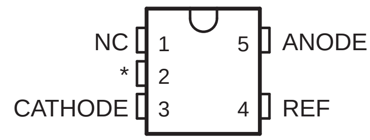
LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATORS

Check for Samples: TLVH431A-Q1, TLVH431B-Q1

FEATURES

- **Qualified for Automotive Applications**
- **Low-Voltage Operation: Down to 1.24 V**
- **Reference Voltage Tolerances at 25°C**
  - **0.5% for B Grade**
  - **1% for A Grade**
- **Adjustable Output Voltage, $V_O = V_{REF}$ to 18 V**
- **Wide Operating Cathode Current Range: 100 μA to 70 mA**
- **0.25-Ω Typical Output Impedance**
- **–40°C to 125°C Specifications**

DBV (SOT-23-5) PACKAGE
(TOP VIEW)



NC − No internal connection

* Pin 2 is attached to Substrate and must be connected to ANODE or left open.

DESCRIPTION/ORDERING INFORMATION

The TLVH431 devices are low-voltage 3-terminal adjustable voltage references, with thermal stability specified over the automotive temperature range. Output voltage can be set to any value between V_{REF} (1.24 V) and 18 V with two external resistors (see Figure 2). These devices operate from a lower voltage (1.24 V) than the widely used TL431 and TL1431 shunt-regulator references.

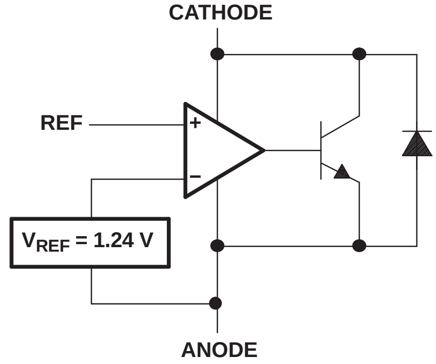
When used with an optocoupler, the TLVH431 devices are ideal voltage reference in isolated feedback circuits for 3-V to 3.3-V switching-mode power supplies. They have a typical output impedance of 0.25 Ω. Active output circuitry provides a very sharp turn-on characteristic, making the TLVH431 an excellent replacement for low-voltage Zener diodes in many applications, including on-board regulation and adjustable power supplies.

ORDERING INFORMATION(1)

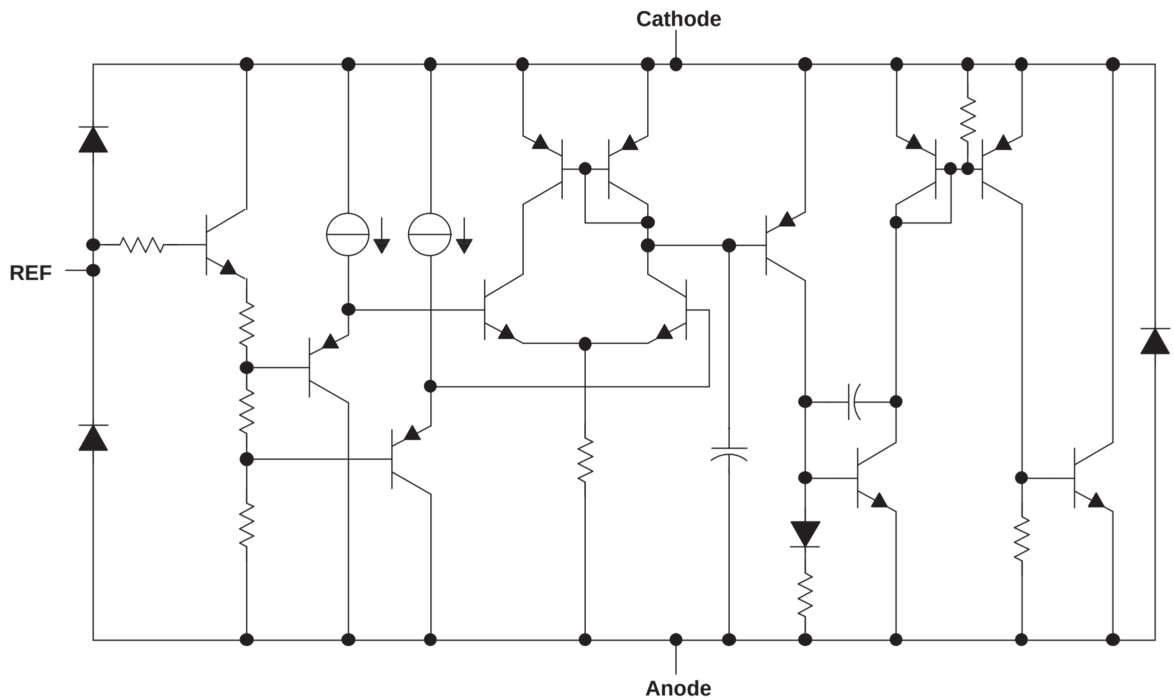
T_A	V_{REF} TOLERANCE	PACKAGE(2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	0.5%	SOT-23-5 – DBV	Reel of 3000	TLVH431BQDBVRQ1	VOPQ
	1%	SOT-23-5 – DBV	Reel of 3000	TLVH431AQDBVRQ1	VOOQ

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.
(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

LOGIC BLOCK DIAGRAM



EQUIVALENT SCHEMATIC



ABSOLUTE MAXIMUM RATINGS[1]

over operating free-air temperature range (unless otherwise noted)

V_{KA}	Cathode voltage[2]	20 V
I_K	Cathode current range	–25 mA to 80 mA
I_{ref}	Reference current range	–0.05 mA to 3 mA
θ_{JA}	Package thermal impedance[3] [4]	206°C/W
T_J	Operating virtual junction temperature	150°C
T_{stg}	Storage temperature range	–65°C to 150°C

(1) 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.
(2) Voltage values are with respect to the anode terminal, unless otherwise noted.
(3) 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.
(4) The package thermal impedance is calculated in accordance with JESD 51-7.

