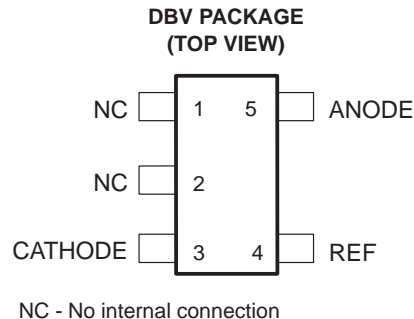


TLV431, TLV431A

LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

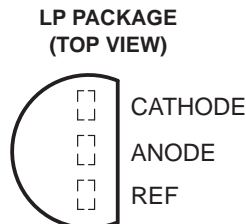
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- Low-Voltage Operation . . . Down to 1.24 V
- 1% Reference Voltage Tolerance (TLV431A)
- Adjustable Output Voltage, $V_O = V_{ref}$ to 6 V
- Low Operational Cathode Current . . . 80 μ A Typ
- 0.25 Ω Typical Output Impedance
- SOT-23 Package
- Package Options Include Plastic SOT-23 (DBV) and Cylindrical (LP) Packages



description

The TLV431 and TLV431A are low-voltage 3-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 on-board 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		CHIP FORM (Y)
	TO-92 (LP)	SOT-23 (DBV)	
0°C to 70°C	TLV431CLP TLV431ACL	TLV431CDBV TLV431ACDBV	TLV431Y
-40°C to 85°C	TLV431ILP TLV431AIL	TLV431IDBV TLV431AIDBV	

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



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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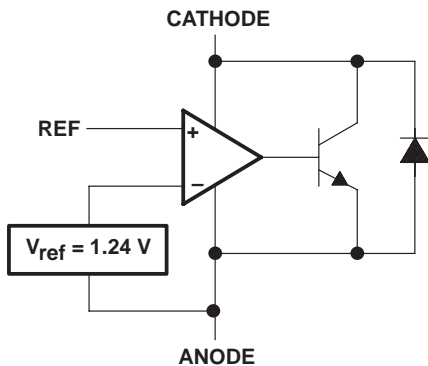
TLV431, TLV431A LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

