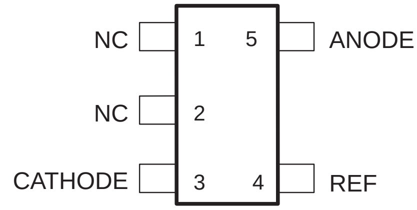
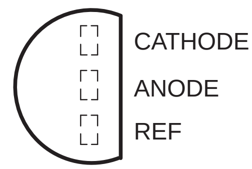
- **Low-Voltage Operation . . . Down to 1.24 V**
- **1% Reference Voltage Tolerance (TLV431A)**
- **Adjustable Output Voltage, $V_O = V_{ref}$ to 6 V**
- **Low Operational Cathode Current . . . 80 μA Typ**
- **0.25 Ω Typical Output Impedance**
- **SOT-23 Package**
- **Package Options Include Plastic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

DBV PACKAGE
(TOP VIEW)



NC - No internal connection

LP PACKAGE
(TOP VIEW)



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.

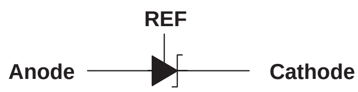
AVAILABLE OPTIONS

T_A	PACKAGED DEVICES		CHIP FORM (Y)
	TO-92 (LP)	SOT-23 (DBV)	
0°C to 70°C	TLV431CLP TLV431ACLP	TLV431CDBV TLV431ACDBV	TLV431Y
–40°C to 85°C	TLV431ILP TLV431AILP	TLV431IDBV TLV431AIDBV	

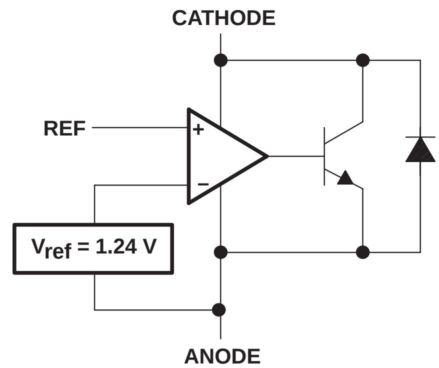
The LP package is available taped and reeled. Add R suffix to device type (e.g., TLV431ACLPR). The DBV is only available taped and reeled.

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.

