

# NCV8502 Series

## Micropower 150 mA LDO Linear Regulators with DELAY, Adjustable RESET, and Monitor FLAG

The NCV8502 is a family of precision micropower voltage regulators. Their output current capability is 150 mA. The family has output voltage options for adjustable, 2.5 V, 3.3 V, 5.0 V, 8.0 V, and 10 V.

The output voltage is accurate within  $\pm 2.0\%$  with a maximum dropout voltage of 0.6 V at 150 mA. Low quiescent current is a feature drawing only 90  $\mu\text{A}$  with a 100  $\mu\text{A}$  load. This part is ideal for any and all battery operated microprocessor equipment.

Microprocessor control logic includes an active  $\overline{\text{RESET}}$  (with DELAY), and a FLAG monitor which can be used to provide an early warning signal to the microprocessor of a potential impending  $\overline{\text{RESET}}$  signal. The use of the FLAG monitor allows the microprocessor to finish any signal processing before the  $\overline{\text{RESET}}$  shuts the microprocessor down.

The active  $\overline{\text{RESET}}$  circuit operates correctly at an output voltage as low as 1.0 V. The  $\overline{\text{RESET}}$  function is activated during the power up sequence or during normal operation if the output voltage drops outside the regulation limits.

The reset threshold voltage can be decreased by the connection of external resistor divider to  $R_{\text{ADJ}}$  lead.

The regulator is protected against reverse battery, short circuit, and thermal overload conditions. The device can withstand load dump transients making it suitable for use in automotive environments. The device has also been optimized for EMC conditions.

### Features

- Output Voltage Options: Adjustable, 2.5 V, 3.3 V, 5.0 V, 8.0 V, 10 V
- $\pm 2.0\%$  Output
- Low 90  $\mu\text{A}$  Quiescent Current
- Fixed or Adjustable Output Voltage
- Active  $\overline{\text{RESET}}$
- Adjustable Reset
- 150 mA Output Current Capability
- Fault Protection
  - ♦ +60 V Peak Transient Voltage
  - ♦ -15 V Reverse Voltage
  - ♦ Short Circuit
  - ♦ Thermal Overload
- Early Warning through  $\overline{\text{FLAG}}$ /MON Leads
- NCV Prefix for Automotive and Other Applications Requiring Site and Change Control
- Pb-Free Packages are Available

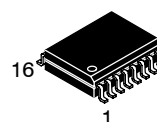


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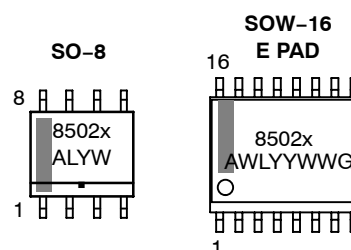


SO-8  
D SUFFIX  
CASE 751



SOIC 16 LEAD  
WIDE BODY  
EXPOSED PAD  
PDW SUFFIX  
CASE 751AG

### MARKING DIAGRAMS



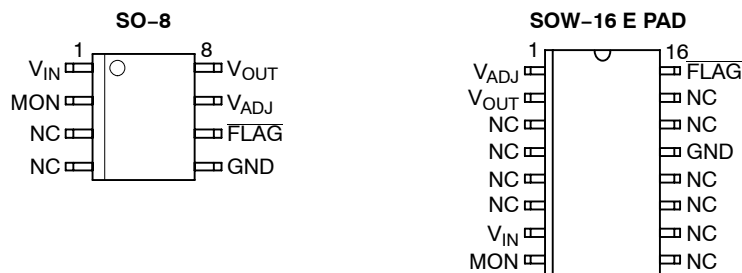
x = Voltage Ratings as Indicated Below:  
A = Adjustable  
2 = 2.5 V  
3 = 3.3 V  
5 = 5.0 V  
8 = 8.0 V  
0 = 10 V  
A = Assembly Location  
WL, L = Wafer Lot  
YY, Y = Year  
WW, W = Work Week  
G or ■ = Pb-Free Device

### ORDERING INFORMATION

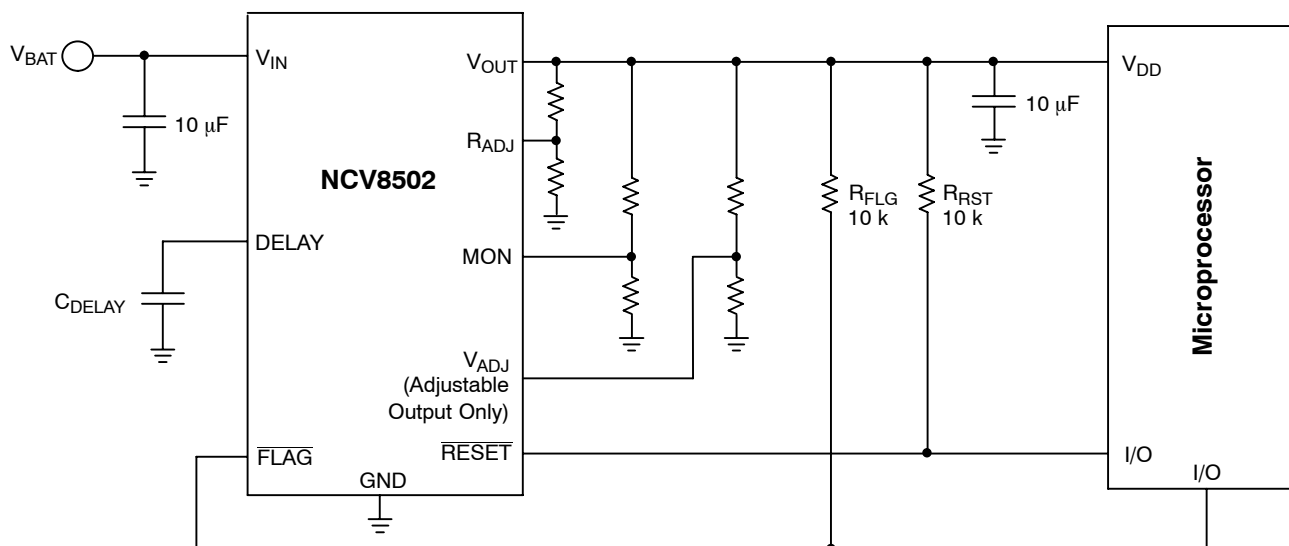
See detailed ordering and shipping information in the package dimensions section on page 12 of this data sheet.

## NCV8502 Series

## PIN CONNECTIONS, ADJUSTABLE OUTPUT



## PIN CONNECTIONS, FIXED OUTPUT



### Figure 1. Application Diagram

**MAXIMUM RATINGS\***

| Rating                                                           | Value      | Unit |
|------------------------------------------------------------------|------------|------|
| V <sub>IN</sub> (dc)                                             | –15 to 45  | V    |
| Peak Transient Voltage (46 V Load Dump @ V <sub>IN</sub> = 14 V) | 60         | V    |
| Operating Voltage                                                | 45         | V    |
| V <sub>OUT</sub> (dc)                                            | –0.3 to 16 | V    |
| Voltage Range (RESET, FLAG)                                      | –0.3 to 10 | 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.

\*During the voltage range which exceeds the maximum tested voltage of  $V_{IN}$ , operation is assured, but not specified. Wider limits may apply. Thermal dissipation must be observed closely.

