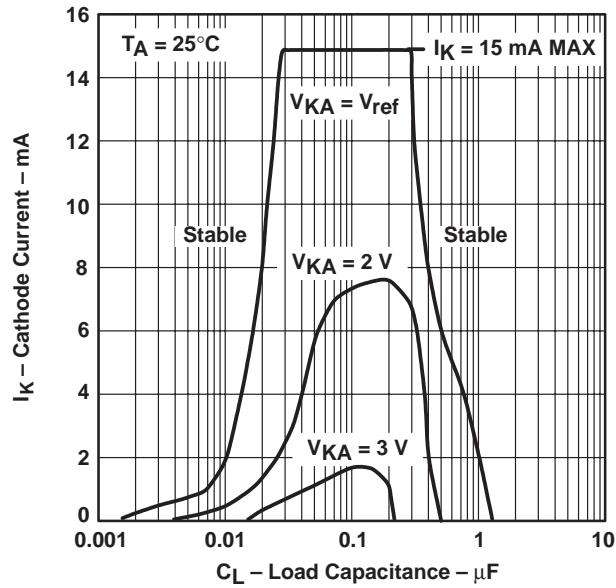


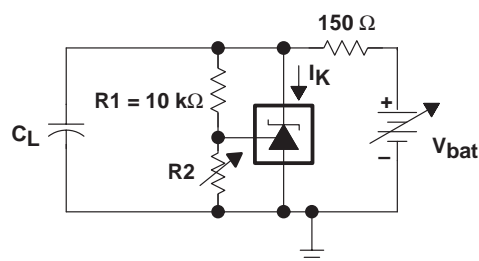
Figure 16

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,  $R2$  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.



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