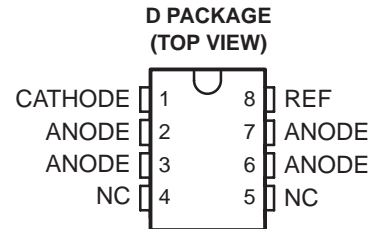


- Qualification in Accordance With AEC-Q100†
- Qualified for Automotive Applications
- Customer-Specific Configuration Control Can Be Supported Along With Major-Change Approval
- 0.4% Initial Voltage Tolerance
- 0.2-Ω Typical Output Impedance
- Fast Turnon . . . 500 ns
- Sink Current Capability . . . 1 mA to 100 mA
- Low Reference Current (REF)
- Adjustable Output Voltage . . . $V_{I(\text{ref})}$ to 36 V

† Contact factory for details. Q100 qualification data available on request.



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 $V_{I(\text{ref})}$ (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.

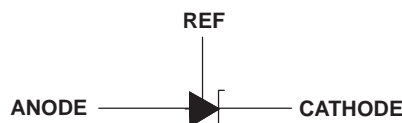
The TL1431Q is characterized for operation over the full automotive temperature range of –40°C to 125°C.

ORDERING INFORMATION

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

‡ Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

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**

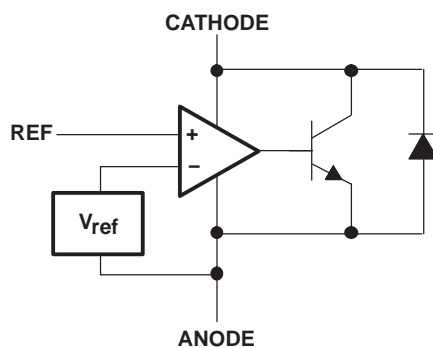
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 2004, Texas Instruments Incorporated

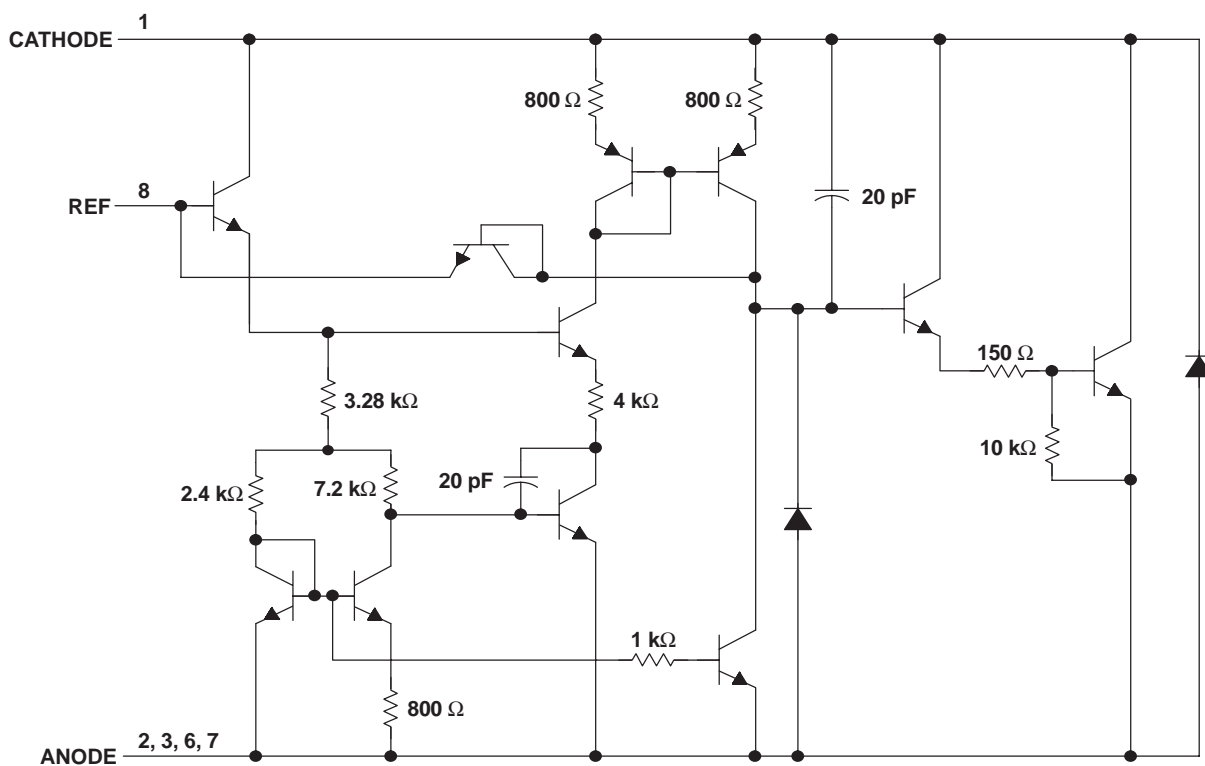
TL1431-Q1 PRECISION PROGRAMMABLE REFERENCE

SLVS534A – JUNE 2004 – REVISED JULY 2004

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

SLVS534A – JUNE 2004 – REVISED JULY 2004

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

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

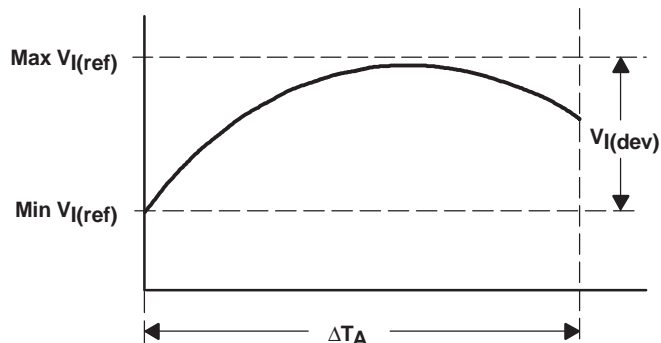
† Full range is -40°C to 125°C for Q-suffix devices.

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

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

where:

ΔT_A is the rated operating temperature range of the device.



