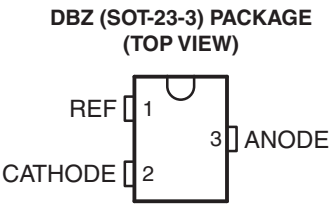


ADJUSTABLE PRECISION SHUNT REGULATORS

FEATURES

- Qualified for Automotive Applications
- Operation From –40°C to 125°C
- Reference Voltage Tolerance at 25°C
  - 0.5%...B Grade
  - 1%...A Grade
- Typical Temperature Drift...14 mV
- Low Output Noise
- Typical Output Impedance...0.2 Ω
- Sink Current Capability...1 mA to 100 mA
- Adjustable Output Voltage...V<sub>ref</sub> to 36 V



DESCRIPTION/ORDERING INFORMATION

The TL432 devices are three-terminal adjustable shunt regulators with specified thermal stability over the automotive temperature range. The output voltage can be set to any value between V<sub>ref</sub> (approximately 2.5 V) and 36 V with two external resistors (see Figure 17). These devices have a typical output impedance of 0.2 Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacements for Zener diodes in many applications such as onboard regulation, adjustable power supplies, and switching power supplies.

The TL432 devices are offered in two grades with initial tolerances (at 25°C) of 0.5% and 1%, for the B and A grade, respectively. In addition, low output drift vs temperature ensures good stability over the entire temperature range.

The devices are characterized for operation from –40°C to 125°C.

ORDERING INFORMATION<sup>(1)</sup>

T <sub>A</sub>	V <sub>ref</sub> TOLERANCE (T <sub>A</sub> = 25°C)	PACKAGE <sup>(2)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	A Grade: 1%	SOT23 – DBZ	Reel of 3000	TL432AQDBZRQ1	TOIQ
	B Grade: 0.5 %			TL432BQDBZRQ1	TOHQ

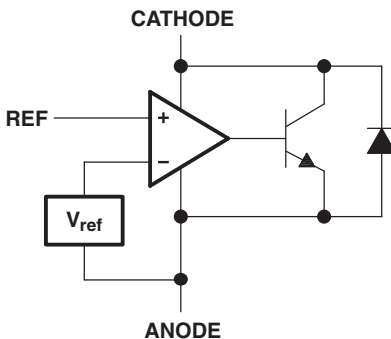
(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](http://www.ti.com).

(2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).

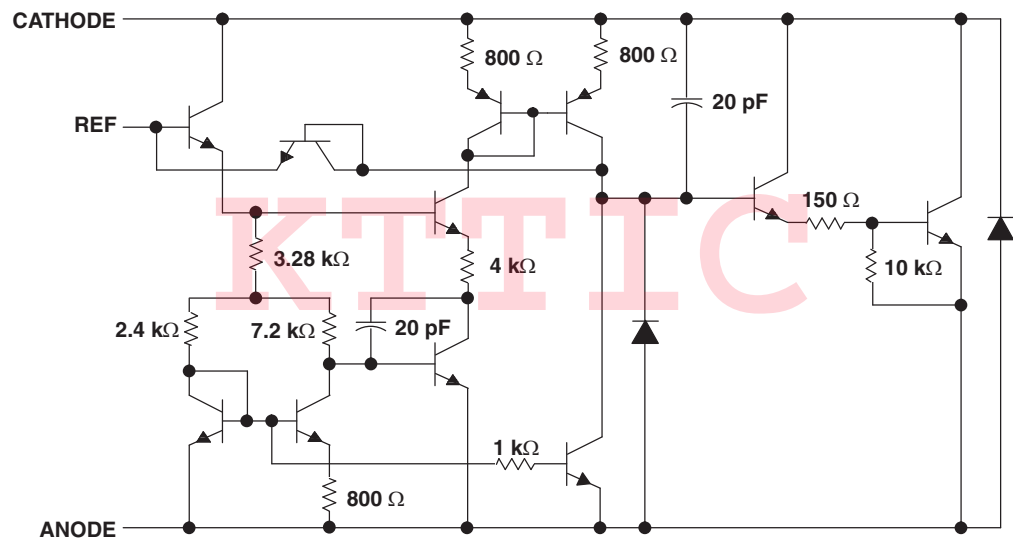
**SYMBOL**



**FUNCTIONAL BLOCK DIAGRAM**



**EQUIVALENT SCHEMATIC**



NOTE: All component values are nominal.

**ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>**

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

V <sub>KA</sub>	Cathode voltage <sup>(2)</sup>	37 V
I <sub>KA</sub>	Continuous cathode current range	–100 mA to 150 mA
	Reference input current range	–50 µA to 10 mA
T <sub>J</sub>	Operating virtual-junction temperature	150°C
T <sub>stg</sub>	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.

**PACKAGE THERMAL DATA**

PACKAGE	BOARD	θ <sub>JC</sub>	θ <sub>JA</sub>
SOT-23-3 (DBZ)	High K, JESD 51-7	76°C/W	206°C/W

**RECOMMENDED OPERATING CONDITIONS**

		MIN	MAX	UNIT
V <sub>KA</sub>	Cathode voltage	V <sub>ref</sub>	36	V
I <sub>KA</sub>	Cathode current	1	100	mA
T <sub>A</sub>	Operating free-air temperature	–40	125	°C

KTTIC

**TL432A-Q1**  
**TL432B-Q1**

SLVS900–NOVEMBER 2008

[www.ti.com](http://www.ti.com)
**TL432A ELECTRICAL CHARACTERISTICS**
over recommended operating conditions,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CIRCUIT	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{\text{ref}}$ Reference voltage	Figure 2	$V_{\text{KA}} = V_{\text{ref}}, I_{\text{KA}} = 10 \text{ mA}$	2470	2495	2520	mV
$V_{\text{I(dev)}}$ Deviation of reference voltage over full temperature range (see Figure 1)	Figure 2	$V_{\text{KA}} = V_{\text{ref}}, I_{\text{KA}} = 10 \text{ mA}, T_A = -40^\circ\text{C} \text{ to } 125^\circ\text{C}$		14	34	mV
$\frac{\Delta V_{\text{ref}}}{\Delta V_{\text{KA}}}$ Ratio of change in reference voltage to the change in cathode voltage	Figure 3	$I_{\text{KA}} = 10 \text{ mA}$				
		$\Delta V_{\text{KA}} = 10 \text{ V} - V_{\text{ref}}$		-1.4	-2.7	mV/V
		$\Delta V_{\text{KA}} = 36 \text{ V} - 10 \text{ V}$		-1	-2	
$I_{\text{ref}}$ Reference current	Figure 3	$I_{\text{KA}} = 10 \text{ mA}, R1 = 10 \text{ k}\Omega, R2 = \infty$		2	4	$\mu\text{A}$
$I_{\text{I(dev)}}$ Deviation of reference current over full temperature range (see Figure 1)	Figure 3	$I_{\text{KA}} = 10 \text{ mA}, R1 = 10 \text{ k}\Omega, R2 = \infty, T_A = -40^\circ\text{C} \text{ to } 125^\circ\text{C}$		0.8	2.5	$\mu\text{A}$
$I_{\text{min}}$ Minimum cathode current for regulation	Figure 2	$V_{\text{KA}} = V_{\text{ref}}$		0.4	0.7	mA
$I_{\text{off}}$ Off-state cathode current	Figure 4	$V_{\text{KA}} = 36 \text{ V}, V_{\text{ref}} = 0$		0.1	0.5	$\mu\text{A}$
$ z_{\text{KA}} $ Dynamic impedance (see Figure 1)	Figure 2	$I_{\text{KA}} = 1 \text{ mA} \text{ to } 100 \text{ mA}, V_{\text{KA}} = V_{\text{ref}}, f \leq 1 \text{ kHz}$		0.2	0.5	$\Omega$