# NCV8502 Series

## MAXIMUM RATINGS\* (continued)

| Rating                                                                                                                                                           | Value                | Unit                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------------------|
| Input Voltage Range (MON, $V_{ADJ}$ , $R_{ADJ}$ )                                                                                                                | -0.3 to 10           | V                    |
| ESD Susceptibility (Human Body Model)                                                                                                                            | 2.0                  | kV                   |
| Junction Temperature, $T_J$                                                                                                                                      | -40 to +150          | °C                   |
| Storage Temperature, $T_S$                                                                                                                                       | -55 to 150           | °C                   |
| Package Thermal Resistance, SO-8: Junction-to-Case, $R_{\theta JC}$<br>Junction-to-Ambient, $R_{\theta JA}$                                                      | 45<br>165            | °C/W<br>°C/W         |
| Package Thermal Resistance, SOW-16 E PAD: Junction-to-Case, $R_{\theta JC}$<br>Junction-to-Ambient, $R_{\theta JA}$<br>Junction-to-Pin, $R_{\theta JP}$ (Note 1) | 15<br>56<br>35       | °C/W<br>°C/W<br>°C/W |
| Lead Temperature Soldering: Reflow: (SMD styles only) (Note 2)                                                                                                   | 240 peak<br>(Note 3) | °C                   |

1. Measured to pin 16.

2. 60 second maximum above 183°C.

3. -5°C / +0°C allowable conditions.

\*During the voltage range which exceeds the maximum tested voltage of  $V_{IN}$ , operation is assured, but not specified. Wider limits may apply. Thermal dissipation must be observed closely.

**ELECTRICAL CHARACTERISTICS** ( $I_{OUT} = 1.0$  mA,  $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ ;  $V_{IN}$  = dependent on voltage option (Note 4); unless otherwise specified.)

| Characteristic                                                                                                                  | Test Conditions                                                                                                                                                                                                              | Min                        | Typ                                | Max                                   | Unit                                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|------------------------------------|---------------------------------------|----------------------------------------------------------------------------------------------------|
| <b>Output Stage</b>                                                                                                             |                                                                                                                                                                                                                              |                            |                                    |                                       |                                                                                                    |
| Output Voltage for 2.5 V Option                                                                                                 | $6.5\text{ V} < V_{IN} < 16\text{ V}$ , $100\text{ }\mu\text{A} \leq I_{OUT} \leq 150\text{ mA}$<br><b><math>5.5\text{ V} &lt; V_{IN} &lt; 26\text{ V}</math></b> , $100\text{ }\mu\text{A} \leq I_{OUT} \leq 150\text{ mA}$ | 2.450<br>2.425             | 2.5<br>2.5                         | 2.550<br>2.575                        | V<br>V                                                                                             |
| Output Voltage for 3.3 V Option                                                                                                 | $7.3\text{ V} < V_{IN} < 16\text{ V}$ , $100\text{ }\mu\text{A} \leq I_{OUT} \leq 150\text{ mA}$<br><b><math>5.5\text{ V} &lt; V_{IN} &lt; 26\text{ V}</math></b> , $100\text{ }\mu\text{A} \leq I_{OUT} \leq 150\text{ mA}$ | 3.234<br>3.201             | 3.3<br>3.3                         | 3.366<br>3.399                        | V<br>V                                                                                             |
| Output Voltage for 5.0 V Option                                                                                                 | $9.0\text{ V} < V_{IN} < 16\text{ V}$ , $100\text{ }\mu\text{A} \leq I_{OUT} \leq 150\text{ mA}$<br><b><math>6.0\text{ V} &lt; V_{IN} &lt; 26\text{ V}</math></b> , $100\text{ }\mu\text{A} \leq I_{OUT} \leq 150\text{ mA}$ | 4.90<br>4.85               | 5.0<br>5.0                         | 5.10<br>5.15                          | V<br>V                                                                                             |
| Output Voltage for 8.0 V Option                                                                                                 | <b><math>9.0\text{ V} &lt; V_{IN} &lt; 26\text{ V}</math></b> , $100\text{ }\mu\text{A} \leq I_{OUT} \leq 150\text{ mA}$                                                                                                     | 7.76                       | 8.0                                | 8.24                                  | V                                                                                                  |
| Output Voltage for 10 V Option                                                                                                  | <b><math>11\text{ V} &lt; V_{IN} &lt; 26\text{ V}</math></b> , $100\text{ }\mu\text{A} \leq I_{OUT} \leq 150\text{ mA}$                                                                                                      | 9.7                        | 10                                 | 10.3                                  | V<br>V                                                                                             |
| Output Voltage for Adjustable Option                                                                                            | $V_{OUT} = V_{ADJ}$ (Unity Gain)<br>$6.5\text{ V} < V_{IN} < 16\text{ V}$ , $100\text{ }\mu\text{A} < I_{OUT} < 150\text{ mA}$<br>$5.5\text{ V} < V_{IN} < 26\text{ V}$ , $100\text{ }\mu\text{A} < I_{OUT} < 150\text{ mA}$ | 1.254<br>1.242             | 1.280<br>1.280                     | 1.306<br>1.318                        | V<br>V                                                                                             |
| Dropout Voltage ( $V_{IN} - V_{OUT}$ )<br>(5.0 V, 8.0 V, 10 V and<br>Adj. > 5.0 V Options Only)                                 | $I_{OUT} = 150\text{ mA}$<br>$I_{OUT} = 1.0\text{ mA}$                                                                                                                                                                       | -<br>-                     | 400<br>100                         | 600<br>150                            | mV<br>mV                                                                                           |
| Load Regulation                                                                                                                 | $V_{IN} = 14\text{ V}$ , $5.0\text{ mA} \leq I_{OUT} \leq 150\text{ mA}$                                                                                                                                                     | -30                        | 5.0                                | 30                                    | mV                                                                                                 |
| Line Regulation                                                                                                                 | $[V_{OUT}(\text{Typ}) + 1.0] < V_{IN} < 26\text{ V}$ , $I_{OUT} = 1.0\text{ mA}$                                                                                                                                             | -                          | 15                                 | 60                                    | mV                                                                                                 |
| Quiescent Current, Low Load<br>2.5 V Option<br>3.3 V Option<br>5.0 V Option<br>8.0 V Option<br>10 V Option<br>Adjustable Option | $I_{OUT} = 100\text{ }\mu\text{A}$ , $V_{IN} = 12\text{ V}$ , $\text{MON} = V_{OUT}$                                                                                                                                         | -<br>-<br>-<br>-<br>-<br>- | 90<br>90<br>90<br>100<br>100<br>50 | 125<br>125<br>125<br>150<br>150<br>75 | $\mu\text{A}$<br>$\mu\text{A}$<br>$\mu\text{A}$<br>$\mu\text{A}$<br>$\mu\text{A}$<br>$\mu\text{A}$ |
| Quiescent Current, Medium Load<br>All Options                                                                                   | $I_{OUT} = 75\text{ mA}$ , $V_{IN} = 14\text{ V}$ , $\text{MON} = V_{OUT}$                                                                                                                                                   | -                          | 4.0                                | 6.0                                   | mA                                                                                                 |
| Quiescent Current, High Load<br>All Options                                                                                     | $I_{OUT} = 150\text{ mA}$ , $V_{IN} = 14\text{ V}$ , $\text{MON} = V_{OUT}$                                                                                                                                                  | -                          | 12                                 | 19                                    | mA                                                                                                 |
| Current Limit                                                                                                                   | -                                                                                                                                                                                                                            | 151                        | 300                                | -                                     | mA                                                                                                 |

4. Voltage range specified in Output Stage of the Electrical Characteristics in boldface type.

## NCV8502 Series

**ELECTRICAL CHARACTERISTICS (continued)** ( $I_{OUT} = 1.0 \text{ mA}$ ;  $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ ;  $V_{IN}$  = dependent on voltage option (Note 5); unless otherwise specified.)

| Characteristic | Test Conditions | Min | Typ | Max | Unit |
|----------------|-----------------|-----|-----|-----|------|
|----------------|-----------------|-----|-----|-----|------|