SLVS139A – JULY 1996 – REVISED APRIL 1998

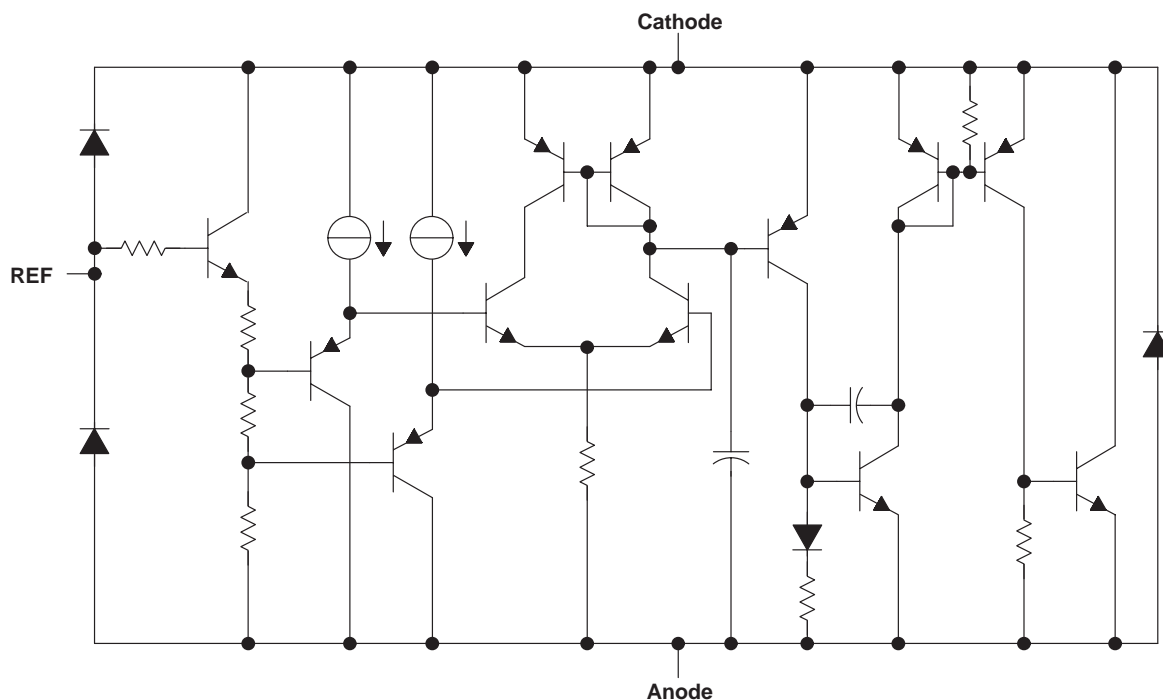
symbol



functional block diagram



equivalent schematic



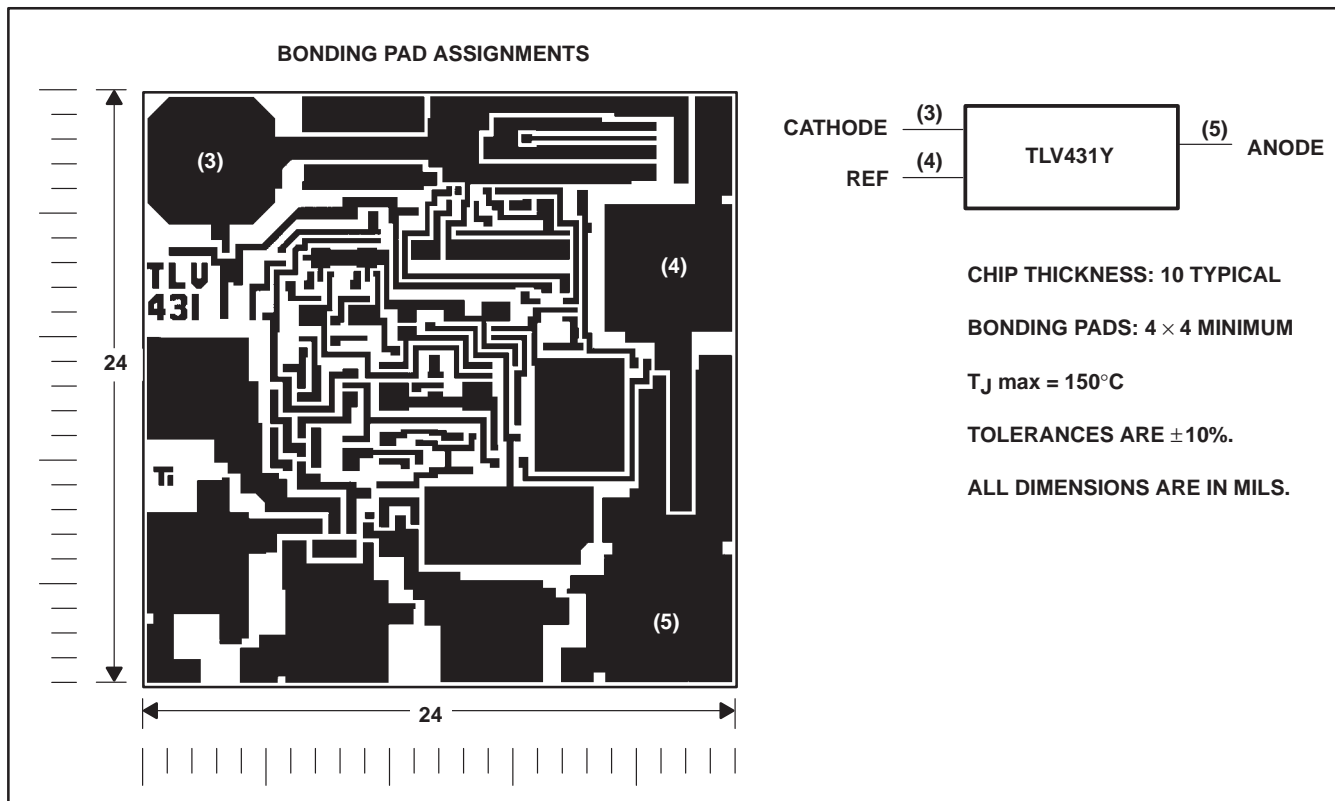
TLV431, TLV431A

LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

SLVS139A – JULY 1996 – REVISED APRIL 1998

TLV431Y chip information

This chip, when properly assembled, displays characteristics similar to the TLV431 and the TLV431A. Thermal compression or ultrasonic bonding can be used on the doped-aluminum bonding pads. These chips can be mounted with conductive epoxy or a gold-silicon preform.



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
Continuous Total Power dissipation, P_D	See Dissipation Rating Table
Storage temperature range, T_{stg}	–65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°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.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING
LP	775 mW	6.2 mW/°C	496 mW	403 mW
DBV	150 mW	1.2 mW/°C	96 mW	78 mW



TLV431, TLV431A

LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

SLVS139A – JULY 1996 – REVISED APRIL 1998

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	

electrical characteristics at 25°C free-air temperature (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	$T_A = 25^\circ\text{C}$	1.222	1.24	1.258	1.222	1.24	1.258	V
		$T_A = \text{full range,}$ (see Note 2 and Figure 1)	1.21		1.27	1.202		1.278	
$V_{ref}(\text{dev})$ V_{ref} deviation over full temperature range (see Note 3)	$V_{KA} = V_{ref}$, $I_K = 10$ mA, (see Note 2 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	$\frac{\text{mV}}{\text{V}}$	
I_{ref} Reference terminal current	$I_K = 10$ mA, $R1 = 10$ k Ω , $R2 = \text{open}$, (see Figure 2)		0.15	0.5		0.15	0.5	μA	
$I_{ref}(\text{dev})$ I_{ref} deviation over full temperature range (see Note 3)	$I_K = 10$ mA, $R1 = 10$ k Ω , $R2 = \text{open}$, (see Note 2 and Figure 2)		0.05	0.3		0.1	0.4	μA	
$I_{K(\text{min})}$ Minimum cathode current for regulation	$V_{KA} = V_{ref}$, (see Figure 1)		55	80		55	80	μA	
$I_{K(\text{off})}$ Off-state cathode current	$V_{KA} = 6$ V, $V_{ref} = 0$, (see Figure 3)		0.001	0.1		0.001	0.1	μA	
$ z_{ka} $ Dynamic impedance (see Note 4)	$V_{KA} = V_{ref}$, $f \leq 1$ kHz, $I_K = 0.1$ mA to 15 mA (see Figure 1)		0.25	0.4		0.25	0.4	Ω	

- NOTES: 2. Full temperature range is -40°C to 85°C for TLV431I, and 0°C to 70°C for the TLV431C.
 3. 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, αV_{ref} , is defined as:

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

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.

