

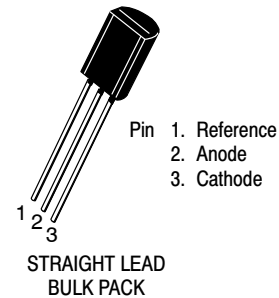
# Programmable Precision References

## TL431A, B Series, NCV431A, B Series, SCV431A

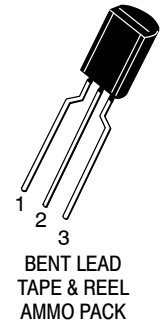
The TL431A, B integrated circuits are three-terminal programmable shunt regulator diodes. These monolithic IC voltage references operate as a low temperature coefficient zener which is programmable from  $V_{ref}$  to 36 V with two external resistors. These devices exhibit a wide operating current range of 1.0 mA to 100 mA with a typical dynamic impedance of 0.22  $\Omega$ . The characteristics of these references make them excellent replacements for zener diodes in many applications such as digital voltmeters, power supplies, and op amp circuitry. The 2.5 V reference makes it convenient to obtain a stable reference from 5.0 V logic supplies, and since the TL431A, B operates as a shunt regulator, it can be used as either a positive or negative voltage reference.

### Features

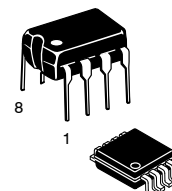
- Programmable Output Voltage to 36 V
- Voltage Reference Tolerance:  $\pm 0.4\%$ , Typ @ 25°C (TL431B)
- Low Dynamic Output Impedance, 0.22  $\Omega$  Typical
- Sink Current Capability of 1.0 mA to 100 mA
- Equivalent Full-Range Temperature Coefficient of 50 ppm/°C Typical
- Temperature Compensated for Operation over Full Rated Operating Temperature Range
- Low Output Noise Voltage
- NCV/SCV Prefixes for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant



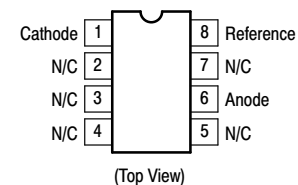
**TO-92**  
**LP SUFFIX**  
**CASE 29-10**



**TO-92**  
**LPRA, LPRE, LPRM,**  
**LPRP SUFFIX**  
**CASE 29-10**



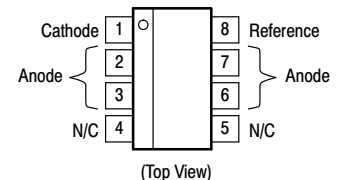
**PDIP-8**  
**P SUFFIX**  
**CASE 626**



**Micro8<sup>™</sup>**  
**DM SUFFIX**  
**CASE 846A**



**SOIC-8**  
**D SUFFIX**  
**CASE 751**



This is an internally modified SOIC-8 package. Pins 2, 3, 6 and 7 are electrically common to the die attach flag. This internal lead frame modification increases power dissipation capability when appropriately mounted on a printed circuit board. This modified package conforms to all external dimensions of the standard SOIC-8 package.

### ORDERING INFORMATION

See detailed ordering and shipping information on page 13 of this data sheet.

NOTE: Some of the device on this data sheet have been **DISCONTINUED**. Please refer to the table on page 14

### DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 14 of this data sheet.

# TL431A, B Series, NCV431A, B Series, SCV431A

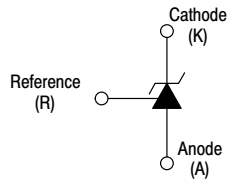


Figure 1. Symbol

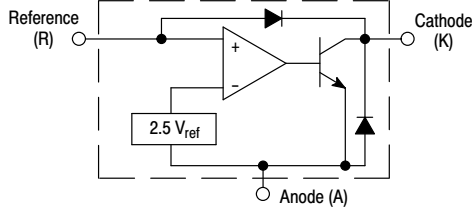


Figure 2. Representative Block Diagram

This device contains 12 active transistors.

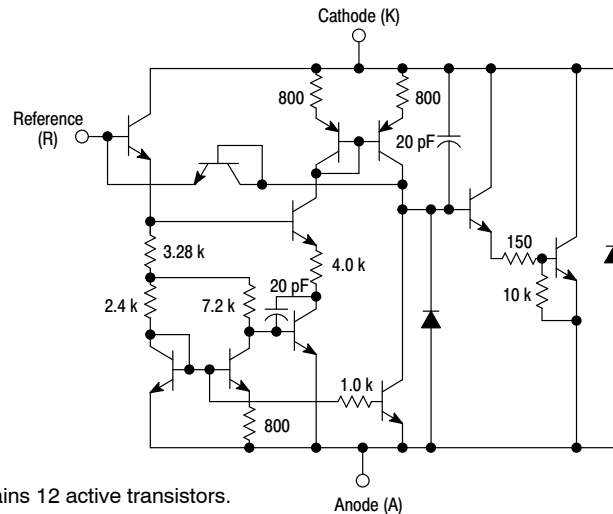


Figure 3. Representative Schematic Diagram

Component values are nominal

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

| Rating                                                                                                                                                                                             | Symbol           | Value                                 | Unit |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|---------------------------------------|------|
| Cathode to Anode Voltage                                                                                                                                                                           | $V_{KA}$         | 37                                    | V    |
| Cathode Current Range, Continuous                                                                                                                                                                  | $I_K$            | -100 to +150                          | mA   |
| Reference Input Current Range, Continuous                                                                                                                                                          | $I_{ref}$        | -0.05 to +10                          | mA   |
| Operating Junction Temperature                                                                                                                                                                     | $T_J$            | 150                                   | °C   |
| Operating Ambient Temperature Range<br>TL431I, TL431AI, TL431BI<br>TL431C, TL431AC, TL431BC<br>NCV431AI, NCV431B, TL431BV, SCV431AI                                                                | $T_A$            | -40 to +85<br>0 to +70<br>-40 to +125 | °C   |
| Storage Temperature Range                                                                                                                                                                          | $T_{stg}$        | -65 to +150                           | °C   |
| Total Power Dissipation @ $T_A = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ Ambient Temperature<br>D, LP Suffix Plastic Package<br>P Suffix Plastic Package<br>DM Suffix Plastic Package | $P_D$            | 0.70<br>1.10<br>0.52                  | W    |
| Total Power Dissipation @ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ Case Temperature<br>D, LP Suffix Plastic Package<br>P Suffix Plastic Package                                 | $P_D$            | 1.5<br>3.0                            | W    |
| ESD Rating (Note 1)<br>Human Body Model per JEDEC JESD22-A114F<br>Machine Model per JEDEC JESD22-A115C<br>Charged Device Model per JEDEC JESD22-C101E                                              | HBM<br>MM<br>CDM | >2000<br>>200<br>>500                 | V    |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. This device contains latch-up protection and exceeds  $\pm 100$  mA per JEDEC standard JESD78.

## RECOMMENDED OPERATING CONDITIONS

| Condition                | Symbol   | Min       | Max | Unit |
|--------------------------|----------|-----------|-----|------|
| Cathode to Anode Voltage | $V_{KA}$ | $V_{ref}$ | 36  | V    |
| Cathode Current          | $I_K$    | 1.0       | 100 | mA   |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

# TL431A, B Series, NCV431A, B Series, SCV431A

## THERMAL CHARACTERISTICS

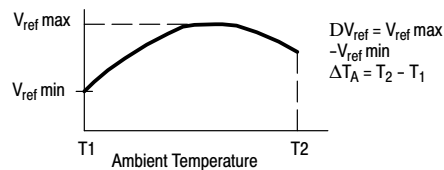
| Characteristic                          | Symbol          | D, LP Suffix Package | P Suffix Package | DM Suffix Package | Unit                 |
|-----------------------------------------|-----------------|----------------------|------------------|-------------------|----------------------|
| Thermal Resistance, Junction-to-Ambient | $R_{\theta JA}$ | 178                  | 114              | 240               | $^{\circ}\text{C/W}$ |
| Thermal Resistance, Junction-to-Case    | $R_{\theta JC}$ | 83                   | 41               | –                 | $^{\circ}\text{C/W}$ |

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

| Characteristic                                                                                                                                                                                                       | Symbol                                 | TL431I       |              |              | TL431C        |              |               | Unit          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|--------------|--------------|--------------|---------------|--------------|---------------|---------------|
|                                                                                                                                                                                                                      |                                        | Min          | Typ          | Max          | Min           | Typ          | Max           |               |
| Reference Input Voltage (Figure 1)<br>$V_{KA} = V_{ref}$ , $I_K = 10\text{ mA}$<br>$T_A = 25^{\circ}\text{C}$<br>$T_A = T_{low}$ to $T_{high}$ (Note 2)                                                              | $V_{ref}$                              | 2.44<br>2.41 | 2.495<br>–   | 2.55<br>2.58 | 2.44<br>2.423 | 2.495<br>–   | 2.55<br>2.567 | V             |
| Reference Input Voltage Deviation Over Temperature Range (Figure 1, Notes 3, 4)<br>$V_{KA} = V_{ref}$ , $I_K = 10\text{ mA}$                                                                                         | $\Delta V_{ref}$                       | –            | 7.0          | 30           | –             | 3.0          | 17            | mV            |
| Ratio of Change in Reference Input Voltage to Change in Cathode to Anode Voltage<br>$I_K = 10\text{ mA}$ (Figure 2),<br>$\Delta V_{KA} = 10\text{ V}$ to $V_{ref}$<br>$\Delta V_{KA} = 36\text{ V}$ to $10\text{ V}$ | $\frac{\Delta V_{ref}}{\Delta V_{KA}}$ | –<br>–       | –1.4<br>–1.0 | –2.7<br>–2.0 | –<br>–        | –1.4<br>–1.0 | –2.7<br>–2.0  | mV/V          |
| Reference Input Current (Figure 2)<br>$I_K = 10\text{ mA}$ , $R_1 = 10\text{ k}$ , $R_2 = \infty$<br>$T_A = 25^{\circ}\text{C}$<br>$T_A = T_{low}$ to $T_{high}$ (Note 2)                                            | $I_{ref}$                              | –<br>–       | 1.8<br>–     | 4.0<br>6.5   | –<br>–        | 1.8<br>–     | 4.0<br>5.2    | $\mu\text{A}$ |
| Reference Input Current Deviation Over Temperature Range (Figure 2, Note 3)<br>$I_K = 10\text{ mA}$ , $R_1 = 10\text{ k}$ , $R_2 = \infty$                                                                           | $\Delta I_{ref}$                       | –            | 0.8          | 2.5          | –             | 0.4          | 1.2           | $\mu\text{A}$ |
| Minimum Cathode Current For Regulation<br>$V_{KA} = V_{ref}$ (Figure 1)                                                                                                                                              | $I_{min}$                              | –            | 0.5          | 1.0          | –             | 0.5          | 1.0           | mA            |
| Off-State Cathode Current (Figure 3)<br>$V_{KA} = 36\text{ V}$ , $V_{ref} = 0\text{ V}$                                                                                                                              | $I_{off}$                              | –            | 20           | 1000         | –             | 20           | 1000          | nA            |
| Dynamic Impedance (Figure 1, Note 5)<br>$V_{KA} = V_{ref}$ , $\Delta I_K = 1.0\text{ mA}$ to $100\text{ mA}$ , $f \leq 1.0\text{ kHz}$                                                                               | $ Z_{KA} $                             | –            | 0.22         | 0.5          | –             | 0.22         | 0.5           | $\Omega$      |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

- $T_{low} = -40^{\circ}\text{C}$  for TL431AIP, TL431AILP, TL431IP, TL431ILP, TL431BID, TL431BIP, TL431BILP, TL431AIDM, TL431IDM, TL431BIDM;  
 $= 0^{\circ}\text{C}$  for TL431ACP, TL431ACLP, TL431CP, TL431CLP, TL431CD, TL431ACD, TL431BCD, TL431BCP, TL431BCLP, TL431CDM, TL431ACDM, TL431BCDM  
 $T_{high} = +85^{\circ}\text{C}$  for TL431AIP, TL431AILP, TL431IP, TL431ILP, TL431BID, TL431BIP, TL431BILP, TL431IDM, TL431AIDM, TL431BIDM  
 $= +70^{\circ}\text{C}$  for TL431ACP, TL431ACLP, TL431CP, TL431ACD, TL431BCD, TL431BCP, TL431BCLP, TL431CDM, TL431ACDM, TL431BCDM
- Guaranteed by design.
- The deviation parameter  $\Delta V_{ref}$  is defined as the difference between the maximum and minimum values obtained over the full operating ambient temperature range that applies.