$\alpha_{V_{I(\text{ref})}}$ is positive or negative, depending on whether minimum $V_{I(\text{ref})}$ or maximum $V_{I(\text{ref})}$, 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

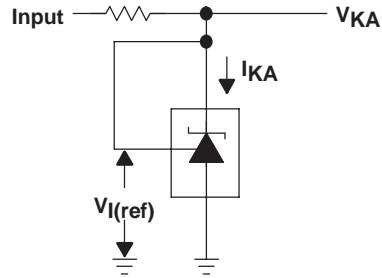


Figure 1. Test Circuit for $V_{(KA)} = V_{ref}$

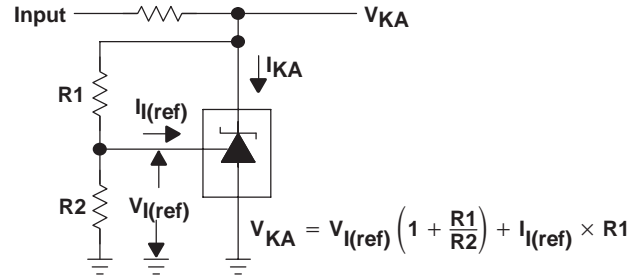


Figure 2. Test Circuit for $V_{(KA)} > V_{ref}$

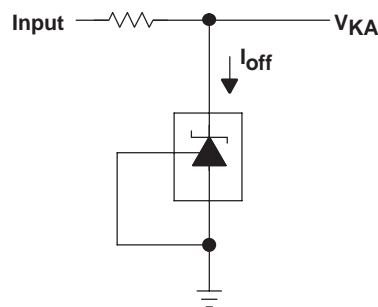


Figure 3. Test Circuit for I_{off}

