

TLV431A, TLV431B

Low Voltage Precision Adjustable Shunt Regulator

The TLV431A and B series are precision low voltage shunt regulators that are programmable over a wide voltage range of 1.24 V to 16 V. The TLV431A series features a guaranteed reference accuracy of $\pm 1.0\%$ at 25°C and $\pm 2.0\%$ over the entire industrial temperature range of -40°C to 85°C. For TLV431B series, the accuracy is even higher, it's $\pm 0.5\%$ and $\pm 1.0\%$ respectively. These devices exhibit a sharp low current turn-on characteristic with a low dynamic impedance of 0.20 Ω over an operating current range of 100 μ A to 20 mA. This combination of features makes this series an excellent replacement for zener diodes in numerous applications circuits that require a precise reference voltage. When combined with an optocoupler, the TLV431A/B can be used as an error amplifier for controlling the feedback loop in isolated low output voltage (3.0 V to 3.3 V) switching power supplies. These devices are available in economical TO-92-3 and micro size TSOP-5 and SOT-23-3 packages.

Features

- Programmable Output Voltage Range of 1.24 V to 16 V
- Voltage Reference Tolerance $\pm 1.0\%$ for A Series and $\pm 0.5\%$ for B Series
- Sharp Low Current Turn-On Characteristic
- Low Dynamic Output Impedance of 0.20 Ω from 100 μ A to 20 mA
- Wide Operating Current Range of 50 μ A to 20 mA
- Micro Miniature TSOP-5, SOT-23-3 and TO-92-3 Packages
- Pb-Free Package is Available

Applications

- Low Output Voltage (3.0 V to 3.3 V) Switching Power Supply Error Amplifier
- Adjustable Voltage or Current Linear and Switching Power Supplies
- Voltage Monitoring
- Current Source and Sink Circuits
- Analog and Digital Circuits Requiring Precision References
- Low Voltage Zener Diode Replacements

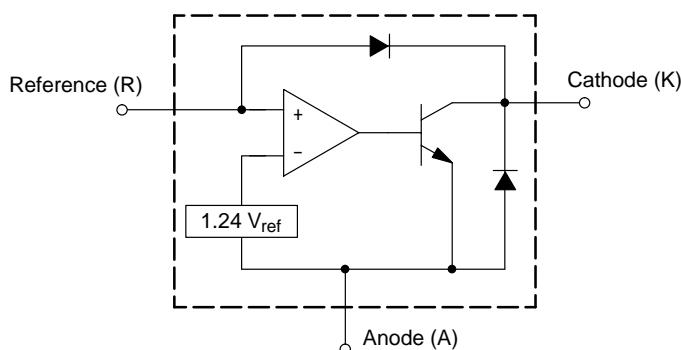
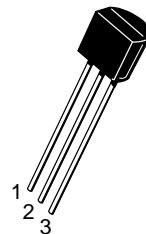


Figure 1. Representative Block Diagram

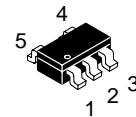


ON Semiconductor®

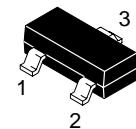
<http://onsemi.com>



TO-92-3-3
LP SUFFIX
CASE 29



TSOP-5
SN SUFFIX
CASE 483



SOT-23-3
SN1 SUFFIX
CASE 318

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 11 of this data sheet.

DEVICE MARKING INFORMATION AND PIN CONNECTIONS

See general marking information in the device marking section on page 11 of this data sheet.

TLV431A, TLV431B

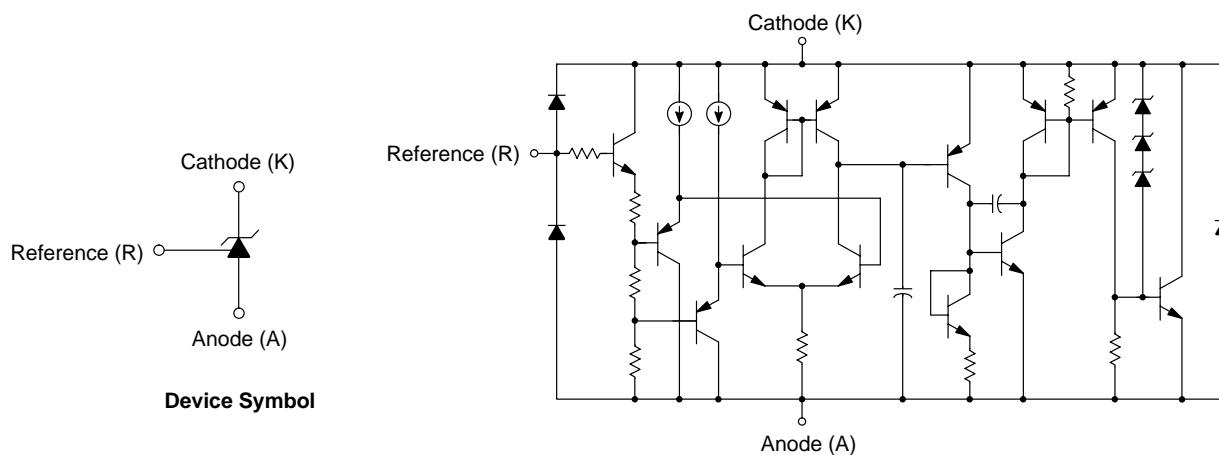


Figure 2. Representative Device Symbol and Schematic Diagram

MAXIMUM RATINGS (Full operating ambient temperature range applies, unless otherwise noted)

Rating	Symbol	Value	Unit
Cathode to Anode Voltage	V_{KA}	18	V
Cathode Current Range, Continuous (Note 1)	I_K	-20 to 25	mA
Reference Input Current Range, Continuous	I_{ref}	-0.05 to 10	mA
Thermal Characteristics LP Suffix Package, TO-92-3 Package Thermal Resistance, Junction-to-Ambient Thermal Resistance, Junction-to-Case SN Suffix Package, TSOP-5 Package Thermal Resistance, Junction-to-Ambient SN1 Suffix Package, SOT-23-3 Package Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$ $R_{\theta JC}$ $R_{\theta JA}$ $R_{\theta JA}$	178 83 226 491	°C/W
Operating Junction Temperature	T_J	150	°C
Operating Ambient Temperature Range (Note 1)	T_A	-40 to 85	°C
Storage Temperature Range	T_{stg}	-65 to 150	°C

1. Maximum package power dissipation limits must not be exceeded.

$$P_D = \frac{T_{J(max)} - T_A}{R_{\theta JA}}$$

NOTE: This device series contains ESD protection and exceeds the following tests:
Human Body Model 2000 V per MIL-STD-883, Method 3015.
Machine Model Method 200 V.