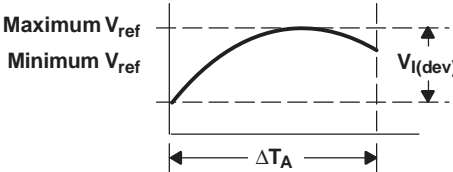
**TL432B ELECTRICAL CHARACTERISTICS**
over recommended operating conditions,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CIRCUIT	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{\text{ref}}$ Reference voltage	Figure 2	$V_{\text{KA}} = V_{\text{ref}}, I_{\text{KA}} = 10 \text{ mA}$	2483	2495	2507	mV
$V_{\text{I(dev)}}$ Deviation of reference voltage over full temperature range (see Figure 1)	Figure 2	$V_{\text{KA}} = V_{\text{ref}}, I_{\text{KA}} = 10 \text{ mA}, T_A = -40^\circ\text{C} \text{ to } 125^\circ\text{C}$		14	34	mV
$\frac{\Delta V_{\text{ref}}}{\Delta V_{\text{KA}}}$ Ratio of change in reference voltage to the change in cathode voltage	Figure 3	$I_{\text{KA}} = 10 \text{ mA}$				
		$\Delta V_{\text{KA}} = 10 \text{ V} - V_{\text{ref}}$		-1.4	-2.7	mV/V
		$\Delta V_{\text{KA}} = 36 \text{ V} - 10 \text{ V}$		-1	-2	
$I_{\text{ref}}$ Reference current	Figure 3	$I_{\text{KA}} = 10 \text{ mA}, R1 = 10 \text{ k}\Omega, R2 = \infty$		2	4	$\mu\text{A}$
$I_{\text{I(dev)}}$ Deviation of reference current over full temperature range (see Figure 1)	Figure 3	$I_{\text{KA}} = 10 \text{ mA}, R1 = 10 \text{ k}\Omega, R2 = \infty, T_A = -40^\circ\text{C} \text{ to } 125^\circ\text{C}$		0.8	2.5	$\mu\text{A}$
$I_{\text{min}}$ Minimum cathode current for regulation	Figure 2	$V_{\text{KA}} = V_{\text{ref}}$		0.4	0.7	mA
$I_{\text{off}}$ Off-state cathode current	Figure 4	$V_{\text{KA}} = 36 \text{ V}, V_{\text{ref}} = 0$		0.1	0.5	$\mu\text{A}$
$ z_{\text{KA}} $ Dynamic impedance (see Figure 1)	Figure 2	$I_{\text{KA}} = 1 \text{ mA} \text{ to } 100 \text{ mA}, V_{\text{KA}} = V_{\text{ref}}, f \leq 1 \text{ kHz}$		0.2	0.5	$\Omega$

### Deviation Parameters

The deviation parameters  $V_{\text{ref(dev)}}$  and  $I_{\text{ref(dev)}}$  are defined as the differences between the maximum and minimum values obtained over the recommended temperature range. The average full-range temperature coefficient of the reference voltage,  $\alpha_{V_{\text{ref}}}$ , is defined as:

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



where:

$\Delta T_A$  is the recommended operating free-air temperature range of the device.

$\alpha_{V_{\text{ref}}}$  can be positive or negative, depending on whether minimum  $V_{\text{ref}}$  or maximum  $V_{\text{ref}}$ , respectively, occurs at the lower temperature.

Example:  $V_{\text{ref}} = 2495 \text{ mV}$  at  $25^{\circ}\text{C}$ ,  $V_{\text{I(dev)}} = 14 \text{ mV}$ ,  $\Delta T_A = 165^{\circ}\text{C}$  for TL432B

$$|\alpha_{V_{\text{ref}}}| = \frac{\left( \frac{14 \text{ mV}}{2495 \text{ mV}} \right) \times 10^6}{165^{\circ}\text{C}} \approx 34 \frac{\text{ppm}}{^{\circ}\text{C}}$$

Because minimum  $V_{\text{ref}}$  occurs at the lower temperature, the coefficient is positive.

### Dynamic Impedance

The dynamic impedance is defined as:  $|z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$

When the device is operating with two external resistors (see Figure 3), the total dynamic impedance of the circuit is given by:

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

Figure 1. Calculating Deviation Parameters and Dynamic Impedance

PARAMETER MEASUREMENT INFORMATION

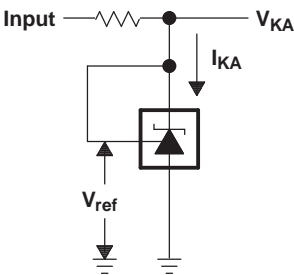


Figure 2. Test Circuit for  $V_{KA} = V_{ref}$

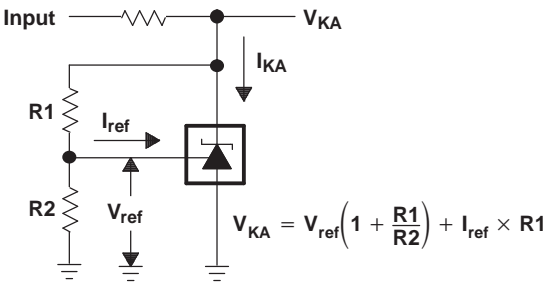


Figure 3. Test Circuit for  $V_{KA} > V_{ref}$

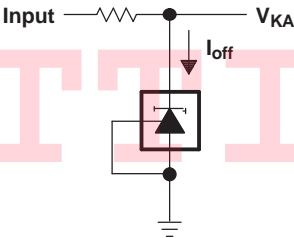


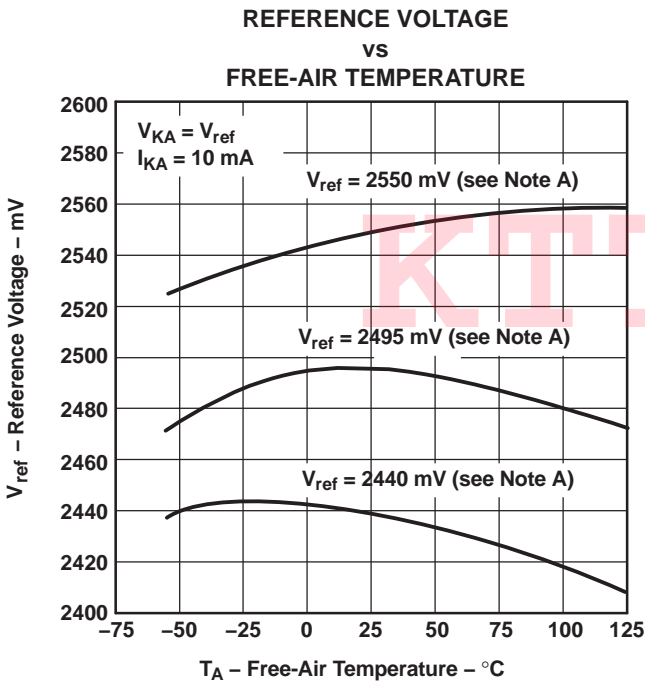
Figure 4. Test Circuit for  $I_{off}$

TYPICAL CHARACTERISTICS

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

Table 1. Graphs

	FIGURE
Reference voltage vs Free-air temperature	Figure 5
Reference current vs Free-air temperature	Figure 6
Cathode current vs Cathode voltage	Figure 7, Figure 8
Off-state cathode current vs Free-air temperature	Figure 9
Ratio of delta reference voltage to delta cathode voltage vs Free-air temperature	Figure 10
Equivalent input noise voltage vs Frequency	Figure 11
Equivalent input noise voltage over a 10-s period	Figure 12
Small-signal voltage amplification vs Frequency	Figure 13
Reference impedance vs Frequency	Figure 14
Pulse response	Figure 15
Stability boundary conditions	Figure 16



A. Data is for devices having the indicated value of  $V_{ref}$  at  $I_{KA} = 10 \text{ mA}$ ,  $T_A = 25^\circ\text{C}$ .  
Figure 5.

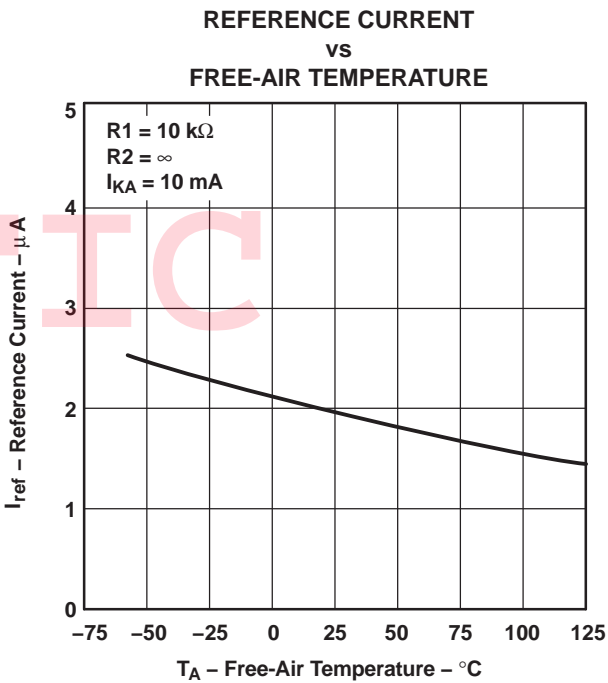


Figure 6.

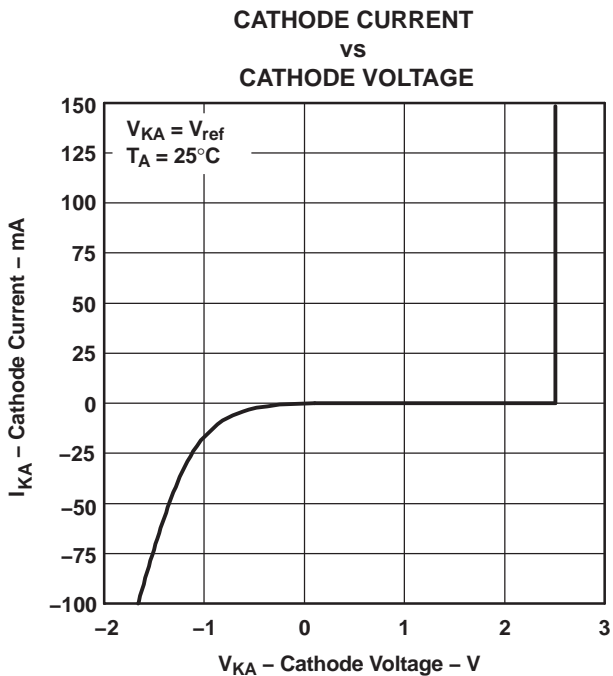


Figure 7.

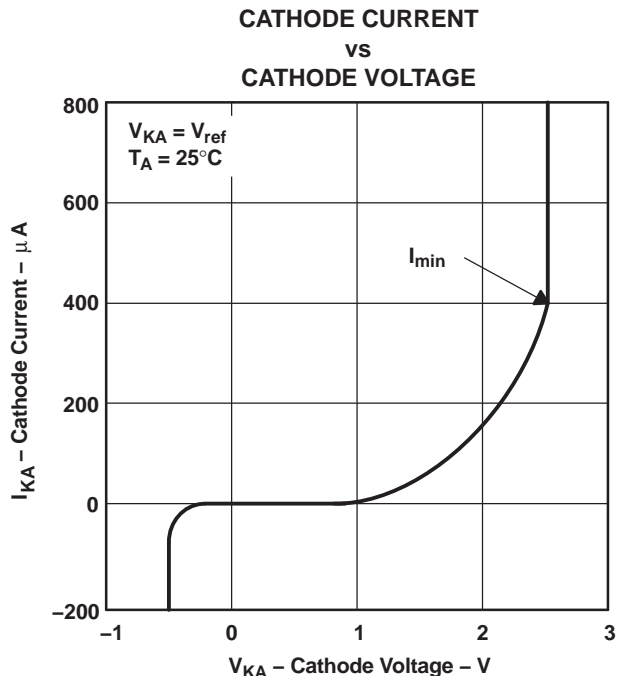


Figure 8.