The average temperature coefficient of the reference input voltage,  $\alpha V_{ref}$  is defined as:

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

$\alpha V_{ref}$  can be positive or negative depending on whether  $V_{ref} \text{ Min}$  or  $V_{ref} \text{ Max}$  occurs at the lower ambient temperature. (Refer to Figure 6.)

Example :  $\Delta V_{ref} = 8.0\text{ mV}$  and slope is positive,

$$V_{ref} @ 25^{\circ}\text{C} = 2.495\text{ V}, \Delta T_A = 70^{\circ}\text{C}$$

$$\alpha V_{ref} = \frac{0.008 \times 10^6}{70 (2.495)} = 45.8 \text{ ppm}/^{\circ}\text{C}$$

- The dynamic impedance  $Z_{KA}$  is defined as:  $|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_K}$ . When the device is programmed with two external resistors,  $R_1$  and  $R_2$ ,

(refer to Figure 2) the total dynamic impedance of the circuit is defined as:  $|Z_{KA}'| \approx |Z_{KA}| \left( 1 + \frac{R_1}{R_2} \right)$

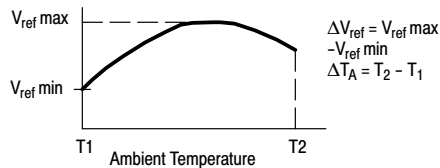
# TL431A, B Series, NCV431A, B Series, SCV431A

## ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C, unless otherwise noted.)

| Characteristic                                                                                                                                                                                              | Symbol                                 | TL431AI /<br>NCV431AI/<br>SCV431AI |              |              | TL431AC       |              |               | TL431BC / TL431BI /<br>TL431BV /<br>NCV431BV |                |                | Unit |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|------------------------------------|--------------|--------------|---------------|--------------|---------------|----------------------------------------------|----------------|----------------|------|
|                                                                                                                                                                                                             |                                        | Min                                | Typ          | Max          | Min           | Typ          | Max           | Min                                          | Typ            | Max            |      |
| Reference Input Voltage (Figure 1)<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 10 mA<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>low</sub> to T <sub>high</sub> (Note 6)               | V <sub>ref</sub>                       | 2.47<br>2.44                       | 2.495<br>–   | 2.52<br>2.55 | 2.47<br>2.453 | 2.495<br>–   | 2.52<br>2.537 | 2.485<br>2.475                               | 2.495<br>2.495 | 2.505<br>2.515 | V    |
| Reference Input Voltage Deviation Over<br>Temperature Range (Figure 1, Notes 7, 8)<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 10 mA                                                           | ΔV <sub>ref</sub>                      | –                                  | 7.0          | 30           | –             | 3.0          | 17            | –                                            | 3.0            | 17             | mV   |
| Ratio of Change in Reference Input Voltage to<br>Change in Cathode to Anode Voltage<br>I <sub>K</sub> = 10 mA (Figure 2),<br>ΔV <sub>KA</sub> = 10 V to V <sub>ref</sub><br>ΔV <sub>KA</sub> = 36 V to 10 V | $\frac{\Delta V_{ref}}{\Delta V_{KA}}$ | –<br>–                             | –1.4<br>–1.0 | –2.7<br>–2.0 | –<br>–        | –1.4<br>–1.0 | –2.7<br>–2.0  | –<br>–                                       | –1.4<br>–1.0   | –2.7<br>–2.0   | mV/V |
| Reference Input Current (Figure 2)<br>I <sub>K</sub> = 10 mA, R1 = 10 k, R2 = ∞<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>low</sub> to T <sub>high</sub> (Note 6)                                 | I <sub>ref</sub>                       | –<br>–                             | 1.8<br>–     | 4.0<br>6.5   | –<br>–        | 1.8<br>–     | 4.0<br>5.2    | –<br>–                                       | 1.1<br>–       | 2.0<br>4.0     | μA   |
| Reference Input Current Deviation Over<br>Temperature Range (Figure 2, Note 7)<br>I <sub>K</sub> = 10 mA, R1 = 10 k, R2 = ∞                                                                                 | ΔI <sub>ref</sub>                      | –                                  | 0.8          | 2.5          | –             | 0.4          | 1.2           | –                                            | 0.8            | 2.5            | μA   |
| Minimum Cathode Current For Regulation<br>V <sub>KA</sub> = V <sub>ref</sub> (Figure 1)                                                                                                                     | I <sub>min</sub>                       | –                                  | 0.5          | 1.0          | –             | 0.5          | 1.0           | –                                            | 0.5            | 1.0            | mA   |
| Off-State Cathode Current (Figure 3)<br>V <sub>KA</sub> = 36 V, V <sub>ref</sub> = 0 V                                                                                                                      | I <sub>off</sub>                       | –                                  | 20           | 1000         | –             | 20           | 1000          | –                                            | 0.23           | 500            | nA   |
| Dynamic Impedance (Figure 1, Note 9)<br>V <sub>KA</sub> = V <sub>ref</sub> , ΔI <sub>K</sub> = 1.0 mA to 100 mA<br>f ≤ 1.0 kHz                                                                              | Z <sub>KA</sub>                        | –                                  | 0.22         | 0.5          | –             | 0.22         | 0.5           | –                                            | 0.14           | 0.3            | Ω    |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

6. T<sub>low</sub> = –40°C for TL431AIP, TL431AILP, TL431IP, TL431ILP, TL431BID, TL431BIP, TL431BILP, TL431BV, TL431AIDM, TL431IDM, TL431BIDM, NCV431AIDMR2G, NCV431AIDR2G, NCV431BVDR2G, SCV431AIDMR2G  
= 0°C for TL431ACP, TL431ACLP, TL431CP, TL431CLP, TL431CD, TL431ACD, TL431BCD, TL431BCP, TL431BCLP, TL431CDM, TL431ACDM, TL431BCDM, SCV431AIDMR2G  
T<sub>high</sub> = +85°C for TL431AIP, TL431AILP, TL431IP, TL431ILP, TL431BID, TL431BIP, TL431BILP, TL431IDM, TL431AIDM, TL431BIDM  
= +70°C for TL431ACP, TL431ACLP, TL431CP, TL431ACD, TL431BCD, TL431BCP, TL431BCLP, TL431CDM, TL431ACDM, TL431BCDM  
= +125°C TL431BV, NCV431AIDMR2G, NCV431AIDR2G, NCV431BVDR2G, NCV431BVDR2G, SCV431AIDMR2G
7. Guaranteed by design.
8. The deviation parameter ΔV<sub>ref</sub> is defined as the difference between the maximum and minimum values obtained over the full operating ambient temperature range that applies.



The average temperature coefficient of the reference input voltage, αV<sub>ref</sub> is defined as:

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

αV<sub>ref</sub> can be positive or negative depending on whether V<sub>ref</sub> Min or V<sub>ref</sub> Max occurs at the lower ambient temperature. (Refer to Figure 6.)

Example : ΔV<sub>ref</sub> = 8.0 mV and slope is positive,

$$V_{ref} @ 25^{\circ}\text{C} = 2.495 \text{ V}, \Delta T_A = 70^{\circ}\text{C}$$

$$\alpha V_{ref} = \frac{0.008 \times 10^6}{70 (2.495)} = 45.8 \text{ ppm}/^{\circ}\text{C}$$

9. The dynamic impedance Z<sub>KA</sub> is defined as  $|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_K}$  When the device is programmed with two external resistors, R1 and R2, (refer

to Figure 2) the total dynamic impedance of the circuit is defined as:  $|Z_{KA}'| \approx |Z_{KA}| \left( 1 + \frac{R1}{R2} \right)$

10. NCV431AIDMR2G, NCV431AIDR2G, NCV431BVDR2G, NCV431BVDR2G, SCV431AIDMR2G T<sub>low</sub> = –40°C, T<sub>high</sub> = +125°C.  
NCV prefix is for automotive and other applications requiring unique site and control change requirements.