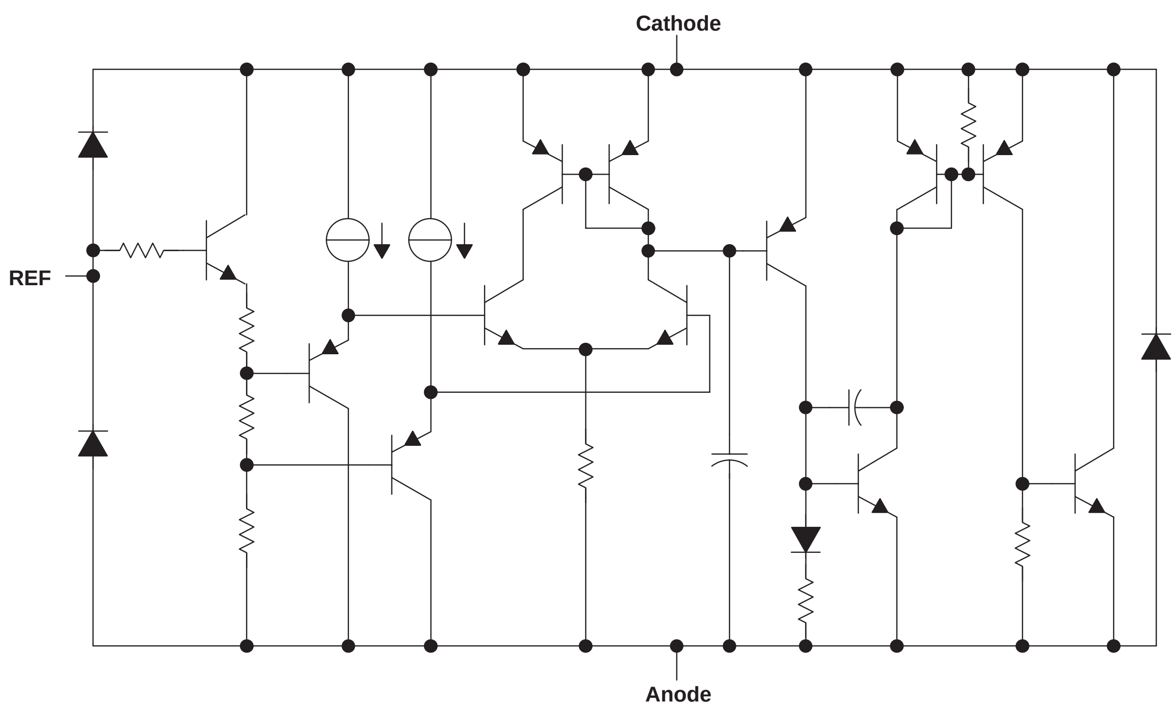
symbol



functional block diagram



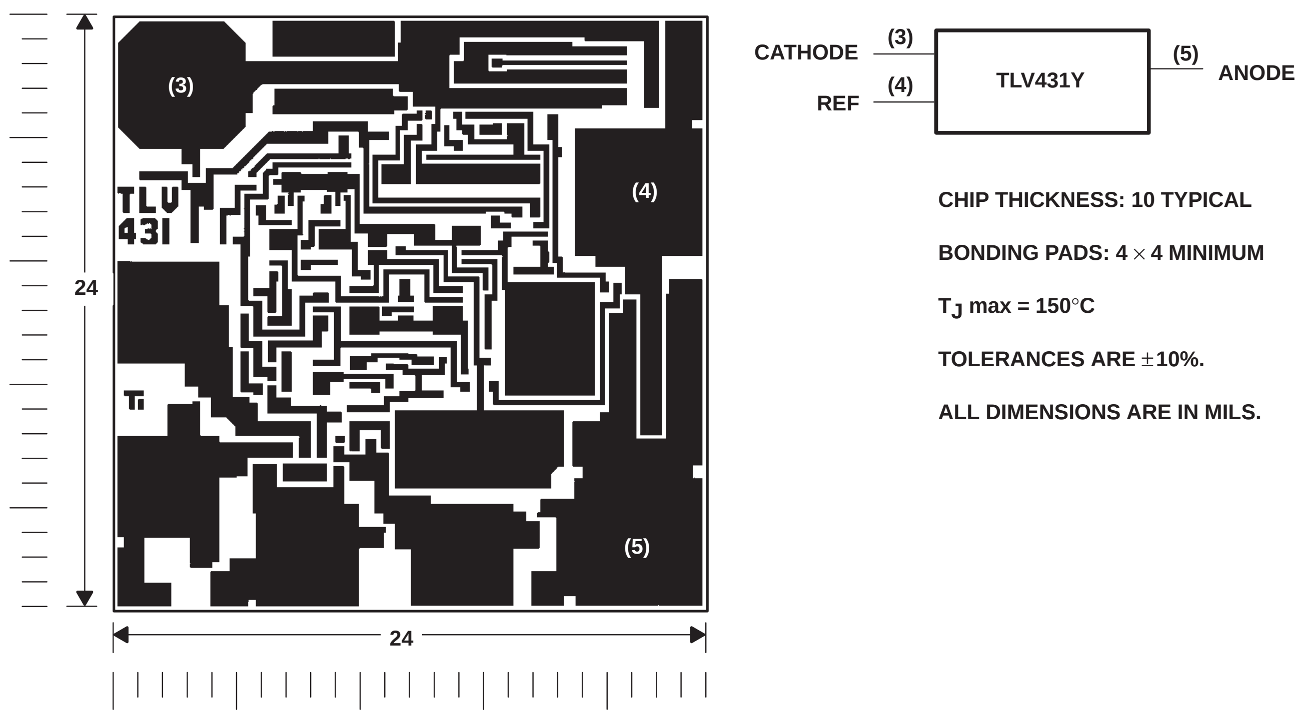
equivalent schematic



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.

BONDING PAD ASSIGNMENTS



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	$T_A \le 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING
LP	775 mW	6.2 mW/°C	496 mW	403 mW
DBV	150 mW	1.2 mW/°C	96 mW	78 mW

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°C	1.222	1.24	1.258	1.222	1.24	1.258	V
			T_A = full range, (see Note 2 and Figure 1)	1.21		1.27	1.202		1.278	
$V_{ref(dev)}$	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	$\frac{mV}{V}$
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 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	$V_{KA} = V_{ref}$, (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 4)	$V_{KA} = V_{ref}$, f ≤ 1 kHz, I_K = 0.1 mA to 15 mA (see Figure 1)			0.25	0.4		0.25	0.4	Ω

NOTES: 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 $V_{ref(dev)}$ 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.

α_{Vref} 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: $\left|z_{ka}\right| = \frac{\Delta V_{KA}}{\Delta I_K}$

When the device is operating with two external resistors (see Figure 2), the total dynamic impedance of the circuit is 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 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	$V_{KA} = V_{ref}$, 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 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)	$V_{KA} = V_{ref}$, 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	$\frac{mV}{V}$
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	$V_{KA} = V_{ref}$, (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 4)	$V_{KA} = V_{ref}$, f ≤ 1 kHz, I_K = 0.1 mA to 15 mA (see Figure 1)			0.25	0.4		0.25	0.4	Ω

NOTES: 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:

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

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.

