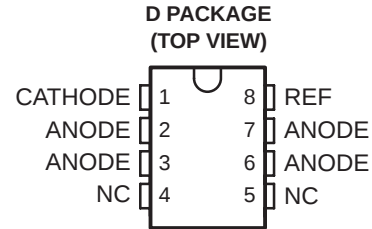


- Qualified for Automotive Applications
- 0.4% Initial Voltage Tolerance
- 0.2-Ω Typical Output Impedance
- Fast Turnon . . . 500 ns
- Sink Current Capability . . . 1 mA to 100 mA
- Low Reference Current (REF)
- Adjustable Output Voltage . . . $V_{I(REF)}$ to 36 V



NC – No internal connection
ANODE terminals are connected internally.

description/ordering information

The TL1431 is a precision programmable reference with specified thermal stability over the automotive temperature range. The output voltage can be set to any value between $V_{I(REF)}$ (approximately 2.5 V) and 36 V with two external resistors (see Figure 16). This device has a typical output impedance of 0.2 Ω. Active output circuitry provides a very sharp turnon characteristic, making the device an excellent replacement for Zener diodes and other types of references in applications such as onboard regulation, adjustable power supplies, and switching power supplies.

The TL1431Q is characterized for operation over the full automotive temperature range of –40°C to 125°C.

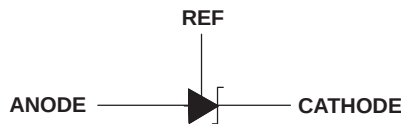
ORDERING INFORMATION†

T_A	PACKAGE‡		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	SOIC (D)	Reel of 2500	TL1431QDRQ1	1431Q1

† 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 <http://www.ti.com>.

‡ Package drawings, thermal data, and symbolization are available at <http://www.ti.com/packaging>.

symbol



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**

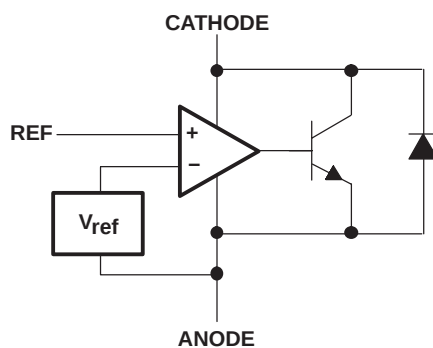
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 2008, Texas Instruments Incorporated

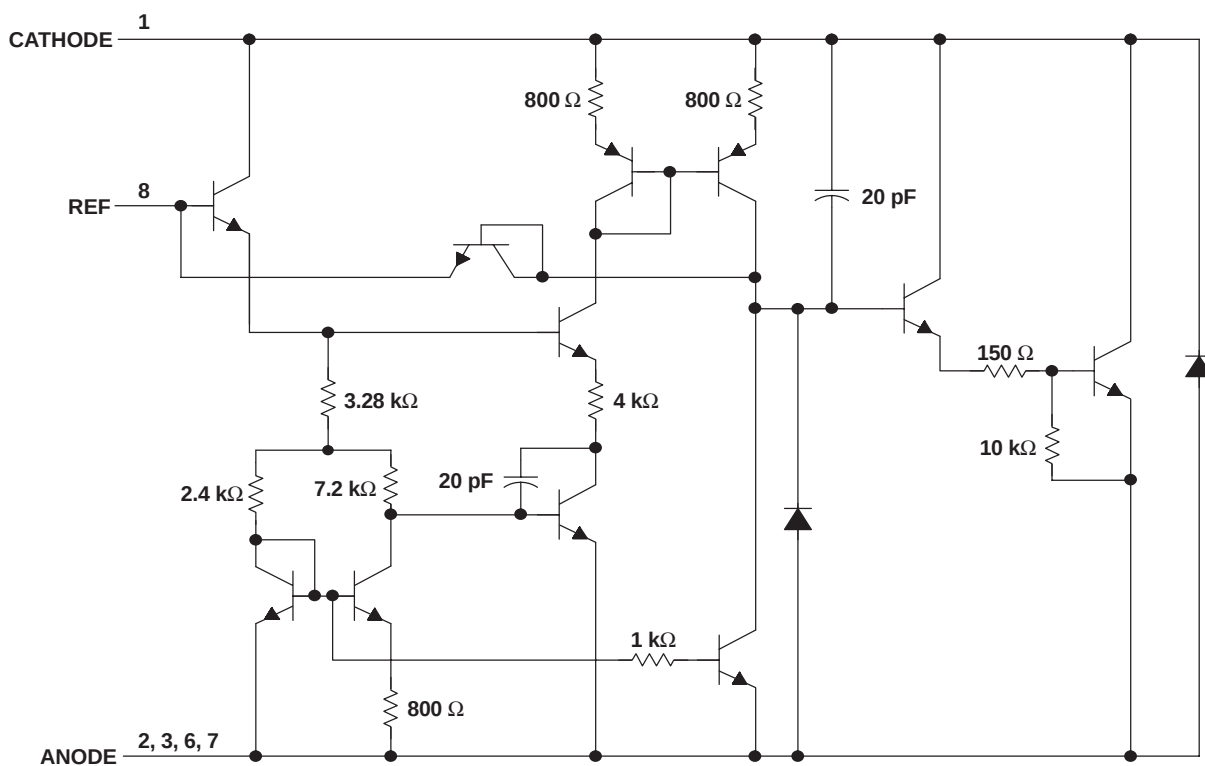
TL1431-Q1 PRECISION PROGRAMMABLE REFERENCE

SLVS534B – JUNE 2004 – REVISED APRIL 2008

functional block diagram



equivalent schematic[†]



[†] All component values are nominal.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)[†]

Cathode voltage, V_{KA} (see Note 1)	37 V
Continuous cathode current range, I_{KA}	–100 mA to 150 mA
Reference input current range, $I_{I(ref)}$	–50 μ A to 10 mA
Package thermal impedance, θ_{JA} (see Notes 2 and 3)	97°C/W
Operating virtual junction temperature, T_J	150°C
Continuous total power dissipation	See Dissipation Rating Table
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. All voltage values are with respect to ANODE, unless otherwise noted.
 2. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.
 3. The package thermal impedance is calculated in accordance with JESD 51-7.