# TL431A, B Series, NCV431A, B Series, SCV431A

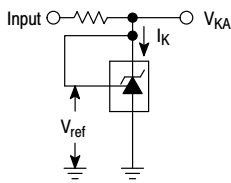


Figure 1. Test Circuit for  $V_{KA} = V_{ref}$

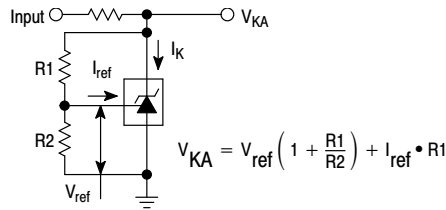


Figure 2. Test Circuit for  $V_{KA} > V_{ref}$

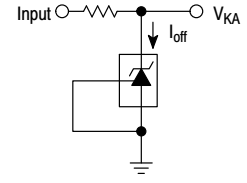


Figure 3. Test Circuit for  $I_{off}$

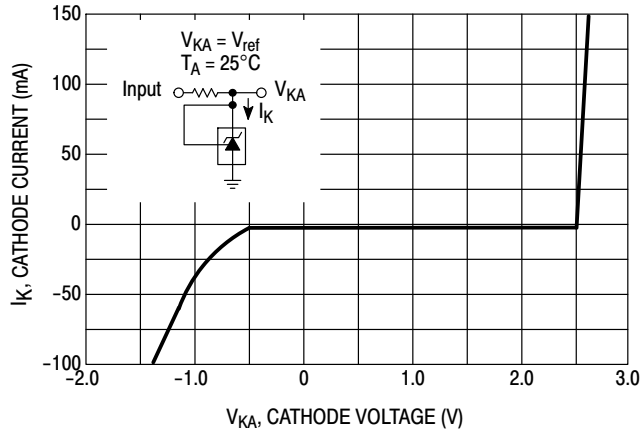


Figure 4. Cathode Current versus Cathode Voltage

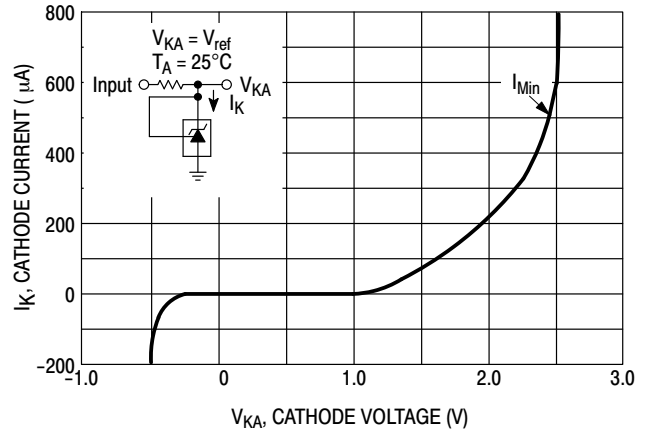


Figure 5. Cathode Current versus Cathode Voltage

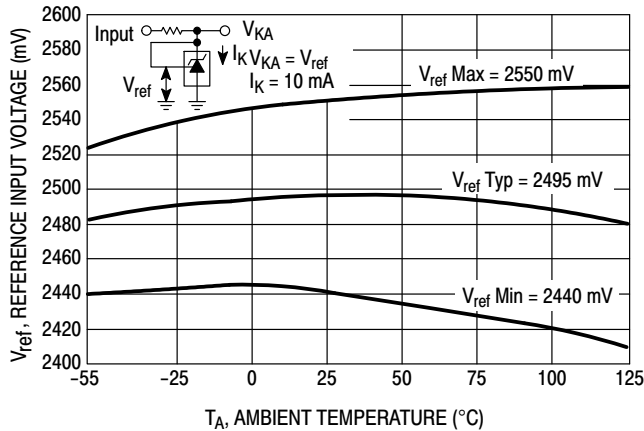


Figure 6. Reference Input Voltage versus Ambient Temperature

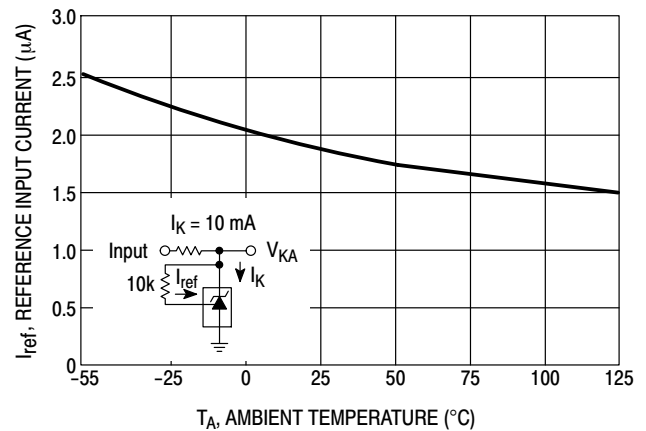
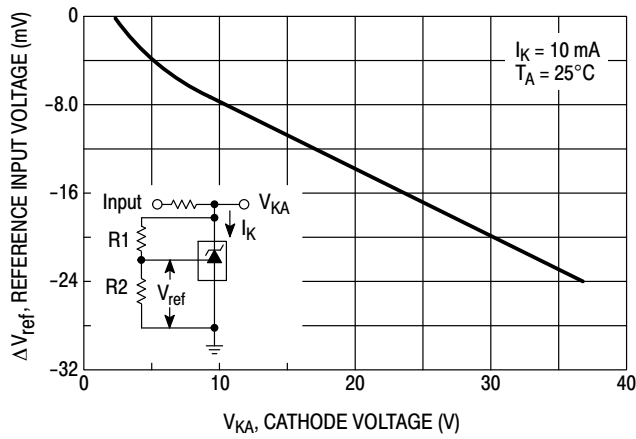
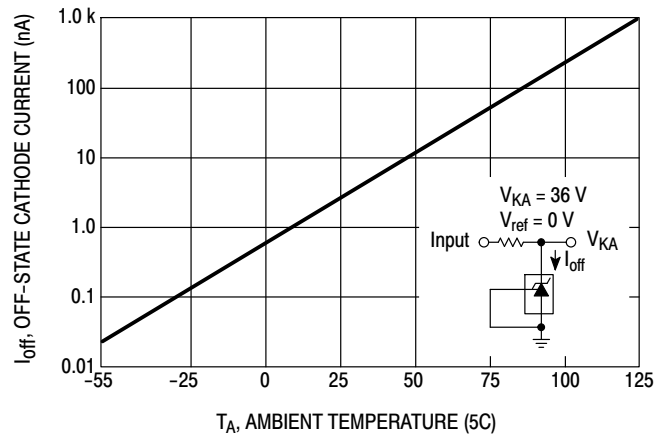


Figure 7. Reference Input Current versus Ambient Temperature

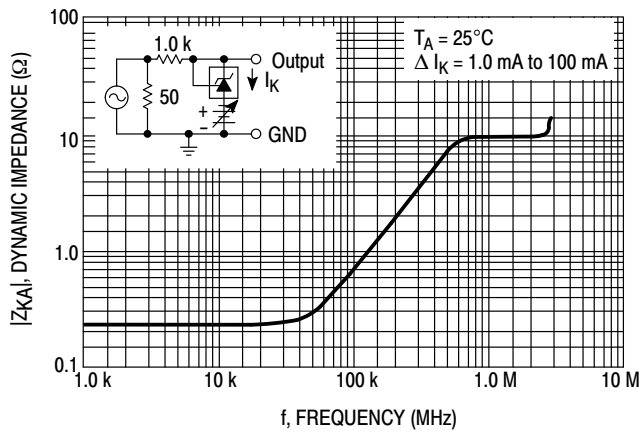
# TL431A, B Series, NCV431A, B Series, SCV431A



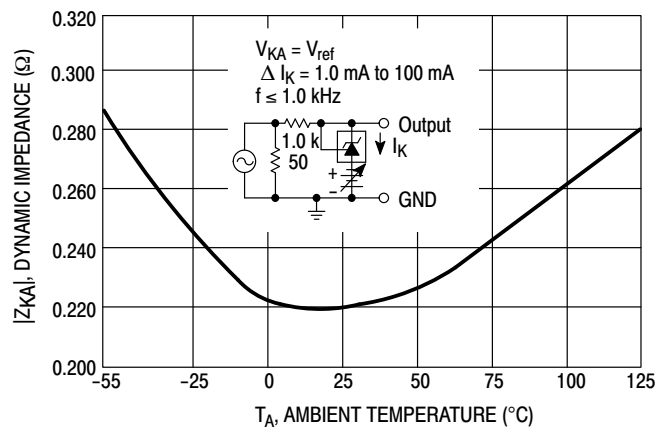
**Figure 8. Change in Reference Input Voltage versus Cathode Voltage**



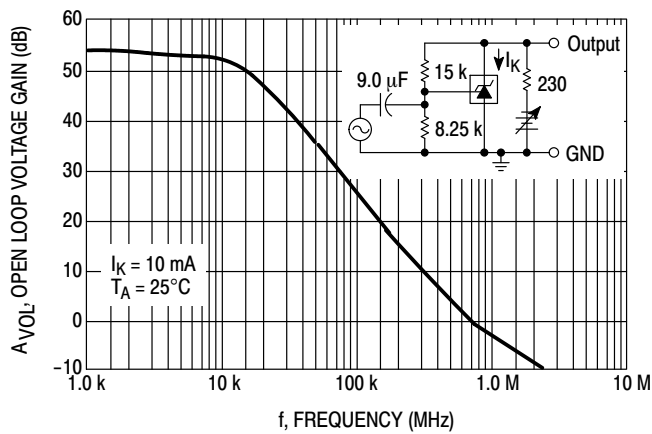
**Figure 9. Off-State Cathode Current versus Ambient Temperature**



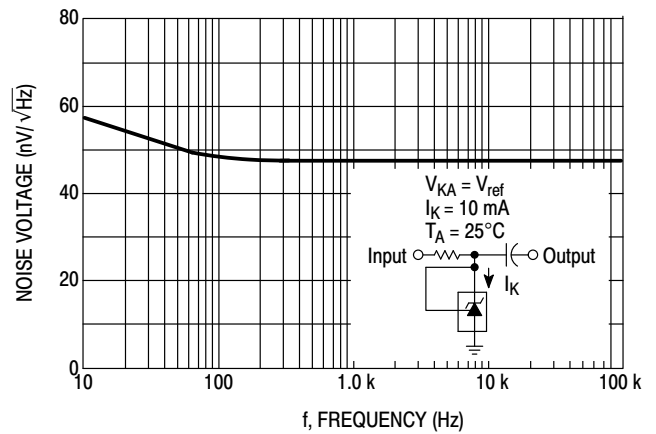
**Figure 10. Dynamic Impedance versus Frequency**