### Output Stage

|                              |                         |     |     |   |                    |
|------------------------------|-------------------------|-----|-----|---|--------------------|
| Short Circuit Output Current | $V_{OUT} = 0 \text{ V}$ | 40  | 190 | – | mA                 |
| Thermal Shutdown             | (Guaranteed by Design)  | 150 | 180 | – | $^{\circ}\text{C}$ |

### Reset Function (RESET)

|                                                                           |                                                                                                        |      |       |                       |               |
|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|------|-------|-----------------------|---------------|
| RESET Threshold for 2.5 V Option<br>HIGH ( $V_{RH}$ )<br>LOW ( $V_{RL}$ ) | $5.5 \text{ V} \leq V_{IN} \leq 26 \text{ V}$ (Note 6)<br>$V_{OUT}$ Increasing<br>$V_{OUT}$ Decreasing | 2.28 | 2.350 | $0.98 \times V_{OUT}$ | V             |
|                                                                           |                                                                                                        | 2.25 | 2.300 | $0.97 \times V_{OUT}$ | V             |
| RESET Threshold for 3.3 V Option<br>HIGH ( $V_{RH}$ )<br>LOW ( $V_{RL}$ ) | $5.5 \text{ V} \leq V_{IN} \leq 26 \text{ V}$ (Note 6)<br>$V_{OUT}$ Increasing<br>$V_{OUT}$ Decreasing | 3.00 | 3.102 | $0.98 \times V_{OUT}$ | V             |
|                                                                           |                                                                                                        | 2.97 | 3.036 | $0.97 \times V_{OUT}$ | V             |
| RESET Threshold for 5.0 V Option<br>HIGH ( $V_{RH}$ )<br>LOW ( $V_{RL}$ ) | $V_{OUT}$ Increasing<br>$V_{OUT}$ Decreasing                                                           | 4.55 | 4.70  | $0.98 \times V_{OUT}$ | V             |
|                                                                           |                                                                                                        | 4.50 | 4.60  | $0.97 \times V_{OUT}$ | V             |
| RESET Threshold for 8.0 V Option<br>HIGH ( $V_{RH}$ )<br>LOW ( $V_{RL}$ ) | $V_{OUT}$ Increasing<br>$V_{OUT}$ Decreasing                                                           | 7.05 | 7.52  | $0.98 \times V_{OUT}$ | V             |
|                                                                           |                                                                                                        | 7.00 | 7.36  | $0.97 \times V_{OUT}$ | V             |
| RESET Threshold for 10 V Option<br>HIGH ( $V_{RH}$ )<br>LOW ( $V_{RL}$ )  | $V_{OUT}$ Increasing<br>$V_{OUT}$ Decreasing                                                           | 8.60 | 9.40  | $0.98 \times V_{OUT}$ | V             |
|                                                                           |                                                                                                        | 8.50 | 9.20  | $0.97 \times V_{OUT}$ | V             |
| Output Voltage Low ( $V_{RLO}$ )                                          | $1.0 \text{ V} \leq V_{OUT} \leq V_{RL}$ , $R_{RESET} = 10 \text{ k}$                                  | –    | 0.1   | 0.4                   | V             |
| DELAY Switching Threshold ( $V_{DT}$ )                                    | –                                                                                                      | 1.4  | 1.8   | 2.2                   | V             |
| DELAY Low Voltage                                                         | $V_{OUT} < \text{RESET Threshold Low(min)}$                                                            | –    | –     | 0.1                   | V             |
| DELAY Charge Current                                                      | DELAY = 1.0 V, $V_{OUT} > V_{RH}$                                                                      | 1.5  | 2.5   | 3.5                   | $\mu\text{A}$ |
| DELAY Discharge Current                                                   | DELAY = 1.0 V, $V_{OUT} = 1.5 \text{ V}$                                                               | 5.0  | –     | –                     | mA            |
| Reset Adjust Switching Voltage ( $V_{R(ADJ)}$ )                           | –                                                                                                      | 1.23 | 1.31  | 1.39                  | V             |

### FLAG/Monitor

|                           |                                        |      |      |      |               |
|---------------------------|----------------------------------------|------|------|------|---------------|
| Monitor Threshold         | Increasing and Decreasing              | 1.10 | 1.20 | 1.31 | V             |
| Hysteresis                | –                                      | 20   | 50   | 100  | mV            |
| Input Current             | MON = 2.0 V                            | –0.5 | 0.1  | 0.5  | $\mu\text{A}$ |
| Output Saturation Voltage | MON = 0 V, $I_{FLAG} = 1.0 \text{ mA}$ | –    | 0.1  | 0.4  | V             |

### Voltage Adjust (Adjustable Output only)

|               |                            |      |   |     |               |
|---------------|----------------------------|------|---|-----|---------------|
| Input Current | $V_{ADJ} = 1.28 \text{ V}$ | –0.5 | – | 0.5 | $\mu\text{A}$ |
|---------------|----------------------------|------|---|-----|---------------|

5. Voltage range specified in Output Stage of the Electrical Characteristics in boldface type.

6. For  $V_{IN} \leq 5.5 \text{ V}$ , a RESET = Low may occur with the output in regulation.

## NCV8502 Series

### PACKAGE PIN DESCRIPTION, ADJUSTABLE OUTPUT

| Package Pin Number |                      | Pin Symbol       | Function                                                                                       |
|--------------------|----------------------|------------------|------------------------------------------------------------------------------------------------|
| SO-8               | SOW-16<br>E PAD      |                  |                                                                                                |
| 1                  | 7                    | V <sub>IN</sub>  | Input Voltage.                                                                                 |
| 2                  | 8                    | MON              | Monitor. Input for early warning comparator. If not needed connect to V <sub>OUT</sub> .       |
| 3, 4               | 3-6, 9-12,<br>14, 15 | NC               | No connection.                                                                                 |
| 5                  | 13                   | GND              | Ground. All GND leads must be connected to Ground.                                             |
| 6                  | 16                   | FLAG             | Open collector output from early warning comparator.                                           |
| 7                  | 1                    | V <sub>ADJ</sub> | Voltage Adjust. A resistor divider from V <sub>OUT</sub> to this lead sets the output voltage. |
| 8                  | 2                    | V <sub>OUT</sub> | ±2.0%, 150 mA output.                                                                          |

### PACKAGE PIN DESCRIPTION, FIXED OUTPUT

| Package Pin Number |                        | Pin Symbol       | Function                                                                                 |
|--------------------|------------------------|------------------|------------------------------------------------------------------------------------------|
| SO-8               | SOW-16<br>E PAD        |                  |                                                                                          |
| 1                  | 7                      | V <sub>IN</sub>  | Input Voltage.                                                                           |
| 2                  | 8                      | MON              | Monitor. Input for early warning comparator. If not needed connect to V <sub>OUT</sub> . |
| 3                  | 9                      | R <sub>ADJ</sub> | Reset Adjust. If not needed connect to ground.                                           |
| 4                  | 10                     | DELAY            | Timing capacitor for RESET function.                                                     |
| 5                  | 13                     | GND              | Ground. All GND leads must be connected to Ground.                                       |
| 6                  | 16                     | RESET            | Active reset (accurate to V <sub>OUT</sub> ≥ 1.0 V)                                      |
| 7                  | 1                      | FLAG             | Open collector output from early warning comparator.                                     |
| 8                  | 2                      | V <sub>OUT</sub> | ±2.0%, 150 mA output.                                                                    |
| –                  | 3-6, 11, 12,<br>14, 15 | NC               | No connection.                                                                           |