4. 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 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

SLVS139A – JULY 1996 – REVISED APRIL 1998

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

PARAMETER	TEST CONDITIONS	TLV431AC			TLV431AI			UNIT			
		MIN	TYP	MAX	MIN	TYP	MAX				
V _{ref}	Reference voltage V _K A = 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 2 and Figure 1)			1.221		1.259	1.215		1.265	
V _{ref(dev)}	V _{ref} deviation over full temperature range (see Note 3)	V _K A = V _{ref} , I _K = 10 mA, (see Note 2 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 _K A = V _{ref} to 6 V, (see Figure 2)			-1.5	-2.7		-1.5	-2.7		$\frac{mV}{V}$
I _{ref}	Reference terminal current	I _K = 10 mA, R1 = 10 kΩ, (see Figure 2)			0.15	0.5		0.15	0.5		μA
I _{ref(dev)}	I _{ref} deviation over full temperature range (see Note 3)	I _K = 10 mA, R1 = 10 kΩ, R2 = open, (see Note 2 and Figure 2)			0.05	0.3		0.1	0.4		μA
I _{K(min)}	Minimum cathode current for regulation	V _K A = V _{ref} , (see Figure 1)			55	80		55	80		μA
I _{K(off)}	Off-state cathode current	V _K A = 6 V, V _{ref} = 0, (see Figure 3)			0.001	0.1		0.001	0.1		μA
z _{ka}	Dynamic impedance (see Note 4)	V _K A = 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: 2. Full temperature range is -40°C to 85°C for TLV431AI, and 0°C to 70°C for the TLV431AC.
3. 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:

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

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.

4. 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 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

SLVS139A – JULY 1996 – REVISED APRIL 1998

electrical characteristics at 25°C free-air temperature

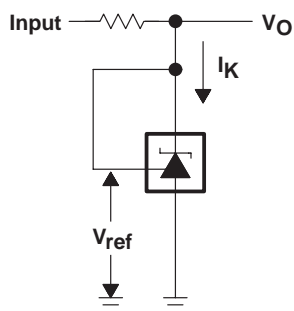
PARAMETER	TEST CONDITIONS	TLV431Y			UNIT
		MIN	TYP	MAX	
V_{ref} Reference voltage	$V_{KA} = V_{ref}$, $I_K = 10 \text{ mA}$, (see Figure 1) $T_A = 25^\circ\text{C}$		1.24		V
$\frac{\Delta V_{ref}}{\Delta V_{KA}}$ Ratio of V_{ref} change in cathode voltage change	$I_K = 10 \text{ mA}$, (see Figure 2) $\Delta V_{KA} = V_{ref} \text{ to } 6 \text{ V}$,		-1.5		$\frac{\text{mV}}{\text{V}}$
I_{ref} Reference terminal current	$I_K = 10 \text{ mA}$, $R_2 = \text{open}$, $R_1 = 10 \text{ k}\Omega$, (see Figure 2)		0.15		μA
$I_{K(\text{min})}$ Minimum cathode current for regulation	$V_{KA} = V_{ref}$, (see Figure 1)		55		μA
I_{off} Off-state cathode current	$V_{KA} = 6 \text{ V}$, $V_{ref} = 0$, (see Figure 3)		0.001		μA
$ z_{ka} $ Dynamic impedance (see Note 4)	$V_{KA} = V_{ref}$, $I_K = 0.1 \text{ mA to } 15 \text{ mA}$ (see Figure 1) $f \leq 1 \text{ kHz}$,		0.25		Ω

NOTE 4: The dynamic impedance is defined as: $|z_{ka}| = \frac{\Delta V_{KA}}{\Delta I_K}$

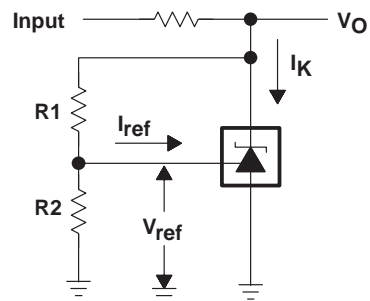
When the device is operating with two external resistors (see Figure 2), the total dynamic impedance of the circuit is given by:

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

PARAMETER MEASUREMENT INFORMATION



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



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

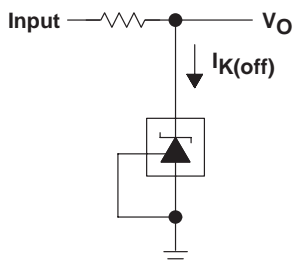


Figure 3. Test Circuit for $I_{K(off)}$

TLV431, TLV431A

LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

SLVS139A – JULY 1996 – REVISED APRIL 1998

PARAMETER MEASUREMENT INFORMATION†

REFERENCE VOLTAGE
vs
JUNCTION TEMPERATURE

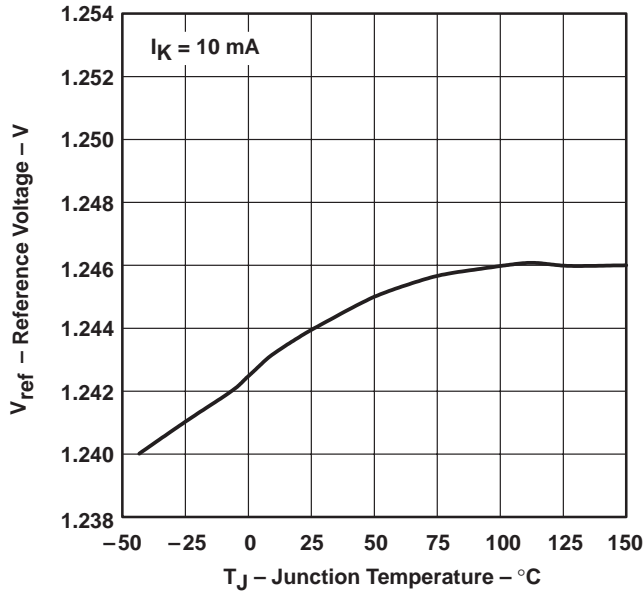


Figure 4

REFERENCE INPUT CURRENT
vs
JUNCTION TEMPERATURE

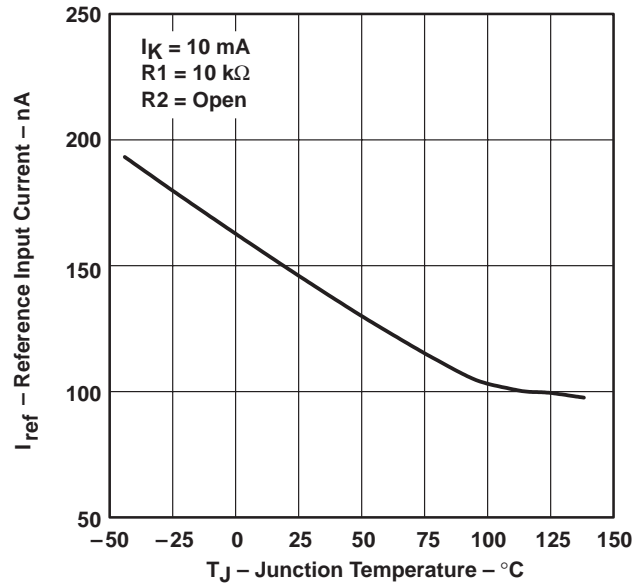


Figure 5

CATHODE CURRENT
vs
CATHODE VOLTAGE

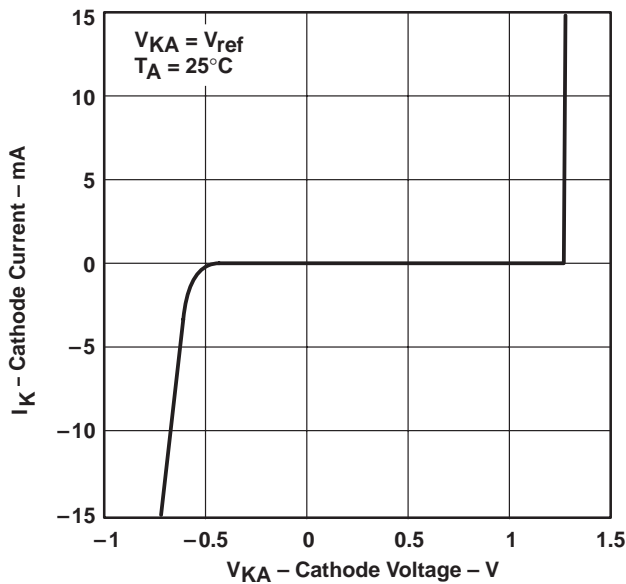


Figure 6

CATHODE CURRENT
vs
CATHODE VOLTAGE

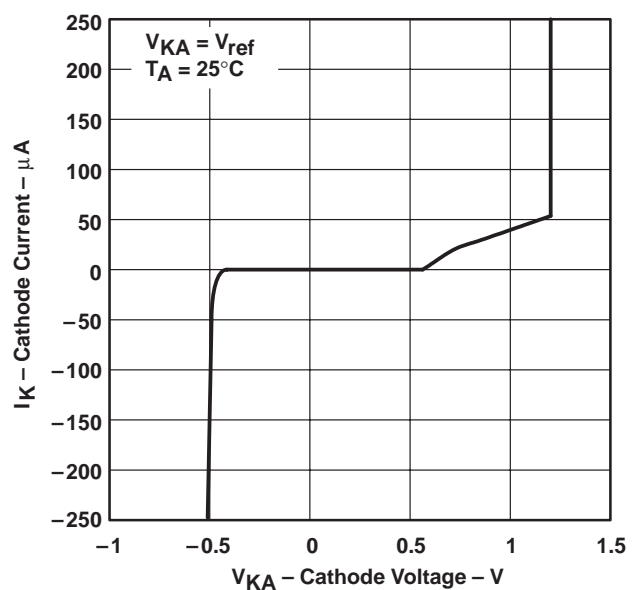
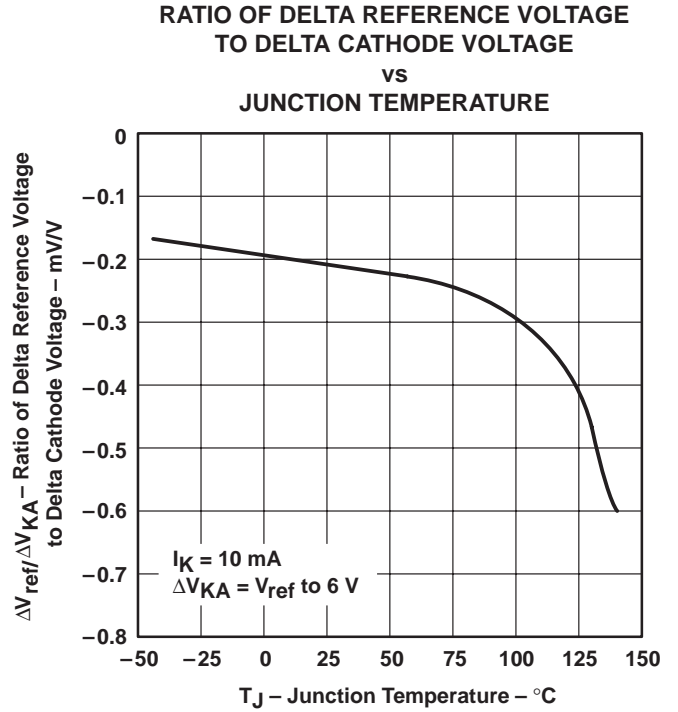
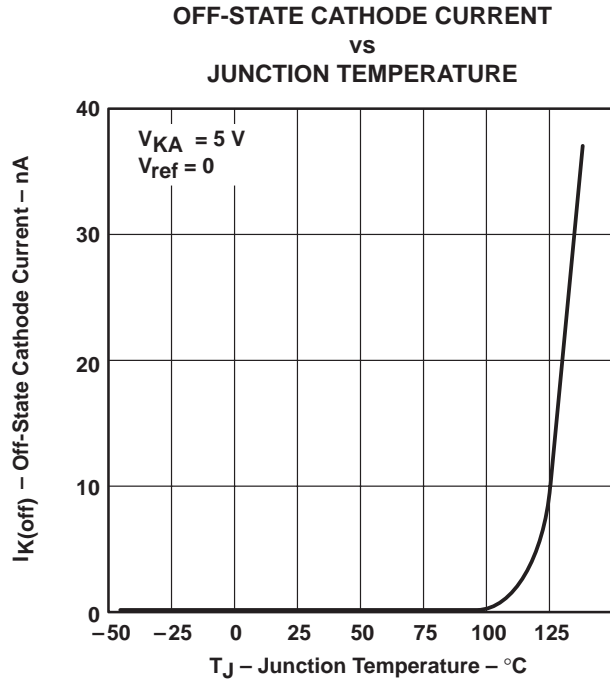