4. 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 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 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 mA, (see Figure 1)	T_A = 25°C		1.24		V
$\frac{\Delta V_{ref}}{\Delta V_{KA}}$	Ratio of V_{ref} change in cathode voltage change	I_K = 10 mA, (see Figure 2)	$\Delta V_{KA} = V_{ref}$ to 6 V,		–1.5		$\frac{mV}{V}$
I_{ref}	Reference terminal current	I_K = 10 mA, R2 = open,	R1 = 10 kΩ, (see Figure 2)		0.15		µA
$I_{K(min)}$	Minimum cathode current for regulation	$V_{KA} = V_{ref}$,	(see Figure 1)		55		µA
I_{off}	Off-state cathode current	V_{KA} = 6 V, (see Figure 3)	V_{ref} = 0,		0.001		µA
$\lvert z_{ka} \rvert$	Dynamic impedance (see Note 4)	$V_{KA} = V_{ref}$, I_K = 0.1 mA to 15 mA (see Figure 1)	f ≤ 1 kHz,		0.25		Ω

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

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

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

PARAMETER MEASUREMENT INFORMATION

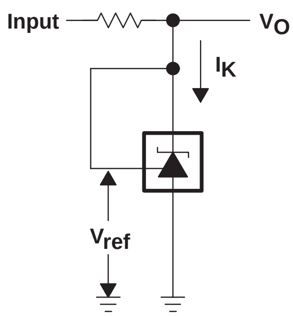


Figure 1. Test Circuit for $V_{KA} = V_{ref}$, $V_O = V_{KA} = V_{ref}$

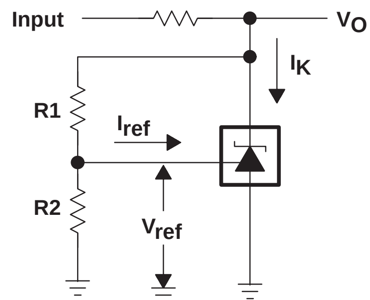


Figure 2. Test Circuit for $V_{KA} > V_{ref}$, $V_O = V_{KA} = V_{ref} \times (1 + R1/R2) + I_{ref} \times R1$