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†

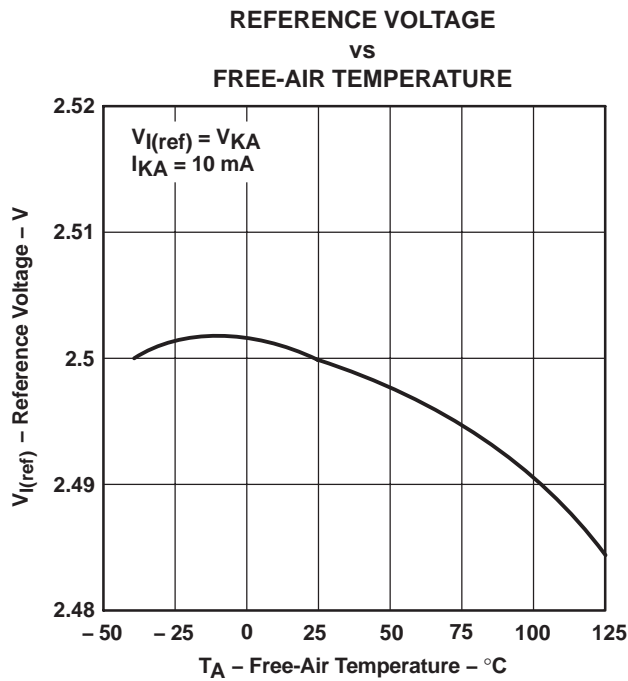


Figure 4

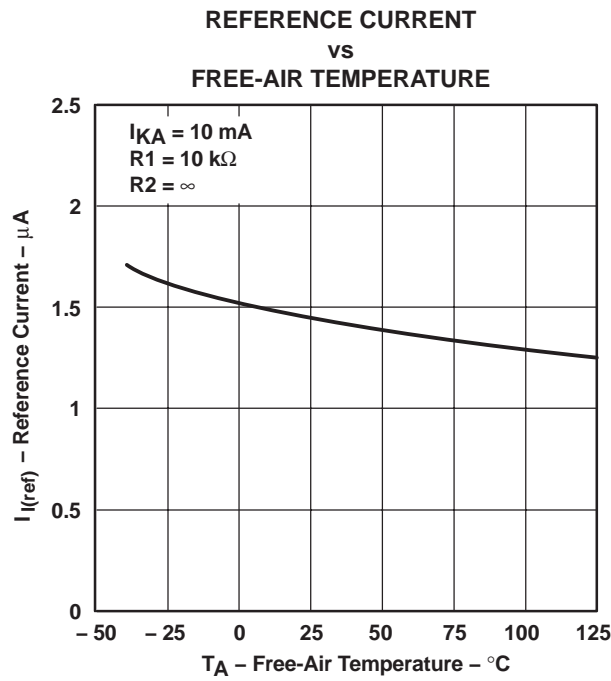


Figure 5

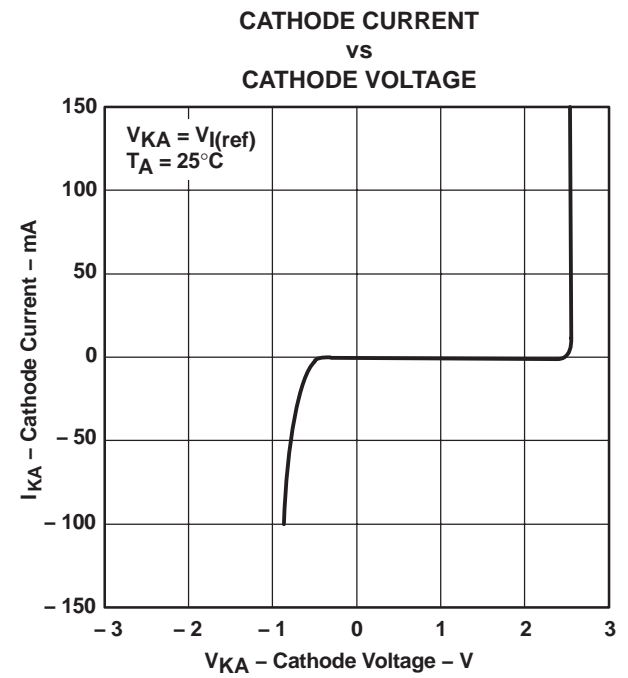


Figure 6

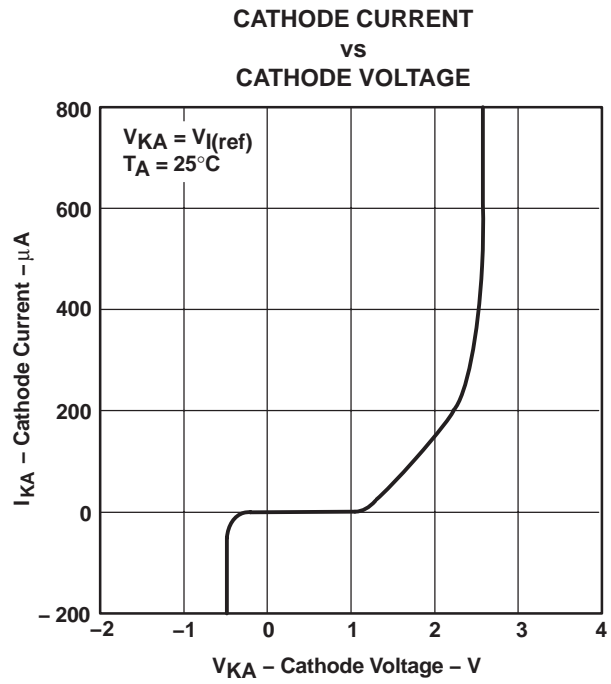


Figure 7

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

TYPICAL CHARACTERISTICS†

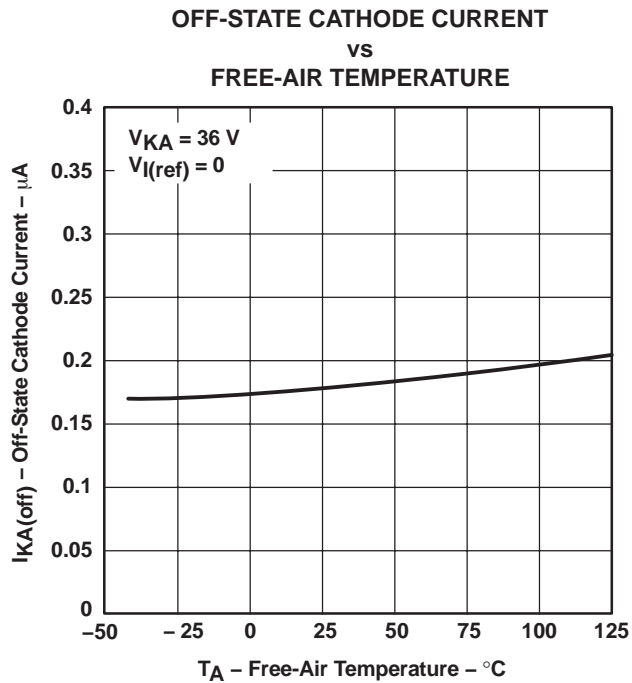


Figure 8

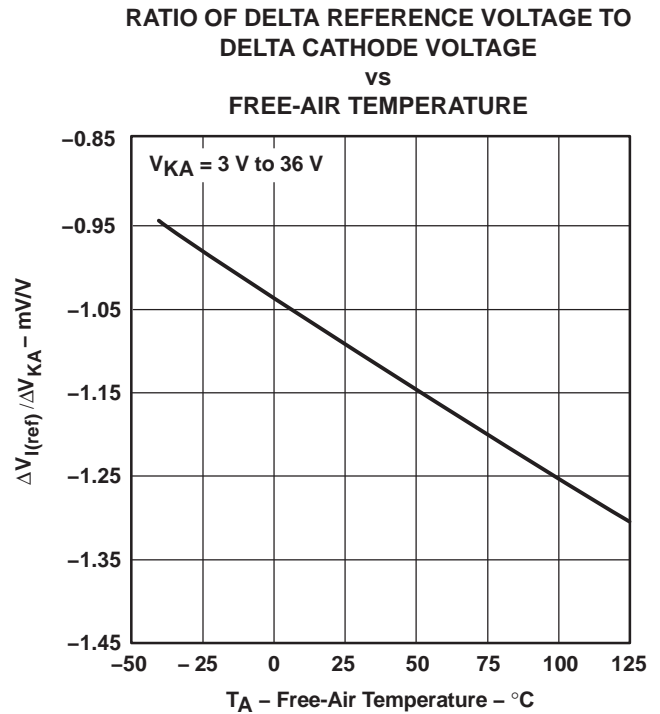


Figure 9

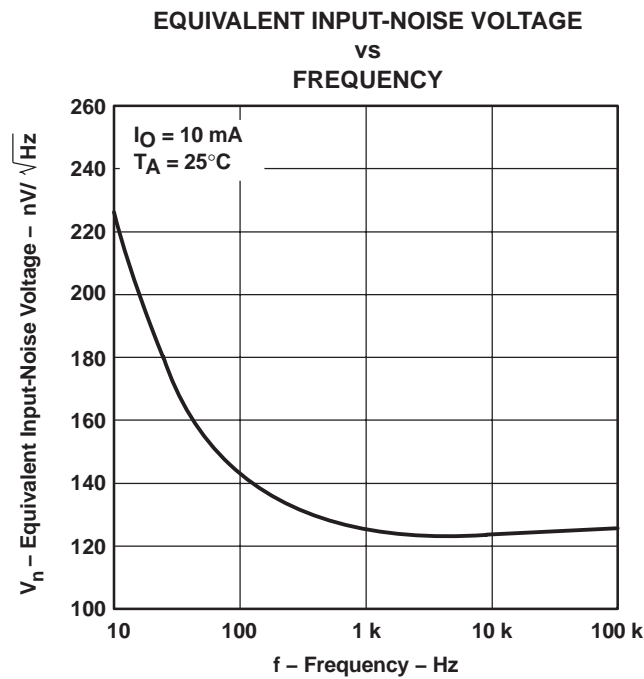