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	$T_A = 125^\circ\text{C}$ POWER RATING
D	1102 mW	10.3 mW/°C	638.5 mW	484 mW	72.1 mW

recommended operating conditions

	MIN	MAX	UNIT
V_{KA} Cathode voltage	$V_{I(ref)}$	36	V
I_{KA} Cathode current	1	100	mA
T_A Operating free-air temperature	–40	125	°C

TL1431-Q1

PRECISION PROGRAMMABLE REFERENCE

SLVS534B – JUNE 2004 – REVISED APRIL 2008

electrical characteristics at specified free-air temperature, $I_{KA} = 10$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TEST CIRCUIT	MIN	TYP	MAX	UNIT
$V_{I(ref)}$ Reference input voltage	$V_{KA} = V_{I(ref)}$	25°C	Figure 1	2490	2500	2510	mV
		Full range		2470		2530	
$V_{I(dev)}$ Deviation of reference input voltage over full temperature range [‡]	$V_{KA} = V_{I(ref)}$	Full range	Figure 1		17	55	mV
$\frac{\Delta V_{I(ref)}}{\Delta V_{KA}}$ Ratio of change in reference input voltage to the change in cathode voltage	$\Delta V_{KA} = 3$ V to 36 V	Full range	Figure 2		-1.1	-2	mV/V
$I_{I(ref)}$ Reference input current	$R1 = 10$ k Ω , $R2 = \infty$	25°C	Figure 2		1.5	2.5	μ A
		Full range				4	
$I_{I(dev)}$ Deviation of reference input current over full temperature range [‡]	$R1 = 10$ k Ω , $R2 = \infty$	Full range	Figure 2		0.5	2	μ A
I_{min} Minimum cathode current for regulation	$V_{KA} = V_{I(ref)}$	25°C	Figure 1		0.45	1	mA
I_{off} Off-state cathode current	$V_{KA} = 36$ V, $V_{I(ref)} = 0$	25°C	Figure 3		0.18	0.5	μ A
		Full range				2	
$ z_{KA} $ Output impedance [§]	$V_{KA} = V_{I(ref)}$, $f \leq 1$ kHz, $I_{KA} = 1$ mA to 100 mA	25°C	Figure 1		0.2	0.4	Ω

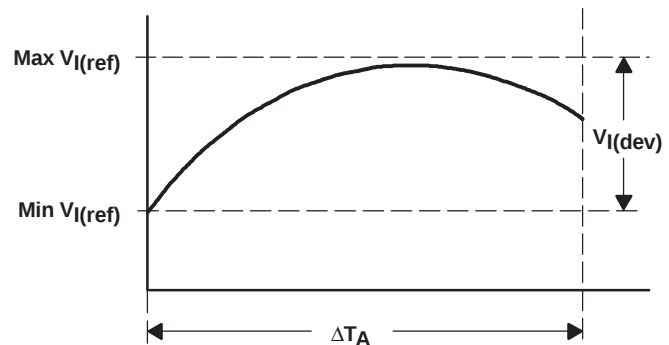
[†] Full range is -40°C to 125°C for Q-suffix devices.

[‡] The deviation parameters $V_{I(dev)}$ and $I_{I(dev)}$ 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 $\alpha_{V_{I(ref)}}$ is defined as:

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

where:

ΔT_A is the rated operating temperature range of the device.



$\alpha_{V_{I(ref)}}$ is positive or negative, depending on whether minimum $V_{I(ref)}$ or maximum $V_{I(ref)}$, respectively, occurs at the lower temperature.

[§] The output 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: $|z'| = \frac{\Delta V}{\Delta I}$,

which is approximately equal to $|z_{KA}| \left(1 + \frac{R1}{R2} \right)$.

PARAMETER MEASUREMENT INFORMATION

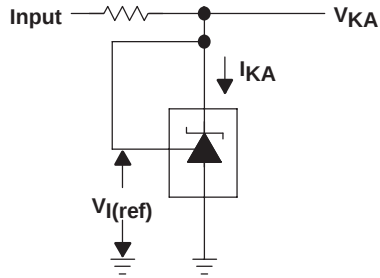


Figure 1. Test Circuit for $V_{(KA)} = V_{ref}$

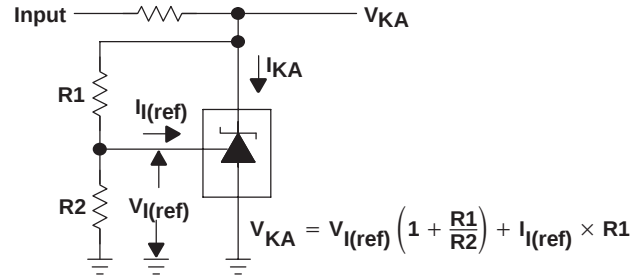


Figure 2. Test Circuit for $V_{(KA)} > V_{ref}$

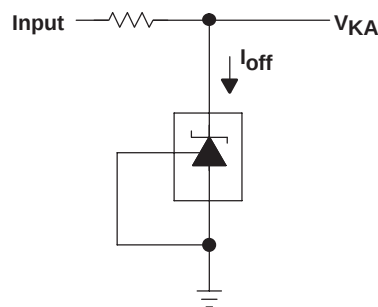


Figure 3. Test Circuit for I_{off}

TYPICAL CHARACTERISTICS

Table of Graphs

	FIGURE
Reference voltage vs Free-air temperature	4
Reference current vs Free-air temperature	5
Cathode current vs Cathode voltage	6, 7
Off-state cathode current vs Free-air temperature	8
Ratio of delta reference voltage to delta cathode voltage vs Free-air temperature	9
Equivalent input-noise voltage vs Frequency	10
Equivalent input-noise voltage over a 10-second period	11
Small-signal voltage amplification vs Frequency	12
Reference impedance vs Frequency	13
Pulse response	14
Stability boundary conditions	15