RECOMMENDED OPERATING CONDITIONS

		MIN	MAX	UNIT
V_{KA}	Cathode voltage	V_{REF}	18	V
I_K	Cathode current (continuous)	0.1	70	mA
T_A	Operating free-air temperature	–40	125	°C

TLVH431A ELECTRICAL CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_{REF}	Reference voltage	$V_{KA} = V_{REF}$, I_K = 10 mA	T_A = 25°C	1.228	1.24	1.252	V
			T_A = full range(1) (see Figure 1)	1.209		1.271	
$V_{REF(dev)}$	V_{REF} deviation over full temperature range(1) (2)	$V_{KA} = V_{REF}$, I_K = 10 mA (see Figure 1)			11	31	mV
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	Ratio of V_{REF} change to cathode voltage change	$V_K = V_{REF}$ to 18 V, I_K = 10 mA (see Figure 2)			–1.5	–2.7	mV/V
I_{ref}	Reference terminal current	I_K = 10 mA, R1 = 10 kΩ, R2 = open (see Figure 2)			0.1	0.5	µA
$I_{ref(dev)}$	I_{ref} deviation over full temperature range(1) (2)	I_K = 10 mA, R1 = 10 kΩ, R2 = open (see Figure 2)			0.15	0.5	µA
$I_{K(min)}$	Minimum cathode current for regulation	$V_{KA} = V_{REF}$ (see Figure 1)			60	100	µA
$I_{K(off)}$	Off-state cathode current	V_{REF} = 0, V_{KA} = 18 V (see Figure 3)			0.02	0.1	µA
$\|z_{KA}\|$	Dynamic impedance(3)	$V_{KA} = V_{REF}$, f ≤ 1 kHz, I_K = 0.1 mA to 70 mA (see Figure 1)			0.25	0.4	Ω

(1) Full temperature range is –40°C to 125°C.
(2) 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:

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

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.
(3) 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 defined as:

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

TLVH431B ELECTRICAL CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_{REF}	Reference voltage	$V_{KA} = V_{REF}$, I_K = 10 mA	T_A = 25°C	1.234	1.24	1.246	V
			T_A = full range(1) (see Figure 1)	1.221		1.265	
$V_{REF(dev)}$	V_{REF} deviation over full temperature range(1) (2)	$V_{KA} = V_{REF}$, I_K = 10 mA (see Figure 1)			11	31	mV
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	Ratio of V_{REF} change to cathode voltage change	I_K = 10 mA, $V_K = V_{REF}$ to 18 V (see Figure 2)			–1.5	–2.7	mV/V
I_{ref}	Reference terminal current	I_K = 10 mA, R1 = 10 kΩ, R2 = open (see Figure 2)			0.1	0.5	µA
$I_{ref(dev)}$	I_{ref} deviation over full temperature range(1) (2)	I_K = 10 mA, R1 = 10 kΩ, R2 = open (see Figure 2)			0.15	0.5	µA
$I_{K(min)}$	Minimum cathode current for regulation	$V_{KA} = V_{REF}$ (see Figure 1)			60	100	µA
$I_{K(off)}$	Off-state cathode current	V_{REF} = 0, V_{KA} = 18 V (see Figure 3)			0.02	0.1	µA
$\lvert z_{KA} \rvert$	Dynamic impedance(3)	$V_{KA} = V_{REF}$, f ≤ 1 kHz, I_K = 0.1 mA to 70 mA (see Figure 1)			0.25	0.4	Ω

(1) Full temperature range is –40°C to 125°C.

(2) 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:

$$\left|\alpha V_{REF}\right|\left(\frac{ppm}{^oC}\right) = \frac{\left(\frac{V_{REF(dev)}}{V_{REF}\,(T_A = 25^oC)}\right) \times 10^6}{\Delta T_A}$$

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.

(3) 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 defined as:

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

PARAMETER MEASUREMENT INFORMATION

Operation of the device at any conditions beyond those indicated under *recommended operating conditions* is not implied.

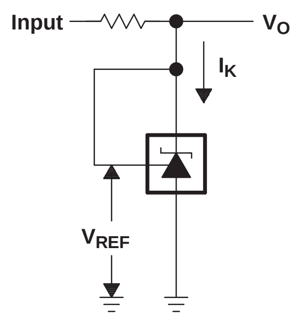


Figure 1. Test Circuit for $V_{KA} = V_{REF}$, $V_O = V_{KA} = V_{REF}$

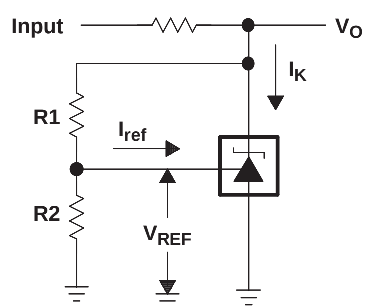


Figure 2. Test Circuit for $V_{KA} > V_{REF}$, $V_O = V_{KA} = V_{REF} \times (1 + R1/R2) + I_{ref} \times R1$

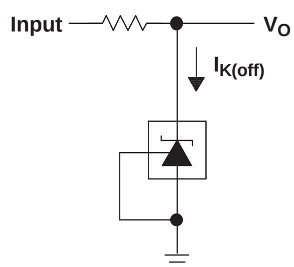


Figure 3. Test Circuit for $I_{K(off)}$

PARAMETER MEASUREMENT INFORMATION (continued)

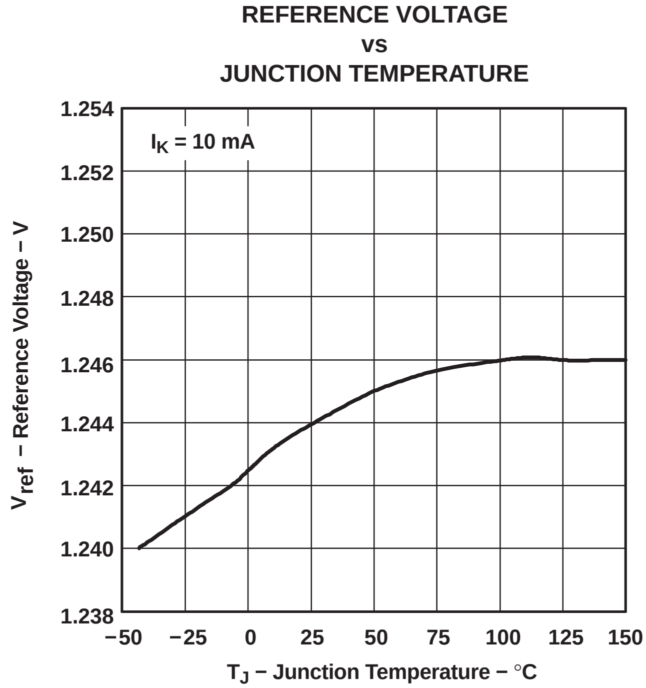


Figure 4.