**Figure 11. Dynamic Impedance versus Ambient Temperature**



**Figure 12. Open-Loop Voltage Gain versus Frequency**



**Figure 13. Spectral Noise Density**

# TL431A, B Series, NCV431A, B Series, SCV431A

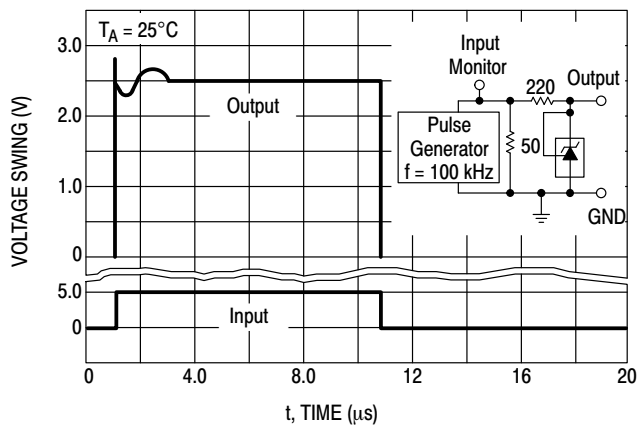


Figure 14. Pulse Response

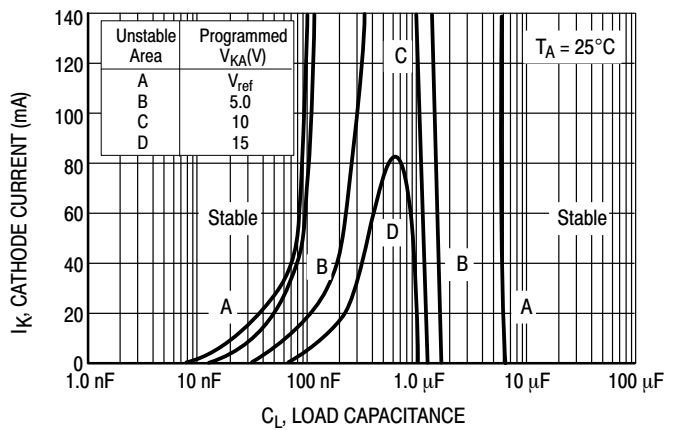


Figure 15. Stability Boundary Conditions

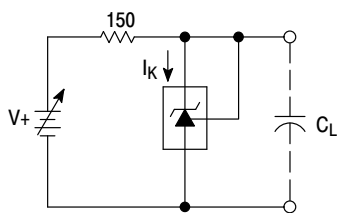


Figure 16. Test Circuit For Curve A of Stability Boundary Conditions

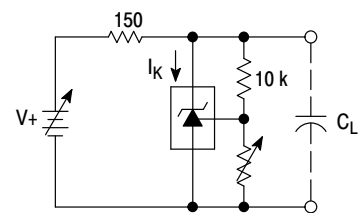


Figure 17. Test Circuit For Curves B, C, and D of Stability Boundary Conditions

## TYPICAL APPLICATIONS

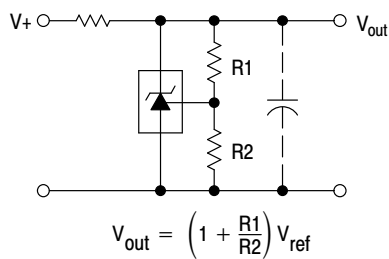


Figure 18. Shunt Regulator

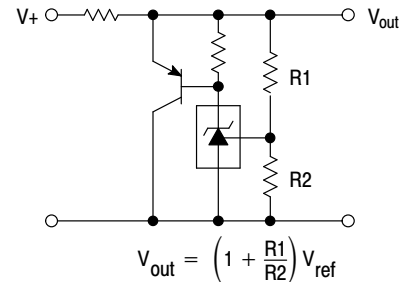


Figure 19. High Current Shunt Regulator

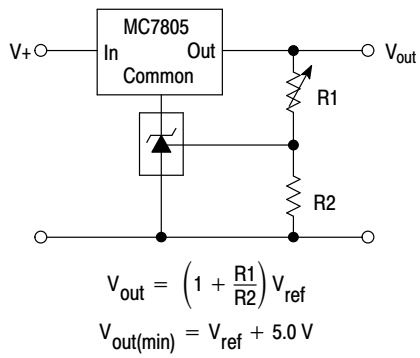


Figure 20. Output Control for a Three-Terminal Fixed Regulator

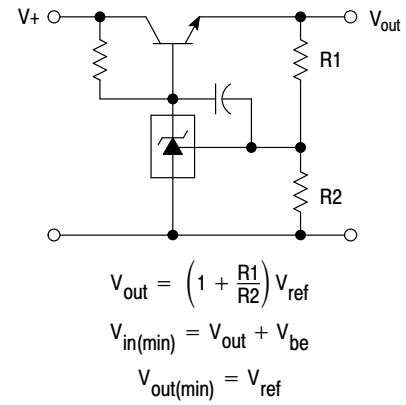


Figure 21. Series Pass Regulator

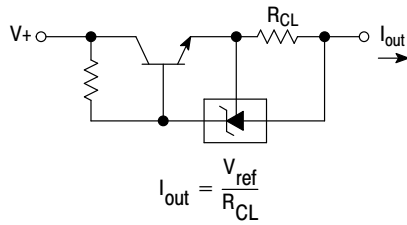


Figure 22. Constant Current Source

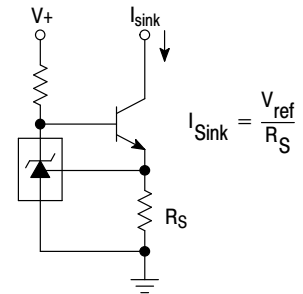


Figure 23. Constant Current Sink

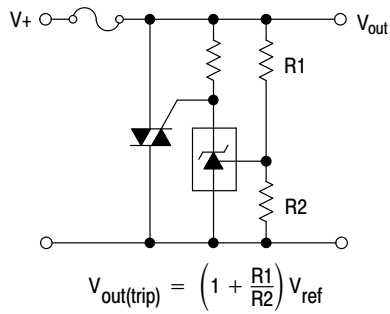


Figure 24. TRIAC Crowbar

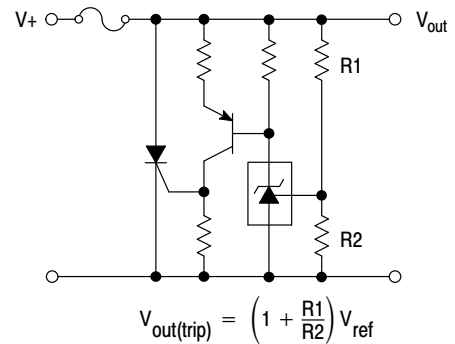
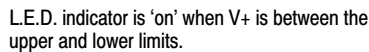


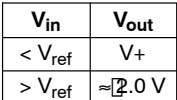
Figure 25. SRC Crowbar

**TL431A, B Series, NCV431A, B Series, SCV431A**

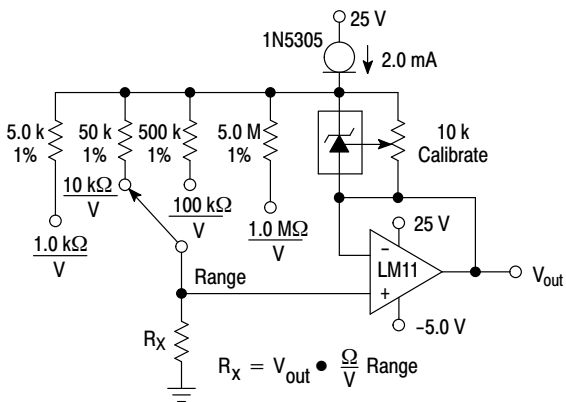
$$\text{Lower Limit} = \left(1 + \frac{R_1}{R_2}\right) V_{\text{ref}}$$

$$\text{Upper Limit} = \left(1 + \frac{R3}{R4}\right) V_{\text{ref}}$$

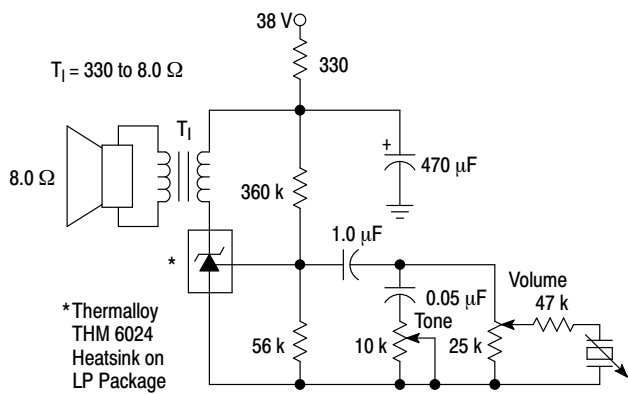
### Figure 26. Voltage Monitor



### Figure 27. Single-Supply Comparator with Temperature-Compensated Threshold



### Figure 28. Linear Ohmmeter



### Figure 29. Simple 400 mW Phono Amplifier

## TL431A, B Series, NCV431A, B Series, SCV431A

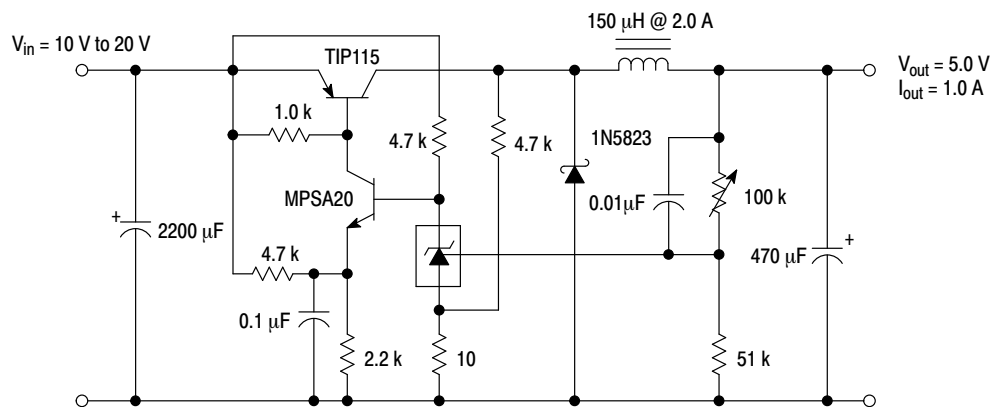


Figure 30. High Efficiency Step-Down Switching Converter

| Test            | Conditions                                                    | Results           |
|-----------------|---------------------------------------------------------------|-------------------|
| Line Regulation | $V_{in} = 10 \text{ V to } 20 \text{ V}, I_o = 1.0 \text{ A}$ | 53 mV (1.1%)      |
| Load Regulation | $V_{in} = 15 \text{ V}, I_o = 0 \text{ A to } 1.0 \text{ A}$  | 25 mV (0.5%)      |
| Output Ripple   | $V_{in} = 10 \text{ V}, I_o = 1.0 \text{ A}$                  | 50 mVpp P.A.R.D.  |
| Output Ripple   | $V_{in} = 20 \text{ V}, I_o = 1.0 \text{ A}$                  | 100 mVpp P.A.R.D. |
| Efficiency      | $V_{in} = 15 \text{ V}, I_o = 1.0 \text{ A}$                  | 82%               |

## APPLICATIONS INFORMATION

The TL431 is a programmable precision reference which is used in a variety of ways. It serves as a reference voltage in circuits where a non-standard reference voltage is needed. Other uses include feedback control for driving an optocoupler in power supplies, voltage monitor, constant current source, constant current sink and series pass regulator. In each of these applications, it is critical to maintain stability of the device at various operating currents and load capacitances. In some cases the circuit designer can estimate the stabilization capacitance from the stability boundary conditions curve provided in Figure 15. However, these typical curves only provide stability information at specific cathode voltages and at a specific load condition. Additional information is needed to determine the capacitance needed to optimize phase margin or allow for process variation.

A simplified model of the TL431 is shown in Figure 31. When tested for stability boundaries, the load resistance is 150  $\Omega$ . The model reference input consists of an input transistor and a dc emitter resistance connected to the device anode. A dependent current source,  $G_m$ , develops a current whose amplitude is determined by the difference between the 1.78 V internal reference voltage source and the input transistor emitter voltage. A portion of  $G_m$  flows through compensation capacitance,  $C_{P2}$ . The voltage across  $C_{P2}$  drives the output dependent current source,  $G_o$ , which is connected across the device cathode and anode.

Model component values are:

$$V_{ref} = 1.78 \text{ V}$$

$$G_m = 0.3 + 2.7 \exp(-I_C/26 \text{ mA})$$

where  $I_C$  is the device cathode current and  $G_m$  is in mhos

$$G_o = 1.25 (V_{cp2}) \mu\text{mhos}.$$

Resistor and capacitor typical values are shown on the model. Process tolerances are  $\pm 20\%$  for resistors,  $\pm 10\%$  for capacitors, and  $\pm 40\%$  for transconductances.

An examination of the device model reveals the location of circuit poles and zeroes:

$$P_1 = \frac{1}{2\pi R_{GM} C_{P1}} = \frac{1}{2\pi * 1.0 \text{ M} * 20 \text{ pF}} = 7.96 \text{ kHz}$$

$$P_2 = \frac{1}{2\pi R_{P2} C_{P2}} = \frac{1}{2\pi * 10 \text{ M} * 0.265 \text{ pF}} = 60 \text{ kHz}$$

$$Z_1 = \frac{1}{2\pi R_{Z1} C_{P1}} = \frac{1}{2\pi * 15.9 \text{ k} * 20 \text{ pF}} = 500 \text{ kHz}$$

In addition, there is an external circuit pole defined by the load:

$$P_L = \frac{1}{2\pi R_L C_L}$$

Also, the transfer dc voltage gain of the TL431 is:

$$G = G_M R_{GM} G_o R_L$$

Example 1:

$I_C = 10 \text{ mA}$ ,  $R_L = 230 \Omega$ ,  $C_L = 0$ . Define the transfer gain.

The DC gain is:

$$G = G_M R_{GM} G_o R_L = (2.138)(1.0 \text{ M})(1.25 \mu)(230) = 615 = 56 \text{ dB}$$

$$\text{Loop gain} = G \frac{8.25 \text{ k}}{8.25 \text{ k} + 15 \text{ k}} = 218 = 47 \text{ dB}$$

The resulting transfer function Bode plot is shown in Figure 32. The asymptotic plot may be expressed as the following equation:

$$A_v = 615 \frac{\left(1 + \frac{jf}{500 \text{ kHz}}\right)}{\left(1 + \frac{jf}{8.0 \text{ kHz}}\right)\left(1 + \frac{jf}{60 \text{ kHz}}\right)}$$

The Bode plot shows a unity gain crossover frequency of approximately 600 kHz. The phase margin, calculated from the equation, would be 55.9 degrees. This model matches the Open-Loop Bode Plot of Figure 12. The total loop would have a unity gain frequency of about 300 kHz with a phase margin of about 44 degrees.

