

# NCP431A, SC431A, NCP431B, NCP432B Series

## Programmable Precision References

The NCP431/NCP432 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 using two external resistors. These devices exhibit a wide operating current range of 40  $\mu\text{A}$  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 NCP431/NCP432 operates as a shunt regulator, it can be used as either a positive or negative voltage reference. Low minimum operating current makes this device an ideal choice for secondary regulators in SMPS adapters with extremely low no-load consumption.

### Features

- Programmable Output Voltage to 36 V
- Low Minimum Operating Current: 40  $\mu\text{A}$ , Typ @ 25°C
- Voltage Reference Tolerance:  $\pm 0.5\%$ , Typ @ 25°C (NCP431B/NCP432B)
- Low Dynamic Output Impedance, 0.22  $\Omega$  Typical
- Sink Current Capability of 40  $\mu\text{A}$  to 100 mA
- Equivalent Full-Range Temperature Coefficient of 50 ppm/°C Typical
- Temperature Compensated for Operation over Full Rated Operating Temperature Range
- SC Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable
- These are Pb-Free Devices

### Typical Applications

- Voltage Adapters
- Switching Power Supply
- Precision Voltage Reference
- Charger
- Instrumentation



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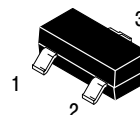
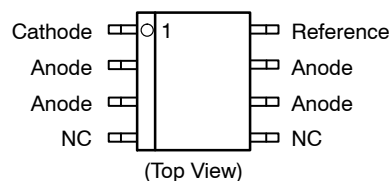


TO-92  
LP SUFFIX  
CASE 29-11

Pin 1. Reference  
2. Anode  
3. Cathode



SOIC-8 NB  
D SUFFIX  
CASE 751



SOT-23-3  
SN SUFFIX  
CASE 318

NCP431  
Pin 1. Reference  
2. Cathode  
3. Anode

NCP432  
Pin 1. Cathode  
2. Reference  
3. Anode

### ORDERING AND MARKING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 14 of this data sheet.

# NCP431A, SC431A, NCP431B, NCP432B Series

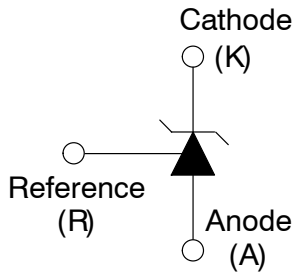


Figure 1. Symbol



Figure 2. Representative Block diagram

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

| Symbol    | Rating  | Value         | Unit |
|-----------|---|---------------|------|
| $V_{KA}$  | Cathode to Anode Voltage  | 37            | V    |
| $I_K$     | Cathode Current Range, Continuous   | -100 to +150  | mA   |
| $I_{ref}$ | Reference Input Current Range, Continuous   | -0.05 to +10  | mA   |
| $T_J$     | Operating Junction Temperature  | 150           | °C   |
| $T_A$     | Operating Ambient Temperature Range   | -40 to +125   | °C   |
| $T_{stg}$ | Storage Temperature Range   | -65 to +150   | °C   |
| $P_D$     | Total Power Dissipation @ $T_A = 25^\circ\text{C}$<br>Derate above 25°C Ambient Temperature<br>D, LP Suffix Plastic Package<br>SN1 Suffix Plastic Package | 0.70<br>0.52  | W    |
| $P_D$     | Total Power Dissipation @ $T_C = 25^\circ\text{C}$<br>Derate above 25°C Case Temperature<br>D, LP Suffix Plastic Package                                  | 1.5           | W    |
| HBM<br>MM | ESD Rating  | >2000<br>>200 | V    |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

## RECOMMENDED OPERATING CONDITIONS

| Symbol   | Condition                | Min       | Max | Unit |
|----------|--------------------------|-----------|-----|------|
| $V_{KA}$ | Cathode to Anode Voltage | $V_{ref}$ | 36  | V    |
| $I_K$    | Cathode Current          | 0.04      | 100 | mA   |

## THERMAL CHARACTERISTICS

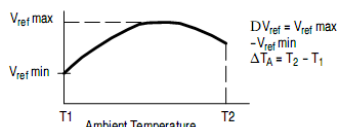
| Symbol          | Characteristic                                   | LP Suffix Package<br>(50 mm <sup>2</sup> x 35 μm Cu) | D Suffix Package<br>(50 mm <sup>2</sup> x 35 μm Cu) | SN Suffix Package<br>(10 mm <sup>2</sup> x 35 μm Cu) | Unit |
|-----------------|--|--|---|--|------|
| $R_{\theta JA}$ | Thermal Resistance,<br>Junction-to-Ambient       | 176  | 210   | 255  | °C/W |
| $R_{\theta JL}$ | Thermal Resistance,<br>Junction-to-Lead (Lead 3) | 75   | 68  | 80   | °C/W |