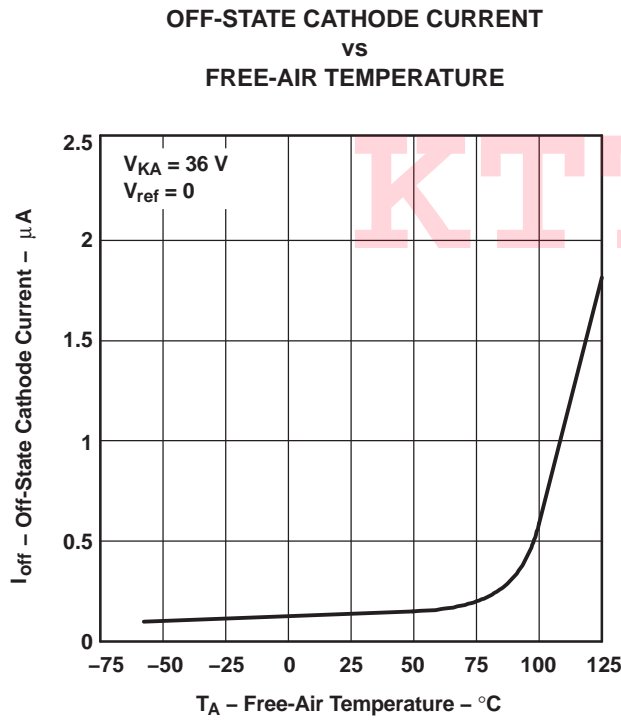


Figure 9.

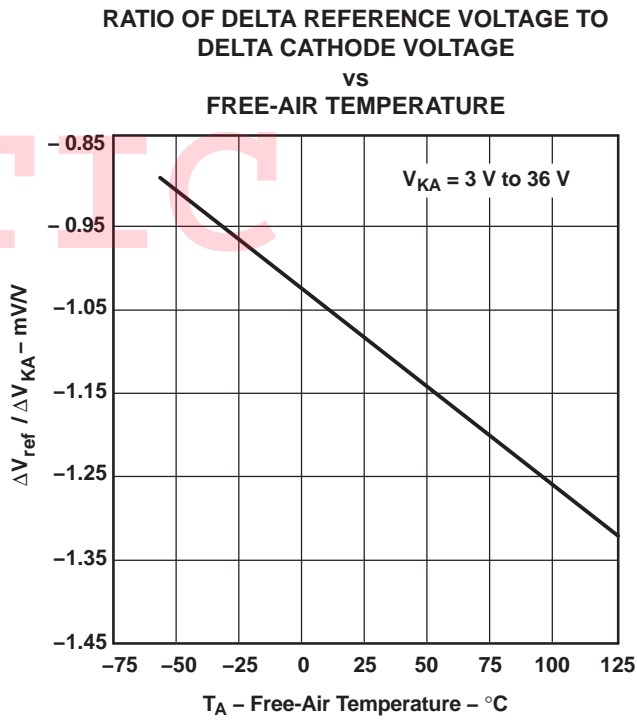
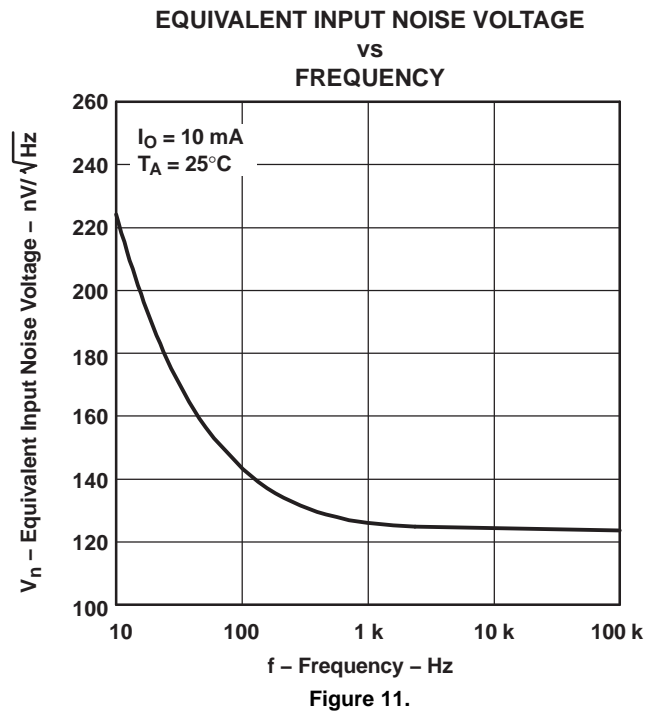


Figure 10.





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EQUIVALENT INPUT NOISE VOLTAGE  
OVER A 10-S PERIOD

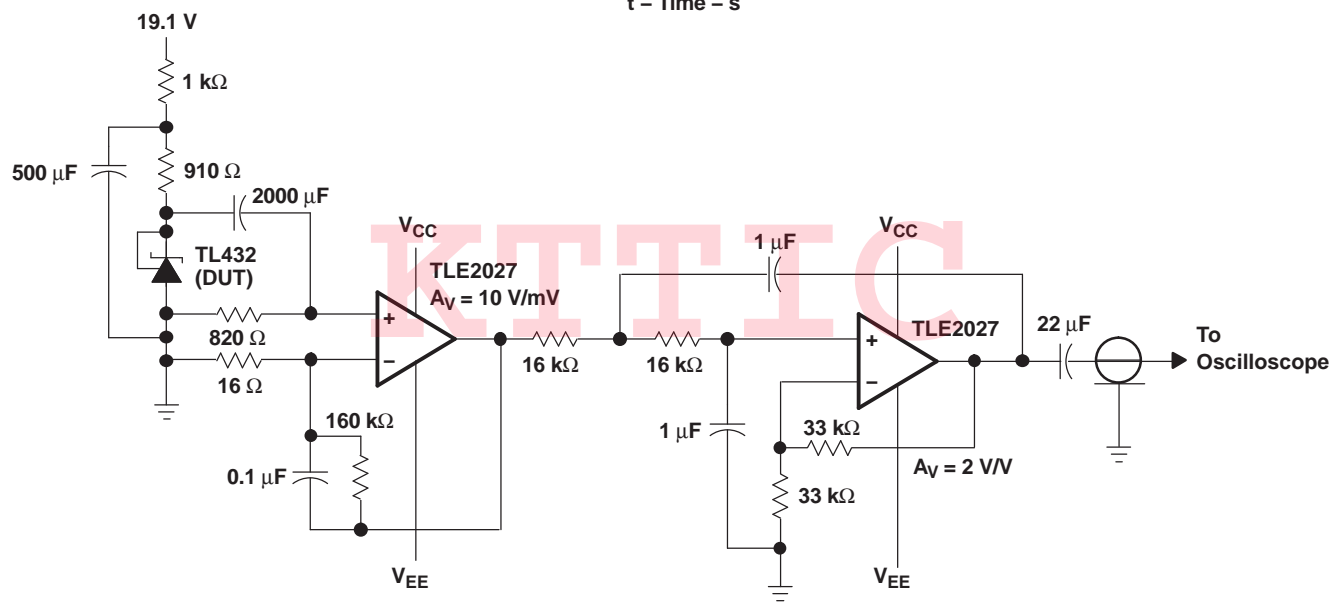
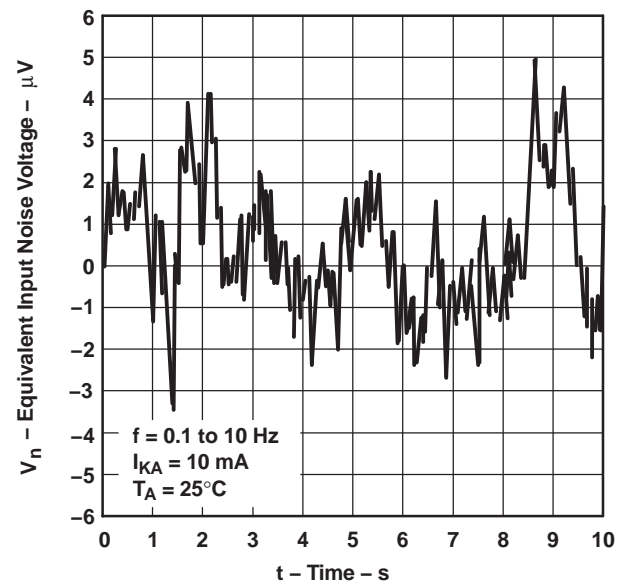