TYPICAL PERFORMANCE CHARACTERISTICS

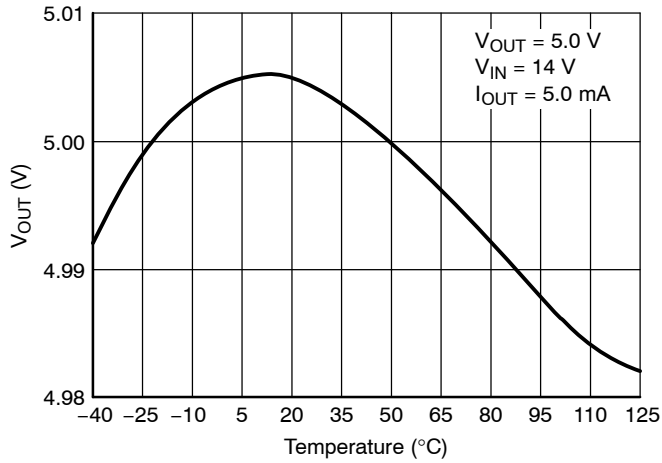


Figure 2. Output Voltage vs. Temperature

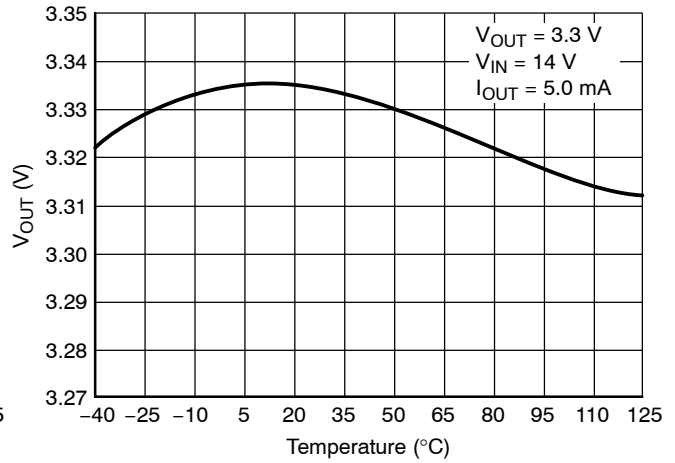


Figure 3. Output Voltage vs. Temperature

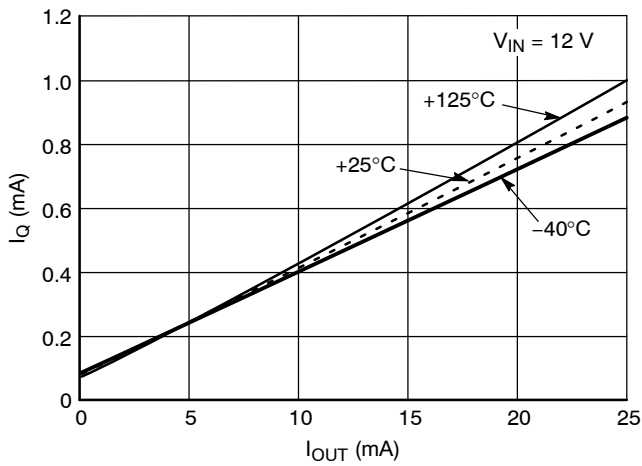


Figure 4. Quiescent Current vs. Output Current

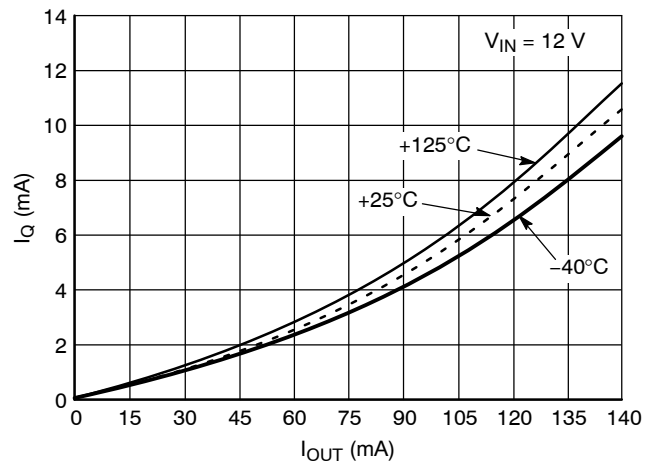


Figure 5. Quiescent Current vs. Output Current

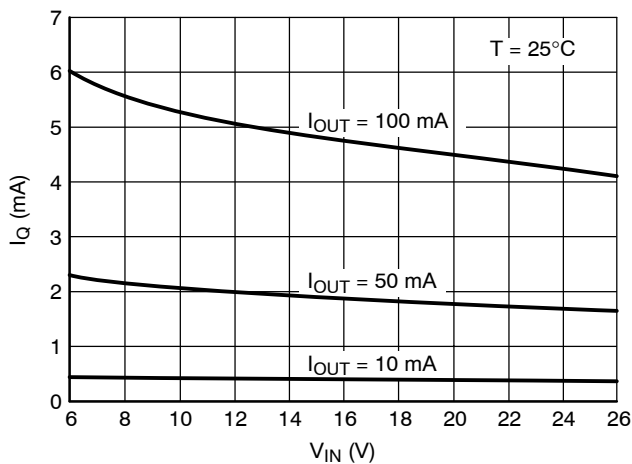


Figure 6. Quiescent Current vs. Input Voltage

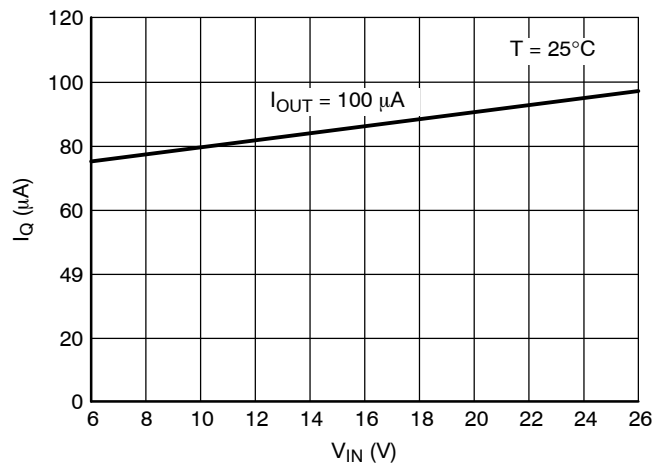


Figure 7. Quiescent Current vs. Input Voltage

TYPICAL PERFORMANCE CHARACTERISTICS

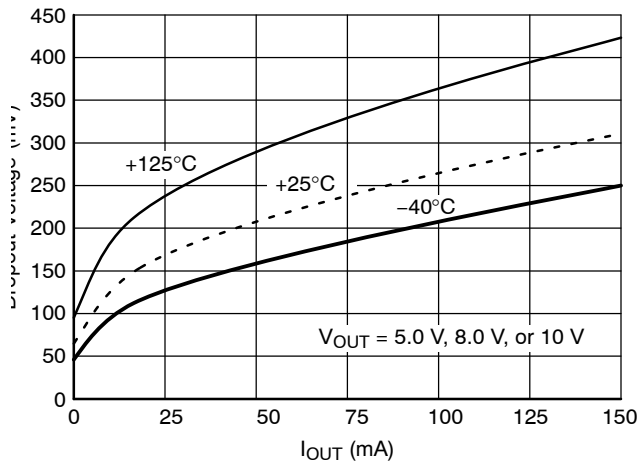


Figure 8. Dropout Voltage vs. Output Current

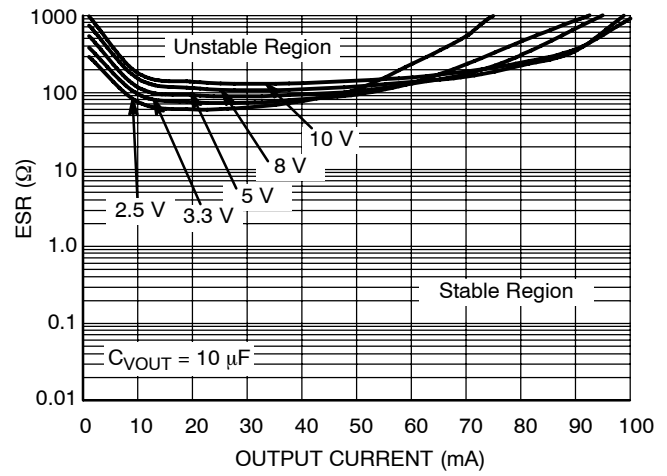


Figure 9. Output Stability with Output Voltage Change

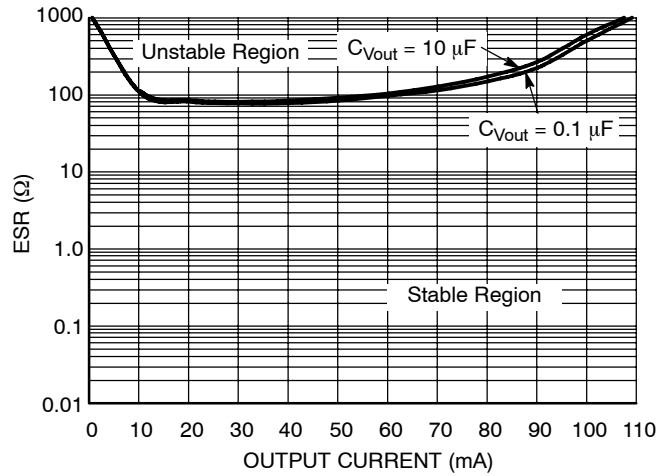


Figure 10. Output Stability with Output Capacitor Change

# NCV8502 Series

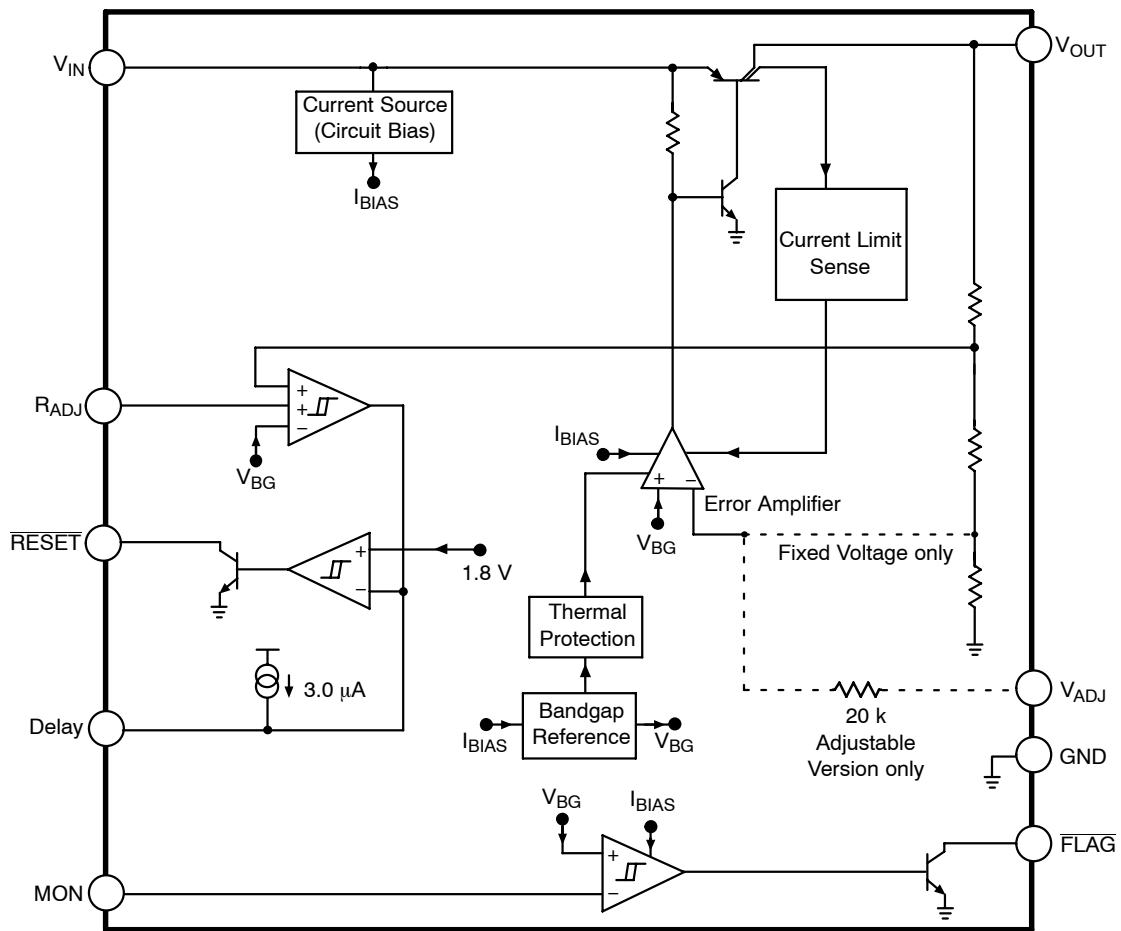


Figure 11. Block Diagram

## CIRCUIT DESCRIPTION

### REGULATOR CONTROL FUNCTIONS

The NCV8502 contains the microprocessor compatible control function  $\overline{\text{RESET}}$  (Figure 12).

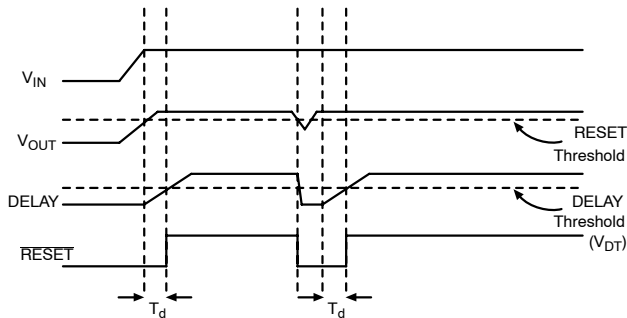