# NCP431A, SC431A, NCP431B, NCP432B Series

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

| Symbol                                 | Characteristic  | NCP431AC       |                |                | NCP431AI       |                |                | NCP431AV/<br>SC431AV |                |                | Unit     |
|--|---|----------------|----------------|----------------|----------------|----------------|----------------|----------------------|----------------|----------------|----------|
|  |   | Min            | Typ            | Max            | Min            | Typ            | Max            | Min                  | Typ            | Max            |          |
| V <sub>ref</sub>                       | Reference Input Voltage<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 1 mA<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>low</sub> to T <sub>high</sub> (Note 1)                       | 2.475<br>2.475 | 2.500<br>2.500 | 2.525<br>2.525 | 2.475<br>2.465 | 2.500<br>2.500 | 2.525<br>2.525 | 2.475<br>2.460       | 2.500<br>2.500 | 2.525<br>2.525 | V        |
| ΔV <sub>refT</sub>                     | Reference Input Voltage Deviation Over Temperature Range (Figure 1, Notes 2, 3)<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 1 mA   | -              | -              | -              | -              | 5.0            | 10             | -                    | 10             | 15             | mV       |
| $\frac{\Delta V_{ref}}{\Delta V_{AK}}$ | Ratio of Change in Reference Input Voltage to Change in Cathode to Anode Voltage<br>I <sub>K</sub> = 1 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 | -              | -2.00<br>-1.28 | -3.1<br>-1.9   | -              | -2.00<br>-1.28 | -3.1<br>-1.9   | -                    | -2.00<br>-1.28 | -3.1<br>-1.9   | mV/<br>V |
| I <sub>ref</sub>                       | Reference Input Current (Figure 2)<br>I <sub>K</sub> = 1 mA, R1 = 220 k, R2 = ∞<br>T <sub>A</sub> = -40°C to +125°C   | -              | 81             | 190            | -              | 81             | 190            | -                    | 81             | 190            | nA       |
| ΔI <sub>refT</sub>                     | Reference Input Current Deviation Over Temperature Range (Figure 2, Note 2, 3)<br>I <sub>K</sub> = 1 mA, R1 = 10 k, R2 = ∞  | -              | 22             | 55             | -              | 22             | 55             | -                    | 22             | 55             | nA       |
| I <sub>min</sub>                       | Minimum Cathode Current For Regulation<br>V <sub>KA</sub> = V <sub>ref</sub> (Figure 1)   | -              | 40             | 80             | -              | 40             | 80             | -                    | 40             | 80             | μA       |
| I <sub>off</sub>                       | Off-State Cathode Current (Figure 3)<br>V <sub>KA</sub> = 36 V, V <sub>ref</sub> = 0 V  | -              | 180            | 1000           | -              | 180            | 1000           | -                    | 180            | 1000           | nA       |
| Z <sub>KA</sub>                        | Dynamic Impedance (Figure 1, Note 3)<br>V <sub>KA</sub> = V <sub>ref</sub> , ΔI <sub>K</sub> = 1.0 mA to 100 mA<br>f ≤ 1.0 kHz  | -              | 0.22           | 0.5            | -              | 0.22           | 0.5            | -                    | 0.22           | 0.5            | Ω        |

- T<sub>low</sub> = -40°C for NCP431AI, NCP431AV, SC431AV  
= 0°C for NCP431AC  
T<sub>high</sub> = 70°C for NCP431AC  
= 85°C for NCP431AI  
= 125°C for NCP431AV, SC431AV
- Guaranteed by design
- The deviation parameter ΔV<sub>refT</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, V<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.

Example: ΔV<sub>refT</sub> = 17 mV and slope is positive  
V<sub>ref</sub> = 2.5 V, ΔT<sub>A</sub> = 165°C (from -40°C to +125°C)

$$\alpha V_{ref} = \frac{0.017 \cdot 10^6}{165 \cdot 2.5} = 41.2 \text{ ppm}/^{\circ}\text{C}$$

- The dynamic impedance Z<sub>KA</sub> is defined as: (|Z<sub>KA</sub>| = (ΔV<sub>KA</sub>/ΔI<sub>K</sub>)). When the device is programmed with two external resistors, R1 and R2, the total dynamic impedance of the circuit is defined as: |Z<sub>KA</sub>| ≈ |Z<sub>KA</sub>| (1 + (R1/R2)).
- SC431AVSNT1G – T<sub>low</sub> = -40°C, T<sub>high</sub> = 125°C. Guaranteed by design. SC Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable.

# NCP431A, SC431A, NCP431B, NCP432B Series

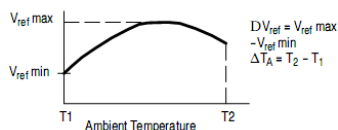
## ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C, unless otherwise noted.)

| Symbol                                 | Characteristic  | NCP431BC<br>NCP432BC |                |                  | NCP431BI<br>NCP432BI |                |                  | NCP431BV<br>NCP432BV |                |                  | Unit |
|--|---|----------------------|----------------|------------------|----------------------|----------------|------------------|----------------------|----------------|------------------|------|
|  |   | Min                  | Typ            | Max              | Min                  | Typ            | Max              | Min                  | Typ            | Max              |      |
| V <sub>ref</sub>                       | Reference Input Voltage<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 1 mA<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>low</sub> to T <sub>high</sub> (Note 6)                       | 2.4875<br>2.4875     | 2.500<br>2.500 | 2.5125<br>2.5125 | 2.4875<br>2.4775     | 2.500<br>2.500 | 2.5125<br>2.5125 | 2.4875<br>2.4725     | 2.500<br>2.500 | 2.5125<br>2.5125 | V    |
| ΔV <sub>refT</sub>                     | Reference Input Voltage Deviation Over Temperature Range (Figure 1, Notes 7, 8)<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 1 mA   | -                    | -              | -                | -                    | 5.0            | 10               | -                    | 10             | 15               | mV   |
| $\frac{\Delta V_{ref}}{\Delta V_{AK}}$ | Ratio of Change in Reference Input Voltage to Change in Cathode to Anode Voltage<br>I <sub>K</sub> = 1 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 | -                    | -2.00<br>-1.28 | -3.1<br>-1.9     | -                    | -2.00<br>-1.28 | -3.1<br>-1.9     | -                    | -2.00<br>-1.28 | -3.1<br>-1.9     | mV/V |
| I <sub>ref</sub>                       | Reference Input Current (Figure 2)<br>I <sub>K</sub> = 1 mA, R1 = 220 k, R2 = ∞<br>T <sub>A</sub> = -40°C to +125°C   | -                    | 81             | 190              | -                    | 81             | 190              | -                    | 81             | 190              | nA   |
| ΔI <sub>refT</sub>                     | Reference Input Current Deviation Over Temperature Range (Figure 2, Note 7, 8)<br>I <sub>K</sub> = 1 mA, R1 = 10 k, R2 = ∞  | -                    | 22             | 55               | -                    | 22             | 55               | -                    | 22             | 55               | nA   |
| I <sub>min</sub>                       | Minimum Cathode Current For Regulation<br>V <sub>KA</sub> = V <sub>ref</sub> (Figure 1)   | -                    | 40             | 80               | -                    | 40             | 80               | -                    | 40             | 80               | μA   |
| I <sub>off</sub>                       | Off-State Cathode Current (Figure 3)<br>V <sub>KA</sub> = 36 V, V <sub>ref</sub> = 0 V  | -                    | 180            | 1000             | -                    | 180            | 1000             | -                    | 180            | 1000             | nA   |
| Z <sub>KA</sub>                        | Dynamic Impedance (Figure 1, Note 8)<br>V <sub>KA</sub> = V <sub>ref</sub> , ΔI <sub>K</sub> = 1.0 mA to 100 mA<br>f ≤ 1.0 kHz  | -                    | 0.22           | 0.5              | -                    | 0.22           | 0.5              | -                    | 0.22           | 0.5              | Ω    |