Figure 7

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

PARAMETER MEASUREMENT INFORMATION†

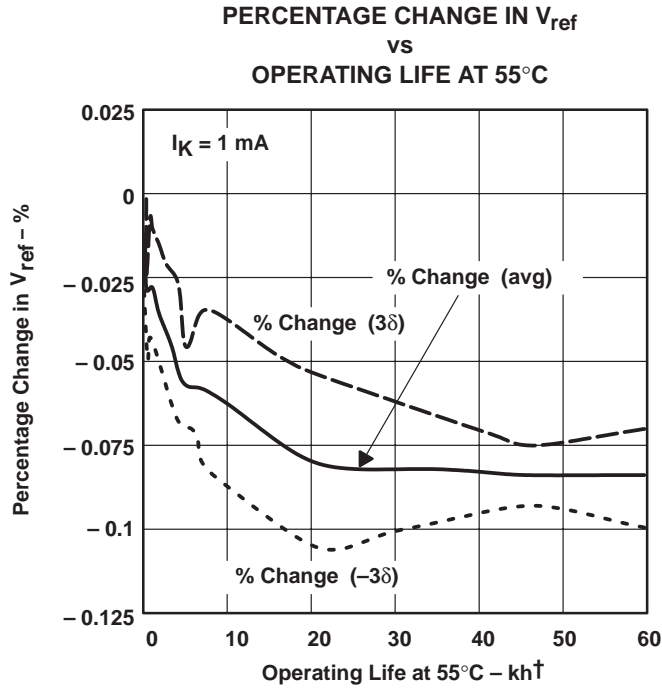


† Operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied.

TLV431, TLV431A LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

SLVS139A – JULY 1996 – REVISED APRIL 1998

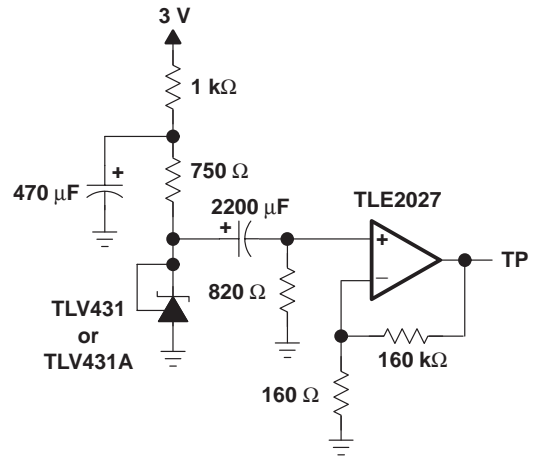
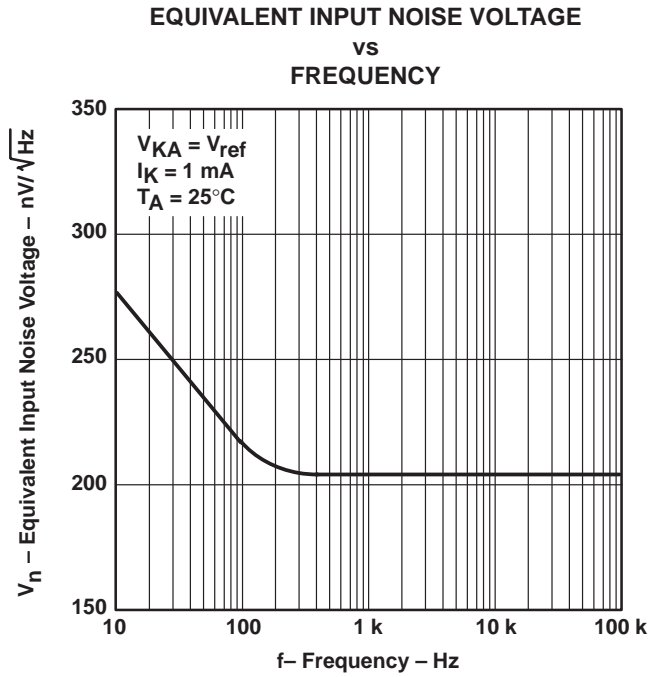
PARAMETER MEASUREMENT INFORMATION



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

Figure 10

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT FOR EQUIVALENT NOISE VOLTAGE