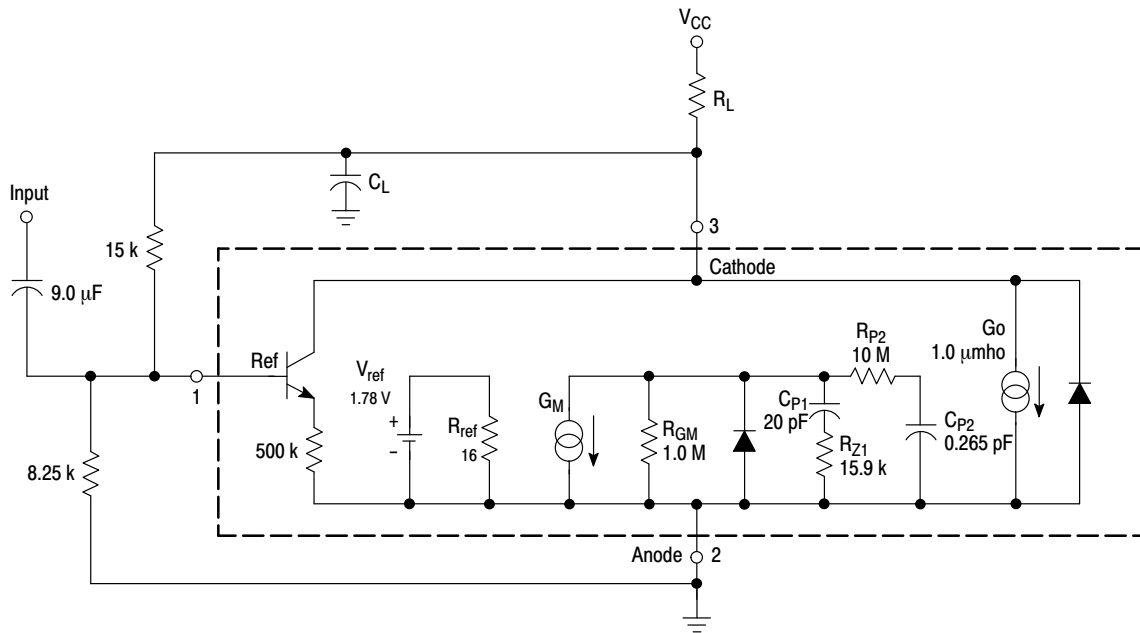


Figure 31. Simplified TL431 Device Model

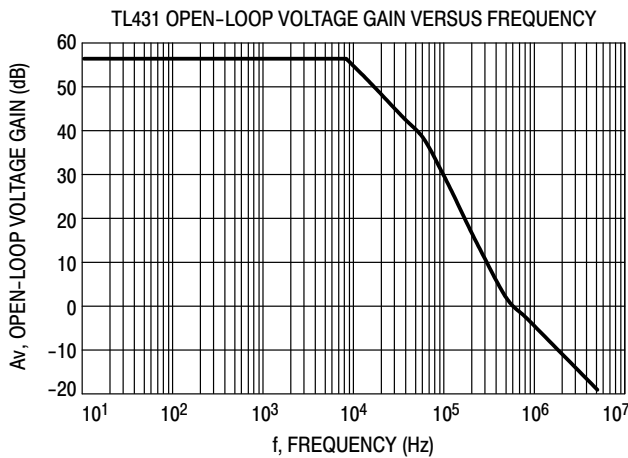


Figure 32. Example 1 Circuit Open Loop Gain Plot

Example 2.

$I_C = 7.5 \text{ mA}$ ,  $R_L = 2.2 \text{ k}\Omega$ ,  $C_L = 0.01 \text{ }\mu\text{F}$ . Cathode tied to reference input pin. An examination of the data sheet stability boundary curve (Figure 15) shows that this value of load capacitance and cathode current is on the boundary. Define the transfer gain.

The DC gain is:

$$G = G_M R_{GM} G_O R_L =$$

$$(2.323)(1.0 \text{ M})(1.25 \text{ }\mu)(2200) = 6389 = 76 \text{ dB}$$

The resulting open loop Bode plot is shown in Figure 33. The asymptotic plot may be expressed as the following equation:

$$A_v = 615 \frac{\left(1 + \frac{jf}{500 \text{ kHz}}\right)}{\left(1 + \frac{jf}{8.0 \text{ kHz}}\right)\left(1 + \frac{jf}{60 \text{ kHz}}\right)\left(1 + \frac{jf}{7.2 \text{ kHz}}\right)}$$

Note that the transfer function now has an extra pole formed by the load capacitance and load resistance.

Note that the crossover frequency in this case is about 250 kHz, having a phase margin of about  $-46$  degrees. Therefore, instability of this circuit is likely.

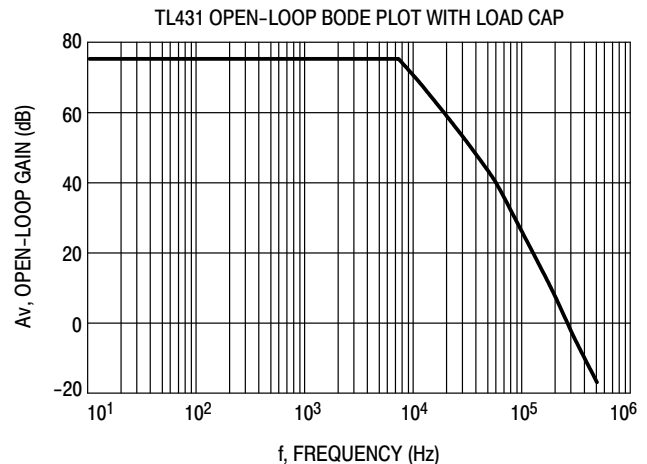


Figure 33. Example 2 Circuit Open Loop Gain Plot

With three poles, this system is unstable. The only hope for stabilizing this circuit is to add a zero. However, that can only be done by adding a series resistance to the output capacitance, which will reduce its effectiveness as a noise filter. Therefore, practically, in reference voltage applications, the best solution appears to be to use a smaller value of capacitance in low noise applications or a very large value to provide noise filtering and a dominant pole rolloff of the system.

# TL431A, B Series, NCV431A, B Series, SCV431A

## ORDERING INFORMATION

| Device         | Marking Code | Operating Temperature Range | Package Code        | Shipping Information†  | Tolerance          |      |
|----------------|--------------|-----------------------------|---------------------|------------------------|--------------------|------|
| TL431ACDG      | AC           | 0°C to 70°C                 | SOIC–8<br>(Pb–Free) | 98 Units / Rail        | 1.0%               |      |
| TL431BCDG      | BC           |                             |                     |                        | 0.4%               |      |
| TL431CDG       | C            |                             |                     |                        | 2.2%               |      |
| TL431ACDR2G    | AC           |                             |                     | 2500 / Tape & Reel     | 1.0%               |      |
| TL431BCDR2G    | BC           |                             |                     |                        | 0.4%               |      |
| TL431CDR2G     | C            |                             |                     |                        | 2.2%               |      |
| TL431BCPG      | BCP          |                             | PDIP–8<br>(Pb–Free) | 50 Units / Rail        | 0.4%               |      |
| TL431ACLPG     | ACLP         |                             | TO–92<br>(Pb–Free)  | 2000 Units / Bag       | 1.0%               |      |
| TL431BCLPG     | BCLP         |                             |                     |                        | 0.4%               |      |
| TL431CLPG      | CLP          |                             |                     |                        | 2.2%               |      |
| TL431ACLPRAG   | ACLP         |                             |                     | 2000 / Tape & Reel     | 1.0%               |      |
| TL431BCLPRAG   | BCLP         |                             |                     |                        | 0.4%               |      |
| TL431CLPRAG    | CLP          |                             |                     |                        | 2.2%               |      |
| TL431BCLPREG   | BCLP         |                             |                     |                        | 0.4%               |      |
| TL431CLPREG    | CLP          |                             |                     |                        | 2.2%               |      |
| TL431ACLPRPG   | ACLP         |                             |                     | 2000 / Tape & Ammo Box | 1.0%               |      |
| TL431BCLPRMG   | BCLP         |                             |                     | 2000 / Fan–Fold        | 0.4%               |      |
| TL431CLPRPG    | CLP          |                             |                     |                        | 2.2%               |      |
| TL431AIDG      | AI           | –40°C to 85°C               | SOIC–8<br>(Pb–Free) | 98 Units / Rail        | 1.0%               |      |
| TL431BIDG      | BI           |                             |                     | 2500s / Tape & Reel    | 0.4%               |      |
| TL431AIDR2G    | AI           |                             |                     |                        | 1.0%               |      |
| TL431BIDR2G    | BI           |                             |                     |                        | 0.4%               |      |
| TL431IDR2G     | I            |                             |                     |                        | 2.2%               |      |
| TL431AILPG     | AILP         |                             | TO–92<br>(Pb–Free)  | 2000 Units / Bag       | 1.0%               |      |
| TL431BILPG     | BILP         |                             |                     |                        | 0.4%               |      |
| TL431ILPG      | ILP          |                             |                     |                        | 2.2%               |      |
| TL431AILPRAG   | AILP         |                             |                     | 2000 / Tape & Reel     | 1.0%               |      |
| TL431BILPRAG   | BILP         |                             |                     |                        | 0.4%               |      |
| SC431ILPRAG    | ILP          |                             |                     |                        | 2.2%               |      |
| TL431ILPRAG    | ILP          |                             |                     | 2000 / Tape & Ammo Box | 1.0%               |      |
| TL431AILPRPG   | AILP         |                             |                     |                        | 2.2%               |      |
| TL431ILPRPG    | ILP          |                             |                     |                        | 2.2%               |      |
| TL431BVDR2G    | BV           |                             | –40°C to 125°C      | SOIC–8<br>(Pb–Free)    | 2500 / Tape & Reel | 0.4% |
| TL431BVLPG     | BVL P        |                             |                     | TO–92<br>(Pb–Free)     | 2000 Units / Bag   |      |
| TL431BVLPRAG   |              | 2000 / Tape & Reel          |                     |                        |                    |      |
| NCV431AIDMR2G* | RAN          | Micro8<br>(Pb–Free)         |                     | 4000 / Tape & Reel     | 1%                 |      |
| SCV431AIDMR2G* | RAP          | SOIC–8<br>(Pb–Free)         |                     | 2500 / Tape & Reel     |                    |      |
| NCV431AIDR2G*  | AV           |                             |                     | 0.4%                   |                    |      |
| NCV431BVDMR2G* | NVB          | Micro8<br>(Pb–Free)         |                     |                        | 4000 / Tape & Reel |      |
| NCV431BVDR2G*  | BV           | SOIC–8<br>(Pb–Free)         |                     |                        | 2500 / Tape & Reel |      |