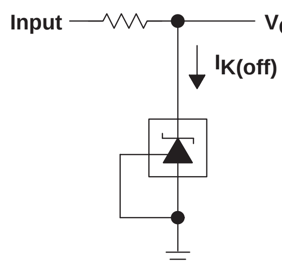


Figure 3. Test Circuit for $I_{K(off)}$

PARAMETER MEASUREMENT INFORMATION†

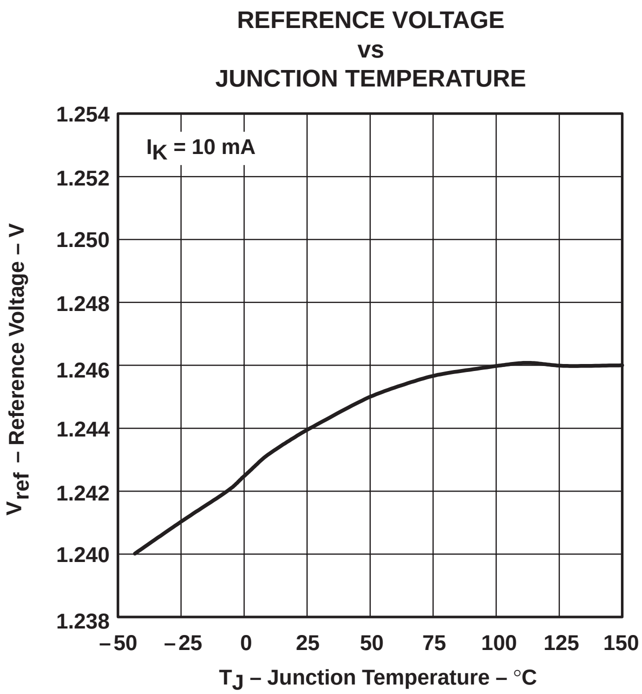


Figure 4

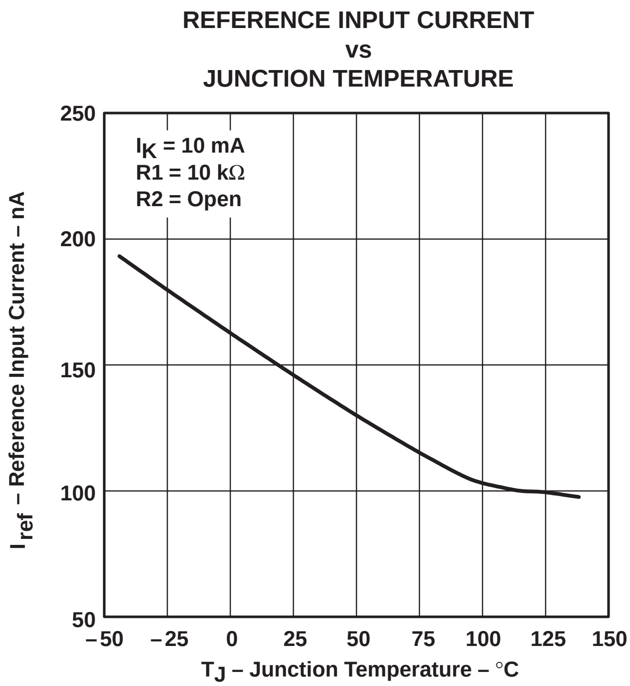


Figure 5

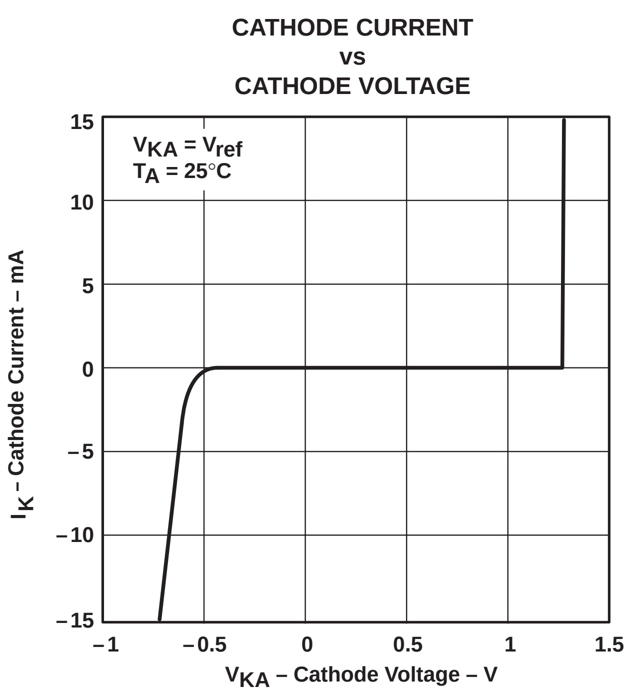


Figure 6

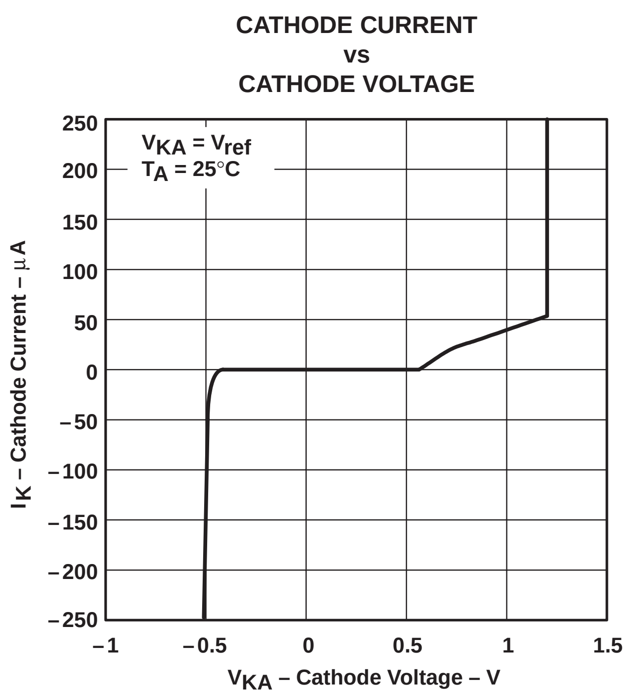


Figure 7

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

PARAMETER MEASUREMENT INFORMATION†

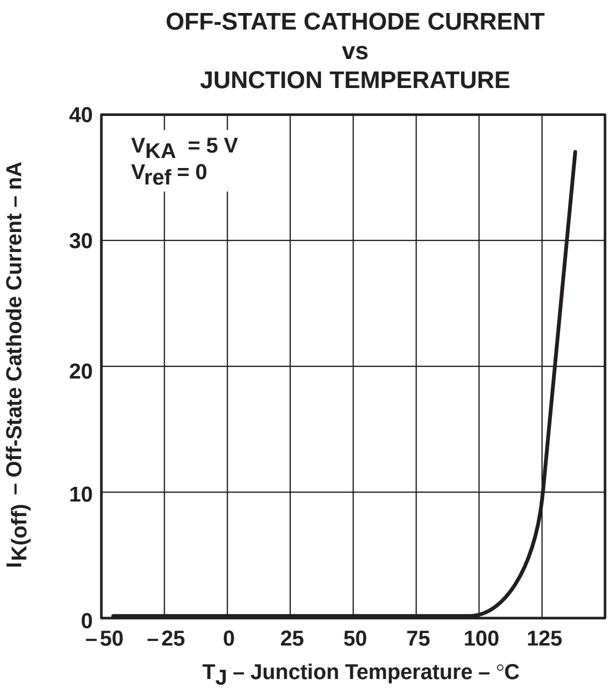