Figure 12. Test Circuit for Equivalent Input Noise Voltage

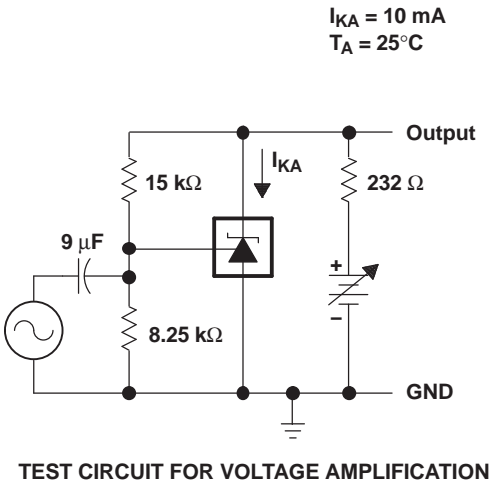
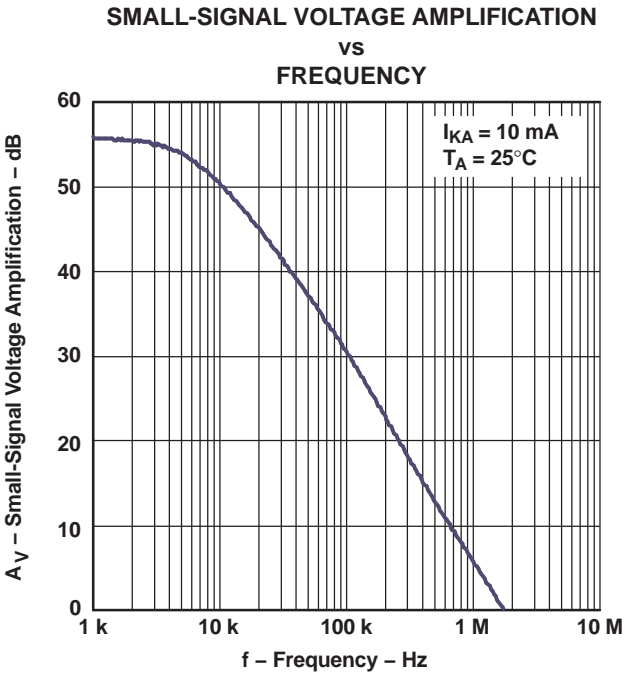


Figure 13.

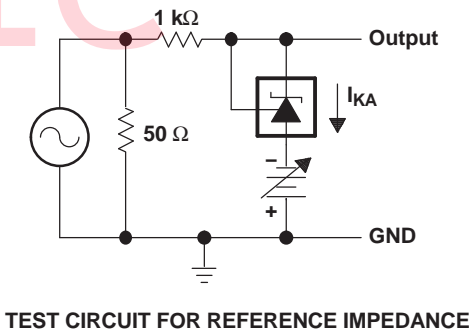
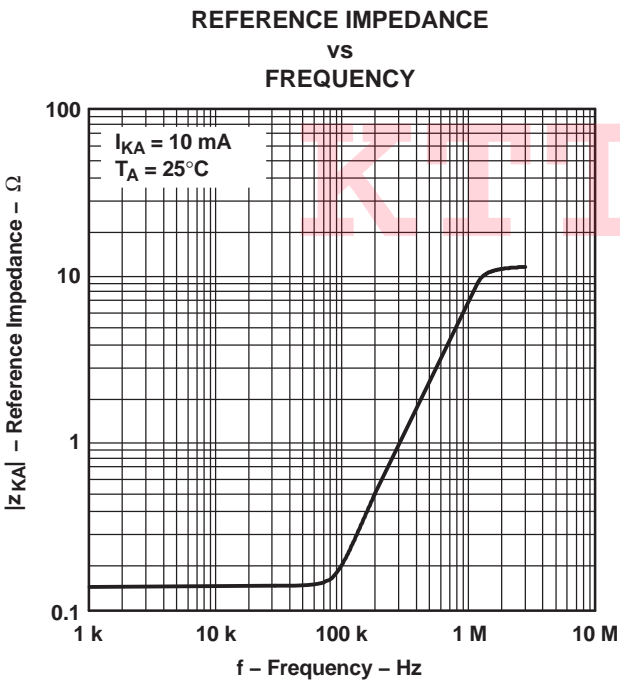
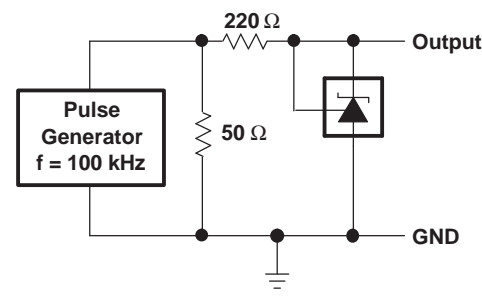
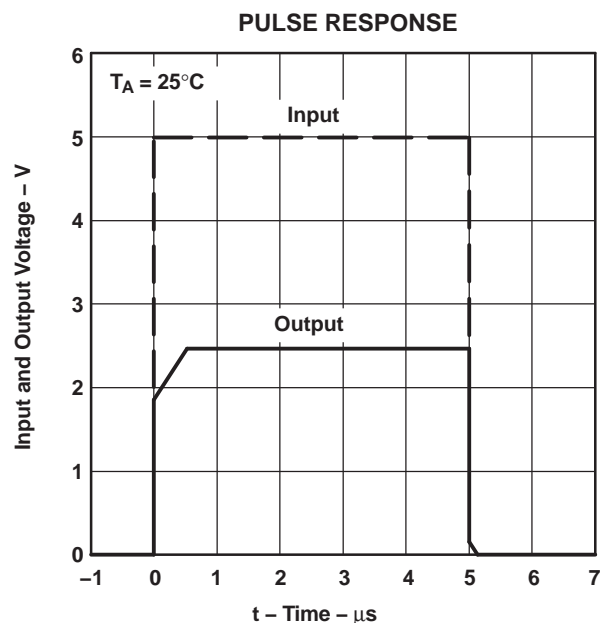
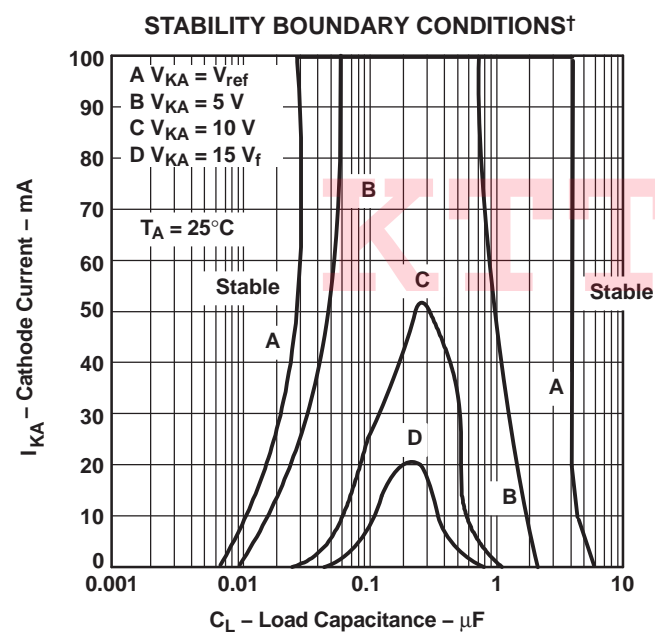