RECOMMENDED OPERATING CONDITIONS

Condition	Symbol	Min	Max	Unit
Cathode to Anode Voltage	V_{KA}	V_{ref}	16	V
Cathode Current	I_K	0.1	20	mA

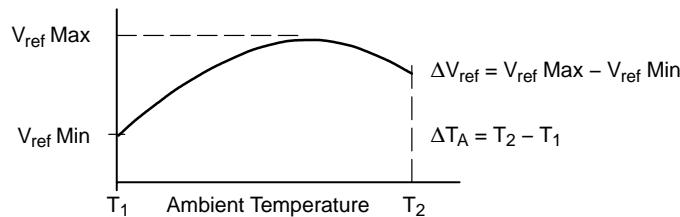
TLV431A, TLV431B

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	TLV431A			TLV431B			Unit
		Min	Typ	Max	Min	Typ	Max	
Reference Voltage (Figure 3) ($V_{KA} = V_{ref}$, $I_K = 10 \text{ mA}$, $T_A = 25^\circ\text{C}$) ($T_A = T_{low}$ to T_{high} , Note 2)	V_{ref}	1.228 1.215	1.240 –	1.252 1.265	1.234 1.228	1.240 –	1.246 1.252	V
Reference Input Voltage Deviation Over Temperature (Figure 3) ($V_{KA} = V_{ref}$, $I_K = 10 \text{ mA}$, $T_A = T_{low}$ to T_{high} , Note 2)	ΔV_{ref}	–	7.2	20	–	7.2	20	mV
Ration of Reference Input Voltage Change to Cathode Voltage Change (Figure 4) ($V_{KA} = V_{ref}$ to 16 V, $I_K = 10 \text{ mA}$)	$\frac{\Delta V_{ref}}{\Delta V_{KA}}$	–	-0.6	-1.5	–	-0.6	-1.5	$\frac{\text{mV}}{\text{V}}$
Reference Terminal Current (Figure 4) ($I_K = 10 \text{ mA}$, $R_1 = 10 \text{ k}\Omega$, $R_2 = \text{open}$)	I_{ref}	–	0.15	0.3	–	0.15	0.3	μA
Reference Input Current Deviation Over Temperature (Figure 4) ($I_K = 10 \text{ mA}$, $R_1 = 10 \text{ k}\Omega$, $R_2 = \text{open}$, Notes 2, 3)	ΔI_{ref}	–	0.04	0.08	–	0.04	0.08	μA
Minimum Cathode Current for Regulation (Figure 3)	$I_{K(min)}$	–	55	80	–	55	80	μA
Off-State Cathode Current (Figure 5) ($V_{KA} = 6.0 \text{ V}$, $V_{ref} = 0$) ($V_{KA} = 16 \text{ V}$, $V_{ref} = 0$)	$I_{K(off)}$	–	0.01 0.012	0.04 0.05	–	0.01 0.012	0.04 0.05	μA
Dynamic Impedance (Figure 3) ($V_{KA} = V_{ref}$, $I_K = 0.1 \text{ mA}$ to 20 mA, $f \leq 1.0 \text{ kHz}$, Note 4)	$ Z_{KA} $	–	0.25	0.4	–	0.25	0.4	Ω

2. Ambient temperature range: $T_{low} = -40^\circ\text{C}$, $T_{high} = 85^\circ\text{C}$.

3. The deviation parameters ΔV_{ref} and ΔI_{ref} are defined as the difference between the maximum value and minimum value obtained over the full operating ambient temperature range that applied.



The average temperature coefficient of the reference input voltage, αV_{ref} is defined as:

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

αV_{ref} can be positive or negative depending on whether V_{ref} Min or V_{ref} Max occurs at the lower ambient temperature, refer to Figure 8.

Example: $\Delta V_{ref} = 7.2 \text{ mV}$ and the slope is positive,

$$V_{ref} @ 25^\circ\text{C} = 1.241 \text{ V}$$

$$\Delta T_A = 125^\circ\text{C}$$

$$\alpha V_{ref} \left(\frac{\text{ppm}}{^\circ\text{C}} \right) = \frac{\frac{0.0072}{1.241} \times 10^6}{125} = 46 \text{ ppm}/^\circ\text{C}$$

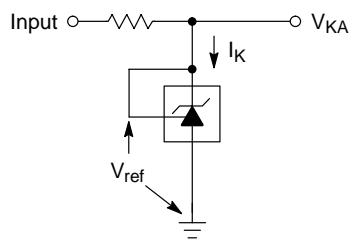
4. The dynamic impedance Z_{KA} is defined as:

$$|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_K}$$

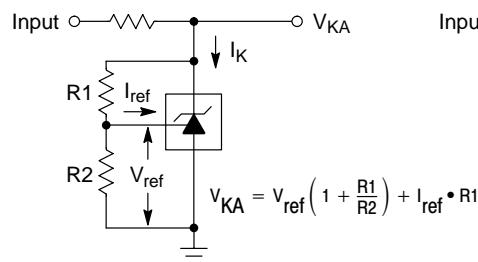
When the device is operating with two external resistors, R_1 and R_2 , (refer to Figure 4) the total dynamic impedance of the circuit is given by:

$$|Z_{KA}'| = |Z_{KA}| \times \left(1 + \frac{R_1}{R_2} \right)$$

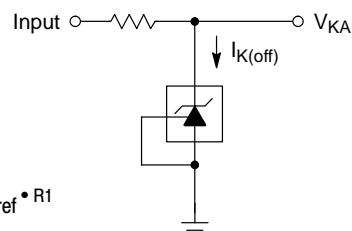
TLV431A, TLV431B



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



**Figure 4. Test Circuit
for $V_{KA} > V_{ref}$**



**Figure 5. Test Circuit
for $I_{K(off)}$**

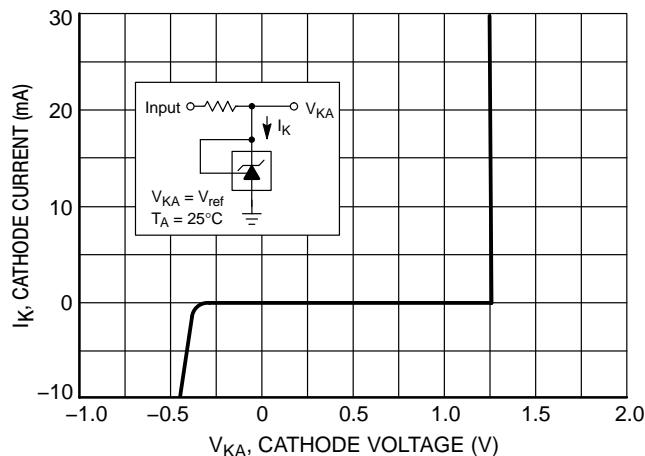


Figure 6. Cathode Current vs. Cathode Voltage

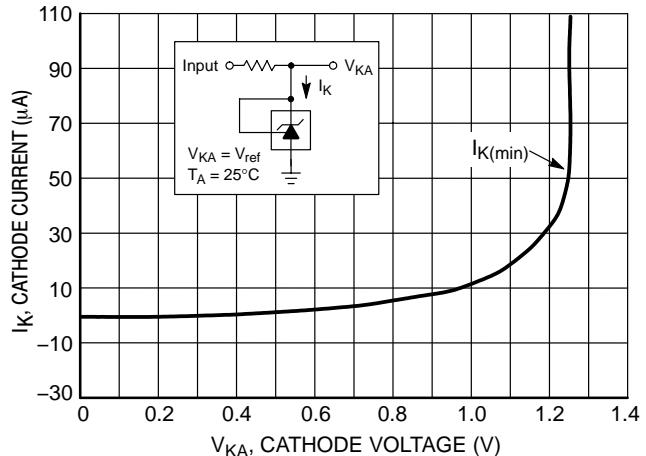
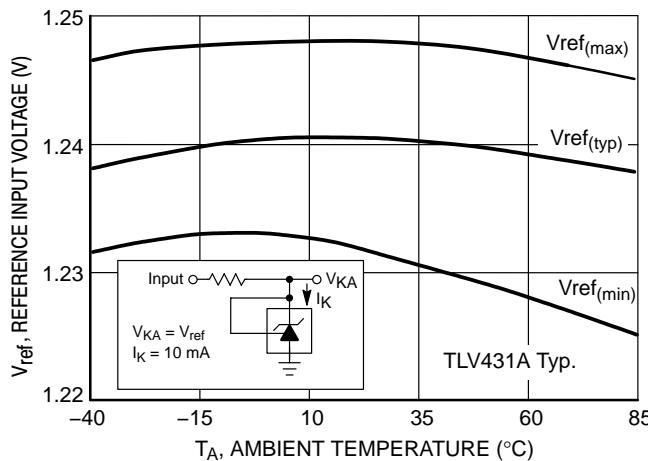
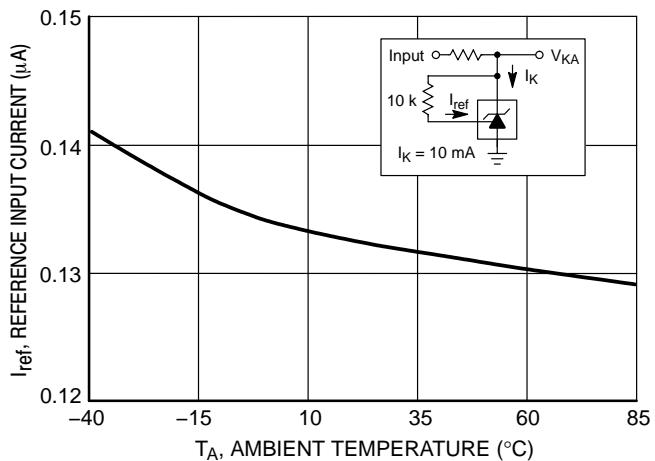