Figure 8

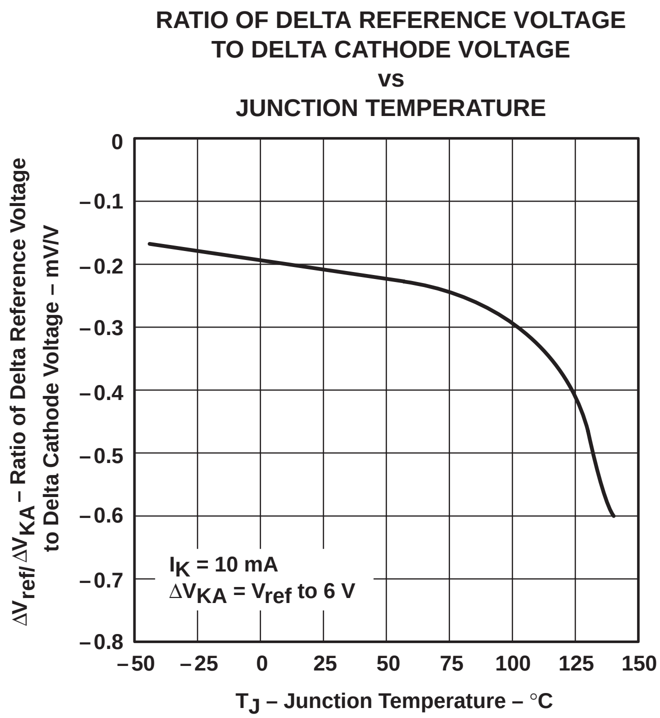
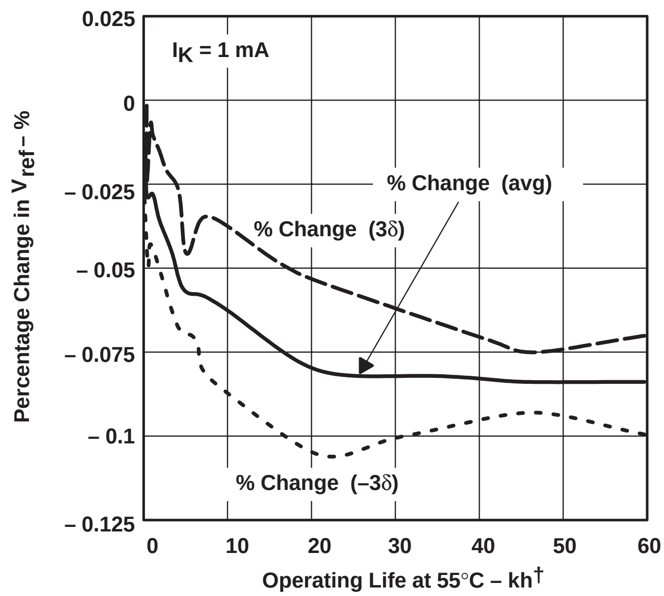


Figure 9

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

PARAMETER MEASUREMENT INFORMATION

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

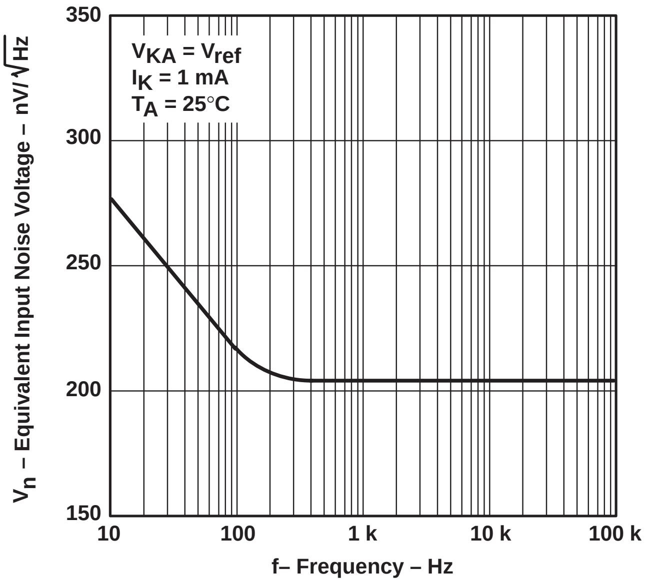


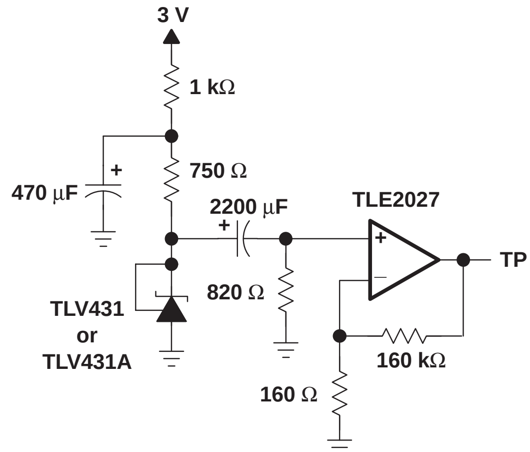
† Extrapolated from life-test data taken at 125°C; the activation energy assumed is 0.7 eV.