Figure 10

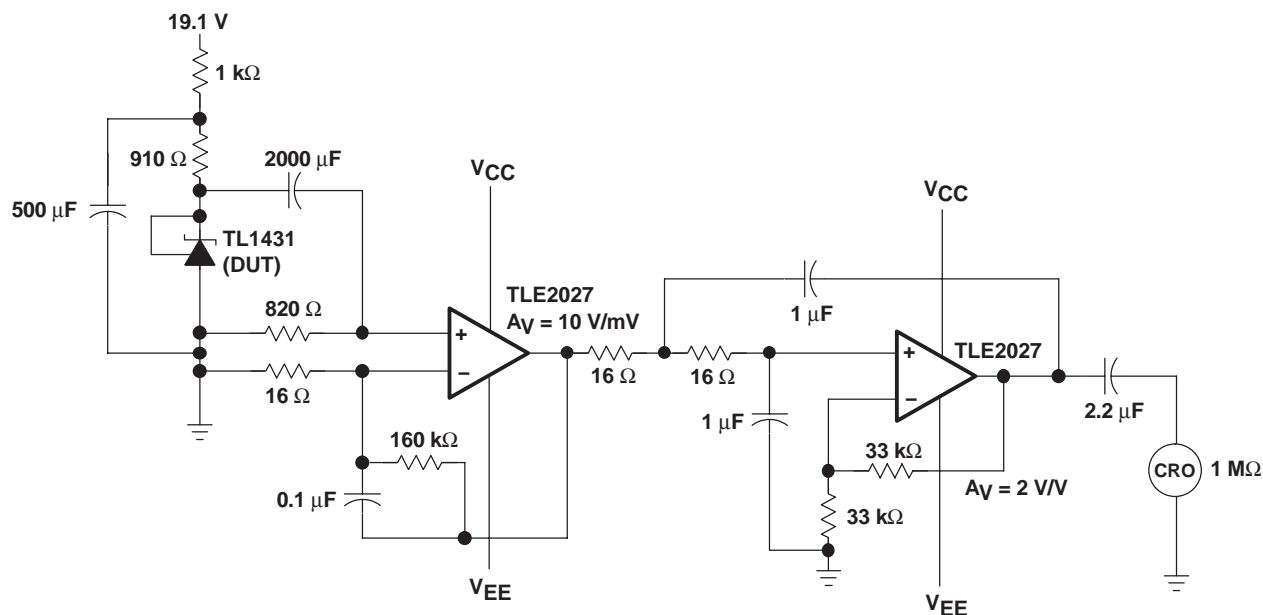
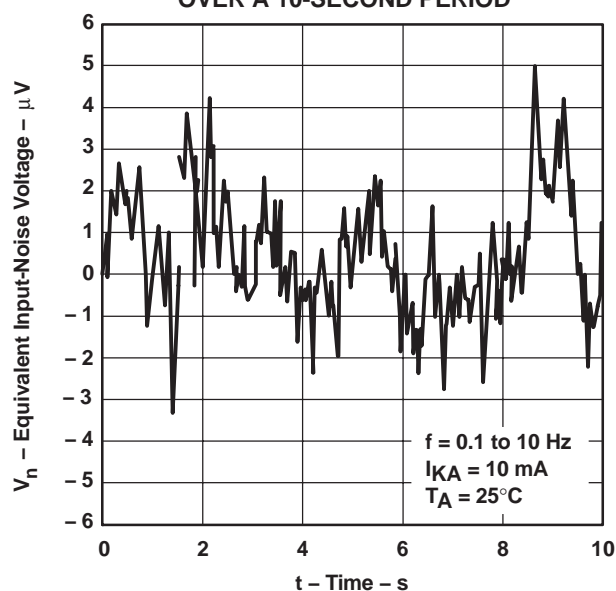
† Data at high and low temperatures are applicable only within the recommended operating free-air temperature ranges of the various devices.

TL1431-Q1 PRECISION PROGRAMMABLE REFERENCE

SLVS534A – JUNE 2004 – REVISED JULY 2004

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

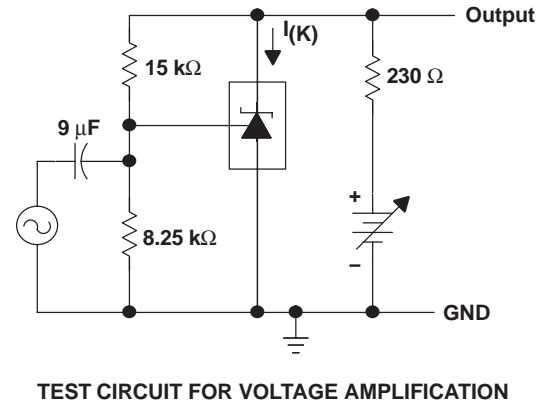
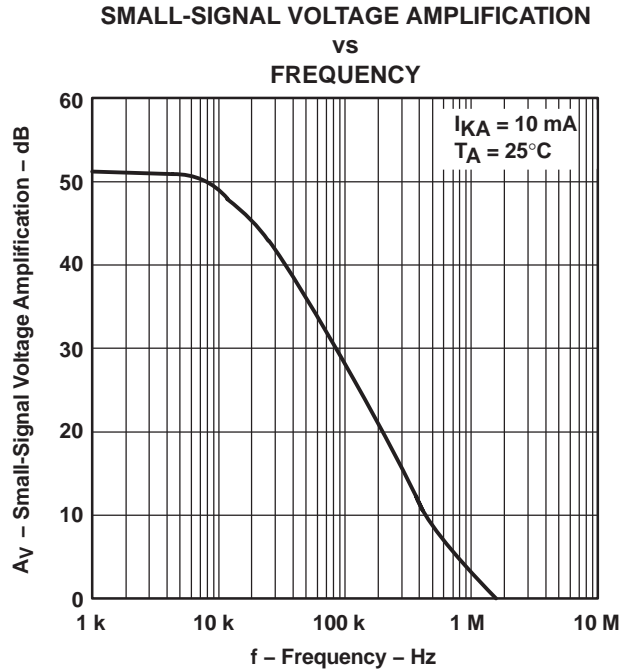