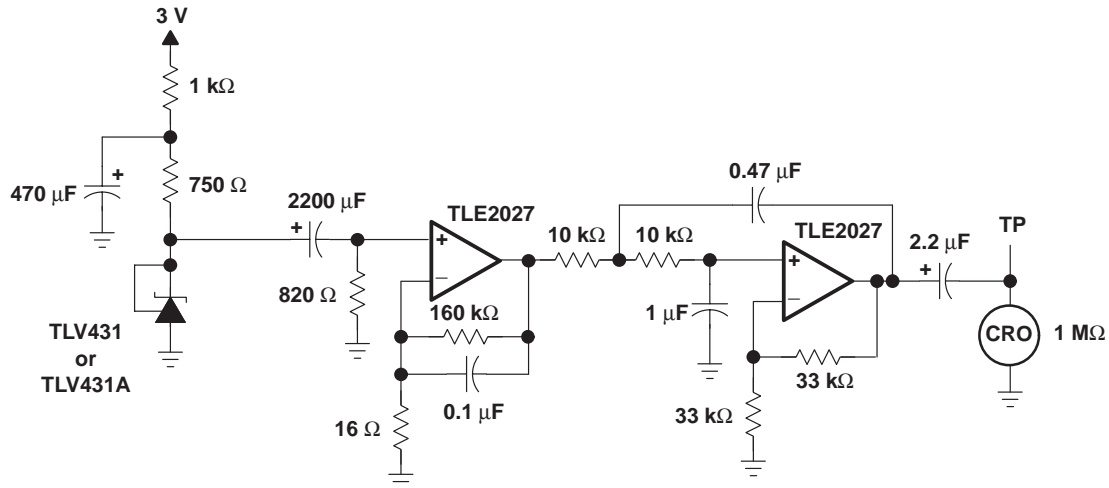
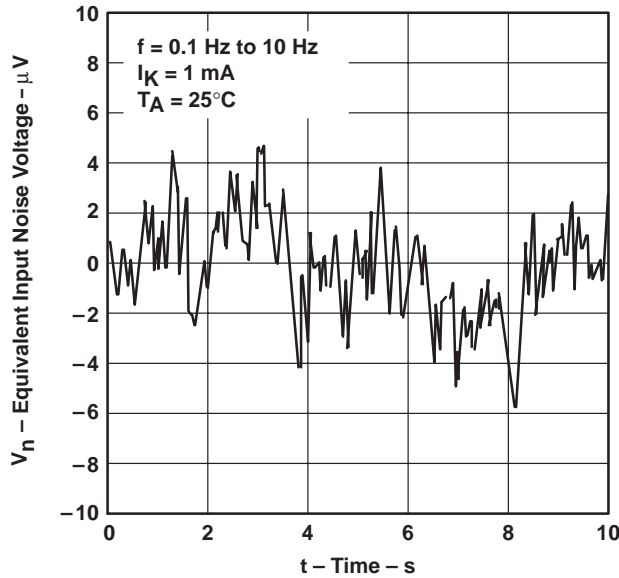
Figure 11