Figure 12. Reset and Delay Circuit Wave Forms

### $\overline{\text{RESET}}$ Function

A  $\overline{\text{RESET}}$  signal (low voltage) is generated as the IC powers up until  $V_{\text{OUT}}$  is within 6.0% of the regulated output voltage, or when  $V_{\text{OUT}}$  drops out of regulation, and is lower than 8.0% below the regulated output voltage. Hysteresis is included in the function to minimize oscillations.

The  $\overline{\text{RESET}}$  output is an open collector NPN transistor, controlled by a low voltage detection circuit. The circuit is functionally independent of the rest of the IC thereby guaranteeing that the  $\overline{\text{RESET}}$  signal is valid for  $V_{\text{OUT}}$  as low as 1.0 V.

### Adjustable Reset Function

The reset threshold can be made lower by connecting an external resistor divider to the  $R_{\text{ADJ}}$  lead from the  $V_{\text{OUT}}$  lead, as displayed in Figure 13. This lead is grounded to select the default value of 4.6 V.

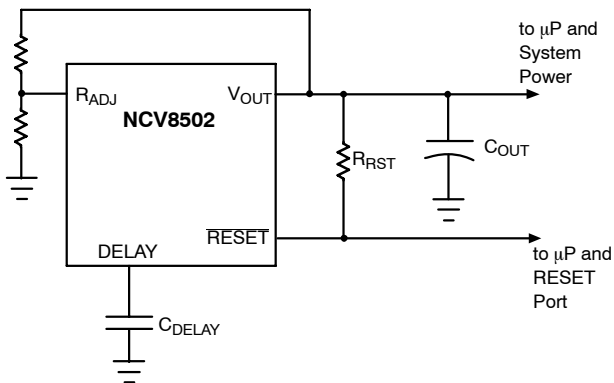


Figure 13. Adjustable  $\overline{\text{RESET}}$

### DELAY Function

The reset delay circuit provides a programmable (by external capacitor) delay on the  $\overline{\text{RESET}}$  output lead.