# TL431A, B Series, NCV431A, B Series, SCV431A

**DISCONTINUED** (Note 11)

| Device       | Marking Code | Operating Temperature Range | Package Code        | Shipping Information†  | Tolerance |
|--------------|--------------|-----------------------------|---------------------|------------------------|-----------|
| TL431ACDMR2G | TAC          | 0°C to 70°C                 | Micro8<br>(Pb-Free) | 4000 / Tape & Reel     | 1.0%      |
| TL431BCDMR2G | TBC          |                             |                     |                        | 0.4%      |
| TL431CDMR2G  | T-C          |                             |                     |                        | 2.2%      |
| TL431ACPG    | ACP          |                             | PDIP-8<br>(Pb-Free) | 50 Units / Rail        | 1.0%      |
| TL431CPG     | CP           |                             |                     |                        | 2.2%      |
| TL431ACLPRG  | ACLP         |                             | TO-92<br>(Pb-Free)  | 2000 / Tape & Reel     | 1.0%      |
| TL431CLPRMG  | CLP          |                             |                     | 2000 / Fan-Fold        | 2.2%      |
| TL431IDG     | I            | -40°C to 85°C               | SOIC-8<br>(Pb-Free) | 98 Units / Rail        | 2.2%      |
| TL431AIDMR2G | TAI          | -40°C to 85°C               | Micro8<br>(Pb-Free) | 4000 / Tape & Reel     | 1.0%      |
| TL431BIDMR2G | TBI          |                             |                     |                        | 0.4%      |
| TL431IDMR2G  | T-I          |                             |                     |                        | 2.2%      |
| TL431AIPG    | AIP          |                             | PDIP-8<br>(Pb-Free) | 50 Units / Rail        | 1.0%      |
| TL431BIPG    | BIP          |                             |                     |                        | 0.4%      |
| TL431IPG     | IP           |                             |                     |                        | 2.2%      |
| TL431AILPRMG | AILP         | -40°C to 85°C               | TO-92<br>(Pb-Free)  | 2000 / Tape & Ammo Box | 1.0%      |
| TL431BVDG    | BV           | -40°C to 125°C              | SOIC-8<br>(Pb-Free) | 98 Units / Rail        | 0.4%      |
| TL431BVDMR2G | TBV          |                             | Micro8<br>(Pb-Free) | 4000 / Tape & Reel     | 0.4%      |
| TL431BVPG    | BVP          |                             | PDIP-8<br>(Pb-Free) | 50 Units / Rail        | 0.4%      |

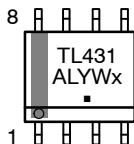
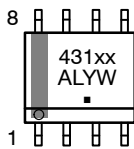
†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, [BRD8011/D](#).

\*NCV/SCV Prefixes for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable.

11. **DISCONTINUED:** This device is not recommended for new design. Please contact your **onsemi** representative for information. The most current information on this device may be available on [www.onsemi.com](http://www.onsemi.com).

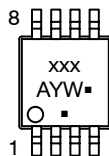
## MARKING DIAGRAMS

**SOIC-8  
D SUFFIX  
CASE 751**

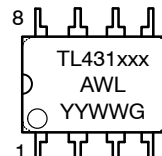


(Exception for the TL431CD and TL431ID only)

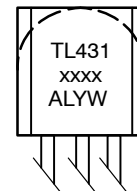
**Micro8  
CASE 846A**



**PDIP-8  
CASE 626**

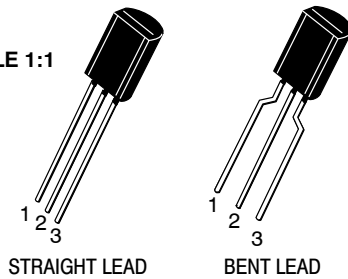


**TO-92 (TO-226)  
CASE 29**



xxxx = See Specific Marking Code  
 A = Assembly Location  
 WL, L = Wafer Lot  
 YY, Y = Year  
 WW, W = Work Week  
 ■ or G = Pb-Free Package  
 (Note: Microdot may be in either location)

SCALE 1:1



STRAIGHT LEAD

BENT LEAD

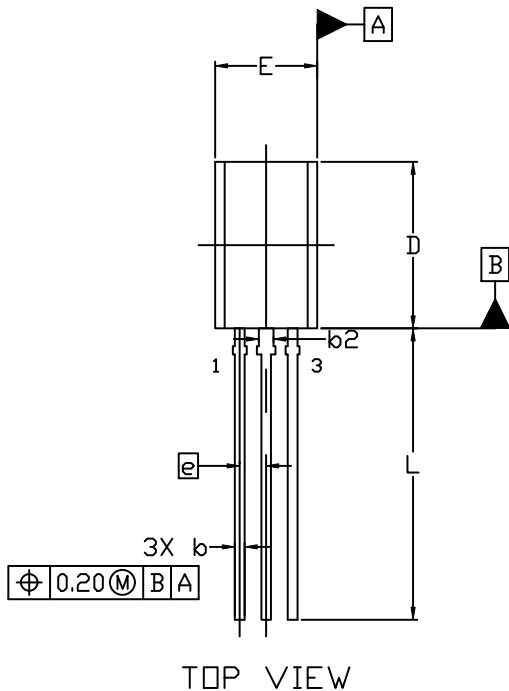
**TO-92 (TO-226) 1 WATT**  
CASE 29-10  
ISSUE D

DATE 05 MAR 2021

## STRAIGHT LEAD



END VIEW



TOP VIEW

### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH OR GATE PROTRUSIONS.
4. DIMENSION b AND b2 DOES NOT INCLUDE DAMBAR PROTRUSION. LEAD WIDTH INCLUDING PROTRUSION SHALL NOT EXCEED 0.20. DIMENSION b2 LOCATED ABOVE THE DAMBAR PORTION OF MIDDLE LEAD.

| DIM | MILLIMETERS |       |       |
|-----|-------------|-------|-------|
|     | MIN.        | NOM.  | MAX.  |
| A   | 3.75        | 3.90  | 4.05  |
| A1  | 1.28        | 1.43  | 1.58  |
| b   | 0.38        | 0.465 | 0.55  |
| b2  | 0.62        | 0.70  | 0.78  |
| c   | 0.35        | 0.40  | 0.45  |
| D   | 7.85        | 8.00  | 8.15  |
| E   | 4.75        | 4.90  | 5.05  |
| E2  | 3.90        | ---   | ---   |
| e   | 1.27 BSC    |       |       |
| L   | 13.80       | 14.00 | 14.20 |

## STYLES AND MARKING ON PAGE 3

|                         |                              |                                                                                                                                                                                  |
|-------------------------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DOCUMENT NUMBER:</b> | <b>98AON52857E</b>           | Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red. |
| <b>DESCRIPTION:</b>     | <b>TO-92 (TO-226) 1 WATT</b> | <b>PAGE 1 OF 3</b>                                                                                                                                                               |

onsemi and onsemi are trademarks of Semiconductor Components Industries, LLC dba onsemi or its subsidiaries in the United States and/or other countries. onsemi reserves the right to make changes without further notice to any products herein. onsemi makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does onsemi 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. onsemi does not convey any license under its patent rights nor the rights of others.

**TO-92 (TO-226) 1 WATT**  
CASE 29-10  
ISSUE D

DATE 05 MAR 2021

**FORMED LEAD**



**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH OR GATE PROTRUSIONS.
4. DIMENSION b AND b2 DOES NOT INCLUDE DAMBAR PROTRUSION. LEAD WIDTH INCLUDING PROTRUSION SHALL NOT EXCEED 0.20. DIMENSION b2 LOCATED ABOVE THE DAMBAR PORTION OF MIDDLE LEAD.

| DIM | MILLIMETERS |       |       |
|-----|-------------|-------|-------|
|     | MIN.        | NOM.  | MAX.  |
| A   | 3.75        | 3.90  | 4.05  |
| A1  | 1.28        | 1.43  | 1.58  |
| b   | 0.38        | 0.465 | 0.55  |
| b2  | 0.62        | 0.70  | 0.78  |
| c   | 0.35        | 0.40  | 0.45  |
| D   | 7.85        | 8.00  | 8.15  |
| E   | 4.75        | 4.90  | 5.05  |
| E2  | 3.90        | ---   | ---   |
| e   | 2.50 BSC    |       |       |
| L   | 13.80       | 14.00 | 14.20 |
| L2  | 13.20       | 13.60 | 14.00 |
| L3  | 3.00 REF    |       |       |

**STYLES AND MARKING ON PAGE 3**

|                         |                              |                                                                                                                                                                                  |
|-------------------------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DOCUMENT NUMBER:</b> | <b>98AON52857E</b>           | Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red. |
| <b>DESCRIPTION:</b>     | <b>TO-92 (TO-226) 1 WATT</b> | <b>PAGE 2 OF 3</b>                                                                                                                                                               |

**onsemi** and **Onsemi** are trademarks of Semiconductor Components Industries, LLC dba **onsemi** or its subsidiaries in the United States and/or other countries. **onsemi** reserves the right to make changes without further notice to any products herein. **onsemi** makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does **onsemi** 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. **onsemi** does not convey any license under its patent rights nor the rights of others.

**TO-92 (TO-226) 1 WATT**  
**CASE 29-10**  
**ISSUE D**

DATE 05 MAR 2021

|                                                                 |                                                                      |                                                              |                                                                 |                                                             |
|-----------------------------------------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------|
| STYLE 1:<br>PIN 1. EMITTER<br>2. BASE<br>3. COLLECTOR           | STYLE 2:<br>PIN 1. BASE<br>2. EMITTER<br>3. COLLECTOR                | STYLE 3:<br>PIN 1. ANODE<br>2. ANODE<br>3. CATHODE           | STYLE 4:<br>PIN 1. CATHODE<br>2. CATHODE<br>3. ANODE            | STYLE 5:<br>PIN 1. DRAIN<br>2. SOURCE<br>3. GATE            |
| STYLE 6:<br>PIN 1. GATE<br>2. SOURCE & SUBSTRATE<br>3. DRAIN    | STYLE 7:<br>PIN 1. SOURCE<br>2. DRAIN<br>3. GATE                     | STYLE 8:<br>PIN 1. DRAIN<br>2. GATE<br>3. SOURCE & SUBSTRATE | STYLE 9:<br>PIN 1. BASE 1<br>2. EMITTER<br>3. BASE 2            | STYLE 10:<br>PIN 1. CATHODE<br>2. GATE<br>3. ANODE          |
| STYLE 11:<br>PIN 1. ANODE<br>2. CATHODE & ANODE<br>3. CATHODE   | STYLE 12:<br>PIN 1. MAIN TERMINAL 1<br>2. GATE<br>3. MAIN TERMINAL 2 | STYLE 13:<br>PIN 1. ANODE 1<br>2. GATE<br>3. CATHODE 2       | STYLE 14:<br>PIN 1. EMITTER<br>2. COLLECTOR<br>3. BASE          | STYLE 15:<br>PIN 1. ANODE 1<br>2. CATHODE<br>3. ANODE 2     |
| STYLE 16:<br>PIN 1. ANODE<br>2. GATE<br>3. CATHODE              | STYLE 17:<br>PIN 1. COLLECTOR<br>2. BASE<br>3. EMITTER               | STYLE 18:<br>PIN 1. ANODE<br>2. CATHODE<br>3. NOT CONNECTED  | STYLE 19:<br>PIN 1. GATE<br>2. ANODE<br>3. CATHODE              | STYLE 20:<br>PIN 1. NOT CONNECTED<br>2. CATHODE<br>3. ANODE |
| STYLE 21:<br>PIN 1. COLLECTOR<br>2. EMITTER<br>3. BASE          | STYLE 22:<br>PIN 1. SOURCE<br>2. GATE<br>3. DRAIN                    | STYLE 23:<br>PIN 1. GATE<br>2. SOURCE<br>3. DRAIN            | STYLE 24:<br>PIN 1. EMITTER<br>2. COLLECTOR/ANODE<br>3. CATHODE | STYLE 25:<br>PIN 1. MT 1<br>2. GATE<br>3. MT 2              |
| STYLE 26:<br>PIN 1. V <sub>CC</sub><br>2. GROUND 2<br>3. OUTPUT | STYLE 27:<br>PIN 1. MT<br>2. SUBSTRATE<br>3. MT                      | STYLE 28:<br>PIN 1. CATHODE<br>2. ANODE<br>3. GATE           | STYLE 29:<br>PIN 1. NOT CONNECTED<br>2. ANODE<br>3. CATHODE     | STYLE 30:<br>PIN 1. DRAIN<br>2. GATE<br>3. SOURCE           |
| STYLE 31:<br>PIN 1. GATE<br>2. DRAIN<br>3. SOURCE               | STYLE 32:<br>PIN 1. BASE<br>2. COLLECTOR<br>3. EMITTER               | STYLE 33:<br>PIN 1. RETURN<br>2. INPUT<br>3. OUTPUT          | STYLE 34:<br>PIN 1. INPUT<br>2. GROUND<br>3. LOGIC              | STYLE 35:<br>PIN 1. GATE<br>2. COLLECTOR<br>3. EMITTER      |