Figure 7. Cathode Current vs. Cathode Voltage

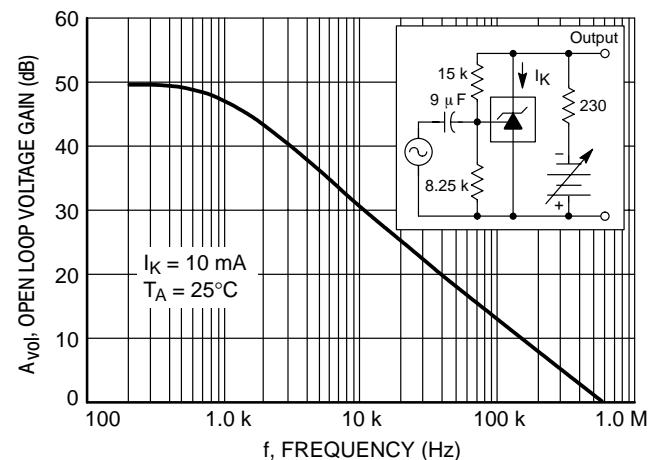
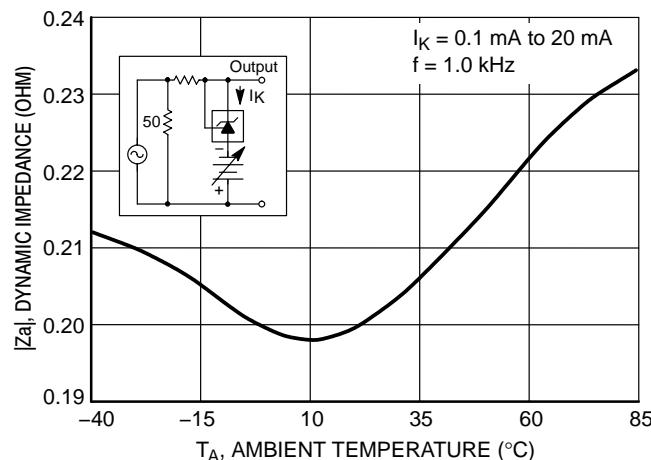
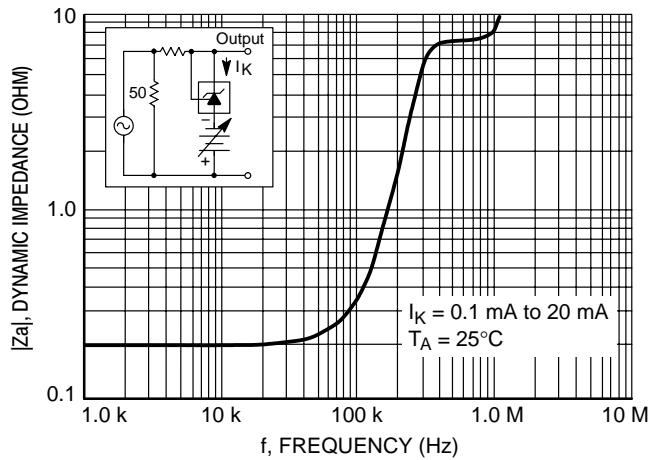
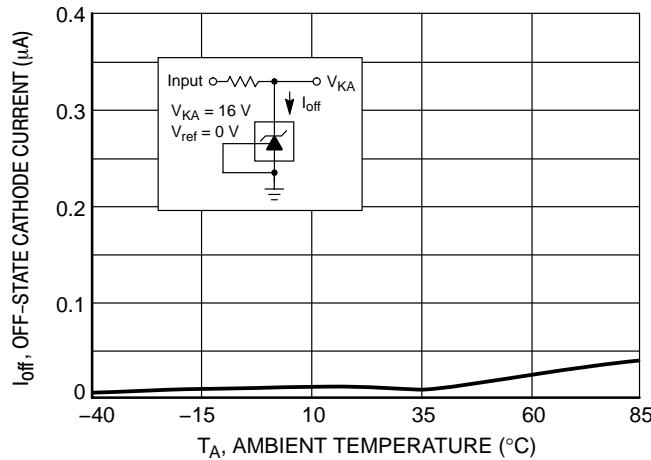
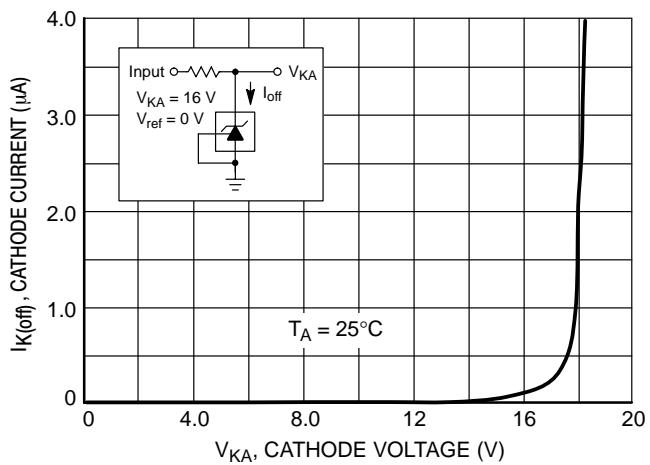
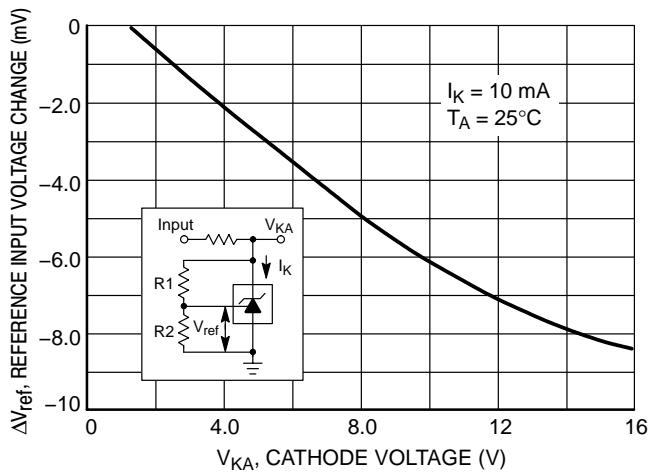