The DELAY lead provides source current (typically 2.5  $\mu\text{A}$ ) to the external DELAY capacitor during the following proceedings:

1. During Power Up (once the regulation threshold has been verified).
2. After a reset event has occurred and the device is back in regulation. The DELAY capacitor is discharged when the regulation ( $\overline{\text{RESET}}$  threshold) has been violated. This is a latched incident. The capacitor will fully discharge and wait for the device to regulate before going through the delay time event again.

### FLAG/Monitor Function

An on-chip comparator is provided to perform an early warning to the microprocessor of a possible reset signal. The reset signal typically turns the microprocessor off instantaneously. This can cause unpredictable results with the microprocessor. The signal received from the  $\overline{\text{FLAG}}$  pin will allow the microprocessor time to complete its present task before shutting down. This function is performed by a comparator referenced to the bandgap reference. The actual trip point can be programmed externally using a resistor divider to the input monitor (MON) (Figure 14). The typical threshold is 1.20 V on the MON pin.

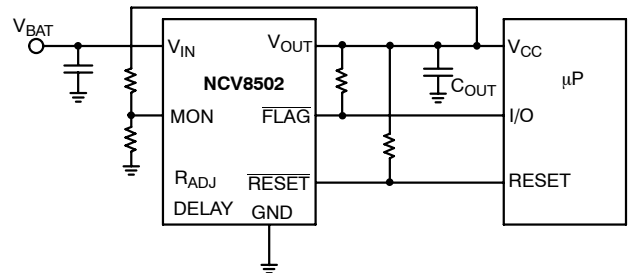


Figure 14.  $\overline{\text{FLAG}}$ /Monitor Function

### Voltage Adjust

Figure 15 shows the device setup for a user configurable output voltage. The feedback to the  $V_{\text{ADJ}}$  pin is taken from a voltage divider referenced to the output voltage. The loop is balanced around the Unity Gain threshold (1.28 V typical).

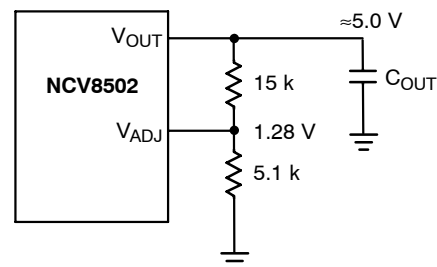


Figure 15. Adjustable Output Voltage

## APPLICATION NOTES

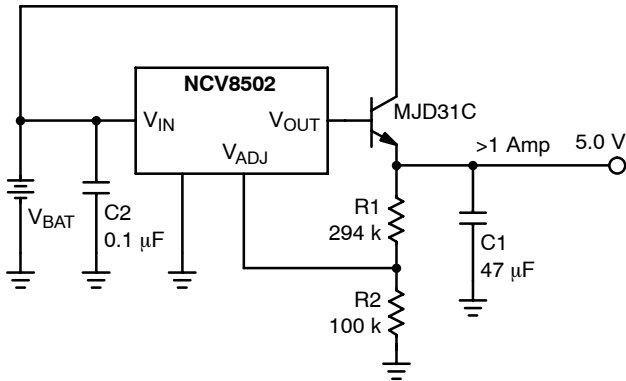


Figure 16. Additional Output Current

### Adding Capability

Figure 16 shows how the adjustable version of parts can be used with an external pass transistor for additional current capability. The setup as shown will provide greater than 1 Amp of output current.

### FLAG MONITOR

Figure 17 shows the FLAG Monitor waveforms as a result of the circuit depicted in Figure 14. As the output voltage falls ( $V_{OUT}$ ), the Monitor threshold is crossed. This causes the voltage on the  $\overline{FLAG}$  output to go low sending a warning signal to the microprocessor that a  $\overline{RESET}$  signal may occur in a short period of time.  $T_{WARNING}$  is the time the microprocessor has to complete the function it is currently working on and get ready for the  $\overline{RESET}$  shutdown signal.

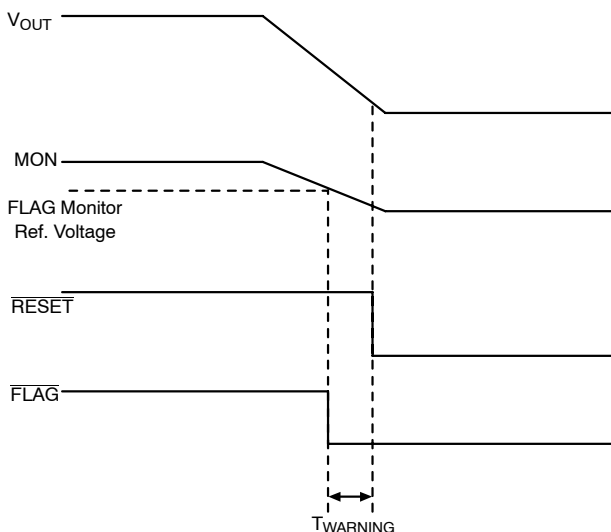
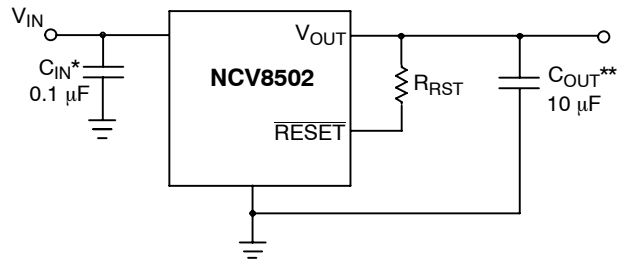


Figure 17. FLAG Monitor Circuit Waveform



\* $C_{IN}$  required if regulator is located far from the power supply filter

\*\* $C_{OUT}$  required for stability. Capacitor must operate at minimum temperature expected

Figure 18. Test and Application Circuit Showing Output Compensation

### SETTING THE DELAY TIME

The delay time is controlled by the Reset Delay Low Voltage, Delay Switching Threshold, and the Delay Charge Current. The delay follows the equation:

$$t_{DELAY} = \frac{[C_{DELAY}(V_{dt} - \text{Reset Delay Low Voltage})]}{\text{Delay Charge Current}}$$

Example:

Using  $C_{DELAY} = 33 \text{ nF}$ .

Assume reset Delay Low Voltage = 0.

Use the typical value for  $V_{dt} = 1.8 \text{ V}$ .

Use the typical value for Delay Charge Current =  $2.5 \mu\text{A}$ .

$$t_{DELAY} = \frac{[33 \text{ nF}(1.8 - 0)]}{2.5 \mu\text{A}} = 23.8 \text{ ms}$$

### STABILITY CONSIDERATIONS

The output or compensation capacitor helps determine three main characteristics of a linear regulator: start-up delay, load transient response and loop stability.

The capacitor value and type should be based on cost, availability, size and temperature constraints.

The value for the output capacitor  $C_{OUT}$  shown in Figure 18 should work for most applications, however it is not necessarily the optimized solution.