TYPICAL CHARACTERISTICS†

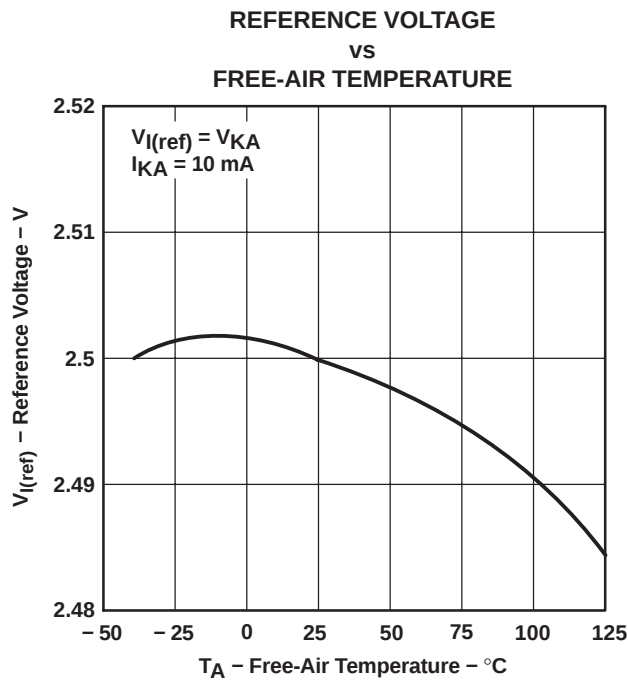


Figure 4

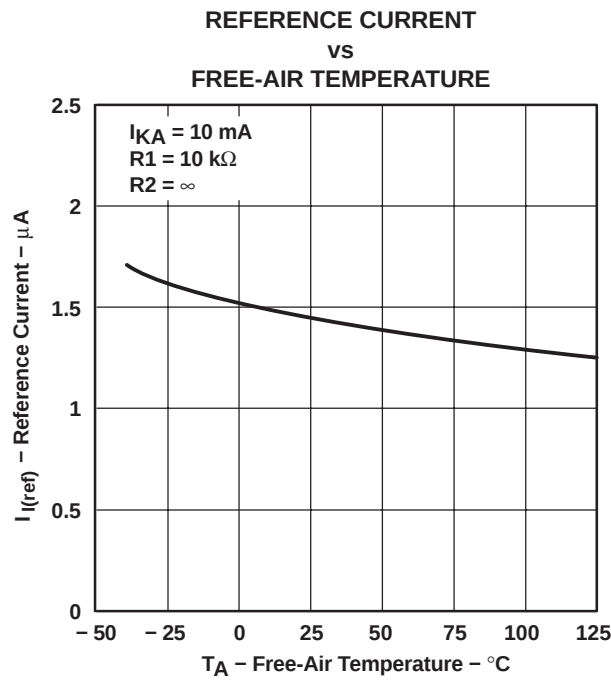


Figure 5

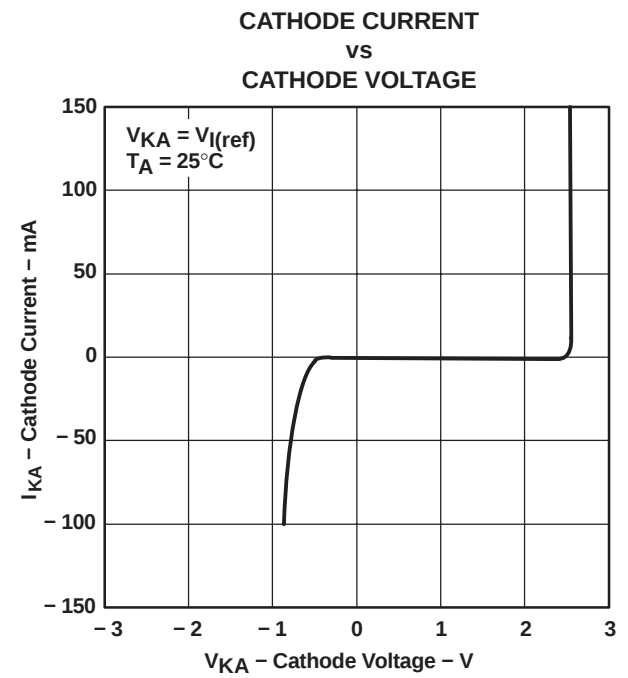


Figure 6

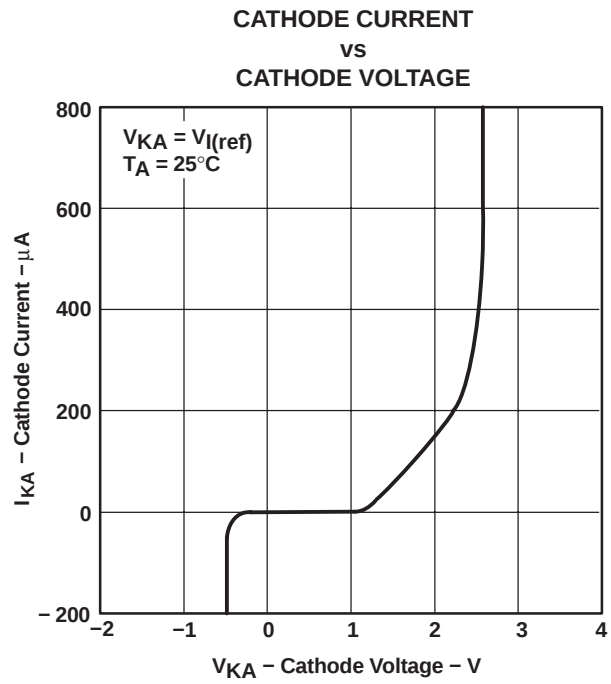


Figure 7

† Data at high and low temperatures are applicable only within the recommended operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS†