6. T<sub>low</sub> = -40°C for NCP431BI, NCP431BV, NCP432BI, NCP432BV  
 = 0°C for NCP431BC, NCP432BC  
 T<sub>high</sub> = 70°C for NCP431BC, NCP432BC  
 = 85°C for NCP431BI, NCP432BI  
 = 125°C for NCP431BV, NCP432BV

7. Guaranteed by design

8. The deviation parameter ΔV<sub>refT</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, V<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.

Example: ΔV<sub>refT</sub> = 17 mV and slope is positive  
 V<sub>ref</sub> = 2.5 V, ΔT<sub>A</sub> = 165°C (from -40°C to +125°C)

$$\alpha V_{ref} = \frac{0.017 \cdot 10^6}{165 \cdot 2.5} = 41.2 \text{ ppm}/^{\circ}\text{C}$$

9. The dynamic impedance Z<sub>KA</sub> is defined as: |Z<sub>KA</sub>| = (ΔV<sub>KA</sub>/ΔI<sub>K</sub>). When the device is programmed with two external resistors, R1 and R2, the total dynamic impedance of the circuit is defined as: |Z<sub>KA</sub>| ≈ |Z<sub>KA</sub>| (1 + (R1/R2))

# NCP431A, SC431A, NCP431B, NCP432B Series

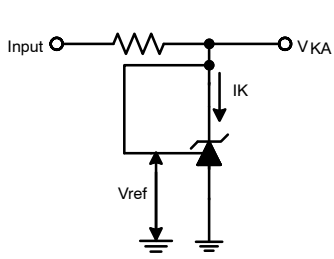


Figure 3. Test Circuit for  $V_{KA} = V_{ref}$



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

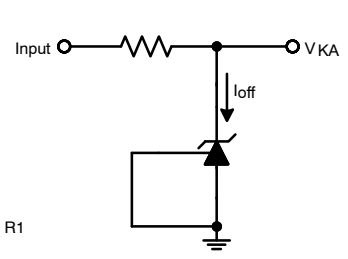


Figure 5. Test Circuit for  $I_{off}$

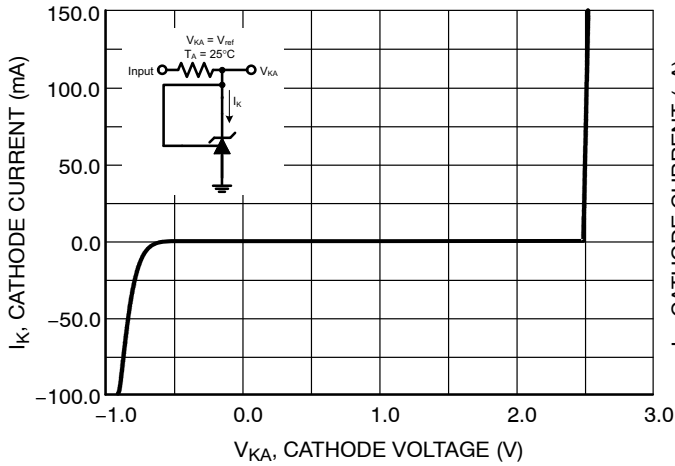


Figure 6. Cathode Current versus Cathode Voltage

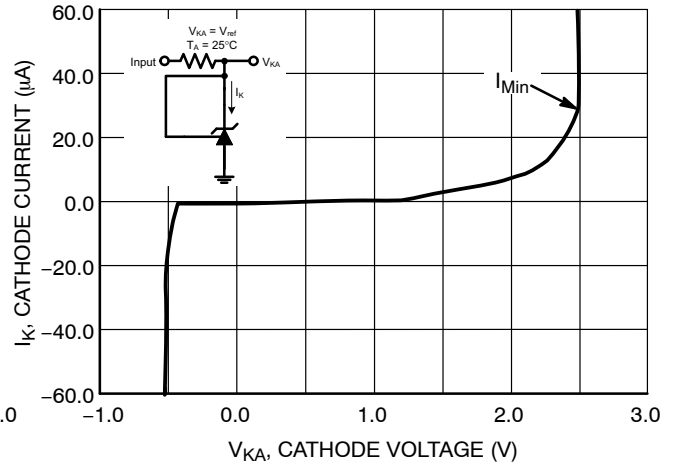


Figure 7. Cathode Current versus Cathode Voltage



Figure 8. Minimum Cathode Current Regulation versus Ambient Temperature

# NCP431A, SC431A, NCP431B, NCP432B Series



**Figure 9. Reference Input Voltage versus Ambient temperature**



**Figure 10. Reference Input Current versus Ambient temperature**



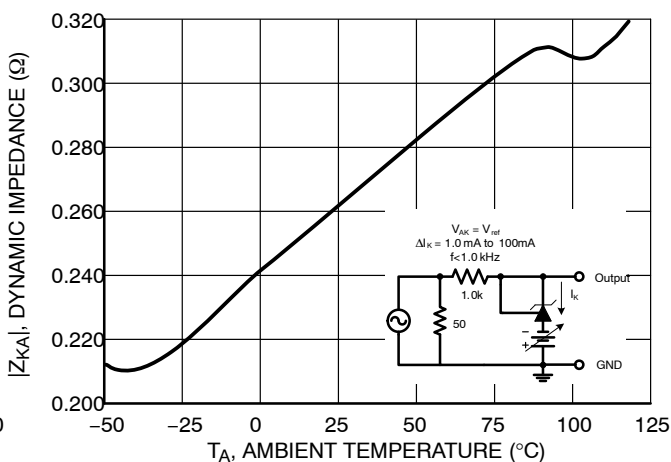
**Figure 11. Change in Reference Input Voltage versus Cathode Voltage**