**Figure 8. Reference Input Voltage versus
Ambient Temperature**



**Figure 9. Reference Input Current versus
Ambient Temperature**

TLV431A, TLV431B



TLV431A, TLV431B

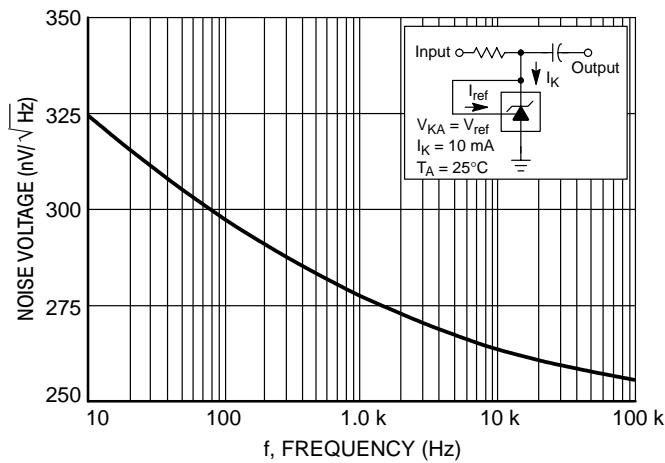


Figure 16. Spectral Noise Density

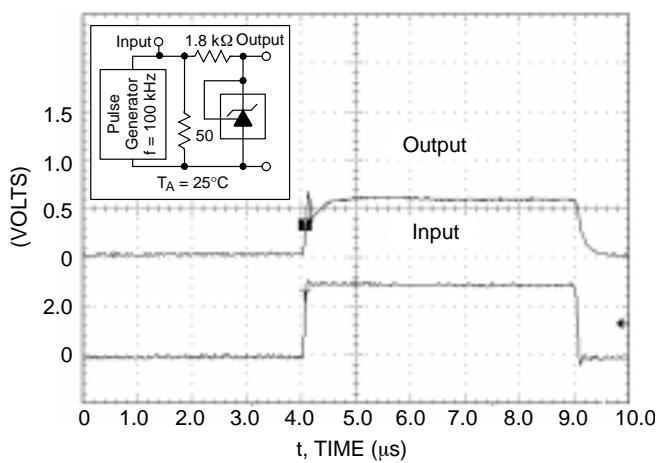


Figure 17. Pulse Response

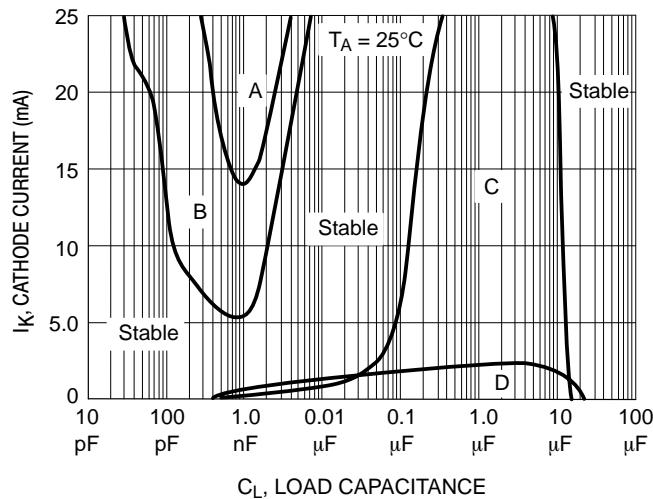
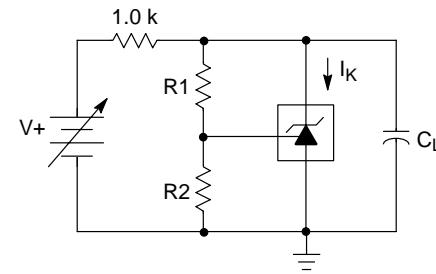


Figure 18. Stability Boundary Conditions



Unstable Regions	V_{KA} (V)	R_1 ($\text{k}\Omega$)	R_2 ($\text{k}\Omega$)
A, C	V_{ref}	0	∞
B, D	5.0	30.4	10

Figure 19. Test Circuit for Figure 18

Stability

Figures 18 and 19 show the stability boundaries and circuit configurations for the worst case conditions with the load capacitance mounted as close as possible to the device. The required load capacitance for stable operation can vary depending on the operating temperature and capacitor

equivalent series resistance (ESR). Ceramic or tantalum surface mount capacitors are recommended for both temperature and ESR. The application circuit stability should be verified over the anticipated operating current and temperature ranges.