Figure 14.

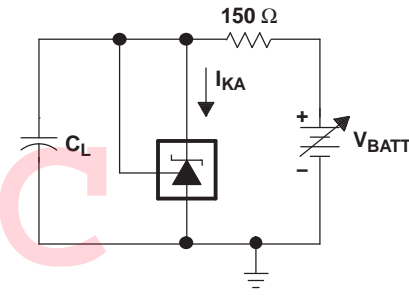


TEST CIRCUIT FOR PULSE RESPONSE

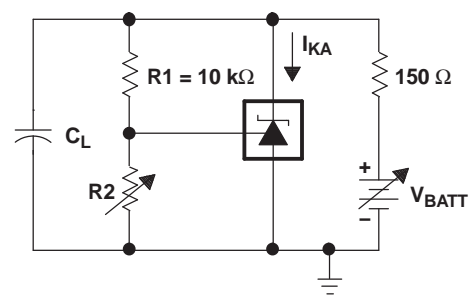
Figure 15.



† The areas under the curves represent conditions that may cause the device to oscillate. For curves B, C, and D, R2 and V+ were adjusted to establish the initial  $V_{KA}$  and  $I_{KA}$  conditions with  $C_L = 0$ .  $V_{BATT}$  and  $C_L$  then were adjusted to determine the ranges of stability.



TEST CIRCUIT FOR CURVE A



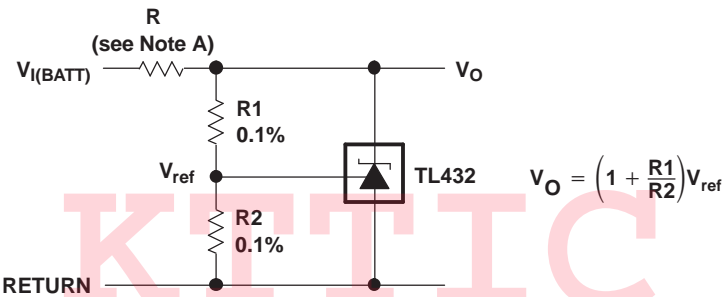
TEST CIRCUIT FOR CURVES B, C, AND D

Figure 16.

APPLICATION INFORMATION

Table 2. Application Circuits

	FIGURE
Shunt regulator	Figure 17
Single-supply comparator with temperature-compensated threshold	Figure 18
Precision high-current series regulator	Figure 19
Output control of a three-terminal fixed regulator	Figure 20
High-current shunt regulator	Figure 21
Crowbar circuit	Figure 22
Precision 5-V 1.5-A regulator	Figure 23
Efficient 5-V precision regulator	Figure 24
PWM converter with reference	Figure 25
Voltage monitor	Figure 26
Delay timer	Figure 27
Precision current limiter	Figure 28
Precision constant-current sink	Figure 29



A. R should provide cathode current ≥1 mA to the TL432 at minimum V<sub>I(BATT)</sub>.

Figure 17. Shunt Regulator

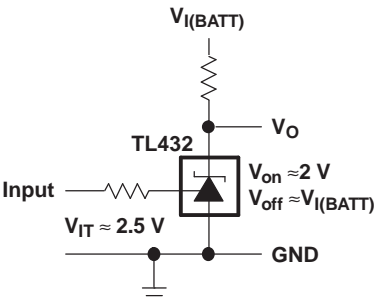
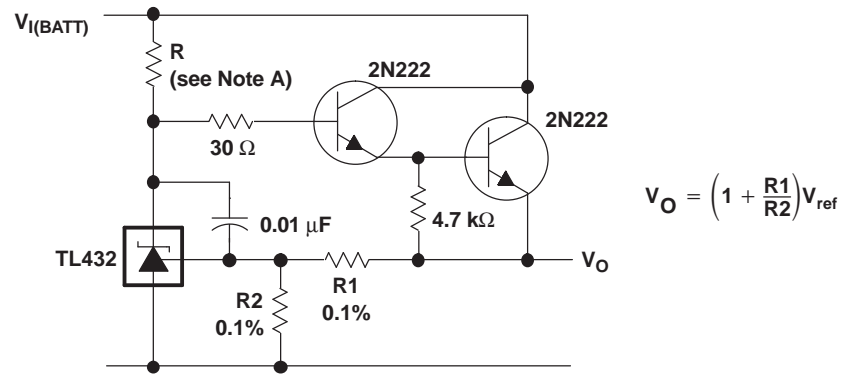