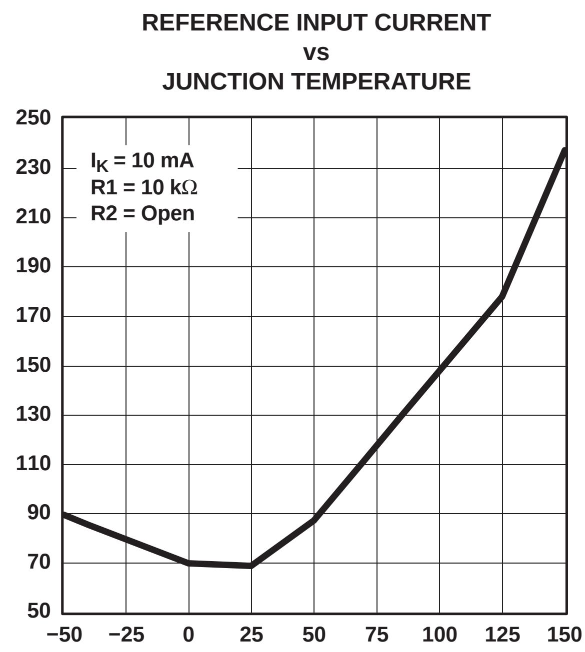


Figure 5.

PARAMETER MEASUREMENT INFORMATION (continued)

CATHODE CURRENT
vs
CATHODE VOLTAGE

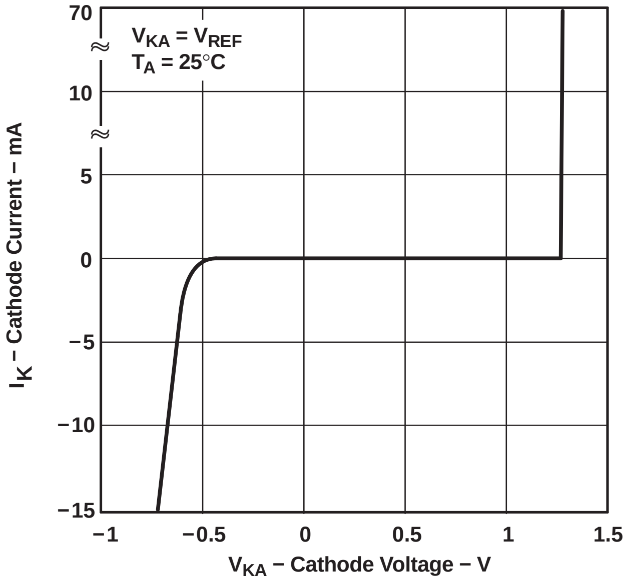


Figure 6.

CATHODE CURRENT
vs
CATHODE VOLTAGE

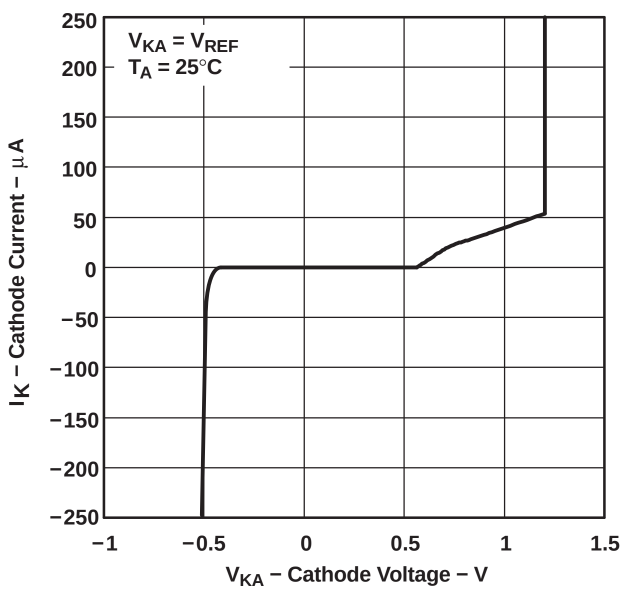


Figure 7.

PARAMETER MEASUREMENT INFORMATION (continued)

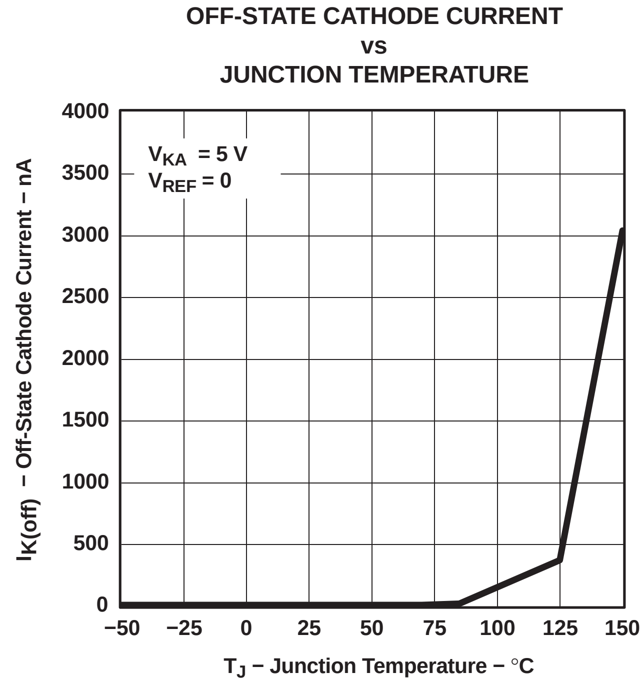


Figure 8.