**Figure 12. Off-State Cathode Current versus Ambient Temperature**



**Figure 13. Dynamic Impedance versus Frequency**



**Figure 14. Dynamic Impedance versus Ambient Temperature**

# NCP431A, SC431A, NCP431B, NCP432B Series



Figure 15. Open-Loop Voltage Gain versus Frequency



Figure 16. Spectral Noise Density

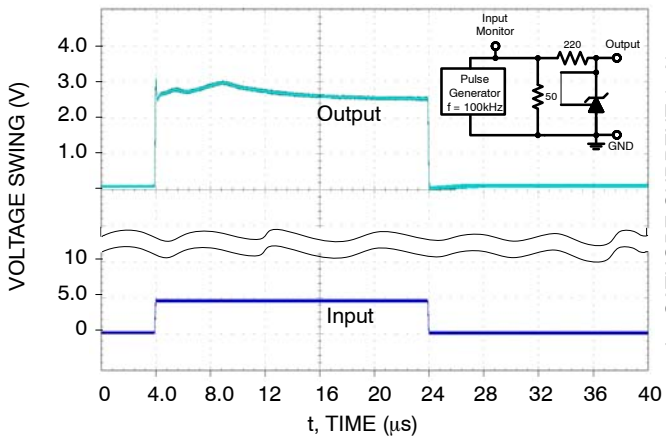


Figure 17. Pulse Response

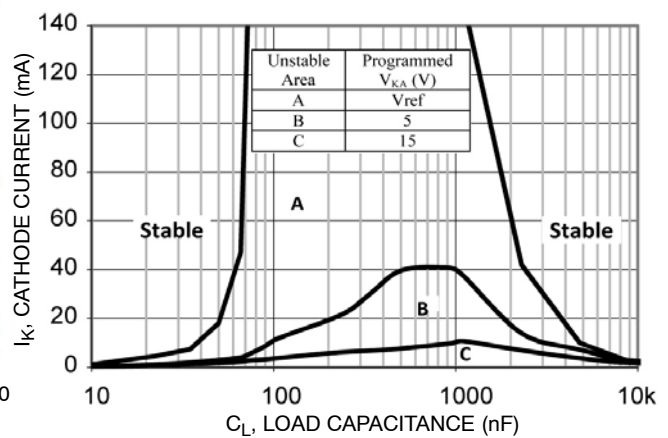


Figure 18. Stability Boundary Conditions



Figure 19. Stability Boundary Conditions for Small Cathode Current

## NCP431A, SC431A, NCP431B, NCP432B Series



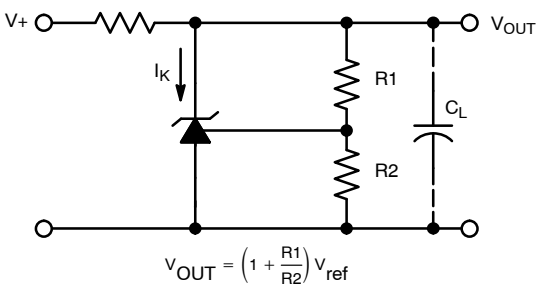
Figure 20. Test Circuit For Curve A of Stability Boundary Conditions



Figure 21. Test Circuit For Curve B And C of Stability Boundary Conditions

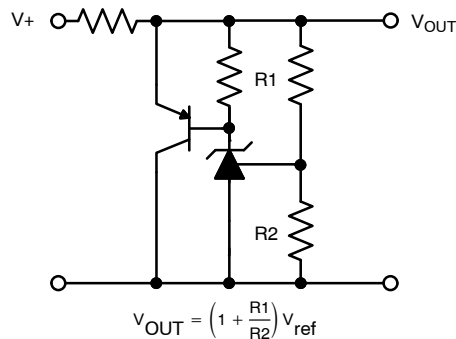


TYPICAL APPLICATIONS



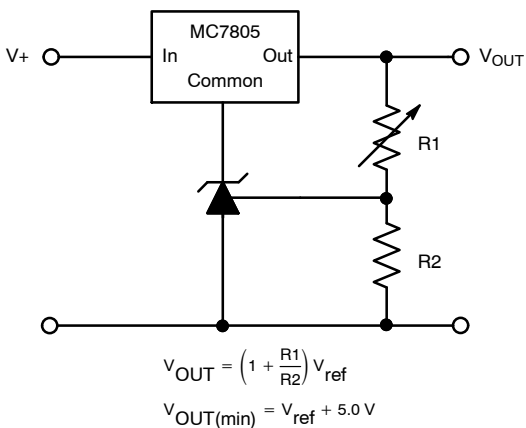
$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