Figure 10

PARAMETER MEASUREMENT INFORMATION

EQUIVALENT INPUT NOISE VOLTAGE
vs
FREQUENCY



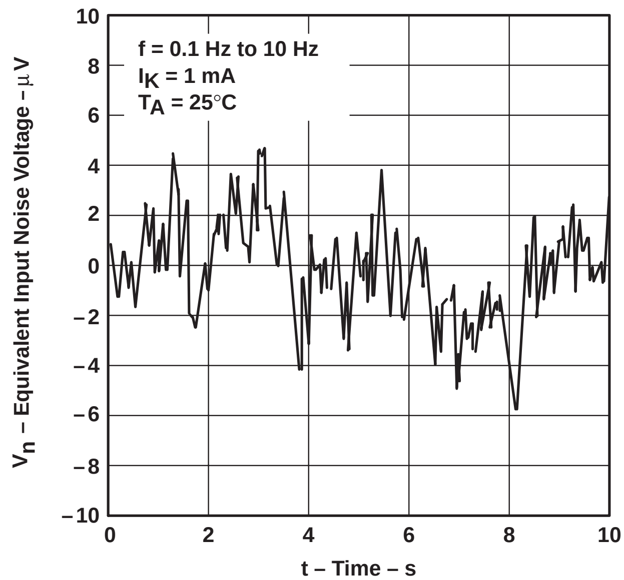


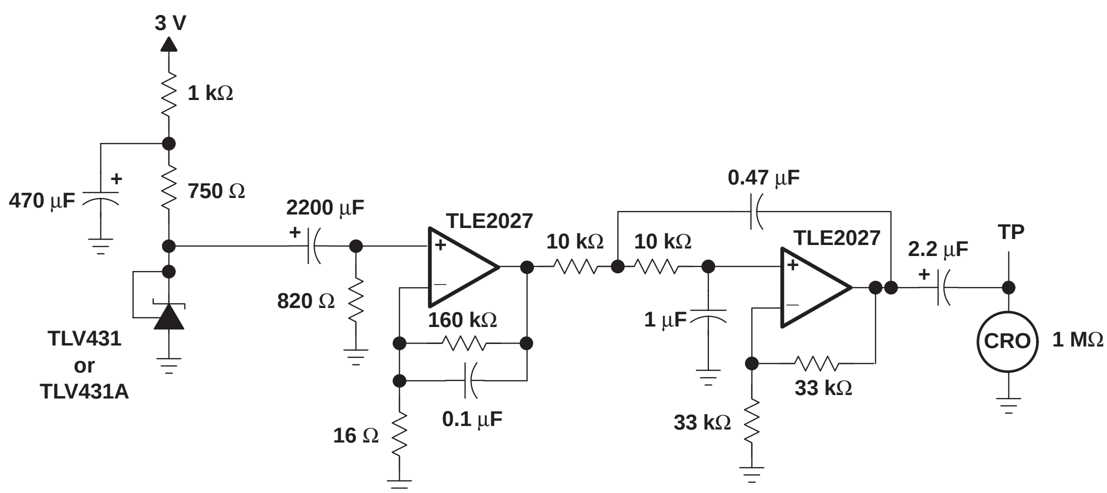
TEST CIRCUIT FOR EQUIVALENT NOISE VOLTAGE

Figure 11

PARAMETER MEASUREMENT INFORMATION

EQUIVALENT INPUT NOISE VOLTAGE
OVER A 10-SECOND PERIOD



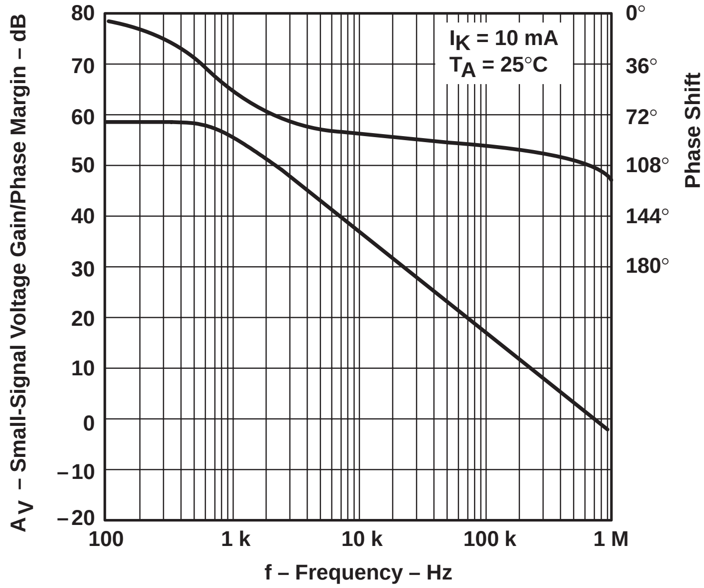


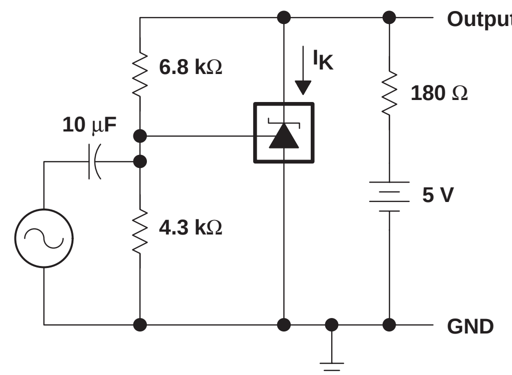
TEST CIRCUIT FOR 0.1-Hz TO 10-Hz EQUIVALENT NOISE VOLTAGE

Figure 12

PARAMETER MEASUREMENT INFORMATION

SMALL-SIGNAL VOLTAGE GAIN
/PHASE MARGIN
vs
FREQUENCY

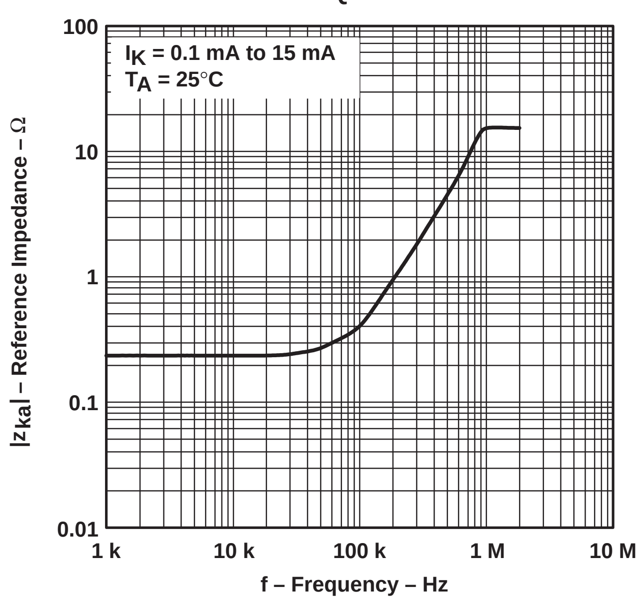