### CALCULATING POWER DISSIPATION IN A SINGLE OUTPUT LINEAR REGULATOR

The maximum power dissipation for a single output regulator (Figure 19) is:

$$P_{D(max)} = [V_{IN(max)} - V_{OUT(min)}]I_{OUT(max)} + V_{IN(max)}I_Q \quad (\text{eq. 1})$$

where:

$V_{IN(max)}$  is the maximum input voltage,

$V_{OUT(min)}$  is the minimum output voltage,

$I_{OUT(max)}$  is the maximum output current for the application, and

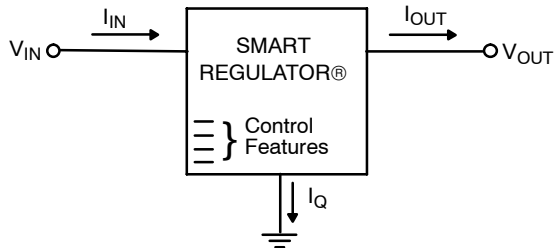
$I_Q$  is the quiescent current the regulator consumes at  $I_{OUT(max)}$ .

Once the value of  $P_{D(max)}$  is known, the maximum permissible value of  $R_{\theta JA}$  can be calculated:

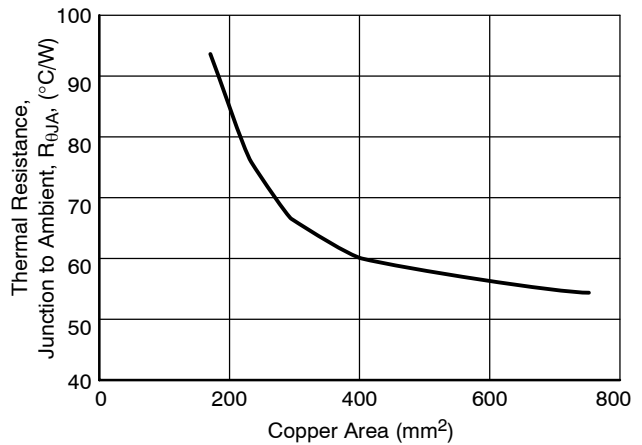
$$R_{\theta JA} = \frac{150^{\circ}\text{C} - T_A}{P_D} \quad (\text{eq. 2})$$

The value of  $R_{\theta JA}$  can then be compared with those in the package section of the data sheet. Those packages with  $R_{\theta JA}$ 's less than the calculated value in equation 2 will keep the die temperature below  $150^{\circ}\text{C}$ .

In some cases, none of the packages will be sufficient to dissipate the heat generated by the IC, and an external heatsink will be required.



**Figure 19. Single Output Regulator with Key Performance Parameters Labeled**



**Figure 20. 16 Lead SOW (Exposed Pad),  $\theta_{JA}$  as a Function of the Pad Copper Area (2 oz. Cu Thickness), Board Material = 0.0625" G-10/R-4**

### HEAT SINKS

A heat sink effectively increases the surface area of the package to improve the flow of heat away from the IC and into the surrounding air.

Each material in the heat flow path between the IC and the outside environment will have a thermal resistance. Like series electrical resistances, these resistances are summed to determine the value of  $R_{\theta JA}$ :

$$R_{\theta JA} = R_{\theta JC} + R_{\theta CS} + R_{\theta SA} \quad (\text{eq. 3})$$

where:

$R_{\theta JC}$  = the junction-to-case thermal resistance,

$R_{\theta CS}$  = the case-to-heatsink thermal resistance, and

$R_{\theta SA}$  = the heatsink-to-ambient thermal resistance.

$R_{\theta JC}$  appears in the package section of the data sheet. Like  $R_{\theta JA}$ , it too is a function of package type.  $R_{\theta CS}$  and  $R_{\theta SA}$  are functions of the package type, heatsink and the interface between them. These values appear in heat sink data sheets of heat sink manufacturers.

## NCV8502 Series

### ORDERING INFORMATION

| Device           | Output Voltage | Package                         | Shipping†        |
|------------------|----------------|---------------------------------|------------------|
| NCV8502DADJ      | Adjustable     | SO-8                            | 98 Units/Rail    |
| NCV8502DADJG     |                | SO-8<br>(Pb-Free)               | 98 Units/Rail    |
| NCV8502DADJR2    |                | SO-8                            | 2500 Tape & Reel |
| NCV8502DADJR2G   |                | SO-8<br>(Pb-Free)               | 2500 Tape & Reel |
| NCV8502PDWADJ    |                | SOW-16 Exposed Pad              | 47 Units/Rail    |
| NCV8502PDWADJG   |                | SOW-16 Exposed Pad<br>(Pb-Free) | 47 Units/Rail    |
| NCV8502PDWADJR2  |                | SOW-16 Exposed Pad              | 1000 Tape & Reel |
| NCV8502PDWADJR2G |                | SOW-16 Exposed Pad<br>(Pb-Free) | 1000 Tape & Reel |
| NCV8502D25       | 2.5 V          | SO-8                            | 98 Units/Rail    |
| NCV8502D25G      |                | SO-8<br>(Pb-Free)               | 98 Units/Rail    |
| NCV8502D25R2     |                | SO-8                            | 2500 Tape & Reel |
| NCV8502D25R2G    |                | SO-8<br>(Pb-Free)               | 2500 Tape & Reel |
| NCV8502PDW25     |                | SOW-16 Exposed Pad              | 47 Units/Rail    |
| NCV8502PDW25G    |                | SOW-16 Exposed Pad<br>(Pb-Free) | 47 Units/Rail    |
| NCV8502PDW25R2   |                | SOW-16 Exposed Pad              | 1000 Tape & Reel |
| NCV8502PDW25R2G  |                | SOW-16 Exposed Pad<br>(Pb-Free) | 1000 Tape & Reel |
| NCV8502D33       | 3.3 V          | SO-8                            | 98 Units/Rail    |
| NCV8502D33G      |                | SO-8<br>(Pb-Free)               | 98 Units/Rail    |
| NCV8502D33R2     |                | SO-8                            | 2500 Tape & Reel |
| NCV8502D33R2G    |                | SO-8<br>(Pb-Free)               | 2500 Tape & Reel |
| NCV8502PDW33     |                | SOW-16 Exposed Pad              | 47 Units/Rail    |
| NCV8502PDW33G    |                | SOW-16 Exposed Pad<br>(Pb-Free) | 47 Units/Rail    |
| NCV8502PDW33R2   |                | SOW-16 Exposed Pad              | 1000 Tape & Reel |
| NCV8502PDW33R2G  |                | SOW-16 Exposed Pad<br>(Pb-Free) | 1000 Tape & Reel |