Figure 22. Shunt Regulator



$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

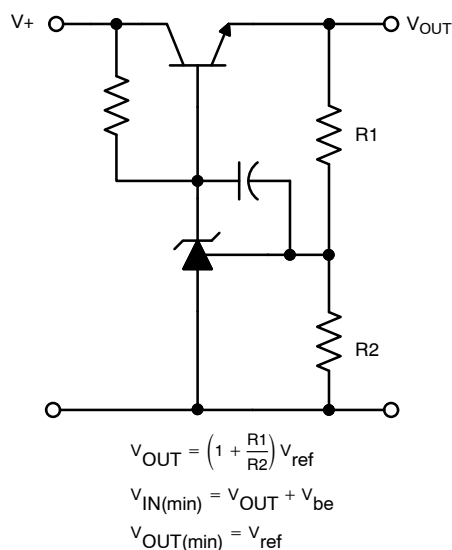
Figure 23. High Current Shunt Regulator



$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

$$V_{OUT(min)} = V_{ref} + 5.0V$$

Figure 24. Output Control for a Tree-Terminal Fixed Regulator

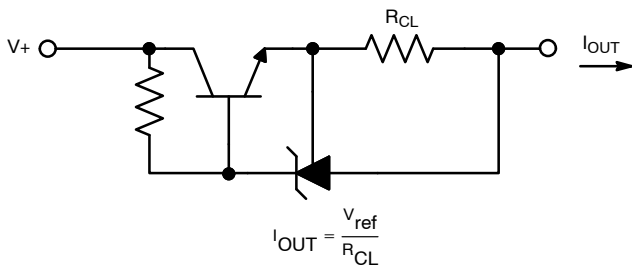


$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

$$V_{IN(min)} = V_{OUT} + V_{be}$$

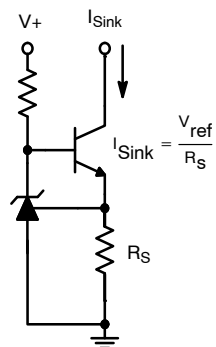
$$V_{OUT(min)} = V_{ref}$$

Figure 25. Series Pass Regulator



$$I_{OUT} = \frac{V_{ref}}{R_{CL}}$$

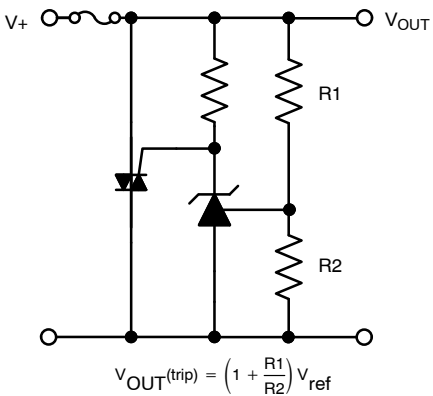
Figure 26. Constant Current Source



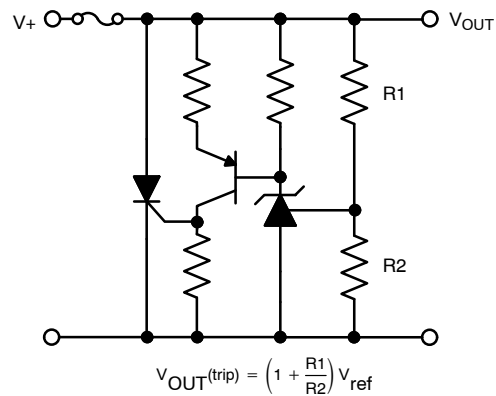
$$I_{Sink} = \frac{V_{ref}}{R_S}$$

Figure 27. Constant Current Sink

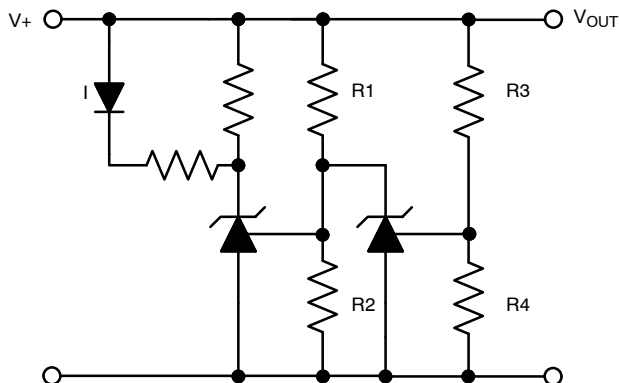
# NCP431A, SC431A, NCP431B, NCP432B Series