Figure 12

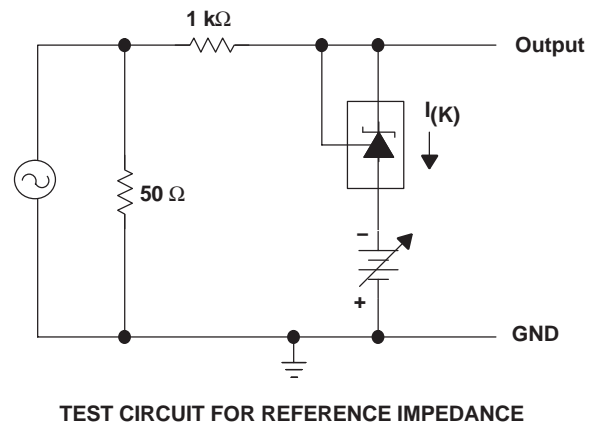
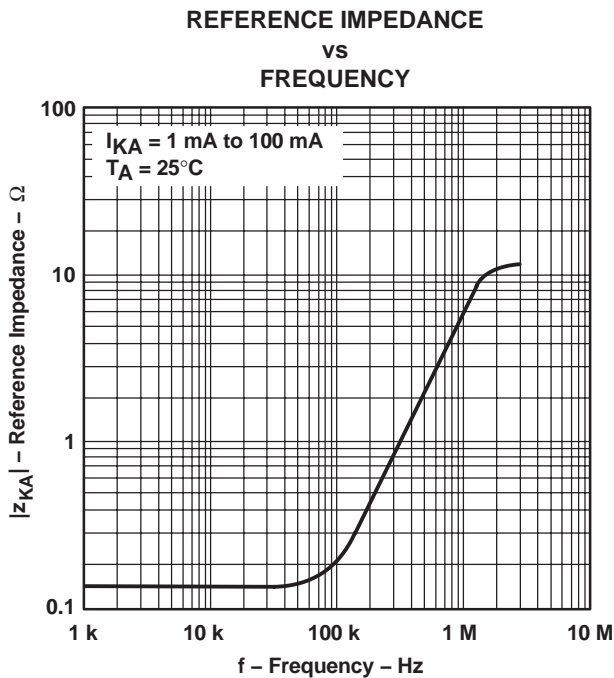