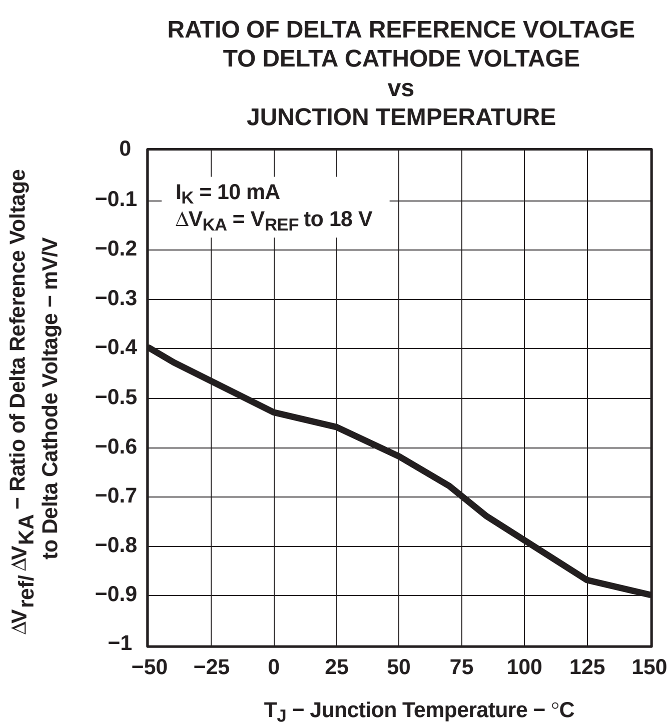
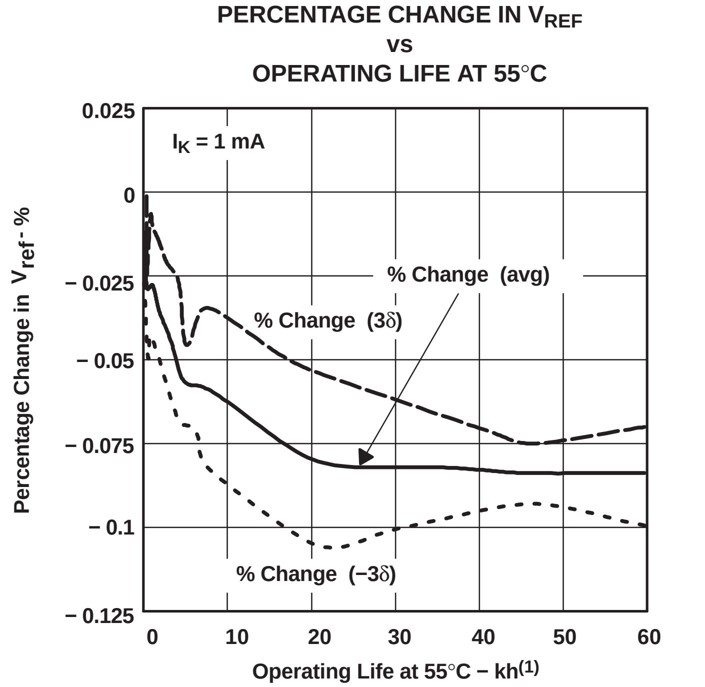


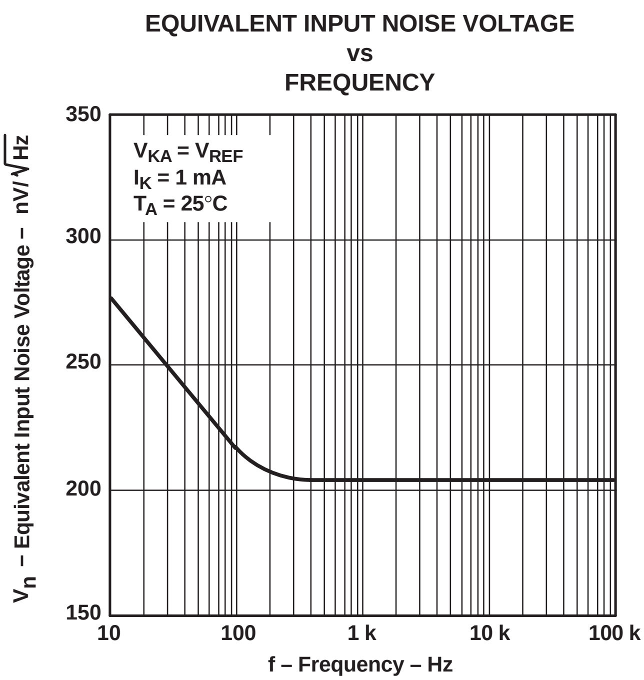
Figure 9.

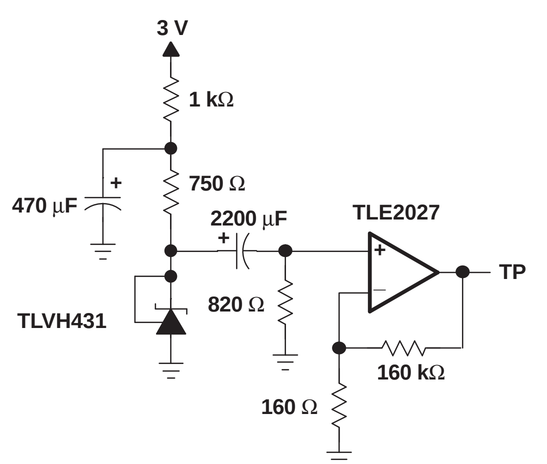
PARAMETER MEASUREMENT INFORMATION (continued)



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

Figure 10.