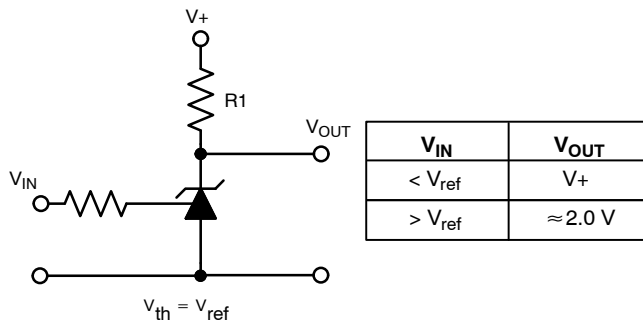
**Figure 28. Triac Crowbar**



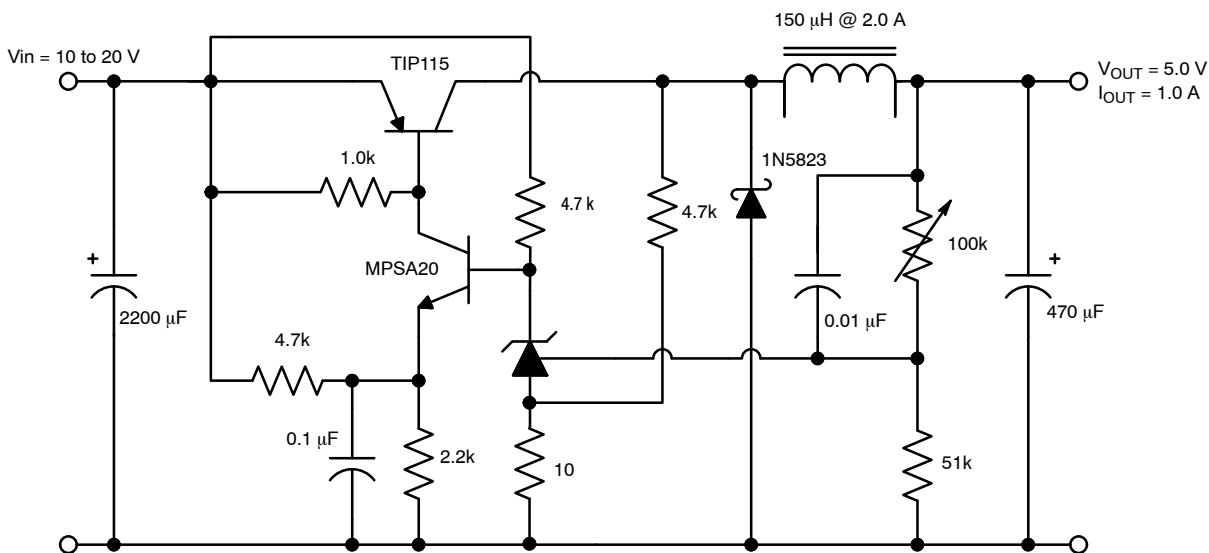
**Figure 29. SRC Crowbar**



**Figure 30. Voltage Monitoring**



**Figure 31. Single-Supply Comparator with Temperature-Compensated Threshold**



**Figure 32. Step-Down Switching Converter**

APPLICATIONS INFORMATION

The NCP431/NCP432 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 18. 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 NCP431/NCP432 is shown in Figure 33. When tested for stability boundaries, the load resistance is 150 Ω. The model reference input consists of an input transistor and a dc emitter resistance connected to the device anode. A dependent current source, G<sub>m</sub>, 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<sub>m</sub> flows through compensation capacitance, CP2. The voltage across CP2 drives the output dependent current source, Go, 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<sub>C</sub> is the device cathode current and G<sub>m</sub> 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 ±20% for resistors, ±10% for capacitors, and ±40% for transconductances.

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

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

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

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

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 NCP431 is:

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

Example 1:

I<sub>C</sub>=10 mA, R<sub>L</sub>= 230 Ω, C<sub>L</sub>= 0. Define the transfer gain.

The DC gain is:

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

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

The resulting transfer function Bode plot is shown in Figure 34. 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°. This model matches the Open-Loop Bode Plot of Figure 15. The total loop would have a unity gain frequency of about 300 kHz with a phase margin of about 44°.

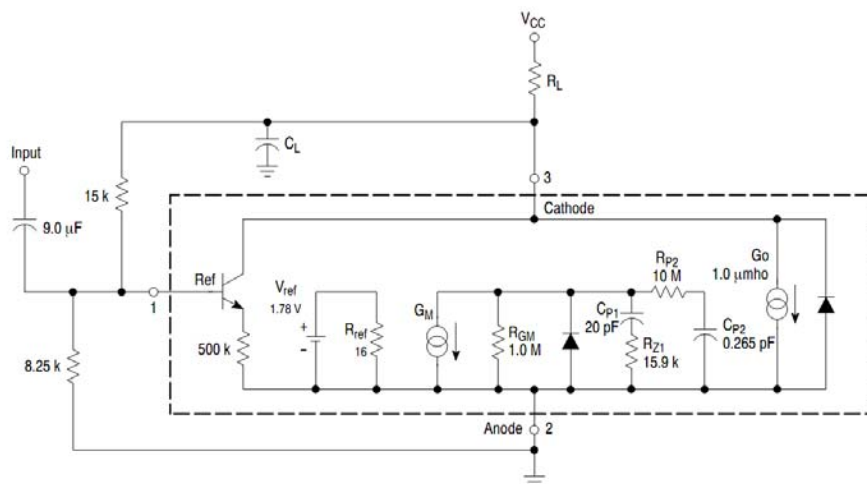


Figure 33. Simplified NCP431/NCP432 Device Model

**NCP431/NCP432 OPEN-LOOP VOLTAGE GAIN VERSUS FREQUENCY**

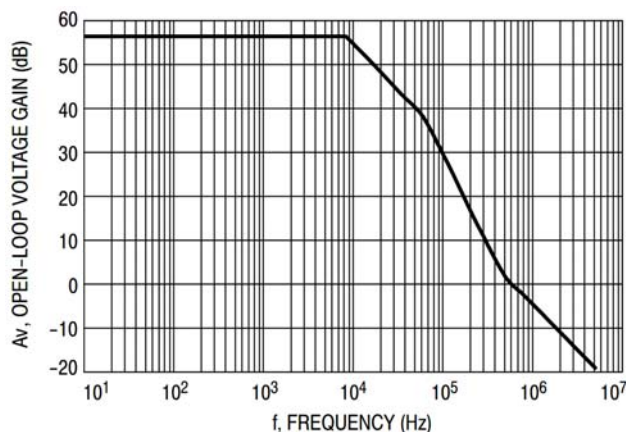


Figure 34. Example 1 Circuit Open Loop Gain Plot

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 18) shows that this value of load capacitance and cathode current is on the boundary.

Define the transfer gain.

The DC gain is:

$$G = G_M R_{GM} G_o R_L = (2.138)(1.0\text{M})(1.25\mu)(230) = 6389 = 76 \text{ dB}$$

The resulting open loop Bode plot is shown in Figure 35. 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  $-46^\circ$ . Therefore, instability of this circuit is likely.

**NCP431/NCP432 OPEN-LOOP BODE PLOT WITH LOAD CAP**

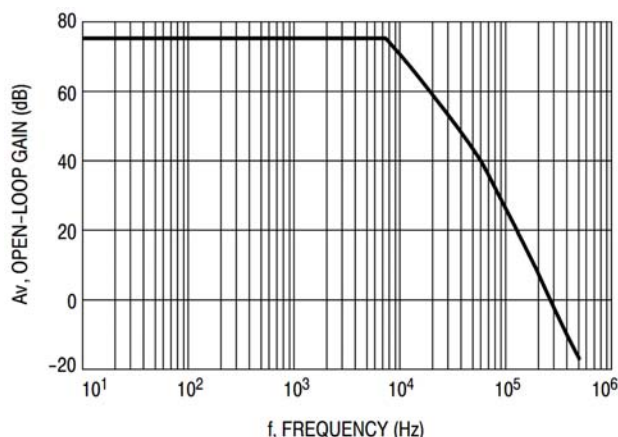


Figure 35. Example 2 Circuit Open Loop Gain Plot

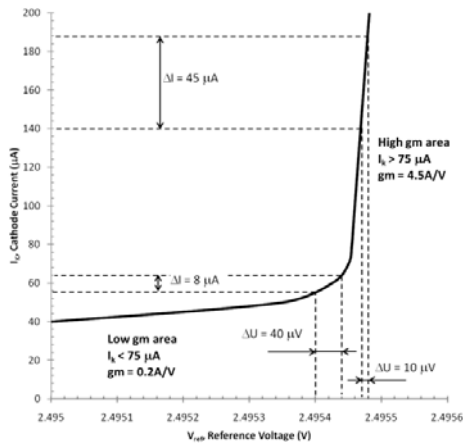
With three poles, this system is unstable. The only hope for stabilizing this circuit is to add a zero. However, that can only be done by adding a series resistance to the output capacitance, which will reduce its effectiveness as a noise filter. Therefore, practically, in reference voltage applications, 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.