**GENERIC  
MARKING DIAGRAM\***



XXXX = Specific Device Code  
A = Assembly Location  
L = Wafer Lot  
Y = Year  
W = Work Week  
■ = Pb-Free Package

(Note: Microdot may be in either location)

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "■", may or may not be present. Some products may not follow the Generic Marking.

|                         |                              |                                                                                                                                                                                     |
|-------------------------|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DOCUMENT NUMBER:</b> | <b>98AON52857E</b>           | Electronic versions are uncontrolled except when accessed directly from the Document Repository.<br>Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red. |
| <b>DESCRIPTION:</b>     | <b>TO-92 (TO-226) 1 WATT</b> | <b>PAGE 3 OF 3</b>                                                                                                                                                                  |

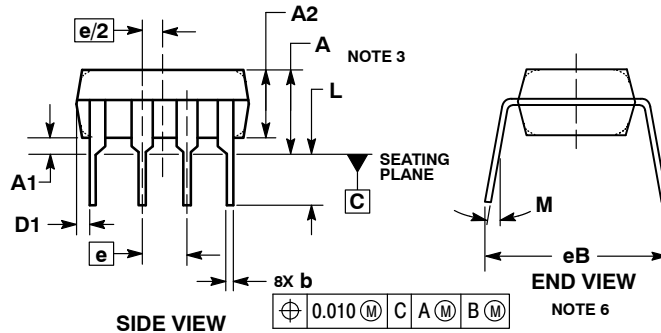
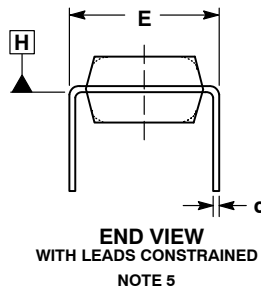
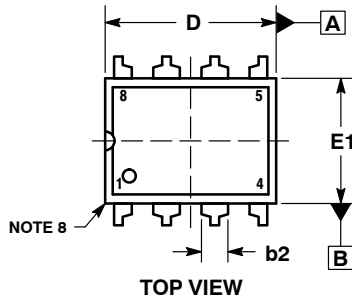
**onsemi** and **onsemi** are trademarks of Semiconductor Components Industries, LLC dba **onsemi** or its subsidiaries in the United States and/or other countries. **onsemi** reserves the right to make changes without further notice to any products herein. **onsemi** makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does **onsemi** 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. **onsemi** does not convey any license under its patent rights nor the rights of others.



SCALE 1:1

PDIP-8  
CASE 626-05  
ISSUE P

DATE 22 APR 2015

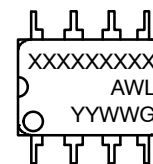


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSIONS A, A1 AND L ARE MEASURED WITH THE PACKAGE SEATED IN JEDEC SEATING PLANE GAUGE GS-3.
4. DIMENSIONS D, D1 AND E1 DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS ARE NOT TO EXCEED 0.10 INCH.
5. DIMENSION E IS MEASURED AT A POINT 0.015 BELOW DATUM PLANE H WITH THE LEADS CONSTRAINED PERPENDICULAR TO DATUM C.
6. DIMENSION eB IS MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.
7. DATUM PLANE H IS COINCIDENT WITH THE BOTTOM OF THE LEADS, WHERE THE LEADS EXIT THE BODY.
8. PACKAGE CONTOUR IS OPTIONAL (ROUNDED OR SQUARE CORNERS).

| DIM | INCHES    |       | MILLIMETERS |       |
|-----|-----------|-------|-------------|-------|
|     | MIN       | MAX   | MIN         | MAX   |
| A   | ---       | 0.210 | ---         | 5.33  |
| A1  | 0.015     | ---   | 0.38        | ---   |
| A2  | 0.115     | 0.195 | 2.92        | 4.95  |
| b   | 0.014     | 0.022 | 0.35        | 0.56  |
| b2  | 0.060 TYP | ---   | 1.52 TYP    | ---   |
| C   | 0.008     | 0.014 | 0.20        | 0.36  |
| D   | 0.355     | 0.400 | 9.02        | 10.16 |
| D1  | 0.005     | ---   | 0.13        | ---   |
| E   | 0.300     | 0.325 | 7.62        | 8.26  |
| E1  | 0.240     | 0.280 | 6.10        | 7.11  |
| e   | 0.100 BSC | ---   | 2.54 BSC    | ---   |
| eB  | ---       | 0.430 | ---         | 10.92 |
| L   | 0.115     | 0.150 | 2.92        | 3.81  |
| M   | ---       | 10°   | ---         | 10°   |

GENERIC  
MARKING DIAGRAM\*



- XXXX = Specific Device Code  
A = Assembly Location  
WL = Wafer Lot  
YY = Year  
WW = Work Week  
G = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

STYLE 1:

- PIN 1: AC IN  
2. DC + IN  
3. DC - IN  
4. AC IN  
5. GROUND  
6. OUTPUT  
7. AUXILIARY  
8. V<sub>CC</sub>

|                  |             |                                                                                                                                                                                     |
|------------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DOCUMENT NUMBER: | 98ASB42420B | Electronic versions are uncontrolled except when accessed directly from the Document Repository.<br>Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red. |
| DESCRIPTION:     | PDIP-8      | PAGE 1 OF 1                                                                                                                                                                         |

onsemi and onsemi are trademarks of Semiconductor Components Industries, LLC dba onsemi or its subsidiaries in the United States and/or other countries. onsemi reserves the right to make changes without further notice to any products herein. onsemi makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does onsemi 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. onsemi does not convey any license under its patent rights nor the rights of others.



SCALE 1:1

SOIC-8 NB  
CASE 751-07  
ISSUE AK

DATE 16 FEB 2011



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. 751-01 THRU 751-06 ARE OBSOLETE. NEW STANDARD IS 751-07.

| DIM | MILLIMETERS |      | INCHES    |       |
|-----|-------------|------|-----------|-------|
|     | MIN         | MAX  | MIN       | MAX   |
| A   | 4.80        | 5.00 | 0.189     | 0.197 |
| B   | 3.80        | 4.00 | 0.150     | 0.157 |
| C   | 1.35        | 1.75 | 0.053     | 0.069 |
| D   | 0.33        | 0.51 | 0.013     | 0.020 |
| E   | 1.27 BSC    |      | 0.050 BSC |       |
| H   | 0.10        | 0.25 | 0.004     | 0.010 |
| J   | 0.19        | 0.25 | 0.007     | 0.010 |
| K   | 0.40        | 1.27 | 0.016     | 0.050 |
| M   | 0°          | 8°   | 0°        | 8°    |
| N   | 0.25        | 0.50 | 0.010     | 0.020 |
| S   | 5.80        | 6.20 | 0.228     | 0.244 |

GENERIC  
MARKING DIAGRAM\*



SCALE 6:1 (mm/inches)



XXXXXX = Specific Device Code  
A = Assembly Location  
L = Wafer Lot  
Y = Year  
W = Work Week  
■ = Pb-Free Package

XXXXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
■ = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

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

STYLES ON PAGE 2

|                  |             |                                                                                                                                                                                     |
|------------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DOCUMENT NUMBER: | 98ASB42564B | Electronic versions are uncontrolled except when accessed directly from the Document Repository.<br>Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red. |
| DESCRIPTION:     | SOIC-8 NB   | PAGE 1 OF 2                                                                                                                                                                         |

onsemi and onsemi are trademarks of Semiconductor Components Industries, LLC dba onsemi or its subsidiaries in the United States and/or other countries. onsemi reserves the right to make changes without further notice to any products herein. onsemi makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does onsemi 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. onsemi does not convey any license under its patent rights nor the rights of others.