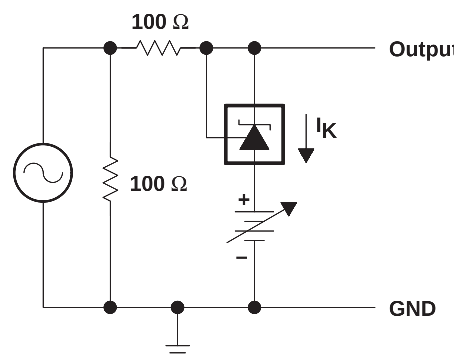


TEST CIRCUIT FOR VOLTAGE GAIN
AND PHASE MARGIN

Figure 13

REFERENCE IMPEDANCE
vs
FREQUENCY

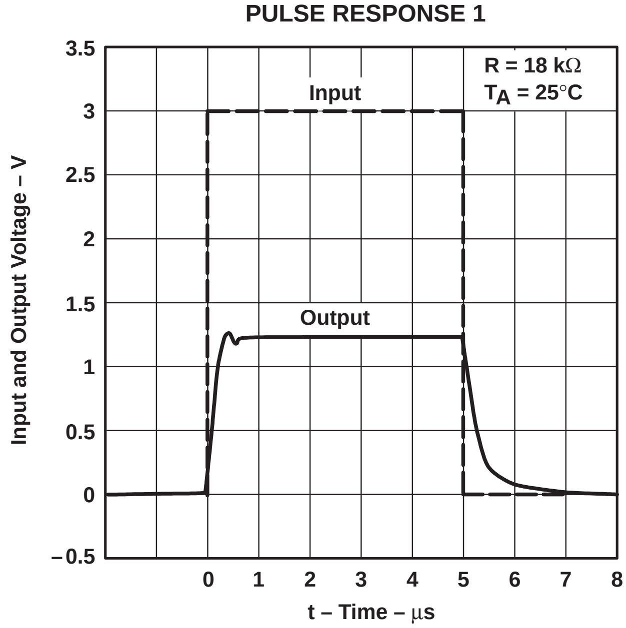


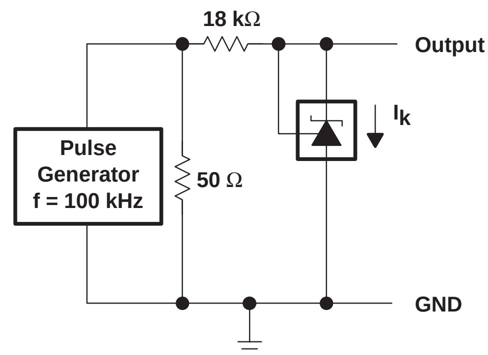


TEST CIRCUIT FOR REFERENCE IMPEDANCE

Figure 14

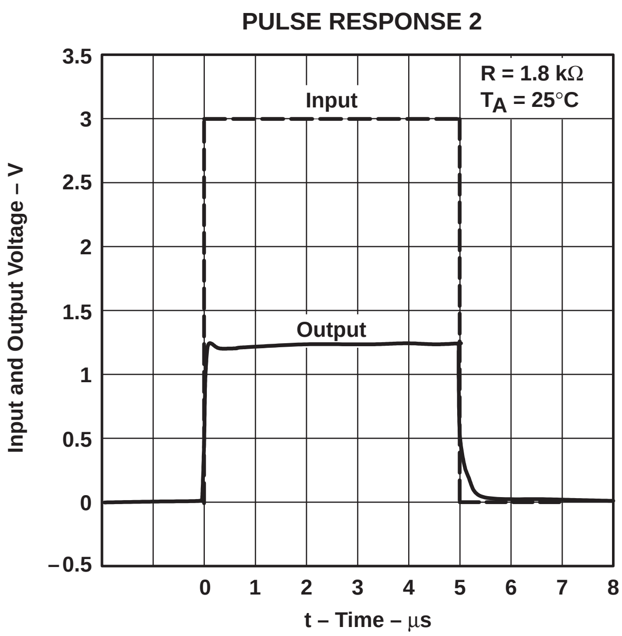
PARAMETER MEASUREMENT INFORMATION

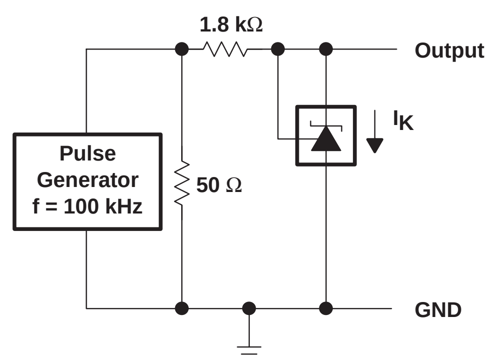




TEST CIRCUIT FOR PULSE RESPONSE 1

Figure 15



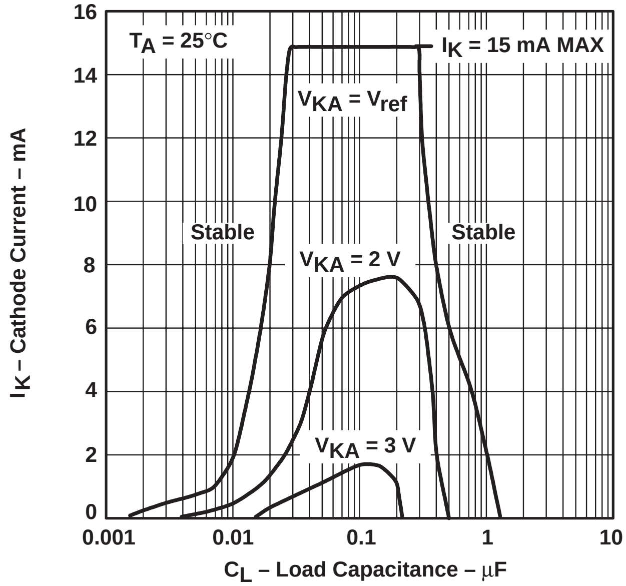


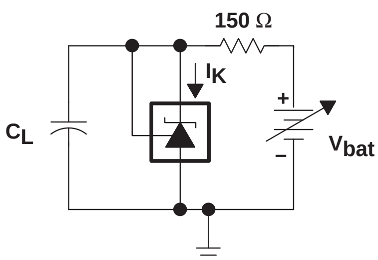
TEST CIRCUIT FOR PULSE RESPONSE 2

Figure 16

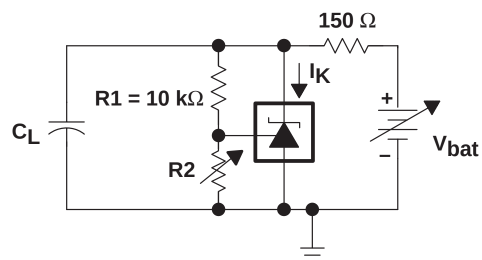