The NCP431/NCP432 is often used as a regulator in secondary side of a switch mode power supply (SMPS).

The benefit of this reference is high and stable gain under low bias currents. Figure 36 shows dependence of the gain (dynamic impedance) on the bias current. Value of

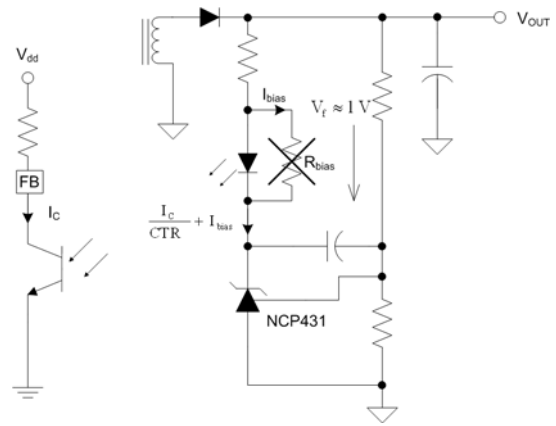
## NCP431A, SC431A, NCP431B, NCP432B Series

minimum cathode current that is needed to assure stable gain is 80  $\mu\text{A}$  maximum.



**Figure 36. Knee of Reference**

Regulator with TL431 or other references in secondary side of a SMPS needs bias resistor to increase cathode current to reach high and stable gain (refer to Figure 37). This bias resistor does not have to be used in regulator with NCP431/NCP432 thanks to its low minimum cathode current.



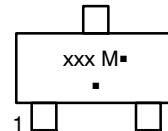
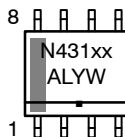
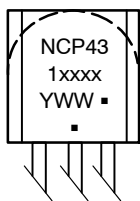
**Figure 37. SMPS Secondary Side and Feedback Connection on Primary Side**

The NCP431/NCP432 operates with very low leakage and reference input current. Sum of these currents is lower than 100 nA. Regulator with the NCP431/NCP432 minimizes parasitic power consumption.

The best way to achieve extremely low no-load consumption in SMPS applications is to use NCP431/NCP432 as regulator on the secondary side. The consumption is reduced by minimum parasitic consumption and very low bias current of NCP431/NCP432.

# NCP431A, SC431A, NCP431B, NCP432B Series

## MARKING DIAGRAMS



xx, xxx, xxx = Specific Device Code  
 A = Assembly Location  
 L = Wafer Lot  
 Y = Year  
 M = Date Code  
 W, WW = Work Week  
 ■ = Pb-Free Package

(\*Note: Microdot may be in either location)

## ORDERING INFORMATION

| Device                        | Marking | Tolerance | Operating Temperature Range | Package                  | Shipping <sup>†</sup> |
|-------------------------------|---------|-----------|-----------------------------|--------------------------|-----------------------|
| NCP431ACDR2G                  | AC      | 1%        | 0°C to 70°C                 | SOIC-8 (Pb-Free)         | 2500 / Tape & Reel    |
| NCP431ACSNT1G                 | VRF     | 1%        |                             | SOT-23-3 (Pb-Free)       | 3000 / Tape & Reel    |
| NCP431BCSNT1G                 | VRJ     | 0.5%      |                             | SOT-23-3 (Pb-Free)       | 3000 / Tape & Reel    |
| NCP432BCSNT1G                 | VRM     | 0.5%      |                             | SOT-23-3 (Pb-Free)       | 3000 / Tape & Reel    |
| NCP431ACLPRAG                 | ACLP    | 1%        |                             | TO-92 (TO-226) (Pb-Free) | 2000 / Tape & Reel    |
| NCP431AIDR2G                  | AI      | 1%        | -40°C to 85°C               | SOIC-8 (Pb-Free)         | 2500 / Tape & Reel    |
| NCP431AISNT1G                 | VRG     | 1%        |                             | SOT-23-3 (Pb-Free)       | 3000 / Tape & Reel    |
| NCP431BISNT1G                 | VRK     | 0.5%      |                             | SOT-23-3 (Pb-Free)       | 3000 / Tape & Reel    |
| NCP432BISNT1G                 | VRN     | 0.5%      |                             | SOT-23-3 (Pb-Free)       | 3000 / Tape & Reel    |
| NCP431AILPRAG                 | AILP    | 1%        |                             | TO-92 (TO-226) (Pb-Free) | 2000 / Tape & Reel    |
| NCP431AVDR2G                  | AV      | 1%        | -40°C to 125°C              | SOIC-8 (Pb-Free)         | 2500 / Tape & Reel    |
| NCP431AVSNT1G / SC431AVSNT1G* | VRH     | 1%        |                             | SOT-23-3 (Pb-Free)       | 3000 / Tape & Reel    |
| NCP431AVLPRAG                 | AVLP    | 1%        |                             | TO-92 (TO-226) (Pb-Free) | 2000 / Tape & Reel    |
| NCP431AVLPG                   | AVLP    | 1%        |                             | TO-92 (TO-226) (Pb-Free) | 2000 Units / Bag      |
| NCP431BVSNT1G                 | VRL     | 0.5%      |                             | SOT-23-3 (Pb-Free)       | 3000 / Tape & Reel    |
| NCP432BVSNT1G                 | VRP     | 0.5%      |                             | SOT-23-3 (Pb-Free)       | 3000 / Tape & Reel    |

<sup>†</sup>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.