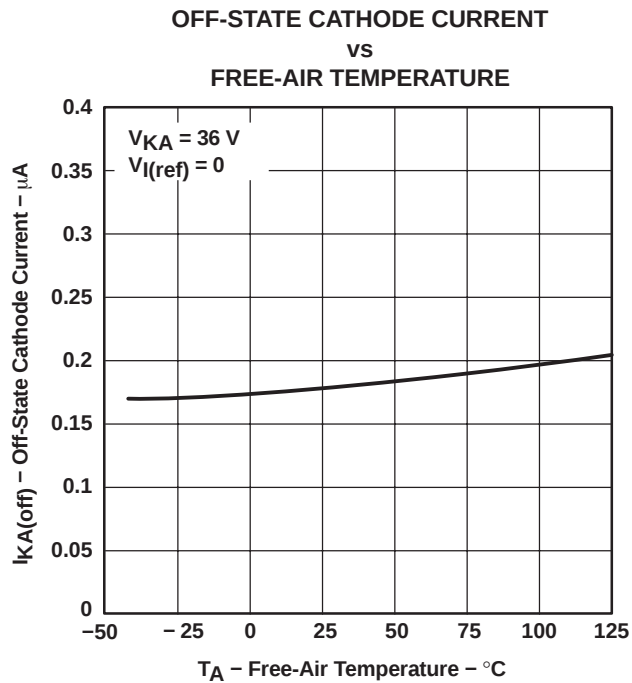


Figure 8

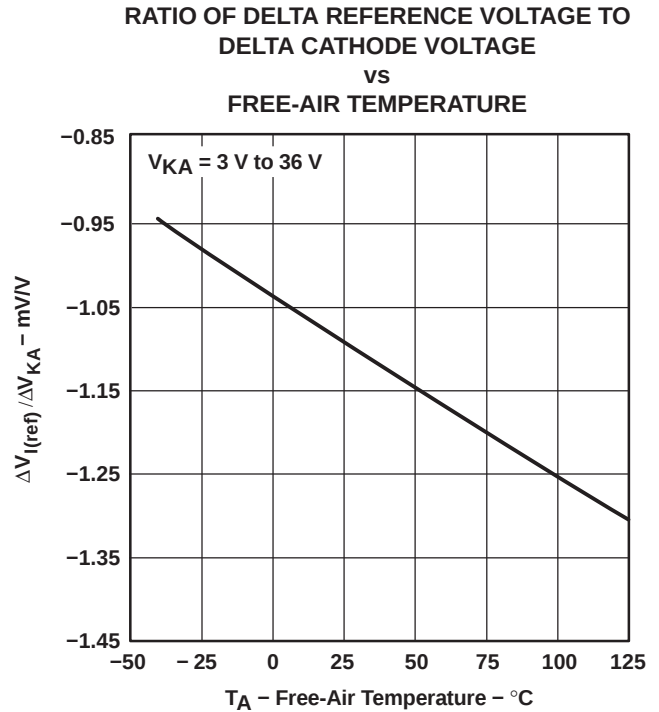


Figure 9

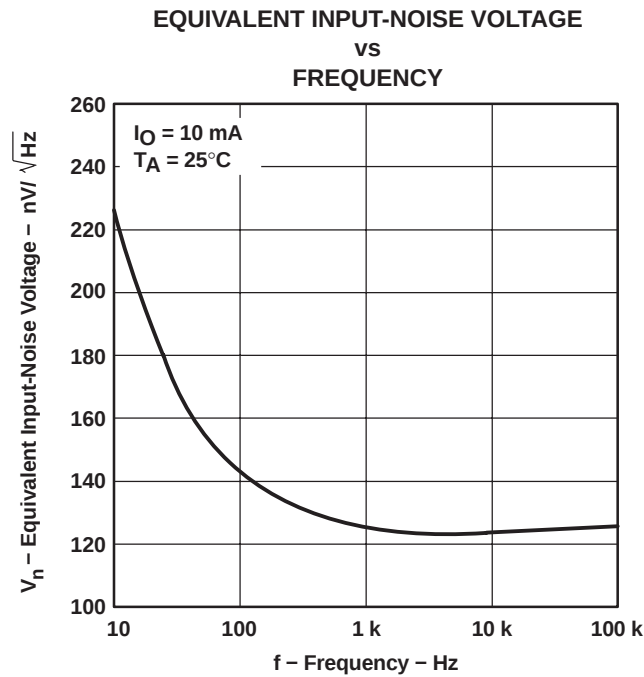
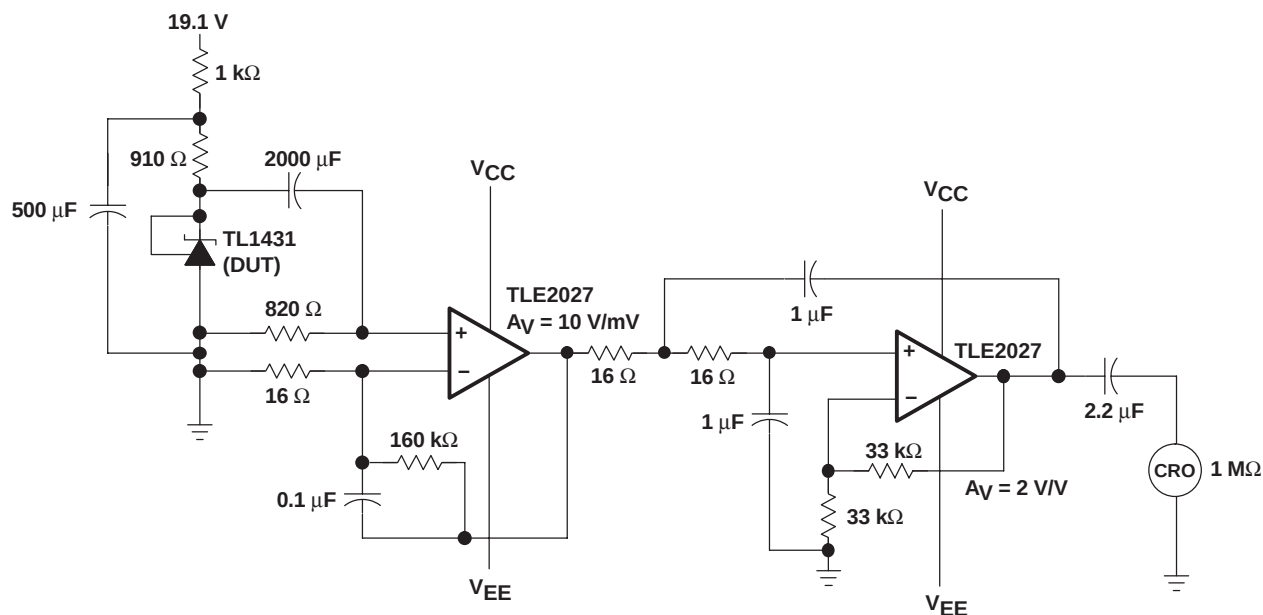
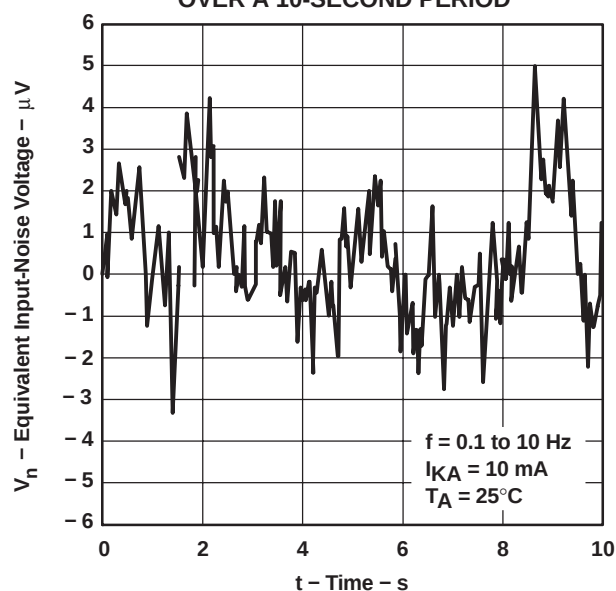


Figure 10

† Data at high and low temperatures are applicable only within the recommended operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS

EQUIVALENT INPUT-NOISE VOLTAGE OVER A 10-SECOND PERIOD



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

Figure 11

TYPICAL CHARACTERISTICS

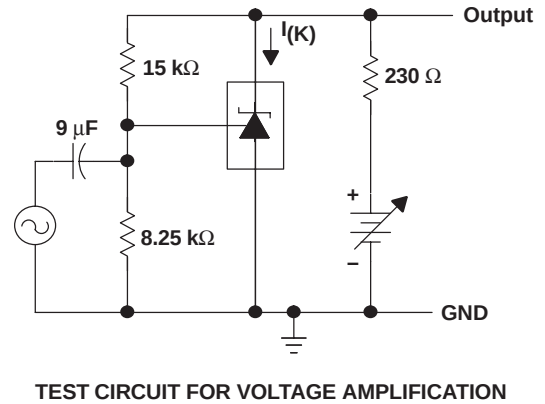
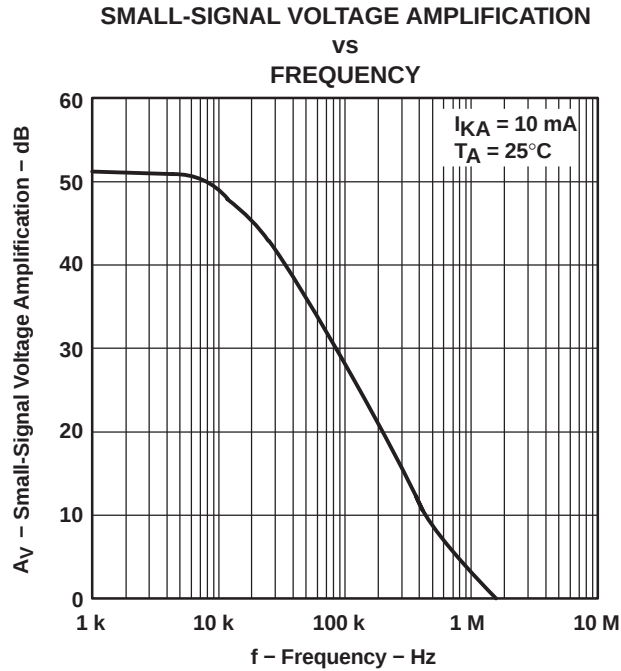