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

## NCV8502 Series

### ORDERING INFORMATION

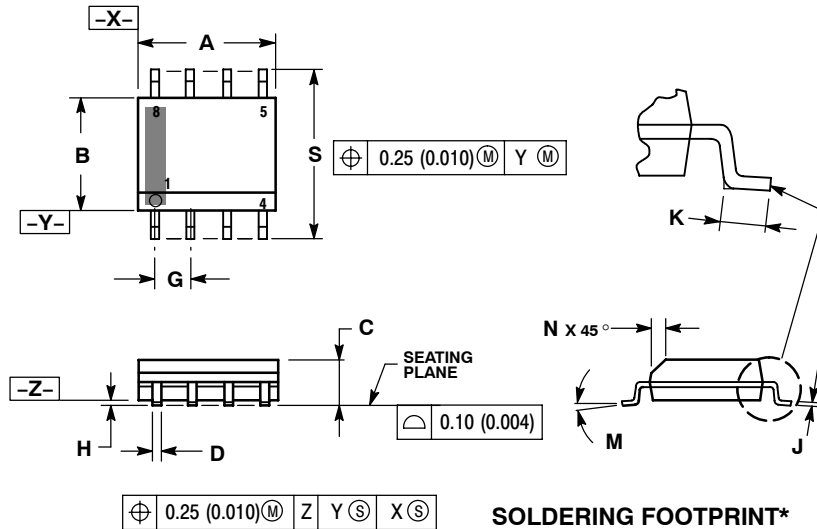
| Device           | Output Voltage | Package                         | Shipping†        |
|------------------|----------------|---------------------------------|------------------|
| NCV8502D50       | 5.0 V          | SO-8                            | 98 Units/Rail    |
| NCV8502D50G      |                | SO-8<br>(Pb-Free)               | 98 Units/Rail    |
| NCV8502D50R2     |                | SO-8                            | 2500 Tape & Reel |
| NCV8502D50R2G    |                | SO-8<br>(Pb-Free)               | 2500 Tape & Reel |
| NCV8502PDW50     |                | SOW-16 Exposed Pad              | 47 Units/Rail    |
| NCV8502PDW50G    |                | SOW-16 Exposed Pad<br>(Pb-Free) | 47 Units/Rail    |
| NCV8502PDW50R2   |                | SOW-16 Exposed Pad              | 1000 Tape & Reel |
| NCV8502PDW50R2G  |                | SOW-16 Exposed Pad<br>(Pb-Free) | 1000 Tape & Reel |
| NCV8502D80       | 8.0 V          | SO-8                            | 98 Units/Rail    |
| NCV8502D80G      |                | SO-8<br>(Pb-Free)               | 98 Units/Rail    |
| NCV8502D80R2     |                | SO-8                            | 2500 Tape & Reel |
| NCV8502D80R2G    |                | SO-8<br>(Pb-Free)               | 2500 Tape & Reel |
| NCV8502PDW80     |                | SOW-16 Exposed Pad              | 47 Units/Rail    |
| NCV8502PDW80G    |                | SOW-16 Exposed Pad<br>(Pb-Free) | 47 Units/Rail    |
| NCV8502PDW80R2   |                | SOW-16 Exposed Pad              | 1000 Tape & Reel |
| NCV8502PDW80R2G  |                | SOW-16 Exposed Pad<br>(Pb-Free) | 1000 Tape & Reel |
| NCV8502D100      | 10 V           | SO-8                            | 98 Units/Rail    |
| NCV8502D100G     |                | SO-8<br>(Pb-Free)               | 98 Units/Rail    |
| NCV8502D100R2    |                | SO-8                            | 2500 Tape & Reel |
| NCV8502D100R2G   |                | SO-8<br>(Pb-Free)               | 2500 Tape & Reel |
| NCV8502PDW100    |                | SOW-16 Exposed Pad              | 47 Units/Rail    |
| NCV8502PDW100G   |                | SOW-16 Exposed Pad<br>(Pb-Free) | 47 Units/Rail    |
| NCV8502PDW100R2  |                | SOW-16 Exposed Pad              | 1000 Tape & Reel |
| NCV8502PDW100R2G |                | SOW-16 Exposed Pad<br>(Pb-Free) | 1000 Tape & Reel |

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

# NCV8502 Series

## PACKAGE DIMENSIONS

SOIC-8 NB  
CASE 751-07  
ISSUE AH

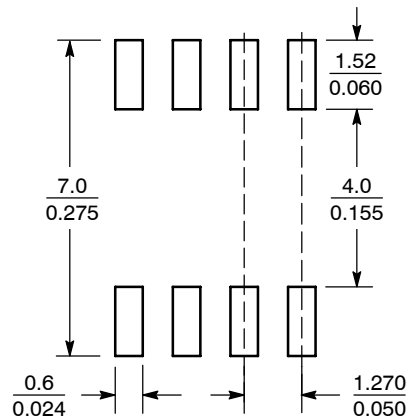


### NOTES:

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 (mm/inches)

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

# NCV8502 Series

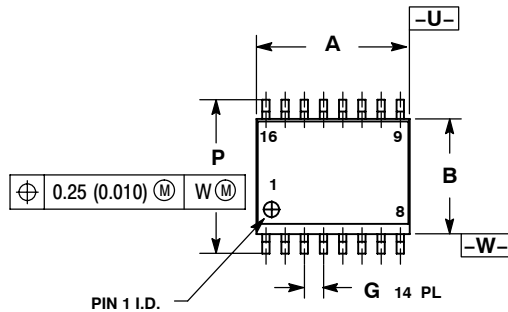
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### SOIC 16 LEAD WIDE BODY, EXPOSED PAD

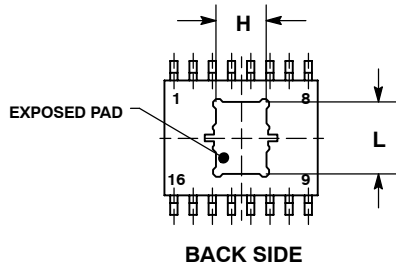
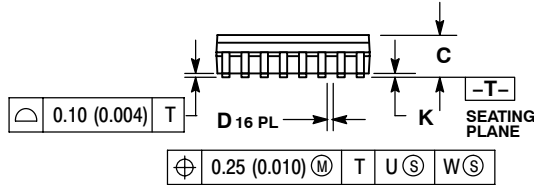
#### PDW SUFFIX

CASE 751AG-01

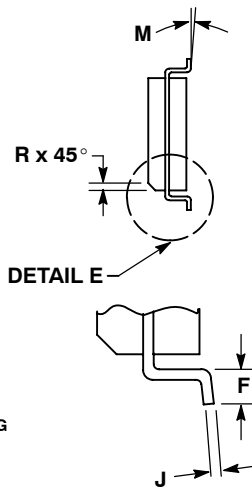
ISSUE O



#### TOP SIDE



#### BACK SIDE



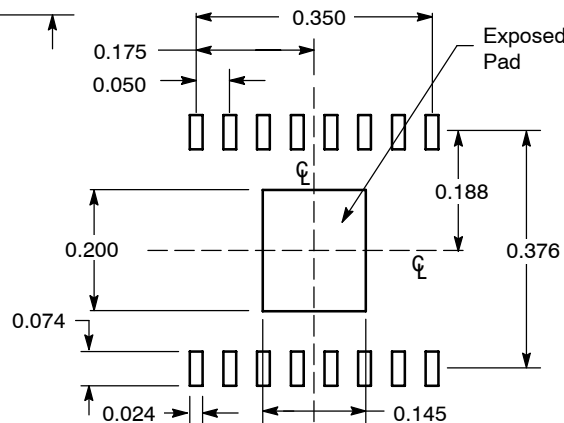
#### DETAIL E

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4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE PROTRUSION SHALL BE 0.13 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. 751R-01 OBSOLETE, NEW STANDARD 751R-02.

| DIM | MILLIMETERS |       | INCHES    |       |
|-----|-------------|-------|-----------|-------|
|     | MIN         | MAX   | MIN       | MAX   |
| A   | 10.15       | 10.45 | 0.400     | 0.411 |
| B   | 7.40        | 7.60  | 0.292     | 0.299 |
| C   | 2.35        | 2.65  | 0.093     | 0.104 |
| D   | 0.35        | 0.49  | 0.014     | 0.019 |
| F   | 0.50        | 0.90  | 0.020     | 0.035 |
| G   | 1.27 BSC    |       | 0.050 BSC |       |
| H   | 3.31        | 3.51  | 0.130     | 0.138 |
| J   | 0.25        | 0.32  | 0.010     | 0.012 |
| K   | 0.00        | 0.10  | 0.000     | 0.004 |
| L   | 4.58        | 4.78  | 0.180     | 0.188 |
| M   | 0°          | 7°    | 0°        | 7°    |
| P   | 10.05       | 10.55 | 0.395     | 0.415 |
| R   | 0.25        | 0.75  | 0.010     | 0.029 |

#### SOLDERING FOOTPRINT\*



DIMENSIONS: MILLIMETERS

\*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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