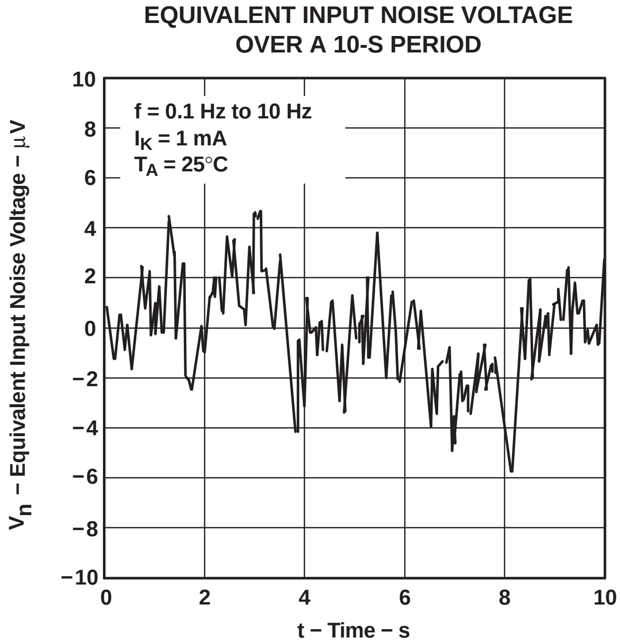


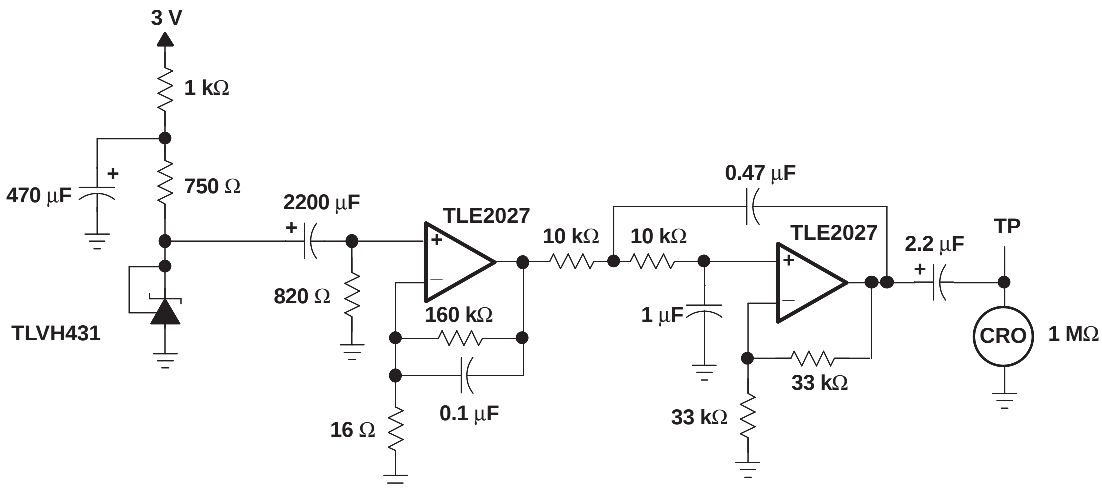


TEST CIRCUIT FOR EQUIVALENT INPUT NOISE VOLTAGE

Figure 11.

PARAMETER MEASUREMENT INFORMATION (continued)





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

Figure 12.

PARAMETER MEASUREMENT INFORMATION (continued)

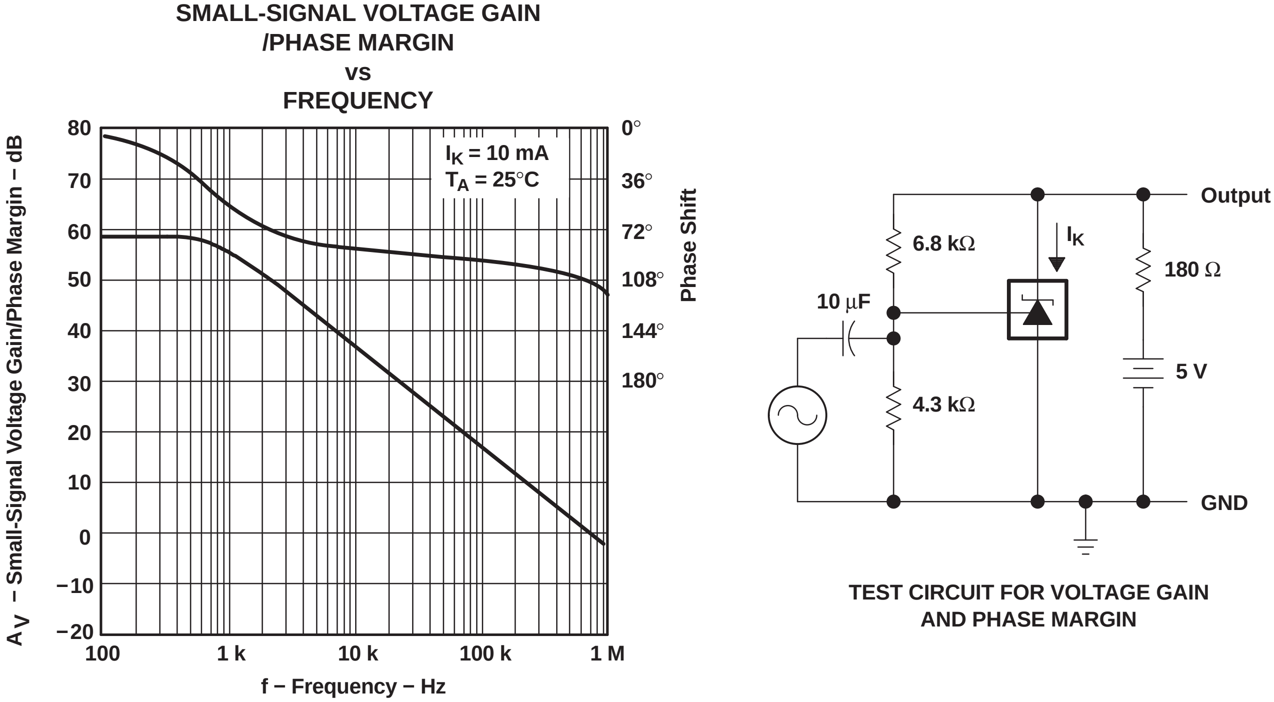


Figure 13.