TLV431A, TLV431B

TYPICAL APPLICATIONS

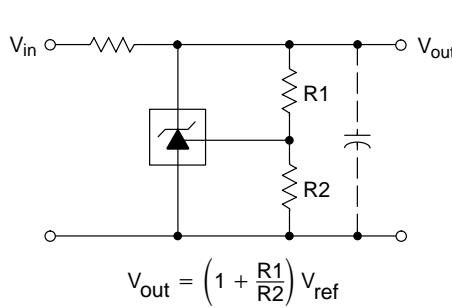


Figure 20. Shunt Regulator

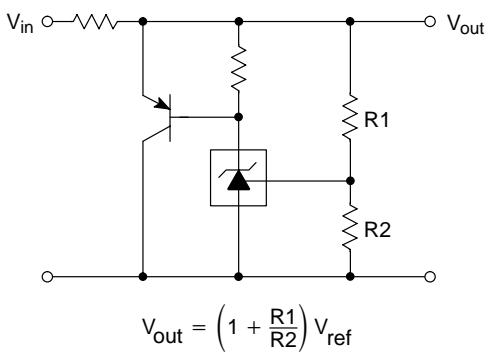


Figure 21. High Current Shunt Regulator

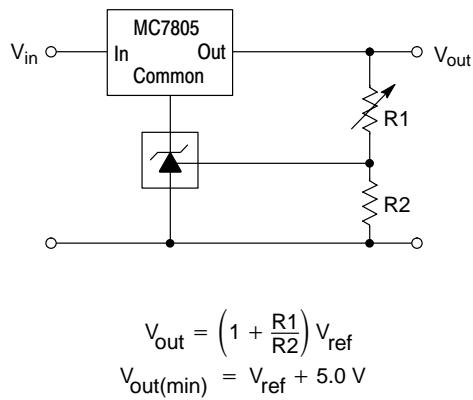


Figure 22. Output Control for a Three Terminal Fixed Regulator

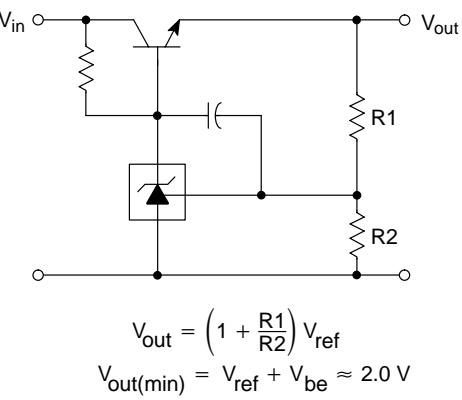


Figure 23. Series Pass Regulator

TLV431A, TLV431B

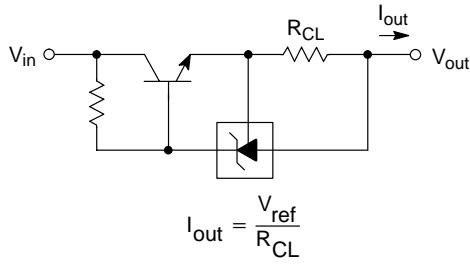


Figure 24. Constant Current Source

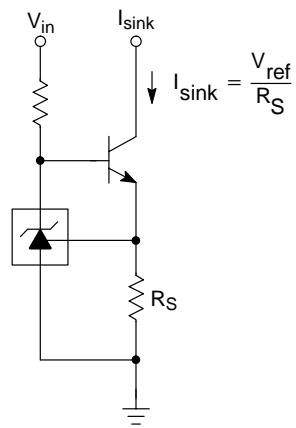


Figure 25. Constant Current Sink

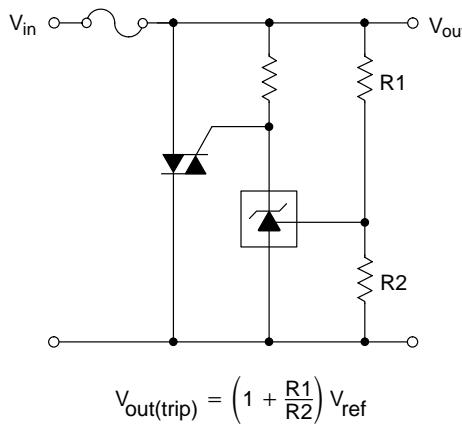


Figure 26. TRIAC Crowbar

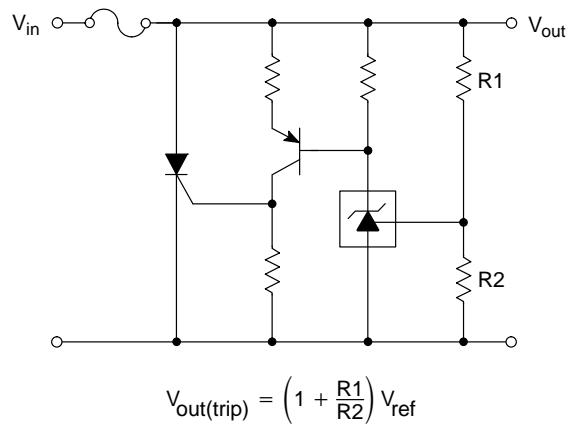
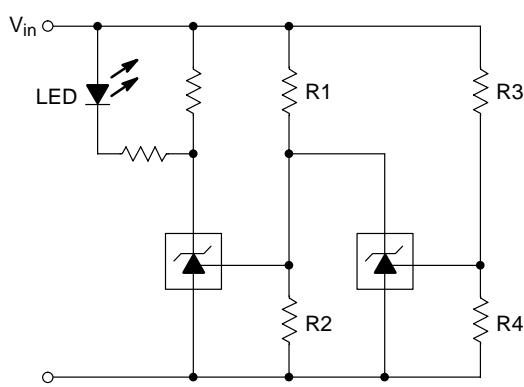