Figure 13

TL1431-Q1

PRECISION PROGRAMMABLE REFERENCE

SLVS534A – JUNE 2004 – REVISED JULY 2004

TYPICAL CHARACTERISTICS

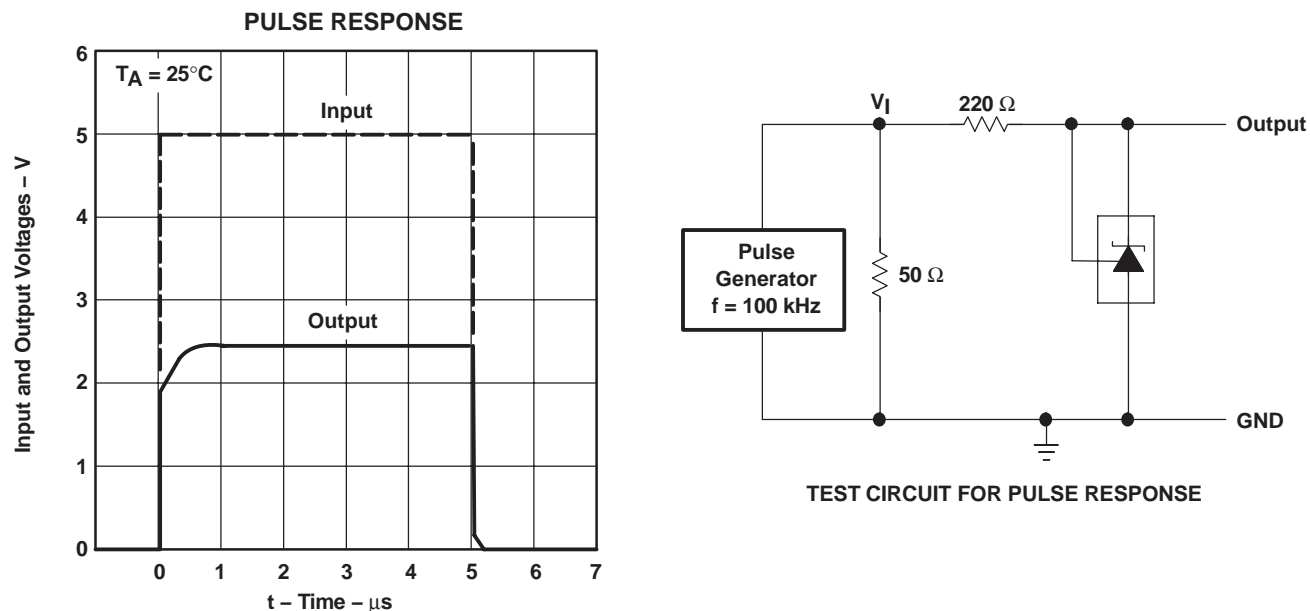


Figure 14

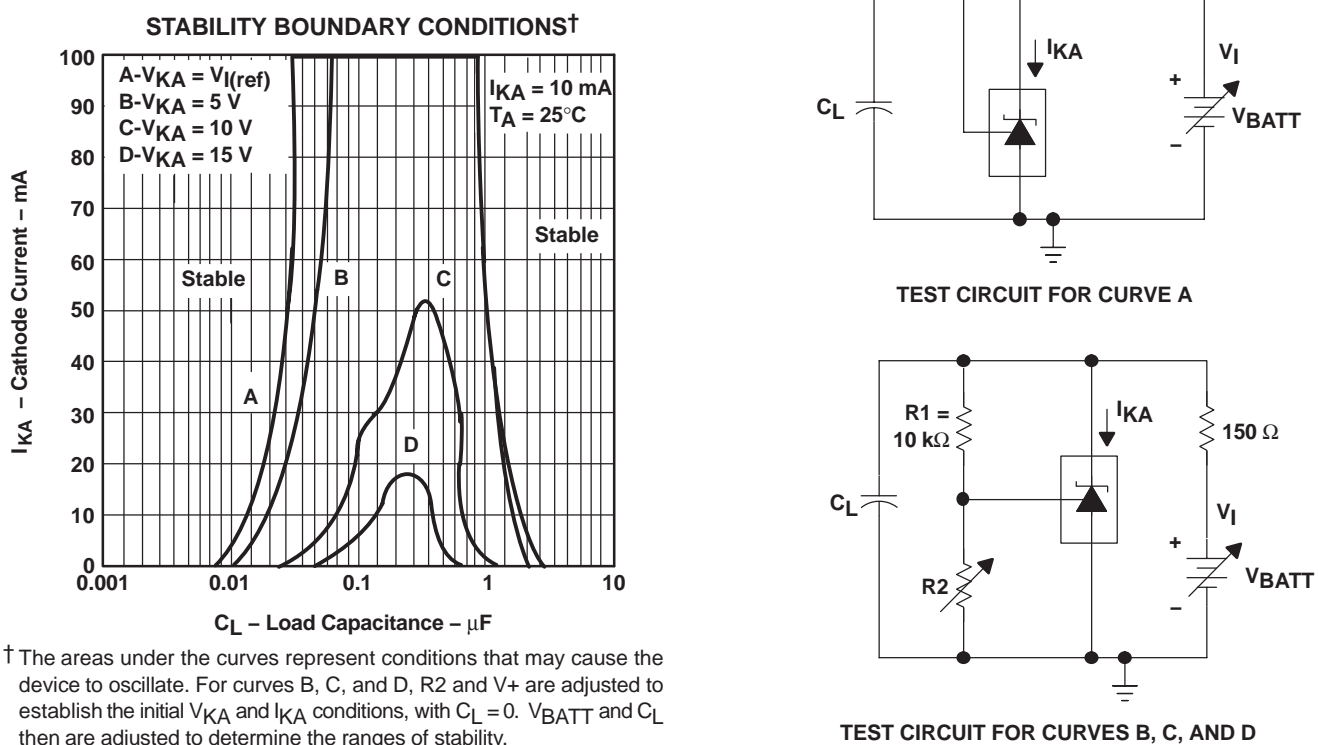
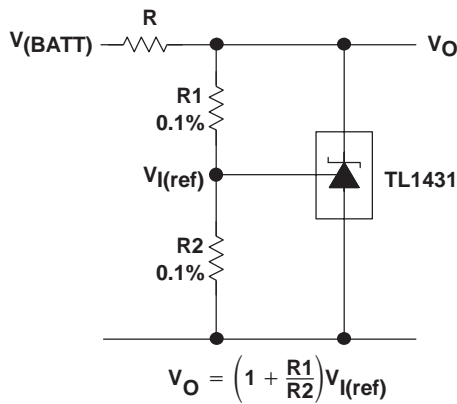


Figure 15

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

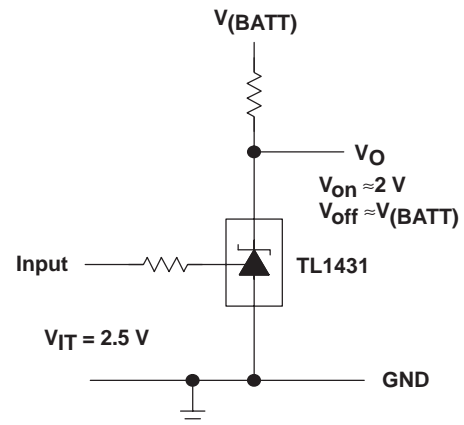
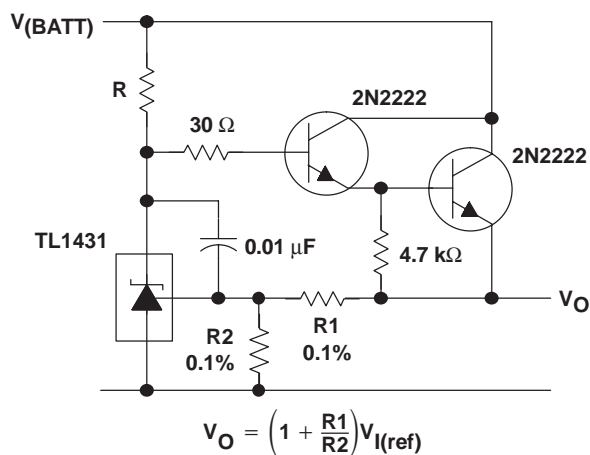


Figure 17. Single-Supply Comparator With Temperature-Compensated Threshold

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

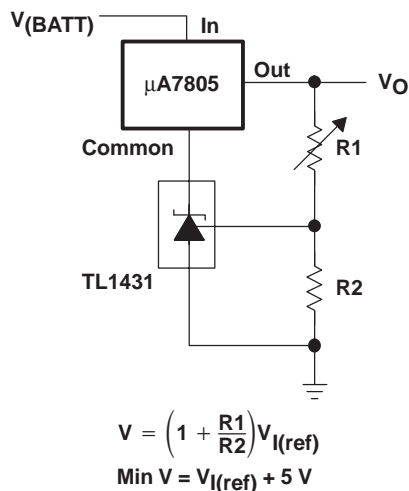


Figure 19. Output Control of a Three-Terminal Fixed Regulator

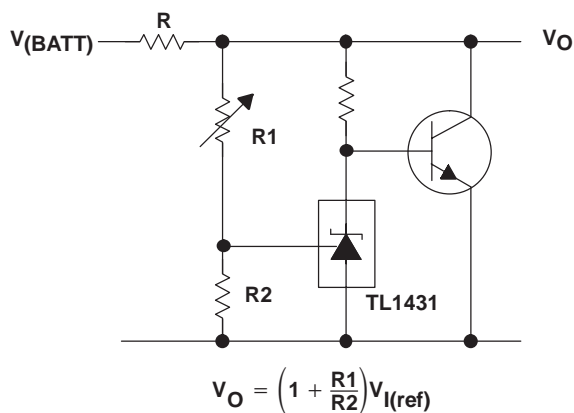
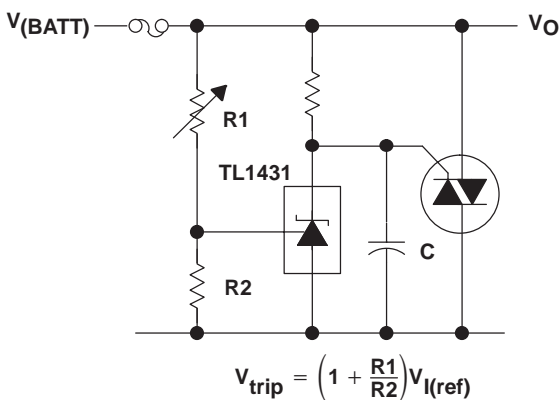