Figure 18. Single-Supply Comparator With Temperature-Compensated Threshold



A. R should provide cathode current  $\geq 1$  mA to the TL432 at minimum  $V_{I(BATT)}$ .

Figure 19. Precision High-Current Series Regulator

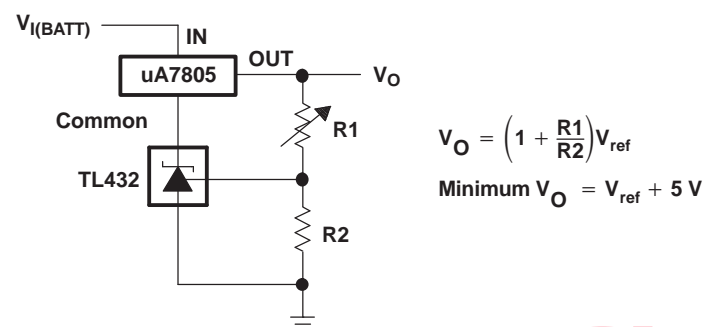


Figure 20. Output Control of a Three-Terminal Fixed Regulator

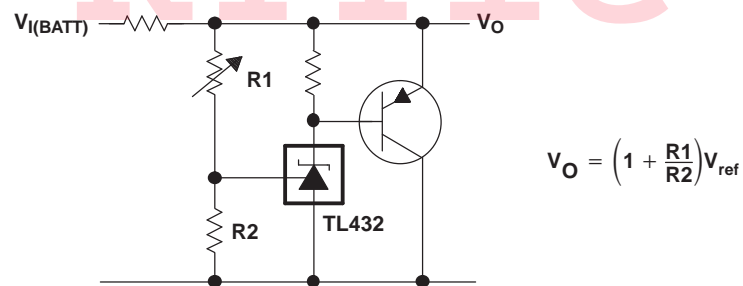
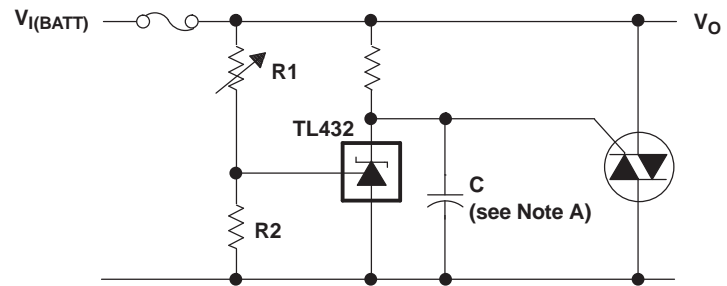


Figure 21. High-Current Shunt Regulator



A. See the stability boundary conditions in Figure 16 to determine allowable values for C.

Figure 22. Crowbar Circuit

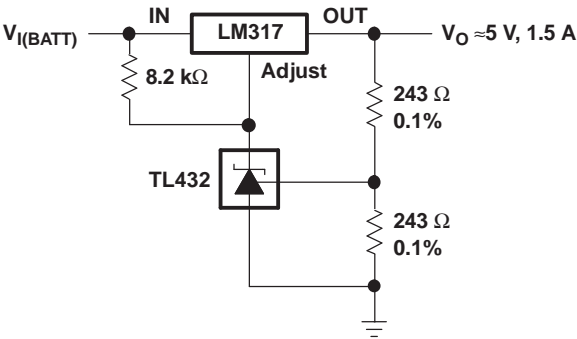
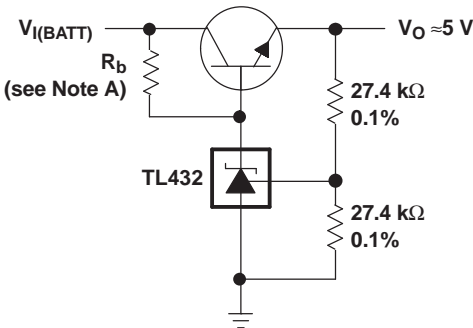


Figure 23. Precision 5-V 1.5-A Regulator



A.  $R_b$  should provide cathode current  $\geq 1\text{ mA}$  to the TL432.

Figure 24. Efficient 5-V Precision Regulator

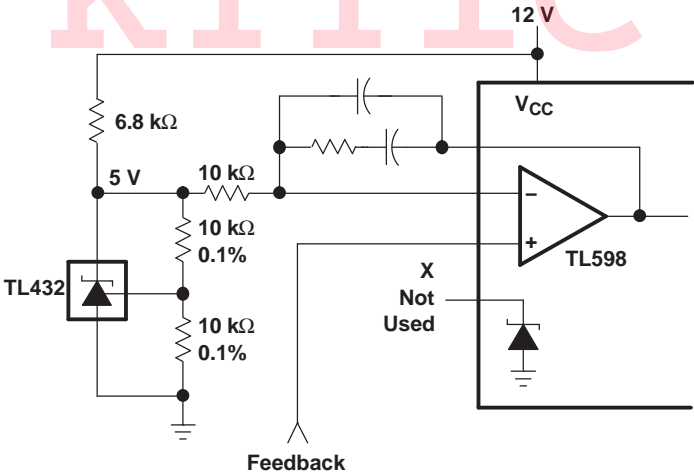
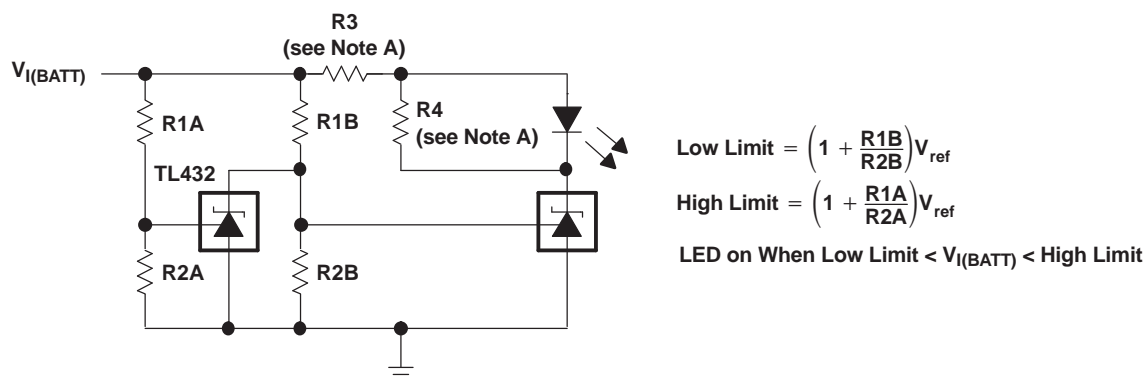


Figure 25. PWM Converter With Reference



- A. R3 and R4 are selected to provide the desired LED intensity and cathode current  $\geq 1$  mA to the TL432 at the available  $V_{I(BATT)}$ .