TLV431, TLV431A LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

SLVS139A – JULY 1996 – REVISED APRIL 1998

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

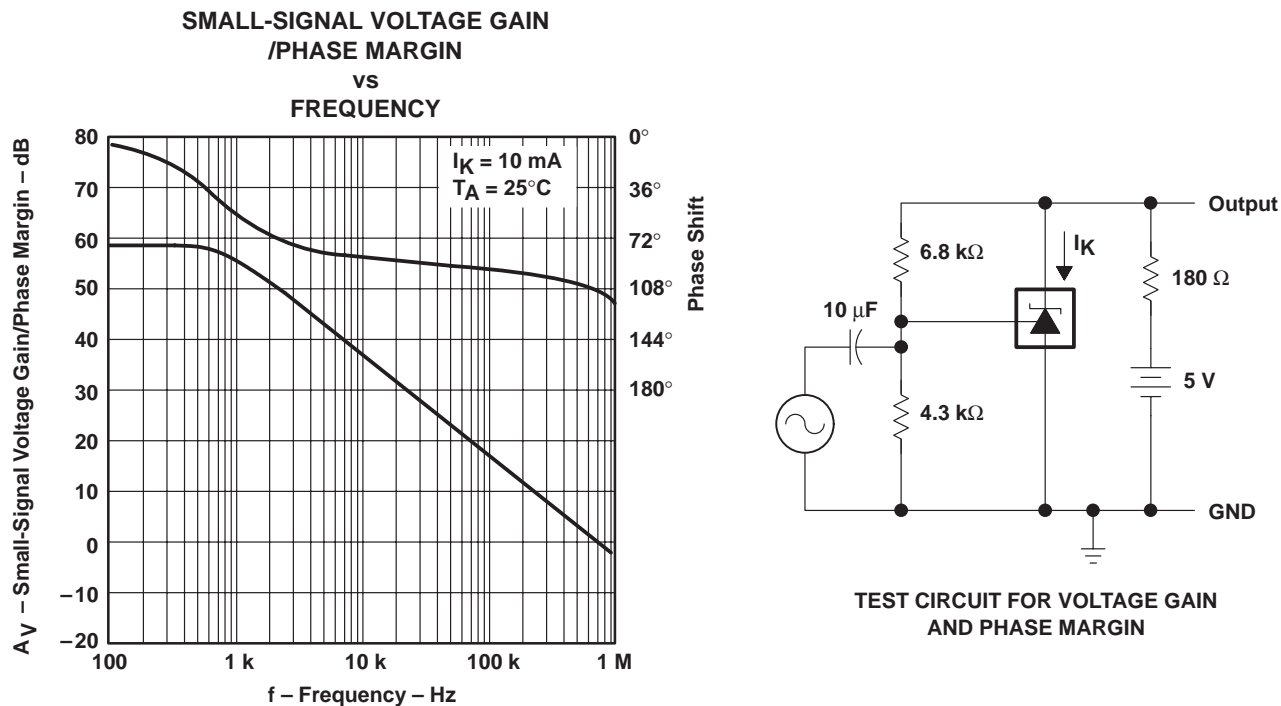


Figure 13

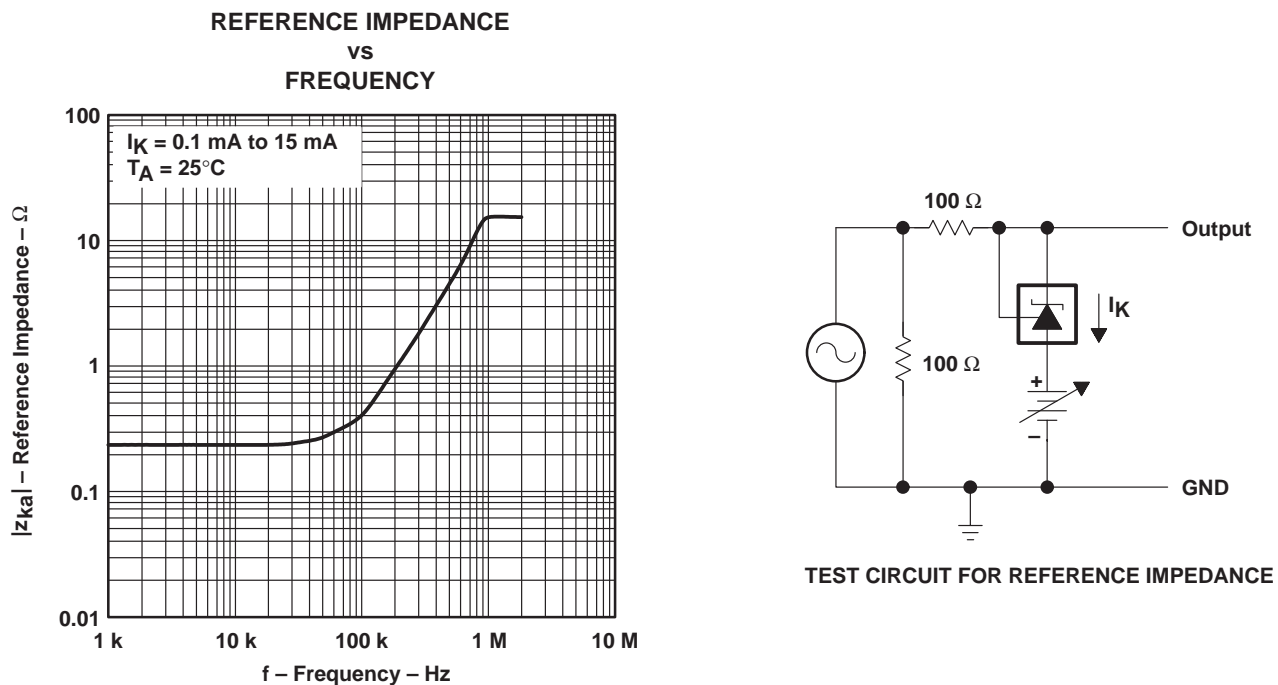


Figure 14

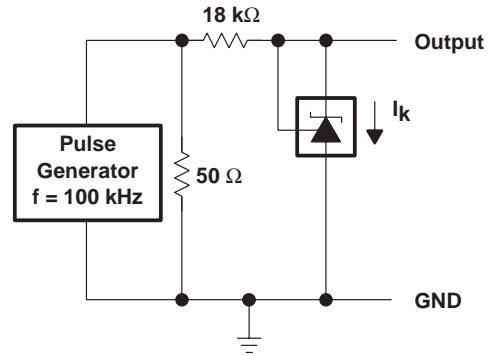
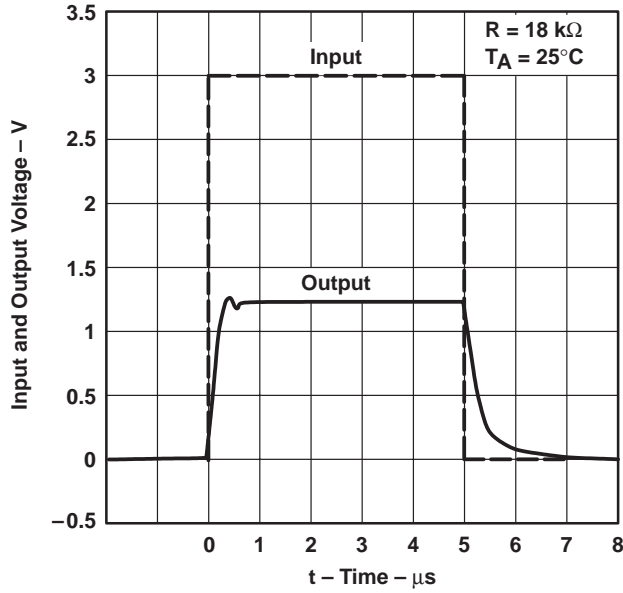
TLV431, TLV431A

LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

SLVS139A – JULY 1996 – REVISED APRIL 1998

PARAMETER MEASUREMENT INFORMATION

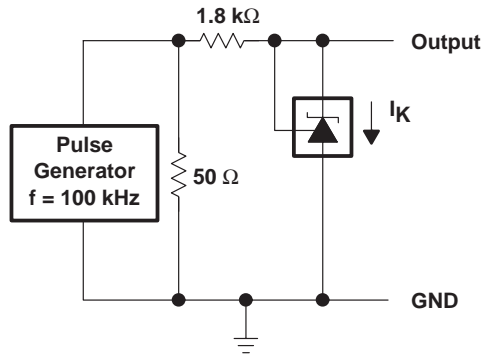
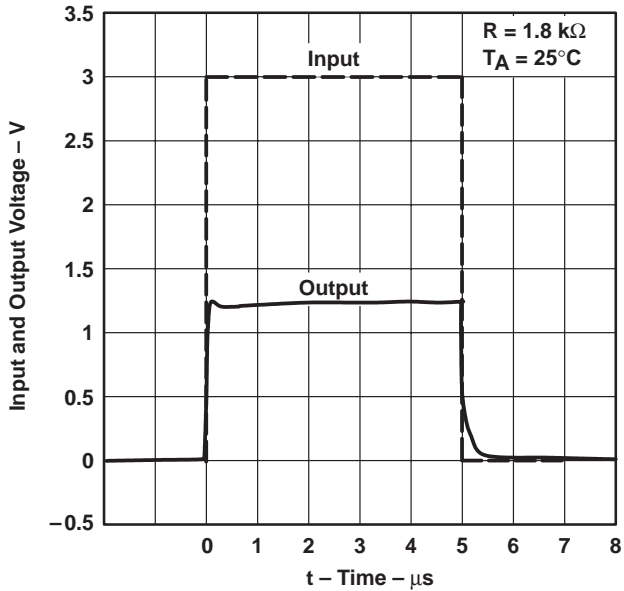
PULSE RESPONSE 1