Figure 27. SCR Crowbar

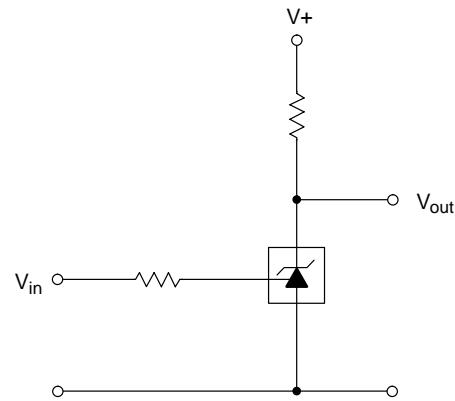
TLV431A, TLV431B



L.E.D. indicator is 'ON' when V_{in} is between the upper and lower limits,

$$\text{Lower limit} = \left(1 + \frac{R_1}{R_2}\right) V_{ref}$$

$$\text{Upper limit} = \left(1 + \frac{R_3}{R_4}\right) V_{ref}$$



V_{in}	V_{out}
$< V_{ref}$	V_+
$> V_{ref}$	$\approx 0.74 \text{ V}$

Figure 28. Voltage Monitor

Figure 29. Single-Supply Comparator with Temperature-Compensated Threshold

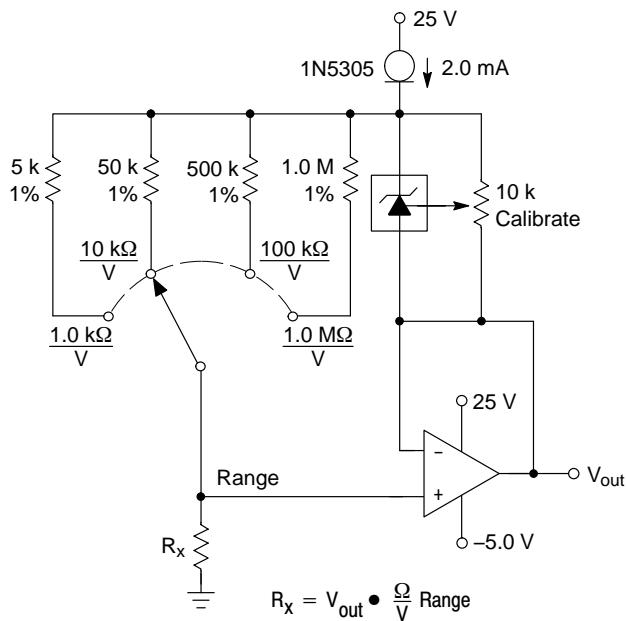


Figure 30. Linear Ohmmeter

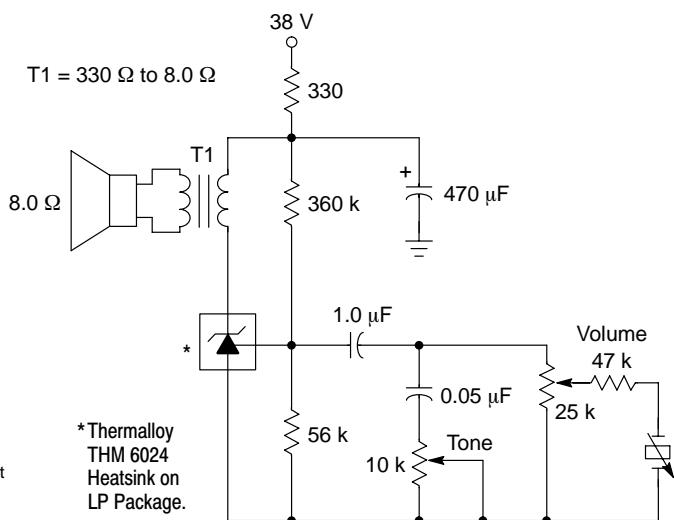


Figure 31. Simple 400 mW Phono Amplifier

TLV431A, TLV431B

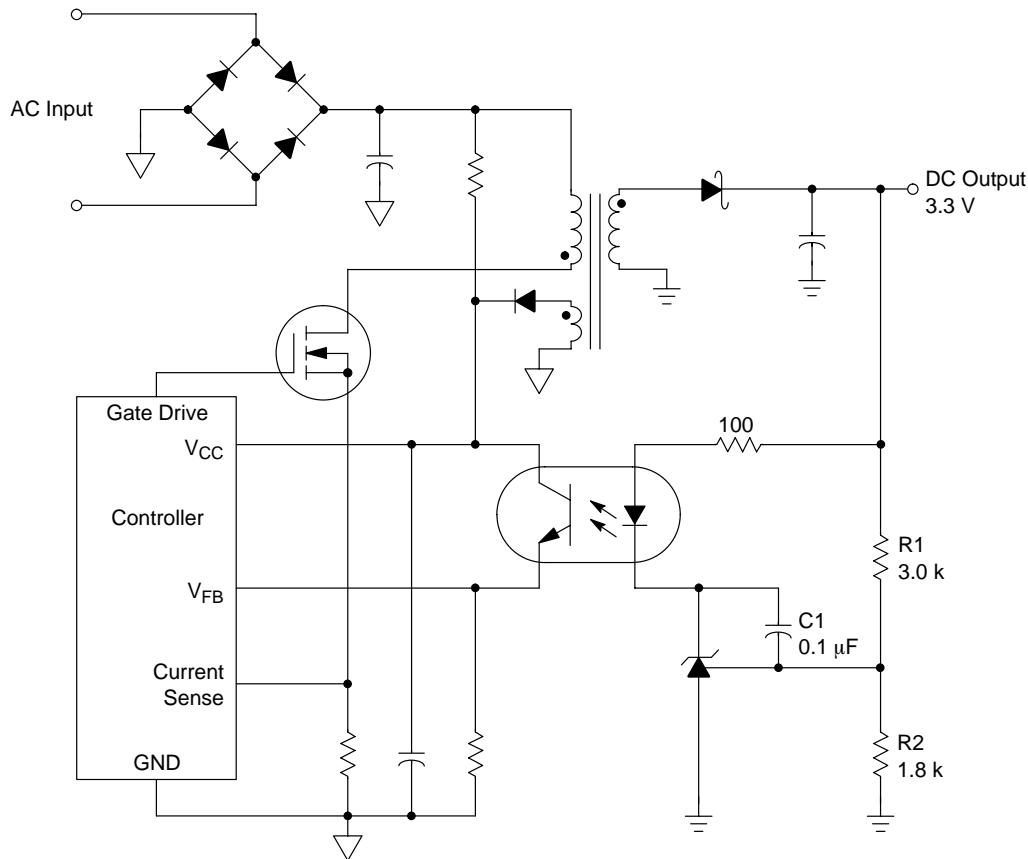
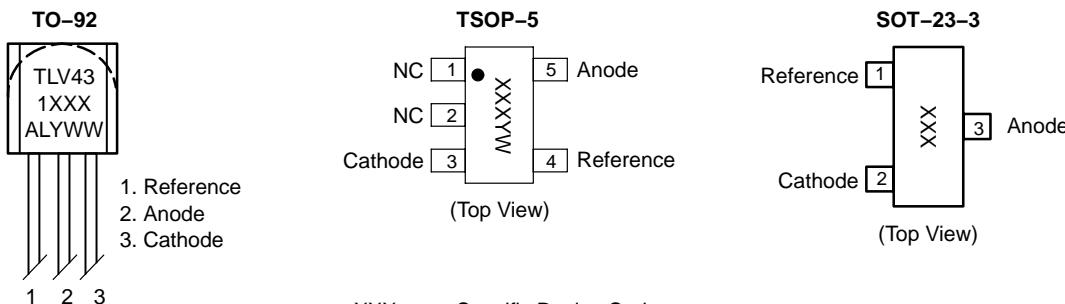


Figure 32. Isolated Output Line Powered Switching Power Supply

The above circuit shows the TLV431A/B as a compensated amplifier controlling the feedback loop of an isolated output line powered switching regulator. The output voltage is programmed to 3.3 V by the resistors values selected for R1 and R2. The minimum output voltage that can be programmed with this circuit is 2.64 V, and is limited by the sum of the reference voltage (1.24 V) and the forward drop of the optocoupler light emitting diode (1.4 V). Capacitor C1 provides loop compensation.

TLV431A, TLV431B

PIN CONNECTIONS AND DEVICE MARKING



XXX = Specific Device Code
 A = Assembly Location
 L = Wafer Lot
 Y = Year
 WW, W = Work Week

ORDERING INFORMATION

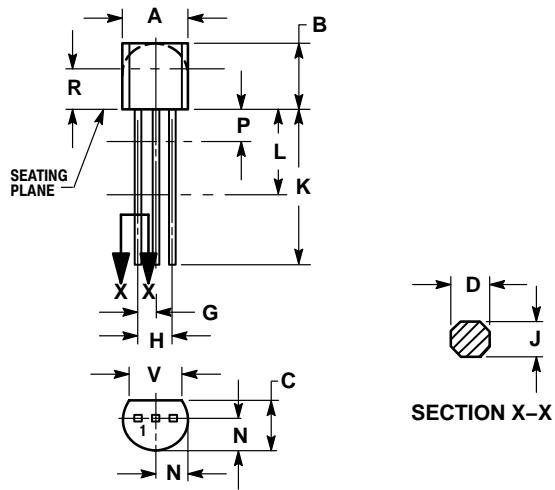
Device	Device Code	Package	Shipping [†]
TLV431ALP	ALP	TO-92-3	6000/Box
TLV431ALPRA	ALP	TO-92-3	2000/Tape & Reel
TLV431ALPRE	ALP	TO-92-3	2000/Tape & Reel
TLV431ALPRM	ALP	TO-92-3	2000/Ammo Pack
TLV431ALPRP	ALP	TO-92-3	2000/Ammo Pack
TLV431ASNT1	RAA	TSOP-5	3000/Tape & Reel
TLV431ASNT1G		TSOP-5 (Pb-Free)	
TLV431ASN1T1	RAF	SOT-23-3	3000/Tape & Reel
TLV431BLP	BLP	TO-92-3	6000/Box
TLV431BLPRA	BLP	TO-92-3	2000/Tape & Reel
TLV431BLPRE	BLP	TO-92-3	2000/Tape & Reel
TLV431BLPRM	BLP	TO-92-3	2000/Ammo Pack
TLV431BLPRP	BLP	TO-92-3	2000/Ammo Pack
TLV431BSNT1	RAH	TSOP-5	3000/Tape & Reel
TLV431BSN1T1	RAG	SOT-23-3	3000/Tape & Reel