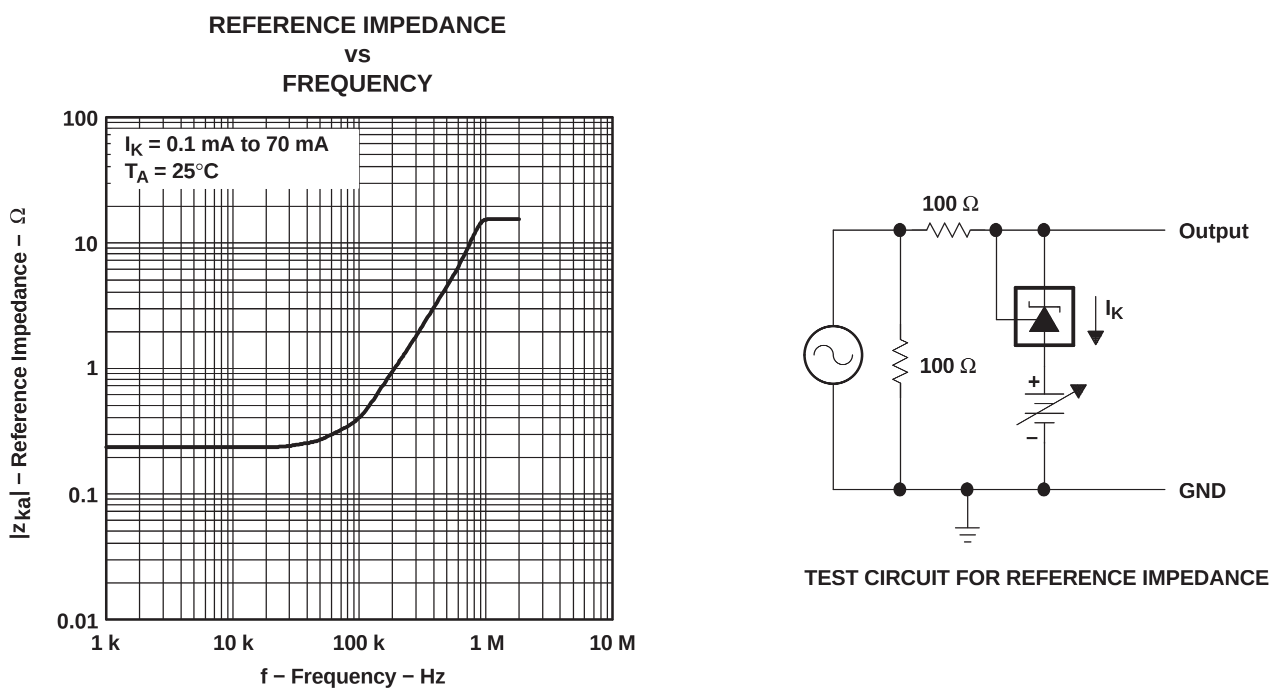
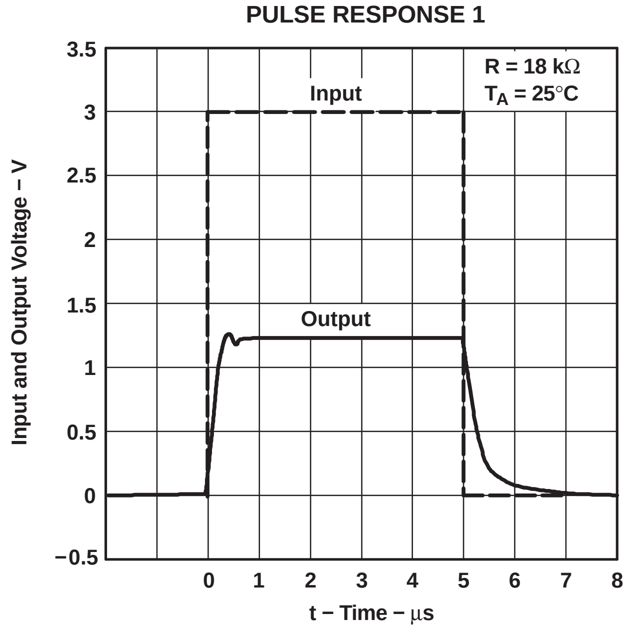
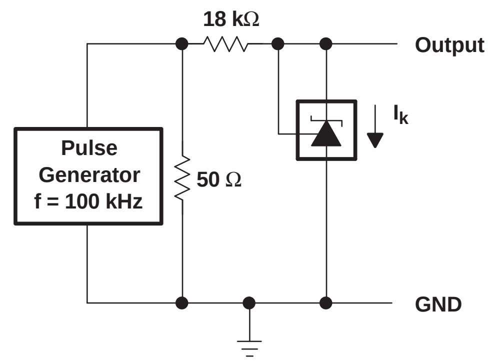


Figure 14.

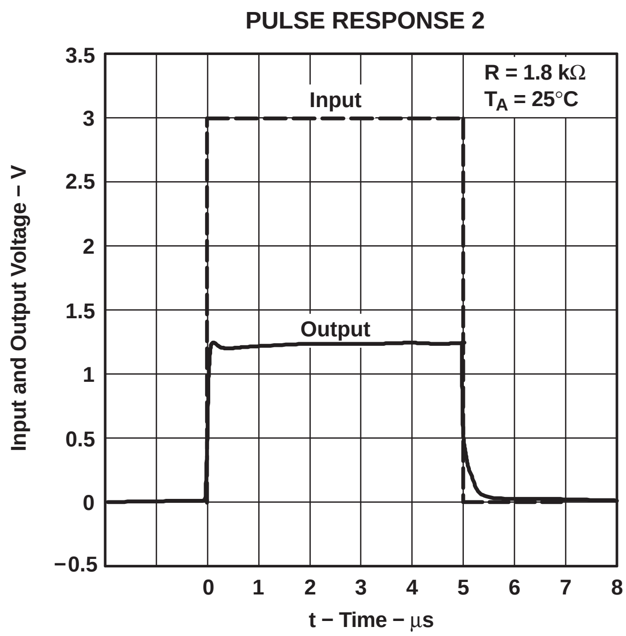
PARAMETER MEASUREMENT INFORMATION (continued)

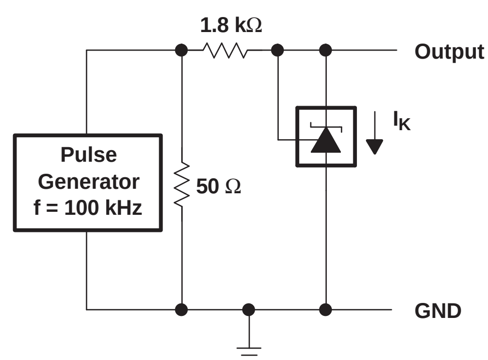




TEST CIRCUIT FOR PULSE RESPONSE 1

Figure 15.





TEST CIRCUIT FOR PULSE RESPONSE 2

Figure 16.