PARAMETER MEASUREMENT INFORMATION†

STABILITY BOUNDARY CONDITION‡





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



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

† 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 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

APPLICATION INFORMATION

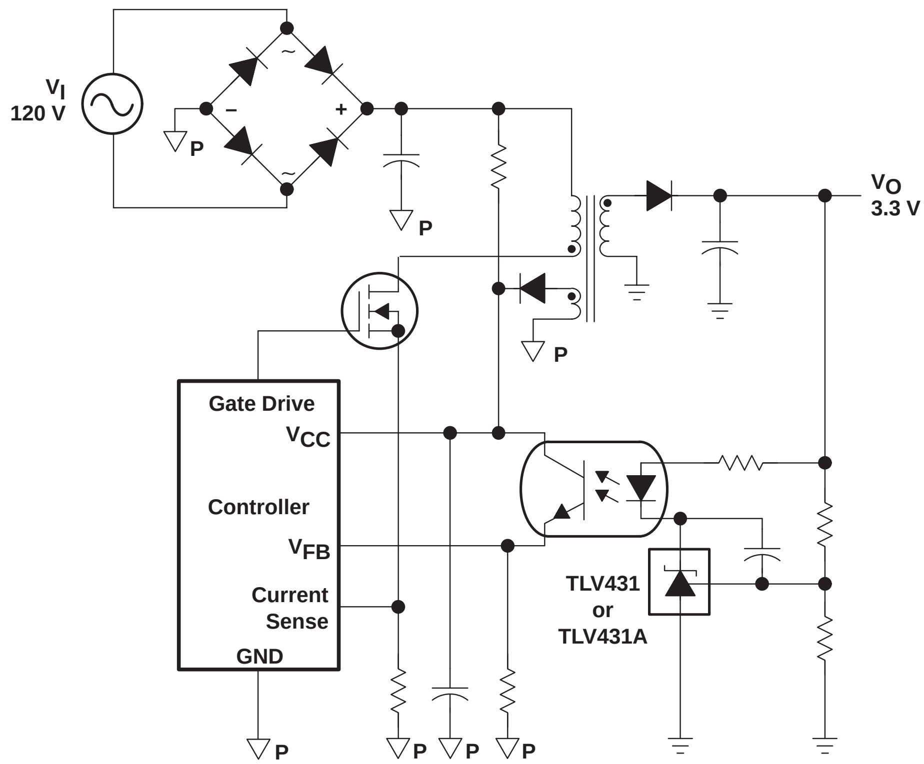


Figure 18. Flyback With Isolation Using TLV431 or TLV431A as Voltage Reference and Error Amplifier

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 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 above topology.