\*SC Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable.

# NCP431A, SC431A, NCP431B, NCP432B Series

## PACKAGE DIMENSIONS

TO-92 (TO-226)  
CASE 29-11  
ISSUE AN



STRAIGHT LEAD

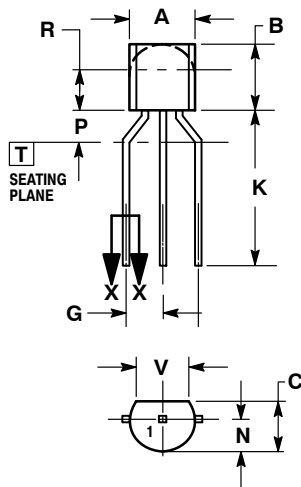


SECTION X-X

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        | ---   |



BENT LEAD



SECTION X-X

NOTES:

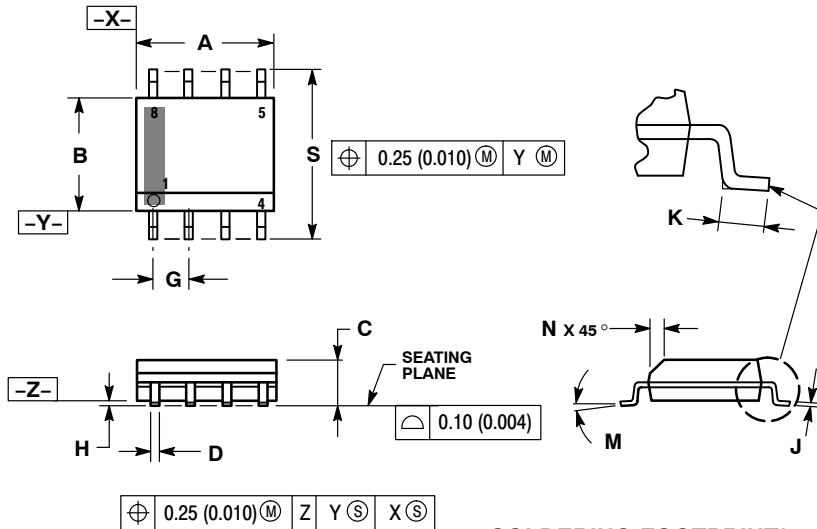
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2. CONTROLLING DIMENSION: MILLIMETERS.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

| DIM | MILLIMETERS |      |
|-----|-------------|------|
|     | MIN         | MAX  |
| A   | 4.45        | 5.20 |
| B   | 4.32        | 5.33 |
| C   | 3.18        | 4.19 |
| D   | 0.40        | 0.54 |
| G   | 2.40        | 2.80 |
| J   | 0.39        | 0.50 |
| K   | 12.70       | ---  |
| N   | 2.04        | 2.66 |
| P   | 1.50        | 4.00 |
| R   | 2.93        | ---  |
| V   | 3.43        | ---  |

# NCP431A, SC431A, NCP431B, NCP432B Series

## PACKAGE DIMENSIONS

SOIC-8 NB  
CASE 751-07  
ISSUE AK

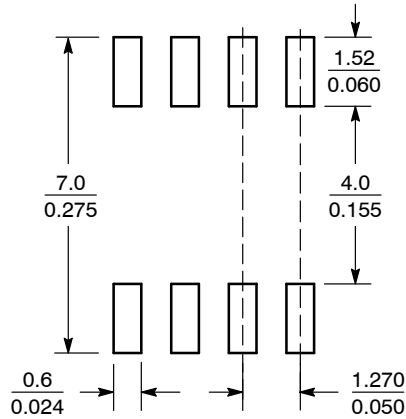


NOTES:

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 |
| G   | 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 |

### SOLDERING FOOTPRINT\*



SCALE 6:1  $\left(\frac{\text{mm}}{\text{inches}}\right)$

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



# NCP431A, SC431A, NCP431B, NCP432B Series

## PACKAGE DIMENSIONS

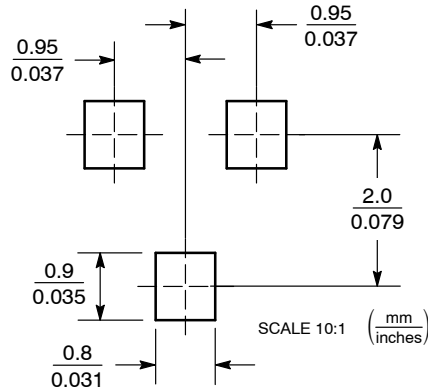
SOT-23 (TO-236)  
CASE 318-08  
ISSUE AP




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  3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
  4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

| DIM   | MILLIMETERS |      |      | INCHES |       |       |
|-------|-------------|------|------|--------|-------|-------|
|       | MIN         | NOM  | MAX  | MIN    | NOM   | MAX   |
| A     | 0.89        | 1.00 | 1.11 | 0.035  | 0.040 | 0.044 |
| A1    | 0.01        | 0.06 | 0.10 | 0.001  | 0.002 | 0.004 |
| b     | 0.37        | 0.44 | 0.50 | 0.015  | 0.018 | 0.020 |
| c     | 0.09        | 0.13 | 0.18 | 0.003  | 0.005 | 0.007 |
| D     | 2.80        | 2.90 | 3.04 | 0.110  | 0.114 | 0.120 |
| E     | 1.20        | 1.30 | 1.40 | 0.047  | 0.051 | 0.055 |
| e     | 1.78        | 1.90 | 2.04 | 0.070  | 0.075 | 0.081 |
| L     | 0.10        | 0.20 | 0.30 | 0.004  | 0.008 | 0.012 |
| L1    | 0.35        | 0.54 | 0.69 | 0.014  | 0.021 | 0.029 |
| HE    | 2.10        | 2.40 | 2.64 | 0.083  | 0.094 | 0.104 |
| theta | 0°          | ---  | 10°  | 0°     | ---   | 10°   |

### SOLDERING FOOTPRINT\*



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

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