**SOIC-8 NB**  
**CASE 751-07**  
**ISSUE AK**

DATE 16 FEB 2011

|                                                                                                                                                                                                   |                                                                                                                                                                                          |                                                                                                                                                                                    |                                                                                                                                                                                                        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>STYLE 1:</b><br>PIN 1. EMITTER<br>2. COLLECTOR<br>3. COLLECTOR<br>4. EMITTER<br>5. EMITTER<br>6. BASE<br>7. BASE<br>8. EMITTER                                                                 | <b>STYLE 2:</b><br>PIN 1. COLLECTOR, DIE, #1<br>2. COLLECTOR, #1<br>3. COLLECTOR, #2<br>4. COLLECTOR, #2<br>5. BASE, #2<br>6. EMITTER, #2<br>7. BASE, #1<br>8. EMITTER, #1               | <b>STYLE 3:</b><br>PIN 1. DRAIN, DIE #1<br>2. DRAIN, #1<br>3. DRAIN, #2<br>4. DRAIN, #2<br>5. GATE, #2<br>6. SOURCE, #2<br>7. GATE, #1<br>8. SOURCE, #1                            | <b>STYLE 4:</b><br>PIN 1. ANODE<br>2. ANODE<br>3. ANODE<br>4. ANODE<br>5. ANODE<br>6. ANODE<br>7. ANODE<br>8. COMMON CATHODE                                                                           |
| <b>STYLE 5:</b><br>PIN 1. DRAIN<br>2. DRAIN<br>3. DRAIN<br>4. DRAIN<br>5. GATE<br>6. GATE<br>7. SOURCE<br>8. SOURCE                                                                               | <b>STYLE 6:</b><br>PIN 1. SOURCE<br>2. DRAIN<br>3. DRAIN<br>4. SOURCE<br>5. SOURCE<br>6. GATE<br>7. GATE<br>8. SOURCE                                                                    | <b>STYLE 7:</b><br>PIN 1. INPUT<br>2. EXTERNAL BYPASS<br>3. THIRD STAGE SOURCE<br>4. GROUND<br>5. DRAIN<br>6. GATE 3<br>7. SECOND STAGE Vd<br>8. FIRST STAGE Vd                    | <b>STYLE 8:</b><br>PIN 1. COLLECTOR, DIE #1<br>2. BASE, #1<br>3. BASE, #2<br>4. COLLECTOR, #2<br>5. COLLECTOR, #2<br>6. EMITTER, #2<br>7. EMITTER, #1<br>8. COLLECTOR, #1                              |
| <b>STYLE 9:</b><br>PIN 1. EMITTER, COMMON<br>2. COLLECTOR, DIE #1<br>3. COLLECTOR, DIE #2<br>4. EMITTER, COMMON<br>5. EMITTER, COMMON<br>6. BASE, DIE #2<br>7. BASE, DIE #1<br>8. EMITTER, COMMON | <b>STYLE 10:</b><br>PIN 1. GROUND<br>2. BIAS 1<br>3. OUTPUT<br>4. GROUND<br>5. GROUND<br>6. BIAS 2<br>7. INPUT<br>8. GROUND                                                              | <b>STYLE 11:</b><br>PIN 1. SOURCE 1<br>2. GATE 1<br>3. SOURCE 2<br>4. GATE 2<br>5. DRAIN 2<br>6. DRAIN 2<br>7. DRAIN 1<br>8. DRAIN 1                                               | <b>STYLE 12:</b><br>PIN 1. SOURCE<br>2. SOURCE<br>3. SOURCE<br>4. GATE<br>5. DRAIN<br>6. DRAIN<br>7. DRAIN<br>8. DRAIN                                                                                 |
| <b>STYLE 13:</b><br>PIN 1. N.C.<br>2. SOURCE<br>3. SOURCE<br>4. GATE<br>5. DRAIN<br>6. DRAIN<br>7. DRAIN<br>8. DRAIN                                                                              | <b>STYLE 14:</b><br>PIN 1. N-SOURCE<br>2. N-GATE<br>3. P-SOURCE<br>4. P-GATE<br>5. P-DRAIN<br>6. P-DRAIN<br>7. N-DRAIN<br>8. N-DRAIN                                                     | <b>STYLE 15:</b><br>PIN 1. ANODE 1<br>2. ANODE 1<br>3. ANODE 1<br>4. ANODE 1<br>5. CATHODE, COMMON<br>6. CATHODE, COMMON<br>7. CATHODE, COMMON<br>8. CATHODE, COMMON               | <b>STYLE 16:</b><br>PIN 1. EMITTER, DIE #1<br>2. BASE, DIE #1<br>3. EMITTER, DIE #2<br>4. BASE, DIE #2<br>5. COLLECTOR, DIE #2<br>6. COLLECTOR, DIE #2<br>7. COLLECTOR, DIE #1<br>8. COLLECTOR, DIE #1 |
| <b>STYLE 17:</b><br>PIN 1. VCC<br>2. V2OUT<br>3. V1OUT<br>4. TXE<br>5. RXE<br>6. VEE<br>7. GND<br>8. ACC                                                                                          | <b>STYLE 18:</b><br>PIN 1. ANODE<br>2. ANODE<br>3. SOURCE<br>4. GATE<br>5. DRAIN<br>6. DRAIN<br>7. CATHODE<br>8. CATHODE                                                                 | <b>STYLE 19:</b><br>PIN 1. SOURCE 1<br>2. GATE 1<br>3. SOURCE 2<br>4. GATE 2<br>5. DRAIN 2<br>6. MIRROR 2<br>7. DRAIN 1<br>8. MIRROR 1                                             | <b>STYLE 20:</b><br>PIN 1. SOURCE (N)<br>2. GATE (N)<br>3. SOURCE (P)<br>4. GATE (P)<br>5. DRAIN<br>6. DRAIN<br>7. DRAIN<br>8. DRAIN                                                                   |
| <b>STYLE 21:</b><br>PIN 1. CATHODE 1<br>2. CATHODE 2<br>3. CATHODE 3<br>4. CATHODE 4<br>5. CATHODE 5<br>6. COMMON ANODE<br>7. COMMON ANODE<br>8. CATHODE 6                                        | <b>STYLE 22:</b><br>PIN 1. I/O LINE 1<br>2. COMMON CATHODE/VCC<br>3. COMMON CATHODE/VCC<br>4. I/O LINE 3<br>5. COMMON ANODE/GND<br>6. I/O LINE 4<br>7. I/O LINE 5<br>8. COMMON ANODE/GND | <b>STYLE 23:</b><br>PIN 1. LINE 1 IN<br>2. COMMON ANODE/GND<br>3. COMMON ANODE/GND<br>4. LINE 2 IN<br>5. LINE 2 OUT<br>6. COMMON ANODE/GND<br>7. COMMON ANODE/GND<br>8. LINE 1 OUT | <b>STYLE 24:</b><br>PIN 1. BASE<br>2. EMITTER<br>3. COLLECTOR/ANODE<br>4. COLLECTOR/ANODE<br>5. CATHODE<br>6. CATHODE<br>7. COLLECTOR/ANODE<br>8. COLLECTOR/ANODE                                      |
| <b>STYLE 25:</b><br>PIN 1. VIN<br>2. N/C<br>3. REXT<br>4. GND<br>5. IOUT<br>6. IOUT<br>7. IOUT<br>8. IOUT                                                                                         | <b>STYLE 26:</b><br>PIN 1. GND<br>2. dv/dt<br>3. ENABLE<br>4. ILIMIT<br>5. SOURCE<br>6. SOURCE<br>7. SOURCE<br>8. VCC                                                                    | <b>STYLE 27:</b><br>PIN 1. ILIMIT<br>2. OVLO<br>3. UVLO<br>4. INPUT+<br>5. SOURCE<br>6. SOURCE<br>7. SOURCE<br>8. DRAIN                                                            | <b>STYLE 28:</b><br>PIN 1. SW_TO_GND<br>2. DASIC_OFF<br>3. DASIC_SW_DET<br>4. GND<br>5. V_MON<br>6. VBULK<br>7. VBULK<br>8. VIN                                                                        |
| <b>STYLE 29:</b><br>PIN 1. BASE, DIE #1<br>2. EMITTER, #1<br>3. BASE, #2<br>4. EMITTER, #2<br>5. COLLECTOR, #2<br>6. COLLECTOR, #2<br>7. COLLECTOR, #1<br>8. COLLECTOR, #1                        | <b>STYLE 30:</b><br>PIN 1. DRAIN 1<br>2. DRAIN 1<br>3. GATE 2<br>4. SOURCE 2<br>5. SOURCE 1/DRAIN 2<br>6. SOURCE 1/DRAIN 2<br>7. SOURCE 1/DRAIN 2<br>8. GATE 1                           |                                                                                                                                                                                    |                                                                                                                                                                                                        |

|                         |                    |                                                                                                                                                                                     |
|-------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DOCUMENT NUMBER:</b> | <b>98ASB42564B</b> | Electronic versions are uncontrolled except when accessed directly from the Document Repository.<br>Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red. |
| <b>DESCRIPTION:</b>     | <b>SOIC-8 NB</b>   | <b>PAGE 2 OF 2</b>                                                                                                                                                                  |

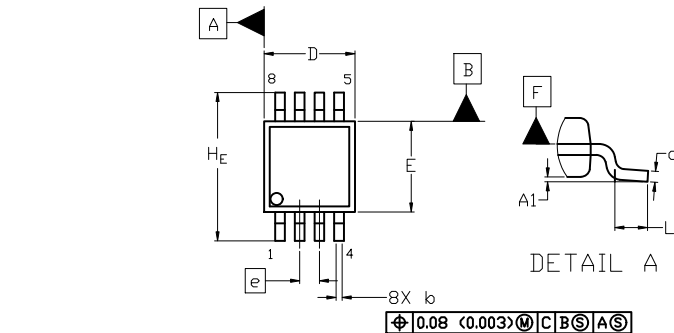
**onsemi** and **onsemi** are trademarks of Semiconductor Components Industries, LLC dba **onsemi** or its subsidiaries in the United States and/or other countries. **onsemi** reserves the right to make changes without further notice to any products herein. **onsemi** makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does **onsemi** 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. **onsemi** does not convey any license under its patent rights nor the rights of others.



SCALE 2:1

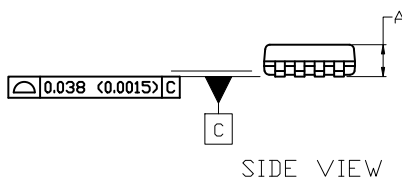
**Micro8**  
**CASE 846A-02**  
**ISSUE K**

DATE 16 JUL 2020

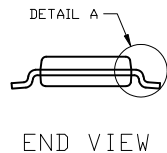


TOP VIEW

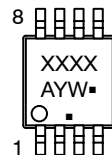
NOTE 3



SIDE VIEW



END VIEW

**GENERIC**  
**MARKING DIAGRAM\***


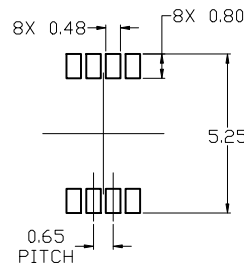
XXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
W = Work Week  
▪ = Pb-Free Package

(Note: Microdot may be in either location)

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE PROTRUSION SHALL BE 0.10 mm IN EXCESS OF MAXIMUM MATERIAL CONDITION.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSION OR GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.15 mm PER SIDE. DIMENSION E DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 mm PER SIDE. DIMENSIONS D AND E ARE DETERMINED AT DATUM F.
5. DATUMS A AND B ARE TO BE DETERMINED AT DATUM F.
6. A1 IS DEFINED AS THE VERTICAL DISTANCE FROM THE SEATING PLANE TO THE LOWEST POINT ON THE PACKAGE BODY.


**RECOMMENDED**  
**MOUNTING FOOTPRINT**

For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERM-10.

| DIM            | MILLIMETERS |      |      |
|----------------|-------------|------|------|
|                | MIN.        | NOM. | MAX. |
| A              | ---         | ---  | 1.10 |
| A1             | 0.05        | 0.08 | 0.15 |
| b              | 0.25        | 0.33 | 0.40 |
| c              | 0.13        | 0.18 | 0.23 |
| D              | 2.90        | 3.00 | 3.10 |
| E              | 2.90        | 3.00 | 3.10 |
| e              | 0.65 BSC    |      |      |
| H <sub>E</sub> | 4.75        | 4.90 | 5.05 |
| L              | 0.40        | 0.55 | 0.70 |

**STYLE 1:**

1. SOURCE
2. SOURCE
3. SOURCE
4. GATE
5. DRAIN
6. DRAIN
7. DRAIN
8. DRAIN

**STYLE 2:**

1. SOURCE 1
2. GATE 1
3. SOURCE 2
4. GATE 2
5. DRAIN 2
6. DRAIN 2
7. DRAIN 1
8. DRAIN 1

**STYLE 3:**

1. N-SOURCE
2. N-GATE
3. P-SOURCE
4. P-GATE
5. P-DRAIN
6. P-DRAIN
7. N-DRAIN
8. N-DRAIN

|                         |                    |                                                                                                                                                                                  |
|-------------------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DOCUMENT NUMBER:</b> | <b>98ASB14087C</b> | Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red. |
| <b>DESCRIPTION:</b>     | <b>MICRO8</b>      | <b>PAGE 1 OF 1</b>                                                                                                                                                               |

onsemi and onsemi are trademarks of Semiconductor Components Industries, LLC dba onsemi or its subsidiaries in the United States and/or other countries. onsemi reserves the right to make changes without further notice to any products herein. onsemi makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does onsemi 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. onsemi does not convey any license under its patent rights nor the rights of others.

**onsemi**, **Onsemi**, and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as-is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** 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. Buyer is responsible for its products and applications using **onsemi** products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by **onsemi**. "Typical" parameters which may be provided in **onsemi** 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. **onsemi** does not convey any license under any of its intellectual property rights nor the rights of others. **onsemi** products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use **onsemi** products for any such unintended or unauthorized application, Buyer shall indemnify and hold **onsemi** 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 **onsemi** was negligent regarding the design or manufacture of the part. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

## ADDITIONAL INFORMATION

### TECHNICAL PUBLICATIONS:

Technical Library: [www.onsemi.com/design/resources/technical-documentation](http://www.onsemi.com/design/resources/technical-documentation)  
onsemi Website: [www.onsemi.com](http://www.onsemi.com)

### ONLINE SUPPORT: [www.onsemi.com/support](http://www.onsemi.com/support)

For additional information, please contact your local Sales Representative at  
[www.onsemi.com/support/sales](http://www.onsemi.com/support/sales)