Figure 12

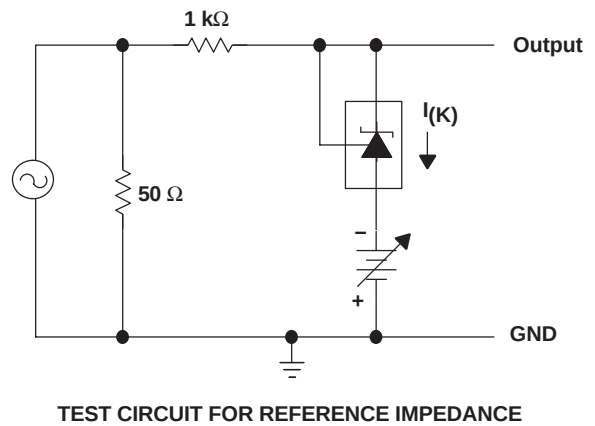
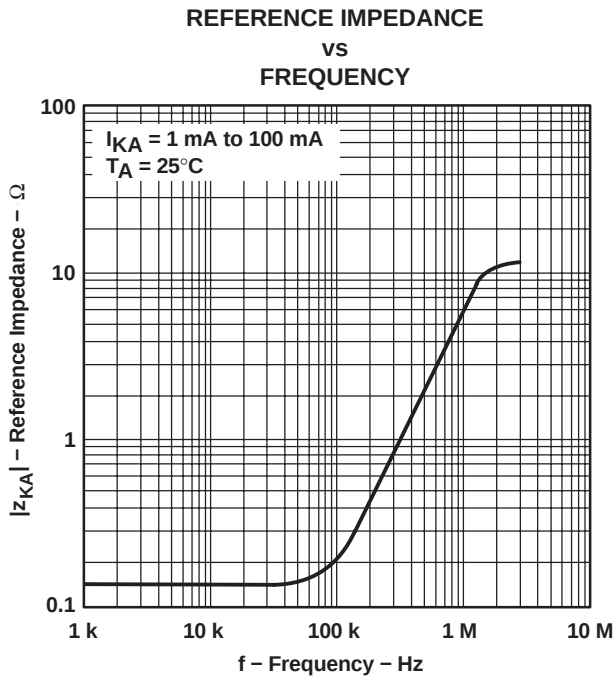


Figure 13

TYPICAL CHARACTERISTICS

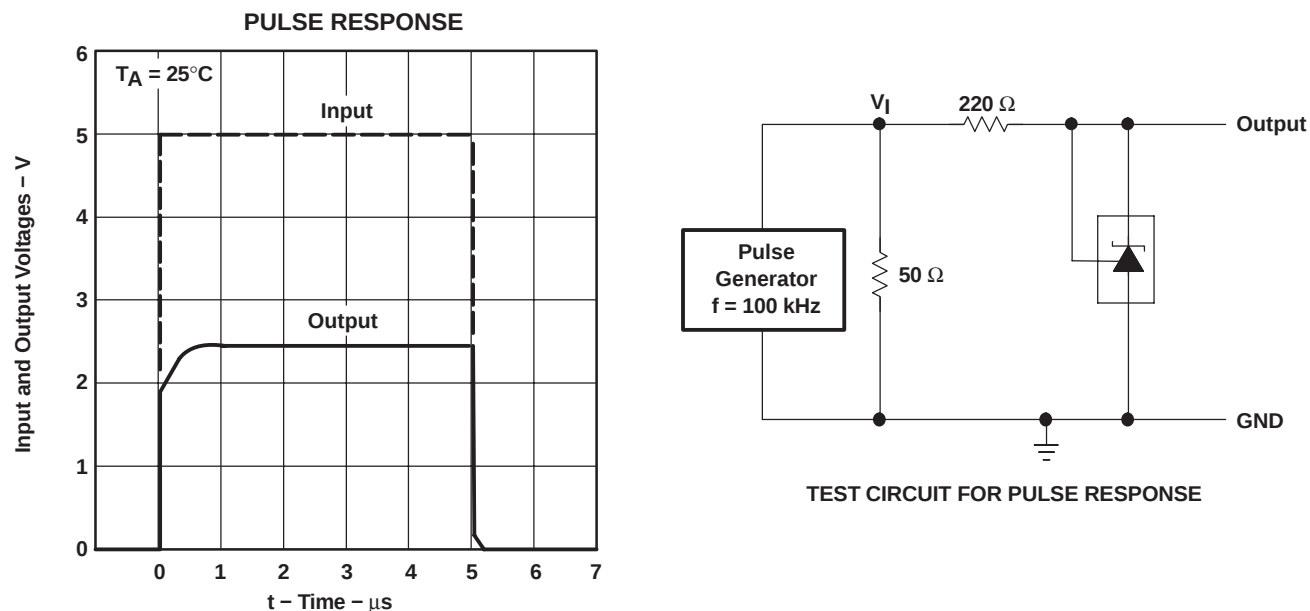


Figure 14

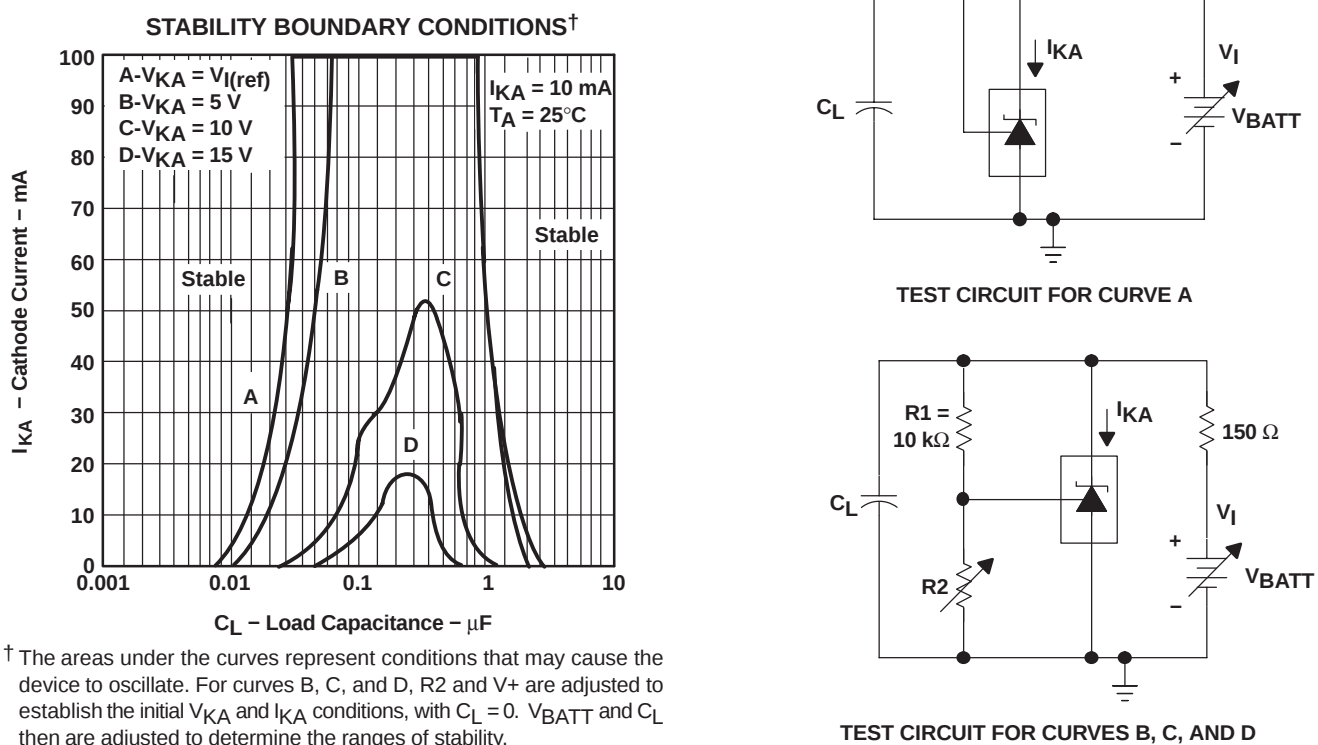
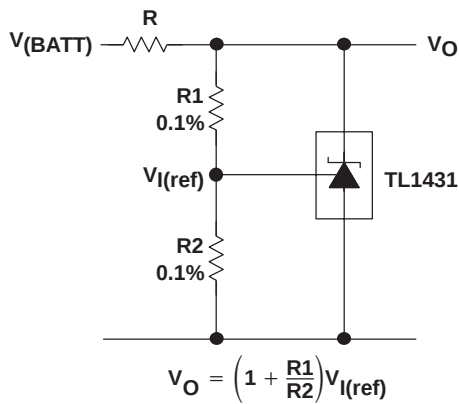