PARAMETER MEASUREMENT INFORMATION (continued)

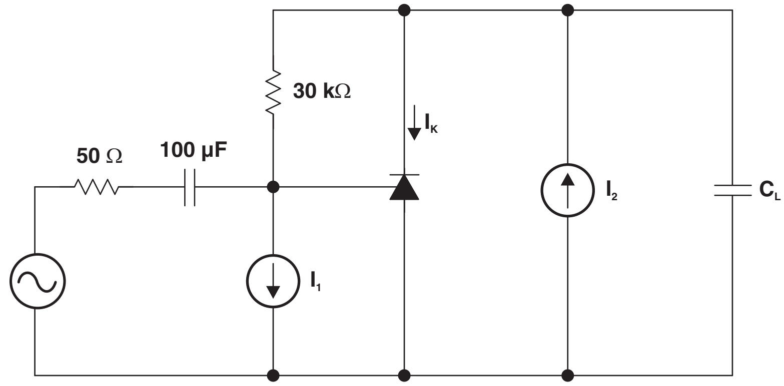


Figure 17. Phase Margin Test Circuit

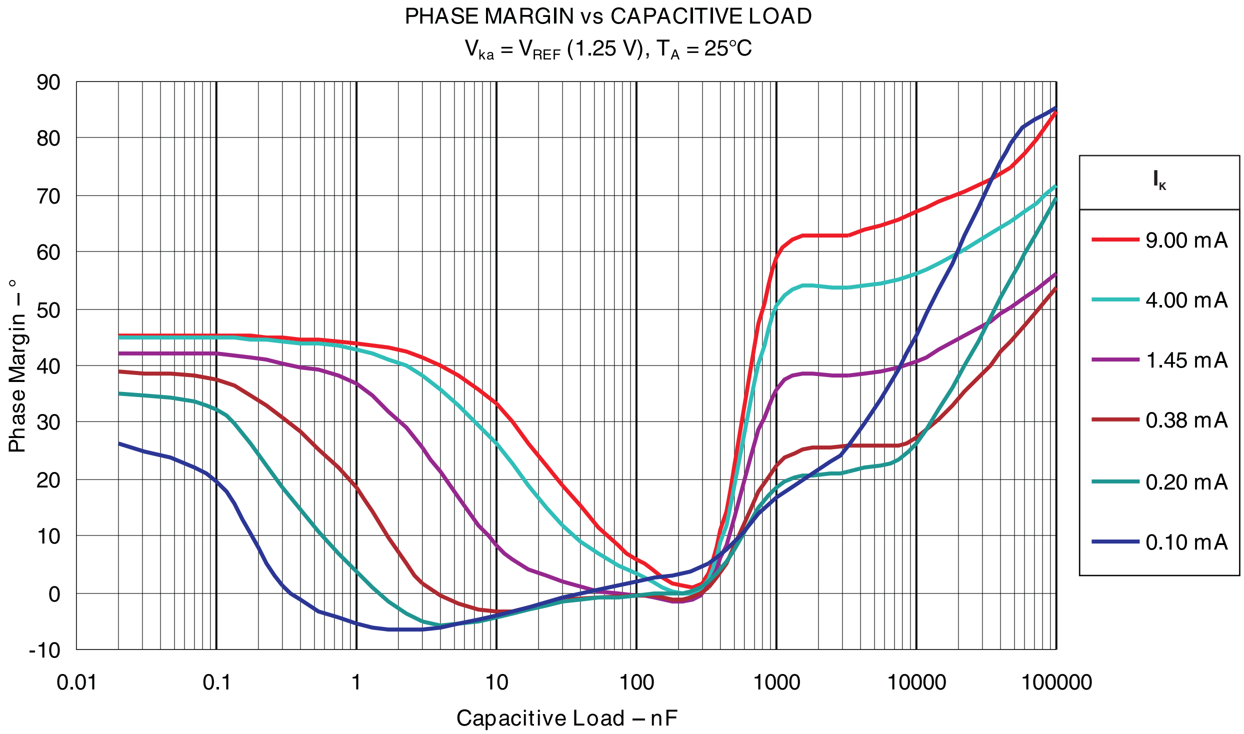


Figure 18.

PARAMETER MEASUREMENT INFORMATION (continued)

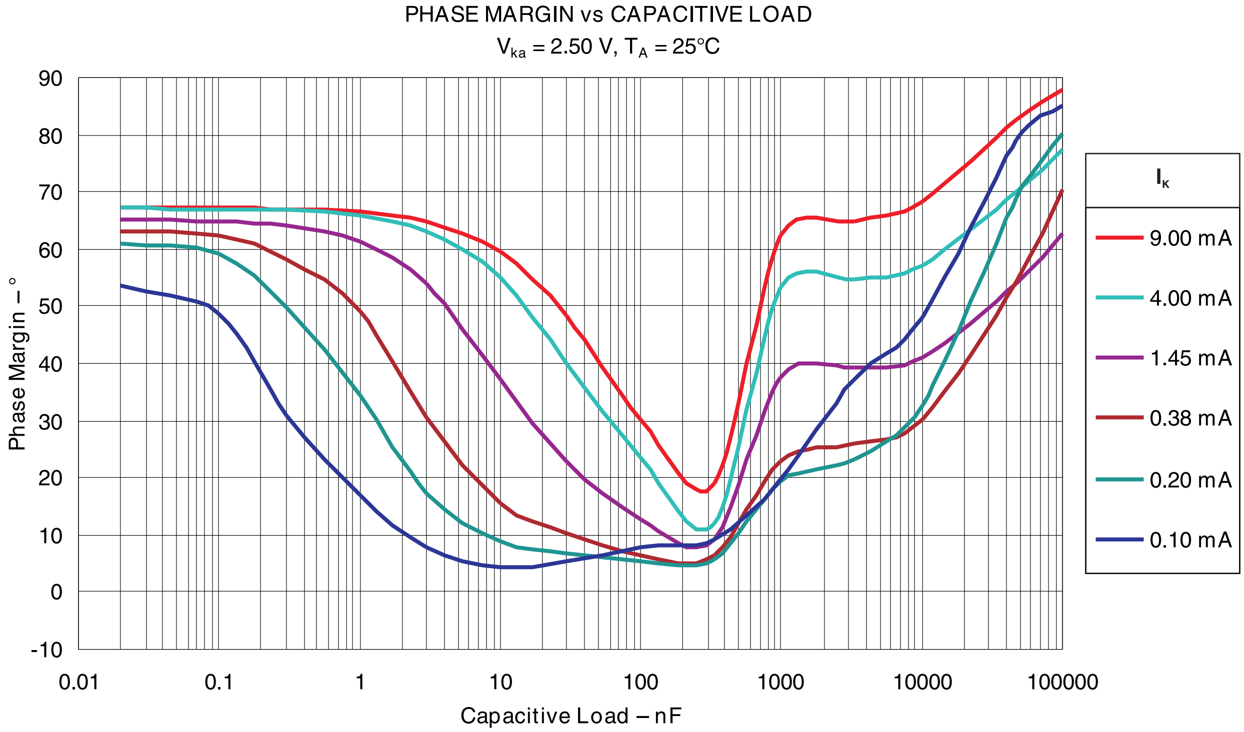


Figure 19.