[†]For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

TLV431A, TLV431B

PACKAGE DIMENSIONS

TO-92-3
LP SUFFIX
CASE 29-11
ISSUE AL



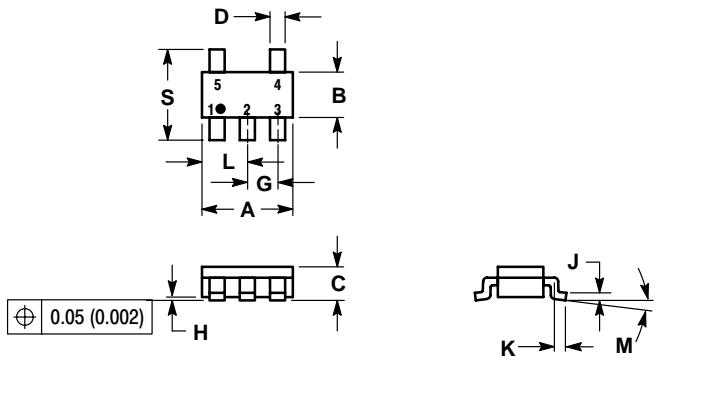
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.175	0.205	4.45	5.20
B	0.170	0.210	4.32	5.33
C	0.125	0.165	3.18	4.19
D	0.016	0.021	0.407	0.533
G	0.045	0.055	1.15	1.39
H	0.095	0.105	2.42	2.66
J	0.015	0.020	0.39	0.50
K	0.500	—	12.70	—
L	0.250	—	6.35	—
N	0.080	0.105	2.04	2.66
P	—	0.100	—	2.54
R	0.115	—	2.93	—
V	0.135	—	3.43	—

TLV431A, TLV431B

PACKAGE DIMENSIONS

TSOP-5
SN SUFFIX
CASE 483-02
ISSUE C

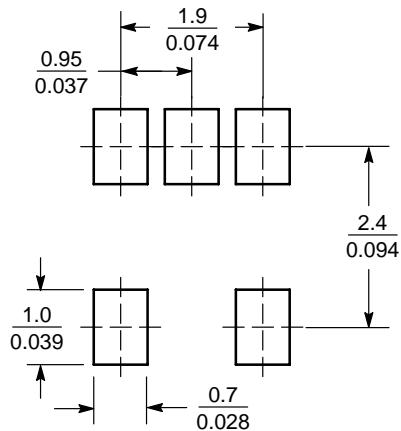


NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. A AND B DIMENSIONS DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.90	3.10	0.1142	0.1220
B	1.30	1.70	0.0512	0.0669
C	0.90	1.10	0.0354	0.0433
D	0.25	0.50	0.0098	0.0197
G	0.85	1.05	0.0335	0.0413
H	0.013	0.100	0.0005	0.0040
J	0.10	0.26	0.0040	0.0102
K	0.20	0.60	0.0079	0.0236
L	1.25	1.55	0.0493	0.0610
M	0	10	0	10
S	2.50	3.00	0.0985	0.1181

SOLDERING FOOTPRINT*



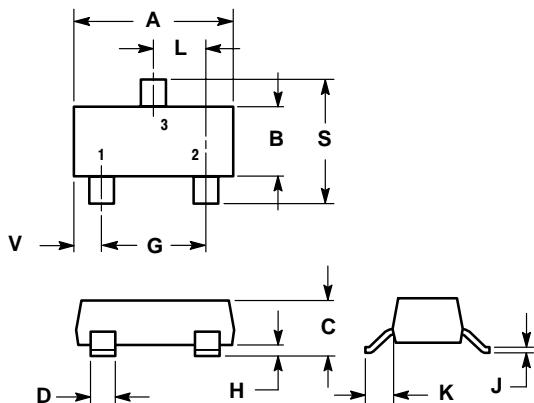
TSOP-5

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

TLV431A, TLV431B

PACKAGE DIMENSIONS

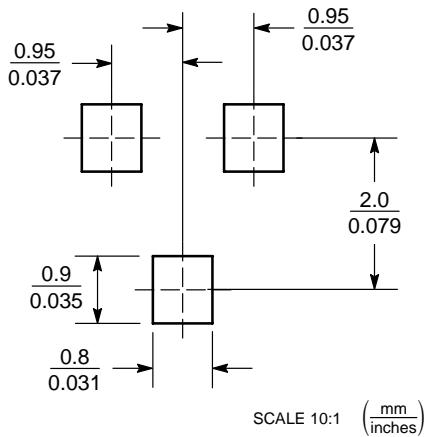
SOT-23-3
SN1 SUFFIX
CASE 318-09
ISSUE AH



NOTES:
 1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
 2. CONTROLLING DIMENSION: INCH.
 3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
 4. 318-01, -02, AND -06 OBSOLETE, NEW STANDARD 318-09.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.1102	0.1197	2.80	3.04
B	0.0472	0.0551	1.20	1.40
C	0.0385	0.0498	0.99	1.26
D	0.0140	0.0200	0.36	0.50
G	0.0670	0.0826	1.70	2.10
H	0.0040	0.0098	0.10	0.25
J	0.0034	0.0070	0.085	0.177
K	0.0180	0.0236	0.45	0.60
L	0.0350	0.0401	0.89	1.02
S	0.0830	0.0984	2.10	2.50
V	0.0177	0.0236	0.45	0.60

SOLDERING FOOTPRINT*



SOT-23-3

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SODERRM/D.

ON Semiconductor and  are registered trademarks of Semiconductor Components Industries, LLC (SCILLC). SCILLC reserves the right to make changes without further notice to any products herein. SCILLC makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does SCILLC assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. "Typical" parameters which may be provided in SCILLC data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. SCILLC does not convey any license under its patent rights nor the rights of others. SCILLC products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the SCILLC product could create a situation where personal injury or death may occur. Should Buyer purchase or use SCILLC products for any such unintended or unauthorized application, Buyer shall indemnify and hold SCILLC and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that SCILLC was negligent regarding the design or manufacture of the part. SCILLC is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:

Literature Distribution Center for ON Semiconductor

P.O. Box 5163, Denver, Colorado 80217 USA

Phone: 303-675-2175 or 800-344-3860 Toll Free USA/Canada

Fax: 303-675-2176 or 800-344-3867 Toll Free USA/Canada

Email: orderlit@onsemi.com

N. American Technical Support: 800-282-9855 Toll Free
USA/Canada

Japan: ON Semiconductor, Japan Customer Focus Center
2-9-1 Kamimeguro, Meguro-ku, Tokyo, Japan 153-0051

Phone: 81-3-5773-3850

ON Semiconductor Website: <http://onsemi.com>

Order Literature: <http://www.onsemi.com/litorder>

For additional information, please contact your local Sales Representative.