Figure 15

APPLICATION INFORMATION

Table of Application Circuits

APPLICATION	FIGURE
Shunt regulator	16
Single-supply comparator with temperature-compensated threshold	17
Precision high-current series regulator	18
Output control of a three-terminal fixed regulator	19
Higher-current shunt regulator	20
Crowbar	21
Precision 5-V, 1.5-A, 0.5% regulator	22
5-V precision regulator	23
PWM converter with 0.5% reference	24
Voltage monitor	25
Delay timer	26
Precision current limiter	27
Precision constant-current sink	28



NOTE A: R should provide cathode current ≥ 1 mA to the TL1431 at minimum $V_{(BATT)}$.

Figure 16. Shunt Regulator

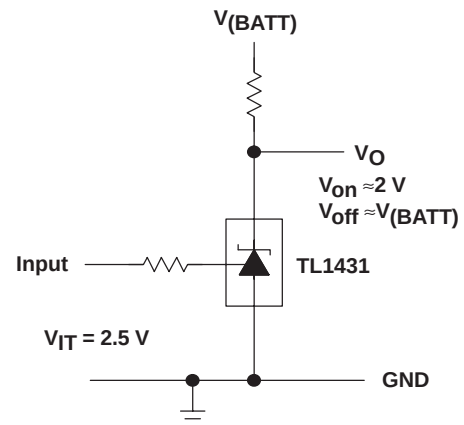
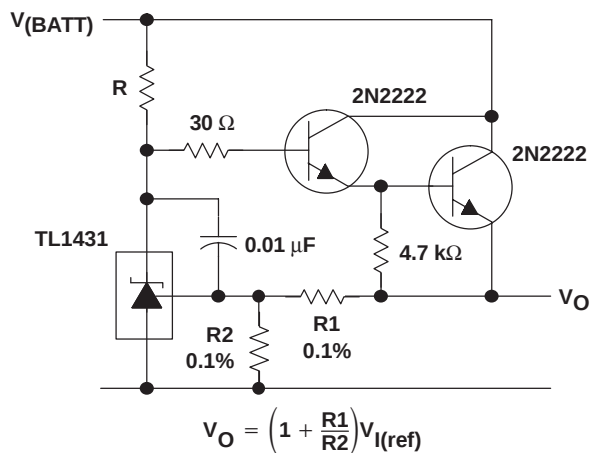


Figure 17. Single-Supply Comparator With Temperature-Compensated Threshold

TL1431-Q1 PRECISION PROGRAMMABLE REFERENCE

SLVS534B – JUNE 2004 – REVISED APRIL 2008

APPLICATION INFORMATION



NOTE A: R should provide cathode current ≥ 1 mA to the TL1431 at minimum $V_{(BATT)}$.

Figure 18. Precision High-Current Series Regulator

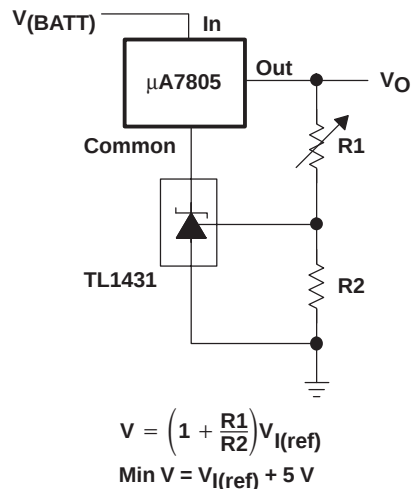


Figure 19. Output Control of a Three-Terminal Fixed Regulator

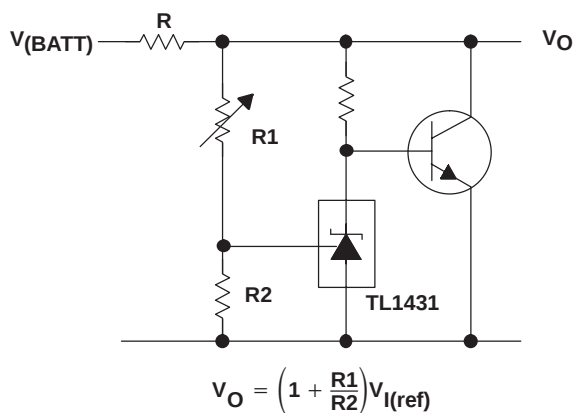
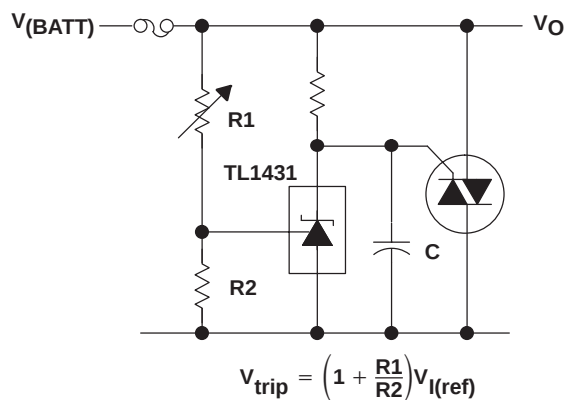


Figure 20. Higher-Current Shunt Regulator



NOTE A: Refer to the stability boundary conditions in Figure 15 to determine allowable values for C.