Figure 26. Voltage Monitor

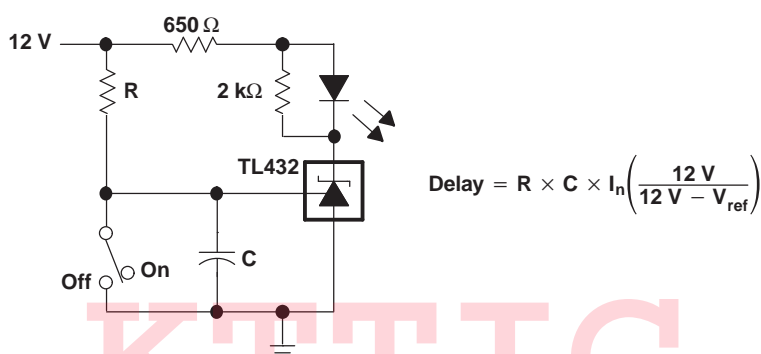


Figure 27. Delay Timer

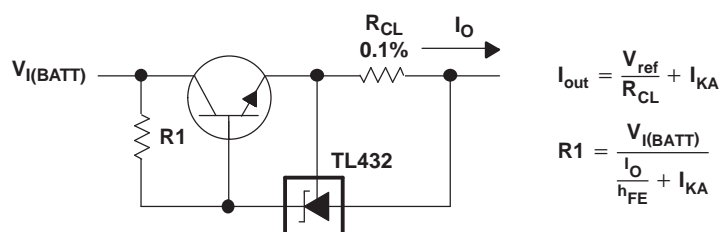


Figure 28. Precision Current Limiter

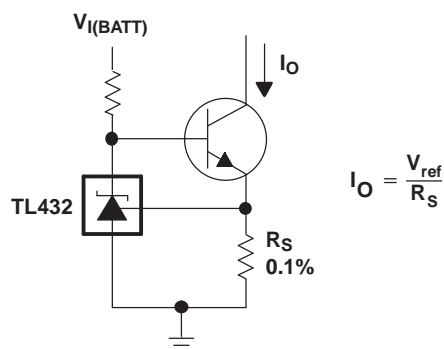


Figure 29. Precision Constant-Current Sink



**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
TL432AQDBZRQ1	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL432BQDBZRQ1	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

<sup>(1)</sup> 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.

<sup>(2)</sup> 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)

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

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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 TL432A-Q1, TL432B-Q1 :**

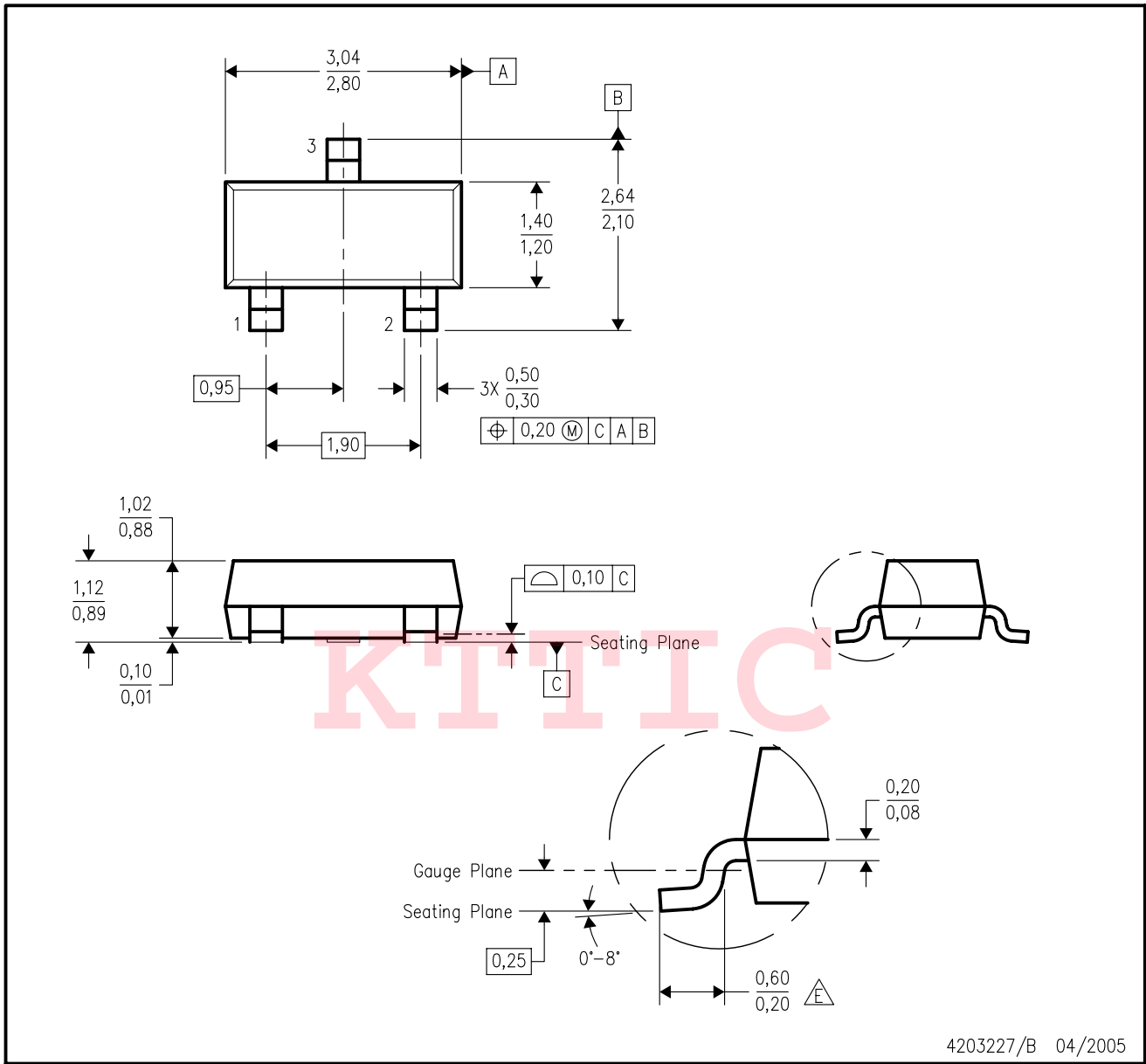
- Catalog: [TL432A](#), [TL432B](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

DBZ (R-PDSO-G3)

PLASTIC SMALL-OUTLINE



4203227/B 04/2005

NOTES: A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.  
B. This drawing is subject to change without notice.  
C. Lead dimensions are inclusive of plating.  
D. Body dimensions are exclusive of mold flash and protrusion. Mold flash and protrusion not to exceed 0.25 per side.  
E. Falls within JEDEC TO-236 variation AB, except minimum foot length.

## IMPORTANT NOTICE

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
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