TEST CIRCUIT FOR PULSE RESPONSE 1

Figure 15

PULSE RESPONSE 2

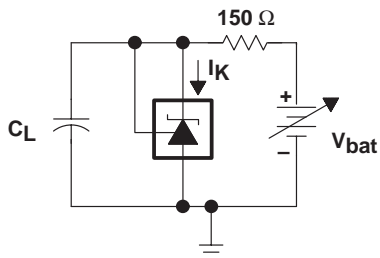
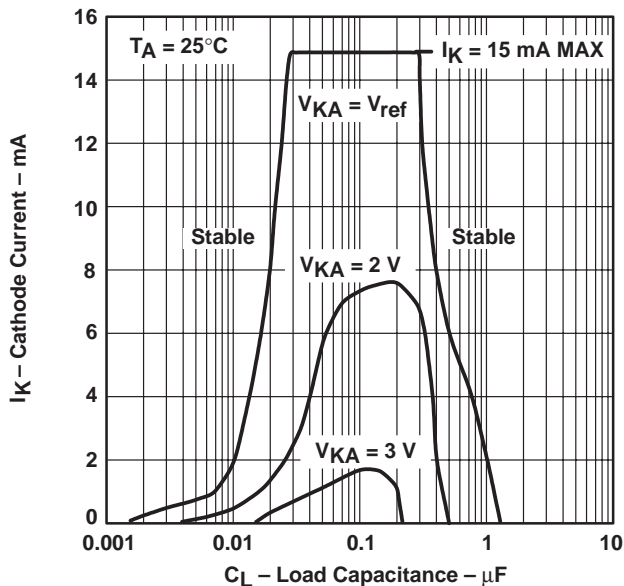


TEST CIRCUIT FOR PULSE RESPONSE 2

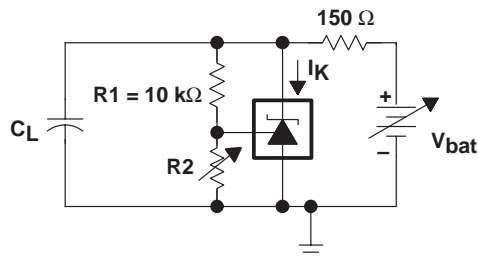
Figure 16

PARAMETER MEASUREMENT INFORMATION†

STABILITY BOUNDARY CONDITION‡



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



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

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

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

TLV431, TLV431A

LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

SLVS139A – JULY 1996 – REVISED APRIL 1998

APPLICATION INFORMATION

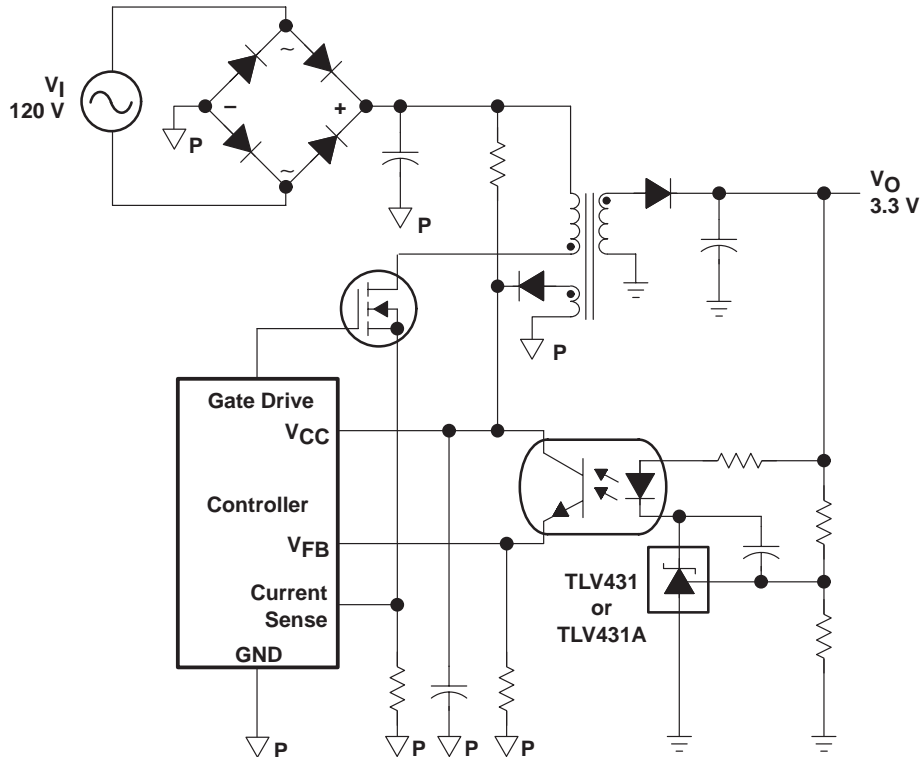


Figure 18. Flyback With Isolation Using TLV431 or TLV431A as Voltage Reference and Error Amplifier

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 in the above topology.

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