Figure 21. Crowbar

APPLICATION INFORMATION

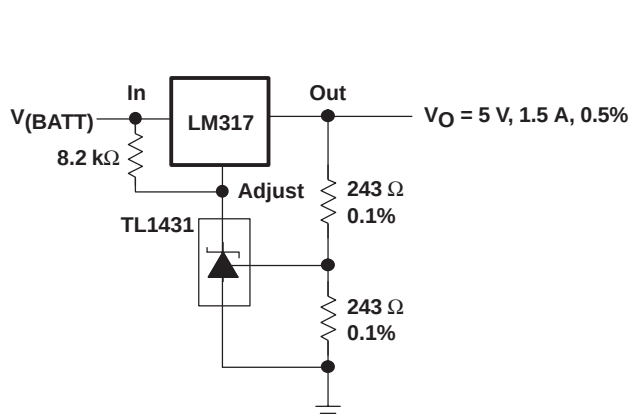
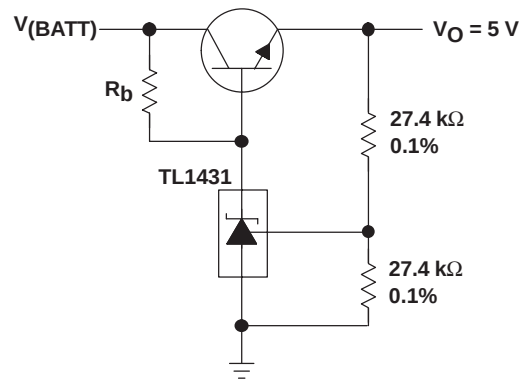


Figure 22. Precision 5-V, 1.5-A, 0.5% Regulator



NOTE A: R_b should provide cathode current $\geq 1\text{ mA}$ to the TL1431.

Figure 23. 5-V Precision Regulator

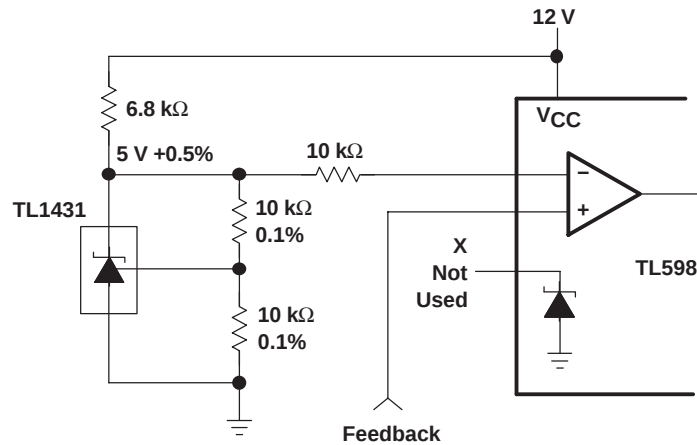
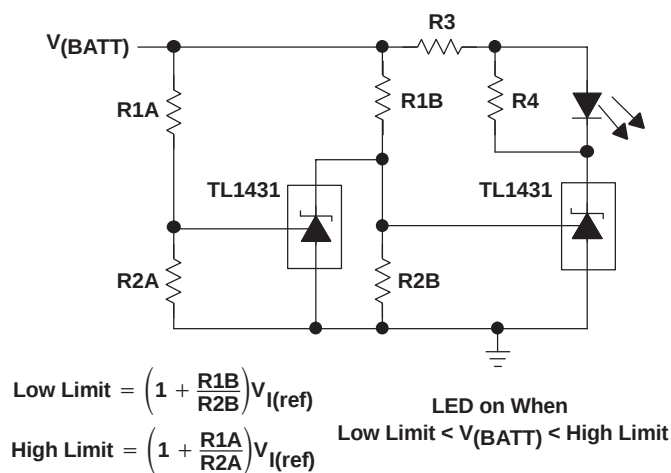


Figure 24. PWM Converter With 0.5% Reference

APPLICATION INFORMATION



NOTE A: Select R3 and R4 to provide the desired LED intensity and cathode current ≥ 1 mA to the TL1431.

Figure 25. Voltage Monitor

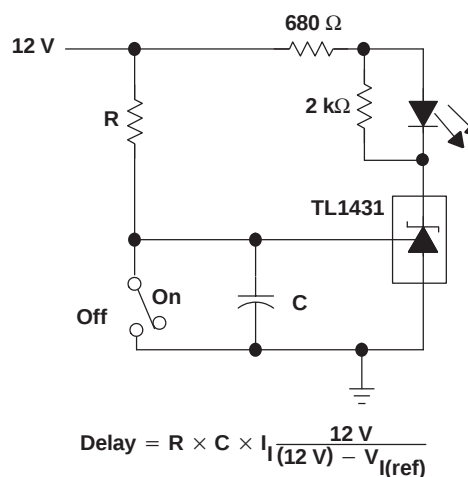


Figure 26. Delay Timer

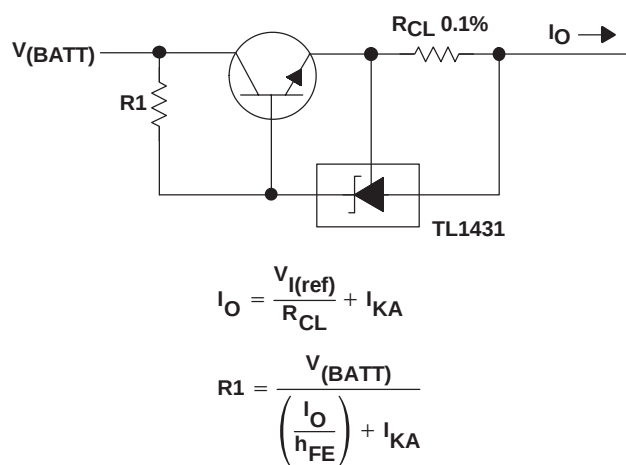


Figure 27. Precision Current Limiter

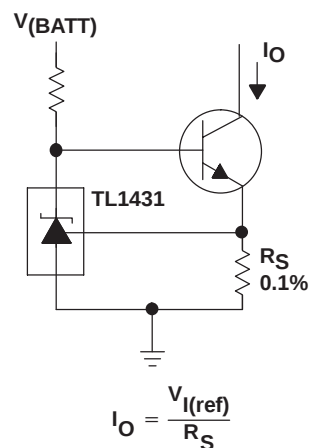


Figure 28. Precision Constant-Current Sink

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/ Ball Finish	MSL Peak Temp ⁽³⁾	Samples (Requires Login)
TL1431QDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TL1431QDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Request Free Samples

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF TL1431-Q1 :

• Catalog: [TL1431](#)

• Enhanced Product: [TL1431-EP](#)