Figure 20. Higher-Current Shunt Regulator



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

Figure 21. Crowbar

APPLICATION INFORMATION

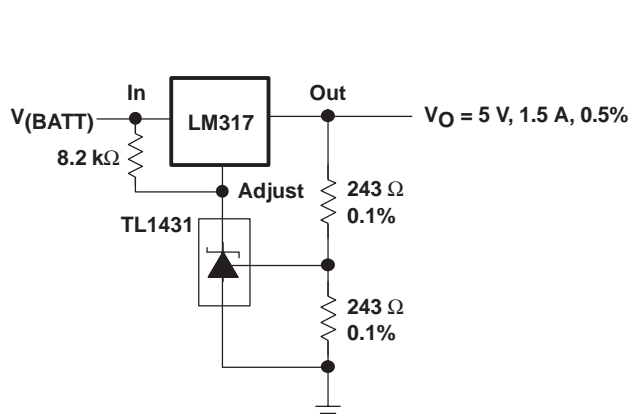
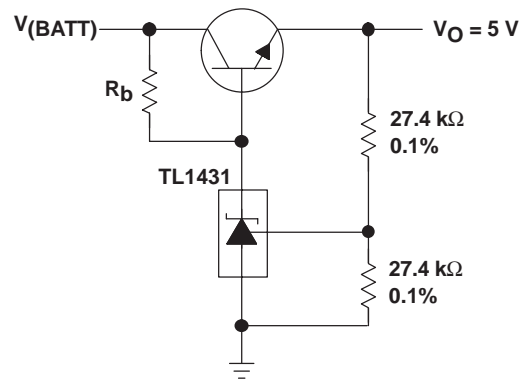


Figure 22. Precision 5-V, 1.5-A, 0.5% Regulator



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

Figure 23. 5-V Precision Regulator

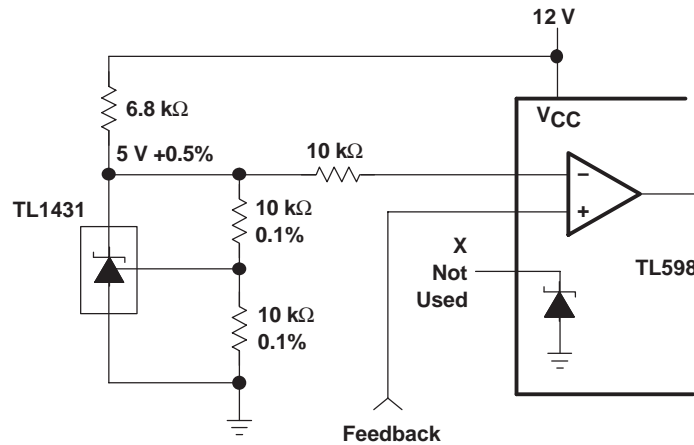
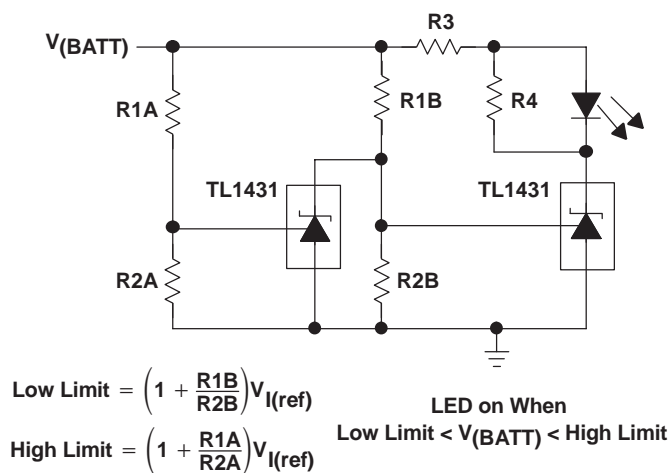