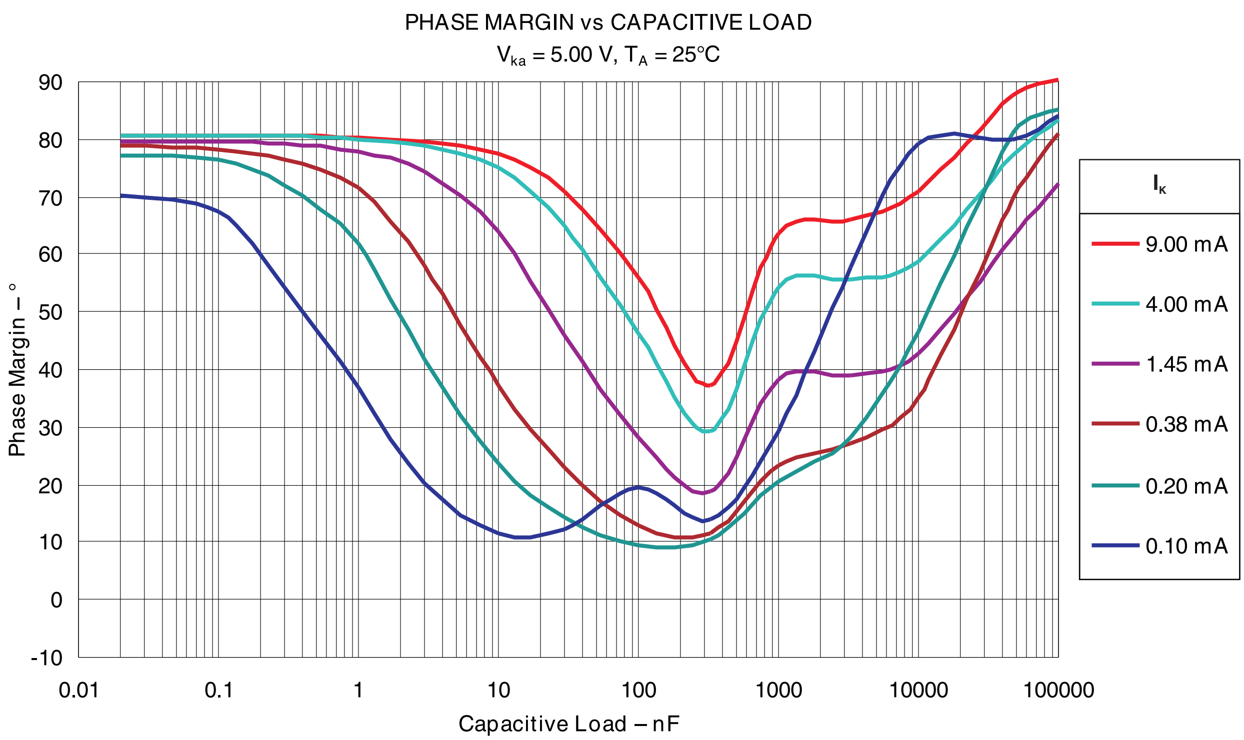


Figure 20.

APPLICATION INFORMATION

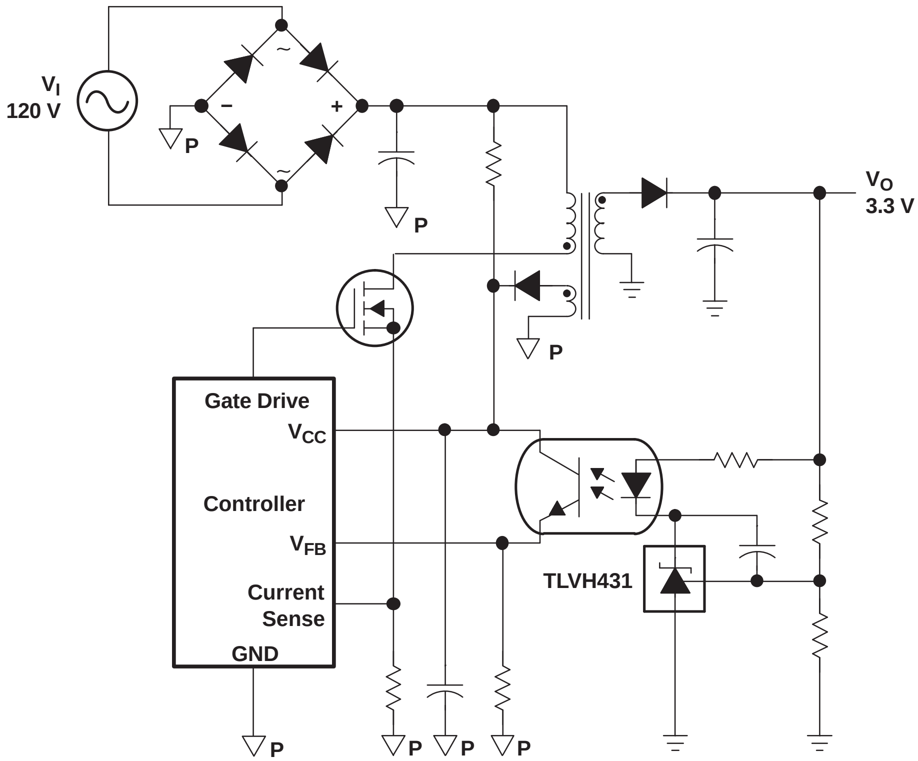


Figure 21. Flyback With Isolation Using TLVH431 as Voltage Reference and Error Amplifier

Figure 21 shows the TLVH431 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). 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 topology shown in Figure 21.

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