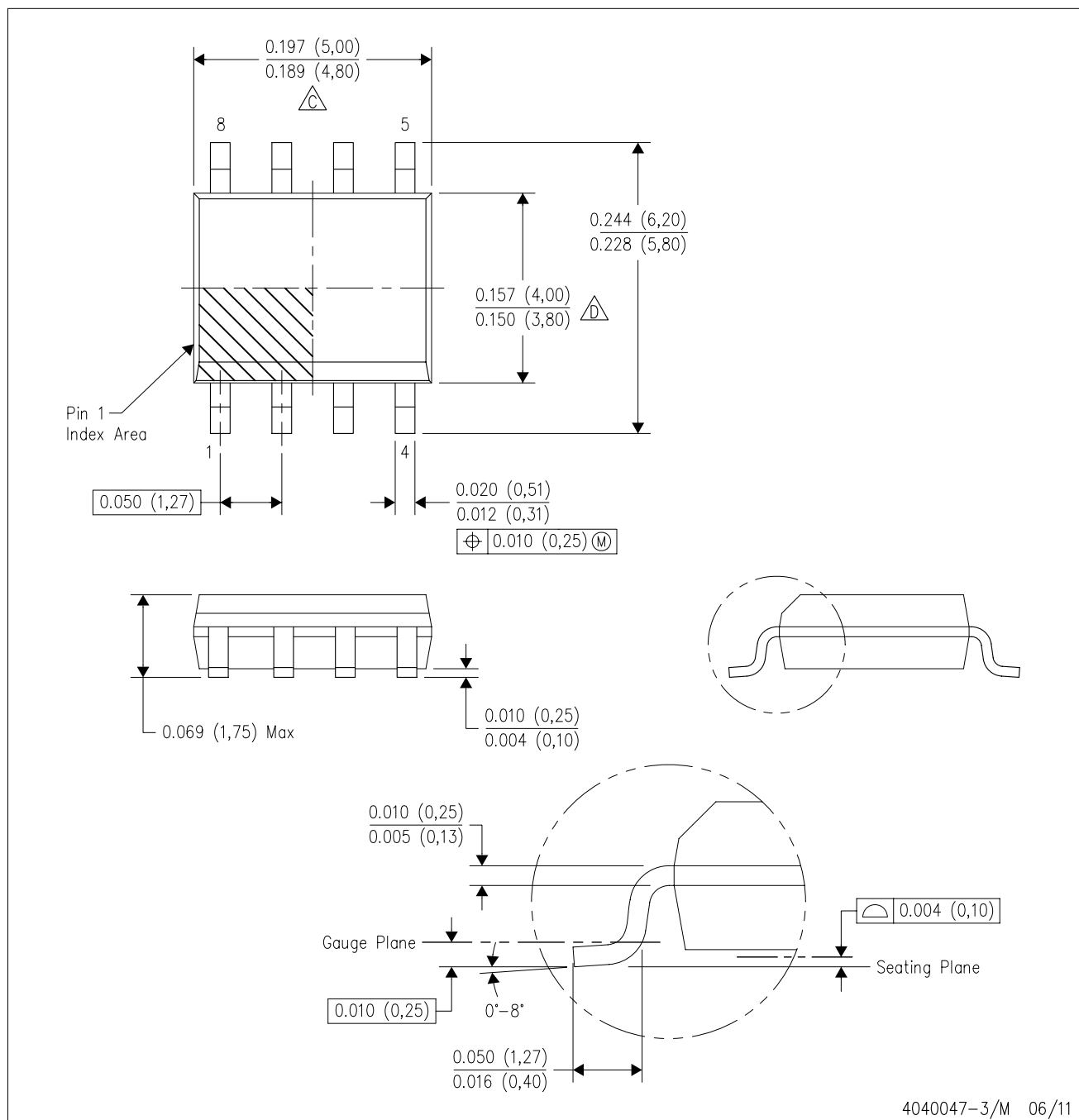
- Military: [TL1431M](#)
- Space: [TL1431-SP](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications
- Military - QML certified for Military and Defense Applications
- Space - Radiation tolerant, ceramic packaging and qualified for use in Space-based application

D (R-PDSO-G8)

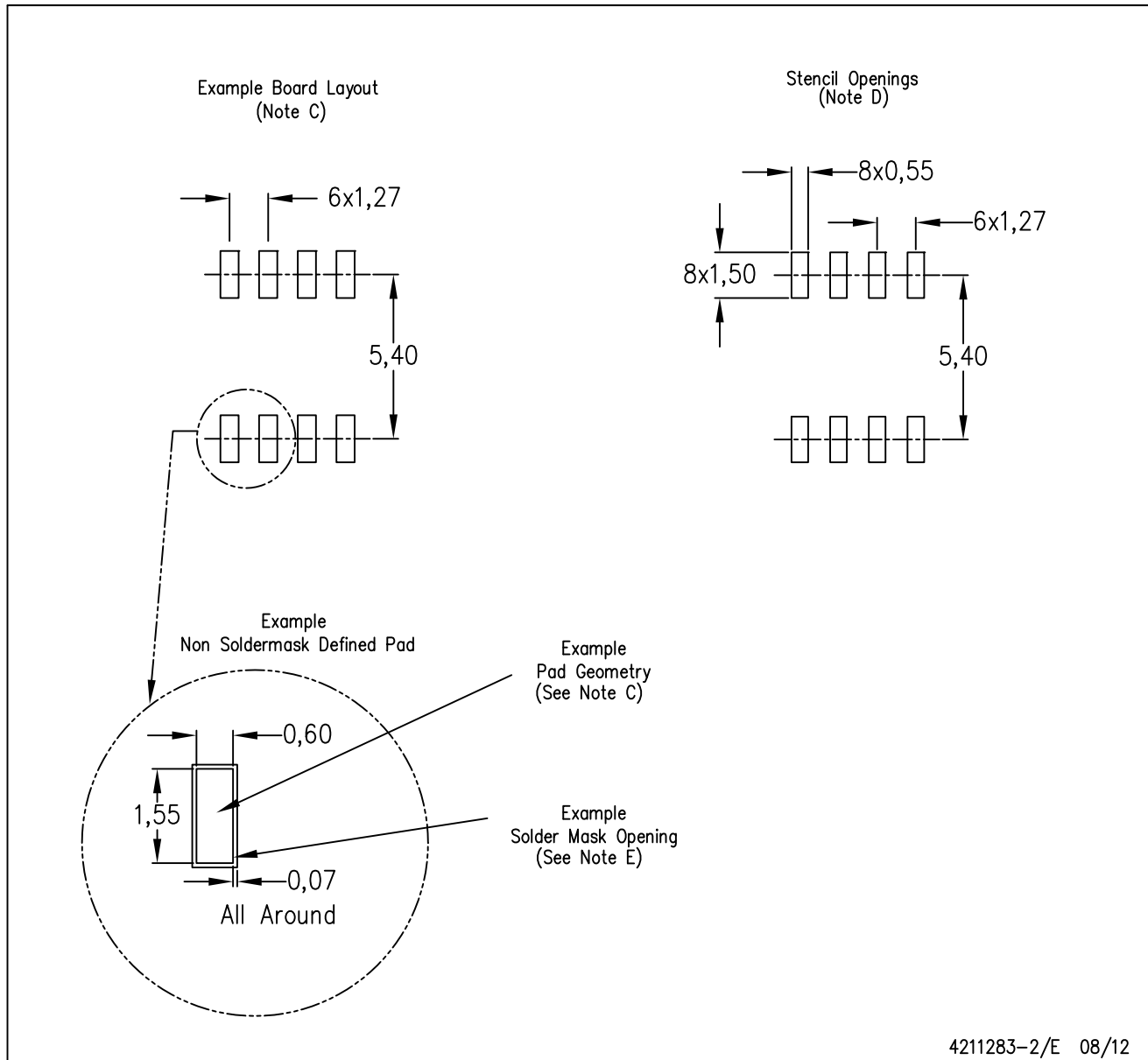
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - $\triangle C$ Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
 - $\triangle D$ Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
 - E. Reference JEDEC MS-012 variation AA.

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46C and to discontinue any product or service per JESD48B. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Mobile Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community e2e.ti.com