Figure 24. PWM Converter With 0.5% Reference

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

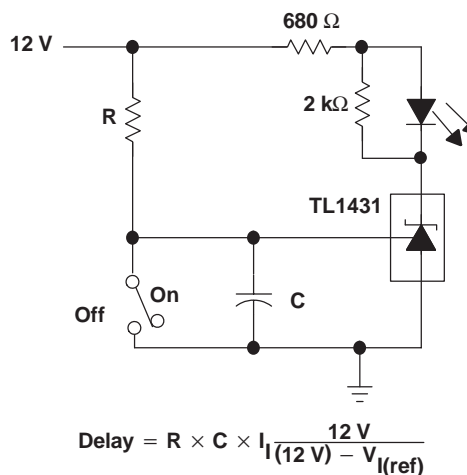


Figure 26. Delay Timer

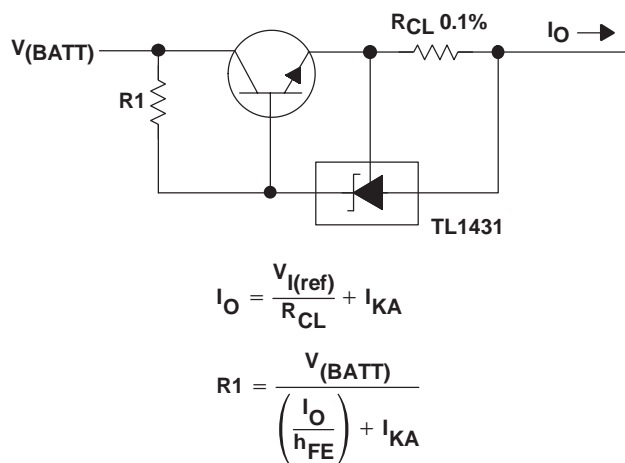


Figure 27. Precision Current Limiter

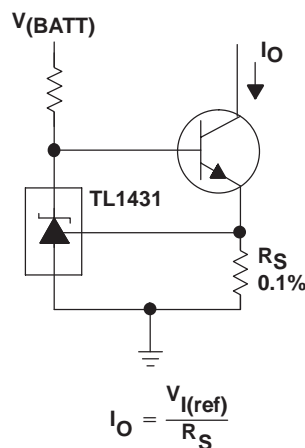


Figure 28. Precision Constant-Current Sink

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|--|
| TL1431QDRQ1 | ACTIVE | SOIC | D | 8 | 2500 | Pb-Free (RoHS) | CU NIPDAU | Level-2-250C-1 YEAR/ Level-1-235C-UNLIM |

⁽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)

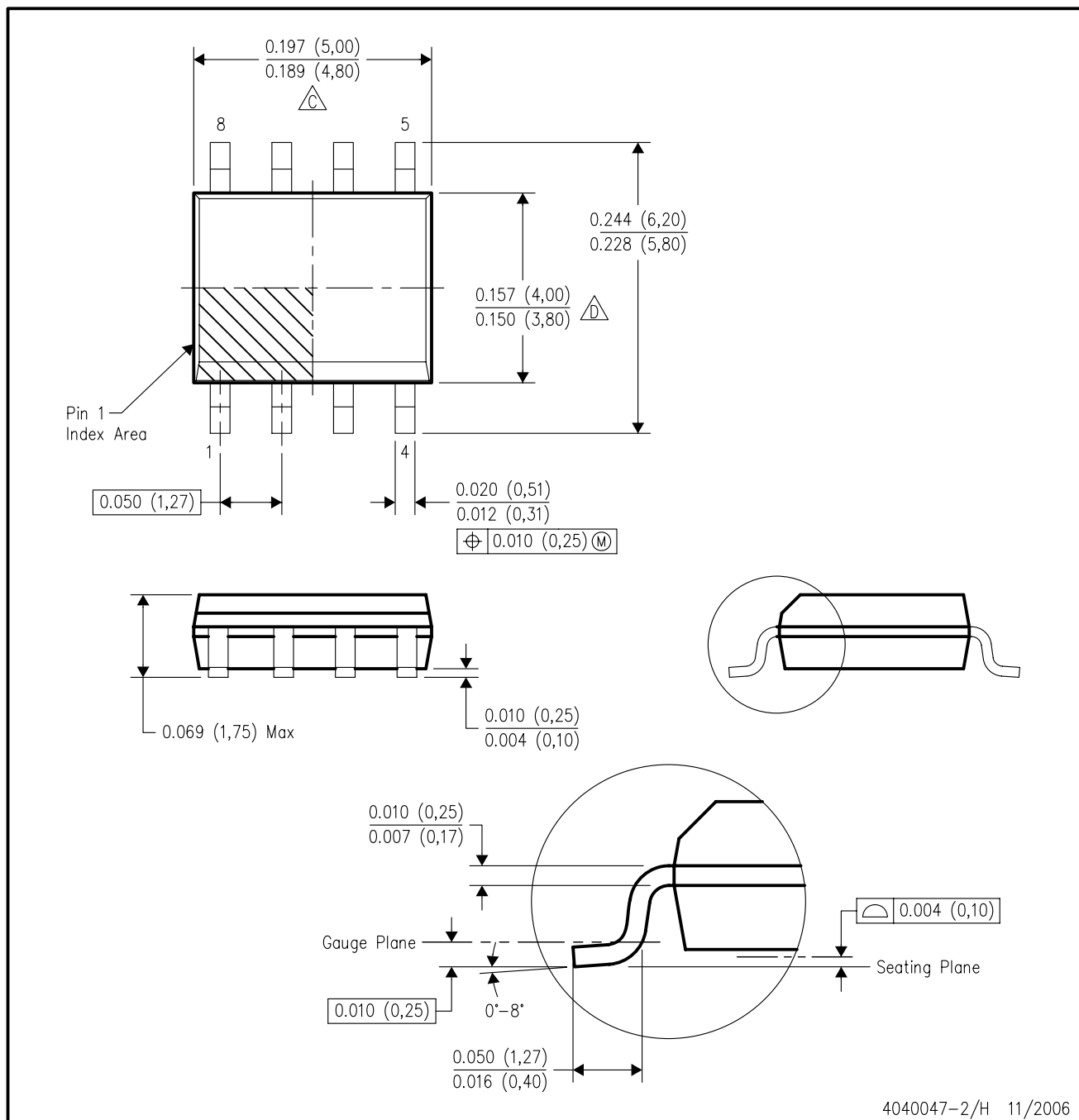
⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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.

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



NOTES:

- A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
D Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
E. Reference JEDEC MS-012 variation AA.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

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

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

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI 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 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. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

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

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

| | |
|--------------------|--|
| Amplifiers | amplifier.ti.com |
| Data Converters | dataconverter.ti.com |
| DSP | dsp.ti.com |
| Interface | interface.ti.com |
| Logic | logic.ti.com |
| Power Mgmt | power.ti.com |
| Microcontrollers | microcontroller.ti.com |
| RFID | www.ti-rfid.com |
| Low Power Wireless | www.ti.com/lpw |

Applications

| | |
|--------------------|--|
| Audio | www.ti.com/audio |
| Automotive | www.ti.com/automotive |
| Broadband | www.ti.com/broadband |
| Digital Control | www.ti.com/digitalcontrol |
| Military | www.ti.com/military |
| Optical Networking | www.ti.com/opticalnetwork |
| Security | www.ti.com/security |
| Telephony | www.ti.com/telephony |
| Video & Imaging | www.ti.com/video |
| Wireless | www.ti.com/wireless |

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2007, Texas Instruments Incorporated